



ECU MS 5.5

Manual

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1 Getting started

Disclaimer

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

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 5.5 inappropriately.

Use the MS 5.5 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 5.5 with uncertified combinations and accessories.

Operation of the MS 5.5 is only certified with the combinations and accessories that are specified in this manual. The use of variant combinations, accessories and other devices outside the scope of this manual are only permitted when they have been determined to be compliant from a performance and safety standpoint by a representative from Bosch Motorsport.

Notice

The Bosch Motorsport MS 5.5 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.

Notice

Drive-by-wire systems

For systems with drive-by-wire additional safety provisions apply. For details please refer to the document „Safety Instructions for Drive-by-Wire Systems in Motorsport Applications“.

2 MS 5: FPGA plus PowerPC

A field-programmable gate array (FPGA) is a semiconductor device containing components called "logic blocks", and programmable interconnects. Logic blocks can be programmed to perform the function of basic logic gates such as AND and XOR, or more complex combinational functions such as decoders or mathematical functions. In most FPGAs, the logic blocks also include memory elements, which may be simple or more complete blocks of memory.

A hierarchy of programmable interconnects allows logic blocks to be interconnected as needed by the system designer, somewhat like a one-chip programmable breadboard. Logic blocks and interconnects can be programmed by the customer or designer, after the FPGA is manufactured, to implement any logical function - hence the name "field-programmable".

With our first FPGA-based ECU family Motronic MS 5 we offer you the possibility to integrate individual designed functions. The systems flexibility allows the support of any unusual engine configuration or chassis functionality.

In combination with a very powerful PowerPC Freescale MPC 5200B that allows synchronized calculator operations, the MS 5 family typifies the state of the art in ECU design.

3 Technical Data



The ECU MS 5.5 engine control unit manages gasoline engines up to 8 cylinders. As a member of our MS 5 family, it features a powerful digital processing core with floating point arithmetic and a high-end FPGA for ultimate performance and flexibility. The MS 5 family utilizes a new software development process based on MATLAB® & Simulink®. It significantly speeds algorithm development by using automatic code and documentation generation. Custom functions can be quickly and easily generated. The flexible hardware design allows the ECU MS 5.5 to support complex or unusual engine or chassis configurations.

The MS 5.5 has an internal 2 GB logger, presenting a cost efficient and weight optimized all-in-one solution.

Application

Engine layout	Max. 8 cyl., 2 bank
Control strategy	Torque structure based
Lambda control	With adaptation function
Speed limiter	
Gear cut for sequential gear box	
Map switch corresponds to 3 different target lambda and spark maps.	
Fuel cut off	
Turbo boost control	
Knock control	
Electronic throttle control	
Traction control	
Sequential fuel injection	

Asymmetric injection timing	Optional
Asymmetric ignition timing	Optional
Calibration interface	CCP via CAN or XCP via Ethernet
Interface to Bosch Data Logging System	
Internal data logger	2 GB
Max. Vibration	Vibration Profile 1 see www.bosch-motorsport.com

Technical Specifications

Mechanical Data	
Aluminum housing	
3 high pin density motorsport connectors	
165 pins, each pin individually filtered	
Vibration suppression via multipoint fixed circuit boards	
Size	180 x 155 x 40 mm
Weight	1,270 g
Protection Classification	IP67 to DIN 40050, Section 9, Issue 2008
Temp. range (at internal sensors)	-20 to 85°C
Electrical Data	
Power consumption. (w/o loads)	Approx. 13 W at 14 V
Power supply	
Operating range	6.5 to 18 V
Recommended	11 to 14 V
Absolute maximum	6 to 24 V
Inputs	
2 thermocouple exhaust gas temperature sensors	
2 lambda interfaces (LSU 4.9)	
1 crankshaft sensor (2-wire, inductive or Hall-effect)	
1 camshaft sensor (2-wire, inductive or Hall-effect)	
2 turbo speed sensors (2-wire, inductive or Hall-effect)	
4 wheel speed sensors (inductive or Hall-effect)	
38 universal analog inputs 0 to 5 V, 12 Bit	
4 analog inputs (angle synchronous or time synchronous triggering up to 250 ksp/s, 12 Bit)	
4 inputs for vibration knock sensors	
1 lap trigger input	
Outputs	
8 injection power stages (peak & hold)	
8 ignition power stages (up to 20 A)	

20 power stages (2 A; low side; PWM)
4 power stages (4 A; low side; PWM)
2 H-bridges (5 A)
3 sensor supplies 5 V/400 mA
1 sensor supply 10 V/100 mA
1 protected Ubat output 1 A
6 diagnostic outputs with selectable internal signals
1 time base reference synch-in/out

Communication

2 x 100 Mbps Ethernet interfaces
1 x RS232 serial interface
3 x 1 Mbps CAN interfaces
1 x LIN interface

Installation Notes

Internal battery for data preservation included.
Required service interval 12 months (internal battery is replaced).
Depending on your experiences with calibration of ECUs we recommend calibration support from Bosch Motorsport.
Please remember that the mating connectors and the programming interface MSA-Box II are not included and must be ordered separately.

Ordering Information

ECU MS 5.5	F 02U V00 285-04
Software	
Modas Sport Calibration Software	Inclusive
Environment (not included)	
Programming interface MSA-Box II	F 02U V00 327-02
Data logger C 60	F 02U V00 875-02
Display DDU 8	F 02U V00 873-05
Connectors (not included)	
AS 6-16-35 SA (yellow)	F 02U 000 467-01
AS 6-16-35 SB (blue)	F 02U 000 468-01
AS 6-16-35 SN (red)	F 02U 000 466-01

3.1 ECU plus Datalogger

The ECU MS 5.5 combines an ECU and a datalogger in a common housing. Due to this reason, some external communication interfaces are shared between those two components:

1. Ethernet
The MS 5.5 features an internal ethernet-switch which interconnects the two external interfaces, the logger-part and the ECU-part of the MS 5.5. Therefore both, the ECU and the datalogger can be accessed using any of the two external ethernet interfaces.
2. CAN
The internal ECU features 3 CAN interfaces (CAN1, CAN2, CAN3), the logger features 2 CAN interfaces (CAN1, CAN2). These interfaces are connected internally as given below:

External Pin	ECU	Datalogger
CAN1	CAN1	CAN1
CAN2	CAN2	CAN2
CAN3	CAN3	

Due to the internal interconnection of logger-CAN1 and ECU-CAN1 resp. logger-CAN2 and ECU-CAN2 the CAN bus speeds must be configured identically on each common CAN-bus (Default CAN speed is 1 Mbaud). E.g. if ECU-CAN1 is configured to a bus speed of 500 kBaud, the datalogger configuration of CAN1 must be set to 500 kBaud as well (using "RaceCon"-configuration tool).

3.2 Input Channels

There are several inputs for temperature measurements e.g. engine temperature *tmot* or intake air temperature *tair*. Temperature inputs have an internal "pull up" resistor for use with a NTC sensor (negative temp. coefficient). These pull ups can be switched software specifically. Depending on the used sensor (e.g. 15 KOhm or 2.5 KOhm NTC) the corresponding linearization curve has to fit. For measuring of accelerator pedal position or pressures, e.g. fuel pressure *pfuel* or oil pressure *poil*, which deliver a voltage (active sensors), pull up resistors are not allowed. These sensors must be calibrated with the sensors offset and sensitivity values (printed on the sensor, if it is from Bosch).

In the default configuration the ECU MS 5.5 needs an inductive speed sensor on the ignition trigger wheel. For the camshaft signal a Hall-effect sensor is necessary. Also for wheel speed measurement Hall-effect sensors are recommended. Four Hall-effect wheel speed sensors can be connected directly to the ECU. Different hardware configurations are available on request.

For wide range Lambda measurement and control the Lambda sensor Bosch LSU 4.9 is used.

3.3 Output Channels

The ECU MS 5.5 has 8 independent injection power stages. These output drivers can deliver a maximum current of 2.2 Ampere. Therefore the injection valves must have at least 6 Ohm internal resistance.

The 8 internal ignition power stages are able to drive high current ignition coils.

3.4 Power Supply

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

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

Connection of the power supply

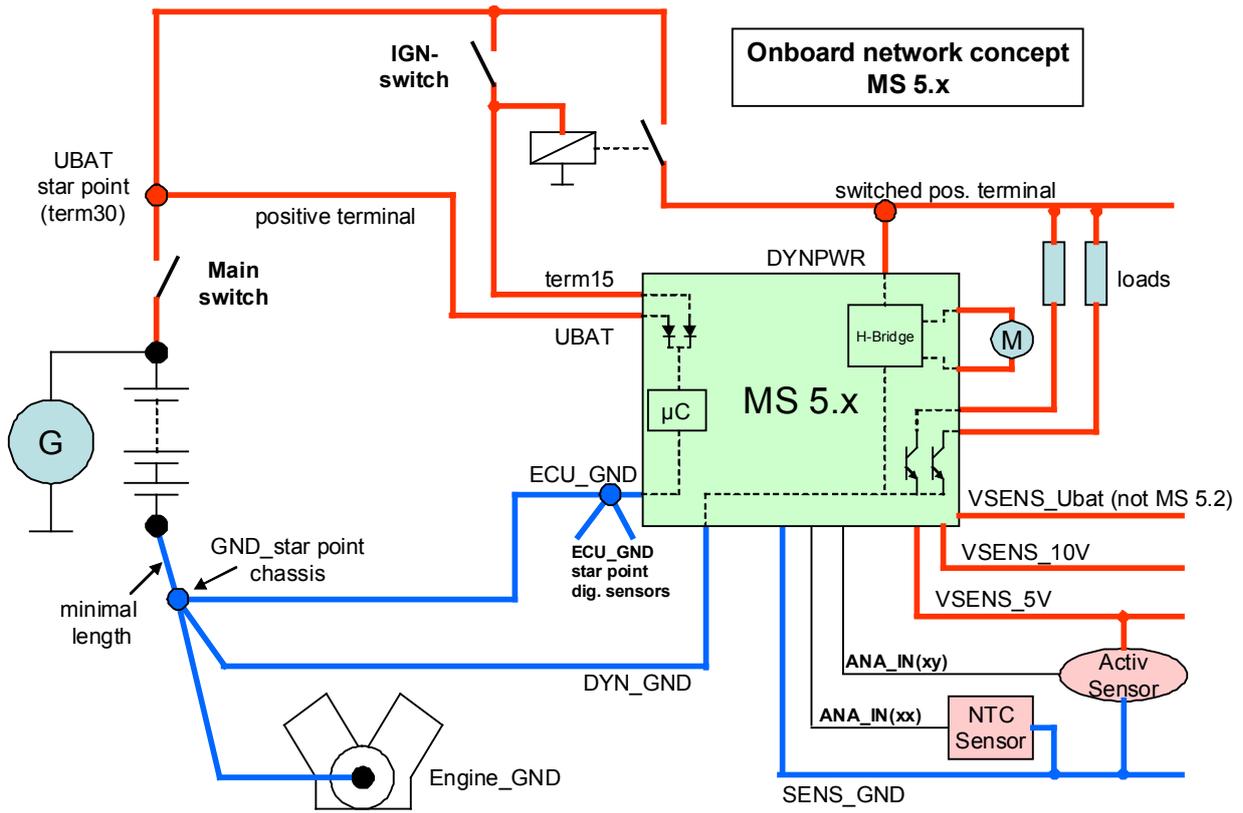
The following notations for power signals are used:

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

Caution

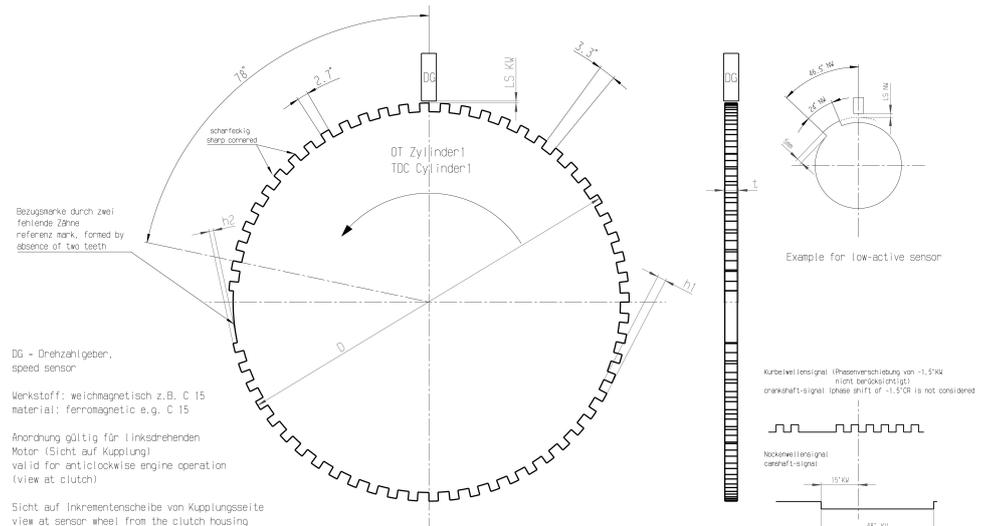
Wrong polarity / high currents

Wrong polarity of the terminals and high currents damage the MS 5.5. Be careful to observe current limits of wires and connector pins!



3.5 Ignition Trigger Wheel

The software assumes a toothed trigger wheel for proper operation. The number of teeth is hard coded by Bosch Motorsport and can not be changed by the customer. We recommend 60 (-2) teeth as shown in the following picture. The crankwheel trigger sensor must be an inductive type for the default configuration. The camshaft trigger sensor is a Hall-effect type with a single tooth trigger wheel. The picture below shows the correct installation position.

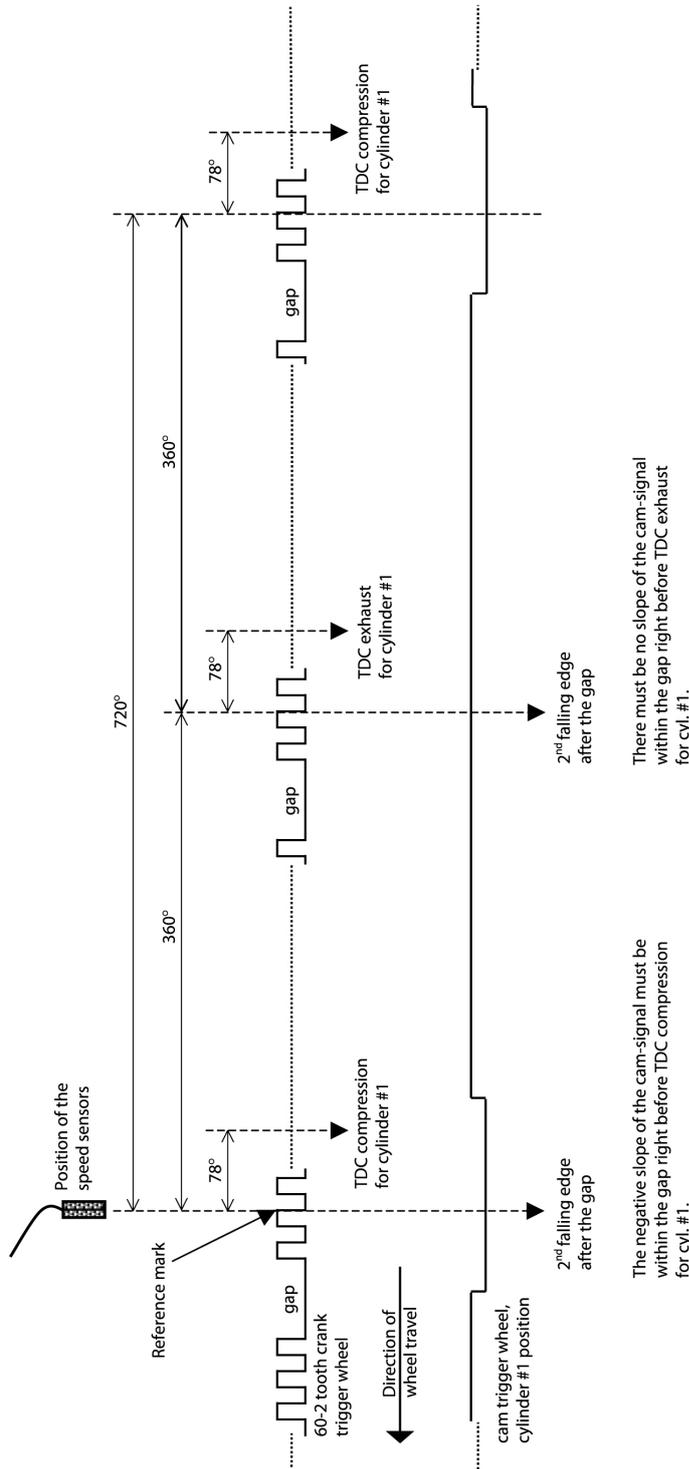


Recommended values:

- $D = \text{min. } 160 \text{ mm}$
- $h_1 = 3.5 \text{ mm}$
- $h_2 = h_1/2$
- $LSKW = 0.8 \text{ mm} \pm 0.3 \text{ mm}$
- $t = \text{min. } 5 \text{ mm}$
- $LSNW = 1 \text{ mm} \pm 0.5 \text{ mm}$

The procedure for correct adjustment of the trigger wheel is described on the picture on the next page.

Speed sensor and trigger installation for MS 5 ECUs with 60-2 trigger wheel



Procedure to find the right position for the crank and cam triggers:

- Step 1 - rotate the engine to the precise position of TDC compression for cylinder #1
- Step 2 - rotate the engine 78 crankshaft degrees backwards
- Step 3 - adjust the position of the crank trigger wheel in reference to its inductive speed sensor: the longitudinal axis of the sensor must point exactly towards the reference mark (2nd falling edge after the gap)
- Step 4 - rotate the engine further 15 crankshaft degrees backwards
- Step 5 - adjust the position of the cam trigger in reference to its hall effect speed sensor: the sensor must be at the begin of the tooth
- Step 6 - turn the engine by 345 crankshaft degrees to reach the position of 78° before TDC exhaust for cyl. #1
- Step 7 - verify that the crank trigger reference mark is in alignment with the longitudinal axis of the sensor (same as Step 3) and that the cam trigger tooth is at the opposite side of its speed sensor

Please note:

- 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 the shape 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

3.6 Sensor Recommendation Clubsport

The sensors listed on this page are partly based on production type parts and proofed hundreds of times in races all over the world. They offer good value for money. The volume of applied sensors may differ depending on individual software extents.

Model	Range of application	Connector Loom	Part No.
NTC M12-L	Ambient air temperature	D 261 205 288	0 280 130 039
NTC M12-H	Fluid temperature (oil, water, fuel)	D 261 205 337	0 281 002 170
TCP-K	Exhaust gas temperature	ASL 0-06-05SD-HE	B 261 209 385-01
PSA-C	Ambient air pressure	D 261 205 289	0 261 230 037
PSA-C	Crankcase pressure	D 261 205 289	0 261 230 037
PSS-10	Fluid pressure (oil, water, fuel)	1 928 403 968	B 261 209 341-01
PSA-C	Air pressure (manifold, boost)	D 261 205 289	0 281 002 389
LSU 4.9	Lambda value	D 261 205 356-01	0 258 017 025
IA-C	Crankshaft revolutions	D 261 205 334	0 261 210 136
HA-P	Camshaft revolutions	D 261 205 335	0 232 103 037
HA-P	Wheel speed	D 261 205 335	0 232 103 037
RP 86	Throttle angle	D 261 205 334	0 280 122 016
RP 100 twin	Acceleration pedal angle	AS 0-07-35SN	B 261 209 591-02
KS-P	Knock	D 261 205 337	0 261 231 120
RP 308	Gear detection	ASL 0-06-05SA-HE	B 261 209 570-01
GSS-2	Gear shift	ASL 0-06-05SC-HE	B 261 209 227-01
AM 600-3	Acceleration	ASL 0-06-05SA-HE	B 261 209 313-02
YRS 3	Yawrate	F 02U 002 235-01	0 265 005 838
RP 308	Steering angle	ASL 0-06-05SA-HE	B 261 209 570-01

3.7 Sensor Recommendation High-End

A lot of the sensors listed on this page are developed for high-end applications. The volume of applied sensors may differ depending on individual software extents. You can find more motorsport sensors on www.bosch-motorsport.com

Model	Range of application	Connector Loom	Part No.
NTC M6-HS	Ambient air temperature	ASL 0-06-05SN-HE	F 02U V00 486-01
NTC M6-HS	Fluid temperature (oil, water, fuel)	ASL 0-06-05SN-HE	F 02U V00 486-01
TCP-K	Exhaust gas temperature	ASL 0-06-05SD-HE	B 261 209 385-01
PSA-C	Ambient air pressure	D 261 205 289	0 261 230 037
PSA-C	Crankcase pressure	D 261 205 289	0 261 230 037
PSC-10	Fluid pressure (oil, water, fuel)	ASL 0-06-05SC-HE	F 02U V01 268-01
PSB-4	Air pressure (manifold, boost)	ASL 0-06-05SC-HE	B 261 209 348-01
LSU 4.9	Lambda value	AS 0-07-35SN	B 261 209 356-05
IS	Crankshaft revolutions	ASL 0-06-05PN-HE	B 261 209 517-01
HA-M	Camshaft revolutions	ASL 0-06-05SC-HE	F 02U V00 627-01
HA-M	Wheel speed	ASL 0-06-05SC-HE	F 02U V00 627-01
RP 100	Throttle angle	ASL 0-06-05SA-HE	B 261 209 127-01
RP 100 twin	Acceleration pedal angle	AS 0-07-35SN	B 261 209 591-02
KS-R	Knock	D 261 205 289	0 261 231 047
RP 308	Gear detection	ASL 0-06-05SA-HE	B 261 209 570-01
GSS-2	Gear shift	ASL 0-06-05SC-HE	B 261 209 227-01
AM 600-3	Acceleration	ASL 0-06-05SA-HE	B 261 209 313-02
YRS 3	Yawrate	F 02U 002 235-01	0 265 005 838
RP 308	Steering angle	ASL 0-06-05SA-HE	B 261 209 570-01

4 Starting up the ECU

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 (FDEF).

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 ECU MS 5.5 system can be used for engines up to 8 cylinders. Please ensure that the correct software variant is loaded in your ECU.

4.1.2 Crankshaft Wheel

The system initially supports wheels with 60-2 teeth. On customer demand other configurations are available. Please refer to the chapter Ignition Trigger Wheel [▶ 11].

4.1.3 Injection

4.1.3.1 Basic Path of Injection Calculation

The ECU MS 5.5 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 α_{th} or intake manifold pressure p_{22} , depending on the system variant) is converted into the engine charge signal rl (relative load). rl is defined as 100 %, if the cylinder is filled with air of 20 Centigrades and 1,013 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, warmup 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 t_e . 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 t_i 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.

4.1.3.2 Initial Steps

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

DISPLACEMENT

Displacement of the engine

CYLBANK

This label assigns cylinders to the respective bank (1 or 2). Lambda control is done bankwise, therefore this adjustment must be done for proper Lambda control. For each cylinder, the appropriate bank is defined as follows (shown for a typical V8 engine):

cylinder	1	2	3	4	5	6	7	8	9	10
CYLBANK	1	1	1	1	2	2	2	2	0	0

Notice

Engines with one Lambda sensor (e.g. 4-in-a-row) run as 1-Bank-Systems.

Set CYLBANK to 1.

QSTAT

Static valve quantity for n-heptane in g/min (injectors are typically measured with n-heptane).

TDTEUB

Battery voltage correction. Characteristics can be requested from the injector valve manufacturer.

Notice

For high pressure injection the characteristic TECORPRAIL applies instead of TDTEUB

MP_MIXCORR(2)

Mixture correction, set to 1.0 for startup.

MIXCORR_APP

Global factor for mixture correction, set to 1.0 for startup.

FINJ_CYL1 ... 8

Cylinder individual corrections. Set to 1.0 for startup. Numbering refers to mechanical cylinders as used at CYLBANK.

CWPRAILCOR

If a correction by fuel pressure is intended, set = 1. In this case please set PRAIL-REF 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.

FRLPAMB

Correction via ambient pressure. Usually the predefined values are suitable. If unsure, set FRLPAMB to 1.0 for first startup. For p/n-systems PALTCOR applies as an offset correction. Neutralize by setting to 0.0.

FRLTINT

Correction via ambient temperature. Usually the predefined values are suitable. If unsure, set FRLTINT to 1.0 for first startup. For p/n-systems FRLPTINT applies accordingly.

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 warmup 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.

4.1.3.3 Injection Angle

MP_EOINJ

End of injection pulse, refers to combustion TDC (degrees before TDC). Make sure, the injection is finished before the inlet valve closes.

Try 200° to 300° for first startup. Direct injection may differ.

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.

Finally the throttle angle potentiometer has to be calibrated (see chapter Throttle Angle [▶ 21]), maximum engine speed should be defined for engine protection (see chapter Revlimit [▶ 19]), all sensors should be checked (see chapter Peripherals [▶ 21]) and the ignition parameters should be preset and observed (see chapter Ignition [▶ 18]).

Basic setup may now be started by setting the appropriate values in the map MP_RL:

4.1.3.4 Load Map

MP_RL

Relative load depending on throttle angle and engine speed. Set value until your desired Lambda is matched.

Notice

If you operate a p/n-system, the maps MP_RLP1 ... 4 are used accordingly. For details please refer to the Function Description LOADCALC.

4.1.3.5 Injection Start

After initial calibration the start factors for injection may be optimized.

FINJSTART_TMOT

Basic start enrichment factor depending on the engine temperature.

MP_INJSTART

Decay of the start enrichment factor over the number of engine revolutions

Notice

For details please refer to the Function Description IN-JPRECTRL.

4.1.4 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_IGN_START

Base spark advance during engine start. Set to 5 to 10 deg, according to engine's requirements.

MP_TDWELL

Coil dwell time. Consult the coil manufacturer for details. Most coils need dwell times about 1.5 to 2.5 milliseconds at 12 to 14 V.

For further background information please refer to the Function Description IGNITION.

DIGN_CYL1 ... 8

Cylinder individual corrections. Set to 0.0. Numbering refers to mechanical cylinders.

4.1.4.1 Ignition Map

MP_IGN

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 dependent 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.

DIGN_MAP2 (3) / DIGN_PACE

Delta value for spark advance depending on the map switch position. Ensure correct switch position. If unsure, set to 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.

4.1.5 Revlimit

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 behaviour by advanced intervention, the engine speed is predicted by means of the speed gradient.

NMAX_GEAR

Maximum engine speed for soft limiter. Set value according to engine's requirements.

DNMAXH

Offset between soft limiter and hard limiter. 500 rpm should be suitable for most of the projects.

DNMAX_MAP2 (3)

Delta value for rev limiter, depending on the map switch position. Ensure correct switch position. If unsure, set to 0 for first startup.

TC_NMAXPR

Prediction time for rev limiter, depends on the inertia torque of the engine. If oscillations occur, reduce value or turn off by setting = 0.0.

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. Set:

- 1 = for injection cutoff,
- 2 = ignition cutoff,
- 3 = injection and ignition cutoff.

NMAX_P

Determines the slope of the soft limiter between soft limit and hard limit. Predefined. Vary according to your engine's dynamic behavior.

4.1.6 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

1. Before switching the system on, check the following steps ...

... Make sure the battery is connected properly,

... all sensors are connected,

... ground wiring is fixed before powering up the system.

2. Check all sensors for errors (bits ..._e) before starting the engine.

Sensors and peripherals can be checked when the system is powered up electrically.

Notice

Do not start the engine before all steps in this chapter are carried out.

4.2.1 Throttle

4.2.1.1 Throttle Angle

UDTHR_MIN, UDTHR_MAX

Minimum and maximum accepted sensor voltage. When violated, an error is set ($E_{thr} = 1$). Set to approx. 100 mV/4900 mV.

Check if the sensor output value uthrottle is changing when throttle is moved.

4.2.1.2 Calibration

THRADJPOS1

Lower calibration point, set to 0.0 %.

THRADJPOS2

Full load point, set to 100.0 %.

CWTHRADJ

Procedure:

1. Close throttle and set CWTHRADJ to 1.
2. Open throttle fully and set CWTHRADJ to 2.
3. Adjust the throttle to idle point.

Do not forget to set CWTHRADJ back to 0. Check calibration by moving throttle.

Notice

It is also possible to recalibrate the idle point afterwards.

For it, proceed as follows.

THRADJIDLE: set value according to your idle position, e.g. 2.0 %.

CWTHRADJ: set to 3.

For further details and project specific variants please refer to the Function Description ISTHROTTLE.

4.2.2 Pressures

All pressures are calculated in the same way. The system usually offers oil pressure (*poil*), ambient pressure (*pamb*), crank pressure (*pcrank*), water pressure (*pwat*) and fuel pressure (*pfuel*). The extent may vary according to software variants.

Example: Ambient pressure

PAMB_OFF, PAMB_GRD

Sensor offset and gradient. Consult the sensor manufacturer for details.

UPAMB_MIN, UPAMB_MAX

Minimum and maximum accepted sensor voltage. When violated, an error is set (E_pamb = 1). Set to approx. 100 mV / 4900 mV.

PAMB_DEF

Default value. If a sensor error is set, the output is switched to the default.

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.

For further details and project specific variants please refer to the Function Description ISPRESS.

4.2.3 Temperatures

All temperatures except the exhaust gas temperature are calculated in the same way. The system usually offers oil temperature (*toil*), intake air temperature (*tint*), engine temperature (*tmot*), fuel temperature (*tfuel*), ...

Example: Intake air temperature

UTINT_MIN, UTINT_MAX

Minimum and maximum accepted voltage. When violated, an error is set ($E_{tint} = 1$). Set to approx. 100 mV / 4900 mV.

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) take the predefined value of 3000 Ω .

The exhaust gas temperature is measured via NiCrNi elements using a special evaluation circuit. Predefined values should be suitable.

For further details and project specific variants please refer to the Function Description ISTEMP.

4.3 Vehicle Test

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

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

For wheel circumference of the front wheels; Consider dynamic increase of your tyre.

CIRCWHEEL_R

For wheel circumference of the rear wheels; Consider dynamic increase of your tyre.

If a lap trigger is used, the lap length must be entered for plausibility:

LLAP

Set value to the length of your track.

For detailed information please refer to the Function Descriptions CARSPEED and LAPFUNC.

5 Data logging

The MS 5.5 has an internal logger, presenting a cost efficient and weight optimized all-in-one solution.

5.1 Software

Which software tools are available?

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.

5.2 Starting up the data logging

The following chapters demonstrate how to set up data logging and how to analyze the recorded data. It shows the most important functions and features of RaceCon and WinDarab. For this tutorial we assume, that you have a MS 5.5 connected to your computer via an MSA II Box or an Ethernet line.

Caution

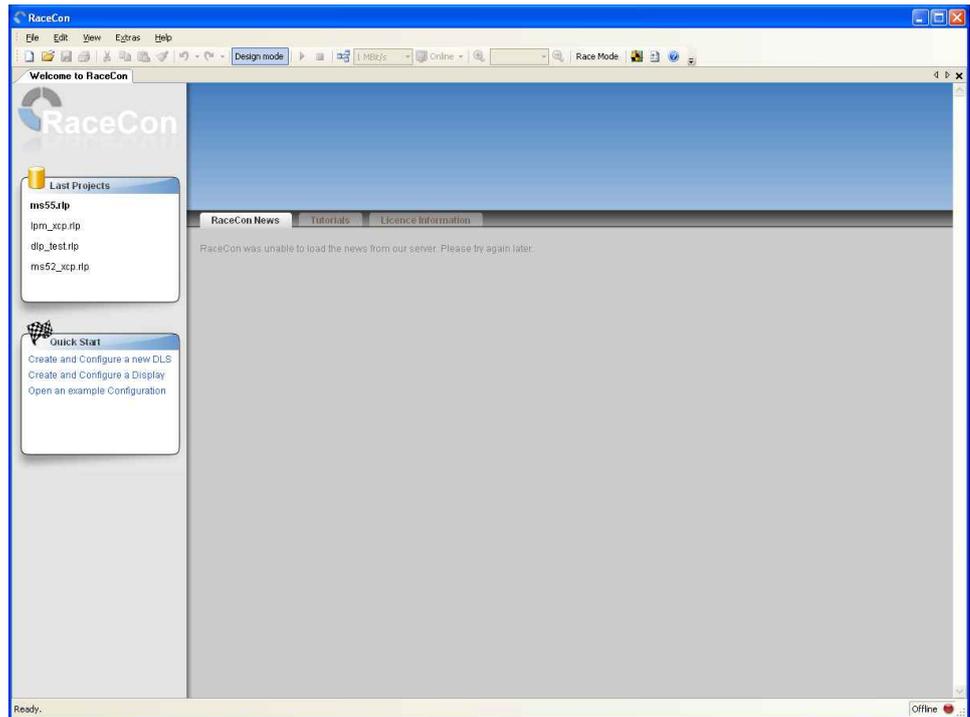
Don't start up the engine unless the steps described in chapter Starting up the ECU [▶ 15] have been performed.

5.2.1 Ethernet configuration

The Ethernet communication is designed to work without manual configuration. There may be special situations where manual configuration of the computer network adapter is required. Please refer to the appendix. Communication is designed to work without manual configuration. There may be special situations where manual configuration of the computer network adapter is required. Please refer to the appendix.

5.3 Welcome to RaceCon

After the start of the program, RaceCon opens a view **Welcome to RaceCon**. With **Last Projects**, former projects can be opened directly.



5.3.1 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. Starting with the configuration, one engine control unit (ECU) shall be placed on the vehicle view.

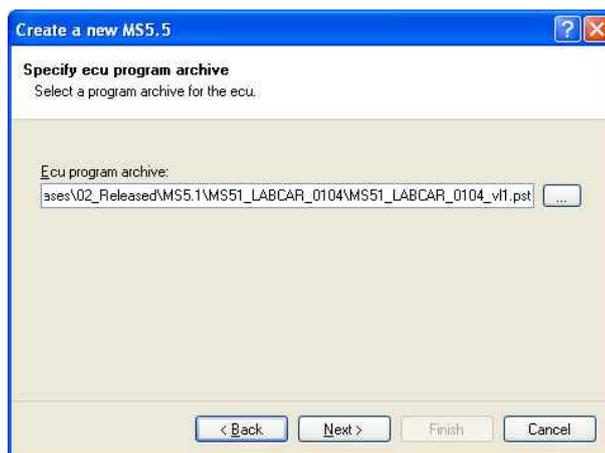
Select an **ECU** model MS 6.1 from the **Toolbox / Devices / ECUs**. Drag the ECU icon with pressed left mouse click on the **vehicle view**, then a dialog opens. Now the Datalogger and ECU program archive **PST files** must be selected. These archives are delivered by Bosch Motorsport.

Specify the datalogger program archive MS 6.1_LOGGER_XXXX_XX.pst.



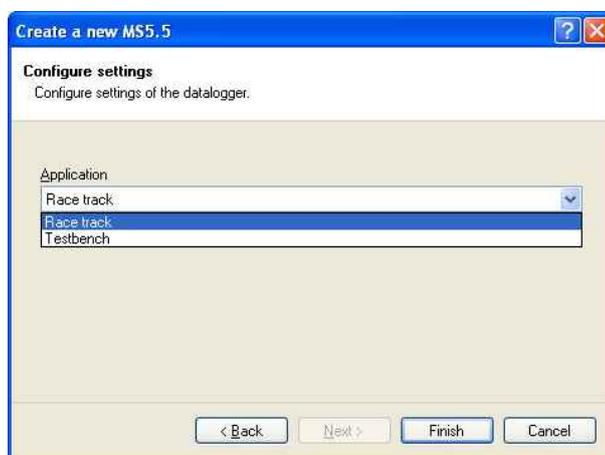
Press Next.

Specify the ECU program archive. MS 6.1_XXXX_XXXX_xx.pst.



Press Next.

Configure the data logger to match your application.

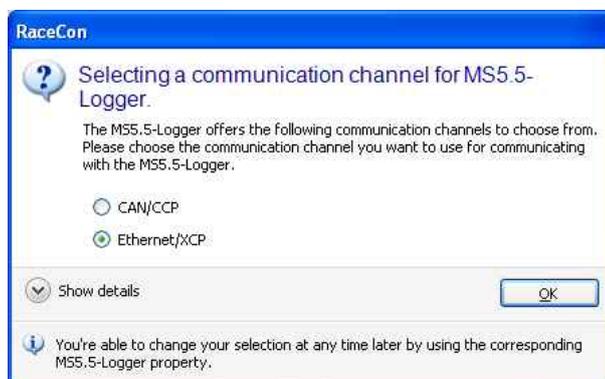


The basic configuration of the project is finished and RaceCon sets up a communication with the MS 6.1.

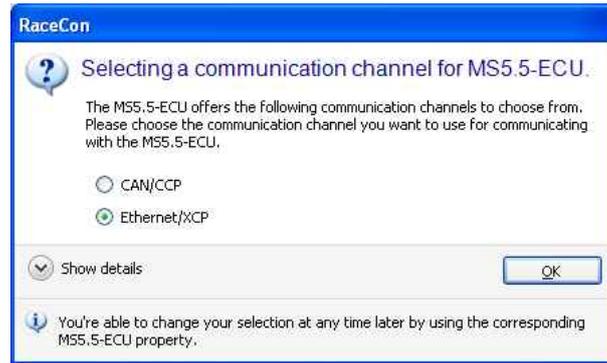
RaceCon supports two communications channels CAN/CCP and Ethernet/XCP. Both channels can be used for calibration, while only Ethernet/XCP can be used for data logging.

The MS 6.1 consists of two components the MS 6.1-Logger and the MS 6.1-ECU, thus the dialog box opens twice and we **must** select Ethernet/XCP in both cases.

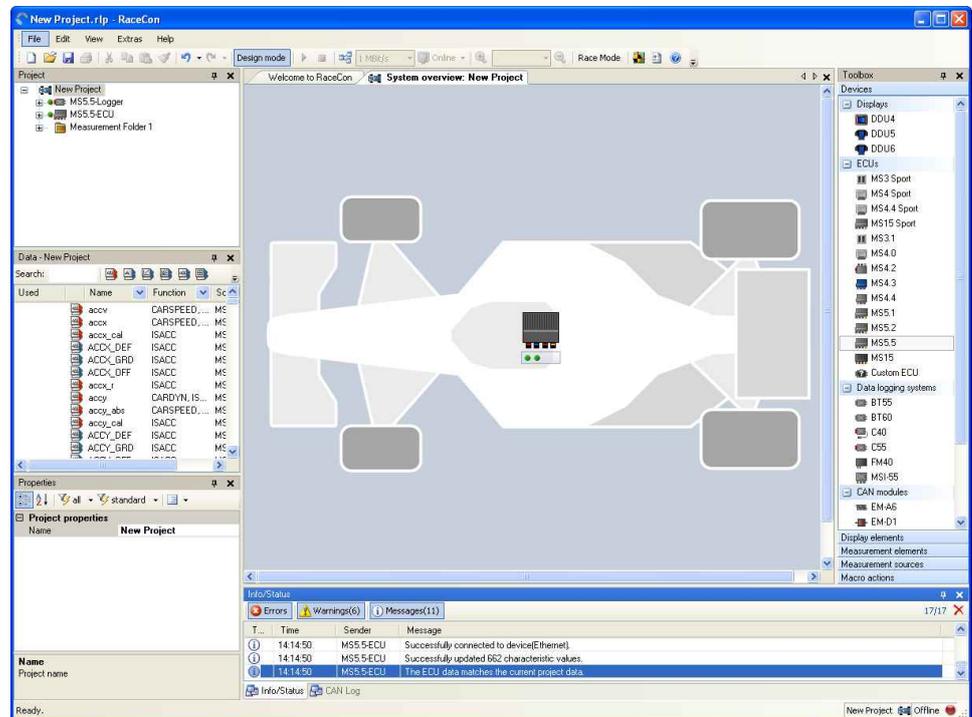
MS 6.1-Logger



MS 6.1-ECU



With these settings done the MS 6.1 appears in the **System overview** and in the Project tree. The Project tree lists all the measurement labels in hierarchic view. Communication between RaceCon and the MS 6.1 is initialized. Two green lights indicate that the MS 6.1-ECU and –Logger are connected and ready for use.



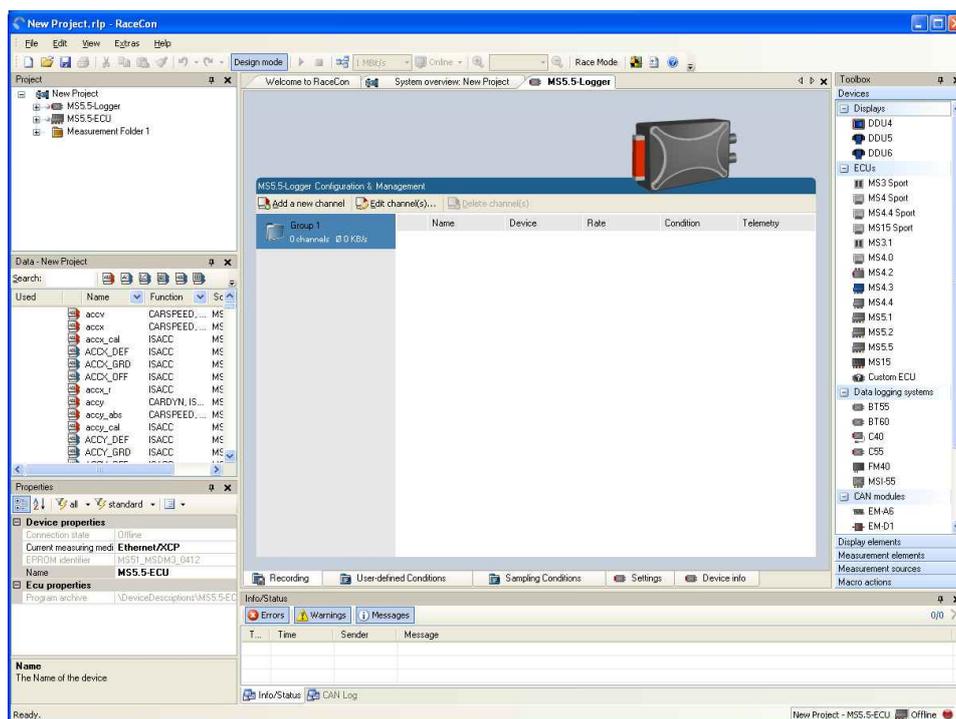
5.3.2 Configuration and Mangement of Recordings

Open the MS 6.1-**Logger Configuration & Management** page by double-clicking on the MS 6.1 symbol in the **System overview**. A new tab MS 6.1-**Logger** is created. You can switch between the **System overview** and the MS 6.1-**Logger view** at any time by clicking on the tab.

5.3.2.1 Create a new recording

At the bottom of the newly created tab MS 6.1-**Logger** you find a set of sheets. The sheet MS 6.1-**Logger Configuration & Management** is displayed. You may switch between the different sheets at any time by clicking on the sheet tab at the bottom of the sheet.

This sheet gives you an overview of the recordings configured for your system. In the next step we will add channels to the recording.



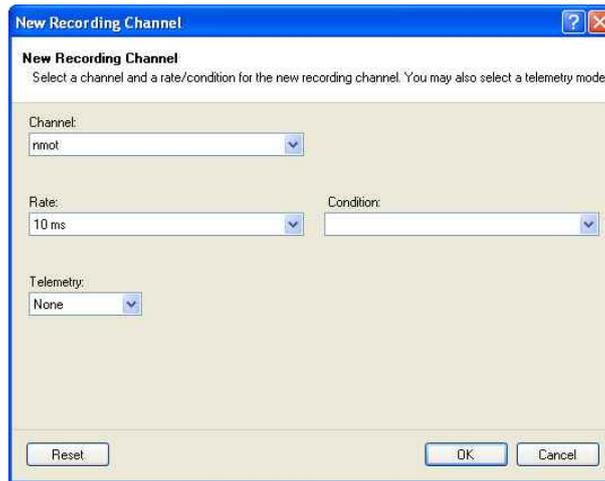
5.3.2.2 Add channels to a recording

Locate the channel on the left side in the Data window and simply drag it onto the Recording sheet. Default values for rate and recording condition are assigned to the channel. You may modify the default values by double clicking on the channel in the recording sheet.

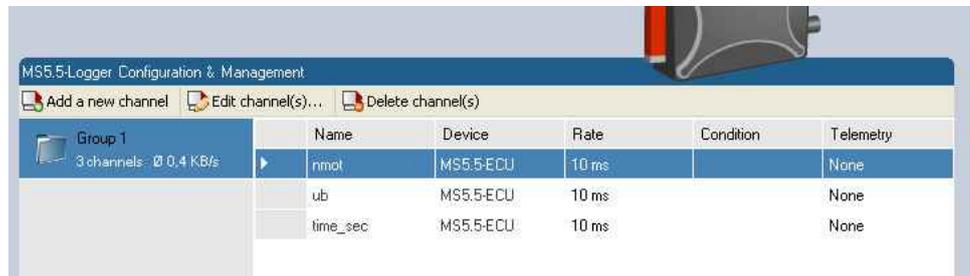
For the purpose of this tutorial leave the condition field unassigned. The recording starts as soon as you download the recording configuration and you will get recorded data while the engine is not running. Recording conditions allow for a sophisticated tailoring of your recording.

Notice

If you double click on the channel in the Data window on the left, the channel will be configured for online measurement, giving a live view on the channel as long as you are connected to the MS 6.1.

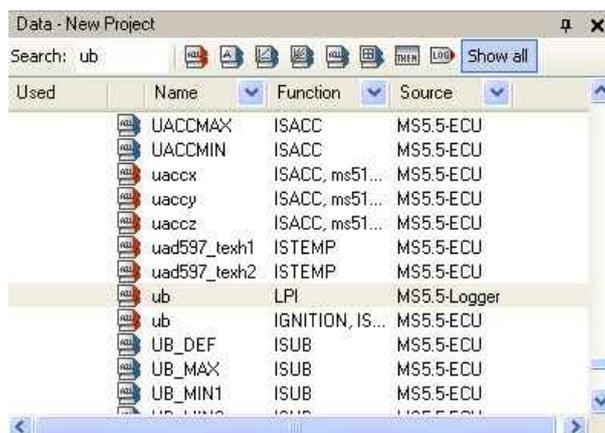


Repeat this step for every channel you want to record. Recommended channels for the tutorial are shown below.



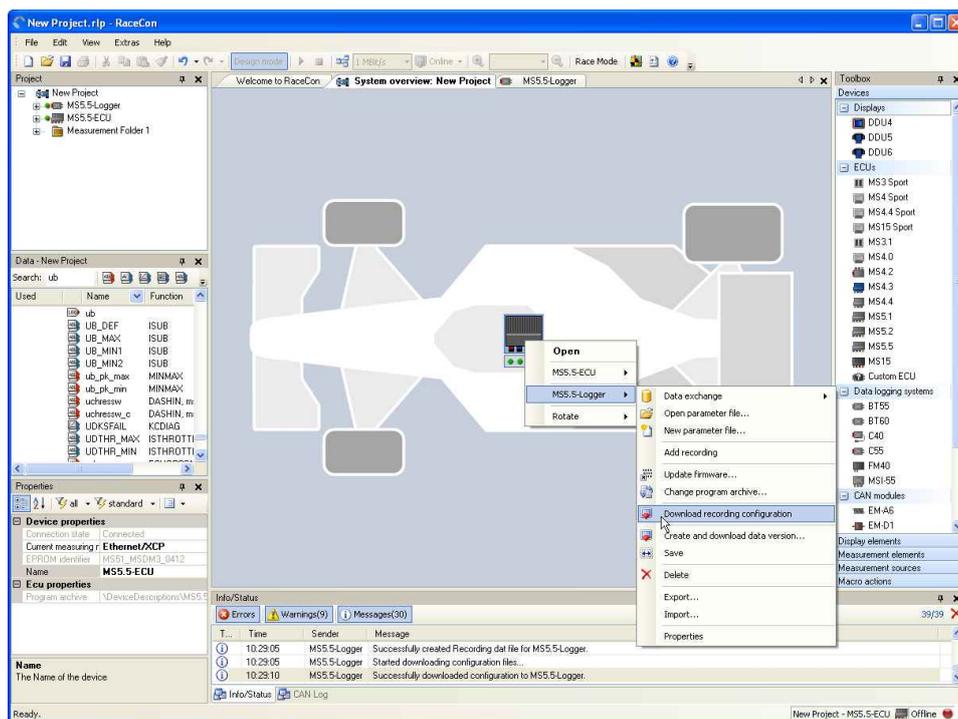
5.3.3 Working with multiple data sources

Some channels are measured multiple times in different areas of the car. A typical example is **ub**, the battery voltage seen by an electronic control unit. The MS 6.1 with the components ECU and Logger integrated into measures the battery voltage **ub** twice. You can easily distinguish them by the source name MS 6.1-ECU and MS 6.1-Logger.



5.3.4 Download recording configuration

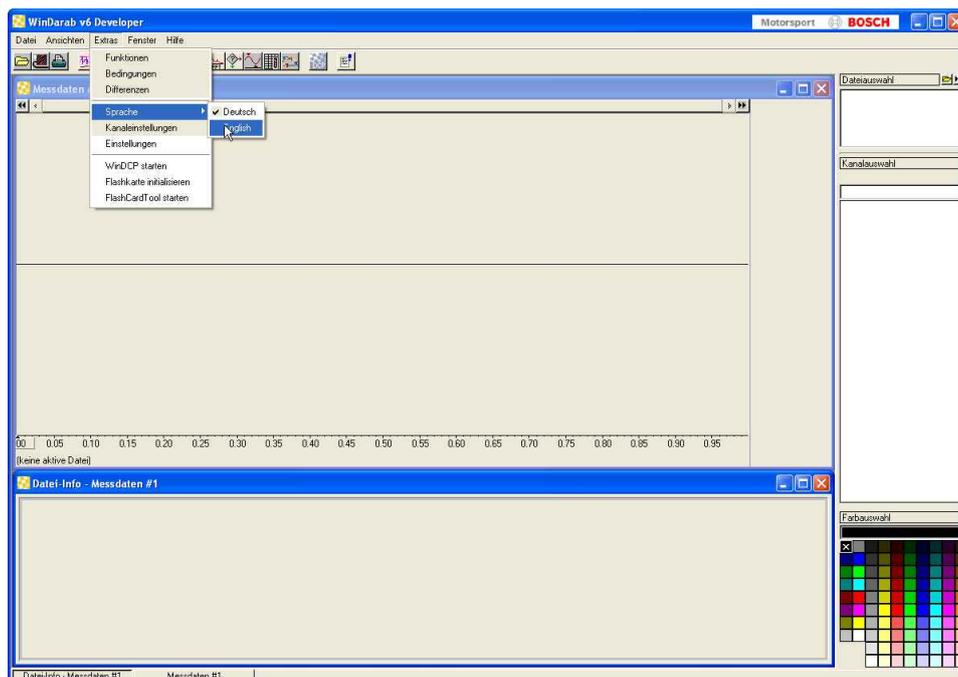
At the top of MS 6.1-Logger you find a set of tabs. Select the **System overview**. Right-clicking on the MS 6.1 symbol in the System overview. A context sensitive menu is displayed. Locate **MS 6.1-Logger / Download recording** and click it.



During the download of the recording configuration the LED MS 6.1 DL_RUN (on the real ECU) will be light orange. When the download is finished the LED MS 6.1 DL_RUN will blink green (5Hz) indicating, that a recording is running.

5.4 Welcome to WinDarab

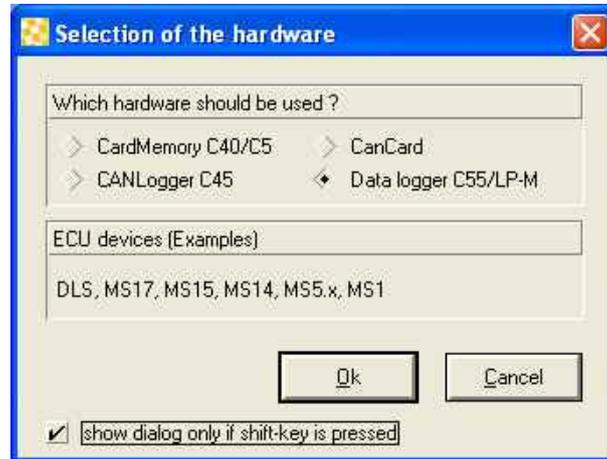
After the start of the program, WinDarab opens set of windows, if you run it for the first time. Close the windows **Rennstrecke** and **Darab-Explorer – Messdaten**. The default language is German. From the main window WinDarab v6 Developer select **Extras / Sprache / English**.



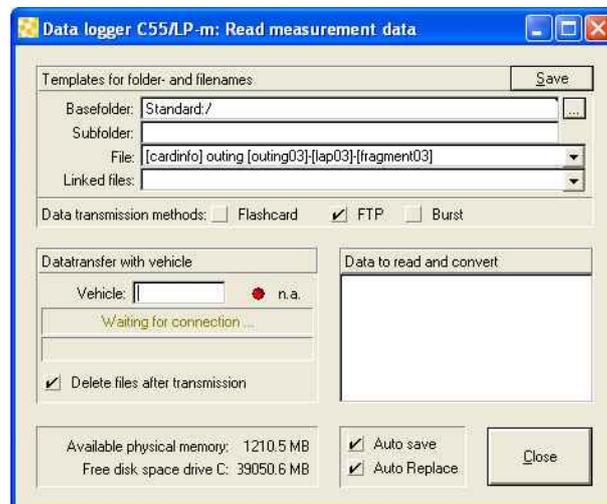
Now you are ready to upload recorded data from the MS 6.1.

5.4.1 Upload recorded data

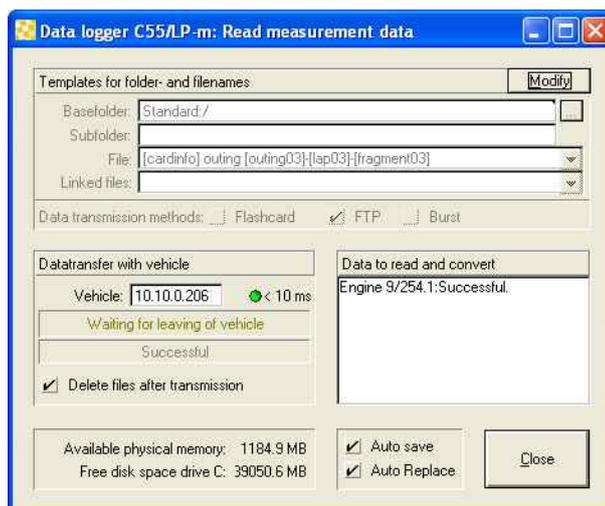
Click on the icon  Read measurement data to start the upload. Select the hardware **Data logger** and tick the box **show dialog only if shift-key is pressed**. So this window won't pop-up during subsequent uploads.



Next the Read measurement data window is displayed. Click on the button **Modify/Save** to display the text Save. Remove the tick **Flashcard** and add the ticks **Delete files after transmission, Auto save** and **Auto Replace**. Click on the button **Save** to save your settings. The button switches back to Modify.



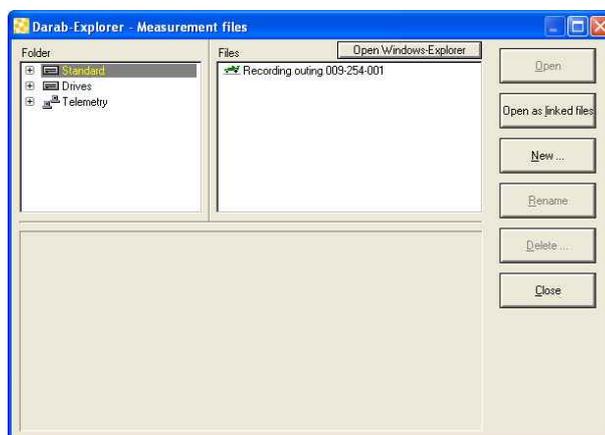
Now enter the IP address of the MS 6.1-Logger **10.10.0.206** into the **Vehicle** field and press the **Return** key. The indicator changes from red to green and the data upload runs automatically. A progress bar and the messages inform you about the status. Once the data upload is finished, click on the Close button.



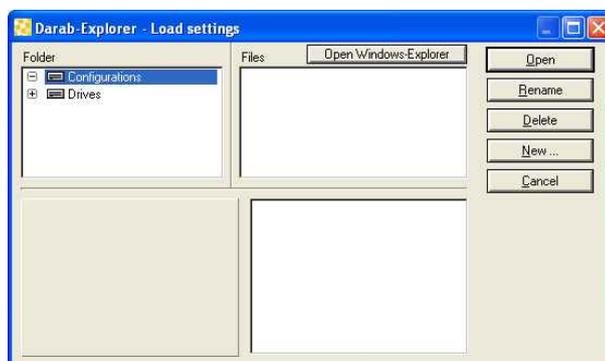
Now the data are stored in your computer and are ready for analysis.

5.4.2 Select the recorded file

Click on the button  open measurement data. WinDarab uses **Darab Explorer** in much the same way that Windows uses Windows Explorer. Darab Explorer is used to manage all files required by WinDarab. Locate the Recording you just uploaded in the previous step in the Files view. Highlight the file with the car symbol and click on **Open**.

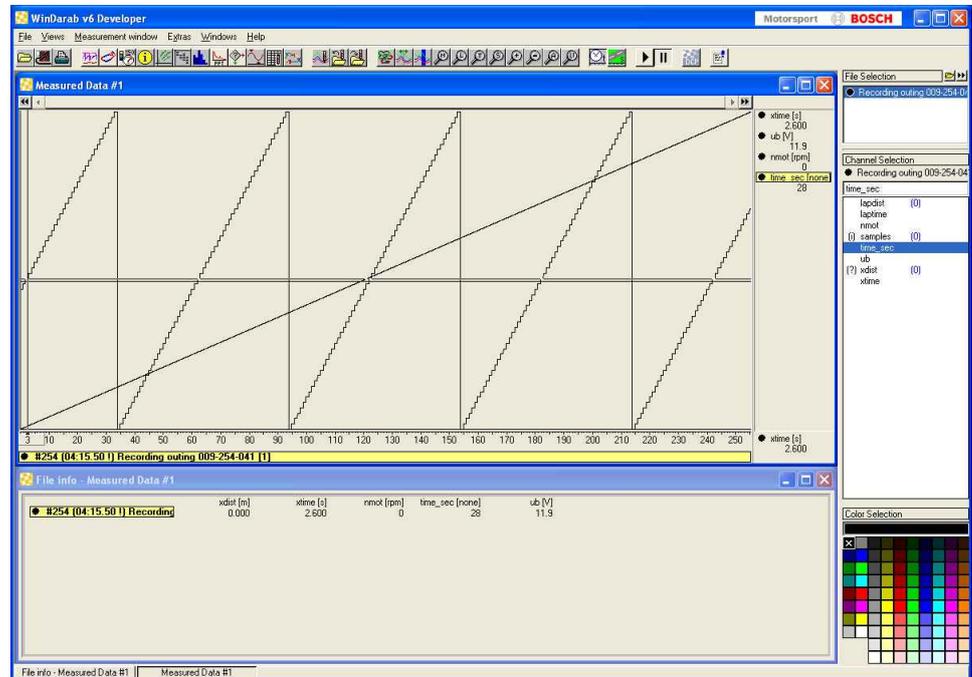


This opens the next window, which you can skip by clicking **Cancel**.



5.4.3 Select channels for display

Locate the channels on the right side in the Channel Selection window and simply drag them onto the Measured Data sheet. Default values for the y-Range of the channels are applied.



5.4.4 Analyze the recorded data

WinDarab offers a rich set of functions and algorithms to visualize and analyze the recorded data. The functions are accessible in the **Views** menu.

- (x,y)-Plot
- Distribution
- Histogram
- FFT
- Flowchart
- Table Min/Max
- Outing Report
- Lap Analysis

Please refer to the WinDarab online help for a description of these advanced features.

6 Extensibility

We developed a lot of extras for the ECUs. That is e.g. Displays and Telemetry units. The communication via Ethernet instead of CAN makes the system work very much quicker.

Find more information on our website on www.bosch-motorsport.com

7 Appendices

The Ethernet communication is designed to work without manual configuration. There may be special situations where manual configuration of the computers network adapter is required.

Reasons for manual configuration:

The computer network interface was configured to use a fixed IP-Address. The network interface should be configured for automatic IP-Address. The MS 5.5 runs a DHCP server which automatically provides the required configuration to the computer network interface.

If it is not practical to use an automatic IP-Address the computer network interface must be set to:

IP-Address: 10.10.0.14

Netmask: 255.255.255.0

Standard-Gateway: <empty>

A firewall is installed on the computer. A firewall is a software that protects a computer from unauthorized access, especially when connected to the internet. This firewall may block parts or all the communication between your computer and the MS 5.5.

Please consult your computer administrator to disable the firewall for this interface.

Bosch Engineering GmbH
Motorsport
Robert-Bosch-Allee 1
74232 Abstatt
Germany
www.bosch-motorsport.com
