Fuel Level Sensor ETS.A

Operating Manual

Contents

1 Purpose

The analogue fuel level sensor ETS.A (below, also ‘sensor’) is intended for measuring changes in the level of liquid fuels and lubricants (LFL) and may be used in vehicles and LFL storage terminals as a component of systems measuring and controlling the volume of LFL such as various types of petrol, diesel and lubricant oils.

The sensor measures the level of its sensing assembly’s immersion in the fuel and provides an analogue output signal proportionate to the level measured.

The sensor may be used with imaging devices or programmable controllers whose signal input specifications correspond to the sensor’s technical parameters.

Figure 1. Fuel Level Sensor ETS.A

To increase reliability and improve operating parameters, the sensor includes the following technical solutions and functions:

- ✓ The sensor’s electronic circuitry is embedded in an elastic compound ensuring maximum protection and reliability in any operating environment. Measuring tubes are made of materials that do not enter into chemical reactions with LFL or their components.
- ✓ The sensor includes a built-in supply voltage stabilizer that prevents its output voltage being affected by supply voltage fluctuations.
- ✓ The sensor also has a built-in algorithm for averaging measured values, which allows readings to be averaged over a given period of time.
- ✓ The sensor includes a built-in self-diagnosis algorithm.

2 Technical Parameters

Parameter	Value
Supply	
Supply voltage, V	10…30
Current consumption, mA	20
Output	
Output signal type	analogue
Operating voltage range, V*	0…10
Lowest output voltage, V	0
Highest output voltage, V	10
Level Measurement	
Lower limit of measurable level of fuel above tank floor, mm	20 and higher
Upper limit value of measurement, mm	200 … 4000
Limiting error of level measurement, % of sensor length	± 1
Additional limiting error by temperature, %**	1 or lower
General Information	
Dimensions, mm	L x 70 x 70
Weight, kg	0.3 to 3
Continuous duration of operation	no limit
Operating temperature range, °C	−40…+70
Relative humidity of ambient air at temperatures not exceeding +40 °C, %	95 or lower

*Upper and lower limit values of output signal and lowest value of the signal depend on the length to which the sensor has been cut.
**Additional limiting error accounts for the effect of the temperature of ambient air in the range of – 40 °C …+70 °C

3 Package Contents

Item Name	Quantity
The sensor ETS.A	1
Extension cable	1
Gasket	1
Operating manual (incl. ratings sheet, warranty coupon)	1
Packaging box	1

*The sensor is supplied in the following standard sizes corresponding to the height of automotive fuel tanks: 700, 500, 350, 300, 180 mm. Sensors of non-standard lengths are available on special order.

4 Construction and Principle of Operation

The sensor operates on the principle of capacity measurement. The sensing assembly of the sensor consists of two concentric tubes which form a cylindrical capacitor. The assembly's capacity depends on the level to which the tubes are immersed in the LFL.

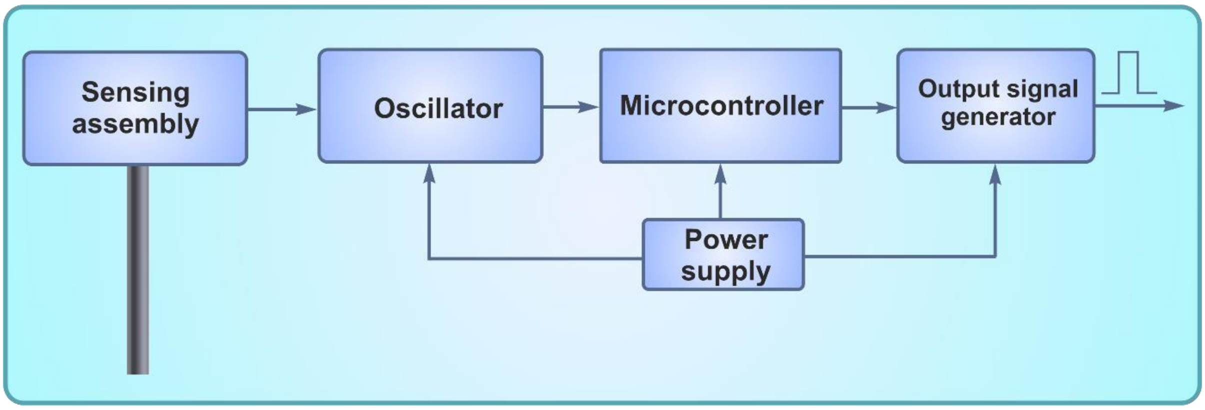


Figure 2. Sensor Components and their Connections

The capacitor is part of the input circuit of an oscillator, which makes the period of the output signal of the oscillator directly dependent on the capacity of the sensing assembly – and, accordingly, on the level of immersion of the sensing assembly's tubes in the fuel. Down the line, a microcontroller measures the period of the signal put out by the oscillator, normalizes and averages it and verifies whether the measured value is within an acceptable range. If the result of the verification is affirmative, the microcontroller generates an analogue signal in the range of its operating voltage (0…10 V) which is directly proportional to the level of immersion of the sensing assembly in the fuel. If the result of the verification is negative or if an error is detected which the built-in self-diagnosis algorithm recognizes, the microcontroller generates an analogue signal whose voltage represents the code assigned to the error concerned (see the table *Diagnostic Codes of Sensor Errors*).

Diagnostic Codes of Sensor Errors

Code (Sensor Output Voltage), V	**Error Description**
1.0	Sensor's lower and upper limits not calibrated
1.2	Sensor's upper limit not calibrated
1.4	Oscillator frequency equals 0
1.6	Division by zero: the sensor is calibrated to a single point
1.8	EEPROM read error
2.0	Beyond upper limit of range, F>(*Fmax +10%)*
2.2	Beyond lower limit of range, F<(*Fmin −10%)*
2.4	Calibration terminal shorted

The power supply is designed to use the input voltage of the vehicle's onboard network to generate a stable supply voltage for the sensor's components, to protect the sensor from spikes in the network's voltage, from polarity switches in the supply and from other noise.

⚠ **IMPORTANT NOTE:** Keep in mind that allowing the sensor to operate for extended periods of time under power supply parameters exceeding, or close to, the rated limit values may result in permanent damage to the sensor's protection circuits as a result of overheating or failure of circuit components. In turn, this may render the sensor non-functional. For operating range values of supply voltage, see the section *Technical Parameters*.

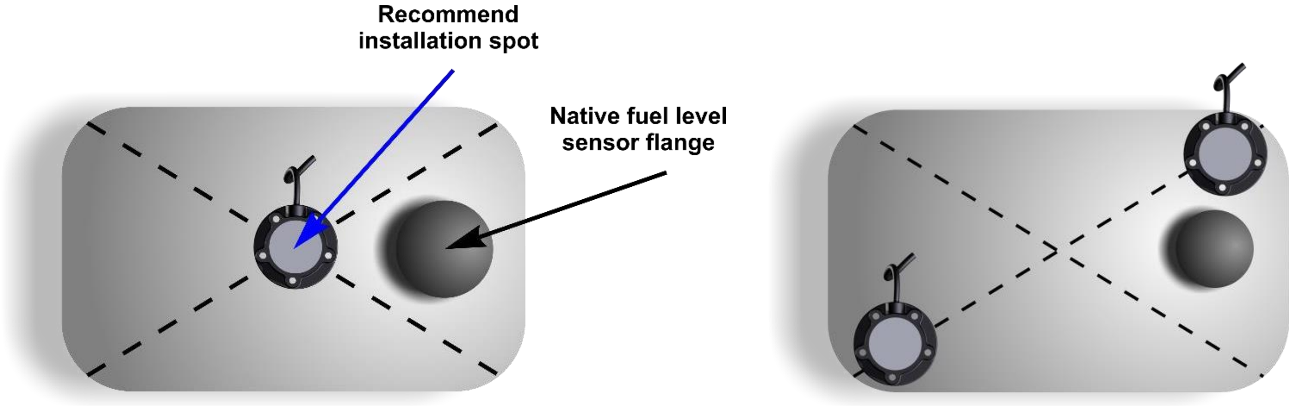
5 Installation and Operation

5.1 Requirements for Use

- Before proceeding to use the sensor it must be inspected for external defects. If visible damage (cracks, chipping, dents, etc.) is detected, the sensor should not be used;
- Upon installation, it is recommended to protect all electrical connections by anti-tamper seals;
- Any repairs must be performed by an authorized service centre;
- The sensor should be operated by personnel who have been informed of the construction, principle of operation and instructions as provided in this Operating Manual;
- The dielectric permeability of the measured environment must be constant. Failure to observe this requirement leads to increased errors of measurement.

5.2 Installation Basics

The sensor may be installed in a standard fuel level sensor inlet or by cutting an opening for the sensor in the tank. It is recommended to install the sensor as close as possible to the geometric centre of the tank (Fig. 3a). in order to avoid the vehicle's tilt affecting the sensor's readings. If the vehicle has two tanks, a sensor must be installed in each. In particular applications (such as when the vehicle is being used in rough terrain) it is recommended to install two sensors in a tank (Fig. 3b). In this case, they must be fitted diagonally at opposite sides of the tank, and the combined output value must be calculated using the formula: $U_{comb} = \frac{U_{sensor1} + U_{sensor2}}{2}$.



a) at geometric centre of the tank

b) two sensors per tank

Figure 3. Sensor Placement

In case of installation to the vehicle's native fuel level sensor's inlet an adapter, available from the manufacturer as an accessory, must also be installed and connected (Fig. 4, see *Operating Manual for USA.ETS Light 3.0*) because the sensor is not equipped for a direct connection to the fuel level gauge on the vehicle's native instrument panel.

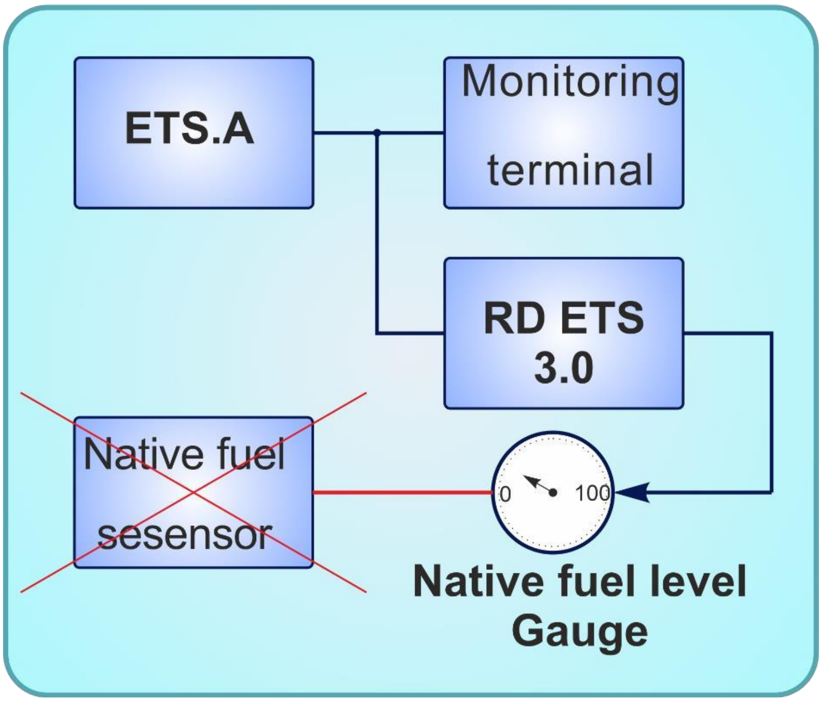


Figure 4. Connecting the Adapter

If the vehicle's instrument panel does not have a sufficient number of input terminals for connecting the required number of fuel level sensors, the readings of several sensors may be combined (Fig. 5) using a summator (see *Operating Manual for Summator ETS 3.0*).

⚠ **IMPORTANT NOTE:** Where the readings of several sensors are to be combined, frequency-based sensors (Fuel Level Sensor ETS.F, available from the manufacturer) must be used, the output signal of the summator being a voltage in the range of 0…10 V.

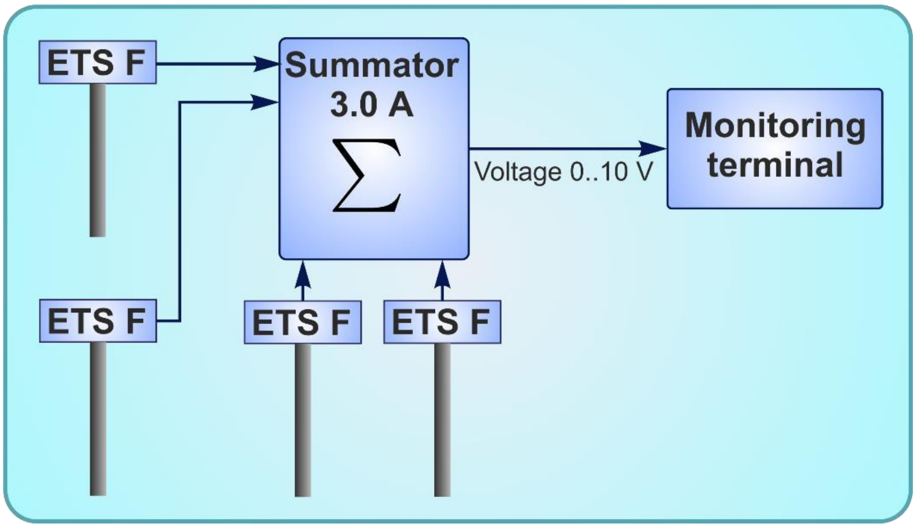


Figure 5. Connecting the Summator ETS 3.0

5.3 Connection

Connector Pin Designations		
Pin Number	**Designation**	**Wire Colour**

1	Sensor signal	green	
2	Supply ground (−)	brown	
3	Supply power (+)	red	

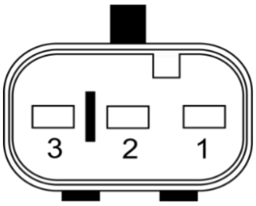
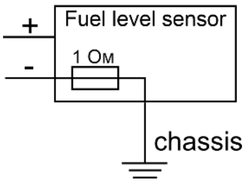


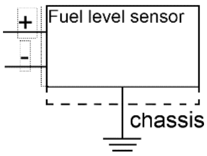
Figure 6. Front View of Sensor's Connector

To allow for different schemes of connecting the sensor to the vehicle, two versions of the sensor are



manufactured:

Version 1: Sensor body made of aluminium. Rated for sensor connection to vehicle's onboard network after the chassis ground switch. Supply ground wire (–) connects to sensor body (resistance between ground wire and the body is < 1 Ω).



Version 2: Sensor with carbon plastic body. Rated for direct connection to the vehicle's battery or onboard network.

Legend

A	connection point for supply power
B	connection point for supply ground
FA	fuse on supply power wire sensor consumption max 20 mA monitoring terminal consumption: according to specifications
DC-DC	Power supply converter with galvanically isolated supply inputs and outputs

Option 1

Allows the monitoring system to operate only IF THE CHASSIS GROUND SWITCH IS IN 'CONNECTED' POSITION (CONNECTION AFTER THE CHASSIS GROUND SWITCH) – a straightforward option.

⚠ **IMPORTANT NOTE:** This connection scheme may be used for sensors with an aluminium as well as with a carbon plastic body.

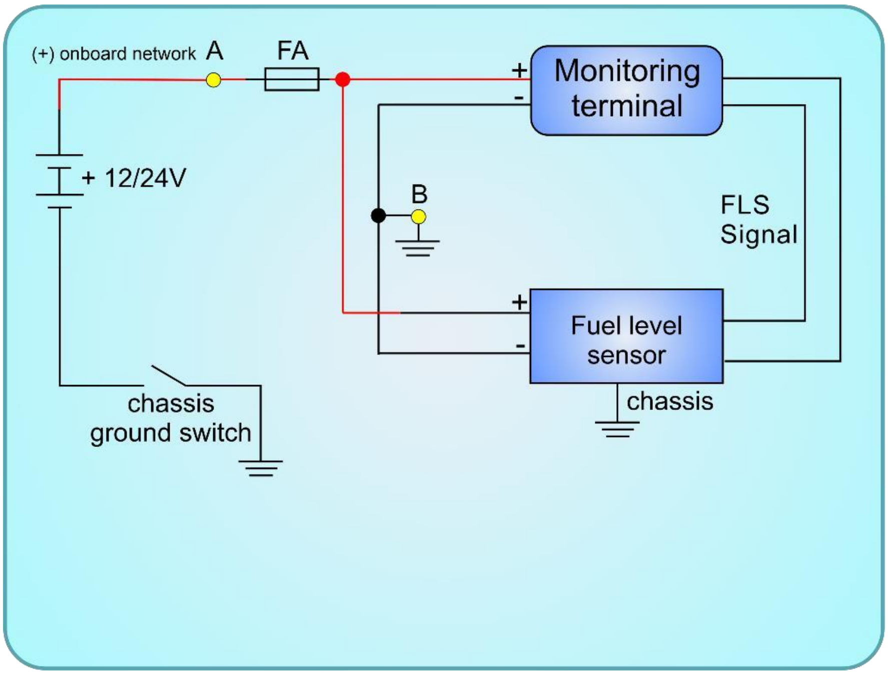


Figure 7. Connection after Chassis Ground Switch

⚠ **NOTE:** The fuse FA must be installed as close as possible to the supply power connection point in order to ensure protection of onboard network from short-circuits in the power supply of the monitoring system.

⚠ **NOTE:** The connection to A is made on an onboard power wire (+) with the ignition off. To prevent fuse blowing due to additional load, it is recommended to place the connection before the native fuse of the circuit. One of the best connection options is the red wire of the ignition switch.

The connection to B is made on the vehicle's chassis under the instrument panel.

⚠ **IMPORTANT NOTE:** Ground wires to the sensor and to the monitoring terminal should be run from the same point.

Advantages:

- ✓ Reliability
- ✓ Simplicity

Disadvantages:

- ✓ Does not allow uninterrupted monitoring of fuel level

Option 2

Guarantees UNINTERRUPTED OPERATION of the monitoring system (CONNECTION BEFORE THE CHASSIS GROUND SWITCH). The option should be used when round-the-clock monitoring of the vehicle is required. The sensor as well as the monitoring terminal must be supplied directly from the battery.

⚠ **IMPORTANT NOTE:** This connection scheme may only be used for sensors with a carbon plastic body.

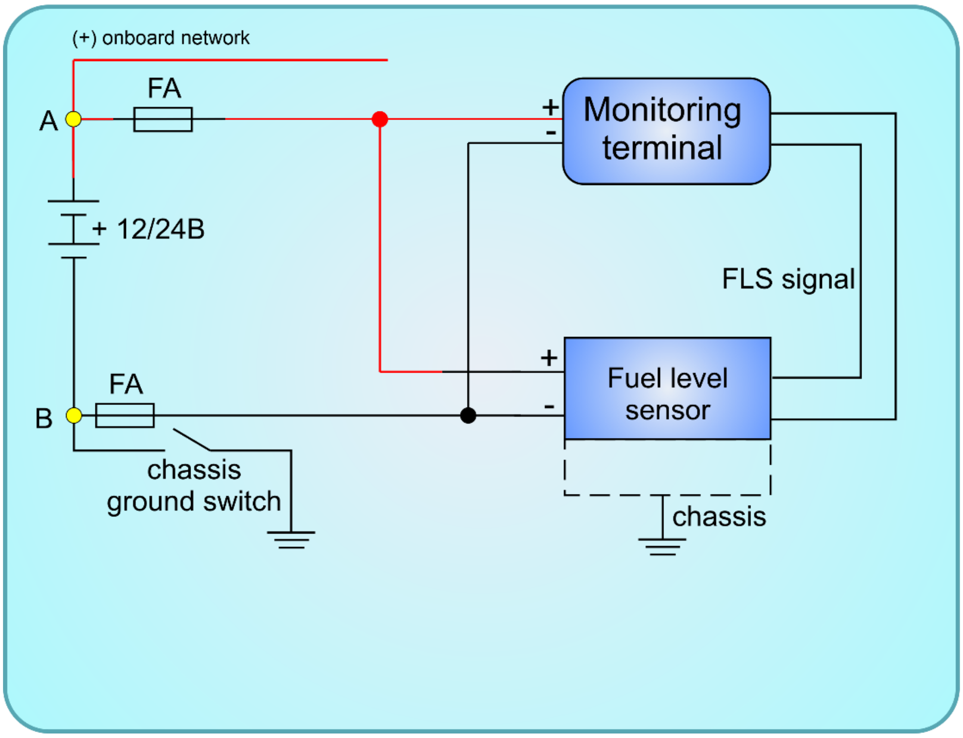


Figure 8. Connection before Chassis Ground Switch

- ⚠ **NOTE:** The fuse FA must be installed as close as possible to the supply power connection point in order to ensure protection of onboard network from short-circuits in the power supply of the monitoring system.
- ⚠ **NOTE:** Points A and B must be connected respectively to power (+) and ground (–) terminals on the battery.
- ⚠ **IMPORTANT NOTE:** This connection scheme MUST NOT be used on fuel tanks of petrol-engine vehicles!
- ⚠ **IMPORTANT NOTE:** When using the scheme, make sure that there is no connection between the sensing assembly's outer tube and the tank body or between the sensing assembly's outer tube and the native fuel level sensor.
- ⚠ **IMPORTANT NOTE:** Installation of the fuse FA2 is mandatory. If, during operation, with the chassis ground switch in 'disconnected' position, the outer tube of the sensing assembly comes into contact with the tank body or the native fuel level sensor, FA2 will protect the wiring of your system from burning out.

Advantages:

- ✓ Simplicity
- ✓ Guarantees round-the-clock monitoring

Disadvantages:

- ✓ Poor reliability, unless protected 100% from contact between the sensing assembly's outer tube and the tank body or the sensing assembly's outer tube and the native fuel level sensor.
- ✓ Cannot be used on fuel tanks of petrol-engine vehicles.

Option 3

Guarantees UNINTERRUPTED OPERATION of the system – the most reliable option.

⚠ **IMPORTANT NOTE:** This connection scheme may be used for sensors with an aluminium as well as with a carbon plastic body.

⚠ **NOTE:** The system uses a power supply converter with galvanically isolated inputs and outputs. The parameters of the supply must be selected having regard to the technical specifications listed in the ratings sheets of the sensor, of the monitoring terminal or of any other applicable devices, adding a 20% reserve.
Sensor supply voltage: 10…33 V.
Sensor supply current: max 20 mA.

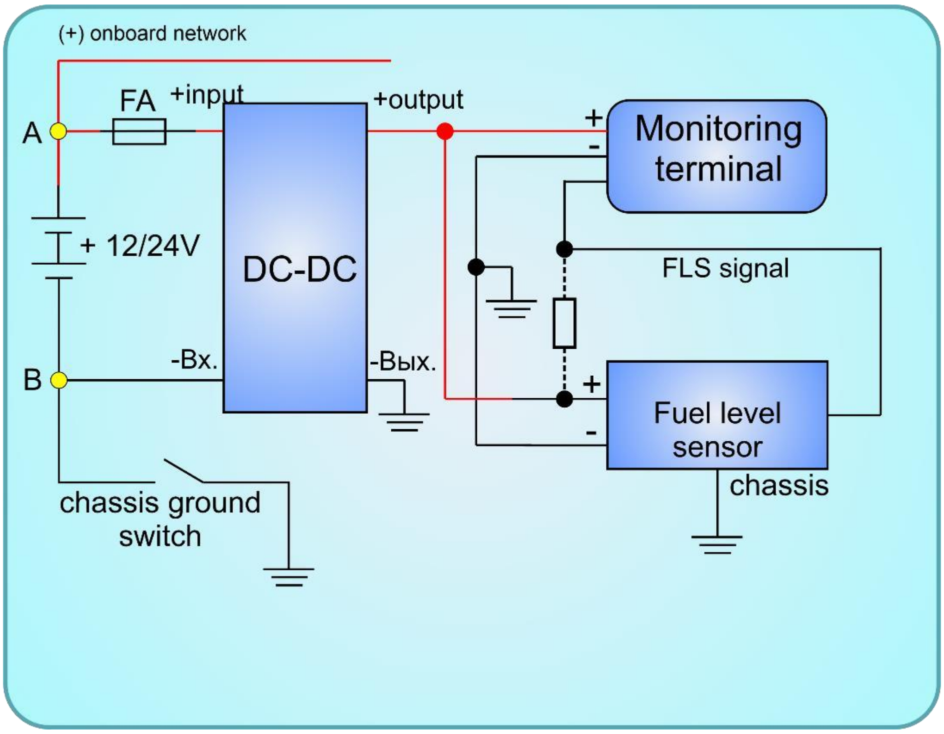


Figure 9. Connection Using a Supplementary DC/DC Converter

⚠ **NOTE:** The fuse FA must be installed as close as possible to the supply power connection point in order to protect the onboard network from short-circuits in the power supply of the fuel consumption monitoring system.

⚠ **NOTE:** Points A and B are connected respectively to the power (+) and ground (−) terminals of the battery.

Advantages:

- ✓ Reliability: DC/DC solution protects both the sensor and the monitoring terminal
- ✓ Ensures round-the-clock monitoring

Disadvantages:

- ✓ Cost

5.4 Installation Sequence

1. Drill the centre opening (select opening placement as shown in Fig. 3) for mounting the sensor, using a bi-metal hole saw with a diameter of 35 mm. Insert the sensor in the opening and mark the spots for fastener holes. A diagram of fastener hole placement is shown in Fig. 10.

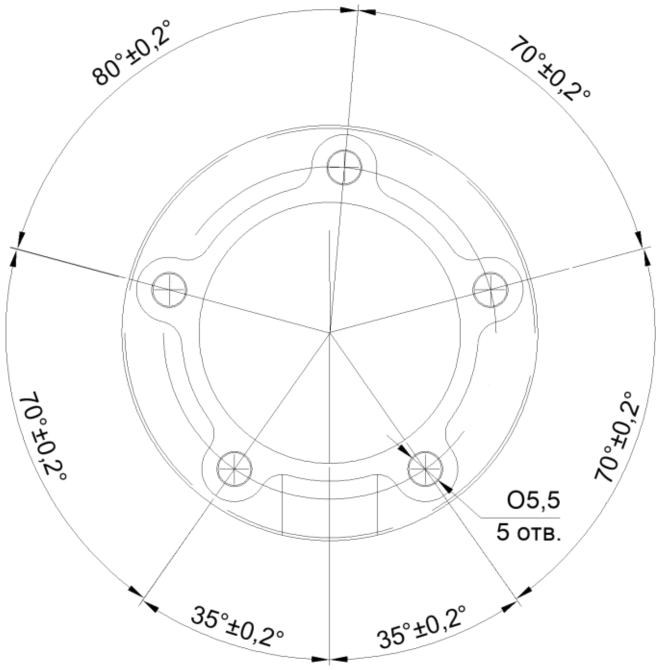


Figure 10. Fastener Hole Placement

⚠ **IMPORTANT NOTE:** In order to prevent an explosion of fuel fumes, a diesel tank MUST BE filled up to the maximum prior to the drilling of any openings! The fuel tank of a petrol engine MUST BE either filled with water or removed and the remaining petrol evaporated!

2. Cut the sensor to required length – see Fig. 11. Use a hacksaw to cut the aluminium tubes to tank height, allowing for at least a 20mm gap between sensor end and tank floor for water/impurity accumulations. Carefully remove any aluminium chips that stick between the tubes. Deburr the tube ends.
3. Plug the end cap supplied with the sensor into the cut end (see section 5.5 for information on the cap).

⚠ **IMPORTANT NOTE:** DO NOT use the sensor without the end cap – this may result in damage to the sensor due to loosening of the tubes during use!

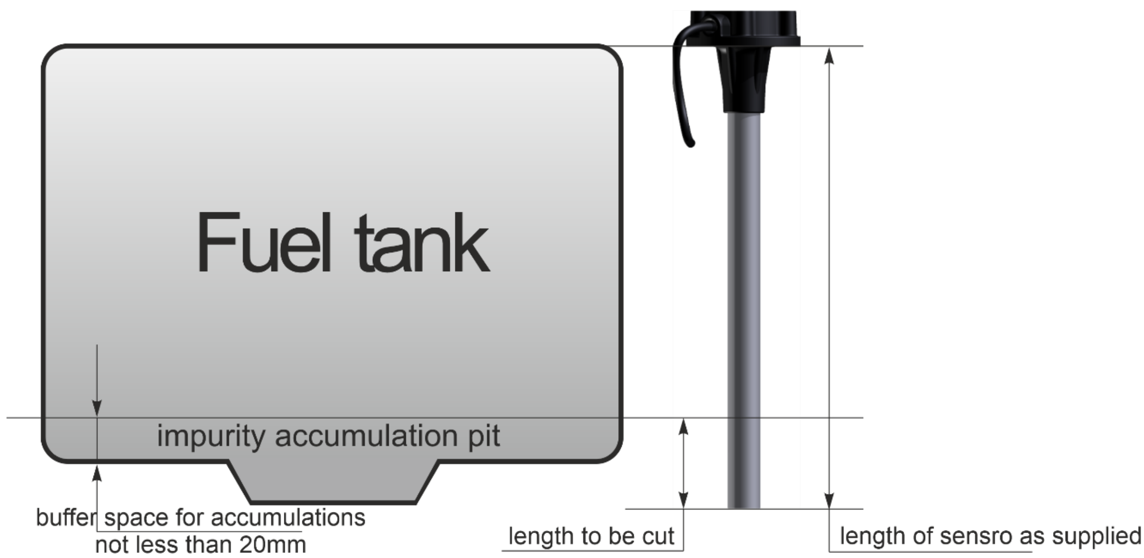


Figure 11. Cutting the Sensor to Required Length

4. Calibrate the sensor if necessary.
5. Run a cable to connect the sensor, making the connections in accordance with the selected connection option (see section 5.3).
6. Check the operation of the sensor. To perform the check, connect the sensor and measure the voltage of its output signal when dry – it should be within the range of 0…3 V. Then measure the voltage of the output signal when the sensor is completely immersed in fuel – it should be within the range of 3.5…10 V.
7. Disconnect the sensor.
8. Install the sensor and fasten it using self-tapping screws (or regular screws, when mounting to native inlet).
9. Connect the sensor.

⚠ **IMPORTANT NOTE:** Be careful not to mix up the wires – connecting the wrong wire may result in damage to the sensor.

⚠ **IMPORTANT NOTE:** DO NOT supply the sensor with a voltage in excess of 33 V!

5.5 End Cap

After having cut the sensor to length, insert the end cap (supplied with the sensor) into the cut end.

⚠ **IMPORTANT NOTE:** DO NOT use the sensor without the end cap – this may result in damage to the sensor due to loosening of the tubes during use!

The end cap has three positions:

Position 1

Before inserting the cap in the cut end of the sensor, the cap's core rod must be pushed up all the way into the body of the cap as shown (Fig. 12).

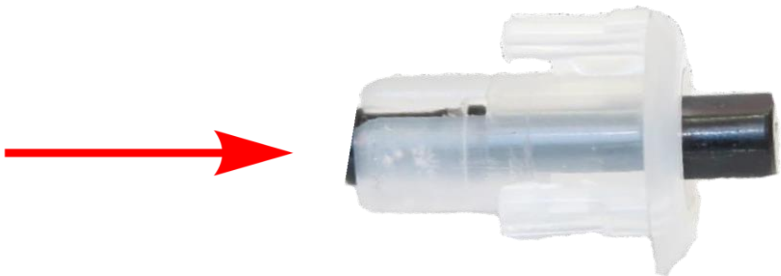


Figure 12. End Cap in Position 1

Position 2

After insertion in the sensor's end, the cap must be seated in place by pushing the rod in until it is flush with the cap. This expands the cap's wings and wedges it in the sensor centre tube (Fig. 13).

Figure 13. End Cap in Position 2

Position 3

To remove the cap from the sensor, its core rod must be pushed in further into the cap body. This allows the wedging wings to retract and makes removal easy (Fig. 14).

Figure 14. End Cap in Position 3

6 Calibration

The purpose of calibration is to obtain a maximum drop in output voltage after cutting the sensing assembly to required length.

To allow for its length to be cut by 50%, the sensor is supplied with the following parameters:

- output voltage when dry: 2.98 V.
- output voltage when completely immersed: 9.8 ± 0.2 V.
- output signal variability range: ≈ 6.82 V.

When the sensor is cut to required length, its output voltage will shift downwards and, at the same time, the output range will decrease. A sensor that has been cut by 50% will have the following parameters:

- output voltage when dry: 0 V;
- output voltage when completely immersed: 3.5 ± 0.2 V;
- output signal variability range: ≈ 3.5 V.

Observe that the drop range of the output signal has been reduced by half (from 6.82 to 3.5 V).

⚠ **IMPORTANT NOTE:** When the sensor is cut by more than 50%, it will have a dead zone at the low end of the range, requiring calibration.

The calibration process adjusts the settings of the sensor, maximizing the drop range of the output signal as follows:

- output voltage of the sensor when dry: 0 V;
- output voltage of the sensor when completely immersed: 9.8 ± 0.2 V;
- output signal variability range: ≈ 9.8 V.

⚠ **IMPORTANT NOTE:** If the sensor is cut to length after calibration, the calibration process must be repeated – otherwise there will be a dead zone at the low end of the sensor's range.

⚠ **IMPORTANT NOTE:** The calibration process may be run also with an uncut sensor in order to extend the drop range of its output voltage.

⚠ **IMPORTANT NOTE:** If the sensor has been immersed in fuel, it must be allowed to drain for at least 5 minutes before starting calibration.

6.1 Calibration using the Universal Service Adapter (ETS.USA)

Calibration sequence:

1. Download the file **DUTConfig** from www.ets-by.ru. Install the application **DUTConfig**.
2. Cut the sensor to required length.
3. Plug the end cap into the cut ends of the sensing tubes (see section 6.3).
4. Connect the sensor to PC as shown in Fig. 15.

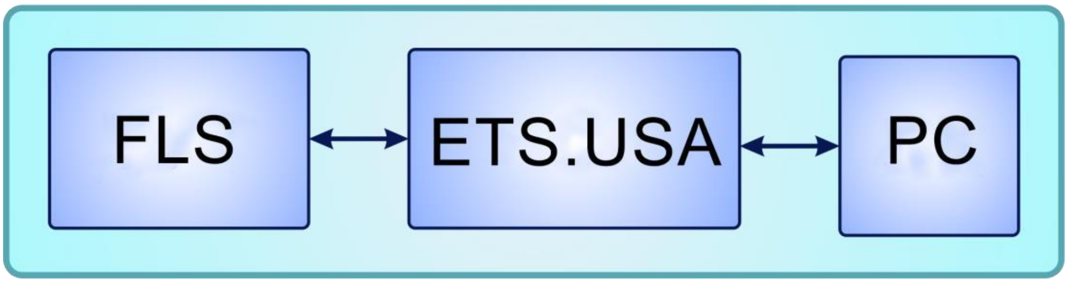


Figure 15. Connecting the Sensor to PC

To connect the sensor to a PC, use the Universal Service Adapter ETS.USA 2.2 (Fig. 16) available from the manufacturer. A 3-pin cable (USA–ETS.F_A, supplied with the adapter) is required to connect the adapter to the sensor and to calibrate the sensor.

Figure 16. Universal Service Adapter ETS.USA 2.2

Connector Pin Assignment for Connecting Adapter to Sensor

DRB-9F		Sensor		
Pin Number	**Pin Designation**	**Pin Number**	**Pin Designation**	**Wire Colour**
6	Input F/U	1	output signal	green
2	ground	2	supply ground (−)	brown
1	+12 V	3	supply power (+)	red
3	Calibration signal	Calibration probe		

5. Select operating mode *Voltage measurement* on the adapter (Fig. 17, green LED must blink, see the adapter's operating manual).

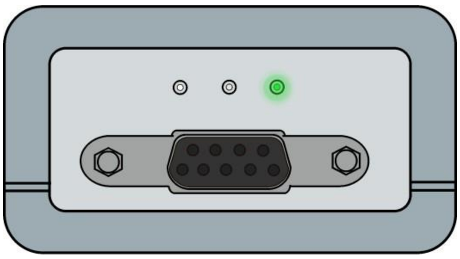


Figure 17. Indication of Adapter Operation in *Voltage Measurement* Mode

6. Run the application **DUTConfig.** In the application window (Fig. 18) select type box *Analog sensor*.

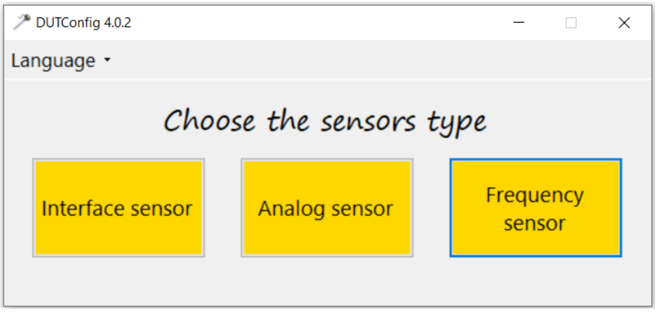


Figure 18. Selecting Sensor Type

7. In the window displayed next (Fig. 19) indicate the connection port. Press the button *Connect.*

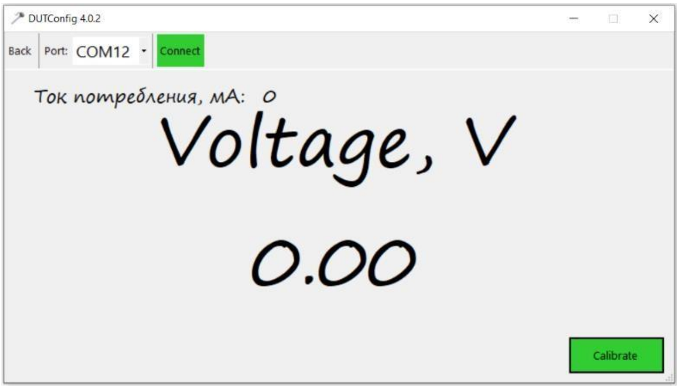


Figure 19. Calibration Window

When the sensor has been successfully connected, the application will indicate the connection (the main window of the application will display the notification message *Connection: on*) (Fig. 20).

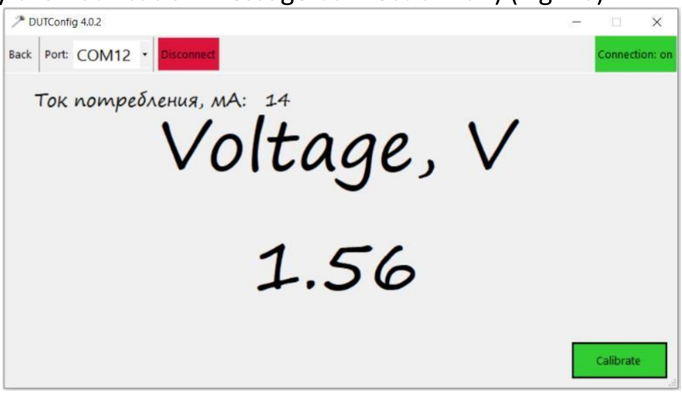


Figure 20. Connecting the Sensor

8. Connect probe to the sensor's centre electrode.

⚠ **IMPORTANT NOTE:** DO NOT touch the electrode!

9. Press the button *Calibrate*.

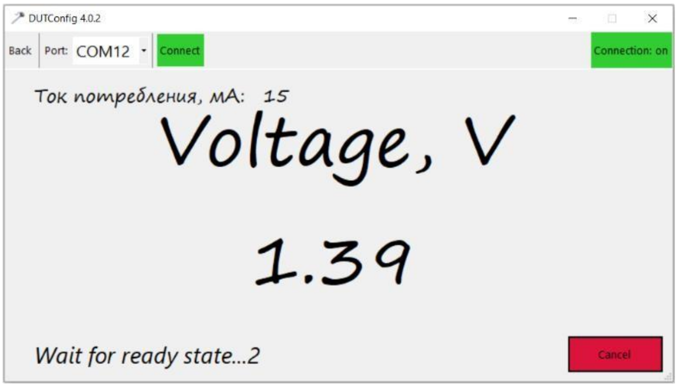


Figure 21. Calibration Process

10. Wait until the application displays a notification window with the message *Disconnect the probe from the central tube* (Fig. 22).

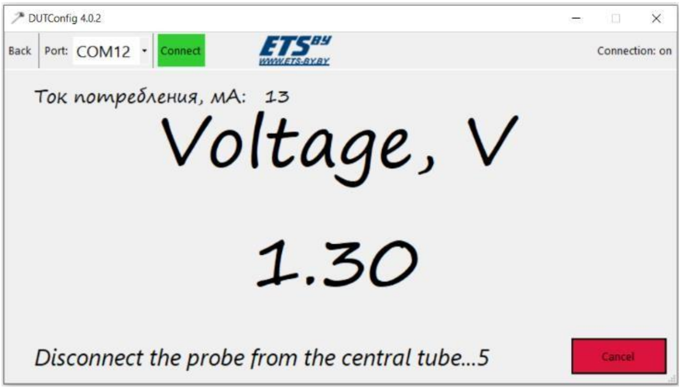


Figure 22. Disconnecting the Probe

11. Disconnect the probe and wait until the application displays the message *Done!* showing completion of the calibration process (Fig. 23).

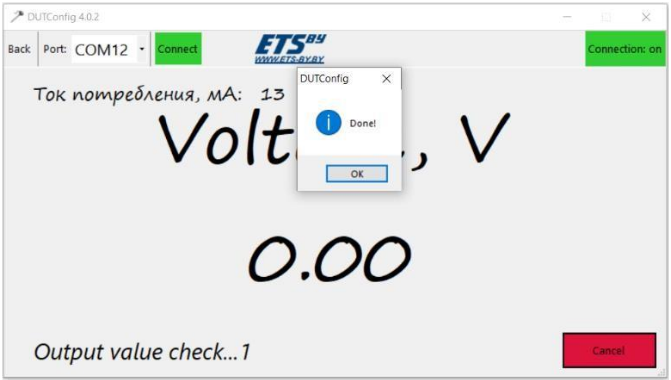


Figure 23. Completion of Calibration

⚠ **IMPORTANT NOTE:** Should an error arise during calibration, repeat the process anew.

As a result of calibration, the voltage provided by the sensor will be 0 V when dry and approximately 9.8 V when completely filled with fuel.

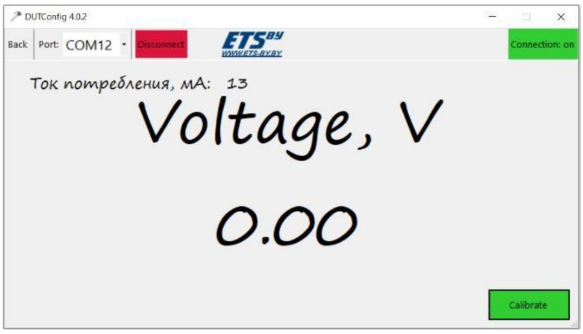


Figure 24. Voltage of Sensor When Dry

7 Troubleshooting

Typical Errors and Instructions for Fixing These

Error	Error Description	Instructions for Fixing
Oscillator frequency equals 0 Code: 1.4 V	**Description:** oscillator not working, the sensor does not measure fuel level. **Explanation:** the error is either occasional (parts shorted by water when in motion) or permanent (in the case of mechanical shorting of wires or sensing tubes) character. When the cause of the error is removed, normal operation resumes. **Cause:** shorting of the tubes of the sensing assembly – either there is water in the fuel or a mechanical short-circuit is present.	1. Allow the sensor to dry, drain water from the tank; 2. Fix the mechanical short-circuit. With the sensor switched off, use a tester to measure resistance between the tubes of the sensing assembly. The measured value should be in the range of 460…500 kΩ.
EEPROM read error Code: 1.8 V	**Description:** The parameters that were set when the sensor was calibrated have become corrupted. **Explanation:** the error manifests as soon as the sensor is switched on and is permanent, i.e. the output signal value is not affected by immersing the sensor in fuel or by shorting its electrodes. **Cause:** possible damage by static discharge when cutting the sensor to length.	1. Short-circuit the electrodes of the sensing assembly by means of a metallic object. If this does not change the output signal of the sensor, the sensor is not functional and has to be replaced. 2. If shorting the electrodes changes the output signal of the sensor, either the measuring device that is being used has a fault or has been connected incorrectly. Measure the output voltage using a properly functioning device that has been connected correctly for voltage measurement.
Upper limit of range exceeded F > Fmax +10% Code: 2.0 V	**Description:** at low levels, the sensor 'sticks' at zero, subsequently displaying the error. **Explanation:** the error is manifested when the sensor is 'dry'. When the sensor is immersed in fuel and after passing the dead zone, normal operation resumes. **Cause:** the sensor has been cut by more than 10% (for non-cuttable sensors), or by more than 60% (for cuttable sensors). The sensor has been incorrectly calibrated. Damage to the sensor's electrodes.	1. Calibrate the sensor. If this does not fix the problem, contact the manufacturer.

Lower limit of range exceeded F < Fmin–10% Code: 2.2 V	**Description:** fuel level shown is higher than actual level in tank, the sensor reports an error at intervals. **Explanation:** the error is encountered when the sensor is immersed to a depth close to the maximum, or – in case of shorting by water – to any depth. If the error switches to 'Generator frequency equals 0', it is caused by the presence of water or impurities in the fuel. **Cause:** the composition of the liquid measured differs from that of diesel or petrol. Periodic shorting of the measuring element in the tank by water or other impurities. The sensor has been incorrectly calibrated.	1. If the error manifests randomly at any level of fuel and the error code switches to 1.4 V ('Generator frequency equals 0') from time to time, follow the instructions for fixing the error coded by 1.4 V. 2. If the error manifests at a specific fuel level, the sensor must be calibrated. If this does not fix the problem, contact the manufacturer.

8 Marking Code

The sensor is manufactured in two versions.

Designation	Body	Averaging	Diagnostic Codes	Maximum Cuttable Length
ETS.AOM	metal	16 sec	yes	50%
ETS.AOУ	carbon plastic	16 sec	yes	50%

Each sensor is diestamped by the interrupted dot method with a 10-digit code marking:

Symbol Meaning	Type of ETS.A	Length Code	Device Code	Date						
Sequential number of code digit	1	2	3	4	5	6	7	8	9	10
Code example	2	3	L	3	6	3	9	6	4	1
Meaning	Analogue	700 mm	Fuel Level Sensor	14:55 22.03.2013						

Sensor Type	
2	Analogue, with diagnostic codes

Length Code	
1	350 mm
2	500 mm
3	700 mm
4	1000 mm
5	1400 mm
6	265 mm
7	680 mm
8	730 mm
9	750 mm
A	Non-standard length

Date — sensor production date, coded in UNIX time without the first and the two last symbols.

UNIX Time			
1	Time when marked	0	0

UNIX time can be converted at the URL: http://www.onlineconversion.com/unix_time.htm
Example. sensor code 22L3639641.
Meaning of example code:
2 – analogue sensor with diagnostic codes;
2 – sensor length: 500mm;
L – type code;
3639641 – coded timestamp:

- code sequence given: 3639641;
  - add '1' before first symbol and '00' after the last → 1363964100;
  - go to URL http://www.onlineconversion.com/unix_time.htm, enter the resulting sequence in the field *Unix timestamp* and press *Submit*. The field below will display the production date – Fri, 22 Mar 2013 14:55:00 GMT.

Figure 27. Conversion of UNIX Timestamp to Human Date

9 Transport and Storage

Transport

Transporting the sensor in its original packaging is allowed under the following conditions:

- ambient air temperature: −40 °C…+80 °C;
- relative humidity at 40 °C: < 95%;
- all covered means of transport are allowed.

Storage

The sensor may be stored in its original packaging under the following conditions:

- ambient air temperature: −40 °C…+80 °C;
- relative humidity at 40 °C: < 95%.

10 Distributor contatcs

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We will be happy to answer Your questions