WISEPOWER

WiseSensing

powered by WISEPOWER

Energy Harvesting Technologies

WISENSING GENERAL DESCRIPTION

The WiseSensing sensor nodes provide a reliable, easy-to-mount and cost effective solution, which is designed for dynamic and static structural health monitoring of large structures. They measure:

- **3-axes accelerations, with a sensitivity in frequency recognition of 0.5Hz at <1mg;**
- **polar angles inclinations, with a sensitivity of 0.02°;**
- **temperature, with a sensitivity of 0.5°C.**

Data communications can be performed by exploiting either Zigbee, LoRa or Cellular protocols, to a dedicated Gateway, which sends data remotely either by Cellular or by Ethernet. The data can be sent either through FTP connection or through an HTTP POST request to a remote server, to be instantly available for analysis.

The main WiseSensing operation's parameters are reconfigurable from remote, such as:

- **the range of measure and ODR for the accelerometer data acquisition;**
- **the axis/axes to acquire;**
- **the number of samples to acquire;**
- **the frequency of measurements during the day;**
- **the threshold and range for the shock accelerometer.**

WiseSensing operation does not rely on any battery replacement, being powered by solar and vibrational energy.

Each node is capable of harvesting clean energy from the environment, transforming it into usable electrical energy in order to power sensors and communication stacks.

WiseSensing is IP67, ROHS 3 and UV-rays resistant, so it is suitable to be installed outside without any additional protection.

WISENSENSING APPLICATION CASES

WiseSensing is designed in order to enable Structural Health Monitoring for large structures.
Its usage is recommended (but it is not limited) for monitoring:

- bridges, viaducts;
- aerial pipelines;
- wind turbines, and in particular wind blades;
- telecommunications antennas' poles;
- power grid poles.

In each of these cases, WiseSensing installation is easy and fast, and can be done either by screw-mounting (optionally exploiting a specifically designed mounting-plate, that guarantees flatness and stability over rough sourfaces), or simply by gluing the sensor to the structure.
A Gateway with WiseSensing dedicated software for data collection needs to be additionally installed in the nearest proximity, and can be either powered directly or through solar energy.

TECHNICAL SPECIFICATIONS

Product reference	
WiseSensing -PWR-COM-MO	
PWR – Power supply system	**COM –** WiFi technologies
VibPV: Non linear vibrational energy harvester transducer + Integrated solar panel (1W) + Li-Ion rechargeable battery (2.6Ah)	**ZB :** ZigBee radio
	CELL : 3G (HSPA/GSM) with 2G fallback radio
PV: Integrated solar panel (1W) + Li-Ion rechargeable battery (2.6Ah)	**LR :** LoRa radio
MO - Mounting Option SM - Screw Mounting Lid **SMO -** Screw Mounting Lid Orthogonal	
Example n°1: WiseSensing-VibPV-ZB-SM, WiseSensing with vibrational harvester PV cell and rechargeable battery, ZigBee wifi module and screw mounting lid option **Example n°2: WiseSensing-PV-LR-SMO**, WiseSensing with PV cell and rechargeable battery, LoRa wifi module and screw mounting lid option	

Environmental and Mechanical Features	
Casing	Waterproof casing
	Dimensions in mm (LxWxH): 120x120x50 mm Weight in grams : 500 g
IP Rating	IP67
Operating Temperature	-30 °C to +75 °C
Norms & Radio Certifications	CE Labelling Directive
	FCC/IC (North America)
	ETSI (Europe)
	ROHS - Directive 2002/95/EC

Sensors specification

Accelerometer for SHM

Accelerometer Technology	Low power MEMS technology
Scalable measurement range	±2g / ±4g/ ±8g
Measurement resolution	3.9 µg/digit @±2g , 7.8 µg/digit @±4g , 15.6 µg/digit @±8g
Typical non-linearity	±0.1% FS
Sensitivity change Vs temperature	±0.01%/°C (-40°C to +125°C)
Zero-g level change vs temperature	±0.02 mg/°C (-40°C to +125°C)
Typical zero-g level offset accuracy	±25 mg
Noise spectral density @ BW 500Hz	25 µg/√Hz

Accelerometer for Shock

Accelerometer Technology	Low power MEMS technology
Scalable measurement range	±2g / ±4g/ ±8g
Measurement resolution	1 mg/digit @±2g , 2 mg/digit @±4g , 4 mg/digit @±8g
Typical non-linearity	±0.5% FS
Sensitivity change Vs temperature	±0.05%/°C (-40°C to +85°C)
Zero-g level change vs temperature	±0.5 mg/°C (-40°C to +85°C)
Typical zero-g level offset accuracy	±50 mg (Z axis) ±35 mg (X,Y axes)
Noise spectral density @ BW 100Hz	920 µg/√Hz

Temperature

Measurement range	from -40°C to +125°C
Accurancy	±0.5°C

RF Specifications	
ZigBee©	
Wireless Protocol Stack	ZigBee©
WSN Topology	Star
Data rate	250 Kbits/s
RF Characteristics	ISM 2.4GHz
TX Power	+8 dBm
Receiver Sensitivity	-103 dBm
Maximum Radio Range	600m (Line of Sight) , 40m (Non Line of Sight)
LoRa™	
Wireless Protocol Stack	LoRa® Technology modulation
Data rate	10937 bps
RF Characteristics	863.000 MHz to 870.000 MHz
TX Power	+14 dBm
Receiver Sensitivity	-146 dBm
Maximum Radio Range	10 km (Line of Sight) , 3km (Non Line of Sight)
Cellular	
Carrier and Technology	3G HSPA/GSM with 2G fall-back
Supported Bands	Band 19 (800 MHz), Band 5 (850 Mhz), Band 8 (900 MHz), Band 2 (1900 MHz), Band 1 (2100 MHz)
RF Throughput	Up to 921 Kbps
Downlink/Uplink Speeds	7.2 Mbps / 5.76 Mbps
RF Options	
Gateway ZigBee©	XGI-20CZ7-E00-W0 [WiFi + ETH0] XGI-20CZ7-EU7-W0 [WiFi + ETH0 + Cellular]

Over-the-air configuration (OTAC) parameters	
ZigBee© /Cellular	
ODR SHM Accelerometer	from 31.25 Hz up to 4000 Hz
Acquisition interval	from evrey hour up to every 8 hour
Samples to acquire	from 1024 up to 32768
Data transmission	1 axis , 2axes or 3 axes
Shock detection threshold	from 1.1g up to 8g
LoRa™	
FFT noise	from ±1σ up to ±3σ
FFT peak number	from 1 up to 4

Current consumption @ 3 V	
During data acquisition	from 3mA up to 5mA
During ZigBee© TX	30mA @ 8dBm
During ZigBee© RX	10mA
During LoRa™ TX	45 mA @14dBm
During LoRa™ RX	10mA
During Cellular TX	710 mA @ 3.3VDC
During Cellular RX/Listening	230mA / 90mA @ 3.3VDC
During sleep mode (shock ON)	7µA

Power supply	
Battery charger	Integrated Lithium-ion battery charger with high precision battery monitoring : · Overvoltage Protection, Overcurrent/Short-Circuit Protection, Undervoltage Protection · Battery Temperature monitoring
Energy havesters	High precision voltage and current monitor of PV and Vibrational harvester

INCLINOMETER TEST

A test was performed, mounting the sensor on a micrometric screw with minimum step of 0.02°.

The progressive inclination measured by the accelerometer was calculated, in degrees, by applying the following geometrical rules to the RMS accelerations on the three measurement axes:

$$\Theta = \frac{180°}{\pi} \arcsin\left(\frac{a_y}{a_{RMS}}\right)$$

$$\Phi = \frac{180°}{\pi} \arctan\left(\frac{a_x}{a_z}\right)$$

The results, when changing the inclination progressively with steps of 0.02° on Θ, are illustrated in Table 1 for the measured Θ and Φ acquiring 1024 samples with ODR = 500Hz, and when changing the inclination on Φ under the same conditions, in Table 2.

After repeating the test with 32768 samples, the sensitivity over the inclination angle was demonstrated to lower to **0.001 deg**.

This is due o the fact that a single measure of rms acceleration on one axis is given by computing the rms of the samples in one measurement for the same axis, and therefore the precision of a single rms measurement increases by increasing the number of samples.

Table 1: Sensitivity test for inclinometer. 1024 samples with ODR = 500Hz. Inclination on Θ

Experimental inclination on Θ	Θ measured	Experimental inclination on Φ	Φ measured
0.02° ± 0.005°	0.023° ± 0.003°	0.000 ° ± 0.005°	0.0027 ± 0.0015°
0.04 ± 0.005°	0.040 ± 0.003°	0.000 ° ± 0.005°	0.0017 ± 0.0015°
0.06 ± 0.005°	0.064 ± 0.003°	0.000 ° ± 0.005°	0.0005 ± 0.0015°
0.08 ± 0.005°	0.085 ± 0.003°	0.000 ° ± 0.005°	0.0016 ± 0.0015°

Table 1: Sensitivity test for inclinometer. 1024 samples with ODR = 500Hz. Inclination on Φ

Experimental inclination on Θ	Θ measured	Experimental inclination on Φ	Φ measured
0.000° ± 0.005°	-0.003° ± 0.003°	0.060° ± 0.005°	0.063 ± 0.002°
0.000 ± 0.005°	-0.002 ± 0.003°	0.080° ± 0.005°	0.084 ± 0.002°
0.000 ± 0.005°	-0.001 ± 0.003°	0.10 ° ± 0.005°	0.107 ± 0.002°
0.000 ± 0.005°	-0.007 ± 0.003°	0.12 ° ± 0.005°	0.129 ± 0.002°

ACCELEROMETER TEST

The accelerometer was excited through a TIRA-vib TV51144 shacker connected to a function generator and a power amplifier, as shown in Figure 1. At first it was driven with a signal of rms = 1 mg having three main frequency components of 3, 5, 7 Hz with white noise overimposed with rms amplitude approximately 10 times smaller in acceleration. Then, the same signal was used, but the frequencies where shifted of 0.5Hz.

WiseSensing was configured to acquire 32768 samples at 125Hz.

In the Figures below the experimental set-up and the power spectrums of the two measured accelerations are shown, demonstrating the capability of the accelerometer to distinguish 0.5Hz shifts in frequencies even in noisy environments.
The peak at around 36Hz that is clearly visible in the spectrum, and whose detection is fully repeatable over different acquisitions, is due to the rotary motor of the voltage amplificator that is governing the shacker, and that is laying on the same table.

Figure 1 : Experimental set-up for testing WiseSensing frequency resolution in noisy environments

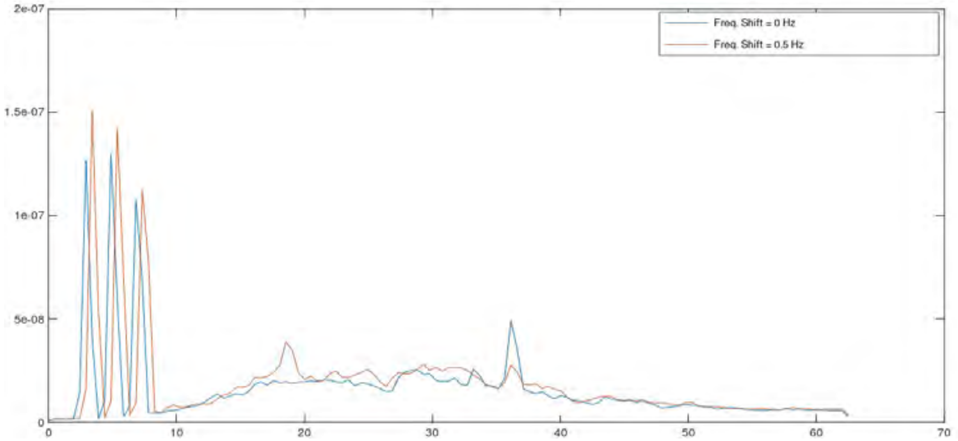

Figure 2 : Time series and power spectrum of the recorded acceleration for a 0.5 Hz shift in the main frequency components