LSG 2000

For Development of Automotive Fuel Injection Systems

Engine Speed Simulator

Documentation

Hardware Revision (1.2)

Software Revision (2.6.8)

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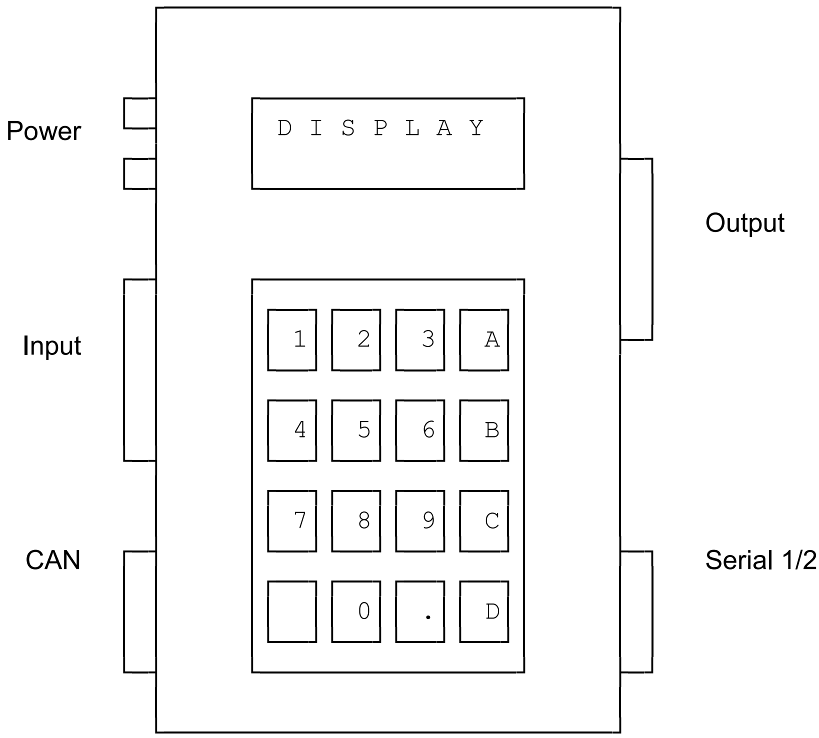
1 General

The LSG 2000 is a laboratory control unit for flexible application. The device reads analog, digital on/off and frequency inputs and creates frequency and pulse-width modulated signals. Signals can be read or sent via CAN interface.
Configuration of the signals can be done via the buttons on the device or via file transfer on RS232 line from a PC. The values are stored in a non-volatile memory.

2 Hardware

2.1 Top View



2.2 Description

2.2.1 Electrical parameters

Supply:	voltage range 7V ... 32V current max. 500mA (without external loads) protected against reverse polarity
Ambient Temperature:	+10°C ... +40°C
Ambient relative Humidity:	20% ... 80%

2.2.2 Interfaces

Serial 1/2 (Tx/Rx):	input/output voltage ±15V short circuit protection
Analog Input 1-7:	input voltage 0 ... 5V max. input current ±1mA τ = 1,5ms
Analog Input 8:	input voltage 0 ... 7V max. input current ±1mA τ = 1ms
Analog Input 9:	input voltage 0 ... 46V max. input current ±1mA τ = 0,15ms
Analog Input 10:	input voltage 0 ... 46V used for internal battery voltage measurement τ = 0,15ms
Digital Input 1-5:	max. input voltage 0 ... 32V max. input current ±3mA switching level L-H max. 3,5V switching level H-L min. 0,5V
Digital Input 6-7:	max. input voltage 0 ... 32V max. input current ±3mA switching level L-H max. 2,5V switching level H-L min. 0,7V
Frequency Input 1-2:	for inductive speed sensors input voltage –32V ... 32V input current –2mA ... +2mA frequency range 50Hz ... 10kHz switching level L-H max. 1,0V switching level H-L min. –1,0V
Frequency Input 3-5:	general purpose digital inputs input voltage –0V ... 32V input current –2mA ... +2mA frequency range 50Hz ... 10kHz

	switching level L-H max. 2,5V switching level H-L min. 0,7V
Power Output 1-8:	output voltage 0V ... 32V max. load current 500mA*/output output clamping energy 10mJ @ repetition rate < 100 Hz short circuit protection * whole load current of all outputs 2A
Signal Output 1-4:	differential output for simulating inductive speed signals output voltage ±10V output impedance approx. 1kOhm short circuit protection

2.2.3 Technical details

Kernel: 16 bit Micro Controller with 16MHz Clock

Memory: The LSG 2000 is equipped with
- an external Flash size of 224 Kbytes for code
- an internal RAM size of 1,5 Kbytes for operation system
- an external RAM size of 14,5 Kbytes for program
- a serial EEPROM of 2 Kbytes for storing the configurations

Address mapping:

`0x00000 - 0x07FFF`	ext. Flash
`0x08000 - 0x080FF`	CAN
`0x0C000 - 0x0F9FF`	ext. RAM
`0x0FA00 - 0x0FFFF`	int. RAM / Special function registers
`0x10000 - 0x3FFFF`	ext. Flash

Serial #1: synchronous serial Interface, RS232
e.g. for programming

Serial #2: synchronous serial Interface, RS232

Analog Inputs: 10 analog inputs with a 10 bit A/D converter

Digital Inputs: 7 digital inputs

Frequency Inputs: 2 frequency Inputs designed to evaluate the signals of inductive tone wheel sensors.

Power Outputs: 8 Power Outputs *1) *2)
Low-Side Switches

Differential Outputs: 4 differential Outputs for simulating inductive speed signals *1)

Display: 16 Characters, 2 Lines
adjustable brightness and contrast

Keyboard: 16 Buttons
0 ... 9 / A ... D / “Blank” (Shift) / “Dot”

*1) Some power outputs are controlled in parallel with differential outputs.
*2) Some micro controller ports can be used as input or output, depending on the application.

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2.3 Terminal Description

2.3.1 Serial 1/2 Interface (Sub-D 9, female)

Pin	Signal	Function	Port	Note
1	ALE	address latch enable	ALE	-
2	TxD0	serial 1 Interface, transmit data	P3.10	-
3	RxD0	serial 1 interface, receive data	P3.11	-
4	POR	power on reset	POR	-
5	GND	ground	-	-
6	NMI	non maskable interrupt	NMI	-
7	TxD1	serial 2 Interface, transmit data	P3.8	-
8	RxD1	serial 2 interface, receive data	P3.9	-
9	GND	ground	-	-

2.3.1.1 Serial cable

The serial cable is just for programming. Is has two yellow plug housings.
Don’t use this cable for other serial devices, because it has a special wiring to bring the LSG 2000 in programming mode.

2.3.2 CAN Interface (Sub-D 9, female)

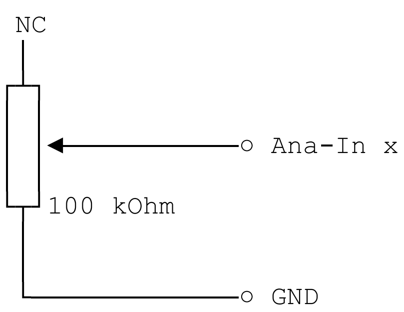
Pin	Signal	Function	Port	Note
1	-	-	-	-
2	CAN-L	CAN low signal	-	-
3	GND	ground	-	-
4	-	-	-	-
5	-	-	-	-
6	-	-	-	-
7	CAN-H	CAN high signal	-	-
8	CAN-L	for BUS termination connect to Pin9	-	-
9	CAN-H R120	for BUS termination connect to Pin8	-	-

For CAN bus termination (120 Ohm) install an external bridge in the connector between pin 8 and pin9.

2.3.3 Inputs (Sub-D 25, female)

Pin	Signal	Cable Mark	Function	Port	Input Circuitry
1	GND		ground	-	-
2	Ana-In 8		grip switch multiple state	P5.7	voltage divider ratio 1,47:1, τ = 1ms
3	Ana-In 6		vehicle speed limit setpoint poti	P5.5	pull-up resistor 10k to Vcc, τ = 1,5ms
4	Ana-In 4	AI4	setpoint auxiliary speed simulator	P5.3	pull-up resistor 10k to Vcc, τ = 1,5ms
5	Ana-In 2	AI2	setpoint engine speed simulator (fine adjust)	P5.1	pull-up resistor 10k to Vcc, τ = 1,5ms
6	GND	GND	Ground	-	-
7	GND		Ground	-	-
8	Digi-In 7		general purpose digital input	CAN P1.6	pull-down resistor 47k
9	Digi-In 4		general purpose digital input	CAN P1.3	pull-up resistor 20k to Vcc
10	Digi-In 2		general purpose digital input	CAN P1.1	pull-up resistor 20k to Vcc
11	Freq-In 3		pedal frequency input #1	P2.2	pull-up resistor 20k to Vcc
12	Freq-In 5		reserve frequency input, or AUX	P2.7	pull-up resistor 20k to Vcc
13	Freq-In 2		cam speed input	P2.1	designed for inductive speed sensor
14	Ana-In 9		general purpose analog input	P5.8	voltage divider ratio 9,36:1, τ = 165µs
15	Ana-In 7		vehicle speed limit multiple state	P5.6	pull-up resistor 10k to Vcc, τ = 1,5ms
16	Ana-In 5		accelerator pedal sensor	P5.4	pull-up resistor 10k to Vcc, τ = 1,5ms
17	Ana-In 3	AI3	setpoint vehicle speed simulator	P5.2	pull-up resistor 10k to Vcc, τ = 1,5ms
18	Ana-In 1	AI1	setpoint engine speed simulator	P5.0	pull-up resistor 10k to Vcc, τ = 1,5ms
19	Bat+		battery plus	-	-
20	Digi-In 6		terminal 15 / key switch	CAN P1.5	pull-down resistor 47k
21	Digi-In 5		vehicle speed limit function on/off	CAN P1.4	pull-up resistor 20k to Vcc
22	Digi-In 3		general purpose digital input	CAN P1.2	pull-up resistor 20k to Vcc
23	Digi-In 1		ramp start/stop	CAN P1.0	pull-up resistor 20k to Vcc
24	Freq-In 4		pedal frequency input #2	P2.6	pull-up resistor 20k to Vcc
25	Freq-In 1		crank speed input	P2.0	designed for inductive speed sensor
-	Ana-In 10		battery voltage measurement	P5.9	Internal

Recommended external circuitry for analog input 1 – 7.



2.3.4 Outputs (Sub-D 15, female)

Pin	Signal	Cable Mark	Function	Port	Output Circuitry
1	Digi-Out		low idle switch	P3.4	low side power stage
2	Digi-Out	VS	vehicle speed signal or cyl. 2 [2] or Power Stage Error Signalization [3]	P2.6	low side power stage
3	Digi-Out	CAM2a (Dig)	cam speed signal (digital) or high frequency #2 [1] or cyl. 4 [2]	P2.9	low side power stage
4	Digi-Out	TRIG	TDC trigger signal or RaceLogic GPS ok Signalization [3]	P2.12	low side power stage
5	Bat+		battery plus	-	-
6	GND	GND	Ground	-	-
7	Digi-Out	CRK1 (Ind)	crank speed signal (inductive sensor) or high frequency #1 [1]	P2.8	positive/negative output signal
8	Digi-Out	CAM1b (Ind)	cam speed signal (inductive sensor)	P2.10	positive/negative output signal
9	Digi-Out		kick down switch or PWG frequency output #1 [4] or cyl. 1 [2]	P2.5	low side power stage
10	Digi-Out	AUX (Dig)	auxiliary (turbo) speed signal (hall effect sensor) or cyl. 3 [2]	P2.7	low side power stage
11	Digi-Out	CAM2b (Dig)	cam speed signal (hall effect sensor) or cyl. 5 [2]	P2.11	low side power stage
12	Digi-Out	CRK2 (Dig)	crank speed signal (hall effect sensor) or PWG frequency output #2 [4] or cyl. 6 [2]	P2.13	low side power stage
13	Bat+		battery plus	-	-
14	Digi-Out	AUX (Ind)	auxiliary (turbo) speed signal (inductive sensor)	P2.7	positive/negative output signal
15	Digi-Out	CAM1a (Ind)	cam speed signal (inductive sensor) or high frequency #2 [1]	P2.9	positive/negative output signal

[1] High frequency outputs are used in operating mode 10 only
[2] Cylinder trigger pulses are active in operating mode 7 only
[3] Adaptonic e1280s support is reserved for operating mode 6 only
[4] PWG frequency simulation is reserved for operating mode 6 only

3 Software

3.1 Introduction

The Software starts with a welcome message:

```
*** LSG 2000 ***
  (c) BEST GbR
```

After one second it will be replaced by the last menu you used.
If you start for the first time the main menu will be displayed:

```
    Main Menu
   Select Mode
```

You come back to the main menu by pressing ‘Dot’+‘Zero’.
By pressing ‘Shift’+’Dot’ in the main menu, the current SW version and author will be displayed:

```
*** LSG 2000 ***
SW 2.6.8 BEST-Jn
```

3.2 Operation Modes

The mode is selected by pressing the according number:

0 = Main Menu
1 = Engine Speed Simulator (including speed wheel configuration)
2 = Vehicle Speed Simulator (including signal configuration)
3 = Universal Frequency Output (Turbo Speed)
4 = Accelerator Pedal and Low Idle Switch Simulator
5 = Vehicle Speed Limiter CAN-Message (Race Truck EDC17C32)
6 = Adaptronic e1280s Serial to CAN Converter
7 = Trigger for max. 6 Cylinder external Injector Power Stage
8 = CAN 250kBaud mini-Analyser
9 = internal Debug Mode
10 = High Frequency Outputs

You can switch between the modes by pressing the ‘Dot’ and the according number at the same time. With ‘Dot’ and ‘zero’ you will return to the main menu.
Switching into menu no. ‘10’ is possible only from main menu by pressing ‘Shift’ + ‘0’.

3.3 Display and Keyboard Options

The keyboard and all external setpoints can be disabled / enabled by pressing the ‘Dot’ button 2 seconds. All other keys are then not working and the background light is switched off. This protected mode can be recognised on the display by a small cross in the upper left corner. The ‘Dot’ button is still active and you must use it to enable normal mode by pressing it again 2 seconds.

In the main menu you can use the buttons **‘A’** and **‘D’** to regulate the brightness in 6 steps and the buttons **‘B’** and **‘C’** to adjust the contrast in 2 steps. Both configurations are stored to be available after power off.

Connected analog inputs or active output signals are detected and lead to a polling display, if you are not in a configuration mode. This polling starts a delay time after you pressed the last button.
Any moving analog input activates the corresponding display.
Polling delay time can be changed in the main menu via **’Shift’ + ‘B’** (more) and **’Shift’ + ‘C’** (less) between 50ms and 12,5s.
Switching delay between functions can be changed via **’Shift’ + ‘A’** (more) and **’Shift’ + ‘D’** (less) between 50ms and 12,5s.

The polling function can be disabled with a polling time set to zero.

3.4 Storing / Loading Configuration

All changes in configuration are stored automatically in to the EEPROM. If you switch off and on the LSG 2000 it starts with the last menu and configuration.

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4 Software Update

4.1 Download

The programming software is freeware by BEST. LSG 2000 users can download software-updates from our Internet homepage www.best-electronic.de for free.
The programming software is running under Win95/98, WinNT, Win2000, WinXP in a DOS emulation window, and some USB/RS232 adapters. Good results can be achieved with Lenovo T61 with serial/parallel port bay adapter.
For extreme difficult timings, BEST provides also a very slow programming software (on the homepage).

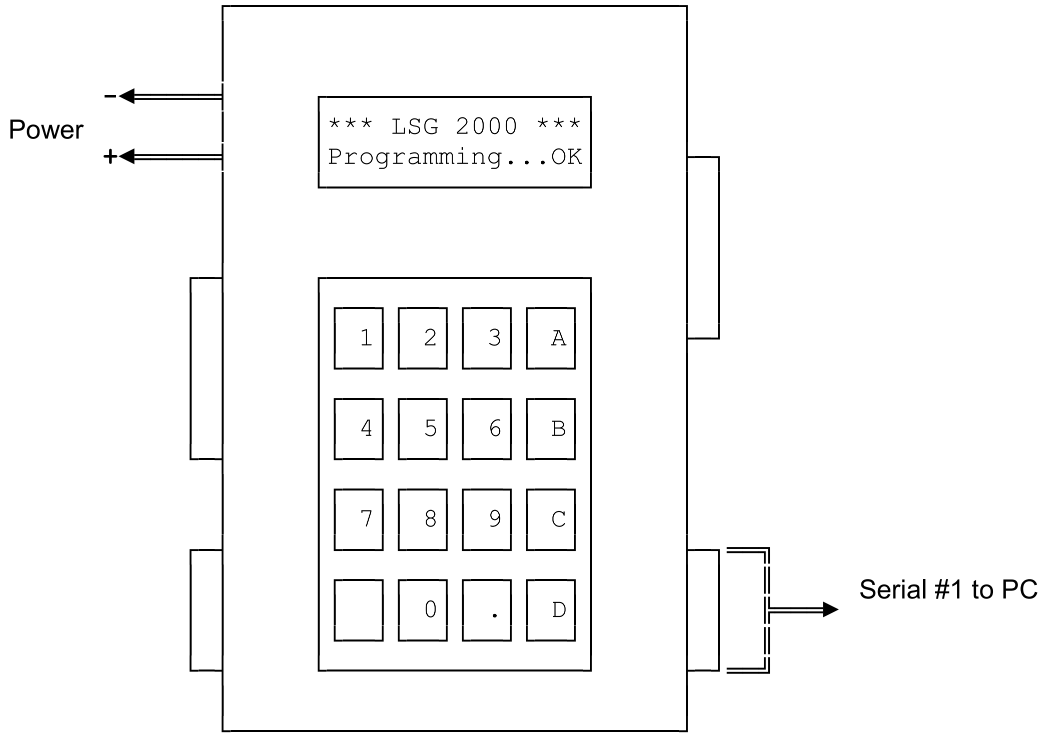
4.2 Programming a new Software

1. Switch OFF the supply voltage from the LSG 2000.

2. Connect the serial interface of the LSG 2000 with the serial interface of your PC using the programming cable of the LSG 2000 (no other cable!).

3. Start the BootStrap Loader software (Version V20 or higher) on your PC. Then switch on the supply voltage of the LSG 2000. Press a key on the PC and wait for programming finished.

4. A program download successfully finished can be checked on the screen of the LSG 2000 when “Programming…OK” is shown.



5 Description of SW Functions

5.1 Engine Speed Simulator

The engine speed simulator generates three signals.

1. The synchronisation pulse for each cylinder is located at TDC (Top Dead Center, 0° crank). "TRIG"

2. The cam speed signal “SEG or CAM” has a reference pulse to detect the first cylinder and can be used in single sensor mode for redundant injection timing.
Use the "Differential-Out" speed signal “CAM1” as an inductive speed sensor and the "Power-Out” speed signal “CAM2” for a speed sensor with open collector or open drain output (e.g. Hall effect sensor).

The Cam outputs “a” must be used for standard CAM-signals and the “b” with special CAM configuration

3. The crank speed signal “INC or CRK” is used for injection timing and has many pulses to reduce the tolerances.
There is an inductive “CRK1” and a digital “CRK2” output for the crank speed signal.

The engine speed simulator can operate by using an analog input or the keyboard for setting an engine speed between 0 and 9999 rpm. There are 25 flexible signal configurations available.
The last configuration is loaded automatically after switching on the LSG 2000.

```
  Config.-Name
Speed: 1234,5rpm
```

Shift + A = Enabling Keyboard / Analog Input
The engine speed is adjusted with the keyboard.
If the potentiometer was active, the current engine speed is taken from this mode.
Moving a potentiometer more than 2mV switches automatically to potentiometer mode.
The engine speed is then calculated from two analog inputs (0..5V).
The first channel is used to set the engine speed in a fast and coarse way (~10rpm/bit).
A fine trimming can be done with the second channel (0.1rpm/bit).
A = Switch to keyboard mode and accelerate (higher engine speed)
D = Switch to keyboard mode and decelerate (lower engine speed)
Number = Switch to keyboard mode and edit engine speed
In keyboard edit mode:
A = Accept (set this engine speed)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to zero)
Number = Enter next number of the engine speed

Shift + B = Start / Stop Ramp
The ramp points must be defined in the mode ‘Shift + D’.
After starting the LSG 2000, the SW loads always the last configuration, stored in EEPROM.
With the external switch input #1 it is possible to start/stop the ramp also when other menus are active. But no button should be pressed on the keyboard in this case.

Shift + C = Enter Configuration Mode
These values must be configured before using the LSG 2000:

- Number of cylinders
- Width of TDC/sync.-pulse (in steps of 1°Cam)
- Cylinder number where to generate the TDC pulse (is always cylinder #1 after power-on)

- Number of segments on crank wheel
- Width of crank-pulse (in steps of 0.1°Crank)
- Start of first crank-pulse after TDC (in steps of 0.1°Crank)
- Number of additional crank-pulses for synchronisation (missing pulses are negative)
  There is only one area (gap) for synchronisation implemented
- Start of gap after TDC (in steps of 0.1°Crank)
- Inversion of the signal

- Number of segments on cam wheel
- Width of cam-pulse (in steps of 0.1°Cam)
- Start of first cam-pulse after TDC (in steps of 0.1°Crank)
- Number of additional cam-pulses for synchronisation (missing pulses are negative)
- Start of first additional cam-pulse after TDC (in steps of 0.1°Crank)
  There is only one area for synchronisation implemented
- Inversion of the signal

- Maximum analog engine speed setpoint (given by external potentiometer)
  This value does not depend on the speed wheel configuration
- Factor between engine speed input and output (pump bench / engine transformation)
- PT1 filter time for engine speed input

A = Increment value
B = Go to previous configuration value
C = Go to next configuration value
D = Decrement value
Number = edit value (entering edit mode)
In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to default)
Number = Enter next number of the value

Please note: you configure always the electrical signal in angle <u>after</u> TDC. This must be a positive number. The SW reference is always the falling edge of the inductive sensor.

If you want to configure a hall effect sensor it would be the rising edge, but with the inversion menu you can switch to the falling edge.

Shift + D = Ramp Mode

To define multi-level ramp it is possible to configure up to 99 different points.
A point has an according engine speed and a time distance to the next point in the list.
The engine speed has the same range as defined in the configuration, and the time is 0 – 99.99sec in steps of 10ms.
If the time between the last point and point 1 is not zero, the ramp starts again automatically, otherwise the ramp stops at the last point and can be restarted with 'Shift + B'.

A = Increment value
B = Go to previous point
C = Go to next point
D = Decrement value
Shift+Dot = Switch between editing the engine speed and the time.
Number = enter edit mode and select engine speed + time

In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
Number = Enter next number of the value

All ramp values are stored automatically in EEPROM. The ramp itself does not start automatically after next switch-on and must be started by "Shift B" in the engine speed menu or the digital input (this input works also in all other menus).

The ramp definition shares the time axis points together with the vehicle speed and pedal value ramps. Times can be modified in all menus which use a ramp with a simultaneous effect in all ramps.

5.1.1 How to configure the engine speed signals

5.1.1.1 Name of configuration (Text Field)

You can load one of twenty-five possible engine speed wheel configurations from the EEPROM. If it is necessary to change a value, you can adjust the following parameters. Each modification will overwrite the previous value in the EEPROM!

One line of text is foreseen to recognise your selection:

```
Sel.Config.:25
 Config.-Name
```

Shift + Number = Overload temporarily current configuration with a default configuration (see examples for Truck configurations)
Shift + Dot = Enable/Disable modifications at all in this selected configuration (marked with a star)
Shift + 0 = Enter/Leave text edit mode

List of possible characters:
abcdefghijklmnopqrstuvwxyzäöüABCDEFGHIJKLMNOPQRTSUVWXYZ
+/-÷=()[]<>&$%@*!?.,;:'^_1234567890(((("

A = Next character from list
B = Shift cursor to previous position
C = Shift cursor to next position
D = Previous character from list
Number = Select character from telephone input mode
- **1** = ' ', '1'
- **2** = 'a', 'b', 'c', '2'
- **3** = 'd', 'e', 'f', '3'
- **4** = 'g', 'h', 'i', '4'
- **5** = 'j', 'k', 'l', '5'
- **6** = 'm', 'n', 'o', '6'
- **7** = 'p', 'q', 'r', 's', '7'
- **8** = 't', 'u', 'v', '8'
- **9** = 'w', 'x', 'y', 'z', '9'
- **0** = '.', ',', ':', '_', '"', '0'

Dot = Switch to capital letters

5.1.1.2 Number of Cylinders - TDC/Sync. Signal

The first parameter is the number of cylinders. With this information the LSG 2000 generates the TDC/sync.-pulse on each TDC exactly at 0°. The Cam signal must be configured **separately**.

```
Select Number of
Cylinders:  6
```

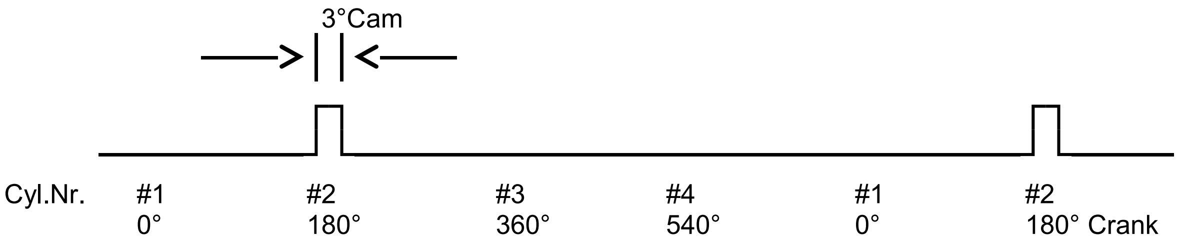
The pulse width (in °Cam) for this signal is configured in the next display. The phase is not configurable.

```
Width of TDC
Pulse:   03 °CAM
```

The TDC-pulse is necessary for trigger purposes. If it is necessary to shift this pulse to another cylinder, you can configure this in the next screen. The new value is stored in the EEPROM for each configuration. The phase cannot be configured and will always be 0°.

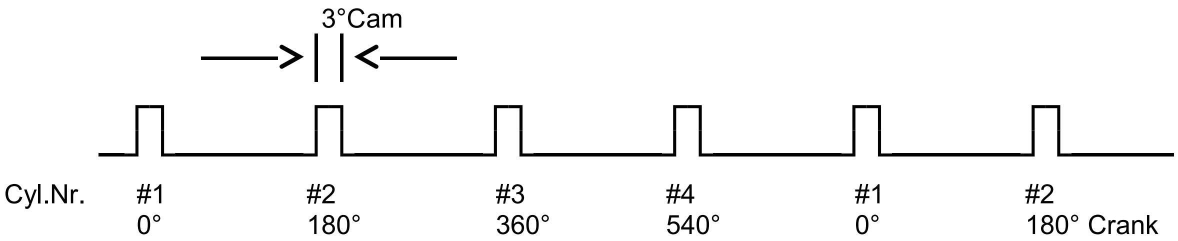
```
Select Cyl. for
TDC Pulse:  2
```

Example for the TDC-signal: number of cylinders = 4, pulse width = 3°Cam, cyl. for TDC pulse = 2



If you select a zero here, the pulse will be generated on each cylinder.

Example for the TDC-signal: number of cylinders = 4, pulse width = 3°Cam, cyl. for TDC pulse = 0



5.1.1.3 Crank Signal

For the crank signal it is necessary to set the number of equidistantly pulses on the crank wheel:

```
Number of Crank
Pulses:    060
```

The pulse width (in °Crank) for this signal is configured in the following display:

```
Width of Crank
Pulse: 2,0 °CRK
```

The phase angle of the electrical pulse to the TDC of the first cylinder must be configured here. This is the falling edge of the physical signal of the inductive sensor.

```
Offset Crank to
TDC:  006,0 °CRK
```

Missing crank pulses are configured with a negative value. Additional pulses have positive values. On the crank wheel we see normally missing pulses (gap). A ‘gap’ must be configured with a negative value. In this SW it is possible to work with several gaps on the wheel.

```
Number of Gap
Pulses:   -2
```

If you work with several gaps (each gap has the same number of missing pulses) on your crank wheel, you must set this value to the according number.

```
Number of Gap
Segments:  1
```

The phase angle of the gap to the TDC of the first cylinder must be configured here. This is the falling edge of the imaginable first pulse of the physical signal in the gap.

```
Phase Gap to
TDC: 168,0 °CRK
```

During some tests it may be useful to invert the output signal. A 'zero' means: no inversion; a 'one' stands for an inverted output. This is necessary to select between holes and teeth on the wheel, or a hall effect sensor.

```
Inversion of
Crank Signal:  0
```

Example for the Crank-signal (Bosch standard configuration):

- number of crank segments = 60
- pulse width = 2°Crank
- offset to TDC = 0°Crank
- number of gap pulses = -2
- number of gap segments = 1
- phase to TDC = 168°Crank
- inversion = 0

5.1.1.4 Equidistant Cam Signal

For the cam signal it is necessary to set the number of equidistant segments on the cam wheel.
This number is normally equal to the number of cylinders, but not automatically adjusted when you change the cylinders.
If you have only one cam pulse (= sync. pulse), you must set the number of the sync. pulses to zero and this value to one.

```
Number of normal
CAM Pulses:  06
```

Hint: A value of zero switches to the “Special” Cam Signal menu with individual Cam pulse definition.

The pulse width (in °Cam) for this signal is configured in the following display. With a zero value you can select a fast start configuration.

```
Width of CAM
Pulse: 002,0°CAM
```

The phase angle of the electrical pulse to the TDC of the first cylinder must be configured here. This is the falling edge of the physical signal of the inductive sensor.

```
Offset CAM to
TDC:  018,0 °CAM
```

Missing cam pulses are configured with a negative value. Additional pulses have positive values. On the cam wheel we see normally an additional synchronisation pulse. If you have only one cam pulse (sync. pulse), you must set the number of the cam pulses to one and this value to zero.

```
Number of Sync.
Pulses:   1
```

The phase angle of the sync pulse to the TDC of the first cylinder must be configured here. This is the falling edge of the physical signal of the inductive sensor.

```
Phase Sync. to
TDC:  333,0° CAM
```

It may be useful to invert the output signal. A ‘zero’ means: no inversion; a ‘one’ stands for an inverted output. This is necessary to select between holes and teeth on the wheel, or a hall effect sensor.

```
Inversion of
CAM Signal:  0
```

Example for the Cam-signal (Bosch standard truck configuration 6 cylinder):

- number of cam segments = 6
- pulse width = 2 °Cam
- offset to TDC = 18 °Cam
- number of sync segments = 1
- phase to TDC = 333 °Cam
- inversion = 0

5.1.1.5 Special Cam Signal

There is one configuration in this device for individual Cam pulse definition. This definition can be selected by multiple of the 25 speed signal configurations.
To switch between both menus, you put a “0” in the field “number of pulses”.

```
Number of extra
CAM Pulses:  10
```

Hint: A value of “0” switches to the “Equidistant” Cam Signal menu.

The pulse width (in °Cam) for this signal is configured in the following display.

```
Width of CAM
Pulse: 002,0°CAM
```

The phase angle of the electrical pulse to the TDC of the first cylinder must be configured for all special Cam pulses individually here. This is the falling edge of the physical signal of the inductive sensor.

```
Phase CAM no. 01
TDC:  018,0 °CRK
```

It may be useful to invert the output signal. A ‘zero’ means: no inversion; a ‘one’ stands for an inverted output. This is necessary to select between holes and teeth on the wheel, or a hall effect sensor.

```
Inversion of
CAM Signal:  0
```

5.1.2 Examples for engine speed wheel configuration

5.1.2.1 SW configuration values

After production, the LSG 2000 contains no speed wheel configuration. Here are some values for your orientation:

1. Truck Standard 4 Cylinder; Crank: 60 teeth, 90° TDC1; Cam: -57° TDC, Sync: -42° TDC1
2. Truck Standard 5 Cylinder; Crank: 60 teeth, 162° TDC1; Cam: -39° TDC, Sync: -24° TDC1
3. Truck Standard 6 Cylinder; Crank: 60 teeth, 180° TDC1; Cam: -42° TDC, Sync: -27° TDC1
4. Truck Standard 8 Cylinder; Crank: 60 teeth, 216° TDC1; Cam: -36° TDC, Sync: -24° TDC1

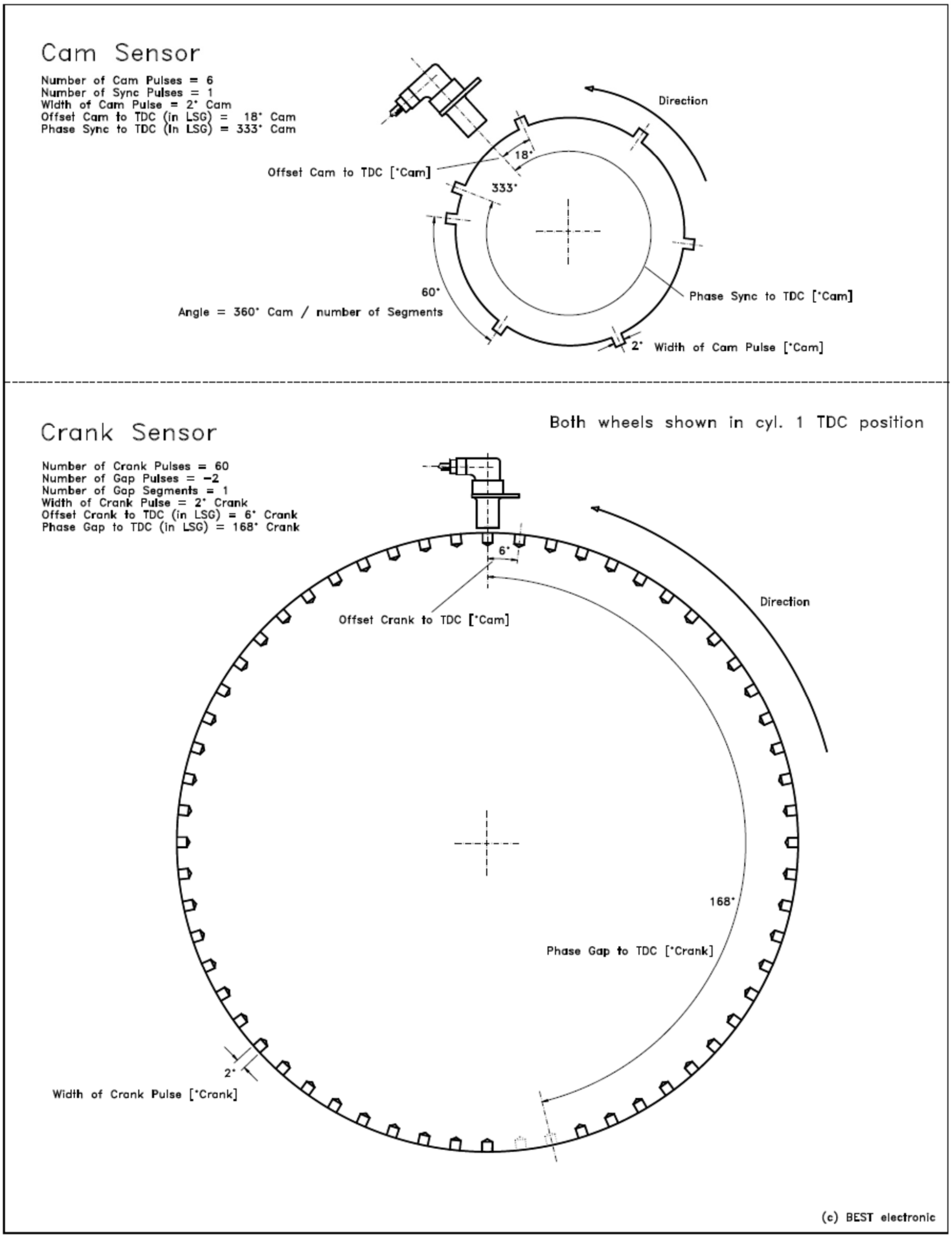
Please note: you configure always the electrical signal in angle after TDC here. This is the falling edge of the physical signal of the inductive sensor.

Here are the standard configuration values for the electrical pulses:

Configuration		Number of Cylinders	Width of TDC pulse [°CAM]	No. of Crank Pulses	Width of Crank Pulse [°CRK]	Offset Crank to TDC1 [°CRK]	No. of Gap Pulses	No. of Gap Segments	Phase Gap to TDC1 [°CRK]	Inversion of Crank Signal	No. of Cam Pulses	Width of Cam Pulse [°CAM]	Offset Cam to TDC1 [°AM]	No. of Sync. Pulses	Phase of Sync to TDC1 [°CAM]	Inversion of Cam Signal	
1	Standard	4	3	60	2,0	6,0	-2	1	78,0	0	4	2,0	33,0	1	318,0	0	
2	Standard	5	3	60	2,0	6,0	-2	1	150,0	0	5	2,0	33,0	1	336,0	0	
3	Standard	6	3	60	2,0	6,0	-2	1	168,0	0	6	2,0	18,0	1	333,0	0	
4	Standard	8	3	60	2,0	6,0	-2	1	204,0	0	8	2,0	9,0	1	336,0	0	

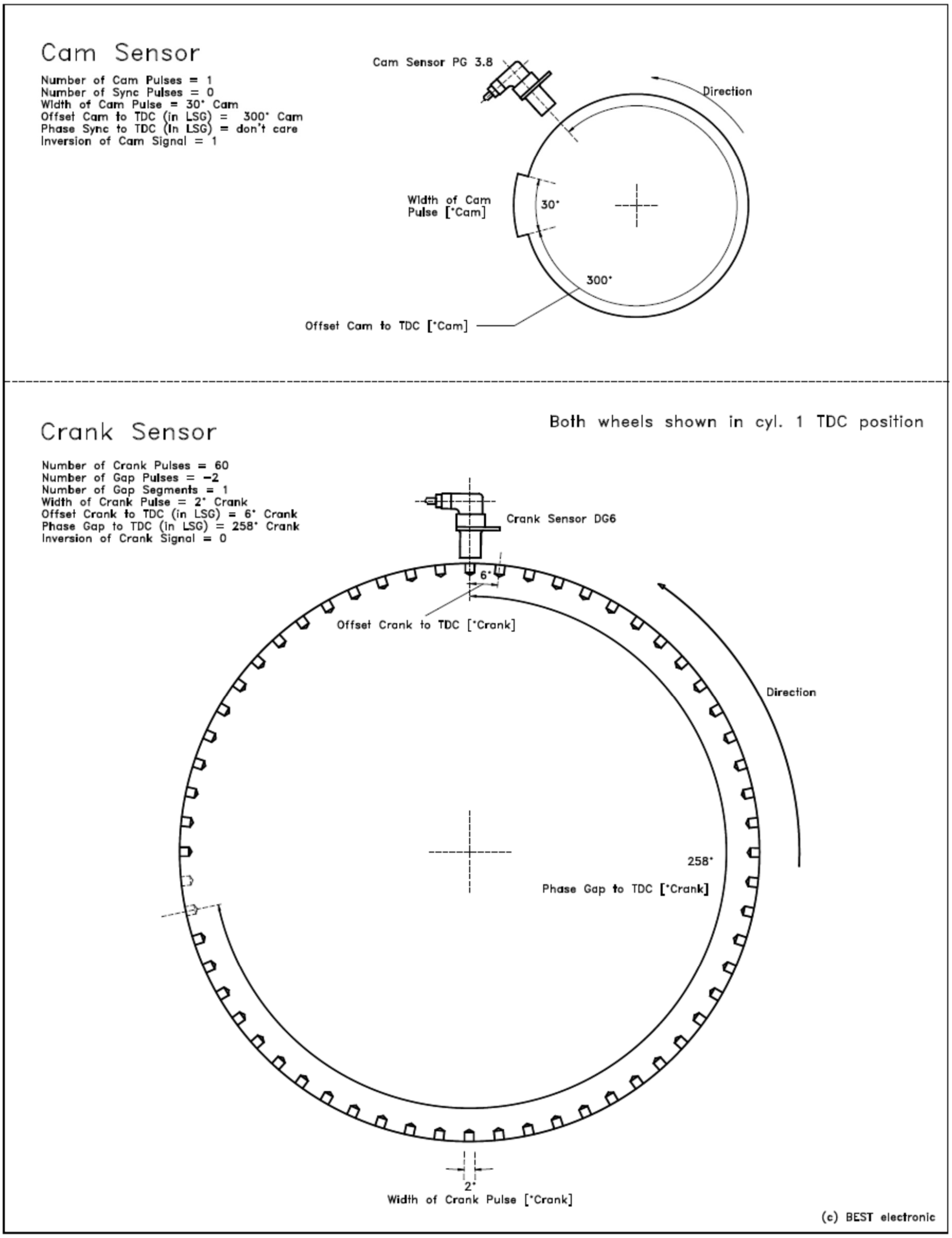
5.1.2.2 Inductive Sensors (Truck)

LSG 2000 Tone Wheel Configuration Example
Crank: 60 - 2 pulses, Cam: 6 + 1 pulses



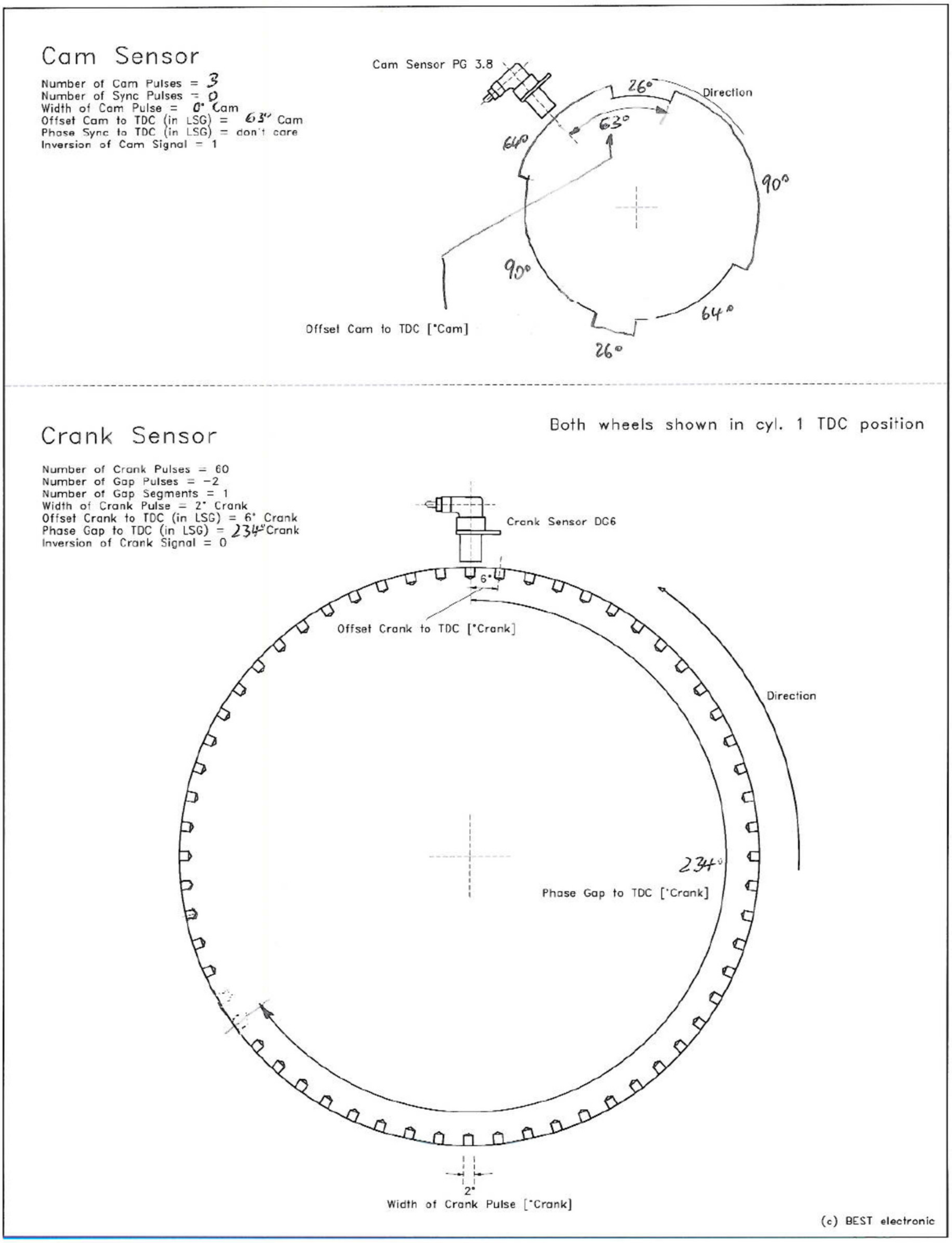
5.1.2.3 Inductive and Hall Sensor (Passenger Cars)

LSG 2000 Tone Wheel Configuration Example
Crank: 60 - 2 pulses, Cam: 1 pulse (hall sensor)



5.1.2.4 Inductive and Fast Start Hall Sensor

LSG 2000 Tone Wheel Configuration Example
Crank: 60 - 2 pulses, Cam: Fast Start (hall sensor)



5.1.3 Engine speed setpoint possibilities

The engine speed setpoint can be controlled through three ways:
- Potentiometers connected to the LSG (rough and fine trimming)
- Inductive speed sensor connected to the LSG
- Special CAN message (see also chapter CAN)

5.1.3.1 Maximum Potentiometer Speed

The maximum analog engine speed setpoint (given by external potentiometer) can be adjusted. It is recommended to set this value not too high, if you need good resolution through the 10bit A/D converter:
Attention: This value will be used in each configuration!
A value set to zero switches the input to the inductive sensors (see next chapter) and disables all other speed setpoints.

```
Select max. Poti
Speed: 6000,0rpm
```

5.1.3.2 Inductive Engine Speed Input (Speed Transformation)

If you set the max. potentiometer speed to zero, the engine speed will be controlled by the frequency input signal #1. This is used on pump test benches which cannot provide the related engine speed signal directly.
In this SW, the input signal will be expected as 60 pulses per revolution (gaps will be ignored).
There is no phase correlation between input and output signal!

The ratio between the input speed and the output speed (Nout = Nin * Factor) can be configured in the range of 0,0001 and 3,0000
Attention: This value will be used in each configuration!

```
Select Nin->Nout
 Factor: 0,6667
```

The LSG will monitor the evaluated input speed (In) versus the calculated output speed (Out):

```
  Config.-Name
In1800 Out1200rm
```

A PT1 filter is used to suppress the oscillations on electrical pump test benches in the speed signal.
Attention: This value will be used in each configuration!

```
 PT1-Filter Time
     01,000s
```

5.1.3.3 CAN setpoint

If the CAN engine speed setpoint message is active, the LSG will show it with a “CSpeed” indication on the screen. During this mode you cannot change the setpoint. To deactivate temporarily the CAN-input, you can press “C”, or change the message ID in the CAN-menu.

Attention: The CAN-message will be evaluated all 10ms. If messages are missing, the last engine speed setpoint will be kept. When a potentiometer is connected, this value will be used.

```
  Config.-Name
CSpeed:1234,5rpm
```

5.2 Vehicle Speed Simulator

The vehicle speed simulator can work separately by using an analog input or the keyboard for setting a vehicle speed between 8 and 250 km/h.
The generated signal must be configured in this mode before using the feature (see next page). The last configuration is loaded automatically after switching on the LSG 2000.

```
Vehicle Speed:
   123,4 km/h
```

Shift + A = Enabling Keyboard / Analog Input
The vehicle speed is adjusted with the keyboard.
If the potentiometer was active, the current vehicle speed is taken from this mode.
Moving a potentiometer more than 2mV switches automatically to potentiometer mode.
The vehicle speed is then calculated from a 10bit analog input (0..5V).
A = Switch to keyboard mode and accelerate (higher vehicle speed)
D = Switch to keyboard mode and decelerate (lower vehicle speed)
Number = Switch to keyboard mode and edit vehicle speed
In keyboard edit mode:
A = Accept (set this vehicle speed)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to zero)
Number = Enter next number of the vehicle speed

Shift + B = Start / Stop Ramp
The ramp points must be defined in the mode 'Shift + D'.
After starting the LSG 2000, the SW uses always the last configuration stored in EEPROM.
With the external switch input #1 it is possible to start/stop the ramp also when other menus are active. But no button should be pressed on the keyboard in this case.

Shift + C = Enter Configuration Mode
These values must be configured before using this output:
- Number of pulses / km
- Width of pulse in time
- Maximum vehicle speed (10,0 – 250,0 km/h)
- Analog input voltage level for 0 km/h
- Analog input voltage level for maximum vehicle speed

A = Increment value
B = Go to previous configuration value
C = Go to next configuration value
D = Decrement value
Number = edit value (entering edit mode)
In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to default)
Number = Enter next number of the value

Shift + D = Ramp Mode

To define multi-level ramp it is possible to configure up to 99 different points.
A point has an according vehicle speed and a time distance to the next point in the list.
The vehicle speed has the same range as defined in the configuration, and the time is 0 – 99.99sec in steps of 10ms.
If the time between the last point and point 1 is not zero, the ramp starts again automatically, otherwise the ramp stops at the last point and can be restarted with 'Shift + B'.

A = Increment value
B = Go to previous point
C = Go to next point
D = Decrement value
Shift+Dot = Switch between editing the vehicle speed and the time.
Number = enter edit mode and select vehicle speed + time

In edit mode:

A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
Number = Enter next number of the value

All ramp values are stored automatically in EEPROM. The ramp itself does not start automatically after next switch-on and must be started by "Shift B" in the vehicle speed menu or the digital input (this input works also in all other menus).

The ramp definition shares the time axis points together with the engine speed and pedal value ramps. Times can be modified in all menus which use a ramp with a simultaneous effect in all ramps.

5.2.1 How to configure the vehicle speed signal

The number of pulses is configured in the tachograph.

```
  Number of
Pulses/km: 08000
```

The tachograph passes a signal frequency from the sensor to the connected ECUs. The real vehicle speed is normalised by the pulse width, created by the tachograph.

```
  Pulsewidth:
   2000 us
```

The tachograph uses this formula: pulse width [ms] = 16000 / (pulses/km).
The ECU calculates the vehicle speed in this way: v [km/h] = 0,225 * f[Hz] * pulse width [ms]

Change the maximum usable vehicle speed here if you want.

```
Maximum Speed:
  250,0 km/h
```

This is the voltage which gives your 0 km/h. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
  Lowest Poti
Voltage: 0100 mV
```

This is the voltage which gives you're the maximal configured vehicle speed. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
  Largest Poti
Voltage: 4300 mV
```

5.3 Auxiliary Speed Output

The auxiliary speed simulator can work separately by using an analog input or the keyboard for setting a speed between 0 and 300.000rpm (foreseen to simulate a turbo charger speed signal). The resolution is only 10rpm because of the wide usable range. The signal will be created always with a duty cycle of 50%. The generated signal must be configured in this mode before using the feature. The last configuration is loaded automatically after switching on the LSG 2000.

```
Aux.Speed Output
   123450 rpm
```

Shift + A = Enabling Keyboard / Analog Input
The speed is adjusted with the keyboard.
If the potentiometer was active, the current speed is taken from this mode.
Moving a potentiometer more than 2mV switches automatically to potentiometer mode.
The speed is then calculated from a 10bit analog input (0..5V).
A = Switch to keyboard mode and accelerate (higher speed)
D = Switch to keyboard mode and decelerate (lower speed)
Number = Switch to keyboard mode and edit speed
In keyboard edit mode:
A = Accept (set this speed)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to zero)
Number = Enter next number of the speed

Shift + B = Start / Stop Ramp
The ramp points must be defined in the mode 'Shift + D'.
After starting the LSG 2000, the SW uses always the last configuration stored in EEPROM.
With the external switch input #1 it is possible to start/stop the ramp also when other menus are active. But no button should be pressed on the keyboard in this case.

Shift + C = Enter Configuration Mode
These values must be configured before using this output:
- Number of pulses per revolution (1-120)
- Pulse width in percentage (not usable, is always 50%)
- Analog input voltage level for 0 rpm
- Analog input voltage level for 300.000 rpm

A = Increment value
B = Go to previous configuration value
C = Go to next configuration value
D = Decrement value
Number = edit value (entering edit mode)
In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to default)
Number = Enter next number of the value

Shift + D = Configuration of Ramp Mode

To define multi-level ramp it is possible to configure up to 99 different points.
A point has an according speed value and a time distance to the next point in the list.
The speed has a range of 0..300.000% and the time is 0 – 99.99sec in steps of 10ms.
If the time between the last point and point 1 is not zero, the ramp starts again automatically, otherwise the ramp stops at the last point and can be restarted with 'Shift + B'.

A = Increment value
B = Go to previous point
C = Go to next point
D = Decrement value
Shift+Dot = Switch between editing the speed value and the time.
Number = enter edit mode and select speed value + time

In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
Number = Enter next number of the value

All ramp values are stored automatically in EEPROM. The ramp itself does not start automatically after next switch-on and must be started by "Shift B" in the pedal value menu or via the digital input (this input works also in all other menus).

The ramp definition shares the time axis points together with the engine speed and vehicle speed ramps. Times can be modified in all menus which use a ramp with a simultaneous effect in all ramps.

5.3.1 How to configure the auxiliary speed output signal

The number of pulses per rotation can be configured between 1 – 120.

```
Number of Pulses
per Rotation:001
```

The pulse width can not be changed. It is fixed to 50% always.

```
   Pulsewidth:
       50%
```

This is the voltage which gives your 0 rpm. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
  Lowest Poti
Voltage: 0100 mV
```

This is the voltage which gives your 300.000rpm. You can control the voltage at the analog input from the pedal sensor by pressing **Shift + Dot**.

```
  Largest Poti
Voltage: 4300 mV
```

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USt-ID Nr. DE194525476

5.4 Pedal Sensor with Low Idle Switch (LIS) and Kick Down Switch (KID)

The input voltage of an analog accelerator pedal sensor gives the low idle switch and kick down switch status at the output.
The generated signal must be configured in this mode before using the feature. The last configuration is loaded automatically after switching on the LSG 2000.

Pedal Value: Percentage of the pedal value is calculated between the lowest and highest voltage level configured for the analog input.

LIS: The voltage is evaluated and the switch status is calculated via hysteretic thresholds. The switch is active, if the voltage is below the lower threshold. The switch is inactive above the upper threshold. It is possible to invert the output level.

KID: The voltage is evaluated via a single threshold. The switch is active, if the voltage is higher than the threshold. Inversion of the output level can be configured.

When the pedal value is given by the keyboard or ramp mode, the LIS and KID are calculated via the min/max voltage level (0%...100%) of the potentiometer configured.

A frequency output signal is created on pin 12 (Sub-D 15) for the use with an external digital / analog converter. This output has duty cycle or frequency modulation over pedal value.
The pedal value is also transmitted in a CAN message (see description chapter 6).

```
  Pedal Value:
000,0% LI:1 KD:0
```

Shift + A = Enabling Keyboard / Analog Input
The pedal value is adjusted with the keyboard.
If the potentiometer was active, the current pedal value is taken from this mode.
Moving a potentiometer more than 2mV switches automatically to potentiometer mode.
The pedal value is then calculated from a 10bit analog input (0..5V).
- **A** = Switch to keyboard mode and accelerate (higher value)
- **D** = Switch to keyboard mode and decelerate (lower value)
- **Number** = Switch to keyboard mode and edit pedal value
  - In keyboard edit mode:
    - **A** = Accept (set this value)
    - **B** = Backspace
    - **C** = Cancel (leave edit mode and use last valid value)
    - **D** = Default (set value to zero)
    - **Number** = Enter next number of the value

Shift + B = Start / Stop Ramp
The ramp points must be defined in the mode 'Shift + D'.
After starting the LSG 2000, the SW uses always the last configuration stored in EEPROM.
With the external switch input #1 it is possible to start/stop the ramp also when other menus are active. But no button should be pressed on the keyboard in this case.

Shift + C = Enter Configuration Mode
These values must be configured before using the LIS and KID outputs:
- Lower voltage for detection of LIS “active”
- Upper voltage for detection of LIS “inactive”
- Output level configuration for LIS pin
- Threshold for detection of KID “active”
- Output level configuration for KID pin
- Voltage level for 0% pedal value
- Voltage level for 100% pedal value

A = Increment value
B = Go to previous configuration value
C = Go to next configuration value
D = Decrement value
Number = edit value (entering edit mode)
In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to default)
Number = Enter next number of the value

Shift + D = Configuration of Ramp Mode
To define multi-level ramp it is possible to configure up to 99 different points.
A point has an according pedal value and a time distance to the next point in the list.
The pedal value has a range of 0..100% and the time is 0 – 99.99sec in steps of 10ms.
If the time between the last point and point 1 is not zero, the ramp starts again automatically, otherwise the ramp stops at the last point and can be restarted with ‘Shift + B’.
A = Increment value
B = Go to previous point
C = Go to next point
D = Decrement value
Shift+Dot = Switch between editing the pedal value and the time.
Number = enter edit mode and select pedal value + time
In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
Number = Enter next number of the value

All ramp values are stored automatically in EEPROM. The ramp itself does not start automatically after next switch-on and must be started by “Shift B” in the pedal value menu or via the digital input (this input works also in all other menus).

The ramp definition shares the time axis points together with the engine speed and vehicle speed ramps. Times can be modified in all menus which use a ramp with a simultaneous effect in all ramps.

5.4.1 How to configure the pedal sensor input and output signals

The low idle switch status will be "active" = 1 if the pedal sensor voltage is below this level. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
Low Idle Sw. Min
Voltage: 0700 mV
```

The low idle switch status will be "inactive" = 0 if the pedal sensor voltage is above this level. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
Low Idle Sw. Max
Voltage: 0750 mV
```

If the inversion flag is not set (=0), the output will be switched to low level in case of active LIS.

```
Inversion Flag:0
Low Idle Switch
```

The kick down switch status will be "active" = 1 if the pedal sensor voltage is above this level. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
Kick Down Switch
Voltage: 4200 mV
```

If the inversion flag is not set (=0), the output will be switched to low level in case of active KID.

```
Inversion Flag:0
Kick Down Switch
```

This is the potentiometer input voltage which gives your 0% pedal value. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
Lowest Poti Inp.
Voltage: 0100 mV
```

This is the potentiometer input voltage which gives your 100% pedal value. You can control the voltage at the analog input from the pedal sensor by pressing **'Shift' + 'Dot'**.

```
Largest Poti Inp
Voltage: 4300 mV
```

This frequency is constant in variable duty cycle output mode. It should be normalized to the ECU maximum pedal voltage input in variable frequency output mode (in combination with a D/A converter).

Hint for frequency mode: Use 5kHz or 10kHz to generate 5V with the D/A converter. This gives best transparency.
The pedal will operate between 0..100%, and the frequency will be limited between the "Poti Output" voltages/frequencies.

```
 PWG D/A Output
 Freq.: 02000Hz
```

This is the output voltage which gives your 0% pedal value in your ECU when using the frequency output in combination with an external D/A converter.

```
Lowest Poti Outp
Voltage: 0100 mV
```

This is the output voltage which gives your 100% pedal value in your ECU when using the frequency output in combination with an external D/A converter.

```
Largest Poti Out
Voltage: 4300 mV
```

The output level for the converter can be inverted by this flag. This affects only the variable duty cycle mode, not the frequency output mode.

```
Inversion Flag:0
Pedal Output
```

This flag set to zero means: fixed frequency and variable duty cycle. Otherwise, the duty cycle is fixed to 50% and the frequency will be varied.

```
Frequency Output
Mode (DC or F):0
```

5.5 Debug Mode

The debug mode is designed for SW programmers and their tests. But it can also help for online diagnostics and telephone trouble shooting.

Shift + A = Shows 5 bytes hexadecimal from the given address.
- **A** = Increment address
- **D** = Decrement address
- **Number** = edit value (entering edit mode)
  - In edit mode:
    - **A** = Accept (set this value)
    - **B** = Backspace
    - **C** = Cancel (leave edit mode and use last valid value)
    - **D** = Default (set value to default)
    - **Number** = Enter next number of the value

Shift + B = Monitors the minimal and maximal hex. values in byte of an given address.
- **A** = Increment address
- **D** = Decrement address
- **Number** = edit value (entering edit mode)
  - In edit mode:
    - **A** = Accept (set this value)
    - **B** = Backspace
    - **C** = Cancel (leave edit mode and use last valid value)
    - **D** = Default (set value to default)
    - **Number** = Enter next number of the value

Shift + C = Monitors the minimal and maximal hex. values in word of an given address.
- **A** = Increment address
- **D** = Decrement address
- **Number** = edit value (entering edit mode)
  - In edit mode:
    - **A** = Accept (set this value)
    - **B** = Backspace
    - **C** = Cancel (leave edit mode and use last valid value)
    - **D** = Default (set value to default)
    - **Number** = Enter next number of the value

Shift + D = Monitors processor port activities
- **A** = Shows next analog input port voltage and frequency input period
- **B** = Shows next digital port pin status (CPU: P1, P2, P3 / P0 = CAN P1+P2)
  - **Number** = changes the respective port pin status (P2.5 – P2.15, P3.4 – P3.8, P3.10)
- **C** = Shows previous digital port pin status
  - **Number** = changes the respective port pin status (P2.5 – P2.15, P3.4 – P3.8, P3.10)
- **D** = Shows previous analog input voltage and frequency input period

The voltage input is slightly debounced to suppress the toggling last two bits.

5.6 High Frequency Outputs

Two high frequency outputs with 50% duty cycle can be used alternatively on digital outputs #1 and #2. The maximum frequency is 20kHz, with a resolution of 0,5µs/bit for the period. Both frequencies can be adjusted and are stored in the EEPROM.

After entering this mode, the following options are possible:

Shift + A = Shows the initial display

```
 LSG Mode: HF
Digital Signals
```

Shift + C = Enters Configuration Mode
These values must be configured before using the outputs:
- Frequency channel #1 between 30 and 20.000Hz
- Frequency channel #2 between 30 and 20.000Hz

```
Frequency on 1st
Channel: 00000Hz
```

```
Frequency on 2nd
Channel: 00000Hz
```

A = Increment value
B = Go to previous configuration value
C = Go to next configuration value
D = Decrement value
Number = edit value (entering edit mode)
In edit mode:
A = Accept (set this value)
B = Backspace
C = Cancel (leave edit mode and use last valid value)
D = Default (set value to default)
Number = Enter next number of the value

You can find here in the configuration menu a special function reserved for our customer Bosch. It is password protected.

```
 Bosch Function
 Password: 0000
```

6 CAN

6.1 Introduction

There are some features included in the basic SW. Full flexible SW is possible by customer specific programming. The CAN chip used in LSG2000 is an Intel AN82527. It is configured to 29bit–IDs and 250kBaud.

Shift + A = Shows the initial display

```
 CAN Status: 43h
EEC1 not avail.
```

The hexadecimal status byte of the CAN chip is shown in the first line. Please refer to the data sheet of the AN8527 for details.

- Status 43h: no CAN connected
- Status 00h: CAN connected, but not active
- Status 18h: CAN connected and active

In the second line, the engine speed information of the J1939 message “EEC1” (ID 0C F0 04 00) will be displayed, if available from another ECU.

6.2 Input Messages

6.2.1 EEC1 Message

The engine speed information of the J1939 message “EEC1” (ID 0C F0 04 00) will be displayed, if available from another ECU.

Shift + A = Shows the EEC1 display

```
 CAN Status: 43h
EEC1 in: 1234rpm
```

With the button “A” this message can be also created (see Output Messages). The button “D” returns to input configuration.

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6.2.2 Free configurable receive message

One flexible message can be configured for reading. The identifier is stored in EEPROM.
The 8 message bytes are presented in hex values on the display.

Shift + B = Shows the content of a message of your choice

```
 ID: 12 34 56 78
Inactive Message
```

The first line shows the user defined ID, and the second line shows all 8 bytes when the message is available on the bus. The first byte in the message is on the right side of the screen. This helps to read values in little Endean format directly.
If this message is not found on the CAN bus, the display shows “Inactive Message”.

Shift + C = Enables the edit mode for the message ID
- **Number** = edit value
- **A** = Accept (set this value)
- **B** = Backspace, necessary to clear existing values
- **C** = Cancel (switch to next byte and use last valid value)

The message ID is stored in the EEPROM and loaded automatically during the next power-on.

6.2.3 Engine Speed Setpoint

The engine speed setpoint can be controlled by an external electronic device. The message ID must be configured here. The engine speed is coded in little Endean format as ½ rpm per bit on byte 1&2.

Shift +D = Enter configuration for engine speed setpoint message
- **Number** = edit value
- **A** = Accept (set this value)
- **B** = Backspace, necessary to clear existing values
- **C** = Cancel (switch to next byte and use last valid value)

```
 Rd-ID: 12345678
CSpeed:NoMessage
```

```
 Rd-ID: 12345678
CSpeed:1234,5rpm
```

6.3 Output Messages

6.3.1 EEC1 Message

A J1939 message “EEC1” (**ID 0C F0 04 00**) can be created with the engine speed only.

Shift + A = Shows the EEC1 display

```
 CAN Status: 43h
EEC1out: 1234rpm
```

With the button “A” this message will be created. The button “D” returns to input configuration.

6.4 Message Buffer Organization

Buffer	Menu	Name	ID	Raster	Send / Receive
#01	1,2,3,4,7,8,9 / 8	EEC1	0x 0C F0 04 00	10 / 50 ms	SEND / RECEIVE
#01	5	EDC 1	0x 18 FF 30 00	10 ms	RECEIVE
#01	6	Adaptronic 9	0x 18 FF F8 00	10 ms	SEND
#02	1,2,3,4,7,8,9	VSC	0x 18 FE F1 00	10 ms	SEND
#02	5	EDC 8	0x 18 FF 37 00	10 ms	RECEIVE
#02	6	RaceLogic 1	0x 18 FB 01 00	1 ms	RECEIVE
#03	1,2,3,4,7,8,9	DEC	0x 0C FF 01 17	10 ms	SEND
#03	6	RaceLogic 2	0x 18 FB 02 00	1 ms	RECEIVE
#04	8	Free	Configurable	10 ms	RECEIVE
#05	1,2,3,4,5,7,8,9	GPS to EDC	0x 18 FF 40 00	10 ms	SEND
#05	6	LSG 1	0x 18 FF 80 00	10 ms	SEND
#06	1,2,3,4,7,8,9	Nspeed	Configurable	10 ms	RECEIVE
#06	5	EDC 9	0x 18 FF 38 00	10 ms	RECEIVE
#06	6	LSG 2	0x 18 FF 81 00	10 ms	SEND
#07	5	LSG 1	0x 18 FF 80 00	10 ms	SEND
#07	6	Adaptronic 1	0x 18 FF F0 00	10 ms	SEND
#08	5	LSG 2	0x 18 FF 81 00	10 ms	SEND
#08	6	Adaptronic 2	0x 18 FF F1 00	10 ms	SEND
#09	5	LSG 3	0x 18 FF 82 00	10 ms	SEND
#09	6	Adaptronic 3	0x 18 FF F2 00	10 ms	SEND
#10	6	Adaptronic 4	0x 18 FF F3 00	10 ms	SEND
#11	6	Adaptronic 5	0x 18 FF F4 00	10 ms	SEND
#12	6	Adaptronic 6	0x 18 FF F5 00	10 ms	SEND
#13	6	Adaptronic 7	0x 18 FF F6 00	10 ms	SEND
#14	6	Adaptronic 8	0x 18 FF F7 00	10 ms	SEND
#15					Receive only