Ultrasonic level sensor
DQL011.1

User manual

Updt. 07/03/2022

Table of contents

1 Introduction

1.1 Main features

DQL011.1 is an ultrasonic sensor for measuring the height of the snowpack.

The robust design of DQL011.1 makes it the ideal solution for reliable measurement of snow-depth in extreme conditions. The additional air temperature detection feature guarantees precise readings over a wide temperature range.

The ultrasonic impulses emitted by this sensor deliver reliable readings even when there is a difficult reflection ratio, as is the case with powdery or fresh snow. The sensor is characterized by a high level of operating reliability, low energy consumption and ease of use in the field.

It has two 4÷20 mA current analog outputs, for snow level and air temperature, and one of the RS-485 serial type with Modbus RTU protocol.

DQL011.1 can be connected to LSI LASTEM data logger to other systems that use the same type of inputs.

1.2 Technical specifications

	DQL011.1	
Snow level	Principle	Ultrasonic (frequency 50 Hz)
	Measurement range	0.7÷10 m (snow distance from the sensor)
	Resolution	1 mm
	Accuracy	<0.1% full scale
	Beam width	12°
Air temperature	Principle	Semiconductor in radiant shield
	Measurement range	-40÷60 °C
	Resolution	0.1 °C
	Accuracy	<0.15%
General information	Power supply	9÷28 Vdc
	Power consumption	Typically: 40 mA, 300 mA (peak, 50 ms), 0.4 mA (stand-by)
	Energy consumption	0.5 Ah/day (1 min measuring interval)
	Serial output	RS- 485 with Modbus RTU protocol: • Snow level • Snow distance • Air temperature • Status of snow
	Analog outputs	Current 2 x 4÷20 mA • Snow level or distance • Air temperature
	Electrical connection	8 pin connector
	Operative temperature	-40÷60 °C
	Protection grade	IP 66
	Weight	1.2 kg
	Material	Aluminum
	Installation	H 3÷10 m (default 3 m) using DYA047 support on Ø 45÷65 mm mast
	Data logger compatibility	M-Log, R-Log, E-Log, ALIEM, Alpha-Log

2 Installation

For the installation of the DQL011.1 sensor, choose a site representative of the monitored area, which is exposed to the wind as little as possible, free of buildings, trees, boulders, fences and other surrounding obstacles that could alter the measurements. The terrain must be flat or only slightly sloping. Also, for safety, the site should be safe from possible avalanches.

2.1 General safety standards

Read the following safety standards to avoid personal injuries and to prevent damages to this product or to the devices connected to it. Use this product strictly in the indicated way to avoid damages.

Only the support staff is authorized to perform the setup and managing procedures.

Power the instrument properly. Observe the power voltage indicated for the instrument model owned.

Connect the instrument properly. Follow meticulously the wiring diagram provided with the equipment.

Do not use the product if a malfunction presence is suspected. If the existence of a malfunction is suspected, do not power the instrument and ask for assistance to the qualified support staff.

Before any operation on electrical connections, power, sensors and communication devices:

- turn off the power
- discharge the accumulated electrostatic charges touching a conducting material or a grounded device

2.2 Mechanical installation

It is recommended to mount the DQL011.1 sensor one meter above the maximum expected level and minimum 3 m above ground. If a snow-depth monitoring site needs to be secured by a fence, the distance between the fence and the sensor should be large enough to avoid snow build-up or snow drift.

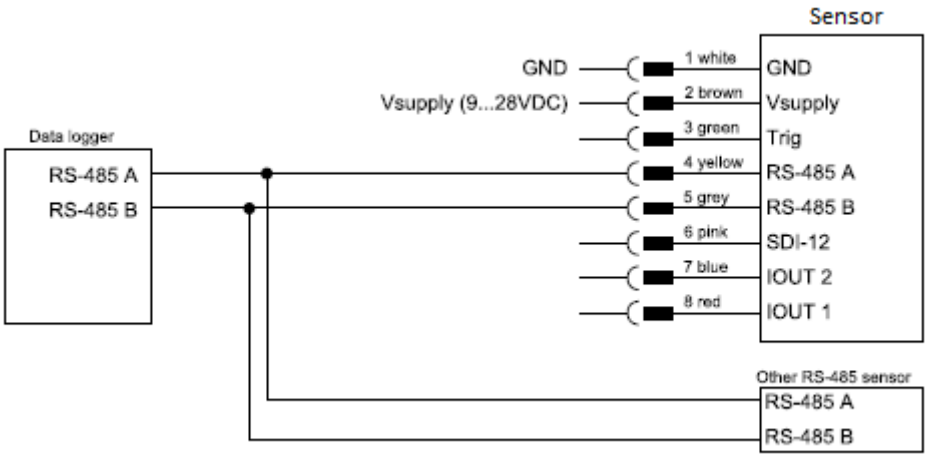
For installation, refer to the documentation supplied with the DQL011.1 sensor.

2.3 Electrical connections

All connections are made through the 8-pole male connector located on the side of the DQL011.1 sensor. The following table shows the numbering and function of the connector contacts.

Connector pin	Color	Signal	Description
1	White	GND	Common analog output / Negative power supply
2	Brown	V +	Positive power supply (9÷28 Vdc)
3	Green	Trig	Positive serial reception (input)
4	Yellow	RS-485 A	“DATA +” RS-485 (D+) output
5	Grey	RS-485-B	“DATA –” RS-485 (D-) output
6	Pink	SDI-12	SDI-12 output
7	Blue	IOUT-2	Positive analog output 2 (air temperature)
8	Red	IOUT-1	Positive analog output 1 (level/distance)

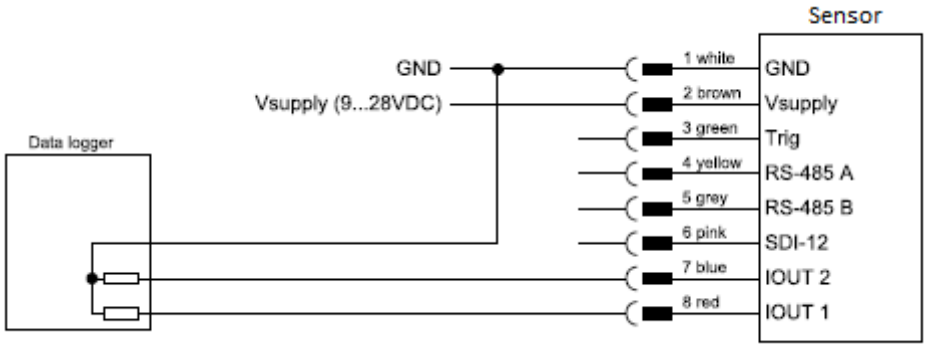
2.3.1 RS-485 serial connection



For more information about RS-485, consult l'EIA (Electronic Industries Association).

2.3.2 Analog output connection

The OUT 1 and OUT 2 outputs are associated respectively with the level (or distance) of the snow and the air temperature.



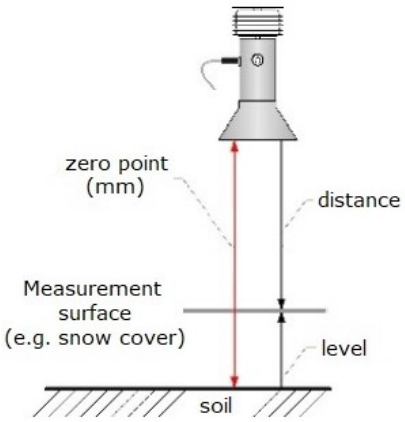
2.3.3 Connection to LSI LASTEM data loggers

To connect the wires to the LSI LASTEM data loggers, refer to the documentation supplied with the DQL011.1 sensor.

2.4 Testing and adjustment

After mounting the DQL011.1 it is advisable to adjust some parameters related to its position.

1. Access to the sensor configuration (§3.1).
2. Enter in *Level and distance* menu.
3. Go to *Level/distance test…* to perform a test reading.
4. Modify the *Distance to zero level* parameter according to the value read in the test of point 3.
5. Press X to return to the main menu, then access to *Technics* and then *IOUT1 settings*.
6. Modify the parameter *IOUT1, 4-20 mA span* according to the value read in the test of point 3.
7. Press X to return to the main menu.
8. Repeat point 3 to check the accuracy of the measurement. If necessary, repeat the adjustment procedure.



3 DQL011.1 Sensor configuration

DQL011.1 is already configured for use with LSI LASTEM data loggers, with both current and Modbus RTU output. These are the operating parameters:

General settings	
A - Measurement trigger	All allowed (interval, trig input, serial command)
B - Measurement interval	60 s
CD - Distance to zero level	3000 mm
CE - Application	snow
DJA - Baudrate	9600 bps
DJB - Parity, stop bits	no par, 1 stop
DJE - Flow control	off

Analog output	
DFA - Output status	Just during trig
DFB - IOUT1, function	Level
DFC - IOUT1, 4-20 mA span	3000 mm
DFD - IOUT1, 4 mA value	0 mm
DFE - IOUT2, function	value, temperature

Digital output	
DIC - Output protocol (OP)	Modbus
DID - OP, measurement output	Just per command
DII - MODBUS, device address	1

Below are other parameters that differ from the default configuration.

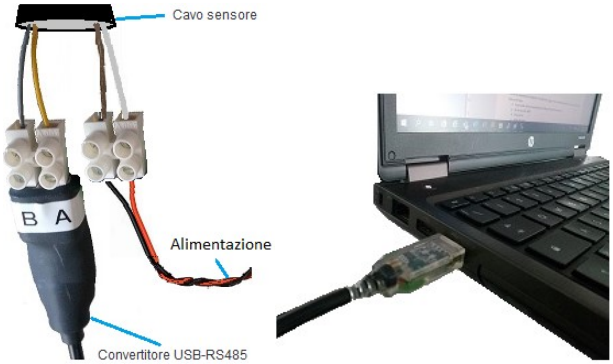
Parameter	**Value**
CF - Moving filter, duration	180 s
CG - Moving filter, type	elim. all spikes
DID - OP, measurement output	just per command
DIE - OP, information	& analysis values
DJC - Minimum response time	30 ms
DJD - Transmitter warm-up time	10 ms

3.1 Access to the configuration

By means of a terminal emulation program, such as Windows Hyper terminal, it is possible to modify the sensor configuration parameters from the PC by connecting via the USB / RS-485 cable supplied.

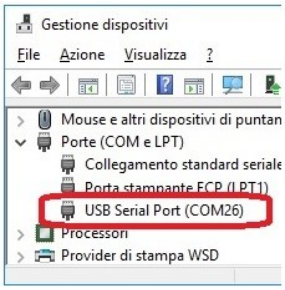
To access the configuration, proceed as follows:

1. Connect the cable with the L-connector to the sensor.
2. Connect the cable wires to the USB/RS-485 converter:
   - yellow: *terminal A*
   - gray: *terminal B*
3. Connect the cable wires to the power supply*:
   - brown: *+ Vcc*
   - white: *- Vcc*



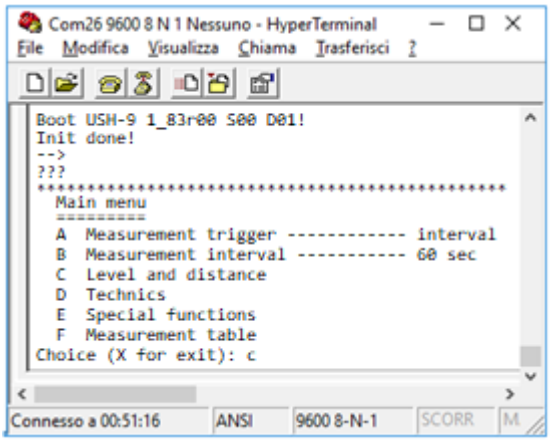
*E-Log and ALIEM supplies 12 Vdc on terminals 31+, 32-, while M-Log and R-Log on terminals 28-, 30+. Alpha-Log on terminals 14+, 16-.

4. Connect to the PC the USB/RS-485 device supplied and identify the serial port associated to the device.
5. Start the terminal emulation program and choose the serial port number identified in the previous point, then set the communication parameters to *9600* bps, *8* data bits, *None* Parity, *1* Stop bit, *No* flow control.



When the sensor is switched on, the message appears on the terminal:

Boot USH-9 1_83r00 S00 D01!
Init done!



Press the **?** key three times to access to the configuration menu.
The menu items can be selected by entering the letter assigned to each item. Upon selection a submenu is opened, or the selected parameter is displayed with its unit. Changes to values are confirmed with **Enter** or discarded with **Esc**. Menus are closed with **X**.
After closing the main menu with **X** the sensor performs an initialization.

The meaning of the most important operating parameters is reported in the following chapters.

3.2 General settings

3.2.1 Measurement trigger

Measurements are initiated by one of the options listed in the table below.

Option	Value	Description
1	Interval (default)	Measurements are initiated in a specified interval.
2	TRIG input	Measurements are triggered by the positive edge of a DC-voltage signal applied to the TRIG input (low: 0 ... 0.6 V, high: 2.2 ... 28 V, pulse duration must be ≥500 ms, delay between pulses must be ≥500 ms).
3	SDI-12/RS-485	Measurements are externally triggered by commands via RS-485 or SDI-12 from, i.e., a data logger.
4	All allowed	Measurement is triggered by all options mentioned above.

3.2.2 Measurement interval

An internal measurement interval can be set. If selected in menu item *Measurement trigger*, measurements are performed in the defined interval. However, a measurement is always completed before a new one is initiated.

3.2.3 OP, information

The main measurement values are always included in the data output string. Additionally, special and analysis values can be included.

Option	Value	Description
1	main values	Only the main values are returned.
2	& special values (default)	Main values and special values are returned.
3	& analysis values	Main, special and analysis values are returned.

3.3 Level/distance measurements

3.3.1 Distance to zero level

It is the distance between the sensors lower edge and the ground surface (e.g. lowest point of river bed, ground without snow).

3.3.2 Application

It activates the settings for specific applications as listed in the following table:

Option	Value	Description
1	snow (default)	Settings for snow applications are active. These settings include precipitation detection and snowfall limits (see *Status limits* and *Advanced settings* menu). Rate of change filtering (*RoC, max. without precip. (./h)* and *RoC, max. at precip. (./h)*) is active.
2	water	Settings for water application are active. Precipitation detection and rate of change filtering (RoC) are deactivated.
3	others	Settings for water and snow applications are inactive. Used for generic level/distance measurements. A constant rate of change filter (*Rate of change, maximum (./h)*) is active.

ATTENTION! By default the sensor is configured for snow-depth measurements. If the instrument is used for water level monitoring, adapt its configuration for water level measurements (§3.4.2).

3.3.3 Moving filter, duration

Every level/distance measurement is stored internally in a buffer for filtering. This setting defines the length of the time window of which the data are stored in the buffer. If the buffer is full, the oldest value is replaced by the most recent one.

3.3.4 Moving filter, type

The level/distance values in the buffer can be filtered by one of the following options:

Option	Value	Description
1	average	The mean value of all buffered values is calculated.
2	elim. neg. spikes	To eliminate negative spikes, the mean value is calculated without the 5 lowest buffered values. If the buffer size is smaller than 10, half of the values are eliminated.
3	maximum	The highest value from the buffer is returned.
4	median	The median value of the buffered data is returned.
5	elim. pos. spikes	To eliminate positive spikes, the mean value is calculated without the 5 highest buffered values. If the buffer size is smaller than 10, half of the values are eliminated.
6	elim. all spike (default)	To eliminate positive and negative spikes, the mean value is calculated without the 5 highest and 5 lowest buffered values. If the buffer size is smaller than 15, two third of the values are eliminated.

3.4 Application

3.4.1 Configuring the DQL011.1 sensor for snow measurements

By default the sensor is configured for snow applications. This can be checked in the setting *Application*, which is set to *snow*.
If the sensor needs to be re-configured for snow applications, set:

- *Application* to *snow*.
- *Moving filter, duration* to *180* seconds.
- *Moving filter, type* to *elim. all spikes*.

ATTENTION! Make sure to upload the modified parameters to the sensor and test the new settings (§2.4).

3.4.2 Configuring the DQL011.1 sensor for water level measurements

If the sensor is used for level monitoring, set:

- *Application* to *water*.
- *Moving filter, duration* to *0* seconds.
- *Moving filter, type* to *median*.

ATTENTION! Make sure to upload the modified parameters to the sensor and test the new settings (§2.4).

3.5 Data output

The measurement values returned by the sensor are arranged in a fixed sequence and identified by an index. They are divided into three groups and can be selected in *OP, information*.

3.5.1 Main values

Index	Value (measurement unit)	Description
01	Level (mm)	Level measurement.
02	Distance (mm)	Distance measurement.
03	Temperature (°C)	Air temperature measurement.
04	Status (-)	Status of snow cover, 3-digit number: • 100 snowfall • 010 snow cover emerges • 001 snow-depth limit exceeded Combinations may occur, e.g. 110, signaling that snowfall and an emerging snow cover are detected.

NOTE! Status is a logic combination of the parameters listed in menu *Status limits*.

3.5.2 Special values

Index	Value (measurement unit)	Description
05	Precipitation (-)	Dimensionless value representing precipitation type and intensity. Its range is 0 to 1000, where 1000 is the most intensive precipitation that can be expected. The value strongly depends on the type of precipitation: wet snow that falls in large flakes gives high values, cold, small flakes give lower values even though snowfall can be intense. Rain generally gives lower values than snow. The precipitation value is used to optimize the rate of change filter (RoC) that is affected by reflections of precipitation. It cannot substitute a rain gauge.
06	Signal quality (dB)	SNR (signal to noise ratio).
07	Std. deviation (mm)	Standard deviation of the measured level.
08	Supply voltage (V)	Power supply voltage.

3.5.3 Analysis values

Index	Value (measurement unit)	Description
09	Signal focus (dB)	Diagnostic variable.
10	Signal strength (dB)	Diagnostic variable.
11	Half-value width (%)	Diagnostic variable.
12	Noise ratio 50 (%)	Diagnostic variable.
13	Noise ratio 85 (%)	Diagnostic variable.
14	Echo amp. (-)	Diagnostic variable.
15	Var. 1 (-)	Diagnostic variable.
16	Var. 2 (-)	Diagnostic variable.
17	Var. 3 (-)	Diagnostic variable.
18	Dist. max. echo (mm)	Diagnostic variable.
19	Dist. last echo (mm)	Diagnostic variable.
20	Distance 0 C (mm)	Diagnostic variable.
21	Case temperature (°C)	Diagnostic variable.
22	Error code1 (-)	Diagnostic variable.

3.5.4 Exception values

Value	Description
9999.998	Initial value: No measurement has been performed yet (position of decimal character is irrelevant).
9999.997	Conversion error: Caused by a technical problem (position of decimal character is irrelevant).
9999999	Positive overflow.
-9999999	Negative overflow.

3.6 RS-485

3.6.1 OP, measurement output

The serial data output can be triggered in the following ways:

Option	Value	Description
1	just per command	The output is only requested by commands via the RS-485 or SDI-12 interface.
2	after measurement (default)	The serial data output is performed automatically right after each measurement.
3	pos. TRIG slope	The output is triggered by a positive edge of a control signal applied to the trigger input.

NOTE! If *OP, measurement output* is set to *pos. TRIG slope*, the data are returned with a delay of 200 ms after the trigger has been set. Make sure that your data acquisition system takes account of this lag to ensure that it receives the most recent data.

The selected combination of *Measurement trigger* and *measurement output* determines the following operation modes:

Parameter	Operation mode		
	Pushing	Polling	Apparent polling
Measurement trigger	internal	TRIG input SDI-12/RS-485	TRIG input SDI-12/RS-485
OP, measurement output	after measurement	just per command	after measurement

4 LSI Lastem data logger configuration

The DQL011.1 sensor is configured to work with both analog and digital outputs. Configure the type of sensor output based on the data logger in use.

	Sensor outputs	
Data logger	**Analog (2 x 4÷20 mA)**	**Digital (RS-485 Modbus RTU)**
Alpha-Log		X
ALIEM	X	
E-Log	X	X
M-Log	X	X
R-Log	X	X

4.1 Use of analog outputs

To use the sensor with analog outputs, start the 3DOM program and proceed as follows:

- Open the current configuration of the data logger.
- Add the *DQL011.1 An* sensor from the sensor library.
- Then, for each measurement:
  - In the *General* tab, adapt the name to the type of measurement selected (distance or level). If you use multiple sensors of the same type, customize the name of the measures to distinguish them from each other.
  - In the *Parameters* tab, modify the parameters of the *User scale* based on the values set in the IOUT1 output of the sensor (§2.4).
  - In the *Elaborations* tab, choose the desired elaborations.
- Save the configuration and send it to the data logger.

4.2 Use of digital output

To use the sensor with analog outputs, start the 3DOM program and proceed as follows:

- Open the current configuration of the data logger.
- Add the *DQL011.1 Dig* sensor from the sensor library. If the data logger in use is Alpha-Log, you will be asked to set the Modbus as input type and the communication parameters of the serial port where the sensor will be connected.
- Then, for each measurement:
  - In the *General* tab, adapt the name to the type of measurement selected (distance or level). If you use multiple sensors of the same type, customize the name of the measures to distinguish them from each other.
  - In the *Elaborations* tab, choose the desired elaborations.
- If the data logger in use is E-Log, set the Modbus protocol and the communication parameters of the sensor in the serial line 2 of the data logger.
- Save the configuration and send it to the data logger.

5 Modbus-RTU

The DQL011.1 sensor implements the Modbus protocol in RTU slave mode.

5.1 Supported commands

The sensor supports the *Read input registers (0x04)* command for accessing the acquired data.
If the data request refers to an incorrect command or register, the sensor does not generate any response message.

5.2 Map of registers

Main value

# Register	Register address	Data	Bytes	Format
1	0x00	2.7519 hardcoded test value	4	float
2	0x02	Level (mm)	4	float
3	0x04	Distance (mm)	4	float
4	0x06	Air temperature (°C)	4	float
5	0x08	Status (-)	4	flaot

Special values

# Register	Register address	Data	Bytes	Format
6	0x10	Precipitation (-)	4	float
7	0x12	Signal quality (dB)	4	float
8	0x14	Std. deviation (mm)	4	float
9	0x16	Supply voltage (V)	4	float

Analysis values

# Register	Register address	Data	Bytes	Format
10	0x18	Signal focus (dB)	4	float
11	0x20	Signal strength (dB)	4	float
12	0x22	Half-value width (%)	4	float
13	0x24	Noise ratio 50 (%)	4	float
14	0x26	Noise ratio 85 (%)		
15	0x28	Echo amp. (-)		
16	0x30	Var. 1 (-)		
17	0x32	Var. 2 (-)		
18	0x34	Var. 3 (-)		
19	0x36	Dist. max. echo (mm)		
20	0x38	Dist. last echo (mm)		
21	0x40	Distance 0 C (mm)		
22	0x42	Case temperature (°C)		
23	0x44	Error code1 (-)		

The Modbus address of the sensor is 1 while the communication parameters are set to 9600 bps, no parity, 8 bits, 1 stop bit and no flow control.

For more information about the Modbus-RTU protocol, visit the website www.modbus.org.

6 Maintenance

6.1 Periodic maintenance

The absence of moving parts minimizes sensor maintenance. However, the device should be inspected occasionally for damage and a dirty sensor surface. To remove dirt use a wet cloth with little force.

ATTENTION! Do not use any abrasive detergent or scraping tool.

6.2 Testing

This type of testing is only required if the user wishes to verify the well functioning of each part of the instrument. Please note that these tests are not intended to establish the operational limitations of the instruments.

Functional check for 4÷20 mA current output

To check the current output, you can use the *Simulate current output...* function.
The operation requires the use of a PC, equipped with an RS-232 port, with a terminal emulation program and the USB/RS-485 cable supplied.

1. Connect the PC to the sensor and access the configuration (§3.1).
2. Enter in the *Technics* menu, then *IOUT Settings*.
3. Choose the *Simulate current value…* function and enter the level/distance value to simulate.
4. Connect the multimeter to the first analog output (§2.3.2) and take the corresponding measurement.

In the table below some example value with the sensor scale set to 0÷3 m:

Value (mm)	Level / Distance output (mA)
0	4 / 20
1500	12
3000	4 / 20

Functional check for RS-485 Modbus-RTU output

The RS-485 digital output can be checked using a PC, equipped with an RS-232 serial port, with the third-party modpoll program (https://www.modbusdriver.com/modpoll.html) and the USB / RS-485 cable supplied.

1. Connect the PC to the sensor and access the configuration (§3.1).
2. Open a DOS Prompt window and type the following command (it is assumed that the transmission parameters are set as follows: *Baudrate: 9600 bps*, *Parity: None* and that the PC serial port used is COM1):

   modpoll -a 1 -r 2 -c 5 -t 3:float COM1 [Enter]

   For the list of available commands, type the command *modpoll /help*.
   [CTRL] + [C] to stop the program.

7 Disposal

This product is a device with high electronic content. In accordance with the standards of environmental protection and collection, LSI LASTEM recommends handling the product as waste of electrical and electronic equipment (RAEE). For this reason, at the end of its life, the instrument must be kept apart from other wastes.

LSI LASTEM is liable for the compliance of the production, sales and disposal lines of this product, safeguarding the rights of the consumer. Unauthorized disposal of this product will be punished by the law.

8 How to contact LSI LASTEM

In case of problem contact the LSI LASTEM technical support sending an e-mail to support@lsi-lastem.com, or compiling the technical support request module at www.lsi-lastem.com.

For further information refer to addresses and numbers below:

- Phone number: +39 02 95.414.1 (switchboard)
- Address: Via ex S.P. 161 – Dosso n. 9 - 20049 Settala (MI)
- Web site: www.lsi-lastem.com
- Commercial service: info@lsi-lastem.com
- After-sales service: support@lsi-lastem.com, Repairs: riparazioni@lsi-lastem.com