Post Box 71 02 28
D-30542 Hannover
Kronsberger Straße 25
D-30559 Hannover

Fon +49(0)511 35 71 00 0
Fax +49(0)511 35 71 00 19
www.schaeper.com
info@schaeper.com

+ messen + steuern +
+ regeln ++ melden +

schaeper
AUTOMATION GMBH

ES-ITD

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

schaeper
AUTOMATION GMBH
ES-ITD

Version 2.41

BA_ITD_EN / 19.04.2022

1 History

Version	Date	Modification
2.41	19.04.2022	- Validity for hardware version G 1.00 to G 1.09 added. - Device display changed to LCD with backlighting. - Error messages are only displayed if the load can no longer be controlled, all other messages are warning messages. - Updated list of warning and error messages. - An internal switching transistor is monitored (error message SYS E003), as of software version 2.43.
2.30	08.06.2018	- Note on warning APP E004 added in section Commissioning. - Operating time counter for the load added, see Figure 4.2: Display sequence, page 6. - A second, selectable variant for the type of determination of the pick-up time has been added, e.g. to be able to evaluate valves with mechanical clearance between solenoid armature and armature. - If the supply voltage of the ES-ITD is switched off during calibration, the calibration is continued after switching on again (external mode) or the calibration display shows "aborted" and the warning message APP W002 is displayed (internal mode). - The minimum holding current is now adjustable from 20% of I_rated. - End position diagnosis on/off added, see Figure 4.2: Display sequence, page 6 and section 8.2.4, page 14. - Warning messages for short circuit and relay rest position changed to error messages. - Safety instructions (page 5) and technical data added. - Commissioning procedure changed and enhanced, see section 6, page 8.
2.10	23.12.2015	1. edition in english language

These operating instructions apply to devices with software versions 2.42 to 2.49 and hardware versions F 1.10 to F 1.19 as well as G 1.00 bis G 1.09.

The version numbers are shown on the device in display C/5, see *4.2* on page *6*.

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.

Table of contents

Table of images

2 Safety instructions

2.1 General information

These operating instructions must be read, understood and observed by all persons entrusted with assembly, installation, commissioning and plant operation.

This document must be kept in a complete and legible condition for future reference and made available to the named persons.

If you have any questions or require further information, please contact schaeper AUTOMATION GMBH.

2.2 Target group

These operating instructions apply to qualified personnel who work in the areas of system planning, assembly, installation, commissioning and system operation. Qualified personnel are persons who have knowledge and experience corresponding to their work and who are familiar with the applicable standards and regulations in order to assess the work to be performed and to recognize possible hazards.

2.3 Intended use

The device may only be used to control solenoid valves or linear solenoids within the voltage and current limits specified in the technical data (see section 13 Technical data, page 21).

In addition, the distances between several devices listed in section 11 Installation Conditions, page 20, and the permissible switch-on times corresponding to the electrical load must be observed.

Electrical installation:
The device may only be installed and connected by qualified personnel with knowledge and experience in the installation of electrical switchgear or by instructed persons under the supervision of a qualified person, observing the applicable accident prevention regulations, standards and directives.

Commissioning:
The device may only be put into operation by qualified personnel with knowledge and experience in the commissioning of electrical, hydraulic or pneumatic systems or by instructed personnel under the supervision of a qualified person, observing the applicable accident prevention regulations, standards and directives.

Maintenance and repair:
The device does not require any maintenance.

Defective devices may only be repaired by schaeper AUTOMATION GMBH.

2.4 Range of application

- The device may only be operated in commercial or industrial facilities.
- Operation in potentially explosive areas is prohibited.

Use in a polluted environment, especially with conductive soiling, is only permitted if the device is installed in an additional protective housing that reliably prevents soiling from entering the device.

2.5 Signal word

The signal word is used to identify actions that may result in hazards to persons.

Meaning of the signal word:

Warning: Danger with a medium degree of risk which, if not avoided, can result in death or serious injury.

Signal word
Nature and source of danger
Possible consequences of disregarding the remedy
➔ Measures to remedy the situation

In addition, the ATTENTION symbol without a signal word is also used for useful hints and tips.

3 Features

- Rated supply voltage: 24V–48V DC, -5% / +25%
- Rated load current: 0.05A–3A DC (see section *11 Installation conditions*, page *19*)
- 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 stateSolenoid valve diagnostics without additional 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-time counter for *ES-ITD* and activated load
- 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 17*),
  Mounting on IEC/EN 60 715 top-hat rail

4 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 16*). 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 *4.2*; 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 4.1: Operating the buttons with a ballpoint pen with retracted tip.

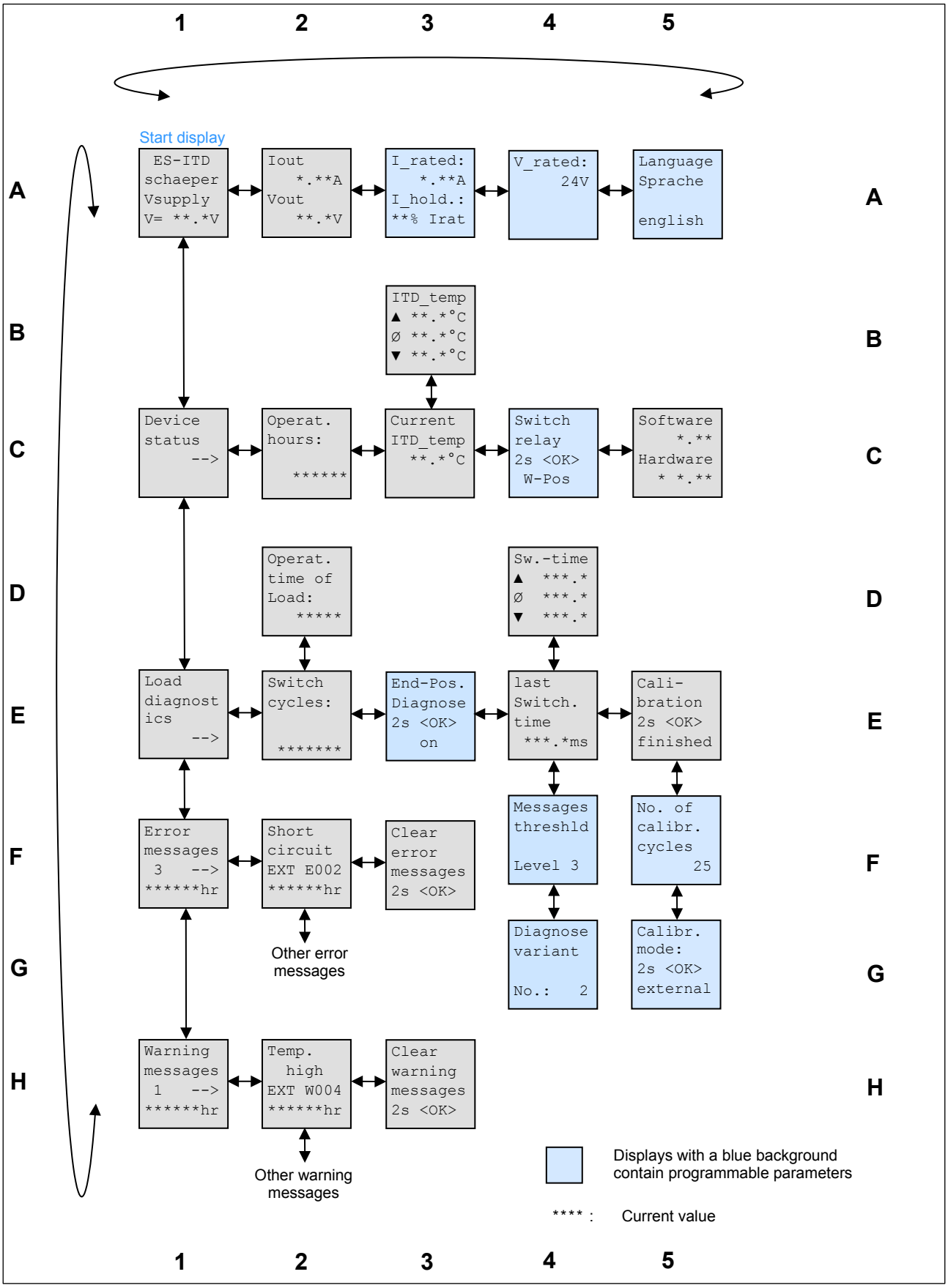


Figure 4.2: Display sequence
Displays referenced using the coordinates on the edges, e.g. *A/3* =

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

5 Programming parameters

The following parameters are programmable, the values of the factory setting are **bold and underlined**:

Parameter	Value range	Description
`I_rated`	0,05 … **1,25** ... 3,0A	Rated current of solenoid valve (load)
`I_hold`	20 … **60** … 67%	Holding current of the solenoid valve in percent of I_rated
`V_rated`	12 … **24**V	Rated voltage of solenoid valve (load)
`Messages threshld`	Level 1 … **3** … 6	Threshold for displaying a warning message or switching on/off the switch-on time diagnosis (see table 8.1 on p. 14)
`Diagnose variant`	1, **2**	Variant 2 is well suited for most valve types, including those with mechanical clearance between solenoid armature and armature. Variant 1 is more suitable for soft switching valves (see section 8.2.3 on page 14).
`End-Pos. Diagnose`	**on**, off	If the supply voltage is too low, the end position diagnosis no longer functions correctly. This can be used to switch this diagnosis on and off (see section 8.2.4, on page 14).
`Switch relay`	**W-Pos**, R-Pos	Status of the output relay for bipolar disconnection of the load: **W**orking position (= load connected to device output) **R**est position (= load disconnected)
`No. of Calibr. cycles`	**5** … 999	Number of switching cycles of the load for the calibration process
`Calibr. mode`	**external**, internal	Activating of the load during the calibration process external: Load is controlled by control input Internal: Load is automatically controlled by the *ES-ITD* at intervals of 10s.
`Language Sprache`	**deutsch**, english	Selecting the language for the displays

The parameters `End-Pos. Diagnose`, `Switch relay` and `Calibr. mode` each have only two states and are switched between these states by pressing the central OK key for at least 2s. The new states are permanently stored in the *ES-ITD* until the next reprogramming and are therefore effective even after the *ES-ITD* is switched off and on again.

To program the other parameters, the programming mode is initiated by simultaneously pressing the cursor keys ◄ and ► . First, a flashing underscore is displayed under the first programmable digit of a parameter. The programmable digit can be moved by the cursor keys ◄ and ► within a parameter, by the cursor keys ▲ and ▼ to other parameters in the same display. If the desired digit of a parameter to be changed is marked by the underscore, pressing the central OK key releases the adjustability and the changeable digit is displayed inversly. The digit is changed using the cursor keys ▲ (+) and ▼ (-). When the desired value has been set, pressing the central OK key completes the setting of this digit and the underscore is displayed again. Then other digits or parameters can be changed in the same way, the decimal point is skipped. The programming with the permanent storage of the changed parameters is completed like initiating the programming mode by simultaneously pressing the cursor keys ◄ and ►, so that the flashing underscore disappears.

6 Commissioning

The following is a step-by-step guide to commissioning the *ES-ITD* solenoid valve driver.
The following steps must be carried out in this order to avoid malfunctions!

1. First, a sufficiently high supply voltage must be provided. It must be at least as high as the sum of the nominal voltage of the solenoid coil and the voltage drop caused by the coil current flowing through the resistance of the load line. A higher supply voltage is reduced to the required level by the *ES-ITD*. The supply voltage is connected to terminals 1 (+) and 2 (-).

   Example: The rated voltage of the solenoid coil is 24V. The supply line is 200m long and has a cross-section of 1.0mm². With a conductor resistance of 20Ω/km the supply line has a total resistance of 8Ω, so that with a rated current of 1.25A a voltage drop of 10V results. The supply voltage must be at least 34V.

2. Now switch to the display for the rated current (display A/3 in figure 4.2) and program the rated current of the solenoid valve as described in section 8 Diagnosis (p. 12) (factory setting: 1.25A).
   In addition, the holding current can be programmed as a percentage of the rated current (factory setting: 60%).

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

3. The rated voltage of the solenoid valve is then programmed in display A/4 (factory setting: 24V).

   4
   A
   ```
   V_rated:
        24V
   ```

4. Selection of the diagnostic variant in the display G/4, (see section 8.2.3, page 14).
   Variant 2 is well suited for most valves, also for valves with mechanical clearance between solenoid armature and armature.
   Variant 1 is more suitable for soft switching valves.

   4
   G
   ```
   Diagnose
   variant

   No.:   2
   ```

5. Press ► to change to the basic display A/1, then press ▼ to display E/1 for load diagnosis, press ◄ to display E/5 for calibration and press ▲ to display G/5 for calibration mode. Here you can choose between external and internal by pressing the OK key for 2s. In internal mode, the *ES-ITD* automatically drives the load every 10s until the calibration process is completed. With this control, the medium controlled by the valve can flow and thus trigger unwanted movements in the system. If this can lead to injuries to persons, it must be prevented that persons have access to the danger zones, e.g. through shut-offs.

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

   (Coordinates of the displays s. p. 6)

   WARNING
   Unwanted plant movement in internal mode
   Severe to fatal injuries
   ➔ Before starting the calibration, prevent that persons have access to hazardous areas

   In the external mode, the load must be switched on for at least 10s (up to and including software version 2.22 for 30s) during the first control, for at least 2.5s during the following control and switched off for at least 200ms with a signal at terminals 13, 14. This on/off cycle must be repeated as often as necessary until the calibration process is completed.

6. Press the ▼ key to return to the E/5 display for starting the calibration procedure. Pressing the OK key starts the calibration, the number of calibration cycles already performed and the total number of calibration cycles to be performed are displayed.
   If the characteristic values for the later diagnosis could not be determined correctly in a control cycle, the number of calibration cycles is not increased! This can be caused, for example, by a switch-on or switch-off time that is too short.
   When all calibration cycles have been carried out, the last line of the display shows "finished".

   5
   E
   ```
   Cali-
   bration
   2s <OK>
   001/005
   ```

   Calibration warning APP W004 (possibly additional warning ***End position EXT W00D***):
   If this message is displayed, the cause may lie in the locked position of a manual override od the valve.

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

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

7 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 and is then dimmed if no button is pressed during this time. After the final keystroke, the screen remains bright for 5 minutes.

7.1 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 *8 Diagnosis*, *page 12*, can be choosed between english and german (deutsch). However in this display the programmable position corresponds to the whole name of the language.

7.2 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 *6, page 8*. The percentage for the holding current can generally be kept at the factory setting of 60%. The rated voltage can be programmed to the right of this display, the factory setting is 24V.

In the load's unactuated state, every 10s a short, low-voltage pulse (approx. 300ms to 1s) 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 21*. 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 switched on with a delay of approx. 100ms and there is often, especially with solenoid valves with low rated current, a warning message `End-Pos. Diag off`! In this case, the *actuation signal* output is only switched to conductive after approx. 170ms.

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.

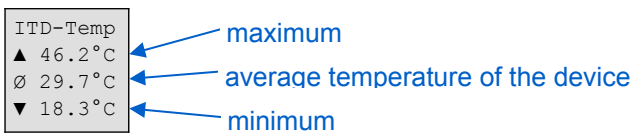
7.2.1 Changeover to holding current

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.

7.3 Device status

From the basic display of `Device status` (see figure *4.2*), 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:



7.4 Load diagnostics

From the basic display of **Load diagnostics** (see *4.2*) 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 *Diagnosis, page 12*.

7.4.1 Preparation and procedure of a calibration process

Before the start of a calibration process, the rated current and voltage of the solenoid coil as well as the appropriate diagnostic variant (the measured switch-on times depend on this, see section Diagnosis, page 12) 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 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. With this control, the medium controlled by the valve can flow and thus trigger unwanted movements in the system. If this can lead to injuries to persons, it must be prevented that persons have access to the danger zones, e.g. through shut-offs.

WARNING

Unwanted plant movement in internal mode
Severe to fatal injuries
➔ Before starting the calibration, prevent that persons have access to hazardous areas

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 activation must take place for 10s (up to and including software version 2.22 for 30s), the following for 2.5s, in order to ensure that the characteristic values of the solenoid valve are reliably determined. Typical times for the first control are approx. 5s, for the following ones 1.5s. 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. After each successful determination of the characteristic values of the solenoid valve, the cycle counter (the number before the slash) is increased by 1. When the calibration process has been concluded, the message **finished** 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 10s (up to and including software version 2.22 for 30s) the first time it is actuated, then for up to 2.5s 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 **locked**. The solenoid valve's stored characteristic values are not changed, and the last **locked** state is saved until a new calibration process is started. In addition, the red error LED lights up and the error message **Calibr. error** is shown in the display. After changing back to the calibration display and starting a new, successful calibration process, the red error LED is switched off.

If the supply voltage to the *ES-ITD* is turned off during an ongoing calibration process, the calibration process will resume in the external mode from the point of interruption when the voltage returns. In the internal mode, the measuring process is aborted (display **canceled**) so that the solenoid valve is not activated unintentionally after the supply voltage has been switched on again. By pressing the OK button for at least 2s, a new calibration process can be started.

If the supply voltage is too low, the armature end position diagnostics cannot be performed correctly. In this case, the end position diagnosis can be switched off (see section 8.2.4, on page 14) to avoid aborting the calibration process.

In the case of soft-switching solenoid valves, the current dip may be too low for measurement of the switch-on time, or a armature stuck error message may occur. In order to avoid aborting the calibration process, level 6 can be programmed in the messages threshold display to suppress the calculation of the switch-on time (see section 8.2.2, on page 13), but then a stuck armature is only detected if it is not stuck in the working end position and the end position diagnosis is switched on!

7.5 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 in most cases, the green *Load on* LED flashes and the indicator outputs *Actuation (load on)* and *Error* are turned off (non conductive).

A special case occurs when the output voltage is approximately as high as the supply voltage when the load is switched on. If then occures a double fault which leads to a low impedance connection of the positive supply voltage with the positive output voltage, the internal fuse of the device may trip. For instructions on how to replace the inserted fuse, contact schaeper AUTOMATION GMBH.

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

8 Diagnosis

The diagnosis of faults is carried out exclusively via the two lines for controlling the solenoid valve; no further sensors and supply lines are required. This makes it extremely easy to retrofit solenoid valve diagnostics in existing installations.

8.1 Electrical

8.1.1 Short-circuit at load output

If a short-circuit is detected, the output is switched off and an error message is displayed. Afterwards, the system checks once every second whether the short-circuit is still present. If the short-circuit persists for more than 5s, a further 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 separated from the *ES-ITD* by two poles. After removing the short-circuit, it is necessary to change to the display `Switch relay`, in order to switch the output relay back to the working position (W-Pos.) by pressing the central OK key for 2s.

In order to switch off the red Err.-LED, which indicates the rest position of the output relay, the relay in the `Switch relay` display must be switched back to the working position (W-Pos.). If the error message `Relay R. Pos.` is left with the key ◄, the display switches automatically to `Switch relay`.

In the actuated state, the output is switched off in the event of a short circuit, the green LED flashes and the signal output "Actuation indicator" is non-conductive. If the short-circuit lasts for less than 5s and the external actuation signal continues to exist, the load output is subsequently switched on again, but the green LED continues to flash and the signal output "Actuation indicator" stays non-conductive until the external actuation signal is switched off.

Even if the load is not actuated, a short circuit is detected by the short measuring pulse (see section Actuating the load, page 9), which is connected to the output every 10s.

If another solenoid valve with significantly higher rated current is connected to an *ES-ITD* to which a solenoid valve with low rated current was connected, a short-circuit will also be detected which leads to the internal load-break relay being switched off after 5s. In this case, the correct rated current must first be programmed and then the relay must be switched back to the working position (see display C/4).

Valve plugs with **integrated free-wheeling diode** form a short circuit if the plug is not connected to the output of the *ES-ITD* with correct polarity and therefore lead to short-circuit error messages.

8.1.2 Cable break at 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 is switched off as soon as the cable break is eliminated.

In the activated state, the output is switched off in the event of a conductor break, the green LED flashes and the Load on signalling output is disabled. The load output is not switched on again even after the conductor break has been removed and the external control signal is still present. To do this, the external control signal must first be switched off and then switched on again.

8.1.3 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 9*) that is switched to the output every 10s. The fault is indicated with the error message `No load`. If the load is actuated, this message appears immediately. Valve connectors with no built-in LED cause a cable break to be reported!

In the activated state, the output is switched off, the green LED flashes and the control signal output is disabled. The load output is not switched on again even after the valve plug has been correctly plugged in and the external control signal is still present. To do this, the external control signal must first be switched off and then switched on again.

8.1.4 Under or over voltage on the supply voltage input

If the supply voltage drops below approx. 21.6V, 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.

If the supply voltage drops very slowly when the device is switched off (the supply voltage drop to values < 2V takes longer than approx. 2s), the above-mentioned messages can also be stored when the device is switched off! If the supply voltage is switched off when the load is activated, warning and error messages can also be stored, which can possibly lead to switched-on yellow and red LEDs and the corresponding indication outputs after the supply voltage has been switched on again.

From a supply voltage of approx. >60V the **warning** message `Vsupply high` is displayed (it is still possible to actuate the load); from approx. >63V the **error** message `Vsupply too high` appears, and the *ES-ITD* disables load actuation.

8.1.5 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. An activation with a jammed armature is also not counted.

8.1.6 Operating-time 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 `Operat. time of load` display shows the sum of the actuation times of the load. The displayed operating time of the load is reset to zero during a calibration procedure.

The times are displayed as **m **s up to less than 60 minutes, as ***h **m up to less than 1000 hours and as ******h from 1000 hours.

8.2 Mechanical

8.2.1 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.

8.2.2 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 22*.

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. This is sometimes helpful with soft-switching solenoid valves if the determination of the switch-on times does not function reliably due to insufficient current dip. In particular, the suppression of warning messages can prevent the calibration phase from being interrupted. 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 6). 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.

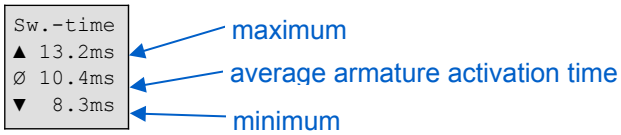
With percentages of 24%, 21% and 15%, the total is set to zero after the third actuation, so the calculation process now starts all over again.

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 8.1: 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.

8.2.3 Diagnostic variants for determining the switch on times

Two diagnostic variants can be selected to determine the switch-on time. For many valve types, different switch-on times are measured for the two variants, which is why the diagnostic variant must be programmed before starting a calibration process.

Variant 1
This variant is best suited for soft-switching solenoid valves, but for valves with mechanical play between the solenoid armature and the control armature, incorrect switch-on times are determined. Bounce times of the armature/control armature are not included in the measured switch-on time.

Variant 2
Variant 2 is active in the factory setting; this allows the switch-on times of most valve types to be determined well, this also applies to valves with mechanical play between the solenoid armature and the control armature. With this variant, bounce times of the armature/control armature are also included in the measured switch-on time.

8.2.4 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.

Since a measuring AC voltage is superimposed on the output voltage for end position detection, but must not fall below the voltage for the holding current, a higher supply voltage is required than just for the correct switching on of the solenoid valve. As an approximate value, the supply voltage ***Uv* should be at least 6V higher** than the output voltage *Uoutput* **when the holding current flows**. Uoutput is shown in the display with the coordinates A/2, see *Figure 4.2: Display sequence*, page 6.

If the supply voltage is too low for end position diagnostics, the warning message `End-Pos. Diag off` is displayed after the valve is switched on and the yellow LED lights up. If this happens during the calibration phase, the calibration is aborted and the end position diagnostics should be switched off.

By pressing the OK button for 2s, the end position detection can be switched on and off in the display `End-Pos. Diagnose` (coordinates E/3).

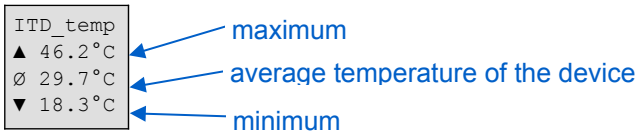
Depending on the valve, monitoring for the arrival in the end position in the actuated state requires a minimum power-on time of up to 2,5s.

8.3 Thermal

8.3.1 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:

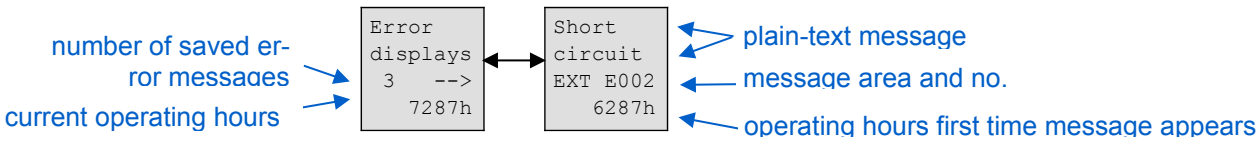


If the internal temperature exceeds 85°C, the warning message **`ITD_temp high`** is displayed; if it exceeds 90°C, the warning message **`ITD_temp too high`** is displayed – it is still possible to actuate the solenoid, however.

9 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 22*.

Some messages may be displayed for a longer period of time if the underlying condition is permanent, e.g. conductor break, internal relay in rest position or unit overtemperature.

9.1 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.

10 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 10.1: Removing plug-in terminals
In device versions with plug-in terminals, these can be removed with the aid of a screwdriver.

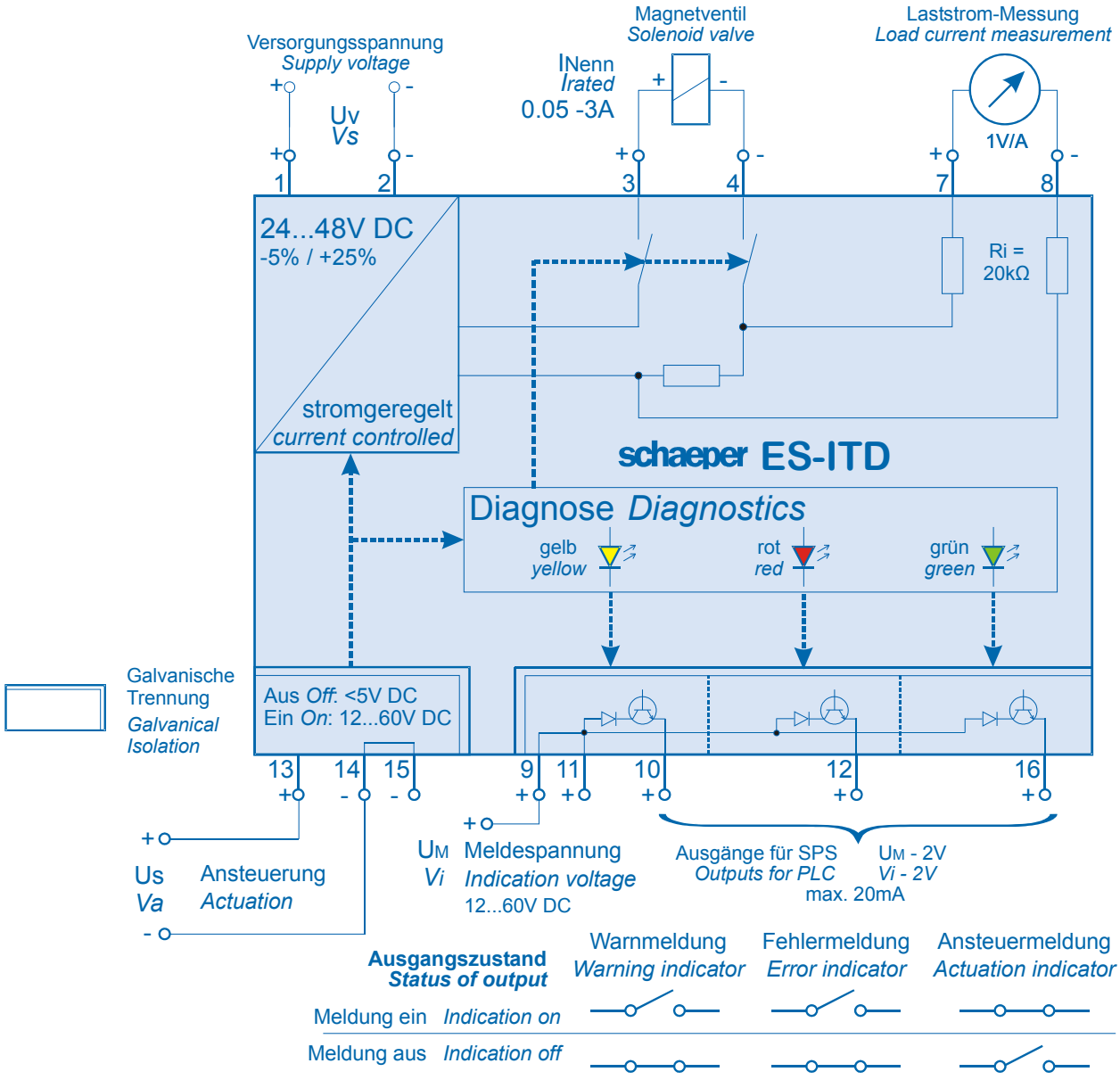


Figure 10.2: connection example

Technical data see section *13, page 21*.

11 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 11.1: Permissible holding current for selected on/off times under different installation conditions.

12 Ordering information

Item no.	Description
EITD-3DA/P/G	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/G	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/G	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

13 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 ≥ 2.5s (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

14 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 error message **Relay rest position** (**EXT E006**) 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 *4.2*) to switch off the error and warning messages.

14.1 Warning messages

Area: SYS	**System warnings**	
Number	**Plain text** Description	Possible causes
W001	**Watchdog Reset** A device reset was triggered by the watchdog timer.	- Very strong external electromagnetic interference - Internal fault in the device

Area: APP	**Application warnings**	
Number	**Plain text** Description	Possible causes
W001	**End-Pos. Diag off** The diagnosis for the detection of the armature end position was cancelled.	- Supply voltage too low, min. 6V above holding voltage necessary
W002	**Calibrat canceled** The calibration in internal mode was aborted.	- Switching off the supply voltage before finishing the calibration
W003	**Warning- message** Error when measuring the load resistance at the beginning of the calibration process.	- Conductor break or load resistance < 1kΩ at the beginning of the calibration process
W004	**Warning- message** No armature movement during the calibration process.	- Armature stucked, e.g. due to manual operation - Armature missing - no inductive load
W005	**Warning- message** Error in measuring the armature movement during the calibration process.	- Too little armature movement due to too low supply voltage - Excessive switch-on time of the armature (e.g. with soft-switching solenoid valve)

Area: EXT External warnings		
Number	**Plain text** Description	Possible causes
W001	**Vsupply too low** Supply voltage for the device is too low, < 19V.	
W002	**Short circuit** Short circuit in the load circuit.	- Reverse polarity plug with free-wheeling diode - load resistance too low - double insulation fault in the IT supply system
W003	**Vsupply low** Supply voltage for the device is low, < 22V.	
W004	**Vsupply high** Supply voltage for the device is high, > 60V.	
W005	**ITD_Temp high** Internal temperature for the device is high, > 85°C.	- Poor thermal installation conditions for the ES-ITD (e.g. too close together). - Ambient temperature too high - Internal defect in the *ES-ITD*
W006	**V-Load too high** Output voltage is too high.	- +Vsupply is at the load output.
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
W008	**Armature fast** The solenoid valve's armature has moved too quickly.	- armature spring broken
W00B	**Short circuit** Short circuit in the load circuit.	- Reverse polarity plug with free-wheeling diode - load resistance too low - double insulation fault in the IT supply system
W00C	**Vsupply < V-Load** Supply voltage is too low for the programmed nominal load current. Activation is still possible.	- Supply voltage too low. - Resistance of the load supply line too high. - Load temperature too high. - Programmed nominal current of the load too high.
W00D	**Error End pos.** The armature of the solenoid valve has not reached its end position in the actuated state.	- Armature dirty
W00E	**Armature stuck** The armature of the solenoid valve has not moved.	- Armature is stuck, e.g. due to dirt or corrosion. - Armature missing.
W00F	**Short circuit** Short circuit in the load circuit during test pulse.	- Reverse polarity plug with free-wheeling diode - load resistance too low - double insulation fault in the IT supply system
W010	**ITD_Temp high** Internal temperature for the device is too high, > 90°C.	- Poor thermal installation conditions for the ES-ITD (e.g. too close together). - Ambient temperature too high - Internal defect in the *ES-ITD*

14.2 Error messages

Area: SYS	System error (Error)	
Number	**Plain text** Description	Possible causes
E003	**Internal Defect** Switching transistor no longer blocks. Subsequently, the internal relay is switched to the rest position.	- Overload of the switching transistor, send unit to manufacturer for repair

Area: APP	Application error (Error)	
Number	**Plain text** Description	Possible causes
E005	**Relay Rest pos** The internal relay for galvanic isolation of the load is in rest position and has therefore disconnected the load.	- Manually switched to rest position - Short circuit for more than 5s duration

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
E004	**Vsupply too high** Supply voltage for the device is too high (> approx. 62V).	- voltage fluctuations too great
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

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 re-programme 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*, *4.2* page *6*)
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