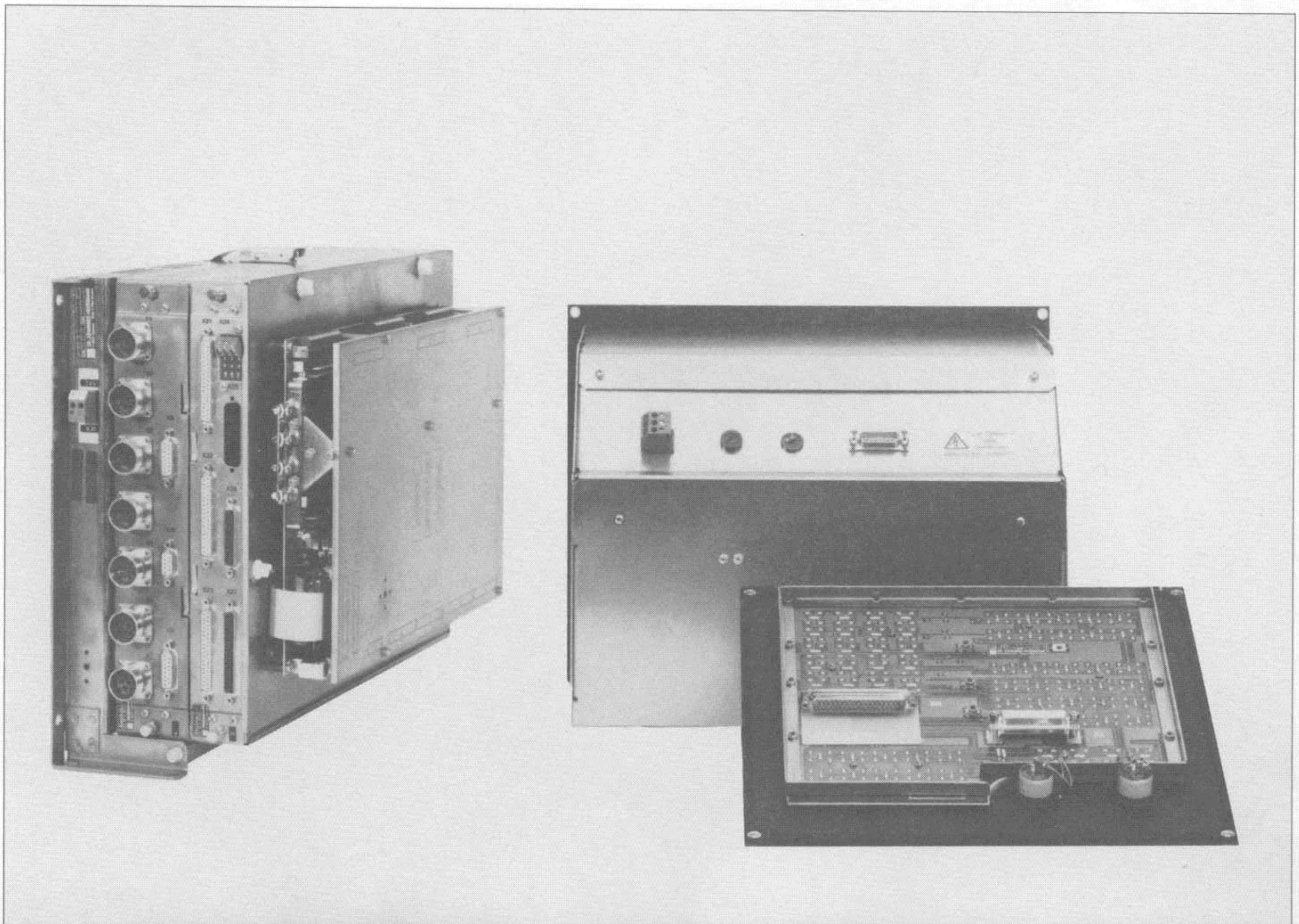
HEIDENHAIN

Manual for Installation and Commissioning

TNC 355



Contents

Volume 1

Volume 2

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
0	April 4, 89				
1	November 21, 89				
2	April 4, 89				
3	February 8, 90				
4	February 8, 90				
5	February 8, 90				
6	November 21, 89				
7	April 4, 89				
8	February 8, 90				
9	November 21, 89				
10	November 21, 89				

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
IN0/1	April 4, 89				
IN1/1	April 4, 89				
IN2/1	April 4, 89				
IN3/1	April 4, 89				

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
T0/1	November 21, 89	T5/1	April 4, 89		
T0/2	April 4, 89	T5/2	November 21, 89		
T1/1	November 21, 89	T5/3	April 4, 89		
T1/2	November 21, 89	T5/4	April 4, 89		
T1/3	November 21, 89	T5/5	April 4, 89		
T2/1	November 21, 89	T5/6	April 4, 89		
T2/2	November 21, 89	T5/7	April 4, 89		
T2/2.1	November 21, 89	T5/8	April 4, 89		
T2/2.2	November 21, 89	T6/1	November 21, 89		
T2/3	February 8, 90	T6/2	April 4, 89		
T3/1	November 21, 89	T7/1	April 4, 89		
T3/1.1	November 21, 89	T7/2	April 4, 89		
T3/2	February 8, 90	T7/3	February 8, 90		
T3/3	November 21, 89	T7/4	February 8, 90		
T3/3.1	November 21, 89	T7/5	February 8, 90		
T3/3.2	April 4, 89	T7/6	April 4, 89		
T3/3.3	February 8, 90	T7/7	April 4, 89		
T3/3.4	November 21, 89	T7/8	November 21, 89		
T3/3.5	April 4, 89	T7/9	November 21, 89		
T3/3.6	November 21, 89	T8/1	November 21, 89		
T3/4	April 4, 89	T8/2	February 8, 90		
T3/5	April 4, 89				
T3/6	April 4, 89				
T3/7	April 4, 89				
T3/8	April 4, 89				
T3/9	April 4, 89				
T3/10	April 4, 89				
T3/11	November 21, 89				
T3/12	April 4, 89				
T3/13	April 4, 89				
T3/14	April 4, 89				
T3/15	April 4, 89				
T4/1	April 4, 89				
T4/2	April 4, 89				
T4/3	November 21, 89				
T4/4	November 21, 89				
T4/5	February 8, 90				
T4/6	February 8, 90				

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
M0/1	November 21, 89				
M1/1	April 4, 89				
M1/2	April 4, 89				
M1/3	April 4, 89				
M1/4	April 4, 89				
M1/5	April 4, 89				
M2/1	April 4, 89				
M2/2	April 4, 89				
M2/3	April 4, 89				
M3/1	February 8, 90				
M3/2	April 4, 89				
M3/3	April 4, 89				
M3/4	February 8, 90				
M3/5	February 8, 90				
M3/5.1	April 4, 89				
M3/5.2	April 4, 89				
M3/6	November 21, 89				
M3/6.1	November 21, 89				
M3/7	April 4, 89				
M3/8	April 4, 89				
M3/9	April 4, 89				
M3/10	April 4, 89				
M3/11	April 4, 89				
M3/12	April 4, 89				
M3/13	April 4, 89				
M3/14	April 4, 89				
M4/1	April 4, 89				
M5/1	April 4, 89				
M5/2	April 4, 89				
M6/1	April 4, 89				
M7/1	February 8, 90				
M7/2	February 8, 90				
M8/1	February 8, 90				
M8/1.1	February 8, 90				
M8/2	February 8, 90				

List of current issues

Sheet	Issue
C0/1	April 4, 89
C0/2	April 4, 89
C0/3	April 4, 89
C1/1	April 4, 89
C1/2	April 4, 89
C1/3	April 4, 89
C1/4	April 4, 89
C1/5	April 4, 89
C1/6	April 4, 89
C1/7	April 4, 89
C1/8	November 21, 89
C1/9	November 21, 89
C1/10	November 21, 89
C1/11	November 21, 89
C1/12	February 8, 90
C1/13	April 4, 89
C1/14	April 4, 89
C1/15	April 4, 89
C1/16	April 4, 89
C1/17	November 21, 89
C1/18	April 4, 89
C1/19	April 4, 89
C1/20	February 8, 90
C1/21	November 21, 89
C1/22	April 4, 89
C1/22.1	April 4, 89
C1/23	April 4, 89
C1/24	April 4, 89
C1/25	April 4, 89
C1/26	April 4, 89
C1/27	April 4, 89
C1/28	April 4, 89
C2/1	April 4, 89
C2/2	April 4, 89
C2/3	April 4, 89
C2/4	November 21, 89
C2/5	November 21, 89
C2/6	November 21, 89
C2/6.1	February 8, 90
C2/6.2	April 4, 89

Sheet	Issue
C2/6.3	April 4, 89
C2/7	November 21, 89
C2/8	April 4, 89
C2/9	April 4, 89
C2/10	April 4, 89
C2/11	April 4, 89
C2/12	April 4, 89
C2/13	April 4, 89
C2/14	April 4, 89
C2/15	April 4, 89
C2/16	April 4, 89
C2/17	April 4, 89
C3/1	February 8, 90
C3/2	April 4, 89
C3/3	April 4, 89
C3/4	April 4, 89
C3/5	April 4, 89
C3/6	April 4, 89
C3/7	April 4, 89
C3/8	April 4, 89
C3/9	November 21, 89
C3/10	April 4, 89
C3/11	April 4, 89
C3/12	February 8, 90
C3/13	April 4, 89
C3/14	April 4, 89
C3/15	April 4, 89
C3/16	April 4, 89
C3/17	April 4, 89
C4/1	April 4, 89
C4/2	April 4, 89
C4/3	April 4, 89
C4/4	April 4, 89
C4/5	April 4, 89
C4/5.1	April 4, 89
C4/6	April 4, 89
C4/7	April 4, 89
C4/8	April 4, 89
C4/9	April 4, 89
C4/10	April 4, 89

Sheet	Issue
C4/11	April 4, 89
C4/12	April 4, 89
C4/13	April 4, 89
C4/14	April 4, 89
C4/15	April 4, 89
C4/16	April 4, 89
C4/17	April 4, 89
C4/18	April 4, 89
C4/19	April 4, 89
C4/20	April 4, 89
C4/21	April 4, 89
C4/22	April 4, 89
C4/23	April 4, 89
C4/24	April 4, 89
C4/25	April 4, 89
C4/26	April 4, 89
C4/27	April 4, 89
C4/28	April 4, 89
C4/29	April 4, 89
C4/30	April 4, 89
C4/31	April 4, 89
C4/32	April 4, 89
C4/33	April 4, 89
C4/34	April 4, 89
C4/35	April 4, 89
C5/1	April 4, 89
C5/2	April 4, 89
C5/3	April 4, 89
C5/4	April 4, 89
C5/5	November 21, 89
C5/6	April 4, 89
C5/7	April 4, 89
C5/8	April 4, 89
C5/9	April 4, 89
C5/10	April 4, 89

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
U0/1	April 4, 89				
U1/1	November 21, 89				
U1/2	April 4, 89				
U1/3	April 4, 89				
U1/4	April 4, 89				
U1/5	April 4, 89				
U2/1	April 4, 89				
U2/2	April 4, 89				
U2/3	April 4, 89				
U3/1	April 4, 89				
U3/2	April 4, 89				

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
D0/1	April 4, 89				
D1/1	April 4, 89				
D1/2	April 4, 89				
D1/3	April 4, 89				
D1/4	April 4, 89				
D1/5	April 4, 89				
D1/6	April 4, 89				
D1/7	April 4, 89				
D1/8	April 4, 89				
D2/1	April 4, 89				
D2/2	April 4, 89				
D2/3	April 4, 89				
D2/4	April 4, 89				
D2/5	April 4, 89				
D2/6	April 4, 89				
D2/7	April 4, 89				
D3/1	April 4, 89				
D3/2	April 4, 89				

List of current issues

Sheet	Issue
P0/1	April 4, 89
P0/2	November 21, 89
P0/3	April 4, 89
P1/1	April 4, 89
P2/1	April 4, 89
P2/2	April 4, 89
P2/3	April 4, 89
P2/4	April 4, 89
P2/5	April 4, 89
P2/6	April 4, 89
P2/7	April 4, 89
P2/8	April 4, 89
P2/9	April 4, 89
P2/10	April 4, 89
P2/11	April 4, 89
P3/1	April 4, 89
P3/2	April 4, 89
P3/3	April 4, 89
P3/4	April 4, 89
P3/5	April 4, 89
P3/6	April 4, 89
P3/7	April 4, 89
P3/8	April 4, 89
P3/9	April 4, 89
P3/10	April 4, 89
P3/11	April 4, 89
P3/12	April 4, 89
P3/13	February 8, 90
P3/14	April 4, 89
P3/15	April 4, 89
P3/16	April 4, 89
P3/17	April 4, 89
P3/18	April 4, 89
P3/19	April 4, 89
P3/20	April 4, 89
P3/21	April 4, 89
P3/22	February 8, 90
P3/23	February 8, 90
P3/24	April 4, 89
P3/25	November 21, 89

Sheet	Issue
P3/26	April 4, 89
P3/27	April 4, 89
P3/28	April 4, 89
P3/29	April 4, 89
P3/30	April 4, 89
P3/31	November 21, 89
P3/32	April 4, 89
P3/33	April 4, 89
P3/34	April 4, 89
P3/35	April 4, 89
P3/36	April 4, 89
P3/37	November 21, 89
P3/38	November 21, 89
P3/39	April 4, 89
P3/40	April 4, 89
P3/41	April 4, 89
P3/42	April 4, 89
P3/43	April 4, 89
P3/44	April 4, 89
P3/45	April 4, 89
P3/46	April 4, 89
P3/47	April 4, 89
P3/48	April 4, 89
P3/49	April 4, 89
P3/50	April 4, 89
P3/51	April 4, 89
P3/52	November 21, 89
P3/53	April 4, 89
P3/54	April 4, 89
P3/55	April 4, 89
P3/56	April 4, 89
P4/1	April 4, 89
P4/2	February 8, 90
P4/3	April 4, 89
P4/4	April 4, 89
P4/5	February 8, 90
P4/6	April 4, 89
P4/7	April 4, 89
P4/8	April 4, 89
P4/8.1	April 4, 89

Sheet	Issue
P4/9	February 8, 90
P4/10	April 4, 89
P4/11	April 4, 89
P4/12	April 4, 89
P4/13	April 4, 89
P4/14	April 4, 89
P5/1	April 4, 89
P6/1	April 4, 89
P6/2	April 4, 89
P6/3	April 4, 89
P6/3.1	April 4, 89
P6/4	April 4, 89
P6/5	April 4, 89
P6/6	April 4, 89
P6/7	April 4, 89
P6/8	April 4, 89
P6/9	April 4, 89
P6/10	April 4, 89
P6/11	April 4, 89
P6/12	April 4, 89
P6/13	April 4, 89
P6/14	April 4, 89
P6/15	April 4, 89
P7/1	April 4, 89
P7/2	April 4, 89
P7/3	April 4, 89
P7/4	April 4, 89
P7/5	April 4, 89

List of current issues

Sheet	Issue	Sheet	Issue	Sheet	Issue
PS0/1	November 21, 89				
PS1/1	November 21, 89				
PS2/1	November 21, 89				
PS2/2	November 21, 89				
PS2/3	November 21, 89				
PS2/4	November 21, 89				
PS2/5	November 21, 89				
PS2/6	November 21, 89				
PS2/7	November 21, 89				
PS2/8	November 21, 89				
PS2/9	November 21, 89				
PS2/10	November 21, 89				
PS2/11	November 21, 89				
PS2/12	November 21, 89				
PS2/13	November 21, 89				
PS2/14	November 21, 89				
PS2/15	November 21, 89				
PS3/1	November 21, 89				
PS3/2	November 21, 89				
PS3/3	November 21, 89				
PS3/4	November 21, 89				
PS3/5	November 21, 89				
PS3/6	November 21, 89				
PS4/1	November 21, 89				
PS4/2	November 21, 89				
PS4/3	November 21, 89				
PS4/4	November 21, 89				
PS4/5	November 21, 89				
PS4/6	November 21, 89				

List of current issues

Operating Manual	Issue: July 89

Contents

Purpose of this manual

This manual contains all information for the installation, electrical connection, commissioning and PLC-programming of the contouring control HEIDENHAIN TNC 355. Every machine tool builder installing HEIDENHAIN numerical controls can obtain this manual for a nominal fee.

In order to ensure that the manual can always be updated to the latest technical level, it has been designed as a compilation of loose sheets. In the event of technical amendments and extensions to the TNC, supplement sheets will be automatically supplied which are to be inserted into the existing manual in accordance with the filing instructions.

The former system in issuing TNC-bulletins for original equipment manufacturers has now been superseded by this manual.

Please note that future supplies of TNC-controls will no longer be accompanied by the individual instruction manuals for installation, interfacing and the PLC-description. All important information for the machine tool builder is contained in this manual. Due to the structure of this manual, it is not possible to supply a copy with each control unit.

The reproduction of pages from this manual, on the part of the machine tool builder, for the compilation of specific machine documentation is, of course, permitted.

Structure of manual

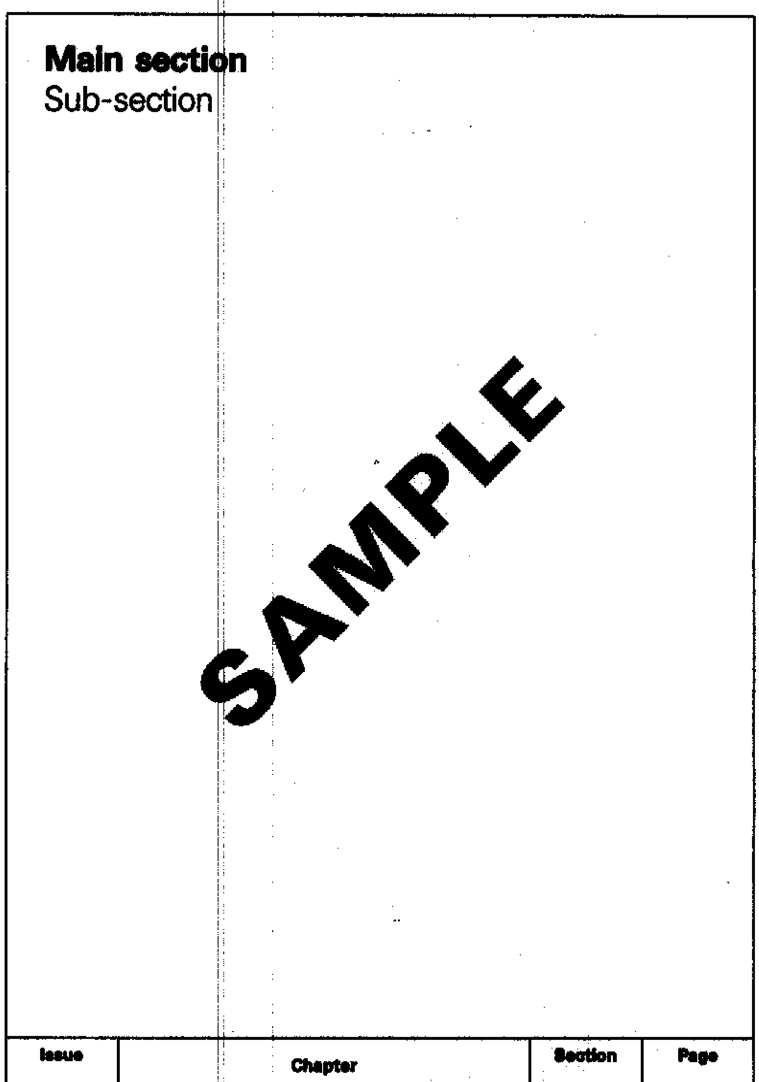
The contents of the manual are subdivided into various chapters.

A basic overview of the contents is indicated on the filing index (see Contents, page 0).

A list of contents is provided at the beginning of each chapter detailing the individual sections.

Layout of information sheets

Each information sheet has the following layout:



The heading of each sheet indicates the main section in bold letters and the specific topic beneath.

The title block at the bottom of each sheet contains the date of issue, chapter title, section number and page number.

This paging system enables easy insertion of both supplementary and exchange sheets.

Supplementary issues

Each supplementary issue contains a brief overview of important amendments and additions. An instruction sheet on filing is also included. After filing, both sheets should be filed into the "Update information" chapter.

Layout of "Filing instructions"-sheet.

Filing Instructions

Index

Remove following sheets	Number of sheets	Insert following sheets	Number of sheets
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.

Issue	Update information	

Sheets for the "Update information"-chapter are filed in accordance with the issue date, since these have no section and page numbers in the title block.

Level of issues

The "Filing instructions" should always be retained in the manual so that, in the event of enquiries, the latest issue level is known.

Immediately after the list of contents a "List of current issues", i.e. for all sheets within this manual, including the issue dates is provided. This list is also updated with every supplementary issue of information.

We hope that this manual will be of good service.

Contents

Contents

Technical data
TNC 355 B (Q) (Export version TNC 355 F [W])[1)]

Control versions	**TNC 355** with visual display unit BE 412 B (12 inch, monochrome) including programmable logic controller (PLC) – **TNC 355 B (F)** = without PLC-board – **TNC 355 Q (W)** = additional inputs and output on PLC-board PL 300
Control type	– **Contouring control for 4 axes** including spindle orientation as a 5th axis (cannot be interpolated with other axes), linear interpolation in 3 out of 4 axes[1)], circular interpolation in 2 out of 4 axes (only if 4th axis is parallel to another linear axis: Contouring programming with the 4th axis conditionally possible), helical interpolation[1)] – **Contouring control for 5 axes,** without spindle orientation (until February 1989)
Program memory	Semi-conductor store for 32 NC-programs, with buffer battery backup, total blocks: 3100; Programmable erase/edit protection
Central tool file	up to 99 tools, especially for toolchangers with flexible addressing
Max. traversing range	± 30000 mm or 1181 in.
Max. traversing speed	30 m/min or 1181 ipm[(05)]
Encoders	HEIDENHAIN incremental linear encoders (with or without distance-coded reference marks), grating period 0.02/0.01 mm (or 0.1 mm for encoder input X5, connection via an appropriate EXE-unit); HEIDENHAIN rotary encoders
Programmable logic controller (PLC)	PLC-cycle time = 20 ms (22 ms for more than 2048 commands)[(05)] 3072 commands[(05)] 1000 User-markers (volatile) 1000 User-markers (non-volatile) 1024 permanently assigned markers 32 counters[(05)] 48 timers[(05)] **Inputs and outputs for TNC 355 B (F)** 57 inputs, 31 outputs (24 V =, max. 100 mA) **Inputs and outputs for TNC 355 Q (W)** In addition to the 57 inputs and 31 outputs of the logic unit the TNC 355 Q (W) also includes an external PLC-board PL 300 with 63 inputs and 31 outputs (24 V =, max. 1.2 A)
Control inputs	Encoders: 4 sinusoidal inputs, 1 squarewave signal input Electronic handwheel (HR 150 or HR 250) Touch probe system (TS 111/TS 511 via APE 110/510 or APE 511)
Control outputs	One analogue output each for X/Y/Z/IV (V) (with automatic offset adjustment), one analogue output for spindle (S)
Operating voltage	NC-part of LE 355: 24 V–, I_{max} = 1.5 A PLC-part of LE 355 B (F): 24 V–, I_{max} = 1.8 A } if half of the inputs/outputs are driven PL 300: 24 V–, I_{max} = 21 A } simultaneously BE 412 B mains voltage: voltage ranges 85 V – 132 V and 170 V – 264 V; Frequency 48 ... 62 Hz
Power consumption	NC-part of LE 355: approx. 30 W PLC-part of LE 355 B (F): approx. 6 W, if approx. 1/3 of the inputs and outputs are driven simultaneously PL 300: depending on the number of connected consumers; approx. 25 W, if approx. 1/3 of the inputs and outputs are driven simultaneously BE 412 B: approx. 40 W
Ambient temperature	Operation 0 ... 45° C/32 ... 113° F, Storage – 30 ... 70° C/– 22 ... 155° F
Weight	Logic unit LE 355 B (F): 8.4 kg (18.5 lb); LE 355 Q (W): 11.6 kg (25.6 lb) Keyboard unit TE 355: 1.6 kg (3.5 lb) Visual display unit BE 412 B: (12 inch) 11.7 kg (25.8 lb)

[1)] Export version TNC 355 F (W) without axis sag compensation

[(05)] As of software level 05 (4 axes)

Technical data
TNC 355 C (S) (Export version TNC 355 G [Y])[1)]

Control versions	**TNC 355** with visual display unit BE 412 B (12 inch, monochrome) including programmable logic controller (PLC) – **TNC 355 C (G)** = without PLC-board – **TNC 355 S (Y)** = additional inputs and output on PLC-board PL 300
Control type	– **Contouring control for 5 axes** plus spindle orientation, linear interpolation in 3 out of 5 axes[1)], circular interpolation in 2 out of 5 axes (only if 4th or 5th axis is parallel to another linear axis: Contouring programming with the 4th and 5th axis conditionally possible), helical interpolation[1)]
Program memory	Semi-conductor store for 32 NC-programs, with buffer battery backup, total blocks: 3100; Programmable erase/edit protection
Central tool file	up to 99 tools, especially for toolchangers with flexible addressing
Max. traversing range	± 30000 mm or 1181 in.
Max. traversing speed	30 m/min or 1181 ipm
Encoders	HEIDENHAIN incremental linear encoders (with or without distance-coded reference marks), grating period 0.02/0.01 mm (or 0.1 mm for encoder inputs X5, X6, connection via an appropriate EXE-unit); HEIDENHAIN rotary encoders
Programmable logic controller (PLC)	PLC-cycle time = 20 ms (22 ms for more than 2048 commands) 3072 commands 1000 User-markers (volatile) 1000 User-markers (non-volatile) 1024 permanently assigned markers 32 counters 48 timers **Inputs and outputs for TNC 355 C (G)** 57 inputs, 31 outputs (24 V=, max. 100 mA) **Inputs and outputs for TNC 355 S (Y)** In addition to the 57 inputs and 31 outputs of the logic unit the TNC 355 S (Y) also includes an external PLC-board PL 300 with 63 inputs and 31 outputs (24 V =, max. 1.2 A)
Control inputs	Encoders: 4 sinusoidal inputs, 2 squarewave signal inputs Electronic handwheel (HR 150/HR 250 or HR 130/HR 330) Touch probe systems TS 120 (TS 111/TS 511 via APE 110/510 or APE 511 and cable adapter)
Control outputs	One analogue output each for X/Y/Z/IV/V (with automatic offset adjustment), one analogue output for spindle (S)
Operating voltage	NC-part of LE 355: 24 V–, I_{max} = 1.5 A PLC-part of LE 355 C (G): 24 V–, I_{max} = 1.8 A } if half of the inputs/outputs are driven PL 300: 24 V–, I_{max} = 21 A } simultaneously BE 412 B mains voltage: voltage ranges 85 V – 132 V and 170 V – 264 V; Frequency 48 ... 62 Hz
Power consumption	NC-part of LE 355: approx. 30 W PLC-part of LE 355 C (G): approx. 6 W, if approx. 1/3 of the inputs and outputs are driven simultaneously PL 300: depending on the number of connected consumers; approx. 25 W, if approx. 1/3 of the inputs and outputs are driven simultaneously BE 412 B: approx. 40 W
Ambient temperature	Operation 0 . . . 45° C/32 . . . 113° F, Storage – 30 . . . 70° C/– 22 . . . 155° F
Weight	Logic unit LE 355 C (G): 8.4 kg (18.5 lb); LE 355 S (Y): 11.6 kg (25.6 lb) Keyboard unit TE 355: 1.6 kg (3.5 lb) Visual display unit BE 412 B: (12 inch) 11.7 kg (25.8 lb)

1) Export version TNC 355 G (Y) without axis sag compensation

Technical data
TNC 355 CR (SR) (Export version TNC 355 GR [YR])[1)]

Control versions	**TNC 355** with visual display unit BE 412B (12 inch, monochrome) including programmable logic controller (PLC) – **TNC 355 CR (GR)** = without PLC-board – **TNC 355 SR (YR)** = additional inputs and output on PLC-board PL 300
Control type	– **Contouring control for 5 axes** plus spindle orientation, linear interpolation in 3 out of 5 axes[1)], circular interpolation in 2 out of 5 axes (only if 4th or 5th axis is parallel to another linear axis: Contouring programming with the 4th and 5th axis conditionally possible), helical interpolation[1)]
Program memory	Semi-conductor store for 32 NC-programs, with buffer battery backup, total blocks: 3100; Programmable erase/edit protection
Central tool file	up to 99 tools, especially for toolchangers with flexible addressing
Max. traversing range	± 30000 mm or 1181 in.
Max. traversing speed	30 m/min or 1181 ipm
Encoders	HEIDENHAIN incremental linear encoders (with or without distance-coded reference marks), grating period 0.02/0.01 mm (or 0.1 mm for encoder inputs for squarewave signals, connection via an appropriate EXE-unit); HEIDENHAIN rotary encoders
Programmable logic controller (PLC)	PLC-cycle time = 20 ms (22 ms for more than 2048 commands) 3072 commands 1000 User-markers (volatile) 1000 User-markers (non-volatile) 1024 permanently assigned markers 32 counters 48 timers **Inputs and outputs for TNC 355 CR (GR)** 57 inputs, 31 outputs (24 V⎓, max. 100 mA) **Inputs and outputs for TNC 355 SR (YR)** In addition to the 57 inputs and 31 outputs of the logic unit the TNC 355SR (YR) also includes an external PLC-board PL 300 with 63 inputs and 31 outputs (24 V ⎓, max. 1.2 A)
Control inputs	Encoders: 1 sinusoidal input, 5 squarewave signal inputs Electronic handwheel (HR 150/HR 250 or HR 130/HR 330) Touch probe systems TS 120 (TS 111/TS 511 via APE 110/510 or APE 511 and cable adapter)
Control outputs	One analogue output each for X/Y/Z/IV/V (with automatic offset adjustment), one analogue output for spindle (S)
Operating voltage	NC-part of LE 355: 24 V–, I_{max} = 1.5 A PLC-part of LE 355CR (GR): 24 V–, I_{max} = 1.8 A } if half of the inputs/outputs are driven PL 300: 24 V–, I_{max} = 21 A } simultaneously BE 412B mains voltage: voltage ranges 85 V – 132 V and 170 V – 264 V; Frequency 48 ... 62 Hz
Power consumption	NC-part of LE 355: approx. 30 W PLC-part of LE 355C (G): approx. 6 W, if approx. 1/3 of the inputs and outputs are driven simultaneously PL 300: depending on the number of connected consumers; approx. 25 W, if approx. 1/3 of the inputs and outputs are driven simultaneously BE 412B: approx. 40 W
Ambient temperature	Operation 0 ... 45° C/32 ... 113° F, Storage – 30 ... 70° C/– 22 ... 155° F
Weight	Logic unit LE 355CR (GR): 8.4 kg (18.5 lb); LE 355SR (YR): 11.6 kg (25.6 lb) Keyboard unit TE 355: 1.6 kg (3.5 lb) Visual display unit BE 412B: (12 inch) 11.7 kg (25.8 lb)

1) Export version TNC 355 GR (YR) without axis sag compensation

Hardware components
4-axis contouring control with spindle orientation

The hardware of the TNC 355 with 4 axes consists of the following components:

The logic unit LE 355 contains the control logic for the 4-axis contouring control with spindle orientation and graphics. It is available in four versions:

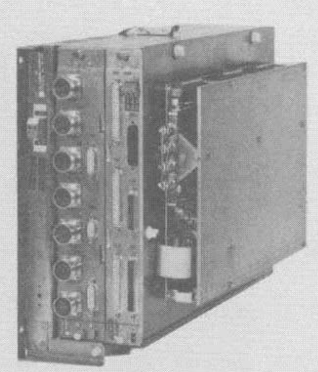
Logic unit
LE 355B
is equipped with a total of 57 PLC-inputs and 31 PLC-outputs (0.1 A).

Logic unit
LE 355Q
is equipped with an additional PLC-board PL 300. PL 300 has 63 inputs and 31 outputs (1.2 A). In comparison to LE 355B, the total number of inputs/outputs is increased to 120 PLC-inputs and 62 PLC-outputs.

LE 355F Export version[1)]

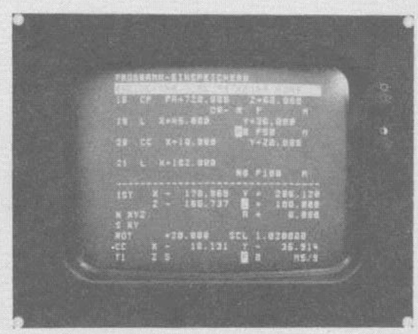
Until Aug. '89 Id.-Nr. 237660..
Since Sept. '89 Id.-Nr. 254581..

LE 355W Export version[1)]



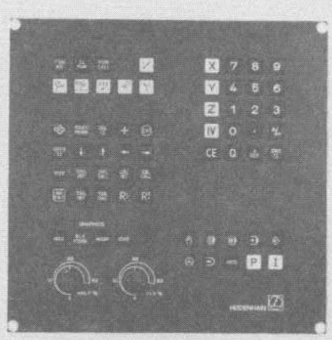
Until Aug. '89 Id.-Nr. 238324..
Since Sept. '89 Id.-Nr. 254582..

Visual display unit BE 412B
connected to the logic unit via special cable.



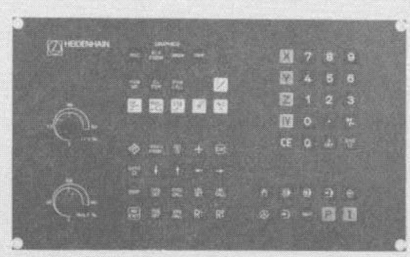
Id.-Nr. 24184501

TNC Keyboard unit TE 355A
connected to the logic unit via special cable.



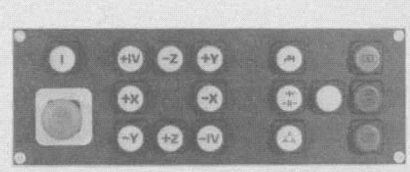
Until Aug. '89 Id.-Nr. 23766102
Since Sept. '89 Id.-Nr. 25501501

TNC Keyboard unit TE 355B
as TE 355A, but width as per BE 412B.



Until Aug. '89 Id.-Nr. 24196401
Since Sept. '89 Id.-Nr. 25501601

HEIDENHAIN Machine operating panel MB 301
connected to the TNC keyboard unit via ribbon cable supplied.



Until Aug. '89 Id.-Nr. 24289401
Since Sept. '89 Id.-Nr. 24388603

1) Export version TNC 355F (W) without axis sag compensation

Hardware components
5-axis contouring control without spindle orientation (until Feb. '89)

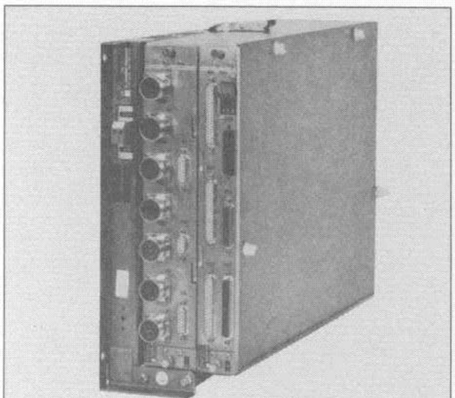
The hardware of the TNC 355 with 5 axes without spindle orientation consists of the following components:

The logic unit LE 355 contains the control logic for the 5-axis contouring control with graphics.
It is available in four versions:

Logic unit
LE 355B
is equipped with a total of 57 PLC-inputs and 31 PLC-outputs (0.1 A).

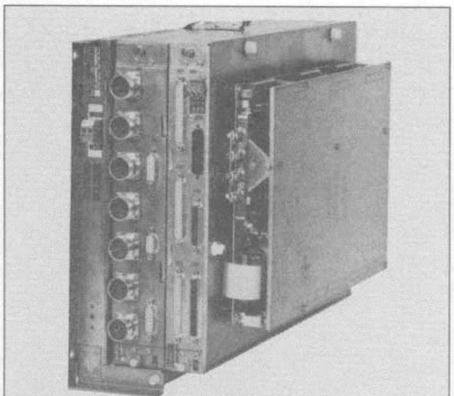
Logic unit
LE 355Q
is equipped with an additional PLC-board PL 300. PL 300 has 63 inputs and 31 outputs (1.2 A). In comparison to LE 355B, the total number of inputs/outputs is increased to 120 PLC-inputs and 62 PLC-outputs.

LE 355F Export version[1)]



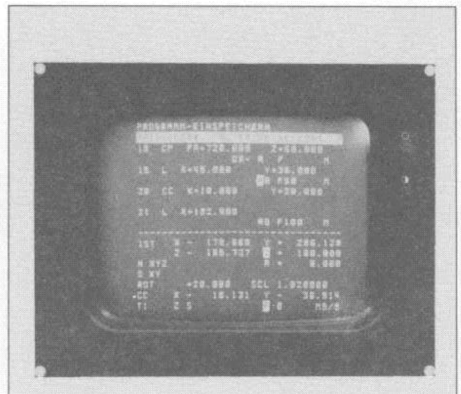
Id.-Nr. 242408..

LE 355W Export version[1)]



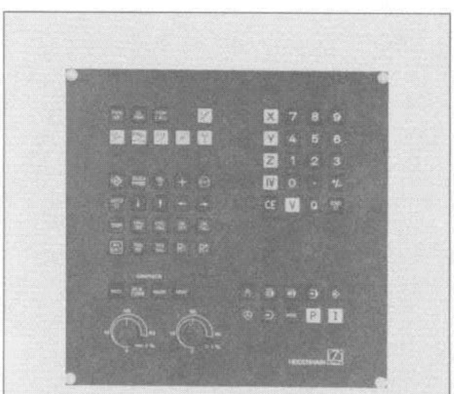
Id.-Nr. 242407..

Visual display unit BE 412B
connected to the logic unit via special cable.



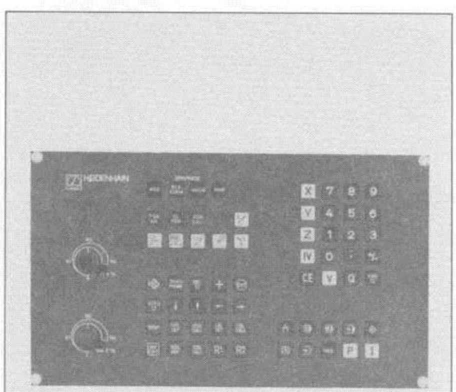
Id.-Nr. 24184501

TNC Keyboard unit TE 355C
connected to the logic unit via special cable.



Until Aug. '89 Id.-Nr. 23766103
Since Sept. '89 Id.-Nr. 25501503

TNC Keyboard unit TE 355D
as TE 355C, but width as per BE 412B.



Until Aug. '89 Id.-Nr. 24196402
Since Sept. '89 Id.-Nr. 25501602

1) Export version TNC 355F (W) without axis sag compensation

Hardware components
5-axis contouring control with spindle orientation

The hardware of the TNC 355 with 5 axes consists of the following components:

The logic unit LE 355 contains the control logic for the 5-axis contouring control with graphics.
It is available in four versions:

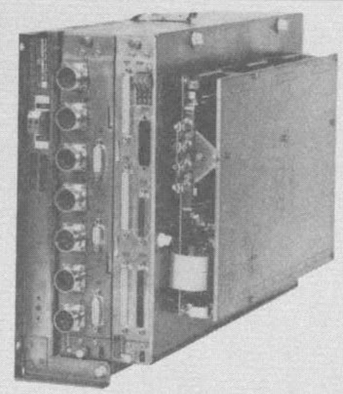
Logic unit
LE 355C
is equipped with a total of 57 PLC-inputs and 31 PLC-outputs (0.1 A).

Logic unit
LE 355S
is equipped with an additional PLC-board PL 300. PL 300 has 63 inputs and 31 outputs (1.2 A). In comparison to LE 355B, the total number of inputs/outputs is increased to 120 PLC-inputs and 62 PLC-outputs.

LE 355G Export version[1)]

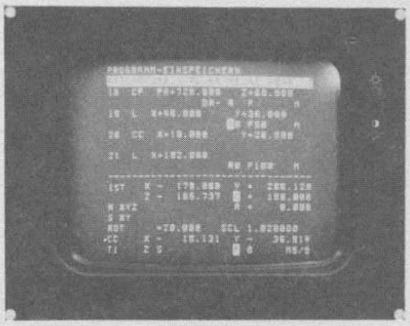
Until Aug. '89 Id.-Nr. 246813..
Since Sept. '89 Id.-Nr. 254819..

LE 355Y Export version[1)]



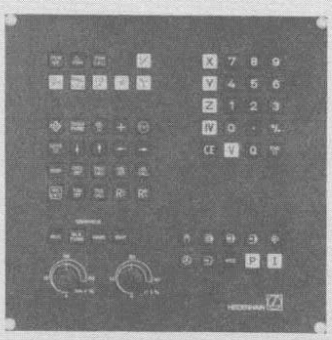
Until Aug. '89 Id.-Nr. 248055..
Since Sept. '89 Id.-Nr. 254820..

Visual display unit BE 412B
connected to the logic unit via special cable.



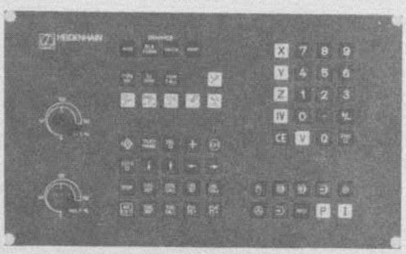
Id.-Nr. 24184501

TNC Keyboard unit TE 355C
connected to the logic unit via special cable.



Until Aug. '89 Id.-Nr. 23766103
Since Sept. '89 Id.-Nr. 25501503

TNC Keyboard unit TE 355D
as TE 355C, but width as per BE 412B.



Until Aug. '89 Id.-Nr. 24196402
Since Sept. '89 Id.-Nr. 25501602

1) Export version TNC 355G (Y) without axis sag compensation

Hardware components

5-axis contouring control with spindle orientation

Up to 5 encoders with squarewave signals can be connected to the TNC 355CR (SR).

The hardware of the TNC 355 with 5 axes consists of the following components:

The logic unit LE 355 contains the control logic for the 5-axis contouring control with graphics.
It is available in four versions:

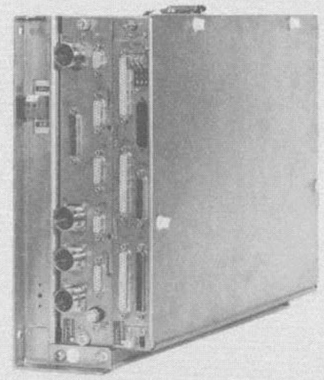
Logic unit
LE 355CR
is equipped with a total of 57 PLC-inputs and 31 PLC-outputs (0.1 A).

Logic unit
LE 355SR
is equipped with an additional PLC-board PL 300. PL 300 has 63 inputs and 31 outputs (1.2 A). In comparison to LE 355B, the total number of inputs/outputs is increased to 120 PLC-inputs and 62 PLC-outputs.

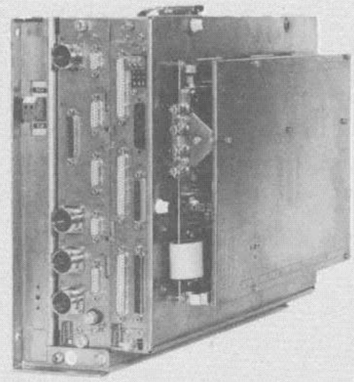
LE 355GR Export version[1)]

LE 355YR Export version[1)]

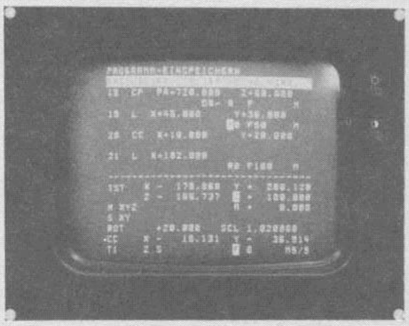
Visual display unit BE 412B
connected to the logic unit via special cable.



Id.-Nr. 249516..

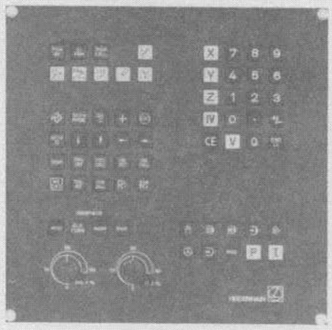


Id.-Nr. 249517..



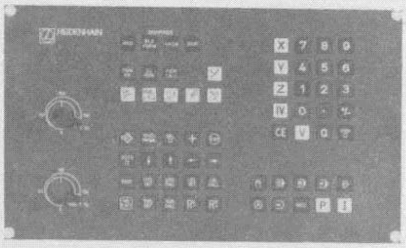
Id.-Nr. 24184501

TNC Keyboard unit TE 355C
connected to the logic unit via special cable.



Until Aug. '89 Id.-Nr. 23766103
Since Sept. '89 Id.-Nr. 25501503

TNC Keyboard unit TE 355D
as TE 355C, but width as per BE 412B.



Until Aug. '89 Id.-Nr. 24196402
Since Sept. '89 Id.-Nr. 25501602

1) Export version TNC 355GR (YR) without axis sag compensation

Hardware components
Difference between TNC 355 variants

LE 355B (Q)
LE 355B (Q) is available in the following versions:
- 4-axis contouring control with spindle orientation
  for 4 encoders with sinusoidal signals and squarewave signal input for spindle orientation.
- 5-axis contouring control without spindle orientation.
  The 5th encoder input for squarewave signals is used for the 5th axis. This eliminates the possibility of having spindle orientation. At connection X8 an additional analogue output is provided for the 5th axis.
  The 5-axis contouring control without spindle orientation will be superseded by the LE 355C (S) in the first quarter of 1989.

LE 355C (S)
5-axis contouring control with spindle orientation.
The conrol is equipped with 4 inputs for encoders having sinusoidal signals and 2 inputs for encoders with squarewave signals. Furthermore, the LE is equipped with 2 additional inputs for connection of the new touch probe system TS 120 and the electronic handwheel with axis selection keys. This handwheel will be available as of mid-1989.

LE 355CR (SR)
5-axis contouring control with spindle orientation.
The control is equipped with an input for an encoder with sinusoidal output signals and 5 inputs for encoders with squarewave signals. In contrast to LE 355C (S), 3 of the encoder inputs for squarewave signals are combined in a 25-pole Sub-D-connector. All other specifications as per LE 355C (S).

TNC-keyboard unit
The keyboard unit for the 5-axis contouring controls (TE 355C (D)) has, instead of the [illegible]-key, a key for the programming of axis V.
On 5-axis controls dialogue initiation for Q-function programming is performed via the Q-key.

Special features of of the 5-axis contouring controls
- The position display of the 5th axis is displayed in the VDU-screen beneath the 4th axis. For this, the display of datum shifts and mirror-imaged axes has been simplified.

  Example:

  N XY

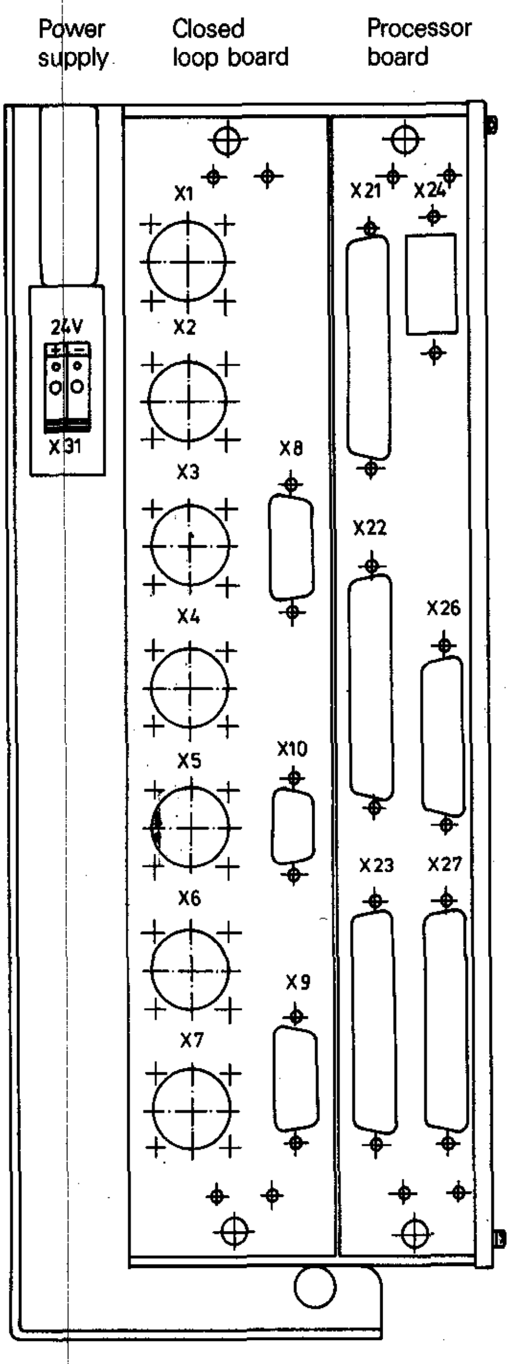
  S X

  The above display signifies that a datum shift is programmed in the axes X and Y and that the X-axis has been mirror-imaged.

- Axis V is always the last axis to traverse the reference mark.
- Axis V cannot be programmed as tool axis (Tool Call)
- The following functions do not apply to axis V:
  .Backlash compensation
  .Automatic lubrication after a programmed distance
  .Linear compensation of machine axes (only applicable to LE 355B (Q))

Connections

Connector locations on LE 355 B (Q) (until August '89)



Closed loop:

X1 = Encoder 1
X2 = Encoder 2
X3 = Encoder 3
X4 = Encoder 4
X5 = Encoder 5

$\}$ Standard allocation (switchover via machine parameters 253 . . . 257)

X6 = Electronic handwheel HR 150/HR 250

X7 = Touch probe system

X8 = Nominal value output for X, Y, Z, IV, S (V)

X9 = Visual display unit BE 412B

X10 = Reference pulse inhibitor

Processor:

X21 = PLC-output

X22 = PLC-input

X23 = Keyboard unit TE 355

X24 = Power supply 24 V– for PLC

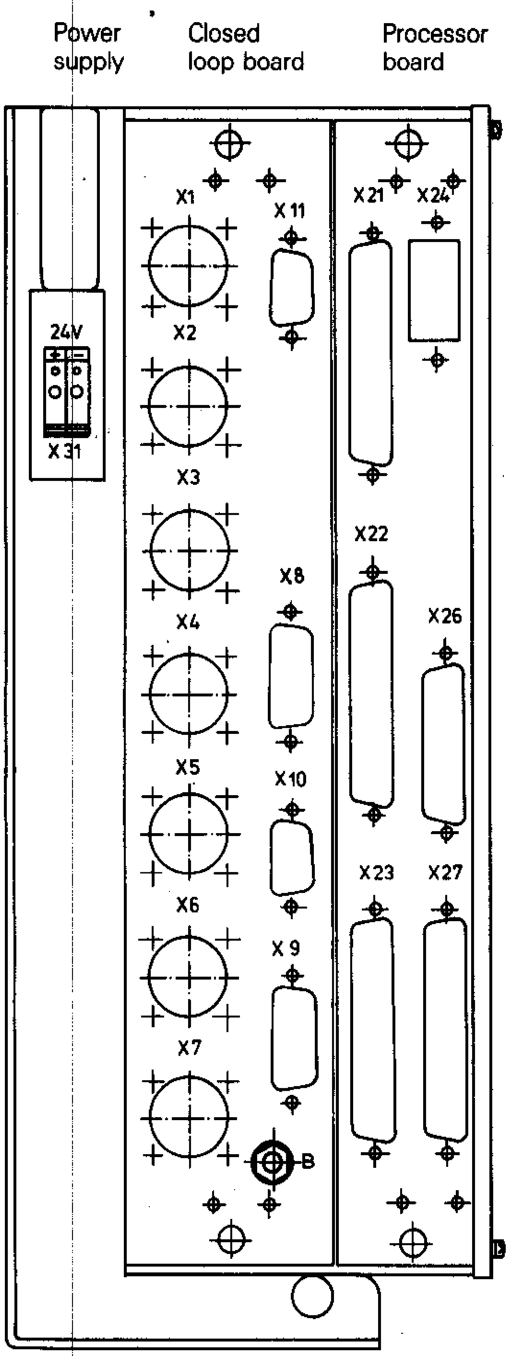
X26 = Data interface RS-232-C/V.24

X27 = Machine operating panel

Power supply:

X31 = Power supply 24 V– for LE

Connections
Connector locations on LE 355 B (Q) (since Sept. '89)



		Color code
Closed loop:		
X1 = Encoder 1	Standard allocation (switchover via machine parameters 253 . . . 257)	
X2 = Encoder 2		
X3 = Encoder 3		
X4 = Encoder 4		
X5 = Encoder 5		
X6 = Electronic handwheel HR 150/HR 250		
X7 = Touch probe system		
X8 = Nominal value output for X, Y, Z, IV, S (V)		Red
X9 = Visual display unit BE 412B		Blue
X10 = Reference pulse inhibitor		Yellow
X11 = Test I/O (for test purpose only)		Red
S = Signal ground		
Processor:		
X21 = PLC-output		Red
X22 = PLC-input		Yellow
X23 = Keyboard unit TE 355		Blue
X24 = Power supply 24 V– for PLC		
X26 = Data interface RS-232-C/V.24		Red
X27 = Machine operating panel		Green
Power supply:		
X31 = Power supply 24 V– for LE		

Connections
Connectors on closed loop board of LE 355 B (Q)

X1, X2, X3, X4 Encoder 1, 2, 3, 4 with sinusoidal signal input

Flange socket, female (9-pole)

Contact No.	Allocation
1	0^{0+}
2	0^{0-}
5	90^{0+}
6	90^{0-}
7	RI+
8	RI–
3	+5 V (U_P)
4	0 V (U_N)
9	Internal screen
Housing	External screen = Unit housing

X6 Electronic handwheels HR 150, HR 250

Flange socket, female (9-pole)

Contact No.	Allocation
1	0^{0+}
2	0^{0-}
5	90^{0+}
6	90^{0-}
3	+5 V (U_P)
4	0 V (U_N)
9	Internal screen (0 V, U_N)
Housing	External screen = Unit housing
7, 8	do not assign

X7 Touch probe system

Flange socket, female (7-pole)

Contact No.	Allocation
1	0 V (U_N)
2	+ 15 ... + 19 V (U_P)
3	Start
4	$\overline{\text{Trigger signal}}$[2]
5	Standby
6	$\overline{\text{Battery warning}}$
7	Internal screen (0 V, U_N)
Connector housing	External screen

X5 Encoder 5 with squarewave signal input (for spindle (S) or for a machine axis)

Flange socket, female (12-pole)

Contact No.	Allocation
5	U_{a1}
6	$\overline{U_{a1}}$
8	U_{a2}
1	$\overline{U_{a2}}$
3	U_{a0}
4	$\overline{U_{a0}}$
–	U_{aS} not included
7	$\overline{U_{aS}}$
2	+5 V (sensor line)[1]
12	+5 V (U_P)
11	0 V (sensor line)[1]
10	0 V (U_N)
9 (via spring)	Screen = Housing

X8 Nominal value output for X, Y, Z, IV, S for the 4-axis contouring control

Flange socket, female (15-pole)
The LE 355 is equipped with 5 analogue nominal value outputs (± 10 volts) for the axes X, Y, Z, IV and S-analogue.
Loading of analogue nominal value outputs:
R min = 5000 Ω
C max = 5000 pF

Contact No.	Allocation
1	Analogue output X-axis
3	Analogue output Y-axis
5	Analogue output Z-axis
7	Analogue output axis IV
8	Analogue output axis S
9	0 V X-axis
11	0 V Y-axis
13	0 V Z-axis
14	0 V axis IV
15	0 V axis S
Housing	External screen = Unit housing
2, 4, 6, 10, 12	do not assign

[1] In the EXE-unit, the sensor line is combined with the appropriate supply line. The signal of the sensor line is not evaluated by the TNC.
[2] Probing stylus in rest position corresponds to signal level high (U_P) see sheet M3/5.

Connections
Connectors on closed loop board of LE 355 B (Q)

X8 Nominal value output for X, Y, Z, IV, V, S for the 5-axis contouring control

The nominal value output for axis V is located on connector X8, pins 4 and 6.

Flange socket, female (15-pole)

Contact No.	Allocation
1	Analogue output X-axis
3	Analogue output Y-axis
5	Analogue output Z-axis
7	Analogue output axis IV
4	Analogue output axis V
8	Analogue output axis S
9	0V X-axis
11	0V Y-axis
13	0V Z-axis
14	0V axis IV
6	0V axis V
15	0V axis S
Housing	External screen = Unit housing
2, 10, 12	do not assign

X9 Visual display unit BE 412 B

Flange socket, female (15-pole)

Contact No.	Allocation
1, 8, 11	0 V
2, 7	+24 V (not used)
9	V SYNC
10	H SYNC
12	LIGHT/DARK
13	VIDEO
Housing	External screen = Unit housing
3 to 6, 14, 15	do not assign

X10 Reference pulse inhibitor

Flange socket, female (9-pole)

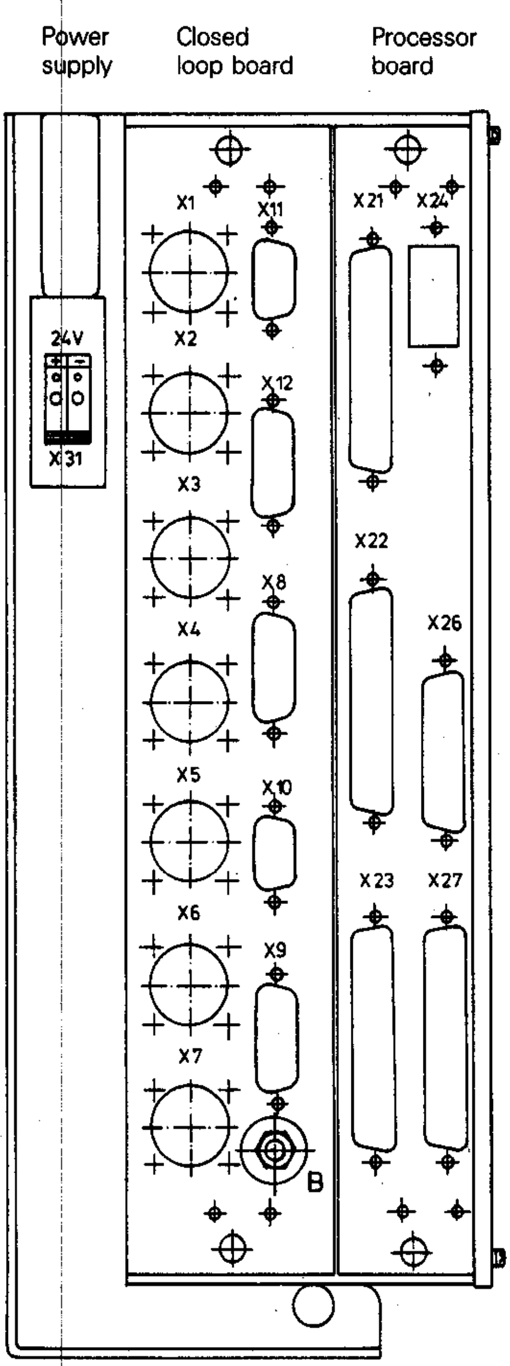
Contact No.	Allocation
1	Screen
2	Reference pulse inhibitor input X1
3	Reference pulse inhibitor input X2
4	Reference pulse inhibitor input X3
5	Reference pulse inhibitor input X4
6	Reference pulse inhibitor input X5[2]
8	+24 V (PLC)[1][2]
9	0 V (PLC)[1]
7	do not assign

[1] Externally supplied voltage for reference pulse inhibitor

[2] Only for LE 355 with Id.-Nr. 237 660..; 238 324..; 242 408..; 242 407.. (until Aug. '89)

Connections

Connector locations on LE 355 C (S)



Closed loop: **Color code**

X1 = Encoder 1
X2 = Encoder 2
X3 = Encoder 3
X4 = Encoder 4
X5 = Encoder 5
X6 = Encoder S

Standard allocation (switchover via machine parameters 253 . . . 257)

X7	= Electronic handwheel HR 150/HR 250	
X8	= Nominal value output for X, Y, Z, IV, V, S	Red
X9	= Visual display unit BE 412B	Blue
X10	= Reference pulse inhibitor	Yellow
X11	= Handwheel with axis selection keys	Red
X12	= Touch probe system TS 120 (TS 111/511)	Yellow
B	= Operational ground	

Processor:

X21	= PLC-output	Red
X22	= PLC-input	Yellow
X23	= Keyboard unit TE 355	Blue
X24	= Power supply 24 V– for PLC	
X26	= Data interface RS-232-C/V.24	Red
X27	= Machine operating panel	Green

Power supply:

X31 = Power supply 24 V– for LE

Connections
Connectors on closed loop board LE 355C (S)

X1, X2, X3, X4 Encoder 1, 2, 3, 4 with sinusoidal signal input

Flange socket, female (9-pole)

Contact No.	Allocation
1	0^{0+}
2	0^{0-}
5	90^{0+}
6	90^{0-}
7	RI+
8	RI–
3	+5 V (U_P)
4	0 V (U_N)
9	Internal screen
Housing	External screen = Unit housing

X5, X6 Encoder 5, S with squarewave signal input

Flange socket, female (12-pole)

Contact No.	Allocation
5	U_{a1}
6	$\overline{U_{a1}}$
8	U_{a2}
1	$\overline{U_{a2}}$
3	U_{a0}
4	$\overline{U_{a0}}$
–	U_{aS} not included
7	$\overline{U_{aS}}$
2	+5 V (sensor line)[1]
12	+5 V (U_P)
11	0 V (sensor line)[1]
10	0 V (U_N)
9 (via spring)	Screen = Housing

X7 Electronic handwheel HR 150, HR 250

Flange socket, female (9-pole)

Contact No.	Allocation
1	0^{0+}
2	0^{0-}
5	90^{0+}
6	90^{0-}
3	+5 V (U_P)
4	0 V (U_N)
9	Internal screen (0 volts)
Housing	External screen = Unit housing
7, 8	do not assign

X8 Nominal value output for X, Y, Z, IV, V, S

Flange socket, female (15-pole)

Contact No.	Allocation
1	Analogue output X-axis
3	Analogue output Y-axis
5	Analogue output Z-axis
7	Analogue output axis IV
4	Analogue output axis V
8	Analogue output axis S
9	0V X-axis
11	0V Y-axis
13	0V Z-axis
14	0V axis IV
6	0V axis V
15	0V axis S
Housing	External screen = Unit housing
2, 10, 12	do not assign

[1] In the EXE-unit, the sensor line is combined with the appropriate supply line. The signal of the sensor line is not evaluated by the TNC.

Connections
Connectors on closed loop board of LE 355 C (S)

X9 Visual display unit BE 412B

Flange socket, female (15-pole)

Contact No.	Allocation
1, 8, 11	0 V
2, 7	+24 V (not used)
9	V SYNC
10	H SYNC
12	LIGHT/DARK
13	VIDEO
Housing	External screen = Unit housing
3 to 6, 14, 15	do not assign

X10 Reference pulse inhibitor

Flange socket, female (9-pole)

Contact No.	Allocation
1	Screen
2	Reference pulse inhibitor input X1
3	Reference pulse inhibitor input X2
4	Reference pulse inhibitor input X3
5	Reference pulse inhibitor input X4
6	Reference pulse inhibitor input X5
8	+24 V (PLC)[1) 3)]
9	0 V (PLC)[1)]
7	do not assign

X11 Handwheel with axis selection keys

Flange socket, female (male) 9-pole

Contact No.	Allocation
2	0 V
3	+ 5 V
4	+ 12 V
5	– 15 V
6	DTR
7	RxD
1, 8, 9	do not assign
Housing	External screen

X12 Touch probe system TS 120 (TS 111/TS 511 only via cable adapter)

Flange socket, female (male) 15-pole

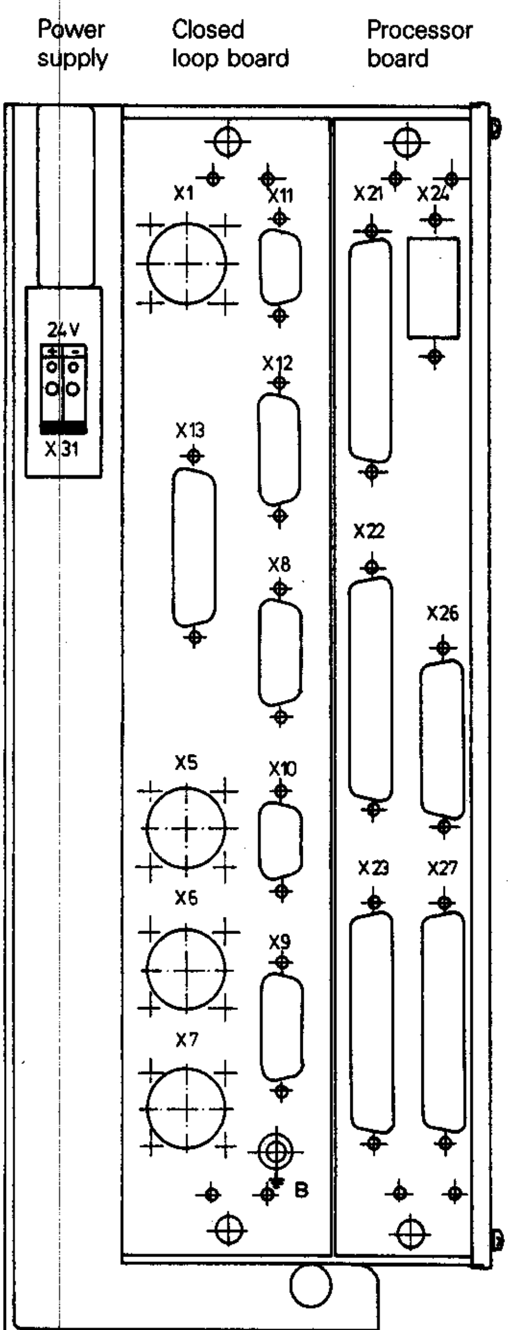
Contact-No.	Allocation
1	0 V screen
3	Standby
4	Start
5	+ 15 V
6	+ 15 ... + 19 V (U_P)
7	$\overline{\text{Battery warning}}$
8	0 V (U_N)
9	Trigger signal
10	$\overline{\text{Trigger signal}}$[2)]
2, 11 to 15	do not assign

1) Externally supplied voltage for reference pulse inhibit

2) Probing stylus in rest position corresponds to signal level high

3) Only on LE 355 with Id.-Nr. 246813.. and 248055..

Connector locations on LE 355 CR (SR)



Closed loop:		**Color code**
X1 = Encoder 1	Standard allocation (switchover via machine parameters 253 . . . 257)	Blue
X13 = Encoder 2, 3, 4		
X5 = Encoder 5		
X6 = Encoder S		
X7 = Electronic handwheel HR 150/HR 250		
X8 = Nominal value output for X, Y, Z, IV, V, S		Red
X9 = Visual display unit BE 412B		Blue
X10 = Reference pulse inhibitor		Yellow
X11 = Handwheel with axis selection keys		Red
X12 = Touch probe system TS 120 (TS 111/511)		Yellow
B = Operational ground		
Processor:		
X21 = PLC-output		Red
X22 = PLC-input		Yellow
X23 = TNC-keyboard unit TE 355		Blue
X24 = Power supply 24 V– for PLC		
X26 = Data interface RS-232-C/V.24		Red
X27 = Machine operating panel		Green

Power supply:

X31 = Power supply 24 V– for LE

Connections

Connectors on closed loop board of LE 355 CR (SR)

X1 Encoder 1 with sinusoidal signal input

Flange socket, female (9-pole)

Contact No.	Allocation
1	0^{0+}
2	0^{0-}
5	90^{0+}
6	90^{0-}
7	RI+
8	RI–
3	+5 V (U_P)
4	0 V (U_N)
9	Internal screen
Housing	External screen = Unit housing

X13 Encoder 2, 3, 4 with squarewave signal

Flange socket, female (25-pole)

Contact No.	Allocation	
1	$\overline{U_{a1}}$	Encoder 4
2	$\overline{U_{a2}}$	
3	$\overline{U_{a0}}$	
4	$\overline{U_{as}}$	
14	U_{a1}	
15	U_{a2}	
16	U_{a0}	
17	0 V	
5	$\overline{U_{a1}}$	Encoder 3
6	$\overline{U_{a2}}$	
7	$\overline{U_{a0}}$	
8	$\overline{U_{as}}$	
18	U_{a1}	
19	U_{a2}	
20	U_{a0}	
21	0 V	
9	$\overline{U_{a1}}$	Encoder 2
10	$\overline{U_{a2}}$	
11	$\overline{U_{a0}}$	
12	$\overline{U_{as}}$	
22	U_{a1}	
23	U_{a2}	
24	U_{a0}	
25	0 V	
13	do not assign	
Housing	External screen	

X5, X6 Encoder 5, 6 with squarewave signal output

Flange socket, female (12-pole)

Contact No.	Allocation
5	U_{a1}
6	$\overline{U_{a1}}$
8	U_{a2}
1	$\overline{U_{a2}}$
3	U_{a0}
4	$\overline{U_{a0}}$
–	U_{aS} not included
7	$\overline{U_{aS}}$
2	+5 V (sensor line)[1]
12	+5 V (U_P)
11	0 V (sensor line)[1]
10	0 V (U_N)
9 (via spring)	Screen = Housing

X7 Electronic handwheels HR 150, HR 250

Flange socket, female (9-pole)

Contact No.	Allocation
1	0^{0+}
2	0^{0-}
5	90^{0+}
6	90^{0-}
3	+5 V (U_P)
4	0 V (U_N)
9	Internal screen (0 volt)
Housing	External screen = Unit housing
7, 8	do not assign

[1] In the EXE-unit, the sensor line is combined with the appropriate supply line. The signal of the sensor is not evaluated by the TNC.

Connections
Connectors on closed loop board of LE 355 CR (SR)

X8 Nominal value output X, Y, Z, IV, V, S

Flange socket, female (15-pole)

Contact No.	Allocation
1	Analogue output X-axis
3	Analogue output Y-axis
5	Analogue output Z-axis
7	Analogue output axis IV
4	Analogue output axis V
8	Analogue output axis S
9	0V X-axis
11	0V Y-axis
13	0V Z-axis
14	0V axis IV
6	0V axis V
15	0V axis S
Housing	External screen = Unit housing
2, 10, 12	do not assign

X9 Visual display unit BE 412 B

Flange socket, female (15-pole)

Contact No.	Allocation
1, 8, 11	0 V
2, 7	+24 V (not used)
9	V SYNC
10	H SYNC
12	LIGHT/DARK
13	VIDEO
Housing	External screen = Unit housing
3 to 6, 14, 15	do not assign

X10 Reference pulse inhibitor

Flange socket, female (9-pole)

Contact No.	Allocation
1	Screen
2	Reference pulse inhibitor input X1
3	Reference pulse inhibitor input X2
4	Reference pulse inhibitor input X3
5	Reference pulse inhibitor input X4
6	Reference pulse inhibitor input X5
9	0 V (PLC)[1]
7	do not assign

X11 Handwheel with axis selection keys

Flange socket, female (male) 9-pole

Contact No.	Allocation
2	0 V
3	+ 5 V
4	+ 12 V
5	– 15 V
6	DTR
7	RxD
1, 8, 9	do not assign

X12 Touch probe system TS 120 (TS 111/TS 511 only via cable adapter)

Flange socket, female (male) 15-pole

Concact No.	Allocation
1	0 V screen
3	Standby
4	Start
5	+ 15 V
6	+ 5 V (U_P)
7	$\overline{\text{Battery warning}}$
8	0 V (U_N)
9	Trigger signal
10	$\overline{\text{Trigger signal}}$[2]
2, 11 to 15	do not assign

[1] Externally supplied voltage for reference pulse inhibitor

[2] Probing stylus in rest position corresponds to signal level high (U_P) see sheet M3/5

Connections
Connectors on processor board

X21 PLC-output

Flange socket, female (37-pole)

Contact No.	Allocation
1	A0 [3]
2	A1 [3]
3	A2 [3]
4	A3 [3]
5	A4 [3]
6	A5 [3]
7	A6 [3]
8	A7 [3]
9	A8
10	A9
11	A10
12	A11
13	A12
14	A13
15	A14
16	A15
17	A16
18	A17
19	A18
20	A19
21	A20
22	A21
23	A22
24	A23
25	A24 [2]
26	A25 [2]
27	A26 [2]
28	A27 [2]
29	A28 [2]
30	A29 [2]
31	A30 [2]
32, 33	do not assign
34	Control operational
35, 36, 37	24 V via external EMERGENCY STOP disconnectible (PLC [1])
Housing	External screen

[1] If required, the supply voltage for the disconnectible outputs can be assigned to connector X24, pin 1

[2] not disconnectible via external EMERGENCY STOP
A0 ... A23 are disconnectible via external EMERGENCY STOP

[3] A0 ... A7 duplicated on X27, Machine operating panel

Connections
Connectors on processor board

X22 PLC-input

Flange socket, female (37-pole)

Contact No.	Allocation
1	E0
2	E1
3	E2
4	E3 Feedback signal for test "Control operational"
5	E4
6	E5
7	E6
8	E7
9	E8
10	E9
11	E10
12	E11
13	E12
14	E13
15	E14
16	E15
17	E16
18	E17
19	E18
20	E19
21	E20
22	E21
23	E22
24	E23
25	E24
26	E25
27	E26
28	E27
29	E28
30	E29
31	E30
32	E31
33, 34	do not assign
35, 36, 37	0 V (PLC)[1]
Housing	External screen

[1] If required, the 0 V-connection can be assigned to connector X24, pin 3.

Connections
Connectors on processor board

X23 Keyboard unit TE 355

Flange socket, female (37-pole)

Contact No.	Allocation	
1	RL0	for key matrix
2	RL1	
3	RL2	
4	RL3	
5	RL4	
6	RL5	
7	RL6	
8	RL7	
9	E128	
10	E129	
11	E130	
12	E131	
13	E132	
14	E133	
15	E134	
16	E135	
17	E136	
18	E137	
19	E138	
20	OUT0	for key matrix
21	OUT1	
22	OUT2	
23	OUT3	
24	OUT4	
25	OUT5	
26	OUT6	
27	OUT7	
28	E139	
29	E140	
30	+15 V (Supply for buttons on machine operating panel)	
31	E141	
32	E142	
33	E143	
34	Spindle override (wiper)	
35	Feed rate override (wiper)	
36	+12 V Override potentiometer	
37	0 V Override potentiometer	
Housing	External screen	

E128 … E143 duplicated on connector X27 for machine operating panel.

X24 Power supply for PLC

Connection terminals

Contact No.	Allocation
1	+24 V EMERGENCY STOP disconnectible[1]
2	+24 V EMERGENCY STOP not disconnectible
3	0 V[2]

[1] If required, the voltage supply can be assigned to connector X21, pin 35, 36, 37.

[2] If required, the 0 V-connection can be assigned to connector X22, pin 35, 36, 37.

Connections
Connectors on processor board

X26 Data interface RS-232-C/V.24

Flange socket, female (25-pole)

Contact No.	Allocation
1	Screen
2	$\overline{RxD}$
3	$\overline{TxD}$
4	CTS
5	RTS
6	DTR
7	GND
8 to 19	do not assign
20	DSR
21 to 25	do not assign
Housing	External screen

X27 Machine operating panel

Flange socket, female (37-pole)
This connection is used if there are insufficient inputs on the TE 355.

Contact No.	Allocation
1	E128[1)]
2	E129[1)]
3	E130[1)]
4	E131[1)]
5	E132[1)]
6	E133[1)]
7	E134[1)]
8	E135[1)]
9	E136[1)]
10	E137[1)]
11	E138[1)]
12	E139[1)]
13	E140[1)]
14	E141[1)]
15	E142[1)]
16	E143[1)]
17	E144
18	E145
19	E146
20	E147
21	E148
22	E149
23	E150
24	E151
25	E152
26	A0[2)]
27	A1[2)]
28	A2[2)]
29	A3[2)]
30	A4[2)]
31	A5[2)]
32	A6[2)]
33	A7[2)]
34	0 V (PLC)
35	0 V (PLC)
36	+24 V (PLC)
37	+24 V (PLC)

X31 Power supply for logic unit (LE)

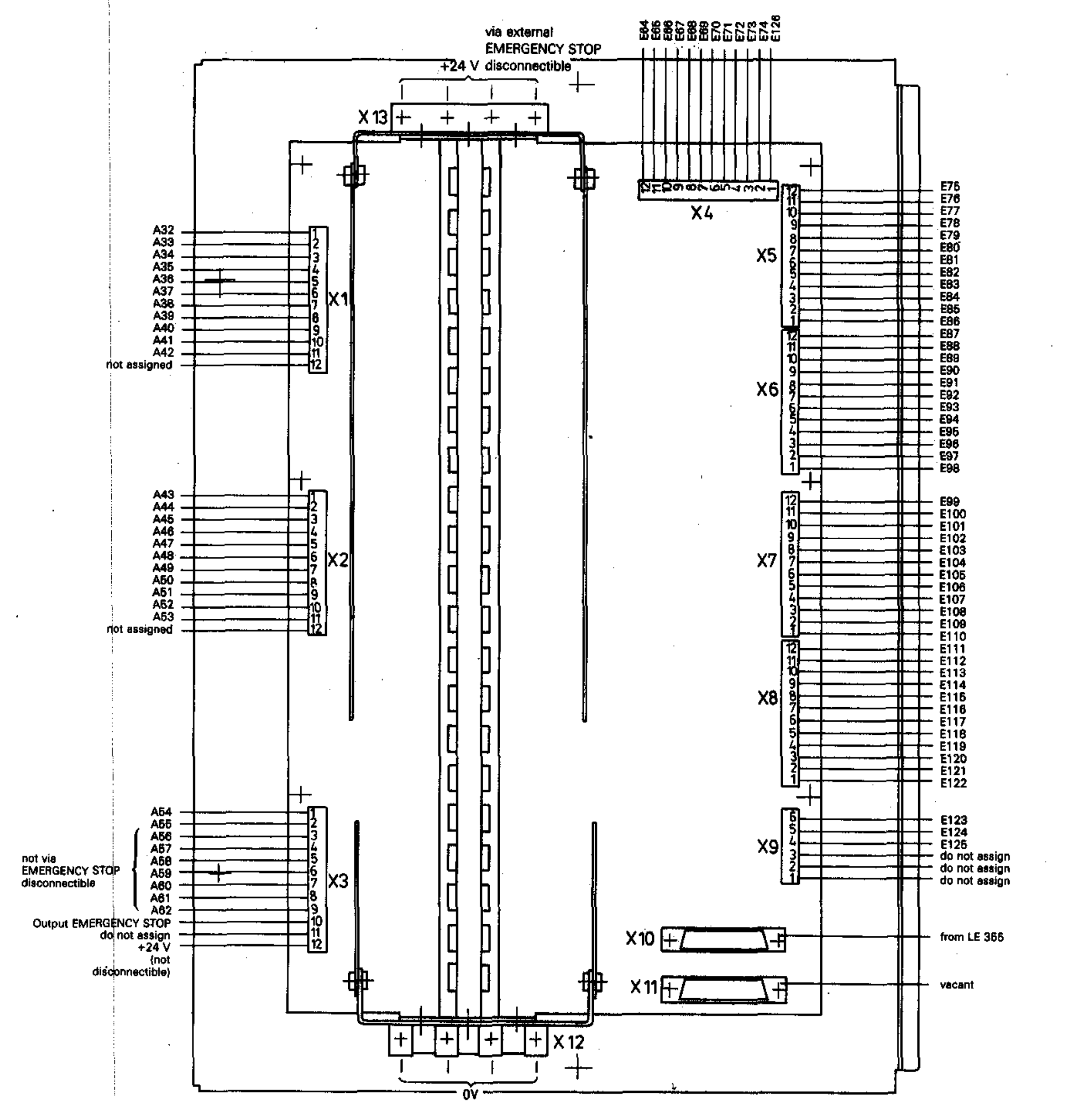
Terminal	Allocation
–	0 V
+	+24 V

1) E128 ... E143 duplicated on connector X23 for TNC-keyboard unit.

2) A0 ... A7 duplicated on connector X21 for PLC-output.

Connections
Connectors for input/output board PL 300

LE 355Q is equipped with an additional board PL 300.



Connections
Connector layouts for input/output board PL 300

X1

Contact No.	Allocation
1	A32
2	A33
3	A34
4	A35
5	A36
6	A37
7	A38
8	A39
9	A40
10	A41
11	A42
12	not assigned

X2

Contact No.	Allocation
1	A43
2	A44
3	A45
4	A46
5	A76
6	A48
7	A49
8	A50
9	A51
10	A52
11	A53
12	not assigned

X3

Contact No.	Allocation
1	A54
2	A55
3	A56
4	A57
5	A58
6	A59
7	A60
8	A61
9	A62
10	Control operational
11	do not assign
12	+24 V not via external EMERGENCY STOP disconnectible[1]

X4

Contact No.	Allocation
1	E126
2	E74
3	E73
4	E72
5	E71
6	E70
7	E69
8	E68
9	E67
10	E66
11	E65
12	E64

X5

Contact No.	Allocation
1	E86
2	E85
3	E84
4	E83
5	E82
6	E81
7	E80
8	E79
9	E78
10	E77
11	E76
12	E75

X6

Contact No.	Allocation
1	E98
2	E97
3	E96
4	E95
5	E94
6	E93
7	E92
8	E91
9	E90
10	E89
11	E88
12	E87

[1] +24 V must be connected in all cases, even if the outputs are not being used.

Connections
Connector layouts for input/output board PL 300

X7

Contact No.	Allocation
1	E110
2	E109
3	E108
4	E107
5	E106
6	E105
7	E104
8	E103
9	E102
10	E101
11	E100
12	E99

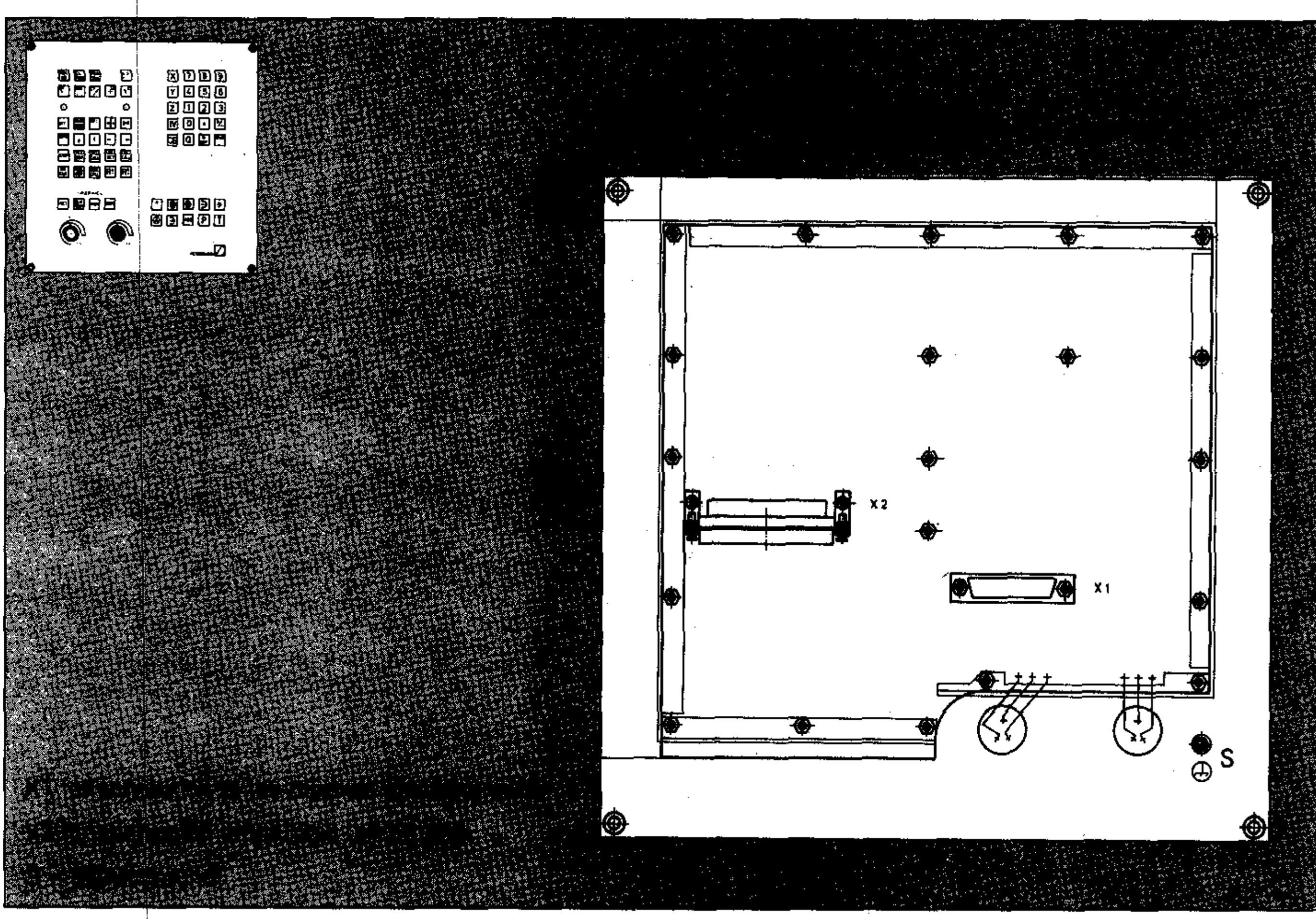
X8

Contact No.	Allocation
1	E122
2	E121
3	E120
4	E119
5	E118
6	E117
7	E116
8	E115
9	E114
10	E113
11	E112
12	E111

X9

Contact No.	Allocation
1	do not assign
2	do not assign
3	do not assign
4	E125
5	E124
6	E123

Connections
Connectors for TNC-keyboard unit TE 355



X1 For connection of the machine operating panel

Flange socket, female (25-pole)

Contact No.	Allocation
1	E140
2	E139
3	E138
4	E137
5	E136
6	E135
7	E134
8	E133
9	E132
10	E131
11	E130
12	E129
13	E128
14[1]	0 V (override potentiometer)
15[1]	+12 V (override potentiometer)
16[1]	Feed rate override potentiometer (wiper)
17[1]	Spindle override potentiometer (wiper)
18 to 21	do not assign
22	+15 V (Supply for buttons of machine operating panel)
23	E143
24	E142
25	E141

[1] **Caution!**
Do not assign if the potentiometer on the TE is to be used.

Connections

Connectors for TNC-keyboard unit TE 355

X2 For connection of the logic unit LE 355

Flange socket, male (37-pole)

Contact No.	Allocation	
1	RL0	for key matrix
2	RL1	
3	RL2	
4	RL3	
5	RL4	
6	RL5	
7	RL6	
8	RL7	
9	E128	
10	E129	
11	E130	
12	E131	
13	E132	
14	E133	
15	E134	
16	E135	
17	E136	
18	E137	
19	E138	
20	OUT0	for key matrix
21	OUT1	
22	OUT2	
23	OUT3	
24	OUT4	
25	OUT5	
26	OUT6	
27	OUT7	
28	E139	
29	E140	
30	+15 V (Supply for buttons of machine operating panel)	
31	E141	
32	E142	
33	E143	
34	Spindle override (wiper)	
35	Feed rate override (wiper)	
36	+12 V Override potentiometer	
37	0 V Override potentiometer	

Connections
Connector for HEIDENHAIN machine operating panel MB 301

HEIDENHAIN offers a universal machine operating panel. The connection of the operating panel is via connector X1 on the TNC-keyboard unit (cable, refer to sheet M3/14).

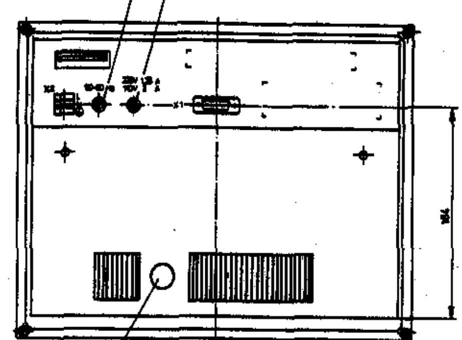
The operating panel has 15 pushbuttons which are connected to the control via PLC-inputs.

The button for switching-on the control voltage, the appropriate lamp and the emergency stop button must be wired separately.

Allocation of the 15 operating buttons to the pins of the connector and the PLC-inputs:

Contact No.	Allocation	Button	Meaning
1	E140	+IV	Axis direction button
2	E139	-IV	Axis direction button
3	E138	+X	Axis direction button
4	E137	+Y	Axis direction button
5	E136	+Z	Axis direction button
6	E135	-Z	Axis direction button
7	E134	-Y	Axis direction button
8	E133	-X	Axis direction button
9	E132		START
10	E131		STOP
11	E130		SPINDLE STOP
12	E129		COOLANT ON
13	E128		TOOL UNCLAMP
22	+15 V (supply)		
23	E143		(Reserve)
24	E142		CLAMP
14 to 21	do not assign		

Connections
Connectors for visual display unit BE 412 B



X1 for connection of the logic unit LE 355

Flange socket, male (15-pole)

Contact No.	Allocation
11	0 V
9	V SYNC
10	H SYNC
12	LIGHT/DARK
13	VIDEO
Housing	External screen = Unit housing
1, 3 to 6, 8, 14, 15	do not assign

X2 Power supply

Selectable 110 V~ or 220 V~

Contact	Allocation
L	Live
N	Neutral
⏚	Earth

Connections
Technical data of PLC-inputs and outputs

Logic unit LE 355

PLC-inputs:

32 inputs on connector for PLC-inputs (E0 to E31);
Feedback signal for test "control operational" on E3;
25 inputs on connector for machine operating panel (E128 to E152);

E128 to E143 are also located on the connector for the TNC-keyboard unit.
These inputs may only be circuited against the internal 15 V-voltage.

Nominal value of power supply: 24 V–;

Voltage ranges: "1"-Signal: Ue = 13 V to 30.2 V;
"0"-Signal: Ue = – 20 V to 3.2 V;

Current ranges: "1"-Signal: Ie = 3.7 mA to 9.1 mA;
"0"-Signal: Ie = 1.5 mA at Ue = 3.2 V;

PLC-outputs:

32 outputs on connector for PLC-outputs (A0 to A30 and "control operational");

A0 to A7 are also located on the connector for the machine operating panel;

A0 to A23 are EMERGENCY STOP-disconnectible;

A24 to A30 and "control operational" are supplied via a non-disconnectible 24 V-voltage;

Nominal value of power supply: 24 V–;

Min. output voltage for "1"-signal: 3 V below supply voltage;

Nominal operational current per output: 0.1 A;

Permissible loading: Resistance load; inductive load only with a quenching diode parallel to inductivity;

Several outputs may not be short-circuited simultaneously;
The short circuiting of one output will not lead to overloading.

PLC-input/output board PL 300

PLC-inputs:

63 inputs (E64 to E126);

Nominal value of power supply: 24V–;

Voltage ranges: "1"-Signal: Ue = 16.5 V to 30 V;
"0"-Signal: Ue = – 20 V to 4 V;

Current ranges: "1"-Signal: Ie = 6.2 mA to 12.6 mA;
"0"-Signal: Ie = 1.6 mA at Ue = 4 V;

PLC-outputs:

32 outputs (A32 to A62 and "control operational");

Nominal value of power supply: 24 V–;

A32 to A55 are disconnectible via the external EMERGENCY STOP;

A56 to A62 and "control operational" are supplied via a non-disconnectible 24 V-voltage.

Min. output for "1"-signal: 3 V below the power supply voltage;

Nominal operational current per output: 1.2 A;

Permissible loading: Resistance load; inductive load only with a quenching diode parallel to inductivity.

Linear and rotary encoders

The TNC has encoder inputs for sinusoidal and squarewave signals.
The following table indicates which inputs are intended for sinusoidal signals (∿) and which for squarewave signals (⎍).

	LE 355B (Q)	LE 355C (S)	LE 355CR (SR)
Input X1	∿	∿	∿
Input X2	∿	∿	⎍[1]
Input X3	∿	∿	⎍[1]
Input X4	∿	∿	⎍[1]
Input X5	⎍	⎍	⎍
Input X6	—	⎍	⎍

The maximum input frequency of the sinusoidal input is 25 kHz. This permits a maximum traversing speed of

.30 m/min (1181 ipm) for linear encoders with a grating period of 20 µm and
.15 m/min (590 ipm) for linear encoders with a grating period of 10 µm.

The maximum input frequency of the squarewave signal input is 250 kHz. This value permits traversing speeds of up to 30 m/min (1181 ipm) – also for a 2-fold evaluation of the encoder signal. However, in this case, the maximum traversing speed applicable to input X5 is limited by the maximum input frequency of the external interpolation and digitizing electronics (EXE).

The encoder inputs can be randomly allocated to the machine axes (see sheet T4/2).

Signal evaluation

The sinusoidal signal inputs (X1 to X4) always undergo a 5-fold interpolation. The interpolation factor of the external electronics (EXE) should be taken into consideration for the squarewave signal input (X5).
The additional signal evaluation can be determined for each axis via machine parameters.

MP 12	**Axis**	Entry values:
MP 13	**Axis Y**	1 ≙ 4-fold
MP 14	**Axis Z**	2 ≙ 2-fold
MP 15	**Axis IV**	
MP 327	**Axis V**	

(With an entry value of 1 a signal subdivision of 20-fold is obtained with e.g. 5-fold interpolation).

[1] With LE 355CR (SR) the inputs for encoders 2, 3 and 4 are combined at input X13.

Linear and rotary encoders

Allocation of axes to the encoder inputs

Encoder inputs for sinusoidal signals and squarewave signals are located on the logic unit. The encoder inputs can be allocated to the machine axes via MP 253 to MP 257.

If **"0"** is entered for MP 253 ... MP 257, the **standard allocation** applies as follows:

MP 253	**Axis X**	Encoder input X1
MP 254	**Axis Y**	Encoder input X2
MP 255	**Axis Z**	Encoder input X3
MP 256	**Axis IV**	Encoder input X4
MP 257	**Axis V**	Encoder input X5

With entry values **1 ... 6** the allocation of encoder inputs to the axes can be **varied as required:**

1 ≙ Encoder input X1
2 ≙ Encoder input X2
3 ≙ Encoder input X3
4 ≙ Encoder input X4
5 ≙ Encoder input X5
6 ≙ Encoder input X6[2]

If, for example, the squarewave input X5 is to be employed for an X-axis[1], the machine parameters are to be programmed as follows:

MP 253	Axis X	**5 ≙ Encoder input X5**
MP 254	Axis Y	2 ≙ Encoder input X2
MP 255	Axis Z	3 ≙ Encoder input X3
MP 256	Axis IV	4 ≙ Encoder input X4
MP 257	Axis V	**1 ≙ Encoder input X1**

[1] If the axis traversing range exceeds 3040 mm or the cable exceeds 20 m (for standard cable) and 30 m (for special cable), squarewave signals are necessary. (This only applies if a linear encoder is to be used, i. e. LB 326).

[2] Not applicable to TNC 355B (Q)

Linear and rotary encoders

Linear and rotary encoders for sinusoidal inputs

The TNC controls the actual position with a digital step of 0.001 mm or 0.001° and subdivides the grating period of the encoders by 20 x or 10 x.

Linear encoders
Incremental linear encoders with a 20 µm or 10 µm grating period such as

- LS 107/LS 107C (measuring lengths 240 mm to 3040 mm)
- LS 704/LS 704C (measuring lengths 170 mm to 3040 mm) or
- LS 403/LS 404/LS 403C/LS 404C (measuring lengths 70 mm to 1240 mm; up to 2040 mm with mounting spar)
- LID 300, LID 310 (measuring lengths 50 mm to 3000 mm)
- LID 311/LID 311C/LID 351/LID 351C (measuring lengths 50 mm to 1500 mm)

should therefore be used.

When using linear encoders with distance-coded reference marks (LS 107C, LS 704C, LS 403C, LS 404C), the absolute position value can be recovered after a traverse of max. 20 mm.

If accuracy requirements permit, measurement with e.g. a rotary encoder type ROD 450 directly connected to the ballscrew, is possible. The required number of lines for the encoder is calculated as follows:

$$\text{line number/revolution} = \frac{\text{ball screw pitch [mm/rev]}}{\text{0.001 [mm] x signal interpolation x gear ratio}}$$

where signal subdivision = signal interpolation x signal evaluation

The signal evaluation can be selected via machine parameter (see sheet T4/1).

Example:
20-fold signal interpolation without grating
line number/rev = 50 x ball screw pitch

10-fold signal interpolation without gearing
line number/rev = 100 x ball screw pitch

Rotary encoders
For angle measurement (with axes IV, V) rotary encoder types ROD 250 and ROD 700 as well as RON 255 and RON 705 with 18000 or 36000 lines are available.

The above formulae assume direct coupling of the rotary encoder to the ballscrew. If intermediate gears are being used, the line numbers have to be correspondingly calculated.

Linear and rotary encoders
Linear and rotary encoders for squarewave signal inputs

To inputs intended for squarewave signals, only encoders having either separate or integral digitizing electronics may be connected[1].

Rotary encoders for oriented spindle stop

For orientation of the main spindle, the rotary encoder ROD 428B with 1024 lines and monitoring signal is recommended.

The max. rpm of the ROD 428B, and hence the spindle, is 12000 rpm.

The max. frequency response of the encoder, 300 kHz, and the limiting frequency of the signal input of the TNC-control, 250 kHz, lie above the mechanical slewing speed permitted by the bearing assembly.

The cable length between ROD 428B and LE 355 must be limited to 20 m (66 ft) to ensure adequate power.

[1] With the TNC 355-version for four NC-axes the squarewave signal input X5 is normally used for spindle orientation.

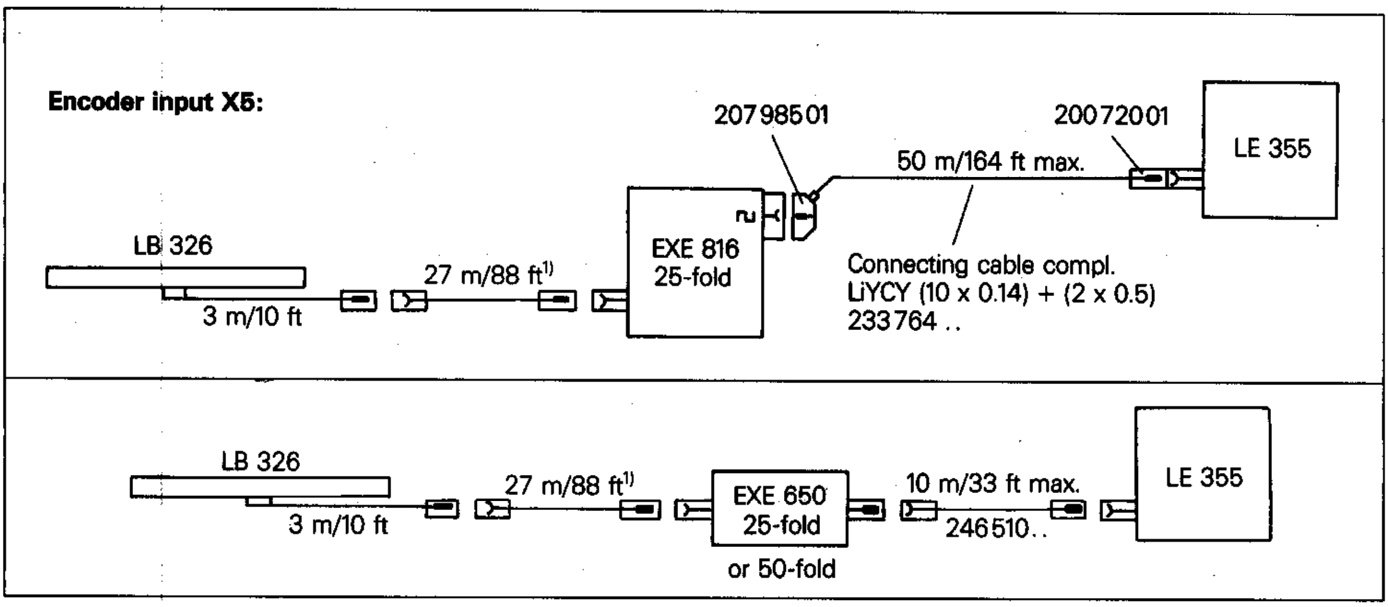
Linear and rotary encoders
Linear and rotary encoders for squarewave signal inputs

Encoders for linear machine axes

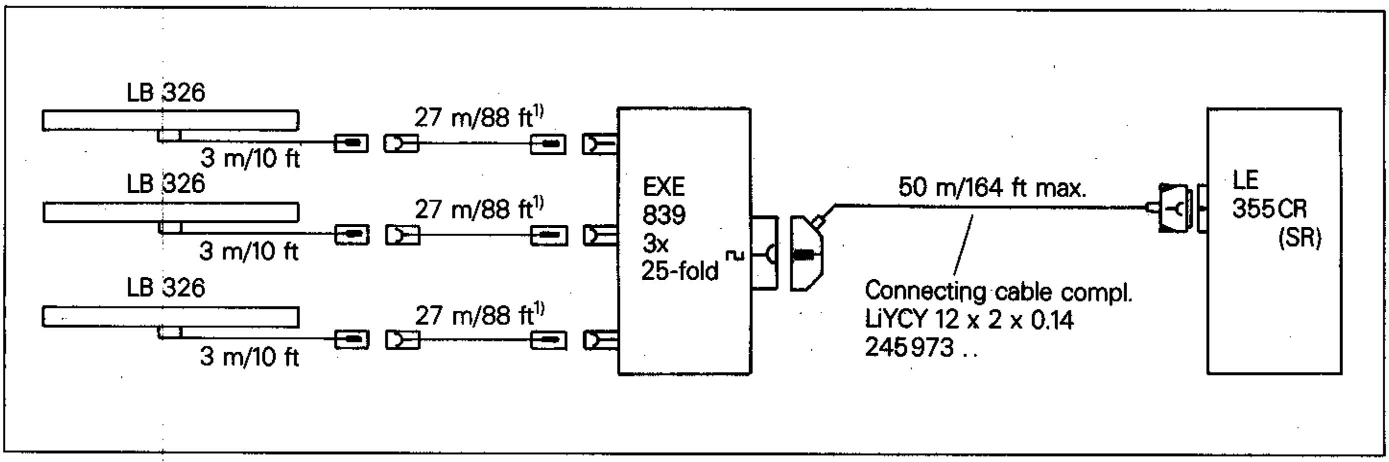
The allocation of the encoder inputs to the axes via parameters MP 253 to MP 257 offers further possibilities (see sheet T4/2). If, for instance, a machine is equipped with an X-axis greater than 3040 mm traverse, thus necessitating the use of LB 326 with an EXE-unit, an encoder input for squarewave signals can be allocated to the X-axis.

Encoder	Grating period	EXE with signal subdivision	Max. cale length EXE/TNC
LB 326	100 µm	EXE 816, 25-fold EXE 839, 25-fold EXE 650, 25-fold	50 m/164 ft connecting cable Id.-Nr. 233764 .. Id.-Nr. 246510 .. 10 m (33 ft) connecting cable Id.-Nr. 246510 ..

TNC 355B (Q) TNC 355C (S)



TNC 355CR (SR)
On the TNC 355CR (SR), the encoder inputs 2, 3 and 4 are combined into one connector (X13). For connection to EXE 839, we recommend the HEIDENHAIN connecting cable Id.-Nr. 245973 ..



[1] The max. length of encoder cable including the extension cable depends on the cable type being used.
The max. length of the older cable was limited to 20 m (66 ft). The newer cable (Id.-Nr. 246662..) has a max. length of 30 m (98 ft).

Linear and rotary encoders
Linear and rotary encoders for squarewave signal inputs

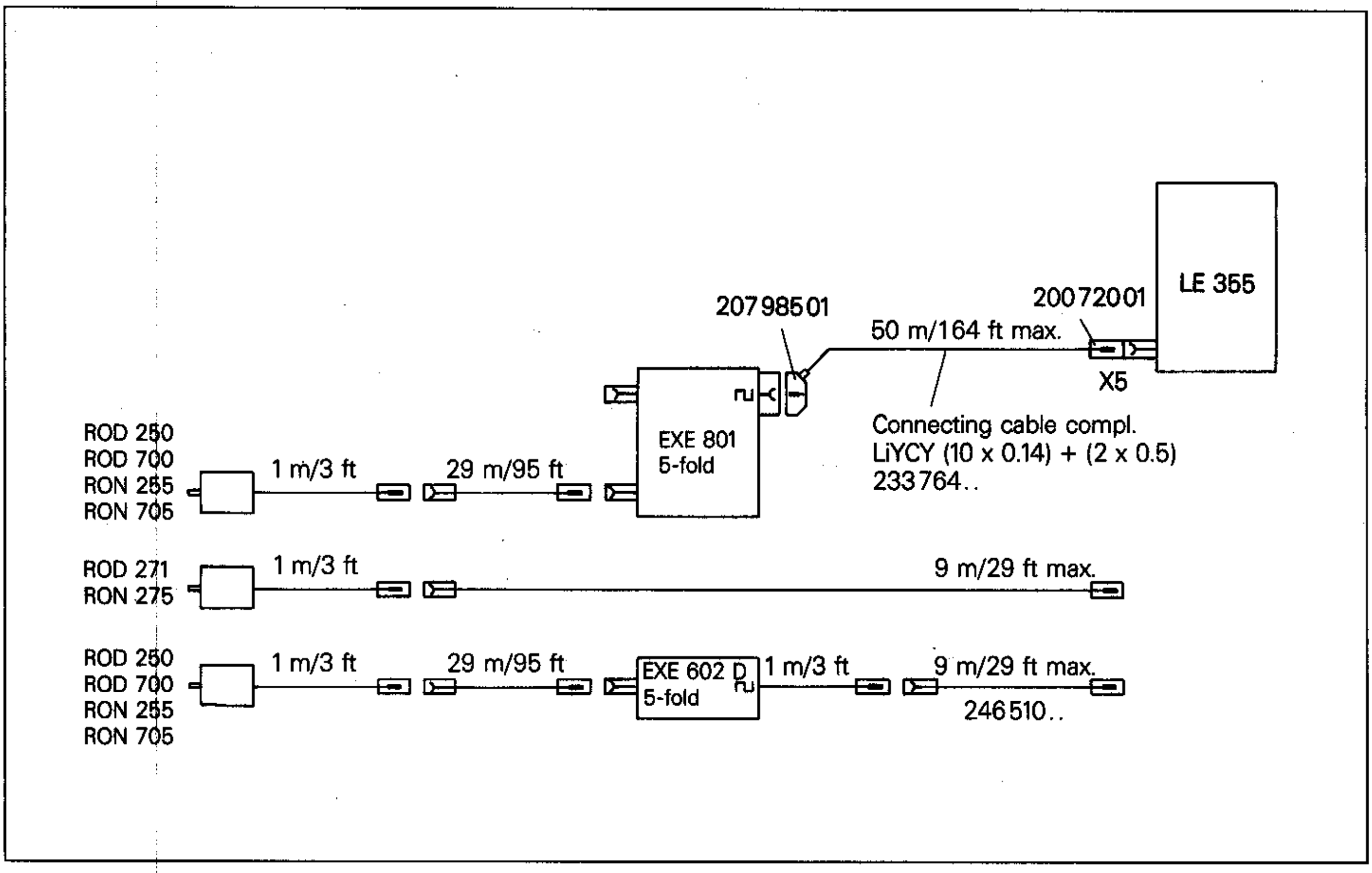
Rotary encoders

If a rotary encoder is being connected to a squarewave signal input, interpolation and digitizing of the encoder signals via EXE-electronics is required.

Rotary encoder with 18 000 or 36 000 lines	EXE with signal interpolation	Max. cable length EXE/TNC
ROD 250/ROD 700 RON 255/RON 705	EXE 801, 5-fold	50 m/164 ft connecting cable
ROD 250/ROD 700 RON 255/RON 705	EXE 602 D, 5-fold	1 m/3 ft cable on EXE+ 9 m/29 ft extension
ROD 271 RON 275	5-fold integral with ROD	1 m/3 ft cable on ROD+ 9 m/29 ft extension

When using ROD-integral electronics or the external digitizing electronics EXE 602 D, the power supply for the digitizing electronics and the encoder is supplied by the TNC 355.

In order to ensure the correct supply voltage, the total length of the connecting cable between EXE and the control is limited to 10 m/32 ft.



Evaluation of reference marks

After switch-on, the reference mark of each axis must be traversed.

The following functions are therefore possible:

- Traverse range limitation through software-limits.
- Re-generation of the last workpiece datum after an interruption in machining.
- Reference for PLC-positionings and positionings using the supplementary functions M91, M92.

The traversing of the reference marks can be performed as follows:

- By pressing the external start button, the axis sequence being determined via machine parameters.
- With the external direction buttons, after entry of the code number **84159.** The axis sequence is determined by the machine operator.

The behaviour of the control during reference mark evaluation is determined via the definition of machine parameters.

Traversing speed when approaching the reference marks

The speed for reference mark approach is determined by machine parameters.

MP 8	**Axis X**	Entry range:
MP 9	**Axis Y**	80 ... 29998 [mm/min]
MP 10	**Axis Z**	Rotary axis:
MP 11	**Axis IV**	80 ... 29998 [°]
MP 323	**Axis V**	

Traversing direction when approaching the reference marks

The traversing direction for reference mark approach can be separately programmed for each axis.

MP 16	**Axis X**	Entry range:
MP 17	**Axis Y**	0 ≙ plus direction
MP 18	**Axis Z**	1 ≙ minus direction
MP 19	**Axis IV**	
MP 329	**Axis V**	

MP 59 Axis sequence when approaching the reference marks

The axis sequence for reference mark approach is determined by MP 59 for the axes X, Y, Z and IV. Axis V is always the last axis to be traversed.
The axis sequence determined by MP 59 can be altered via markers within the PLC-program. This is advantageous for operation on machines with changing tool axes.
Via the code number **84159** the operator can traverse the axes over the reference marks in any desired sequence via the external axis direction buttons, e.g. for backing-off the tool after a power failure.

Entry values for MP 59 determine the sequence for reference mark approach as follows:

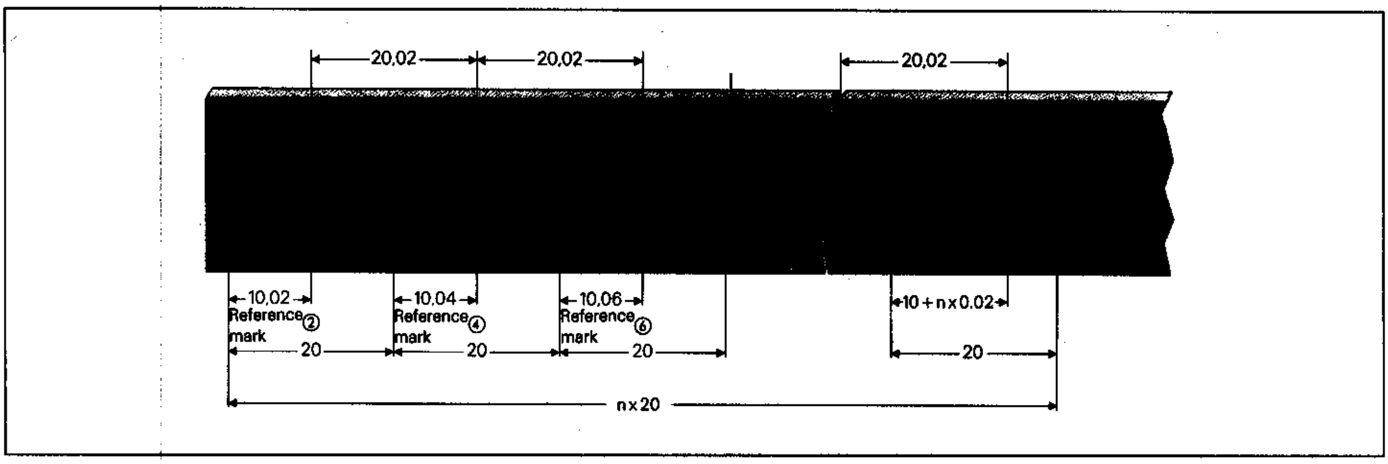
0 ≙ X Y Z IV	12 ≙ Z X Y IV
1 ≙ X Y IV Z	13 ≙ Z X IV Y
2 ≙ X Z Y IV	14 ≙ Z Y X IV
3 ≙ X Z IV Y	15 ≙ Z Y IV X
4 ≙ X IV Y Z	16 ≙ Z IV X Y
5 ≙ X IV Z Y	17 ≙ Z IV Y X
6 ≙ Y X Z IV	18 ≙ IV X Y Z
7 ≙ Y X IV Z	19 ≙ IV X Z Y
8 ≙ Y Z X IV	20 ≙ IV Y X Z
9 ≙ Y Z IV X	21 ≙ IV Y Z X
10 ≙ Y IV X Z	22 ≙ IV Z X Y
11 ≙ Y IV Z X	23 ≙ IV Z Y X

Evaluation of reference marks
Encoders with distance-coded reference marks

In connection with TNC 355 we recommended the use of linear and rotary encoders with distance-coded reference marks.

On C-type encoders[1] with distance-coded reference marks a reference mark track is located adjacent to the incremental track on the scale.
By counting the measuring steps from one mark to the next, the absolute position can be determined.

When using linear encoders, this version reduces the traversing distance for the reference mark routine to only 20 mm.



With distance-coded reference marks, software limits and positioning procedures with M91, M92 are referenced to the so-called "zero-reference mark". The zero-reference mark on a linear encoder is the first reference mark which is located 5 mm from the beginning of the measuring length. (On rotary encoders, the zero-reference mark is indicated).

Encoders having one reference mark can be used in conjunction with the distance-coded versions on the same machine.

If, for example, the distance-coded reference marks of the Z-axis are traversed after switching the power on, the axis will stop after only 20 mm. Backing-off the tool from the workpiece is therefore only manually possible, via a code number.

An encoder without distance-coded reference marks can, therefore, also be installed for the Z-axis.

From machine parameters, the control determines if encoders with distance-coded reference marks are being used.

Reference mark spacings for distance-coded linear and rotary encoders

MP 242	**Axis X**	Entry range:
MP 243	**Axis Y**	0 ... 65535
MP 244	**Axis Z**	0 ≙ No distance-coded reference marks
MP 245	**Axis IV**	1000 ≙ Linear encoders with 20 µm grating period
MP 328	**Axis V**	1000 ≙ Rotary encoders with 36 reference marks and 18000 lines

The entry value is determined by the following formula:

$$\text{Linear encoders: Entry value} = \frac{\text{Constant spacing (e.g. 20000 µm)}}{\text{Grating period (e.g. 20 µm)}}$$

$$\text{Rotary encoders: Entry value} = \frac{\text{Line number x 2}}{\text{Number of reference marks}}$$

[1] LS 107C, LS 704C, LS 403C, LS 404C, ROD 250C, ROD 271C, RON 255C, RON 275C, ROD 700C, ROD 800C

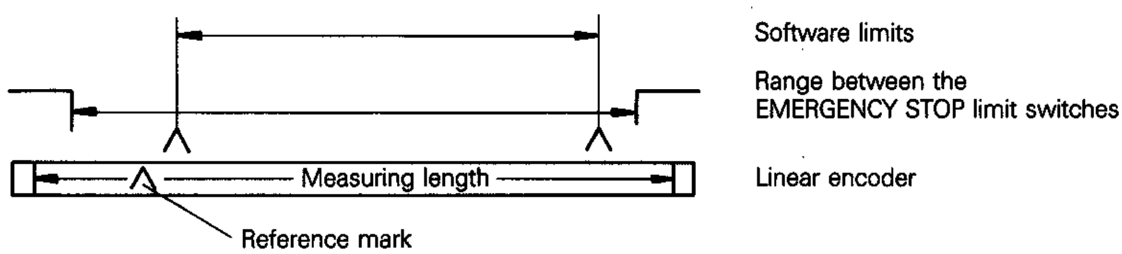
Evaluation of reference marks
Linear encoders with one reference mark at the end of the traversing range

Behaviour during reference mark approach depends on MP 69.

MP 69 **Reference mark approach**

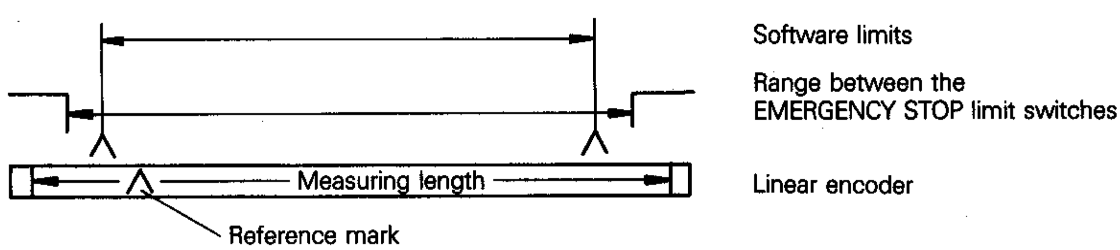
MP 69 = 0

After traversing the reference marks, the axes traverse to the software limits (MP 44 to MP 51). If the axis position is past the reference mark when switching-on, the machine traverses to the EMERGENCY STOP switch. To prevent this, the reference mark must be located outside the software limit.



MP 69 = 1

After traversing the reference mark each axis returns to that reference mark. In this case, the reference mark location must be inside the software limit.



Please note:
If, in the second case, the spindle head is between the reference mark and the software limit when starting the reference mark routine, the machine traverses to the EMERGENCY STOP switch.

MP 69 = 2 see sheet T5/7

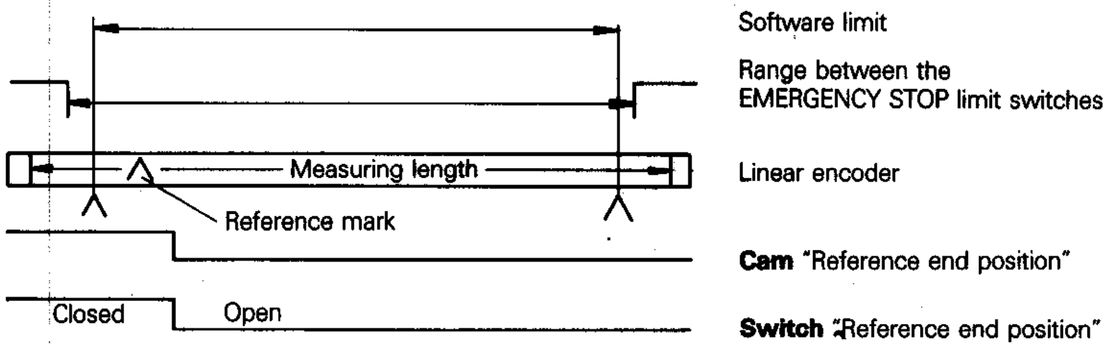
Evaluation of reference marks
Cams for reference end position

If the axis position is past the reference mark, i.e. just before the software limit, the EMERGENCY STOP limit switch is automatically approached when performing the reference mark routine.

In this case the axis must be manually traversed in the opposite direction, prior to the reference mark routine.

This procedure can be automated with the aid of a reference cam.

For the operation sequence of automatic reference mark approach with "reference end position" see flow diagram on sheet T5/6.



For the triggering signal "reference end position" any required number of vacant inputs can be assigned via the PLC-program. Activation of the reference end position function is executed by markers M2556 to M2559 (see sheet P3/22).

Evaluation of reference marks
for linear measurement via ballscrew and rotary encoder

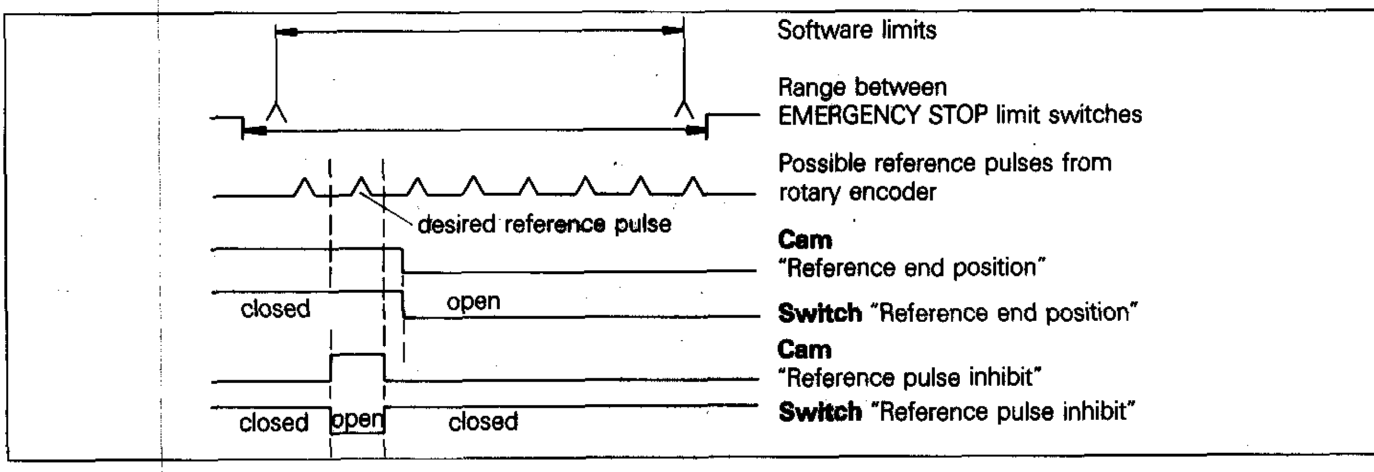
If measurement is being performed with a rotary encoder and ballscrew, a reference mark is traversed with every rotation of the encoder. With the aid of the control inputs "reference pulse inhibitors" at connection X10, undesired reference mark signals can be suppressed by means of a cam. Inputs for reference pulse inhibitors must be activated via machine parameters.

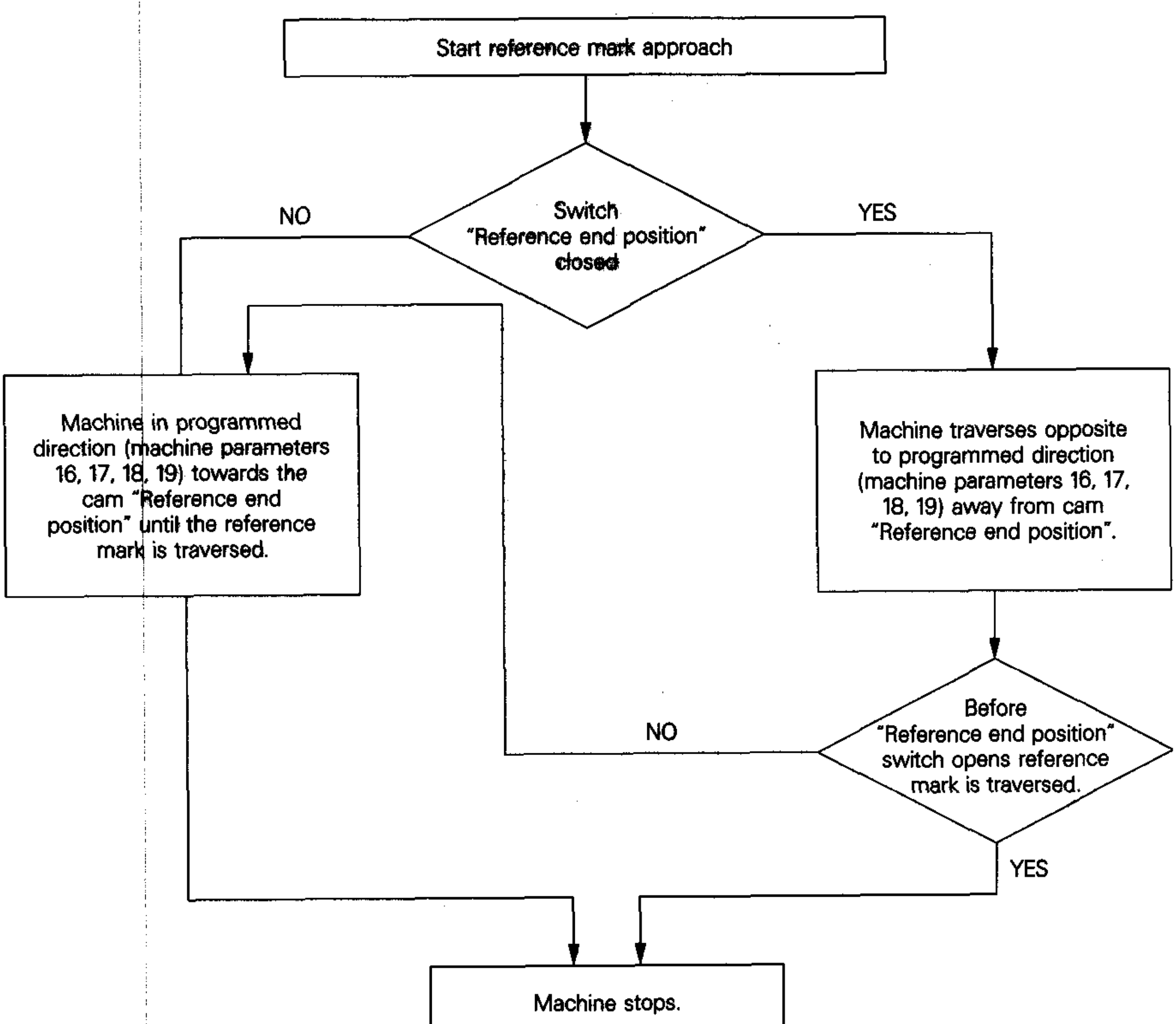
Release for reference pulse inhibitors

MP 20	**Axis X**	Entry values:
MP 21	**Axis Y**	Bit 1
MP 22	**Axis Z**	+ 0 ≙ Reference pulse inhibitor inactive
MP 23	**Axis IV**	+ 2 ≙ Reference pulse inhibitor active
MP 239	**Axis S**	
MP 330	**Axis V**	

For function of Bit 0, see sheet C3/16.

Evaluation of reference marks
for linear measurement via ballscrew and rotary encoder





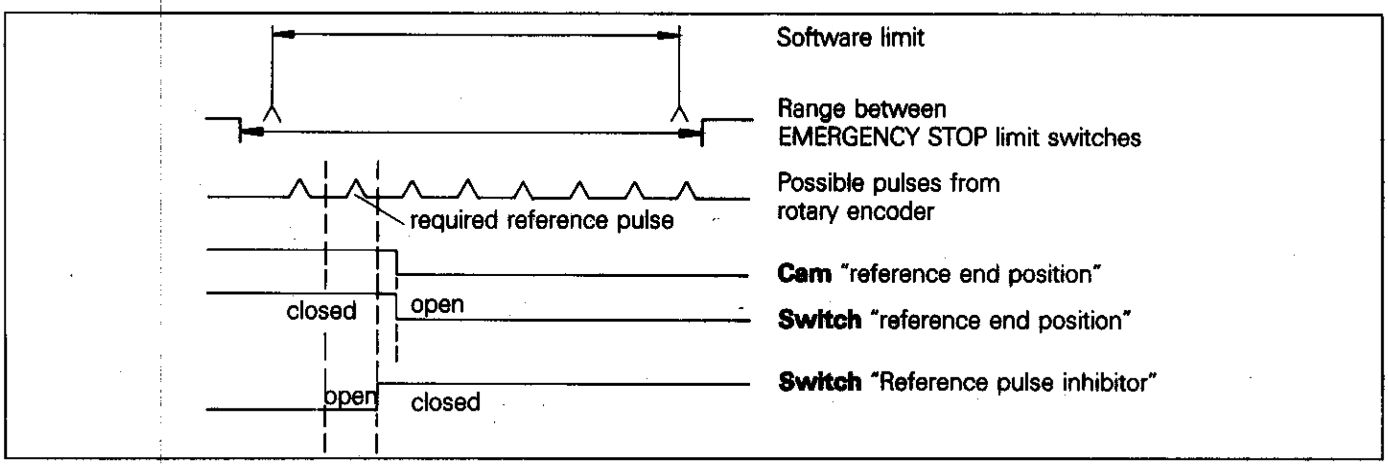
Evaluation of reference marks
for linear measurement via ballscrew and rotary encoder

Special procedure for approaching reference marks[05]

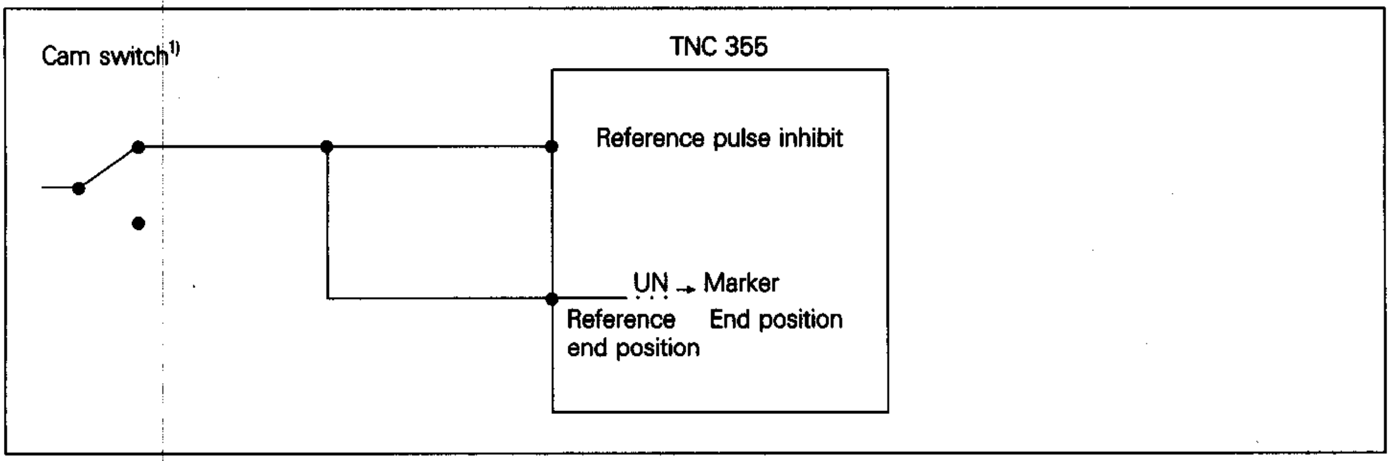
The special procedure for reference mark approach is only required if there are several reference marks within the axis traversing range (e.g. when employing rotary encoders for feedback) and there are no additional cams installed for reference pulse suppression, but only one cam for the reference end position. The special procedure for reference mark approach can be activated via MP 69.

In this case, the switch for the reference pulse inhibitor is also used for the reference end position. Since a number of reference marks can be covered by the "reference end position" cam, the axes which are located within the range of the reference end position must be backed-off from the reference end position cam prior to approaching the reference marks. The display "Pass over X/Y/Z/IV reference mark" for the axes on the reference end position cams is displayed in inverse characters. If, during the backing-off procedure, reference marks are traversed, they are not evaluated. When all axes are off the reference end position cams, the reference mark approach is carried out as normal and, in each case, the 1st reference mark after the closing of the switch "reference end position" is evaluated. After traversing the reference mark, the axis is stopped (see flow diagram, sheet T5/8).

MP 69 **Reference mark approach**
Entry value 0 or 1 see sheet T5/3
+ 2 ≙ Special procedure for reference mark approach active.



Switch for "reference pulse inhibitor" and "reference end position"

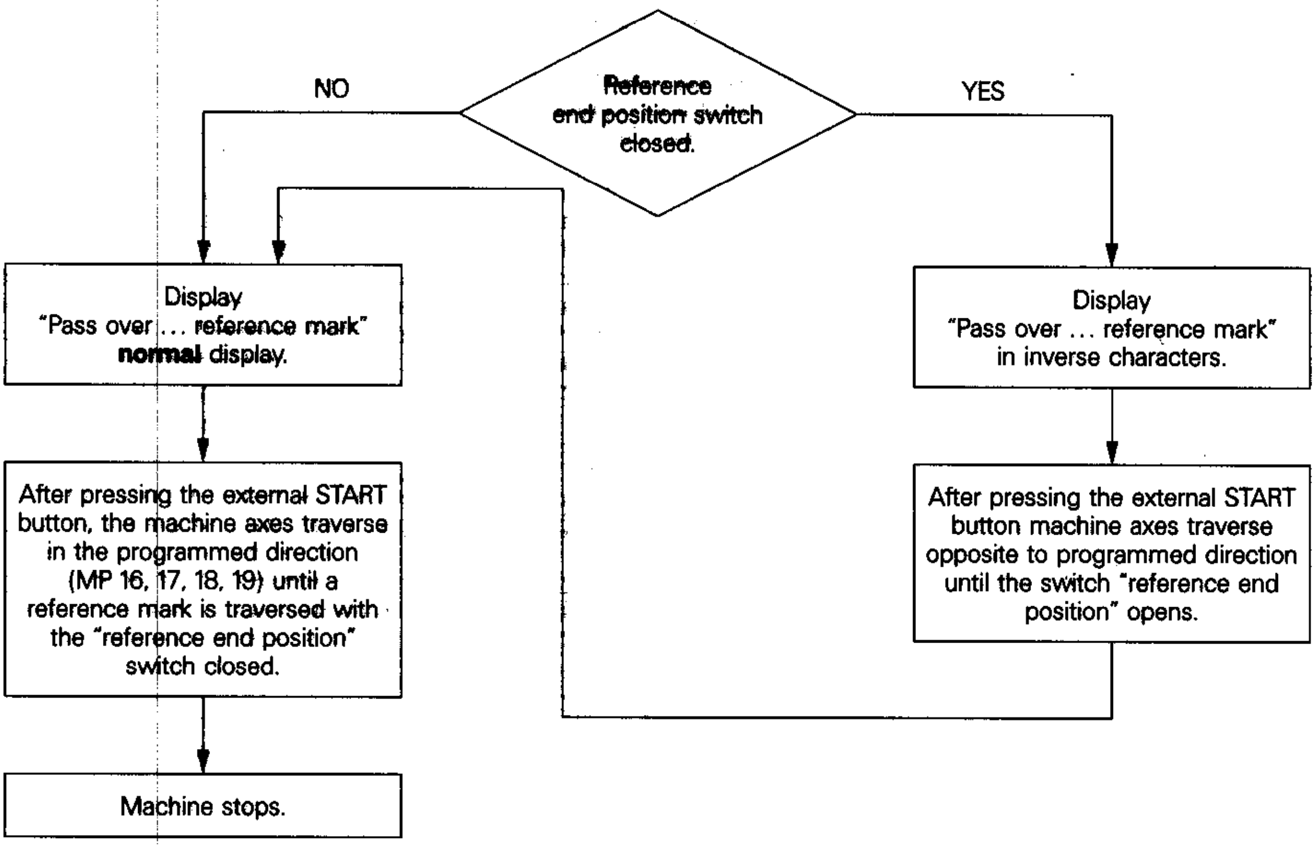


1) The cam switch must be a normally closed configuration, driving the "reference pulse inhibit" input directly. This avoids any processing delay associated with the PLC-program.

For recognition of the reference end position the signal must be inverted via the PLC.

(05) As of Software version 05 (4 axes)

Evaluation of reference marks
for linear measurement via ballscrew and rotary encoder



Accessories
Electronic handwheels

Four versions are available:

Portable handwheel with magnetic fasteners. Connectible via cable adapter (see sheet T7/8):

HR 250	Axis selection via axis keys at the TNC
HR 330	Axis selection via axis keys in handwheel housing. Additional keys for emergency stop, rapid traverse and traverse direction are integral on HR 330.

Handwheel for incorporation in machine operating panel: connectible via extension cable or directly onto the LE 355 (see sheet M3/4)

HR 150	Flush-mount version of HR 250
HR 130	Flush-mount version of HR 330

The HR 330/HR 130 handwheels can be installed only on the LE 355C/S and LE 355CR/SR.

A machine parameter must be set to correspond to the handwheel model employed. This is possible only with a special software available from HEIDENHAIN.

MP 171

Bit 0 **Selection of handwheel**
+ 0 ≙ HR 150/HR 250
+ 1 ≙ HR 130/HR 330

Machine vibrations can be transmitted to the handwheel and therefore lead to unwanted axis movement. The response sensitivity can be reduced via machine parameter MP 247.

MP 247 **Hysteresis for electronic handwheel**
Entry range:
0 ... 65535 [increments]

1 increment is 1/10000 of a handwheel revolution.

Accessories
3D-Touch probe systems

The 3D-touch probe systems from HEIDENHAIN are available in three versions:

.TS 111 with cable transmission to APE-unit (interface electronics)
.TS 120 with cable transmission and integral APE interface electronics
.TS 511 with infra-red transmission to SE 510 (receiving window) and APE-unit (interface electronics)
For connections, see sheet M3/5

Caution!

The touch probe system can only be used if marker 2503 has been reset in the PLC. Locking of the spindle, especially for the application of the 3D-touch probe system TS 111 or TS 120, should be provided by the machine tool builder.

Machine parameters for 3D-touch probe systems

MP 171 **Selection of touch probe systems**
0 ≙ TS 511
2 ≙ TS 111 or TS 120

MP 215 **Feed rate for probing**
Entry range: 80 ... 3000 [mm/min]

MP 216 **Measuring range**
Entry range: 0 ... 19999,999 [mm]

If the measuring point is not reached within the measuring range, the following error message is displayed:

TOUCH POINT INACCESSIBLE

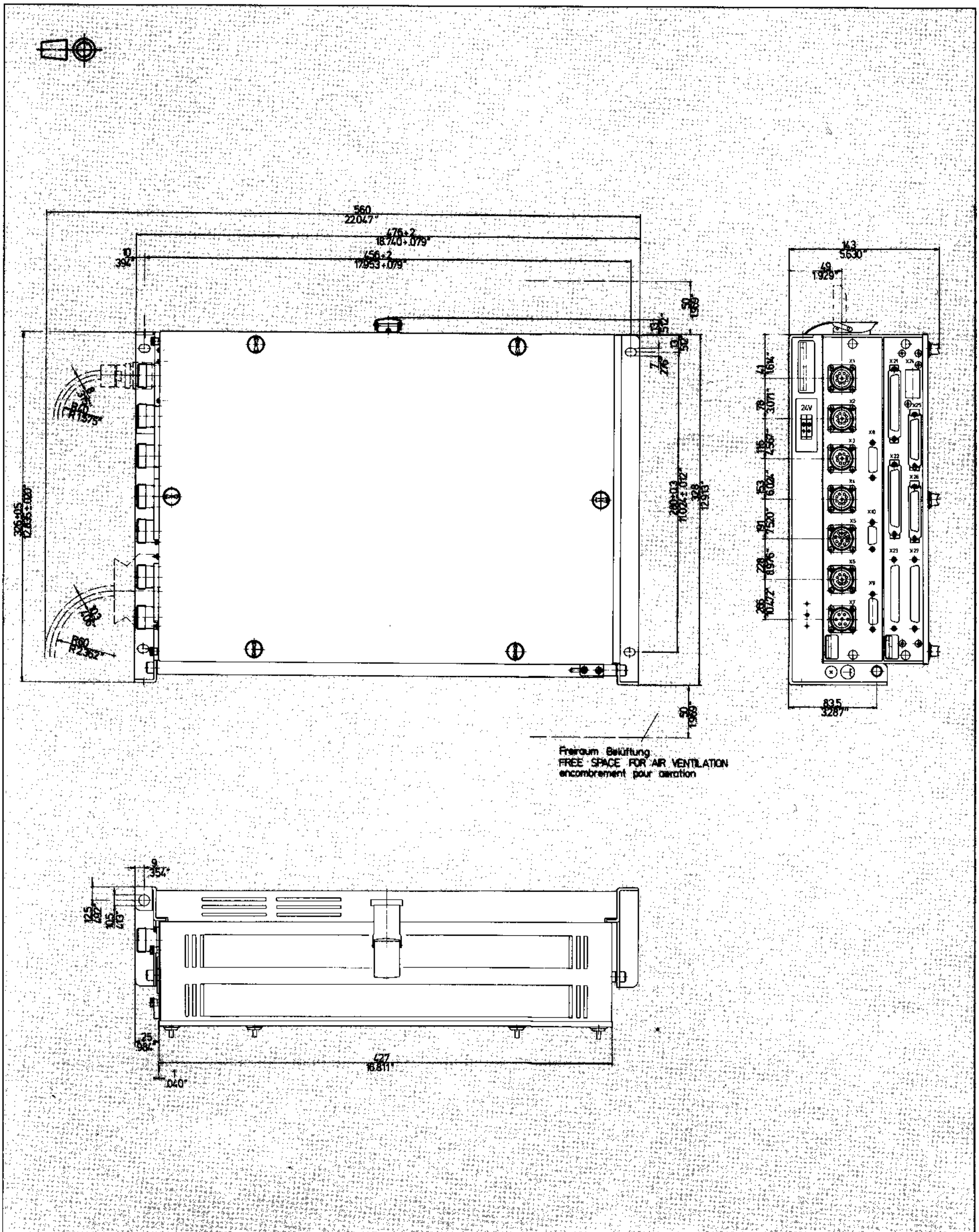
MP 235 **Safety clearance above measuring point for automatic measurement**
Entry range: 0 ... 19999,999 [mm]

The axes are positioned in rapid traverse (MP 251) until the safety clearance is reached. Probing is then executed at a programmed feed rate (MP 215).

MP 251 **Rapid traverse for probing**
Entry range: 80 ... 29998 [mm/min]

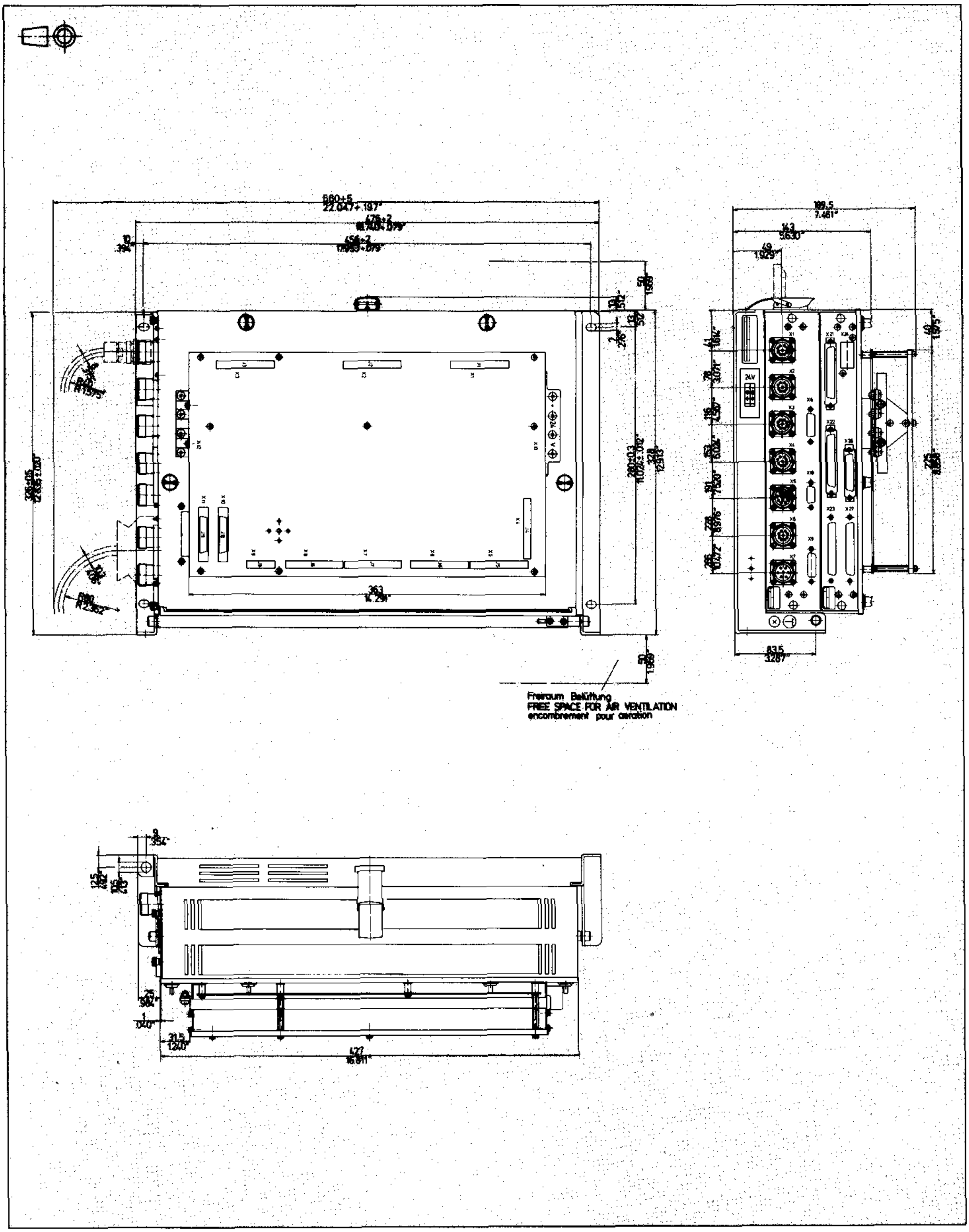
Dimensions mm/INCH

1. Dimensions LE 355 B



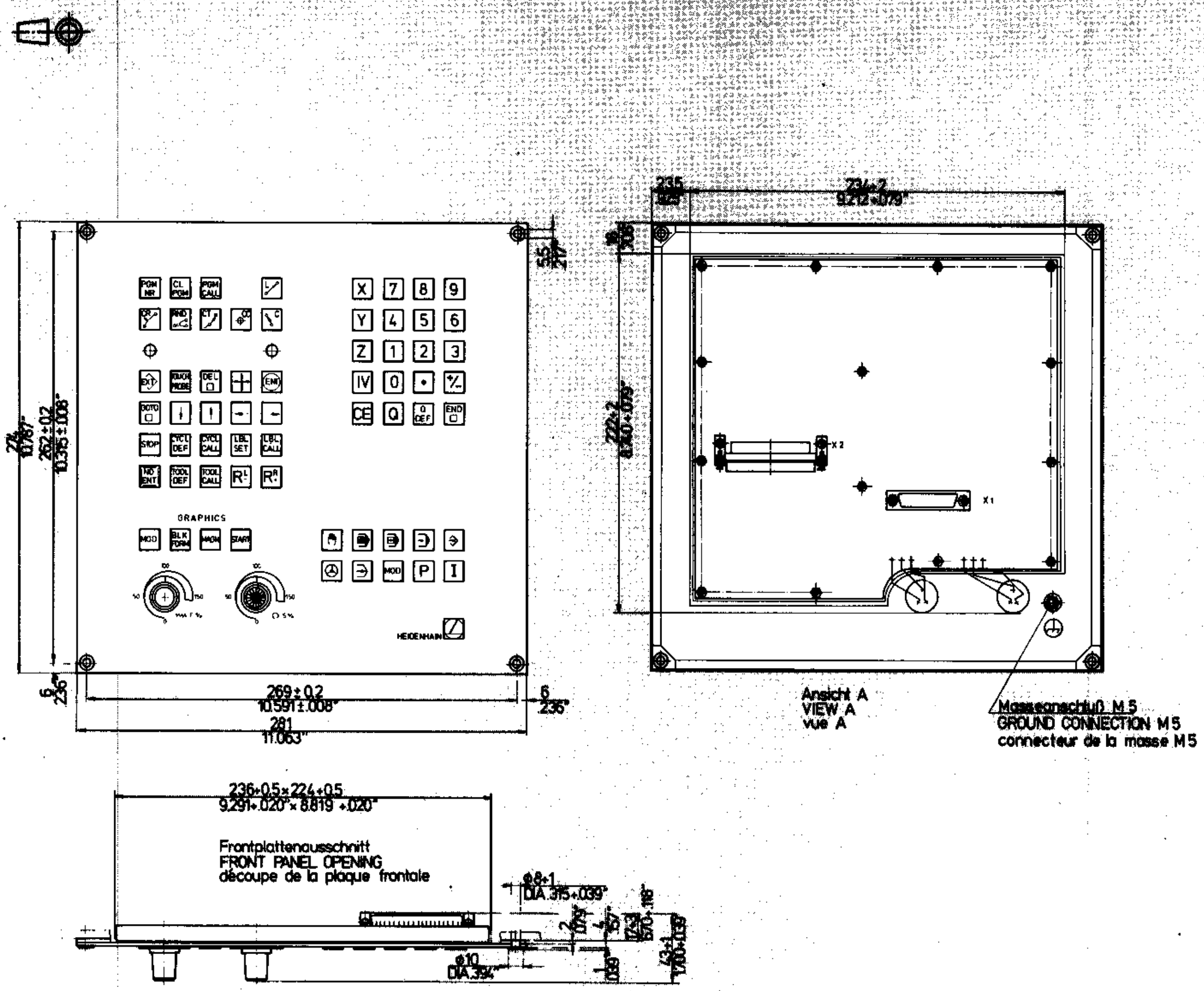
Dimensions mm/INCH

2. Dimensions LE 355Q



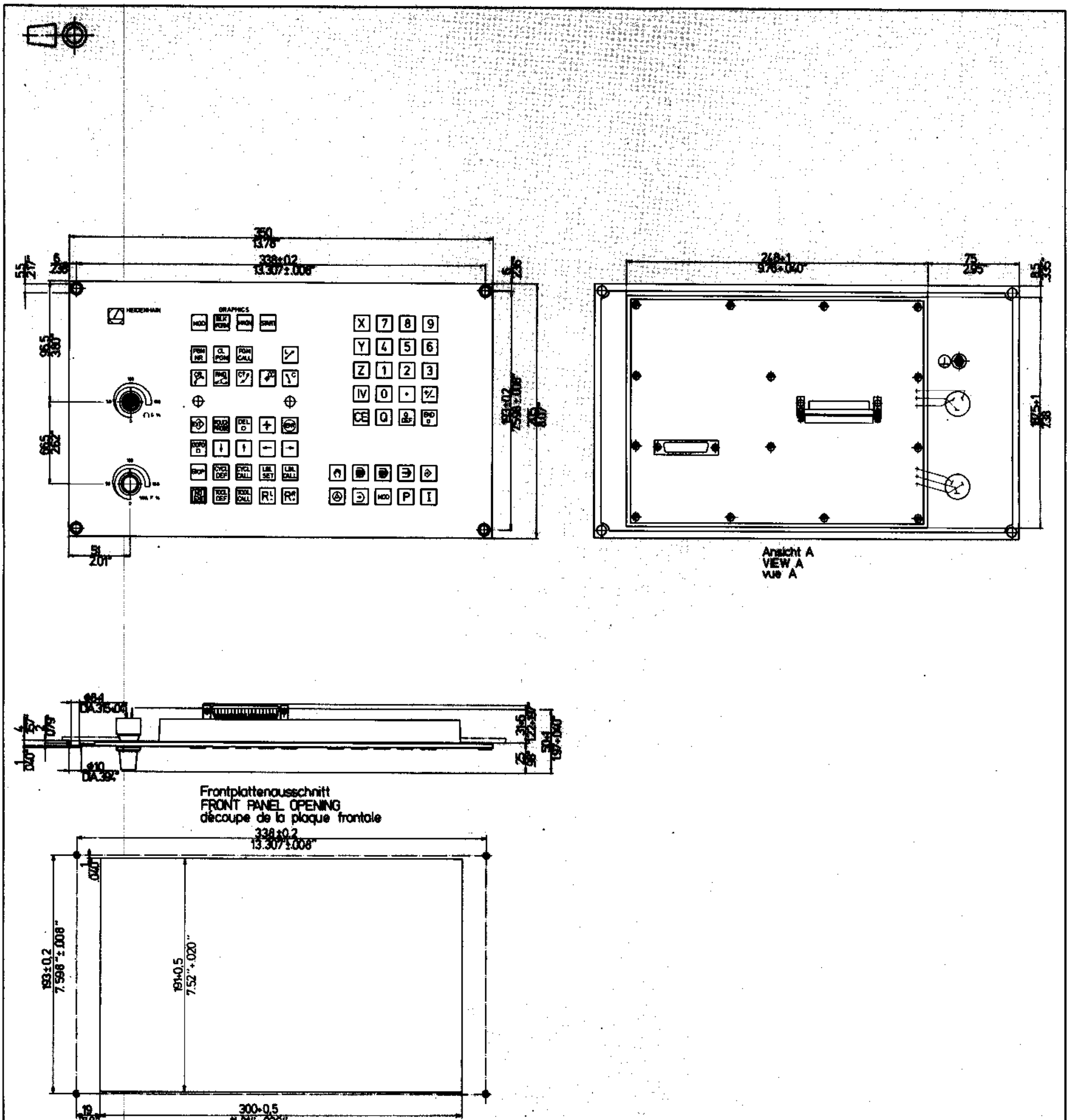
Dimensions mm/INCH

3. Dimensions TE 355 A/C



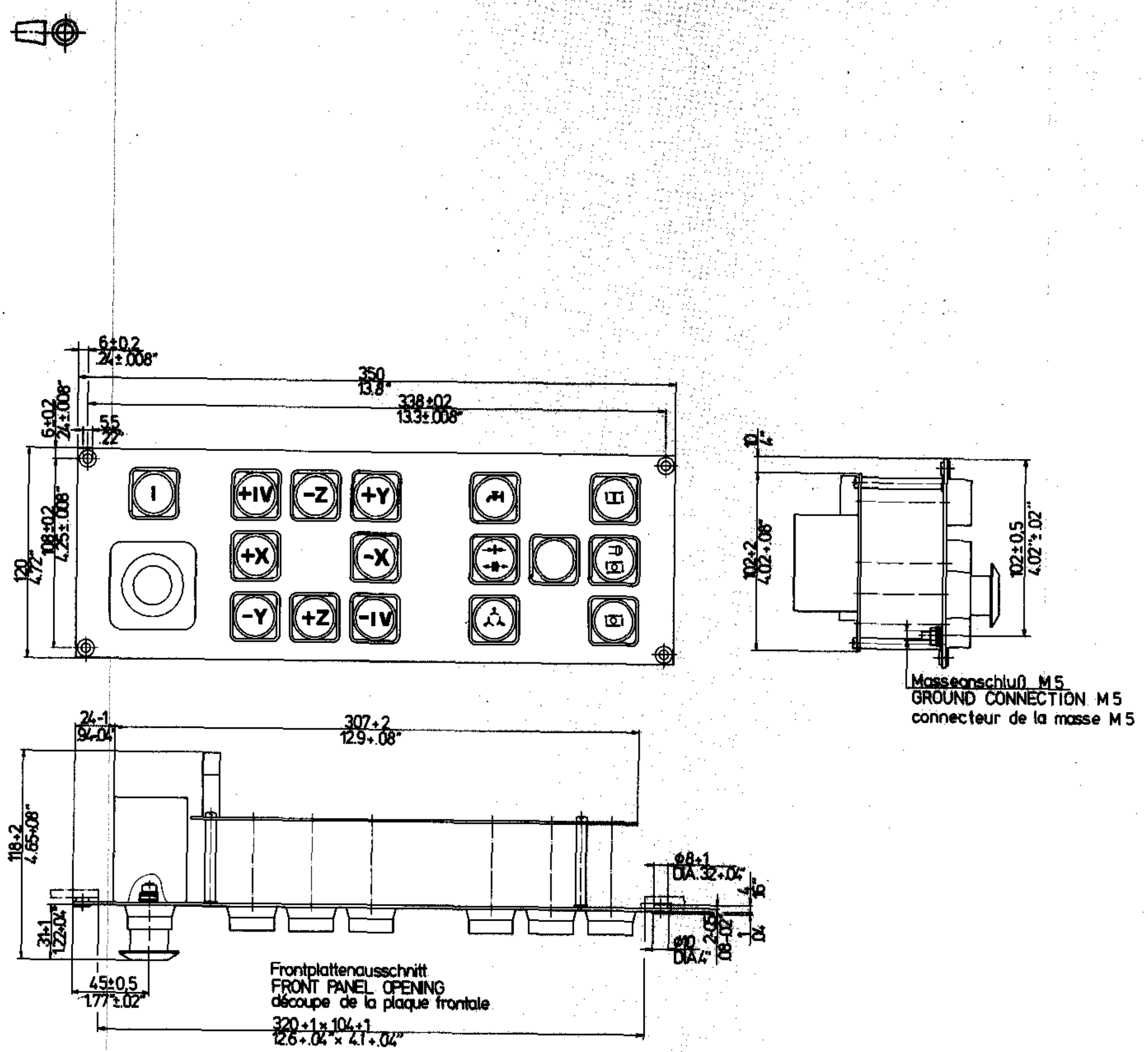
Dimensions mm/INCH

4. Dimensions TE 355B/D



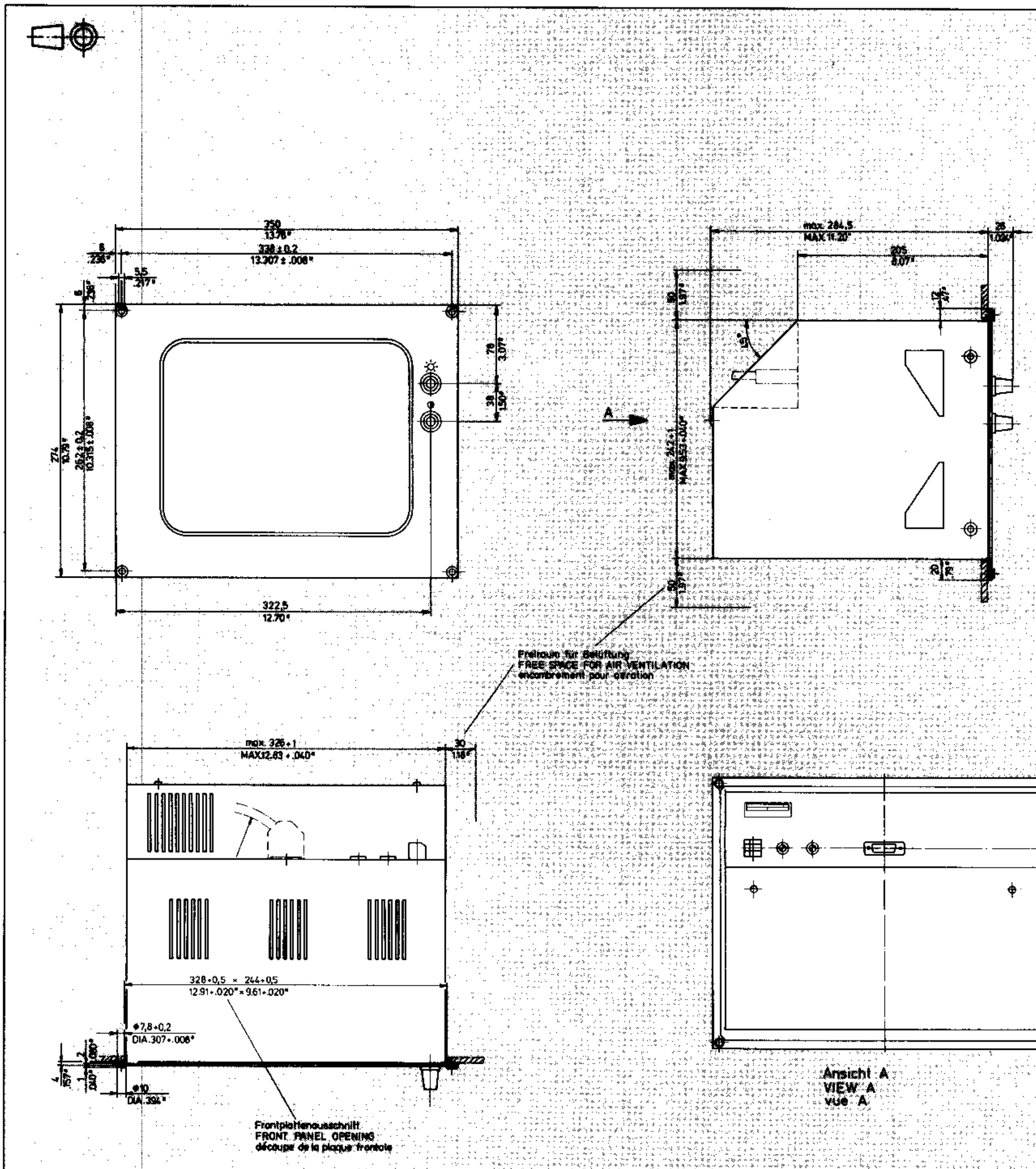
Dimensions mm/INCH

5. *Dimensions* HEIDENHAIN Machine operating panel MB 301



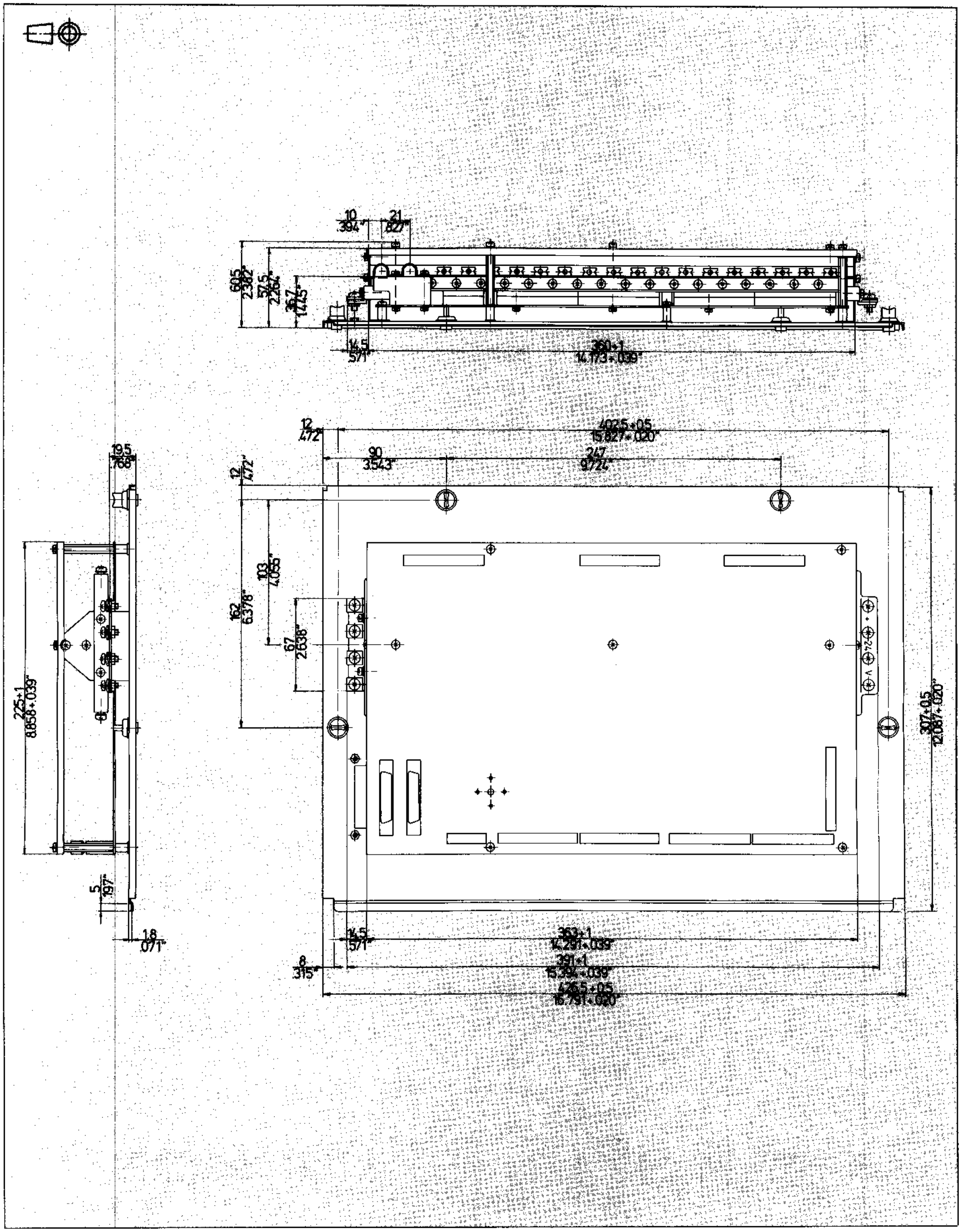
Dimensions mm/INCH

6. Dimensions BE 412 B



Dimensions mm/INCH

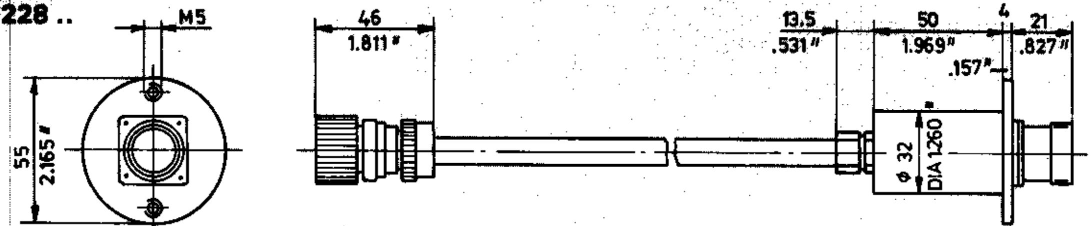
7. Dimensions PL 300



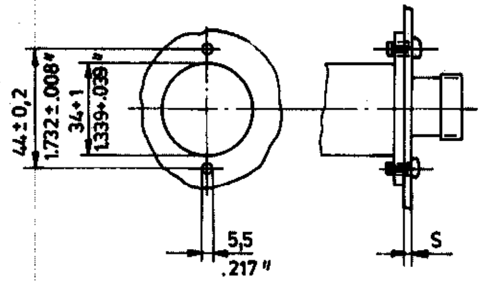
Dimensions mm/INCH

8. Dimensions Adapter

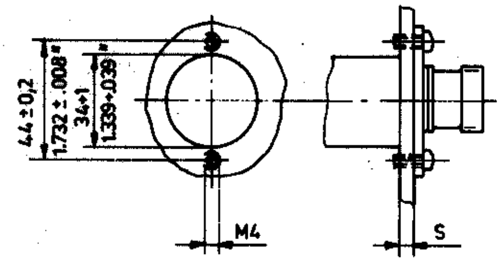
Cable adapter for HR 250
Id.-Nr. 218228 ..



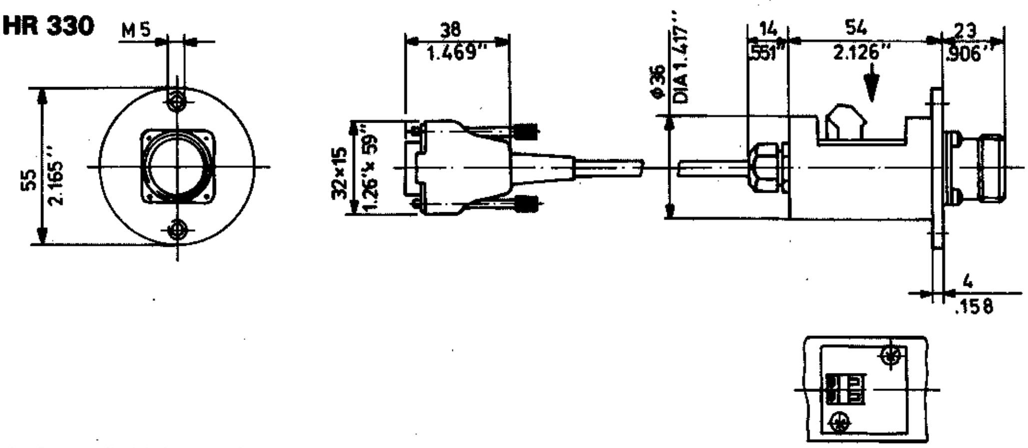
Installation hole for wall thickness S < 4/.157"



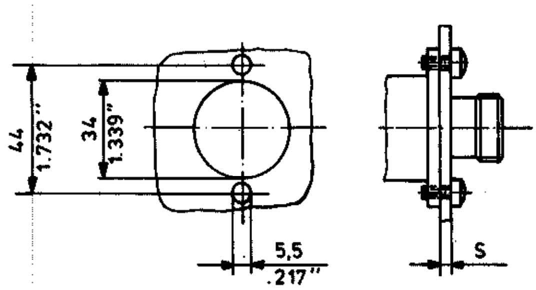
Installation hole for wall thickness S > 4/.157"



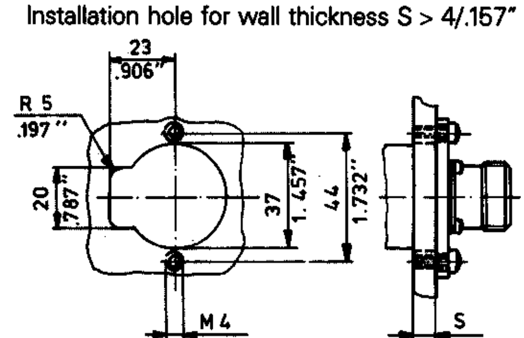
Cable adapter for HR 330
Id.-Nr. 249889 ..



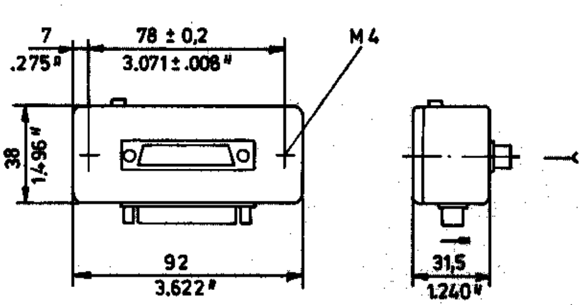
Installation hole for wall thickness S < 4/.157"



Installation hole for wall thickness S > 4/.157"

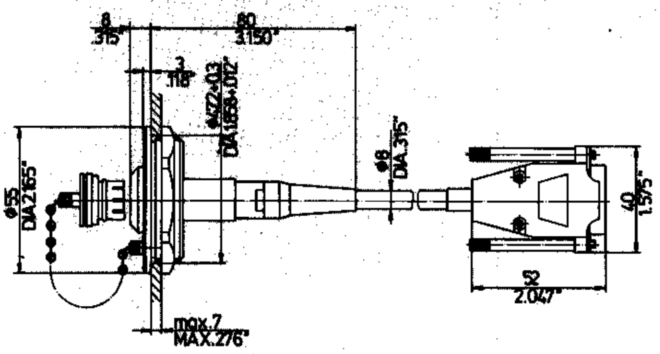


RS-232-C/V.24
Adapter Block
Id.-Nr. 23975801



Dimensions mm/INCH

Cable adapter for TS 120
Id.-Nr. 244 891 ..



Software overview
NC-software numbers

Standard and export version

In addition to the standard software which contains all capability features of the TNC 355, an export version is offered. Until software versions 12 (4 axes) and 06 (5 axes) the following functions were not included in the export version:

- 3D interpolation
- blockwise transfer and simultaneous execution
- automatic compensation in one axis, dependent on another axis.

Beginning with software version 13 (4 axes) and 7 (5 axes), the only inhibited function is the "automatic compensation in one axis dependent on another axis." This function is also called axis sag compensation (see sheet I2/6.1).

NC-software number overview

Depending on the software variation and the language, a different software number is designated. English language is available as the second language for every control. The last two digits of the software number indicate the software version.

TNC 355 for 4 axes with spindle orientation

Standard version (TNC 355B/Q)		Export version (TNC 355F/W)	
NC-software number	Language	NC-software number	Language
237320..	D (German)	237330..	D (German)
...322..	F (French)	...332..	F (French)
...323..	I (Italian)	...333..	I (Italian)
...324..	E (Spanish)	...334..	E (Spanish)
...326..	S (Swedish)	...336..	S (Swedish)
...327..	DK (Danish)	...337..	DK (Danish)
...328..	SF (Finnish)	...338..	SF (Finnish)
...329..	NL (Dutch)	...339..	NL (Dutch)

TNC 355 for 5 axes

TNC 355B/Q/F/W **without spindle orientation** (phase-out as of February 89)

TNC 355C/S/G/Y and CR/SR/GR/YR **with spindle orientation**

Standard version (TNC 355B/Q and C/S (CR/SR))		Export version (TNC F/W and G/Y (GR/YR))	
NC-software number	Language	NC-software number	Language
237340..	D (German)	237350..	D (German)
...342..	F (French)	...352..	F (French)
...343..	I (Italian)	...353..	I (Italian)
...344..	E (Spanish)	...354..	E (Spanish)
...346..	S (Swedish)	...356..	S (Swedish)
...347..	DK (Danish)	...357..	DK (Danish)
...348..	SF (Finnish)	...358..	SF (Finnish)
...349..	NL (Dutch)	...359..	NL (Dutch)

Software overview
NC-software releases

TNC 355 for 4 axes

NC-software version	Date of release	
2373. .01	July 1987	
2373. .02	October 1987	
2373. .03	November 1987	
2373. .04	December 1987	
2373. .05	May 1988	
2373. .08	October 1988	
2373. .09	November 1988	
2373. .10	February 1989	
2373. .11	March 1989	
23733.13	October 1989	Only for export version

TNC 355 for 5 axes

NC-software version	Date of release
2373. .01	May 1988
2373. .02	April 1988
2373. .04	January 1989
2373. .05	March 1989
23735.07	October 1989

Contents

Provisions for installation
Electrical interference

Remember, electronic equipment with faster signal processing and increasing responsiveness is also more susceptible to interference! Therefore, protect the equipment against interference by following the instructions and recommendations given in this manual.

Possible sources of interference are:
.strong magnetic fields from transformers or electric motors
.relays, circuit breakers and solenoid valves
.high frequency instruments, pulse generators and stray magnetic fields from relay power supplies
.power lines and feed lines to the abovementioned equipment.

Interference voltage is mainly produced and transmitted through **capacitive** or **inductive engagement.** Stray pickup can be caused via power lines and equipment inputs and outputs.

The following **protective measures** must be taken to avoid electrical interference:
.**Minimum distance** from the LE 355 and its signal conductors(1) to **interference-producing instruments: ≥ 20 cm/8 in.**
.**Minimum distance** from the LE 355 and its signal conductors to **interference-conducting cables: ≥ 10 cm/4 in.**

Please note:
When **laying** all LE 355 signal lines together with other interference-conducting cables in metal cable ducts, sufficient decoupling can be attained through a grounded partition.

The lines must be shielded according to **DIN VDE 0160.**
For **signal lines only(2) special HEIDENHAIN cable may be used!**

Lay signal lines as short as possible and, if possible, **without intermediate clamp terminals!**(2)

For nominal value connections to a transfer unit, only HEIDENHAIN cable should be used.

Always use **HEIDENHAIN plug connectors and couplings** for connecting signal lines.

Please note:
Follow the **assembly instructions** for plugs and couplings (see diagram page M3/3).
.If there are plug connections within a line, coincidental contacts between plug/coupling housing and other metal parts must be prevented: **e.i. either insulate or secure connector housing!**

Besides cable shielding, **metal housings** of encoders, digitizing electronics, controls etc. also serve as shielding.
They must have **equal potential** and be connected to a **common operational ground** via the machine housing or a separate potential equalization line.
In this regard, note the special remarks in the individual sections.

The **potential equalization lines** of the appropriate units must have cross-sections of **at least 6 mm² Cu.**

The **potential equalization line** of the LE 355 must be connected to the terminal on the LE 355 and to the **protective ground.**

(1) Signal conductors are all encoder cables, nominal value cables, RS-232-C/V.24 cables, connecting cables for the electronic handwheel and the touch probe system.

(2) With exception of the nominal value cables.

Provisions for installation
Temperature

Permissible ambient temperature in operation: 0° C ... 45° C (32° F ... 113° F).

See measuring points $\Huge{ⅰ}$ ° C (sheets M2/2; M2/3).

Remember that the reliability of electronic equipment decreases greatly during prolonged operation at high temperature!
Use appropriate **precautions** to ensure compliance to permissible ambient temperatures:

Maintain the **free space** necessary for adequate air circulation (see sheet M1/3).

When mounting, refer to figs. on sheets M2/2; M2/3; M1/3 regarding temperature.

Please note:
.Select a mounting location that provides good air circulation for the LE 355.
.LE 355 must not be located in the flow of pre-heated air from another source.

The control cabinet must be dustproof, i.e. cable grommets, the cabinet door etc. must be properly sealed against penetration of dust.

For closed steel housings without artificial cooling the standard value for heat extraction is approx. 3 W/m² surface and per ° C temperature rise between internal and external air.

Please note:
When calculating the excess temperature the **total power dissipation of all instruments** that are operating in the control cabinet must be included.

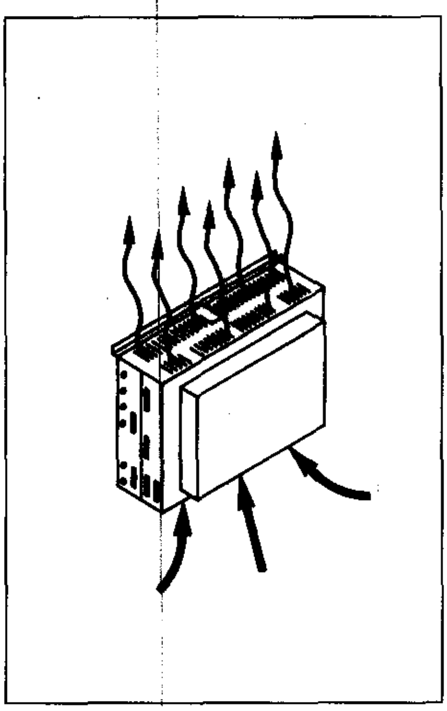
HEIDENHAIN recommends the installation of a ventilator for better heat extraction.
The ventilator should amplify the effect of natural convection.
It must be mounted so that the warm air is extracted from the LE 355 and that no artificially heated air is blown in.
The extracted air should, if possible, run along surfaces that provide a good outward heat conductivity (e.g. sheet metal).

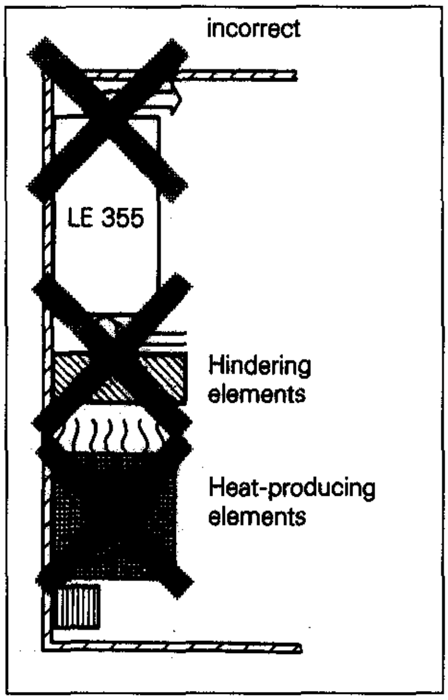
A further improvement for heat removal can be attained through the **use of a heat exchanger** (with separate external and internal circulation).

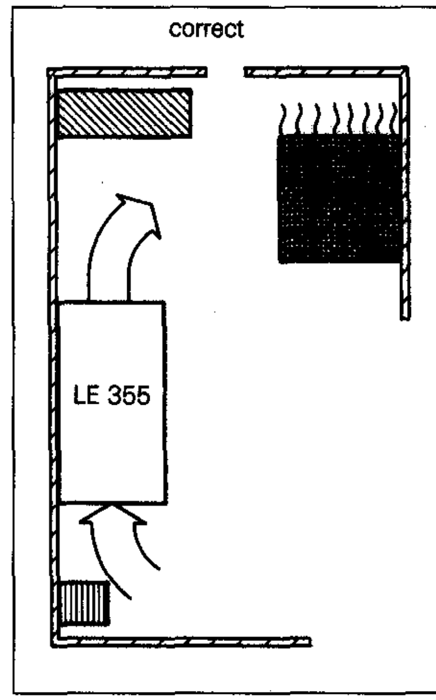
Cooling by exchanging exterior with interior air in the control cabinet: If this cooling method is intended, the ventilator must be mounted such, that it extracts the air from the control cabinet and that only **filtered** external air can flow into the control cabinet.
HEIDENHAIN advises against this cooling method, since the functional reliability of electronic components is endangered by air contaminants (fine dust, vapours, etc.).
Moreover, in addition to the abovementioned disadvantages, an inadequatly maintained filter causes a progressive decrease in cooling efficiency.
Regular maintenance of the filter is therefore imperative!

Provisions for installation
Temperature

Recommended mounting attitudes







Provisions for installation
Air humidity

Permissible air humidity: **≤ 75 %** (permanent operation)
≤ 95 % (maximum 30 days/year, naturally distributed).

In tropical regions it is recommended not to turn the control off, if the danger of condensation on the PCBs exists! The heat generated by the control itself prevents condensation and has no other disadvantages.

Provisions for installation
Mechanical vibration

Permissible vibration: ≤ 0.5 g

Installing the logic unit LE 355

Always regard the following points when installing the LE 355:
.mechanical accessibility
.permissible environmental conditions
.electrical interference
.the regulations valid in your country for mains power supply.

Mounting attitude
HEIDENHAIN recommends the horizontal mounting attitude for LE 355, see illustration sheet M2/2.

Connections are then on the left, vertically arranged.
The vertical mounting position (illustrated on sheet M2/3) is less favourable due to insufficient heat ventilation.

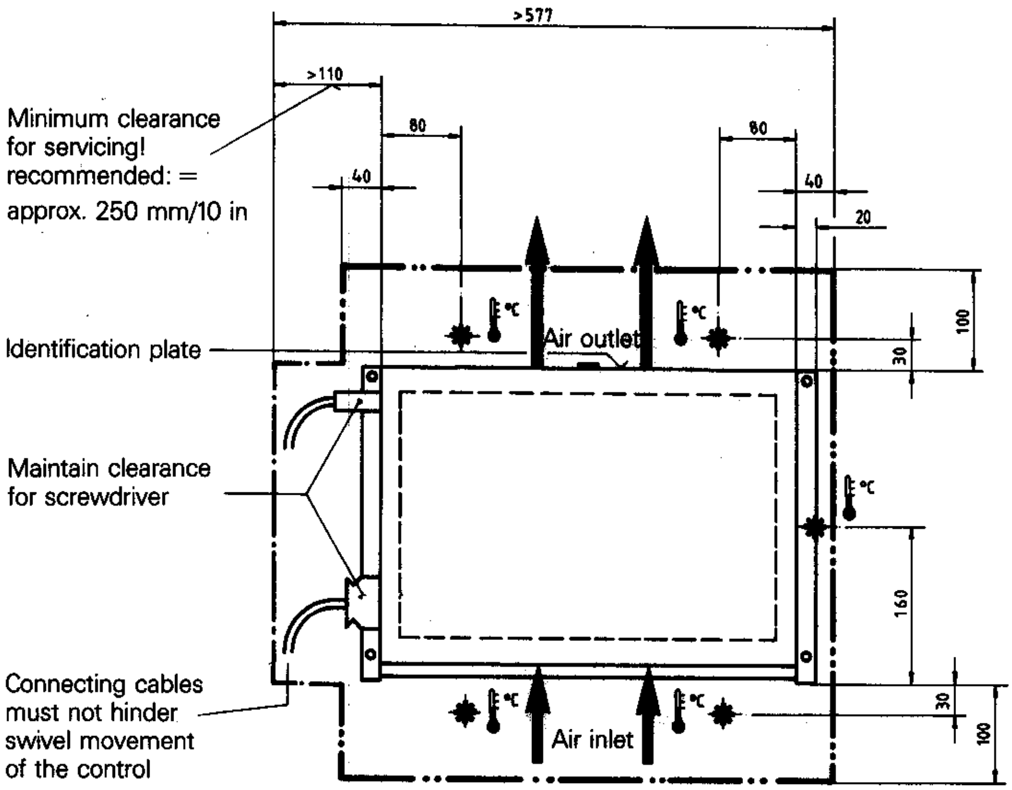
Mounting accessibility
The angular freedom of movement necessary for servicing purposes (exchanging subassemblies) must be maintained (see figs. on sheets M2/2; M2/3).

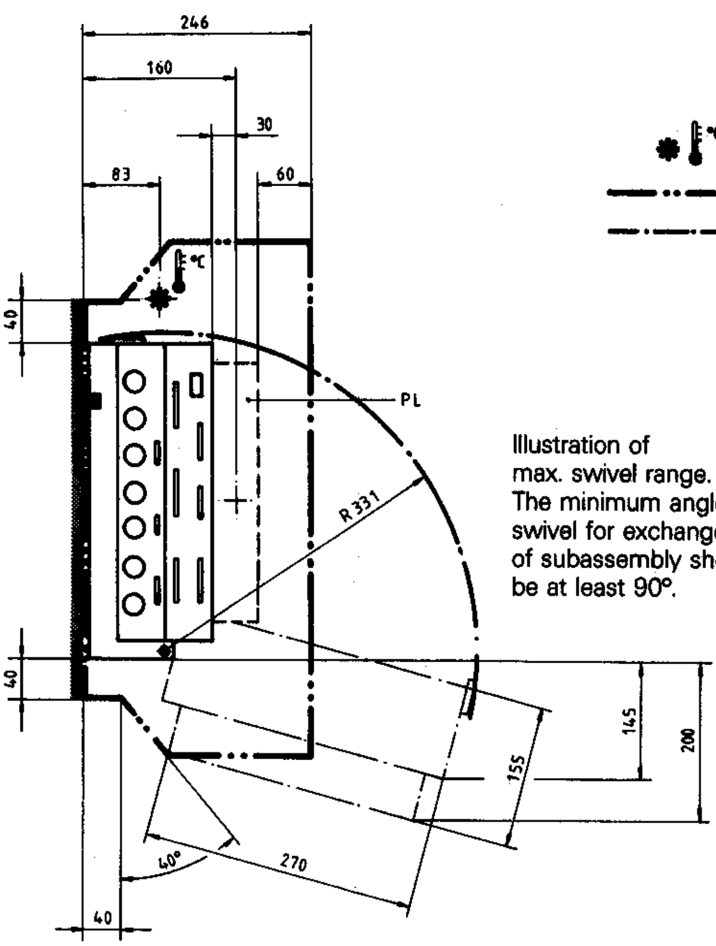
Allow **free space for the plug connectors!**
Minimum clearance on the basis of the permissible cable bend radii: > 110 mm/4.3 in (see figs. on sheets M2/2; M2/3).
Recommended clearance for servicing: approx. 250 mm/10 in.

The **legibility** of
.**identification and rating plates,**
.**NC and PLC software number stickers, and**
.**plug connector designations**
must be ensured.

Installing the logic unit LE 355

LE 355 Horizontal mounting





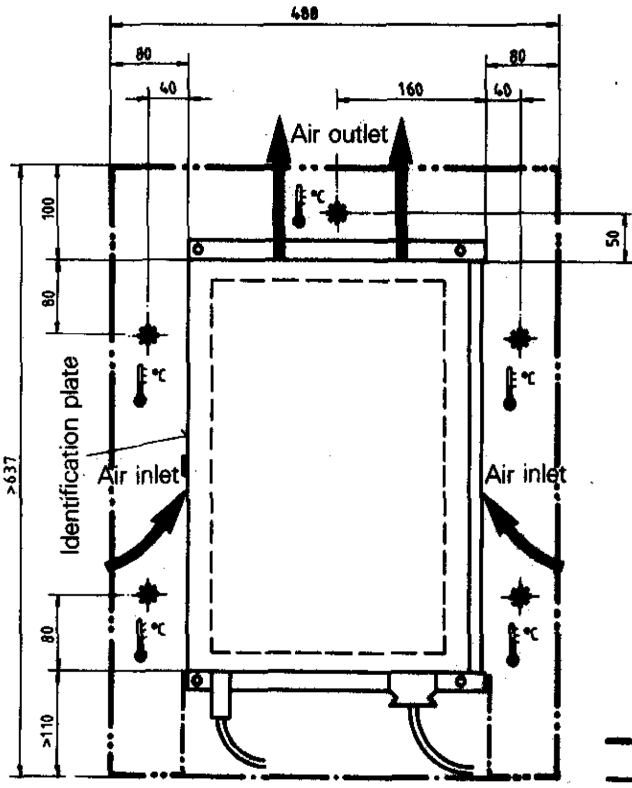
Measuring point for ambient temperature

Free space for air circulation

Free space for servicing

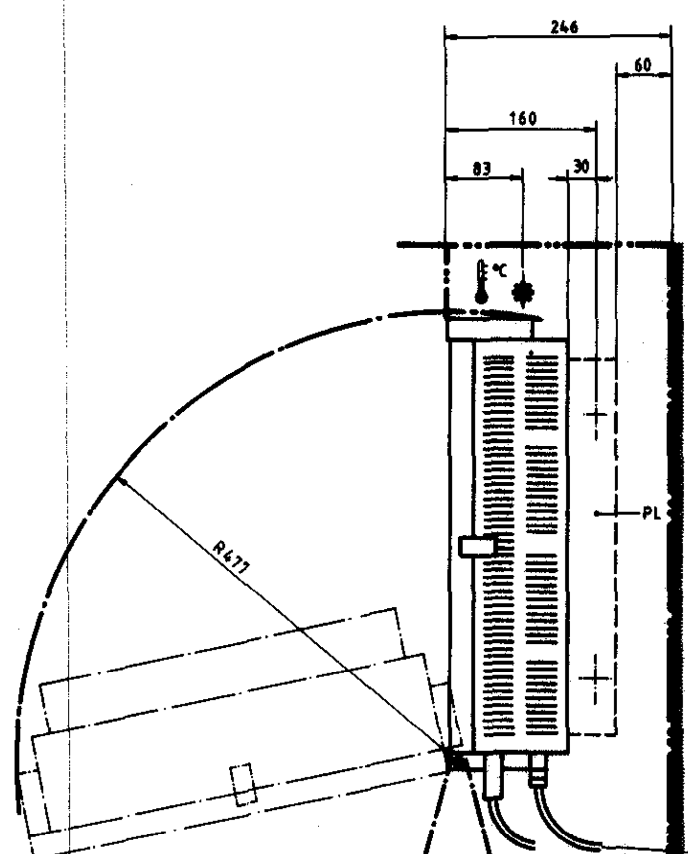
Installing the logic unit LE 355

LE 355 Vertical mounting

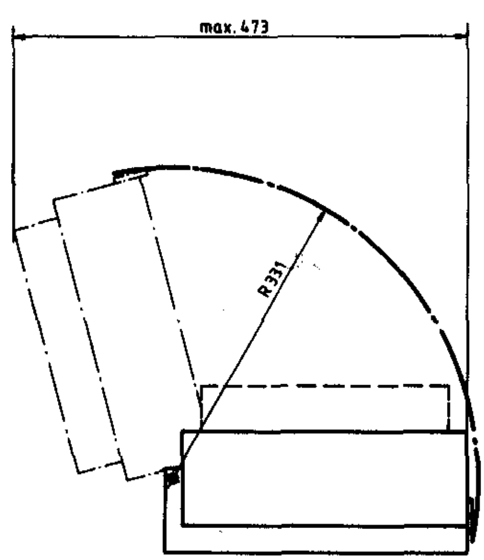


Minimum clearance
for servicing!
recommended:
= approx. 250 mm/10 in

Measuring point for ambient temperature
Free space for air circulation
Free space for servicing



View X (opened for exchange of subassembly)



Connecting cables must not hinder free movement of the control

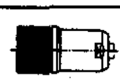
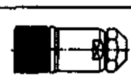
Recommended swivel angle > 90° for accessibility of plug connectors and identification plate

Electrical connection of the logic unit LE 355
Connecting the encoders

Mounting
Mount the encoders according to the mounting instructions of each respective encoder!

Electrical interference
When laying the encoder cable, refer to the general remarks in section M1 "Electrical interference"!

Encoder lines must be laid without intermediate terminals.
Use only HEIDENHAIN plug connectors and couplings to connect encoder lines.

Pole arrangement \ Type		Plug connector		
				
7 poles	—	228 561 07 (D6) 228 561 06 (D8)	- -	- -
	≺	228 561 08 (D8)	- -	- -
9 poles	—	228 561 02 (D6) 228 561 03 (D8)	228 561 04 (D6) -	- 228 561 05 (D8)
	≺	228 561 17 (D6) 228 561 11 (D8)	- -	- 228 561 12 (D8)
12 poles	—	228 561 10 (D6) 228 561 13 (D8)	- -	- -
	≺	- 228 561 14 (D8)	- -	- -

Pole arrangement \ Type		Coupling	
			
7 poles	—	- -	- -
	≺	228 562 04 (D6) 228 562 03 (D8)	- -
9 poles	—	- -	- -
	≺	- 228 562 01 (D8)	- 228 562 02 (D8)
12 poles	—	228 562 06 (D6) 228 562 05 (D8)	- -
	≺	- 228 562 12 (D8)	- -

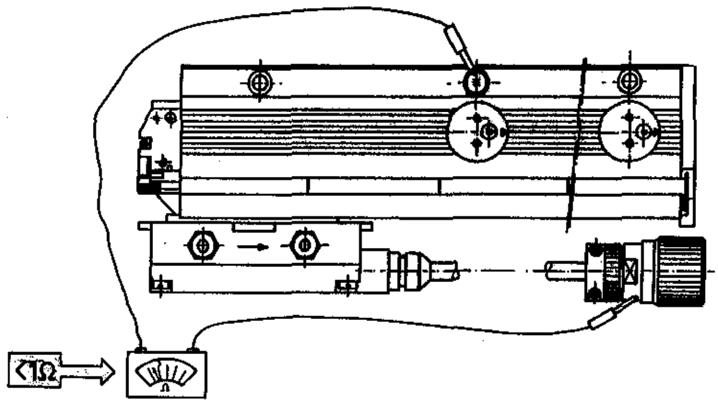
Use only HEIDENHAIN double shielded cable with twisted wire pairs, Id.-Nr. 200775.., as extension cable for the X, Y, Z and IV encoder axes!
.The inner shield (pin 9) must have no electrical contact with the outer shield (plug housing)!
.The outer shield of the encoder cable must be connected to the ground connection of the LE 355 (see Grounding diagram section M8).
.The encoder is grounded via its mechanical fixings; with sealed linear encoders via the mounting block and the scale housing (see Grounding diagram section M8).
The maximum cable length between the encoder scanning unit and LE 355 (or the EXE-unit) is 20 m/65 ft. with the standard cable (Id.-Nr. 20077502) and 30 m/98 ft. with the special cable (Id.-Nr. 22856701).

Use only HEIDENHAIN single shielded cable, Id.-Nr. 246512.. as extension cable for the encoder connection X5.
.The shield must be electrically connected to the LE 355 via the plug housing and to the machine housing via the ground connection of the LE 355 (see Grounding diagram sheet M8/1).

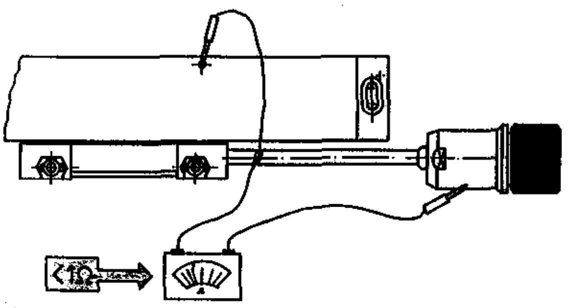
With external digitizing electronics (EXE), the ground connection must be electrically connected to the machine housing.
Required cross-section ≥ 6 mm^2.

Electrical connection of the logic unit LE 355
Connecting the encoders

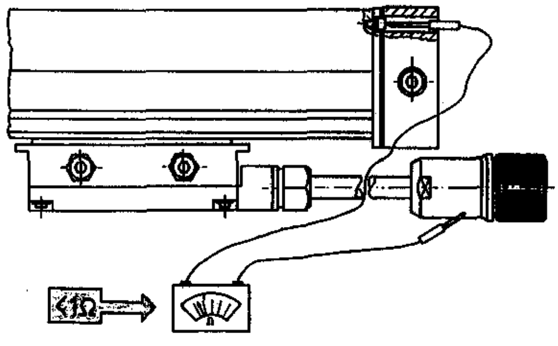
Please note:
Check electrical connection between the mounting block of the scanning unit and the scale unit housing. Since the encoder connector and the mounting block of the scanning unit are connected via the external shield of the cable, this check can be made between the encoder connector and encoder housing.
During this check, no connection should be made to the LE 355.



LS 107/LS 107C



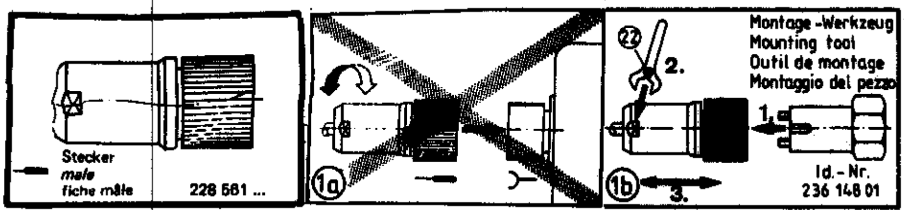
LS 403/LS 403C/LS 404/LS 404C

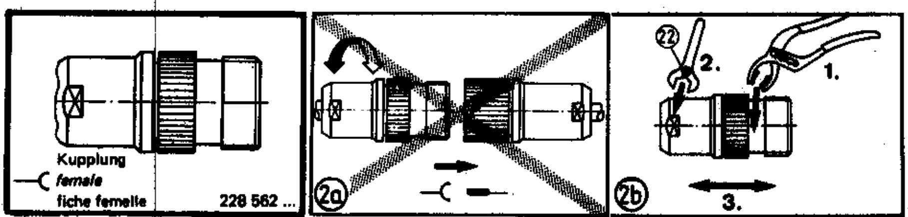


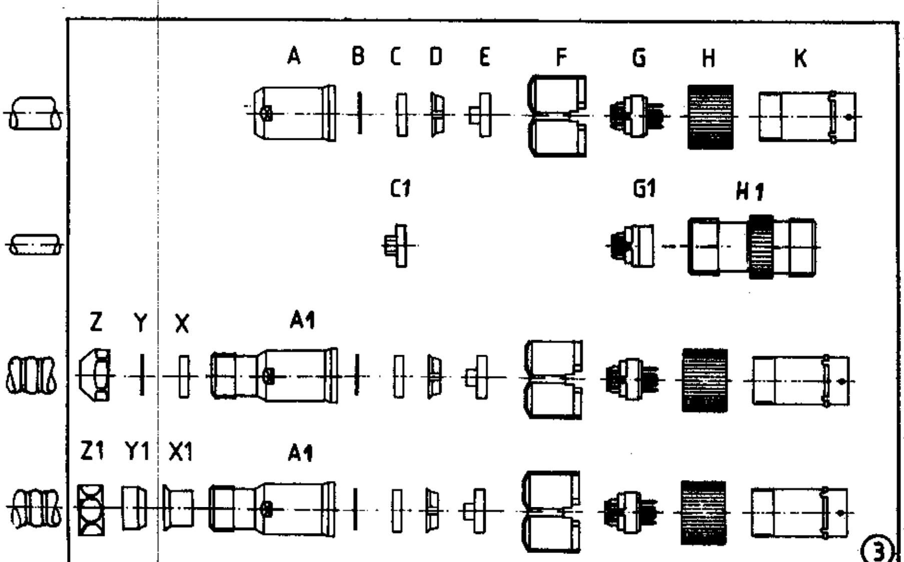
LS 704/LS 704C

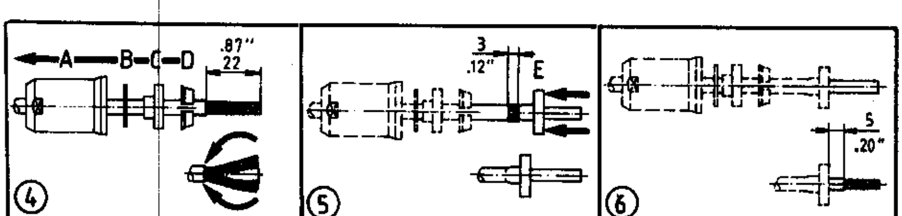
Electrical connection of the logic unit LE 355
Connecting the encoders

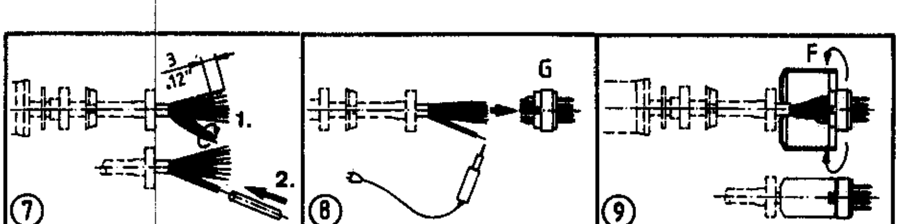
Assembling the Plug connector 228561..
Assembling the Coupling 228562..











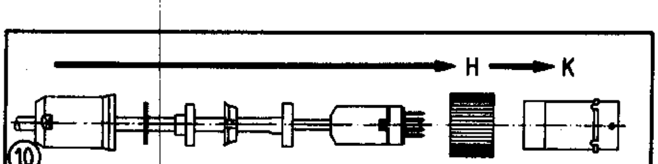


Fig.

1a+ 2a Do not open a plug connector or coupling by counteracting with a mating connector!

1b To assemble the plug an assembly tool Id.-Nr. 23614801 and a 22-mm open jaw spanner must be used.

2b To assemble the coupling an adjustable pipe wrench with plastic jaw-linings must be used.

3 This figure illustrates the various parts for plug and coupling and the two different gland versions PG7 and PG9, for the armoured tubing. The PG9 gland, Id.-Nr. 20962901, consisting of the parts X_1, Y_1, Z_1, must be ordered separately.

4 Slide parts A – D onto the cable thereby assembling the gland for the armoured tubing, according to fig. 3 if applicable. Remove 22 m/ 0.87 inch from the outer insulation. Twist outer screening open and fold back.

5 Cut the outer screening back to 3 mm/0.12 inch of the outer layer of insulation and slide the contact bushing E between the inner layer of insulation and the woven screening.

6 Remove inner insulation to 5 mm/ 0.20 inch.

7 1) Twist inner screening together.
2) Insulate the twisted inner screening with thermo-shrinkable sleeve.

8 Remove 3 mm/0.12 inch of insulation from all the strands. Twist, tin and solder onto G or G_1 according to the connector layout plan.

9 Assemble part F.

10 Close connector together.

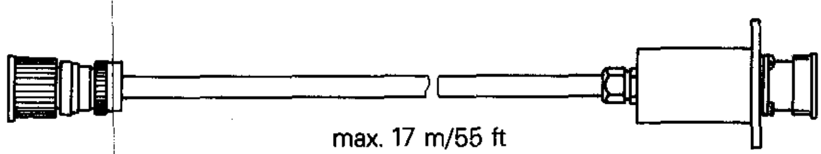
Electrical connection of the logic unit LE 355
Connecting the electronic handwheel

Refer to the remarks in section M1 "Electrical interference" when laying the cable.
Shielding and grounding, see grounding diagram on M8/1.

HR 250/HR 150
The HR 150 can be connected directly to the logic unit LE 355. The HR 250 must be connected to the logic unit LE 355 via the HEIDENHAIN cable adapter.

An extension can be made with the original HEIDENHAIN encoder extension cable (Id.-Nr. 235806..).

Cable adapter for HR 250
Id.-Nr. 218228 ..



max. 17 m/55 ft

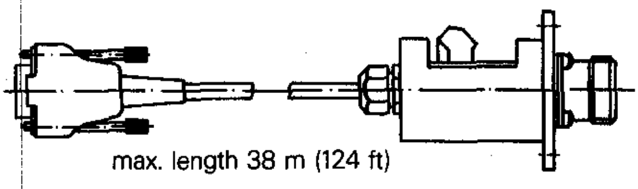
Layout for handwheel adapter and encoder extension cable

Pin	Colour
1	green
2	yellow
3	brown
4	white
5	blue
6	red
7	grey
8	pink
9	white/brown

The maximum cable length between LE 355 and HR 250 is 20 m/65 ft, i.e. with a 3 m/10 ft cable on the HR 250 the cable adapter may have a max. length of 17 m/55 ft.

HR 330/HR 130
The handwheels HR 130 and HR 330 can only be connected to the LE 355C/S and LE 355CR/SR (see sheet T6/1).
The HR 130 can be connected directly to the TNC. The HR 330 must be connected to the TNC via the HEIDENHAIN cable adapter.

Cable adapter for HR 330
Id.-Nr. 249889 ..



max. length 38 m (124 ft)

Electrical connection of the logic unit LE 355
Connecting the touch probe systems

Mounting
When mounting, refer to the mounting instructions of the touch probe system being employed!

Electrical interference

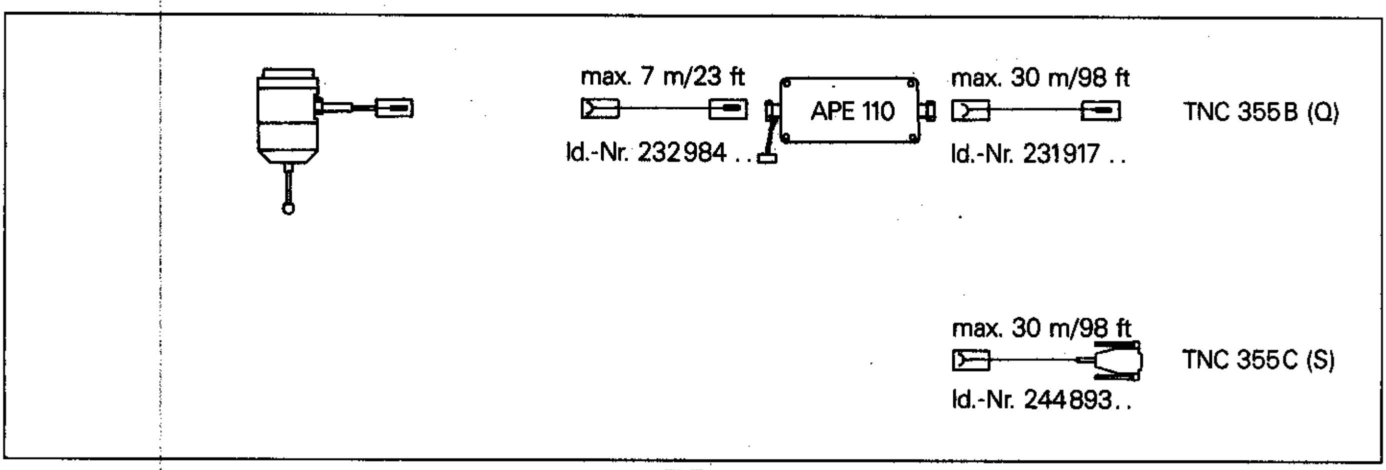
Use only HEIDENHAIN double shielded cable as specified in the respective mounting instructions!

The inner shield and outer shield must not be electrically connected.

When laying the cable refer to the remarks in section M1 "Electrical interference".

Shielding and grounding see grounding diagram on sheet M8/1.
The interface electronics APE 110/APE 510 must be grounded via the grounding terminal by means of an earthing cable with a cross-section of 6 mm^2 Cu!

TS 111



Connector layout TS 111
Connector, male, 7-pole

Contact No.	**Allocation**
1	Reference voltage
2	Symmetry lines 1 + 2
3	LED Anode (+ 5 V)
4	LED Cathode
5	Sensor signal 1
6	Sensor signal 2
7	Internal screen (0 V)
Connector housing	Outer screen

APE 110-connection to subsequent electronics
(7-pole flange socket, male)

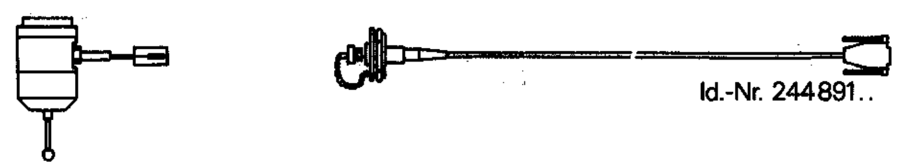
APE 110		**Subsequent electronics**
Pin	Signal	Signal
1	U_N	0 V
2	U_P	+ 24 V (15 ... 29 V)
3	not assigned	
4	$\overline{\text{Trigger signal}}$	$\overline{\text{Trigger signal}}$
5	Bridge to U_P	Ready
6	Bridge to U_P	Battery warning
7	Internal screen	0 V
Connector housing	External screen	Housing potential

By altering the switch setting S_1, S_2 in the APE 110 the trigger signal can be inverted.

Electrical connection of the logic unit LE 355
Connecting the touch probe systems

TS 120

The interface electronics (APE) are incorporated within the touch probe system TS 120.



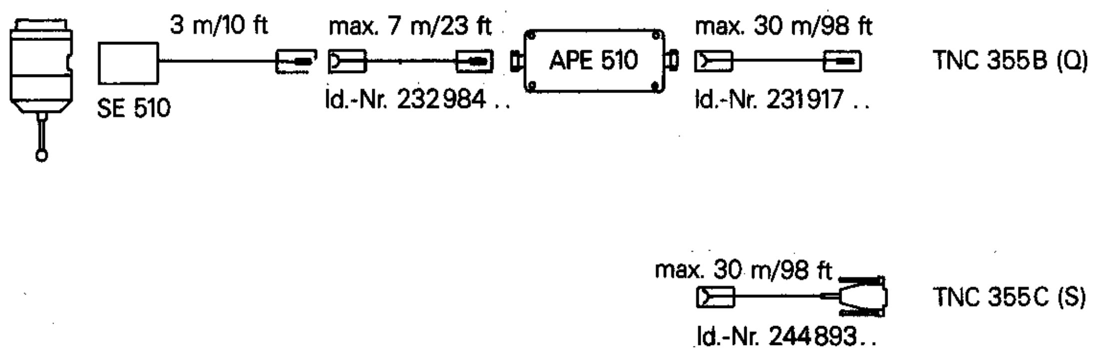
Connector layout TS 120
Lemosa-connector

Contact No.	Allocation
1	0 V
2	+ 5 V
3	
4	
5	Trigger signal
6	$\overline{\text{Trigger signal}}$[1]
Housing	External screen

[1] Touch probe system in rest position means signal at high level

Electrical connection of the logic unit LE 355
Connecting the touch probe systems

TS 511



Mount the transmitter/receiver unit SE 510 insulated or electrically conductive with the machine!

The potential must be distinctly conductive or insulated in the event of e.g. vibration.

Connector layout SE 510
Connector, male, 7-pole

Contact No.	Allocation
1	0 V (U_N)
2	+ 12 V (U_P)
3	Vacant
4	Flash signal
5	Vacant
6	IR-signal
7	Internal screen (0 V)
Connector housing	External screen

APE 510 Connection to subsequent electronics
(7-pole flange socket, male)

	APE 510/511		Subsequent electronics
Pin	Signal		Signal
1	U_N	←	0 V
2	U_P	←	+ 24 V (15 ... 29 V)
3	Start	←	Start
4	$\overline{\text{Trigger signal}}$	→	$\overline{\text{Trigger signal}}$
5	Standby	→	Standby
6	$\overline{\text{Battery warning}}$	→	$\overline{\text{Battery warning}}$
7	Internal screen	←	0 V
Connector housing	External screen	←	Housing potential

By altering the switch settings S_1 to S_4 in the APE 510, the signals can be inverted.

Electrical connection of the logic unit LE 355
Connecting the nominal value outputs

Specifications

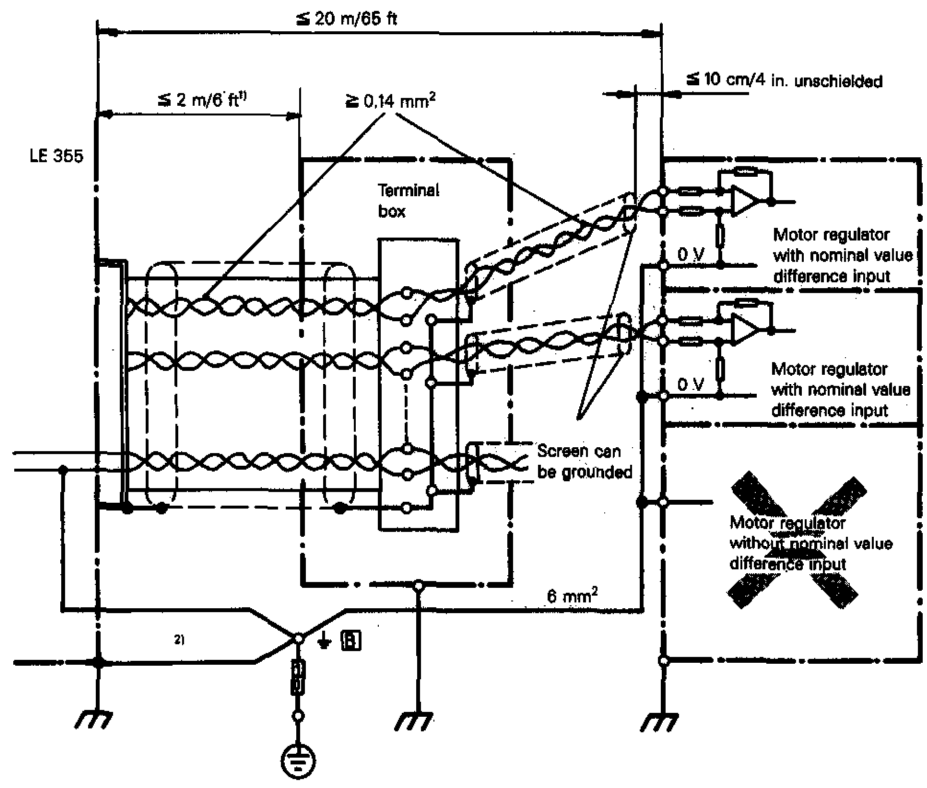
Nominal value output 0 – 9 V
max. load 2 mA
max. capacitance 4.7 nF

Cable layout and electrical protection against interference

When laying the cable, refer to the remarks on section M1 **"Electrical Interference".**

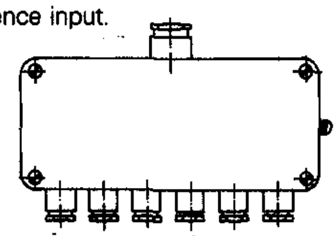
The nominal value outputs must **not have more than one intermediate terminal clamp.**
The intermediate terminal clamp must be either in the control cabinet or in a grounded metal terminal box! This is necessary if branch-offs are necessary to servo-inputs with remote location. This is the only possibility for sufficiently grounding the lines to the servos.

Intermediate terminal connections with a grounded terminal box within the interface cabinet



Caution
HEIDENHAIN recommends the connection of motor regulators with nominal value difference input.

If required, terminal boxes are available from HEIDENHAIN, Id.-Nr. 251 249 01.

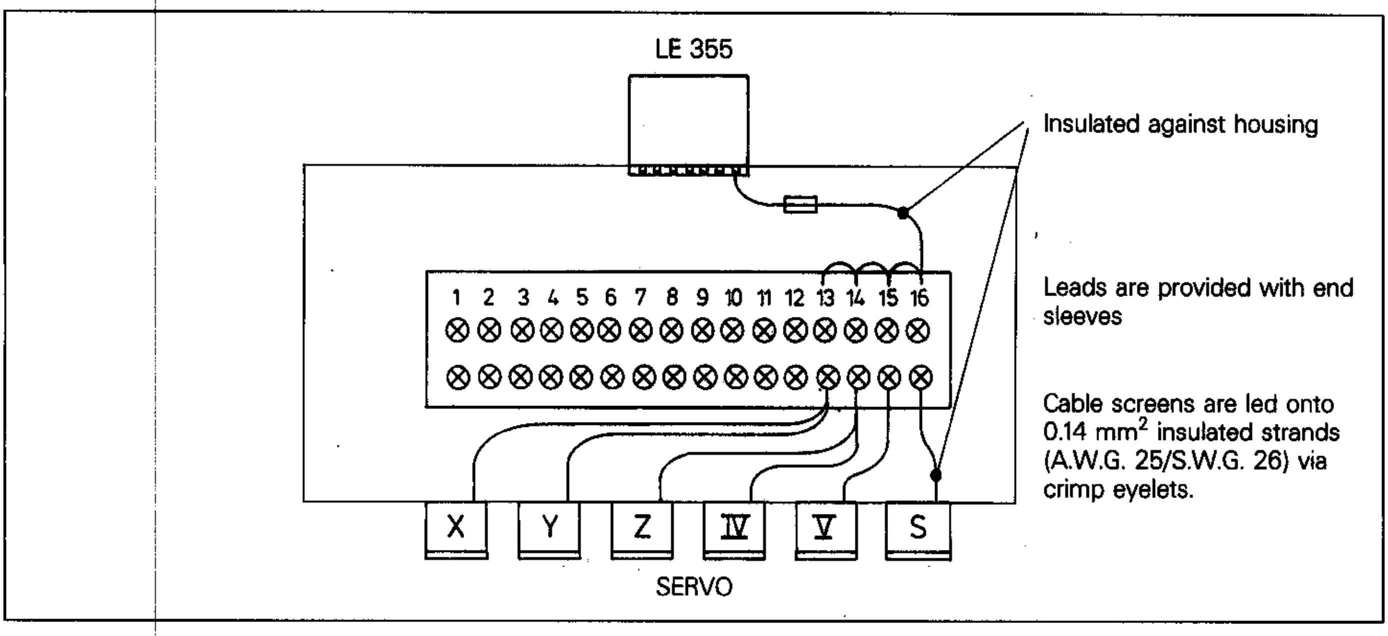


[1] Only for TNC 355 B/Q (TNC 355 F/W) with motor regulator having no nominal value difference input.

[2] The nominal value line is grounded directly at the operational ground B (not applicable to TNC 355 B/Q (F/W)).

Electrical connection of the logic unit LE 355
Connecting the nominal value outputs

Proposed configuration for connection of shields in the terminal box Id.-Nr. 25124901.



Layout:

Terminal

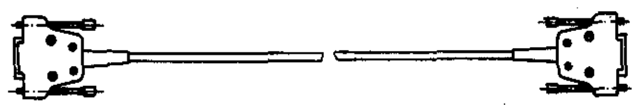
1	Analogue output	X-axis
2	Analogue output 0 V	X-axis
3	Analogue output	Y-axis
4	Analogue output 0 V	Y-axis
5	Analogue output	Z-axis
6	Analogue output 0 V	Z-axis
7	Analogue output	axis IV
8	Analogue output 0 V	axis IV
9	Analogue output	axis V
10	Analogue output 0 V	axis V
11	Analogue output	axis S
12	Analogue output 0 V	axis S
13, 14, 15, 16	Screen	

The terminal box housing is to be mounted on the machine such that a reliable electrical connection is guaranteed. The cover is likewise to be electrically connected to the terminal box housing via the two screws.

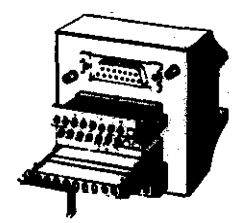
Electrical connection of the logic unit LE 355
Connecting the nominal value outputs

Cable between LE 355 and terminal box with 15-poles, female including transfer unit
This solution in only applicable if the distance between the transfer unit and the input of the servo-amplifier is not greater than 10 cm/4 in.

Id.-Nr. 244007 ..



Transfer unit
PHOENIX CONTACT Type FLKM-D 15 SUB/S Order No. 22811131
Murrelektronik Type UGSub 15 S Order No. 54031 + 2-off 54079

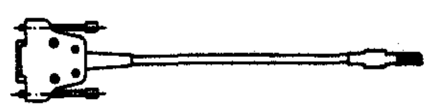


PHOENIX CONTACT
Elektrizitätsgesellschaft
Postfach 1341
4933 Blomberg/West Germany
Tel. (05235) 550
Telex: 935863
FAX: (05235) 55200

Murrelektronik
Fabrikstr. 10
7155 Oppenweiler/West Germany
Tel. (07191) 470
FAX: (07191) 4730

Cable between LE 355 and terminal box

Id.-Nr. 244006 ..



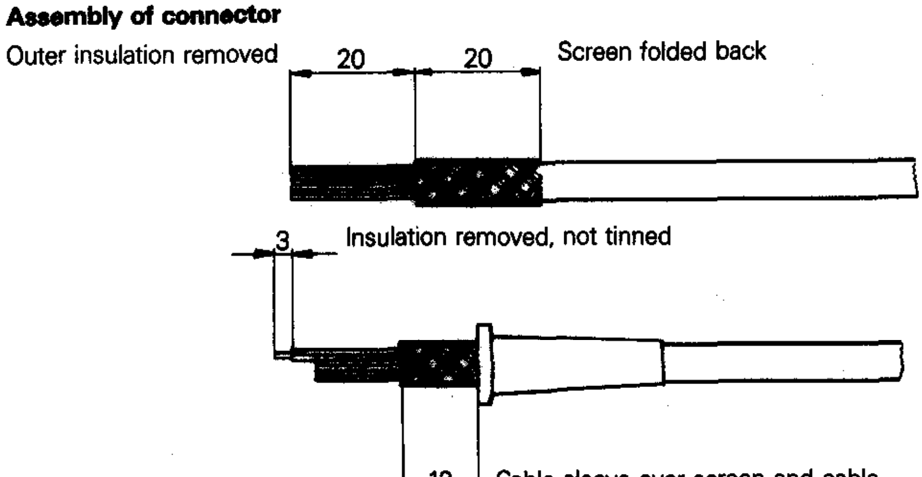
Screen is beneath rubber sleeve.
If necessary, extend with strand.

Connector, 15-pole, solder terminals
for prefabricated cable
Id.-Nr. 243971ZY

Layout, see below

Layout:
1 = brown
2 = vacant
3 = yellow
4 = red/blue
5 = pink
6 = grey/pink
7 = red
8 = violet
9 = white
10 = vacant
11 = green
12 = vacant
13 = grey
14 = blue
15 = black

Assembly of connector



Electrical connection of the logic unit LE 355
Connecting the data interface RS-232-C/V.24

Cable layout and electrical protection against interference

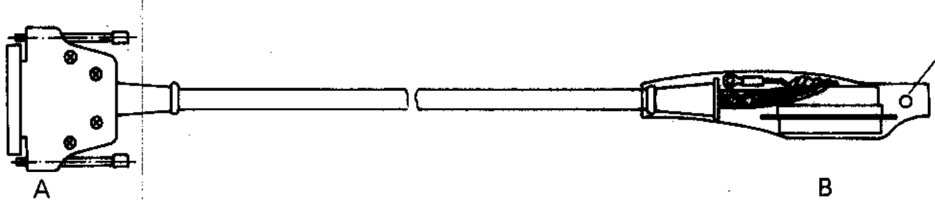
Use only **HEIDENHAIN cables and adapters.**

With proper connection we guarantee trouble-free **data transmission up to 20 m/65 ft** between the LE 355 and the peripheral unit.

Grounding, see diagram on sheet M8/1.

If a HEIDENHAIN external RS-232-C-data transmission cable Id.-Nr. 242 869 01 with 3 m/10 ft is being used, the internal RS-232-C/V.24 transmission cable may have a max. length of 17 m/55 ft.

Cable between LE 355 and RS-232-C/V.24 adapter
Id.-Nr. 239 760 ..



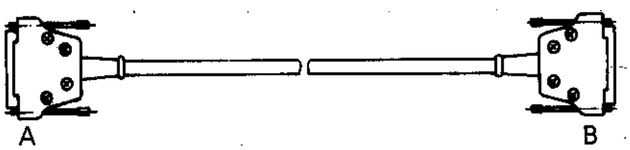
Lug for drawing-in the cable. The connector housing is supplied in a separate bag and is assembled after the cable has been installed.

Layout for cables Id.-Nr. 239 760 ..
and Id.-Nr. 242 869 01

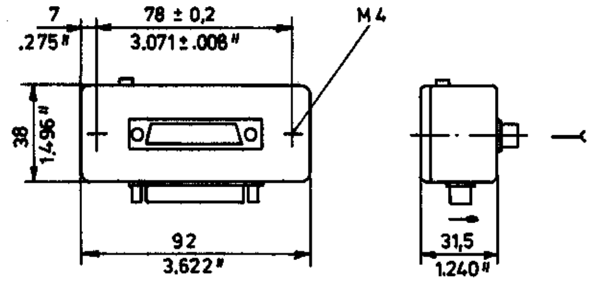
Location A	Location B	Colour
Pin	Pin	
1	1	white/brown
3	2	yellow
2	3	green
5	4	pink
4	5	grey
20	6	brown
6	20	blue
7	7	red

In the RS-232-C/V.24 adapter the pins of the sockets are connected one-to-one.

Cable VB, V.24
RS-232-C-connection to peripheral units, 3 m/10 ft long
Id.-Nr. 242 869 01



RS-232-C/V.24 adapter
Id.-Nr. 239 758 01



Electrical connection of the logic unit LE 355
Connecting the PLC-inputs and outputs

Cable layout

To connect the PLC-input/outputs to the LE 355, use one of the following cables (see sheet M3/10):

Permissible cable length: **≤ 20 m/65 ft,** with cross-section of core **≥ 0.14 mm² Cu.**

The connecting terminals of the PLC-input/outputs of the PLC board **PL 300** are individually wired.
Permissible cable length: **≤ 20 m/65 ft,** with cross-section **≥ 0.5 mm² Cu.**

Electrical protection against interference

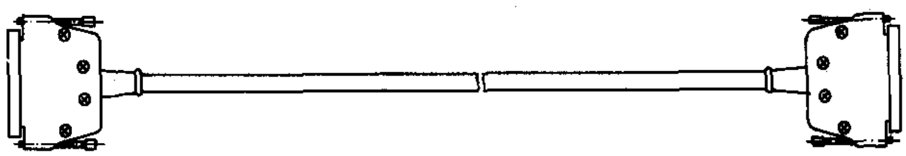
Minimum distance between the LE 355 and PL 300 to **interference-producing equipment ≥ 20 cm/8 inches, to interference-producing cables ≥ 10 cm/4 inches,** see also section M1 **"Electrical interference".**

Please note:
.The effect of sources of interference (e.g. breakers, relays, solenoid valves, etc.) can be significantly reduced through an interference rejection circuit.
.All inductors, breakers, solenoid valves etc. in and outside of the control cabinet – even those that are not used or triggered by the LE 355 or PL 300 – must be provided with an interference rejection circuit (e.g. a quenching diode).
Refer to the manufacturer's specifications when using an interference rejection circuit!

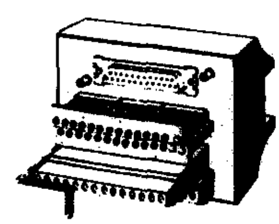
Grounding
.The **0 V-line** of the control voltage for the **PLC-input/outputs** of the LE 355 and PL 300 **must** be electrically connected to **the common grounding point of the machine** (= operating ground ⏚ B)!
Ground wire cross-section: **≥ 6 mm²** (see grounding diagram, sheet M8/1).

Electrical connection of the logic unit LE 355
Connecting the PLC-inputs and outputs

Cable between LE 355 and terminal box with 37 poles, female
Id.-Nr. 244017 . .



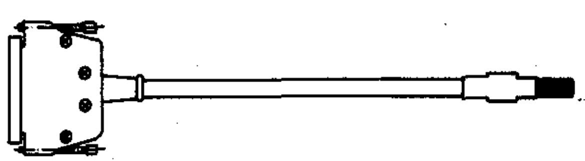
Recommended transfer unit from:
PHOENIX CONTACT Type FLKM-D 37 SUB/S Order No. 2281115
Murrelektronik Type UGSub 37 S Order No. 54096 + 2-off 54079



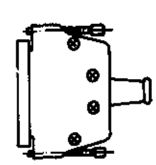
PHOENIX CONTACT
Elektrizitätsgesellschaft
Postfach 1341
4933 Blomberg
West Germany
Tel. (05235) 550
Telex: 935863
FAX: (05235) 55200

Murrelektronik
Fabrikstr. 10
7155 Oppenweiler
West Germany
Tel. (07191) 470
FAX (07191) 4730

Cable between LE 355 and terminal box
Id.-Nr. 244005 . .

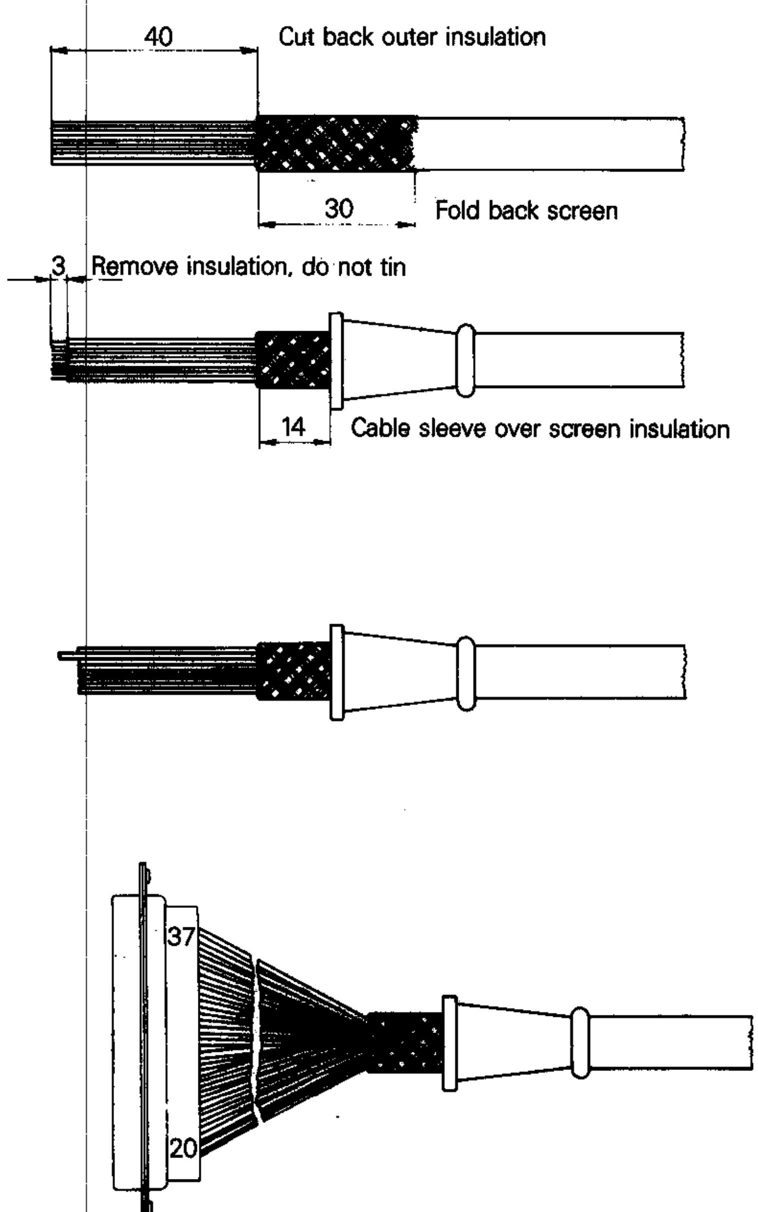


Connector, 37-pole, solder terminals,
for prefabricated cable
Id.-Nr. 243937ZY



Assembly, see next sheet

Electrical connection of the logic unit LE 355
Connecting the PLC-inputs and outputs



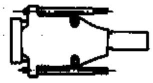
Layout:

1 = grey/red
2 = brown/black
3 = white/black
4 = green/black
5 = brown/red
6 = white/red
7 = white/green
8 = red/blue
9 = yellow/red
10 = grey/pink
11 = black
12 = pink/brown
13 = yellow/blue
14 = green/blue
15 = yellow
16 = red
17 = grey
18 = blue
19 = pink
20 = white/grey
21 = yellow/grey
22 = green/red
23 = white/pink
24 = grey/green
25 = yellow/brown
26 = grey/brown
27 = yellow/black
28 = white/yellow
29 = grey/blue
30 = pink/blue
31 = pink/red
32 = brown/blue
33 = pink/green
34 = brown
35 = yellow/pink
36 = violet
37 = white

Electrical connection of the logic unit LE 355
Inputs for reference pulse inhibitors

A 9-pole plug connector can be supplied by HEIDENHAIN for the connection of the reference pulse inhibitor.

Connector, 9-pole
Id.-Nr. 244503ZY



Electrical connection of the logic unit LE 355
Connecting the TNC-keyboard unit TE 355 and the machine operating panel

Cable layout and electrical protection against interference

Use only the **HEIDENHAIN cable Id.-Nr. 239759..** to connect the TE 355 to the LE 355.

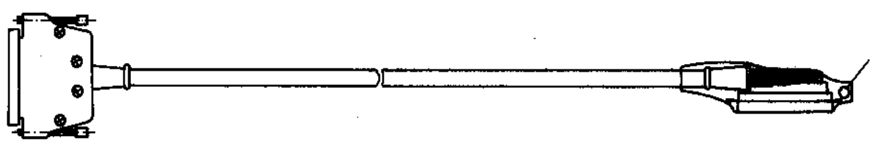
Please note:
.Maintain necessary free space **for access to connections** in the event of service.
.**Permissible cable bending radius: r ≧ 50 mm/2 inches.**

Screening and **grounding** must be executed as per the grounding diagram on sheet M8/1.

The machine operating panel can be connected to the LE 355 either directly or via the TNC-keyboard unit (TE 355).

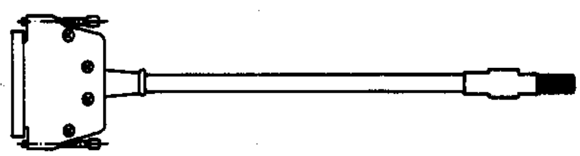
HEIDENHAIN recommends the following cables and also offers a connector, should the operator be compelled to manufacture his own cable.

Cable between LE 355 and TNC-keyboard unit or machine operating panel
Id.-Nr. 239759 ..



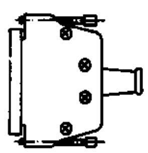
Lug for drawing-in cable. The connector housing is supplied in a separate bag and is assembled after the cable has been installed.

Cable between LE 355 and machine operating panel
Id.-Nr. 244005 ..



see assembly instructions sheet M3/11 for layout

Connector, 37-pole
Id.-Nr. 243937ZY



see assembly instructions sheet M3/11

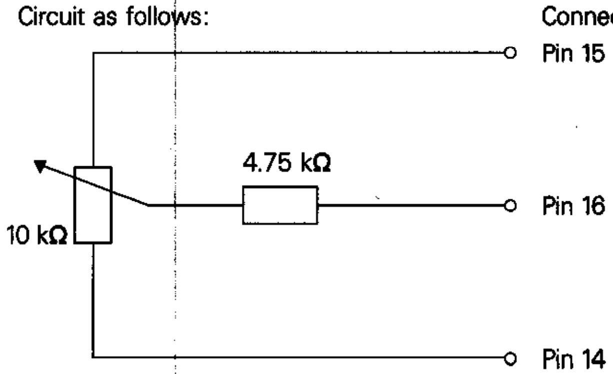
max. cable length 20 m/65 ft

Plug connection for machine transportation
For large-sized machines, a plug connection is advantageous within the cable between the LE and operating panel. Due to interference, however, only one separation is permitted with the TE. The additional cable can be supplied as an extension cable: Extension cable, 37-pole, Id.-Nr. 244505 ..

Connection of an external feed potentiometer
Instead of the integral feed potentiometer on the TE 355, an external potentiometer may also be connected. If an external potentiometer in being installed, the feed potentiometer on the TE 355 must be disconnected.

Circuit as follows:

Connector X1 on TE 355



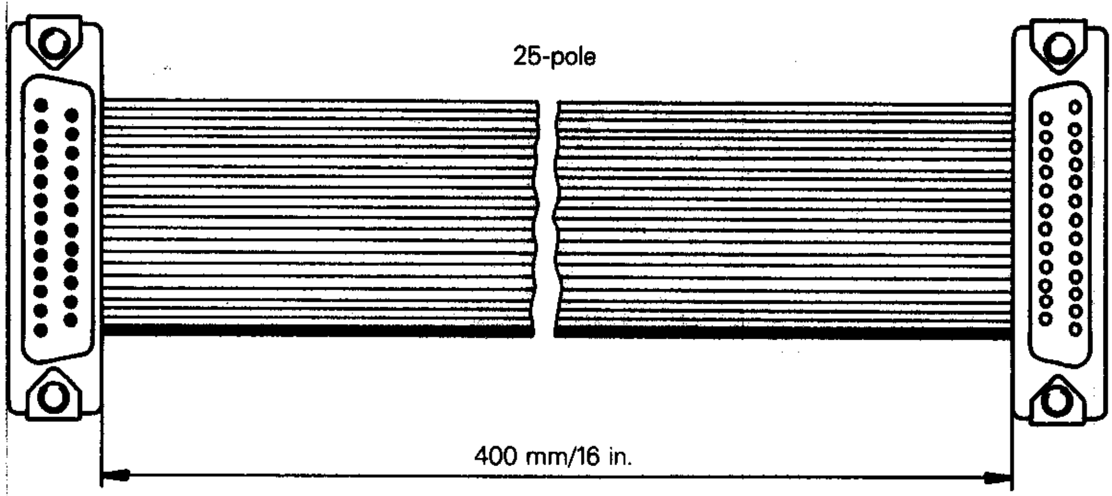
The 4.75 kΩ resistor is used for current limitation in the event that the connectors for the keyboard unit and machine operating panel are interchanged.

Electrical connection of the logic unit LE 355
Connecting the TNC-keyboard unit TE 355 and the machine operating panel

Connecting cable TNC-keyboard – Machine operating panel

If no PLC-outputs are required and 16 PLC-inputs are adequate, the machine operating panel can be connected to the LE 355 via a short cable which extends to the TNC-keyboard unit.
HEIDENHAIN offers a universal machine operating panel.

Ribbon cable between TNC-keyboard unit and HEIDENHAIN Machine operating panel
Id.-Nr. 242 894 01



Installing the visual display unit BE 412 B

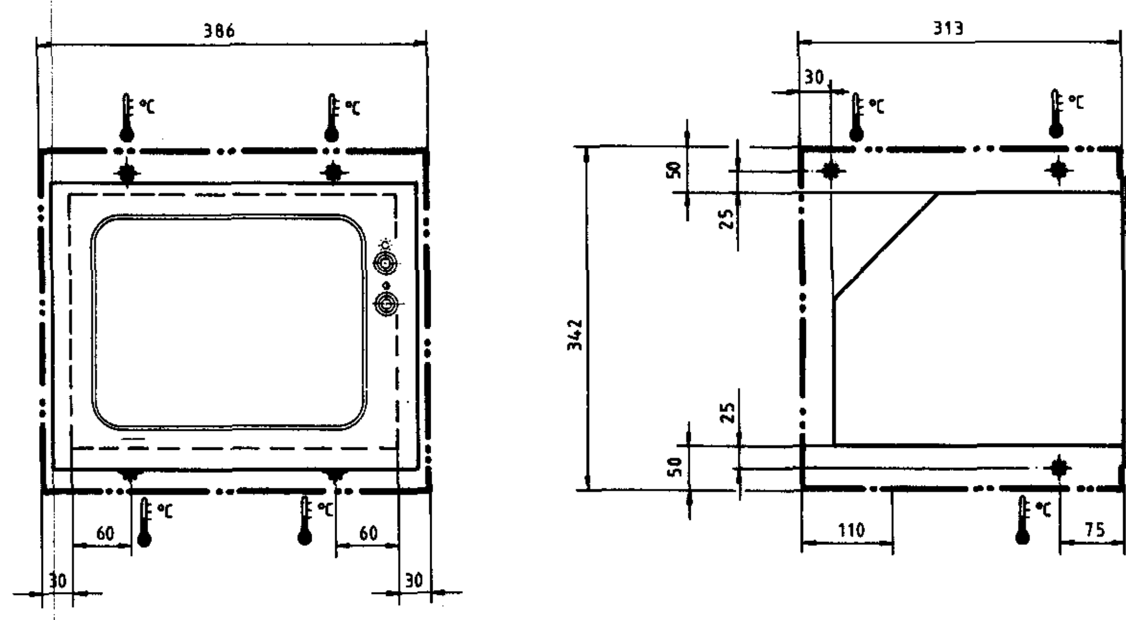
Refer to temperature and air humidity requirements in section M1.

Electrical protection against interference

When installing the visual display unit, remember that it is sensitive to **stray magnetic pickup.** The position and geometry of the picture can be impaired by magnetic interference fields. **Alternating fields** lead to periodic dislocations or distortions of the picture.
Maintain a **minimum clearance of 0.5 m/20 inches** between the BE 412 B housing and the source of interference (e. g. permanent magnets, motors, transformers, etc.).

Use only the **HEIDENHAIN connecting cable** to connect the BE 412 B to the LE 355.

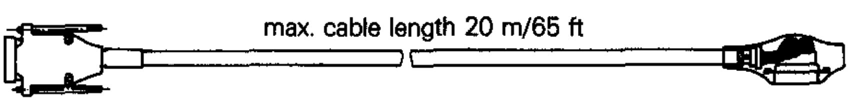
For **shielding and grounding,** see grounding diagram sheet M8/1.



Measuring point for ambient temperature

Free space for air circulation

Cable between LE 355 and BE 412 B
Id.-Nr. 242874 ..



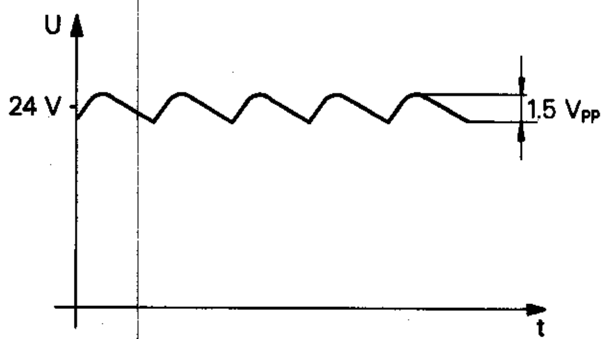
Lug for drawing-in the cable. The connector housing is supplied in a separate bag and is assembled after the cable has been installed.

Plug connection for machine transportation

With large-sized machines, this cable connection can be supplied with a separation point.
An extension cable can be ordered from HEIDENHAIN:
Extension cable, 15-pole, Id.-Nr. 244504 ..

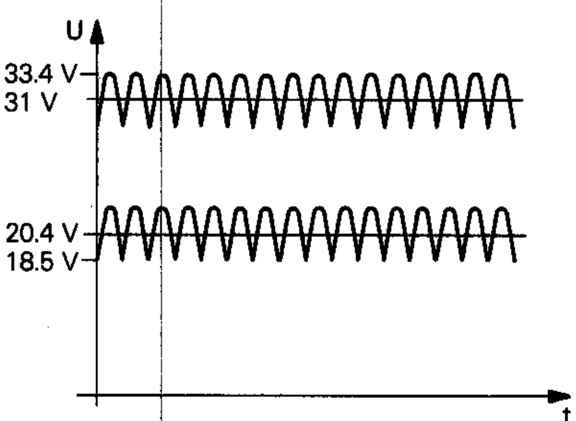
Power supply
Logic unit LE 355 and PL 300

The LE 355 must not be supplied by the machine control voltage! The LE 355 needs its own, external, separately generated supply voltage to VDE 0551. 24 V DC-voltage with a permissible oscillated AC-component of 1.5 V_{PP} (recommended filter capacitor 10000 μF/40 V–).



The **PLC-part** (PLC-inputs and outputs of the LE 355 and PL 300) is operated on the **24 V control voltage of the machine** which is generated according to VDE 0550.

Superimposed oscillated AC components which derive from an uncontrolled three-phase non-filtered bridge circuit with a ripple factor (see DIN 40110/10.75, Section 1.2) of 5 % are permitted. This results in a maximum absolute value of 33.4 V for the upper voltage limit and a minimum absolute value of 18.5 V for the lower limit.



The **0 V-lines** of the two power sources must be **connected together ($\varnothing \geq 6$ mm^2)** and to the **central operating ground of the machine** (⏚ $\boxed{B}$) via an earth ground **($\varnothing \geq 6$ mm^2).**

The voltages must comply with the definitions given below:

<table>
<tr><th>Unit</th><th></th><th>Supply voltage</th><th>Voltage range
Average DC voltage</th><th>Max. current consumption</th><th>Power consumption</th></tr>
<tr><td rowspan="2">LE 355</td><td>NC</td><td>24 V
(VDE 0551)</td><td rowspan="3">Lower limit
20.4 V ⎓

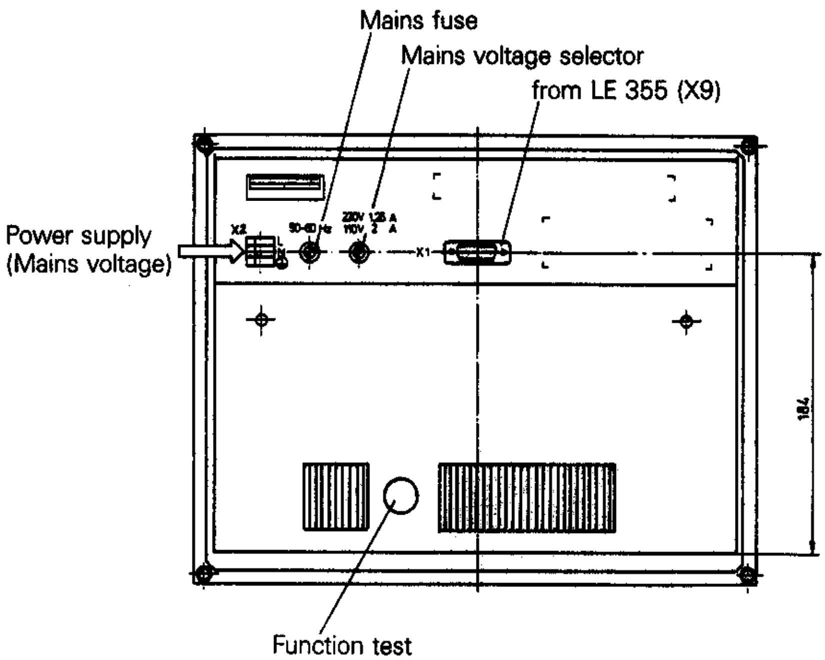
Upper limit
31 V ⎓[1)]</td><td>1.5 A</td><td>approx. 30 W</td></tr>
<tr><td>PLC</td><td rowspan="2">24 V
(VDE 0550)</td><td>1.8 A
if half of the inputs and outputs are driven simultaneously</td><td>approx. 6 W
if approx. 1/3 of the inputs and outputs are driven simultaneously</td></tr>
<tr><td>PL 300</td><td></td><td>21 A
if half of the inputs and outputs are driven simultaneously</td><td>approx. 25 W
if approx. 1/3 of the inputs and outputs are driven simultaneously</td></tr>
</table>

[1)] Voltage increases up to 36 V ⎓ for t < 100 ms are permissible.

Power supply
Visual display unit BE 412 B

The visual display unit BE 412 B is supplied by an AC mains voltage. The operating voltage can be set from two ranges via the voltage selector. Before connecting the VDU, check the voltage selected and the mains fuse rating.

Supply voltage	Voltage range	Frequency range	Power consumption	Mains fuse
110 V~	85 V~ – 132 V~	48 ... 62 Hz	approx. 40 W	M 2 A
220 V~	170 V~ – 264 V~			M 1.25 A



Designation of units

The following possibilities are available for the designation of the units with numbers (e.g. A...):

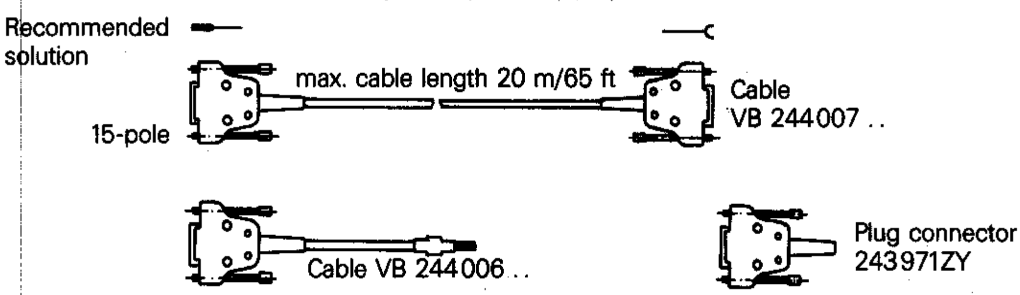
- TNC-keyboard unit: Script field on PCB;
- Sheet metal housings: Hole pattern for plug-in label SS2 of Messrs. Lütze.

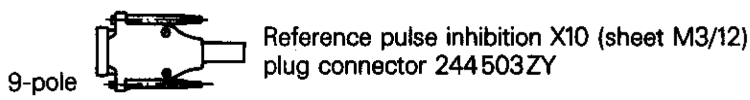
Address:

Friedrich Lütze GmbH & Co.
Bruckwiesenstraße 17–19
Postfach 1224
D-7056 Weinstadt-Grossheppach/West Germany
Tel. 07151/6053-0
Telex 724339

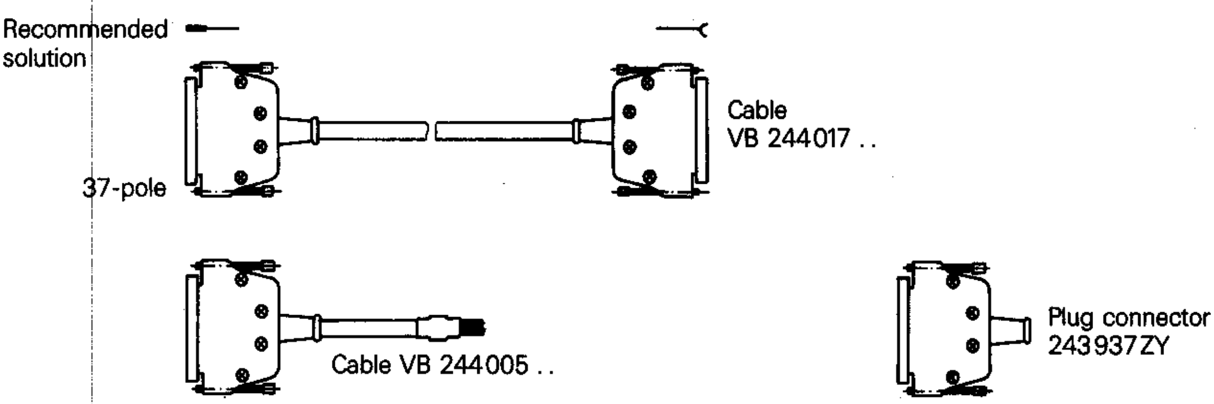
Overview of cables

Nominal value output X8 (sheet M3/10)

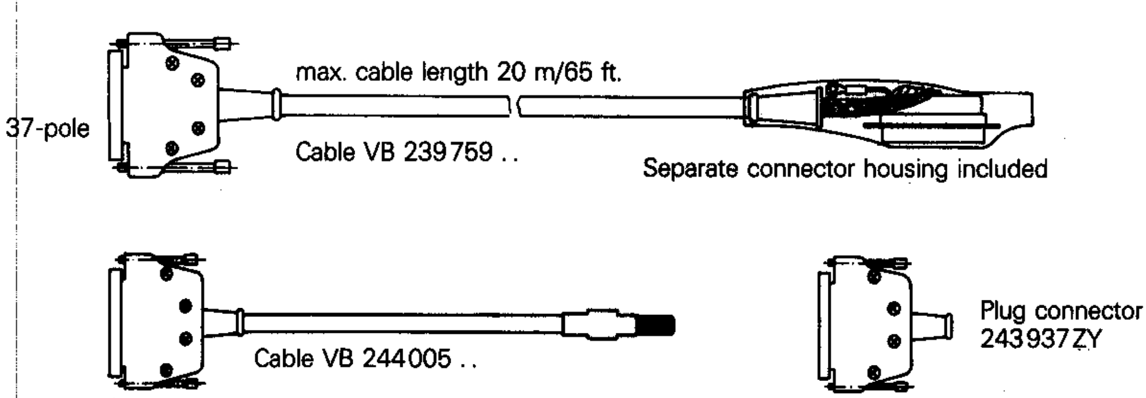




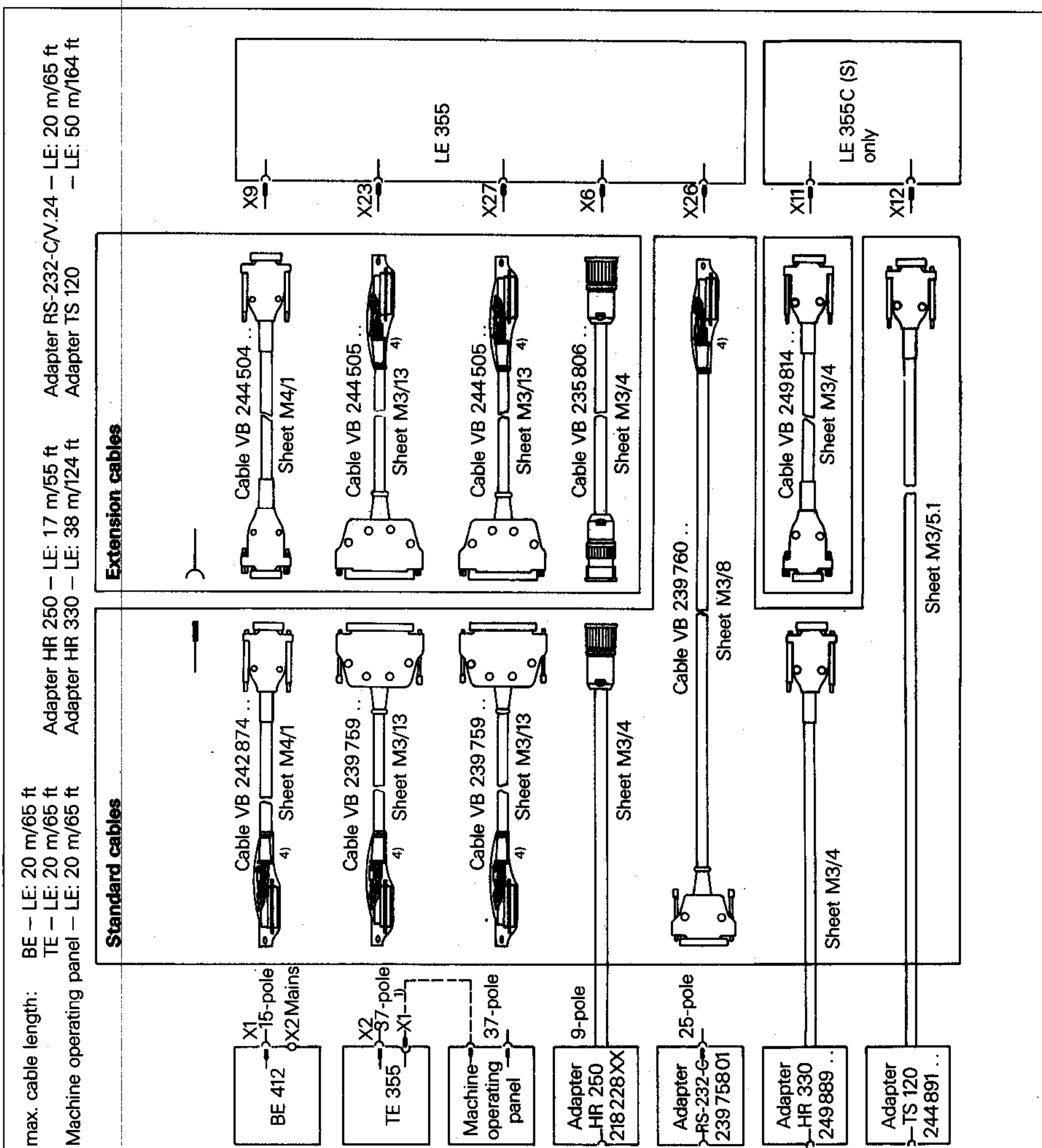
PLC In-Output X21, X22 (sheet M3/9)



Machine operating panel, X27 (sheet M3/13)
TNC-keyboard cable TE 355, X23



Overview of cables



1) If required, the machine operating panel may be connected via the TE 355; Connecting cable see sheet M3/14.

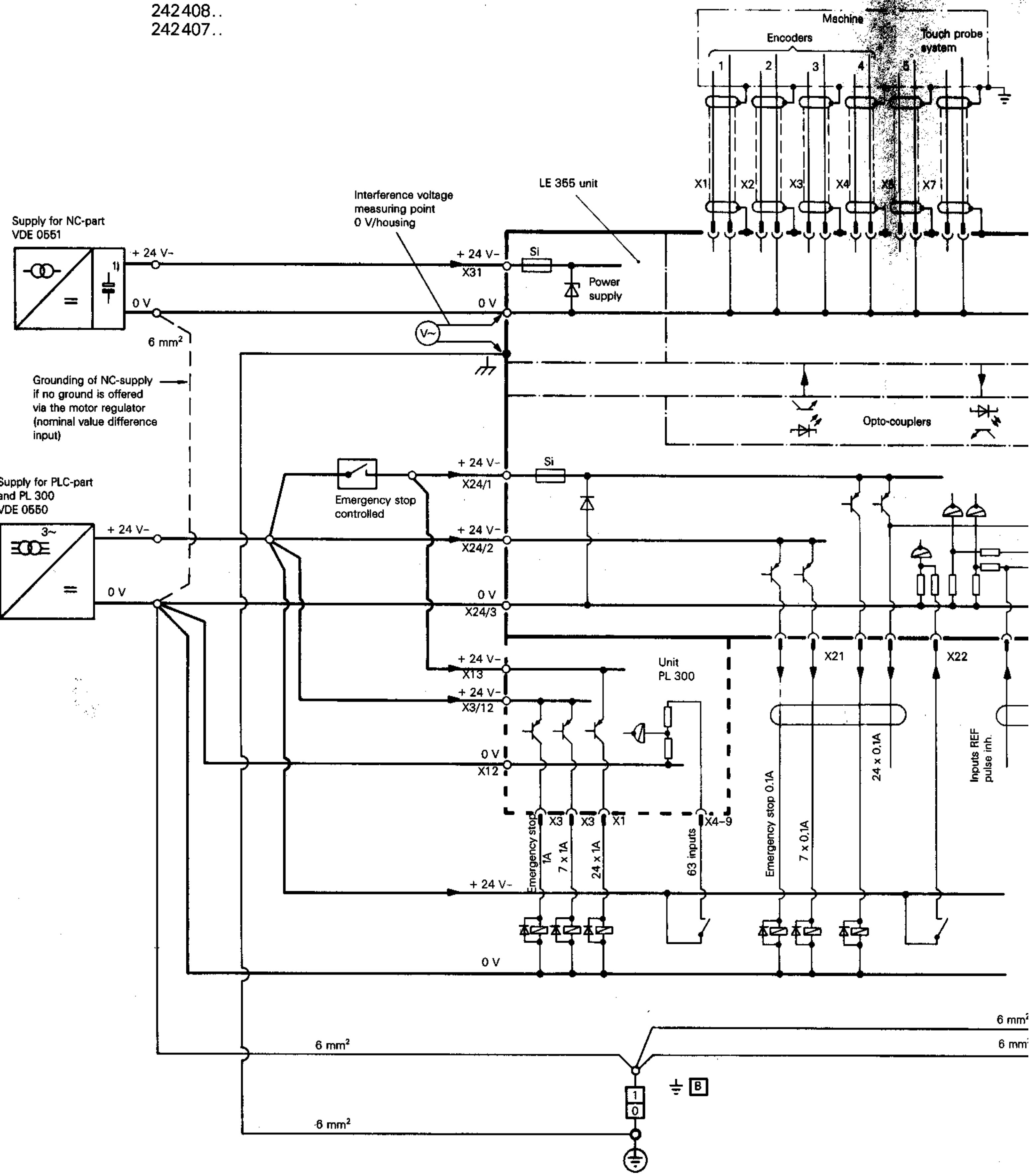
2) RS-232-C/V.24-connection to peripheral units 3 m/10 ft long Id.-Nr. 242869 01 (sheet M3/8)

3) Instead of the HR adapter the flush-mounted handwheel HR 150 or HR 130 can be connected (sheet M3/4)

4) Separate connector housing included.

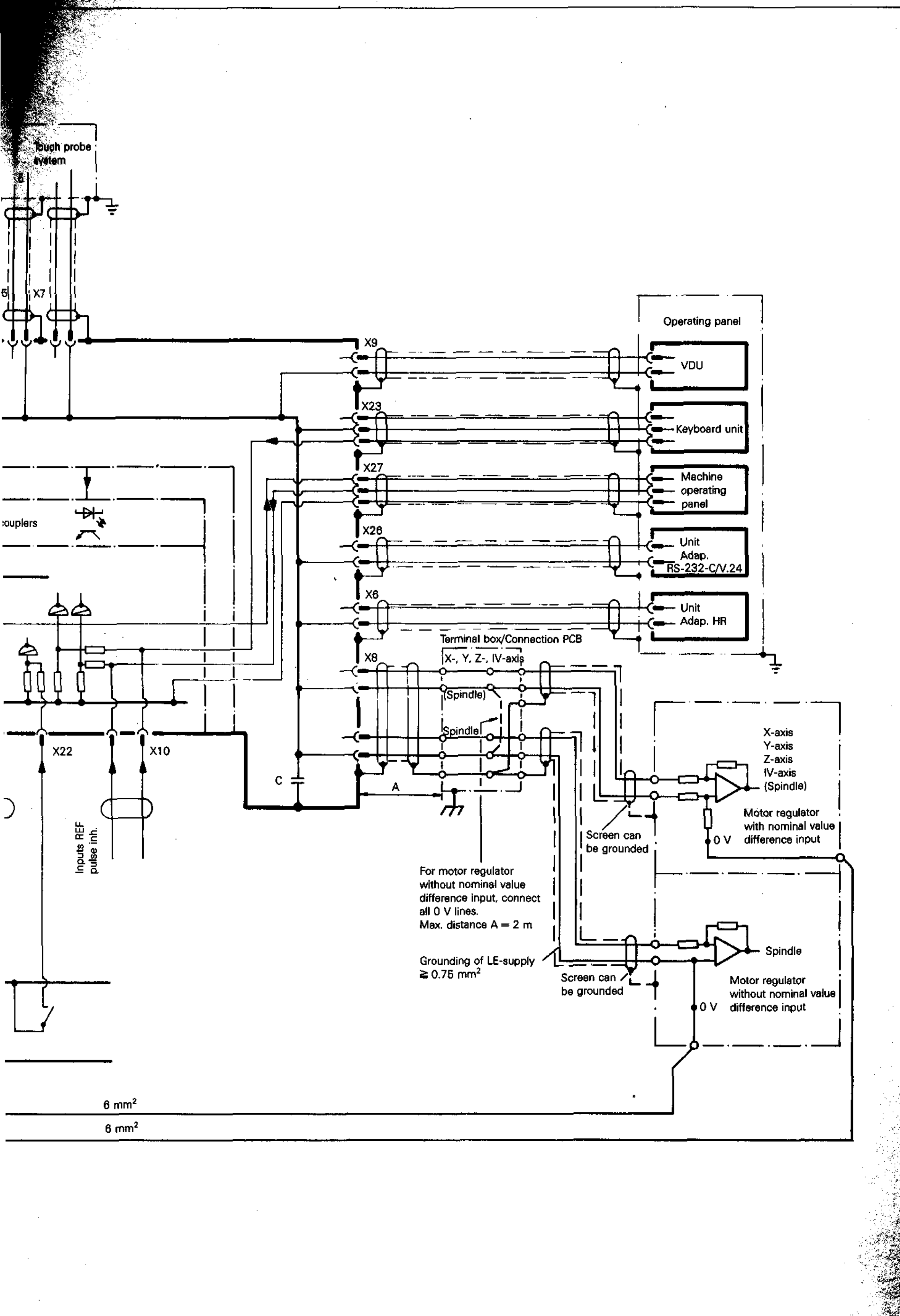
rounding diagram TNC 355 B (Q)

355 B (Q) with Id.-Nr. 237660..
238324..
242408..
242407..



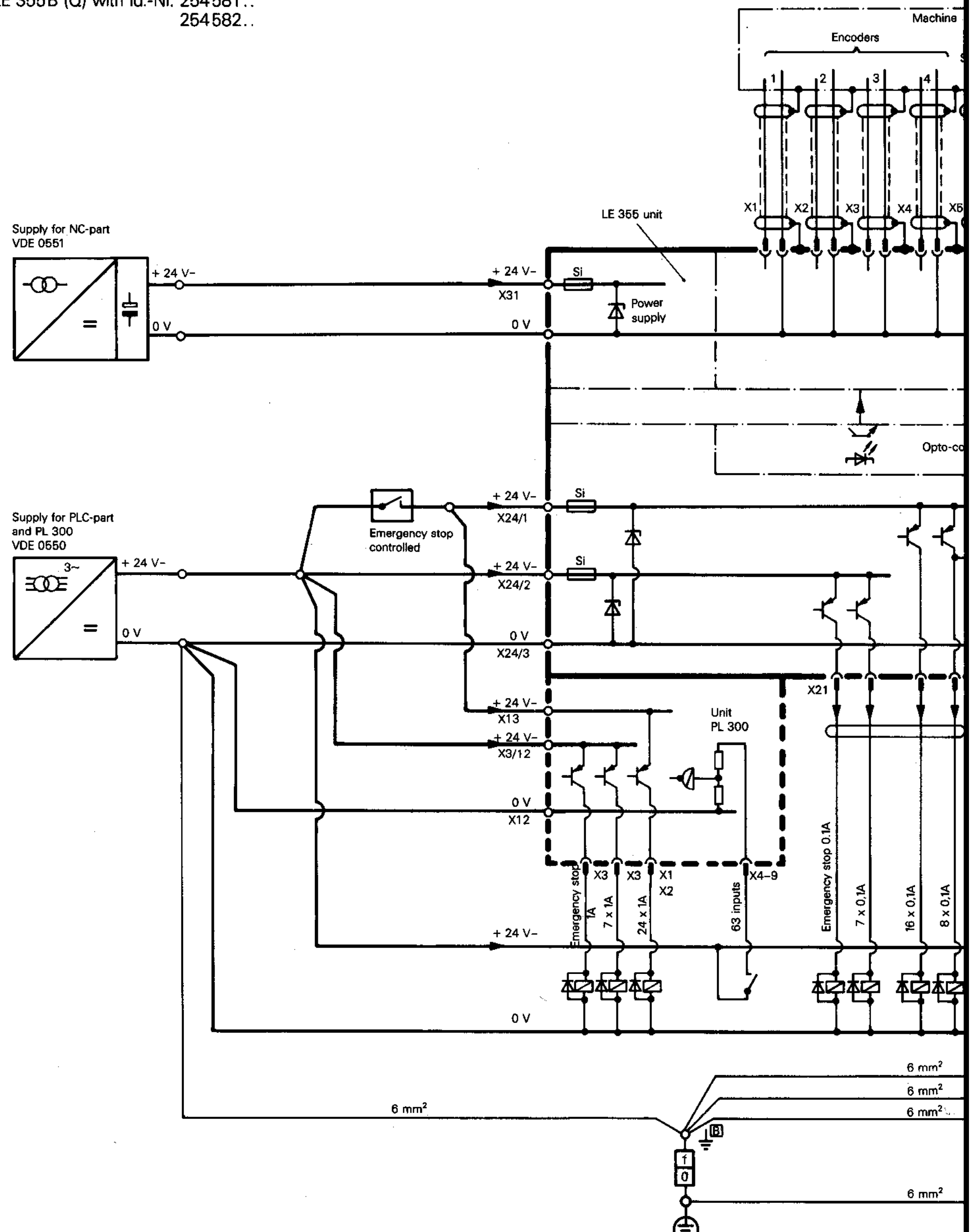
1) HEIDENHAIN recommends a capacitor with 10 000 µF.

Is
Febru

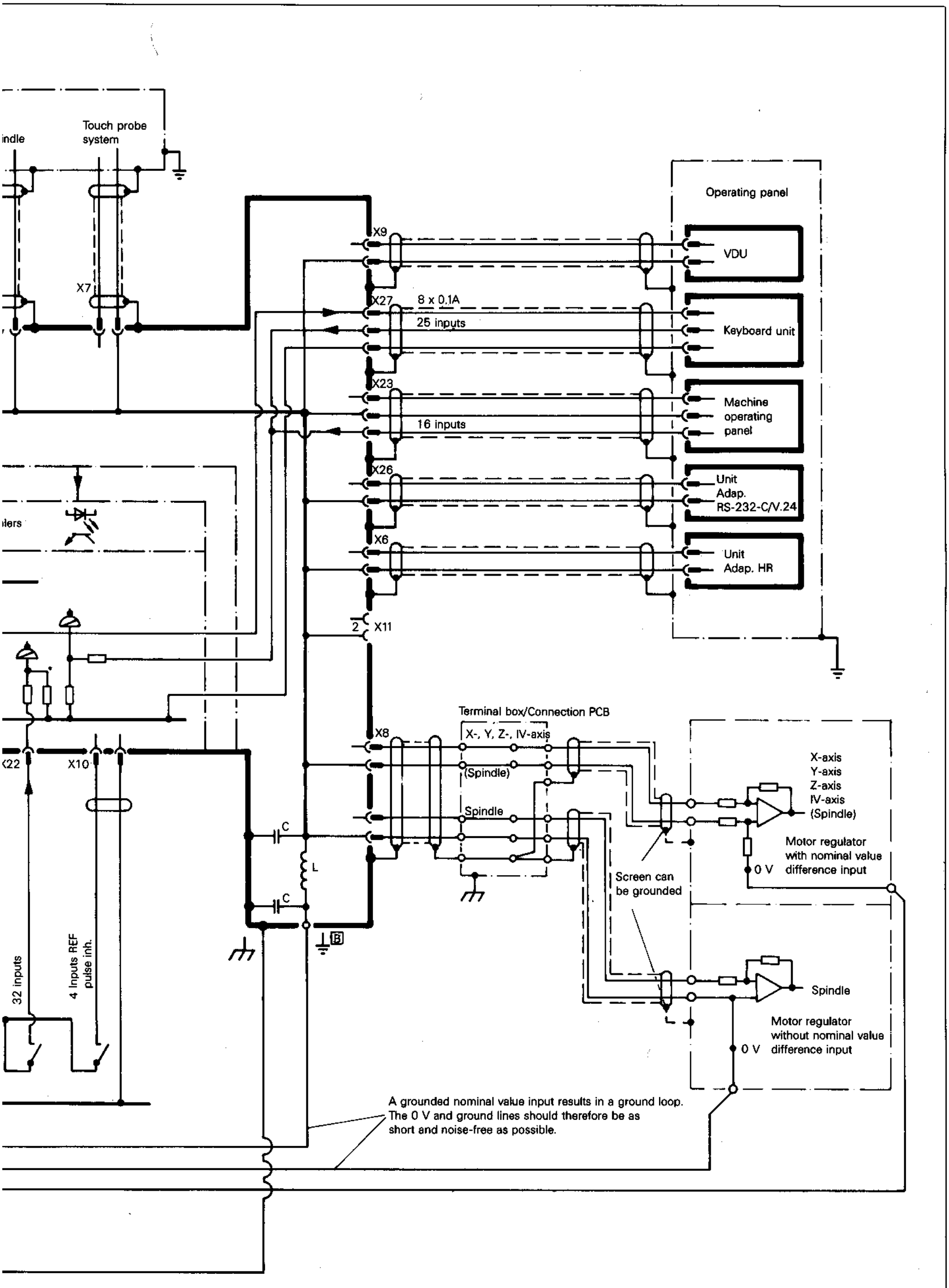

Touch probe system
X7
Operating panel
X9
VDU
X23
Keyboard unit
X27
Machine operating panel
X26
Unit Adap. RS-232-C/V.24
X6
Unit Adap. HR
Terminal box/Connection PCB
X8
X-, Y, Z-, IV-axis
(Spindle)
Spindle
:ouplers
X22
X10
C
A
Inputs REF pulse inh.
X-axis
Y-axis
Z-axis
IV-axis
(Spindle)
Motor regulator with nominal value difference input
0 V
Screen can be grounded
For motor regulator without nominal value difference input, connect all 0 V lines.
Max. distance A = 2 m
Grounding of LE-supply ≧ 0.75 mm²
Spindle
Motor regulator without nominal value difference input
6 mm²
6 mm²

Grounding diagram TNC 355 B (Q)

LE 355B (Q) with Id.-Nr. 254581..
254582..

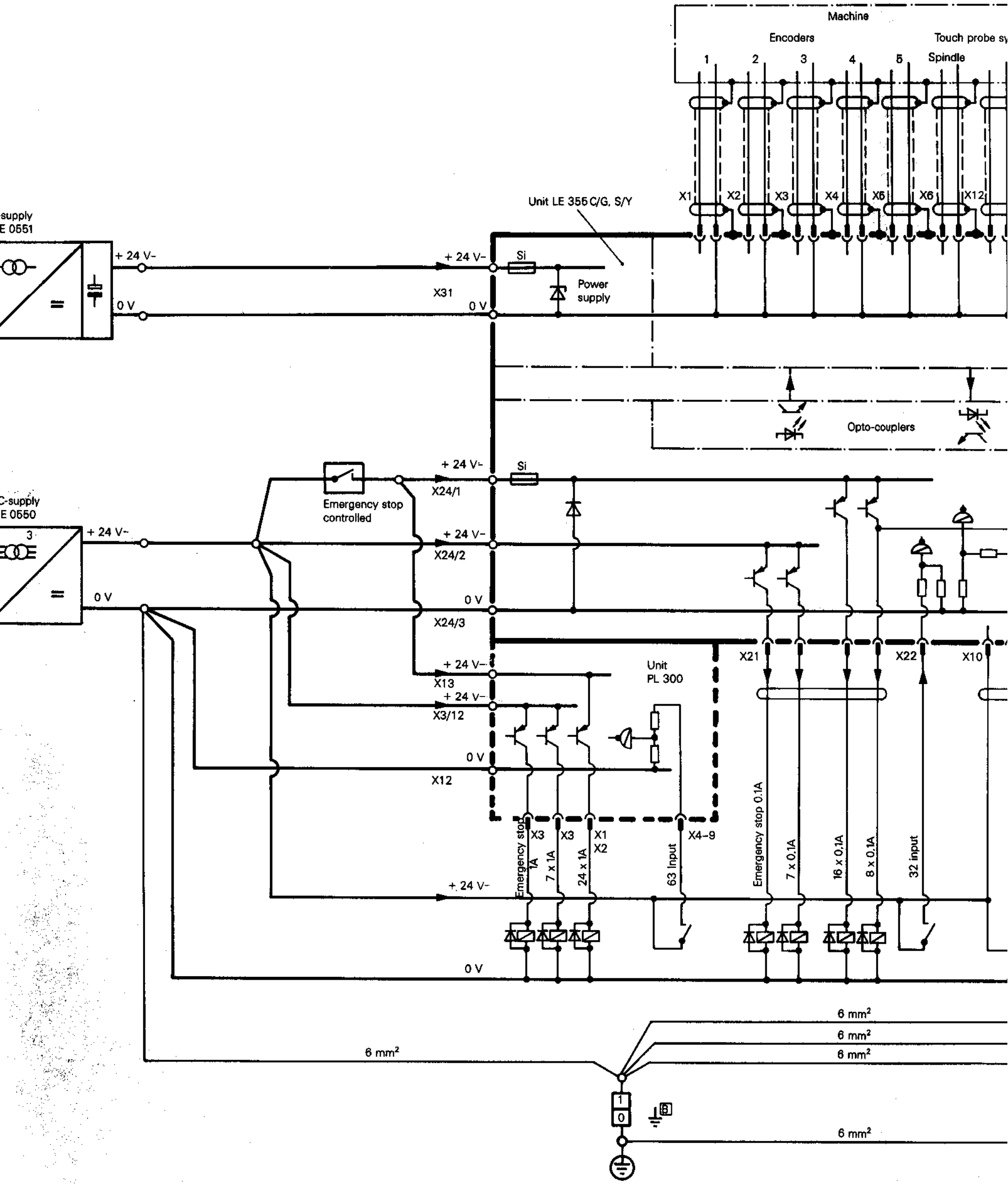


[1] HEIDENHAIN recommends a capacitor with 10 000 µF.

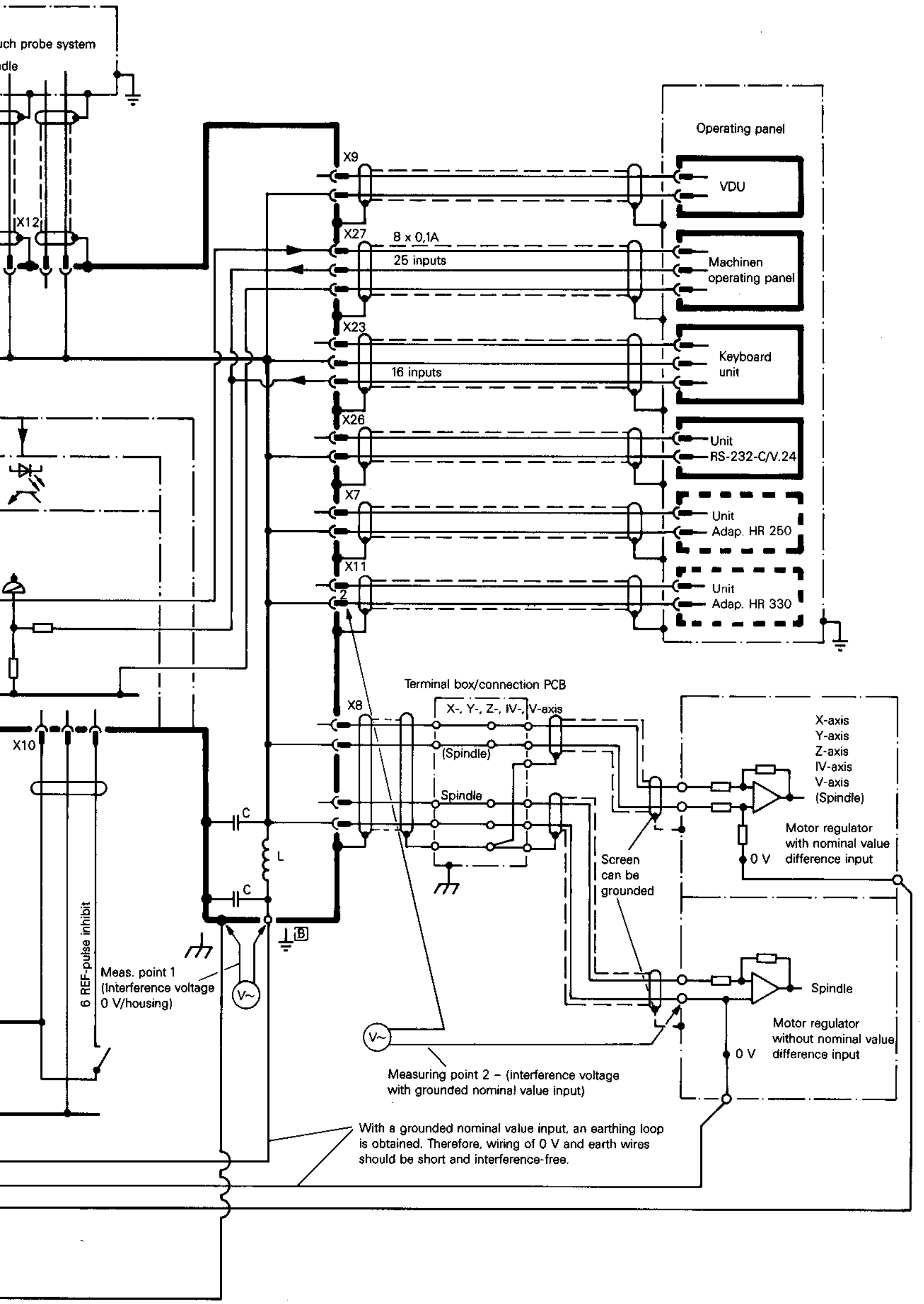


indle
Touch probe system
X7
X9
X27
8 x 0.1A
25 inputs
X23
16 inputs
X26
X6
X11
X8
X22
X10
Operating panel
VDU
Keyboard unit
Machine operating panel
Unit Adap. RS-232-C/V.24
Unit Adap. HR
llers
Terminal box/Connection PCB
X-, Y, Z-, IV-axis
(Spindle)
Spindle
C
L
X-axis
Y-axis
Z-axis
IV-axis
(Spindle)
Motor regulator with nominal value difference input
0 V
Screen can be grounded
Spindle
Motor regulator without nominal value difference input
32 inputs
4 Inputs REF pulse inh.
A grounded nominal value input results in a ground loop. The 0 V and ground lines should therefore be as short and noise-free as possible.

rounding diagram TNC 355 C (S)



Febru



uch probe system
dle
X12
X10
Operating panel
X9
VDU
X27
8 x 0,1A
25 inputs
Machinen operating panel
X23
16 inputs
Keyboard unit
X26
Unit RS-232-C/V.24
X7
Unit Adap. HR 250
X11
Unit Adap. HR 330
Terminal box/connection PCB
X8
X-, Y-, Z-, IV-, V-axis
(Spindle)
Spindle
X-axis
Y-axis
Z-axis
IV-axis
V-axis
(Spindle)
Motor regulator with nominal value difference input
0 V
Screen can be grounded
Spindle
Motor regulator without nominal value difference input
0 V
C
L
C
B
6 REF-pulse inhibit
Meas. point 1 (Interference voltage 0 V/housing)
V~
V~
Measuring point 2 – (interference voltage with grounded nominal value input)
With a grounded nominal value input, an earthing loop is obtained. Therefore, wiring of 0 V and earth wires should be short and interference-free.

Contents

Contents

Contents

Machine parameters
General

Machine parameters
In order that the machine can correctly execute programmed instructions the control must know specific machine data, e.g. traverses, accelerations etc.
These data are determined by the machine manufacturer and entered into the control via machine parameters.

Moreover, certain functions which can be made possible with the TNC, but are only characteristic of specific machine types, can be activated via machine parameters e.g. an automatic toolchanger.

User-parameters
In the MOD-function "User-parameters" certain machine parameters can be easily accessed, e.g. to change over from HEIDENHAIN plain language to ISO. The user-parameters being accessible via the MOD-function are determined by the machine tool manufacturer. See description sheet C1/28.

Edit protection for machine parameters
Certain machine parameters may not or can only be altered by the machine manufacturer.
Therefore, access to machine parameters is controlled by a code number.
The entry of the code number may also be inhibited by the machine manufacturer, by using the PLC-marker 2062 and a key-operated switch (sheet P3/7).

Entry values
Entry values are e.g. numbers 0 or 1 for the selection of functions, signs or counting direction and numerical values for feeds, traverses, etc.

Furthermore, there are summated entry values which are calculated through the combination of several functions (multiple functions, see next page).

Machine parameters
General

Entry values for multiple functions of machine parameters

Max. 8 functions can be activated by bit 0–7. The entry value results from the sum of the decimal numerical values of the bits for the functions requested.

Bit 0–7	7	6	5	4	3	2	1	0
Value	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Decimal numerical value	128	64	32	16	8	4	2	1

Example: Determination of entry values for machine parameter 92

Function	Parameter No.	Entry values		Page
Parameter with multiple function	92 Bit			
Decimal character	0	+ 0 ≙ Decimal comma + 1 ≙ Decimal point		
Dialogue	1	+ 0 ≙ First dialogue + 2 ≙ Second dialogue (English)		
Memory test when switching-on	2	+ 0 ≙ Perform memory test + 4 ≙ No memory test		
Checksum test when switching-on	3	+ 0 ≙ Perform checksum test + 8 ≙ No checksum test		
Change from program run single block to program run full sequence when machining continuous contours	4	+ 0 ≙ The precalculated contour is executed (up to 14 blocks) + 16 ≙ Interruption at current block		
Counting mode if axis IV operates as position display for a rotary axis	5	+ 0 ≙ Axis IV counts 0 … 29 999,999 [°] + 32 ≙ Axis IV counts 0 … 359,999 [°] → 0		

The entry value for MP 92 is determined by adding the entry values of the required functions.
E.g. the following functions are required:

Function	Bit	Entry values
Decimal point	0	+ 1
First dialogue language	1	+ 0
No memory test when switching-on	2	+ 4
No checksum test when switching-on	3	+ 8
Interruption of current block when changing over from program run single block to program run full sequence	4	+ 16
Axis IV counts: 0 … 359,999° → 0	5	+ 32
Sum of entry values:		61

If 61 is entered for MP 92 the above functions are activated.

Function		Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Rapid traverse	X Y Z IV	0 1 2 3	80[1] ... 29998[05] [mm/min] Rotary axis: 80[1] ... 29998[05] [°/min]			C2/3
Manuel feed	X Y Z IV	4 5 6 7	80 ... 29998[05] [mm/min] Rotary axis: 80 ... 29998[05] [°/min]			C2/3
Speed when approaching reference marks	X Y Z IV	8 9 10 11				T5/1
Signal evaluation, input	X1 X2 X3 X4	12 13 14 15	1 ≙ 4-fold (max. traversing speed 30 [m/min]) 2 ≙ 2-fold (max. traversing speed 15 [m/min])	1 1 1 1		T4/1 T4/3
Traversing direction when approaching reference marks	X Y Z IV	16 17 18 19	0 ≙ Positive direction 1 ≙ Negative direction (with correct programming of parameter Nos. 20 to 27)	1 1 1 1		T5/1 C3/16
Machine parameters with multiple functions	X Y Z IV	20 21 22 23		0 0 0 0		C3/16
Counting direction		Bit 0	+ 0 ≙ Positive counting direction + 1 ≙ Negative counting direction			C3/16
Enable for reference pulse inhibit		1	+ 0 ≙ Ref. pulse inhibit inactive + 2 ≙ Ref. pulse inhibit active			T5/5
Enable for non-linear axis error compensation	(09)	2	+ 0 ≙ Inactive + 4 ≙ Active			C2/6.2
Output of smallest possible voltage increment of 2.44 mV.	(09)	3	+ 0 ≙ Output of 2.44 mV, when calculated nominal value is equal to, or greater than 1.22 mV. + 8 ≙ Output of 2.44 mV, when calculated nominal value is greater than 0.			C4/5.1

(1) The smallest entry value depends on the acceleration determined by MP 54, MP 297, MP 298, MP 299.

(05) As of software level 05 (4 axes) the maximum traversing speed of 15999 mm/min was increased to 29998 mm/min. The feed in the NC-program can now only be programmed in stages of 2 mm/min.

(09) As of software level 09 (4 axes), 04 (5 axes)

Machine parameters
Complete list of machine parameters

Function		Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Polarity of nominal value voltage	X	24	0 ≙ Pos. with pos. traverse direction	0		C3/16
	Y	25	1 ≙ Neg. with pos. traverse direction	0		
	Z	26		0		
	IV	27		0		
Integral factor	X	28	0 … 65535			C4/3
	Y	29				C4/5; C4/6
	Z	30				C4/8; C4/9
	IV	31				C4/21 …
Factor for difference value	X	32	0 … 65.535			C4/5; C4/6
	Y	33				C4/11 …
	Z	34				C4/9
	IV	35				
Backlash compensation	X	36	– 1.000 … + 1.000 [mm]			C2/6
	Y	37				
	Z	38				
	IV	39	Rotary axis – 1.000 … + 1.000 [°]			
Correction factor for linear compensation	X	40	– 1.000 … + 1.000 [mm/m]			C2/6
	Y	41				
	Z	42				
	IV	43				
Software limit switch ranges	X+	44	– 30000.000 … + 30000.000 [mm]			C3/17
	X–	45				
	Y+	46				
	Y–	47				
	Z+	48				
	Z–	49				
	IV+	50	Rotary axis:			
	IV–	51	– 30000.000 … + 30000.000 [°]			
Analogue voltage at rapid, X-axis		52 (06)	+ 4.5 … + 9 [V]			C4/10; C4/24
Approach speed in precontrol mode		53	0.1 … 10 [m/min]			C4/5 C4/9; C4/19

(06) As of software level 06 (4 axes)/03 (5 axes), the analogue voltage at rapid for all axes can be separately entered via MP 52, MP 300, MP 301, MP 302, MP 338.

Function	Parameter No.	Entry range		Preliminary entry values	Optimised entry values	Description see sheet
Acceleration X(05)	54	0.001 … 3.0 [m/s²]				C2/3;C3/8;C4/3…/ C4/16; C4/24
Radial acceleration	55	0.001 … 3.0 [m/s²]				C4/17
Position supervision for operation with speed precontrol (erasable)	56	0.001 … 30 [mm]				C3/14; C4/9 C4/16;C4/23;C4/33
Position supervision for operation with speed precontrol (Emergency-stop)	57					
Position window X, Y, Z	58	0.001 … 2.000 [mm](07)				C2/4
Axis sequence for reference mark approach	59	0 ≙ X Y Z IV 1 ≙ X Y IV Z 2 ≙ X Z Y IV 3 ≙ X Z IV Y 4 ≙ X IV Y Z 5 ≙ X IV Z Y	12 ≙ Z X Y IV 13 ≙ Z X IV Y 14 ≙ Z Y X IV 15 ≙ Z Y IV X 16 ≙ Z IV X Y 17 ≙ Z IV Y X			T5/1 C3/16
		6 ≙ Y X Z IV 7 ≙ Y X IV Z 8 ≙ Y Z X IV 9 ≙ Y Z IV X 10 ≙ Y IV X Z 11 ≙ Y IV Z X	18 ≙ IV X Y Z 19 ≙ IV X Z Y 20 ≙ IV Y X Z 21 ≙ IV Y Z X 22 ≙ IV Z X Y 23 ≙ IV Z Y X			
Speed precontrol	60	0 ≙ on	1 ≙ off			C4/1 …; C4/24
Output of tool numbers or tool pocket numbers	61	0 ≙ No output 1 ≙ Output only when tool number changes 2 ≙ Output of tool number with every tool call 3 ≙ Output of tool pocket number (if MP 225 ≧ 1)				C2/16 C2/17
	62	0 ≙ No output of spindle rpm				C5/1
Coded output of spindle speed		1 ≙ Coded output only when rpm changes 2 ≙ Coded output with every tool call				C5/2 …
Analogue output of spindle speed		3 ≙ Gear switching signal only when gear range changes 4 ≙ Gear switching signal with every tool call 5 ≙ Without gear switching signal				C5/4 …
RPM code limit	63	01991 ≙ No limit				C5/3; C5/4
Oscill. behaviour during acceleration in precontrol mode	64	0.01 – 0.999				C4/5; C4/10; C4/12; C4/17

(05) As of software level 05 (4 axes)/01 (5 axes), the acceleration can be separately entered for all axes via MP 54, MP 297, MP 298, MP 299, MP 335.

(07) As of software level 07 (4 axes)/04 (5 axes), the entry range was extended from 0.5 mm to 2.000 mm.

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Display step	65	0 ≙ 1 µm 1 ≙ 5 µm			C2/7; C4/6
Non-functional, temporarily	66	Enter 0			
Dwell time in "Tapping cycle"	67	0 … 65.535 [s]			C2/14
Memory function for direction buttons	68	0 ≙ off 1 ≙ on			C2/8
Approach to reference marks	69	0 ≙ After approaching the reference marks the axes automatically traverse to the software limit switches			T5/3
		1 ≙ After approaching the reference marks the axes automatically traverse to the reference marks			T5/3
		2 ≙ Special routine for approaching reference marks			T5/7
Nominal value voltage for spindle drive during gear change	70	0 … 9.999 [V]			C5/3
Characters for program beginning and end	71	0 … 65535			D1/6; D2/5
Selection of inhibited axes	72 Bit				
X-axis	0	+ 0 ≙ Enabled + 1 ≙ Inhibited			C2/4
Y-axis	1	+ 0 ≙ Enabled + 2 ≙ Inhibited			C2/4
Z-axis	2	+ 0 ≙ Enabled + 4 ≙ Inhibited			C2/4
IV-axis	3	+ 0 ≙ Enabled + 8 ≙ Inhibited			C2/4
V-axis	4[1]	+ 0 ≙ Enabled + 16 ≙ Inhibited			C2/4

(1) Only for TNC 355 with 5 NC-axes

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Advanced switchpoint for "Tapping" cycle (only active with BCD-output of spindle rpm)	73	0 … 65.535 [s]			C2/14
Feed rate and spindle override	74 Bit				C2/8
Feed rate override if rapid traverse button is pressed in an automatic operating mode	0	+ 0 ≙ Override inactive + 1 ≙ Override active			
Feed rate override in 2%-stages or variable	1	+ 0 ≙ 2%-stages + 2 ≙ Variable			
Feed rate override if rapid traverse button and external direction buttons are pressed in the "manual" mode	2	+ 0 ≙ Override inactive + 4 ≙ Override active			
Spindle override in 2%-stages or variable	3	+ 0 ≙ 2%-stages + 8 ≙ Variables			C5/9
Reference signal evaluation for inhibited axes	75	0 ≙ Reference signal evaluation without display "Pass over.-reference mark" 1 ≙ Reference signal evaluation with display "Pass over.-reference mark" 2 ≙ No reference signal evaluation			C2/4

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Position display and encoder supervision	76 Bit				C2/5
Position display and encoder supervision for **inhibited axes**	0	+ 0 ≙ Inactive + 1 ≙ Active			
The supervision of encoder inputs for each axis can be separately switched off by means of bit 1 to bit 5. This applies to **inhibited** axes as well as **enabled** axes. The display remains active if bit 0 = 1.	1	Encoder input X + 0 ≙ With supervision + 2 ≙ Without supervision			
	2	Encoder input Y + 0 ≙ With supervision + 4 ≙ Without supervision			
	3	Encoder input Z + 0 ≙ With supervision + 8 ≙ Without supervision			
	4	Encoder input IV + 0 ≙ With supervision + 16 ≙ Without supervision			
	5	Encoder input V + 0 ≙ With supervision + 32 ≙ Without supervision			
	6(04)	Encoder input S + 0 ≙ With supervision + 64 ≙ Without supervision			
PLC-program from RAM or from EPROM	77 Bit				P3/52
	0	+ 0 ≙ 1st and 2nd K commands from RAM + 1 ≙ 1st and 2nd K commands from EPROM			
	1(05)	+ 0 ≙ 3rd K commands from EPROM + 2 ≙ 3rd K commands from RAM			
S-analogue output 0 Gear rpm range 1 2 3	78 79 80 81	0 … 99999.999 [rpm]			C5/4
Gear rpm range 4 or 5 threshold speed 6 7	82 83 84 85	0 … 99999.999 [rpm]			
S-Analogue voltage with S-override at 100 %	86	0 … 9.999 [V]			C5/4; C5/5

(04) As of software level 04 (5 axes)

(05) As of software level 05 (4 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
S-analogue voltage with S-override at maximum	87	0 ... 9.999 [V]			C5/4; C5/5
Limitation of S-override Maximum Minimum	 88 89	0 ... 150 [%]			C5/4; C5/5; C5/8
Designation for axis IV	90	0 ≙ A 3 ≙ U 1 ≙ B 4 ≙ V 2 ≙ C 5 ≙ W			C2/5
Constant contouring speed at corners	91	0 ... 179.999 [°]			C2/10
Multiple parameter function	92 Bit				
Decimal character	0	+ 0 ≙ Decimal comma + 1 ≙ Decimal point			C2/7; D1/6
Dialogue language	1	+ 0 ≙ First dialogue + 2 ≙ Second dialogue (English)			C3/10
Memory test when switching on (RAM)	2	+ 0 ≙ Memory test is carried out + 4 ≙ No memory test			C3/9
Checksum test when switching on (RAM + EPROM)	3	+ 0 ≙ Checksum test is carried out + 8 ≙ No checksum test			C3/9
Change from program run full sequence to program run single block when machining continuous contours	4	+ 0 ≙ The precalculated contour is completed (up to 14 blocks) + 16 ≙ Interruption at current block			C2/10
Counting mode if axis IV operates as a position display for a rotary axis	5	+ 0 ≙ Axis IV counts 0 ... 29999.999 [°] + 32 ≙ Axis IV counts 0 ... 359.999 [°] → 0			C2/7
Activation of functions for Hirth coupling on axis IV	6(07)	+ 0 ≙ No Hirth coupling + 64 ≙ Hirth coupling employed			C2/6
Activation of functions for Hirth coupling on axis V **Please note** With active Hirth coupling MP 65 only determines the display step for axes X, Y and Z, MP 260 applies for axis IV. MP 342 applies for axis V.	7(04)	+ 0 ≙ No Hirth coupling +128 ≙ Hirth coupling employed			C2/6

(04) As of software level 04 (5 axes)

(07) As of software level 07 (4 axes)/04 (5 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Actual-Nominal value transfer after external EMERGENCY STOP	8[10]	+ 0 ≙ Transfer + 256 ≙ No transfer			C2/4
Stepover factor for pocket milling	93	0.1 … 1.414			C2/10
PLC: Counter preset value for counters 0 – 15	94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109	0 … 65535			P3/53
PLC: Programmed duration for timers 0 – 15	110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125	0 … 65535 (in units of 20 ms)			P3/55

(10) As of software level 10 (4 axes)/04 (5 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
PLC: 30 positioning values for PLC-positioning	126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156	– 30000.000 ... + 30000.000 [mm]			P3/7
Activation of next tool number, programmable with TOOL CALL ../.. or the following pocket number, programmable with TOOL DEF	157	0 ≙ No output of next tool number 1 ≙ Output of next tool number only when changing tool number (TOOL CALL ../..) 2 ≙ Output of next tool number with every (TOOL CALL ../..) 3 ≙ Output of next tool pocket number, programmable with TOOL DEF (if MP 225 ≧ 1)			C2/16 C2/17
Setting of a binary number using 16 markers (Markers 2192 to 2207)	158	0 ... 65535			P3/42

Function		Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Automatic lubrication after programmed traverse distance in	X Y Z IV	159 160 161 162	0 … 65535 (in units of 65536 µm)			P3/6
Feed rate for parameter Nos. 126 to 156	X Y Z IV	163 164 165 166	80 … 29998 [mm/min]			P3/7
Display of current feed rate before start in **MANUAL** (in all axes same feed rate i.e. smallest programmed feed rate, from parameters 4 to 7 and 322)(05)		167	0 ≙ No display 1 ≙ Display			C2/7
Ramp gradient for S-analogue voltage		168	0 … 1.999 [V/ms]			C5/5
Standstill supervision		169	0.001 … 30 [mm]			C4/34
Programming station		170	0 ≙ Control 1 ≙ Programming station: PLC active 2 ≙ Programming station: PLC inactive			C2/9
Selection of touch probe system or handwheel only with special software (see sheet T6/1)		171	0 ≙ TS 511 2 ≙ TS 111 or TS 120			T6/2
Polarity of S-analogue voltage		172	0 ≙ M03: Positive voltage M04: Negative voltage 1 ≙ M03: Negative voltage M04: Positive voltage 2 ≙ M03 and M04: Positive voltage 3 ≙ M03 and M04: Negative voltage			C5/4 C5/5
Erasure of status display and Q parameters with M02, M30 and program end		173	0 ≙ Status display not to be erased 1 ≙ Status display to be erased			C2/10
Position supervision in trailing operation	Emergency-stop erasable	174 175	0 … 100 [mm]			C4/33 C3/14

(05) As of software level 05, this machine parameter is inactive when traversing reference marks.

Function		Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Multiplication factor for K_V-factor		176	0.001 … 1.000			C4/24; C4/27
K_V-factor for trailing operation	X Y Z IV	177 178 179 180	0.100 … 10.000			C4/24 …
Characteristic kink		181	0 … 100.000 [%]			C4/24; C4/27
Minimum feed rate override when tapping Maximum feed rate override when tapping		182 183	0 … 150 [%] 0 … 150 [%]			C2/14
Minimum voltage for S-analogue output		184	0 … 9.999 [V]			C5/4; C5/5
Delay for cutout of residual nominal value voltage when "Positioning error" displayed		185	0 … 65.535 [s]			C4/33
Datum for positioning blocks with M92:	X Y Z IV	186 187 188 189	– 30000.000 … + 30000.000 [mm] or – 30000.000 … + 30000.000 [°]			C2/13
Programming of rpm S = 0 permitted (voltage value of MP 184 can be less)		190	0 ≙ S = 0 Permitted 1 ≙ S = 0 Not permitted			C5/9
Display of current spindle rpm before spindle start		191	0 ≙ on 1 ≙ off			C2/7; C5/9
Position window axis IV		192	0.001 … 2.000 [mm or °][07]			C2/4

(07) As of software level 07 (4 axes)/04 (5 axes), the entry range was extended from 0.5 mm to 2.000 mm.

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
PLC: Timer duration for timers 16–31	193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208	0 … 65535 (in units of 20 ms)			P3/55
Activation of PLC-macro commands (Setting of markers 3200 … 3263)	209 210 211 212	0 … 9999			P3/47
"Scaling factor" cycle effective for 2 or 3 axes	213	0 ≙ 3 axes (3D) 1 ≙ 2 axes (working plane)			C2/11
Output of M- and S-functions	214 Bit				C2/11
Programmed stop with M06	0	+ 0 ≙ Programmed stop with M06 + 1 ≙ No programmed stop with M06			
Output of M89	1	+ 0 ≙ Normal output at the beginning of the block + 2 ≙ Modal cycle call at the end of the block			
Axis halt if spindle rpm only is changed with a TOOL CALL	2	+ 0 ≙ Axis halt + 4 ≙ No axis halt			C5/9
Axis standstill with output of an M-function **Exceptions:** The axis halts with M-functions resulting in a programmed stop (as M00, M02 …) or with a STOP or a CYCL-CALL-block	3	+ 0 ≙ Axis halt + 8 ≙ No axis halt			C2/11

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Touch probe system: probing speed	215	80 ... 3000 [mm/min]			T6/2
Touch probe system: measuring range	216	0 ... 19999.999 [mm]			T6/2
Programming language changeover, HEIDENHAIN-dialogue/ISO-format	217	0 ≙ HEIDENHAIN-dialogue 1 ≙ ISO (G-codes)			C2/9
"Transfer Blockwise" ASCII-character for data input	218	0 ... 65535			D2/5
"Transfer Blockwise" ASCII-character for data output	219	0 ... 65535			D2/5
"Transfer Blockwise" ASCII-character for beginning and end of the command block	220	0 ... 12079			D2/5
"Transfer Blockwise" ASCII-character for acknowledge/ not acknowledge	221	0 ... 12079			D2/5
Data format and transmission stop for data interface RS-232-C/V.24	222	0 ... 255			D1/7
Operating mode: data interface RS-232-C/V.24	223	0 ≙ "Standard data interface" 1 ≙ „Transfer Blockwise"			D1/6
"Transfer Blockwise" ASCII-code data transmission completed	224	0 ... 12079			D2/5
Central tool file	225	0 ≙ No central tool file 1 ... 99 ≙ Central tool file Entry value = Number of tool pockets			C2/16
Graphics printout: Number of control characters to set printer interface + 1 control character	226	0 ... 65535			D3/1
Graphics printout: 2 control characters to set printer interface	227 228 229	0 ... 65535			D3/1
Graphics printout: Number of control characters prefixing every print line + 1 control character	230	0 ... 65535			D3/1
Graphics printout: 2 control characters prefixing every print line	231 232 233	0 ... 65535			D3/1

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Movement supervision	234	0.03 … 10 [V]			C4/34
Touch probe system: Safety clearance above measuring point for automatic probing	235	0 … 19999.999 [mm]			T6/2
Graphics	236 Bit				C2/9
Graphics: Projection of "View in three planes"	0	+ 0 ≙ German standard[1] + 1 ≙ U.S. standard[2]			
Coordinate system rotation of machining plane	1	+ 0 ≙ No rotation + 2 ≙ Coordinate system rotated			
Activation of axis S for spindle orientation	237	0 ≙ Axis inactive 1 ≙ Axis serves in orienting main spindle, without position display 2 ≙ As entry value 1, however with position display (is displayed instead of axis IV)			C5/10
K_V-factor for axis S (spindle)	238	0.100 … 10.000			C5/10
Counting direction and reference pulse inhibit for spindle orientation axis	239 Bit				
Counting direction	0	+ 0 ≙ Positive + 1 ≙ Negative			C5/10
Reference pulse inhibit	1	+ 0 ≙ Inactive + 2 ≙ Active			T5/5; C5/10
Position value of reference mark for axis S (spindle)	240	0 … 360.000			C5/10

[1] First angle projection

[2] Third angle projection

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Cycles for milling variable contour pockets	241 Bit				C2/12
Cycle "Rough-out": Milling direction for outline milling of contour	0	+ 0 ≙ Outline mill pockets CCW, CW for islands + 1 ≙ Outline mill pockets CW, CCW for islands			
Cycle "Rough-out": Sequence for outline milling and roughing-out	1	+ 0 ≙ Outline mill, then rough-out pocket + 2 ≙ Rough-out pocket, then outline mill			
Combining corrected or uncorrected contours	2	+ 0 ≙ Combine corrected contours + 4 ≙ Combine uncorrected contours			
Reference mark spacing for distance-coded encoders X Y Z IV	242 243 244 245	0 ... 65535 0 ≙ No distance-coded reference marks 1000 ≙ Linear encoder with 20 µm grating period or angle encoder with 36 reference marks and 18000 lines			T5/2
Position window for axis S (spindle)	246	1 ... 65535 [increments]			C2/4
Hysteresis for electronic handwheel	247	0 ... 65535 [increments]			T6/1
Spindle rpm for spindle orientation	248	0 ... 99999.999 [rpm](06)			C5/10
Setting of a binary sum with 16 markers (markers 2208 to 2223)	249	0 ... 65535			P3/43
Setting of a binary sum with 16 markers (markers 2224 to 2239)	250	0 ... 65535			P3/43
Touch probe system: rapid traverse for probing	251	180 ... 29998 [mm/min]			T6/2
Automatic, drive offset adjustment	252	1 ... 65535 [in units of 20 ms] 0 ≙ No automatic adjustment			C4/8; C4/22 C4/6
Allocation of axes to encoder inputs X Y Z IV V	253 254 255 256 257	0 ≙ Standard allocation 1 ≙ Encoder input X1 2 ≙ Encoder input X2 3 ≙ Encoder input X3 4 ≙ Encoder input X4 5 ≙ Encoder input X5 6 ≙ Encoder input X6(04)			T3/1; T4/2; T4/5

(04) As of software level 04 (5 axes)

(06) As of software level 06 (4 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Analogue output of spindle rpm if marker 2501 is set	258	0 ... 99999.999 [rpm] Direction of rotation always positive			C5/9
Language conversion for user-cycles: Difference between dialogue numbers of the second (English) and the first language	259	0 ... 50			U1/3
Increment for axis IV, if Hirth coupling is activated via MP 92	260(07)	0 ... 9.999 [°] Entry value 0 is treated as 0.001			C2/6
Shift for axis IV, if Hirth coupling is activated via MP 92	261(07)	– 30000.000 ... + 30000.000 [°]			C2/6
Number of global Q-parameters which are transferred from a user-cycle to the program called	262(05)	0 ... 50 When entering 40, Q-parameters Q60 ... Q99 are global			U1/4
Difference between Q-parameter numbers for "DLG-DEF"-block and „DLG-CALL"-block in user-cycle	263	0 ... 50 0 "DLG-CALL"-blocks only			U1/2
PLC: programmed duration for timers 32 – 47	264(05) 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279	0 ... 65535 (in units of 20 ms)			P3/56

(05) As of software level 05 (4 axes)

(07) As of software level 07 (4 axes)/04 (5 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
PLC: predetermined counter value for counters 16 to 31	280(05) 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295	0 … 65535			P3/54
Limitation of feed rate override in %, if marker 2509 is set	296	0 … 150 [%]			P3/41
Acceleration Y Z IV **The acceleration for the X-axis is determined by MP 54.**	297(05) 298(05) 299(05)	0.001 … 3.0 [m/s²]			C2/3; C4/3 C3/8; C4/16 C4/9 …; C4/24
Analogue voltage at rapid Y Z IV **The analogue voltage for the X-axis is determined by MP 52.**	300(06) 301(06) 302(06)	+ 4.5 … + 9 [V]			C4/10 C4/24
Entry values for datum correction activated by markers 2816, 2817, 2819 1st Datum correction X 2nd Datum correction X 3rd Datum correction X	 303(07) 304(07) 305(07)	 – 30000.000 … + 30000.000 [mm]			C2/13
1st Datum correction Y 2nd Datum correction Y 3rd Datum correction Y	306(07) 307(07) 308(07)	– 30000.000 … + 30000.000 [mm]			C2/13

(05) As of software level 05 (4 axes)

(06) As of software level 06 (4 axes)/03 (5 axes)

(07) As of software level 07 (4 axes)/04 (5 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
1st Datum correction Z 2nd Datum correction Z 3rd Datum correction Z	309(07) 310(07) 311(07)	– 30000.000 … + 30000.000 [mm]			C2/13
1st Datum correction IV 2nd Datum correction IV 3rd Datum correction IV	312(07) 313(07) 314(07)	– 30000.000 … + 30000.000 [mm] or – 30000.000 … + 30000.000 [°]			C2/13
%-Factor for analogue spindle voltage if marker 2822 is set	315(07)	0 … 150 [%]			P3/35
Ramp gradient – S-Analogue voltage for deceleration	316(07)	0 … 1.999 [V/ms] 0 ≙ Acceleration and deceleration from MP 168			
Ramp gradient for S-Analogue, when M 2816 is set					
Acceleration	317(07)	0 … 1.999 [V/ms]			
Deceleration	318(07)	0 … 1.999 [V/ms]			
Reserved	319	0			

(07) As of software level 07 (4 axes)/04 (5 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Selection of inhibited axes	72 Bit				C2/4
Axis V	4	+ 0 ≙ Axis V released + 16 ≙ Axis V inhibited			
Designation for axis V	320	0 ≙ A 3 ≙ U 1 ≙ B 4 ≙ V 2 ≙ C 5 ≙ W			C2/5
Rapid traverse for axis V	321	80(1) … 29998 [mm/min] Rotary axis: 80(1) … 29998 [°/min]			C2/3
Manual feed axis V	322	80 … 29998 [mm/min] Rotary axis: 80 … 29998 [°/min]			C2/3
Speed when approaching reference marks	323				T5/1
Feed rate for PLC-positioning of axis V	324				P3/38
Software limit switch ranges V +	325	– 30000.000 … + 30000.000 [mm] Rotary axis: – 30000.000 … + 30000.000 [°]			C3/12
V –	326				
Signal evaluation, input X5	327	1 ≙ 4-fold 2 ≙ 2-fold (max. traversing speed limited by EXE-input frequency)			T4/1
Spacing of reference marks for distance-coded encoder on axis V	328	0 … 65535 0 ≙ No distance-coded reference marks 1000 ≙ Linear encoders with 20 µm grating period or angle encoder with 36 reference marks and 18000 lines			T5/2
Traversing direction when approaching reference marks	329	0 ≙ Positive direction 1 ≙ Negative direction (with correct programming of machine parameters 330 and 331)			T5/1 C3/16

(1) The smallest entry value depends on the acceleration determined by MP 335

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Machine parameters with multiple functions	330 Bit				
Counting direction of axis V	0	+ 0 ≙ Positive + 1 ≙ Negative			C3/16
Reference pulse inhibit of axis V	1	+ 0 ≙ Inacitve + 2 ≙ Active			T5/5
Enable for non-linear axis error compensation in axis V	2(09)	+ 0 ≙ Inactive + 4 ≙ Compensation effective			C2/6.2
Output of smallest possible voltage increment of 2.44 mV for axis V	3(09)	+ 0 ≙ Output of 2.44 mV, when calculated nominal value is equal to, or greater than 1.22 mV. + 8 ≙ Output of 2.44 mV, when calculated nominal value is greater than 0.			C4/5.1
Polarity of nominal value voltage	331	0 ≙ Positive with positive traversing direction 1 ≙ Negative with positive traversing direction			C3/16
Factor for difference value	332	0 ... 65.535			C4/5; C4/6; C4/9 ...
K_V-factor for trailing operation	333	0.100 ... 10.000			C4/24 ...
Datum set via axis key V	334	0 ≙ Inactive, datum is transferred from MP 337 1 ≙ Active			C2/8
Acceleration of axis V	335	0.001 ... 3.0 [m/s^2]			C2/3; C3/8; C4/3; C4/10; C4/16; C4/24
Position window of axis V	336	0.001 ... 2.000 [mm](04) Rotary axis: 0.001 ... 2.000 [°](04)			C2/4
Datum of axis V	337	– 30000.000 ... + 30000.000 [mm]			C2/8
Analogue voltage at rapid, axis V	338(03)	+ 4.5 ... + 9 [V]			C4/10; C4/24
Entry values for datum correction, activated via markers 2816, 2817, 2819 1st Datum correction V 2nd Datum correction V 3rd Datum correction V	 339(04) 340(04) 341(04)	– 30000.000 ... + 30000.000 [mm] or – 30000,000 ... + 30000,000 [°]			C2/13

(03) As of software level 03 (5 axes)

(04) As of software level 04 (5 axes)

(09) As of software level 09 (4 axes)/04 (5 axes)

Function	Parameter No.	Entry range	Preliminary entry values	Optimised entry values	Description see sheet
Increment for axis V, if Hirth coupling is activated via MP 92	342(04)	0 … 9.999 [°] Entry value 0 is treated as 0.001			C2/6
Shift for axis V if Hirth coupling is activated via MP 92	343(04)	– 30000.000 … + 30000.000 [°]			C2/6
Factor for linear compensation, axis V	344(04)	– 1.000 … + 1.000 [mm/m]			C2/6

(04) As of software level 04 (5 axes)

Machine parameters
Entry of machine parameters

Machine parameters are either entered into the empty memory during the first commissioning procedure or subsequently edited to change certain machine and control functions, i.e. alteration of entry values.

Whereas during the first commissioning of a **certain machine type** the machine parameters are determined in the given sequence and then entered manually, values which are already known can be externally stored via the RS-232-C/V.24 interface and transferred to other machines of the same type, if required.

External storage of machine parameters is also recommended for the end customer as this permits – if need be – the quick exchange of a control unit.

Code numbers for machine parameters

531210 → Erasure of machine parameter memory

Key-in code number via MOD-function and enter with ENT.

OPERATING PARAMETERS ERASED! appears in the visual display.

Erase display with CE-key; the control requests the entry of machine parameters:

MACHINE PARAMETER PROGRAMMING
MACHINE PARAMETER MP 0?
MP 0:

Subsequently, the values are entered manually or read-in from the external data medium via the data interface.

Please note: With this code number the PLC-markers M 1000 ... M 2000 are also reset to logical "0".

95148 → Editing of machine parameter list

If values are only to be edited, or missing values supplemented, this is performed by entering the code number via the MOD-function.

After pressing ENT the list of entry values is displayed commencing with MP 0.

Specific machine parameters may be addressed with the keys ↓ and ↑ or GOTO.

Entry is by keying-in the numerical value and entering with ENT.

Transfer of machine parameters with external storage unit

Machine parameters can be read-in and out via the RS-232-C/V.24 data interface, normally from or to an FE 401 or ME 101/102 from HEIDENHAIN. The transfer from a non-HEIDENHAIN peripheral unit, e.g. paper tape punch/reader is also possible.

The RS-232-C/V.24 data interface of the TNC can be converted for the following operating modes via the MOD-function key.

FE: Data interface for the HEIDENHAIN Floppy Disc Unit FE 401. The machine parameters are stored as an NC-program under a program number.

ME: Data interface for the HEIDENHAIN Magnetic Tape Unit ME 101 or ME 102. The Baud rate is set to 2400 Baud.
Standard data format: 7 data bits
1 stop bit (2 stop bits for 110 Baud)
Even Parity

EXT: Data interface convertible via machine parameters, see sheet D1/6.
Data entry with erased memory has limited possibilities in this operating mode. See next page.

Machine parameters
Entry of machine parameters

Entry with erased memory

The machine parameters can either be entered manually or read-in via the external data interface.

After MAINS POWER-ON and MEMORY TEST the **operating mode ME is automatically preselected** by the TNC.
If read-in is desired in another mode, selection is made via the MOD-function key (sheet D1/2).

Please note:
Since no machine parameters have been entered, the RS-232-C/V.24 interface cannot yet be modified in the **EXT** operating mode.

For EXT the standard data format is therefore valid: 7 data bits
1 stop bit (2 stop bits for 110 Baud)
Even Parity

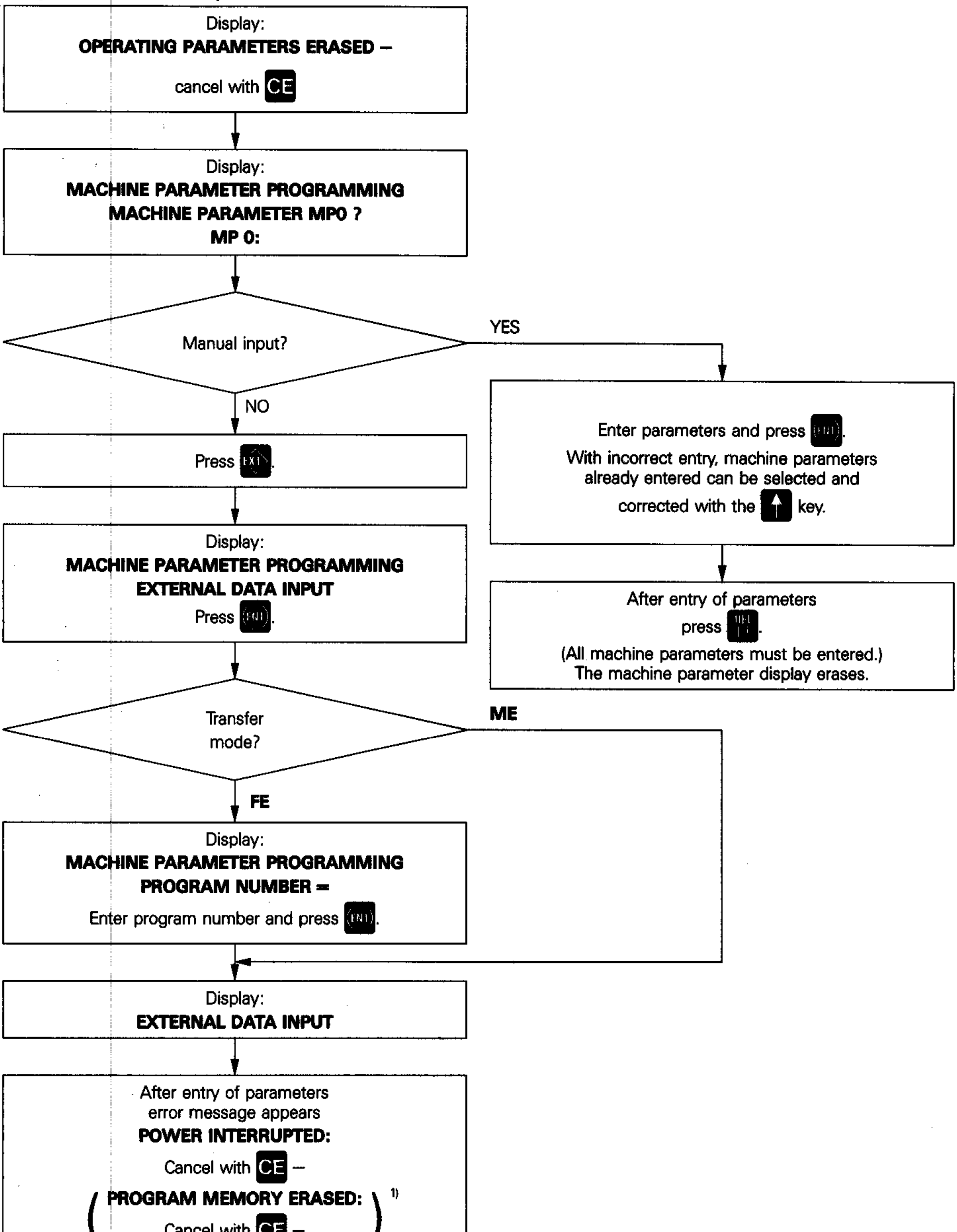
In contrast to ME-operation the transmission rate can be set from 110 to 9600 Baud via the operating mode EXT.

If, therefore, a punched tape reader with standard data format is to be used for reading-in machine parameters, this is possible in the EXT operating mode.

Machine parameters

Entry of machine parameters

Entry with erased memory



1) In the event of program memory erasure, e.g. removal of buffer battery.

Machine parameters
Entry of machine parameters

Read-in and editing with a programmed memory

If stored machine parameters are to be amended, supplemented or completely overwritten by external entry, proceed as follows:

Press [key].

↓

Display:
VACANT BLOCKS

↓

Press [↑].

↓

Display:
CODE NUMBER =

↓

Enter code number 95 148 and press [key].

↓

Display:
MACHINE PARAMETER PROGRAMMING
MACHINE PARAMETER MP0 ?
and complete parameter list.

↓

Overwrite stored values by external entry?

YES:

Press [EXT].

↓

Display:
MACHINE PARAMETER PROGRAMMING
EXTERNAL DATA INPUT
Press [ENT].

↓

with external input continue as described on sheet C1/25.

NO:

Select parameter No. required by pressing [↓] or [↑] or [key].

↓

Key-in value, and press [ENT].

↓

After parameter entry press [key].
The machine parameter display erases.

Please note:
If certain machine parameters are altered within a test phase several times, one after the other, the entry of the code number may be avoided to save time.

If the mains is not switched-off, the machine parameter list can be selected again by pressing [ENT] in the manual operating mode. After mains power-off, this is no longer possible.

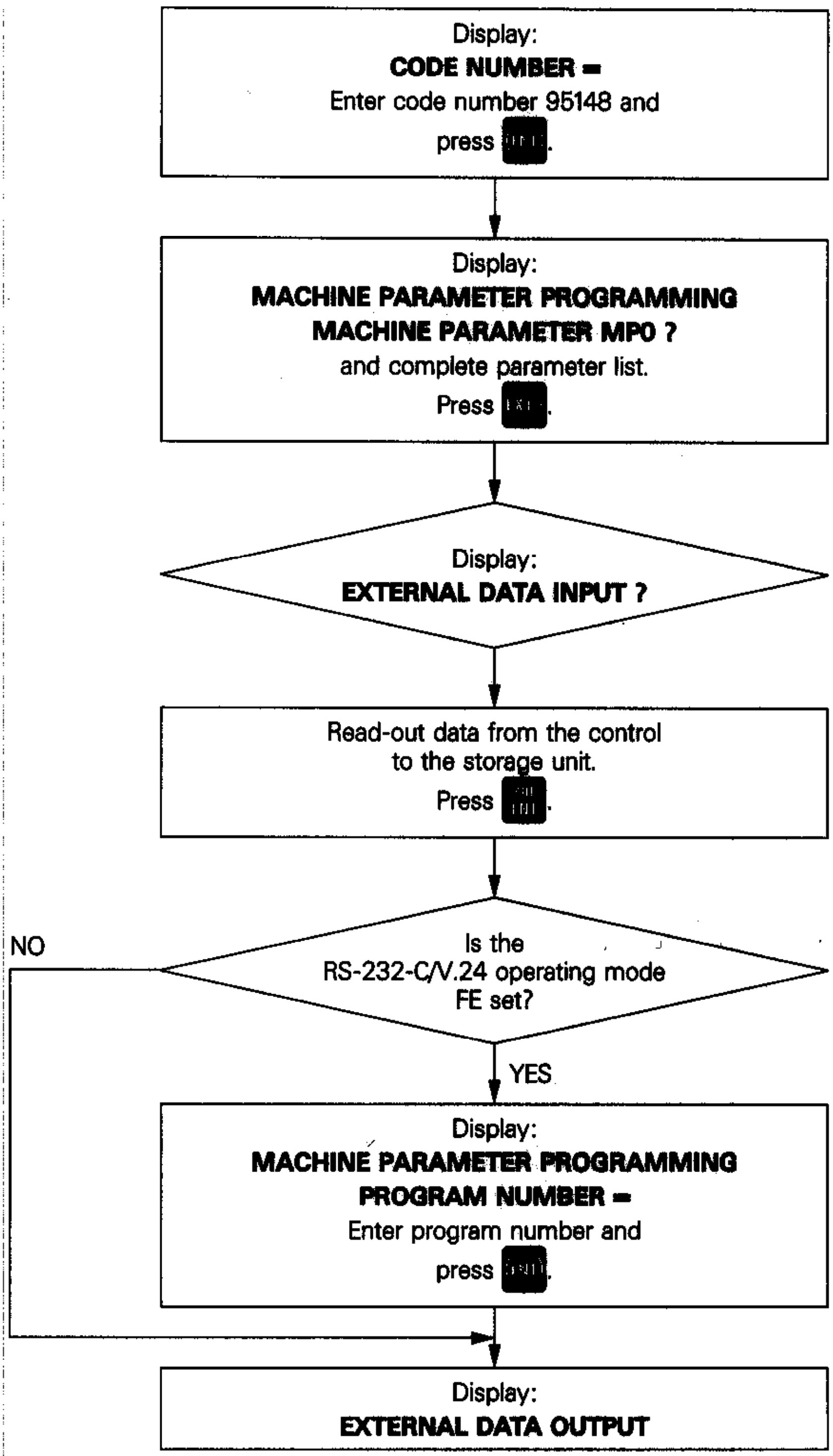
Machine parameters
Entry of machine parameters

External storage of machine parameters

After final definition, the machine parameters must always be stored on an external data storage unit.

The machine parameter list is selected via the MOD-key with the code number or, as described, on sheet C1/26 , with the -key in the manual operating mode.

Data format and interface adaptation have to be carried out as described on sheets C1/23 and D1/2.



After transmission, the TNC automatically switches to the manual operating mode.

Machine parameters
Machine parameters as user-parameters

Up to 16 machine parameters can be made accessible to the machine user via the MOD-function. The user-parameters can be assigned by the machine manufacturer as required.

Assignment of user-parameters
If a machine parameter is be made accessible to the user, the P -key has to be additionally pressed during programming.

Example:
MP 217 0 P

The following error message appears if it is attempted to program more than 16 user parameters.

TOO MANY USER PARAMETERS

After pressing ENT, the letter P suffixes the entry value.

The following dialogue texts for the dialogue display of the user-parameters are stored in the PLC-EPROM:

DIALOGUE display	Machine parameter
USER PAR. 1	Machine parameters with the lowest parameter number
USER PAR. 2 USER PAR. 3 USER PAR. 4 USER PAR. 5 USER PAR. 6 USER PAR. 7 USER PAR. 8 USER PAR. 9 USER PAR. 10 USER PAR. 11 USER PAR. 12 USER PAR. 13 USER PAR. 14 USER PAR. 15	Machine parameters arranged according to increasing parameter numbers
USER PAR. 16	Machine parameters with highest parameter number

Instead of USER PAR. 1 etc. any text with up to 16 positions can be displayed. This requires an alteration of the standard PLC-EPROM. The PLC-EPROM is altered at our works in Traunreut, West Germany. Please contact HEIDENHAIN in Traunreut or one of our foreign representations.

Please note:
The dialogue texts USER PAR. 1 to USER PAR. 16 are stored in the PLC-EPROM under the addresses of the PLC error messages PLC: ERROR 84 to PLC: ERROR 99. If error messages are required instead of the displays for user-parameters, the corresponding dialogue texts in the PLC-EPROM have to be changed (address of USER PAR. 1 = address of PLC: ERROR 84 etc.).
If special dialogues for user-parameters were defined in the customized PLC-program, the **allocation of the texts** to the machine parameter No. is shifted if further user-parameters are **subsequently** inserted.

Description of machine parameters

The description of machine parameters for related functions can be found in the pertinent sections.
The sections are listed in the machine parameter list (see sheets C1/3 to C1/22).

Machine parameters which cannot be clearly assigned to a section of the manual are compiled and described on the following pages.

Description of machine parameters

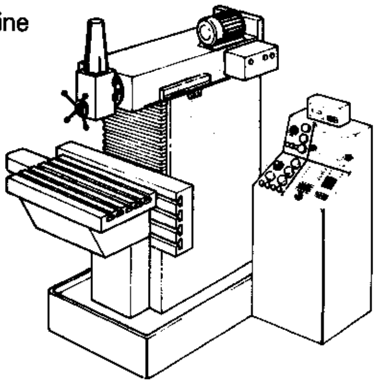
Machine parameters for the axes

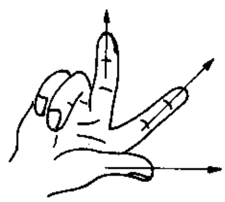
Axis designation for NC-machines

The coordinate axes and traversing directions for numerically controlled machine tools are defined in the DIN-standard 66 217. The three main axes are clearly defined by a standard. The traversing directions can be determined by means of the "Right-Hand-Rule".

In addition, the movement of the tool towards the workpiece constitutes a negative traversing direction.

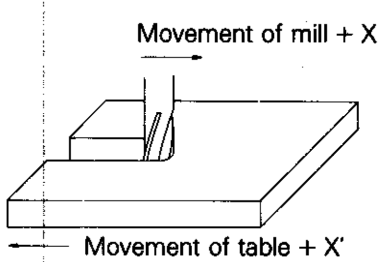
Example:
Universal milling machine





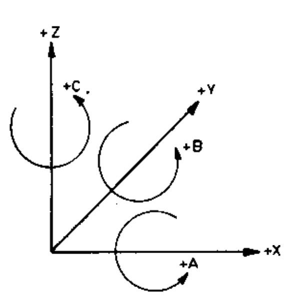
"Right-Hand-Rule":
The coordinate directions are represented by the fingers.

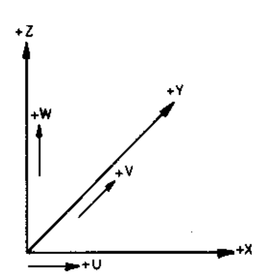
When programming, only the **tool movement** is considered (relative movement of tool), i. e. whilst programming the operator always assumes that the tool is moving.



With the universal milling machine as illustrated above, the milling tool should, for example, traverse in a positive direction in the X-axis. However, due to the table moving in this axis and not the tool, the table must move in the left-hand direction. The relative movement of the tool is therefore in the right-hand direction, i. e. in the positive X-direction. In this case, the traversing direction of the table is designated to DIN 66 217 as + X'.

The machine manufacturer decides whether the **fourth axis** is to be used for a rotary table or as an additional linear axis and also which designation this axis will receive on the display screen:





Fourth axis as rotary axis

The rotary axis is designated with letters **A, B** or **C**; the correlation to the main axes and the rotating direction is shown in the above illustration.

Fourth axis as linear axis

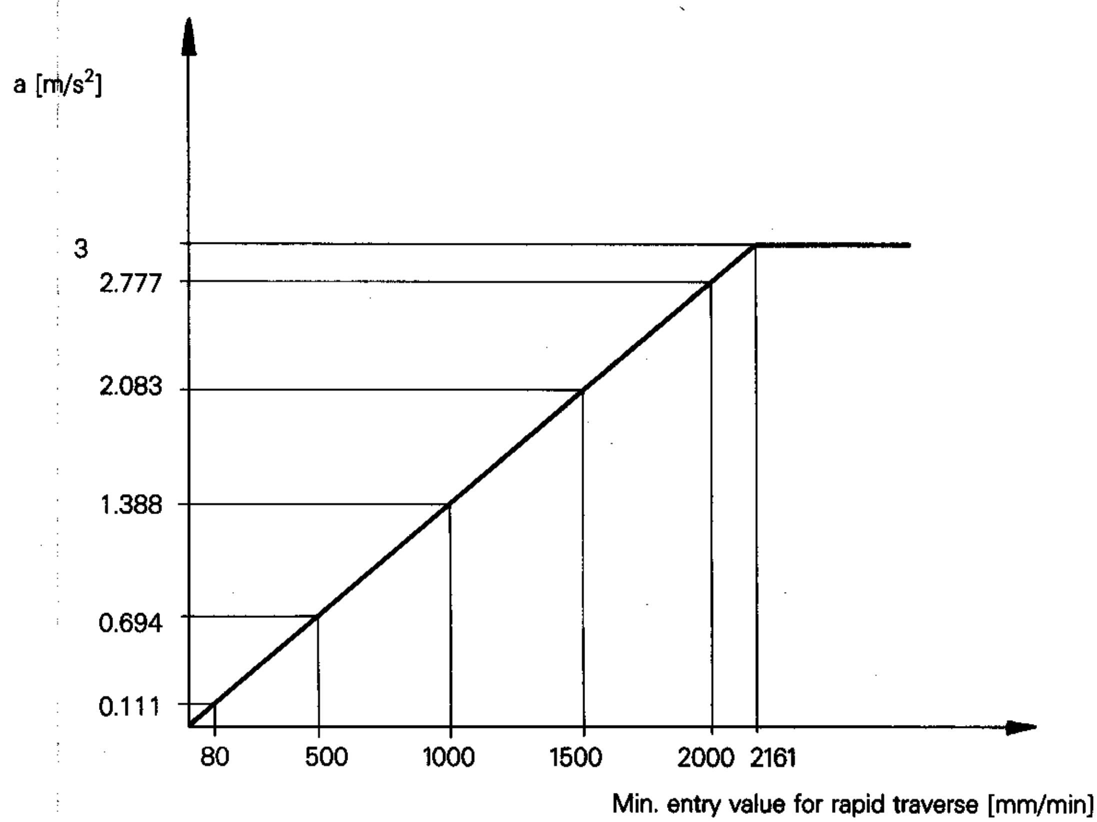
If the fourth axis is to be used as a linear axis, the designation of this axis is **U, V** or **W.**
The correlation to the main axes is shown above.

Rapid traverse

The maximum traversing speed of an axis (rapid traverse) is defined via machine parameters. The respective rapid traverse has to be adjusted with 9 V at the input of the servo-amplifier.

MP 0	**Axis X**	Entry range:
MP 1	**Axis Y**	80 ... 29998 [mm/min]
MP 2	**Axis Z**	Rotary axis:
MP 3	**Axis IV**	80 ... 29998 [°/min]
MP 321	**Axis V**	

The minimum entry value depends on the acceleration entered in MP 54, MP 297, MP 298, MP 299, MP 335 (see sheets C4/3; C4/16).



Manual feed

The maximum feeds in "Manual" can be limited via separate machine parameters.

MP 4	**Axis X**	Entry range:
MP 5	**Axis Y**	80 ... 29998 [mm/min]
MP 6	**Axis Z**	Rotary axis:
MP 7	**Axis IV**	80 ... 29998 [°/min]
MP 322	**Axis V**	

Position window

MP 58 **Position window for axis X, Y, Z**
MP 192 **Position window for axis IV**
MP 336 **Position window for axis V**
Entry range:
0.001 ... 2.000 [mm] or [°]
MP 246 **Position window for axis S**
Entry range:
1 ... 65535 [increments]

The position window determines the limits in which the control considers the position as being achieved. After having reached the position window, the control begins with the execution of the next block. The entry of 0.05 means, for example, that the machine considers a position as reached if the actual value of the position reaches the nominal value to within ± 0.05 mm. Although the control begins with the execution of the next block, it continues in trying to position the machine exactly to the nominal position value. The entry value for the position window should not be less than 0.01 mm. If the entry value is too small, the positioning time and thus, the transition from program block to program block, may be prolonged.

Actual-Nominal value transfer[10]

By setting machine parameters it is possible to determine whether the current actual value should be transferred as a nominal value after an external EMERGENCY STOP. By not having a transfer of the actual value, possible drifting of the axis after an EMERGENCY STOP can be corrected. It should be noted that an axis drift which is greater than the position window leads to the error message "Gross positioning error".

MP 92 **Bit 8** **Actual-Nominal value transfer after an external EMERGENCY STOP**

Entry value: + 0 ≙ Transfer
+ 256 ≙ No transfer

MP 72 Selection of the axes inhibited for controlling

The position loop for each axis may be separately inhibited by means of bits 0 to bit 4 of MP 72.

Bit 0	**Axis X**	+ 0 ≙ Enabled + 1 ≙ Inhibited
Bit 1	**Axis Y**	+ 0 ≙ Enabled + 2 ≙ Inhibited
Bit 2	**Axis Z**	+ 0 ≙ Enabled + 4 ≙ Inhibited
Bit 3	**Axis IV**	+ 0 ≙ Enabled + 8 ≙ Inhibited
Bit 4	**Axis V**	+ 0 ≙ Enabled + 16 ≙ Inhibited

In addition, the reference signal evaluation can be cancelled via MP 76. The position display and encoder supervision can be cancelled via MP 76.

MP 75 Reference signal evaluation for inhibited axes
0 ≙ No display "Pass over reference mark" for inhibited axes. The position display begins to count on passing over the reference mark.
1 ≙ "Pass over reference mark" is displayed for inhibited axes. Reference marks for inhibited axes must be approached in the sequence, as programmed under MP 59.
2 ≙ No display "Pass over reference mark". The position display is set to 0 after a power interruption and counts without having to pass over the reference marks.

(10) As of software level 10 (4 axes)/04 (5 axes)

Description of machine parameters
Machine parameters for the axes

MP 76 Position display and encoder supervision

The position display and the encoder supervision of axes inhibited by MP 72 can be cancelled by means of bit 0 of MP 76.

Bit 0 **Position display and encoder supervision for inhibited axes**
+ 0 ≙ Inactive
+ 1 ≙ Active

The supervision of encoder inputs can be separately switched off for each axis by means of bit 1 to bit 6. This applies to both **inhibited** and enabled axes. The position display remains active if Bit 1 = 0.

Encoder supervision for inhibited and enabled axes

Bit 1 **Encoder input X**
+ 0 ≙ With supervision
+ 2 ≙ Without supervision

Bit 2 **Encoder input Y**
+ 0 ≙ With supervision
+ 4 ≙ Without supervision

Bit 3 **Encoder input Z**
+ 0 ≙ With supervision
+ 8 ≙ Without supervision

Bit 4 **Encoder input IV**
+ 0 ≙ With supervision
+ 16 ≙ Without supervision

Bit 5 **Encoder input V**
+ 0 ≙ With supervision
+ 32 ≙ Without supervision

Bit 6 **Encoder input S**(04)
+ 0 ≙ With supervision
+ 64 ≙ Without supervision

Axis designation for axes IV and V

The axis designation is determined with MP 90 for axis IV and with MP 320 for axis V. Axis designation A, B or C signifies that the axis is to be used for the control or for the display of a rotary axis. In this case, this axis is excluded from mm/inch-conversion and can operate with one of the other axes in linear interpolation without tool compensation. If U, V or W is used, the axis is defined as an additional linear axis. The mm/inch-changeover is applicable and can operate either in linear interpolation with one or two of the other axes, or with one of the other axes including tool radius compensation.

MP 90 **Axis designation for axis IV**
Entry values:

0 ≙ A	3 ≙ U
1 ≙ B	4 ≙ V
2 ≙ C	5 ≙ W

MP 320 **Axis designation for axis V**
Entry values:

0 ≙ A	3 ≙ U
1 ≙ B	4 ≙ V
2 ≙ C	5 ≙ W

(04) As of software level 04 (5 axes)

Description of machine parameters
Machine parameters for the axes

Special functions for a rotary table with Hirth coupling

The special functions for a Hirth coupling in the fourth or fifth axis are activated by MP 92, Bit 6 or Bit 7. Activation of Hirth coupling is only appropriate if the fourth or fifth axis is a rotary axis.

After activation, the display step from MP 260 or MP 342 takes effect.

Via MP 261 or MP 343 a shift of the Hirth coupling with respect to the encoder reference mark can be entered.

MP 92 **Parameter for multiple functions**

Bit 6 **Activation of functions for Hirth coupling of axis IV**(07)
+ 0 ≙ No Hirth coupling
+ 64 ≙ Hirth coupling employed

Bit 7 **Activation of functions for Hirth coupling of axis V**(04)
+ 0 ≙ No Hirth coupling
+ 128 ≙ Hirth coupling employed

Bit 1 to bit 4 and bit 5 see sheet C1/9

MP 260 **Increment for axis IV if Hirth coupling is activated via MP 92.**
Entry range: 0 ... 9.999 [°]
Entry range: 0 is treated as 0.001

MP 342 **Increment for axis V if Hirth coupling is activated via MP 92.**(04)
Entry range: 0 ... 9.999 [°]
Entry range: 0 is treated as 0.001

MP 261 **Shift for axis IV if Hirth coupling is activated via MP 92.**
Entry range: – 30000.000 ... + 30000.000 [°]

MP 343 **Shift for axis V if Hirth coupling is activated via MP 92.**(04)
Entry range: – 30000.000 ... + 30000.000 [°]

Hints on operating and programming.

Manual operating mode:

.Traversing with external directional buttons: after releasing a direction button the axis moves to a position which corresponds to the next multiple of the display step.

.Datum set: If a value which is not a multiple of the display step is entered, it is automatically rounded-off upwards or downwards.

Automatic operating modes:

When programming, nominal position values which are not a multiple of the display step may also be entered. During execution of the block, the error message "ENTRY VALUE INCORRECT" is displayed.

(04) As of software level 04 (5 axes)

(07) As of software level 07 (4 axes)

Description of machine parameters
Machine parameters for the axes

Error compensation of machine axes

Backlash compensation

With a linear measurement via spindle and rotary encoder a slight amount of play between table movement and rotary encoder can be compensated for by machine parameters. An entry value of 50 µm should however, not be exceeded.

MP 36	**Axis X**	Entry range:
MP 37	**Axis Y**	– 1.000 ... + 1.000 [mm]
MP 38	**Axis Z**	Rotary axis:
MP 39	**Axis IV**	– 1.000 ... + 1.000 [°]

Correction factor for linear compensation

Linear compensation of individual axes can be programmed by machine parameters. The correction either extends or shortens the measuring range.

MP 40	**Axis X**	Entry range:
MP 41	**Axis Y**	– 1.000 ... + 1.000 [mm/m]
MP 42	**Axis Z**	
MP 43	**Axis IV**	
MP 344	**Axis V**(04)	

Note: The linear compensation is only effective if the non-linear axis error compensation is not.

Non-linear axis error compensation(09)

In all axes, non-linear corrections can be made at 64 points in each axis. These corrections are stored and edited via tables.

The relationship of the correction of a certain axis can be randomly programmed to the same axis or to any other axis.

Format of display: e.g.

X = F (X)

axis to be corrected   erroneous axis

The axis in brackets is the erroneous axis, the deviation of which, is corrected by the axis which is to be compensated.

Example for spindle pitch error compensation of X-axis:

Axis to corrected X = F (X)

Example for deflection compensation of Y-axis:

Axis to corrected Z = F (Y)

On a machine having an overhanging horizontal Y-axis, the deflection of this axis can be compensated for via the Z-axis.

(04) As of software level 04 (5 axes)

(09) As of software level 09 (4 axes)/04 (5 axes)

Machine parameters for the axes

Non-linear axis error compensation is activated by machine parameters.

MP 20	**Axis X**	Bit 2, enable for non-linear axis error compensation
MP 21	**Axis Y**	Entry values:
MP 22	**Axis Z**	+ 0 ≙ Non-linear axis error compensation inactive
MP 23	**Axis IV**	+ 4 ≙ Non-linear axis error compensation active
MP 330	**Axis V**	

Depending on the correction value list, 64 correction points can be stored for each axis.

With the code number **105296**, the dialogue for entry of the correction value list is initiated.

The following is displayed:

	COMPENSATION VALUE LIST		
Dialogue line	AXIS FAULTY ?		
1st line	X = F ($\boxed{X}$)		
2nd line	DATUM		+ 0.000
3rd line	DIST		1
as of 4th line	0	X + 0.000	X + 0.000
	1	X + 0.002	X + 0.000
	2	X + 0.004	X + 0.000
	3	X + 0.006	X + 0.000

After calling-up the correction value list via the code number axis X = F (X) is displayed corresponding to the ballscrew error compensation for the axis in the 1st line. The erroneous axis (X) is displayed in inverted characters.
By pressing the appropriate axis key the erroneous axis can be changed.

E.g.: Pressing of axis **Y** results in X = F (Y).

Via the GO TO -key another compensation axis can be selected, i.e. another table can be edited.

E.g. GO TO **Z** means Z = F (X).

For each axis to be compensated, only one table can apply.

Individual lines are selected via the cursor keys ↓ ↑. As of line 4, the GO TO -key can also be used.

Datum for correction values (2nd line)

The datum is the starting point for compensation of the erroneous axis. This point is entered in absolute and is referenced to the reference mark. The correction value of the datum is stored under the address 0.
The datum should be allocated such, that corrections increase in the positive counting direction. If, for example, the datum is located to the left of the reference mark, the distance to the datum is entered as a negative value.

Description of machine parameters
Machine parameter for the axes

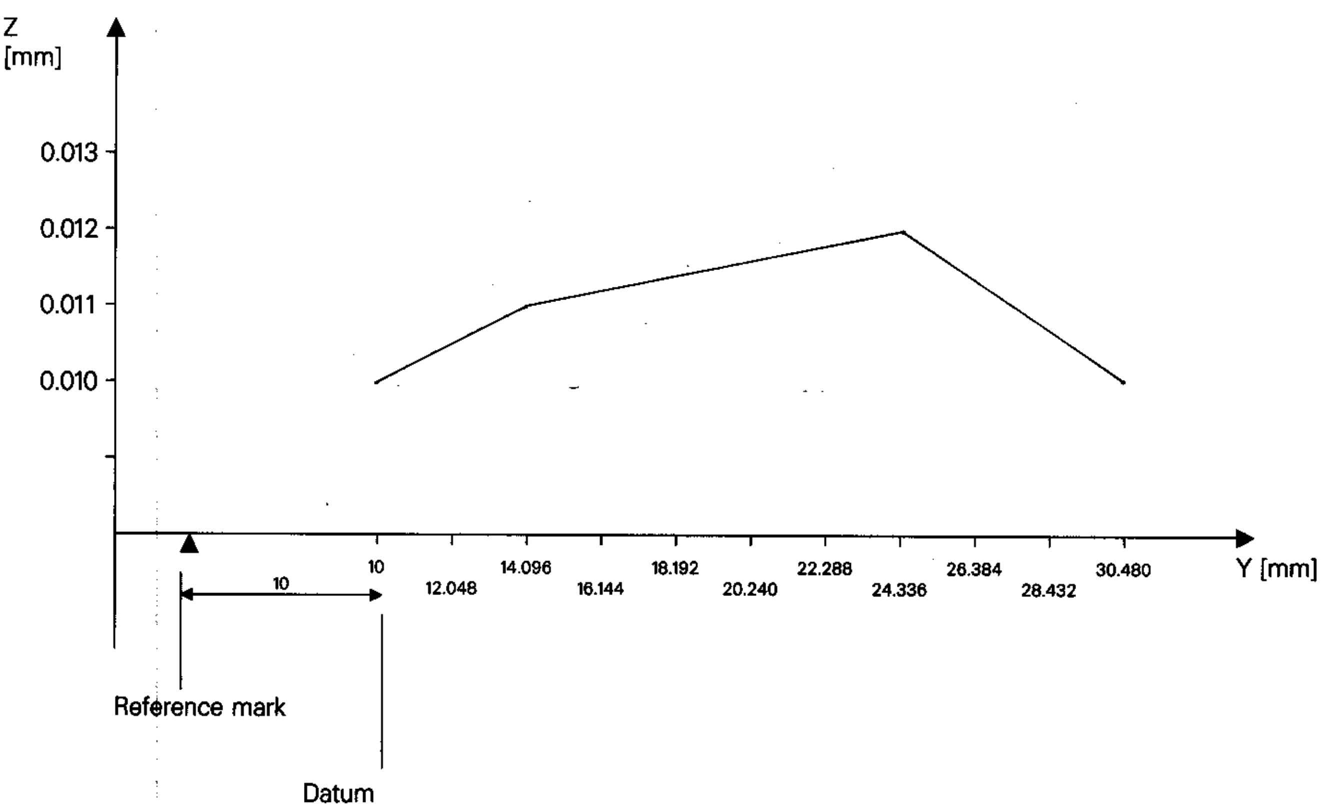
Spacings between correction points (increment) (3rd line)

The spacing increment for the 64 correction points is entered as an indice to the base of 2. The entry range is 1 ... 20 corresponding 2 µm ... 1.048 m
Example: Required spacing 32 µm
$32 \triangleq 2^5$
therefore, entry value for DIST = 5

Correction values

As of the 4th line up to 64 correction values can be stored in addresses 0 to 63 for each table. Only the kink-points of the error curve have to be entered. ([NO ENT] means that an entry is not made). Linear interpolation exists between the kink-points. It should be noted that the maximum possible gradient of the compensation curve of 1 mm/m should not be exceeded, otherwise the error message COMP. VALUE DIFFERENCE EXCESSIVE is displayed.

Example: Z = F (Y); DIST = 11 ⟹ Spacing 2^{11} = 2.048 mm; Datum = 10



The editing procedure is ended by pressing [END]. However, for every correction point, the keys [ENT] or [NO ENT] must be pressed; otherwise the error message "COMP. VALUE DIFFERENCE EXCESSIVE" is displayed.

Input and output of correction lists via the RS-232-C/V.24 data interface

In addition to manual entry, the tables can be read-in via the RS-232-C/V.24 data interface. Similar to the machine parameter list, this program is called-up via a program number. Data transmission is carried out, as normal, via the [EXT]-key.

Description of machine parameters
Machine parameters for displays

MP 65 **Display step**
0 ≙ 1 µm
1 ≙ 5 µm
The 5 µm display step is normally sufficient for milling and boring.
The optimisation of approach behaviour is carried out with a 1 µm display step.

For entry value = 1 the programmed nominal value is rounded to Ø or 5 µm.
With active Hirth coupling (MP 92 Bit 6, see sheet C2/6), MP 65 determines the display step only for the axes X, Y, Z. Axis IV is governed by MP 260.

MP 92 **Multiple function parameter**

Bit 0 **Decimal character**
+ 0 ≙ Decimal comma
+ 1 ≙ Decimal point

Bit 0 of MP 92 influences the decimal sign of the position display as well as the decimal sign for data output via the RS-232-C/V.24 data interface (see sheet D1/6).

Bit 5 **Counting mode if the axis IV operates as position display for a rotary table**
+ 0 ≙ Axis IV counts 0 ... 29 999.999 [°]
+ 32 ≙ Axis IV counts 0 ... 359.999 [°] → 0

If the axis IV operates as a position display for a rotary table and is always rotated in the same direction, the counter will overflow after 29 999.999°. The position display after 359.999° is reset to 0 by setting bit 5 of MP 92.

Bit 1 to bit 4 and bit 6 see sheet C1/9.

MP 167 **Display of momentary feed prior to start in manual operating mode**
0 ≙ No display
1 ≙ Display

If a display of the momentary feed is requested, and if the feeds in MP 4 to MP 7 and MP 322 vary, the feed in all axes is reduced to the lowest value within MP 4 to MP 7 and MP 322.[05]

MP 191 **Display of the momentary spindle rpm prior to start**
0 ≙ Off
1 ≙ On

[05] When traversing over the reference marks, MP 167 is no longer effective as of software level 05.

Description of machine parameters
Machine paramters for machine operation

MP 68 **Memory function for direction buttons**
0 ≙ Off
1 ≙ On

MP 68 activates the memory function for the external direction buttons which can be realised via marker 2450 and complement marker 2466 (see sheet P3/22).

The memory function permits continuous traverse of axes even after the release of the external direction buttons.

MP 74 **Feed and spindle overrides**

Bit 0 **Feed override if the rapid traverse button is pressed in operating mode "Program run"**
+ 0 ≙ Override inactive
+ 1 ≙ Override active

Bit 1 **Feed override in 2%-stages or variable**
+ 0 ≙ 2%-stages
+ 2 ≙ Variable

Bit 2 **Feed override if the rapid traverse button and the external direction buttons are pressed in the "manual" mode**
+ 0 ≙ Override inactive
+ 4 ≙ Override active

Bit 3 **Spindle override in 2%-stages or variable**
+ 0 ≙ 2%-stages
+ 8 ≙ Variable

Datum set for axis V

The datum of axis V can either be set via axis key V or MP 337.

MP 334 **Datum set via axis key V**
0 ≙ Inactive, the reference mark is transferred from MP 337
1 ≙ Active

MP 337 **Datum for axis V**
Entry range: – 30000.000 ... + 30000.000 [mm]

Description of machine parameters
Machine parameters for control programming

MP 170 **Control as programming station**
0 ≙ Control
1 ≙ Programming station: PLC active
2 ≙ Programming station: PLC inactive

The TNC 355 can be used as a programming station without additional wiring.

MP 217 **Changeover HEIDENHAIN dialogue-programming – ISO-programming**
0 ≙ HEIDENHAIN dialogue
1 ≙ ISO (G-codes)

When compiling programs directly at the machine, we recommend programming according to the HEIDENHAIN-dialogue-concept.
With external compilation of programs, the ISO-format (G-codes) can be advantageous, since postprocessors in the ISO-format are often less expensive to create.
When changing over, all NC-programs contained in the TNC-memory are translated into the appropriate programming language.

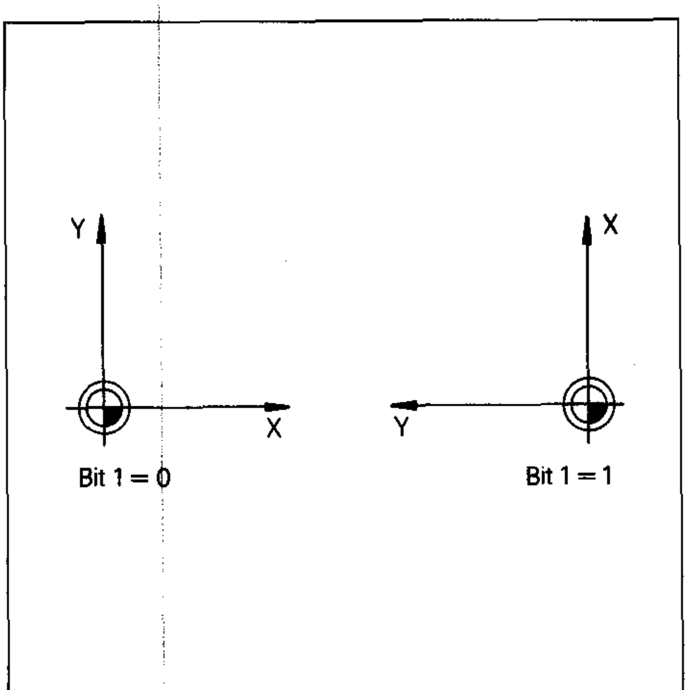
MP 236 **Graphics**

Bit 0 **Changeover of the "Projection in three planes"**
+ 0 ≙ German standard
+ 1 ≙ U.S. standard

"Projection in three planes" can be changed over from the U.S. standard to the German standard with bit 0.

Bit 1 **Rotation of the coordinate system by 90°** in the working plane
+ 0 ≙ No rotation
+ 2 ≙ Coordinate system rotated

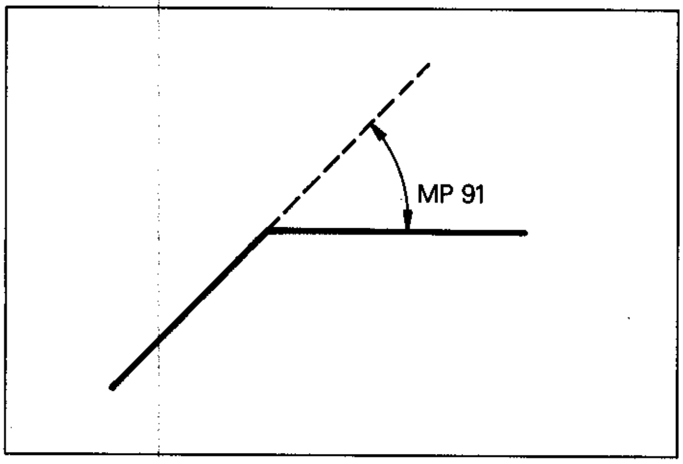
With bit 1 the working plane can be rotated by 90° in the graphics display. This is convenient if e.g the Y-axis operates as the tool axis.



Description of machine parameters
Machine parameters for program run

MP 91 **Constant contouring speed at corners**
Entry range: 0 ... 179.999 [°]

MP 91 determines the angle with which a contour corner is milled at a constant contouring speed.
This machine parameter is effective for operation with speed precontrol as well as in trailing operation.



If a high contouring speed is necessary, a low value has to be entered for MP 91.
When machining 3D-contours, a high entry value is recommended.

MP 92 **Multiple function parameter**

Bit 4 **Change from program run single block to program run full sequence when machining continuous contours**
+ 0 ≙ The precalculated contour is completed (up to 14 blocks)
+ 16 ≙ Interruption of current block

Bit 0 to bit 3, bit 5 and bit 6 see sheet C1/9

MP 93 **Stepover factor for pocket milling**
Entry range: 0.1 ... 1.414

MP 93 determines the stepover factor for the tool path in the canned cycles "Pocket Milling" and "Circular Pocket". The feed during rough-out milling is calculated according to the formula:

Feed = MP 93 x tool radius

MP 93 is **not** effective with the cycle **"Rough-out"** for variable contour pocket milling.

MP 173 **Erasure of the status display with M02, M30 and program end**
0 ≙ Status display is not erased
1 ≙ Status display is erased

If MP 173 is programmed with "1", the coordinate conversions, the current tool and the Q-parameters are erased at the end of a machining program.

MP 213 **Cycle "Scaling factor" effective for 2 or 3 axes**
0 ≙ 3 axes (in 3D)
1 ≙ 2 axes (working plane)

MP 214 **Output of M- and S-functions**

Bit 0 **Programmed stop with M06**
+ 0 ≙ Programmed stop with M06
+ 1 ≙ No programmed stop with M06

Bit 1 **Output of M89**
+ 0 ≙ Normal output at the beginning of block
+ 2 ≙ Modal cycle call at end of block

Bit 2 **Axis halt if spindle rpm only is changed with a TOOL CALL**
+ 0 ≙ Axis halt
+ 4 ≙ No axis halt

Bit 3 **Axis halt with output of an M-function**
+ 0 ≙ Axis halt
+ 8 ≙ No axis halt

If bit 3 is set, the M-functions still have to be acknowledged. In this mode the following functions should **not** be executed:
- PLC-positioning (see sheet P3/7)
- Transfer of Q-parameters from the PLC to the NC
- Setting of gear range via the PLC

Axis halt cannot be cancelled with M-functions which result in a programmed stop (as M00, M02 ...) or by a STOP or by a CYCL-CALL-block.

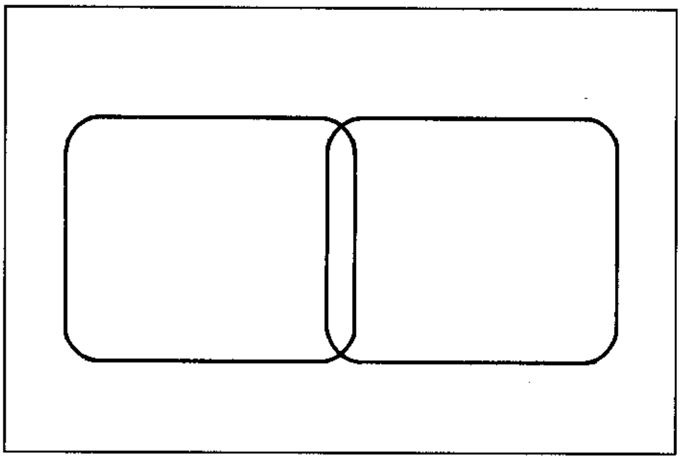
Description of machine parameters
Machine parameters for program run

MP 241 **Cycles for milling variable contour pockets**

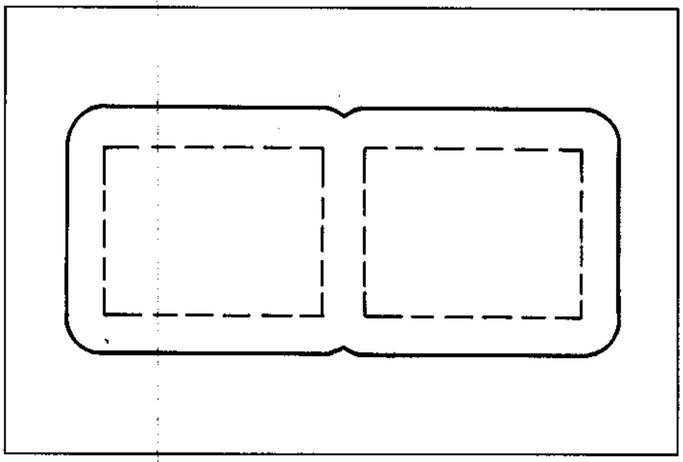
Bit 0 **Cycle Rough-out: milling direction for outline milling of contour**
+ 0 ≙ Outline mill pockets CCW, with islands CW
+ 1 ≙ Outline mill pockets CW, with islands CCW

Bit 1 **Cycle Rough-out: sequence for outline milling and roughing out**
+ 0 ≙ Outline mill, then rough-out pocket
+ 2 ≙ Rough-out pocket, then outline mill

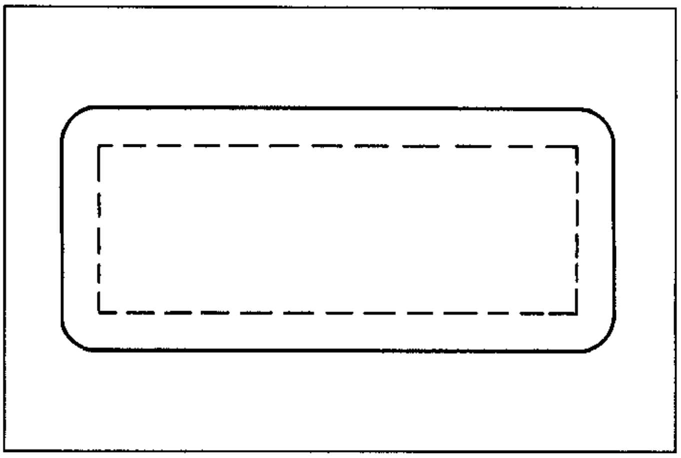
Bit 2 **Combining corrected or uncorrected contours (tool radius compensation)**
+ 0 ≙ Combine corrected contours
+ 4 ≙ Combine uncorrected contours



Example: Two pockets which slightly intersect.



Bit 2 = 0: (Entry + 0) The Control roughs-out out pockets separately, since the corrected contours (the paths of the tool centre) do not intersect. Material remains at the internal corners.



Bit 2 = 1: (Entry + 4) The control roughs-out out pockets simultaneously since the incorrected contours are combined and intersect. No material remains at the internal corners. For the combining of incorrected contours the control requires more computing time than that for the combining of corrected contours.

Please note:
There may be cases, especially in Q-parameter programs in which the combination of incorrected contours may lead to undesired results. In such cases bit 2 = 0 should be entered (Entry + 0).

Positioning blocks with M92

If function M92 is programmed in a positioning block, the nominal value of the position is not referenced to the workpiece datum, but to a position which is defined by MP 186 to MP 189. (The entry values are referenced to the reference point of the appropriate axis).

MP 186	**Axis X**	Entry range:
MP 187	**Axis Y**	− 30000.000 ... + 30000.000 [mm]
MP 188	**Axis Z**	Rotary axis:
MP 189	**Axis IV**	− 30000.000 ... + 30000.000 [°]

Datum corrections defined by machine parameters

Three datum corrections can be entered for all axes via **MP 303** to **MP 314** and **MP 339** to **MP 341**.
These datum corrections are activated by markers (see sheet P3/36).

The required datum is defined with markers 2816 and 2817:

M2817	M2816	
0	0	No datum correction
0	1	1st Datum correction
1	0	2nd Datum correction
1	1	3rd Datum correction

The datum correction is activated by marker 2819.

After activation, the position display indicates the position now referenced to the shifted datum.

Example:

Actual value for X-axis (if M2819 not set) = 100
MP 303 = **+ 20** i.e. 1st datum correction for X-axis = + 20
M2816 = 1
M2817 = 0 } i.e. 1st datum correction selected

If M2819 is now set, the datum value from MP 303 is added to the value in the actual position display.
This results in an actual value display for the X-axis = 120.
This corresponds to a datum correction (displacement) of the X-axis by **− 20.**
The 1st, 2nd or 3rd datum correction is always added to the original actual value being displayed (100 in this example).

Description of machine parameters
Machine parameters for the canned cycle "Tapping"

MP 67 **Dwell time for rotation change of working spindle for "tapping" cycle**
Entry range: 0 ... 65.535 s

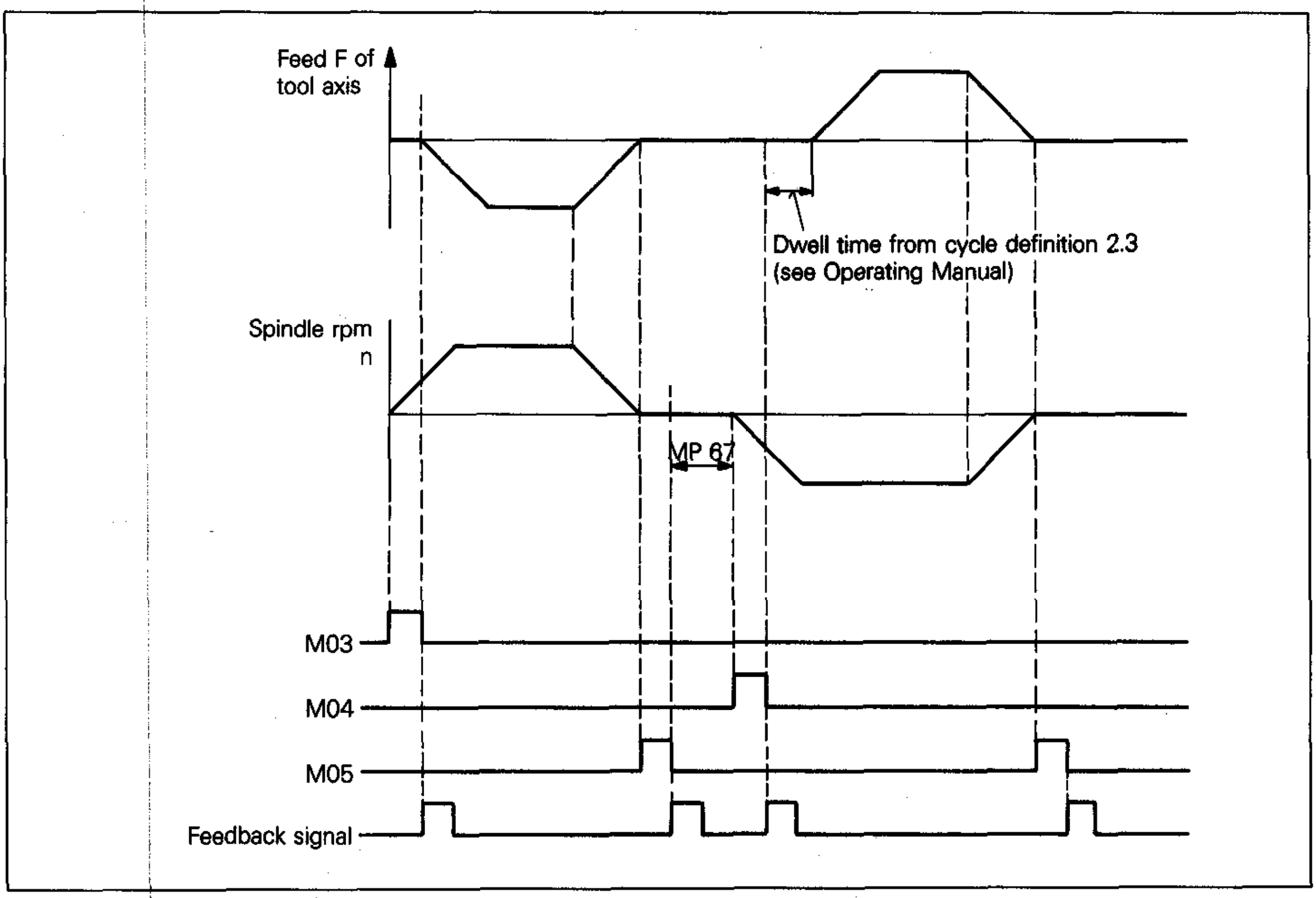
MP 73 Advanced switchpoint for switch-off time of spindle during "tapping" cycle (only effective with BCD-output of spindle rpm)

Entry range: 0 ... 65.535 s

MP 182 **Minimum feed override with "tapping" cycle**
Entry range: 0 ... 150 [%]

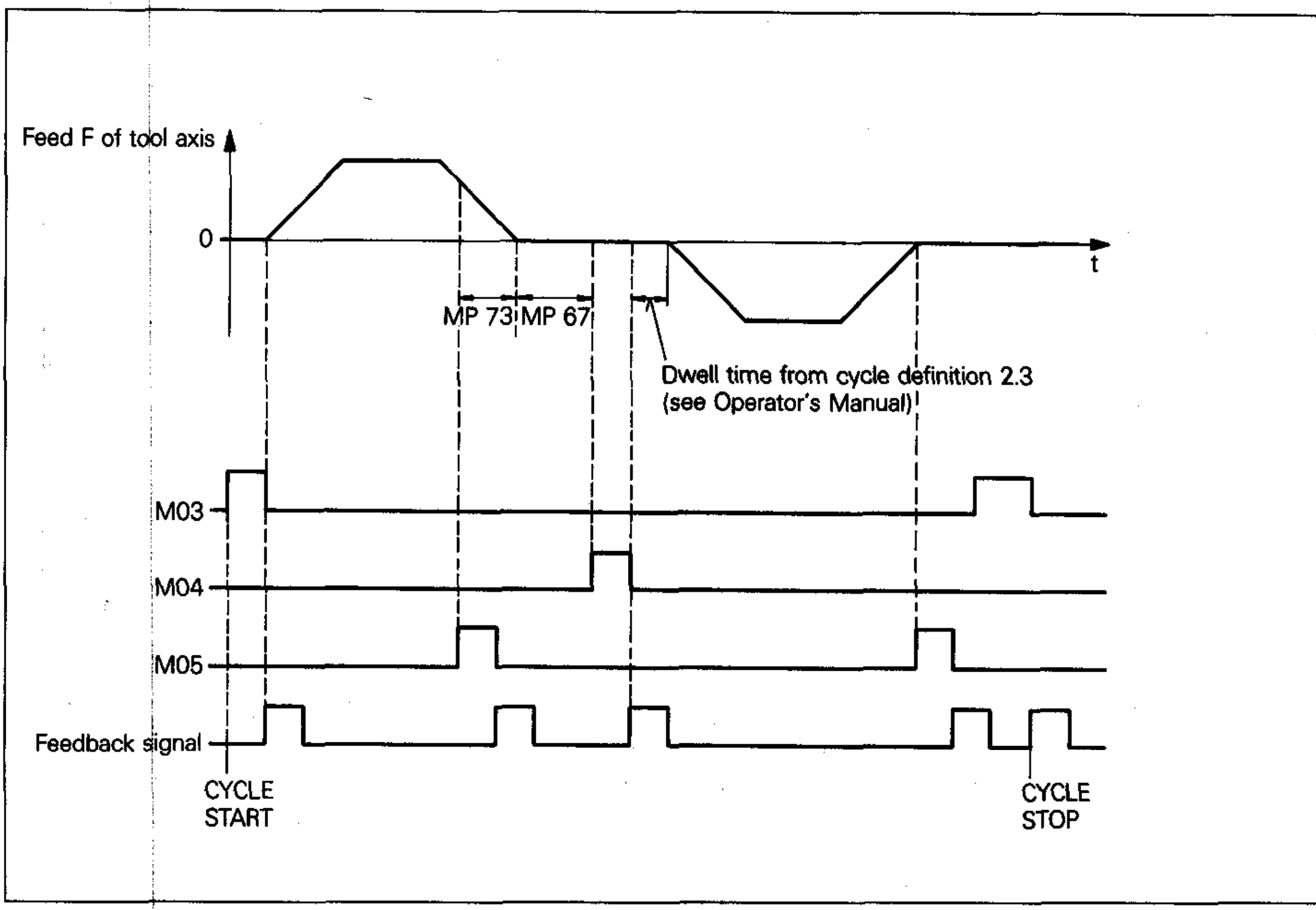
MP 183 **Maximum feed override with "tapping" cycle**
Entry range: 0 ... 150 [%]

Timing diagram for "tapping" cycle with analogue output of spindle rpm



Description of machine parameters
Machine parameters for canned cycle "Tapping"

Timing diagram for "tapping" cycle with BCD-coded output of spindle rpm



Description of machine parameters
Machine parameters for tool numbers and toolchanger

MP 61 **Output of tool numbers or tool pocket numbers**
0 ≙ No output
1 ≙ Output of tool number, only when tool number changes
2 ≙ Output of tool number with every tool call
3 ≙ Output of tool pocket number

Entry value "3" is only significant if the central tool file has been addressed by MP 225.

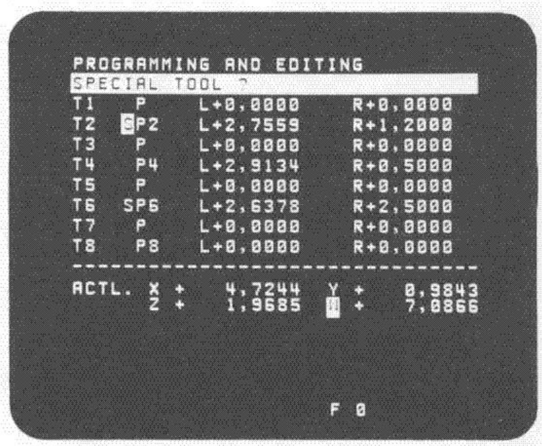
MP 157 **Activation of next tool number, programmable with TOOL CALL ../.. or the following tool pocket number, programmable with TOOL DEF**
0 ≙ No output of next tool number
1 ≙ Output of next tool number only when tool number (TOOL CALL ../..) is changed
2 ≙ Output of next tool number with every tool call (TOOL CALL ../..)
3 ≙ Output of next tool pocket number, programmable with TOOL DEF.

The entry value "3" is only significant if the central tool file has been addressed by MP 225.

MP 225 **Central tool file**
0 ≙ No central tool file
1 ... 99 ≙ Central tool file

The number of tools of the central tool file is entered into MP 225. The central tool file is therefore automatically addressed.

The central tool file is addressed via program number 0 and then edited, output and read-in in the operating mode "programming and editing". Up to 99 tools can be stored. The tool number, the length and the radius are entered for each tool including the tool pocket number if a tool magazine with flexible addressing is being used.



Depending on what is selected for MP 61 and MP 157 the control transmits either the tool number or the tool pocket number to the integral PLC when the central tool file is active, i. e. tool magazines with
.fixed tool pocket addressing and
.flexible addressing
can be controlled.

Via PLC-inputs tool and pocket numbers can be read-in in BCD-code and stored in the central tool file, e. g. for automatic insertion into the tool magazine.

Tool magazine with fixed tool pocket address

MP 61 **Entry value 1 or 2**

If MP 61 contains entry value 1 or 2, the central tool file does **not store** tool pocket numbers. The NC-part of the control only transmits the tool number to the integral PLC. Therefore, a tool magazine with fixed tool pocket addressing can be controlled.

MP 157 **Entry value 1 or 2**

If MP 157 contains the entry values 1 or 2 the entry of the number for the next tool is requested when programming a tool call. The VDU display:

TOOL CALL ../..

During a tool call, the control therefore outputs the number of the current tool and, in addition, the number of the subsequent tool.

Tool magazine with flexible addressing

MP 61 **Entry value 3**

MP 157 **Entry value 3**

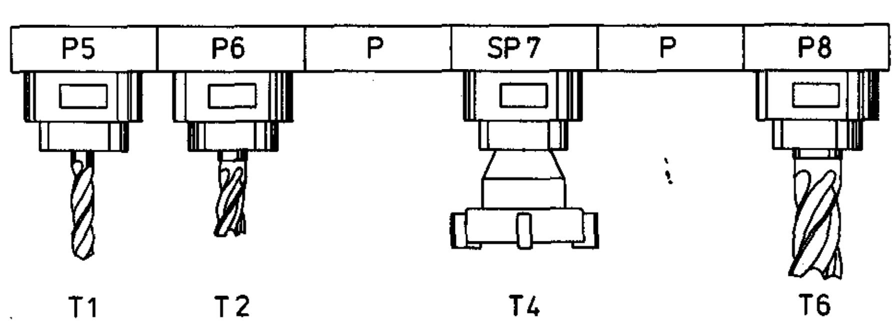
If **MP 61** and **MP 157** contain the entry value **3** the control takes over the administration of the tool pocket numbers. The NC-part of the control transmits the tool pocket number to the integral PLC, thus enabling a tool magazine with flexible addressing to be controlled. Flexible addressing means that during machining the next tool is being sought in the toolchanger and, with a subsequent toolchange, the old tool is exchanged for a new tool. The control remembers which tool number is stored under which tool pocket number. The tool being sought is programmed via TOOL DEF.
Tools which – due to their size – occupy three tool pockets are considered as special tools. A special tool is either always stored in a permanent pocket or is exchanged for another special tool (depending on marker 2601). A special tool is programmed by setting the cursor to the dialogue question
SPECIAL TOOL?
and responding with the END-key.

For safety reasons, with special tools, the preceding and following tool pocket numbers should be erased by setting the cursor and pressing the NO ENT-key. Instead of an erased tool pocket number a * is displayed.

"S" for special tool and "P" for tool pocket number are only displayed if the value 3 was entered in MP 61 and MP 157.

When using special tools, P0 (spindle) – or another pocket in the magazine – has to be vacant!

Vacant tool pocket numbers to accomodate a special tool



P.. tool pocket numbers within the magazine
SP7 tool pocket number for special tool

Commissioning the machine
Code numbers for commissioning

Certain operating conditions and functions are selected by code numbers.

Code number entry is via the MOD-key. After pressing MOD and ↑, the dialogue

CODE NUMBER

is displayed.

The desired code number is entered and ENT is pressed.

Code number	Function
95148	**Machine parameter mode** Exit via the DEL-key or END-key
951026	**PLC-mode** Exit via the END-key
531210	**Erasure of machine parameters** and PLC-markers M1000 ... M2000
84159	**Traversing of reference marks** with direction buttons
75368	**Automatic offset adjustment** (see sheet C4/8)
105296	**Non-linear axis compensation** Editing of correction tables (see sheet C2/6.1) Exit via the END-key

Commissioning the machine
Checks before switch-on

.Check installation and grounding as described in sections M5 and M8.

.Check wiring of encoders as described in section M3.

Caution!
Before switching-on the interface cabinet, the 24 V-supply voltage from the NC-part and the PLC-part of the TNC 355, as well as the mains supply of the VDU have to be disconnected at the terminals.

Furthermore, we recommend that all servo-amplifiers be separated from the power supply prior to switching-on the interface cabinet.

Commissioning the machine
Checks subsequent to switching-on the interface cabinet

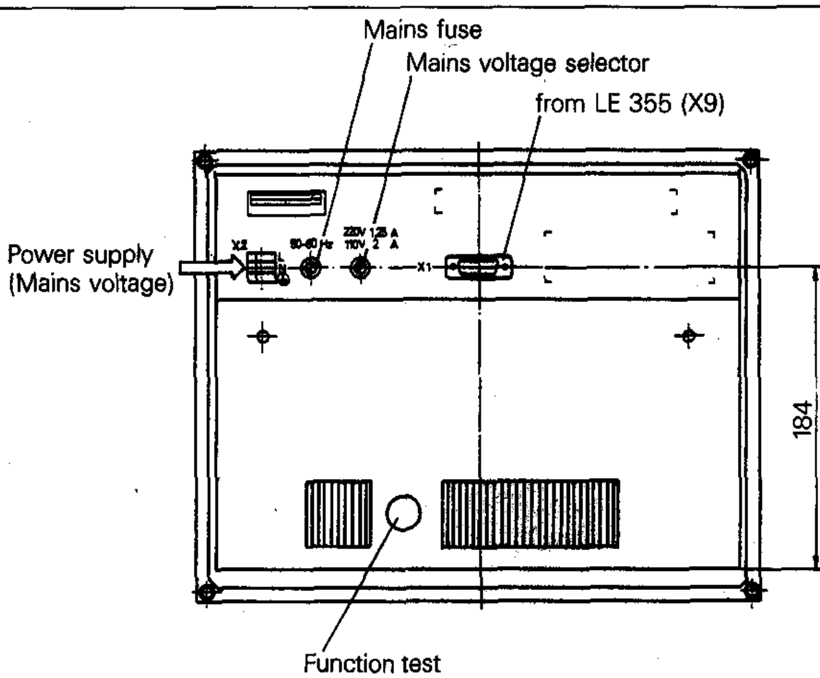
Checking the supply voltage for the LE and PLC

The voltage from both power supply units have to correspond with the definition on sheet M5/1.

Checking the mains voltage for BE

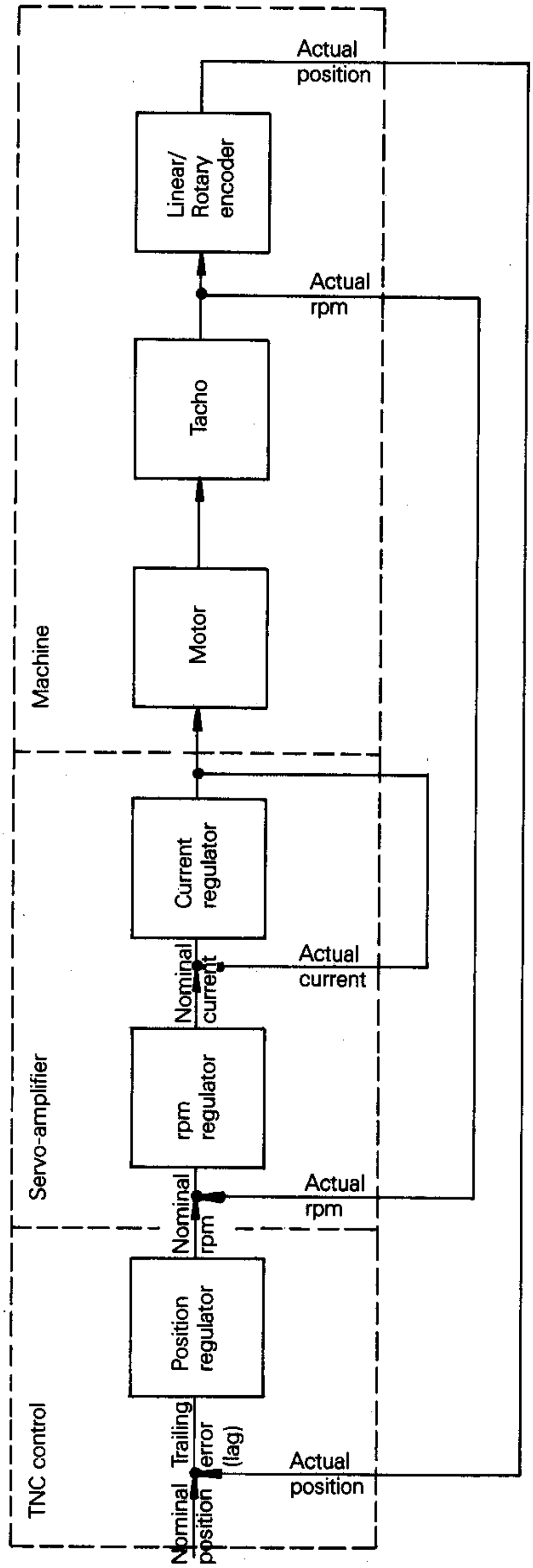
The visual display unit BE 412B is supplied by an AC mains voltage. The operating voltage can be set from two ranges via the voltage selector. Before connecting the VDU, check the voltage selected and the mains fuse rating.

Supply voltage	Voltage range	Frequency range	Power consumption	Mains fuse
110 V~	85 V~ - 132 V~	48 ... 62 Hz	approx. 40 W	M 2 A
220 V~	170 V~ – 264 V~			M 1.25 A



Commissioning the machine
Description of position loop

Block circuit diagram of a position loop



Commissioning the machine
Description of position loop

A position loop consists of
.the regulator and
.the regulating path.

For NC-machines the **regulator** is specified as a cascade regulator. The

position regulator } control

is subordinate to the

rpm regulator
and the } servo-amplifier
current regulator

The **regulating path** is constituted by the machine with motor and axis slide.

Commissioning the machine
Commissioning the servo-amplifiers

Commissioning has to be carried out in the following sequence for all servo-amplifiers:

- **Short-circuit the nominal value line**
  Disconnect terminals and short-circuit the nominal value line at the servo-amplifier.
- **Activate regulator enable**
  Disconnect regulator enable at the servo-amplifier and wire externally.
- **Apply power supply**
  Apply power supply at the servo-amplifier.
- **Coarse offset adjustment**
  If the axis moves, adjust offset potentiometer such, that the axis comes to a standstill. After the offset adjustment, remove the short-circuit bridge at the nominal value input again.
- **Coarse speed adjustment**
  Connect battery to the nominal value input.
  Adjust 9 V at the battery and tune the driving motor via the tacho-potentiometer to the nominal rpm. The nominal rpm can be determined with a tachometer at the drive motor.
- **Optimising the servo-amplifier**
  (see below)
- **Determination of acceleration**
  (see sheet C3/8)

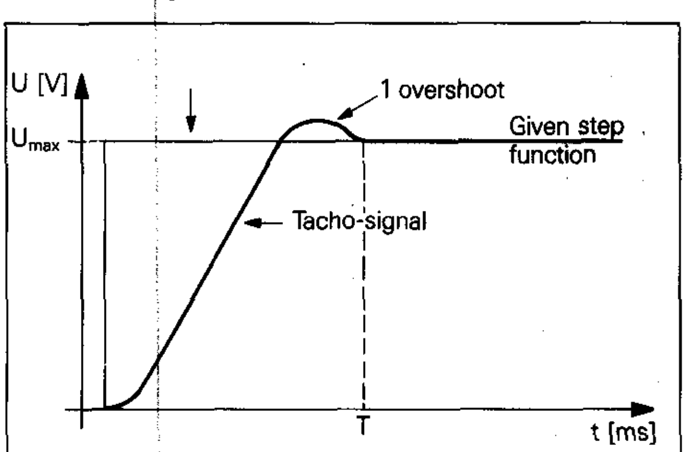
Optimising the servo-amplifier

For the control the regulated path consists of a servo-amplifier, motor and axis slide.

Before optimising the position loop of the control, the regulated path has to be optimised first.

The characteristic feature of a controlled system is the "step response".

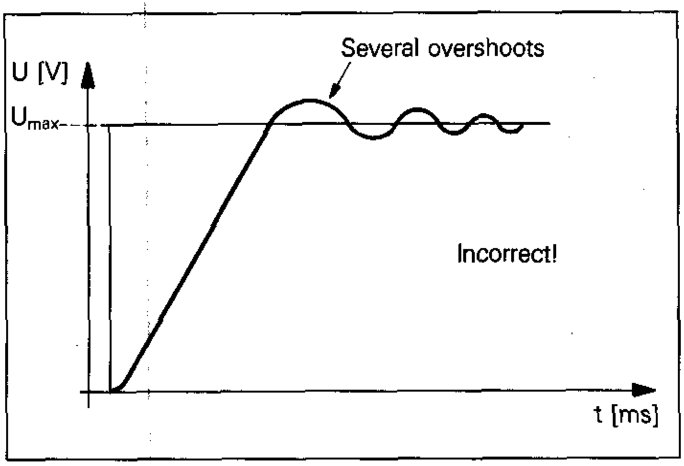
A step function (9 V) is applied at the input of the servo-amplifier with a battery-operated unit. The step response of the tacho-signal can be displayed with an oscilloscope. When determining the step response, the axis should be loaded with the admissible weight of the workpiece.



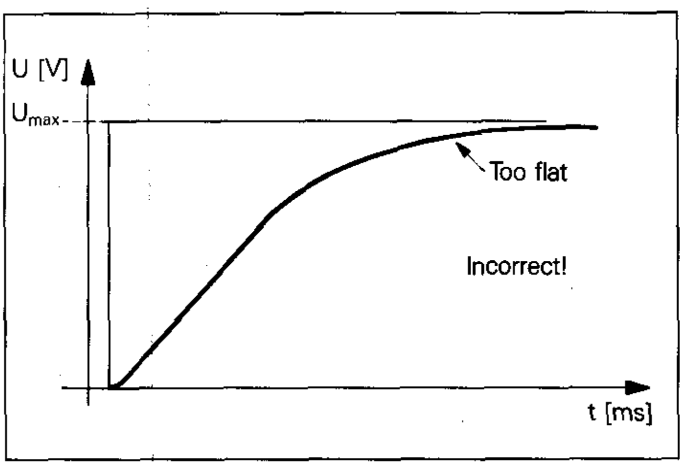
The subordinate position loops (current regulator and rpm regulator) must be optimised such, that the step response displays **one overshoot** in the tacho-signal picture.

Commissioning the machine
Commissioning the servo-amplifier

The signal should not be as follows:



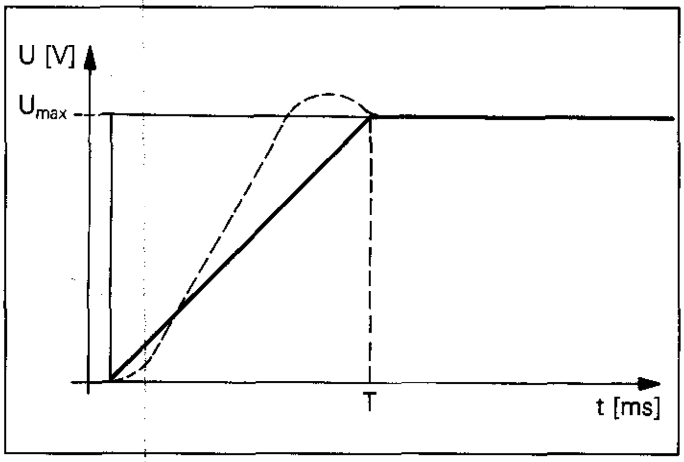
P-part of the subordinate position loops to high or I-part too low



P-part of the subordinate position loops too low or I-part too high

Determining the acceleration

The maximum acceleration can be determined from the step response. For simplicity it is assumed that the tacho-signal shows a linear characteristic.



The acceleration time T can be derived from this diagram.

For safety reasons the time T is extended by 10 %.

Therefore:

$$\boxed{T' = 1.1 \times T}$$

The acceleration results from:

$$\boxed{a = \frac{V_{max}}{T'}}$$

The step response has to be determined for all axes.

The values determined for the acceleration are also the **entry values for MP 54, MP 297, MP 298, MP 299 and MP 335.**

Commissioning the machine
TNC switch-on

Switch-off interface cabinet after checking the supply voltages and adjusting servo-amplifiers. Connect supply voltage to the NC and the PLC-parts of the TNC and the VDU and also connect the nominal value lines to terminals.

After switch-on, the TNC carries out a RAM memory test and check sum test for EPROM and RAM. This test can be selectively cancelled via MP 92. Waiting time during commissioning can therefore be avoided if the mains has to be switched-off often.

MP 92 **Multiple function parameter**

Bit 2 **Memory test when switching-on (RAM)**
+ 0 ≙ Memory test is carried out
+ 4 ≙ No memory test

Bit 3 **Checksum test when switching-on (RAM + EPROM)**
+ 0 ≙ Checksum test is carried out
+ 8 ≙ No checksum test

Bit 0, bit 1 and bit 4 to bit 6 see sheet C1/9.

After the memory test the control displays the message:

OPERATING PARAMETERS ERASED.

Enter machine parameters as described in sheets C1/23–26.

After entry of the machine parameters the TNC responds with

POWER INTERRUPTED.

If the machine-specific PLC-program is not stored in the PLC-EPROM, the PLC-program has to be entered into the RAM-memory as described in section P4.

Commissioning the machine
Selecting the dialogue language

Two dialogues are stored in the TNC 355.

After switching-on the control, plain language dialogues appear in the first language on the screen.

English is contained as a second dialogue language in every TNC 355. The following dialogue languages are available:

First dialogue language	Second dialogue language
German	**English**
French	English
Italian	English
Spanish	English
Danish	English
Dutch	English
Finish	English

Selection of the second dialogue language "English"

If the commissioning of export machines is not possible in the language of the country of destination, the possibility of commissioning in the English dialogue language is possible in most cases. This therefore eliminates the necessity of a dialogue EPROM change. Changeover is via machine parameter MP 92.

MP 92 **Multiple function parameter**

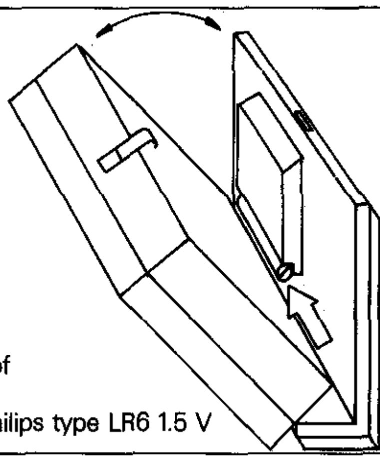
Bit 1: **Dialogue language**
+ 0 ≙ First dialogue
+ 2 ≙ Second dialogue (English)

(Bit 0 and bit 2 to 6, see sheet C1/9).

Commissioning the machine
Buffer battery

The buffer battery is the voltage backup source of the RAM-memory for NC-programs, PLC-programs and machine parameters, when the control is switched-off.
If the message
= EXCHANGE BUFFER BATTERY =
is displayed, the batteries have to be exchanged.

The batteries are located behind a screwed PG-gland within the power supply unit of LE 355.
In addition to the batteries, an accumulator is used with the TNC 355 for backup of the memory content.
The mains voltage can therefore be switched-off when exchanging the batteries. The accumulator buffers the memory content, without batteries, for approx. 2 weeks. The accumulator is only charged when the TNC is switched-on.



Battery type
Mignon cells, leak-proof
IEC-designation „LRG":
Recommendation: Philips type LR6 1.5 V

Commissioning the machine
Output "Control operational"

The output "Control operational" is available as an option on the LE 355 (connector X21, pin 34) and on the power board PL 300 (terminal X3, pin 10). Only the loading capacity with 100 mA, respectively 1.2 A is different.

A malfunction of the control or the machine is displayed by this function. All important conditions of the control electronics, encoders and machine are monitored.

A flashing error message is displayed simultaneously when switching-off the control voltage externally.

The condition "Control non-operational" can only be cancelled by switching-off the mains supply for the TNC 355 after rectification of the fault.

If a malfunction of the control or the machine is discovered, the output "Control operational" is opened. At the same time, all PLC-outputs are switched-off, i.e., opened. This also applies to the outputs which are supplied via the non-disconnectible 24 V voltage.

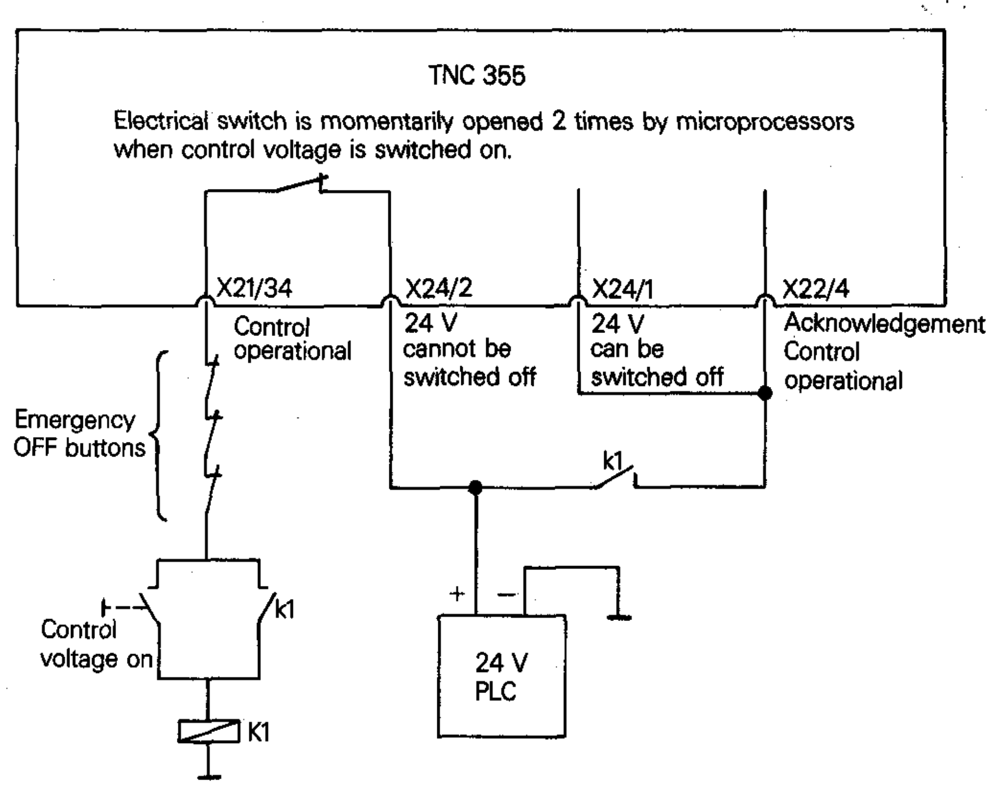
Checking the "Control operational" function

In the event of a fault, the output "Control operational" should switch-off the 24 V-supply voltage in the machine interface. Since this function is very important for safety, this output is monitored by the control for every mains voltage switch-on.

The output "Control operational" is controlled by two monoflops:

.Monoflop for the position loop processor
.Monoflop for the main processor

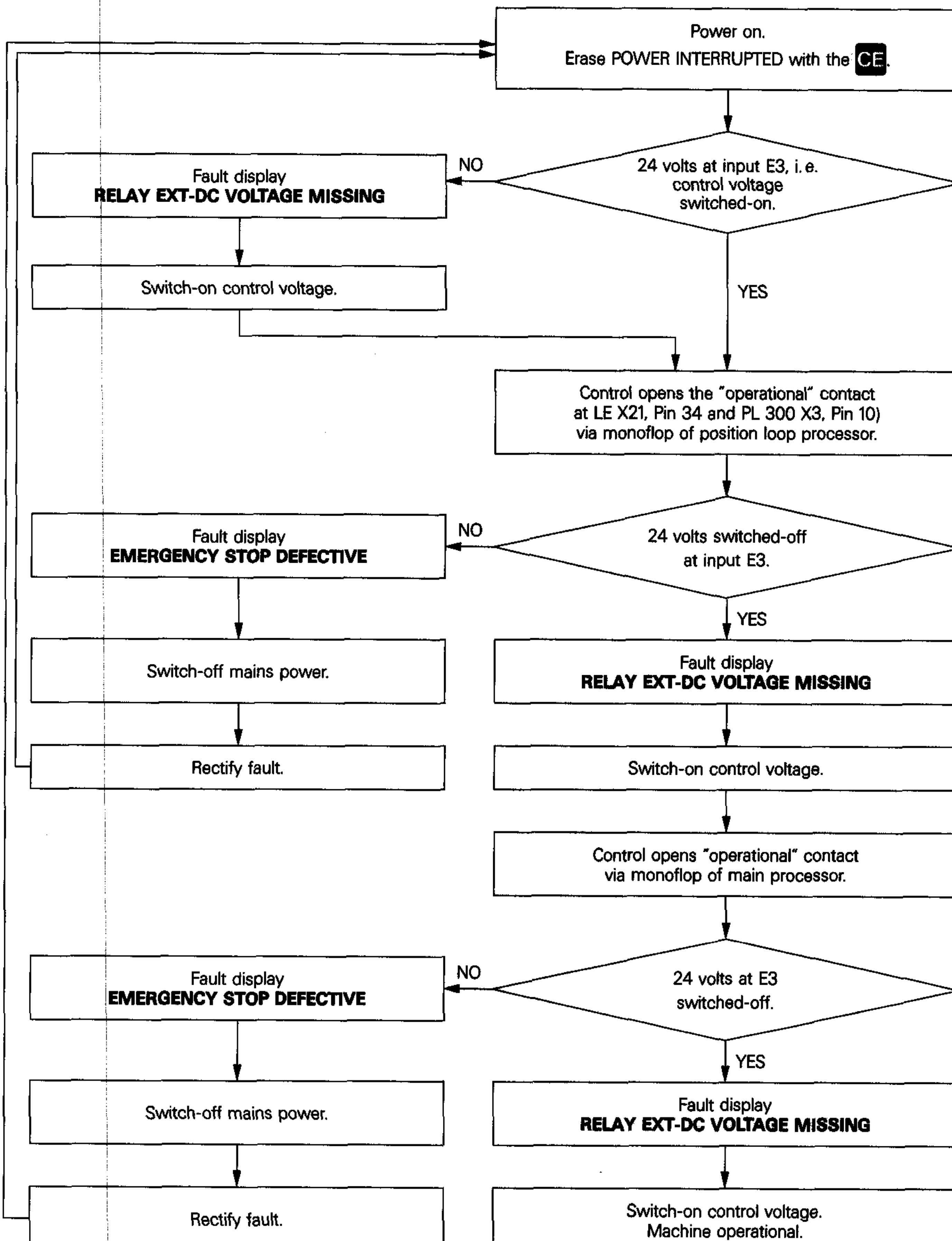
Both directions of this output are monitored when switching-on the control (see flow diagram, sheet C3/14).



PLC-input E3 (connector X22): Acknowledgement for monitoring of output "Control operational"

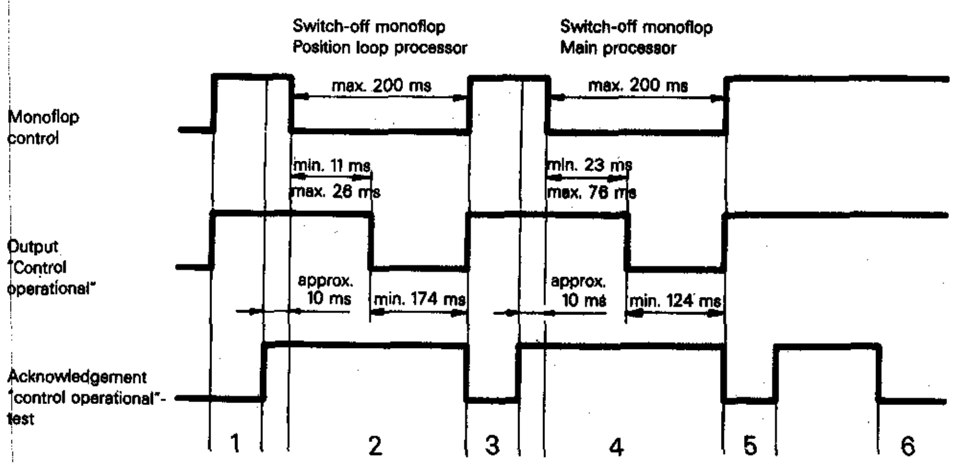
Commissioning the machine
Output "Control operational"

Check routine for output "Control operational"



Commissioning the machine
Output "Control operational"

Timing diagram



	Fault display
1. Wait for control voltage	**RELAY EXT-DC VOLTAGE MISSING**
2. The control voltage has to switch-off within 174 ms, otherwise ...	**EMERGENCY STOP DEFECTIVE**
3. Wait for control voltage	**RELAY EXT-DC VOLTAGE MISSING**
4. The control voltage has to switch-off within 124 ms, otherwise ...	**EMERGENCY STOP DEFECTIVE**
5. Wait for control voltage	**RELAY EXT-DC VOLTAGE MISSING**
6. Control-external process switches-off control voltage	**EXTERNAL EMERGENCY STOP**

External EMERGENCY STOP

If the control voltage + 24 V is switched-off by an external control function the control will display the error message "EMERGENCY STOP".
This error message is not displayed in the flashing mode and can be erased with the CE-key by switching-on the control voltage once more.

Attention!

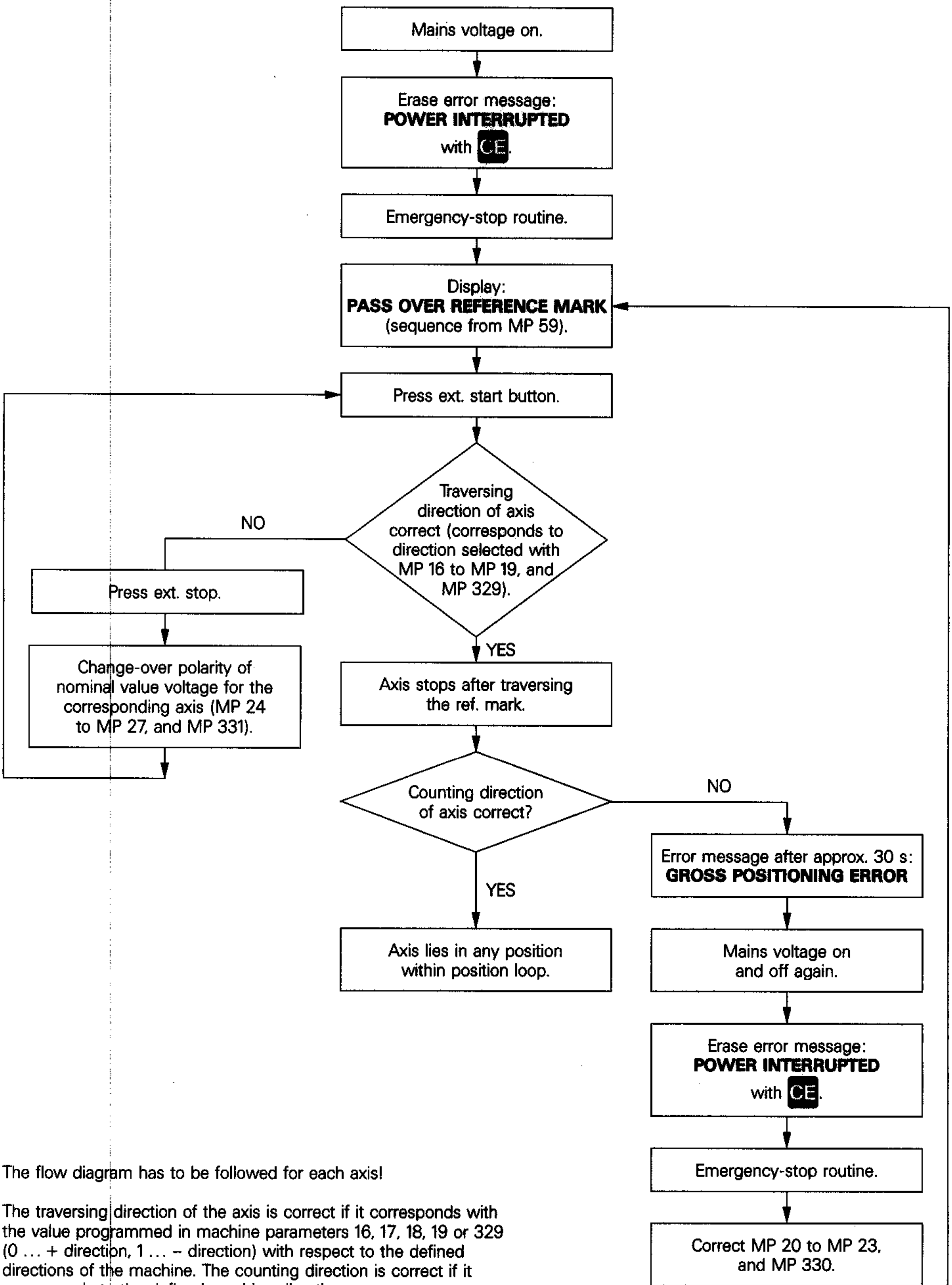
The external Emergency stop is evaluated by the control as an external stop. If the external Emergency stop is activated during an axis movement, the axis moved is decelerated as with an external stop. If the servo-amplifiers are blocked by an external emergency-stop and the programmed values from machine parameters 56 to 175 (position supervision erasable), respectively machine parameters 57 or 174 (position supervision EMERGENCY STOP) are exceeded, the error message POSITIONING ERROR or GROSS POSITIONING ERROR A is displayed.

Commissioning the machine
Checking the external emergency-stop circuit

Check the function of the external emergency-stop circuit by pressing

.the emergency-stop push-knob and
.the emergency-stop limit switches of the axes.

Commissioning the machine
Checking the traversing and counting directions



The flow diagram has to be followed for each axis!

The traversing direction of the axis is correct if it corresponds with the value programmed in machine parameters 16, 17, 18, 19 or 329 (0 ... + direction, 1 ... – direction) with respect to the defined directions of the machine. The counting direction is correct if it corresponds to the defined machine directions.

Commissioning the machine
Software limit switch ranges

Determination of machine-related axis limit values

In operating mode "Manual" select display mode REF via .

Position display show distance to the reference mark.

Traverse all axes until shortly before emergency-stop limit switches – using either the direction buttons or the handwheel – in positive or negative direction, and note display values on position displays including sign.

Program values noted for MP 44 to MP 51, and MP 325, MP 326.

Select display mode **ACTL** via .

Optimising the NC-axes

Preconditions

For precise and fast positioning of the machine axes, the machine parameters have to be optimised for acceleration and approach, at the control.

Before optimising, the following conditions have to be fulfilled:

.All commissioning checks carried out (see section C3)
.Current rpm regulators of servo-amplifiers adjusted
.Machine parameters programmed with preliminary entry values. List of preliminary machine parameters (see C1/3 to C1/22).
.Complete PLC-program entered for all machine functions.
.Software limit switch ranges determined.

Operation with trailing error or with speed precontrol

With machine parameter 60 it can be selected as to whether the control operates with speed precontrol or with trailing error.

MP 60 **Speed precontrol**
0 ≙ Speed precontrol on
1 ≙ Speed precontrol off, operation with trailing error

Optimising the NC-axes
Trailing operation

In the modes "Manual", "Programming and editing" and "Electronic handwheel", operation with trailing error is always selected, independently of machine parameter 60.

In the operating modes "Teach-in", Program run single block" and "Program run full sequence" machine parameter 60 has to be programmed with "1" for operation with trailing error.

Advantages:

.High computing speed
.Function M 90 "Constant contouring speed on corners" is effective.

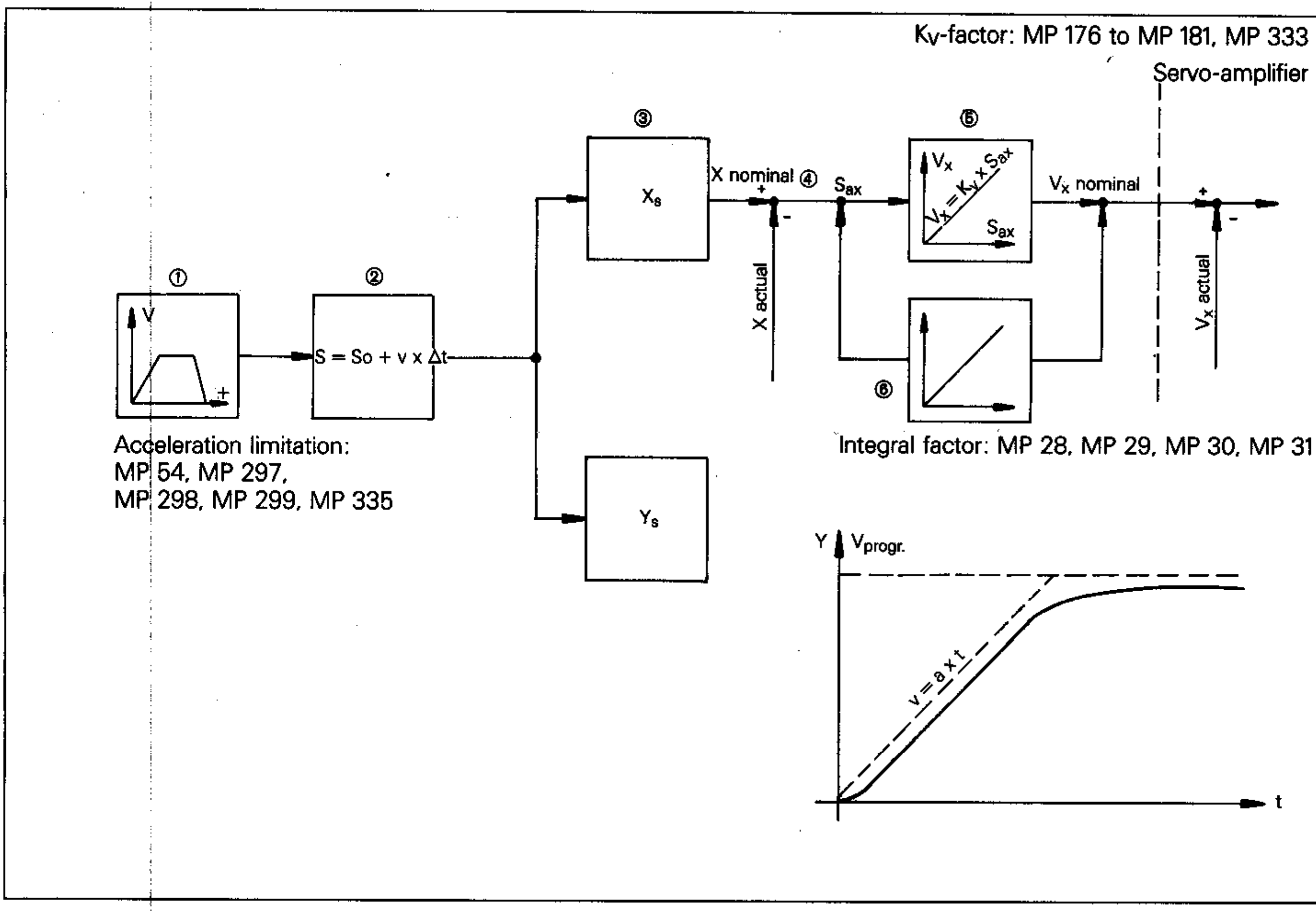
Therefore both make the operation with trailing error suitable for 3D-contouring operation.

Disadvantage:

Contouring errors can occur with high traversing speeds; a programmed circle radius will become smaller, depending on the K_V-factor and the traversing speed.

Optimising the NC-axes
Trailing operation

With acceleration limitation via MP 54, MP 297, MP 298, MP 299, MP 335



① The control calculates the nominal value of the speed every 6 ms taking the entered acceleration into consideration (MP 54, MP 297, MP 298, MP 299, MP 335).

② The nominal value of the travel is determined every 6 ms from the nominal value of the speed.

$s = s_0 + v \times \Delta t$

- s = nominal value of travel
- s_0 = previous nominal value of travel
- v = nominal value of speed
- Δt = cycle time for the closed loop (6 ms)

③ The nominal value of the travel is separated in X- and Y- (if necessary Z-) components.

④ The axis-related nominal value of the travel is compared with the actual value of the position and the trailing error S_a is determined.

$S_{ax} = X_{NOMINAL} - X_{ACTUAL}$

- S_{ax} = trailing error for the X-axis
- $X_{NOMINAL}$ = nominal value of travel for the X-axis
- X_{ACTUAL} = actual value of travel for the X-axis

⑤ The trailing error is multiplied by the K_v-factor and is transferred as the nominal value of the speed (analogue voltage) to the servo-amplifier.

$V_{XNOMINAL} = K_V \times S_{ax}$

- $V_{XNOMINAL}$ = nominal value of the speed for the X-axis
- K_V = position loop gain factor
- S_{ax} = trailing error for the X-axis

⑥ With stationary axes, the integral factor is additionally effective; it effects an offset adjustment.

Optimising the NC-axes
Operation with speed precontrol

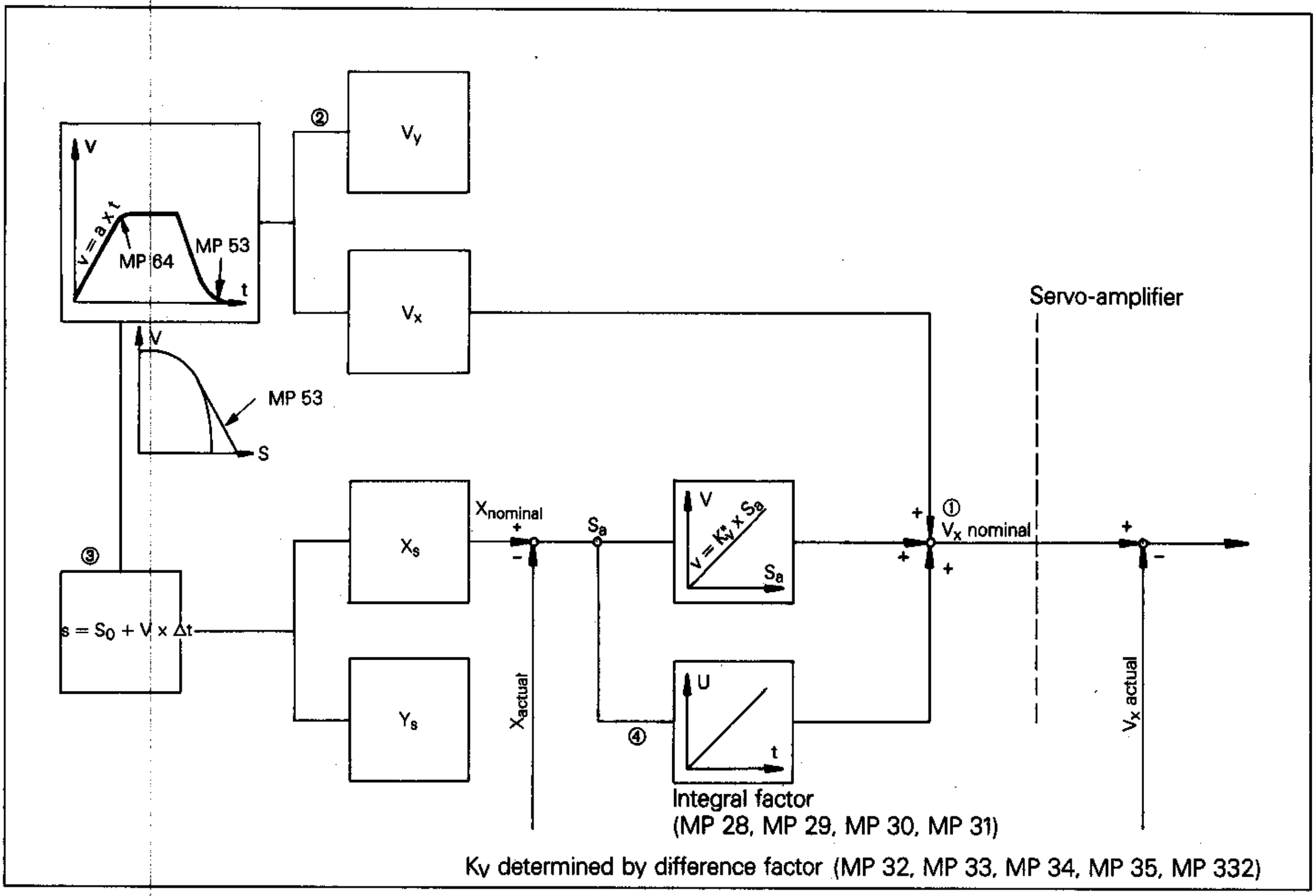
In the operating modes "Positioning with manual input", "Program run single block" and "Program run full sequence" machine parameter 60 has to be programmed with "0" for operation with speed precontrol.

Advantage:
High contouring accuracy with high speed.

Disadvantage:
Less suitable for 3D-contour machining.

Please note:
Operation with trailing error is always effective for manual operating modes.

Optimising the NC-axes
Operation with speed precontrol



① For operation with speed precontrol, the nominal value of the speed (analogue voltage to servo-amplifier) is generated by three components:
.speed precontrol
.trailing error and
.integral part

② The speed component allows operation with a trailing error close to "0", which means in most cases, the nominal value of the position corresponds to the actual position value.

③ Small deviations around the actual position value are compensated for as described in "Operation with trailing error".

④ With stationary axes the integral factor is additionally effective; it effects an offset adjustment.

Optimising the NC-axes
Voltage increment at nominal value output

The nominal value outputs of the TNC 355 are equipped with a 12 bit digital-analogue converter, i.e. $2^{12} - 1 = 4095$ steps can be output. The maximum voltage of the analogue outputs is 10 V, thus resulting in a smallest voltage increment of 10 V : 4095 = 2.44 mV.

Output of a voltage increment, see sheet C4/11 and C4/26.

By setting machine parameters it can be determined as to when the smallest possible voltage increment is output for a small nominal value deviation.[04]

MP 20	**Axis X**	Bit 3, output of smallest voltage increment of 2.44 mV
MP 21	**Axis Y**	Entry values:
MP 22	**Axis Z**	+ 0 ≙ Output of 2.44 mV, if calculated nominal value is equal to, or greater than
MP 23	**Axis IV**	1.22 mV.
MP 330	**Axis V**	+ 8 ≙ Output of 2.44 mV, if calculated nominal value is greater than 0.

By entering the value + 8 a nominal value voltage is output, even with the slightest deviation of the nominal value (i.e. one counting pulse from the encoder.

[04] As of software level 04 (5 axes) and 09 (4 axes).

Optimising the NC-axes
Fine offset adjustment at the servo-amplifier

Check entry values for the following machine parameters:

Function		Parameter No.	Entry value
Integral factor	X	28	0
	Y	29	0
	Z	30	0
	IV	31	0
Factor for difference value	X	32	1
	Y	33	1
	Z	34	1
	IV	35	1
	V	332	1
Speed precontrol		60	0 ≙ on
Display step		65	0 ≙ 1 µm
Automatic drive offset adjustment		252	0

Optimising the NC-axes
Fine offset adjustment at the servo-amplifier

Erase offset memory

Erase offset memory at the TNC control as follows:

Enter code number 75368 and press .

↓

Press .

↓

Exit from MOD-operating mode with .

Switch on trailing error display and select operating mode "Program run"

Press three times.

↓

Dialogue display:
POSITION DISPLAY

↓

Press until
LAG
appears in front of axis designation X.

↓

Exit from MOD-operating mode with .

↓

Select operating mode "Program full sequence" ,
"Program single block" or
"Positioning with manual data input" .

↓

Carry out fine offset adjustment
Turn offset potentiometers until trailing error display show "0" or symmetrically oscillate about "0".

Optimising the NC-axes
Fine offset adjustment through the control

Offset adjustment via a code number

An automatic offset adjustment can be carried out by entering code number 75386. The control displays the offset values in the dialogue line in the sequence X, Y, Z, IV, (V) in 2.44 mV-units, e.g.

0 1 0 2

The display signifies: no offset in the X-axis, 2.44 mV in Y, no offset in the Z-axis and 4.88 mV in axis IV.
The automatic offset adjustment is addressed by pressing the -key. The offset values displayed in the screen are transferred and the control automatically outputs a corresponding voltage to compensate the offset values.
If the offset adjustment is to be switched-off, the code number 75368 has to be re-entered and the -key pressed.

Automatic drive offset adjustment

A duration can be programmed via machine parameter 252, after which the automatic offset adjustment is repeated.

MP 252 **Automatic drive offset adjustment**
Entry range: 1 ... 65535 [in units from 20 ms]
0 ≙ No automatic adjustment

The automatic offset adjustment is carried out if the given duration has lapsed and the following conditions have been fulfilled:
.all axes are at a standstill
.the spindle is not switched-on and
.the axes are not clamped.

Moreover, an offset adjustment is immediately carried out after approaching the reference marks.
With controlled traversing an adjustment is also possible within the duration between "Nominal value in target" and "Actual value not in the target window", providing the nominal value is in the target for longer than 5 s.

With every offset-adjustment 2.44 mV are compensated. If the offset voltage is greater than 2.44 mV, it is completely compensated after several adjustment cycles.

The maximum admissible offset voltage is 100 mV. If this voltage is reached or exceeded, the error message

= GROSS POSITIONING ERROR E =

is displayed.

Automatic offset adjustment with the aid of the integral factor

The integral factor (MP 28, MP 29, MP 30, MP 31) also carries out an automatic offset adjustment. The effect and the optimisation of the integral factor is explained in C4/21....

Since the integral factor is **continuously** in operation, this could lead to an instability of the closed loop if the drives have a slight backlash. HEIDENHAIN therefore recommends the integral factor 0 in this case.

Optimising the NC-axes
Speed adjustment through the control

Check entry values for the following machine parameters:

Function		Parameter No.	Entry values
Integral factor	X Y Z IV	28 29 30 31	0 0 0 0
Factor for difference value	X Y Z IV	32 33 34 35	1 1 1 1
Approach speed in precontrol mode		53	1
Acceleration	X	54	value from the adjustment, sheet C3/8
Position supervision for operation with speed precontrol	 (erasable) (emergency-stop)	 56 57	 10 30
Speed precontrol		60	0
Acceleration	Y Z IV	297 298 299	values from adjustment, sheet C3/8
Diff. factor for speed precontrol Acceleration	V V	332 335	1 value from adjustment, sheet C3/8

With auxiliary operating mode switch-over displays to trailing error.

↓

Enter following program in operating mode
PROGRAMMING AND EDITING

```
LBL 1
X 100¹⁾ R0 F 29998
X    0  R0 F 29998
CALL LBL   1  100/100
```

↓

Press ext. start in operating mode[2]
AUTOMATIC PROGRAM RUN
Machine runs,
actual value displays show trailing error.

↓

At servo-amplifier using velocity potentiometer (tacho-feedback), tune trailing error to a mean for both directions as near to "0" as possible.

↓

Repeat adjustment for all the other axes.

[1] Program traverse range as large as possible for the corresponding axis.

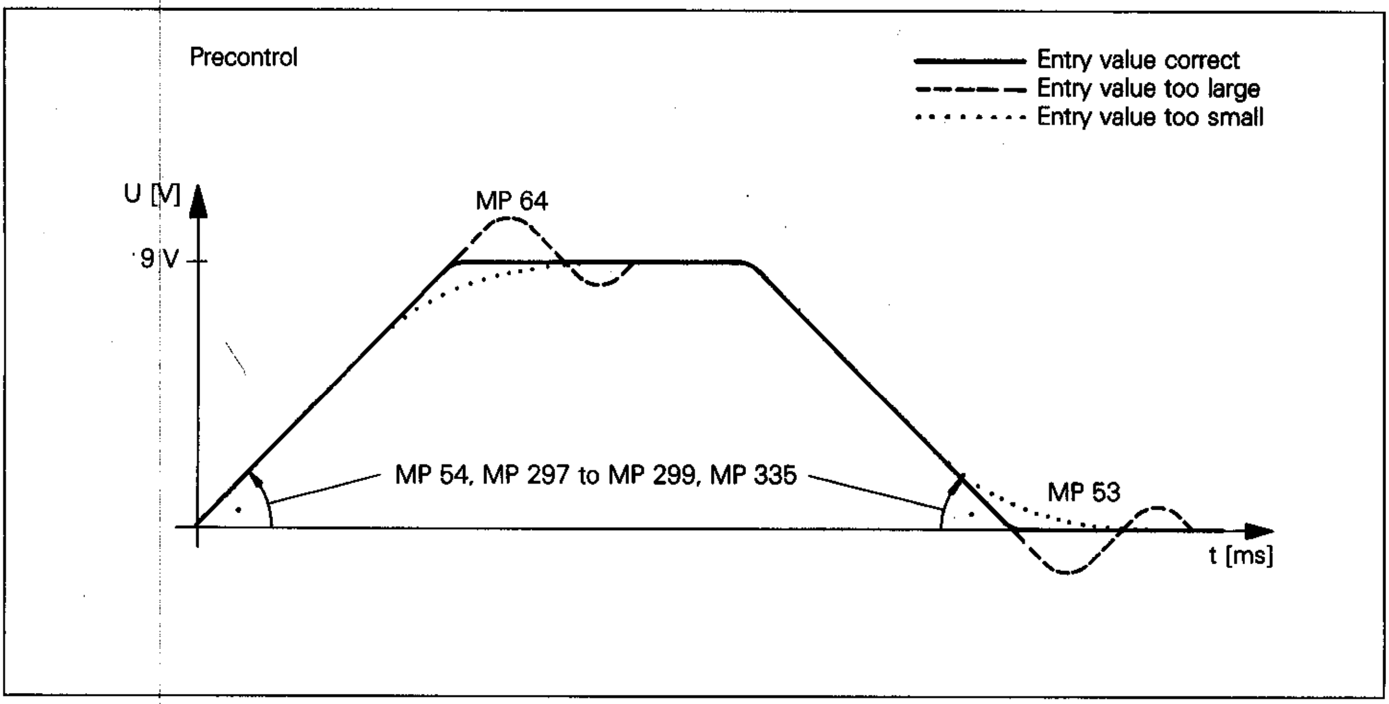
[2] Reduce feed speed with override potentiometer for preadjustment of the trailing error, if necessary.

Optimising the NC-axes
Optimising operation with speed precontrol

Machine parameters for operation with speed precontrol

Check entry values for the following machine parameters:

Function		Parameter No.	Preliminary entry value
Integral factor	X Y Z IV	28 29 30 31	0
Factor for difference value	X Y Z IV	32 33 34 35	1
Analogue voltage at rapid	X	52	9 [V]
Approach speed in precontrol mode		53	0.5 [m/min]
Acceleration	X	54	Entry value from sheet C3/8 or 0.2 [m/s^2]
Speed precontrol		60	0 ≙ on
Oscillation behaviour when accelerating		64	0.1
Acceleration	Y Z IV	297 298 299	Entry values from sheet C3/8 or 0.2 [m/s^2]
Analogue voltage at rapid	Y Z IV	300 301 302	9 [V]
Difference factor for speed precontrol	V	332	1
Acceleration	V	335	Entry values from sheet C3/8 or 0.2 [m/s^2]
Analogue voltage at rapid	V	338	9 [V]



Optimising the NC-axes
Optimising operation with speed precontrol

Difference factor

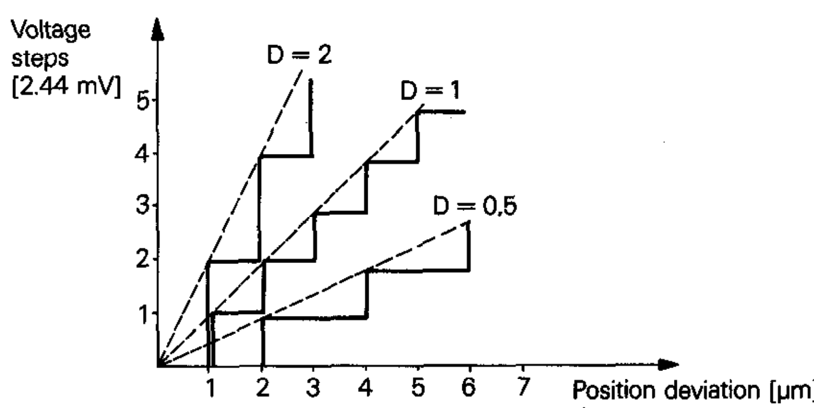
The difference factor is the multiplier for the voltage difference per µm position deviation from the nominal value.

$\Delta U = D \times 2.44$ mV ΔU = Voltage difference per µm position deviation
D = Difference factor

The control can only output full converter steps.

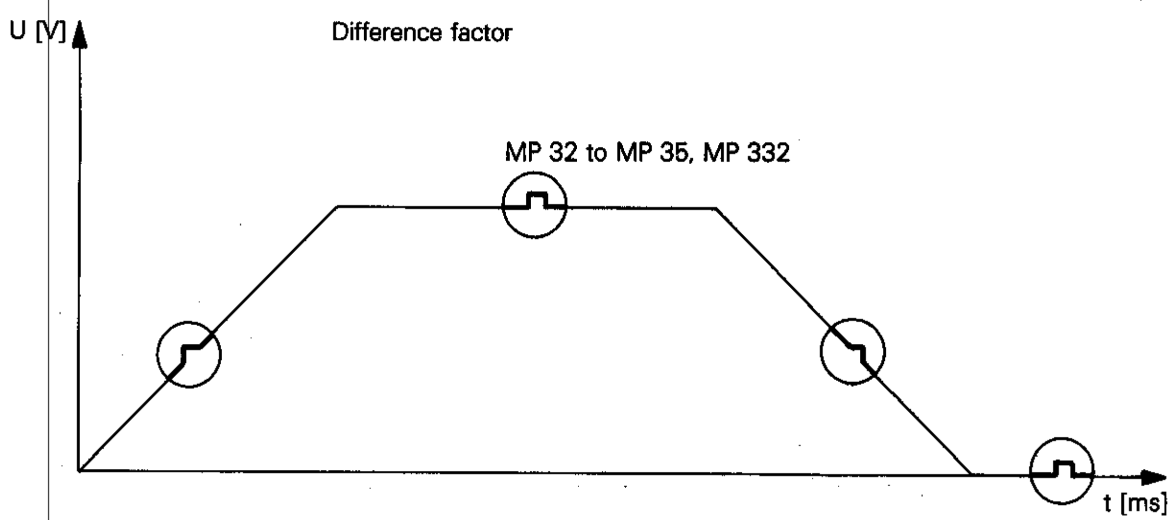
Example:
.with D = 1 position deviation 2.44 mV is output per µm
.with D = 0.5 position deviation 2.44 mV is output per 2 µm
.with D = 2 position deviation 4.88 mV is output per µm (double converter step).

The effect of the difference factor with various entry values is shown by the following diagram:



Optimising the NC-axes
Optimising operation with speed precontrol

The difference factor is effective when an axis is stationary or moving.



If the K_V-factor and the rapid traverse of a machine are known, the difference factor can be taken from the following table (explanation of K_V-factor see sheet C4/25).

Rapid [m/min]	Minimal voltage step	$K_V = 1$	1.2	1.4	1.6	1.8	2
1	≥ 4.88 mV/µm	3.68	4.42	5.16	5.90	6.63	7.37
2	2.44 mV/µm	1.84	2.21	2.58	2.95	3.31	3.68
3		1.22	1.47	1.72	1.96	2.21	2.45
4	2.44 mV/2 µm	0.92	1.10	1.29	1.47	1.65	1.84
5		0.73	0.88	1.03	1.18	1.32	1.47
6		0.61	0.73	0.86	0.98	1.10	1.22
7		0.52	0.63	0.73	0.84	0.94	1.05
8	bad regulating behaviour at standstill	0.46	0.55	0.64	0.73	0.82	0.91
9		0.40	0.49	0.57	0.66	0.73	0.81
10		0.36	0.44	0.51	0.59	0.66	0.73
11		0.34	0.40	0.47	0.54	0.60	0.67
12		0.31	0.37	0.43	0.49	0.55	0.61
13		0.28	0.34	0.40	0.45	0.51	0.58
14		0.26	0.32	0.37	0.42	0.47	0.53
15		0.25	0.30	0.34	0.39	0.44	0.49
16		0.23	0.28	0.32	0.37	0.41	0.46

Optimising the NC-axes
Optimising operation with speed precontrol

The difference factor can be calculated for higher traversing speeds and higher K_V-factors. For intermediate values it can be calculated as follows:

1. Calculate trailing error

$$Sa = \frac{v}{K_V}$$

Sa = Trailing error (lag)
v = Rapid traverse
K_V = Position loop gain

$$Sa = \frac{4\ [m/min]}{1.2\ \frac{[m/min]}{mm}}$$

Sa = 3.333 mm

2. Calculate voltage step per µm position deviation

$$\Delta U = \frac{U_{max}}{Sa}$$

ΔU = Voltage step per µm position deviation
U_{max} = Output voltage with rapid traverse
Sa = Trailing error (lag)

$$\Delta U = \frac{9000\ [mV]}{3333\ [\mu m]}$$

$$\Delta U = 2.7\ \frac{[mV]}{[\mu m]}$$

3. Determine difference factor

$$D = \frac{\Delta U\ [mV/\mu m]}{2.44\ [mV/\mu m]}$$

D = Difference factor
ΔU = Voltage step per µm position deviation

$$D = \frac{2.7}{2.44}$$

$$D = 1.1$$

Please note:
The best regulating behaviour results from a

Difference factor $\geqq$ 1.

If the differential factor is substantially less than 1, operation with trailing error (lag) and characteristic kink is recommended (see C4/2).

Optimising the NC-axes
Optimising operation with speed precontrol

Optimise difference factor

Adjustment is carried out as follows:

Connect storage oscilloscope to tachometer of the servo-amplifier of the X-axis.

↓

Enter following program
in operating mode
PROGRAMMING AND EDITING

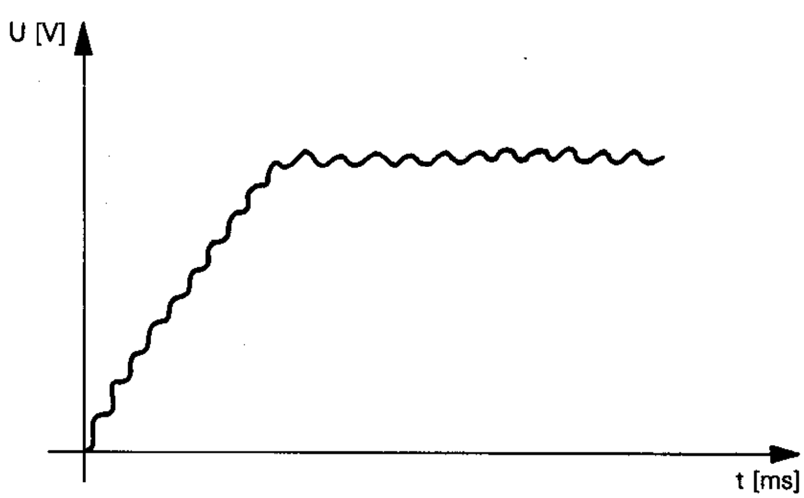
LBL 1
X 100 R0 F 29998
X 0 R0 F 29998
CALL LBL 1 Rep 100/100

↓

Press ext. start
in operating mode
PROGRAM RUN SINGLE BLOCK
Machine runs.

↓

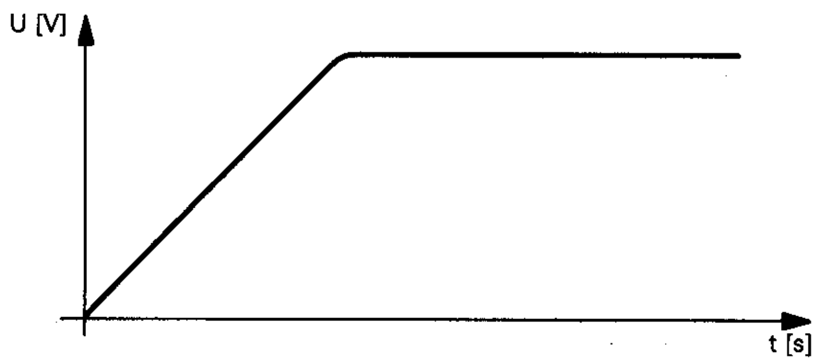
Difference factor MP 32: Increase entry value until position loop oscillates.



↓

Optimising the NC-axes
Optimising operation with speed precontrol

Difference factor MP 32: Reduce entry value until no oscillations can be detected.



Repeat adjustment procedure for axes Y, Z, IV and V.

Optimising the NC-axes
Optimising operation with speed precontrol

Optimise acceleration

If the maximum acceleration of the regulated path could not be determined with the battery-operated unit as decribed on sheet C3/8, the acceleration has to be optimised as follows:

Connect storage oscilloscope to tachometer of servo-amplifier of X-axis..

↓

Entry of following values for position supervision
MP 56: 0.5
MP 57: 30

↓

Enter following program in operating mode
PROGRAMMING AND EDITING

```
LBL 1
X 100   R0 F 29998
X   0   R0 F 29998
CALL LBL 1 Rep 100/100
```

↓

MP 54
Increase "Acceleration" in small steps.

↓

Press ext. start in operating mode
PROGRAM RUN SINGLE BLOCK
Machine runs.

↓

Control stops machine.
Error display
POSITIONING ERROR

NO → back to "MP 54 Increase "Acceleration" in small steps."

YES ↓

Enter acceleration from MP 54 in MP 297 to MP 299 and MP 335.
Traverse the Y, Z, IV and the V-axis with the acceleration value found.
Reduce values, if necessary.

↓

Enter the 0.7 to 0.9-fold factor of the determined values as acceleration in MP 54, MP 297 to MP 299 and MP 335.

Optimising the NC-axes
Optimising operation with speed precontrol

Radial acceleration

MP 55 **Radial acceleration**
Entry range: 0.001 ... 3.0 m/s^2

The machine parameter for radial acceleration limits the feed for circular movements via the following formula:

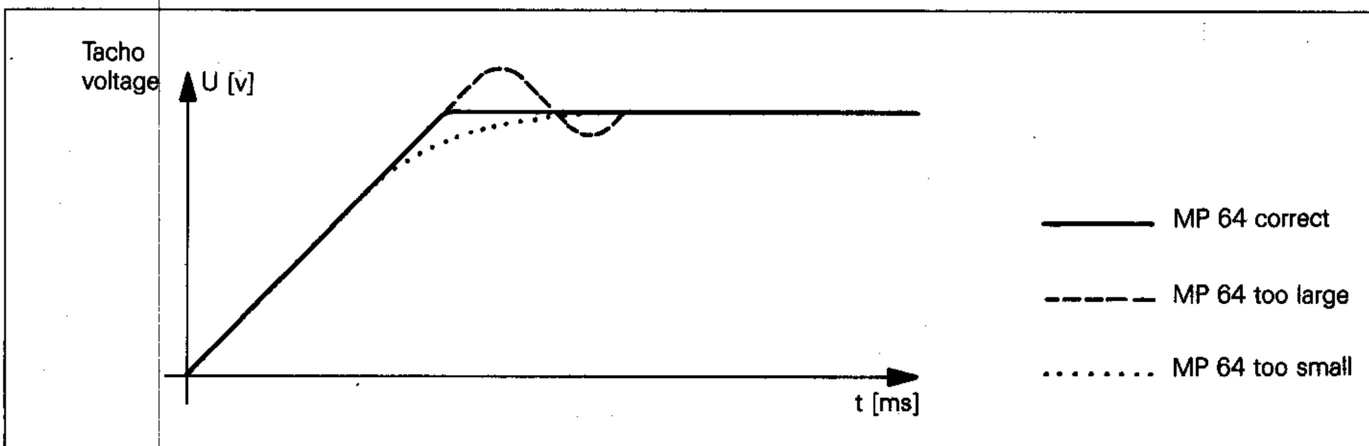
$$v = \sqrt{r \times MP\ 55}$$

v = Maximum feed for circular movements
r = Circle radius

For MP 55 HEIDENHAIN recommends a value ranging between half and the total value of MP 54.

Optimising the overshoot behaviour

The shape of the acceleration curve is influenced in all axes by MP 64.



Since MP 64 is effective for all axes, the worst axis determines the entry value. Overshoot should not occur in any axis.

Optimising the NC-axes
Optimising operation with speed precontrol

The adjustment is carried out as follows:

Connect storage oscilloscope to tachometer of the servo-amplifier X

↓

Enter following program in operating mode **PROGRAMMING AND EDITING**

```
LBL 1
X 100  R0  F  29998
X    0  R0  F  29998
CALL LBL 1  Rep 100/100
```

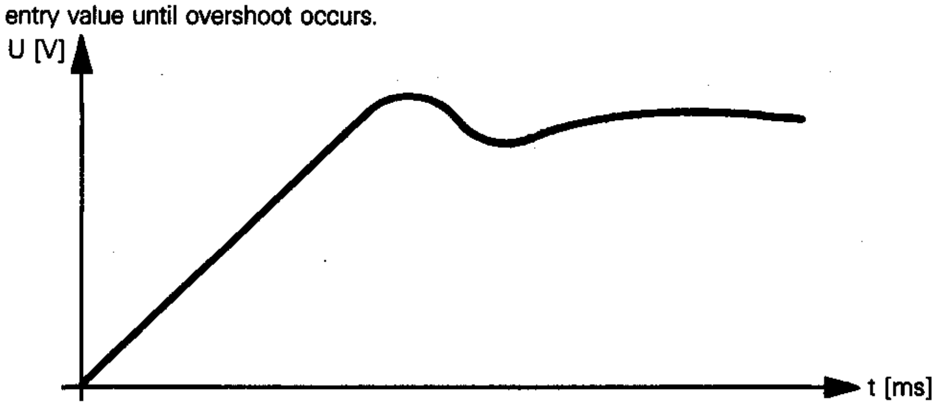
↓

Press ext. start in the operating mode **PROGRAM RUN SINGLE BLOCK**

Machine runs

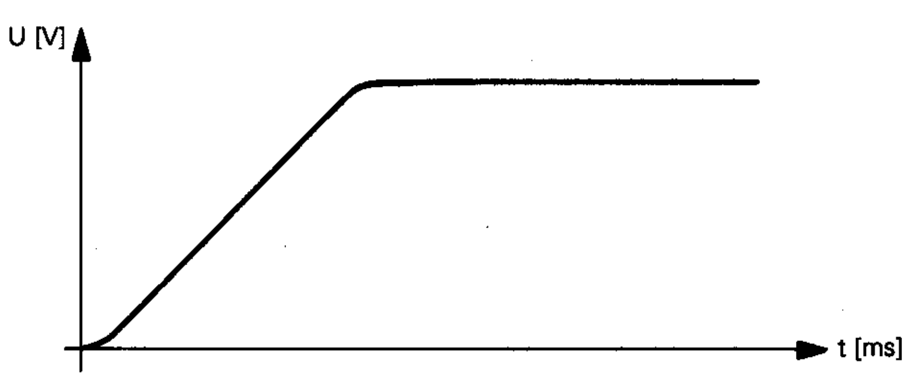
↓

MP 64: Increase entry value until overshoot occurs.



↓

MP 64: Increase entry value until overshoot stops.



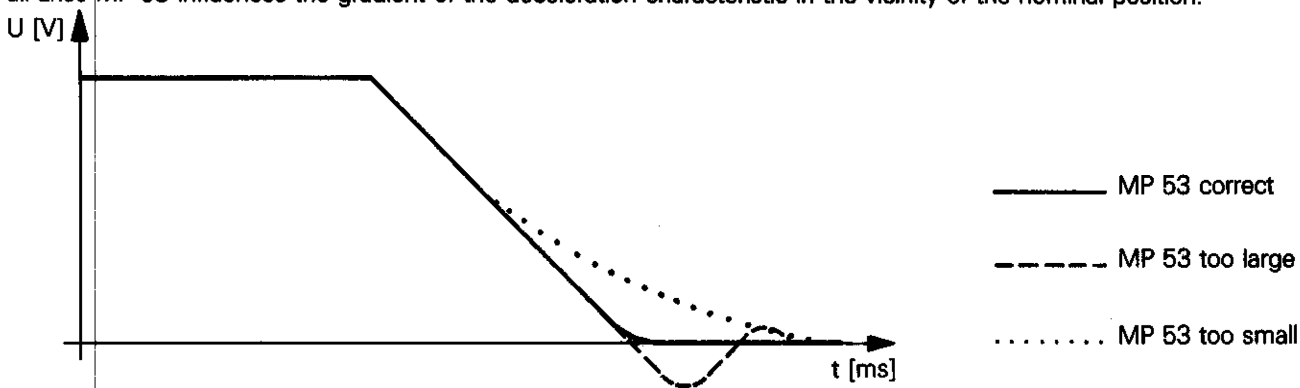
↓

Check axes Y, Z, IV and V and correct MP 64, if necessary.

Optimising the NC-axes
Optimising operation with speed precontrol

Gradient of characteristic when approaching position

In all axes MP 53 influences the gradient of the deceleration characteristic in the vicinity of the nominal position.



Since MP 53 is effective for all axes, the worst axis determines the entry value. No nominal position of any axis should be traversed.

Please note:
If the entry for MP 53 is too small, the positioning durations into the nominal position substantially increase. Therefore optimise MP 53 carefully!

Connect storage oscilloscope to tachometer of servo-amplifier.

↓

Enter following program in operating mode **PROGRAMMING AND EDITING**

```
LBL 1
X 100  R0  F  29998
X    0  R0  F  29998
CALL LBL 1  Rep 100/100
```

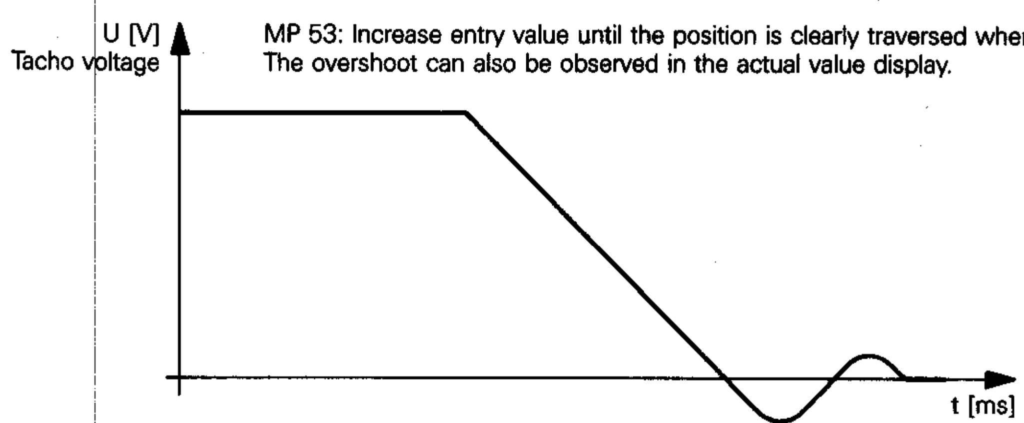
↓

Press ext. start in operating mode **PROGRAM RUN SINGLE BLOCK**

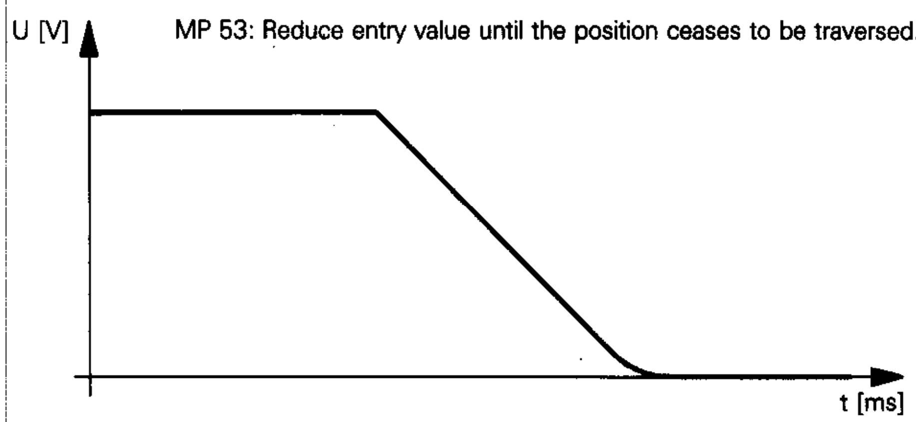
↓

Optimising the NC-axes
Optimising operation with speed precontrol

MP 53: Increase entry value until the position is clearly traversed when approaching. The overshoot can also be observed in the actual value display.



MP 53: Reduce entry value until the position ceases to be traversed.



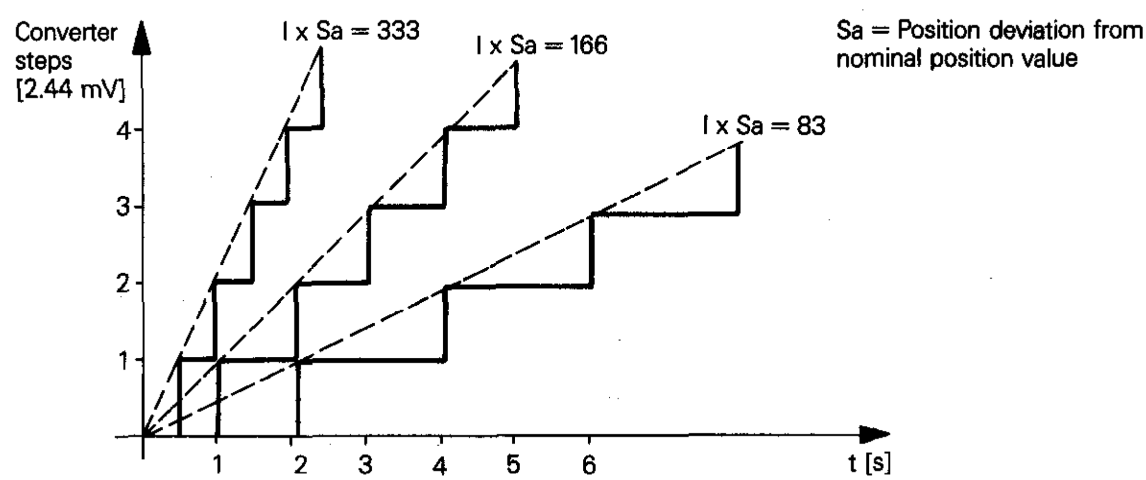
Control the Y-, Z-, IV- and V-axis and correct MP 53, if necessary.

Optimising the NC-axes
Optimising operation with speed precontrol

Integral factor X, Y, Z, IV

The integral factor (MP 28 to MP 31) effects an automatic offset adjustment for standstill with slight position deviations (the offset adjustment of the servo-amplifier has to be carried out before determining MP 28 to MP 31).

The function of the integral factor for various entry values is shown in the following diagram:



Example:
Position deviation from nominal position value: 1 µm.
Entry value for integral factor 333: the control compensates with 2.44 mV after 1/2 second.
Entry value for integral factor 83: the control compensates with 2.44 mV after two seconds.

Optimising the NC-axes
Optimising operation with speed precontrol

Optimising the integral factor

MP 65: "0" (Display step = 1 μm).
Machine remains in position in closed loop condition.

↓

MP 28 (for X-axis):
Increase entry value[1] until closed loop condition distinctly changes (observe actual value display).

↓

MP 28: Decrease entry value to a point where the closed loop condition normalizes[2] again.

↓

Repeat adjustment for axes Y, Z, IV and V.

Whether an integral factor is possible in connection with the automatic offset adjustment with MP 252, can only be judged by considering the whole machine. The optimum solution should be found during commissioning.

[1] First entry value 100 and then increase entry value by 100 each time.

[2] For backlash-prone drives, the entry value should be "0".

Optimising the NC-axes
Optimising operation with speed precontrol

Position supervision for the precontrol mode

MP 56	erasable	Entry range: 0.001 ... 30 [mm]
MP 57	Emergency-stop	

With MP 56 and MP 57, ranges for constant positioning supervision of the machine are determined. This supervision is effective as soon as the machine axes are being held in closed loop by the control. When the limits of parameter 56 are exceeded, the control stops (error message **POSITIONING ERROR**), while the control initiates an "Emergency-stop" if the limits of parameter 57 are exceeded. The error message **POSITIONING ERROR** can be cancelled with CE, whereas the mains voltage for the control has to be switched-off every time for "Emergency-stop" and the reference marks have to be subsequently traversed. Recommended entry values:

Machine parameters		**No.**	**Entry value**	**Supervision range**
Position supervision for operation with speed precontrol	(erasable)	56	0.5	± 0.5 mm
	(emergency-stop)	57	10[1)]	± 10 mm

[1)] If the machine drives permit a narrower limits, these should be programmed.

Optimising the NC-axes
Optimising of operation with lag

Machine parameters for trailing operation

Function		Parameter No.	Preliminary entry values
Analogue voltage at rapid	X	52	9 [V]
Acceleration	X	54	Entry values from sheet C3/8
Speed precontrol		60	1 ≙ off
Multiplication factor for K_V-factor		176	1
K_V-factor for trailing operation	X Y Z IV	177 178 179 180	1
Characteristic kink		181	Derived from the following formula: Entry value $= \frac{\text{max. machining feed x 100\%}}{\text{rapid traverse}}$
Acceleration	Y Z IV	297 298 299	
Analogue voltage at rapid	Y Z IV	300 301 302	9 [V]
K_V-factor for trailing operation	V	333	1
Acceleration	V	335	Entry values from sheet C3/8
Analogue voltage at rapid	V	338	9 [V]

Acceleration

In trailing operation the acceleration is proportional to the K_V-factor, i. e. a higher acceleration automatically results from a higher K_V-factor. To avoid this effect, TNC 355 operates with an acceleration limitation.

The acceleration is limited by MP 54, MP 297, MP 298, MP 299 and MP 335, i. e. by the same machine parameters which are effective for speed precontrol (same entry values).

Position loop gain: K_V-factor

The K_V-factor determines the traversing speed of an axis with a determined trailing error. The K_V-factor is calculated according to the following formula:

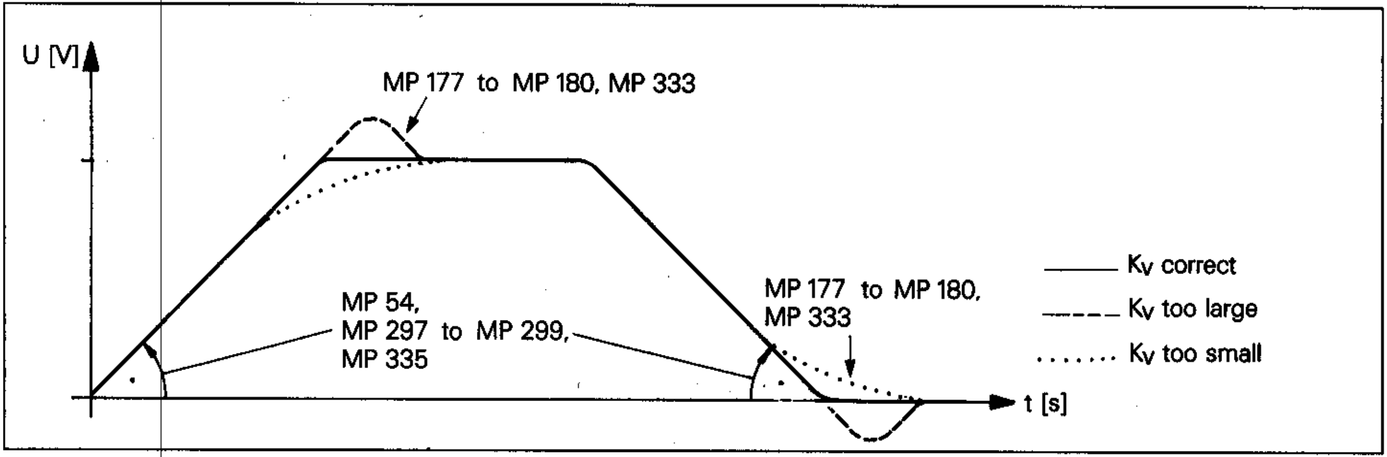
$K_V = \frac{vE}{Sa}$

K_V = Position loop gain
vE = Rapid traverse
Sa = Trailing error (lag)

The K_V-factor has to be matched to the machine tool.
If a very a high K_V-factor is selected, the trailing error becomes very small at a certain speed. If the trailing error is too small, the axis slide cannot approach the required position precisely, due to its inertia: the axis overshoots. It may even occur, that the position loop carries out self-induced oscillations.

If the K_V-factor is too small, the acceleration and the approach to the position occur too slowly.

Optimising the NC-axes
Optimising of operation with lag



In trailing operation it is also advantageous if at least one voltage step is output for each µm position deviation.

In the section "Differential factor" (see sheet C4/11...) it is explained that the control outputs 4095 voltage steps for 10 V analogue voltage: this corresponds to 3685 steps for 9 V analogue voltage.

In order that a voltage step per µm position deviation is output, the trailing error should not exceed 3.685 mm:

$$Sa \leq 3.685 \text{ mm}$$

Sa = trailing error for 9 V

With increasing trailing error, a greater position deviation is required for a voltage step. With smaller trailing error, several voltage steps are output per µm position deviation.

Example:
With Sa = 7.370, 2.44 mV are output per 2 µm position deviation.
With Sa = 1.842, 4.88 mV are output per 1 µm position deviation.

The trailing error by which a voltage step can be output per 1 µm position deviation is normally calculated to the following formula:

$$Sa \leq \frac{4.095 \text{ [mm] } MP\ 52 \text{ [V]}}{10 \text{ [V]}}$$

Sa = Trailing error with rapid traverse
MP 52 = Analogue voltage with rapid traverse

Optimising the NC-axes
Optimising of operation with lag

Calculation of voltage step per µm position deviation

The voltage step per µm position deviation can be calculated by the following formula:

$\Delta U = \frac{MP\ 52\ [mV]}{Sa\ [\mu m]}$ ΔU = Voltage in mV per µm position deviation
MP 52 = Analogue voltage with rapid traverse
Sa = Trailing error (lag)

$Nu = \frac{\Delta U\ [mV/\mu m]}{2.44\ [mV]}$ Nu = Voltage steps per µm position deviation

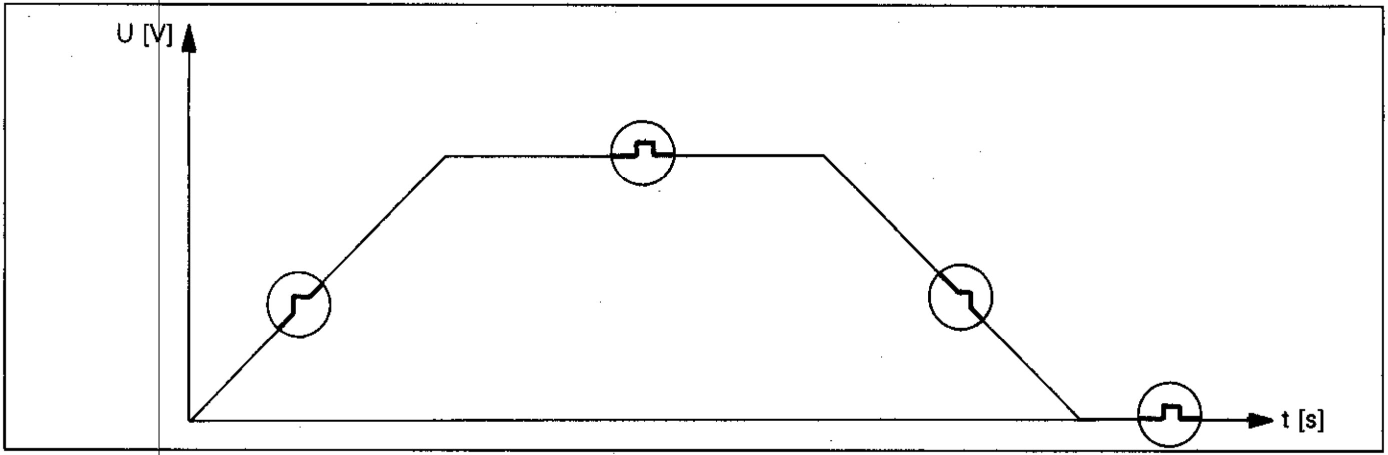
$$\boxed{Nu = \frac{MP\ 52\ [mV]}{Sa\ [\mu m] \times 2.44\ [mV]}}$$

Example:
$K_V = 1$; $V_E = 2$ m/min; MP 52 = 9 V

$Sa = \frac{V_E}{K_V}$; $Sa = \frac{2}{1}$ [mm]; Sa = 2000 µm

$Nu = \frac{MP\ 52\ [mV]}{Sa\ [\mu m] \times 2.44\ [mV]}$; $Nu = \frac{9000\ [mV]}{2000\ [\mu m] \times 2.44\ [mV]}$

Nu = 1.85 Voltage steps per µm position deviation

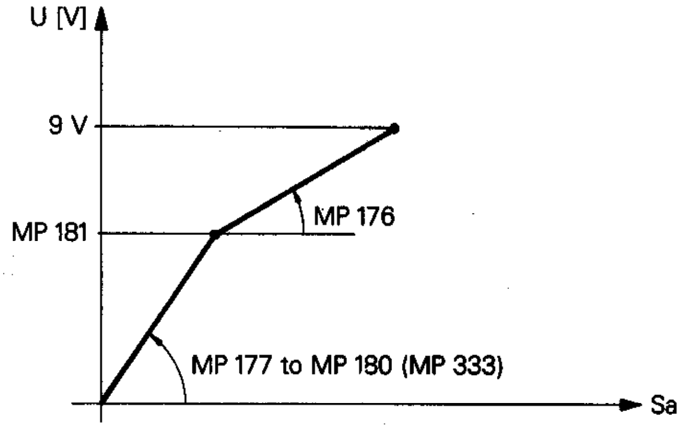


Optimising the NC-axes
Optimising of operation with lag

Characteristic kink

In most cases the K_V-factor cannot be increased for machines having high rapid traverse speeds such, that an optimum controlling behaviour results for the machining speed or standstill. Therefore, a characteristic kink can be entered in most cases.

The location of the characteristic kink is determined via MP 181. The K_V-factor is multiplied within the upper range by the factor from MP 176.



Calculation of the total lag using the characteristic kink

$Sa = \frac{v_E}{K_V}$

Sa = Trailing error (lag)
v_E = Rapid traverse
K_V = Position loop gain

$$Sa = \frac{v_E\,[m/min]}{K_V\,\frac{[m/min]}{[mm]} \times 100\,[\%]} \times \left(MP\,181\,[\%] + \frac{100\,[\%] - MP\,181\,[\%]}{MP\,176}\right)$$

Advantages of a characteristic kink

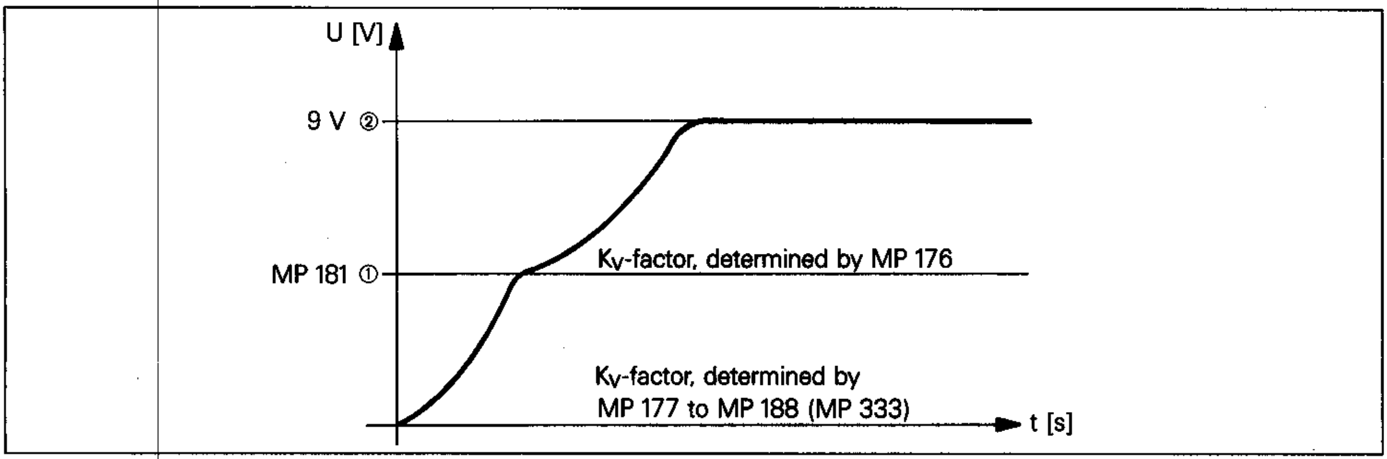
- High K_V-factor in the lower range, i.e. a higher voltage step per µm position deviation
- Lower K_V in the upper range

Please note:
The characteristic kink must lie above the highest machining feed.

Optimising the NC-axes
Optimising of operation with lag

Optimising the K_V-factor

To determine the optimum position loop gain (K_V-factor) in the lower range, the adjustment has to be initially carried out with the machining feed. In a second adjustment the K_V-factor is determined for rapid traverse.



① Maximum machining feed; the characteristic kink has to lie here or above.

② Rapid traverse

Optimising the NC-axes
Optimising of operation with lag

Optimising the K_V-factor for machining feed

Adjustment is carried out as follows:

Connect storage oscilloscope to tachometer of the servo-amplifier of X-axis.

↓

Enter following program in operating mode

PROGRAMMING AND EDITING

LBL 1
X 100[1] R0 F[2] ...
X 0 R0 F[2] ...
CALL LBL 1 Rep 100/100

↓

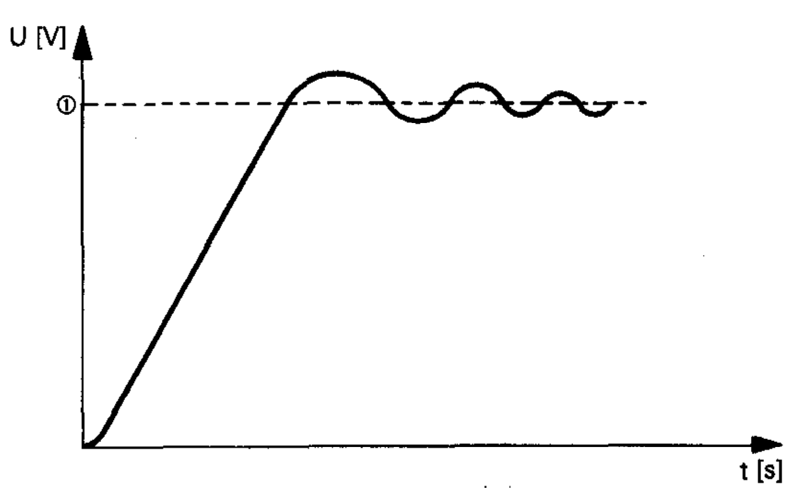
Press ext. start in operating mode

PROGRAM RUN SINGLE BLOCK

Machine runs.
Note: Set feed override to 100 %.

↓

MP 177: Increase entry value until position loop oscillates or until an overshoot occurs after the acceleration ramp.



① Machining feed

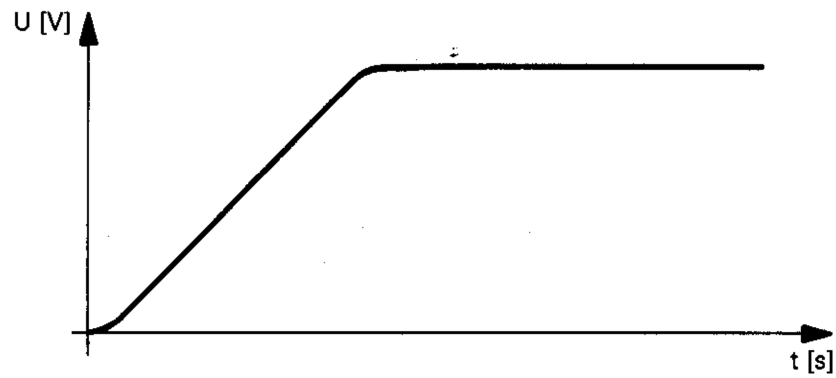
↓

[1] Program the traverses as large as possible for the corresponding axes.

[2] Enter max. machining feed.

Optimising the NC-axes
Optimising of operation with lag

MP 177: Reduce entry value until no oscillations are detectable.



Repeat adjustment for axes Y, Z, IV and V.

Please note:
The K_V-factor has to be the same for axes which commonly interpolate. In this case, the worst axis determines the entry value.

Optimising the NC-axes
Optimising of operation with lag

Optimising the K_V-factor for rapid traverse

Adjustment is carried out as follows:

Check multiplication factor for K_V (MP 176 = 1) and characteristic kink
(MP 181 = $\frac{\text{max. machining feed x 100\%}}{\text{rapid traverse}}$).

↓

Connect storage oscilloscope to tachometer
of the servo-amplifier of X-axis.

↓

Enter following program
in operating mode
PROGRAMMING AND EDITING

LBL 1
X 100[1] R0 F 29.998
X 0 R0 F 29.998
CALL LBL 1 Rep 100/100

↓

Press ext. start
in operating mode
PROGRAM RUN SINGLE BLOCK
Machine runs.

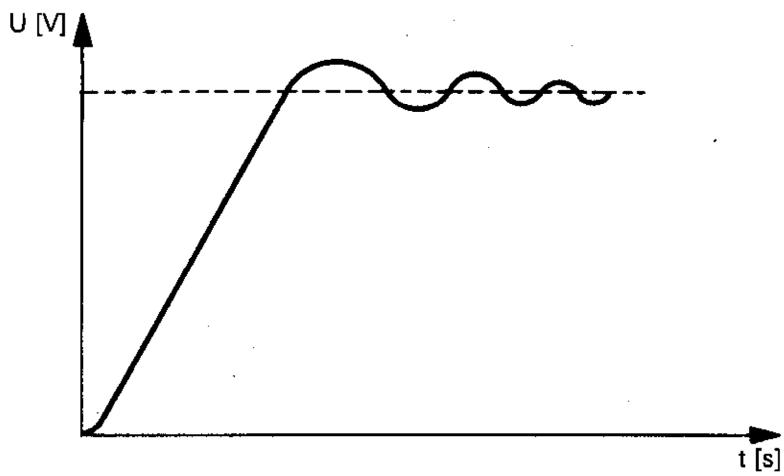
↓

[1] Program the traverses as large as possible for the corresponding axes.

Optimising the NC-axes

Optimising of operation with lag

Does the tacho signal show overshoot?



YES → Reduce MP 176 in steps until overshoot can no longer be detected.

NO → Characteristic kink not required.

Repeat adjustment for axes Y, Z, IV and V.

Please note:
The worst axis determines the entry value for MP 176.

Optimising the NC-axes
Supervision of positioning

Supervision for trailing operation

With parameters 175 – position supervision (erasable) – and 174 – position supervision (Emergency-stop) – the ranges for constant position supervision of the machine are determined. Supervision becomes active as soon as the machine axes are held in closed loop by the control.

If the limit of parameter 175 is exceeded, the control stops and the error message

POSITIONING ERROR .

is displayed.

This error message can be cancelled by pressing CE.

Exceeding the limit of parameter 174 leads to an emergency-stop of the control; the flashing error message **GROSS POSITIONING ERROR A** is diplayed. This error message can only be cancelled by switching-off the mains voltage for the control.

Function	Parameter No.	Recommended entry values
Position supervision in trailing operation		
Emergency-stop	174	1.4x trailing error with rapid traverse[1]
erasable	175	1.2x trailing error with rapid traverse[1]

Position Supervision for operation with precontrol

For operation with precontrol, the ranges for position supervision are determined by MP 56 (erasable) and MP 57 (Emergency-stop).

Function	Parameter No.	Recommended entry values
Position supervision for operation with precontrol		
erasable	56	0.5
Emergency-stop	57	10[1]

Switching-off the residual nominal value voltage when error message "Positioning error" is displayed.

If blocked axes cause the error message "POSITIONING ERROR" a residual voltage may remain at the nominal value output.

A duration can be determined via MP 185, after which, this residual nominal value voltage is switched-off with the error message "Positioning error".

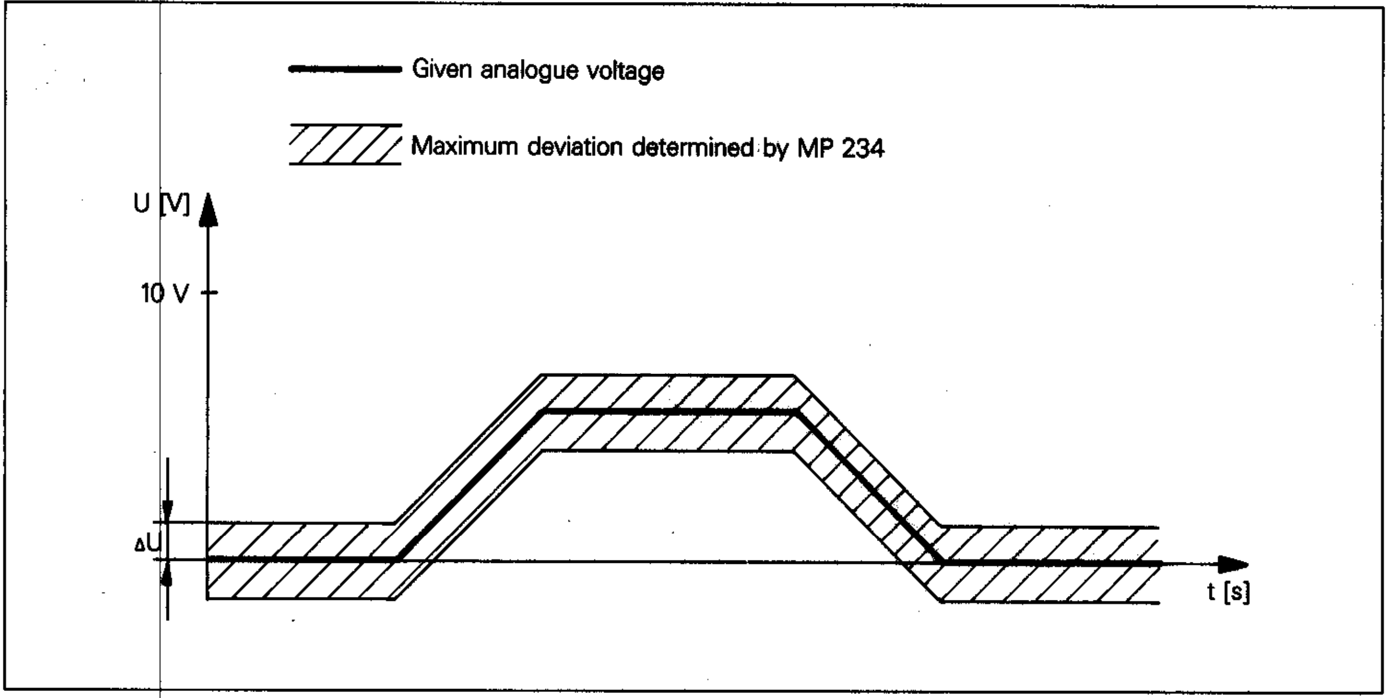
MP 185 **Delay for cutout of residual nominal value voltage when error message "Positioning error" is displayed.**
Entry range: 0 ... 65.535 [s]

[1] If the machine drives permit a narrower limit, this should be programmed.

Optimising the NC-axes
Supervision of positioning

Movement supervision

The maximum admissible deviation of the analogue voltage is monitored by the given voltage of the nominal value as per MP 234. If the maximum admissible deviation is exceeded, the error message **GROSS POSITIONING ERROR** is displayed.



Function	Parameter No.	Recommended entry value
Movement supervision	234	0.03 … 10 [V]

MP 234 is active in trailing operation and with speed precontrol.

Standstill supervision

With parameter 169 the range is determined in which the non-controlled axes may be moved. If the programmed limit is exceeded, the control goes into emergency-stop and displays the flashing error message

GROSS POSITIONING ERROR D.

This supervision can also respond

.if, when approaching the nominal position, an overshoot occurs, which exceeds the entry value of MP 169 or

.if the axis moves in the opposite direction on commencement of positioning (e.g. wrong counting direction, release of clamps).

Function	Parameter No.	Recommended entry value
Standstill supervision	169	0.001 … 30 [mm]

Optimising the NC-axes
Overview of error messages
GROSS POSITIONING ERROR

The error message **GROSS POSITIONING ERROR** can be displayed for various reasons.

Suffixes A – E are displayed to indicate the specific error cause:

Error message	Error cause
GROSS POSITIONING ERROR A	Position supervision MP 57 or MP 174 exceeded.
GROSS POSITIONING ERROR B	10-volt nominal value voltage of control for precontrol operation exceeded.
GROSS POSITIONING ERROR C	Limit for movement supervision MP 234 exceeded.
GROSS POSITIONING ERROR D	Limit for standstill supervision MP 169 exceeded.
GROSS POSITIONING ERROR E	Limit for automatic cyclic offset adjustment (100 mV) exceeded.

Optimising the main spindle
Controlling the main spindle

With TNC 355 the main spindle is controlled via M-functions M03, M04 and M05 by means of a closed loop. The main spindle[1] can be oriented via a PLC-positioning.

The spindle speeds can be output either BCD-coded or via an analogue voltage output having up to 8 programmable gear ranges.

If no output of spindle speeds is required, MP 62 = 0 has to be programmed.

[1] not applicable to TNC 355 B for 5 NC-axes

Optimising the main spindle
Coded output of spindle speeds

The spindle speed is programmed in the NC-block in rpm. The S-function is transferred via marker 2064 (Bit 0, lsb) to marker 2071 (Bit 7, msb), with coded output of spindle rpms; and BCD-coded in two decades via the strobe marker 2064 of the NC-part to the control of the PLC-part of the control. The NC-part of the control awaits the continuation of program run until the acknowledgement is given via marker 2481 that the gear was changed.

List of coded S-functions

Coding of S-functions

S-function Code	rpm	Bit 7654	3210
S 00	0	0000	0000
S 01	0.112	0000	0001
S 02	0.125	0000	0010
S 03	0.14	0000	0011
S 04	0.16	0000	0100
S 05	0.18	0000	0101
S 06	0.2	0000	0110
S 07	0.224	0000	0111
S 08	0.25	0000	1000
S 09	0.28	0000	1001
S 10	0.315	0001	0000
S 11	0.355	0001	0001
S 12	0.4	0001	0010
S 13	0.45	0001	0011
S 14	0.5	0001	0100
S 15	0.56	0001	0101
S 16	0.63	0001	0110
S 17	0.71	0001	0111
S 18	0.8	0001	1000
S 19	0.9	0001	1001
S 20	1	0010	0000
S 21	1.12	0010	0001
S 22	1.25	0010	0010
S 23	1.4	0010	0011
S 24	1.6	0010	0100
S 25	1.8	0010	0101
S 26	2	0010	0110
S 27	2.24	0010	0111
S 28	2.5	0010	1000
S 29	2.8	0010	1001
S 30	3.15	0011	0000
S 31	3.55	0011	0001
S 32	4	0011	0010
S 33	4.5	0011	0011
S 34	5	0011	0100
S 35	5.6	0011	0101
S 36	6.3	0011	0110
S 37	7.1	0011	0111
S 38	8	0011	1000
S 39	9	0011	1001
S 40	10	0100	0000
S 41	11.2	0100	0001
S 42	12.5	0100	0010
S 43	14	0100	0011
S 44	16	0100	0100
S 45	18	0100	0101
S 46	20	0100	0110
S 47	22.4	0100	0111
S 48	25	0100	1000
S 49	28	0100	1001

S-function Code	rpm	Bit 7654	3210
S 50	31.5	0101	0000
S 51	35.5	0101	0001
S 52	40	0101	0010
S 53	45	0101	0011
S 54	50	0101	0100
S 55	56	0101	0101
S 56	63	0101	0110
S 57	71	0101	0111
S 58	80	0101	1000
S 59	90	0101	1001
S 60	100	0110	0000
S 61	112	0110	0001
S 62	125	0110	0010
S 63	140	0110	0011
S 64	160	0110	0100
S 65	180	0110	0101
S 66	200	0110	0110
S 67	224	0110	0111
S 68	250	0110	1000
S 69	280	0110	1001
S 70	315	0111	0000
S 71	355	0111	0001
S 72	400	0111	0010
S 73	450	0111	0011
S 74	500	0111	0100
S 75	560	0111	0101
S 76	630	0111	0110
S 77	710	0111	0111
S 78	800	0111	1000
S 79	900	0111	1001
S 80	1000	1000	0000
S 81	1120	1000	0001
S 82	1250	1000	0010
S 83	1400	1000	0011
S 84	1600	1000	0100
S 85	1800	1000	0101
S 86	2000	1000	0110
S 87	2240	1000	0111
S 88	2500	1000	1000
S 89	2800	1000	1001
S 90	3150	1001	0000
S 91	3550	1001	0001
S 92	4000	1001	0010
S 93	4500	1001	0011
S 94	5000	1001	0100
S 95	5600	1001	0101
S 96	6300	1001	0110
S 97	7100	1001	0111
S 98	8000	1001	1000
S 99	9000	1001	1001

Optimising the main spindle
Coded output of spindle speeds

Machine parameters for coded output of spindle speeds

MP 62 **Output of spindle speed, coded or analogue**
0 ≙ No output of spindle rpm
1 ≙ Coded output only when rpm changes
2 ≙ Coded output with every TOOL CALL
(entry values 3 to 5 see "Analogue output", sheet C5/4)

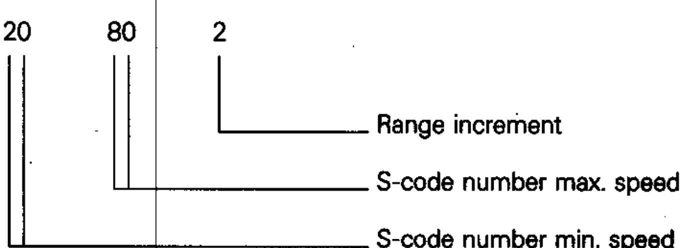
MP 63 **RPM code limit**

The minimum rpm and the maximum admissible rpm of the spindle can be entered with MP 63.
The rpm step can be determined within the admissible rpm range.

The code is entered as a 5-digit number.

	Number of decades	S-code number
Min. rpm ...	2	00 – 99
Max. rpm ...	2	00 – 99
Step	1	1 – 9

Example:
2 0 8 0 2 is entered as an rpm-code; i.e., the minimum spindle speed is determined on S 20 (1 rpm), the maximum spindle speed on S 80 (1000 rpm). The range is defined more precisely by indicating that only every second rpm is programmed.



Thus, 00991 means no limitation.

If an rpm which lies between two standard table values is programmed in the NC-block, it is automatically rounded-off to the next lower rpm.

MP 70 **Nominal value voltage for spindle drive during gear change**
Entry range: 0 ... 9.999 [V]

By setting markers in the PLC-program, an oscillating voltage can be output to change the gears. MP 70 determines the height of the voltage being output.

Optimising the main spindle
Analogue output of spindle speeds

Speeds of 0 ... 99999.999 rpm can be programmed with analogue output of the spindle speed. The programmed speed is output as an analogue DC-voltage from 0 ± 10 volts.

The polarity of the output voltage is determined by MP 172. Up to 8 gear ranges can be defined by means of MP 78 to MP 85. The nominal speed of the first gear range is determined by MP 78 and the eighth gear range by MP 85.

The control is equipped with an S-override potentiometer. The minimum and maximum voltage values can be programmed with MP 86 to MP 89 as well as MP 184.

Machine parameters for analogue output of spindle speeds

MP 62 **Output of spindle speed, coded or analogue**
0 ≙ No output of spindle rpm
3 ≙ Gear switching signal only when gear range changes
4 ≙ Gear switching signal with every TOOL CALL
5 ≙ Without gear switching signal
(Entry values 1 and 2 see "Coded output", sheet C5/3)

MP 63 **RPM code limit**
MP 63 has to be programmed with **00991** for analogue output of spindle speeds!

RPM ranges for gear ranges

MP 78 Gear range 1

MP 79 Gear range 2

MP 80 Gear range 3

MP 81 Gear range 4

MP 82 Gear range 5

MP 83 Gear range 6

MP 84 Gear range 7

MP 85 Gear range 8

The nominal speed is entered for each gear range with S-override 100 %. Gear ranges which are not required are deleted by entering the value 0.

Speed supervision with MP 82 to MP 85

If only four gear ranges are to used, MP 82 to MP 85 can be used for monitoring the speed.

In this case MP 78 to MP 85 are divided in two groups:

MP 78 ... MP 81 determines the gear ranges and
MP 82 ... MP 85 speed supervision.

The entry values in MP 82 ... MP 85 have to be smaller than the entry values in MP 78 ... MP 81; hence the control recognizes that speed supervision has to be carried out.

The control indicates undershooting of the limit speed by setting marker 2006.

Optimising the main spindle
Analogue output of spindle speeds

Speeds for gear ranges

MP 78 Gear range 1
MP 79 Gear range 2
MP 80 Gear range 3
MP 81 Gear range 4

The nominal speed for S-override 100% is entered for every gear range.

Limit speed for speed supervision

MP 82 Limit speed for gear range 1
MP 83 Limit speed for gear range 2
MP 84 Limit speed for gear range 3
MP 85 Limit speed for gear range 4

Marker 2006

1 ≙ Limit speed not attained
0 ≙ Limit speed exceeded

Determination of the analogue voltage

MP 86 **S-analogue voltage with S-override at 100%**
Entry range: 0 ... 9.999 [V]

MP 87 **S-analogue voltage at maximum**
Entry range: 0 ... 9.999 [V]

MP 184 **S-analogue voltage at minimum**
Entry range: 0 ... 9.999 [V]

MP 184 serves in protecting the drive motor, however it is inactive, if spindle orientation is active with the control.

MP 168 **Ramp gradient for S-analogue voltage**
Entry range: 0 ... 1.999 [V/ms]

The gradient of S-analogue is determined with the same ramp for both the acceleration and the deceleration via MP 168.

As of software level 07 (4 axes)/04 (5 axes), MP 168 only determines the ramp for the acceleration of the spindle.
The ramp for spindle deceleration is defined by MP 316.

MP 316 **Ramp gradient for S-analogue voltage for spindle deceleration**
Entry range: 0 ... 1.999 [V/ms]
0 = deceleration from MP 168

Ramp gradient for S-analogue voltage when marker 2816 is set

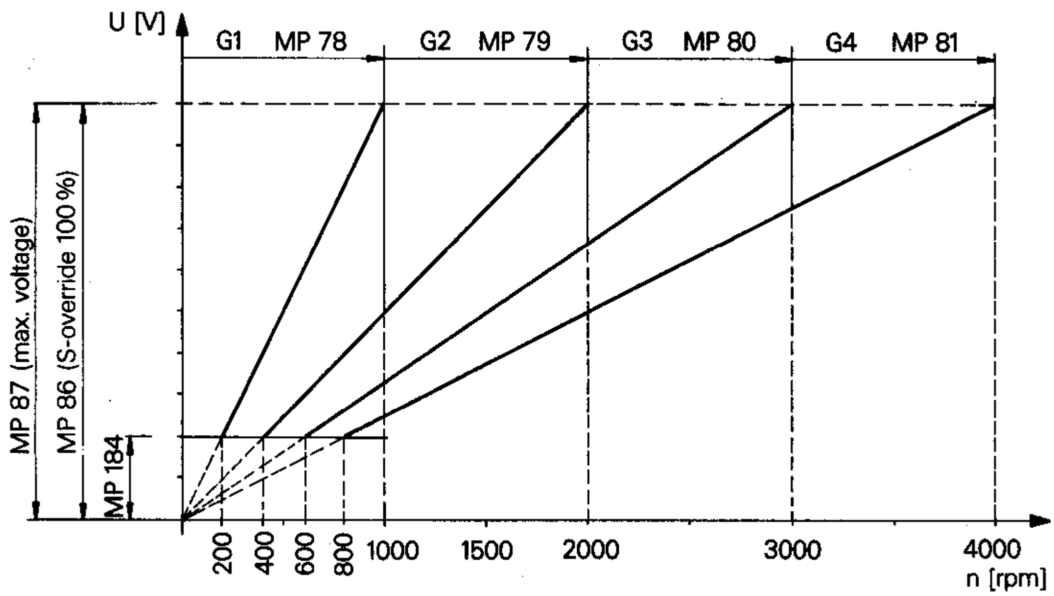
As of software level 07 (4 axes)/04 (5 axes), the selection of a second ramp for acceleration and deceleration is possible via marker 2816.

MP 317 **Acceleration**
MP 318 **Deceleration**
Entry range: 0 ... 1.999 [V/ms]

MP 172 **Polarity of S-analogue voltage**
0 ≙ M03: positive; M04: negative
1 ≙ M03: negative; M04: positive
2 ≙ M03 and M04: positive
3 ≙ M03 and M04: negative

Optimising the main spindle
Analogue output of spindle speeds

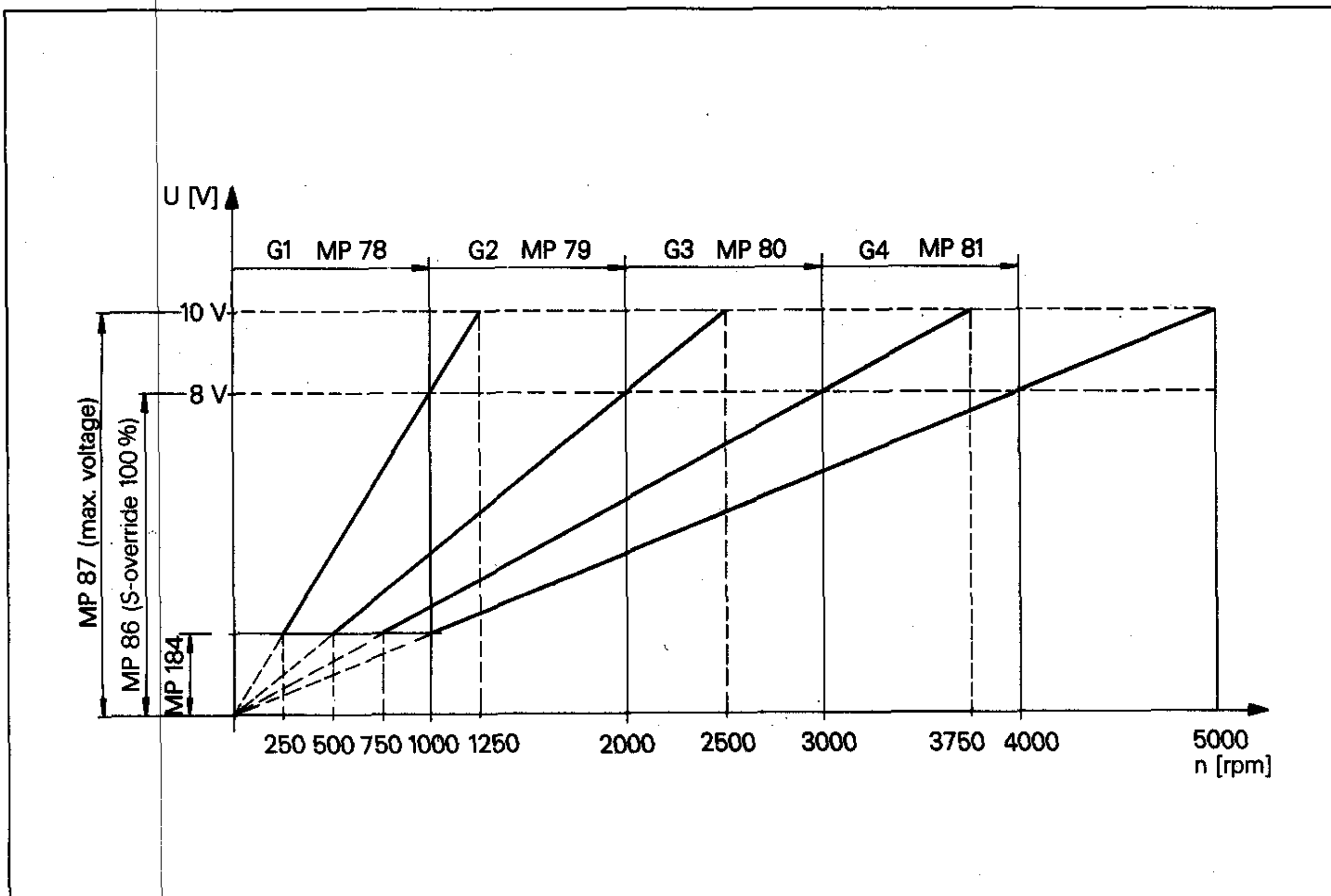
Speed ranges with four gear ranges if MP 86 = MP 87



● Limitation through MP 184, e.g. 2 V

Optimising the main spindle
Analogue output of spindle speeds

Speed ranges with four gear ranges if MP 86 < MP 87



Optimising the main spindle
Analogue output of spindle speeds

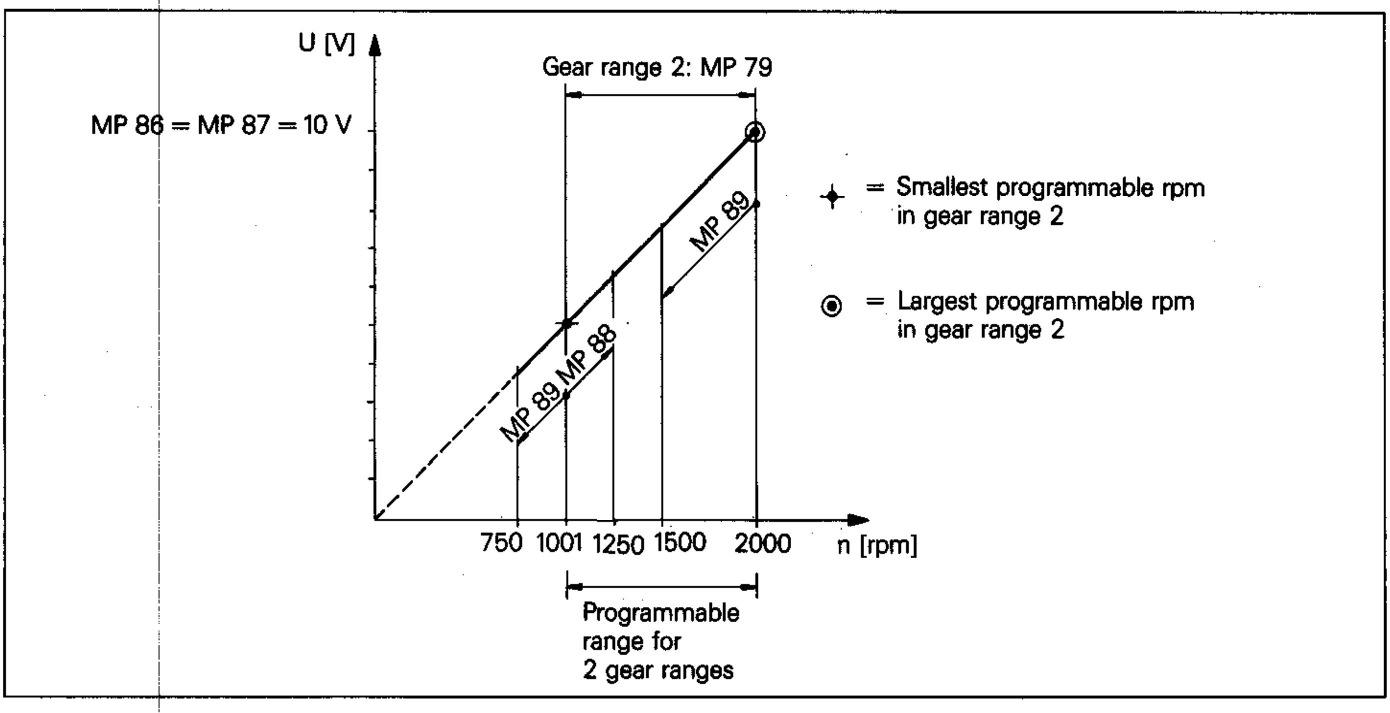
Limitation of S-override

MP 88 **Maximum**
Entry range: 0 ... 150 %

MP 89 **Minimum**
Entry range: 0 ... 150 %

Example:
Gear is in range 2

Gear range 1: MP 78 = 1000
Gear range 2: MP 79 = 2000
MP 86 = MP 87 = 9.999 [V]
MP 88 = 125 %
MP 89 = 75 %



Optimising the main spindle
Analogue output of spindle speeds

Further functions

MP 74 **Feed and spindle override**

Bit 3 **Spindle override in 2 %-stages or variable**
+ 0 ≙ 2 %-stages
+ 8 ≙ Variable
(Bit 0, bit 1 and bit 2, see sheet C2/8)

MP 190 **Programming or rpm S = 0 permitted**
0 ≙ S = 0 permitted
1 ≙ S = 0 not permitted
The voltage value in MP 184 can be less with MP 190.

MP 191 **Display of the actual spindle rpm before spindle start**
0 ≙ On
1 ≙ Off

MP 214 **Axis halt if rpm only is changed with a TOOL CALL**

Bit 2
+ 0 ≙ Axis halt
+ 4 ≙ No axis halt
(Bit 0, Bit 1 and Bit 3, see sheet C2/11)

MP 258 **S-Analogue output of spindle rpm if marker 2501 is set**
Entry range: 0 ... 99999.999 [rpm]
Direction of rotation always positive.

Optimising the main spindle
Orientation of main spindle

An orientation of the main spindle can be programmed via the position loop for the axis S. This is, e.g., important for an automatic toolchange or when using a TS 511/TS 120 3D-touch probe with infra-red signal transmission.

ROD 428 with 1024 lines (see sheet T4/4) is a suitable rotary encoder.

Spindle orientation is principally carried out as a PLC-positioning. The nominal value of the position for orientation is either determined via

.the orientation cycle or
.via MP 126 to MP 156.

The position value on the reference mark for the axis S is entered via MP 240, since the setting of a datum is not possible via an axis key.

Machine parameters for spindle orientation

MP 237 **Activation of axis S for spindle orientation**
0 ≙ Axis inactive
1 ≙ Axis active, without position display
2 ≙ As entry value 1, however, with position display
(is displayed instead of axis IV)

MP 238 **K_V-factor for axis S (spindle)**
Entry range: 0.100 ... 10.000

MP 239 **Counting direction and reference pulse inhibit for spindle orientation axis**

Bit 0
+ 0 ≙ Positive counting direction
+ 1 ≙ Negative counting direction

Bit 1
+ 0 ≙ Reference pulse inhibit inactive
+ 2 ≙ Reference pulse inhibit active

MP 240 **Position value on the reference mark for axis S (spindle)**
Entry range: 0 ... 360.000 [°]

MP 246 **Position window for axis S (spindle)**
Entry range: 0 ... 65535 [increments]

MP 248 **Spindle rpm for spindle orientation**
Entry range: 0 ... 99999.999 [rpm]

Contents

Programming of user-cycles

User-cycles are NC-programs in which variable program data are programmed via Q-parameters (see Operating Manual). Programming of user-cycles within the NC-program memory is performed with program numbers 99999968 to 99999999. User-cycles are tested in the NC-program memory and can be subsequently assigned to an EPROM. This is carried out by HEIDENHAIN.

A customized EPROM is especially important if you do not wish to reserve program memory for user cycles. The PLC EPROM can store up to 32 different user cycles with a total of 2100 program blocks.

A maximum of 100 customer-specific dialogue texts for the cycle description and entry parameters can be stored in the control.

User-cycles can be called-up either via CYCL CALL or with the cycle definition CYCL DEF. This is determined during compilation of the user-cycle in the "dialogue block".

Call-up of a user-cycle with CYCL DEF in only performed if a standard cycle is to be called via CYCL CALL within a user-cycle.

In a user-cycle 15 numbers for dialogue texts can be specified via the "dialogue block".
The first number defines the cycle description and the remaining numbers define the corresponding dialogue questions for entry of the Q-parameters.

Assignment of a value of the user-cycle is made via CYCL DEF as with the permanently stored HEIDENHAIN canned cycles.
When paging, user-cycles are displayed by cycle numbers 68 to 99 (cycle selection via CYCL-DEF).

In the Transfer Blockwise mode with simultaneous machining, application of user-cycles is not possible, since the corresponding parameters are not stored.

Programming of user-cycles
Programming the "dialogue block"

Programming the "dialogue block" is only possible with program numbers 99999968 to 99999999.
For definition of the necessary plain language dialogues, two possibilities are offered:

"DLG-DEF": Call-up of user-cycle via CYCL DEF
"DLG-CALL": Call-up of user-cycle via CYCL CALL

After dialogue initiation for the definition of plain language dialogues using the and -keys, the following dialogue question is displayed:

DLG-DEF = ENT/DLG-CALL = NO ENT

By pressing the key or , the "DLG-DEF"- or "DLG-CALL"-block is programmed.

Since both "DLG-DEF" and "DLG-CALL" user-cycles can be contained in a main program, Q-parameters for the dialogues must be stored in separate Q-address locations.

MP263 **Q-parameter numbers for "DLG-DEF" and "DLG-CALL"-block**
Entry range: 0 ... 50

Entry value ≙ difference between Q-numbers for the "DLG-DEF" and the "DLG-CALL"-blocks.

Entry parameters for the "DLG-CALL"-block are assigned to program parameters Q1 to Q14. With the "DLG-DEF"-block the entry parameters are assigned to the Q-parameters Q (1 + MP 263) to Q (14 + MP 263).

Example:

If the entry value in machine parameter 263 = 50, the cycle parameters (of a cycle with "DLG-DEF") are assigned to the program parameters as follows:

First cycle parameter = Q 51
Second cycle parameter = Q 52
.
.
.
Fourteenth cycle parameter = Q 64

Programming of user-cycles
Dialogue language for user-cycles

As with standard dialogues, user-cycles can also be displayed in two languages.

The entry value for machine parameter MP 259 is added to the dialogue number of the original language. The English text of the appropriate dialogue is stored under this dialogue number.

MP 259 **Language switchover for user-cycles**
Entry range: 0 ... 50
Entry value ≙ difference between Q-number of second (English) and first dialogue language.

Selection – as to whether original or English dialogue – automatically takes place simultaneously to the selection of the plain language standard dialogue via machine parameter MP 92.

Example:

Entry value in MP 259: 50

Dialogues for user-cycle "Bolt hole circle"

0 Bolt hole circle
1 Number of holes
2
.
.
.
50 Bolt hole circle
51 Number of holes
12
.
.
.

Programming of user-cycles
Hints for compiling user-cycles

Test of user-cycles
User-cycles which are still stored within the NC-program memory can also be recalled via PGM-call. For testing, the operating mode "Single block" is also possible.
(With PGM-CALL all Q-parameters are globally effective).

Nesting of user-cycles
Further user-cycles can be called within an existing user-cycle. Max. four nesting levels are permitted.

Q-parameters with special significance for user-cycles

The following Q-parameters simplify the compilation of user-cycles:

Q108	Tool radius last called
Q109	Current tool axis
Q110	M-function last output for spindle rotating direction
Q111	Coolant on/off was programmed
Q112	Stepover factor for pocket milling (entry value from machine parameter MP 93)
Q113	Program contains mm or inch-data.

Detailed descriptions of these Q-parameters can be found in the Operating Manual.

Entry values for user-cycles
The entry values for user-cycles are stored as Q-parameters (see Operating Manual). Within a user-cycle calculations may be made with these Q-parameters. After a return jump into the main program, the original entry values are again valid i.e., Q-parameters can be altered locally.

MP 262 **Global Q-parameters**

Entry range: 0 ... 50

A certain number of globally effective Q-parameters can be defined by MP 262. "Globally effective" means that the contents of these Q-parameters are transferred from the program being called to the user-cycle and altered if required. These altered values are transferred to the program being called after completion of the user-cycle and can be altered or used as required. If, for instance, 40 is entered for MP 262, the Q-parameters Q60[1] ... Q99 are global.

Non-permitted functions within user-cycles

- Program part repeats
  Program part repeats cannot be executed in user-cycles which have been stored within the EPROM.
  Program part repeats can, however, be easily programmed via Q-parameters (see following example "Bolt Hole Circle")

- Program call-ups
  Program call-ups via PGM-CALL are not permitted within user-cycles.

- Cycle 14 "Contour"
  Cycle 14 "Contour" must be defined within the main program.

- Tool definitions
  Tool definitions must be located within the main program or within the central tool file.

Interruption of user-cycles
In user-cycles, the programming of functions which interrupt the cycle sequence is not permitted, e.g. M-functions or tool calls which terminate the cycle.

[1] Q60 = Q (100 – MP 262)

Programming of user-cycles
Standard dialogues

The following dialogues texts for the cycle description and the entry parameters are stored in the PLC-EPROM:

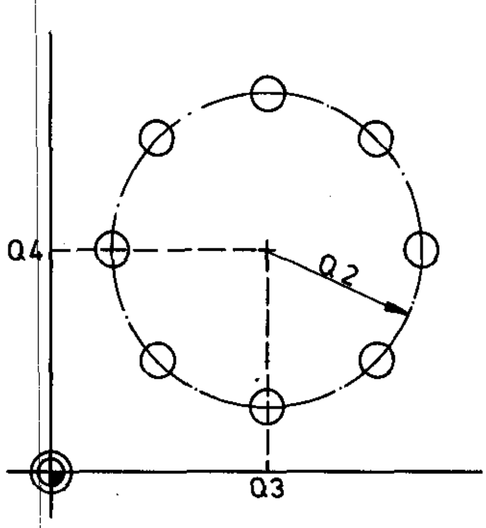
Dialogue No. 0 USER CYCL
Dialogue No. 1 CYCL PARAMETER 1
Dialogue No. 2 CYCL PARAMETER 2
.
.
.
Dialogue No. 14 CYCL PARAMETER 14

Instead of these standard dialogues, HEIDENHAIN can store up to 100 different customer-specific dialogues in the PLC-EPROM.

Example for a user-cycle

The following user-cycle serves as an example. This cycle is not stored within the control.

The user-cycle 68 "Bolt hole circle" requires the following entry parameters:



Q1 = Number of holes
Q2 = Radius of pitch circle
Q3 = X-coordinate for pitch circle centre
Q4 = Y-coordinate for pitch circle centre
Q5 = Set-up clearance for Z-axis
Q6 = Drilling depth in Z-axis
Q7 = Feed rate for drilling

The first hole of the pitch circle is located on the 0°-axis of the X-Y-coordinate system. The variable parameter program which is stored derives the hole spacing from the total number of holes and executes machining.

Program example for the user-cycle "Bolt hole circle"

```
 0 BEGIN PGM 99999968      MM   P
 1 DLG-CALL 0/1/2/3/4/5/6/7/ / / /
 2 FN 1 : Q6 = +Q6 + +Q5
 3 FN 4 : Q50 = +360.000 DIV      +Q1
 4 FN 0 : Q60 = +0.000
 5 CC X + Q3   Y + Q4
 6 LBL 11
 7 LP PR + Q2   PA + Q60   R0 F29998 M
 8 L IZ + Q6               R0 FQ7    M
 9 L IZ – Q6               R0 F29998 M
10 FN 1 : Q60 = +Q60 + +Q50
11 FN 12 : IF +Q60 LT +361.000 GOTO LBL 11
12 END PGM 99999968                 MM   P
```

Parameter program for user-cycle 68 "Bolt hole circle" (if stored within the EPROM" of the control, display on the VDU is not possible).

For the user-cycle "Bolt hole circle", the following dialogues must be stored within the EPROM:

Dialogue No. 0   BOLT HOLE CIRCLE
Dialogue No. 1   NUMBER OF HOLES
Dialogue No. 2   RADIUS
Dialogue No. 3   X-COORDINATE
Dialogue No. 4   Y-COORDINATE
Dialogue No. 5   SET-UP CLEARANCE
Dialogue No. 6   TOTAL HOLE DEPTH
Dialogue No. 7   FEED RATE

Example for a user-cycle

Programming of a user-cycle within the NC-program memory

Operating mode ______________

Dialogue initiation ______________

PROGRAM NUMBER =		Key-in program number between 99999968 and 99999999.
	ENT	Enter into memory.

MM = ENT / INCH = NO ENT	ENT	for dimensions in mm
	or	
	NO ENT	for dimensions in inches

0 BEGIN PGM 99999968		Dialogue initiation for opening dialogues required for the cycle.
1 END PGM 99999968	NO ENT	

DLG-DEF = ENT / DLG CALL = NO ENT	ENT	Cycle designation for DLG-DEF
0 BEGIN PGM 99999968	or	
1 DLG-DEF	NO ENT	Cycle designation for DLG-CALL
2 END PGM 99999968		

DIALOG-NUMBER ?		First dialogue number: Cycle designation
0 BEGIN PGM 99999968	ENT	
1 DLG-DEF		Second dialogue number: Cycle parameter Q1
2 END PGM 99999968	ENT	
		Third dialogue number: Cycle parameter Q2
	ENT	
	. . .	Up to 15 dialogues (0-99) can be defined.
	etc.	

Example for a user-cycles

Binary output of user-cycles for programming a PLC-EPROM

User-cycles are output in binary with the PLC-program (output of PLC-program, see PLC-description).

Data is output in the following sequence:
.PLC-program
.Macro-programs
.Dialogue texts
(for PLC-error messages and user-cycles)
.User-cycles
After output of the dialogue texts, the following dialogue is displayed:

READ-OUT ALL PROGRAMS ?

If all programs are to be read-out: ENT — All user-cycles within the EPROM and RAM are output. If a cycle within the EPROM has the same number within the RAM, the cycle within the RAM is output.

If only certain programs are to be read-out: NO ENT

OUTPUT = ENT / END = NO ENT

Set cursor to desired cycle number

99999970 99999982 99999993

99999995

In the program menue, only those programs are displayed, which are stored within the EPROM.

ENT — Transfer selected cycle to data medium.

OUTPUT = ENT / END = NO ENT

99999970 99999982 99999993

99999995

The cursor is set to the next cycle number.

Should data output from the EPROM be completed: NO ENT — The control finally reads-out the user-cycles from the RAM.

PLC-EDITING FUNCTION

The control returns to the mode PLC-EDITING FUNCTION

User-cycles within a machining program

Operating mode ____________

Dialogue initiation ____________

CYCL DEF 68 BOLT HOLE CIRCLE	ENT	Enter cycle into memory.
NUMBER OF HOLES		Key-in number of holes.
	ENT	Enter into memory.
RADIUS		Key-in pitch circle radius.
	ENT	Enter into memory.
X-COORDINATE		Key-in X-coordinate for pitch circle centre.
	ENT	Enter into memory.
Y-COORDINATE		Key-in Y-coordinate for pitch circle centre.
	ENT	Enter into memory.
SET-UP CLEARANCE		Key-in set-up clearance.
	+/	Key-in appropriate sign.
	ENT	Enter into memory.
TOTAL HOLE DEPTH		Key-in hole depth.
	+/	Key-in appropriate sign.
	ENT	Enter into memory.
FEED RATE		Key-in feed rate for drilling.
	ENT	Enter into memory.

User-cycles within a machining program

Display example:

CYCL DEF 68.0 BOLT HOLE CIRCLE

CYCL DEF 68.1 Q1 = +27

Q2 = +40 Q3 = +50

CYCL DEF 68.2 Q4 = +50

Q5 = –2 Q6 = –20

CYCL DEF 68.3 Q7 = 100

The cycle definition requires 4 program blocks:
Q1 = Number of holes
Q2 = Radius
Q3 = X-coordinate for pitch circle centre
Q4 = Y-coordinate for pitch circle centre
Q5 = Set-up clearance
Q6 = Hole depth
Q7 = Feed rate for drilling

Machining program using the cycle "Bolt Hole Circle"

0	**BEGIN PGM 1000**	**MM**	
1	**BLK FORM 0.1 Z X + 0.000 Y. + 0.000 Z – 20.000**		Blank form definition
2	**BLK FORM 0.2 X + 100.000 Y + 100.000 Z + 0.000**		
3	**TOOL DEF 1 L + 0.000 R + 2.000**		Tool definition
4	**TOOL CALL 1 Z S**		Tool call-up
5	**L Z + 2.000 R0 F15999**	**M03**	Move to set-up clearance
6	**CYCL DEF 68.0 BOLT HOLE CIRCLE**		Cycle definition: "Bolt hole circle"
7	**CYCL DEF 68.1 Q1 = + 27.000 Q2 = + 40.000 Q3 = + 50.000**		
8	**CYCL DEF 68.2 Q4 = + 50.000 Q5 = – 2.000 Q6 = – 20.000**		
9	**CYCL DEF 68.3 Q7 = + 100.000**		
10	**CYCL CALL**	**M**	Cycle call
11	**END PGM 1000**	**MM**	

Contents

Standard data interface RS-232-C/V.24

The control is equipped with a serial data interface RS-232-C/V.24

Via this interface programs or data can be loaded down from the control memory to an external storage unit such as a magnetic tape unit, floppy disc unit or another peripheral unit e.g. a printer.

Transfer of data is also possible from the peripheral unit into the control.

The following can be input or output via the RS-232-C/V.24 interface of the TNC 355:

.NC-programs
.PLC-programs
.Machine parameters
.Matrix for graphics print-out
.Q-parameter values to a printer

The operating mode of the interface (ME-operation, FE-operation or operation with another peripheral unit) must be set before hand.

"Transfer blockwise"

Under the heading of "Transfer blockwise" the following function are possible:

- **Data transmission in FE-mode**
  between a TNC 355 and an FE 401 or IBM-PC
- **Data transmission with command block, BCC and ACK/NAK-protocol**
  in the EXT-mode after adaptation of the data interface
- **Data transmission in the aforementioned operating modes with simultaneous program run**
  The TNC 355 can read-in and execute in data blocks, long machining programs which are normally compiled externally with a host computer.

Computers with a bulk memory or the HEIDENHAIN Floppy disc unit FE 401 can be employed. It is recommended to use a multitasking operating system, in order that the computer can carry out other tasks while linked to one or several TNC 355-units.
In general, the host computer requires an especially compiled software in order execute data transfer to and from the TNC 355.

Graphics print-out

This necessitates a matching of the matrix via the machine parameters of TNC 355 as per the instruction manual of the printer-unit being connected. Detailed description sheet D3/1.

Standard data interface RS-232-C/V.24
Switchover of ME-FE-EXT transfer modes

For data transmission, the TNC 355 can be switched to the following 3 operating modes via the MOD-key:

ME – For connection of the HEIDENHAIN magnetic tape units ME 101/ME 102.
Data format and the Baud rate 2400 have been adapted to the ME.

FE – For connection of the HEIDENHAIN floppy disc unit FE 401 and the IBM-PC.[1)]
Data transmission, such as read-in, read-out or transfer blockwise is performed via a special protocol for data protection. Data format and Baud rate 9600 are adapted to the FE.

EXT – For adaptation of transmission to other peripheral units in standard data format as well as in transfer blockwise.
The interface for data transmission is adapted via machine parameters and the Baud rate is freely selectable.

Peripherals for the EXT-mode can be:

a tape puncher or reader
a printer or matrix printer for graphics print-out
a bulk memory or programming station.

Select operating mode ME-FE-EXT by pressing MOD-key

Press MOD.
Press ↓, ↑ or MOD several times until the mode RS-232-C/V.24-INTERFACE with display ME, FE or EXT appears.
Press ENT repeatedly until desired mode is displayed.

In the EXT-mode, the Baud rate is set as follows:

Select mode via MOD.
Press ↓, ↑ or ENT repeatedly until **BAUD-RATE** is displayed.
If necessary, enter new value for Baud rate (possible values: 110, 150, 300, 600, 1200, 2400, 4800, 9600 Baud).
Enter into memory with ENT.
With graphics print-out the control automatically switches to the EXT-mode, regardless of the mode which has already been set (ME or FE).

Note: Leave auxiliary mode MOD by pressing DEL.

1) With special software from HEIDENHAIN.

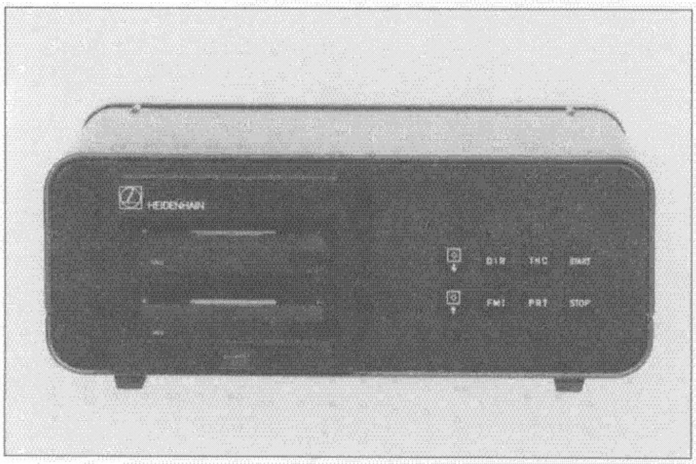
Standard data interface RS-232-C/V.24
Floppy disc unit FE 401

FE 401 – portable floppy disc unit for data storage.

With very long programs, which exceed the memory capacity of the control, "transfer blockwise" is possible with simultaneous program run.

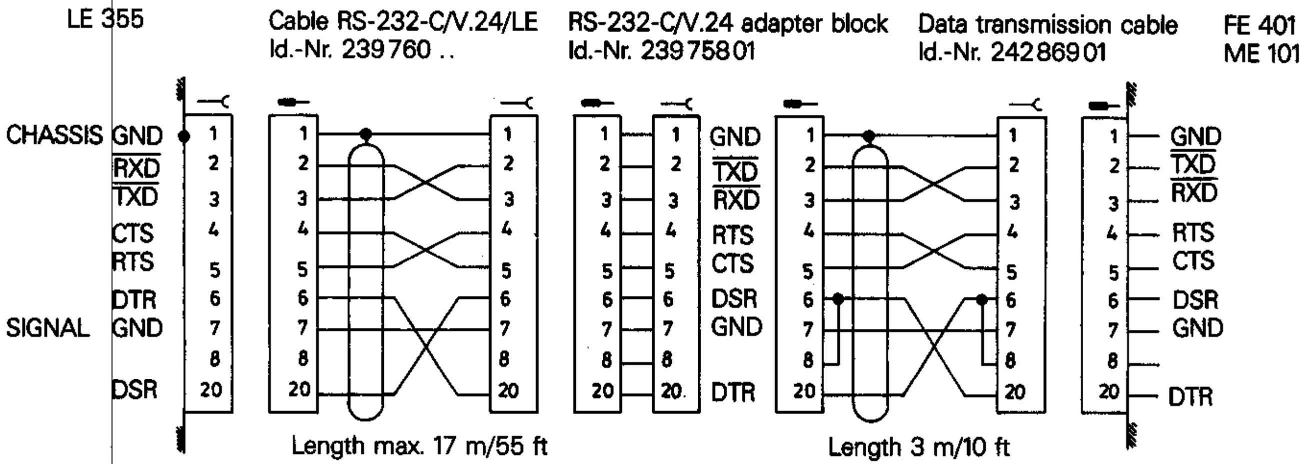
A further advantage against the magnetic tape units ME 101/ME 102 is the greater storage capacity. For example, up to 256 programs with a total of approx. 25000 program blocks can be stored. This corresponds to a storage capacity of approx. 790 kBytes.

Moreover, the FE 401 is equipped with 2 disc drives for the copying of disc information.

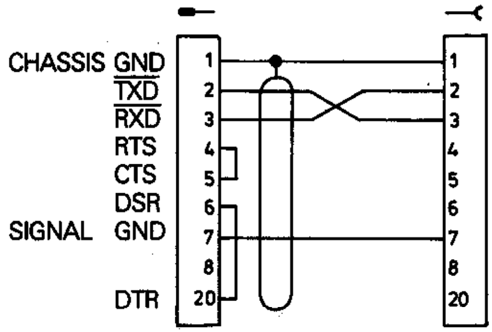


Standard data interface RS-232-C/V.24
Connecting cables for RS-232-C/V.24

HEIDENHAIN supplies the following connecting cables:



For RS-232-C/V.24 data transmission with DC1/DC3-protocol, a simple wiring layout of the data transmission cable is sufficient.



Signal designations:

$\overline{\text{TXD}}$	Transmit data
$\overline{\text{RXD}}$	Receive data
RTS	Request to send
CTS	Clear to send
DSR	Data set ready
DTR	Terminal ready

Layout of the cable between LE 355 and RS-232-C/V.24 adapter

In the cable between LE 355 and the RS-232-C-V.24 adapter block (Id.-Nr. 239760..) the data lines and control lines are crossed. At plug connection X 26 of LE 355 the layout conforms to the data transmission unit.
Due to the crossed data and control lines of the cable between the LE 355 and the RS-232-C/V.24 adapter, the layout at the RS-232-C/V.24 adapter conforms to a Data Terminal Unit. The external units can, therefore, be connected by the standard data transmission cable from HEIDENHAIN (Id.-Nr. 24286901).

Standard data interface RS-232-C/V.24

Characters for external programming and transmission protocol

Data transmission and control via the RS-232-C/V.24 interface is governed by ASCII-characters. The following table indicates the character code:

Character	Code DEC	Code BINARY
NUL	000	0000000
SOH	001	0000001
STX	002	0000010
ETX	003	0000011
EOT	004	0000100
ENQ	005	0000101
ACK	006	0000110
BEL	007	0000111
BS	008	0001000
HT	009	0001001
LF	010	0001010
VT	011	0001011
FF	012	0001100
CR	013	0001101
SO	014	0001110
SI	015	0001111
DLE	016	0010000
DC1 (X-ON)	017	0010001
DC2 (TAPE)	018	0010010
DC3 (X-OFF)	019	0010011
DC4	020	0010100
NAK	021	0010101
SYN	022	0010110
ETB	023	0010111
CAN	024	0011000
EM	025	0011001
SUB	026	0011010
ESC	027	0011011
FS	028	0011100
GS	029	0011101
RS	030	0011110
US	031	0011111
SP	032	0100000
!	033	0100001
”	034	0100010
	035	0100011
$	036	0100100
%	037	0100101
&	038	0100110
’	039	0100111
(	040	0101000
)	041	0101001
*	042	0101010
+	043	0101011

Character	Code DEC	Code BINARY
’	044	0101100
–	045	0101101
.	046	0101110
/	047	0101111
0	048	0110000
1	049	0110001
2	050	0110010
3	051	0110011
4	052	0110100
5	053	0110101
6	054	0110110
7	055	0110111
8	056	0111000
9	057	0111001
:	058	0111010
;	059	0111011
<	060	0111100
=	061	0111101
>	062	0111110
?	063	0111111
	064	1000000
A	065	1000001
B	066	1000010
C	067	1000011
D	068	1000100
E	069	1000101
F	070	1000110
G	071	1000111
H	072	1001000
I	073	1001001
J	074	1001010
K	075	1001011
L	076	1001100
M	077	1001101
N	078	1001110
O	079	1001111
P	080	1010000
Q	081	1010001
R	082	1010010
S	083	1010011
T	084	1010100
U	085	1010101
V	086	1010110
W	087	1010111

Character	Code DEC	Code BINARY
X	088	1011000
Y	089	1011001
Z	090	1011010
[	091	1011011
	092	1011100
]	093	1011101
	094	1011110
–	095	1011111
’	096	1100000
a	097	1100001
b	098	1100010
c	099	1100011
d	100	1100100
e	101	1100101
f	102	1100110
g	103	1100111
h	104	1101000
i	105	1101001
j	106	1101010
k	107	1101011
l	108	1101100
m	109	1101101
n	110	1101110
o	111	1101111
p	112	1110000
q	113	1110001
r	114	1110010
s	115	1110011
t	116	1110100
u	117	1110101
v	118	1110110
w	119	1110111
x	120	1111000
y	121	1111001
z	122	1111010
	123	1111011
	124	1111100
	125	1111101
DEL	127	1111111

Standard data interface RS-232-C/V.24
Machine parameter for data transmission in EXT-mode

MP 223 **Operating mode data interface RS-232-C/V.24**
0 ≙ "Standard data interface"
1 ≙ "Transfer blockwise"

Parameter 223 determines the operating mode of the RS-232-C/V.24 data interface.

In the operating mode "Standard data interface", machine parameters MP 218 to MP 221 and MP 224 (see sheet D2/5) are non-functional. If the standard data interface is only being used, 0 can be entered for this machine parameter.

MP 71 **Characters for program beginning and end**
Define entry value as follows: 0 ... 65535

With parameter 71 the ASCII-character code (see sheet D1/5) for "program end" and "program beginning" is defined for external programming. ASCII-characters 1 – 47 are acceptable.

The character for "program end" is transmitted in all cases regardless of whether a "standard data interface" or "Transfer blockwise" is being used. The character for "Program beginning" is only transmitted in "Transfer blockwise".

Determination of entry value:

Example:	Program end:	ETX	BINARY code	00000011
	Program beginning:	STX	BINARY code	00000010

Bit 0 – 7	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Value	128	64	32	16	8	4	2	1
Insert 0 or 1 as appropriate	0	0	0	0	0	0	1	1

Bit 8 – 15	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**
Value	32768	16384	8192	4096	2048	1024	512	256
Insert 0 or 1 as appropriate	0	0	0	0	0	0	1	0

Entry value:

$$\begin{array}{r} 1 \\ 2 \\ +\,512 \\ \hline 515 \end{array}$$

The entry value for machine parameter 71 is therefore 515.

MP 92 **Parameter with multiple function**

Bit 0 **Decimal character**
0 ≙ Decimal comma
1 ≙ Decimal point

Depending on MP 92 the control transmits either a decimal comma or a decimal point for numerical values. When reading-in, the decimal character is processed independently of MP 92.
Depending on MP 92 the decimal character alters for the position display (see sheet C2/7).

Standard data interface RS-232-C/V.24
Machine parameters for data transmission in EXT-mode

MP 222 determines the data format. Bit 1 is only significant for "Transfer blockwise".
0 is entered for the standard data interface.

Function	Parameter No.	Entry value	
Data format and transmission stop for RS-232-C/V.24 data interface	222 Bit		
7 or 8 data bits	0	+ 0 ≙ 7 data bits (ASCII-code with 8th bit = parity) + 1 ≙ 8 data bits (ASCII-code with 8th bit = 0. 9th bit = parity)[1]	+
Block Check Character	1	+ 0 ≙ BCC at random[2] + 2 ≙ BCC not control character[3]	+
Transmission stop through RTS[4]	2	+ 0 ≙ Inactive + 4 ≙ Active	+
Transmission stop through DC3	3	+ 0 ≙ Inactive + 8 ≙ Active	+
Character parity even or odd	4	+ 0 ≙ Even + 16 ≙ Odd	+
Character parity required	5	+ 0 ≙ Not required + 32 ≙ Required	+
Number of stop bits	6/7	7 | 6 0 | 0 1 1/2 stop bits 0 | I 2 stop bits I | 0 1 stop bit I | I 1 stop bit	
		Setting of bit 6: + 64	+
		Setting of Bit 7: + 128	+
		Entry value	

[1] **Please note:**
With hardcopy printout of a graphics image, the TNC automatically switches to 8 data bits (see sheet D3/1).

[2] **Entry value + 0:**
The BCC can be allocated with any random or control character.

[3] **Entry value + 2:**
If the calculation of the BCC with "Transfer blockwise" results in a number less than 20 HEX (control character), a character "Space" (20 HEX) is transmitted before ETB. This ensures that the BCC is always greater than 20 HEX and therefore not a control character (see sheet D2/4).

[4] If the control switches the RTS-output to 0 V, the output DTR is simultaneously switched to 0 V (connected to the DSR-input of the peripheral unit). If the DSR-input of the peripheral unit is not allowed to be switched to 0 V during data transmission, a logical "1" should be circuited to DSR via a bridge connection.

Example for the determination of the entry value

Standard data format:

7 data bits (ASCII-code with 8th bit = parity)
Transmission stop through DC3
Character parity even
Character parity required
1 stop bit

Bit 0 – 7	7	6	5	4	3	2	1	0
Value	128	64	32	16	8	4	2	1
Insert 0 or 1 as appropriate	1	0	1	0	1	0	0	0

Calculated entry value for parameter 222: 168

Standard data interface RS-232-C/V.24
External programming

A few hints on external programming

.A program must begin with the characters CR LF or LF or CR FF or FF[1].

.The end of the "program end"-block must finish with CR LF or CR FF or FF and additionally EXT (control C) or instead of EXT a character entered with machine parameter 71[1].

.Spaces between individual words may be left out.

.Zeros after the decimal comma may be left out.

.When reading-in ISO-blocks, the "*"-character at the end of the block is unnecessary.

.When reading-out ISO-blocks, the "*"-character is not output by the control.

.When reading-in NC-programs, comments which are marked with "*" or ";" are overread.

A compilation of block formats for TNC 355 is available from **HEIDENHAIN**.

[1] CR, LF at the program beginning and CR, LF or LF or FF after every block is not necessary for "Transfer blockwise". These functions are taken over by the control characters.

Transfer blockwise

Via the serial data interface machining programs can be transferred from an external storage unit or the FE-unit and executed. This is performed in the PROGRAM RUN-mode with "transfer blockwise" and permits the execution of machining programs which exceed the capacity of the control memory.

The data interface can be programmed via machine parameters. The RS-232-C/V.24 interface of the TNC must be adapted to either external or FE-operation!

By using the EXT-key in the operating mode single block/automatic program run, data transmission can be started from an external storage unit. The control stores the program blocks in the storage space which is available and interrupts data transmission when the vacant storage space is exceeded.

The display screen discontinues to show program blocks until either the available storage space is full or the complete program is transferred.

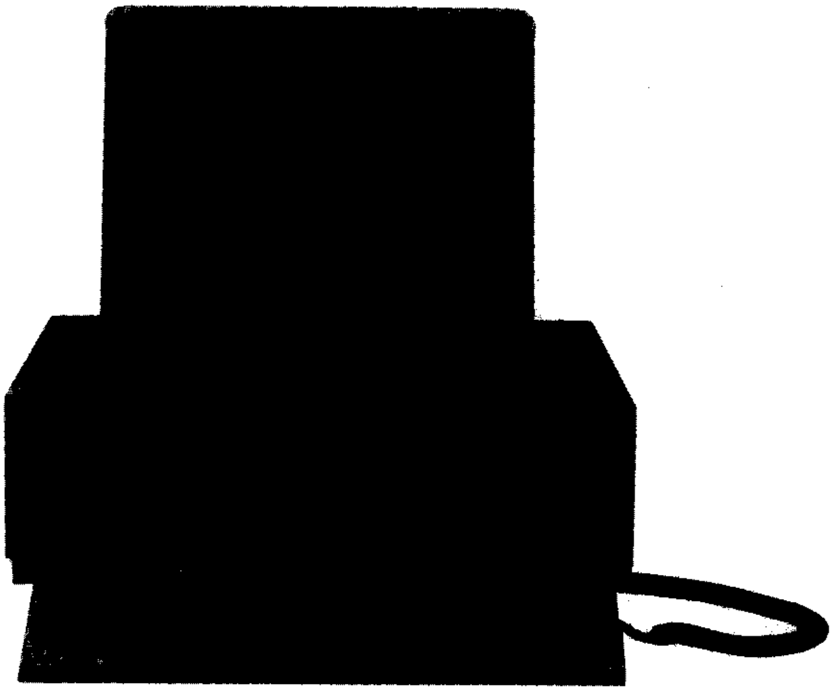
Although program blocks are not being displayed, program run can be started via the external START -button.

In most cases, only short program blocks are executed when working with an external storage unit. In order to avoid unnecessary interruptions of program run after start, a substantial number of program blocks should be stored as a buffer. It is therefore advantageous to wait until the available storage space is full.

After start, the executed blocks are erased and further blocks are continually called-up from the external store.

"Transfer blockwise"

"Transfer blockwise" using the HEIDENHAIN Floppy disc unit FE 401 and the IBM-PC



When in the FE-mode, the RS-232-C/V.24-interface is automatically adapted to the FE 401, regardless of the machine parameters which have been programmed. Mode selection is initiated by the MOD-function.

With special software from HEIDENHAIN blockwise transfer to and from an IBM-PC is possible; also from the PC to FE 401. Details are available from HEIDENHAIN.

Blockwise transfer
„Transfer blockwise" via EXT-mode

TNC 355 is connected to the external computer via the RS-232-C/V.24 data interface in the operating mode "EXT". Control characters for computer link-up are specified by machine parameters.

Data transmission can be started from the TNC 355. After starting, the control transmits a heading block to the external computer. This heading block contains the program number and information specifying whether transmission is to be from the computer to the control or vice-versa. Transmission of this heading block is followed by the machining program.

Each block, which has been transferred, is checked by a "block check character BCC". This is an important check procedure of the "transfer blockwise" mode, since there are no further checks of the machining program possible between data transmission and program execution.

If a transmitted program block has been recognized as error-free, the next block is called up. An erroneous block has to be re-transmitted.

Transferred blocks are read into a buffer memory in the TNC 355, and can be executed from this memory. During program run, the executed blocks are deleted and new blocks replenish the memory.
Continuous contouring operation, without interruptions is therefore possible.

The following ASCII-characters are used for control of data transmission (as per ISO R 646):

SOH ≙ Start of Heading, Binary code 0000001
SOH signifies the data transfer heading: a character sequence which contains the program number and the information "data input" or "data output". Data check for the heading commences with the character SOH (see sheet D2/4).

STX ≙ Start of Text, Binary code 0000010
STX signifies the beginning of a program block. Block protection for the text (BCC) commences with STX.

ETB ≙ End of Transmission Block, Binary code 0010111
ETB finalizes a data transmission block. The character following ETB is for data check (BCC).

ETX ≙ End of Text, Binary code 0000011
ETX is transmitted at the end of a program.

ACK ≙ Acknowledge, Binary code 0000110
ACK ist signalled by the receiving station to confirm that the data block was transmitted error-free.

NAK ≙ Negative Acknowledge, Binary code 0010101
NAK is signalled by the receiving station when an error is detected for a data block.
The transmitting station must then re-transmit the block.

EOT ≙ End of Transmission, Binary code 0000100
EOT ends data transmission. This character is transmitted by the TNC 355 to the external computer at the end of a program entry and in the event of an error.

With machine parameters, ASCII-characters (substitute characters) with decimal code from 1 to 47 may substitute the above characters.

Further control characters, which cannot be replaced by machine parameters:

DC1 ≙ Start data transmission (Device Control 1), Binary code 00010001
DC1 starts data transmission.

DC3 ≙ Interrupt data transmission (Device Control 3), Binary code 00010011
DC3 interrupts data transmission.

Transfer blockwise
Data protection with "Block Check Character BCC"

"Transfer blockwise" with simultaneous program execution requires data check procedures (ISO 1155 and ISO 2111). For this reason, during the "transfer blockwise" mode of the TNC 355, a parity check of the complete transmitted block (length parity) is performed in addition to the parity check of the individual characters (cross parity). This is performed with the "Block Check Character BCC", which completes the individual bits of the transmitted character of a data block for an even length parity.

At the end of a block, the control checks data transmission via the BCC. For this, the TNC 355 generates a BCC and compares it with the BCC being received. If the generated BCC and the received BCC are identical, the control signals ACK to the peripheral unit.

If the BCC's are not identical, the control signals NAK, and the block must be re-transmitted to the peripheral unit. This procedure is repeated up to 3 times and the following error message is then displayed:

TRANSFERRED DATA INCORRECT

With data output the control can transmit a BCC to the peripheral unit. The TNC 355 then waits for the signal NAK or ACK from the peripheral unit. If the peripheral unit transmits ACK, the next program block is transmitted.

If, however, the peripheral unit transmits NAK, the program block is repeated. The control repeats the same block up to 3 times. If the peripheral unit transmits NAK each time, the following error message is displayed:

PROGRAM INCOMPLETE

Example showing the formation of the BCC

Bit No.	P[1]	6	5	4	3	2	1	0
1. Character SOH	1	0	0	0	0	0	0	1
2. Character H	0	1	0	0	1	0	0	0
3. Character 1	1	0	1	1	0	0	0	1
4. Character 5	0	0	1	1	0	1	0	1
5. Character E	1	1	0	0	0	1	0	1
6. Character ETB	0	0	0	1	0	1	1	1
BCC	1	0	0	1	1	1	1	1

All bits are completed for an even length parity with the BCC.

[1] P = Bit for character parity (cross parity)

Transfer blockwise
Machine parameters for „Transfer blockwise" in EXT-mode

The determination of entry values is described under parameter 71 (see sheet D1/6).

Parameter No.	Bit	Function	Entry values for:
71	0 ... 7 8 ... 15	ETX or random ASCII-character, Character for program end. STX or random ASCII-character, Character for program beginning.	ETX and STX: 515
218	0 ... 7 8 ... 15	H or random ASCII-character. Transmitted within heading block for **data input** before program number. E or random ASCII-character. Transmitted within heading block for **data input** after program number.	H and E: 17736
219	0 ... 7 8 ... 15	H or random ASCII-character. Transmitted within heading block for **data output** before program number. A or random ASCII-character. Transmitted within heading block for **data output** after program number.	H and A: 16712
220	0 ... 7 8 ... 15	ETB or substitute character (decimal code 1 – 47) is transmitted at the **end** of the **heading block**. SOH or substitute character (decimal code 1 – 47) is transmitted at the **beginning** of the **heading block**.	ETB and SOH: 279
221	0 ... 7 8 ... 15	ACK or substitute character (decimal code 1 – 47) positive acknowledgement is transmitted when data block is received as **correct**. NAK or substitute character (decimal code 1 – 47) negative acknowledgement is transmited when data block is received as **erroneous**.	ACK and NAK: 5382
224	0 ... 7	EOT or substitute character (decimal code 1 – 47) is transmitted at **end** of **data transmission**.	EOT: 4

Transfer blockwise

Protocol for „Transfer blockwise" in EXT-mode

In operating modes

.**TRANSFER BLOCKWISE** in **SINGLE BLOCK/AUTOMATIC PROGRAM RUN**

and

.**READ-IN SELECTED PROGRAM**

data transmission from the peripheral unit to the TNC 355 is performed as follows:

Operation/Dialogue display	Data from TNC → peripheral unit (output TXD)	Data from peripheral unit → TNC (input RXD)	Remarks
Select Operating mode Single block/Automatic	–	–	–
Press EXT	–	–	–
Dialogue display **PROGRAM NUMBER**	–	–	–
Key-in program number and enter into memory with ENT	–	–	–
Dialogue display **TRANSFER BLOCKWISE**	SOH	–	Control transmits SOH (Beginning of heading block)
	H	–	H = Beginning of program number
	Program No.	–	The program number may have 1 – 8 digits[1]
	E	–	E = Control waits for data input
	ETB	–	ETB = End of Transmission Block
	BCC	–	BCC is generated between SOH and ETB
	DC1	–	DC1 = Start data transmission
	–	ACK or NAK	The peripheral unit transmits ACK = Data transmission correct NAK = Data transmission erroneous. Repeat heading
	–	STX	The peripheral unit transmits STX (Start of text)
	–	Block Text	The first program block is transmitted
	–	ETB	ETB = End of Transmission Block
	–	BCC	BCC is generated between STX and ETB
	ACK or NAK	–	The control transmits ACK = Data transmission correct, next block NAK = Data transmission erroneous. Repeat block
	–	STX	The second program block is transmitted
		Block Text	
		ETB	
		BCC	
	ACK or NAK	etc.	
	etc.		
		ETX	Program end
	EOT	–	End of Transmission

[1] In operating modes
.Program directory
.Read-in all programs
and
.Read-in program offered
no program number is output
by TNC 355.

Please note:
CR, LF at program beginning and CR, LF or LF or FF after every block are not required for "Transfer blockwise". This function is carried out by the control character.

Transfer blockwise
Overview of control characters in various modes

Program input from a peripheral unit into the TNC 355

The TNC transmits the following heading block for activation of entry:		**Block format**	**Program end**	**From TNC at end of transmission**
."Read-in selected program" ."Transfer blockwise" in single block/automatic program run	."Program directory" ."Read-in all programs" ."Read-in program offered"			
SOH/H/Program No./ E/ETB/BCC/DC1 (Program No. max. 8 digits)	SOH/H/E/ETB/BCC/DC1	STX/Block text/ETB/BBC (control transmits NAK or ACK after every block)	ETX	EOT

Program output from the TNC 355 to peripheral unit

The TNC transmits the following heading block before every program:	**Block format**	**Program end**	
SOH/H/Program No./A/ETB/BCC/DC1 (Program No. max. 8 digits)	STX/Block text/ETB/BCC (control waits for NAK or ACK after every block)[1]	ETX	

Heading block for error messages from peripheral unit to TNC 355

SOH/error message/ETB/BCC (the error message may contain up to 32 characters).

[1] With NAK, the control repeats the same block up to 3 times. If the peripheral unit transmits NAK, the following error message is displayed:

PROGRAM INCOMPLETE

Graphics printout

In the "EXT"-mode a suitable matrix printer can be connected to the RS-232-C/V.24 port of the TNC 355.
Adaptation of the control to the matrix printer is performed via MP 226 to MP 233. With the aid of MP 226 to MP 229 the ASCII-characters which are transmitted prior to each print-out are determined. MP 230 to MP 233 determines the ASCII-characters which are transmitted to the printer before each line.

Control characters before to each image
In MP 226 Bits 8 – 15 the number of control characters which is transmitted before each image, is determined. This entry is **binary** coded. All subsequent control characters are defined by the ASCII-table.

Control characters before each line
In MP 230 Bits 8 – 15 the number of control characters which is transmitted before each line is determined. This entry is **binary** coded. All subsequent control characters are defined by the ASCII-table.

Output of control characters
Output of control characters takes place in the following sequence: Firstly the information of bits 8 – 15 and then the information of bits 0 – 7.

Please note:
When printing a graphics image, the control automatically switches to 8 data bits.

Adaptation of the printer TI OMNI 800 model 850 XL

Entry values for machine parameters

Parameter No.	Bit	Function	Entry values for:
226	8 – 15 0 – 7	Number of control characters from the control for setting the printer interface (binary) Control character	3 and ESC: 795
227	8 – 15 0 – 7	Control characters Number of points/Line spacing (binary)	A and 8: 16648
228	8 – 15 0 – 7	unassigned	0
229	8 – 15 0 – 7	unassigned	0
230	8 – 15 0 – 7	Number of control characters from the control before each printer line (binary) Line feed	5 and LF: 1290
231	8 – 15 0 – 7	Control character Control character	ESC and N: 6990
232	8 – 15 0 – 7	Number of points per line	512: 2
233	8 – 15 0 – 7	unassigned	0

For MP 222 enter value 169 and for MP 223 enter value 0.

Setting the code switch
The TI-Matrix printer is equipped with a code switch.
The following switch settings are required for graphics printout:

Switch setting	1 on 8 bit data format
Switch setting	2 off Line shift non-automatic
Switch setting Switch setting Switch setting	3 off 4 on Letter set German 5 on
Switch setting Switch setting Switch setting	6 on 7 on 9600 Baud 8 off

Connecting cable for TI-Matrix printer

RS-232-C/V.24 Adapter output 25-pole	TI-printer input 36-pole	
1	1	CHASSIS GND
7	19	SIGNAL GND
6	34	DSR
20	33	$\overline{\text{DTR}}$
2	16	$\overline{\text{TXD}}$
5	15	$\overline{\text{CTS}}$
3	35	$\overline{\text{RXD}}$

Graphics printout

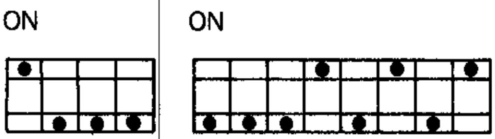
Adaptation of EPSON matrix printers

Entry values for machine parameters

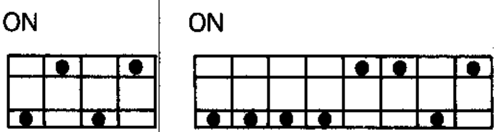
Parameter No.	Entry value
222	169
223	0
226	795
227	13080
228	0
229	0
230	1805
231	2587
232	10757
233	2

Setting the code switches
The EPSON matrix printer is equipped with four code switches. Two are located on the basis PCB and two on the interface PCB. The following settings are required for graphics printout:

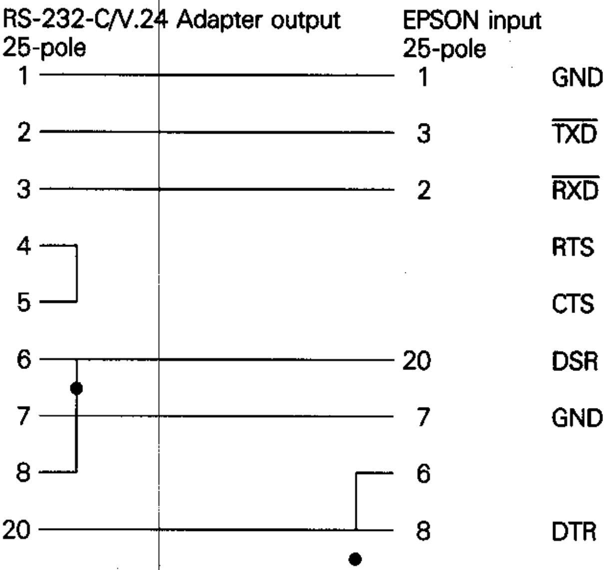
Code switch on the basis PCB



Code switch on the interface PCB



Connecting for EPSON printer



Contents

Contents

Contents

Introduction

The PLC (Programmable Logic Control) is a programmable interface for the control of signals between the machine tool and the TNC.
For such control a large number of logical combinations (PLC-commands) of inputs, outputs and markers may by necessary.
These combinations are achieved by the PLC-program.
This program has great flexibility and enables TNC controls to be fitted to a variety of machine tools.
The HEIDENHAIN TNC 355 control has an integral PLC which gives the following advantages:
.The PLC-program can be entered via the keyboard of the control, no external programming station being necessary.
.After the programming of PLC-functions, an immediate test is possible.
.During machine operation, error messages can be displayed on the screen of the control.
.The hardware for connecting the control to the machine is simplified.

A PLC-program will, irrespective of length, cycle every 20 ms (with selection of th extra 1000 commands this increases to 22 ms, see sheet P3/54).
This results in the inputs being interrogated and the outputs and markers being updated once every 20 ms (22 ms).
In the following sections, the PLC-commands, pre-assigned markers and PLC-operating modes are described in detail.

Programming of the HEIDENHAIN PLC
Description of the PLC-commands

It is convenient to represent the integrated PLC in the HEIDENHAIN control as relays or various logic circuits. These comprise commands that the binary operations (logic gates) execute.

A PLC-program can consist of up to **3072 commands**. Each individual logic command combines two input values, of which the first is the result of the previous logic gate and the second is self-addressed with the logic command. Gates with inputs are possible using a series string of multiple commands.

The following commands are programmable:

Command	Abbreviation
No Operation	NOP
Assignment	=
AND AND with negative operand (NAND) OR OR with negative operand (NOR) Exclusive OR Exclusive OR with negative operand (exclusive NOR)	U UN O ON XO XON
Set marker or output if result of previous logic gate is logic "1" Set marker or output if result of previous logic gate is logic "0" Reset marker or output if result of previous logic gate is "1" Reset marker or output if result of previous logic gate is "0"	S SN R RN

Programming of the HEIDENHAIN PLC
Description of the PLC-commands

No Operation: NOP
No Operation designates an empty memory location in the command memory.

Every memory location in the command memory which is not occupied by another command, functions as a NOP-command.

Command	Abbreviation
No operation	NOP

Assignment: =
The preceding logic circuit is assigned to a marker or output: a logic sequence is interrupted.

Command	Abbreviation	PLC-Program
Assignment	=	U E1 U E2 = M30

AND-command: U
With the aid of the U-command, two input variables can be gated according to the logical AND-function.

The first input variable is
either
the logic result of an immediately preceding gating operation (U, UN, O, ON, XO, XON)
or
logic "1" in the event of an immediately preceding operation being S, SN, R, RN or =.

The second input variable is self-addressed with the U-command.

Command	Abbreviation	Symbol	PLC-Program
AND	U	Preceding result E27 &	U E27

AND-command with inverted operand: UN
With the aid of the UN-command, two input variables can be gated according to the logical AND-function.

The first input variable is
either
the logic result of an immediately preceding gating operation (U, UN, O, ON, XO, XON)
or
logic "1" in the event of an immediately preceding operation being S, SN, R, RN or =.

The second input variable is self-addressed with the UN-command and **inverted**.

Command	Abbreviation	Symbol	PLC-Program
AND with inverted operand	UN	Preceding result E12 &	UN E12

OR-command: O
With the aid of the O-command, two input variables can be gated according to the logical OR-function.

The first input variable is
either
the logic result of an immediately preceding gating operation (U, UN, O, ON, XO, XON)
or
logic "0" in the event of an immediately preceding operation being S, SN, R, RN or =.

The second input variable is self-addressed with the O-command.

Command	Abbreviation	Symbol	PLC-Program
OR	O	Preceding result —[≥1] E8 —	O E8

OR-command with inverted operand: ON
With the aid of the ON-command, two input variables can be gated accordingly to the logical OR-function.

The first input variable is
either
the logic result of an immediately preceding gating operation (U, UN, O, ON, XO, XON)
or
logic "0" in the event of an immediately preceding operation being S, SN, R, RN or =.

The second input variable is self-addressed with the ON-command and **inverted**.

Command	Abbreviation	Symbol	PLC-Program
OR with inverted operand	ON	Preceding result —[≥1] E19 —o	ON E19

Exclusive OR-command: XO
With the aid of the XO-command, two input variables can be gated according to the logical Exclusive OR-function.

The first input variable is
either
the logic result of an immediately preceding gating operation (U, UN, O, ON, XO, XON)
or
logic "0" in the event of an immediately preceding operation being S, SN, R, RN or =.

The second input variable is self-addressed with the XO-command.

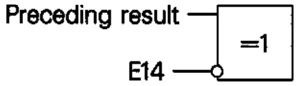
Command	Abbreviation	Symbol	PLC-Program
Exclusive OR	XO	Preceding result —[=1] E11 —	XO E11

Note:
An Exclusive OR-function generates a logic "1" at the output, when **only one** input is set to logic "1". If both inputs are logic "1" or logic "0", the output generates a logic "0".

Exclusive OR-command with inverted operand: XON
With the aid of the XON-command, two input variables can be gated according to the logical Exclusive NOR-function.

The first input variable is
either
the logic result of an immediately preceding gating operation (U, UN, O, ON, XO, XON)
or
logic "0" in the event of an immediately preceding operation being S, SN, R, RN or =.

The second input variable is self-addressed with the XON-command and **inverted**.

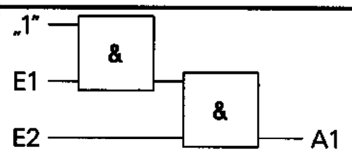
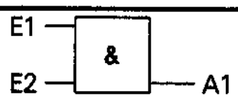
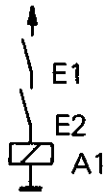
Command	**Abbreviation**	**Symbol**	**PLC-Program**
Exklusiv OR command with inverted operand	XON		XON E14

Programming of the HEIDENHAIN PLC
Programming of logic sequences

The logic commands of the PLC can be arranged in chains to form a logic sequence.

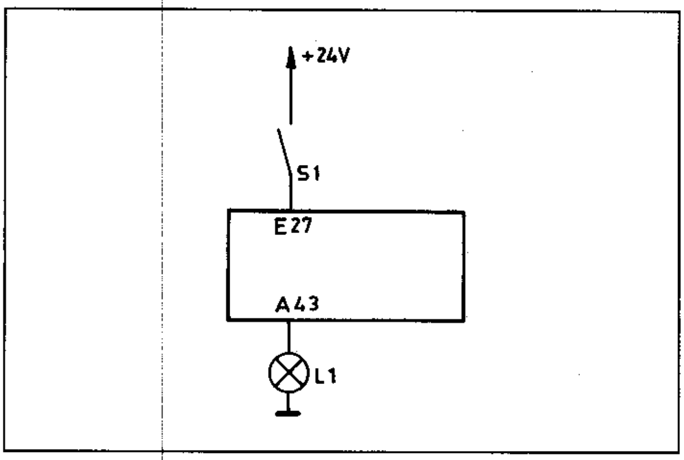
Logic sequences are interrupted by the PLC-commands: S, SN, R, RN or =; a new logic sequence begins after these commands.

Logic sequences with U-commands
A logic sequence with U-commands effects a series switching of contacts. These contacts are normally open.
This corresponds to an AND-gate.

PLC-Program	Gating-logic	Abbreviated symbol	Truth table E1	E2	A1	Contact example
U E1 U E2 = A1			0 0 1 1	0 1 0 1	0 0 0 1	

Examples:

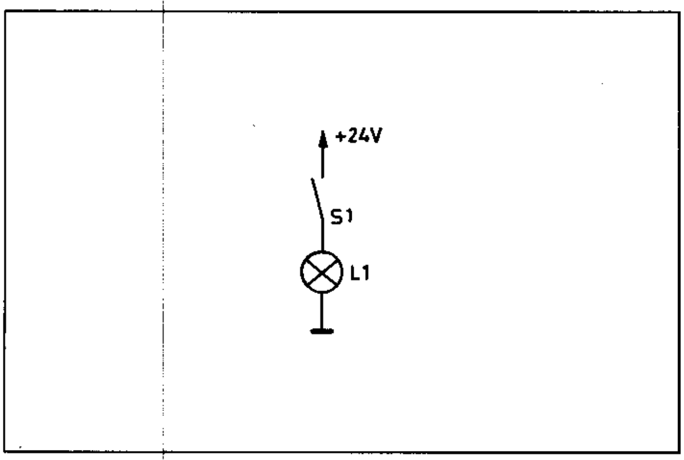
a)



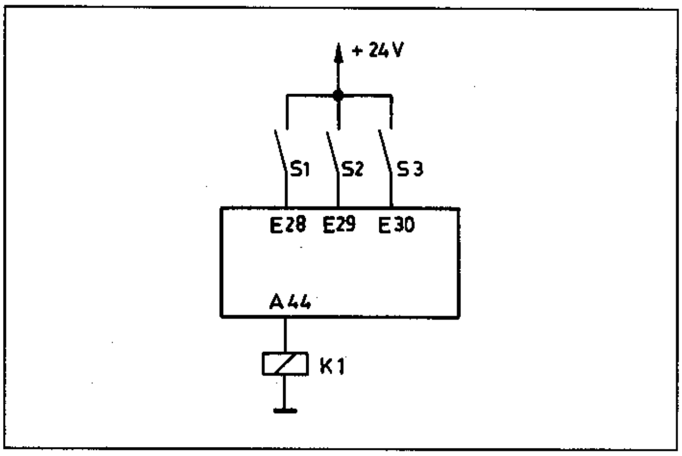
The lamp L1 is connected to the output 43.
The closing of the contacts S1 should result in the illumination of the lamp. The contacts are connected to input E27 of the PLC.

PLC-program: U E27
= A43

This PLC-program effects the following switching:



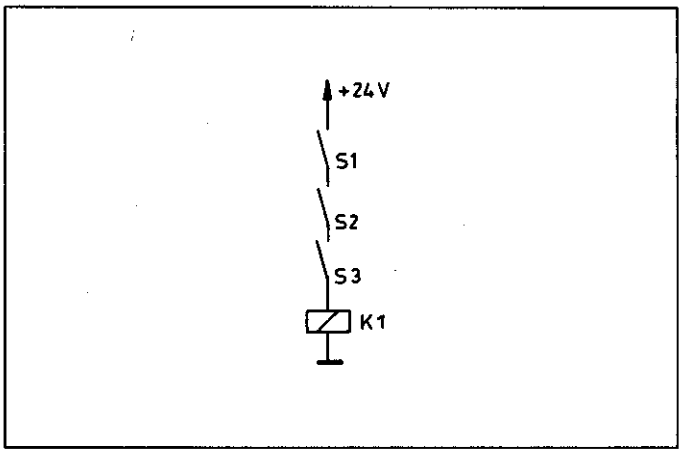
b)



The relay K1 should energise, in the event of the contacts S1, S2 and S3 closing simultaneously.

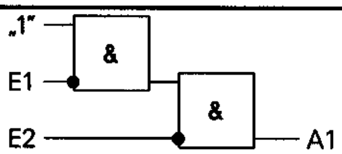
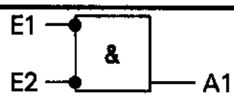
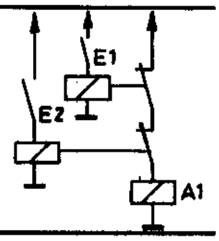
PLC-program: U E28
U E29
U E30
= A44

The PLC-program effects a series switching of the contacts S1, S2 and S3:



Programming of the HEIDENHAIN PLC
Programming of logic sequences

Logic sequences with UN-commands
A logical sequence with UN-commands effects a series switching of contacts. These contacts are normally closed. This corresponds to an AND gate with inverted operands.

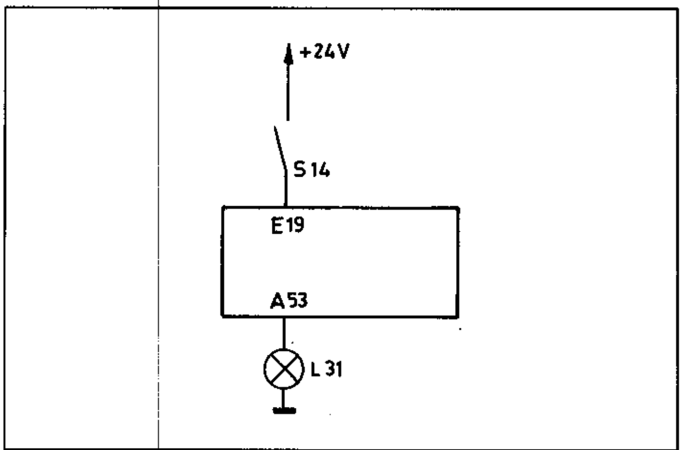
PLC-Program	Gating-logic	Abbreviated symbol	Truth table E1	E2	A1	Contact example
UN E1 UN E2 = A1			0 0 1 1	0 1 0 1	1 0 0 0	

It can be deduced from the truth table that this logic element is behaving as a NOR-function. This also follows the mathematical rules governing Boolean algebra:

$\overline{E1} \times \overline{E2} = \overline{E1 + E2}$

Examples:

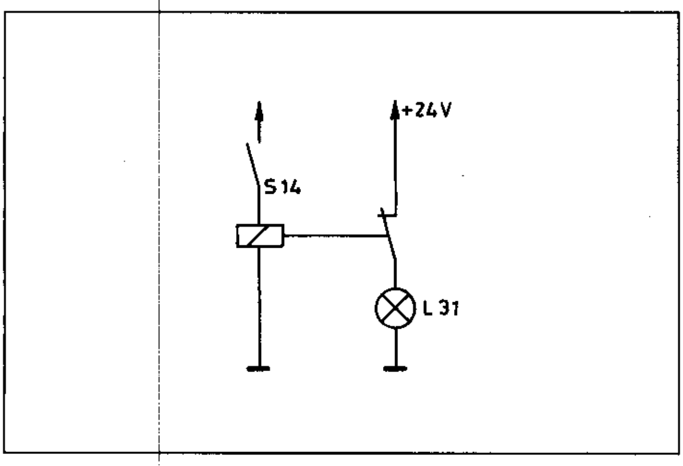
a)



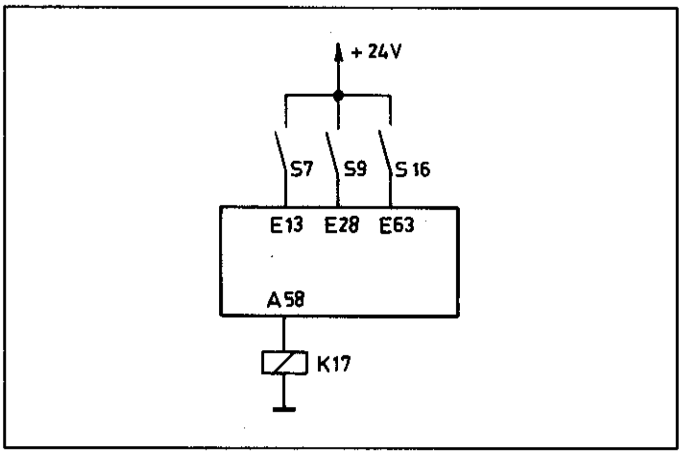
The lamp L31 should illuminate when the contact S14 is opened.

PLC-program: UN E19
= A53

This PLC-program effects the following switching:



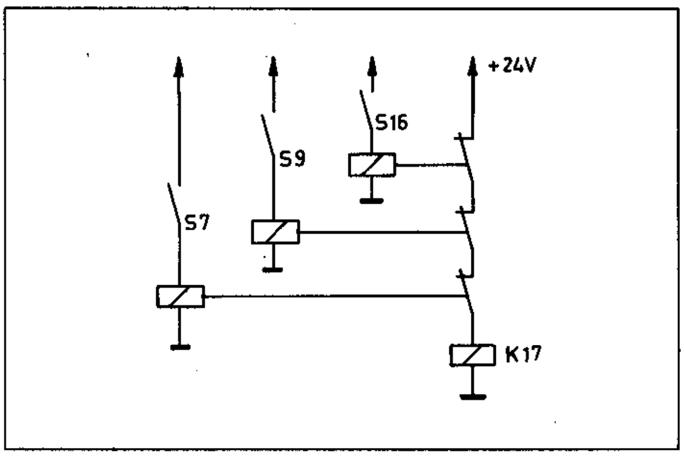
b)



The relay K17 should only energise when all three contacts S7, S9 and S16 are open.

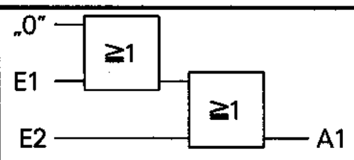
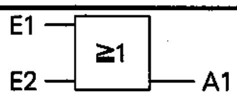
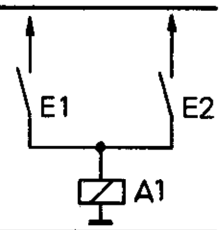
PLC-program: UN E13
UN E28
UN E63
= A58

This PLC-program effects the following switching:



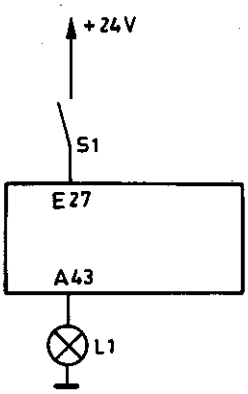
Programming of the HEIDENHAIN PLC
Programming of logic sequences

Logic sequences with O-commands
A logical sequence with O-commands effects a parallel switching of contacts. These contacts are normally open. This corresponds to an OR-gate.

PLC-Program	Gating-logic	Abbreviated symbol	Truth table E1	E2	A1	Contact example
O E1			0	0	0	
O E2			0	1	1	
= A1			1	0	1	
			1	1	1	

Examples:

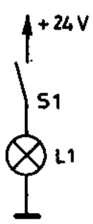
a)



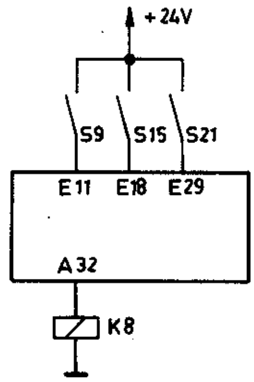
Lamp L1 is connected to output 43.
The closing of contact S1 illuminates the lamp.
The contact is connected to input E27 of the PLC.

PLC-program: O E27
= A43

This PLC-program effects the following switching:



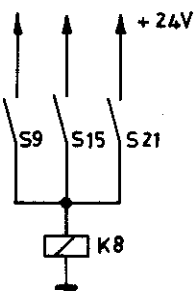
b)



The relay K8 should energise when the contact S9, S15, S21 or any combination thereof are simultaneously closed.

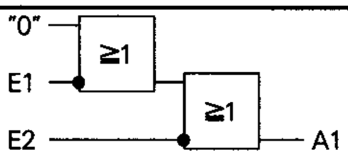
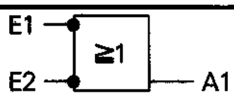
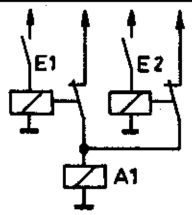
PLC-program: O E11
O E18
O E29
= A32

This PLC-program effects a parallel switching of contacts S9, S15 and S21:



Programming of the HEIDENHAIN PLC
Programming of logic sequences

Logic sequences with ON-commands
A logical sequence with ON-commands effects a parallel switching of contacts. These contacts are normally closed.
This corresponds to an OR-gate with inverted operand.

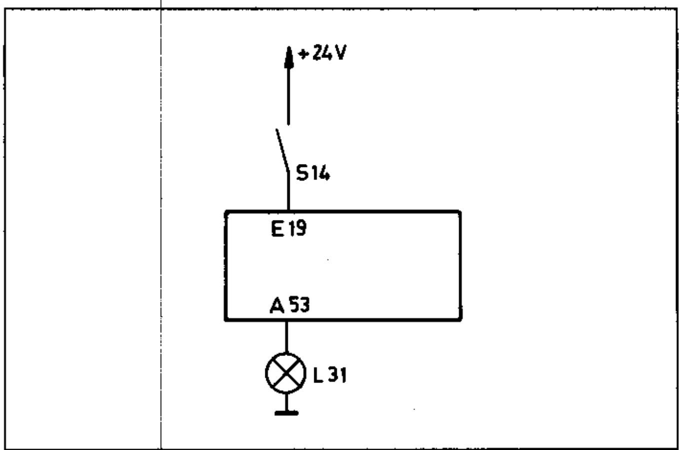
PLC-Program	Gating-logic	Abbreviated symbol	Truth table E1	E2	A1	Contact example
ON E1 ON E2 = A1			0 0 1 1	0 1 0 1	1 1 1 0	

It can be deduced from the truth table that this logic element is behaving as a NAND-function.
This also follows the rules governing the Boolean Algebra:

$\overline{E1} + \overline{E2} = \overline{E1 \times E2}$

Examples:

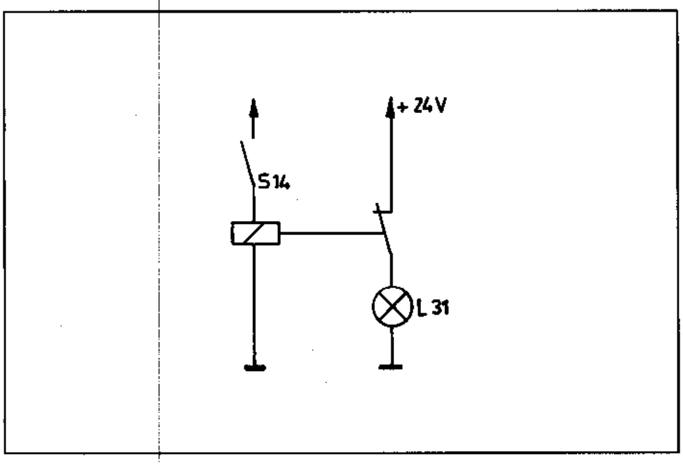
a)



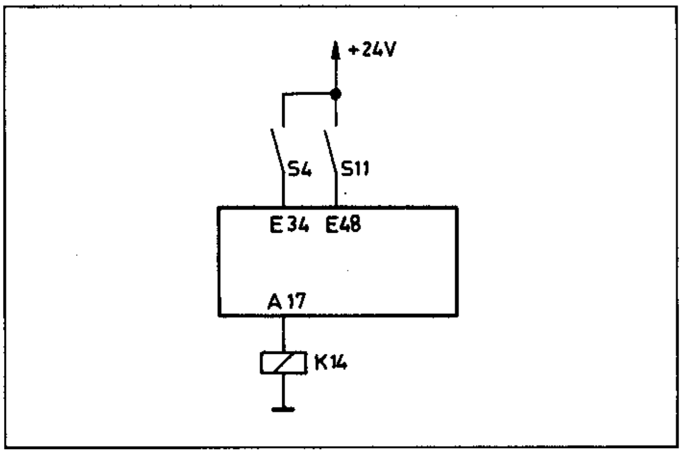
Lamp L31 should illuminate in the event of contact S14 being open.

PLC-program: ON E19
= A53

This PLC-program effects the following switching:



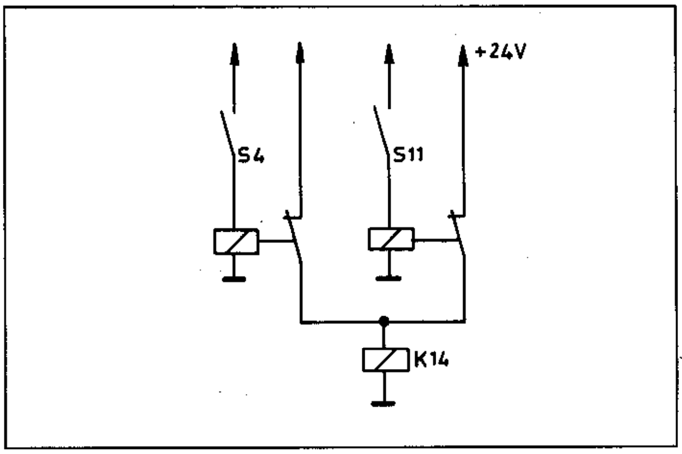
b)



The relay K14 should energise when contact S4, S11, or both, are open.

PLC-program: ON E34
ON E48
= A17

This PLC-program effects the following switching:



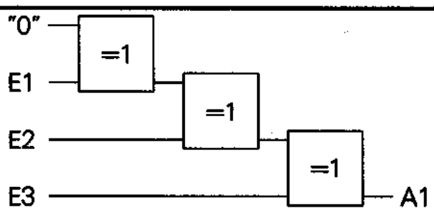
Logic sequence with XO/XON-commands
A logic sequence with XO or XON-commands can, for example, be used for a parity-check.

Example:
A 3 bit binary number is to be checked for parity with the aid of a logic sequence consisting of XO-commands.

PLC-Program

```
XO E1
XO E2
XO E3
=  A1
```

Gating logic



Truth table

E1	E2	E3	A1
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

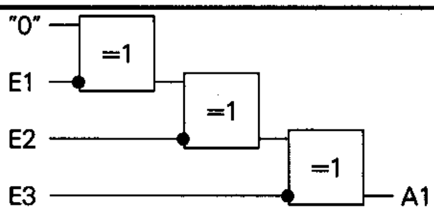
The logic sequence produces a logic "1" for odd parity and a logic "0" for even parity.

The parity-check can also be carried out using a logic sequence consisting of XON-commands.

PLC-Program

```
XON E1
XON E2
XON E3
=   A1
```

Gating logic



Truth table

E1	E2	E3	A1
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

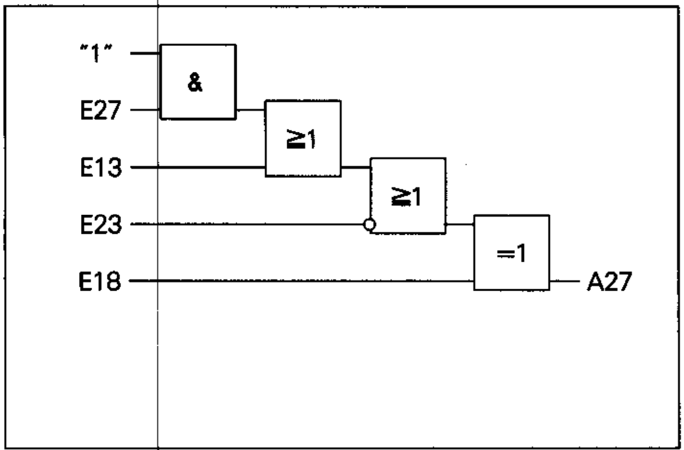
The logic sequence produces a logic "0" for odd parity and a logic "1" for even parity.

Programming of an arbitrary logic sequence
Arbitrary logic sequences may be assembled from various logic commands.

Example:

```
U   E27
O   E13
ON  E23
XO  E18
=   A27
```

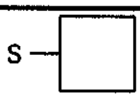
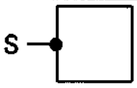
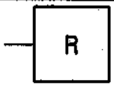
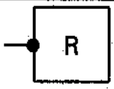
This program effects the following switching:



Programming of the HEIDENHAIN PLC
Setting and resetting of a marker

With the aid of the command S or SN, a marker can be set, dependent upon the preceding logic result.

With the aid of the command R or RN, a marker can be reset, dependent upon the preceding logic result.

Function	Abbreviation	Symbol	PLC-Program
Set marker or output if previous gating result is "1"	S		U E1 U M10 S M15
Set marker or output if previous gating result is "0"	SN		U E1 U M11 SN M16
Reset marker or output if previous gating result is "1"	R		U M10 R M16
Reset marker or output if previous gating result is "0"	RN		U M11 RN M15

Examples:

a)
Setting a marker

PLC-program:
```
U E25
U M33
U M61
S M300
```

If input 25 and marker 33 and 61 are logic "1", then marker 300 wil be set to "1". In contrast to the = -functions, marker 300 remains set even if the logic result in the next PLC-program cycle produces logic "0". Normally, the marker is reset by the command R or RN.

b)
Resetting of a memory location

PLC-program:
```
U E18
U E30
R M300
```

Address designations for markers, timers, counters, PLC-inputs and PLC-outputs

Address	Designation
M 0 – M 999	Freely assignable user-markers which are reset upon control switch-on
M 1000 – M 1999	Freely assignable user-markers whose status is maintained during a power interruption. These markers are also unaffected upon control switch-on. These markers may be reset with the code number 531210.
M 2000 – M 2447	Markers for signals from NC to PLC (NC → PLC).
M 2448 – M 3023	Markers for signals from PLC to NC (PLC → NC).
M 3264 – M 3279	Markers for the call-up of macro programs
M 3024 – M 3199	Markers for signals from macros to PLC and PLC to macros
M 3200 – M 3263	Markers for the inputs values to MP 209 – MP 212
Z 0 – Z 25	Markers for counters
T 0 – T 41	Markers for timers
E 0 – E 31; E 128 – E 152	PLC-inputs on the logic unit LE 355
E 63 – E 126	PLC-inputs on the input/output board PL 300
A 0 – A 30	PLC-outputs on the logic unit LE 355
A 32 – A 62	PLC-outputs on the input/output board PL 300

Description of the markers
Markers for axes X, Y, Z, IV

Axis enable

Marker No.	Function	Signal direction
2000 2001 2002 2003	Enable axis X Enable axis Y Enable axis Z Enable axis IV	NC → PLC

The markers for axis enable are set by the NC-part as follows:

NC supply switch-on:
.clear the error message **"POWER INTERRUPTED"**
.PLC-supply switch-on
After PLC-supply switch-on the markers 2000 – 2003
(and marker 2016) are automatically set.

The axis enable markers remain set to "1" after the PLC-supply switch-on in order that the control holds the machine axes in closed loop.

Note:
The axis enable markers are reset if the control loop is opened from the PLC-part of the control (e.g. for axis clamping, see sheet P3/4).

Description of the markers
Markers for axes X, Y, Z, IV

Axes in position X, Y, Z, IV

Marker No.	Function	Signal direction
2008 2009 2010 2011	X-axis in position Y-axis in position Z-axis in position IV-axis in position	NC → PLC

Standstill supervision

Marker No.	Function	Signal direction
2664	No standstill supervision of X-axis if control loop open	PLC → NC
2665	No standstill supervision of Y-axis if control loop open	
2666	No standstill supervision of Z-axis if control loop open	
2667	No standstill supervision of IV-axis if control loop open	

When the axes X, Y, Z or IV have achieved the positioning tolerance (defined as a window parameters 58 and 192, see sheet C1/5) after a move, the corresponding markers are set to "1" by the NC-part of the control (this also applies to the condition after power switch-on).

When the axes X, Y, Z or IV are moving and are not within the positioning-window: the corresponding markers are reset to zero by the NC-part of the control (this also applies during the reference mark approach procedure).

If an axis is deflected from the position window the corresponding "axis in position" marker (M 2008 to M 2011) is reset provided the appropriate "standstill supervision" marker (M 2664 to M 2667) is set. If the markers (M 2664 to M 2667) are not set then the "axis in position" marker will remain set when the position window is exceeded.

Note:
The marker "axis in position" is not set for contours which can be machined at a constant contouring speed.
Setting only takes place:
.for discontinuous contours (e.g. internal corners)
.with an interruption of the program run.

Traversing of axes

Marker No.	Function	Signal direction
2128 2129 2130 2131	X-axis traversing Y-axis traversing Z-axis traversing IV-axis traversing	NC → PLC

Traverse direction

Marker No.	Function	Signal direction
2160	0 Traverse direction X + 1 Traverse direction X −	NC → PLC
2161	0 Traverse direction Y + 1 Traverse direction Y −	
2162	0 Traverse direction Z + 1 Traverse direction Z −	
2163	0 Traverse direction IV + 1 Traverse direction IV −	

Description of the markers
Markers for axes X, Y, Z, IV

Opening the control loop

Marker No.	Function	Signal direction
2492 2493 2494 2495	Enable opening of control loop for the X-axis Enable opening of control loop for the Y-axis Enable opening of control loop for the Z-axis Enable opening of control loop for the IV-axis	PLC → NC
2544 2545 2546 2547	Open X-axis control loop Open Y-axis control loop Open Z-axis control loop Open IV-axis control loop	

Operation with open loop control (after a positioning procedure) generally implies a longer delay in switching axes over. Since these delays are unnecessary for machines with permanently activated live servo control loops, the marker **"Enable control loop" (markers 2492 to 2495)** has been made available. Only when these markers are set, does the NC-part of the control wait for the **PLC-signal "Open control loop" (markers 2544 to 2547),** when the marker **"Axis in Position" (markers 2008 to 2011)** from the NC-part of the control has been set (see "PLC-examples").
In operation without "Enable Opening of Control Loop", the switching over from one axis to another takes place as quickly as possible.

Should a control loop be opened (e.g. for clamping of axes), the markers are set as follows:

Set corresponding enable marker 2492 to 2495.

↓

The axis is in position (marker 2008 to marker 2011) and the control loop should be opened: corresponding markers 2544 to 2547 must be set.

↓

Control loop should be closed again: reset corresponding markers 2544 to 2547.

Description of the markers
Markers for axes X, Y, Z, IV

Markers for transfer of actual position values as nominal values (Teach-in)

Marker No.	Function	Signal direction
2552 2553 2554 2555	Teach-in for position loop X-axis Teach-in for position loop Y-axis Teach-in for position loop Z-axis Teach-in for position loop IV-axis	PLC → NC

If the appropriate markers 2552 to 2555 are set to logic "1", the momentary actual position value is transformed into the nominal value.

Note:
The transfer of actual position to nominal is possible only in manual mode or during an MST-strobe.

Current tool axis

Marker No.	Function	Signal direction
2100 2101 2102 2103	X-axis is tool axis Y-axis is tool axis Z-axis is tool axis IV-axis is tool axis	NC → PLC

The markes 2100 – 2103 correspond to the current tool axis defined by the "Tool Call" function.

Description of the markers
Markers for axes X, Y, Z, IV

Traverse-dependent lubrication pulses

Marker No.	Function	Signal direction
2012 2013 2014 2015	Lubrication pulse necessary **X**, when traverse limit exceeded Lubrication pulse necessary **Y**, when traverse limit exceeded Lubrication pulse necessary **Z**, when traverse limit exceeded Lubrication pulse necessary **IV**, when traverse limit exceeded	NC → PLC

The traverse section, after which a lubrication pulse-marker should be set, is specified for each axis as a machine parameter (Machine parameters 159 to 162).

Entry is in 65 536 µm-units, i.e. to obtain the entry value, the required traversing distance in µm (microns) is to be divided by 65 536 µm (microns).

Example:
Required traversing distance: 100 000 000 µm
Entry value: $\frac{100\,000\,000\ \mu m}{65\,536\ \mu m} \approx 1526$

When the traverse limit for an axis is exceeded, the corresponding lubrication pulse-marker is then set to "1" by the NC-part of the control.

The summation of the traverse sections covered can be reset to zero by the PLC-program using the following markers.

Marker No.	Function	Signal direction
2548	The summation of the traverse – dependent lubrication to be reset in the **X-axis**	PLC → NC
2549	The summation of the traverse – dependent lubrication to be reset in the **Y-axis**	
2550	The summation of the traverse – dependent lubrication to be reset in the **Z-axis**	
2551	The summation of the traverse – dependent lubrication to be reset in the **IV-axis**	

Description of the markers
Markers for axes X, Y, Z, IV

PLC-Positioning

Marker No.	Function	Error message	Signal direction
2452	Start PLC-positioning X-axis	E	PLC → NC
2453	Start PLC-positioning Y-axis	F	
2454	Start PLC-positioning Z-axis	G	
2455	Start PLC-positioning IV-axis	H	
2468	Complemented start PLC-positioning X-axis		
2469	Complemented start PLC-positioning Y-axis		
2470	Complemented start PLC-positioning Z-axis		
2471	Complemented start PLC-positioning IV-axis		
2560	PLC-position X-axis (lsb)		
2561	PLC-position X-axis		
2562	PLC-position X-axis		
2563	PLC-position X-axis		
2564	PLC-position X-axis (msb)		
2565	PLC-position Y-axis (lsb)		
2566	PLC-position Y-axis		
2567	PLC-position Y-axis		
2568	PLC-position Y-axis		
2569	PLC-position Y-axis (msb)		
2570	PLC-position Z-axis (lsb)		
2571	PLC-position Z-axis		
2572	PLC-position Z-axis		
2573	PLC-position Z-axis		
2574	PLC-position Z-axis (msb)		
2575	PLC-position IV-axis (lsb)		
2576	PLC-position IV-axis		
2577	PLC-position IV-axis		
2578	PLC-position IV-axis		
2579	PLC-position IV-axis (msb)		

With machine parameters 126 to 156 (see sheet C1/11), 31 position values can be programmed, e.g. for return to toolchange position. The markers for PLC-positioning are only active during the output of a G-M-S-T signal (G = gear range signal, M = auxiliary function, S = spindle speed, T = tool number).
Simultaneous PLC-positioning and spindle orientation is possible.

Note:
.Software limit switches are not taken into account.
.Tool compensations are not considered.
.A PLC-positioning procedure automatically ends path compensation.

Description of the markers
Markers for axes X, Y, Z, IV

The PLC-positions are coded as follows:

PLC-Code msb lsb	calls-up the position in machine parameter
0 0 0 0 0	126
0 0 0 0 1	127
0 0 0 1 0	128
0 0 0 1 1	129
0 0 1 0 0	130
0 0 1 0 1	131
0 0 1 1 0	132
0 0 1 1 1	133
0 1 0 0 0	134
0 1 0 0 1	135
0 1 0 1 0	136
0 1 0 1 1	137
0 1 1 0 0	138
0 1 1 0 1	139
0 1 1 1 0	140
0 1 1 1 1	141
1 0 0 0 0	142
1 0 0 0 1	143
1 0 0 1 0	144
1 0 0 1 1	145
1 0 1 0 0	146
1 0 1 0 1	147
1 0 1 1 0	148
1 0 1 1 1	149
1 1 0 0 0	150
1 1 0 0 1	151
1 1 0 1 0	152
1 1 0 1 1	153
1 1 1 0 0	154
1 1 1 0 1	155
1 1 1 1 0	156

Note:
PLC-code 11111 addresses the reference mark as PLC-position. With distance coded reference marks this is taken as the first mark at the left hand end of scale.

A PLC-positioning (e.g. for the X-axis) is programmed as follows:

Call-up PLC-position during a TOOL-CALL output by setting the markers 2560 to 2564.

↓

Start the PLC-positioning by setting the marker 2452 and resetting the complement marker 2468.

↓

If the "PLC-position" is reached, the NC-part of the control then resets the marker 2452 "start PLC-Positioning". The complemented marker 2468 is correspondingly set.

Termination of PLC-positioning
When terminating a PLC-positioning the markers for "start PLC-positioning" (M 2452, M 2453, M 2454, M 2455) are reset and "complemented start PLC-positioning" (M 2468, M 2469, M 2470, M 2471) are set.

Note:
The feedrate for the PLC-positioning is specified in machine parameters 163 to 166 (see sheet C1/12). In the event of simultaneous PLC-positioning (up to 3 axes), the PLC-positions will be approached in a straight line at the lowest of the specified feedrates.

Description of the markers
Markers for M-S-T code outputs

Coded M-S-T code output

Marker No.	Function	Signal direction
2032	1. Bit T-Code (lsb)	NC → PLC
2033	2. Bit T-Code	
2034	3. Bit T-Code	
2035	4. Bit T-Code	
2036	5. Bit T-Code	
2037	6. Bit T-Code	
2038	7. Bit T-Code	
2039	8. Bit T-Code (msb)	
2044	Strobe signal for S-Code	
2045	Strobe signal for M-Code	
2046	Strobe signal for T-Code	
2047	Strobe signal for second T-Code (see machine parameter 157)	
2064	1. Bit S-Code (lsb)	
2065	2. Bit S-Code	
2066	3. Bit S-Code	
2067	4. Bit S-Code	
2068	5. Bit S-Code	
2069	6. Bit S-Code	
2070	7. Bit S-Code	
2071	8. Bit S-Code (msb)	
2072	1. Bit M-Code (lsb)	
2073	2. Bit M-Code	
2074	3. Bit M-Code	
2075	4. Bit M-Code	
2076	5. Bit M-Code	
2077	6. Bit M-Code	
2078	7. Bit M-Code	
2079	8. Bit M-Code (msb)	
2481	Feedback S-Code complete	PLC → NC
2482	Feedback M-Code complete	
2483	Feedback T-Code complete	
2484	Feedback 2^{nd} T-Code complete	

The markers for the M-S-T outputs and the markers for the strobe signals are set by the NC-part of the control when an auxiliary function (M), coded spindle R.P.M. (S), or tool number (T) is programmed.

Note:
The output of the S- and T-functions can be suppressed by machine parameters 61 and 62 (see sheet C1/5).

The programmed and unsuppressed S- and T-functions are, in the event of a tool call, output in the following sequence by the NC-part of the control:
.first the tool number T
.finally the spindle RPM S

With an automatic toolchanger it may be necessary to output a second tool number for the next tool after changing of the current tool. The second T-code is activated by machine parameter 157 (see sheet C1/11) and is output after the feedback "first T-code completed". A search can then be made in the tool magazine for the next tool prior to the next toolchange.

Description of the markers
Markers for M-S-T code outputs

Coded M-S-T code output

The setting and resetting of the corresponding markers proceeds as follows:

An M, S or T-function is programmed and output:
The NC-part of the control sets the marker for the corresponding code and afterwards (0 ms or 20 ms delay) for the strobe signal.

↓

After the PLC-programme has recoginised the strobe signal as logic "1", the M-S-T code must be decoded in the PLC-part of the control and output.
The NC-part of the control waits for the feedback signal M-S-T code complete.

↓

After the function has been executed, the marker corresponding to the "Feedback Auxiliary Function Complete" must be set in the PLC-part of the control.
The NC-part of the control resets the marker for the strobe signal (The markers for the M-S-T code remain set until the next output of a M-S-T code).

Note:
The timing for the code output must be implemented via the PLC.

Description of the markers
Markers for M-S-T code outputs

Decoded M-code output

Marker No.	Function	Signal direction
1900	Auxiliary function M00	NC → PLC
1901	Auxiliary function M01	
1902	Auxiliary function M02	
1903	Auxiliary function M03	
1904	Auxiliary function M04	
1905	Auxiliary function M05	
1906	Auxiliary function M06	
1907	Auxiliary function M07	
1908	Auxiliary function M08	
1909	Auxiliary function M09	
1910	Auxiliary function M10	
1911	Auxiliary function M11	
1912	Auxiliary function M12	
1913	Auxiliary function M13	
1914	Auxiliary function M14	
1915	Auxiliary function M15	
1916	Auxiliary function M16	
1917	Auxiliary function M17	
1918	Auxiliary function M18	
1919	Auxiliary function M19	
1920	Auxiliary function M20	
1921	Auxiliary function M21	
1922	Auxiliary function M22	
1923	Auxiliary function M23	
1924	Auxiliary function M24	
1925	Auxiliary function M25	
1926	Auxiliary function M26	
1927	Auxiliary function M27	
1928	Auxiliary function M28	
1929	Auxiliary function M29	
1930	Auxiliary function M30	
1931	Auxiliary function M31	
1932	Auxiliary function M32	
1933	Auxiliary function M33	
1934	Auxiliary function M34	
1935	Auxiliary function M35	
1936	Auxiliary function M36	
1937	Auxiliary function M37	
1938	Auxiliary function M38	
1939	Auxiliary function M39	
1940	Auxiliary function M40	
1941	Auxiliary function M41	
1942	Auxiliary function M42	
1943	Auxiliary function M43	
1944	Auxiliary function M44	
1945	Auxiliary function M45	
1946	Auxiliary function M46	
1947	Auxiliary function M47	
1948	Auxiliary function M48	
1949	Auxiliary function M49	
1950	Auxiliary function M50	
1951	Auxiliary function M51	
1952	Auxiliary function M52	

Description of the markers
Markers for M-S-T code outputs

Marker No.	Function	Signal direction
1953 1954 1955	Auxiliary function M53 Auxiliary function M54 Auxiliary function M55	NC → PLC
1956 1957 1958 1959 1960	Auxiliary function M56 Auxiliary function M57 Auxiliary function M58 Auxiliary function M59 Auxiliary function M60	
1961 1962 1963 1964 1965	Auxiliary function M61 Auxiliary function M62 Auxiliary function M63 Auxiliary function M64 Auxiliary function M65	
1966 1967 1968 1969 1970	Auxiliary function M66 Auxiliary function M67 Auxiliary function M68 Auxiliary function M69 Auxiliary function M70	
1971 1972 1973 1974 1975	Auxiliary function M71 Auxiliary function M72 Auxiliary function M73 Auxiliary function M74 Auxiliary function M75	
1976 1977 1978 1979 1980	Auxiliary function M76 Auxiliary function M77 Auxiliary function M78 Auxiliary function M79 Auxiliary function M80	
1981 1982 1983 1984 1985	Auxiliary function M81 Auxiliary function M82 Auxiliary function M83 Auxiliary function M84 Auxiliary function M85	
1986 1987 1988 1989	Auxiliary function M86 Auxiliary function M87 Auxiliary function M88 Auxiliary function M89	
2496	Release marker for decoded M-code output	PLC → NC

If the marker 2496 is set, the programmed M-functions are output in decoded form via markers 1900 to 1989. The release marker 2496 is necessary since the markers 1900 to 1989 are located within the range of user markers. If markers 1900 – 1989 are required for other functions, marker 2496 must be reset.

Note:
There is no output with markers M90 to M99.

Description of the markers
Markers for spindle speed

Analogue output of spindle speed

Marker No.	Function	Signal direction
2004	"0" means: The analogue voltage for the spindle drive is located in the ramp. With a change of the S-override potentiometer of > 2 %, the marker 2004 is also reset	NC → PLC
2005	"1" means: The analogue voltage for the spindle drive is 0V	
2042	"1" means: The control operates with S-analogue "0" means: The control operates with coded output of spindle rpm	
2043	Strobe signal gear range code (G-Code) for S-analogue output	
2104 2105 2106	1. Bit gear range code for S-analogue (lsb) 2. Bit gear range code for S-analogue 3. Bit gear range code for S-analogue (msb) These markers are set from the NC but may be overwritten in the PLC using marker M2814.	NC → PLC (PLC → NC)
2480	Feedback signal gear range code for S-analogue complete	PLC → NC
2485	Status display and output of analogue voltage for M03	
2486	Status display and output of analogue voltage for M04	
2487	Status display M05	
2489	Inversion of analogue voltage. The polarity which has been determined by MP 172 is reversed	
2490 2491	Spindle CCW for gearchange Spindle CW for gearchange These markers are active in M05 status	
2814	With this marker a different gear range than that defined by markers 2104–2106 may be selected. The markers 2104–2106 should be overwritten by the PLC and be activated via setting marker M 2814. After the gearchange marker 2814 is reset by the NC-part. The markers 2104–2106 remain unchanged until the next gearchange signal.	PLC → NC (NC → PLC)
2092	If the dialogue "wrong speed" is displayed, the marker is set.	NC → PLC
2501	With analogue output of the spindle speed, the speed determined in machine parameter 258 is issued if the marker is set (see sheet C5/9).	PLC → NC

Markers for spindle speed

Analogue output of spindle speed

Marker No.	Function	Signal direction
2823	For analogue output of spindle speed two pairs of ramps, defined by MP 168, MP 316, MP 317 and MP 318 (see sheet C5/5), are available. The first pair of ramps (MP 168/ MP 316) is active if marker 2816 = 0. The second pair of ramps MP 317/MP 318) is active if marker 2816 = 1. Marker 2823 is the corresponding strobe marker.	PLC → NC
2006	When output of spindle speed is analogue, this marker is set if a certain speed is not attained. "1" = given speed not attained "0" = given speed exceeded	NC → PLC

If the marker 2006 is to be used, then there are only four gear ranges available for the analogue output of the spindle speed. The gear ranges are defined via machine paramter 78 ... 81.

The entry values in machine parameters 82 ... 85 must be smaller than the entry values in machine parameters 78 ... 81. If within one gear range (machine parameters 78 ... 81) the associated value in machine parameters 82 ... 85 is not reached, then marker 2006 is set (see PLC-examples).

If the entry values in machine parameters 82 ... 85 are greater than the entry values in machine parameters 78 ... 81, then these entry values are considered gear ranges and marker 2006 is not set.

With analogue output of spindle speed (S-analogue activated by machine parameter 62) the speed range for each gear is defined in machine parameters (machine parameters 78 – 85).

Markers for spindle speed

Analogue output of spindle speed

When a spindle speed requiring a new gear range, is programmed, the markers will be set as follows:

A new gear range is necessary: the analogue voltage for the previous spindle speed is reduced to 0, the control sets the markers for the gear range code and then (0 or 20 ms delay) the marker for the strobe signal.

After the PLC-programme has recognized the strobe signal as logic "1", the gear range code must be decoded in the PLC-part of the control and output. The NC-part of the control waits for the feedback "gear code complete".

An analogue voltage can be output for changing gear. For this purpose the markers 2490 and 2491 must be correspondingly set in the PLC-part: the markers initiate the rotation of the spindle in a clockwise (marker 2491) or in an anticlockwise (marker 2490) direction, the analogue voltage level is set in machine parameter 70.

After the gearchange is complete, marker 2480 for the feedback signal must be set by the PLC-program. The direction of rotation of the spindle is determined in the PLC-programme by markers 2485 to 2487. The status display M03, M04 and M05 is generated in the VDU-screen, simultaneously with these markers.

After the gearchange is complete, the control outputs the relevant analogue voltage (determined by machine parameters 86, 87, 88, 89, see sheet C1/8).

For an example of the programming of the analogue spindle speed see PLC-examples.

Description of the markers
Markers for spindle speed

Coded output of spindle speed

Marker No.	Function	Signal direction
2080	1. Bit for min. rpm (lsb)	NC → PLC
2081	2. Bit for min. rpm	
2082	3. Bit for min. rpm	
2083	4. Bit for min. rpm	
2084	5. Bit for min. rpm	
2085	6. Bit for min. rpm	
2086	7. Bit for min. rpm	
2087	8. Bit for min. rpm (msb)	
2088	1. Bit for step width (lsb)	
2089	2. Bit for step width	
2090	3. Bit for step width	
2091	4. Bit for step width (msb)	

The minimum rpm and the step width from the machine parameter "limitation of rpm-code" (machine parameter 63) is transferred into the markers 2080 to 2091 (see sheet C5/3).

Description of the markers
Markers for TNC-keys

Operating mode-code

Marker No.	Function	Signal direction
2176	1. Bit for the operating mode-code (lsb)	NC → PLC
2177	2. Bit for the operating mode-code	
2178	3. Bit for the operating mode-code	
2179	4. Bit for the operating mode-code (msb)	

The operating mode code is determined by the selected operating mode. The operating modes are coded as follows:

0000	=	Programme entry and editing
0001	=	Manual operation
0010	=	Electronic handwheel
0011	=	Single block positioning with MDI
0100	=	Program run, single block
0101	=	Program run full sequence
0110	=	Program test

Decoded operating mode-code

Marker No.	Function	Signal direction
2049	Programming during program run	NC → PLC
2050	Program entry and editing	
2051	Manual operation	
2052	Electronic handwheel	
2053	Single block positioning with MDI	
2054	Program run, single block	
2055	Program run full sequence	
2056	Program test	
2057	Approach to reference point	

Markers 2049 to 2057 depend on the operating mode which has been selected and are set accordingly.

Description of the markers
Markers for TNC-keys

Currently activated axis key: X, Y, Z, IV

Marker-No.	Function	Signal direction
2096 2097 2098 2099	Currently activated TNC-axis key X Currently activated TNC-axis key Y Currently activated TNC-axis key Z Currently activated TNC-axis key IV	NC → PLC

These markers identify the currently activated TNC-axis key: The corresponding symbol will be displayed on the VDU-screen in reverse image (e.g. $\boxed{X}$).
These markers can, for example, be employed for an external handwheel display. An external handwheel control panel can be implemented by using these markers in conjunction with the markers for external operation of the TNC-keys (see PLC-examples).

Code for the external selection of TNC-keys

Marker No.	Function	Signal direction
2800 2801 2802 2803 2804 2805 2806 2807 2808	1. Bit TNC key code (lsb) 2. Bit TNC key code 3. Bit TNC key code 4. Bit TNC key code 5. Bit TNC key code 6. Bit TNC key code 7. Bit TNC key code 8. Bit TNC key code (msb) Strobe for key code	PLC → NC

Each key operation on the front panel of the TNC can be simulated by an external signal via the markers for the TNC-key code.

However, the following should be noted:

.The TNC-key code must be reset by a pulse
.for the strobe of a key code, only one PLC-cycle may be set, otherwise the same key will be simulated several times
.After execution of the function the control resets the key code strobe. After reset of the TNC-key code strobe, a new press of the key can be simulated.

Description of the markers
Markers for TNC-keys

The keys are coded as follows:

Key	Code msb lsb
PGM NR	0011 1011
	0011 1100
	0011 1101
	0011 1110
	0011 1111
	0100 0000
	0100 0001
MOD	0100 0010
P	0100 0011
I	0100 0100
PGM CALL	0100 0101
	0100 0111
	0100 1000
	0100 1001
	0100 1010
	0100 1011
	0100 1100
	0100 1101
TOUCH PROBE	0100 1110
TOOL DEF	0101 0100
TOOL CALL	0101 0101
R^L	0101 0110
R^R	0101 0111
↑	0101 1000
←	0101 1001
→	0101 1010
CYCL DEF	0101 1011
CYCL CALL	0101 1100
LBL SET	0101 1101
LBL CALL	0101 1110
NO ENT	0101 1111

Key	Code msb lsb	
	0110 0000	
	0110 0001	
	0110 0010	
	0110 0011	
	0110 0100	
	0110 0101	
	0110 0110	
	0110 0111	
	0110 1000	
CE	0110 1001	
IV	0110 1010	
Z	0110 1011	
Y	0110 1100	
X	0110 1101	
	0110 1110	
	0110 1111	
	0111 0000	
	0111 0001	
	0111 0010	
	0111 0011	
	0111 0100	
	0111 0101	
	0111 0110	
	0111 0111	
	0111 1000	(Graphics)
	0111 1001	
	0111 1010	
	0111 1011	
	0111 1100	
	0111 1101	
	0111 1110	
9	0111 1111	

Description of the markers
Markers for TNC-keys

Markers for inhibiting TNC-keys

Marker No.	Function	Signal direction
2182	Inhibited TNC key pressed	NC → PLC
2855	PGM NR Inhibit	PLC → NC
2856	Inhibit	
2857	Inhibit	
2858	Inhibit	
2859	Inhibit	
2860	Inhibit	
2861	Inhibit	
2862	MOD Inhibit	
2863	P Inhibit	
2864	Inhibit	
2865	PGM CALL Inhibit	
2867	Inhibit	
2868	Inhibit	
2869	Inhibit	
2870	Inhibit	
2871	Inhibit	
2872	Inhibit	
2873	Inhibit	
2874	TOUCH PROBE Inhibit	
2880	TOOL DEF Inhibit	
2881	TOOL CALL Inhibit	
2882	R Inhibit	
2883	R Inhibit	
2884	Inhibit	
2885	Inhibit	
2886	Inhibit	
2887	CYCL DEF Inhibit	
2888	CYCL CALL Inhibit	
2889	LBL SET Inhibit	
2890	LBL CALL Inhibit	
2891	NO ENT Inhibit	

Description of the markers
Markers for TNC-keys

Marker No.	Function	Signal direction
2892	STOP Inhibit	PLC → NC
2893	EXT Inhibit	
2894	CL PGM Inhibit	
2895	DEL □ Inhibit	
2896	⌖ Inhibit	
2897	ENT Inhibit	
2898	GOTO □ Inhibit	
2899	↓ Inhibit	
2900	Q DEF Inhibit	
2901	CE Inhibit	
2902	IV Inhibit	
2903	Z Inhibit	
2904	Y Inhibit	
2905	X Inhibit	
2906	Q Inhibit	
2907	0 Inhibit	
2908	1 Inhibit	
2909	4 Inhibit	
2910	7 Inhibit	
2911	· Inhibit	
2912	2 Inhibit	
2913	5 Inhibit	
2914	8 Inhibit	
2915	END □ Inhibit	
2916	MOD Inhibit	
2917	BLK FORM Inhibit	
2918	MAGN Inhibit	
2919	START Inhibit	
2920	+/− Inhibit	
2921	3 Inhibit	
2922	6 Inhibit	
2923	9 Inhibit	

The keys on the TNC front panel can be inhibited by setting the corresponding markers. When an inhibited TNC-key is pressed, the NC-part signals this by setting the marker 2182.

This marker must be reset again by the PLC-program.

Description of the markers
Markers for external buttons and switches

Marker-No.	Function	Error messages	Signal direction
2448 2449 2450	NC-Start NC-Rapid Latching function for Manual traverse	A B C	PLC → NC
2451	Feed release	D	
2456 2457 2458 2459 2460 2461 2462 2463	Manual traverse X+ Manual traverse X− Manual traverse Y+ Manual traverse Y− Manual traverse Z+ Manual traverse Z− Manual traverse IV+ Manual traverse IV−	I J K L M N O P	
2464 2465 2466	Complemented NC-Start Complemented NC-Rapid Override Complemented latching Function for manual traverse		
2467 2472 2473 2474 2475 2476 2477 2478 2479	Complemented feed release Complemented manual traverse X+ Complemented manual traverse X− Complemented manual traverse Y+ Complemented manual traverse Y− Complemented manual traverse Z+ Complemented manual traverse Z− Complemented manual traverse IV+ Complemented manual traverse IV−		
2488	$\overline{\text{NC-Stop}}$ ("0" corresponds to Stop)		
2556 2557 2558 2559	Reference end position for the encoder input X1 Reference end position for the encoder input X2 Reference end position for the encoder input X3 Reference end position for the encoder input X5		

Important functions are controlled via marker and complementary markers.

Please see sheet P3/38 for markers for axis V.

Description of the markers
Markers for external buttons and switches

The signals from external buttons and switches must set the corresponding markers in the PLC-program and generate the complemented markers with the inverted information in the same PLC-cycle. Should both markers not be correctly set or reset, then the flashing message

ERROR IN PLC-PROGRAM A/B/C ...

is displayed.

The displayed letter A, B, C etc. indicates at which marker the fault lies (see list above).

Example:

The NC-start button is provided with two normally open contacts. The markers are then set as follows:

```
U   E18      (first contact of the NC-start button)
=   M2448

UN  E19      (second contact of the NC-start button)
=   M2464
```

If only one NC-start contact exists, the program may be written in the following way:

```
U   E18      (NC-start button)
=   M2448

UN  E18      (NC-start button)
=   M2464
```

The following program is wrong and should not be implemented.

```
U   E18      (NC-start button)
=   M2448

UN  M2448
=   M2464
```

A defect in the memory cell M2448 cannot be recognized with this method of programming!

Description of the markers
Screen displays

Markers for error messages

Marker No.	Function	Signal direction
2815	Flashing error message from PLC	PLC → NC
2924	Error message 0 from PLC to be displayed in VDU-screen	
2925	Error message 1	
2926	Error message 2	
2927	Error message 3	
2928	Error message 4	
2929	Error message 5	
2930	Error message 6	
2931	Error message 7	
2932	Error message 8	
2933	Error message 9	
2934	Error message 10	
2935	Error message 11	
2936	Error message 12	
2937	Error message 13	
2938	Error message 14	
2939	Error message 15	
2940	Error message 16	
2941	Error message 17	
2942	Error message 18	
2943	Error message 19	
2944	Error message 20	
2945	Error message 21	
2946	Error message 22	
2947	Error message 23	
2948	Error message 24	
2949	Error message 25	
2950	Error message 26	
2951	Error message 27	
2952	Error message 28	
2953	Error message 29	
2954	Error message 30	
2955	Error message 31	
2956	Error message 32	
2957	Error message 33	
2958	Error message 34	
2959	Error message 35	
2960	Error message 36	
2961	Error message 37	
2962	Error message 38	
2963	Error message 39	
2964	Error message 40	
2965	Error message 41	
2966	Error message 42	
2967	Error message 43	
2968	Error message 44	
2969	Error message 45	
2970	Error message 46	
2971	Error message 47	
2972	Error message 48	
2973	Error message 49	
2974	Error message 50	
2975	Error message 51	
2976	Error message 52	

Description of the markers
Screen displays

Marker No.	Function	Signal direction
2977 2978 2979	Error message 53 Error message 54 Error message 55	PLC → NC
2980 2981 2982 2983 2984	Error message 56 Error message 57 Error message 58 Error message 59 Error message 60	
2985 2986 2987 2988 2989	Error message 61 Error message 62 Error message 63 Error message 64 Error message 65	
2990 2991 2992 2993 2994	Error message 66 Error message 67 Error message 68 Error message 69 Error message 70	
2995 2996 2997 2998 2999	Error message 71 Error message 72 Error message 73 Error message 74 Error message 75	
3000 3001 3002 3003 3004	Error message 76 Error message 77 Error message 78 Error message 79 Error message 80	
3005 3006 3007	Error message 81 Error message 82 Error message 83	

Error messages PLC → NC
The NC-part of the control can display error messages from the PLC-part. The PLC-error messages are selected via markers **2924 to 3023.**
The error messages are coded from 0–83. When a marker for a PLC-error message is set, the following error message is displayed, e.g.

PLC : ERROR 58

on the VDU-screen of the control.

Plain language error messages can also be displayed instead of the coded error messages (e.g. Oil pressure too low).
The error messages 0–83 may have up to 32 characters. The error messages 84–99 may have up to 16 characters as user parameters.
Should you require specific plain language error messages, please contact your nearest HEIDENHAIN agency.

A PLC-error message during program run freezes the screen block display but the program will continue to run. After erasure of the error message with CE the current block will again be displayed. If the program run should be stopped by an error message, this must be done by the PLC-program.

The setting of the **marker 2815** results in the markers 2924 to 3023 being checked. If one of these markers is set, then the error message will be shown as a flashing display. Should none of the markers for the PLC-error messages be set, then

EMERGENCY STOP PLC

is shown as a flashing dislplay.

Description of the markers
Screen displays

Markers for user parameters

Marker No.	Function	Signal direction
3008 3009	User parameter 16 User parameter 15	PLC → NC
3010 3011 3012 3013 3014	User parameter 14 User parameter 13 User parameter 12 User parameter 11 User parameter 10	
3015 3016 3017 3018 3019	User parameter 9 User parameter 8 User parameter 7 User parameter 6 User parameter 5	
3020 3021 3022 3023	User parameter 4 User parameter 3 User parameter 2 User parameter 1	

User-parameters
Up to 16 machine parameters can be made accessible to the machine operator via the MOD-function. These user-parameters can be assigned by the machine tool builder at his own discretion.

The following dialogue texts are contained in the PLC-EPROM for the dialogue display of user-parameters.

Dialog-display	Machine parameter
USER PAR. 1	Machine parameter with lowest parameter number
⋮	
USER PAR. 8	Machine parameters allocated according to increasing parameter numbers
⋮	
USER PAR. 16	Machine parameter with the highest parameter number

Any dialogue text with a max. of 16 characters may be displayed instead of USER PAR. 1 etc. This requires an amendment of the standard PLC-EPROM which can only be performed by HEIDENHAIN.
Please contact your local HEIDENHAIN-agency or our factory in Traunreut, West Germany.

Please note:
The dialogue texts USER PAR. 1 to USER PAR. 16 are stored in the PLC-EPROM under the address of the PLC: ERROR 84 to PLC: ERROR 99. If, however, error messages are required instead of dialogues, the corresponding dialogue texts within the PLC-EPROM must be revised (Address of USER PAR. 1 = Address of PLC: ERROR 84 etc.).

Out of the ASCII signs, the signs from HEX 20 to HEX 5F are permissible for error messages and dialogues.

Description of the markers
Screen displays

Markers for status display and other dialogues

Marker No.	Function	Signal direction
2508 2657	lsb; msb for the display of a second auxiliary function The first auxiliary function is M03, M04 or M05.	PLC → NC
2062	Marker is set when the dialogue "code number" is displayed.	NC → PLC
2092	Marker is set when the dialogue "wrong rpm" is displayed.	NC → PLC

The second auxiliary function is coded as follows:

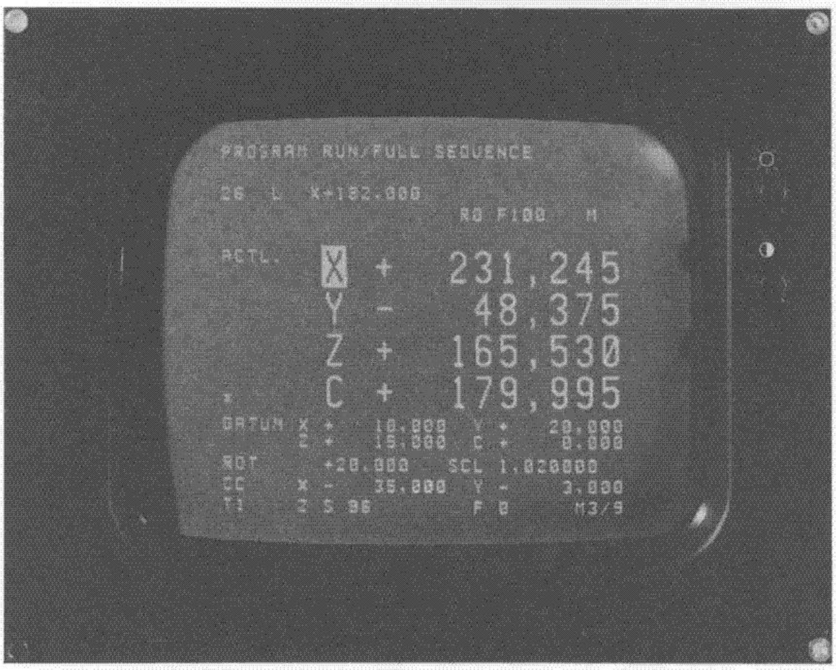
M2508	M2657	Display
0	0	/9 (first coolant off)
0	1	/7 (second coolant off)
1	0	/8 (first coolant on)
1	1	/K (second coolant on)

Description of the markers
Screen displays

Markers for control status

Marker No.	Function	Signal direction
2183	Program interruption (Display: "Control in operation" flashing)	NC → PLC
2184	Control in operation (Display: "Control in operation" either on or flashing)	
2190	Eraseable error message is displayed	
2191	Error message: "External emergency stop" is displayed	

Display: Control in operation
The initial program status is displayed in the VDU-screen of the TNC via the symbol ✱ (see illustration).



The NC-part of the control signals a program interruption to the PLC via marker 2183 (display flashes). The initial status is signalled via the marker 2184 (display on or flashing).
When both markers are reset, the program run has been terminated.

Error message NC → PLC
When an **eraseable error message** is displayed in the VDU, the NC-part of the control sets the marker **2190.**
When the **error message EXTERNAL EMERGENCY STOP** is displayed, the NC-part of the control sets the marker **2190 and 2191**. With flashing error messages from the NC, the program run of the PLC is halted and the PLC-outputs set to "0".

Description of the markers
Screen displays

Markers for status display and other dialogues

Marker No.	Function	Signal direction
2508 2657	lsb; msb for the display of a second auxiliary function The first auxiliary function is M03, M04 or M05.	PLC → NC
2062	Marker is set when the dialogue "code number" is displayed.	NC → PLC
2092	Marker is set when the dialogue "wrong rpm" is displayed.	NC → PLC

The second auxiliary function is coded as follows:

M2508	M2657	Display
0	0	/9 (first coolant off)
0	1	/7 (second coolant off)
1	0	/8 (first coolant on)
1	1	/K (second coolant on)

Description of the markers
Markers for the transfer of numerical values

With the following markers, coded numerical values can be transferred via PLC-inputs to parameters Q 100 to Q 107 (see PLC-examples).

Marker No.	Function	Signal direction
2560 2576	Marker for the numerical value which is to be transferred from the PLC to the NC.	PLC → NC
2809	Strobe for transfer of the numerical value	
2810 2811 2812	Data format of numerical value	
2816 2817 2818	Assignment of numerical value to Q-parameters Q 100 to Q 107	

Please note:
Markers 2560 to 2576 have now been assigned double functions!
These markers are already being used for PLC-positioning.

Markers 2810, 2811 and 2812 determine the data format of the numerical value which is to be transferred.
At present, the following data format can be defined:

M 2810 = 0
M 2811 = 0
M 2812 = 0

By resetting the markers 2810, 2811 and 2812 it can determined that the information of markers 2560 to 2576 corresponds to a numerical value with 4 decades, BCD-code with sign.

Marker No.	Function	Signal direction
M 2560 M 2561 M 2562 M 2563	1st decade (lsb) 1st decade 1st decade 1st decade (msb)	PLC → NC
M 2564 M 2565 M 2566 M 2567	2nd decade (lsb) 2nd decade 2nd decade 2nd decade (msb)	
M 2568 M 2569 M 2570 M 2571	3rd decade (lsb) 3rd decade 3rd decade 3rd decade (msb)	
M 2572 M 2573 M 2574 M 2575	4th decade (lsb) 4th decade 4th decade 4th decade (msb)	
M 2576	Sign	

Description of the markers
Markers for the transfer of numerical values

Markers 2816, 2817 and 2818 determine to which Q-parameter (Q 100 to Q 107) the numerical value should be assigned.

2816	0	1	0	1	0	1	0	1
2817	0	0	1	1	0	0	1	1
2818	0	0	0	0	1	1	1	1
Parameter	Q 100	Q 101	Q 102	Q 103	Q 104	Q 105	Q 106	Q 107

Transfer of the numerical value is effected by setting the marker 2809 if an M, S or T-function has been output.

Description of the markers
Markers for touch probe systems TS 111/TS 120/TS 511

Marker No.	Function	Signal direction
2503	Release marker for touch probe system	PLC → NC
2022	Probe system, prior to a probing cycle, is not ready e.g. probe is not connected	NC → PLC
2023	Stylus already deflected when starting probing cycle	
2024	Touch probe system ready or not ready during probing cycle e.g. transmission beam interrupted	
2025	Stylus was deflected Probing function executed	
2026	Probing function completed	
2027	Battery voltage too low (TS 511)	

Marker 2503 is reset by the NC-part of the control, if a probing function has been started. The control waits before execution of the probing function until the PLC has reset the marker 2503 (see PLC-examples.)
For instance, this marker can suppress the beginning of a measuring procedure if the spindle has not be cleaned with compressed air prior to insertion of the touch probe.
If the touch probe stylus is deflected prior to starting a probing cycle, marker 2023 is set by the NC-part of the control.
If the stylus is deflected during a probing procedure, marker 2025 is set.
If the probing procedure is completed (touch probe has returned to the safety clearance), marker 2026 is set. Marker 2026 is also set if

.an error message has interrupted the probing procedure or
.the probing procedure has been interrupted by pressing the external STOP-button.

For TS 511 there is an additional markers 2024 for the message "Touch probe system ready" and 2027 in the event of insufficient battery power. The marker 2024 is logically "1" if the touch probe is not ready after starting a probe cycle.
The marker 2027 is logically "1" if the battery voltage is too low.

Description of the markers
Markers for activating jog positioning

The jog positioning can be activated via the integrated PLC. In this way it is possible to additionally enter a step distance in the operating mode "electronic handwheel". When an axis direction is pressed the corresponding axis moves by the distance entered (see PLC-examples).

Marker No.	Function	Signal direction
2498	Activating jog positioning	PLC → NC
2512	X + Start marker	PLC → NC
2513	X – Start marker	
2514	Y + Start marker	
2515	Y – Start marker	
2516	Z + Start marker	
2517	Z – Start marker	
2518	IV + Start marker	
2519	IV – Start marker	
2528	X + Complement marker	PLC → NC
2529	X – Complement marker	
2530	Y + Complement marker	
2531	Y – Complement marker	
2532	Z + Complement marker	
2533	Z – Complement marker	
2534	IV + Complement marker	
2535	IV – Complement marker	

Description of the markers
Markers for determining axis sequence upon approaching the reference marks

Marker No.	Function	Signal direction
2602	If the marker is set, the reference marks will be approached in the sequence set by markers 2603 – 2607. If it is reset, the sequence is as defined in MP 59.	PLC → NC
2603 2604 2605 2606 2607	Axis sequence for approaching the reference marks (lsb) Axis sequence for approaching the reference marks Axis sequence for approaching the reference marks Axis sequence for approaching the reference marks Axis sequence for approaching the reference marks (msb) The axis sequence may be changed even if an axis has already moved.	PLC → NC

The markers 2603 to 2607 determine the axis sequence upon approaching the reference marks:

2607	2606	2605	2604	2603	Axis sequence				Signal direction
0	0	0	0	0	X	Y	Z	IV	PLC → NC
0	0	0	0	1	X	Y	IV	Z	
0	0	0	1	0	X	Z	Y	IV	
0	0	0	1	1	X	Z	IV	Y	
0	0	1	0	0	X	IV	Y	Z	
0	0	1	0	1	X	IV	Z	Y	
0	0	1	1	0	Y	X	Z	IV	PLC → NC
0	0	1	1	1	Y	X	IV	Z	
0	1	0	0	0	Y	Z	X	IV	
0	1	0	0	1	Y	Z	IV	X	
0	1	0	1	0	Y	IV	X	Z	
0	1	0	1	1	Y	IV	Z	X	
0	1	1	0	0	Z	X	Y	IV	PLC → NC
0	1	1	0	1	Z	X	IV	Y	
0	1	1	1	0	Z	Y	X	IV	
0	1	1	1	1	Z	Y	IV	X	
1	0	0	0	0	Z	IV	X	Y	
1	0	0	0	1	Z	IV	Y	X	
1	0	0	1	0	IV	X	Y	Z	PLC → NC
1	0	0	1	1	IV	X	Z	Y	
1	0	1	0	0	IV	Y	X	Z	
1	0	1	0	1	IV	Y	Z	X	
1	0	1	1	0	IV	Z	X	Z	
1	0	1	1	1	IV	Z	Y	Y	

(see also PLC-examples)

Description of the markers

Markers for switching from X, Y or Z axis to the 4^{th} axis

With the markers 2526, 2542, 2590, 2591 axis moves in X, Y or Z may be switched to the 4^{th} axis.

Marker No.	Function	Signal direction
2526	Changing the X-, Y- or Z-axis onto the fourth axis. Markers 2590 and 2591 determine the changed axis.	PLC → NC
2542	Complement marker for marker 2526	
2590 2591	Determination of the axis that is to be changed onto the fourth axis	PLC → NC

The axis that is to be changed is determined via markers 2590 and 2591 as follows (see PLC-examples):

2591	2590	Axis
0	0	X-axis
0	1	Y-axis
1	0	Z-axis
1	1	4^{th} axis

After the markers 2590 and 2591 are set the change is executed with markers 2526 and 2542 (complement).
If for example in a program the position nominal values for the Y-axis are to be processed with the fourth axis, then the markers are to be set as follows:

Marker 2590 $\hat{=}$ 1 and
Marker 2591 $\hat{=}$ 0

The NC-part of the control after a PLC-run automatically sets

Marker 2526 $\hat{=}$ 0 and
Marker 2542 $\hat{=}$ 1

but the change is retained.
If the change is to be reversed, then set

Marker 2590 $\hat{=}$ 1 and
Marker 2591 $\hat{=}$ 1

The change can be reactivated through

Marker 2526 $\hat{=}$ 1 and
Marker 2542 $\hat{=}$ 0

Description of the markers
Markers for imposing a percentage factor on the spindle voltage

With the following markers the spindle voltage may be limited to a defined percentage of maximum:

Marker No.	Function	Signal direction
2822	With this marker set the spindle voltage is limited to the %-factor (Strobe marker) as defined in machine parameter 315.	PLC → NC
2816	With the marker set the %-factor can be applied with marker 2822.	PLC → NC

Please note:
M 2816 has more than one function (datum shift, transfer of numerical values to Q-parameters).

Description of the markers
Markers for the transfer of a datum correction

With the following markers a datum correction, previously defined in machine parameters, may be activated:

Marker No.	Function	Signal direction
2819	With this marker set the 1st, 2nd or 3rd datum correction is activated, as defined in MP 303 to MP 314 (Strobe marker)	PLC → NC
2816 2817	(lsb): Marker for defining 1st, 2nd or 3rd datum correction (msb): Marker for defining 1st, 2nd or 3rd datum correction	PLC → NC

M2817	M2816	
0	0	Datum correction cancelled
0	1	1st datum correction
1	0	2nd datum correction
1	1	3rd datum correction

The datum correction updates the actual position display.

A datum correction may be active in all 4 axes.
For further information see sheet C2/13.

Description of the markers
Markers for axis S

The 5th axis may be used for spindle orientation. The spindle positioning is effected via the PLC-program with a PLC-positioning routine.

Marker No.	Function	Signal direction
2499	Open control loop for axis S. A pre-marker is not required for opening the control loop.	PLC → NC
2527 2543	Start PLC-positioning of axis S. Complementary start of PLC-positioning for axis S.	
2580 2581 2582 2583 2584	PLC-position axis S (lsb) PLC-position axis S PLC-position axis S PLC-position axis S PLC-position axis S (msb)	
2656	Spindle orientation from standstill "0" Orientation with M03 "1" Orientation with M04 (static marker)	PLC → NC

Markers 2580 to 2584 call-up the following PLC-positions:

PLC-Code	calls position in machine parameter
0 0 0 0 0	126
0 0 0 0 1	127
0 0 0 1 0	128
0 0 0 1 1	129
0 0 1 0 0	130
0 0 1 0 1	131
0 0 1 1 0	132
0 0 1 1 1	133
0 1 0 0 0	134
0 1 0 0 1	135
0 1 0 1 0	136
0 1 0 1 1	137
0 1 1 0 0	138
0 1 1 0 1	139
0 1 1 1 0	140
0 1 1 1 1	141
1 0 0 0 0	142
1 0 0 0 1	143
1 0 0 1 0	144
1 0 0 1 1	145
1 0 1 0 0	146
1 0 1 0 1	147
1 0 1 1 0	148
1 0 1 1 1	149
1 1 0 0 0	150
1 1 0 0 1	151
1 1 0 1 0	152
1 1 0 1 1	153
1 1 1 0 0	154
1 1 1 0 1	155
1 1 1 1 0	156

If markers 2580 to 2584 are all set to logical 1, then the position of the fifth axis as per cycle definition "orientation" is transferred.
If the cycle "orientation" was not processed in the program run, the spindle positions to the reference mark.
Spindle orientation is effected with the rotation direction (M03 or M04) last programmed. If the spindle is at standstill, then orientation is in accordance with the status of marker 2656.

Description of the markers
Markers for axis V

The following PLC-markers that are used for spindle orientation with a 4 axis control version are used alternatively for the V axis:

Marker No.	Function	Signal direction
M 2507	Open control loop axis V	PLC → NC
M 2522 M 2538	Start PLC-positioning axis V Complement start PLC-positioning axis V	PLC → NC PLC → NC
M 2580 M 2581 M 2582 M 2583 M 2584	PLC-position axis V (lsb) PLC-position axis V PLC-position axis V PLC-position axis V PLC-position axis V (msb)	PLC → NC
M 2016 M 2017 M 2668 M 2148	Axis V release Axis V in position No standstill supervision for axis V when control loop opened (see sheet P3/3) Currently activated TNC-axis key V	NC → PLC NC → PLC PLC → NC NC → PLC
M 2500	Activation closed loop opening axis V	PLC → NC
M 2505	Actual value transfer axis V	PLC → NC
M 2506	Reference end position axis V	PLC → NC
M 2520 M 2521 M 2536 M 2537	Start jog positioning axis V + Start jog positioning axis V − Complement start jog positioning axis V + Complement start jog positioning axis V −	PLC → NC
M 2524 M 2525 M 2540 M 2541	Manual traverse V + Manual traverse V − Complement manual traverse V + Complement manual traverse V −	PLC → NC

The following markers are not provided for axis V:

Marker for a lubrication pulse after a certain distance is exceeded

Marker for resetting the cumulative lubrication distance

Description of the markers
Markers for the ascending and descending edges of PLC-inputs

Markers for ascending edges of PLC-inputs
M 1500 – M 1531 for E 0 – E 31
M 1563 – M 1626 for E 63 – E 126
M 1628 – M 1652 for E 128 – E 152

Markers for descending edges of PLC-inputs
M 1700 – M 1731 for E 0 – E 31
M 1763 – M 1826 for E 63 – E 126
M 1828 – M 1852 for E 128 – E 152

M 2497 is the release marker for the ascending and descending edge monitoring

The markers are set for 1 PLC-cycle provided release marker 2497 is set.

Description of the markers
Markers for the first PLC-program cycle after power on and after interruption of PLC-program

Marker No.	Function	Signal direction
2180	1st PLC-program cycle after a power on (after cancellation of the error message "Power interrupted" by pressing CE)	NC → PLC
2185	1st PLC-program cycle after interruption of PLC-program (if MP 77 = 0 and the "PLC-editing function" is left)	

Marker 2180 is set at logic "1" only during the first PLC-program-cycle after a power on. This also applies to Marker 2185 during the first PLC-program-cycle after an interruption of the PLC-program.

Description of the markers
Miscellaneous markers

Marker No.	Function	Signal direction
2048	"1" denotes: Tapping cycle is called	NC → PLC
2041	"1" denotes: English dialogue selected	NC → PLC
2060	"1" denotes: DIN/ISO programming selected	NC → PLC
2061	"1" denotes: The block "END-PGM", M02 or M30 has been actioned.	NC → PLC
2063	"1" denotes: Program No. 0 (central tool file) selected	NC → PLC
2510	"1" denotes: Spindle override inactive	PLC → NC
2511	"1" denotes: Feedrate override inactive	PLC → NC
2504	"1" denotes: When operating with axis clamping and there is a continuous contour transition in the subsequent block, a stationary axis will be clamped	PLC → NC
2596	"1" denotes: Central tool file may be accessed in background editing mode. Any TOOL-CALLs in the running program await an exit from background editing or the selection of a different program.	PLC → NC
2509	"1" denotes: The feedrate override is fixed at the % defined in machine parameter 296.	PLC → NC

Description of the markers
Markers affected by machine parameters

Markers can be set or reset via machine parameters 158, 249 and 250.
The contents of these markers can be utilised to activate various PLC-program routines. It is therefore possible to employ one PLC-program for various machines. In the event, for example, that machines of a particular series are fitted with different gear ranges, a common PLC-program can be employed for these machines. The different PLC-program routines for the decoding the gear ranges are selected by appropriate entry values in the machine parameters.

The values of the markers which are to be set for a machine are simply added and the resultant numerical value is entered as a machine parameter.

Machine parameter 158

Marker No.	Function	Signal direction
2192 2193	Value 1 Value 2	NC → PLC
2194 2195	Value 4 Value 8	
2196 2197	Value 16 Value 32	
2198 2199	Value 64 Value 128	
2200 2201	Value 256 Value 512	
2202 2203	Value 1024 Value 2048	
2204 2205	Value 4096 Value 8192	
2206 2207	Value 16384 Value 32768	

Example:
The marker 2193, 2199 and 2206 should be set. The entry value for machine parameter 158 is established as follows:

Marker No. 2193: Value	2
Marker No. 2199: Value	128
Marker No. 2206: Value	16384
Entry valaue	16514

Note:
These markers should not be set in the PLC-program. Setting and resetting should, without exception, take place via machine parameter 158.

Description of the markers
Markers affected by machine parameters

Machine parameter 249

Marker No.	Function	Signal direction
2208 2209	Value 1 Value 2	NC → PLC
2210 2211	Value 4 Value 8	
2212 2213	Value 16 Value 32	
2214 2215	Value 64 Value 128	
2216 2217	Value 256 Value 512	
2218 2219	Value 1024 Value 2048	
2220 2221	Value 4096 Value 8192	
2222 2223	Value 16384 Value 32768	

Machine parameter 250

Marker No.	Function	Signal direction
2224 2225	Value 1 Value 2	NC → PLC
2226 2227	Value 4 Value 8	
2228 2229	Value 16 Value 32	
2230 2231	Value 64 Value 128	
2232 2233	Value 256 Value 512	
2234 2235	Value 1024 Value 2048	
2236 2237	Value 4096 Value 8192	
2238 2239	Value 16384 Value 32768	

Description of the markers
Markers for the activation of user-cycles

User-cycles can be activated or inhibited via markers 2240 to 2271.

Marker No.	Function	Signal direction
2240 2241	User-cycle 68 User-cycle 69	NC → PLC
2242 2243 2244 2245 2246	User-cycle 70 User-cycle 71 User-cycle 72 User-cycle 73 User-cycle 74	
2247 2248 2249 2250 2251	User-cycle 75 User-cycle 76 User-cycle 77 User-cycle 78 User-cycle 79	
2252 2253 2254 2255 2256	User-cycle 80 User-cycle 81 User-cycle 82 User-cycle 83 User-cycle 84	
2257 2258 2259 2260 2261	User-cycle 85 User-cycle 86 User-cycle 87 User-cycle 88 User-cycle 89	
2262 2263 2264 2265 2266	User-cycle 90 User-cycle 91 User-cycle 92 User-cycle 93 User-cycle 94	
2267 2268 2269 2270 2271	User-cycle 95 User-cycle 96 User-cycle 97 User-cycle 98 User-cycle 99	

User-cycles are inhibited by setting the appropriate markers.

Description of the markers
Markers for toolchanger support

Marker No.	Function	Signal direction
2093	"1" signifies: A change from a special tool to a normal tool or vice versa is programmed and the first pocket number is output. This "1" signifies, that a second pocket number follows.	NC → PLC
2600	"1" signifies: With special tools, the pocket for the new tool is output first, and then the pocket for the old tool (effective only for active central tool file and flexible pocket addressing).	PLC → NC
2601	"1" signifies: A special tool is returned to the original pocket in spite of flexible pocket addressing (effective only for active central tool file and flexible pocket addressing).	
2595	In addition to the pocket number from the NC-part the tool number may be placed in markers 2112 – 2119 via the strobe signal marker 2046 or 2047. For outputs of two pocket numbers, two tool number would be given.	PLC → NC
2598	"1" signifies: A tool number is transferred to the NC-part of the control in BCD format with the aid of the markers 2560 to 2567 (2 decades). The corresponding tool pocket is transferred from the NC-part of the control to the PLC in BCD format with the aid of the markers 2112 to 2119 (2 decades). M2598 is automatically reset by the NC-part of the control.	PLC → NC (NC → PLC)
2599	"1" signifies: A tool number is transferred to the NC-part of the control in BCD format with the aid of the markers 2560 to 2567 (2 decades) and the corresponding tool pocket number is transferred to the NC-part of the control with the aid of markers 2572 to 2579. They are stored in the centrol tool file. M2599 is automatically reset by the NC-part of the control. The screen display is first entered with the keys PGM NR, GOTO, ↓, ↑ in programming and editing mode.	PLC → NC (NC → PLC)

Note:
Markers 2560 to 2567 or 2572 to 2579 already have the following functions: markers for PLC-positioning or markers for transfer of a numerical value from the PLC to the NC.

Description of the markers
Markers for toolchanger support

Marker No.	Function	Signal direction
2820	"1" signifies: The central tool file is not updated through TOOL CALL but rather through the setting of the marker 2821 after the TOOL CALL. Marker 2820 must be set statically in order to address this function.	PLC → NC
2821	"1" signifies: Update central tool file if marker 2820 is set.	PLC → NC
	Tool pocket number if marker 2598 is set to "1". Tool number if marker 2595 is set to "1".	
2112	1st decade (lsb)	NC → PLC
2113	1st decade	
2114	1st decade	
2115	1st decade (msb)	
2116	2nd decade (lsb)	
2117	2nd decade	
2118	2nd decade	
2119	2nd decade (msb)	
	Tool number if markers 2598 or 2599 are set to "1".	
2560	1st decade (lsb)	PLC → NC
2561	1st decade	
2562	1st decade	
2563	1st decade (msb)	
2564	2nd decade (lsb)	
2565	2nd decade	
2566	2nd decade	
2567	2nd decade (msb)	
	Tool pocket number if marker 2599 is set to "1".	
2572	1st decade (lsb)	PLC → NC
2573	1st decade	
2574	1st decade	
2575	1st decade (msb)	
2576	2nd decade (lsb)	
2577	2nd decade	
2578	2nd decade	
2579	2nd decade (msb)	

Description of the markers
Macro-programming

Markers for the call-up of macro programs

The TNC 355 can be equipped with customer-specific macro programmes e.g. for the control of toolchangers with fixed or flexible addressing. If the standard PLC-memory capacity is insufficient up to 300 PLC-commands may be stored in a macro.

The following markers are available for the call-up of macro-programs:

Marker No.	Function	Signal direction
3264	Customer-specific macro 1	PLC → NC
3265	Customer-specific macro 2	
3266	Customer-specific macro 3	
3267	Customer-specific macro 4	
3268	Customer-specific macro 5	
3269	Customer-specific macro 6	
3270	Customer-specific macro 7	
3271	Customer-specific macro 8	
3272	Customer-specific macro 9	
3273	Customer-specific macro 10	
3274	Customer-specific macro 11	
3275	Customer-specific macro 12	
3276	Customer-specific macro 13	
3277	Customer-specific macro 14	
3278	Customer-specific macro 15	
3279	Customer-specific macro 16	
2189	Undefined macro called-up	NC → PLC

Markers 3024 – 3199 are used for messages from the macro-programs to the PLC or vice versa.
Entry values in the machine parameters 209 to 212 are transferred to the macros via the **markers 3200 – 3263**.
If PLC-functions are to be stored as macros, contact your nearest HEIDENHAIN sales office.

If an undefined macro is called, the error message "Error in PLC-program Q" is displayed.

Description of the markers
Macro-programming

Macro-programs for the control of toolchangers

Four macro-programs support the control of a toolchanger via special markers.

Marker No. for macro-activation	Description	Function
M 3264	Tool No. or pocket No. BCD-dual conversion	Tool No. (Pocket No., T-code) in M 2032 … M 2039 Nominal value in M 3024 … M 3031 the tool No. (Pocket No., BCD) is converted BCD-dual and transferred to the nominal value – if T-code = 0, M 3043 set to "1" – if T-code greater than max. value, M 3044 is set to "1"
M 3265	Increase actual value	The actual value (M 3032 … M 3039) can assume the values 1, 2 … max. value. – actual value + 1, if actual value is less than maximal value – actual value = 1, if actual value greater than or equal to max. value
M 3266	Decrease actual value	The actual value (M 3032 … M 3039) can assume the values 1, 2 … max. value. – actual value − 1, if actual value greater than 1 – actual value = max. value, if actual value = 1
M 3267	Actual/Nominal value comparison	Actual value in M 3032 … M 3039 Nominal value in M 3024 … M 3031 – if actual value = nominal value, M 3040 is set to "1" – if distance actual/nominal value less than or equal to distance to speed reduction, M 3041 is set to "1" – if the shorter distance from actual-to-nominal distance is positive, (direction 1 – 2), M 3042 is set to "1"

Description of the markers
Macro-programming

The following markers are also required for the macro-programs for control of a toolchanger:

Markers for nominal values of pocket numbers:	
M 3024	1st bit (lsb)
M 3025	2nd bit
M 3026	3rd bit
M 3027	4th bit
M 3028	5th bit
M 3029	6th bit
M 3030	7th bit
M 3031	8th bit (msb)

Markers for actual values of pocket numbers:	
M 3032	1st bit (lsb)
M 3033	2nd bit
M 3034	3rd bit
M 3035	4th bit
M 3036	5th bit
M 3037	6th bit
M 3038	7th bit
M 3039	8th bit (msb)

Interrogation markers	
M 3040	"1" if actual value = nominal value
M 3041	"1" if distance between pocket number actual/nominal value is less or equal to distance for speed reduction (machine parameter 209)
M 3042	"1" if the shortest distance from pocket number actual value to nominal value is positive (direction 1-2-3-4 etc.)
M 3043	"1" if T-code (M 2032 – M 2039) = 0
M 3044	"1" if T-code greater than the max. pocket number (machine parameter 209)

With machine parameter 209, the maximum number of tool magazine pockets and the distance to the speed reduction is determined.

The entry value is calculated as follows:

(Distance to speed reduction x 256) + max. number of magazine pockets = machine parameter 209.

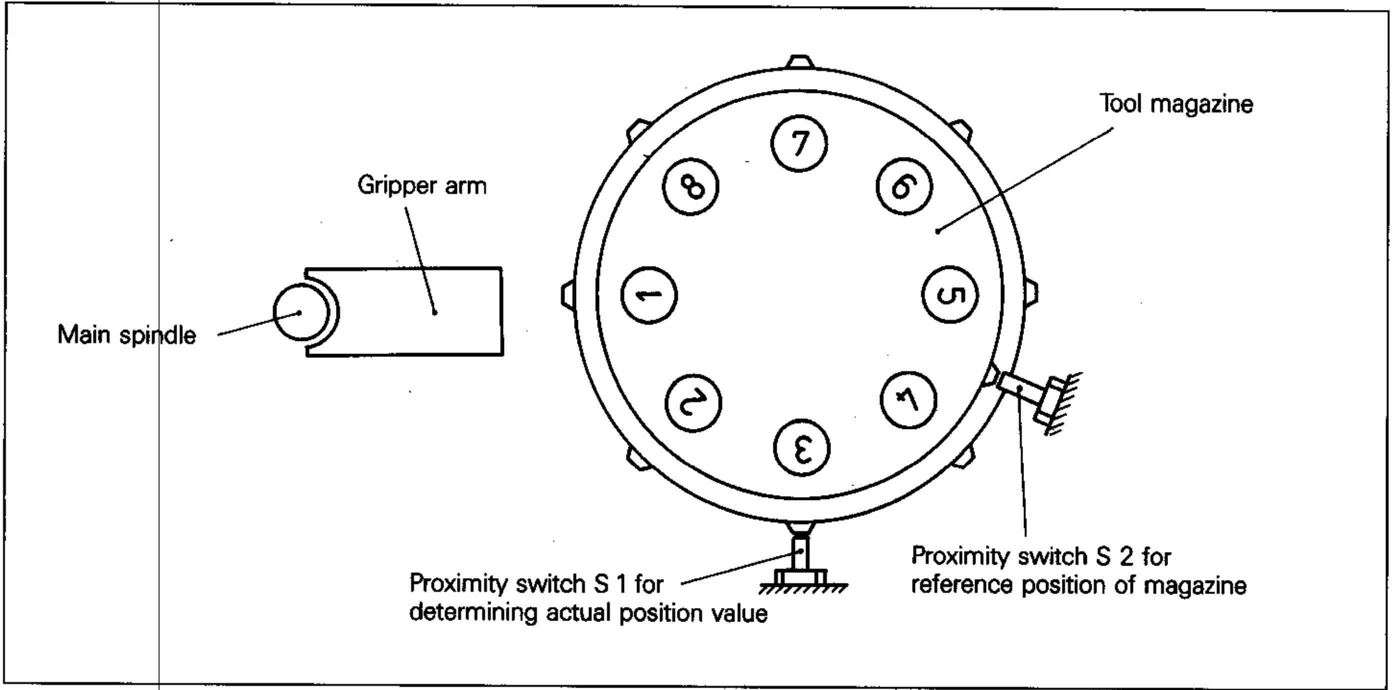
Example:
Number of magazine pockets = 36
Distance to speed reduction = 2 (places)

2 x 256 + 36 = 548

548 must be entered for machine parameter 209.

Description of the markers
Macro-programming

Mechanical layout and functioning of a toolchanger



.With the first tool call, the tool magazine is rotated to the reference position (proximity switch S 2).
On reaching the proximity switch, the markers for the actual value of the pocket number (M 3032 to M 3039) is set.

.The tool number (T-code) in the markers M 2032 to M 2039 is converted BCD-to-dual by setting the marker M 3264 and transferred to the markers for the nominal value of the pocket number (M 3024 to M 3031). If marker M 3264 is set, the nominal and actual values are compared and the interrogation markers M 3043 and M 3044 are automatically set by the PLC.

If the T-code = 0, M 3043 is set to "1".

If the T-code greater than the maximum value, M 3044 is set to "1".

Interrogation markers can be further linked within the PLC-program.

T-code = 0 means that no tool is to be searched for, since the tool call with number 0 only eliminates **tool compensation.**

If the T-code is greater than the maximum value, an error message can e.g. be displayed.

Please note:
Markers M 3043 and M 3044 are **not automatically reset.**
Reset must take place within the PLC-program.

.By setting the marker M 3267, the actual value (M 3032 to M 3039) of the tool position is compared with the nominal value (M 3024 to M 3031).

.If the actual value = nominal value, M 3040 is set to "1".

.If the distance actual/nominal value is less than or equal to the distance to the speed reduction, marker M 3041 is set to "1".

If the shorter distance from actual-to-nominal value is positive (direction 1 – 2), marker M 3042 is set to "1".

Description of the markers
Macro-programming

.If the direction of rotation is defined (marker M 3042), the tool which is called-up can be searched for via the shortest distance.

The actual value of the magazine position can assume the values 1, 2, 3, 4 ... maximum value.

Depending on the rotation direction of the magazine, the actual value of the magazine position after every signal of the proximity switch S 1 must be either increased by one value or reduced by one value.

Increase actual value: set marker M 3265!

New actual value = old actual value + 1, if the actual value is less than the maximum value.

New actual value = 1, if the actual value is greater or equal to the maximum value.

Decrease actual value: Set marker M 3266!

New actual value = old actual value − 1, if the actual value is greater than 1.

New actual value = maximum value, if actual value = 1.

Please note:
Markers M 3265 and M 3266 should only be set for the duration of one PLC-cycle at a time.
If these markers are set for longer than this the actual value register will be incremented or decremented at each PLC-cycle.

.If the distance between the actual and nominal value is less than or equal to the speed reduction distance (i.e. marker M 3041 = 1) the rotation speed of the magazine should be reduced.

.If the actual value = nominal value (i.e. marker M 3040 = 1) the magazine should be stopped as the selected tool is in the change position.

Description of the markers
Macro-programming

Extension of the PLC-memory

With the TNC 355 the PLC-memory may be extended by 1024 commands to give a total memory capacity of 3072 commands.

These extra commands are activated by the **setting of marker M 3279**. If marker M 3279 is set, there is **no CRC test of the EPROMs or checksum test of the RAM and machine parameters.** The PLC-cycle time is also increased to 22 ms. **Therefore the extra commands should only be used for functions that do not need to be permanently active, with marker M 3279 being set only as and when necessary.**

Whether the additional commands are to be run from RAM or EPROM is selected with machine parameter 77 (bit 2).

For editing, these commands can only be accessed with the GOTO key and not the ↓ and ↑ keys.

Marker No.	Function	Signal direction
3279	"1" denotes: Additional commands addressed.	PLC → NC

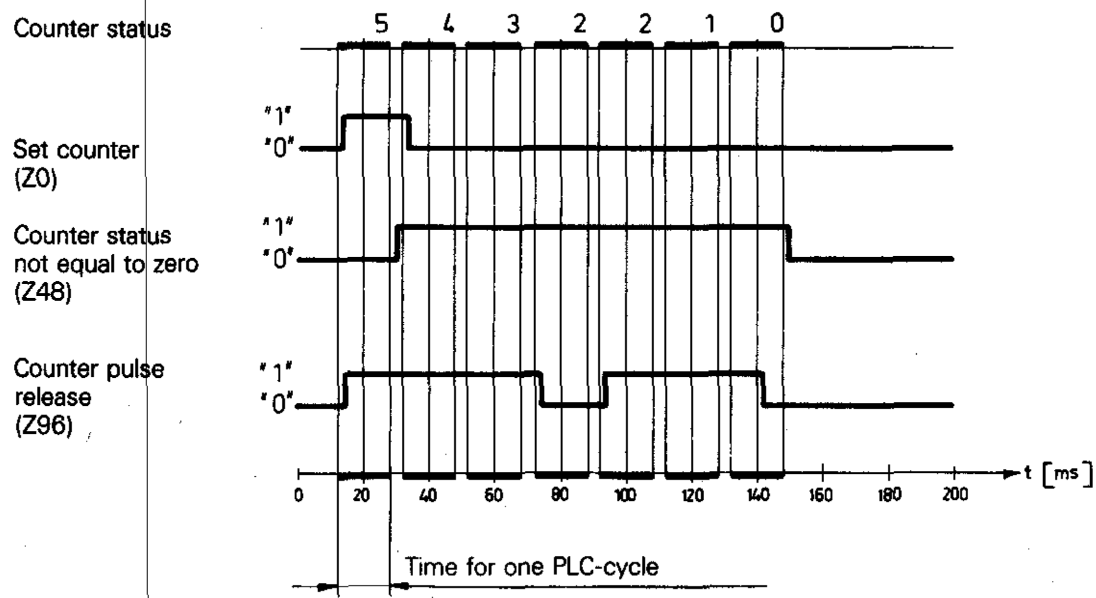
Description of the markers
Counters

The PLC has 32 counters at its disposal, each of the 32 counters being controlled through two special markers with the identification Z. Whether or not the counter status has reached "0" can be interrogated by the use of an additional marker, also represented by the identification Z. The counter is set to the entry value programmed in the corresponding machine parameter (max. 65535) and counts backwards to the counter status "0". The counter is decremented by 1 with every cycle of the PLC-program that the counter pulse release is set to "1".

Function	Marker identification	Remarks
Set counter	Z0 to Z31	Through the assignment of a logic "1", the corresponding counter will be set to the preset value in the machine parameter. The assignment of the logic "1" must only exist for one PLC-cycle, otherwise the setting will be repeated at each subsequent cycle.
Counter not equal to "0"	Z48 to Z79	The marker Z48 to Z79 corresponding to the counter Z0 to Z31 is at logic "1" when a counter has been set. The counter has been set. The counter status can be interrogated via Z48 to Z79. On reaching the counter status "0" the marker for the counter status is set again to logic "0". **Note:** For the duration of the first program cycle after the setting of the counter, the corresponding marker Z48 to Z79 remains at logic "0".
Counter pulse-release	Z96 to Z127	The counter will be decremented by "1" if the corresponding marker has a logic state "1" at the end of a PLC-cycle. In the event of the corresponding marker having a logic state "0" at the end of a PLC-cycle, no decrement occurs.

Pulse diagram

The corresponding machine parameter has been set to 5 (e.g. machine parameter 94).



Description of the markers
Counters

Allocation of the counter-markers to the machine parameters:

Set counter	Z0	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10	Z11	Z12	Z13	Z14	Z15
Counter status not equal to "0"	Z48	Z49	Z50	Z51	Z52	Z53	Z54	Z55	Z56	Z57	Z58	Z59	Z60	Z61	Z62	Z63
Counter pulse release	Z96	Z97	Z98	Z99	Z100	Z101	Z102	Z103	Z104	Z105	Z106	Z107	Z108	Z109	Z110	Z111
Machine parameter for preset value	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109

Set counter	Z16	Z17	Z18	Z19	Z20	Z21	Z22	Z23	Z24	Z25	Z26	Z27	Z28	Z29	Z30	Z31
Counter status not equal to "0"	Z64	Z65	Z66	Z67	Z68	Z69	Z70	Z71	Z72	Z73	Z74	Z75	Z76	Z77	Z78	Z79
Counter pulse release	Z112	Z113	Z114	Z115	Z116	Z117	Z118	Z119	Z120	Z121	Z122	Z123	Z124	Z125	Z126	Z127
Machine parameter for preset value	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295

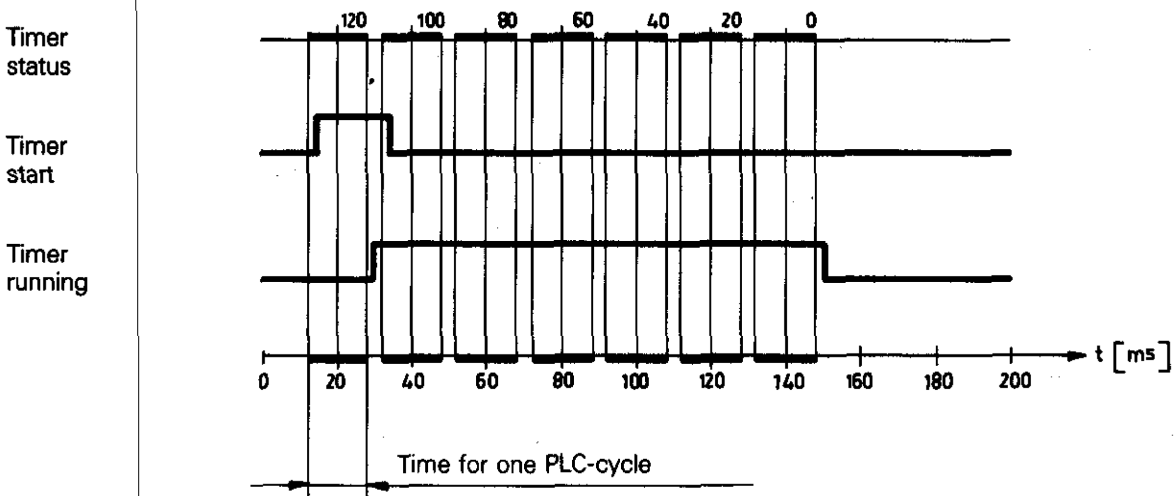
Description of the markers
Timers

The PLC has 48 timers at its disposal.
The start of each of the 48 timers is controlled by a special marker with the identification T. The timers time out from the times programmed in the corresponding machine parameters. The unit of time is 20 ms (max. 65535 units programmable).
An additional special marker with the identification T enables "Timer running" to be interrogated.

Function	Marker identification	Remarks
Timer start	T0 to T47	Through the assignment of a logic "1", the corresponding timer will be set to the preset value in the associated machine parameter and started. The assignment of the logic "1" must only exist for one PLC-cycle, otherwise the setting will be repeated on each subsequent program cycle.
Timer running	T48 to T95	The marker T48 to T95 corresponding to the timer T0 to T47 is at logic "1", when a timer has been set. The status "Timer running" can be interrogated via T48 to T95. On the timing out of the timer, the marker "Timer running" is set again to logic "0". **Note:** For the duration of the first program cycle after the setting of the timer, the corresponding marker T48 to T95 remains at logic "0".

Pulse diagram

The corresponding machine parameter has been set to 120 ms (e.g. machine parameter 110).



Description of the markers
Timers

Allocation of the markers:

Timer start	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
Timer running	T48	T49	T50	T51	T52	T53	T54	T55	T56	T57	T58	T59	T60	T61	T62	T63
Machine parameter	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125

Timer start	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28	T29	T30	T31
Timer running	T64	T65	T66	T67	T68	T69	T70	T71	T72	T73	T74	T75	T76	T77	T78	T79
Machine parameter	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208

Timer start	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41	T42	T43	T44	T45	T46	T47
Timer running	T80	T81	T82	T83	T84	T85	T86	T87	T88	T89	T90	T91	T92	T93	T94	T95
Machine parameter	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279

PLC-modes
Selection and exit of PLC-modes

The control offers the possibility of programming the PLC at the machine and subsequent testing of the program.

Press MOD.

↓

Select the MOD-mode "Code number"
by pressing ↑.

↓

Enter "code number" 95 10 26
and press ENT.

↓

The control automatically switches to the mode
Dialogue display: **TABELLE E/A/Z/T/M**

The mode keys select the following PLC-modes:

Key	Mode
≙ TAB	Tabelle E/A/Z/T/M (see sheet P4/11).
≙ PCT	PLC-Programm Trace-Funktion (see sheet P4/10).
≙ PCE	PLC-Editier-Funktion (see sheet P4/2).

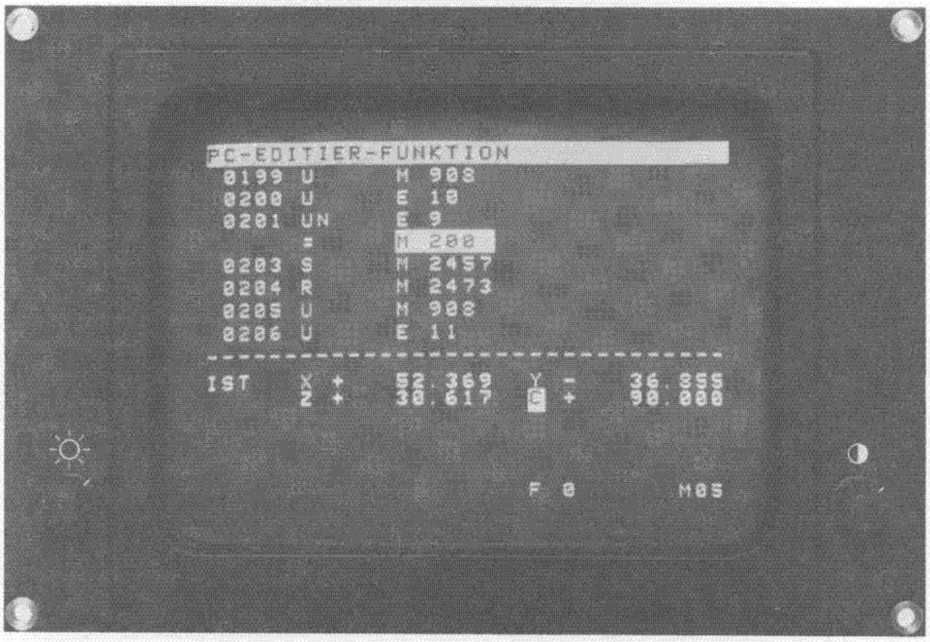
The PLC-modes are exited by pressing END.

Message translation:
TABELLE E/A/Z/T/M = TABLES E–inputs/A–outputs/Z–counters/T–timers/M–markers
PLC-PROGRAMM TRACE-FUNKTION = PLC TRACE MODE
PLC-EDITIER-FUNKTION = PLC EDITING MODE

PLC-modes
PLC-editing mode

The mode "PLC-Editier-Funktion" is selected with the PCE key.

The VDU displays the following:



In this mode, the PLC-program can be compiled and edited.

When compiling the PLC-program at the control, the PLC-program is stored internally in RAM (Random Access Memory). A PLC-program can be copied from the control onto a ME 101/102 cassette, FE 401-floppy disc or directly into an EPROM programming unit. A master EPROM with the PLC-program is compiled by HEIDENHAIN from the media containing the PLC-program. Program administration is also carried out by HEIDENHAIN.
In the control, there is a socket provided for the EPROM. Machine parameter 77 selects whether the machine should utilise the PLC-program in RAM or EPROM.

For editing purposes, a program can be copied from EPROM into RAM.

Machine parameter 77
Bit 0: 1st and 2nd K commands from RAM or EPROM
+ 0 ≙ 1st and 2nd K commands from RAM
+ 1 ≙ 1st and 2nd K commands from EPROM

Bit 1: 3rd K commands from RAM or EPROM(05)
+ 0 ≙ 3rd K commands from EPROM
+ 1 ≙ 3rd K commands from RAM

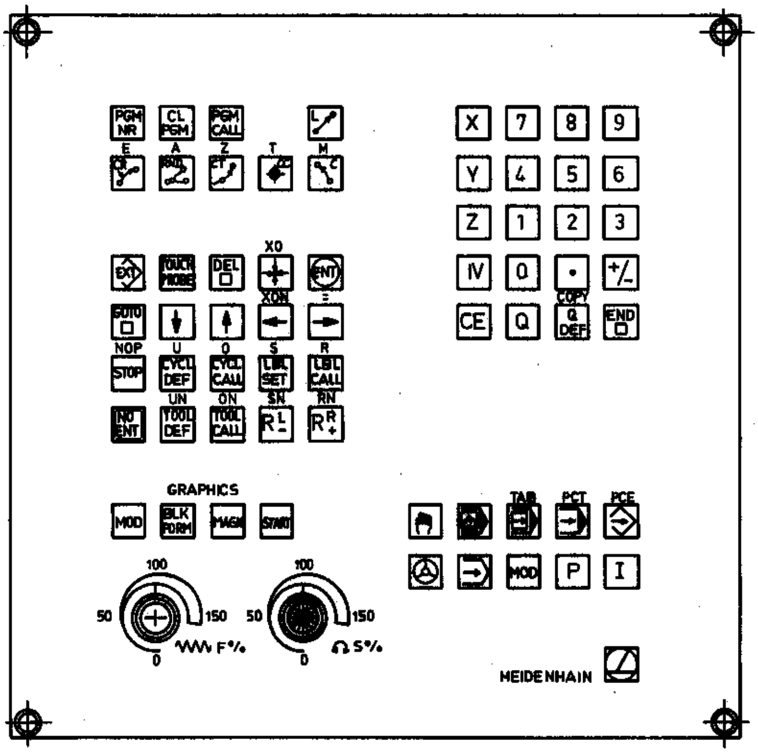
Note:
The PLC-program in the RAM-memory is checked after control switch-on. An erroneous program is erased and the following error message is displayed:

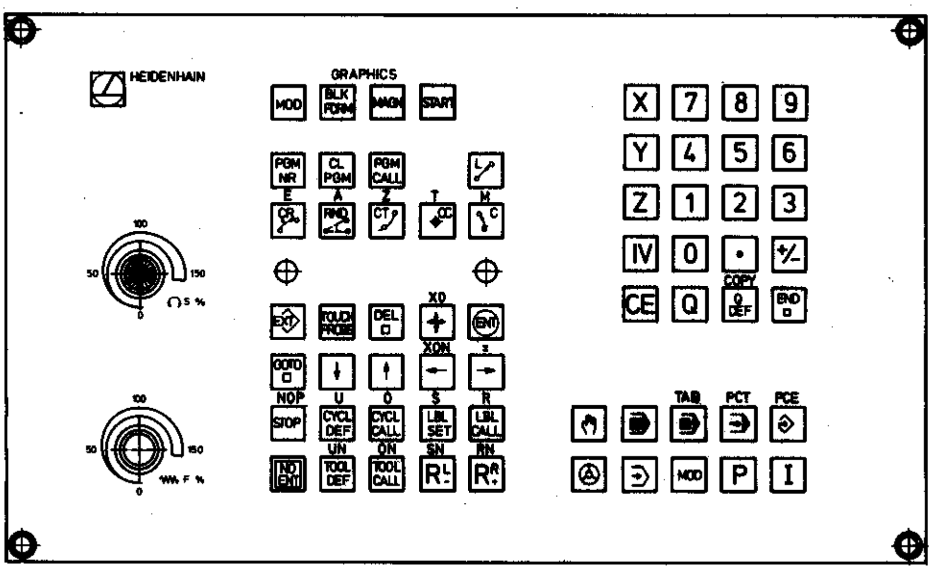
PLC: PROGRAM MEMORY ERASED

(05) As of software version 05 (4 axes)

PLC-modes
PLC-editing mode

Keyboard layout for PLC-programming
If PLC editing mode is selected some of the keys on the keyboard are assigned for programming functions. A PLC programming keyboard overlay shows the appropriate key designations.





PLC-modes
PLC-editing mode

Key designations

TNC-Symbol	PLC-Symbol	PLC-Function
CL PGM	CL PGM	When ENT is also pressed, the PLC-program is erased
DEL □	DEL □	Clears the actual PLC-command (VDU blank)
GOTO □	GOTO □	If an additional numerical value (0 ... 3071) and ENT is pressed, the respective PLC-command is selected
↓	↓	Selects the following PLC-command
↑	↑	Selects the previous PLC-command
0 DEF	COPY	Transfers PLC-program (EPROM) into RAM after additional press of the ENT-key.
EXT	EXT	Input/Output of PLC-programs to Cassette (ME), Disc unit (FE) or Printer
END □	END □	Exits from the PLC-editor into normal NC operation
STOP	NOP	Enters the PLC-command NOP
CYCL DEF	U	Description of the PLC-commands see sheets P2/1 – P2/11
TOOL DEF	UN	
CYCL CALL	O	
TOOL CALL	ON	
✛	XO	
←	XON	
→	=	
LBL SET	S	
R L	SN	
LBL CALL	R	
R R	RN	
		The following keys provide the PLC-commands with the operands. Terminate operand input with the ENT key or by entering the next PLC-command
CR	E	Input; plus the necessary numerical value (0 ... 31, 63 ... 152)
RND	A	Output; plus the necessary numerical value (0 ... 62)
CT	Z	Counter; plus the necessary numerical value (0 ... 31)
CC	T	Timer; plus the necessary numerical value (0 ... 47)
C	M	Marker; plus the necessary numerical value (0 ... 3023)

PLC-modes
PLC-editing mode

Programming PLC-commands

Control in "PLC-program editor" mode.

Commence input by pressing a PLC-instruction key:
U UN O ON XO XON S SN R RN or =
(Pushbutton layout, see sheet P4/3)

Press operand key E A Z T M
(Pushbutton layout, see sheet P4/3)

Enter numerical value: keys 0 ... 9.
Termination of operand entry by pressing ENT or entry of next PLC-command.

Programming the NOP PLC-command: NOP press.

Note:
Free command lines are displayed on the VDU as NOP's.

Call-up of a specific PLC-command

Press the GOTO □ key.
Dialogue display: **GOTO PGM-ZEILE = 0**

Press operand key E A Z T M
(Pushbutton layout, see sheet P4/3)

Enter numerical value: buttons 0 ... 9 and terminate entry with ENT key (permitted values 0 – 3071).

The entered block is displayed.

Message translation:
GOTO PGM-ZEILE = GOTO PGM LINE

PLC-modes
PLC-editing mode

Sequential checking of PLC-commands

Select the command number from which the program is to be checked with the GOTO key.

↓

With the Cursor key ↓ or ↑ page forwards or reverse.

Deleting PLC-commands

Select the line number of the command to be deleted.

↓

Press the DEL key.

Entering PLC-commands into an existing program

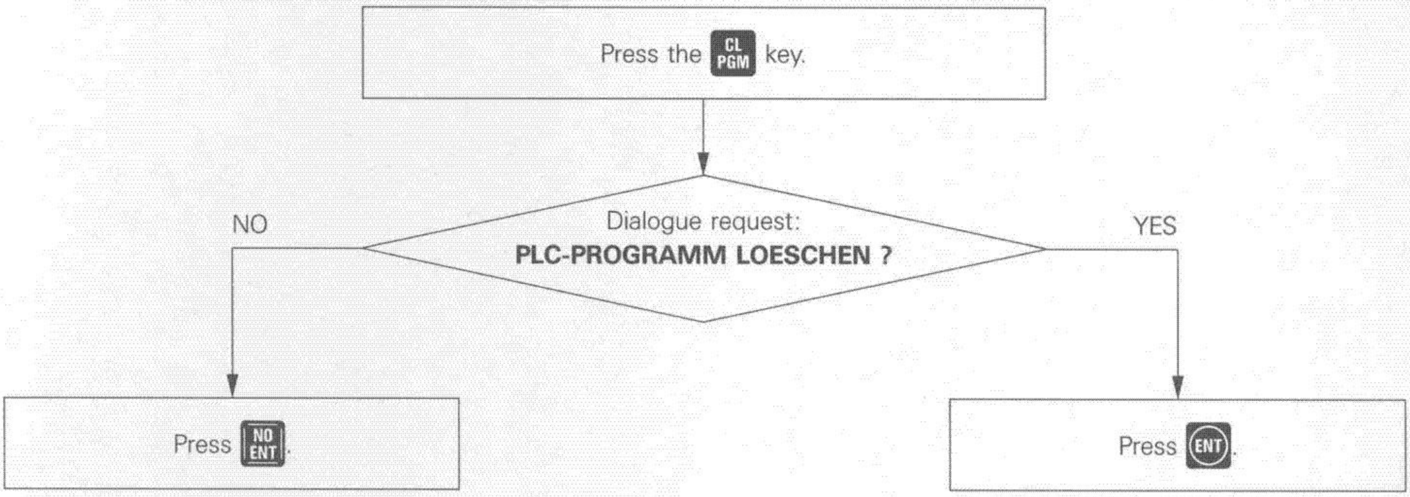
Select the command, behind which the additional command is to be entered with the GOTO key.

↓

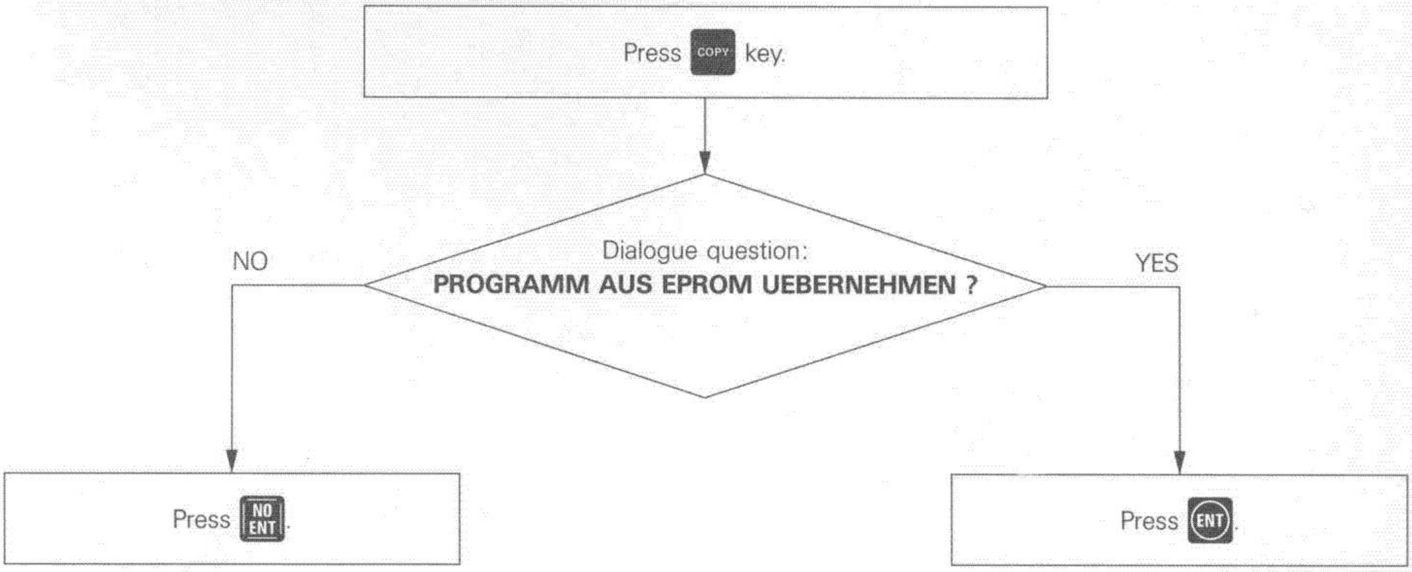
Enter new command and store.

PLC-modes
PLC-editing mode

Deleting a PLC-program



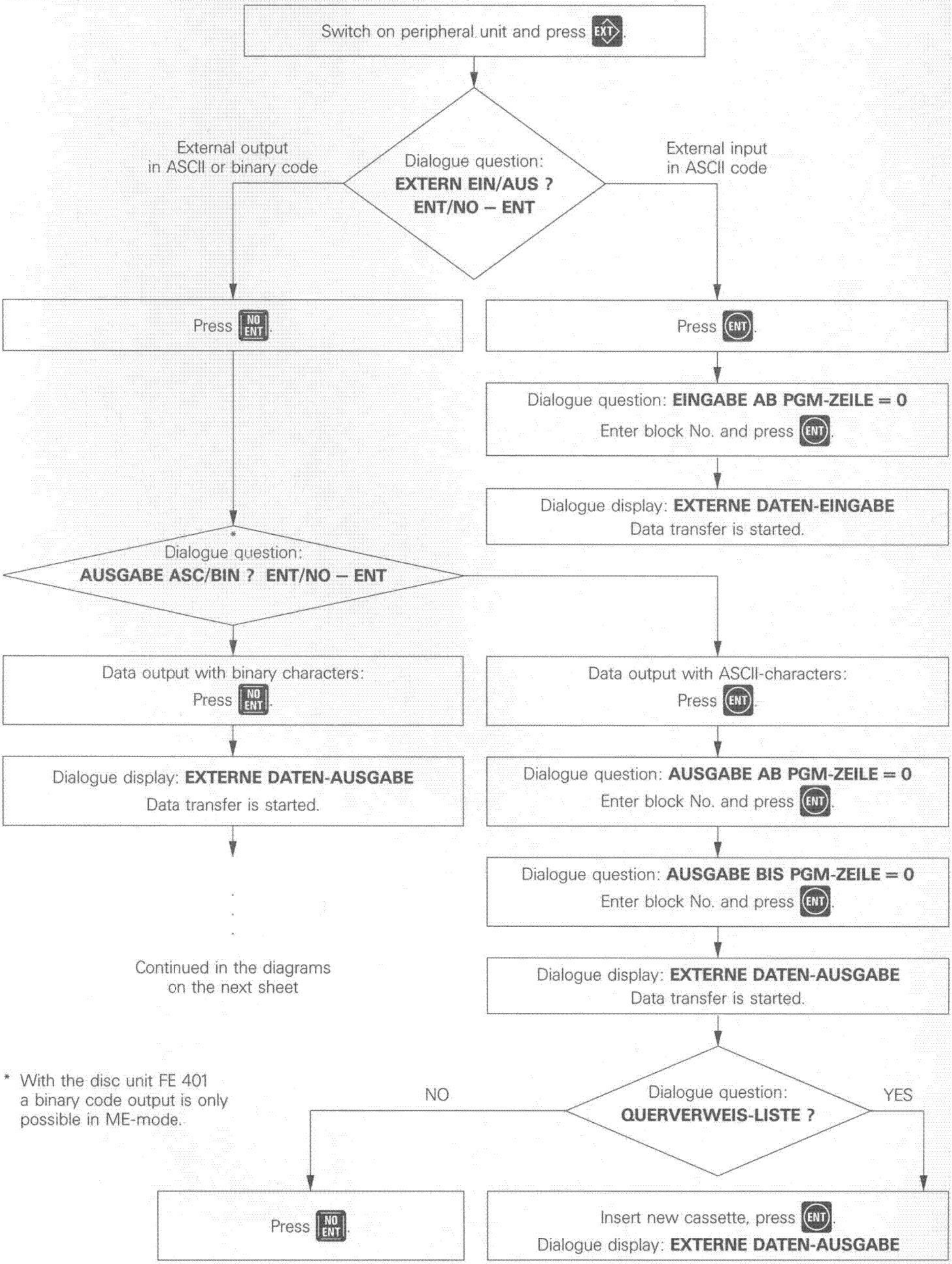
Transfer of a PLC-program from EPROM to RAM storage



Message translation:
PLC-PROGRAMM LOESCHEN = ERASE PLC PROGRAM
PROGRAMM AUS EPROM UEBERNEHMEN = TRANSFER PROGRAM FROM EPROM

PLC-modes
PLC-editing mode

Input/output of PLC-programs on disc, magnetic tape or printer



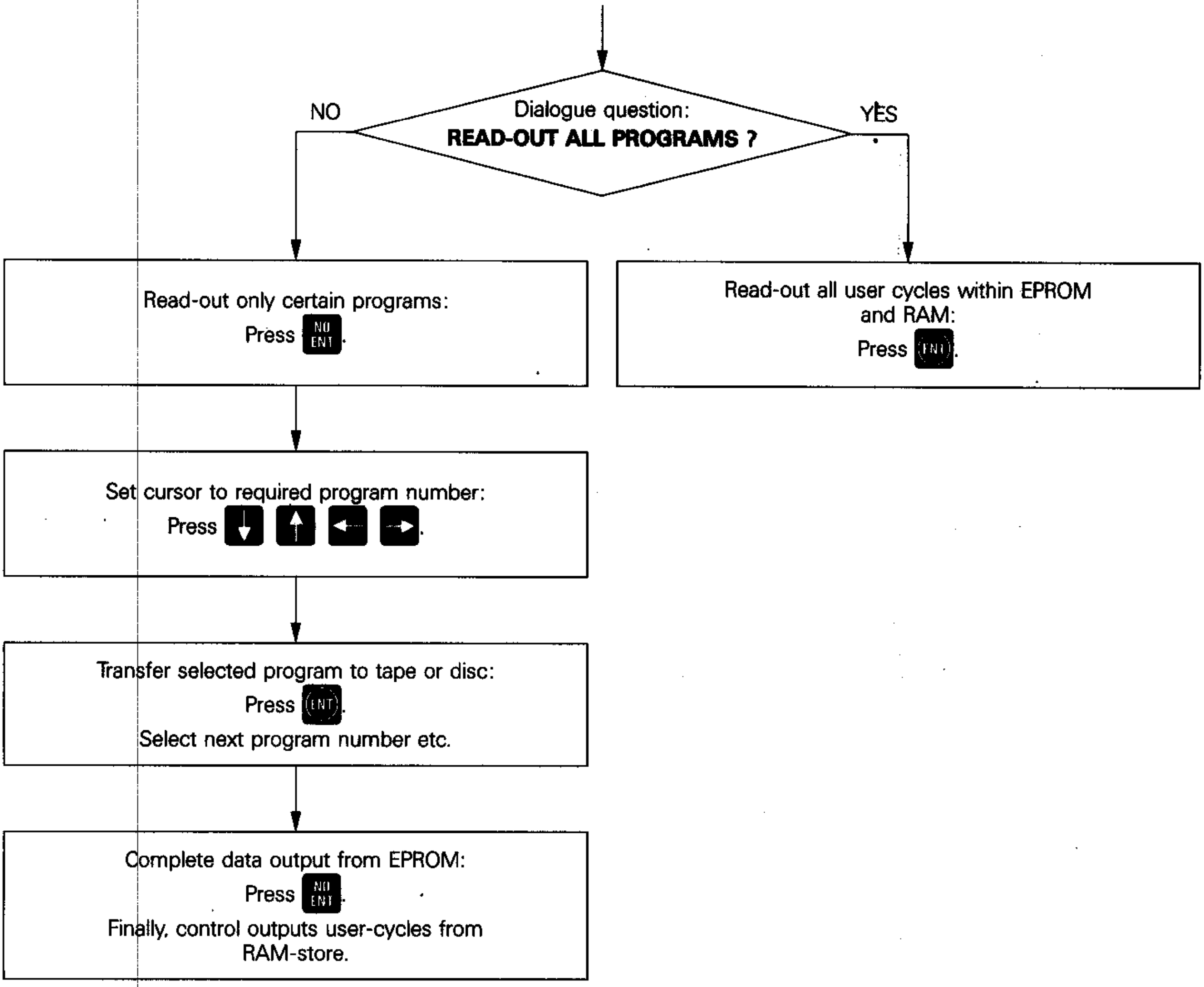
* With the disc unit FE 401 a binary code output is only possible in ME-mode.

PLC-modes
PLC-editing mode

Message translation:
EXTERN EIN/AUS ENT/NO – ENT = EXTERNAL INPUT/OUTPUT ENT/NO – ENT
AUSGABE ASC/BIN ENT/NO – ENT = OUTPUT ASCII/BINARY ENT/NO – ENT
EXTERNE DATEN-AUSGABE = EXTERNAL DATA OUTPUT
AUSGABE AB PGM-ZEILE = OUTPUT FROM PGM LINE
AUSGABE BIS PGM-ZEILE = OUTPUT TO PGM LINE
QUERVERWEIS-LISTE = CROSS REFERENCE LIST
EXTERNE DATEN-EINGABE = EXTERNAL DATA INPUT
EINGABE AB PGM-ZEILE = INPUT FROM PGM LINE

PLC-modes
PLC-editing mode

Binary output of user-cycles for compiling a PLC-EPROM

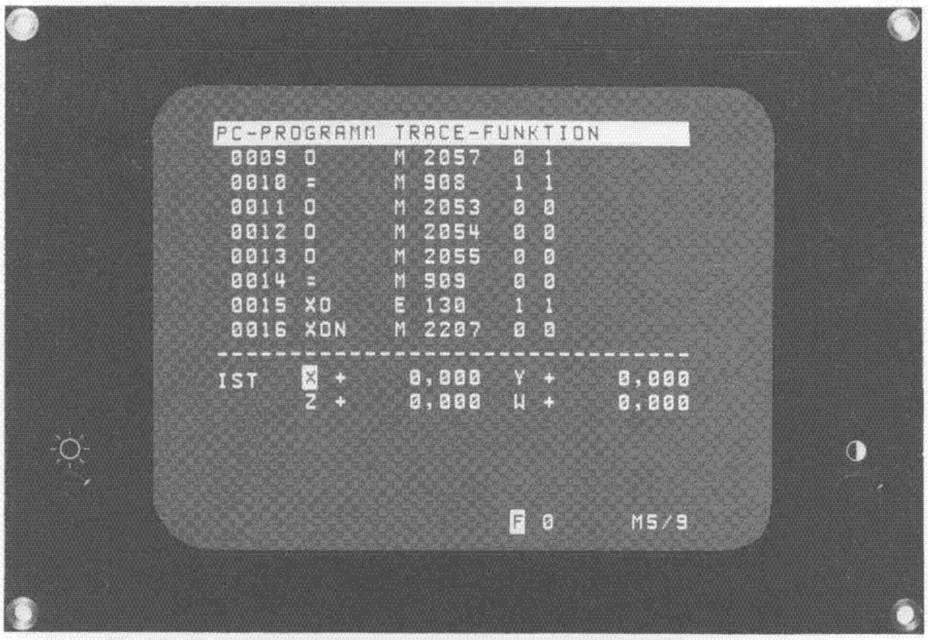


Please note:
With the aid of the HEIDENHAIN magnetic tape unit, floppy disc unit or another peripheral unit, program sections within the PLC-store can be shifted. For this, the program section to be shifted has to be read-out. With a new read-in, the program section is shifted to the command number which has been entered in response to the dialogue question "INPUT FROM PGM-LINE =".

PLC-modes
PLC-trace mode

The PLC-trace mode is accessed via the mode key PCT (see sheet P4/1).

The screen display is as follows:



In this mode the functioning of the PLC-program in the RAM memory may be verified. Alongside the PLC-commands is displayed both the individual status of the operands and the cumulative result of the logic sequences.
(The individual status of the operands is shown in the left hand column).

The PLC-trace mode may be used during machine operation. First the NC-program must be started and then PLC-trace mode accessed via entry of the code number 951026.

In the PLC-operating modes "Trace" and "Editing", inputs, outputs, counters, timers and markers can be sought using the GOTO key.

PLC-modes
PLC-tables E/A/Z/T/M

Select the "Operand display" mode by pressing the TAB key (see sheet P4/1).

The VDU-display shows the following dialogue:

TABELLE E/A/Z/T/M

By pressing the respective operand key the states of all the

Inputs : E key

Outputs : A key

Counters : Z key

Timers : T key

Markers : M key

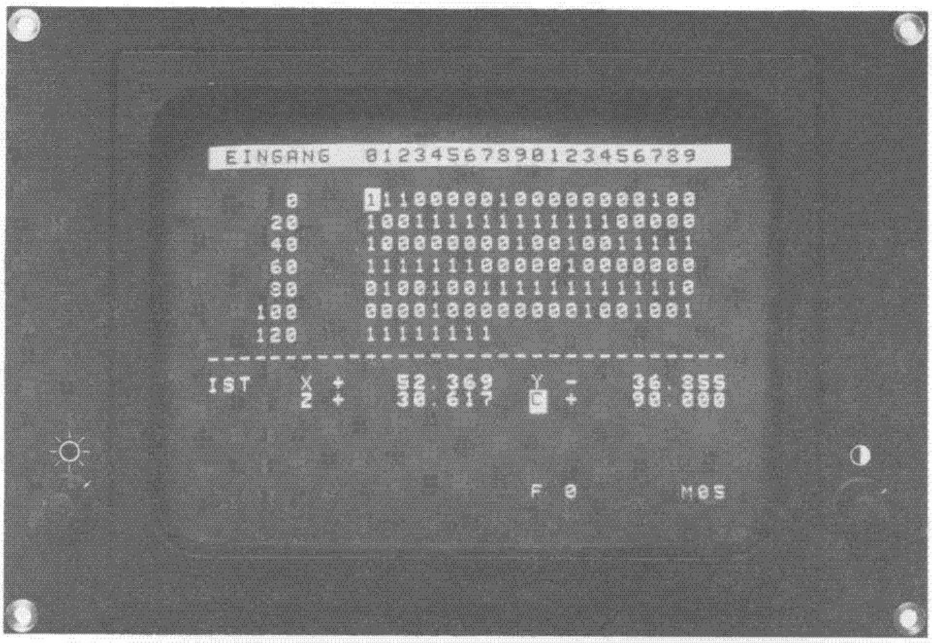
are displayed on the VDU.

The cursor keys ↓, ↑ and ←, → enable a specified operand to be highlighted in inverse video on the VDU-display, in order that the logic state of an operand can be easily observed.

Marker logic state display:
As only 120 markers can be displayed simultaneously, the GOTO □ key and the entry of a numerical value selects some other marker range.

In the PLC-mode "TABELLE E/A/Z/T/M" the buttons S and R can be used to set and reset inputs, outputs, counters, timers and markers.

The VDU-displays the following (e. g. the logic input states):



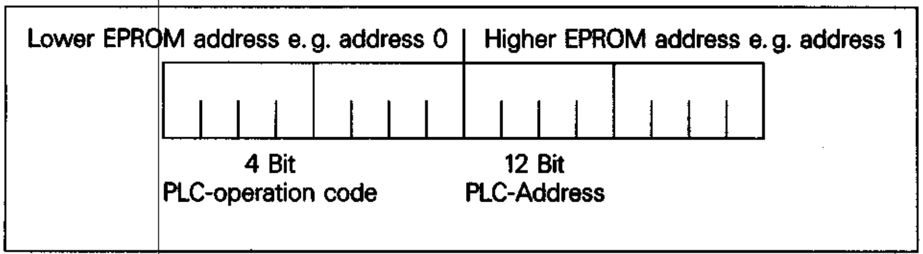
Message translation:
TABELLE E/A/Z/T/M = TABLES E–inputs/A–outputs/Z–counters/T–timers/M–markers

PLC-modes
Off-line programming of the PLC

An off-line programming terminal is not currently available from HEIDENHAIN. This section provides information as to the format of the PLC-commands so that off-line programming terminal suppliers can develop a terminal for the HEIDENHAIN-PLC if necessary.

Note:
With external programming, comments following PLC-commands must be separated from the PLC-command by the character *.

PLC-command format
Every PLC-command requires a 16 bit word i.e 2 bytes are defined in the PLC-command memory.
An command consists of a 4 bit PLC-operation code and the 12 bit PLC-address. The PLC-operation code defines the binary instruction and the PLC-address calls a memory location for the operands which are to be processed.



PLC-operation codes for PLC-commands

Abbreviation	PLC-operation code
NOP	0000
U UN	0001 0010
O ON	0011 0100
XO XON	0101 0110
S	0111
SN	1000
R	1001
RN	1010
=	1011
NOP	1111

PLC-modes
Off-line programming of the PLC

PLC-addresses for the PLC-commands

Abbreviation	PLC-address (Hexadecimal)
M0 – M3279	000 – CCF
E0 – E152	CD0 – D68
A0 – A63	E50 – E8F
Z0 – Z31	F10 – F2F
Z48 – Z79	F40 – F5F
Z96 – Z127	F70 – F8F
T0 – T47	FA0 – FCF
T48 – T95	FD0 – FFF

Address allocation of PLC-commands

PLC-Operand	msb – PLC-Address	EPROM-Address 0
PLC-Address	lsb	EPROM-Address 1
PLC-Operand	msb – PLC-Address	EPROM-Address 2
PLC-Address	lsb	EPROM-Address 3
PLC-Operand	msb – PLC-Address	EPROM-Address 4
PLC-Address	lsb	EPROM-Address 5
PLC-Operand	msb – PLC-Address	EPROM-Address 4094
PLC-Address	lsb	EPROM-Address 4095
Internal PLC-software		Address 8191

PLC-modes
Off-line programming of the PLC

Address allocation for PLC-EPROM
The PLC-program is permanently stored within an EPROM HN 27512.

Address allocation:

Address	Content	Remark
0000	4 K PLC-commands	
1000	B * R11	Assembler command: Return jump into main program
1002	Macro-table	Jump addresses for macro-programs
1042	Macros (assembler code)	ascending as of address 1042
	Macro (PLC-code)	descending as of address 1FFE
2000	Error messages	
2C80	Plain language dialogues for user-cycles	
3900	PLC-software No.	
390C	2800 NC-Blocks	user-cycles
FDEC	Directory 32 PGMs	
FFEC	vacant	
FFFE	CRC-sums	
FFFF		

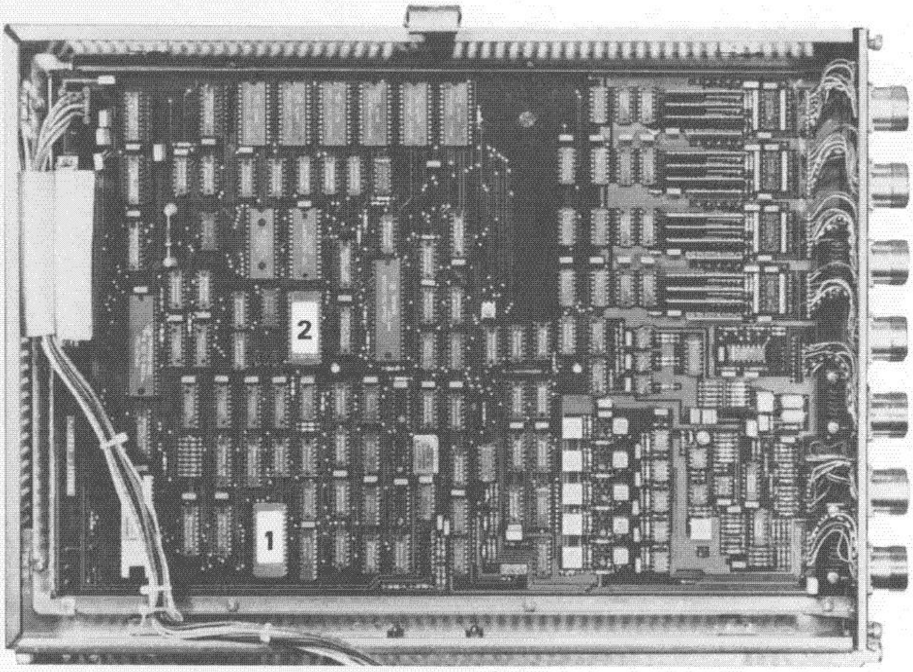
Exchange of PLC-EPROM's

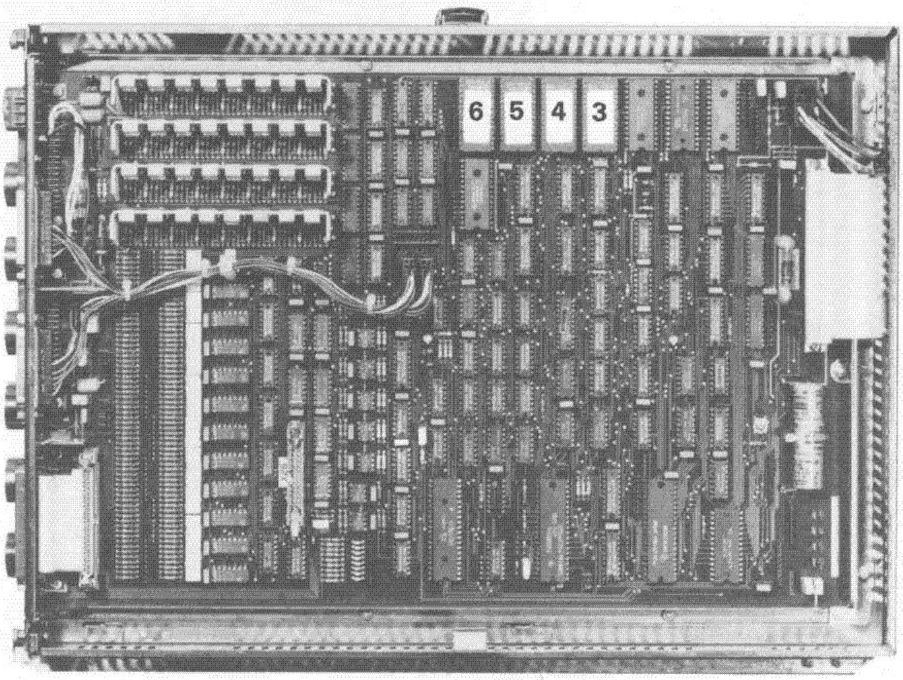
The PLC-program together with internal PLC-software and PLC-dialogue messages are permanently stored on an EPROM type HN 27512 (address locations see sheet P4/14).

The EPROM is found on the **first circuit board** under the control cover plate. It carries the designation . . . . 6 . (the spaces represent variable characters).

Note:
The PLC-software number can be displayed in "MOD" mode (see operating manual).

The EPROM location can be seen in the following diagrams:





Note:
Customer specific PLC-programs can be fitted before delivery of the control. If no particular PLC-program is specified the control will be delivered with the HEIDENHAIN standard PLC-program.
For more detailed information contact your local HEIDENHAIN office.

List of markers for signal exchange between PLC and NC

Note:
Markers M 1900 to M 1999 are either user markers of markers for signal exchange between PLC and NC depending on the status of marker M 2496 (see sheet P3/12).

Marker No.	Function	Section/Page
2000	Enable axis X	P3/2
2001	Enable axis Y	P3/2
2002	Enable axis Z	P3/2
2003	Enable axis IV	P3/2
2004	"0" = analogue voltage for spindle drive is located in ramp	P3/13
2005	"1" = analogue voltage for spindle drive is 0 V	P3/13
2006	Marker for under or over predetermined spindle speed	P3/14
2008	X-axis in position	P3/3
2009	Y-axis in position	P3/3
2010	Z-axis in position	P3/3
2011	IV-axis in position	P3/3
2012	Lubrication pulse necessary, X-axis limit exceeded	P3/6
2013	Lubrication pulse necessary, Y-axis limit exceeded	P3/6
2014	Lubrication pulse necessary, Z-axis limit exceeded	P3/6
2015	Lubrication pulse necessary, IV-axis limit exceeded	P3/6
2016	Release V-axis (NC-axis)	P3/38
2017	V-axis (NC-axis) in position	P3/38
2022	Probe system not ready	P3/31
2023	Stylus already deflected at start of probing cycle	P3/31
2024	Probing system ready (TS 511)	P3/31
2025	Stylus deflected. Probing procedure completed.	P3/31
2026	Probing procedure completed	P3/31
2027	Battery voltage too low (TS 511)	P3/31
2032	1. Bit T-Code (lsb)	P3/9
2033	2. Bit T-Code	P3/9
2034	3. Bit T-Code	P3/9
2035	4. Bit T-Code	P3/9
2036	5. Bit T-Code	P3/9
2037	6. Bit T-Code	P3/9
2038	7. Bit T-Code	P3/9
2039	8. Bit T-Code (msb)	P3/9
2041	English dialogue language is selected	P3/41
2042	Control operates with S-analogue	P3/13
2043	Change signal G-Code for S-analogue	P3/13
2044	Change signal S-Code	P3/9
2045	Change signal M-Code	P3/9
2046	Change signal T-Code	P3/9
2047	Change signal 2nd T-Code (see machine parameter 157)	P3/9
2048	Tapping cycle is called	P3/41
2049	Background editing mode	P3/17

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2050	Programming	P3/17
2051	Manual operation	P3/17
2052	Electronic handwheel	P3/17
2053	Positioning with MDI	P3/17
2054	Program run single block	P3/17
2055	Program run full sequence	P3/17
2056	Program test	P3/17
2057	Approach to reference point	P3/17
2060	Marker for DIN/ISO programming (from NC No. ... 05)	P3/41
2061	Marker showing activation of END-PGM, M02, M30 (from NC No. ... 05)	P3/41
2062	Marker for display "code number"	P3/27
2063	Marker for central tool file	P3/41
2064	1. Bit S-Code (lsb)	P3/9
2065	2. Bit S-Code	P3/9
2066	3. Bit S-Code	P3/9
2067	4. Bit S-Code	P3/9
2068	5. Bit S-Code	P3/9
2069	6. Bit S-Code	P3/9
2070	7. Bit S-Code	P3/9
2071	8. Bit S-Code (msb)	P3/9
2072	1. Bit M-Code (lsb)	P3/9
2073	2. Bit M-Code	P3/9
2074	3. Bit M-Code	P3/9
2075	4. Bit M-Code	P3/9
2076	5. Bit M-Code	P3/9
2077	6. Bit M-Code	P3/9
2078	7. Bit M-Code	P3/9
2079	8. Bit M-Code (msb)	P3/9
2080	1. Bit for minimum rpm (lsb)	P3/16
2081	2. Bit for minimum rpm	P3/16
2082	3. Bit for minimum rpm	P3/16
2083	4. Bit for minimum rpm	P3/16
2084	5. Bit for minimum rpm	P3/16
2085	6. Bit for minimum rpm	P3/16
2086	7. Bit for minimum rpm	P3/16
2087	8. Bit for minimum rpm (msb)	P3/16
2088	1. Bit for step width (lsb)	P3/16
2089	2. Bit for step width	P3/16
2090	3. Bit for step width	P3/16
2091	4. Bit for step width (msb)	P3/16

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2092	Marker for display "wrong rpm"	P3/13
2093	Toolchange of special to normal tool (from NC No. ... 05)	P3/45
2096	Currently activated TNC axis key X	P3/18
2097	Currently activated TNC axis key Y	P3/18
2098	Currently activated TNC axis key Z	P3/18
2099	Currently activated TNC axis key IV	P3/18
2100	X-axis is tool axis	P3/5
2101	Y-axis is tool axis	P3/5
2102	Z-axis is tool axis	P3/5
2103	IV-axis is tool axis	P3/5
2104	1. Bit gear change Code S-Analogue (lsb)	P3/13
2105	2. Bit gear change Code S-Analogue	P3/13
2106	3. Bit gear change Code S-Analogue (msb)	P3/13
2112	Tool pocket number 1st decade (lsb)	P3/46
2113	Tool pocket number 1st decade	P3/46
2114	Tool pocket number 1st decade	P3/46
2115	Tool pocket number 1st decade (msb)	P3/46
2116	Tool pocket number 2nd decade (lsb)	P3/46
2117	Tool pocket number 2nd decade	P3/46
2118	Tool pocket number 2nd decade	P3/46
2119	Tool pocket number 2nd decade (msb)	P3/46
2128	Traversing of X-axis(10)	P3/3
2129	Traversing of Y-axis(10)	P3/3
2130	Traversing of Z-axis(10)	P3/3
2131	Traversing of IV-axis(10)	P3/3
2148	Currently activated TNC axis key V	P3/38
2160	Traverse direction X-axis(10)	P3/3
2161	Traverse direction Y-axis(10)	P3/3
2162	Traverse direction Z-axis(10)	P3/3
2163	Traverse direction IV-axis(10)	P3/3
2176	Code operating mode (lsb)	P3/17
2177	Code operating mode	P3/17
2178	Code operating mode	P3/17
2179	Code operating mode (msb) 0000 = Programming 0001 = Manual operation 0010 = Electronic handwheel 0011 = Positioning with MDI 0100 = Program run single block 0101 = Program run full sequence	P3/17
2180	1st PLC-cycle run after power on	P3/40

(10) As of Software version 10 (4 axes)

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2182	Inhibited TNC-key pressed	P3/20
2183	Program interruption (flashing of operation display lamp)	P3/28
2184	Control in operation (permanent operation pilot)	P3/28
2185	1st PLC-cycle run after interruption of PLC-program	P3/40
2189	Undefined macro called	P3/47
2190	Erasable error display is displayed	P3/28
2191	Error "external emergency stop" is displayed	P3/28

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
	Markers influenced by machine parameter 158	
2192	(value 1)	P3/42
2193	(Value 2)	P3/42
2194	(Value 4)	P3/42
2195	(Value 8)	P3/42
2196	(Value 16)	P3/42
2197	(Value 32)	P3/42
2198	(Value 64)	P3/42
2199	(Value 128)	P3/42
2200	(Value 256)	P3/42
2201	(Value 512)	P3/42
2202	(Value 1024)	P3/42
2203	(Value 2048)	P3/42
2204	(Value 4096)	P3/42
2205	(Value 8192)	P3/42
2206	(Value 16384)	P3/42
2207	(Value 32768)	P3/42
	Markers affected by machine parameter 249	
2208	(Value 1)	P3/43
2209	(Value 2)	P3/43
2210	(Value 4)	P3/43
2211	(Value 8)	P3/43
2212	(Value 16)	P3/43
2213	(Value 32)	P3/43
2214	(Value 64)	P3/43
2215	(Value 128)	P3/43
2216	(Value 256)	P3/43
2217	(Value 512)	P3/43
2218	(Value 1024)	P3/43
2219	(Value 2048)	P3/43
2220	(Value 4096)	P3/43
2221	(Value 8192)	P3/43
2222	(Value 16384)	P3/43
2223	(Value 32768)	P3/43
	Markers affected by machine parameter 250	
2224	(Value 1)	P3/43
2225	(Value 2)	P3/43
2226	(Value 4)	P3/43
2227	(Value 8)	P3/43
2228	(Value 16)	P3/43
2229	(Value 32)	P3/43
2230	(Value 64)	P3/43
2231	(Value 128)	P3/43

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2232	(Value 256)	P3/43
2233	(Value 512)	P3/43
2234	(Value 1024)	P3/43
2235	(Value 2048)	P3/43
2236	(Value 4096)	P3/43
2237	(Value 8192)	P3/43
2238	(Value 16384)	P3/43
2239	(Value 32768)	P3/43
2240	User-cycle 68	P3/44
2241	User-cycle 69	P3/44
2242	User-cycle 70	P3/44
2243	User-cycle 71	P3/44
2244	User-cycle 72	P3/44
2245	User-cycle 73	P3/44
2246	User-cycle 74	P3/44
2247	User-cycle 75	P3/44
2248	User-cycle 76	P3/44
2249	User-cycle 77	P3/44
2250	User-cycle 78	P3/44
2251	User-cycle 79	P3/44
2252	User-cycle 80	P3/44
2253	User-cycle 81	P3/44
2254	User-cycle 82	P3/44
2255	User-cycle 83	P3/44
2256	User-cycle 84	P3/44
2257	User-cycle 85	P3/44
2258	User-cycle 86	P3/44
2259	User-cycle 87	P3/44
2260	User-cycle 88	P3/44
2261	User-cycle 89	P3/44
2262	User-cycle 90	P3/44
2263	User-cycle 91	P3/44
2264	User-cycle 92	P3/44
2265	User-cycle 93	P3/44
2266	User-cycle 94	P3/44
2267	User-cycle 95	P3/44
2268	User-cycle 96	P3/44
2269	User-cycle 97	P3/44
2270	User-cycle 98	P3/44
2271	User-cycle 99	P3/44

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2448	NC-start	P3/22
2449	NC-rapid	P3/22
2450	Memory function for manual traversing	P3/22
2451	Feed release	P3/22
2452	Start PLC-positioning X-axis	P3/7
2453	Start PLC-positioning Y-axis	P3/7
2454	Start PLC-positioning Z-axis	P3/7
2455	Start PLC-positioning IV-axis	P3/7
2456	Manual traversing X+	P3/22
2457	Manual traversing X–	P3/22
2458	Manual traversing Y+	P3/22
2459	Manual traversing Y–	P3/22
2460	Manual traversing Z+	P3/22
2461	Manual traversing Z–	P3/22
2462	Manual traversing IV+	P3/22
2463	Manual traversing IV–	P3/22
2464	Complemented NC-start	P3/22
2465	Complemented NC-rapid	P3/22
2466	Complemented memory function for manual traversing	P3/22
2467	Complemented feed release	P3/22
2468	Complemented start PLC-positioning X-axis	P3/7
2469	Complemented start PLC-positioning Y-axis	P3/7
2470	Complemented start PLC-positioning Z-axis	P3/7
2471	Complemented start PLC-positioning IV-axis	P3/7
2472	Complemented manual traverse X+	P3/22
2473	Complemented manual traverse X–	P3/22
2474	Complemented manual traverse Y+	P3/22
2475	Complemented manual traverse Y–	P3/22
2476	Complemented manual traverse Z+	P3/22
2477	Complemented manual traverse Z–	P3/22
2478	Complemented manual traverse IV+	P3/22
2479	Complemented manual traverse IV–	P3/22
2480	Feedback signal gear change code S-Analogue	P3/13
2481	Feedback S-Code	P3/9
2482	Feedback M-Code	P3/9
2483	Feedback T-Code	P3/9
2484	Feedback 2nd T-Code	P3/9
2485	Status display and sign of analogue output M03	P3/13
2486	Status display and sign of analogue output M04	P3/13
2487	Status display M05	P3/13
2488	NC-stop	P3/22

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2489	Inversion of analogue voltage	P3/13
2490	Spindle ccw for gear change	P3/13
2491	Spindle cw for gear change	P3/13
2492	Activation control loop opening X-axis	P3/4
2493	Activation control loop opening Y-axis	P3/4
2494	Activation control loop opening Z-axis	P3/4
2495	Activation control loop opening IV-axis	P3/4
2496	Release marker for decoded M-Code-output via markers 1900 – 1999	P3/12
2497	Release marker for ascending edges (see markers 1500 – 1652) and for descending edges (see markers 1700 – 1852) of PLC-inputs	P3/39
2498	Activation jog positioning	P3/32
2499	Open control loop for V-axis. A pre-marker is not required for opening the control loop (spindle)	P3/37
2500	Activation control loop opening for V-axis (NC-axis)	P3/38
2501	Marker for output of spindle speed according to MP 258	P3/13
2503	Release marker for probing function	P3/31
2504	Marker for axis clamping during constant contouring	P3/41
2505	Actual value transfer for V-axis (NC-axis)	P3/38
2506	Reference end position for V-axis (NC-axis)	P3/38
2507	Open control loop V-axis (NC-axis)	P3/38
2508	Marker for status display M08/M09	P3/27
2509	Activation of %-factor for feedrate override	P3/41
2510	Spindle override inactive (from NC-No. … 10)	P3/41
2511	Feedrate override inactive	P3/41
2512	X+ Start marker for jog positioning	P3/32
2513	X– Start marker for jog positioning	P3/32
2514	Y+ Start marker for jog positioning	P3/32
2515	Y– Start marker for jog positioning	P3/32
2516	Z+ Start marker for jog positioning	P3/32
2517	Z– Start marker for jog positioning	P3/32
2518	IV+ Start marker for jog positioning	P3/32
2519	IV– Start marker for jog positioning	P3/32
2520	V+ Start marker for jog positioning	P3/38
2521	V– Start marker for jog positioning	P3/38
2522	Start PLC-positioning V-axis (NC-axis)	P3/38
2524	Manual traversing V+	P3/38
2525	Manual traversing V–	P3/38
2526	Switching to the fourth axis	P3/34
2527	Start PLC-positioning V-axis (spindle orientation)	P3/37
2528	X+ Complement marker for jog positioning	P3/32
2529	X– Complement marker for jog positioning	P3/32
2530	Y+ Complement marker for jog positioning	P3/32

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2531	Y– Complement marker for jog positioning	P3/32
2532	Z+ Complement marker for jog positioning	P3/32
2533	Z– Complement marker for jog positioning	P3/32
2534	IV+ Complement marker for jog positioning	P3/32
2535	IV– Complement marker for jog positioning	P3/32
2536	V+ Complement marker for jog positioning	P3/38
2537	V– Complement marker for jog positioning	P3/38
2538	Complement PLC-positioning V-axis (NC-axis)	P3/38
2540	Complement manual traverse V+	P3/38
2541	Complement manual traverse V–	P3/38
2542	Complement marker for marker 2526	P3/34
2543	Complement PLC-positioning V-axis (spindle orientation)	P3/37
2544	Open control loop X-axis	P3/4
2545	Open control loop Y-axis	P3/4
2546	Open control loop Z-axis	P3/4
2547	Open control loop IV-axis	P3/4
2548	Reset accumulated distance in X-axis for travel-dependent lubrication	P3/6
2549	Reset accumulated distance in Y-axis for travel-dependent lubrication	P3/6
2550	Reset accumulated distance in Z-axis for travel-dependent lubrication	P3/6
2551	Reset accumulated distance in IV-axis for travel-dependent lubrication	P3/6
2552	Transfer actual position value X-axis	P3/5
2553	Transfer actual position value Y-axis	P3/5
2554	Transfer actual position value Z-axis	P3/5
2555	Transfer actual position value IV-axis	P3/5
2556	Reference end position X-axis	P3/22
2557	Reference end position Y-axis	P3/22
2558	Reference end position Z-axis	P3/22
2559	Reference end position IV-axis	P3/22
2560	PLC-position X-axis (lsb); tool number 1st decade (lsb); numerical value 1st decade (lsb)	P3/7; P3/46; P3/29
2561	PLC-position X-axis; tool number 1st decade; numerical value 1st decade	P3/7; P3/46; P3/29
2562	PLC-position X-axis; tool number 1st decade; numerical value 1st decade	P3/7; P3/46; P3/29
2563	PLC-position X-axis; tool number 1st decade (msb); numerical value 1st decade (msb)	P3/7; P3/46; P3/29
2564	PLC-position X-axis (msb); tool number 2nd decade (lsb); numerical value 2nd decade (lsb)	P3/7; P3/46; P3/29
2565	PLC-position Y-axis (lsb); tool number 2nd decade; numerical value 2nd decade	P3/7; P3/46; P3/29
2566	PLC-position Y-axis; tool number 2nd decade; numerical value 2nd decade	P3/7; P3/46; P3/29

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2567	PLC-position Y-axis; tool number 2nd decade (msb); numerical value 2nd decade (msb)	P3/7; P3/46; P3/29
2568	PLC-position Y-axis; numerical value 3rd decade (lsb)	P3/7; P3/29;
2569	PLC-position Y-axis (msb); numerical value 3rd decade	P3/7; P3/29;
2570	PLC-position Z-axis (lsb); numerical value 3rd decade	P3/7; P3/29;
2571	PLC-position Z-axis; numerical value 3rd decade (msb)	P3/7; P3/29;
2572	PLC-position Z-axis; tool number 1st decade (lsb); numerical value 4th decade (lsb)	P3/7; P3/46; P3/29
2573	PLC-position Z-axis; tool number 1st decade; numerical value 4th decade	P3/7; P3/46; P3/29
2574	PLC-position Z-axis (msb); tool number 1st decade; numerical value 4th decade	P3/7; P3/46; P3/29
2575	PLC-position IV-axis (lsb); tool number 1st decade (msb); numerical value 4th decade (msb)	P3/7; P3/46; P3/29
2576	PLC-position IV-axis; tool number 2nd decade (lsb); numerical value sign	P3/7; P3/46; P3/29
2577	PLC-position IV-axis; tool number 2nd decade	P3/7; P3/46
2578	PLC-position IV-axis; tool number 2nd decade	P3/7; P3/46
2579	PLC-position IV-axis (msb); tool number 2nd decade (msb)	P3/7; P3/46
2580	PLC-position V-axis (lsb)	P3/37; P3/38
2581	PLC-position V-axis	P3/37; P3/38
2582	PLC-position V-axis	P3/37; P3/38
2583	PLC-position V-axis	P3/37; P3/38
2584	PLC-position V-axis (msb)	P3/37; P3/38
2590	Designation of axis to be switched to IVth axis (lsb)	P3/34
2591	Designation of axis to be switched to IVth axis (msb)	P3/34
2595	Output of tool number in addition to pocket number (from NC No. 09)	P3/45
2596	Central tool file accessed during program run (from NC No. 07)	P3/41
2598	Marker for tool number transfer (from NC No. ... 05)	P3/45
2599	Marker for tool number transfer (from NC No. ... 05)	P3/45
2600	Marker for pocket number (from NC No. ... 05)	P3/45
2601	Marker for location of special tool (from NC No. ... 05)	P3/45
2602	Designation of reference mark approaches	P3/33
2603	Axis sequence for reference mark approach (lsb) (from NC No. ... 07)	P3/33
2604	Axis sequence for reference mark approach (from NC No. ... 07)	P3/33
2605	Axis sequence for reference mark approach (from NC No. ... 07)	P3/33
2606	Axis sequence for reference mark approach (from NC No. ... 07)	P3/33
2607	Axis sequence for reference mark approach (msb) (from NC No. ... 07)	P3/33
2656	Spindle orientation from standstill (from NC No. ... 06)	P3/37
2657	Display of second auxiliary function (msb) (from NC No. ... 06)	P3/27

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2664	No standstill supervision on X-axis(09)	P3/3
2665	No standstill supervision on Y-axis(09)	P3/3
2666	No standstill supervision on Z-axis(09)	P3/3
2667	No standstill supervision on IV-axis(09)	P3/3
2668	No standstill supervision on V-axis(09)	P3/38
2800	TNC key code (lsb) for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2801	TNC key code for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2802	TNC key code for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2803	TNC key code for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2804	TNC key code for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2805	TNC key code for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2806	TNC key code for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2807	TNC key code (msb) for remote operation of TNC keys (for coding see markers 2855 – 2923)	P3/18
2808	Strobe for key code	P3/18
2809	Strobe for numerical value transfer (markers 2560 – 2576) from the PLC	P3/29
2810 2811 2812	Format of numerical value in markers 2560 – 2576	P3/29 P3/29 P3/29
2814	Activate gearchange (from NC No. ... 06)	P3/13
2815	Flashing PLC-error message	P3/24
2816	Marker for %-factor of spindle analogue; selection of Q-parameter (lsb); selection of datum correction (lsb); selection of spindle analogue ramps	P3/35; P3/29; P3/36; P3/14
2817	Selection of Q-parameter; selection of datum correction (msb)	P3/29; P3/36
2818	Selection of Q-parameter (msb)	P3/29
2819	Strobe for activating datum correction (from NC No. ... 07)	P3/36
2820	Central tool file update (from NC No. ... 06)	P3/46
2821	Strobe for central tool file update (from NC No. ... 06)	P3/46
2822	Strobe for %-factor of spindle analogue (from NC No. ... 07)	P3/35
2823	Selection of spindle analogue ramps (from NC No. ... 09)	P3/14

(09) (from NC No. ... 09)

List of markers for signal exchange between PLC and NC

Marker No.	Function	Key-Code msb	Key-Code lsb		Section/Page
2855	PGM NR Inhibit	0011	1011		P3/20
2856	L Inhibit	0011	1100		P3/20
2857	RND Inhibit	0011	1101		P3/20
2858	CC Inhibit	0011	1110		P3/20
2859	C Inhibit	0011	1111		P3/20
2860	 Inhibit	0100	0000		P3/20
2861	 Inhibit	0100	0001		P3/20
2862	MOD Inhibit	0100	0010		P3/20
2863	P Inhibit	0100	0011		P3/20
2864	I Inhibit	0100	0100		P3/20
2865	PGM CALL Inhibit	0100	0101		P3/20
2867	CR Inhibit	0100	0111		P3/20
2868	 Inhibit	0100	1000		P3/20
2869	 Inhibit	0100	1001		P3/20
2870	 Inhibit	0100	1010		P3/20
2871	 Inhibit	0100	1011		P3/20
2872	 Inhibit	0100	1100		P3/20
2873	CT Inhibit	0100	1101		P3/20
2874	TOUCH PROBE Inhibit	0100	1110		P3/20
2880	TOOL DEF Inhibit	0101	0100		P3/20
2881	TOOL CALL Inhibit	0101	0101		P3/20
2882	RL Inhibit	0101	0110		P3/20
2883	RR Inhibit	0101	0111		P3/20
2884	↑ Inhibit	0101	1000		P3/20
2885	← Inhibit	0101	1001		P3/20
2886	→ Inhibit	0101	1010		P3/20
2887	CYCL DEF Inhibit	0101	1011		P3/20

List of markers for signal exchange between PLC and NC

Marker No.	Function	Key-Code msb	lsb		Section/Page
2888	CYCL CALL Inhibit	0101	1100		P3/20
2889	LBL SET Inhibit	0101	1101		P3/20
2890	LBL CALL Inhibit	0101	1110		P3/20
2891	NO ENT Inhibit	0101	1111		P3/20
2892	STOP Inhibit	0110	0000		P3/21
2893	EXT Inhibit	0110	0001		P3/21
2894	CL PGM Inhibit	0110	0010		P3/21
2895	DEL □ Inhibit	0110	0011		P3/21
2896	Inhibit	0110	0100		P3/21
2897	ENT Inhibit	0110	0101		P3/21
2898	GOTO □ Inhibit	0110	0110		P3/21
2899	↓ Inhibit	0110	0111		P3/21
2900	Q DEF Inhibit	0110	1000		P3/21
2901	CE Inhibit	0110	1001		P3/21
2902	IV Inhibit	0110	1010		P3/21
2903	Z Inhibit	0110	1011		P3/21
2904	Y Inhibit	0110	1100		P3/21
2905	X Inhibit	0110	1101		P3/21
2906	Q Inhibit	0110	1110		P3/21
2907	0 Inhibit	0110	1111		P3/21
2908	1 Inhibit	0111	0000		P3/21
2909	4 Inhibit	0111	0001		P3/21
2910	7 Inhibit	0111	0010		P3/21
2911	· Inhibit	0111	0011		P3/21
2912	2 Inhibit	0111	0100		P3/21
2913	5 Inhibit	0111	0101		P3/21
2914	8 Inhibit	0111	0110		P3/21

List of markers for signal exchange between PLC and NC

Marker No.	Function	Key-Code msb	lsb		Section/Page
2915	END □ Inhibit	0111	0111		P3/21
2916	MOD Inhibit	0111	1000		P3/21
2917	BLK FORM Inhibit	0111	1001		P3/21
2918	MAGN Inhibit	0111	1010		P3/21
2919	START Inhibit	0111	1011		P3/21
2920	+/_ Inhibit	0111	1100		P3/21
2921	3 Inhibit	0111	1101		P3/21
2922	6 Inhibit	0111	1110		P3/21
2923	9 Inhibit	0111	1111		P3/21
2924	Error message 0				P3/24
2925	Error message 1				P3/24
2926	Error message 2				P3/24
2927	Error message 3				P3/24
2928	Error message 4				P3/24
2929	Error message 5				P3/24
2930	Error message 6				P3/24
2931	Error message 7				P3/24
2932	Error message 8				P3/24
2933	Error message 9				P3/24
2934	Error message 10				P3/24
2935	Error message 11				P3/24
2936	Error message 12				P3/24
2937	Error message 13				P3/24
2938	Error message 14				P3/24
2939	Error message 15				P3/24
2940	Error message 16				P3/24
2941	Error message 17				P3/24
2942	Error message 18				P3/24
2943	Error message 19				P3/24
2944	Error message 20				P3/24
2945	Error message 21				P3/24
2946	Error message 22				P3/24
2947	Error message 23				P3/24
2948	Error message 24				P3/24
2949	Error message 25				P3/24

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2950	Error message 26	P3/24
2951	Error message 27	P3/24
2952	Error message 28	P3/24
2953	Error message 29	P3/24
2954	Error message 30	P3/24
2955	Error message 31	P3/24
2956	Error message 32	P3/24
2957	Error message 33	P3/24
2958	Error message 34	P3/24
2959	Error message 35	P3/24
2960	Error message 36	P3/24
2961	Error message 37	P3/24
2962	Error message 38	P3/24
2963	Error message 39	P3/24
2964	Error message 40	P3/24
2965	Error message 41	P3/24
2966	Error message 42	P3/24
2967	Error message 43	P3/24
2968	Error message 44	P3/24
2969	Error message 45	P3/24
2970	Error message 46	P3/24
2971	Error message 47	P3/24
2972	Error message 48	P3/24
2973	Error message 49	P3/24
2974	Error message 50	P3/24
2975	Error message 51	P3/24
2976	Error message 52	P3/24
2977	Error message 53	P3/25
2978	Error message 54	P3/25
2979	Error message 55	P3/25
2980	Error message 56	P3/25
2981	Error message 57	P3/25
2982	Error message 58	P3/25
2983	Error message 59	P3/25
2984	Error message 60	P3/25
2985	Error message 61	P3/25
2986	Error message 62	P3/25
2987	Error message 63	P3/25
2988	Error message 64	P3/25

List of markers for signal exchange between PLC and NC

Marker No.	Function	Section/Page
2989	Error message 65	P3/25
2990	Error message 66	P3/25
2991	Error message 67	P3/25
2992	Error message 68	P3/25
2993	Error message 69	P3/25
2994	Error message 70	P3/25
2995	Error message 71	P3/25
2996	Error message 72	P3/25
2997	Error message 73	P3/25
2998	Error message 74	P3/25
2999	Error message 75	P3/25
3000	Error message 76	P3/25
3001	Error message 77	P3/25
3002	Error message 78	P3/25
3003	Error message 79	P3/25
3004	Error message 80	P3/25
3005	Error message 81	P3/25
3006	Error message 82	P3/25
3007	Error message 83	P3/25
3008	User-parameter 16	P3/26
3009	User-parameter 15	P3/26
3010	User-parameter 14	P3/26
3011	User-parameter 13	P3/26
3012	User-parameter 12	P3/26
3013	User-parameter 11	P3/26
3014	User-parameter 10	P3/26
3015	User-parameter 9	P3/26
3016	User-parameter 8	P3/26
3017	User-parameter 7	P3/26
3018	User-parameter 6	P3/26
3019	User-parameter 5	P3/26
3020	User-parameter 4	P3/26
3021	User-parameter 3	P3/26
3022	User-parameter 2	P3/26
3023	User-parameter 1	P3/26

PLC-programming sheets
PLC-inputs on logic unit LE 355

Input	Comments
E 0	
E 1	
E 2	
E 3	
E 4	
E 5	
E 6	
E 7	
E 8	
E 9	
E 10	
E 11	
E 12	
E 13	
E 14	
E 15	
E 16	
E 17	
E 18	
E 19	
E 20	
E 21	
E 22	
E 23	
E 24	
E 25	
E 26	
E 27	
E 28	
E 29	
E 30	
E 31	
E 128	
E 129	
E 130	
E 131	
E 132	
E 133	
E 134	

Input	Comments
E 135	
E 136	
E 137	
E 138	
E 139	
E 140	
E 141	
E 142	
E 143	
E 144	
E 145	
E 146	
E 147	
E 148	
E 149	
E 150	
E 151	
E 152	

PLC-programming sheets
PLC-inputs on input/output board PL 300

Input	Comments
E 63	
E 64	
E 65	
E 66	
E 67	
E 68	
E 69	
E 70	
E 71	
E 72	
E 73	
E 74	
E 75	
E 76	
E 77	
E 78	
E 79	
E 80	
E 81	
E 82	
E 83	
E 84	
E 85	
E 86	
E 87	
E 88	
E 89	
E 90	
E 91	
E 92	
E 93	
E 94	
E 95	
E 96	
E 97	
E 98	
E 99	
E 100	
E 101	
E 102	

Input	Comments
E 103	
E 104	
E 105	
E 106	
E 107	
E 108	
E 109	
E 110	
E 111	
E 112	
E 113	
E 114	
E 115	
E 116	
E 117	
E 118	
E 119	
E 120	
E 121	
E 122	
E 123	
E 124	
E 125	
E 126	

PLC-programming sheets

PLC-outputs on logic unit LE 355

Output	Comments
A 0	
A 1	
A 2	
A 3	
A 4	
A 5	
A 6	
A 7	
A 8	
A 9	
A 10	
A 11	
A 12	
A 13	
A 14	
A 15	
A 16	
A 17	
A 18	
A 19	
A 20	
A 21	
A 22	
A 23	
A 24	
A 25	
A 26	
A 27	
A 28	
A 29	
A 30	

PLC-outputs on input/output board PL 300

Output	Comments
A 32	
A 33	
A 34	
A 35	
A 36	
A 37	
A 38	
A 39	
A 40	
A 41	
A 42	
A 43	
A 44	
A 45	
A 46	
A 47	
A 48	
A 49	
A 50	
A 51	
A 52	
A 53	
A 54	
A 55	
A 56	
A 57	
A 58	
A 59	
A 60	
A 61	
A 62	

PLC-programming sheets
Marker list

Marker No.	Comments
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	

Marker No.	Comments
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	

PLC-programming sheets
PLC-program listing

Command No.	Command	Comments
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
0		

Contents

General Information

The PLC-standard-program described here has the Ident-Nr. 24040205.

It is employed on all TNC 355 Contouring Controls as of software number 23732005 (TNC 355B/Q) or as of software number 23734004 (TNC 355C), unless the machine manufacturer requests a special PLC program.

The statements list is provided with commentaries marked with an asterisk "*". The commentaries are not stored in the TNC. The statements are numbered sequentially.

Statement list

```
* ***********************************************************
* Beginning of PLC program

* Direct OR gating:
*   Is given if the signals are gated through the operation "O"
*   e.g. 0001  O   E  1
*        0002  O   E  1
*        0003  =   A  1
* Indirect OR gating:
*   Is given if the signals to various locations activate a signal
*   e.g. 0001  R   A  1
*        0002  RN  A  1
*
*        0003  U   E  1
*        0004  S   A  1
*
*        0005  U   E  2
*        0006  S   A  1

* ***********************************************************
* Start conditions of the PLC program

* Conclusion of the gating result
  0  =    M 0      * End of the logical chain !!

* Open position control loop of the spindle axis with the first PLC cycle and set enable markers
  1  O    M 2180   * 1st PLC run-through after power on
  2  O    M 2185   * 1st PLC run-through after interruption of PLC-standard program
  3  S    M 2499   * Inhibit control loop spindle axis

* Enable decoded M-functions
  4  S    M 2496   * Enable marker decoded M-code output M1900-1999
  5  SN   M 2496   * Enable marker decoded M-code output M1900-1999


* ***********************************************************
* Decode operating modes
  6  O    M 2050   * Operating mode: programming and editing
  7  O    M 2051   * Operating mode: manual operation
  8  O    M 2052   * Operating mode: electronic handwheel
  9  O    M 2057   * Traversing the reference point
 10  =    M 908    * Manual operating mode

 11  O    M 2053   * Single block positioning via manual data input (MDI)
 12  O    M 2054   * Single block program run
 13  O    M 2055   * Automatic program run
 14  =    M 909    * Controlling operating mode

* ***********************************************************
* CNC Stop keys invert depending on MP 158

 15  XO   E 130    * Spindle and feed stop
 16  XON  M 2207   * Set via MP 158 significance 32768
 17  =    M 902    * Spindle and feed (inverted if MP 158 > 32768)

 18  XO   E 131    * STOP key
 19  XON  M 2207   * Set via MP 158 significance 32768
 20  =    M 903    * CNC stop key (inverted if MP 158 > 32768)
```

Statement list

```
* ***********************************************************************
* Enable axes
  21  U   M 2000  * Enable X-axis
  22  =   A 0     * Enable X-axis

  23  U   M 2001  * Enable Y-axis
  24  =   A 1     * Enable Y-axis

  25  U   M 2002  * Enable Z-axis
  26  =   A 2     * Enable Z-axis

  27  U   M 2003  * Enable 4th axis
  28  =   A 3     * Enable 4th axis

  29  U   M 2016  * Enable 5th axis
  30  =   A 4     * Enable 5th axis

* ***********************************************************************
* Reference positions are not present in standard PLC
* 00  U   E 4
* 00  =   M 2556

* 00  U   E 5
* 00  =   M 2557

* 00  U   E 6
* 00  =   M 2558

* 00  U   E 7
* 00  =   M 2559

* 00  U   E 8
* 00  =   M 2506

* ***********************************************************************
* Manual travel of tool axes through the machine operator
* e.g. with hand crank

  31  U   E 144   * Input for opening the position control loop
  32  =   M 917   * Buffered marker manual activation
  33  =   M 919   * Manual activation

* Input E 144 debouncing
  34  U   E 144   * Input for opening the position control loops
  35  =   M 917   * Buffered marker manual activation

* Activate control loop inhibit
  36  U   M 919   * Manual activation
  37 =    M 2492  * Activation control loop inhibit for the X-axis
  38  =   M 2493  * Activation control loop inhibit for the Y-axis
  39  =   M 2494  * Activation control loop inhibit for the Z-axis
  40  =   M 2495  * Activation control loop inhibit for the 4th axis
  41  =   M 2500  * Activation control loop inhibit for the 5th axis
```

Statement list

```
* **************************************************************
* Inhibit the control loops for the X/Y/Z/4th/5th axis if it is in position and manual activation is active.
  42  U    M 919    * Manual activation
  43  U    M 2008   * The X-axis is in position
  44  =    M 930    * Manual and X-axis in position
  45  S    M 931    * Transfer actual position value to nominal value X-axis

  46  U    M 919    * Manual activation
  47  U    M 2009   * The X-axis is in position
  48  =    M 932    * Manual and Y-axis in position
  49  S    M 933    * Transfer actual position value to nominal value Y-axis

  50  U    M 919    * Manual activation
  51  U    M 2010   * The Z-axis is in position
  52  =    M 934    * Manual and Z-axis in position
  53  S    M 935    * Transfer actual position value to nominal value Z-axis

  54  U    M 919    * Manual activation
  55  U    M 2011   * The 4th axis is in position
  56  =    M 936    * Manual and 4th axis in position
  57  S    M 937    * Transfer actual position value to nominal value 4th axis

  58  U    M 919    * Manual activation
  59  U    M 2017   * The 5th axis is in position
  60  =    M 938    * Manual and 5th axis in position
  61  S    M 939    * Transfer actual position value to nominal value 5th axis

* **************************************************************
* Activated feed enable after closing of position control loop

* Erase timer 15 for an indirect OR gating
  62  R    T 15     * Triggering of timer 15 MP 125 in 20 ms units
  63  RN   T 15     * Triggering of timer 15 MP 125 in 20 ms units

* **************************************************************
* Teach-in into nominal value if marker 2206 = 1
* activated through MP 158
  64  UN   M 930    * Manual and X-axis in position
  65  U    M 931    * Transfer actual position value to nominal value X-axis
  66  U    M 2206   * Is set via MP 158 significance 16384
  67  =    M 2552   * Teach-in in control loop X-axis
  68  S    T 15     * Triggering of timer 15 MP 125 in 20 ms units
  69  R    M 931    * Transfer actual position value to nominal value X-axis

  70  UN   M 932    * Manual and Y-axis in position
  71  U    M 933    * Transfer actual position value to nominal value Y-axis
  72  U    M 2206   * Is set via MP 158 significance 16384
  73  =    M 2553   * Teach-in in control loop Y-axis
  74  S    T 15     * Triggering of timer 15 MP 125 in 20 ms units
  75  R    M 933    * Transfer actual position value to nominal value Y-axis
```

Statement list

```
 76  UN  M 934   * Manual and Z-axis in position
 77  U   M 935   * Transfer actual position value to nominal value Z-axis
 78  U   M 2206  * Is set via MP 158 significance 16384
 79  =   M 2554  * Teach-in in control loop Z-axis
 80  S   T 15    * Triggering of timer 15 MP 125 in 20 ms units
 81  R   M 935   * Transfer actual position value to nominal value Z-axis

 82  UN  M 936   * Manual and 4th axis in position
 83  U   M 937   * Transfer actual position value to nominal value 4th axis
 84  U   M 2206  * Is set via MP 158 significance 16384
 85  =   M 2555  * Teach-in in control loop 4th axis
 86  S   T 15    * Triggering of timer 15 MP 125 in 20 ms units
 87  R   M 937   * Transfer actual position value to nominal value 4th axis

 88  UN  M 938   * Manual and 5th axis in position
 89  U   M 939   * Transfer actual position value to nominal value 5th axis
 90  U   M 2206  * Is set via MP 158 significance 16384
 91  =   M 2505  * Teach-in in control loop 5th axis
 92  S   T 15    * Triggering of timer 15 MP 125 in 20 ms units
 93  R   M 939   * Transfer actual position value to nominal 5th axis

* ***********************************************************
* Address markers for the opening of the control loop
 94  O   T 15    * Triggering of timer 15 MP 125 in 20 ms units
 95  O   T 63    * Timer 15 is running (delay feed enable)
 96  =   M 940   * Delay time

 97  U   M 930   * Manual and X-axis in position
 98  UN  M 2552  * Actual value transfer in control loop X-axis
 99  S   M 2544  * Inhibit control loop X-axis

100  U   M 930   * Manual and X-axis in position
101  UN  M 2552  * Actual value transfer in control loop X-axis
102  O   M 940   * Delay time
103  RN  M 2544  * Inhibit control loop X-axis

104  U   M 932   * Manual and Y-axis in position
105  UN  M 2553  * Actual value transfer in control loop Y-axis
106  S   M 2545  * Inhibit control loop Y-axis

107  U   M 932   * Manual and Y-axis in position
108  UN  M 2553  * Actual value transfer in control loop Y-axis
109  O   M 940   * Delay time
110  RN  M 2545  * Inhibit control loop Y-axis

111  U   M 934   * Manual and Z-axis in position
118  UN  M 2554  * Actual value transfer in control loop Z-axis
113  S   M 2546  * Inhibit control loop Z-axis

114  U   M 934   * Manual and Z-axis in position
115  UN  M 2554  * Actual value transfer in control loop Z-axis
116  O   M 940   * Delay time
117  RN  M 2546  * Inhibit control loop Z-axis
```

Statement list

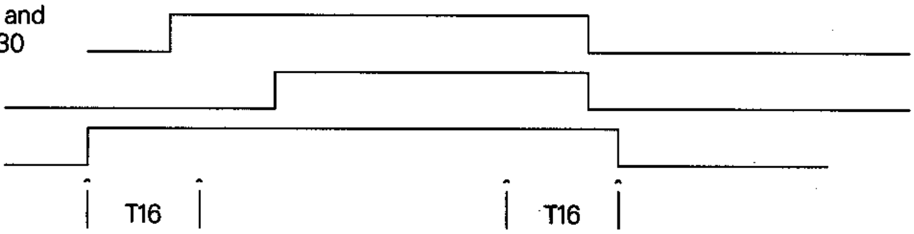
```
118  U    M 936    * Manual and 4th axis in position
119  UN   M 2555   * Actual value transfer in control loop 4th axis
120  S    M 2547   * Inhibit control loop 4th axis

121  U    M 936    * Manual and 4th axis in position
122  UN   M 2555   * Actual value transfer in control loop 4th axis
123  O    M 940    * Delay time
124  RN   M 2547   * Inhibit control loop 4th axis

125  U    M 938    * Manual and 5th axis in position
126  UN   M 2507   * Actual value transfer in control loop 5th axis
127  S    M 2505   * Inhibit control loop 5th axis

128  U    M 938    * Manual and 5th axis in position
129  UN   M 2507   * Actual value transfer in control loop 5th axis
130  O    M 940    * Delay time
131  RN   M 2505   * Inhibit control loop 5th axis

* ***********************************************************
* Spindle stop and feed stop
*
* Spindle stop and
* feed stop E130
*
* Spindle stop
*
* Feed stop
*
* Delay time
```




```
* Clear timer 16 for an indirect OR gate
132  R    T 16     * Triggering of timer 16 MP 193 in 20 ms units
133  RN   T 16     * Triggering of timer 16 MP 193 in 20 ms units

* Interrupt spindle and feed
134  U    M 902    * Spindle and feed stop (inverted is MP 158 > 32768)
135  UN   M 914    * Spindle stop and feed stop
136  S    M 914    * Spindle stop and feed stop
137  S    M 916    * Feed stop via input E 130 on keyboard
138  S    T 16     * Triggering of timer 16 MP 193 in 20 ms units

* Re-enable spindle and feed
139  U    E 132    * Start key
140  U    M 914    * Spindle stop and feed stop
141  R    M 914    * Spindle stop and feed stop
142  S    T 16     * Triggering of timer 16 MP 193 in 20 ms units

* Stop spindle with delay
143  U    M 914    * Spindle stop and feed stop
144  UN   T 16     * Triggering of timer 16 MP 193 in 20 ms units
145  UN   T 64     * Timer 16 running (delay time spindle feed stop)
146  =    M 915    * Spindle stop via input E 130 on keyboard

* Enable feed after cancelation S stop and F stop
147  U    M 916    * Feed stop via input E 130 on keyboard
148  UN   M 914    * Spindle stop and feed stop
149  UN   T 16     * Triggering of timer 16 MP 193 in 20 ms units
150  UN   T 64     * Timer 16 running (delay time spindle feed stop)
151  R    M 916    * Spindle stop via input E 130 on keyboard
```

Statement list

```
* Operation spindle stop and feed stop reset after CNC program interrupt
  152  U    M 914   * Spindle stop and feed stop
  153  UN   M 2184  * Control in operation (permanent operation pilot)
  154  R    M 914   * Spindle stop and feed stop
  155  R    M 915   * Spindle stop through the input E 130 of the keyboard
  156  R    M 916   * Feed stop through the input E 130 of the keyboard
  157  =    M 918   * Clear stored spindle marker after CNC program interrupt

* ***********************************************************

* Feed enable for tool axes
  158  R    M 2451  * Feed enable
  159  RN   M 2451  * Feed enable
  160  S    M 2467  * Complemented feed enable
  161  SN   M 2467  * Complemented feed enable

  162  UN   T 15    * Triggering of timer 15 MP 125 in 20 ms units
  163  UN   T 63    * Timer 15 running (delay feed enable)
  164  UN   M 916   * Feed stop via input E 130 of keyboard
  165  U    E 5     * Feed enable for the tool axes
  166  S    M 2451  * Feed enable
  167  R    M 2467  * Complemented feed enable

* ***********************************************************

* Clearing the key markers
  168  O    M 0     * End of logical chain !!
  169  ON   M 0     * End of logical chain !!
  170  R    M 2448  * NC start
  171  R    M 2449  * NC rapid traverse
  172  R    M 2450  * Store function for manual traverse
  173  R    M 2456  * Manual traverse X+
  174  R    M 2457  * Manual traverse X–
  175  R    M 2458  * Manual traverse Y+
  176  R    M 2459  * Manual traverse Y–
  177  R    M 2460  * Manual traverse Z+
  178  R    M 2461  * Manual traverse Z–
  179  R    M 2462  * Manual traverse 4th axis +
  180  R    M 2463  * Manual traverse 4th axis –
  181  R    M 2524  * Manual traverse 5th axis +
  182  R    M 2525  * Manual traverse 5th axis –
```

Statement list

```
183  S    M 2464  * Complemented NC start
184  S    M 2465  * Complemented NC rapid traverse
185  S    M 2466  * Complemented memory function for manual traverse
186  S    M 2472  * Complemented manual traverse X+
187  S    M 2473  * Complemented manual traverse X–
188  S    M 2474  * Complemented manual traverse Y+
189  S    M 2475  * Complemented manual traverse Y–
190  S    M 2476  * Complemented manual traverse Z+
191  S    M 2477  * Complemented manual traverse Z–
192  S    M 2478  * Complemented manual traverse 4th axis +
193  S    M 2479  * Complemented manual traverse 4th axis –
194  S    M 2540  * Complemented manual traverse 5th axis +
195  S    M 2541  * Complemented manual traverse 5th axis –

* CNC stop not make-contact ??!!
196  UN   M 902   * Spindle and feed stop (inverted if MP 158 > 32768)
197  UN   M 903   * CNC stop key (inverted if MP 158 > 32768)
198  =    M 2488  * NC stop low active 0 = stop; 1 = not stop

199  U    E 132   * Start key
200  U    M 920   * Buffered marker start key
201  S    M 2448  * NC start
202  R    M 2464  * Complemented NC start

* Debouncing the start key
203  U    E 132   * Start key
204  =    M 920   * Buffer marker start key

205  U    E 141   * Rapid traverse key
206  U    M 921   * Buffer marker RAPID TRAVERSE key
207  S    M 2449  * NC rapid traverse
208  R    M 2465  * Complemented NC rapid traverse

* Debouncing the rapid traverse key
209  U    E 141   * Rapid traverse key
210  =    M 921   * Buffer marker RAPID TRAVERSE key

* Manual traverse store via start key
211  U    M 908   * Manual operating mode
212  U    M 132   * Start key
213  S    M 2450  * Store function for manual traverse
214  R    M 2466  * Complemented memory function for manual traverse

* ***************************************************************
 Axis direction button X+
215  U    M 908   * Manual operating mode
216  U    M 138   * Direction button X+
217  UN   E 133   * Direction button X–
218  S    M 2456  * Manual traverse X+
219  R    M 2472  * Complemented manual traverse X+

* Axis direction button X–
220  U    M 908   * Manual operating mode
221  U    E 133   * Direction button X–
222  UN   E 138   * Direction button X+
223  S    M 2457  * Manual traverse X–
224  R    M 2473  * Complemented manual traverse X–
```

Statement list

```
* Axis direction button Y+
  225  U    M 908   * Manual operating mode
  226  U    E 137   * Direction button Y+
  227  UN   E 134   * Direction button Y–
  228  S    M 2458  * Manual traverse Y+
  229  R    M 2474  * Complemented manual traverse Y+

* Axis direction button Y–
  230  U    M 908   * Manual operating mode
  231  U    E 134   * Direction button Y–
  232  UN   E 137   * Direction button Y+
  233  S    M 2459  * Manual traverse Y–
  234  R    M 2475  * Complemented manual traverse Y–

* Axis direction button Z+
  235  U    M 908   * Manual operating mode
  236  U    E 136   * Direction button Z+
  237  UN   E 135   * Direction button Z–
  238  S    M 2460  * Manual traverse Z+
  239  R    M 2476  * Complemented manual traverse Z+

* Axis direction button Z–
  240  U    M 908   * Manual operating mode
  241  U    E 135   * Direction button Z–
  242  UN   E 136   * Direction button Z+
  243  S    M 2461  * Manual traverse Z–
  244  R    M 2477  * Complemented manual traverse Z–

* Axis direction button 4th axis +
  245  U    M 908   * Manual operating mode
  246  U    E 139   * Direction button 4th axis +
  247  UN   E 140   * Direction button 4th axis –
  248  S    M 2462  * Manual traverse 4th axis +
  249  R    M 2478  * Complemented manual traverse 4th axis +

* Axis direction button 4th axis –
  250  U    M 908   * Manual operating mode
  251  U    E 140   * Direction button 4th axis –
  252  UN   E 139   * Direction button 4th axis +
  253  S    M 2463  * Manual traverse 4th axis –
  254  R    M 2479  * Complemented manual traverse 4th axis –

* Axis direction button 5th axis +
  255  U    M 908   * Manual operating mode
  256  U    E 146   * Direction button 5th axis +
  257  UN   E 147   * Direction button 5th axis –
  258  S    M 2524  * Manual traverse 5th axis +
  259  R    M 2540  * Complemented manual traverse 5th axis +

* Axis direction button 5th axis –
  260  U    M 908   * Manual operating mode
  261  U    E 147   * Direction button 5th axis –
  262  UN   E 146   * Direction button 5th axis +
  263  S    M 2525  * Manual traverse 5th axis –
  264  R    M 2541  * Complemented manual traverse 5th axis –
```

Statement list

```
* ***********************************************************************
* Coolant address of output for the coolant is set or reset in memory

* Coolant ON
  265  O    M 1908  * Decoded M function M08
  266  O    M 1913  * Decoded M function M13
  267  O    M 1914  * Decoded M function M14
  268  U    M 2045  * Change signal M code
  269  S    M 910   * Buffer marker for coolant on/off

* Coolant OFF
  270  O    M 1909  * Decoded M function M09
  271  O    M 1900  * Decoded M function M00
  272  O    M 1902  * Decoded M function M02
  273  O    M 1930  * Decoded M function M30
  274  U    M 2045  * Change signal M code
  275  O    M 2191  * Error message "EMERGENCY OFF" is displayed
  276  R    M 910   * Buffered marker for coolant on/off

* Coolant ON/OFF input was not activated
  277  UN   E 129   * Coolant ON/OFF
  278  S    M 911   * Input E 129 was or is not activated

* Switch off coolant if it was ON
  279  U    M 910   * Buffered marker for coolant ON/OFF
  280  U    M 911   * Input E 129 was or is not activated
  281  U    E 129   * Coolant ON/OFF
  282  R    M 910   * Buffered marker for coolant ON/OFF
  283  R    M 911   * Input E 129 was or is not activated

* Switch on coolant if it was OFF
  284  UN   M 910   * Buffered  marker for coolant ON/OFF
  285  U    M 911   * Input E 129 was or is not activated
  286  U    E 129   * Coolant ON/OFF
  287  S    M 910   * Buffered marker for coolant ON/OFF
  288  R    M 911   * Input E 129 was or is not activated

  289  U    M 910   * Buffered marker for coolant ON/OFF
  290  =    A 18    * M08 Coolant ON/OFF

* ***********************************************************************
* Spindle address
* The spindle can be started from the control panel via the spindle right of spindle left; this is only possible in the
* manual operating mode.
* A spindle start is conducted through the output of M03/04/13/14

* Manual start of spindle
  291  U    M 908   * Manual operating mode
  292  U    E 142   * Spindle ON clockwise with manual operating mode
  293  UN   M 913   * Spindle counterclockwise with manual operating mode
  294  =    M 912   * Spindle clockwise with manual operating mode

  295  U    M 908   * Manual operating mode
  296  U    E 143   * Spindle ON counterclockwise with manual operating mode
  297  UN   M 912   * Spindle clockwise with manual operating mode
  298  =    M 913   * Spindle counterclockwise with manual operating mode
```

Statement list

```
* Spindle Start operation clockwise run
  299  O    M 1903  * Decoded M function M03
  300  O    M 1913  * Decoded M function M13
  301  U    M 951   * 2nd Buffered marker change signal M
  302  O    M 912   * Spindle clockwise with manual operating mode
  303  S    M 922   * Buffered marker output M03
  304  R    M 923   * Buffered marker output M04
  305  R    M 924   * Buffered marker output M05

* Spindle start operation counterclockwise run
  306  O    M 1904  * Decoded M function M04
  307  O    M 1914  * Decoded M function M14
  308  U    M 951   * 2nd Buffered marker change signal M
  309  O    M 913   * Spindle counterclockwise with manual operating mode
  310  R    M 922   * Buffered marker output M03
  311  S    M 923   * Buffered marker output M04
  312  R    M 924   * Buffered marker output M05

* Spindle Stop operation
  313  O    M 1900  * Decoded M function M00
  314  O    M 1902  * Decoded M function M02
  315  O    M 1904  * Decoded M function M05
  316  O    M 1906  * Decoded M function M06
  317  O    M 1930  * Decoded M function M30
  318  U    M 2045  * Change signal M code
  319  O    M 918   * Clear stored spindle marker after CNC program interruption
  320  R    M 922   * Buffered marker output M03
  321  R    M 923   * Buffered marker output M04
  322  S    M 924   * Buffered marker output M05

* ****************************************************************
* Spindle stop with emergency off or output M19
* Output of the decoded M03/4/5 functions
* and the enable for the spindle
* Spindle marker reset during spindle orientation with M19
* Spindle marker reset during emergency off
  323  U    M 1919  * Decoded M function M19
  324  U    M 2044  * Change code M code
  325  U    M 2204  * Is set through MP 158 significance 4096
  326  O    M 2991  * Error message "EMERGENCY STOP" appears
  327  R    M 922   * Buffered marker output M03
  328  R    M 923   * Buffered marker output M04
  329  S    M 924   * Buffered marker output M05

* Output spindle on with M03/M13 and statue display M03
* With S analogue output of voltage
  330  U    M 922   * Buffered marker M03
  331  UN   M 915   * Spindle stop through the input E 130 of the keyboard
  332  UN   M 2043  * Change signal gear range code for S-analogue
  333  =    M 2485  * Status display and algebraic sign of analogue output M03
  334  =    A 16    * M03 spindle clockwise

* Output spindle ON with M04/M14 and status display M04
* With S analogue output of voltage
  335  U    M 923   * Buffered marker M04
  336  UN   M 915   * Spindle stop through the input E 130 of the keyboard
  337  UN   M 2043  * Change signal gear range code for S-analogue
  338  =    M 2486  * Status display and algebraic sign of analogue output M04
  339  =    A 17    * M04 spindle clockwise
```

Statement list

```
* Status display M05
* With S-analogue output of zero voltage
  340  O   M 924   * Buffered marker output M05
  341  O   M 915   * Spindle stop through the input E 130 of the keyboard
  342  O   M 2043  * Change signal gear range code for S-analogue
  343  =   M 2487  * Status display and algebraic sign of analogue output M05

* Enabling the cutter spindle
  344  O   M 922   * Buffered marker output M03
  345  O   M 923   * Buffered marker output M04
  346  ON  M 2499  * Inhibit control loop spindle axis
  347  UN  M 915   * Spindle stop through the input E 130 of the keyboard
  348  ON  M 2005  * 1 = S-analogue is equal zero volt
  349  =   A 15    * Mill motor ON main spindle active

* ***********************************************************

* Strobe signal formation for the M-code
* Acknowledgement of M-code

* Positive flank from the M-strobe
  350  U   M 2045  * Change signal M-code
  351  UN  M 926   * 1st buffered marker change signal M
  352  =   M 951   * 2nd buffered marker change signal M

  353  U   M 2045  * Change signal M-code
  354  =   M 926   * 1st buffered marker change signal M

* Start timer for the strobe signal formation
  355  U   M 951   * 2nd buffered marker change signal M
  356  UN  T 58    * Timer 10 running
  357  UN  T 59    * Timer 11 running
  358  UN  T 60    * Timer 12 running
  359  =   T 10    * Triggering of timer 10 MP 120 in 20 ms units
  360  =   T 11    * Triggering of timer 11 MP 121 in 20 ms units
  361  =   T 12    * Triggering of timer 12 MP 122 in 20 ms units

* M-Acknowledgement reset if no M-output
  362  UN  M 2045  * Change signal M-code
  363  R   M 2482  * Acknowledgement M-code

* Timer reset for the strobe formation if no M-output
  364  R   T 58    * Timer 10 running
  365  R   T 59    * Timer 11 running
  366  R   T 60    * Timer 12 running

* Output of M-strobe
  367  O   M 1903  * Decoded M-function M03
  368  O   M 1904  * Decoded M-function M04
  369  O   M 1905  * Decoded M-function M05
  377  O   M 1913  * Decoded M-function M13
  371  O   M 1914  * Decoded M-function M14
  372  U   M 2045  * Change signal M-code
  373  =   M 907   * Decoded M-functions M03/04/05/13/14

  374  U   M 907   * Decoded M-functions M03/04/05/13/14
  375  UN  T 58    * Timer 10 running
  376  U   T 59    * Timer 11 running
  377  =   A 21    * M-strobe
```

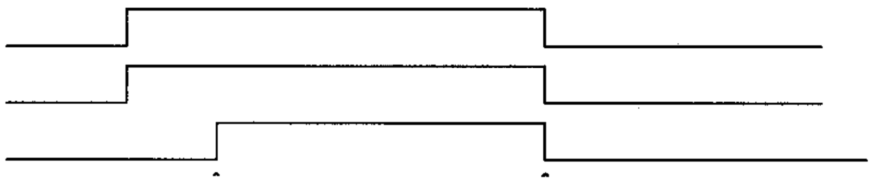
Statement list

```
* Acknowledgement of the above mentioned M functions M03/04/05/13/14
  378  U    M 907   * Decoded M-functions M03/04/05/13/14
  379  UN   T 12    * Triggering of timer 12 MP 122 in 20 ms units
  380  UN   T 60    * Timer 12 running
  381  U    E 145   * Acknowledgement of auxiliary function (M-function)
  382  S    M 2482  * Acknowledgement M-code

* Acknowledgement of M function M00/02/08/09/30
  383  UN   M 1906  * Decoded M-function M06
  384  UN   M 907   * Decoded M-function M03/04/05/13/14
  385  U    M 2045  * Change signal M-code
  386  UN   T 12    * Triggering of timer 12 MP 122 in 20 ms units
  387  UN   T 60    * Timer 12 running
  388  S    M 2482  * Acknowledgement M-code

* T1 code output must be suppressed with MP 61 (MP 61 = 0)
* T1 code = tool code with length and radius compensation for CNC program
* T2 code output must be suppressed with MP 157 (MP 157 = 0)
* T2 code readying of tool in tool magazine
* S-code output must be suppressed with MP 62 (MP 62 = 0)
* S-code = slew speed selection via gear stages
* G-code output must be suppressed with MP 78 to 85
* (MP 67 bis 85 = 0)
* G-code = gear stage for analogue spindle of the main spindle drive

* ************************************************************
* Manual tool change with output of M06
*
* Output M06
*
* Output A19
*
* Output A6
```



```
*                      Release tool 1st time     Release tool 2nd time
*                      E128                      E128
*
* Tool holder release key was not pressed
  389  UN   E 128   * Open tool holder
  390  S    M 906   * Tool release key was NOT pressed with M06 output

* Output of the M function M06
  391  U    M 1906  * Decoded M function M06

  392  U    M 2045  * Change signal M code
  393  =    A 19    * M06 manual tool change

  394  SN   T 18    * Triggering of timer 18 MP 195 in 20 ms units
  395  R    T 18    * Triggering of timer 18 MP 195 in 20 ms units
  396  RN   M 906   * Tool release key was NOT pressed with M06 output

* Activate output tool release
  397  U    E 128   * Open tool holder
  398  U    M 906   * Tool release key was NOT pressed with M06 output
  399  UN   M 905   * Tool is released in the spindle
  400  UN   T 66    * Timer 18 running (delay for opening the tool holder)
  401  S    A 6     * Release tool holder
  402  =    T 17    * Triggering of timer 17 MP 194 in 20 ms units
  403  R    M 906   * Tool release key was NOT pressed with M06 output
  404  S    M 905   * Tool is released in the spindle
```

Statement list

```
* Deactivate output tool release
  405  U    E 128    * Open tool holder
  406  U    M 906    * Tool release key was NOT pressed with M06 output
  407  U    M 905    * Tool is released in the spindle
  408  UN   T 65     * Timer 17 running (delay for acknowledgement of M06)
  409  R    A 6      * Release tool holder
  410  R    M 906    * Tool release key was NOT pressed with M06 output
  411  R    M 905    * Tool is released in the spindle
  412  S    M 904    * Acknowledgement of the M function M06

* Acknowledgement of the M function M06
  413  U    M 904    * Acknowledgement of the M function M06
  414  S    M 2482   * Acknowledgement M code
  415  R    M 904    * Acknowledgement of the M function M06

* ****************************************************************
* Spindle jog when gear changing with S analogue
  416  U    M 2043   * Change signal gear code for S analogue
  417  UN   M 968    * Buffered marker T13 running
  418  UN   T 13     * Triggering of timer 13 MP 123 in 20 ms units
  419  UN   T 14     * Triggering of timer 14 MP 124 in 20 ms units
  420  UN   T 61     * Timer 13 running (jog duration counterclockwise)
  421  UN   T 62     * Timer 14 running (jog duration clockwise)
  422  =    T 13     * Triggering of timer 14 MP 124 in 20 ms units
  423  S    M 968    * Timer 13 running

  424  U    M 2043   * Change signal gear code for S analogue
  425  U    M 968    * Buffered marker T13 running
  426 UN    T 13     * Triggering of timer 13 MP 123 in 20 ms units
  427  UN   T 14     * Triggering of timer 14 MP 124 in 20 ms units
  428  UN   T 61     * Timer 13 running (jog duration counterclockwise)
  429  UN   T 62     * Timer 14 running (jog duration clockwise)
  430  =    T 14     * Triggering of timer 14 MP 124 in 20 ms units
  431  R    M 968    * Timer 13 running

  432  UN   M 2043   * Change signal gear code for S analogue
  433  R    T 61     * Timer 13 running (jog duration counterclockwise)
  434  R    T 62     * Timer 14 running (jog duration clockwise)

  435  U    T 61     * Timer 13 running (jog duration counterclockwise)
  436  =    M 2490   * Spindle counterclockwise for gear change with G-code – now always

  437  U    T 62     * Timer 14 running (jog duration counterclockwise)
  438  =    M 2491   * Spindle clockwise for gear change with G-code – now always

* ****************************************************************
* Spindle positioning with the M-function M19
  439  U    M 1919   * Decoded M function M19
  440  U    M 2045   * Change signal M code
  441  UN   M 970    * Buffered marker for M19
  442  U    M 2204   * Set through MP 159 significance 4096
  443  =    M 971    * Positive edge of M19

  444  U    M 1919   * Decoded M function M19
  445  U    M 2045   * Change signal M code
  446  =    M 970    * Buffered marker for M19
```

Statement list

```
* PLC position spindle axis => orient cycle
 447  U   M 971   * Positive edge of M19
 448  UN  M 2205  * Set via MP 158 significance 8192
 449  S   M 2580  * PLC positioning 5/spindle axis lsb

* PLC position spindle axis => MP 156
 450  U   M 971   * Positive edge of M19
 451  U   M 2205  * Is set through MP 158 significance 8192
 452  R   M 2580  * PLC positioning 5/spindle axis lsb

* Start PLC positioning of spindle axis
 453  U   M 971   * Positive edge of M19
 454  R   M 2499  * Inhibit control loop spindle axis
 455  S   M 2581  * PLC positioning 5/spindle axis
 456  S   M 2582  * PLC positioning 5/spindle axis
 457  S   M 2583  * PLC positioning 5/spindle axis
 458  S   M 2584  * PLC positioning 5/spindle axis
 459  S   M 2527  * Start PLC positioning spindle axis (only with G/M/S/T code)
 460  R   M 2543  * Complement start PLC positioning spindle axis

* ************************************************************
* Open position control loop of spindle axis
 461  O   M 1900  * Decoded M-function M00
 462  O   M 1902  * Decoded M-function M02
 463  O   M 1903  * Decoded M-function M03
 464  O   M 1904  * Decoded M-function M04
 465  O   M 1905  * Decoded M-function M05
 466  O   M 1913  * Decoded M-function M13
 467  O   M 1914  * Decoded M-function M14
 468  O   M 1930  * Decoded M-function M30
 469  U   M 2045  * Change signal M code
 470  S   M 2499  * Inhibit control loop spindle axis

* Interrupt the PLC positioning spindle axis
 471  UN  M 2045  * Change signal M code
 472  R   M 2527  * Start PLC positioning spindle axis (only with G/M/S/T code)
 473  S   M 2543  * Acknowledgement M code

* Acknowledgement M19 as PLC positioning spindle axis
 474  U   M 1919  * Decoded M function M19
 475  U   M 2045  * Change signal M code
 476  U   M 2204  * Is set through MP 158 significance 4096
 477  UN  M 2527  * Start PLC positioning spindle axis (only with G/M/S/T code)
 478  S   M 2482  * Acknowledgement M code

* ************************************************************
* Error message from the PLC program

* Gear code is active MP 62 = 5 ?!
 479  U   M 2043  * Change signal gear code for S analogue
 480  =   M 2924  * Error message 0

* Spindle code is active MP 62 = 0 ?!
 481  U   M 2044  * Change signal S code
 482  =   M 2925  * Error message 1
```

Statement list

```
* Unused M function is active programming error
  483  O    M 1900   * Decoded M function M00
  484  O    M 1902   * Decoded M function M02
  485  O    M 1903   * Decoded M function M03
  486  O    M 1904   * Decoded M function M04
  487  O    M 1905   * Decoded M function M05
  488  O    M 1906   * Decoded M function M06
  489  O    M 1908   * Decoded M function M08
  490  O    M 1909   * Decoded M function M09
  491  O    M 1913   * Decoded M function M13
  492  O    M 1914   * Decoded M function M14
  493  O    M 1919   * Decoded M function M19
  494  O    M 1930   * Decoded M function M30
  495  =    M 901    * M functions used

  496  UN   M 901    * M functions used
  497  U    M 2045   * Change signal M code
  498  =    M 2926   * Error message 2

* T1-Code output active MP 61 = 0 ?!
  499  U    M 2046   * Change signal tool code T code
  500  =    M 2927   * Error message 3

* T-2-Code output active MP 157 = 0 ?!
  501  U    M 2047   * Change signal 2nd tool code 2nd T code
  502  =    M 2928   * Error message 4

* ************************************************************
* PLC Program End
```

Functions of markers, inputs, outputs and timers
Function of markers

M 0	End of the logical chain !!
M 901	M functions used
M 902	Spindle stop and feed stop (inverted if MP 158 > 32768)
M 903	CNC stop key (inverted if MP 158 > 32768)
M 904	Acknowledgement of the M function M06
M 905	Tool has been loosened in the spindle
M 906	Tool release key was NOT pressed with output M06
M 907	Decoded M function M03/04/05/13/14
M 908	Manual operating mode
M 909	Controlling operating mode
M 910	Buffered marker for coolant ON/OFF
M 911	Input E 129 was or is not activated
M 912	Spindle clockwise with manual operating mode
M 913	Spindle counterclockwise with manual operating mode
M 914	Spindle stop and feed stop
M 915	Spindle stop through the input E 130 of the keyboard
M 916	Feed stop through the input E 130 of the keyboard
M 917	Buffered marker manual activation
M 918	Erase stored spindle marker after CNC program interrupt
M 919	Manual activation
M 920	Buffered marker start key
M 921	Buffered marker RAPID TRAVERSE key
M 922	Buffered marker output M03
M 923	Buffered marker output M04
M 924	Buffered marker output M05
M 926	1st buffered marker change signal M
M 930	Manual and X-axis in position
M 931	Transfer actual position value to the nominal value X-axis
M 932	Manual and Y-axis in position
M 933	Transfer actual position value to the nominal value Y-axis
M 934	Manual and Z-axis in position
M 935	Transfer actual position value to the nominal value Z-axis
M 936	Manual and 4th axis in position
M 937	Transfer actual position value to the nominal value 4th axis
M 938	Manual and 5th axis in position
M 939	Transfer actual position value to the nominal value 5th axis
M 940	Delay time
M 951	2nd buffered marker T13 running
M 968	Buffered marker T13 running
M 970	Buffered marker for M19
M 971	Buffered marker from M19
M 1900	Decoded M function M00
M 1902	Decoded M function M02
M 1903	Decoded M function M03
M 1904	Decoded M function M04
M 1905	Decoded M function M05
M 1906	Decoded M function M06
M 1908	Decoded M function M08
M 1909	Decoded M function M09
M 1913	Decoded M function M13
M 1914	Decoded M function M14
M 1919	Decoded M function M19
M 1930	Decoded M function M30
M 2000	X-axis enable
M 2001	Y-axis enable
M 2002	Z-axis enable
M 2003	4th axis enable
M 2005	1 = S-analogue is equal 0 volt

Function of markers, inputs, outputs and timers
Function of markers

M 2008 The X-axis is in position
M 2009 The Y-axis is in position
M 2010 The Z-axis is in position
M 2011 The 4th axis is in position
M 2016 Enable the 5th axis
M 2043 The 5th axis is in position
M 2044 Change signal S code
M 2045 Change signal M code
M 2046 Change signal tool code T Code
M 2047 Change signal tool code 2nd T Code
M 2050 Operating mode: programming and editing
M 2051 Operating mode: manual operation
M 2052 Operating mode: Electronic handwheel
M 2053 Operating mode: Positioning with manual data input
M 2054 Operating mode: Program run single block
M 2055 Operating mode: Program run automatic
M 2057 Traversing the reference mark
M 2180 1st PLC run-through after power-on
M 2184 Control in operation (permanent operation pilot)
M 2185 1st PLC run-through after interruption of the PLC program
M 2191 Error message "EMERGENCY OFF" is displayed
M 2204 Is set via MP 158 significance 4096
M 2205 Is set via MP 158 significance 8192
M 2206 Is set via MP 158 significance 16384
M 2207 Is set via MP 158 significance 32768
M 2448 NC start
M 2449 NC rapid traverse
M 2450 Store function for manual traverse
M 2451 Feed enable
M 2456 Manual traverse X+
M 2457 Manual traverse X–
M 2458 Manual traverse Y+
M 2459 Manual traverse Y–
M 2460 Manual traverse Z+
M 2461 Manual traverse Z–
M 2462 Manual traverse 4+
M 2463 Manual traverse 4–
M 2464 Complement NC start
M 2465 Complement NC rapid traverse
M 2466 Complement store function for manual traverse
M 2467 Complement feed enable
M 2472 Complement manual traverse X+
M 2473 Complement manual traverse X–
M 2474 Complement manual traverse Y+
M 2475 Complement manual traverse Y–
M 2476 Complement manual traverse Z+
M 2477 Complement manual traverse Z–
M 2478 Complement manual traverse 4+
M 2479 Complement manual traverse 4–
M 2482 Acknowledgement M code
M 2485 Status display and algebraic sign of the analog output M03
M 2486 Status display and algebraic sign of the analog output M04
M 2487 Status display of the analog output M05
M 2488 NC stop low active 0 = stop 1 = no stop
M 2490 Spindle counterclockwise for gear change with G code – now always
M 2491 Spindle clockwise for gear change with G code – now always
M 2492 Activate control loop inhibit for the X axis
M 2493 Activate control loop inhibit for the Y axis
M 2494 Activate control loop inhibit for the Z axis
M 2495 Activate control loop inhibit for the 4th axis

Functions of markers, inputs, outputs and timers
Function of markers

M 2496	Enable marker decoded M code output M1900–1999
M 2499	Inhibit control loop spindle axis
M 2500	Activate control loop inhibit for the 5th axis
M 2505	Actual position value transfer to control loop 5th axis
M 2507	Inhibit control loop 5th axis
M 2524	Manual traverse 5+
M 2525	Manual traverse 5–
M 2527	Start PLC positioning spindle axis (only with G/M/S/T code)
M 2540	Complement manual traverse 5+
M 2541	Complement manual traverse 5–
M 2543	Complement start
M 2544	Complement control loop X axis
M 2545	Complement control loop Y axis
M 2546	Complement control loop Z axis
M 2547	Complement control loop 4th axis
M 2552	Actual position value transfer to control loop X axis
M 2553	Actual position value transfer to control loop Y axis
M 2554	Actual position value transfer to control loop Z axis
M 2555	Actual position value transfer to control loop 4th axis
M 2580	PLC positioning 5/spindle axis lsb
M 2581	PLC positioning 5/spindle axis
M 2582	PLC positioning 5/spindle axis
M 2583	PLC positioning 5/spindle axis
M 2584	PLC positioning 5/spindle axis msb
M 2924	Error message 0
M 2925	Error message 1
M 2926	Error message 2
M 2927	Error message 3
M 2928	Error message 4

Functions of markers, inputs, outputs and timers
Function of inputs

E 5	Feed release for the tool axes
E 128	Open tool holder
E 129	Coolant ON/OFF
E 130	Spindle and feed stop
E 131	STOP key
E 132	Start key
E 133	Direction key X–
E 134	Direction key Y–
E 135	Direction key Z–
E 136	Direction key Z+
E 137	Direction key Y+
E 138	Direction key X+
E 139	Direction key 4+
E 140	Direction key 4–
E 141	Rapid traverse key
E 142	Spindle on clockwise with manual operating mode
E 143	Spindle on counterclockwise with manual operating mode
E 144	Input for opening the position control loop
E 145	Acknowledgement of the miscellaneous function (M function)
E 146	Direction key 5+
E 147	Direction key 5–

Functions of markers, inputs, outputs and timers
Function of outputs

A 0	Enable X axis
A 1	Enable Y axis
A 2	Enable Z axis
A 3	Enable 4th axis
A 4	Enable 5th axis
A 6	Release tool holder
A 15	Mill motor on main spindle active
A 16	M03 spindle clockwise
A 17	M04 spindle counterclockwise
A 18	M08 coolant ON/OFF
A 19	M06 manual tool change
A 21	M strobe

Functions of markers, inputs, outputs and timers
Function of timer

T 10	Triggering of timer 10 MP 120 in 20 ms units
T 11	Triggering of timer 11 MP 121 in 20 ms units
T 12	Triggering of timer 12 MP 122 in 20 ms units
T 13	Triggering of timer 13 MP 123 in 20 ms units
T 14	Triggering of timer 14 MP 124 in 20 ms units
T 15	Triggering of timer 15 MP 125 in 20 ms units
T 16	Triggering of timer 16 MP 193 in 20 ms units
T 17	Triggering of timer 17 MP 194 in 20 ms units
T 18	Triggering of timer 18 MP 195 in 20 ms units
T 58	Timer 10 running
T 59	Timer 11 running
T 60	Timer 12 running
T 61	Timer 13 running (jog duration counterclockwise)
T 62	Timer 14 running (jog duration clockwise)
T 63	Timer 15 running (delay feed enable)
T 64	Timer 16 running (delay spindle feed stop)
T 65	Timer 17 running (delay for the acknowledgement M06)
T 66	Timer 18 running (delay for the opening of the tool holder)

Cross reference lists

Cross reference list for markers

M 0	= - 0	O - 168	ON - 169					
M 901	= - 495	UN - 496						
M 902	= - 17	U - 134	UN - 196					
M 903	= - 20	UN - 197						
M 904	S - 412	U - 413	R - 415					
M 905	UN - 399	S - 404	U - 407	R - 411				
M 906	S - 390	RN - 396	U - 398	R - 403	U - 406	R - 410		
M 907	= - 373	U - 374	U - 378	UN - 384				
M 908	= - 10	U - 211	U - 215	U - 220	U - 225	U - 230	U - 235	U - 240
	U - 245	U - 250	U - 255	U - 260	U - 291	U - 295		
M 909	= - 14							
M 910	S - 269	R - 276	U - 279	R - 282	UN - 284	S - 287	U - 289	
M 911	S - 278	U - 280	R - 283	U - 285	R - 288			
M 912	= - 294	UN - 297	O - 302					
M 913	UN - 293	= - 298	O - 309					
M 914	UN - 135	S - 136	U - 140	R - 141	U - 143	UN - 148	U - 152	R - 154
M 915	= - 146	R - 155	UN - 331	UN - 336	O - 341	UN - 347		
M 916	S - 137	U - 147	R - 151	R - 156	UN - 164			
M 917	U - 32	= - 35						
M 918	= - 157	O - 319						
M 919	= - 33	U - 36	U - 42	U - 46	U - 50	U - 54	U - 58	
M 920	U - 200	= - 204						
M 921	U - 206	= - 210						
M 922	S - 303	R - 310	R - 320	R - 327	U - 330	O - 344		
M 923	R - 304	S - 311	R - 321	R - 328	U - 335	O - 345		
M 924	R - 305	S - 312	R - 322	R - 282	U - 340			
M 926	UN - 351	= - 354						
M 930	= - 44	UN - 64	U - 97	U - 100				
M 931	S - 45	U - 65	R - 69					
M 932	= - 48	UN - 70	U - 104	U - 107				
M 933	S - 49	U - 71	R - 75					
M 934	= - 52	UN - 76	U - 111	U - 114				
M 935	S - 53	U - 77	R - 81					
M 936	= - 56	UN - 82	U - 118	U - 121				
M 937	S - 57	U - 83	R - 87					
M 938	= - 60	UN - 88	U - 125	U - 112				
M 939	S - 61	U - 89	R - 93					
M 940	= - 96	O - 102	O - 109	O - 116	O - 123	O - 130		
M 951	U - 301	U - 308	= - 352	U - 355				
M 968	UN - 417	S - 423	U - 425	R - 431				
M 970	UN - 441	= - 446						
M 971	= - 443	U - 447	U - 450	U - 453				
M 1900	O - 272	O - 313	O - 461	O - 483				
M 1902	O - 299	O - 314	O - 462	O - 484				
M 1903	O - 271	O - 367	O - 463	O - 485				
M 1904	O - 306	O - 368	O - 464	O - 486				
M 1905	O - 315	O - 369	O - 465	O - 487				
M 1906	O - 316	UN - 383	U - 391	O - 488				
M 1908	O - 265	O - 489						
M 1909	O - 270	O - 490						
M 1913	O - 266	O - 300	O - 370	O - 466	O - 491			
M 1914	O - 267	O - 307	O - 371	O - 467	O - 492			
M 1915	U - 323	U - 439	U - 444	U - 474	O - 493			
M 1930	O - 273	O - 317	O - 468	O - 494				
M 2000	U - 21							
M 2001	U - 23							
M 2002	U - 25							
M 2003	U - 27							
M 2005	ON - 348							

Cross reference lists
Cross reference list for markers

M 2008	U - 43							
M 2009	U - 47							
M 2010	U - 51							
M 2011	U - 55							
M 2016	U - 29							
M 2017	U - 59							
M 2043	UN- 332	UN- 337	O - 342	U - 416	U - 424	U - 432	U - 479	
M 2044	U - 481							
M 2045	U - 268	U - 274	U - 318	U - 324	U - 350	U - 353	UN- 362	U - 372
	U - 385	U - 392	U - 440	U - 445	U - 469	U - 471	U - 475	U 497
M 2046	U - 499							
M 2047	U - 501							
M 2050	O - 6							
M 2051	O - 7							
M 2052	O - 8							
M 2053	O - 11							
M 2054	O - 12							
M 2055	O - 13							
M 2056	O - 9							
M 2180	O - 1							
M 2184	UN- 153							
M 2185	O - 2							
M 2191	O - 275	O - 326						
M 2204	U - 325	U - 442	U - 476					
M 2205	UN- 448	U - 451						
M 2206	U - 66	U - 72	U - 78	U - 84	U - 90			
M 2207	XON 16	XON 19						
M 2448	R - 170	S - 201						
M 2449	R - 171	S - 207						
M 2450	R - 172	S - 213						
M 2451	R - 158	RN- 159	S - 166					
M 2456	R - 173	S - 218						
M 2457	R - 174	S - 223						
M 2458	R - 175	S - 228						
M 2459	R - 176	S - 233						
M 2460	R - 177	S - 238						
M 2461	R - 178	S - 243						
M 2462	R - 179	S - 248						
M 2463	R - 180	S - 252						
M 2464	S - 183	R - 202						
M 2465	S - 184	R - 208						
M 2466	S - 185	R - 214						
M 2467	S - 160	SN- 161	R - 167					
M 2472	S - 186	R - 219						
M 2473	S - 187	R - 224						
M 2474	S - 188	R - 229						
M 2475	S - 189	R - 234						
M 2476	S - 190	R - 239						
M 2477	S - 191	R - 244						
M 2478	S - 192	R - 249						
M 2479	S - 193	R - 254						
M 2482	R - 363	S - 382	S - 388	S - 414	S - 478			
M 2485	= - 333							
M 2486	= - 338							
M 2487	= - 343							
M 2488	= - 198							
M 2490	= - 436							
M 2491	= - 438							
M 2492	= - 37							
M 2403	= - 38							
M 2494	= - 39							
M 2495	= - 40							

Cross reference lists

Cross reference list for markers

M 2496	S	- 4	SN- 5		
M 2499	S	- 3	ON- 346	R - 454	S - 470
M 2500	=	- 41			
M 2505	=	- 91	S - 127	RN- 131	
M 2507	UN	- 126	UN- 129		
M 2524	R	- 181	S - 258		
M 2525	R	- 182	S - 263		
M 2527	R	- 459	R - 472	UN- 477	
M 2540	S	- 194	R - 259		
M 2541	S	- 195	R - 264		
M 2543	R	- 460	S - 473		
M 2544	S	- 99	RN- 103		
M 2545	S	- 106	RN- 110		
M 2546	S	- 113	RN- 117		
M 2547	S	- 120	RN- 124		
M 2552	=	- 67	UN- 98	UN- 101	
M 2553	=	- 73	UN- 105	UN- 108	
M 2554	=	- 79	UN- 112	UN- 115	
M 2555	=	- 85	UN- 119	UN- 122	
M 2580	S	- 448	R - 452		
M 2581	S	- 455			
M 2582	S	- 456			
M 2583	S	- 457			
M 2584	S	- 458			
M 2924	=	- 480			
M 2925	=	- 482			
M 2926	=	- 498			
M 2927	=	- 500			
M 2928	=	- 502			

Cross reference lists
Cross reference list for inputs

```
E   5  U  - 165
E 128  UN - 389  U  - 397  U  - 405
E 129  UN - 277  U  - 281  U  - 286
E 130  XO -  15
E 131  XO -  18
E 132  U  - 139  U  - 199  U  - 203  U  - 212
E 133  UN - 217  U  - 221
E 134  UN - 227  U  - 231
E 135  UN - 237  U  - 241
E 136  U  - 236  UN - 242
E 137  U  - 226  UN - 232
E 138  U  - 216  UN - 222
E 139  U  - 246  UN - 252
E 140  UN - 247  U  - 251
E 141  U  - 205  U  - 209
E 142  U  - 292
E 143  U  - 296
E 144  U  -  31  U  -  34
E 145  U  - 381
E 146  U  - 256  UN - 262
E 147  UN - 257  U  - 261
```

Cross reference lists
Cross reference list for outputs

A	0	=	-	22		
A	1	=	-	24		
A	2	=	-	26		
A	3	=	-	28		
A	4	=	-	30		
A	6	S	-	401	R	- 409
A	15	=	-	349		
A	16	=	-	334		
A	17	=	-	339		
A	18	=	-	290		
A	19	=	-	393		
A	21	=	-	377		

Cross reference lists

Cross reference list for timers

T	10	= - 359								
T	11	= - 360								
T	12	= - 361	UN- 379	UN- 386						
T	13	UN- 418	= - 422	UN- 426						
T	14	UN- 419	= - 427	= - 430						
T	15	R - 62	RN- 63	S - 68	S - 74	S 80	S - 86	S - 92	O - 94	UN- 162
T	16	R - 132	RN- 113	S - 138	S - 142	S 144	UN- 144	UN- 149		
T	17	= - 402								
T	18	SN- 394	R - 395							
T	58	UN- 356	R - 364	UN- 375						
T	59	UN- 357	R - 365	U - 376						
T	60	UN- 358	R - 366	UN- 380	UN- 387					
T	61	UN- 420	UN- 428	R - 433	U - 435					
T	62	UN- 421	UN- 429	R - 434	U - 437					
T	63	O - 95	UN- 163							
T	64	UN- 145	UN- 150							
T	65	UN- 408								
T	66	UN- 400								