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Design and Implementation of General Purpose Remote Terminal Unit (R.T.U)

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Abstract - This paper introduce the design and development of multifunctional sensor nodes, the design based on microcontroller which represent the heart of any low cost R.T.U. A small size R.T.U can be used as a server provides the required data in the remote area. The proposed R.T.U is of low cost, low power, easy to implement and efficient to be used in different applications.

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Design and Implementation of General Purpose Remote Terminal Unit (R.T.U)

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Abstract - This paper introduce the design and development of multifunctional sensor nodes, the design based on microcontroller which represent the heart of any low cost R.T.U. A small size R.T.U can be used as a server provides the required data in the remote area. The proposed R.T.U is of low cost, low power, easy to implement and efficient to be used in different applications.

I. Introduction

Telemetry is the science of gathering information at some remote location and transmitting the data to a convenient location to be examined and recorded, when telemetry is used both to monitor and control, the term supervisory control and data acquisition (SCADA) is often used to describe the system.[1]

Telemetry system consists of three parts, which are: central unit, RTU and communication media.[2]

A remote terminal unit (R.T.U) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a central unit or SCADA by transmitting the required data to the system and sometimes by using messages from the central unit to control connected objects.[2]

The remote terminal unit consists mainly from three major parts (sensors, microprocessor or controller, Communications parts), Each R.T.U composed from the sensors that provide the required data for a certain application, the microcontroller which is the most important part of the R.T.U that collect the data from the sensors, process it and give it to the communication part for delivering it to the central unit.[2]

Microcontrollers are devices also known as computer in a chip, the design in cooperates all of the features found in a microprocessor (CPU, ALU,PC,SP and all registers) it has also other added features need it to be a complete computer : Rom, RAM, serial and parallel I/O, counters and a clock circuit. The prime use of the microcontroller is to control the operation of the R.T.U using a fixed program which is stored in ROM.[3]

The microcontroller is an embedded system which is used by individuals, who are, in the main, unaware that the system is a computer–based. The microcontroller is not flexible, it does not have an operating system; it's programmed to perform the required task.[4]

The microcontroller inside the R.T.U itself can not send data over any transmition media unless it is interfaced with parts or IC's capable of doing that [1].

To make the proposed R.T.U send data over computer networks, the controller inside the R.T.U need to have a TCP/IP protocol in the code memory making it an Ethernet node, well the controller also needs special parts that allow us to reach this media.[5]

Ethernet is the technology for LANs, Standardized in IEEE 802.3. In the OSI reference system, Ethernet is at the Data Link layer. used to connect computers in home and offices. It is also possible to interconnect networks by router and Gateways end with WANs.[6]

TCP/IP is a suite of protocols used in the internet to allow communication between computers, it is a layered protocol based on the open system interconnection OSI model, The term TCP/IP refers to communications that use TCP and IP protocols.[5]

II. Hardware Design of the Proposed System

a) *The Hardware Design of the R.T.U.*

The propose hardware design of the R.T.U is shown in figure (1)

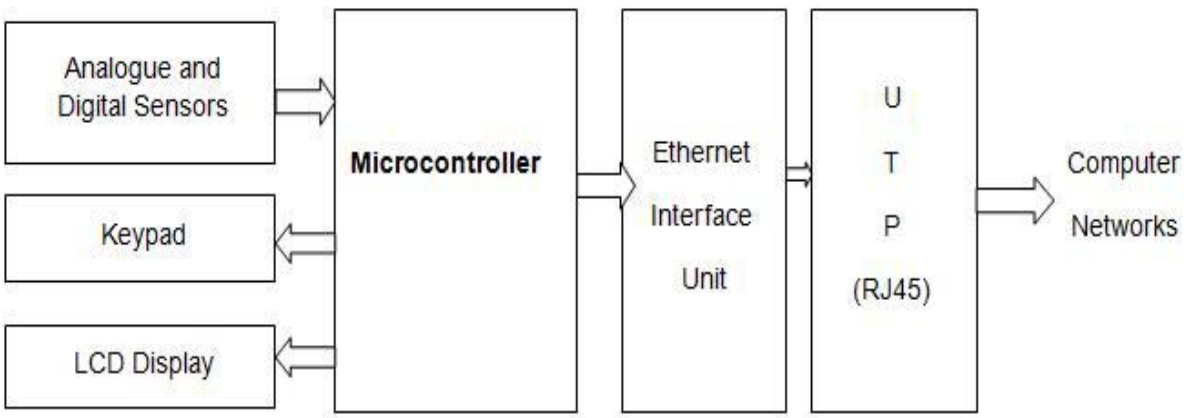


Figure 1 : The block diagram of the proposed R.T.U

The proposed R.T.U was implemented by using the following electronic components

- PIC16F887 Microcontroller.
- LM35 and DS18s20 as a temperature sensors.
- ENC28J60 as the Ethernet controller.
- Keypad and LCD

The PIC16F887 microcontroller has an 35-I/O pins, 14-I/O pin can be programmed to be either analogue or digital inputs, the other I/O pins can interface digital inputs. [7]

The first step of implementing the proposed design of Ethernet system is to interface the microcontroller (PIC16F887) with sensors, accessory part and the Ethernet controller 28J60. These interfaces include the hardware connections and programs reside in the mind of the microcontroller, the details can be summarized by the following sections

i. *data collection part*

The data collection section is performed by interface the PIC16F887 with sensors. The sensors identify which data is to be collected such as temperature, pressure, humidity, force and etc. LM35 and DS18s20 were selected as examples of analogue and digital sensors respectively.

The LM35DZ is an analogue sensor that is used for reading temperature range from -55 ^{o} to + 150 ^{o}. The PIC16F887 microcontroller has a built in Analogue-to-digital (ADC), so that the sensor's analogue signal can be connected directly to the analog input of the microcontroller.

DS18S20 is an example of digital sensors that read temperature provides 9-bit centigrade temperature measurement range from -55^{o} to +125^{o}.

In the implemented R.T.U two LM35 and two DS18S20 were connected to the PIC 16F887.

ii. *Accessory Part*

Adding a keypad and LCD display to the proposed R.T.U give to it aesthetic, not only this, in some applications the user want to interact with the R.T.U such as give it a new IP address or see some results, in the designed and implemented Ethernet R.T.U keypad and LCD display were added for security assigning a password to R.T.U.

iii. *Ethernet module part*

The PIC16F887 microcontroller can be connected to the computer network media via an Ethernet controller unit.

Microchip ENC28J60 is a stand- alone Ethernet controller with SPI (Serial peripheral interface). The ENC 28J60 meets all of the IEEE 802.3 specification, support one 10BASE-T port full duplex mode. ENC28j60 was used in the implementation of the proposed R.T.U.

b) The Hardware Design of the Central Unit

The main function of the central unit is to receive, process, store and display the data received from the R.T.U.

The implemented hardware consists of PC with NIC (network interface card) and IP address 192.168.1.67.

III. The Software Design

a) The Software Design of R.T.U.

The general flow chart of the implemented program is shown in figure (2), complex functions were given in subroutines. These routines easily give a good understanding of the main program. This program was implemented to reside in the ROM of the PIC16F887 which perform the operation of data collection from sensors and transmitting these data to the central unit via the communication media.

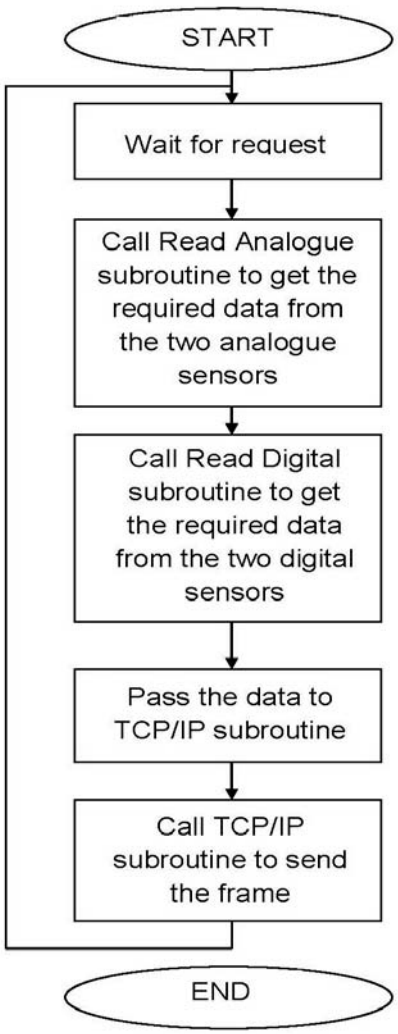


Figure 2 : The implemented program in the mind of R.T.U

There is no end stage in this flow chart because the R.T.U will always waiting for any request from the central unit.

With interfacing (hardware and software) with Ethernet controller the PIC now has NIC (network

interface card), the Ethernet system was become a R.T.U which is capable of sending the collected data.

The designed and implemented Ethernet R.T.U has the following features:-

a. Port Address 80:- the port address operates in transport layer guaranty the delivery of the data to the collect application in the PC. Port 80 is a HTTP (hypertext transfer protocol) function as a request-respond protocol in the client server model.

b. IP Address 192.168.1.60:- the IP address operate in the network layer guaranty the delivery of the packet to the correct device in the wide area network, each device on the computer network must have a unique IP address.

c. MAC Address 00.14.A5.67.19.3F h: - the MAC address operates in data link layer guaranty delivery of the frame to the correct device in local area network. Each device in the LAN has a unique MAC address.

d. The Speed of R.T.U:- is 10Mbs which is a good data transfer rate, this good data rate allow the R.T.U to transfer images and videos.

b) Software Design of Central Unit

The software was designed and implemented in visual basic program as shown in figure (3).

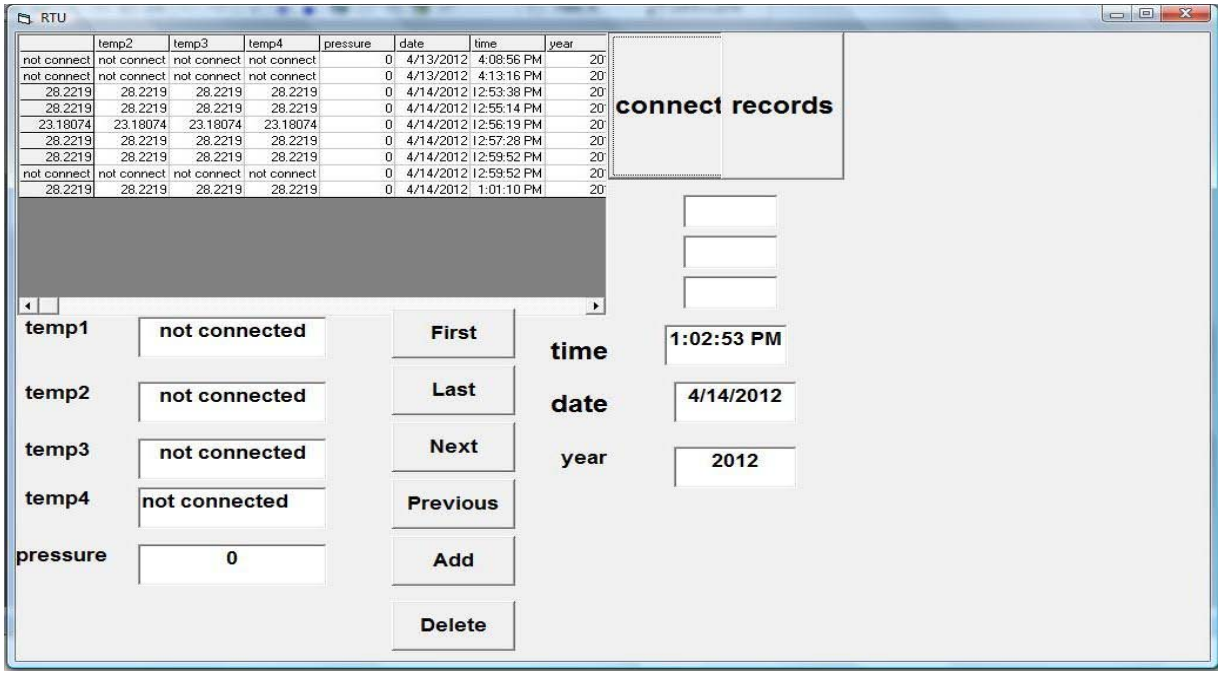


Figure 3 : The designed and implemented central unit program

Programming in visual basic is a combination of visually arranging components or controls on a form and writing additional lines of code for the functionality. The Winsock control can be used for TCP communications, properly must be set for TCP protocol, the IP address and port number of the target device are stored in the' Remote Host' and 'Remote Port' properties, these properties can be set either on design time or run time.

The flow chart of the implemented central unit program is shown in figure (4).

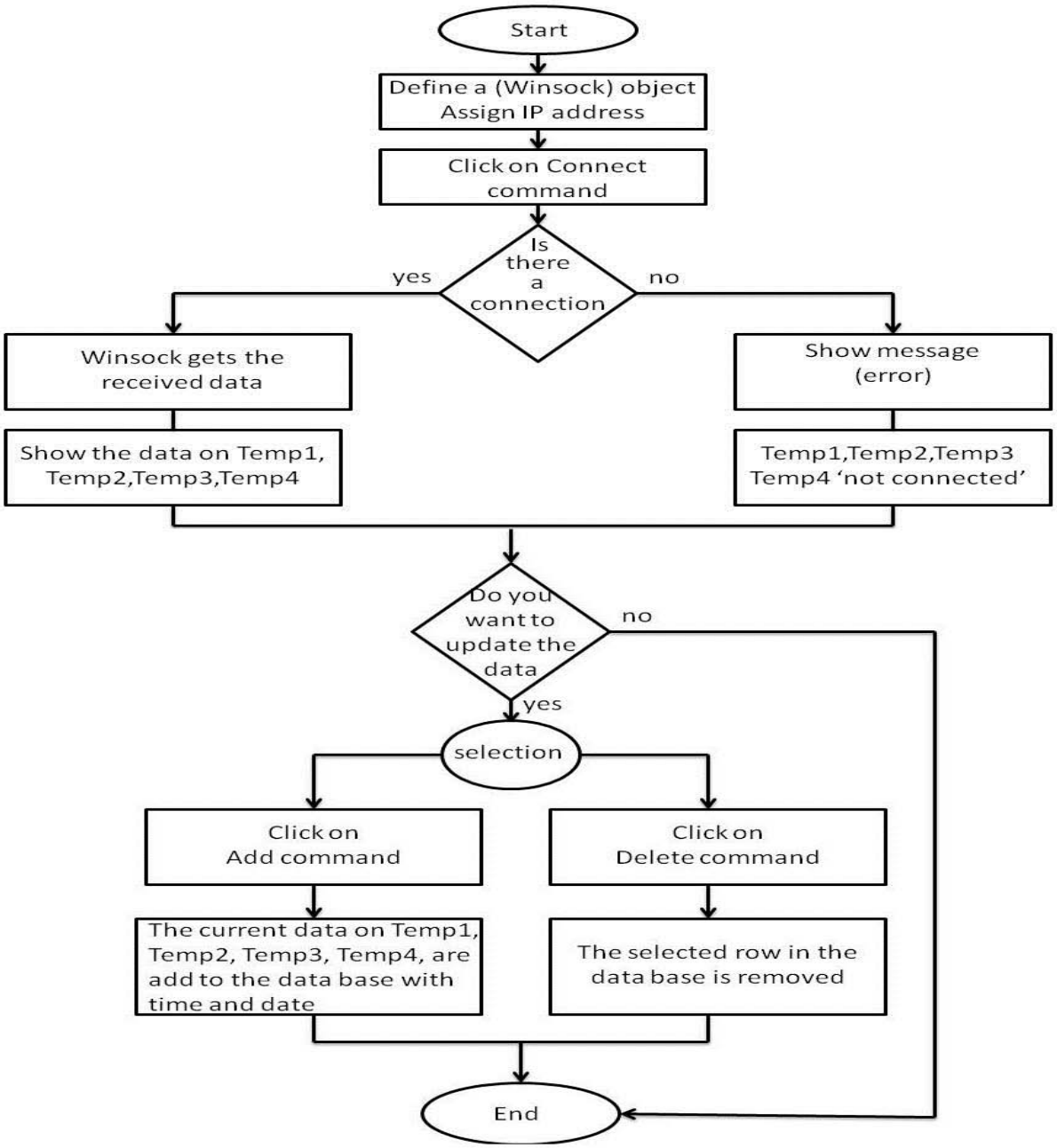


Figure 4 : Flow chart of the central unit program

IV. Result and Discussion

The Ethernet R.T.U was designed and implemented successfully as shown in figure (5). The technical specifications for the R.T.U are:

- Supplied voltage: - 5volt.
- Operating frequency: - 5Mhz.
- Output current: - 100mA.
- Bit rate: - 10Mbs.
- Number of input: - 2 analogue signal, 2 digital signal.

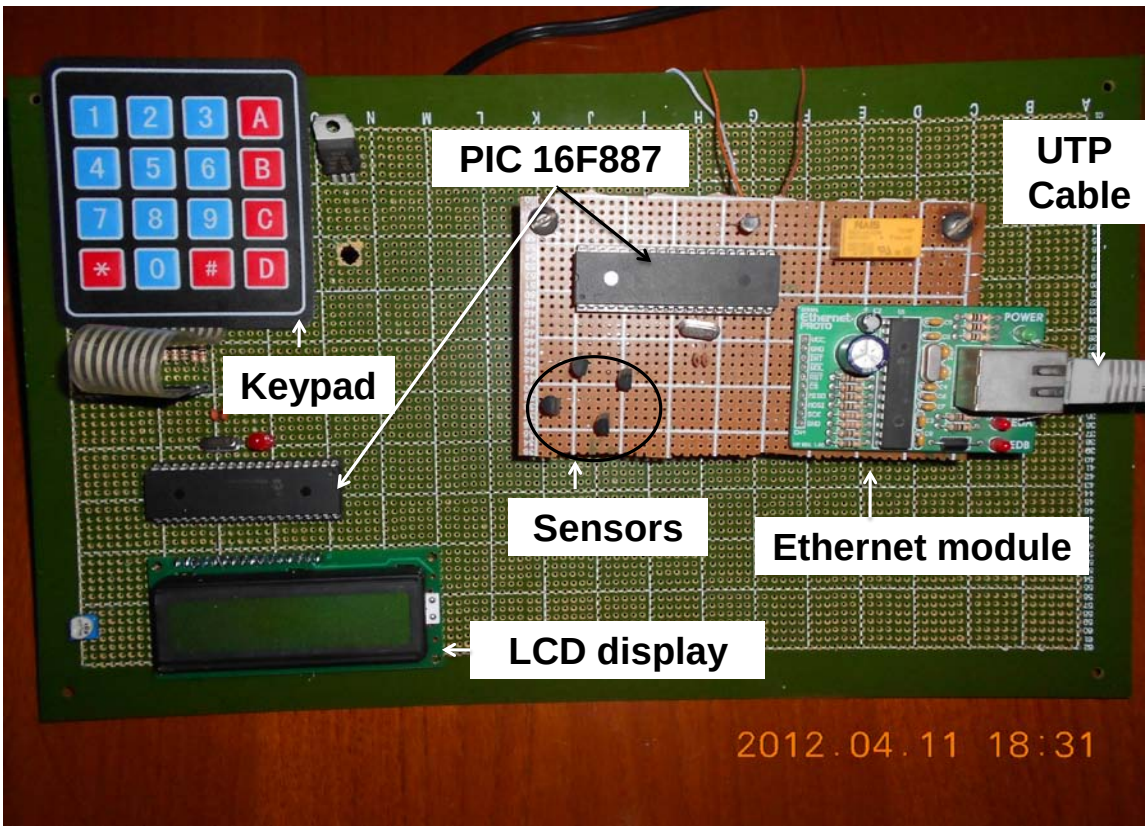


Figure 5 : The implemented Ethernet R.T.U

Figure (6) shows a connection between R.T.U and central unit over a WAN . A router was added to allow access to WAN and internet networks.

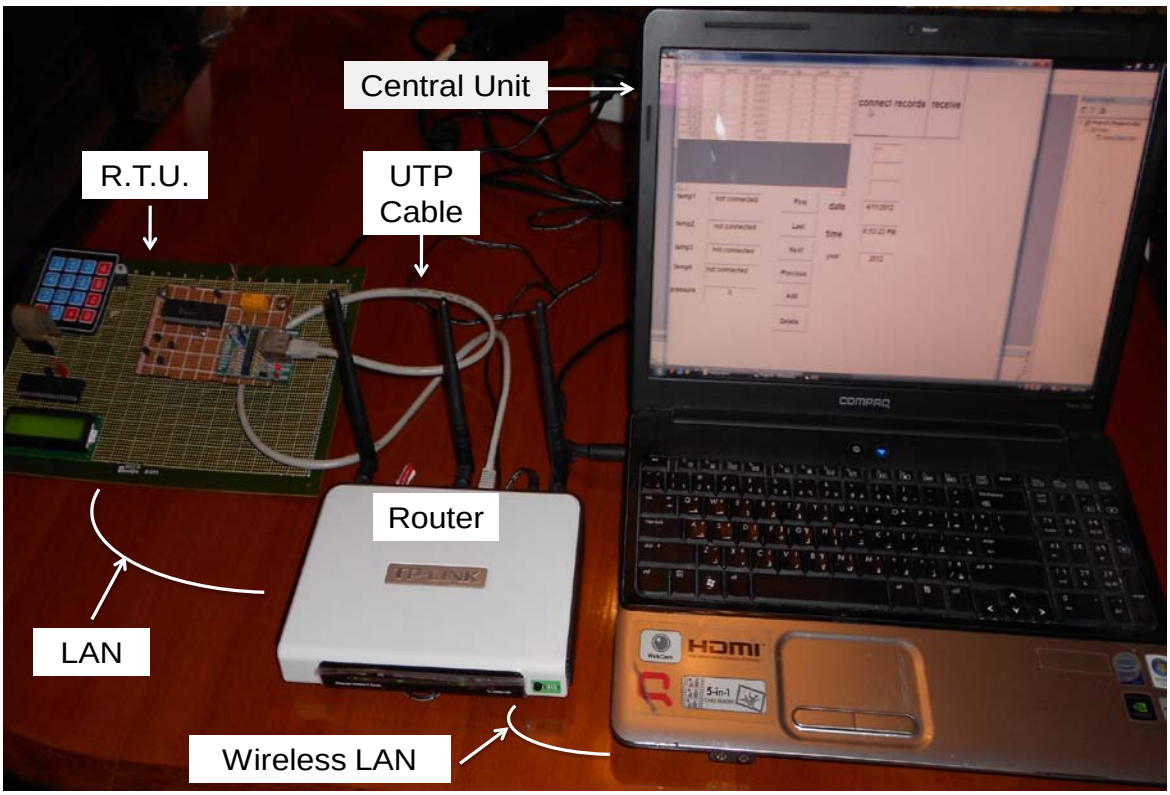


Figure 6 : The implemented telemetry system over WAN

When the R.T.U is switched ON the LCD display shows a "Enter the password "message. The password should be entered by the user correctly. Then LCD shows a "OK" message and activate the other part of the R.T.U.

When the implemented R.T.U is connected to central unit, clicking on the connect command field will start a connection and request the implemented R.T.U to send its data to central unit, the R.T.U collects the data from the sensors process it and send it to central unit.

In the central unit the data has been received from R.T.U is displayed in Temp 1, Temp 2, Temp 3 and Temp 4 fields as shown in figure (7).

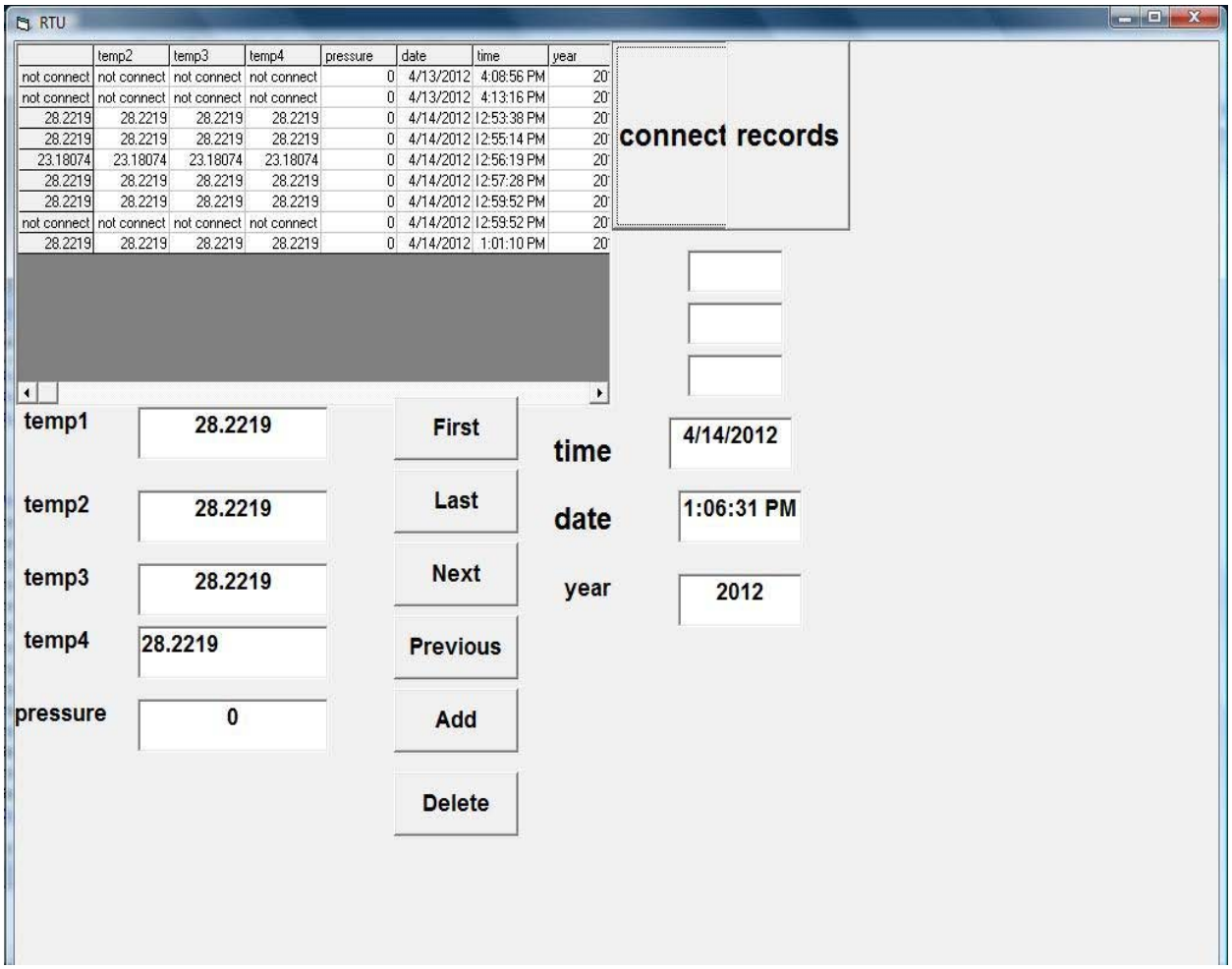
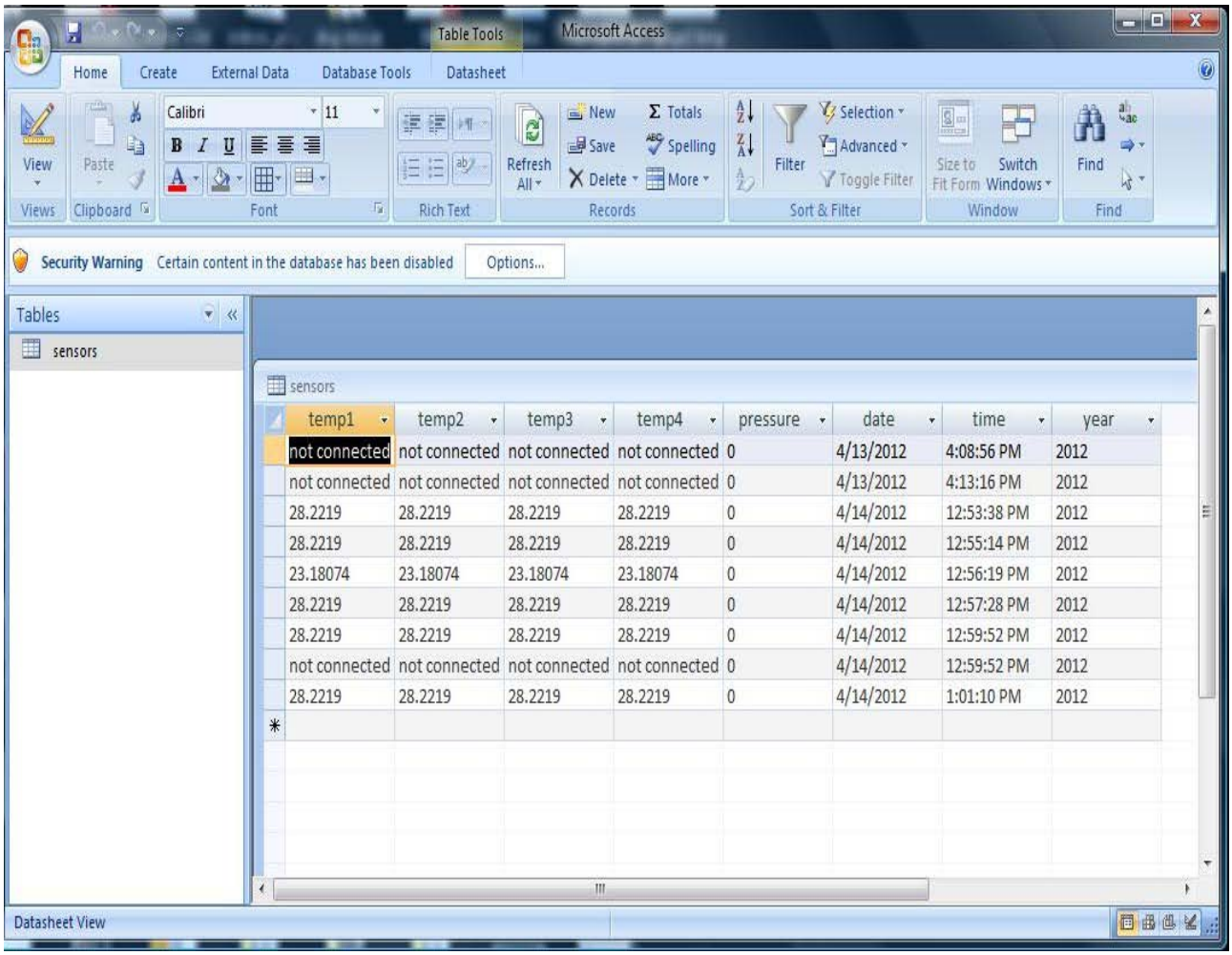


Figure 7 : The central unit program shows the data received

A data base and access files were constructed which modify and update by the implemented central unit program, the access sheet is shown in figure (8).

The data base and the access sheet store the received data at the exact time and date on which the data was collected.

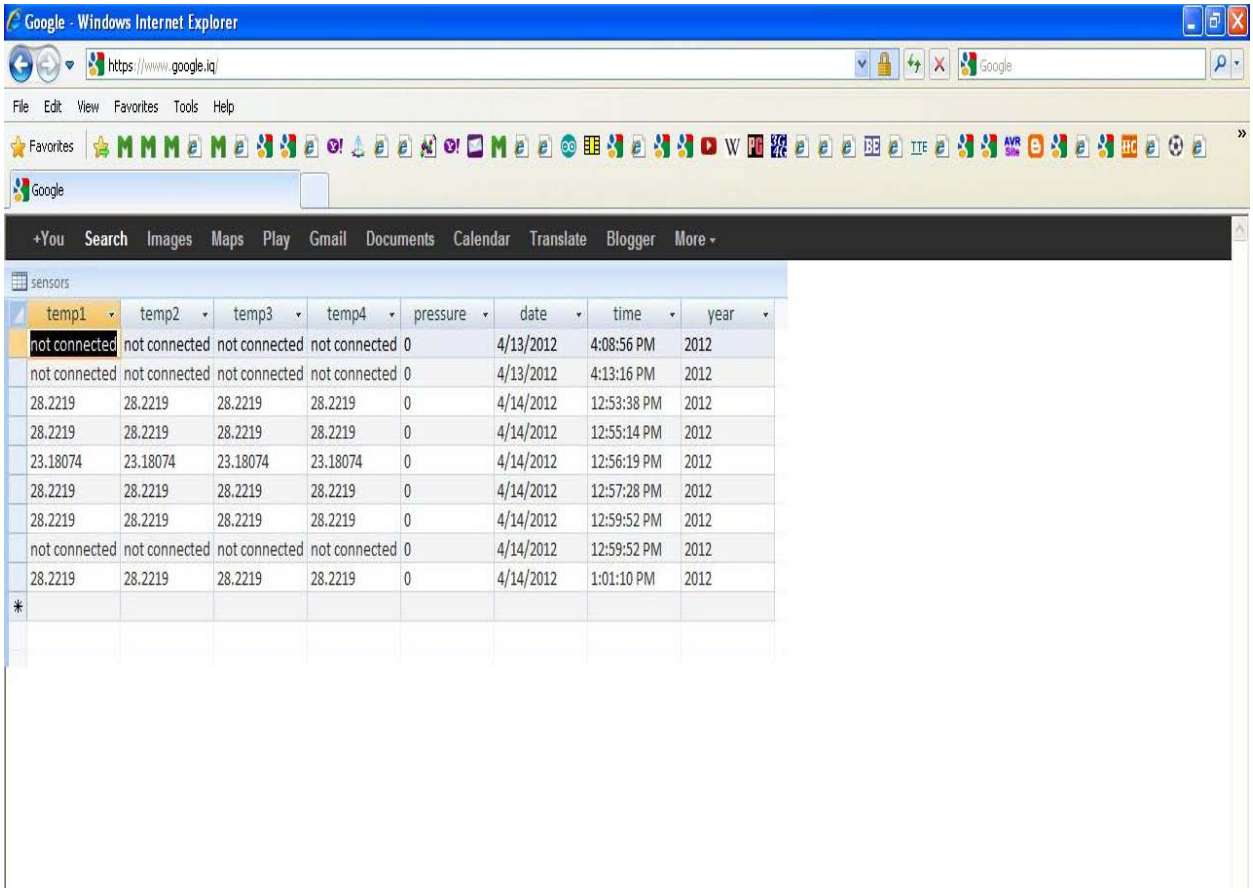
The benefit of having a data base is to provide reliable persistent storage and the ease of extract data to obtain reports.



temp1	temp2	temp3	temp4	pressure	date	time	year
not connected	not connected	not connected	not connected	0	4/13/2012	4:08:56 PM	2012
not connected	not connected	not connected	not connected	0	4/13/2012	4:13:16 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:53:38 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:55:14 PM	2012
23.18074	23.18074	23.18074	23.18074	0	4/14/2012	12:56:19 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:57:28 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:59:52 PM	2012
not connected	not connected	not connected	not connected	0	4/14/2012	12:59:52 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	1:01:10 PM	2012

Figure 8 : Constructed access files

A web page was constructed in the central unit to show the received data in the internet pages as shown in figure (9).



temp1	temp2	temp3	temp4	pressure	date	time	year
not connected	not connected	not connected	not connected	0	4/13/2012	4:08:56 PM	2012
not connected	not connected	not connected	not connected	0	4/13/2012	4:13:16 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:53:38 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:55:14 PM	2012
23.18074	23.18074	23.18074	23.18074	0	4/14/2012	12:56:19 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:57:28 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	12:59:52 PM	2012
not connected	not connected	not connected	not connected	0	4/14/2012	12:59:52 PM	2012
28.2219	28.2219	28.2219	28.2219	0	4/14/2012	1:01:10 PM	2012

Figure 9 : The constructed web page

V. Conclusions

In this paper a telemetry system was designed and implemented. The remote terminal unit which was designed and implemented has the following features:

- Low cost and small size RTU unit.
- PIC16F887 microcontroller gives the proposed system the ability to be used in different applications.
- The use of Ethernet facilitates the communication mechanism allowing the proposed system to run over any computer network infrastructure.
- The designed software in the central unit allow data to be stored in a database which provide reliable persistent storage. This allow The ease of extract data and obtain reports and the ease of data management to some level of quality.
- The use of Internet Browser allows the data to be shared in many locations that have access to the designed web page.
- The use of TCP ensured the delivery of packets on the contrary of the use of UDP which is unreliable.

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