Bluetooth Based Telemetry/ PLC System

Abstract
Bluetooth has been one of the best trustable short distance wireless communication systems that can be accessed and used very easily. It is envisaged that it will allow for the replacement of the many propriety cables that connect one device to another with one universal radio link. Its key features are robustness, low complexity, low power and low cost. Designed to operate in noisy frequency environments, the Bluetooth radio uses a fast acknowledgement and frequency hopping scheme to make the link robust. In this work, a telemetry/PLC Bluetooth based system will be introduced and described. The system is a general data acquisition and control system that may be used in several application in industry , biomedical equipments , building management systems and Car Area Networks (CANs) . The system described is completely built using the AT 89C52 μ-controller and the **Blu2i** Bluetooth module from **TDK** system. Example of applications of the system are in security, home appliances control, and remote data acquisition .Experimental work confirm the estimated system performance .

I- Introduction

Since Introduced in 1999 the Bluetooth RF link has been used in several custom applications in different areas of interest. Bluetooth is the name given to a new technology using short-range radio links, intended to replace the cable(s) connecting portable and/or fixed electronic devices [1]. Its key features are robustness, low complexity, low power and low cost [2]. Designed to operate in noisy frequency environments, the Bluetooth radio uses a fast acknowledgement and frequency hopping scheme to make the link robust. Bluetooth radio modules operate in the unlicensed ISM band at 2.4GHz, and avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet [3]. Compared with other systems in the same frequency band, the Bluetooth radio hops faster and uses shorter packets. Recently, for example, instead of data-cables, which make difficult the daily work with patients, using the **Bluetooth™ Technology** can bring a solution to this situation. Distances of up to 100 m can be simply and securely overcome at data rates up to 720 kbit/s. Low energy consumption; encrypted communication and simple configuration make Bluetooth the **ideal transmission technique for medical applications [4]**. Cable connections based on RS232 can also be replaced by Bluetooth and Bluetooth enable devices. Today the target products in the market include:

1-Intelligent Devices Audio Peripherals :
• Headsets • Speakers
• Stereo Receiver

2-Data Peripherals:
• Mice • Keyboards • Joysticks
• Cameras • Digital Pens

3-Embedded Applications:
• Cars: Power lock controls • Grocery store updates • Closed Systems
• Industrial systems • MIDI musical instruments • PCs • Cellular Phones
• PDAs • Printers
• LAN access points

The Usage Models covers the following applications :
• Computer to Computer File Transfer • Dialup Networking
• Synchronization • 3 in 1 Phone • Ultimate Headset• Computer Speakerphone
• Cordless Computer • Instant Postcard• Hidden Computing • Conference Table

The Characteristics of a Bluetooth link and module may be summarized as:
• Unlicensed 2.4GHz radio band
• ISM (industrial, scientific, medical) band - Available worldwide
• Also used by Microwave ovens, 802.11, Home RF…
• Gross data rate of 1 Mbit/s
• Basic 10m range extended to 100m with amplifiers
• TDMA - TDD - Frequency hopping
• Mixed voice / data paths
• Encryption
• Low power
• Low cost
• Extremely small

Programmable logic controller (PLC) is a basic building block needed in many applications in industry , security systems, data acquisition and home appliances monitoring and control [5]. In general a PLC may be either PC (Personal Computer) or μ-controller based system according to the application. It picks up analog and digital signal from attached transducers used to measure the physical quantities to be controlled. These signals are then processed digitally through suitable software in order to generate the digital control signals needed to complete the control process. So many systems or PC based cards are available from several manufactures that works as PLC [6]. These systems can

be used from remote sites using Remote Terminal Units (RTUs) that may use wire, fiber optics or wireless links for data transmission using a suitable MODEM. The Bluetooth technology may help in implementing such systems to overcome some technical problems manifest specially when trying to build such system in old building or noisy environments, some of these problems are:

1- Building is old and wire connection is impossible
2- A lot of noise exists.
3- Data security is not ensured.

In this paper we describe a simple approach that make use of this technology for implementing a μ- controller telemetry / PLC module that can be simply accessed and programmed using any portable data terminal equipment (DTA) attached to a Bluetooth device for example any Laptop or even some cellular phones available in the market. The system block diagram is shown in Fig.1 where the Bluetooth module attached to the μ-controller will be resident in a fixed place within short distances from the transducers (few tens of meters) .The data pick up Laptop can access, download, up load and command the telemetry /PLC module when it enters the covered RF .A resident assembly program on the μ-controller board allows it to transmit and receive data bytes to and through the attached Bluetooth module under the control of:

1- A program running by the Laptop
2- Using the keyboard of the laptop
3- A far end computer, if the Laptop is connected to another computer through a network , or even the internet .

The μ- controller is programmed in such a way that it continuously measures and stores in its RAM all readings from the attached transducers and keeping the control signal needed by the process under control . A user can remotely access the controller by enabling a Bluetooth module attached to his Laptop and start searching any active Bluetooth device within coverage range . Once seen by the Laptop side the control is taken by the user which will be capable at this instant to download the stored data and change the set points of the running algorithm at the m- controller side .

II- System Description and Design Procedure

Referring to Figure.1 the system contains the following basic units:

1- The Bluetooth module
2- The μ-controller.
3- Transducers & Process under control interfacing

II-1 The Bluetooth module

The blu2i Module from TDK [7] contains a complete Bluetooth interface and requires no further hardware to implement full Bluetooth communication. The module has an integrated, high performance antenna together (see Fig.2) with all RF and Baseband circuitry, it may be interfaced to any data terminal equipped with a serial port using AT commands. The module runs specific firmware within the Virtual Processor that includes a serial Port Profile and AT command interpreter. The module provides access to 5 General I/O lines and 2 analogue I/O lines to provide Bluetooth connection to simple devices such as switches or LEDs without requiring any processing at the module end. Blu2i module features are listed in table 1 :

Table 1
Blu2i module features

Implementation	Feature
Class 1	Bluetooth Transmission
2.400 – 2.485Ghz	Frequency
+0dBm	Minimum Transmit Power
+6dBm	Maximum Transmit Power
Better than-85dB	Receive Sensitivity
+2dBi	Antenna Gain
Up to 100 meters free space	Range
Up to 200Kbps	Data Transfer Rate
24 x 69 x 5 mm	Physical size
8g	Weight
Bluetooth 1.1 PRODUCT listing	Fully Bluetooth pre-qualified
Less than 36mA during data transfer	Current consumption
-20°C to +75°C	Temperature Range
PCM interface at 64Kbps	Audio
Vcc = 3.6V to 6V.	Power supply

II-2 The μ- controller

The system uses the 89C52 single chip μ- controller from ATMEL [4]. This chip is an 8-bit, low –power, high performance CMOS μ-controller suitable for so many applications. It is also available in the local market with a relatively low price. The core structure is as same as that of the well known chip 8051 μ -controller and has the same instruction set. The 89C52 chip contains the following sections:

1- Standard 80C51 CPU
2- Full–Duplex UART (Universal Asynchronous Receiver Transmitter).
3- 3 programmable timers.
4- 8 k byte Flash memory.
5- 4 I/O programmable ports
6- Crystal Oscillator circuit where the crystal is connected externally. The chip can also work from external clock generator while disabling the Crystal oscillator.

The functions of the μ-controller in the system are:

a- Initiate the attached Bluetooth and make it ready to communicate with the Laptop. This is important to acknowledge the far end control units that the system is ready. This step is done once when system power is turned ON, and each time the power is turned ON.
b- Check the reception of any commands and sending a confirmation .
c- Process the received commands and produce all signals needed to physically execute this command .

d- Perform any needed tests and acquire all possible signals that confirm the execution of the received commands.
e- Send a confirmation message to the Laptop and return again in waiting state for another commands.

Of course the above functions are general and the system driving software may be written to adopt a specified application. The UART part of the 89C52 serves to communicate with the UART part of the attached Bluetooth module.

The end user part of the system includes all the necessary circuits and sensors needed to couple, apply input or output signals from the □-controller to the units to be controlled .The measurement of the physical quantities to be controlled is done using suitable sensors and then we adapt output signals from these sensors to be interfaced to the I/O ports of the □-controller. Among the circuit that may be employed in general are:

1- Different types of sensors, analog or digital, to sense temperature, pressure , speed, …etc
2- Analog signal processing circuits.
3- Programmable counters and timers, power switches: mechanical relays or semiconductor switches.
4- A/D and D/A circuits
5- Input output latch circuits.

III System Operation

To put the system in operation we have to program the Bluetooth module and give it a pass code. This step is applied once using a standard RS232 connection with any PC. The following steps have to be followed to establish the connection:

1- Open the hyper terminal and make a new connection.. Choose communication port for example COM1.
2- Set the properties of the COM port as follows:

Bits per second: 9600 Data bits: 8 `Parity: None
Stop bits: 1 Flow control: Xon /Xoff

3- Use the Hayes command set (AT command set) to initiate, send and receive binary data in ASCII code.

4 - Run Hyper Terminal under windows on that particular COM port , then

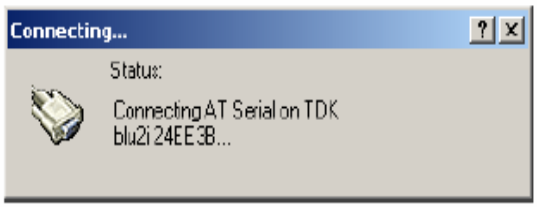
- Type in ats0=1 <cr>
- Type in ats512=4 <cr>
- Type in ats502=1 <cr>
- Type in ats536=1 <cr>
- Type in at+btk=”XXXX” <cr>

where XXXX is a numeric PIN of your choice.

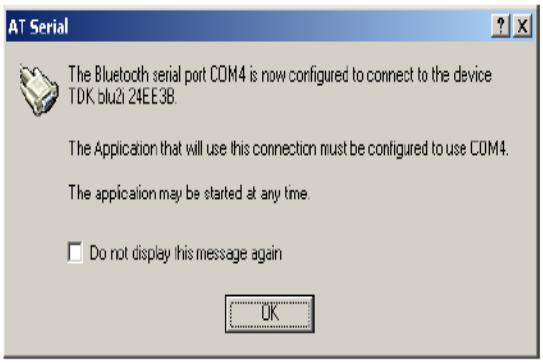
- Type in at&w <cr>
- Type in atz <cr>

<cr> is the return button on your PC keyboard

Plug your Bluetooth device in any USB Adaptor on your PC or Laptop, double click on ‘My Bluetooth Places’ then Click on ‘View devices in range’, you will see all devices in range, choose from them the device you wish to connect to (in this case the TDK blu2i device). Right click on the icon and click on ‘Connect to Bluetooth Serial Port’. You will see the screen ‘connecting’ as below:



as well as a prompt in your bottom right hand tray of your PC which will ask for you to enter a pass code. Now enter the PIN number which you specified earlier for the blu2i module, and click on ‘OK’. Once you have successfully entered the correct PIN number you will be able to connect to that device any time you wish without having to reenter the PIN code. When you double click on the icon you will see the following:



and then click on ‘Search for devices in range’. An icon named blu2i24EE3B will be displayed with other devices in range , double click on the relevant device which you

This will tell you which COM port is configured to be used with your USB Adaptor. In this case COM4.
Click on ‘OK’ and then double click on the icon and you will see a response that shows the device is connected. Now you know that you can use port 4 from any programming language C++ or Visual basic for example or a communication package (hyper terminal) to communicate (send or receive bytes) with any other computer or m- controller attached to the TDK blu2i device with numeric PIN chosen above. To configure another TDK blu2i device repeat steps 1 to 5 but use other PIN numbers.

IV Application example in industrial zones

One of the most important applications of the above technique is in building telemetry /PLC wireless system in industrial environment. The schematic given in Fig.3 gives a proposal of such system where each card telemetry /PLC wireless Bluetooth module has its own PIN number and the location of each module is chosen to cover a predefined zone within the industrial site. A person carrying the Laptop can move freely within the site and acquire the data or send a command to Module 1000 or 2000 or 3000 as being in its coverage zone.

V- Experimental work

One module of the system described above was completely built and tested in the laboratory to verify the system function. Fig.4 gives a complete circuit diagram for the module where the A/D converter circuit used contain a built in 16 channel multiplexer . The module can provide 16 analog single ended channels or 8 differentials input channels . As the conversion time of the used A/D circuit is 100 ms , the sampling frequency is highly limited , under software control the maximum sampling frequency obtained was about 100/sample/channel/sec which is reasonable for slow varying control signals like temperature , pressure ,flow …etc and most of signals and quantities involved in process measurements and control . The A/D converter is wired to one port of the µ- controller , the fourth port is wired to a D/A converter to provide analog control signal if any .1/2 of the vthird port is used for multiplexer addressing , while the second half + port 2 provide 12 general purpose digital I/O function and may be used for any digital control . The module used single 5 V dc power supply for all circuit. The system performance is completely agreed with that described above.

IV Conclusion

Bluetooth is one of the best trustable short distance wireless communication systems that can be accessed and used very easily. It is envisaged that it will allow for the replacement of the many propriety cables that connect one device to another with one universal radio link. A telemetry/PLC Bluetooth based system may be built and put in operation. The system is a general data acquisition and control system that may be used in several application in industry , biomedical equipments , building management systems and Car Area Networks (CANs) .The Bluetooth technology may help in implementing such systems to overcome some technical problems manifest specially when trying to build such system in old building or noisy environments. An Example of working such system in noisy industrial environment is given.. The system described is completely built using commercial low cost components which are easily available in the market. The design procedure is given in details and even non- electronic engineers can build and operate the system . . Example of applications are home security, home appliances control, and remote data acquisition. .Experimental work confirm the estimated system performance and showed excellent and promising advantages of such technique in replacing traditional wired system.

References

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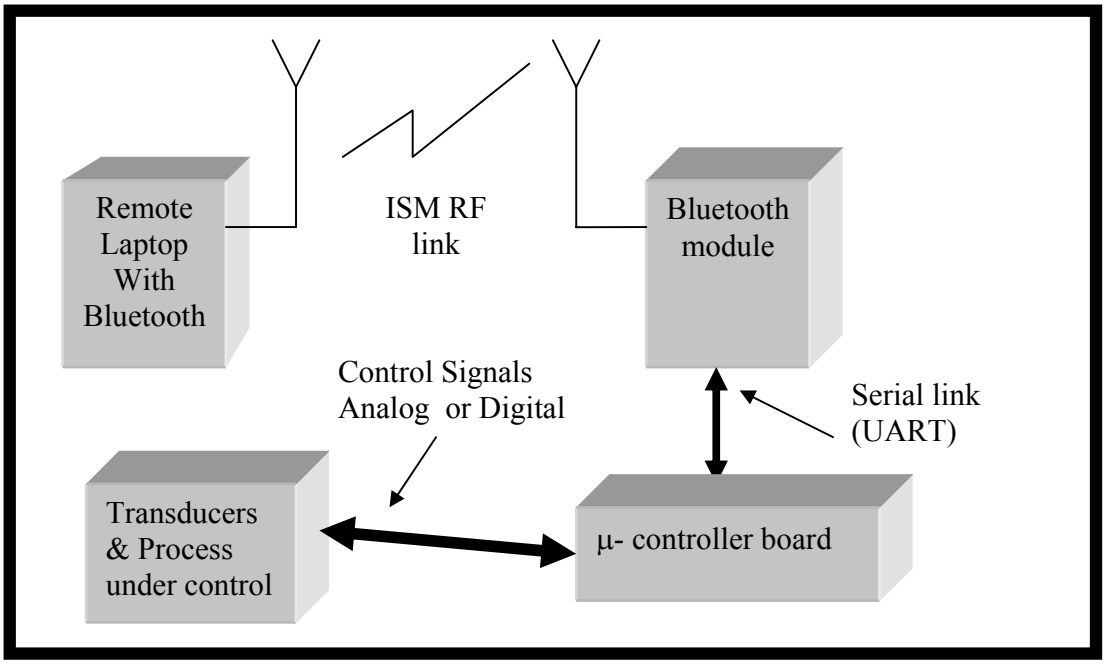

Figure 1 The system block diagram

Figure 2 The Blu2i module

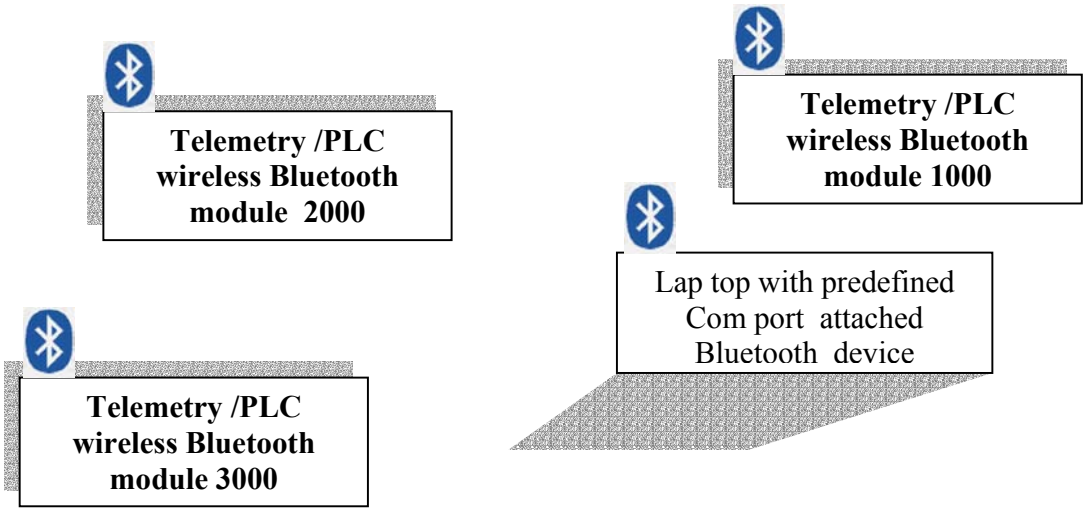

Figure 3 Application example in industrial zones

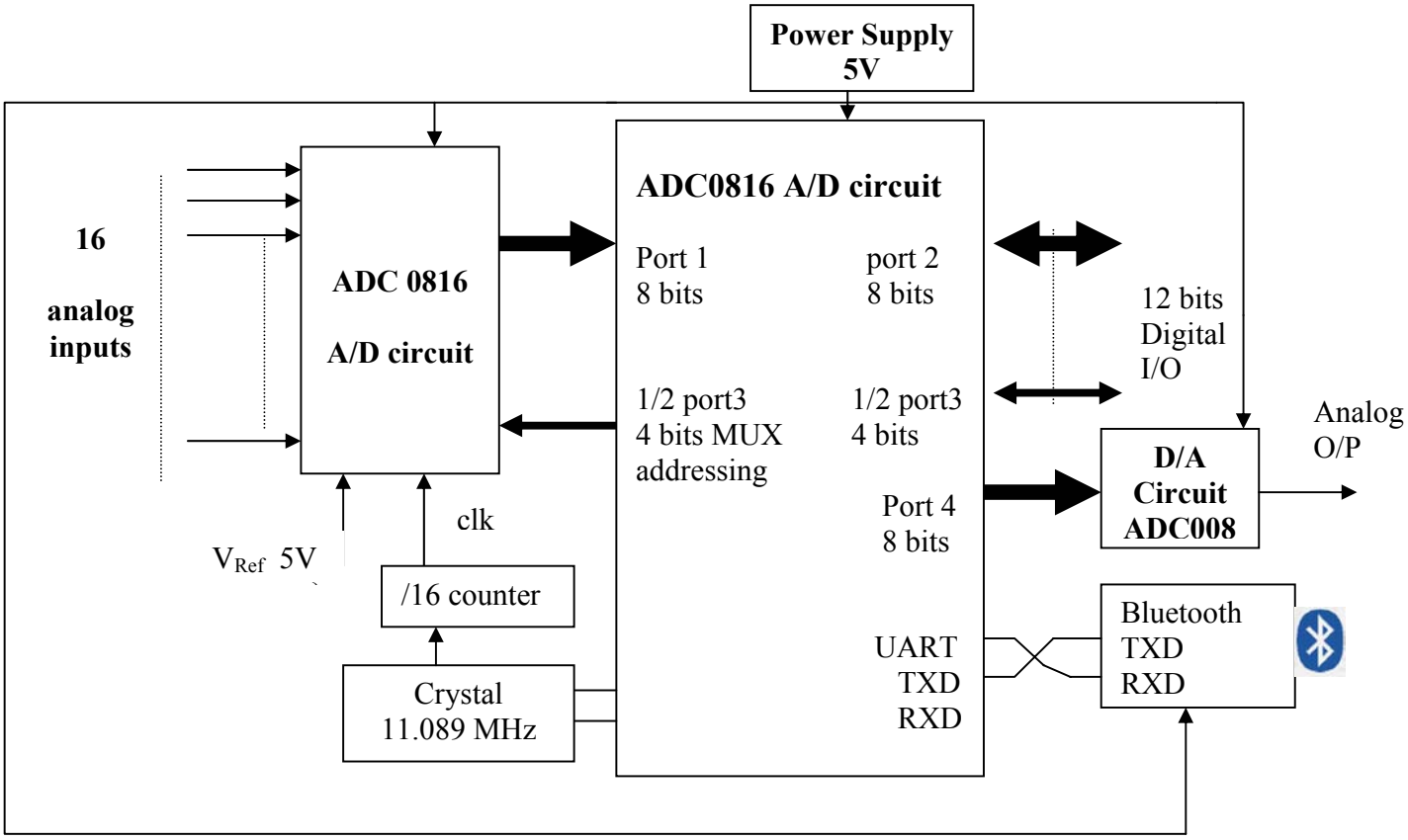

Figure 4 Circuit diagram for the built module