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AUTOMATION GMBH

ES-ITD

power semiconductor relay – current driver – solenoid valve driver
actuation and diagnostics for switching solenoid valves

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AUTOMATION GMBH
ES-ITD

1 History

Version	Date	Modification
2.10	23.12.2015	1. edition in english language

These operating instructions apply to devices with software versions 2.10 to 2.19 and hardware versions F 1.00 to F 1.09.

The version numbers are shown on the device in display C/5, see *3.2* on page *5*.

The clickable links in the **PDF file** of this document, which lead to more details/information in the document or to the Internet, are in italics and underlined.

The *ES-ITD* device uses the real-time operating system FreeRTOS, vers. 7.1.1; detailed information and the source code can be found on the *www.FreeRTOS.org* internet site.

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2 Features

- Rated supply voltage: 24V–48V DC, -5% / +25%
- Rated load current: 0.05A–3A DC (see section *8 Installation conditions*, page *12*)
- Power semiconductor relay to drive solenoid switch valves, not for proportional valves
- Suitable for use in IT supply systems
- After the load has been switched on, power is reduced to a configurable holding value
- Cable break and short-circuit monitoring at load output, in both actuated and unactuated state
- Solenoid valve diagnostics with no other sensors, e.g. end position, activation time and armature sticking
- Galvanically isolated indicator outputs for actuated load, warnings and errors
- Switching-cycle counter for load
- Operating-hour counter for *ES-ITD*
- Small plain-text display, 4 lines of 8 characters, selection of the display language
- Device measurements max. 111.4 x 22.5 x 124.5mm³ (see *page 10*),
  Mounting on IEC/EN 60 715 top-hat rail

3 Operation

When the ES-ITD is switched on, the start display appears on the screen. If an error or a warning is currently present, this message appears in place of the start display. Pressing the ◄ cursor button acknowledges the message; the display changes to the basic display of *warning messages* or *error messages* as applicable. The amber or red LED changes to a continuous light if the message is still there; otherwise it switches off (see section *Warning and error messages, page 9*). In case of diagnostics values for the armature movement, the LED switches off immediately after the acknowledgement and starts flashing again if the error or warning occurs again at the next actuation.

After switching on, the display screen remains bright for 5 minutes then dims if no button is pressed during this time. After the final keystroke, the screen remains bright for 5 minutes. When the screen is dimmed, pressing any button only increases the brightness; a further keystroke is required to perform the corresponding function.

The display layout is shown in Figure *3.1*; the operator switches to the different displays with the corresponding cursor buttons.

Because of the buttons' small size, they are equipped with operating aids: the central OK button has a raised outer edge, while the four cursor buttons each have a small dome in the middle. These acts as guides for a ballpoint pen with a retracted tip. Avoid using sharp-edged objects, such as a screwdriver blade, as these can damage the buttons.

Figure 3.1: Operating the buttons with a ballpoint pen with retracted tip.

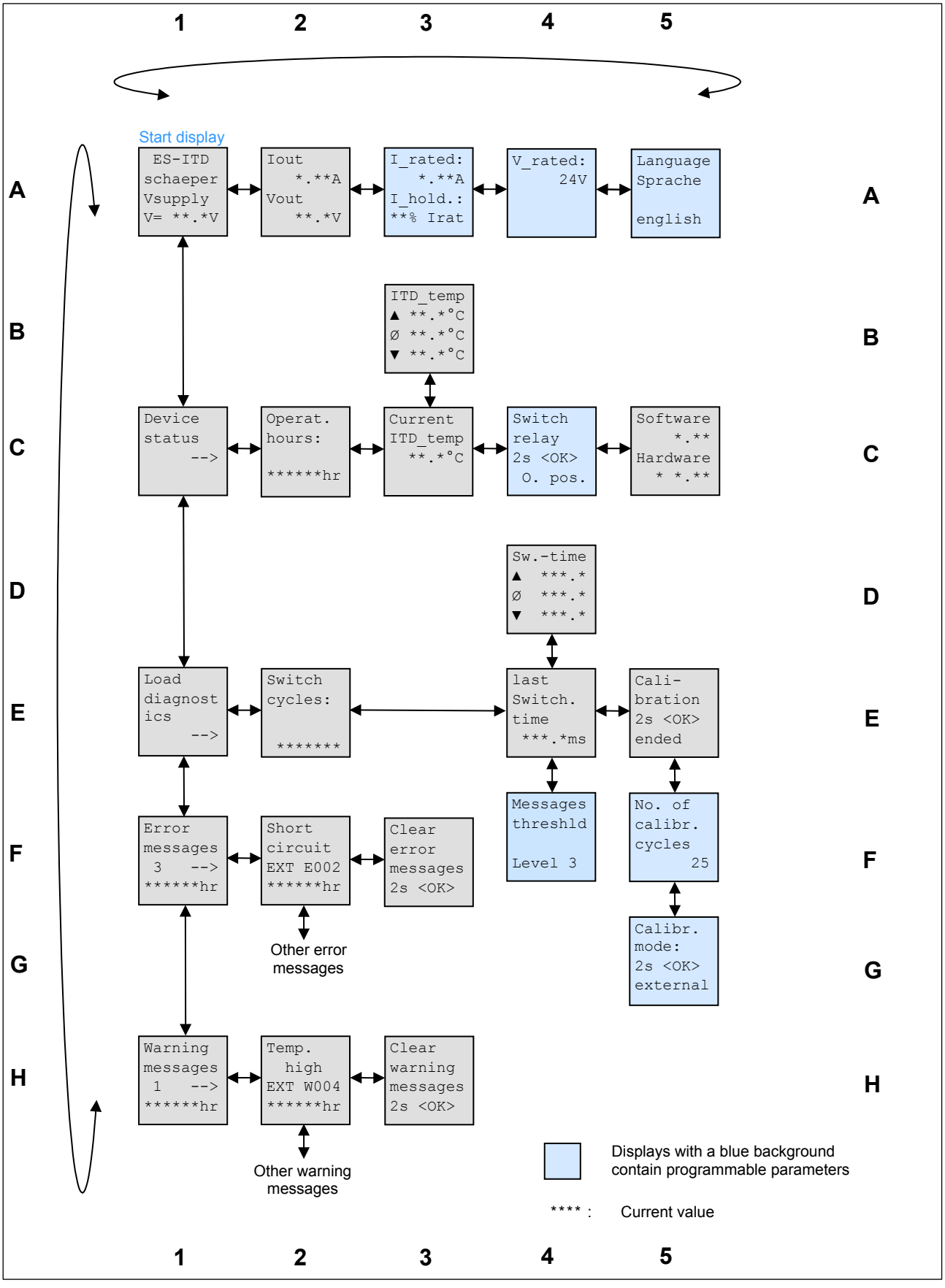


Figure 3.2: Display sequence
Displays referenced using the coordinates on the edges, e.g. *A/3* =

```
I_rated:
   *.**A
I_hold.:
**% Irat
```

4 Functions

When the ES-ITD is switched on, the start display appears on the screen. If an error or a warning is currently present, this message appears in place of the start display. After switching on, the display screen remains bright for 5 minutes (up to and including software version 1.80, for 1 minute) and then dimmed if no button is pressed during this time. After the final keystroke, the screen remains bright for 5 minutes

4.1 Selection of the display language

By pushing the cursor button ◄ there is a change from the start display to the display for selection of the language. According to section *5 Programming parameters*, *page 8*, can be choosed between english and german (deutsch). However in this display the programmable position corresponds to the whole name of the language.

4.2 Actuating the load

Before the load can be correctly actuated, the load's rated current must be programmed. To do this, come out of the start display and go to the **I_rated:** display by pressing the ► cursor button twice. Here, programme the load's rated current as described in the section *Programming parameters*, *page 8*. The percentage for the holding current can generally be kept at the factory setting of 60%.

In the load's unactuated state, every 10s a short, low-voltage pulse (approx. 300ms) is switched to the load. This does not cause any movement in the solenoid valve's armature, but can be detected by a short, weak flash in any LED present in the socket. This pulse serves to determine the load resistance and to detect a possible short circuit in the load circuit even when the load is switched off. The circuit is permanently monitored for any cable breaks whether the load is on or off.

To actuate the load, a voltage signal is applied to terminals 13 and 14 as described in the section *Technical data*, *page 17*. The load output is switched on with a delay of max. 3ms after the actuation signal, as long as no error message prevents this. When an actuation signal is applied to terminals 13 and 14, the green *Load on LED* lights up and the *actuation indication* transistor output (terminals 15 and 16) is switched to conductive state, if the solenoid valve has been correctly activated. The *actuation indication* output is switched to conductive state max. 4ms after an actuation signal has been applied, and closed again once the actuation signal is switched off. If an error is detected that prevents the solenoid from being activated, the *actuation signal* output is turned off and the green *Load on* LED continues to flash until the actuation signal is switched off.

If the supply and actuation voltage are both activated simultaneously, the load is **not** switched on and the green *Load on* LED flashes. The actuation voltage must be switched off and back on, but no earlier than 200ms after the supply voltage has been activated; only then can the load be switched on.

For diagnostics purposes, when switched on, a constant voltage is applied to the load. The *ES-ITD* calculates this voltage from the programmed rated current for the load and the load resistance detected during the calibration process, to ensure the solenoid valve is safely switched on in accordance with its rated values. Since the load resistance calculated during the calibration process also includes the resistance on the lead from the *ES-ITD* to the load, the load is switched on with sufficient voltage even with a long lead, as long as a sufficiently high supply voltage is available.

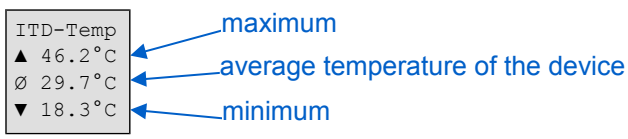
If the supply voltage is too low to be able to actuate the load with the necessary voltage, a warning message is displayed.

Approx. 300ms after the load has been actuated, the device switches to current control and the current is adjusted down to the programmed holding current. This significantly reduces the solenoid's temperature and increases its service life.

4.3 Device status

From the basic display of **Device status** (see *3.2*), the ◄ cursor button takes you to the display of the software and hardware version, and the ► cursor button to the display of the *ES-ITD*'s operating hours. The next display on the right is the device's current temperature; here, pressing the ▲ or ▼ cursor button takes you to the max., average and min. temperatures.

Display example:



4.4 Load diagnostics

From the basic display of **Load diagnostics** (see 3.2) the ◄ cursor button takes you to the displays for the calibration process. These are used to diagnose some of the load's characteristic values for a solenoid valve (for example), in order to be able to identify any errors and faults on the load.

The scope of the load diagnostics and the meaning of the measured values are detailed in the section *Diagnostics, page 14*.

4.4.1 Preparation and procedure of a calibration process

Before the start of a calibration process, the solenoid's rated current and voltage must be programmed.

Because the response times / cycle times depend on the medium's viscosity and differential pressure, the calibration process must be carried out under the anticipated operating conditions, to avoid false warning messages. You also need to bear in mind that viscosity increases with low average temperatures.

In the **Calibr. mode** display, load actuation during the calibration process has to be programmed to external or internal. In the external mode, the load must be actuated via terminals 13, 14; in the internal mode the load is automatically actuated every 10s until the calibration process has been completed.

The **No. of calibr. cycles** display is used to programme the required number of times the load must be actuated for the complete calibration process. The first actuation must last up to 30s, the next ones up to 2s; the cycle counter in the **Calibration** display only increases when the actuation lasted long enough to successfully determine the solenoid valve's characteristic values. When the calibration mode is set to *internal*, the calibration process lasts (*number of calibration cycles x 10s + max. 30s)*.

The calibration process is started by pressing the central *OK* button for at least 2s: the last line now displays **000/010**, for instance, e.g. the next time the load is actuated the first of a total of 10 calibration processes will be started. When the calibration process has been concluded, the message **ended** is displayed.

Once the calibration process has started, firstly the load's electrical resistance (including the lead's resistance) is measured on the terminals 3 and 4, and this is used, together with the load's programmed rated current, to calculate the actuation voltage needed to switch on. Next the load is actuated according to the programmed number of calibration cycles. During this, further characteristic values are calculated for later diagnostics. When the load is actuated externally, it must be switched on for up to 30s the first time it is actuated, then for up to 2s during the following times, to ensure that the reference values can be calculated for the end position detection. When the load is actuated internally, it is only switched off once the end position has been successfully detected.

If, when starting the calibration process, a state is detected that prevents the correct measurement of the load resistance, e.g. pending actuation signal, cable break, short circuit, no load connected, or the output relay is in rest position, the calibration process is cancelled and the last line of the **Calibration** display shows the value **disabled**. The solenoid valve's stored characteristic values are not changed, and the last **disabled** state is saved until a new calibration process is started.

If, after the calibration process has started, errors occur when measuring the load resistance or determining the armature movement, the calibration process is also interrupted and the last line of the **Calibration** display shows the value **error**. The solenoid valve's stored characteristic values are not changed, and the last **error** state is saved until a new calibration process is started. In addition, the red error LED lights up and the error message **Calibr. error** appears on the display. The red error LED goes out after you change back to the **Calibration** display and start a new, successful calibration process.

A new calibration process can be started by pressing the central *OK* button for at least 2s.

If the supply voltage to the *ES-ITD* is turned off during an ongoing calibration process, the calibration process will resume from the point of interruption when the voltage returns.

4.5 Use in IT supply networks

The *ES-ITD* is designed in such a way that the attached solenoid valve cannot be switched on either accidentally or deliberately in floating IT supply networks if a double, low-resistance insulation fault occurs. If the double fault occurs during actuation, the solenoid valve is switched off, the green *Load on* LED flashes and the indicator outputs *Actuation (load on)* and *Error* are turned off (non conductive).

Depending on the type of double fault, the device displays various warning or error messages, e.g. **Insulat. error**, **Short circuit**, **Load output off** or **Cable break**.

5 Programming parameters

The following parameters can be programmed:

Parameter	Value range	Description
`I_rated`	0.05–3.0A	Rated current of solenoid valve (load)
`I_hold.`	50–67%	Holding current of solenoid valve as percentage of Rated *I*
`V_rated`	12–24V	Rated voltage of solenoid valve (load)
`Message threshld`	Level 1–7	Threshold for displaying a warning message or switching off the mechanical diagnostics (see *10.1* on p. *15*)
`Switch relay`	O. pos., R. pos.	State of output relay for two-pole load separation: Operating position or Rest position
`No. of calibr. cycles`	5–999	Number of load switch cycles for the calibration process
`Calibr. mode`	external, internal	Load actuation during the calibration process external: load actuated from control input internal: load activated automatically by *ES-ITD* at 10s intervals
`Language Sprache`	english, deutsch	Selection of the display language

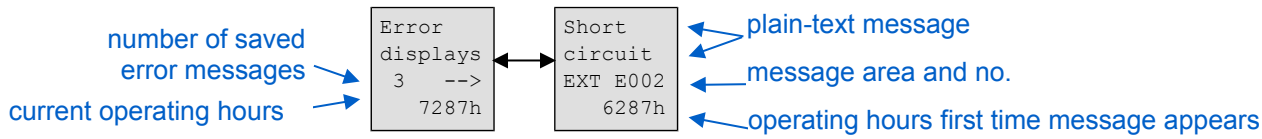
The parameters `Switch relay` and `Calibr. mode` each have only two states and are switched between those states by pressing the central *OK* button for at least 2s. The new states are permanently stored in the *ES-ITD* until they are next reprogrammed and are therefore still effective after the *ES-ITD* has been switched off and back on again.

The other parameters are numerical values. To reprogramme them, initiate the programming mode by simultaneously pressing the ◄ and ► cursor buttons. A flashing underscore appears under the first programmable position of a parameter. You can change the programmable position by using the ◄ and ► cursor buttons within a parameter and the ▲ and ▼ cursor buttons to move to other parameters in the same display. If the parameter position you want to edit is underlined, you can release it for adjustment by pressing the central *OK* button. This displays the editable position in reverse. The position is changed using the ▲ (+) and ▼ (-) cursor buttons. When the desired value is reached, pressing the central *OK* button terminates editing, and the underscore is displayed again. Then other positions or parameters can be changed in the same way; the decimal point will be skipped. Complete programming and permanently save the changed parameters in the same way as you initiated the programming mode, by simultaneously pressing the ◄ and ► cursor buttons, so that the flashing underscore disappears again.

6 Warning and error messages

If warnings or errors appear, the amber or red LED lights up for at least 1s, and after max. 1s the corresponding message is displayed. Simultaneously, the transistor output *warning* (terminals 9 and 10) or *error* (terminals 11 and 12) switches to closed state (closed-circuit principle).

New messages are shown in the display panel on the device as in the display on the right in the following example:



The basic message displays (on the left in the example) indicate whether there are already any saved messages. You can use the current indication of operating hours to estimate when messages have occurred. In the above example, the error message of short circuit occurred after 6287h of *ES-ITD* operation; the *ES-ITD* device has currently been operating for 7287h, so the error occurred 1000 operating hours earlier.

If the ► cursor button is pressed in a basic message display, the last saved message is displayed. The last line shows the number of hours the *ES-ITD* had been in operation at the time this message first occurred. If this message occurs again later, with no other message occurring in the meantime, the amber or red LED lights up for at least 1s and the old message is displayed with the original indication of operating hours. Pressing the ▲ cursor button displays the immediately preceding messages. The ▼ cursor button takes you directly from the display of the most recent message to the oldest message.

The plain-text message may also read **`Warning message`** or **`Error message`**, especially if the message does not stem from the **`EXT`** area.

Warning and error messages are listed in the section *List of warning and error numbers, page 18*.

Some messages may be displayed for longer because the related measurements only take place at relatively long intervals. For example, if the armature's mechanical movement is impermissibly delayed, the amber LED stays on to indicate a still-existing warning message even once the message has been accepted. The amber LED only goes out once an actuation of the solenoid valve has returned a valid value for the armature's movement time. If an impermissible value is measured with the renewed actuation, the amber LED continues to stay on.

6.1 Clearing the message memory

The messages remain stored until you explicitly delete them. When the message memory is full (10 messages), the oldest message is overwritten with each new message.

To clear the error messages, go to the **`Clear error messages`** display and start the delete process by pressing the central *OK* button for at least 2s. This always deletes all the stored messages. When all stored error messages are deleted, the screen shows the basic error display with the number of messages as "0", and the red LED is off. A corresponding procedure applies to deleting the stored warning messages.

If a message memory is cleared while a message is still present (the corresponding LED is continuously lit), the LED goes out briefly then comes back on again, and the message reappears on the screen.

7 Connections

Connections

1	+ Vs, supply voltage
2	- Vs, supply voltage
3	+ Load (galv. connected to Vs)
4	- Load (galv. connected to Vs)
5	(not connected)
6	(not connected)
7	+ Meas. output, voltage output for load current
8	- Meas. output, voltage output for load current (1V/A, internal resistance 20kΩ, cable lenght < 3m)
9	+ Vi, indication voltage (galv. isolated to Vs, Va)
10	warning indicator (galv. isolated to Vs, Va)
11	internally connected to terminal 9
12	error indicator (galv. isolated to Vs, Va)
13	+ Va, actuation voltage (galv. isolated to Vs, Vi)
14	- Va, actuation voltage (galv. isolated to Vs, Vi)
15	internally connected to terminal 14
16	actuation indicator (galv. isolated to Vs, Va) (Load on)

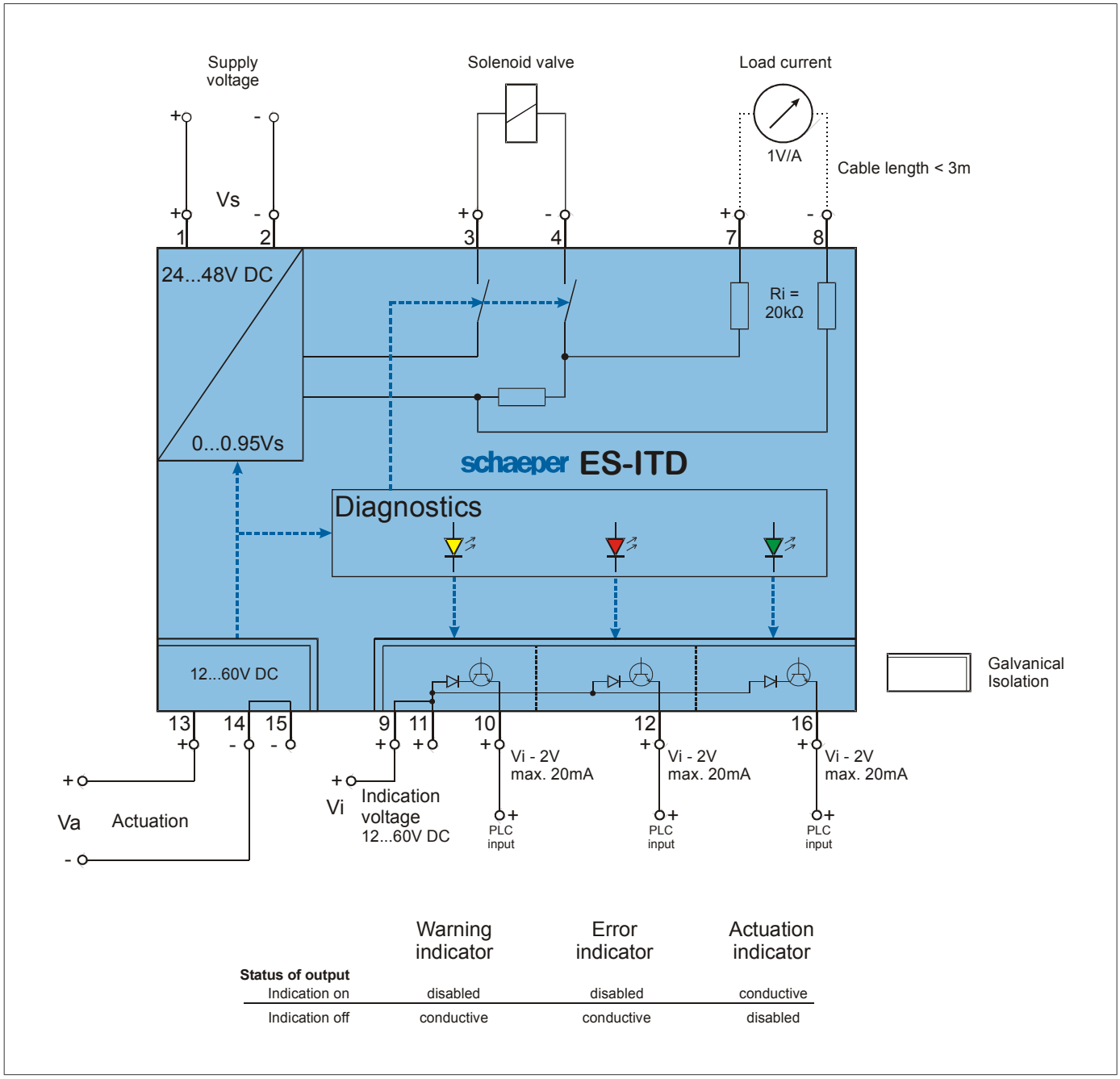
Terminals 9 & 11, pos. indication voltage, are internally connected.
Terminals 14 & 15, neg. indication voltage, are internally connected.

Dimensions

W	22,5mm	
H	fixed screw terminals:	90,0mm
	plug-in screw terminals:	103,6mm
	plug-in spring-loaded terminals:	111,4mm
D	124,5mm (depth)	

Connection example see next page.

Figure 7.1: Removing plug-in terminals
In device versions with plug-in terminals, these can be removed with the aid of a screwdriver.



Status of output	Warning indicator	Error indicator	Actuation indicator
Indication on	disabled	disabled	conductive
Indication off	conductive	conductive	disabled

Figure 7.3: connection example

Technical data see section *12*, *page 17*.

8 Installation conditions

For temperature reasons, the *ES-ITD* may only be installed vertically. The following table gives the permissible activation times depending on the supply voltage, the holding current and the distance from neighbouring installations, with an ambient temperature of max. 50°C.

The value for d_{le} represents the distance to the left, and d_{ri} the distance to the right of the *ES-ITD* housing. If multiple *ES-ITD* devices are installed side-by-side, it is thermally preferable not to simultaneously actuate devices that are directly adjacent.

max. U_{in} [V]	**max. $I_{holding}$ [A]** d_{le} = 0mm d_{ri} = 0mm	d_{le} = 0mm d_{ri} ≥ 5mm	d_{le} ≥ 5mm d_{ri} ≥ 5mm	**max. on / min. off time** (at max. ambient temperature 50°C)
60	0.3	0.6	0.6	Unlimited / 0s
48	0.4	0.8	0.9	
36	0.6	1.2	1.3	
24	1.1	2.0	2.0	
60	1.8	2.0	2.0	10s / 50s
48	2.0	2.0	2.0	
36	2.0	2.0	2.0	
24	2.0	2.0	2.0	
60	0.8	1.2	1.2	30s / 30s
48	1.1	1.7	1.8	
36	1.6	2.0	2.0	
24	2.0	2.0	2.0	
60	1.2	1.3	1.4	30s / 60s
48	1.7	2.0	2.0	
36	2.0	2.0	2.0	
24	2.0	2.0	2.0	
60	0.7	1.1	1.1	120s / 120s
48	1.0	1.6	1.6	
36	1.4	2.0	2.0	
24	1.8	2.0	2.0	

Table 8.1: Permissible holding current for selected on/off times under different installation conditions.

9 Commissioning

The following are step-by-step instructions on how start using the *ES-ITD* solenoid actuation system.
The following steps must be carried out in the given order to avoid malfunction.

1. First you must make a sufficiently high supply voltage available. It should be at least as high as the sum of the solenoid's rated voltage and the voltage drop caused by the coil current on the lead's resistance. The *ES-ITD* drops a higher supply voltage to the required level. The supply voltage is connected on the terminals 1 (+) and 2 (-).

   Example: The solenoid's rated voltage is 24V. The lead is 200m long and has a cross-section of 1.0mm^2. With a conductor resistance of 20Ω/km, the lead has a total resistance of 8Ω, producing a voltage drop of 10V with a rated current of 1.25A. The supply voltage should be at least 34V.

2. Now you need to change to the display screen for the rated current (display *A/3* in 3.2) and programme the solenoid valve's rated current, as described in the section *5 Programming parameters* (p. *8*).

   3
   A
   ```
   I_rated:
      1.25A
   I_hold.:
   60% Irat
   ```

3. Next, programme the solenoid valve's rated voltage in display *A/4*.

   A
   ```
   V_rated:
        24V
   ```

4. Use the ► button to go to the basic display *A/1*, press the ▼ button twice to go to display *E/1* for the load diagnostics, the ◄ button to go to display *E/5* for calibration and the ▲ button to go to display *G/5* for the calibration mode. Switch between *external* and *internal* by pressing the *OK* button for 2s.
   In the *internal* mode, the ES-ITD actuates the load automatically every 10s until the calibration process has been completed. In the external mode, the load must be switched on for at least 30s during the first actuation and for at least 2s during the following actuations, with a signal to the terminals 13 and 14, and be turned off for at least 200ms. This on/off cycle must be repeated as often as necessary until the calibration process has been completed.

   5
   G
   ```
   Calibr.
   mode:
   2s <OK>
   external
   ```

5. Go back to display *E/5* with the ▼ button to start the calibration process. Press the *OK* button to start calibration; the number of calibration cycles already carried out and the total number of calibration cycles to be carried out are displayed.
   If, in an actuation cycle, the characteristic values for later diagnostics could not be determined correctly, the number of calibration cycles carried out is not increased. A possible cause can be a too-short on or off time.
   Once all the calibration cycles have been performed, the last line of the display shows the message "ended".

   5
   E
   ```
   Cali-
   bration
   2s <OK>
   001/010
   ```

   5
   E
   ```
   Cali-
   bration
   2s <OK>
   ended
   ```

(Display coordinates, see p. 5)

The *ES-ITD* is now ready for use.

10 Diagnostics

Fault diagnostics are carried out solely via the two wires that actuate the solenoid valve. No other sensors or lines are required. This means that it is also very simple to retrofit solenoid-valve diagnostics into existing installations.

10.1 Electrical

10.1.1 Short circuit on load output

If a short circuit is detected, the output is switched off and a warning message is displayed. Thereafter the load is checked once a second to test whether the short circuit persists. If the short circuit lasts more than 5s, an error message is displayed, the red error LED lights up for 1s and the output relay opens its contacts (`R. pos.`, rest position), so that the load is galvanically isolated from the *ES-ITD* on both poles. Once the short circuit has been rectified, you must go to the `Switch relay` display then press the central *OK* button for 2s to switch the output relay back into the operating position (`O. pos.`).

To switch off the amber warning LED indicating that the output relay is in the rest position, the relay must be switched back to the operating position (`O. pos.`) in the `Switch relay` display. If you navigate away from the warning display `relay rest pos.` with the ◄ button, the screen automatically changes to the `Switch relay` display.

Even when the load is not being actuated, a short circuit is detected by the short measuring pulse (see section *Actuating the load*, *page 6*) that is switched to the output every 10s.

Valve connectors with a **built-in free-wheeling diode** form a short circuit if the connector is not connected to the *ES-ITD* output with correct polarity, and therefore produce a corresponding warning and error message.

10.1.2 Cable break on the load output

The load circuit is permanently monitored for a cable break in both the actuated and unactuated state and if one found an error message is displayed. The red error LED indicating the cable break goes out as soon as the cable break has been rectified.

10.1.3 No load on output

If a valve connector **with a built-in LED** is incorrectly plugged to the solenoid valve and there is therefore no electrical contact to the solenoid, this is detected, when the load is not actuated, by the short measuring pulse (see section *Actuating the load*, *page 6*) that is switched to the output every 10s and the fault is indicated with the error message `No load`. Valve connectors with no built-in LED cause a cable break to be reported!

10.1.4 Under or over voltage on the supply voltage input

If the supply voltage drops below approx. 22.8V, the warning message `Vsupply low` is displayed. Because of the resistance of long leads to the solenoid, a higher voltage than the solenoid's rated voltage may be necessary for correct actuation. As a result, the device also checks whether this higher voltage is available as the supply voltage. If the supply voltage is lower than the voltage required to actuate the solenoid valve, the error message `Vsupply < Vload` is displayed, but it is still possible to actuate the load. In case of leads with greater resistance, the necessary supply voltage increases accordingly; this is taken into account by measuring the total load resistance on the *ES-ITD* output.

From a supply voltage of approx. >60V the **warning** message `Vsupply high` is displayed (it is still possible to actuate the load); from approx. >62V the **error** message `Vsupply too high` appears, and the *ES-ITD* disables load actuation.

10.1.5 Switching-cycle counter

The load's power-on events are counted and displayed on the `Switching cycles:` screen. This value is set to zero at the start of a calibration process, as calibration is typically only carried out after a new solenoid valve has been connected. The counter is only incremented if at least 50% of the rated current has flowed at power-on: i.e. in case of a cable break or if the solenoid valve is not plugged in, the power-on event triggered by an external actuation signal is not counted.

10.1.6 Operating-hour counter

Here the *ES-ITD*'s operating time is measured and shown in the `Operating hours:` display. This value is also shown on the `Error messages` and `Warning messages` screens, to enable the saved errors to be classified chronologically.
The load's operating hours are not measured.

10.2 Mechanical

10.2.1 Armature stuck

If, during actuation, the armature in the solenoid does not move or moves too slowly, i.e. takes more than approx. 300ms to arrive in the operating position, the error message **armature stuck** is displayed.

10.2.2 Armature moves too fast or too slow

During calibration, max. and min. values for the armature's activation time are measured and saved. These values serve as a reference for the permissible range of activation times. If current readings exceed or fall below these reference values by an adjustable threshold, then, depending on the size and frequency of the deviation, a warning message is displayed. Possible reasons for this are listed in the section *List of warning and error numbers, page 18*.

The adjustable threshold for the generation of a warning message means that the system can be better adapted to different spreads of measurement values for different solenoid valves and operating conditions. The adjustment is made in stages, so the generation of a warning message can also be completely suppressed when activation times are too high. A message about an error in the armature's end position can also be suppressed.

The warning message **Armature fast** is displayed if the time is at least 40% below the min. reference value. The warning message **Armature slow** is displayed if the max. reference value is exceeded by at least 4 times the threshold value corresponding to the programmed level in the **Reporting threshold** display (see display *F/4*, page 5). These overruns are totalled for all actuations occurring in immediate succession for which the current measured value for activation time exceeds the applicable threshold. If the threshold is not exceeded in an actuation, the total reached by then is reset to zero. If the total exceeds 4 times the threshold value, the warning message **Armature slow** is displayed. With this procedure, significant overruns of the threshold value are displayed more quickly than minor ones.

Examples:
The current measured value exceeds the max. reference value four times in immediate succession by the following percentages: 22%, 24%, 21% and 22% → the total is equal to 89%, which is higher than 4 times the threshold value for level 1 – 80% – so after the fourth actuation the warning message is produced.

With percentages of 44% and 38%, the total is already greater than 80% after the second actuation, so the warning message is displayed at this point.

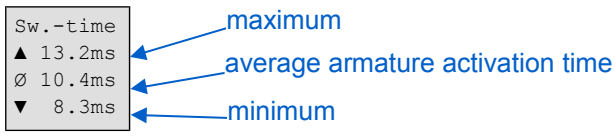
With percentages of 24%, 21% and 15%, the total is set to zero after the third actuation, so the calculation process now starts all over again.

Level	Threshold
1	20%
2	35%
3	50%
4	70%
5	100%
6	No message if the activation time is too great
7	Also no message of an end position error

Table 10.1: Adjustable levels and associated thresholds for warning messages in case of an armature movement that is too slow

The **Sw.-time** display in the load diagnostics display area shows the maximum, average and minimum values for the armature switching time since the last calibration process. The values shown here indicate the time taken from the start of the increase in the load current to when the armature reaches its end position.

Display example:



Because the response times / cycle times depend on the medium's viscosity and differential pressure, the calibration process must be carried out under the anticipated operating conditions, to avoid false warning messages. You also need to bear in mind that viscosity increases with very low average temperatures.

10.2.3 Armature does not reach the end position

After switching on, once the current through the solenoid valve has been reduced to the holding current, a gauging alternating current is temporarily overlaid on the output voltage. The amplitude and phase shift of the alternating voltage and current are evaluated to calculate the armature's position. The necessary characteristic values for this monitoring are determined during the calibration process. If the armature did not reach the mechanical end position in the actuated state, the error message **`End position error`** is produced.

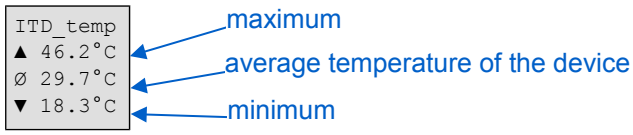
Depending on the valve, monitoring for the arrival in the end position in the actuated state requires a minimum power-on time of up to 2s.

10.3 Thermal

10.3.1 Monitoring the temperature in the ES-ITD

The internal temperature of the *ES-ITD* is measured continuously, and the current value is shown in the **`Current ITD_temp:`** display in the device status display area. The **`ITD_temp`** display shows the maximum, average and minimum values for the internal temperature.

Display example:



If the internal temperature exceeds 85°C, the warning message **`ITD_temp high`** is displayed; if it exceeds 90°C, the error message **`ITD_temp too high`** is displayed – it is still possible to actuate the solenoid, however.

11 Ordering information

Item no.	Description
EITD-3DA/P/F	Solenoid valve actuation for load with 0.05–3A rated current, with measurement of armature end position in actuated state, connections: permanent screw terminals
EITD-3DA/S/F	Solenoid valve actuation for load with 0.05–3A rated current, with measurement of armature end position in actuated state, connections: plug-in screw terminals
EITD-3DA/F/F	Solenoid valve actuation for load with 0.05–3A rated current, with measurement of armature end position in actuated state, connections: plug-in spring terminals

12 Technical data

Power supply terminals 1(+) and 2(-)	Rated voltage range 24–48V DC (-5% / +25%), Own consumption approx. 0.6W without actuating the load, up to approx. 6W when load actuated
Load output terminals 3(+) and 4(-)	For solenoid valve rated current of 0.05A to 3.0A, after armature activation, reduction to adjustable, controlled holding current
Actuation input terminals 13(+) and 14(-)	Galvanically isolated from load output and from indicator outputs (protected against reverse polarity) Power on: 12– 60V DC Power off: 0– 5V DC
Indicator outputs for load on, warning, error	Galvanically isolated, max. 60V DC/20mA (disabled in case of reverse polarity) Transistor outputs max. 2V voltage drop with conductive output max. 50µA output current with disabled output
Meas. output terminals 7(+) and 8(-)	1V/A to measure load current, internal resistance 20kΩ, permissible cable length < 3m
Load diagnostics	
Cable break	permanent monitoring
Short circuit	permanent monitoring during actuation without actuation, monitoring every 10s
Armature activation time	up to max. 300ms, measurement only in actuation times > 300ms
Armature end position (activated)	max. measurement error 0.5mm, measurement only during activation times ≥ 2s (depending on solenoid valve)
Temperature	Operation: -20–+50°C, Condensation not permitted storage: -40–+85°C
Connections	Permanent screw terminals: 1 x 0.5–2.5mm² 2 x 0.5–1.5mm² (with dual wire ferrule) strip/sleeve length 8mm
	Plug-in screw terminals: 1 x 0,5–2.5mm² 2 x 0.5–1.0mm² (with dual wire ferrule) strip/sleeve length 8mm
	Plug-in spring terminals: 1 x 2.5mm² with wire ferrule 2 x 0.5–1.5mm² (with dual wire ferrule) strip/sleeve length 12mm
EMC directive: CE	2014/30/EU *Interference:* Meets requirements of EN 61326-1:2013 (Industrial sector, class A) There may be electromagnetic interference when used in residential sectors. *Immunity:* Meets requirements of EN 61326-1:2013 (Industrial sector, class A)
Installation	Can be snapped onto top-hat rail according to DIN EN 60715
Dimensions	W: 22.5mm, D: 124.5mm (inc. front panel buttons) H: 90.0 mm (fixed screw terminals) H:103.6mm (plug-in screw terminals) H: 111.4mm (plug-in spring-loaded terminals)
Weight	approx. 100g

Subject to change

13 List of warning and error numbers

The following areas exist for warning and error messages:

ROS Real-time operating system

INI Initialisation

MEM Memory areas (EEPROM, FLASH)

SYS System

APP Application

EXT External areas (over/undervoltage, short circuit, cable break, diagnostics etc.)

I2C I^2C interface

Only the areas **APP** and **EXT**, together with a few from the **MEM**, indicate important information for users of the *ES-ITD* device; messages from the other areas are only of interest to the manufacturer, although they could mean device malfunctions.

WARNING: Should messages from the other areas occur repeatedly or continuously, the device must be returned to the manufacturer for checking.

If a **short circuit** has lasted more than 5s, the internal relay is switched to the rest position so the load is galvanically isolated from the device on both poles. In addition, the warning message **Relay rest position** (**EXT W006**) is displayed.

Once the error has been resolved, the relay must first be switched back to the operating position in the `Switch relay` display (see 3.2) to switch off the error and warning messages.

13.1 Warning messages

Area: EXT External warnings		
Number	**Plain text** Description	Possible causes
W002	**Short circuit** Momentary short circuit in the load circuit.	- temporary short circuit in the lead to the solenoid - double insulation fault in the IT supply system
W003	**Vsupply low** Supply voltage for the device is low, < 22.8V.	
W004	**Vsupply high** Supply voltage for the device is high, > 60V.	
W005	**ITD_temp high** Device's internal temperature is high (> 85°C).	- poor thermal installation conditions for the *ES-ITD* (e.g. set up too close together) - ambient temperature too high - internal failure in the *ES-ITD*
W006	**Relay rest position** The internal relay for galvanic isolation of load is in the rest position and has therefore isolated the load.	- manually switched to rest position - short circuit lasting more than 5s
W007	**Armature slow** The solenoid valve's armature has moved too slowly.	- there is too much friction, e.g. due to heavy soiling or medium's viscosity too high

Area: EXT	External warnings	
Number	**Plain text** Description	Possible causes
W008	**Armature fast** The solenoid valve's armature has moved too quickly.	- armature spring broken
W00A	**Short circuit** Short circuit in the load circuit.	- short circuit in the load circuit - load resistance too low - double insulation fault in the IT supply system

13.2 Error messages

Area: EXT	External error (Error)	
Number	**Plain text** Description	Possible causes
E001	**Cable break** Cable break in the load circuit.	- cable break in lead to load - valve connector with no LED removed from solenoid - double insulation fault in the IT supply system
E002	**Short circ. > 5s** Short circuit in the load circuit lasting more than 5s.	- short circuit in lead to load - valve connector with free-wheeling diode connected with the wrong polarity - double insulation fault in the IT supply system
E003	**Load output off** Despite external actuation signal, the valve is not driven because of external or internal fault. The red LED goes out only after switching off the external actuation signal.	- Errors and warnings, which led to the shutdown of the load output, can already be eliminated (see messages in the error/warn memory.). - Double insulation fault in the IT supply network
E004	**Vsupply too high** Supply voltage for the device is too high (> 62V).	- voltage fluctuations too great
E005	**ITD_temp too high** Internal temperature of *ES-ITD* is too high (>90°C).	- poor thermal installation conditions for the *ES-ITD* (e.g. set up too close together) - ambient temperature too high - internal failure in the *ES-ITD*
E006	**No load** Load output resistance too high. Upcoming actuation signal is disabled and only released again after the fault has been rectified, and device has been switched off and actuated again.	- there is no solenoid valve connected to the valve connector, the only load present is the LED in the valve connector. - corroded connector contacts
E007	**Insulat. error** Double insulation fault in the IT system. Output voltage is too high.	- +Vsupply connected to load output due to double insulation fault in the IT supply network
E00C	**Vsupply < Vload** Supply voltage is too low for the programmed load current. Actuation still possible.	- supply voltage too low - resistance in load lead too high - load temperature too high - load's programmed rated current too high
E011	**End position error** The solenoid valve's armature has not reached its end position in actuated state.	- valve dirty
E012	**Armature stuck** The solenoid valve's armature has not moved.	- armature sticking, e.g. due to dirt or corrosion - armature missing

Area: APP	**Application error (Error)**	
Number	**Plain text** Description	Possible causes
E001	**Calibr. error** Error while measuring the load resistance at start of calibration process.	- cable break or short circuit at start of calibration process
E002	**Calibr. error** Error while measuring the armature movement during the calibration process.	- armature sticking - armature missing - no inductive load
E003	**Calibr. error** Error while measuring the armature movement during the calibration process.	- armature movement too small because supply voltage too low - armature's switching time too great (e.g. with a soft-shift solenoid valve)

Area: MEM	**Memory error (Error)**	
Number	**Plain text** Description	Possible causes / action
E002	**Error indication** Error while reading parameter data from the EEPROM.	- faulty EEPROM - strong external interference Action: check rated I, holding I, rated U, number of calibration cycles and calibration mode and reprogramme min. 1 parameter
E003	**Error indication** Error while reading data from the EEPROM.	- faulty EEPROM - strong external interference Action: reset relay position (see display *C/4*, *3.2* page *5*)
E007	**Error indication** Error while reading data on characteristic values from the EEPROM.	- faulty EEPROM - strong external interference Action: Switch device off and back on again; if error indication persists, recalibrate