

## General Description

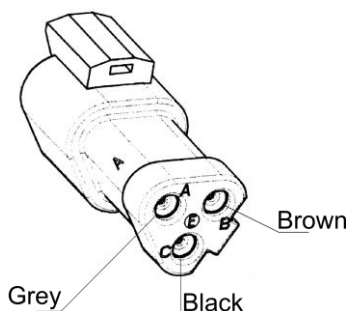
**ELS25** is a patented smart optical device, which is usually combined with a hydraulic steering cylinder. The main application is on rough terrain machines, to detect when the wheels are correctly aligned. The alignment occurs when the sensor detects a different refraction index zone, which is marked on the hydraulic cylinder's rod.

The product is based on reflective sensor as input stage, a computing unit (microprocessor device) and an output stage with high side driver, which can deliver up to 150mA.

The sensor includes "smart" functions and special algorithms that allow to continuously adapt the device to the wear of the system during the time, improve the life of the system, guarantee the high reliability (MTTF = 103 years at 24V) and be able to work in the harsh environment (temperature variations, rod wear, presence of electromagnetic disturbs, presence of humidity, shocks and vibrations). In addition, the particularity of this serie is that it provides diagnostic functions to auto detect possible failures. At every boot-up the ELS25 can collect information about the functioning of the logic unit, of the output stage and of the sensor module.

## Applications

Steering machines  
Surface cleaning machines  
Rough terrain machines  
Road building machines  
Construction machines  
Agricultural machines  
Logistic machines  
Loaders



## Features

- Especially designed for earth moving environment
- Diagnostic functions onboard
- MTTF = 103 years @ 24V
- Meets all ISO 7637-2 and ISO16750-2 requirements, including Load Dump at max levels
- Smart interface and smart algorithm
- High input voltage range
- High temperature range
- High current output
- IP67
- Inversion of polarity protection
- Overload protection

## Pin Functions

### ELS25

Cable color	Name	Function
Brown	V <sub>CC</sub>	Power Supply
Black	GND	Ground
Grey	OUT	Output (PNP)

## Ordering Information

**ELS25-DT-CE03** With a 60cm cable + DT04-3P-CE03

**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Min	Max	Unit
T <sub>s</sub>	Storage Temperature	-40	85	°C
T <sub>A</sub>	Operating Temperature Range	-20	80	°C
V <sub>CC</sub>	Supply Voltage Range		30	V
I <sub>o</sub>	Max output current (depending on ambient temperature)	-	150	mA

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.  
Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

**ELECTRICAL CHARACTERISTICS**

T<sub>A</sub> = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>CC</sub>	Supply Voltage Range	battery	8,5	24	30	V
V <sub>j</sub>	Jump start voltage allowable				36	V
OL	Overload protection (output shutdown)	8V < V <sub>CC</sub> < 30V	-	-	340	mA
I <sub>CC</sub>	Device current consumption	No load, whole voltage and temperature range		15	30	mA
I <sub>LOAD</sub>	Load current	8V < V <sub>CC</sub> < 30V	1	100	150	mA
V <sub>OH</sub>	Output voltage high	8V < V <sub>CC</sub> < 30V	V <sub>CC</sub> -0.7		V <sub>CC</sub>	V
V <sub>OL</sub>	Output voltage low	V <sub>CC</sub> = 30V R <sub>L</sub> <30kΩ	0		700	mV
R	Min detection range	I <sub>LOAD</sub> =100mA	3			ms
	Max detection speed (mark width of 3mm)				1	m/s
t <sub>D1</sub>	Setup and diagnostic functions	At the Boot-Up	590	600	610	ms
t <sub>D2</sub>	Diagnostic signal	At the Boot-Up	1590	1600	1610	ms
τ	Response time	ON-OFF I <sub>LOAD</sub> =100mA		20	30	us
		OFF-ON I <sub>LOAD</sub> =100mA		50	100	us

**MECHANICAL CHARACTERISTICS**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
IP	Protection grade	-			IP67	
Out	Output configuration	-		PNP		
Lc	Length tolerance (cable 3x0.5mm <sup>2</sup> )	-		± 20		mm

**RELIABILITY PARAMETERS**

Symbol	Parameter	Conditions	Value	Unit
MTTF	Mean Time To Failure	30°C, 24V	103	Years
DC	Diagnostic	At the Boot-Up	-	-
S	Structure	-	Not redundant	-

**MECHANICAL DIMENSIONS**

The dimensions are expressed in mm, tolerance  $\pm 0.1$ mm.

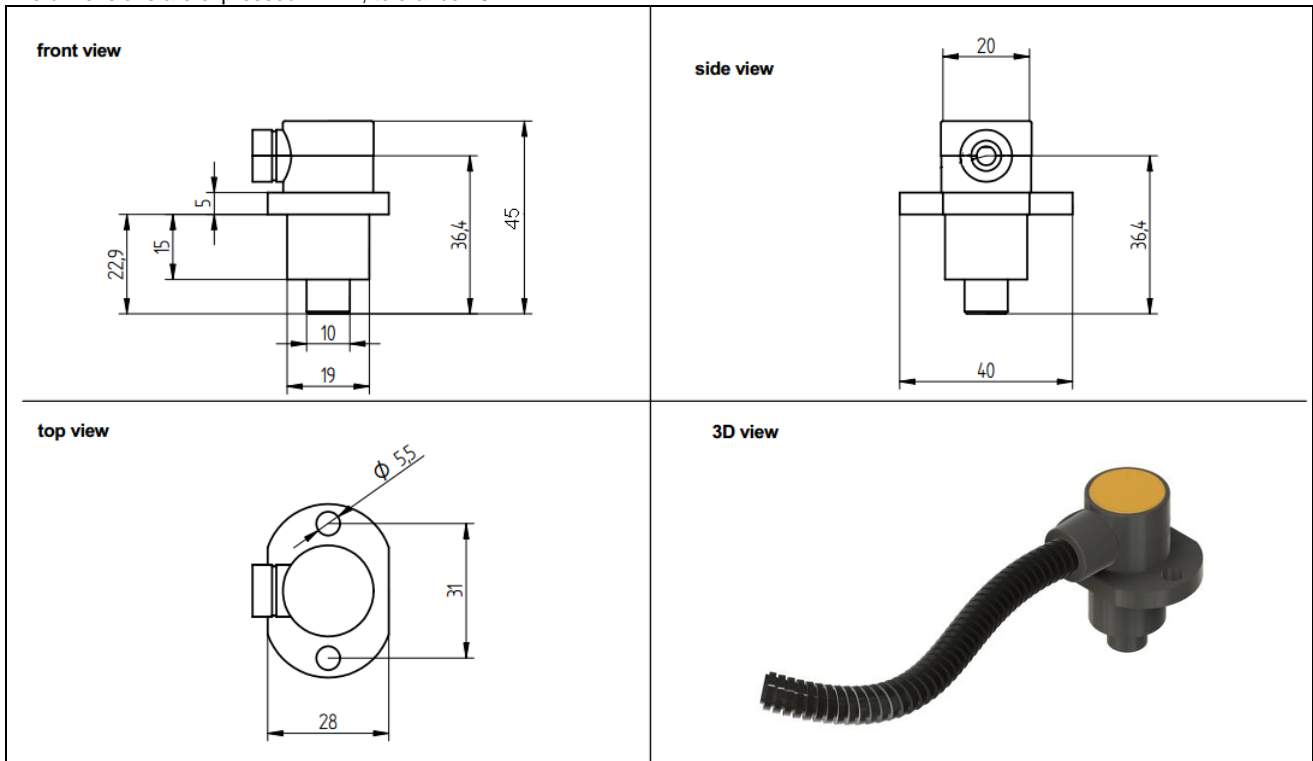


Figure 1 – Right angle version

**OUTPUT CONFIGURATION**

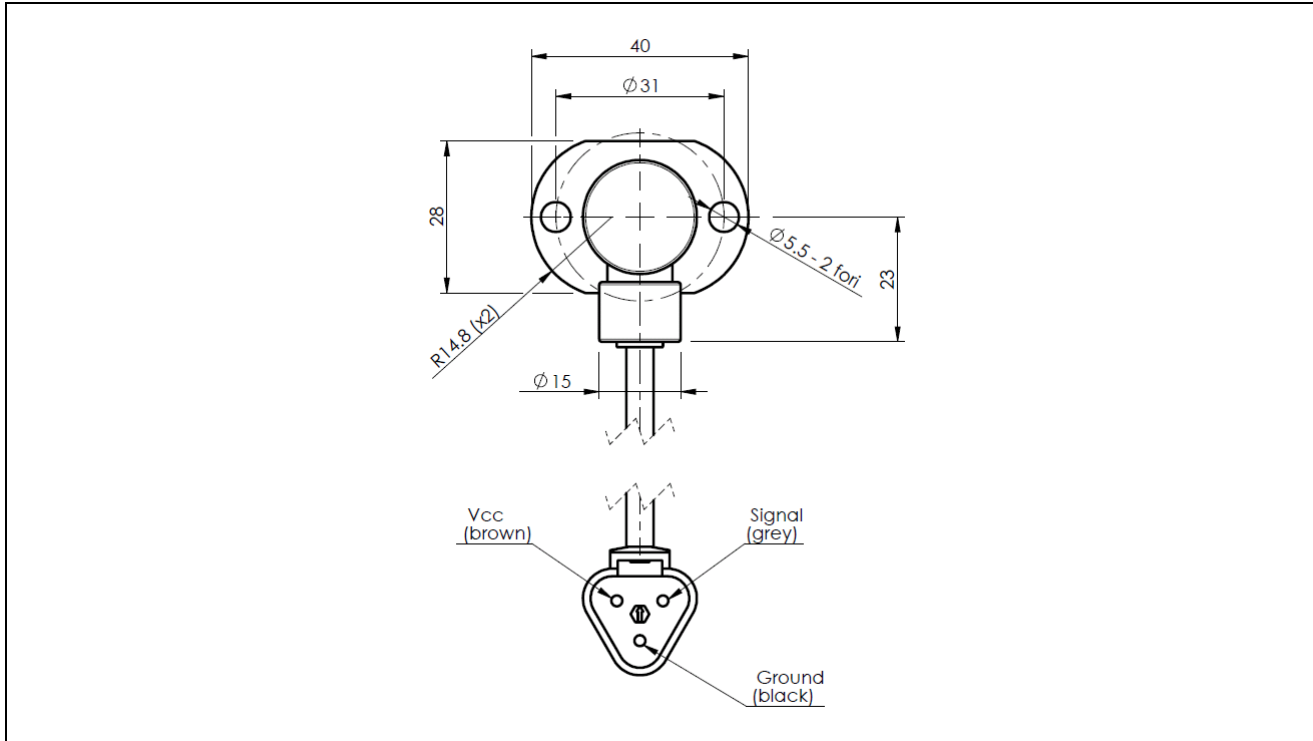


Figure 2 – ELS25-DT-CE03 configuration

REGULATORY COMPLIANCE TABLE

Reference norma-	Description	Test Type	Status
ISO13766 cl. 5.6	Earth moving machinery: broadband and narrowband emissions from ESA	Emission	pass
ISO13766 cl. 5.6	Earth moving machinery: immunity of ESA to electromagnetic radiation	Emission	pass
ISO13766 cl. 5.8-5.9	Immunity of ESA to electromagnetic radiated, bulk current injection, electrostatic discharge	Immunity	pass
EN 60068-2-6	Sinusoidal vibration test	Environmental test	pass
EN 60068-2-27	Shock test	Environmental test	pass
ISO 7637-2	Road vehicles - Electrical disturbances from conduction and coupling. Part 2: Electrical transient conduction along supply lines only	Immunity	pass
ISO 16750-2	Road vehicles - Environmental conditions and testing for electrical and electronic equipment. Part 2: Electrical loads	Immunity	Pass†
EN 60529	Degrees of protection provided by enclosures	Dust and water protection	IP67

Table 1 – Compliance table

† Load Dump pulse and Cranking pulse only.

## Application circuits

### RESISTIVE LOAD

A typical output load is a lamp. For such resistive loads no precautions shall be taken: the output stage is protected against reverse of polarity, short circuit and temperature. The power absorbed by the output stage is equal to  $R_{DS(ON)} * I_{load}$ .

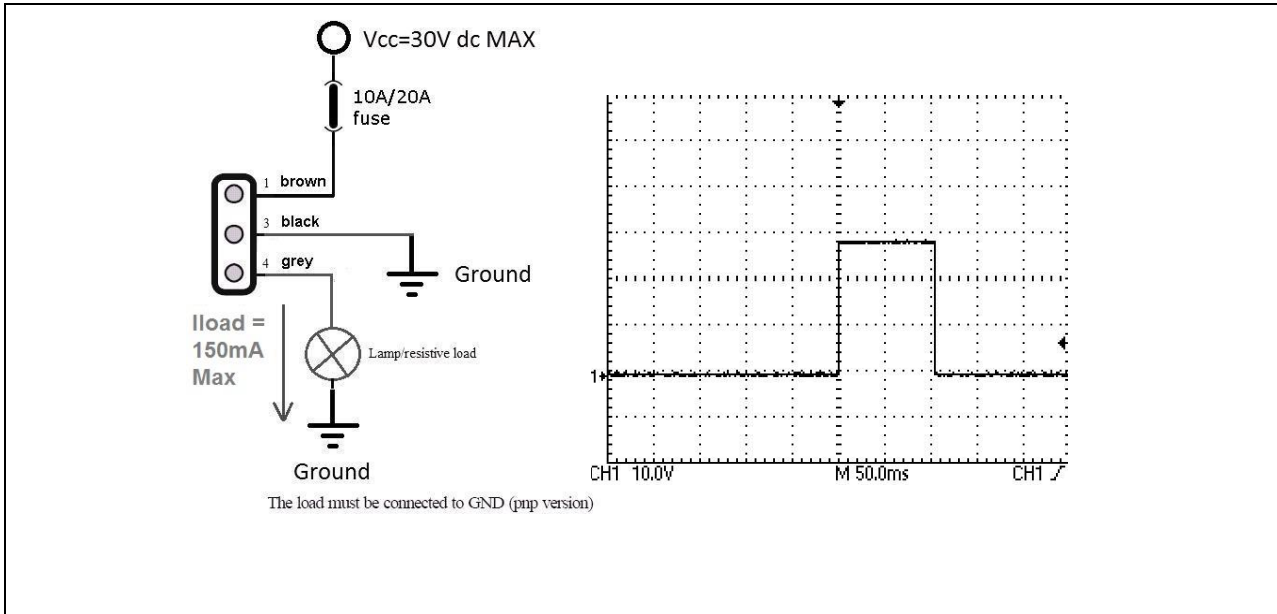


Figure 3 – Resistive load connection and  $V_{OUT}$  transition graph

### INDUCTIVE LOAD

Inductive loads are described by inductance L and resistance R. At switch ON, the inductive load causes a slow current ramp up, based on the time constant  $\tau=L/R$ . At switch OFF, due to inductance, the current attempts to continue to flow in the same direction, which causes the load voltage to invert.

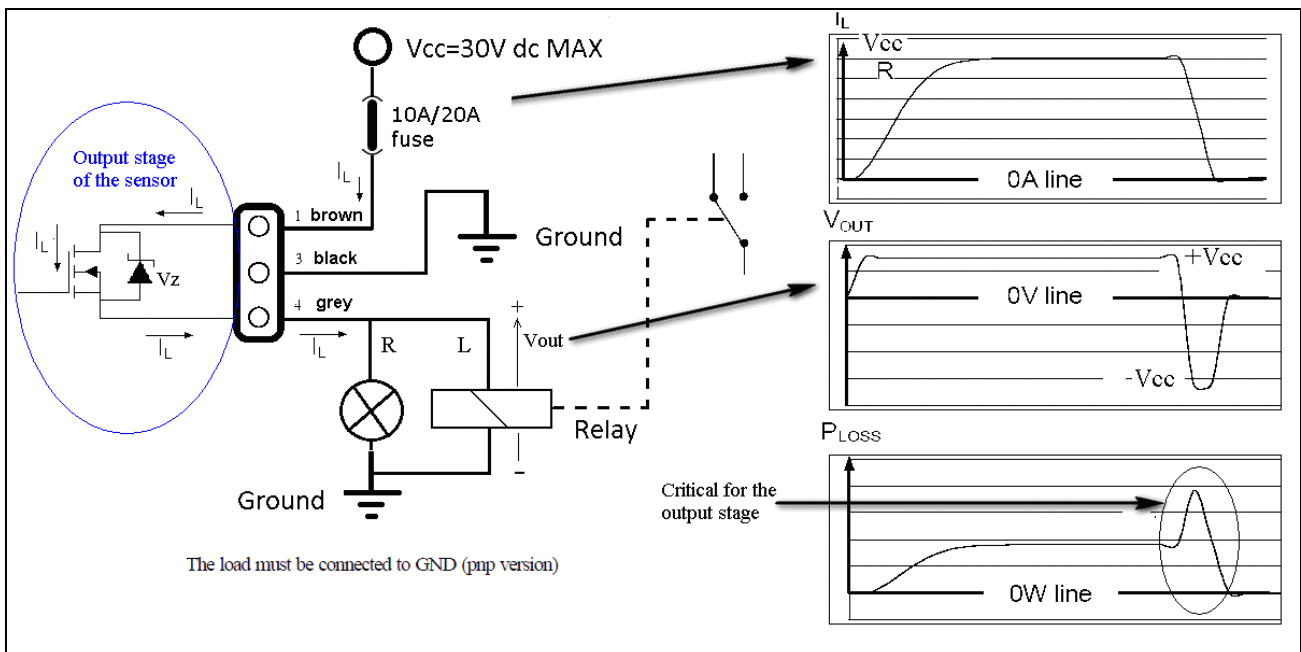


Figure 4 – Inductive load connection without protection

## ELS25

In this case, depending on the supply voltage and on the time constant, there is a real risk to break the output stage of the sensor. The output stage is composed of a logic stage, a power mosfet and a zener diode: the diode protects the output against overvoltages. If the  $V_{DS}$  of the output stage during the transitory becomes very high (double the  $V_{CC}$  value) for long period, it can destroy the mosfet or the zener protection diode inside the output stage. In order to avoid this possible situation, the use of a freewheeling diode in parallel to the load is recommended.

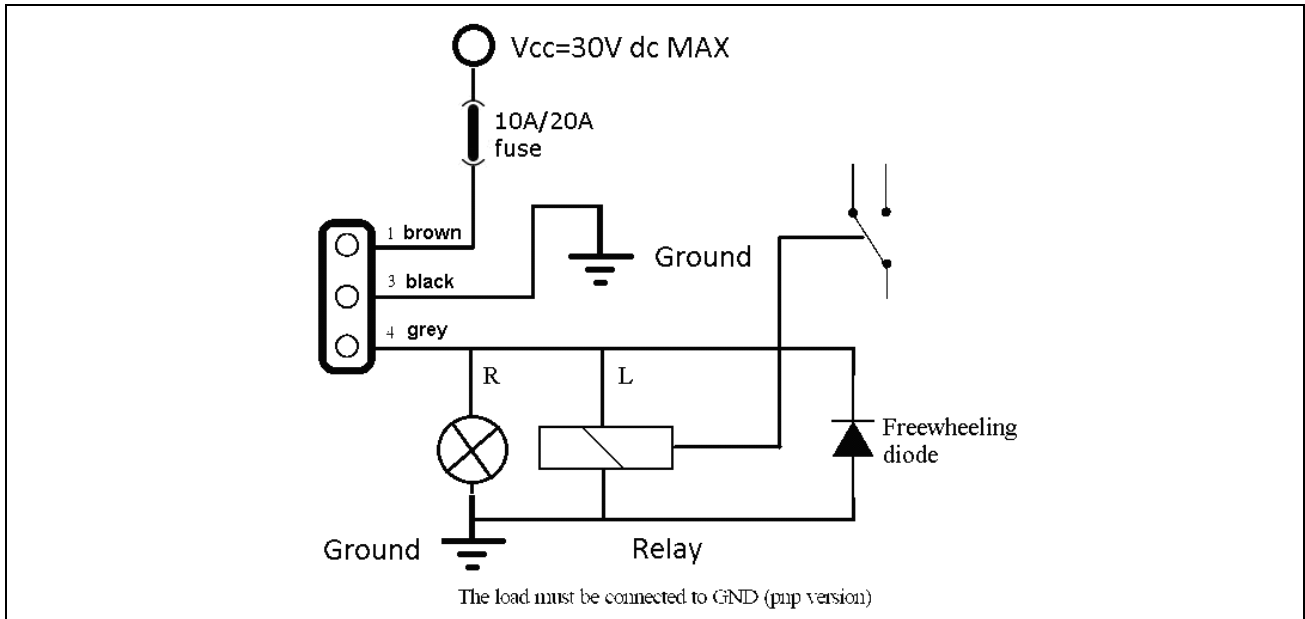


Figure 5 – Inductive load connection with protection freewheeling diode

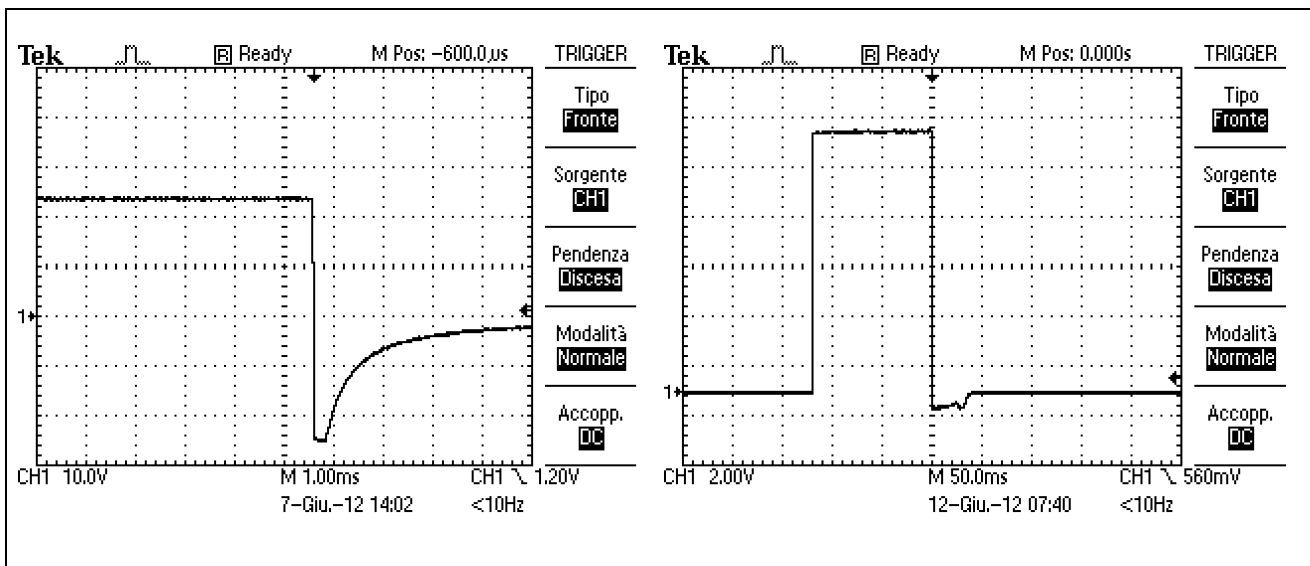


Figure 6 –  $V_{OUT}$  transitions without and with freewheeling diode

## Load dump considerations

Load dump means the disconnection of a powered load. It can cause large voltage spikes from the inductive generator(s). In automotive electronics, it refers to the disconnection of the vehicle battery from the alternator while the battery is being charged. Due to such a disconnection of the battery, other loads connected to the alternator see a surge in power line. Load dump may occur as a result of cable corrosion, poor connection or of intentional disconnection with the engine running. The pulse shape and parameters for an alternator with no centralized load dump suppression (Chap. 4.6.4 Test A ISO16750-2 2010.) are given in Figure 7 left side. The pulse shape and parameters for an alternator with centralized load dump suppression (Chap. 4.6.4 Test B ISO16750-2 2010) are given in Figure 7 right side. The ELS25 is protected against load dump disturbs (see Chap. 4.6.4 ISO16750-2 2010) at 24V: the load dump amplitude is suppressed (clamped) by the addition of two limiting devices, which preserve the electronic from these destructive pulses.

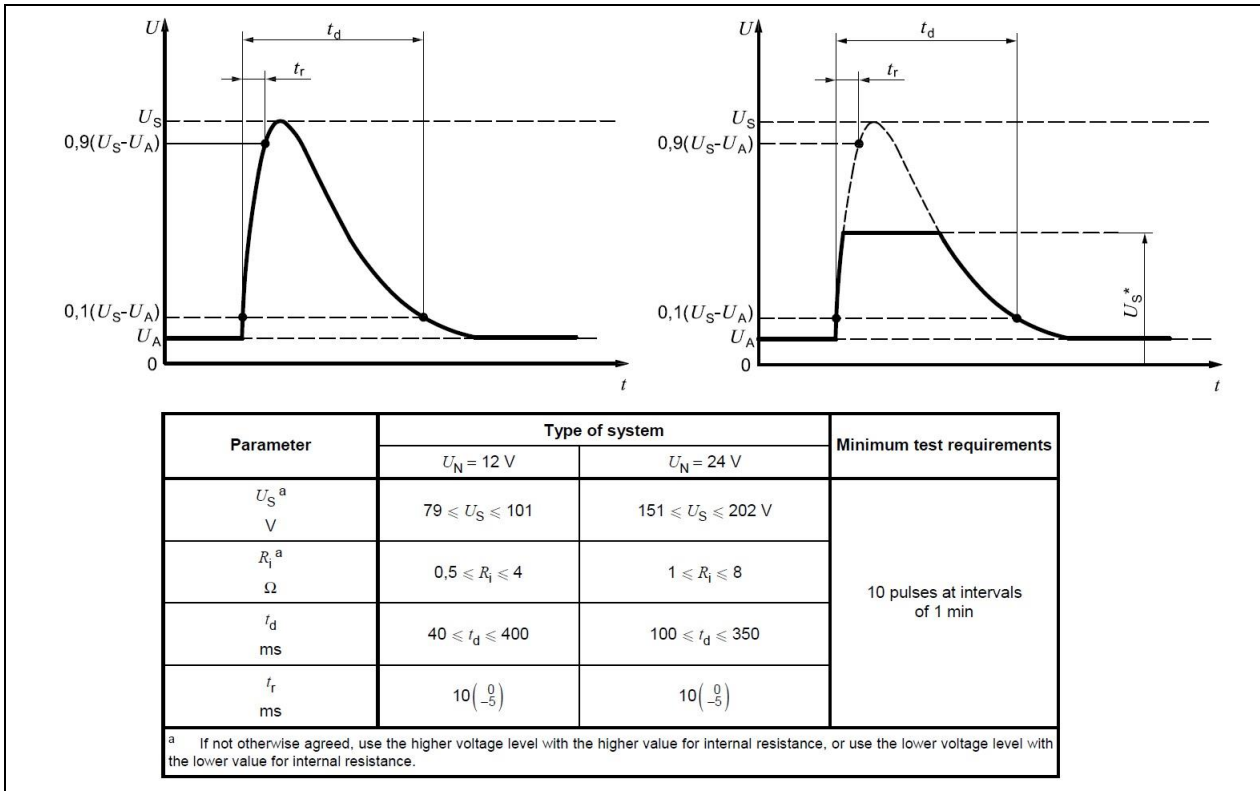


Figure 7 – Load dump typical waveform at 24V: test A (unsuppressed) and test B (suppressed)

**Diagnostic**

At the boot-up, the sensor enters automatically in diagnostic mode and, for the first 2.2 s the OUT pin is used as signalling output.

The implemented features can diagnose the functioning of:

- the logic unit
- the output stage
- the sensor module.

In case of failure of at least one of this function, the sensor stops working and the results of the diagnostic functions are stored in EEPROM (the EEPROM can be read only by the producer).

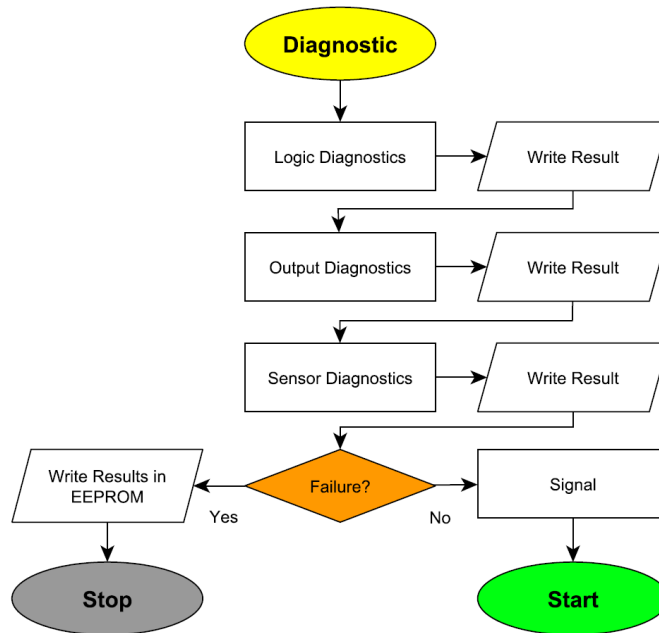


Figure 8 – Diagnostic flow chart

**Note:** it is important to avoid the shut down of the sensor during the diagnostic phase. A sudden disconnection of power may cause a wrong diagnosis, and, in this case, a new boot up/restart is required.

**Note:** in order to function properly, the diagnostic must be started only when the sensor is positioned within its cylinder.



**SIGNAL**

Initially, the system takes 600 ms for the initialization and for the processing of the diagnostic functions. Successively, the sensor functioning state is communicated by means of a 1.6 seconds signal.

The signal is composed by 3 transitions of the duration of 200 ms each (ON-OFF-ON) and by a successive OFF state of the duration of 1 s. At the end of the signal, the sensor enters in operational mode.

In case of failure of any of the diagnosed parts, the output remains OFF, excluding the operational mode.

**Note:** the first 600 ms of the period of 2.2 s are not significant for the state signalling function. During this time the output changes are caused by the setup phase of the microcontroller and execution of the diagnostic functions.

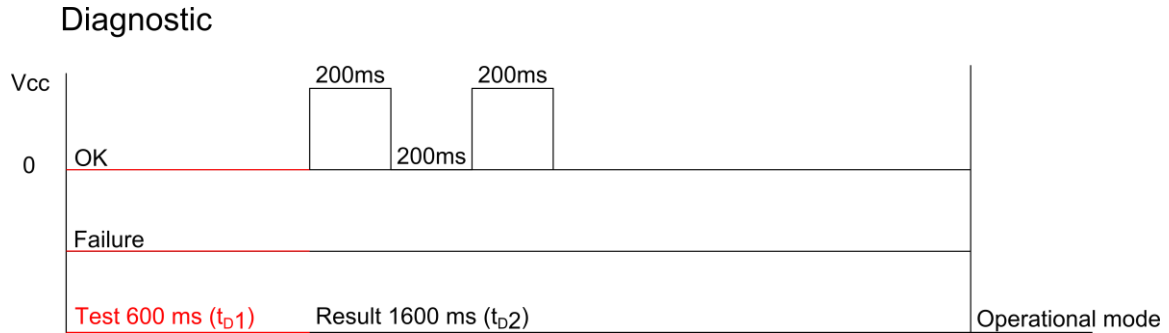


Figure 9 – Diagnostic signal

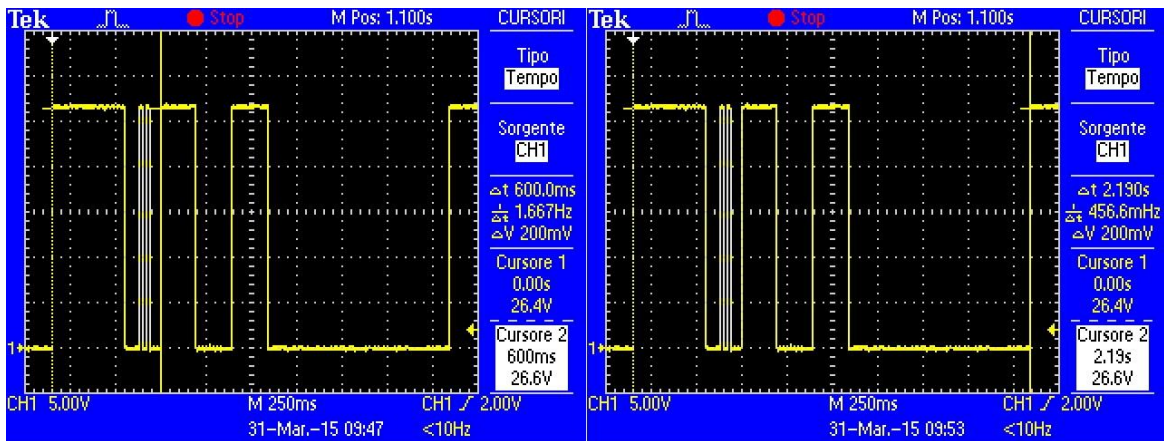


Figure 10 – Diagnostic signal – Oscilloscope

**LOGIC UNIT**

The sensor uses the EEPROM memory embedded in the microcontroller to save some functional parameters. The most important parameter is the gain value of the optical sensor which is set during the calibration phase. To ensure the consistency of the data, the gain value is combined with a 5 bytes hex code and the sequence so obtained is processed to calculate the CRC-8 value (CCITT polynomial).

EEPROM	
Address	Value
0x00	Factory Parameters
0x01	
0x02	
0x03	
0x04	
0x05	
0x06	Sensor Gain Hex Code
0x07	
0x08	
0x09	
0x0A	
0x0B	CRC-8
0x0C	
...	...
0xFD	Logic Fail
0xFE	Output Fail
0xFF	Sensor Fail

**Figure 11 – EEPROM structure**

At every boot-up, the sensor reads from EEPROM the gain value and the 5 bytes code, re-calculates the CRC-8 value and compares it with the CRC-8 value stored in EEPROM. If they are equal, the data stored in memory are valid and there is no memory corruption, otherwise a logic unit failure is reported.

**Note:** During the functioning, the execution of the software is monitored by a watchdog timer. In case of anomalous delays, the sensor resets itself and the diagnostic will be repeated.

## OUTPUT STAGE

The output stage is diagnosed by means of a serie of sequential changes on the component (OFF-ON-OFF-ON-OFF).

The output driver is controlled by the MCU by means of a digital pin; at every transition, thanks to an analog feedback pin, the MCU acquires 16 samples, it calculates the average value and it determines if the output stage is correctly responsive. The output state thresholds are the following:

- OFF < 1,5V.
- ON > 7,5V.

If all the transitions were positive it means that the output stage works correctly, otherwise an output stage failure is reported.

Figure 12 shows the output stage diagnostic and the time duration of one (left) and five (right) transitions.

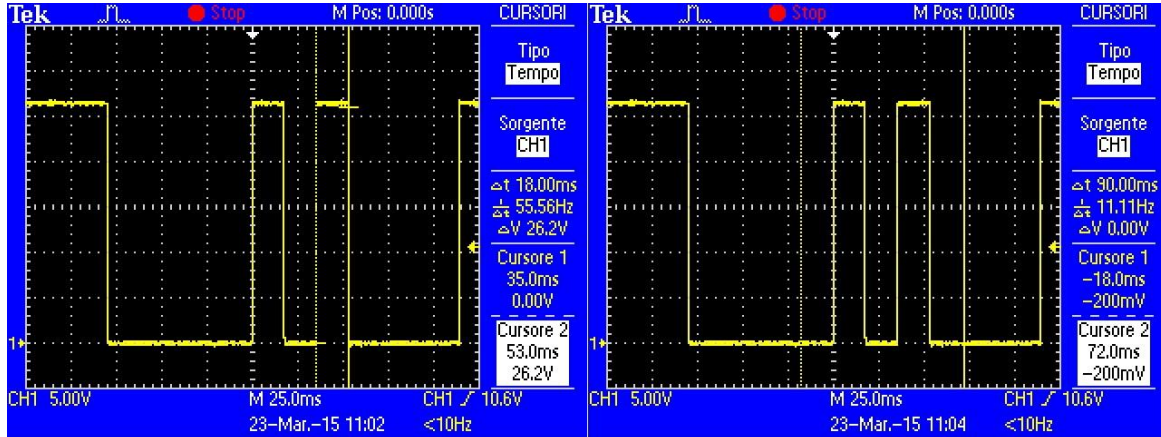


Figure 12 – Output stage diagnostic detail – Oscilloscope

## SENSOR MODULE

The sensor module is represented by a light emitting diode, a photo receiver and an amplifier. The functioning of the input stage is tested analyzing the sensor response with different gain values. Thanks to a special algorithm, based on gain variations, it is possible to test the correct functioning of every component. If one of them does not respond as expected, a sensor module failure is reported.