ES5335.1 Arbitrary Signal Generator PCIe Board

User's Guide

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Contents

1 Introduction

The ES5335.1 Arbitrary Signal Generator PCIe Board is used to stimulate ECUs with speed-synchronous analog and pulse-width modulated signals. This manual contains the description of the ES5335.1 Arbitrary Signal Generator PCIe Board.

This section contains details of the basic functions and area of application of the ES5335.1 Arbitrary Signal Generator PCIe Board.

WARNING!

Some components of the ES5335.1 Arbitrary Signal Generator PCIe Board may be damaged or destroyed by electrostatic discharges. Please keep the board in its storage package until it is installed. The ES5335.1 Arbitrary Signal Generator PCIe Board should only be taken from its package, configured and installed at a working place that is protected against static discharge.

1.1 Applications

The ES5335.1 Arbitrary Signal Generator PCIe Board is used to generate the following vehicle signals:

- Speed-synchronous signals
  - Speed signal (is used by the engine ECU to acquire the speed and the crankshaft angle)
  - Camshaft signal (the camshaft signal is required by the ECU for cylinder recognition)
- Pulse-width modulated signals
  - Wheel rotation speed signal (simulation of vehicle speed)
  - Pedal value signal (simulation of accelerator, clutch and brake)
- Simulation of four independent knock sensors
- Misfiring simulation

1.2 Features

The ES5335.1 Arbitrary Signal Generator PCIe Board has the following features:

- Central crankshaft angle clock generator unit for generating speed-synchronous signals. The maximum speed is 30000 rpm with a resolution of 0.011 °CA.
- Six freely programmable arbitrary signal generators which can be clocked by the central crankshaft generator or by a local clock generator (0 - 1 MHz) (per signal generator)
- There are 12 signal banks available for all signal generators which can be written in real time during runtime.
- Six 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 (in the case of 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 software.
- Every output channel has its own galvanic isolation
- Every output channel can be deactivated via software
- Simulation of knock sensors and misfiring simulation possible
- Knock generator with 4 independent outputs
- Short-circuit-proof and overvoltage proof to ±60 V
- The integration of the PCIe interface and signal conditioning in the FPGA results in extremely low total latency times (< 5 µs) between the DVE model and signal output with the ES5335.1 Arbitrary Signal Generator PCIe Board.

The following figure shows the front panel of the ES5335.1 Arbitrary Signal Generator PCIe Board with

- the connector for the signal outputs (see "Connector for the Signal Outputs" on page 32),
- the clock signal output (see "Connector for the RPM Signal" on page 33) for outputting crankshaft angle clock signals

and

- the LED display (see "Indicators" on page 33)

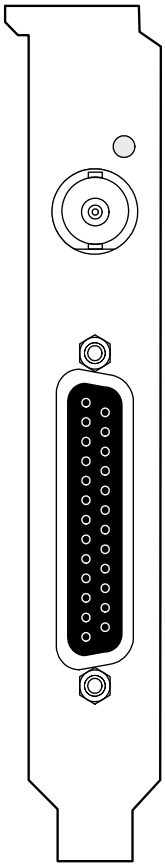


Fig. 1-1 Front Panel of the ES5335.1 Arbitrary Signal Generator PCIe Board

1.3 Block Diagram

Fig. 1-2 shows a block diagram with all important functional units of the ES5335.1 Arbitrary Signal Generator PCIe Board.

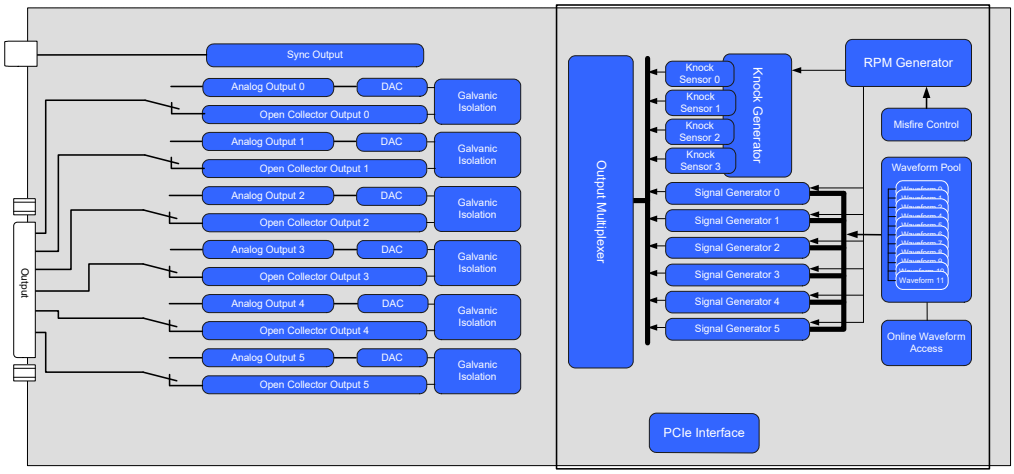


Fig. 1-2 Block Diagram of the ES5335.1 Arbitrary Signal Generator PCIe Board

The ES5335.1 Arbitrary Signal Generator PCIe Board has six **signal outputs** which can be used flexibly – every output can be assigned one of the available internal signals.

The outputs of six **arbitrary signal generators** and of a knock generator with four internal outputs are available as internal signals.

The six arbitrary signal generators can be timed using a central RPM generator or an individual local frequency. An individual phase shift is possible with each of the arbitrary signal generators.

There are twelve **signal banks** available centrally any of which can be read out and output by the six signal generators. The maximum resolution is 65536 data points. The signal banks can be written online (from the running simulation model).

The speed can be modulated via **misfire control**. This makes angle-related speed variations possible which enables misfiring to be simulated, for example.

The **knock signal generator** generates the structure-borne noise which occurs with a combustion engine due to knocking. The frequency and envelope curve of the knock signal can be configured. A cylinder-specific assignment to one of four internal outputs of the knock signal generator makes it possible to simulate knock signals of more complex engines.

Up to twelve cylinders are supported both with misfiring and with the knock signal generator.

1.4 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.

1.4.1 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.

1.4.2 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.

1.4.3 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.

1.4.4 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 36)
- Use with signal conditioning that falls outside the specified ranges (see voltages, currents and power consumption in the section "Technical Data and Norms" on page 35)

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.

1.5 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 14)
	Identification for China RoHS (see "RoHS Conformity" on page 14)
	Identification for WEEE directive (see "Taking the Product Back and Recycling" on page 15)

Observe the information in the chapter "Technical Data and Norms" on page 35.

1.5.1 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.

1.5.2 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.

1.5.3 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.

1.6 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. 1-3 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).

1.7 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.

1.8 About This Manual

This manual consists of the following chapters:

1.8.1 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 important information on the following topics:

- "Installing the ES5335.1 in the Realtime PC" on page 20

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

- "RPM Master/Slave Configuration" on page 21

  The RPM unit on the ES5335.1 can be operated as a master or slave.

- "Migrating Existing Projects" on page 23

  The hardware configuration of an existing project (in LABCAR-RTC) with one or several ES1335.1 can be used completely even if these are replaced by ES5335.1 Arbitrary Signal Generator PCIe Boards.

2.1 Installing the ES5335.1 in the Realtime PC

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

2.1.1 Requirements and Specifications

The hardware of the Realtime PC (if not purchased from ETAS) should satisfy the following requirements.

Processor	Intel Core i7 Intel Core 2 Family (Duo and Quad) Intel Pentium® Family (incl. Pentium D) Intel Celeron® Family Intel P4
Level2 cache	Min. 1 MB, 2 MB for large models
RAM	1 GB recommended
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
PCI slots	Min. 3
Onboard Ethernet adapter (Ethernet adapter for connecting to the user PC)	All boards supported by the Linux core Version 2.6.33.5 (e.g. Realtek 8139, SiS900, Intel 8255x, Intel 82573x, Intel Gigabit Network Connection 82574L, 82583V, 82567V-3, 82567LM-4, 82567LM-3, 82567LF-3, 82567V-4, 82577LM, 82577LC, 82578DM, 82578DC)
PCI/PCIe Ethernet adapter (Ethernet adapter for connecting to the ES1130)	- Intel PRO/100 card S, revision 12 (0C) or higher - Intel PRO/1000 Family - Intel PRO/1000 PT Quad Server adapter PCIe x4 connector - Intel Gigabit CT Desktop adapter - Supermicro AOC-UG-i4 PCIe x8 UIO connector
Hard disk	IDE or SATA, min. 20 GB, 40 GB and more recommended
Graphics card	VGA-compatible (text mode only)
Monitor	Only required for basic installation
Keyboard	PS/2, only required for basic installation
CD-ROM drive	IDE or SATA, only required for basic installation (bootable)
Operating system	Not necessary

Tab. 2-1 Requirements and Specifications for the Realtime PC (12/2010)

PCI-Express Specification

The PCI-Express slots for the ES5335.1 must be "x4" wide. The supported protocol is Version 2.0, but the boards are downward-compatible to 1.1 and 1.0.a.

Required Power Supply

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 ES5335.1 Arbitrary Signal Generator PCIe Board:

- Before installation, power off your Realtime 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 ES5335.1 Arbitrary Signal Generator PCIe Board may be damaged or even destroyed by static discharge. Leave the board in its transport package until you want to install it.
The ES5335.1 Arbitrary Signal Generator PCIe Board 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 RPM Master/Slave Configuration

The RPM unit on the ES5335.1 can be operated as a master or slave.

Note

The following only applies to boards in PCI-Express slots!

2.2.1 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 Realtime PC.
- Observe the points described in "Installation" on page 21.
- 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.

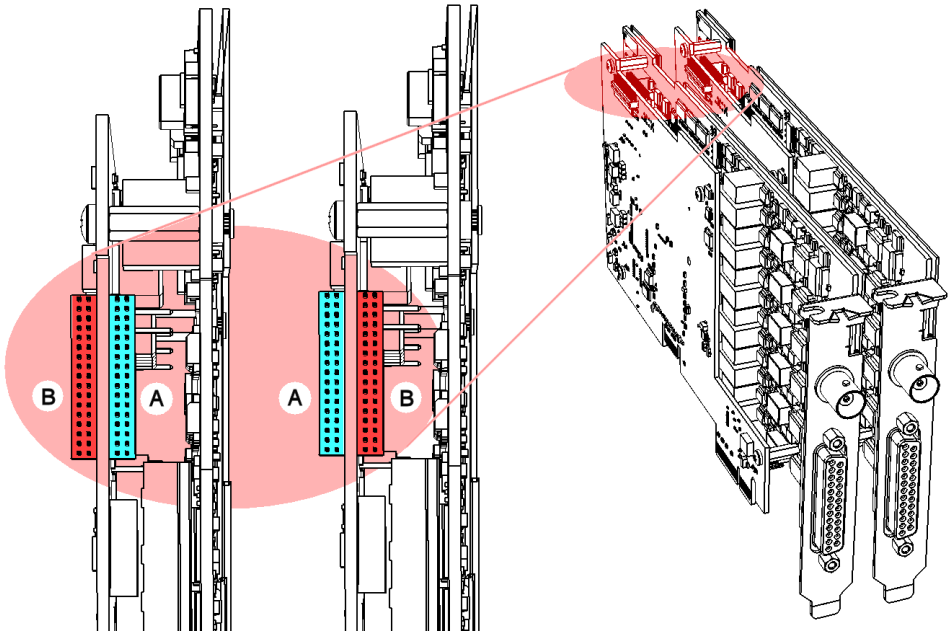


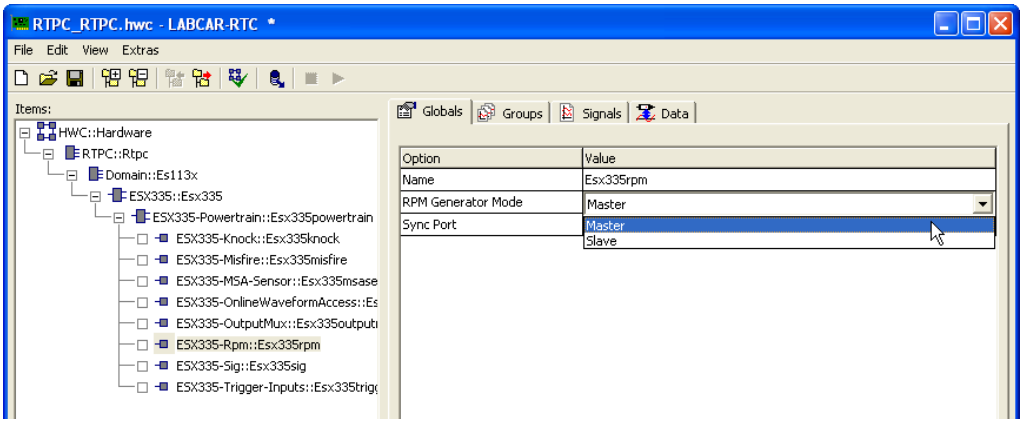
Fig. 2-1 Connecting the RPM Buses of Two Boards

Note

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

2.2.2 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 relevant "ESX335-RPM" item.



In the "Globals" tab, you can set the "RPM Operating Mode" option accordingly.

2.3 Migrating Existing Projects

The hardware configuration of an existing project (in LABCAR-RTC) with one or several ES1335.1 can be used completely even if these are replaced by ES5335.1 Arbitrary Signal Generator PCIe Boards.

With the hardware configuration in LABCAR-RTC, there is only one item for the ES1335.1 Arbitrary Signal Generator Board and the ES5335.1 Arbitrary Signal Generator PCIe Board which means that no distinction is made between the two cards in the hardware configuration.

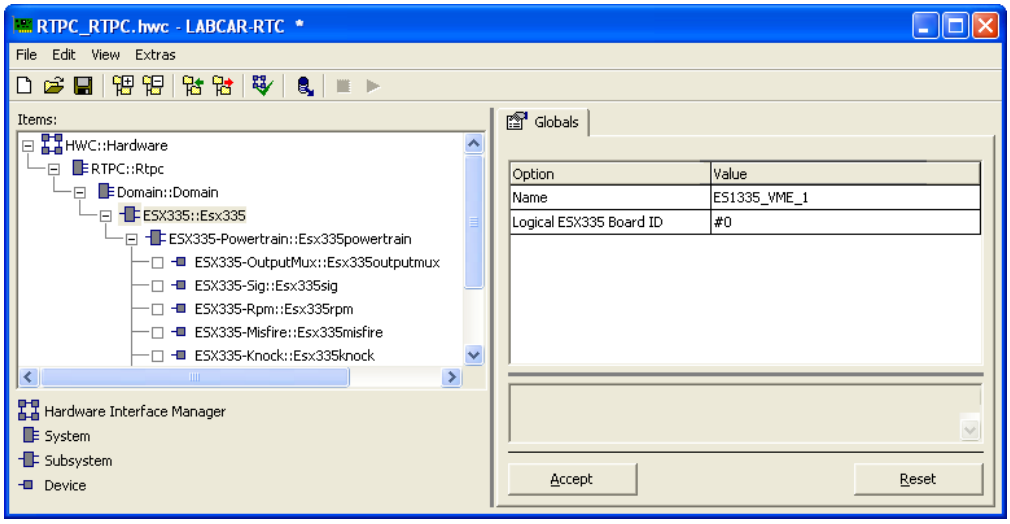
In LABCAR-RTC, board IDs simply have to be assigned to the instances defined there. In the Web-Interface of LABCAR-RTPC, these logical IDs are simply mapped to the actual boards (in the VME system or in the PCI-Express slots).

2.3.1 Procedure

A description of the most general scenario is presented below in which in addition to an ES1335.1 (in the VME system) a new ES5335.1 is used in a PCI-Express slot.

Logical Board ID for ES1335.1

1. Open the (old) project with the ES1335.1 in LABCAR-IP.
2. Open the hardware configuration (**Project** → **RTIO Editor**).
3. Select the "ESX335" subsystem.
4. The numbering of the boards in the VME system is adopted (in the order in which they are inserted into the slots): ("Logical Board ID" option).



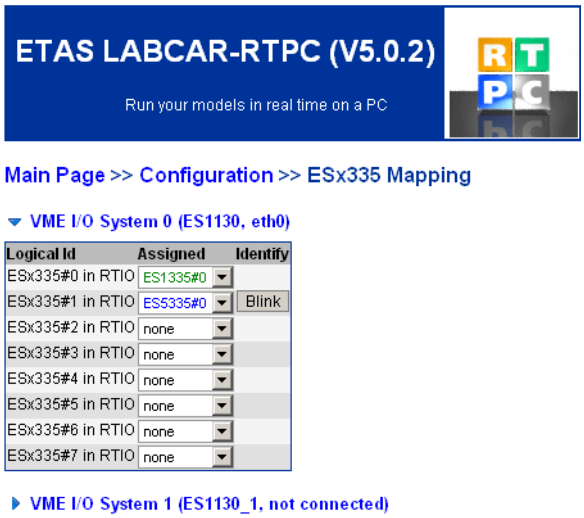
To configure new ES5335.1

1. Create a new "ESX335" subsystem or copy an existing one.
2. Assign a "Logical Board ID" to the new instance.

3. Configure the hardware for your particular application.
4. Save the modifications and exit the LABCAR-RTC hardware editor.

To map the boards

1. Boot your Realtime PC.
2. In your browser, call up the LABCAR-RTPC Web-Interface at (http://192.168.40.14).
3. If necessary, stop the Simulation Controller after booting (**Stop Simulation Controller**).
4. Go to the mapping page: **Main Page** → **Configuration** → **ES1335/ES5335 Mapping** (in the "PCI Express Hardware Configuration" box).
5. Make the following assignments in the table:
   - Logical ID "ESx335#0" (the ES1335.1 in the VME system) to "ES1335#0"
   - Logical ID "ESx335#1" (the ES5335.1 in the PCIe slot) to "ES5335#0"



Identifying the PCI-Express Boards

If there are several ES5335.1 in PCIe slots, you can find out which board is which by clicking on **Blink**: The LED on the front panel of this board will then flash for 15 seconds.

3 Hardware Features

This chapter contains information on the features of the ES5335.1 Arbitrary Signal Generator PCIe Board.

3.1 RPM-Generator

The ES5335.1 Arbitrary Signal Generator PCIe Board 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 signal banks. The maximum speed is 30000 rpm, the resolution around 0,011 °KW.

The speed signal itself can be modulated using a misfiring generator.

An angle- or speed-based synchronization of several ES5335.1 Arbitrary Signal Generator PCIe Boards is possible. For this purpose, one ES5335.1 is configured as RPM master; all other ES5335.1s are configured as RPM slaves.

Master and slave(s) are linked by connecting the ports on the boards in a special way (see "RPM Master/Slave Configuration" on page 21).

The crankshaft angle clock signal consists of three signals (see Fig. 3-1):

- The synchronization signal at 0 °CA ("Sync")
- The actual clock signal ("Clock")
- The signal for the direction of rotation ("Direction")

  A "high" level DOR signal means "rotation with increasing crankshaft angle"; a "low" level means "rotation with decreasing crankshaft angle".

One of these three signals (plus „engine speed") can be output using a multiplexer at the "SYNC" connector on the front panel (see "Connector for the RPM Signal" on page 33).

The following figure shows the four individual signals during one rotation of the camshaft.

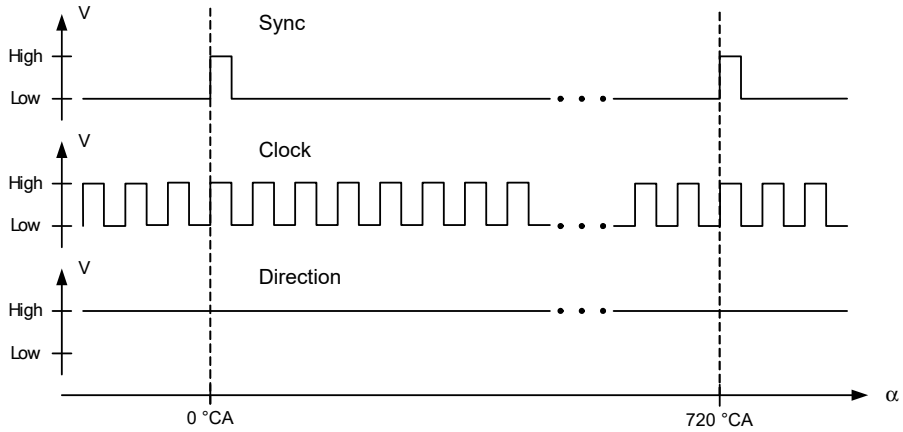


Fig. 3-1 The Four Components of the Crankshaft Clock Signal

3.1.1 Angular Resolution

The crankshaft angle is calculated on every edge (rising or falling) of the clock signal. The angular resolution is thus determined by the number of edges of the clock signal – this number n_{edges} is an RTIO parameter and can be selected (in powers of two) from 16 to $2^{16} = 65536$.

The angular resolution $\Delta\alpha$ is then:

$$\Delta\alpha = \frac{720\ °}{n_{edges}}$$

There is thus a maximum angular resolution of 0.011 °CA for the maximum number of edges. The maximum speed with this resolution is 30000 rpm.

3.1.2 Angle-Specific Speed Modulation (Misfiring Simulation)

The term "speed modulation" is a general term for speed variations which can occur due to misfiring or during the normal four-stroke cycle of a combustion engine.

The speed variations which occur are described using a modulation profile $\delta(\alpha)$, in which α is the crankshaft angle (0 to 720°) and δ the relative deviation from the target speed n_0 (see Fig. 3-2).

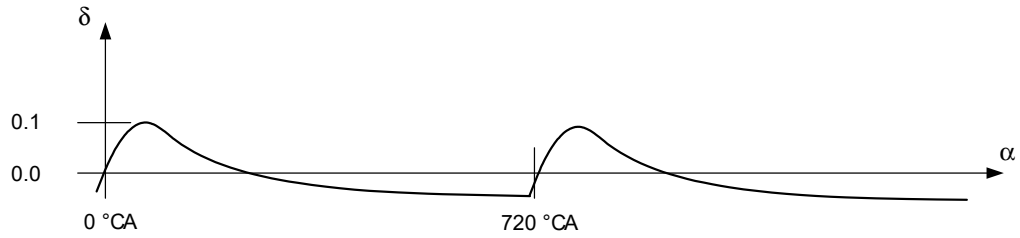


Fig. 3-2 Modulation Profile of the Engine Speed

If the phase shifts α_I between the individual cylinders are taken into consideration, the resulting engine speed $n(\alpha)$ is as follows with a crankshaft angle of α:

$$n(\alpha) = n_0 \cdot \prod_{I=1}^{m_Z} [1 + \delta(\alpha - \alpha_I) \cdot d_I]$$

m_Z is the number of cylinders and d_I a cylinder-specific attenuation coefficient between 0.0 and 1.0. This coefficient simulates differences between the cylinders due to fabrication tolerances, deterioration and abrasion.

3.2 Arbitrary Signal Generators

There are six arbitrary signal generators available on the ES5335.1 Arbitrary Signal Generator PCIe Board. Each of these signal generators can read out and output one of the twelve signal banks available centrally.

3.2.1 Signal Banks

In the ES5335.1 there are twelve signal banks available with up to 2^{16} points which can be used by the six arbitrary signal generators. The signal banks can be written by the user via tables – the signal trace is written to the table of the relevant signal bank in an interpolation procedure.

All 12 signal traces have the same length (signal length = number of points the signal bank consists of) corresponding to the angular resolution. If, for example, a resolution of 65536 clock pulses per camshaft revolution is specified, all signals consist of 65536 points.

The values of the signal bank are written with integers with a sign (16 bit) – the user specifies the values using floating-point numbers normalized to the interval [-1.1].

Amplitudes

The value of the analog signal which is ultimately available at the signal output is created by multiplying the angle-specific signal bank value with an amplitude value. The amplitude value is channel-specific and is specified normalized to [0 ,1].

If the internal voltage reference of 10 V is used, the normalized value 1.0 corresponds to an output voltage V_{out} of 10 V; when using an external reference voltage V_{ext}, the normalized value 1.0 corresponds to an output voltage $V_{out} = V_{ext}$.

3.2.2 Phase Shifts

It is possible to modify the signal output of a signal generator with regard to its phase relation. A target phase specified by the user is not immediately accepted by the hardware but is started with a phase change speed (in °CA/s) specified by the user. This avoids phase jumps which could result in error entries in the ECU.

3.2.3 Clock Sources

There are two possible clock sources for the signal generators:

- The central crankshaft angle clock generator (see section 3.1 on page 25), whose clock applies to all signal generators.
- A local clock generator with variable frequency (max. 1 MHz)

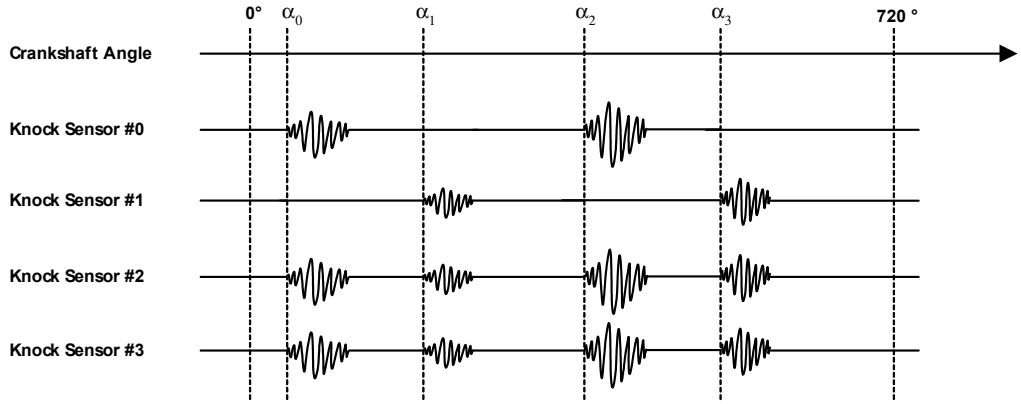
  There is a separate local clock generator available for every signal generator.

3.3 Knock Signal Generation

The knock signal generator unit enables the simulation of four knock sensors. The knock angle, i.e. the angle at which the knock signal is generated, is thus the same for all four sensors. These knock angles are usually identical to the ignition angles of the cylinders.

Every knock sensor can be configured so that it detects a structure-borne noise coming from a specific cylinder (or not). If the sensor detects the knocking of a cylinder, the sensor outputs a knock package every time the crankshaft angle is the same as the ignition angle of this cylinder. If the sensor does not detect the knocking of a cylinder, no knock package is output.

In the following figure, knock sensor #0 detects the knocking from cylinders 0 and 2, knock sensor #1 the knocking from cylinders 1 and 3. Knock sensors #2 and #3, on the other hand, detect knocking from all four cylinders.



The knock signal generator unit supports engines with up to 12 cylinders. The knock signal is stored in a separate signal bank and read out and output with a frequency of 1 MHz.

Please note that this signal bank is not one of the twelve signal banks of the arbitrary signal generators. The signal bank has a length of 2^{16} points so that knock signals with a length of up to 2^{16} µs can be read out and output.

The knock curve, the knock angles and knock signal amplitudes are identical for all four knock sensors.

3.4 Output Multiplexer

The output multiplexer enables the assignment of the internal signals (of the six arbitrary signal generators and four knock sensors) to the six available physical outputs of the ES5335.1. It is possible to apply an internal signal to several outputs.

3.5 Output Configuration

Each of the six outputs of the ES5335.1 Arbitrary Signal Generator PCIe Board can be configured differently

- Usage of the internal voltage reference (10 V) or a reference voltage applied from outside.

  Note

  An external reference should only be used for signals with which the output latency time of the ES5335.1 is too long.

- Output of an analog signal or a digital signal derived from the output voltage.

  The digital signal is derived from the analog signal when the analog output value in the FPGA is routed to a comparator. The comparator threshold corresponds to 1 V when the internal reference is used or 0.1 x V_{ext} when the external reference is used,

- When used as digital output: As open-collector output or with internal pull-up.
- Deactivated completely

Overcurrent Cutout

The currents through the analog and digital output stage are measured and interrupted if the current through the analog output stage exceeds 33 mA or if the current through the digital output stage exceeds 115 mA.

Pin Assignment

For more details on the pin assignment of the connectors for the signal outputs, refer to section "Connector for the Signal Outputs" on page 32.

4 Pin Assignment and Indicators

This chapter contains the description of the pin assignment of the connectors and the indicators of the ES5335.1 Arbitrary Signal Generator PCIe Board. It consists of the following sections:

- "Pin Assignment" on page 31

  This describes the pin assignment of all the connectors on the front panel.
- "Indicators" on page 33

  This section describes the meaning of the LED display on the front panel.

4.1 Pin Assignment

This section describes the pin assignment of the connectors for the signal output, test outputs and for the inputs for external signals:

- "Connector for the Signal Outputs" on page 32
- "Connector for the RPM Signal" on page 33

4.1.1 Connector for the Signal Outputs

The connector for the signal outputs, external reference voltages and analog ground is a DSUB 25 connector (female). The shielding is at front panel and housing potential and thus at protective earth.

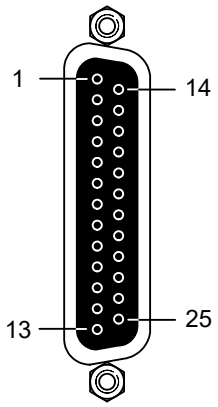


Fig. 4-1 Connector for the Signal Outputs

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

Tab. 4-1 Pin Assignment of the "Analog Out" Connector

4.1.2 Connector for the RPM Signal

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

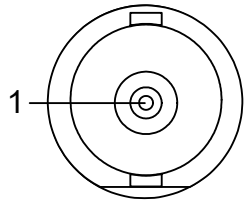


Fig. 4-2 Connector for the RPM Signal

Pin	Signal
1	"Sync", "Clock", "Direction" or "Engine Speed" (see Hardware Configuration in LABCAR-RTC: ESX335-Rpm Item, "Globals" tab, "Sync Port" option)

Tab. 4-2 Pin Assignment for the RPM Signal

4.2 Indicators

There is an LED on the front panel of the ES5335.1 Arbitrary Signal Generator PCIe Board that identifies the board (in the Web-Interface of LABCAR-RTPC).

5 Technical Data and Norms

Analog Output Stage

External reference voltage	-10 V ... +10 V
Output voltage range	-10 V ... +10 V (internal reference) $-V_{ext}$ ... $+V_{ext}$ (external reference)
Output frequency	1 MHz max.
Accuracy	With internal reference: Typical: ±5 mV (20 °C/68 °F, without load) With external reference: Typical: 12 bit (20 °C/68 °F, without load)
Output current	Typical: ±36 mA (20 °C/68 °F)
Overvoltage protection	±60 V
Galvanic isolation	Yes

Digital Output Stage

Rise time	Typical: 1 µs (20 °C/68 °F, 1 nF load)
Fall time	Typical: 50 ns (20 °C/68 °F, 1 nF load)
Internal pull-up functionality	Current source, current 9.5 mA typical
Output voltage (internal pull-up)	5 V
Output current	Typical: 120 mA (20 °C/68 °F)
Overvoltage protection	±60 V
Galvanic isolation	Yes

Electrical Data

Current consumption	820 mA @ +3,3 V DC 653 mA @ +12 V DC

Note

The power supply of the PC in which the ES5335.1 and possibly further PCIe boards are installed should be designed for power consumption of at least 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 (6560 ft) above sea level

Physical Dimensions

Length	240 mm (9.45 in)
Height	115 mm (4.53 in)
Weight	350 g (0.8 lb)

5.1 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 Order Information and Scope of Delivery

Order Name	Short Name	Order Number
ES5335.1 Arbitrary Signal Generator PCIe Board	ES5335.1-A	F-00K-106-832
Optional Accessories	**Short Name**	**Order Number**
Calibration Service for ES5335	K_ES5335	F-00K-106-840

Scope of Delivery ES5335.1-A	Number of Pieces
ES5335.1 Arbitrary Signal Generator PCIe Board	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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