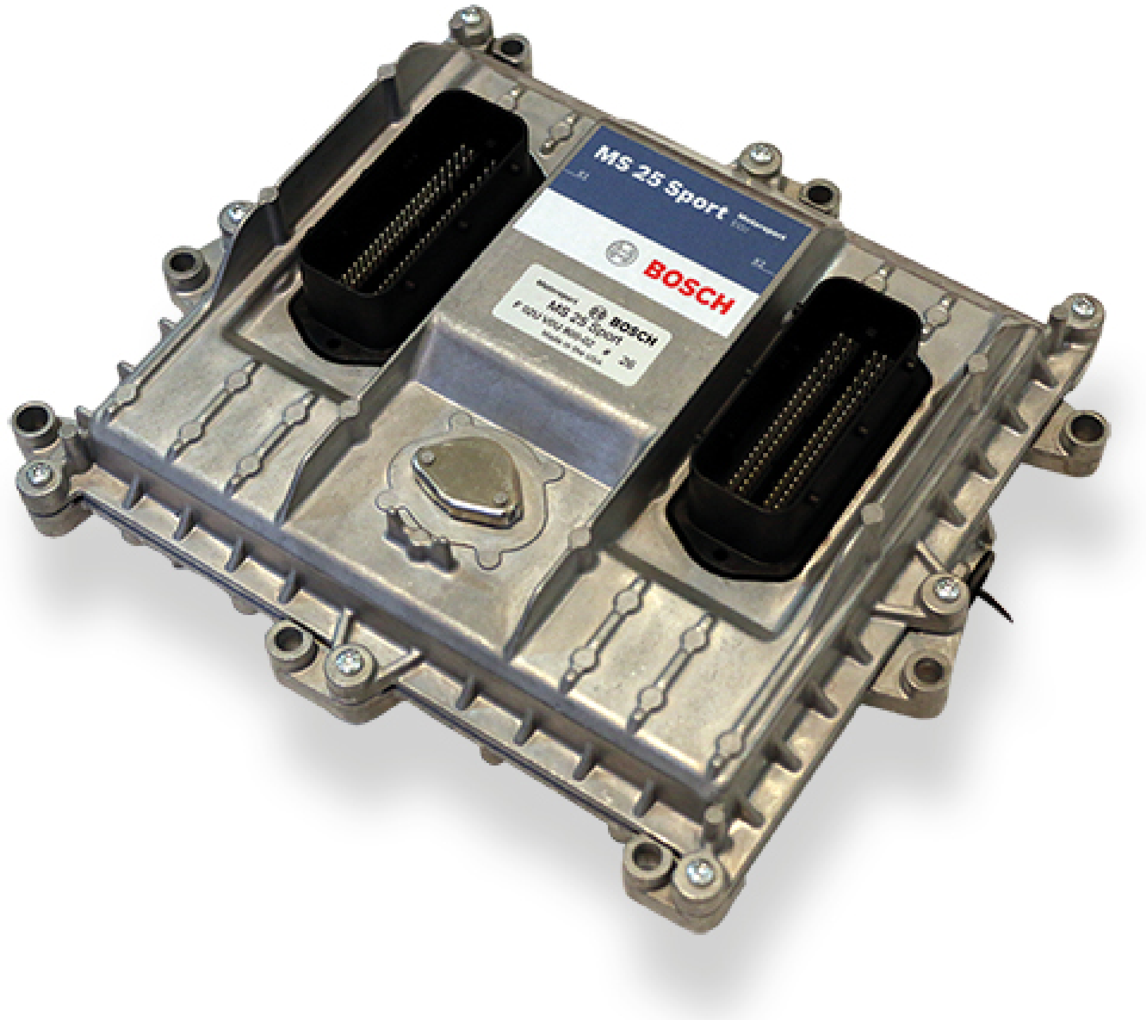
BOSCH



Engine Control Uni MS 25 Sport

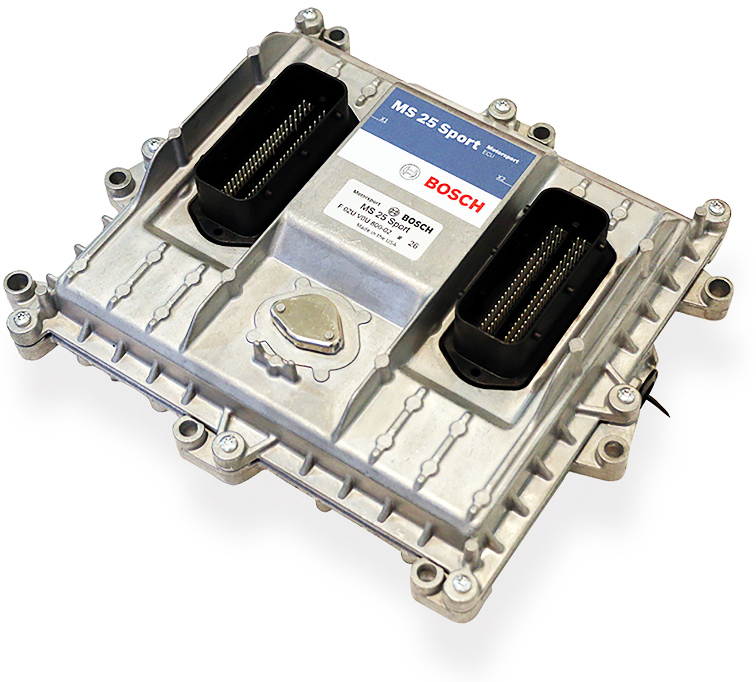
Manual

Version 1.0 17/04/2024

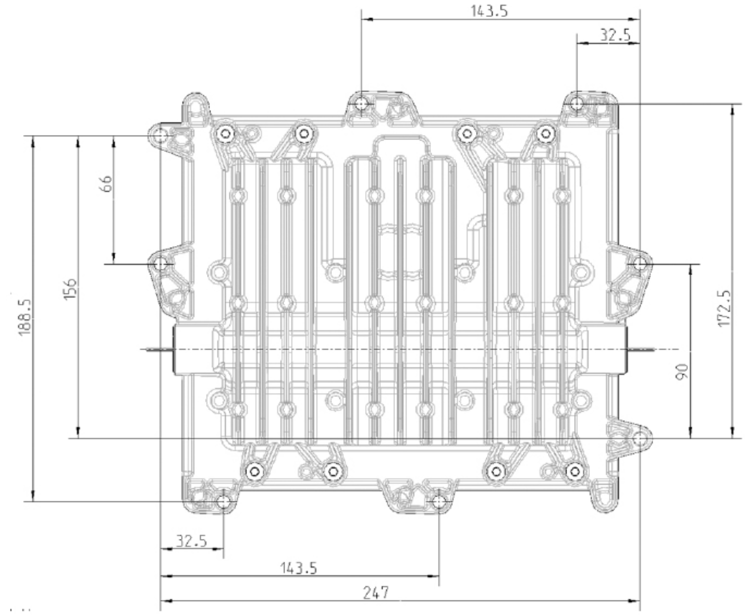
Content

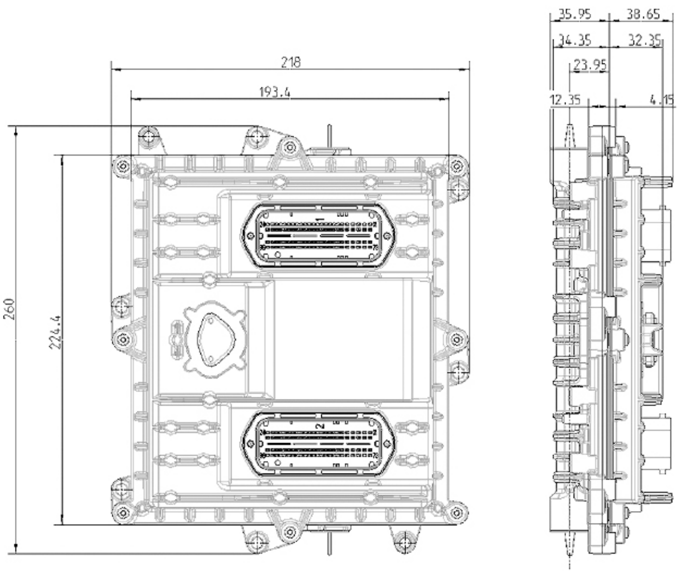
1 Technical data

The ECU MS 25 Sport engine control unit manages common rail Diesel engines with solenoid valve injectors up to 8 cylinders. The MS 25 Sport utilizes software development process based on MATLAB® & Simulink®.



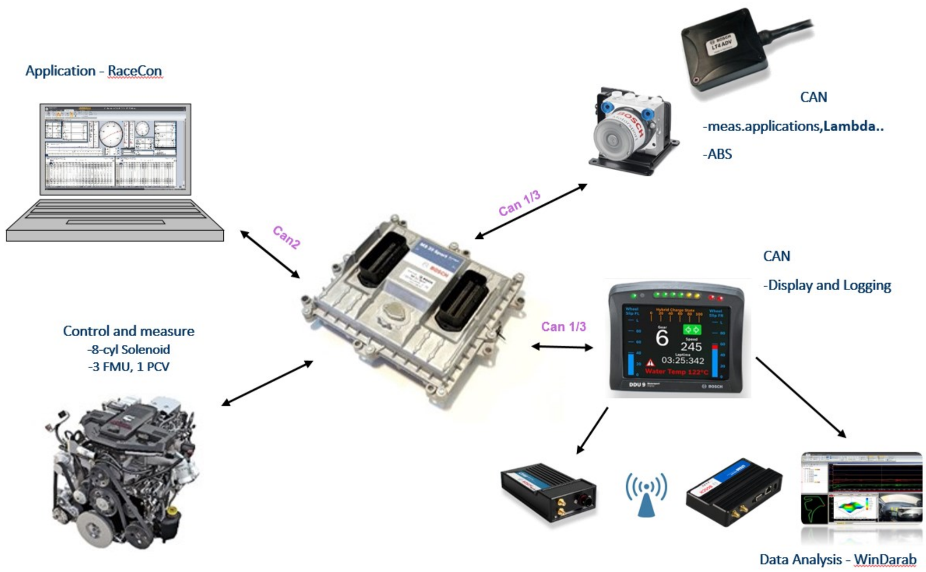
Mechanical Drawing





1.1 System Layout

- Controls max. 8 cylinders with 5 injections (Pilot2-, Pilot1-, Main-, Post2- and Post1 injection)
- Two engine hydraulic bank measurement, control and monitoring strategy for rail pressure with one (FMU) or two actuator (FMU+PCV) operation
- Two engine bank related separated lines for physical air mass, boost pressure and turbo speed determination and control
- One lambda LSU 4.9 measurement supported directly by MS 25 Sport. 2-bank measurement and control as option via external CAN measurement
- Integrated torque-structure for power control functions as speed- and launch limitations or regulations. Gear and map position dependent torque limitations
- Gear cut support with rail pressure control feedback



1.2 Pin Layout

The pin layout is also placed at Bosch Motorsport Homepage.

Some pins and functions are optional and not included in the base version of the MS 25 Sport software.

Engine connector (X2 - Engine) 1928405313

PIN	Name	Main function	PIN Name	Signal
1	InjectorPwrStg 2 -	InjectorPwrStg 2 "bank2"	O_P_SVL21	
2	InjectorPwrStg 5 -	InjectorPwrStg 5 "bank2"	O_P_SVL22	
3	InjectorPwrStg 8 -	InjectorPwrStg 8 "bank2"	O_P_SVL23	
6	Oil press./temp. gnd	Oil Pressure and Temperature Ground	G_R_DF03	
7	Boost press. supply +5V	Boost pressure sensor supply	V_V_5VSS1A	
8	5V sens. Supply 5	5V Sensor supply 5	V_V_5VSS2C	
9	CAM/CRK hall supply +5V	CAM/CRK speed sensor supply (HALL)	V_V_5VSS2F	
10	5V sens. Supply 6	5V sensor supply 6	V_V_5VSS2E	
11	rail press. supply +5V	Rail pressure sensor supply	V_V_5VSS3B	
12	Fuel Temp Signal	Fuel Temp Signal	I_A_AN18	tfuel
13	oil temp. signal	Oil temperature sensor signal	I_A_AN15	toil
14	fuel feed press.	Fuel Feed Pressure	I_A_AN09	pfuel
16	exhaust/water1 press. signal	Exhaust gas / water pressure 1	I_A_AN02	pwat
17	CAN3+ (Display)	CAN Interface (Display/logger)	B_D_CANH2	
18	CAN3- (Display)	CAN Interface (Display/logger)	B_D_CANL2	
19	Sens. Gnd 5	Sensor ground 5	G_R_AN02	
21	waste gate 2 / VGT2	Waste Gate 2 / Variable Turbine Geometry 2	O_T_RL3	
22	GPU5 LS	General purpose output 5 (LS)	O_T_RL07	
23	GPU3 LS	General purpose output 3 (LS)	O_T_RL09	
24	Battery plus output 32	Battery Plus Output 32	O_V_RH32	
25	InjectorPwrStg 2 +	InjectorPwrStg 2 "bank2"	O_P_SVH21	
26	InjectorPwrStg 5 +	InjectorPwrStg 5 "bank2"	O_P_SVH22	
27	InjectorPwrStg 8 +	InjectorPwrStg 8 "bank2"	O_P_SVH23	
30	Wheelspeed ground	Wheel sensor ground rear	G_R_AMS	
31	oil press. supply +5V	Oil pressure sensor supply	V_V_5VSS1F	
32	Sensor Supply 7 +5V	Sensor supply 7	V_V_5VSS1E	
33	Water press. Supply +5V	Water press sensor supply	V_V_5VSS2B	
34	5V Sensor supply 8	Sensor supply 8	V_V_5VSS3C	
35	oil press. signal	Oil pressure sensor input signal	I_A_AN01	poil
36	rail press. signal	Rail pressure sensor signal	I_A_RAILPS	prail
37	boost temp. signal	MAT (Boost temperature)	I_A_AN16	tint
39	coolant temp. signal	Coolant temperature sensor signal	I_A_AN17	tmot
40	Sensor gnd 8	Sensor ground 8	G_R_AN08	
41	SENT (optional)	input for SENT interface	I_D_SENT	
42	Sensor gnd 7	Sensor ground 7	G_R_AN20	
45	fuel pump relay	Fuel Pump	O_S_RL19	
46	GPU2 LS	General purpose output 2 (LS)	O_T_RL06	
47	GPU1 LS	General purpose output 1 (LS)	O_T_RL05	
49	InjectorPwrStg 1 +	InjectorPwrStg 1 "bank1"	O_P_SVH11	
50	InjectorPwrStg 4 +	InjectorPwrStg 4 "bank1"	O_P_SVH12	

51	InjectorPwrStg 7 +	InjectorPwrStg 7 "bank1"	O_P_SVH13	
52	InjectorPwrStg 3 +	InjectorPwrStg 3 "bank3"	O_P_SVH32	
53	InjectorPwrStg 6 +	InjectorPwrStg 6 "bank3"	O_P_SVH33	
54	fwheel_rl	Wheelspeed frequency input, rear left (Hall)	I_F_AMS	vwheel_rl
55	LIN (OPTIONAL)	LIN interface (Optional)	B_D_LIN	
56	fwheel_rr	Wheelspeed frequency input, rear right (Hall)	I_F_IATS	vwheel_rr
57	waste gate 1 / VGT1	Waste Gate 1 / Variable Turbine Geometry 1	O_T_RL02	
58	FMU1 supply	Supply FMU	O_V_MEU	
59	Cooland/fuel temp gnd	Coolant and fuel temperature sensor ground	G_R_AN18	
60	rail press. gnd	Rail pressure sensor ground	G_R_RAILPS	
61	amb/water2 press. signal	ambient pressure / water pressure 2	I_A_AN03	pwat2
62	Wastegate press. Signal	wastegate pressure sensor 1 signal	I_A_AN07	pwgc
63	LSU VM	LSU4.9 - VM	G_R_LSVG	
64	LSU IP	LSU4.9 - IP	I_A_LSCP	
65	crankshaft -	Crankshaft speed sensor signal Negative (Inductive)	I_F_CRSNEG	
66	crankshaft +	Crankshaft speed sensor signal Positive (Inductive)	I_F_CRSPOS	
67	camshaft - (OPTIONAL)	Optional CamShaft Sensor Signal (Inductive)	I_F_CASNEG	
68	camshaft + (OPTIONAL)	Optional CamShaft Sensor Signal (Inductive)	I_F_CASPOS	
69	Sensor gnd 6	Sensor ground 6	G_R_AN07	
72	LSU heat-	lambda sensor heater low side PWM output	O_T_LSH	
73	InjectorPwrStg 1 -	InjectorPwrStg 1 "bank1"	O_P_SVL11	
74	InjectorPwrStg 4 -	InjectorPwrStg 4 "bank1"	O_P_SVL12	
75	InjectorPwrStg 7 -	InjectorPwrStg 7 "bank1"	O_P_SVL13	
76	InjectorPwrStg 3 -	InjectorPwrStg 3 "bank3"	O_P_SVL32	
77	InjectorPwrStg 6 -	InjectorPwrStg 6 "bank3"	O_P_SVL33	
78	CAM/CRK (hall) ground	CAM/CRK speed sensor ground (Hall)	G_R_DF02	
79	cam hall signal	camshaft position sensor (Hall)	I_F_DF02	
80	CrankShaft Hall (OPTIONAL)	Optional crankshaft speed sensor signal (Hall)	I_F_DF06	
81	PCV1 (FMU2) LS	Rail pressure control valve 1 LS (opt FMU2 LS)	O_T_PCV	
82	PCV1 Supply	Supply PCV1	O_V_PCV	
83	FMU1 LS	Fuel Metering Unit 1 LS	O_T_MEU	
84	Sens. Supply 12V	Sensor supply	O_V_VDD12	
86	boost press. signal	MAP (boost pressure)	I_A_AN05	pboost
87	LSU UN	LSU4.9 - UN	I_A_LSVN	
88	LSU IA	LSU4.9 - IA	I_A_LSCA	
89	Shield GND	Shield ground	G_R_RES	
90	boost press./temp. gnd	boost pressure and temperature sensor Ground	G_R_AN05	
91	turbospeed2+	Turbocharger speed 2 (Inductive)	I_F_DF05	nturbo2
92	turbospeed2-	Ground for turbocharger speed 2 (Inductive)	G_R_DF05	
93	turbospeed1+	Turbocharger speed 1 (Inductive)	I_F_DF04POS	nturbo1
94	turbospeed1-	Ground for turbocharger speed 1 (Inductive)	I_F_DF04NEG	
96	LSU heat+	Battery plus output 22	O_V_RH22	

Vehicle connector (X1 - Vehicle) 1928405312

PIN	Name	Main function	PIN Name	Signal
1	Battery plus 4	Battery plus %	V_V_BAT+4	
3	Battery minus 1	Battery minus %	G_G_BAT-1	
5	Battery minus 4	Battery minus %	G_G_BAT-4	
7	airbox press. signal	airbox pressure sensor signal	I_A_AN23	pairbox
9	fuel return temp	temperature sensor signal for return fuel	I_A_AN22	tleak
10	Sensor gnd 1	Sensor Ground 1	G_R_AN10	
11	pit speed sw	pit speed limiter digital switch	I_S_DIG03	
14	Launch sw	Launch control switch	I_S_DIG07	
16	egt1 signal	Exhaust gas temperature sensor signal 1	I_A_AN13	texh
17	egt2 signal	Exhaust gas temperature sensor signal 2	I_A_AN19	texh2
18	egt1/egt2 gnd	EGT1 / EGT2 Ground	G_R_AN13	
21	glowplug relay HS	Glowplug Relay HS	O_T_RH06	
25	Battery plus 3	Battery plus %	V_V_BAT+3	
26	Battery plus 5	Battery plus %	V_V_BAT+5	
27	12V Sw/FMU3 (HS) Supply	Supply for switches and FMU3 (HS)	O_V_RH31	
28	Battery minus 2	Battery minus %	G_G_BAT-2	
32	Map Switch	Map position switch	I_A_AN24	mapsw
33	Sensor gnd 4	Sensor Ground 4	G_R_AN11	
34	Engine Speed Output	Engine Speed Output Signal (tach)	O_F_DA01	
36	Laptrg	Laptrigger input	I_S_DIG08	
37	Pace sw	Pace switch	I_S_DIG04	
39	Sensor gnd 2	Sensor Ground 2	G_R_AN12	
40	gearbox temp. signal	Gearbox Temperature Sensor Signal	I_A_AN14	tgear
41	Ambient temp. signal	Ambient Temperature Sensor Signal	I_A_AN26	tamb
43	Sensor gnd 3	Sensor Ground 3	G_R_AN14	
46	CAN1 +	CAN Interface	B_D_CANH0	
47	CAN1 -	CAN Interface	B_D_CANL0	
49	Battery plus 2	Battery plus %	V_V_BAT+2	
50	12V Supply Relay (HS)	Relay Supply (HS)	O_V_RH11	
52	Battery minus 5	Battery minus %	G_G_BAT-5	
53	VSS	Vehicle speed sensor signal (Hall)	I_F_VSS	speed
54	VSS GND	Vehicle Speed Sensor Ground	G_R_VSS	
57	aps2 gnd	Accelerator pedal position sensor 2 ground	G_R_APP2	
60	fuel reset sw	Fuel Reset Switch	I_S_DIG02	
61	MILSpec	MILSpec Warning Lamp (LS)	O_S_RL20	
64	fwheel_fr	Wheelspeed frequency input, front right (Hall)	I_F_DF01	vwheel_fr
65	Wheel sens. Gnd. Front	Wheel Sensor Ground Front	G_R_DF01	
66	aps1 supply +5V	Accelerator pedal supply 1	V_V_5VSS2D	
67	5V sens. Supply 4	Sensor Supply 4	V_V_5VSS2A	
68	5V sens. Supply 2	Sensor Supply 2	V_V_5VSS1D	

PIN	Name	Main function	PIN Name	Signal
69	terminal 15	Terminal 15 (switched BAT+)	I_S_T15	
71	CAN 2 + (Diag)	CAN Interface (Diag) - MSA-Box2 ecu interface	B_D_CANH1	
72	MIL	MIL Warning Lamp (LS)	O_S_RL12	
73	Battery plus 1	Battery plus %	V_V_BAT+1	
75	Battery minus 3	Battery minus %	G_G_BAT-3	
78	aps2 signal	Accelerator pedal position signal 2	I_A_APP2	aps_b
79	aps1 signal	Accelerator pedal position signal 1	I_A_APP1	aps_a
80	aps1 gnd	Accelerator pedal position sensor 1 ground	G_R_APP1	
81	Wet sw	Wet switch	I_S_DIG06	
84	fwheel_fl	Wheelspeed frequency input, front left (Hall)	O_T_RL13	vwheel_fl
86	GPU4 LS	General purpose output 4 (LS)	O_T_RL08	
87	FMU3 LS	Fuel Metering Unit 3 LS	O_T_RL01	
89	Shield GND	Shield ground	G_G_RL13	
90	5V sens. Supply 3	Sensor Supply 3	V_V_5VSS3A	
91	5V sens. Supply 1	Sensor Supply 1	V_V_5VSS1C	
92	aps2 supply +5V	Accelerator pedal supply 2	V_V_5VSS1B	
93	Auxiliary Relay LS	Auxiliary Relay LS	O_S_RL27	
94	glowplug relay LS	Glowplug Relay LS	O_S_RL26	
95	CAN 2 - (Diag)	CAN Interface (Diag) - MSA-Box2 ecu interface	B_D_CANL1	

1.3 Input Channels

Only active (0 to 5 V) exhaust gas temperature sensors are supported.

See chapter Initial Data Application [▸ 22] for further information and calibration examples for different sensors.

1.4 Output Channels

The MS 25 Sport has 8 injector power stages on three banks. Only solenoid valve type common rail injectors are supported. Injector current profile must be calibrated for used injector type (CRIN1, CRIN3, CRI2.X, ...).

1.5 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 Engine On-switch.

– Term 30 is an unswitched battery positive rail (same as battery positive terminal).

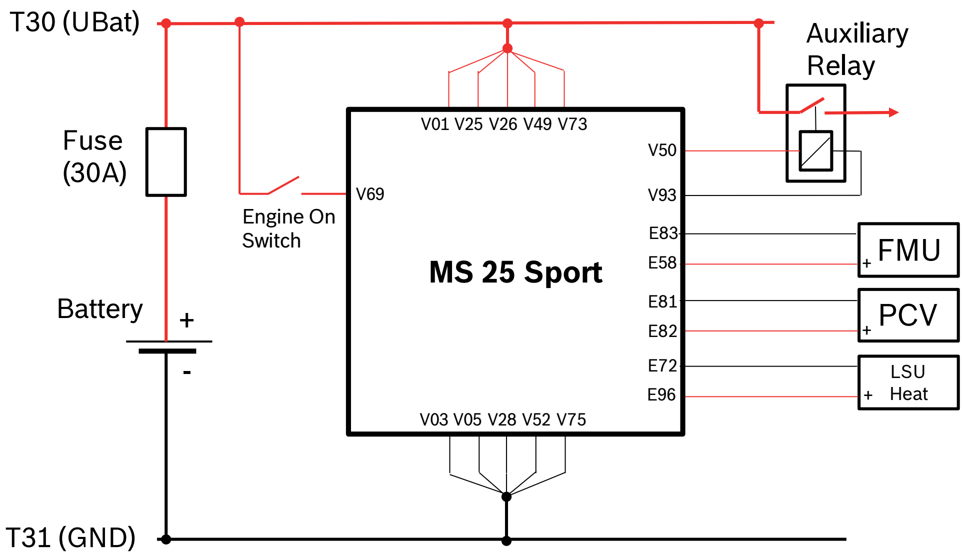
– Term 31 is an unswitched ground rail (same as battery negative terminal).

– MS 25 Sport needs constant Term 30 and ECU should be powered on and off only with Engine On-switch (Term 15). Constant voltage on Term 30 is required to preserve critical information during ECU shutdown.

⚠ CAUTION

Wrong polarity / high currents

Wrong polarity of the terminals and high currents damage the MS 25 Sport. Be careful to observe current limits of wires and connector pins!

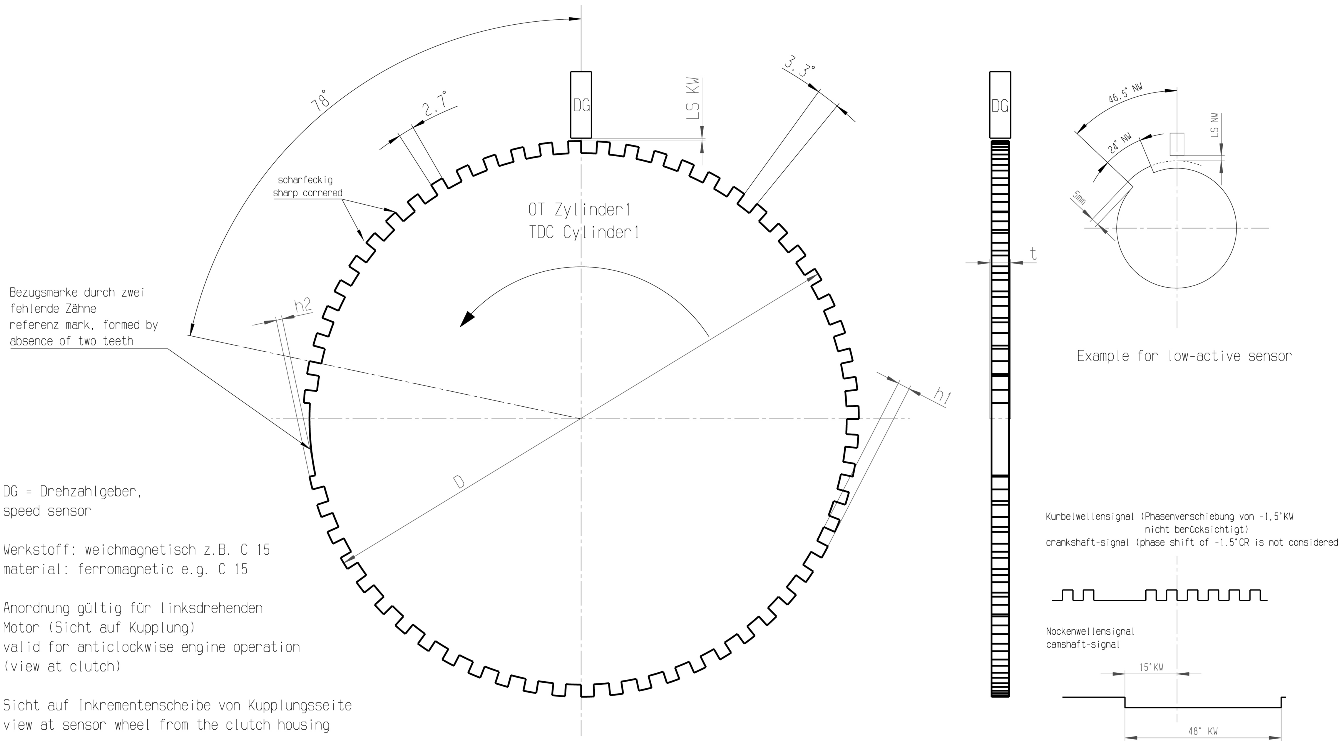


1.6 Trigger Wheel

The software assumes a toothed trigger wheel for proper operation. The number of the teeth is hard coded by Bosch Motorsport and can't be changed by the customer. Custom gap teeth numbers are optional.

We recommend 60 (-2) teeth as shown in the following picture. The crank wheel trigger sensor must be an inductive type for the default configuration, Hall-effect crank sensor is optional and requires software change.

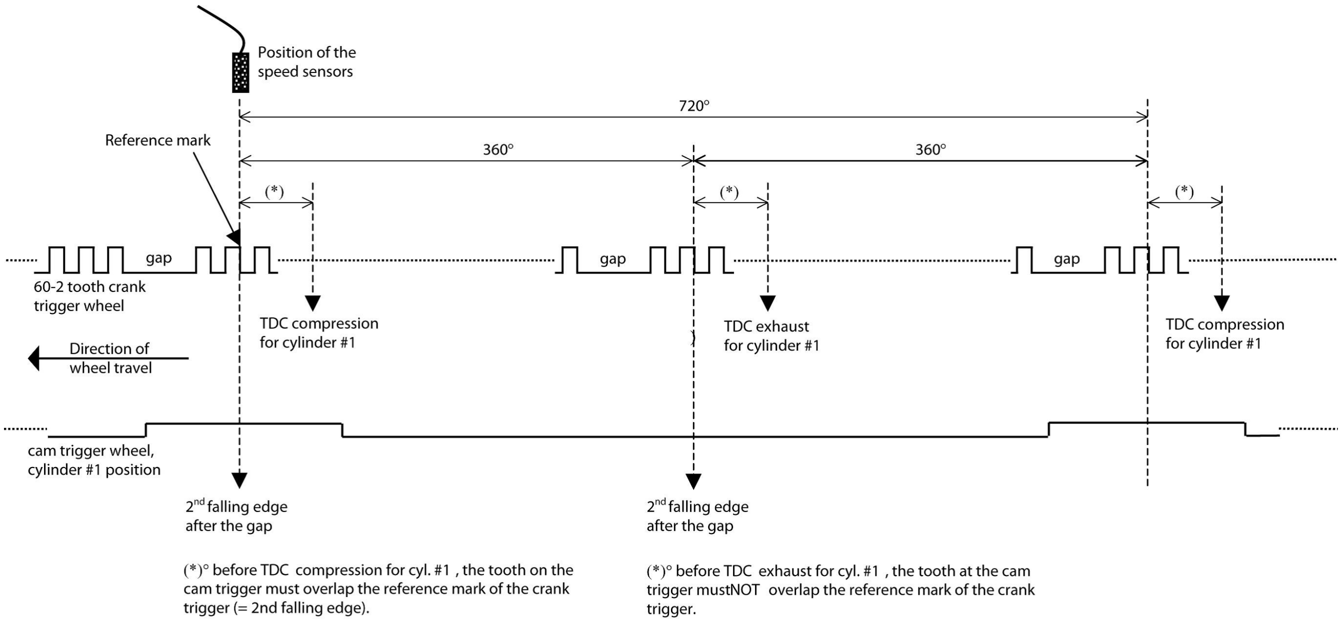
The camshaft trigger sensor is a Hall-effect type with a single tooth trigger wheel, but other configurations can be configured with calibration. Inductive cam sensor is optional and requires software change. The picture below shows the correct installation position.



Recommended values:

- D=min. 160 mm
- h1=3.5 mm
- h2=h1/2
- LSKW=0.8 mm ± 0.3 mm
- t=min. 5 mm
- LSNW=1 mm ± 0.5 mm

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



Procedure to find the right position for the crank and cam trigger

1. Rotate the engine to the precise position of TDC compression for cylinder #1
2. Rotate the engine 78 crankshaft degrees backwards
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)
4. Rotate the engine further 15 crankshaft degrees backwards
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
6. Turn the engine by 345 crankshaft degrees to reach the position of 78° before TDC exhaust for cylinder #1
7. Verify that the crank trigger reference 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

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 Starting up the ECU

2.1 Installation of software tools

PC tools and ECU programs for the MS 25 Sport are available at Bosch Motorsport homepage for free download.

- RaceCon version 2.5.3.0 or later: used for system configuration, data application and online measurement.
- WinDarab V7: Data analysis tool, Light version as shareware or expert version, if license available
- MS 25 Sport customer_delivery: ECU programs and function description

All tools are delivered as self-installing executable files.

Select your personal installation folder.

2.2 Communication PC to device

For assistance, Bosch Motorsport homepage explains the necessary PC installations for MSA-BOX 2 diagnostics cable.

Bosch-Motorsport.com → Downloads → Software → MSA-BOX

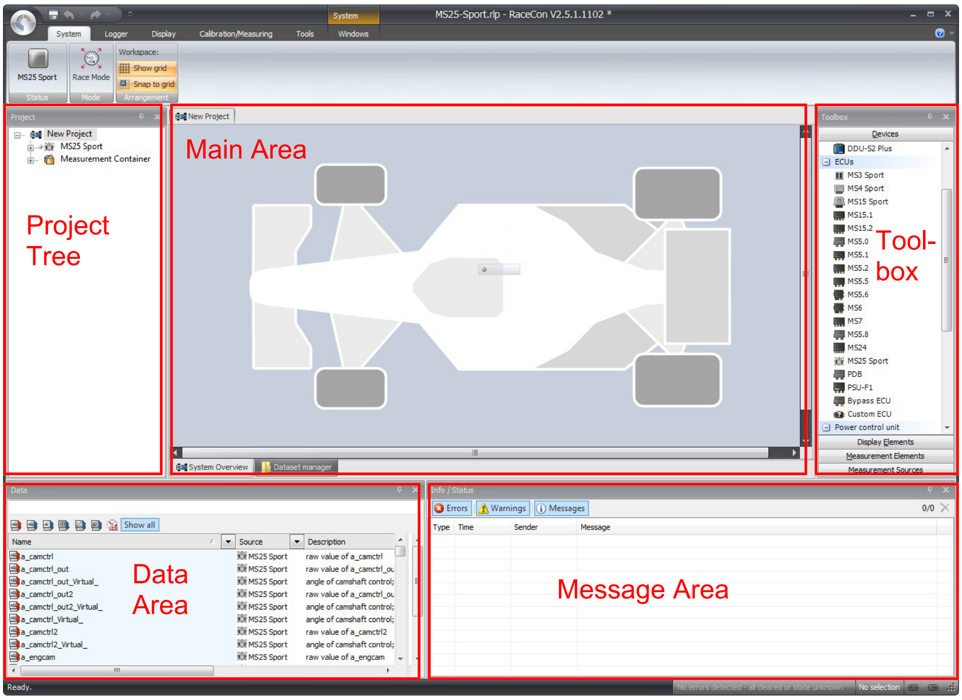
Successful connection between PC and MS 25 Sport is shown as green marked connection in the top left corner of RaceCon.

2.3 MS 25 Sport programming

System programming or flashing of the device has to be done with the Bosch Motorsport system configuration tool RaceCon. After the start of the tool RaceCon opens a view Welcome to RaceCon. With Last Projects former projects can be opened directly.

2.3.1 First steps to create and configure a Project

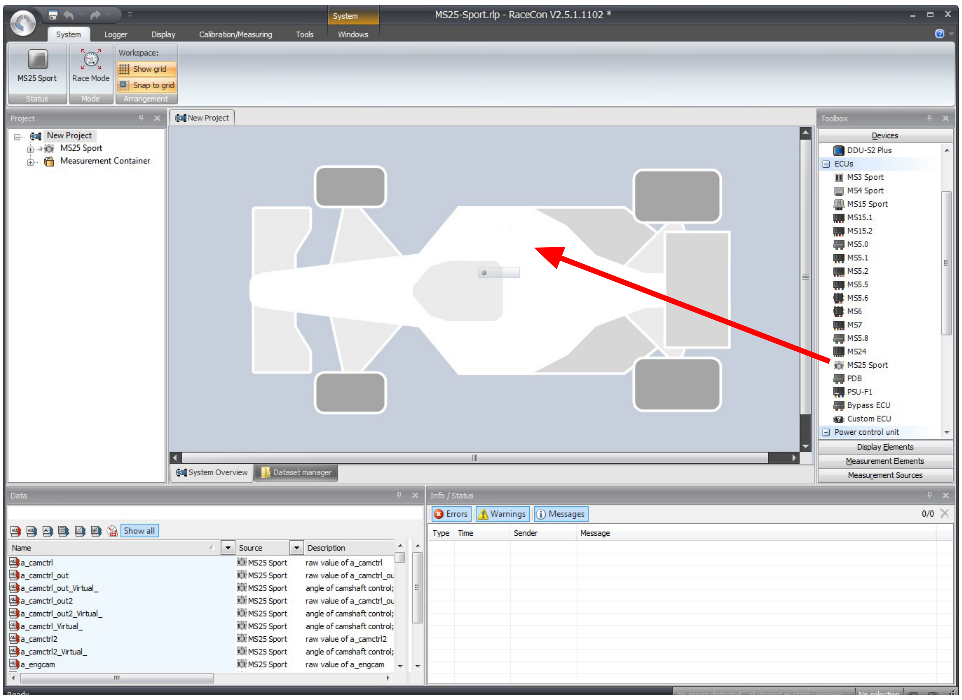
File / New / RaceCon Project: opens a new project in RaceCon



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.

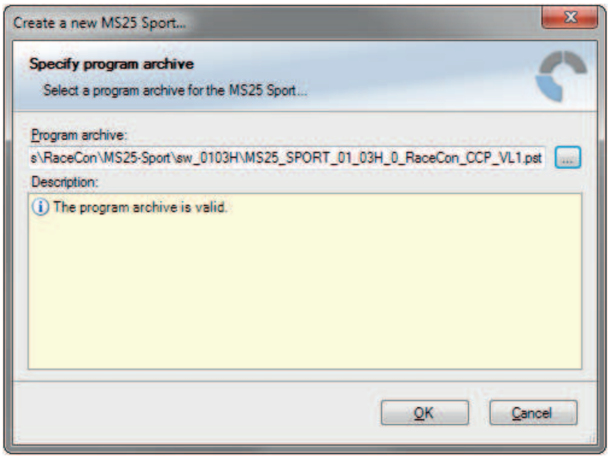
Select an ECU model MS 25 Sport from the Toolbox / Devices / ECUs.

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

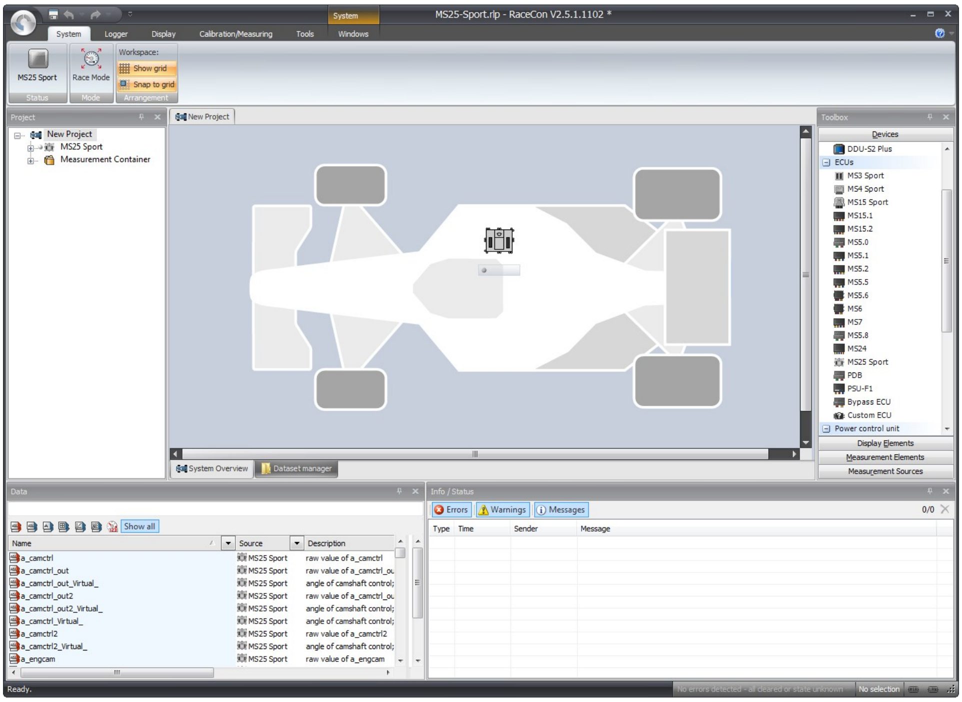


Now the ECU program archive PST files must be selected. These archives are delivered by Bosch or are available at Bosch Motorsport homepage.

Specify the MS 25 Sport program archive:
MS25_SPORT_XX_XXX_X_RaceCon_CCP_VL1.pst

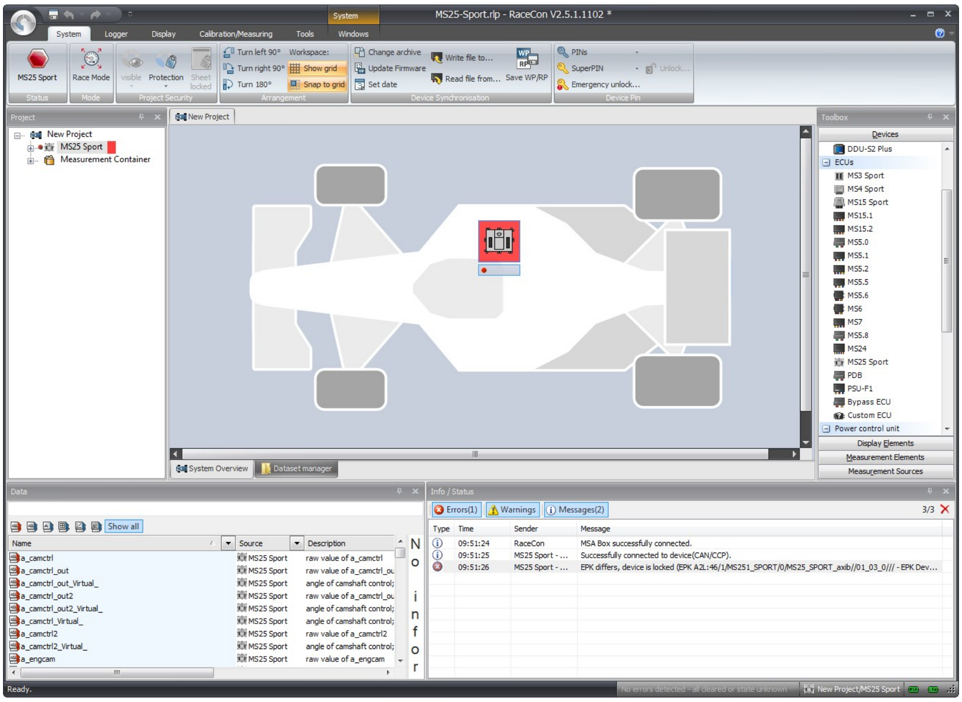


Installation may now be saved as customer project for further data application.



2.3.2 Connecting to the ECU for calibration and programming

If in the project tree and main display area MS 25 Sport icon is shown as >red< it means that the software in the device differs from what is in the RaceCon project.

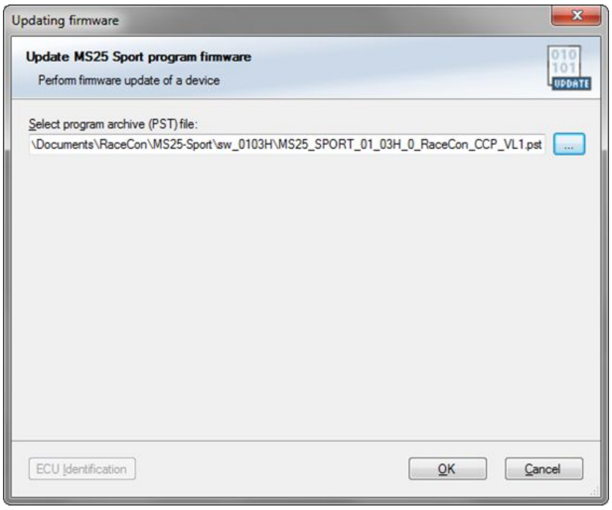


To synchronize MS 25 Sport and RaceCon or update the firmware of the device:

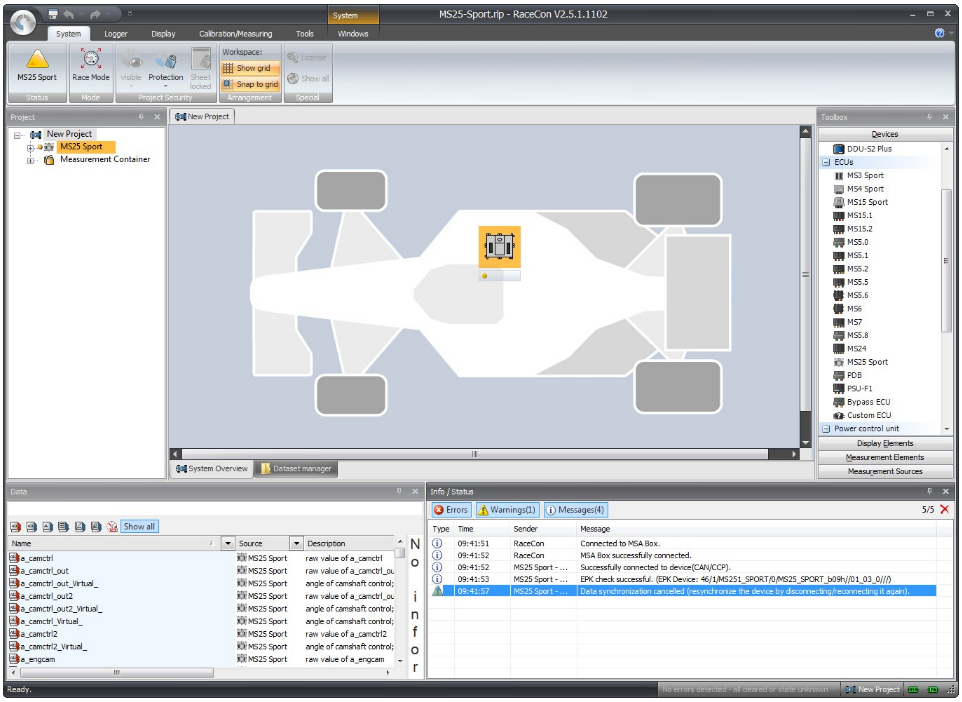
Project tree / right mouse button to the red MS 25 Sport / synchronize / update firmware >select customer software of the MS 25 Sport (file with extension: -.pst)

NOTICE

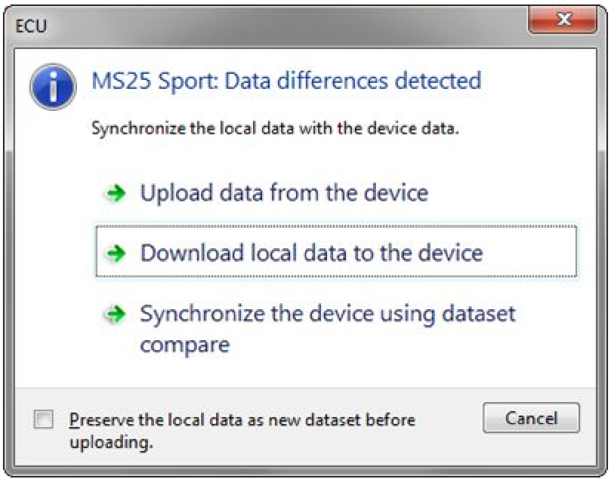
Do not interrupt flash process.



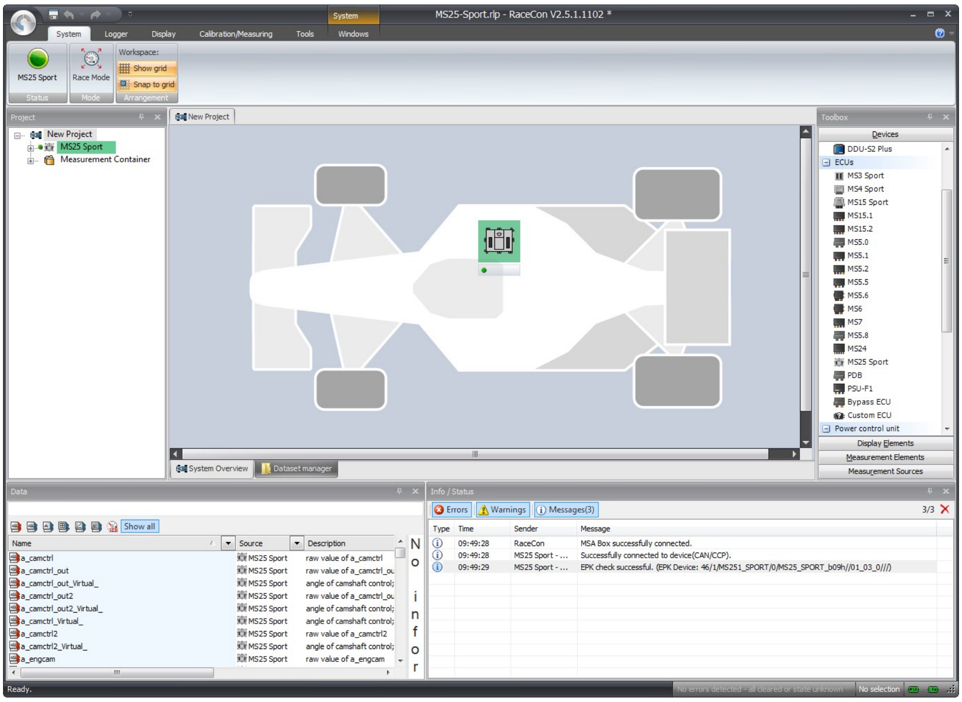
In the project tree if the MS 25 Sport is shown as >yellow<, means the firmware of the MS 25 Sport device and project are identical, but the data is different.



Either the offline configured data has to be sent to ECU (download local data to the device) or current ECU data can be read to RaceCon project (upload data from the device).

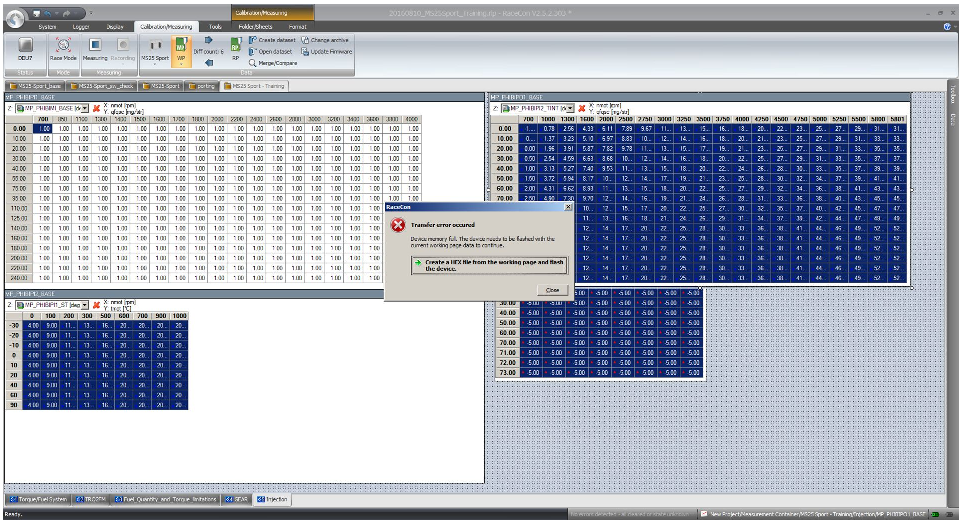


MS 25 Sport is shown as >green<, means firmware and data of the device and the project are now identical.

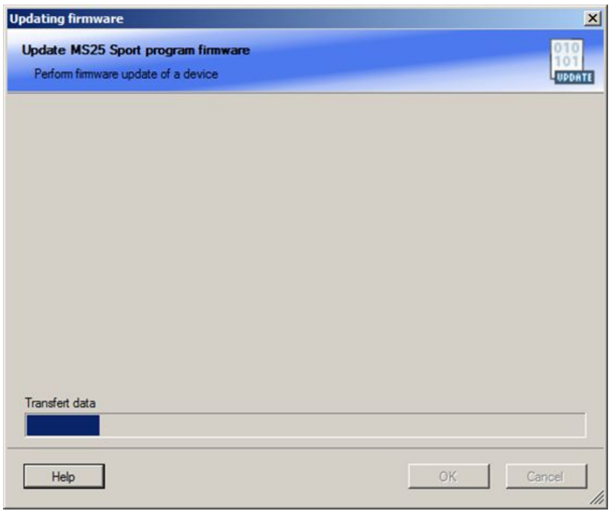


NOTICE

During calibration, data download (WP load from file ...) or any WP memory management option when MS 25 Sport WP memory limit may be reached RaceCon lets the user to program the changes to the ECU to keep the calibration and continue working.



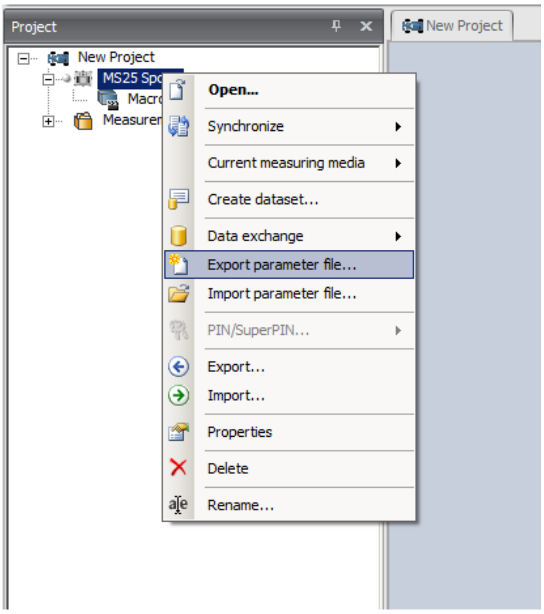
Transfer error occurred, device memory full. Click on the option → *Create HEX file from the working page and flash the device*. RaceCon automatically saves the hex file and starts programming



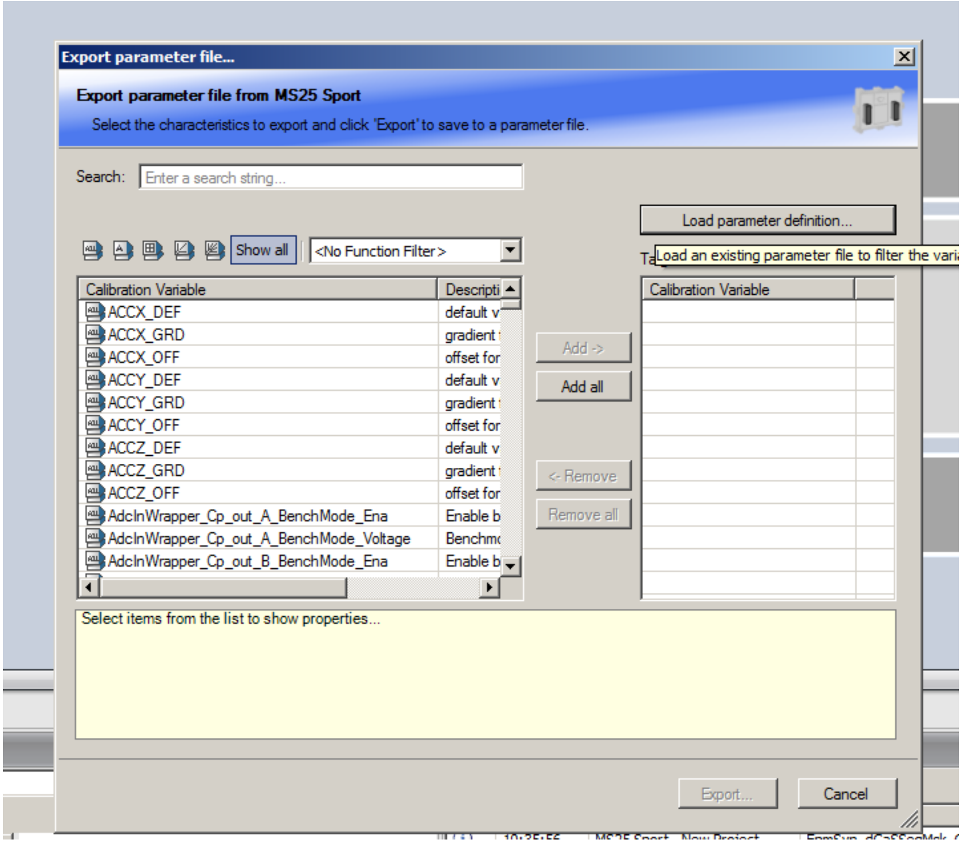
After successful programming of dataset ECU state is synchronized and user can continue calibration. Note, WP to RP diff count is set to 0 so tracking of changes before memory limit reached and programming is lost.

2.3.3 Handling of calibrations with parameter files

To export parameter file (DCM or PAR-file), right click on MS 25 Sport ECU in the project tree or ECU icon and select *Export parameter file* …

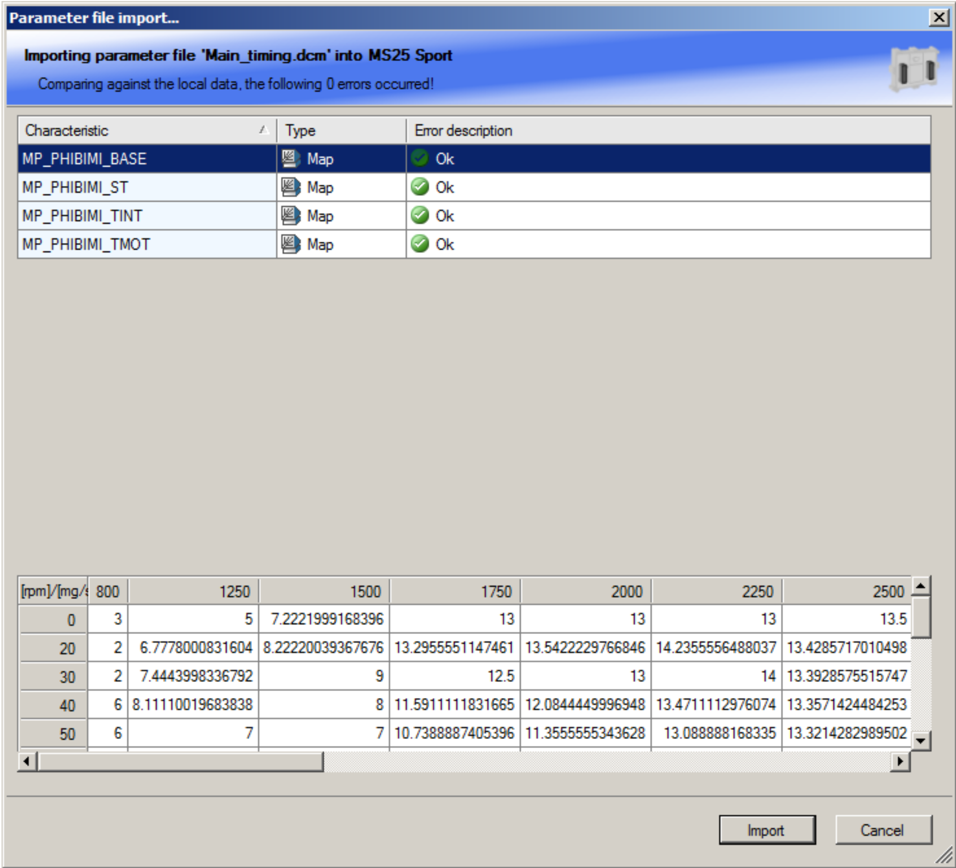


Dialog window opens for selection of calibration variables to be exported as parameter file. Existing parameter file can be used as filter to select same variables automatically as in that existing file.



To import calibration from existing parameter file, right click MS25 Sport ECU on the project tree or in the ECU icon and select *Import parameter file* … Dialog opens to select file.

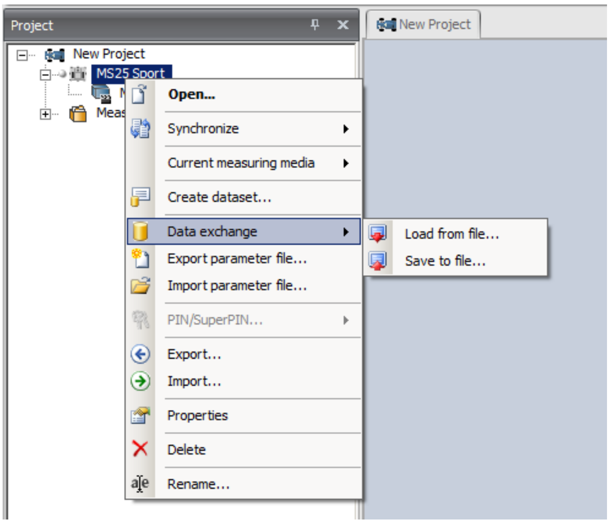
Once parameter file successfully read to the importer, check for Error description if all the parameters can be imported properly. In case of porting calibration from older software with differences on table sizes etc., it is important to pay attention if all values can be imported properly.



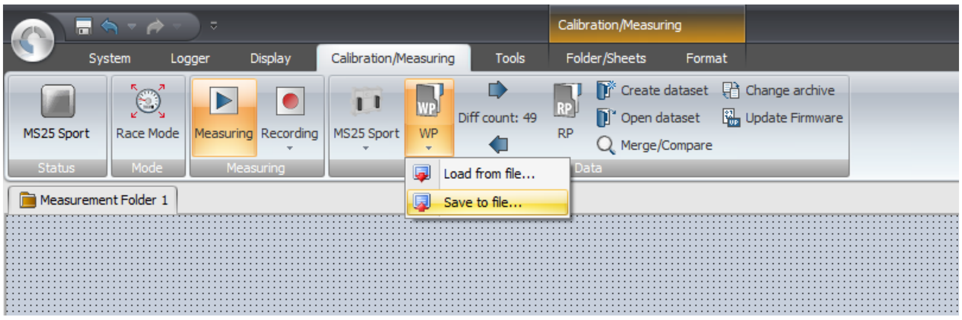
2.3.4 Handling of calibrations with HEX-files

Complete ECU calibrations can also be saved and opened as HEX-files. This works fine within same software version projects if no ECU software (program archive/a2l) is changed.

HEX-files can be saved or opened in the Project tree ...



... or under Calibration/Measuring view.



NOTICE

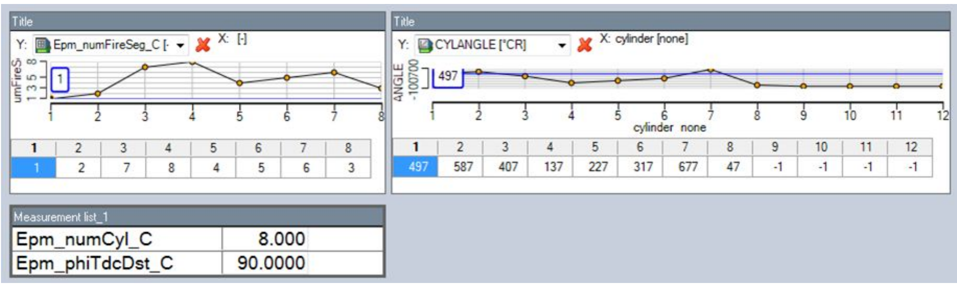
If PAR or HEX-file is loaded to the ECU Working page memory which has enough calibration differences to fill the physical memory reserved for working page calibration has to be flash programmed.

This will happen automatically if online connection to ECU exists and user will be informed with transfer error occurred dialog. See chapter Connecting to the ECU for calibration and programming [▷ 15] for further information.

2.4 Initial Data Application

2.4.1 Basic Engine Data

The MS 25 Sport can be used for engines up to 8 cylinders. Cylinder number (Epm_numCyl_C), firing order (Epm_numFireSeg_C), cylinder angles (CYLANGLE) and spacing between cylinders TDCs in v-engine (Epm_phiTdcDst_C) must be calibrated according the engine in the Engine Position Management (EPM) function. See calibration guidelines for further information and examples of engine and calibration configurations.

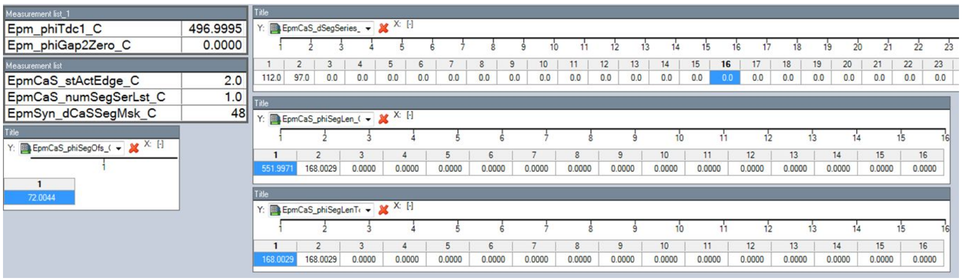


2.4.2 Engine Speed and Position Management

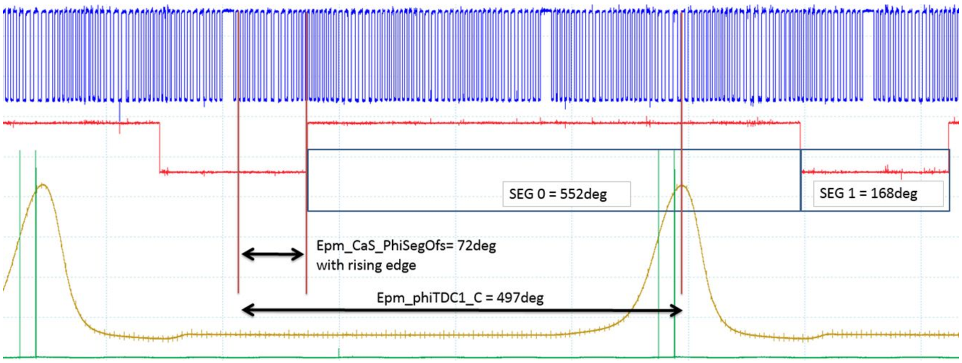
The system initially supports crankshaft wheels with 60-2 teeth. Please refer to the chapter Trigger Wheel [▷ 10].

Several types of camshaft wheel are supported by calibration. Please refer to chapter Trigger Wheel for basic one teeth motorsport cam trigger and see calibration guidelines for more help on calibrating different Diesel OEM type cam wheels.

Calibration example for 60-2 crank and simple one teeth cam wheel



Matching signals for the calibration above. Blue=crank, red=cam, yellow=cylinder 1 pressure, green=cyl 1 Injector energizing.



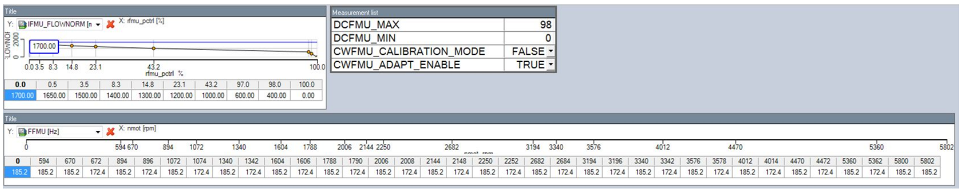
2.4.3 Hydraulic System and Components

2.4.3.1 High Pressure Pump and Fuel Metering Unit FMU

The characteristic curve IFMU_FLOWNORM (Fuel Metering Unit nominal curve), used to calculate the current equivalent of FMU flow ratio, is very important for correct rail pressure controller behavior under any engine operation conditions.

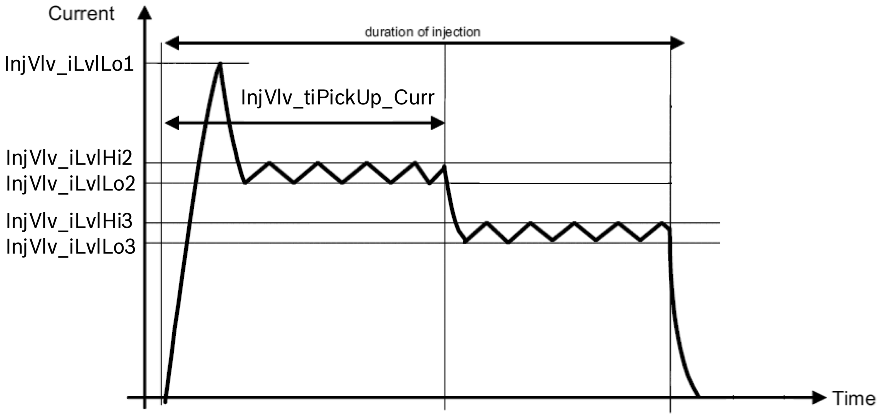
Either current-less open or closed type metering units can be used. ECU measures actual current for metering unit and the control strategy is current control.

Calibration example for typical CP3 pump

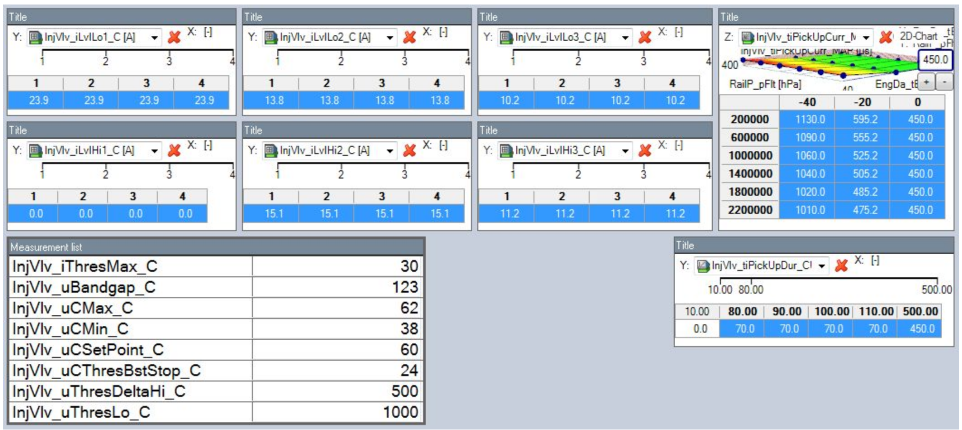


2.4.3.2 Injector Energizing Profile

Injector energizing (current profile) must be correct for used solenoid injector type. The current profile has several different calibration parameters, but the three most important parameters are different current levels for booster, pickup, and holding current, which can be calibrated in the injector initialization function.



Calibration example for CRIN3 injector energizing

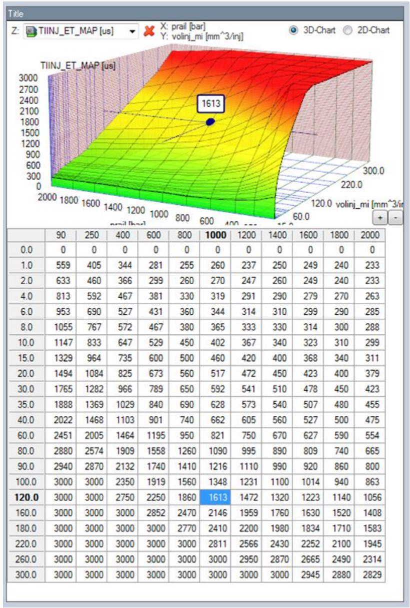


See application hints for more details on the correct calibration of injector energizing for different injector types.

2.4.3.3 Injector Energizing Time Map

Injector energizing time map TIINJ_ET_MAP is needed to convert the requested injection quantity (corrected as volume) to desired injection duration as function of rail pressure. Energizing time map must be known for the used injector and nozzle and should be calibrated for the entire operation range of rail pressure.

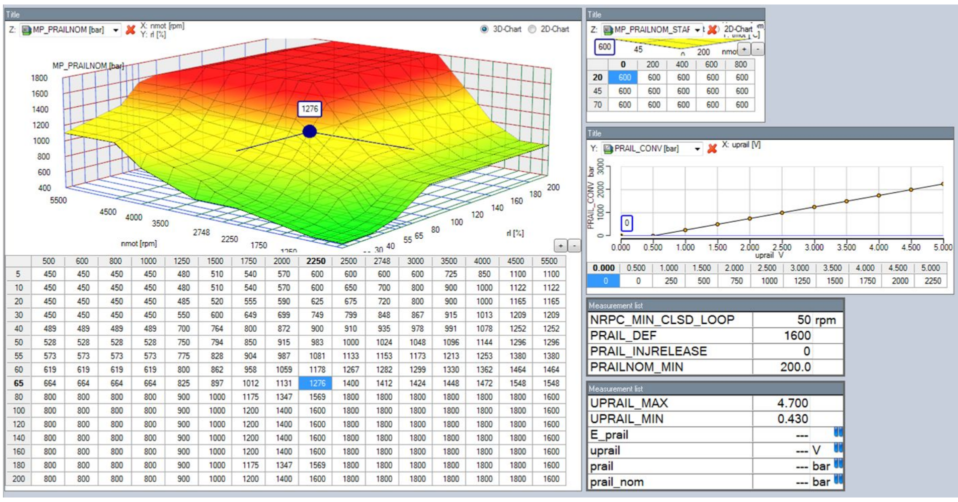
Using wrong energizing time map may end in unexpected engine torque behavior and can cause serious engine damage.



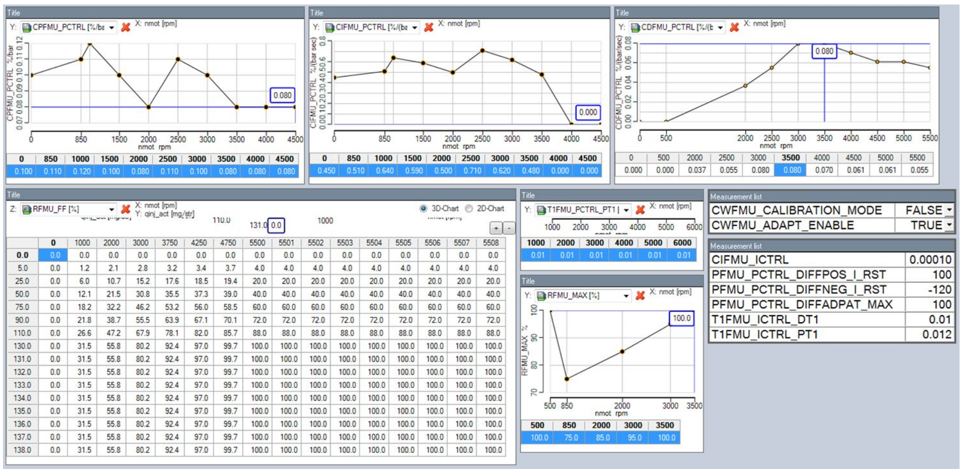
2.4.3.4 Rail Pressure Sensor, Setpoint Map and Controller

The rail pressure sensor is the most important sensor as injection quantity is directly related to rail pressure and an incorrect sensor curve PRAIL_CONV can result in incorrect injection quantity which may lead to serious engine damages.

Maximum allowed system pressure should not be exceeded. In a one actuator concept the mechanical pressure limiter valve PRV mounted directly in the fuel rail is only designed to open and protect the system very few times during its life time, which must be considered in rail pressure setpoint map calibration.

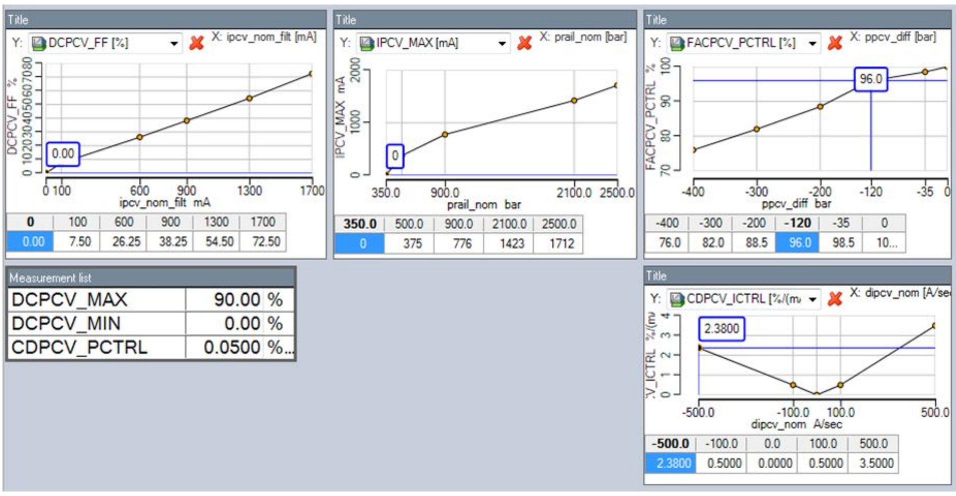


Rail pressure control calibration parameters



2.4.3.5 Pressure Control Valve PCV and 2-Actuator RPC Concept

In the case of a 2-actuator rail pressure control concept, pressure control valve calibration is needed. Incorrect calibration of pressure control valve can make rail pressure control RPC unstable and it is important to ensure that pressure control valve closing current is sufficient for used rail pressure range to keep the valve closed during normal operation.



2.4.4 Torque and Fuel System

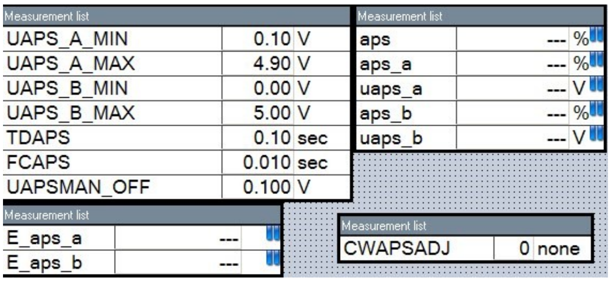
2.4.4.1 Accelerator Pedal Sensor APS

The accelerator pedal signal is a direct input for the drivability base map, which scales the aps signal for driver requested torque into a percentage of the maximum limited torque, specified as injection quantity from curve CL_QTLIM. Before starting any new engine and application accelerator pedal position sensor signal has to be learned to achieve the range from 0 to 100 % of torque request from the pedal. 0 and 100 % pedal positions are learned with calibration trigger CWAPSADJ and after successful learning an ECU power cycle is needed with a complete shutdown sequence (Engine On –switch off, wait 30 sec) to store the learned values in the EEPROM.

CWAPSADJ=0 no action

CWAPSADJ=1 Calibrate first point (0 %)

CWAPSADJ=2 Calibrate second point (100 %)

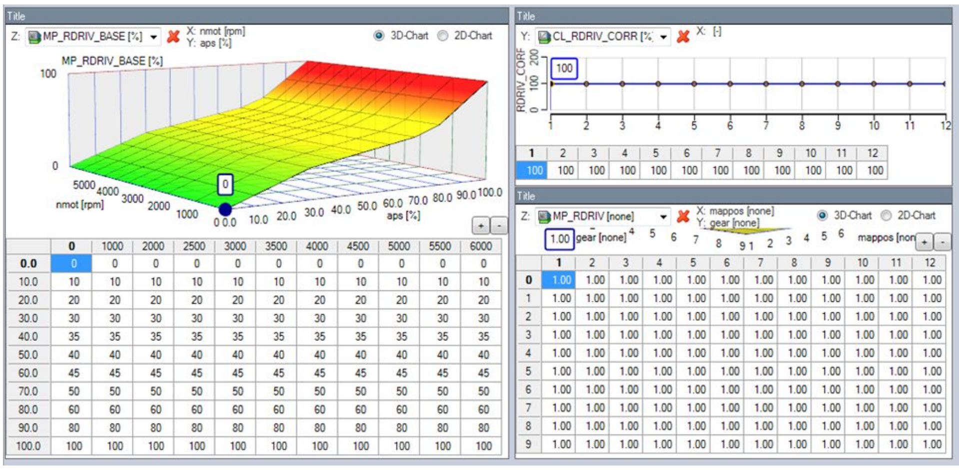


2.4.4.2 Drivability and Torque Structure

MP_RDRIV_BASE map is used to scale driver input from accelerator pedal sensor to requested torque (0 to 100 % of injection quantity) as function of engine speed and 0 to 100 % accelerator pedal signal.

There are several correction maps for fine tuning of driver torque request, for example corrections based on gear and different map switch position.

Torque limitations are quantity based and once driver demand as a percentage of max limited quantity is evaluated, this fuel mass is converted to engine and driveline torque in units of Nm.



2.4.4.3 Quantity and Torque Limitations

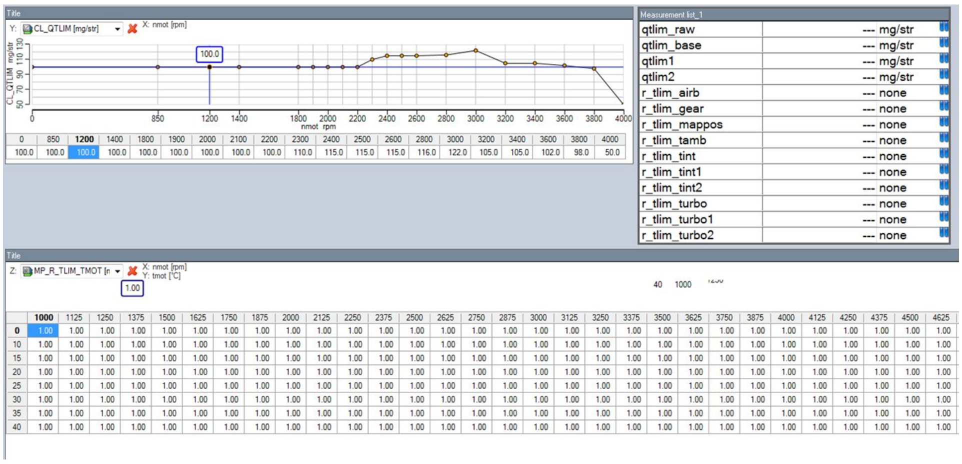
Quantity and torque limitations are split into two separate functions: SLIM, which is fuel quantity smoke limiting, and TLIM, which is engine torque limiting function.

Smoke limitation is defined as quantity limitation (mg/stroke) based on mass air flow corrected by ambient pressure. Torque limitations are all correction factors based on engine temperature *tmot*, intake temperature *tint*, exhaust temperature *texh*, ambient temperature *tamb*, airbox pressure *pairb*, and map and *gear* position.

There are also other limitations available which affect the injected quantity and torque, for example turbo speed *nturbo* limitation.

The main limitation curve where the correction factors listed above are applied is CL_QTLIM, which limits the maximum injection quantity for given engine speed.

Low and high idle governors can also affect the injection quantity and engine torque output.



0	850	1200	1400	1800	1900	2000	2100	2200	2300	2400	2500	2600	2800	3000	3200	3400	3600	3800	4000
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	110.0	115.0	115.0	115.0	116.0	122.0	105.0	105.0	102.0	98.0	50.0

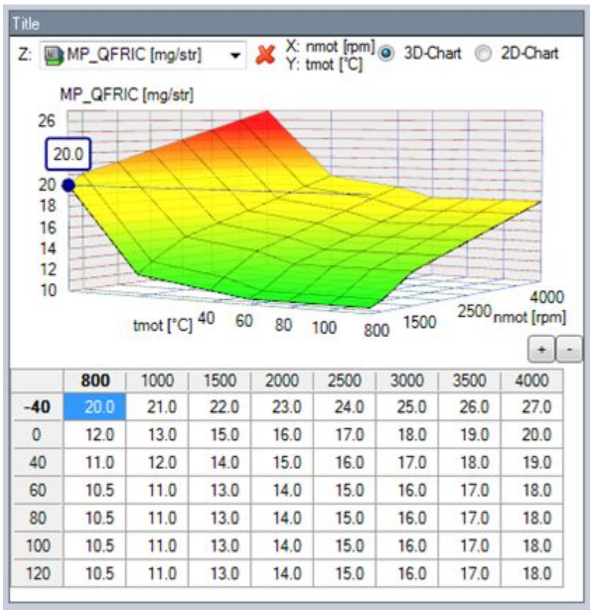
	1000	1125	1250	1375	1500	1625	1750	1875	2000	2125	2250	2375	2500	2625	2750	2875	3000	3125	3250	3375	3500	3625	3750	3875	4000	4125	4250	4375	4500	4625
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

For first engine firing it is recommended to calibrate all the limitation factors to 1 and ensure that the CL_QTLIM is calibrated safely.

2.4.4.4 Friction Quantity

Friction quantity *qfric* is the fuel quantity that is needed to idle the engine under normal operating conditions without additional accessory loads. Friction quantity is calculated by a map MP_QFRIC as a function of engine speed and engine temperature.

Correct calibration of friction quantity is important as it is used as a pre-controller in several other functions like low idle controller.

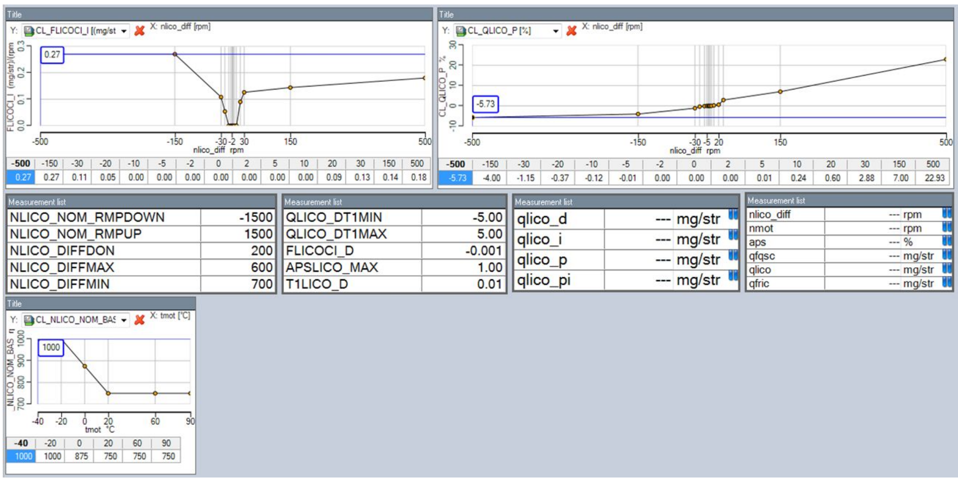


	800	1000	1500	2000	2500	3000	3500	4000
-40	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0
0	12.0	13.0	15.0	16.0	17.0	18.0	19.0	20.0
40	11.0	12.0	14.0	15.0	16.0	17.0	18.0	19.0
60	10.5	11.0	13.0	14.0	15.0	16.0	17.0	18.0
80	10.5	11.0	13.0	14.0	15.0	16.0	17.0	18.0
100	10.5	11.0	13.0	14.0	15.0	16.0	17.0	18.0
120	10.5	11.0	13.0	14.0	15.0	16.0	17.0	18.0

2.4.4.5 Low Idle Controller

Low idle controller LICO is a PID controller which is working directly with the friction map MP_QFRIC as a pre-control input. The base set point map for low idle is CL_NLICO_NOM_BAS, which defines the setpoint value as function of engine temperature *tmot*.

If the engine friction map calibration is changed within the low idle setpoint operating range, correct low idle controller behavior must be checked.

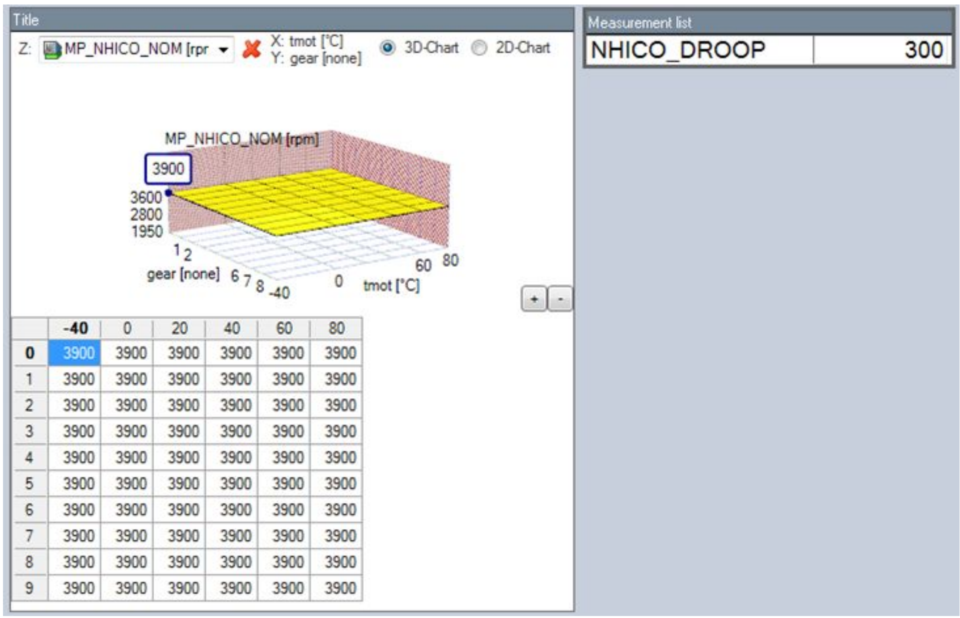


2.4.4.6 High Idle Controller

High idle controller nominal value is calibrated in the map MP_NHICO_NOM based on *gear* and coolant temperature *tmot*.

Droop value NHICO_DROOP defines the speed droop for enabling of the high idle engine speed control.

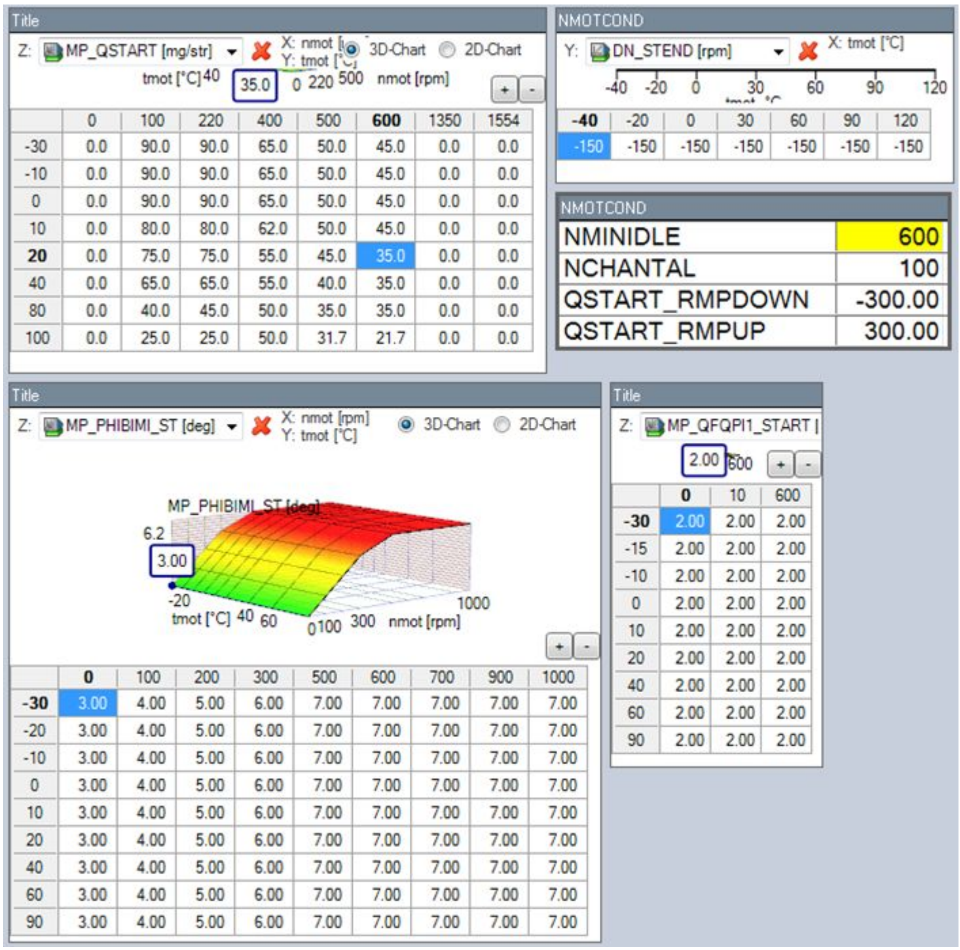
High idle controller is a simple P controller. The friction map MP_QFRIC calibration within the high idle controller engine speed range is important for the controller to function properly.



2.4.4.7 Engine Start Fuel Quantity

MP_QSTART is the fuel quantity map for engine start as a function of engine speed *nmot* and engine temperature *tmot*. There is also a step limiter for ramping up and down when transitioning from start to running mode.

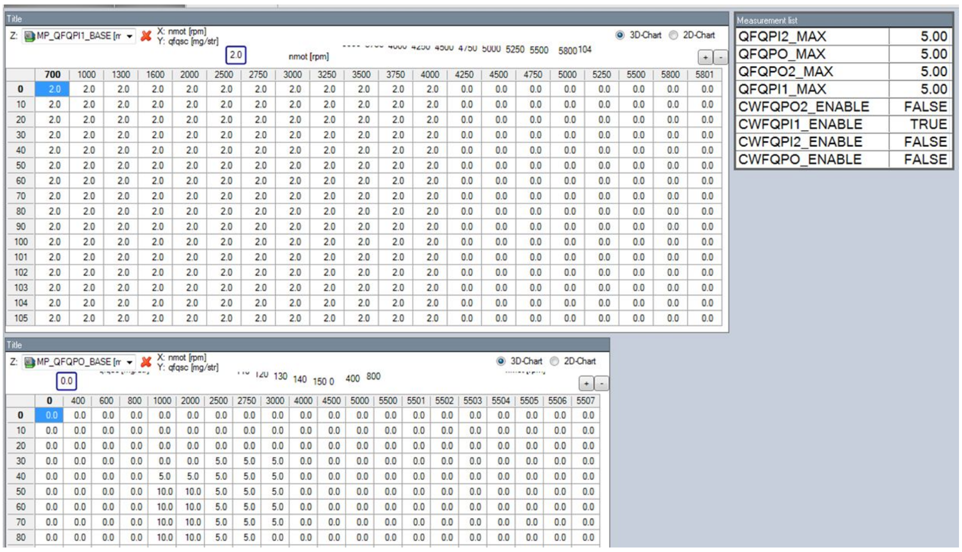
Engine speed transitions from start to normal running mode happen based on the NMOT-COND function calibration.



2.4.4.8 Fuel Quantity Setpoint Calculation

Total fuel quantity setpoint *qfqsc* limits or sets the fuel quantity that must be injected into the engine. The FQSC function reads the requests of fuel quantity and torque from various functions and prioritizes them before finalizing the quantity that needs to be injected. See function definition for further information on the fuel quantity setpoint calculation, including where its output *qfqsc* is used, and what the different function priorities are to take over the actual injected quantity under different engine operation conditions.

Additional pilot and post injections are also enabled and calibrated within this function. Post1 injection is not calculated as a torque generating injection in the software and its timing should be late enough to not produce torque. See Injection System [▸ 31] for detailed explanation of injection timing.

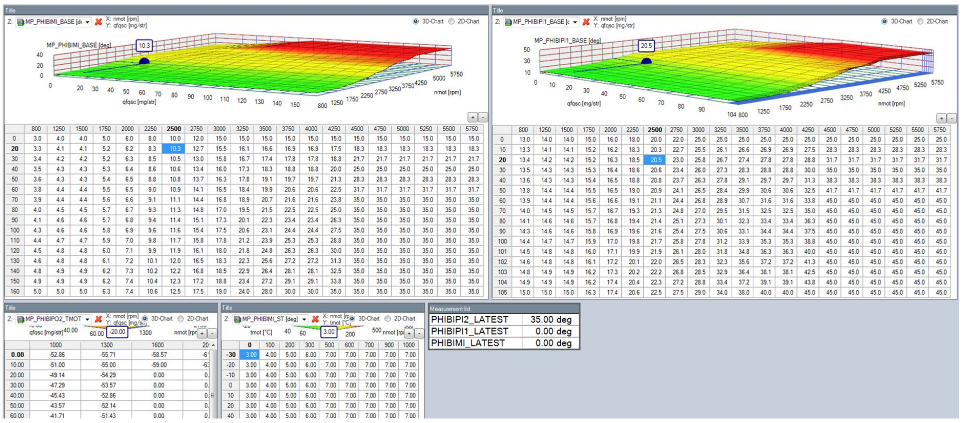


2.4.5 Injection System

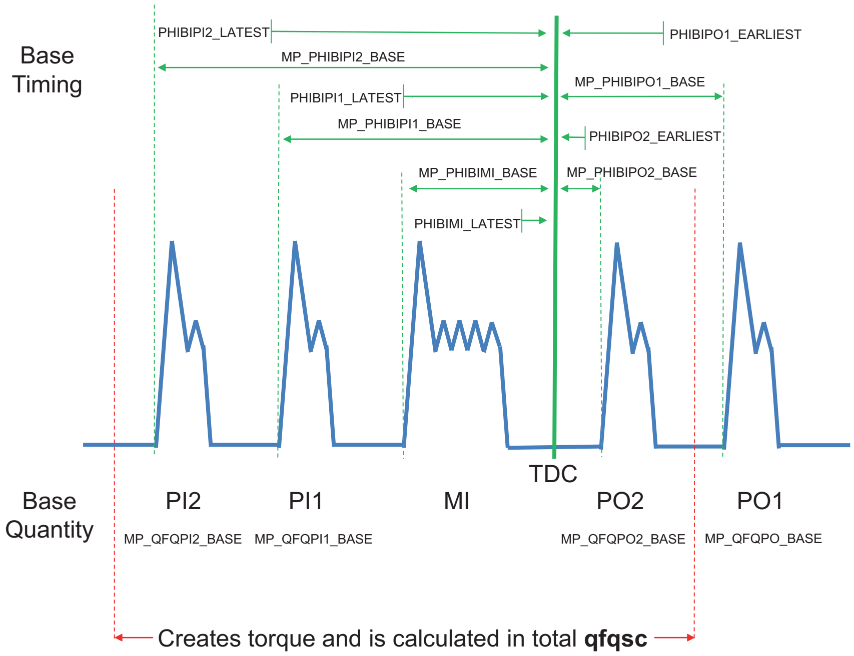
Injection quantities (total fuel quantity with or without pilot or post injections) are calculated under the Torque and Fuel System functions.

The Injection System function calculates injection timing and prioritization between multiple injections, fuel density, and finally outputs the actual desired injection time for the injector driver.

If the calibrated injection timing for the desired fuel quantity and energizing time overlap, the injection with higher priority wins. Main injection is always the highest priority.



Injection naming and order with base timing and quantity calibration parameters are explained in the picture below. All injection timing parameters are referenced to top dead center (TDC).



Post1 (PO1) injection is not calculated as torque generating injection and is not included in the total injection quantity setpoint calculation *qfqsc*. Timing before TDC is positive and after is negative.

3 Peripherals

Sensors and peripherals can be checked when the system is powered up electrically using the Engine On -switch.

⚠ **CAUTION**

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

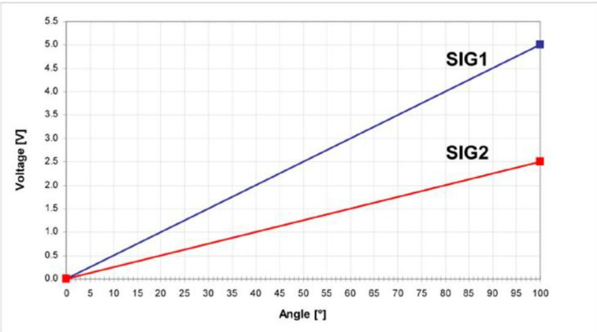
Make sure the battery is connected properly, all sensors are connected, and ground wiring is fixed before powering up the system. Check all sensors for errors (E_...) and reliable measure values before starting the engine.

APS safety

– Acceleration pedal and its position sensor is the main request for engine torque (injection quantity) in common rail Diesel engines. As this is considered drive-by-wire system safety features have been introduced on the MS 25 Sport ISAPS function.

– APS has to have two signals, main pedal signal 1 and redundant signal 2 with 0.5 scale.

– Calculated difference of pedal signal 1 voltage – 2*pedal signal 2 voltage has to be below 0.5 V or less than UAPS_CM_MAX



Analog sensor inputs

Inputs with fixed pull-up resistors are prepared to handle passive sensor elements, for instance temperature sensors with integrated resistors (NTC- or PT100 sensors). Inputs without any pull-up resistors are prepared to handle active sensor elements, which deliver 0 to 5 V signals, for instance pressure-, potentiometer- or acceleration sensors. Each sensor input is mapped clearly for pressure or temperature measurement in the pinout and the only exception is exhaust gas temperature, where only 0 to 5 V output sensors are supported.

Error detection of an analog input signal detects short circuits to ground, U”function”_MIN recommended to be set to 0.2 V, and short circuits 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 many different pressure channels, please see function description Input Signal Processing for details. For gradient and offset information please contact the sensor manufacturer.

Example oil pressure sensor:

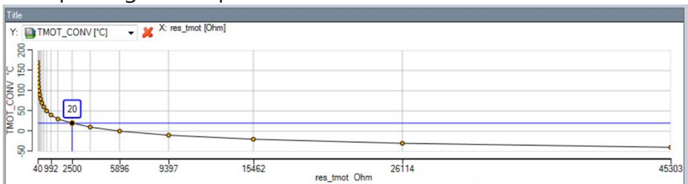
Measurement list	
FCPOIL	0.500 sec
POIL_GRD	400.0 mV/bar
POIL_OFF	500.0 mV
POIL_DEF	1.000 bar
TDPOIL	0.50 sec
UPOIL_MAX	4.80 V
UPOIL_MIN	0.20 V

Measurement list	
upoil	--- V
poil	--- bar
E_poil	---

Temperature measurements

The system offers many different temperature channels, please see function description Input Signal Processing for details. Sensor linearization curves for temperature sensors are applied directly as resistance for each temperature point.

Example engine temperature sensor:



40	47	57	59	61	78	102	135	180	244	338	475	679	992	1483	**2500**	3792	5896	9397	15462	26114	45303
170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	-10	-20	-30	-40

Measurement list	
utmot	--- V
tmot	--- °C
E_tmot	---
FCTMOT	1.00 sec
TMOT_DEF	40
TDTMOT	1.0 sec
UTMOT_MAX	4.800
UTMOT_MIN	0.100

4 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 25 Sport inappropriately.

Use the MS 25 Sport 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 25 Sport with uncertified combinations and accessories

Operation of the MS 25 Sport 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 25 Sport 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.

5 Engine Performance Calibration

Summary of basic Diesel engine calibration:

- The correct calibration for the beginning of injection angle is one of the most important things. A good calibration will make the engine powerful, economical and reliable.
- In case the injection angle is calibrated too early (big values), this will cause high / early cylinder peak pressures, which can damage/crack the piston!
- In case the injection angle is calibrated too late (small values), this will cause very high exhaust gas temperatures, which may damage the turbocharger!

The most important information to calibrate the beginning of injection angle correctly is cylinder pressure indication! The cylinder pressure indication system is a stand-alone system and this it is not part of the MS 25 Sport system provided by Bosch. If recommendations for a cylinder pressure system are needed, please contact Bosch Motorsport for further information.

While optimizing the performance calibration the following values need to be monitored very carefully so that their respective limits are not exceeded:

- Cylinder pressure
- Exhaust gas temperature
- Turbocharger speed
- Torque limitation given by engine mechanics (based on material properties of e.g. crankshaft, bearing forces, cylinder head gasket etc...)
- All the other engine parameters which could have a destructive impact such as coolant temperature tmot, oil pressure poil, oil temperature toil and so on

Basic engine calibration targets are:

- Reliable engine start without big overshoots in engine speed when low idle speed setpoint is reached for the first time
- Stable engine operation in low idle controller with minimal oscillations and good injection quantity pre control coming from the friction map so that there is only small PID controller interference
- Good rail pressure build-up during engine start until rail pressure setpoint is reached
- Stable rail pressure control at rail pressure setpoint suitable for the hydraulic components
- Fast reaction of rail pressure to changes in the rail pressure setpoint with minimal over- / undershoots when the setpoint is reached
- Max. boost pressure setpoint adapted to the given engine configuration.
- Stable boost pressure control at boost pressure setpoint
- Full load optimization with main injection angle, fuel quantity calibrated for the given engine configuration
- Smoke limitation appropriately calibrated to ensure a fast engine reaction without high smoke opacity
- Limitation of engine speed to the maximum allowed value in combination with a fitting cut in engine speed of the high idle controller

6 Bosch Motorsport support

Thanks to our vast experience with Diesel engines, we are able to provide engineering support according to customer specific needs regarding the following aspects:

- Engine calibration: dataset preparation, first start at dyno, fine optimization at dyno or vehicle
- Software development: update specification and implementation
- Fuel injection equipment upgrade: component selection and delivery within a wide portfolio including series production and sample parts
- Engine management system technical definition: engine control unit/ sensors/actuator selection and delivery within a wide portfolio including series production and sample parts

Feel free to contact your local Bosch Motorsport support team for further information.

7 Legal

7.1 Legal Restrictions of Sale

The sale of this product in Mexico is prohibited.

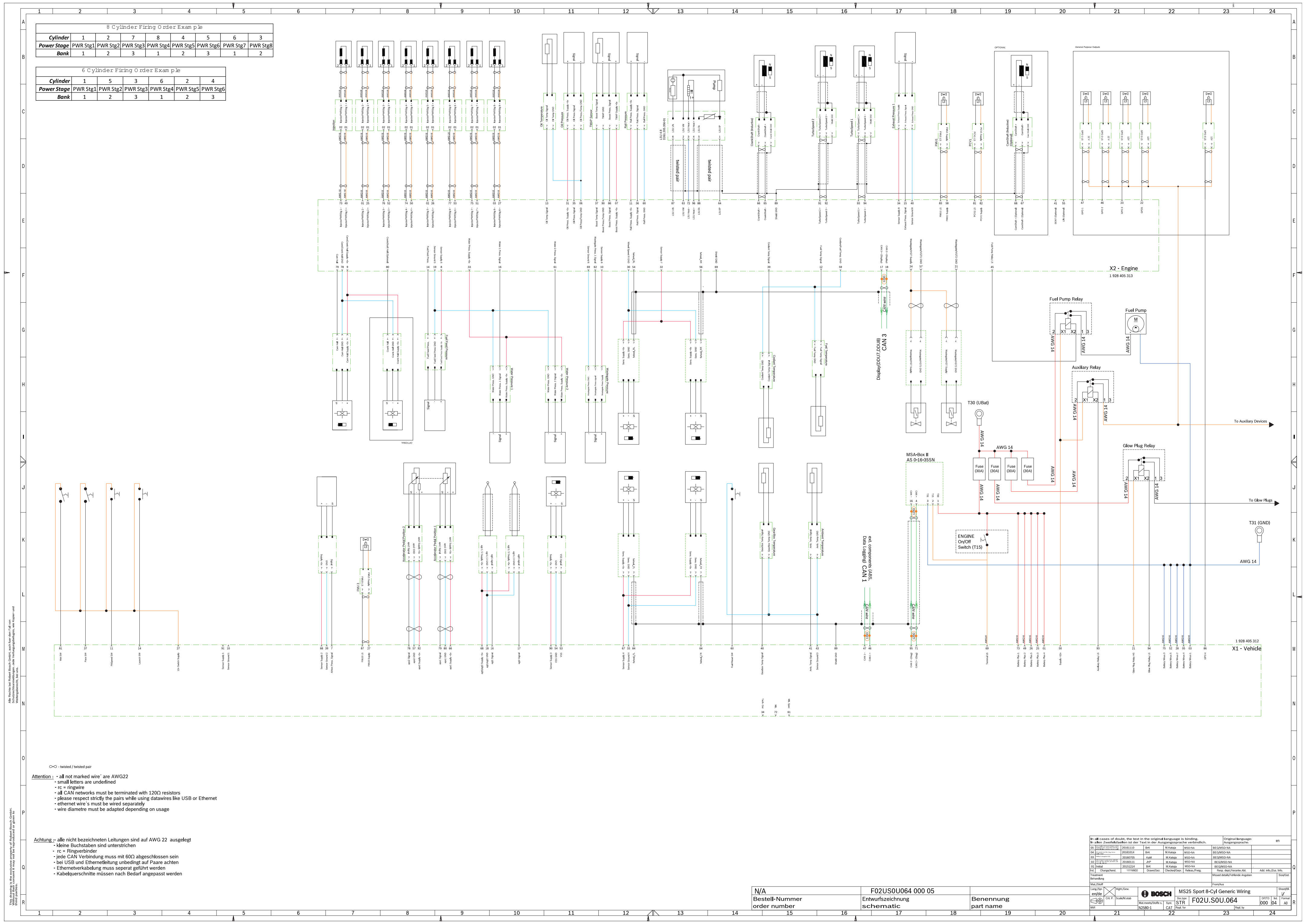
Due to embargo restrictions, sale of this product in Russia, Belarus, Iran, Syria, and North Korea is prohibited.

8 REACH Statement

According to the REACH regulations, any supplier of an article containing a substance of very high concern (SVHC) in a concentration above 0.1 % (w/w) has the duty to provide the recipient of the article with sufficient information to allow safe use of the article. Our product contains:

SVHC Substance	CAS Number
Diboron trioxide	1303-86-2
Lead monoxide	1317-36-8
Lead	7439-92-1
Silicic acid, lead salt	11120-22-2

9 Wiring Harness



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