LSG 1000

For Development of Automotive Fuel Injection Systems

Engine Speed Simulator

Hardware (V 1.1)

Software (V 1.2.5)

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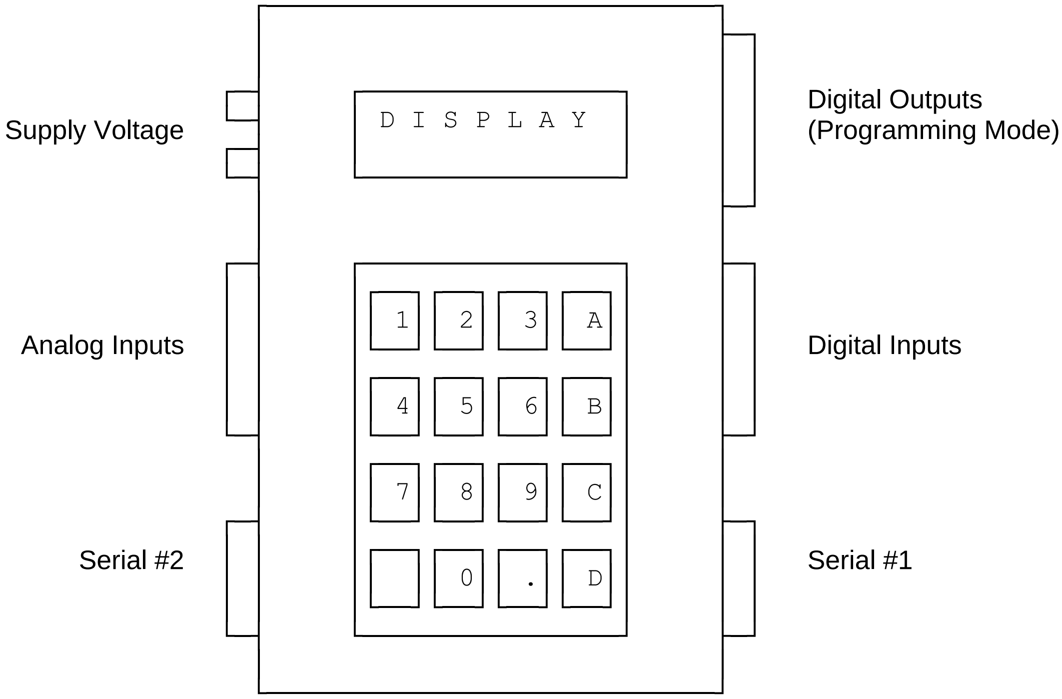
1 General

The LSG1000 is a Laboratory Control Unit for flexible application.

2 Hardware

2.1 Top View



2.2 Description

Supply Voltage:	7V ... 36V Protected against reverse polarity
Supply Current:	max. 500mA (without external loads)
Ambient Temperature:	+10°C ... +40°C
Kernel:	16 bit Micro Controller with 16MHz Clock

Memory:	The LSG 1000 is equipped with - an external Flash size of 208 Kbytes for code - an internal RAM size of 1,5 Kbytes for operation system - an external RAM size of 14,5 Kbytes for program - an external Flash size of 32 Kbytes for dataset - a serial EEPROM of 2 Kbytes for storing the configurations
Address mapping:	`0x00000 – 0x0BFFF` ext. Flash `0x0C000 – 0x0F9FF` ext. RAM `0x0FA00 – 0x0FFFF` int. RAM / Special function registers `0x10000 – 0x3BFFF` ext. Flash `0x3C000 – 0x3FFFF` ext. Flash for dataset
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 Range: 0 ... 5 V all Analog Inputs have an 10 kOhm pull-up Resistor to VCC (+5V) and an R/C-Filter with τ = 1ms
Digital Inputs:	8 digital inputs max. resistance to GND for LOW = 1 kOhm min. resistance to GND for HIGH = 10 kOhm Range: 0 ... 5 V all Digital Inputs have an 10 kOhm pull-up Resistor to VCC (+5V)
Digital Outputs:	8 Power Outputs Low-Side Switches max. 8 x 500 mA for inductive loads: Output clamping energy 10mJ @ repetition rate < 100 Hz
Differential Outputs:	4 differential Outputs for Engine Speed Signals Output impedance 10 kOhm Using a differential Output reduce the number of Power Outputs
Display:	16 Characters, 2 Lines adjustable brightness and contrast
Keyboard:	16 Buttons 0 ... 9 A ... D “Blank” (Shift) “Dot”

2.3 Terminal Description

The corresponding SW-function to each pin can be found in chapter 4.x

2.3.1 Serial Interface #1

Pin	Function	Port
1	n.c.	
2	TxD1	P3.8
3	RxD1	P3.9
4	n.c.	
5	GND	
6	n.c.	
7	n.c.	
8	n.c.	
9	n.c.	

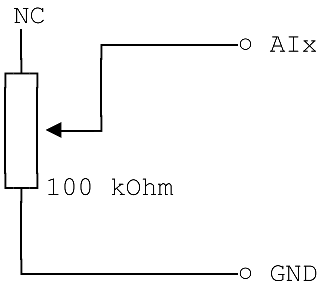
2.3.2 Serial Interface #2

Pin	Function	Port
1	n.c.	
2	RxD2	P3.11
3	TxD2	P3.10
4	n.c.	
5	GND	
6	n.c.	
7	n.c.	
8	n.c.	
9	n.c.	

2.3.3 Analog Input

Pin	Function	Port
1	ANA-IN2	P5.1
2	ANA-IN4	P5.3
3	ANA-IN6	P5.5
4	ANA-IN8	P5.7
5	ANA-IN10	P5.9
6	GND	
7	GND	
8	GND	
9	ANA-IN1	P5.0
10	ANA-IN3	P5.2
11	ANA-IN5	P5.4
12	ANA-IN7	P5.6
13	ANA-IN9	P5.8
14	GND	
15	GND	

Recommended external circuitry for analog engine speed setpoint



2.3.4 Digital Input

Pin	Function	Port
1	GND	
2	GND	
3	GND	
4	GND	
5	DIGI-IN2	P2.9
6	DIGI-IN3	P2.10
7	DIGI-IN5	P2.12
8	DIGI-IN7	P2.14
9	GND	
10	GND	
11	GND	
12	DIGI-IN1	P2.8
13	DIGI-IN4	P2.11
14	DIGI-IN6	P2.13
15	DIGI-IN8	P2.15

2.3.5 Digital Output

Pin	Function	Port
1	DIGI-OUT1	P2.0
2	DIGI-OUT3	P2.2
3	$+U_{Batt.}$	
4	$+U_{Batt}$	
5	$+U_{Batt}$	
6	DIGI-OUT8	P2.7
7	DIGI-OUT7	P2.6
8	N-OUT2	P2.1
9	N-OUT4	P2.3
10	N-OUT3	P2.2
11	N-OUT1	P2.0
12	GND	
13	GND	
14	DIGI-OUT2	P2.1
15	DIGI-OUT4	P2.3
16	$+U_{Batt}$	
17	$+U_{Batt}$	
18	$+U_{Batt}$	
19	$+U_{Batt}$	
20	$+U_{Batt}$	
21	DIGI-OUT5	P2.4
22	DIGI-OUT6	P2.5
23	NMI	
24	ALE	
25	RESET	

Please note: The ‘N-OUTx’ are derived from the respective ‘DIGI-OUTx’.

3 Software

3.1 Introduction

The Software starts with a welcome message:

```
*** LSG 1000 ***
   © 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 1000 ***
SW 1.2.5 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
3 = free
4 = free
5 = free
6 = free
7 = free
8 = Configuration Low Idle Switch
9 = 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 20 steps and the buttons B and C to adjust the contrast in 2 steps. Both configurations are stored to be available after power off.
In the editor mode the buttons 'Shift' (blank button) and 'Dot' together negate the number on the display.

3.4 Storing / Loading Configuration

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

4 Configuration

4.1 Analog Inputs

Analog In 1:	Setpoint Engine Speed (coarse trimming)
Analog In 2:	Setpoint Engine Speed (fine trimming)
Analog In 3:	Setpoint Vehicle Speed
Analog In 4:	free
Analog In 5:	Pedal Sensor
Analog In 6:	free
Analog In 7:	free
Analog In 8:	free
Analog In 9:	free
Analog In 10:	free

4.2 Digital Inputs

Digital In 1:	Terminal 15*
Digital In 2:	free
Digital In 3:	free
Digital In 4:	free
Digital In 5:	free
Digital In 6:	free
Digital In 7:	Ramp Start/Stop
Digital In 8:	free

4.3 Digital Outputs

Digital Out 1:	"INC1"	Increment Signal / high frequency #1
Digital Out 2:	"SEG"	Segment Signal / high frequency #2
Digital Out 3:		Vehicle Speed Signal
Digital Out 4:	"INC2"	<u>Inverted</u> INC1 Signal
Digital Out 5:	"TRIG2"	Sync. Signal (TDC each cylinder)
Digital Out 6:	"TRIG1"	TDCx Signal (TDC only one selectable cylinder)
Digital Out 7:		Vehicle Speed Signal / high frequency #2
Digital Out 8:		Low Idle Switch

4.4 Derivated Digital Outputs

N-Out 1:	"INC1"	Increment Signal / high frequency #1
N-Out 2:	"SEG"	Segment Signal / high frequency #2
N-Out 3:		Vehicle Speed Signal
N-Out 4:	"INC2"	<u>Inverted</u> INC1 Signal

5 Software Update

5.1 Hardware

- The flash can be programmed via RS232 serial interface directly with a standard PC.
- Cable from the serial interface of the PC to the serial #1 interface of the LSG1000.
- Program Connector, to switch into programming mode

5.2 Software

The programming software is freeware by BEST. Registered users can download software-updates from our Internet home page www.best-electronic.de

5.3 Programming a new Software

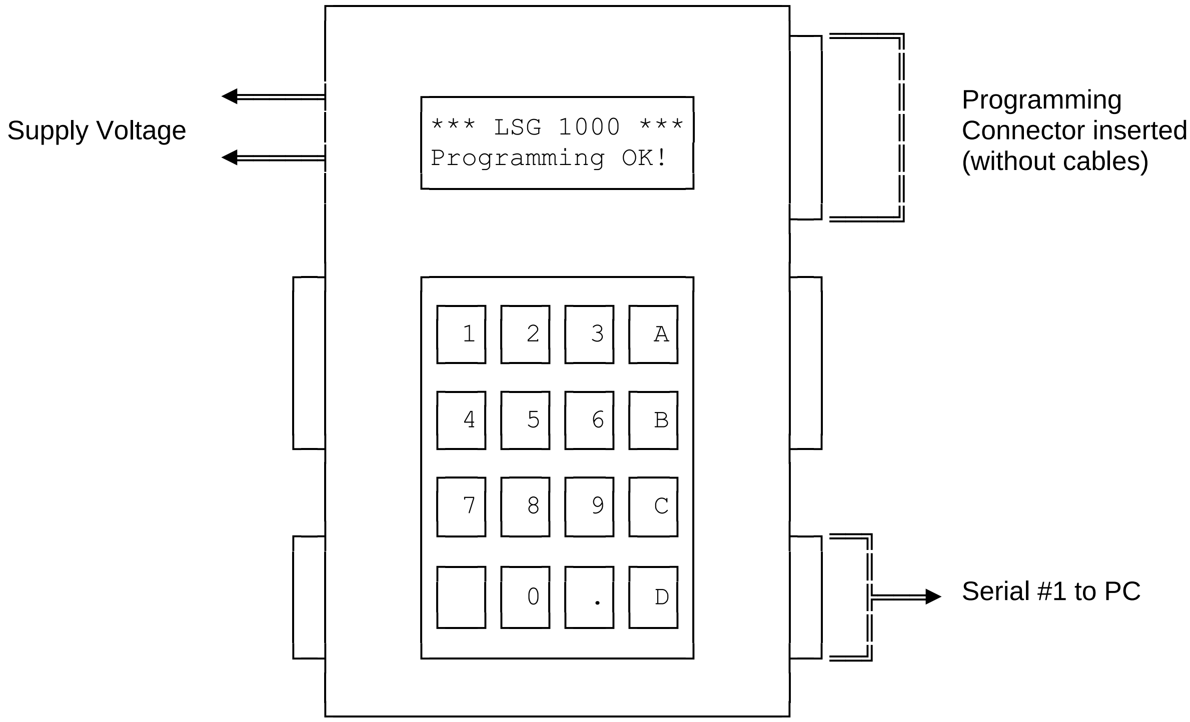
1. Switch OFF the supply voltage from the LSG.

2. Connect the serial interface #1 of the LSG1000 with the serial interface of your PC.

3. Replace the digital output connector (25 pins) with the “Program Connector”. This is the single male connector with a bridge inside the housing.

4. Start the BootStrap Loader software on your PC and switch on the supply voltage to the LSG when the program requires a “RESET” of the LSG.

5. A successful programming can be checked only on the screen of the LSG when “Programming OK!” is shown. Sometimes the program download is not successful. In this case you must restart the procedure.



6 Operation Modes

6.1 Engine Speed Simulator

The engine speed simulator generates four signals.
1. The synchronisation pulse comes for each cylinder and is located at TDC (0° crank). "TRIG2"
2. The TDC1 pulse is generated only on one configurable cylinder TDC (0°crank). "TRIG1"
3. The cam speed signal “SEG” has a reference pulse to detect the first cylinder and can be used in single sensor mode for redundant injection timing.
Use the "N-Out" speed signal instead of an inductive speed sensor and the "DIGI-Out" speed signal for a speed sensor with open collector or open drain output (e.g. Hall sensor).
4. The crank speed signal is used for injection timing and has many pulses to reduce the tolerances. "INC1" and “INC2” (optional).
Use the "N-Out" speed signal instead of an inductive speed sensor and the "DIGI-Out" speed signal for an speed sensor with open collector or open drain output (e.g. Hall sensor).
The inverted signal (INC2) is used for systems with redundant crank sensor.
5. The output signal starts every time at 90° Crank, when you start to increase the speed from zero.

The engine speed simulator can work by using an analog input or the keyboard for setting an engine speed between 0 and 9999 rpm. The generated signals must be configured.
The last configuration is started automatically after switching on the LSG.

```
Engine Speed:
 1234,5 rpm
```

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 4 bits switches automatically to potentiometer mode.
The engine speed is then calculated from two 10bit 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, the SW uses always the last configuration, stored in EEPROM.
With the external switch input #7 (tip function) 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:

- Number of cylinders
- Width of TDC/sync.-pulse (in steps of 1°Cam)
- Cylinder number where to generate the TDC1 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 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 signal

- Maximum analog engine speed setpoint (given by external potentiometer)
  This value does not depend on the speed wheel configuration

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. If you use the derived output signal, the falling edge is interesting for you. In this case you have to subtract the duty cycle of the pulse from your target angle.

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 an range of 0-9999rpm and the time 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 (the digital port works also in all other menus).

6.1.1 How to configure the engine speed signals

You can load one of ten possible configurations from the EEPROM:

```
Select Config.
Number:   3
```

If it is necessary to change a value, you can adjust the following parameters. Each modification will overwrite the previous value in the EEPROM!

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:

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

6.1.1.1 TDC signal

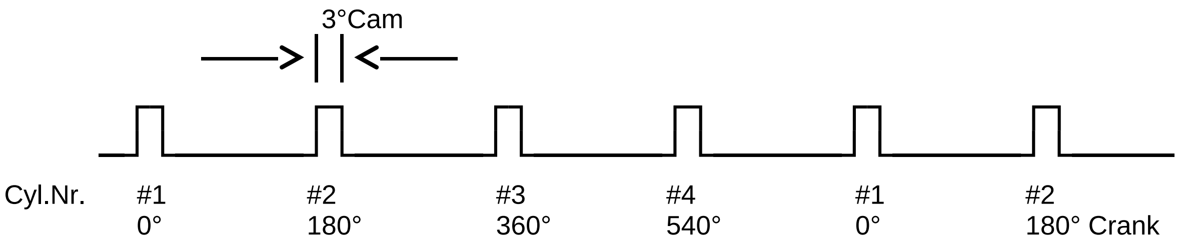
The first parameter is the number of cylinders. With this information the LSG generates the TDC/sync.-pulse on each TDC exactly at 0°. The Cam signal must be configured **separately**.

```
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:    3  °Cam
```

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



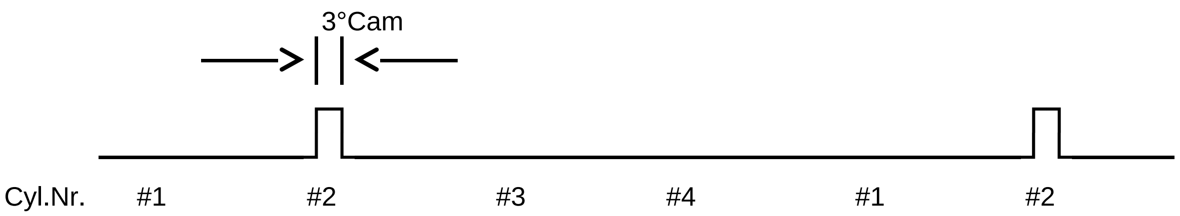
6.1.1.2 TDC1/sync. signal

The TDC1-pulse is automatically generated on the first cylinder after power-on. For some special trigger it is necessary to shift this pulse to another cylinder. You can configure this in the next screen. The new value is not stored in the EEPROM.

```
Select Cyl. for
TDC1 pulse:  2
```

The pulse width (in °Cam) for this signal is the same as the TDC/sync. pulse for each cylinder. The phase can not be configured and will be always 0°.

Example for the TDC1-signal: number of cylinders = 4, pulse width = 3°Cam, cyl. for TDC1 pulse = 2



0° 180° 360° 540° 0° 180° Crank

6.1.1.3 Crank signal

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

```
Number of Crank
Pulses:     60
```

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

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

The phase angle of the electrical pulse to the TDC of the first cylinder must be configured. If you have only the value of the derived signal (for an ECU), you must subtract the pulse width and apply this value here. The result can not be negative. In this case you must configure the next pulse.

```
Offset Crank to
TDC:  4,0 °Crank
```

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. If you have only the value of the derived signal (for an ECU), you must subtract the pulse width and apply this value here. The result can not be negative. In this case you must configure the next pulse.

```
Phase Gap to
TDC: 166,0°Crank
```

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.

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

Example for the Crank-signal (standard configuration 6 cylinder):

- number of crank segments = 60
- pulse width = 2°Crank
- offset to TDC = 4°Crank
- number of gap pulses = -2
- number of gap segments = 1
- phase to TDC = 166°Crank
- inversion = 0

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6.1.1.4 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 Cam
Pulses:     6
```

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. If you have only the value of the derived signal (for an ECU), you must subtract the pulse width and apply this value here. The result can not be negative. In this case you must configure the next pulse.

```
Offset Cam to
TDC:   16,0 °Cam
```

Missing segment 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. If you have only the value of the derived signal (for an ECU), you must subtract the pulse width and apply this value here. The result can not be negative. In this case you must configure the next pulse.

```
Phase Sync to
TDC:  331,0° Cam
```

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.

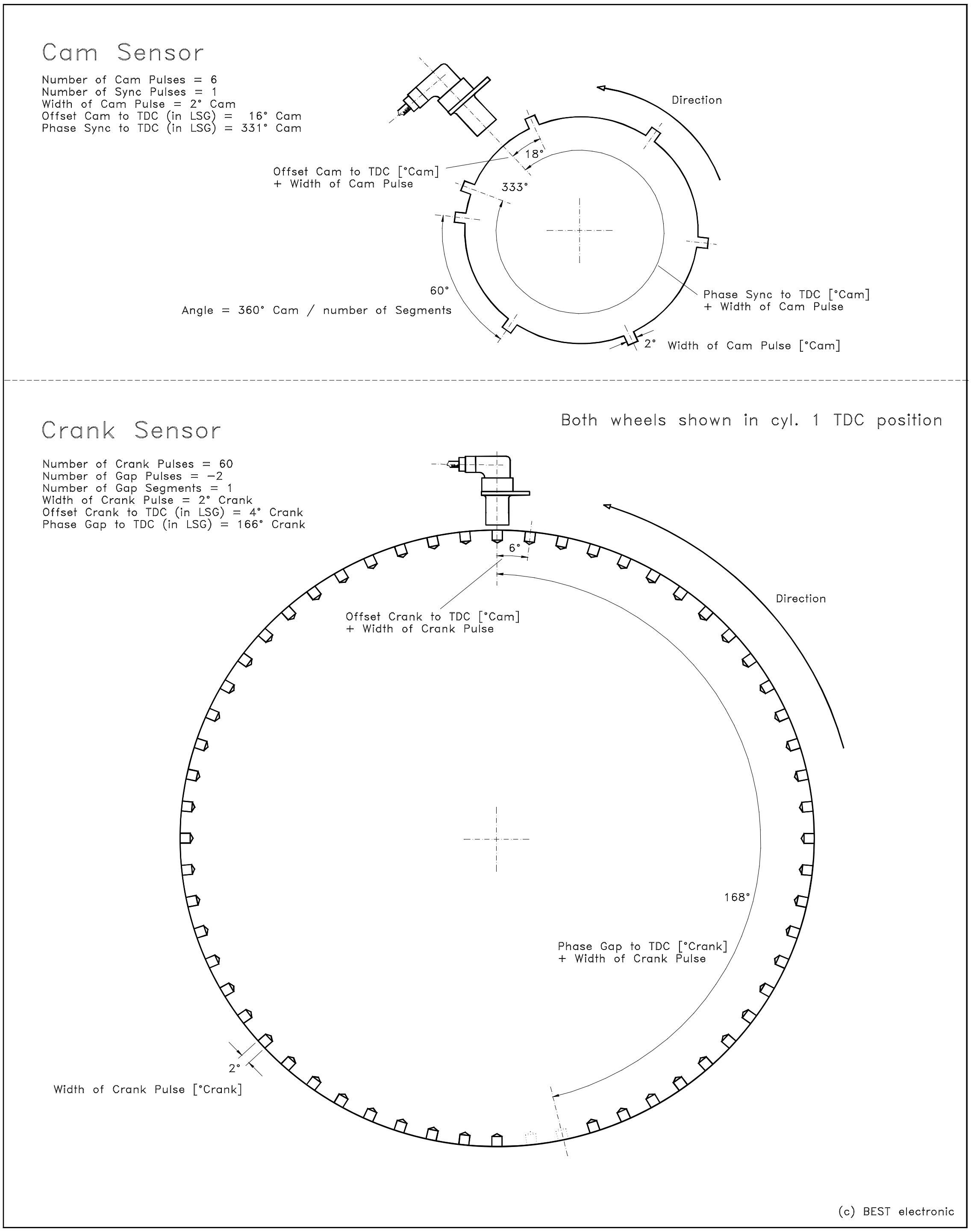
```
Inversion of
Cam Signal: 0
```

Example for the Cam-signal:
- number of cam segments = 6
- pulse width = 2°Cam
- offset to TDC = 16°Cam
- number of sync segments = 1
- phase to TDC = 331°Cam
- inversion = 0

6.1.2 Examples for engine speed wheel configuration

6.1.2.1 Wheel and sensor application

LSG 1000 Tone Wheel Configuration Example
Crank: 60 - 2 pulses, Cam: 6 + 1 pulses



6.1.2.2 Examples

After production, the LSG contains ten speed wheel configurations. The settings are:

1: Standard 4 Cylinder; Crank: 60 teeth, 90° TDC; Cam: -57° TDC, Sync: -42° TDC
2: Standard 5 Cylinder; Crank: 60 teeth, 162° TDC; Cam: -39° TDC, Sync: -24° TDC
3: Standard 6 Cylinder; Crank: 60 teeth, 180° TDC; Cam: -42° TDC, Sync: -27° TDC
4: Standard 8 Cylinder; Crank: 60 teeth, 216° TDC; Cam: -36° TDC, Sync: -24° TDC
5: Special 4 Cylinder; Crank: 60 teeth, 228° TDC; Cam: -57° TDC, Sync: -42° TDC
6: Special 6 Cylinder; Crank: 60 teeth, 90° TDC; Cam: -42° TDC, Sync: -27° TDC
7: Special 6 Cylinder; Crank: 60 teeth, 318° TDC; Cam: -42° TDC, Sync: -27° TDC
8: Special 4 Cylinder; Crank: 60 teeth, 150° TDC; Cam: -57° TDC, Sync: -42° TDC
9: Special 6 Cylinder; Crank: 60 teeth, 150° TDC; Cam: -42° TDC, Sync: -27° TDC
10: Special 6 Cylinder; Crank: 117 teeth, 184,6° TDC; Cam: -42° TDC, Sync: -27° TDC

Please note: you configure always the electrical signal in angle <u>after</u> TDC. This must be a positive number. If you use the derived output signal, the falling edge is interesting for you. In this case you have to subtract the duty cycle of the pulse from your target angle.

Here are the standard configuration values for the electrical pulses after delivery. The user can change the values. In this case you should note the changes into an own table.

Configuration		Number of Cylinders	Width of TDC pulse	No. of Crank Pulses	Width of Crank Pulse [°Crank]	Offset Crank to TDC1 [°Crank]	No. of Gap Pulses	No. of Gap Segments	Phase Gap to TDC1 [°Crank]	Inversion of Crank Signal	No. of Cam Pulses	Width of Cam Pulse [°Cam]	Offset Cam to TDC1 [°Cam]	No. of Sync. Pulses	Phase of Sync to TDC1 [°Cam]	Inversion of Cam Signal
1	Standard	4	3	60	2,0	4,0	-2	1	76,0	0	4	2,0	31,0	1	316,0	0
2	Standard	5	3	60	2,0	4,0	-2	1	148,0	0	5	2,0	31,0	1	334,0	0
3	Standard	6	3	60	2,0	4,0	-2	1	166,0	0	6	2,0	16,0	1	331,0	0
4	Standard	8	3	60	2,0	4,0	-2	1	202,0	0	8	2,0	7,0	1	334,0	0
5	Special	4	3	60	2,0	4,0	-2	1	214,0	0	4	2,0	31,0	1	316,0	0
6	Special	6	3	60	2,0	4,0	-2	1	76,0	0	6	2,0	16,0	1	331,0	0
7	Special	6	3	60	2,0	4,0	-2	1	304,0	0	6	2,0	16,0	1	331,0	0
8	Special	4	3	60	2,0	4,0	-2	1	136,0	0	4	2,0	31,0	1	316,0	0
9	Special	6	3	60	2,0	4,0	-2	1	136,0	0	6	2,0	16,0	1	331,0	0
10	Special	6	3	117	1,0	2,1	-2	1	177,4	0	6	2,0	16,0	1	331,0	0

After changing a configuration value, the old number will be overwritten in the EEPROM!

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6.2 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.

```
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 4 bits 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 + C = Enter Configuration Mode

These values must be configured before using the LSG:

- Number of pulses / km
- Width of pulse

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

6.2.1 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: pulsewidth [ms] = 16000 / (pulses/km).

The ECU calculates the vehicle speed in this way: v [km/h] = 0,225 * f[Hz] * pulsewidth [ms]

6.3 Low Idle Switch (LIS) Configuration

The voltage of an analog accelerator pedal gives the low idle switch status. The voltage is evaluated and the switch status is calculated via a hysteresis. 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 signal.

Shift + A = Show analog input value and LIS status

```
Pedal Value:
0123mV  LIS: 1
```

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

- Upper threshold for analog input
- Lower threshold for analog input
- Inversion flag for the signal (0 = not inverted – like described above; 1 = inverted)

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

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6.4 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** = Show next analog input port voltage
- **B** = Show next digital port pin status
  - **Number** = changes the respective port pin status (P2.0 – P2.7, P3.8, P3.10)
- **C** = Show next digital port pin status
  - **Number** = changes the respective port pin status (P2.0 – P2.7, P3.8, P3.10)
- **D** = Show previous analog input voltage

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

6.5 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 = Show the initial display

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

Shift + C = Enter Configuration Mode
These values must be configured before using the outputs

- Frequency channel #1
- Frequency channel #2

```
Frequency on 1st
Channel: 12345Hz
```

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