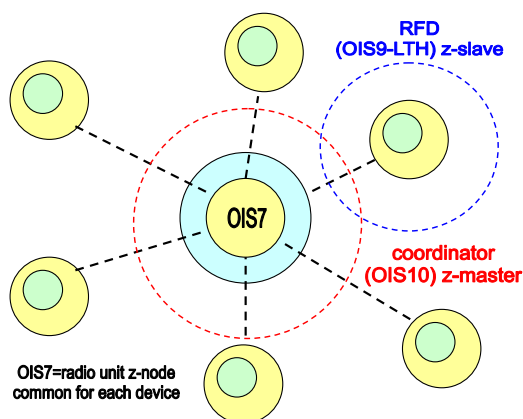


General Description

Optoi Z-slave LTH consists in a 802.15.4 standard compliant 2.4GHz transmitter unit (z-node OIS7) plus a sensor board (sensor node OIS6 with Luminosity, Temperature and Humidity parameters), which is interchangeable. Z-slave is ready to be a RFD (reduced function device) stand alone. Any RFD is unique (MAC address equipped) and can be connected to a coordinator to build a star network. Each network needs at least one coordinator as a controller (i.e. OIS10-USB Z-master) and up to 19 RFD's (see **Figure 1** or **App. note**). In order to extend the network, more coordinators can be connected to each others in Modbus standard (the coordinators become slaves in Modbus protocol). The very low battery consumption and the secure data transmission provide the consumer with flexibility, mobility, and ease of use by building wireless intelligence everywhere. In fact there are many applications for sensors where wiring is very expensive or even impossible. The transmission data rate is selectable by the user, in order to save the energy power of the batteries. Due to their little dimensions, the items can be easily plugged for example into standard wall boxes or anywhere else.

Applications

Industrial environments
 Factory automation systems
 Home and industrial control
 Home automation
 Building automation
 Smart sensors network



**Figure 1 – Star network
 (1 coordinator, many RFD's)**

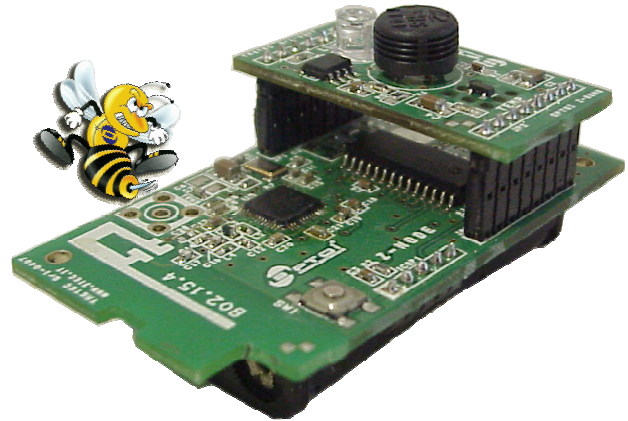


Figure 2 – Z-slave LTH module

Features

- **Low power consumption**
 (expected battery duration ≈ 2 years)
- **High distance range covered**
 (≈ 30m with its integrated antenna)
- **Factory calibrated sensors**
- **802.15.4 standard, unique MAC address**
- **Modular**
 (it can be plugged into standard wall boxes)
- **Small dimensions**
 (L=75,5mm W=36,5mm H=35,0mm)
- **Ecological**
 (environmental power saving)
- **Global band transmission**
 (16 channels @ 2.4GHz)
- **External SMA antenna capability**
 (it can extend the range more than 100m)
- **High receiver sensitivity**
 (up to -90dBm)

Optoi-Bee WSN Ordering Information

OIS6	Luminosity, humidity and temperature sensors module
OIS7	802.15.4 transmission module (z-node board)
OIS9-LTH	Complete z-slave LTH with integrated antenna (sensors + tx node)†

† External antenna on request, ask to the fab for more information

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Min	Max	Unit
T _A	Operating Temperature Range	-10	60	°C
V _{CC}	Supply Voltage Range (two batteries AAA or AA)	2.4	3.6	V
T _S	Storage Temperature Range	-25	85	°C

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

ELECTRICAL Z-SLAVE CHARACTERISTICS

T_A = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{CC}	Supply Voltage Range		2.4	3	3.3	V
I _{CC}	Supply dc current at V _{CC} =2.5V	Idle		2.1		µA
		Average (tx every 30s)		230		µAh
		Peak (during tx mode)		24		mA
t _b	AA battery duration (master connected) ‡	Tx every 64 s		2		years
		Tx every 32 s		1		years
d	Distance covered (with integrated antenna)	outdoor		70		m
		indoor		30		m
d	Distance covered (coordinator with external 5 dBi antenna, RFD with integrated antenna)	outdoor		500		m
		indoor		100		m

SENSORS CHARACTERISTICS

-10°C < T_A < 70°C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ΔL	Luminosity linear detection range		0		2000	lux
L _{ACY}	Luminosity precision			±15	±25	lux
L _P	Luminosity accuracy	range 0:2000 lux		30	50	lux
ΔT	Temperature detection range		-10		60	°C
T _{ACY}	Temperature precision			±0.1		°C
T _P	Temperature accuracy	range -10:70°C		±0.5	±1	°C
ΔH	Relative humidity detection range		0		100	%
H _{ACY}	Humidity precision			±0.1		%
H _P	Humidity accuracy §	range 20:80% R.H.		±2	±3	%

EEPROM CONFIGURATION

The Z-slave is equipped with the following default values. A different configuration can be made.

Location	Parameter	Description	Default value **
0x00	MAC address	MAC module address	Optoi IAB
0x06	Short address	Least significant address word	
0x08	App_number	Application ID # in a channel (0-255)	134
0x09	Net_identifier	Net ID # in a channel (0-255)	125
0x0A	Channel start search	Start channel searching a network	1 st ch, 11
0x0B	Tx power	Tx power level (from 0dBm to -25dBm) see next table	255 (0dBm)
0x0C	Measure delay	Not used	
0x0D	Wake up and send data time	Time interval of transmission (multiple of 8s)	4
0x0F	Search time	Time interval to try searching a network (multiple of 8s)	81
0x10	Debug enable	Enables the debug on serial port (00 or FF = disabled)	0 (Disabled)
0x11	Binding mode	Not used	
0x13	Channel stop search	Stop channel searching a network	16 th ch, 26

‡ This is not a test parameter, but for information only.

§ The humidity accuracy can decrease down to 5% near the upper temperature limit

** Default value is used if the EEPROM location is at 0xFF (empty), decimal value

OIS9-LTH

0x14	Modbus address	Not implemented	
0x15	Max last net activity	Not used	
0x20	Humidity read cal low 1 st point	Humidity frequency read during cal (1 st point)	Cal value (factory calibrated)
0x21	Humidity read cal high 1 st point		
0x22	Humidity freq real low 1 st point	Humidity value of calibration (1 st point)	20% R.H.
0x23	Humidity freq real high 1 st point		
0x24	Humidity read cal low 1 st point	Humidity frequency read during cal (2 nd point)	Cal value (factory calibrated)
0x25	Humidity read cal high 2 nd point		
0x26	Humidity freq real low 2 nd point	Humidity word of calibration (2 nd point)	80% R.H.
0x27	Humidity freq real high 2 nd point		
0x28	Luminosity read cal low 1 st point	Luminosity value read during cal (1 st point)	Cal value (factory calibrated)
0x29	Luminosity read cal high 1 st point		
0x2A	Luminosity real low 1 st point	Luminosity word of calibration (1 st point)	0 lux
0x2B	Luminosity real high 1 st point		
0x2C	Luminosity read cal low 1 st point	Luminosity value read during cal (2 nd point)	Cal value (factory calibrated)
0x2D	Luminosity read cal high 2 nd point		
0x2E	Luminosity real low 2 nd point	Luminosity word of calibration (2 nd point)	2000 lux
0x2F	Luminosity real high 2 nd point		
0x30	Temperature read cal low	Temperature value read during cal	Cal value (factory calibrated)
0x31	Temperature read cal high		
0x32	Temperature real low	Temperature word of calibration	40°C
0x33	Temperature real high		
0x38	Temp th lo LOW	Temperature threshold low word	Disabled
0x39	Temp th hi LOW		
0x3A	Temp th lo HIGH	Temperature threshold high word	Disabled
0x3B	Temp th hi HIGH		
0x3C	Hum th lo LOW	Humidity threshold low word	Disabled
0x3D	Hum th hi LOW		
0x3E	Hum th lo HIGH	Humidity threshold high word	Disabled
0x3F	Hum th hi HIGH		
0x40	Lum th hi LOW	Luminosity threshold low word	Disabled
0x41	Lum th lo LOW		
0x42	Lum th lo HIGH	Luminosity threshold high word	Disabled
0x43	Lum th hi HIGH		

TRANSCEIVER POWER

Current consumption [mA]	Output power [dBm]	Description	EEPROM value
17.4	0	0 dBm power transmission (1mW)	0x1F
16.5	-1	-1 dBm power transmission (0.8 mW)	0x1B
15.2	-3	-3 dBm power transmission (0.5 mW)	0x17
13.9	-5	-5 dBm power transmission (0.3 mW)	0x13
12.5	-7	-7 dBm power transmission (0.2 mW)	0x0F
11.2	-10	-10 dBm power transmission (0.1 mW)	0x0B
9.9	-15	-15 dBm power transmission (31.5 uW)	0x07
8.5	-25	-25 dBm power transmission (3.15 uW)	0x03

MECHANICAL DIMENSIONS

Units = mm

Mechanical tolerance = ± 0.2 mm

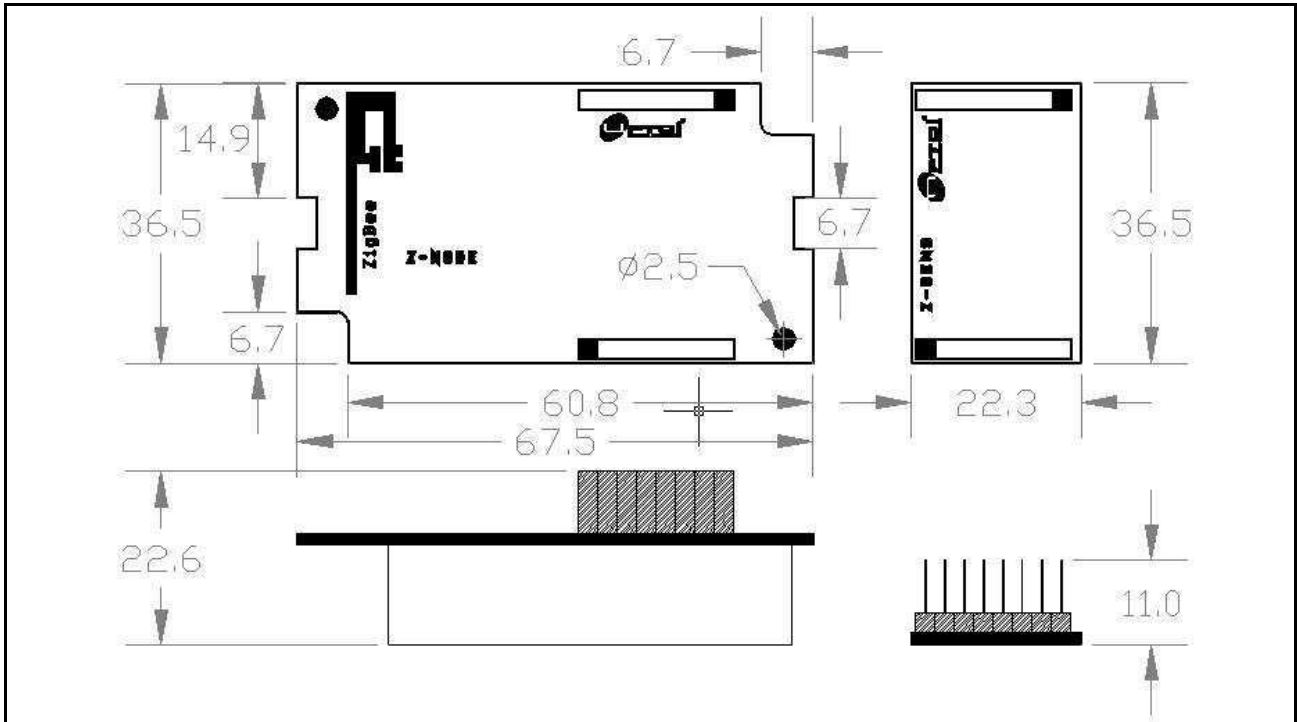


Figure 3 – mechanical dimensions



Figure 4 – Z-slave's configurations

Detailed Description

The z-slave OIS9 is a network element named also RFD. In the network it is just capable of talking; it talks only to a coordinator, in specific its coordinator. The object has few memory resources and it do not stores data. The only stored information are its parameters. The z-slaves transmits on a specific radio channel of 802.15.4 standard, over 2.4 GHz and it cannot relay data from other devices.

The node has a 64 bit unique address, the lowest part (16 bit) is the network address.

Standard 802.15.4

The stack is compliant to 802.15.4 standard, which is based on the OSI (Open Systems Interconnection) seven layers model, but specifies the two lower levels: the physical layer (PHY) and the medium access control sub-layer (MAC). The network and the application layers are Optoi proprietary. The responsibilities of the network layer (NWK) are the following:

- starting a network, the ability to successfully establish a new network;
 - joining and leaving a network, the ability to gain membership (join) or relinquish membership (leave) a network;
 - configuring a new device, the ability to sufficiently configure the stack for operation as required;
 - addressing, the ability of a coordinator to assign addresses to devices joining the network.
 - synchronization within a network, the ability for a device to achieve synchronization with another device either through tracking beacons or by polling;
 - security, applying security to outgoing frames and removing security to terminating frames;
 - routing: routing frames to their intended destinations.
- The application layer (APS) has the responsibility of:
- maintaining tables for binding;
 - initiating and responding to binding requests;
 - establishing a secure relationship between network devices.

Binding Procedure

The first initialization (also called binding) configures the network: it consists in the registration of each sensor in the network, assigning a unique ID code to the component. The binding is the logical link (“virtual wire”) between z-master and z-slave. It is assigned one time only, in the first phase of net configuration. For a binding procedure these steps must be followed:

- switch on the z-master that controls the network;
- hold down the button on the z-slave that must be binded;
- connect the batteries on z-slave and wait until the green led blinks;
- the z-master will recognize the new device that wants belong to the network, showing the message “binding request” on its LCD;
- just press OK letting the z-slave join the network, if manual binding is selected.

The binding procedure can also be set to automatic (z-master menu), in this case pay attention because all the z-slaves requests will be satisfied automatically, until the z-master addressing space will be full.

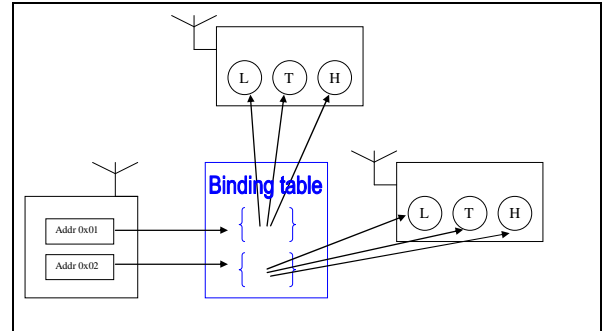


Figure 5 – binding procedure

Channels

The available channels in the band 2.4GHz are 16, from 11th to 26th. Regarding the binding procedure it is possible to let the z-slave search in some channels only. The start search and stop search channels are set at the EEPROM locations 0x12 (start) and 0x13 (stop). The permitted values are from 0x0B (ch 11) to 0x1A (ch 26). By default the node searches in the whole band: the start channel is set to 11 and the stop channel to 26. The IEEE 802.15.4 has two PHY layers, that operate at 868/915MHz and 2.4GHz. This last frequency is used worldwide and this product is tuned on this band.

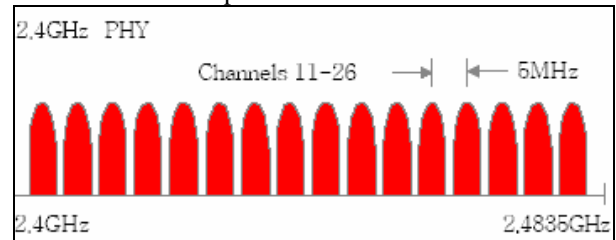


Figure 6 – frequency channels

Joining/leaving the network

Even if the node leaves the network, z-master maintains the information regarding this node. After the z-slave is binded, it can leave or join the network in every moment; it is always recognized by the coordinator. This case could happened for instance when the batteries are low, or when the signal isn’t good enough; the node becomes inactive and cannot transmit its values . A particularly attention must be paid if some z-slaves have the same network address. The z-master will recognize both z-slaves and the values will be overwritten every time at the address space reserved.

Data transmission-wake-up time

The data of the three sensors is transmitted every specified time interval. This value is user selectable (see table EEPROM areas) and it is specified at the address 0x0A (wake-up and send data) in multiple of 8s.

In order to improve the module’s performances, it is also possible to set another time interval, value specified at the address 0x0C (wake-up alarm and send data). This data represents the sending time interval in

case of one or more sensor's values exceed the threshold parameters (see thresholds EEPROM area). If z-master doesn't reply to the z-slave message, z-slave transmits again for maximum 5 times, after which the module resets itself and searches again a network. If it doesn't find any nets, it goes to sleep.

Data format

The message from the slave to the master is built in this form:

Node ID	TEMP	HUM	LUM	BAT	CRC
RFD addr.	temperature level	humidity level	luminosity level	battery level	CRC code

Z-slave waits the master response and then goes to sleep.

When it wakes up again (every 8s) z-slave tests the switch value and if pressed, waits to be released. Both leds will blink at high frequency. When the switch will be released the node will reset itself.

If the switch is not pressed and it is time to send data, the z-slave transmits the string; if there are no data to transmit, the device goes to sleep again. The transmission rate can be only multiple of 8s (wake-up time).

At the location 0x0F the user can set the time in which the z-slave is trying to search the network again (default every 10 minutes).

Sleepmode

The z-slave goes into sleep mode after receiving the command "go to sleep" by z-master.

The second reason is when the z-slave doesn't find any network (because the master is switched off or there is no field).

In the first case the wake-up time is 8 seconds, in the second case it is set into the EEPROM area at the address 0x0F.

Transmission power

The transmission power is user selectable and the value must be set into the EEPROM at the address 0x0B. The default value is the maximum value, 0dBm. A lower value means less module power consumption. See the specific table to set the desired value.

Sensors

The OIS6 sensors board is build up with three fundamental sensors: temperature, relative humidity and luminosity.

The sensors are very accurate, they in are factory calibrated and the drifts are controlled by a microprocessor unit. The temperature accuracy is 1°C full range, the humidity is 1% R.H. (in the range 30-70% R.H.) and the luminosity is 15 lux full range.††

The humidity degree of accuracy is obtained first with a initial calibration (in factory) and second thanks to an internal temperature compensation during operation. The recovery time after condensation (90% to 10% R.H.) is less than 10s.

The responsivity of the luminosity sensor is centered on the human eye peak responsivity; the output is internally filtered, in order to achieve a noise rejection

†† These values are invalid if the sensor board is changed without calibration

to 50Hz and 100Hz. The response of this sensor is reset to zero at wavelengths > 700nm, so that infrared radiations emitted by lamps are also rejected.

Accuracy and precision

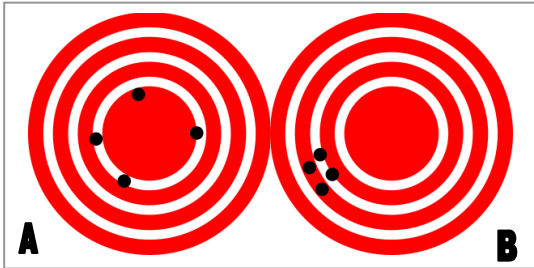


Figure 7 – accurate (A) and precise (B) measurement

Accuracy is the degree of truthfulness in a measurement. Repeated measurements are compared to arrows that are fired at a target. Accuracy describes the closeness of arrows to the bulls eye at the target center. Arrows that strike closer to the bulls eye are considered more accurate. The closer a system's measurements to the accepted value, the more accurate the system is considered to be.

Precision is the degree of reproducibility of a measure. Precision is the size of the cluster one would expect if this were repeated many times under the same conditions. When all arrows are grouped tightly together, the cluster is considered precise since they all struck close to the same spot, if not necessarily near the bull's-eye.

Network

The allowed network type is a star network. Each coordinator is able to manage up to 19 z-slaves. If more elements are needed it is possible to build a Modbus network. Each z-sensor is linked to its coordinator only (binding) and it cannot interfere with the other elements. In order to avoid undesired interferences it is suggested to operate in different channels for every WSN. In **Error. L'origine riferimento non è stata trovata.** a multiple WSN can be observed. In this case it is necessary to have a master Modbus, which could be a PC for example. The master Modbus must poll every z-master in order to avoid collisions. The z-masters send the data only if polled. Each z-master is the coordinator of its WSN. The master Modbus is needed to coordinate the multiple system.

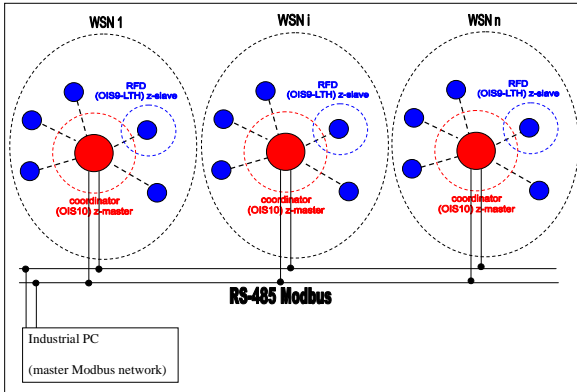


Figure 8 – multiple WSN

REGULATORY COMPLIANCE TABLE

Generic normative	Description	Level
ETSI EN 301 489-17 V1.2.1 (2002)	Electromagnetic compatibility and Radio spectrum Matters (ERM) EMC standard for radio equipment and services Part 17 Specific conditions for 2.4GHz	-
ETSI EN 301 489-1 V1.6.1 (2005)	Electromagnetic compatibility and Radio spectrum Matters (ERM) EMC standard for radio equipment and services. Part1 Common technical requirements	-
ETSI EN 300 328 V1.7.1 (2006-10)	Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4GHz ISM band and using wide band modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive	-
EN 61000-6-1 (2007)	Electromagnetic compatibility (EMC). Generic standards. Immunity for residential, commercial and light-industrial environments	-
EN 61000-6-3 (2007)	Electromagnetic compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments	-
EN 60950-1 (2006)	Information technology equipment. Safety. General requirements	-

Application notes



Connecting the z-master

The z-master is composed in two parts. The easier version of master point is simply a z-node (tx and rx board) plus a master (USB or MODBUS) board (OIS7 + OIS8 = OIS10).

The two items are plugged together with standard strip connectors.

Install the USB serial port drivers into your PC (www.ftdi.com) if you have the OIS10-USB model.

Simply connect the z-master to the PC via USB port and choose the option “search the best driver for this application”.

The OS will recognize the device as a general purpose USB device.

Install the software “Domotic WSN” and run the application. If there are z-slaves already connected to the master they are recognized by the software, otherwise connect the z-slaves following the procedure below.

Connecting the z-slaves

The z-slave is composed in two parts. The first version of z-slave is the OIS9-LTH: this is a multi sensor board (luminosity, temperature and relative humidity) combined with a z-node (OIS6 + OIS7 = OIS9).

The sensor’s values are transmitted every time slot (this parameter can be modified) and after transmission the module goes to sleep.

For the first time installing a network a “binding” procedure is necessary: this procedure associates the slaves to a master. Only the binded slave can talk to the master into its net; the master stores the slaves ID for other times.

The binding procedure is described below:

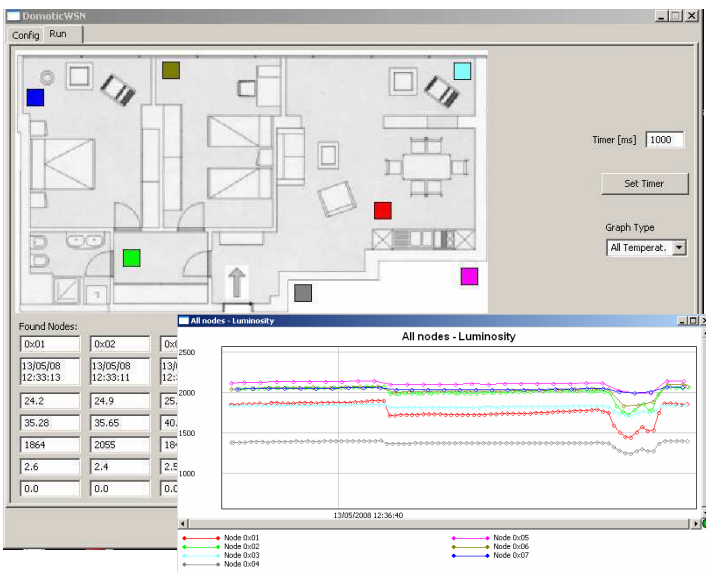
- press the switch on the z-node and connect the power supply (batteries); after that release the switch;
- the master display should show a message “binding request”;
- press the switch correspondent on the master to accept the binding request;



- the slave is stored into the master memory as authorized slave.

Demo Software

Launch the file “Domotic WSN”. The program searches for the master connected and displays either the connection or the number of slaves connected to the master. A plant (jpeg format) can be loaded from the panel and the user can place the sensors in the right position on the map. The sensors can be added or removed from the main panel. Pushing the run button an acquisition begins. A graph can visualize the trend of the physical values VS the time. The sensor’s data can be stored in a unique file or in split files for each node.



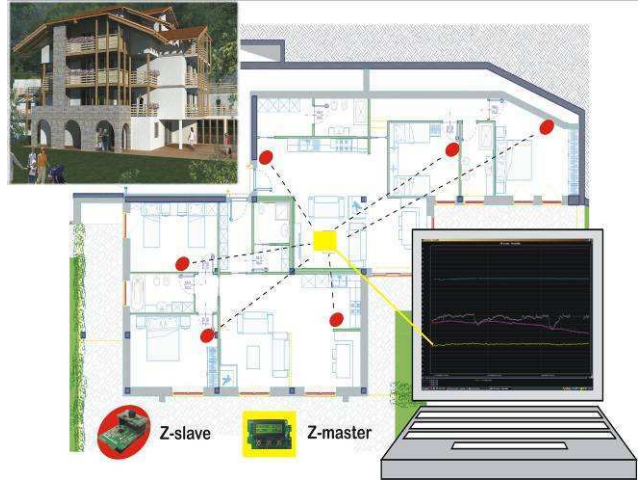
Low power detecting systems	Outdoor Air Quality	Industrial remote monitoring
Low cost and flexible transmission	Process control	Wireless Sensors Networks
Energy conservation	Green building systems	Indoor Air Quality

Safety indoor monitoring

Optoi-Bee OIS9-LTH can be used as building safety monitoring. The wireless power supply and data transmission of the z-slave can avoid wire connection problems.

The most indoor wellness parameters like temperature, luminosity level and relative humidity can be controlled directly by a master node. The z-master node can be connected to a PC (OIS10-USB), to another bus network (OIS10-MODBUS) or simply operate as data logger, in order to record data, control or activate alarms, switches, relay...

The wellness and security parameters in disable and old-age people houses often needs to be controlled by a supervisory sensor network. This kind of network is easy to install and to use, compared to previous custom installations of home master remotes.



Outdoor monitoring

OIS9 can also be used in outdoor applications, in order to measure the main parameters like air quality or outdoor wellness parameters. The continuous monitoring of essential parameters in streets, cities, quarters is very important for the human wellness and safety. The sensor networks in general can also help to monitor bridge conditions, streets conditions, real-time tracking of agriculture environments.

The Kyoto protocol observance means more and frequent ambient parameters control. Wireless networks could be built by the cities that want to examine the ambient situation around.

Production parameters control

The advantage of using wireless sensors in industrial field are the lower installation costs compared to wired systems.

The industrial waste needs often to be monitored, either to prevent pollution, or to increase the system efficiency. This is compliant with Kyoto protocol and with the new industrial politics.

Energy saving

With the increased cost of energy and demands by corporate boards to “go green”, there has never been a better time to consider the value proposition of an enterprise energy management strategy for buildings. It is necessary to achieve sustainable and green buildings. Moreover the cut of energy costs like lighting, heating, ventilation, cooling can be realized trough more efficient energy management and control.

