# WIRELESS SENSOR NETWORK BASED CONVEYOR SURVEILLANCE SYSTEM

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**Abstract**: In the paper we will introduce an intelligent conveyor surveillance system. We started a research project to design and develop a conveyor surveillance system based on wireless sensor network and GPRS communication. Our system is able to measure temperature on fixed and moving, rotating surfaces and able to detect smoke. We would like to introduce the developed devices and give an application example.

**Keywords**: surveillance, remote monitoring, conveyor, wireless

## 1. Introduction

In industry, where the transportation of the exploited raw materials to the processing spots is transacted by long, outdoor conveyors, there are several cases that there's no up-to-date, automated monitoring system, which would observe the condition of the conveyor and the line. The main reason for this is that it is very expensive to equip the long line with conventional intelligent wired transducer systems. It is also a problem that the location of the outdoor wires worsens the reliability of the system since it is often liable to natural impacts and intentional human abuse.
The observation of the conveyor is very important, for instance, if a roll is stuck due to abrasion. In this case it is flushed by the increasing friction thus at shutdown the hot roll can easily ignite the conveyor-belt.
In the paper we describe the structure of a low-budget, wireless monitoring system, which does not require too much upkeep. The task of this would be to offer an affordable alternative in order to enhance operational safety.

## 2. Requirements of an outdoor, long-distance conveyor surveillance system

Existing systems on the market are made for some sort of definite purpose, so in case of special needs arise, finding an appropriate solution is very difficult. A conveyor remote monitoring system is a good example for it.

- For the following reasons we prefer **wireless communication technologies:**
  - in case of a regular wire-based surveillance system there are high costs of kilo-meters long communication and power wires,
  - vulnerabilities of long wires due to the outdoor usage.
- **Low device cost per measuring point** is also important:
  - in order to achieve effective protection measuring points should be installed

in an appropriate density (but not in a linear distribution because there are parts on the line which are more or less used).

- **Low power consumption and battery powered devices** are essential:
  - along the conveyor lines a suitable power source is usually not available.
- **Compactness and universality:**
  - these systems will be extensions of the already existing SCADA/DCS systems. The installation and maintenance processes have to be uncomplicated. The highlight of universality is important because of the diversity of conveyor lines' mechanical structures and parameters.

## 3. Our solution to meet these requirements

In our structure the wireless communication nodes (WCN) and the microprocessor-based sensors are separate devices. The WCNs are in some kind of redundant line (ad-hoc mesh) topology along the conveyor line. These transmit the collected measurement data to a gateway device, for example a GPRS modem or Ethernet network through an IEEE 802.15.4 standard-based radio chip. To one WCN several (and different types of) sensors can be attached depending on the needs of the actual measuring point. These connections are wire-based in master-slave topology (multiplexed RS232), so there is no need for additional radio chips. This can be considered as an advantage in cost effectiveness and low power consumption [2.].

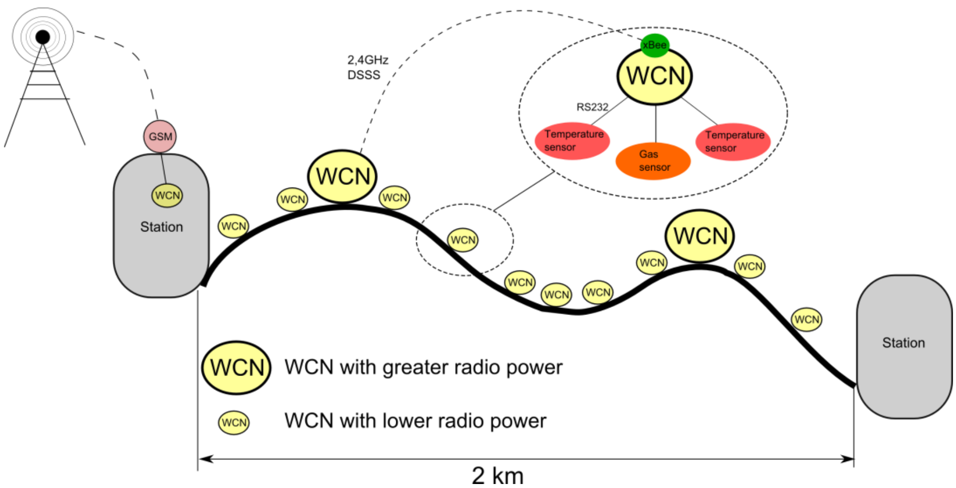


Figure 1. Application example

## 4. Wireless communication

It was mentioned before that we use an already standardized solution for wireless communication. This is the Digi International's DigiMesh [3.], a kind of enhancement of ZigBee. It's big advantage on ZigBee is its support of the cyclic sleep mode due to it has only one type of node (fig. 2.). Each node is a router and end device at the same time, and can go to sleep mode, despite of ZigBee routers.

In cyclic sleep mode there are sleep-times and wake-times. In the network each node is always in the same mode. A specified node, named the sleeping coordinator is responsible for the synchronization of these times. So it follows that except of the sleeping coordinator, all devices can be supplied from battery, which is a main requirement.

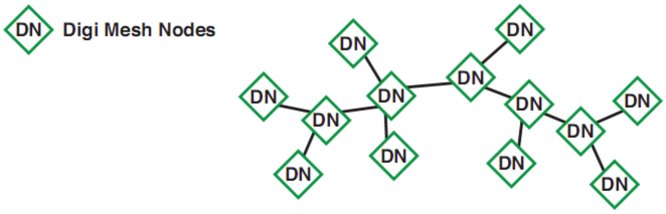


Figure 2. DigiMesh network topology [5.]

## 5. The Wireless Communication Node

The device has four main part:

1. A TI MSP430 micro-controller,
2. an xBee transmitter,
3. a multiplexer IC,
4. a switching power supply.

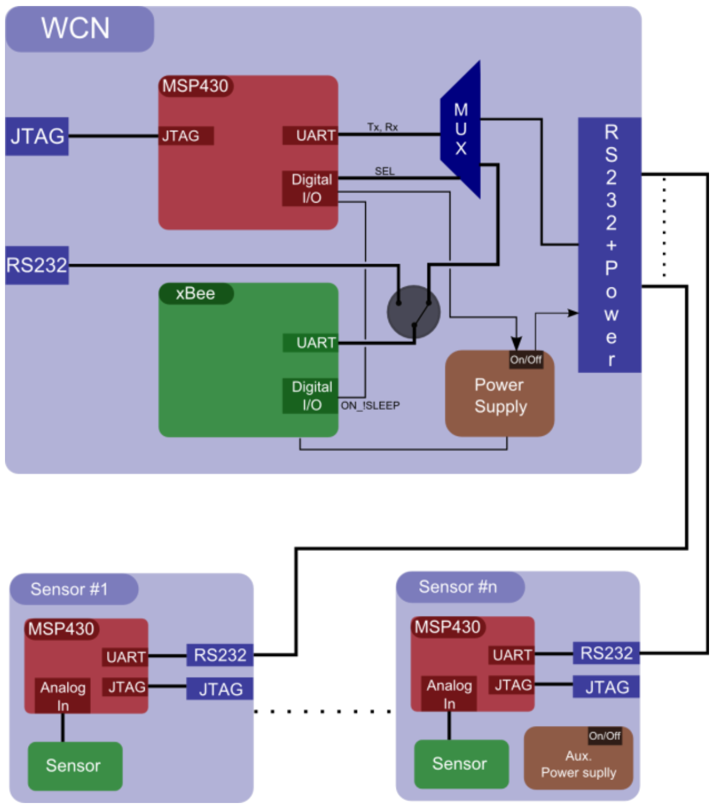


Figure 3. Schematic of WCN and sensors

The device is controlled by the microprocessor which can be programmed through JTAG. It has an UART serial interface where the microprocessor-based sensors are connected to. We have to use multiplexers too, because of the MSP430 has only two serial ports, but the WCN has to host more sensors. The collected data is transmitted by an xBee device.

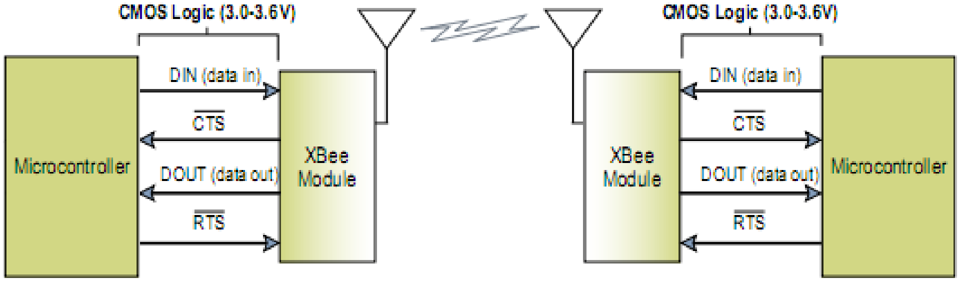


Figure 4. Microcontroller-xBee connection

This can be configured via it's serial port by a PC or the MSP430. We setup it from PC, so the WCN doesn't need to contain a HMI. Thanks to the intelligence of the DigiMesh protocol, in case of placing new devices into the network, the old one's configuration doesn't have to been modified. The power-supply accepts a relative high voltage range (4.5-40V). Thanks to the high efficiency of the used supply and the low power consumption of the circuit the power-source can be batteries, with optional solar-cell recharging system. The sensors gets the needed voltage from the WCN's power-supply (or from them auxiliary supply in case of higher power consumption) only in wake periods. This is solved by an MSP430-controlled electronic switch after the power-supply. This is possible due to the wire-based connection between the WCN and the sensors.
In the xBee's wake-time it sends a digital high signal (ON_!SLEEP) to an interrupt input port of the micro-controller. That wakes up the MSP430, which opens the electronic switch. Consequently, the sensors get their voltage, do the measurement tasks, and send the data to the WCN after it asked. When the xBee's wake period had elapsed, it's sleep-time begins. The ON_!SLEEP signal falls down to digital zero, so the micro-controller does the same with the electronic switch and finally it goes to sleep-mode too [1.].

## 6. Sensors

In a conveyor surveillance system, we advise three kind of sensors:

- Pt100 thin film temperature sensors for contacting temperature measurement on the fix parts,
- IR thermocouples for non-contacting temperature measurement on the rotating and moving parts of the conveyor,
- gas sensors for detecting smoke.

The Pt100 and the gas sensor can be easily adapted to the micro-controller's A/D unit, due to their resistive characteristics.
The gas sensor's measurement algorithm is a bit more difficult than the Pt100's, because we have to register the alteration of it's resistance despite of an absolute value. It varies from the exposure of different gases. (fig. 5.)
In the sensor there is a heating resistor, which supports the appropriate operating temperature. It follows that the measurement cannot begin instantly after the wakening, a temperature rise-time must have been waited for achieving the correct measurement data. We must also consider the quite bit temperature influence of the environment. It can be compensated in software by an additional temperature measurement.
The IR thermocouple generates a very small (~μV) voltage on its output, which depends on the infra light radiation of the pointed surface and the temperature of the environment. The environment temperature minus the target temperature can be defined from the voltage

by modifying it with a constant belonging to the surface of the target's material. The small voltage should be amplified by an amplifier circuit. We get the target temperature by adding the environment temperature to the measured value.

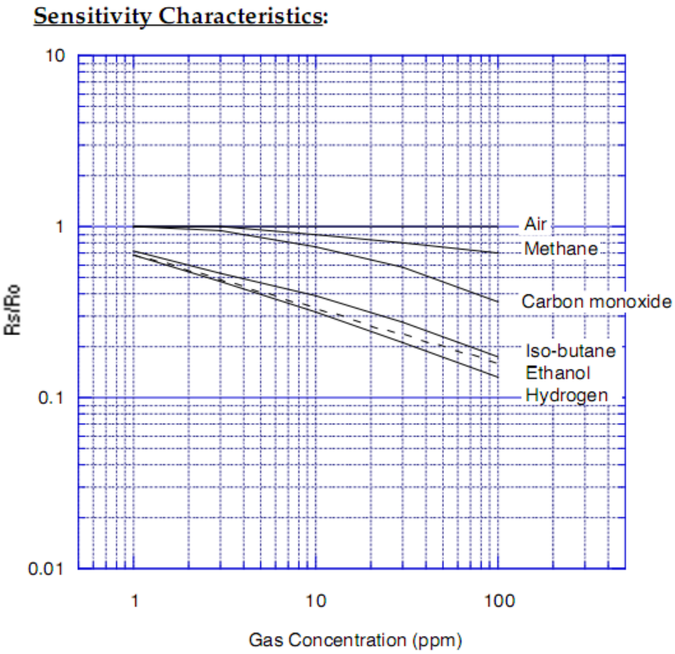


Figure 5. Characteristic of the TGS 2600 sensor [4.]

Figure 6. Temperature sensors

In the lack of using microprocessor these measurement processes would require more complex electrical circuits, which would be disadvantages on cost-, power-efficiency and on reliability. The benefits of micro-controller based measurement can be clearly seen.

## Summary

The goal of the innovation was to find a solution for an industrial problem in a way that is portable enough to realize it as an expansion of an already existing technology.
The main features of the system are the supporting of wireless technology, cost- and power-efficiency, universality, and compactness. The microprocessor-aided measurement highly contributes in the advancing of these requirements.
By using another sensor, the system can be easily adapted in totally different applications like medical patient remote monitoring, home automation, traffic density monitoring in crowded cities...etc.

The development is in the prototyping phase, so we are looking forward to an opportunity where we can test our concept in real industrial environment.

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## References

[1.] KOLOZSI-TÓTH, M.: **Final Thesis - Developing a self-organizing, wireless remote monitoring system for conveyors.** - University of Miskolc, 2011.
[2.] AJTONYI, I.: **Ipari kommunikációs rendszerek IV.** , AUT-INFO Kft., 2011
[3.] Digi International: Demystifying 802.15.4 and ZigBee, 2008
[4.] www.figarosensor.com/
[5.] www.digi.com