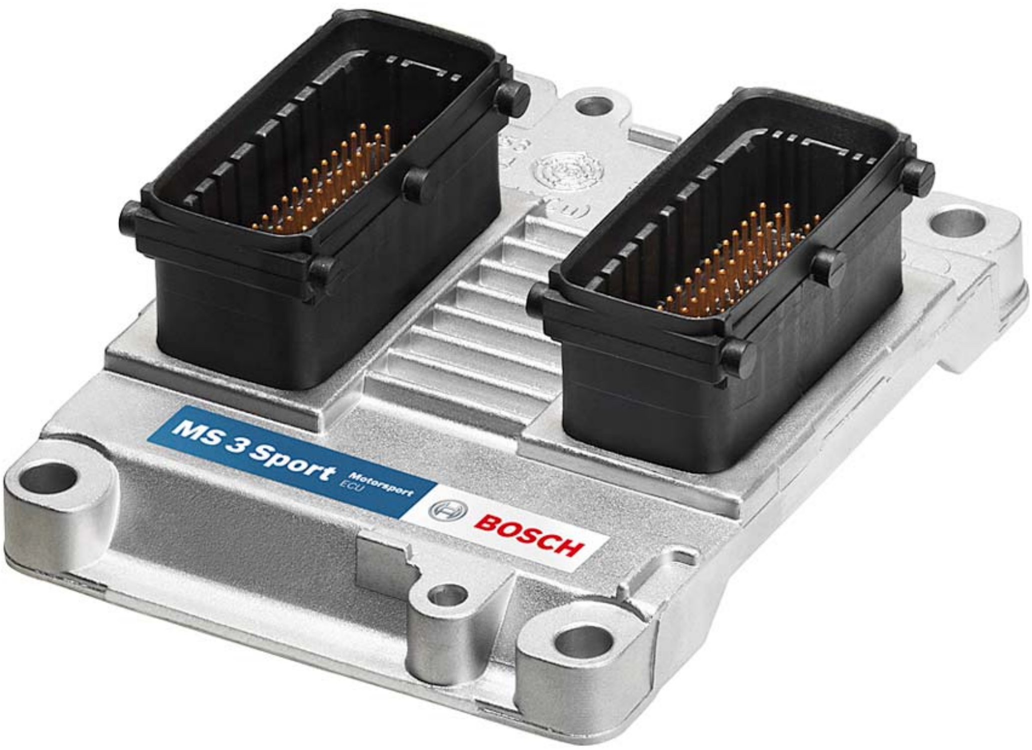
Bosch Motorsport

ECU MS 3 Sport

Manual

F 02U 002 561-01

BOSCH
Invented for life



Content

1 Getting started

Important Notes:

Use the ECU MS 3 Sport only as intended in this manual. Any maintenance or repair must be performed by authorized and qualified personnel approved by Bosch Motorsport.

Operation of the ECU MS 3 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 are only permitted when they have been determined to be compliant from a performance and safety standpoint by a representative from Bosch Motorsport.

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“.

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.

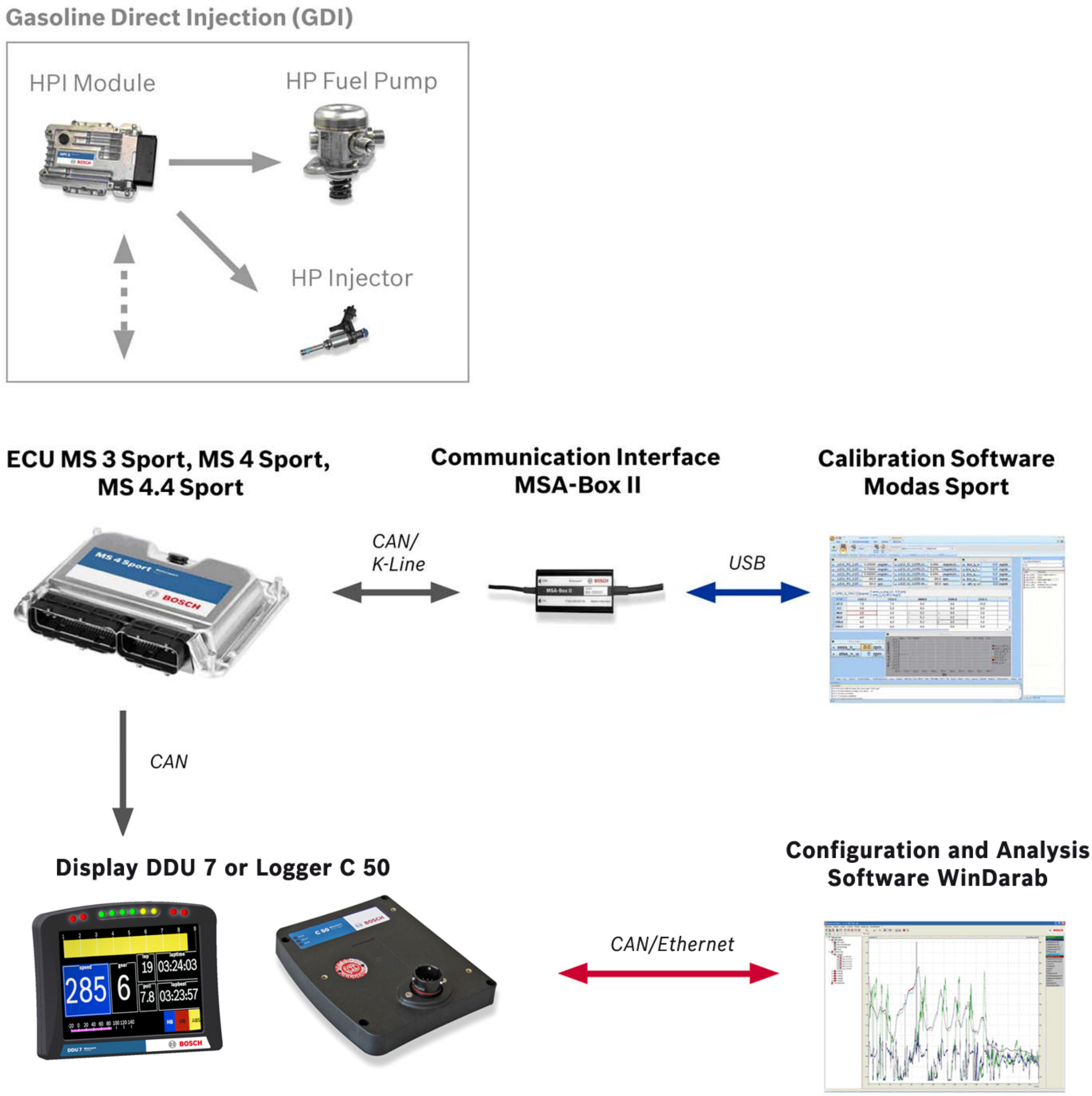
Edition: November 11

Before starting:

Before starting your engine for the first time, install the complete software from the installation CD. Bosch Motorsport software is developed for Windows 2000/XP. Connect the PC Link Adapter (MSA Box) or the Ethernet line (depending on calibration equipment) to your computer and install the driver. 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.

2 Sport Systems – Overview

The Sport Systems support an easy to understand user concept. The ECUs are configured as so called Alpha/N versions. This means that the engine characteristic map is based on engine speed, throttle position, and engine temperature. The injected amount of fuel and the ignition point are derived from these values.



3 ECU MS 3 Sport

The MS 3 Sport is the first Bosch engine management system to be manufactured with full hybrid technology. Therefore it is very small, lightly and robust against vibrations. The MS 3 Sport is suitable for naturally aspirated engines with up to 6 cylinders and has internal ignition output stages. In addition to many other functions an independent lambda control for two wide range lambda sensors is included. There are optional upgrades for knock control, EGAS and traction control.

Application	
Engine layout	up to 6 cylinders, 2 bank
Control strategy	alpha/n
Lambda control	dual
Pitspeed limiter	✓
Gear cut for sequential gear box	✓
Map switch (3 positions - each corresponds to different target lambda and spark maps)	✓
Fuel cut off	✓
Sequential fuel injection	✓
Asymmetric injection timing	✓
Asymmetric ignition timing	✓
Knock control	optional
Electronic throttle control	optional
Traction control	optional
Interface to Bosch Motorsport ABS M4 kit	✓
Support of 60-2 and 36-2 crankshaft trigger wheels	
Max. vibration	*Vibration Profile 3 (see Appendix or www.bosch-motorsport.com)*

Mechanical Data	
Extremely small and flat aluminium pressure casting housing	
Four mounting points on housing	
Extremely shock and vibration proof hybrid technology	
Size	120 x 90 x 40 mm
Weight	250 g
Temperature range	-40 ... 125 °C

Connectors	
Mating connector I	D 261 205 139
Mating connector II	D 261 205 140

Software	
Modas Sport Calibration Software	inclusive
WinDarab Analysis Software	on request

Electrical Data	
Max. power consumption	10 W at 14 V
Inputs	
2 lambda sensor interfaces LSU	
4 inputs for Hall-effect wheel speed sensors	
1 input for inductive crankshaft sensor	
1 input for Hall-effect camshaft sensor	
17 analog inputs 0 ... 5 V	
2 knock sensor inputs	
6 digital inputs	
Outputs	
6 injection power stages	
6 ignition power stages	
16 power stages (2 A/1 A; low side; PWM)	
2 power stages for lambda heater	
1 H-bridge (5 A)	
2 sensor supplies (5 V/100 mA)	
Communication interfaces	
1 K-line serial interface	
1 CAN interface for external communication	

Optional Accessories	
MSA-Box II	**F 02U V00 327-01**
Data logger C 50	**F 02U V01 164-01**
Display DDU 7	**F 02U V01 130-01**

Optional Functionality	
Knock Control SW upgrade	**F 01T A20 053-01**
Electronic Throttle Control SW upgrade	**F 01T A20 051-01**
Traction Control SW upgrade	**F 01T A20 052-01**

Part Number	
MS 3 Sport	**F 01T A20 067-01**

3.1 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 an NTC sensor (negative temperature coefficient). Depending on the used sensor (e.g. 15 KOhm or 2.5 KOhm NTC) the corresponding linearization curve has to fit.

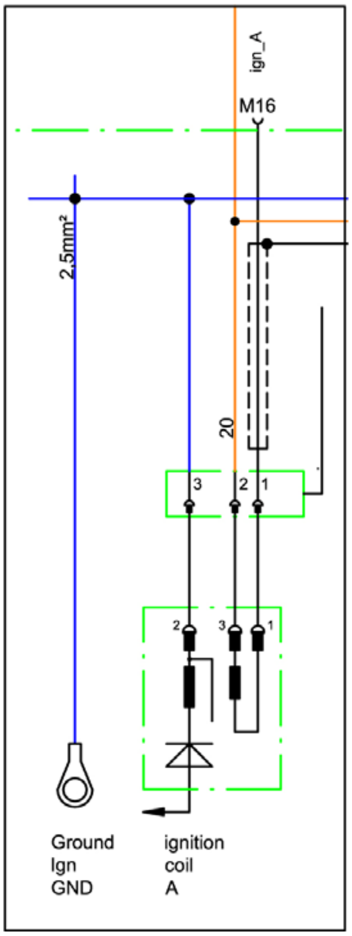
For measuring of throttle position *ath* or pressures f.e. *pfuel, poil,* which deliver a voltage (active sensors), pull-up resistors are not allowed. These sensors must be calibrated with the sensors offset and sensitivity values (at Bosch sensors you find this values printed on the sensor housing).

The ECU MS 3 Sport needs an inductive speed sensor on the ignition trigger wheel. For the camshaft sensor a Hall-effect sensor is necessary. Also for wheel speed measurement Hall-effect sensors are recommended. 4 Hall-effect wheel speeds can be connected directly to the ECU. For wide range lambda measurement and control the lambda sensor Bosch LSU 4.2 is needed.

3.2 Output Channels

The ECU MS 3 Sport has 6 independent injector power stages. These output drivers can deliver a maximum current of 2.2 Ampere. Therefore the valves must have at least 6 Ohm internal resistance.

The ECU MS 3 Sport has integrated ignition power stages. The wiring is shown in the following picture.



A typical 6 cylinder engine with firing order 1-5-3-6-2-4 is connected as follows:

Firing	1	5	3	6	2	4
IGN	A	B	C	D	E	F
INJ	A	B	C	D	E	F

3.3 Power supply

The ECU MS 3 Sport requires an external main relay to be wired to the harness. This relay is controlled by the ECU MS 3 Sport to realize that important information can be stored after switching off the ignition.

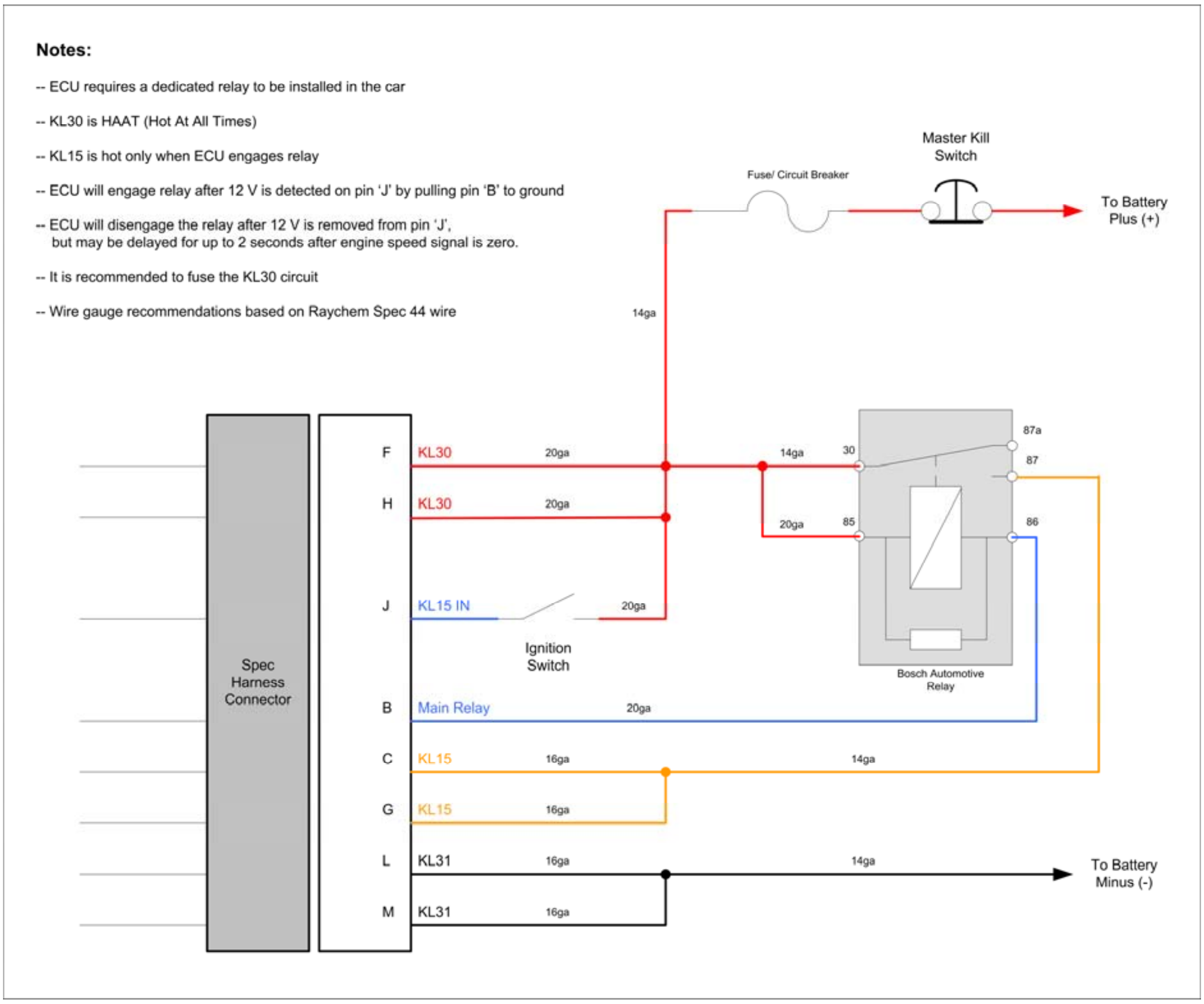
Please ensure that you have a good ground installation. That means:

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

The following notations for power signals are used:

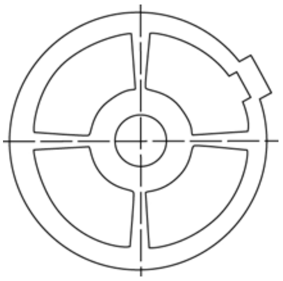
- KL15 is a switched battery rail controlled by the ECU driver
- KL30 is an unswitched battery positive rail (same as battery positive terminal)
- KL31 is an unswitched ground rail (same as battery negative terminal)

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

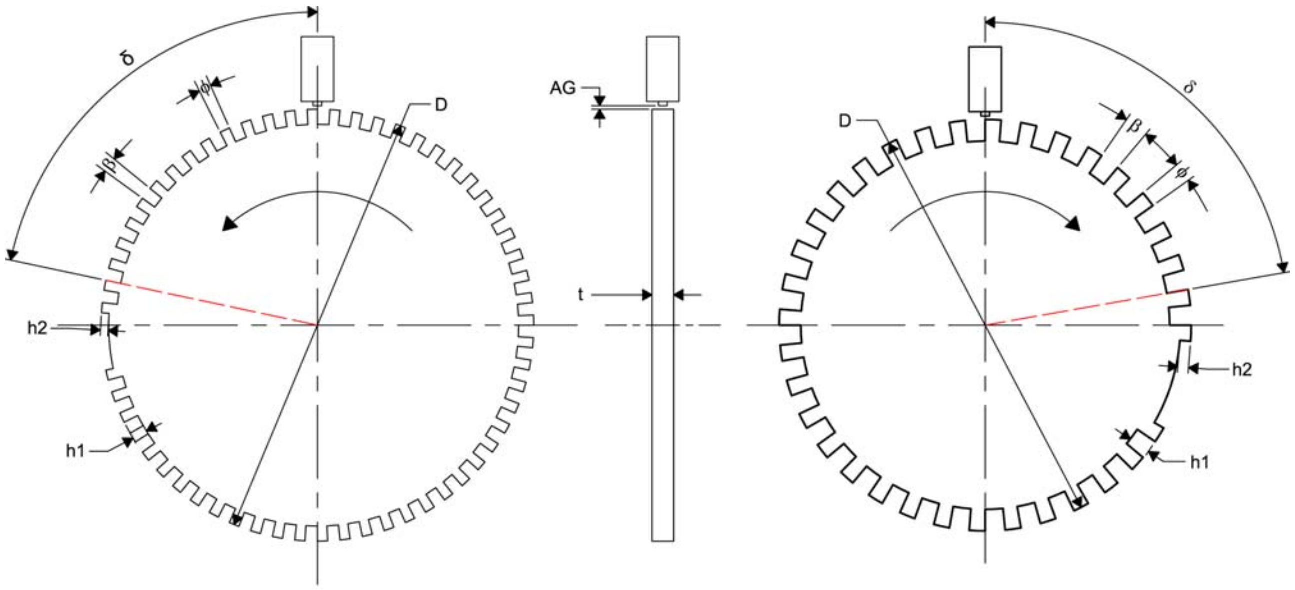


3.4 Ignition trigger wheel

The camshaft trigger sensor is a Hall-effect type with a single tooth trigger wheel.



The software assumes a 60-2 teeth or a 36-2 teeth trigger wheel for proper operation. The type can be choosen in the software. The crankwheel trigger sensor must be an inductive type for default configuration. For the camshaft sensor a hall sensor must be used. The picture below shows the correct installation position.



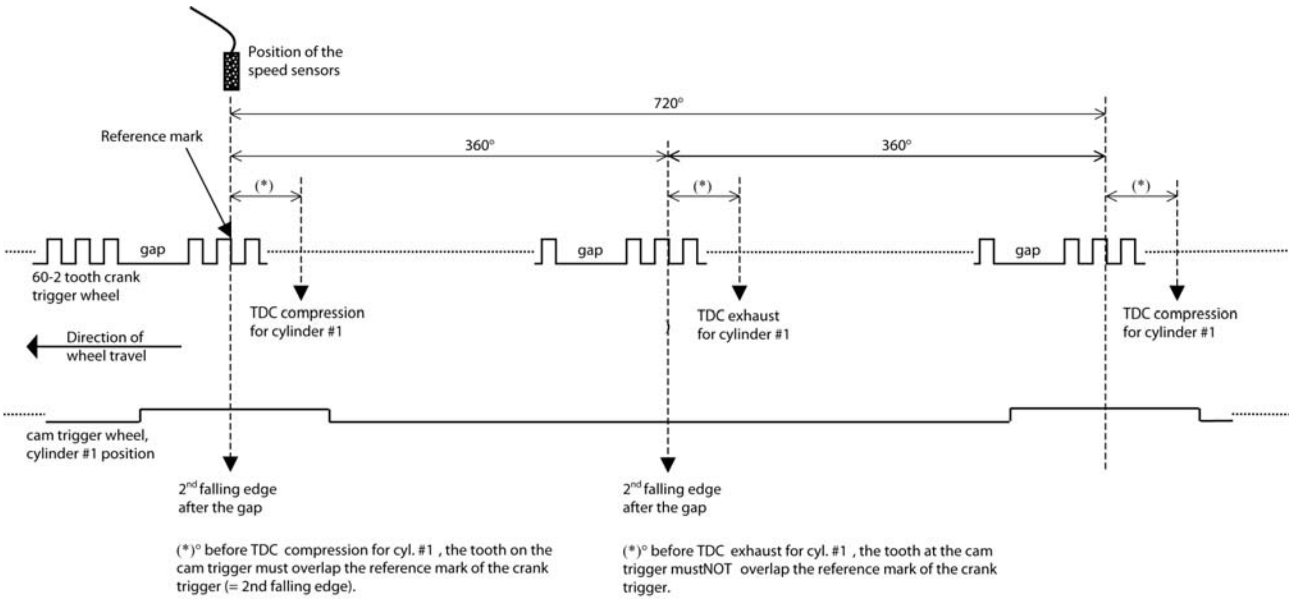
Symbol	Benennung	Nennabmessungen
Z	Zähnezahl	60 (-2)
D	Durchmesser	> 100 mm
h1	Zahnhöhe	3.5 mm
h2	Lückenhöhe	h1/2
AG	Luftspalt	0.8 ± 0.3 mm
t	Zahnraddicke	> 5.0 mm
δ	TDC - REF	frei wählbar
β	Lückenbreite	3.30°
ϕ	Zahnbreite	2.70°

Symbol	Description	Nominal Dimension
Z	tooth count	36 (-2)
D	diameter	> 95.3 mm [3.750 in]
h1	tooth depth	5.0 mm [0.197 in]
h2	gap depth	h1/2
AG	air gap	0.8 ± 0.3 mm
t	wheel thickness	> 5.0 mm [0.197 in]
δ	TDC to REF	frei wählbar
β	gap width	5.55°
ϕ	tooth width	4.45°

3.5 Mounting position of the speed sensors

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

1. Rotate the engine to the precise position of TDC compression for cylinder #1.
2. Rotate the engine (*) 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. Adjust the position of the cam trigger in reference to its hall effect speed sensor: the sensor must be about at the center of the tooth.
5. Turn the engine by 360 crankshaft degrees to reach the position of (*)° before TDC exhaust for cyl. #1.
6. 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 must be wide enough to ensure a safe overlap of the crank trigger reference mark at any time.
- The hall effect signal is the inversion of the shape of its cam trigger: the tooth effects a 'low' signal at the sensor and vice versa.
- With 4 and 6 cylinder engines, the value of 66 degrees must be replaced by 78 degrees.

3.6 Sensor recommendation Clubsport

The sensors shown 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.


NTC M12-L


NTC M12-H


TCP-K


PSA-C


PSS-10


LSU 4.2


IA-C


HA-P


RP 86


RP 100 twin


KS-P


RP 308

GSS-2

AM 600-3

YRS 3

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**
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**
PSA-C	Air pressure (manifold, boost)	D 261 205 289	**0 281 002 389**
LSU 4.2	Lambda value	D 261 205 138	**0 258 006 065**
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**
KS-P	Knock	D 261 205 337	**0 261 231 120**
RP 308	Gear detection	ASL 0-06-05SA-HE	**B 261 209 570**
GSS-2	Gear shift	ASL 0-06-05SC-HE	**B 261 209 227**
AM 600-3	Acceleration	ASL 0-06-05SA-HE	**B 261 209 313-01**
YRS 3	Yaw rate	F 02U 002 235-01	**0 265 005 838**
RP 308	Steering angle	ASL 0-06-05SA-HE	**B 261 209 570**

The volume of applied sensors may differ depending on individual software extents.

4 Starting up the ECU

4.1 Offline Data Application

The following chapter deals only with the main parameters which should be checked before a first engine startup. Several functions are recommended to be switched off, many software labels will not be explained in detail. To work on these functions and labels after the first startup, please refer the full-scope function description.

The Offline data application guide shall help to get the engine started the first time without problems.

Important hint	• Wrong engine setup data may lead to serious engine damages! If the TDC angles do not match the expected configuration of a symmetrical or V engine the setup won't be accepted and for safety reasons the engine will not start (engsetupOK_b = 0).

4.1.1 Basic engine data

How many cylinders does the engine have?

The new Clubsport System can be used for engines with different number of cylinders using the same program.

How many teeth does the crankshaft wheel have?

The System supports wheels with 60-2 or 36-2 teeth. The TDC angles are defined starting from the second tooth after the gap in the rotating direction. The first cylinder in the firing order should have its TDC after the gap.

Is the ignition symmetrical? If not, how are the angles defined?

Engines with 6 and 8 cylinders can have a V configuration which in some cases requires unsymmetrical ignition angles. The Clubsport Software supports any variation but you must define the TDC angle for each cylinder accordingly.

Is the harness wired according to the firing order?

The Clubsport System is defined to have the first cylinder in the firing order connected to the output A, the second to output B and so on. This is the recommended wiring configuration. In this case, your TDC angles must be input in ascending order.

First make sure you have installed the calibration software following the instructions provided. Then follow these steps:

1. Look for the characteristic value CYLNUMBER and enter the cylinder number of your engine.
2. If the crankshaft wheel has 36-2 teeth set CRANKWHEEL36 to 1. It if has 60-2 set it to 0 (default value).
3. Enter the TDC angles for each cylinder according to the convention defined above in TDCCYL1 to TDCCYLN where *N* is the number of cylinders of the engine.

Example 1

To better understand this process a symmetrical 6 cylinder engine with a standard crankshaft wheel will be described. The first TDC is 78° from the second tooth after the gap. In this case the following parameters must be input:

CYLNUMBER = 6

CRANKWHEEL36 =0

TDCCYL1 = 78

TDCCYL2 = 198

TDCCYL3 = 318

TDCCYL4 = 438

TDCCYL5 = 558

TDCCYL6 = 678

Notice that the angle between each TDC is 120° because the engine has symmetrical ignition.

Example 2

Now suppose the same engine has a V configuration 90°-150°. In this case the TDC angles are:

TDCCYL1 = 78

TDCCYL2 = 168

TDCCYL3 = 318

TDCCYL4 = 408

TDCCYL5 = 558

TDCCYL6 = 648

4.1.2 Injection: INJCALC

TIBAT_OFF Battery voltage correction. Predefined value for Bosch Type valves EV6, characteristics can be requested by the valve manufacturer.

TI_FAK Global factor, set to 1.0 for startup.

4.1.2.1 Injection Map

TI_DEF Base Injection timing in milliseconds.

The injection time depends mainly on throttle position, engine speed, fuel pressure and injection valve type. To get a first estimation, the following characteristics must be known:

- displacement per cylinder VC (m3)
- expected intake manifold pressure (after throttle) pi [Pa]
- desired lambda value λ
- operating fuel pressure pf [bar]
- injection valve flow rate Qstat [g/min] at reference fuel pressure pfRef [bar]
- intake air temperature Ti [K]

The fuel mass mf is calculated by:

$$m_f = \frac{p_i \cdot V_C}{R \cdot T_i} \cdot \frac{1}{14.5} \cdot \frac{1}{\lambda}$$

[kg] with R = 287 [J/kg] constant

The energizing time of the injection valves is calculated by:

$$ti = \frac{m_f}{Q_{stat}} \cdot \sqrt{\frac{p_{f\,Ref}}{p_f}} \cdot 10^6 \cdot 60$$

[ms]

TITAIR_FAK Correction by intake air temperature. This value is predefined. If unsure, set it to 1.0 constantly for first startup.

TITMOT_FAK Correction by engine coolant temperature. This value is predefined. If unsure, set it to 1.0 constantly for first startup.

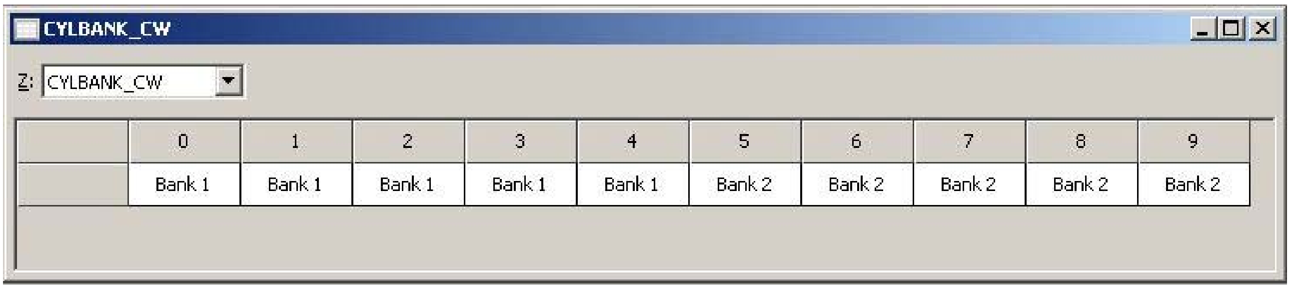
TIPFUEL_FAK Correction by fuel pressure. This value is predefined. If unsure, set it to 1.0 constantly for first startup.

TIREVPCORR_FAK Correction by ambient pressure / airbox pressure. This value is predefined. If unsure, set it to 1.0 constantly for first startup.

PCORR_CW Select correction mode. Ambient (0) or airbox (1) pressure.

4.1.2.2 Cylinder Individual

CYLBANK_CW Lambda control is done bankwise, therefore this adjustment must be done for proper lambda control. Open the label and allocate the cylinders to the right bank via dropdown menu.



Note: Engines with one lambda sensor (e.g. 4-in-a-row) run as 1-Bank-Systems. Set CYLBANK_CW to 0.

TIREVATH_FAK_x Cylinder individual corrections. Set to 1.0 for first startup. Numbering refers to firing order!

INJOFFPATTERN Torque reduction by injection fade out. Different, repeating fade out patterns can be defined for several full power strokes of the engine (720° crank or 2 full rotations). This prevents single cylinders from cooling down too much and makes it possible to find optimal patterns.

Example 4 cylinder engine:

fade out level injoff →

y/x	0	1	2	3	4
0	0	1 (=0001b)	3 (=0011b)	7 (=0111b)	15 (=1111b)
1	0	2 (=0010b)	12 (=1100b)	7 (=0111b)	15 (=1111b)
2	0	4 (=0100b)	3 (=0011b)	14(=1110b)	15 (=1111b)
3	0	8 (=1000b)	12 (=1100b)	13(=1110b)	15 (=1111b)

The cylinders are assigned bitwise, the lowest bit represents cylinder 1 in firing order (FO1), e.g. injoff = 1:

- First power stroke 0°-720°: Cylinder 1 (FO1) is faded out
- Second power stroke 720°-1440°: Cylinder 2 (FO2) is faded out
- Third Power stroke 1440°-2160°: Cylinder 3 (FO3) is faded out
- Fourth Power stroke 2160°-2880°: Cylinder 4 (FO4) is faded out
- Fifth Power stroke 2880°-3600°: Cylinder 1 (FO1) is faded out
- ...

4.1.2.3 Injection Start

TISTARTBASE	Base injection time for engine start. Can be set to a value near full load from the maps TI_MIN/DEF/MAX in atmospheric engines. Scale down proportional to boost pressure for turbo engines. Further corrections: Predefined. If unsure, set to 1.0 for first startup.

4.1.2.4 Injection Angle

INJANGREVATH	End of injection pulse, refers to combustion TDC. Make sure, the injection is ended before the inlet valve closes. Try 200° - 300° for first startup.
INJANGSTREV	End of injection pulse in engine start. Refer to INJANGREVATH.

4.1.3 Injection Controls

4.1.3.1 LAMCTRL

LAMCTRL_CW	Deactivate by setting = 0.
LAM_MIN **LAM-DEF** **LAM-MAX**	Desired Lambda map, map-switch dependant.

4.1.3.2 INJCUT

INJCUTGEAR	Deactivate by setting = 0.0.

4.1.3.3 INJENRICH

INJENRICHREV_MIN	Deactivate by setting = 32768.

4.1.4 Ignition: IGNCALC

Important note: Positive values stand for ignition angles before TDC, negative values after TDC. Begin with moderate values to protect your engine from damages.

IGNSTARTREV	Base spark advance in engine start. Set to 5 – 10 deg.
IGNSTARTTMOT_OFF	Correction by engine coolant temperature. Set to 0.0 for first startup.
TDWELLBATTREV	Coil dwell time. Consult the coil manufacturer for details. Most coils need dwell times about 1.5 to 2.5 milliseconds at 12 – 14 V.
TDWELLMAX_OFF	Dwell time limitation. Stay with predefined value for first startup.
IGNREV_OFF_x	Cylinder individual correctons. Set to 0.0. Numbering refers to firing order!

4.1.4.1 IGNITION_MAPS

IGN_MIN **IGN_DEF** **IGN_MAX**	Base Injection timing in deg crankshaft before TDC, map-switch dependant. Use modest values at the first time. Atmospheric engines may run safe at 20 – 25 deg in part load, Turbo engines at high boosts may demand even less spark advance. These values are strongly dependant on compression ratio, fuel quality, temperature and engine specifics. If you know you're using "bad" fuel, run at high temperatures or your engine is very sensitive on spark advance, go to the safe side. Further corrections: Predefined. If unsure, set to 0.0 for first startup.

4.1.5 Inj + Ign Controls:

4.1.5.1 GEARCUT:

GCREV_THR	Deactivate by setting = 32768.

4.1.5.2 REVLIMIT:

The Rev-Limiter works in three steps:

- Soft limitation by ignition retardation
- Hard limitation by Injection cut off
- Absolute limitation by full injection and ignition cut off

REVLIMITSOFTGEAR	Soft limiter, gear dependant: Apply the revs at which the limiter shall become active (same value to all gear break points on dyno).
IGNREVLIMITSOFT	Apply the ignition angle (absolute) dependant on the engine overspeed (rev – REVLIMITSOFTGEAR).
REVLIMITHARDGEAR	Exceeding this values, the injection will be cut off.
REVLIMITIGNOFF_OFF	Maximum overspeed relative to REVLIMITHARDGEAR. Injection and ignition fade out when exceeded.

4.1.5.3 SPEEDLIMIT:

SPEEDLIMITREV_MIN	Deactivate by setting = 32768.

4.1.5.4 TRACTIONCTRL:

TC_CW	Deactivate by setting = 0.

4.2 Online Data Application

Sensors and peripherals can be checked when the system is powered up electrically. Do not start the engine before all steps in this chapter are carried out. Make sure the battery is connected properly, all sensors are connected, ground wiring is fixed before powering up the system. Check all sensors for errors (bits ..._e) before starting the engine.

4.2.1 PRESSURES

All pressures are calculated in the same way. The system offers oil pressure (poil), ambient pressure (pamb), crank pressure (pcrank) and fuel pressure (pfuel).

Example: Ambient pressure

PAMB_OFF, PAMB_GRD	Sensor offset and gradient. Consult the sensor manufacturer for details.
PAMB_UMX, PAMB_UMN	Maximum and minimum accepted sensor voltage. When violated, an error is set (pamb_e = 1). Set to approx. 250 mV / 4750 mV.
PAMB_DEF	Default value. If a sensor error is set, the output is switched to the default.
PAMB_FIL	Filter constant. Use modest values, ~ 10 - 40 milliseconds.
All other variables	All other variables are named by the same rule, replace “pamb” by e.g. “poil” to apply data for the oil pressure sensor.

4.2.2 TEMPERATURES

All temperatures are calculated in the same way. The system offers oil temperature (toil), intake air temperature (tair), engine temperature (tmot), fuel temperature (tfuel), ...

Example: Intake air temperature

TAIR_UMX, TAIR_UMN	Maximum and minimum accepted sensor voltage. When violated, an error is set (tair_e = 1). Set to approx. 200 mV / 4800 mV.
TAIR_LIN	Sensor characteristic. Consult the sensor manufacturer.

4.2.3 LAMDET

LAMTYPE_CW	Select the sensor type: LSU4.2 (set to 0) or LSU4.9 (set to 1).
All other labels	Keep the predefined values.

4.2.4 GEARDET

Refer the function description if needed. For engine application not necessary.

4.2.5 ATHDET

ATH_UMN, ATH_UMX	Maximum and minimum accepted sensor voltage. When violated, an error is set (ath_e = 1). Set to approx. 250 mV / 4750 mV.

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

4.2.5.1 CALIBRATION:

ATHPOS1	Lower calibration point, set to 0.0 %.
ATHPOS2	Full load point, set to 100.0 %.
ATHIDLECAL	Set to desired idle ath value.
ATH_CW	Close throttle and set ATH_CW to 1. Open throttle fully and set ATH_CW to 2. Set throttle to idle point and set ATH_CW to 3.

Check calibration by moving throttle.

5 Extensibility

We developed a lot of extras for the ecus. That is e.g.:

- Displays
- Data loggers
- Telemetry units

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

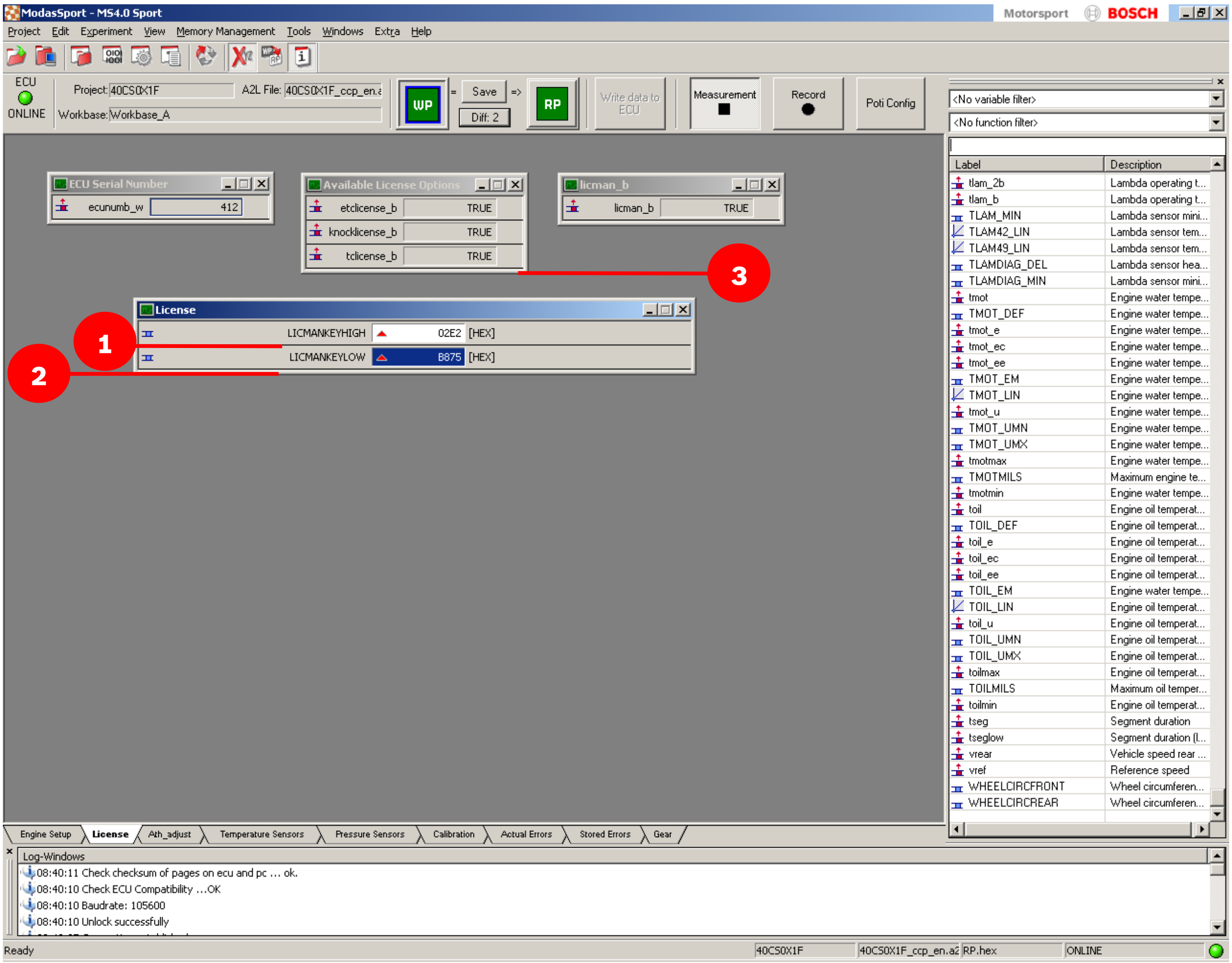
Moreover, you can expand some additional functions of your ecu by sending us the serial number. Than we will send you the licence for:

- Traction control
- Drive by wire
- Knock control

6 Activation of Softwareoptions

If you buy optional software, you will get a codenumber with eight ciphers from us. We enable this codenumber exclusively for one defined ECU-serialnumber. It will work with this ECU only.

Start the application tool Modas Sport. You will find a predefined worksheet called **Licence** there, see picture below.



Example code: 02E2 B875

Fill in the first four ciphers of your licence code (here 02E2) into the input box LICMANKEYHIGH (1)

Fill in the last four ciphers of your licence code (here B875) into the input box LICMANKEYLOW (2)

If you have filled in the right licence code, the according softwareoption will be set on TRUE (3).

Exception: Near Bank/Far Bank and VVT. These functions require an ECU-software-update. Please contact us for more information.

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