BOSCH

Data Logger C 60

Manual

Version 1.1 5/17/2018

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1 Preparation

Use the C 60 only as intended in this manual. Any maintenance or repair must be performed by authorized and qualified personnel approved by Bosch Motorsport.
Operation of the C 60 is only certified with the combinations and accessories that are specified in this manual. The use of variant combinations, accessories, and other devices outside the scope of this manual are only permitted when they have been determined to be compliant from a performance and safety standpoint by a representative from Bosch Motorsport.
Read the manual carefully and follow the application hints step by step. Do not hesitate to contact us, contact data can be found on the last page of this document.

Disclaimer

Due to continuous enhancements, we reserve the rights to change any illustrations, photos and technical data within this manual.
Please retain this manual for your records.

Notice!

In this document, all screenshots are created by way of example for a display. Please consider this and replace the product names with the name of your device.

2 Power Supply

Please ensure that you have a good ground installation. That means:

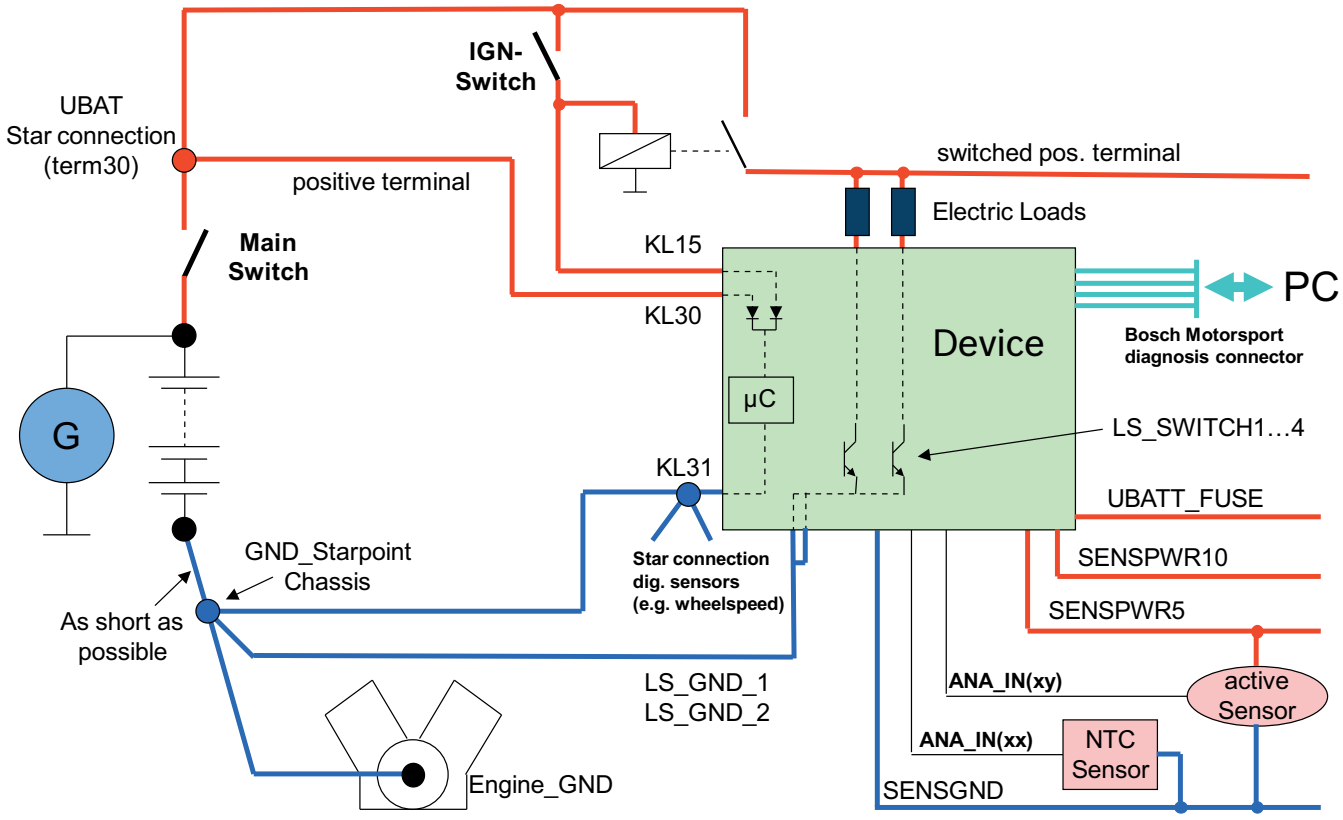
– A ground that has a solid, low resistance connection to the negative battery terminal
– Connection should be free from dirt, grease, paint, anodizing, etc.
– Use large diameter wire
– More metal-to-metal contact is better!

The following notations for power signals are used:

– KL 15 is a switched battery rail controlled by the IGN-switch
– KL 30 is an unswitched battery positive rail (same as battery positive terminal)
– KL 31 is an unswitched ground rail (same as battery negative terminal)

Be careful to observe current limits of wires and connector pins!

3 Onboard Network Concept



Notice!
This schematic is not device specific, please see the section ‘Technical Data’ for the specifications of your device.

4 Technical Data

The data logger C 60 is a compact and light weight data logging system for motorsport applications. This allows for synchronized acquisition of engine data from the ECU and chassis data from up to 26 analog and 4 digital input channels. Additional input devices can be connected via Ethernet and CAN buses.
Recorded data from the 2 GB logger can be downloaded via high speed Ethernet or via wireless connection with the BT 60 burst telemetry system.
Software upgrades for the C 60 (field upgradable by entering a key) activate additional recording on USB flash drive, CCP-master and additional input channels.

Application

Converters	8 kHz AD converters with digital low pass filter
Configurable math channels	
User configurable CAN in/out messages	
Sampling rate	Max. 1,000 Hz for all channels
Online data compression	
Logging rate	Max. 300 kB/s
Recording channels	Up to 720 per connected device
Logged data download speed	Max. 1,000 kB/s
Internal storage capacity	2 GB
3-port network switch	
BT 60 WLAN burst telemetry support	

FM 40 long range telemetry support, GSM telemetry support	
RS232 GPS input	
CCP-Master, data acquisition from ECU that support CAN calibration protocol (optional)	

Technical Specifications

Mechanical Data	
Size	105 x 34.5 x 137.5 mm
Weight	495 g
Protection Classification	IP67 to DIN 40050, Section 9, Issue 2008
Operating temperature (internal)	-20 to 65°C
Max. vibration	Vibration profile 1 (see Appendix or www.bosch-motorsport.com)

Electrical Data	
Supply voltage	8 to 18 V
Max. power consumption (w/o loads)	10 W at 14 V

Inputs	
Analog channels	6
Input range	0 to 5 V
Resolution	12 bit
Switchable pull up resistor	3 kΩ

Outputs	
PWM outputs (low side switch 2 A each)	4
Sensor supply 5 V ± 1 % (250 mA)	1

Environment

Software Upgrade 1	
GPS input	
Additional analog channels	20
Rotational channels (input Hall/inductive)	4
Additional sensor supply 5 V (250 mA each)	3
Sensor supply 10 V (250 mA)	1
Sensor supply 12 V (1 A), non regulated	1
RS232	GPS
	F 02U V00 703-01
Software Upgrade 2	

CCP-Master (ASAP 2 file from ECU manufacturer required)	F 02U V00 797-01
Software Upgrade 3	
USB-Port unlocked (Rugged USB flash drive 2 GB Bosch File System (BFS) format included, works with Bosch File System (BFS) preformatted USB Flash drive only)	F 02U V00 872-02
Adapter cable to USB-Port (included in Upgrade)	F 02U V01 343-01
Adapter for wiring harness (included in Upgrade)	F 02U 002 996-01

Connectors and Wires	
Motorsports connectors double density	2 x 41 pins
Mating connector I AS-DD 6-12-41SN	F 02U 002 216-01
Mating connector II AS-DD 6-12-41SA	F 02U 004 180-01

Communication

Configuration via RaceCon over Ethernet or MSA-Box II	
CAN interfaces	2
Ethernet 100BaseT	3
RS232	Telemetry
Lap trigger input	1

Installation Notes

The required software (.pst file) for this device is available in the download area of our homepage www.bosch-motorsport.com.
Download data and save configurations before sending device as it will be reset during service.

Internal accumulator for data preservation and clock included
Recommended service interval: 24 months (inclusive accumulator change)
Send device to Bosch dealer for service.
Charge accumulator for > 6 h after installation (supply with power).
Charge accumulator twice per year for > 6 h (supply with power).

5 Disposal

Hardware, accessories and packaging should be sorted for recycling in an environment-friendly manner.

Do not dispose of this electronic device in your household waste.

Waste electronic equipment must be disposed of properly according to Electrical and Electronics Act (ElektroG) and the European WEE directive.

6 Inputs and Outputs

6.1 Input Channels

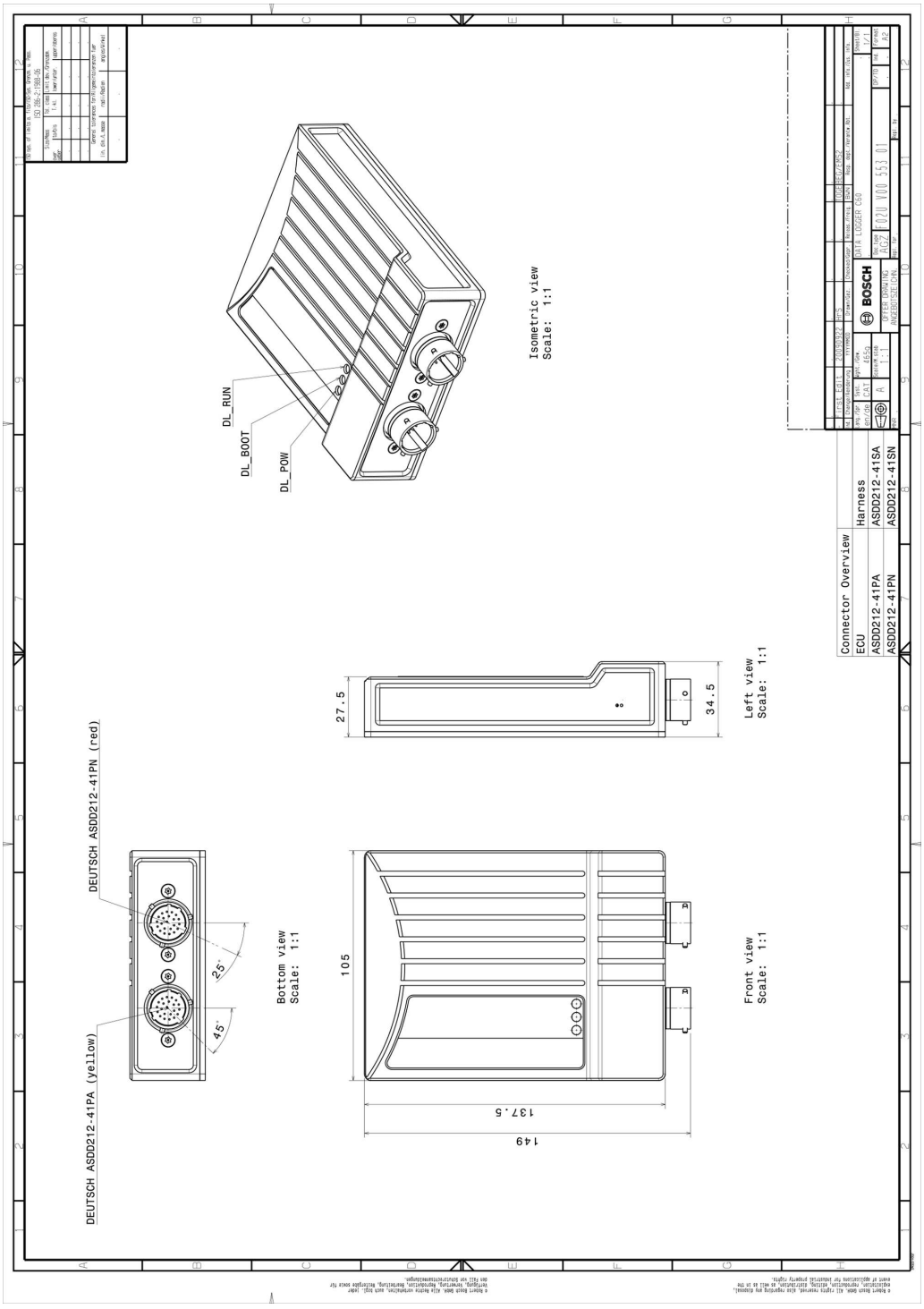
6.1.1 Analog inputs

The C 60 analog inputs accept an input signal of 0 to 5 V. A 3.01 kOhm pull-up resistor can be activated by software.

6.2 Output Channels

6.3 Communication Channels

7 Mechanical Drawing



8 Starting up the C 60

8.1 Before starting

Install the software required C 60 operation. It is developed for Windows 2000/XP/Vista/7.
Following software versions are used in this manual:

- C 60 setup, configuration and calibration: RaceCon 2.1.0
- Measurement data analysis: WinDarab V7

Set up the 100 Mbit Ethernet connection to the C 60.

- All three Ethernet ports of C 60 are internally connected by a network switch
- All Ethernet ports have ‘cable auto crossover’ functionality

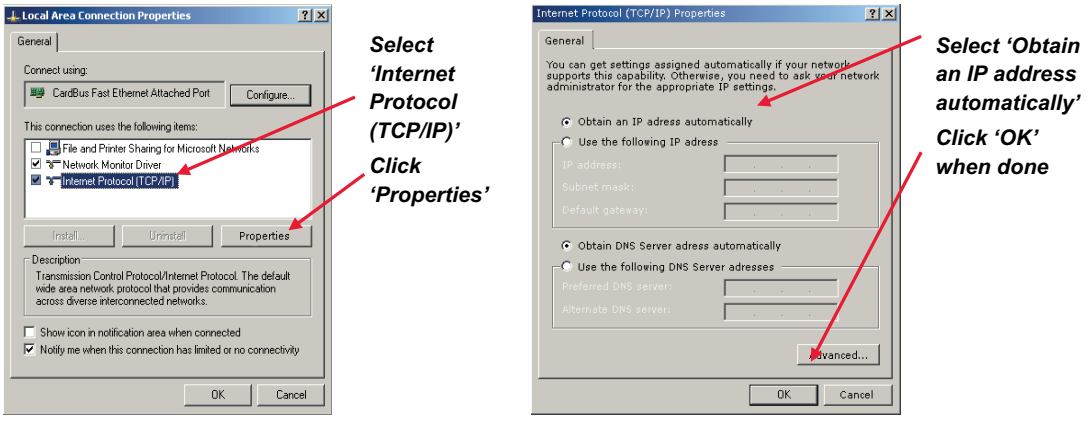
Minimum wiring loom of the Life connector (red):

Pin	Description
Pin 1+2+3	12 V supply voltage
Pin 4+5	GND supply voltage
Pin 6	Ethernet Tx+
Pin 7	Ethernet Tx-
Pin 8	Ethernet Rx+
Pin 9	Ethernet Rx-
Pin 10	Ethernet Screen

8.1.1 Setting up the network interface

The C 60 contains a DHCP server, network addresses can be assigned automatically to the configuration PC. The IP address of C 60 is 10.10.0.207.

1. Switch off the PC’s firewall.
2. Set up the PC’s network interface as shown in the screenshots.

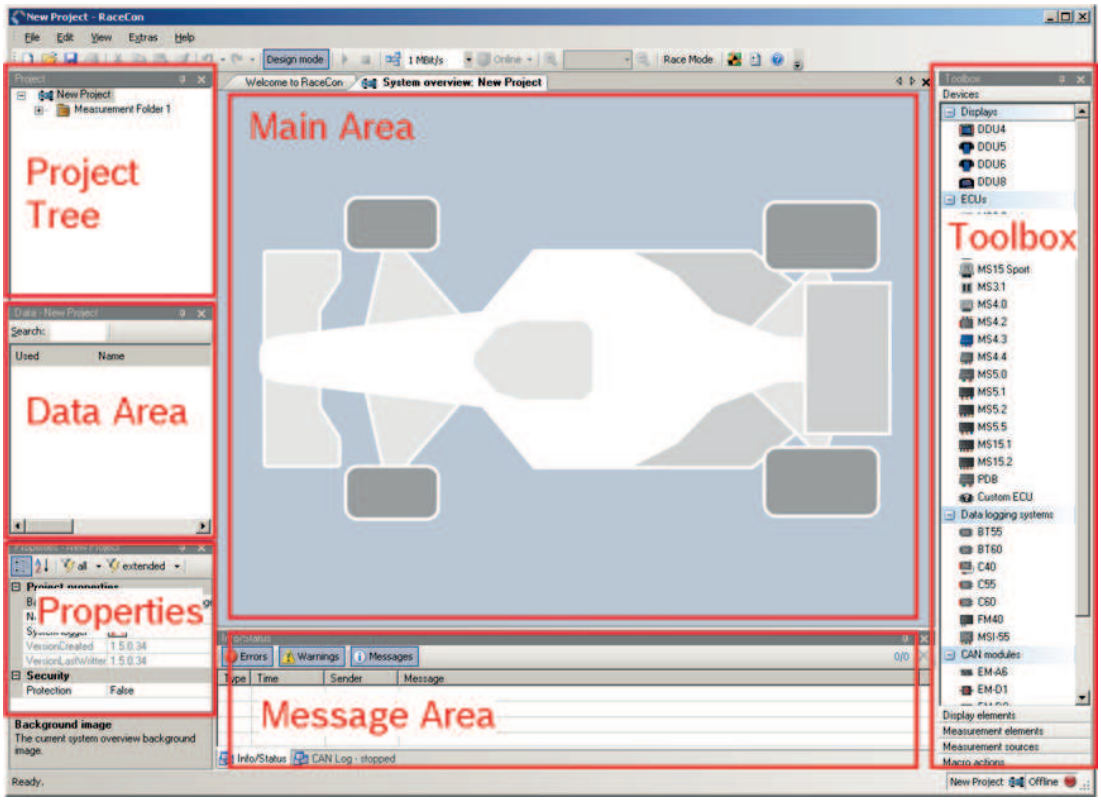


8.1.2 About RaceCon

RaceCon is an all integrated software tool for configuration and calibration of Bosch Motorsport hardware products. It is used to set up, configure and calibrate the C 60.
For better understanding, Bosch Motorsport offers a video tutorial that explains many functions of RaceCon. The video tutorial is available in the ‘Software Download’ section of www.bosch-motorsport.com.

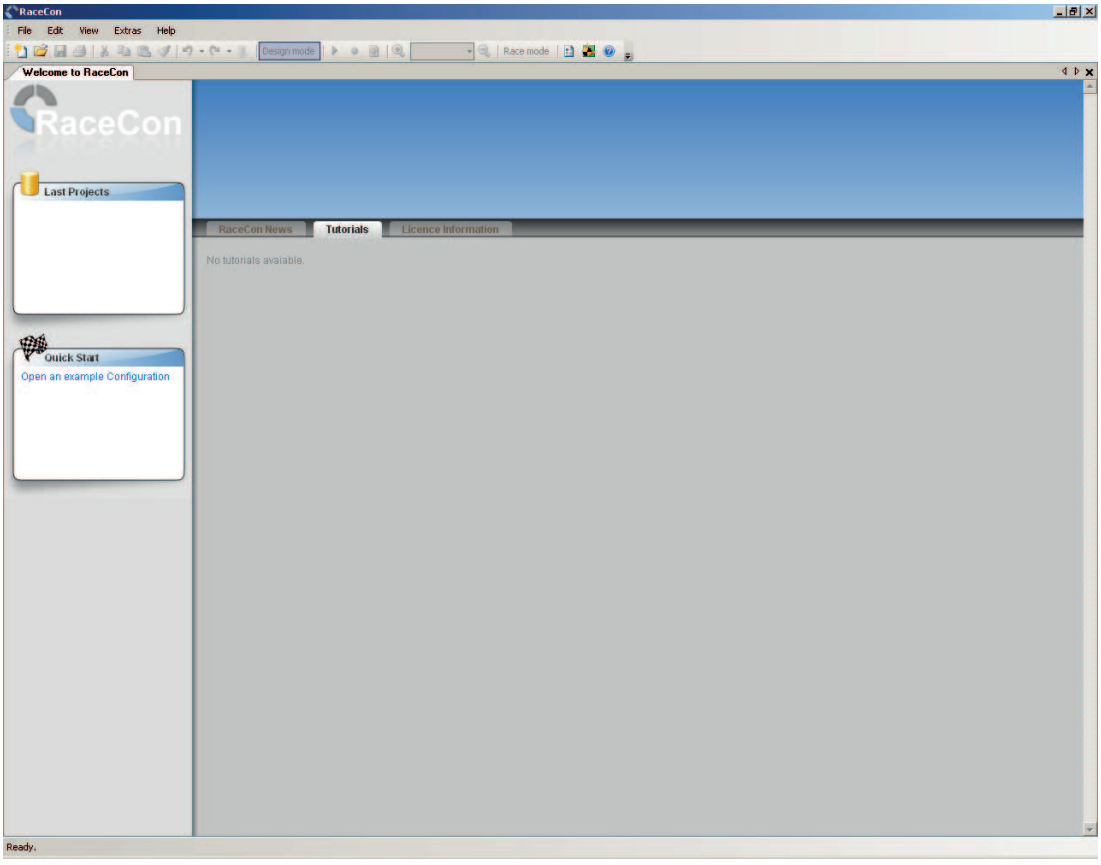
8.1.3 Connecting the Unit to RaceCon

The following screenshot shows an overview of the RaceCon Main Screen with its areas.

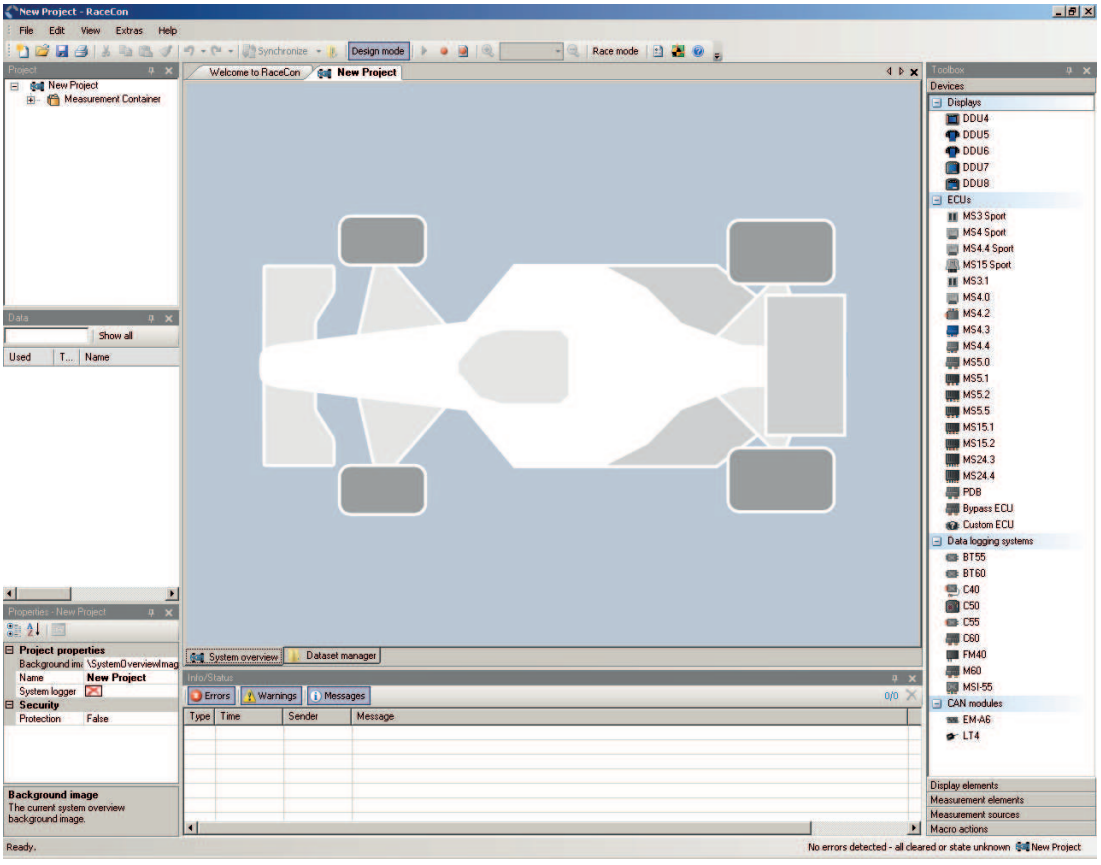


All (sub-) windows are resizable and dockable.

1. Start the RaceCon software.



In the ‘File’ menu select ‘New’ to create a new project.



In the Toolbox select the C 60 and drag it into the Main Area. A pop up window to specify the C 60 program archive appears.

1. An information shows that the archive is valid or not.
   Select the program archive delivered with the C 60 (.PST file).

Click ‘Next’.

1. Select ‘Race track’.
2. Choose the way to switch display pages that fits to your hardware configuration.
3. Click ‘Finish’. The C 60 is inserted into the project and RaceCon tries to connect to the device.

4. RaceCon detects configuration differences between the C 60 and the RaceCon project and asks for permission for data download.
5. Click ‘OK’ to proceed.

The download starts and the C 60 carries out a reset.

After the reset RaceCon reconnects to the C 60. Local configuration on both the PC and C 60 match (Indicated by green background and dot). The C 60 is now connected to RaceCon.

8.2 Feature activation

– Optional software feature packages are available for the C 60 If you have purchased an optional software feature package, it must be activated before it becomes operational.
– The feature activation status is stored permanently in the device and requires activating once only.
– As the activation key is device specific, a key delivered with one C 60 does not work on any other C 60 .
– If you have not purchased an option package, the next steps can be skipped.
1. To activate a feature, double-click on ‘C 60’ in the Project Tree and click on the ‘Features info’ tab in the Main Area.

The ‘C 60 features info’ window appears.

1. Double-click on the feature you want to activate. A feature unlock window appears.

2. Enter the activation key you received for this feature on this device and click ‘OK’ when done. The feature’s status changes to ‘unlocked’.

3. Perform these steps to activate other features you purchased.
4. Switch the car’s ignition off and on again to cycle the power of C 60.

8.3 First recording (Quick start)

This chapter explains the configuration of the recording of the battery voltage channel. See chapter ‘*Recording and Telemetry, page 84*’ for a detailed instruction to configure recordings. This function requires the installation of Software Upgrade 1. For data recording on the C 60 , the software upgrade ‘C 60 Datalogger’ must be activated. See chapter ‘Feature activation’ for an instruction to activate software upgrades on C 60.
1. Expand the C 60 Project Tree by clicking ‘+’.
2. Expand the Logger Tree by clicking ‘+’.
3. Double-click on ‘Recording’.
4. The C 60 recording configuration area opens.

In C 60 Project Tree, click on ‘C 60’ to display the available measurement channels. In the data window, scroll down to ‘ub’ (measurement channel for battery voltage).

Drag + drop the ‘ub’ measurement channel into the recording area.

Right-click on ‘C 60’ in the C 60 Project Tree and choose ‘Download configuration’.

The configuration download starts and the C 60 carries out a reset.

1. As we did not define global start conditions, recording starts immediately.
2. Start the WinDarab software.
3. Disconnect the C 60 network cable.
4. Click on the ‘Import/Export’ icon.
5. Select ‘Data logger C50/C55/C60/DDU7/DDU8’ and click ‘OK’ when done.

6. The ‘Read measurement Data’ dialog opens.

7. Click on ‘Modify’ button and select the base folder.
8. Choose ‘FTP’ as data transmission method.
9. Choose ‘XXXXXXXXXX’ in the Vehicle dropdown list.
10. Activate ‘Auto save’.
11. Click ‘Save’ when done.

Connect the C 60 network cable. Data transmission from the C 60 starts automatically. Measurement files are stored automatically in the base folder.

1. Click on ‘Close’ when transmission has finished.
2. Click on the Start button and choose ‘Open measurement file’.
3. Select the measurement files from the storage folder.
4. Click on ‘Open’.
5. Click in ‘New Desktop‘ to open a new measurement data window.
6. Drag the ‘ub’ measurement channel from the Channel list and drop it into the measurement data window. ‘ub’ measurement channel‘s graph is displayed.

Notice!
For more detailed descriptions and instructions refer to the WinDarab V7 manual.

8.4 Status LEDs

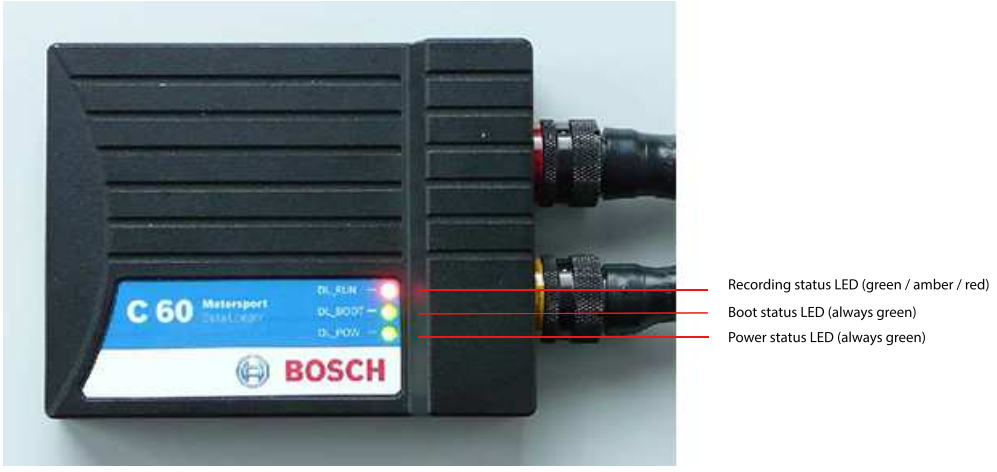


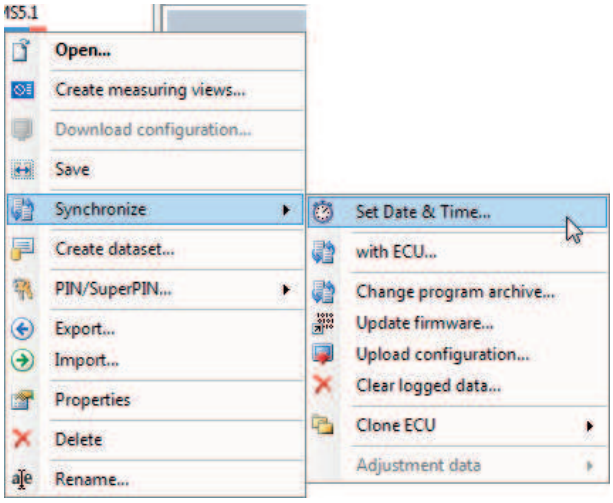
Figure 8.1:

C 60 Recording Status LED

		Recorded Data	Telemetry
	Amber constant • No measurement configuration on C 60	No	No
	Blinking green slow • Measurement configuration loaded • Start condition(s) not fulfilled	No	Yes
	Blinking green fast • Measurement configuration loaded • Start conditions fulfilled • C 60 is recording data	Yes	Yes
	Blinking amber slow • Measurement configuration loaded • Measurement setup error (external device missing) • Start condition(s) not fulfilled	No	Yes (but some missing)
	Blinking amber fast • Measurement configuration loaded • Measurement setup error (external device missing) • Start conditions fulfilled, C 60 is recording data	Yes (but some missing)	Yes (but some missing)
	Blinking red fast • Firmware update in progress • Do not power off C 60	No	No
	Blinking red slow • Firmware update has finished	No	No
	Red constant • Error during firmware update	No	No

8.5 Set Time & Date

The C 60 is equipped with a real time clock which is supplied by an internal accumulator. Once this accumulator is charged correctly by 12 V supply of the C 60, ‘Date & Time’ can be programmed by RaceCon. We recommend min. 5 hours charge time.
Please connect the C 60 to the PC and click on ‘Set Date & Time’ in the Context menu of the C 60.



9 Channel Configuration

9.1 Math and condition channels

9.1.1 Math channels

Math channel

- Arithmetic and logical operations on up to 4 measurement channel(s)
- Numerical result
- Result can be used as input source for various display elements (numeric elements, alarms, Bargraphs) and further calculations in the whole RaceCon project

Conditional function

- Arithmetic and logical operations on one or more measurement channel(s)
- If-Else structure with reset
- Numerical result
- Result can be used as input source for various display elements (numeric elements, alarms, Bargraphs) and further calculations in the whole RaceCon project

All math channels can be used globally in the whole C 60 project.

9.1.2 Creating a new math channel

1. Follow the steps shown in the screenshot.

The ‘create/edit math channel’ window appears.

Create/Edit Math Channel Window

1. Define the math channel using the following configuration possibilities:

1. Click ‘Finish’ when done. The math channel is displayed in the C 60 math channel window.

9.1.3 Creating a new conditional function

1. Follow the steps shown in the screenshot.

The ‘create/edit conditional function’ window appears.

Create/Edit Conditional Function Window

1. Define the conditional function using the following configuration possibilities:

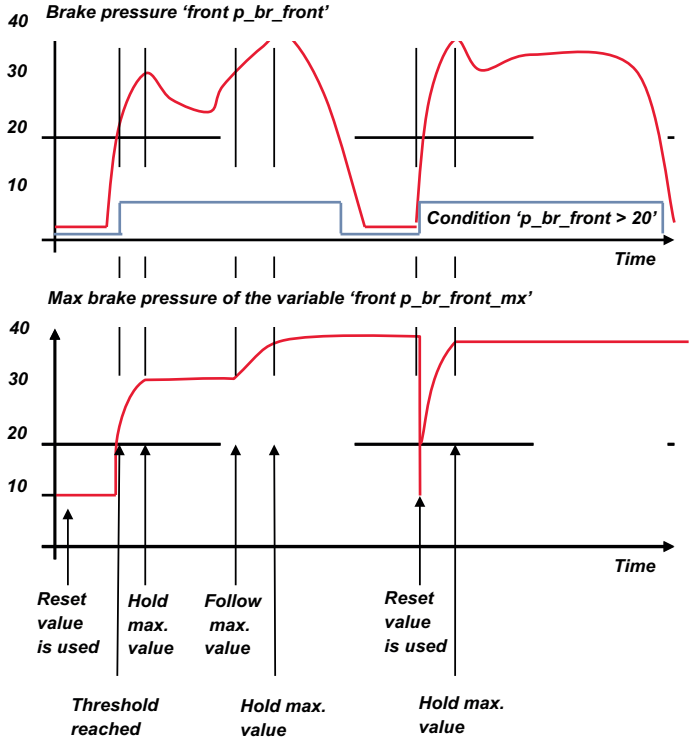
1. Click ‘Finish’ when done.

The conditional function works the following way:
The program always calculates the condition entered in the IF window and checks if the condition is TRUE or FALSE.
If the condition entered in the IF window is TRUE, the program calculates the condition entered in the THEN window. The returned value is the content of the new variable (entered in ‘Name’).
If the condition entered in the IF window is FALSE, the program calculates the condition entered in the OTHERWISE window. The returned value is the content of the new variable (entered in ‘Name’).
The reset value is always set for the new variable (entered in ‘Name’):

- before If-condition becomes TRUE for the first time after power-up
- when If-condition changes state from FALSE to TRUE.

An example of a condition to set up the maximum front brake pressure is given on the next page.
The conditional function is displayed in the C 60 math channel window.

Example: Setting up a condition for maximum front brake pressure.



- At power-up, the reset value (10) is used for 'p_br_front_mx'.
- 'p_br_front' rises to 30. As 'p_br_front' is > 20 (condition is TRUE), the condition 'max (p_br_front, p_br_front_mx)' in the THEN window is triggered. The condition sets the bigger value as new value for 'p_br_front_mx'. As 'p_br_front' (30) is bigger than 'p_br_front_mx' (10), the new value for 'p_br_front_mx' is set to 30.
- Although 'p_br_front' falls to 25, the value of 'p_br_front_mx' stays 30. This is caused by the THEN-condition, because p_br_front_mx' (30) is still bigger than p_br_front' (25).
- As 'p_br_front' rises to 40. As 'p_br_front' (40) is bigger than 'p_br_front_mx' (30), the new value for 'p_br_front_mx' is set to 40.
- As 'p_br_front' falls below 20, the IF-condition turns to FALSE. Now the OTHERWISE-condition is triggered. Because the condition 'p_br_front_mx' sets the value of 'p_br_front_mx' and the value that is already set to 40 before, nothing changes.
- When 'p_br_front' rises to 40, the If-condition changes to TRUE again and triggers the THEN-condition. Now the reset value (10) is used for 'p_br_front_mx' in the THEN-condition.
- Because 40 is bigger than 10 the new value of 'p_br_front_mx' is 40.

9.2 Condition channels

Condition channel

- Logical operations on measurement channel(s)
- If-Else structure with reset
- Logical result
- Result can be used as input source for Alarm display elements and further calculations in the whole RaceCon project.

Condition combination

– Combination of several (up to 16) condition channels for more complex calculations
– Logical results

All conditions can be used globally in the whole C 60 project.

9.2.1 Creating a new condition channel

1. Follow the steps shown in the screenshot.

The ‚create/edit condition‘ window appears.

Create/Edit Condition Window

1. Define the condition channel using the following configuration possibilities:

1. Click ‘Ok’ when done.

The conditional channel is displayed in the C 60 condition channel window.

9.2.2 Creating a new condition combination

1. Follow the steps shown in the screenshot.

The ‚create/edit condition combination‘ window appears.

Create/Edit Condition Window

1. Define the condition combination using the following configuration possibilities:

Choose a channel (condition, conditional function, math, measurement channel with binary values) to be compared.
Combine multiple conditions by adding ‘AND’ or ‘OR’ relations.
To negate a condition, right-click on the condition and select ‘Negation (!)’.
Combine several (up to 16) conditions.

1. Click ‘Next’ to got to the next page.
   Choose the output setting of the result.
   Constant TRUE/FALSE: Result is as a constant with the value TRUE or FALSE.
   Blinking: Result is a blinking if the condition is fulfilled.
   Pulse: Result is a short one-time pulse if the condition is fulfilled.
   Toggling output: Result is a pulse that lasts until the next condition is fulfilled.
2. Click ‘Finish’ when done.

The conditional combination is displayed in the C 60 condition channel window.

9.3 CPU Load Limits

As all microprocessors, the C 60’s processor has limited capacities. The current load of the processor can be monitored using the channel “cpu_load”. When configuring your device, please make sure the used CPU load is in a save range below 100 %.
Bosch recommends a maximum CPU load of 85 % (averaged). Exceeding this limit might result in C 60 not being able to fulfill its required measuring/logging/display tasks or even in the C 60 crashing and rebooting.
Main factors influencing the CPU load are:

– Number and complexity of math channels
– Number and complexity of conditions
– CAN traffic on both CAN lines
– Display configuration, especially displaying pictures

– Logger configuration (total logging rate [kB/s], conditional measurement rates)

To help respecting the limit of 85 % CPU load, the C 60 creates an error memory entry. To trigger this error entry, the CPU load must exceed the limit for 5 minutes without interruption. When being confronted with this error memory entry (see ‘Error info’ in RaceCon) or when being confronted with C 60 resets due to complex configuration setups, please consider reducing the demands on the C 60 adapting the influencing factors mentioned above.

10 CAN Bus

C 60 has two fully configurable CAN buses.

- Baudrate (125 kBit ... 1 MBit)
- 11 Bit or 29 Bit identifiers
- Input configuration: Read messages from CAN bus and convert to C 60 measurement/ display variables. CAN bus supports row counter configuration.
- Output configuration: Write C 60 measurement variables to CAN messages, output frequency and row counter are configurable, CAN gateway functionality (transfer from one bus to the other).

10.1 CAN bus trivia

CAN message

- 11 Bit (standard) or 29 Bit (extended) identifier
- Up to 8 bytes of data payload

CAN bus

- Needs termination resistors (120 Ohm) in wiring harness
- All devices connected to the bus must use identical data rate

Configuration of C 60 bus data rate by double click on the CAN bus in project tree (1 MBaud, 500 kBit, 250 kBit, 125 kBit)

Row counter concept

- Re-use (multiplex) of message identifiers
- One byte of message contains row counter
- 7 bytes payload remaining
- Position of row counter is configurable

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x100	0	p_oil		t_oil				
0x100	1	s_dam_fl		s_dam_fr				
0x100	2	s_dam_rl		s_dam_rr				

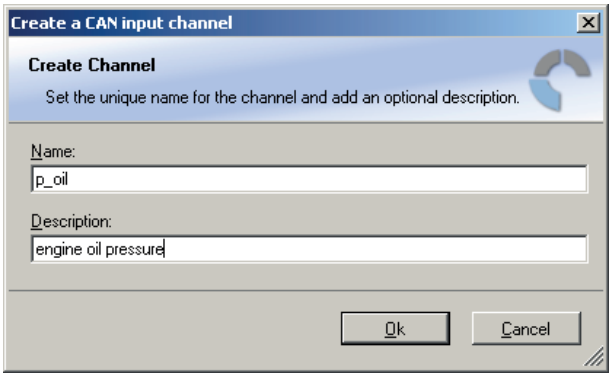
Message Id ***Row Counter*** ***Payload Area***

10.2 CAN input

10.2.1 Input configuration

10.2.2 Create a new CAN channel

1. Right-click on CAN Input of desired bus (CAN1 or CAN2).
2. Select ‘New CAN Channel’ from menu.
3. Insert name and description of channel.



4. Click ‘OK’ when done.

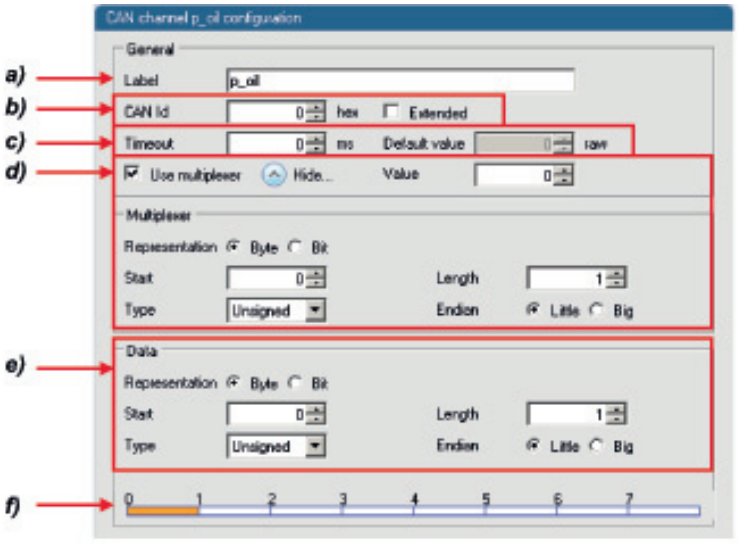
The channel is listed in the Data window and a CAN channel configuration window opens.

10.2.3 CAN channel configuration

10.2.4 Extracting data from CAN bus

Representation: Byte

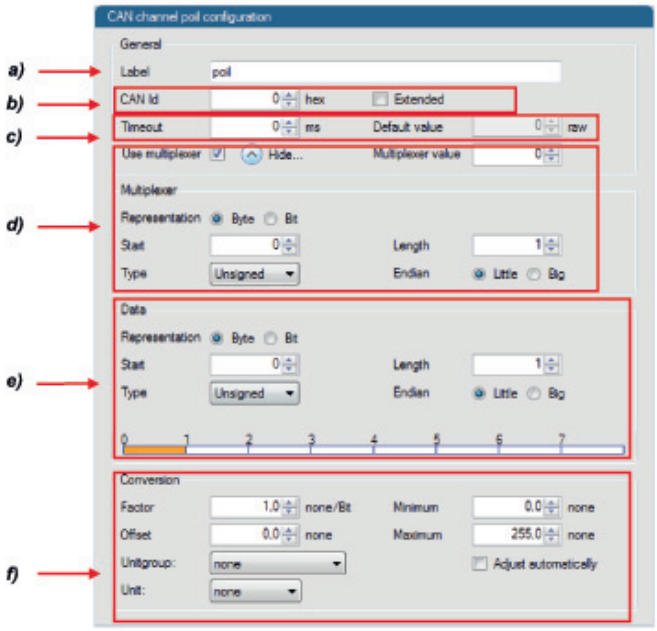
Some CAN devices need to be addressed by a byte represented CAN channel. The address can be assigned in this window and is illustrated by a bargraph.



a) Enter name of the CAN-channel.
b) Enter CAN message ID. Check the box, if extended IDs (29 bit) are used.
c) If replacement values are used, specify time-out period and raw value.
d) Check the box, if a multiplexer (row counter) is used.
e) Enter data position, length and format.
f) The bargraph shows assignment of the bytes.
• Red colored fields show the assignment of the data bytes.
• Orange colored fields show the assignment of the multiplexer bytes.

Representation: Bit

Some CAN devices need to be addressed by a bit represented CAN channel. The address can be assigned in this window and is illustrated by a matrix table.



a) Enter name of the CAN-channel.
b) Enter CAN message ID. Check the box, if extended IDs (29 bit) are used.
c) If replacement values are used, specify time-out period and raw value.
d) Check the box, if a multiplexer (row counter) is used.
e) Enter data position, length and format. The matrix table shows the assignment of the bits.
f) Enter a Conversation to get physical values

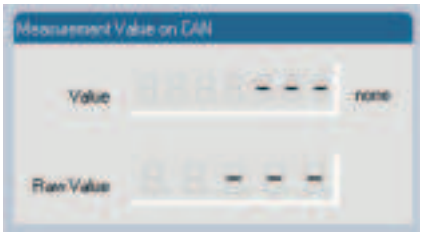
10.2.5 Conversion to physical values

a) Enter factor (gain) for conversion to physical value.
b) Enter offset for conversion to physical value.
c) Select type of physical value.
d) Select unit of physical value.
e) Enter minimum physical limit of the channel. (for manual setup)
f) Enter maximum physical limit of the channel. (for manual setup)
g) Check the box to automatically adjust the limits of the channel.

10.2.6 Special features

CAN analyzer functionality

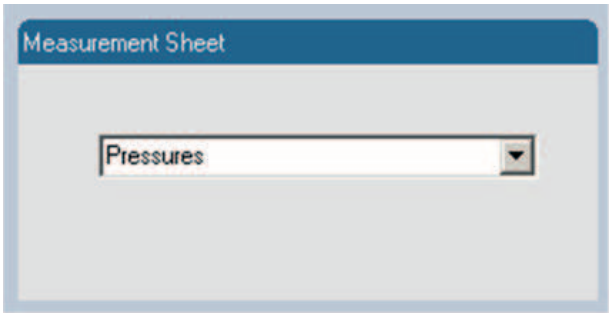
This functionality is only available, if a MSA-Box (I & II) is used to connect the C 60 to the PC. Choose the CAN bus that is connected to the MSA-Box to display the raw value and the converted physical value here.



Automatic creation of online measurement sheets

The CAN channel can be automatically inserted to a measurement sheet. Insert a name for a new sheet or select an existing sheet from the listbox.

For an online view of the value measured by the C 60, insert the channel in an online measurement sheet which is described in the next chapter.



10.2.7 Online view of CAN channels in vehicle

1. Double-click on ‘Sheet 1’ in Project Tree.

Measurement Sheet 1 is displayed in Main Area.

1. Click on ‘Measurement elements’ in the Toolbox.
2. Drag the desired Measurement element (e.g. Numeric Indicator) and drop it on the Measurement Sheet.

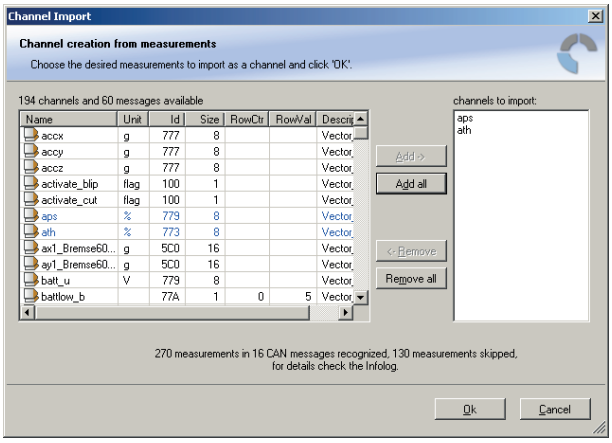
1. Click on folder ‘CAN Input’ of desired CAN bus to display available channels.
2. Drag desired Measurement channel and drop it on the Measurement element.

The measurement element displays the values of the assigned channel.

1. Connect PC to the vehicle and switch to ‘Race Mode’ by clicking ‘F11’ on the keyboard to display online data.

10.2.8 Import a CAN database (DBC) file

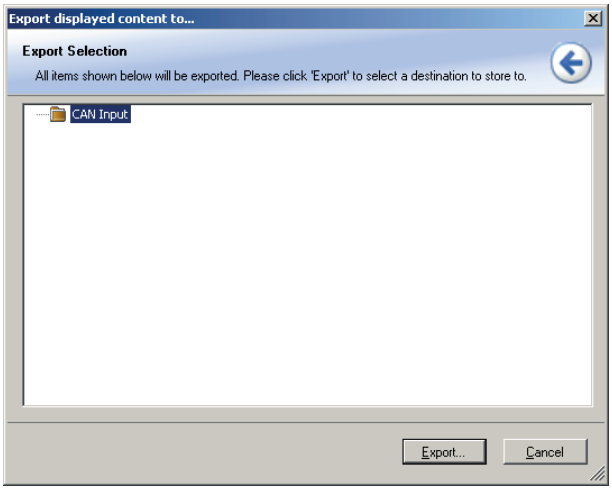
1. Right-click on CAN Input of desired bus (CAN1 or CAN2).
2. Select ‘Import DBC file’ from menu.
   A file browser opens.
3. Select DBC file to import and click ‘OK’ when done.
   A channel import window opens.



4. Select desired channels on the left and use the ‘Add’ button to add them to import list.
5. Click ‘OK’ when complete.
   The channels are inserted in the Data window.

10.2.9 Export RaceCon CAN configuration

1. Right-click on CAN Input of desired bus (CAN1 or CAN2).
2. Select ‘Export...’ from menu. An ‘Export Selection’ window opens.



3. Specify the filename.
4. Click ‘OK’ when done.

10.2.10 Import RaceCon CAN configuration

1. Right-click on CAN Input of desired bus (CAN1 or CAN2).
2. Select ‘Import...’ from menu.
   A file browser opens.
3. Select the input file and click ‘OK’.
   An ‘Import Selection’ window opens.

1. Select channels to import.
2. Drag and drop the channel to ‘CAN Input’ of desired CAN bus on right hand side.
3. Click ‘Next’.
   If a measurement channel belongs to more than one source (e.g. C 60 and ECU MS 5.1), the ‘Solve Label Ambiguity’ window opens.

4. Assign the ambiguous channels to the desired source.

5. Click ‘Finish’.

10.2.11 Export to dbc file

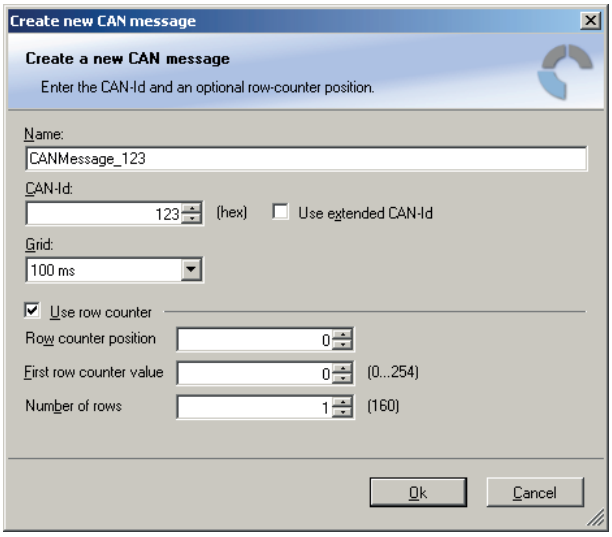
Click on this option to save the CAN configuration to a Vector dbc file format. It will open an explorer window where the dbc file can be saved on the harddisc.

10.3 CAN output

10.3.1 Output configuratin

10.3.2 Create a new CAN output message channel

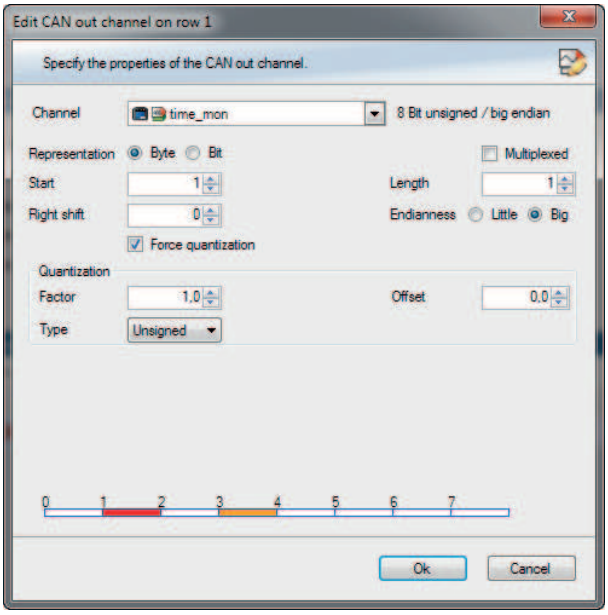
1. Right-click on CAN Output of desired bus (CAN1 or CAN2).
2. Select ‘New CAN Message’ from menu.
   The ‘Create new CAN message’ window opens.



3. Enter name of message, CAN-Id and Grid (output interval).
4. Optionally, specify a row counter (multiplexer).
5. Click ‘OK’ when done.
   A CAN message configuration window opens in the Main Area.

1. Click on ‘C 60’ in the C 60 Project Tree to display all labels.
2. Select the desired measurement channel and drop it on message’s bytes.

The measurement channel is assigned to the CAN message.
A double Click on one of the defined CAN channels opens the following dialogue:



In this dialogue additional settings are possible:

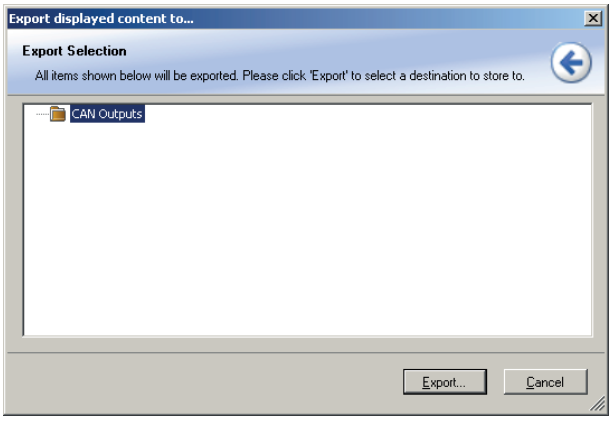
– Representation: Also a Bitwise CAN signal can be defined. Please define position and length in this case.
– Quantization: Physical values can be calculated by entering Factor/Offset. Signed and unsigned is optional.

10.3.3 Edit CAN Message Multiplexer settings

1. Click “Use multiplexer”, the Option “Hide” opens the multiplexer settings.
   Representation: Choose Byte or Bit Type of multiplexer
   Start, Length: Define start position and length of multiplexer (Byte or Bitwise possible)
   Endianness: Define Byte order (Little Endian –LB, HB, Big Endian –HB, LB)

10.3.4 Export RaceCon CAN configuration

1. Right-click on CAN Output of desired bus (CAN1 or CAN2).



2. Select ‘Export...’ from menu. The ‘Export Selection’ window opens.
3. Specify the filename.
4. Click ‘OK’ when done.

10.3.5 Import RaceCon configuration

1. Click right on CAN Output of desired bus (CAN1 or CAN2).
2. Select ‘Import...’ from menu.
   A file browser opens.

3. Select the input file and click ‘OK’.
   An ‘Import Selection’ window opens.

1. Select channels to import.
2. Drag and drop the channel to ‘CAN Output’ of desired CAN bus on right hand side.
3. Click ‘Next’.
   If a measurement channel belongs to more than one source (e.g. C 60 and ECU MS 5.1), the ‘Solve Label Ambiguity’ window opens.

1. Assign the ambiguous channels to the desired source.
2. Click ‘Finish’.

11 Analog and Frequency Inputs

11.1 Features

24 analog inputs with Software Upgrade 2; 4 analog inputs without upgrade
- 0 ... 5 V
- 12 bit A/D converter
- Switchable 3.01 kOhm pull-up resistor
- 8 kHz acquisition rate, up to 1 kHz recording rate
- Linear phase digital filter

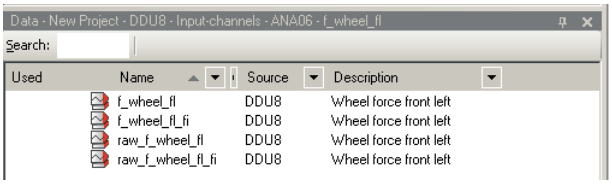
4 frequency inputs with Software Upgrade 2; no frequency inputs without upgrade
- 5 V Hall-effect type, 2.5 V trigger level
- 20 kHz max. frequency
- 10 ms measurement window

4 PWM outputs
- Low-side switch
- Up to 2 A each
- Output frequency selectable

11.2 Analog inputs

11.2.1 Measurement channels

For each analog channel, several ‘subchannels’ are available.



Measurement labels with the characters ‘raw’ show the exact values in mV.
Measurement labels with the characters ‘_fi’ show filtered values.
The word ‘name’ in the table is a placeholder for the channel’s name.

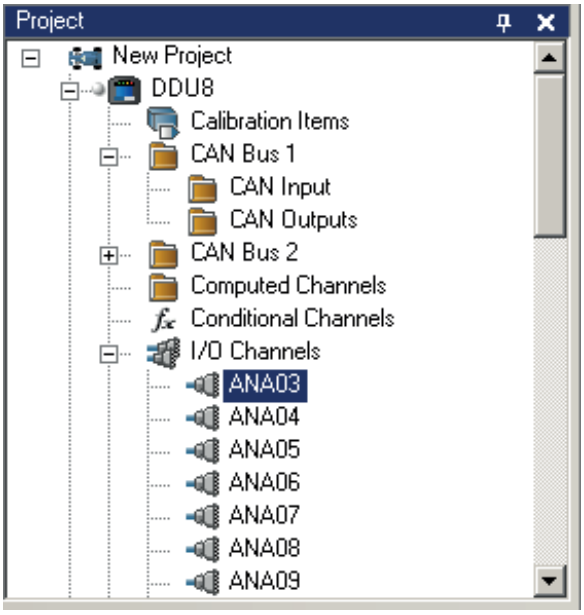
Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

Filtered channels are routed through digital low pass filters:
- C 60 uses A/D converter oversampling and digital filtering to recording rate
- Digital filters eliminate ‘out-of-band’ noise
- Cut-off frequency automatically adjusted to recording rate
- Linear phase – no signal distortion
- Latency compensation – no filter delay in recorded data

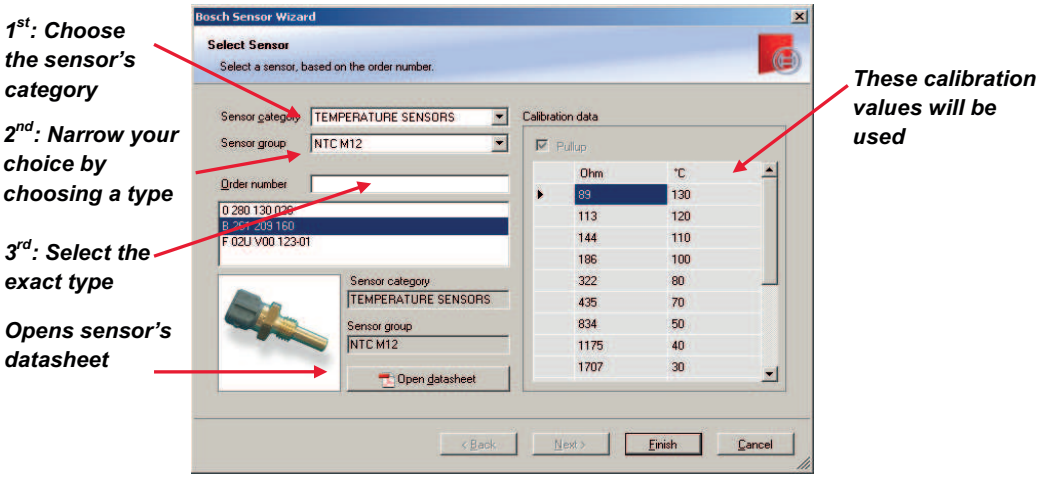
11.3 Configuring inputs

11.3.1 Configuring a predefined Bosch sensor with the 'Bosch Sensor Wizard'

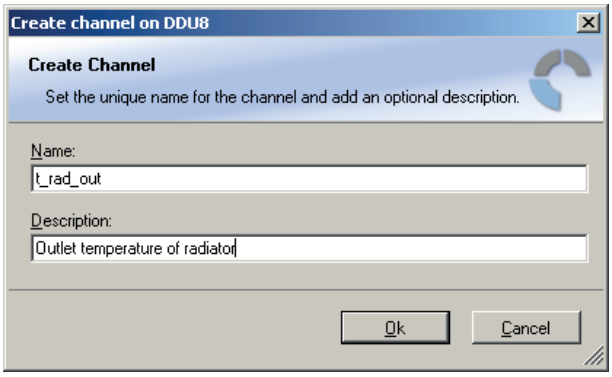
1. Click on ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.



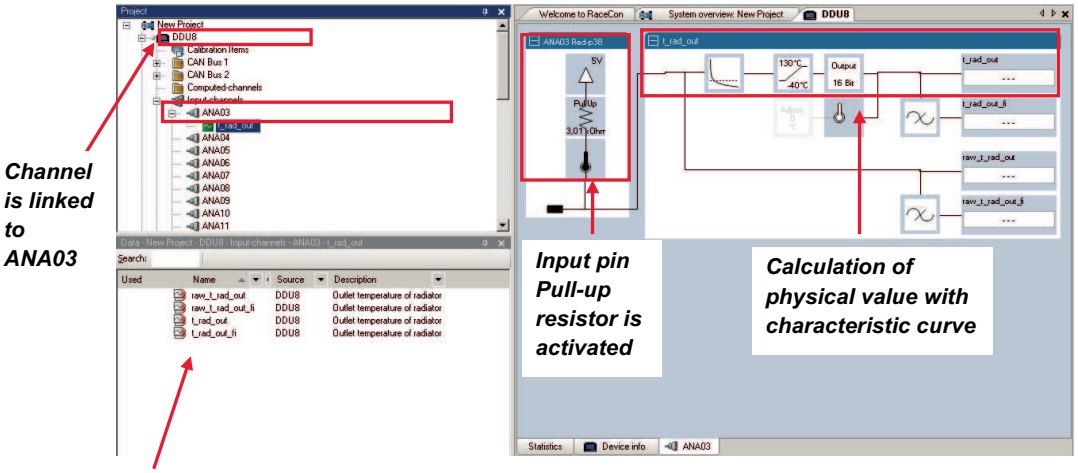
3. Drag the ‘Bosch Sensor Wizard’ from the Toolbox and drop it on the desired analog input channel in the C 60 Project Tree. The ‘Bosch Sensor Wizard’ opens.



4. Click ‘Finish’ when done.
5. The ‘Create channel’ window opens.
6. Enter channel name and description.



7. Click ‘Ok’ when done.
   The channel is inserted into the C 60 Project Tree.



Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

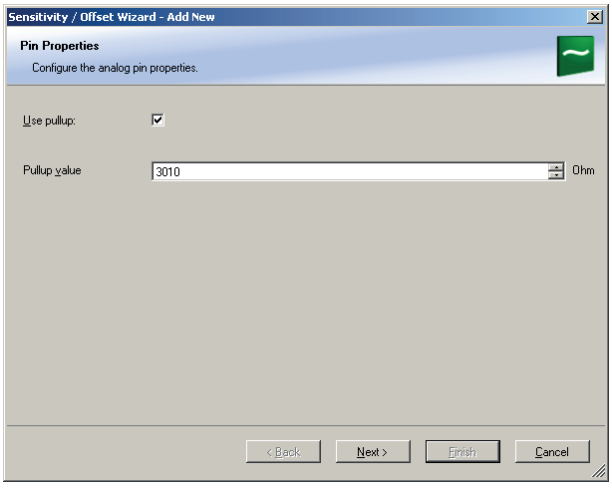
11.3.2 Configuring a generic linear sensor

Example: Acceleration sensor 5 g

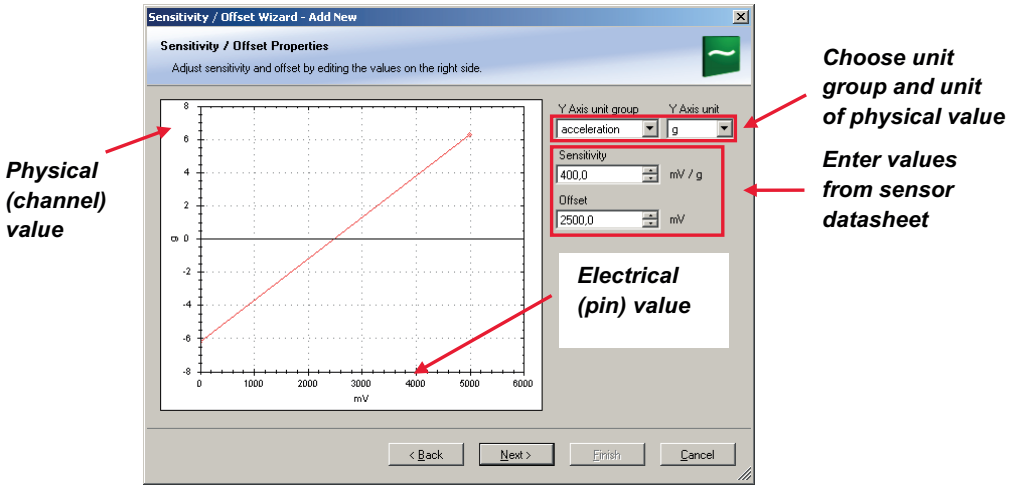
Output Signal					
Zero g (T_A = 25°C, V_{DD} = 5.0 V)(4)	V_{OFF}	2.25	2.5	2.75	V
Zero g (V_{DD} = 5.0 V)	V_{OFF}	2.0	2.5	3.0	V
Sensitivity (T_A = 25°C, V_{DD} = 5.0 V)(5)	S	380	400	420	mV/g
Sensitivity (V_{DD} = 5.0 V)	S	370	400	430.1	mV/g
Bandwidth Response	f_{-3dB}	42.5	50	57.5	Hz
Nonlinearity	NL_{OUT}	–1.0	—	+1.0	% FSO

From sensor data sheet – operating characteristics:
Sensitivity 400 mV/g, Offset 2500 mV
The sensor has a linear output signal with sensitivity and offset

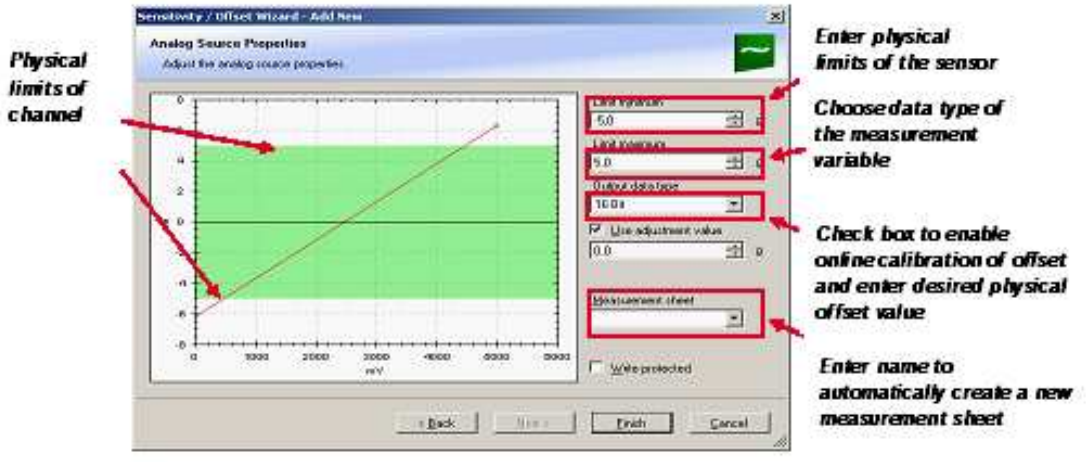
1. Click on ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Sensitivity/Offset’ analog signal source from the Toolbox and drop it on the desired analog input channel in the C 60 Project Tree. A ‘Sensitivity/Offset Wizard’ opens.
4. To activate the internal pullup-resistor, check the box.
   The internal pullup-resistor is used to get a 5 V signal at the analog channel of the C 60. It allows you to use a push-button.
   The fixed value of the internal pullup-resistor is 3010 Ohm. If using an additional external pullup-resistor, set up the overall resistance.



5. Click ‘Next’ when done.
   The second part of the ‘Sensitivity/Offset Wizard’ opens.

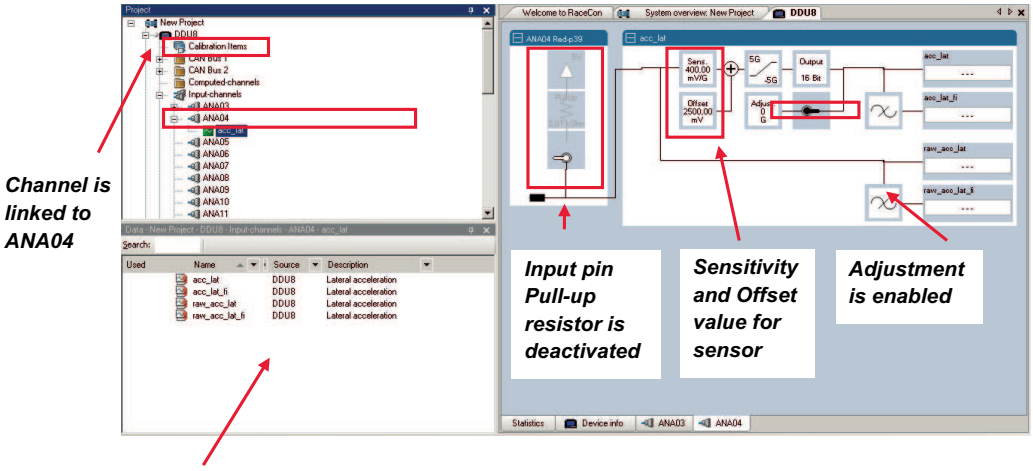


6. Click ‘Next’ when done. The third part of the ‘Sensitivity/Offset Wizard’ opens.



Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

7. Click ‘Finish’ when done.
8. Enter channel name and description.
9. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.



Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

11.3.3 Configuring a generic non-linear sensor

Example: Thermistor 5 kOhm

– From sensor data sheet: resistance values over temperature

PART NR.: 2381 640 502
HTCLE100E3502

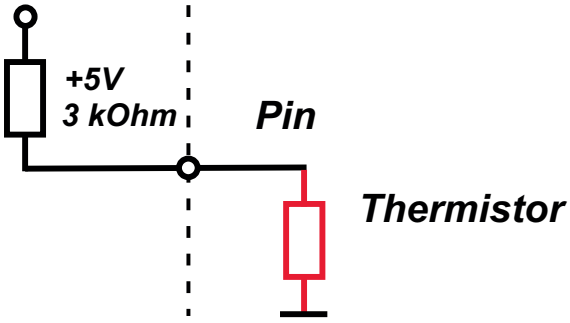
Toper [°C]	RT [Ω]
-40	166 047
-35	119 950
-30	87 600
-25	64 643
-20	48 179
-15	36 250
-10	27 523
-5	21 078

Toper [°C]	RT [Ω]
0	16 277
5	12 669
10	9 936
15	7 849
20	8 244
25	5 000
30	4 030
35	3 267

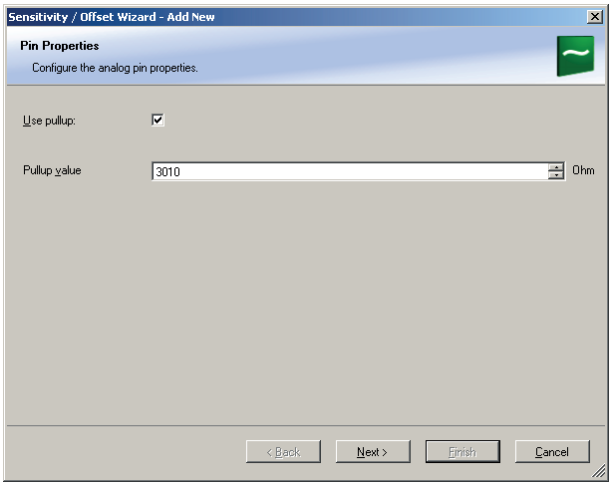
Toper [°C]	RT [Ω]
40	2 685
45	2 166
50	1 903
55	1 494
60	1 245
65	1 024
70	876
75	740

Toper [°C]	RT [Ω]
80	628
85	535
90	457
95	399
100	338
105	292
110	251
115	221

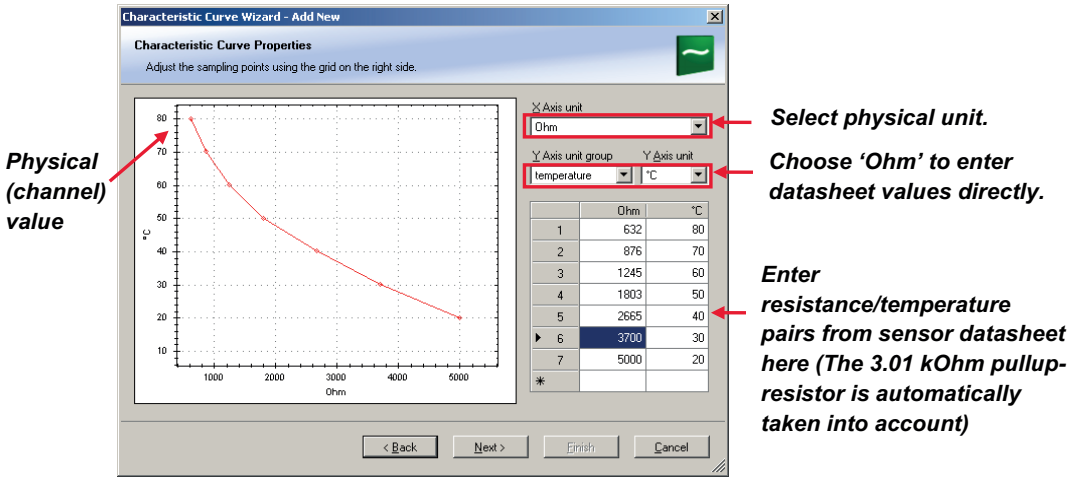
– The sensor has a nonlinear behaviour
– Use characteristic curve for linearization
– Input voltage is the ratio between pull-up resistor and thermistor



1. Click ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Characteristic Curve’ analogue signal source from the Toolbox and drop it on the desired analogue input channel in the C 60 Project Tree. A ‘Characteristic Curve Wizard’ opens.
4. To activate the internal pull up-resistor, check the box.
   The C 60 pull up-resistor is used to get a 5V signal at the analogue channel of the C 60. It allows you to use a push-button.
   The fixed value of the internal pull up-resistor is 3010 Ohm. If using an additional external pull up-resistor, set up the overall resistance.

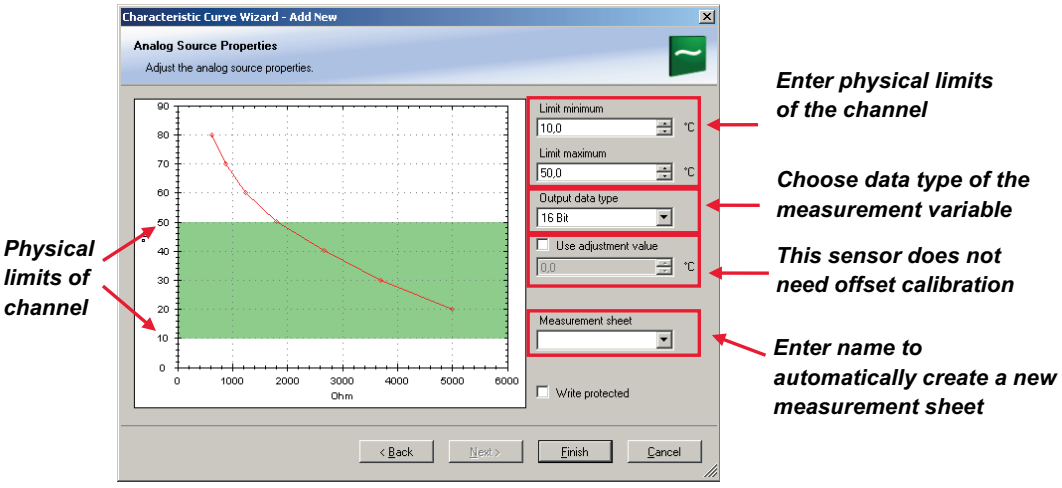


5. Click ‘Next’ when done.
   The second part of the ‘Sensitivity/Offset Wizard’ opens.



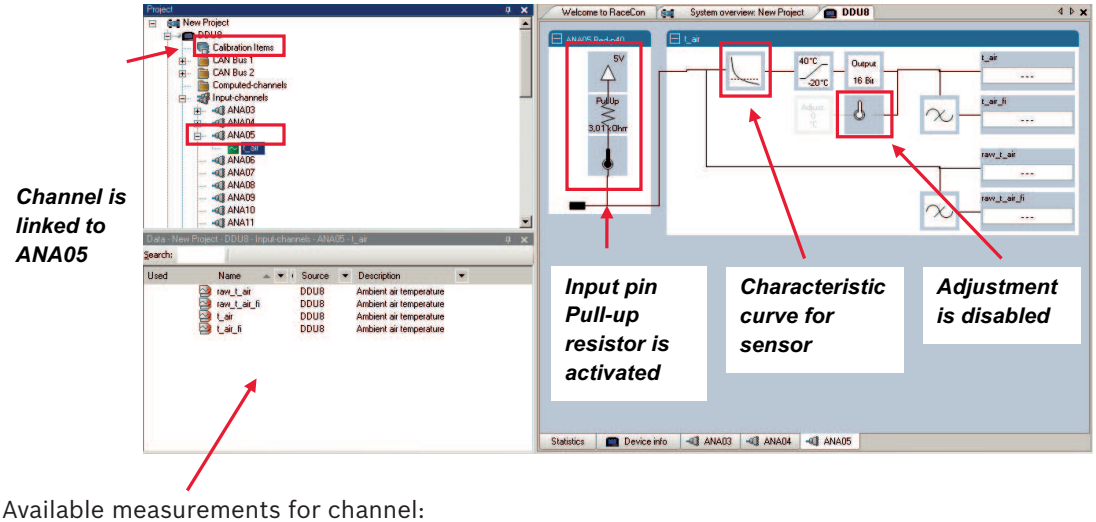
6. Click ‘Next’ when done.

The third part of the ‘Characteristic Curve Wizard’ opens.



Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

7. Click ‘Finish’ when done.
8. Enter channel name and description.
9. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.



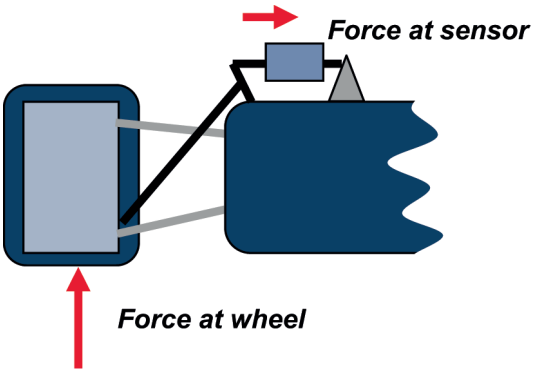
Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

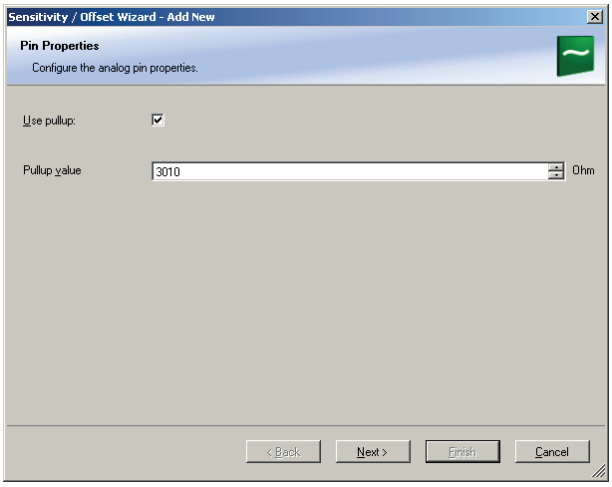
11.3.4 Configuring a multipoint adjustment

Example: Measurement of wheel force

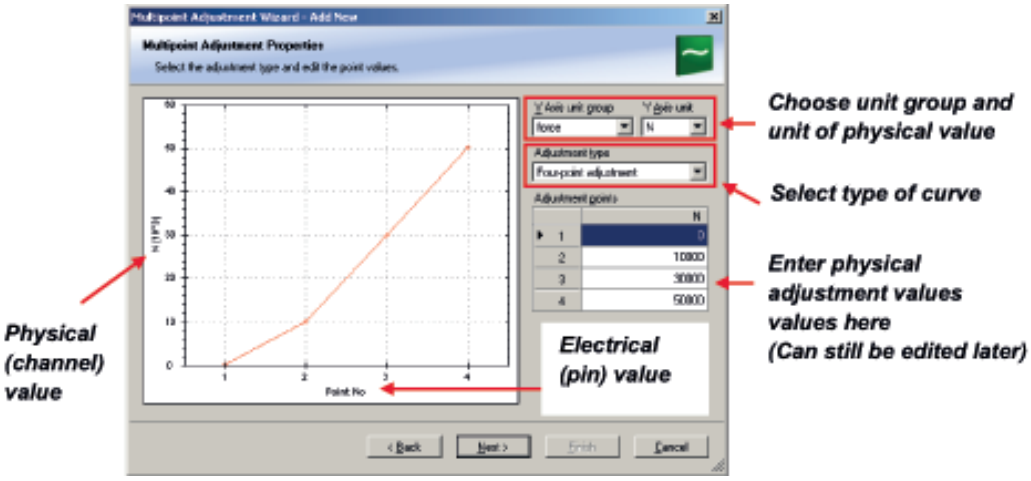
- Physical property ‘wheel force’ not directly measureable
- Load transfer through suspension kinematics
- Physical value at sensor position defined by vehicle
- Curve definition by online adjustment at vehicle



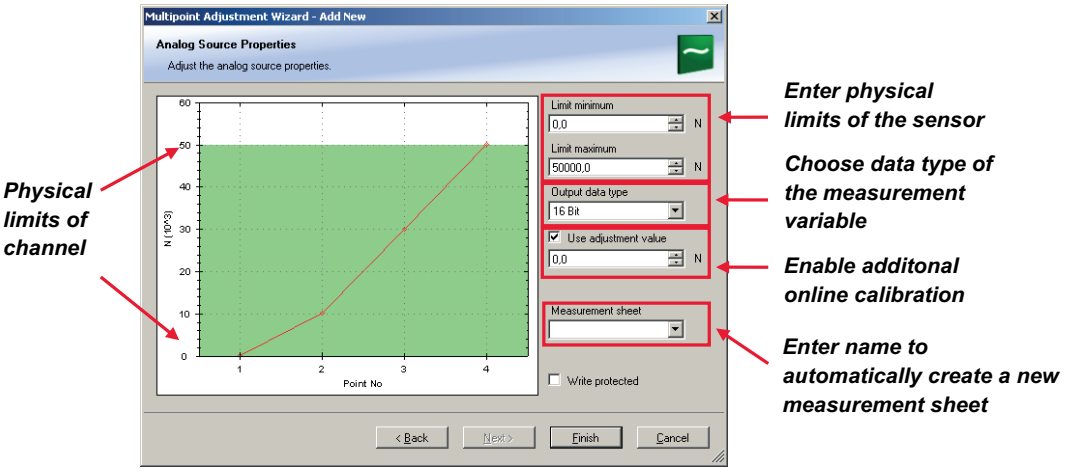
1. Click on ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Multipoint Adjustment’ analog signal source from the Toolbox and drop it on the desired analog input channel in the C 60 Project Tree.
4. A ‘Multipoint Adjustment Wizard’ opens.
5. To activate the internal pullup-resistor, check the box.
   The internal pullup-resistor is used to get a 5 V signal at the analog channel of the C 60. It allows you to use a push-button.
   The fixed value of the internal pullup-resistor is 3010 ohm. If using an additional external pullup-resistor, set up the overall resistance.



6. Click ‘Next’ when done. The second part of the ‘Multipoint Adjustment Wizard’ opens.

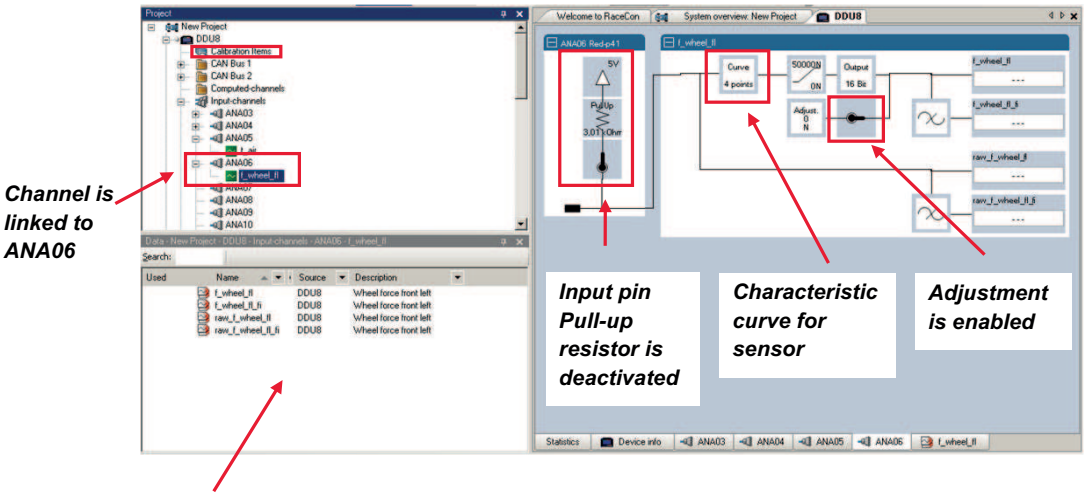


7. Click ‘Next’ when done. The third part of the ‘Multipoint Adjustment Wizard’ opens.



Notice!
Working with automatically created measurement sheet is explained in chapter ‘Setting up an online measurement’.

8. Click ‘Finish’ when done.
9. Enter channel name and description.
10. Click ‘OK’ when done.
    The channel is inserted into the C 60 Project Tree.



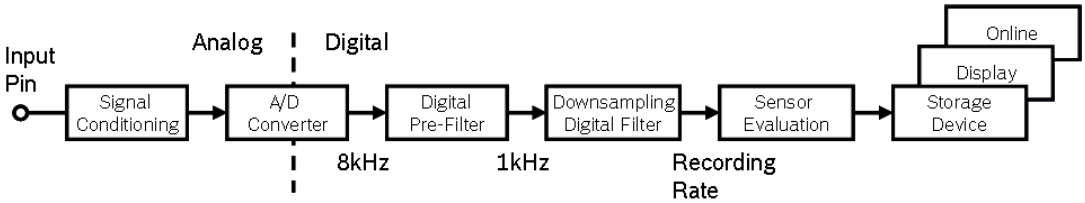
Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

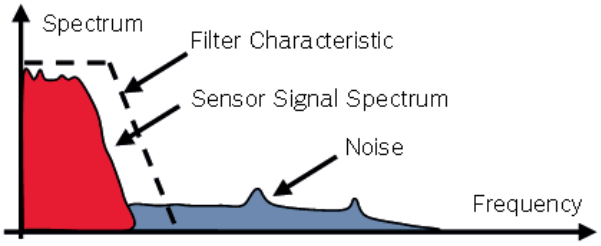
Online definition of the curve is covered in the chapter '*Online calibration of measurement channels, page 70*' of this manual.

11.3.5 Digital filter details

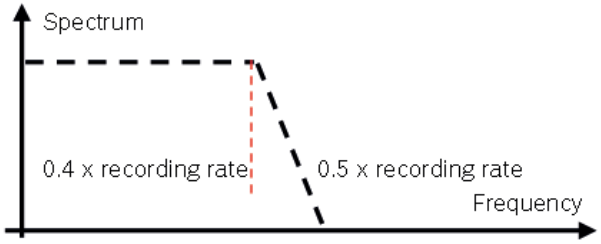
C 60 uses A/D converter oversampling and digital filtering to recording rate.



Digital filters eliminate 'out-of-band' noise



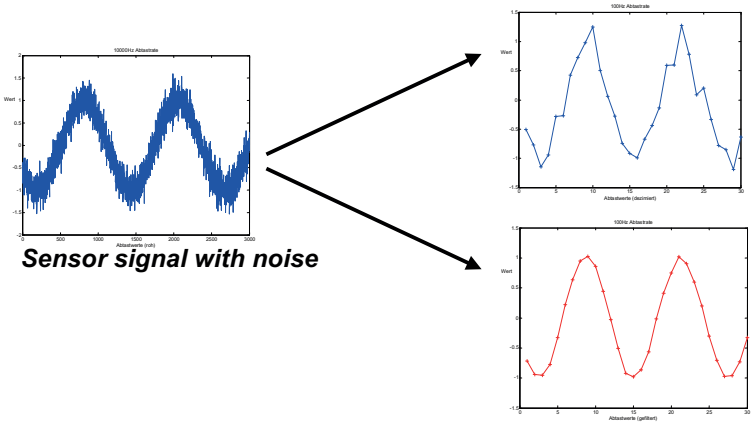
Cut-off frequency automatically adjusted to recording rate



Example:

- 100 Hz recording rate (10 ms)
- < 40 Hz pass band (> 99 %)
- 50 Hz stop band (< 1 %)

Linear phase – no signal distortion



Latency compensation – no filter delay in recorded data

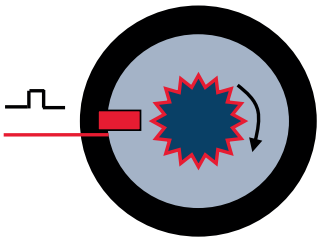
- Filtering is (smart) averaging over several samples
- Filtered signal is delayed with respect to real time signal
- C 60 filters have constant, frequency independent delay
- Delay (e.g. 22 samples at 10 ms) is corrected during recording
- No delay filtered vs. unfiltered in recorded data
- Correction is (of course) not possible for real time data (display, online, PWM out)
- Use filtered data for recording, use unfiltered data for real-time

11.3.6 Configuring a frequency input

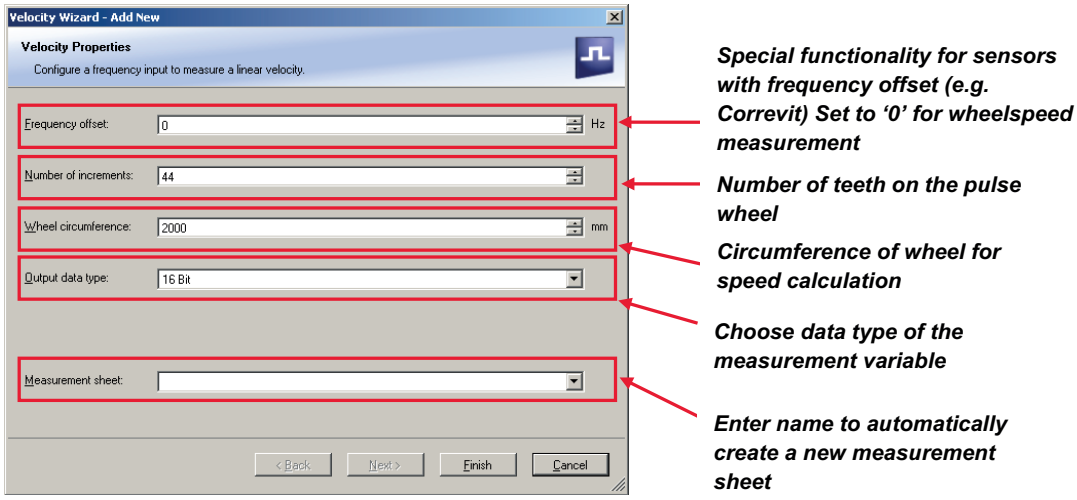
This function requires the installation of Software Upgrade 2.

Example: measurement of wheel speed

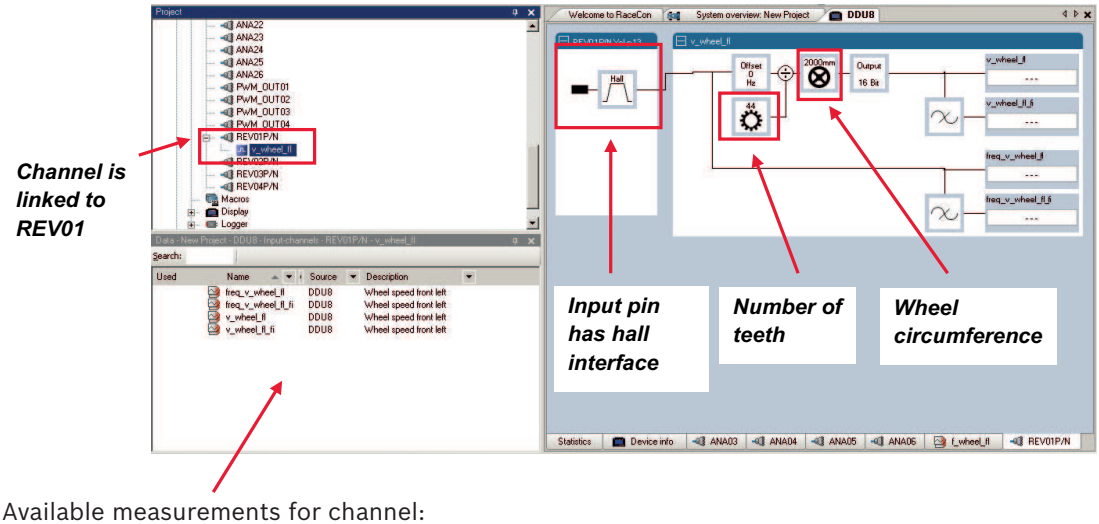
- Pulse wheel attached to wheel
- Each passing tooth of pulse wheel triggers hall sensor
- Calculation of wheel speed with wheel circumference



1. Click ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Velocity’ digital signal source from the Toolbox and drop it on the desired ‘REV’ input channel in the C 60 Project Tree.
4. The ‘Velocity Wizard’ opens.



5. Click ‘Finish’ when done.
6. Enter channel name and description.
7. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.



Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

Notice!
Measurement of ‘Revolution’ is similar.

11.4 Computed sources

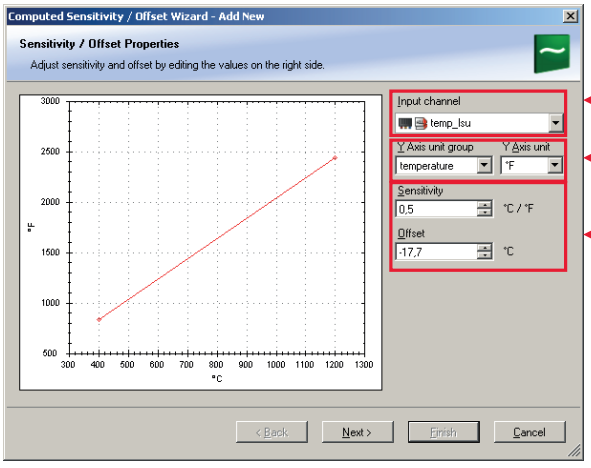
11.4.1 Configuring computed sources

Computed sources receive data from a measurement channel rather than an input pin.

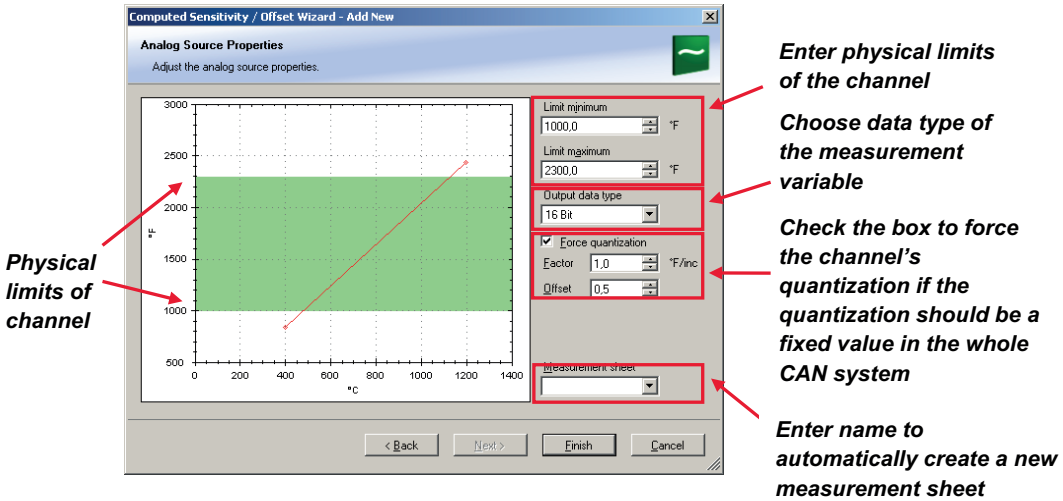
- Sensitivity/Offset calculation on input channel
- Characteristic curve calculation on input channel
- Computed vehicle speed
- PWM output control (covered in a special section)
- Lap trigger (covered in a special section)

Example: Sensitivity/offset calculation on input channel

1. Click ‘Measurement Sources’ in the Toolbox.
2. Drag the ‘Sensitivity/Offset’ computed source from the Toolbox and drop it on ‘Computed Channels’ in the C 60 Project Tree.
   A ‘Computed Sensitivity/Offset Wizard’ opens.



3. Click ‘Next’ when done.
4. The second part of the ‘Computed Sensitivity/Offset Wizard’ opens.



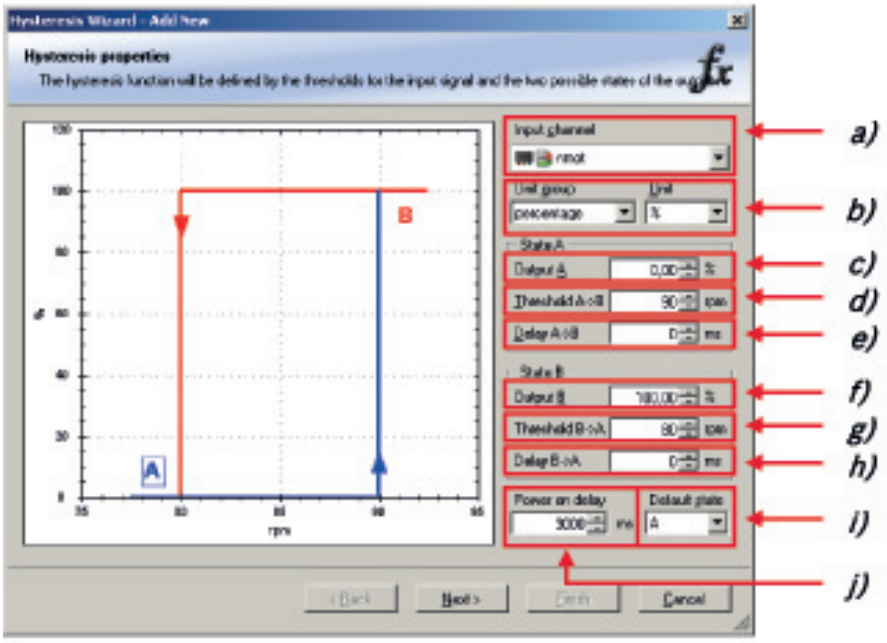
Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

5. Click ‘Finish’ when done.
6. Enter channel name and description.
7. Click ‘OK’ when done. The channel is inserted into the C 60 Project Tree.

11.5 Hysteresis

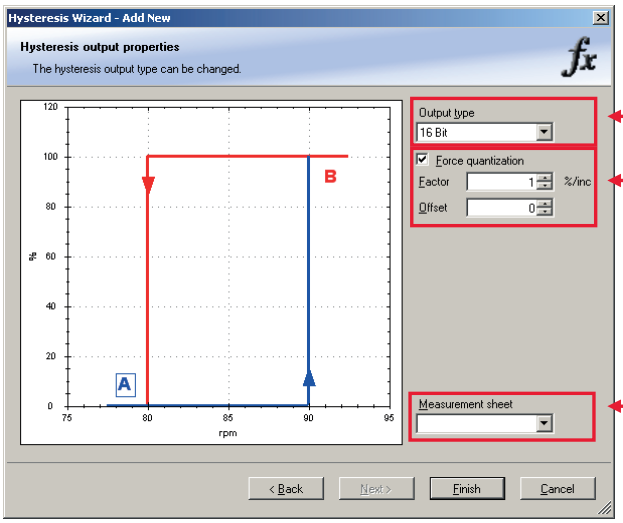
The hysteresis function avoids the high-frequent switchover of the measurement channel value. The hysteresis can be adjusted for each input measurement channel individually and can be used for further processing.

1. Click ‘Measurement Sources’ in the Toolbox.
2. Drag the ‘Hysteresis’ computed source from the Toolbox and drop it on ‘Computed Channels’ in the C 60 Project Tree.
3. A ‘Hysteresis Wizard’ opens.



a) Choose input measurement channel.
b) Choose unit group and unit of output.
c) Enter output value of state A in the unit selected in b).
d) Enter threshold value when state changes from A to B.
e) Enter delay time when state changes from A to B.
f) Enter output value of state B in the unit selected in b).
g) Enter threshold value when state changes from B to A.
h) Enter delay time when state changes from B to A.
i) Enter time when the hysteresis function is activated after vehicle’s startup.
j) Enter the channel’s state (A or B) at startup.

4. Click ‘Next’ when done.
   The second part of the ‘Hysteresis Wizard’ opens.

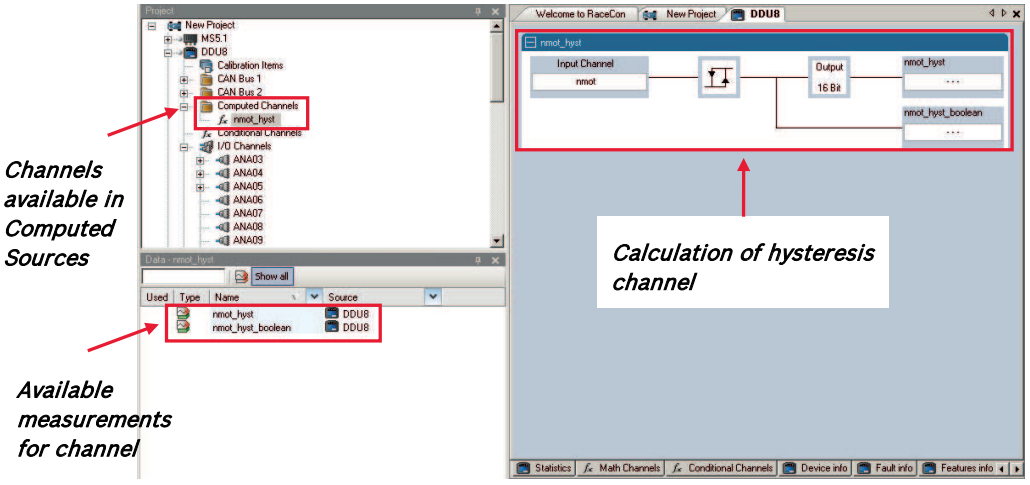


Choose data type of the measurement variable

Check the box to force the channel's quantization if the quantization should be a fixed value in the whole CAN system

Enter name to automatically create a new measurement sheet

5. Click 'Finish' when done.
6. Enter channel name and description.
7. Click 'OK' when done.
   The channel is inserted into the C 60 Project Tree.



Channels available in Computed Sources

Available measurements for channel

Calculation of hysteresis channel

11.5.1 Special functionality: vehicle speed

This functionality allows:

- high performance vehicle owners to measure wheel spin under acceleration and wheel slip/lock under braking.
- calculating vehicle 'speed over ground'.

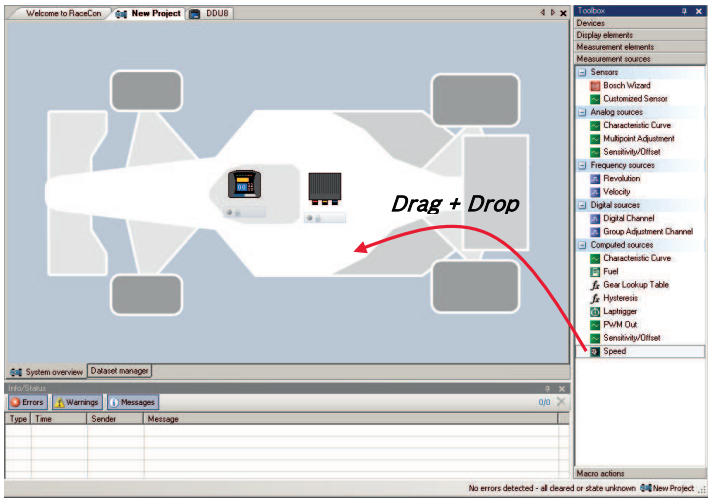
Vehicle speed calculation function

- Calculating vehicle speed of 2 wheel drive: (Wheel speeds of non-driven axle as input)
  Calculated speed is average of both speeds if speed difference between wheels < limit.
  Calculated speed is maximum of both speeds if speed difference between wheels > limit.
- Calculating vehicle speed of 4 wheel drive: (Wheel speeds of all wheels as input)
  Calculated speed is speed of 2nd fastest wheel.

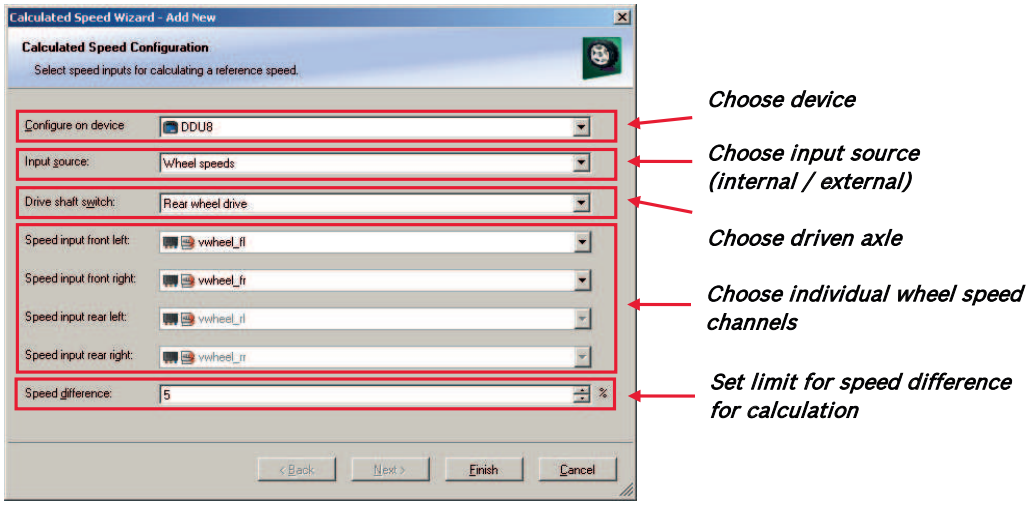
11.5.2 Setting up calculated speed

1. Click on tab 'System Overview'.
2. Click on 'Measurement Sources' in the Toolbox.

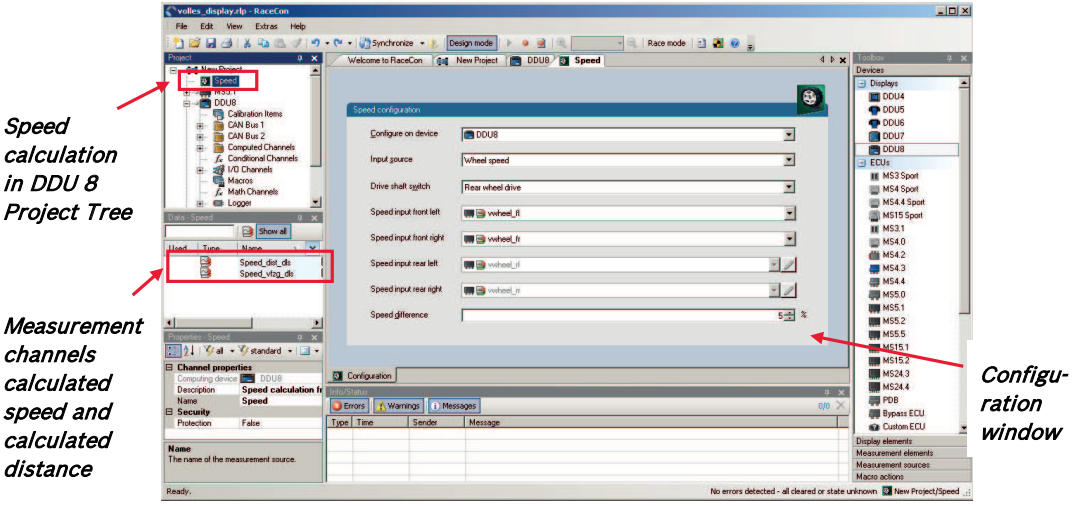
3. Drag the ‘Speed’ computed source from the Toolbox and drop it on ‘Computed Channels’ in the C 60 Project Tree. Do not drop it on ‘C 60’!



A ‘Calculated Speed Wizard’ opens.



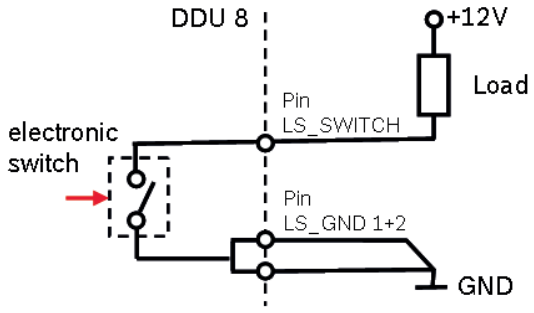
4. Click ‘Finish’ when done.
The speed calculation is inserted into the C 60 Project Tree.



11.6 Configuring PWM outputs

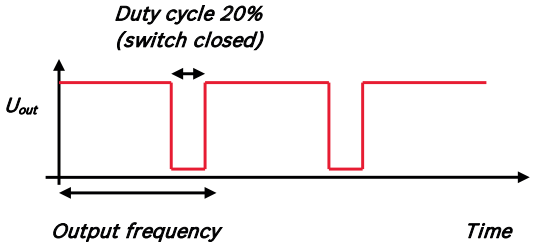
PWM

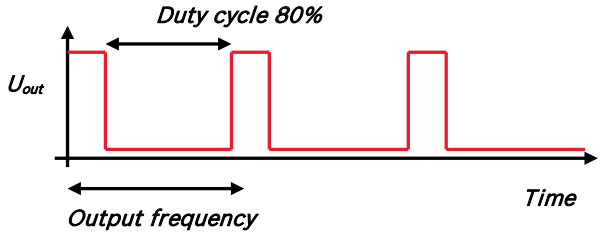
- Pulse Width Modulation
- Output frequency is constant
- ‘On time’ (duty cycle) controlled by input channel



C 60 has 4 PWM outputs

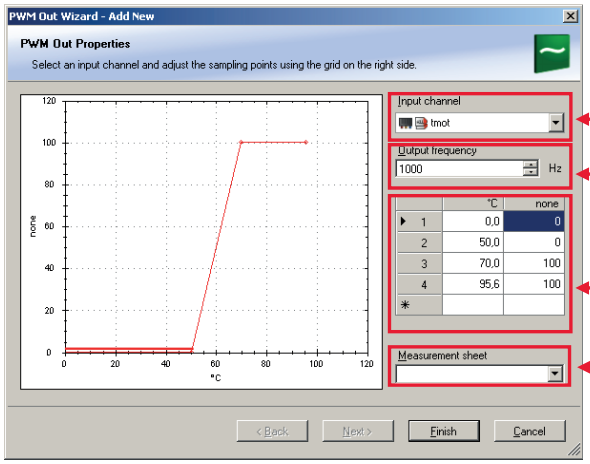
- Low-side switch
- Up to 2 A each
- Selectable output frequency
- Duty cycle controlled by characteristic curve





11.6.1 Configuring a PWM output

1. Click on ‘Measurement Sources’ in the Toolbox.
2. Drag the ‘PWM Out’ computed source from the Toolbox and drop it on the desired ‘PWM_OUT’ channel in the C 60 Project Tree.
3. A ‘PWM Out Wizard’ opens.

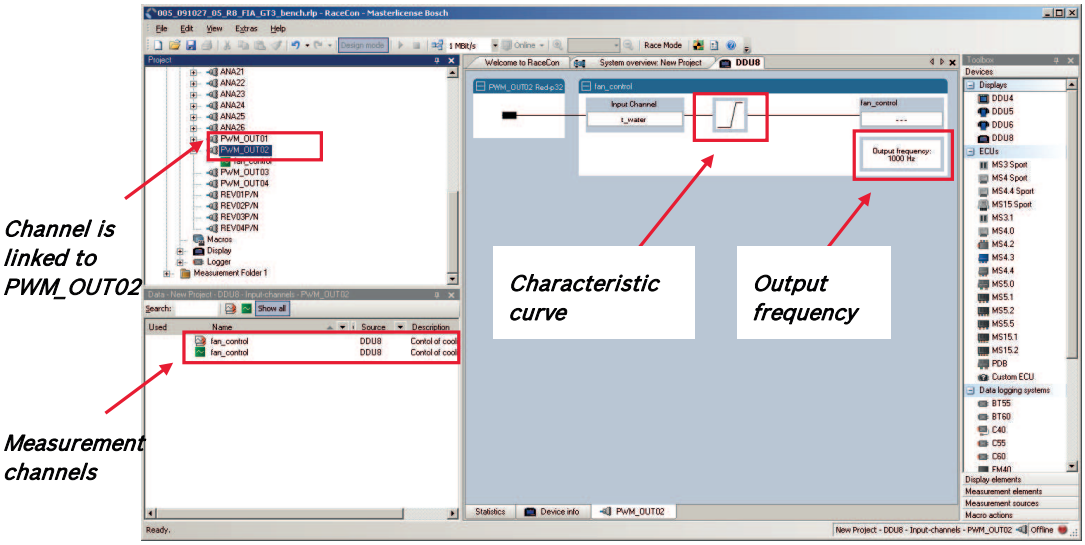


Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

Notice!
Choosing a filtered channel as an input for ‘PWM_OUT’ will cause delayed reaction due to the delay introduced by the digital filter.
Use unfiltered values for this purpose.

Notice!
The ‘power-on’ state of the PWM output is ‘switch open’ (0% duty cycle).

4. Click ‘Finish’ when done.
5. Enter channel name and description.
6. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.



Measurement label	Function
pwm_err_ls_out_01_OL	PWM output 1 error open load
pwm_err_ls_out_01_OT	PWM output 1 error over temperature
pwm_err_ls_out_01_SCB	PWM output 1 error short circuit to battery
pwm_err_ls_out_01_SCG	PWM output 1 error short circuit to GND

Tab. 11.1: Diagnostic channels

Notice!
The diagnosis of PWM output 2-4 is similar.

11.7 Analog inputs

11.7.1 Measurement channels

For each analog channel, several ‘subchannels’ are available.

Measurement labels with the characters ‘raw’ show the exact values in mV.
Measurement labels with the characters ‘_fi’ show filtered values.
The word ‘name’ in the table is a placeholder for the channel’s name.

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

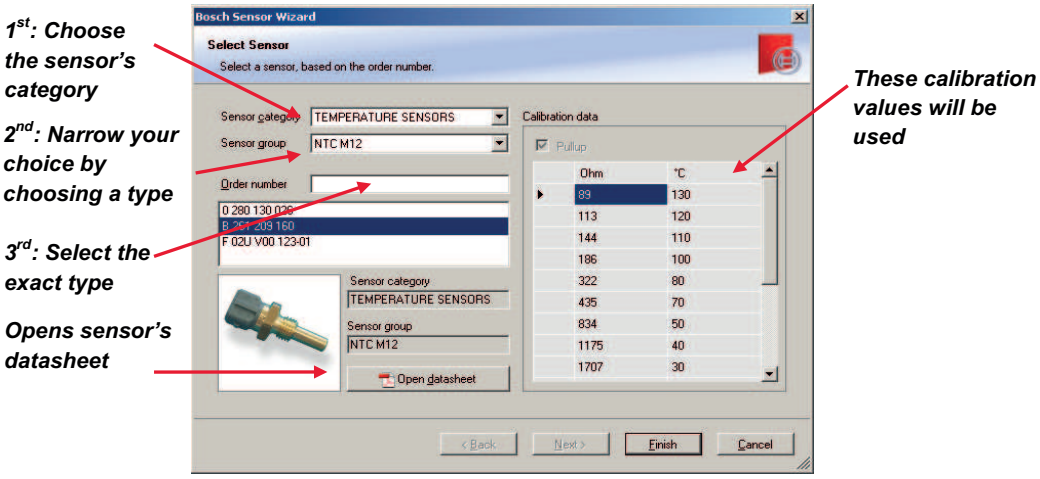
Filtered channels are routed through digital low pass filters:
- C 60 uses A/D converter oversampling and digital filtering to recording rate
- Digital filters eliminate ‘out-of-band’ noise
- Cut-off frequency automatically adjusted to recording rate
- Linear phase – no signal distortion
- Latency compensation – no filter delay in recorded data

11.8 Configuring inputs

11.8.1 Configuring a predefined Bosch sensor with the 'Bosch Sensor Wizard'

1. Click on ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.

1. Drag the ‘Bosch Sensor Wizard’ from the Toolbox and drop it on the desired analog input channel in the C 60 Project Tree. The ‘Bosch Sensor Wizard’ opens.



2. Click 'Finish' when done.
3. The 'Create channel' window opens.
4. Enter channel name and description.

1. Click 'Ok' when done.
   The channel is inserted into the C 60 Project Tree.

Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

11.8.2 Configuring a generic linear sensor

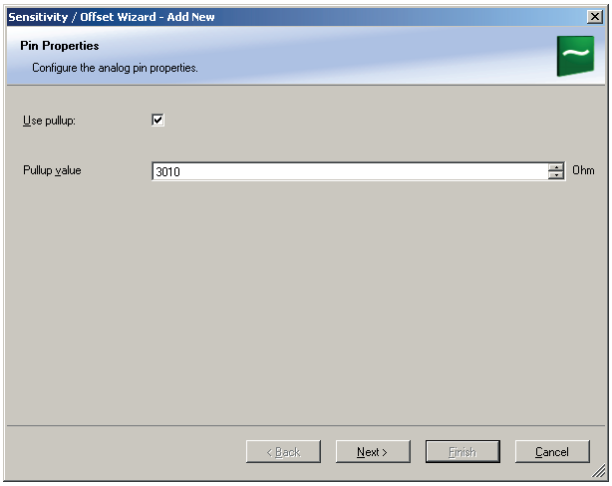
Example: Acceleration sensor 5 g

Output Signal					
Zero g (T_A = 25°C, V_{DD} = 5.0 V)(4)	V_{OFF}	2.25	2.5	2.75	V
Zero g (V_{DD} = 5.0 V)	V_{OFF}	2.0	2.5	3.0	V
Sensitivity (T_A = 25°C, V_{DD} = 5.0 V)(5)	S	380	400	420	mV/g
Sensitivity (V_{DD} = 5.0 V)	S	370	400	430.1	mV/g
Bandwidth Response	f_{-3dB}	42.5	50	57.5	Hz
Nonlinearity	NL_{OUT}	–1.0	—	+1.0	% FSO

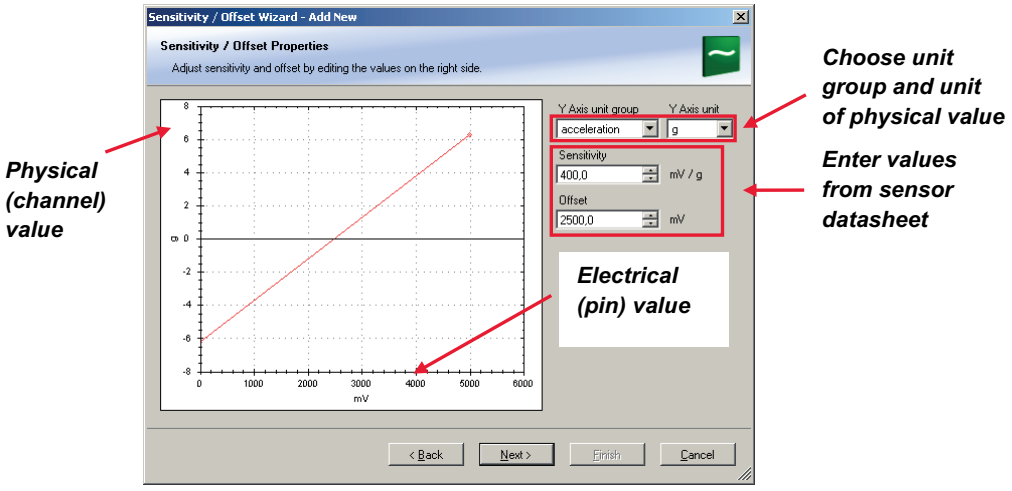
From sensor data sheet – operating characteristics:
Sensitivity 400 mV/g, Offset 2500 mV
The sensor has a linear output signal with sensitivity and offset

1. Click on 'Measurement Sources' in the Toolbox.
2. Expand the list of 'I/O Channels' by clicking on '+' in the C 60 Project Tree.
3. Drag the 'Sensitivity/Offset' analog signal source from the Toolbox and drop it on the desired analog input channel in the C 60 Project Tree. A 'Sensitivity/Offset Wizard' opens.
4. To activate the internal pullup-resistor, check the box.
   The internal pullup-resistor is used to get a 5 V signal at the analog channel of the C 60. It allows you to use a push-button.

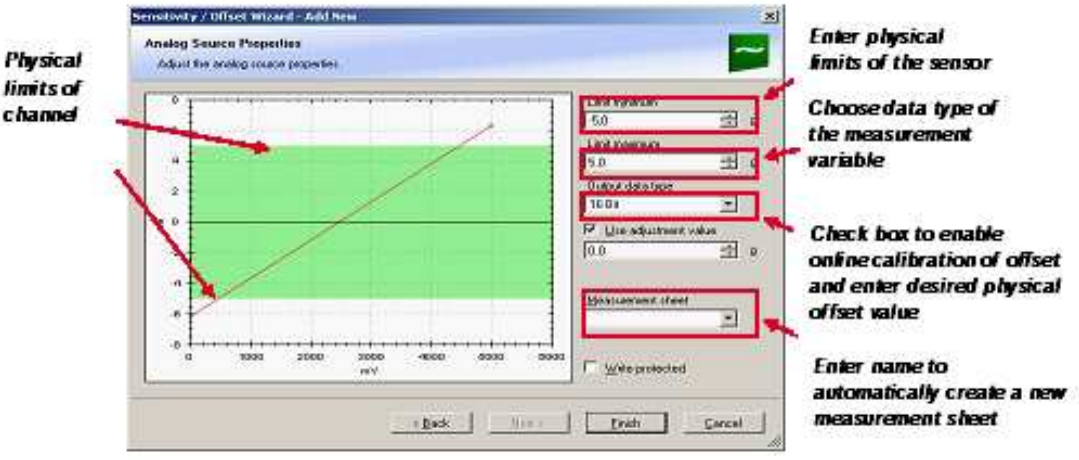
The fixed value of the internal pullup-resistor is 3010 Ohm. If using an additional external pullup-resistor, set up the overall resistance.



5. Click ‘Next’ when done.
   The second part of the ‘Sensitivity/Offset Wizard’ opens.



6. Click ‘Next’ when done. The third part of the ‘Sensitivity/Offset Wizard’ opens.



Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

7. Click ‘Finish’ when done.
8. Enter channel name and description.
9. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.

   Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

11.8.3 Configuring a generic non-linear sensor

Example: Thermistor 5 kOhm

– From sensor data sheet: resistance values over temperature

PART NR.: 2381 640 502
HTCLE100E3502

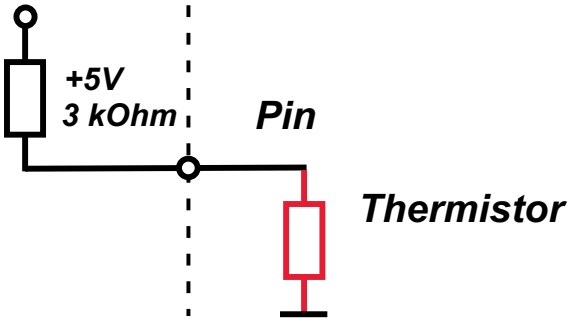
Toper [°C]	RT [Ω]
-40	166 047
-35	119 950
-30	87 600
-25	64 643
-20	48 179
-15	36 250
-10	27 523
-5	21 078

Toper [°C]	RT [Ω]
0	16 277
5	12 669
10	9 936
15	7 849
20	8 244
25	5 000
30	4 030
35	3 267

Toper [°C]	RT [Ω]
40	2 685
45	2 166
50	1 903
55	1 494
60	1 245
65	1 024
70	876
75	740

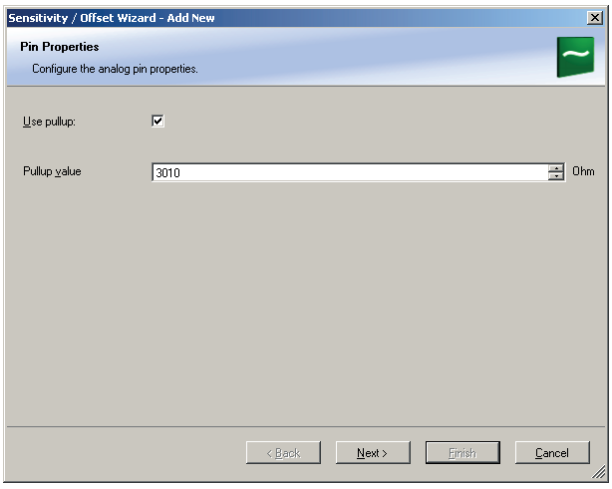
Toper [°C]	RT [Ω]
80	628
85	535
90	457
95	399
100	338
105	292
110	251
115	221

– The sensor has a nonlinear behaviour
– Use characteristic curve for linearization
– Input voltage is the ratio between pull-up resistor and thermistor

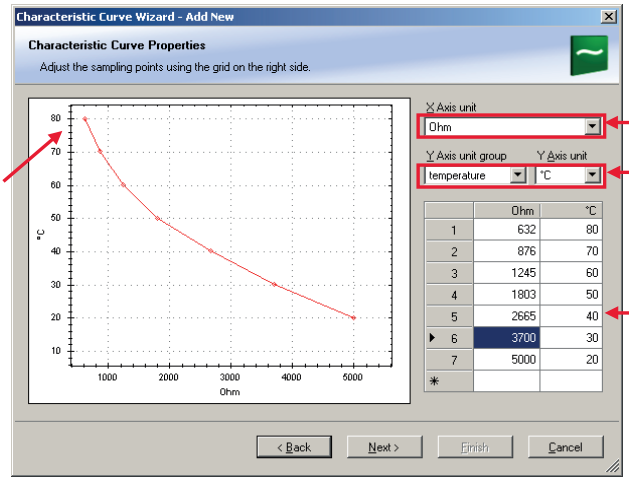


1. Click ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Characteristic Curve’ analogue signal source from the Toolbox and drop it on the desired analogue input channel in the C 60 Project Tree. A ‘Characteristic Curve Wizard’ opens.
4. To activate the internal pull up-resistor, check the box.
   The C 60 pull up-resistor is used to get a 5V signal at the analogue channel of the C 60.

It allows you to use a push-button.
The fixed value of the internal pull up-resistor is 3010 Ohm. If using an additional external pull up-resistor, set up the overall resistance.



5. Click ‘Next’ when done.
The second part of the ‘Sensitivity/Offset Wizard’ opens.



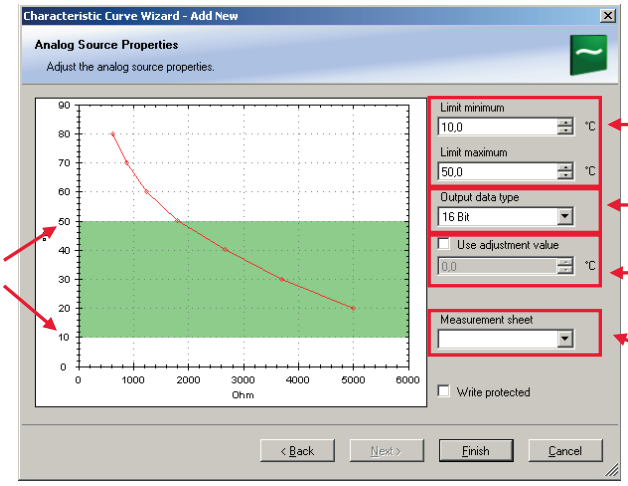
Physical (channel) value

Select physical unit.

Choose ‘Ohm’ to enter datasheet values directly.

Enter resistance/temperature pairs from sensor datasheet here (The 3.01 kOhm pullup-resistor is automatically taken into account)

6. Click ‘Next’ when done.
The third part of the ‘Characteristic Curve Wizard’ opens.



Physical limits of channel

Enter physical limits of the channel

Choose data type of the measurement variable

This sensor does not need offset calibration

Enter name to automatically create a new measurement sheet

Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

7. Click ‘Finish’ when done.
8. Enter channel name and description.
9. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.

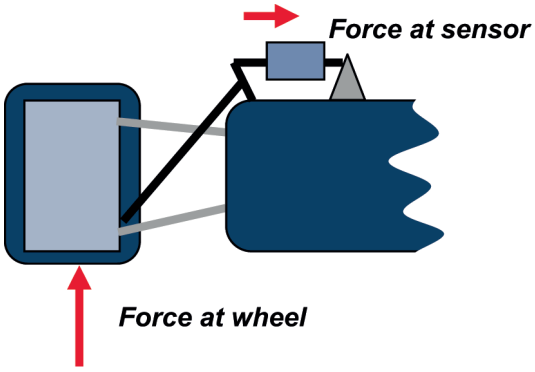
Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

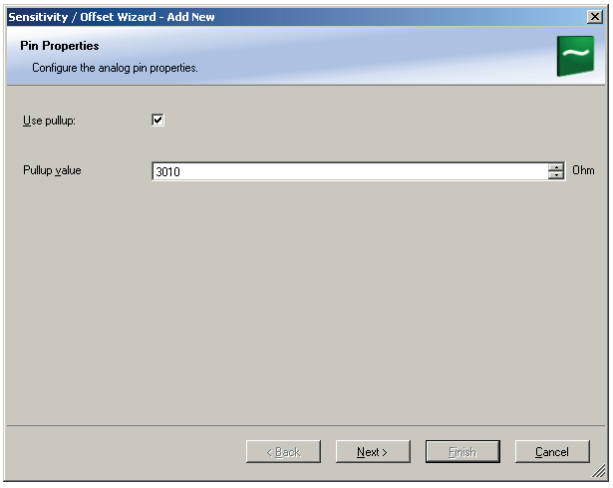
11.8.4 Configuring a multipoint adjustment

Example: Measurement of wheel force

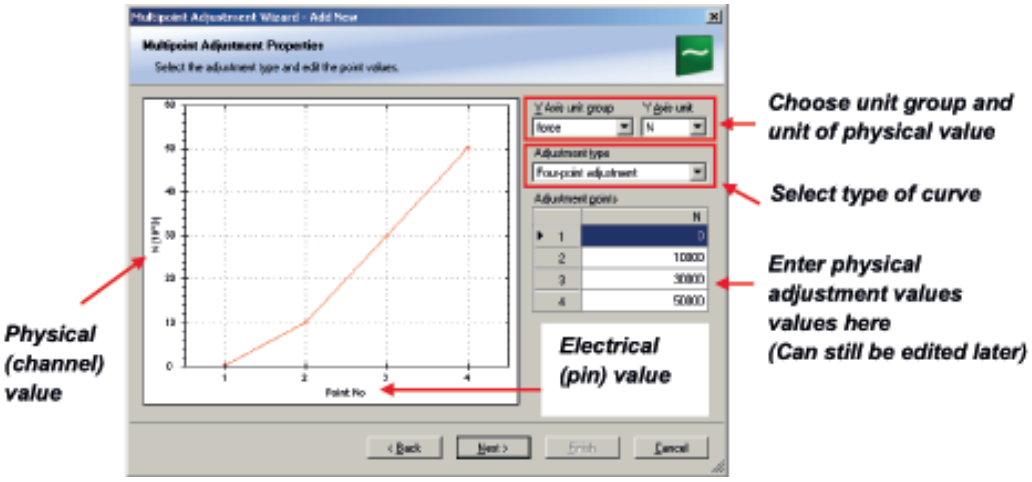
- Physical property ‘wheel force’ not directly measureable
- Load transfer through suspension kinematics
- Physical value at sensor position defined by vehicle
- Curve definition by online adjustment at vehicle



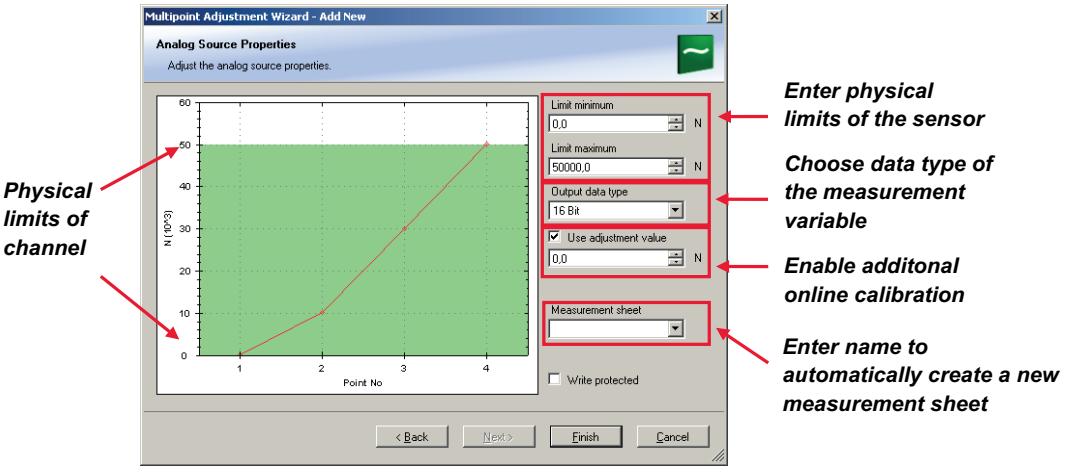
1. Click on ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Multipoint Adjustment’ analog signal source from the Toolbox and drop it on the desired analog input channel in the C 60 Project Tree.
4. A ‘Multipoint Adjustment Wizard’ opens.
5. To activate the internal pullup-resistor, check the box.
   The internal pullup-resistor is used to get a 5 V signal at the analog channel of the C 60. It allows you to use a push-button.
   The fixed value of the internal pullup-resistor is 3010 ohm. If using an additional external pullup-resistor, set up the overall resistance.



6. Click ‘Next’ when done. The second part of the ‘Multipoint Adjustment Wizard’ opens.



7. Click ‘Next’ when done. The third part of the ‘Multipoint Adjustment Wizard’ opens.



Notice!
Working with automatically created measurement sheet is explained in chapter ‘Setting up an online measurement’.

8. Click ‘Finish’ when done.
9. Enter channel name and description.

10. Click ‘OK’ when done.
    The channel is inserted into the C 60 Project Tree.

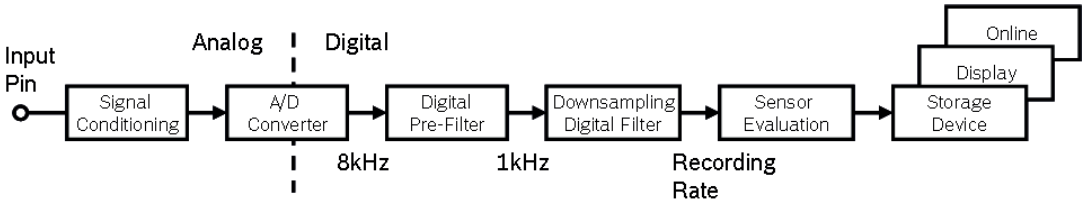
Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

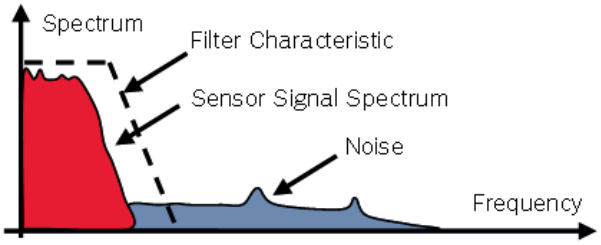
Online definition of the curve is covered in the chapter ‘*Online calibration of measurement channels, page 70*’ of this manual.

11.8.5 Digital filter details

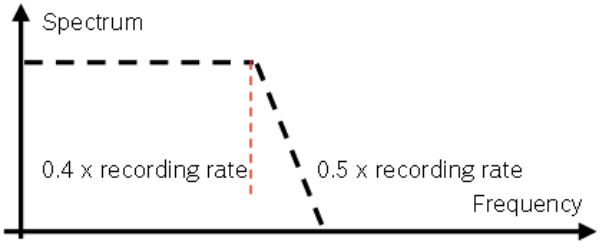
C 60 uses A/D converter oversampling and digital filtering to recording rate.



Digital filters eliminate ‘out-of-band’ noise



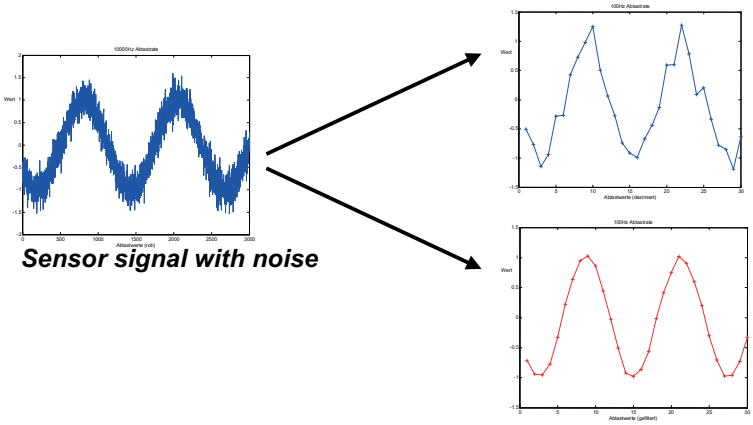
Cut-off frequency automatically adjusted to recording rate



Example:

- 100 Hz recording rate (10 ms)
- < 40 Hz pass band (> 99 %)
- 50 Hz stop band (< 1 %)

Linear phase – no signal distortion



Latency compensation – no filter delay in recorded data

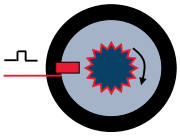
- Filtering is (smart) averaging over several samples
- Filtered signal is delayed with respect to real time signal
- C 60 filters have constant, frequency independent delay
- Delay (e.g. 22 samples at 10 ms) is corrected during recording
- No delay filtered vs. unfiltered in recorded data
- Correction is (of course) not possible for real time data (display, online, PWM out)
- Use filtered data for recording, use unfiltered data for real-time

11.8.6 Configuring a frequency input

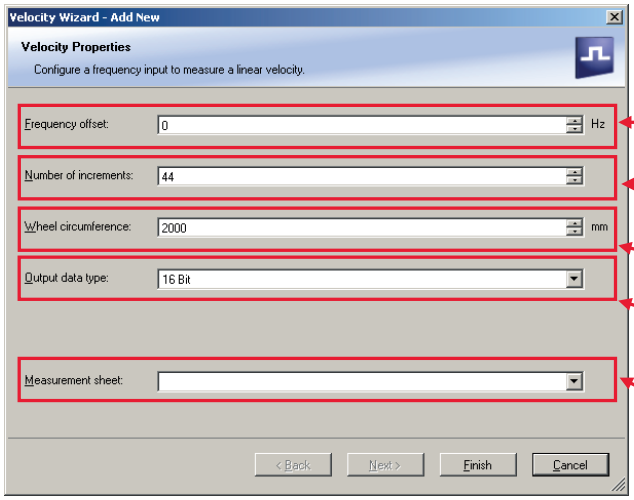
This function requires the installation of Software Upgrade 2.

Example: measurement of wheel speed

- Pulse wheel attached to wheel
- Each passing tooth of pulse wheel triggers hall sensor
- Calculation of wheel speed with wheel circumference



1. Click ‘Measurement Sources’ in the Toolbox.
2. Expand the list of ‘I/O Channels’ by clicking on ‘+’ in the C 60 Project Tree.
3. Drag the ‘Velocity’ digital signal source from the Toolbox and drop it on the desired ‘REV’ input channel in the C 60 Project Tree.
4. The ‘Velocity Wizard’ opens.



5. Click 'Finish' when done.
6. Enter channel name and description.
7. Click 'OK' when done.
   The channel is inserted into the C 60 Project Tree.

Available measurements for channel:

Measurement label	Function
raw_name	mV value of sensor
raw_name_fi	filtered mV value of sensor
name	physical value of sensor
name_fi	filtered physical value

Notice!
Measurement of 'Revolution' is similar.

11.9 Computed sources

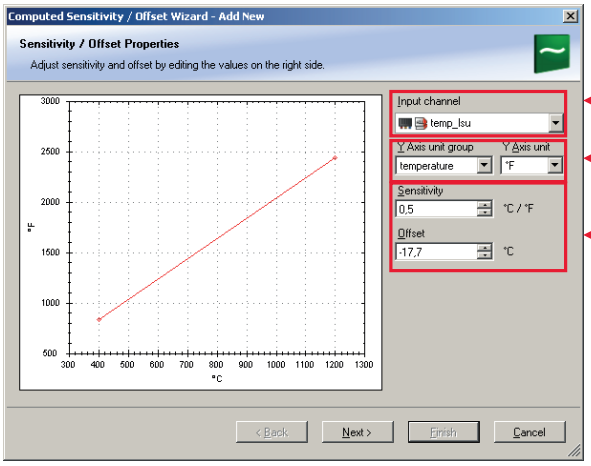
11.9.1 Configuring computed sources

Computed sources receive data from a measurement channel rather than an input pin.

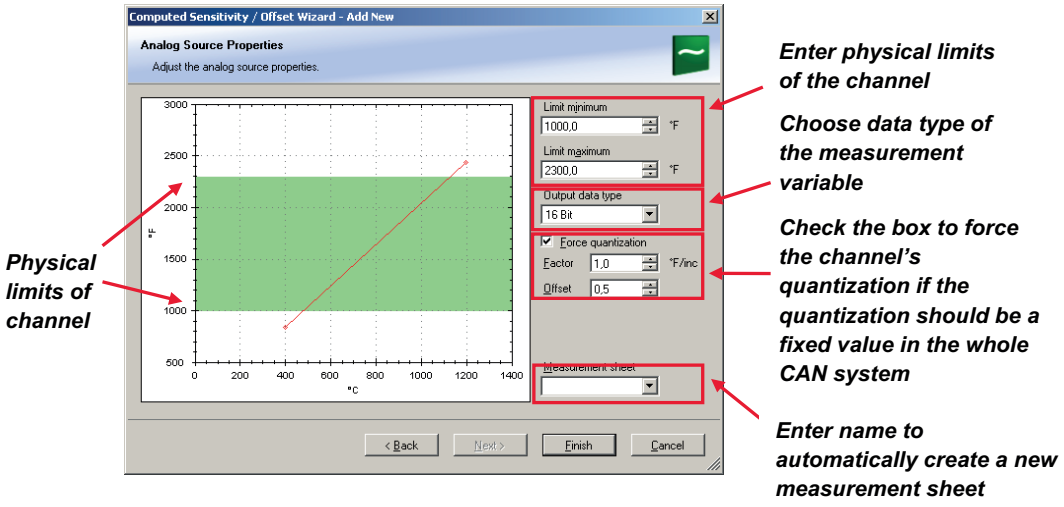
- Sensitivity/Offset calculation on input channel
- Characteristic curve calculation on input channel
- Computed vehicle speed
- PWM output control (covered in a special section)
- Lap trigger (covered in a special section)

Example: Sensitivity/offset calculation on input channel

1. Click 'Measurement Sources' in the Toolbox.
2. Drag the 'Sensitivity/Offset' computed source from the Toolbox and drop it on 'Computed Channels' in the C 60 Project Tree.
   A 'Computed Sensitivity/Offset Wizard' opens.



3. Click ‘Next’ when done.
4. The second part of the ‘Computed Sensitivity/Offset Wizard’ opens.



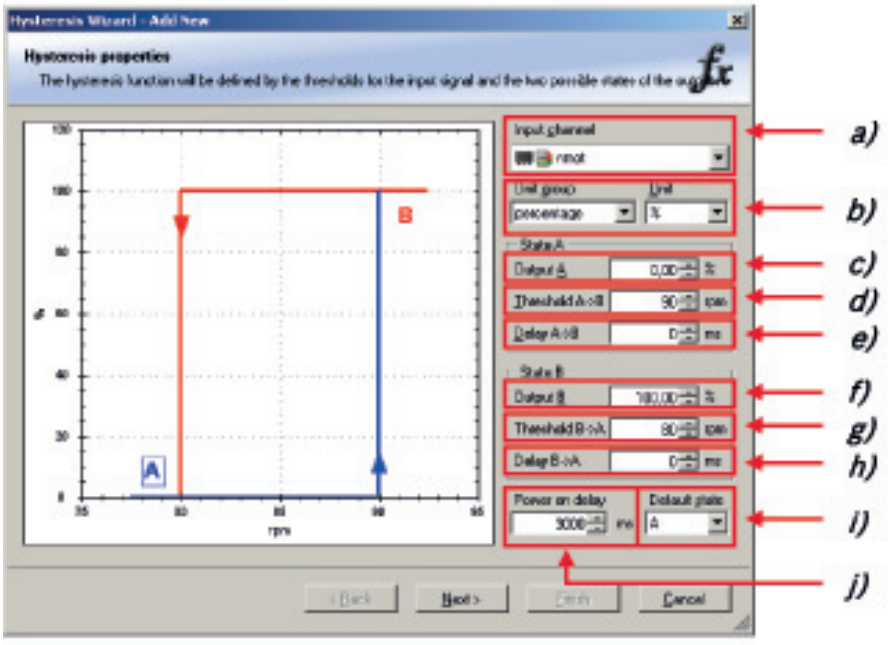
Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

5. Click ‘Finish’ when done.
6. Enter channel name and description.
7. Click ‘OK’ when done. The channel is inserted into the C 60 Project Tree.

11.10 Hysteresis

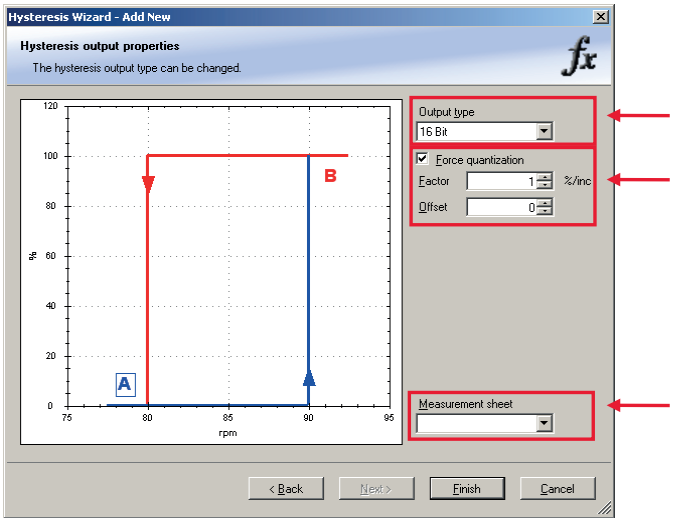
The hysteresis function avoids the high-frequent switchover of the measurement channel value. The hysteresis can be adjusted for each input measurement channel individually and can be used for further processing.

1. Click ‘Measurement Sources’ in the Toolbox.
2. Drag the ‘Hysteresis’ computed source from the Toolbox and drop it on ‘Computed Channels’ in the C 60 Project Tree.
3. A ‘Hysteresis Wizard’ opens.



a) Choose input measurement channel.
b) Choose unit group and unit of output.
c) Enter output value of state A in the unit selected in b).
d) Enter threshold value when state changes from A to B.
e) Enter delay time when state changes from A to B.
f) Enter output value of state B in the unit selected in b).
g) Enter threshold value when state changes from B to A.
h) Enter delay time when state changes from B to A.
i) Enter time when the hysteresis function is activated after vehicle's startup.
j) Enter the channel's state (A or B) at startup.

4. Click 'Next' when done.
   The second part of the 'Hysteresis Wizard' opens.



Choose data type of the measurement variable

Check the box to force the channel's quantization if the quantization should be a fixed value in the whole CAN system

Enter name to automatically create a new measurement sheet

5. Click 'Finish' when done.
6. Enter channel name and description.
7. Click 'OK' when done.
   The channel is inserted into the C 60 Project Tree.

11.10.1 Special functionality: vehicle speed

This functionality allows:

- high performance vehicle owners to measure wheel spin under acceleration and wheel slip/lock under braking.
- calculating vehicle ‘speed over ground’.

Vehicle speed calculation function

- Calculating vehicle speed of 2 wheel drive: (Wheel speeds of non-driven axle as input)
  Calculated speed is average of both speeds if speed difference between wheels < limit.
  Calculated speed is maximum of both speeds if speed difference between wheels > limit.
- Calculating vehicle speed of 4 wheel drive: (Wheel speeds of all wheels as input)
  Calculated speed is speed of 2nd fastest wheel.

11.10.2 Setting up calculated speed

1. Click on tab ‘System Overview’.
2. Click on ‘Measurement Sources’ in the Toolbox.
3. Drag the ‘Speed’ computed source from the Toolbox and drop it on ‘Computed Channels’ in the C 60 Project Tree. Do not drop it on ‘C 60’!

   A ‘Calculated Speed Wizard’ opens.

4. Click ‘Finish’ when done.
   The speed calculation is inserted into the C 60 Project Tree.

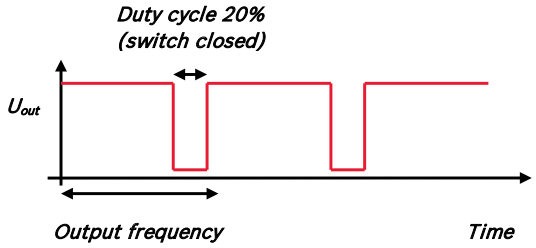
11.11 Configuring PWM outputs

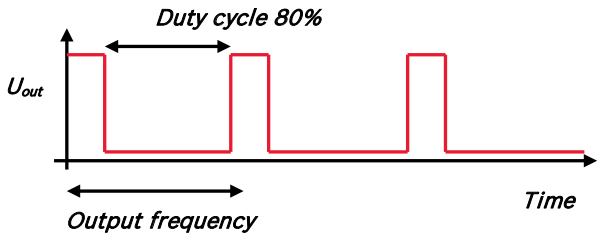
PWM

- Pulse Width Modulation
- Output frequency is constant
- ‘On time’ (duty cycle) controlled by input channel

C 60 has 4 PWM outputs

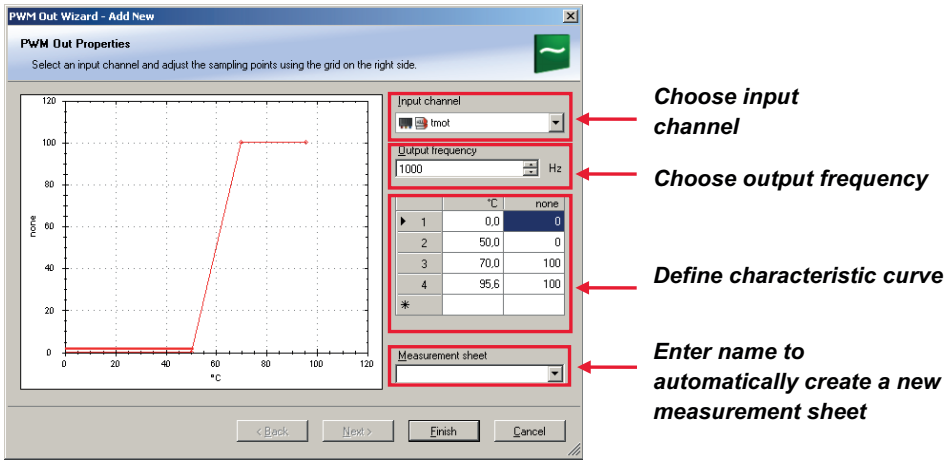
- Low-side switch
- Up to 2 A each
- Selectable output frequency
- Duty cycle controlled by characteristic curve





11.11.1 Configuring a PWM output

1. Click on ‘Measurement Sources’ in the Toolbox.
2. Drag the ‘PWM Out’ computed source from the Toolbox and drop it on the desired ‘PWM_OUT’ channel in the C 60 Project Tree.
3. A ‘PWM Out Wizard’ opens.



Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

Notice!
Choosing a filtered channel as an input for ‘PWM_OUT’ will cause delayed reaction due to the delay introduced by the digital filter.
Use unfiltered values for this purpose.

Notice!
The ‘power-on’ state of the PWM output is ‘switch open’ (0% duty cycle).

4. Click ‘Finish’ when done.
5. Enter channel name and description.
6. Click ‘OK’ when done.
   The channel is inserted into the C 60 Project Tree.

Measurement label	Function
pwm_err_ls_out_01_OL	PWM output 1 error open load
pwm_err_ls_out_01_OT	PWM output 1 error over temperature
pwm_err_ls_out_01_SCB	PWM output 1 error short circuit to battery
pwm_err_ls_out_01_SCG	PWM output 1 error short circuit to GND

Tab. 11.2: Diagnostic channels

Notice!
The diagnosis of PWM output 2-4 is similar.

12 Online Measurement

C 60 configuration

- System configuration (channel + display configuration, CAN I/O, PWM Out, etc.) is stored in the C 60
- Use RaceCon to create and download configuration from the PC to C 60
- Communication interface: Ethernet
- Communication protocol: XCP

Online measurement + calibration

- System status and diagnosis
- Check and calibrate sensors in the vehicle
- Live display of sensor values on the PC
- Use RaceCon for diagnosis, online measurement and calibration
- Communication interface: Ethernet
- Communication protocol: XCP

12.1 Achieving an online connection

12.1.1 Set up the PC for access to the Unit

1. Switch off local firewall on the PC.
2. Set IP Configuration for the Ethernet interface to ‘automatic configuration’ (DHCP). See chapter ‘Setting up the network interface’ for details.
3. Start RaceCon.
4. Establish the Ethernet connection to the vehicle.
5. Power on the vehicle.

12.1.2 Going online

Click ‘OK to download RaceCon configuration to C 60.
The download starts.

A green dot and background at the device in the project view and the C 60 Project Tree indicate a successful download and system consistency.

If the system’s configuration in RaceCon has been changed, the dot and background becomes yellow and a configuration download is necessary.

12.1.3 Configuration download

1. Right-click on C 60 in the C 60 Project Tree.
2. Select ‘Download configuration’.

The configuration download starts.

A Green dot and background indicate a successful download.

12.2 Setting up an online measurement

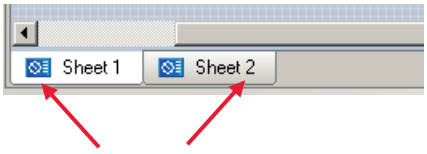
C 60 supports online measurement of sensor values and diagnostic variables.
Expand ‘Measurement Container’ and ‘Measurement Folder 1’ in the Project Tree and double-click on ‘Sheet1’. ‘Sheet 1’ is opened in the Main Area.

From the context menu of the project, new measurement pages can be created.

From the context menu of a measurement page, the folder can be renamed and deleted. It also allows the creation of measurement pages.

From the context menu of a measurement page, the page can be renamed and deleted.

To change between different pages, click on the tabs on the bottom of the Main Project Area.



Tabs to switch between sheets

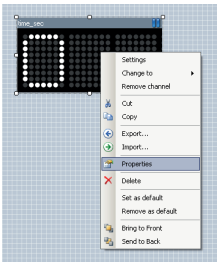
To add an element to a measurement sheet, do following steps:

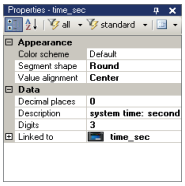
1. Drag a measurement element from the Toolbox and drop it on the measurement sheet.

1. Click on ‘C 60’ in the Project Tree to display all measurement channels.
2. Select the desired measurement channel and drop it on the measurement element.

If the C 60 is online, the value is displayed.

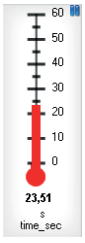
The measurement element’s appearance can be changed using the Properties Menu.



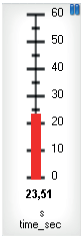


RaceCon offers different types of measurement elements:

Circular gauge



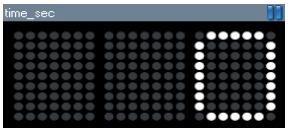
Temperature gauge



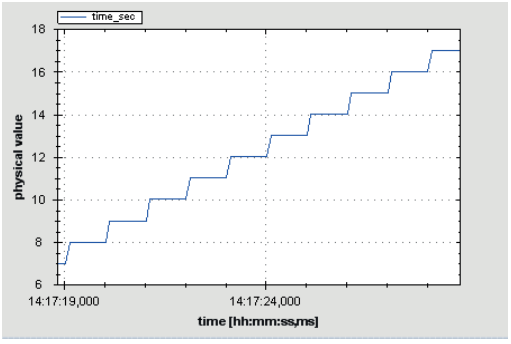
Vertical Bar graph style

Horizontal Bar graph style

Measurement label



Numeric indicator



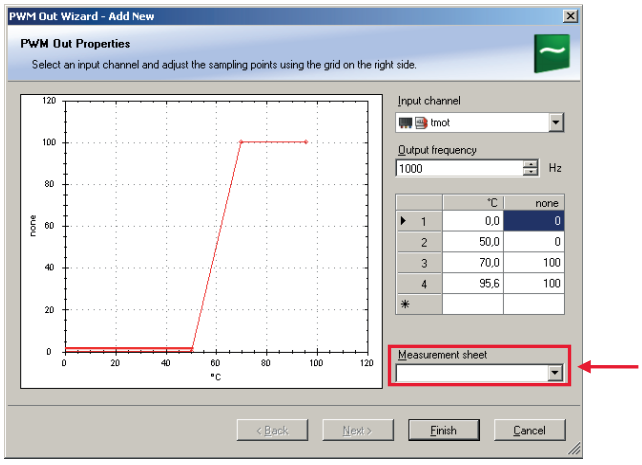
Oscilloscope (Chart)

12.2.1 Automatic creation of measurement sheets

RaceCon can create measurement sheets automatically.

You can create and use measurement sheets with the C 60 as well as with all other devices connected to RaceCon.

1. During the configuration of a measurement channel, select a measurement sheet from the list box or enter a name for a new measurement sheet.



Select existing sheet from list or enter name of new sheet

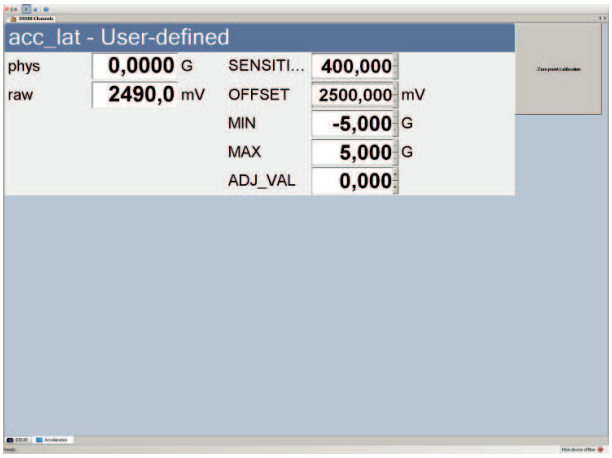
2. To create the sheets, right-click on C 60 and select ‘Create measurement views...’ from the C 60 context menu.
3.

The automatically created sheet is inserted in the Project Tree under ‘Measurement Container’ and ‘Device Channels’. If the C 60 is connected to RaceCon, live values of the channels are shown.

The Button “Zero Point Adjustment” is active when the C 60 is online. This function zeros only when this functionality is activated in the settings of this channel. (see chapter ‘*Enable online offset calibration for measurement channel, page 70*’)

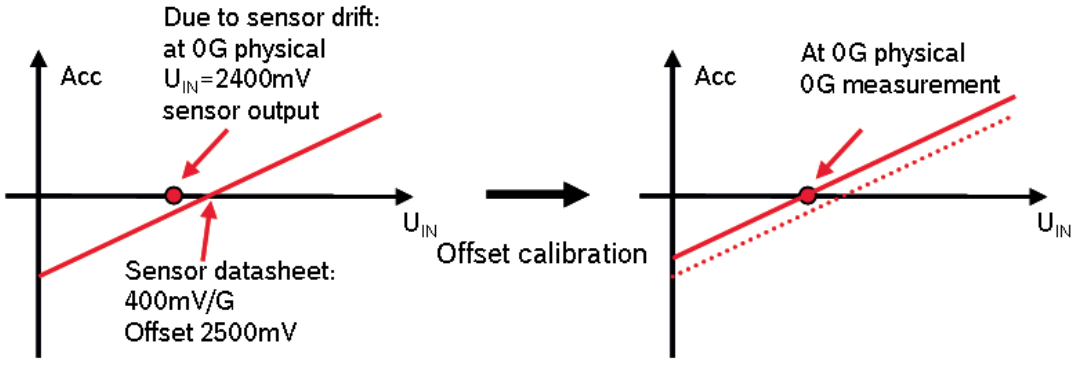
12.2.2 Using the measurement sheets

1. When RaceCon is online, press the ‘F11’ key to switch from ‘Design Mode’ into ‘Race Mode’.
2. The measurement sheet is extended to full screen.
3. The button for offset calibration is active.
4. Switch between different sheets using the tabs at the bottom of the page or the keyboard shortcuts associated with the sheets.
5. Press the ‘Esc’ key to return to ‘Design Mode’.



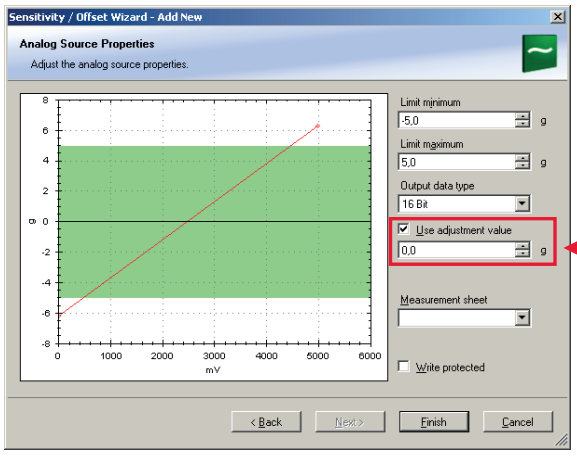
12.3 Online calibration of measurement channels

- Analog sensors drift with age, temperature, etc.
- Manual calibration is necessary
- Solution: online offset calibration
- Example: acceleration sensor

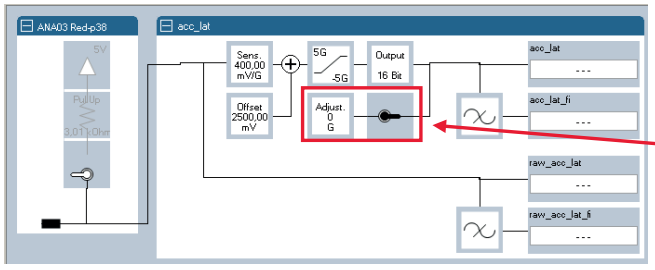


12.3.1 Enable online offset calibration for measurement channel

During creation of the measurement channel



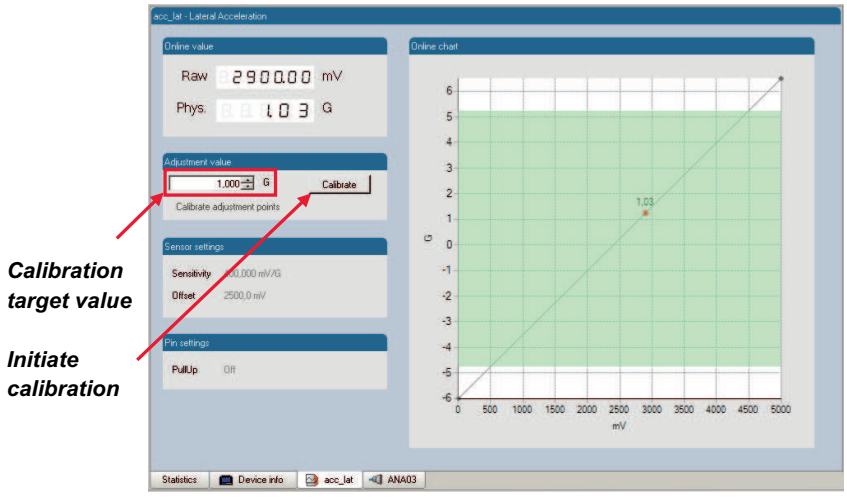
In the channel view



12.3.2 Performing the online offset calibration

C 60 has to be connected to RaceCon to calibrate the sensor's offset.

1. Apply the desired physical condition to the sensor (e.g. 1 G to an acceleration sensor).
2. Open the measurement channel's online page by double-clicking on the measurement channel name in the Data Area.
3. Enter the physical target value (e.g. 1 G) and press the 'Calibrate' button.



The sensor's offset is now calibrated.

12.4 Group adjustment

Group adjustment is the simultaneous online calibration of several channels. This is useful e.g. to set all wheel forces and damper positions to '0' when the vehicle is positioned on a flat patch.

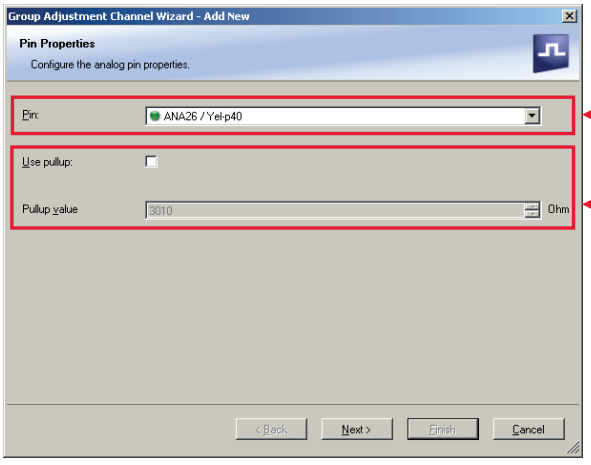
12.4.1 Configuration of group adjustment

Group adjustment consists of two components:

– An input channel which triggers the adjustment event
– A group of input channels linked to the group adjustment event

12.4.2 Setting up the group adjustment trigger channel

1. Click ‘Measurement Sources’ in the Toolbox.
2. Drag the ‘Group Adjustment Channel’ element from the Toolbox and drop it on the C 60
3. A ‘Group Adjustment Channel Wizard’ opens.



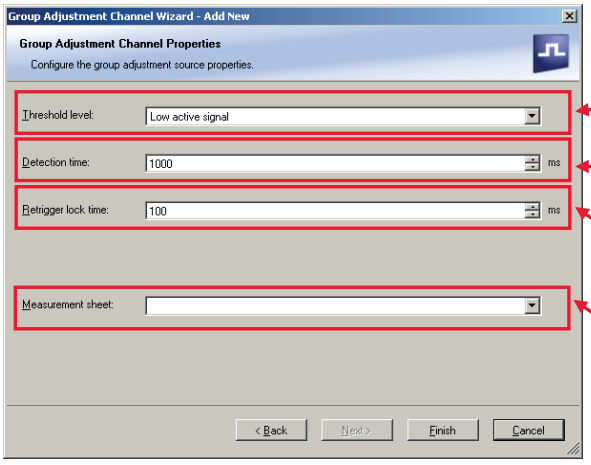
Select the pin to which the sensor shall be connected

Check the box to activate the internal DDU 8 pullup-resistor and set the resistor value

Notice!

If a low-active signal is selected as an input channel, do not forget to enable the pull-up resistor for the pin. Otherwise the group adjustment will be triggered periodically.
See chapter ‘*Configuring a generic linear sensor, page 36*’ for further information concerning the pull-up-resistor.

4. Click ‘Next’ when done.
   The second part of the ‘Computed Sensitivity / Offset Wizard’ opens.



Signal is active high or active low

Define minimum active time to detect activation

Define minimum time between two activations

Enter name to automatically create a new measurement sheet

Notice!
Working with automatically created measurement sheets is explained in chapter ‘Setting up an online measurement’.

5. Click ‘Finish’ when done.
6. Enter channel name and description.
7. Click ‘OK’ when done.

12.4.3 Assigning channels to the group adjustment

1. Double-click on the created channel (e.g. ‘grp_adj_channel’) in the Project Tree.
2. In the Main Area, an overview of the available adjustment channels opens.
3. To add measurement channel(s) to the group adjustment event, check the ‘Calibrate’ box of the desired channel(s).

The selected measurement channels are added to the group adjustment event.

12.4.4 Triggering the group adjustment

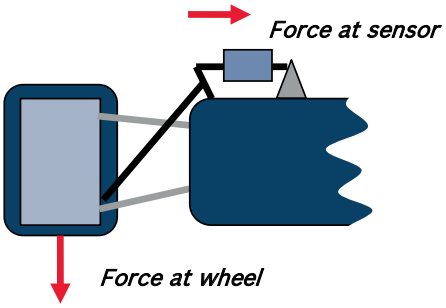
1. Connect the input pin to GND using a push-button.
2. Make sure the pullup-resistor is enabled, if you selected ‘active low’ trigger polarity.
3. Double-click on the input channel ‘grp_adj_channel’ of the group adjustment.
4. Download the configuration on the C 60. To connect the C 60 to RaceCon, see chapter ‘Connecting the Unit to RaceCon’.
5. Open a measurement sheet by clicking on the desired measurement sheet in the Project Tree.
6. Drag the ‘grp_adj_channel’ and the ‘input_grp_adj_channel’ to the online measurement sheet.
7. Press and release the push-button.
8. The measurement labels indicate the state of the input pin and the state of the adjustment.

Notice!
A display alarm can be linked to the trigger channel to indicate that the trigger has been detected.

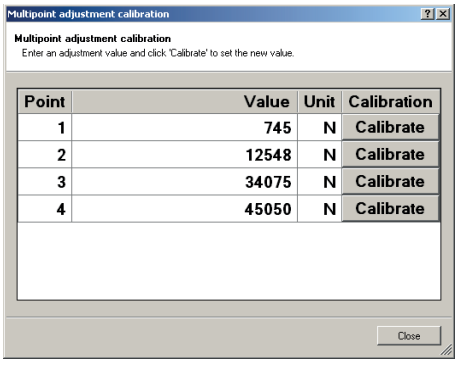
12.5 Online calibration of multipoint adjustment channels

Example: measurement of wheel force

– Physical property ‘wheel force’ not directly measureable
– Load transfer through suspension kinematics
– Physical value at sensor position defined by vehicle
– Curve definition by online adjustment at vehicle



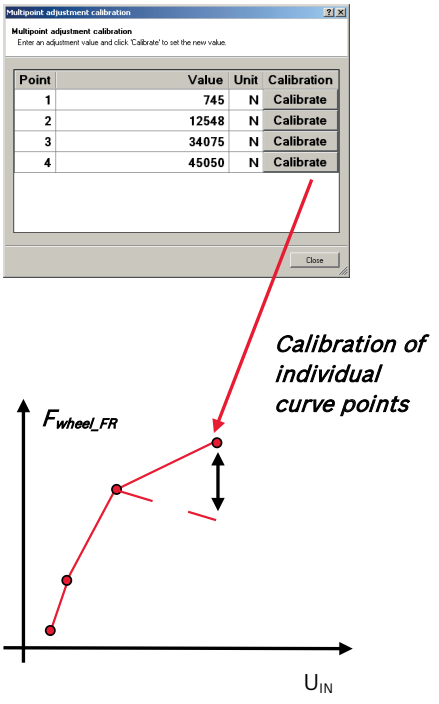
1. Create a multipoint adjustment measurement channel. To create a multipoint channel, see chapter '*Configuring a multipoint adjustment, page 41*'.
2. Download the configuration on the C 60. To connect the C 60 to RaceCon, see chapter 'Connecting the Unit to RaceCon'.
3. Click on the desired channel in the C 60 Project Tree.
4. Double-click on a measurement channel in the Data Area to open the online view.
5.
6. Click on 'Calibrate adjustment points' to open calibration window.

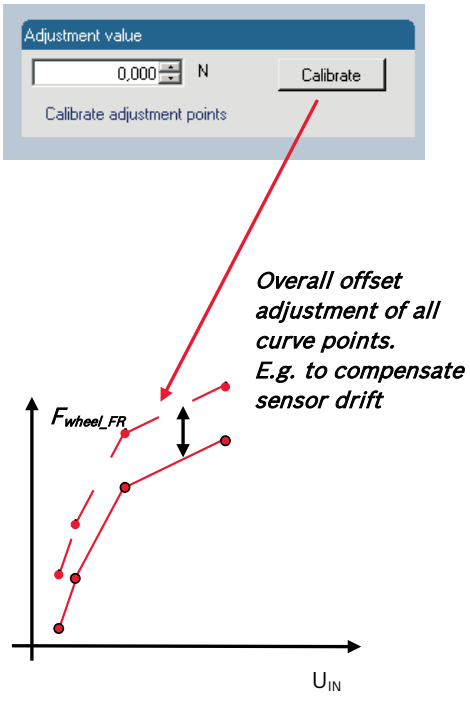


7. Apply the desired physical condition to the sensor (e.g. by applying a force on the wheel).
8. Enter the physical value in the value column of the desired calibration point (e.g. 745 N).
9. Press the 'Calibrate' button of the desired calibration point.
10. Repeat for all curve points.
11. Click 'Close' when done.

The calibration curve is displayed in the online view.

Adjustment points vs. offset adjustment





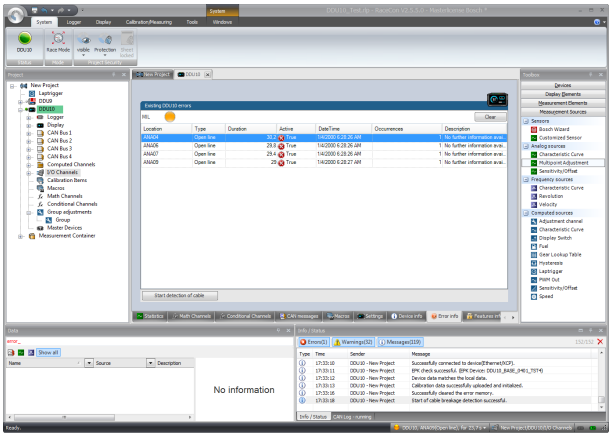
13 Error Memory

13.1 General note

In this chapter “Error Memory”, a lot of screenshots are created by way of example for DDU 8. Please consider this and replace the product name ‘DDU 8’ in this case with the name of your product.

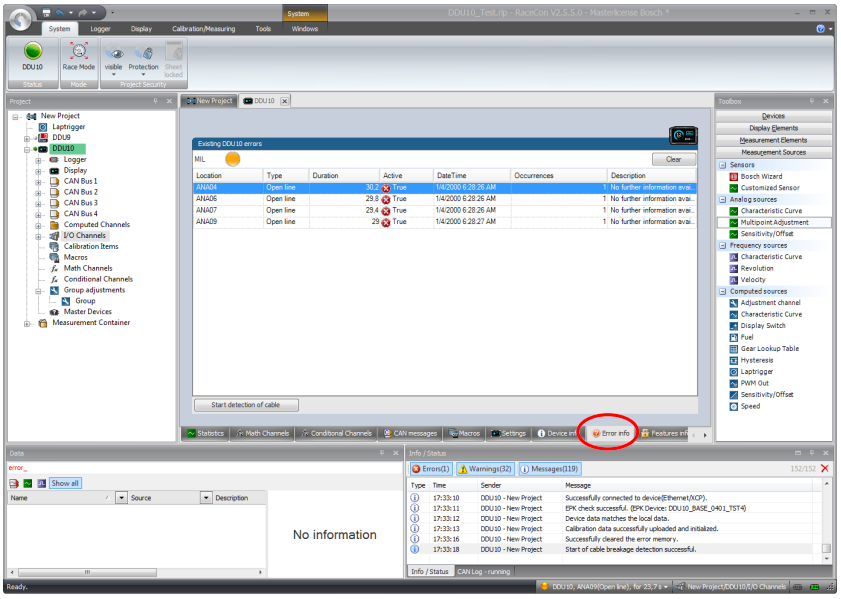
13.2 Error memory representation in RaceCon

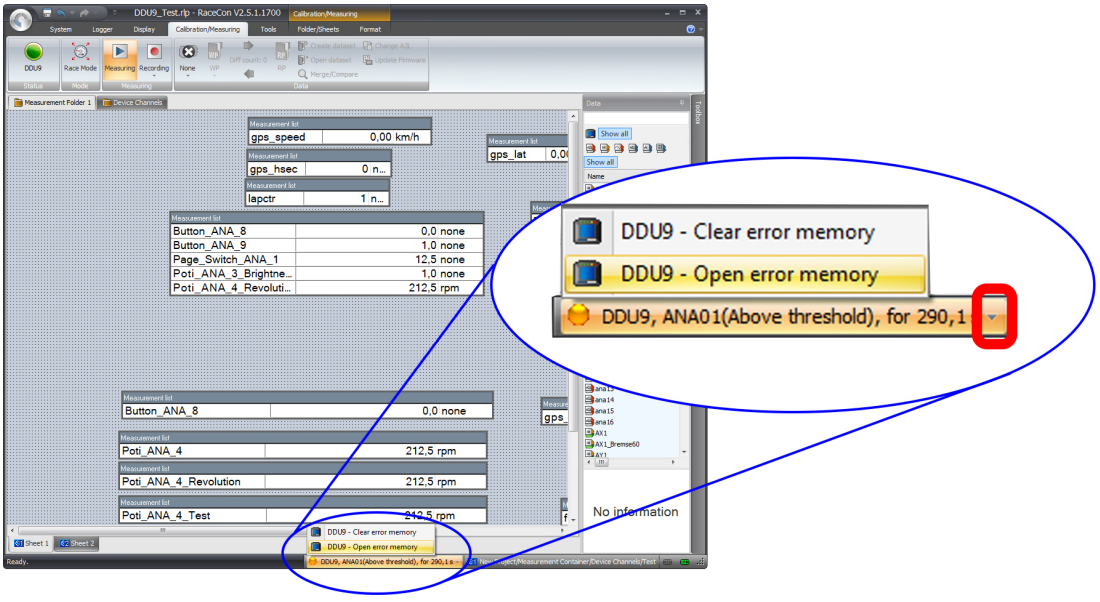
Bosch Motorsport devices feature an error memory. Information on errors can be visualized via RaceCon (online measurement) or can be transmitted via telemetry.



13.2.1 Accessing the memory

The error memory can be accessed as shown in the illustration:





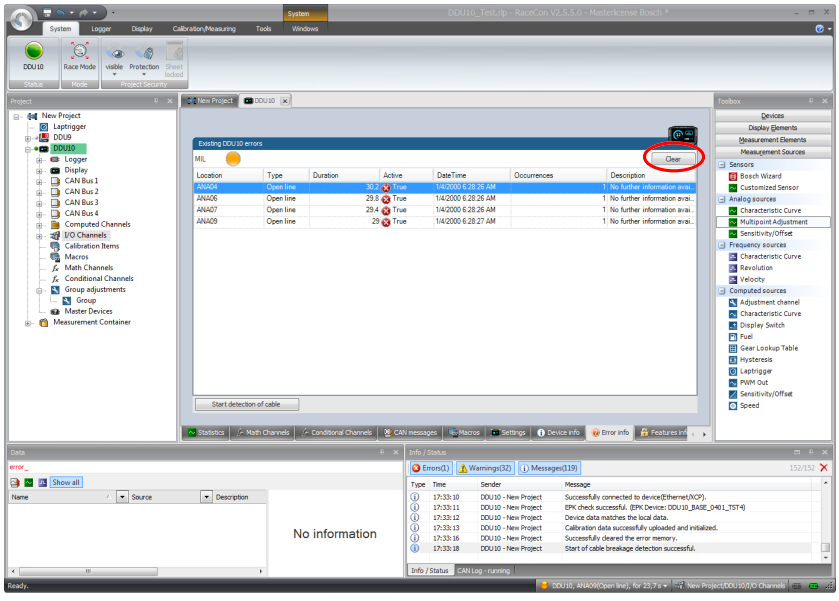
The memory is situated inside the device and is non-volatile. As a consequence, an error which has occurred and has not been cleared by the user will remain in the error memory even after a power cycle. The error state will then reflect if the error is still active or not.
An error is deleted from the list when

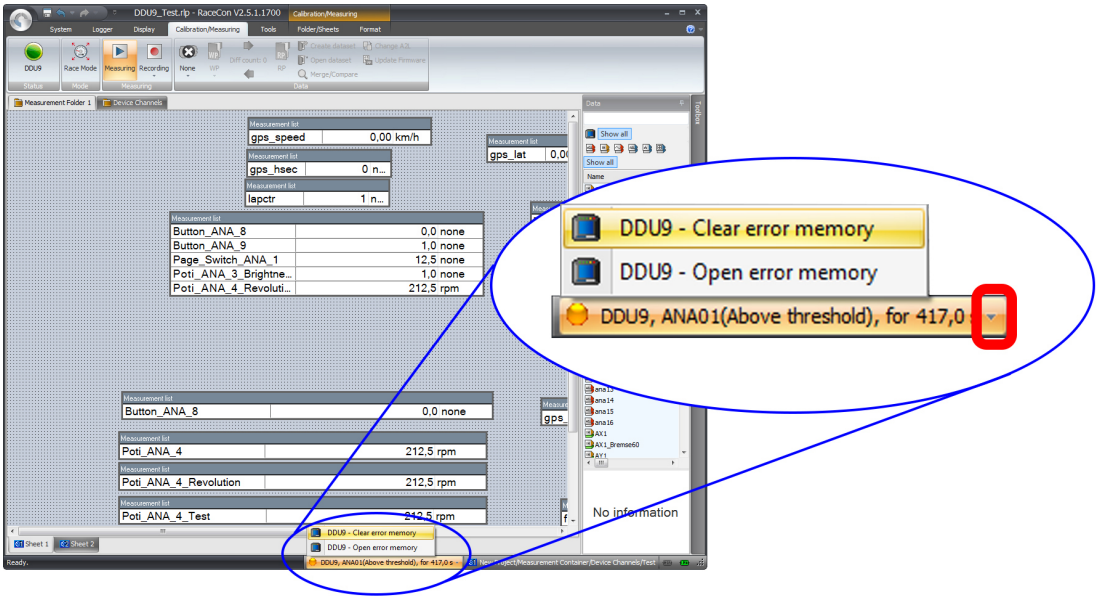
– the user actively clears the error memory
– the user updates the firmware

The error memory is not cleared by a configuration download and is not cleared by a power cycle.

13.2.2 Clearing the error memory

There are two ways of clearing the error memory, both are shown in the following illustration:





13.3 Information on errors available from the error memory

In general, properties of the error memory and properties of an individual error need to be distinguished.

13.3.1 Error Memory Properties

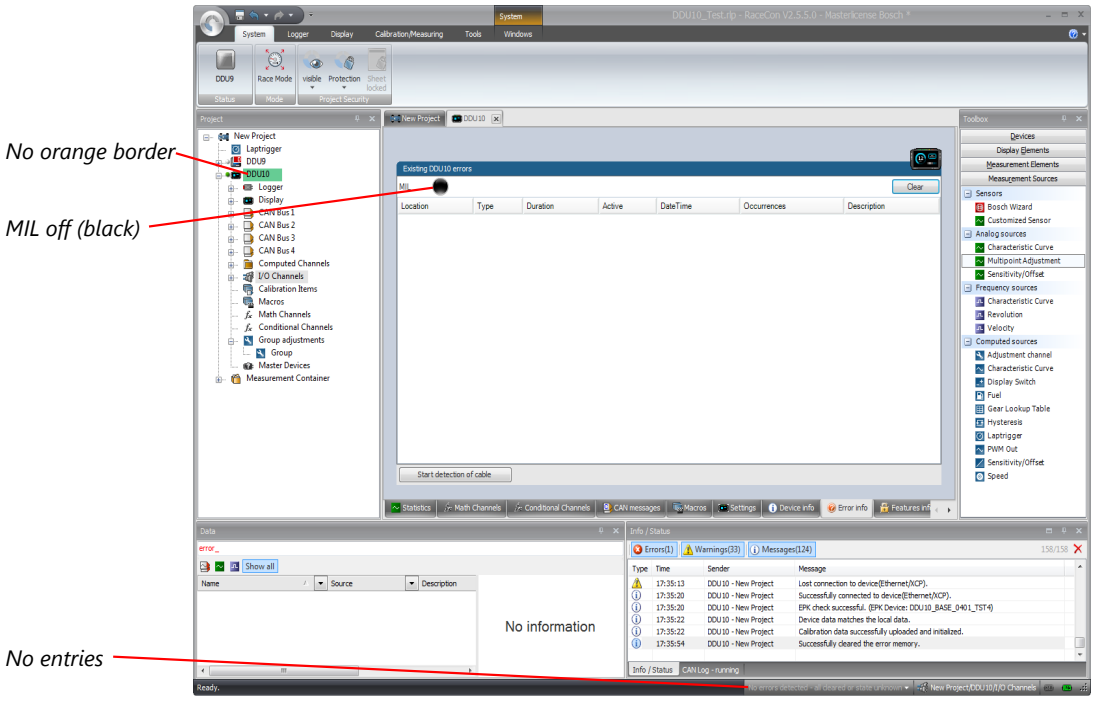
The following property is available for the error memory itself:

– Error Status (device measurement label “error_state”)
  0: no error present in memory
  1: at least one inactive error present in memory, no active errors
  2: at least one active error present in memory

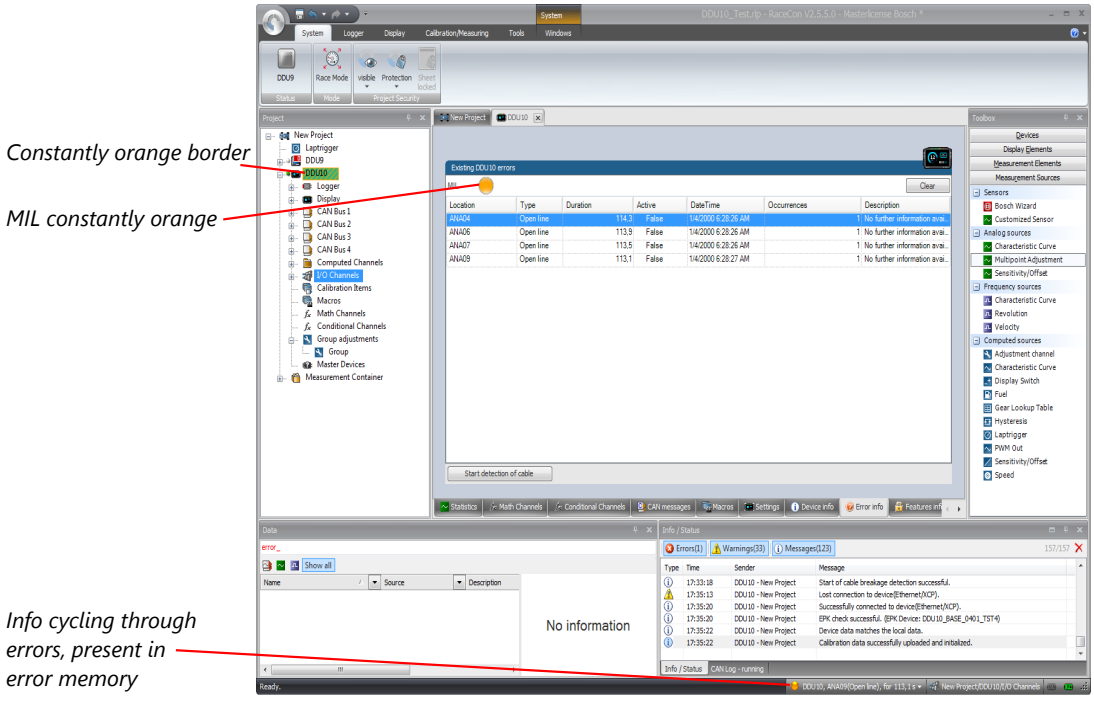
If displayed in a measurement sheet, this property’s value (0, 1 or 2) is translated into a verbal description:

It is also represented by a color scheme within RaceCon (provided RaceCon is online with the system):

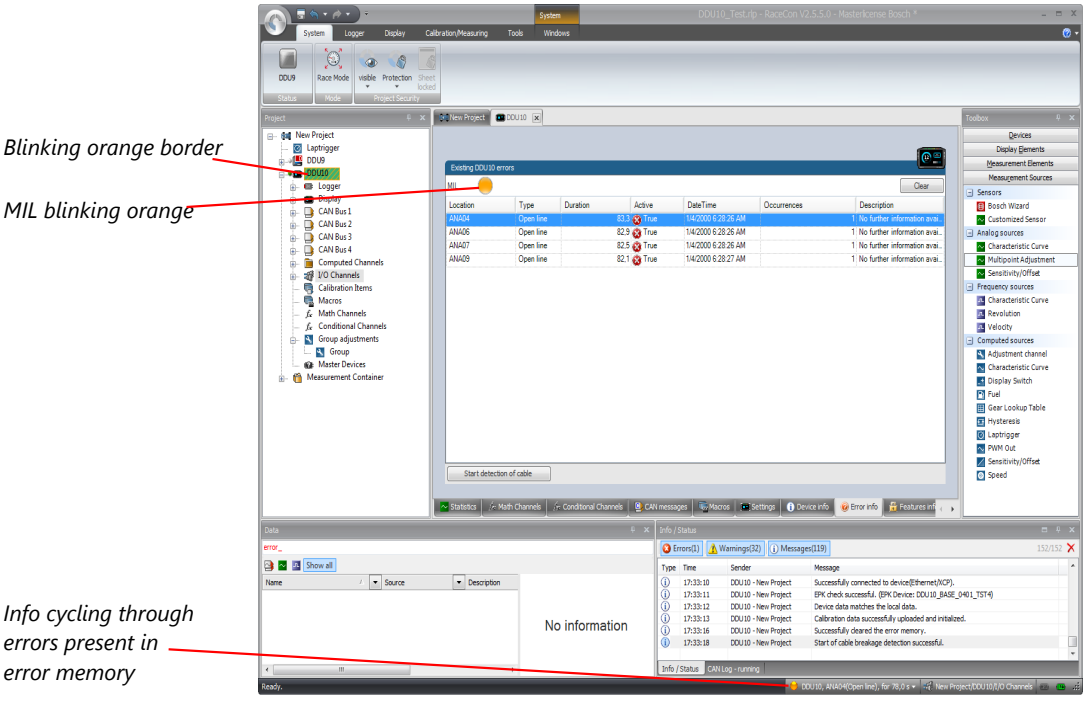
0 (no error present in memory):



1 (at least one inactive error present in memory, no active errors):



2 (at least one active error present in memory):



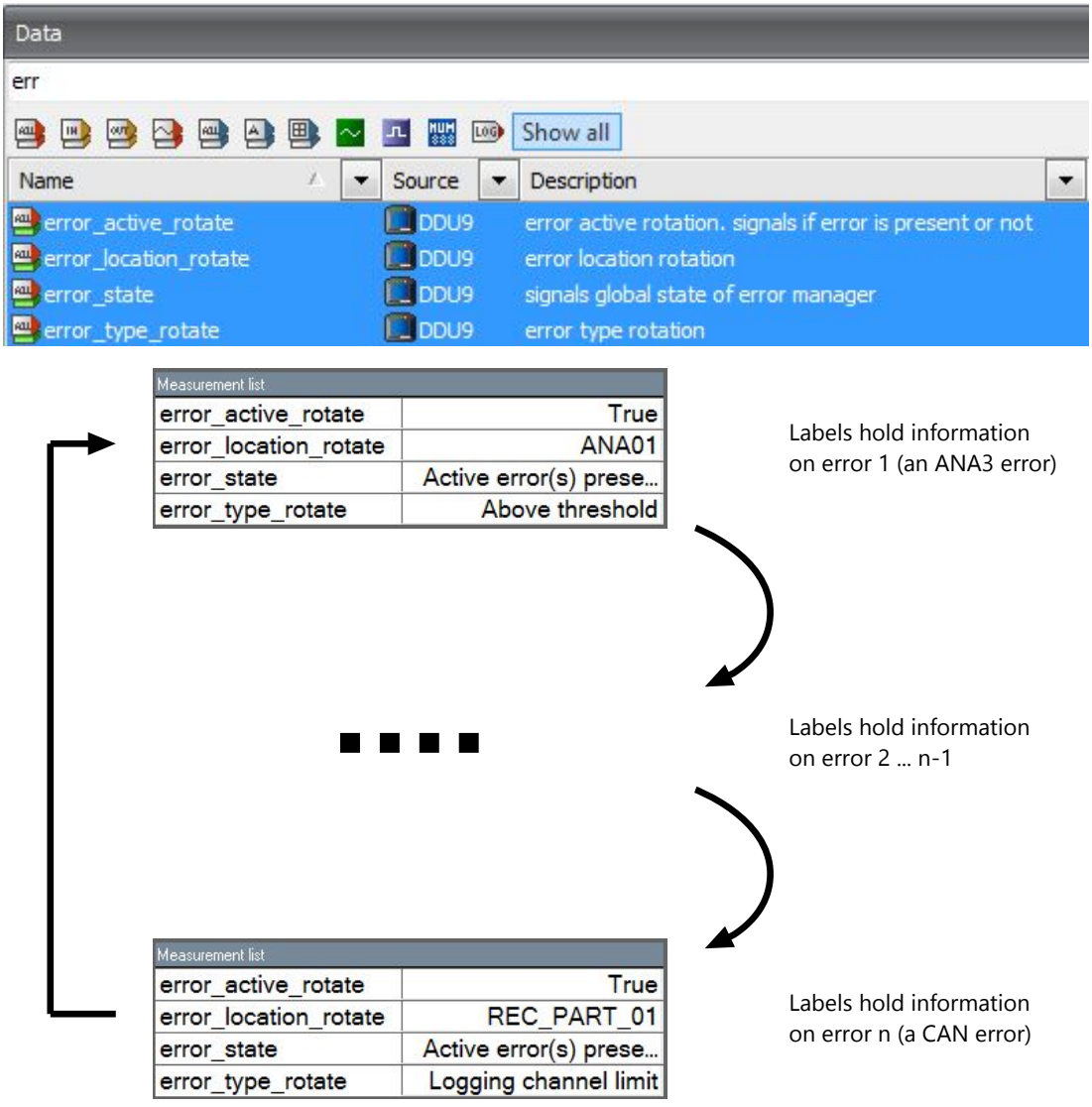
13.3.2 Error Properties

The following channels are recognized and memorized inside the devices:

- Error type (device label “error_type_rotate”):
  e.g. “below_threshold” for a violation of the minimum voltage range defined in the configuration, “shortcut_Batt” for a shortcut to battery voltage etc.
- Error locations (device label “error_location_rotate”):
  e.g. “ANA01” for an error concerning the first ANA channel
- Error durations
  How long has the error been active? If an error encounters a non-active period before being cleared from the memory and is then detected again, the error duration keeps on accumulating. The number of active periods can be seen from the “number of occurrences”.
- Number of occurrences
  How many times has the error been detected since the last time the error memory was cleared.
- Error active state (device label “error_active_rotate”)
  All failure modes are continuously diagnosed; any error detected will be written to the error memory. Once an error is detected, it is qualified as “active”.
  - 1 (TRUE) Error was detected in most recent diagnose run (active)
  - 0 (FALSE) Error is inactive: error was not detected in most recent diagnostic run, however the error has not been cleared from the memory by the user and remains in the non-volatile memory

The aforementioned channels (error_active_rotate, error_location_rotate, error_type_rotate) are device specific properties (e.g. C 60) and are not related to the complete RaceCon project (e.g. “error no. 3 from the error memory”). Therefore, only one property label is available in each device. The errors from the error memory (possibly more than one error possible per device) share these three labels. The labels cycle through the errors currently present in the memory and represent the respective property of each error periodically.

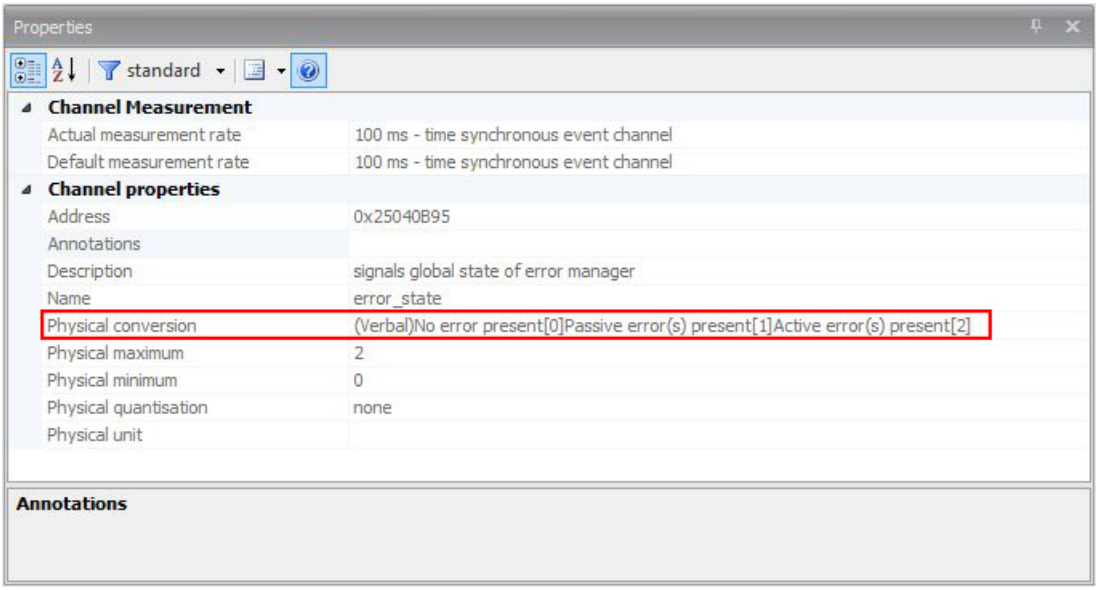
The following screenshot shows error properties, which can be displayed or logged:



After the last error and its error properties have been displayed, the labels will start again with the first error in the error memory stack and its error properties will be displayed again. Therefore, monitoring these labels over a sufficiently long period provides the information on all individual errors in the error memory.
To understand this behavior, it is recommended to observe the three labels in a measurement sheet (while more than one error is active) and watch the values change periodically:

Measurement list	
error_active_rotate	True
error_location_rotate	REC_PART_01
error_state	Active error(s) prese...
error_type_rotate	Logging channel limit

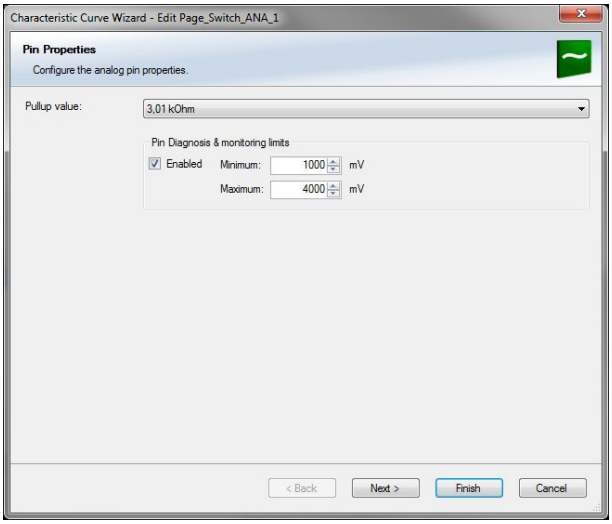
The verbal representation of the numerical codes of these labels can be visualized in the properties window of the measurement page:

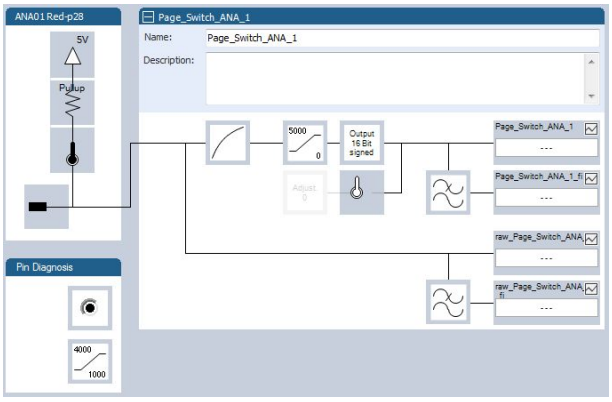


13.4 Analog Input Diagnosis

13.4.1 Monitoring limits / Shortcut Detection / Cable Breakage

The pin diagnosis functionality (check whether measurement is within the desired range) can be activated in the ANA pin setup wizard; to allow for a diagnosis regarding shortcut to ground, shortcut to battery voltage and cable breakage, a minimum / maximum has to be defined.

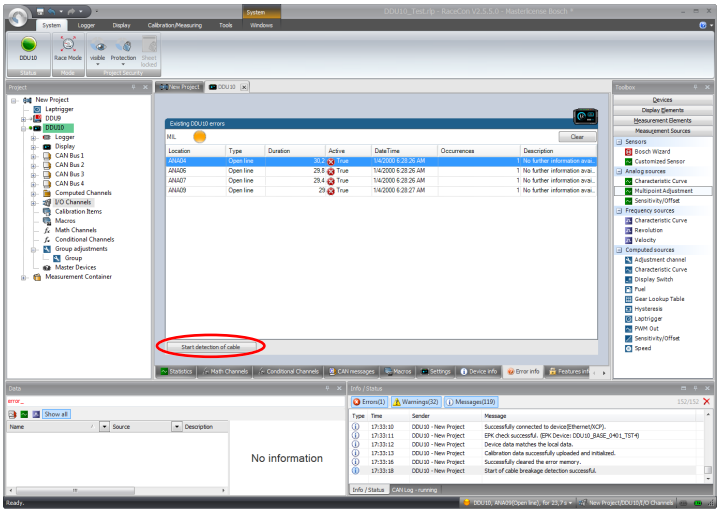




13.4.2 Open Line Detection

The implementation of open line detection consists of pull up resistors being activated and deactivated; evaluating the behavior of the measured value detects cable breakage, regardless of the pull up resistor being activated by the user.

1. Open the Error Memory of the Device.
2. Click "start detection of cable".
3. Check the Error Memory for new fault entries, regarding "Open line errors".



14 Recording and Telemetry

14.1 Features

Recording

- Synchronized recording of C 60 analog and digital input channels, C 60 internal measurement channels, ECU data, Data from external sensor interfaces
- Up to two independent recordings
- Measurement rate 1 ms to 1 s
- Two global start conditions (thresholds)
- Up to 16 measurement conditions (fast-slow-switches)

Telemetry

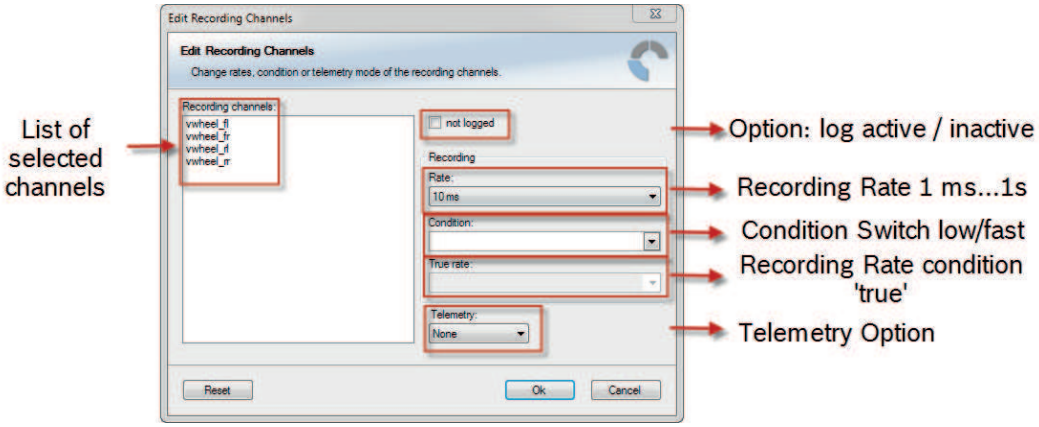
- Support for long-range online telemetry
- Individual programmable team code
- Fast block – slow block mechanism
- Programmable data rate

Burst telemetry

- Support for burst telemetry (BT 60)
- Programmable IP configuration
- BT 60 diagnosis via C 60

14.2 Configuration of recordings

1. Expand the list of ‘Loggers’ by clicking on ‘+’ in the C 60 Project Tree.
2. Double-click on ‘Recording’ in C 60 Project Tree.
3. The recording configuration is displayed in the Main Area.
4.
5. To add measurement channels to a recording, click ‘C 60’ in the C 60 Project Tree.
6. In the Data Area, the measurement channels are displayed.
7. Drag and drop desired measurement channels into recording group.
8.
9. To edit channel’s settings, mark the channel(s) and click ‘Edit Channel’.
   An ‘Edit Recording Channels’ window opens.



Notice!

If no condition is defined or condition is ‘false’, measurement channels are recorded at the value chosen in ‘Rate’.

If the condition is ‘true’, measurement channels are recorded at the value chosen in ‘True rate’.

10. Click ‘OK’ when done.

Using fast block/slow block transmission

C 60 telemetry uses available bandwidth of Telemetry Unit FM 40 (19,200 baud -> approx. 1,700 bytes/s). The bandwidth has to be divided into channel information to be transmitted high-frequently and low-frequently using the ‘fast/ slow block’ setting.

Channels are grouped into 8 blocks which are transferred each cycle:

– Fast block (Block 1) is transferred every cycle and used for a high-frequent transmission of channel information (e.g. speed, rpm).
– Slow blocks (Block 2...n) are transferred every n-th cycle and used for a low-frequent transmission of channel information (e.g. tire pressure, oil temperature).

Transmission Scheme

If the maximum bandwidth of a block is reached, a warning will be displayed. To fix this problem you can view the allocation of the channels and data rate in the ‘Statistics’ tab of the Main Area. See chapter ‘Recording statistics’ for more information.

14.2.1 Adding a recording

C 60 supports up to two independent recordings.

To add a recording, select ‘Add Recording’ from the context menu of the Logger in the C 60 Project Tree.

Maximum two Recordings are possible. In the DDU DTM Software the 2nd Recording is reserved for Scruteneering Data. This Recording is invisible (protected).

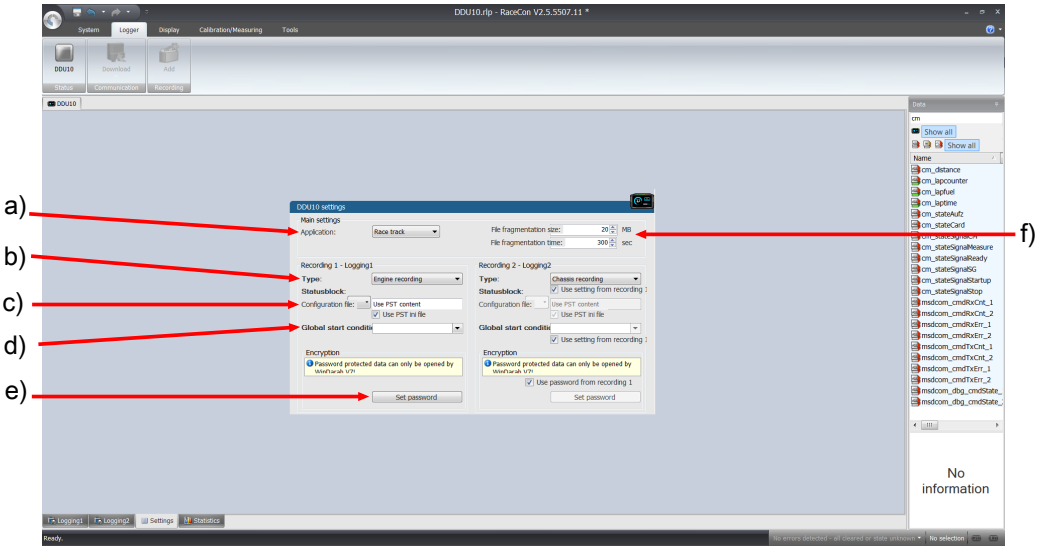
14.2.2 Adding a recording group

Recording channels can be grouped.

To add a new group, select ‘Add group’ in the context menu of the recording. The groups can be renamed to ‘Gearbox’, ‘Aero’, ‘Engine’, etc.

14.2.3 Logger settings

To display the global C 60 settings, open the ‘Logger’ window and click on the ‘Settings’ tab at the bottom.



a) Choose setting for outing counter mode:
• For testbench (without lap trigger) select 'Testbench'.
• For racetrack (with lap trigger) select 'Racetrack'.
b) Choose wether the logging partition shall be named Engine recording or Chassis recording.
c) Advanced setting: Select your logging configuration file, if provided by your Bosch Support Engineer.
d) Choose or create the condition to start recording
e) Enter a password hint and a password (optional).
f) Setting for automatic fragmentation. Do not change!

14.2.4 Recording statistics

The tab 'Statistics' shows the channels' allocation and their current data rate related to the transmission frequency of the C 60 and the whole transmission system.
The overview helps to detect bandwidth bottlenecks of channels. Bandwidth bottlenecks can be solved by changing the 'fast/slow block' setting for each channel.
The data rate of the whole system is often less than the data rate of the C 60 and limits the overall transmission speed.

14.2.5 Recording diagnosis

The channel 'statectrl_ok' of the C 60 can be used for online monitoring of recording status.

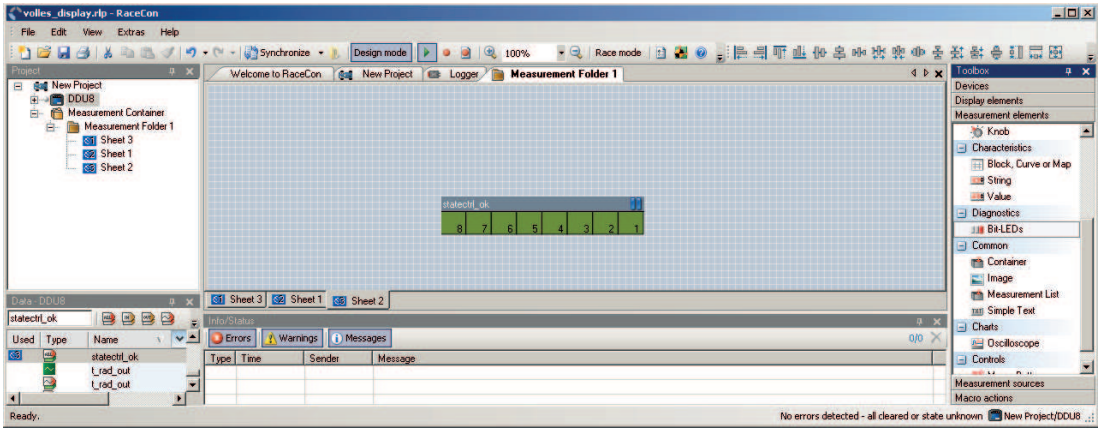
Bit	Value	Name
0	1	RECORD
1	2	DATAOK
2	4	BLKOK
3	8	-
4	16	-
5	32	-
6	64	STARTED
7	128	-

Content of status bits

Name	Bitset	Bit cleared
RECORD	Measurement data is recorded.	No measurement data will be stored because measurement thresholds are not reached.
DATAOK	Received data without error.	Discarding received data because of wrong timestamps. Check wiring of SYNC signal.
BLKOK	All measurement blocks have been set up correctly.	Some measurement blocks have not been set up correctly.
STARTED	A measurement has been set up.	A measurement is not set up. Either no recording configuration has been found or logger software upgrade is not activated.

14.2.6 Displaying online recording diagnosis ("statectrl_ok")

1. To add a Recording Diagnosis element to a measurement sheet, drag a ‘Bit-LED’ element from the Toolbox and drop it on measurement sheet.
2. Drag channel ‘statectrl_ok’ from the Data Area and drop it on the ‘Bit-LED’ element.

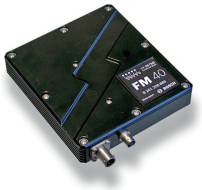


The ‘Bit-LED’ element shows the state of received channel data in bit-representation. A green highlighted channel means 0, a red highlighted channel means 1.

– Measurement correctly initialized, but recording threshold(s) not reached: 254
– Measurement correctly initialized, C 60 is recording data: 255
– Values less than 254 indicate an error state

14.3 Configuration of online telemetry

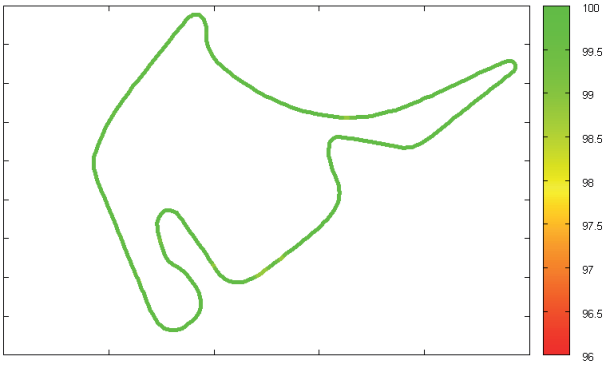
14.3.1 Long range telemetry system FM 40



440 MHz band
25 KHz bandwidth
10 W max. RF output
19.2 kBit/s data rate - unidirectional
RS232 interface

Full online track coverage on almost all tracks

Link quality at Hockenheim



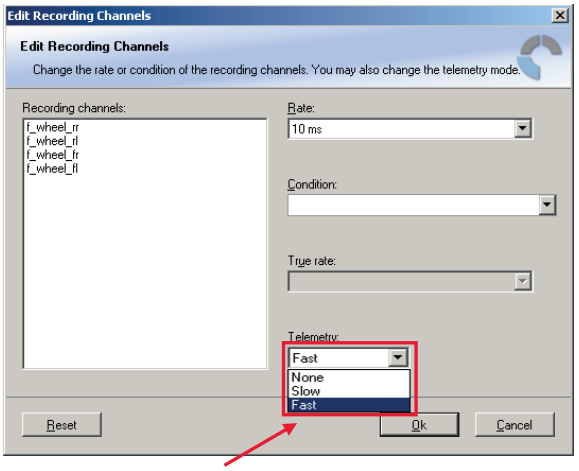
14.3.2 Hardware setup

14.3.3 Software setup

1. Drop FM 40 from Toolbox into system overview.
2.
3. Click on FM 40 in Project Tree to display the Properties Menu.

Adding channels to telemetry

1. Expand the list of ‘Loggers’ by clicking on ‘+’ in the C 60 Project Tree.
2. Double-click on ‘Recording’ in C 60 Project Tree.
   The recording configuration is displayed in the Main Area.
3. Click ‘Edit channel(s)’.
   The ‘Edit Recording Channels’ window appears.
4. Choose between ‘Fast/Slow block’ transmission.
   See chapter ‘Adding a recording group’ for information about ‘Fast/Slow block’.



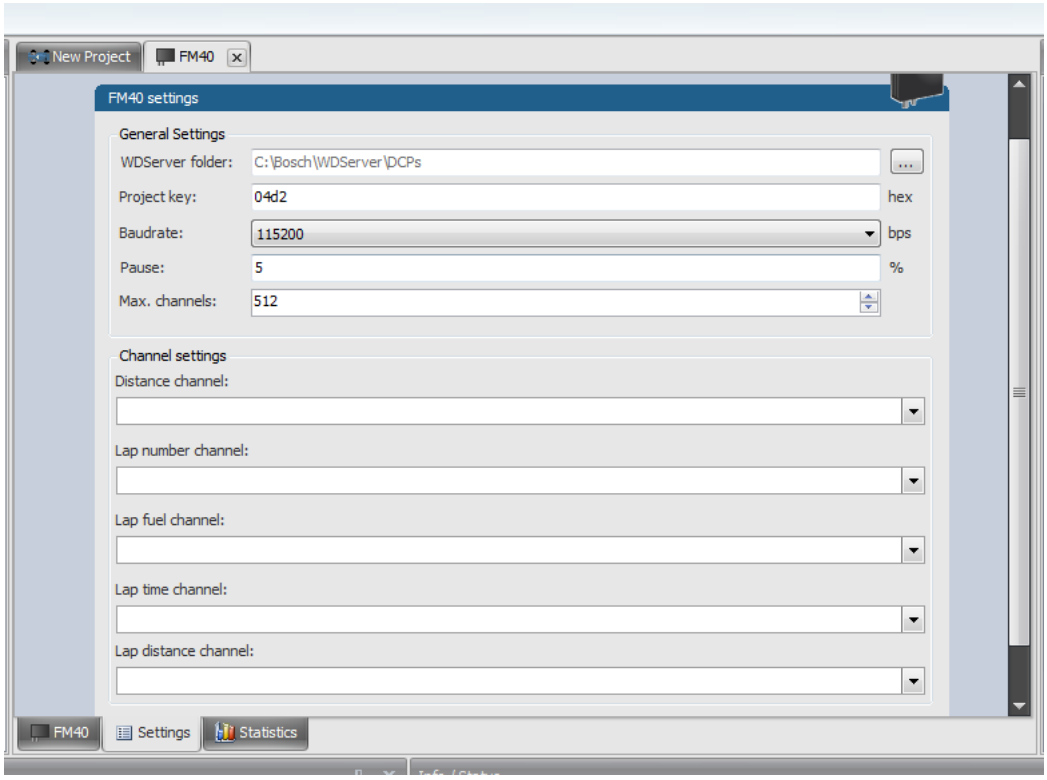
None – channel(s) are not transferred
Slow – channel(s) are transferred in the slow telemetry block
Fast – channel(s) are transferred in the fast telemetry block

14.3.4 Telemetry channels with special functionality

The FM40 allows the transmission of special information such as running distance of current lap, lap number of current lap and lap time, fuel consumption of last lap completed. You have to assign the channel type to the telemetry channel so that it is recognized accurately by RaceCon.

Channel's names are e.g.: distlap, fuelcons, lapctr, laptime. Different channel names are possible between different devices (e.g. ECU MS 3 Sport, ECU MS 5.1).

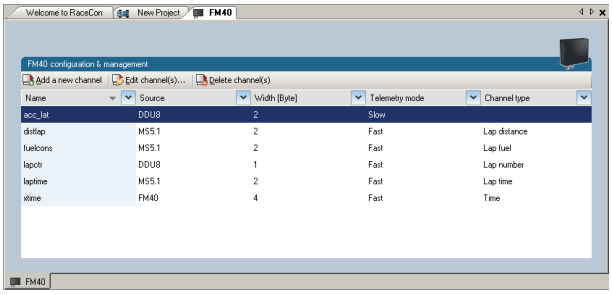
1. Double-click on FM40 in the project tree. An overview of all available telemetry channels is displayed.
2. Click on the ‘Settings’ tab at the bottom, to edit the channels.



3. Assign the desired channels to the channel types. The table below shows the function of the available channel types.
4. Click ‘Ok’ when done.

Measurement channel	Function
Distance	Running distance of current lap
Lap number	Lap number of current lap
Lap fuel	Fuel consumption of last lap completed
Lap time	Exact lap time of lap completed

The telemetry channels and their assigned channel types are displayed in the overview list.



14.4 Configuration of burst telemetry

14.4.1 Hardware setup

14.4.2 Software setup

The IP address of the C 60 must be compatible with the address range of the pit PC, the BT 60 and the BR 60.

1. Drop BT 60 from Toolbox into system overview.
2.
3. Open a measurement sheet.
4. Drag the channel ‘BURST_DEVICE_IP’ to the measurement sheet.
5.
6. Switch to ‘Race Mode’.
7. Enter the desired IP address.

14.5 Setup for USB recording

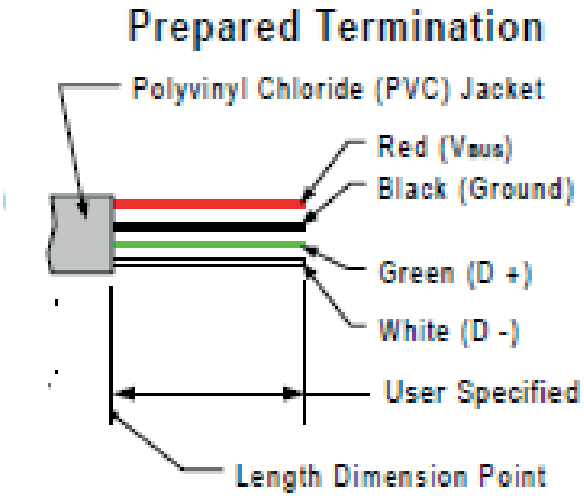
This function requires the installation of Software Upgrades. Look into the datasheet of your device, to see which upgrades are available for your device.
Software Upgrade USB_DATA enables USB recording. To activate Software Upgrade USB_DATA, enter the license key as described in the chapter ‘Feature activation’.
For USB recording, Software Upgrade FULL_LOG_1 should also be enabled.

Wiring harness

Bit	Value
USB_Device_Power	Power (red)
USB_Device_DP	D+ (green)
USB_Device_DN	D- (white)
USB_Device_Gnd	GND (black)

For further information, see the pinlayout of the device.

Colors matching a standard USB cable



Storage device

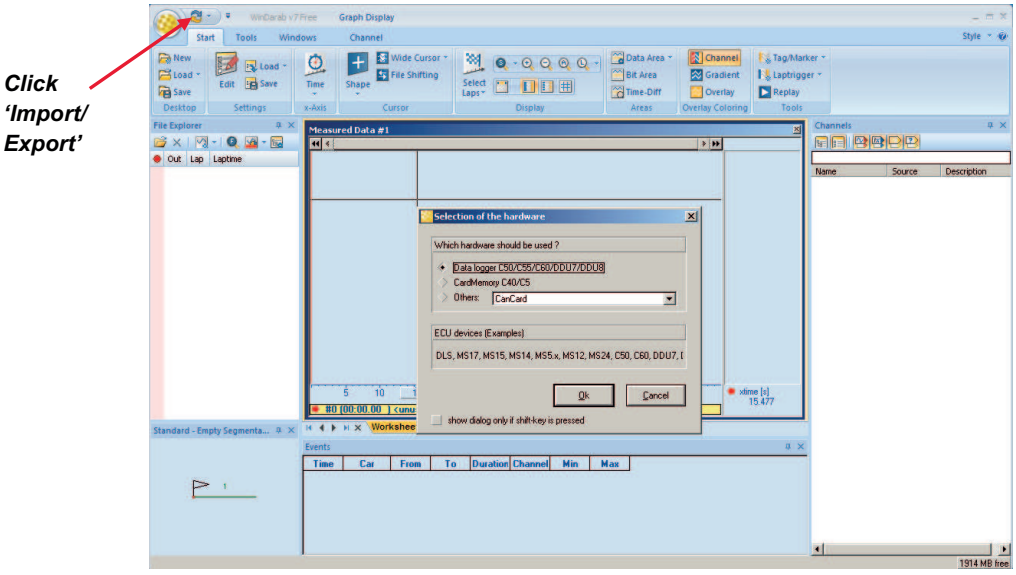
The recording function can be used with a dedicated Bosch Motorsport USB device. The USB device has to be preformatted with the Bosch File System (BFS) in RaceCon before first use. To format the USB device with the Bosch File System (BFS), do the following steps:

1. In RaceCon, select ‘Tools’ - ‘Extras’ and choose ‘Format USB stick’.
2. Press ‘Format’.

An USB device is recognized by Windows as a ‘storage medium’, but it can only be initialized with RaceCon and read with WinDarab.

14.5.1 Recording data on USB device

1. Plug an USB device to C 60.
2. Prepare a recording configuration in RaceCon.
3. Power on the system and connect with RaceCon to the vehicle.
4. Download the configuration to the C 60.
5. Record measurement data. If an USB device is present, the C 60 stores the data in parallel on the internal memory and the USB device.
6.
7. Power off the system.
8. Remove USB device from the vehicle.
9. Start the WinDarab software.
10. Click on the ‘Import/Export’ icon.
11. Select ‘Data logger C50/C55/C60/DDU7/DDU8’ and click ‘OK’ when done. The ‘Read measurement data’ dialog opens.



12. Click on ‘Settings’ tab and select the option ‘Flash Card/USB Stick’.
13. Activate ‘Apply changes’.
14.
15. Insert the USB device into the PC. Data transmission from device starts automatically. Measurement files are stored automatically in the base folder.
16. Click ‘Close’ when transmission has finished.
17. Click on the Start button and choose ‘Open measurement file’.
18. Select the measurement files from the storage folder.
19. Click on ‘Open’.
20. Click in ‘New Desktop‘ to open a new measurement data window.
21. Drag the desired measurement channel from the Channel list and drop it into the measurement data window. The measurement channel‘s graph is displayed.

Notice!
For more detailed descriptions and instructions refer to the WinDarab V7 manual.

14.5.2 USB device handling hints

Using the USB device

Always plug the USB device into vehicle before power up to ensure that all measurement data is stored on the USB device.
If the USB device is plugged in after recording has started, only the current data is saved. Data recorded on the C 60 before the USB device is plugged in will not be saved.

Removing the USB device

Always power off the system before unplugging the USB device!
If the USB device is unplugged while recording is active, parts of the measurement data may be missing.
If the USB device is unplugged and re-inserted for < 4 s while the C 60 is powered up, the C 60 still records data.
If the USB device is unplugged and re-inserted for > 4 s while the C 60 is powered up or a different USB device is plugged in, the C 60 restarts. In this case, the C 60 is not operational for 1.5 s.

14.5.3 Troubleshooting

When no data on the USB device is recorded:
Configure the measurement label **usb_mediastate** on a RaceCon measurement view or on a C 60 display page.
The value of **usb_mediastate** reflects the operating condition of the USB bus:

State	Description
0: Wait: Device not found	The USB device is not found (also: waiting for re-plug stick). No USB device inserted. USB device is defect. No electrical connection or wiring harness problem. USB software upgrade not activated (Purchase of unlock code needed).
1: Wait: Device detected	An USB device is found, but not yet installed.
2: Ok: Media installed	The USB device is found and is operational (idle). This does not imply that recording data is written!
3: Stop: Device unplugged	The USB device has been removed. The C 60 performs a restart when an USB device is re-plugged in.
4: Ok: Media access	Data is currently read from/written to the USB device.
5: Error: Media error	The communication to the USB device broke down. The USB device is defect. The USB device is not supported by C 60.
6: Error: Media corrupt	The USB device is not in valid BFS format. (Hint: Re-format the USB device in RaceCon.)

15 Lap Trigger

15.1 Lap trigger (timing beacon)

Why do we need a lap trigger (timing beacon)?

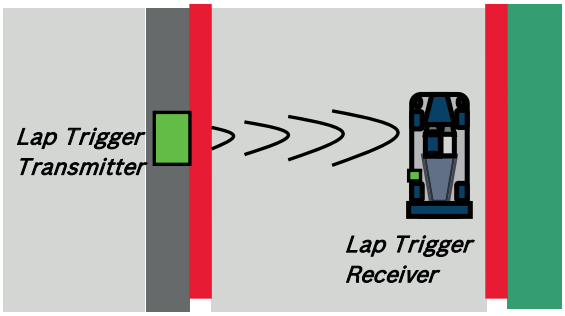
- Vehicle lap time measurement
- Calculation of lap-dependent functions (lap fuel consumption, min/max values)
- Calculation of lap distance dependent functions
- Control of data logging system

Types of Systems

- GPS based (low cost, low precision)
- IR based (low cost, high precision, limited reliability)
- RF (microwave) based (high precision, high reliability)

IR and RF based Systems consists of

- Transmitter (trackside unit)
- Receiver (in-vehicle unit)



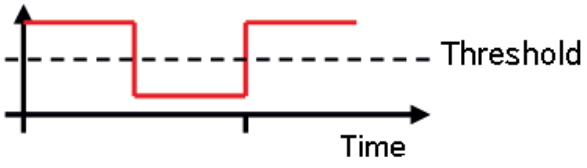
15.1.1 Electrical trigger signal

In C 60 all sources of measurement channels can be used as trigger signal.

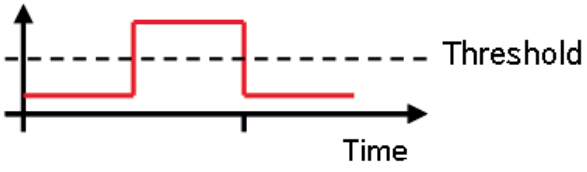
- Analog input
- Digital input
- CAN input

Signal (measurement channel) properties

Low active signal (Bosch triggers): Trigger releases if signal is below the threshold.



High active signal (other manufacturer's triggers): Trigger releases if signal is above the threshold.



Two types of trigger signal:

- Main trigger (end-of-lap at start/finish line)

– Sub-trigger (segment time, optional, not applicable with GPS lap trigger)

Bosch standard:

– Main trigger 20 ms, low active (Recommendation for RaceCon “Detecion Time” setting: 15 ms, Setting must be a slightly shorter period than the signal length of the trigger to avoid a missed trigger due to the update rate)
– Sub trigger 40 ms, low active (Recommendation for RaceCon “Detecion Time” setting: 30 ms)

15.1.2 Prevention of false triggers

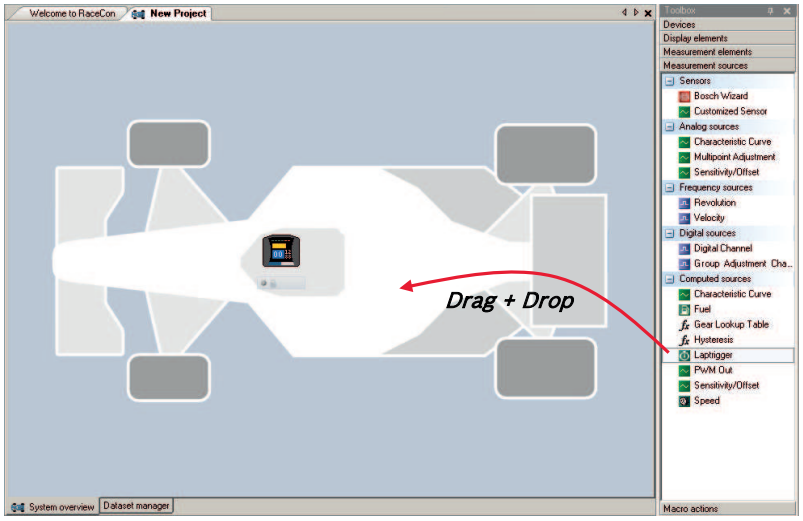
– Race track topology and transmitter location frequently cause false triggers.
– Software functionality prevents acceptance of false triggers.
– Minimum vehicle speed for acceptance of trigger prevents false triggers while vehicle is stationary in the pits.
– Time based re-trigger protection prevents false triggers due to signal reflections on main straight.
– Lap distance based retrigger protection prevents false triggers due to track topology.

15.1.3 Forced triggers

Lap distance based insertion of ‘forced trigger’.
Under race conditions, trigger signals are sometimes missed. Software functionality introduces ‘forced trigger’.

15.1.4 Setting up a lap trigger

1. Click ‘Measurement Sources’ in Toolbox.
2. Drag ‘Laptrigger’ into ‘System Overview’ and drop it on vehicle. Do not drop it on ‘C 60’!



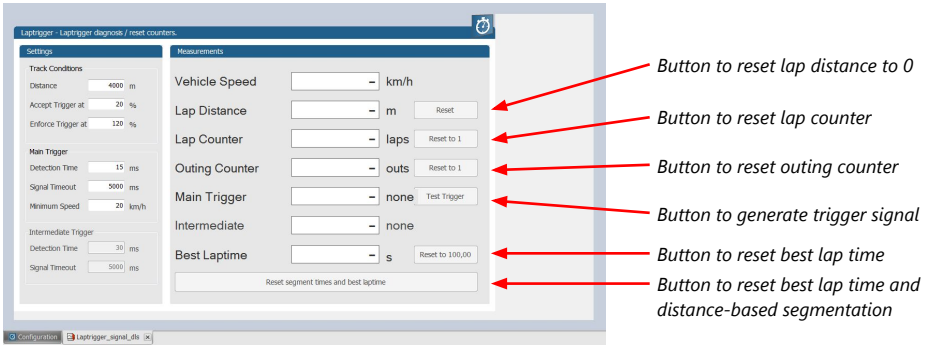
A ‘Laptrigger Wizard’ window opens.

Notice!
In this example, the Rx is connected to the dedicated lap trigger pin of C 60. The channel ‘speed’ is calculated from 4 wheel speeds.

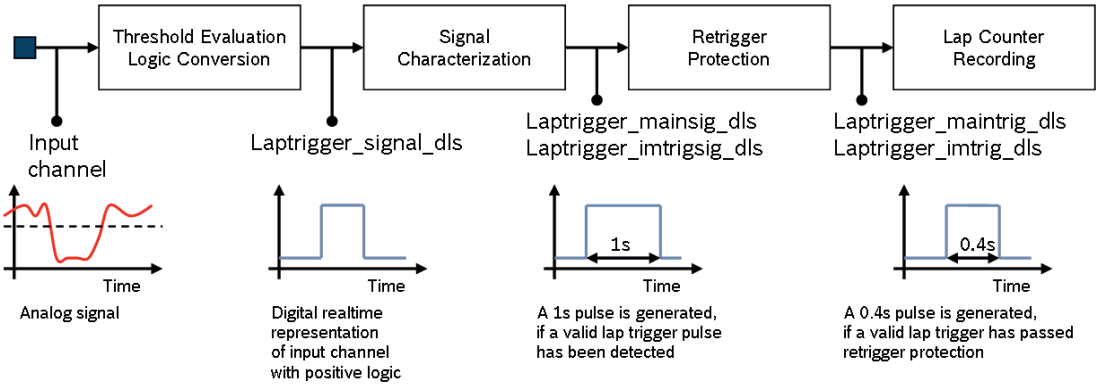
3. Click ‘Finish’ to complete the operation.
   A pre-configured lap trigger window opens.

15.1.5 Lap trigger channel diagnosis/counter reset

To display a quick lap trigger channel diagnosis and to reset counters use the diagnosis page in RaceCon. Any ‘Laptrigger_xxx’ channel can be displayed.
Double-click on any ‘Laptrigger_xxx’ channel in the Data Area. Example: ‘laptrigger_lapdist_dls’
A diagnosis window opens in Main Area.



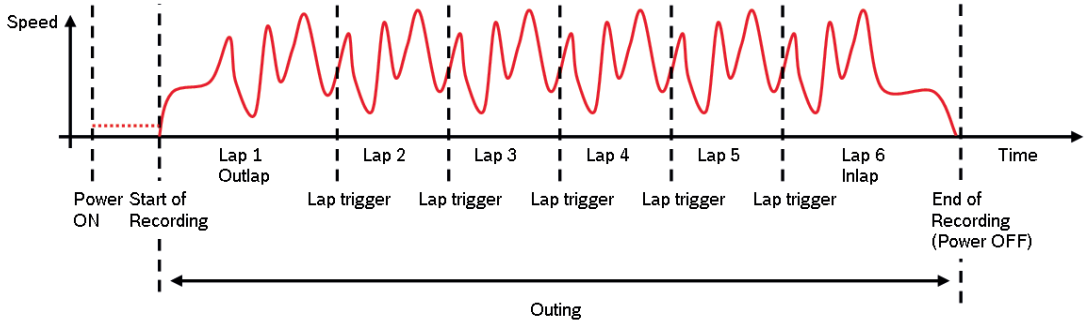
Lap trigger diagnosis scheme



15.1.6 Lap trigger presettings

When the reset buttons on the diagnosis page are activated, these values are used.

15.2 Counting outing/laps/fragments



Functionality

- Power ON: system + measurement is initialized but not yet started
- Global start condition fulfilled: recording starts
- Reception of valid lap trigger: recording of lap completed, new lap starts

– Power OFF or Global start condition not fulfilled: recording of lap completed, system shutdown

The system is counting:

Outing:

– The outing counter is incremented with each power cycle when at least one valid lap (not by forced lap trigger) was recorded

Lap:

– Leaving the pits to lap trigger
– Lap trigger to lap trigger
– Enforced lap trigger (see Distance based forced trigger)

Fragment:

– Test bench operation
– Power cycle on track or box (e.g. engine stalled)
– File fragmentation size [MB], time [sec]

Channels for display

To display counters use the following channels:

Channel	Function
Laptrigger_outcnt_dls	Outing counter
Laptrigger_lapctr_dls	Lap counter
Fractr	Fragment counter

Counting in WinDarab

To automatically name recorded files use filename templates in WinDarab dialog:

Filename template	Function
[outing]	Value of outing counter
[lap]	Value of lap counter
[fragment]	Value of fragment counter

[###03] indicates: ‘always use 3 digits with leading zeros’.

15.3 Lap timing

There are different possibilities to adjust the lap trigger to the timing situation.
The detection time defines the minimum time the input signal changes its state. E.g. a low active signal needs to be below the threshold for min. 15 ms to release the trigger.

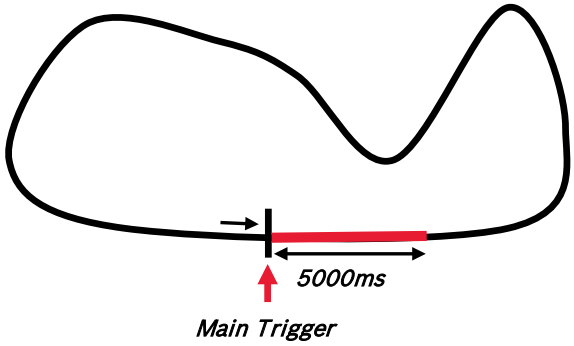
Channels for display

To display lap times use the following channels:

Channel	Function
Laptrigger_lapctr_dls	Number of completed laps
Laptrigger_laptime_dls	Running laptime
Laptrigger_laptime_best_dls	Laptime of best lap
Laptrigger_laptimeold_dls	Laptime of last lap completed
Laptrigger_laptimeseg_dls	Segment time of last segment
Laptrigger_lapctr_dls	Number of completed laps

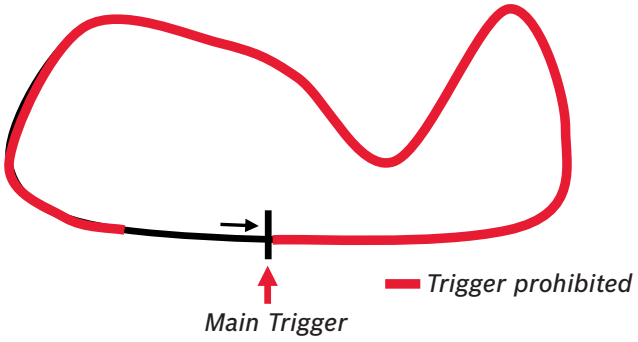
15.3.1 Time based retrigger protection

Trigger is locked for 5 s after main trigger was received.
To deactivate time based retrigger protection, set ‘Retrigger lock time’ to 0 ms.



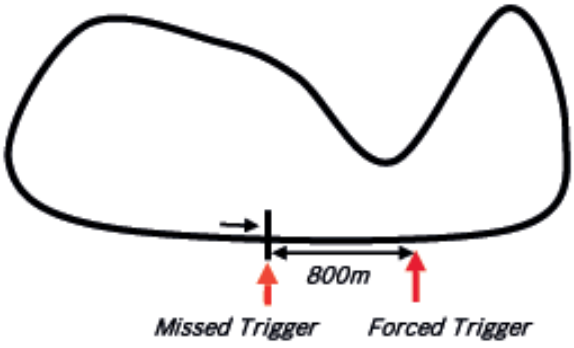
15.3.2 Distance based retrigger protection

Trigger is locked until 80% of track distance has been covered (3,200 m).
To deactivate distance based retrigger protection, set min distance to 0%.



15.3.3 Distance based forced trigger

After a missed main trigger, a forced trigger is inserted, if 120% of the track distance has been covered (4,800 m). In this case, the channel ‘Laptrigger_distlap_dls’ starts at 800 m.
To deactivate distance based forced trigger, uncheck box.



15.3.4 Segment timing

Segment timing is the calculation of elapsed time for parts of laps (segments).

Segments are defined:
- based on sub-trigger signals (additional transmitters)
- based on distance travelled

Times for segments are compared to:
- Last lap completed
- Fastest lap

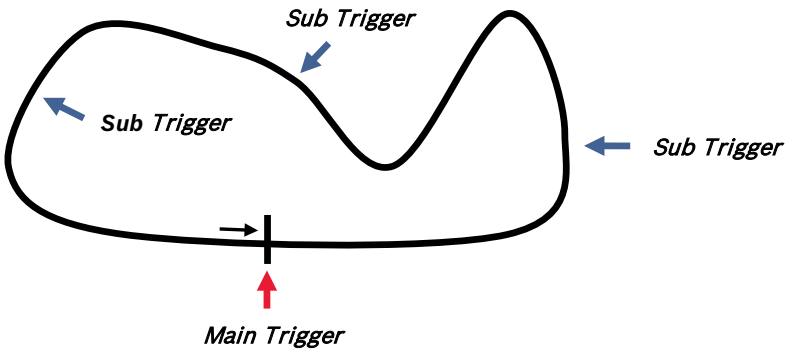
Channels for display

To display segment times use the following channels:

Channel	Function
Laptrigger_lapdiff	Time difference between finished lap and last lap
Laptrigger_lapdiffb	Time difference between finished lap and best lap
Laptrigger_lapseg_dlast	Difference of lap segment time compared to last lap
Laptrigger_lapseg_dbest	Difference of lap segment time compared to best lap

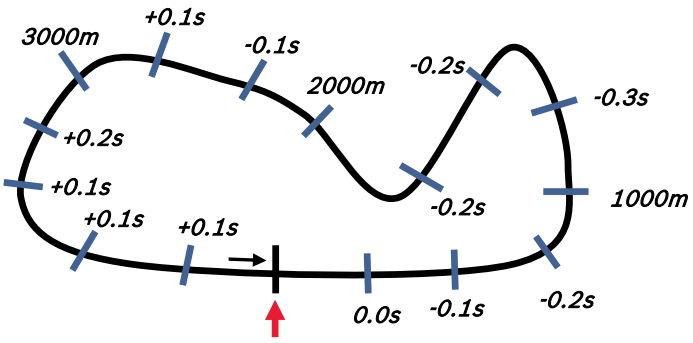
15.3.4.1 Sub trigger mode

Using main trigger (20 ms pulse) at Start-Finish-Line. 3 sub triggers (40 ms pulse) positioned at 1,000 m, 2,000 m and 3,000 m.
To deactivate sub trigger mode uncheck box.



15.3.4.2 Distance mode

Using main trigger (20 ms pulse) at Start-Finish-Line.
Set ‘Mode’ to ‘Distance’ and enter desired segment distances.
Segment time is automatically calculated at each segment. Time difference to last lap and fastest lap is automatically calculated at each segment.
To deactivate distance mode set ‘Mode’ to ‘None’.



15.3.5 Countdown timer

Some race classes require a minimum time spent in the pits. An additional lap trigger Tx is configured as a segment trigger positioned at pit entry. The trigger signal starts a timer countdown.

The current value of the timer is stored in the variable **Laptrigger_cntdown_dls** which can be displayed.

16 Firmware

16.1 Firmware and configuration

C 60 holds 4 types of data:
Firmware: the software (PST program file) of the C 60.
Configuration: the configuration of Input channels, CAN I/O, PWM, display configuration, recording + telemetry configuration.
Calibration data: Characteristic curves and offsets created by online calibration at the vehicle.
Recorded data: Measurement data recorded during vehicle operation.

16.2 Firmware update

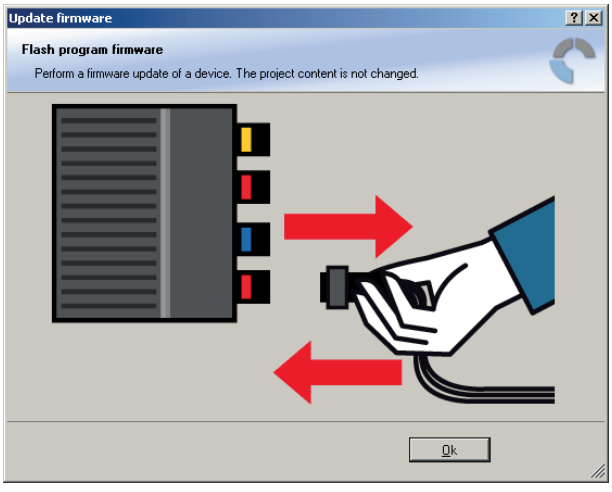
The scheme shows the process during each connection between RaceCon and C 60.

16.2.1 Performing the firmware update

Firmware update is only possible if the C 60 is connected to RaceCon.
The configuration of Input channels, CAN I/O, display, recording + telemetry will not be changed.

1. In the C 60 Project Tree, right-click on ‘C 60’ and choose ‘Synchronize’ then ‘Update firmware’. A pop-up menu opens.
2.
3. Select the destination of the firmware archive (PST).

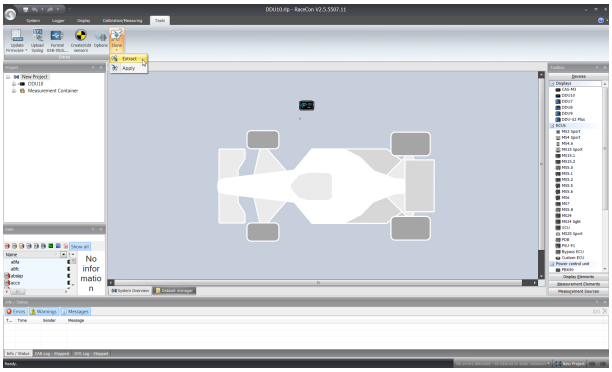
4. Click ‘OK’ when done.
5. The firmware update starts. The C 60 displays the message ‘Updating firmware’. Do not switch off the car’s ignition or interrupt the power supply of theC 60!
6.
7. When the firmware update is complete, the C 60 displays the message ‘Updating firmware finished. Do a powercycle.’
8. Switch the car’s ignition off and on again to cycle the power of theC 60.



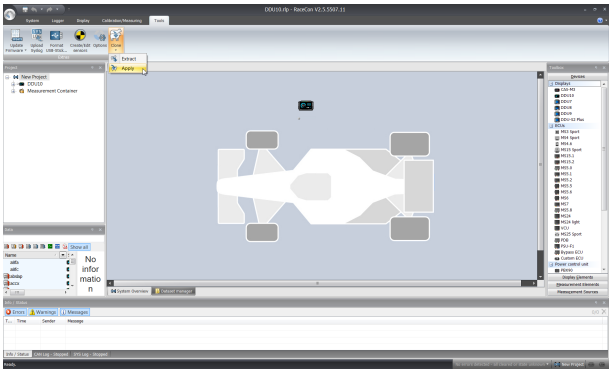
17 Clone the Unit

To replace a C 60 by another device, it is possible to clone it. A clone is a 1:1 copy of a device.
Create a clone file:

1. Click ‘Clone extract’ in Extras menu.



2. Choose the hardware device which should be cloned.
3. Define destination and filename.
4. Click ‘OK’ to start procedure.
5.
6. Change the device.
7. Click ‘Clone apply’ in Extras menu.



8. Choose clone file.
9. Click ‘Ok’.

Please remember that following properties are not stored into the clone:

– Lifetime of device
– Serial number
– Upgrade features

18 GPS Sensor

18.1 GPS (Global Positioning System)

Space-based global navigation satellite system
GPS provides positioning, navigation, and timing services to worldwide users
GPS receiver (sensor) gives digital information about position (longitude, latitude, height), ground speed, course, and status

Two types of GPS receivers:
CAN output -> Read in messages via CAN Input of C 60 (not covered here)
Serial output -> Read in messages via RS232 Interface of C 60 (serial interface 2)

18.1.1 Serial interface characterization

Serial Interface is characterized by:
Voltage levels: RS232 is standard (+/-12 V), UART (0 V/ 5 V) needs level shifter
Baud rate: 9,600 is standard for GPS, C 60 supports 1,200 to 115,200 baud. GPS Rx interface baud rate must match C 60 interface baud rate. C 60 Baud rate can be set with the 'GPS_BAUDRATE' characteristic Data format: C 60 expects 8 data bits, no parity bit, 1 stop bit (8N1)

18.2 Protocol

C 60 expects NMEA Protocol (ASCII).
The following messages are decoded:

Message	Function
GGA	GPS fix information
GSA	Overall satellite data
GSV	Detailed satellite data
RMC	Recommended minimum data for GPS
VTG	Vector track and speed over the ground

On most GPS sensors, these messages are activated in the default configuration.

18.3 Sensor recommendation

The system has been tested with the Navilock NL-8004P MD6 Serial PPS Multi GNSS Receiver. This sensor is based on a U-Blox 8 chipset and is fully configurable with the Navilock "U-Center" software. To use this sensor with Bosch Motorsport components the transfer rate, the satellite system and the update rate needs be reconfigured. More information about the configuration can be found in the Appendix.

18.4 Measurement labels

The decoded NMEA messages are copied to these C 60 measurement labels.

Measurement label	Function
gps_PDOP	Position Dilution Of Precision
gps_HDOP	Horizontal Dilution Of Precision
gps_VDOP	Vertical Dilution Of Precision

Measurement label	Function
gps_lat	Latitude in NDEG - +/-[degree][min].[sec/60]
gps_long	Longitude in NDEG - +/-[degree][min].[sec/60]
gps_elv	Antenna altitude above/below mean sea level (geoid) in meters
gps_speed	Speed over the ground in kilometers/hour
gps_direction	Track angle in degrees
gps_declination	Magnetic variation degrees (Easterly var. subtracts from true course)
gps_year	Years since 1900
gps_mon	Months since January - [0,11]
gps_day	Day of the month - [1,31]
gps_hour	Hours since midnight - [0,23]
gps_min	Minutes after the hour - [0,59]
gps_sec	Seconds after the minute - [0,59]
gps_hsec	Hundredth part of second - [0,99]
gps_smask	Mask specifying types of packages from which data has been obtained
gps_sig	GPS quality indicator (0 = Invalid; 1 = Fix; 2 = Differential, 3 = Sensitive)
gps_fix	Operating mode, used for navigation (1 = Fix not available; 2 = 2D; 3 = 3D)

These measurement labels are arrays, where the indexed element points to the same satellite. (E.g. gps_info_satsigstrength[3] tells the receiving signal strength of satellite 3. Satellite 3 has the SAT-ID given in gps_info_satid[3])

Measurement label	Function
gps_info_satid[ ]	Satellite PRN number
gps_info_satinuse[ ]	Used in position fix
gps_info_satelevation[ ]	Elevation in degrees, 90 maximum
gps_info_satazimuth[ ]	Azimuth, degrees from true north, 000 to 359
gps_info_satsigstrength[ ]	Signal, 00-99 dB

18.5 GPS troubleshooting

Electrical

Is the transmitter signal of the GPS sensor connected to the receiver pin of serial interface 2 of the C 60?

Is the GPS sensor powered up?

Does the GPS sensor deliver RS232 signal levels?

Interface

Do the baud rates of the GPS sensor and the C 60 match?

Is the GPS sensor set up for 8N1 transmission parameters?
Is the GPS sensor set up for NMEA messages?
Are the GGA, VTG, RMC messages activated?
Is Software Upgrade 2 activated in the C 60?

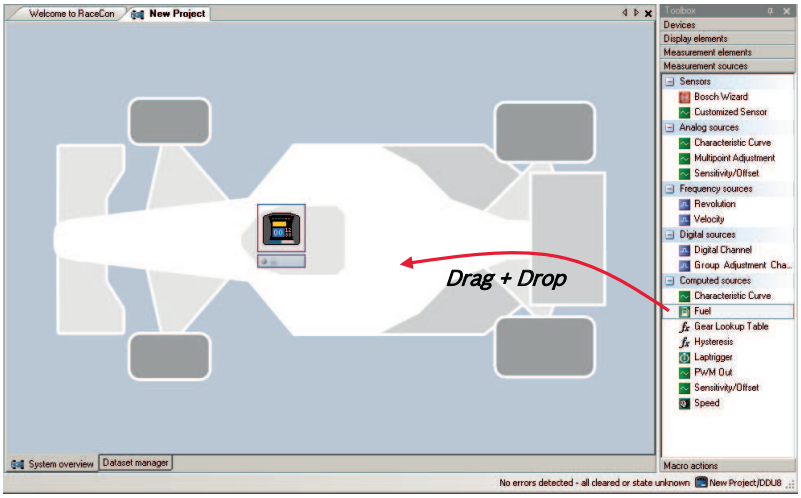
GPS sensor start-up

Does the GPS sensor ‘view’ the sky?
Did the GPS sensor complete its initial start-up procedure? This may take up to 20 min.
A correct reception is indicated when ‘gps_fix’ is showing ‘3D Fix’.

19 Fuel Consumption Calculation

19.1 Setting up fuel consumption calculation and tank management

1. Select ‘Measurement Sources’ in Toolbox.
2. Drag ‘Fuel’ element and drop it on the vehicle in System Overview. Do not drop it on the C 60!

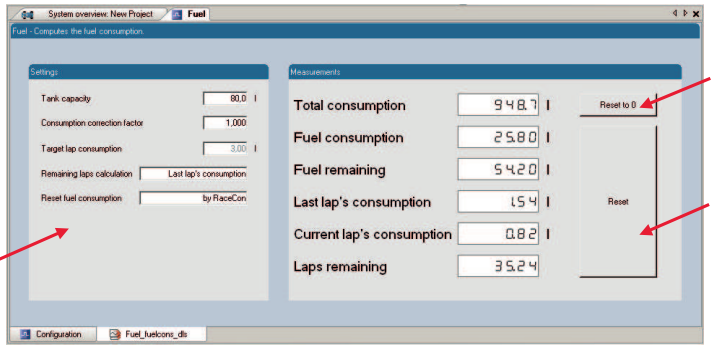


A ‘fuel consumption wizard‘ opens.

3. Press ‘Finish’ when done.

19.2 Fuel consumption diagnosis/counter reset

To display a fuel consumption diagnosis and to reset counters, use the diagnosis page in RaceCon.
Double-click on any ‘fuel_xxx’ channel in channel list.
A diagnosis window opens in Main Area.

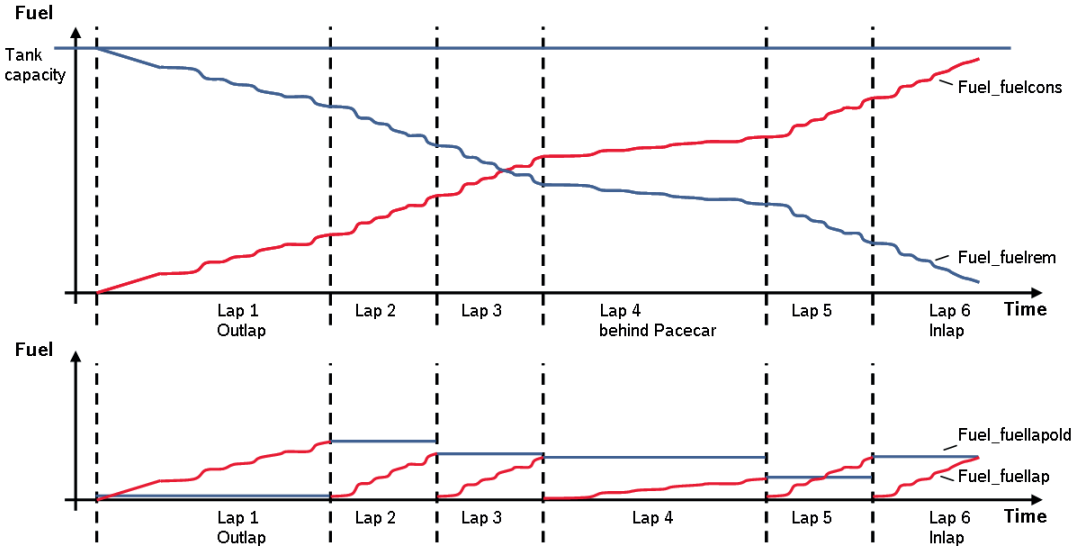


Settings overview

Button to reset total fuel consumption (Reset with RaceCon only)

Button to reset fuel consumption manually (Can also be triggered ‘by signal source’ or ‘on power down’)

19.3 Example



Measurement label	Function
Fuel_fuelcons_dls	Running fuel consumption, starting at ‘0’
Fuel_fuelrem_dls	Remaining fuel in tank, starting at tank capacity
Fuel_fuellap_dls	Fuel consumption for current lap, starting at ‘0’
Fuel_fuellapold_dls	Fuel consumption of last lap completed
Fuel_laprem_dls	Remaining laps with fuel in tank

20 C 60 Enhancement

21 RaceCon Shortcuts

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