BOSCH

Engine Control Unit MS 7.4

Manual

Version 2.0 22/04/2024

Content

1 Getting Started

Disclaimer

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

Before starting

Before starting your engine for the first time, install the complete software. Bosch Motorsport software is developed for Windows operation systems. Read the manual carefully and follow the application hints step by step. Don't hesitate to contact us. Contact data can be found on the backside of this document.

⚠ CAUTION

Risk of injury if using the MS 7.4 inappropriately.

Use the MS 7.4 only as intended in this manual. Any maintenance or repair must be performed by authorized and qualified personnel approved by Bosch Motorsport.

⚠ CAUTION

Risk of injury if using the MS 7.4 with uncertified combinations and accessories

Operation of the MS 7.4 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 is only permitted when they have been determined to be compliant from a performance and safety standpoint by a representative from Bosch Motorsport.

NOTICE

For professionals only

The Bosch Motorsport MS 7.4 was developed for use by professionals and requires in depth knowledge of automobile technology and experience in motorsport. Using the system does not come without its risks.

It is the duty of the customer to use the system for motor racing purposes only and not on public roads. We accept no responsibility for the reliability of the system on public roads. In the event that the system is used on public roads, we shall not be held responsible or liable for damages.

2 Technical Data

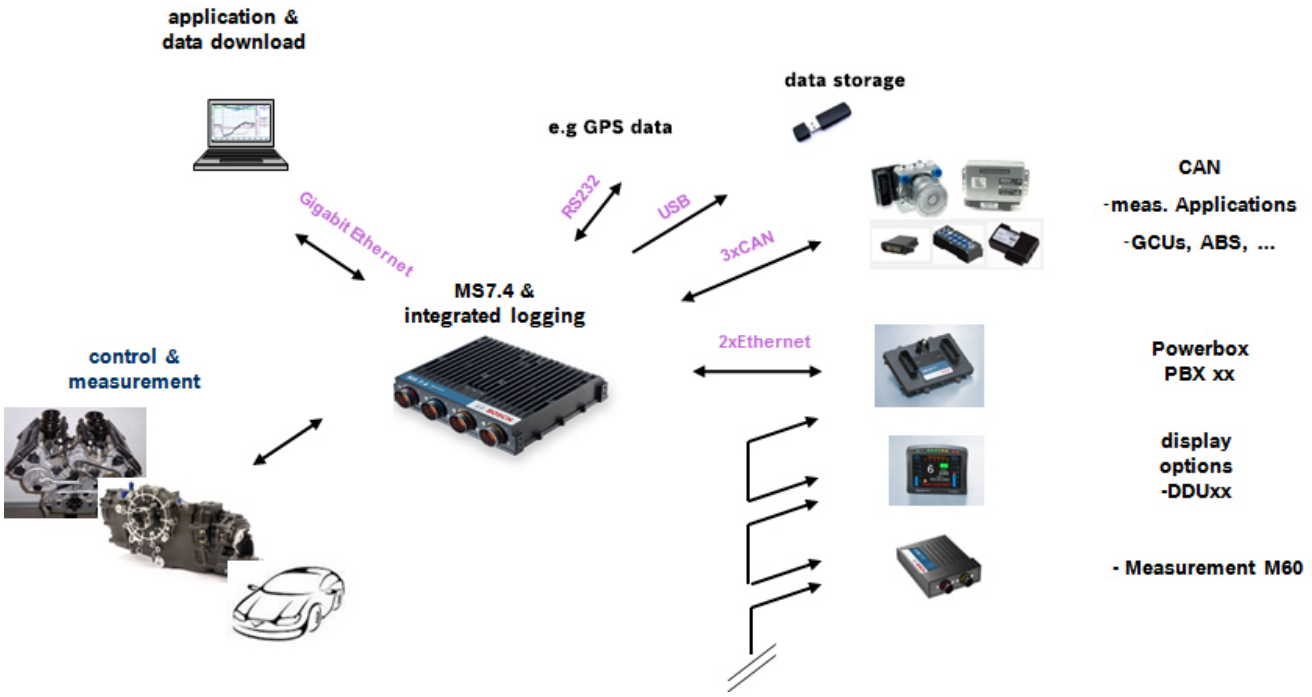
The MS 7.4 engine control unit features a powerful digital processing dual-core with floating point arithmetic and a high-end field programmable gate array FPGA for ultimate performance and flexibility.

The software development process is based on MATLAB® & Simulink®. It significantly speeds algorithm development by using automatic code and documentation generation.

Custom functions can be generated quickly and easily. The flexible hardware design allows the MS 7.4 to support complex or unusual engine or chassis configurations. Integrated logger control areas present a cost efficient and weight optimized all-in-one solution.

2.1 System Layout

- Controls for max. 12 cylinder engines are available with the selection of low- or high pressure injection.
- Integrated torque-structures for power control functions as speed-, launch, rpm and traction limitations or regulations
- Two engine bank related separated lines for physical air mass determination, influenced by own Lambda corrections
- Options from simple gear cut support up to complete gear change functions
- Different target maps to differ applications like Lambda-, spark- and electrical throttle controls
- State of the art engine functions like fuel cut off, idle control, injection valve corrections and knock control are already integrated in the basic program structure.
- Sequential fuel injection realized also for asymmetric injection and ignition timings
- Determination of combustion chamber pressure
- Various networks like 1 Gigabit Ethernet for communication to application tools, 2 Ethernet, 1 USB, 1 LIN for system communication, 3 configurable CAN for external device communication and 1 RS232 for e.g. GPS data.
- Functionalities may be linked to in- and outputs for free system design or harness adaptation.
- Internal data logger divided into 2 partitions, 4 GB each
- Option to copy all data to removable USB stick



2.1.1 Upgrades

The MS 7.4 provides the possibility to operate a wide range of different engine requirements and race track operating conditions.

Additional packages may be ordered separately, all of these may be activated later. The license concept is related to the individual device and the requested upgrading.

CCA Hardware Upgrade per device

Enable Customer Code Area

PERF_LOG_1

Increase logging partition 1 from 4 GB to 16 GB memory

Gear Control Package 1

Gear control MEGA-Line functionality, has to be used with MEGA-Line components (License model via MEGA-Line)

-- Link to MEGA-Line Support Request--

-- Link to MEGA-Line License Request Form --

Gear Control Package 2

Gear control Bosch Motorsport functionality

Accessories

- Rugged USB flash drive
- Mating connector for USB flash drive on car loom side
- Adapter cable to PC USB-Port
- Cylinder pressure detection base package

- Knock detection via cylinder pressure evaluation
- Programming interface cable

NOTICE

Verify the necessity of gearbox control licenses by checking the Features info window in RaceCon (see section Feature / License Activation [▶ 20]).

2.2 Mechanical Data

Milled aluminum housing	
4 Motorsport connectors, 264 pins in total	
Vibration suppression via multipoint fixed circuit boards	
Size without connectors	198 x 180 x 42 mm
Weight	1,610 g
Protection Classification	IP67
Temperature range	-20 to 85°C, measured at internal sensor
Inspection services recommended after 250 h or 2 years, internal battery to be replaced during service	

2.2.1 Installation

Mounting	4 housing integrated screw sockets
Offer drawing	Available at Bosch Motorsport homepage on the MS 7.4 product page. Please find item "Offer Drawing".
3D-Model	Available at Bosch Motorsport homepage on the MS 7.4 product page. Please find item "3D Data".

Recommendation

Use rubber vibration absorbers for soft mounting in the vehicle. To assist the heat flow, especially if HP injection is active, the device must be mounted uncovered and air circulation must be guaranteed around the entire surface area.

Inside touring cars placement passenger side is favoured, open connectors should not be uncovered to vertical axe. It must be assured in mounting position that water cannot infiltrate through wiring harness into the ECU and that the pressure compensating element and the sealing in the revolving groove do not get submerged in water. Wiring harness needs to be fixed mechanically around the ECU in a way that excitation of ECU has the same sequence.

2.3 Electrical Data

Power supply	6 to 18 V
CPU	Dual Core 1,000 MHz; FPGA

2.3.1 Communication

1 Ethernet 1 Gbit
2 Ethernet 100 Mbit
3 CAN
1 LIN
1 USB
1 RS232 for GPS or Telemetry, switchable depending on SW version
1 Time sync synchronization Ethernet
2 Network screens

2.3.2 Inputs

The analogue inputs are divided in different hardware classes and qualities.

3.01 kOhm pull-ups are switchable to assist passive sensor elements like NTC temperature sensors or to change to active signal inputs.

To improve measurement tasks, angle related measurements are an option for some inputs, mainly used for engine related leading signals.

The connection between function and related input is freely selectable, beside electronic throttle functionalities.

All linearization mappings are open to the customer, some signals offer online modes to calibrate gain and offset.

Digital inputs for speed measuring offer diverse hardware options to connect inductive- or digital speed sensors.

Please respect: For camshaft- or wheel speed signals Hall-effect or DF11 sensors have to be used and for wide range Lambda measurement and control the Lambda sensor Bosch LSU 4.9 has to be used.

41 analog inputs in a mix of different hardware designs
6 x reserved for electronic throttle controls
29 x 0 to 5 V, switchable 3.01 kOhm pull-up
6 x option for time synchronous measurement, switchable 3.01 kOhm pull-up

8 fast analog inputs for cylinder pressure recognition
0 to 5 V, switchable 3.01 kOhm pull-up

8 analog / digital inputs
0 to 5 V, switchable 3.01 kOhm pull-up, frequency measurement

2 thermocouple probes
2 x thermocouple exhaust gas temperature sensors (K-type)

20 internal measurements
1 x ambient pressure
1 x triax acceleration
2 x ECU temperature
10 x ECU voltage (e.g. sensor supply)
6 x ECU current (e.g. sensor supply)

8 function related inputs
2 x Lambda interfaces for LSU 4.9 sensor types
1 x lap trigger / beacon input
4 x knock sensors (switchable to 2 inputs with symmetrical operation)
1 x digital switch for engine ON/OFF

10 digital inputs for speed and position measurements
2 x switchable Hall or inductive sensors for flywheel measurement
2 x Hall sensors for sync wheel detection (camshaft)
4 x switchable Hall or DF11 sensors for camshaft position or wheel speed
2 x switchable Hall or inductive sensors for turbo speed measurement

2.3.3 Sensor supplies and screens

4 x sensor supplies 5 V / 50 mA
3 x sensor supplies 5 V / 400 mA
1 x sensor supply ubat / 250 mA
9 x sensor grounds
2 x sensor screens

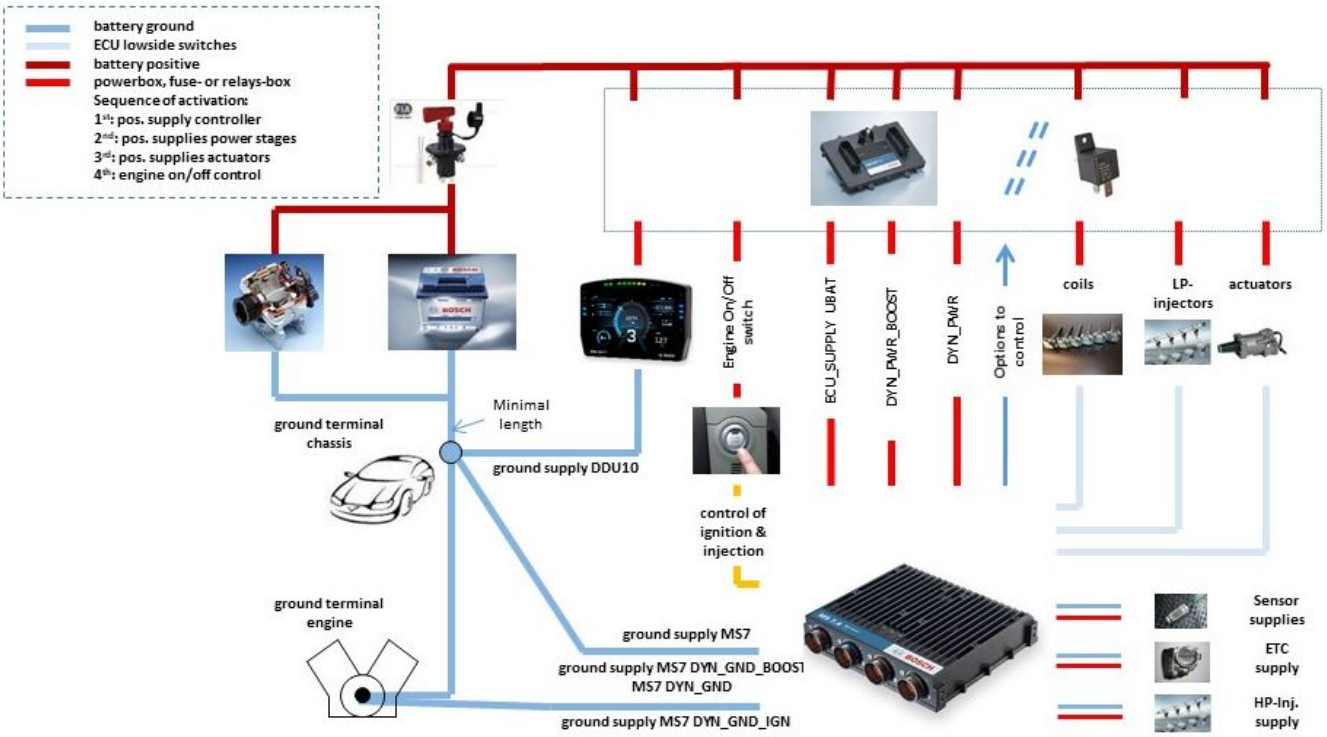
2.3.4 Outputs

19 freely configurable outputs in a mix of different hardware designs
4 x 2.2 amp pwm lowside switch
6 x 3 amp pwm lowside switch
2 x 4 amp pwm lowside switch
2 x 1 amp pwm lowside switch
1 x 8.5 amp H-bridge
4 x Moog control ±12 mA
43 function related outputs
12 x ignition controls, support of coils with integrated amplifier only, 8 of them switchable to support coils without integrated amplifier and a max. current of 20 amps
12 x low pressure injection power stages for high impedance valves (max. 2.2 amps and min. 6 Ohm internal resistance of the injectors), may also be used as standard output 2.2 amps (no freewheeling, operation only during engine run) or for control of an additional HPI 5
8 x high pressure injection power stages for magnetic valves (HDEV 5)
2 x outputs for high pressure pump controls (MSV)
2 x 8.5 amp H-bridge for electronic throttle control
2 x 3 amp pwm lowside switch for Lambda heater
5 x muxed output signals
Switchable internal signals like flywheel, trigger wheel, engine rpm, knock signals

2.3.5 Supply System

Please ensure that you have a good ground installation with a solid, low resistance connection to the battery minus terminal. The connection should be free from dirt, grease, paint, anodizing, etc.

- MS 7.4 power consumption at appr. 13 V (vary according to use cases)
  - ~ 25 - 30 amps (4 cyl. FDI at 8,500 1/min/200 bar single injection, 1 MSV, 1 electronic throttle, standard chassis equipment)
  - ~ 35 - 40 amps (8 cyl. FDI at 8,500 1/min/200 bar single injection, 2 MSV, 2 electronic throttle, standard chassis equipment)
- Power consumption of LP-injectors, actuators and coils are to calculate separately.
- The MS 7.4 power supply is separated into the maintenance of controller and power stages.
- Ensure controller supply UBAT is activated before the power stages.
- The MS 7.4 is able to control a main relay or even the power box itself via a low side output.
- As long as the controller is activated, data logging, telemetry and communication is also ongoing.
- The engine On/Off switch activates the ignition and injection outputs to enable engine start separately from power supply.



2.3.6 Harness / Wiring

The wiring diagram is available at Bosch Motorsport website on the MS 7.4 product page.

NOTICE

The wiring diagram shows a principle of wiring and connection options.

ECU pin relation may change to customer data application and program layout. Sensor-, actuator- and power supplies may also change to the request of the project.

Harness connectors

The MS 7.4 is equipped with Motorsport connectors. On the harness side the following types apply:

LIFE	AS6-18-35SN (red ring)
ACTUATOR	AS6-18-35SB (blue ring)
COMBINED	AS6-18-35SC (orange ring)
SENSOR	AS6-18-35SA (yellow ring)

Wiring

Bosch Motorsport recommends using the specified cable material and harness layout for wiring applications.

For Ethernet and USB connection CAT5 specified material is recommended. For Gigabit Ethernet CAT6E specified material is recommended. Pairs and shield connections have to be strictly respected as shown in the wiring diagram.

For USB, the maximum wiring length is limited to 3 m and it is not allowed to be included into a common harness and also there is no interruption allowed.

Keep network wiring in distance to main sources of electrical noise like coils, coil- and HP-injector wirings and also in distance to any telemetry transmitter.

CAN-networks need a 120 Ohm termination at 2 ends of the wiring. The MS 7.4 is able to switch on an internal 120 Ohm termination, set CWCANx_TERM true to enable the termination.

For wiring layout respect the common rules of failure reduction like separated sensor power supply between important system sensors (e.g. camshaft detection) and measure options (e.g. damper position).

Be ensure HP-injectors, electronic throttles and other high frequently switched actuators are connected within the wiring limits of 2.5 m and all wires are manufactured as twisted pairs.

Office harness

Reduced layout to realize communication between PC, MS 7.4 device and Display DDU, recommended for flash configuration, display configuration and installation tasks. Bosch Motorsport part number: F 02U V02 289

2.3.7 Ignition Trigger Wheel

To detect the engine position and to calculate the exact crankcase position, the system assumes toothed trigger wheels for proper operation. Recommended is to use 60 (-2) teeth for the flywheel and one teeth for the camshaft detection. Modifications of the mechanical designs are possible, such as using quick-start production designs for the camshaft or different number of teeth for the flywheel **(limited to 30 to 60 teeth)**.

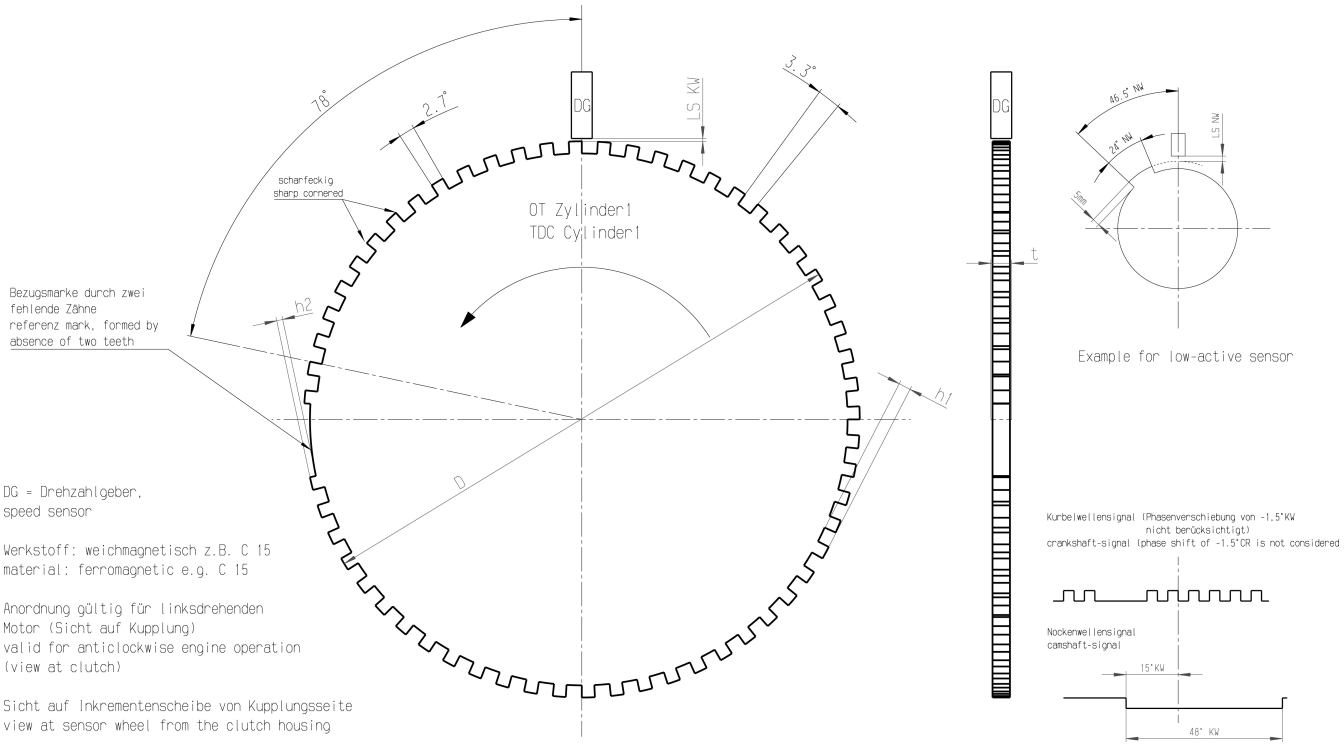
NOTICE

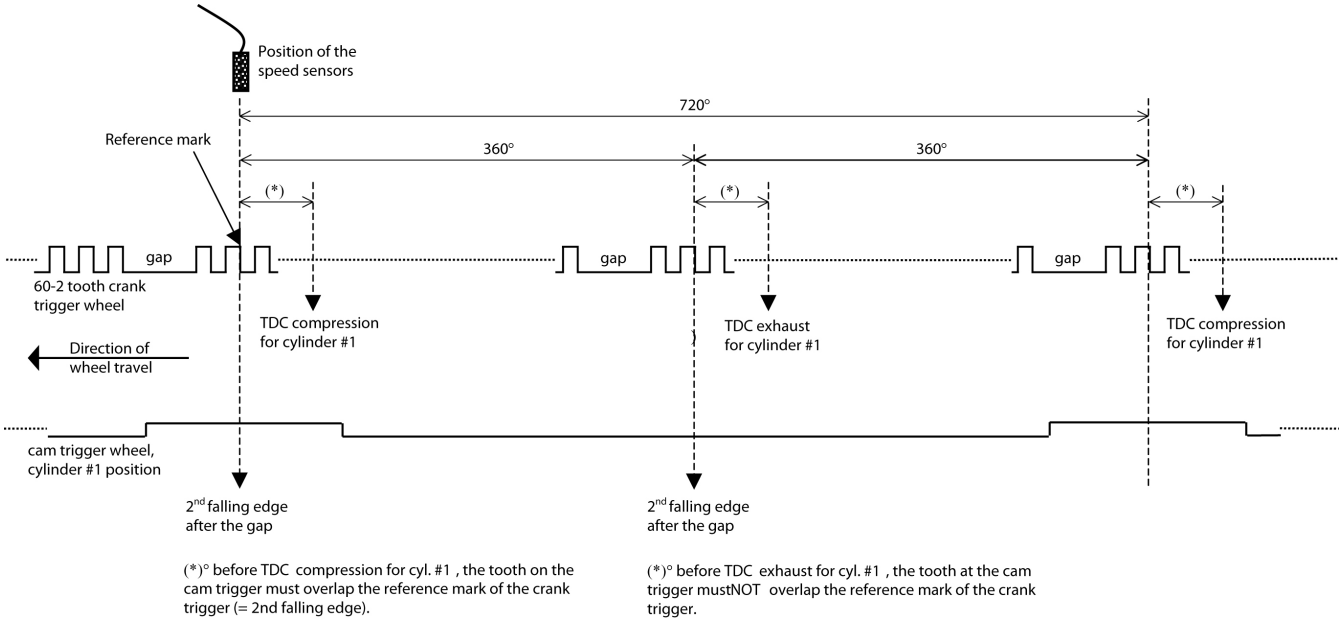
Less number of teeth reduces the accuracy of the system angle measurement.

Not usable are flywheels with 4-1 or 6-1 teeth. Please follow the description below as recommendation for the mechanical dimensions.

Recommended values:

- D = min. 160 mm
- h1 = 3.5 mm
- h2 = h1/2 (important for the use of inductive sensor)
- LSKW = 0.8 mm +/- 0.3 mm
- t = min. 5 mm
- LNSW = 1.0 mm +/- 0.5 mm





NOTICE

All angles are shown and indicated in crankshaft degrees.

The width of the cam trigger tooth is not important, however it is recommended to use at least 48 crankshaft degrees (24 cam degrees).

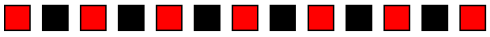
The Hall effect signal may be the inversion of its cam trigger: the tooth effects a “low” signal at the sensor and vice versa for other trigger wheel configurations the indicated values may vary.

2.4 Description of Device Status LEDs

The MS 7.4 provides state LEDs showing various operation states by means of color / blinking frequency. In detail, there exits three LEDs: ”LOG” (Data logger), ”RUN” (Motronic Run) and ”POW” (Motronic Power). Indications are as follows:

RUN	
	Black constant • Device Processor Boot in progress
	Blinking green slow (5Hz) • Device Processor Boot finished, Device is operating
	Blinking green fast (10Hz) • Device is in emergency state, engine start not possible. • Flashed firmware is not running properly. Please flash new firmware.

LOG

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

POW

Black constant
• One or more internal Power Supplies missing, Device is not operating

Green constant
• All internal Power Supplies of the Device available

2.5 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.

3 Starting up

3.1 Installation of Software Tools

PC tools and ECU programs for the MS 7.4 system are available at Bosch Motorsport homepage for free download.

RaceCon V2.5.1.1102 or higher	Mainly used for system configuration
Modas Sport V1.08.018 or higher	Data application and online measurement
WinDarab V7	Data analysis tool, Light version as share-ware or Expert version if license available
MS 7.4 customer_delivery	ECU programs and function description

All tools are delivered as self-installing executable files.

Select your personal installation folder.

3.1.1 Communication PC to device

Ethernet as used network may have some restrictions by firewall and IT protections. Be assure no firewall is active at the PC.

For assistance, Bosch Motorsport homepage explains the necessary PC installations.

The MS 7.4 provides Gigabit Ethernet to communicate between tool and ECU. Please ensure that all components comply with this standard to take advantage of the increased data rate.

MS 7.4 devices are connectable via commercial CAT7 cables to the PC; also Bosch Motorsport offers diagnostic cable and programming harnesses as track- and office connections.

Successful connection between PC and MS 7.4 is shown as green marked connection in the top left corner of RaceCon.

3.2 Configuration of the system

Bosch MS 7.4 devices are delivered in a not engine executable mode. The customer has to include the correct programs, data applications and licenses.

The MS 7.4 offers two mainly different configuration areas, related to the two core areas of the controller.

MS 7.4 ECU

1st core area for the functional part of the MS 7.4 program. The available content is documentated in the functional descriptions Bosch Motorsport adds to the customer deliveries. Application works will be done via opening the data labels in the edition windows of INCA, Modas Sport or RaceCon.

MS 7.4 Logger

2nd core area for the tool displayed parts like logger-, lap trigger, telemetry and CAN-network configurations. Application work will be done in the predefined function windows of RaceCon.

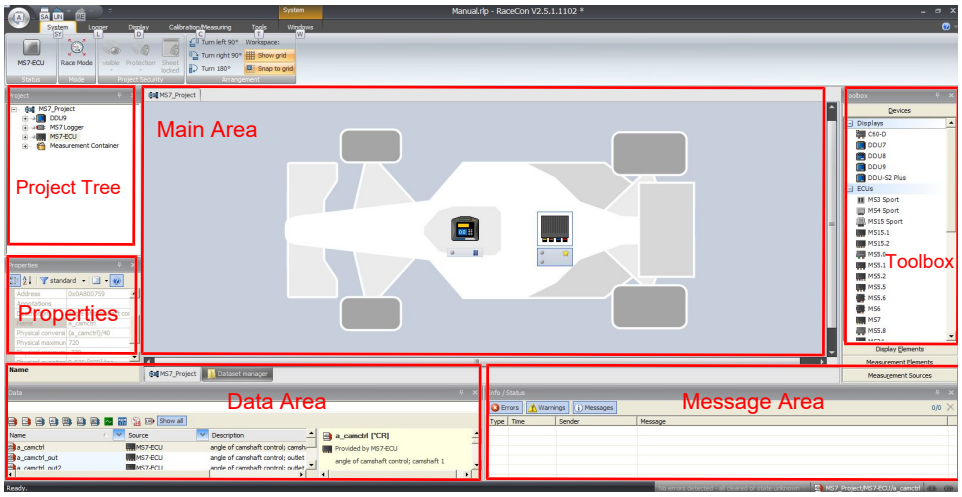
MS 7.4 Programming

For system programming or flashing of the device we developed the system configuration tool RaceCon. After the start of the tool, RaceCon opens the screen “Welcome to Race-Con”.

With “Last Projects” former projects can be opened directly.

3.2.1 First Steps to create and configure a Project

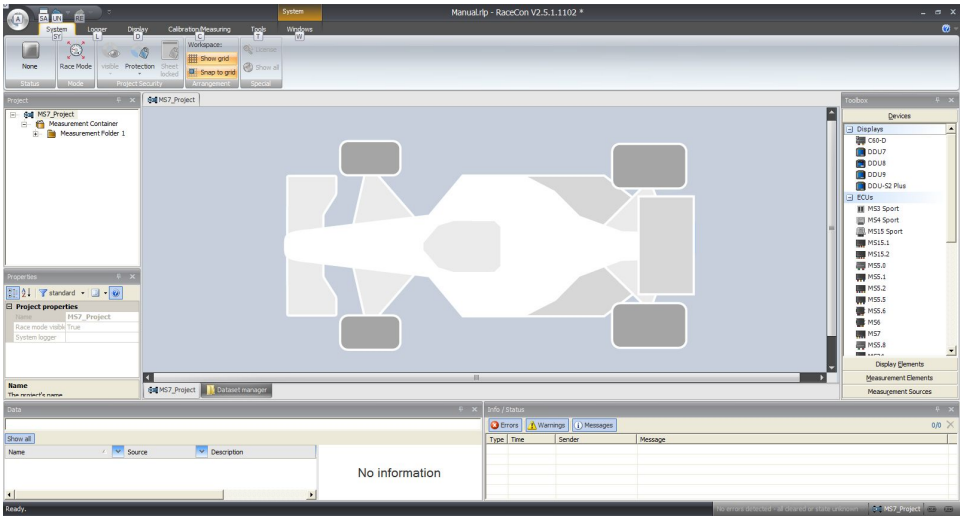
File / New / RaceCon Project opens a new project in RaceCon.



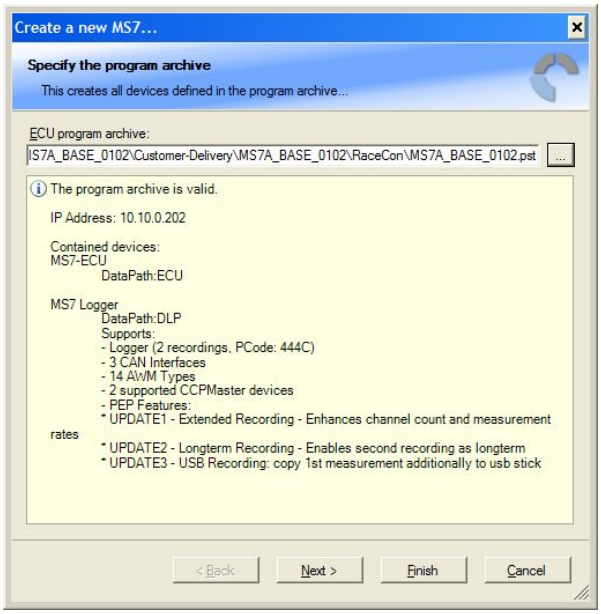
To create a new vehicle configuration, the devices can be pushed via drag & drop from the toolbox to the vehicle. Then they are part of the project and can be configured.

Select an ECU model MS 7.4 from the Toolbox / Devices / ECUs.

Drag the ECU icon with pressed left mouse click on the vehicle view, then a dialog opens.

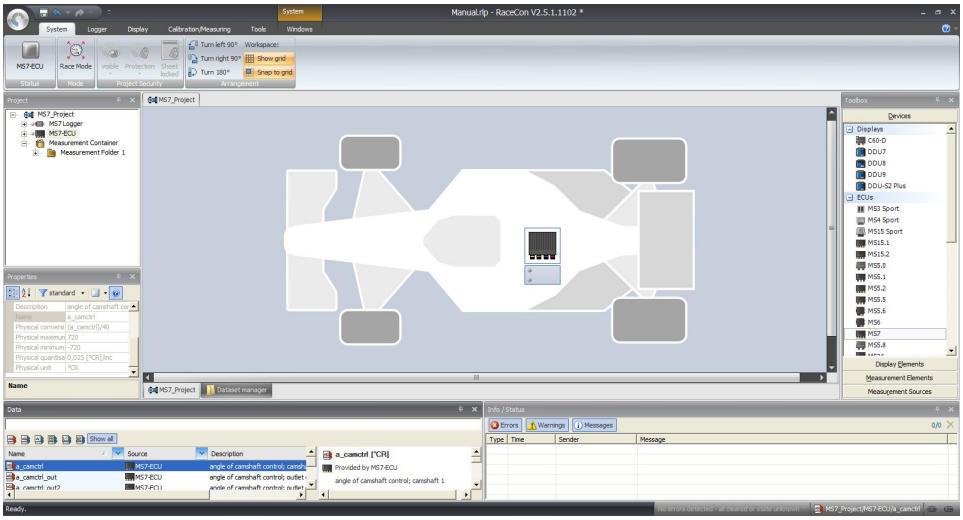


Now the ECU program archive PST files must be selected. These archives are delivered by Bosch. Specify the MS 7.4 program archive: MS 7.4_XXX_xxx.pst.



Access to all configurable data is now available.

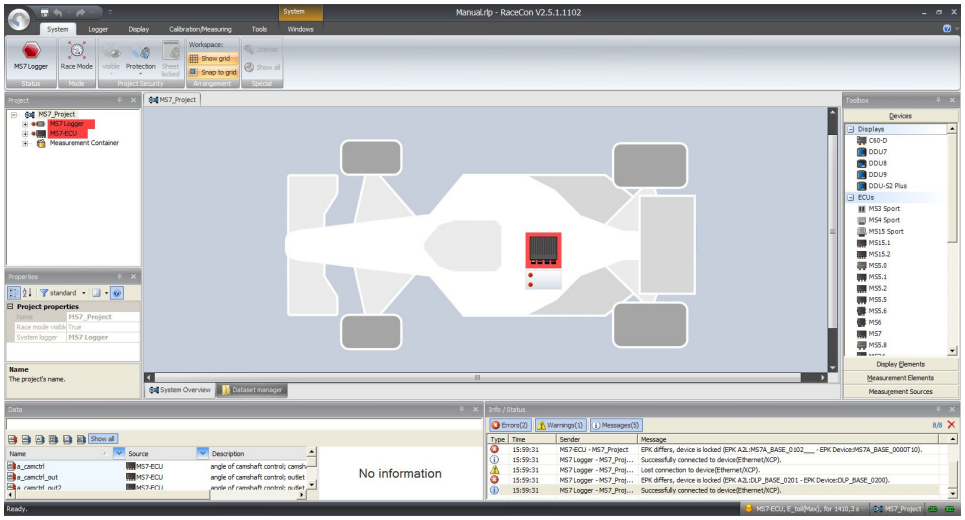
Installation may now be saved as customer project for further data application.



3.2.2 Programs Installation

Going Online for program and license configuration

In the project tree both parts of the MS 7.4 core are shown as >red<, that means MS 7.4 device and RaceCon project differ in the used program version.

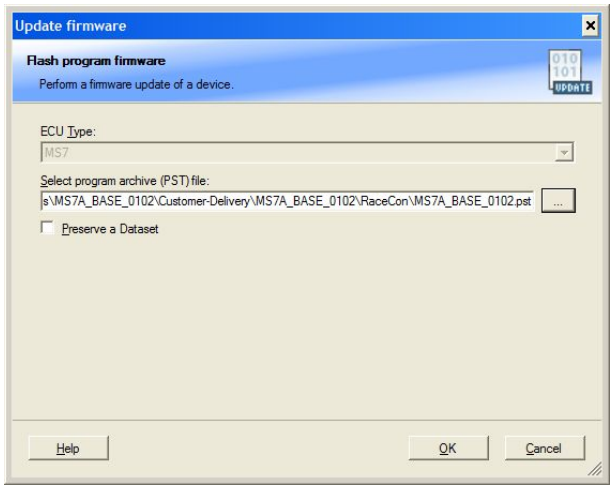


Synchronize MS 7.4 and RaceCon program version / update the firmware of the device:

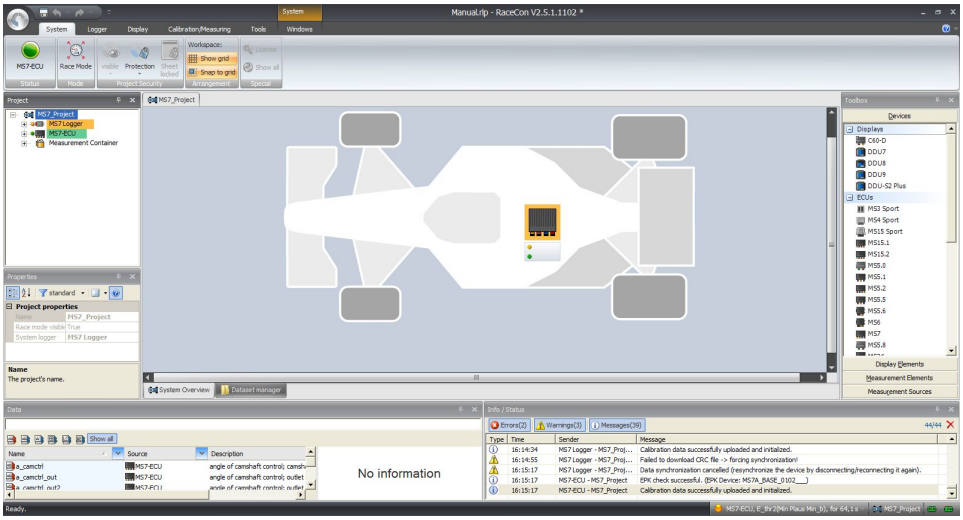
Project-tree / right mouse button to one of the red MS 7 core / synchronize / update firmware >select customer software of the MS 7.4 (file with extension: -.pst)

NOTICE

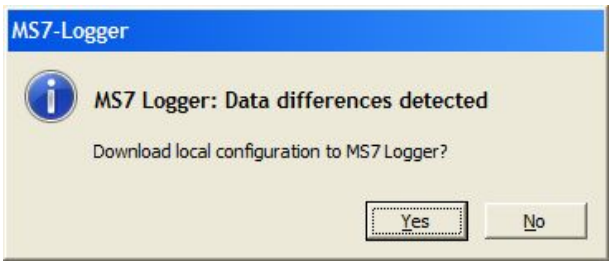
Do not interrupt flash process.



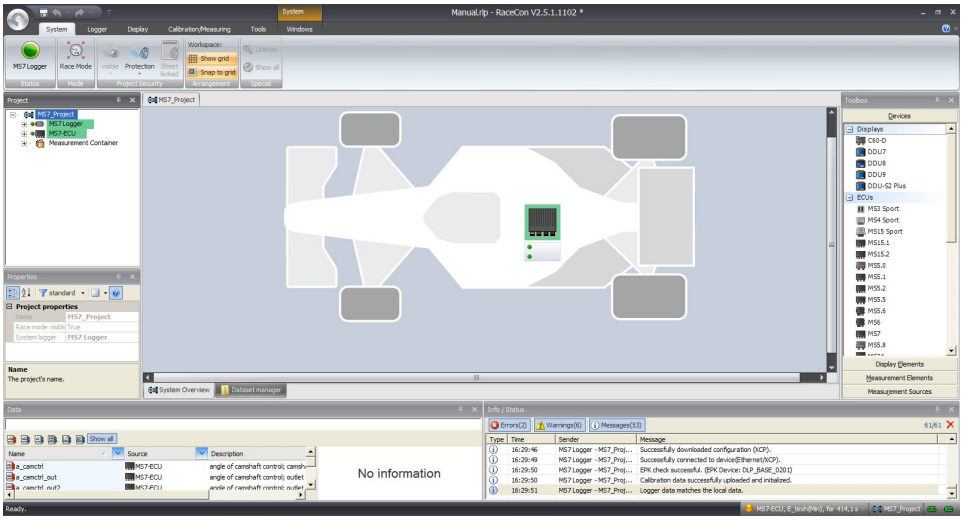
In the project tree, the MS 7 logger core is shown as >yellow<, means the firmware of MS 7 device and project are identical, but the data differs.



The offline preconfigured data have to be sent to the MS 7.4. Option one, select: Project tree / right mouse button to the yellow MS 7 core / synchronize / or follow the RaceCon menu:

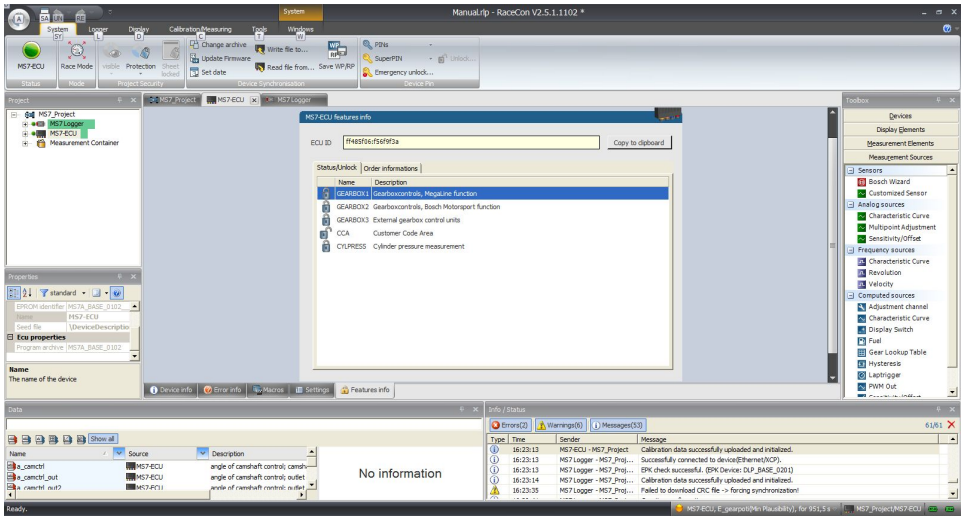


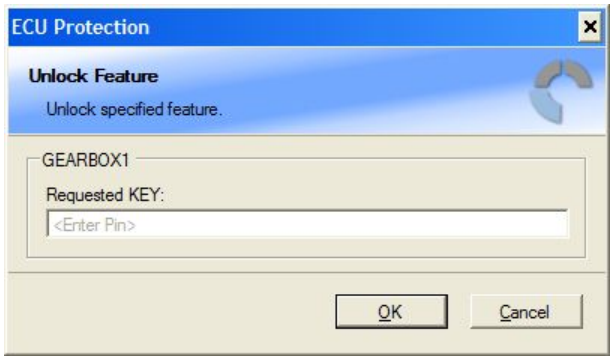
Both MS 7 cores are shown as green, means firmware and data of device and project are now identical.



3.2.3 Feature / License Activation

For code area generation, additional functionalities and/or data logging licenses may be requested for activation. Generally all MS 7 licenses are related to one specific device and the delivered code is only to activate for this ECU. Both cores, MS 7 ECU and MS 7 logger, content own license structures. Double-click to the core symbol at the project and choice features info. Select the license feature and activate the functionality using the related license code.





The licenses for gearbox and engine controls are to activate at the MS 7 ECU core. The licenses for logger related packages like Ethernet telemetry are handled in the MS 7 logger core. MS 7.4 ECU is now ready for customer data and use.

4 Prepare Data Base

Using RaceCon, the data base is already generated and the modification may start immediately. For information, please see RaceCon manual.

ModasSport uses the two MS 7.4 programs MS7a_xxxx_yyyy_data.s19 and MS7a_xxxx_yyyy_ms_a2l for work folder generation.

For help, please follow the Modas Sport manual instructions.

4.1 Initial Data Application

The following chapter deals only with the main parameters which should be checked before a first engine startup. Several functions are recommended to be switched off, many software labels will not be explained in detail. To work on these functions and labels after the first startup, please refer the full-scope function description. The offline data application guide shall help to get the engine started the first time without problems.

⚠ CAUTION

Wrong engine setup data may lead to serious engine damages.

4.1.1 Basic Engine Data

The MS 7.4 system can be used for engines up to 12 cylinders. Please ensure that the correct software variant is loaded in your ECU. Define the engine parameters like number of cylinders, firing order, injection system, and cam- and crankshaft designs in relation to TDC.

4.1.2 Crank- and Camshaft Wheel

The system initially supports wheels with 60-2 teeth. Other configurations **in** the limits between **30- and 60 teeth** may be possible to configure also. Please refer also to the chapter Ignition Trigger Wheel [▶ 12].

Main Data Labels to configure for crank- and camshaft wheel	
CRANK_TOOTH_CNT	Number of teeth of the flywheel (including the missing teeth) **(limited to 30-60 teeth)**
PIN_IN_CRANK	Selection of used crankshaft input pin
CWINTF_L43_L44	Selection of used crankshaft sensor type (Hall or inductive type), example for used pins L43/L44
CRANK_GAP_TOOTH_CNT	Number of missing teeth on the flywheel
PIN_IN_CAM_x	Selection of used camshaft input pin
CAM_MODE	Camshaft position detection mode
CAM_TOOTH_CNTx	Number of teeth on the camshaft
CAM_POS_EDGESx	Position [°CRK] of positive camshaft edges
CAM_NEG_EDGESx	Position [°CRK] of negative camshaft edges (online measurement, see channels cam_neg(pos)_edges_xxx)
ANG_CAM_CATCHx	Max. deviation of cam edges angles allowed

Main Data Labels to configure for crank- and camshaft wheel	
SYNC_CAM	Camshaft signal used for engine synchronization

4.1.3 Initial Steps

The following data must be set initially to start injection calibration for the first time.

Main Data Labels to configure for firing order and engine design	
DISPLACEMENT	Displacement of all cylinders
CYLBANK	Cylinder allocations bank 1 or bank 2 Example typ. 8 cyl. engine: Cylinder 1 2 3 4 5 6 7 8 9 10 11 12 CYLBANK 1 1 1 1 2 2 2 2 0 0 0 0 Engines with one Lambda sensor (e.g. 4-in-a-row) run as 1-bank-systems Set CYLBANK to 1.
CYLNUMBER	Number of cylinders
CYLANGLE	Angle of cylinder TDCs relative to reference mark (RM → TDC)
CWINJMODE	Selection of injection mode
QSTAT	Static valve quantity for n-heptane in g/min (injectors are typically measured with n-heptane)
TDTEUB	Battery voltage correction low-pressure injection. Characteristics can be requested at the injector valve manufacturer.
TECORPRAIL	Battery voltage correction high-pressure injection. Characteristics can be requested at the injector valve manufacturer.

4.1.4 Basic Path of Injection Calculation

The ECU MS 7.4 is a so called physically based system. This means in particular that corrections are made according to their origin influence (e.g. air temperature, fuel pressure etc.). For it, the initial engine load signal (throttle angle ath) or the engine charge signal rl (relative load) is defined as 100 %, if the cylinder is filled with air of 20°C and 1013 mbar ("standard condition"). Corrections related to the air path (air temperature, ambient pressure) are therefore performed to this value rl. Based on this central value most of the relevant ECU signals are calculated, first and foremost injection and ignition.

Due to this constellation changes in the air path are centrally considered for all following functions, independently whether they are caused by ambient influences, mechanical changes of the intake system or even a change from alpha/n-system to p/n-system.

Using this rl value, a relative fuel mass rfm is constructed. For an operating point of rl = 100 %, a fuel amount of 100 % is needed, if the desired Lambda = 1. All corrections to the desired fuel quantity like start enrichment, warm up factor, transient compensation, but also the desired Lambda value and the correction factor of the Lambda control are considered as an adjustment of this relative fuel mass. I.e. all corrections are still made independently of the size and other specifications of the injectors.

Next step is the conversion of the relative fuel mass to a desired injection time te. Here the engine´s displacement, the fuel flow through the injector and influences of the fuel pressure are considered.

Finally the actual duration of the control pulse ti is calculated, considering pick-up delays of the injectors, fuel cutoff (e.g. overrun cutoff, speed limiter, gear cut) and cylinder individual correction factors. Please refer also to the system overview in the Function Description ECOV.

4.1.5 Main Data Labels to configure for Engine Start up

Main Data Labels to configure for engine start up	
MP_MIXCORR(2)	Mixture correction, set to 1.0 for startup
MIXCORR_APP	Global factor for mixture correction, set to 1.0 for the begin of startup
CWPRAILCOR	If a correction by fuel pressure is intended, set = 1. In this case please set PRAILREF according to the referenced fuel pressure. Also refer to MP_P22MOD. Usually the predefined values are suitable. If unsure, set CWPRAILCOR to 0 for first startup.
FINJ_WARMUP	Correction via engine coolant temperature. Usually the predefined values are suitable. Ensure, that for coolant temperatures driven on your dyno during calibration, no warm up factor applies (i.e. FINJ_WARMUP is 0.0 for this temperature).
MP_LAM_MP1	Desired Lambda value, valid for map position 1. According to your expectations, e.g. 0.9. For alternative positions of your map switch the maps MP_LAM_MP2 (3) or (_PACE) apply, therefore ensure correct switch position

4.1.6 Main Data Labels for Load Calculation

Main Data Labels for Load Calculation	
CWLOAD	Decision between alpha/n or p/n related load calculation
CWLOADP1	Decision between P1 and ambient pressure
alpha/n system	
FRLPAMB_P1	Correction via intake air pressure
FRLTINT	Correction via ambient temperature Usually the predefined values are suitable. If unsure, set FRLTINT to 1.0 for first startup.
MP_RL	Relative load depending on throttle angle and engine speed. Set value until your desired Lambda is matched.
p/n system	
FRLPTINT	Correction via ambient temperature. Usually the predefined values are suitable. If unsure, set FRLPTINT to 1.0 for first startup.
FRLPTHR	Factor to throttle dependence. If unsure, set to 1.0 for startup.

Main Data Labels for Load Calculation	
MP_RLP1 ...P4	Relative load depending on throttle position 1-4
PALTCOR	Altitude correction for relative load. If unsure, set PALTCOR to 0.0.
MP_RL	Relative load depending on throttle angle and engine speed. Set value until your desired Lambda is matched.
Notice: For details please refer to the Function Description LOADCALC.	

4.1.7 Main Data Labels for Injection

Main Data Labels for injection	
CWHPI	Choice LP- or HP battery voltage correction
CWINJANGMODE	Choice of angle of injection relation
MP_AOINJ	Map begin/end of injection
LP-system	Standard choice to end of injection pulse, refers to combustion TDC (degrees before TDC). Make sure, the injection is finished before the inlet valve closes. Try 200° - 300° for first startup.
HP-system	Standard choice to start of injection pulse.
Notice: Before calibration starts, turn off Lambda closed loop control.	
CWLC	Codeword for enabling of the Lambda closed loop control. Set to 0 during initial calibration, afterwards = 1

4.1.8 Main Data Labels for Ignition

The MS 7.4 provides two alternatives to drive the ignition coils: For engines up to 8 cylinders the internal powerstages may be used. Alternatively or for engines up to 12 cylinders external powerstages may be used.	
IGNDRV_TYPE	For ignition coils with integrated powerstage set IGNDRV_TYPE to 0 („External PS (CK200)“). To use the ECU’s internal powerstages (for ignition coils without integrated powerstage), set IGNDRV_TYPE to 1 (“Internal PS”) The ECU must be restarted for changes to take effect.

Main Data Labels for ignition	
Notice: Positive values stand for ignition angles before TDC, negative values after TDC. Begin with moderate values to protect your engine from damages.	
MP_TDWELL	Coil dwell time. Consult the coil manufacturer for details. Most coils need dwell times about 1.5 to 2.5 ms at 12 to 14 V. For further background information please refer to the Function Description IGNITION.
DIGN_CYL1-...12	Cylinder individual corrections. Set to 0.0. Numbering refers to mechanical cylinders.
MP_IGN_START/DIGN_ST_TINT	Base spark advance during engine start. Set to 5 to 10 deg, according to the requirements of the engine.

Main Data Labels for ignition	
MP_IGN(2/3)	Base ignition timing in deg crankshaft before TDC. Use modest values at the first time. Atmospheric engines may run safe at 20 to 25 deg in part load, turbo engines at high boosts may demand even less spark advance. These values are strongly dependant on compression ratio, fuel quality, temperature and engine specifics. If you know you're using "poor" fuel, run at high temperatures or your engine is very sensitive on spark advance, go to the safe side.
MP_DIGN_TEMP/MP_DIGN_TEMPW	Ignition angle temperature dependent
DIGN_APPL	Delta value for spark advance, use for application work. Start at 0.0 for first startup.
IGN_IDLE_STAT	Ignition timing during idle. 10 deg are suitable for most applications
NIDLE_NOM / DIGN_IDLECTRL	Desired engine idle speed for idle stabilization. Set value to desired speed or deactivate stabilization by setting DIGN_IDLECTRL to 0.0.

4.1.9 Main Data Labels for Engine Speed Limitation

The rev limiter works in two steps:

- Soft limitation by ignition retardation or cylinder individual cutoff of injection and/or ignition
- Hard limitation by injection cut off and/or ignition cutoff of all cylinders

To achieve a good dynamic behavior by advanced intervention, the engine speed is predicted by means of the speed gradient.

Main Data Labels for engine speed limitation	
CWNMAX_CUTOFF	Codeword for type of intervention during soft limiter: 0 = only ignition retard 1 = injection cutoff 2 = ignition cutoff, 3 = injection and ignition cutoff
CWNMAXH_CUTOFF	Codeword for type of intervention during hard limiter: 1 = injection cutoff 2 = ignition cutoff, 3 = injection and ignition cutoff
NMAX_GEAR	Engine speed limit, gear dependent
NMAX_P	Determines the slope of the soft limiter between soft limit and hard limit. Predefined. Vary according to your engine´s dynamic behavior.
TC_GEARNMAXPR	Prediction time for rev limiter, depends on the inertial torque of the engine. If oscillations occur, reduce value or turn off by setting = 0.0.

4.1.10 Main Data Labels for Cutoff Pattern

Cutoff Pattern	
MP_COPATTERN	Defines the appropriate cylinders for torque reduction by cylinder cutoff. At the beginning of an intervention the next possible cylinder for starting the cutoff pattern is determined. Based on this info the actual pattern is taken out of the map. Pattern should be defined in view of minimized oscillations of the crankshaft. Usually a regular distribution of firing and non-firing cylinders leads to the best result. However, investigations of the individual engine are recommendable. For it, cutoff pattern can be also turned on manually via CUTOFF_APP and CWCUTOFF_APP Example: 4-cylinder engine Start Cyl./Cutoff stage 1 2 3 4 1 1 (=0001b) 2 (=0010b) 4 (=0100b) 8 (=1000b) 2 9 (=1001b) 6 (=0110b) 6 (=0110b) 9 (=1001b) 3 11 (=1011b) 14 (=1110b) 7 (=0111b) 13 (=1101b) 4 15 (=1111b) 15 (=1111b) 15 (=1111b) 15 (=1111b) The cylinders are assigned bitwise, the lowest bit represents cylinder 1. Numbering refers to mechanical cylinders, e.g. pattern = 9: Mechanical cylinders 1 and 4 are fade out.
CUTOFF_APP	Cutoff pattern for test purposes. Bit representation as described at MP_COPATTERN
CWCUTOFF_APP	Codeword for type of intervention during test cutoff: Set: 1 = injection cutoff 2 = ignition cutoff 3 = injection and ignition cutoff.
Notice: This option is also useful for searching a misfiring cylinder. Select one cylinder after the other during test cutoff and watch your engine.	

4.2 Peripherals

Sensors and peripherals can be checked when the system is powered up electrically. Do not start the engine before all steps in this chapter are carried out.

NOTICE

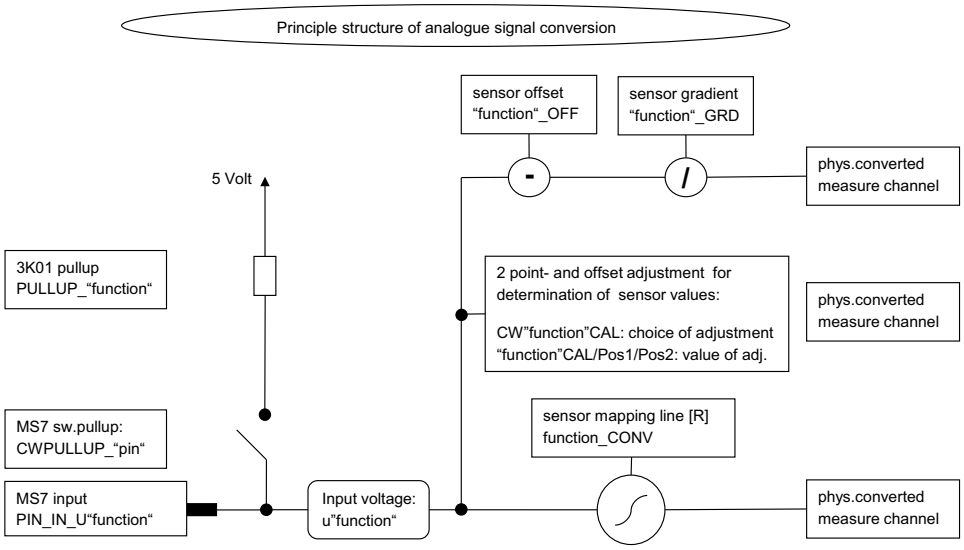
Make sure the battery is connected properly, all sensors are connected and ground wiring is fixed before powering up the system. Check all sensors for errors (E_...) and reliable measure values before starting the engine.

Sensor configuration

The MS 7.4 has the option to link a lot of functionalities to a possible hardware input. The chapters “ECUPINS, SWITCHMATRIX and Input Signal Processing” of the functional description explains the details.

Analogue sensor inputs

The physical way of conversion from sensor signal voltage to physical values follows the same structures. Usually inputs provide switchable 3.01 kOhm pull-ups. The pull-up resistor itself is not modifiable. Error detection of an analogue input signal detects short cuts to ground, U”function”_MIN recommended to be set to 0.2 V and short cuts to power supply U”function”_MAX recommended to be set to 4.8 V. Failures are activated after the adjustable debounce time of diagnosis TD”function”. If a sensor error is set, the output is switched to the default value “function”_DEF.



Pressure measurements

The system offers a lot of different pressure channels, please see function description input signal processing for details. For gradient and offset information contact sensor manufacturer.

Example: Ambient Pressure	
PAMB_OFF, PAMB_GRD	Sensor offset and gradient
UPAMB_MIN, UPAMB_MAX	Minimum and maximum accepted sensor voltage. When violated, an error is set (E_pamb = 1).
PAMB_DEF	Default value if an error occurred.
FCPAMB	Filter constant. For ambient pressure use 1 second, for other pressures choose appropriate values, ~ 100 to 200 milliseconds.

All other variables are named by the same rule, replace “pamb” by e.g. “poil” to apply data for the oil pressure sensor.

Temperature measurements

The system offers a lot of different temperature channels, please see function description input signal processing for details.

Example: Intake Air Temperature	
UTINT_MIN, UTINT_MAX	Minimum and maximum accepted sensor voltage. When violated, an error is set (E_tint = 1).
TINT_CONV	Sensor characteristic. Consult the sensor manufacturer.
PULLUP_TINT	Value of the used pull-up resistor. If only the ECU´s pull-up is used (standard case), keep the predefined value of 3.01 kOhm.

Thermocouples

The exhaust gas temperatures are measured via thermocouple elements, using a special evaluation circuit. Predefined values should be suitable for NiCrNi or k-type elements. For further details and project specific variants please refer to the function description.

Digital sensor inputs

Most of the MS 7.4 digital sensor inputs used for frequency measurements are possible to configure to different sensor types.

CWINTF_L43_L44 / CWINTF_L10_L19	Selection between Hall effect or inductive sensor for flywheel measurement, related to the appropriate contacts of MS 7.4. (Use ECU ground L20 if Hall type is selected.)
CWINTF_L01 / CWINTF_L02 / CWINTF_L06 / CWINTF_L11 /	Selection between Hall effect or DF11 sensors for frequency measurements like cam- or wheel speeds, related to the appropriate contacts of MS 7.4. (Use ECU ground L20 for reference.)
CWINTF_L47_L46 / CWINTF_L08_L07	Selection between Hall effect or inductive sensors for frequency measurement like turbo speed, related to the appropriate contacts of MS 7.4. (Use ECU ground L20 if Hall type is selected.)

The contacts L37 and L03 are usually (but not necessarily) used for cam signal. They are fixed as Hall effect inputs.

4.3 Throttle Control

The system supports mechanic and electronic throttle controls.

Electronic Throttle Control is a safety-critical function. The Bosch Motorsport Electronic Throttle Control System (ETC) is designed and developed exclusively for use in racing cars during motorsport events and corresponds to prototype state. Therefore the driving of an ETC equipped vehicle is limited exclusively to professional race drivers while motorsport events and to system-experienced drivers on closed tracks for testing purposes. In both cases the driver must be instructed regarding the functionality, possible malfunctions of the system and their consequences and must be familiar with possible emergency actions (e.g. pressing the emergency stop switch or the main switch). The system must have emergency switch, whose activation at least cuts the throttle valve actuator from the power supply. Depending on specific use and/or construction, the safety functions, fault detec-

tions and fault responses of the ETC system may differ in several points from ETC systems used in series production. Hence before each vehicle-commissioning the system must be checked for accuracy and faultlessness.

The functionality of the ETC diagnosis and the fault responses are described in the technical documents, handed over to the customer together with the system. Each driver must be briefed regarding the system description. Further information you will find in document “SICHERHEITSHINWEISE-Systemanforderungen zum Betrieb eines Bosch Engineering GmbH EGas-Systems” or can be enquired at Bosch Motorsport.

The customer is responsible for the activation of all ETC-relevant diagnosis and for their correct parameterization. By disregarding this information the functionality of the ECU and the safety cannot be ensured.

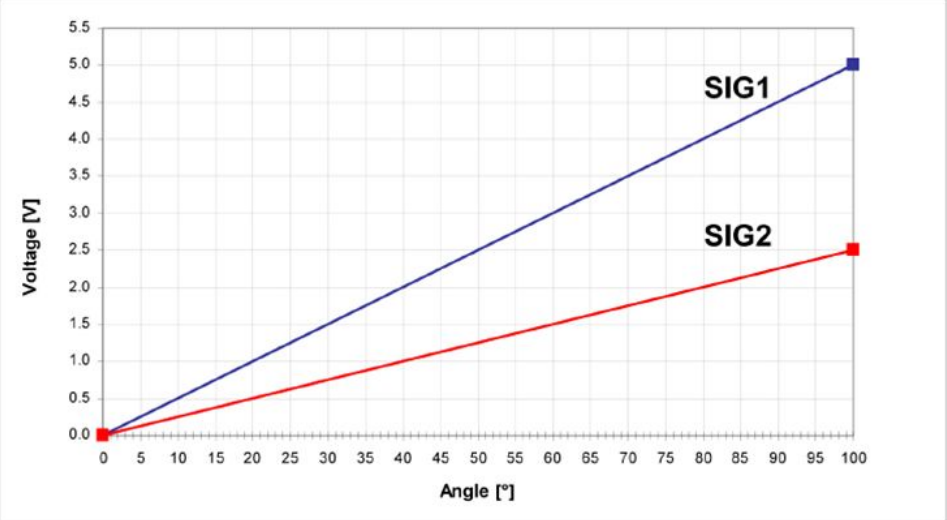
Notice: For detailed information see function description ETC.

The usual route of ETC determines the drivers input measuring the pedal position and transferring this leading signal via functionality options into the control of an electrical throttle actuator. Pedal- and actuator positions are generally measured in a secondary redundant way to verify the reliability of the function. To activate the system, first verify the signal tolerances and error messages by moving acceleration pedal and throttle actuator manually. An inactive system usually is the result of inverted wired sensor signals or actuator controls. Calibrate the pedal- and throttle positions.

Verification of acceleration pedal signals:

The mathematic value of voltage pedal signal 1 - 2*voltage pedal signal 2 has to be below 0.5 V or below value of “UAPSCM_MAX”.

The signal sequences of an acceleration pedal sensor:



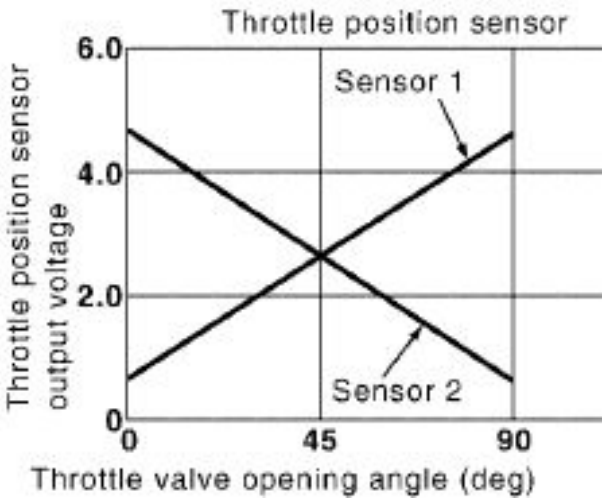
uaps_a	Voltage APS potentiometer a
uaps_b	Voltage APS potentiometer b
aps	Acceleration pedal position
UAPS_MIN, UAPS_MAX:	Minimum and maximum accepted sensor voltage. Set to approx. 200 mV/4,800 mV. Check if the uaps(x) outputs are changing when the pedal is moved.

CWAPSADJ	Codeword to adjust acceleration pedal signal: 0 = calibration inactive 1 = calibrate release pedal 2 = calibrate full-pressed pedal
E_aps	Detected error messages of acceleration pedal functionality. If errors are detected, the ETC functionality will become inactive.

Verification of throttle position signals:

The addition of voltage throttle signal 1 (uthrottle) and voltage throttle signal 2 (uthrottle_b) results in 5 V due to inverted lines. Hence the added signal minus 5 V has to be below the value of “UDTHRCM_MAX” (recommended 0.2 V) to be plausible.

Signal principle of a throttle position sensor:



Throttle position main data labels:

CWTHR	Codeword for type of throttle controls: 0 = mechanical throttle 1 = mechanical throttle with backup potentiometer 2 = electric throttle single bank 3 = electric throttle dual bank

Throttle position signals:

UDTHR_MIN, UDTHR_MAX	Minimum and maximum accepted sensor voltage. When violated, an error is set (E_thr = 1). Set to approx. 200 mV/4,800 mV. Check if the uthrottle(xx) outputs are changing when throttles are moved.
uthrottle uthrottle_b uthrottle2 uthrottle2_b	2 sensor output values and their redundant signals (_b). The system expects a rising up voltage for the main signals and a falling voltage for the redundant one.
UDTHRCM_MAX	max. allowed difference between sensor output and redundant signal

	abs (uthrottle(x)+uthrottle(x)_b)-5 V < UD-THRCM_MAX

Calibration:

CWTHRADJ	Codeword for throttle adjust: 1 = automatically calibration process 2 = calibrate lower mechanical stop 3 = calibrate upper mechanical stop 4 = calibrate limp home position

Manual procedure:

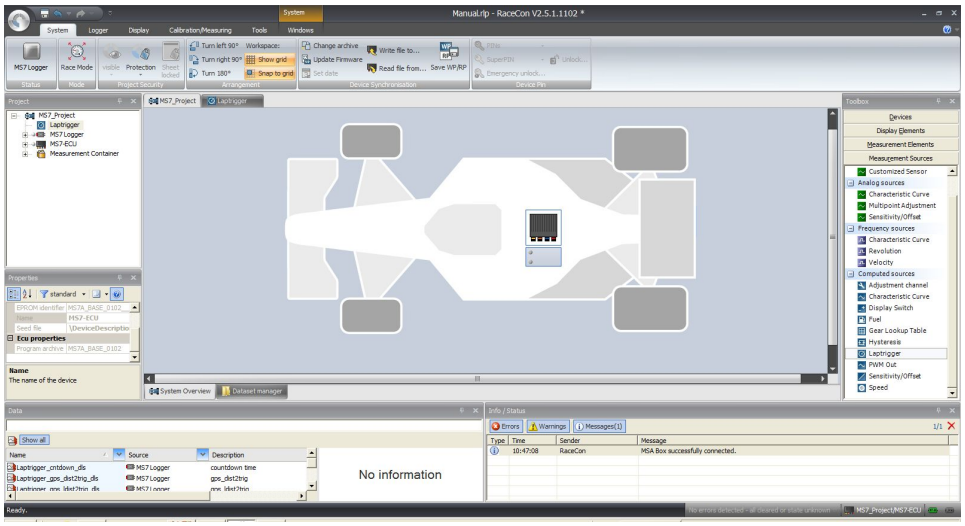
- Close throttle and set CWTHRADJ to 2.
- Open throttle fully and set CWTHRADJ to 3.
- Adjust the throttle to idle point.
- Do not forget to set CWTHRADJ back to 0. Check calibration by moving throttle.

4.4 Vehicle Test

Before starting with your vehicle test, some initial data should be set:

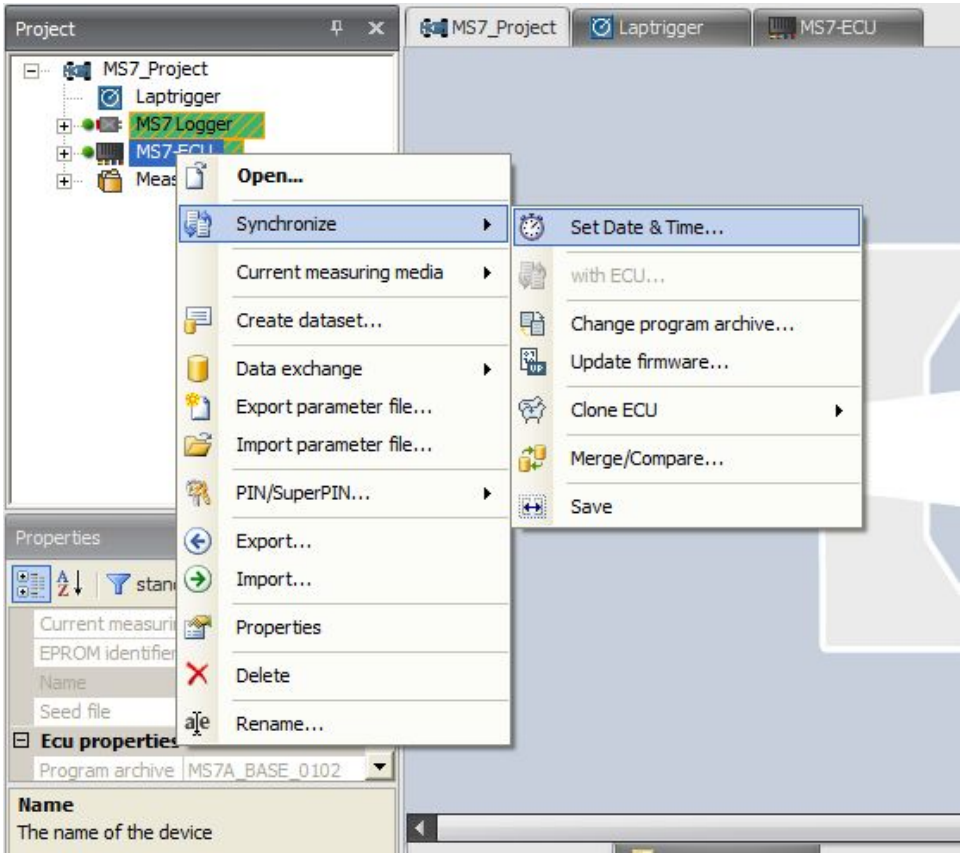
Speed & distance measurements	The signals for speed calculation may be available from different sources, like MS 7.4 own measurement, GPS data or via CAN received information from ABS calculation. For MS 7.4 own calculation, mechanical influenced data like number of available sensors, front wheel drive, number of detected increments, wheel circumferences and dynamic corrections like corner speed application a lot of functional options assist the calculation of the effective vehicle speed. Distance measure channels may be derived from speed information. For detailed information see function description >CARSPEED<.
CWWHEELCAN	Selection for car speed from CAN signal
CWWHEEL	Connected number of wheel speed sensors or -signals
CWFWD	Selection of front driven vehicle
CWSPEEDDYN	Release of dynamic speed calculation
INC_FRONT	Number of pulses per revolution of the front speed signal
INC_REAR	Number of pulses per revolution of the rear speed signal
CIRCWHEEL_F	Wheel circumference of the front wheels. Consider dynamic increase of the tire.
CIRCWHEEL_R	Wheel circumference of the rear wheels. Consider dynamic increase of the tire.

vwheel_xx	Measure channel of the individual wheel speeds
speed	Result of calculated vehicle speed
accv	Result of speed based derivation of longitudinal acceleration
ltdist	Lifetime distance as accumulated result of speed derivation
Lap information and -functions	The necessary data application is integrated in the system configuration tool RaceCon. The wizard leads to configure the beacon input, asks for trustable limits of lap- and signal detection. Additional options for track segmentation, additional on track beacons are also available. Drag and drop the subfolder lap trigger of the measurement sources into the project and follow the wizard.



	Depending to the configuration, values for lap- and outing counter, lap time, segment times and differential lap- or segment times for data analysis and driver information will be created.
Laptrigger_xxxx_yy	Results and measure channels of lap-functionalities. Drag and drop the subfolder “Laptrigger” to the project and follow the wizard.
Consumption-calculation	Designed in the same way as lap-information, subfolder is called “fuel”. Drag and drop the subfolder to the project and follow the wizard.
Set time & date	MS 7.4 device is equipped with a real time clock which is permanently supplied by a battery. In order to set time and date, please connect the ECU to the PC and click on “SET DATE & TIME” in the context menu of the MS 7.4.

time_xx	The measure channels of the real time clock



5 ECU plus Data Logger

The MS 7.4 combines ECU and data logger in one common housing for a cost efficient and weight optimized all-in-one solution.

5.1 Software Tools

RaceCon	Create and configure a project
	Configuration & management of recordings
	Create a new recording
	Add channels to a recording
	Create user-defined conditions for the recording
	Download recording configuration
WinDARAB	Upload recorded data
	Display and analyze the data

6 First Steps

Install the software required for the operation of the MS 7.4. It is developed for Windows system software. The following software versions are used in this manual:

- MS 7.4 setup, configuration and calibration: RaceCon Version 2.6.
- Measurement data analysis: WinDarab V7

Set up the 100 Mbit ethernet connection to the MS 7.4.

- The ethernet port has “cable auto crossover” functionality.

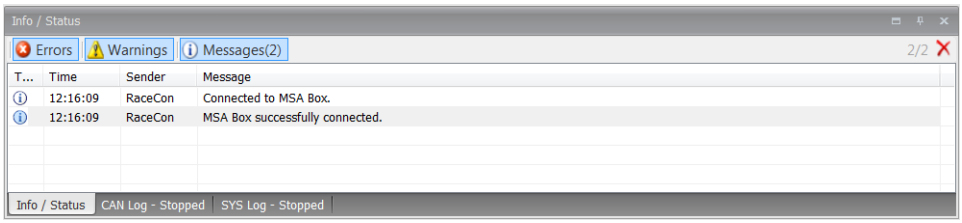
6.1 Connecting the unit to RaceCon

For testing new device configurations, you can connect the device to your computer via MSA-Box or ethernet cable.

Connection via MSA-Box

1. Reassure that the MSA-Box driver is installed properly on your computer. If needed, download the MSA-Box driver from www.bosch-motorsport.com.
2. Connect an ethernet line of the device to the ethernet line of the MSA-Box.

   Please note, that the MSA-Box also requires power supply on the MSA-Box connector of your wiring loom.
3. Open RaceCon and connect the MSA-Box to the computer.
4. In the ‘Info / Status‘ Box of RaceCon, you will receive messages that the connection was successful.



5. Reassure that the device is switched on.
6. ‘Link LED’ at the computer’s network adapter will illuminate.

   If the LED is off, check the wiring harness.

   After you created a RaceCon project with the device, the status icon of the device will switch from grey to one of the following colors: red, orange, green. For further information on how to set up a project, see the chapter “Setting up a new RaceCon Project [▶ 36]”. For the status color, see chapter “Color indication [▶ 47]”.

Connection via Ethernet Cable

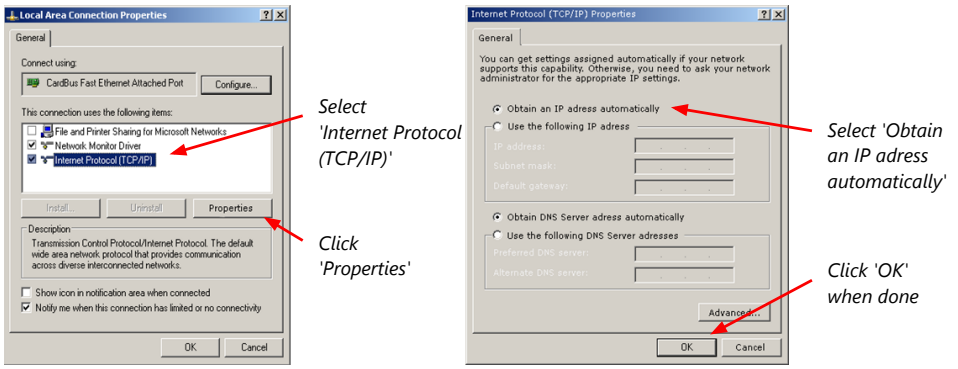
Instead of connecting the ethernet line to the MSA-Box, connect the ethernet directly to your computer.

Troubleshooting while setting up the network interface

The MS 7.4 contains a DHCP server, network addresses can be assigned automatically to the configuration PC. In case of problems during the network connection, please try the following steps:

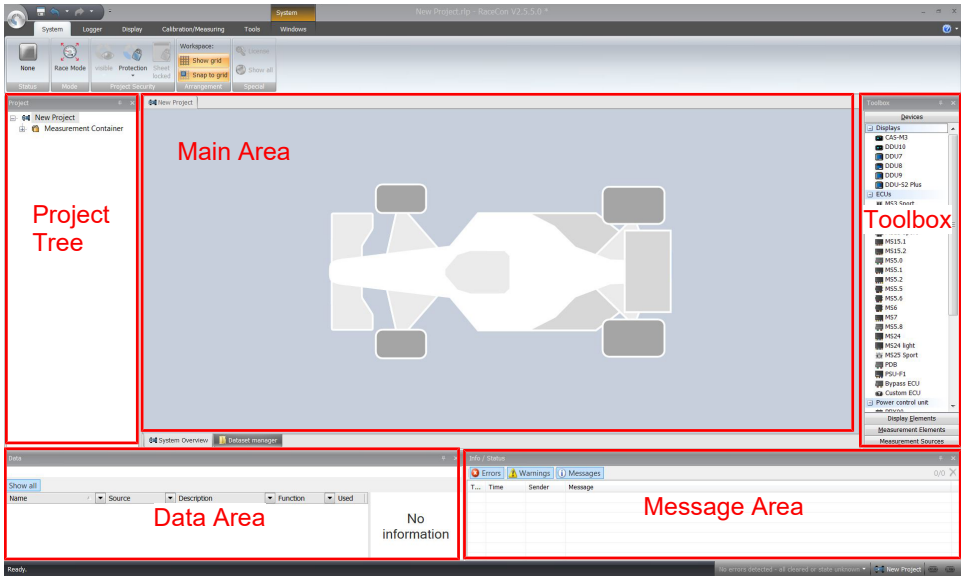
1. Switch off the PC’s firewall.

2. Reconfigure the PC or the MSA-Box network interface settings to obtain an IP address automatically as shown in the pictures below.

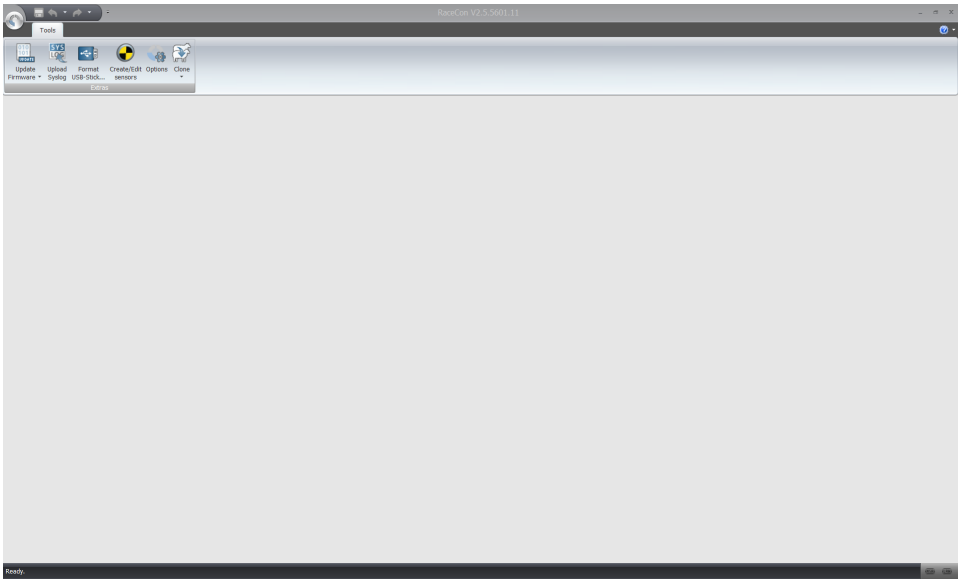


6.2 Setting up a new RaceCon Project

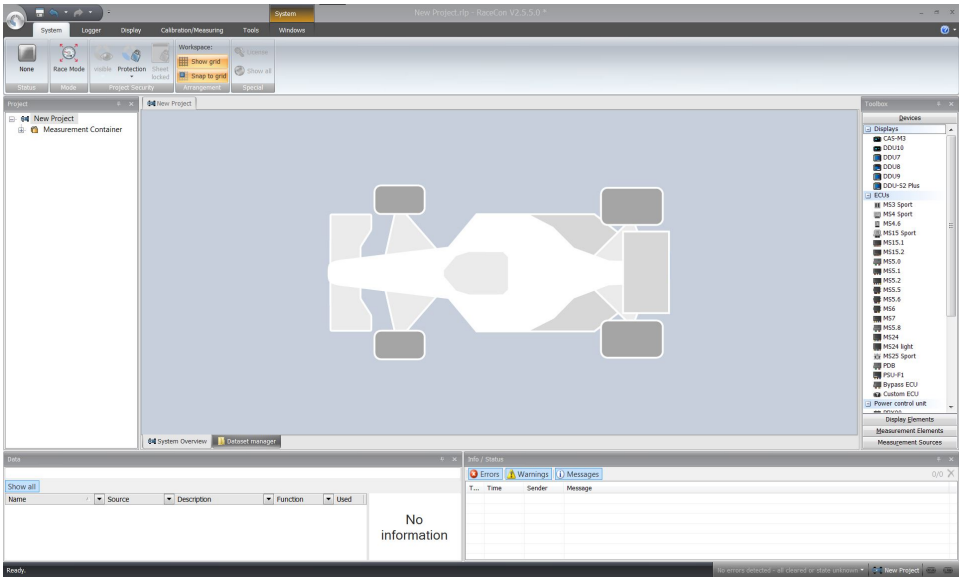
The following screenshot shows an overview of the RaceCon Main Screen with its areas. All (sub-) windows are resizable and dockable. You can find them under the 'Windows' tab.



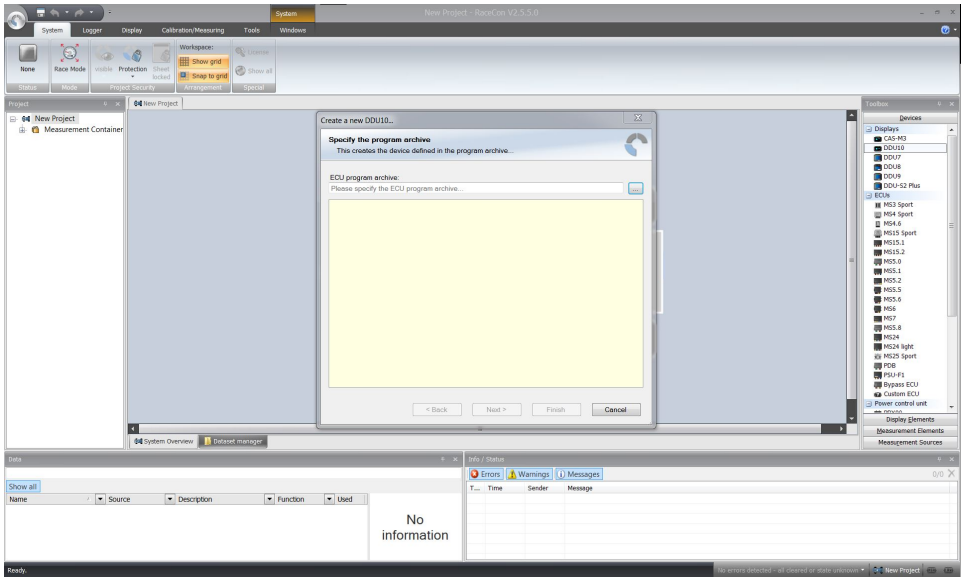
1. Start the RaceCon software.



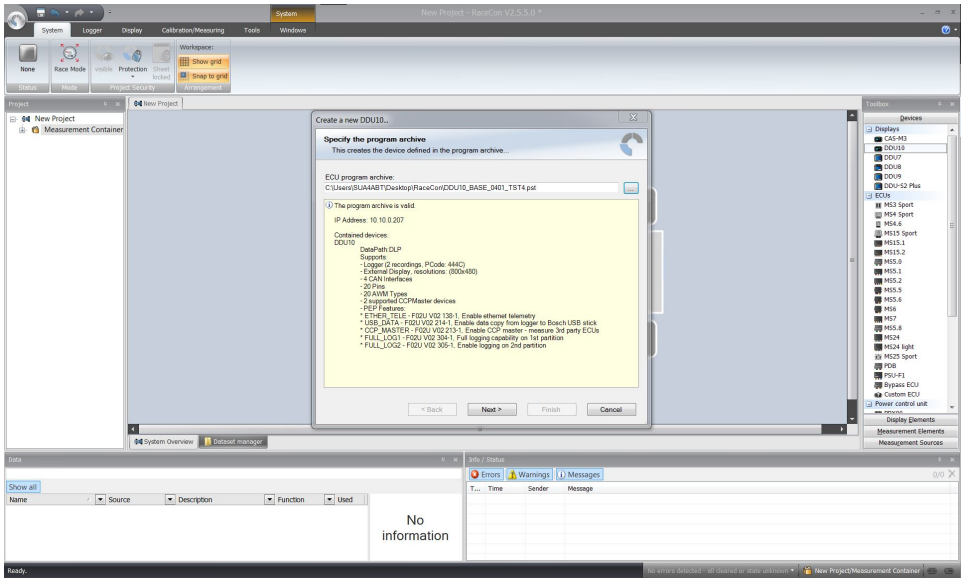
2. In the ‘File’ menu, select ‘New project’ to create a new project.



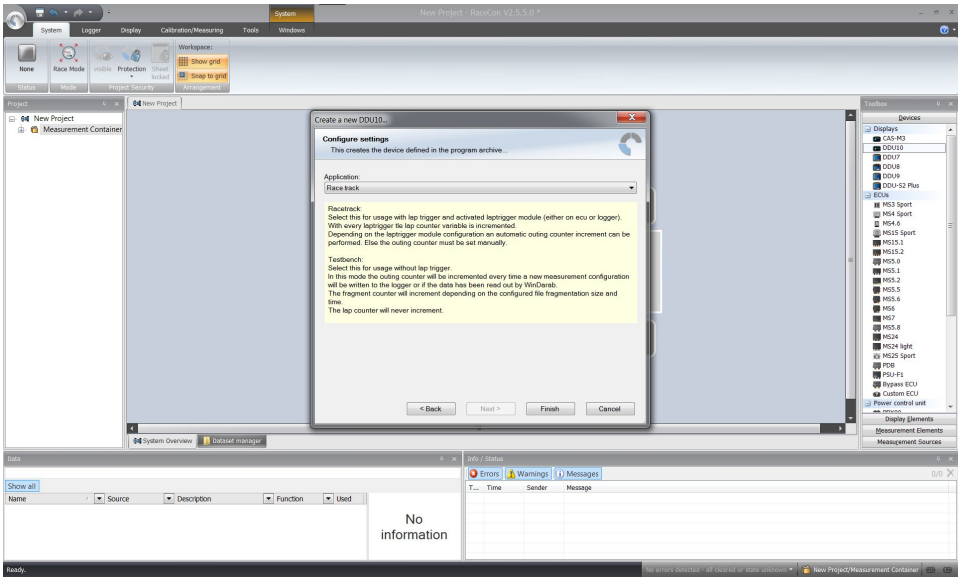
3. In the Toolbox, select the MS7 and drag it into the Main Area. A pop up window to specify the MS7 program archive appears.



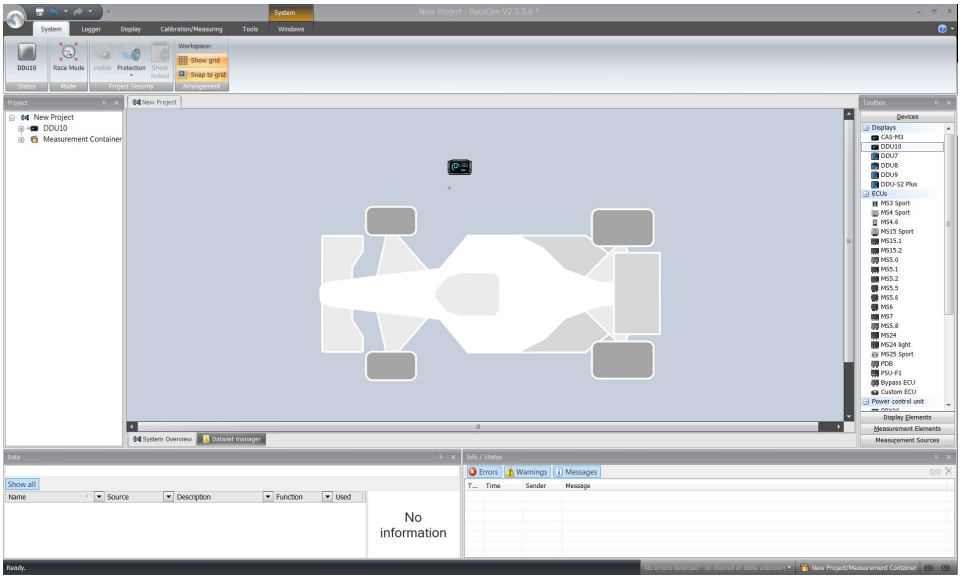
4. Download the firmware for the MS 7.4 from www.bosch-motorsport.com. An information shows if the archive is valid or not.
   Click ‘Next’.



5. Select ‘Race track’ or ‘Testbench’ mode according to your application.

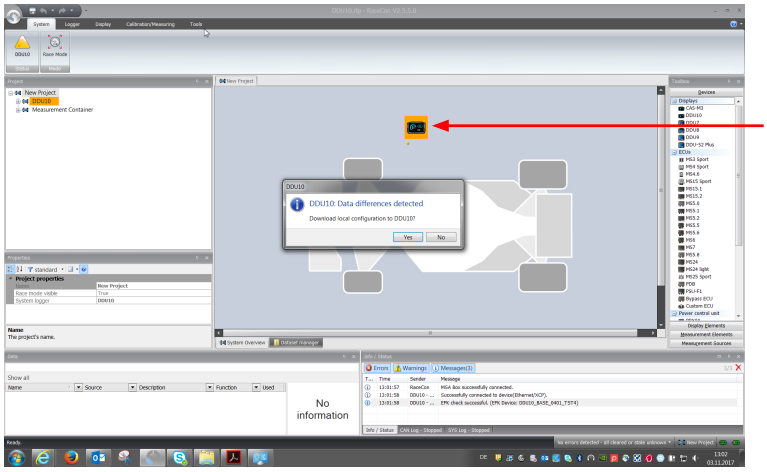


6. Click ‘Finish’. The MS 7.4 is inserted into the project and RaceCon tries to connect to the device.



RaceCon detects configuration differences between the MS 7.4 and the RaceCon project and asks for permission for data download.

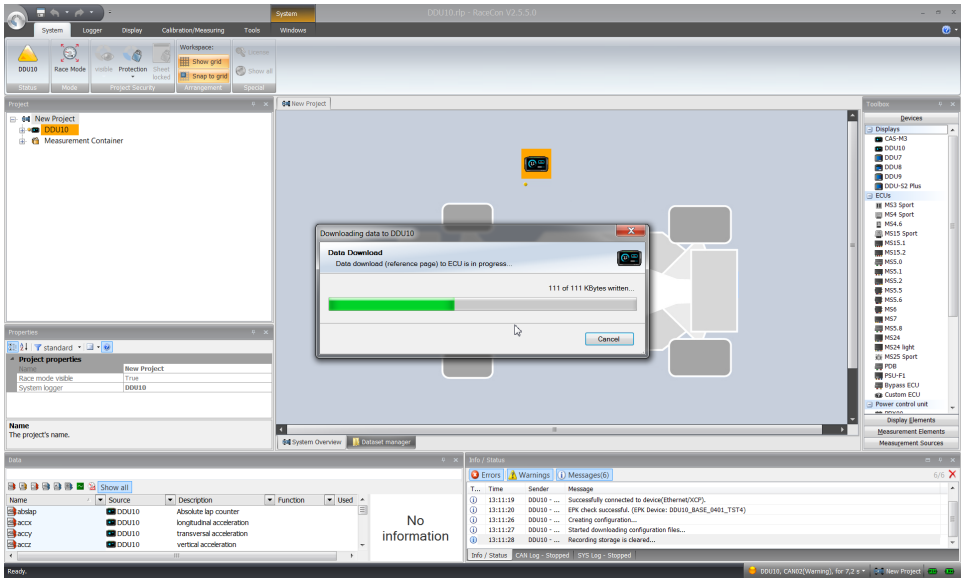
Click ‘Yes’ to download the configurations to the device or ‘No’ to continue without downloading the data.



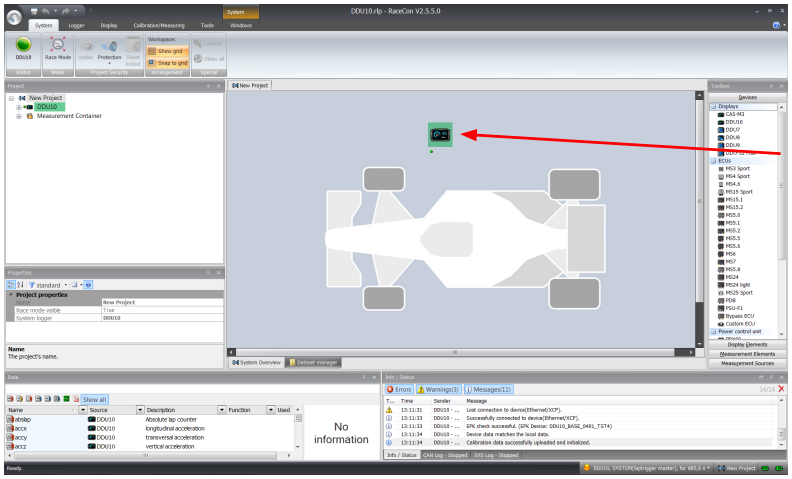
Successful ethernet connection, Device "talks" to PC.

If the device turns red, you might need to do a firmware update on the device. For more information see chapter “Firmware update [▶ 120]”.

The download starts and the MS 7.4 carries out a reset.



After the reset, RaceCon reconnects to the MS 7.4. Local configuration on both the PC and MS 7.4 match (indicated by green background and dot). The MS 7.4 is now connected to RaceCon.



Green background and dot indicate matching configuration

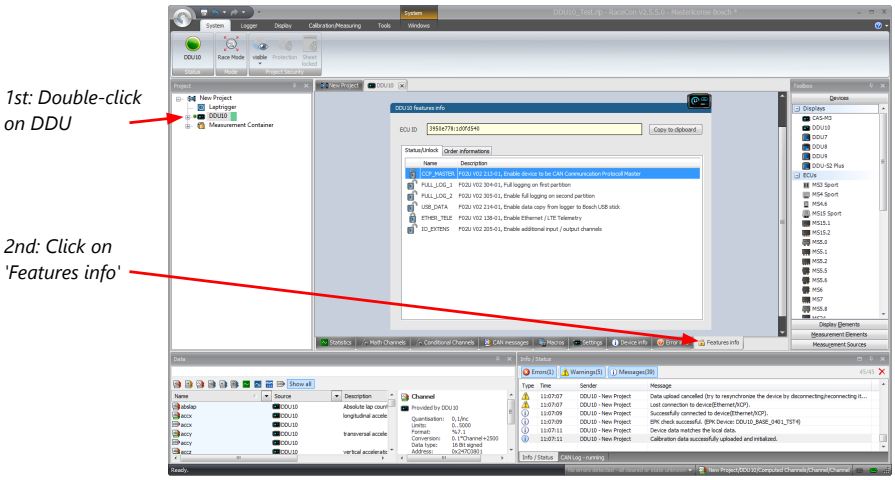
For further information on the color indication, see chapter “Color indication [▶ 47]”.

6.3 Feature activation

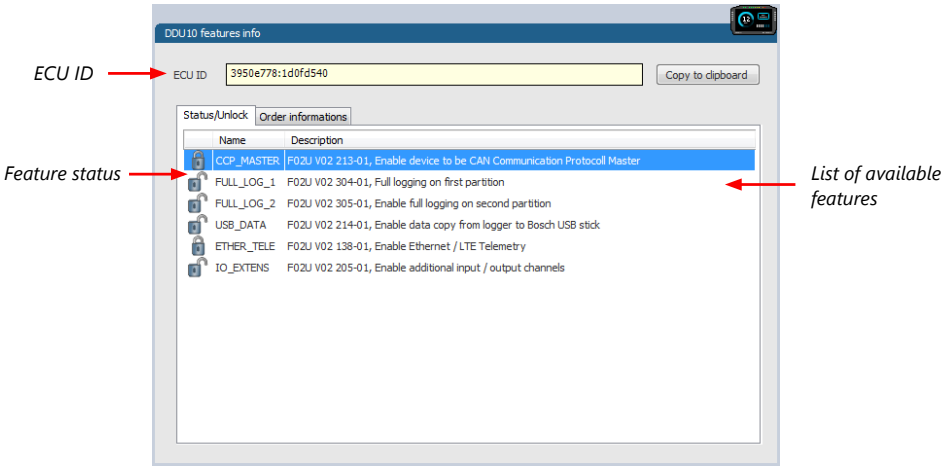
- Optional software feature packages are available for the MS 7.4
- All software feature packages can be purchased prior to delivery or after you have received your device.
- If you have purchased an optional software feature package, it must be activated before it becomes operational.
- The feature 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 MS 7.4 does not work on any other MS 7.4.
- When purchasing a software feature package, you have to tell Bosch the ECU ID code.

  The ECU ID code is device specific and can be found in the 'features info' window, shown in the screenshots below.
- If you have not purchased an optional software feature package, the next steps can be skipped.

1. Ensure a connection to the device.
2. To activate a feature, double-click on 'MS 7.4' in the Project Tree.
3. Click on the 'Features info' tab in the Main Area.

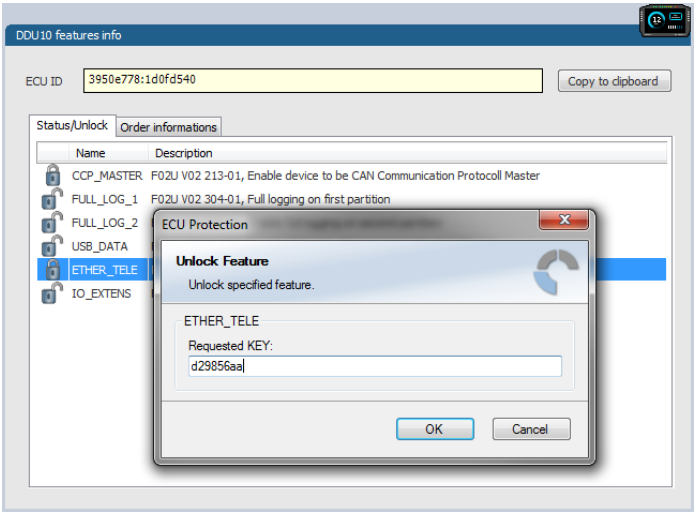


4. The 'MS 7.4 features info' window appears.

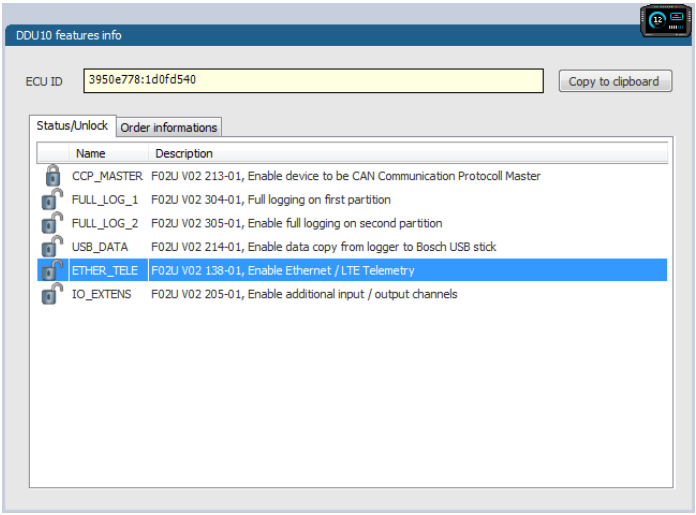


Locked (disabled) Unlocked (activated)

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



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

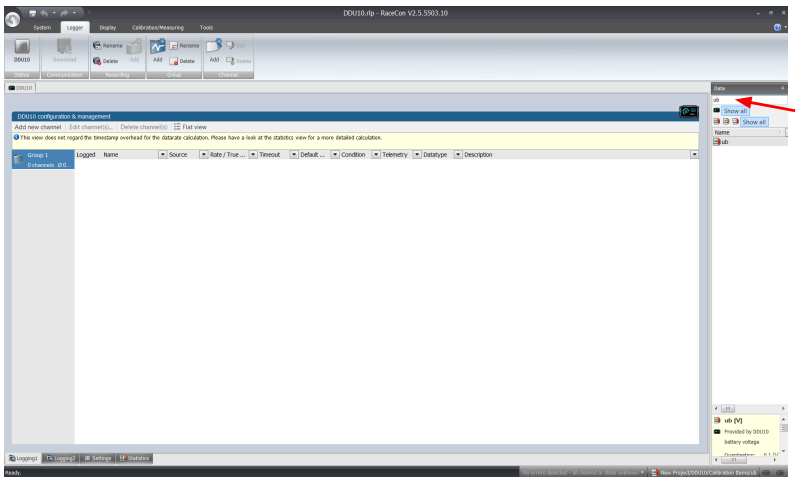


7. Perform these steps to activate other features you purchased.
8. Switch the car's ignition off and on again to cycle the power of MS 7.4.

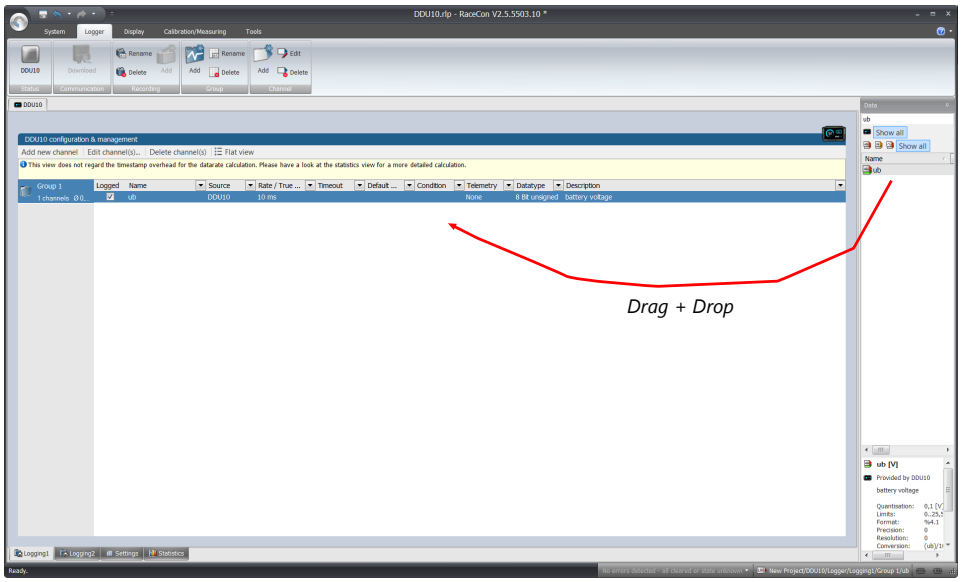
6.4 First recording (Quick Start)

This chapter explains the configuration of the recording of the battery voltage channel. See chapter 'Recording [▶ 86]' for a detailed instruction to configure recordings.

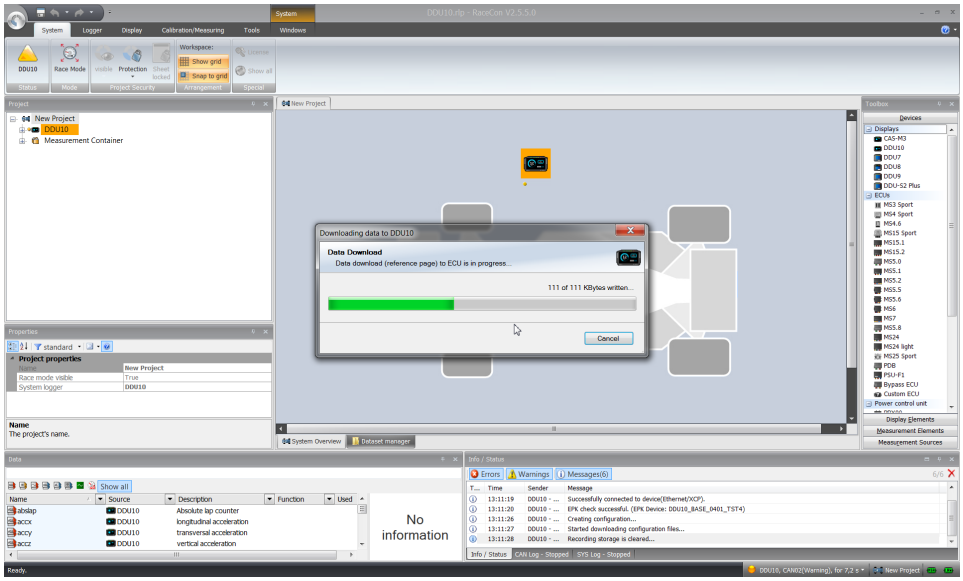
1. Click on the 'Logger' tab to go to the page 'Logger'.
2. Use the search bar in the 'Data' window, to search for 'ub' (measurement channel for battery voltage).



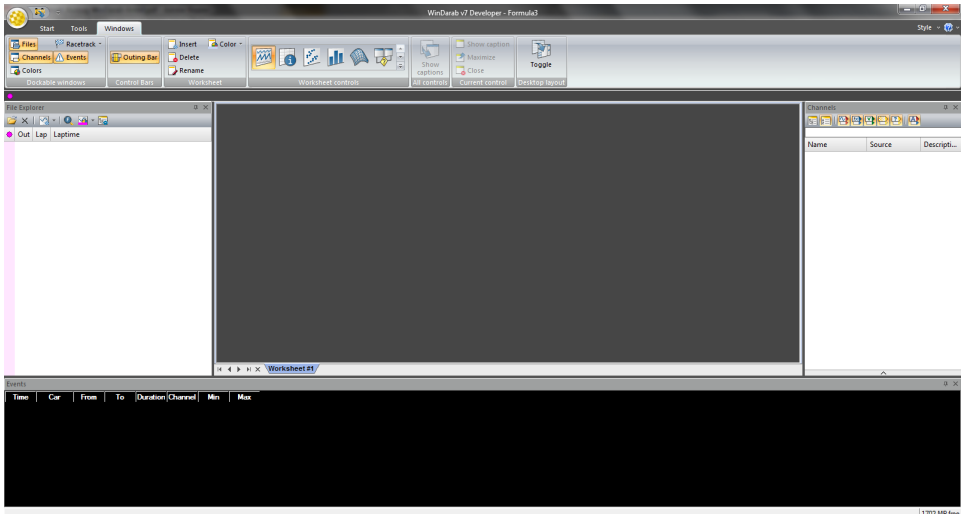
3. Drag and drop the 'ub' measurement channel into the recording area.



4. Click on the 'Download' button in the upper left corner. The configuration download starts and the MS 7.4 carries out a reset. Now you can find the 'ub' measurement channel in the 'Data Area'. As we did not define global start conditions, recording starts immediately.



5. Start the WinDarab software.

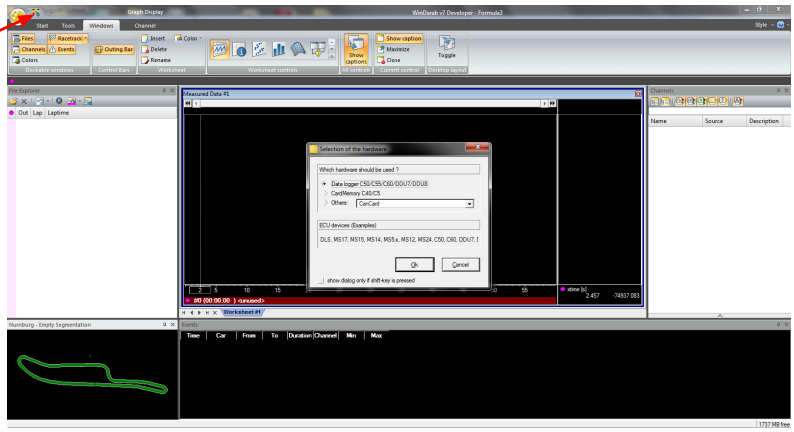


6. Disconnect the MS 7.4 network cable.

7. Click on the ‘Read Data from Logging Device’ icon.

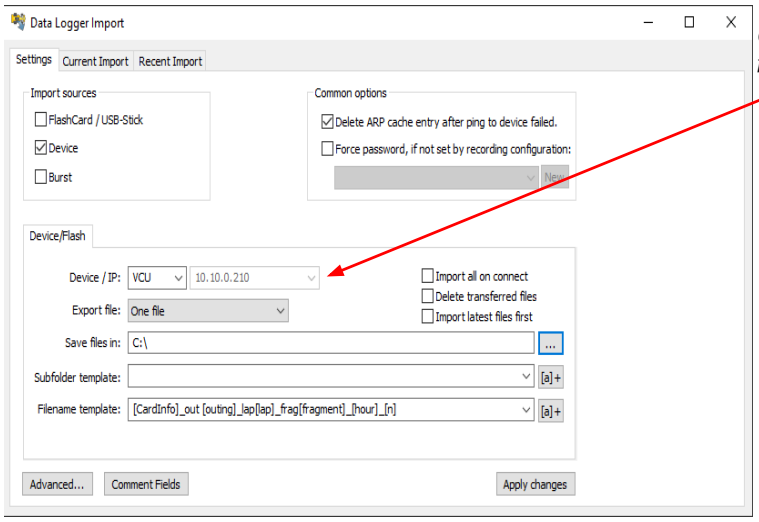
   Choose your logger and click ‘OK’ when done. The ‘Data Logger Import’ dialog opens. Refer to the WinDarab V7 manual for instructions on how to use the ‘Data Logger Import’ dialog and for more detailed descriptions and instructions.

Click 'read data from logging device'



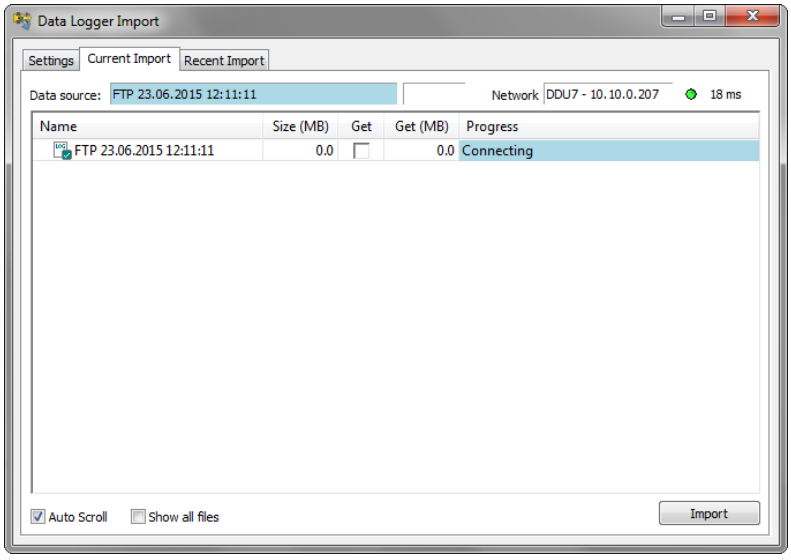
8. Choose the device and the IP address for the device.

   Click ‘Apply changes’ when done.

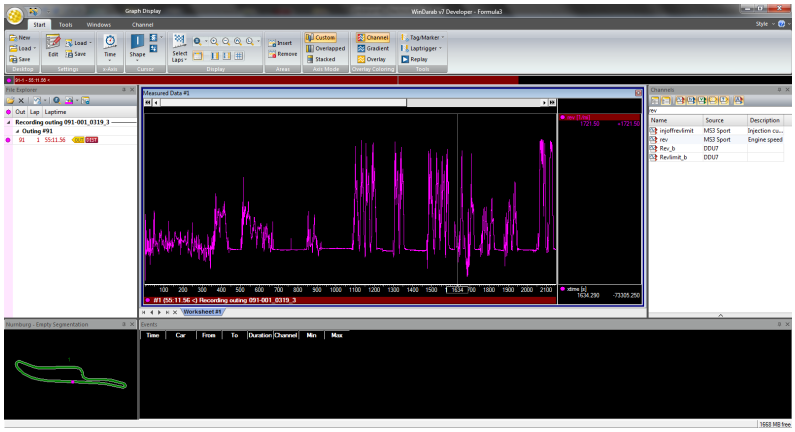


Choose your Device / IP from dropdown list

9. Connect the MS 7.4 network cable.
10. Click on the ‘Current Import’ tab.
11. Click on ‘Import’ in the lower right corner. If the ‘Import all on connect’ box is checked, the data transmission from the MS 7.4 starts automatically. Measurement files are stored automatically in the folder defined under ‘Settings’.



12. Click on ‘Close’ when the transmission has finished.
13. Click on the Start button and choose ‘Open measurement file’.
14. Select the measurement files from the storage folder.
15. Click on ‘Open’.
16. Click on ‘New Desktop’ to open a new measurement data window.
17. Drag the ‘ub’ measurement channel from the channel list and drop it into the measurement data window. The ‘ub’ measurement channel‘s graph is displayed.

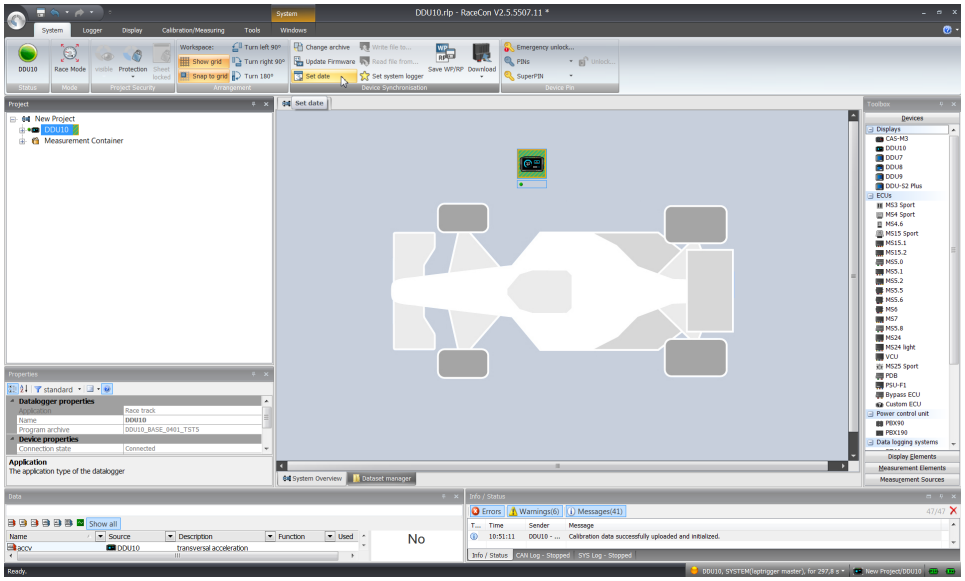


6.5 Set date and time

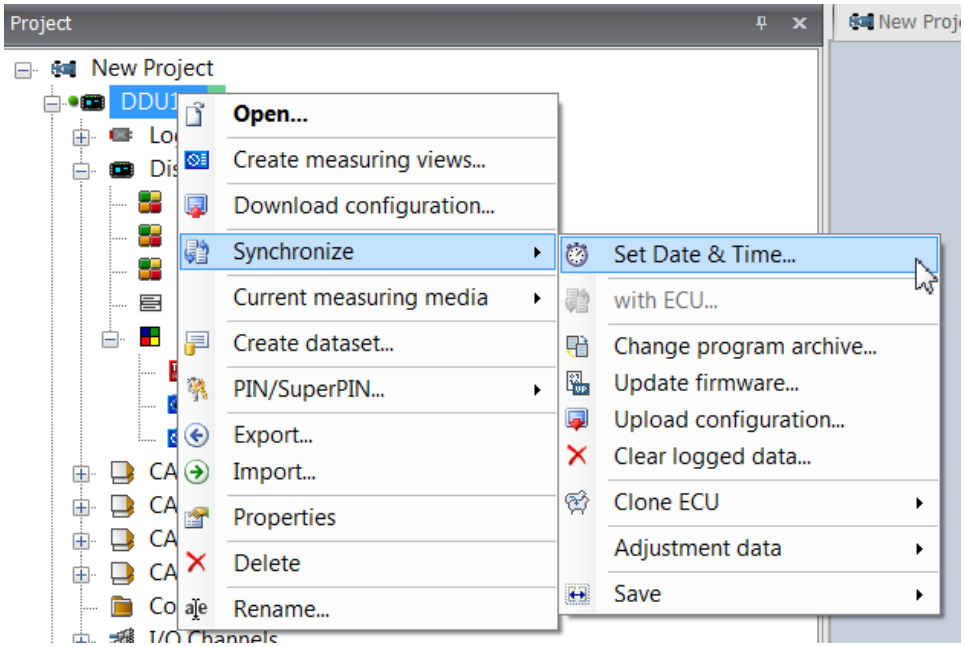
The MS 7.4 is equipped with a real time clock which is supplied by an internal accumulator. Once this accumulator is charged correctly by 12 V supply of the display, ‘Date & Time’ can be programmed by RaceCon.

Reassure that the time is set correctly, if the device has not been used for more than two weeks.

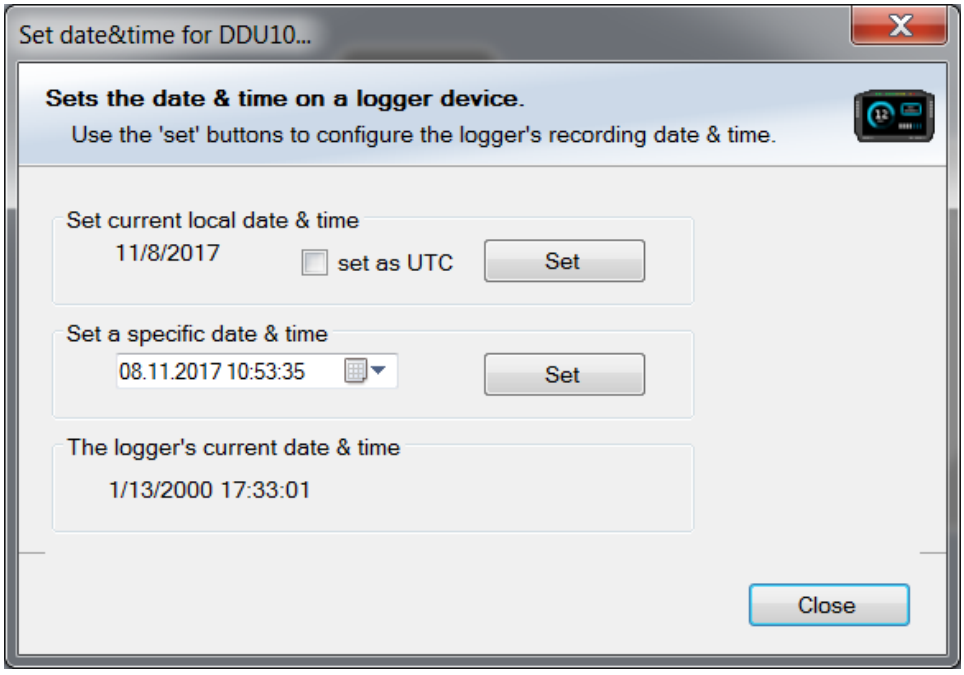
1. Connect the MS 7.4 to the PC.
2. Click on the ‘Set date’ button in the ‘System’ tab menu.



3. Alternatively, click on ‘Set Date & Time’ in the context menu of the device. A ‘Set Date & Time’ menu opens



4. Set the current local date and time as coordinated universal time.
5. At 'Set a specific date & time' click and type on the value you want to change or choose from the dropdown menu.

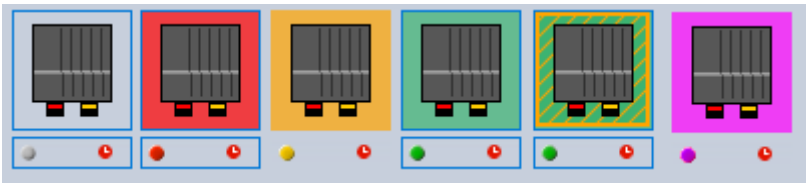


6.6 Color indication

The color indication in RaceCon visualizes different messages, such as differences between tool and device, status of the device configuration or the accrual of errors.

Visible color indications:

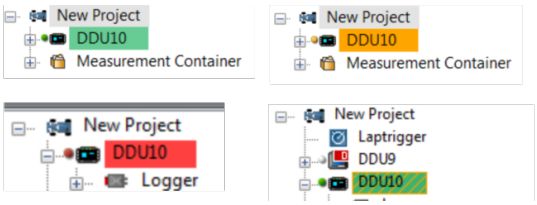
– In the status area in the upper left corner.



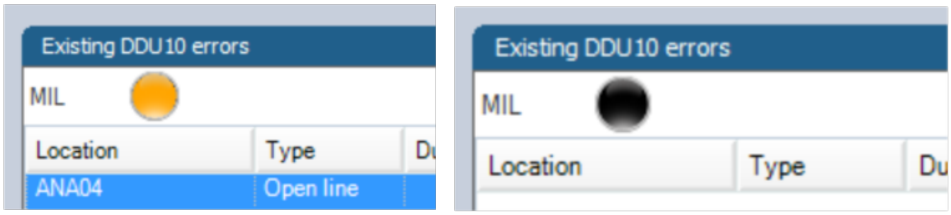
– As a background, as well as a little dot around the display icon in the ‘System window’.

– As a colored stripe beside the device name in the project tree.

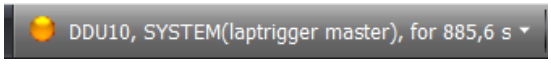
– As a colored background around the device name in the project tree.



– As a colored MIL in the “Error Info” window.



– As a colored dot in the error memory at the bottom.



The colors and their meaning:

– Grey: No connection with the device.

– Green: Matching configuration and firmware between device and project.

– Orange: A different configuration between device and project.

– Red: A different firmware between device and project.

– Purple: Device is bricked, too many resets. Reflash the device, reconsider last changes.

– Colored background with orange stripes: Matching configuration with stored (inactive) errors in the device.

– Blinking colored background with orange stripes: Matching configuration with active errors in the device.

– Black MIL: No errors.

– Orange MIL: Inactive Errors (Error entries existing, but no longer active).

– Blinking MIL (orange/black): Active Errors.

For further information, see chapter Error Memory Properties.

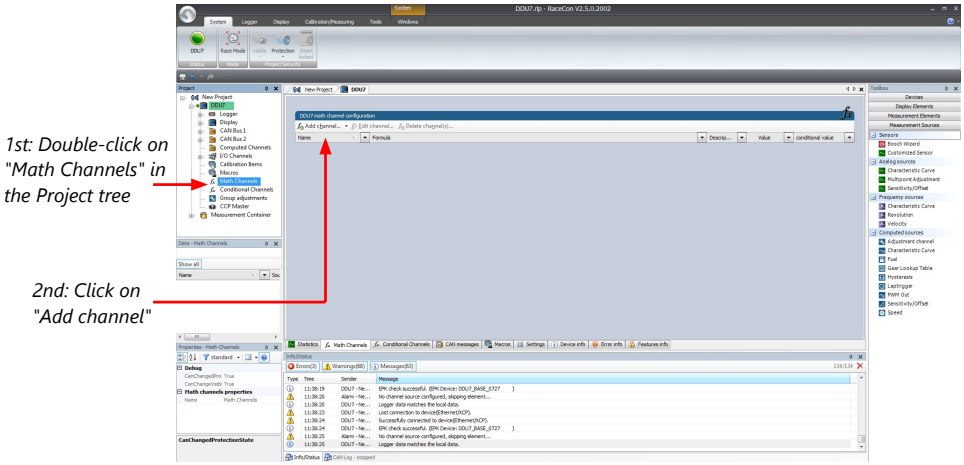
7 Project Configuration

7.1 Math Channels

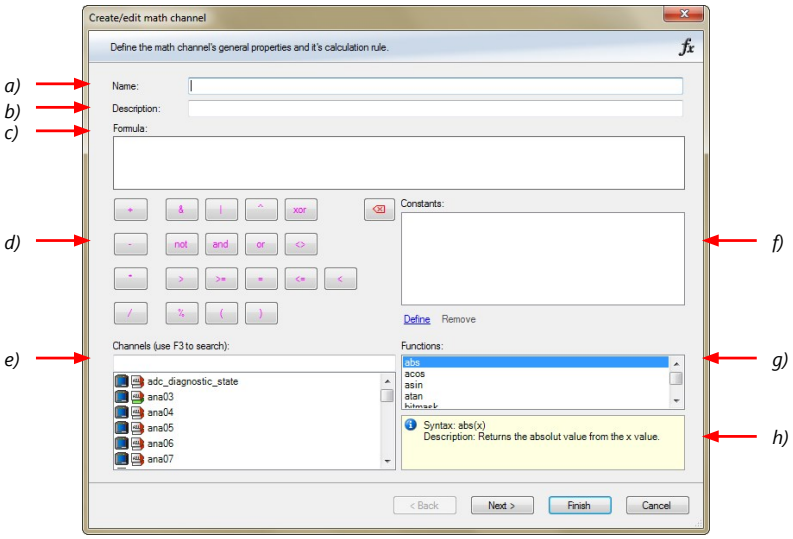
- Arithmetic and logical operations on up to 4 measurement channel(s)
- Numerical result
- Result can be used as input source for various display elements (numeric elements, alarms, bargraphs) and further calculations in the whole RaceCon project

Creating a new Math Channel

1. Follow the steps shown in the screenshot. The “Create/edit math channel” window appears.



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



a) Enter the name of the math channel.
b) Enter a description of the math channel.
c) Enter the formula.
d) Select the logical operator.
e) Choose a measurement channel.
f) Define a value that can be used as a constant in the formula.
g) Choose a function.
h) Describes the function selected above.

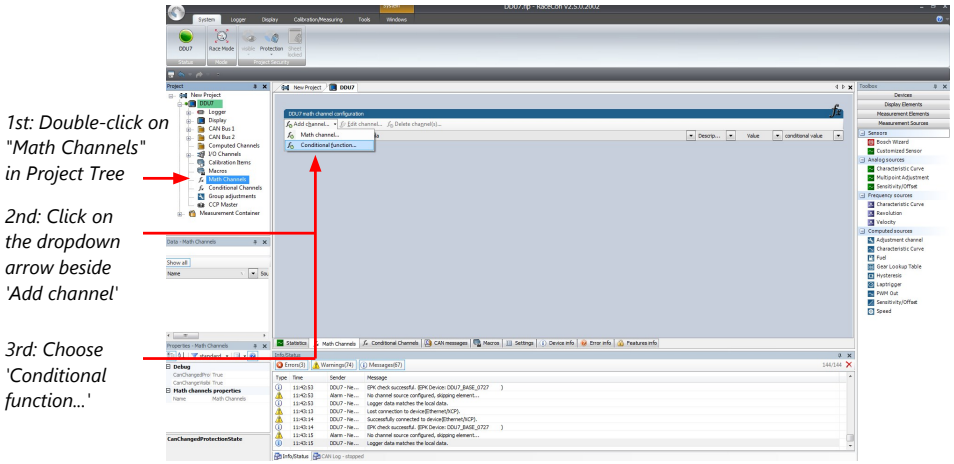
Click ‘Finish’ when done. The math channel is displayed in the math channel window.

7.2 Conditional Functions

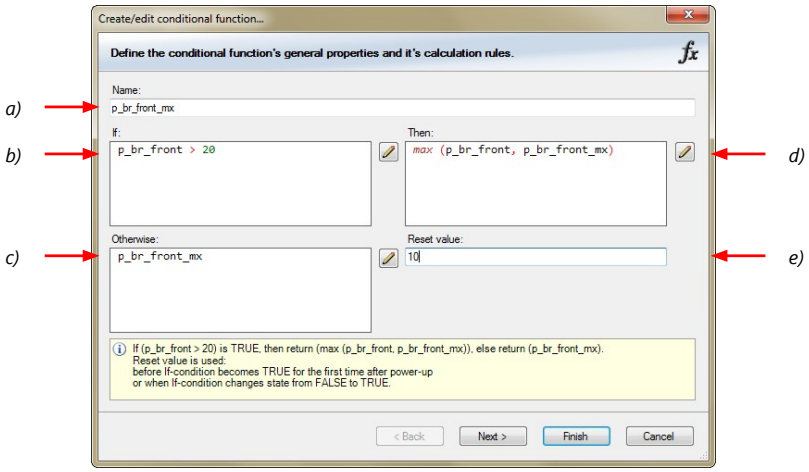
- Arithmetic and logical operations on one or more measurement channel(s)
- If-Else structure with reset
- Numerical result
- Result can be used as input source for various display elements (numeric elements, alarms, bargraphs) and further calculations in the whole RaceCon project.
  All math and conditional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

Creating a new Conditional Function

1. Follow the steps shown in the screenshot. The “create/edit math channel” window appears.



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



a) Enter the name of the conditional function.
b) Enter the If-condition. Click pencil symbol to open an editor to enter expressions.
c) Enter the Then-condition. Click pencil symbol to open an editor to enter expressions.
d) Enter the Otherwise-condition. Click pencil symbol to open an editor to enter expressions.
e) Enter the reset value (must be a number).

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”).

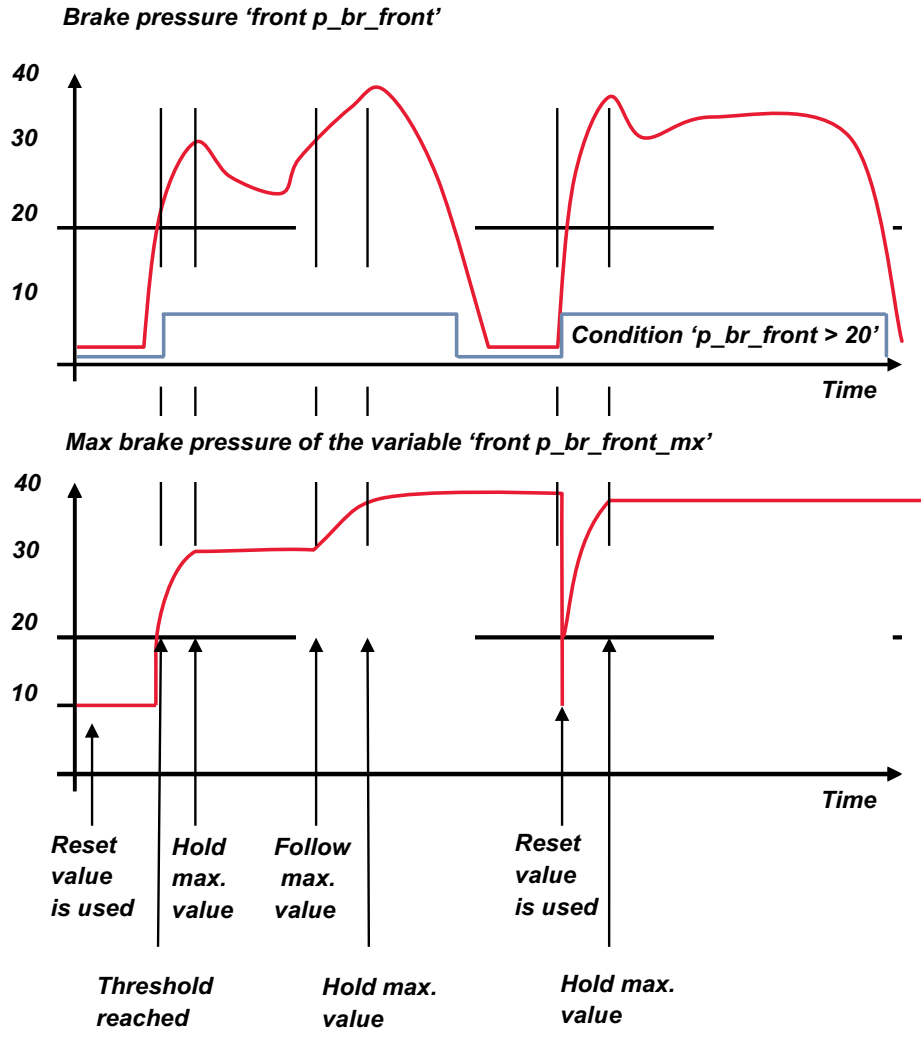
The reset value is always set for the new variable (entered in “Name”):

- before the If-condition becomes TRUE for the first time after power-up
- when the 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 MS 7.4 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’.

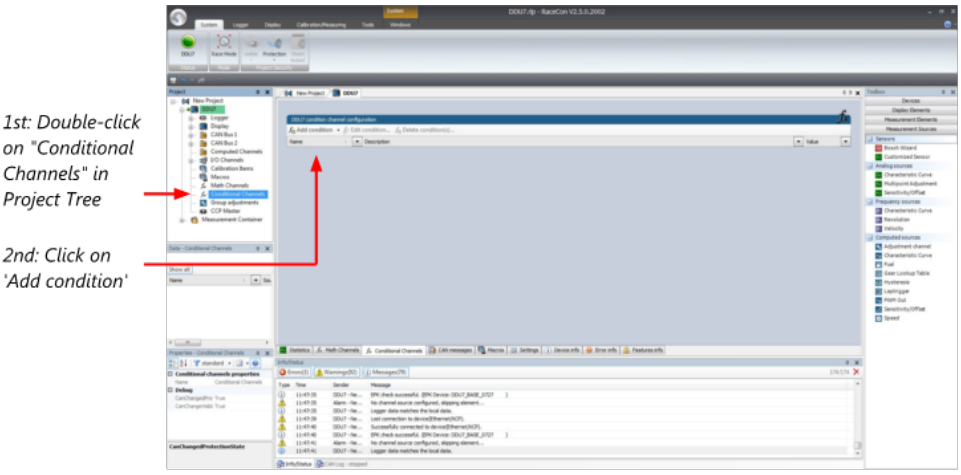
- ‘p_br_front’ rises to 30. As ‘p_br_front’ is > 20 (condition is TRUE), the condition ‘max (p_br_front, p_br_front_mx)’ in the THEN window is triggered. The condition sets the bigger value as new value for ‘p_br_front_mx’. As ‘p_br_front’ (30) is bigger than ‘p_br_front_mx’ (10), the new value for ‘p_br_front_mx’ 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).
- ‘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 is already set to 40, 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.
- The new value of ‘p_br_front_mx’ is 40 because 40 is bigger than 10.

7.3 Conditional Channels

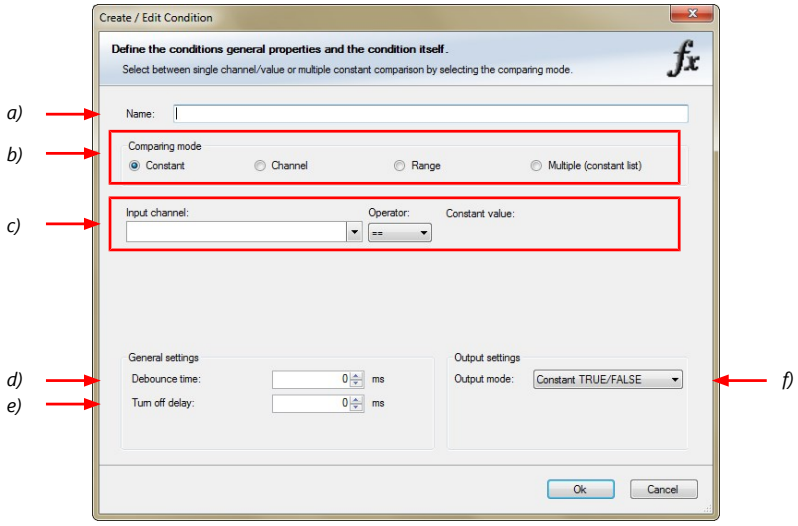
- Logical operations on measurement channel(s)
- If-Else structure with reset
- Logical result
- Result can be used as input source for alarm display elements and further calculations in the whole RaceCon project.

Creating a new Conditional Channel

1. Follow the steps shown in the screenshot. The “Create/edit condition” window appears.



2. Define the condition channel, using the following configuration possibilities:



a) Enter the name of the conditional channel.

b) Select the comparing mode:

- Constant: Compare a measurement channel with a constant value.
- Channel: Compare a measurement channel with a measurement channel.
- Range: Compare a measurement channel with a defined value range.
- Multiple: Compare a measurement channel with up to 5 constant values.

c) Depending on the chosen comparing mode, you can enter the following values:

- Constant: Choose the measurement channel or condition, the operator and enter the value of the channel.
- Channel: Choose the measurement channel or condition, the operator and the measurement channel or condition to be compared.
- Range: Choose the measurement channel or condition, the operator and define the minium and maximum value.
- Multiple: Choose the measurement channel or condition, the operator and enter the value of up to 5 constants.

d) Enter the minimal time to detect the signal of the measurement channel, to avoid high-frequent switchovers.

e) Enter the time by which the signal of the measuring channel is delayed after its end.

f) Choose the output setting of the result.

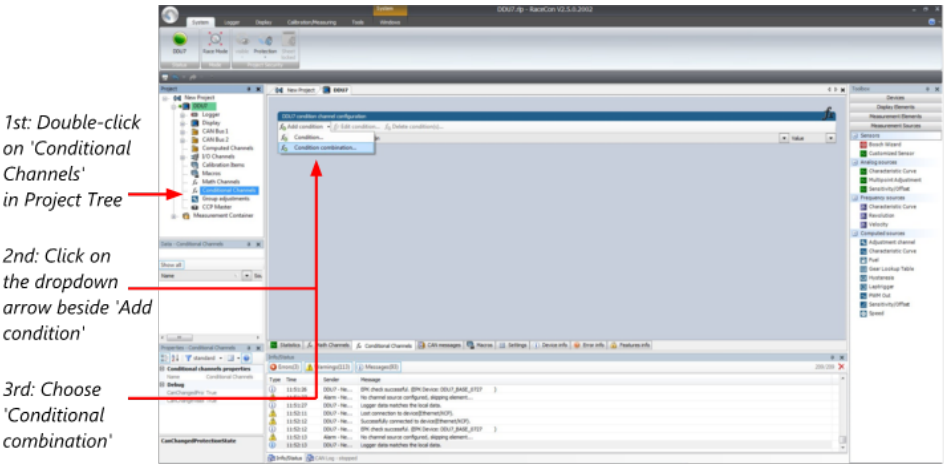
- Constant TRUE/FALSE: Result is as a constant with the value TRUE or FALSE.
- Blinking: Result is a blinking, if the condition is fulfilled.
- Pulse: Result is a short one-time pulse, if the condition is fulfilled.
- Toggling output: Result is a pulse that lasts until the next condition is fulfilled.
- Click ‘Ok’ when done. The conditional channel is displayed in the MS 7.4 condition channel window.

7.4 Condition Combination

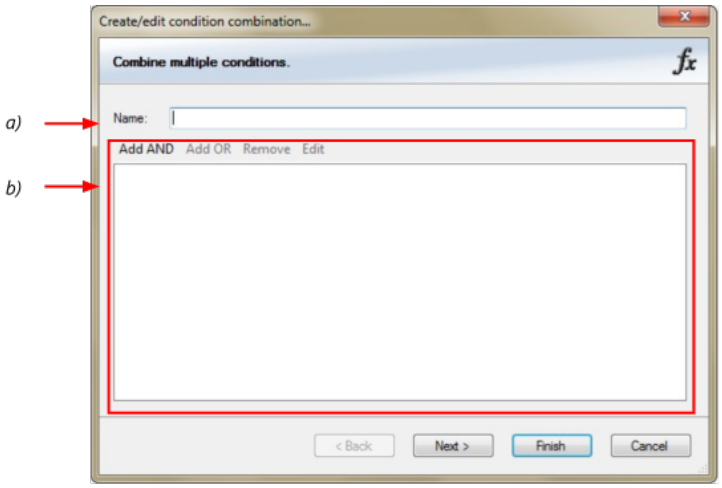
- Combination of several (up to 16) conditional channels for more complex calculations
- Logical results
- All conditions can be used globally in the whole MS 7.4 project.

Creating a new Condition Combination

Follow the steps shown in the screenshot.



The "Create/edit condition combination" window appears. Define the condition combination, using the following configuration possibilities:

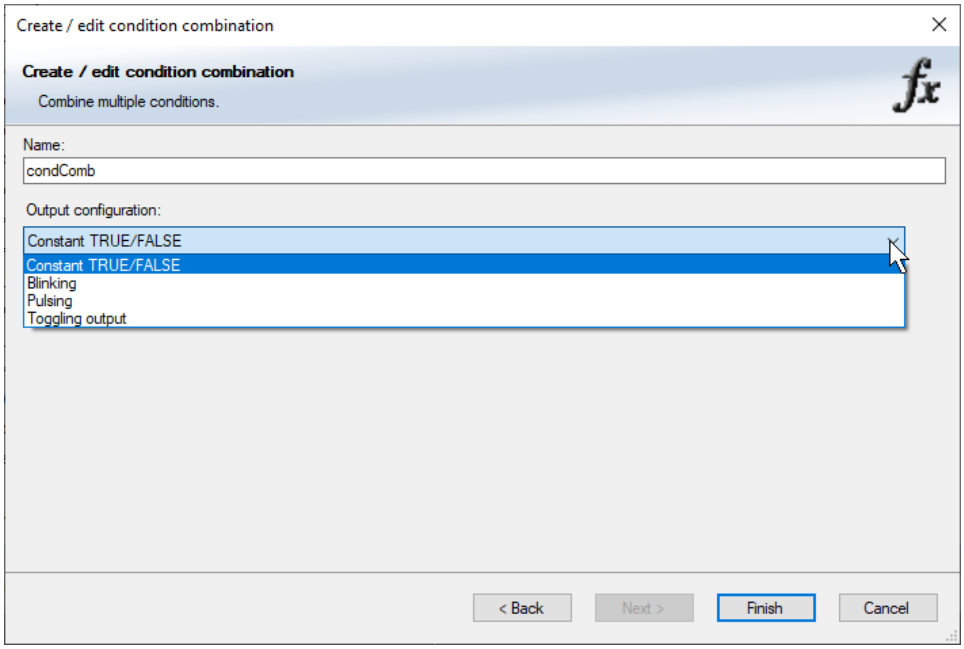


a) Enter the name of the condition combination.

b) Create the condition combination in the window.

- 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, click with the right mouse-button on the condition and select 'Negation (!)'.
- Combine several (up to 16) conditions.

Click 'Next' to go 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.
- Pulsing: 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.

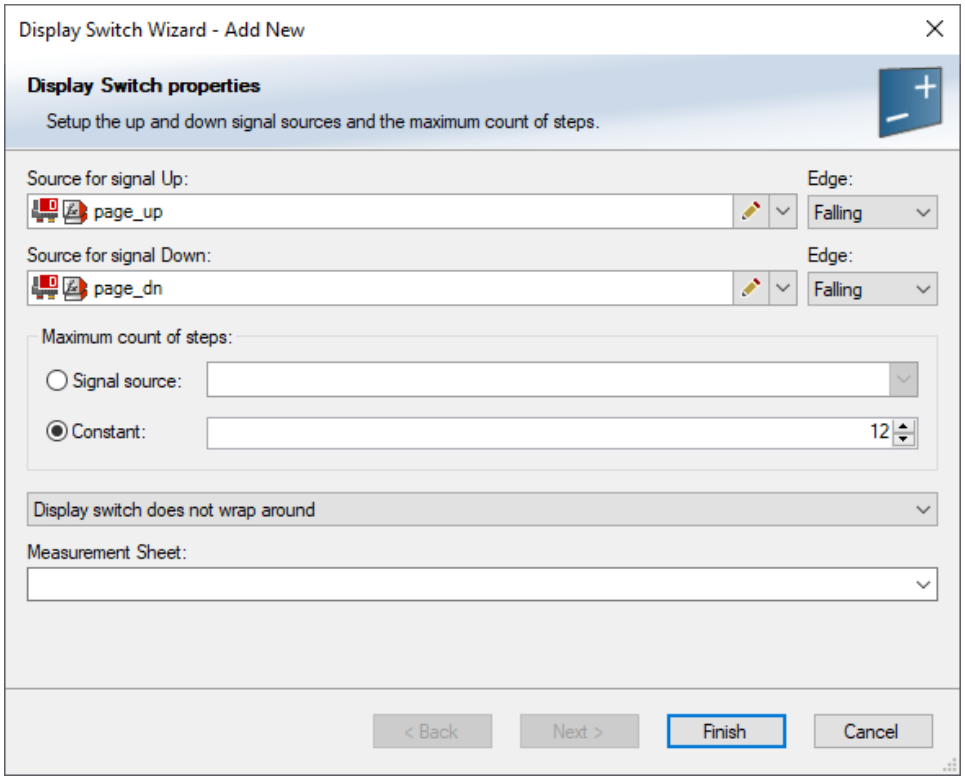
Click ‘Finish’ when done. The conditional combination is displayed in the MS 7.4 condition channel window.

7.5 Display Switch Module

You can use the Display Switch Module to switch display pages and brightness. The output is a display page or brightness output that can be used in display configurations. The value sustains over a power cycle.

The conditions for incrementing/decrementing the value can be set freely. The maximum value can be set as constant or read from a measurement.

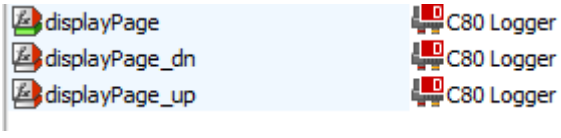
The page can be configured to wrap around. In this case, no page down condition is needed.



The resulting outputs are the display switch value and the input conditions.

Measurement label	Function
name	page or brightness value
name_**dn**	input condition for decrement
name_**up**	input condition for increment

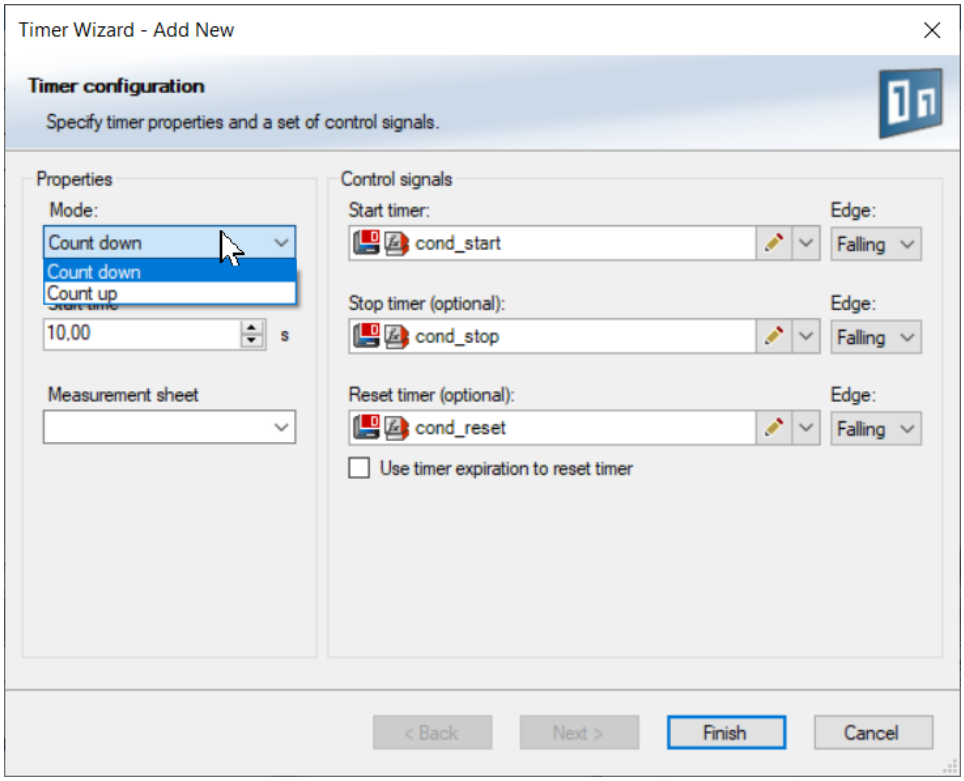
Example:



7.6 Timer Module

The Timer Module is designed to implement timing triggers, i.e. for rallye stage timing or minimum pit time calculations. Any event in the system can be used for starting, stopping and resetting the timer.

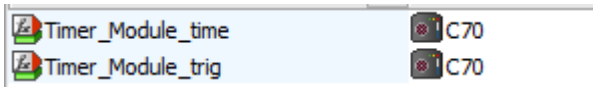
Up counting mode and down counting mode are available, triggers are fired at set time (up counting) or at zero (down counting). The running timer will keep its state over a power cycle.



The output channels for this module depend on the name used for the module and are called ..._time and ..._trig.

Measurement label	Function
name_**time**	actual timer value
name_**trig**	trigger set by timer alarm

In this example, the module is named “Timer_Module”. Resulting channels are:

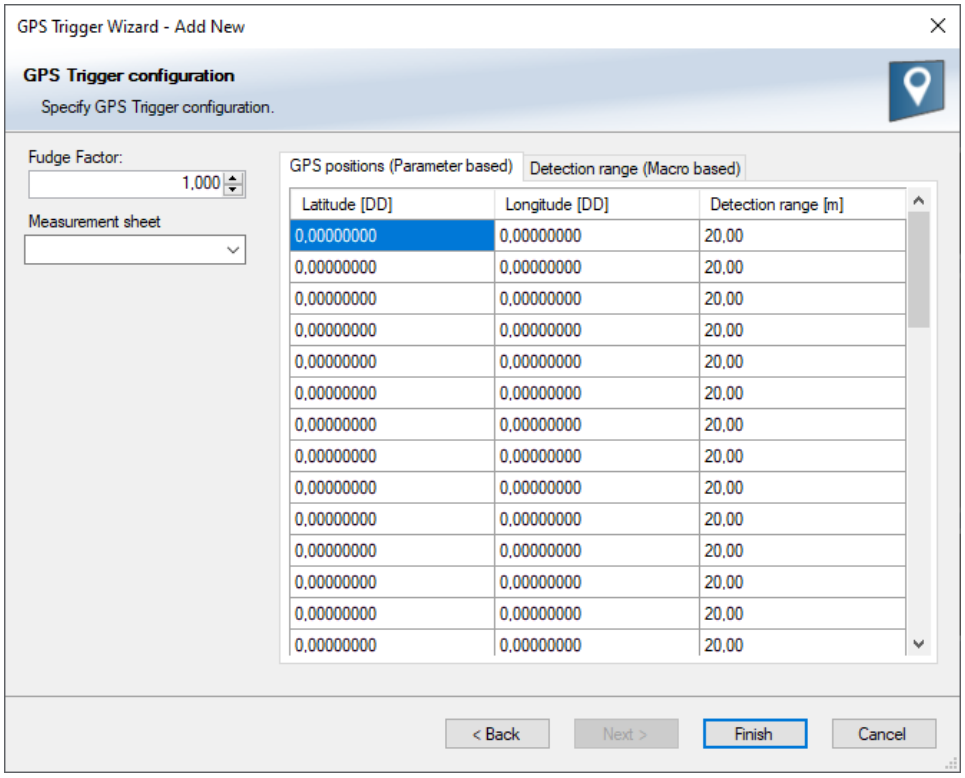


7.7 GPS Trigger Module

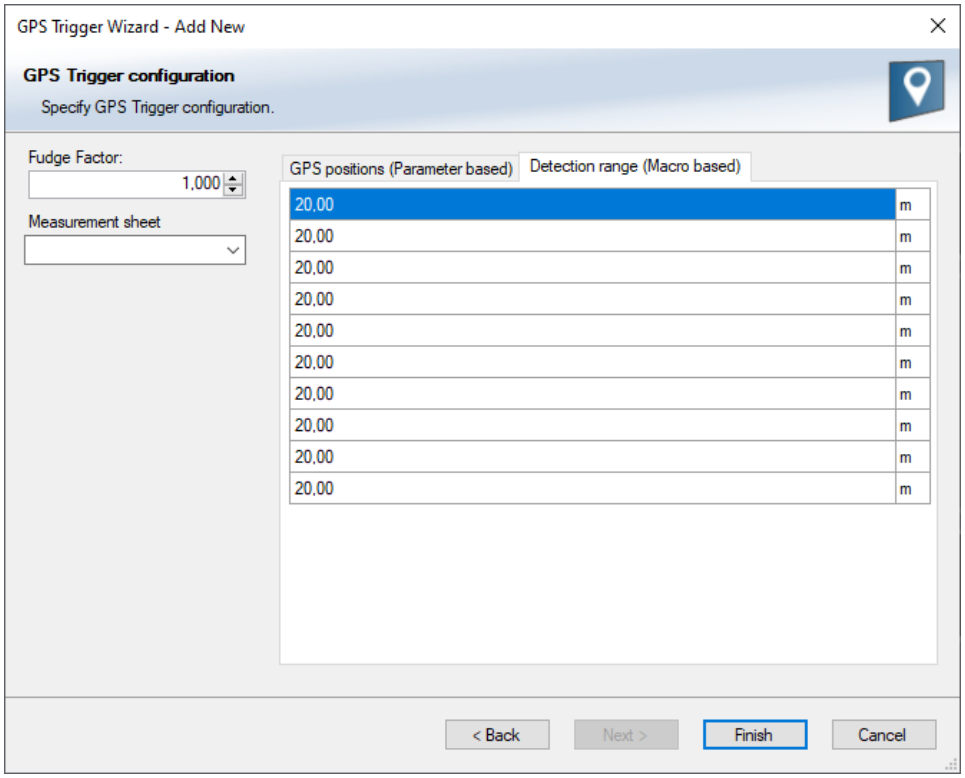
The GPS Trigger Module triggers depending on GPS-position, like the GPS-laptrigger.

There are 50 GPS trigger points for parameter application of latitude/longitude coordinates, as well as 10 macro-based coordinates.

If the car passes one of the trigger points, an output signal is set to 1 shortly. Each trigger requires a defined latitude, longitude, and detection range.



The parameter-based trigger points need to be set manually in RaceCon, the macro-based trigger points will store latitude and longitude values when the configurable trigger condition comes true (i.e., steering wheel button). This trigger condition and the detection range need to be configured in RaceCon.

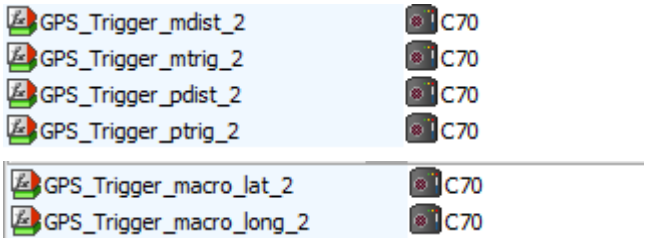


The GPS trigger points can also be used for segment triggering. If used as segment triggers and i.e., 3 trigger points are selected, the laptrigger module will use the first 3 trigger points on the list.

The channel names depend on the name used for the module, in this example GPS_Trigger. Each trigger has a distance and a trigger channel with the abbreviation m for macro or p for parameter based. The trigger channel will be set to 1, when the lowest distance to the trigger point is detected. For the macro-based trigger, the stored latitude and longitude values can be seen with the channels.

Measurement label	Function
name_**lat**	interpolated gps latitude
name_**long**	interpolated gps longitude
name_**ptrig_1..50**	trigger output of parameter based trigger (n)
name_**pdist_1..50**	distance to trigger of parameter based trigger (n)
name_**mtrig_1..10**	trigger output of macro based trigger (n)
name_**mdist_1..10**	distance to trigger of parameter based trigger (n)
name_**macro_lat_1..10**	stored latitude for macro based trigger (n)
name_**macro_long_1..10**	stored longitude for macro based trigger (n)

Example:



7.8 CPU Load Limits

As all microprocessors, the two processors of the MS 7.4 have limited capacities. The current load of the processors can be monitored using the channel “cpu_load_001” or “cpu_load_002”. 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 the MS 7.4 not being able to fulfill its required measuring/logging/display tasks or even in 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
- Logger configuration (total logging rate [kB/s], conditional measurement rates)

To help respecting the limit of 85 % CPU load, the MS 7.4 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 MS 7.4 resets due to complex configuration setups, please consider reducing the demands on the MS 7.4 adapting the influencing factors mentioned above.

8 CAN Configuration

The MS 7.4 has 3 fully configurable CAN bus(es).

- Baudrate 125 kbaud to 1 Mbaud
- 11 Bit or 29 Bit identifiers
- Input configuration: Read messages from CAN bus and convert to MS 7.4 measurement/display variables. CAN bus supports row counter configuration.
- Output configuration: Write RaceCon measurement variables to CAN messages; output frequency and row counter are configurable, CAN gateway functionality (transfer from one bus to another).

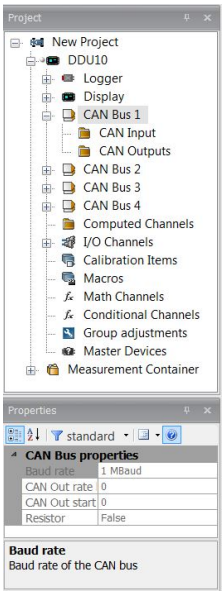
8.1 CAN Bus Trivia

CAN Message

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

CAN Bus

- Needs termination resistors in wiring harness
- All devices connected to the bus must use identical data rate
- Configuration of bus data rate in the 'CAN messages overview' menu. To access the menu, double-click on one of the CAN bus items of the project tree



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

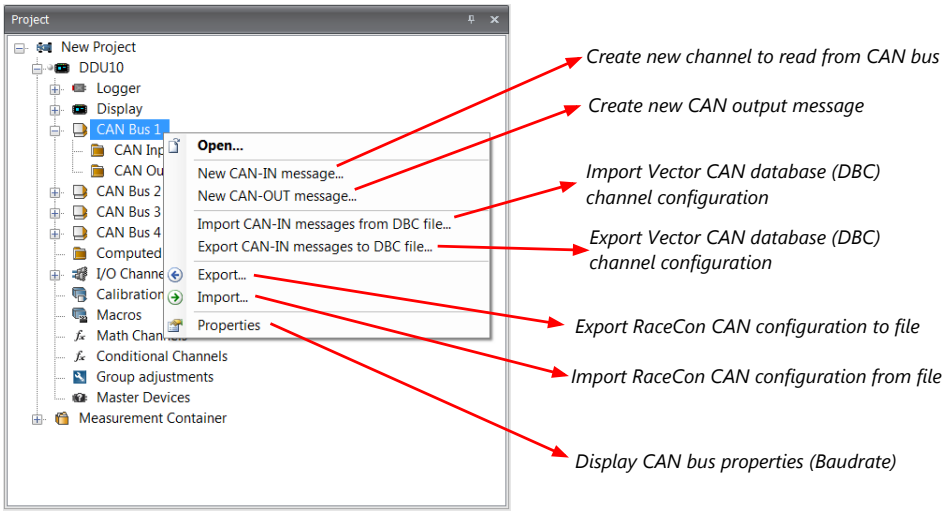
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x100	0	p_oil		t_oil				
0x100	1	s_dam_fl		s_dam_fr				
0x100	2	s_dam_rl		s_dam_rr				

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

8.2 CAN input

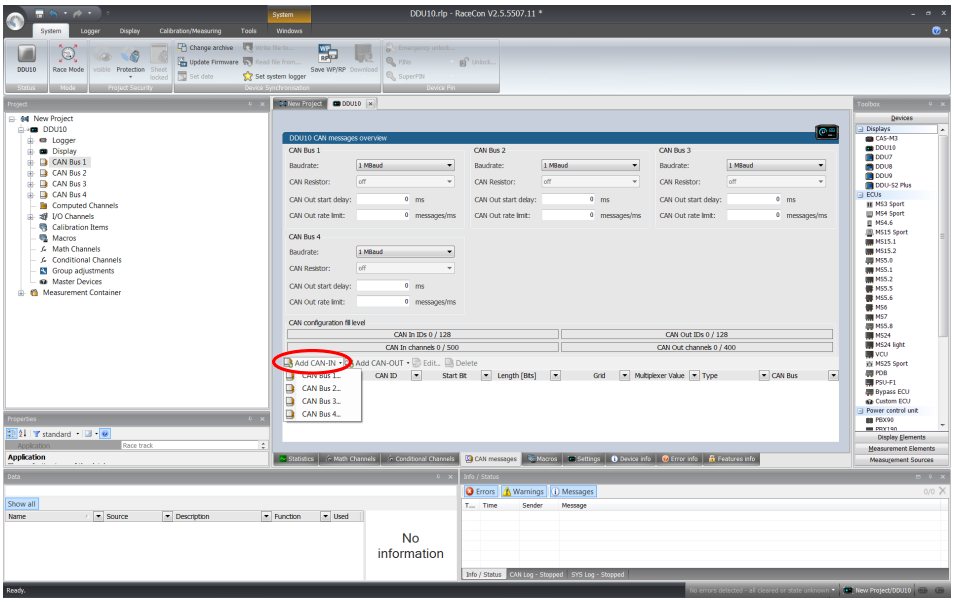
8.2.1 Input configuration

Click with the right mouse button on the desired CAN bus to open the CAN bus drop-down menu.



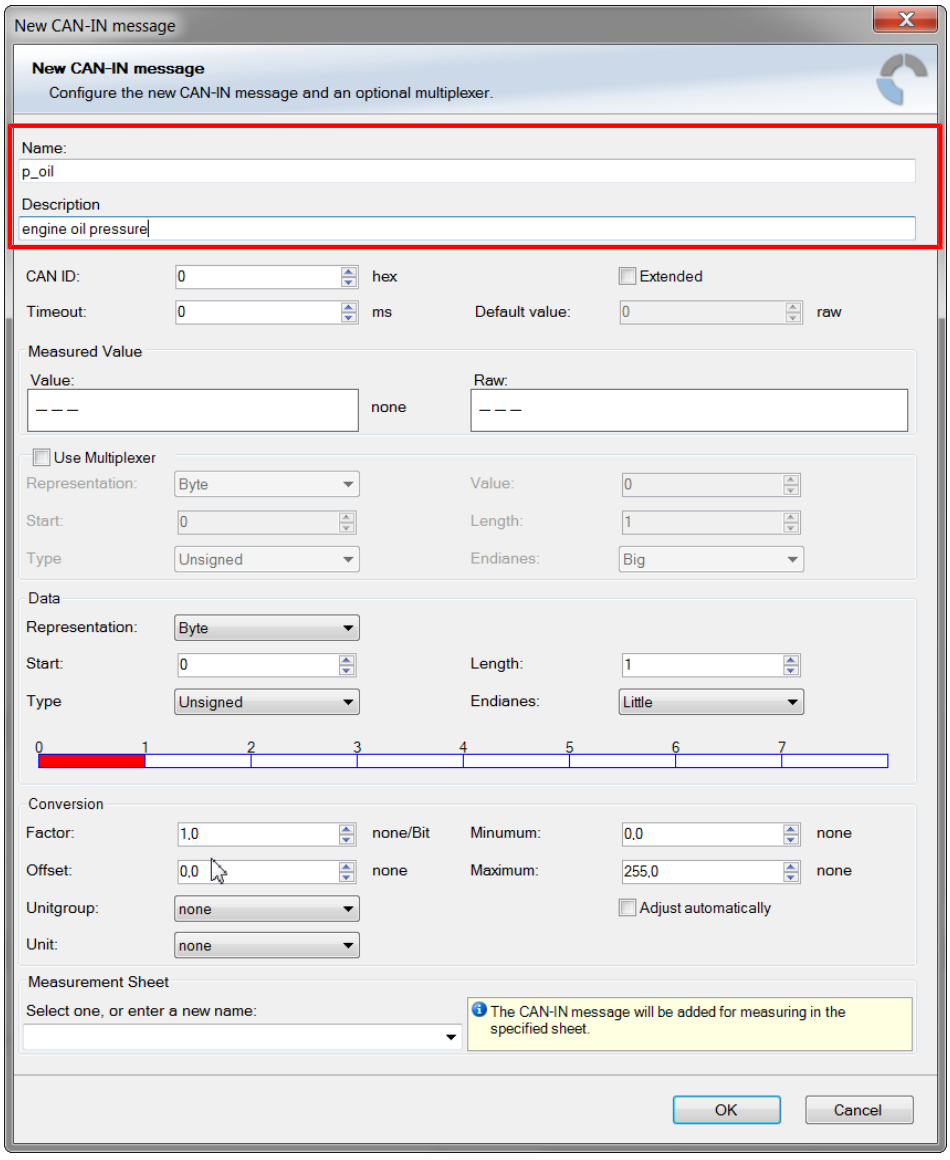
8.2.2 Create new CAN Input channel

1. Double-click on any CAN bus item, to open the "CAN messages overview".
2. Select ‘Add CAN-IN’ and choose the desired CAN bus for the new input channel.

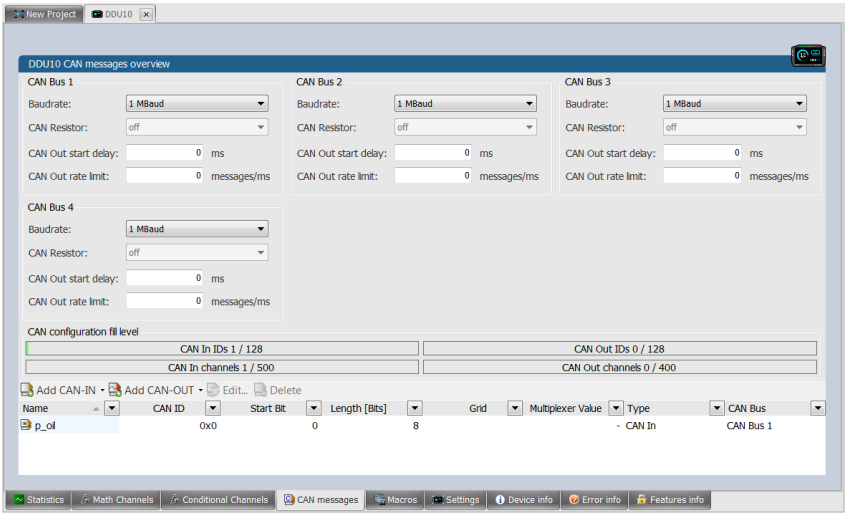


3. A CAN channel configuration window opens.

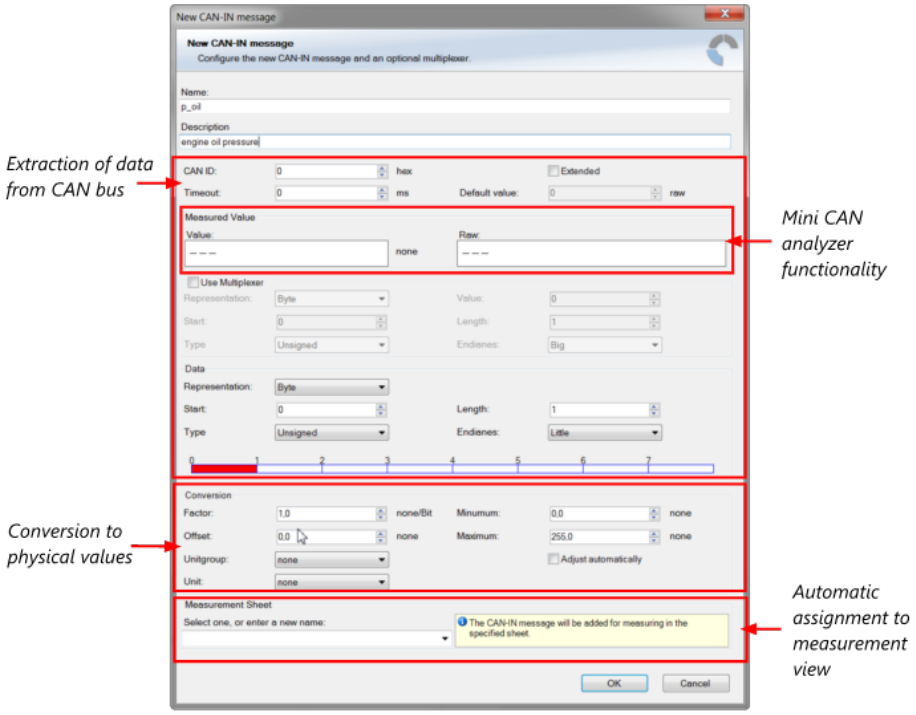
4. Insert the name and description of the channel.



5. Click ‘OK’ when done.
   The channel is listed in the Data window.



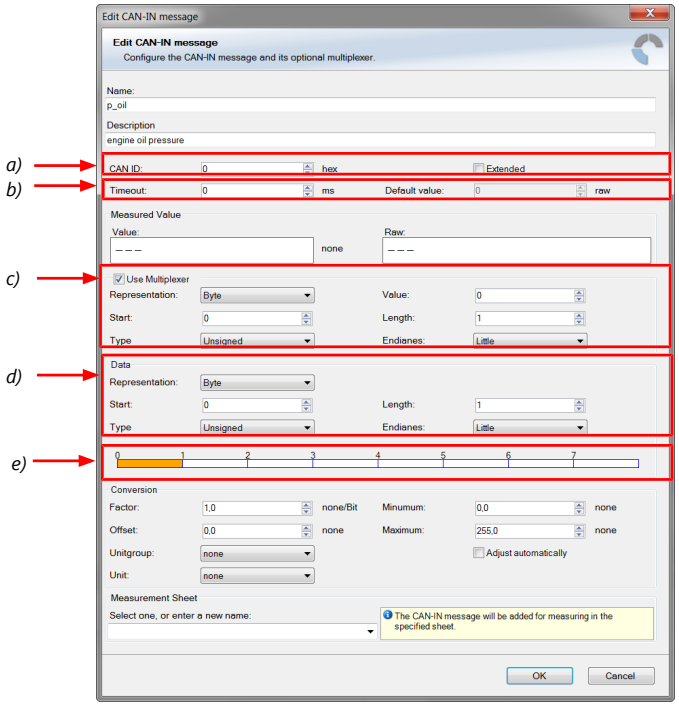
CAN channel configuration



8.2.3 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 CAN message ID. If extended IDs (29 bit) are used, check the box.

b) If replacement values are used, specify time-out period and raw value.

c) If a multiplexer (row counter) is used, check the box.

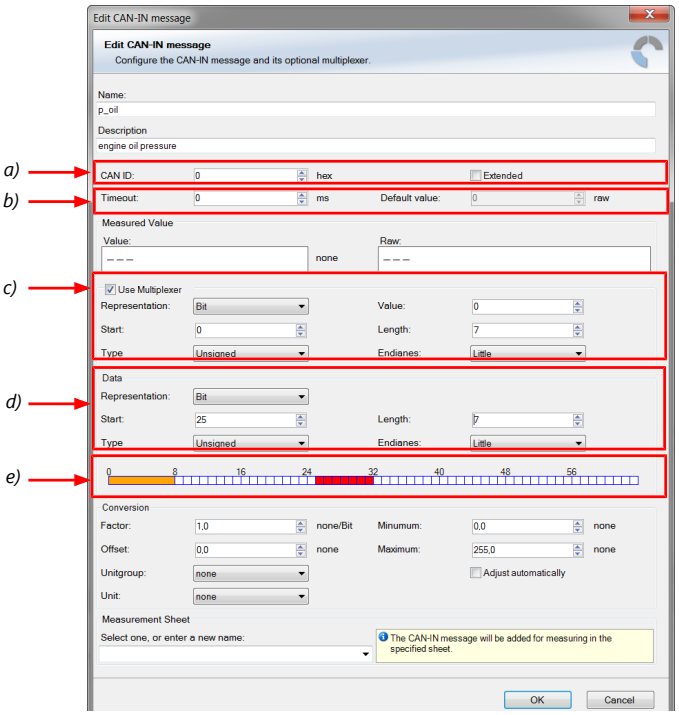
d) Enter data position, length and format.

e) 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 CAN message ID. If extended IDs (29 bit) are used, check the box.

b) If replacement values are used, specify time-out period and raw value.

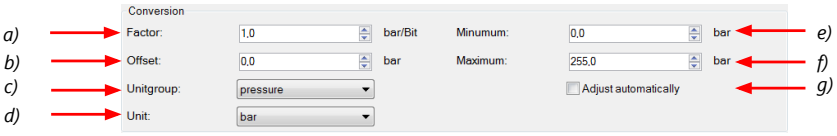
c) If a multiplexer (row counter) is used, check the box.

d) Enter data position, length and format.

e) 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.

Conversion to physical value



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.

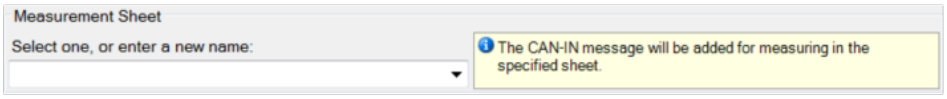
CAN analyzer functionality

This functionality is only available, if a MSA-Box (I or II) is used to connect the MS 7.4 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.

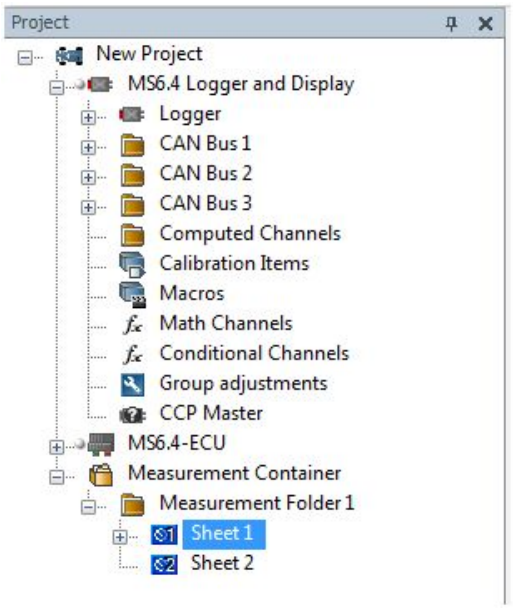
Automatic creation of online measurement sheets

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

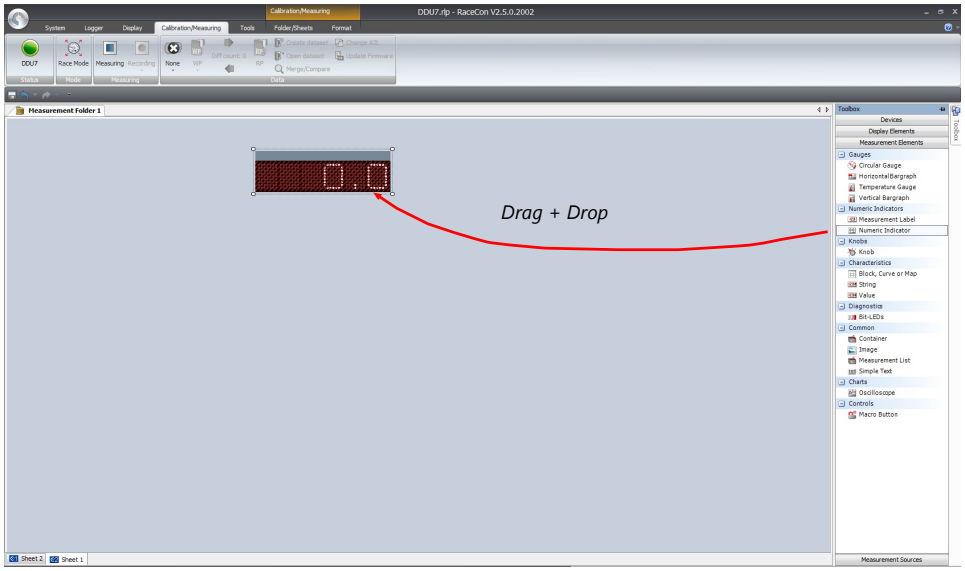
For an online view of the value measured by the MS 7.4, insert the channel in an online measurement sheet which is described in the chapter Setting up an online measurement [▷ 75].



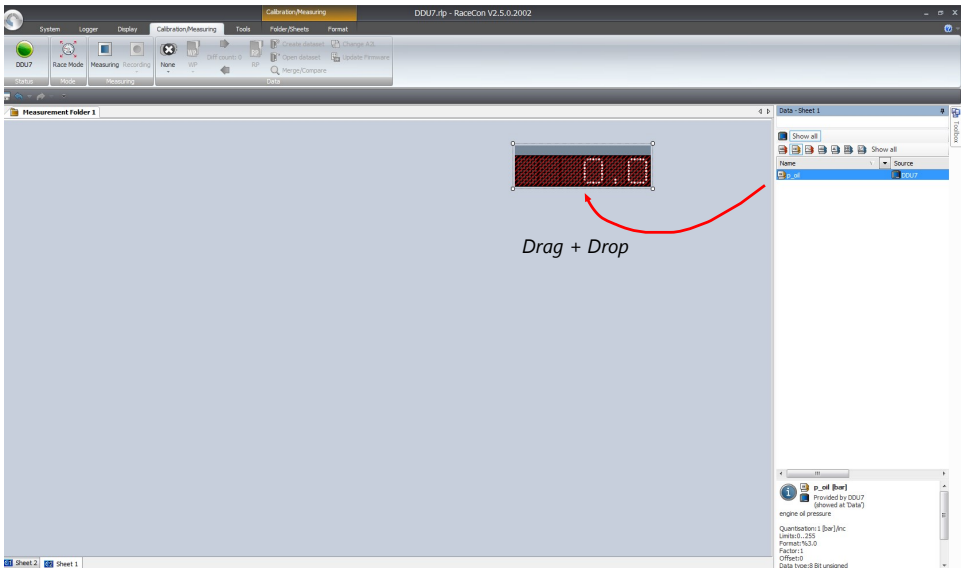
8.2.4 Online view of CAN channels in vehicle



1. Double-click on ‘Sheet 1’ in Project Tree. Measurement Sheet 1 is displayed in Main Area.
2. Click on ‘Measurement elements’ in the Toolbox.
3. Drag the desired Measurement element (e.g. Numeric Indicator) and drop it on the Measurement Sheet.



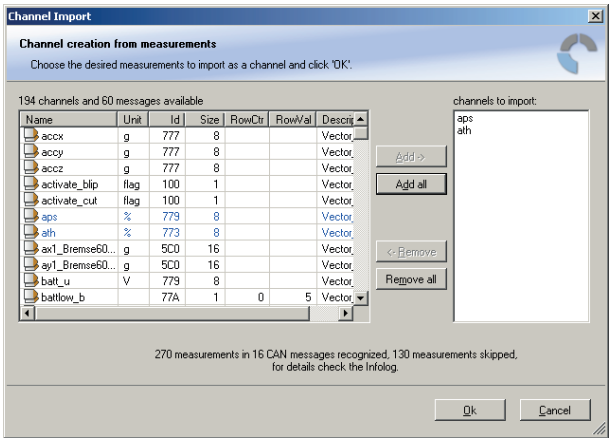
4. Click on folder ‘CAN Input’ of desired CAN bus to display available channels.
5. Drag desired Measurement channel and drop it on the Measurement element.



6. The measurement element displays the values of the assigned channel.
7. Connect PC to the vehicle and switch to ‘Race Mode’ by clicking ‘F11’ on the keyboard to display online data.

8.2.5 Import a CAN database (DBC) file

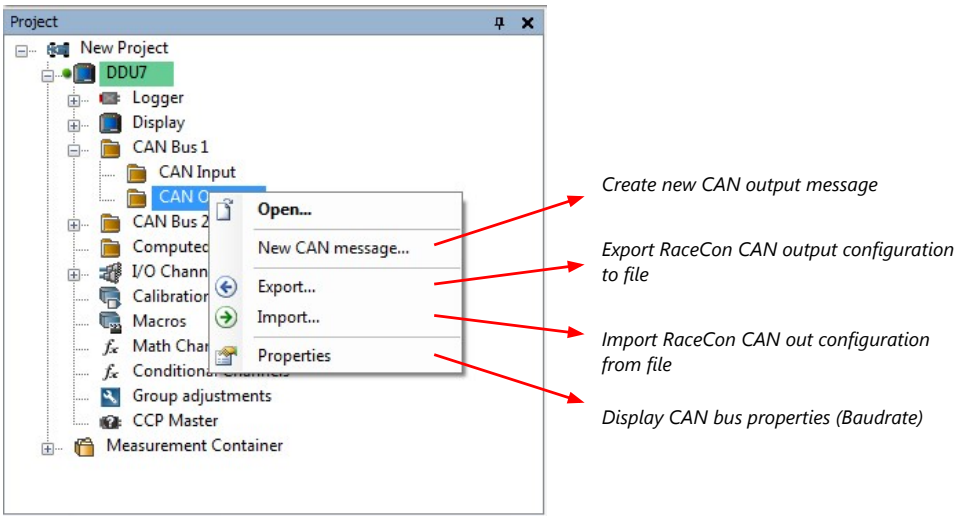
1. Right-click on CAN Input of desired bus (CAN1 or CAN2).
2. Select ‘Import DBC file’ from menu. A file browser opens.
3. Select DBC file to import and click ‘OK’ when done. A channel import window opens.



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.

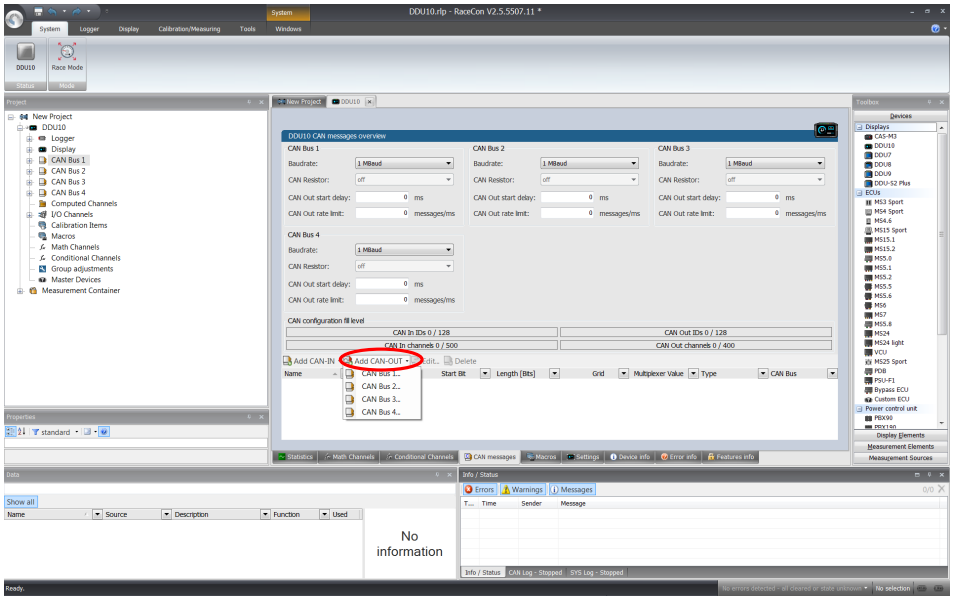
8.3 CAN output

8.3.1 Output configuration

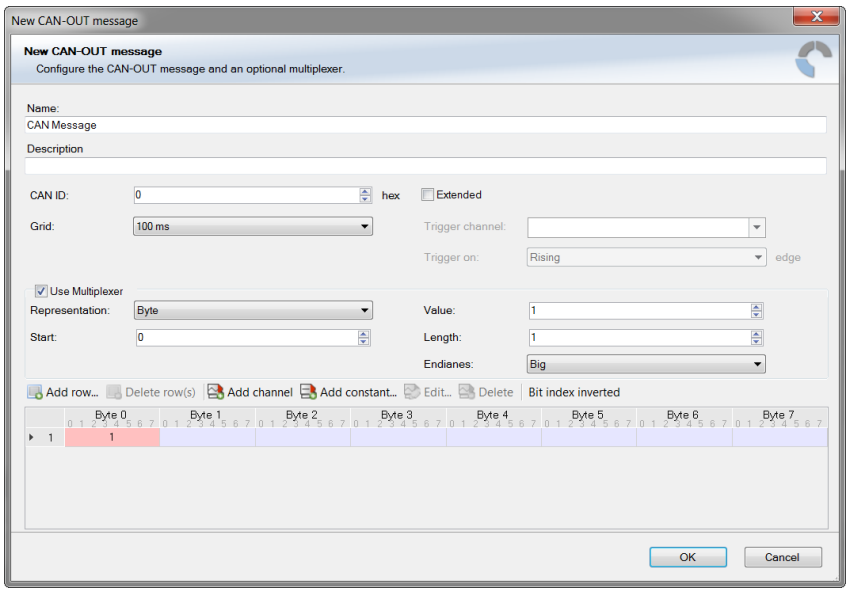


8.3.2 Create a new CAN output message channel

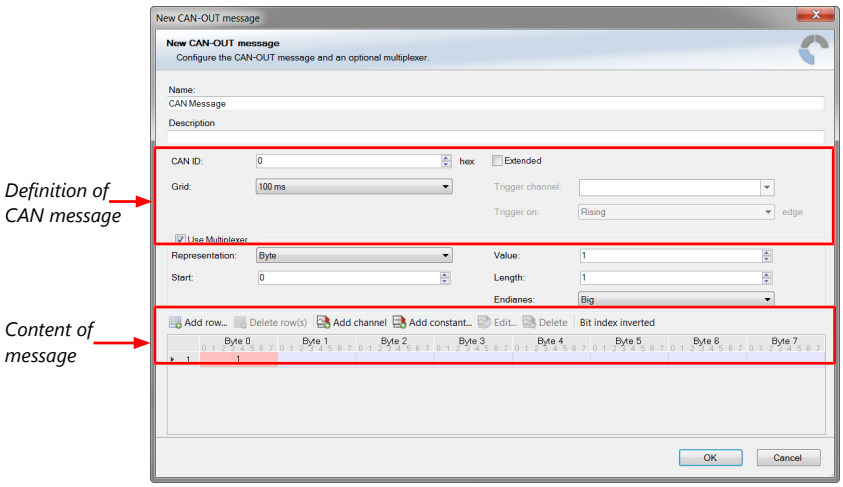
- Double-click on any CAN bus item to open the "CAN messages overview".
- Select ‘Add CAN-OUT’ and choose the desired CAN bus for the new output channel.



– The ‘New CAN-OUT message’ window opens.

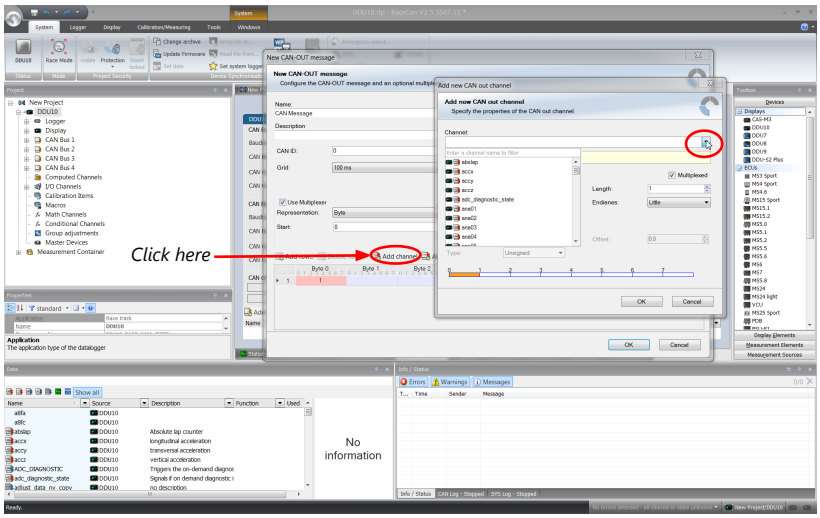


– Enter name of message, description, CAN-Id, and Grid (output interval). Optionally, specify a multiplexer.



– Click on ‘Add channel...’ or ‘Add constant...’, this opens the ‘Add new CAN out channel’ window.

– Select the desired measurement channel and specify the message settings.

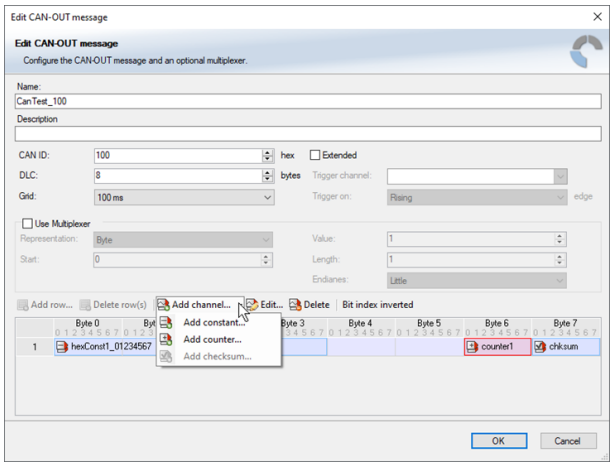


The measurement channel is now assigned to the CAN message.

8.3.2.1 Add CAN out constant

To send a constant value on the CAN, perform the following steps:

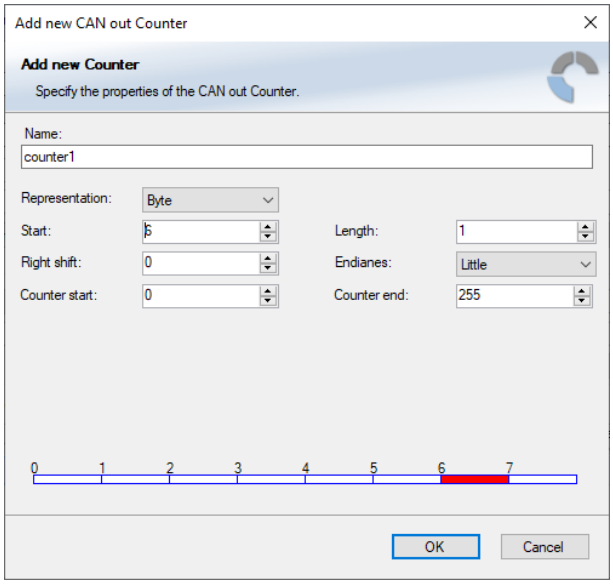
1. Create a new CAN output message or edit an existing message.
2. Click small arrow beside ‘Add channel...’ and select ‘Add constant...’. The ‘Add new CAN Out constant’ window appears.
3. Define the name of the constant, the required value in hex and define the CAN channel settings.
4. Click ‘OK’ when done.



8.3.2.2 Adding CAN out counter

To send a counter value on the CAN, perform the following steps:

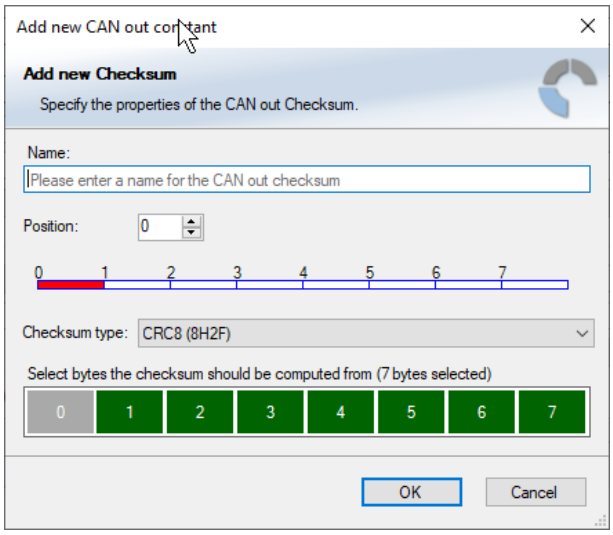
1. Create a new CAN output message or edit an existing message.
2. Click small arrow beside ‘Add channel...’ and select ‘Add counter...’. The ‘Add new CAN out counter’ window appears.
3. Define the name of the counter, define the CAN channel settings.
4. Click ‘OK’ when done.



8.3.2.3 Adding CAN out checksum

To send a checksum on the CAN, perform the following steps:

1. Create a new CAN output message or edit an existing message.
2. Click small arrow beside 'Add channel...' and select 'Add checksum...'. The 'Add new CAN out checksum' window appears.
3. Define the name of the checksum, the algorithm, the byte which should be covered by the checksum and define the CAN channel settings.
4. Click 'OK' when done.



8.4 Multiplexer

Row counter concept

If certain channel messages are not time-critical and can be imported or exported slowly, you can use a multiplexer to put several channel messages on one message identifier.

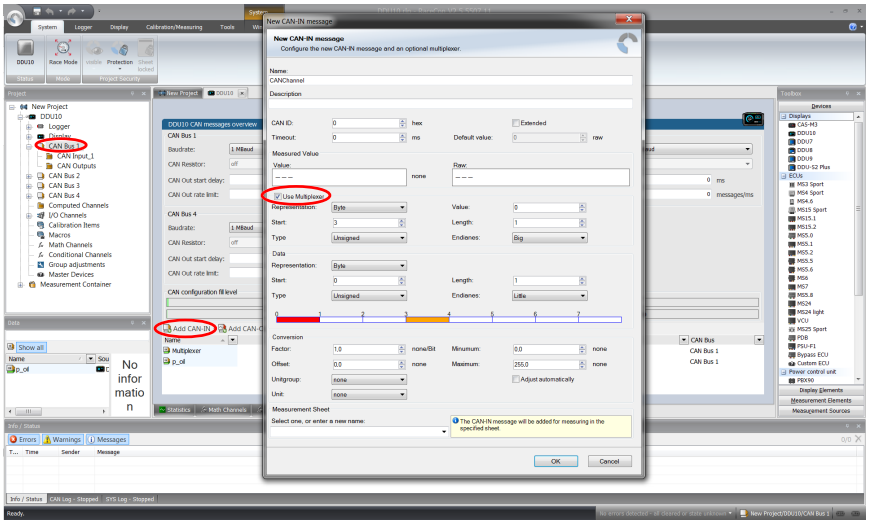
- Re-use (multiplex) of message identifiers by splitting it into several rows.
- Every row is assigned to a unique value of the multiplexer.
- One byte of message contains row counter.

– 7 bytes payload remaining. A multiplexer does not have to consist of one byte only, it can consist of several bytes as well as single bits.

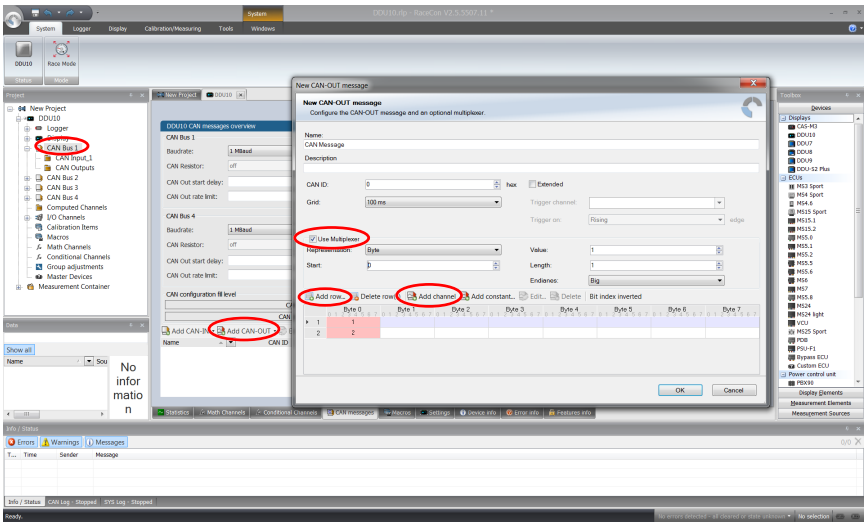
– Position of row counter is configurable.

To use a multiplexer perform the following steps:

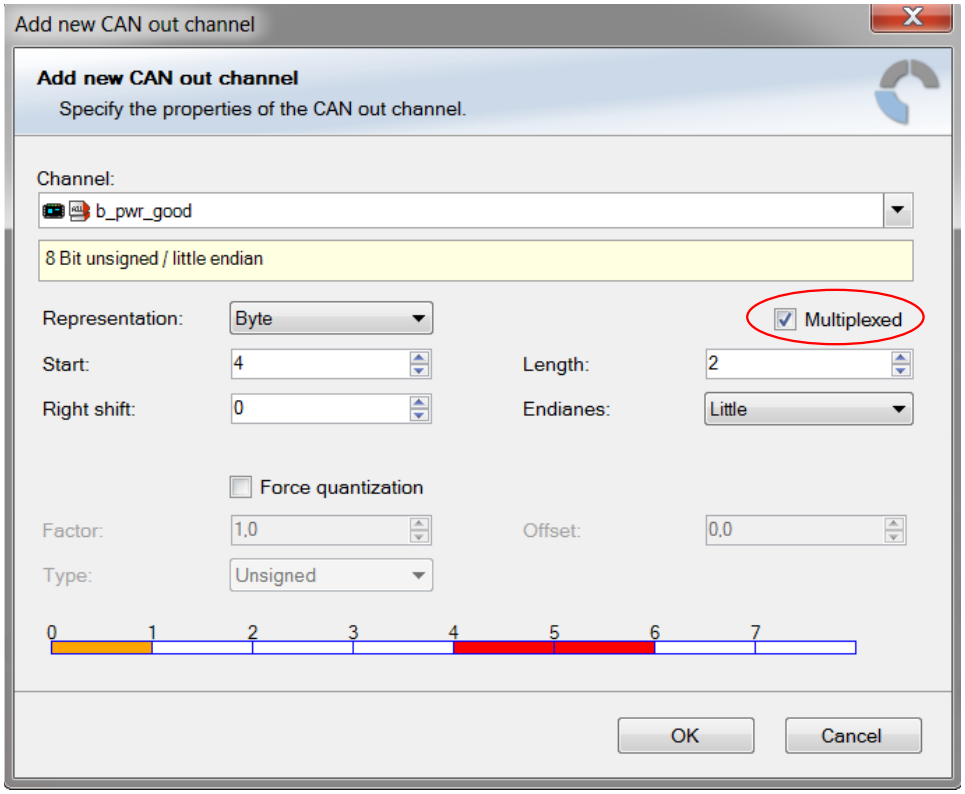
1. Double-click on any CAN bus item to open the “CAN messages overview”.
2. Select ‘Add CAN-IN’ and choose the desired CAN bus for the new input channel.
3. Check the box ‘Use Multiplexer’ and configure the multiplexer for the new CAN-IN channel.



4. To configure the multiplexer for a CAN-OUT channel, select ‘Add CAN-OUT’.
5. Check the box ‘Use Multiplexer’ and click on the button ‘Add row…’ to split the message identifiers into several rows.
6. Click on one row and select ‘Add channel’ to assign a channel to the row.

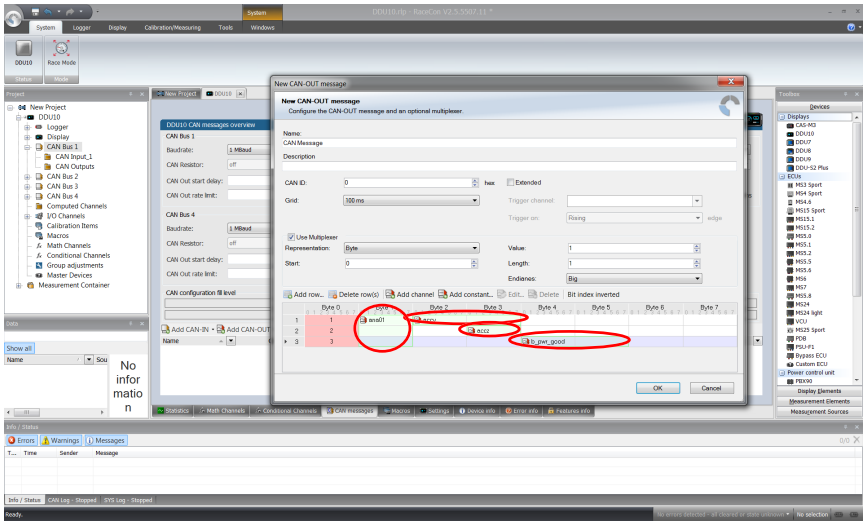


7. The ‘Add new CAN out channel’ dialog opens.
8. Select a channel and configure it. To assign it to the row selected before, check the box ‘Multiplexed’.
9. To move the channel message, change the “Start” value or click and hold the green field in the “Add new CAN out message” window.
10. Click ‘OK’ when done.



11. The channel message is assigned to the selected fields.

12. Click ‘OK’ when done.



9 Export and Import in RaceCon

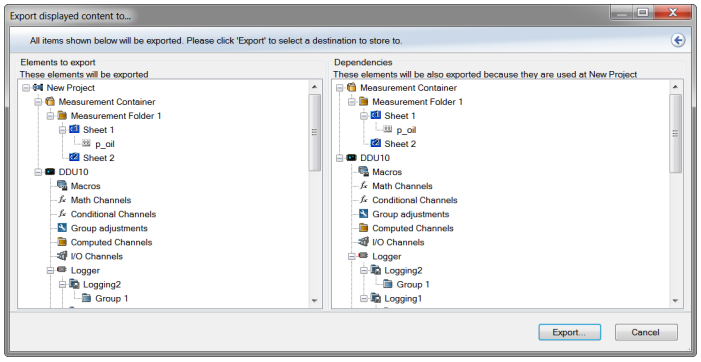
You can perform an export or an import on almost any level in the project tree.

9.1 Export in RaceCon

You can choose to export the whole project or you can export specific parts of the project.

Proceed with the following steps to perform an export:

1. Click with the right mouse button on an item in the project tree.
2. Select 'Export...' from menu. An 'Export Selection' window opens.



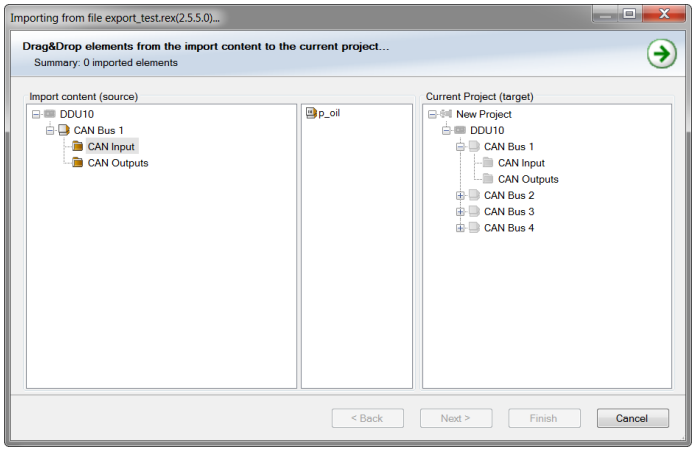
3. Click on 'Export' to select a destination to store.
4. Specify the filename.
5. Click 'Save' when done.

9.2 Import in RaceCon

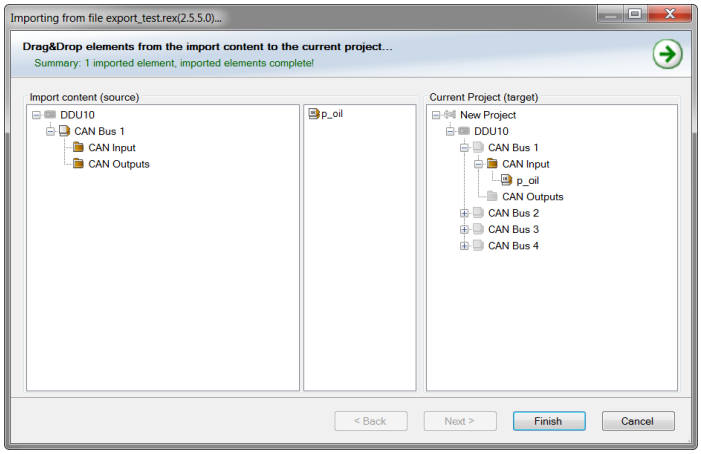
You can choose to import into the whole project or you can import into specific parts of the project.

Proceed with the following steps to perform an import:

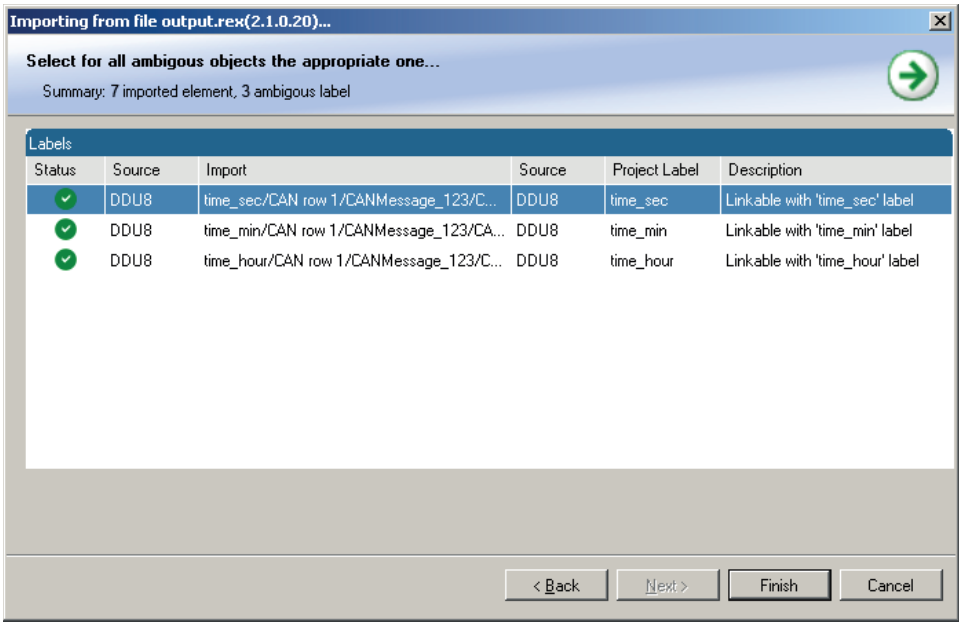
1. Click with the right mouse button on any item in the project tree.
2. Select 'Import...' from menu. A file browser opens.
3. Select the input file and click 'Open'. An 'Import Selection' window opens.



4. Select channels to import.
5. Drag and drop the channel to 'CAN Input' of desired CAN bus on right hand side.



6. Click ‘Finish’. If a measurement channel belongs to more than one source (e.g. MS 7.4 and MS 6), the ‘Solve Label Ambiguity’ window opens.



7. Assign the ambiguous channels to the desired source.
8. Click ‘Finish’.

10 Online Measurement and Calibration

MS 7.4 configuration

- System configuration (channel + display configuration, CAN I/O, etc.) is stored in the MS 7.4
- Use RaceCon to create and download configuration from the PC to MS 7.4 Communication interface: Ethernet
- Communication protocol: XCP

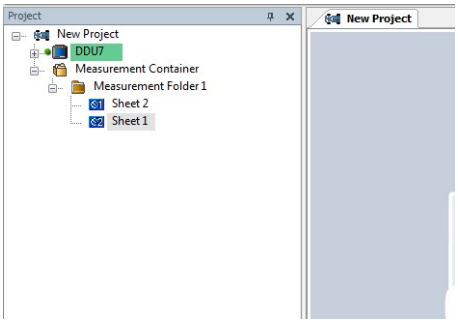
Online Measurement and Calibration

- 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

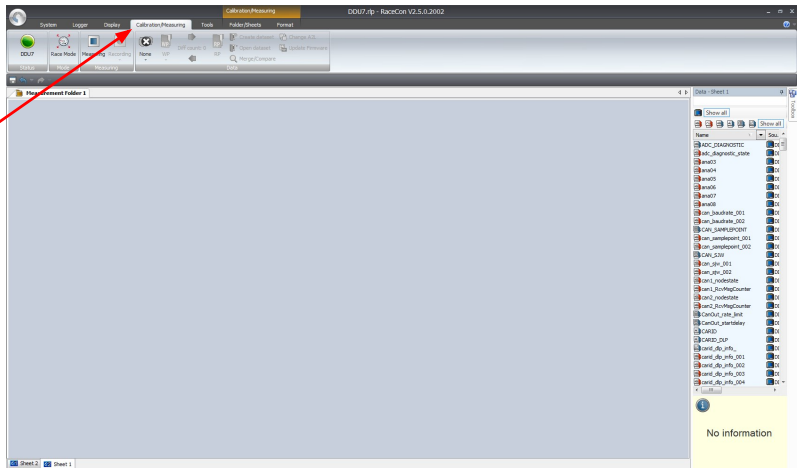
10.1 Setting up an online measurement

MS 7.4 supports online measurement of sensor values and diagnostic variables.

1. Expand ‘Measurement Container’ and ‘Measurement Folder 1’ in the Project Tree and double-click on ‘Sheet1’. Alternatively, click on the ‘Calibration/Measuring’ tab to open the window directly. ‘Sheet 1’ opens in a new ‘Calibration/Measuring’ window.

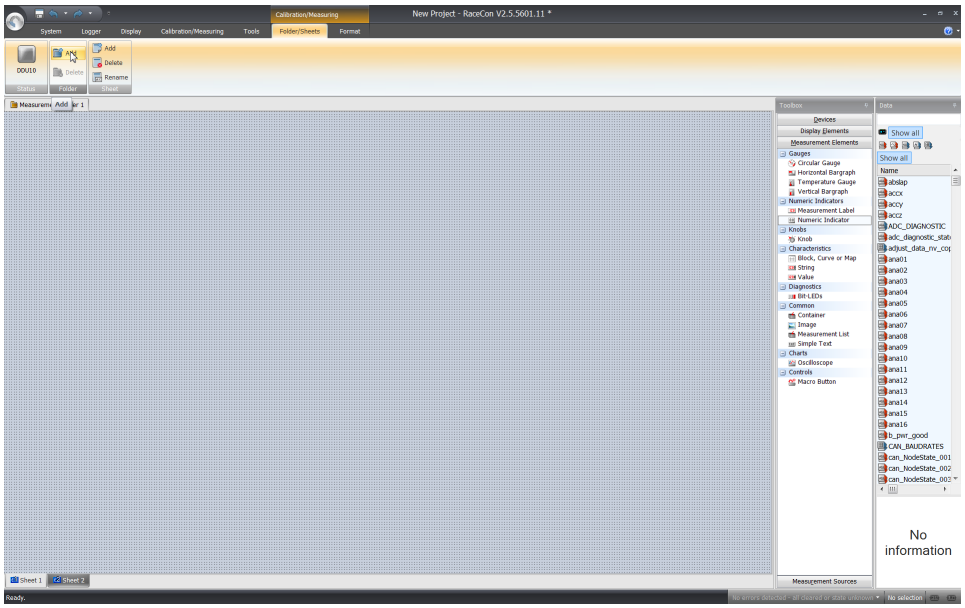


RaceCon changes automatically to "Calibration/ Measuring"



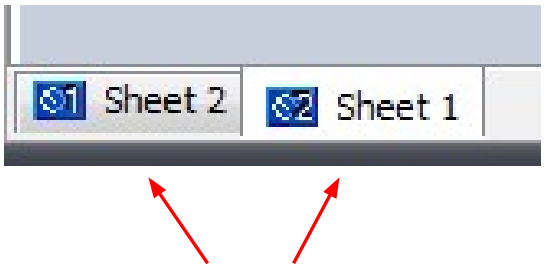
2. Click on the ‘Folder/Sheets’ tab, which appears when you are in the ‘Calibration/ Measurement’ window, to create a new measurement folder.

3. Click on the ‘Add’ button for folders in the upper left corner.



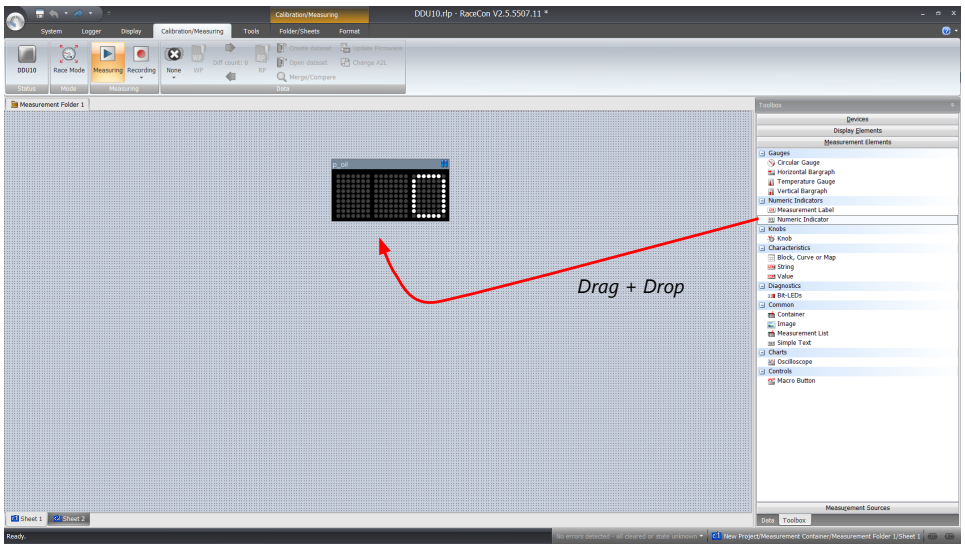
In the menu for sheets, you will find buttons to add, delete and rename new sheets

1. To change between different sheets, click on the tabs on the bottom of the ‘Calibration/Measuring’ window.



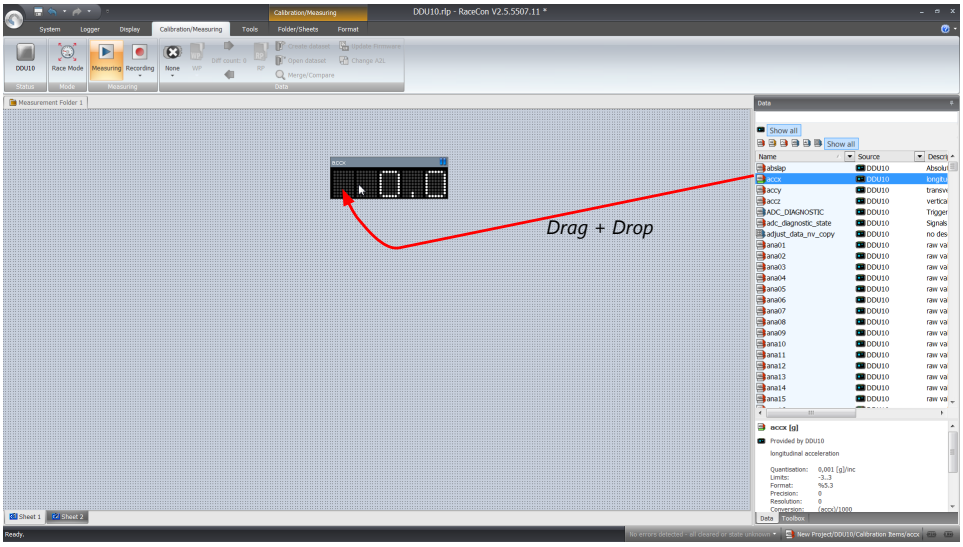
To add an element to a measurement sheet, perform the following steps:

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



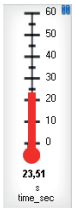
2. Select the desired measurement channel from the ‘Data’ area and drop it on the measurement element.

If the MS 7.4 shows the green status, the value is displayed.

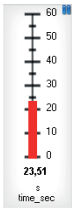


RaceCon offers different types of measurement elements:

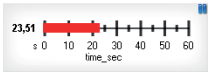
Circular gauge



Temperature gauge



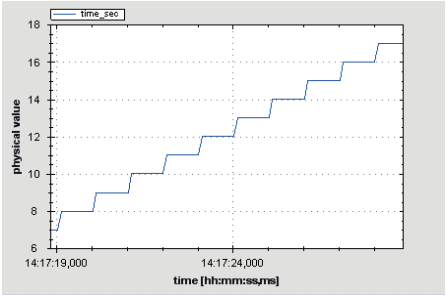
Vertical Bar graph style



Horizontal Bar graph style

Measurement label

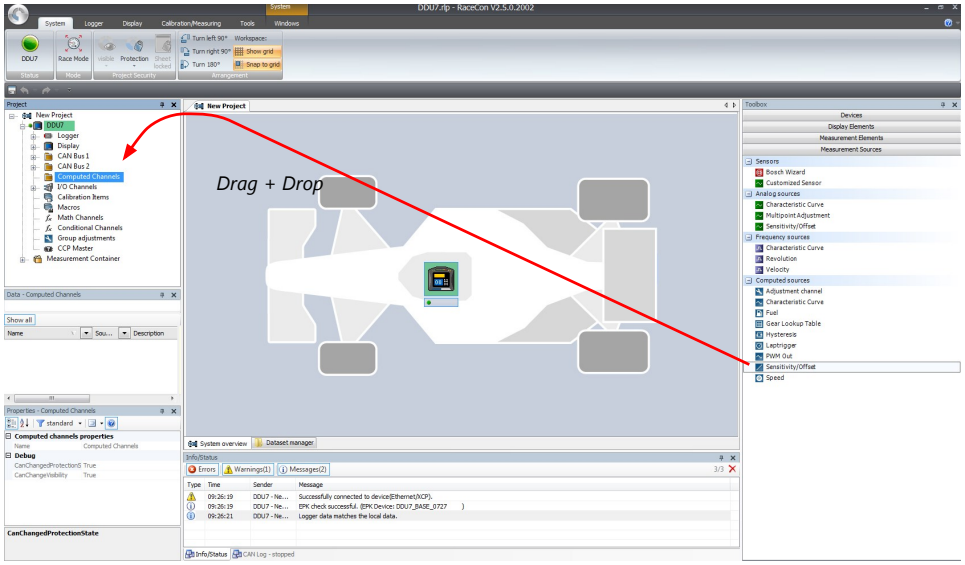
Numeric indicator



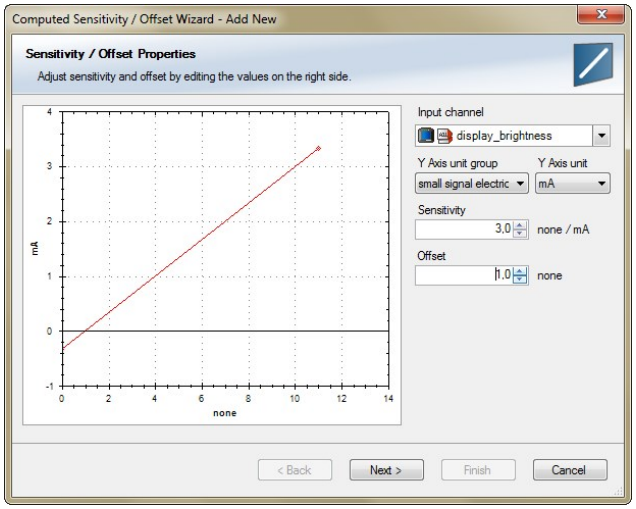
Oscilloscope (Chart)

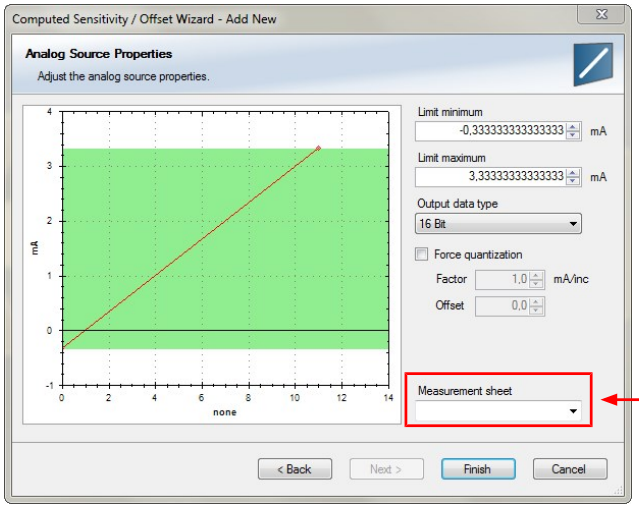
10.1.1 Automatic creation of measurement sheets

RaceCon can create measurement sheets automatically.
You can create and use measurement sheets with the MS 7.4 as well as with all other devices connected to RaceCon.

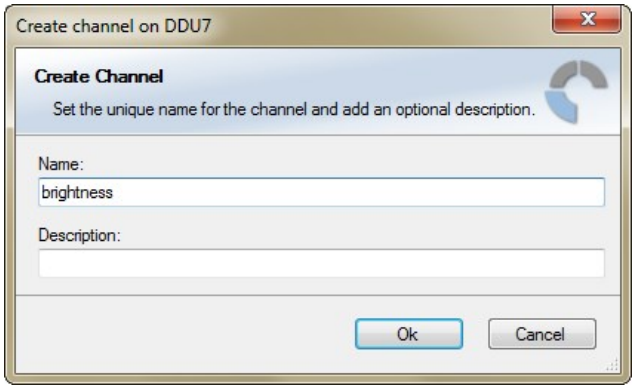


1. During the configuration of a measurement channel, select a measurement sheet from the list box or enter a name for a new measurement sheet.

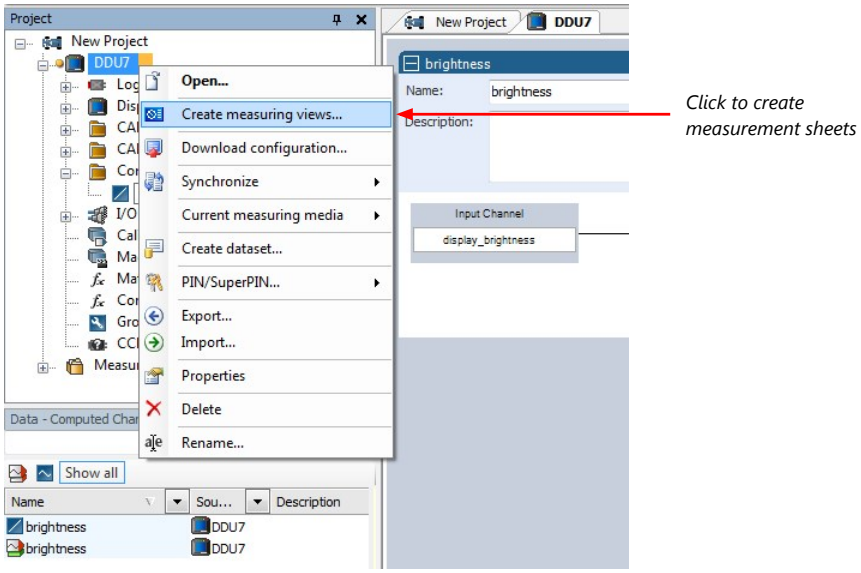




Select existing sheet from list or enter name of new sheet



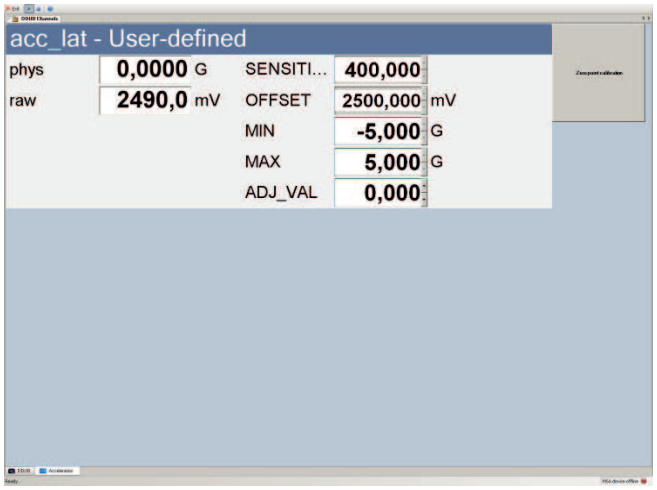
2. To create the sheets, right-click on MS 7.4 and select ‘Create measurement views…’ from the MS 7.4 context menu.



The automatically created sheet is inserted in the Project Tree under ‘Measurement Container’ and ‘Device Channels’. If the MS 7.4 is connected to RaceCon and the status is green, live values of the channels are shown.

10.1.2 Using the measurement sheets

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



10.2 Using the Measurement Sheets

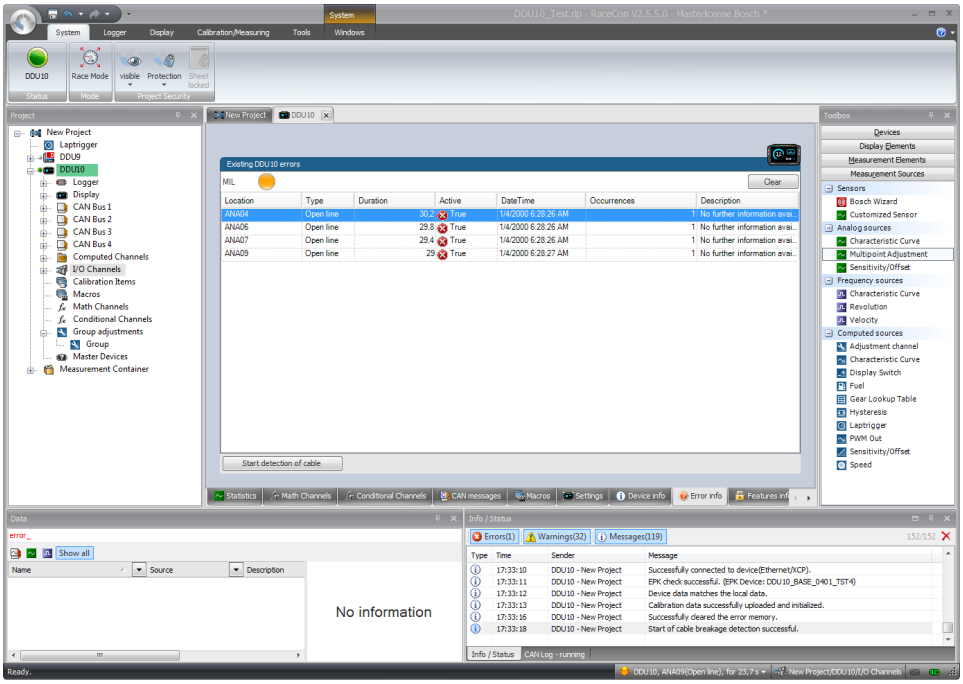
- When RaceCon is online, press “F11” key to switch from Design Mode into Race Mode.
- The measurement sheet is extended to full screen.
- Switch between different sheets using the tabs at the bottom of the page or the keyboard shortcuts associated with the sheets.
- Press ESC key to return to Design Mode.

11 Error Memory

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.

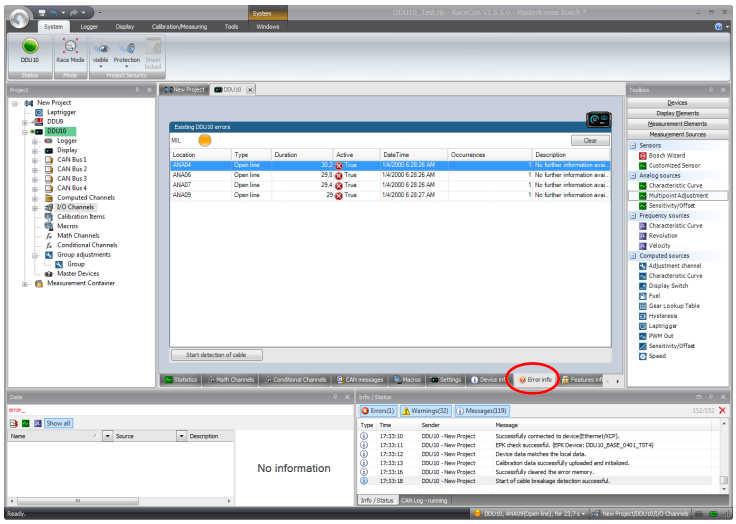
11.1 Error memory representation in RaceCon

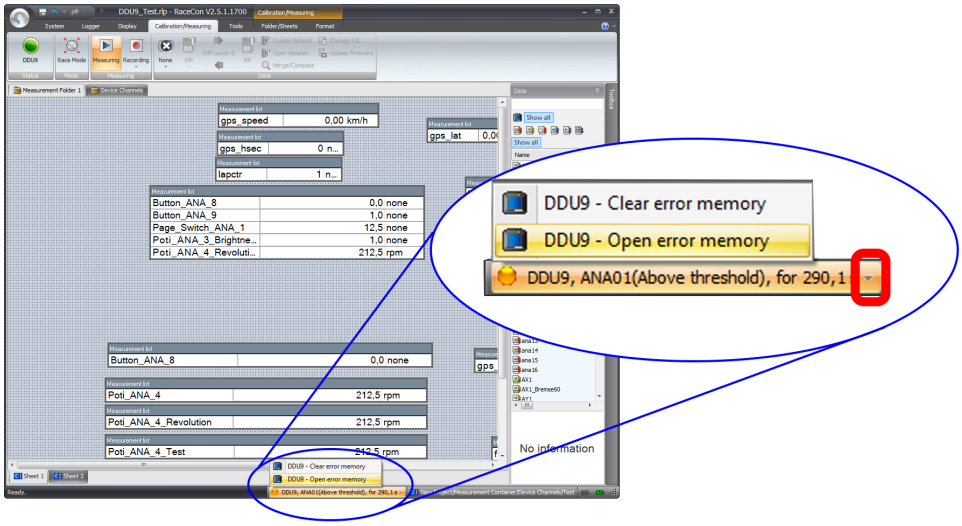
Bosch Motorsport devices feature an error memory. Information on errors can be visualized via RaceCon (online measurement) or can be transmitted via telemetry.



11.1.1 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.

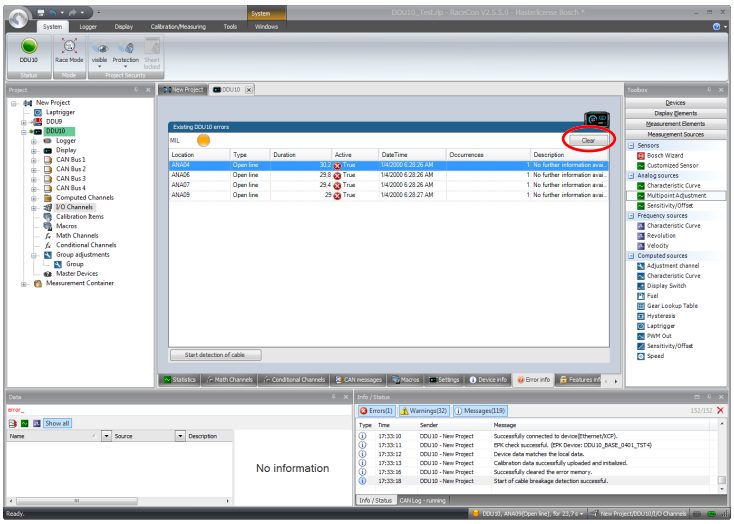
An error is deleted from the list when

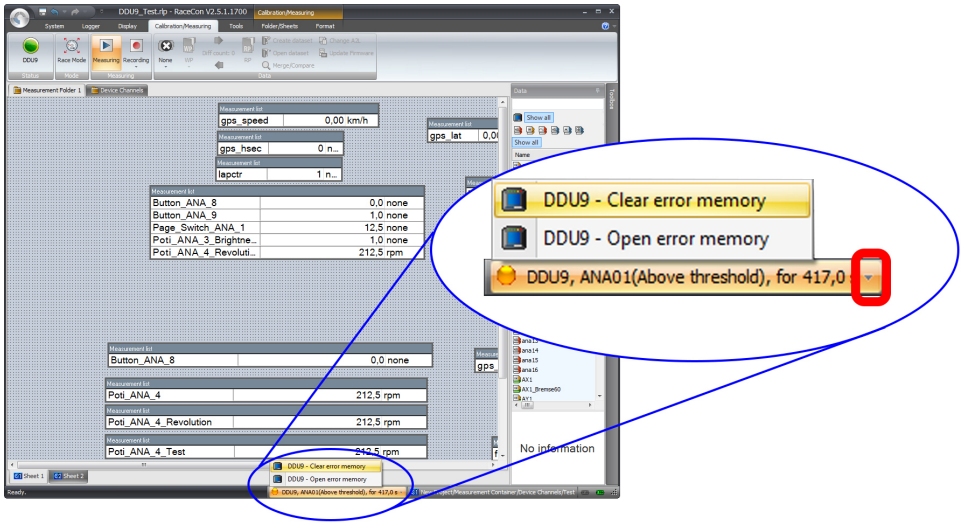
- the user actively clears the error memory
- the user updates the firmware

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

11.1.2 Clearing the error memory

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





11.2 Writing an Error

For the functional part of the MS 7.4 system (MS 7.4 -ECU) the error bits are related to the function and have to be distinguished if the function is activated. If an error is detected, the information may be shown as part of the error monitor in RaceCon, as display information and as measure channel. To support driver visibility, an activated error may activate also an output to enable the MIL-light (B_mildiag will be enabled).

CW_EM_xxx	Individual error related to a function
0	Error will not be stored in the monitor
1	Error is stored in the monitor
2	Not valid
3	Error is stored in the monitor and the MIL condition is switched on

The single error bits may be collected in the error monitor.

11.3 Error Memory Properties

The following property is available for the error memory itself.

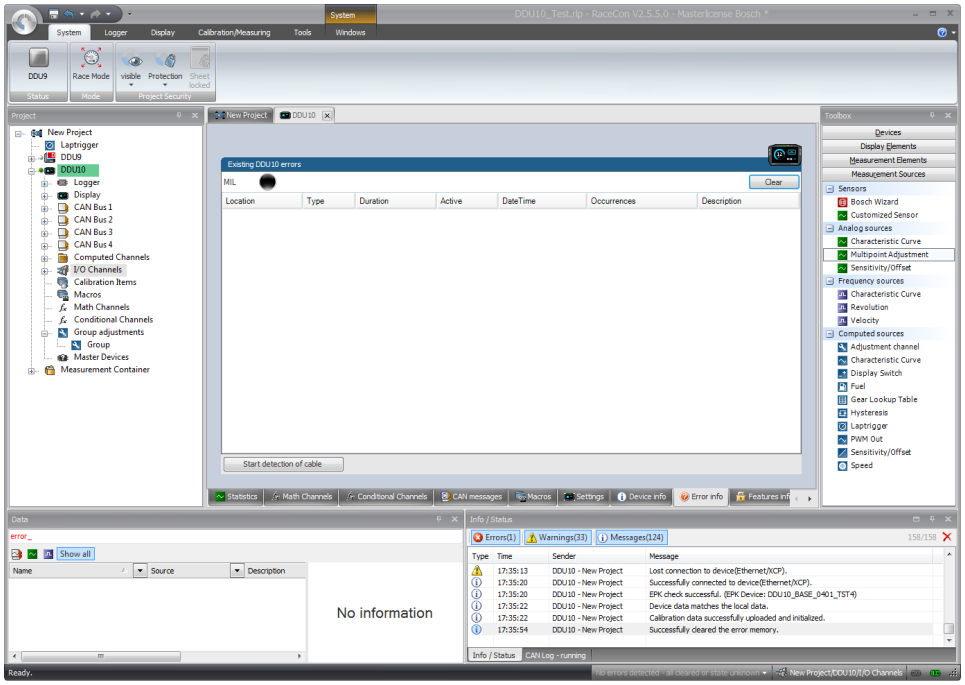
CLRERRMON	Reset of the error monitor
Error Status /device measurement label error_state	
0	No error present in the memory
1	At least one inactive error present in memory, no active errors
2	At least one active error present in memory

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

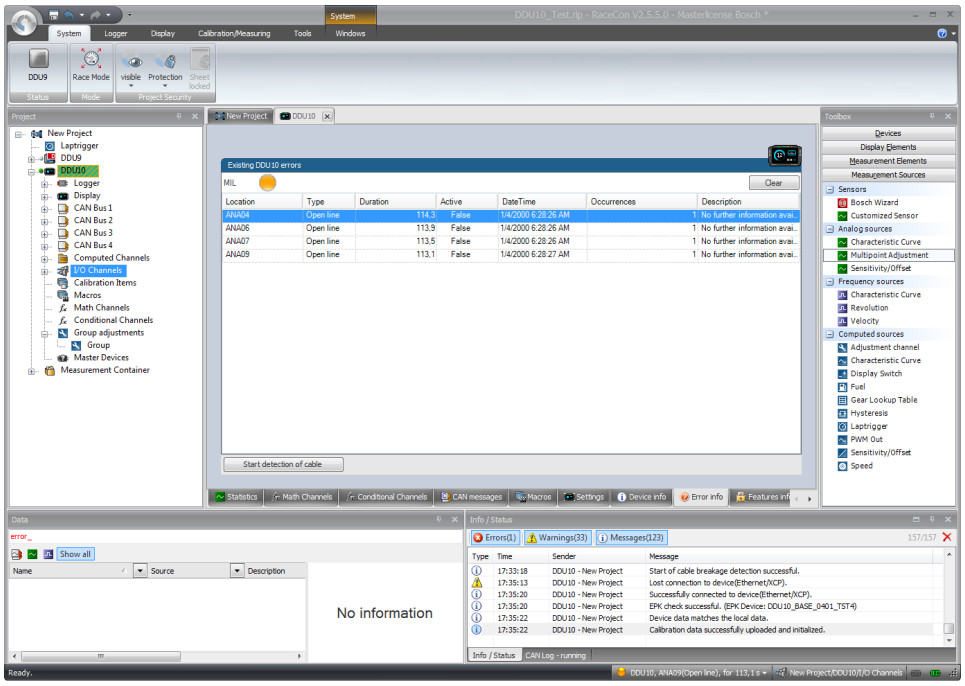
Measurement list	
CLRERRMON	TRUE
error_state_MS7-ECU	Active error(s) present
error_state_MS7 Logger	Active error(s) present

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

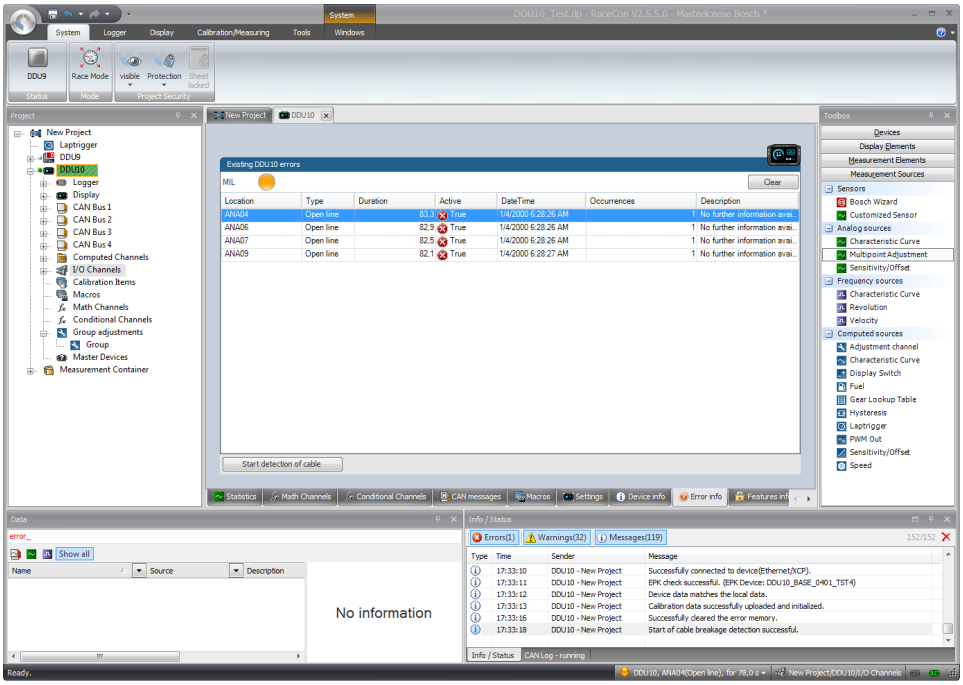
0 (no error present in memory)



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



2 (at least one active error present in memory)


Existing DDU10 errors
MIL
Clear
Location
Type
Duration
Active
DateTime
Occurrences
Description
ANA04 Open line 83.3 True 1/4/2000 6:28:26 AM 1 No further information avai...
ANA06 Open line 82.9 True 1/4/2000 6:28:26 AM 1 No further information avai...
ANA07 Open line 82.5 True 1/4/2000 6:28:26 AM 1 No further information avai...
ANA09 Open line 82.1 True 1/4/2000 6:28:27 AM 1 No further information avai...
Start detection of cable
No information

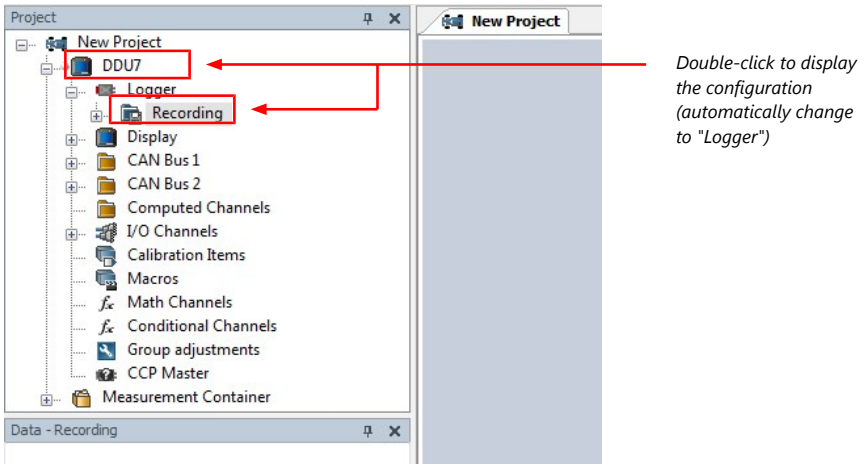
12 Recording

12.1 Features

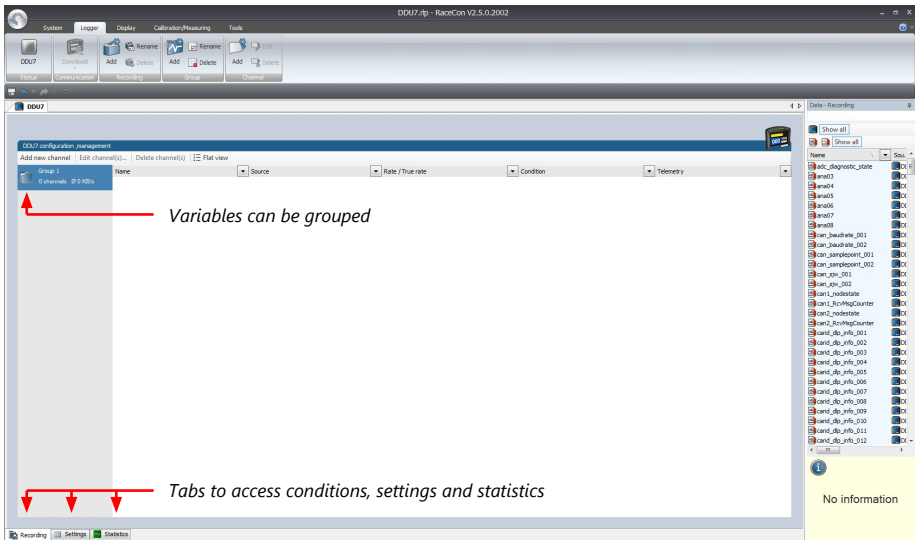
- Synchronized recording of MS 7.4 analog and digital input channels, MS 7.4 internal measurement channels, ECU data, Data from external sensor interfaces
- Up to two independent recordings
- Measurement rate 1 ms to 1 s
- Two global start conditions (thresholds)
- Up to 16 measurement conditions (fast-slow-switches)

12.2 Configuration of recordings

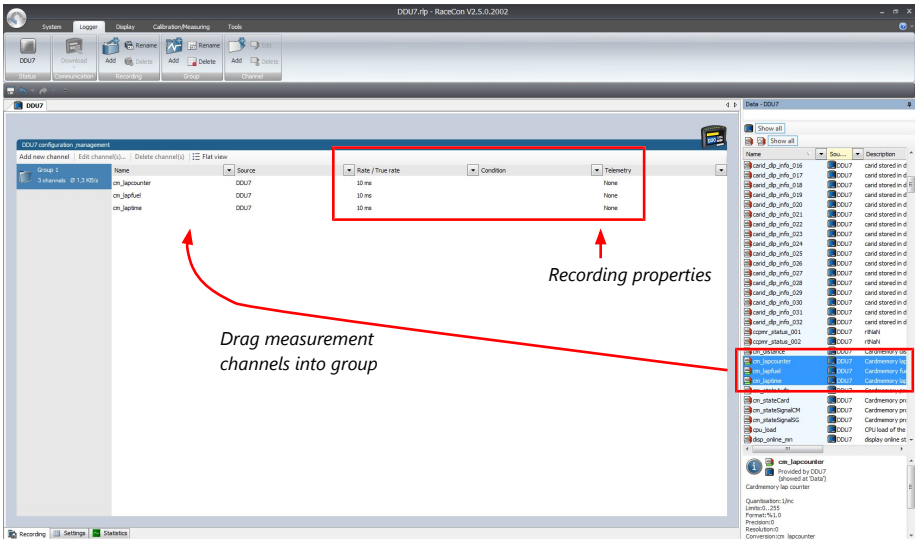
1. Expand the list of 'Loggers' by clicking on '+' in the MS 7.4 Project Tree.



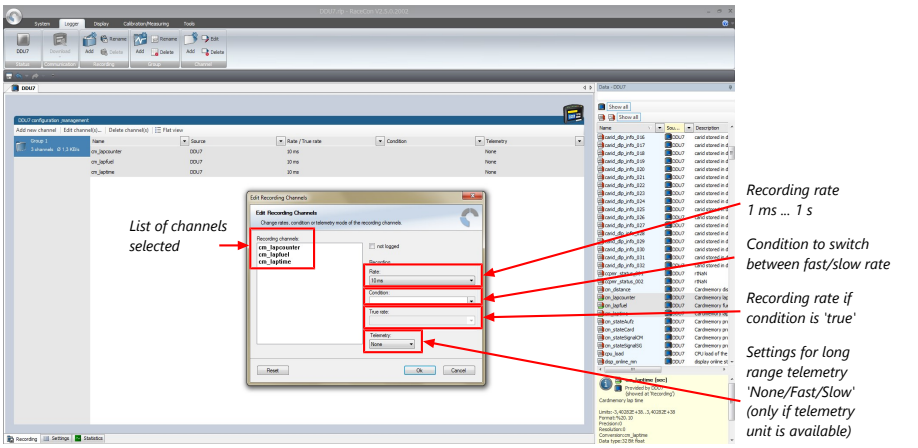
2. Double-click on 'Recording' in MS 7.4 Project Tree. The recording configuration is displayed in the Main Area.



3. To add measurement channels to a recording, click 'MS 7.4' in the MS 7.4 Project Tree. In the Data Area, the measurement channels are displayed.
4. Drag and drop desired measurement channels into recording group.



5. To edit channel's settings, mark the channel(s) and click 'Edit Channel'. An 'Edit Recording Channels' window opens.



6. Click 'OK' when done.

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'.

Using fast block/slow block transmission

MS 7.4 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).

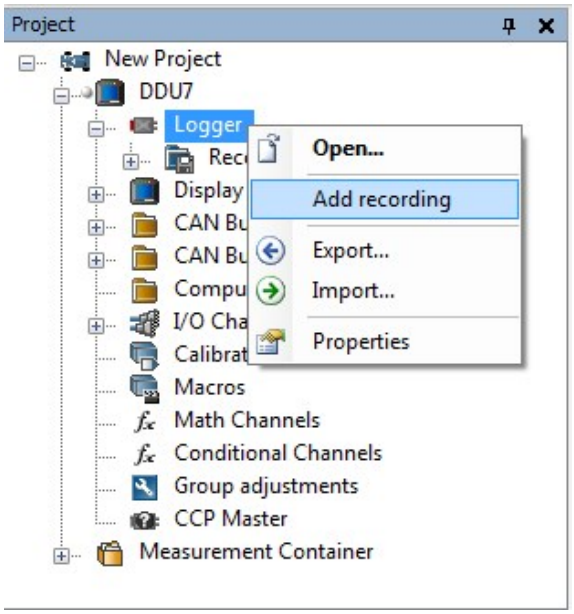
Transmission Scheme

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 [▶ 90]' for more information.

12.2.1 Adding a recording

MS 7.4 supports up to two independent recordings.

To add a recording, select 'Add Recording' from the context menu of the Logger in the MS 7.4 Project Tree.

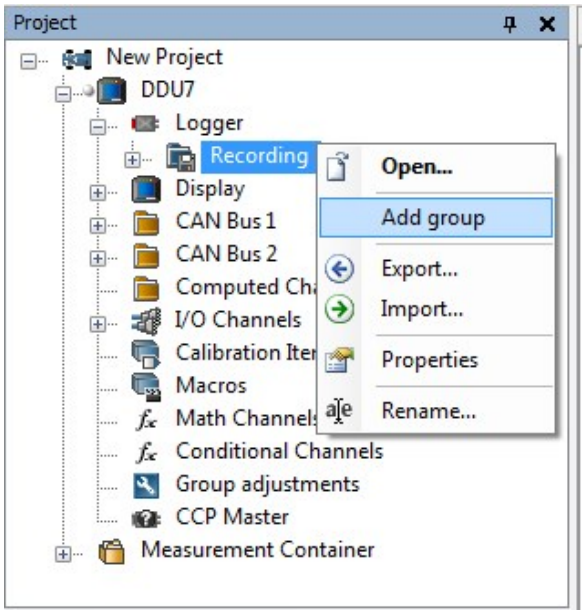


Maximum two recordings are possible. In the device software the 2nd recording is reserved for scruteneering data. This recording is invisible (protected).

12.2.2 Adding a recording group

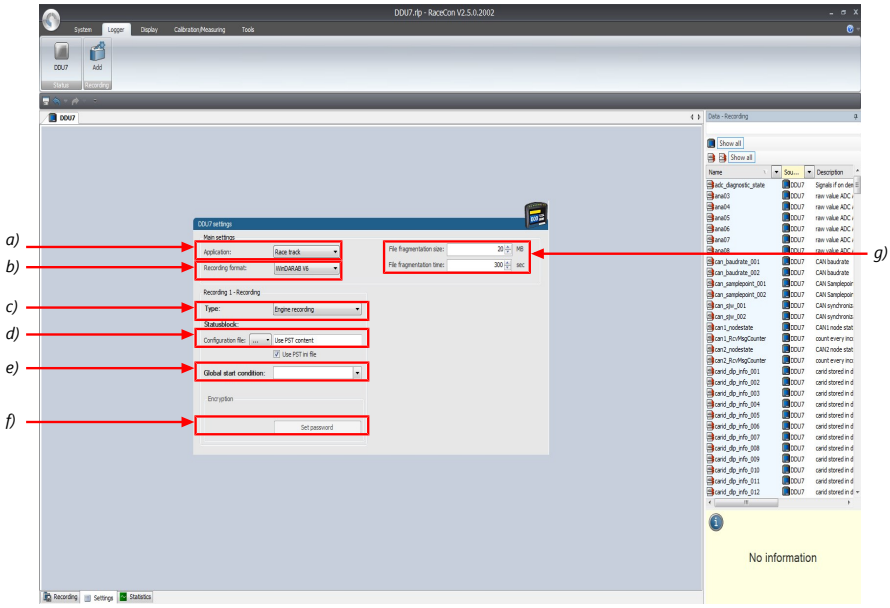
Recording channels can be grouped.

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.



12.2.3 Global settings

To display the global MS 7.4 settings, select the 'Settings' Tab.



a) Choose setting for outing counter mode:

- For testbench (without lap trigger) select 'Testbench'.
- For racetrack (with lap trigger) select 'Racetrack'.

b) Choose your WinDarab version. In V6 the file is encrypted by WinDarab. In V7 you can enter an optional self created password in the 'Encryption' field shown in f).

c) Recording Type (Engine or Chassis).

d) Statusblock configuration file for custom Statusblock definition.

e) Choose or create the condition to start recording.

f) If selecting WinDarab V7 in b), enter a password hint and a password (optional).

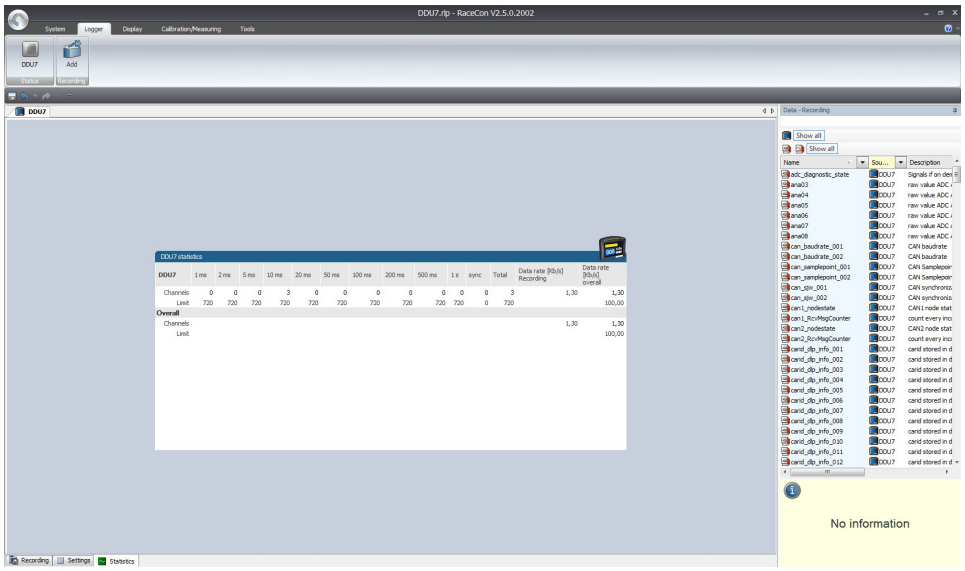
g) Setting for automatic fragmentation. Do not change!

12.2.4 Recording statistics

The tab ‘Statistics’ shows the channels’ allocation and their current data rate related to the transmission frequency of the MS 7.4 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 MS 7.4 and limits the overall transmission speed.



12.2.5 Recording diagnosis

The channel ‘statectrl_ok’ of the MS 7.4 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	-

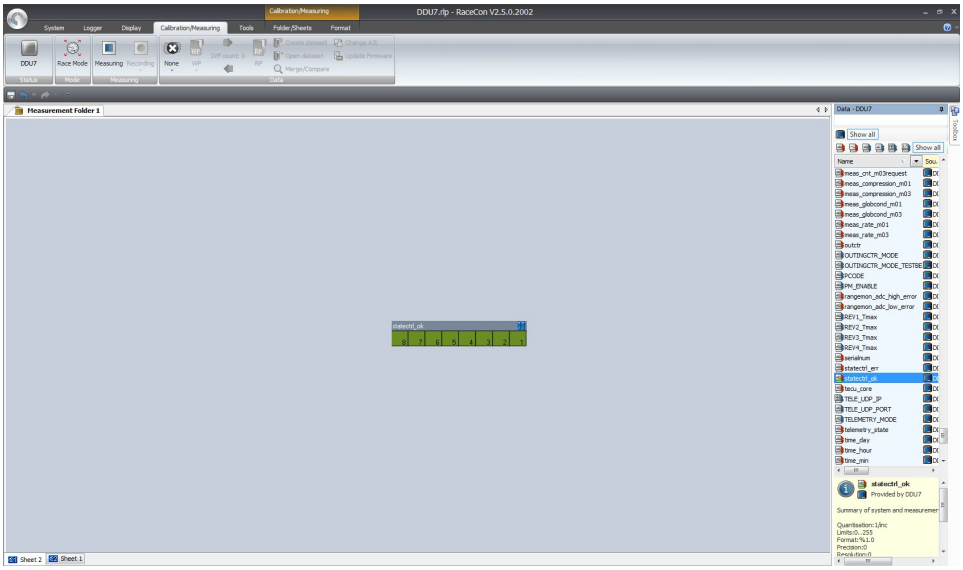
Content of status bits

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.

Name	Bitset	Bit cleared
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.

12.2.6 Displaying online recording diagnosis ('statectrl_ok')

1. To add a Recording Diagnosis element to a measurement sheet, change to page “Calibration/Measuring“ and 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, MS 7.4 is recording data: 255
- Values less than 254 indicate an error state
- ‘statectrl_ok’ can be linked to an alarm on the display. See chapter ‘'Alarm' display element’ for details.

12.2.7 Further measurement labels

These additional measurement labels may help you diagnosing the state and operation of the data logging in more detail. There are a few more, but these are usually enough. Please refer to statectrl_ok, mentioned in more detail in chapter 'Recording diagnosis'.

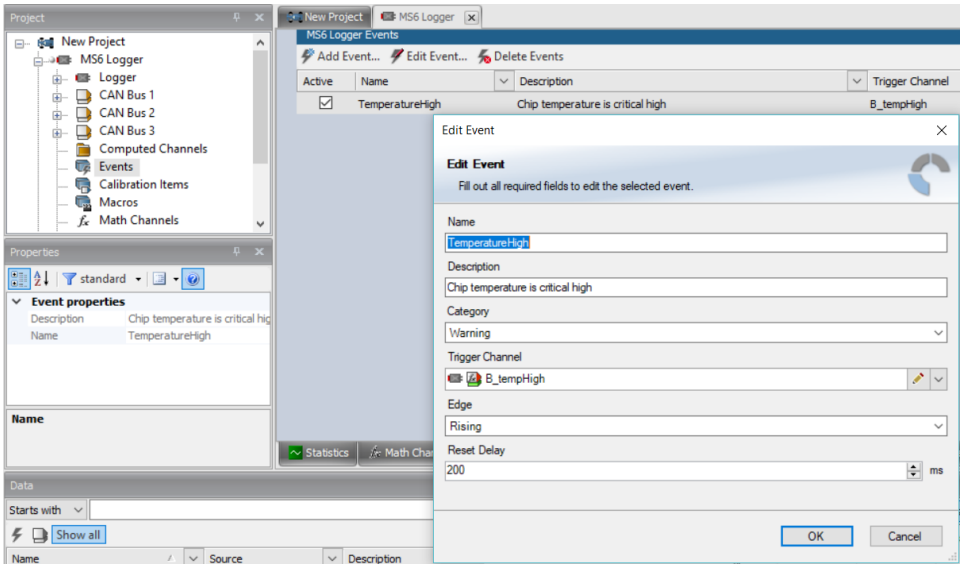
Measurement label	Function
card_part1_size	Size of the first logging data partition in MB.
card_part2_size	Size of the second logging data partition in MB. Attention, second logging can also be stored on first partition, depending on chosen settings (Logger -> Settings).
ftp_UserLoggedIn	This measurement allows to monitor for active FTP connections. RaceCon (WinDCP) and WinDarab may not connect in parallel.
meas_globcond_m01 / _m03	State of the global logging start condition for first / second logging. TRUE means data is actively recorded.
meas_rate_m01 / _m03	Incoming measurement data rate (first / second logging) for further processing. Does not include compression. Active when meas_globcond_m0x is TRUE but may also be active while meas_globcond_m0x is FALSE, if a pretrigger time is configured. In that case data is transferred to the pretrigger buffer, but not necessarily written to storage medias.
meas_cnt_ecu / _fde	Processed data blocks for first / second logging. This does not ensure writing the data to a storage media, e.g., if pretrigger is configured and meas_globcond is FALSE.
meas_cnt_int / _forked	Processed data blocks per media (internal / USB).
meas_compression_m01 / _m03	Compression factor for first / second logging. For example, factor 2.0 means incoming data can be reduced to half the size, before data is written to storage medias.
meas_pretrig_buf_size_ecu / _fde	Size of data buffered in pretrigger, e.g., while global logging condition is FALSE. Data will be forwarded to storage medias when logging condition becomes TRUE.
meas_backend_buf_size_ecu / _fde	Size of data buffered (for first / second logging) for processing by different storage medias (intern / USB). It is possible, that e.g., internal storage has processed the data already, while USB is still busy writing the data blocks. Data is removed from the buffer as soon as all medias have processed it.
meas_write_rate_intern_001 / _002	Effective data write rate to internal storage media, after compression, for first / second logging.
meas_write_rate_usb_001 / _002	Effective data write rate to USB storage media, after compression, for first / second logging.

12.3 Event logging

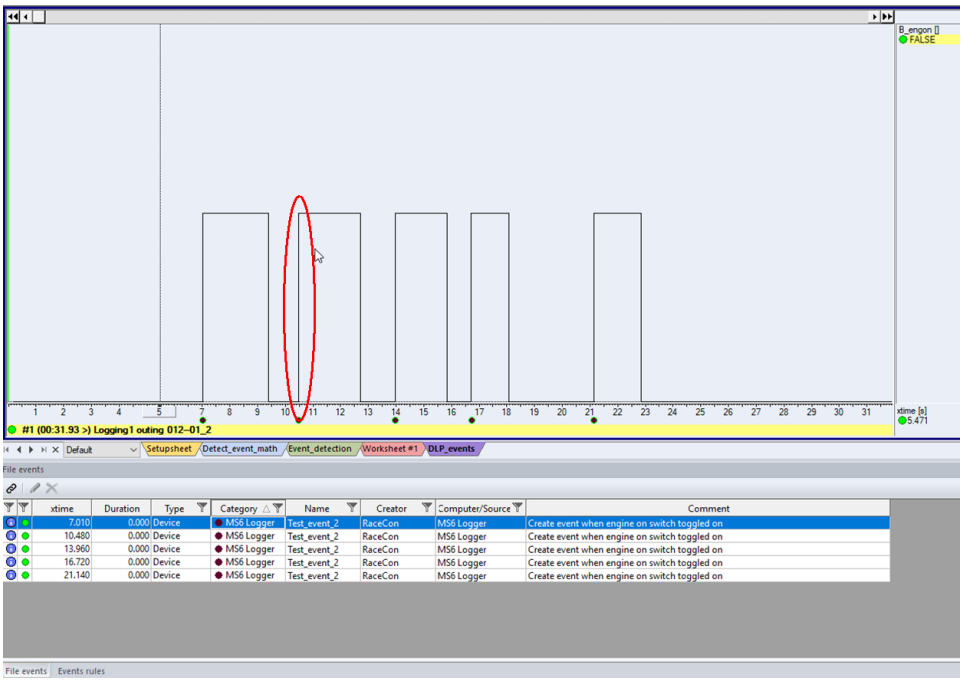
Event Logging implements the possibility to observe a channel if short spikes are expected. With Event Logging, every occurrence of a user defined threshold (more complex conditions are possible) leads to an event being raised. It is listed in a table along with its time stamp, its ID and even with a text string freely definable in RaceCon.

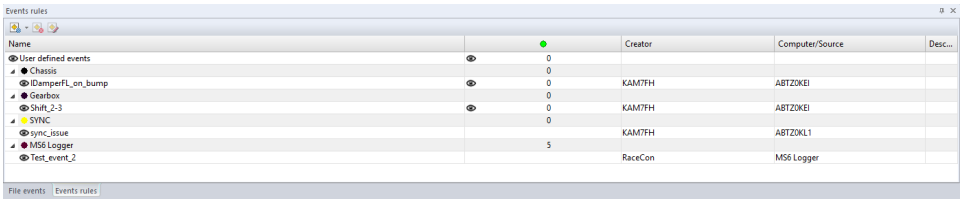
Events are stored as text in logging data and displayed in WinDarab like Darab-Events. Possible use cases are error entry, etc.

Configuration in RaceCon:



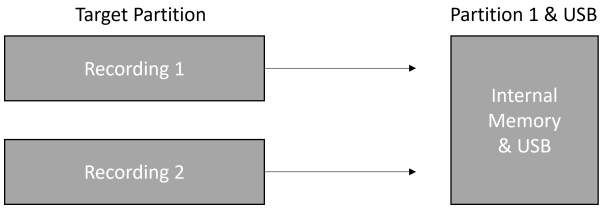
Display in WinDarab:





12.4 Data Logger and USB recording

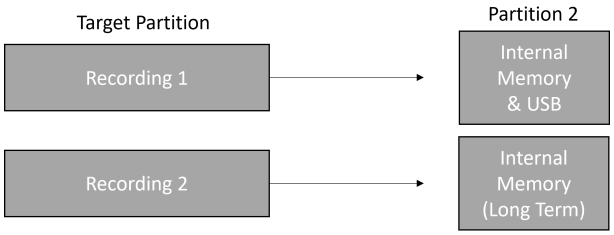
Default settings:



Data from **Recording 1** and **Recording 2** are stored both into the Internal Memory and additionally on the USB stick in copy.

To download the data from the Internal Memory of the logger, the Data Logger must be selected in WinDarab and the data will be downloaded in parallel.

Alternative setting:



Recording 1 is stored on the Internal Memory and additionally on the USB stick in copy. To download this data, the Data Logger must be selected in WinDarab.

Recording 2 is stored on only the Internal Memory. To download this data, the Long Term logger must be selected in WinDarab.

12.5 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 DATA_USB enables USB recording. To activate Software Upgrade DATA_USB, enter the license key as described in the chapter 'Feature activation' [▷ 41].

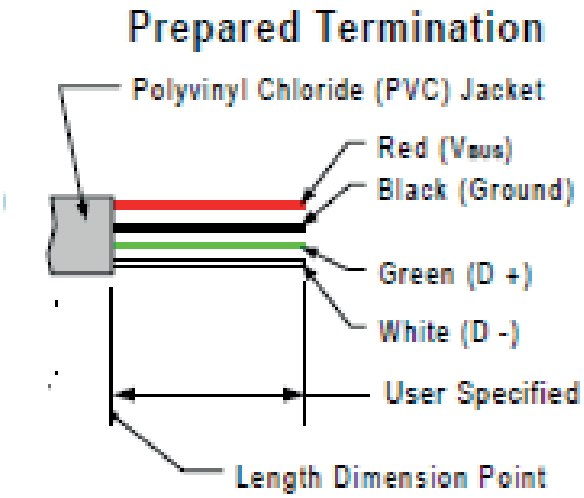
For USB recording, Software Upgrade FULL_LOG_1 should also be enabled.

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 must 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:

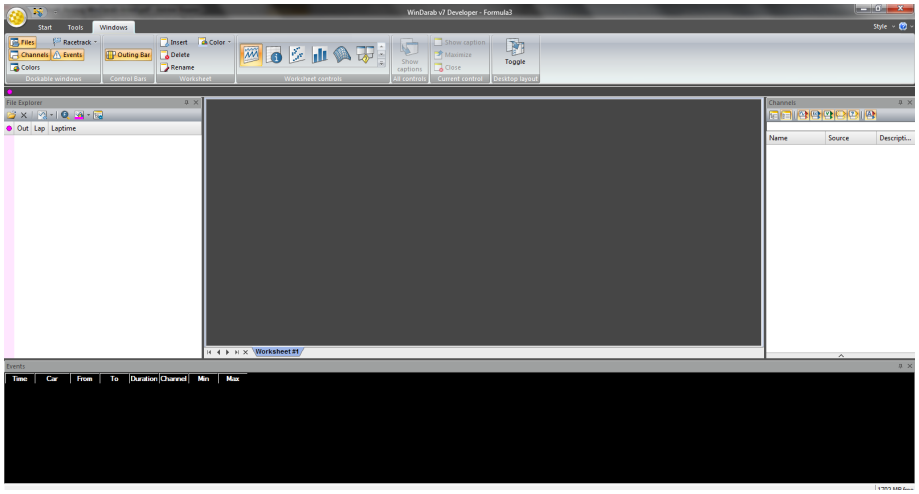
In RaceCon, select 'Tools' - 'Extras' and choose 'Format USB stick'.

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.

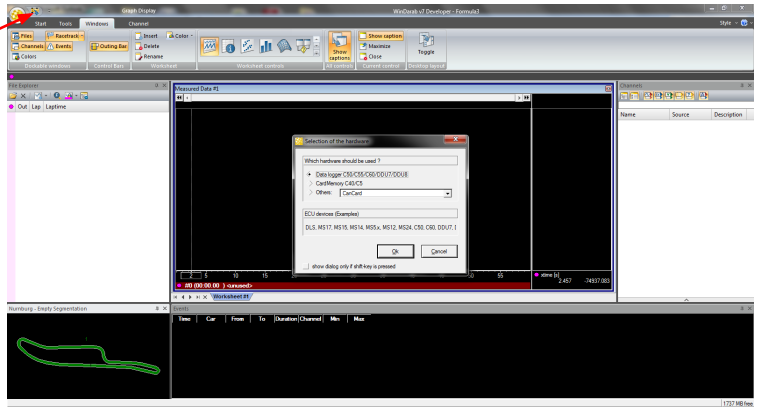
12.5.1 Recording data on USB device

1. Plug an USB device to MS 7.4.
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 MS 7.4.
5. Record measurement data. If an USB device is present, the MS 7.4 stores the data in parallel on the internal memory and the USB device.
6. Power off the system.
7. Remove USB device from the vehicle.
8. Start the WinDarab software.

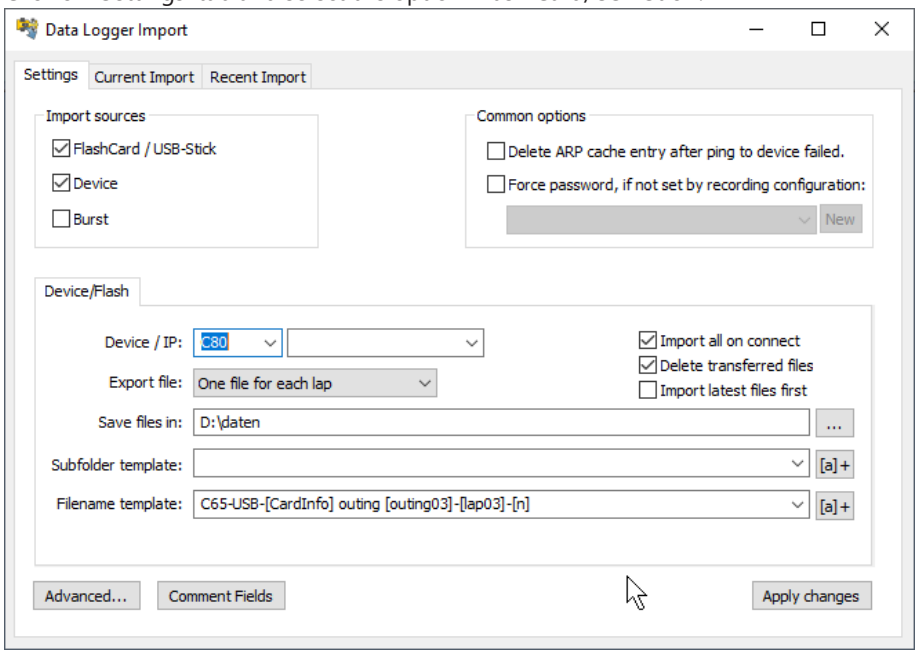


9. Click on the ‘Import/Export’ icon.
10. Select ‘Data logger CXX/DDUX/MSX and click ‘OK’ when done. The ‘Read measurement data’ dialog opens.

Click 'read data from logging device'

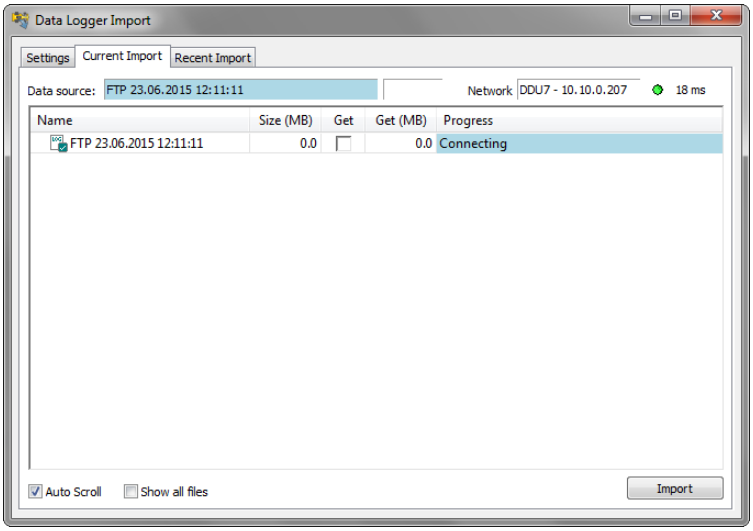


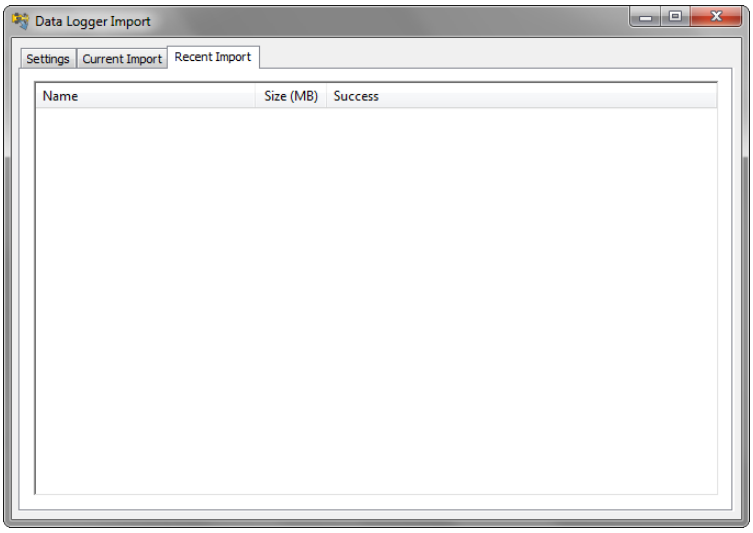
11. Click on ‘Settings’ tab and select the option ‘Flash Card/USB Stick’.



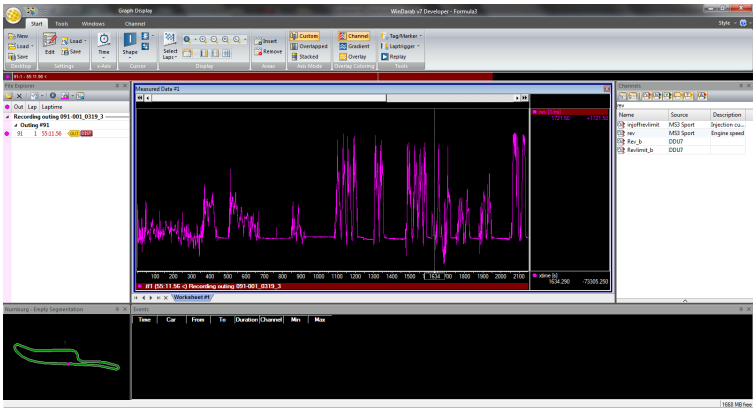
12. Activate ‘Apply changes’.

    Insert the USB device into the PC. Data transmission from device starts automatically. Measurement files are stored automatically in the base folder.





13. Click ‘Close’ when transmission has finished.
14. Click on the Start button and choose ‘Open measurement file’.
15. Select the measurement files from the storage folder.
16. Click on ‘Open’.
17. Click in ‘New Desktop‘ to open a new measurement data window.
18. Drag the desired measurement channel from the Channel list and drop it into the measurement data window. The measurement channel‘s graph is displayed



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

12.5.2 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 MS 7.4 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!

12.5.3 Troubleshooting

When no data on the USB device is recorded:

Configure the measurement label **usb_mediastate** on a RaceCon measurement view or on a MS 7.4 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!
4: Stop: Device unplugged	The USB device has been removed. The MS 7.4 performs a restart when an USB device is re-plugged in.
5: Error: Media error	The communication to the USB device broke down. The USB device is defect. The USB device is not supported by MS 7.4.
6: Error: Media corrupt	The USB device is not in valid BFS format. (Hint: Re-format the USB device in RaceCon.)

13 Lap Trigger

13.1 Lap trigger (timing beacon)

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

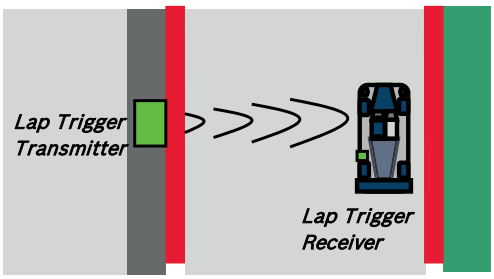
- Vehicle lap time measurement
- Calculation of lap-dependent functions (lap fuel consumption, min/max values)
- Calculation of lap distance dependent functions
- Control of data logging system

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)



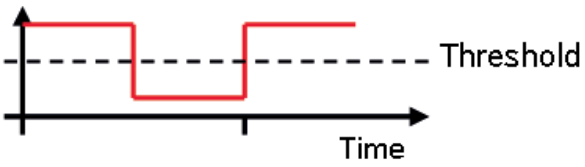
13.1.1 Electrical trigger signal

In MS 7.4 all sources of measurement channels can be used as trigger signal.

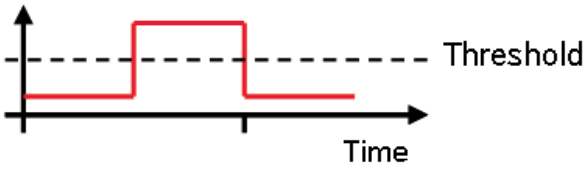
- Analog input
- Digital input
- CAN input

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)

13.1.2 GPS Lap trigger

The GPS lap trigger uses a GPS signal to trigger the lap timer. To function this timer an external GPS sensor (see GPS Sensor [▶ 114]) has to be connected to the device and a detection point with a detection range has to be defined in RaceCon.

The GPS detection point is defined by the latitude and longitude. The easiest way to get the latitude and longitude of a finishing line is due to a web mapping program such as google maps. With google maps, simply left-klick on the spot where you want to set the detection point. The information about the latitude and longitude will show up, in general the latitude is given at first. You should insert at least five decimal places for sufficient precision.

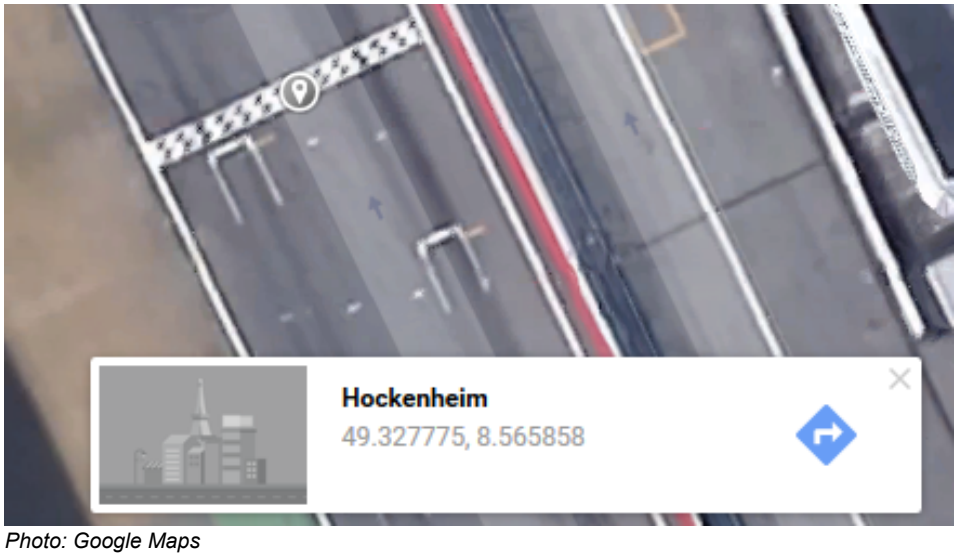


Photo: Google Maps

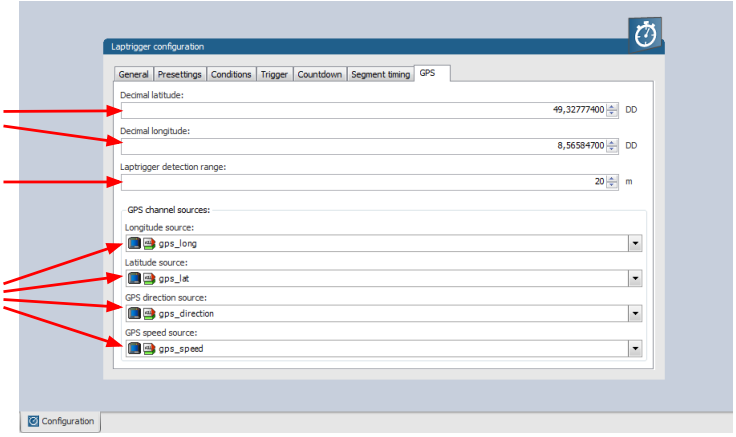
The detection range defines the radius of a circle around the detection point in which the lap trigger can be set. The lap trigger will be set as soon as the distance between the car and the detection point has reached its smallest peak. By this function an imaginary finishing line is calculated inside of the detection circle.

The imaginary finishing line can only be calculated if all channel sources are defined correctly. The latitude and longitude channel sources are mandatory for the functionality. Missing direction or speed source lowers the precision of the system.

Define the latitude and longitude of the GPS detection point.

Define the detection range around the detection point.

Define the channel sources for Longitude, Latitude, Direction and Speed.



Note

The configuration of the sensor update rate and the detection range must insure to receive a valid GPS point in the detection range, despite the occurring vehicle speed near the detection point.

13.1.3 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 Home Straight.
- Lap distance based retrigger protection prevents false triggers due to track topology.

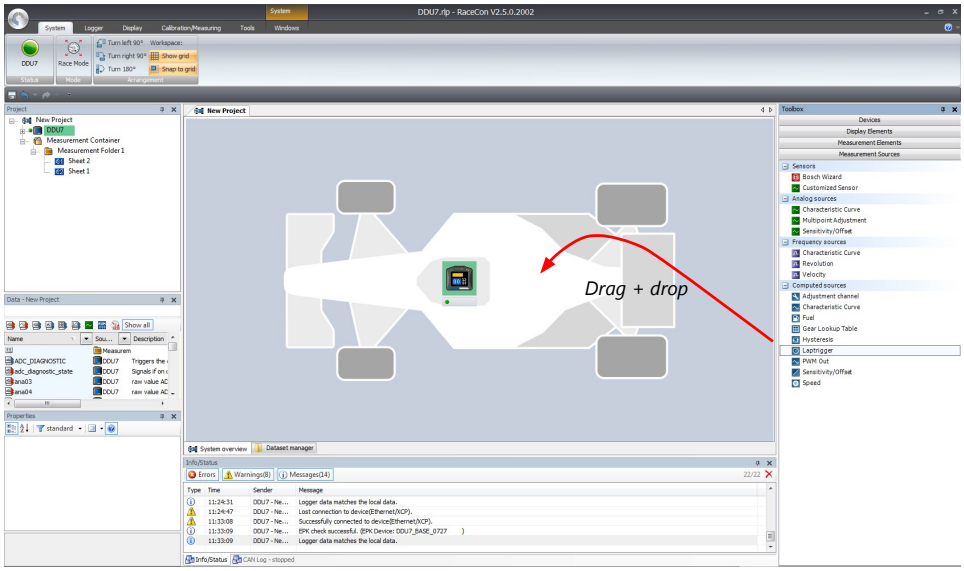
13.1.4 Forced triggers

Lap distance based insertion of ‘forced trigger‘.

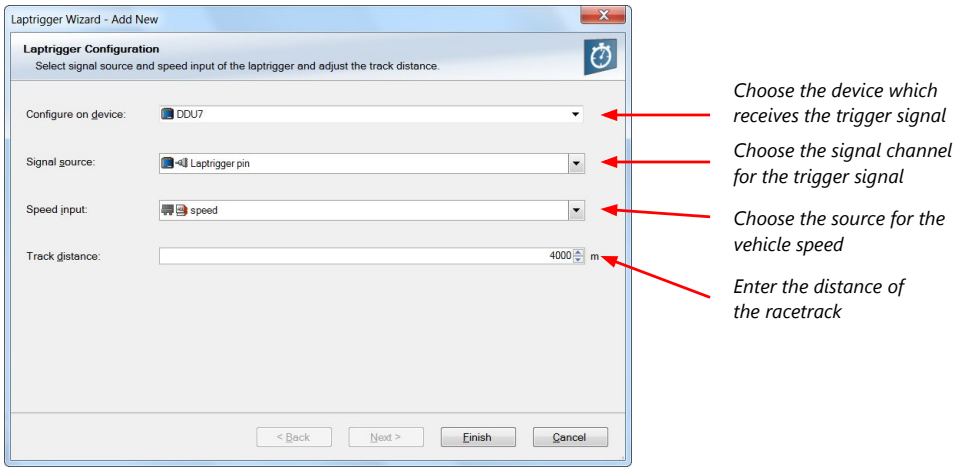
Under race conditions, trigger signals are sometimes missed. Software functionality introduces ‘forced trigger‘.

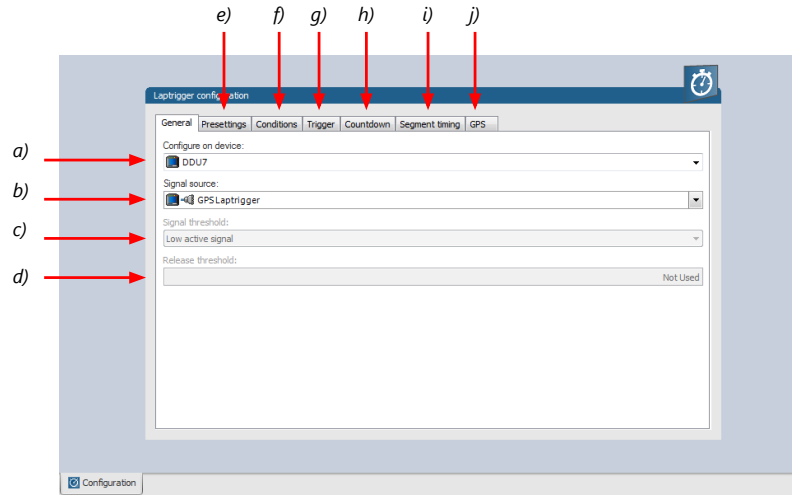
13.1.5 Setting up a lap trigger

1. Click ‘Measurement Sources‘ in Toolbox.
2. Drag ‘Laptrigger‘ into ‘System Overview‘. Do not drop it on ‘MS 7.4‘!



A ‘Laptrigger Wizard‘ window opens.





a) Change signal device, if desired.

b) Change signal channel, if desired.

c) Choose signal threshold. See chapter 'Electrical trigger signal' for details.

d) Define threshold of input channel signal when trigger is released. Only possible, if no digital source is selected as signal source.

e) Define presettings for trigger. See chapter 'Lap trigger presettings' for details.

f) Define condition settings; change signal for vehicle speed, define speed settings. See chapter 'Distance based retrigger protection' and 'Distance based forced trigger' for details.

g) Define settings for main trigger. See chapter 'Lap timing' for details.

h) Define settings for counddown timer. See chapter 'Countdown timer' for details.

i) Define settings for sub trigger. See chapter 'Segment timing' for details.

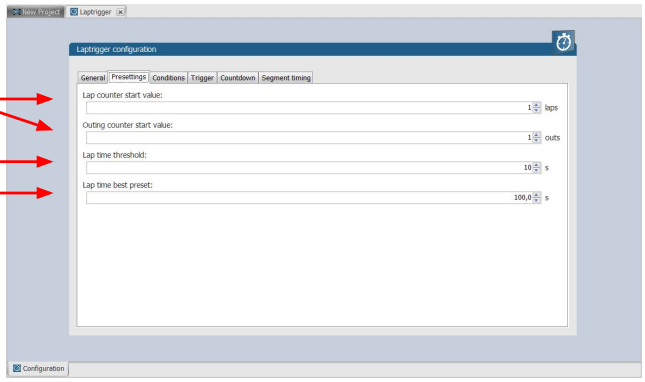
j) Define settings for a GPS lap trigger. See chapter 'GPS lap trigger' for details. Only applicable if the signal source is set to 'GPS lap trigger'.

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

Preset values for lap counter and outing counter

Minimum laptime that a new 'best laptime' is accepted

Preset value for 'best laptime'

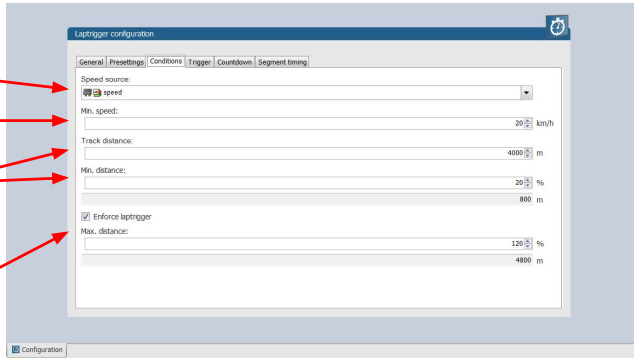


Change signal for vehicle speed, if desired.

Enter minimum speed for trigger release.

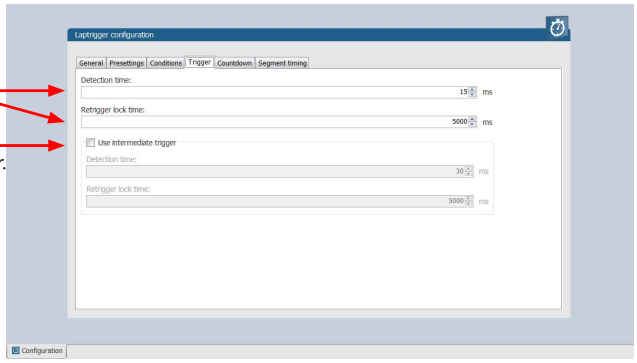
Define settings for distance based retrigger protection.

Define settings for distance based forced trigger.

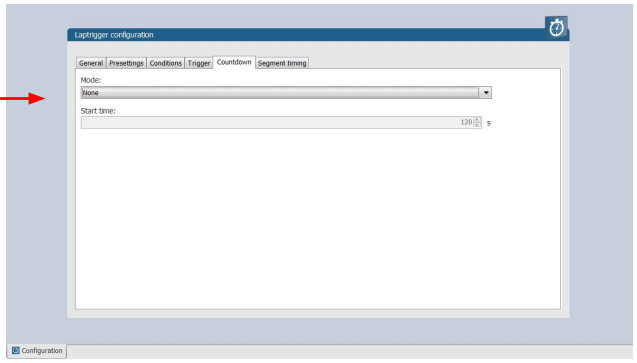


Define settings for lap timing (main trigger).

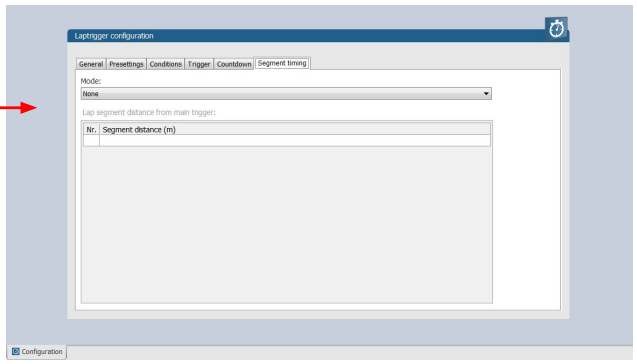
Define settings for sub trigger. Not applicable with a GPS lap trigger.



Define settings for countdown timer.



Define settings for segment timing.

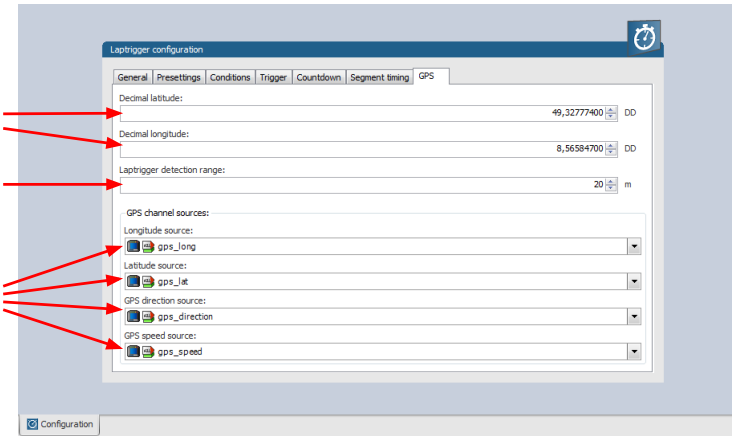


Only applicable for a GPS Laptrigger

Define the latitude and longitude of the GPS detection point.

Define the detection range around the detection point.

Define the channel sources for Longitude, Latitude, Direction and Speed.

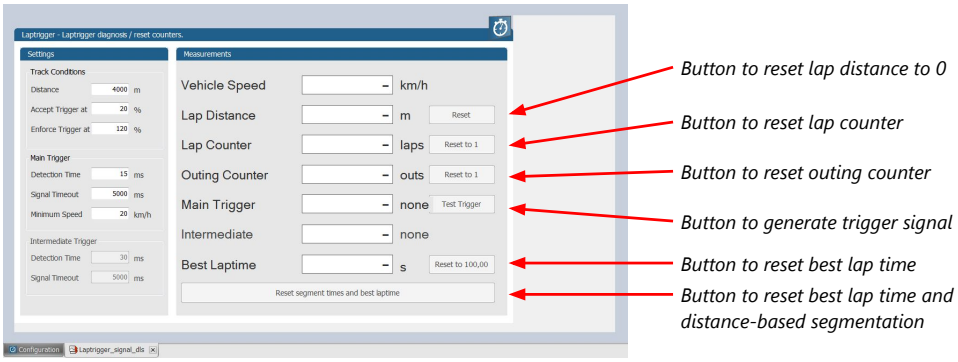


13.1.6 Lap trigger channel diagnosis/counter reset

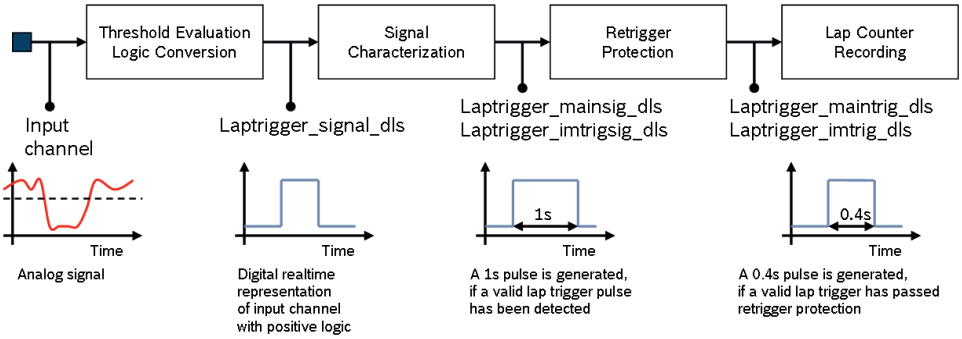
To display a quick lap trigger channel diagnosis and to reset counters use the diagnosis page in RaceCon. Any ‘Laptrigger_xxx’ channel can be displayed.

Double-click on any ‘Laptrigger_xxx’ channel in the Data Area. Example: ‘laptrigger_lap-dist_dls’

A diagnosis window opens in Main Area.

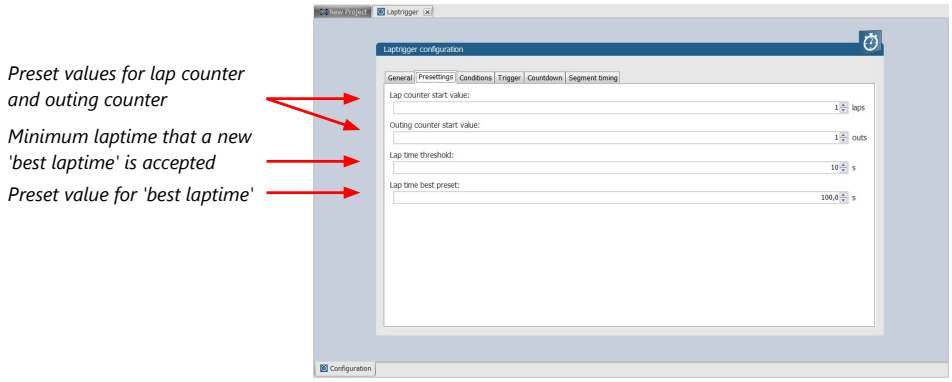


Lap trigger diagnosis scheme

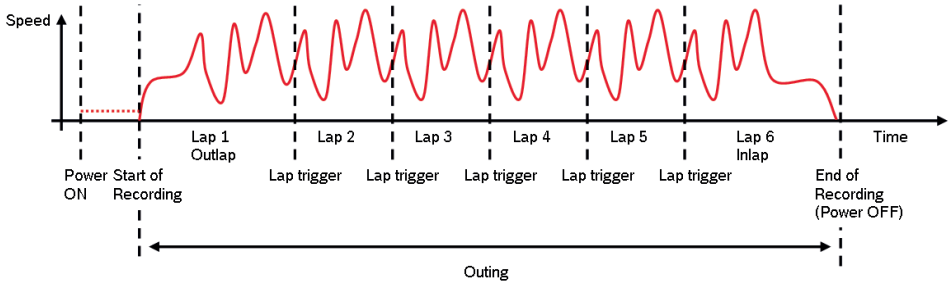


13.1.7 Lap trigger presettings

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



13.2 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 [▶ 108])

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’.

13.3 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

Channel	Function
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

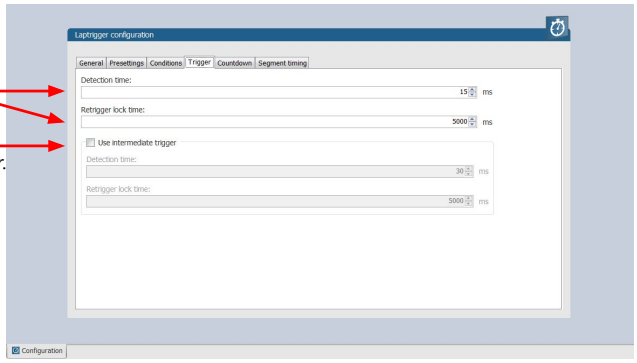
13.3.1 Time based retrigger protection

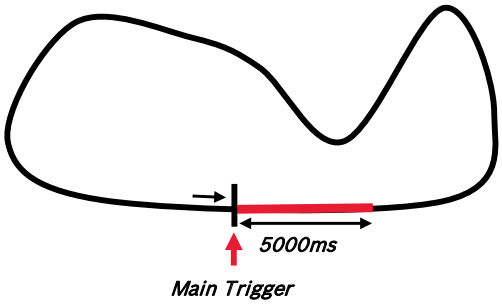
Trigger is locked for 5 s after main trigger was received.

To deactivate time based retrigger protection, set 'Retrigger lock time' to 0 ms.

Define settings for lap timing (main trigger).

Define settings for sub trigger. Not applicable with a GPS lap trigger.





13.3.2 Distance based retrigger protection

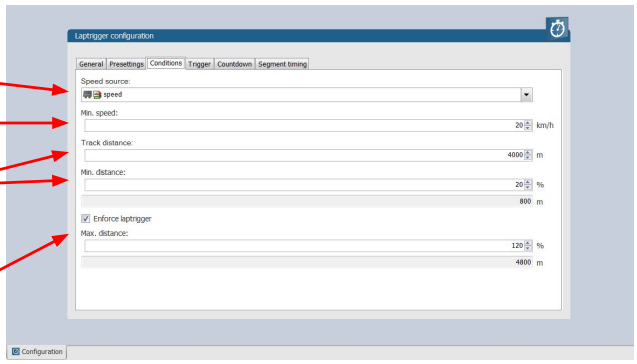
Trigger is locked until configured min distance (i.e. 80 % → 3200 m) of track distance (i.e. 4000 m) has been covered. To deactivate distance based retrigger protection, set min distance to 0 %.

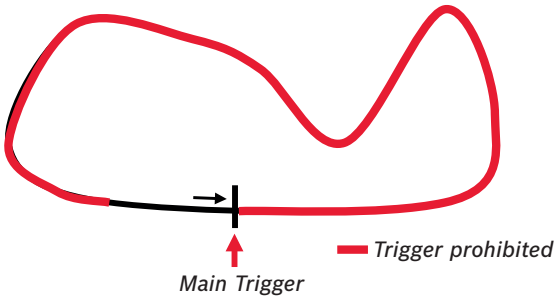
Change signal for vehicle speed, if desired.

Enter minimum speed for trigger release.

Define settings for distance based retrigger protection.

Define settings for distance based forced trigger.





13.3.3 Distance based forced trigger

After a missed main trigger, a forced trigger is inserted, if the configured max. distance (i.e. 120 % → 4800 m) of the track distance (i.e. 4000 m) has been reached. In this case, the channel 'Laptrigger_distlap_dls' starts at the delta between the max. distance and the track distance (i.e. 800 m).

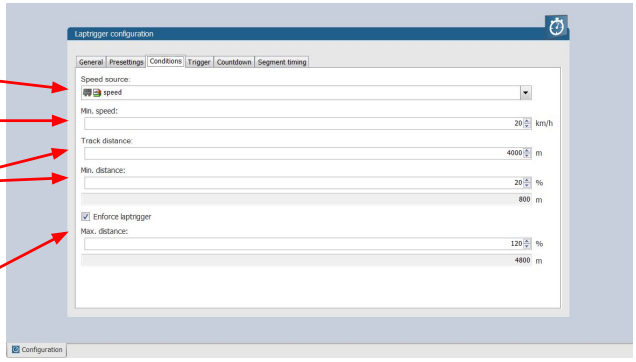
To deactivate distance based forced triggers, uncheck box.

Change signal for vehicle speed, if desired.

Enter minimum speed for trigger release.

Define settings for distance based retrigger protection.

Define settings for distance based forced trigger.



13.4 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

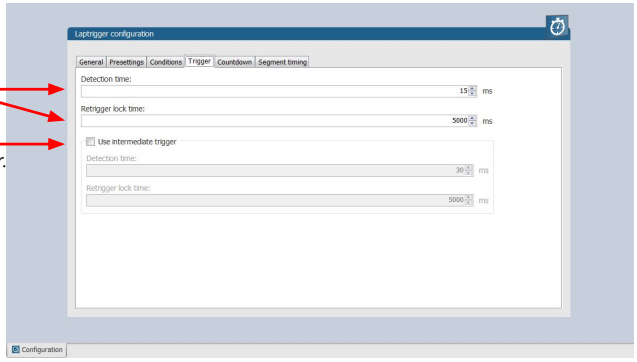
13.4.1 Sub trigger mode

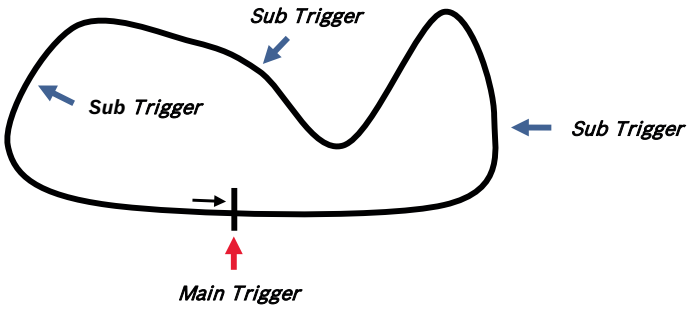
Using main trigger (20 ms pulse) at Start-Finish-Line. 3 sub triggers (40 ms pulse) positioned at 1,000 m, 2,000 m and 3,000 m.

To deactivate sub trigger mode uncheck box.

Define settings for lap timing (main trigger).

Define settings for sub trigger. Not applicable with a GPS lap trigger.





The sub trigger mode cannot be used with the GPS lap trigger.

13.4.2 Distance mode

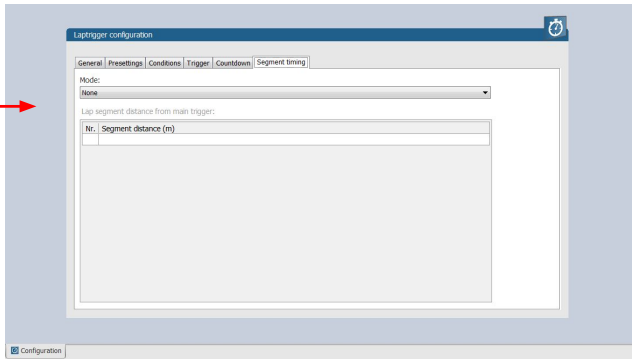
Using main trigger (20 ms pulse) at Start-Finish-Line.

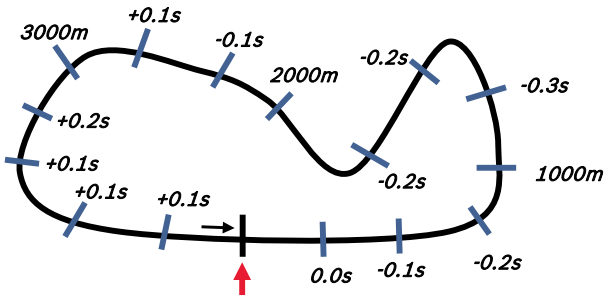
Set ‘Mode’ to ‘Distance’ and enter desired segment distances.

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’.

Define settings for segment timing.



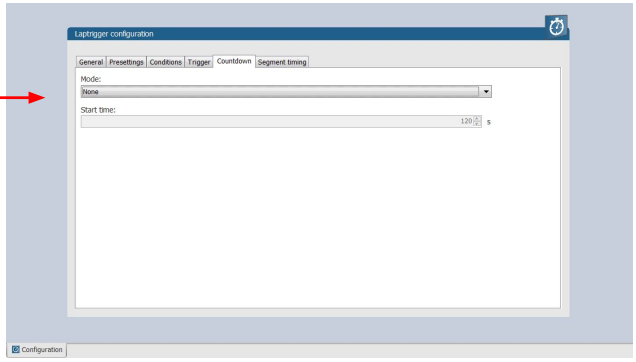


13.5 Countdown timer

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.

Define settings for countdown timer.

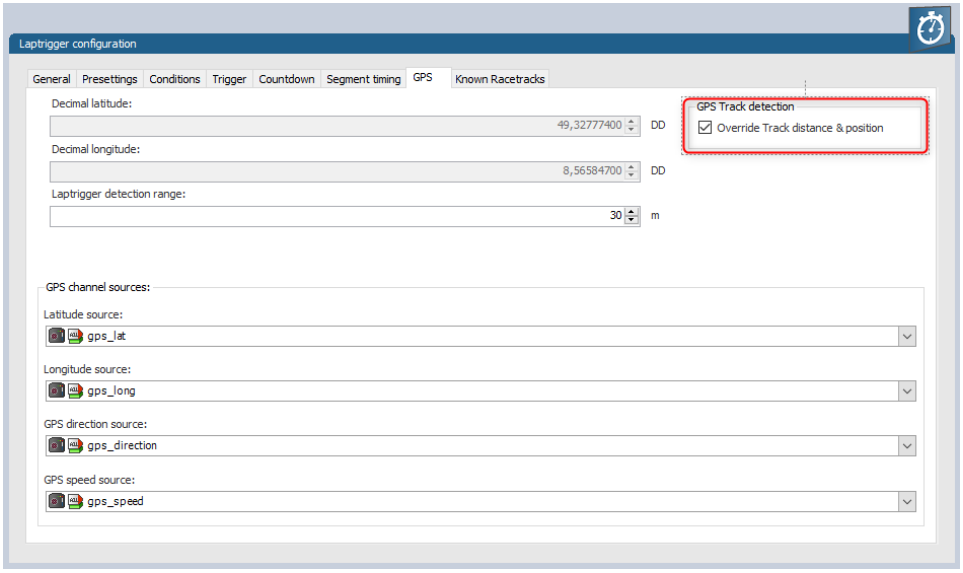


13.6 Automatic GPS Track Detection

With the GPS lap trigger, an automatic track detection can be activated by checking the highlighted box in the lap trigger configuration at the GPS tab.

Activating this functionality will overwrite the GPS trigger point coordinates and the track length with the values of a detected racetrack. The coordinates and the track length will be grayed out in the tool.

The function will compare the current GPS position with the coordinates of the known Racetracks list and use the closest GPS trigger point. If there are track variants with different track length, the system will adapt itself to the correct variant, if it is in the known racetrack list, after ~three detected laps. Please note that the track length needs to be quite accurate, within +/- 100 m, to adapt itself to another variant.

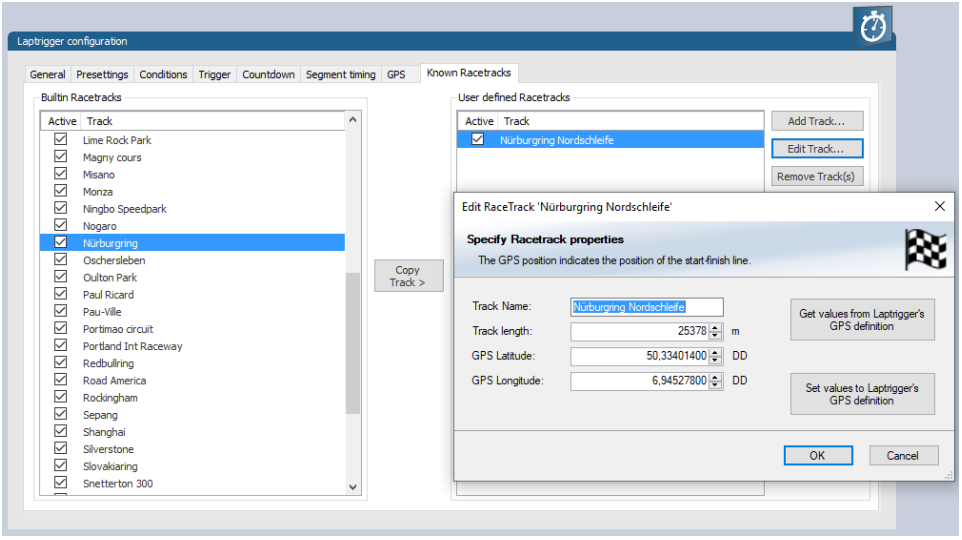


The known Racetrack list can be found in the lap trigger configuration menu within the Known Racetracks tab. It contains a built-in list and a user-defined list. Each track can be activated or deactivated with the checkbox to manually set the variant if needed.

User defined tracks can either be added from scratch with the Add Track button or with the Copy Track button as a modified version of a built in track. Both buttons will open the same Edit Race Track menu.

In the menu a track name, length and the coordinates of the detection point is required. The coordinates can be pulled from the GPS tab with the button “Get values …” or sent to the GPS tab with the button “Set values …”. This allows an easy interaction with the manual GPS lap trigger mode.

The user-defined tracks will be part of the project. If the tracks are required in another project, the lap trigger module can be ex-/imported into another project.



Following signals are assigned to the function:

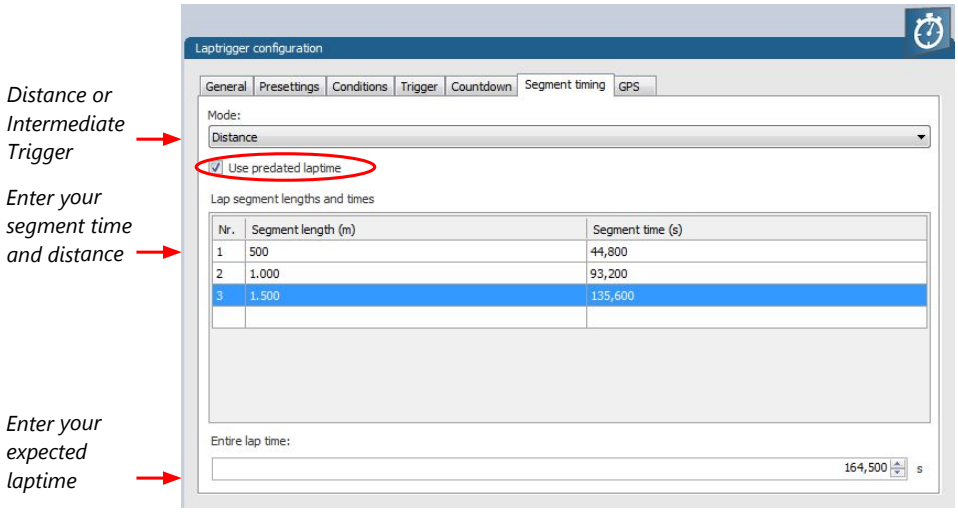
Laptrigger_trackdet_id	Signal will show the track name from the Racetracks list as an enumeration or can show the ID number as raw value. The enumerated name will also be visible in the logging.
Laptrigger_trackdet_laplen	Track length of the used track variant
Laptrigger_trackdet_lat	Latitude GPS coordinate of the used GPS trigger point
Laptrigger_trackdet_long	Longitude GPS coordinate of the used GPS trigger point

13.7 Predicted Laptime

The predicted laptime function allows to compare the current lap- and segment time with the predicted time of an expected lap. Additionally, the function can estimate the laptime of the current lap. This functionality is integrated in the laptrigger module in RaceCon.

13.7.1 Setting up the predicted laptime

To use the predicted laptime function you need to set up a laptrigger as described in the chapter Lap Trigger [▶ 99]. Under the ribbon “Segment timing”, you need to choose your segmentation mode which can either be distance or intermediate trigger based.



For the distance mode, you need to check on an old lap or estimate how long it takes to travel the segment distance. Please enter those values into input field. The values can also be copied and pasted to the input field from an excel sheet as a normal text. In the intermediate trigger, you just need to set the expected time the driver takes to reach the segment trigger.

Note

Please note that the segment time and length is always measured from the start line or where the main lap trigger is set.

13.7.2 Functionality and channel outputs

Following output channels are generated by the predicted laptime function.

Laptrigger_lapdiff_pred_dls	Laptime difference between the predicted and the last laptime
Laptrigger_lapsegdiffpred_dls	lagseg difference between the last segment and the predicted segment
Laptrigger_Lapcurrpred_dls	Estimated laptime of the current lap, based on the predicted laptime and the predicted segment deviations

The channel Laptrigger_lapdiff_pred_dls is updated as soon as the main lap trigger is received. Both other channels are updated as soon as the next segment distance is travelled, or the next intermediate trigger is received.

14 GPS Sensor

14.1 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 MS 7.4 (not covered here)

Serial output -> Read in messages via RS232 Interface of MS 7.4

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, MS 7.4 supports 1,200 to 115,200 baud. GPS Rx interface baud rate must match MS 7.4 interface baud rate. MS 7.4 Baud rate can be set with the 'GPS_BAUDRATE' characteristic Data format: MS 7.4 expects 8 data bits, no parity bit, 1 stop bit (8N1)

14.1.1 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, MS 7.4 supports 1,200 to 115,200 baud. GPS Rx interface baud rate must match MS 7.4 interface baud rate. MS 7.4 Baud rate can be set with the 'GPS_BAUDRATE' characteristic Data format: MS 7.4 expects 8 data bits, no parity bit, 1 stop bit (8N1)

14.2 Protocol

MS 7.4 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.

14.3 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 need to be reconfigured. More information about the configuration can be found in the Appendix.

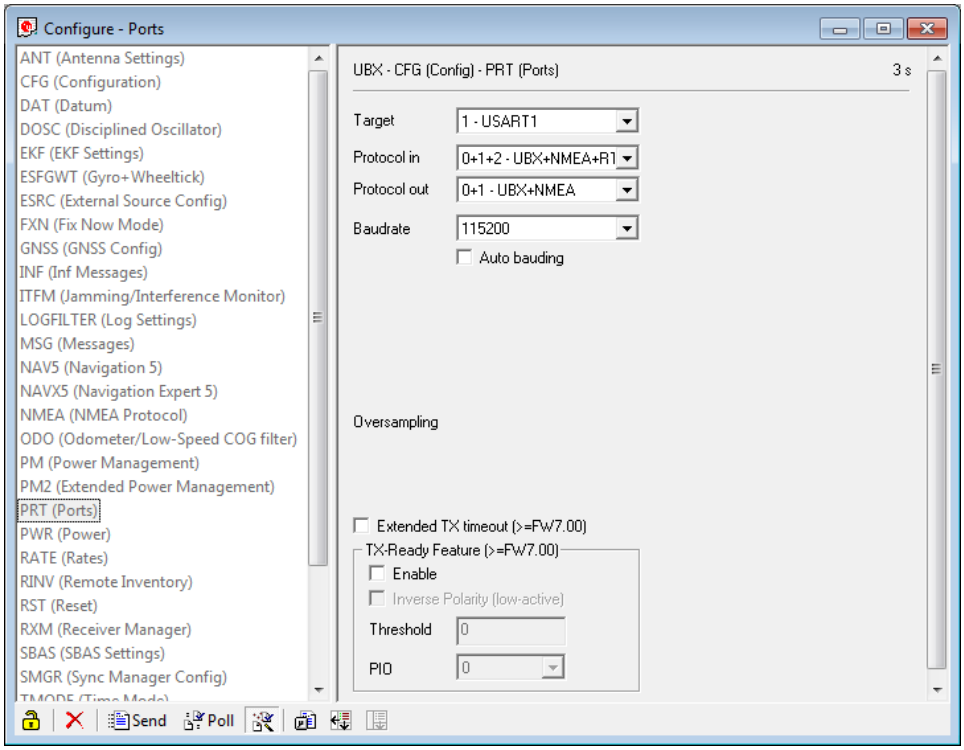
14.3.1 Configuration of the recommended Navilock NL-8004P MD6 Serial PPS Multi GNSS Receiver

For the sensor configuration, the sensor needs to be connected to the Navilock software "U-Center" which is available from Navilock free of charge. Navilock offers a USB connection cable for the sensor.

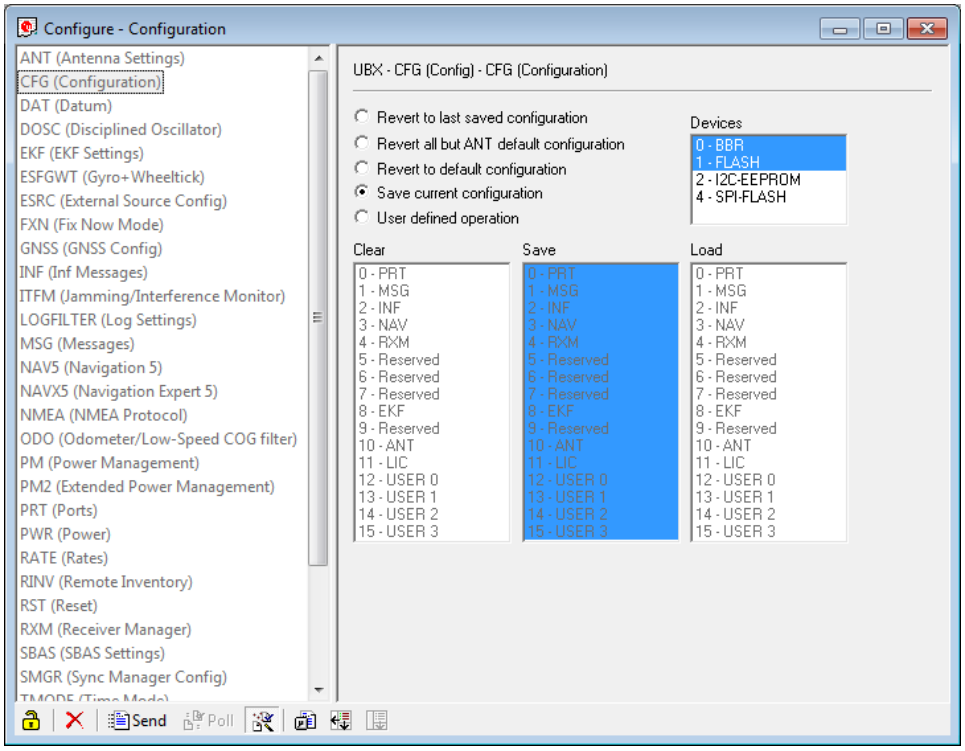
In "U-Center" click **"View"** – **"Configuration View"** to start the configuration. The following 3 points have to be changed:

Transfer Rate

- Click on "**PRT (Ports)".**
- Change the baud rate to a fixed value, this value needs to meet the setting of RaceCon. For a good signal quality we recommend 115,200 baud.
- Click on **"Send"** to store the new setting in "U-Center".

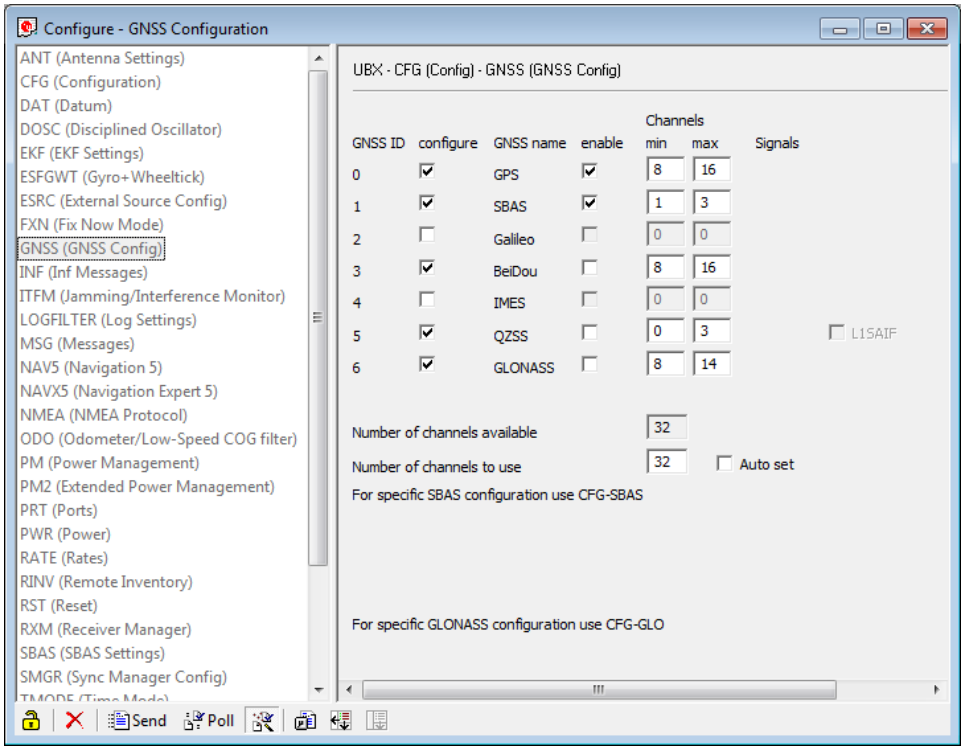


- Click on **"CFG (Configuration)".**
- Click on **"Send"** to save the new setting on the sensor.



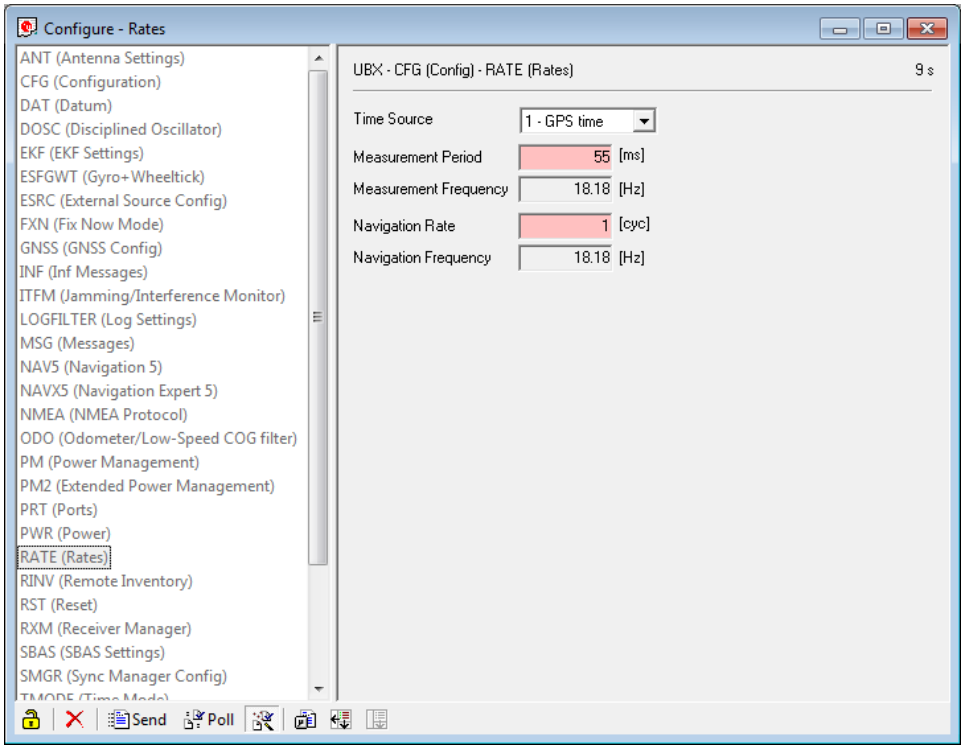
Satellite System

- Click on **“GNSS (GNSS Config)”.**
- Set the ticks as shown in the following picture.
- Click on “**Send**” to store the new setting in “U-Center”.
- As during configuration step 1, click on “**CFG (Configuration)**”.
- Click on“**Send**” to save the new setting on the sensor.



Update Rate

- Click on **“RATE (Rates)”.**
- Change the “Measurement Period” to 55 ms.
- Change the “Navigation Rate” to 1 cyc.
- Values which lead to a lower frequency will lower the precision of the sensor, we recommend the mentioned values.
- Click on “**Send**” to store the new setting in “U-Center”.
- As during configuration step 1, click on “**CFG (Configuration)**”.
- Click on“**Send**” to save the new setting on the sensor.



Note

Sensor needs reception for visible signal.
It takes time to start the sensor.

14.4 Measurement labels

The decoded NMEA messages are copied to these MS 7.4 measurement labels.

Measurement label	Function
gps_PDOP	Position Dilution Of Precision
gps_HDOP	Horizontal Dilution Of Precision
gps_VDOP	Vertical Dilution Of Precision
gps_lat	Latitude +/- [degree]
gps_long	Longitude +/- [degree]
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

Measurement label	Function
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	Bit mask over received NMEA sentences (Bit 0 = GGA, Bit 1 = GSA, Bit 2 =GSV, Bit 3 = RMC, Bit 4 =VTG) within last second.
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

14.5 GPS troubleshooting

Electrical

Is the transmitter signal of the GPS sensor connected to the receiver pin of serial interface of the MS 7.4?

Is the GPS sensor powered up?

Does the GPS sensor deliver RS232 signal levels?

Is the sensor connected to the „sensor ground“ of the device?

Interface

Do the baud rates of the GPS sensor and the MS 7.4 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?

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’.

GPS sensor values are frozen

Does the sensor has lost its reception? The old values will be kept if the reception is lost. The gps_smask channel shows which NMEA sentence is received.

15 Firmware

15.1 Firmware and configuration

MS 7.4 holds 2 types of data:

Firmware: The software (PST program file) of the MS 7.4.

Configuration: The default parameters for controlling the output of the MS 7.4.

15.2 Firmware update

Firmware updates are performed via XCP. Following standards are supported:

- ASAM MCD-1 (XCP); Version 1.5.0; Date: 2017-11-30
- ASAM MCD-2 MC (ASAP2 / A2L); Version 1.7.1; Date: 2018-01-30

Additional files for firmware update (like ProF-Scripts for INCA) will be provided by BOSCH.

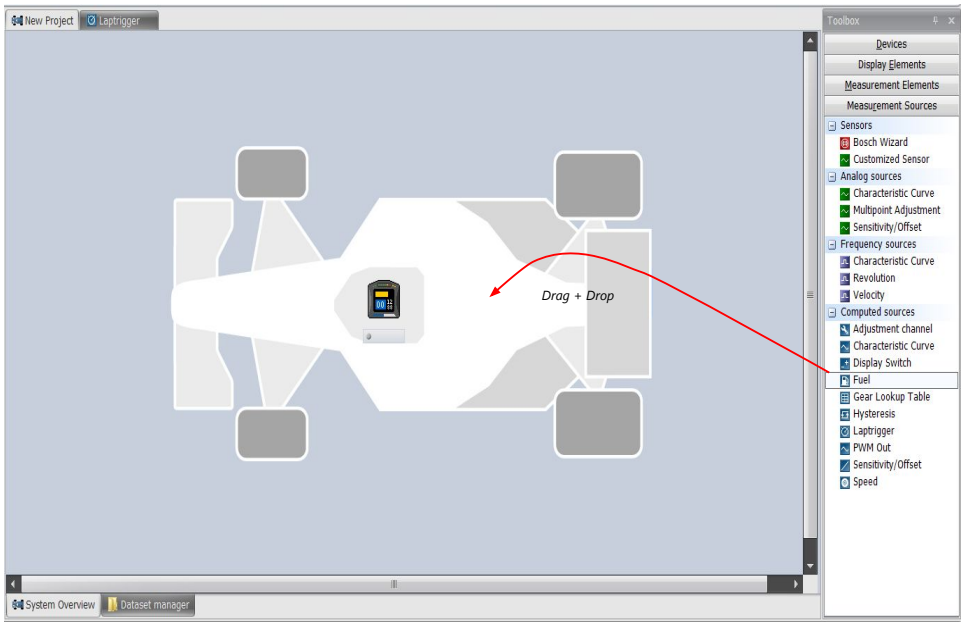
16 Cloning the Unit

Chapter left intentionally blank

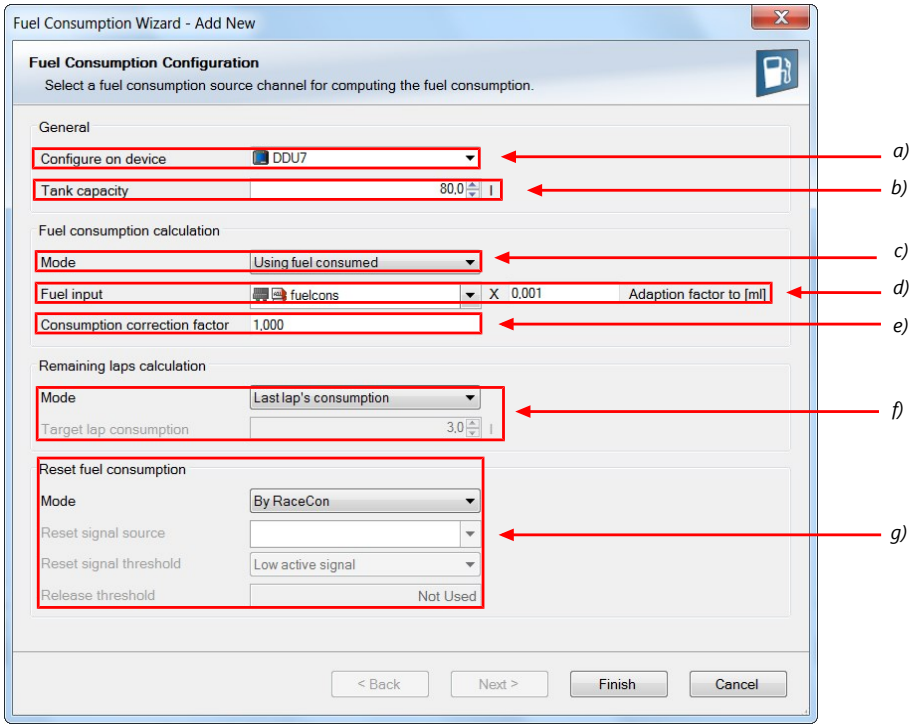
17 Fuel Consumption Calculation

17.1 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 MS 7.4!



A ‘fuel consumption wizard’ opens.



a) Change device for fuel calculation, if desired.

b) Enter tank capacity of vehicle.

c) Choose calculation mode:

- using fuel consumed (summed-up fuel consumption)
- using fuel flow rate (momentary fuel consumption)

d) Choose input channel and enter adaption factor. Use adaption factor to adapt value of input channel to:

- 1ml per inc for summed-up fuel consumption
- 1ml/s per inc for momentary consumption

e) Enter factor to correct calculated consumption in device vs. 'real' consumption of vehicle, if required.

f) Choose method to calculate remaining laps with fuel in tank, if desired:

- using fuel consumption of last lap completed
- using target lap consumption (entered in the field 'Target lap consumption')

g) Choose values to initiate a reset of fuel consumption, if desired:

- Manually using RaceCon
- On 'power down' (assuming that the tank is filled each time the ignition is turned off)
- By signal source as input channel (e.g. a switch connected to input pin)

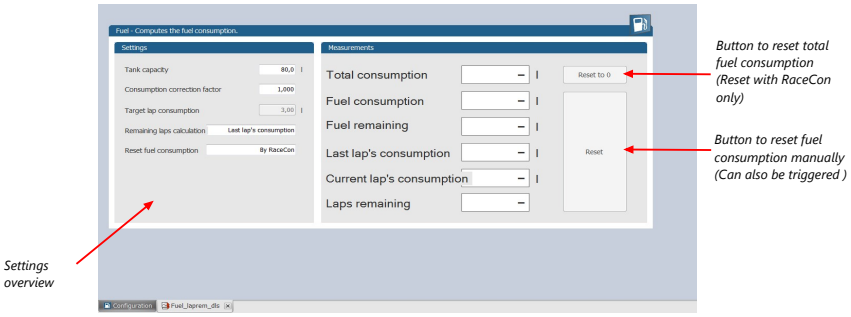
Press 'Finish' when done.

17.2 Fuel consumption diagnosis/counter reset

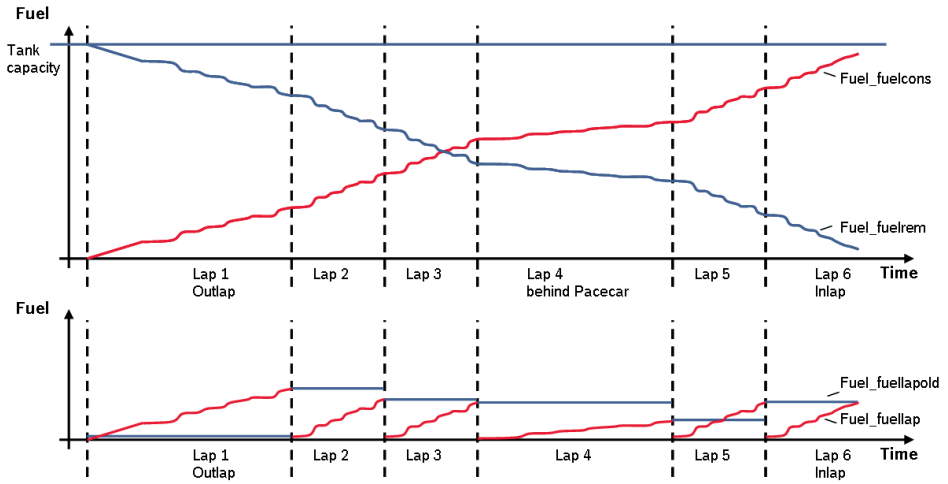
To display a fuel consumption diagnosis and to reset counters, use the diagnosis page in RaceCon.

Double-click on any 'fuel_xxx' channel in channel list.

A diagnosis window opens in Main Area.



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

18 RaceCon Shortcuts

The table shows important shortcuts simplify controlling the MS 7.4 in RaceCon.

Shortcut	Function
General navigation	
F1	Open RaceCon help
F2	Rename selected object
F3	Select Data Area
F4	Select Project Tree
F5	-
F6	Start the data comparison
F7	Start dataset manager
F8	Toggle WP/RP
F9	Start measurement
CTRL + F9	Start recording
F10 or Alt	Go to menu bar
F11	Toggle display to fullscreen 'Race Mode'
F12	Enlarge main screen
CTRL + Tab	Switch between opened windows
Project Tree	
Plus (+) at numeric pad or right cursor	Expand selected node
Minus (-) at numeric pad or left cursor	Close selected node
Star (*) at numeric pad	Open all nodes
DEL	Delete seleted object
Display page, measurement page	
Cursor	Move selected display element one grid unit in chosen direction
SHIFT + cursor	Enlarge/reduce selected display element one grid unit
Tab	Switch between display elements

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The primary ANTLR guy:

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xml_io_tools

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19.2.9 Avalonia

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20 Pinlayout

The pin layout is also placed at Bosch Motorsport homepage on the MS 7.4 product page. Please find item "Pin Layout". Most of MS 7.4 functions to pin relations may be modified to projects demands. Please see details in the function description SWITCHMATRIX. Bosch Motorsport tests check the defined connections of the pin layout

Analog Inputs								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
27				analog input	I_A_ANA01	AWG24	universal input 0-5V - pull up switchable	pedal a (fixed)
2				analog input	I_A_ANA02	AWG24	universal input 0-5V - pull up switchable	throttle 1a (fixed)
21				analog input	I_A_ANA03	AWG24	universal input 0-5V - pull up switchable	throttle 2a (fixed)
29				analog input	I_A_ANA04	AWG24	universal input 0-5V - pull up switchable	tamb
3				analog input	I_A_ANA05	AWG24	universal input 0-5V - pull up switchable	tfuel
20				analog input	I_A_ANA06	AWG24	universal input 0-5V - pull up switchable	pbrake_f
47				analog input	I_A_ANA07	AWG24	universal input 0-5V - pull up switchable	pbrake_r
46				analog input	I_A_ANA08	AWG24	universal input 0-5V - pull up switchable	poil
12				analog input	I_A_ANA09	AWG24	universal input 0-5V - pull up switchable	pwat
28				analog input	I_A_ANA10	AWG24	universal input 0-5V - pull up switchable	pclutch
53				analog input	I_A_ANA11	AWG24	universal input 0-5V - pull up switchable	utint
38				analog input	I_A_ANA12	AWG24	universal input 0-5V - pull up switchable	pfuel
45				analog input	I_A_ANA13	AWG24	universal input 0-5V - pull up switchable	toil
37				analog input	I_A_ANA14	AWG24	universal input 0-5V - pull up switchable	tmot2
7				analog input	I_A_ANA15	AWG24	universal input 0-5V - pull up switchable	tmot
8				analog input	I_A_ANA16	AWG24	universal input 0-5V - pull up switchable	prail
13				analog input	I_A_ANA17	AWG24	universal input 0-5V - pull up switchable	pedal b (fixed)
6				analog input	I_A_ANA18	AWG24	universal input 0-5V - pull up switchable	throttle 1b (fixed)
14				analog input	I_A_ANA19	AWG24	universal input 0-5V - pull up switchable	throttle 2b (fixed)
1				analog input	I_A_ANA20	AWG24	universal input 0-5V - pull up switchable	prail2
19				analog input	I_A_ANA21	AWG24	universal input 0-5V - pull up switchable	toil2
	60			analog input	I_A_ANA22	AWG24	universal input 0-5V - pull up switchable	gear
	46			analog input	I_A_ANA23	AWG24	universal input 0-5V - pull up switchable	pcrank
	28			analog input	I_A_ANA24	AWG24	universal input 0-5V - pull up switchable	pgear
	54			analog input	I_A_ANA25	AWG24	universal input 0-5V - pull up switchable	pservo
	39			analog input	I_A_ANA26	AWG24	universal input 0-5V - pull up switchable	shiftupsw
	38			analog input	I_A_ANA27	AWG24	universal input 0-5V - pull up switchable	shiftdnsw
	47			analog input	I_A_ANA28	AWG24	universal input 0-5V - pull up switchable	sdam_fl
	61			analog input	I_A_ANA29	AWG24	universal input 0-5V - pull up switchable	sdam_fr
	55			analog input	I_A_ANA30	AWG24	universal input 0-5V - pull up switchable	sdam_rl
	48			analog input	I_A_ANA31	AWG24	universal input 0-5V - pull up switchable	sdam_rr
	62			analog input	I_A_ANA32	AWG24	universal input 0-5V - pull up switchable	steer
	53			analog input	I_A_ANA33	AWG24	universal input 0-5V - pull up switchable	p1
	45			analog input	I_A_ANA34	AWG24	universal input 0-5V - pull up switchable Voltage devider switchable to 0-26V	tgear

Analog Inputs								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
	37			analog input	I_A_ANA35	AWG24	universal input 0-5V - pull up switchable Voltage devider switchable to 0-26V	tservo
5				analog input	I_A_ANA36_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 1
10				analog input	I_A_ANA37_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 2
11				analog input	I_A_ANA38_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 3
17				analog input	I_A_ANA39_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 4
25				analog input	I_A_ANA40_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 5
26				analog input	I_A_ANA41_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 6
34				analog input	I_A_ANA42_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 7
4				analog input	I_A_ANA43_PCYL	AWG24	fast analog input 0-5V - pull up switchable	cylinder pressure recognition 8
44				analog input	I_A_ANA44_FADC	AWG24	analog input 0-5V, pull up switch., time or angular synchronism measurement	up21
64				analog input	I_A_ANA45_FADC	AWG24	analog input 0-5V, pull up switch., time or angular synchronism measurement	up21_2
43				analog input	I_A_ANA46_FADC	AWG24	analog input 0-5V, pull up switch., time or angular synchronism measurement	up22
59				analog input	I_A_ANA47_FADC	AWG24	analog input 0-5V, pull up switch., time or angular synchronism measurement	up22_2
52				analog input	I_A_ANA48_FADC	AWG24	analog input 0-5V, pull up switch., time or angular synchronism measurement	reserve
36				analog input	I_A_ANA49_FADC	AWG24	analog input 0-5V, pull up switch., time or angular synchronism measurement	reserve
51				thermocouple	I_A_TEXH1P	twisted pair (AWG24) shielded	Thermocouple 1 +	utexh
58					I_A_TEXH1N		Thermocouple 1 -	
65				thermocouple	I_A_TEXH2P	twisted pair (AWG24) shielded	Thermocouple 2 +	utexh2
60					I_A_TEXH2N		Thermocouple 2 -	

Combined Analog/Digital Inputs								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
	21			analog / dig input	I_AD_ANADIG01	AWG24	selectable universal input 0-5V / digital input 0-12V - pull up switchable	mapsw
	22			analog / dig input	I_AD_ANADIG02	AWG24	selectable universal input 0-5V / digital input 0-12V - pull up switchable	pitspeedsw
	29			analog / dig input	I_AD_ANADIG03	AWG24	selectable universal input 0-5V / digital input 0-12V - pull up switchable	launchsw
	30			analog / dig input	I_AD_ANADIG04	AWG24	selectable universal input 0-5V / digital input 0-12V - pull up switchable	tcsw
	31			analog / dig input	I_AD_ANADIG05	AWG24	selectable universal input 0-5V / digital input 0-12V - pull up switchable	wetsw
	40			analog / dig input	I_AD_ANADIG06	AWG24	selectable universal input 0-5V / digital input 0-12V - pull up switchable	chressw
	49			analog / dig input	I_AD_ANADIG07	AWG24	selectable universal input 0-5V / digital input 0-12V / SENT - pull up switchable	reserve
	56			analog / dig input	I_AD_ANADIG08	AWG24	selectable universal input 0-5V / digital input 0-12V / SENT - pull up switchable	reserve

Further Inputs							
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
			43	digital input	I_F_DIG01P_HALL_IND	twisted pair (AWG24) shielded	hall or inductive sensor selectable	CRANK_1+
			44		I_F_DIG01N_HALL_IND			CRANK_1-
			10	digital input	I_F_DIG02P_HALL_IND	twisted pair (AWG24) shielded	hall or inductive sensor selectable	CRANK_2+
			19		I_F_DIG02N_HALL_IND			CRANK_2-
			37	digital input	I_F_DIG03_HALL	AWG24	hall sensor	CAM_1
			3	digital input	I_F_DIG04_HALL	AWG24	hall sensor	CAM_2
			11	digital input	I_F_DIG05_HALL_DF11	AWG24	hall or DF11 sensor selectable	speed1 / CAM3
			1	digital input	I_F_DIG06_HALL_DF11	AWG24	hall or DF11 sensor selectable	speed2 / CAM4
			2	digital input	I_F_DIG07_HALL_DF11	AWG24	hall or DF11 sensor selectable	speed3
			6	digital input	I_F_DIG08_HALL_DF11	AWG24	hall or DF11 sensor selectable	speed4
			47	digital input	I_F_DIG09P_HALL_IND	twisted pair (AWG24) shielded	hall or inductive sensor circuit selectable	TURBO_1+
			46		I_F_DIG09N_HALL_IND			TURBO_1-
			8	digital input	I_F_DIG10P_HALL_IND	twisted pair (AWG24) shielded	hall or inductive sensor circuit selectable	TURBO_2+
			7		I_F_DIG10N_HALL_IND			TURBO_2-
			21	digital input	I_S_LAPTRIG	AWG24	laptrigger input	LAPTRIGGER
			57	digital input	I_S_ENGRUN	AWG24	digital input, pull down	Engine Switch

Outputs							
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
			12	lowside switch 4A	O_S_LS01	AWG20		SHIFT_UP
			34	lowside switch 4A	O_S_LS02	AWG20		SHIFT_DN
			17	lowside switch 3A	O_S_LS03	AWG20		WGC_INC
			59	lowside switch 3A	O_S_LS04	AWG20		WGC_DEC
			6	lowside switch 3A	O_S_LS05	AWG20		CAMCTRL_IN
			51	lowside switch 3A	O_S_LS06	AWG20		CAMCTRL_IN2
			43	lowside switch 3A	O_S_LS07	AWG20		CAMCTRL_OUT
			65	lowside switch 3A	O_S_LS08	AWG20		CAMCTRL_OUT2
			19	lowside switch 2.2A or INJ1	O_S_LS09	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
			52	lowside switch 2.2A or INJ2	O_S_LS10	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
			18	lowside switch 2.2A or INJ3	O_S_LS11	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
			60	lowside switch 2.2A or INJ4	O_S_LS12	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
			10	lowside switch 2.2A or INJ5	O_S_LS13	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
			53	lowside switch 2.2A or INJ6	O_S_LS14	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
			27	lowside switch 2.2A or INJ7	O_S_LS15	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	

Outputs								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
		61		lowside switch 2.2A or INJ8	O_S_LS16	AWG20	to be used as low side switch or high imp. Injectors, no freewheeling, runs only with engine speed	
		5		lowside switch 2.2A or INJ9	O_S_LS17	AWG20	to be used as low side switch or high imp. injectors or control of external HDEV 9-12, no freewheeling, runs only with engine speed	
		44		lowside switch 2.2A or INJ10	O_S_LS18	AWG20	to be used as low side switch or high imp. injectors or control of external HDEV 9-12, no freewheeling, runs only with engine speed	
		25		lowside switch 2.2A or INJ11	O_S_LS19	AWG20	to be used as low side switch or high imp. injectors or control of external HDEV 9-12, no freewheeling, runs only with engine speed	
		45		lowside switch 2.2A or INJ12	O_S_LS20	AWG20	to be used as low side switch or high imp. injectors or control of external HDEV 9-12, no freewheeling, runs only with engine speed	
		11		lowside switch 2.2A	O_S_LS21	AWG20		MIL
		36		lowside switch 2.2A	O_S_LS22	AWG20		FUELPUMP
		35		lowside switch 2.2A	O_S_LS23	AWG20		WGC_INC2
		64		lowside switch 2.2A	O_S_LS24	AWG20		WGC_DEC2
		26		lowside switch 1A	O_S_LS25	AWG20		MAINRELAY
			14	lowside switch 1A	O_S_LS26	AWG20		STARTER
		4		lowside switch 3A	O_S_LSH1	AWG20	Lambda Heater Output	LAM_1_HEATER
		58		lowside switch 3A	O_S_LSH2	AWG20	Lambda Heater Output	LAM_2_HEATER
	26			MSV controller	O_P_MSV1P	AWG20		MSV_1P
	35				O_P_MSV1N	AWG20		MSV_1N
	18			MSV controller	O_P_MSV2P	AWG20		MSV_2P
	11				O_P_MSV2N	AWG20		MSV_2N
		66		H-Bridge 8.5A	O_S_HBR1P	AWG20	for EGAS	EGAS_1P
		62			O_S_HBR1N	AWG20		EGAS_1N
		63		H-Bridge 8.5A	O_S_HBR2P	AWG20	for EGAS	EGAS_2P
		57			O_S_HBR2N	AWG20		EGAS_2N
		2		H-Bridge 8.5A	O_S_HBR3P	AWG20		HBRIDGE_1P
		1			O_S_HBR3N	AWG20		HBRIDGE_1N
	34			High Pressure Injection	O_P_INJ1P	AWG20	High Pressure Injection +	INJ_1P
	25				O_P_INJ1N	AWG20	High Pressure Injection -	INJ_1N
	58			High Pressure Injection	O_P_INJ2P	AWG20	High Pressure Injection +	INJ_2P
	59				O_P_INJ2N	AWG20	High Pressure Injection -	INJ_2N
	52			High Pressure Injection	O_P_INJ3P	AWG20	High Pressure Injection +	INJ_3P
	44				O_P_INJ3N	AWG20	High Pressure Injection -	INJ_3N
	5			High Pressure Injection	O_P_INJ4P	AWG20	High Pressure Injection +	INJ_4P
	4				O_P_INJ4N	AWG20	High Pressure Injection -	INJ_4N
	10			High Pressure Injection	O_P_INJ5P	AWG20	High Pressure Injection +	INJ_5P
	17				O_P_INJ5N	AWG20	High Pressure Injection -	INJ_5N
	51			High Pressure Injection	O_P_INJ6P	AWG20	High Pressure Injection +	INJ_6P
	43				O_P_INJ6N	AWG20	High Pressure Injection -	INJ_6N

Outputs								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
	6			High Pressure Injection	O_P_INJ7P	AWG20	High Pressure Injection +	INJ_7P
	27				O_P_INJ7N	AWG20	High Pressure Injection -	INJ_7N
	2			High Pressure Injection	O_P_INJ8P	AWG20	High Pressure Injection +	INJ_8P
	1				O_P_INJ8N	AWG20	High Pressure Injection -	INJ_8N
		50		Ignition	O_P_IGN01	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_1
		3		Ignition	O_P_IGN02	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_2
		33		Ignition	O_P_IGN03	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_3
		9		Ignition	O_P_IGN04	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_4
		24		Ignition	O_P_IGN05	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_5
		8		Ignition	O_P_IGN06	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_6
		42		Ignition	O_P_IGN07	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_7
		16		Ignition	O_P_IGN08	AWG20/AWG24	selectable int. ignition power stage or ignition driver	IGN_8
		7		Ignition	O_P_IGN09	AWG24	ignition driver cyl 9-12	IGN_9
		20		Ignition	O_P_IGN10	AWG24	ignition driver cyl 9-12	IGN_10
		13		Ignition	O_P_IGN11	AWG24	ignition driver cyl 9-12	IGN_11
		14		Ignition	O_P_IGN12	AWG24	ignition driver cyl 9-12	IGN_12
		46		MOOG Control	O_A_MOOG1P	AWG24	H-Bridge 12mA +	
		38			O_A_MOOG1N	AWG24	H-Bridge 12mA -	
		54		MOOG Control	O_A_MOOG2P	AWG24	H-Bridge 12mA +	
		47			O_A_MOOG2N	AWG24	H-Bridge 12mA -	
		39		MOOG Control	O_A_MOOG3P	AWG24	H-Bridge 12mA +	
		48			O_A_MOOG3N	AWG24	H-Bridge 12mA -	
		40		MOOG Control	O_A_MOOG4P	AWG24	H-Bridge 12mA +	
		31			O_A_MOOG4N	AWG24	H-Bridge 12mA -	
			29	DIAG_MUX	O_A_MUX1	AWG24 shielded	PushPull driver Diagnosis Multiplexer (KS1A, eng. speed, int. Signals)	MUXCTRL_CH1
			30		O_A_MUX2	AWG24 shielded	PushPull driver Diagnosis Multiplexer (KS1B, cam speed, int. Signals)	MUXCTRL_CH2
			38		O_A_MUX3	AWG24 shielded	PushPull driver Diagnosis Multiplexer (KS2A, cam speed, int. Signals)	MUXCTRL_CH3
			39		O_A_MUX4	AWG24 shielded	PushPull driver Diagnosis Multiplexer (KS2B, cam speed, int. Signals)	MUXCTRL_CH4
			31		O_A_MUX5	AWG24 shielded	PushPull driver Diagnosis Multiplexer (MF1, MF2, MF combined, cam speed, int. Signals)	MUXCTRL_CH5

Communication								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
			48	CAN Bus 1	BI_CAN1_H	CAN-Ltg	up to 1Mbit/s, switchable Terminator	CAN_1_H, use for Motronic, Power-box, HPI and ABS control functions
			56		BI_CAN1_L			CAN_1_L

Communication							
S	C	A	L	I/O Type	SIG_NAME	LEAD	DESCRIPTION	FUNCTION
			62	CAN Bus 2	BI_CAN2_H	CAN-Ltg	up to 1Mbit/s, switchable Terminator	CAN_2_H, use for external ECU / gearbox control
			55		BI_CAN2_L			CAN_2_L
			12	CAN Bus 3	BI_CAN3_H	CAN-Ltg	up to 1Mbit/s, switchable Terminator	CAN_3_H, use for measurement purposes
			13		BI_CAN3_L			CAN_3_L
			66	Gigabit Ethernet	BI_GETH_D1+_TX+	Ethernet Ltg. (CAT6), shielded to G_C_COMSCR	1000 Mbit/s	GETH_0P (Application Interface)
			61		BI_GETH_D1-_TX-			GETH_0N (Application Interface)
			65		BI_GETH_D2+_RX+			GETH_1P (Application Interface)
			54		BI_GETH_D2-_RX-			GETH_1N (Application Interface)
			64		BI_GETH_D3+			GETH_2P (Application Interface)
			60		BI_GETH_D3-			GETH_2N (Application Interface)
			59		BI_GETH_D4+			GETH_3P (Application Interface)
			53		BI_GETH_D4-			GETH_3N (Application Interface)
			26	100 Mbit Ethernet	BI_ETH1_RX+	Ethernet Ltg. (CAT5), shielded to G_C_COMSCR	100 Mbit/s	ETH1RX+
			25		BI_ETH1_RX-			ETH1RX-
			18		BI_ETH1_TX+			ETH1TX+
			17		BI_ETH1_TX-			ETH1TX-
			35	100 Mbit Ethernet	BI_ETH2_RX+	Ethernet Ltg. (CAT5), shielded to G_C_COMSCR	100 Mbit/s	ETH2RX+
			34		BI_ETH2_RX-			ETH2RX-
			36		BI_ETH2_TX+			ETH2TX+
			27		BI_ETH2_TX-			ETH2TX-
			42	Realtime Network SERCOS	BI_RETH1_RX+	Ethernet Ltg. (CAT5), shielded to G_C_COMSCR	100MBit/s Ring Output 1	RETH1RX+
			41		BI_RETH1_RX-			RETH1RX-
			50		BI_RETH1_TX+			RETH1TX+
			49		BI_RETH1_TX-			RETH1TX-
			24		BI_RETH2_RX+	Ethernet Ltg. (CAT5), shielded to G_C_COMSCR	100MBit/s Ring Output 2	RETH2RX+
			23		BI_RETH2_RX-			RETH2RX-
			33		BI_RETH2_TX+			RETH2TX+
			32		BI_RETH2_TX-			RETH2TX-
			15	RS232	BI_RS232_RX	AWG24	Serial interface	RS232_RX
			16		BI_RS232_TX	AWG24		RS232_TX
			51	USB	BI_USB_DP	USB Ltg.	USB interface, supply 5V/500mA	USB_DP
			45		BI_USB_DN			USB_DN
			58		G_R_USBGND			USB_GND
			52		O_V_USB5V			USB_5V
			9	LIN Bus	BI_LIN	AWG24, shielded	LIN interface	LIN
			22	TIMEBASE	BI_TIMESYNC	AWG24	Timesync line between Bosch devices	SYNC

Supply								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
			63	Supply In	V_UBAT	AWG20	ECU Processor Supply	
			5	Supply In	V_DYNPWR	AWG20	ECU Supply	
		28		Supply In	V_DYNPWR	AWG20	ECU Supply	
		30		Supply In	V_DYNPWR	AWG20	ECU Supply	
	13			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	15			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	32			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	33			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	36			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	41			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	42			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	50			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
	64			Supply In	V_DYNPWR_BOOST	AWG20	ECU Booster Supply	
			4	Ground In	G_DYNGND	AWG20	DYN Ground	
	3			Ground In	G_DYNGND	AWG20	DYN Ground	
		22		Ground In	G_DYNGND	AWG20	DYN Ground	
		29		Ground In	G_DYNGND	AWG20	DYN Ground	
		32		Ground In	G_DYNGND	AWG20	DYN Ground	
		56		Ground In	G_DYNGND	AWG20	DYN Ground	
	7			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	8			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	9			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	12			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	14			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	16			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	20			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	23			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
	24			Ground In	G_DYNGND_BOOST	AWG20	ECU Booster Ground	
		15		Ground In	G_DYNGND_IGN	AWG20	ECU Ignition Ground	
		21		Ground In	G_DYNGND_IGN	AWG20	ECU Ignition Ground	
		23		Ground In	G_DYNGND_IGN	AWG20	ECU Ignition Ground	
		41		Ground In	G_DYNGND_IGN	AWG20	ECU Ignition Ground	
		49		Ground In	G_DYNGND_IGN	AWG20	ECU Ignition Ground	
		55		Ground In	G_DYNGND_IGN	AWG20	ECU Ignition Ground	
			20	Ground In	G_ECUGND	AWG20	ECU Ground	
			40	Ground Out	G_C_COMSCR	AWG24	connection for communication screen	
			28	Ground Out	G_C_USBSCR	AWG24	connection for USB screen	
35				Ground Out	G_C_SENSSCR	AWG24	connection for signal screens	
	19			Ground Out	G_C_SENSSCR	AWG24	connection for signal screens	
		37		Ground Out	G_C_ACTSCR	AWG24	connection for actuator screens	

Supply								
S	**C**	**A**	**L**	**I/O Type**	**SIG_NAME**	**LEAD**	**DESCRIPTION**	**FUNCTION**
42				Supply Out	O_V_SENS5_APS1	AWG24	sensor supply 5V, ca. 50mA, for aps a	
50				Supply Out	O_V_SENS5_APS2	AWG24	sensor supply 5V, ca. 50mA, for aps b	
56				Supply Out	O_V_SENS5_THR1	AWG24	sensor supply 5V, ca. 50mA, for throttle poti(s) a	
48				Supply Out	O_V_SENS5_THR2	AWG24	sensor supply 5V, ca. 50mA, for throttle poti(s) b	
24				Supply Out	O_V_SENS5_1	AWG24	sensor supply 5V, ca. 400mA	
9				Supply Out	O_V_SENS5_2	AWG24	sensor supply 5V, ca. 400mA	
	66			Supply Out	O_V_SENS5_3	AWG24	sensor supply 5V, ca. 400mA	
	63			Supply Out	O_V_SENS_BAT	AWG24	sensor supply ubat, ca. 250mA	
41				Ground Out	G_R_SENS5_APS1	AWG24	sensor ground for aps a	
49				Ground Out	G_R_SENS5_APS2	AWG24	sensor ground for aps b	
63				Ground Out	G_R_SENS5_THR1	AWG24	sensor ground for throttle poti(s) a	
57				Ground Out	G_R_SENS5_THR2	AWG24	sensor ground for throttle poti(s) b	
16				Ground Out	G_R_SENS5_1	AWG24	sensor ground	
15				Ground Out	G_R_SENS5_2	AWG24	sensor ground	
	65			Ground Out	G_R_SENS5_3	AWG24	sensor ground	
	57			Ground Out	G_R_SENS_BAT	AWG24	sensor ground	
18				Ground Out	G_R_PCYL	AWG24	sensor ground for cylinder pressure sensors	

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