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"IoT" Wireless Sensor Networks
and the "microSP" Technology

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Abstract

A "WSN" can be defined as a network of devices that communicate information, measurements and alarms collected from a monitored area via wireless links. The data are then forwarded through multiple nodes and with one or more "IoT" gateways are transferred to other networks. In most cases of "IoT" sensor networks, it is a matter of implementing levels 1, 2 and 3 of the ISO/OSI model in limited areas using "Unlicensed" frequencies in the sub-GHz ISM or SRD bands. The "microSP" RF short pulse transmission technology allows the creation of compact, low-cost wireless sensors that can operate without replacing the batteries for over 20 years.

"IoT" WSN - Wireless Sensor Networks

The "IoT" sensors when operating in a dedicated network with limited coverage and when the data to be transferred are of the order of a few bytes can profitably use the "unlicensed" sub-GHz frequencies. Also for reasons of costs, installation and maintenance problems. Normally the areas to be covered are limited to 10-100 meters and in any case the regulations (EU and FCC for example) set strict limits due to the fact that "unlicensed" frequencies are substantially granted on the basis of not disturbing and not preventing their use to devices of other users.
Coverage when limited to small areas It is not so much a problem of propagation of radio waves, but a problem of coexistence with other systems, collisions of messages and the presence of interference and broadband noise on the radio channel. In itself, the radio waves propagate very well: in free space and with the antennas a few meters above the ground, with 10mW of radiated power and -110dBm Rx sensitivity the coverage is more than 10 km .
Fig.1 and Fig.2 show two typical cases of generic "IoT" networks in which one, two or more "IoT" gateways can be present to monitor the area in which the wireless devices are arranged. Clearly, this is just one of the many configurations that the network can assume taking into consideration the fact that very different types of sensors or wireless alarms may be required.
Wireless sensor networks on sub-GHz bands for "IoT" applications should not be confused with "Information Technology" wireless applications ("IT" wireless networks, i.e. devices such as WiFi, Bluetooth, etc.) in which the data speed and the amount of data to manage is much greater.
Obviously, there can be many cases in which the aforementioned devices can be used or where a two-way radio communication must be used at higher data transfer rates.

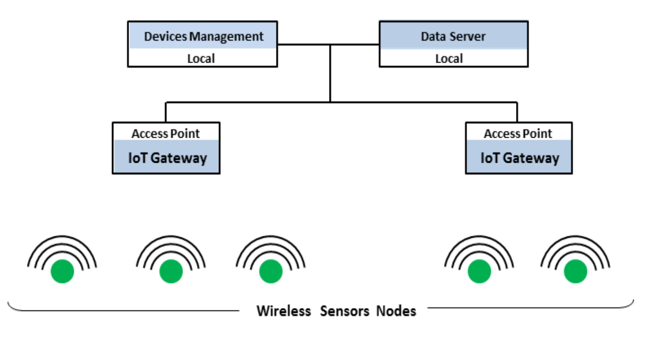


Fig. 1 - Generic "IoT" WSN (Wireless Sensor Network)

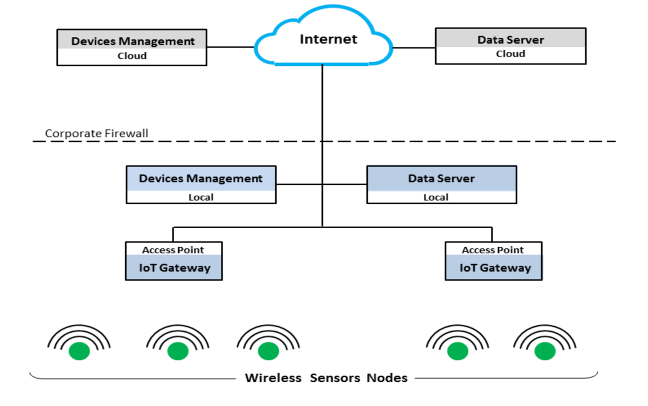


Fig. 2 - Generic "IoT" WSN with access to the "Cloud"

In this AN-902 Application Note, our goal is to introduce the "microSP" Technology in the specific case of a mono-directional, compact, low-cost wireless sensors, powered by a small lithium battery and capable of running maintenance-free for many, many years. Then it is clear that more complex control and telemetry problems can be solved only with bidirectional high-speed data transmission devices.

For monodirectional devices, the "microSP" Technology is the best solution.

Or at least, the best for the highest number of expected "Billions" of sensors ......

“IoT” WSN - The “microSP” Technology

It should always be kept in mind, as widely stated above, that the configuration of an "IoT" network of wireless devices presents a great variety of possible implementations. This being said, you can see in Figure 3 an example of how a "WSN" can be realized both with the monodirectional "microSP" Technology and with "Bidirectional” devices.

For monodirectional devices characterized by low cost and low power consumption, the "microSP" Technology is an excellent transmission "Standard". A different transmission standard is necessary for bidirectional devices where a higher bit-rate and greater coverage are most likely required: in most cases, the goal is to implement simple "IoT" networks with “low power” wireless devices (Short Range Devices), low cost, low energy consumption and (almost always) small quantity and low-speed data transmission. Bidirectional transceivers in most cases can use a simple NBFM modulation with a 1mW ERP and with an Rx sensitivity of -125dBm or better.

The example in Fig.3 shows two possible embodiments of the "IoT" Networks: one in the case of a network with only "microSP" devices, the other with even the most complex management of bidirectional RF links. In any case, Gateways are “Access Points” that can receive from all wireless sensors, perform a first data processing and monitor the entire network. Then more complete management of the collected data will be carried out elsewhere.

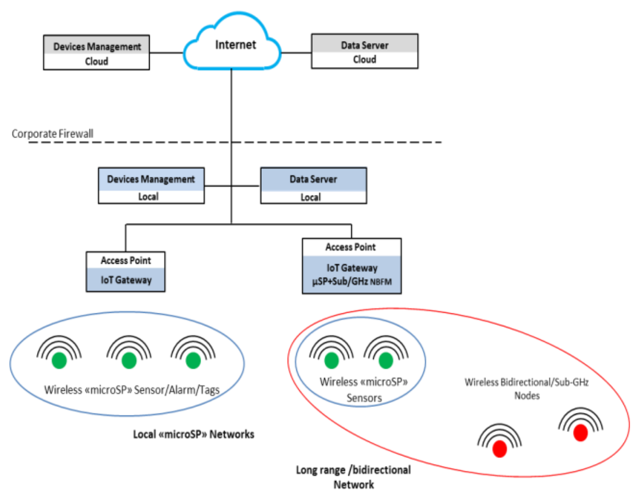


Fig. 3 - “microSP” WSN (Wireless Sensor Network)

Gateways Design Strategy

The "IoT" networks of wireless and non-wireless sensors can be used with great benefits in civil and industrial applications, as well as in Smart Cities and agriculture: it must be clear that sooner or later this large amount of data must be managed and processed. Having a large number of sensors and an enormous amount of data collected makes no sense if the data is not analyzed and exploited. This is especially true for "microSP" wireless sensors, which are monodirectional devices.

In a well-designed "IoT" network, it is of fundamental importance to decide the control and storage of the collected data and also the management of a pre-alarm and alarm system for critical or dangerous situations. Part of this analysis can conveniently be located in the "IoT" Gateway, for example to perform a preliminary screening of the large number of messages coming from remote sensors.

The Gateway, in addition to the recognition of the devices that are part of its network, should carry out a first check of the measures and alarms and of the alarm thresholds and also of the efficiency of all the nodes of the network.

Fig. 4 - A “microSP” Transmitter applied to a Honeywell GLAB01A1A Limit-Switch

In all wireless sensor and alarm networks, whether they are bidirectional or unidirectional devices, it is essential to continuously monitor the efficiency of each individual device: this is particularly important in monodirectional devices such as "microSP" wireless sensors. The periodic emission of a "Heartbeat" message solves this problem, but it must be managed very carefully both at "Device" and "Gateway" level to avoid saturating the radio channel with redundant transmissions, with the danger of message collisions and great confusion.
Therefore we strongly recommend that the gateways (and more generally the "access points"), in particular in the case of networks with hundreds or more wireless devices, make a first analysis of the data or alarms collected. For example, to capture and manage only the messages from the sensors that are part of their networks: this can avoid overloading the server with which they communicate. Again as an example, gateways can avoid sending hundreds of heartbeat messages, which do not contain any alarms or even significant data changes, to the networks to which they are connected,

An example of IoT Gateways management can be found in the IBM MQTT for Sensor Network Protocol (MQTT-SN Version 1.2) where two types of gateways are defined, namely "Transparent" and "Aggregating" GWs, and where it is considered cheaper, though more complex, the solution of the Aggregating GW.

Wireless Sensors Design Strategy.

A wireless device designed to collect measurements of physical quantities, alarms or alarm thresholds or even simple Tag or Beacon transmitters must be designed taking into account not only their main data transmission function but also all the problems encountered by those who must test , program and evaluate their functionality with reference to the specific application. We must also think about the installation phase, the "Address" acquisition (pairing) and the reliability test of the radio link.
It is worth mentioning again that we are discussing specific cases of "IoT" wireless networks, such as those described above, without wishing to consider a large number of other possible applications. Must be clear, as an example, that we are not talking about sophisticated industrial telemetry systems, such as Wireless-Scada Systems, where normally the use of dedicated radio channels is required.

An example of a "microSP" Wireless Sensor

In "IoT" networks such as those described in Figures 1, 2 and 3, "microSP" wireless sensors can advantageously be used. These are unidirectional devices that must be designed taking into account the above in relation to the configuration of the networks and the ability of the gateways to receive and manage a large amount of collected data. To better understand how it works, the best thing is to describe a typical "microSP" wireless sensor: the SKS3137VT (Figure 5) is an example of a sensor to measure temperature and vibration.

The sensor is designed to measure temperature with a 1% accuracy and continuously monitor the level of vibration or shock. To make the system as flexible as possible and adapt it to various control and alarm situations, up to 8 different operational schemes and in Threshold levels can be defined for both temperature and vibration with an immediate transmission of an alarm situation. It is also possible to select and activate, during the installation phase, an "autolearning" transmission mode and a special "test" mode with accelerated transmission and measurements sampling times.
This is a wireless device the motto for which is: "Install it and forget it!". Once activated and for more than twenty years, the SKS3137VT will keep you informed on the status and excessive vibrations of a machine, for example.
Or on the possible tampering of a precious painting in a Museum.

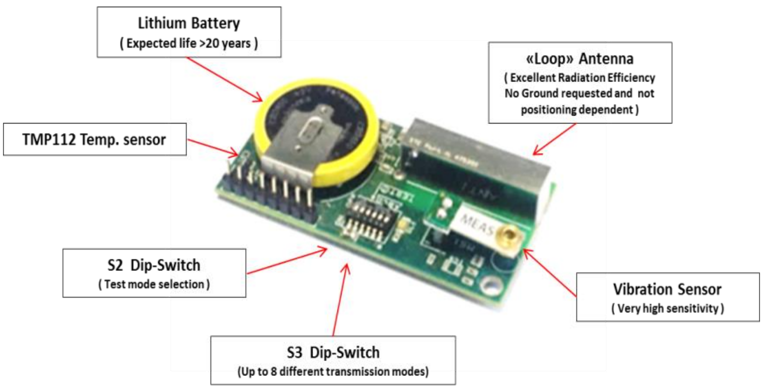
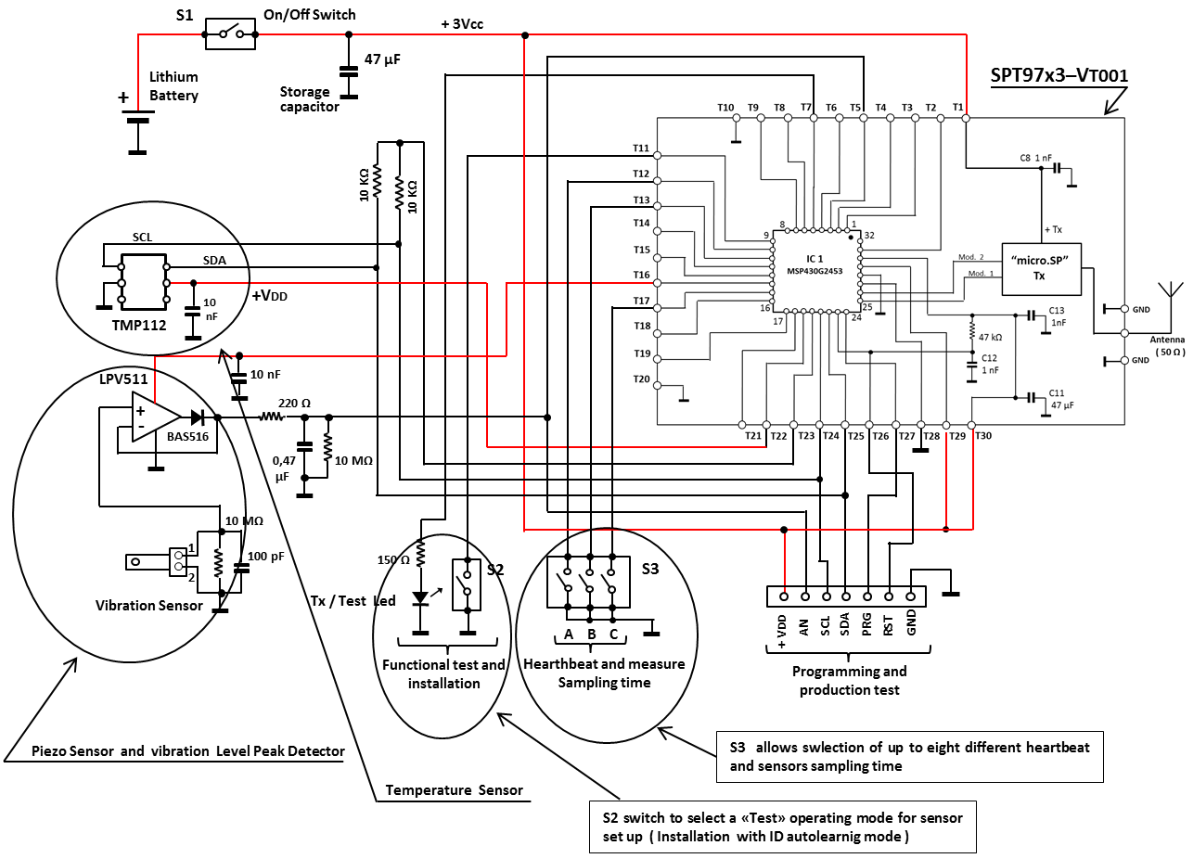


Fig.5 - The SKS3137VT "microSP" Wireless Sensor

The SKS3137VT "microSP" Sensor
Block Diagram and simplified schematic



Operating Modes

S3 Selector	Measure sampling time (sec.)		Tx Repetition time (sec.)	Current and Expected Lifespan CR2450 Batt.	
A B C	Vibration	Temperature	Heartbeat	µA	Years
0 0 0	2 (1)	30	120	2	20
0 0 1	2 (1)	30	60	2,5	16
0 1 0	10 (2)	10	120	2	20
0 1 1	10 (2)	10	60	2,5	16
1 0 0	5 (3)	10	60	3	12
1 0 1	5 (3)	10	30	3,5	10
1 1 0	Active mode (4)	10	120	1,5	25
1 1 1	Active mode (4)	10	15	4	10

Notes :
(1) Vibration level peak detector RC time constant >2 s – measurement sampled every two seconds .
(2) Vibration level peak detector RC time constant >10 s – measurement sampled every ten seconds .
(3) Permanent Vcc Supply to the Amplifier/Peak Detector with short (2 sec) RC time constant.
(4) In active mode the Amplifier/Peak Detector is permanently "on" and the RC time constant is <2 sec. The vibration level is sampled every second and an immediate transmission is performed at a predetermined alarm level.

Test mode

"Test Mode" is activated by S2. In "Test Mode" the setting of S3 ("A", "B" and "C") is irrelevant. When SKS3137VT is in "Test Mode", a quick transmission mode is forced to facilitate the "Setting" and "Test" operations of the wireless network. Sensors sampling and data transmission are performed every 2 seconds.
In "Test Mode" the "Duty Cycle" set by the International Normative is exceeded and the system's ability to function properly is also significantly reduced, increasing the message collisions probability.

! Test mode must not be used during the normal operating mode