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Bluetooth technology for industrial application (Party slave)

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ABSTRACT: The cable transmission of the information between computer devices or / and electronic devices is increasingly replaced by wireless transmission. Bluetooth modules are currently among the best performing wireless communication devices. They are characterized by their small size, excellent radio range and low power consumption.
The Bluetooth technology is commonly used for creating wireless networks in the IT field (keyboard, mouse, printer…). However, this technology can be used in many more application.
In this paper we describe a way to apply the Bluetooth technology in various industrial fields.
The project objective is to establish a Bluetooth communication between industrial supervision system (SS) and a peripheral such as a motor. The peripheral is configured as a slave, while the supervision system is configured as a master.
In this article we describe the party of the Bluetooth peripheral.

KEYWORDS: Bluetooth, Industrial chain, Bluetooth Profiles, Serial port profile, Slave.

1 INTRODUCTION

Among the first applications where wireless was used in industrial applications was in wireless control of Automated Guided Vehicles (AGV) and cranes in warehouses where proprietary radios where used to achieve flexible control of the moving devices.

During the last 14 years, standardized radio technologies like Wireless LAN / WLAN (IEEE 802.11), IEEE 802.15.4 and Bluetooth technology (IEEE802.15.1) have become the dominating technologies for wireless data transmission. [1]

The Bluetooth technology is specified for transmission over short and medium distances. It's highly favored for industrial applications due to the cost-efficiency and to the following advantages: [1] [2].

- Eliminate expensive transmission media such as flexible cables, swivels, etc.
- Eliminate expensive and heavy maintenance
- Bypassing long distances and areas where cables cannot physically fit
- Fast and easy installation and commissioning
- High flexibility if there is a need to modify an installation

- Easy integration of devices into the network
- low power consumption, and automatic power control
- Robust and reliable radio link thanks to Adaptive Frequency Hopping (AFH), Forward Error Correction (FEC), narrow frequency channels, and low sensitivity to reflections /multi-path.
- Security features with 128-bit encryption and authentication

2 INDUSTRIAL CHAIN

An Industrial chain as shown in Figure 1 consists mainly of two blocks, the first is the supervision system and monitoring, the second is the production chain.

The supervision system and monitoring is composed of a control and processing station and an industrial controller (PCL). His role is to ensure its quality production and the best functioning of the equipments of the production chain.

The production chain is composed of actuators such as motors and jacks and sensors. [3]

The two blocks are connected by cables or optical fiber. The connection cables are of two types: one type (Control lines) for controlling the actuators by the system of supervision, the other (Status lines) is to transmit the state of the equipment of the production chain.

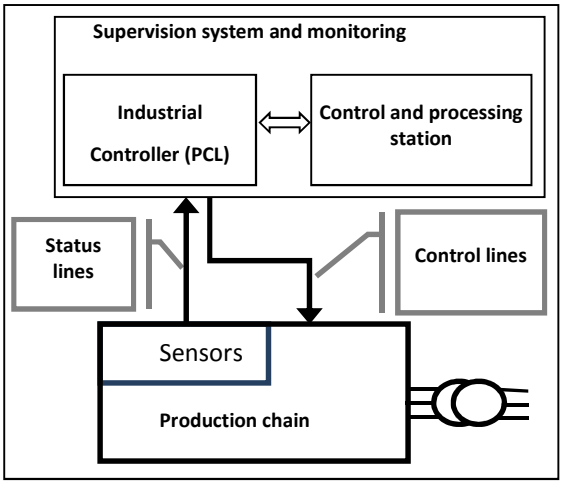

Fig. 1. Synoptic of an industrial chain

The signals associated to an element in a production line (for example a motor) are approximately seven (See figure 2). Five signals associated to sensors of state of the motor and two for control (start and stop motor). A machine consisting average of five motors, each uses 7 x50m of cable, in total about 2 km of cable per machine. [4]

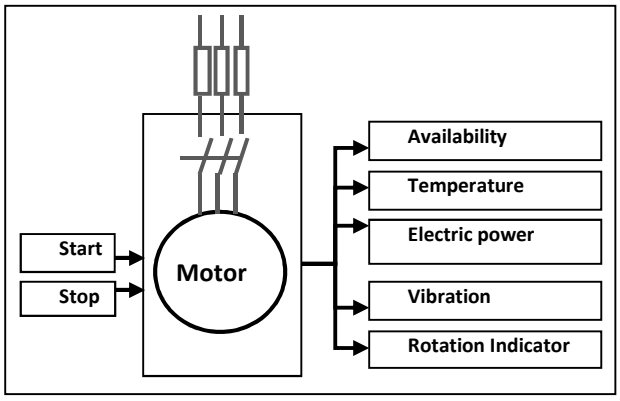

Fig. 2. Signals associated to a motor

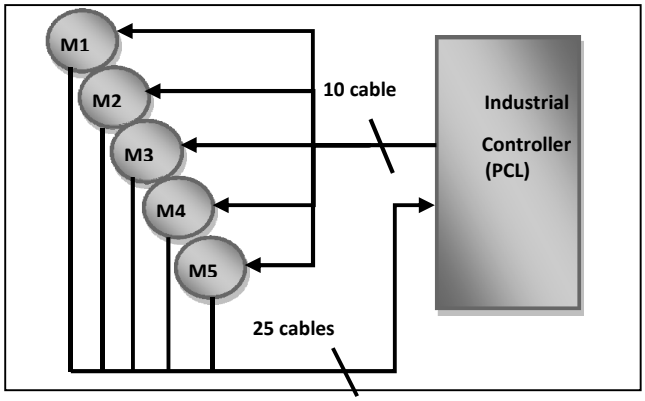

Fig. 3. Cabling of an industrial machine (5 motors)

3 BLUETOOTH NETWORK

Bluetooth devices all operate in the 2.4 GHz frequency band. This means that it uses the same radio frequencies as microwaves, 802.11. What makes Bluetooth different from the other technologies is that it divides the 2.4 GHz band into 79 channels and employs channel hopping techniques so that Bluetooth devices are always changing which frequencies they're transmitting and receiving on.

Bluetooth devices can operate in two modes: master or slave. The master is the first device that provides synchronization, all others are considered slaves. When the slave connects to the master it receives an address and clock, it uses this information to calculate the frequency hopping sequence

A master can control up to seven slaves in his zone. These form a small network called Piconet. Also, one apparatus can participate in several piconets, being the slave in one and master in another. The interlacing of several piconets forms what is called a Scatternet (See figure 4). Thanks to the frequency jumping, 10 independent piconets can transmit at maximum output (or up to 80 apparatus). [5]

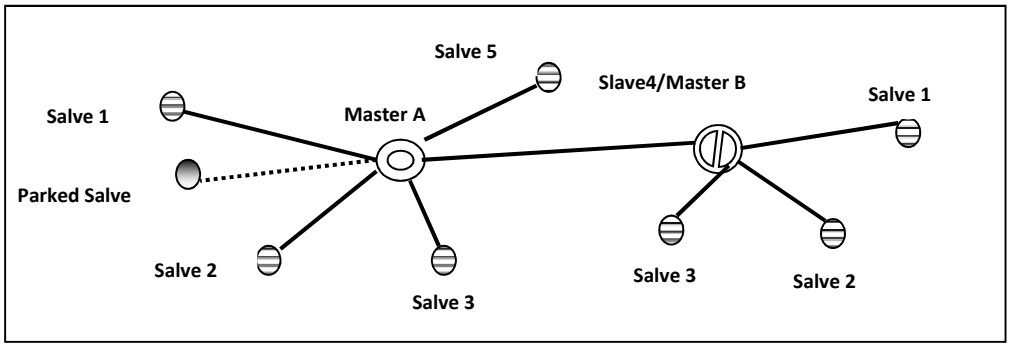

Fig. 4. Bluetooth network (piconet and scatternet)

4 SERIAL PORT PROFILE (S.P.P.)

A Bluetooth profile is a specification regarding an aspect of Bluetooth-based wireless communication between devices. In order to use Bluetooth technology, a device must be compatible with the subset of Bluetooth profiles necessary to use the desired services.

The Serial Port Profile defines the requirements for Bluetooth devices necessary for setting up emulated serial cable connections using RFCOMM between two peer devices

Essentially, the Serial Port Profile defines the protocols and procedures that shall be used by devices using Bluetooth for RS232 serial cable emulation. The scenario covered by this profile deals with legacy applications using Bluetooth as a cable replacement, through a virtual serial port abstraction (See figure 5). [5]

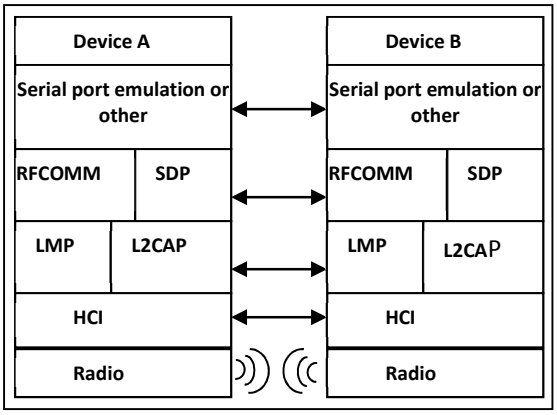

Fig. 5. Serial Port Profile model

5 THE PROJECT OBJECTIVE

The objective of the project is to replace in an industrial chain all cabled transmissions low and medium distance by a wireless Bluetooth Type (Figure6). This transformation requires the use of hardware and software resources.

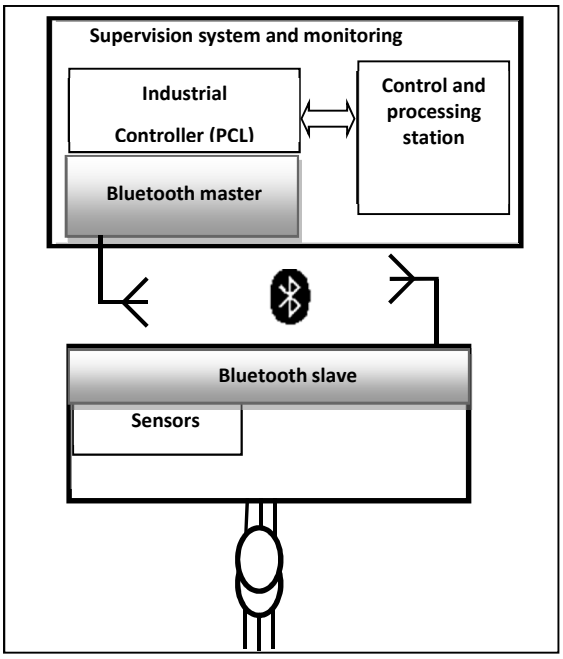

Fig. 6. Synoptic of an industrial chain with Bluetooth transmission

6 THE HARDWARE PART OF THE PERIPHERAL

Materially the Bluetooth communication between the peripheral system and the supervision system is provided by a special Bluetooth module.

The first interest of this module is the fact of belonging to the class using the Bluetooth SPP protocol (RFCOMM). This feature reduces the real Bluetooth communication to a virtual serial communication between the Bluetooth module and the system of supervision (SS).

The second advantage is that this module can be programmed to always remain a slave.

6.1 BLUETOOTH MODULE

Ezurio's Embedded Intelligent Bluetooth Serial Module BISMS02BI-01 is a fully Bluetooth solution designed for lowest cost of integration Bluetooth functionality into products. The module is qualified to Bluetooth Version 2.0.

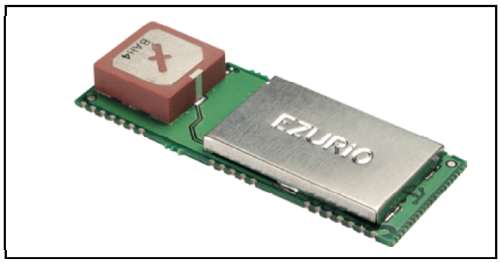

Fig. 7. Bluetooth Serial Module BISMS02BI-01

The Embedded Intelligent Bluetooth Serial Module is designed to give a rugged solution that is ideal for industrial automation and ruggedized handheld devices.

The Embedded Intelligent Serial Module is based on Cambridge Silicon Radio's BlueCore4 chipset. The Module has an integrated, high performance antenna which is matched with the Bluetooth RF and baseband circuitry.

The firmware integrated into the module implements the higher layer Bluetooth protocol stack, up to and including the Generic Access Profile (GAP), Service Discovery Profile (SDAP), Serial Port Profile (SPP) and Audio Gateway.

A virtual processor is used within the BC04 to implement an AT command processor. This interfaces to the host system over a straight forward serial port using an extensive range of AT commands.

In addition to the Bluetooth functionality, The Embedded Intelligent Serial Module provides access to 6 General I/O lines and one ADC input. These can be configured to extend the UART control or to provide connection to devices without requiring any external processing. The GPIO lines can be accessed either via the wired host UART connection, or remotely over the Bluetooth link.

A low cost development system and integrated RS232 products with the same firmware are available for fast product evaluation and development. [6]

The new structure allows the industrial machine to communicate via Bluetooth with the monitoring system is shown in Figure 8.

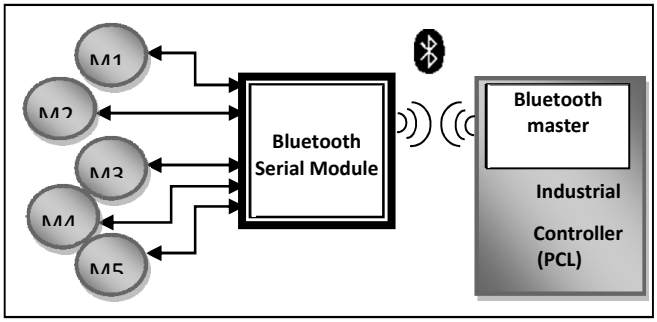

Fig. 8. Bluetooth communication between a device and a system of supervision

6.2 THE ELECTRONIC CARD

The electronic card presented to the figure 9 is capable of driving at least 5 motors with 7 signals for each one. It operates one Bluetooth module BISMS02BI-01, multiplexers and registers (CD4051 BM: Analog multiplexer, CD4094B: register).

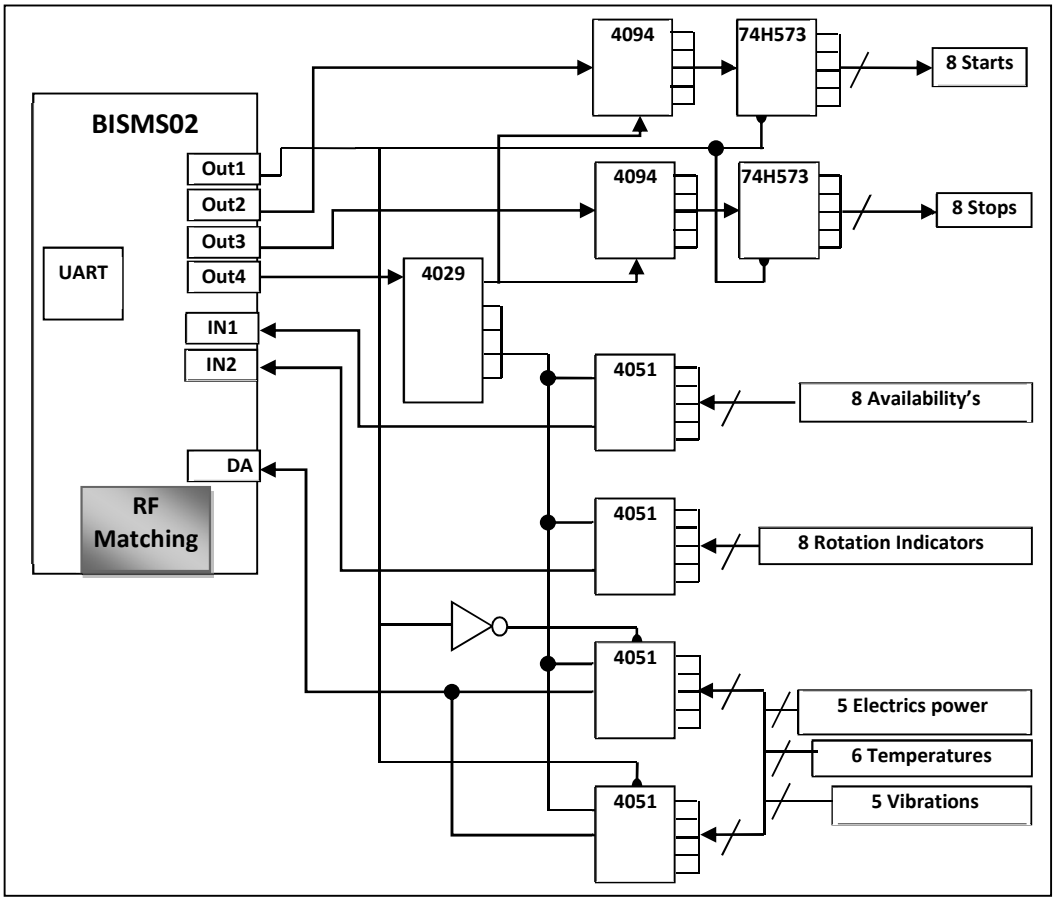

Fig. 9. Schema of the electronic card

7 THE SOFTWARE PART OF THE PERIPHERAL SLAVE

The establishment of a connection between two Bluetooth devices is relatively a complicated procedure, which ensures a level of safety. The steps of this sequence are as follows: The steps of this sequence are as follows:

- Passive mode (In normal use a device operates in "passive mode", it is listening to the network)
- Phase inquisition providing research and discovery of the connection.
- Synchronization (paging).
- Service Discovery.
- Creating a communication channel.
- Pairing with a PIN (security).
- Using the network.

The software part of the slave system is based on the module configuration. This configuration consists of several procedures (See figure 10) to apply to the registers of the module, we cite a few:

- Configuration for be a slave
- Configuration for enabling serial port profile
- Configuration for be discoverable
- Configuration for be connectable
- Configuration for have an automatic response
- For the security of communication we use encrypted mode with a PIN code

The programming uses the industry standard Hayes AT protocol used in telephony modems which is appropriate for cable replacement scenarios. The telephony commands have been extended to make the EZURiO device perform the two core

actions of a Bluetooth device, which is make/break a connection and Inquiry. Many others AT commands are also provided to perform ancillary functions, such as, pairing, trusted device database management and S Register maintenance. [7]

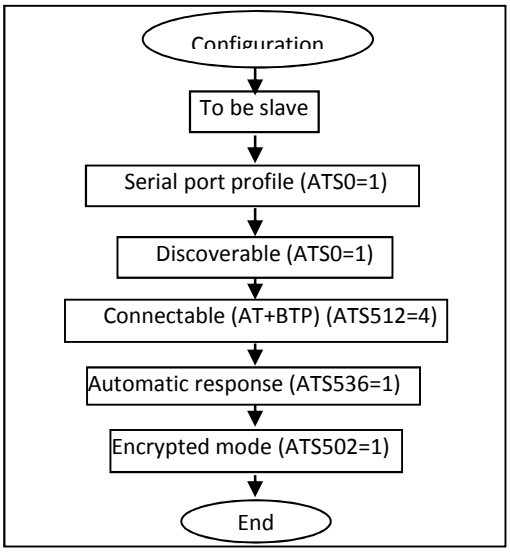

Fig. 10. Organization chart for the configuration of Bluetooth module.

8 CONCLUSION

In this paper we showed the hardware and software levels to develop for exploiting the Bluetooth system as a means of communication between a device of a production chain and an industrial supervision system.

The proposed solution presents a very low cost compared to cable transmission. In addition it promotes energy optimization and minimizes electrical accidents and nature pollution.

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