BRIEF INFORMATION

Oil level sensors

- Level sensors of the fourth generation: revamped design and function
- Particularly high robustness against interference
- Continuous measurement of the engine oil level in the static and dynamic range

PRODUCT FEATURES

Application

Oil sensors in vehicles ensure that the engine does not run with insufficient oil without such a situation being noticed. The triedand-tested technology of ultrasonic sensors works on the runtime principle and records the fill level continuously when the vehicle is being driven. When the engine is running (dynamic measuring range), the fill level is significantly lower than the fill level when the engine is at a standstill (static measuring range). In mobile engines, an oil dipstick measures the oil level only in the static range. This oil level sensor can measure the oil level continuously, i.e. in both the dynamic and also the static range. Thus information is provided about the oil level during the entire engine operation, a process which can often last several hours in construction vehicles, tractors and forklifts.

The sensor continuously monitors the oil level during the entire operation of the engine. This function ensures that the oil level does not fall below the required minimum during engine operation, thus preventing the oil film from breaking down (which would result in engine damage). Another advantage of the sensor is the integrated temperature sensor, which provides an input variable for the thermal management of the engine. Marginal influences, such as vehicle leaning, lateral and longitudinal accelerations, are compensated by averaging out in the vehicle's control unit.

Using the oil level sensor for measuring special media, e.g. transmission and hydraulic oils, requires prior inspection and approval by FORVIA HELLA.

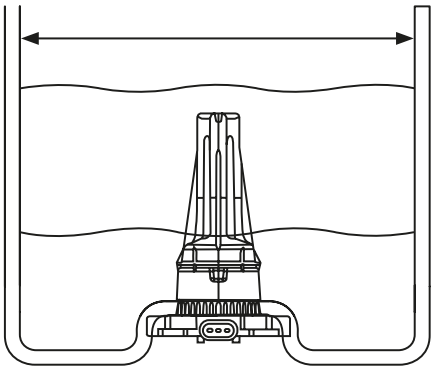
PRODUCT FEATURES

Design and function
The sensor architecture of the PULS (Packed Ultrasonic Level Sensor) oil level sensor consists of one single multi-chip module that integrates the ultrasonic sensor, the temperature sensor and also an ASIC (Application Specific Integrated Circuit). This compactness gives the sensors a higher level of impact and vibration resistance than those sensors fitted with a large number of electronic components. The ultrasonic sensor integrated in the multi-chip module emits a signal that is reflected by the engine oil/air interface.

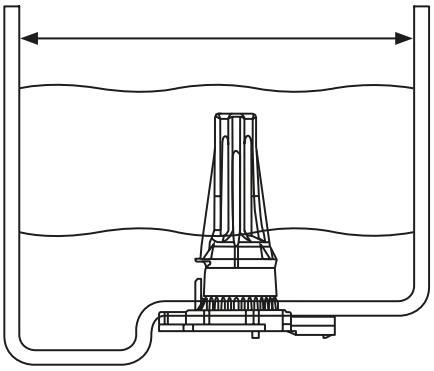
The term of the signal is measured and the height is calculated in line with the sound velocity in the medium. The damping cup installed above the multi-chip module is designed „to calm" the medium, (especially) in the dynamic measuring range. The damping cup has openings at the base and at the tip, which allow the oil to flow permanently.

Installation
The sensor is designed to be vertically flush-mounted from below into the bottom of an oil pan. Usually the oil level sensor is located on a ledge in the oil pan in order to protect the sensor base. This installation position, combined with the openings which make a permanent flow of oil possible, prevents sludge from forming within the damping cup.

SCHEMATIC DIAGRAM

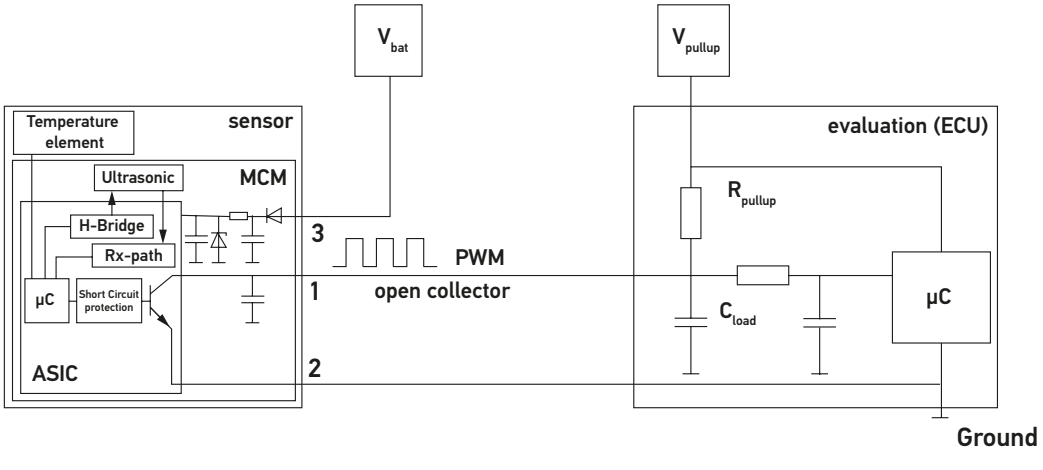


Left side of oil pan — Right side of oil pan



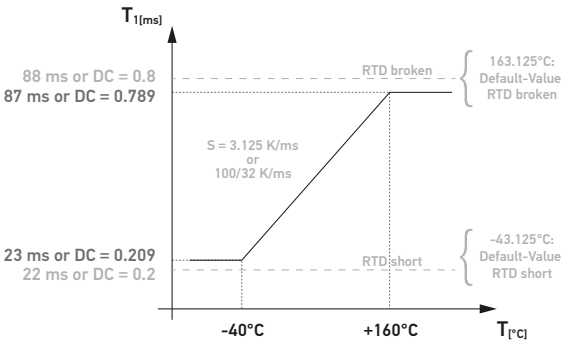
Front of oil pan — Back of oil pan

BLOCK DIAGRAM



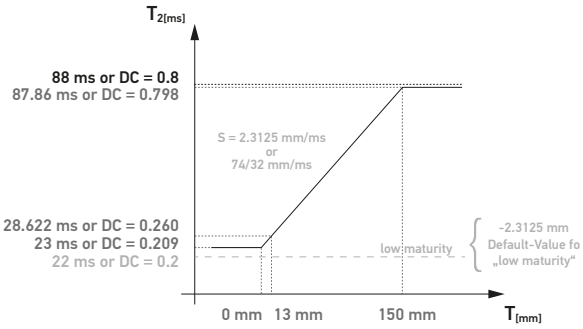
RECORDING THE LIQUID LEVEL (STATIC AND DYNAMIC)

T_1: Temperature evaluation (T_1 Temp)



T_1/T = DC = 0.2 : T_1 = 22 ms => Short circuit temperature sensor (-43 to125°C)
T_1/T = DC = 0.209 : T_1 = 23 ms => -40°C
T_1/T = DC = 0.789 : T_1 = 87 ms => 160°C
T_1/T = DC = 0.8 : T_1 = 88 ms => Temperature sensor defective (163 to125°C)

T_2: Temperature evaluation (T_2 Level)



T_2/T = DC = 0.2 : T_2 = 22 ms => Unreliable signal
(Level output -2.3125 mm)
T_2/T = DC = 0.209 : T_2 = 23 ms => Level = 0 mm
T_2/T = DC = 0.260 : T_2 = 28.622 ms => Level = 13 mm
T_2/T = DC = 0.798 : T_2 = 87.86 ms => Level = 150 mm

For levels below 13 mm or above 150 mm, T_2 is fixed at 28.622 ms or alternatively at 87.86 ms.

T_3: Diagnostic evaluation

PWM Pulse (Diagnostic values marked in bold print)

Temp. T_1	Level T_2	Diagnostic T_3	Diagnostic Information	Diagnostics of environmental conditions	Diagnostics of sensor failure	Transmission priority diagnostics*
23...87 ms	23...87,86 ms	**22 ms**	Status OK			5
23...87 ms	**28,62 ms** (13 mm)	**66 ms**	Level outside the range (<13 mm)	X		4
23...87 ms	**87,86 ms** (150 mm)	**66 ms**	Level outside the range (>150 mm)	X		4
≤10 °C 23...32,6 ms	**22 ms** (-2,3125 mm)	**66 ms**	Temperature outside the range for level measurement	X		4
≤10 °C 23...32,6 ms	**22 ms** (-2,3125 mm)	**66 ms**	Level out of range (noise)	X		4
22 ms (-43,125 °C)	**22 ms** (-2,3125 mm)	**55 ms**	**Temperature element short-circuited**		X	1
23 ms (-40 °C)	**22 ms** (-2,3125 mm)	**55 ms**	Temperature out of range (low)	X		1
87 ms (-160 °C)	**22 ms** (-2,3125 mm)	**55 ms**	Temperature out of range (high)	X		1
88 ms (-163,125 °C)	**22 ms** (-2,3125 mm)	**55 ms**	**Temperature element broken**		X	1
32,6...87 ms	**22 ms** (-2,3125 mm)	**44 ms**	**Piezoceramics open/short-circuited**		X	3
32,6...87 ms	**22 ms** (-2,3125 mm)	**33 ms**	Voltage out of range	X		2

T_3/T = DC
DC = 0.2, 0.3, 0.4, 0.5 oder 0.6
* Signal with the highest priority is transmitted.

CONVERSION FORMULAS IN THE CONTROL UNIT

$$Temp_{comp}\,[°C] = 3{,}125\ \frac{K}{ms} \cdot \left(T_1 \cdot \frac{110\ ms}{T[ms]} - 23\ ms \right) - 40\ K$$

or

$$Temp_{comp}\,[°C] = \frac{100}{32}\ \frac{K}{ms} \cdot \left(T_1 \cdot \frac{110\ ms}{T[ms]} - 23\ ms \right) - 40\ K$$

$$diagnostic[ms] = T_3[ms]$$

$$Level_{comp}\,[mm] = 2{,}3125\ \frac{mm}{ms} \cdot \frac{T[ms]}{110\ ms} \cdot \left(T_2[ms] \cdot \frac{110\ ms}{T[ms]} - 23\ ms \right)$$

or

$$Level_{comp}\,[mm] = 2{,}3125\ \frac{mm}{ms} \cdot \left(T_2[ms] - 23\ ms \cdot \frac{T[ms]}{110\ ms} \right)$$

or

$$Level_{comp}\,[mm] = \frac{74}{32}\ \frac{mm}{ms} \cdot \left(T_2[ms] - 23\ ms \cdot \frac{T[ms]}{110\ ms} \right)$$

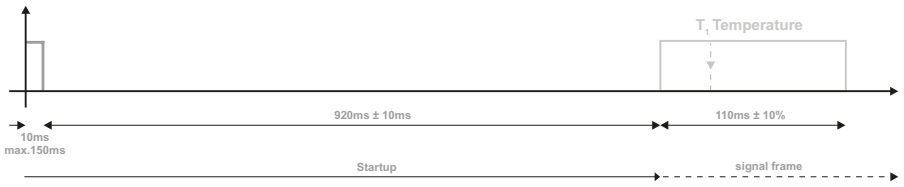
OUTPUT CHARACTERISTICS

The minimum pull-up voltage of the sensor depends on the low-level threshold value stored in the control unit and also on a potential ground offset. It can be calculated using the following formula:

Name	Symbol	Min	Typical	Max	Unit	Remarks
Output voltage, low	V_{ol}	–	–	$0.0375 \times V_{pullup} + 1\,V$	V	The required ground displacement of 1 V must be taken into account for dimensioning of the low level threshold
Output voltage, high[1)]	V_{oh}	V_{pullup} - 0.5 V	–	–	V	Open circuit with output capacity = 1nF (Under external capacitive load, please observe the slew rate)
Pull-up voltage	V_{pullup}	–	–	16	V	The minimum voltage results from the ECU; high/low limit values in consideration of output voltages at PIN 1 (signal)
Output current at low level	I_{ol}	–	–	10	mA	For $V_{ol} > 0.0375 \times V_{pullup} + 1\,V$
Output current at high level	I_{oh}	-50	0	50	µA	For $GND < V_{oh} < V_{pullup}$
PWM open collector resistor[2)]	R_{pullup}	1,6	–	10	kOhm	To be implemented in the engine control unit
Capacitive load[3)]	C_{load}	–	–	50	nF	–
Output current – short-circuit detection	I_{ol_SHORT}	65	–	–	mA	–

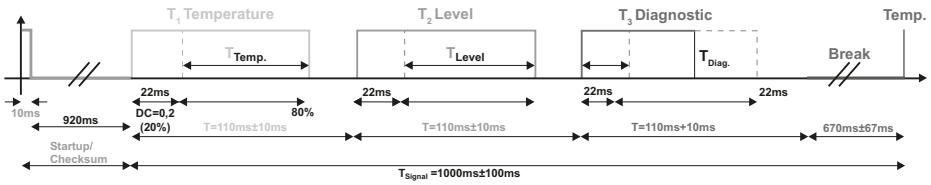
[1)] Open collector with output capacitance = 1nF (with external capacitive load, please observe slew rate).
[2)] To be implemented in the on-board computer.
[3)] Capacitive load at pulse communication output.

STARTUP BEHAVIOUR AFTER POWER ON



PWM (OPEN COLLECTOR) SIGNAL EVALUATION

The PWM output signal consists of three pulses that are repeated cyclically every 1,000 ms ± 10%. The pulses contain coded information about the oil temperature, oil level and diagnosis.

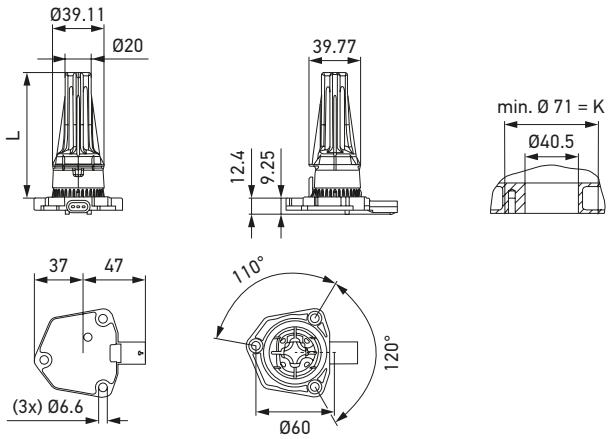


TECHNICAL DETAILS

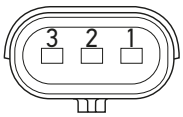
Technical data	
Operating voltage range	Single-voltage (9–16 V)
Rated voltage	12 V
Polarity reversal voltage	Up to 14 V/60 s
Overvoltage	15 s at 28 V 250 ms at 32 V
Current consumption	8 mA During measurement: max. 50 mA
Measuring range (static and dynamic)	13 mm to L -6 mm[1)]
Temperature range	-40 °C to +160 °C
Temperature range (for oil level measurement)[1)]	-10 °C to +150 °C
Re-heating temperature	Max. 5.700 h at 125 °C Max. 240 h at 145 °C Max. 60 h at 160 °C
Storage temperature	-40 °C to +150 °C
Report[2)]	PWM
Protection class	IP 6K9K
Weight	Variant-dependent
Mating connector[3)]	MLK 872-858-541 (3way 1.2 SealStar)
Compliant	CISPR 25
Protection	Polarity reversal protection, overvoltage protection
Viscosities	1 mm²/s to 1.300 mm²/s

[1)] Dependent on damping cup length (see variant overview)
[2)] Level output over -10 °C. At temperatures below -10 °C, an „empty" signal is sent (18 mm) together with the diagnostic signal „out of tolerance".
[3)] This accessory is not included in the scope of delivery. Available from Hirschmann.

Dimensional sketch



Pin assignment/electrical connection



Pin 1: OUTPUT
Pin 2: KL 31 GND
Pin 3: KL 15 UBAT

This sensor has an improved meander structure for optimised behaviour under dynamic conditions in oil and it also has improved response times.

Tolerance of level measurement

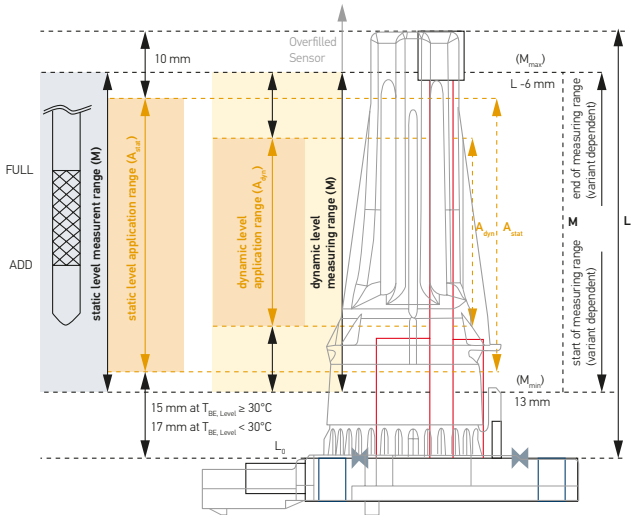
Oil level	Temperature range	Operating voltage	Tolerance
13 mm to L -6 mm	-10 °C ≤ T < 30 °C	9–16 V	±4 mm
13 mm to L -6 mm	30 °C ≤ T < 150 °C	9–16 V	+2 mm

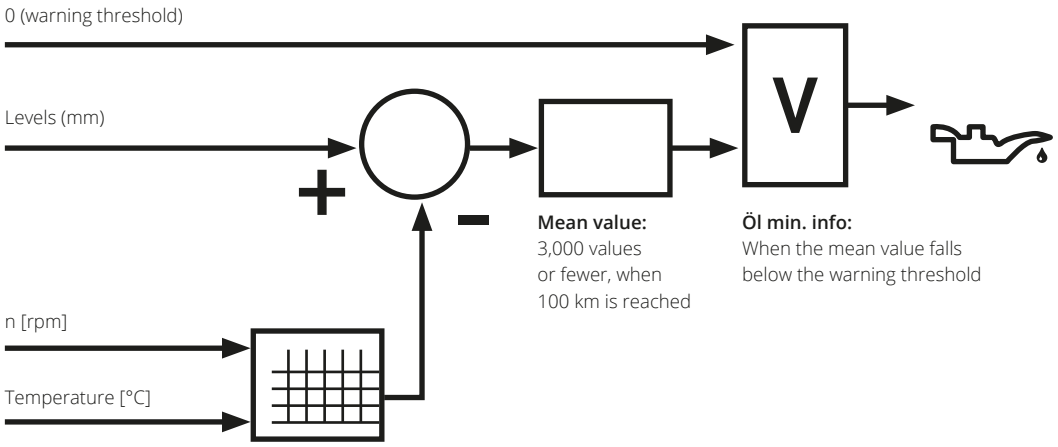
Temperature measurement tolerance

Oil level	Temperature range	Operating voltage	Tolerance
alle	60 °C ≤ T < 120 °C	6–16 V	±2 K

DYNAMIC MEASUREMENT OF THE ENGINE OIL LEVEL

For dynamic measurement (while the engine is running), an evaluation algorithm in the control unit must be developed, which compensates for the marginal influences of the engine (oil volume, oil temperature, speed) and of the vehicle (longitudinal and lateral acceleration, uphill and downhill motion). As a result of subsequent averaging, the influences brought about by driving conditions cancel themselves out over longer periods of time.Hence, either a warning can be triggered with respect to the minimum oil volume reached or the oil volume that is actually still available can be calculated.





3D map: Compensation of engine speed and oil temperature

PROGRAM OVERVIEW

Variant	Measuring range	Part number
Length of damping cup 150 mm	Static and dynamic 13–144 mm	**On request**

ACCESSORIES

Description	Part number
Sealing ring*	**On request**

* Whenever the sensor is remounted, a new sealing ring must be used. This is available from FORVIA HELLA.