ES5340.2 Electric Drive Simulation Board

User's Guide

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1 Introduction

This User's Guide contains the description of the ES5340.2 Electric Drive Simulation Board. In this chapter, you can read information about the basic functions and application area of the ES5340.2 Electric Drive Simulation Board.

CAUTION!

Some components of the ES5340.2 Electric Drive Simulation Board can be damaged or destroyed by electrostatic discharge. Leave the board in the transport packaging until it is installed.
The ES5340.2 Electric Drive Simulation Board must always be removed from the transport packaging, configured and installed at a workstation that is protected from electrostatic discharge.

1.1 Properties

The ES5340.2 Electric Drive Simulation Board with PCI-Express interface is used to test ECUs for inverters/electric motors on the signal level. The ES5340.2 is designed for applications with extremely high speed and accuracy requirements.

It enables simulation of an inverter with electric motor, either on the Real-Time PC or directly on the FPGA of the board.

1.1.1 Signals

The ES5340.2 measures the inverter control signals from the ECU – using the measuring results, an inverter/electric motor model can be simulated on the RTPC, the output variables of which (current and voltage signals and angle and speed information) are returned to the ECU via the ES5340.2.

The sensor signals can be displayed in analog or digital form. All common position sensors, such as resolvers, sine and digital encoders, can be displayed.

Other analog and digital signals are also possible, such as fault signals, battery charge levels or DC/DC converter control.

1.1.2 Inverter/PMSM[1] Model

For the ES5340.2 Electric Drive Simulation Board, a configurable FPGA-based inverter/PMSM model is offered. It models a 6-gate inverter and a permanent magnet synchronous machine (PMSM) with mechanical system.

The FPGA model generates all electrical and mechanical values for the inverter and the electric motor and takes into account all important physical effects, such as saturation and temperature effects.

Its distinguishing feature is a highly balanced ratio of speed to accuracy. With the FPGA-based model, the model run times are reduced significantly from approximately 10 µs with a C code model (see "Real-Time PC Model" on page 9) generated from Simulink® to 800 ns.

1. **P**ermanent **M**agnet **S**ynchronous **M**achine

Fig. 1-1 below shows the components and interfaces of the complete "ECU - I/O model (- DVE)" system.

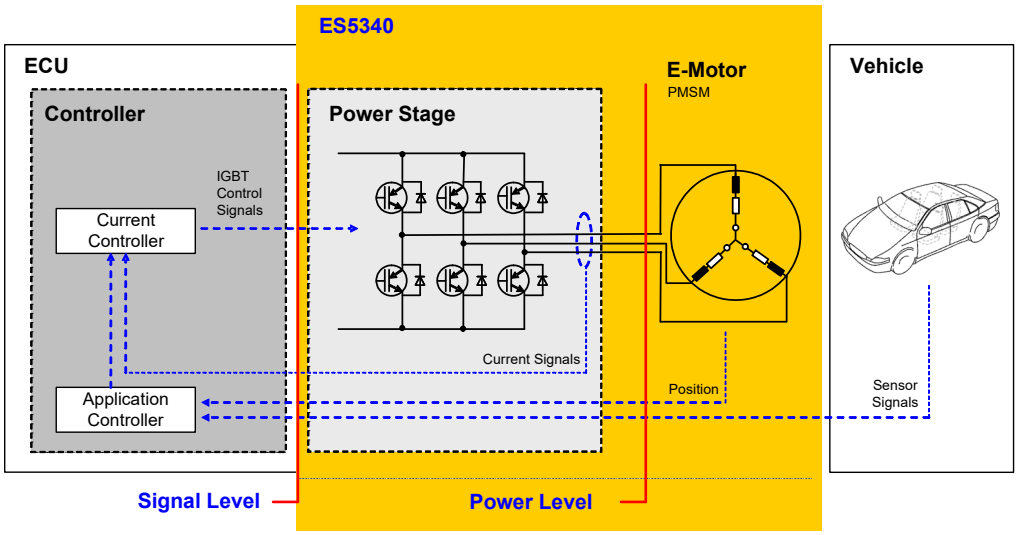


Fig. 1-1 Components and interfaces of the ES5340.2

Parameterization of the Inverter

The inverter is configured using the typical variables, such as switching times, polarity or resistances of the switches and diodes. In addition, for each switch, the "open"/"closed" error states can be configured. Of course, what is known as "free wheeling" (in which all 6 switches are open) can also be simulated.

In addition, for the entire inverter, the power loss of the ohmic components is simulated – for the ohmic components, their value can also be calculated depending on the temperature.

For the input wiring of the inverter, the internal resistance of the battery and the capacity of the DC voltage link are taken into account – thus also allowing the voltage in the DC voltage link to be simulated.

Parameterization of the PMSM

The PMSM is likewise configured via typical variables, such as the number of pole pairs and cogging positions. Additional variables such as resistance, inductance, the magnetic flow and the cogging torque can be changed during run time. This ensures highly accurate simulation of the phase currents and electrical torque, and all important variables can be changed in real time.

For the PMSM, the power loss of the ohmic components can also be simulated and their temperature dependence can be calculated.

Parameterization the Connection to the Drive Train

For the mechanical connection to the drive train, the FPGA model also includes a simulation of the spring-mass system. The system is configured with the typical variables of coefficient of friction, moment of inertia for rotor and load, torsional rigidity and damping. The load moment of the drive train can be preset and changed during run-time.

Fig. 1-2 shows the most important in- and output variables of the simulation model. These variables can either be connected with another PC-based simulation model or output as electrical signals using the ES5340.2 Electric Drive Simulation Board or other hardware.

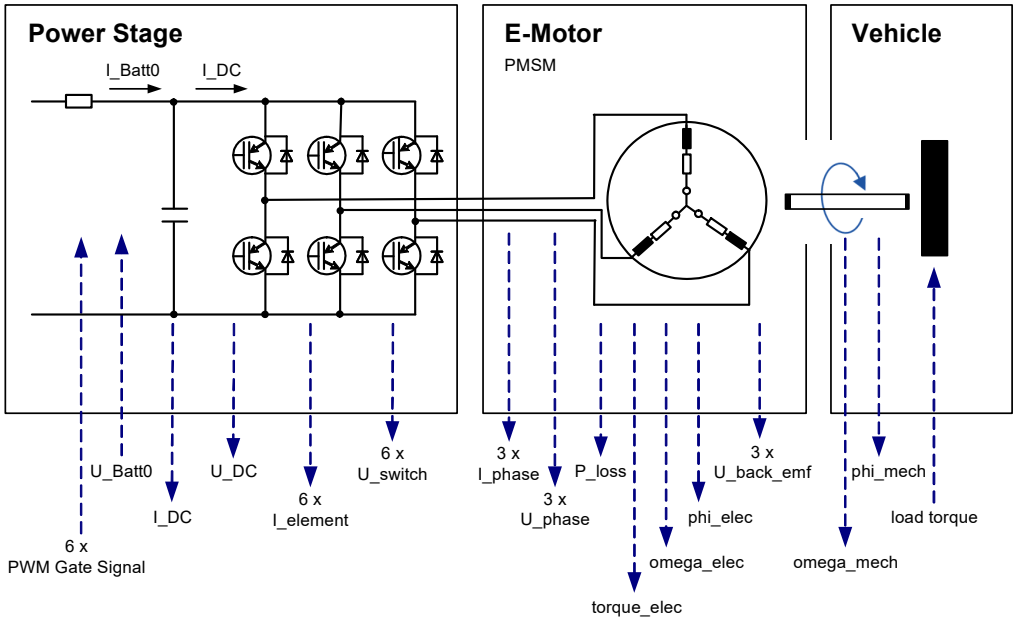


Fig. 1-2 Inputs and outputs of the FPGA model

1.1.3 Real-Time PC Model

Alternatively, a model of the electric motor can also be simulated on the Real-Time PC. The ES5340.2 Electric Drive Simulation Board located in this Real-Time PC (or connected to it via a PCI-Express expansion system) serves as an analog and digital I/O interface to the ECU.

Thus low latencies of between 5 µs and 10 µs are obtained for measurement of the PWM control signals (for the inverter).

RPM Unit

The RPM unit present on the ES5340.2 can take over the position and speed of the electric motor calculated by the model and then function as the RPM master in the system.

Prediction of the Phase Currents

The current signals are output, supported by hardware, with an update rate of 1 MHz. By means of prediction, this takes place independently of the step size of the Real-Time PC simulation model.

Clock Recovery for IGBT Control Signals

The synchronization for measuring the duty cycles and the control signals takes place using an external synchronization signal or using clock recovery, i.e. the automatic synchronization of center-aligned PWM control signals.

1.1.4 Expansion with Slave Board

Using the ES5340.1-S slave board, 6 additional analog and 6 additional digital outputs can be added (see "Versions of the ES5340.2 Electric Drive Simulation Board" on page 10).

1.2 Versions of the ES5340.2 Electric Drive Simulation Board

The master board has the properties described below; the number of outputs can be increased using an optional slave board (see "Electric Drive Simulation Slave Board (ES5340.1-S)" on page 10).

1.2.1 Electric Drive Simulation Master Board (ES5340.2-M)

This board contains the full range of function:

I/O

- 8 analog outputs (incl. simulation of analog position sensor signals)
- 8 digital outputs (incl. simulation of digital position sensor signals)
- 20 digital inputs
- 4 analog inputs

Model Support

- FPGA model available
- RTPC model possible

1.2.2 Electric Drive Simulation Slave Board (ES5340.1-S)

This board has a reduced scope of function compared to the Master Board:

I/O

- 6 analog outputs (without simulation of analog position sensor signals)
- 6 digital outputs (without simulation of digital position sensor signals)

The source of each output signal is the values of the FPGA and RTPC model of a ES5340.2-M.

The following figure shows the front panel of the ES5340.2 Electric Drive Simulation Board with the various connections.

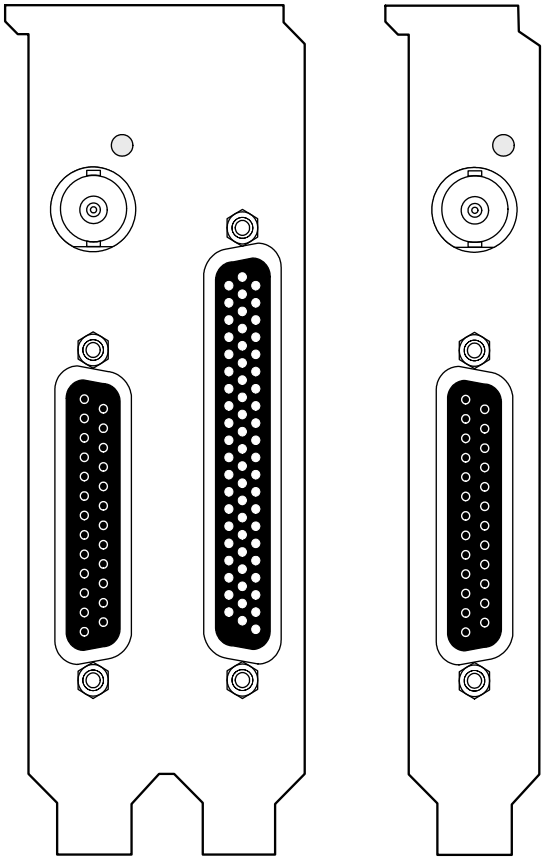


Fig. 1-3 Front panel of the ES5340.2 Electric Drive Simulation Board (left: master, right: slave)

The function and assignment of the connectors are described in Chapter "Connector Assignment and Display Elements" on page 97.

1.3 Block Diagram

Fig. 1-4 shows a block diagram with all important functional units of the ES5340.2 Electric Drive Simulation Board.

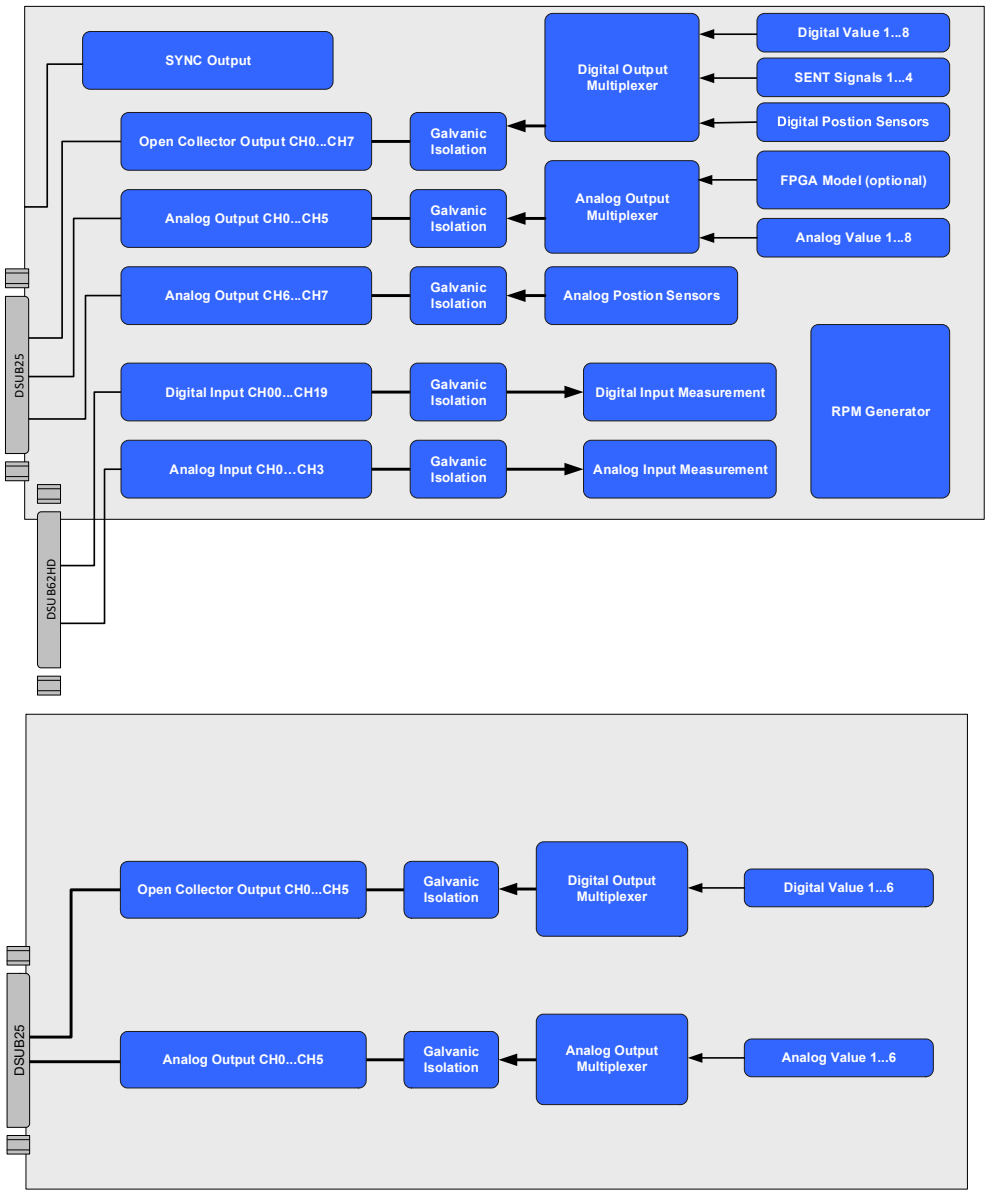


Fig. 1-4 Block diagram of the ES5340.2 Electric Drive Simulation Board: Master ES5340.2-M (top) and slave ES5340.1-S (bottom)

1.4 Basic Safety Instructions

Please adhere to the safety instructions in this manuals 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 113)
- 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 111)

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 18)
	Identification for China RoHS (see "RoHS Conformity" on page 18)
	Identification for WEEE directive (see "Taking the Product Back and Recycling" on page 19)

Observe the information in the chapter "Technical Data and Standards" on page 111.

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. 1-5 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 115).

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:

- "Introduction" on page 7
  This chapter
- "Installation and Configuration" on page 23
- "Hardware Description" on page 31
- "FPGA Models" on page 49
- "Configuring the Hardware in LABCAR-RTC" on page 65
- "Connector Assignment and Display Elements" on page 97
- "Order Information and Scope of Delivery" on page 103
- "Technical Data and Standards" on page 111
- "ETAS Contact Addresses" on page 115

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 ES5340.2 in the Real-Time PC" on page 24

  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.

- "Master/Slave Configuration" on page 25

  To extend the I/O capacity of the ES5340.2-M (master), a slave card (ES5340.1-S) can be installed. This makes it possible to increase the number of analog and digital outputs by six each.

- "RPM Master/Slave Configuration" on page 26

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

- "“Exclusive Core Usage” Mode" on page 28

  When the phase currents and voltages in a software model (on the Real-Time PC) are simulated according to the PWM signals of the inverter controller, the model has to be calculated in a task < 50 µs.

2.1 Installing the ES5340.2 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 with PCs tested and released by ETAS as well as known installations (`LABCAR-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 is more than 800 µs, PCs not released by ETAS may not detect the card!

When using the ES5340.2, 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 Electric Drive Simulation Board:

- 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 Electric Drive Simulation Board 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 Electric Drive Simulation 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 Master/Slave Configuration

To extend the I/O capacity of the ES5340.2-M (master), a slave card (ES5340.1-S) can be installed. This makes it possible to increase the number of analog and digital outputs by six each.

For this purpose, you have to decide whether you are going to work with an FPGA model or a model on the Real-Time PC.

Using an FPGA Model on the Master

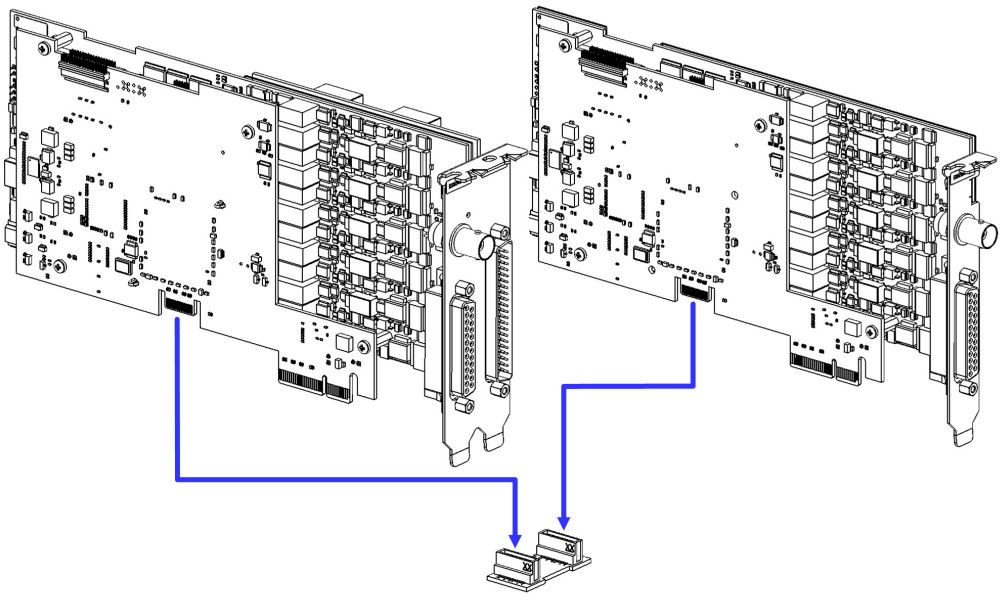
By connecting the master and slave card of what is referred to as a Gigabit Link, all the slave card outputs can be addressed by the FPGA model with the typically low latencies (< 1 µs) (see "Connecting Master and Slave via Gigabit Link" on page 25).

Using a Model on the Real-Time PC

In this case, the ES5340.1-S can simply be inserted into a PCI-Express slot – once configured in LABCAR-RTC, the outputs of the ES5340.1-S can be addressed via the LABCAR-OPERATOR Connection Manager.

2.2.1 Connecting Master and Slave via Gigabit Link

The following figure shows the connection of an ES5340.2-M with an ES5340.1-S via Gigabit Link.

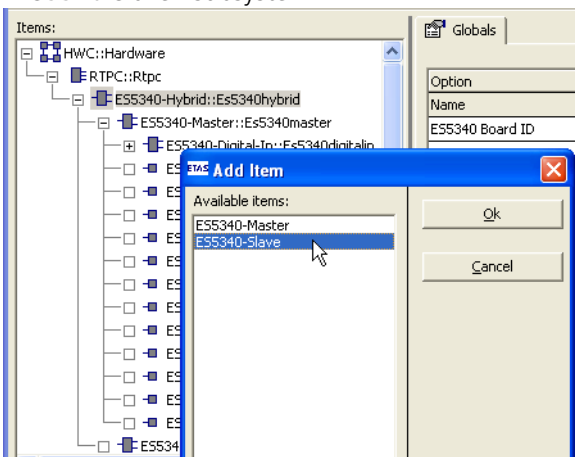


The bridge for the Gigabit Link is a small board with two connectors supplied with an ES5340.1-S. The slave card has to be installed to the right of the master.

First connect master and slave with the bridge (see figure) and then insert them into two neighboring PCI-Express slots.

2.2.2 Configuration in LABCAR-RTC

To configure the slave card in LABCAR-RTC, you have to incorporate an "ES5340-Slave" subsystem.



You can then configure the additional outputs to suit your requirements.

2.3 RPM Master/Slave Configuration

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

The RPM unit can also assume the position and speed of the e-engine calculated by the model and then act as RPM master in the system. For this purpose, the RPM buses of the master and of one or more of the slaves have to be connected as described below.

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 24.
- 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.

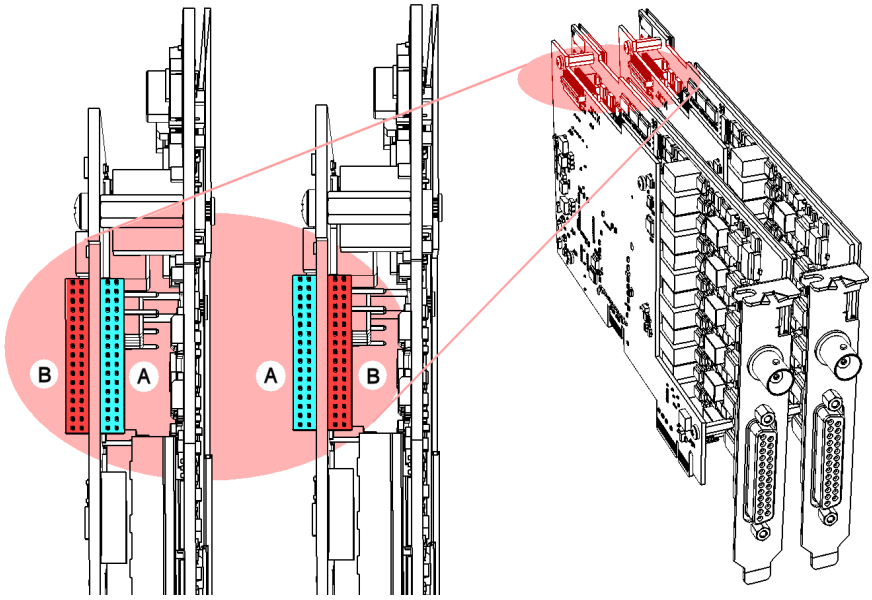


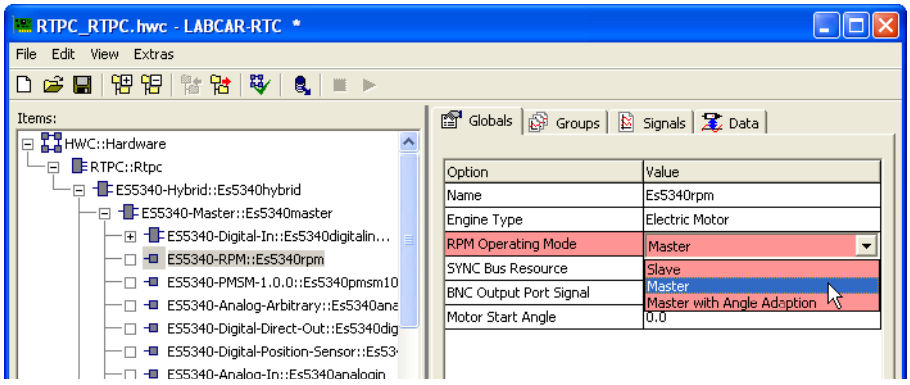
Fig. 2-1 Connecting the RPM buses of two boards

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 relevant "ES5340-RPM" item. In the "Globals" tab, you can set the "RPM Operating Mode" option accordingly (see "Configuring the RPM unit in LABCAR-RTC" on page 48).



2.4 "Exclusive Core Usage" Mode

When the phase currents and voltages in a software model (on the Real-Time PC) are simulated according to the PWM signals of the inverter controller, the model has to be calculated in a task < 50 µs.

This can be done by directly accessing a dedicated processor core ("Exclusive Core Usage"). This means that between the control signals being output and the current signals being measured there are no raster losses in the ECU.

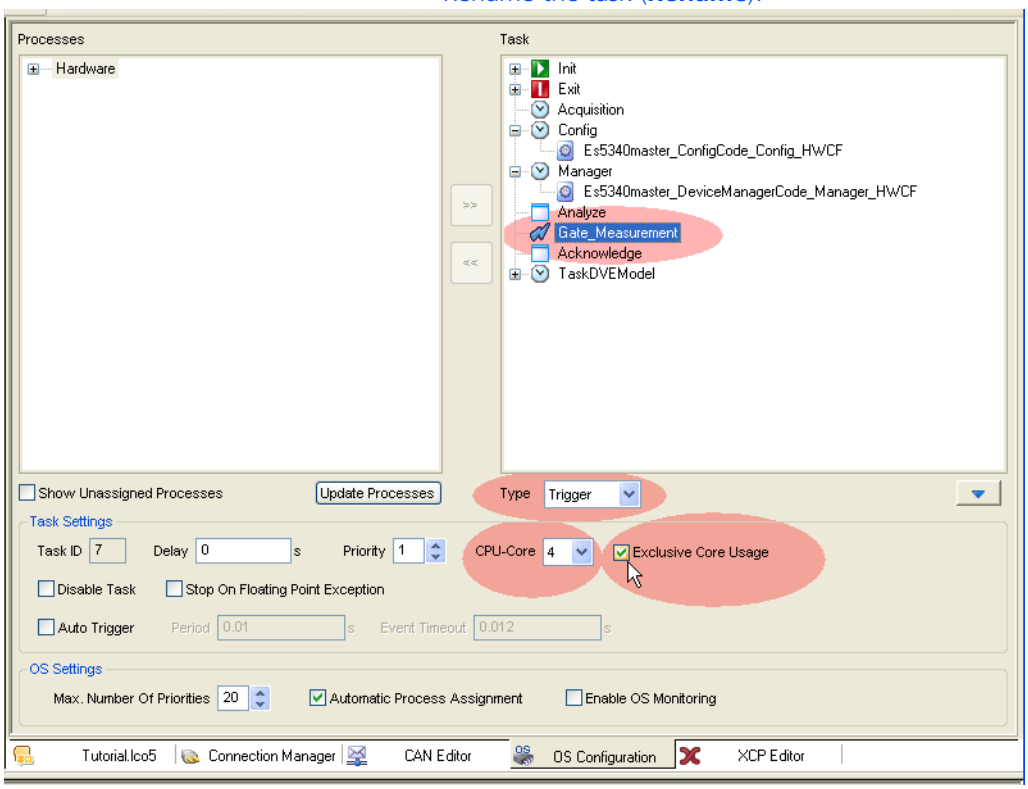
Prerequisites

To use this mode the processor of the Realtime PC must have at least four cores and at least one of these cores must not be being used by another task (see below).

To create a task for "Exclusive Core Usage"

1. Toggle to the "OS Configuration" tab in LABCAR-IP.
2. Create a new task (**Add Task** in the shortcut menu) in the "Task" box.

   Rename the task (**Rename**).



3. Select "Trigger" as "Type".
4. Select the option "Exclusive Core Usage".

5. For "CPU Core", select the core that is to be available exclusively for this task.

   Only cores not used by another task are displayed here – you may have to release a core (by reconfiguring other tasks).

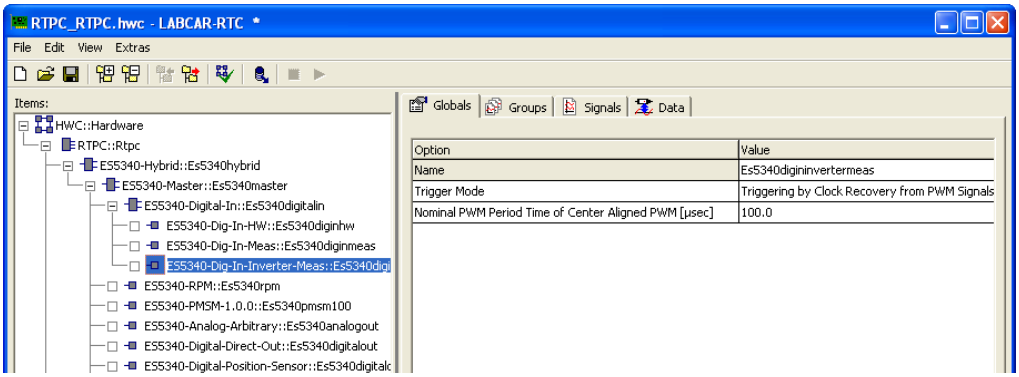
Note

The total number of existing processor cores is not known in LABCAR-IP – only assign cores that are actually available!

6. Save the project.

To configure measuring in LABCAR-RTC

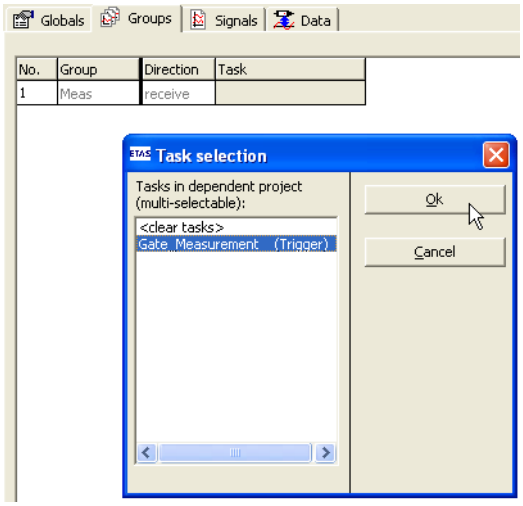
1. Open the hardware configuration in LABCAR-RTC.
2. Select the item "ES5340-Dig-In-Inverter-Meas".
3. In the "Globals" tab, select the required settings for the options "Trigger Mode" and "Nominal PWM Period Time of Center-Aligned PWM [µsec]".



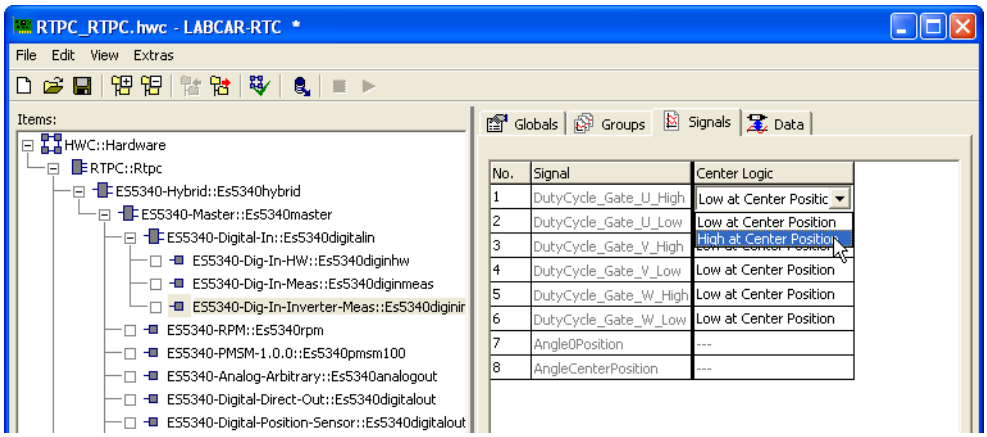
4. Toggle to the "Groups" tab.
5. Click the table field in the "Task" column.
6. The "Task selection" window opens.

   All "Trigger" tasks for which "Exclusive Core Usage" has been activated and which are defined in the OS Configuration of LABCAR-IP are listed here.

7. Select the required task and click **Ok**.



8. Set the polarity of the gate signals in the "Signals" tab ("Center Logic" column).



9. Save the settings (**File** → **Save**).

3 Hardware Description

This chapter provides a description of the inputs and outputs of the ES5340.2 Electric Drive Simulation Board along with the signals that it can measure and those that can be generated for it.

Note

The step-by-step execution of the configuration is in the chapter "Configuring the Hardware in LABCAR-RTC" on page 65.

Specifically, it includes information about the following topics:

- **"Generating Analog Signals" on page 32**

  These outputs are used for different analog signals via an output multiplexer.

  – "Specification" on page 32
  – "Configuring the Analog Signals" on page 33

- **"Output Multiplexers for the Analog Signals" on page 36**

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

- **"Generating Digital Signals" on page 38**

  These outputs are used for different digital signals via an output multiplexer.

  – "Specification" on page 38
  – "Configuring the Digital Signals" on page 40

- **"Output Multiplexers for the Digital Signals" on page 41**

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

- **"Analog Inputs" on page 42**

  The ES5340.2-M has four inputs for measuring analog signals.

  – "Specification" on page 42
  – "Configuring the Analog Inputs" on page 42

- **"Digital Inputs" on page 42**

  The ES5340.2-M has 20 inputs for measuring digital signals.

  – "Specification" on page 42
  – "Configuring the Digital Inputs" on page 43

- **"RPM Generator" on page 47**

  The ES5340.2 Electric Drive Simulation Board has a central RPM Generator that outputs a speed-specific clock signal.

  – "Angle Clock Signal" on page 47
  – "Synchronization" on page 48
  – ""Master with Angle Adaptation" RPM Mode" on page 48

3.1 Generating Analog Signals

These outputs are used for different analog signals via an output multiplexer.

The **ES5340.2-M** has **eight analog outputs**, two of which are dedicated to simulating the analog speed sensor/resolver. The other six analog outputs can be used to simulate additional analog speed sensors or to output analog signals.

The **ES5340.1-S** has **six analog** outputs (no simulation of speed sensors possible).

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 **electrically insulated** 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.

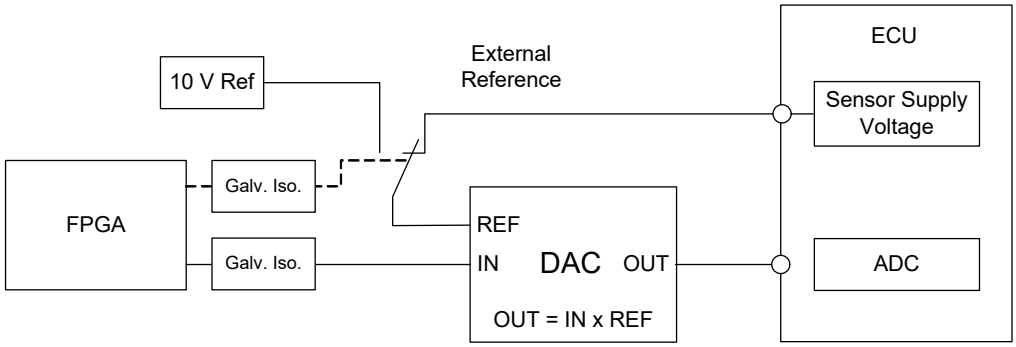


Fig. 3-1 Schematic circuit diagram of the analog outputs

For each of the six channels CH0 to CH5, 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).

Only the same external reference can be assigned to the two channels reserved for the simulation of the analog resolver speed sensor, CH6 and CH7. In this case, the external reference can be connected to two pins: one for GND and one for the signal of the external reference (see "Assignment of the connectors for the inputs" on page 100) .

3.1.2 Configuring the Analog Signals

Which signals are assigned to the eight (ES5340.2-M) or six (ES5340.1-S) outputs is defined in the output multiplexer (see **"Output Multiplexers for the Analog Signals" on page 36**).

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 an RTPC model – specified by the value of "OutValue_*n*" [-1.0 to +1.0]:

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

Resolver

If a resolver is used as the speed sensor, two analog channels (CH6 and CH7) can be used for the output of the sine and cosine signal (see Fig. 3-2).

The following sensor chips have been tested:

- R/D Converter AD2S1210 (Analog Devices)
- Smartcoder® AU6802N1 (Tamagawa Seiki)

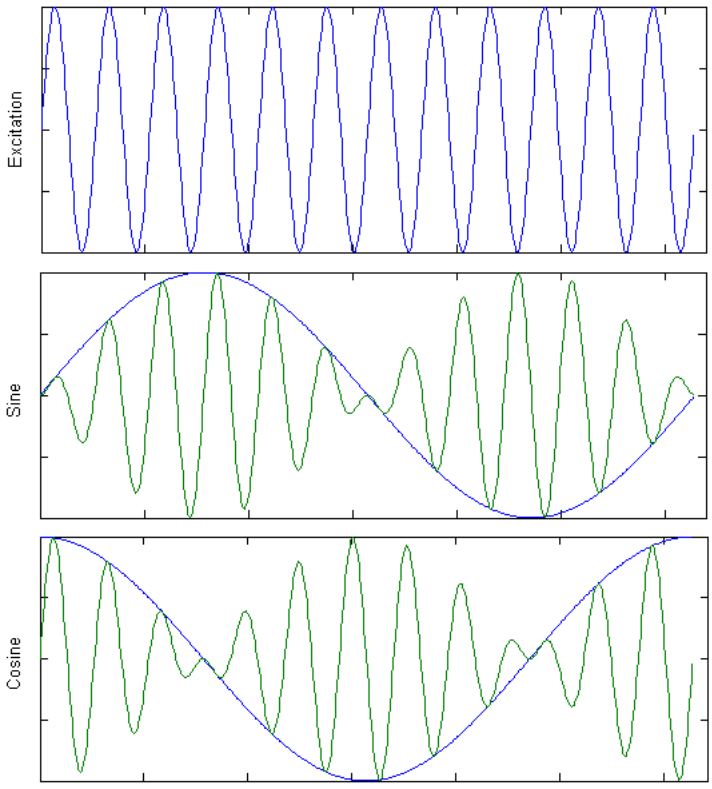


Fig. 3-2 Signals for the resolver

The excitation signal is connected instead of an external reference (see Fig. 3-3 and "Assignment of the connectors for the inputs" on page 100).

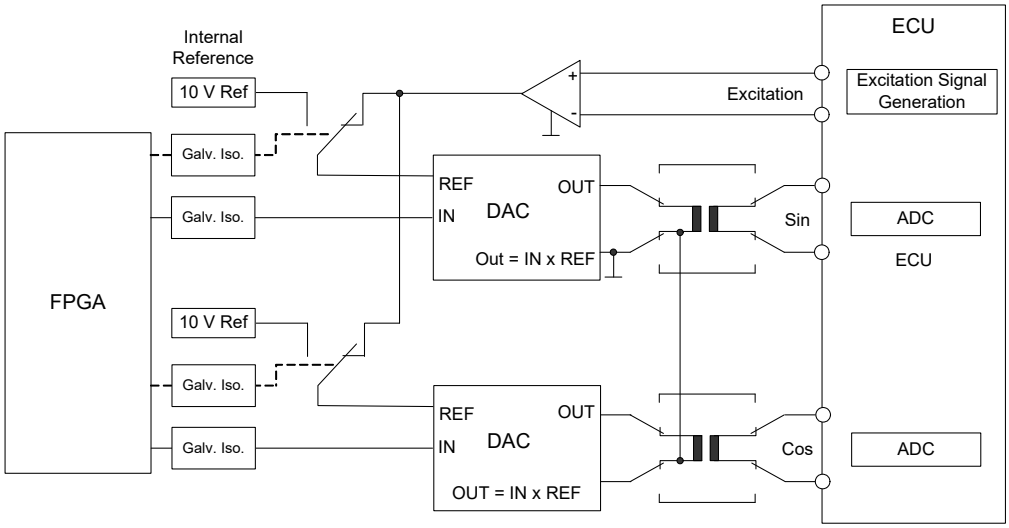


Fig. 3-3 Schematic circuit diagram of an analog output configured as "resolver"

Note

When using a resolver as position sensor, AGND of channel 6 (pin 43 and 44 of the DSUB62HD connector) has to be connected with AGND of channel 7 (pin 45 and 46 of the DSUB62HD connector)!
Without this connection the ES5340.2 cannot detect the excitation signal!

Sine Encoder

If a sine encoder (Vogt sensor) is used as the speed sensor, any two analog channels can be used for the A and B signals (see Fig. 3-4).

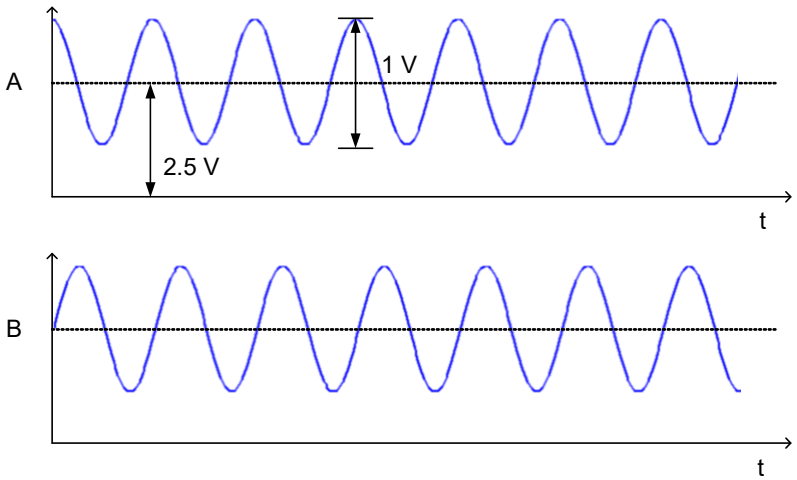


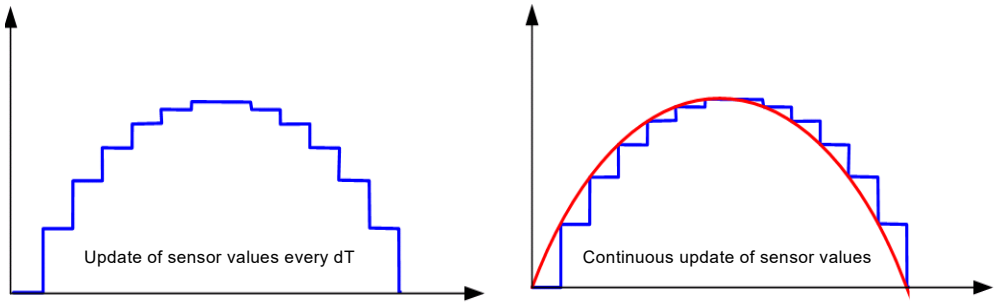
Fig. 3-4 Signals A and B of the sine encoder

Sine Extrapolated

If a model that runs on the Real-Time PC is used for the simulation, it can be used to generate sinusoidal signals such as phase currents I_u, I_v ,I_w.

With each computing cycle, the Real-Time PC model calculates an amplitude value for each phase current and phase voltage and a phase for these. With these values, the phase currents or phase voltages are output, independently of the computing cycle of the PC-based model, with an update rate of 1 µs.

The advantage of this is that the output signals are not step functions (with the step size of the PC-based model), but rather are output continuously, so to speak.



The signal generators are controlled by the central RPM unit, which runs at the mechanical angular velocity.

Analog Arbitrary

Here, preset "waveform tables" are output – the following can be configured:

- The amplitude value
- A voltage offset
- A phase
- The value for a phase change speed

Outputs for arbitrary signals can be used to output user-defined signal patterns (based on the current angle of the simulated electric motor).

This signal pattern can be used, for example, to simulate specific position sensors and other variables with a direct relationship to the motor angle.

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 two different sources:

- Outputs of the FPGA model
- Signals of type "Analog Direct Out" and analog arbitrary signals (incl. position sensors such as resolvers and sine encoders)

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

For a ES5340.2-M, eight signals can be configured for the outputs here; for a ES5340.1-S, an additional six can be configured.

Note

For slave cards (ES5340.1-S), only "Analog Direct Out" can be selected.

When using an FPGA model, the following signals are available as multiplexer inputs:

Signal	Component	Meaning
U_DC	Inverter	Inverter voltage
U_Phase_X (X = U,V,W)	Inverter	Voltage phase X
U_d	Inverter	Voltage in d direction
U_q	Inverter	Voltage in q direction
U_switch_XH (X = U,V,W)	Inverter	Voltage through high-side switch phase X
U_switch_XL (X = U,V,W)	Inverter	Voltage through low-side switch phase X
I_element_XH (X = U,V,W)	Inverter	Current through the high-side switch phase X
I_element_XL (X = U,V,W)	Inverter	Current through the low-side switch phase X
I_DC	Inverter	Inverter current
U_back_EMF_X (X = U,V,W)	PMSM*	Back EMF phase X
I_d	PMSM*	Voltage in d direction
I_q	PMSM*	Voltage in q direction
I_Phase_X (X = U,V,W)	PMSM*	Current phase X
T_el	PMSM*	Torque of electric motor
Omega_mech	Mechanical system	Angular velocity: rotor
Phi_mech	Mechanical system	Angle: rotor
Omega_el	Mechanical system	Angular velocity: electrical field
Phi_el	Mechanical system	Angle: electrical field
T_Mech	Mechanical system	Resulting mechanical torque
* Permanent magnet synchronous machine (PMSM)		

Fig. 3-5 FPGA model signals as inputs for the analog multiplexer

3.3 Generating Digital Signals

These outputs are used for different digital signals via an output multiplexer.

The **ES5340.2-M** has **eight digital outputs**, while the **ES5340.1-S** has **six digital outputs**.

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 41**).

A schematic diagram for a digital output is shown in Fig. 3-6 on page 39.

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. 3-6.
- By closing S2, the low-phase of the signal is generated. By opening S2, the high-phase is generated.

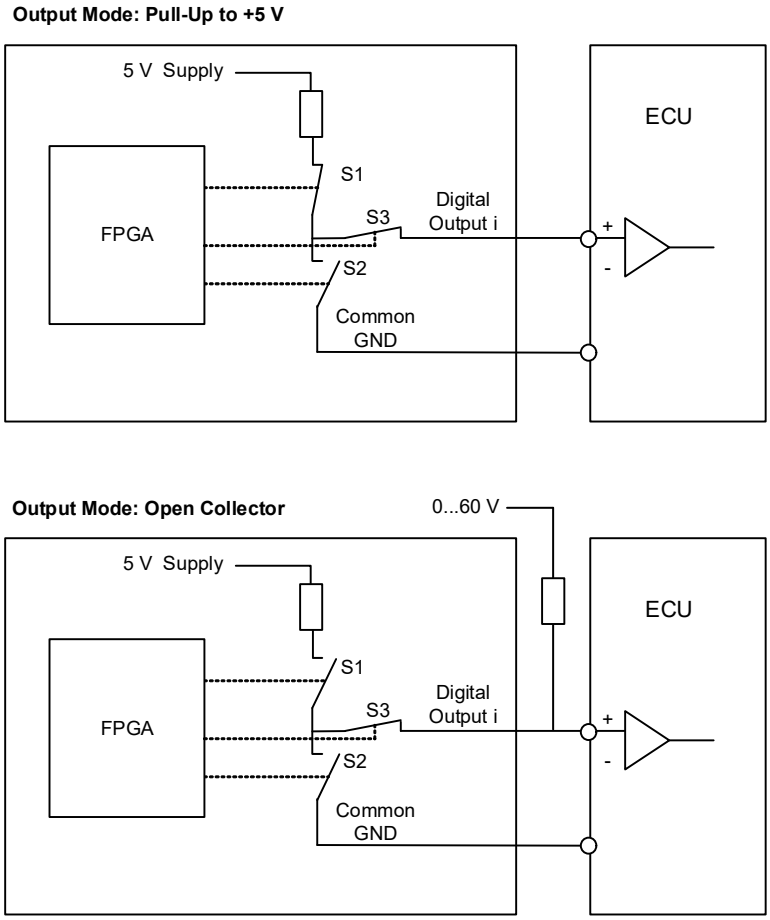


Fig. 3-6 Schematic circuit diagram of a digital output

3.3.2 Configuring the Digital Signals

Which signals are assigned to the eight (ES5340.2-M) or six (ES5340.1-S) outputs is defined in the output multiplexer (see **"Output Multiplexers for the Digital Signals" on page 41**).

You can configure the digital channels themselves as follows.

Digital Position Sensor

A digital output configured in this way supplies 3 signals with adjustable rise and drop-off of the edges (see Fig. 3-7).

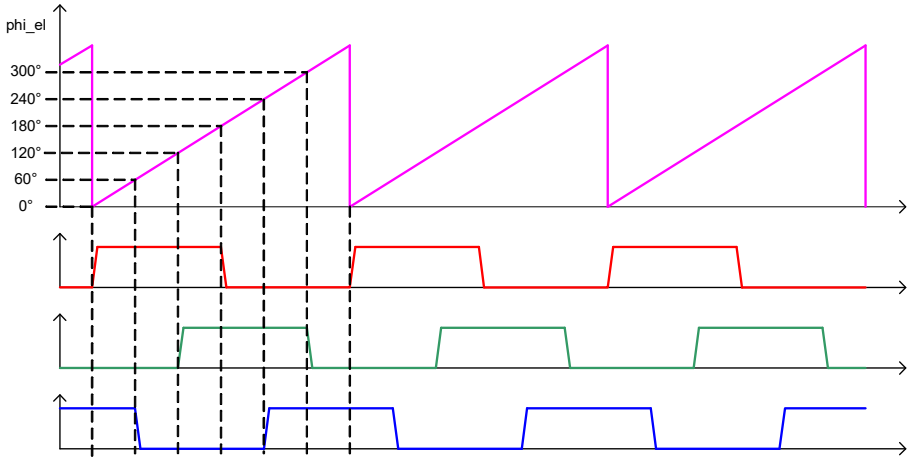


Fig. 3-7 Timing for 120° phase-shifted pulses with 180° duration

Digital Direct Out

These outputs enable you to directly stimulate ECU inputs using values from the model.

Digital Arbitrary

Outputs for arbitrary digital signals can be used to output user-defined signal patterns (based on the current angle of the simulated electric motor).

This signal pattern can be used, for example, to simulate specific position sensors and other variables with a direct relationship to the motor angle.

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

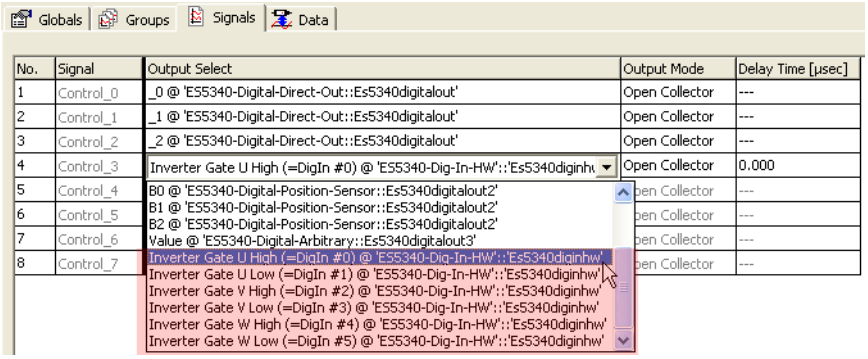
Each digital output has a multiplexer that can be used to define the signal for this output.

Sources for the Digital Outputs

The digital output channels can be driven by different sources:

- FPGA model outputs
- Signals of the type "Digital Direct Out" and digital arbitrary signals (incl. position sensor)
- SENT signals (ES5340-Out-SENT-V3)
- The delayed control signals for the inverter: six inverter control signals with an adjustable time delay can be output to the ECU for diagnostic purposes.

The sources are configured in LABCAR-RTC with the "ES5340-Digital-Out-Mux" item, "Signals" tab in the "Output Select" column. In addition to the signals configured by the user, the inverter gate signals are always available here that can be sent back to the ECU (in some cases, with an adjustable delay).



For a ES5340.2-M, eight signals can be configured for the outputs here; for a ES5340.1-S, an additional six can be configured.

Note

For slave cards (ES5340.1-S), only "Digital Direct Out" can be selected.

3.5 Analog Inputs

The ES5340.2-M has four inputs for measuring analog signals.

Note

The ES5340.1-S (Slave Board) does not have any analog inputs!

3.5.1 Specification

The **operating 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 "Globals" tab.

3.6 Digital Inputs

The ES5340.2-M has 20 inputs for measuring digital signals.

Note

The ES5340.1-S (Slave Board) does not have any digital inputs!

3.6.1 Specification

The **operating voltage range** is 0 to +60 V. All inputs are **galvanically isolatedgalvanically 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.

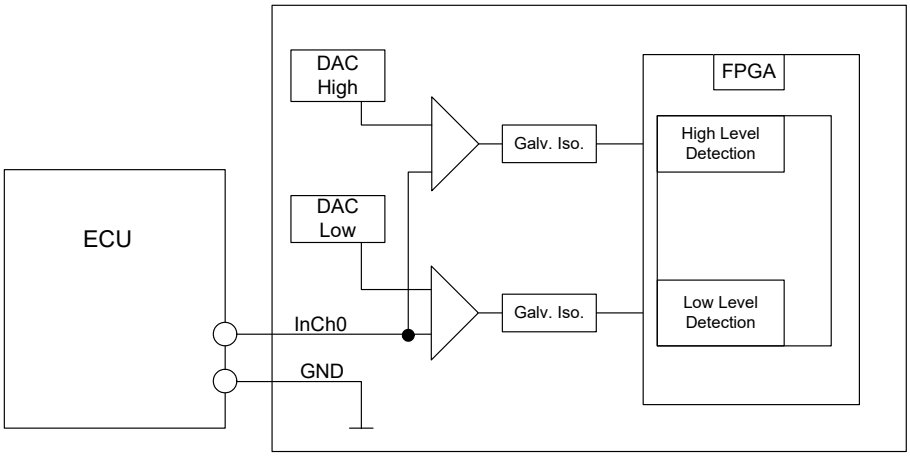
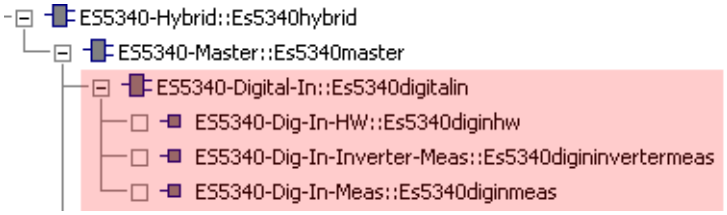


Fig. 3-8 Schematic circuit diagram of a digital input

3.6.2 Configuring the Digital Inputs

Six of the digital inputs are used to measure the gate control of the IGBT of the inverter; additional inputs can be used to measure DC/DC converter control, for example.



After you add the "ES5340-Digital-In" item to the hardware configuration, the following items are available:

- **ES5340-Dig-In-HW**

  For configuring the measurement of inverter gate signals

- **ES5340-Dig-In-Inverter-Meas**

  If a model is run on the Real-Time PC, an item must be added for measurement of the inverter gate signals from the ECU; in addition, a mapping of the current/voltage values to the analog outputs must be created.

  The duty cycles and the period of the PWM signals are measured and forwarded to the software model. The measurement itself can be synchronized to an external signal or to the PWM period determined by clock recovery.

- **ES5340-Dig-In-Meas**

  For general measurement of various properties of digital signals (frequencies, duty cycles etc.).

3.6.3 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. 3-9 on page 45.

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 46) can be configured by software.
For this reason, make sure that +VBAT and -VBAT are always connected.

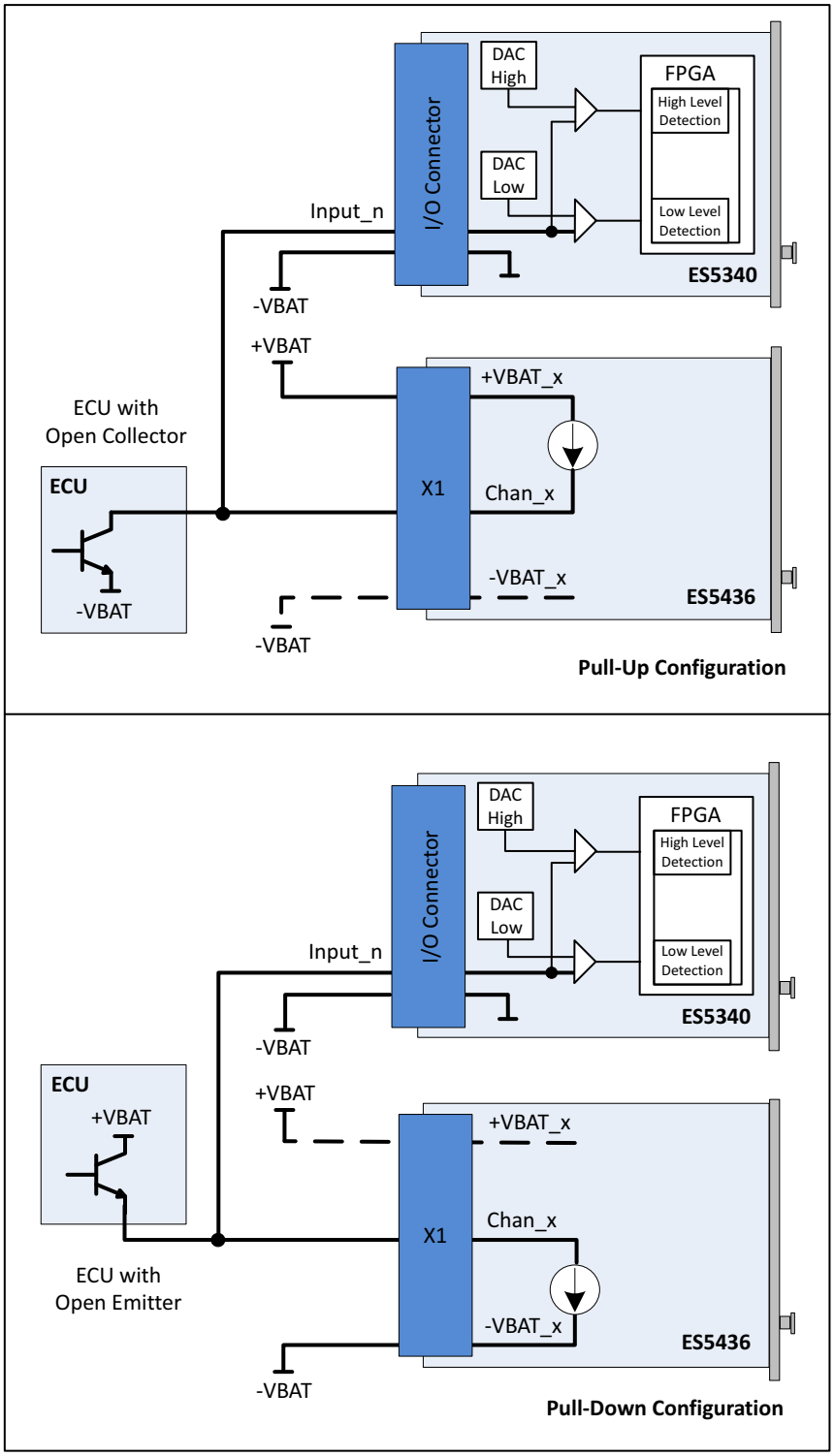


Fig. 3-9 Measurement of digital ECU output signals in the configuration "Pull-Up" or "Pull-Down" using ES5340 for measurement and ES5436.1 as load simulation

3.6.4 Configuration as H-Bridge

Fig. 3-10 shows the configuration as H-bridge.

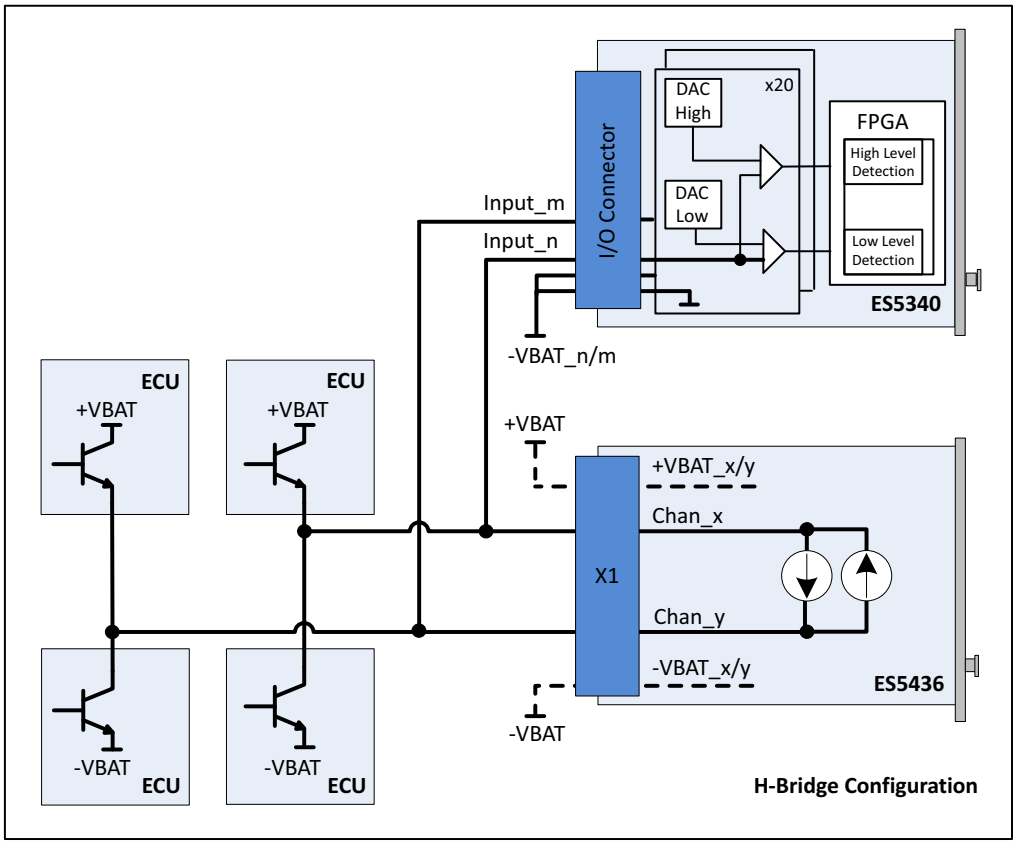


Fig. 3-10 Block diagram for configuration as H-bridge using ES5340 for measuring Chan_x and Chan_y

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. 3-10) must be connected to the same -VBAT potential.

3.7 RPM Generator

The ES5340.2 Electric Drive Simulation Board 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 combustion engine)
- 30000 rpm (for 360° mechanical angle of an electric motor)

The maximum angle resolution is 0.011 °CA (16 Bit).

3.7.1 Angle Clock Signal

The angle clock signal consists of three signals (see Fig. 3-11):

- 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 "Connectors for the Angle Clock Signal (ES5340.2-M only)" on page 101).

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° and "Low" (= 0 V) for crankshaft angles between 360° and 720°.

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

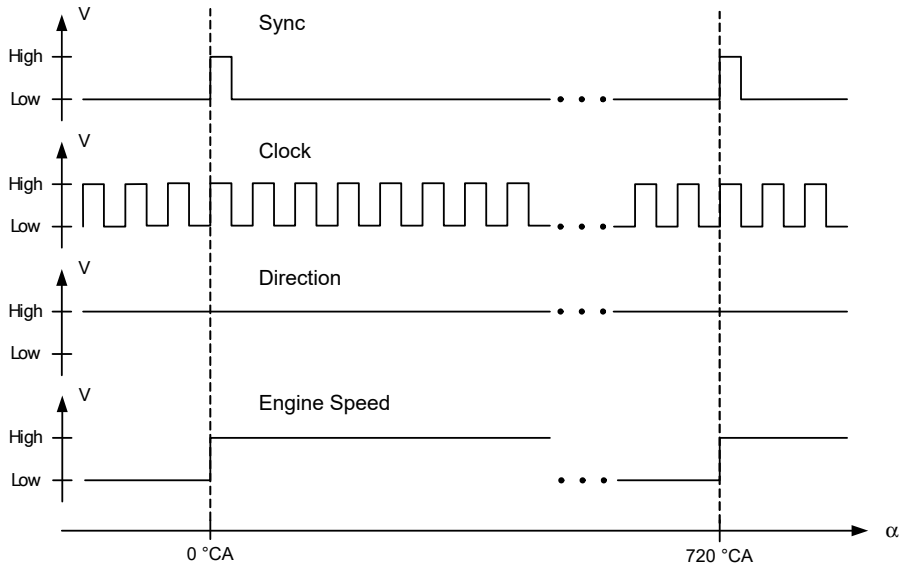


Fig. 3-11 Sync, Clock, Direction and Engine Speed signals

3.7.2 Synchronization

An angle or speed-based synchronization of multiple ES5340.2 Electric Drive Simulation Boards is possible. For this purpose, any ES5340.2 is configured as the RPM master, all other ES5340.2 as RPM slaves.

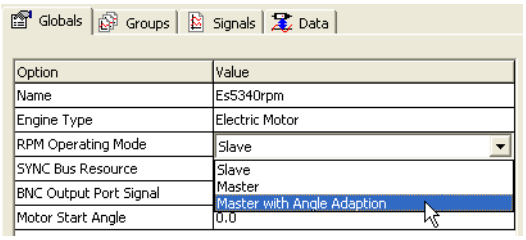
3.7.3 "Master with Angle Adaptation" RPM Mode

To enable synchronization of the RPM unit with a model on the Real-Time PC or the FPGA model, the RPM unit (as the master) must be adapted to the current angle of the respective model (angle adaptation).

The speed, angle and the difference between the target angle (model) and current angle are calculated by the model. The RPM unit is then sped up or slowed down – this ensures that the speed difference is eliminated within the next simulation period (without changing the number of pulses of a "mechanical" period, 360 °).

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 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 and transmitted to the system hardware on the SYNC bus.

- **Master with Angle Adaptation**

  The angle clock signal is generated – based on the mechanical angular velocity *and* the current angle – on the ES5340.2 and transmitted to the system hardware on the SYNC bus.

4 FPGA Models

This chapter provides a description of the FPGA models available for purchase for the ES5340.2 Electric Drive Simulation Board.

Note

If you want to purchase a model separately later, the chapter "Order Information and Scope of Delivery" on page 103 provides additional ordering information.

4.1 Permanent Magnet Synchronous Machine (PMSM) Model

The ES5340.2-M can be expanded by adding a configurable, FPGA-based inverter/PMSM model. It maps a 3-phase inverter and a permanent magnet synchronous machine (PMSM) with mechanical system.

With great simulation accuracy, the model takes into account all important physical effects required for a reliable test, such as saturation and temperature effects of engine parameters. In particular, this enables very accurate calculation of the simulated phase currents.

Within the entire model, calculation takes place using floating-point arithmetic rather than fixed-point arithmetic. As a result, a very high level of accuracy is obtained over the entire parameter and simulation range. The FPGA-based model provides an additional, significant reduction of the cycle times of the model to 850 ns – compared to approx. 10 µs when running a corresponding model on a Real-Time PC.

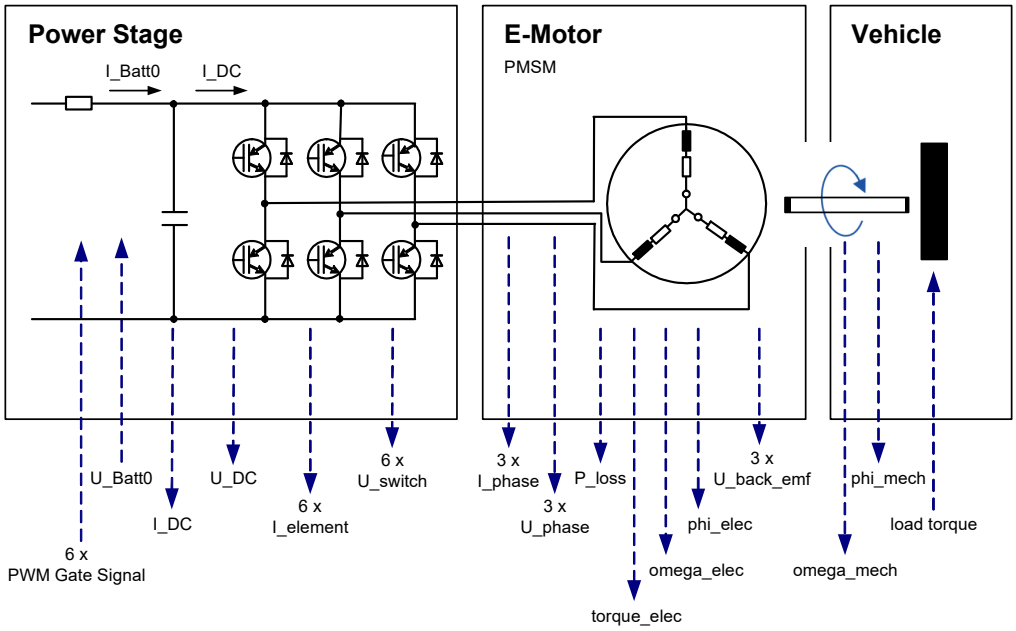


Fig. 4-1 The modeled system

Inverter

The inverter has the following tasks:

- Generating AC voltage to operate the 3-phase electric motor from the DC voltage of the battery (motor operation)

as well as:

- Generating DC voltage to charge the battery from the AC voltage of the electric motor (generator mode, recuperation)

The inverter is controlled by the hybrid ECU according to the requirement of torque or speed – depending on the driver command (accelerate, brake) and battery charge level.

Specifically, this means (see Fig. 4-2):

- Measuring the position (φ) and speed (dφ/dt) of the electric motor
- Measuring the DC-link current (I_{DC}), the DC-link voltage (U_{DC}) and the phase currents ($I_{U,V,W}$, I_{DC}) from/to the electric motor

and, as a result,

- Calculating the target voltages at the motor terminals
- and, in turn, calculating the switching phases of the switches in the inverter branches

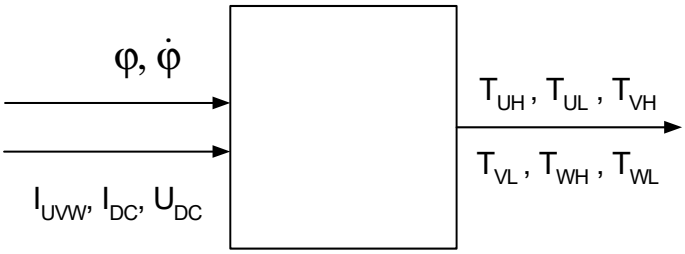


Fig. 4-2 Measurement and control variables of the inverter ECU

Synchronous Motor (PMSM)

The "PMSM" part of the model is used to simulate the phase currents and the torque of the electric motor.

The PMSM is likewise configured via typical variables, such as the number of pole pairs and cogging positions. Additional variables such as resistance, inductance, the magnetic flow and the cogging torque can be changed during run time. For the PMSM, the power loss of the ohmic components can also be simulated and their temperature dependence can be calculated.

Mechanical System

For the mechanical connection to the drive train, the FPGA model also includes a simulation of the spring-mass system. The system is configured with the typical variables of coefficient of friction, moment of inertia for rotor and load, torsional rigidity and damping. The load moment of the drive train can be preset and changed during run-time.

4.1.1 Inverter – Parameters, Inputs and Outputs

This section provides the description of all parameters, inputs and outputs of the "Inverter" part of the model.

Properties of the Inverter Model

The inverter model has the following properties:

- Switches can be high- or low-active
- Simulation of hardware failures (switches always open or closed)
- Simulation of phase voltages U_Phase_X (X = U, V, W) and U_d, U_q
- Simulation of phase voltages on free wheeling (all six inverter switches open)
- Simulation of DC voltage link
- Simulation of voltages across a switch and of current through the switch
- Simulation of ohmic losses in switches and diodes.
- Information on phase errors (upper and lower switches are open simultaneously)

Parameters

The parameters of the inverter model are configured in LABCAR-RTC in the "Globals" tab of the item for the FPGA model.

Note

For details about configuring the FPGA model in LABCAR-RTC, refer to the section "FPGA model" on page 71.

Parameter [unit]	Description	Default value
Gate Signal Polarity []	"High Active": switches through when gate is "High" "Low Active": switches through when gate is "Low"	"High Active"
R_SW_ON [Ω]	Resistance of the switch in conductive state (20 °C, 68 °F)	0.001
U_SW_Fwd [V]	Forward voltage across switch in conductive state (20 °C, 68 °F)	0.7
R_D_Fwd [Ω]	Resistance of the diode in conductive state (20 °C, 68 °F)	0.001
U_D_Fwd [V]	Forward voltage across diode in conductive state (20 °C, 68 °F)	0.7
T_Switch [s]	Switching time (for calculating the ohmic losses)	0.000005
a_Inv [1/K]	Temperature coefficient of the ohmic resistance of switch and diode	0.00393
R_Batt [Ω]	Internal resistance of the battery for the inverter voltage	0.5
C_DC [mF]	Capacitance of DC voltage link	0.5

Tab. 4-1 Parameters of the inverter model

Inputs

In addition to the voltage and temperature of the inverter, you can configure signals here that you can use simulate failures of the inverter during runtime (switch getting stuck on "High" or "Low").

You can connect the inputs of the inverter model to other models (in the Connection Manager of LABCAR-IP) or stimulate them in the Signal Center in LABCAR-EE.

Input [unit]	Description	Default value
Fail_HS_X (X=U,V,W) []	Gate failure highside switch phase X: 0 = no failure 1 = stuck on "Low" 2 = stuck on "High"	0
Fail_LS_X (X=U,V,W) []	Gate failure lowside switch phase X: 0 = no failure 1 = stuck on "Low" 2 = stuck on "High"	0
U_Batt0 [V]	Input voltage of the inverter	0.0
Theta_Inv [°C]	Temperature of the inverter	20.0

Tab. 4-2 Inputs of the inverter model

Outputs

You can connect the outputs of the inverter model with analog or digital outputs (in LABCAR-RTC) and to other models (in the Connection Manager of LABCAR-IP).

Output [unit]	**Description**	**Signal available as multiplexer input**
U_Phase_X (X=U,V,W) [V]	Voltage Phase X	Analog MUX
U_d [V]	Voltage in d direction	Analog MUX
U_q [V]	Voltage in q direction	Analog MUX
I_DC [A]	Total inverter current	Analog MUX
U_DC [V]	Inverter voltage	Analog MUX
I_element_XH (X=U,V,W) [A]	Current through upper switch phase X	Analog MUX
I_element_XL (X=U,V,W) [A]	Current through lower switch phase X	Analog MUX
U_switch_XH (X=U,V,W) [V]	Voltage through upper switch phase X	Analog MUX
U_switch_XL (X=U,V,W) [V]	Voltage through lower switch phase X	Analog MUX
P_Loss_Inv [W]	Ohmic losses in inverter	- *
Error []	Error register If upper and lower switches are at "High" simultaneously, a phase error occurs Bit 0: Phase U Bit 1: Phase V Bit 2: Phase W	- *

* Model output (can be used by another model or managed in the Connection Manager (LABCAR-IP) and the Signal Center (LABCAR-EE))

Tab. 4-3 Outputs of the inverter model

4.1.2 PMSM – Parameters, Inputs and Outputs

This section provides the description of all parameters, inputs and outputs of the "PMSM" part of the model.

Properties of the PMSM Model

The PMSM model has the following properties:

- Simulation of phase currents I_Phase_X (X = U, V, W) and I_d, I_q
- Simulation of counter emf
- Consideration of cogging torque when simulating the torque of the electrical motor
- Output of status signal (U_phase_U > U_phase_V) for the matching of position sensors
- Simulation of ohmic losses
- Setting of simulation start values for I_d and I_q
- R_d, R_q, L_d, L_q and magnetic flux can be changed in real-time

Parameters

The parameters of the electric motor model are configured in LABCAR-RTC in the "Globals" tab of the item for the FPGA model.

Parameter [unit]	Description	Default value
Pole Pairs []	Number of pole pairs of the electric motor	12
Ncog []	Number of cogging positions	18
T_cm [Nm]	Maximum amount of cogging torque	0.0
Id Init [A]	Initial value of I_d (see Tab. 4-6 on page 56)	0.0
Iq Init [A]	Initial value of I_q (see Tab. 4-6 on page 56)	0.0
a_M [1/K]	Temperature coefficient of R_d and R_q	0.00430

Tab. 4-4 Parameters of the PMSM model

Inputs

You can connect the inputs of the PMSM model to other models (in the Connection Manager of LABCAR-IP) or stimulate them in the Signal Center in LABCAR-EE.

Input [unit]	Description	Default value
Rd [Ω]	Coil resistance in d direction	0.0125
Rq [Ω]	Coil resistance in q direction	0.0125
Ld [H]	Coil inductance in d direction	0.000211
Lq [H]	Coil inductance in q direction	0.000211
Psi [Vs]	Magnetic flux	0.0382
Theta_M [°C]	Engine temperature	20.0

Tab. 4-5 Inputs of the PMSM model

Outputs

You can connect the outputs of the PMSM model with analog or digital outputs (in LABCAR-RTC) and to other models (in the Connection Manager of LABCAR-IP).

Output [unit]	Description	Signal available as multiplexer input
I_d [A]	Current in d direction	Analog MUX
I_q [A]	Current in q direction	Analog MUX
I_phase_X (X=U,V,W) [A]	Current Phase X	Analog MUX
U_back_EMF_X (X=U,V,W) [V]	Voltage X back EMF	Analog MUX
ZeroPos []	Signal is active if phase voltage U_Phase_U > U_Phase_V	Digital_MUX
T_el [Nm]	Torque of electric motor	-
P_Loss_M [W]	Ohmic losses of the motor	-

Tab. 4-6 Outputs of the PMSM Model

4.1.3 Mechanical System – Parameters, Inputs and Outputs

This section provides the description of all parameters, inputs and outputs of the "Mechanical system" part of the model.

Properties of the Mechanical Model

The mechanical model has the following properties:

- Simulation of angle and angular velocity of the rotor and the electrical field
- Resulting mechanical torque

Parameters

The parameters of the mechanical system model are configured in LABCAR-RTC in the "Globals" tab of the item for the FPGA model.

Parameter [unit]	Description	Default value
f [Nms]	Coefficient of friction of the electric motor	1.7
J_E [kgm^2]	Moment of inertia of the rotor	0.12
J_L [kgm^2]	Moment of inertia of the load (powertrain etc.)	0.10
C [Nm/rad]	Torsional stiffness ("spring constant") of the "spring" between rotor and load.	1500000
D [Nms/rad]	Damping of the "spring" between rotor and load.	100
Phi_mech_init [°]	Initial mechanical angle	0.0
Omega_mech_init [1/s]	Initial mechanical speed	0.0

Tab. 4-7 Parameters of the mechanical model

Inputs

You can connect the inputs of the mechanical model to other models (in the Connection Manager of LABCAR-IP) or stimulate them in the Signal Center in LABCAR-EE.

Input [unit]	Description	Default value
T_L [Nm]	Load moment	

Tab. 4-8 Inputs of the mechanical model

Outputs

You can connect the outputs of the mechanical model with analog or digital outputs (in LABCAR-RTC) and to other models (in the Connection Manager of LABCAR-IP).

Output [unit]	**Description**	**Signal available as multiplexer input**
Omega_mech [1/s]	Angular velocity: rotor	Analog MUX
Phi_mech [°]	Angle: rotor	Analog MUX
Omega_el [1/s]	Angular velocity: electrical field	Analog MUX
Phi_el [°]	Angle: electrical field	Analog MUX
T_mech [Nm]	Resulting mechanical torque	Analog MUX

Tab. 4-9 Outputs of the mechanical model

4.2 Induction Machine (IM) Model

The FPGA model of an induction machine (IM) is build up out of a three-phase inverter and an induction machine including mechanics. Many experiences out of the development of electrical drives took influence on this model. So it is able to simulate the essential physical effects needed for reliable tests, like temperature effects or saturations of motor parameters. It is build up according to a balanced behavior between runtime and accuracy.

Within the whole model calculations are made with floating-point arithmetic which results in a very high accuracy over the whole parameter- and simulation-area. With the FPGA based model the model step sizes are once more reduced drastically to 850 ns – according to about 10 µs of a related model executed on a real-time PC. This makes it possible to detect a PWM signal via Hardware with a high accuracy and directly use this signal in the inverter model.

The model consists of three parts:

- Inverter
- Induction machine (IM)
- Mechanical load.

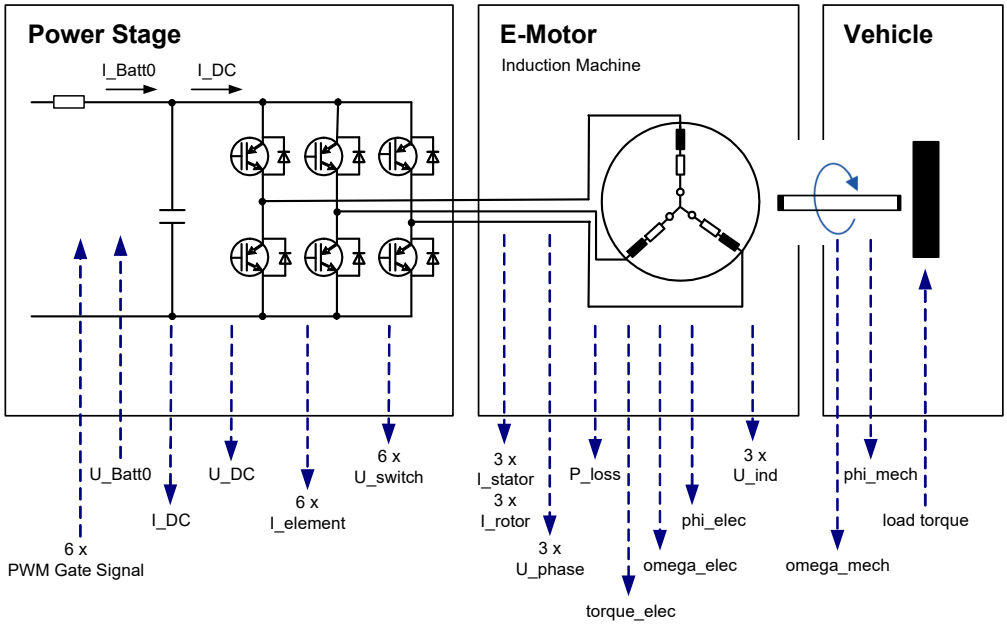


Fig. 4-3 The modeled system

Inverter Model

The parameterization of the inverter is done by using typical values like switching times, polarity or resistances of switches and diodes. For every switch it is possible to parameterize the failure states "Open" and "Closed". Also the "freewheeling" can be simulated, when all six switches are opened.

For the whole inverter also the temperature dependent power loss of ohmic components is considered. The inputs of the inverter include the inner resistance of the battery as well as the intermediate circuit capacitance, which makes it possible to simulate the intermediate circuit voltage.

IM Model

The parameterization of the induction machine is done by using typical values like pole pair number or temperature coefficient. Other values like resistances, inductivities and temperature are changeable during runtime. This allows for a very accurate simulation of phase currents and electrical torque.

Mechanical Model

For the mechanical connection to the drive train, the spring-damper system is also simulated inside the model. The parameterization of the mechanical model is done by using typical values like friction coefficient, inertias for rotor and load, torsional stiffness and damping. The load torque of the drive train can be changed by the user during runtime.

4.2.1 Inverter – Parameters, Inputs and Outputs

Parameters

Parameter [unit]	Description	Value range	Default value
Gate Signal Polarity	"High Active": Conducting when gate is "High" "Low Active": Conducting when gate is "Low"	Low Active, High Active	High Active
U_SW_Fwd [V]	Forward voltage across switch in conductive state (20 °C, 68 °F)	0.0 - 3.0	0.7
U_D_Fwd [V]	Forward voltage across free-wheeling diode in conductive state (20 °C, 68 °F)	0.0 - 3.0	0.7
T_Switch [s]	Switching time	0.0000002 - 0.000001	0.0000005
a_Inv [1/K]	Temperature coefficient of the ohmic resistance of the inverter	0.0 - 0.01	0.00393
R_Batt [Ω]	Internal resistance of battery	0.01 - 10.0	0.5
C_DC [mF]	Capacitance of intermediate circuit	0.01 - 10.0	0.5

Tab. 4-10 Parameters of the inverter model

Inputs

Input [unit]	Description	Value range	Default value
Fail_HS_X (X=U,V,W) []	Gate failure highside switch phase X: 0 = no failure 1 = stuck on "Low" 2 = stuck on "High"	0, 1, 2	0
Fail_LS_X (X=U,V,W) []	Gate failure lowside switch phase X: 0 = no failure 1 = stuck on "Low" 2 = stuck on "High"	0, 1, 2	0
U_Batt0 [V]	Input voltage of the inverter	0.0..1500.0	0.0
Theta_Inv [°C]	Temperature of the inverter	-50.0..200.0	20.0
R_SW_ON [Ω]	Resistance of the switch in conductive state (20 °C, 68 °F)	0.0..0.05	0.001
R_D_Fwd [Ω]	Resistance of the diode in conductive state (20 °C, 68 °F)	0.0..0.05	0.001

Tab. 4-11 Inputs of the inverter model

Outputs

Output [unit]	Model Value (min) default / range	Model Value (max) default / range	DAC Voltage (min) default / min	DAC Voltage (max) default / max
I_Batt	-1500 / -1500..1500	1500 / -1500..1500	-10.0 / -10.0	10.0 / 10.0
U_DC [V]	0 / 0..1500	1500 / 0..1500	0 / 0	10.0 / 10.0
I_DC [A]	-1500 / -1500..1500	1500 / -1500..1500	-10.0 / -10.0	10.0 / 10.0
I_element_XH (X=U,V,W) [A]	-1500 / -1500..1500	1500 / -1500..1500	-10.0 / -10.0	10.0 / 10.0
I_element_XL (X=U,V,W) [A]	-1500 / -1500..1500	1500 / -1500..1500	-10.0 / -10.0	10.0 / 10.0
U_switch_XH (X=U,V,W) [V]	-150 / -150..1500	1500 / -1500..1500	-1.0 /-1.0	10.0 / 10.0
U_switch_XL (X=U,V,W) [V]	-150 / -150..1500	1500 / -1500..1500	-1.0 /-1.0	10.0 / 10.0
U_phase (X=U,V,W) [V]	-150 / -150..1500	1500 / -1500..1500	-1.0 /-1.0	10.0 / 10.0
P_loss_Inv [W]	4000 / 0.0..20000	4000 / 0.0..20000	-	-

Tab. 4-12 Outputs of the inverter model

4.2.2 Induction Machine – Parameters, Inputs and Outputs

Parameters

Parameter [unit]	Description	Value range	Default value
Pole Pairs []	Number of pole pairs	1 - 16	12
I_stator_X_Init (X=U,V,W) [A]	Initial current in stator phases	-1500.. +1500	0
I_rotor_X_Init (X=U,V,W) [A]	Initial current in rotor phases	-1500.. +1500	0
a_M [1/K]	Temperature coefficient of ohmic resistance of the stator coils	0.0..0.01	0.00430

Tab. 4-13 Parameters of the IM model

Inputs

Input [unit]	Description	Value range	Default value
Rs1 [Ω]	Stator coil resistance at 20 °C	0.0..1.0	0.1
Rs2 [Ω]	Rotor coil resistance at 20 °C	0.0..1.0	0.1
Lm [H]	Effective inductance	0.0..1.0	0.025
Ls1 [H]	Stator coil inductance	0.0..0.1	0.001
Ls2 [H]	Rotor coil inductance	0.0..0.1	0.001
Theta_M [°C]	Engine temperature	-50.0..200.0	20.0

Tab. 4-14 Inputs of the IM model

Outputs

Output [unit]	Model value (min) default / range	Model value (max) default / range	DAC voltage (min) default / min	DAC voltage (max) default / max
I_stator_X (X=U,V,W) [A]	-1500	+1500	-10.0 / -10.0	10.0 / 10.0
I_rotor_X (X=U,V,W) [A]	-1500	+1500	-10.0 / -10.0	10.0 / 10.0
U_ind_X (X=U,V,W) [V]	-1500	+1500	-10.0 / -10.0	10.0 / 10.0
T_el [Nm]	-1000 / -1000..1000	1000 / -1000..1000	-10.0 / -10.0	10.0 / 10.0
P_loss_M [W]	4000 / 0.0 - 20000	4000 / 0.0 - 20000	-	-

Tab. 4-15 Outputs of the IM model

4.2.3 Mechanical System – Parameters, Inputs and Outputs

Parameters

Parameter [unit]	Descriptions	Value range	Default value
f [Nms]	Friction coefficient of E-machine	0.0 - 10.0	1.7
J_E [kgm^2]	Inertia of rotor	0.0 - 1.0	0.12
J_L [kgm^2]	Inertia of load	0.0 - 10.0	0.10
C [Nm/rad]	Torsional stiffness	0.0 - 10000000.0	1500000.0
D [Nms/rad]	Damping between rotor and load	0.0..1000.0	100.0
Phi_mech_Init [°]	Inital mechanical angle	0.0..360.0	0.0
Omega_mech_Init [rad/s]	Initial mechanical velocity	-833.333.. +833.333	0.0

Tab. 4-16 Parameters of the mechanical model

Inputs

Input [unit]	Description	Value Range	Default value
T_L [Nm]	Torque of electric motor	-1000.0..1000.0	0.0

Tab. 4-17 Inputs of the mechanical model

Outputs

Output [unit]	Model value (min) default / range	Model value (max) default / range	DAC voltage (min) default / min	DAC voltage (max) default / max
Omega_mech [rad/s]	-50000 / -50000..50000	50000 / -50000..50000	-10.0 / -10.0	10.0 / 10.0
Phi_mech [°]	0 / 0..360	360 / 0..360	0 / -10.0	10.0 / 10.0
Omega_el [rad/s]	-10000 / -50000..50000	10000 / -50000..50000	-10.0 / -10.0	10.0 / 10.0
Phi_el [°]	0 / 0..360	360 / 0..360	0 / -10.0	10.0 / 10.0
T_mech [Nm]	-2000 / -2000..2000	2000 / -2000..2000	-10.0 / -10.0	10.0 / 10.0

Tab. 4-18 Outputs of the mechanical model

5 Configuring the Hardware in LABCAR-RTC

This chapter provides a description of the procedure for configuring the hardware in LABCAR-RTC.

- **"General Settings" on page 66**

  This section provides a description of a few basic settings of the hardware configuration.

  – ""ES5340-Master" item" on page 66
  – "Measuring the Gate Trigger Signals" on page 67
  – "RPM Unit" on page 69

- **"Integration of the Model" on page 71**

  The next step consists of configuring the connections to a model.

  – "FPGA model" on page 71
  – "Software Model" on page 75

- **"I/O Configuration" on page 81**

  This chapter provides a description of the configuration of the input and output channels of the ES5340.2.

  – "Position sensors" on page 81
  – "Analog Outputs" on page 84
  – "Digital Outputs" on page 86
  – "Analog Inputs" on page 89
  – "Digital Inputs" on page 90
  – "Signal Output via the Analog Multiplexer" on page 92
  – "Signal Output via the Digital Multiplexer" on page 94

5.1 General Settings

This section provides a description of a few basic settings of the hardware configuration.

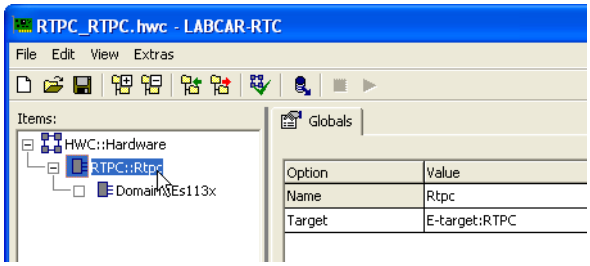
In particular, they include:

- "Creating an "ES5340-Master" Item" on page 66
- "Adding an "ES5340-Digital-In" Item" on page 67
- "Adding an "ES5340-Dig-In-HW" Item" on page 67
- "Assigning Inverter Gates to Measurement Channels" on page 68
- "Creating an "ES5340-RPM" Item" on page 69

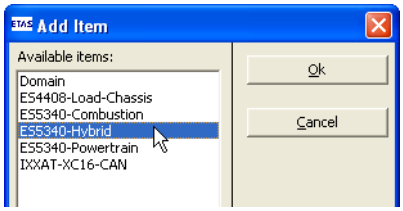
5.1.1 "ES5340-Master" item

Creating an "ES5340-Master" Item

1. In LABCAR-IP, select **Project** → **RTIO Editor**.
   The editor of LABCAR-RTC is opened.
2. Select the "RTPC" system.

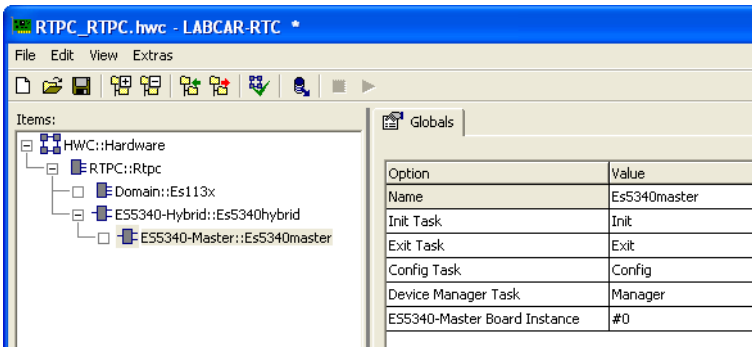


3. Right-click and select **Add Item**.
4. In the selection dialog, select the item "ES5340-Hybrid".



5. Click **OK**.
   The item is added.

6. In the same way, add an "ES5340-Master" item to the "ES5340-Hybrid" item.



7. Select **File** → **Save**.

Note

Error messages in the monitor window indicate that the configuration of the hardware is not yet complete.

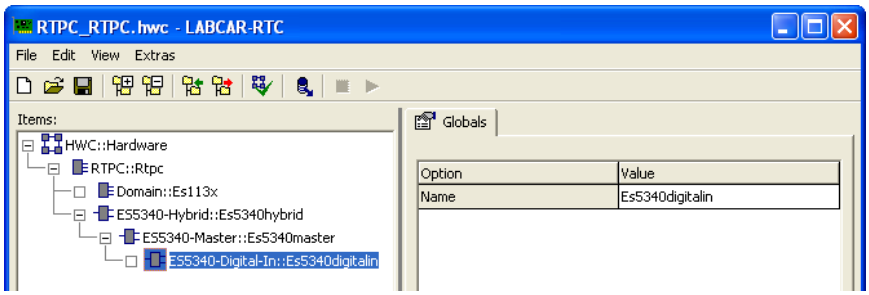
5.1.2 Measuring the Gate Trigger Signals

To measure the PWM control signals for the inverter, you have to add an item for measuring digital signals.

Adding an "ES5340-Digital-In" Item

1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Digital-In" item and click **OK**.

   The item is added.

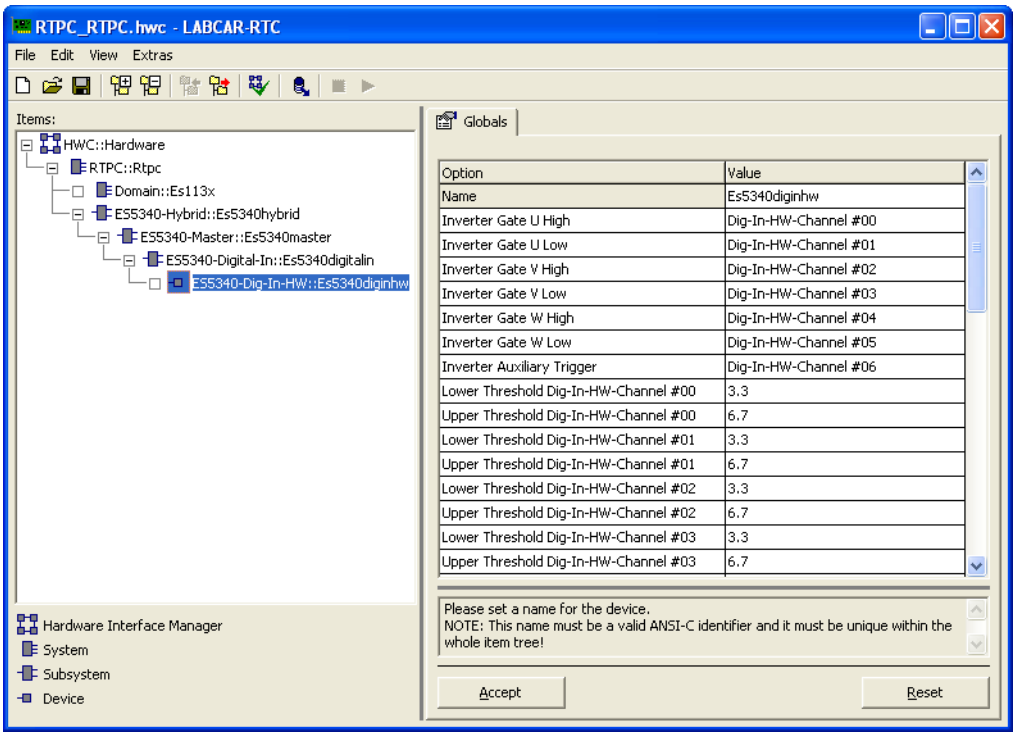


Adding an "ES5340-Dig-In-HW" Item

1. Right-click the "ES5340-Digital-In" item and select **Add Item**.

2. In the list, select the "ES5340-Dig-In-HW" item and click **OK**.

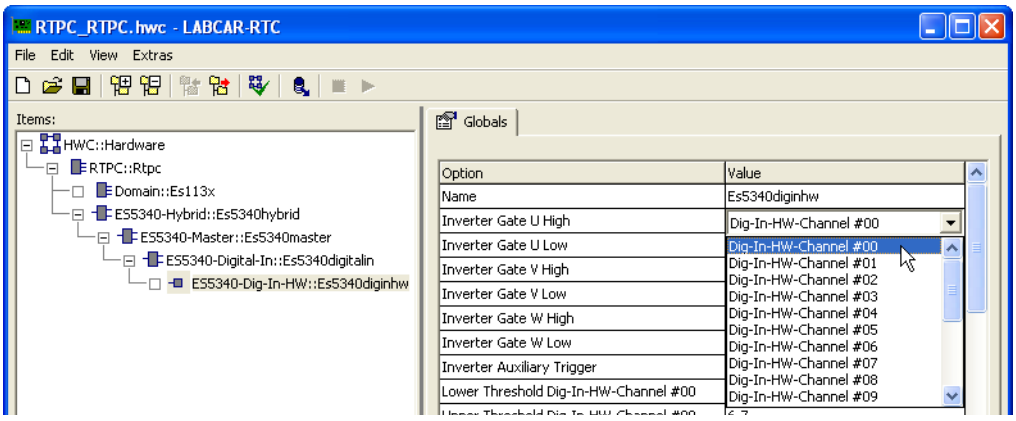
   The item is added.



Assigning Inverter Gates to Measurement Channels

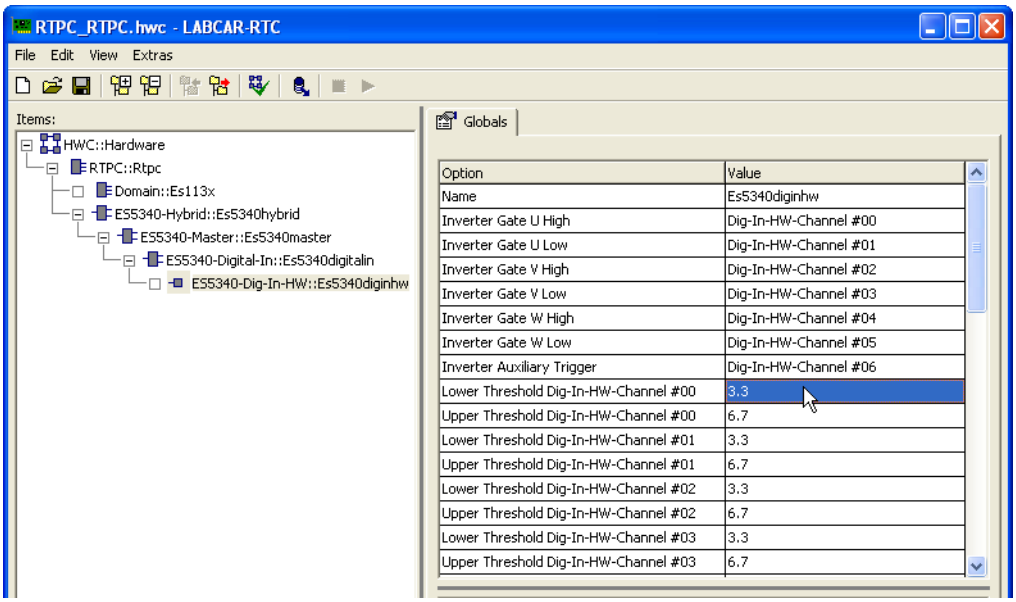
For the ES5340.2-M, we assume that six gate signals are present (two for each phase).

1. Assign the gate signals to the desired measurement channels.



When measuring the gate control, for each measurement channel, one upper and one lower voltage level can be specified, below (above) which the signal is identified as "low" ("high").

2. Edit the option for the corresponding threshold values accordingly.



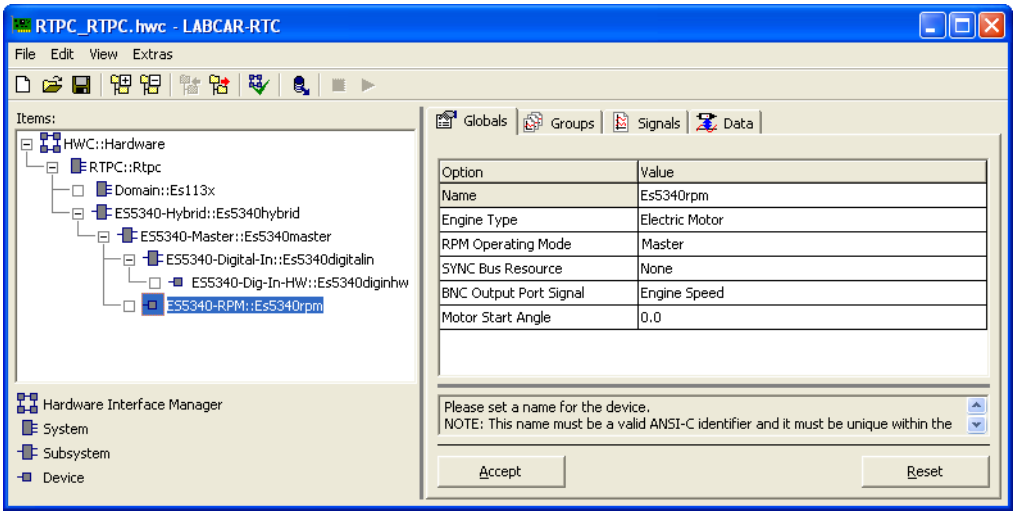
5.1.3 RPM Unit

The RPM unit is used to generate speed and angle information that is required by position sensors and other angle-synchronous signals.

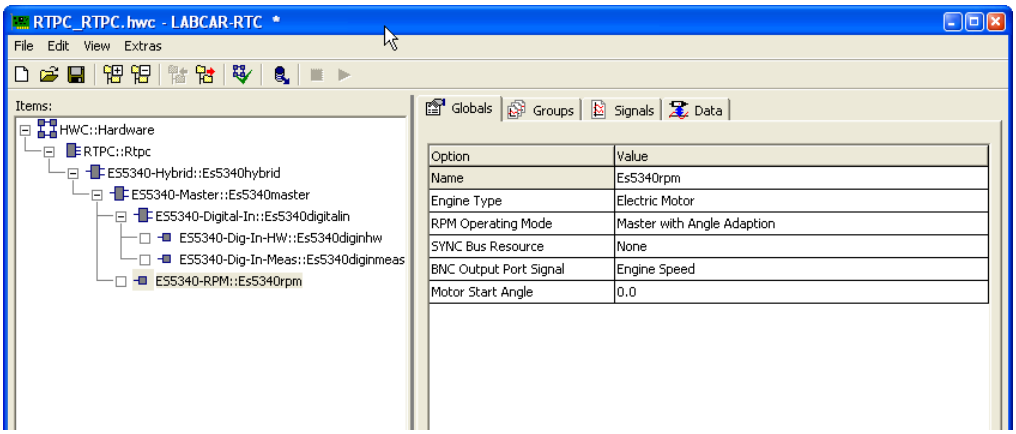
Creating an "ES5340-RPM" Item

1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-RPM" item and click **OK**.

   The item is added.



3. For the specific application "Electric Motor", configure the settings in the "Globals" tab as shown:



The ES5340.2 can thus be configured as the RPM master for other hardware.

5.2 Integration of the Model

The next step consists of configuring the connections to a model.

This requires different measures depending on the type of the model:

- FPGA model

  This model is run autonomously on the ES5340.2 Electric Drive Simulation Board and is configured in LABCAR-OPERATOR.

  Note

  The FPGA model is an optional component of the ES5340.2 Electric Drive Simulation Board and must be ordered separately (see "Order Information and Scope of Delivery" on page 103).

- Software model

  A software model (ASCET, Simulink or C code) is run on the Real-Time PC, synchronized with the PWM signals from the ECU.

Specifically, the following measures are described:

- "FPGA model" on page 71
  - "Adding the FPGA Model in LABCAR-RTC" on page 71
  - "Configuring the Model Parameters" on page 73
  - "Configuring the Value Ranges" on page 74
  - "Determining Default Values" on page 75
  - "Configuring Outputs for Current/Voltage Sensors" on page 77
- "Software Model" on page 75
  - "Configuring the Inverter Gate Measurement" on page 75
  - "Adding Analog Outputs ("Direct out")" on page 77
  - "Adding Analog Outputs (for Predicted Values)" on page 78

5.2.1 FPGA model

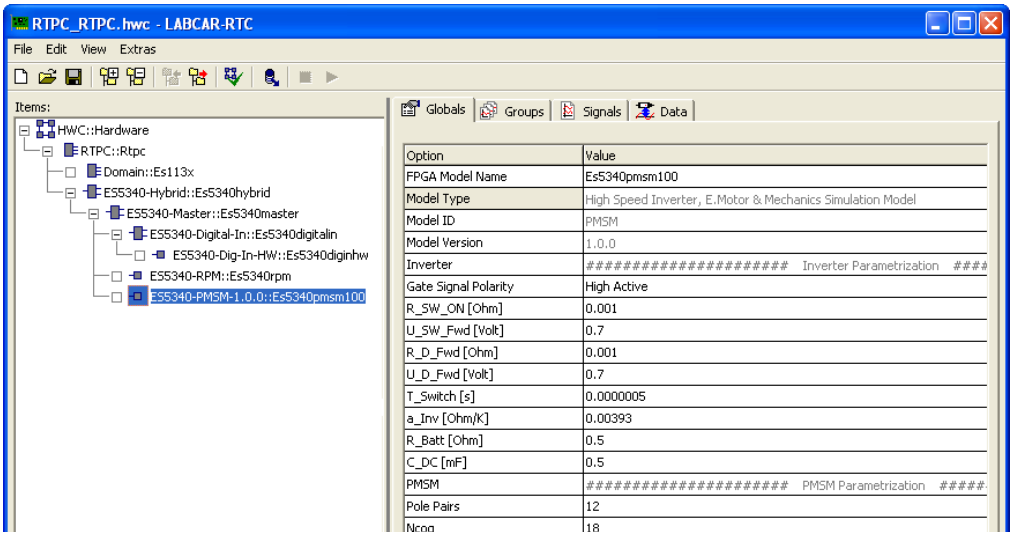
For configuring the FPGA model, you first have to add the corresponding item.

Adding the FPGA Model in LABCAR-RTC

1. Select the "ES5340-Master" item and click **Add Item**.

2. From the list, select the "ES5340-PMSM-X.X.X" item and click **OK**.

   The item is added.



Configuring the Model Parameters

The model is configured in the "Globals" tab and is divided into three model components: "Inverter", "PMSM" and "Mechanics".

Globals | Groups | Signals | Data

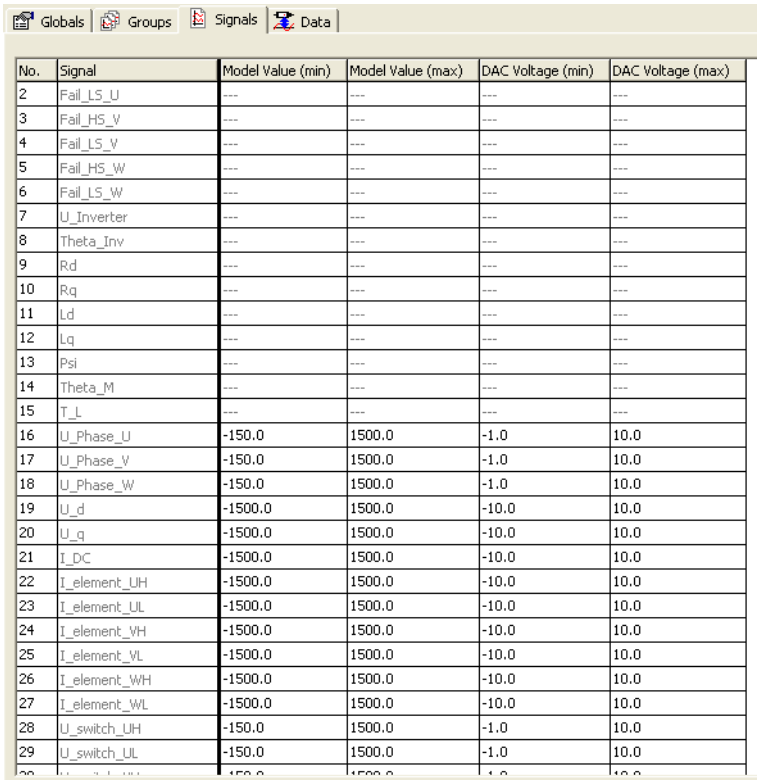
Option	Value
FPGA Model Name	Es5340pmsm100
Model Type	High Speed Inverter, E.Motor & Mechanics Simulation Model
Model ID	PMSM
Model Version	1.0.0
Inverter	########## Inverter Parametrization ##########
Gate Signal Polarity	High Active
R_SW_ON [Ohm]	0.001
U_SW_Fwd [Volt]	0.7
R_D_Fwd [Ohm]	0.001
U_D_Fwd [Volt]	0.7
T_Switch [s]	0.0000005
a_Inv [Ohm/K]	0.00393
R_Batt [Ohm]	0.5
C_DC [mF]	0.5
PMSM	########## PMSM Parametrization ##########
Pole Pairs	12
Ncog	18
T_cm [Nm]	0.0
Id Init [A]	0.0
Iq Init [A]	0.0
a_M [Ohm/K]	0.0043
Mechanics	########## Mechanics Parametrization ##########
f [Nms]	1.7
J_E [kgm²]	0.12
J_L [kgm²]	0.1
C [Nm/rad]	1500000.0
D [Nms/rad]	100.0
Phi_mech_init [°]	0.0
Omega_mech_init [1/s]	0.0

Note

For a detailed description of the model variables, refer to the chapter on "FPGA Models" on page 49,

Configuring the Value Ranges

The valid value ranges for the model variables are configured in the "Signals" tab. Adapt the mapping between the physical and electrical variables according to your hardware.



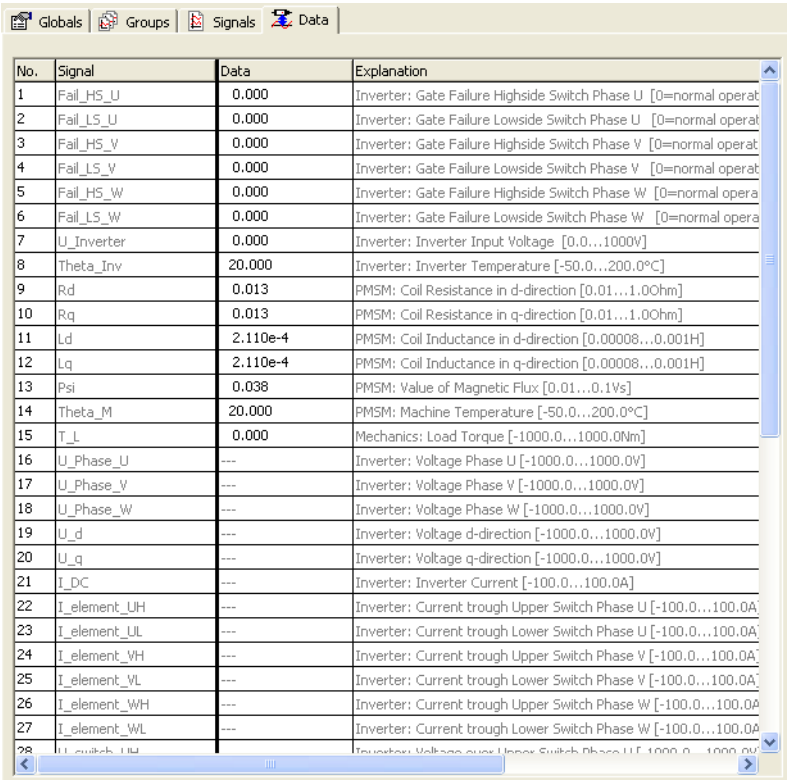
No.	Signal	Model Value (min)	Model Value (max)	DAC Voltage (min)	DAC Voltage (max)
2	Fail_LS_U	---	---	---	---
3	Fail_HS_V	---	---	---	---
4	Fail_LS_V	---	---	---	---
5	Fail_HS_W	---	---	---	---
6	Fail_LS_W	---	---	---	---
7	U_Inverter	---	---	---	---
8	Theta_Inv	---	---	---	---
9	Rd	---	---	---	---
10	Rq	---	---	---	---
11	Ld	---	---	---	---
12	Lq	---	---	---	---
13	Psi	---	---	---	---
14	Theta_M	---	---	---	---
15	T_L	---	---	---	---
16	U_Phase_U	-150.0	1500.0	-1.0	10.0
17	U_Phase_V	-150.0	1500.0	-1.0	10.0
18	U_Phase_W	-150.0	1500.0	-1.0	10.0
19	U_d	-1500.0	1500.0	-10.0	10.0
20	U_q	-1500.0	1500.0	-10.0	10.0
21	I_DC	-1500.0	1500.0	-10.0	10.0
22	I_element_UH	-1500.0	1500.0	-10.0	10.0
23	I_element_UL	-1500.0	1500.0	-10.0	10.0
24	I_element_VH	-1500.0	1500.0	-10.0	10.0
25	I_element_VL	-1500.0	1500.0	-10.0	10.0
26	I_element_WH	-1500.0	1500.0	-10.0	10.0
27	I_element_WL	-1500.0	1500.0	-10.0	10.0
28	U_switch_UH	-150.0	1500.0	-1.0	10.0
29	U_switch_UL	-150.0	1500.0	-1.0	10.0

Note

Note that the values of "DAC Voltage (min)" and "DAC Voltage (max)" are intended as absolute values that are not undershot/exceeded by the D/A converters of the hardware.

Determining Default Values

For certain model inputs, default values can be defined in the "Data" tab.



No.	Signal	Data	Explanation
1	Fail_HS_U	0.000	Inverter: Gate Failure Highside Switch Phase U [0=normal operat
2	Fail_LS_U	0.000	Inverter: Gate Failure Lowside Switch Phase U [0=normal operat
3	Fail_HS_V	0.000	Inverter: Gate Failure Highside Switch Phase V [0=normal operat
4	Fail_LS_V	0.000	Inverter: Gate Failure Lowside Switch Phase V [0=normal operat
5	Fail_HS_W	0.000	Inverter: Gate Failure Highside Switch Phase W [0=normal opera
6	Fail_LS_W	0.000	Inverter: Gate Failure Lowside Switch Phase W [0=normal opera
7	U_Inverter	0.000	Inverter: Inverter Input Voltage [0.0...1000V]
8	Theta_Inv	20.000	Inverter: Inverter Temperature [-50.0...200.0°C]
9	Rd	0.013	PMSM: Coil Resistance in d-direction [0.01...1.0Ohm]
10	Rq	0.013	PMSM: Coil Resistance in q-direction [0.01...1.0Ohm]
11	Ld	2.110e-4	PMSM: Coil Inductance in d-direction [0.00008...0.001H]
12	Lq	2.110e-4	PMSM: Coil Inductance in q-direction [0.00008...0.001H]
13	Psi	0.038	PMSM: Value of Magnetic Flux [0.01...0.1Vs]
14	Theta_M	20.000	PMSM: Machine Temperature [-50.0...200.0°C]
15	T_L	0.000	Mechanics: Load Torque [-1000.0...1000.0Nm]
16	U_Phase_U	---	Inverter: Voltage Phase U [-1000.0...1000.0V]
17	U_Phase_V	---	Inverter: Voltage Phase V [-1000.0...1000.0V]
18	U_Phase_W	---	Inverter: Voltage Phase W [-1000.0...1000.0V]
19	U_d	---	Inverter: Voltage d-direction [-1000.0...1000.0V]
20	U_q	---	Inverter: Voltage q-direction [-1000.0...1000.0V]
21	I_DC	---	Inverter: Inverter Current [-100.0...100.0A]
22	I_element_UH	---	Inverter: Current trough Upper Switch Phase U [-100.0...100.0A
23	I_element_UL	---	Inverter: Current trough Lower Switch Phase U [-100.0...100.0A
24	I_element_VH	---	Inverter: Current trough Upper Switch Phase V [-100.0...100.0A
25	I_element_VL	---	Inverter: Current trough Lower Switch Phase V [-100.0...100.0A
26	I_element_WH	---	Inverter: Current trough Upper Switch Phase W [-100.0...100.0A
27	I_element_WL	---	Inverter: Current trough Lower Switch Phase W [-100.0...100.0A

5.2.2 Software Model

If a model is run on the Real-Time PC, an item must be added for measurement of the inverter gate signals from the ECU; in addition, a map of the current/ voltage values to the analog outputs must be created.

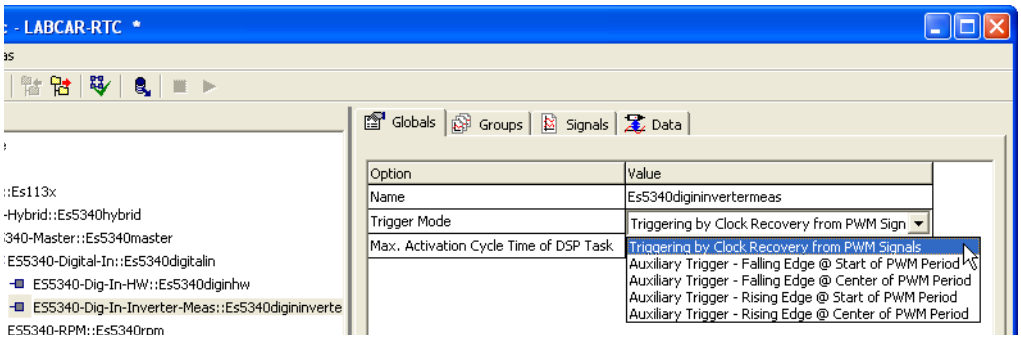
The duty cycles and the period of the PWM control signals are measured and forwarded to the software model. The measurement itself can be synchronized to an external signal or to the PWM period determined by clock recovery.

Configuring the Inverter Gate Measurement

1. Right-click the "ES5340-Digital-In" item and select **Add Item**.
2. In the list, select the "ES5340-Dig-In-Inverter-Meas" item and click **OK**.

   The item is added.

3. In the "Globals" tab, select the type of triggering to be used for the measurement ("Trigger Mode").



4. Under "Nominal PWM Period Time...", enter the period length of the PWM task of the ECU.

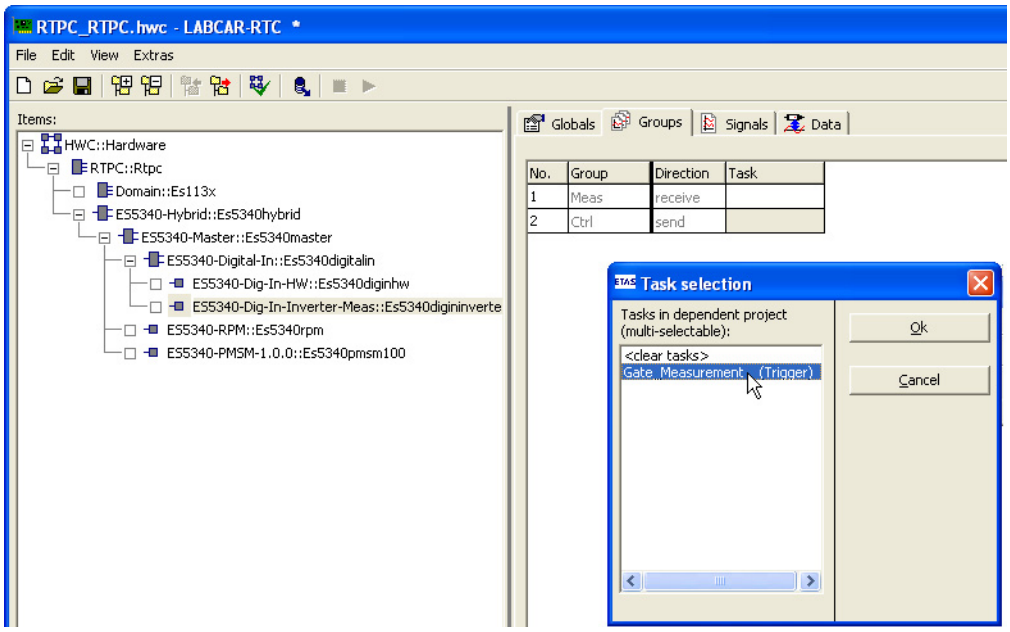
Note

If you enter "0.0" here, the period of the "Receive" task is applied as the period length here.

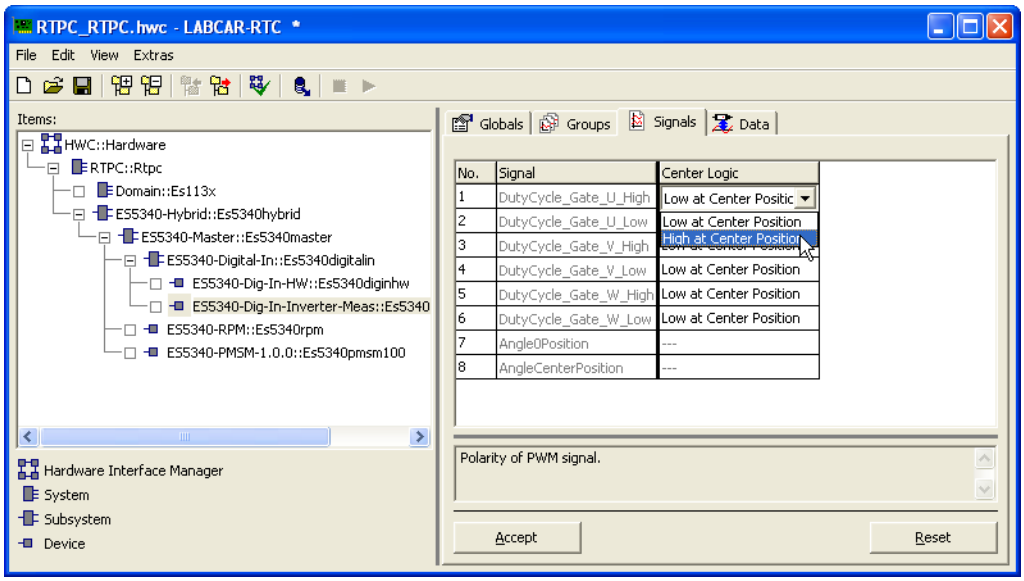
5. In the "Groups" tab, select the task to be activated in the Real-Time PC after each period of the PWM measurement.

Note

For this purpose, a task of type "Trigger" must first have been defined in the OS configuration of LABCAR-IP in which the option "Exclusive Core Usage" is enabled (see "“Exclusive Core Usage” Mode" on page 28).



6. In the "Center Logic" column, configure the polarity of the gate signals.



Configuring Outputs for Current/Voltage Sensors

Output values of the model, such as alternating currents or direct currents/voltages, can be output synchronously to the PWM period using analog outputs.

For this purpose, two options exist:

- Direct output

  The values of the model are converted from physical to electrical values and enabled on the D/A converter on the ES5340.2.

- Predicted output

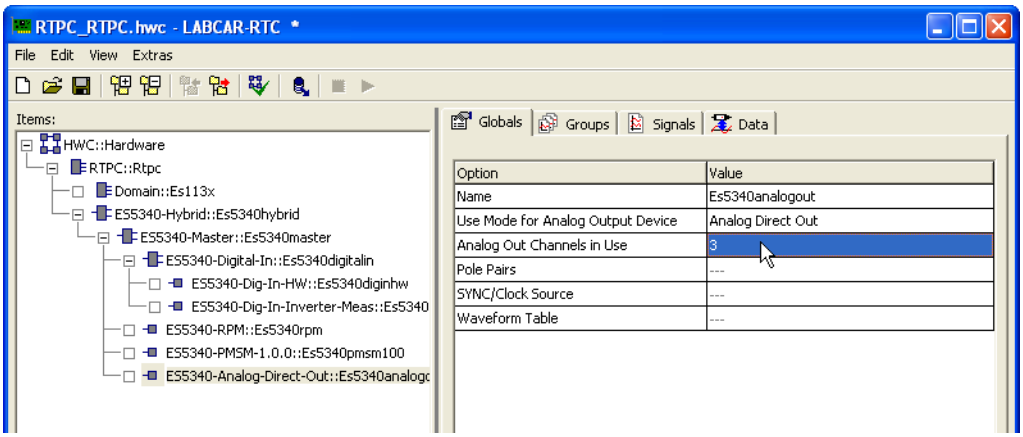
  Only the amplitude and phase of the AC signal are taken over from the model; the resulting sine wave, on the other hand, is generated in the hardware. This results in much faster updating of the values for the D/A converter output with smaller step sizes for model calculation.

Adding Analog Outputs ("Direct out")

1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Analog-Out" item and click **OK**.

   The item is added.

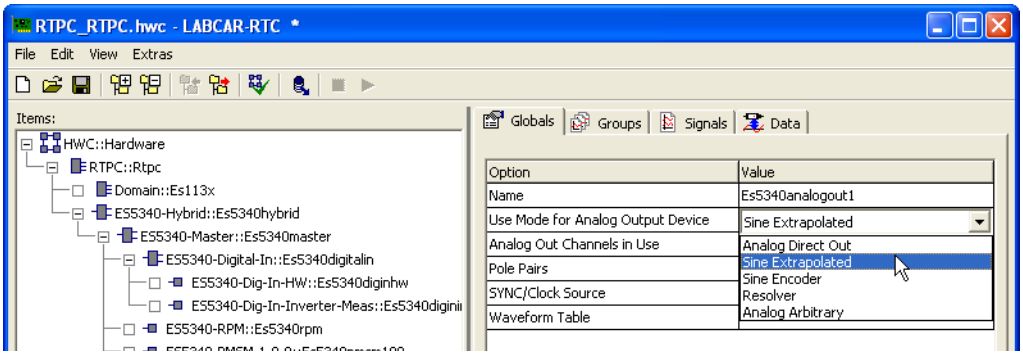
3. Leave the operating mode set to "Analog Direct Out" and select the number of desired outputs.



For an additional configuration of this item, refer to the section on "Analog Outputs" on page 84.

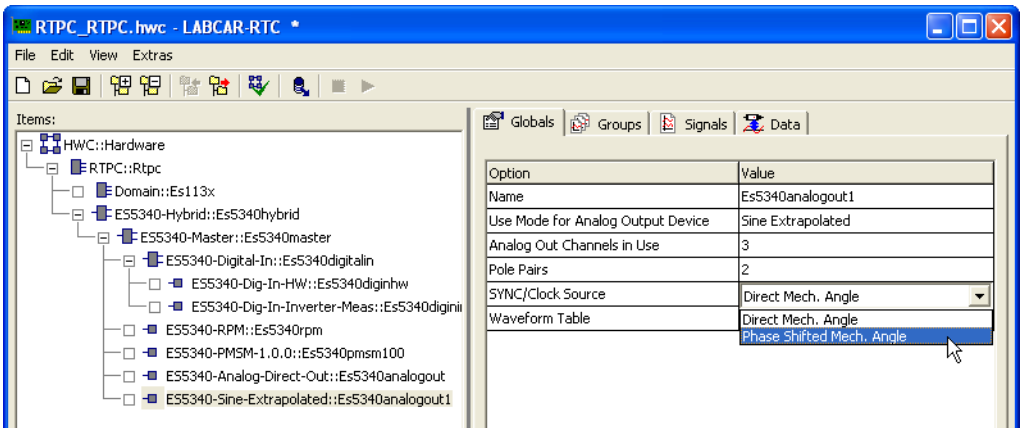
Adding Analog Outputs (for Predicted Values)

1. Insert an "ES5340-Analog-Out" item as described above.
2. For the operating mode, select "Sine Extrapolated".

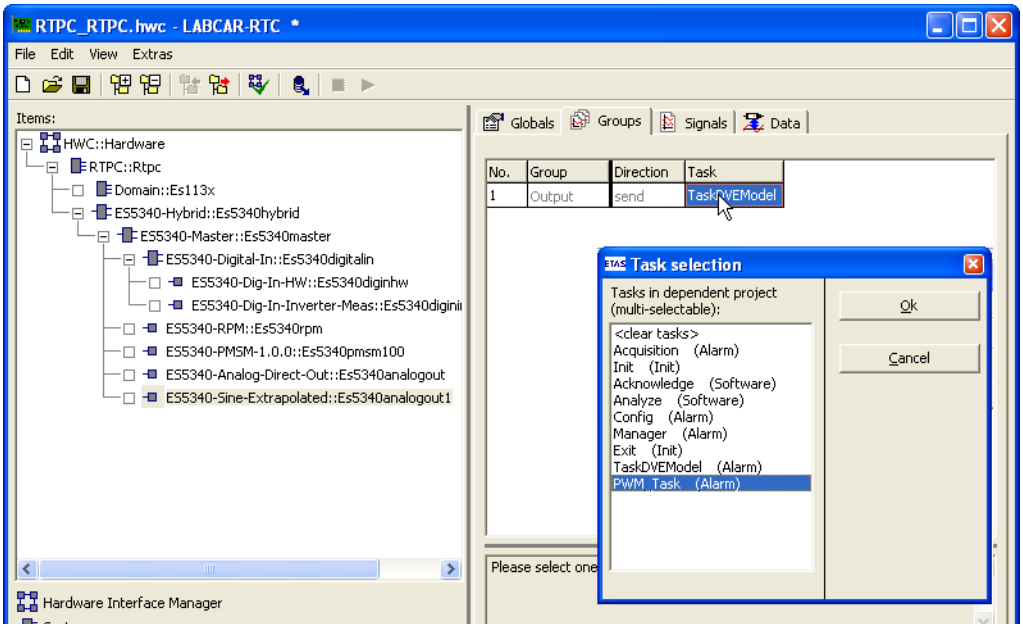


3. Enter the desired number of outputs of this type.
4. Make sure that the correct number for the pole pairs is specified.

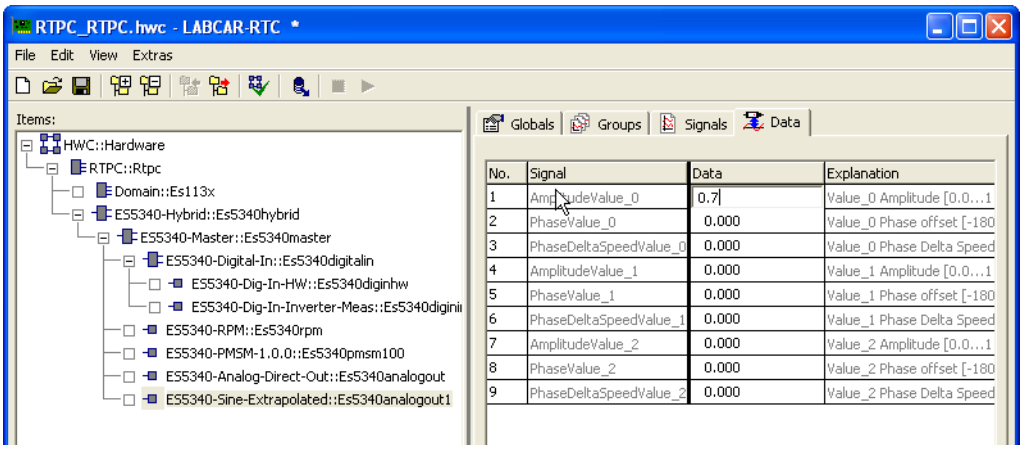
5. So that the phases of the signals can still be changed later, for the option "Clock Source", select the setting "Phase Shifted Mech. Angle".



6. To enable synchronized hardware access, change the task in the "Groups" tab.



7. Finally, you can configure default values for the amplitude and phase in the "Data" tab.



5.3 I/O Configuration

This chapter provides a description of the configuration of the input and output channels of the ES5340.2.

Specifically, it includes information about:

- "Adding an Analog Position Sensor" on page 81
- "Adding a Digital Position Sensor" on page 82
- "Adding Outputs of Type "Direct Analog Out"" on page 84
- "Adding Outputs of Type "Analog Arbitrary"" on page 85
- "Adding Outputs of Type "Direct Digital Out"" on page 86
- "Adding Outputs of Type "Digital Arbitrary"" on page 88
- "Adding an Analog Input" on page 89
- "Adding a Digital Input" on page 90
- "Configuring the signal sources of the analog multiplexer" on page 92
- "Configuring the voltage reference and output type" on page 93
- "Defining the Default Values" on page 94
- "Configuring the Signal Sources of the Digital Multiplexer" on page 94
- "Configuring the output mode" on page 95
- "Defining the Default Values" on page 96
- "Exiting LABCAR-RTC" on page 96

5.3.1 Position sensors

To generate position information for the ECU, specific items must be added to the hardware configuration.

There are two types of position sensors:

- Analog sensors

  Example of these include resolvers and sine encoders
- Digital sensors

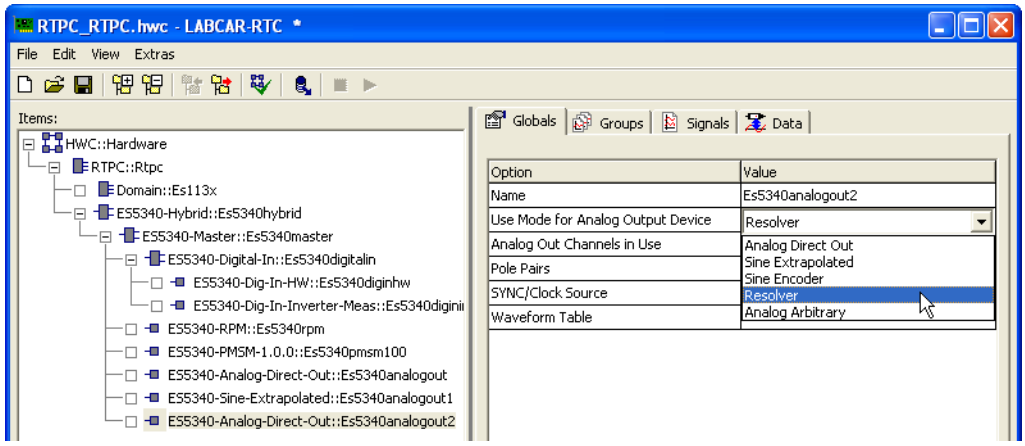
  An example of a digital sensor is the "Trixy" sensor in BOSCH ECUs.

Adding an Analog Position Sensor

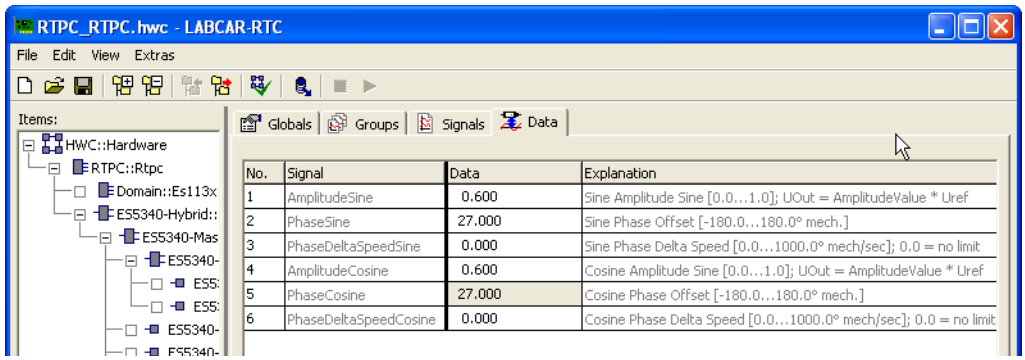
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Analog-Out" item and click **OK**.

   The item is added.
3. Select "Resolver" or "Sine Encoder" operating mode

– The "Resolver" sensor type uses an external excitation signal and returns a differential output signal (refer also to "Configuring the voltage reference and output type" on page 93).
– The type "Sine Encoder" does not need an excitation signal and has a single-ended output.



4. Define the number of pole pairs.
5. For "SYNC/Clock Source", select the setting "Direct Mech. Angle."
6. Define default values (in the "Data" tab).

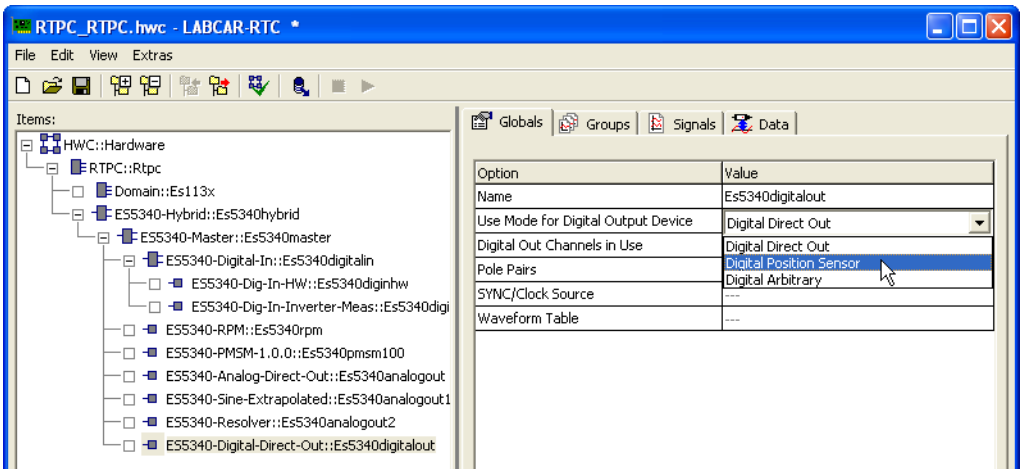


Adding a Digital Position Sensor

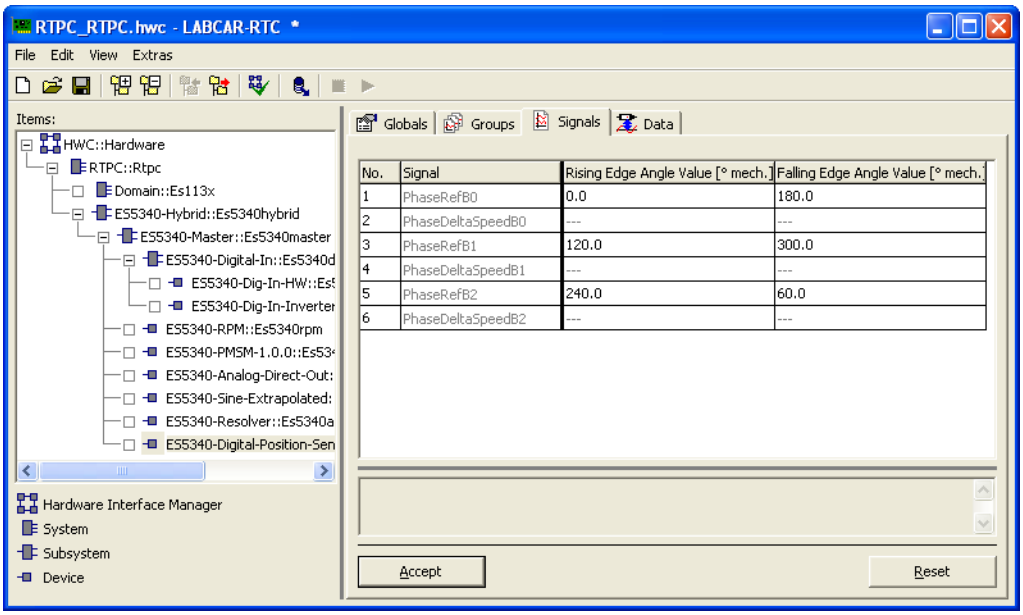
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Digital-Out" item and click **OK**.

   The item is added.

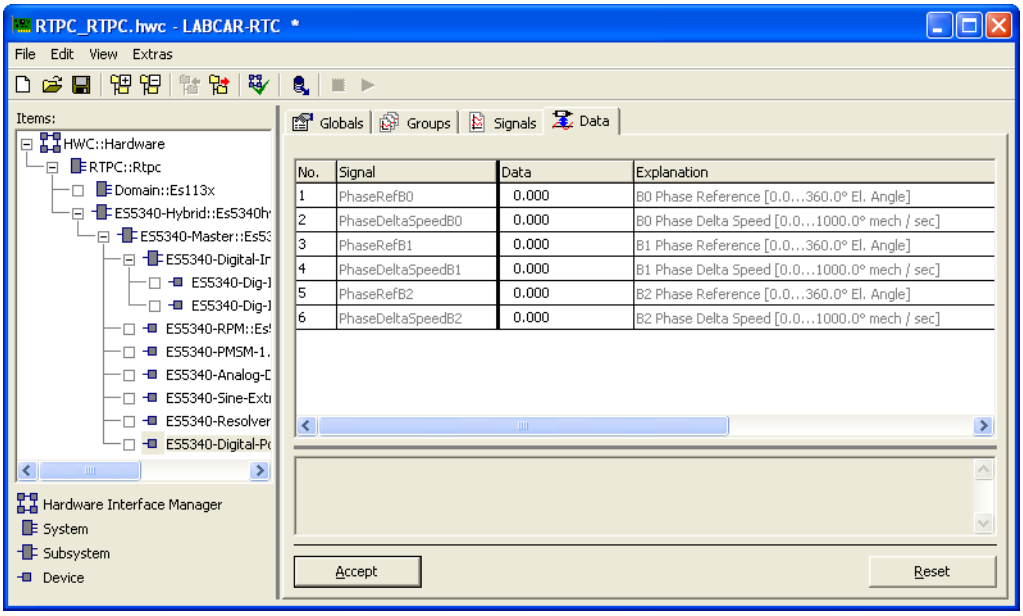
3. As the operating mode, select "Digital Position Sensor".



4. Define the number of pole pairs.
5. For "SYNC/Clock Source", select the setting "Direct Mech. Angle."
6. Configure the signal type (in the "Signals" tab).



7. Define default values (in the "Data" tab).



5.3.2 Analog Outputs

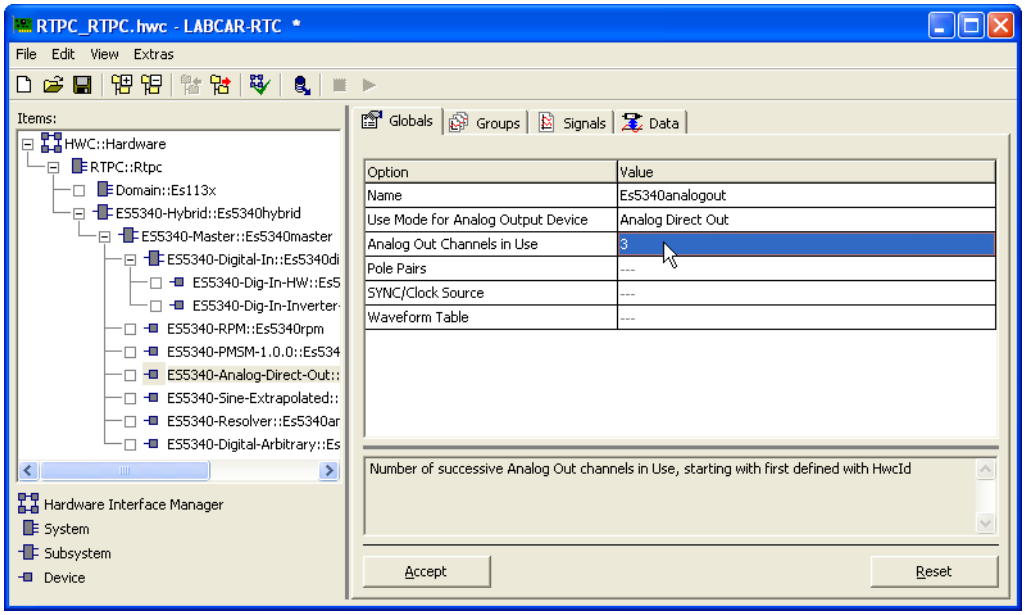
These outputs are used to output analog values from a model to the A/D converters of the ECU.

Adding Outputs of Type "Direct Analog Out"

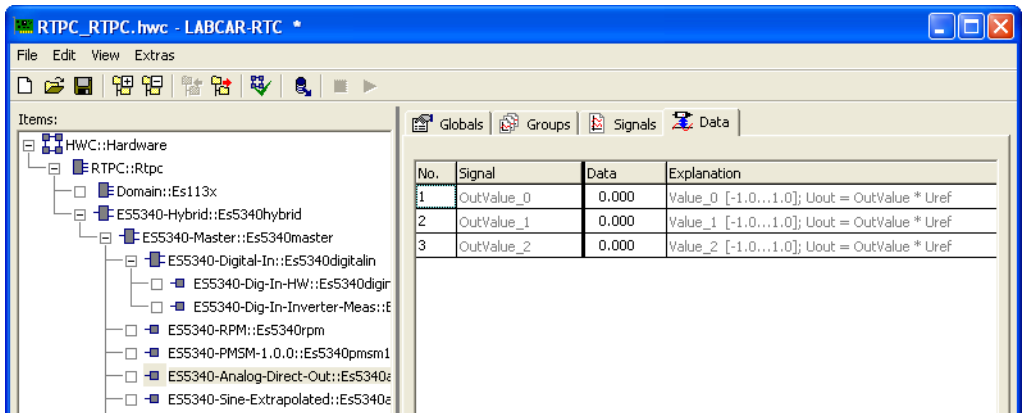
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Analog-Out" item and click **OK**.

   The item is added.
3. Leave the option "Use Mode for Analog Output Device" in the default setting, "Analog Direct Out".

4. To configure multiple analog outputs in this item, select the desired number in the "Globals" tab.



5. Select the "Data" tab to configure default values for the outputs.



Adding Outputs of Type "Analog Arbitrary"

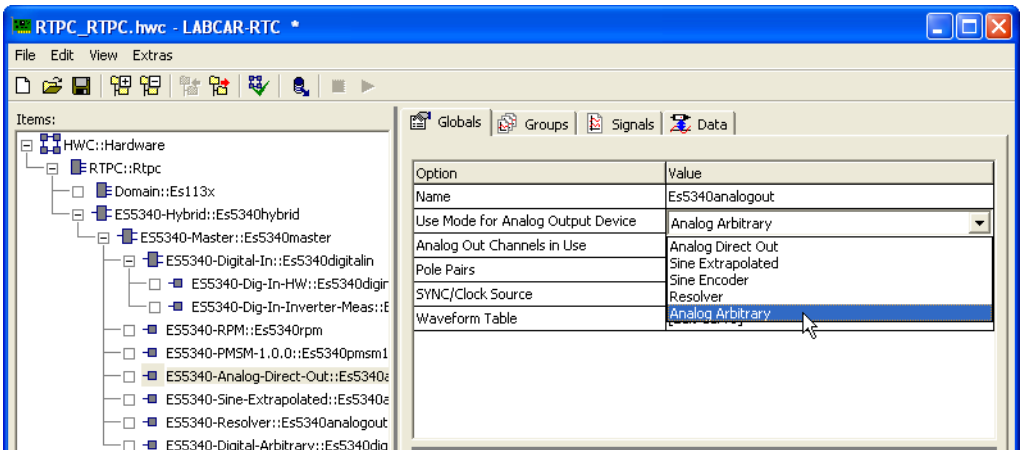
Outputs for arbitrary signals can be used to output user-defined signal patterns (based on the current angle of the simulated electric motor).

This signal pattern can be used, for example, to simulate specific position sensors and other variables with a direct relationship to the motor angle.

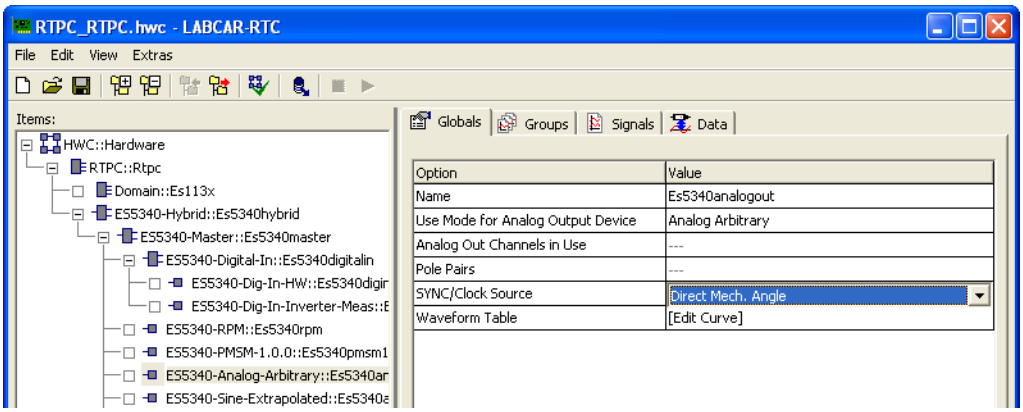
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Analog-Out" item and click **OK**.

   The item is added.

3. For the option "Use Mode for Analog Output Device", select the "Analog Arbitrary" setting.



4. With the option "SYNC/Clock Source", the output can be synchronized to the current motor angle or a phase-shifted angle (e.g. for predicting current values) can be used.



5. With the "WaveformTable" option, you can edit the desired output in the form of a table.
6. Select the "Data" tab to configure default values for the outputs.

5.3.3 Digital Outputs

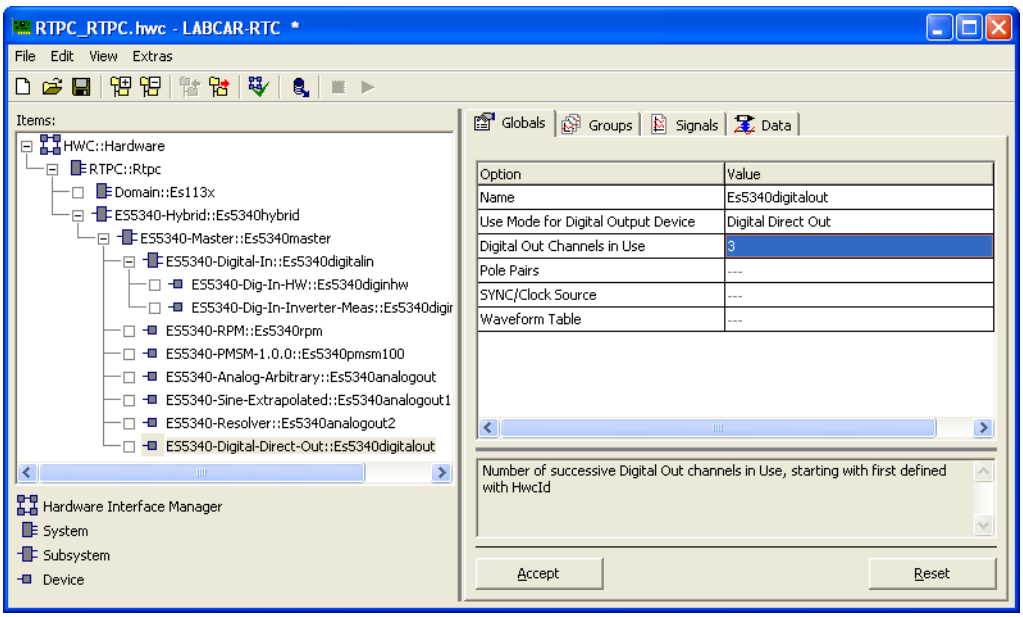
These outputs enable you to directly stimulate ECU inputs using values from the model.

Adding Outputs of Type "Direct Digital Out"

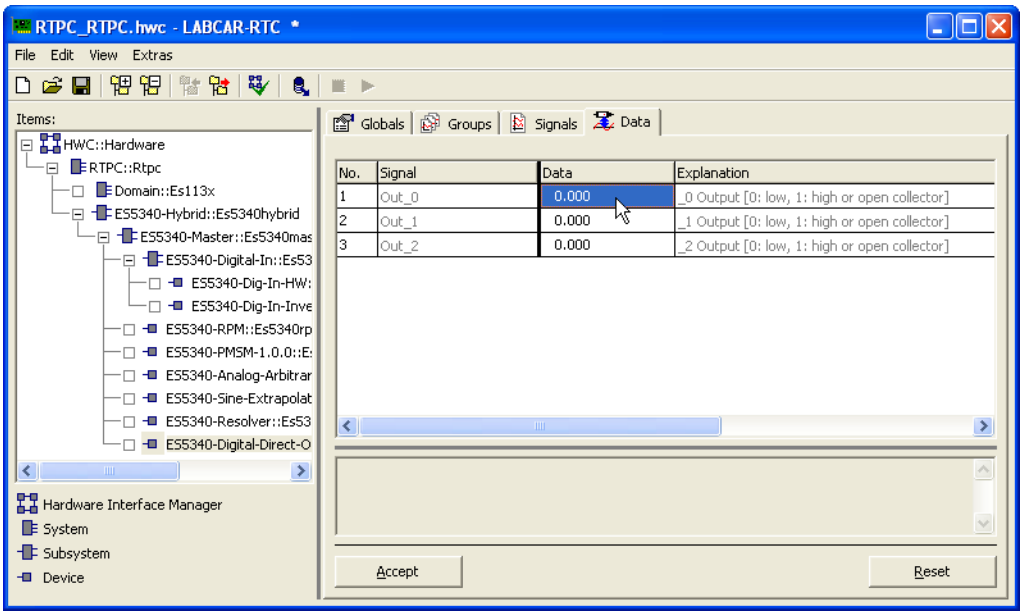
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Digital-Out" item and click **OK**.

   The item is added.

3. Leave the option "Use Mode for Digital Output Device" in the default setting, "Digital Direct Out".
4. To configure multiple digital outputs in this item, select the desired number in the "Globals" tab.



5. Select the "Data" tab to configure default values for the outputs.



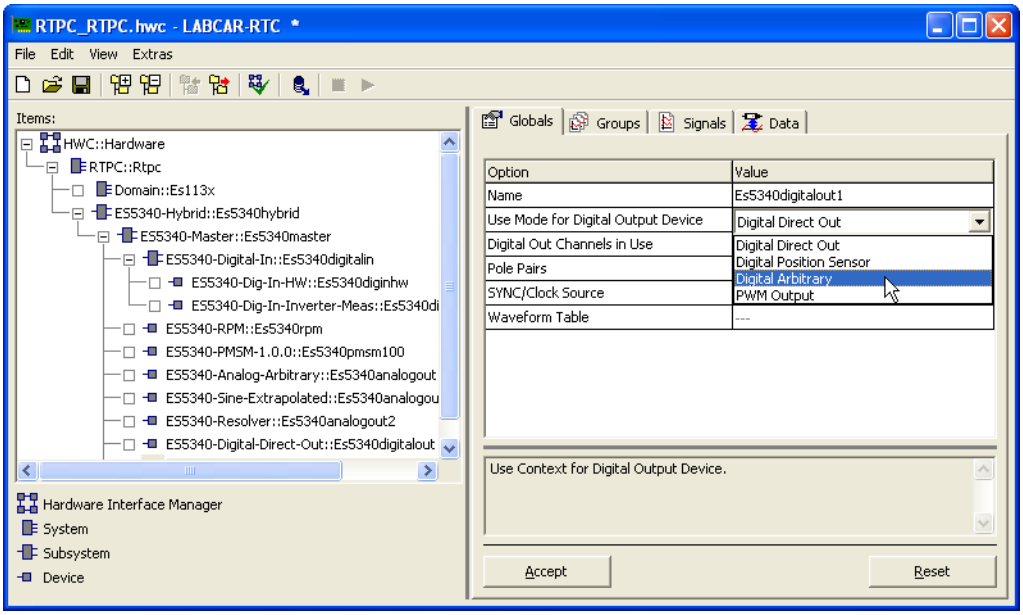
Adding Outputs of Type "Digital Arbitrary"

Outputs for arbitrary digital signals can be used to output user-defined signal patterns (based on the current angle of the simulated electric motor).

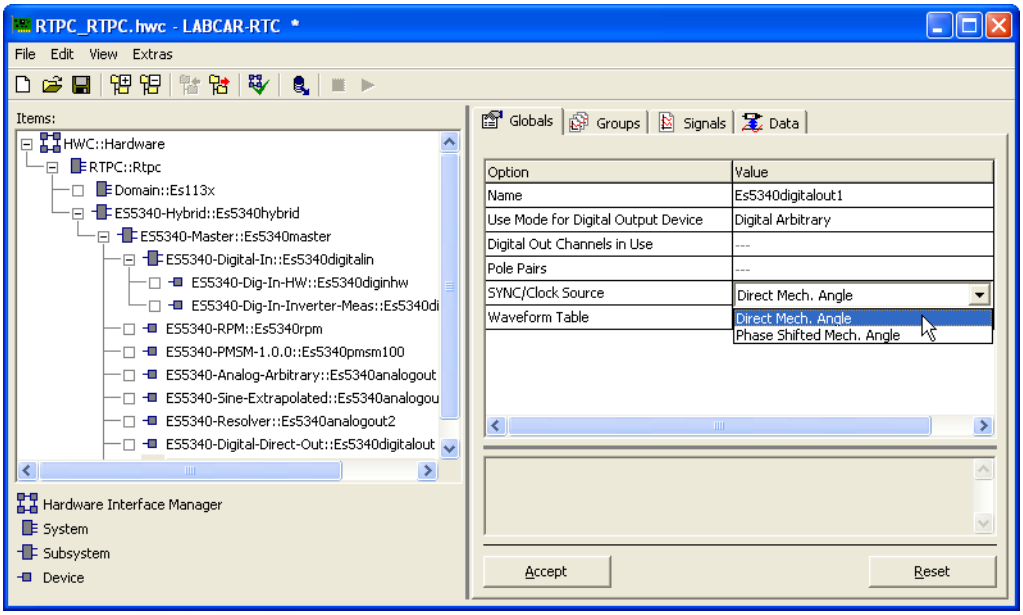
This signal pattern can be used, for example, to simulate specific position sensors and other variables with a direct relationship to the motor angle.

1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Digital-Out" item and click **OK**.

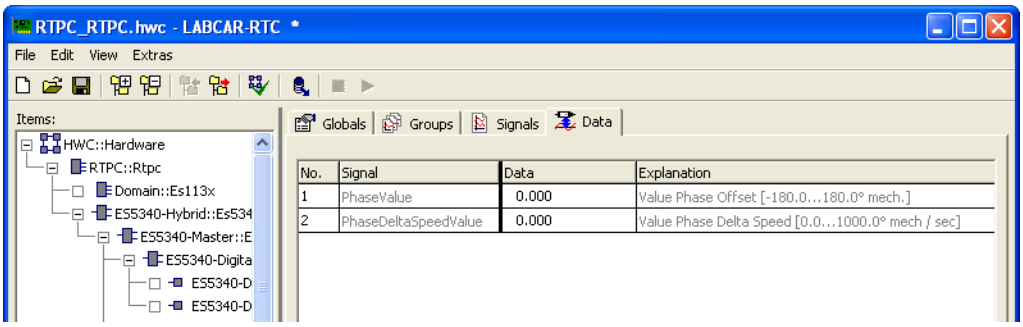
   The item is added.
3. For the option "Use Mode for Digital Output Device", select the "Digital Arbitrary" setting.



4. With the option "SYNC/Clock Source", the output can be synchronized to the current motor angle or a phase-shifted angle (e.g. for predicting current values) can be used.



5. With the "WaveformTable" option, you can edit the desired output in the form of a table.
6. Select the "Data" tab to configure default values for the outputs.



5.3.4 Analog Inputs

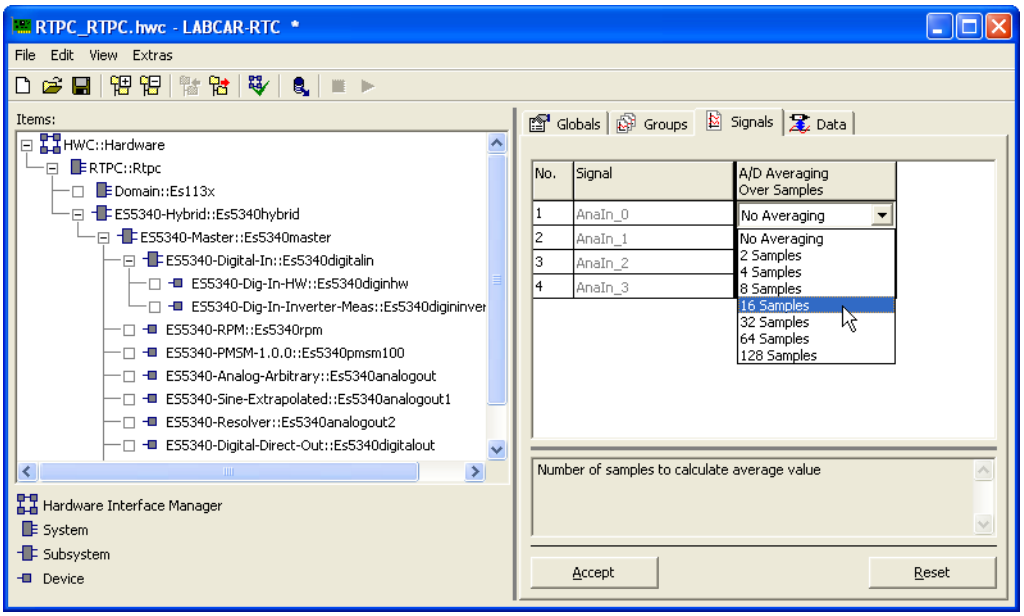
The four analog inputs of the ES5340.2 can be used to measure analog signals from the ECU.

Adding an Analog Input

1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Analog-In" item and click **OK**.

   The item is added.

3. Select the "Signals" tab to, if necessary, calculate an average of a configurable number of measured values.



5.3.5 Digital Inputs

The digital inputs can be used to measure various properties of digital signals (frequencies, duty cycles etc.).

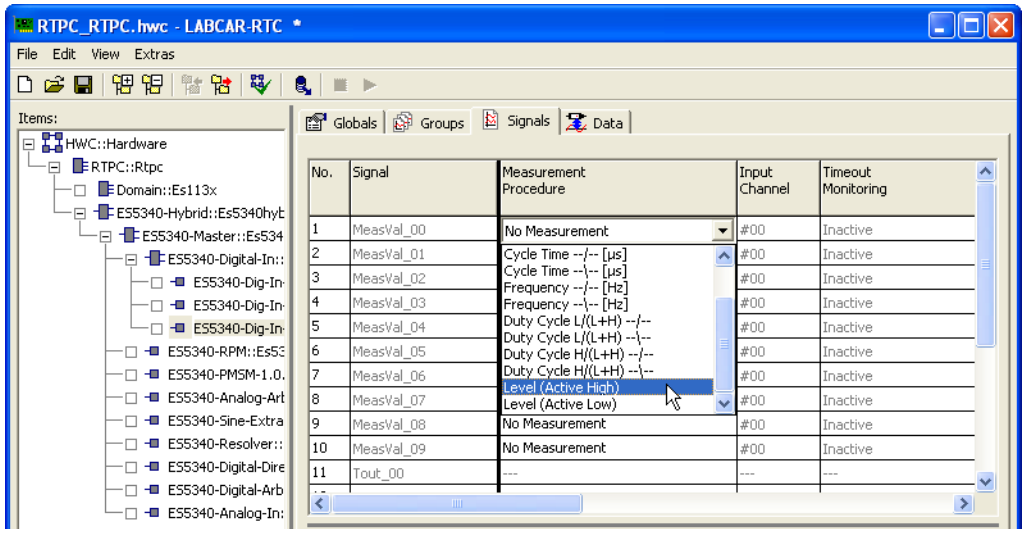
Adding a Digital Input

1. Right-click the "ES5340-Dig-In" item and select **Add Item**.
2. In the list, select the "ES5340-Dig-In-Meas" item and click **OK**.

   The item is added.

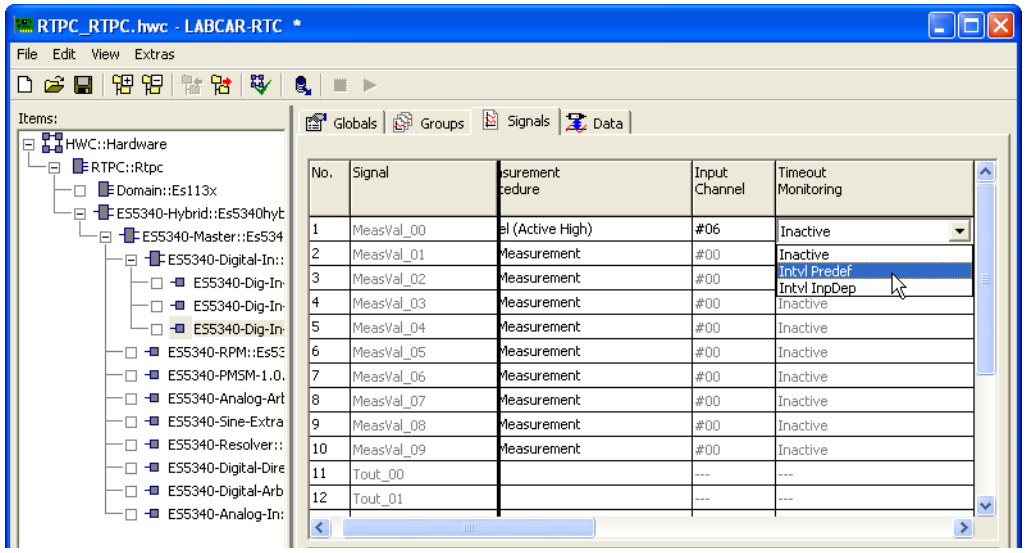
3. To configure the measurement, select the "Signals" tab.

   You can configure the measurement method in the "Measurement Procedure" column. For a digital input channel, multiple measurements can be carried out.



For each "ES5340-Dig-In-Meas" item, ten measurements are possible – if more measurements are needed, additional items of the type "ES5340-Dig-In-Meas" can be added.

4. For edge-based measurements, enable timeout monitoring to ensure a corresponding response to missing edges in the signal.



5.3.6 Signal Output via the Analog Multiplexer

Finally, you have to assign the defined logical signal sources to pins of the physical outputs on the ES5340.2.

Note

For each "ES5340-Master" item, only one output multiplexer can be configured.

Configuring the signal sources of the analog multiplexer

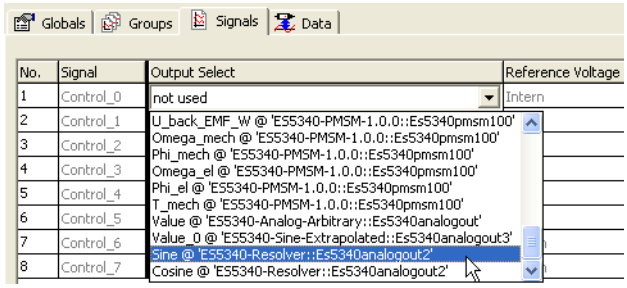
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Analog-Out-Mux" item and click **OK**.

   The item is added.
3. Switch to the "Signals" tab.

   In the "Output Select" column, you can now define a signal source for each of the eight output pins.
4. To do so, click the corresponding cell in the table.

   The following signal sources are available:

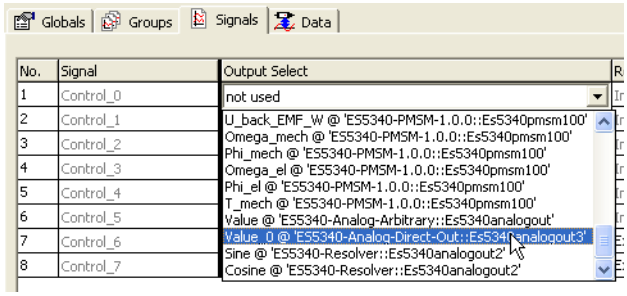
   – Analog position sensors:



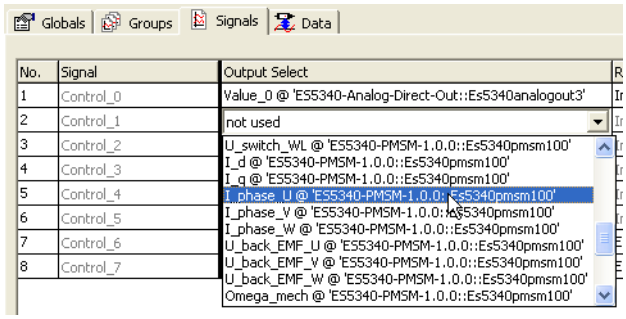
Note

Position sensors of type "Resolver" can be assigned to outputs 6 and 7 only.

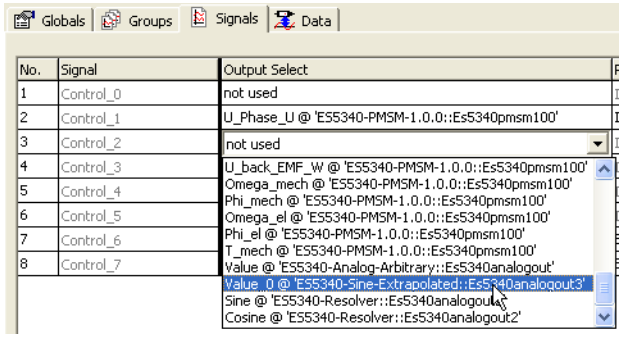
   – Direct analog output (Analog-Direct-Out):



– Analog output values from the FPGA model:

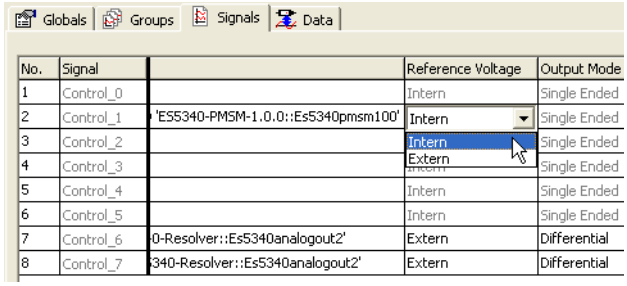


– Predicted analog outputs:



Configuring the voltage reference and output type

1. In the "Reference Voltage" column, select whether the internal reference voltage or an external reference voltage is to be used.



2. In the "Output Mode" column, select whether the signal is to be configured as "single-ended" or "differential".

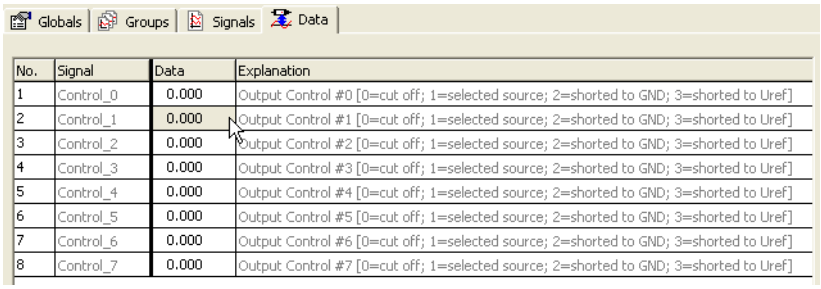
Note

Position sensors of the type "Resolver" can be assigned to outputs 6 and 7 only – for these, an external reference and differential output are configured automatically.

Defining the Default Values

1. Select the "Data" tab to configure default values for the outputs.

   Four different settings exist for the output control:



5.3.7 Signal Output via the Digital Multiplexer

For output of the digital signals, an item must be defined for a digital output multiplexer.

Note

For each "ES5340-Master" item, only one digital multiplexer can be configured.

Configuring the Signal Sources of the Digital Multiplexer

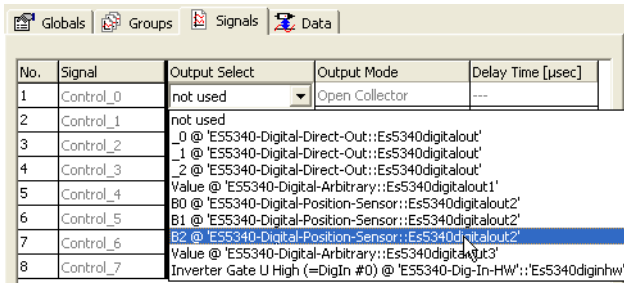
1. Right-click the "ES5340-Master" item and select **Add Item**.
2. In the list, select the "ES5340-Digital-Out-Mux" item and click **OK**.

   The item is added.
3. Switch to the "Signals" tab.

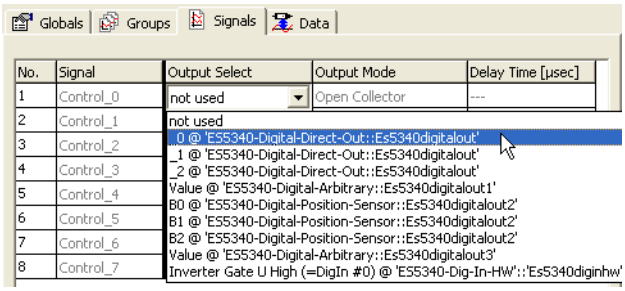
   In the "Output Select" column, you can now define a signal source for each of the eight output pins.
4. To do so, click the corresponding cell in the table.

   The following signal sources are available:

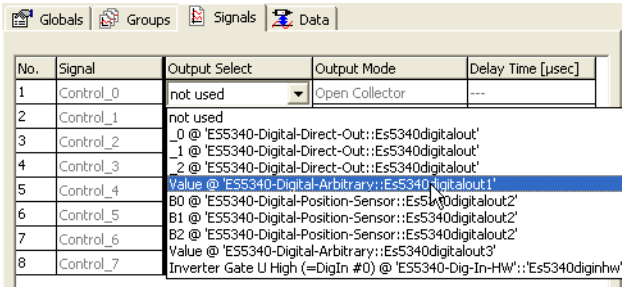
   – Digital position sensors



– Direct digital output (Digital-Direct-Out):

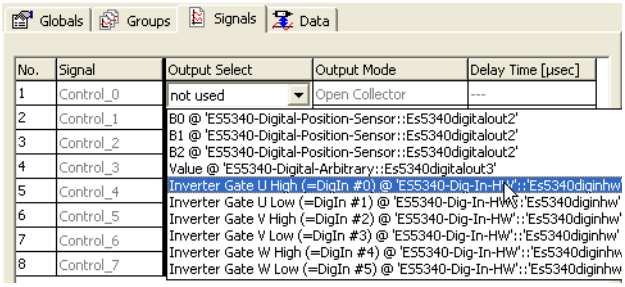


– Digital arbitrary signals (Digital-Arbitrary):



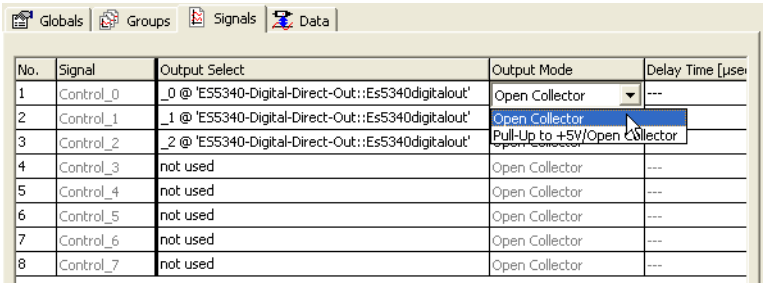
– Feedback of the inverter gate signals

The PWM signals can be fed back for diagnostic purposes (with a configurable delay).



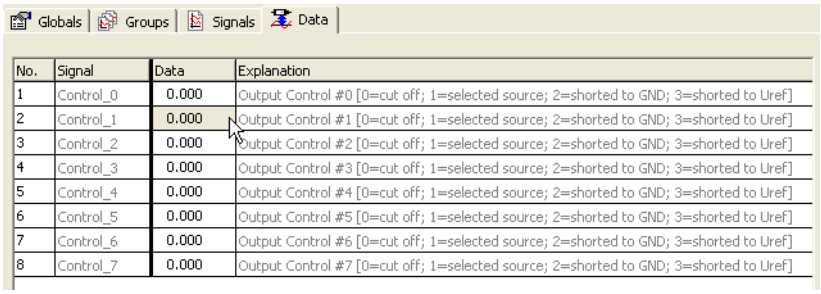
Configuring the output mode

1. Select the desired output mode ("Open Collector" or "Pull-Up to +5 V").



Defining the Default Values

1. Select the "Data" tab to configure default values for the outputs.
2. Four different settings exist for the output control:

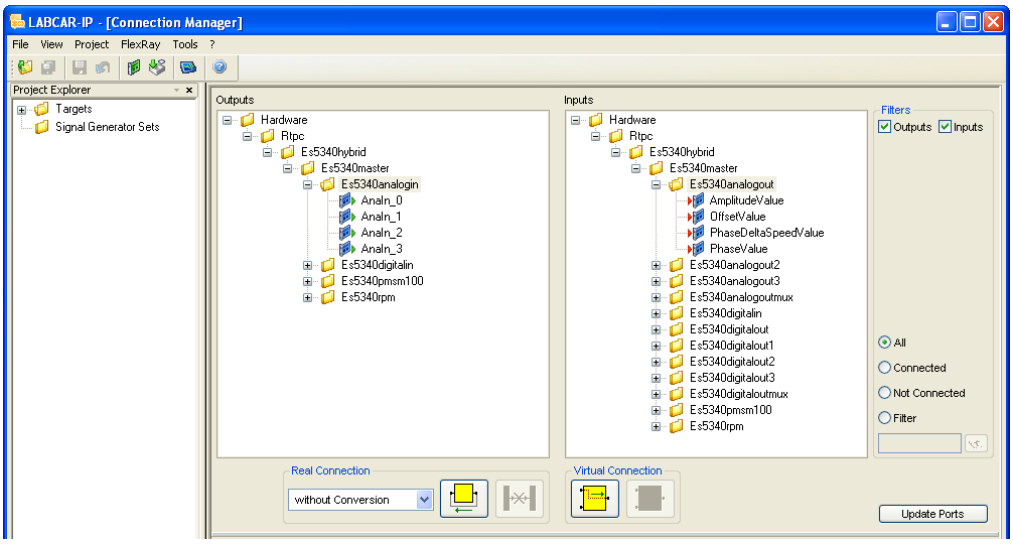


No.	Signal	Data	Explanation
1	Control_0	0.000	Output Control #0 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
2	Control_1	0.000	Output Control #1 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
3	Control_2	0.000	Output Control #2 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
4	Control_3	0.000	Output Control #3 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
5	Control_4	0.000	Output Control #4 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
6	Control_5	0.000	Output Control #5 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
7	Control_6	0.000	Output Control #6 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]
8	Control_7	0.000	Output Control #7 [0=cut off; 1=selected source; 2=shorted to GND; 3=shorted to Uref]

Exiting LABCAR-RTC

1. Save the settings with **File** → **Save**.
2. In LABCAR-IP, start the code generation (**Project** → **Build**).

   The inputs and outputs of the hardware (and of the FPGA model where applicable) are now available in the Connection Manager.



6 Connector Assignment and Display Elements

This chapter contains the description of the connectors and display elements of the ES5340.2 Electric Drive Simulation Board. It consists of the following sections:

- "Connector Assignment" on page 98

  Here, all connectors on the front panel are described.

  – "Connectors for the Outputs (ES5340.2-M and ES5340.1-S)" on page 98
  – "Connectors for the Inputs (ES5340.2-M only)" on page 99
  – "Connectors for the Angle Clock Signal (ES5340.2-M only)" on page 101
- "Display Elements" on page 101

  Here, the meaning of the LED display on the front panel is described.

6.1 Connector Assignment

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

6.1.1 Connectors for the Outputs (ES5340.2-M and ES5340.1-S)

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

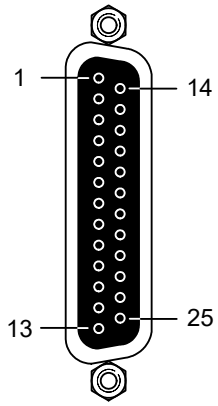


Fig. 6-1 Connectors for the outputs (top view)

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. 6-1 Assignment of the connectors for the outputs

Note

Analog and digital ground of an output channel are identical!

6.1.2 Connectors for the Inputs (ES5340.2-M only)

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

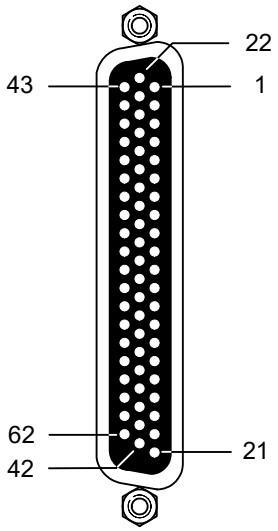


Fig. 6-2 Connectors for the inputs (top view)

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	
* See note on page 101!					

Tab. 6-2 Assignment of the connectors for the inputs

Note

If using a resolver as position sensor, AGND of channel 6 has to be connected to AGND of channel 7. In this case you must carry out at least one of the two following connections:
- Connection of Pin 43 (channel 6) with Pin 45 or Pin 46 (channel 7)
- Connection of Pin 44 (channel 6) with Pin 45 or Pin 46 (channel 7)

6.1.3 Connectors for the Angle Clock Signal (ES5340.2-M only)

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

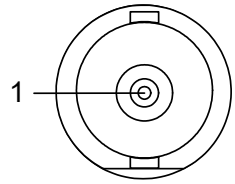


Fig. 6-3 Connectors for the angle clock signal

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

Tab. 6-3 Assignment of the connectors for the angle clock signal

6.2 Display Elements

The front panel of the ES5340.2 Electric Drive Simulation Board has an LED for identifying the board from the Web Interface of LABCAR-RTPC.

7 Order Information and Scope of Delivery

This chapter includes the general order information of the ES5340.2 Electric Drive Simulation Board and for optional accessories.

It also describes the procedure of ordering the FPGA model for subsequent installation.

7.1 General Order Information

Order Name	Short Name	Order Number
Electric Drive Master Board (Multi I/O)	ES5340.2-M	F-00K-107-937
Optional Accessories:		
Electric Drive Slave Board (Multi I/O)	ES5340.1-S	F-00K-107-054
FPGA Inverter/PMSM Model for ES5340	LCM_PMSM5340	F-00K-107-259
FPGA Inverter/IM Model for ES5340	LCM_IM5340_U1	F-00K-108-251
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-M	Number of Pieces
ES5340.2-M Electric_Drive_Master_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

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
Gigabit Link (available in three lengths, depending on the distance between the slots that are fitted with ES5340.2-M and ES5340.1-S in the RTPC)	1

7.2 Separate Order of an FPGA Model

FPGA-based models are available for the ES5340.2 Electric Drive Simulation Board (Master). If you have not purchased them along with the hardware, when purchasing a model subsequently, you are required to have ETAS upgrade the ES5340.2.

After we receive the quotation and your order, you have to send the corresponding ES5340.2 to ETAS along with a repair order.

Following is a description of how to create the repair order on the ETAS homepage.

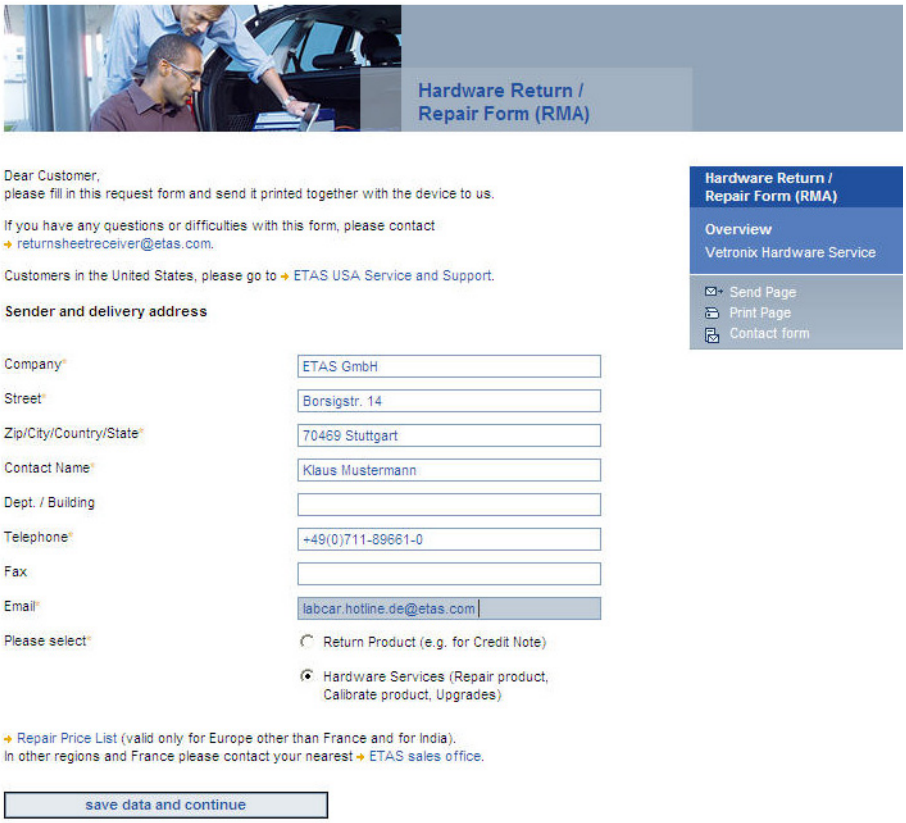
Navigating to the repair page

1. Go the ETAS website (www.etas.com)
2. Click **Support Center** → **Hardware Return / Repair Form**.

   The page is opened.

Entering contact information

1. Enter your data and address.

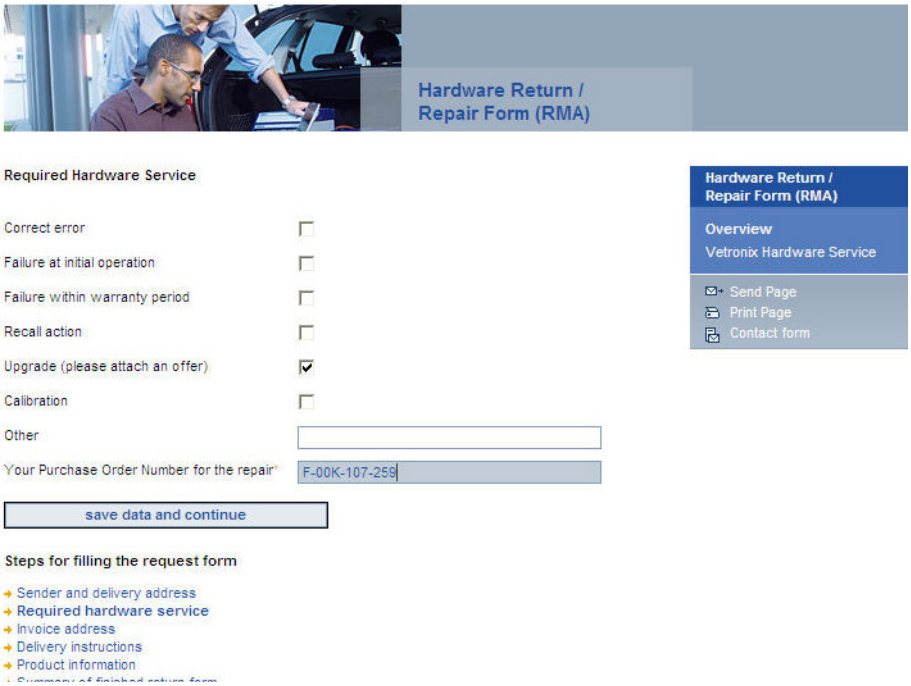


2. Select **Hardware Service**.
3. Click **save data and continue**.

   The input data are stored and the following page opens.

Selecting the hardware service

1. On the "Required Hardware Service" page, select the option **Upgrade (please attach an offer)** as the reason for the return.



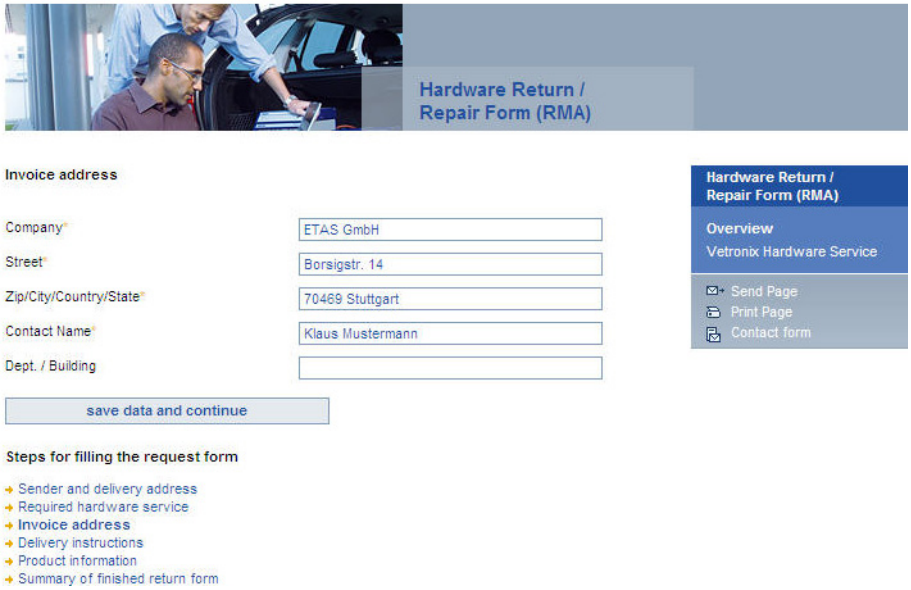
2. In the field "Your Purchase Order Number for the repair", enter the order number of the model (see "General Order Information" on page 103).
3. Click **save data and continue**.

   The input data are stored and the following page opens.

Entering the invoice address

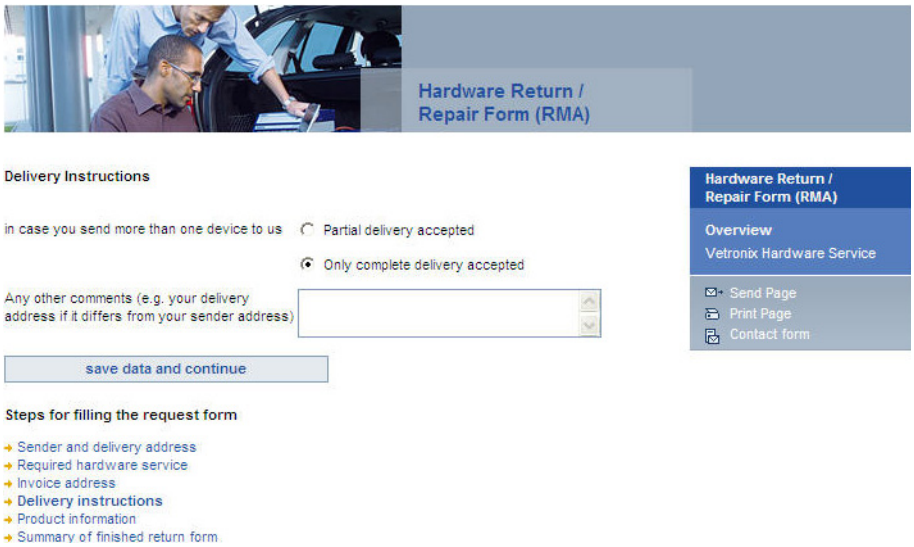
1. Enter the "Invoice Address" on the corresponding page.

   This should match the address on your quote (offer).



Selecting the delivery type

1. On the "Delivery Instructions" page, select the option "Only complete delivery accepted".



2. Click **save data and continue**.

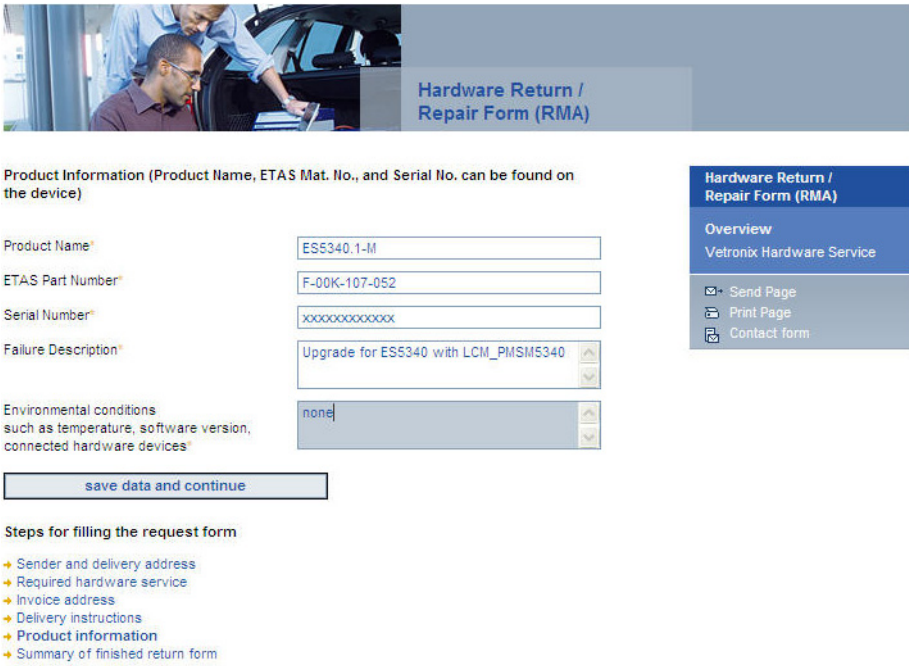
   The input data are stored and the following page opens.

1. Entering the product information
2. Enter the following data on the "Product Information" page:
   - Product Name (ES5340.2-M)
   - ETAS Part Number (F-00K-107-937)
   - The serial number of your ES5340.2-M.

Note

The serial number is found on the sticker on the printed circuit board.

3. In the "Failure Description" field, enter a text such as "Upgrade for ES5340 with LCM_*XXXX*5340".



4. Click **save data and continue**.

   The input data are stored and the following page opens.

Summary of the repair order

1. The last page shows a summary of the order.

Hardware Return / Repair Form (RMA)

Please make sure that you filled everything correctly. After having clicked to generate your printable return form, you won't be able to edit your data any more.

→ Click here to generate your printable return form.

Hardware Return / Repair Form (RMA)
Overview
Vetronix Hardware Service
Send Page
Print Page
Contact form

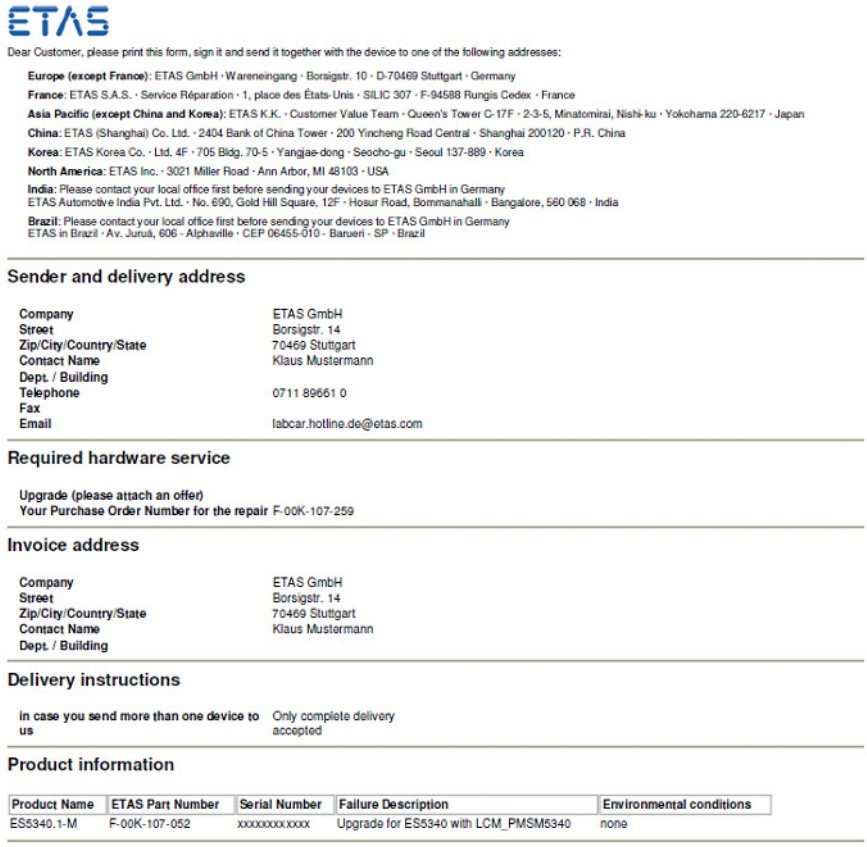
Sender and delivery address	
Company	ETAS GmbH
Street	Borsigstr. 14
Zip/City/Country/State	70469 Stuttgart
Contact Name	Klaus Mustermann
Telephone	0711 89661 0
Email	labcar.hotline.de@etas.com
Required hardware service	
Upgrade	
Your Purchase Order Number for the repair	F-00K-107-259
Invoice address	
Company	ETAS GmbH
Street	Borsigstr. 14
Zip/City/Country/State	70469 Stuttgart
Contact Name	Klaus Mustermann
Delivery instructions	
Only complete delivery accepted	
Product information	
Product Name	**ES5340.1-M**
ETAS Part Number	F-00K-107-052
Serial Number	xxxxxxxxxxxx
Failure Description	Upgrade for ES5340 with LCM_PMSM5340
Environmental conditions	none

Steps for filling the request form

→ Sender and delivery address
→ Required hardware service
→ Invoice address
→ Delivery instructions
→ Product information
→ **Summary of finished return form**

2. Review the data once again.
3. If necessary, select a link at the bottom of the page to enter the corresponding changes.

4. Then, print out the form, sign it and send it, along with the hardware and the quote, to the ETAS Repair Department (specifying the RMA number).



ETAS

Dear Customer, please print this form, sign it and send it together with the device to one of the following addresses:

Europe (except France): ETAS GmbH · Wareneingang · Borsigstr. 10 · D-70469 Stuttgart · Germany

France: ETAS S.A.S. · Service Réparation · 1, place des États-Unis · SILIC 307 · F-94588 Rungis Cedex · France

Asia Pacific (except China and Korea): ETAS K.K. · Customer Value Team · Queen's Tower C-17F · 2-3-5, Minatomirai, Nishi-ku · Yokohama 220-6217 · Japan

China: ETAS (Shanghai) Co. Ltd. · 2404 Bank of China Tower · 200 Yincheng Road Central · Shanghai 200120 · P.R. China

Korea: ETAS Korea Co. · Ltd. 4F · 705 Bldg. 70-5 · Yangjae-dong · Seocho-gu · Seoul 137-889 · Korea

North America: ETAS Inc. · 3021 Miller Road · Ann Arbor, MI 48103 · USA

India: Please contact your local office first before sending your devices to ETAS GmbH in Germany
ETAS Automotive India Pvt. Ltd. · No. 690, Gold Hill Square, 12F · Hosur Road, Bommanahalli · Bangalore, 560 068 · India

Brazil: Please contact your local office first before sending your devices to ETAS GmbH in Germany
ETAS in Brazil · Av. Juruá, 606 - Alphaville · CEP 06455-010 - Barueri - SP · Brazil

Sender and delivery address

Company	ETAS GmbH
Street	Borsigstr. 14
Zip/City/Country/State	70469 Stuttgart
Contact Name	Klaus Mustermann
Dept. / Building	
Telephone	0711 89661 0
Fax	
Email	labcar.hotline.de@etas.com

Required hardware service

Upgrade (please attach an offer)	
Your Purchase Order Number for the repair	F-00K-107-259

Invoice address

Company	ETAS GmbH
Street	Borsigstr. 14
Zip/City/Country/State	70469 Stuttgart
Contact Name	Klaus Mustermann
Dept. / Building	

Delivery instructions

in case you send more than one device to us	Only complete delivery accepted

Product information

Product Name	ETAS Part Number	Serial Number	Failure Description	Environmental conditions
ES5340.1-M	F-00K-107-052	xxxxxxxxxxxx	Upgrade for ES5340 with LCM_PMSM5340	none

Upon successful completion of the RMA order, ETAS will send an e-mail confirmation to the e-mail address you have provided.

Von:	returnsheetreceiver@etas.com
An:	labcar.hotline.de@etas.com
Datum:	21.10.2010 17:06
Betreff:	ETAS RMA 10_0678

Dear Customer,

this is to confirm that we received your Hardware Service Request. You requested service (repair/calibration/upgrades) for the following item(s):

- Product: ES5340.1-M
  Serial Number: xxxxxxxxxxx

If you want us to service the item(s), please send us the item(s) to be serviced together with the following documents:
- the paper copy of the RMA form you have just created
- your official purchase order

Please note that we will not be able to process your Hardware Service Request without the documents mentioned above.

Please contact us if you need our price list for repairs.

Please understand that for items sent to us without the documents mentioned above, we reserve the right of returning them at the sender's expense.

Sincerely,
ETAS GmbH
Hardware Services

8 Technical Data and Standards

8.1 Technical Data

Analog Outputs

Number on ES5340.2-M	8 (6 single-ended, 2 differential or single-ended for resolver sensor)
Number on ES5340.1-S	6 (single-ended)
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 on ES5340.2-M	8
Number on ES5340.1-S	6
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 duty cycle (50%) between 1 Hz and 10 kHz	±0.2%...±2% (linear)
Accuracy 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 (ES5340.2-M only)

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 (ES5340.2-M only)

Number	20
Input voltage range	0 to +60 V
Frequency range	1 Hz...100 kHz
Duty cycle	0%...100%
Resolution 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

Speed Sensors (ES5340.2-M only)

Supported systems	Resolver Digital Encoder Sine Encoder Freely programmable waveform

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.

Electrical Data

Current consumption ES5340.2-M	980 mA @ +3.3 V DC 780 mA @ +12 V DC
Current consumption ES5340.1-S	820 mA @ +3.3 V DC 653 mA @ +12 V DC

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-M:

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

ES5340.1-S:

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

8.2 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.

9 ETAS Contact Addresses

ETAS HQ

ETAS GmbH

Borsigstraße 24 Phone: +49 711 3423-0

70469 Stuttgart Fax: +49 711 3423-2106

Germany WWW: www.etas.com

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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