



Operating Instructions



Scanning Unit Exchange

LC 1x3

LC 4x3

LC 1x5

LC 4x5

ATS Software ID 539862-xx
Software Version 3.0.xx

Product key option 21,
ID 1080333-xx required

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1 General

1.1 How to use these instructions

About these instructions

These operating instructions are valid for the ATS **A**djusting and **T**esting **S**oftware Version 3.0.xx ID 539862-xx with active product key Option 21, ID 1080333-xx.

The ATS software is executable on the following hardware:

- PWM 20 ID 731626-01 and
- PC expansion board IK 215 ID 386249-xx

Explanation of the symbols

Symbols represent the type of information.



Note

E.g., reference to more detailed information in another chapter



Attention

E.g., indication of error messages that may be displayed or repetition of program steps



DANGER

E.g., information that incorrect operation may cause the danger of electrical shock or lead to the destruction of components

Other documentation

For more information please refer to the following documentation:

- LC Replacing Instructions
AE LC 1x3_1x5 ID 1098560-90
AE LC 4x3_4x5 ID 1096193-90
- User's Manual ATS Software ID 543734-xx
- HEIDENHAIN User's Manual Cable and Connection Technology ID 1117945-xx
- PWM 20 Operating Instructions ID 1125089-xx
- IK 215 Operating Instructions ID 549369-xx
- Documentation of the machine tool builder
- Interfaces of HEIDENHAIN Encoders ID 1078628-xx
- Mounting instructions of the encoders
- Encoder brochures (www.heidenhain.de)

Target group

The activities described in this manual may only be performed by specialists for service, maintenance and commissioning who have profound knowledge of electronics, electrical engineering and NC machine-tool technology.



Note

Keep these instructions for later reference!

Screen displays



Note

The screenshots and displays in these instructions depend on the encoder type connected and on the product key. Thus, they may differ from your testing situation. The images only serve as examples!

1.2 Safety precautions



Note

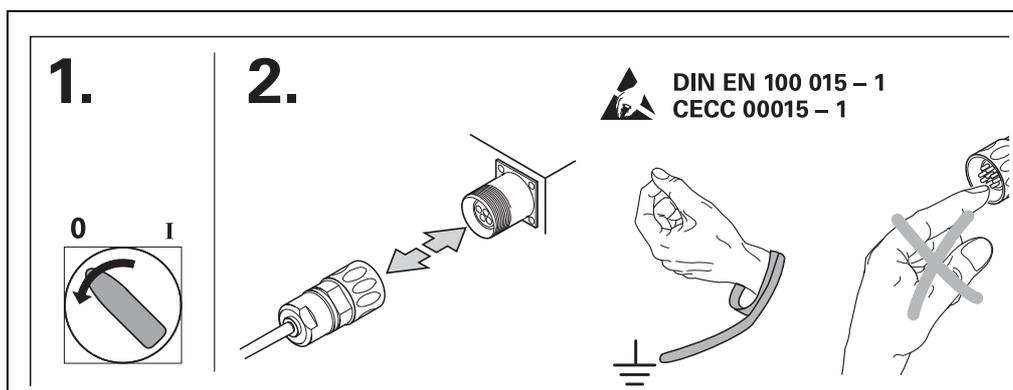
Observe the safety precautions below to avoid injury or damage to persons or products.

To avert potential dangers, only use the product in the manner described!

A service exchange scanning unit in factory default condition does not work with an NC control before it is programmed.

When connecting encoders to the test unit, please note the following:

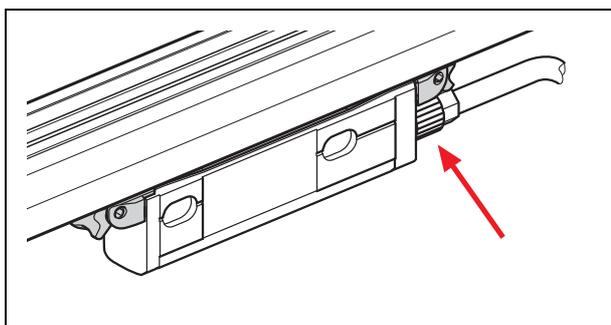
1. Switch off the encoder power supply ("Disconnect encoder").
2. Then connect or disconnect the plugs.
Observe the ESD precautions!
Make sure that the connector contacts are clean!



Note

To avoid contact problems, always tighten the coupling ring when you connect the adapter cable!

Only switch on the power of the scanning unit, while it is in the scale housing!





DANGER

Do not operate defective units!

When the programming of the scanning head is completed, the encoder memory is reset to its factory default setting.

The ATS software offers the possibility of storing and editing machine-specific or equipment-specific information in the customer's memory area.

The data may comprise safety-relevant information.

When servicing, please take care to adapt this memory area. Noncompliance with this warning could result in damage to the machine or in personal injury.

When troubleshooting always contact the machine tool builder for information (e.g. meaning of the data in the OEM memory).



Note

Support is provided by HEIDENHAIN Traunreut or by the HEIDENHAIN agencies (see "Contact" at the end of this manual).

2 Exchanging LC scanning units

2.1 General information

This software function serves to exchange defective scanning units of LC 1x3*, 1x5, 4x3 and 4x5.

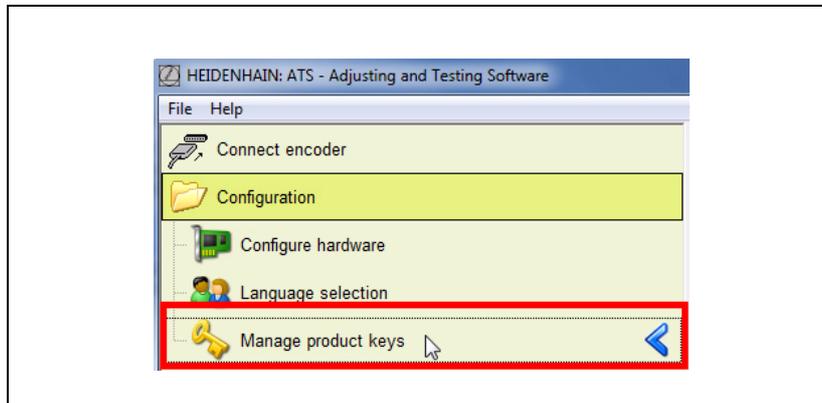
* The placeholder x stands for the interface, e.g. LC 115 or LC 185 means HEIDENHAIN **EnDat**; **Fanuc**, **Mitsubishi** and **SIEMENS** are represented by **9**. The interface type is specified through the first letter of the company name, e.g. LC 495 **S** for SIEMENS, etc.

With this software, you can associate new service scanning units with the scale unit by means of data transfer and run a functional test.

The required data is read out from the original scanning unit and transferred to the new one. The interface of the scanning unit must work for this purpose. If the data cannot be read out, the LC needs to be replaced.

The function "LC service programming OEM customers" must be enabled through the product-key option 21 in the ATS software; also see chapter "Manage product keys" in the User's Manual for the ATS software.

In the ATS, you can look up under "Manage product keys / Currently available options" whether a product key is active.



Note

For general information on installing and operating a PWM 20, please refer to the User's Manual of the ATS Software (ID 543734-xx) and the PWM 20 Operating Instructions (ID 729905-xx).

2.2 Absolute linear encoders that are supported

The exchange of scanning units of the following linear encoders is supported:

LC 183, LC 193F, LC 193M

LC 189*, LC 199F, LC 199M

LC 483, LC 493F, LC 493M

LC 489*, LC 499F, LC 499M

LC 115, LC 185, LC 195F, LC 195M, LC 195S

LC 415, LC 485, LC 495F, LC 495M, LC 495S

* LC x89 (EnDat) are only supported as of software 3.0.06

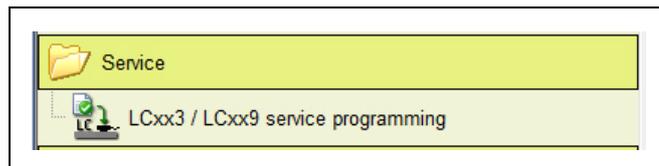


Note

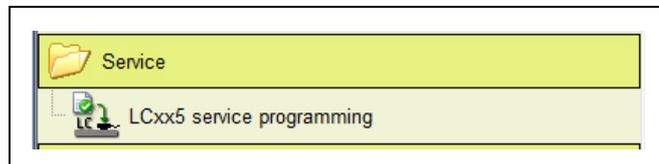
Encoders with "Functional Safety" and older LC 1x2 and LC 4x1 are not supported!

The following service function can be executed:

LC xx3/LC xx9 service programming



LC xx5 service programming



The service function the ATS uses to program the scanning unit depends on the connected LC (dynamic selection of function).

When you select the function, a wizard starts that will guide you through the programming steps.



Note

Read the messages and follow the course of the program!

Consult HIF (**H**esis **I**ncluding **F**ilebase) to find out whether the service scanning unit is compatible.

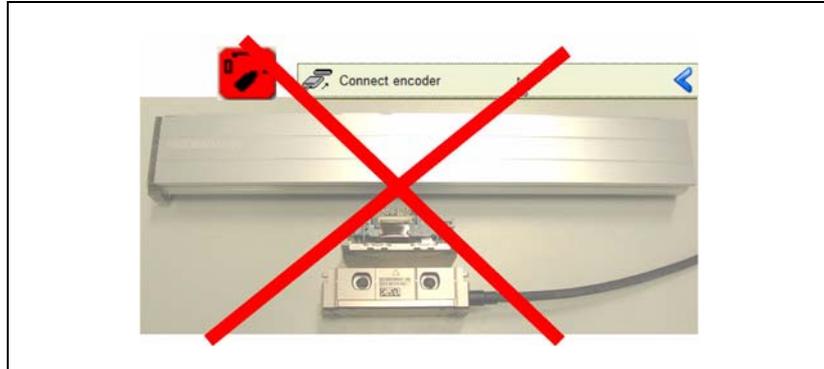
HIF is available to registered users at <https://portal.heidenhain.de>.

The Encoders Service helpline also provides information.



Attention

Do not power the scanning unit (AE) outside the scale unit!
Illumination control may overdrive and damage the infrared LED.



3 Information on cleaning encoders

3.1 General information

Before you replace a scanning unit, check the scale unit and the glass scale for contamination and clean them, if required. A contaminated scale may cause malfunctions or failure of the new exchange scanning unit.

Every service scanning unit (exchange scanning unit) is delivered with replacing instructions.

Please observe the prescribed procedure:

- ▶ Opening the linear encoder
- ▶ Cleaning
- ▶ Exchanging the scanning unit
- ▶ Closing and sealing the linear encoder

Replacing instructions:

Device (scanning unit)	ID of replacing instructions
AE LC 1x3_1x5	1098560-90
AE LC 4x3_4x5	1096193-90



Note

The replacing instructions also contain ID numbers and names of consumable items (sealants, lubricants, shipping braces, etc.)

Use appropriate material for cleaning, such as soft, lint-free cloth and isopropyl alcohol or standard glass cleaner.

Do not scratch the inside of the scale.

Use the recommended sealants and lubricants.

Sealant: Paktan 6090 ID 200417-02 (to seal the end blocks of LC 4xx)

Sealant: Terostat-MS 930 ID 256535-01 (to seal the gap between sealing lip and LC 1xx end block)

Lubricant: Molykote 111 ID 202173-03 (to lubricate the closing edge of the sealing lips)

4 Service traversing device

4.1 General information

For inspection and programming, the scanning gap (air gap) between the scanning unit and the scale housing must be optimally adjusted.

To ensure this, there is the possibility of mounting the encoder via a mechanical traversing device (ID 371963-01). The encoder-specific mounting tolerances must be observed for this purpose.



Traversing device ID 371963-01



Note

The scanning unit must not be moved in the scale housing without defined scanning gap!
If a slanted scanning unit is moved, it may grind against the inside of the scale housing; the resulting abrasion particles can cause malfunctions!
Alternatively, you can use the shipping braces.

5 Exchanging scanning units of LC 1x3 and LC 4x3

5.1 General Information

Example of an encoder designation:

Scale LC 183; original scanning unit AE LC 183; exchange scanning unit AE LC 1xx Service



Note

With the ATS product key option 21 only service scanning units can be programmed through data transfer (data are read out from the original AE and transferred to the Service AE). Backup the data of the linear encoder before you exchange the scanning unit!

Ensure that the service scanning unit is compatible!

For further information, refer to

- the online database HIF (**H**ESIS **I**ncluding **F**ilebase) at <https://portal.heidenhain.de> (for registered users only!)
- the HEIDENHAIN helpline, phone no.: +49 (8669) 31-3104

5.2 Procedure for LC xx3 / LC xx9 service programming

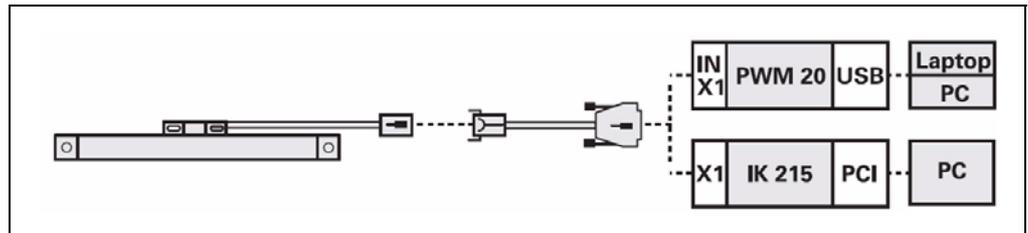
- ▶ Start the ATS software and connect the original linear encoder to the test unit via an adapter cable.

The User's Manual Cable and Connection Technology PWM 20 Testing Package contains various adapter cables.



Note

Use the transportation lock or the traversing device to stabilize the scanning unit and to avoid damage inside the scale unit.

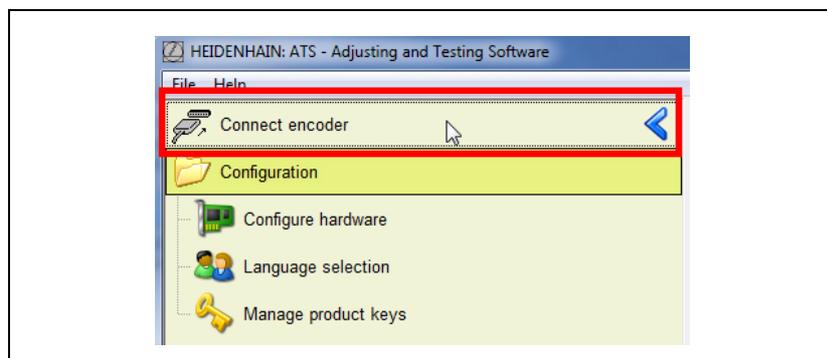


- ▶ 1. Connect the defective LC 1x3, 1x9 or LC 4x3, 4x9 to the PWM 20.
- ▶ 2. Connect the encoder.



Note

It is important that you always connect/identify the defective LC first!

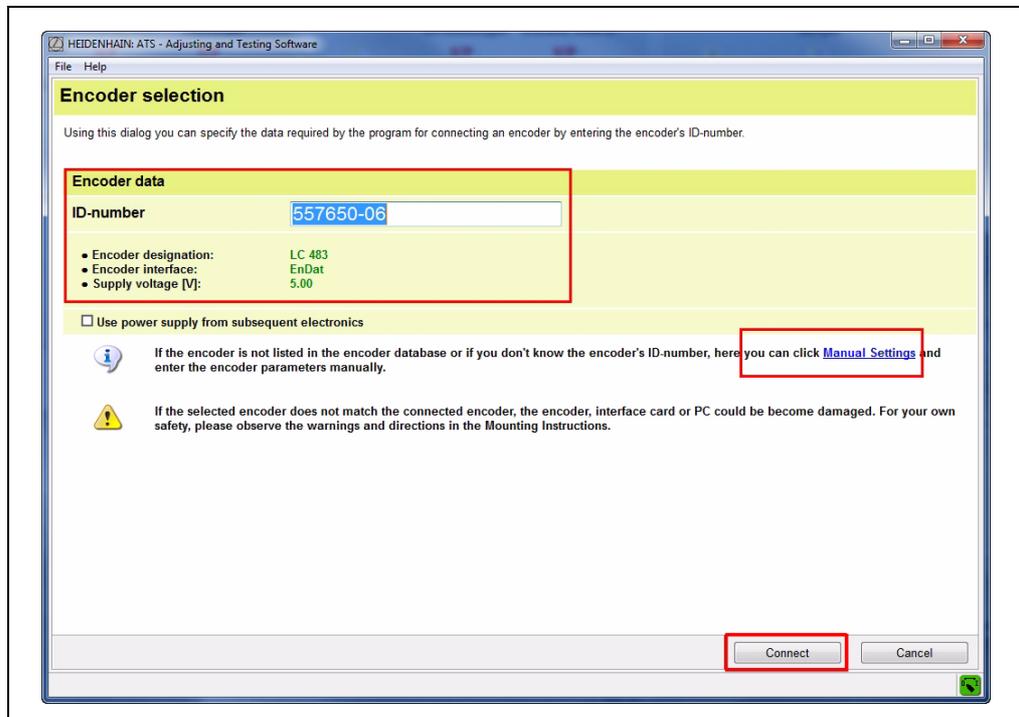


- ▶ 3. Enter the ID of the LC and press the "Connect" button to start.
Alternatively, you can also connect manually (click [Manual settings](#)).

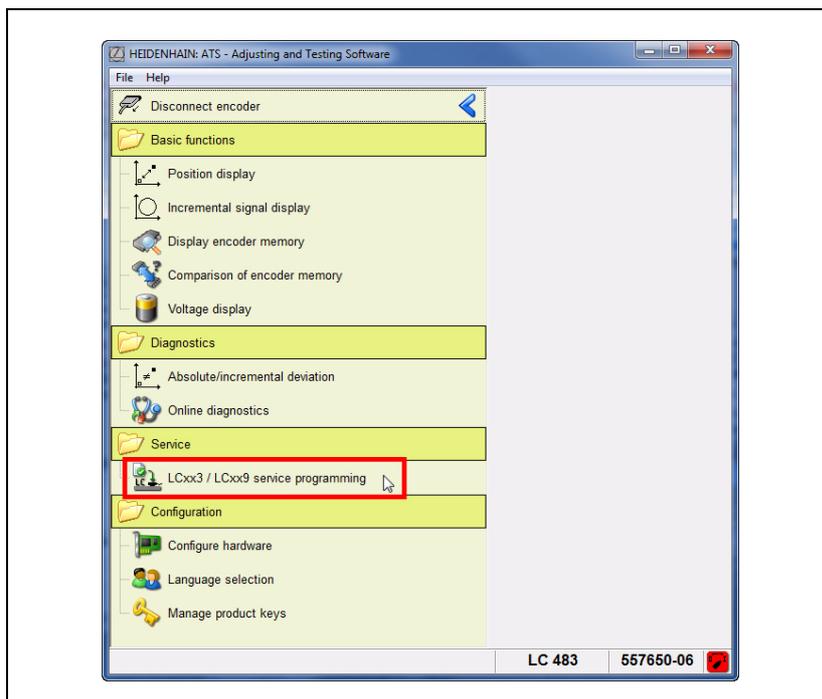


Note

Always use the ID on the ID label of the scale unit!
Do not set the checkmark in the field "Use power supply from subsequent electronics"!
This function is intended for the feed-through mode.



- In the basic menu of the program for replacing scanning units, start the function "LC xx3 / LC xx9 service programming".



An overview of the next program steps appears.

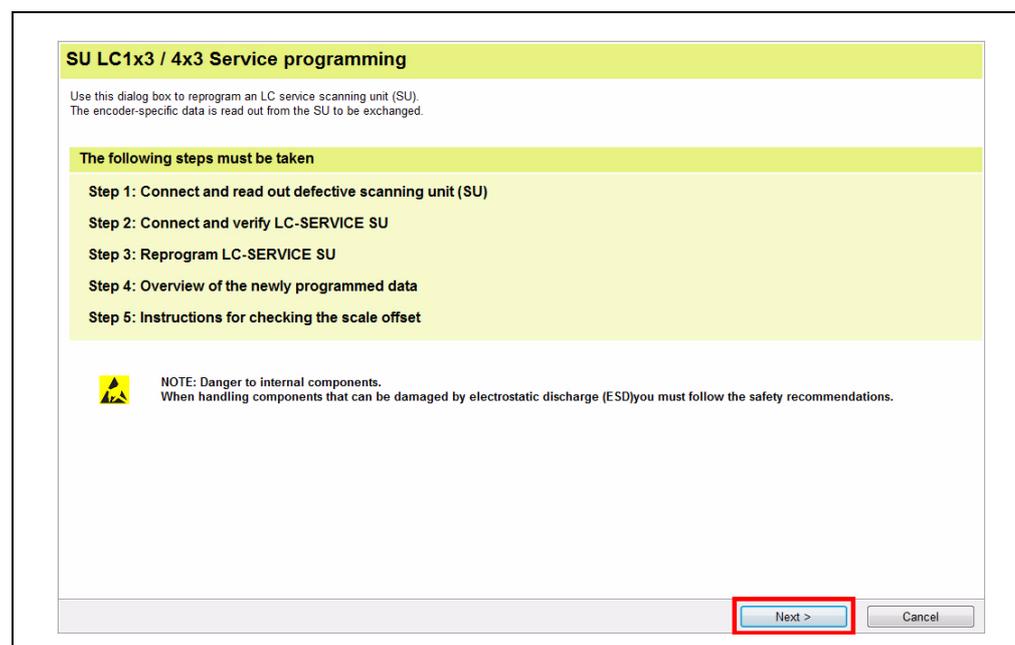
- Press the "Next >" button to go to step 1: Read out defective scanning unit.

The defective LC the scanning unit of which is supposed to be exchanged, must already be connected!



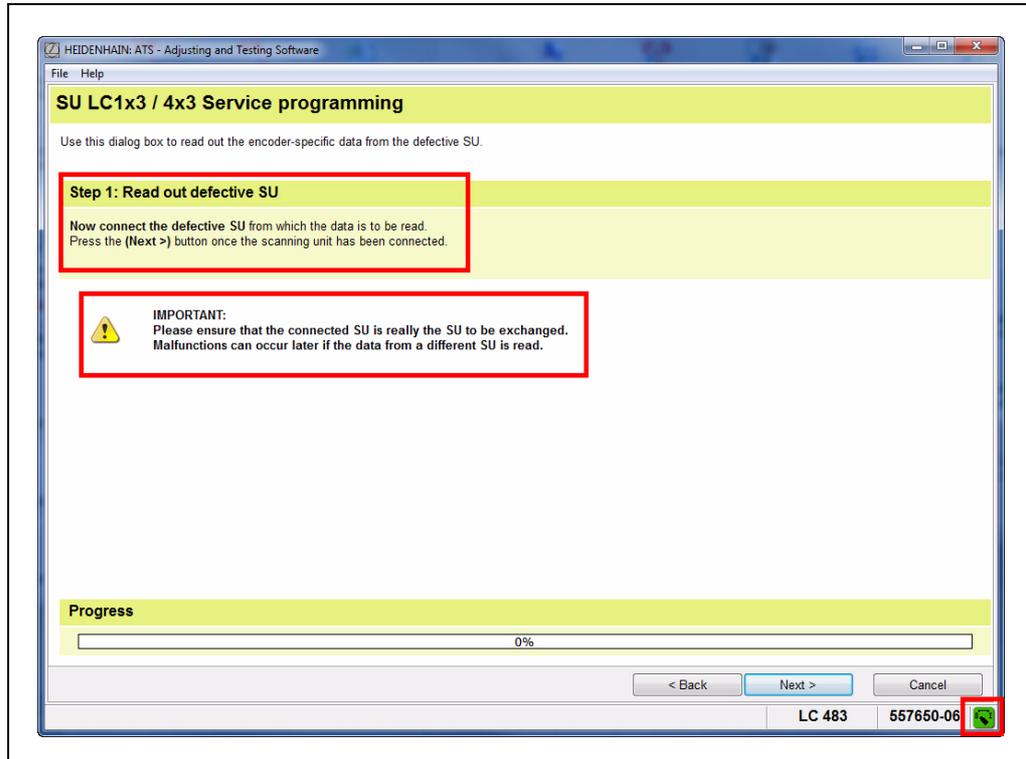
Note

Once this function is active, the supply voltage for the LC is switched off. The switch is displayed in green . Only dis(connect) the encoder while the symbol is green!

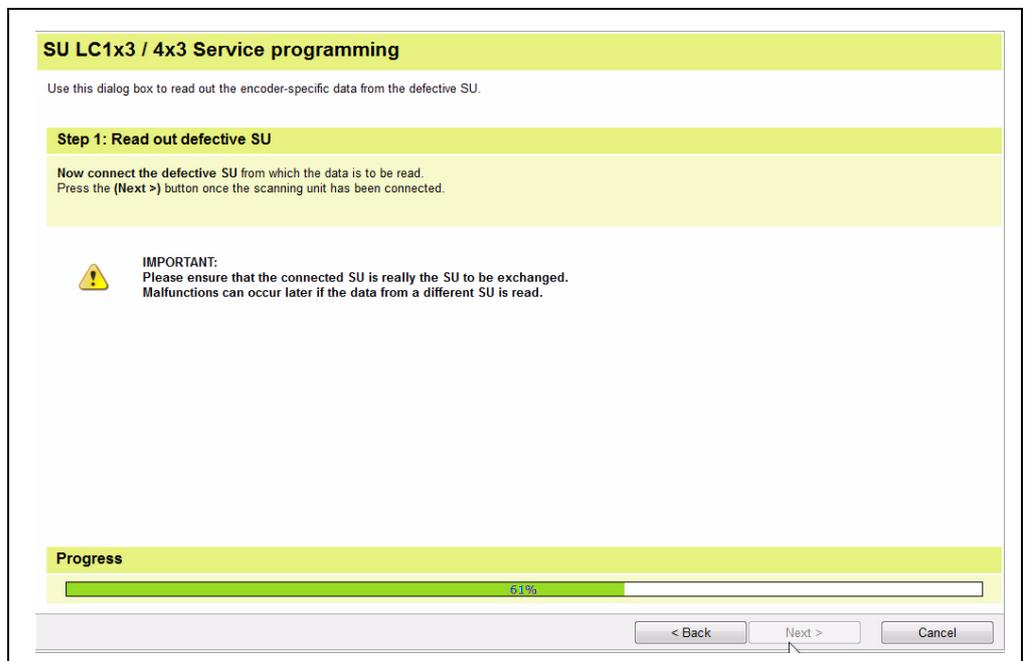


Step 1:

- ▶ Press the "Next >" button to start reading out the data of the defective scanning unit.



The progress of the data transfer is displayed as a progress bar.

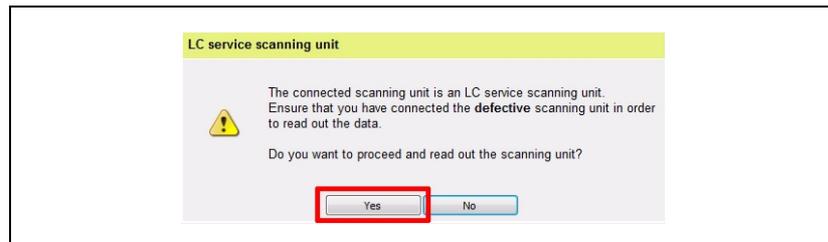


Error messages/warnings that may be displayed:

Example 1:

The ATS software reports an LC service scanning unit.
This may have two causes:

1. Was accidentally the exchange scanning connected?
 - ▶ Click the "No" button to cancel.
2. The scanning unit of the LC was already exchanged earlier.
 - ▶ Click the "Yes" button to read out the data of the connected scanning unit.



Example 2:

Error message, if no data can be read out from the encoder memory of the LC. There could be a connection problem (connector). In this case you have to replace the entire encoder, or contact the HEIDENHAIN helpline (repairing may be possible).



Step 2:

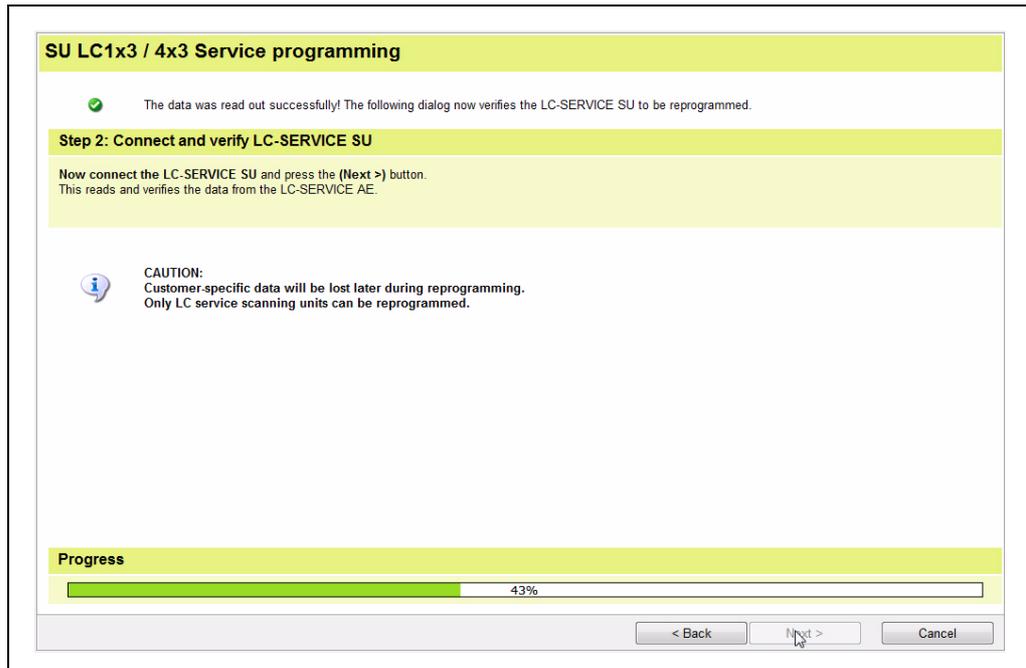
- ▶ After the data of the defective scanning unit was read out successfully, connect the new Service AE to the PWM 20. The supply voltage is switched off now!



Attention

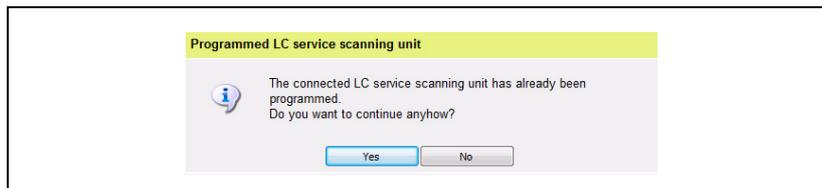
Do not power the scanning unit (AE) outside the scale unit! Illumination control may overdrive and damage the infrared LED.

- ▶ When you press the "Next >" button, the ATS checks whether the correct exchange scanning unit is connected.



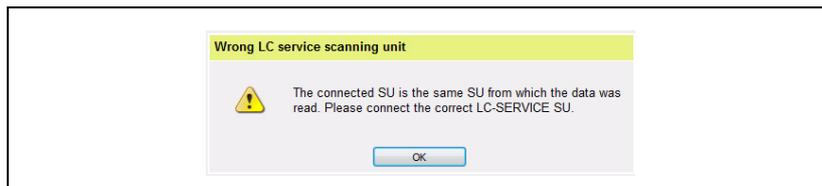
Example 1:

The connected scanning unit has already been programmed.
Multiple programming of service scanning units is possible without any problems.
Click "Yes" to continue verification.



Example 2:

The Service AE was not connected.



Step 3:

- ▶ Press the "Next >" button to write the data of the defective scanning unit to the Service scanning unit.



Note

Customer data (OEM data, offset of reference point, etc.) are overwritten here (**reset to factory default condition**)!
You may have to run a data backup beforehand (see User's Manual of the ATS software).



Attention

Do not disconnect the scanning unit while it is being programmed, as this would destroy the AE scanning unit!

SU LC1x3 / 4x3 Service programming

In this step the linear-encoder data that was read is written into the LC service scanning unit. Before you apply the data to the LC service scanning unit, please check all data shown under "Linear-encoder data."

Step 3: Reprogram LC-SERVICE SU

Please press the (Next >) button now in order to apply the determined data.

Linear-encoder data

• Designation:	LC 483	• ID number:	557650-06
• Interface:	EnDat 2.2	• Measuring step:	5 nm
• Code bits:	32		

Data relevant to operation is changed in this step.
NOTE: Customer-specific data can be lost during this step.

CAUTION: Do not disconnect the SU during programming under any circumstances, since this could damage it.

Progress

41%

< Back Next > Cancel

Step 4:

- ▶ Display of the newly programmed data of the LC service scanning unit
- ▶ Press the "Next >" key to activate position verification (step 5).

SU LC1x3 / 4x3 Service programming

The LC service scanning unit was programmed successfully. Please check its correct operation with suitable diagnostic tools.

Step 4: Overview of the newly programmed data

The LC-SERVICE SU was programmed successfully.
Press the (Next >) button for information about the position inspection.

Data of the reconfigured LC service scanning unit

• Designation:	LC 483
• ID number:	557650-06
• Interface:	EnDat 2.2
• Measuring step:	5 nm
• Code bits:	32
• Datum offset:	0 mm

IMPORTANT: The correct operation of the new LC service scanning unit must be checked before it is put into operation. It must be tested as described on the next page.

< Back Next > Cancel

Step 5:

Finally, the program inspects whether the LC is fully functional.

For this purpose, two defined positions marked with arrows on scale and scanning unit must be exactly aligned.

Alternatively, you can use the dimension * indicated in the drawing for the distance between the front faces of scale unit and scanning unit (see displayed drawing).



Note

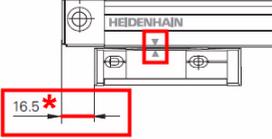
The displayed drawing is to be considered an example.

On LC models with mounting spar, the end blocks at the scale housing are smaller and without holes. This means that the dimensions are different. The position of the arrows is decisive.

SU LC1x3 / 4x3 Service programming

Instructions for checking the scale offset after reprogramming.

Drawing for LC4x3 and LC4x9



Step 5: Instructions for checking the scale offset

- 1) After concluding the dialog, please move the newly programmed LC-SERVICE scanning unit to the position indicated in the drawing above (where the SU and cassette arrows meet).
- 2) The position dialog is automatically started when the "Position inspection" button is pressed.
- 3) The absolute position must now indicate the value $4\,000\,000 \pm 100\,000$ (in measured value display) or the value $20\,000\mu\text{m} \pm 500\mu\text{m}$ (in position display).

If the position inspection from step 3) does not show a correct value, the newly programmed unit may not be used under any circumstances!

< Back Position verification



Attention

To inspect the scale offset, the scanning unit must be guided mechanically with high precision. This is obtained by mounting the LC to a HEIDENHAIN traversing device. The displayed dimensional drawing (see above) shows the dimensions for the examination on the Service traversing device.

Alternatively, you can also use the transportation lock (two red plastics parts slid below the scanning unit). The position where measuring starts cannot be reached as long as the transportation lock is mounted.

In this case you have to work with a guide mark (line on the scanning unit; see figures).

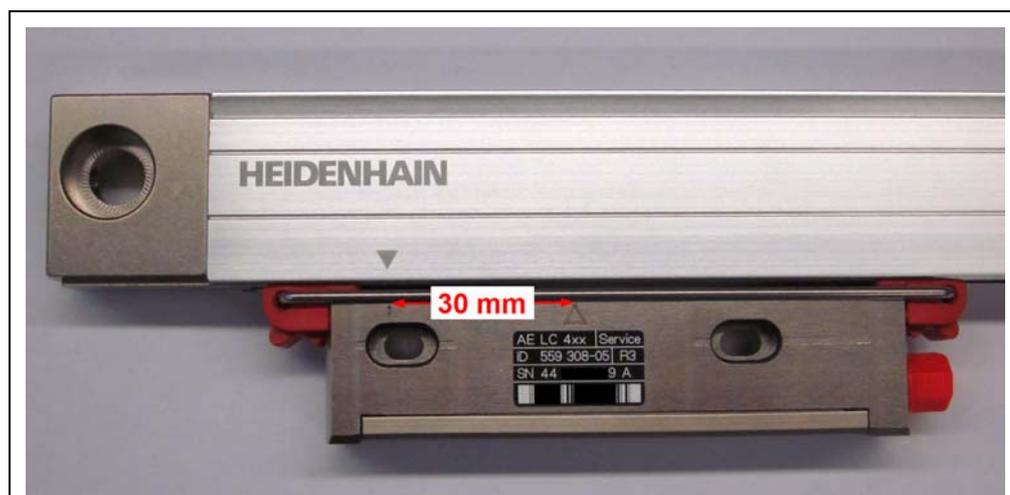
The negative example below shows an LC 4x3 which was moved to the position where measuring starts without the required second transportation lock. The position of the scanning unit towards the scale housing is mechanically undefined. The scanning unit is oblique towards the scale!



Note

The current scanning units already have a guide mark.

Exactly align the guide mark on the Service AE and the arrow point on the scale housing. The red transportation locks must be engaged.



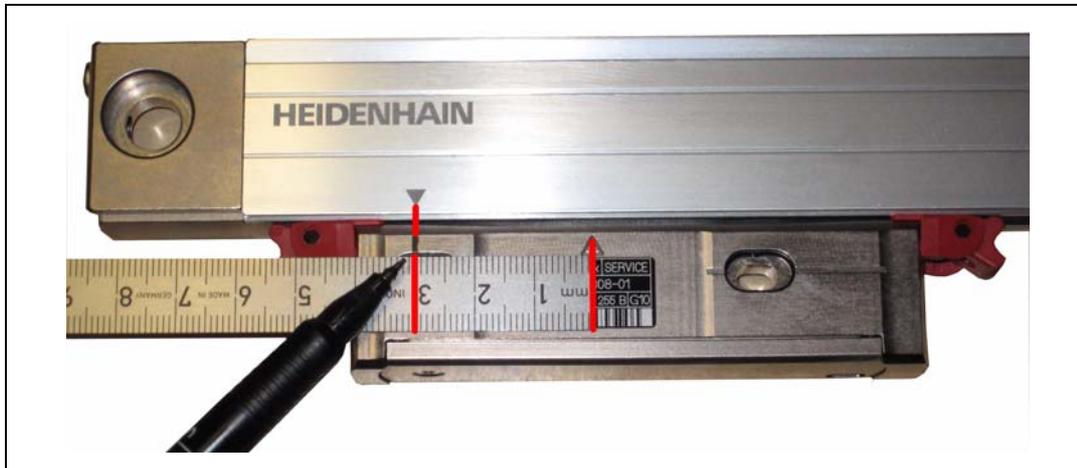
Preparing the LC for position verification, if there is no guide mark on the service scanning unit:

For position verification without traversing device, a guide mark needs to be added on the scanning unit (AE).

Mark the scale housing at 30 mm distance left from the arrow point on the scanning unit (see figure).

Exactly align the new marking and the arrow point on the scale housing.

The distance between the two arrow points is precisely 30 mm.



► Start the inspection with the "Position verification" button.



Attention

Observe the messages on the screen!

The additional traverse distance of 30 mm must be added to the value in the graphics.

The measured value [steps] depends on the resolution!

The position can be displayed in steps or in μm .

Scale offset at the guide mark, absolute position in [steps]:

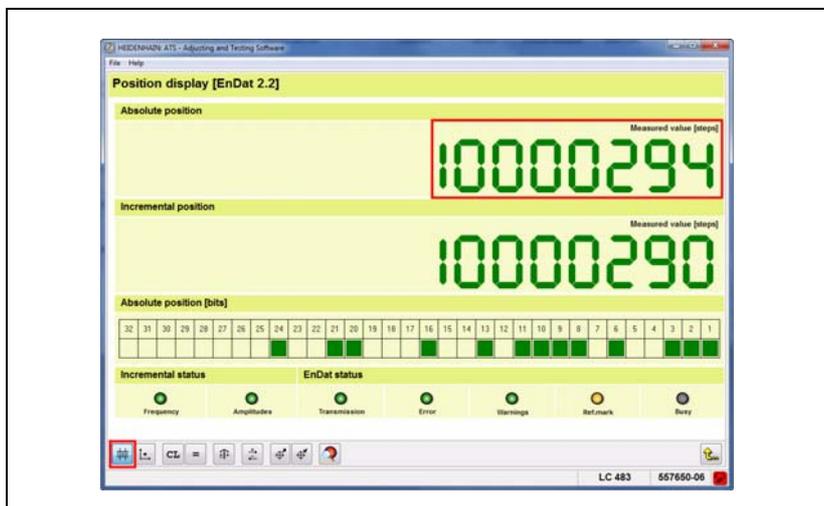
100 000 000 steps; tolerance $\pm 100\ 000$ steps with an LC with 5 nm resolution

Calculation:

Measured value steps = Measuring range [μm] / Resolution [μm]

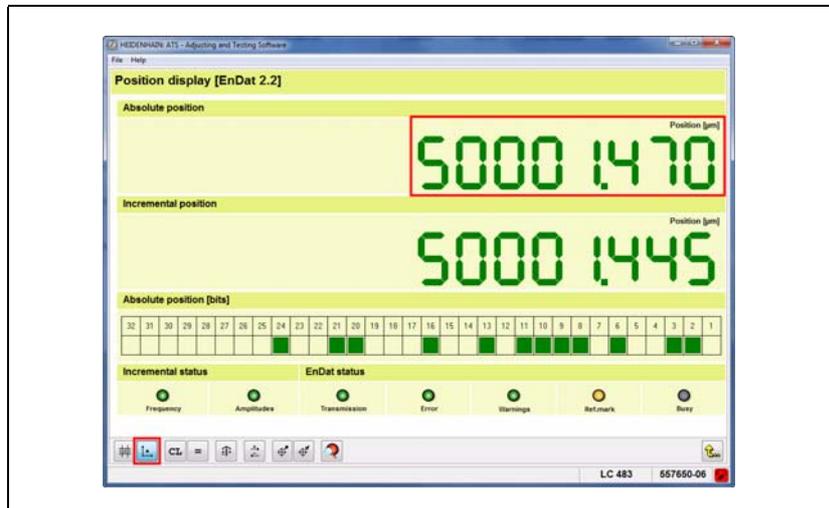
$$\frac{(20\ 000 + 30\ 000)\ \mu\text{m}}{0.005\ \mu\text{m}} = 10\ 000\ 000\ \text{Steps}$$

Example: LC with 5 nm resolution

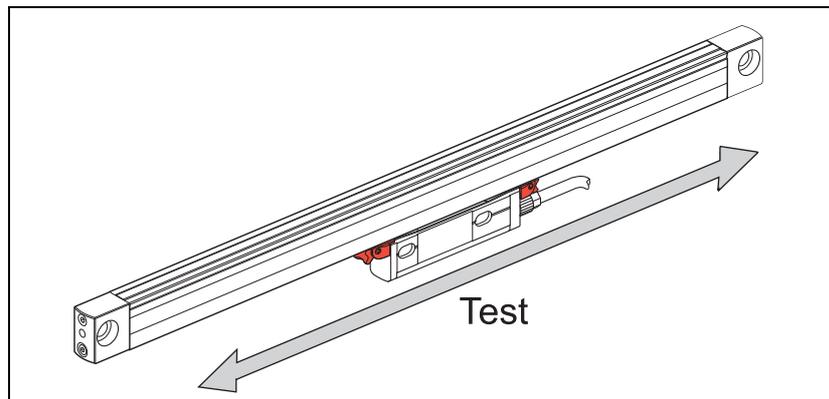


Scale offset at the guide mark, absolute position in [µm]:
 Display value 50 000; tolerance ± 500 µm

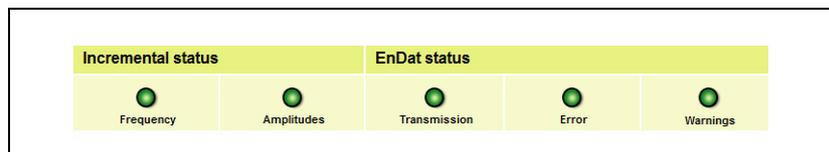
Calculation:
Position value [µm] = Value from displayed graphics [µm] + Guide mark [µm]
20 000 µm + 30 000 µm = 50 000 µm



When step 5 is completed, the exchange of the LC scanning unit is finished.



No alarms or warnings may be generated.
 The LED displays must be "green" for the incremental and the EnDat status!



Note

Always use the transportation lock or a suitable traversing device when you move the scanning unit. This avoids mechanical damage inside the scale unit.
 Mount the LC to the machine according to the mounting instructions.
 Observe the mounting dimensions and tolerances!
 The position where measuring starts (arrows are opposite each other) cannot be reached as long as the transportation lock is mounted.

6 Exchanging scanning units of LC 1x5* and LC 4x5*

6.1 General information

This software function serves to exchange defective scanning units of the following LC models:
LC 115, LC 185, LC 195, LC 195S, LC 195F
LC 415, LC 485, LC 495, LC 495S, LC 495F



Note

On the ID label of the scanning unit, the ID number is printed, but the model name is not.
On encoders with "Functional Safety" option, exchange of scanning unit is not supported.

* **x** = Placeholder for the interfaces:

1 = EnDat without incremental signal

8 = EnDat with 1Vpp incremental A/B signals

9 = No EnDat with interface code S = Siemens, F = Fanuc, M = Mitsubishi
(for further information see respective product catalogs)

With this software, you can associate new service scanning units with the scale unit and run a functional test.

The required data is read out from the original scanning unit and transferred to the new one. Moreover, the offset of the zero point on the scale is written to the new scanning unit.

The interface of the scanning unit must work for this purpose. If the data cannot be read out, the entire LC needs to be replaced.

The function "LC service programming OEM customers" must be enabled through the product-key option 21 in the ATS software. (Also see chapter "Manage product keys" in the User's Manual for the ATS Software.)

In the ATS, you can look up under "Manage product keys / Currently available options" whether a product key is active.

6.2 Procedure for LC xx5 service programming

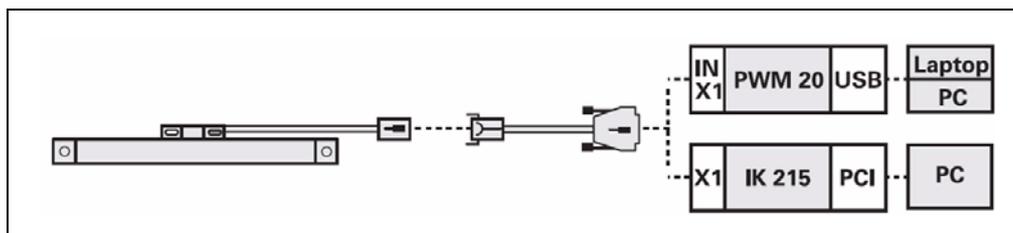
- ▶ Start the ATS software and connect the original linear encoder to the test unit via an adapter cable.

The User's Manual "Cable and Connection Technology PWM 20 Testing Package" contains various adapter cables.



Note

Use the transportation lock or the traversing device to stabilize the scanning unit and to avoid damage inside the scale unit.



- ▶ 1. Connect the defective LC 1x5 or LC 4x5 to the PWM 20.

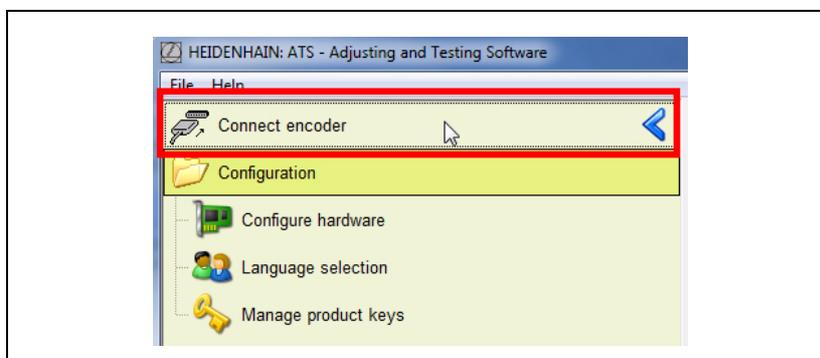


Note

It is important that you always connect/identify the defective LC first!
Do not power the scanning unit outside the LC scale unit!
Illumination control may overdrive and damage the infrared LED.



- ▶ 2. Establish a connection to the encoder.

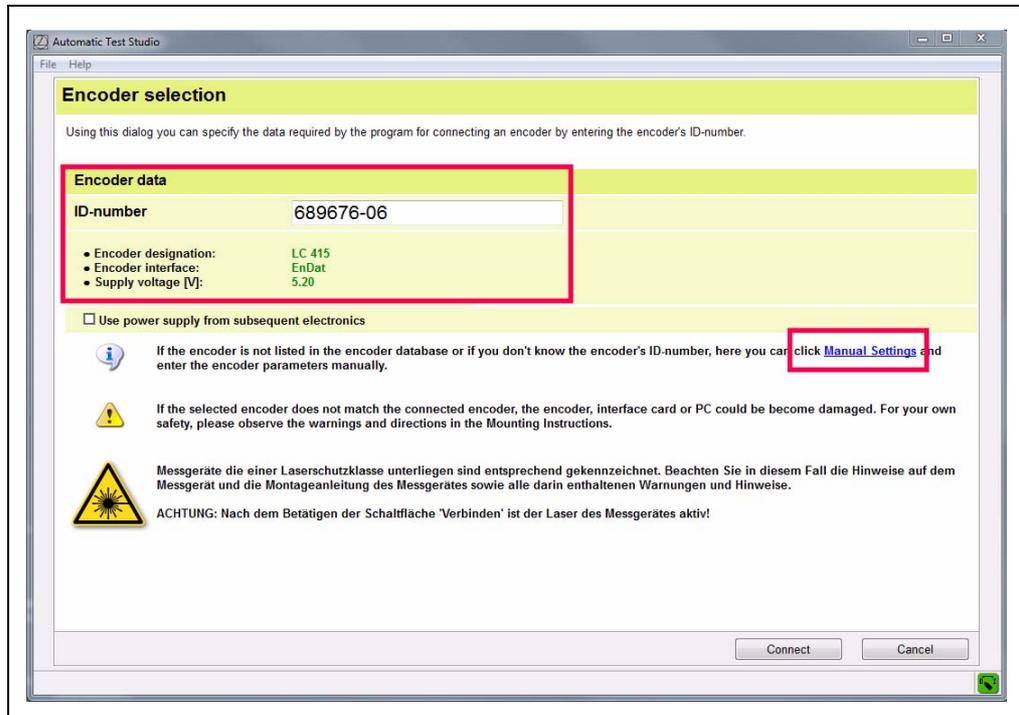


- ▶ 3. Enter the ID of the LC and press the "Connect" button to start.
Alternatively, you can also connect manually (click [Manual settings](#)).

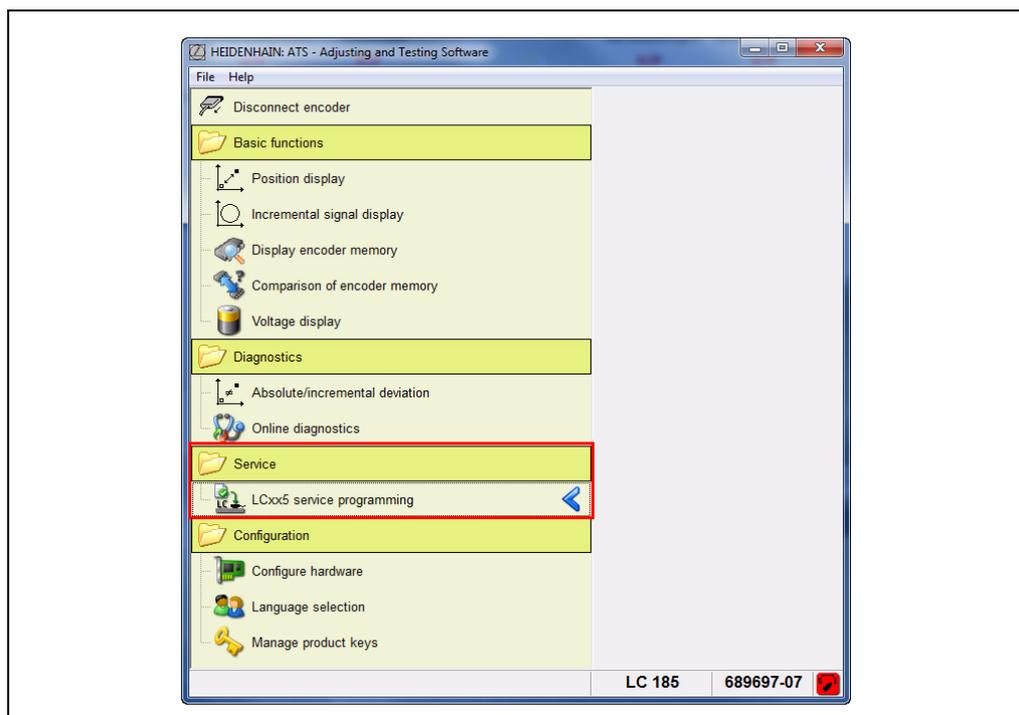


Note

Do not set the checkmark in the field "Use power supply from subsequent electronics"! This function is intended for the feed-through mode. If you activate this function, the encoder power supply is switched to the subsequent electronics (e.g. machine control system) and the LC is not powered (ATS error message).



- ▶ 4. Select "LC xx5 service programming" to start the exchange of the scanning unit.



An overview of the next program steps appears.
The defective LC the scanning unit of which is supposed to be exchanged, must already be connected.



Note

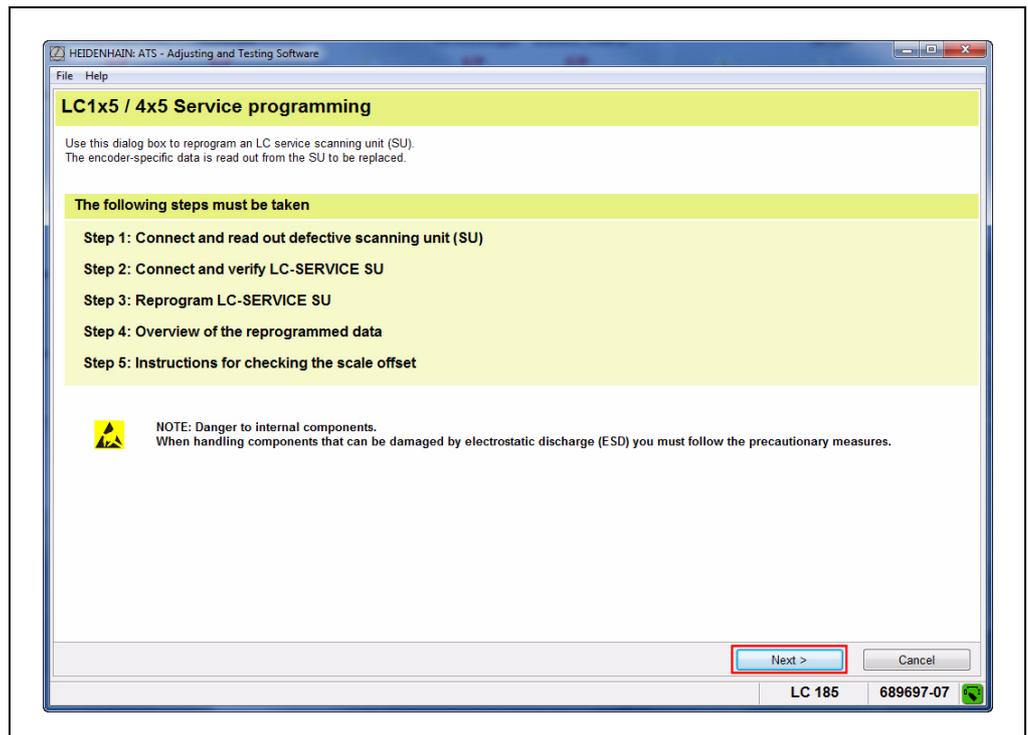
The software switches off the supply voltage of the LC to ensure that the encoder is not under power when it is reconnected.

► Press the "Next >" button to go to step 1: Read out defective scanning unit.



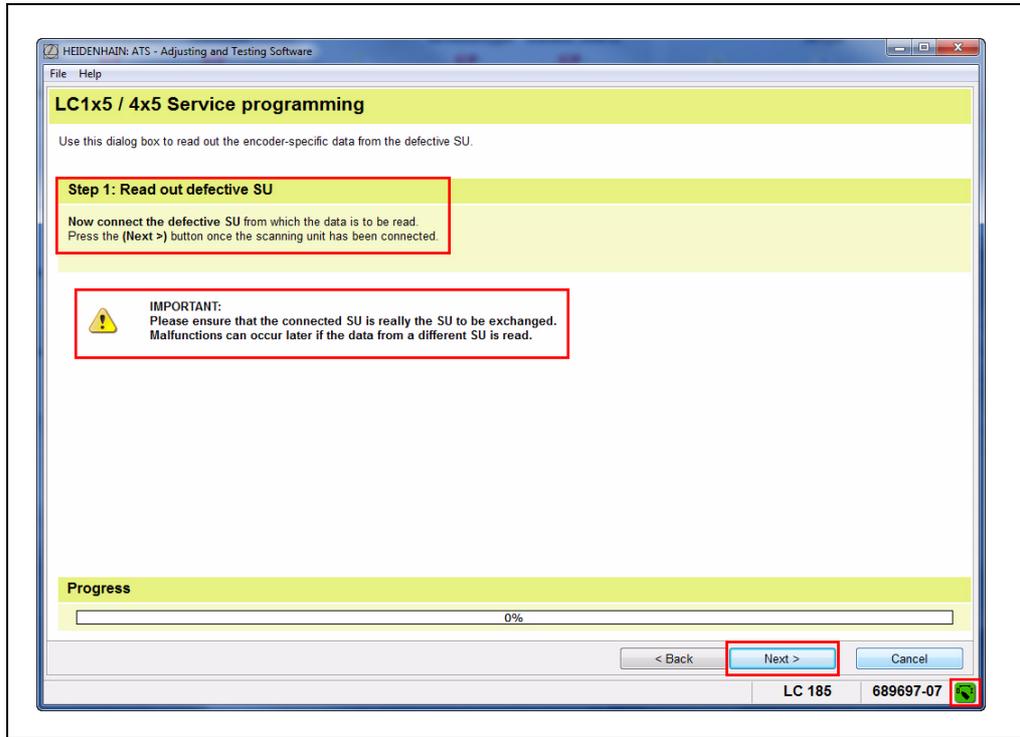
Note

Note the displayed messages!

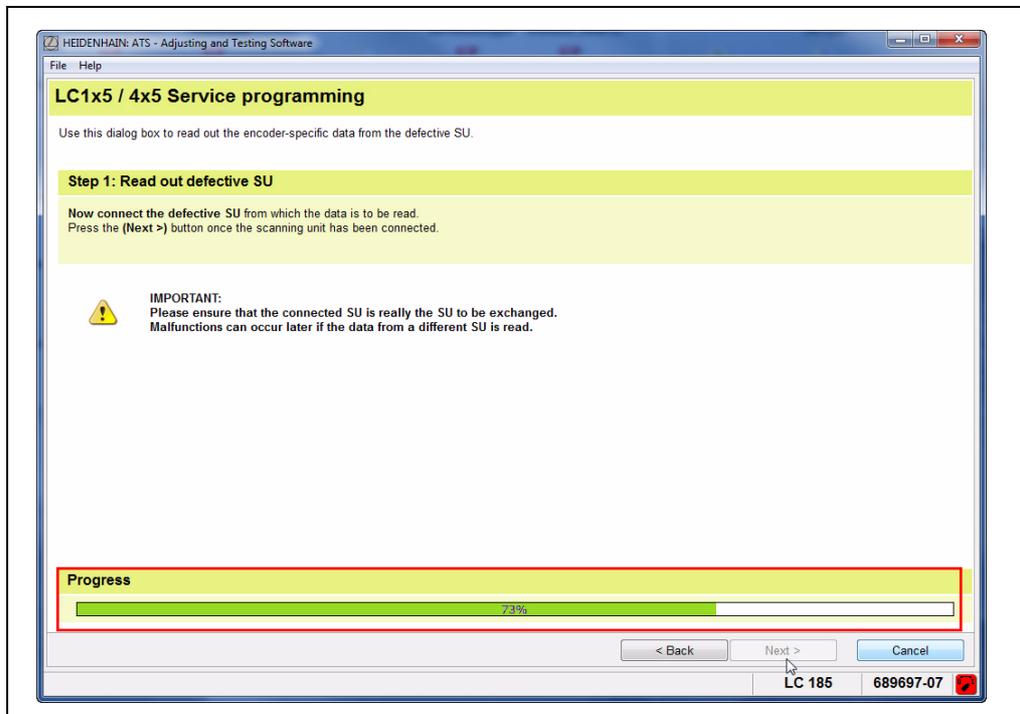


Step 1:

- ▶ Press the "Next >" button to start reading out the data from the defective scanning unit.



The progress of the data transfer is displayed as a progress bar.



Warnings and error messages **may be** displayed.

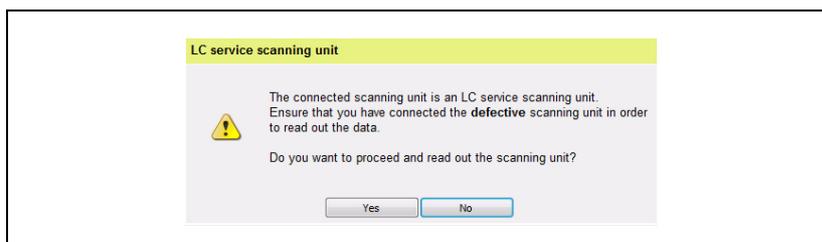
Example 1:

The ATS software reports an LC service scanning unit.

This may have two causes:

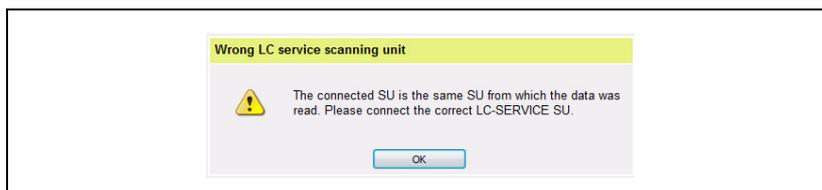
1. Was accidentally the exchange scanning connected?
2. The scanning unit of the LC was already exchanged earlier.

- ▶ Click the "No" button to cancel Service programming.
- ▶ Click the "Yes" button to read out the data of the connected scanning unit.



Example 2:

Information that the service scanning unit was not connected



Example 3:

Error message, if no data can be read out from the encoder memory of the LC. There could be a connection problem (connector). In this case you have to replace the entire encoder, or contact the HEIDENHAIN helpline (repairing may be possible).



Step 2:

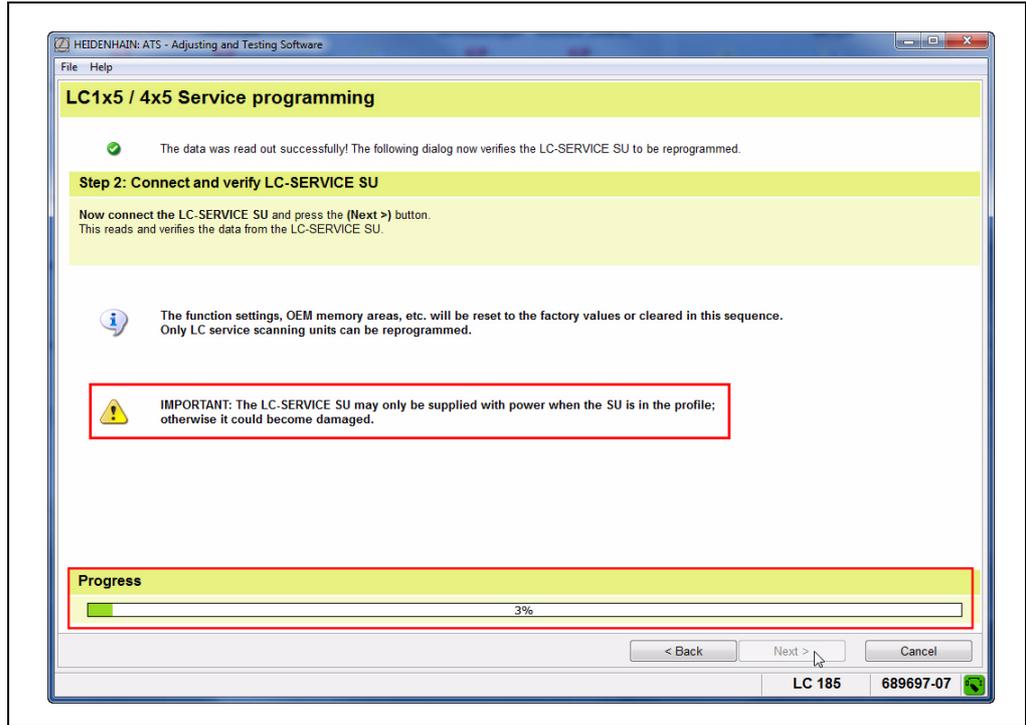
- ▶ After the data of the defective scanning unit was read out successfully, connect the Service AE to the PWM 20. The supply voltage is switched off now!



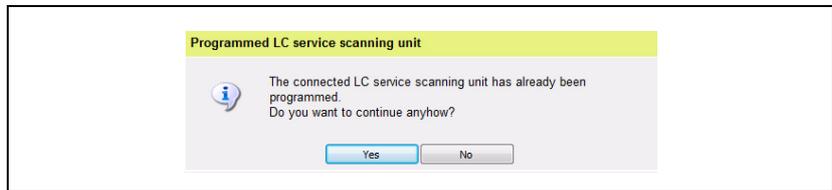
Attention

Do not power the scanning unit (AE) outside the scale unit! Illumination control may overdrive and damage the infrared LED.

- ▶ When you press the "Next >" key, the ATS checks whether the correct exchange scanning unit is connected.



Example: The AE of this LC was already exchanged.
The connected scanning unit has already been programmed.
Multiple programming of Service scanning units is possible without any problems.
Click "Yes" to continue verification.



Step 3:

The data read out from the defective LC is displayed.

- ▶ Press the "Next >" button to write the data of the defective scanning unit to the service scanning unit.



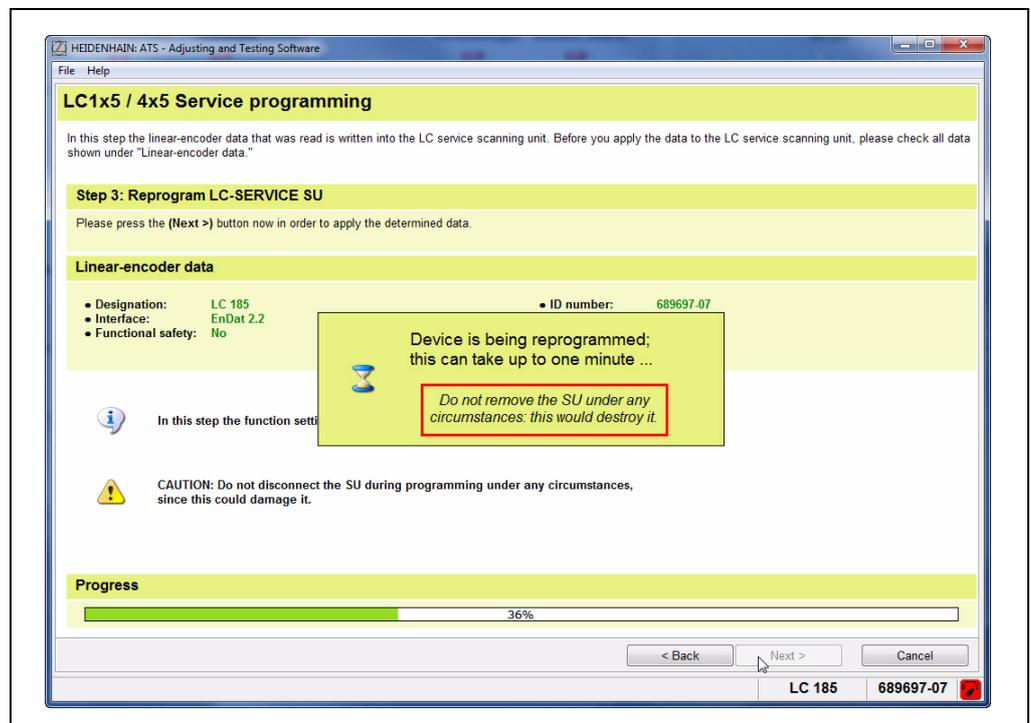
Note

Customer data (OEM data, offset of reference point, etc.) are overwritten here (**reset to factory default condition**)!
You may have to run a data backup beforehand (see User's Manual of the ATS software).



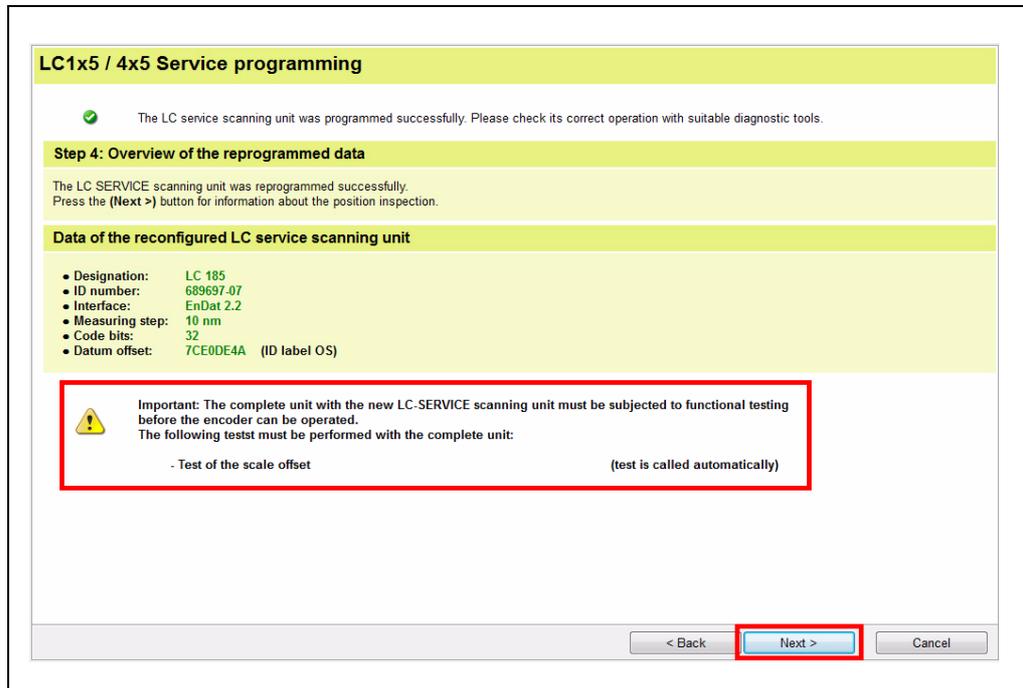
Attention

Do not disconnect the scanning unit while it is being programmed, as this would destroy the AE!



Step 4:

- ▶ Display of the newly programmed LC Service scanning unit
- ▶ Press the "Next >" key to activate position verification (step 5).

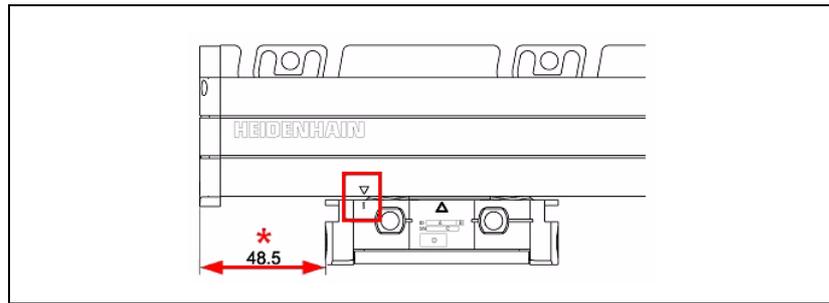


- ▶ Now move the service scanning unit to the position shown in the dimension drawing.

In addition to the triangular mark, service scanning units have a marking line on their mounting base. This line on the service scanning unit must be aligned with the triangular mark on the scale housing (see figure).



Alternatively, you can use the dimension * indicated in the drawing for the distance between the front faces of scale unit and scanning unit (see figure).



Note

The procedure is the same for LC 1x5 and LC 4x5!
The value * depends on the LC model (slimline LC; with or without mounting spar; full-size LC)!

Step 5:

- Press the "Position check" button to start the inspection of the scale offset after finishing programming.



Attention

Observe the messages on the screen!
The measured value display changes according to the encoder resolution.

HEIDENHAIN: ATS - Adjusting and Testing Software

File Help

LC1x5 / 4x5 Service programming

Instructions for checking the scale offset after reprogramming.

Drawing for LC1x5

Step 5: Instructions for checking the scale offset

- 1) After concluding the dialog, please move the reprogrammed LC-SERVICE scanning unit to the position indicated in the drawing above (where the marking line on the SU and the arrow on the cassette meet).
- 2) The position dialog is automatically started when the "Position inspection" button is pressed.
- 3) The absolute position must now indicate the value $5\ 000\ 000 \pm 100\ 000$ (in measured value display) or the value $50\ 000\ \mu\text{m} \pm 1\ 000\ \mu\text{m}$ (in position display).

If the position inspection from step 3) does not show a correct value, the reprogrammed unit may not be used under any circumstances!

< Back Position check

LC 185 689697-07

The position can be displayed in steps or in μm .

Scale offset with position display in [steps]:

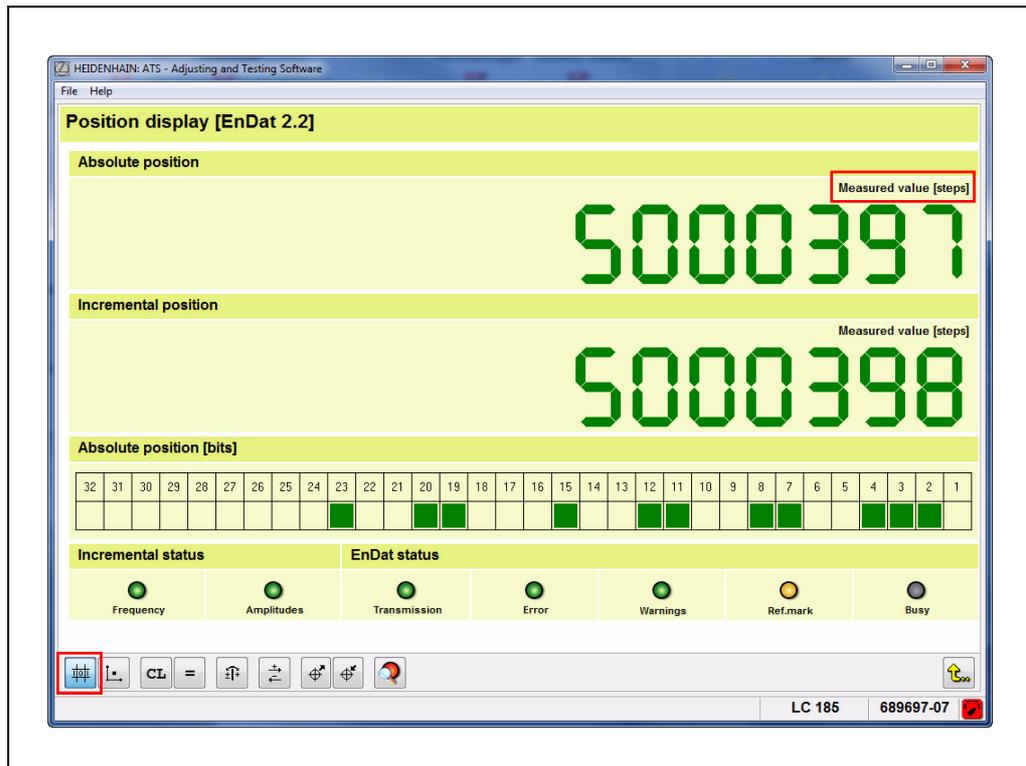
Value 5 000 000; tolerance $\pm 100\,000$ steps with an LC with 5 nm resolution
The value depends on the resolution!



Attention

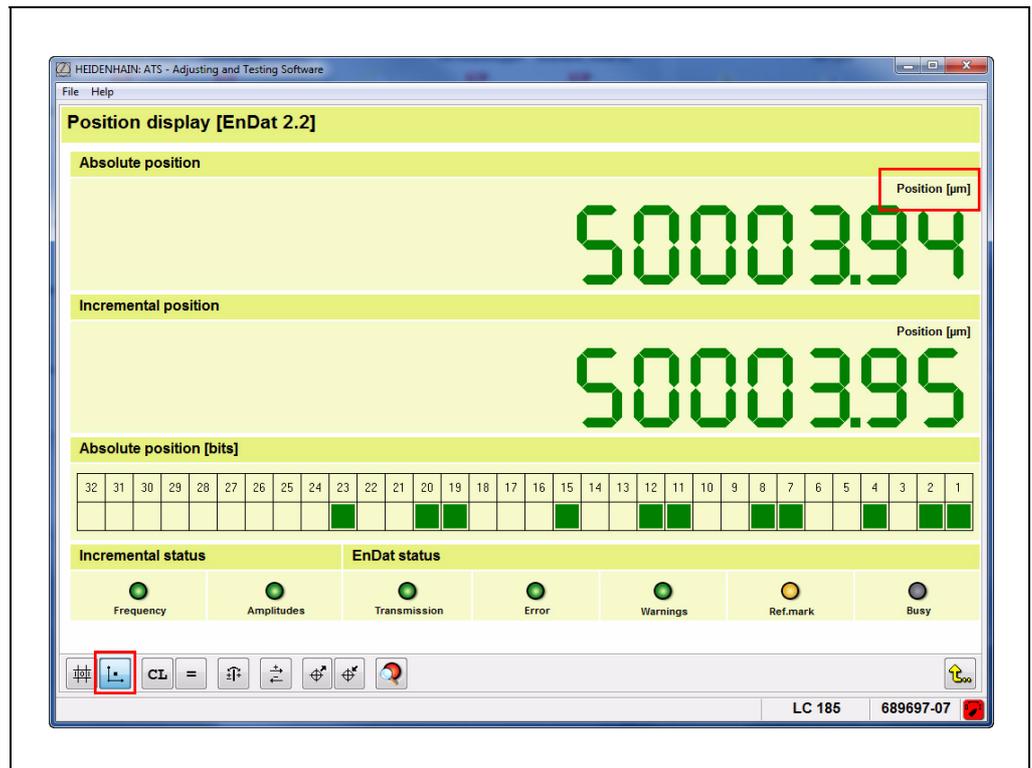
If the specified value is not reached during the position inspection, the LC is not functional!

Example: LC with 5 nm resolution



Scale offset with position display in [μm]:

Value 50 000; tolerance ± 1000



7 Functional check

7.1 General information

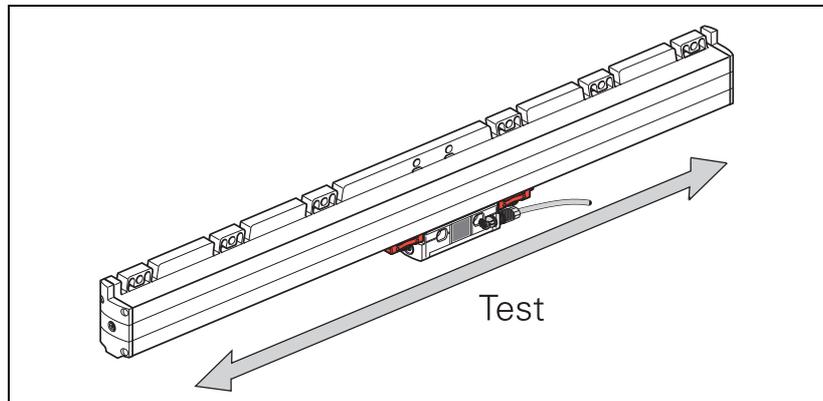
After programming the Service scanning unit of the LC linear encoder, run a functional test with the PWM 20.

- The scanning unit must traverse the entire measuring range. No warnings or alarms may occur (if there are any: delete them and inspect the measuring range again.)
- Check the OEM memory areas and reset all values to zero, if necessary. (You may have to load the data of the original scanning unit).
- Check the beginning of measurement.
- Check the zero point. The LC must on no account reach the zero point. Reset the zero point!
- The analog output signals must be within the prescribed tolerance limits.
- Check the functional reserve with the help of the online diagnosis [open loop].
In the bar diagrams, the markers should be in the area to the right, between 50 % and 100 %.

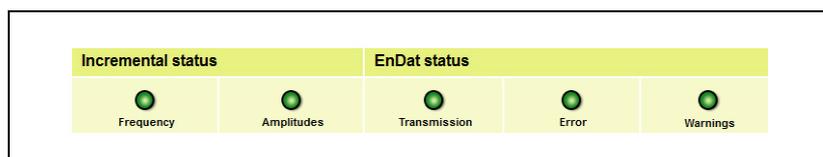


Note

The functions are described in the User's Manual "ATS-Software", ID 543734-xx.



No alarms or warnings may be generated. The LED displays must be "green" for the incremental and the EnDat status!



Note

Always use the transportation lock or a suitable traversing device when you move the scanning unit. This avoids mechanical damage inside the scale unit.
Mount the LC to the machine according to the mounting instructions.
Observe the mounting dimensions and tolerances!

8 Contact

Your HEIDENHAIN helpline

The qualified, multilingual specialists of the **HEIDENHAIN helpline** in Traunreut support you in solving your problems.

Especially if you need **technical support** the HEIDENHAIN helpline team can provide detailed advice and information on measuring systems, controls, and NC and PLC programming.

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