ES5340.2 Internal Combustion Engine Application

User's Guide

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Contents

1 Introduction

This chapter contains information on the following topics:

1.1 Features

The ES5340.2 Internal Combustion Engine Application (short: ES5340.2-ICE) is used to sample, evaluate and generate angle-synchronous ECU signals in two- and four-stroke combustion engines and has the following features:

1.1.1 Analog and Digital Inputs and Outputs

- Four analog inputs
- Eight analog outputs
- Eight digital or PWM outputs

1.1.2 Measuring Signals

There are 20 digital inputs available for measuring signals. The signals can be measured with a number of time-based (cycle time, frequency, duty cycle, high time etc.) and angle-based measurement modes.

1.1.3 Generation of Arbitrary Signals

There are eight freely programmable arbitrary signal generators for generating arbitrary signals. These can be synchronized by the central angle clock generator or by one local clock generator (per signal generator) (0 - 1 MHz).

- There are 16 signal banks available for all signal generators. During run-time, it is possible to switch between them in real time.
- Eight D/A converters with 16 bit resolution and an output voltage range of -10 V to +10 V
- The accuracy of the output voltage is ±5 mV (with an internal reference).
- Every signal generator has an internal or external voltage reference
- Output modes:
  - analog, galvanically isolated
  - digital (open collector/pull-up, 10 mA), galvanically isolated

  The output mode can be changed using the software.
- Every output channel has its own galvanic isolation

- Every output channel can be powered off using the software
- Simulation of knock sensors and misfiring possible
- Knock generator with four independent outputs
- Short-circuit-proof and protected against overvoltage up to ±60 V

The following figure shows the front panel of the ES5340.2 Internal Combustion Engine Application with the various connections.

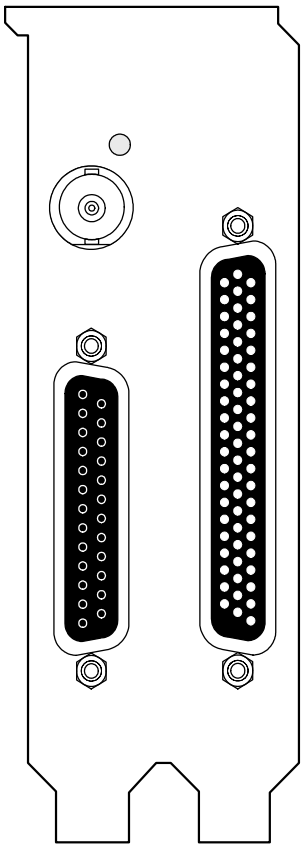


Fig. 1-1 Front Panel of the ES5340.2 Internal Combustion Engine Application

The function and assignment of the connectors are described in the chapter "Connector Assignment and Display Elements" on page 43.

1.2 Basic Safety Instructions

Please adhere to the safety instructions in this manual to avoid injury to yourself and others as well as damage to the device.

1.2.1 Labeling of Safety Instructions

The safety instructions contained in this manual are shown with the standard danger symbol shown below:

The following safety instructions are used. They provide extremely important information. Please read this information carefully.

CAUTION!

indicates a low-risk danger which could result in minor or less serious injury or damage if not avoided.

WARNING!

indicates a possible medium-risk danger which could lead to serious or even fatal injuries if not avoided.

DANGER!

indicates a high-risk, immediate danger which could lead to serious or even fatal injuries if not avoided.

1.2.2 General Safety Information

Please read the product safety advice ("ETAS Safety Advice") as well as the following safety instructions to avoid injury to yourself and others as well as damage to the device.

Note

Please read the documentation accompanying the product (this User's Guide) carefully before using the product.

ETAS GmbH cannot be made liable for damage which is caused by incorrect use and handling and not adhering to the safety instructions.

1.2.3 Requirements for Users and Duties for Operators

The product may be assembled, operated and maintained only if you have the necessary qualifications and experience for this product. Improper use or use by a user without sufficient qualifications can put life at risk or cause damage to health or property.
The system integrator is responsible for the safety of systems that use the product.

General Safety at Work

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

1.2.4 Intended Use

Field of Application of the Product

The product is a PCI-Express plug-in board for the RTPC main board in the ES5300.1-A Housing or for an RTPC by ETAS (TP_RTPC_2/3U.x). The product must be used solely in the ES5300.1-A Housing or RTPC intended for this purpose.

The intended use of the product is as follows:

- Use as a component in industrial lab facilities or at industrial workplaces
- Use as a hardware interface for ECUs in a hardware-in-the-loop test system
- Use in conjunction with ETAS software that supports the ES5300.1-A Housing and the ES5300.1-B Housing
- Use as an interface in conjunction with software programs that operate the standardized, documented and open APIs from ETAS software products

The product is **not** intended for the following:

- Use within a vehicle on the road
- Use as part of a life support system
- Use as part of a medical application
- Applications in which misuse may result in injury or damage
- Use in environments in which conditions prevail that fall outside the specified ranges (see "Ambient Conditions" on page 51)
- Use with signal conditioning that falls outside the specified ranges (see voltages, currents and power consumption in the section "Technical Data and Standards" on page 49)

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 must only be operated in a technically flawless state, in accordance with its intended purpose and in a safety-conscious and hazard-aware manner under consideration of the documentation regarding the product. If the product is not used in accordance with its intended purpose, its product safety may be impaired.

Requirements for Operation

- Use the product only according to the specifications in the corresponding user manual. If the product is used in any other way, product safety is no longer ensured.
- Do not use the product in a wet or damp environment.
- 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!

WARNING!

Fire hazard!
Only use fuses that comply with the specification in the User's Guide for the product. Never bridge defective fuses!
Failure to observe the fuse specification can lead to excess currents, short circuits and fires.

Power Supply

The product is powered by the ES5300.1-A Housing or the ES5300.1-B Housing via the PCIe slot on the main board of the RTPC.

Insulation Requirements for Lab Power Supplies to Circuits Connected to the HIL System:

- The power supply to live circuitry must be safely isolated from the supply voltage. For example, use a car battery or a suitable lab power supply.
- Only use lab power supplies with dual protection for the supply network (with double/reinforced insulation (DI/RI)). This requirement is met by lab power supplies that comply with IEC/EN 60950 or IEC/EN 61010.
- The lab power supply must be approved for use at a height of 2000 m and in ambient temperatures of up to 40 °C.

De-Energizing a Plug-In Board

Switch off the ES5300.1-A Housing or the ES5300.1-B Housing and external power supplies, and unplug the power cable and other plug connectors attached to the plug-in board. Wait at least three minutes before removing the plug-in board.

Approved Cables

The signal lines must not exceed a maximum length of 3 m.

WARNING!

Fire hazard!
Use only approved cables for creating cable assemblies (e.g. for connecting the ECU and external loads). The cables used must, in particular, be suitable for the currents, voltages and temperatures which occur and must be flameretardant in accordance with one of the following standards IEC 60332-1-2, IEC 60332-2-2, UL 2556/ UL1581VW-1!

Requirements for the Installation Location

WARNING!

This is class A equipment. This equipment can cause radio interference in residential areas. Should that be the case, the operator may be requested to institute reasonable measures.

Requirements for Ventilation

CAUTION!

The air circulation inside the ES5300.1-A Housing and the ES5300.1-B Housing can only be maintained if all free slots are covered with front plates. Otherwise, it may lead to overtemperatures and trip the overtemperature protection of the ES5300.1-A or the ES5300.1-B. For this reason, install front plates in all free slots!

Transport and Installation

CAUTION!

Some components of the product can be damaged or destroyed by electrostatic discharges. Leave the plug-in board in its transport packaging until it is installed.
Only remove, configure and install the product at a workplace that is protected against electrostatic discharges.

CAUTION!

In order to prevent damage to the plug-in boards and the LABCAR Housing, and thereby also avoid damage to property or health, observe the installation instructions and information contained in the relevant User's Guides.

Connecting/Disconnecting Devices

To avoid injuries and hardware damages, please observe the following precautionary measures:

- Do not apply any voltages to the connections of the product that do not correspond to the specifications of the respective connection.
- Do not connect or disconnect any devices while the ES5300.1-A Housing, the ES5300.1-B Housing or connected devices are switched on. First, switch off the ES5300.1-A Housing and the ES5300.1-B Housing by shutting down the real-time PC and by pressing the On/Off switch at the rear, then unplug the power cable.
- When plugging in connectors, ensure that they are inserted straight and no pins are bent.

Maintenance

The product does not require maintenance.

Repairs

If an ETAS hardware product needs to be repaired, return the product to ETAS.

Cleaning

The product is not expected to require cleaning.

1.3 Identifications on the Product

The following symbols are used for identifying the product:

Symbol	Description
	The User's Guide must be read prior to the startup of the product
	Identification for CE conformity (see "CE Marking" on page 12)
	Marking for KCC conformity (see "KC Mark" on page 12)
	Identification for China RoHS (see "RoHS Conformity" on page 12)
	Identification for WEEE directive (see "Taking the Product Back and Recycling" on page 14)

Observe the information in the chapter "Technical Data and Standards" on page 49.

1.3.1 CE Marking

ETAS confirms that the product meets the product-specific applicable European Directives with the CE marking affixed to the product or its packaging. The CE Declaration of Conformity for the product is available upon request.

1.3.2 KC Mark

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.

1.3.3 RoHS Conformity

European Union

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

ETAS confirms that the product corresponds to this directive which is applicable in the European Union.

China

ETAS confirms that the product meets the product-specific applicable guidelines of the China RoHS (Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation) applicable in China with the China RoHS marking affixed to the product or its packaging.

1.4 Taking the Product Back and Recycling

The European Union has passed a directive called Waste Electrical and Electronic Equipment, or WEEE for short, to ensure that systems are set up throughout the EU for the collection, treatment and recycling of electronic waste.

This ensures that the devices are recycled in a resource-saving way representing no danger to health or the environment.

Fig. 1-2 WEEE Symbol

The WEEE symbol on the product or its packaging shows that the product must not be disposed of as residual garbage.

The user is obliged to collect the old devices separately and return them to the WEEE take-back system for recycling.

The WEEE Directive concerns all ETAS devices but not external cables or batteries.

For more information on the ETAS GmbH Recycling Program, contact the ETAS sales and service locations (see "ETAS Contact Addresses" on page 55).

1.5 Materials Subject to Declaration

Some products from ETAS GmbH (e.g. modules, boards, cables) use components with materials that are subject to declaration in accordance with the REACH regulation (EC) 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.

1.6 About This Manual

This manual consists of the following chapters:

- "Introduction" on page 5

  This chapter
- "Installation and Configuration" on page 17

  This chapter contains information on how to install and configure the ES5340.2 Internal Combustion Engine Application.
- "Hardware Description" on page 21

  This chapter provides a description of the inputs and outputs of the ES5340.2 Internal Combustion Engine Application along with the signals that it can measure and those that can be generated for it.
- "Connector Assignment and Display Elements" on page 43

  This chapter contains the description of the connectors and display elements of the ES5340.2 Internal Combustion Engine Application.
- "Technical Data and Standards" on page 49

  This chapter contains the technical data on the ES5340.2 Internal Combustion Engine Application.
- "Ordering Data and Scope of Delivery" on page 53

1.6.1 Using This Manual

Representation of Information

All activities to be carried out by the user are shown in what we call a "Use-Case" format, i.e. the target to be achieved is defined briefly in the title and the individual steps necessary to achieve this target are then listed. The information is displayed as follows:

Target definition

Any introductory information...

1. Step 1

   Possibly an explanation of step 1...
2. Step 2

   Possibly an explanation of step 2...

Any concluding remarks...

Concrete example:

To create a new file

If you want to create a new file, no other file may be open.

1. Select **File** → **New**.

   The "Create file" dialog box appears.
2. Enter a name for the file in the "File name" field.

   The file name must not exceed 8 characters.
3. Click **OK**.

The new file is created and saved under the name specified. You can now work with the file.

Typographic Conventions

The following typographic conventions are used:

Select **File** → **Open**.	Menu commands are shown in boldface/ blue.
Click **OK**.	Buttons are shown in boldface/blue.
Press <ENTER>.	Keyboard commands are shown in angled brackets in block capitals.
The "Open File" dialog box appears.	Names of program windows, dialog boxes, fields etc. are shown in quotation marks.
Select the file `setup.exe`.	Text in drop-down lists, program code, as well as path and file names are shown in the `Courier` font.
A conversion between the file types logical and arithmetic is *not* possible.	Content markings and newly introduced terms are shown in *italics*.

Important notes for the user are shown as follows:

Note

Important note for the user.

2 Installation and Configuration

This chapter contains information on how to install and configure the ES5340.2 Internal Combustion Engine Application.

2.1 Installing the ES5340.2-ICE in the Real-Time PC

If you are setting up your real-time PC yourself or installing the PCI Express board in an existing real-time PC at a later date, make sure you carefully follow the tips and instructions contained in this chapter.

2.1.1 Requirements and Specifications

Released PCs and Known Installations

A list of PCs tested and released by ETAS as well as known installations (`ETAS RTPC Vx.y.z HW Compatibility List.pdf`) can be found in the web interface of LABCAR-RTPC at **Main Page** → **Documentation**.

Note

Because the booting time of the ES5340.2-ICE is more than 800 µs, PCs not released by ETAS may not detect the board!

When using the ES5340.2-ICE, the hardware of the real-time PC should fulfill the following requirements - in addition to the hardware specifications described in the "LABCAR-RTPC User's Guide":

Southbridge Chip	ICH 2, 4, 5, 6, 7, 8, 9 e.g. Intel chipsets 915, 925, 945, 955, 965, 975, E7230 and X38, X48, X58
PCIe slots	Min. 1 (x4 or more)

Tab. 2-1 Additional Requirements for the Real-Time PC

Note

To guarantee the necessary performance when using several PCI Express boards, the power supply should have a minimum performance of 400 W!

2.1.2 Installation

Please observe the following when installing an ES5340.2 Internal Combustion Engine Application:

- Before installation, power off your real-time PC and disconnect it from the mains.
- Please take the following precautionary measures to avoid hardware being damaged by static discharge:

CAUTION!

Some components of the ES5340.2-ICE may be damaged or even destroyed by static discharge. Leave the board in its transport package until you want to install it.
The ES5340.2-ICE should only be taken from its package, configured and installed at a working place that is protected against static discharge.

- Follow the instructions of the PC manufacturer on how to install expansion boards.

2.2 Installing the ES5340.2-ICE in the ES5300.1-A Housing

To install an ES5340.2-ICE in the ES5300.1-A Housing it must first be mounted on a PCI Express carrier board (ES5370.1 Carrier Board PCI Express x16 socket, GEN1/2 x1 Link) intended for this purpose which is then inserted into the ES5300.1-A.

For a detailed description, refer to the User's Guide on the ES5300.1-A Housing.

2.3 RPM Master/Slave Configuration

The RPM unit on the ES5340.2-ICE can be operated as a master or slave.

Note

The following only applies to boards in PCI Express slots!

2.3.1 Connecting the RPM Buses of Two Boards

There are two connectors on each board for connecting the RPM signal. These are connected with an appropriate cable.

Installation

- When installing a further board or connecting two existing boards for a master/slave configuration, first power off your real-time PC.
- Observe the points described in "Installation" on page 18.
- Connect the neighboring connectors of two boards (connectors A in Fig. 2-1) with one of the ribbon cables provided.

- Terminate the opposing connections (connectors B in Fig. 2-1) with the terminating connectors provided.

  An individual board must be terminated with one terminating connector.

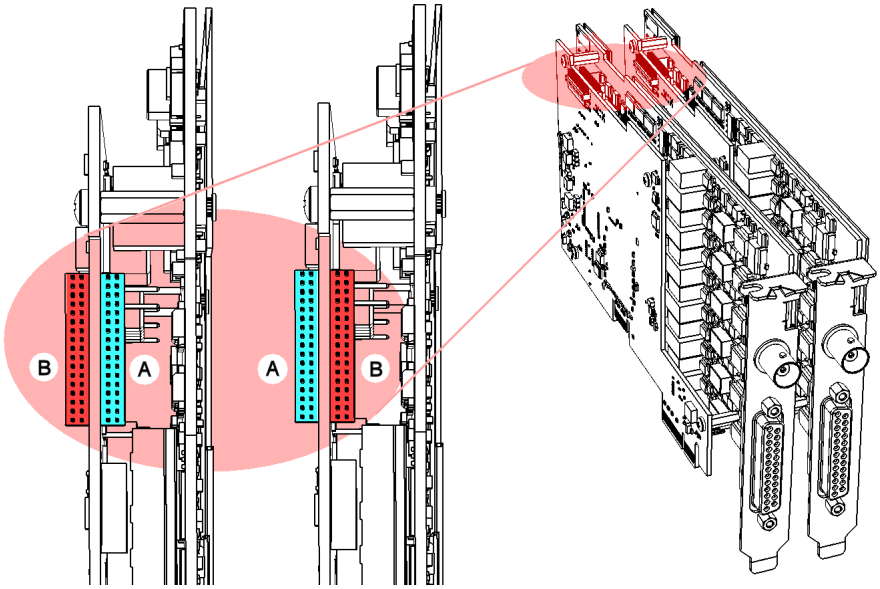


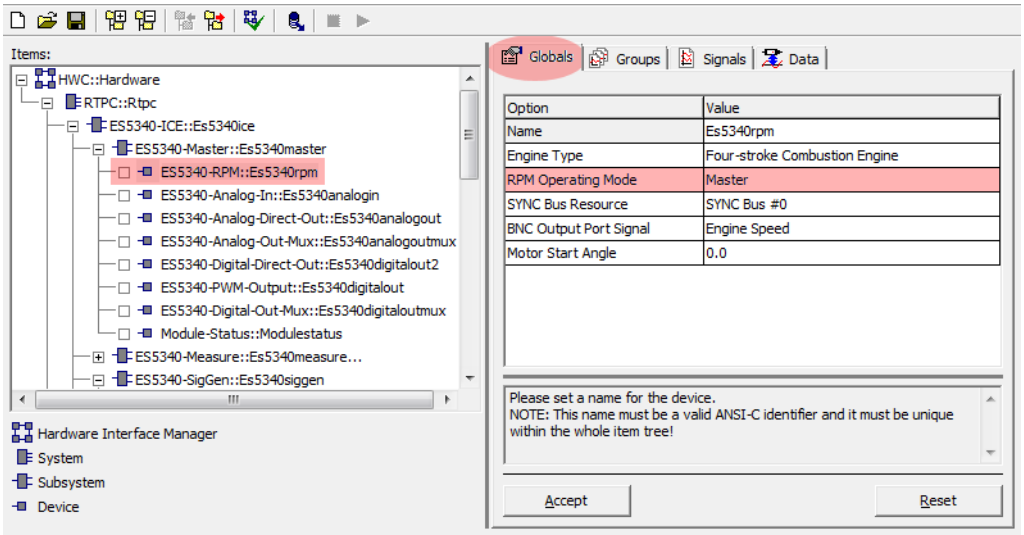
Fig. 2-1 Connecting the RPM Buses of Two Boards

Note

Before carefully pushing the connectors into the sockets, make sure that the pins are lined up correctly with the socket!

2.3.2 Configuration of the RPM Unit (in LABCAR-RTC)

The allocation of whether an RPM unit is to act as a master or slave is defined in the "ES5340-RPM" item. In the "Globals" tab, you can set the "RPM Operating Mode" option accordingly.



3 Hardware Description

This chapter provides a description of the inputs and outputs of the ES5340.2 Internal Combustion Engine Application along with the signals that it can measure and those that can be generated for it.

Specifically, it includes information about the following topics:

- **"Generating Analog Signals" on page 22**

  The ES5340.2 Internal Combustion Engine Application has eight analog outputs. These outputs are used for different analog signals via an output multiplexer.

  – "Specification" on page 22
  – "Configuring the Analog Signals" on page 23

- **"Output Multiplexers for the Analog Signals" on page 24**

  Each analog output has a multiplexer that can be used to define the signal for this output.

- **"Generating Digital Signals" on page 25**

  The ES5340.2 Internal Combustion Engine Application has eight digital outputs. These outputs are used for different digital signals via an output multiplexer.

  – "Specification" on page 25
  – "Configuring the Digital Signals" on page 27

- **"Output Multiplexers for the Digital Signals" on page 28**

  Each digital output has a multiplexer that can be used to define the signal for this output.

- **"Analog Inputs" on page 29**

  The ES5340.2 Internal Combustion Engine Application has four inputs for measuring analog signals.

  – "Specification" on page 29
  – "Configuring the Analog Inputs" on page 29

- **"Digital Inputs" on page 30**

  The ES5340.2 Internal Combustion Engine Application has 20 inputs for measuring digital signals.

  – "Specification" on page 30
  – "Threshold Comparison" on page 30
  – "Configuring the Digital Inputs" on page 31
  – "Measurement Modes" on page 35
  – "Rail Pressure Measurements" on page 36

- **"Arbitrary Signal Generators" on page 37**
  – "RPM Generator" on page 38
  – "Waveform Pool for Signal Generators" on page 38
  – "Knock Signal Generator" on page 39
  – "Misfire Control" on page 39

– "Sequence Tables" on page 40
– "MSA Sensor" on page 40

- **"RPM Generator" on page 40**

  The ES5340.2 Internal Combustion Engine Application has a central RPM generator that outputs a speed-specific clock signal.

  – "Angle Clock Signal" on page 41
  – "Synchronization" on page 41
  – "Configuring the RPM Unit in LABCAR-RTC" on page 42

3.1 Generating Analog Signals

The ES5340.2 Internal Combustion Engine Application has eight analog outputs. These outputs are used for different analog signals via an output multiplexer.

3.1.1 Specification

The **output voltage range** is -10 V to +10 V for internal reference or -12 V to +12 V for external reference voltage – the **resolution** of the D/A converter is 16 bits.

All outputs are **galvanically isolated** and have an **electric strength** of ±60 V. In addition, each output has a cutoff relay.

The **accuracy** (internal reference) is ±5 mV, while the **maximum current** of an output is ±30 mA.

The following illustration shows the schematic circuit diagram of an output.

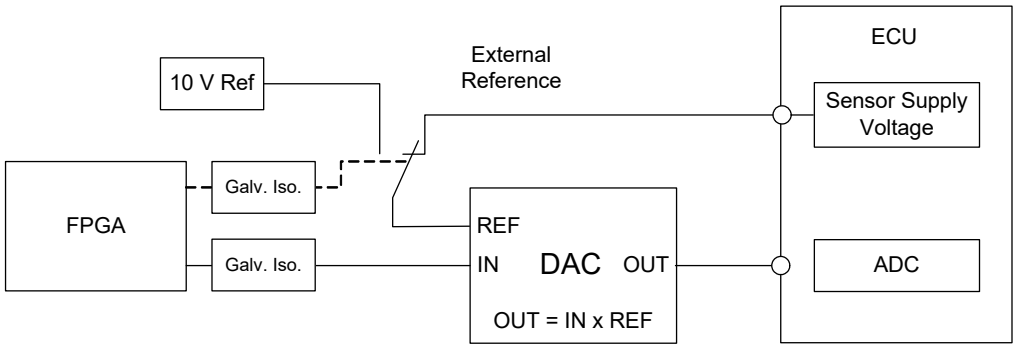
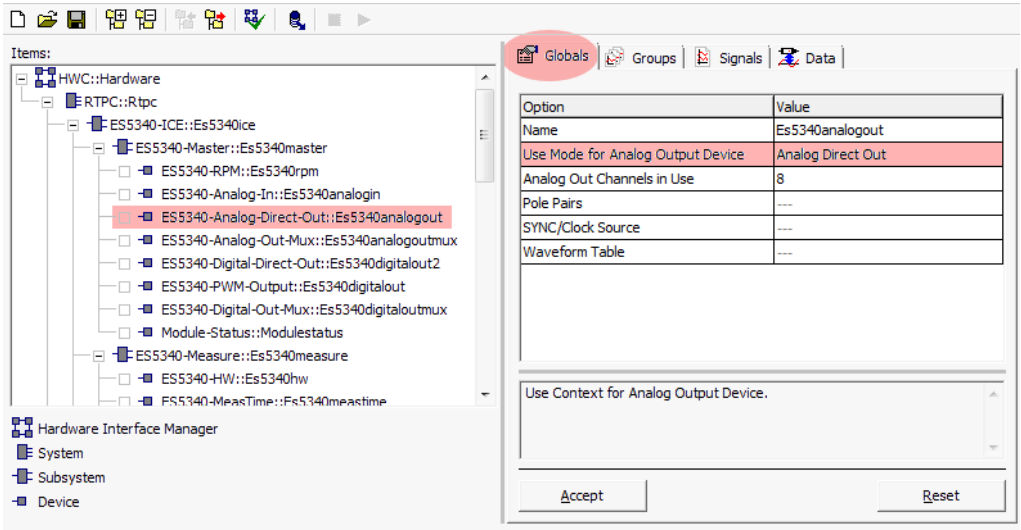


Fig. 3-1 Schematic Circuit Diagram of the Analog Outputs

For each of the eight channels CH0 to CH7, you can choose between the internal (10 V) and the external source for the reference voltage (in LABCAR-RTC: "ES5340-Analog-Out-Mux" device, "Signals" tab, "Reference Voltage" column).

3.1.2 Configuring the Analog Signals

Which signals are assigned to the eight outputs is defined in the output multiplexer (see **"Output Multiplexers for the Analog Signals" on page 24**).



You can configure the analog channels themselves as follows.

Analog Direct Out

This can be used to output constant voltages and values calculated in the computation grid of a model – specified by the value of "OutValue_*n*" [-1.0 to +1.0]:

$$U_{out} = OutValue\_n * U_{Ref}$$

3.2 Output Multiplexers for the Analog Signals

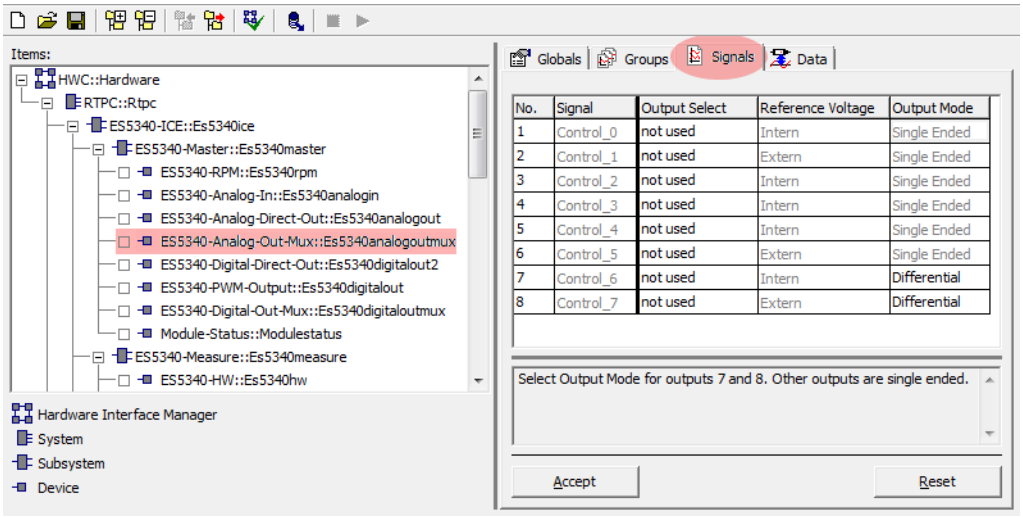
Each analog output has a multiplexer that can be used to define the signal for this output.

Sources for the Analog Outputs

The analog output channels can be driven by different sources:

- Signals from ES5340-Analog-Direct-Out
- Signals from ES5340-Analog (arbitrary signal generators)
- Signals from ES5340-Knock (knock generators)

The sources are configured in LABCAR-RTC with the "ES5340-Analog-Out-Mux" item, "Signals" tab in the "Output Select" column.



In the case of an ES5340.2 Internal Combustion Engine Application, eight signals can be configured for the outputs here.

3.3 Generating Digital Signals

The ES5340.2 Internal Combustion Engine Application has eight digital outputs. These outputs are used for different digital signals via an output multiplexer.

3.3.1 Specification

The **output voltage** is 0 to 60 V (open collector) or 5 V (internal pull-up).

All outputs are **galvanically isolated** and have an **electric strength** of ±60 V – in addition, each output has a cutoff relay.

The **maximum current** of an output is ±15 mA. The **rise time** (0 V → 5 V) is 2 µs, while the **fall time** (5 V → 0 V) is 2 µs.

Signal Generation

The configuration of the digital outputs can be done in the RTIO editor by the item „ES5340-Digital-Out-Mux“ (see **"Output Multiplexers for the Digital Signals" on page 28**).

A schematic diagram for a digital output is shown in Fig. 3-2 on page 26.

S1 is a slow switch to select the "Output Mode".

S3 is a slow switch to cut off the signal.

S2 is a fast low-side switch to generate the output signal "Digital Output i" in real-time. In doing so, S3 is closed.

Generation of a digital output signal "Digital Output i":

- The signal that is set in the "Signals" tab through "Output Select" determines the cycle time for S2.
- The pull-up resistor determines the voltage level of the signal. In the column "Output Mode" in the "Signals" tab, you can choose between an internal pull-up resistor ("Pull-Up to +5 V") and an external pull-up resistor ("Open Collector"), see Fig. 3-2.
- By closing S2, the low-phase of the signal is generated. By opening S2, the high-phase is generated.

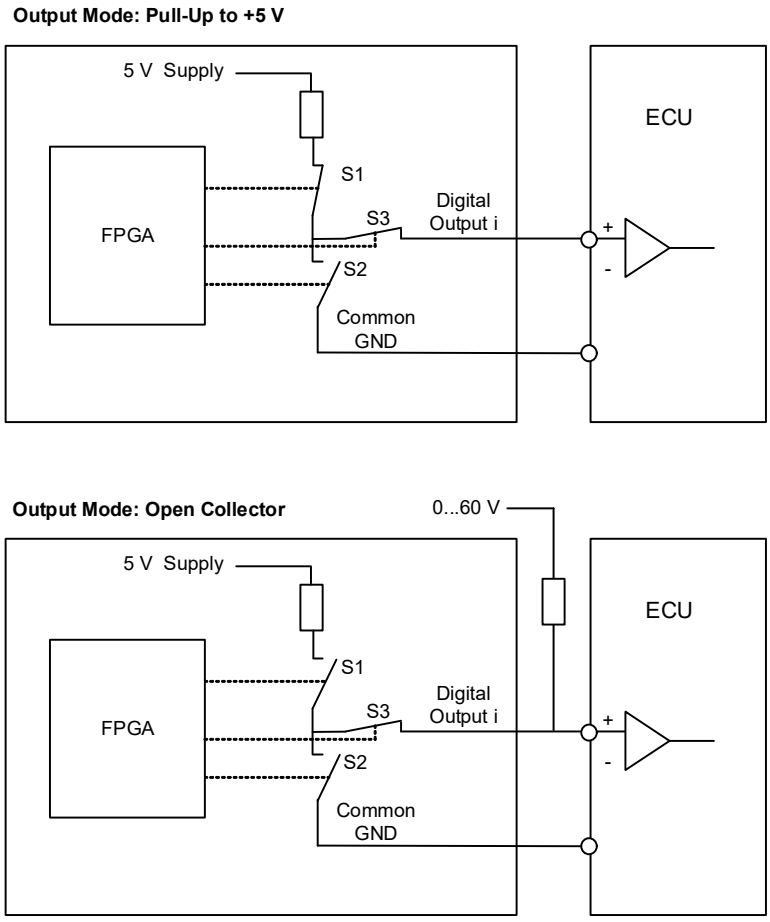


Fig. 3-2 Schematic Circuit Diagram of a Digital Output

3.3.2 Configuring the Digital Signals

Which signals are assigned to the eight outputs is defined in the output multiplexer (see **"Output Multiplexers for the Digital Signals" on page 28**).

You can configure the digital channels themselves as follows.

Digital Direct Out

These outputs enable you to directly stimulate digital ECU inputs.

PWM Output

Here frequencies between 0 Hz and 100 kHz and duty cycles between 0.0 and 1.0 can be selected.

SENT Signals

The generation of signals according to the SENT specification SAE J2716 is possible on four output channels.

3.4 Output Multiplexers for the Digital Signals

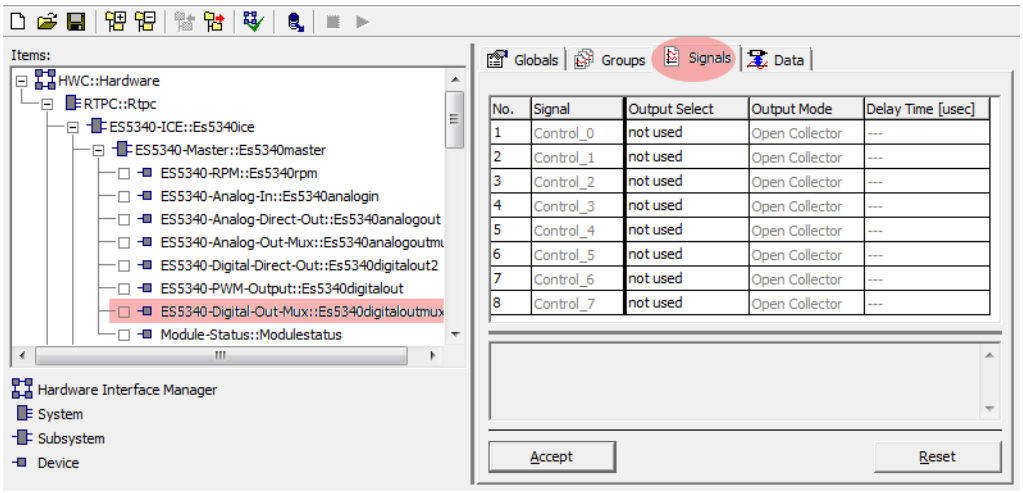
Each digital output has a multiplexer that can be used to define the signal for this output.

Sources for the Digital Outputs

The digital output channels can be driven by different sources:

- Output values of all Digital-Out RTIO elements (ES5340-Digital-Direct-Out and ES5340-PWM-Output)
- Digital signals of the arbitrary signal generators (ES5340-SigGen)
- SENT signals (ES5340-Out-SENT-V3)
- MSA Sensor signal

The sources are configured in LABCAR-RTC with the "ES5340-Digital-Out-Mux" item, "Signals" tab in the "Output Select" column.



The output mode can be set to "Open Collector" or "Pull-Up to +5V".

3.5 Analog Inputs

The ES5340.2 Internal Combustion Engine Application has four inputs for measuring analog signals.

3.5.1 Specification

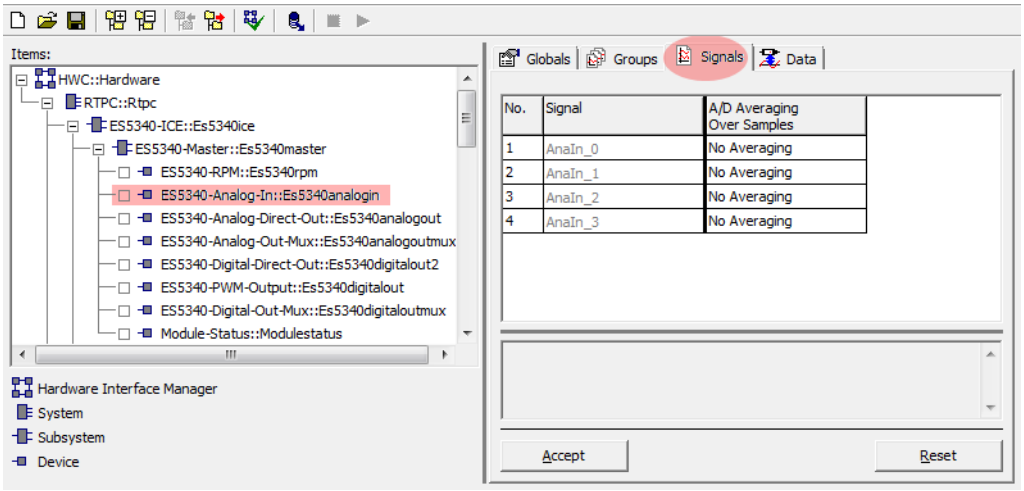
The **input voltage range** for two inputs is 0 to 5 V, with two additional inputs, it is 0 V to +40 V. All inputs are **galvanically isolated** and have an **electric strength** of ±60 V – the **impedance** of the inputs is 1 MΩ.

The **sampling rate** is 500 kSamples/s (software averaging is possible using 2^n (n =1 to 8) samples) at a **resolution** of 12 bits.

3.5.2 Configuring the Analog Inputs

The analog inputs can be used to measure battery voltages and other constant voltages (control signals).

The type of averaging used for the detected signals can be configured in LABCAR-RTC in the "ES5340-Analog-In" item of the "Signals" tab.



3.6 Digital Inputs

The ES5340.2 Internal Combustion Engine Application has 20 inputs for measuring digital signals.

3.6.1 Specification

The **input voltage range** is 0 to +60 V. All inputs are **galvanically isolated** and have an **electric strength** of ±60 V.

The maximum **input frequency** is 125 kHz, and the **resolution** is 8 ns (125 MHz).

Each input has two independently **programmable thresholds** for determining the status of the input ("High" or "Low"). The setting range for these threshold values is 0 V to +10 V.

The following illustration shows the schematic circuit diagram of a digital input.

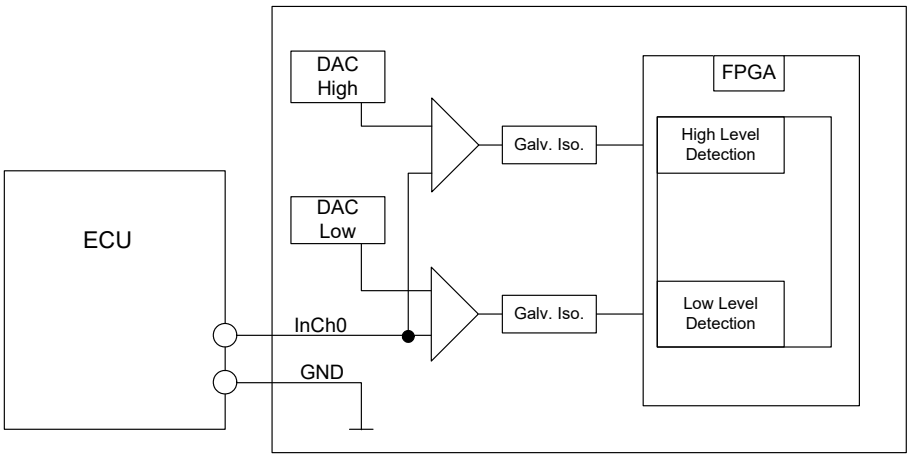


Fig. 3-3 Schematic Circuit Diagram of a Digital Input

3.6.2 Threshold Comparison

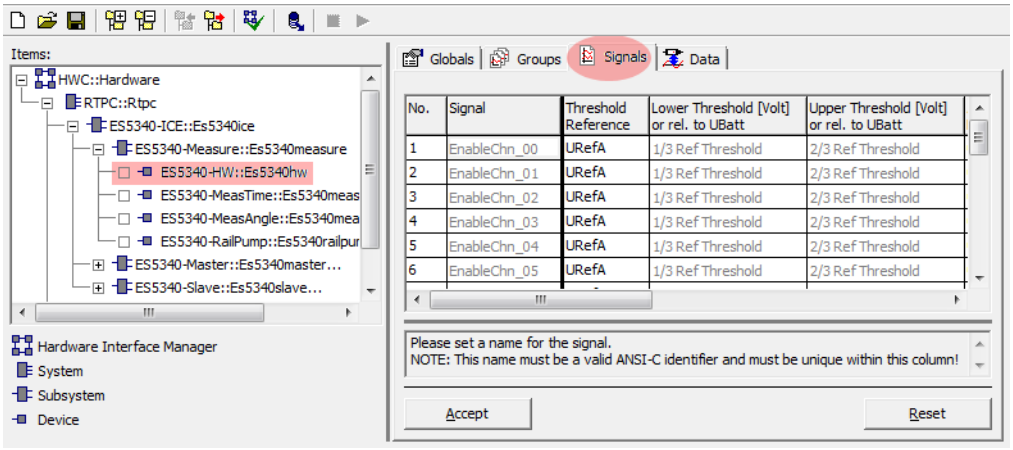
Each of the 20 input signals of the ES5340.2-ICE is compared to two threshold values in the FPGA. This comparison leads to a conversion of the analog input signal to digital 0/1 information.

The thresholds can be configured by software – the following three possibilities are available:

- Comparison to 1/3 UBatt_X and 2/3 UBatt_X (X = A...E)
- Comparison to the four analog inputs AnaIn_0...3
- Comparison to any two thresholds which can be configured by software (RTIO).

3.6.3 Configuring the Digital Inputs

The reference voltages and the angle windows are configured in the "ES5340-HW" item in the RTIO.



The measurement modes are defined in the items "ES5340-MeasTime" and "ES5340-MeasAngle".

3.6.4 Configuration with ES5436.1 to Measure ECU Digital Output Signals

Digital outputs of ECUs are often configured as open emitter or open collector. In a vehicle, such outputs are connected to small loads.

To measure such digital output signals of an ECU in an HiL setup, the ES5436.1 can be used as load simulation and the ES5340 for measurement.

A schematic diagram for the ECU, the ES5340 and the ES5436.1 is shown in Fig. 3-4 on page 33.

The ES5436.1 has 48 current channels for currents in the range of 5 mA to 150 mA. These current channels can be combined with the 20 digital inputs of the ES5340.

CAUTION!

Before connecting the ES5436.1, read the ES5436.1 User's Guide.

Technical Data of the ES5436.1 Power Sources

Output	Data
Output current	5 mA to 150 mA
Output voltage	Passive circuit
Accuracy	+/- 3 mA at 150 mA
Galvanic isolation	max. 60 V to ground potential (functional separation)
Overvoltage protection	60 V abs. max.

Tab. 3-1 Technical data of the power sources

Note

In the idle state (non activated load channel, operation mode "disabled") the power source's idle state current is ~70 µA.

Note

If the external voltage +VBAT < 6 V the power source doesn't carry any current.

When connecting the ES5436.1, observe the following note:

Note

The ES5436.1 use cases "Pull-Up", "Pull-Down" and "Bipolar" ("Bipolar" for H-bridge configuration, see "Configuration as H-Bridge" on page 34) can be configured by software.
For this reason, make sure that +VBAT and -VBAT are always connected.

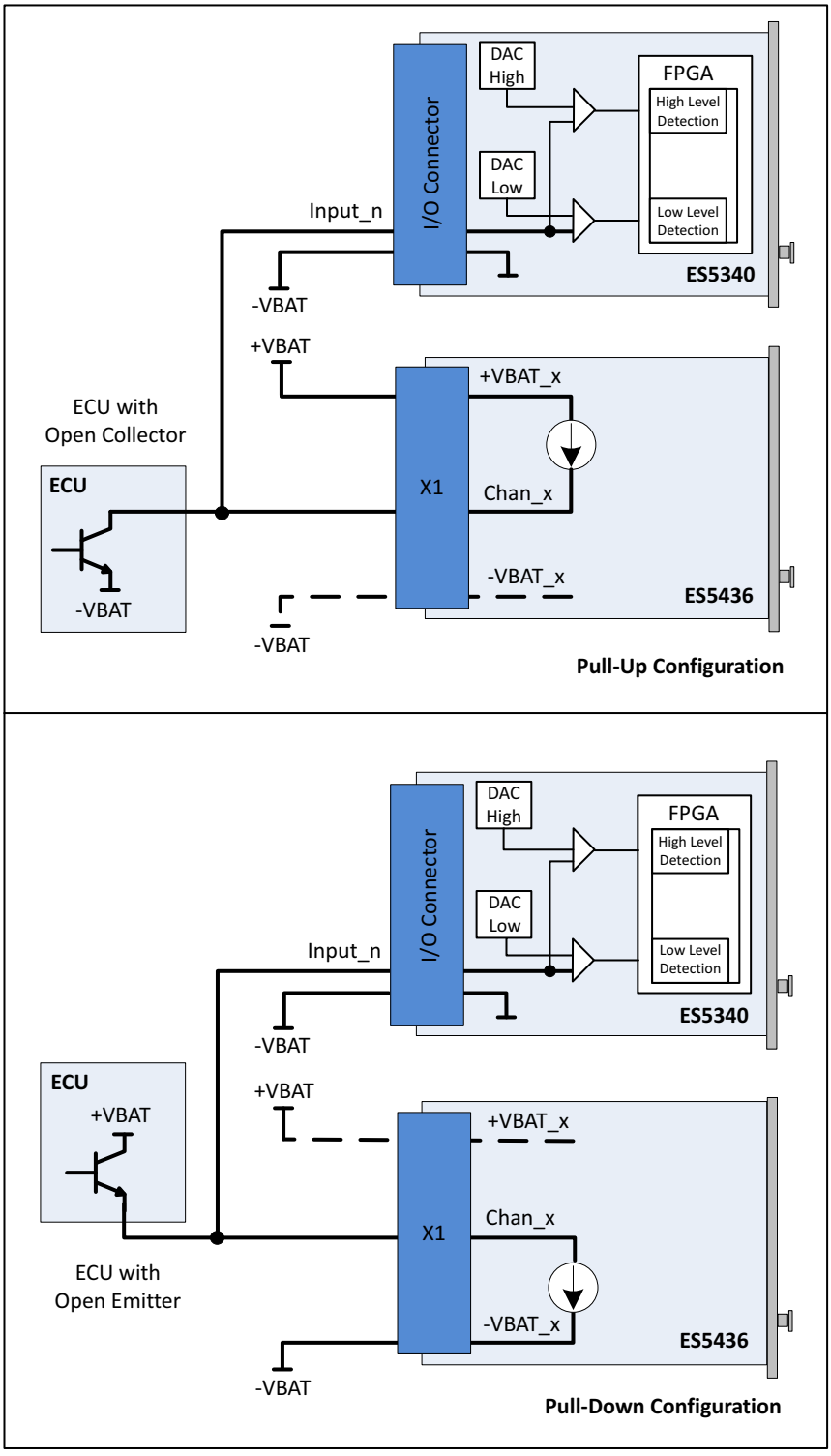


Fig. 3-4 Measurement of digital ECU output signals in the configuration "Pull-Up" or "Pull-Down" using ES5340 for measurement and ES5436.1 as load simulation

3.6.5 Configuration as H-Bridge

Fig. 3-5 shows the configuration as H-bridge.

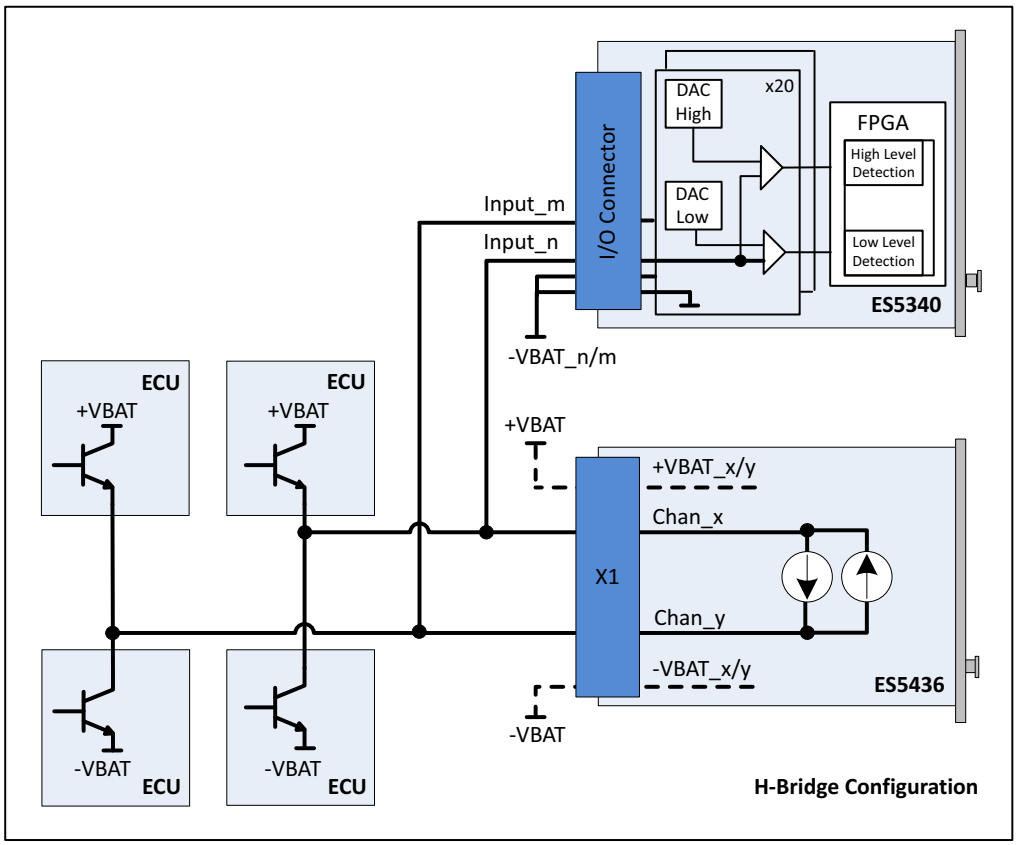


Fig. 3-5 Block diagram for configuration as H-bridge using ES5340 for measuring Chan_x and Chan_y

In case of H-bridge configuration, observe the following notes:

Note

Channel 2i and channel 2i+1 of the ES5436.1 are coupled in each case and can be used for an H-bridge. Only if channels 2i and 2i+1 are used, there will be a current flow through the H-bridge.

Note

The ES5436.1 use cases "Pull-Up", "Pull-Down" and "Bipolar" (for H-bridge) can be configured by software.
For this reason, make sure that +VBAT and -VBAT are always connected.

Note

For the ES5340, the connections -VBAT_m and -VBAT_n (Fig. 3-5) must be connected to the same -VBAT potential.

3.6.6 Measurement Modes

The following measurement modes are available for the ES5340.2 Internal Combustion Engine Application. A detailed description of the individual methods is contained in the User's Guide for LABCAR-RTC.

Time-based Modes

With time-based (asynchronous) measurements, the relevant measure value (e.g. frequency, duty cycle or hightime) is calculated on the basis of the most recent edge entries available in the memory.

- Pulse-width measurements
  - High Time
  - Low Time
- Frequency and cycle time measurements
  - Cycle Time --/--
  - Cycle Time --\--
  - Frequency --/--
  - Frequency --\--
- Duty cycle measurements
  - Duty Cycle L/(L+H) --/--
  - Duty Cycle L/(L+H) --\--
  - Duty Cycle H/(L+H) --/--
  - Duty Cycle H/(L+H) --\--
- Level measurements
  - Level (Active High)
  - Level (Active Low)

Angle-synchronous Modes

Angle windows which are specified by a lower angle window limit (LWL) in CA° and an upper angle window limit (UWL) in °CA are characteristic for angle-synchronous measurements.

The user can define up to three angle windows per hardware channel which can overlap but whose size must not exceed 720 °CA (360 °CA with two-stroke engine).

- Additive pulse-width measurements
  - Additive Hightime
  - Additive Lowtime
- Measuring edges: angle stamp
  - Rising Edge of n-th Pulse
  - Falling Edge of n-th Pulse
- Measuring width of n-th pulse
  - H-Time n-th Pulse (H-Valid.)
  - H-Time n-th Pulse (L-Valid.)

  - H-Time n-th Pulse (Pu Qual.)
  - L-Time n-th Pulse (Pu Qual.)
- Measuring edges: time stamp
  - Time Stamp of n-th Rising Edge
  - Time Stamp of n-th Falling Edge
- Pulse count
  - Number of Low-Pulses
  - Number of High-Pulses

3.6.7 Rail Pressure Measurements

The ES5340.2 Internal Combustion Engine Application provides the "ES5340-RailPump" item with the following speed-synchronous measurement modes for measuring rail pressure:

- Angle of first rising edge of a pulse sequence
- Angle of first falling edge of a pulse sequence
- Angle of last rising edge of a pulse sequence
- Angle of last falling edge of a pulse sequence

Measuring First Edges

The measurement mode for the first falling (or rising) edge works as follows (see the example of a first falling edge in Fig. 3-6 on page 36):

After the definition of a measurement window (reaching from LWL to UWL) in the RTIO, a search takes place for the first falling edge of a pulse sequence. The angle range between this first falling edge and a specified reference angle is returned as measure value. The first rising edge is measured the same way.

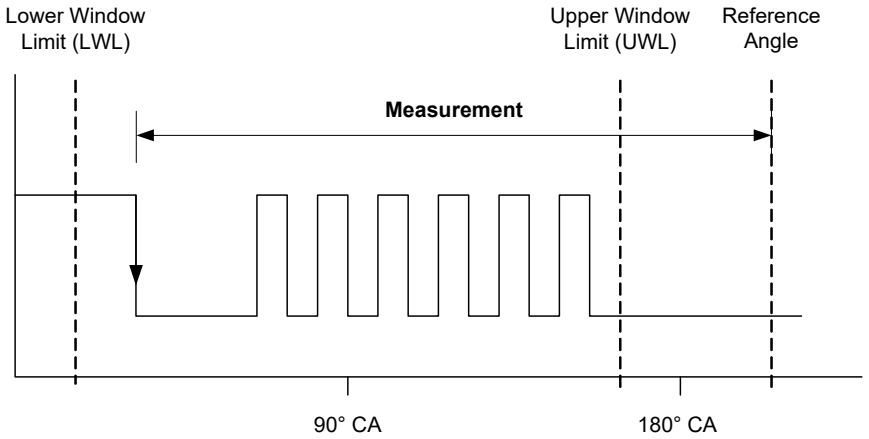


Fig. 3-6 Example: Angle of the First Falling Edge of a Pulse Sequence

Note

Angle windows and reference angles can also be shifted by an offset angle in relation to the crankshaft angle.

Transferring the Measure Values

In this case, the measure value can be determined as soon as the first falling edge is reached and then transferred to the RTIO.

Measuring Last Edges

Fig. 3-7 shows an example of a last falling edge - the angle difference between the last falling edge before the upper window limit is reached and a reference angle is measured. The last rising edge is measured the same way.

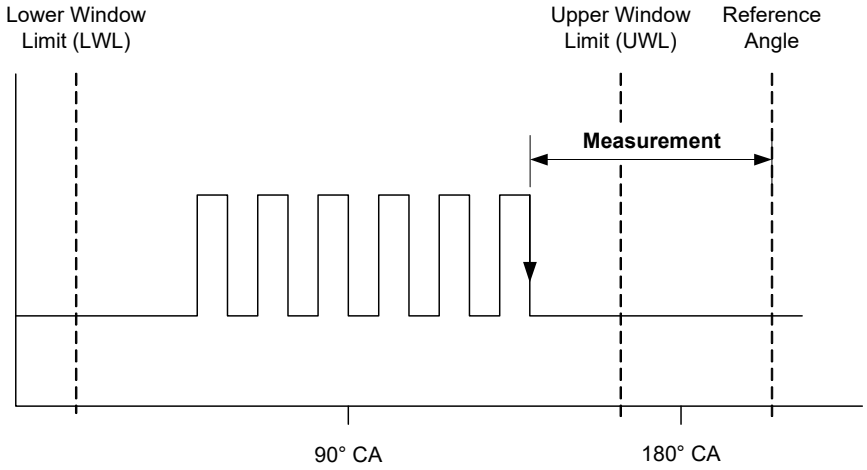


Fig. 3-7 Example: Angle of the Last Falling Edge of a Pulse Sequence

Transferring the Measure Values

The determination and subsequent transfer of the measure values is as follows: The angle of the falling edge currently detected is always stored in a register of the ES5340.2-ICE – as soon as a new falling edge is detected, the register is overwritten with the new angle value.

Once the upper window limit is reached, the angle value last stored is read from the register, the difference to the reference angle (= the measure value) is calculated and then transferred to the RTIO.

3.7 Arbitrary Signal Generators

There are eight analog and eight digital signal generators available on the ES5340.2-ICE. Each of the signal generators can play back one of the 16 waveforms. A central RPM generator and one variable clock generator per signal generator (maximum frequency: 1 MHz) are available as clock sources.

One individual basic phase as well as an additional phase shift can be selected per signal generator. The speed at which a change of the phase shift takes effect can be defined.

When using the variable clock generator, the frequency of the clock generator, the trigger mode (single shot, continuous) and a trigger signal can be specified.

The amplitude of the internal output signal of the signal generator can be varied between 0.0 and 1.0.

3.7.1 RPM Generator

The ES5340.2-ICE has a central speed generator (RPM generator) which outputs an engine-speed-specific clock signal. This clock signal can be used by the signal generators to read out and output the waveforms. The maximum speed is 60000 rpm, the resolution in around 0.1 rpm. The speed signal itself can be modulated using a misfire generator.

For measuring purposes, the speed signal can be applied to the "SYNC" port (on the front panel) of the ES5340.2-ICE (see "Sync Port" on page 240).

Angular Resolution

The angular resolution is 65536 points per cycle. With a typical four-stroke engine with a period of 720 °CA, this corresponds to an angular resolution of around 0.01 °CA.

3.7.2 Waveform Pool for Signal Generators

There are 16 waveforms available which can be used by the arbitrary signal generators. The user can describe the waveforms with tables. The signal trace in the table is written to the relevant waveform using an interpolation procedure.

Waveform resolution.

The maximum resolution of a waveform is determined by the maximum possible number of 65536 data points. Here too, the resolution can be reduced to 16 points in powers of two; please note that the resolution (1/(number of data points)) of a waveform must be smaller than or equal to the angular resolution. Normally the resolution of a waveform should correspond to the angular resolution.

The waveforms are read out and output by the signal generators. Either the central RPM generator can act as clock source or a variable frequency generator (maximum frequency: 1 MHz) in the signal generator is used.

Waveform resolution smaller than angular resolution.

If a high-frequency signal is to be output via the signal generator (using the variable frequency generator), it might be necessary to keep the resolution of one waveform smaller than the angular resolution.

The following example illustrates the procedure:

If a sinusoidal signal of 40 kHz is to be output, the signal table describes a single sine period. The angular resolution is 65536 points. Due to a maximum frequency of the variable clock generator of 1 MHz, the maximum signal frequency for the sinusoidal signal is 1 MHz/65536 = 15.25 Hz which, of course, is considerably less than the desired 40 kHz. By reducing the waveform resolution to, for example, 16 data points, the sinusoidal signal is stored several times in succession (in fact 65536/16 = 4096-fold) in the waveform with 65536 data points. This results in a total maximum frequency for the sinusoidal signal of 1 MHz/16 = 62.5 kHz, which is above the desired frequency of 40 kHz. Due to a corresponding reduction of the variable clock frequency (f=1/rate) to 640 kHz, the desired sinusoidal signal can be generated with 40 kHz.

The example shows that due to a reduction in the waveform resolution in comparison to the angular resolution, the waveform resolution is not really reduced. The signal of the signal table is simply written to the waveform several times in succession and the "visible" resolution thus reduced.

3.7.3 Knock Signal Generator

The knocking which occurs with a combustion engine can be simulated by the knock signal generator. A knock signal consists of individual knock packages. A knock package itself consists of a sinusoidal oscillation with selectable frequency and an envelope curve which modulates the sinusoidal oscillation with a duration which can be defined.

The following figure shows an individual knock package. A sine half wave is used as an envelope curve.

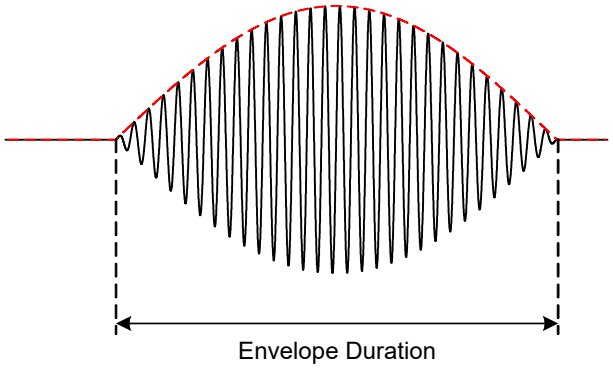


Fig. 3-8 A Knock Package

Non-knocking combustion also generates noises which are acquired by a real structure-borne noise knock sensor. A distinction is made between correct and knocking combustion via the control of the amplitude of the knock signal.

In addition, there is also a stochastic variation of the amplitude of a knock package. This is used for the simulation of variations in the knock signals which occur in real operation.

A certain amount of noise also exists if no knock package is being output. This basic noise is required for example to be able to get through the initial diagnostics of the sensor. Modern ECUs treat inputs without noise as faulty or not present.

The angular position (in °CA) of a knock signal as well as the occurrence of the knock event can now be controlled individually for each cylinder using a probability value or sequence tables (see "Sequence Tables" on page 40).

The knock signal generator has four internal outputs. You can select which cylinders serve the relevant output. In multi-cylinder vehicles, it is important that individual knock packages can overlay each other.

Note

A maximum of four waveforms can overlay each other!

3.7.4 Misfire Control

A control mechanism is available on the ES5340.2-ICE to simulate misfiring; this results in a modulation of the speed of the RPM generator in a specific angle range. It is possible to modify the speed in relation to the specified speed of the RPM generator (reduce/increase by the factor 0.01 to 2.0). When simulating misfiring, the speed is normally reduced in comparison to the defined speed.

The start effect angle of speed modulation can be defined for each individual cylinder. The effect of speed modulation can be controlled for each cylinder using a probability value or sequence tables (see "Sequence Tables" on page 40).

Speed modulation can be defined via four modulation profiles which represent the course of modulation over a complete period of 720 °CA (or 360 ° for two-stroke engines). A value of 1.0 represents a non-existent modulation; 0.01 reduces the speed to 1% of the specified speed; 2.0 doubles the specified speed. One of the four available modulation profiles can be selected individually per cylinder.

3.7.5 Sequence Tables

Sequence tables are used with the misfire generator and the knock signal generator. They make it possible for the user to describe complex knock and misfiring sequences.

A table with a maximum of 100 data points is used for this purpose. Once the sequence has been started, the sequence proceeds one data point per period. In the case of misfiring, a value greater than 0.5 at the relevant data point means that misfiring occurs in this period. With the knock signal generator, this value in the table can also be used to define the intensity with which the knock sensor perceives the knock signal (close cylinder: high value, distant cylinder: low value).

After 100 data points, the sequence is either started from the beginning again ("Sequence trigger = continuous"), or play-back is terminated ("Sequence trigger = Single Shot") and has to be restarted via the relevant trigger signal.

It is possible to specify one individual sequence per cylinder. There is, however, one common sequence ("Common Sequence") both with the misfire generator and the knock generator which all cylinders can access. This facilitates the fast setting of sequences which are to be used for several cylinders.

3.7.6 MSA Sensor

Signal generators are also used to simulate crankshaft sensors which can detect the direction of rotation (MSA sensors). A tooth pulse has no fixed angle width but a fixed pulse duration. Moreover, the output signal is predefined as being a low-active open collector signal.

If an MSA sensor RTIO element is used, (potential) tooth center information is calculated for all waveform traces during configuration and stored in the waveform pool. However, not all waveforms are necessarily suitable for this algorithm; when an unsuitable waveform is selected, an error message is issued.

3.8 RPM Generator

The ES5340.2 Internal Combustion Engine Application has a central RPM generator that outputs a speed-specific clock signal.

This RPM unit generates a 16-bit angle value that, in turn, is used for generating arbitrary signals using analog or digital signal generators.

The maximum speed is:

- 60000 rpm (for 720° crankshaft angle of a four-stroke engine)
- 30000 rpm (for 360° crankshaft angle of a two-stroke engine)

The angle resolution is 0.011 °CA (16 bit).

3.8.1 Angle Clock Signal

The angle clock signal consists of three signals (see Fig. 3-9 on page 41):

- The synchronization signal at 0 °CA
- The actual clock signal
- The signal for the direction of rotation (DOR)

  A "High" level of the DOR signal means "rotation with increasing crankshaft angle," while a "Low" level means "rotation with decreasing crankshaft angle".

One of these three clock signals can be output via a multiplexer to the BNC connection on the front panel (see "Connector for the Angle Clock Signal" on page 47).

In addition, the engine speed can be output to this connection. This signal is "High" (= 5 V) if the current crankshaft angle is between 0° and 360° (or 0° and 180°) and "Low" (= 0 V) for crankshaft angles between 360° and 720° (or 0° and 360°).

The following illustration shows the course of the four signals over one camshaft revolution.

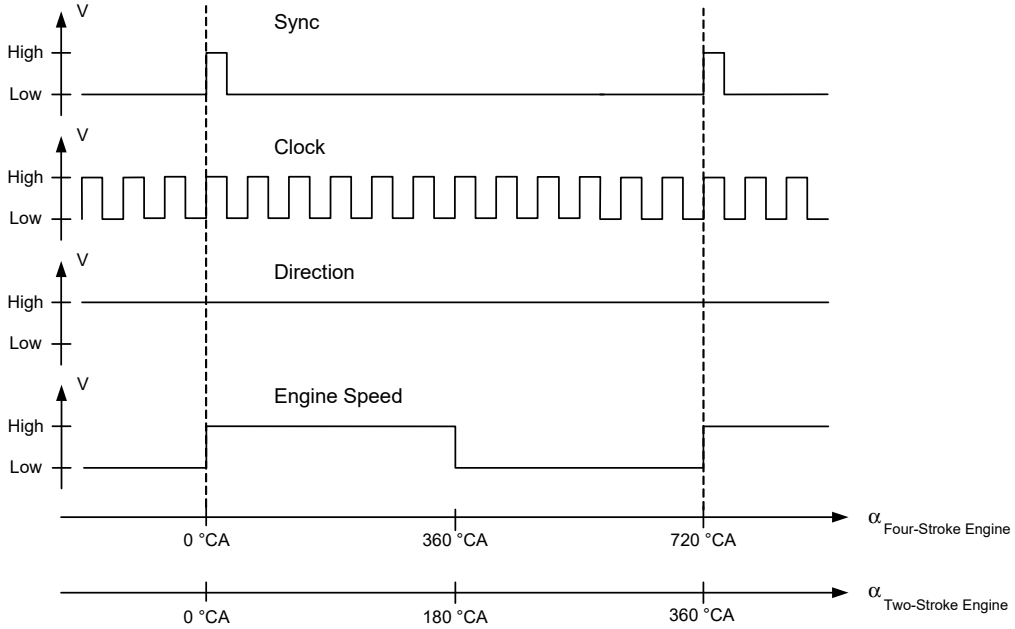


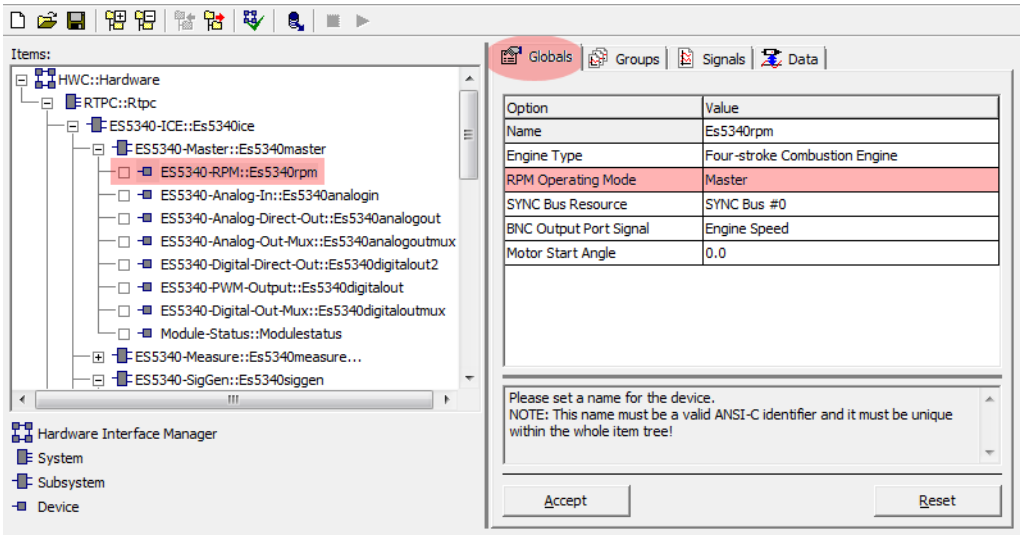
Fig. 3-9 Sync, Clock, Direction and Engine Speed Signals

3.8.2 Synchronization

An angle- or speed-based synchronization of multiple ES5340.2-ICE is possible. For this purpose, any ES5340.2-ICE is configured as the "RPM master", all others as "RPM slave".

3.8.3 Configuring the RPM Unit in LABCAR-RTC

To define the operating mode of the RPM unit, select the item "ES5340-RPM" in LABCAR-RTC and select the "RPM Operating Mode" option in the "Globals" tab.



The following settings are possible for the "RPM Operating Mode" option:

- **Slave**

  The ES5340.2-ICE is synchronized to an external angle clock signal.

- **Master**

  The angle clock signal is generated – based on the mechanical angular velocity – on the ES5340.2-ICE.

4 Connector Assignment and Display Elements

This chapter contains the description of the connectors and display elements of the ES5340.2 Internal Combustion Engine Application.

It consists of the following sections:

4.1 Connector Assignment

This section describes the assignment of the connectors of the inputs and outputs of the ES5340.2-ICE.

4.1.1 Connector for the Outputs

The connector is a DSUB25 connector (female). The shielding is to the front panel and housing potential and thus to protective earth.

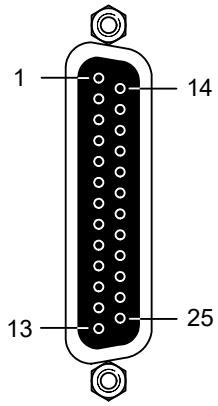


Fig. 4-1 Connector for the Outputs (Top View)

Pin	Signal	Pin	Signal
1	Analog Output Channel 0	14	Ground Channel 0
2	External Ref. Channel 0	15	Digital Output Channel 0
3	Analog Output Channel 1	*16*	Ground Channel 1
4	External Ref. Channel 1	*17*	Digital Output Channel 1
5	Analog Output Channel 2	*18*	Ground Channel 2
6	External Ref. Channel 2	*19*	Digital Output Channel 2
7	Analog Output Channel 3	*20*	Ground Channel 3
8	External Ref. Channel 3	*21*	Digital Output Channel 3
9	Analog Output Channel 4	*22*	Ground Channel 4
10	External Ref. Channel 4	*23*	Digital Output Channel 4
11	Analog Output Channel 5	*24*	Ground Channel 5
12	External Ref. Channel 5	*25*	Digital Output Channel 5
13	n.c.	Housing to protective earth	

Tab. 4-1 Assignment of the Connector for the Outputs

Note

Analog and digital ground of an output channel are identical!

4.1.2 Connector for the Inputs

The connector is a DSUB62HD connector (male). The shielding is to protective earth.

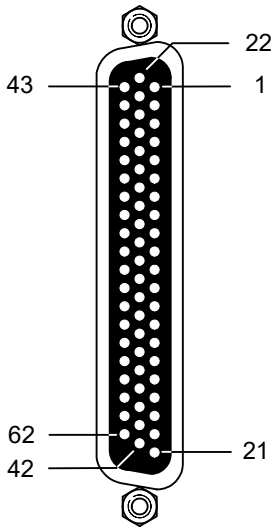


Fig. 4-2 Connector for the Inputs (Top View)

Pin	Signal	Pin	Signal	Pin	Signal
1	Analog Output Channel 6 –	22	Analog Output Channel 6 +	43	Analog Output Channel 6 AGND
2	Digital Output Channel 6	23	Excitation +	44	Digital Output Channel 6 AGND
3	Analog Output Channel 7 –	24	Analog Output Channel 7 +	45	Analog Output Channel 7 AGND
4	Digital Output Channel 7	25	Excitation –	46	Digital Output Channel 7 AGND
5	Digital Input Channel 0	26	Digital Input Channel 13	47	Digital Input Ground
6	Digital Input Channel 1	27	Digital Input Channel 14	48	Digital Input Ground
7	Digital Input Channel 2	28	Digital Input Channel 15	49	Digital Input Ground
8	Digital Input Channel 3	29	Digital Input Channel 16	50	Digital Input Ground
9	Digital Input Channel 4	30	Digital Input Channel 17	51	Digital Input Ground
10	Digital Input Channel 5	31	Digital Input Channel 18	52	Digital Input Ground
11	Digital Input Channel 6	32	Digital Input Channel 19	53	Digital Input Ground
12	Digital Input Channel 7	33	Digital Input Ground	54	Digital Input Ground
13	Digital Input Channel 8	34	Digital Input Ground	55	Digital Input Ground
14	Digital Input Channel 9	35	Digital Input Ground	56	Digital Input Ground
15	Digital Input Channel 10	36	Digital Input Ground	57	Digital Input Ground
16	Digital Input Channel 11	37	Digital Input Ground	58	Digital Input Ground
17	Digital Input Channel 12	38	Digital Input Ground	59	Digital Input Ground
18	Digital Input Ground	39	Analog Input Ground	60	Analog Input Ground
19	Analog Input Channel 0	40	Analog Input Channel 2	61	Analog Input Ground
20	Analog Input Channel 1	41	Analog Input Channel 3	62	Analog Input Ground
21	Analog Input Ground	42	Analog Input Ground	Housing to protective earth	

Tab. 4-2 Assignment of the Connector for the Inputs

4.1.3 Connector for the Angle Clock Signal

The connector for the angle clock signal is a BNC connector (female).

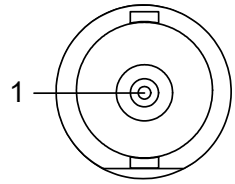


Fig. 4-3 Connector for the Angle Clock Signal

Pin	Signal
1	"Sync", "Clock", "Direction" or "Engine Speed" (see hardware configuration in LABCAR-RTC: ES5340-RPM Item, "Globals" tab, "BNC Output Port Signal" option)

Tab. 4-3 Assignment of the Connector for the Angle Clock Signal

4.2 Display Elements

The front panel of the ES5340.2 Internal Combustion Engine Application has an LED for identifying the board from the web interface of LABCAR-RTC.

5 Technical Data and Standards

5.1 Technical Data

This chapter contains the technical data on the ES5340.2 Internal Combustion Engine Application.

Analog Outputs

Number	8
Output voltage range	-10 V to +10 V (internal reference) -12 V to +12 V (external reference)
Accuracy without load	±5 mV (+23 °C/+73 °F)
Accuracy with load (12 kΩ)	±10 mV (+23 °C/+73 °F)
Output current	±30 mA (typical)
Resolution	16 bit
Overvoltage protection	±60 V
Galvanic isolation	Yes

Digital Outputs

Number	8
Output voltage range	Open collector: 0 to 60 V Internal pull-up: 5 V
Output current	Max. ±15 mA
Frequency range	1 Hz...100 kHz
Accuracy between 1 Hz and 10 kHz	±0.04%
Accuracy between 10 kHz and 100 kHz	±0.4%
Rise time (0 V → 5 V)	2 µs (typical)
Fall time (5 V → 0 V)	2 µs (typical)
Duty cycle	0%...100%
Accuracy of duty cycle (50%) between 1 Hz and 10 kHz	±0.2%...±2% (linear)
Accuracy of duty cycle (50%) between 10 kHz and 100 kHz	±2%...±20% (linear)
Clock rate for PWM generation	8 ns
Overvoltage protection	±60 V
Galvanic isolation	Yes
Max. number of SENT signals	4
SENT specification (version)	SAE J2716
Galvanic group SENT	One group with 4 channels

Analog Inputs

Number	4
Input voltage range	0...+5 V (CH0, CH2) 0 V to 40 V (CH1, CH3)
Accuracy	±50 mV (CH0, CH2) ±200 mV (CH1, CH3)
Resolution	12 bit
Impedance	1 MΩ
Sampling rate	500 kSamples/s
Overvoltage protection	±60 V
Galvanic isolation	Yes

Digital Inputs

Number	20
Input voltage range	0 to +60 V
Frequency range	1 Hz...100 kHz
Duty cycle	0%...100%
Resolution of duty cycle	0.1%
Accuracy between 1 Hz and 10 kHz	±0.04%
Accuracy between 10 kHz and 100 kHz	±0.4%
Resolution	8 ns (125 MHz)
Programmable thresholds for high/low detection of input signal	Adjustable: 0 V to +10 V
Overvoltage protection	±60 V
Galvanic isolation	Yes

RPM Clock Module

Angular resolution	0.011 °CA
Max. engine speed	60000 rpm

Data Acquisition

Max. number of pulses per channel and 720° CA	32
Minimum pulse width	100 ns
Duty cycle	0 ... 100%
Rise and fall time measurement	800 ns … 300 µs
Frequency range	0.1 Hz ... 20 kHz
Accuracy of frequency measurement	± (160 ns + 0.1%)
Accuracy of high-time	± (0.5 µs + 0.5%)

Electrical Data

Current consumption	980 mA @ +3.3 V DC 780 mA @ +12 V DC

Voltages/Currents/Power Consumption

The maximum permitted voltages and currents for the products comply with the PCI-Express specifications. To guarantee the necessary outputs when more than one PCI-Express board is in operation, the RTPC power unit must have a minimum output of 400 W.

Ambient Conditions

Environment	Use only inside enclosed and dry rooms
Max. contamination level	2
Temperature during operation	5 °C to 40 °C (41 °F to 104 °F)
Relative humidity	0 to 95% (non-condensing)
Operating altitude	Max. 2000 m above sea level

Physical Dimensions

ES5340.2-ICE:

Length	240 mm (9.45 in)
Hight	115 mm (4.53 in)
Weight	480 g (1.1 lb)

5.2 Fulfilled Norms and Standards

The product meets the following norms and standards:

Standard	Test
IEC 61326-1	Electrical equipment for measurement, control and laboratory use – EMC requirements (industrial setting)
IEC 61010-1	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements

The product is only intended for use in industrial settings in accordance with EN 61326-1. Avoid potential radio interference when using the module outside of the industrial settings with additional shielding measures!

WARNING!

This is class A equipment. This equipment can cause radio interference in residential areas. Should that be the case, the operator may be requested to institute reasonable measures.

6 Ordering Data and Scope of Delivery

Order name	Short name	Order number
ES5340.2 Internal Combustion Engine Application	ES5340.2-ICE	F-00K-109-496
Optional Accessories:		
Electric Drive Slave Board (Multi I/O)	ES5340.1-S	F-00K-107-054
Calibration Service for ES5340 Master	K_ES5340-M	F-00K-107-056
Calibration Service for ES5340 Slave	K_ES5340-S	F-00K-107-057

Scope of Delivery ES5340.2-ICE	Number of Pieces
ES5340.2 Internal Combustion Engine Application	1
Terminating connector	1
Ribbon cable short for installation in neighboring RTPC slots	1
Ribbon cable long for installation in the ES5370.1	1

Scope of Delivery ES5340.1-S	Number of Pieces
ES5340.1-S Electric_Drive_Slave_Board (Multi I/O)	1
Terminating connector	1
Ribbon cable short for installation in neighboring RTPC slots	1
Ribbon cable long for installation in the ES5370.1	1

7 ETAS Contact Addresses

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ETAS Subsidiaries and Technical Support

For details of your local sales office as well as your local technical support team and product hotlines, take a look at the ETAS website:

ETAS subsidiaries	WWW:	www.etas.com/en/contact.php
ETAS technical support	WWW:	www.etas.com/en/hotlines.php

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