Two red lines intersect on a blue background. One line starts from the top right and goes down-left. The other starts from the top left and goes down-right. They meet at a point in the upper middle of the page. There are small white circles at the intersection and at the end of the line starting from the top left.

ETAS ES441.1

Counter and Frequency Module with Sensor Supply

User Guide

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1 About this Document

1.1 Classification of Safety Messages

The safety messages used here warn of dangers that can lead to personal injury or damage to property:



DANGER

indicates a hazardous situation with a high risk of death or serious injury if not avoided



WARNING

indicates a hazardous situation of medium risk which could result in death or serious injury if not avoided.



CAUTION

indicates a hazardous situation of low risk which may result in minor or moderate injury if not avoided.

NOTICE

indicates a situation which may result in damage to property if not avoided.

1.2 Presentation of Instructions

The target to be achieved is defined in the heading. The necessary steps for his are in a step-by-step guide:

Target definition

1. Step 1
2. Step 2
3. Step 3
- > Result

1.3 Typographical Conventions

Bold	Menu commands, buttons, labels of the product
<i>Italic</i>	Emphasis on content and newly introduced terms

1.4 Presentation of Supporting Information

 **NOTE**

Contains additional supporting information.

1.5 Scope of Supply

Prior to the initial commissioning of the module, please check whether the module was delivered with all required components and cables (see chapter 10.1 on page 120).

Additional cables and adapters can be obtained separately from ETAS. A list of available accessories and their order designation is located in chapter "Accessories" on page 120 of this manual or in the ETAS product catalog.

1.6 Additional Information

The configuration instructions for the module under INCA can be found in the corresponding software documentation.

2 Basic Safety Notices

This chapter contains information about the following topics:

- "General Safety Information" on page 9
- "Requirements for Users and Duties for Operators" on page 9
- "Intended Use" on page 9

2.1 General Safety Information

Please observe the Product Safety Notices ("ETAS Safety Notice") and the following safety notices to avoid health issues or damage to the device.

 **NOTE**

Carefully read the documentation (Product Safety Advice and this User's Guide) that belongs to the product prior to the startup.

ETAS GmbH does not assume any liability for damages resulting from improper handling, unintended use or non-observance of the safety precautions.

2.2 Requirements for Users and Duties for Operators

The product may be assembled, operated and maintained only if you have the necessary qualification and experience for this product. Incorrect operation or operation by users without sufficient qualification may lead to injuries or death or property damages.

The safety of systems that are using the product is the responsibility of the system integrator.

General safety at work

The existing regulations for safety at work and accident prevention must be followed. All applicable regulations and statutes regarding operation must be strictly followed when using this product.

2.3 Intended Use

Application area of the product

This product was developed and approved for applications in the automotive area. The module is suitable for use in interiors, in the passenger cell, in the trunk, in the engine compartment or in the exterior area of vehicles.

For use in other application areas, please contact your ETAS contact partner.

Requirements for the technical state of the product

The product is designed in accordance with state-of-the-art technology and recognized safety rules. The product may be operated only in a technically flawless condition and according to the intended purpose and with regard to safety

and dangers as stated in the respective product documentation. If the product is not used according to its intended purpose, the protection of the product may be impaired.

Requirements for operation

- Use the product only according to the specifications in the corresponding User's Guide. With any deviating operation, the product safety is no longer ensured.
- Observe the requirements on the ambient conditions.
- Do not use the product in potentially explosive atmospheres.

Electrical safety and power supply

- Observe the regulations applicable at the operating location concerning electrical safety as well as the laws and regulations concerning work safety!
- Connect only current circuits with safety extra-low voltage in accordance with EN 61140 (degree of protection III) to the connections of the module.
- Ensure the compliance with the connection and adjustment values (see the information in the chapter "Technical Data").
- Do not apply any voltages to the connections of the module that do not correspond to the specifications of the respective connection.

Power supply

- The power supply for the product must be safely disconnected from the supply voltage. For example, use a car battery or a suitable lab power supply.
- Use exclusively lab power supplies with double protection to the supply system (with double insulation / with reinforced insulation (DI/ RI)).
- The lab power supply must be approved for an operating altitude of 5,000 m and for an ambient temperature of up to 120 °C.
- For normal operation of the modules as well as for very long standby operation, it is possible that the vehicle battery will be drained.

Connection to the power supply

- The power cable may not be connected directly to the vehicle battery or the lab power supply, but only via a suitable fuse.
- Ensure that the connections of the lab power supply, the power supply at the module and the vehicle battery are easily accessible!
- Route the power cable in such a way that it is protected against abrasion, damages, deformation and kinking. Do not place any objects on the power cable!



DANGER

Dangerous electrical voltage!

Connect the power cable only with a suitable vehicle battery or with a suitable lab power supply! The connection to power outlets is not allowed!

To prevent an inadvertent insertion in power outlets, ETAS recommends to equip the power cables with safety banana plugs in areas with power outlets.

De-energizing the module

The module does not have an operating voltage switch. The module can be de-energized as follows:

- Disconnecting the cables from the measurement inputs
and
- Disconnecting the module from the power supply
 - Switching off the lab power supply
or
 - Disconnecting the module from the lab power supply
Separating device is the lab plug of the power cable or the plug of the power cable at the connection of the module
or
 - Disconnecting the module from the vehicle battery
Separating device is the lab plug of the power cable or the plug of the power cable at the connection of the module
or
 - Disconnecting the vehicle battery.

Cabling

Approved cables:

- Use exclusively ETAS cables at the connections of the module!
- Adhere to the maximum permissible cable lengths!
- Do not use any damaged cables! Cables may be repaired only by ETAS!



CAUTION

Never apply force to insert a plug into a socket.

Ensure that there is no contamination in and on the connection, that the plug fits the socket, and that you correctly aligned the plugs with the connection.



CAUTION

Damage possible to connectors of the modules or the ES4xx_BRIDGE!

Fasten the two modules with screws to the stop inside the module without canting them.

For detailed information about cabling, see the User's Guide of the module.



CAUTION

Potential equalization in the vehicle is possible via the shield of the connecting cables of the modules!

Install the modules only at locations with the same electrical potential or isolate the modules from the installation location.

Requirements for the place of installation

- Place the module or the module block on a smooth, even and firm foundation.
- The module or module block must always be securely fastened.

Requirements on the ventilation

- Keep the module away from heat sources and protect it against direct exposure to the sun.
- The free space above and behind the module must be selected so that sufficient air circulation is ensured.

Fixing the module on a carrier system

When selecting the carrier system, observe the static and dynamic forces that could be created by the module or the module block at the carrier system.



CAUTION

Damage or destruction of the module is possible.

The modules of series ES400 are approved only for installation and operation at components or locations that ensure compliance with the technical data of the modules, such as:

- the resistance to vibration of the modules (for example, install modules only on spring-loaded bodies, not on wheel suspensions or directly at the motor) and
- the temperature resistance of the modules (for example, do not install modules on the motor, turbocharger, exhaust manifold or their environments).



CAUTION

During the installation of the modules, observe the permissible temperature range of the cable ties being used!

Damage of the module and loss of properties acc. to IP67



CAUTION

Loss of Features as defined by IP67!

Water standing at the pressure balance element damages the membrane!
Please observe which way the module is pointing when installing vertically!

Transport

- Mount and connect the modules only at the location of their startup!
- Do not transport the modules at the cable of the module or any other cables.

Maintenance

The product is maintenance-free.

Repair

If a repair of an ETAS hardware product should become necessary, send the product to ETAS.

Cleaning the module housing

- Use a dry or lightly moistened, soft, lint-free cloth for cleaning the module housing.
- Do not use any sprays, solvents or abrasive cleaners which could damage the housing.
- Ensure that no moisture enters the housing. Never spray cleaning agents directly onto the module.

3 ES400 Product Family

This chapter contains information on the following topics:

- "Wiring Concepts in Test Vehicles" on page 14
- "Features of the ES400 Line" on page 15
- "Housing" on page 16
- "Ports" on page 17
- "LED" on page 18

3.1 Wiring Concepts in Test Vehicles

For the test phase, several hundred sensors must be installed in a test vehicle in various areas, e.g. in the engine compartment and in the floor area. The sensors, which are positioned all over the vehicle, then have to be connected to the measuring instruments of the test setup.

Today's standard solutions with their central setup of measuring instruments inside the vehicle require complex cabling to connect the widely distributed sensors with the measuring instruments. Numerous, usually long connection cables between the sensors and the measuring instruments, bundled together to form several fat wiring harnesses, require a highly modified splash wall of the test vehicle. This involves long setting-up times as well as high costs.

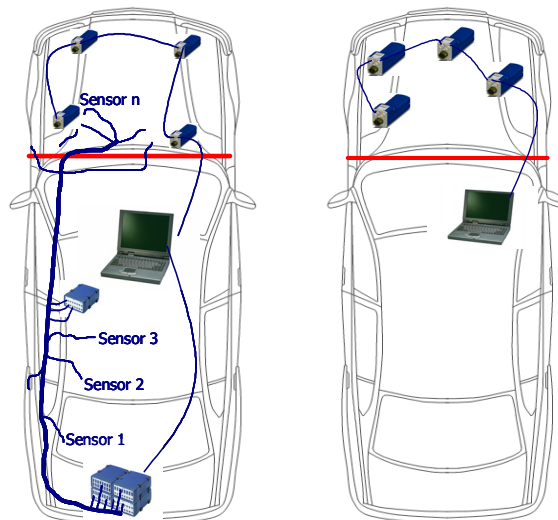


Fig. 3-1 Central and Decentral Sensor Cabling

With the ES400 modules, ETAS provides a decentral solution which considerably simplifies the test setup of the sensors.

The basic idea of this concept is to install the modules of the ES400 family as close as possible to the sensors, to concatenate the modules with each other and to connect just the first module of this chain with the laptop in the vehicle.

3.2 Features of the ES400 Line

3.2.1 Advantages of the Decentral Wiring Concept

- The compact ES400 modules can be mounted close to the sensors with short connection cables.
- The simple assembly and wiring principle (daisy chain topology) of the modules
 - requires only one common cable between the modules for power supply and data transfer
 - considerably reduces the setting-up times for tests
 - simplifies the maintenance and the extension of the test setup
- The only item in the vehicle is the laptop which is connected to the modules with just one cable.
- Test vehicles equipped with an ES400 measurement system can be used flexibly because the vehicles do not have to be modified for changed or new test tasks.

3.2.2 Further Features

This list provides an overview of the other features of the ES400 line in addition to decentral cabling:

- The ES400 modules have a very compact design.
- Each module has an LED for localizing the module.
- The Counter and Frequency Module with Sensor Supplies of the ES400 family use a XCP-based protocol which is compatible to the existing ETAS Ethernet topology.

The concept fulfills the following requirements:

- high bandwidth to be able to realize lots of channels with high resolutions (typical in measuring and calibration applications) with fast sampling rates
- simple application based on the Ethernet integration in INCA, no complicated setting of bus parameters,
- simple to integrate in measurement and calibration tools manufactured by third-party suppliers due to the use of XCP as application protocol
- support of all probes and pressure sensors used in the automotive industry
- Innovative, battery-saving power supply management
 - automatic power-saving feature (“Standby”)
 - “Wake Up” via the Ethernet interface
- Part of the ETAS Tool Suite
- Daisy Chain Configuration Tool (stand-alone operation)

- Modules suitable for use in automotive applications; suitable for use in the development environment and in the vehicle on test drives:
 - Housing, connectors and cables waterproof and dustproof in acc. with IP65 or IP67; designed for use in the engine compartment or the outside area of the vehicle
 - rugged to acceleration or mechanical damage
 - rugged to extreme environmental conditions (temperature, dampness, EMC)
 - very low temperature coefficients contribute to the reduction in the number of measurement errors

For the complete technical data of the ES441.1, refer to the chapter “Technical Data” on page 92.

3.3 Housing

A sturdy metal housing is used for the ES441.1; it has ports on the front of the device so it can fit into tight spaces. The ES441.1 is specifically designed to be installed in engine compartment, but also in the passenger cell.

The housings of the ES400 family can quickly and easily be connected to one another to create a measurement system (see section 6.2 on page 59). The modules can easily be screwed directly to a carrier system or attached to it using cable fasteners both in the vehicle and in the lab.

These simple and uncomplicated ways of attaching the modules make them flexible in terms of assembly. These methods of attachment can also be used in harsh environmental conditions (salt fog, dirt).



CAUTION

Loss of Features as defined by IP67!

Do not open or change the module housing!

Works on the module housing may be executed only by qualified technical personnel.

3.4 Ports

All ports of the ES400 measuring modules are on the front of the device (see Fig. 3-2 on page 17).

The LEMO and Souriau connectors used adhere to protection class IP67. All ports are reverse-polarity protected due to the exclusive use of coded LEMO or Souriau connectors.

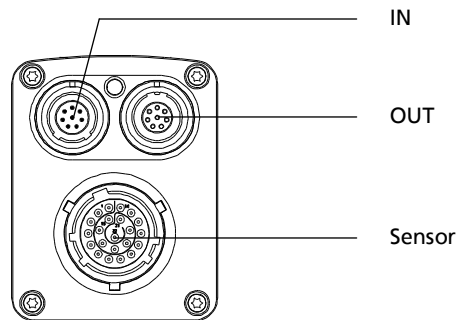


Fig. 3-2 Front

3.4.1 “Sensor” Port

The front of the ES441.1 features a 22-pin Souriau port to which four sensors can be connected using a adapter cable. An individual sensor power supply port is available for each sensor.

The use of a “cable tail” or “whip” solution with just one connector makes it possible to change the modules quickly within complex test setups.

3.4.2 Daisy Chain Ports (“IN”, “OUT”)

The modules are connected using a daisy chain topology. This means each module has an explicit input socket and an explicit output socket. The Ethernet data line and the supply voltage are routed through the daisy chain ports of the module:


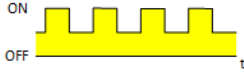



- “IN” (input)
- “OUT” (output)

The PC, the modules ES523, ES59x, ES600.2, ES891, ES910.3 or the Drive Recorder ES720 are connected at the “IN” port (input). The “OUT” port (output) is connected to the following module of the ES400 line or remains free on the last module of the chain.

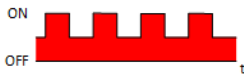

3.5 LED

Every module has an LED. It indicates the following states of the module: Operational State




3.5.1 Operational State

Display		State
	off	No power supply to the module
	yellow flashing 0,25 s on / 0,25 s reduced	Initialization of the module not yet complete - Further modules in a chain not initialized yet
	green illuminated semi bright	Normal
	yellow illuminated semi bright	At least one sensor supply voltage is activated.
	green flashing 0,1 s on / 1,9 s off	Standby No Ethernet connection established

3.5.2 Service State

Display		State
	red flashing 0,25 s on / 0,25 s reduced	Module identification
	red flashing 0,1 s on / 0,6 s off	Update of the firmware / HDC

3.5.3 Functional State

Display		State
	yellow-red flashing 0,5 s yellow reduced / 0,5 s red reduced	Warning Overload on a sensor supply voltage channel
	red illuminated fully bright	Error during self-test
	red illuminated semi bright	Internal error

4 Hardware Description

This chapter contains information on the following topics:

- "Features of the ES441.1" on page 19
- "Block Diagram" on page 20
- "Measurement Channels" on page 20
- "Data Transfer" on page 23
- "Power Supply" on page 28
- "Configuration" on page 31
- "Tool Integration" on page 31
- "Firmware Update" on page 31
- "Calibration" on page 31

4.1 Features of the ES441.1



Fig. 4-1 ES441.1 Housing

The ES441.1 Counter and Frequency Module with Sensor Supply is a member of the family of ES400-Modules. The ES441.1 can acquire digital signals at four input channels. There is a sensor supply for every channel

For the complete technical data of the ES441.1, refer to the chapter "Technical Data" on page 92.

4.2 Block Diagram

The ES441.1 is a module with four identical measurement channels, its own sensor supply for every measurement channel, two shared Ethernet interfaces and a power supply.

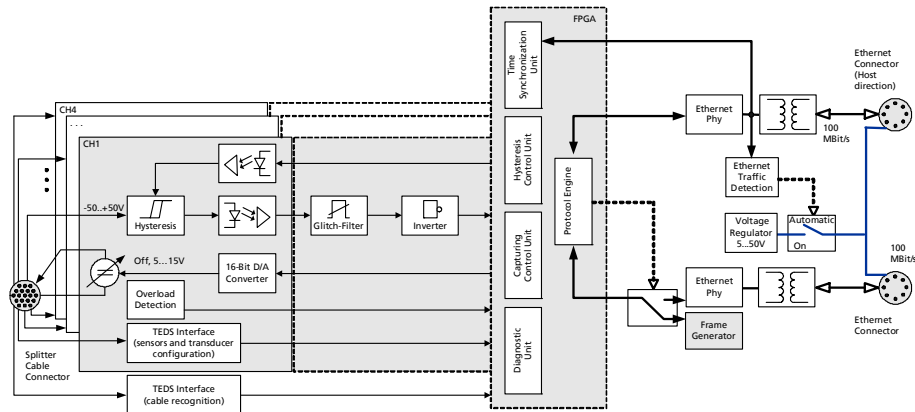


Fig. 4-2 Block Diagram

4.3 Measurement Channels

All measurement channels of the ES441.1 are identical. They consist of an input stage with signal acquisition and signal processing.

The measurement channels are designed for input voltages of -50 V to +50 V. The minimum pulse width is limited to 120 ns. This limitation avoids the acquisition of interfering pulses on the measurement channels. The input impedance is greater than 2 MΩ .

4.3.1 Input Stage with Signal Acquisition and Signal Processing

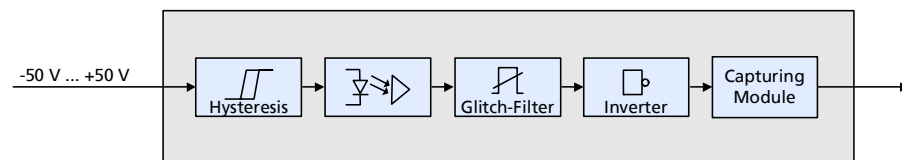


Fig. 4-3 Input Stage

The input stage of every measurement channel (see Fig. 4-3 on page 20) consists of the following components:

- Schmitt trigger with a configurable hysteresis,
- galvanic isolation,
- interfering voltage filter,
- inverter and
- signal acquisition and signal processing.

Configurable Hysteresis

The hysteresis and the corresponding values for the LOW and HIGH levels can be configured independently of one another in the calibration software (see Fig. 4-4 on page 21).

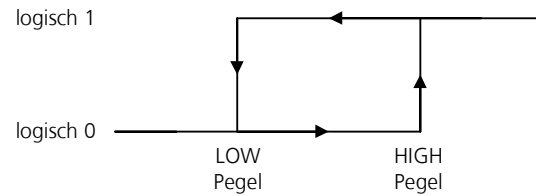


Fig. 4-4 Definition of the Hysteresis for the Input Channel

They can be configured separately in a range of -50 V to +50 V for every input channel of the ES441.1. The minimum resolution of the switching thresholds is 0.1 V. The hysteresis is defined completely by both levels and the edge direction.

The configurable hysteresis results in noise suppression. This feature facilitates application in environments with noise interference and/or noise signals. The quality of signal interpretation is improved considerably.

Galvanic Isolation

The measurement channels are galvanically isolated from each other and from the power supply.

Interfering Voltage Filter

In the input stage, an interfering voltage filter frees the input signal of short interfering pulses. The filter characteristics (duration) can be configured in the calibration software. The interfering voltage filter can be disabled if necessary.

Inverter

The input signal of every channel of the ES441.1 can be inverted independently of the other channels if necessary. Selection takes place in the calibration software.

Signal Acquisition and Signal Processing

In this function group, the input signal is sampled and processed in accordance with the measuring capability selected in the calibration software. Measuring capabilities can be selected independently of one another for the measurement channels of the ES441.1.

The measuring capabilities of the ES441.1 are described in chapter 5 on page 32.

4.3.2 Sensor Supply

Every sensor that can be switched to the ES441.1 has an individual sensor supply voltage which can be set separately.

The cable connected to the sensor port of the ES441.1 transfers both the sensor supply voltage and the sensor output voltage for the sensor. Additional cables or an additional external power supply for the sensor supply voltage are not required.

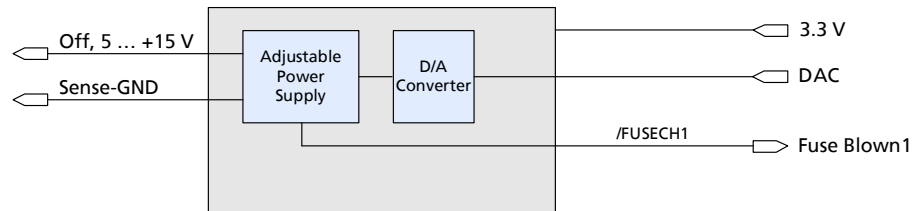


Fig. 4-5 Sensor Supply for a Sensor Channel

The sensor supply voltage is generated from the module operating voltage in every sensor channel. The sensor supply voltage can be modified in steps. The user can switch off the sensor supply voltage of each sensor channel in the application software, select one of the defined values between +5 V and +15 V or enter or define any value within the value range.

With a short-circuit of the sensor supply output against ground, the sensor power supply of this channel is automatically switched off. Every sensor supply output is protected against overvoltage. A fuse blows if the maximum value is exceeded. When a short-circuit occurs and a fuse blows, the application software receives channel-specific information which can be evaluated.

i NOTE

The supply voltages of the sensors are not galvanically isolated from the operating voltage of the module.

4.4 Data Transfer

For data transfer, the ES930.1 as well as the ES4xx and ES63x modules use a 100 Mbit/s Ethernet network connection in duplex operation. The data transfer can be adapted flexibly to suit the test setup and the measurement task.

i NOTE

The complete Ethernet bandwidth is available for both measure data and control variables.
Calibration procedures can take place in a Rapid Prototyping application without delay with measure data being acquired at the same time.

4.4.1 Communication Protocols

The universal ASAM measure and calibration protocol XCP is used for serial communication. On the Ethernet transport and network layer, the UDP/IP protocol is used (see Fig. 4-6 on page 23).

Within the XCP protocol, the modules transfer, among other things, module ID, time stamp and measure and/or stimulation data in an extremely precise and predictable time pattern. The communication protocol used for the modules avoids repeated transfer of protocol data, which takes place, for example, in handshake-based systems. This makes a high bandwidth available for reference data.

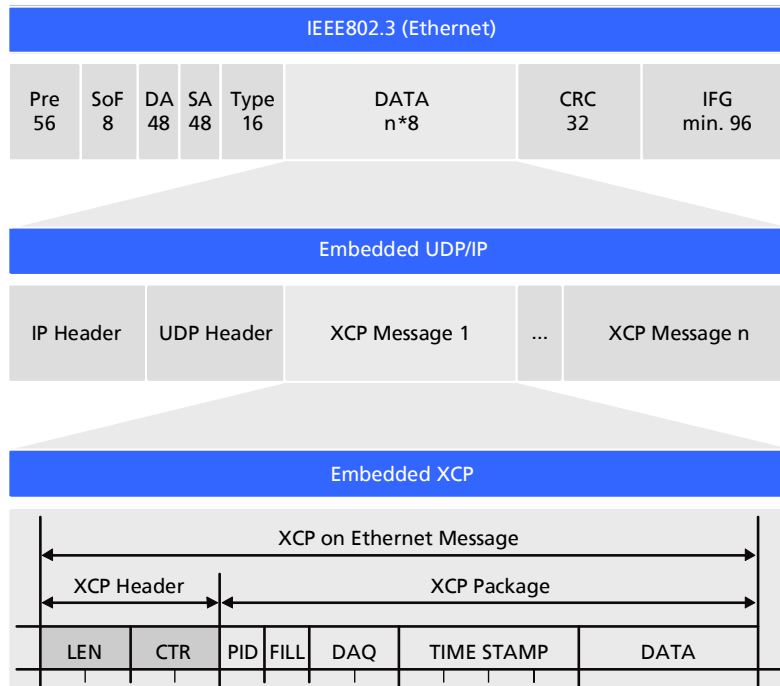


Fig. 4-6 Message Format "XCP on UDP" (Schematic)

Using the UDP/IP standard for data transfer makes it possible to connect the modules directly to a PC, a router or a switch. In XCP communication, the PC has the master function.

No real-time requirements are made. Data acquisition on a PC, which generally does not have to fulfil high real-time requirements, can thus be connected directly to an ES400 chain. With a real-time-capable master, such as, for example, a Rapid Prototyping system, lots of different kinds of I/O signal can be accessed with extremely short cycle times.

NOTE

The communication protocol used by the ES400 family makes it possible for third-party suppliers to use the communication protocol for their own, non-ETAS applications once the modules have been configured with the „ES4xx Configuration Tool from ES4xx_DRV_SW“ .

4.4.2 Realization

Time Slice Procedure

The modules in the daisy chain transfer the data to the master using a 100 MBit/s Ethernet connection time-controlled, i.e. without being prompted. The PC assumes the function of the master. In the network, the modules respond like a single Ethernet device with one MAC address.

All daisy chained modules have a generator which is only activated in the last module of each chain after the test setup has been connected to the PC. The frequency of the generator or the period duration of the time slices generated can be set in the application program. It corresponds to the measuring frequency of the measurement channel with the highest acquisition rate in the chain.

A binary counter linked to the generator periodically counts the time slices generated (value range: $2^{16} = 65536$). The last module in the chain sends the relevant number of time slices in the IP header. The Ethernet frames are transferred from module to module within the chain.

Each module in the chain receives bandwidth to transfer its measure data in freely selectable time slices assigned within the period of the binary counter. The module uses the number of the time slice to determine whether it can insert an XCP message with its measure data into the current time slice.

The fastest module, which determines the period duration of the time slices generated, transfers data in every time slice. An Ethernet frame then contains at least one XCP-on-Ethernet data package. The length of the Ethernet frame transferred inside a time slice increases with the number of modules which can insert their data into this time slice.

The numbering of the time slices ensures, for example, that two modules which work with half the sampling rate of the generator never attach their data to the same Ethernet frame. One module uses only the odd frame numbers and the other only the even ones. This mechanism also ensures for certain that the assigned frames do not exceed the length of a time slice.

The measure data is automatically distributed to the frames so that the available bandwidth is used perfectly.

The time slice procedure makes both measurements of fast signals and the acquisition of a large number of channels with a low sampling rate possible.

If a few fast signals and lots of slow ones are acquired in a chain, the slow signals can be transferred in time multiplex procedure.

 **NOTE**

Due to data transfer by Ethernet, there are virtually no limitations in terms of the number of modules in a module chain even with fast sampling rates.

Clock Generator for Synchronizing Modules

The clock generator for the synchronization of the modules is either the first module in an module chain or the network module ES600. In both cases, the measure data is synchronized with a tolerance of one microsecond. Using an ES600 network module, several ES4xx/ES63x/ES93x chains can be synchronized with each other or with the modules of the ES600 series. The ES4xx/ES63x/ES93x and ES600 modules add the relevant time stamp to the Ethernet data package for every measure value. The exact assignment in terms of time of the measure data of the ES4xx/ES63x/ES93x and ES600 modules used resulting from this makes precise analysis of the correlations of measure signals possible.

Synchronizing the Modules and INCA Signal Processing

Data transfer does not require synchronization of the local timebases of the ES4xx/ES63x/ES93x modules. The time stamps are still synchronized by the system to be able to correlate measure data and sampling times of different modules in terms of time after data transfer. A precise time and drift synchronization takes place in the modules via a hardware connection.

No bandwidth is required for this, unlike time synchronization in acc. with IEEE1588 (Precision Time Protocol). The modules add the time stamp to the Ethernet data package for every measure date.

The combination of time stamp synchronization, full duplex and time slice procedure results in a very high reference data rate of the modules.

4.4.3 Examples

Example 1

Fig. 4-7 on page 26 shows an example of an application with three concatenated ES400 modules with the same acquisition rates. The transfer scheme for this configuration is shown in Fig. 4-8 on page 26.

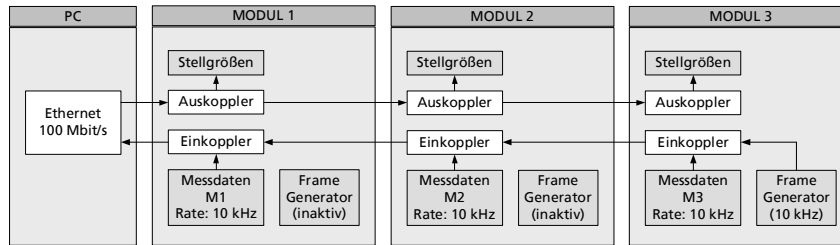


Fig. 4-7 Time-Multiplex Data Transfer Between an ES400 Module Chain and a PC

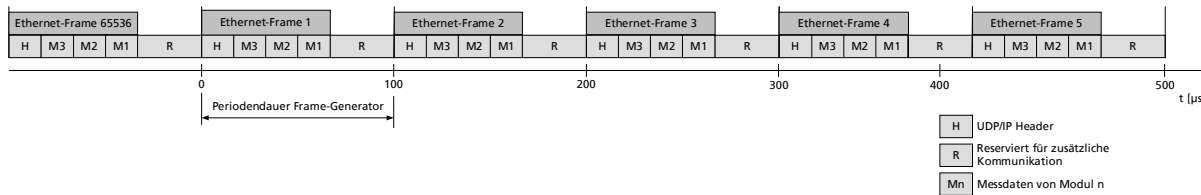


Fig. 4-8 Transfer Scheme for Example 1 (Simplified, Not True to Scale)

In this example, the third module periodically generates 2^{16} (65536) time slices each 100 microseconds long. Modules 1, 2 and 3 acquire measurements with the same rate of 10 kHz each. Module 1, Module 2 and Module 3 link their measurements to each time slice (see Fig. 4-8 on page 26). Independently of this, control variables can be transferred at the same time from the PC to the modules.

Example 2

Fig. 4-9 on page 27 shows an example in which three modules with different acquisition rates are linked to each other. The transfer scheme for this configuration is shown in Fig. 4-10 on page 27.

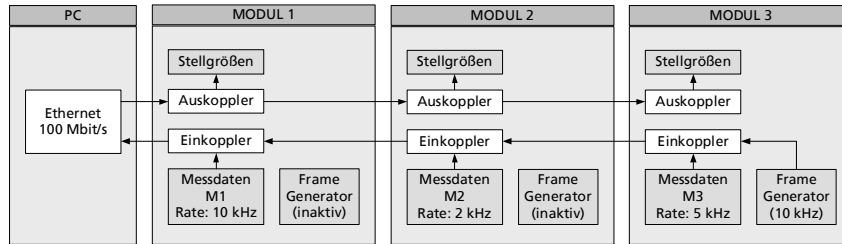


Fig. 4-9 Time-Multiplex Data Transfer Between an ES400 Module Chain and a PC

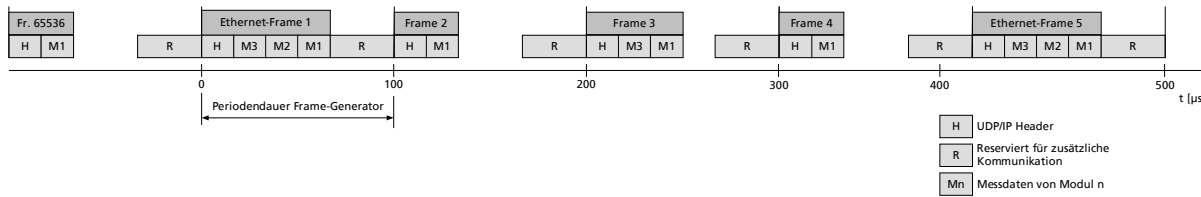


Fig. 4-10 Transfer Scheme for Example 2 (Simplified, Not True to Scale)

In this example, the third module periodically generates 2^{16} (65536) time slices (Ethernet frames) each 100 microseconds long. The ES400 modules 1, 2 and 3 acquire measurements at a rate of 10 kHz, 2 kHz and 5 kHz. Module 1 links its measurements to each Ethernet frame, module 2 to every fifth Ethernet frame and module 3 to every second Ethernet frame (bottom figure).

Independently of this, control variables can be transferred at the same time from the PC to the modules.

4.5 Power Supply

4.5.1 Supply Voltage

DC/DC converters in every module guarantee both the operation as well as the launch of the ES400 modules with supply voltages between 5 V and 50 V DC over the entire temperature range.

With the power supply management of the ES441.1, you can use an automatic power-saving feature ("Standby") as well as a "Wake Up" function via the Ethernet interface.

4.5.2 Supplying the ES400 Modules via the Connecting Line

In the simplest application case, the modules are directly linked to one another. They are connected to the supply voltage via the previous module all the way.

4.5.3 Additional Supply of the ES400 Modules via a Y-Boost Cable

If the supply voltage at the input of a module is too low because of the current consumption of the previous modules, multiple feeding of the supply voltage can guarantee this and the following modules sufficient supply voltage in longer module chains.

In this application case, you have to split the module chain. Swap the existing connection cable between the two modules for a Y boost cable for additional, direct feeding of the supply voltage. The module chain is now closed again and the power supply of the following modules guaranteed.

The special design of the Y boost cable avoids reverse feeding into the front parts of the module chain and thus arising potential differences.

When is it necessary to use a Y boost cable?

An exact calculation of the current consumption of a module chain is only possible if numerous variables are known:

- supply voltage of the first module at the input
- minimum supply voltage at the last module of the chain
- number and type of the modules
- consumption of sensor power supply of the connected sensors
- cable length
- cable type
- ambient temperature

The necessary minimum voltage for supplying power to the system must be determined individually for each test set-up.

NOTE

Please contact our local experts to discuss your particular ES441.1 configurations.

Example 1:

For module chains which are equipped exclusively with ES410.1 or ES441.1, ETAS recommends the use of Y boost cables if the length of the module chain is longer than 10 modules.

Example 2:

For module chains which are equipped exclusively with ES411.1 or ES413.1 or ES421.1, ETAS recommends the use of Y boost cables if the length of the module chain

- is longer than 16 modules (without sensor feeding) or
- is longer than 10 modules (with sensor feeding).

Example 3:

For module chains which are equipped exclusively with ES415.1 or ES420.1, ETAS recommends the use of Y boost cables if the length of the module chain

- is longer than 8 modules (without sensor feeding) or
- is longer than 5 modules (with sensor feeding).

Example 4:

With a minimum voltage of 7.7 V, no additional feeding is necessary with a Y cable if the module chain consists of the following modules:

- nine ES420.1 or ES421.1 and
- four ES410.1 or ES411.1 or ES413.1 (without sensor feeding) and
- one ES441.1

Example 5:

With a minimum voltage of 7.7 V, no additional feeding is necessary with a Y cable if the module chain consists of the following modules:

- five ES420.1 or ES421.1 and
- two ES415.1 (without sensor feeding) and
- one ES441.1

Example 6:

With a minimum voltage of 9 V, no additional feeding is necessary with a Y cable if the module chain consists of the following modules:

- nine ES420.1 or ES421.1 and
- four ES410.1 or ES411.1 or ES413.1 (with sensor feeding) and
- one ES441.1

Example 7:

With a minimum voltage of 9 V, no additional feeding is necessary with a Y cable if the module chain consists of the following modules:

- five ES420.1 or ES421.1 and
- two ES415.1 (with sensor feeding) and
- one ES441.1

 **NOTE**

All examples apply at 85 °C ambient temperature.

4.6 Configuration

The configuration of the ES441.1 is performed entirely via the GUI within INCA.

The configuration of the individual channels is saved either in INCA or in the individual ES400 modules. In the first case, you can prepare settings for specific measure tasks, e.g. in the lab. The second case is of interest to users who share a test carrier with a corresponding ES400 test setup. In this way, several users can call up the saved configuration directly from the modules.

4.7 Tool Integration

The ES400 modules can be selected and configured in INCA and support the open protocol XCP-on-Ethernet. This enables easy integration of the modules into other measure software.

The measure system can be connected directly to the PC's Ethernet port. No additional devices or interface converters are necessary.

4.8 Firmware Update

The firmware of the module can be updated by the user so that future versions of the module can also be used. The firmware update is done with the help of the service software "Hardware Service Pack" (HSP) from the connected PC.

NOTE

During a firmware update, neither the voltage supply nor the Ethernet connection may be interrupted!

4.9 Calibration

A calibration service for this product is available. Calibrate this product on a regular basis to ensure reliable accuracy of the measured values.

NOTICE

ETAS recommends a calibration interval of 12 months.

The seal of approval on the product shows the date of the last calibration. In the calibration certificate you will find information on the measurement accuracy.

Please contact your local ETAS representative for information on obtaining the calibration service (see chapter "Contact Information" on page 124). For information on ordering the calibration service, refer to chapter "Calibration" on page 122.

5 Functional Description

This chapter contains information on the following topics:

- "Measuring Sensor Signals" on page 32
- "Definitions" on page 33
- "Signal Sampling" on page 35
- "Overview of the Measuring Capabilities of the ES441.1" on page 36
- "Overflow" on page 37
- "Measuring Signal State" on page 37
- "Counter" on page 38
- "Time Measurement" on page 48
- "Frequency Measurement" on page 51
- "Timeout (Monitoring the Input Signal)" on page 56
- "Example" on page 57

5.1 Measuring Sensor Signals

5.1.1 Acquisition and Conversion

In the automotive sector, non-electrical variables, such as temperature, torque, force, pressure, fluid level, course (distance) and flow often need to be measured. These non-electrical physical variables are converted to electric signals using transducers and sensors and then further processed.

Acquiring these signals is the basis for determining information. The following table contains a few examples:

Measuring Capability	Information to be Determined
Frequency measurement	Revolutions per minute
	Velocity
Counter measurement	Flow rate
	Position
PWM measurement	Activation duration of servomotors
	Control of heating elements

5.1.2 Configuration and Adaptation

Configuring Signals in the Calibration Software

The signals acquired can, for example, be configured in accordance with the following criteria:

- name or
- unit or
- acquisition rate.

Adapting Signals in the Calibration Software

It is possible to adapt or correct the acquired values using mathematical algorithms.

The following methods are available:

- Offset: adding a constant to the measure values
- Factor: multiplying the measure values with a fixed factor
 - Conversion to physical variables
Example: conversion of duty cycle to electrical performance
 - Compensation of scaling factors of the measure hardware
Example: prescalers in turbocharger measure sensors
Example: measuring in wheel arches with powered axles
- Linearization of measure curves or all measure results
 - Correction of measure errors
 - Compensation of the non-linearity of sensors
Example: flow sensor, axle speed is not in proportion to the flow rate

The signals measured and their adaptation enable the physical, technical and derived variables and measure values to be represented in the physical unit required.

5.2 Definitions




This section defines signals which are used in the description of the measuring capabilities of the ES441.1.

NOTE

All definitions in this section are definitions for digital signals.

5.2.1 Key

Tab. 5-1 on page 33 shows all symbols used in the figures in the Functional Description chapter.

Symbol	Meaning
	Time stamp for previous samples
	Current time stamp
	Resulting sampling value

Tab. 5-1 Symbols Used

5.2.2 State

The term state describes the level of a signal at a particular sampling time. The state of an input signal is either active or inactive. The active state is shown by the value 1 or HIGH, the inactive state by the value 0 or LOW.

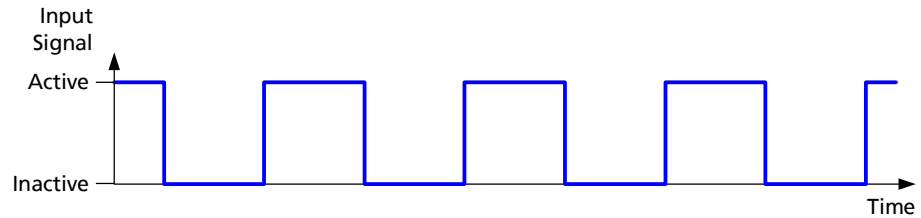


Fig. 5-1 Active and Inactive State

5.2.3 Pulse

The term pulse describes the course of a signal change in time from one state to another and then back to the original state.

A pulse is limited by exactly one inactive-active and one active-inactive edge. The two edges follow one another.

The pulse of an input signal is either active or inactive. An active pulse starts with an inactive-active edge, an inactive pulse starts with an active-inactive edge.

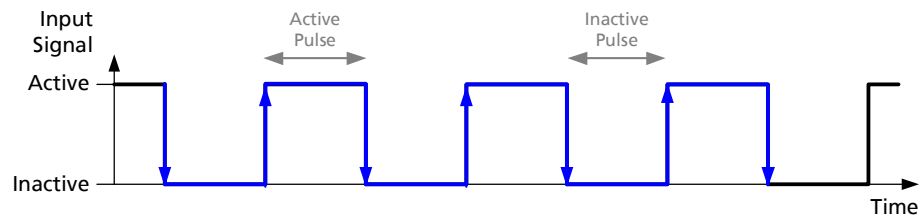


Fig. 5-2 Active and Inactive Pulse

5.2.4 Period

A period starts with a change of state or an inactive-active or an active-inactive edge of the signal. It always consists of one active and one inactive pulse.

If the period starts with an inactive-active edge, the period consists of a sequence of an active pulse with a subsequent inactive pulse. If the period starts with an active-inactive edge, the period consists of a sequence of an inactive pulse with a subsequent active pulse.

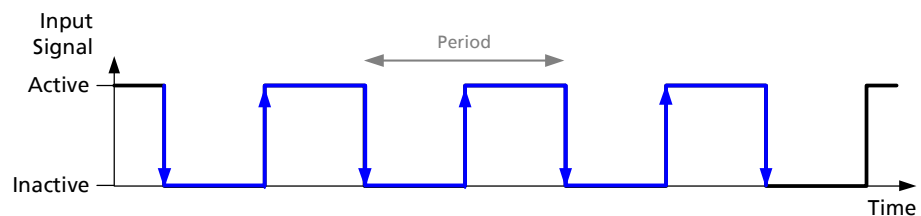


Fig. 5-3 Period, Starting with an Active-Inactive Edge

5.2.5 Cycle

A cycle is a repeated sequence of one or more periods.

A cycle describes an integral multiple of a period:

$$\text{Cycle} = n * \text{period}$$

A cycle can start with:

- an inactive-active edge or
- an active-inactive edge.

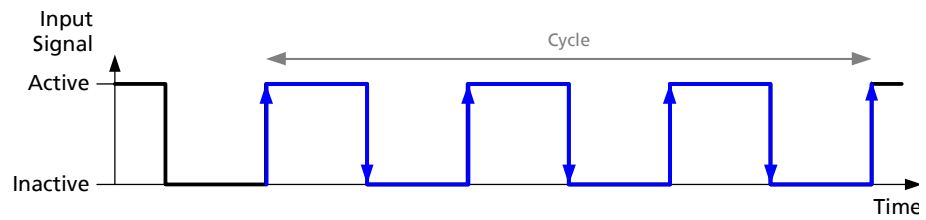


Fig. 5-4 Cycle, Starting with an Inactive-Active Edge and n=3

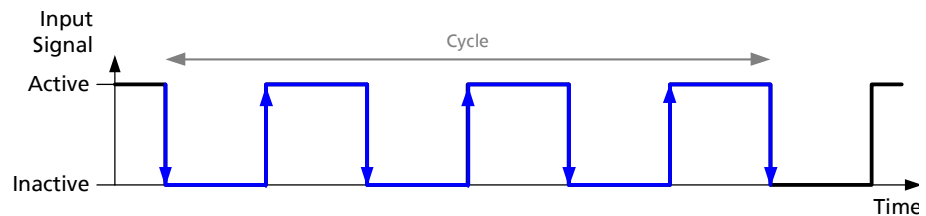


Fig. 5-5 Cycle, Starting with an Active-Inactive Edge and n=3

5.3 Signal Sampling

5.3.1 Sampling and Rates

The sampling rate can be selected independently for every channel of the ES441.1 in fixed steps in the calibration software. The data is sampled synchronously at a fixed sampling rate.

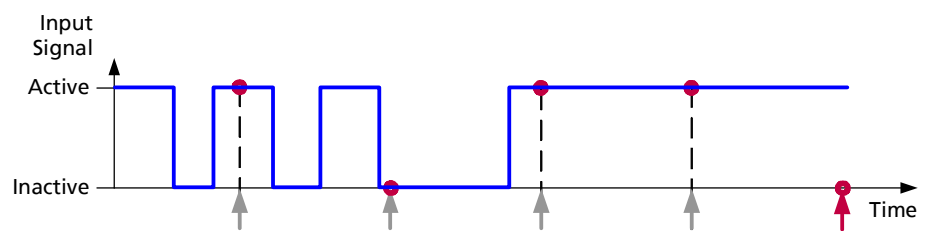


Fig. 5-6 Sampling Data

The module supports fixed measure rates. Several measure rates can be assigned to each input simultaneously. A maximum of eight different sampling rates are supported simultaneously per ES441.1 module.

5.3.2 What to do in the Case of Oversampling by the Calibration Software

In oversampling, a signal is acquired which has a higher sampling rate than is actually necessary for the transfer of the signal bandwidth.

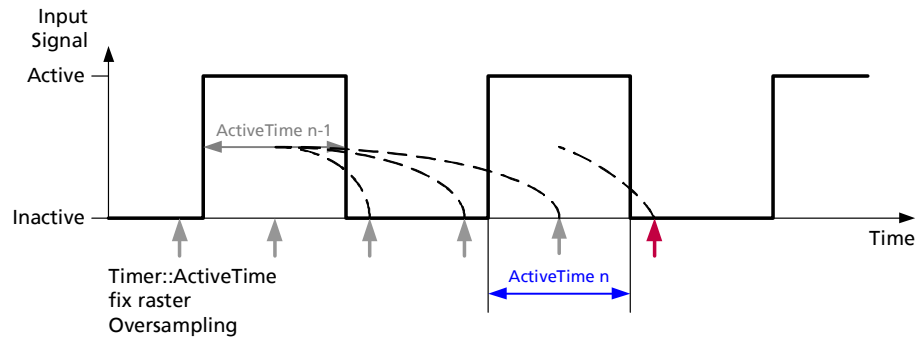


Fig. 5-7 Oversampling

If the relatively slow input signal is sampled with a high sampling rate (oversampling), a new measure value cannot be determined each time sampling takes place (see Fig. 5-7 on page 36). In such a case, the last valid measure value acquired is used again.

5.4 Overview of the Measuring Capabilities of the ES441.1

The ES441.1 module can acquire digital signals at the four input channels and evaluate these using various measuring capabilities:

Measuring Capability	Measure Signal
State (signal state)	State
Event counting	Events
Time measurement	Inactive duration
	Active duration
	Period duration
Frequency measurement	Frequency measurement within one period with support of the relative error estimate during configuration
	Determination of the duty cycle
	Period

i NOTE

In the calibration software, a measurement channel can be assigned any other measurement channel of the module in all measuring capabilities as the qualifying channel.

i NOTE

In the calibration software, any measuring capability can be selected for each individual input channel at the same time independently of the other input channels.

All measure signals of each measuring capability selected can be executed at the same time in all channels.

All signals mentioned above can be acquired at the same time on all four channels of the ES441.1.

5.5 Overflow

32-bit counters which are independent of one another are the basis for both the counter function and time measuring. Every counter value corresponds to a time unit of 20 ns. A counter overflow happens when a counter reaches its maximum value. The counter continues to count.

5.6 Measuring Signal State

The active and inactive state of the input signal is determined at every sampling point. The active state is shown by the value 1 or HIGH, the inactive state by the value 0 or LOW.

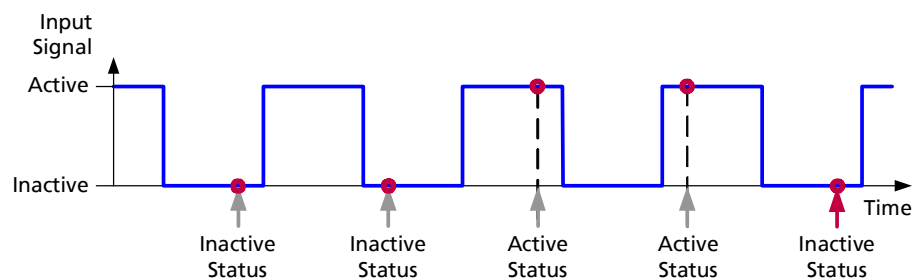


Fig. 5-8 Measuring the Active and Inactive State (Fixed Measure Rate)

Which input channels of the ES441.1 state should be measured on can be specified in the calibration software.

In the additional signal "stateCombined", the state of the four input channels at any one time is shown together in one byte. One bit of the signal represents the state of the signal of a specifically assigned input channel (see table).

Input Channel	Bit Position in "stateCombined"
1	2 ⁰
2	2 ¹
3	2 ²
4	2 ³

In the calibration software, you can also configure which of the four input channels should be used to generate the additional signal "stateCombined".

 **NOTE**

The state of an input channel which has not been selected is set to 0.

5.7 Counter

5.7.1 Measurement Modes

In the calibration software, parameters and measurement modes can be selected for event counting for every measurement channel:

- Counter modes with freely configurable parameters
 - Type of event to be counted (edges or cycles)
 - Evaluation of the signal at the measurement channel regardless of signals at other measurement channels or
 - Evaluation of the signal at the measurement channel depending on any other measurement channel of the module which is assigned to the measurement channel as a qualifying channel (trigger channel)
- Counter modes with parameters which can be configured with restrictions

These measurement modes of the ES441.1 in its function as a counter can be divided into four groups:

"Standard without Qualifying Signal" Counter Mode

The signal at the measurement channel is counted regardless of signals at other measurement channels (see section 5.7.2 on page 39). All counter parameters can be configured freely in the calibration software.

"Standard with Qualifying Signal" Counter Mode

Every measurement channel can be assigned any other measurement channel of the module as a qualifying channel (trigger channel) in the counter mode "Standard with qualifying signal". Depending on the configuration in the calibration software, the input signal of the qualifying channel is evaluated and measurement controlled at the assigned measurement channel (see section 5.7.3 on page 40). All counter parameters can be configured freely in the calibration software.

"Up/Down" Counter Mode

The counter of every measurement channel can be assigned the input signals of any other measurement channel of the module in "Up/Down" counter mode in addition to the input signals of its own measurement channel. The signal edges of these two measurement channels are analyzed and the counter state incremented or decremented (see section 5.7.4 on page 44). Some counter parameters can be configured freely in the calibration software.

“X1”, “X2” and “X4” Counter Modes

Every measurement channel can be assigned any other measurement channel of the module as a qualifying channel (trigger channel) in the counter modes “X1”, “X2” and “X4”. Some counter parameters are set by default when using the counter modes “X1”, “X2” and “X4” and cannot be changed in the calibration software. Depending on the selected counter mode, the input signal of the qualifying channel is evaluated and measurement controlled at the assigned measurement channel (see section 5.7.5 on page 45).

5.7.2 “Standard without Qualifying Signal” Counter Mode

In the “Standard without qualifying signal” counter mode, the signal at the measurement channel is counted regardless of signals at other measurement channels. The counter assigned to the measurement channel is configured as an up-counter.

In this mode, the ES441.1 can count edges with the following measurement modes in accordance with the configuration in the calibration software:

- Counting the edges when the input signal changes from inactive to active state
- Counting the edges when the input signal changes from active to inactive state
- Counting the edges when the input signal changes from inactive to active state and from active to inactive state and
- Counting the cycles

The following counter operating modes can be selected in the calibration software for measurement modes without a qualifying signal:

- Resetting the counter after every sampling point or
- Counter in Free Running Mode. The counter counts from the start of measuring without being reset during measuring. If the count scope (overflow) is reached and the measurement is not yet completed, the counter starts to count from the beginning again. The counter overflows after 2^{32} signal transitions to be counted.

The following figures show examples of the “Standard without qualifying signal” counter mode.

Counting the Inactive-Active Edges

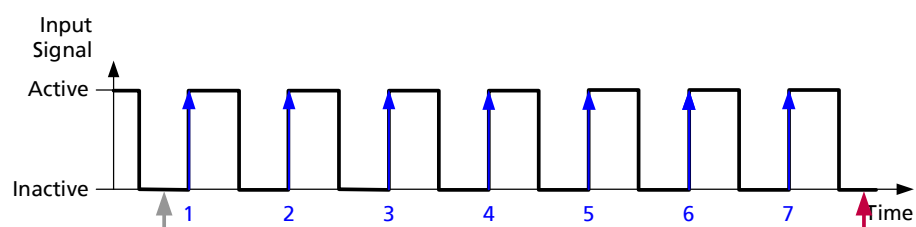


Fig. 5-9 Counting the Inactive-Active Edges

In the example in Fig. 5-9, the counter is reset at every sampling point.

Counting the Active-Inactive Edges

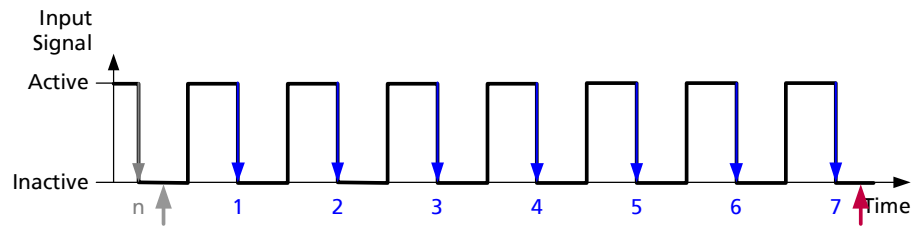


Fig. 5-10 Counting the Active-Inactive Edges

In the example in Fig. 5-10, the counter is reset at every sampling point.

Counting the Inactive-Active and Active-Inactive Edges

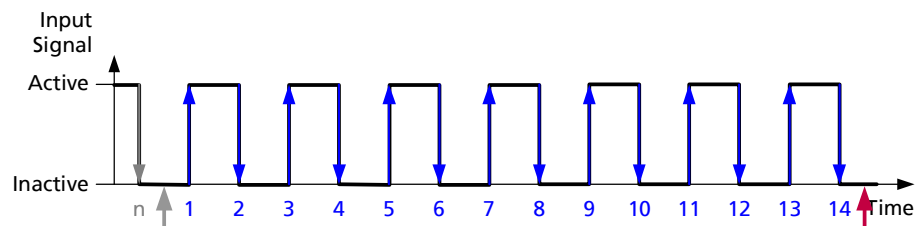


Fig. 5-11 Counting the Inactive-Active and Active-Inactive Edges

In the example in Fig. 5-11, the counter is reset at every sampling point.

Counting Cycles

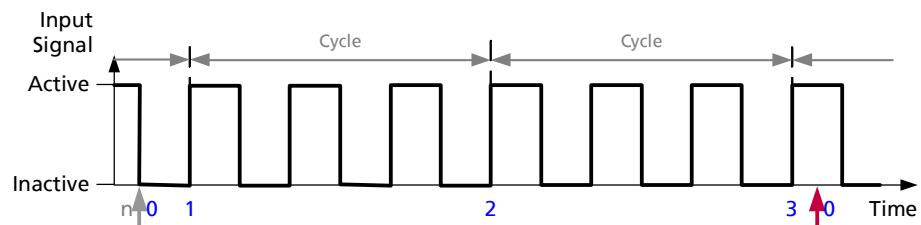


Fig. 5-12 Counting Cycles

The counter is reset at every sampling point.

5.7.3 “Standard with Qualifying Signal” Counter Mode

Every measurement channel can be assigned any other measurement channel of the module as a qualifying channel (trigger channel) in the “Standard with qualifying signal” counter mode. Depending on the configuration in the calibration software, the input signal of the qualifying channel is evaluated and measurement controlled at the assigned measurement channel.

In this mode, the ES441.1 can count edges with the following additional measurement modes:

- Up-counter with measurement control (triggering) in acc. with
 - the state of the qualifying signal,
 - the edges of the qualifying signal and
- up-/down-counter with control of the counting direction in acc. with the state of the qualifying signal.

The following counter operating modes can be selected in the calibration software for measurement modes with a qualifying signal:

- Resetting the counter after every sampling point or
- Resetting the counter with the edge of the qualifying channel selected in the calibration software or
- Counter in Free Running Mode. The counter counts from the start of measuring without being reset during measuring. If the count scope (overflow) is reached and the measurement is not yet completed, the counter starts to count from the beginning again. The counter overflows after 2^{32} signal transitions to be counted.

NOTE

During the measure phase determined by the qualifying signal, continually updated counting results are available.

The following figures show examples of the “Standard with qualifying signal” counter mode.

Counting with Resetting in acc. with the Qualifying Signal

In this counter mode, the ES441.1 is configured as an up-counter with the counter being reset by the signal at the qualifying channel (trigger channel).

In this mode, the ES441.1 can count edges with the following measurement modes in accordance with the configuration in the calibration software:

- Counting the edges when the input signal changes from inactive to active state
- Counting the edges when the input signal changes from active to inactive state
- Counting the edges when the input signal changes from inactive to active state and from active to inactive state and
- Counting the cycles

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Resetting the counter with the inactive-active edge of the signal at the qualifying channel or resetting the counter with the active-inactive edge of the signal at the qualifying channel.

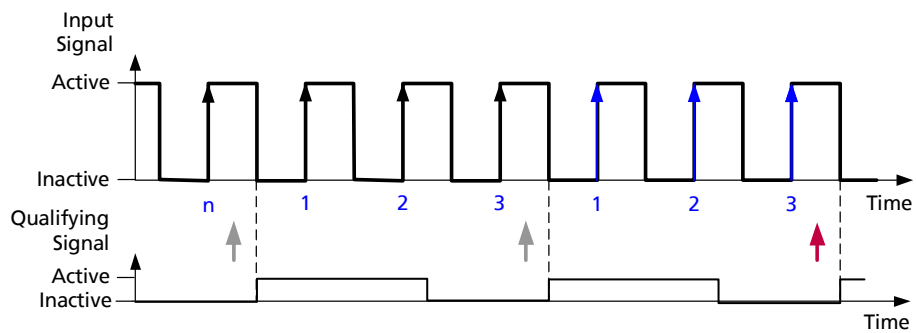


Fig. 5-13 Counting the Inactive-Active Edges with Resetting with the Inactive-Active Edge of the Qualifying Channel

In the example shown in Fig. 5-13 on page 42 a configurable edge of the assigned qualified signal resets the counter. The signal at the measurement channel is counted with the inactive-active edge of the qualifying signal.

Counting During a Defined State of the Qualifying Signal

Counting the edges selected in the calibration software at the measurement channel is controlled by evaluating the state of the signal at the qualifying channel (trigger channel):

- "Gate1": The edges at the measurement channel are only counted when the qualifying channel is active or
- "Gate2": The edges at the measurement channel are only counted when the qualifying channel is inactive.

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Resetting the counter with the edge of the qualifying channel selected in the calibration software or
- Counter in Free Running Mode (no resetting).

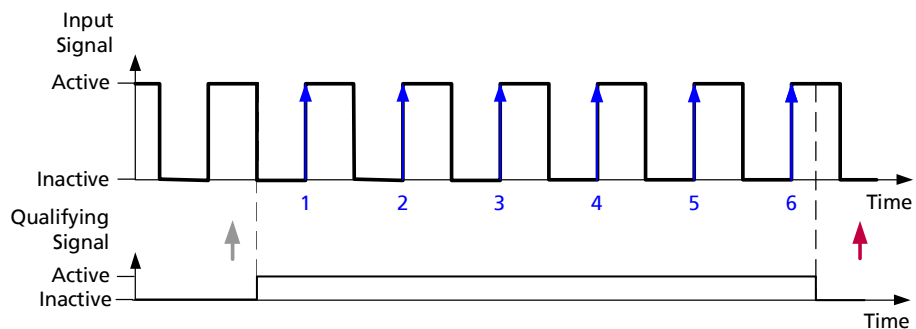


Fig. 5-14 Counting the Inactive-Active Edges when the Qualifying Signal is Active

In the example shown in Fig. 5-14, the active-inactive edge of the assigned qualifying signal resets the counter. The signal at the measurement channel is counted when the qualifying signal is active.

Count Direction Control in acc. with the State of the Qualifying Signal

In this counter mode, the ES441.1 is configured as an up-/down-counter with the count direction being controlled in acc. with the state at the assigned qualifying channel (trigger channel). The counter can be positive or negative.

In the counter modes "Up/Down1" and "Up/Down2", the counter is incremented or decremented by comparing the state of the signal at the measurement channel and at the qualifying channel:

- "Up/Down1": The counter is incremented when the states differ and decremented when the states of the measurement channel and qualifying channel are identical
- "Up/Down2": The counter is incremented when the states are identical and decremented when the states of the measurement channel and qualifying channel differ

In the counter modes "Up/Down3" and "Up/Down4", the counter is incremented or decremented depending on the evaluation of the state of the signal at the qualifying channel:

- "Up/Down3": The counter is incremented when the qualifying channel is active and decremented when it is inactive
- "Up/Down4": The counter is incremented when the qualifying channel is inactive and decremented when it is active

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Resetting the counter with the edge of the qualifying channel selected in the calibration software or
- Counter in Free Running Mode (no resetting of the counter).

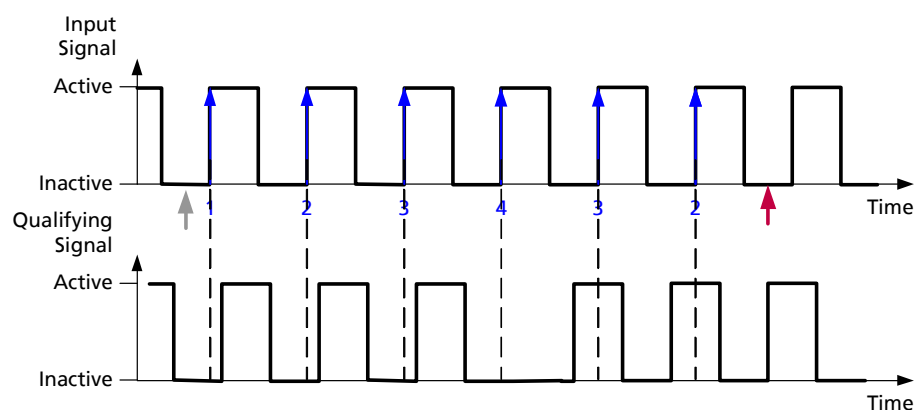


Fig. 5-15 Counting the Inactive-Active Edges in "Up/Down1" Counter Mode

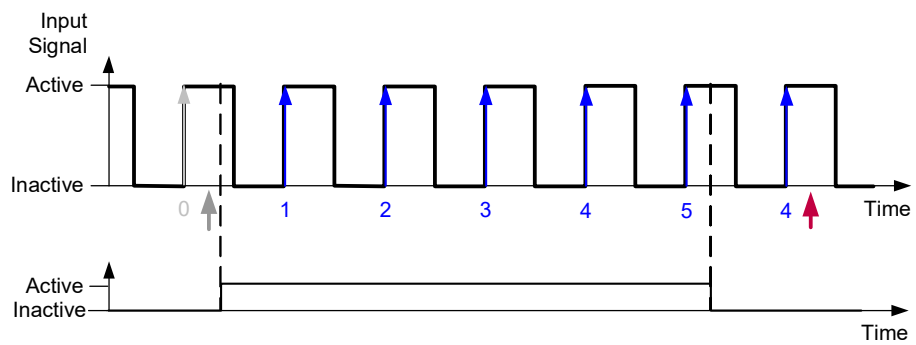


Fig. 5-16 Counting the Inactive-Active Edges in “Up/Down3” Counter Mode

5.7.4 “Up/Down” Counter Mode

The counter of every measurement channel can be assigned the input signals of any other measurement channel of the module in “Up/Down” counter mode in addition to the input signals of its own measurement channel. The assigned measurement channels are configured as A/B counter inputs of an up-/down-counter.

In this counter mode, the inactive-active edges of the signals at both measurement channels are analyzed and the counter incremented or decremented:

- The counter is incremented with inactive-active edges at the measurement channel
- and
- decremented with inactive-active edges at the qualifying channel.

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Counter in Free Running Mode (no resetting of the counter).

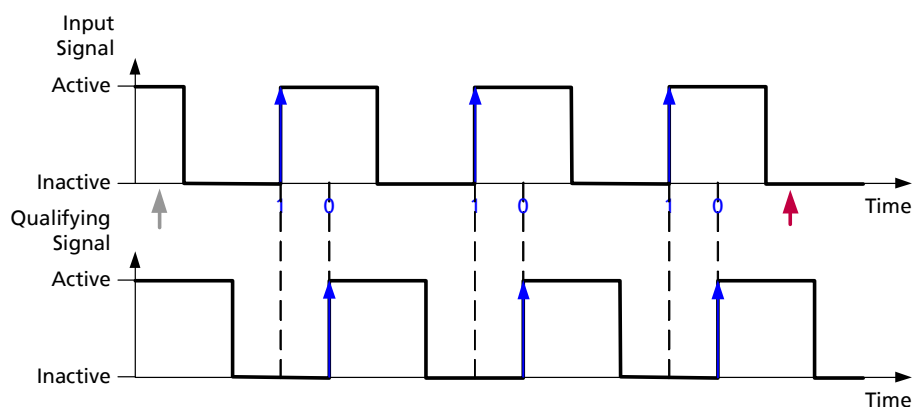


Fig. 5-17 “Up/Down” Counter Mode

When to use the “Up/Down” counter mode:

- Acquisition of data from incremental transducers
- Position determination

5.7.5 “X1”, “X2” and “X4” Counter Modes

Every measurement channel can be assigned any other measurement channel of the module as a qualifying channel (trigger channel) in the counter modes “X1”, “X2” and “X4”.

Some counter parameters are set by default when using the counter modes “X1”, “X2” and “X4” and cannot be changed in the calibration software.

Depending on the selected counter mode, the input signal of the qualifying channel is evaluated and measurement controlled at the assigned measurement channel.

In this mode, the ES441.1 can count edges with the following additional measurement modes:

Up-/down-counter with control of the count direction in acc. with

- the edges of the qualifying signal (counter mode “X1”),
- the edges of the qualifying signal (counter mode “X2”), and
- the edges of the qualifying signal with analysis of the qualifying signal (counter mode “X4”).

When to use the counter modes “X1”, “X2” and “X4”

- Coding/encoding digital signals
- Use in digital control circuits with movement control and digital data input systems
- Quadrature functions
- Linear or rotary incremental quadrature encoder
- Digital potentiometers

“X1” Counter Mode

In counter mode “X1”, the ES441.1 is configured as an up-/down-counter with the count direction being controlled by comparing the state of the signals at the measurement channel and the qualifying channel (trigger channel). The active-inactive edges are counted at the measurement channel:

- The counter is incremented when there are inactive-active edges at the measurement channel and the states of the measurement channel and qualifying channel differ,
and
- decremented when there are inactive-active edges at the measurement channel and the states of the measurement channel and qualifying channel are identical,

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Counter in Free Running Mode (no resetting of the counter).

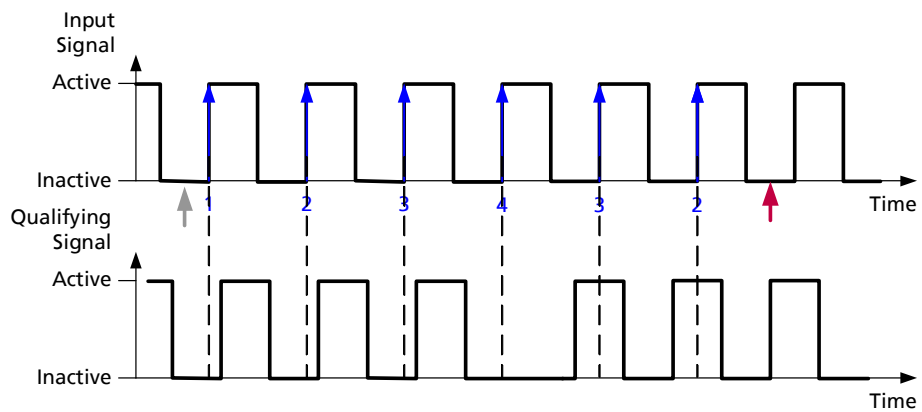


Fig. 5-18 X1 Counter Mode

“X2” Counter Mode

In counter mode “X2”, the ES441.1 is configured as an up-/down-counter with the count direction being controlled by comparing the state of the signals at the measurement channel and the qualifying channel (trigger channel). The inactive-active and active-inactive edges at the measurement channel:

- The counter is incremented when there are inactive-active and active-inactive edges at the measurement channel and the states of the measurement channel and qualifying channel differ,
- and
- decremented when there are inactive-active and active-inactive edges at the measurement channel and the states of the measurement channel and qualifying channel are identical,

The phase difference of the signals of the two channels determines the count direction.

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Counter in Free Running Mode (no resetting of the counter).

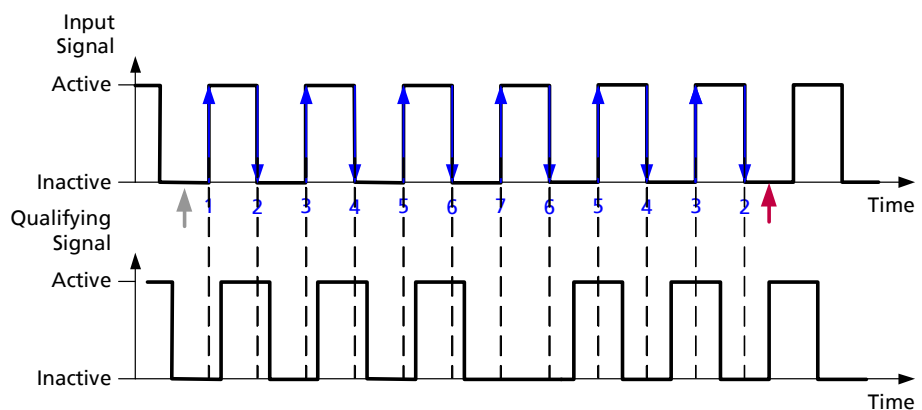


Fig. 5-19 X2 Counter Mode

“X4” Counter Mode

In counter mode “X4”, the ES441.1 is configured as an up-/down-counter whose measurement channel and its assigned second channel are analyzed as equal channels. Both edges of the signals at the measurement channel and at the assigned second channel are evaluated according to different rules. The phase difference of the signals of the two channels determines the count direction.

Rules for evaluating signal edges at the measurement channel:

- The counter is incremented when the signal edges at the measurement channel and the signal at the qualifying channel do not have an identical state and
- decremented when the signal edges at the measurement channel and the signal at the qualifying channel have an identical state.

Rules for evaluating signal edges at the qualifying channel:

- The counter is incremented when the signal edges at the qualifying channel and the signal at the measurement channel have an identical state and
- decremented when the signal edges at the qualifying channel and the signal at the measurement channel do not have an identical state.

In the calibration software, the type of counter resetting can be selected for this counter mode:

- Resetting the counter after every sampling point or
- Counter in Free Running Mode (no resetting of the counter).

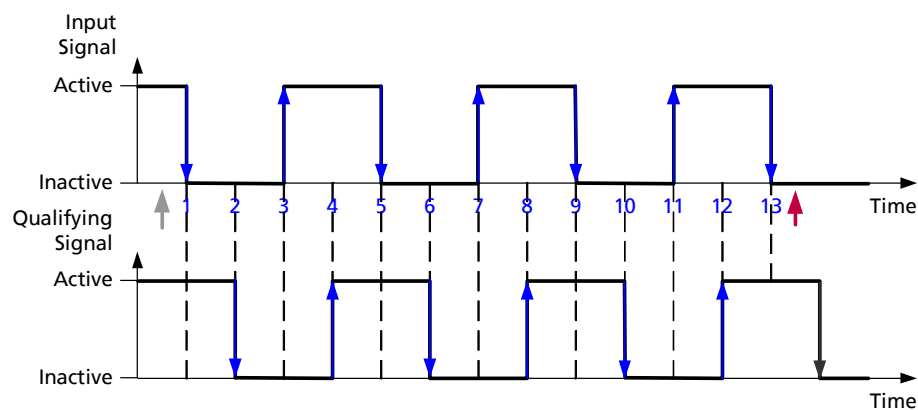


Fig. 5-20 X4 Counter Mode

Prerequisites for using counter mode X4:

- The signal at the measurement channel and the signal at the qualifying channel have the same signal shape and
- the phase difference between the two signals is around a quarter of the period duration of the frequency of the signal at the measurement channel.

Advantages of the X4 counter mode in comparison to counter modes X1 and X2:

- Greater resolution of the counter result
- Greater accuracy of the counter result

When to use the X4 counter mode:

- Acquisition of data from incremental transducers (phase-shifted signals),
- Position determination
- Quadrature encoder/quadrature decoder for incremental transducers

5.8 Time Measurement

5.8.1 Measurement Modes

During time measurement, the ES441.1 always acquires the active time, the inactive time and the period duration of the signal at the measurement channel, regardless of the measure value selected in the calibration software. With these measure values, the signals can be determined completely in varying periods of time. In the calibration software, parameters and measurement modes can be selected for every measurement channel for time measurement:

- Duration of the measurement
- Evaluation of the signal at the measurement channel regardless of signals at other measurement channels (without qualifying signal) or
- Evaluation of the signal at the measurement channel depending on any other measurement channel of the module assigned to the measurement channel as a qualifying channel (trigger channel).

5.8.2 Measurement Modes without a Qualifying Signal

For measurement modes without a qualifying signal, the signal at the measurement channel is used for time measurement regardless of signals at other measurement channels. The active and/or inactive duration of the input signal can be determined with every measurement channel. The period of time for measuring this time is configured in the calibration software. The ES441.1 can determine active and inactive times with the following time-controlled measurement modes:

- Measuring during the last period
- Measuring during the last complete cycle
- Measuring between two sampling points and
- Measuring to the last current sampling point

The following modes for time measurement can be selected in the calibration software for measurement modes without a qualifying signal:

- Resetting the timer after every sampling point or
- Resetting the timer with the edge of the qualifying channel selected in the calibration software or

- Timer in Free Running Mode. The timer counts from the start of measuring without being reset during measuring. If the count scope (overflow) is reached and the measurement is not yet completed, the timer starts to count from the beginning again. The timer overflows after 2^{32} signal transitions to be counted or after $2^{32} * 20 \text{ ns} = 85.9 \text{ s}$.

The following figures show examples of determining various time sections totaled from the start of measurement to the current sampling point without a qualifying signal.

Measuring the Active Time During the Last Period

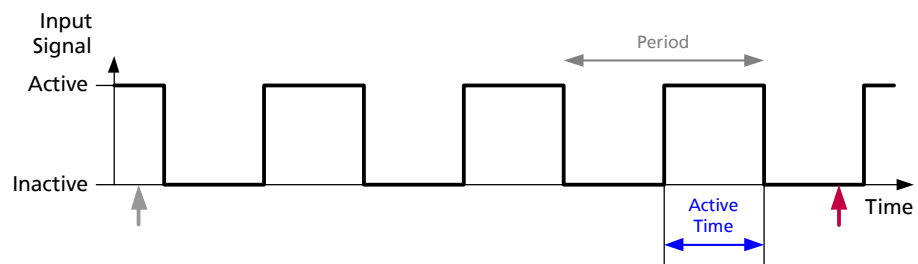


Fig. 5-21 Measuring the Active Time During the Last Period

Measuring the Active Time of a Cycle

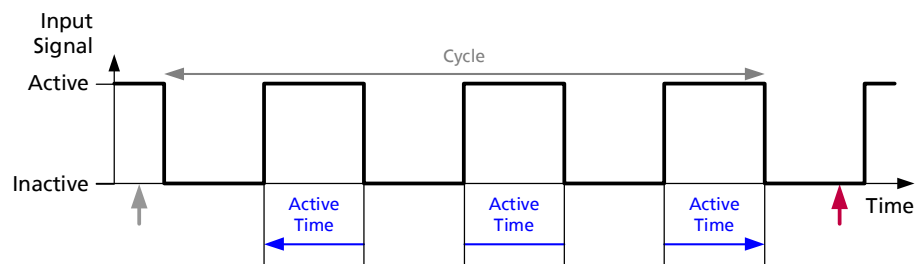


Fig. 5-22 Measuring the Active Time of a Cycle

Measuring the Active Time Between Two Sampling Points

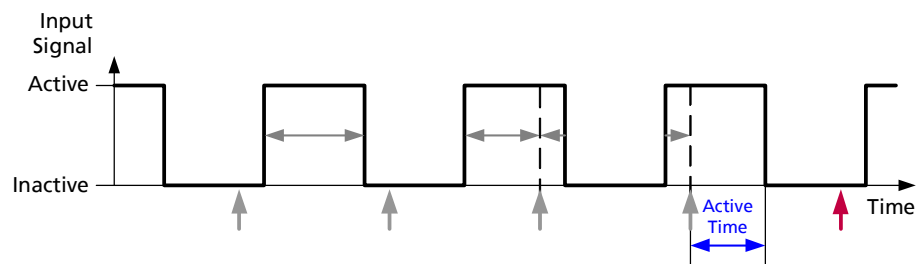


Fig. 5-23 Measuring the Active Time Between Two Sampling Points

Measuring the Active Time until the Last Current Sampling Point

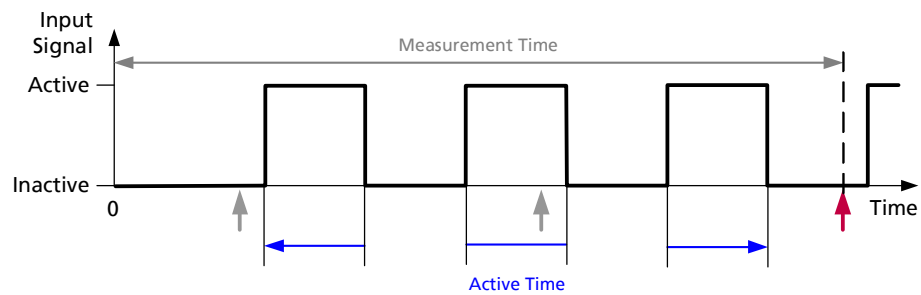


Fig. 5-24 Measuring the Active Time until the Last Current Sampling Point

The total amount of active time can be determined without any gaps over the entire measuring time (see Fig. 5-24 on page 50).

Measuring Period Duration

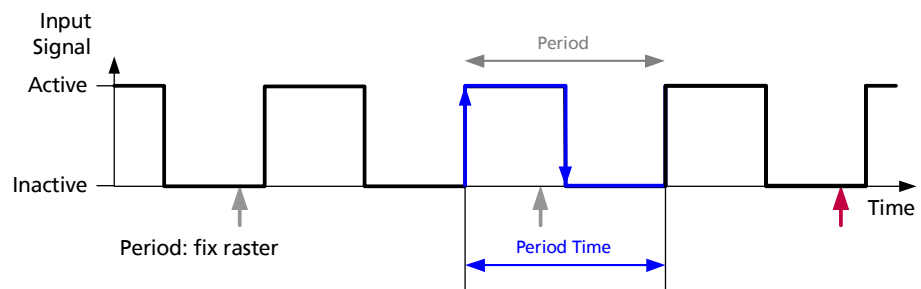


Fig. 5-25 Measuring Period Duration

The period duration is determined by measuring the active and inactive time.

The period duration is measured according to the selection of the period in the calibration software, i.e. whether the period is to begin with an inactive-active edge or with an active-inactive edge (see section 5.2.4 on page 34).

5.8.3 Measurement Modes with a Qualifying Signal

Any measurement channel can be assigned any other measurement channel of the module as a qualifying channel. Depending on the configuration in the calibration software, the input signal of the qualifying channel is evaluated and measurement controlled at the assigned measurement channel. This measurement mode can only be used if "Measuring until the last current sampling point" is selected in the calibration software.

With this assignment, the ES441.1 can determine active and inactive times using the additional measurement modes:

- "Window1": Measuring only takes place when the signal of the qualifying channel is active,
- "Window2": Measuring only takes place when the signal of the qualifying channel is inactive.

Resetting the timer cannot be selected for time measurement in the calibration software for measurement modes with a qualifying signal.

i NOTE

As the edges of the signal at the measurement channel and the signal at the qualifying channel do not necessarily occur at the same time, a new measure value only becomes available when the window defined by the qualifying signal has been exited.

The following figures show examples of determining different time sections with a qualifying signal.

Measuring the Active Time with a Qualifying Signal

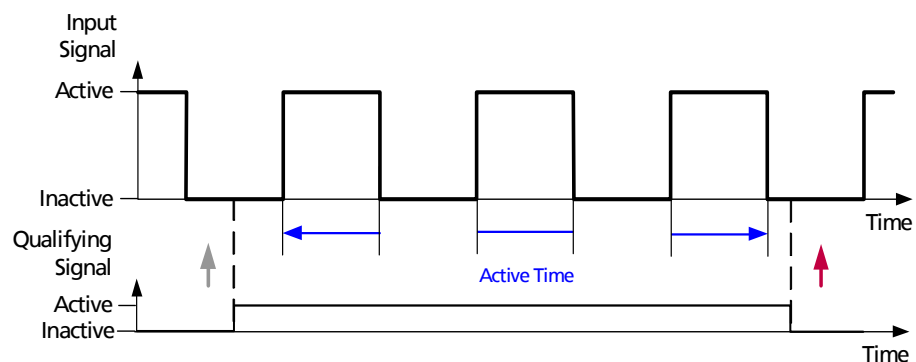


Fig. 5-26 Measuring the Active Time During an Active Qualifying Signal

5.9 Frequency Measurement

During frequency measurement, the ES441.1 always acquires the duration within a period or a cycle of the signal at the measurement channel, regardless of the measure value selected in the calibration software.

The period duration measured directly is the basis of the subsequent frequency calculation in the ES441.1:

$$f = 1 / T$$

The values determined are linked to an additional calculation error coupled to the resolution of the ES441.1 (see section 5.9.5 on page 54).

5.9.1 Measurement Modes

In the calibration software, parameters and measurement modes can be selected for frequency measurement for every measurement channel:

- Duration of the measurement
- Evaluation of the signal at the measurement channel regardless of signals at other measurement channels (without qualifying signal) or
- Evaluation of the signal at the measurement channel depending on any other measurement channel of the module which is assigned to the measurement channel as a qualifying channel (trigger channel)

5.9.2 Measurement Modes without a Qualifying Signal

For measurement modes without a qualifying signal, the signal at the measurement channel is used for frequency measurement regardless of signals at other measurement channels. The duration to be measured by the ES441.1 to determine frequency is selected in the calibration software:

- Measuring the duration of the last period or
- Measuring the duration of the last cycle

The frequency and duty cycle are calculated from these measurements.

With the frequency, determined on the basis of the measuring of the duration of the last cycle, and the number of periods per cycle, the ES441.1 can calculate the number of revolutions per minute (RPM) (see example in section 5.11 on page 57).

The following figures show examples of determining frequencies within different time sections without a qualifying signal.

Frequency Measurement within the Last Period

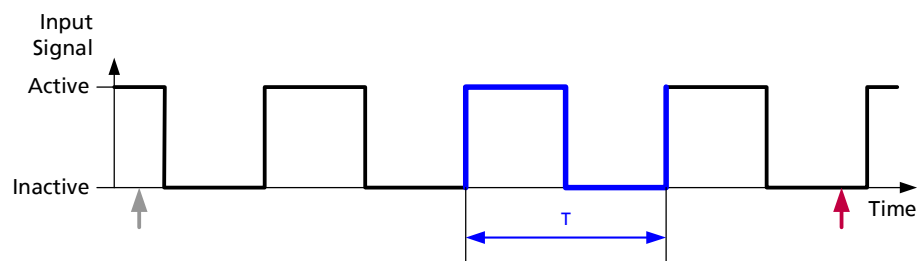


Fig. 5-27 Frequency Measurement within the Last Period

Frequency Measurement within a Cycle

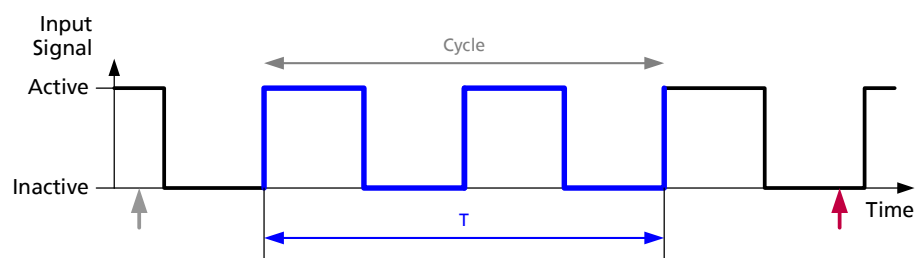


Fig. 5-28 Frequency Measurement within a Cycle

5.9.3 Measurement Modes with a Qualifying Signal

Any measurement channel can be assigned any other measurement channel of the module as a qualifying channel. Depending on the configuration in the calibration software, the input signal of the qualifying channel is evaluated and the sign of the frequency of the signal at the measurement channel determined.

These measurement modes of the ES441.1 in the frequency function can be divided into four groups:

- "Sign1": Determination of the sign of the acquired frequency value by evaluating the state of the signal of the qualifying channel
 - Assignment of the "+" sign when the signal of the qualifying channel is active
 - Assignment of the "-" sign when the signal of the qualifying channel is inactive
- "Sign2": Determination of the sign of the acquired frequency value by evaluating the state of the signal of the qualifying channel
 - Assignment of the "-" sign when the signal of the qualifying channel is active
 - Assignment of the "+" sign when the signal of the qualifying channel is inactive
- "Sign3": Determination of the sign of the acquired frequency value by comparing the edges of the signal at the measurement channel and the signal of the qualifying channel
 - Assignment of the "+" sign when the states of the signal at the measurement channel and the signal at the qualifying channel are identical
 - Assignment of the "-" sign when the states of the signal at the measurement channel and the signal at the qualifying channel are not identical.
- "Sign4": Determination of the sign of the acquired frequency value by comparing the edges of the signal at the measurement channel and the signal of the qualifying channel
 - Assignment of the "-" sign when the states of the signal at the measurement channel and the signal at the qualifying channel are identical
 - Assignment of the "+" sign when the states of the signal at the measurement channel and the signal at the qualifying channel are not identical.

The following figures show examples of determining the sign of the acquired frequency value depending on a qualifying signal.

Sign Assignment in acc. with the State of the Qualifying Signal

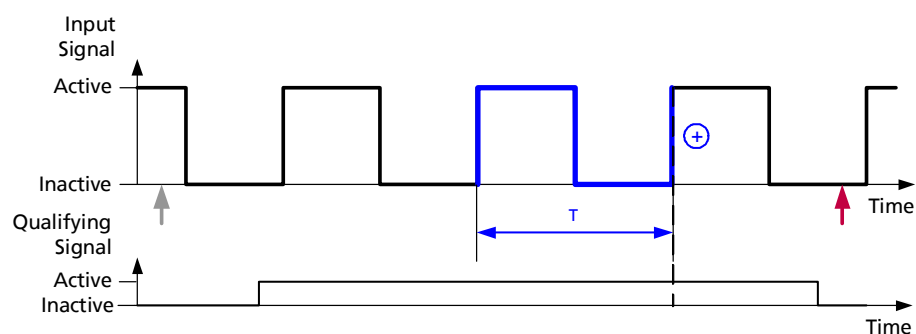


Fig. 5-29 Determination of the Sign of the Acquired Frequency Value when the Qualifying Signal is Active

The state of the signal at the qualifying channel is evaluated. In the example (see Fig. 5-29 on page 53), the ES441.1 was configured in the calibration software in such a way that the sign of the determined frequency value is set to "+" when the signal of the qualifying channel is active.

Sign Assignment by Comparing the State of the Signal at the Measurement Channel with the State of the Qualifying Signal

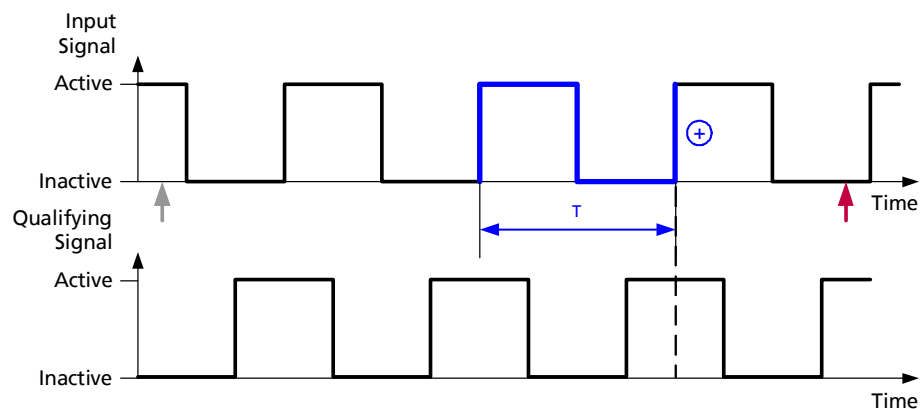


Fig. 5-30 Determination of the Sign of the Acquired Frequency Value When the Signals at the Measurement Channel and the Qualifying Channel are Identical

The state of the signal at the measurement channel and the state of the signal of the qualifying channel are compared. In the example (see Fig. 5-30 on page 54), the ES441.1 was configured in the calibration software in such a way that the sign of the determined frequency value is set to "+" when the signals at the measurement channel and the qualifying channel are identical.

5.9.4 Measuring the Duty Cycle

The duty cycle specifies the ratio of the length of the active state (pulse duration) to the period duration of the digital signal.

Calculation of the duty cycle:

$$\text{Duty cycle} = \text{active time} / (\text{active time} + \text{inactive time}) \text{ in } \%$$

The duty cycle is determined from the time measurement of the active and inactive time as a quotient of the active and inactive time during a period.

5.9.5 Measurement Accuracy

Theoretical Error During Frequency Measurement

The ES441.1 measures the period duration with the accuracy of the internal timebase of 20 ns. The frequency to be determined is calculated and corresponds to the reciprocal value of the period duration:

$$f = 1 / T.$$

Due to the integer division in the ES441 module, the result of frequency measurement is issued as an integer value with a resolution of 0.02 Hz (quantization). The jitter of the internal timebase can be ignored and is excluded from the examination of the measurement error.

The following is true, with the frequency f and n periods per cycle:

$$x = f / n$$

The theoretical error $e(x)$ is thus:

$$e(x) = x \cdot 20 \text{ ns} + 0.02 \text{ Hz} / x$$

In the case of low frequencies, measurement accuracy is mainly governed by the error of the integer division. In the case of high frequencies, the resolution of the internal timebase of the ES441.1 has a greater influence on measurement accuracy.

Increasing Measurement Accuracy with Low Frequencies

When determining low frequencies, the result can be inaccurate due to the integer calculations. This error can be avoided by measuring the period duration instead of the frequency and calculation of the reciprocal value in the calibration software on the PC (either as a formula in the A2L file or as a calculated signal).

- Advantage of the procedure:
 - No additional error by integer division
- Disadvantages of the procedure:
 - A possible division by zero in the calibration software must be considered,
 - The Timeout function is not available for the frequency.

Increasing Measurement Accuracy with High Frequencies

When determining high frequencies, the result can be inaccurate due to measurement errors in the determination of the period duration by the internal timebase. This error can be avoided or diminished if the frequency is measured over one cycle instead of over the period duration. The share of the measurement error that is contributed by the internal timebase is then distributed to the n periods of the cycle.

When measuring a cycle of frequency f_c with n periods instead of a period of the frequency f_p , the following is true for the measurement result:

$$f_p = n \cdot f_c$$

NOTE

The measurement error can be very high when measuring very high frequencies or very short periods as the period duration of the signal to be measured and the resolution of the internal timebase of the ES441.1 are of comparable dimension. This is why, with high frequencies, the frequency should be determined using the cycle duration and not the period duration.

5.10 Timeout (Monitoring the Input Signal)

The Timeout function enables the signals at the input channels to be monitored. This time can be configured separately for each measurement channel in the calibration software.

A check is carried out to see whether at least one signal change has taken place within this time. If there is no signal change, no new measure values can be determined. Depending on the measuring capability activated, the ES441.1 assigns fixed values to all sample values which follow in terms of time with the Timeout function. They are transferred to the calibration software the next time sampling takes place. These values are determined according to the measuring capability.

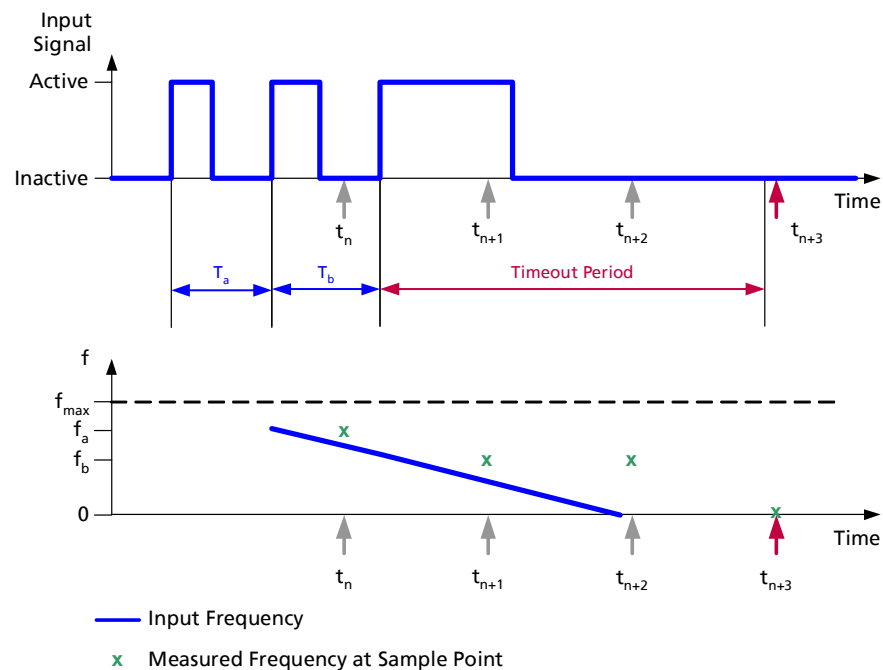


Fig. 5-31 Timeout

If the timeout of the ES441.1 has expired,

- the measured frequency (revolutions/min, velocity, flow, ...) is set to zero,
- the duty cycle is set to 0% or 100% depending on the state,
- the active and inactive time of measurements of the state, period duration or cycles are set to zero and
- the period duration is set to zero.

Frequencies whose period durations exceed the selected timeout cannot be measured.

The Timeout function is also used when the input signal is outside the measuring range of the ES441.1.

Example: Frequency Measurement around Zero

If there is no change of the input signal after the expiry of a timeout in the measuring capability frequency measurement, the measure value is determined as being $f = 0$ Hz.

5.11 Example

In the automotive sector, measuring the speed of wheels, gears, fans, water pumps, turbines is essential to be able to determine vehicle velocity or flow, for example.

For determining the speed in revolutions/minute, an extended configuration of the number of periods per revolution is necessary.

Application

A speed sensor wheel with 60-2 teeth assembled on the crankshaft returns a periodically structured signal pattern via a sensor. The number of revolutions per time unit is a measure of the wheel speed. This wheel, with division into 60, usually has 58 teeth. The position of the two missing teeth defines the reference mark for the position of the crankshaft. One revolution of the wheel is thus a cycle which consists of 60-2=58 periods.

Simplified Example

The configuration principle is demonstrated by the following simplified example.

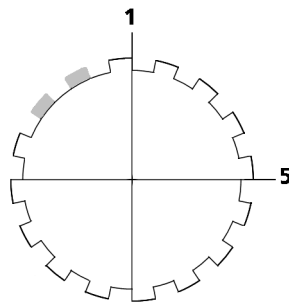


Fig. 5-32 16-2 "Speed Sensor" Wheel

To be able to determine a speed with the ES441.1, a cycle has to be defined in the configuration software, for example:

$$1 \text{ revolution} = 1 \text{ cycle} = (16-2) \text{ periods}$$

The module always counts complete cycles. The result is a frequency or number of revolutions per minute.

This mode can be used to determine the average speed with periodic input signals.

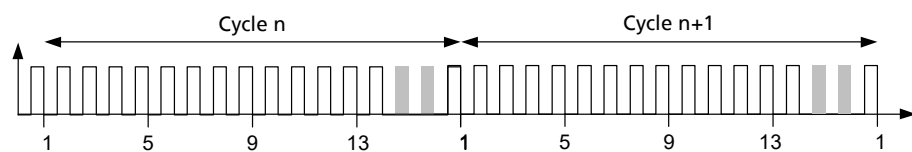


Fig. 5-33 Principle of the Input Signal of a "Speed Sensor" Wheel

Every cycle in the example has 14 periods (see Fig. 5-33 on page 57). One cycle can be assigned to a full revolution or a section. The measure result does not depend on the start of the cycle.

6 Getting Started

This chapter contains information on the following topics:

- "General Installation Recommendations" on page 58
- "Assembly" on page 59
- "Drilling Template" on page 73
- "Applications" on page 74
- "Wiring Examples" on page 76
- "Wiring" on page 81

6.1 General Installation Recommendations

6.1.1 Assembly Environment and Components for Attaching the Module



CAUTION

The module can be damaged or destroyed.

The modules of the ES400 line are only admissible for assembly and operation on components or in locations which guarantee adherence to the technical data of the modules during operation (see chapter 8 on page 92).

Adhere to the technical data of the modules for operation, such as

- the vibration resistance of the modules (only assemble modules on sprung masses, for example, and not on wheel suspensions or directly on the engine) and
- the temperature resistance of the modules (for example do not assemble modules on the engine, turbocharger, exhaust manifold or within their vicinity).

6.1.2 Potential Equalization in the Vehicle and Mounting the Modules



CAUTION

Potential equalization in the vehicle over the shield of the Ethernet connecting cables of modules may occur!

Mount the modules only to components with the same electrical potential or insulate the modules from the components.

6.1.3 Guarantee of Features as defined by IP67



CAUTION

Loss of Features as defined by IP67!

Water standing at the pressure balance element damages the membrane!
Please observe which way the module is pointing when installing vertically!

If installing the ES400 modules where water or other liquids could collect, install the modules so that the (black) pressure balance element on the back of the modules is not pointing upwards or that liquids can drain away.

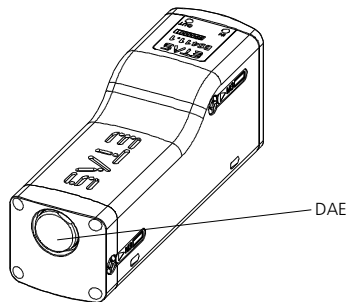


Fig. 6-1 Position of the Pressure Balance Element

Standing liquids or liquids which do not flow away from the pressure balance element can permanently damage the membrane. The module then loses the features defined by IP67.

6.2 Assembly

6.2.1 How to Connect and Attach ES400 Modules

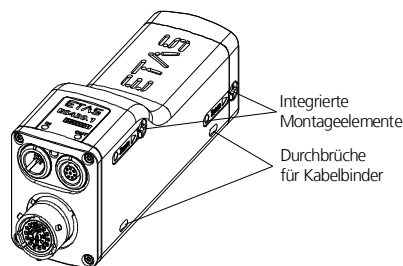


Fig. 6-2 How to Attach ES400 Modules

Integrated Assembly Elements

Every ES400 module has two integrated assembly elements to enable different assembly possibilities. If several modules are required in one location, they can be connected quickly, without any additional parts, using the integrated assembly elements to form a measuring instrument block (cascading). The two integrated assembly elements also make it possible to screw the modules directly onto other components (parts of the vehicle body, units).

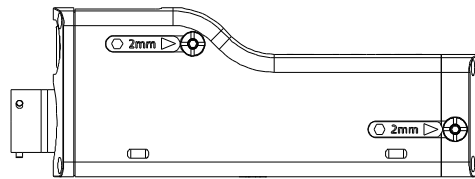


Fig. 6-3 Accessing the Integrated Assembly Elements

You can access and use the two integrated assembly elements of a module via the holes indicated (see Fig. 6-3 on page 60) on the right-hand side of the module.

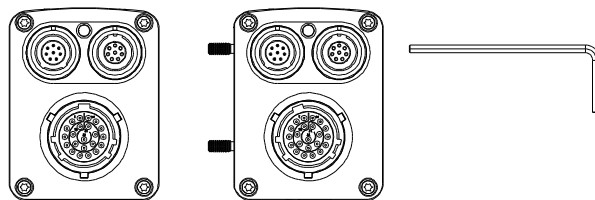


Fig. 6-4 Unscrewed Integrated Assembly Elements

Openings for Cable Fasteners

Every module base has two openings each on the right and left-hand side for attaching the modules to other components using cable fasteners.

Examples for mounting

Examples for mounting using the different possibilities to connect and attach ES400 modules are:

- Connect ES400 modules with the integrated assembly elements (cascading)
- Attaching ES400 modules with the integrated assembly elements:
 - on DIN rails with ES4xx angle brackets (left)
 - on other components
- Attaching ES400 modules with screws:
 - on DIN rails with ES4xx angle brackets (right)
 - on other components
- Attaching ES400 modules with cable fasteners:
 - on DIN rails with ES4xx angle brackets (left)
 - on DIN rails with ES4xx angle brackets (right)
 - on other components

6.2.2 Connecting Several ES400 Modules Mechanically

You can combine any ES400 modules with each other using the integrated assembly elements of the ES400 modules.

Here, you connect the ES400 modules using the integrated assembly elements.

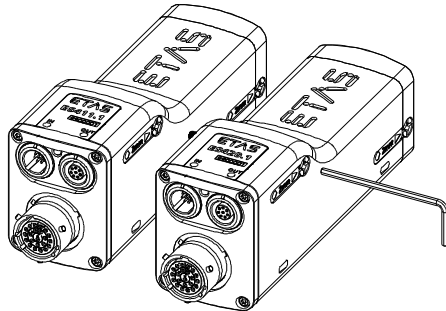


Fig. 6-5 Connecting Several ES400 Modules Using the Integrated Assembly Elements

Rules on Connecting the Modules

Observe the following rules when connecting the modules as required:

i NOTE

The two integrated assembly elements can only be accessed from the right-hand side of the module and can only be turned using an Allen key.
When connecting the modules, you must therefore always screw the module on the right to the module on its left.
You can only successively screw additional modules, but not module blocks, onto the right-hand side of this module block.
When creating module blocks, observe the defined order.

Preparing the Modules

To position the modules:

1. Position the modules to be connected in the required order.

i NOTE

Both modules' ports must point left.

2. Position the modules so that their fronts are in a line.
3. Hold the two modules together firmly on their outer sides.

Connecting the Modules

To connect several ES400 modules, you require a 2 mm Allen key (minimum length 20 mm).

To connect the modules:

1. Insert the Allen key into a hexagon socket on the right-hand side of the right-hand module.

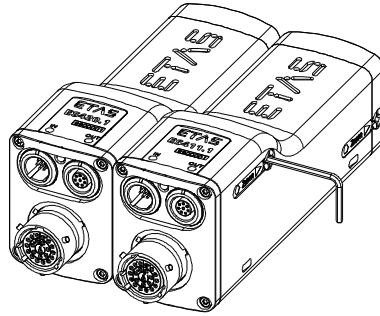


Fig. 6-6 Connected ES400 Modules

2. Screw the two modules by turning the Allen key clockwise as far as it will go within the module.

i NOTE

Screw the two modules together without getting them off-thread!

Both modules are now connected mechanically on one side.

3. Insert the Allen key into the other hexagon socket of the right-hand module.
4. Screw the two modules by turning the Allen key clockwise as far as it will go within the module.

i NOTE

Screw the two modules together without getting them off-thread!

Both modules are now completely connected mechanically.

Connecting to Other Modules

i NOTE

You can only successively screw additional modules, but not module blocks, onto the right-hand side of this module.

To connect the ES400 module to other modules, you require a 2 mm Allen key (minimum length 20 mm).

To connect to other modules:

1. Assemble other modules in accordance with the procedure described in the section 6.2.2 on page 61.

6.2.3 Attaching ES400 Modules to Other Components Using the Integrated Assembly Elements

The integrated assembly elements of the ES400 modules can not only be used to connect modules to each other but also to connect them to other components.

Here, you connect the ES400 module to the component using the integrated assembly elements. Screwing the two together works in the same way as connecting several modules.

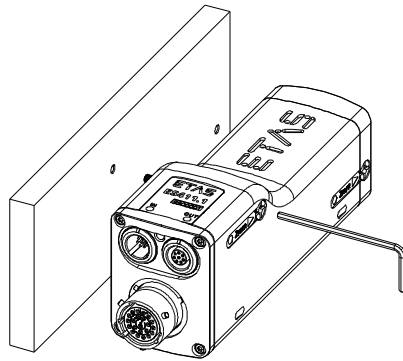


Fig. 6-7 Attaching a Module to Other Components with the Integrated Assembly Elements

Rules on Attaching the Modules to Other Components

Observe the following rules when connecting the modules as required to other components:

i NOTE

The two integrated assembly elements can only be accessed from the right-hand side of the module and can only be turned using an Allen key. You therefore have to screw the module to the other component from the right. You can only successively screw additional modules, but not module blocks, onto the right-hand side of this module.

Preparing the Component

To cut the thread in the component:

1. Cut two M3 threads into the selected component. The threads should be cut 8 mm deep.

i NOTE

Use the drilling template (see Fig. 6-13 on page 73).

Connecting the Module to the Component

To connect the ES400 module to the component, you require a 2 mm Allen key (minimum length 20 mm).

To connect the module and the component:

1. Position the module to the right of the other component.
2. Align the integrated assembly elements of the module with the drill holes.
3. Insert the Allen key into a hexagon socket on the right-hand side of the module.
4. Screw the two parts together by turning the Allen key clockwise as far as it will go within the module.

NOTE

Screw the two parts together without getting them off-thread!

Both parts are now connected mechanically on one side.

5. Insert the Allen key into the other hexagon socket of the module.
6. Screw the two parts together by turning the Allen key clockwise as far as it will go within the module.

NOTE

Screw the two parts together without getting them off-thread!

Both parts are now completely connected mechanically.

Connecting to Other Modules

NOTE

You can only successively screw additional modules, but not module blocks, onto the right-hand side of this module.

To connect the ES400 module to other modules, you require a 2 mm Allen key (minimum length 20 mm).

To connect to other modules:

1. Assemble other modules in accordance with the procedure described in the section 6.2.2 on page 61.

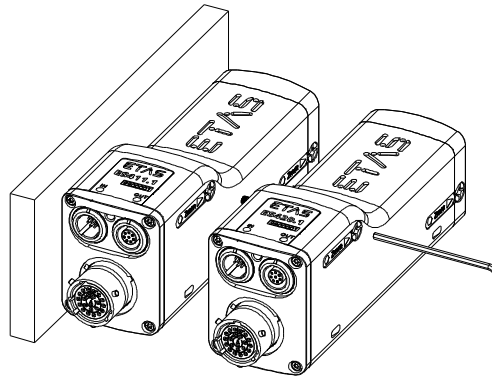


Fig. 6-8 Connecting to Other Modules

6.2.4 Attaching ES400 Modules on DIN Rails with the Integrated Assembly Elements

With the integrated assembly elements of the ES400 modules, you can not only connect the modules with each other, but also with DIN rails.

For this fastening variant, you connect the ES400 module with the DIN rail using an ES4xx angle bracket (left). The screw connection follows the principle of connecting several modules.

Fasten the ES400 modules on DIN rails with the integrated assembly elements using the following steps:

1. Connect the module with the ES4xx angle bracket (left).
2. Connect the module with additional modules (as required).
3. Connect the ES4xx angle bracket with the DIN rail.

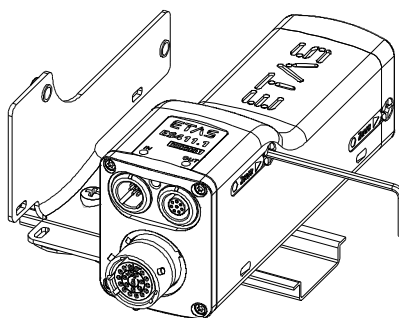


Fig. 6-9 Fastening to an ES4xx Angle Bracket (left) using the Integrated Assembly Elements

Rules on Connecting the Modules on the DIN Rails using the ES4xx Angle Bracket (left)

To be able to fasten the modules in the desired arrangement with the ES4xx angle bracket (left) on DIN rails, observe the following rules:

NOTE

The two integrated assembly elements are accessible only from the right side of the module and can be rotated with a hex key.

For this reason, the module must always be screwed onto the ES4xx angle bracket (left) from the right side.

Additional modules can only be screwed onto the right side of this module, but not any module blocks.

Connect the Module with the ES4xx Angle Bracket (left)

Connecting the ES400 module with the ES4xx angle bracket (left) requires a 2 mm hex key (minimum length 20 mm).

Connecting the module and the ES4xx Angle Bracket (left):

1. Position the module to the right of the ES4xx angle bracket (left).
2. Align the integrated assembly elements of the module with the bores.
3. Insert the hex key in a hexagon head on the right side of the module.
4. Screw the parts together by turning the hex key clockwise to the stop within the module.

NOTE

Screw the two parts together without canting the threads!

Both parts are now mechanically connected on one side.

5. Insert the hex key in the other hexagon head of the module.
6. Screw the parts together by turning the hex key clockwise to the stop within the module.

NOTE

Screw the two parts together without canting the threads!

Both parts are now completely connected mechanically.

Connecting with Additional Modules

i NOTE

Additional modules can only be screwed onto the right side of this module, but not any module blocks.

Connecting the ES400 module with additional modules requires a 2-mm hex key (minimum length 20 mm).

Connecting with additional modules:

1. Connect additional modules according to the procedure described in chapter 6.2.2 on page 61.

Connecting the ES4xx Angle Bracket with the DIN Rail

Connecting the ES4xx Angle Bracket (left) with the DIN rail

1. Place the ES4xx angle bracket onto the DIN rail.
2. Insert the hooks of the ES4xx angle bracket into the upper part of the DIN rail.
3. Engage the ES4xx angle bracket in the DIN rail by pressing on the ES4xx angle bracket or the module.

The module connected with the ES4xx angle bracket is fastened to the DIN rail.

6.2.5 Attaching ES400 Modules to Other Components with Screws

Here, you connect the ES400 module to the component using two additional M3 screws which are screwed into the drill holes of the component. The integrated assembly elements of the module are not used.

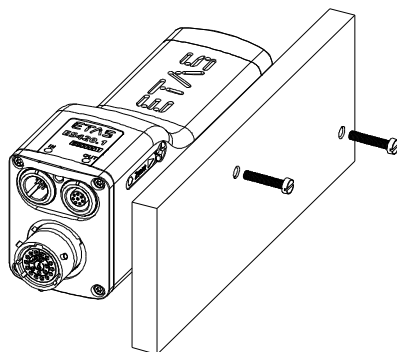


Fig. 6-10 Attaching to Other Components Using Additional Screws

Rules on Attaching the Modules to Other Components

Observe the following rules when connecting the modules as required to other components:

NOTE

The two integrated threaded holes in the module are only accessible from the right-hand side of the module.
You therefore have to screw the other component onto the module from the right.
Once the module is screwed to the other component, you cannot screw any further modules to this one.

Preparing the Component

NOTE

The pivot of the integrated assembly element can be screwed around 6 mm out of the module.

To drill the openings in the component:

1. Drill two holes in the selected component.

NOTE

Use the drilling template to prepare the component (see Fig. 6-13 on page 73).

Connecting the Module to the Component

To connect the ES400 module to the component, you need two screws M3 and a screwdriver.

To connect the module and the component:

1. Position the module to the right of the other component.
2. Align the threaded drill holes of the integrated assembly elements on the right-hand side of the module to the openings in the component.
3. Insert one screw into a hole in the component.
4. Screw the screw from the right-hand side of the component into the module.

NOTE

Screw the two parts together without getting them off-thread!

Both parts are now connected mechanically on one side.

5. Insert the other screw into the other hole in the component.

- Screw the screw from the right-hand side of the component into the module.

i NOTE

Screw the two parts together without getting them off-thread!

Both parts are now completely connected mechanically.

Connecting to Other Modules

i NOTE

If a module has been screwed to the other component, no other modules can be screwed to this module component connection.

You can attach several ES400 modules to the other component using the method described in this chapter if you first connect all modules to be installed with each other step by step (see section 6.2.2 on page 61). The module on the extreme right of the module block is connected to the other component like an individual module - using screws.

6.2.6 Attaching ES400 Modules on DIN Rails using Screws

With the integrated assembly elements of the ES400 modules, you can not only connect the modules with each other, but also with DIN rails.

For this fastening variant, you connect the ES400 module with the DIN rail using an ES4xx angle bracket (right) and two additional M3 screws inserted through their bores. The integrated assembly elements of the module are not used.

Fasten the ES400 modules on DIN rails with the integrated assembly elements using the following steps:

1. Connect the module with additional modules (as required).
2. Connect the module with the ES4xx angle bracket (right).
3. Connect the ES4xx angle bracket with the DIN rail.

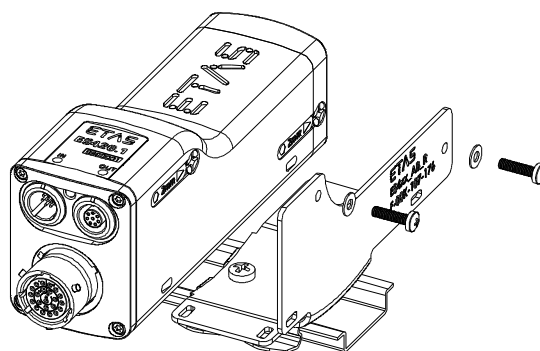


Fig. 6-11 Fastening on DIN Rails with Additional Screws

Rules on Connecting the Modules on the DIN Rails using the ES4xx Angle Bracket (right)

To be able to fasten the modules in the desired arrangement with the ES4xx angle bracket (right) on DIN rails, observe the following rules:

NOTE

The two integrated thread bores in the module for accepting the screws can be accessed only from the right side of the module.

For this reason, the ES4xx angle bracket (right) must always be screwed onto the module from the right side.

If the module is screwed onto the ES4xx angle bracket (right), no additional modules can any longer be screwed onto this module.

Preparing the Component

NOTE

The pin of the integrated assembly element can be screwed out of the module by approximately 6 mm.

Connecting the Module with the ES4xx Angle Bracket (right)

To connect the ES400 module with the ES4xx angle bracket (right) requires two M3 screws, two washers and a screwdriver.

Connecting the module and the ES4xx Angle Bracket (right):

1. Position the module to the left of the ES4xx angle bracket (right).
2. Align the thread bores of the integrated assembly elements on the right side of the module with the through bores of the ES4xx angle bracket (right).
3. Insert one screw through the bore of the ES4xx angle bracket (right).
4. Fasten the screw with the module from the right side of the ES4xx angle bracket.

NOTE

Screw the two parts together without canting the threads!

Both parts are now mechanically connected on one side.

5. Insert the other screw through the other bore of the ES4xx angle bracket (right).
6. Fasten the screw with the module from the right side of the ES4xx angle bracket.

NOTE

Screw the two parts together without canting the threads!

Both parts are now completely connected mechanically.

Connecting with Additional Modules

i NOTE

If a module is screwed onto the other component, no additional modules can be screwed onto this module-component connection.

Several ES400 modules can be fastened to the other component with the connection type described in this chapter if you connect all modules to be attached first with each other step by step (see chapter 6.2.2 on page 61). The module which is the furthest to the right of the module block is subsequently connected with the ES4xx angle bracket (right) as a single module and fastened to the DIN rail using screws.

Connecting the ES4xx Angle Bracket with the DIN Rail

Connecting the ES4xx Angle Bracket (right) with the DIN rail

1. Place the ES4xx angle bracket onto the DIN rail.
2. Insert the hooks of the ES4xx angle bracket into the upper part of the DIN rail.
3. Engage the ES4xx angle bracket in the DIN rail by pressing on the ES4xx angle bracket or the module.

The module connected with the ES4xx angle bracket is fastened to the DIN rail.

6.2.7 Attaching ES400 Modules to Other Components Using Cable Fasteners

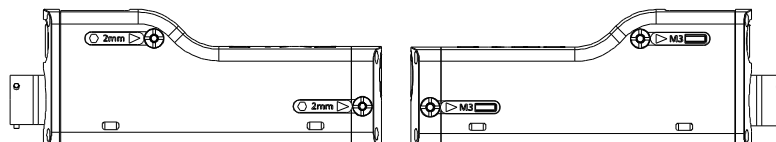


Fig. 6-12 Openings for Cable Fasteners in ES400 Modules

Every module base has openings for two cable fasteners each on the right- and left-hand side (see Fig. 6-12 on page 71). Just use cable fasteners to quickly attach the modules to other components in the test environment in the immediate proximity of the measuring points.



CAUTION

When assembling the modules, observe the admissible temperature range of the cable fasteners used!

Attaching ES400 Modules to Other Components Using Cable Fasteners

With this method of attachment, you connect the ES400 module or ES400 module blocks to the component using additional cable fasteners inserted through the openings of the modules. The integrated assembly elements of the module are not used.

Fastening ES400 Modules on DIN Rails using Cable Fasteners

For this fastening variant, the ES400 module or ES400 module blocks are connected with an ES4xx angle bracket (right) or with an ES4xx angle bracket (left) using additional cable fasteners inserted through the breakouts of the module. The integrated assembly elements of the module are not used.

The modules fastened to the ES4xx angle bracket are subsequently attached to the DIN rail.

Connecting the ES4xx Angle Bracket with the DIN rail

1. Place the ES4xx angle bracket onto the DIN rail.
2. Insert the hooks of the ES4xx angle bracket into the upper part of the DIN rail.
3. Engage the ES4xx angle bracket in the DIN rail by pressing on the ES4xx angle bracket or the module.

The module connected with the ES4xx angle bracket is fastened to the DIN rail.

6.3 Drilling Template

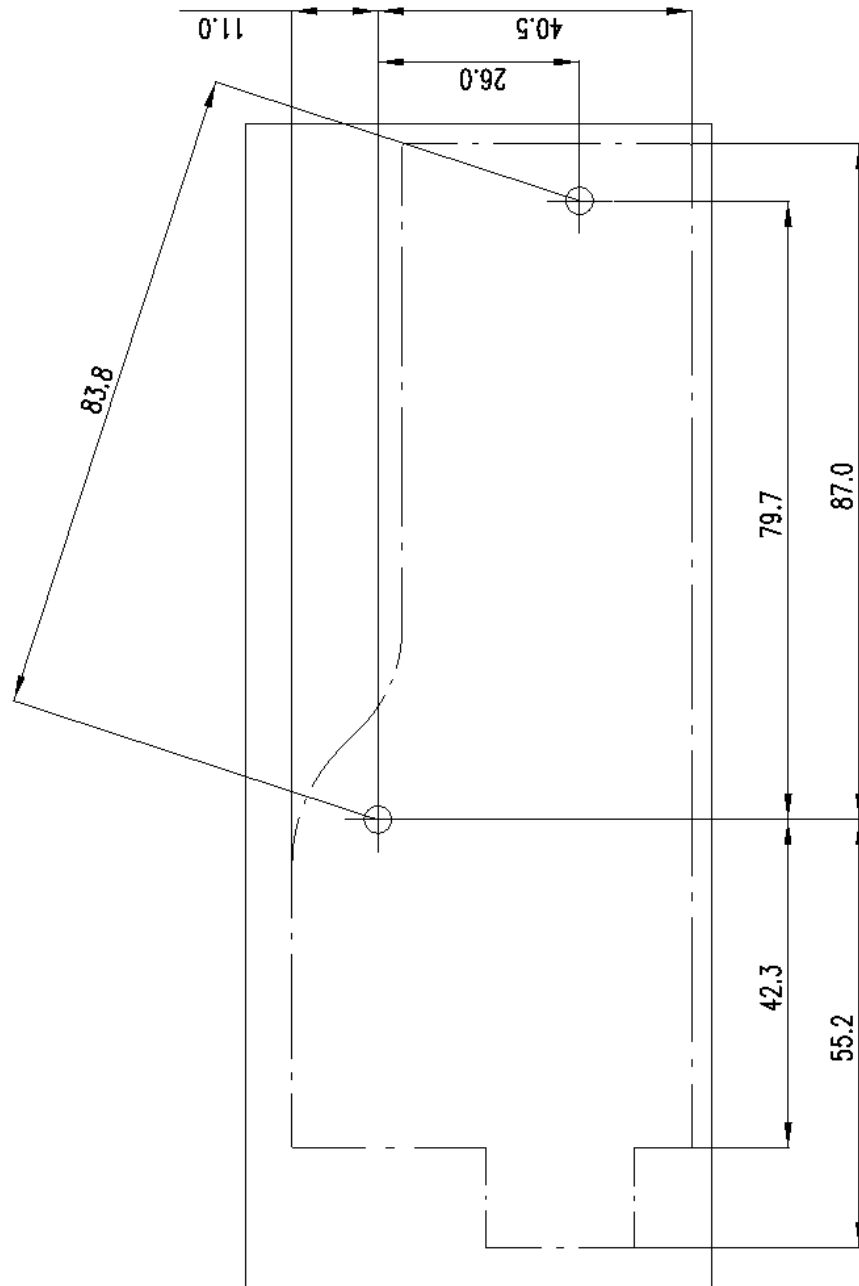


Fig. 6-13 Drilling Template

6.4 Applications

6.4.1 General

The modules ES4xx/ES63x/ES93x can be used for the following applications, individually or as part of a daisy chain module chain:

- Measuring and calibrating with INCA
- Rapid Prototyping with INTECRIO (with ES910.3 Prototyping Module or with RTPRO-PC).

Additional ECU and bus interface modules as well as measuring modules are networked with each other via Ethernet and connected with the daisy chain module chain.

The measuring setup can be supplemented with a drive recorder to record all of the data acquired by the connected modules. The drive recorder ES720.1 supports the simultaneous recording of different measurements (multi-recording). The data are stored in the ASAM standard format MDF (Measure Data Format). They can be conveniently evaluated using the Measure Data Analyzer MDA from ETAS and easily be compared with INCA reference measurements. The drive recorder ES720.1 can automatically transfer the recorded measure data encrypted and compressed via LAN, WLAN or wireless radio to customer-specific data servers.

6.4.2 ES441.1 with additional ETAS Modules (MC Application)

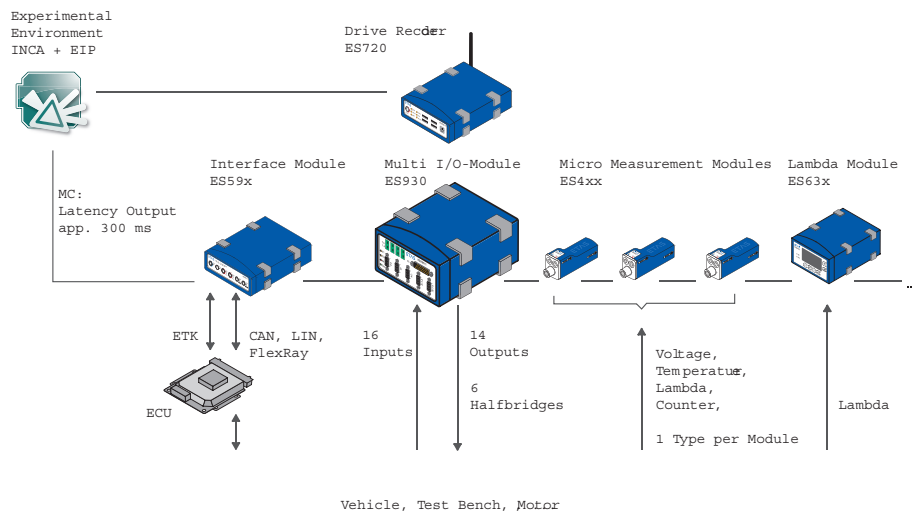


Fig. 6-14 ES441.1 with additional ETAS Modules for MC Applications

The ETAS Daisy Chain concept enables a simple network architecture since only the ES441.1 or the first module of the module chain is connected with the PC or with the "ETH" port of the ES59x.1.

Additional bus analysis functions on the CAN, LIN and FlexRay buses as well as (X)ETK bypass applications with measuring and calibrating can be made accessible with ES59x modules.

6.4.3 ES441.1 with additional ETAS Modules (Rapid Prototyping Application)

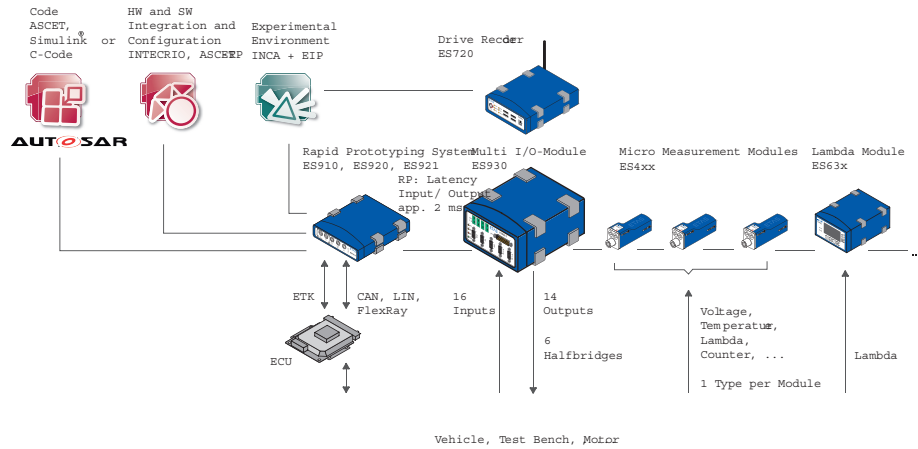


Fig. 6-15 ES441.1 with ES910.3 and additional ETAS Modules for Rapid Prototyping Applications

The concept of the ES4xx/ES63x/ES93x product family to install the modules as close as possible to the sensors, the chain the modules with each other, and to connect only the first module of this chain with the ES910.3 or the RTPRO-PC, enables a simple network architecture.

The combination of ES910.3 or RTPRO-PC with daisy chain modules can process information from sensors and control actuators in the Rapid Prototyping model.

From the Rapid Prototyping model, it is possible to access the connected modules whose signals are processed directly in the Rapid Prototyping model.

The ES910.3 or RTPRO-PC can access all customary ECU interfaces (ETK, XETK, CAN, LIN, FlexRay) and calculate the new control functions in the bypass.

Parallel to the bypass RP functionality, all control and diagnostics parameters as well as all measure signals of the connected ECU can be accessed with INCA. In addition, INCA/INCA-EIP offers access to all bypass and model sizes created in the ES910.3 Prototyping Module.

6.5 Wiring Examples

6.5.1 ES400 Modules with additional ETAS Modules (Measurement and Calibration)

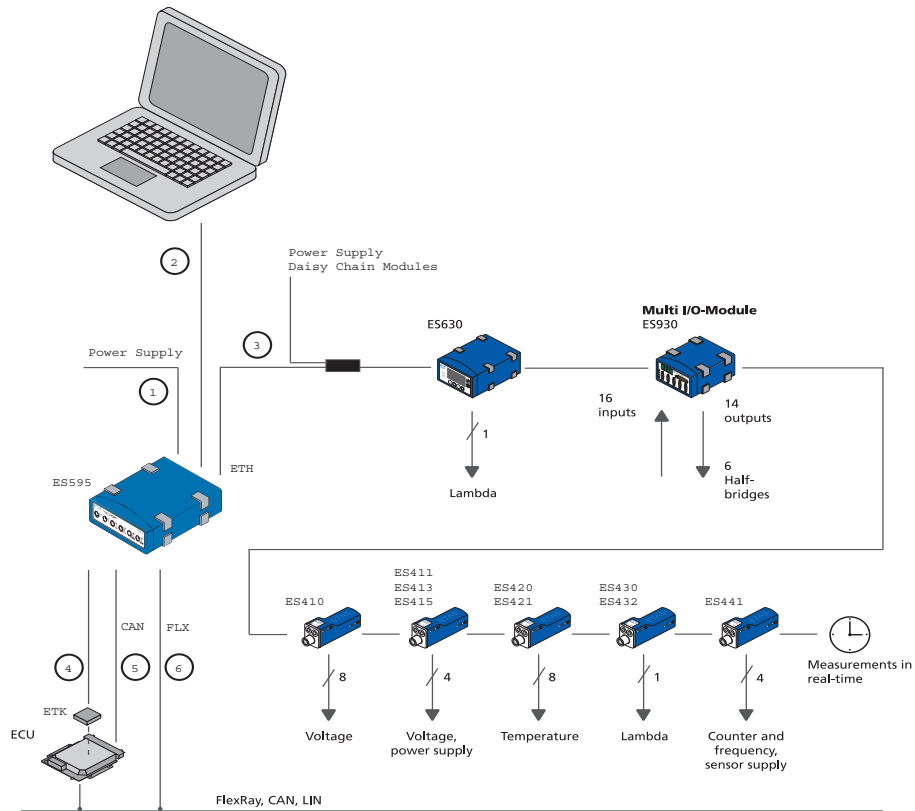


Fig. 6-16 ES400 Modules with additional ETAS Modules (Measurement and Calibration)

Cable in Fig. 6-16	Function	Order name
1	Power supply cable	CBP120, CBP1205
2	Host connection cable	CBE100
3	Power supply and Ethernet cable Daisy Chain modules	CBEP430, CBEP4305
4	ETK connection cable	CBM150
5, 6	CAN/LIN/FLX connection cable (CAN/LIN/FLX combined)	CBCF100

6.5.2 ES400 Modules with additional ETAS Modules and Drive Recorder (Measurement and Calibration)

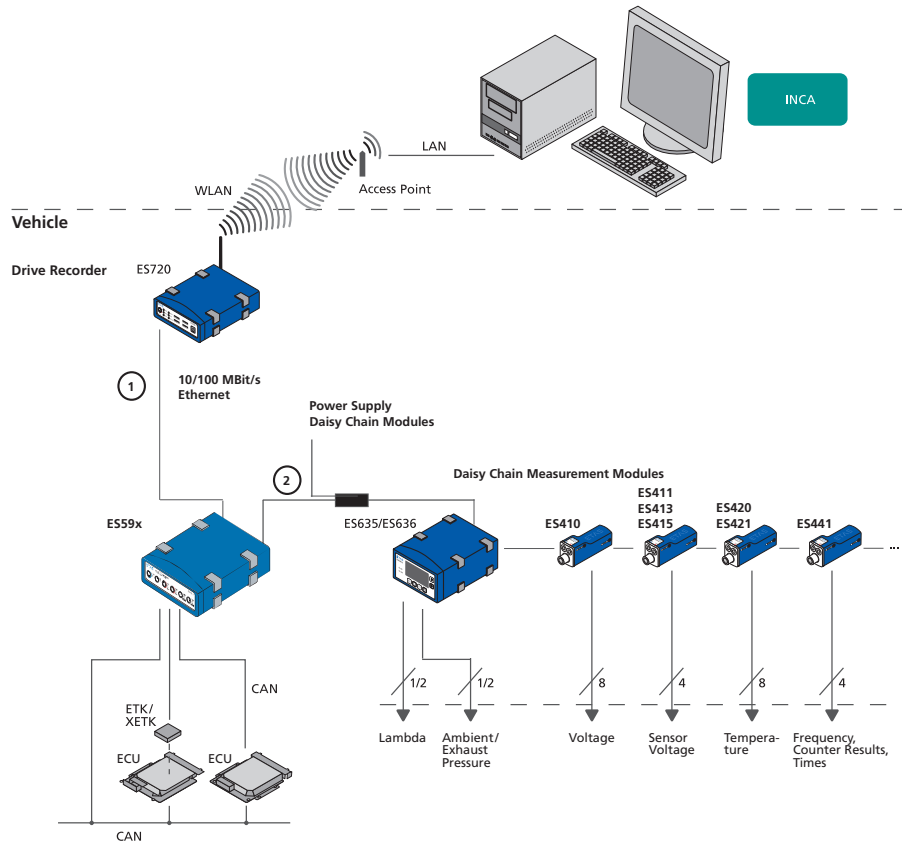


Fig. 6-17 ES400 Modules with additional ETAS Modules and Drive Recorder (Measurement and Calibration)

Cable in Fig. 6-17	Function	Order name
1	ES520-, ES59x-, ES6xx-, ES1120- or ES1135- Ethernet cable	CBE130, CBE140
2	Power supply and Ethernet cable Daisy Chain modules	CBEP430, CBEP4305

6.5.4 ES400 Modules with ES910.3 and Drive Recorder (Rapid Prototyping)

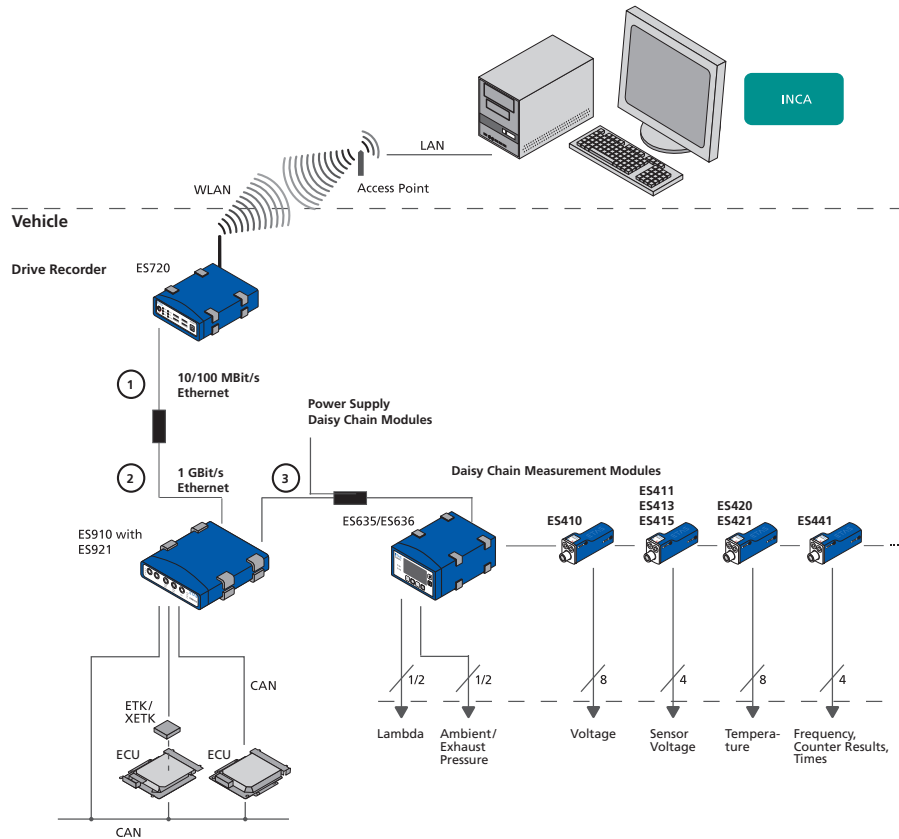


Fig. 6-19 ES400 Modules with ES910.3 and Drive Recorder (Rapid Prototyping)

Cable in Fig. 6-19	Function	Order name
1	Ethernet adapter cable (100 Mbit/s)	CBAE330 (connected to cable 2)
2	Ethernet connection cable(1 Gbit/s)	CBE230 (connected to cable 1)
3	Power supply and Ethernet cable Daisy Chain modules	CBEP430, CBEP4305

6.5.5 ES400 Modules with ETAS RTPRO-PC (Rapid Prototyping)

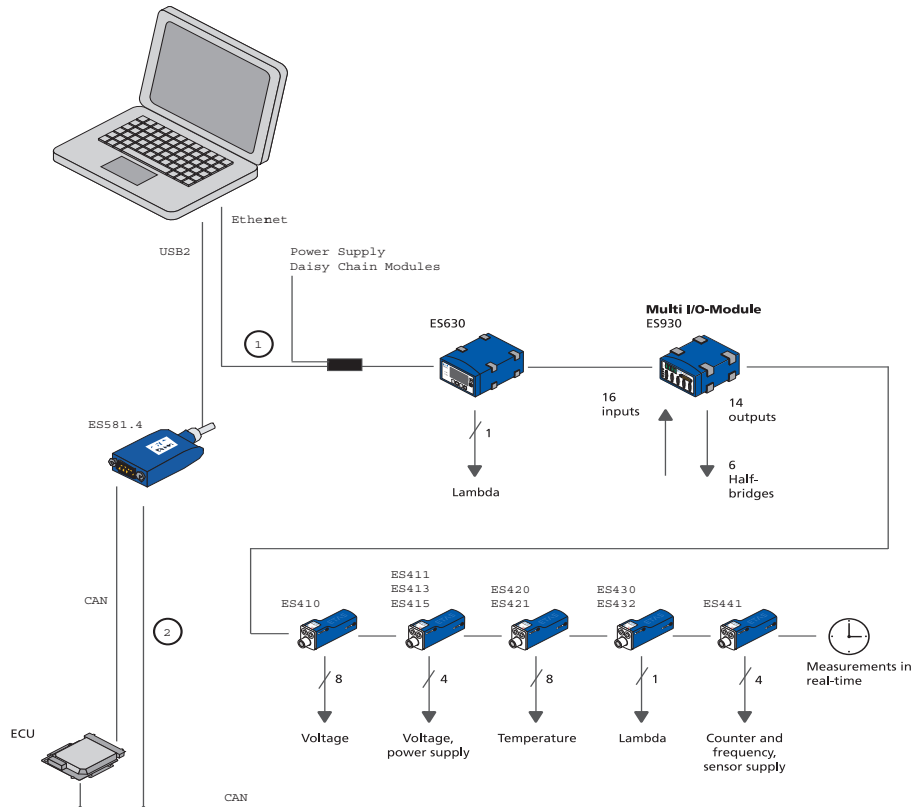


Fig. 6-20 ES400 Modules with ETAS RTPRO-PC (Rapid Prototyping)

Cable in Fig. 6-20	Function	Order name
1	Power supply and Ethernet cable PC and Daisy Chain modules	CBEP410, CBEP4105, CBEP415, CBEP4155
2	CAN and FlexRay Y-interface cable	CBCF100

6.6 Wiring

The ports may be wired in any order. Special connecting cables are available and can be ordered separately. An overview is contained in the chapter "Cables and Accessories" on page 105.

6.6.1 "Sensor" Port

To connect the sensors with the ES441.1, you can use different standard and adapter cables. Detailed information about the cables offered by ETAS is located in chapter "Cable for the Connection "Sensor"" on page 115.

Standard and Adapter Cable

- Cable CBAV400.1

If you replaced modules with BNC cabling with ES441.1 modules in your measuring setup, the use of these adapter cables enables you to continue using the existing cabling of your measuring setup.

- Cable CBAV411.1

You can customize the open connection of cable CBAV411.1 and adapt it to the specific plug connector system of your measuring setup.

- Cable CBAV412.1
- Cable CBAV417.1

To wire the ES441.1 with the sensors

1. If there is a protective cap at the "Sensor" port, remove it.
2. Connect the sensor cable to the "Sensor" port of the ES441.1.
3. Connect the sensors and transducers to the ports of the sensor cables of the ES441.1.
4. For your application software, jot down the assignment of the sensors to the inputs of the ES441.1 in accordance with the wiring of the test set-up.

6.6.2 Daisy Chain Ports ("IN", "OUT")

Wiring goes from the first module towards the end of the module chain.

To wire the first module with the following module

1. Connect an Ethernet cable to the "OUT" port of the first module.
 2. Connect the Ethernet cable to the "IN" port of the next module.
- or
- If two modules are connected mechanically, connect their adjacent "IN" and "OUT" ports to the ES4xx_BRIDGE.

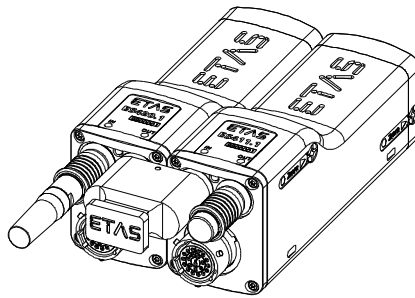


Fig. 6-21 ES441.1 with ES4xx_BRIDGE



CAUTION

The ports of the modules or the ES4xx_BRIDGE can be damaged!

Screw the two modules together without getting them off-thread as far as it will go within the module.

3. Continue to wire or connect further modules as described above.

To wire the first module with the PC and the power supply

1. Connect the combined Ethernet and power supply cable to the "IN" port of the ES441.1.
2. Connect the RJ-45 connector to the free Ethernet interface port of your PC.
3. Connect the supply voltage connector of the combined Ethernet and power supply cable to the desired power supply.
Note the color coding of the connectors.

To wire the module chain with additional current feeding

1. End the module chain after the last module whose power supply is still guaranteed in the entire operational range.
2. Connect the combined Ethernet and power supply cable to the "OUT" port of the ES441.1 of the last module of the chain towards the PC.
3. Connect the combined Ethernet and power supply cable to the "IN" port of the ES441.1 of the next module towards the end of the chain.
4. Connect the supply voltage connector of the combined Ethernet and power supply cable to the desired power supply.
Note the color coding of the connectors.

7 Troubleshooting Problems

This chapter contains information on the following topics:

- “LED Displays” on page 83
- “Troubleshooting ES441.1 Problems” on page 83
- “Problems and Solutions” on page 86

7.1 LED Displays

Please observe the LEDs which provide information on the functions of the interface and the ES441.1 (see the chapter “LED” on page 18) to be able to judge the operational state of the ES441.1 as well as troubleshooting measures.

7.2 Troubleshooting ES441.1 Problems

The following table lists some of the possible problems with a remedy.

If you have any further questions, please contact our Customer Support (see chapter “Contact Information” on page 124).

Problem	Diagnostic Questions	Possible Solutions
The application program cannot find any ETAS Daisy Chain modules.	Are all modules' LEDs flashing green?	Check that the function for automatic change to energy saving mode on your PC Card has been disabled ¹⁾ . Disable this function.
	Did you configure the network card correctly?	INCA, Config Tool and HSP operation: Check that your network card has been configured in accordance with section 7.3 on page 86. Stand-alone operation: Check that the IP address used belongs to your IP subnetwork and has been entered in the A2L file.
	Did you install the required firmware on the module?	Check with HSP whether the required firmware is installed on the module.
	Did you install the application software required?	Check that the application software installed on your PC corresponds to the requirements listed in section 8.9.2 on page 97.
	Power supply	Check that your power supply and test setup correspond to the requirements listed in section 4.5 on page 28.
	Is the hardware connected to the PC?	Check that the wiring is undamaged.
	Are the modules in the module chain connected correctly?	Check that the wiring is undamaged.

Problem	Diagnostic Questions	Possible Solutions
Measurement does not start.	Are you being prompted to carry out an update in the INCA-Monitorlog or in the Config-Tool?	Update the modules.
	Is there no data from the module?	<p>Check that your power supply and test setup correspond to the requirements listed in section 4.5 on page 28.</p> <p>Check that the wiring of the hardware to the PC is correct/intact.</p> <p>Check that the modules in the module chain are connected correctly.</p>
	You are using the ES4xx Configuration Tool and the module is supplying no data?	<p>Check whether the position of one or more modules in the chain has changed.</p> <p>Check that you are not using an incorrect A2L file.</p> <p>Check whether you have loaded the measure configuration to the module chain.</p> <p>Check that you have not assigned the same IP address to two module chains.</p>
	Is the module supplying usable data?	Check that the sensor is connected correctly.
Data is lost during data transfer.	Are you using WLAN in your test setup?	WLAN is not permissible within this ETAS network. Wire your test setup (ETAS modules and their connection to the PC) with ETAS cables only.
	Are you using the correct type of network card in your laptop?	Check whether you are using a PCMCIA network card in your laptop. PCMCIA cards with an 8- or 16-bit data bus are not suitable. Only use PCMCIA cards with a 32-bit data bus, mini-PCI or ExpressCards.
	Are you operating the ETAS Daisy Chain modules on a PC with multi-core processor?	Install a current driver for the network card that supports the NDIS protocol.
	Are you using ES441.1 modules common with other ES4xx modules?	Operate the ES441.1 modules at the beginning of the module chain close to the host (PC, drive recorder).

Problem	Diagnostic Questions	Possible Solutions
The LED is showing red.	Have you just carried out an update?	For users of the INCA/INTECRIO/ASCET-RP/ Configuration tool: Switch the module off and on again. For users of the Config tool: Switch the module off and on again. Load the measuring configuration again. If the LED continues to show red, send the module to ETAS for repair.
The firmware of one or more modules cannot be updated.	Is the module to be updated in a module chain?	Update the firmware of these ETAS Daisy Chain modules separately.

¹⁾: The manufacturers of PC Cards have different names for this function.
Example: "Link down Power saving" (refer to Chapter 8.9.1 on page 97).

7.3 Problems and Solutions

7.3.1 Network Adapter Cannot Be Selected via Network Manager

Cause: APIPA is disabled

The alternative mechanism for IP addressing (APIPA) is usually enabled on all Windows 7, 8.1 and 10 systems. Network security policies, however, may request the APIPA mechanism to be disabled. In this case, you cannot use a network adapter which is configured for DHCP to access ETAS hardware. The ETAS Network Manager displays a warning message.

The APIPA mechanism can be enabled by editing the Windows registry. This is permitted only to users who have administrator privileges. It should be done only in coordination with your network administrator.

To enable the APIPA mechanism:

1. Open the Registry Editor:
 - Windows 7, 8.1:
 - 1.1 Click on the Windows symbol.
 - 1.2 Enter `regedit` in the entry field.
 - 1.3 Push <ENTER>.
 - Windows 10:
 - 1.1 Rightclick on the Windows symbol.
 - 1.2 Click on **Search**.
 - 1.3 Enter `regedit` in the entry field.
 - 1.4 Push <ENTER>.

The registry editor is displayed.

2. Open the folder `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\`
3. Click **Edit** → **Find** to search for the key `IPAutoconfigurationEnabled`.

If you cannot find any instances of the registry key mentioned, the APIPA mechanism has not been disabled on your system. i.e. there is no need to enable it. Otherwise proceed with the following steps:

4. Set the value of the key `IPAutoconfigurationEnabled` to 1 to enable the APIPA mechanism.

You may find several instances of this key in the Windows registry which either apply to the TCP/IP service in general or to a specific network adapter. You only need to change the value for the corresponding network adapter.
5. Close the registry editor.
6. Restart your workstation in order to make your changes take effect.

7.3.2 Search for Ethernet Hardware Fails

Cause: Personal Firewall blocks Communication

For a detailed description on problems caused by personal firewalls and possible solutions see chapter 7.3.3 on page 89.

Cause: Client Software for Remote Access blocks Communication

PCs or notebooks which are used outside the ETAS hardware network sometimes use a client software for remote access which might block communication to the ETAS hardware. This can have the following causes:

- A firewall which is blocking Ethernet messages is being used (see „Cause: Personal Firewall blocks Communication“ on page 87)
- By mistake, the VPN client software used for tunneling filters messages. As an example, Cisco VPN clients with versions before V4.0.x in some cases erroneously filtered certain UDP broadcasts.

If this might be the case, please update the software of your VPN client.

Cause: ETAS Hardware hangs

Occasionally the ETAS hardware might hang. In this case switch the hardware off, then switch it on again to re-initialize it.

Cause: Network Adapter temporarily has no IP Address

Whenever you switch from a DHCP company LAN to the ETAS hardware network, it takes at least 60 seconds until ETAS hardware can be found. This is caused by the operating system's switching from the DHCP protocol to APIPA, which is being used by the ETAS hardware.

Cause: ETAS Hardware had been connected to another Logical Network

If you use more than one PC or notebook for accessing the same ETAS hardware, the network adapters used must be configured to use the same logical network. If this is not possible, it is necessary to switch the ETAS hardware off and on again between different sessions (repowering).

Cause: Device driver for network card not in operation

It is possible that the device driver of a network card is not running. In this case you will have to deactivate and then reactivate the network card.

Deactivating and reactivating the network card:

1. Open the Control Panel:
 - Windows 7, 10:
 - 1.1 Click on the Windows symbol.
 - 1.2 Click on **Control Panel**.
 - Windows 8.1:
 - 1.1 Click on the Windows symbol.
 - 1.2 Enter `Control Panel` in the entry field.
 - 1.3 Push <ENTER>.

2. Click on **Network and Sharing Center**.
3. Click on **Change adapter settings**.
4. Right click on the used network adapter.
5. Select **Deactivate** in the context menu.
6. In order to reactivate the network adapter right click on it again.
7. Select **Activate**.

Cause: Laptop energy management deactivates the network card

The energy management of a laptop computer can deactivate the network card. Therefore you should turn off energy monitoring on the laptop.

Switching off Energy Monitoring on Laptop

1. Open the Control Panel:
 - Windows 7, 10:
 - 1.1 Click on the Windows symbol.
 - 1.2 Click on **Control Panel**.
 - Windows 8.1:
 - 1.1 Click on the Windows symbol.
 - 1.2 Enter `Control Panel` in the entry field.
 - 1.3 Push <ENTER>.
2. Click on **Device Manager**.
3. In the Device Manager open the tree structure of the entry **Network Adapter**.
4. Right click on the used network adapter.
5. Select **Properties** in the context menu.
6. Switch off energy monitoring as follows:
 - i. Select the **Energy Management** tab.
 - ii. Deactivate the Computer can switch off device to save energy option.
7. Select the **Extended** tab.
8. If the property **Autosense** is included, deactivate it.
9. Click **OK** to apply the settings.

Cause: Automatic disruption of network connection

It is possible after a certain period of time without data traffic that the network card automatically interrupts the Ethernet connection. This can be prevented by setting the registry key `autodisconnect`.

Setting the Registry Key autodisconnect:

1. Open the Registry Editor:
 - Windows 7, 8.1:
 - 1.1 Click on the Windows symbol.
 - 1.2 Enter `regedit` in the entry field.
 - 1.3 Push <ENTER>.

- Windows 10:
 - 1.1 Rightclick on the Windows symbol.
 - 1.2 Click on **Search**.
 - 1.3 Enter `regedit` in the entry field.
 - 1.4 Push <ENTER>.
- 2. Select under `HKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\lanmanserver\parameters` the Registry Key `autodisconnect`.
- 3. Change its value to `0xffffffff`.

7.3.3 Personal Firewall Blocks Communication

Reason: Missing releases in the firewall block the ETAS hardware

Personal firewalls may interfere with access to ETAS Ethernet hardware. The automatic search for hardware typically cannot find any Ethernet hardware at all, although the configuration parameters are correct.

Some actions in ETAS products can lead to problems if the firewall is not properly parameterized, e.g. when opening the experiment environment in ASCET or for the hardware search by INCA or HSP.

If a firewall is blocking communication to ETAS hardware, you must either disable the firewall software while working with ETAS software, or the firewall must be configured to give the following permissions:

- Outgoing limited IP broadcasts via UDP (destination IP 255.255.255.255) for the destination port 17099 or 18001
- Incoming limited IP broadcasts via UDP (destination IP 255.255.255.255, originating from source IP 0.0.0.0) for destination port 18001
- Directed IP broadcasts via UDP to the network configured for the ETAS application, destination ports 17099 or 18001
- Outgoing IP unicasts via UDP to every IP address in the network configured for the ETAS application, destination ports 17099 to 18020
- Incoming IP unicasts via UDP originating from any IP address in the network configured for the ETAS application, originating ports 17099 to 18020, destination ports 17099 to 18020
- Outgoing TCP/IP connections to the network configured for the ETAS application, destination ports 18001 to 18020

NOTE

The ports to be used in a specific case depend on the hardware used. For more detailed information about the port numbers to be used, see the respective hardware documentation.

In Windows 7, 8.1 and 10, a Personal Firewall program is part of the scope of delivery and enabled by default. On many other systems, similar programs from independent providers can frequently be found, such as Symantec, McA-

fee or BlackIce. The procedure for the configuration of ports may differ in the various programs. More detailed information can be found in the user documentation of your firewall program.

Below is a sample description about how to configure the Windows firewall if the hardware access is being blocked.

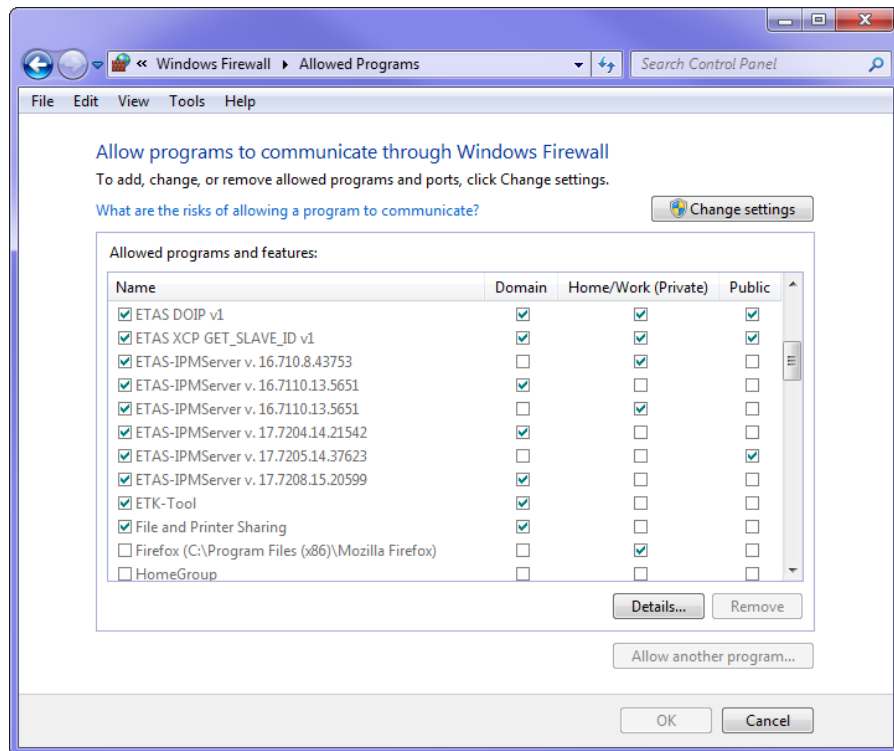
Solution for Windows Firewall, user with administrator rights

Enabling ETAS products in the firewall control:

1. Open the Control Panel:
 - Windows 7, 10:
 - 1.1 Click on the Windows symbol.
 - 1.2 Click on **Control Panel**.
 - Windows 8.1:
 - 1.1 Click on the Windows symbol.
 - 1.2 Enter `Control Panel` in the entry field.
 - 1.3 Push <ENTER>.
2. Click on **Windows Firewall** (Win 7, 8.1) or **Windows Defender Firewall** (Win 10).



3. Click on **Allow a program / app or feature through Windows (Defender) Firewall.**



This window lists the exceptions that are not blocked by the firewall.

4. Click on **Change settings.**
5. Check the boxes to enable the respective program for the corresponding network.
6. Ensure that the ETAS products and services to be used are correctly configured exceptions.
7. Click on **OK.**
8. Close the **Windows Firewall.**

The firewall no longer blocks the ETAS product. The setting is retained after a restart of the PC.

Solution for Windows Firewall, user without administrator rights

This chapter is directed at users with restricted rights, e.g. no changes to the system, restricted write permissions, local login.

Working with an ETAS product requires the rights "Write" and "Modify" in the directories `ETAS`, `ETASData` and the temporary ETAS directories. Otherwise, an error message appears if the product is being started and a database is being opened. A correct operation of the product is not possible since the database file as well as various `*.ini` files are modified during the work.

The ETAS software must be installed by an administrator in any case. It is recommended that the administrator ensures that the ETAS product or the processes are added to the list of selected exceptions of the Windows Firewall after the installation.

8 Technical Data

This chapter contains information on the following topics:







- "General Data" on page 92
- "RoHS conformity" on page 95
- "CE conformity" on page 95
- "Product return and recycling" on page 96
- "Declarable Substances" on page 96
- "Use of Open Source software" on page 96
- "System Requirements" on page 97
- "Electrical Data" on page 98
- "Pin Assignment" on page 102




8.1 General Data

This section contains details of the admissible environmental conditions as well as the mechanical data.

8.1.1 Product labeling

The following symbols are used for product labeling:

Symbol	Description
	Prior to operating the product, be sure to read the user's guide!
	Labeling of the daisy chain port, "IN" (input; Ethernet connection to the upstream module or the PC, power supply of the module)
	Labeling of the daisy chain port, "OUT" (output; Ethernet connection and power supply of the downstream module)
CH	Connection of sensor cable
SN: 1234567	Serial number (seven-digit)
Vx.y.z	Hardware version of the product
F 00K 123 456	Ordering number of the product, see chapter 10.1 on page 120
5-50V  Pmax=6W	Operating voltage range (DC), Power consumption
	Labeling for WEEE, see chapter 8.6 on page 96
	Marking for CE conformity (Chapter 8.3 on page 95)

Symbol	Description
	Marking for UKCA conformity (Chapter 8.4 on page 95)
	Marking for KCC conformity (Chapter 8.5 on page 95)
	Labeling for RoHS (China), see chapter on page 95

8.1.2 Standards and Norms

The module adheres to the following standards and norms

Norm	Test
DIN EN 60068-2-1	Premature fatigue cold test
DIN EN 60068-2-2	Premature fatigue heat test
DIN EN 60068-2-13	Negative pressure
DIN EN 60068-2-14 Na	Temperature shock
DIN EN 60068-2-14 Nb	Temperature change: Temperature: Tu -40 °C / To +120 °C, Number of cycles: 10, Unit under test: active
DIN EN 60068-2-56	Humidity storage
DIN EN 60068-30, Variant 1	Climate change
DIN EN 60068-2-64, ISO 16750-3	Vibration, noise: 3 space axis, test duration 4 h, Unit under test: active
	In addition, the combination was tested by cascaded modules.
ISO 16750-3, Sec. 4.2.2.2	Mech. shock 3 space axis, half sinus, Acceleration: 500 m/s ² , Shock duration: 6 ms, Shocks per direction and axis: 10, Units under test: active
ISO 16750-3, Sec. 4.3	Drop test Number of drops: 2, Height: 1 m, Surface: concrete, steel Units under test: passive
ISO 16750-4, Sec. 5.2	Phased temperature test

Norm	Test
ISO 16750-4, Sec. 5.4.2	Splash water Air temperature: To +120 °C, Cycle duration: 30 min, Splash length: 3 s, Splash quantity: ca. 3 l, Splash water temperatur: +2 °C ± 2 °C, Medium: water, put in 3% Arizona dust fine, Number of cycles: 100, Unit under test: active
ISO 16750-4, Sec. 5.5.1.; DIN EN 60068-2-52	Salt fog: Severity level: 5, Test duration: 16 d, Units under test: passive
ISO 16750-5	Chemical resistance: Identification A-W, Prüflinge passiv
DIN 5596-1	Stone impact
IPX7	Protection class test: Protection class IP67 (with cables connected)
EN61000-4-2	Immunity ESD
EN61000-4-3	Immunity radiated RF
EN61000-4-4	Immunity EFT/B
EN61000-4-5	Immunity surge
EN61000-4-6	Immunity conducted RF
DIN EN 55022	Emission radiation/ radio interference voltage

8.1.3 Environmental Conditions

Operating temperature range	-40 °C to +120 °C -40 °F to +248 °F
Storage temperature range (module without packaging)	-40 °C to +125 °C -40 °F to +257 °F
Altitude	max. 5000 m / 16,400 ft
Protection class	IP67



CAUTION

Loss of Features as defined by IP67!

Do not open or change the module!

Works on the module may be executed only by qualified technical personnel.

8.1.4 Maintenance the Product

Do not open or change the module! Works on the module housing may be executed only by qualified technical personnel. Send defect modules to ETAS.

8.1.5 Cleaning the product

We recommend to clean the product with a dry cloth.

8.1.6 Mechanical Data

Dimensions (H x W x D)	51.5 mm x 40 mm x 142 mm / 37.5 mm x 40 mm x 129 mm
	2.0 in x 1.57 in x 5.59 in 1.48 in x 1.57 in x 5.08 in
Weight	350 g / 0.77 lb

8.1.7 Modules in one chain

Modules in chain	Max. 254 in one chain
------------------	-----------------------

8.2 RoHS conformity

European Union

The EU Directive 2011/65/EU limits the use of certain dangerous materials for electric and electronic devices (RoHS conformity).

ETAS confirms that the product meets this directive applicable in the European Union.

China

ETAS confirms that the product meets the "China RoHS" (Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation) guidelines applicable to the People's Republic of China with a China RoHS label attached to the product or its packaging.

8.3 CE conformity

With the CE mark attached to the product or its packaging, ETAS confirms that the product corresponds to the product-specific, applicable directives of the European Union.

The CE Declaration of Conformity for the product is available upon request.

8.4 UKCA conformity

With the UKCA mark attached to the product or its packaging, ETAS confirms that the product corresponds to the product-specific, applicable standards and directives of Great Britain.

The UKCA declaration of conformity for the product is available on request.

8.5 KCC conformity

With the KC mark attached to the product and its packaging, ETAS confirms that the product has been registered in accordance with the product-specific KCC guidelines of the Republic of Korea.

8.6 Product return and recycling

The European Union (EU) has issued the guideline on waste electric and electronic equipment (Waste Electrical and Electronic Equipment - WEEE) in order to ensure the institution of systems for collection, handling, and disposal of all electronic scrap.

This ensures that the devices are recycled in a resource-friendly way that does not represent any risk to personal health and the environment.



Fig. 8-1 WEEE symbol

The WEEE symbol (see Fig. 8-1 on page 96) on the product or its packaging identifies that the product may not be disposed of together with the remaining trash.

The user is obligated to separate the waste equipment and to provide it to the WEEE return system for reuse.

The WEEE Directive applies to all ETAS devices, but not to external cables or batteries.

Additional information about the recycling program of ETAS GmbH is available from the ETAS sales and service locations (see chapter "Contact Information" on page 124).

8.7 Declarable Substances

European Union

Some products from ETAS GmbH (e.g. modules, boards, cables) use components with substances that are subject to declaration in accordance with the REACH regulation (EU) no.1907/2006.

Detailed information is located in the ETAS download center in the customer information "REACH Declaration" (www.etas.com/Reach). This information is continuously being updated.

8.8 Use of Open Source software

The product uses Open Source Software (OSS). This software is installed in the product at the time of delivery and does not have to be installed or updated by the user. Reference shall be made to the use of the software in order to fulfill OSS licensing terms. Additional information is available in the document "OSS Attributions List" at the ETAS website www.etas.com.

8.9 System Requirements

This section tells you what hardware and software is needed to operate your ES441.1 module.

8.9.1 Hardware

Power supply

Operation of the modules requires a power supply voltage of 5 V to 50 V / 6 V to 50 V DC.

PC with one Ethernet interface

A PC with one open Ethernet interface (100 Mbit/s, full duplex) with RJ-45 connection is required.

Requirement to ensure successful initialization of the module

NOTE

It is imperative you disable the function which automatically switches to power-saving mode on your PC network adapter when there is no data traffic on the Ethernet interface!

To deactivate the power saving mode

Choose in System Control Center / Device Manager / Network Adapter the used network adapter by double-click. Deactivate the "Allow the computer to turn off this device to save power" option in the "Power Management" register. Confirm your configuration.

The manufacturers of network adapter have different names for this function.

Example:

- "Link down Power saving"
- "Allow the computer to turn off this device to save power".

8.9.2 Software

To configure the ES441.1 and for control and data acquisition, you need software in the following versions:

- INCA V6.2.0 with ES400 INCA Add-On V1.1.3 and higher
or
- ES4xx Configuration Tool V1.1.3 and higher from ES4xx_DRV_SW (stand-alone operation)
or
- INTECRIO V3.0 with ES400 INCA Add-On V1.1.3 and higher
or
- Integration into software not based on XCP-on-Ethernet via a C-based library V1.3.0.

Operating the ES441.1 with limited function scope (amongst others no usage of measurement methods with qualifying signal) is possible using the following software versions:

- INCA V5.4.1 with ES400 INCA Add-On V1.1.0 and higher
or
- ES4xx Configuration Tool V1.1.0 and higher from ES4xx_DRV_SW (stand-alone operation)
or
- INTECRIO V3.x with ES400 INCA Add-On V1.1.0 and higher
or
- ES4xx driver LabVIEW Integration V1.0.0 and higher from ES4xx-
_DRV_SW
or
- Integration into software not based on XCP-on-Ethernet via a C-based library.

i NOTE

Operating the ES441.1 with older software versions is not possible.

8.10 Electrical Data

This chapter contains information on the following topics:

- "Host Interface" on page 99
- "Power Supply" on page 99
- "Sensor Power Supply" on page 100
- "Input Channels" on page 101

i NOTE

ETAS guarantees measurement accuracy of the ES441.1 for one year. Please use our calibration service (see section 4.9 on page 31)!

i NOTE

Unless otherwise specified, all data applies at 25 °C.

8.10.1 Host Interface

Connection	100Base-T Ethernet; 100 Mbit/s, Full Duplex PC Card 32-bit
Protocol	XCP on UDP/IP
IP address	Dynamic via INCA or via ES4xx Configuration Tool from ES4xx_DRV_SW (stand-alone operation)

 **NOTE**

For the successful initialization of the network card of your PC, observe chapter 8.9.1 on page 97.

8.10.2 Power Supply

Operating voltage	Temperature range -40 °C to +85 °C: 5 V to 50 V DC Temperature range -40 °C to +120 °C: 6 V to 50 V DC
Power consumption (operation, sensors not connected)	Typ. 1.8 W at 12 V DC
Power consumption (operation; all channels loaded with 30 mA)	Max. 4.6 W at 12 V DC
Power consumption (standby, sensors not connected, room temperature)	Typ. 25 mW at 12 V DC
Polarity inversion protection, load dump protection ¹⁾	With CBEP410, CBEP4105, CBEP415, CBEP4155, CBEP420, CBEP4205, CBEP425, CBEP4255, CBEP430, CBEP4305 cable
Overvoltage category (AC mains supply)	II

¹⁾: The module may be used only with central load dump protection.

8.10.3 Sensor Power Supply

Features

Sensor power supply channels	4, separate per input channel
Output voltage	Each channel can be set separately: "Off", in steps (5 V, 8 V, 10 V, 12 V, 15 V) or freely selectable as a value in the range 5 V to 15 V
D/A converter	16-bit (resolution 229 μ V)
Protection	Outputs (plus) short-circuit proof against ground and up to 26 V over-voltage. Ground connected to operating voltage ground and protected by a fuse.
Diagnostics	Short-circuit detection per channel; overload conditions reduce the output voltage

Characteristics

Parameter	Min	Max	Unit
Accuracy of the sensor supply voltage without load	-	± 10	mV
Accuracy of the sensor supply voltage with 3 k Ω load	-	± 5	mV
Resistance of sensor supply voltage outputs including CBAV411.1-2 cable	-	1.6	Ohm
Ripple voltage V_{pp} (measurement limited to 80 MHz)	-	20	mV
Max. voltage drift (temperature)	-1	+1.2	mV/K
Output current	-	30	mA
Output current protection	-	200	mA

8.10.4 Input Channels

No. of input channels	4, each channel with a separate sensor voltage supply
Input voltage range	±50 V
Switching thresholds	Hysteresis; active and inactive level configurable individually
Hysteresis treshold range	-50.0 V to +50 V
Hysteresis treshold resolution	0.1 V
Hysteresis treshold accuracy	±0.1 V
Hysteresis drift over temperature	±0.2 V
Interfering voltage filter	Debouncing, configurable in the calibration software
Pulse width	120 ns (min.)
Time resolution	20 ns (50 MHz)
Accuracy time resolution	±100 ppm
Counter length	32 bit
Measuring capabilities	Event counting; measurement of frequency, duty cycle, active duration, inactive duration, period duration, state, combination of two channels facilitate evaluation of complex signals
Sampling rate	0.5 to 10000 samples/s, can be configured in the calibration software
Sampling rates	0.1 ms, 0.2 ms, 0.5 ms, 1 ms, 2 ms, 5 ms, 10 ms, 20 ms, 50 ms, 0.1 s, 0.2 s, 0.5 s, 1 s, 2 s
Maximum input voltage (dry environment)	Input-to-input: 60 V DC / 30 V AC Input-to-ground of voltage supply or housing: 60 V DC / 30 V AC
Maximum Input voltage (wet environment)	Input-to-input: 35 V DC / 16 V AC Input-to-ground of voltage supply or housing: 35 V DC / 16 V AC
Input impedance	> 2 MΩ < 250 pF

8.11 Pin Assignment

This chapter contains information on the following topics:

- “IN” Connector” on page 102
- “OUT” Connector” on page 103
- “Sensor” Connector” on page 104

i NOTE

All connectors are shown with a view of the front of the ES441.1.
All shields are at case potential.

8.11.1 “IN” Connector

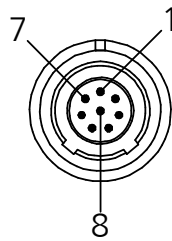


Fig. 8-2 “IN” Connector

Pin	Signal	Meaning
1	UBatt	Operating voltage
2	Ground	Ground
3	RX-	Received data, minus
4	TX-	Send data, minus
5	RX+	Received data, plus
6	Ground	Ground
7	UBatt	Operating voltage
8	TX+	Send data, plus

The following plug is mounted on "IN" connector:

LEMO 1B 8-pin L-coding (connection identified in green)

8.11.2 "OUT" Connector

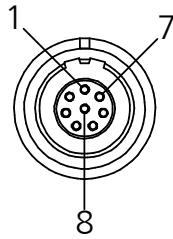


Fig. 8-3 "OUT" Connector

Pin	Signal	Meaning
1	UBatt	Operating voltage
2	UBatt	Operating voltage
3	Ground	Ground
4	RX+	Received data, plus
5	TX-	Send data, minus
6	RX-	Received data, minus
7	Ground	Ground
8	TX+	Send data, plus

The following socket is mounted on "OUT" connector:

LEMO 1B 8-pin A-coding (connection identified in yellow)

8.11.3 "Sensor" Connector

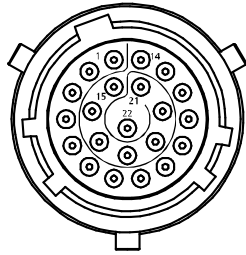


Fig. 8-4 "Sensor" Connector

Pin	Signal	Meaning
1	CH2 In+	Sensor channel 2, input plus
2	CH2 SGND	Sensor channel 2, Sensor supply voltage, GND ^{*)}
3	CH2 S+	Sensor channel 2, Sensor supply voltage, plus
4	CH3 SGND	Sensor channel 3, Sensor supply voltage, GND ^{*)}
5	CH3 S+	Sensor channel 3, Sensor supply voltage, plus
6	CH3 In-	Sensor channel 3, input minus
7	CH3 In+	Sensor channel 3, input plus
8	CH4 In+	Sensor channel 4, input plus
9	CH4 In-	Sensor channel 4, input minus
10	CH4 S+	Sensor channel 4, Sensor supply voltage, plus
11	CH4 SGND	Sensor channel 4, Sensor supply voltage, GND ^{*)}
12	CH1 S+	Sensor channel 1, Sensor supply voltage, plus
13	CH1 SGND	Sensor channel 1, Sensor supply voltage, GND ^{*)}
14	CH1 In+	Sensor channel 1, input plus
15	CH2 In-	Sensor channel 2, input minus
16	CH2 TEDS+	Sensor channel 2, TEDS+
17	CH3 TEDS+	Sensor channel 3, TEDS+
18	TEDS+	Cable, TEDS+
19	CH4 TEDS+	Sensor channel 4, TEDS+
20	CH1 TEDS+	Sensor channel 1, TEDS+
21	CH1 In-	Sensor channel 1, input -
22	CH1 TEDS- CH2 TEDS- CH3 TEDS- CH4 TEDS- TEDS-	Sensor channel 1, TEDS- Sensor channel 2, TEDS- Sensor channel 3, TEDS- Sensor channel 4, TEDS- Cable, TEDS-

^{*)}: connected with operating voltage ground

9 Cables and Accessories

This chapter contains information on the following topics:

- "Combined Ethernet and Power Supply Cable" on page 106
- "Ethernet Cable" on page 112
- "Cable for the Connection "Sensor"" on page 115
- "Protective Caps" on page 118
- "Angle Brackets" on page 119

 **NOTE**

Only use ETAS cables at the interfaces of the module. Adhere to the maximum cable lengths!

9.1 Combined Ethernet and Power Supply Cable

This chapter contains information on the following cables:

- "CBEP410.1 Cable" on page 107
- "CBEP4105.1 Cable" on page 107
- "CBEP415.1 Cable" on page 108
- "CBEP4155.1 Cable" on page 108
- "CBEP420.1 Cable" on page 109
- "CBEP4205.1 Cable" on page 109
- "CBEP425.1 Cable" on page 110
- "CBEP4255.1 Cable" on page 110
- "CBEP430.1 Cable" on page 111
- "CBEP4305.1 Cable" on page 111

9.1.1 Overview



DANGER

Dangerous electrical voltage!

Connect the power cable only with a suitable vehicle battery or with a suitable lab power supply! The connection to power outlets is not allowed!

To prevent an inadvertent insertion in power outlets, ETAS recommends to equip the combined ethernet and power supply cables with safety banana plugs in areas with power outlets.

You can use combined ethernet and power supply cables with standard banana plugs or with safety banana plugs:

Cables with standard banana plugs	Cables with safety banana plugs
CBEP410.1	CBEP4105.1
CBEP415.1	CBEP4155.1
CBEP420.1	CBEP4205.1
CBEP425.1	CBEP4255.1
CBEP430.1	CBEP4305.1

9.1.2 CBEP410.1 Cable

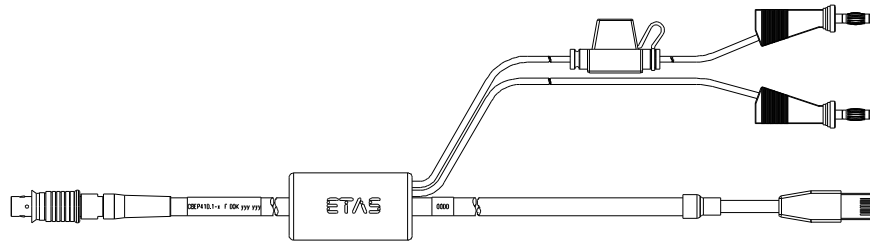


Fig. 9-1 CBEP410.1 Cable

Connection of an ES4xx/ES63x/ES93x module to PC and power supply (stand-alone operation). Supply battery in the vicinity of the module.

Not compatible with ES610, ES611, ES620 and ES650. For connecting this modules use CBEP120 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP410.1-3	3 m	F 00K 104 927

9.1.3 CBEP4105.1 Cable

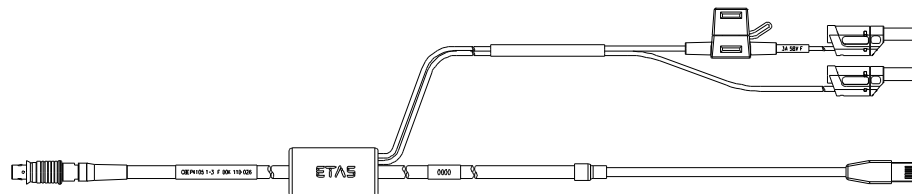


Fig. 9-2 CBEP4105.1 Cable

Connection of an ES4xx/ES63x/ES93x module to PC and power supply (stand-alone operation). Supply battery in the vicinity of the module.

Not compatible with ES610, ES611, ES620 and ES650. For connecting this modules use CBEP120 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP4105.1-3	3 m	F 00K 110 026

9.1.4 CBEP415.1 Cable

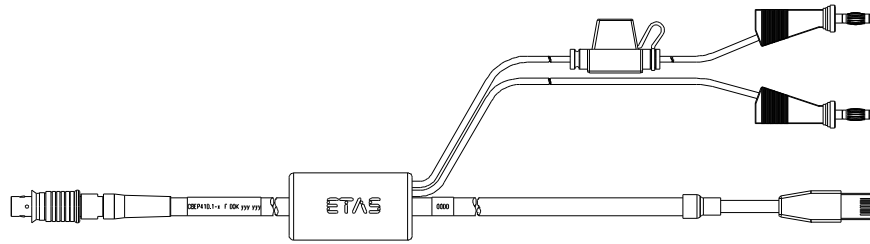


Fig. 9-3 CBEP415.1 Cable

Connection of an ES4xx/ES63x/ES93x module to PC and power supply (stand-alone operation). Supply battery at the other end (i.e. in the trunk).

Not compatible with ES610, ES611, ES620 and ES650. For connecting this modules use CBEP120 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP415.1-5	5 m	F 00K 105 680

9.1.5 CBEP4155.1 Cable

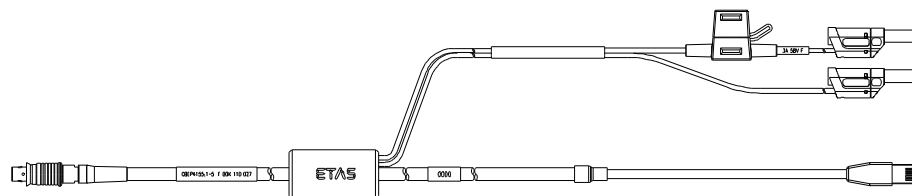


Fig. 9-4 CBEP4155.1 Cable

Connection of an ES4xx/ES63x/ES93x module to PC and power supply (stand-alone operation). Supply battery at the other end (i.e. in the trunk).

Not compatible with ES610, ES611, ES620 and ES650. For connecting this modules use CBEP120 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP4155.1-5	5 m	F 00K 110 027

9.1.6 CBEP420.1 Cable

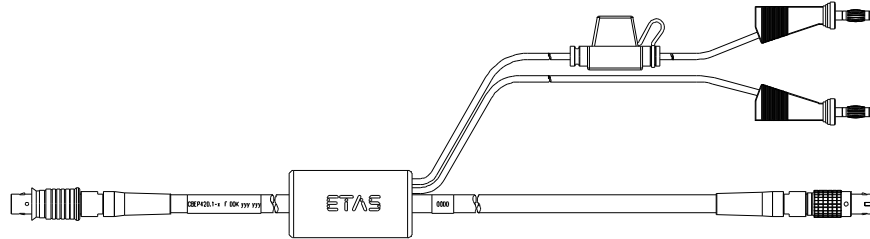


Fig. 9-5 CBEP420.1 Cable

Ethernet and voltage supply connection of an ES4xx/ES63x/ES93x measurement module with an ES600 network module or ES592/ES593-D/ES595 interface module (if the current consumption of the connected ES4xx/ES63x chain exceeds 2.5 A), an ES1135 simulation/system controller card or an ES720 Drive Recorder.

Not compatible with ES610, ES611, ES620 and ES650. For connecting this modules use CBEP120 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP420.1-3	3 m	F 00K 105 292

9.1.7 CBEP4205.1 Cable

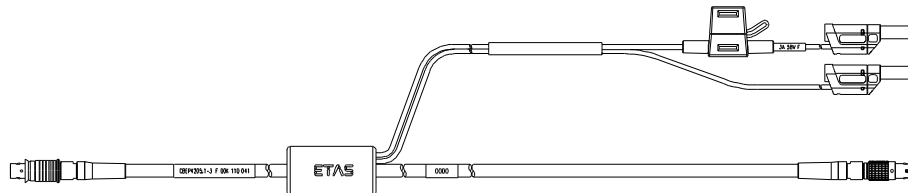


Fig. 9-6 CBEP4205.1 Cable

Ethernet and voltage supply connection of an ES4xx/ES63x/ES93x measurement module with an ES600 network module or ES592/ES593-D/ES595 interface module (if the current consumption of the connected ES4xx/ES63x chain exceeds 2.5 A), an ES1135 simulation/system controller card or an ES720 Drive Recorder.

Not compatible with ES610, ES611, ES620 and ES650. For connecting this modules use CBEP120 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C/ -40 °F to +257 °F

Product	Length	Order number
CBEP4205.1-3	3 m	F 00K 110 041

9.1.8 CBEP425.1 Cable

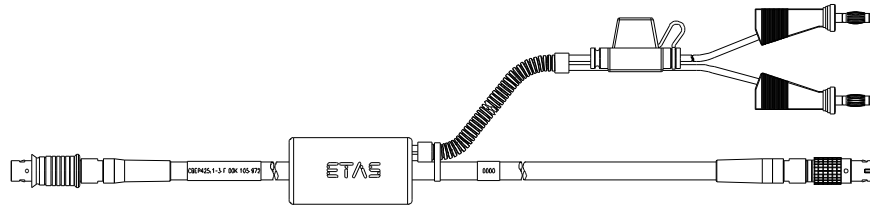


Fig. 9-7 CBEP425.1 Cable

Ethernet and voltage supply connection of an ES4xx/ES63x/ES93x measurement module with an ES600 network module or ES592/ES593-D/ES595 interface module (if the current consumption of the connected ES4xx/ES63x/ES93x chain exceeds 2.5 A), an ES1135 simulation/system controller card or an ES720 Drive Recorder.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP425.1-3	3 m	F 00K 105 972

9.1.9 CBEP4255.1 Cable

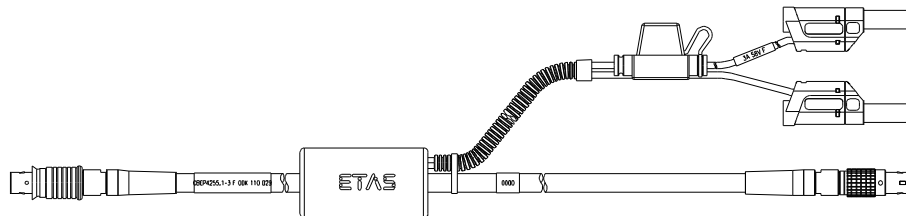


Fig. 9-8 CBEP4255.1 Cable

Ethernet and voltage supply connection of an ES4xx/ES63x/ES93x measurement module with an ES600 network module or ES592/ES593-D/ES595 interface module (if the current consumption of the connected ES4xx/ES63x/ES93x chain exceeds 2.5 A), an ES1135 simulation/system controller card or an ES720 Drive Recorder.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP4255.1-3	3 m	F 00K 110 029

9.1.10 CBEP430.1 Cable

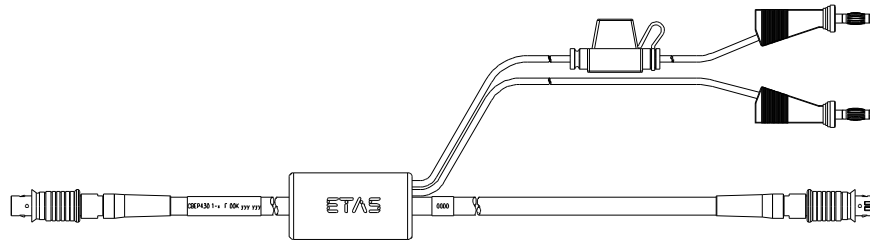


Fig. 9-9 CBEP430.1 Cable

To chain ES4xx/ES63x/ES93x modules and connect an ES4xx/ES63x/ES93x chain to an ES910.3 Rapid Prototyping module. Additional connection to the power supply to compensate for voltage losses in long chains.

Not compatible with ES59x, ES6xx, ES11xx. For connecting this modules use CBE130 or CBE140 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP430.1-0m5	0.5 m	F 00K 104 928

9.1.11 CBEP4305.1 Cable

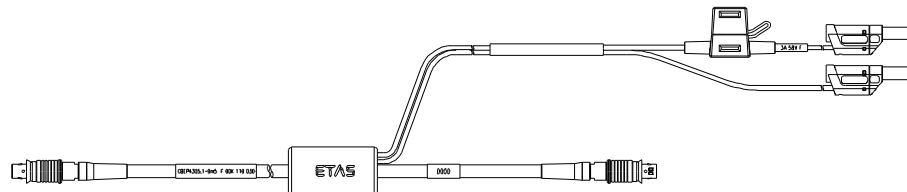


Fig. 9-10 CBEP4305.1 Cable

To chain ES4xx/ES63x/ES93x modules and connect an ES4xx/ES63x/ES93x chain to an ES910.3 Rapid Prototyping module. Additional connection to the power supply to compensate for voltage losses in long chains.

Not compatible with ES59x, ES6xx, ES11xx. For connecting this modules use CBE130 or CBE140 cable.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEP4305.1-0m5	0.5 m	F 00K 110 030

9.2 Ethernet Cable

This chapter contains information on the following cables:

- "CBE400.2 Cable" on page 112
- "CBE401.1 Cable" on page 112
- "CBE430.1 Cable" on page 113
- "CBE431.1 Cable" on page 113
- "CBEX400.1 Cable" on page 113
- "ES4xx_BRIDGE" on page 114

9.2.1 CBE400.2 Cable

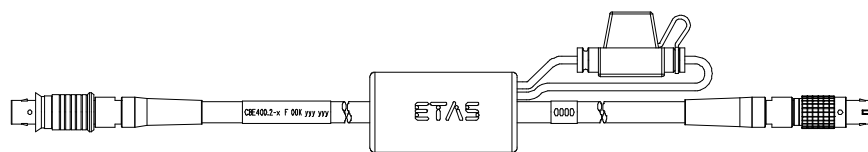


Fig. 9-11 CBE400.2 Cable

Ethernet and voltage supply connection of an ES4xx/ES63x/ES93x measuring module at an ES600 network module or at an ES592/ES593-D/ES595 interface module.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBE400.2-3	3 m	F 00K 104 920

9.2.2 CBE401.1 Cable

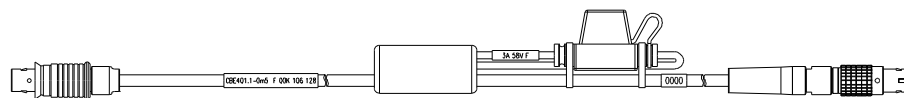


Fig. 9-12 CBE401.1 Cable

Highly flexible Ethernet and voltage supply connection of an ES4xx/ES63x/ES93x measuring module at an ES600 network module or at an ES592/ES593-D/ES595 interface module.

Cable includes reverse-polarity, load-dump protection and replaceable standard fuse (MINI flat automotive fuse, quick-response, 3 A, 58 V).

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBE401.1-0m5	0.5 m	F 00K 106 128

9.2.3 CBE430.1 Cable

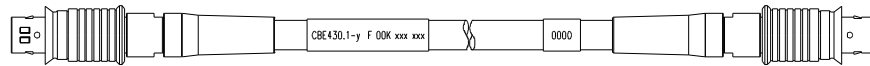


Fig. 9-13 CBE430.1 Cable

Cable for chaining ES4xx/ES63x/ES93x modules. Not compatible with ES59x, ES6xx, ES11xx. For connecting this modules use CBE130 or CBE140 cable.

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBE430.1-0m45	0.45 m	F 00K 104 923

9.2.4 CBE431.1 Cable

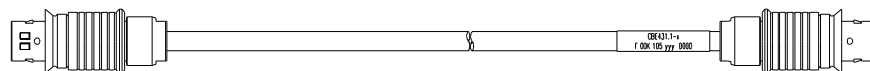


Fig. 9-14 CBE431.1 Cable

Highly flexible cable for chaining successive ES4xx/ES63x/ES93x modules.

Not compatible with ES59x, ES6xx, ES11xx. For connecting this modules use CBE130 or CBE140 cable.

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBE431.1-0m14	0.14 m	F 00K 105 676
CBE431.1-0m30	0.30 m	F 00K 105 685

9.2.5 CBEX400.1 Cable

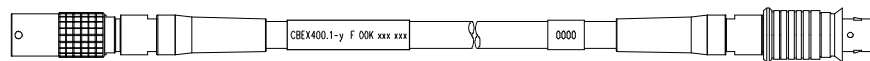


Fig. 9-15 CBEX400.1 Cable

Ethernet extension cable to increase the length of ES4xx/ES63x/ES93x Ethernet cables. Can also be used to connect ES4xx via PC, ES600 or ES1135 alternatively while keeping cable installation through bulkhead.

Robust, waterproof and dust-proof (IP67).

Temperature rated for: -40 °C to +125 °C / -40 °F to +257 °F

Product	Length	Order number
CBEX400.1-3	3 m	F 00K 105 294

9.2.6 ES4xx_BRIDGE

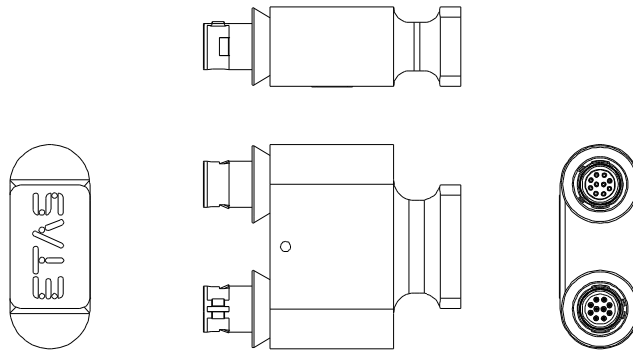


Fig. 9-16 ES4xx Bridge

Ethernet bridge connecting blocked ES400 modules. Facilitates very compact measurement setups. IP67 compliant.

Product	Order number
ES4xx_BRIDGE	F 00K 105 684

9.3 Cable for the Connection "Sensor"

9.3.1 CBAV400.1 Cable

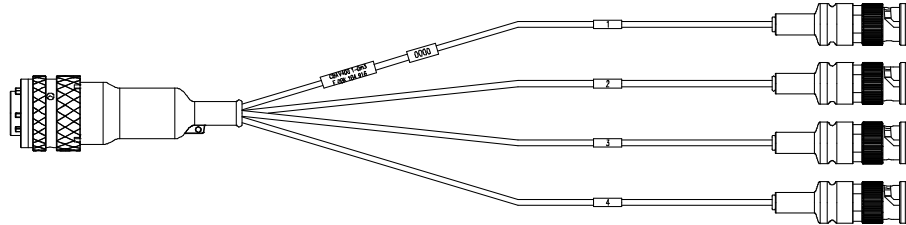


Fig. 9-17 CBAV400.1 Cable

The CBAV400.1 cable consists of four identical cable sections, marked n=1 to n=4. Each cable section [n] is assigned to an ES4xx measurement channel [n] and wired according to the same scheme.

i NOTE

The sensor supply voltage of the module **cannot** be used if the cable CBAV400.1 is used.

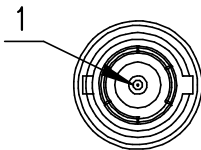


Fig. 9-18 Connection „Sensor“ (one Cable Section)

The assignment of the connections of the BNC connector of a cable section to the signals of a measurement channel [n] is shown in the table.

Pin	Signal	Meaning
1 (inside)	CH[n] In+	Measurement channel [n], input (+)
Outside	CH[n] In-	Measurement channel [n], input (-)

Notes about the Application

If you replaced modules with BNC cabling with ES4xx modules in your measuring setup, the use of these adapter cables enables you to continue using the existing cabling of your measuring setup.

Temperature rated for: -40 °C to +125 °C

Product	Length	Order number
CBAV400.1-0m3	0.3 m	F 00K 104 916

9.3.2 CBAV411.1 Cable

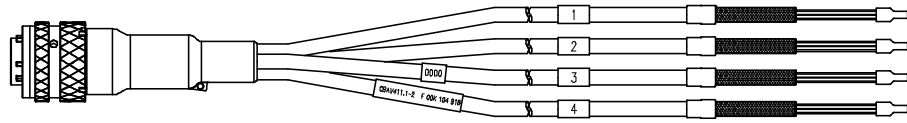


Fig. 9-19 CBAV411.1 Cable

The CBAV411.1 cable consists of four identical cable sections, marked n=1 to n=4. Each cable section [n] is assigned to an ES4xx measurement channel [n] and wired according to the same scheme.

The assignment of the cable connections of a cable section to the signals of a measurement channel [n] is shown in the table.

Signal	Meaning	Color
CH[n] In+	Measurement channel [n], input (+)	Green
CH[n] In-	Measurement channel [n], input (-)	Yellow
CH[n] S+	Measurement channel [n], sensor supply (+)	Brown
CH[n] SGND	Measurement channel [n], sensor supply (GND)	Pink
CH[n] TEDS+	Measurement channel [n], interface TEDS (+) ^{*)}	Gray
CH[n] TEDS-	Measurement channel [n], interface TEDS (-) ^{*)}	White

^{*)} TEDS acc. IEEE1451.4

Notes about the Application

With the universal cable CBAV411.1, sensors or measuring transducers can be connected to the ES4xx module.

You can customize the open connection of sensor cable CBAV411.1 and adapt it to the specific plug connector system of your measuring setup.

Temperature rated for: -40 °C to +125 °C

Product	Length	Order number
CBAV411.1-2	2 m	F 00K 104 918

9.3.3 CBAV417.1 Cable

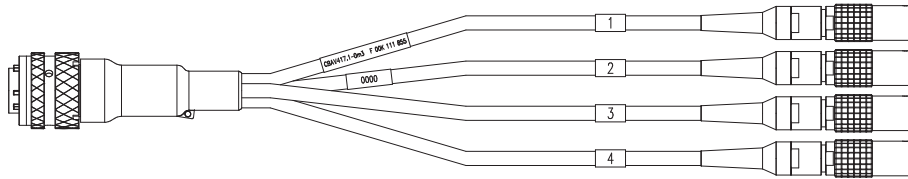


Fig. 9-20 CBAV417.1 Cable

The CBAV417.1 cable consists of four identical cable sections with LEMO plugs, marked n=1 to n=4. Each cable section [n] is assigned to an ES4xx measurement channel [n] and wired according to the same scheme.

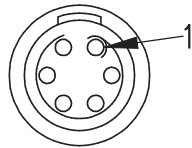


Fig. 9-21 Connection „Sensor“ (one Cable Section)

The assignment of the connections of the LEMO connector of a cable strand to the signals of a measurement channel [n] is represented in the table.

Pin	Signal	Meaning
1	CH[n] In+	Measurement channel [n], input (+)
2	CH[n] In-	Measurement channel [n], input (-)
4	CH[n] S+	Measurement channel [n], sensor supply (+)
5	CH[n] SGND	Measurement channel [n], sensor supply GND *)

*) : connected with operating voltage Ground

Notes about the Application

Temperature rated for: -40 °C bis +125 °C

Product	Length	Order number
CBAV417.1-0m3	0.3 m	F 00K 111 855

9.4 Protective Caps

The connections "IN" and "OUT" of the ES441.1 can be protected with different protective caps according to the operating conditions.

9.4.1 Protective Caps supplied

The "IN" and "OUT" ports of the ES4xx are covered with simple dust and transport caps on delivery. These caps are only suitable for the limited temperature range of -40 °C to +70 °C

i NOTE

The protective caps supplied are in no way a replacement for or viable alternative to the caps CAP_LEMO_1 and CAP_LEMO_1B_LC.

9.4.2 Cap CAP_LEMO_1B

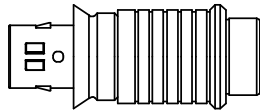


Fig. 9-22 Cap CAP_LEMO_1B

The cap CAP_LEMO_1B protects the connection "IN" or "OUT" against dirt according to IP67.

Product	Order number
CAP_LEMO_1B	F 00K 105 298

9.4.3 Cap CAP_LEMO_1B_LC

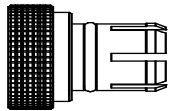


Fig. 9-23 Cap CAP_LEMO_1B_LC

The cap CAP_LEMO_1B_LC protects the connection "IN" or "OUT" in an inexpensive way against dirt.

Product	Order number
CAP_LEMO_1B_LC	F 00K 105 683

9.4.4 Cap CAP_SOURIAU_8STA

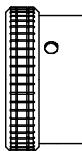


Fig. 9-24 Cap CAP_SOURIAU_8STA

The cap CAP_SOURIAU_8STA protects the "Sensor" port against water and dirt.

Product	Order number
CAP_SOURIAU_8STA	F 00K 105 303

9.5 Angle Brackets

9.5.1 Angle Bracket Left

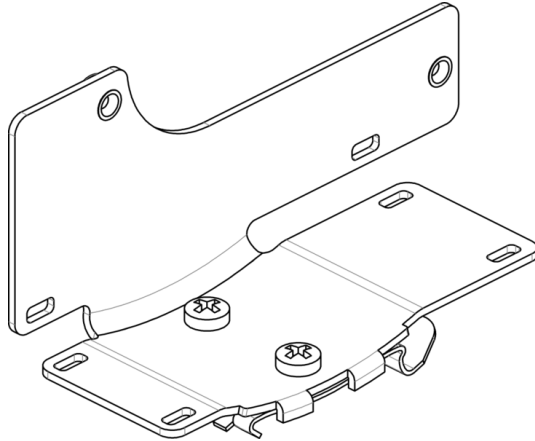


Fig. 9-25 Angle Bracket Left

Angle Bracket for mounting ES4xx modules to a DIN rail 35 x 7.5 (EN 60715 TH35). Stainless steel V2A. For mounting on left side of an ES4xx module.

Product	Order number
Angle bracket left	F 00K 107 175

9.5.2 Angle Bracket Right

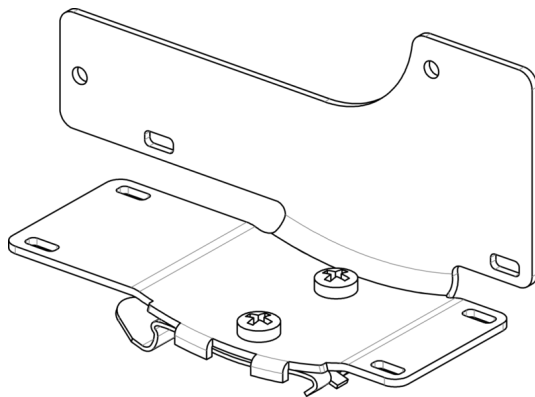


Fig. 9-26 Angle Bracket Right

Angle Bracket for mounting ES4xx modules to a DIN rail 35 x 7.5 (EN 60715 TH35). Stainless steel V2A. For mounting on right side of an ES4xx module.

Product	Order number
Angle bracket right	F 00K 107 176

10 Ordering Information

10.1 ES441.1

Order name	Short name	Order number
ES441.1 Counter and Frequency Module with Sensor Supply (4-CH)	ES441.1	F 00K 105 785

Scope of supply

ES441.1 Counter and Frequency Module with Sensor Supply (4-CH), CDROM ES4xx_DRV_SW_CD (drivers for ES4xx and documentation), List "Content of this Package", ES4xx Safety Advice, China-RoHS-leaflet_Compact_green_cn, Calibration-Certification

NOTE

Cables are not part of the scope of supplies of the module and must be ordered separately (see chapter 10.2.1 on page 120).

10.2 Accessories

10.2.1 Cables

NOTE

If you require customized cables, please contact your ETAS contact partner or sales.de@etas.com.

Cables for the connectors "IN" and "OUT"

Ethernet cable

Order name	Short name	Order number
Ethernet Chain Connection Cable, Lemo 1B FGF - Lemo 1B FGL (8mc-8fc), 3 m	CBE400.2-3	F 00K 104 920
Ethernet Chain Connection Cable, Highly Flexible, Lemo 1B FGF - Lemo 1B FGL (8mc-8fc), 0.5 m	CBE401.1-0m5	F 00K 106 128
Ethernet Chain Connection Cable, Lemo 1B FGA - Lemo 1B FGL (8mc-8fc), 0m45	CBE430.1-0m45	F 00K 104 923

Order name	Short name	Order number
Ethernet Chain Connection Cable, Highly Flexible, Lemo 1B FGA - Lemo 1B FGL (8mc-8fc, 0m14)	CBE431.1-0m14	F 00K 105 676
Ethernet Chain Connection Cable, Highly Flexible, Lemo 1B FGA - Lemo 1B FGL (8mc-8fc, 0m30)	CBE431.1-0m30	F 00K 105 685
Ethernet Extension Cable, Lemo 1B PHL - Lemo 1B FGL (8mc-8fc), 3 m	CBEX400.1-3	F 00K 105 294

Combined Ethernet and power supply cable

Order name	Short name	Order number
Ethernet PC Connection and Power Supply Cable, Lemo 1B FGL - RJ45 - Banana (8fc-8mc-2mc), 3 m	CBEP410.1-3	F 00K 104 927
Ethernet PC Connection and Power Supply Cable, Lemo 1B FGL - RJ45 - Safety Banana (8fc-8mc-2mc), 3 m	CBEP4105.1-3	F 00K 110 026
Ethernet PC Connection and Power Supply Cable, Power Feeder close to PC, Lemo 1B FGL - RJ45 - Banana (8fc-8mc-2mc), 5 m	CBEP415.1-5	F 00K 105 680
Ethernet PC Connection and Power Supply Cable, Power Feeder close to PC, Lemo 1B FGL - RJ45 - Safety Banana (8fc-8mc-2mc), 5 m	CBEP4155.1-5	F 00K 110 027
Ethernet Connection and Power Supply Cable, Lemo 1B FGF - Lemo 1B FGL - Banana (8mc-8fc-2mc), 3 m	CBEP420.1-3	F 00K 105 292
Ethernet Connection and Power Supply Cable, Lemo 1B FGF - Lemo 1B FGL - Safety Banana (8mc-8fc-2mc), 3 m	CBEP4205.1-3	F 00K 110 041
Ethernet Connection and Power Supply Cable, Power Feeder close to Interface Module, Lemo 1B FGF - Lemo 1B FGL - Banana (8mc-8fc-2mc), 3 m	CBEP425.1-3	F 00K 105 972
Ethernet Connection and Power Supply Cable, Power Feeder close to Interface Module, Lemo 1B FGF - Lemo 1B FGL - Safety Banana (8mc-8fc-2mc), 3 m	CBEP4255.1-3	F 00K 110 029
Ethernet Chain Connection and Power Supply Cable, Lemo 1B FGL - Lemo 1B FGA - Banana (8fc-8mc-2mc), 0m5	CBEP430.1-0m5	F 00K 104 928
Ethernet Chain Connection and Power Supply Cable, Lemo 1B FGL - Lemo 1B FGA - Safety Banana (8fc-8mc-2mc), 0m5	CBEP4305.1-0m5	F 00K 110 030

Ethernet Bridge

Order name	Short name	Order number
Bridge to connect two assembled ES4xx Modules	ES4xx_BRIDGE	F 00K 105 684

Cables for the connector "Sensor"

Analog input cables

Order name	Short name	Order number
Analog Input Splitter Cable with BNC Plug, Souriau 8ST12-35 - BNC (22mc-4x2fc), 0m3	CBAV400.1-0m3	F 00K 104 916
Analog Input Splitter Cable, Souriau 8ST12-35 - open wires (22mc-4c), 2 m	CBAV411.1-2	F 00K 104 918
Analog Input Splitter Cable, Souriau 8ST12-35 - Lemo 0B PHG (22mc-4x6fc), 0m3	CBAV412.1-0m3	F 00K 104 919
Analog Input Splitter Cable, Souriau 8ST12-35 - Lemo 1B PHG (22mc-4x6fc), 0m3	CBAV417.1-0m3	F 00K 111 855

10.2.2 Protective caps

Order name	Short name	Order number
Cap to protect open LEMO 1B sockets against dirt	CAP_LEMO_1B	F 00K 105 298
Cap to protect open LEMO 1B sockets against dirt, cost effective	CAP_LEMO_1B_LC	F 00K 105 683
Cap to protect unused Souriau sockets against dirt and water	CAP_SOURIAU_8STA	F 00K 105 303

10.2.3 Angle brackets

Order name	Short name	Order number
ES4xx Angle Bracket left	ES4xx_AB_L	F 00K 107 175
ES4xx Angle Bracket right	ES4xx_AB_R	F 00K 107 176

10.2.4 Calibration

NOTICE

ETAS recommends a calibration interval of 12 months.

10.2.4.1 Factory calibration

Factory calibration service

- Verification of measurement accuracy
- Issue a standard-compliant calibration certificate

Order name	Short name	Order number
Calibration service for ES441	C_ES441	F-00K-112-738

Adjustment service

- Verification of measurement accuracy
- Adjustment of the measuring accuracy to the smallest possible deviation
- Issue standard-compliant calibration certificates for "pre-adjustment" and "post-adjustment"

Order name	Short name	Order number
Adjustment service for ES441	A_ES441	F-00K-105-802

10.2.4.2 Accredited calibration

Accredited calibration service according to ISO/IEC 17025

- Verification of measurement accuracy by accredited calibration laboratory¹
- Issue an internationally recognized ISO/IEC 17025 calibration certificate.²

Order name	Short name	Order number
DAkkS calibration service for ES441	DAkkS_C_ES441	F-00K-112-781

Accredited adjustment service according to ISO/IEC 17025

- Verification of measurement accuracy by accredited calibration laboratory¹
- Adjustment of the measuring accuracy to the smallest possible deviation
- Issue of internationally recognized, ISO/IEC 17025 compliant calibration certificates for "pre-adjustment" and "post-adjustment"²

Order name	Short name	Order number
DAkkS adjustment service for ES441	DAkkS_A_ES441	F-00K-111-778

1. Accreditation by Deutsche Akkreditierungsstelle (DAkkS)
2. Supervision of the calibration certificate by DAkkS

11 Contact Information

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ETAS technical support Internet: www.etas.com/en/hotlines.php

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