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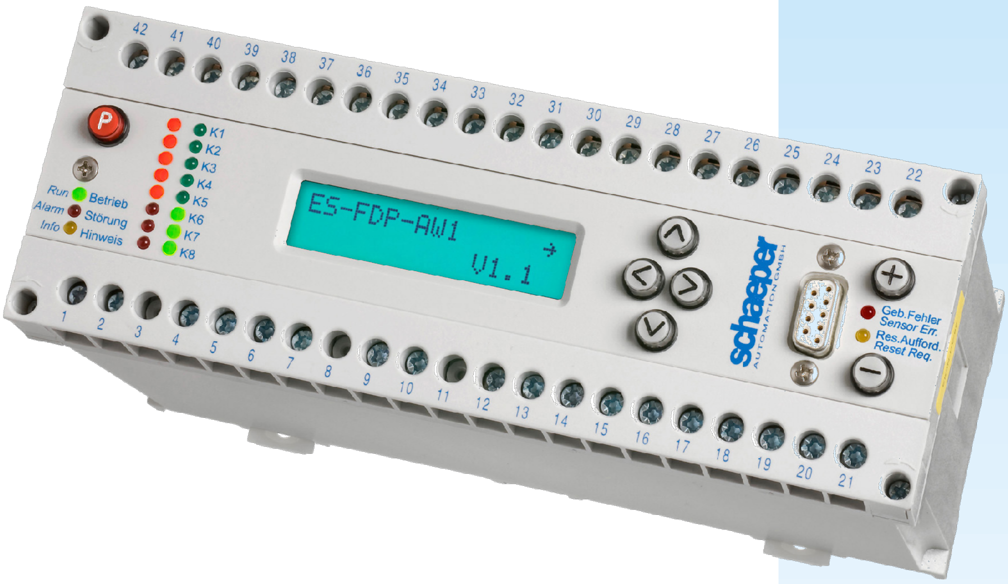
ES-FDP-AW1

Digital Drive Monitor

Operating Instructions



BA_AW1_E.DOC 27.02.2020

Important information

For a high degree of operating safety, all processors have a **Watchdog** as well as **software write protection** for the **EEPROM and Flash-EPROM** memorys, in order to prevent a change of the programmed parameters with strong external interferences. **However, one hundred percent safety can not be achieved with processor systems. The system must therefore have a redundant system for safety-orientated use.**

The danger of a change of the programmed data due to extreme external interferences is minimized if the code plug is removed during the operation of the device.

These operating instructions for the Digital Drive Monitor ES-FDP-AW1 are for the device as it stands February 2020. The current software-version is V1.1.
Subject to changes without notice!

Differences between the software versions

As of version 1.1, the LED for the valid code plug is omitted. Instead, a corresponding message text is shown on the display when the code plug is plugged in.
Instead of the code plug LED, an LED **Reset request** is now available which indicates that the device expects a position calibration.

Other versions of the device:

- **Frequency and slip monitor, ES-FDP-FS...,** frequency range 0,1 ... 4000 Hz, frequency ratios programmable

- **Signal pre-processor, ES-SV11,** supplementary device for use with the digital slip- and frequency monitor **ES-FDP-FS...,** includes sensor supply, rotational direction recognition by evaluation of 2 phase signal, open circuit monitoring.

- **Digital Synchronization monitor ES-SVGL2,** for monitoring synchronization. Includes sensor supply, rotational direction recognition by evaluation of 2 phase signal, open circuit monitoring.

- **Digital crane frequency control system, ES-FDP-KR...,** Standard and two-step operation

Application

The drive monitor ES-FDP-AW1 combines the device functions of the signal pre-processing device ES-SV11.2, of the synchronisation monitor ES-SVGL2, as well as of the frequency and slip monitor ES-FDP-FS... in only one device.

The device contains the sensor supply and sensor monitoring, a signal pre-processing unit for debouncing the sensor signals, as well as the monitoring for overspeed, underspeed, frequency ratio, slip, synchronisation, torsion, position, shaft breakage, gear breakage, standstill and unintentional lowering.

General characteristics

☺ extremely space-saving

☺ especially easy to program using large L.C.-Display with back-lighting

☺ Display with plain text, alternatively German or English-language

☺ protection from unauthorized programming by code plug and optionally by password

☺ 8 switching channels, the desired monitoring function can be programmed for each switching channel

☺ double -LED-display (red/green) for each programmed monitoring function

☺ 5 relay outputs

☺ Assignment of the switching channels to the relays freely programmable

☺ programmable time delay for the monitoring functions

☺ analogue output, current or voltage (Option)

☺ Sensor supply and open-circuit monitoring

☺ 6 enable inputs (with programmable time delay) which can be allocated to the monitoring functions as required

☺ measuring inputs are electrically isolated from the other in and outputs

☺ Flash-EPROM and EEPROM for programmable values (no batteries required), with software write protection for extremely high data safety

☺ high noise immunity (watchdog, redundant data storage for automatic error recognition)

☺ easy to service due to **removable screw-on terminal strip, thus enabling the devices to be changed quickly without the danger of wiring errors**

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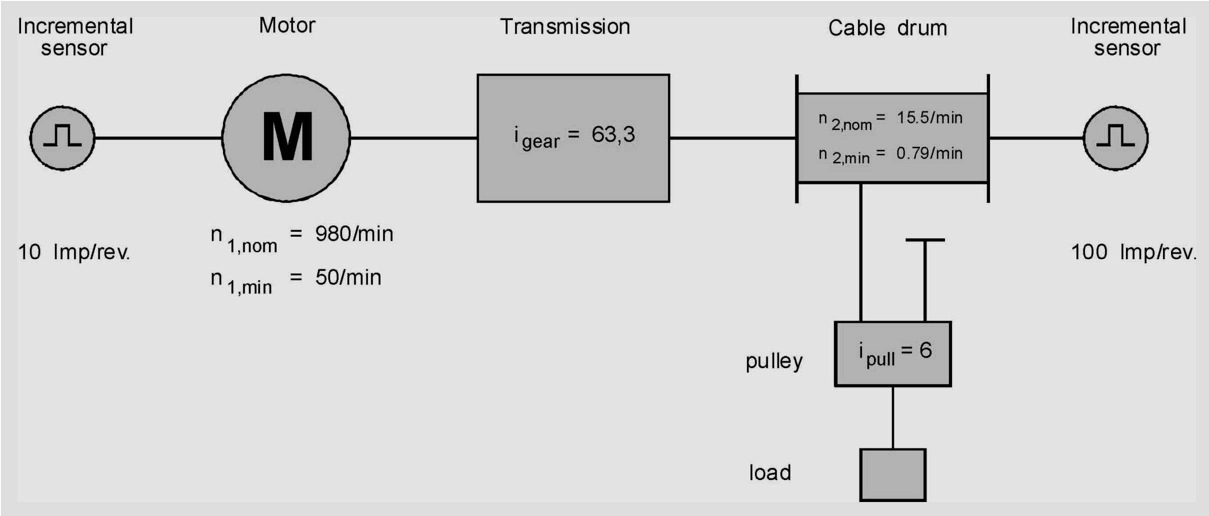


Fig. 1: Example of a hoist to be monitored

In the example shown, a drive monitor ES-FDP-AW1 can monitor for shaft breakage, overspeed and sensor failure. Furthermore, it can be monitored, for example, that the load may only be moved at reduced speed from a certain position. The drive monitor detects both the rotational positions of the motor and the drum as well as the respective rotational speeds. For this purpose, the rotary movements must be detected by incremental encoders, or by scanning cams or toothed wheels with proximity switches. 2-phase sensor signals are required for the detection of the rotary movements. The incremental encoder normally provides these signals; when scanning with proximity switches, 2 proximity switches must be used and arranged in such a way that 2 signals with a phase shift of approx. 90° result.

A possible programming of the device for the above monitoring task is described in detail in the chapter „Application example“, p. 36.

2 Device funktion

2.1 Illustration of the device function

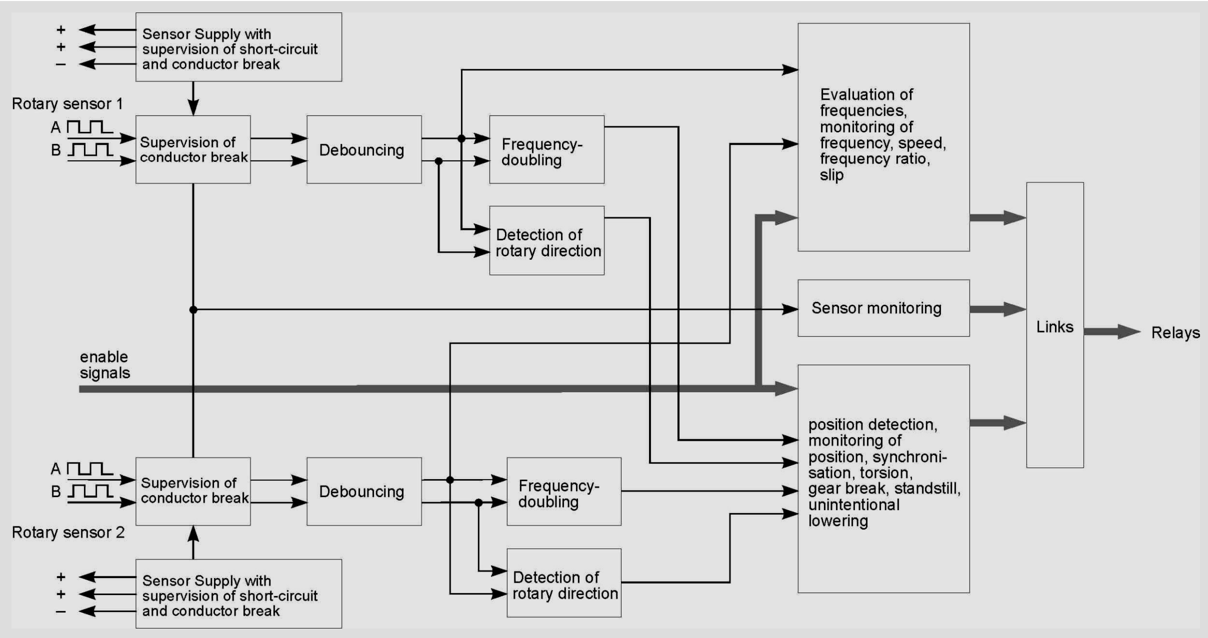


Fig. 2: Block diagram of the ES-FDP-AW1

The block diagram explains the functions of the device. By evaluating 2-phase sensor signals, the device carries out debouncing and direction detection and passes the processed signals on to the 2 evaluation units for position and frequency detection. There the monitoring of the programmed limit values is carried out. If limit values are exceeded, the assigned relays switch over.

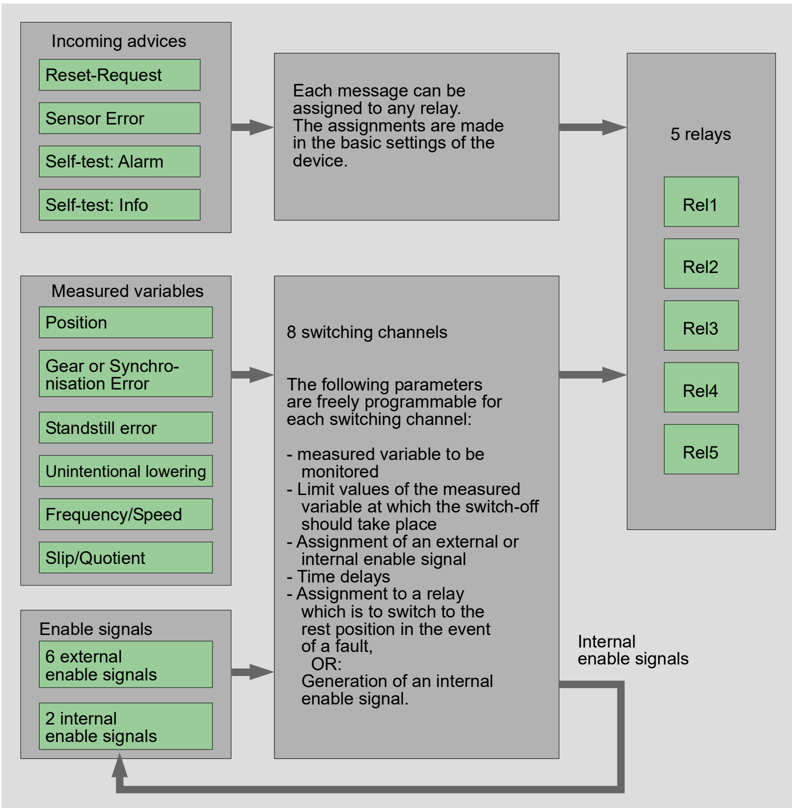


Fig. 3: Overview of the evaluation of the measured values

2.2 Measurement Inputs

2.2.1 Sensor supply

Each output for the sensor supply (20..24V DC) may be loaded with max. 50mA. For supply of the incremental sensors, two outputs are switched in parallel, so that 100mA is available. At higher currents the internal current limiter works. In that case the sensors do not output correct signals, so computing of the signals is not possible. The device signals sensor fault.

The sensor supply is optionally also available for Namur proximity switches.

2.2.2 Sensor inputs

The inputs for the rotary sensors evaluate phase shifted pulse sequences, such as those created by incremental sensors or two proximity switches mounted in a shifted manner. On the one hand, the **direction of rotation** is determined from this, on the other hand, **bouncing** of the pulses, e.g. due to torsional vibrations or suspension of the drive train, is suppressed.

The sensor inputs are optionally also available for Namur proximity switches.

2.2.3 Sensor faults

Monitoring of short-circuits and interruptions in the connection lines to the sensors is carried out separately for each sensor by monitoring the current consumption. For the proper functioning of this monitoring system, **incremental sensors with push-pull output or proximity switches with built-in load resistance** (max. 10kΩ) must be used! With this, the sensors are continuously monitored (also when the drive is standing still), if the correct mains supply for the drive monitor is connected.

In case of encoder error the assigned relay switches in rest position.

2.3 Position detection

The resolution of the position detection corresponds to 4 times the sensor resolution (by evaluating the 4 edges of the 2-phase signal). With the help of the programmed sensor pulses per revolution, the rotation of the system part is determined (in number of encoder revolutions). By entering a conversion factor, which results from the drum size and the ratio of the pulley, the position can be displayed and evaluated directly according to the load movement.

2.3.1 Position calibration and position evaluation

For evaluation or monitoring of the position, calibration to the current actual position is necessary after switching on the drive monitor. This is done by moving to a reference position. Subsequently, by applying a "calibration reset" pulse, the position detection in the drive monitor is set to this reference value. Applying this pulse simultaneously confirms that the system is in the correctly aligned state, i.e. the synchronism deviation or the synchronism deviation for gear monitoring are reset to "0" in the device.

The device signals with the LED **Reset Req.** *(Reset-Request)* that a position calibration is required. Furthermore, the relay assigned to the *Reset-Request* remains in the rest position until the correct alignment and positioning of the system is confirmed by applying the "calibration reset" pulse.

The value range of the position detection extends over a movement corresponding to a sensor rotation of $-532*10^6$ to $+532*10^6$ increments. If the positive or negative maximum value is exceeded, a new calibration is required and this is indicated by the signal LED **Reset Req.** and by the assigned relay.

The restriction of the value range is only relevant for the position monitoring. At an encoder pulse frequency of 4kHz it corresponds to an operation time of approx. 36 hours in one rotary direction. The monitoring for synchronisation and gear breakage works independently and is not affected by this.

An extended value range for the position detection is optionally available.

2.3.2 Synchronization monitoring

For synchronisation monitoring, the maximum permissible path difference is checked by evaluating the encoders. The synchronisation error can be programmed and displayed (after entering the conversion factor for drum circumference and pulley ratio) directly in the unit of the load path, i.e. the switch-off value is programmed as how many cm of misalignment of the system are permissible.

2.3.3 Gearbox monitoring

If a gearbox is to be monitored, the transmission ratio must be programmed. To determine the synchronous deviation, the rotary motion of one of the sensors is converted according to the gear factor and then compared with the other. Depending on the programming, the maximum permissible deviation can be programmed either as an angular error (related to encoder 2, i.e. generally on the output side of the gear unit) or as an additional load path caused by this error.

In contrast to a monitoring of the frequency quotient of the sensor signals (as with the devices ES-FDP-FS..) the actual deviation from the nominal position is controlled. For this reason, short-term rapid fluctuations within the permitted gear backlash do not lead to an unintentional response of the monitoring system.

2.3.4 Monitoring for standstill

Monitoring for standstill must be activated by applying an enable signal (e.g. from the master switch). After a programmable activation time delay, the position of the load must not change any more (or only slightly according to a programmed maximum load movement).

Important: For monitoring, the sensor signals from encoder 2 are evaluated, and the monitored maximum load movement refers to s2. The rotary motion of encoder 1 is not included for monitoring for standstill.

2.3.5 Monitoring for unintentional sinking

Monitoring for unintentional sinking must be activated by applying an enable signal (e.g. from the master switch). After a programmable activation time delay, the position of the load may only change in the direction of lifting.

Important: For monitoring, the sensor signals of encoder 2 are evaluated, and the monitored permissible load movement in the direction of lowering refers to s2. The rotary motion of encoder 1 is not included for monitoring for unintentional lowering.

2.4 Frequency acquisition

The input signals of the two measuring inputs are processed by debouncing and then they are used for frequency acquisition by storing the times of the edges. The frequencies f1 and f2 of the input signals are then calculated by evaluating the period durations (resolution: ≤0,5μs). In a cycle time of approx. 8 ms the device checks whether input pulses have arrived and evaluates them (frequency and quotient calculation, switching commands to the relays).

2.4.1 Calculation of the frequencies

For frequencies > approx. 120 Hz the measuring time of approx. 8 ms results in averaging over several input pulses. For lower frequencies, the frequency is recalculated with each incoming pulse. The frequency values thus determined are evaluated, e.g. for monitoring for overspeed or underspeed.

By default, input frequencies of 0.1 ... 4000 Hz are processed. However, a frequency range extended downwards (from 0.001 Hz) is also possible.

2.4.2 Speed measurement

For easy programming and clarity, the frequency values can also be programmed and displayed as rpm speeds. The conversion is made by using the programmed encoder resolutions.

2.4.3 Calculation of the Quotients

If both input frequencies are > about 120 Hz, the quotient **Q** is calculated by dividing **Q = f1/f2**. If at least one of the frequencies is lower, the input signal cycles are compared. An average is determined for the high input frequency for the cycle duration of the lowest, i.e. the measurement times for both inputs are matched before the division is carried out (cf. Fig. 4).

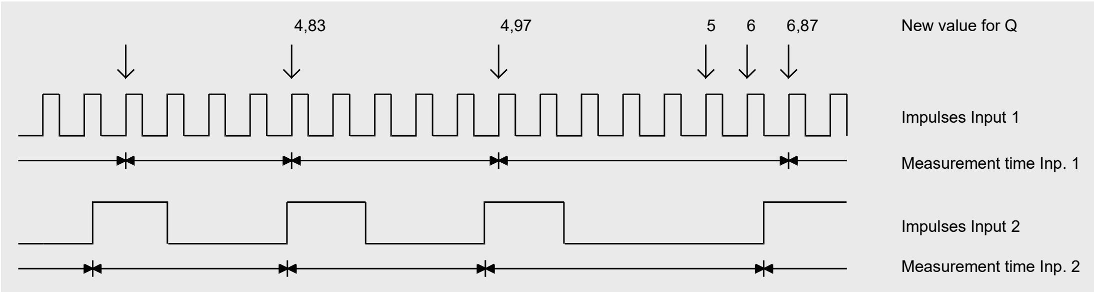


Fig. 4: Measurement times for the calculation of the quotients

If no impulse is received at one input (e.g. due to a open circuit) **Q** changes in jumps with every impulse to the other input, ensuring that the relay is activated quickly.

The quotient can be entered either as frequency ratio **Qf=f1/f2** or as speed ratio **Qn=n1/n2**. The unit carries out the conversion to frequency values required for internal evaluation using the programmed sensor resolution (pulses per revolution).

Important: When the system is stopped, the frequency ratio **Q** is undefined. Furthermore, a change in direction of rotation generally leads to a short-term change in the frequency ratio. In both cases, the quotient monitoring must be interrupted to avoid faulty switching.

After applying the supply voltage and after a change in the direction of rotation (which is detected by the evaluation of the 2-phase encoder signals), the quotient **Q** is first set to a setpoint **Q-Reset** in order to avoid faulty switching due to the otherwise undefined value of **Q**. After a new startup, the device immediately evaluates any contradictions between the input pulses and the **Q-Reset** value and corrects the quotient if necessary. Depending on the pulse sequence at the measuring inputs, the current quotient is normally determined correctly after 2, at the latest after 3 pulses from the lower input frequency. Due to this possibility of **Q-Reset** programming, in almost all cases the programming of a start-up delay (with the help of the enable inputs) becomes unnecessary.

2.5 Enable inputs

For the activation of the monitoring functions, 6 external enable inputs and additionally 2 internal enable signals are available. They can be assigned to the monitoring functions as required. The enable signals can be individually time-delayed. The device is available for different enable voltages (12V, 24V, 230V AC/DC).

The enable inputs are galvanically isolated from all other inputs and outputs.

2.6 Evaluation of the measured values

8 switching channels are available for monitoring the measured values. Any measured variable to be monitored can be assigned to each switching channel. The switching function can be adapted to the specific monitoring problem in many ways. If there is a deviation from the permitted value, the device is switched off immediately or after a programmed delay time. The activation of each switching channel can be made dependent on enable signals.

2.7 List of the monitored variables

The following parameters are used for the calculation of the monitored operating values, some of them must be programmed in the basic settings:

Se1Res Resolution sensor 1, is programmed in the display `Sensor 1 imp/rev:`

Se2Res Resolution sensor 2, is programmed in the display `Sensor 2 imp/rev:`

Imp1 Number of impulses from sensor 1

Imp2 Number of impulses from sensor 2

α1 Angle of rotation sensor 1 in number of revolutions **α1 = Imp1 / Se1Res**

α2 Angle of rotation sensor 2 in number of revolutions **α2 = Imp2 / Se2Res**

Conv1 Position conversion sensor 1, is programmed in the display `Sensor 1 conv. s1/rev:`

Conv2 Position conversion sensor 2, is programmed in the display `Sensor 2 conv. s2/rev:`

Rat Gear ratio **Rat = Rn / Rd**, programmed in the display `Rat.`

The following determined variables are defined for the monitoring tasks:

s1	Position 1	**s1 = α1 * Conv1**
s2	Position 2	**s2 = α2 * Conv2**
ds	Synchronization deviation, as an absolute value (always positive)	for synchronisation monitoring, the gear ratio must be programmed to **Rat = 1**. The following applies: **ds = | α2 − α1 | * Conv2**
	Synchronous deviation for gearbox, as an absolute value (always positive)	if a gear ratio **Rat ≠ 1** is programmed, applies: **ds = | α2 − α1/Rat | * Conv2**
US	(**U**nintentionel **S**inkage) Lowering movement during lifting operation	**US** = change of **s2** in direction of lowering during lifting operation (after the activation time has expired)
St	Load movement at standstill (standstill deviation)	**St** = change of **s2** at standstill (after the activation time has expired)
f1	Pulse frequency of sensor 1	Number of sensor pulses per second
f2	Pulse frequency of sensor 2	Number of sensor pulses per second
n1	Speed sensor 1 (rpm)	**n1 = 60 * f1 / Se1Res**
n2	Speed sensor 2 (rpm)	**n2 = 60 * f2 / Se2Res**
Qf	Frequency quotient:	**Qf = f1 / f2**
Qn	Speed quotient:	**Qn = n1 / n2**

Table 1: Monitored variables

2.8 Further Notes

For display or control purposes one of the monitored variables **Q, f, s** or **ds** can be output using the analogue output (option).

In order to reduce the temperature in the device it is recommended that the device is installed with a distance of 5 - 10 mm to all other fittings.

Note: The device must only be programmed when the main plant is switched off, because during the programming the outputs can switch in an undefined manner.

3 Displays and Operation

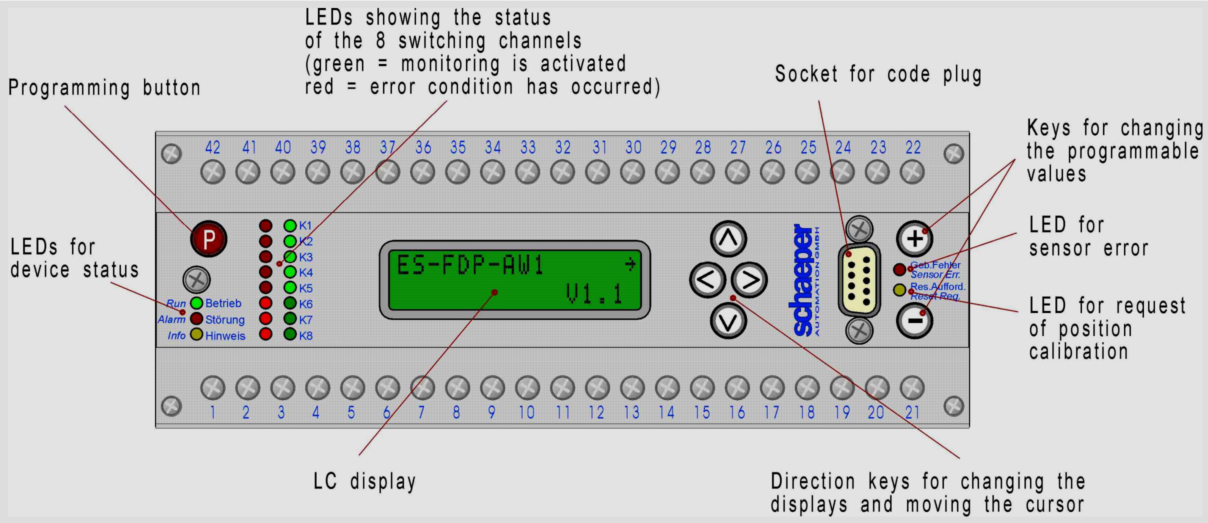


Fig. 5: Operating elements of the device

3.1 LED Indicators

Run (green) Mains voltage is connected and the self-test is finished.

Alarm (red) The program flow has been disturbed by external influences (e.g. considerable interference from switched lines, EMP) or due to an internal error in the device in such a manner that the device can not function properly. After the automatic error correction has been finished the LED is switched off, the LED **Info** remains on up to reading the error number (see chapter 5). If no automatic error correction is possible the LED **Alarm** remains on permanently. Measures for the resumption of operation are described in chapter 5, “Device Errors” (see page 29).

Info (yellow) This LED indicates disturbing influences which only occur temporarily, thus enabling preventative measures to be taken. The LED lights up when an error occurs or if invalid parameters are programmed. It only goes out after acknowledgement or interruption of the supply voltage. Acknowledgement takes place as described in chapter 5, “Device Errors”, from page 29.

K1 a **K8** (green und red) States of the 8 switching channels (monitoring functions)
red → programmed limit values of the switching channel have been exceeded.
green → monitoring is programmed.
both LEDs off → no monitoring is programmed.

Sensor Err. (red) a sensor error has been detected.

Reset Req. (yellow) Reset Request. Request of a position calibration. Message appears after applying the mains voltage or after the occurrence of encoder errors. For correct operation of the position monitoring task, the reference position must then be approached and the system must be correctly aligned. By applying a position reset pulse, the device then adopts the reference data.

3.2 LC-Display

3.2.1 Back-lighting

For better readability with poor light conditions, the LC-Display is equipped with back-lighting. The lighting is activated with the press of any key and automatically goes out approx. 3 minutes after the last key is pressed.

3.2.2 Basic Display and Software-Version

After the power supply has been connected, the device responds by giving its type identification in the upper line. The version-No. **V** of the software will be shown in the lower line.

```
ES-FDP-AW1     →
           V1.1
```

3.2.3 Selecting the Displays

The sequence of the displays is shown in Table 2 (p. 16). The left column shows the main displays. For each of the monitoring functions K1..K8, for example, there is a main display. Missing information that does not fit into the main display is shown in the corresponding subordinate displays. The arrow → in a display indicates the existence of subordinate secondary displays..

The displays are selected using the cursors (∧, ∨, <, >). The main displays are obtained using the keys ∧ and ∨ (for sequence see Table 2). The key > calls up the subordinate display belonging to the current main display (if available). Then the keys ∧ or ∨ are used to select the other secondary displays belonging to the same main display. From a subordinate display, the key < returns to the corresponding main display or to the higher-level display.

3.2.4 Display of current states (relay and enable inputs)

The second main display shows the current states of the relays and of the signals at the enable inputs:

```
Rel. 1 2 3 4 5 →    EnIn 1 2 3 4 5 6
   = A A R R A         = - + - + - -
```

A or R , + or -: current values

For the enable signals, a + means that voltage is present at the corresponding enable input, a - is displayed when no voltage is present.

For the relays, an A means that no assigned monitoring function has reacted, i.e. the relay is in the **A**ctive position. An R means that the relay has switched to the **R**est position due to a triggered monitoring function.

3.2.5 Display of the Measured Values

In the third place of the main display is the display of the measured values:

```
s1=****** ds=  →    n1=****** Qn=
s2=****** ******    n2=****** ******
```

*****: current values

Each of the two displays can be configured to show 1 to 3 measured values as required. The following measured variables can be displayed:

s1, s2, ds, f1, f2, n1, n2, Qf, Qn. (see Table 1 for the significance of the measured variables).

If values over 9999 must be displayed, a "k" as a thousand multiplier appears. Thus, the display 14k30 for example, represents a value of 14300.

When displaying frequency or speed, the display changes to <min when the frequency falls below the minimum frequency (0.1 Hz in the standard version).

If the quotient is kept at a constant value due to the programmed **Q-Reset** function and an existing **Q-Reset** condition (see chapter 4.3.9, Quotient Reset, page 25), this is indicated by the display Qr=***** instead of Qf=***** or Qn=*****.

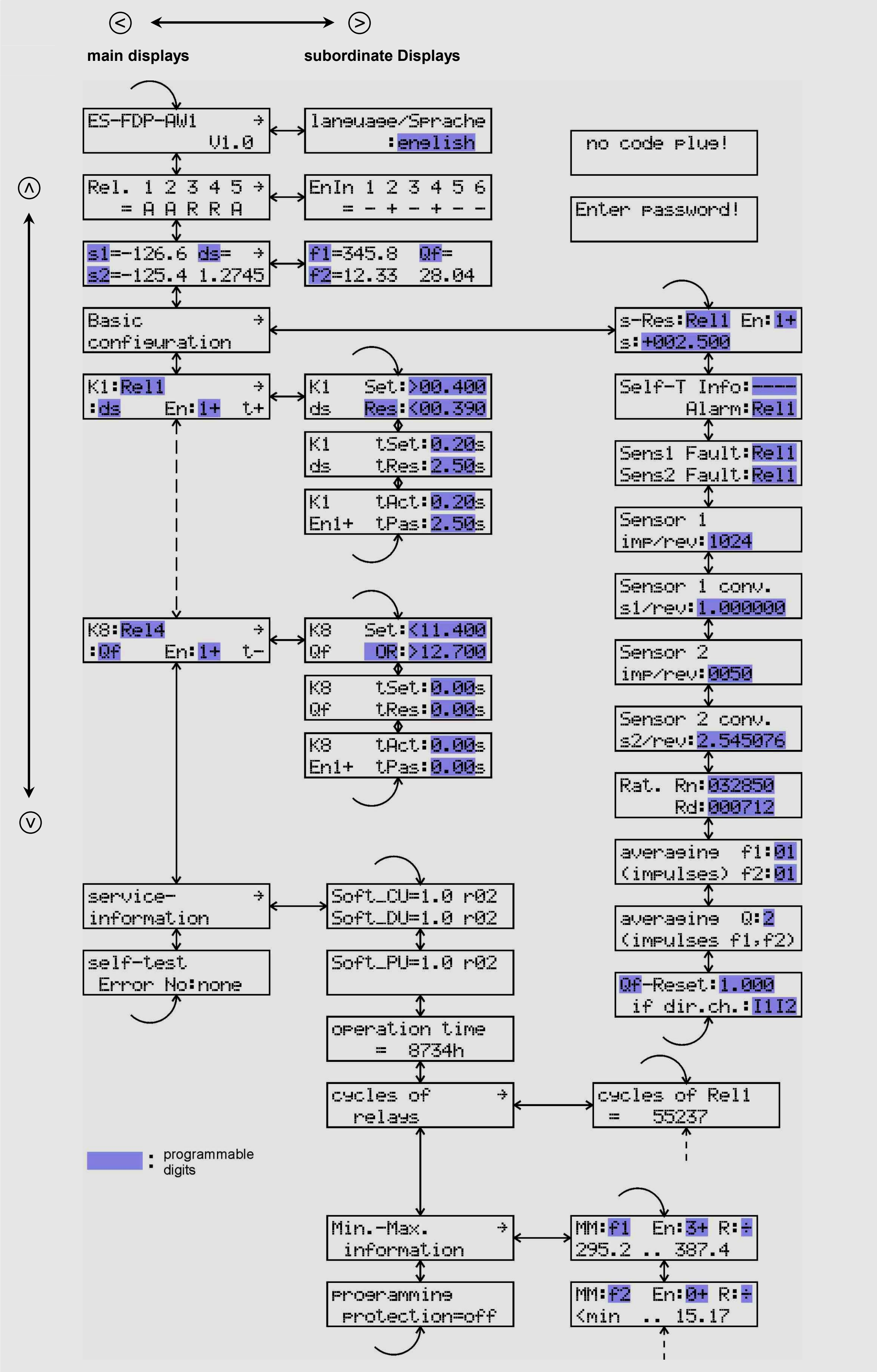


Table 2: Sequence of the displays

Table 3: Alphabetical list of the meaning of the display texts

=	Display of a current value
:	after the colon the parameters to be set can be programmed.
..	(in the display of the min. and max. values) stands between the minimum and the maximum measured value (from .. to)
÷	R:÷ (in the display of the min. and max. values): no reset of the stored min. and max. values takes place.
>	if > is programmed before the limit value, this value must be reached or exceeded in order for the switching function to be executed. The comparison is carried out as "greater or equal", i.e. an exact reaching of the limit value is sufficient for switching.
>max	the permitted value range was exceeded.
<	if < is programmed before the limit value, the measured value must fall below the limit value for the switching function to be executed. The comparison is carried out as "less than", i.e. an exact reaching of the limit value is not yet sufficient for switching.
<min	the measured frequency or speed is below the evaluated frequency range.
+	- *in the display* EnIn 1 2 3 4 5 6: Enable voltage is applied - *behind a digit for enable assignment*: the selected function is active when a voltage is applied at the enable input.
-	- *in the display* EnIn 1 2 3 4 5 6: Enable voltage is not applied - *behind a digit for enable assignment*: the selected function is active if no voltage is applied at the enable input.
--	- *in the display* s-Res: No enable input assigned - *in the displays* K1..K8: No valid assignment to a measured variable.
----	no relay assigned
→	Indication of the existence of subordinate displays
1+ to 6+	Assignment of an external enable input. The monitoring function is activated when voltage is applied to the enable input.
7+ to 8+	Assignment to an internal enable signal. The monitoring function is activated when the internal enable is active.
1- to 6-	Assignment of an external enable input. The monitoring function is activated when no voltage is present at the enable input.
7- to 8-	Assignment to an internal enable signal. The monitoring function is activated when the internal enable is not active.
A	Active position (*in the display indicating the relay states*)
Alarm:	(*in the display* Self-T): Assignment of a relay that is to switch to the rest position in the event of acute device malfunctions.
AND:	The function Res: within the switching channels K1 .. K8 can be reprogrammed to AND:. This is required if 2 conditions are to be fulfilled simultaneously to trigger the switching channel (to implement a window function).
averaging	programming of an averaging for the calculation of frequencies/speeds or for the calculation of the quotient.
Basic configuration	In this display group all necessary basic settings for the required device function are carried out.
cycles of relays	Display group to indicate the relay switching cycles for each relay
code plug ok!	appears as message when a valid code plug is inserted
data error	(*in the display* self-test) appears if the device has detected faulty data in the flash memory.
deutsch	display language is German

dir.ch.:	(*in the display* Q-Reset) Here you define whether a change of direction of input 1 (sensor 1) or input 2 (sensor 2) or both should trigger a Q-reset.
ds	variable for monitoring the gearbox or synchronisation error
english	display language is English
En:	programming an assignment to an enable input
En1+ to En8+	Information about the programmed enable assignment to a switching channel (*in the display for enable delay times*)
En1- to En8-	Information about the programmed enable assignment to a switching channel (*in the display for enable delay times*)
EnIn 1 2 3 4 5 6	Current signals at the external enable inputs 1 ... 6
enter password!	appears as a message if the programming button is pressed but the device is protected by a password.
Error No:	Indication of the error number in case of device malfunctions.
ES-FDP-..	device type
f1	frequency of sensor 1
f1:	(*in the display* averaging): Programming of an averaging for the calculation of f1.
f2	frequency of sensor 2
f2:	(*in the display* averaging): Programming of an averaging for the calculation of f2.
I1	(*in the display* Q-Reset) Q-Reset is to be triggered by direction change of the sensor at input 1.
I2	(*in the display* Q-Reset) Q-Reset is to be triggered by direction change of the sensor at input 2.
I1I2	(*in the display* Q-Reset) Q-Reset is to be triggered by a direction change of both the sensor at input 1 and the sensor at input 2.
if dir.ch.:	(= when the direction of the input:… changes). Here you define whether a change of direction of input 1 (sensor 1) or input 2 (sensor 2) or both should trigger a Q-reset.
IEn7 or IEn8	internal enable signal 7 or 8.
imp/rev	sensor resolution (impulses per revolution)
(impulses)	(*in the display* averaging): is used for information that the averaging is carried out over a programmable number of pulses and not over a fixed time.
(impulses f1,f2)	(*in the display* averaging Q): is used for information that at least the programmed number of pulses of each frequency input f1 and f2 is used for the calculation of the mean value.
Info:	(*in the display* Self-T) Assignment of a relay that is to switch in the rest position in the event of stored information messages.
K (K1 to K8)	Switching channel (K1..K8) for monitoring a measured variable for permitted limit values
language/Sprache	display language
limit error	(*in the display* self-test) appears if switching values are programmed which are not within the range of the permitted input frequency of the device.
Min.-Max. information	group of subordinated displays for showing the minimum and maximum values of the measured variables
MM	Display of the min. and max. values for the specified measured variable.
n1	Speed (rpm) of the system part monitored by sensor 1
n2	Speed (rpm) of the system part monitored by sensor 2
none	(*in the display* self-test) appears if no device fault is present or has been stored.
no code plug!	appears as a message if the programming button is pressed without a code plug being inserted.

off	(*in the display* programming protection) means that the software programming protection is not activated.
on	(*in the display* programming protection) means that the software programming protection is activated.
operation time	Operation time of the device
OR:	The function Res: within the switching channels K1 ... K8 can be reprogrammed to OR:. This is required if the response of the switching channel is to be triggered by 2 different conditions (to implement a window function).
programming protection	This display specifies whether the software programming protection is activated or not.
Q:	(*in the display* averaging Q): programming of averaging for the calculation of the quotient Q.
Qf	Frequency ratio, Qf = f1 / f2
Qf-Reset:	Setpoint for Qf, for resetting the quotient after applying the mains voltage or after changes in direction of the rotary movements.
Qn	Speed ratio Qn = n1 / n2
Qn-Reset:	Setpoint for Qn, for resetting the quotient after applying the mains voltage or after changes in direction of the rotary movements.
R	- (*in the display indicating the relay states*): Rest position - R:R (*in the displays of the min. and max. value*): When R:R is programmed the stored min. and max. values for this measured variable are reset on completion of programming.
R:	(*in the displays of the min. and max. value*): Programming of a Reset. To reset the stored values and restart the min/max recording.
R1R2	Relay 1 and relay 2 simultaneously
R3R4	Relay 3 and relay 4 simultaneously
Rat.	Display for programming the gear ratio of the gearbox
Rd	Denominator of the quotient by which the gear ratio is defined.
Rel1 to Rel5	Relay 1 to Relay 5
:Rel1 to :Rel5	Assignment of a relay to a switching channel or a monitoring function
Rel. 1 2 3 4 5	Current position of relays 1 to 5
Res:	(*in the displays for the switching channels*). Programming of a reset value at which a triggered switching channel is reset to the good state.
rev	revolution
Rn	Numerator of the quotient by which the gear ratio is defined.
s:	(*in the display* s-Res:) Programming the reset position of the drive
s-Res:	Display for programming the data for a position calibration and a synchronization reset of the system
s1	Variable for position monitoring with sensor 1
s1/rev:	Programming a factor for position conversion for s1
s2	Variable for position monitoring with sensor 2
s2/rev:	Programming a factor for position conversion for s2
Self-T	Display for assigning the relays that are to switch to the rest position in the event of device faults or stored messages.
self-test	In this display, the error numbers are specified when device faults occur.
Sensor 1	Sensor 1
Sensor 2	Sensor 2
Sens1 Fault: and Sens2 Fault:	Assignment of the relays that are to switch to the rest position in the event of an encoder error.
Sensor ... conv.	Factor for path conversion in position calculation

service-information	The service information display group contains useful information about service data (such as operating time, relay switching cycles, etc.).
Set:	Programming of a limit value at which the switching channel should operate.
Soft_AU=	shows the software revision number of the analog unit.
Soft_CU=	shows the software revision number of the central unit
Soft_DU=	shows the software revision number of the display and operating unit
Soft_PU=	shows the software revision number of the position unit
t+	means that delay times are programmed for this switching channel
t-	means that no delay times are programmed for this switching channel
tAct:	delay time at the enabling of a switching channel
tPas:	Delay time for ending the enabling of a switching channel
tRes:	Delay time when resetting a switching channel
tSet:	Delay time for the response of a switching channel
V..	software version

3.3 Programming

3.3.1 Code plug

For programming the unit, a code plug is required which is plugged into the socket provided on the front plate (see Fig. 5, p. 14). The following message appears on the display for approx. 3 seconds:

```
code plug ok!
```

The code plug may only be removed again at the end of the programming process.

If the key Ⓟ is pressed without the code plug inserted, the following display appears:

```
no code plug!
```

3.3.2 Programming sequence

The meaning of the programmable parameters of the selected display is described from page 22 (chapter Programming the functions). The programming procedure is always the same and is carried out according to Table 4. The unintentional change of a value is avoided by the fact that two buttons must be pressed simultaneously. Even if the programming key is pressed by mistake, the programming mode can be exited as described in step 6.

	key to be used
1. Select required display	(∧), (∨), (<), (>)
2. Switch on programming mode K4:Rel1 → :s1 En:5+ t- (The Ⓟ key will be flashing and in the display the cursor "_" will appear)	Ⓟ
3. Move the cursor to the value which is to be adjusted	(∧), (∨), (<), (>)
4. Set the desired value (separate for each digit) (a flashing cursor fills the whole character field)	Ⓟ and ⊕ (simultaneously) or Ⓟ and ⊖ (simultaneously)
5. Repeat steps 3. and 4. until all values in the display have been set	
6. Programming of the values and leaving programming mode	⊕ and ⊖ (simultaneously) (do not press Ⓟ !)

Table 4: Programming sequence

In general, only those values can be programmed that are defined. The respective programmable values are described in the chapter “Programming the functions”. The decimal point can be moved for switching values and time delays. The decimal point cannot be set to the first position for time delays.

Example: For programming the switching value "50" the following representation types are equivalent:

50.00 050.0 0050. 00050

But: .50.0 is taken as 0.5 due to the first decimal point!

Warning: The device should only be programmed when the main plant is switched off, because the outputs can switch in an undefined way during the programming procedure.

4 Programming the functions

4.1 Display Language

After selecting the following display, the language of the display texts can be programmed:

```
language/Sprache
      :english
```

Programming options: deutsch, english

The display texts which appear if the German language is selected are described in the German-language version of the operating instructions.

4.2 Configuration of the displays for the current measured values

The current measured values are shown in the following displays:

```
s1=****** ds=  ÷      f1=*****  Qf=
s2=****** *****       f2=*****  *****
```

*****: current values

Programming options: s1, s2, ds, f1, f2, n1, n2, Qf, Qn ( )

For each of the two displays, you can configure which of the measured variables are to be displayed. In each display, 1 to 3 measured values can be shown. For the lower as well as for the right value in the displays it is possible to program a blank „ “ instead of one of the available measurands, then no measurement is displayed there.

4.3 Basic configuration

The subordinated displays contain all basic settings for configuring the device function. The correct programming of these values is a condition for the calculation of the measured values and thus for the monitoring functions of the unit.

4.3.1 Position calibration

After applying the operating voltage, the device sets the values for s1 and s2, as well as the differential counters for the synchronisation and gear breakage monitoring to "0", as the actual current values are not known.

The device now needs information about the correct alignment of the system to enable synchronisation, gear breakage or position monitoring. The same applies after the occurrence of an encoder error, because even then the position of the system is undefined for the device.

By an LED **Reset Req.** (Reset Request) as well as by a relay configured for this function, the device requests a position calibration. The corresponding function is programmed in the following display:

```
s-Res:Rel1 En:1+
s:+000.000
```

Programming options: Rel1, Rel2, Rel3, Rel4, Rel5, R1R2, R3R4, ----

numbers 1… 6, -, followed by +, -

+, - (for the first digit of the number)

numbers 0… 9, . (for the following digits of the number)

In the upper line, the function "Reset request" is assigned to one of the relays. This relay remains in the rest position until the operator has confirmed the correct alignment of the system by applying a calibration signal. The calibration is carried out via the enable input specified in the top right of the display after En:. If a + is programmed behind the number for the enable channel, the calibration is performed by applying a voltage to the enable input; if a - is programmed here, it is performed by interrupting the voltage at the enable input.

When the calibration reset is carried out, the differential counters for the synchronism or gear breakage monitoring are reset to "0". At the same time the absolute positions s1 and s2 are set to the value programmed at the lower line of the display. This is only of importance if, in addition to gear breakage or synchronism, the position of the system is to be monitored.

If no calibration is to be carried out, for example, because the device is only to be used to monitor for overspeed or slip and not for operating data relevant to the position, both the relay assignment and the enable assignment can be deactivated. The reset request function is thus deactivated and the LED **Reset Req.** is then also deactivated:

```
s-Res:---- En:--
s:+000.000
```

The value programmed after `s:` is then without meaning. In this case, the device sets the values for s1 and s2, as well as the differential counters for the synchronism or gear breakage monitoring to "0" when the operating voltage is applied. Further calculations are based on these values. Even after encoder errors which lead to faulty position detection, no position reset is requested.

4.3.2 Relay assignment for device failure

In the following display it is assigned which relays should switch in rest position in case of device faults of the ES-FDP-AW1 and in case of stored info messages:

```
Self-T Info:----
      Alarm:Rel1
```

Programming options: `Rel1`, `Rel2`, `Rel3`, `Rel4`, `Rel5`, `R1R2`, `R3R4`, `----`

In the top line the assignment is made for the relay for the messages (Info), and in the bottom line for the relay for device faults (Alarm).

4.3.3 Relay assignment for sensor fault

In the following display, the relays that are to switch in the rest position if the sensor monitoring detects a sensor error are defined:

```
Sens1 Fault:Rel1
Sens2 Fault:Rel1
```

Programming options: `Rel1`, `Rel2`, `Rel3`, `Rel4`, `Rel5`, `R1R2`, `R3R4`, `----`

If no error monitoring is programmed here for one sensor (`----`), the LED **Sensor Err.** will not light up if this sensor has an error or if no sensor is connected to the corresponding sensor input.

4.3.4 Sensor resolution

To convert the input pulses into rotation angle and the input frequencies into speeds, the number of pulses per shaft revolution must be programmed for the used sensors. This is done in the following displays:

```
Sensor 1
imp/rev:0024
```

```
Sensor 2
imp/rev:0050
```

Programming options: Numbers `0` … `9` (for each digit of the numbers)

Using the programmed values of the resolution of Sensor 1 (in the formula as **Se1Res**) and of Sensor 2 (**Se2Res**) and the measured input frequencies f1, f2, the speeds result as follows:

$$\mathbf{n1} = \frac{\mathbf{f1}}{\mathbf{Se1Res}} \cdot \mathbf{60} \qquad \text{and} \qquad \mathbf{n2} = \frac{\mathbf{f2}}{\mathbf{Se2Res}} \cdot \mathbf{60} \qquad \text{[rpm]}$$

The sensors must be selected in a way that the permitted input frequencies of the device are not exceeded. If, by reprogramming the sensor resolution, the programmed speeds for one or more switching channels correspond to an input frequency which is above the permitted limit frequency of 4kHz, the following message appears for approx. 3 seconds (example for switching channel 4):

```
K4 val. too high
for sens.imp/rev
```

At the same time, the yellow LED **Info** will light up. Acknowledgement takes place as described in chapter 5.

4.3.5 Displacement conversion

After programming the sensor resolutions, the drive monitor can calculate the respective angle of rotation of the two encoders. For the simplest possible handling, it makes sense to use the position of the load directly for the specification of the position. A corresponding conversion factor (displacement per revolution) must be programmed for this:

```
Sensor 1 conv.
s1/rev:1.000000
```

```
Sensor 2 conv.
s2/rev:2.545076
```

Programming options: Numbers 0 … 9 , . (for each digit of the numbers)

For s to correspond to the load displacement, the conversion factor must be calculated as follows:

$Conv_{(1,2)}$ = (rope path on the drum per drum revolution) / (pulley transmission ratio)

With a programming of **$Conv_{(1,2)}$ = 1**, the position **s** results in "*number of shaft revolutions*". For monitoring gear backlash this representation is more illustrative.

4.3.6 Gear ratio

To calculate the synchronous deviation between the input and output side of a gearbox, the gearbox ratio must be programmed. The gear ratio **Rat** can generally be represented exactly as the ratio of two integers **Rat = Rn / Rd**, these values are programmed in the following display.

```
Rat. Rn:032850
     Rd:000712
```

Programming options: Numbers 0 … 3 (for the first digit of the numbers)
Numbers 0 … 9 (for the other digits of the numbers)

For **Rn** and for **Rd** values up to a maximum of 399999 can be programmed.

4.3.7 Averaging function for frequency monitoring

In some applications it is not guaranteed that the input pulses will be steady. If a drive is monitored with incremental encoders that have too high resolutions, irregularities may occur due to play or vibrations, for example. The frequency fluctuates around an average value; the short-term frequency peaks can lead to unintended triggering of the monitoring. Uneven input pulses also occur when scanning a gear rim with proximity switches if the teeth are not exactly evenly distributed. The averaging function can be used to make the unit less sensitive in such cases. The averaging of the input frequencies is not carried out over a fixed period of time, but over a programmable number of input pulses.

```
averaging  f1:32
(impulses) f2:01
```

The number of input pulses over which averaging is to be carried out is set separately for input 1 and input 2. The maximum number of averaging is 32 in each case.

A programmed averaging for f1 or f2 only affects the calculation of the input frequencies or speeds and **has no influence on the quotient calculation**.

4.3.8 Averaging function for quotient monitoring

The programming of an averaging for the quotient calculation is done in the following display. A maximum value of 8 pulses can be programmed here.

```
averaging  Q:8
(impulses f1,f2)
```

When determining the quotient, the measuring period is selected in such a way that **at least the number of pulses programmed as averaging occurred on both inputs**. If, for example, a value of 8 is programmed, averaging takes place over the time in which 8 input pulses of the slower frequency occurred.

Compared to a fixed measuring time, averaging over a fixed number of input pulses has the advantage that irregularities are filtered out even if the pulses occur very slowly. At the same time, a fast reaction time at high frequency is achieved, since the measuring time is also correspondingly short due to the fast pulse sequence (particularly important for monitoring overspeed).

A special feature of the devices of the series **ES-FDP-...** is that not simply the number of pulses programmed for averaging is waited for and then an evaluation is carried out, but that **each incoming input pulse is evaluated** (if not several pulses fall within a measuring period, then only one evaluation is carried out). This is possible by internally storing the times of the last input pulses. With each new input pulse, the previous ones are included in the calculation (according to the programmed averaging number) and the average value calculated is used for the evaluation and control of the switching channels.

4.3.9 Quotient reset

To avoid faulty switching of the output relays for the quotient **Q**, the quotient is set to the set value **Qr (Q-Reset)** after applying the mains voltage or after changing the direction of rotation of the drive. This set value must correspond to the value **Q** during operation of the fault-free drive. This prevents faulty switching until a current value is calculated.

```
Qf-Reset:1.000
 if dir.ch.:I1I2
```

Programming options: `Qf`, `Qn`

Numbers `0` … `9` , `.` (for each digit of the number)

`I1`, `I2`, `I1I2`, `----`

At the top left of the display, you first select `Qf` or `Qn` to define whether the **Q-Reset** value is entered as a ratio of frequencies or speeds. Behind `Qf-Reset:` or `Qn-Reset:` the corresponding reference value is programmed. In the second line it is defined by which input signal `I1` or `I2` (or both `I1I2`) the Q-Reset should be triggered. If a `----` is programmed here, the Q-reset is only carried out once after applying the mains voltage, but not when the direction of rotation is changed.

4.4 Switching channels

4.4.1 General information

The monitoring of the measured variables is carried out by the switching channels **K1** to **K8**. The assignment of the switching channels **K1** to **K8** to one of the measured values `s1`, `s2`, `ds`, `f1`, `f2`, `n1`, `n2`, `Qf` oder `Qn` each, or for monitoring for standstill `ST` or unintentional sinking `US`, is freely selectable.

For each switching channel 4 displays are used to completely program the switching behaviour.

```
K1:Rel1        →
:ds    En:1+  t+
```

```
K1   Set:>00.400
ds   Res:<00.390
```

```
K1     tSet:0.20s
ds     tRes:2.50s
```

```
K1     tAct:0.00s
En1+   tPas:0.00s
```

4.4.2 Meaning of the internal enable signals

A switching channel is generally used to monitor a measured variable for compliance with certain limit values and to trigger a relay if a limit value is exceeded. However, it is also possible not to switch a relay but to generate an internal enable signal `IEn7` or `IEn8` instead. An application example is the implementation of a position-dependent speed monitoring. A hoist is to be moved in a certain load position only at reduced speed. A switching channel is used to monitor the load position and generates an internal enable signal when the critical position is reached. This enable signal activates the switching channel used to monitor the reduced maximum speed.

4.4.3 Configuration of the switching channel

```
K1:Rel1        →
:ds    En:1+  t+
```

```
...
```

The measured variable to be monitored is programmed at the bottom left of the display.

Programming options: `s1`, `s2`, `ds`, `f1`, `f2`, `n1`, `n2`, `Qf`, `Qn`, `US`, `St`

At the top you program which relay is to switch to the rest position when the switching channel responds.

Programming options: `Rel1`, `Rel2`, `Rel3`, `Rel4`, `Rel5`, `R1R2`, `R3R4` (relay)

`IEn7`, `IEn8` (internal enable signal)

`----` (switching channel is not active)

In the bottom line, after "`En:`", it is programmed whether the switching channel is to operate depending on an enable signal or always is active. If the number `0` is programmed here, then the relevant switching channel is always activated, i.e. an enable is not required. The numbers `1` ... `8` specify an assigned enable input. A following `+` causes the activation when voltage is present at the enable input, a following `–` causes the activation when there is no voltage applied to the release input.

Programming options: Number `0` (switching channel is always active)

Numbers `1`… `6` (activation with external enable signal)

Numbers `7`, `8` (activation with internal enable signal)

`+` (Activation by voltage at the enable input)

`–` (Activation by voltage interruption at the enable input)

Particularities when configuring a switching channel for monitoring for unintentional sinking (US)

Monitoring for unintentional sinking must be activated by an enable signal. Programming a switching channel for monitoring for unintentional sinking is therefore only possible if an enable assignment is set. If an attempt is made to carry out the programming without assigning an enable signal, the unit desactivates the switching channel and dashes ---- appear in the display instead of the relay assignment and the US assignment:

```
K1:----       →    ...
:--    En:0   t+
```

Only one single switching channel can be programmed to monitor for unintentional sinking. If an attempt is made to program a second switching channel to US, the above display also appears and the channel remains inactive.

Particularities when configuring a switching channel for monitoring for standstill (St)

Monitoring for standstill must be activated by an enable signal. Programming a switching channel for monitoring for standstill is therefore only possible if an enable assignment is set. If an attempt is made to carry out the programming without assigning an enable signal, the unit desactivates the switching channel and dashes ---- appear in the display instead of the relay assignment and the St assignment:

```
K1:----       →    ...
:--    En:0   t+
```

Only one single switching channel can be programmed to monitor for standstill. If an attempt is made to program a second switching channel to St, the above display also appears and the channel remains inactive.

4.4.4 Switching values

The switching values are programmed in the first subordinate display. On the left, below the marking of the switching channel, the monitored measured variable is displayed again for information. By default, i.e. when hysteresis switching functions are realized, the display looks as follows:

```
...           →    K1   Set:>00.400
                   ds   Res:<00.390
```

Programming options: Res:, AND:, OR:

>, <

+, − (only for signed measured variables)

Numbers 0 … 9 , . (for each digit of the numbers)

The value behind Set: indicates when the switching channel is to respond and the assigned relay is to switch to the rest position. If the condition behind Res: is fulfilled, the switching channel is reset. A switching hysteresis can thus be realized by entering 2 different values.

Attention! The following applies to all switching functions: A programmed > sign is always evaluated as "greater or equal", i.e. the switching channel is already switched when the programmed numerical value is reached. However, a programmed < sign is evaluated as "less than", i.e. the programmed numerical value must be undershot in order for the channel to switch.

To implement window switching functions, the Res: in the display must be reprogrammed into an AND: or an OR:. If AND: is programmed, the assigned relay switches to rest position if the current value of the measured variable is within the programmed window. Outside the window, the switching channel is reset:

```
...           →    K1   Set:>01.000
                   ds   AND:<02.000
```

If OR: is programmed the assigned relay switches to the rest position if the current value of the measured variable is outside the programmed window. Within the window, the switching channel is reset:

```
...            →
```

```
K1   Set:<01.000
ds    OR:>02.000
```

When programming window functions, the values in the display are always automatically rearranged so that the smaller value is at the top and the < and > symbols correspond to the logic required for a correct AND: or OR: function, i.e. an implausible logic operation is corrected into a meaningful one. After programming is complete, you should therefore check again whether the window function implemented (according to the display) corresponds to the desired function.

4.4.5 Breach of the cut-off frequency when programming the switching values

If a switching value higher than 4000Hz is programmed for frequency monitoring, the following message appears for approx. 3 seconds (example for switching channel 4):

```
K4  values too
          high
```

If a switching value is programmed for speed monitoring which corresponds to a sensor frequency higher than 4000Hz, the following message appears for approx. 3 seconds (example for switching channel 4):

```
K4 val. too high
for sens.imp/rev
```

The yellow LED **Info** lights up simultaneously with the messages. The switching values must be corrected so that they are within the permitted frequency range of the device. To reset the **Info** LED, the error message must then be acknowledged as described in chapter 5.

4.4.6 Time delay for the switching channels

In the second subordinated display for each switching channel, switching delay times can be programmed.

```
K1     tSet:0.20s
ds     tRes:2.50s
```

Programming options: Numbers 0 … 9 (first digit of the numbers)
Numbers 0 … 9 , . (following digits of the numbers)

If a value tSet is programmed, the limit value programmed as Set: must be exceeded for at least the time tSet for the switching channel to be triggered. The same applies to the time tRes for the reset switching value.

4.4.7 Enable delay times for the switching channels

If an enable signal is assigned to the switching channel, the enable condition required for activation must be present at least for the time tAct before the switching channel becomes active. If the enable condition is no longer fulfilled, the switching channel is switched back to passive after the time tPas has elapsed.

```
K1     tAct:0.20s
En1+   tPas:2.00s
```

Programming options: Numbers 0 … 9 , . (for each digit of the numbers)

4.5 Password programming protection

For safety reasons against an unauthorized change of the programmed parameters a password-programming protection can be activated in addition to the code plug. If the password-programming protection is active and a programming attempt is made by pressing the button Ⓟ (with inserted code plug) the following display appears:

```
enter password!
```

On request the operator of the device will get information about the activation of the password-programming protection by request of an additional data sheet.

5 Device Errors

5.1 Self-test

During operation the device permanently executes a self-test. At occurring errors the LEDs **Info** and possible **Alarm** on the front light up. The **Alarm** LED indicates a serious error which prevents the correct operation of the device. The device usually eliminates the error automatically and resumes the normal operation. The **Info** LED lights on until acknowledgment. The current error number can be read in the display **self-test**.

```
self-test
 Error Nr:***
```

***: current error number

If several error numbers are stored, these are called after each other by pressing the button ⊳ repeatedly. To acknowledge the error number displayed currently the code plug must be inserted. Then keep the key Ⓟ pushed down and press the key ⊖ simultaneously. This is to do repeatedly until the word `none` appears instead of an error number. For the purpose of a later fault analysis the error nos. should be noted down. An interruption of the mains voltage also leads to deleting stored error numbers and resetting the **Info** LED.

If after a serious disturbance no error correction is possible, the **Alarm** LED lights permanently. This occurs for example if extreme disturbing influences have changed the programmed parameters in the EEPROM or in the flash memory. In this case the relay assigned to the device fault remains in the rest position. The necessary measures are described in the following chapters.

5.2 Meaning of the error messages

Extreme external disturbances can cause errors in the program flow or in the stored data. The device detects these by means of the self-test and makes the appropriate corrections. The detected errors and the corrective measures are characterized by the error numbers (see Table 5 and Table 6). The error number thus indicates the effect of the fault; the causes (i.e. the sources of the fault) cannot be detected by a test program.

The column "Location of the fault" in the tables shows where the fault occurred:

- **CU =** Central unit, module responsible for the central control of the device, for the calculation of the frequency and slip-related measured variables, and for the evaluation of the corresponding programmed limit values.
- **PU =** Position unit, module for position detection, responsible for the calculation of the position-related measured variables and the evaluation of the corresponding programmed limit values.
- **DU =** Display unit, module for the operating of the device and display of measured values and device status.
- **AU =** Analogue unit, module responsible for generating the PWM signal used for the analogue output (only for devices with optional analogue output).

Error number	Location of the fault	Meaning	Required measures (cf. Table 7)
001	DU, CU	Incompatible software in central unit and display unit	1
002	CU	The data in the EEPROM does not correspond to the data of the display unit	2
003	CU	Forbidden data in the EEPROM	2
004	CU	Configuration data in the microcontroller is faulty	1
005	CU,AU	Incompatible software between central unit and analogue unit	1
009	CU	Watchdog timer has triggered and reset has been initiated	3
010	CU	Reset occurred due to undervoltage	4
011	CU	Other unauthorized reset condition occurred	3
012	CU	The permitted cycle time was exceeded	3
013	CU	The permitted time for data exchange with display unit and analogue unit was exceeded	3
017	CU	Forbidden values in switching registers	3
018	CU	Forbidden values in registers for the data interchange control	3
019	CU	Wrong values in registers for the Capture control (frequency recording)	3
020	CU	Reserved	3
021	CU	Reading the EEPROM couldn't be executed correctly, possible because a forbidden write operation was still active	3
023	CU	Data in the RAM do not correspond to the values transmitted by the display unit	2
025	CU	No i2c bus connection to the display unit	3
026	CU	Bus collision at i2c data transmission appeared	3
027	CU	No Acknowledge of the I2c slave	3
028	CU	Received i2c data have check sum errors	3
029	CU	Data error with received data from the position unit	3
030	CU	No i2c connection to the analogue unit	3
032	CU	Reserved for equipment testing	3
033	DU	Display unit does not receive any data of the central unit	3
034	DU	Check sum error at received data	3
035	DU	Data error of the stored parameters in flash memory (cf. chapter 5.3)	3
036	DU	Error of the i2c slave state machine	3
037	DU	Reserved for tests	3
038	DU	Error at the recording of the relay-switching cycles	3
039	DU	Error at the recording of the service data	3
040	DU	programmed switching values are above the cut-off frequency of the device	5
041	DU	Watchdog timer has responded and has triggered reset	3
042	DU	Reset was triggered because of low voltage	4
043	DU	Other forbidden Reset condition appeared	3
044	DU	Forbidden interrupt occurred	3
045	DU	Configuration data in the microcontroller is faulty	1

Table 5: Error numbers at the self-test, central unit and display unit

Error number	Location of the fault	Meaning	Required measures (cf. Table 7)
049	AU	Program sequence error in the analogue unit	3
050	AU	reset occurred due to undervoltage	4
051	AU	received i2c data have checksum errors	3
052	AU	temporarily no data reception from the central unit	3
065	DU, PU	Incompatible software between position unit and display unit	1
066	PU	Data in EEPROM does not match the data in the display unit	2
067	PU	Impermissible data in EEPROM	2
068	PU	Faulty configuration data in the microcontroller	1
073	PU	Watchdog timer has responded and triggered reset	3
074	PU	Reset occurred due to undervoltage	4
075	PU	Other unauthorized reset condition occurred	3
076	PU	Cycle time was not maintained	3
077	PU	The permitted time for data exchange with the display unit was exceeded	3
081	PU	Impermissible values in switching registers	3
082	PU	Impermissible values in registers for data exchange control	3
084	PU	Reserved	3
085	PU	Reading the EEPROM could not be carried out correctly, possibly because a write operation was still active without permission	3
087	PU	Data in RAM does not match the values transmitted by the display unit	2
089	PU	No i2c bus connection to the display unit	3
090	PU	Bus collision occurred during i2c data transmission	3
091	PU	no acknowledgement from I2c slave	3
092	PU	received i2c data have checksum errors	3
093	PU	Data error on data received from central unit	3
096	PU	Reserved for device testing	3

Table 6: Error numbers at the self-test, position unit and analogue unit

Required Measure	
1	Turn off power supply and switch on again. If furthermore the error appears, the device must be sent in for repair to the manufacturer. Otherwise note down error number and inform the manufacturer.
2	Turn off power supply and switch on again. If furthermore the error appears, programmed parameters are changed by extreme disturbing influences. This is recognized by redundant storage. Select an arbitrary programmable display, switch on the programming mode and finish normally. Parameters do not have to be changed to this. The device corrects all perhaps faulty data to permissible values. This may possibly result in further info messages which then have to be acknowledged **Attention: A following check of all programmed data is absolutely required.** Note down error number and inform the manufacturer.
3	Acknowledge error, note down error number and inform the manufacturer.
4	Acknowledge error, remove external cause for undervoltage or short-time voltage drops at the operational location.
5	Reprogram switching values in a way that the permissible frequency range of the device is not exceeded. Afterwards the error has to be acknowledged.

Table 7: Required measures after appearance of errors

5.3 Data error of the stored parameters in the flash memory

The programmable parameters of the device are stored in the flash memory of the display unit. A change of the programmed data is very unlikely. A storage of faulty data can happen, for example, if the supply voltage fails directly during the completion of programming. If the device detects faulty data in the flash memory during the self-test, the red **Alarm** LED lights up and the relay assigned to the device fault is switched to the rest position. When selecting the main display for the self-test, the following display appears:

```
self-test
 data error    →
```

Pressing the button (>) directly leads to the display in which the error has appeared. The programming mode is selected, all programmed values have to be checked for correctness and corrected if necessary. Afterwards, the programming is completed normally by pressing the buttons (+) and (−) simultaneously.

If, after selecting the self-test display, the message “data-error“ continues to appear, the programmed parameters of another display are faulty and the procedure must be repeated. Then, after correcting all faulty data, the selection of the self-test display leads to the error number 035. This error number was caused by the faulty data in the flash memory and must now be acknowledged.

5.4 Programming of switching values above the limit frequency

If the permissible limit frequency of the unit (4000Hz) is not taken into account when programming switching values, the yellow **info** LED lights up and, immediately after the programming, a corresponding message appears on the display for approx. 3 seconds (display examples for switching channel 4):

```
K4  values too
          high
```

or

```
K4 val. too high
for sens.imp/rev
```

As long as these values are not corrected, the yellow **info** LED remains lit. After selecting the display **self-test** display, the following message appears:

```
self-test
limit error    →
```

After pressing the button (>) one reaches directly the display in which a too high switching value is programmed. After correction of all switching values which were programmed higher than the permitted limit frequency, error no. 040 is still indicated in the display **self-test**, which can then be acknowledged normally.

5.5 Wiring of the enable inputs

In some cases the cause of a disturbance can be an extreme switching over-voltage at an enable input. **An external wiring with varistors or load resistances can help in this case.**

Example for enable control with 230V, AC: Suitable are load resistances R=10kΩ/10W or varistors for 275V which are suitable for operating directly at line voltage.

5.6 Wear of relay contacts with inductive loads

If the output relays switch inductive loads (e. g. contactors) they should be protected by a damping circuit. Otherwise the generated arc when switching off may cause high wear of the contacts and may lead to unit faults in awkward cases (the yellow **Info** – LED will light).

With contactors with 230VAC control voltage RC circuits bring good results, but varistor circuits decrease the arc only insignificantly. For the dimensioning the wirings suggested by the contactor manufacturers should be used, since these are particularly coordinated with the respective types.

Pay attention that each damping circuit of the contactors can entail an increase of the switch-off delay time.

5.7 Blown Fuse

The device fuse is soldered onto the printed circuit board next to the transformer. To replace it, unscrew the terminal strips from the unit and loosen the head plate with a screwdriver as shown in Fig. 10 on page 44. Now the assembled circuit boards can be removed from the housing.

A fuse of the type **TR5 160mA/250V, slow-blow** should be soldered in.

Make sure that the plug contacts are properly seated during assembly!

6 Service-Informationen

Information about the device state is summarized under the main display service-information.

```
service-        →
information
```

The operating time of the device as well as the number of the operating cycles of the relay contacts can be seen in the subordinated displays. Furthermore it is shown, whether the password programming-protection of the device is active.

6.1 Software versions

The first two subordinate displays of the service information shows the versions and the revision numbers of the device software:

```
Soft_CU=********
Soft_DU=********
```

```
Soft_PU=********
```

********: current software version

Soft_CU designates the software version of the central unit, **Soft_DU** designates the software version of the display unit. **Soft_PU** in the second display designates the software version of the position unit.

If the device is equipped with an analog output, the second display additionally shows in the lower line the software version of the analog unit **Soft_AU**:

```
Soft_PU=********
Soft_AU=********
```

********: current software version

6.2 Operating time

This display provides information about the operating time of the device (= application of the mains voltage).

```
operation time
    =******h
```

******: operating time (hours)

Here the operating time is increased by 10 minutes each time 10 minutes have elapsed and is stored in the permanent memory. As a result of this procedure, up to 10 minutes too little operating time is determined for each device switch-on period. A correct detection therefore requires that the normal power-on period of the unit is several hours.

6.3 Operating cycles of the relays

The operating cycles of the individual output relays K1..K5 are shown in the following displays:

```
cycles of     →      cycles of Rel1
  relays              =********

                     cycles of Rel2
                      =********
                          :
```

`********`: operating cycles of the relais

These values are also stored in the permanent memory every 10 minutes only. Exactly as in the case of the operating time the part of the cycles that arises at every power-on period of the device up to 10 minutes will not be taken into account. Again a correct recording therefore presupposes a respectively long power-on period of the device.

6.4 Recording the minimum and maximum values of the measured variables

In order to determine the real operating behaviour of the drives, it is often helpful to record the maximum and sometimes also minimum values that occur. The device carries out this recording for the positions, the position deviation, the input frequencies and for the quotient, and the respective recording can still be made dependent on the enable signals applied. The following displays are available for the required settings and the display of the results:

```
Min.-Max.     →      MM:f1  En:3+ R:÷
 information         ***** .. *****

                     MM:f2  En:0+ R:÷
                     ***** .. *****

                     MM:Qf  En:2- R:÷
                     ***** .. *****

                     MM:s1  En:1+ R:÷
                     ***** .. *****

                     MM:s2  En:1+ R:÷
                     ***** .. *****

                     MM:ds  En:1+ R:÷
                     ***** .. *****
```

`****..****`: current min. and max. values

The measured value to be recorded is shown in the top left of the display. Instead of `f1`, `n1` can also be selected, similarly `n2` can be selected instead of `f2`, and `Qn` can be selected instead of `Qf`.

The upper display in the example is to be interpreted as follows: `f1` is measured, and programming `3+` for enable means that enable input 3 must be activated for the acquisition to take place. So if no enable signal 3 is applied, the measurement of the min. and max. values is stopped and only continued when the enable voltage is applied again. If the value `3-` is programmed behind `FG:`, the acquisition is always performed when no voltage is applied at the enable input 3. Values `1` to `5` or `0` can be programmed for the enable assignment. `0` means that the acquisition is always active regardless of the enable signals (in this case, the `+` or `-` is irrelevant).

The `R:` in the upper line stands for a reset of the recorded min/max values. This is done by selecting the programming mode and programming an `R` instead of the `÷` (top right). When programming is complete, the min.-max. values stored for this measurand are reset.

The result of the min/max recording is displayed in the bottom line. The minimum value is displayed at the bottom left, the maximum value is displayed behind the two dots `..` .

When recording the minimum and maximum values of frequencies or quotients, any programmed averaging for the corresponding measurand is taken into account. If the unaveraged values are to be recorded, the averaging for frequency and quotient calculation must be programmed to "1" in the corresponding displays before the recording.

As with the other service data, the recorded min. and max. values are saved in the permanent memory at intervals of 10 minutes. This means that a single peak value that occurred within the last 10 minutes before an interruption of the mains supply may not be taken into account.

6.5 Programming protection

This display shows whether the password programming protection of the device is activated. The operator of the device will receive more detailed information on request from the manufacturer, in the form of a separate data sheet.

```
programming
protection =off
```

or

```
programming
protection =on
```

7 Application example

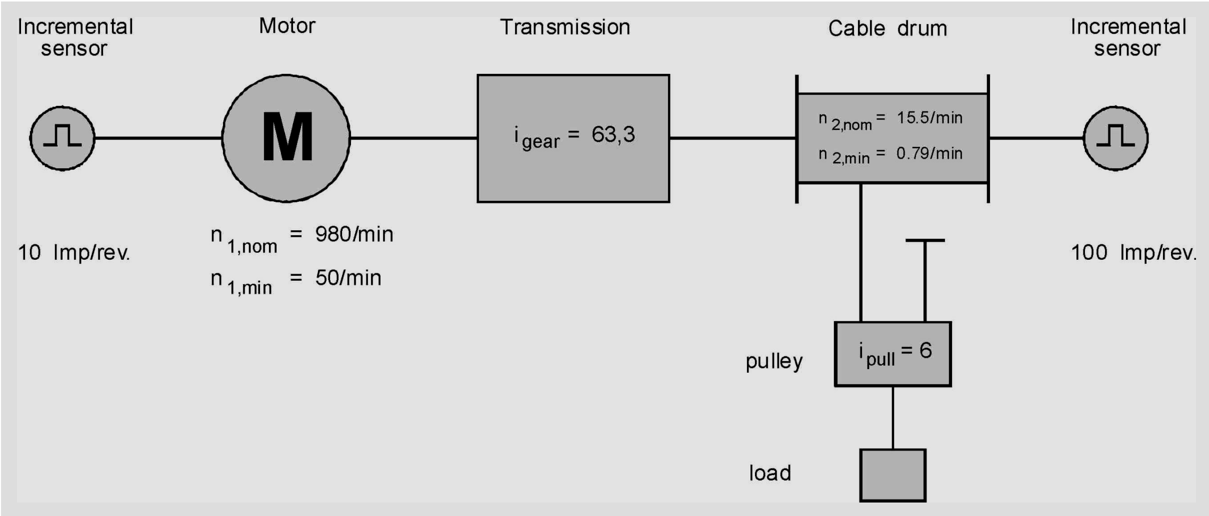


Fig. 6: Example of a hoist to be monitored

The hoist unit shown in the figure is to be monitored with the drive monitor ES-FDP-AW1. This is explained below and an example of programming for the device is shown.

Deactivation of the reset request

Since in this example no position-dependent data and no synchronism is to be monitored, a calibration of the position (or a confirmation of the correct alignment of the system) after applying the operating voltage (or after occurrence and elimination of an encoder error) is not necessary. The reset request function can therefore be deactivated:

```
Reset:---- En:--
s:+000.000
```

This also deactivates the LED **Reset Req.** (Reset Request). The position set value programmed behind `s:` is irrelevant. A position reset is not requested even after senor errors.

When the operating voltage is applied, the device now sets the values for s1 and s2, as well as the differential counters for the synchronisation or gear breakage monitoring to "0". Further calculations are based on these values.

Sensor monitoring

The incremental encoders are monitored by the hardware of the device; it is only necessary to program in the basic settings which relay should react in the event of an error:

```
Sens1 Fault:Rel1
Sens2 Fault:Rel1
```

Gearbox monitoring

The next step will be the monitoring for gear and shaft breakage. In order to monitor the gearbox, the respective angle of rotation of the motor-side shaft is to be compared with that of the drum-side shaft.

If the motor-side rotation angle is designated ***α1*** and the drum-side rotation angle ***α2***, the following should apply for the angles: $\alpha 1 = i_{gear} * \alpha 2$. Deviations result from the total play of the system, calculated from the encoder on the motor side to the encoder on the drum side. Furthermore, the accuracy of the acquisition from ***α1*** and ***α2*** is limited by the resolution of the sensors.

First of all, it is important to set the sensor resolutions correctly in order to record the angles of rotation. Then the device calculates the angles of rotation ***α1*** and ***α2*** each as "number of revolutions of the monitored shaft".

```
Sensor 1
imp/rev:0010
```

```
Sensor2
imp/rev:0100
```

Next, the gear factor ***Rat*** must be entered. Let us assume that the above gear is three stages and has the following gear ratios: ***Rat = (105/20) * (62/15) * (35/12) = 227850/3600***. The gear ratio is then programmed as the ratio of two integers ***Rat = Rn / Rd*** as follows:

```
Rat. Rn:227850
     Rd:003600
```

The exact programming of the gear factor has the advantage that no deviations can add up in the case of large load travel. (Important for drives that only run in one direction, such as belt drives).

For the evaluation of the synchronous deviation the variable ***ds*** is used, which is defined as follows: $ds = | \alpha 2 - \alpha 1/Rat | * Conv2$.

ds is thus the absolute value of the deviation taking into account the gear factor, and the conversion constant ***Conv2*** determines the unit in which ds is evaluated.

Conv2 is programmed in the **Basic configuration** after selecting the display **Sensor 2 conv.**. If the factor 1 is programmed here, the deviation ds is evaluated in the unit "*number of revolutions at sensor 2*", i.e. "*number of drum revolutions*":

```
Sensor 2 conv.
s2/rev:1.000000
```

If the position deviation ***ds*** is to be evaluated directly corresponding to the load displacement, then the conversion ***Conv2*** based on the drum diameter ***D*** and the transmission ratio of the pulley i_{Pull} results as follows $Conv2 = \pi * D / i_{pull}$. With a rope drum diameter of ***D = 80cm*** and a transmission ratio of the pulley $i_{pull} = 6$, results ***Conv2 = 41,888***. With this programming, ***ds*** corresponds to the deviation of the load from the target position, indicated in cm.

```
Sensor2 conv.
s2/rev:0041.888
```

Now a switching channel must be configured for monitoring the gearbox:

```
K1:Rel2       →
:ds    En:0   t-
```

```
K1   Set:>02.000
ds   Res:<00.900
```

```
K1    tSet:0.00s
ds    tRes:0.00s
```

```
K1    tAct:0.00s
En0   tPas:0.00s
```

The measured variable to be monitored is configured in the bottom line of the left display (`:ds`). Since the monitoring should always be active regardless of an enable signal, `En:0` is programmed. When the gearbox monitoring is triggered, relay 2 is to switch (`Rel2`, upper line).

In the first right display the switch-off value is programmed. This value must be selected greater than the sum of the max. system backlash and the detection inaccuracies by the sensors. Let us assume that the travel conversion was programmed with ***Conv2 = 41,888*** so that the limit values for ***ds*** must be entered as the permissible deviation of the load travel in cm.

In the example a switch-off value of ***ds* = 2.000 *cm*** was programmed. On the drum side, this value corresponds to a deviation of approx. 17.2° from the nominal angle of rotation.

Additional delay times are not desired for monitoring, so that all times in the middle right display are programmed to 0.00s.

The enable delay times in the lower right display are ineffective because no enable assignment has been programmed.

Speed monitoring

With the gear ratio i_{gear} **= 63,3**, a drum speed of $n_{2,nom} = n_{1,nom} / i = 15{,}482\ min^{-1}$ is obtained at the nominal motor speed $n_{1,nom} = 980\ min^{-1}$.

Switching channel **K2** is used for overspeed monitoring of the rope drum. Thus n2 is programmed as the monitored variable. When an impermissibly high speed is reached, the output relay Rel3 should switch to the rest position. This monitoring function is constantly active. Therefore the corresponding enable input is set to 0. The switch-off value is programmed to 17.000 (rpm).

```
K2:Rel3        →
:n2    En:0   t-
```

```
K2   Set:>17.000
n2   Res:<15.000
```

```
K2    tSet:0.00s
n2    tRes:0.00s
```

```
K2    tAct:0.00s
En0   tPas:0.00s
```

K3 is assigned to motor speed n1 and monitors the minimum speed of the motor. After a certain time, the drive must have reached its minimum speed. If this is then <45.0 rpm, there is an error and Rel4 switches to rest position.

When the motor is operated, a voltage must be applied to enable input 2 (FG:2+). This then activates the monitoring with a delay of 0.50 s.

```
K3:Rel4        →
:n1    En:2+  t+
```

```
K3   Set:<45.000
n1   Res:>46.000
```

```
K3    tSet:0.00s
n1    tRes:0.00s
```

```
K3    tAct:0.50s
En2+  tPas:0.00s
```

Standstill monitoring

Switching channel **K4** is programmed for monitoring for standstill and thus assigned to the measured variable St. It is activated by applying a voltage to the enable input 3 (FG:3+) with the programmed enable time delay of 1.00s. If a load movement of more than 01.000 cm still occurs afterwards, the relay Rel5 switches to the rest position.

```
K4:Rel5        →
:St    En:3+  t+
```

```
K4   Set:>01.000
St   Res:<00.900
```

```
K4    tSet:0.00s
St    tRes:0.00s
```

```
K4    tAct:1.00s
En3+  tPas:0.00s
```

Monitoring for unintentional sinking

Switching channel **K5** is programmed for monitoring for unintentional sinking (`US`) and also switches relay `Rel5` in the event of an error. In lifting mode, enable 4 is activated (`FG:4+`) and activates the monitoring after a time delay of `2,00s`.

If afterwards a load movement in the direction of lowering of more than `01.000` cm still takes place, the relay `Rel5` is switched to the rest position.

```
K5:Rel5         →
:US     En:4+   t+
```

```
K5    Set:>01.000
US    Res:<00.900
```

```
K5     tSet:0.00s
US     tRes:0.00s
```

```
K5     tAct:2.00s
En4+   tPas:0.00s
```

The switching channels **K6** to **K8** are not used in this example; they could still be used for position monitoring or position-dependent speed monitoring, for example.

8 Allocation of Terminals

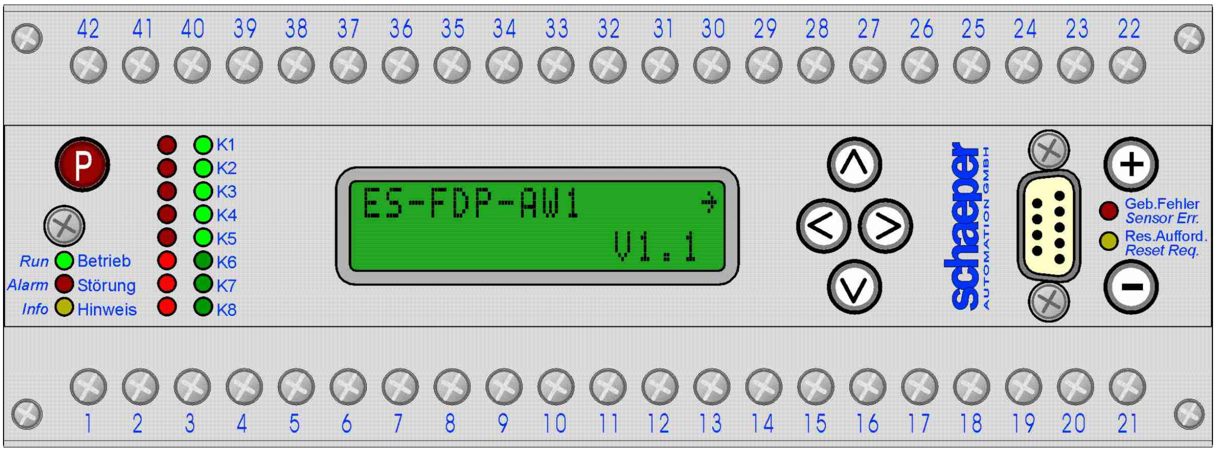


Fig. 7: Front plate and terminal strips

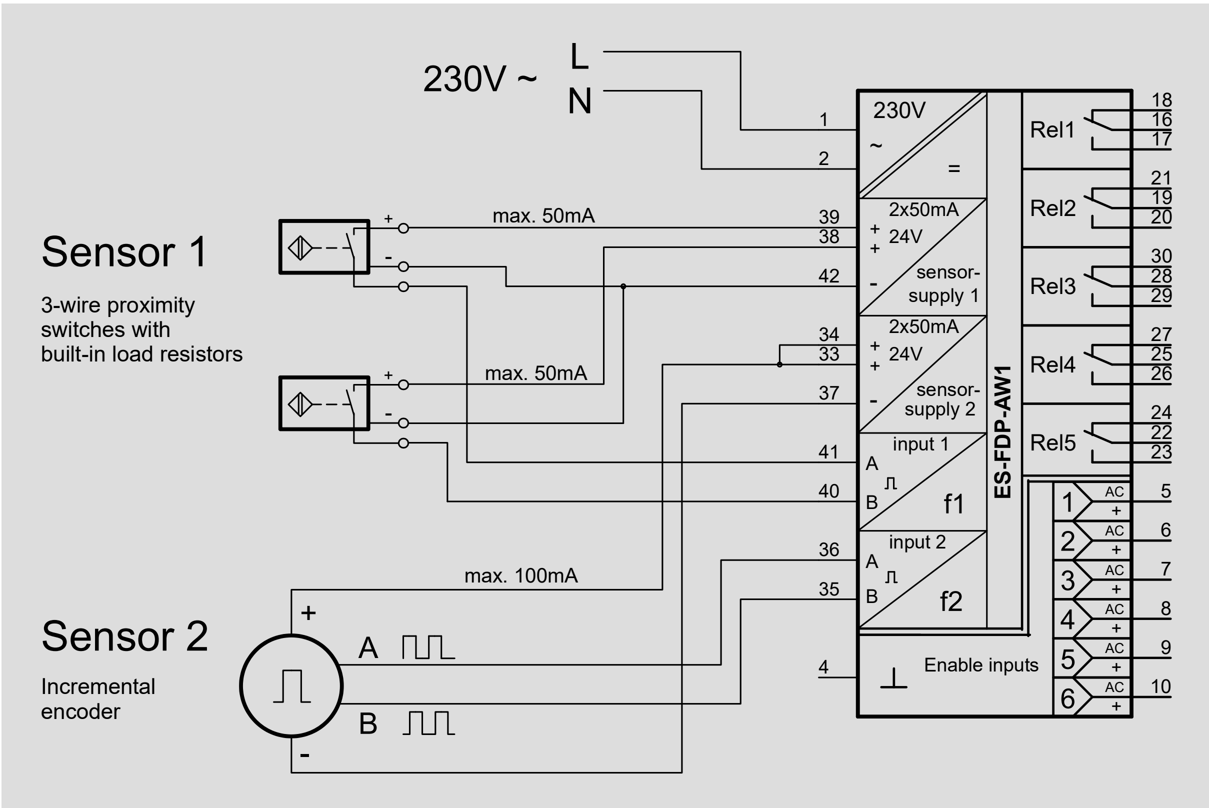


Fig. 8: Connection example for proximity switches and incremental sensors

1,2	Power supply
4	Ground for enable inputs **–** *for enable with DC* ***N*** *for enable with AC*
5	Enable input 1 **+** *for enable with DC* ***L*** *for enable with AC*
6	Enable input 2 **+** *bei Freigabe mit DC* ***L*** *bei Freigabe mit AC*
7	Enable input 3 **+** *bei Freigabe mit DC* ***L*** *bei Freigabe mit AC*
8	Enable input 4 **+** *bei Freigabe mit DC* ***L*** *bei Freigabe mit AC*
9	Enable input 5 **+** *bei Freigabe mit DC* ***L*** *bei Freigabe mit AC*
10	Enable input 6 **+** *bei Freigabe mit DC* ***L*** *bei Freigabe mit AC*
12	Analogue output **"+"** (Option)
13	Analogue output **"–"** (Option)
39	Sensor supply Sensor 1a, **"+"** 24V, max. 50 mA
38	Sensor supply Sensor 1b, **"+"** 24V, max. 50 mA
42	Sensor supply **"–",** Ground for Sensor 1

34	Sensor supply Sensor 2a, **"+"** 24V, max. 50 mA
33	Sensor supply Sensor 2b, **"+"** 24V, max. 50 mA
37	Sensor supply **"–",** Ground for Sensor 2
41	Sensor 1, Input Phase A
40	Sensor 1, Input Phase B
36	Sensor 2, Input Phase A
35	Sensor 2, Input Phase B
16,17,18	Relay 1 16 change-over switch 17 make contact 18 rest contact
19,20,21	Relay 2 19 change-over switch 20 make contact 21 rest contact
28,29,30	Relay 3 28 change-over switch 29 make contact 30 rest contact
25,26,27	Relay 4 25 change-over switch 26 make contact 27 rest contact
22,23,24	Relay 5 22 change-over switch 23 make contact 24 rest contact

Do not make connections to terminals not listed.

9 Device versions and ordering codes

Overview of the available device versions:		
Device:	**Order code**	**Description**
ES-FDP-AW1	**EAW1-** *ii/fv* **	Drive Monitor

** Breakdown of the order code *ii/fv*

ii	Measuring input	***f***	Enable inputs	***v***	Supply voltage
3D	for incremental or 3-wire sensors	9	Enable voltage 230V AC/DC	9	230V AC, 50-60Hz
2D	for 2-wire sensors	7	Enable voltage 110V AC/DC	7	110V AC, 50-60Hz
		2	Enable voltage 24V AC/DC		
		1	Enable voltage 12V AC/DC		

Example: EAW1-3D/99:

Version for incremental or 3-wire sensors, enabling voltage 230V, supply voltage 230V

10 General technical data

Measurement inputs:	for incremental sensors or 3-wire-proximity switches (PNP or NPN) with built in load resistance or 2-wire-proximity switches
Frequency range:	0,1 ... 4000 Hz (standard) (**Specification applies to 2-phase input pulses with 90° phase offset)**
Measuring principle:	Position acquisition by incremental counting, Frequency acquisition by period duration measurement
Sensor supply:	20…24 V=, 4 x 50mA or 2 x 100mA
Enable inputs:	depending on device version: for 12V (10 ... 40V) AC/DC, or 24V (20 ... 80V) AC/DC, or 115V (97 ... 150V) AC/DC, or 230V (195 ... 260V) AC/DC
Switching outputs:	5 relays, 1 change-over contact, 250 V~, 5 A electrical contact life: 1,0 x 10^5 switching cycles at 250V~, 5A / 30V=, 5A and resistive load 3,5 x 10^4 switching cycles at 250V~, 5A and cos φ = 0,4 2,0 x 10^5 switching cycles at 250V~, 2A and cos φ = 0,4
Supply voltage:	230V ~, ±10%, 50 ... 60 Hz. **Attention: the build-in Varistor for protection against voltage transients is not fuse-protected internally!**
Power consumption:	approx. 24 VA
Fuses:	Type TR5 160 mA / 250 V, slow-blow (soldered in)
Ambient temperature:	-10 ... +50 °C (operation) -20 ... +70 °C (storage)
Housing dimensions:	L = 200 mm, W = 75 mm, H = 126 mm with screw and snap-on mounting (DIN 46 277, 35 mm rail)
Behavior in fire:	according to UL: V-0 or VDE 0304: stage I (housing and keys)
Connection terminals:	removable connector block with self-lifting BI-slotted screws for 2x2,5 mm^2; including terminal cover with protection against accidental contact according to VBG 4 and VDE 0106 part 100
Creep resistance:	Insulation group C 250VE/300VG (creeping distance 4 mm); according to DIN 57110 and VDE 0110
Protective system:	IP 40
Mass:	approx. 1300 g

(Subject to changes without notice)

11 Housing Dimensions

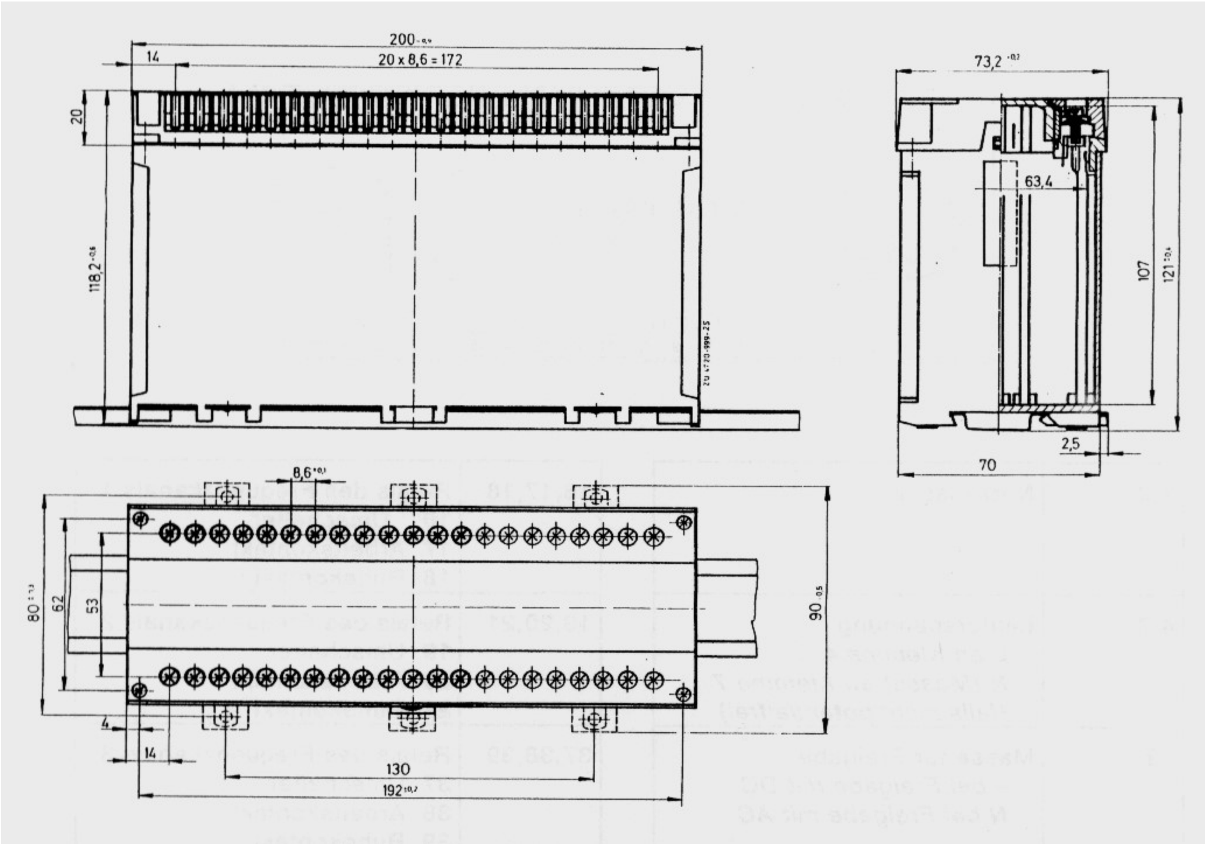


Fig. 9: Housing Dimensions

Removing the terminal strip: The terminal strip is loosened and removed from the device by unscrewing the two outer fastening screws. When changing the device the connector blocks are simply attached to the replacement device and screwed on. It is immediately ready for operation without any wiring work being necessary.

Removing the front plate: Both terminal strips must be removed before the front plate can be removed from the cover. This is then carried out as follows: place a screwdriver with a size of max. 0,6 x 4,5 DIN 5264 in one of the two recesses on the side, a light pressure is used to turn it to the left or right, thus unlatching the projection on the front plate from the casing. The same procedure must be carried out on the opposite side. The front plate can then be removed from the casing.

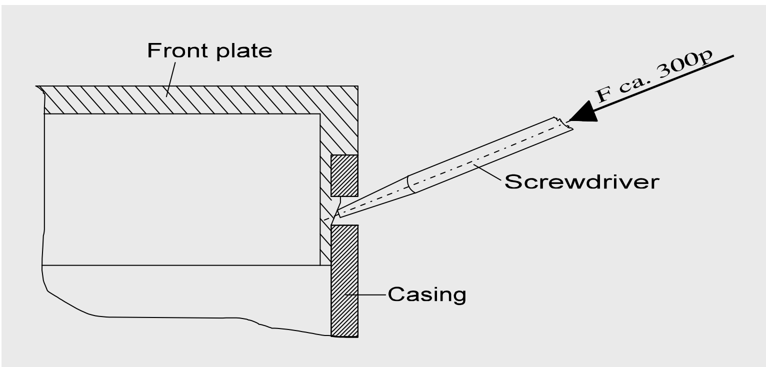


Fig. 10: Removing the front plate

12 Programming Reference Material

General and Basic Configuration

Display	Display	
`ES-FDP-AW1 →` `V1.1`	`language/Sprache` `:english`	**ES-FDP-AW1** (with english diplays)
`Rel. 1 2 3 4 5 →` `= * * * * *`	`EnIn 1 2 3 4 5 6` `= * * * * * *`	**Device number:**
`__=****** __= →` `__=****** ******`	`__=****** __=` `__=****** ******`	**Date:**
`Basic →` `configuration`	`s-Res:____ En:__` `s:________`	**Place of assembly:**
:	`Self-T Info:____` `Alarm:____`	
	`Sens1 Fault:____` `Sens2 Fault:____`	**Construction-No.:**
	`Sensor 1` `imp/rev:____`	
	`Sensor 1 conv.` `s1/rev:________`	
	`Sensor 2` `imp/rev:____`	
	`Sensor 2 conv.` `s2/rev:________`	
	`Rat. Rn:______` `Rd:______`	
	`avaraging f1:__` `(impulses) f2:__`	
	`avaraging Q:_` `(impulses f1,f2)`	
	`Q_-Reset:_____` `if dir.ch.:____`	

`*..*:` **current values**

Programming Reference Material

Switching channels K1 … K4

ES-FDP-AW1

(with english displays)

```
ES-FDP-AW1      →   language/Sprache
          V1.1              :english
        :
        :
        :
K1:____         →   K1   Set:_______
:__    En:__   t*        ___:_______

                    K1     tSet:____s
                           tRes:____s

                    K1     tAct:____s
                    En     tPas:____s

K2:____         →   K2   Set:_______
:__    En:__   t*        ___:_______

                    K2     tSet:____s
                           tRes:____s

                    K2     tAct:____s
                    En     tPas:____s

K3:____         →   K3   Set:_______
:__    En:__   t*        ___:_______

                    K3     tSet:____s
                           tRes:____s

                    K3     tAct:____s
                    En     tPas:____s

K4:____         →   K4   Set:_______
:__    En:__   t*        ___:_______

                    K4     tSet:____s
                           tRes:____s

                    K4     tAct:____s
                    En     tPas:____s
```

..: **current values**

Programming Reference Material

Switching channels K5… K8

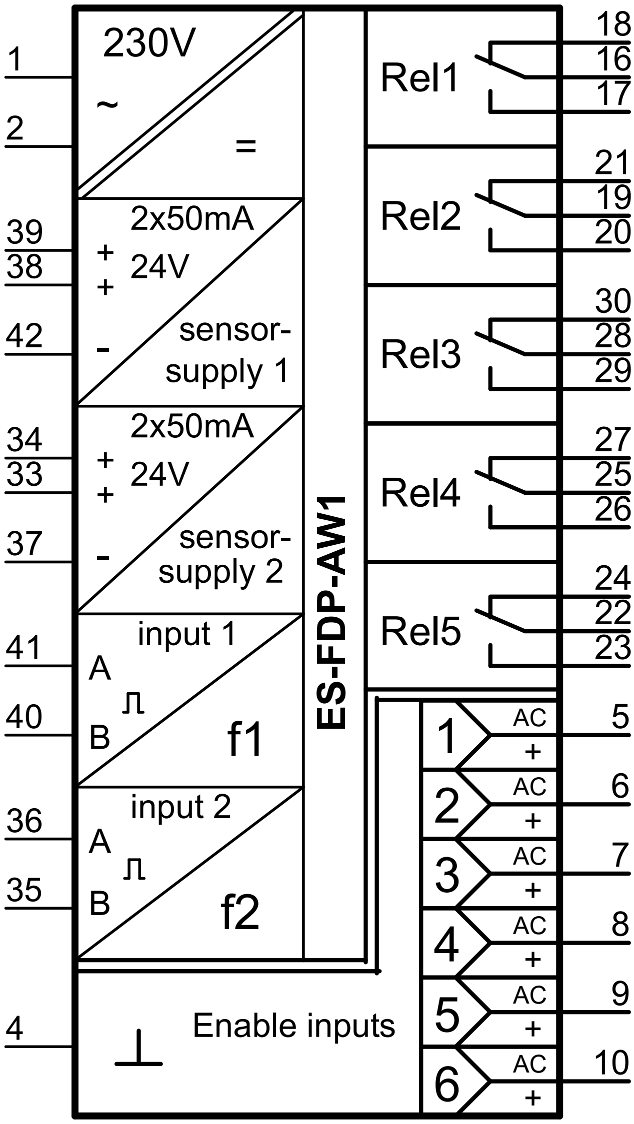
ES-FDP-AW1

(with english displays)

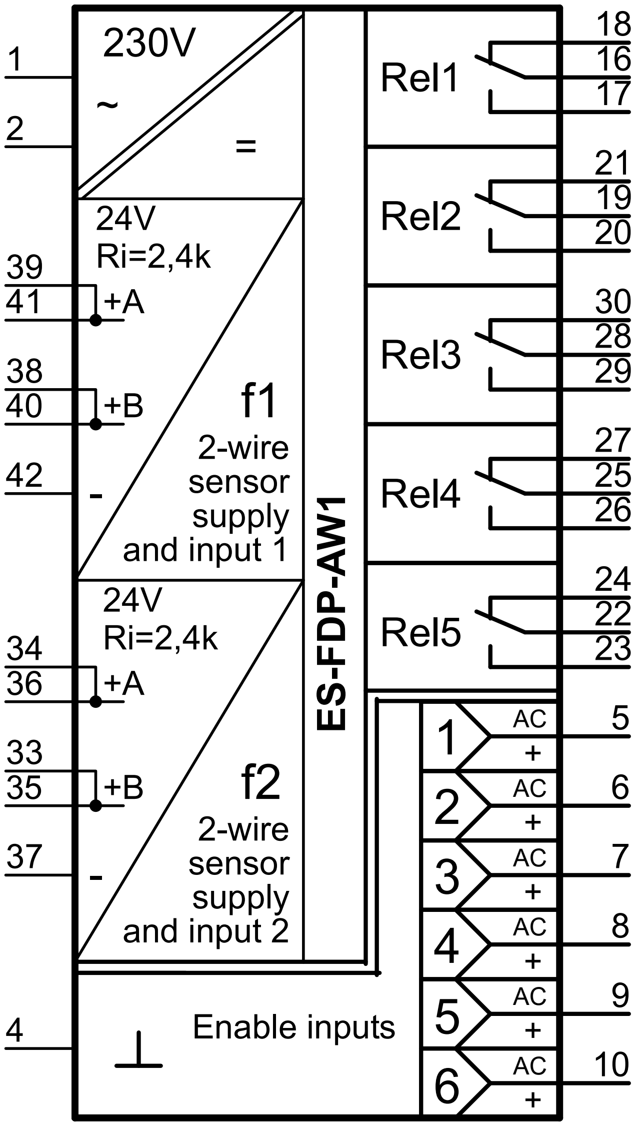
```
ES-FDP-AW1     →    language/Sprache
          V1.1            :english
        .
        .
        .
K5:____        →    K5   Set:_______
:__    En:__  t*         ___:_______

                    K5    tSet:____s
                          tRes:____s

                    K5    tAct:____s
                    En    tPas:____s

K6:____        →    K6   Set:_______
:__    En:__  t*         ___:_______

                    K6    tSet:____s
                          tRes:____s

                    K6    tAct:____s
                    En    tPas:____s

K7:____        →    K7   Set:_______
:__    En:__  t*         ___:_______

                    K7    tSet:____s
                          tRes:____s

                    K7    tAct:____s
                    En    tPas:____s

K8:____        →    K8   Set:_______
:__    En:__  t*         ___:_______

                    K8    tSet:____s
                          tRes:____s

                    K8    tAct:____s
                    En    tPas:____s
```

..: **current values**

13 Wiring Symbols



Circuit diagram of the device version for the connection of incremental or 3-wire encoders



Circuit diagram of the device version for the connection of 2-wire sensors