Environmental Data Acquisition Using (ENC28J60)

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Abstract -- **Ethernet is a local area technology, which is used for reliable and efficient transfer and access of information across the devices connected to the network. Once a device is attached to the network, it will have the ability to communicate with any other attached device. This allows the network to expand to accommodate new devices without requiring any modification to those devices already on the network.**

I. INTRODUCTION

In an industry there are many locations in which we need exact amount of environmental parameters such as temperature, humidity, CO_2 gas etc. To get type of system which is capable of continuously monitor and control such parameters of an environment we need embedded field.

In case of embedded applications, the lightweight protocols like SPI, I2C and UART would not add the capability of controlling your standalone device from any remote place. That is when the need for adding an Ethernet interface to your embedded device is felt. To facilitate this need you would need some additional hardware which would include an Ethernet PHY and a networking protocol stack.

Along with the industry in many of the cases such as hospital, research centers we need to have such a system utility. The major part of the system goes to the Ethernet controller ENC28J60, which is used for remote monitoring of environmental data through the internet.

II. SYSTEM DEVELOPMENT

A. General Description

Many of the physical quantities in environment are analog in the nature. However the microcontroller based design requires the data to present in digital format. As a preliminary test of a system we will just measure the room temperature and display the current room temperature on to the LCD connected to the PIC16F877A microcontroller. The same readings are to be transmitted to the internet via the SPI (Serial Peripheral Interface) pins (i.e. SDI, SDO, SCK, CS) of microcontroller device, which are connected to the SPI pins of a suitable Ethernet Controller (in this case we use ENC28J60 Ethernet Controller) which then converts the data acquired by MCU into the Ethernet packets for transmission over the internet. The generalized block diagram of a system is as shown in the figure below:
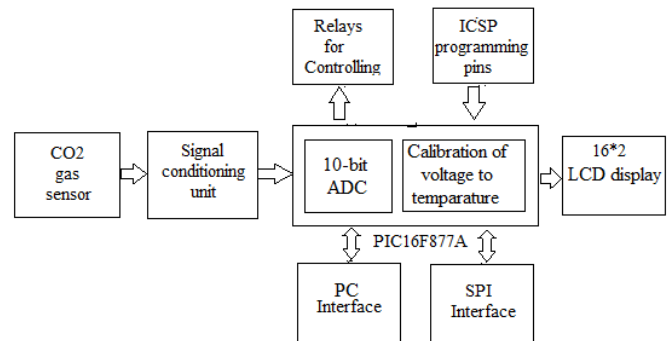

Figure 1. General block diagram of a system

B. CO_2 gas sensor module

The CO2 Gas Sensor Module is designed to allow a microcontroller to determine when a preset Carbon Dioxide gas level has been reached or exceeded. Interfacing with this sensor is done through a 4-pin SIP header and requires two I/O pins from the host microcontroller. The sensor module is intended to provide a means of comparing gas sources and being able to set an alarm limit when the source becomes excessive.

Features:
- Easy SIP header interface
- Compatible with most microcontrollers
- Low-power standby mode

Key Specifications:
- Power requirements: 6.5 – 12 VDC @

  - ~165 mA (heater on) / ~1.2 mA (heater off)

  - Interface: 1 TTL compatible input (CNTL), 1 TTL compatible output (ALR)

  - Operating temperature: 32°F to 158°F (0°C to 70°C)

  - Dimensions: 1.50" x 1.00" x 1.00" (38.1 mm x 25.4 mm x 25.4 mm)

Application Ideas:

- Gas level over-limit alarm

- Stand-alone/background sensing device

- Environmental monitoring equipment

microcontroller is used to convert the analogue output of the sensor into its equivalent digital value. The internal ADC of the microcontroller has eight channels of analogue input and gives 10-bit digital output. In this project, the r e f e r e n c e voltage to the ADC is the same as the supply voltage to the microcontroller, i.e., 5V.
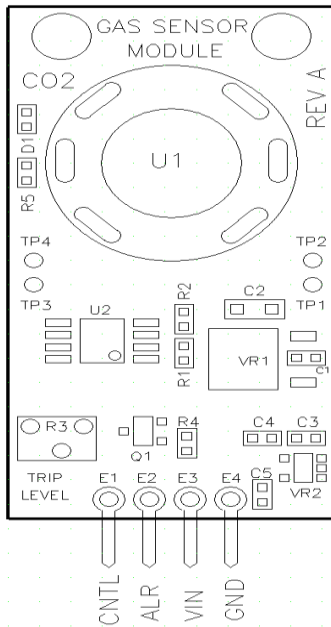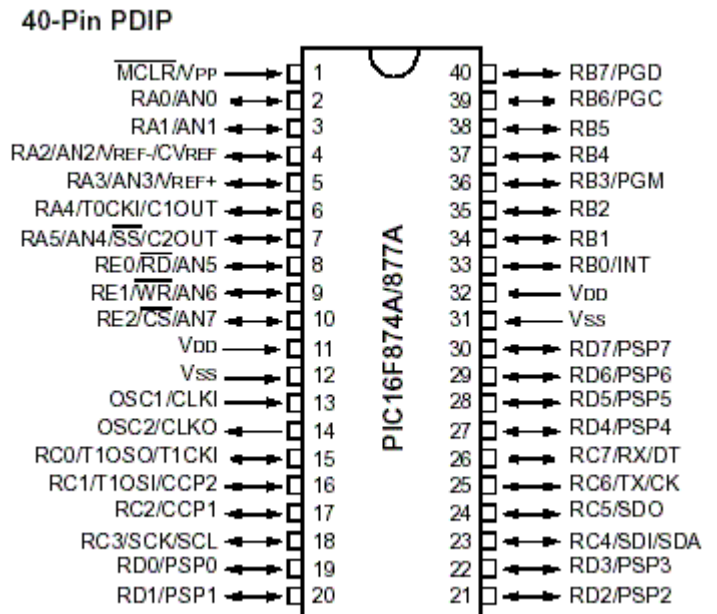

Figure 2. Top view of CO₂ gas sensor

Figure 4. Pin diagram of PIC16F877A

C. Microcontroller Unit (MCU) PIC16F877A

IC PIC16F877A is an 8-bit microcontroller with 8k×14-bit flash program memory, 368 bytes of RAM and many other extra peripherals like ADC, universal synchronous asynchronous receiver transmitter, master synchronous serial port, timers, compare capture and pulse-width modulation modules, and analogue comparators. It is based on the reduced instruction set computer (RISC) architecture.
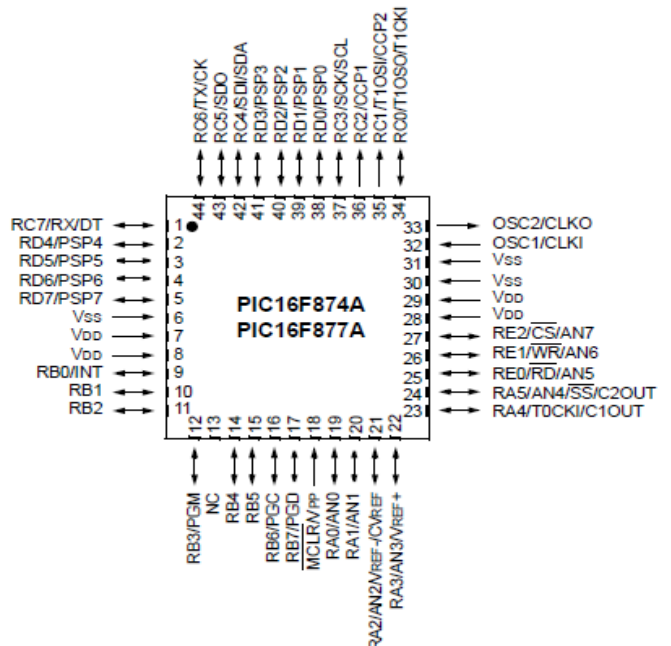

Figure 3. PIC16F877A in PDIP and QFP

The microcontroller processes the sensor output to compute the temperature in degree Celsius. The internal ADC of the

Figure 5. Pin diagram of PIC16F877A

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The resolution of the ADC can be calculated as follows:
Resolution = Vref / (1024-1)   … (as it is a 10-bit ADC)
$$= 5/1023$$
$$= 4.887 \text{ mV} \qquad\qquad \text{… (1)}$$

It means that for 4.887mV change in the analogue input, the ADC output changes by binary '1' with a reference voltage of 5V. Analogue output of the sensor at its pin 2 is connected to Port A at RA0 for conversion into digital equivalent.

D. LCD (Liquid Cristal Display) Controller HD44780

A 16×2 LCD based on HD44780 controller is used for displaying the temperature. The control lines EN, R/W and RS of the LCD module are connected to pins RA1, RA2 and RA3 of Port A of the microcontroller, respectively. The commands and the data to be displayed are sent to the LCD module in the nibble mode from Port D of the microcontroller. The higher four bits of the LCD (D4 through D7) are connected to the lower nibble of Port D (RD0 through RD3). PIC16F877A is used here to display message on the Hitachi HD44780-based character LCD module.
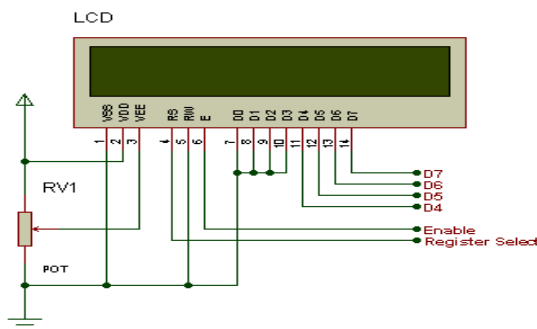

Figure 6. LCD used in 4-bit mode

Here PIC16F877A microcontroller is connected to HD44780 LCD in 4-bit interface data, only four bus lines (DB4 to DB7) are used for data transfer. Bus lines DB0 to DB3 are having no connection with microcontroller. The data transfer between the HD44780U and the PIC16F877A is completed after the 4-bit data has been transferred twice.

As for the order of data transfer, the four high order bits (for 8-bit operation, DB4 to DB7) are transferred before the four low order bits (for 8-bit operation, DB0 toDB3).Any character on HD44780 LCD is displayed by sending its respective ASCII code. Hence to display 1 on LCD microcontroller has to send 31h as data. When RS pin =0 instruction register is selected and information on data bus is taken as commands.

E. Ethernet Controller IC

ENC28J60:

Ethernet controller ENC28J60 from Microchip forms the building block for our Ethernet Interface add-on Board. It's an SPI based add-on chip which has Ethernet PHY and MAC to equip any embedded controller with SPI interface with network capability.

Through this interface our controller can communicate with other devices connected on the network including PCs. It provides easy connection to any microcontroller with only few ports via SPI which makes it perfect for adding Ethernet connectivity to embedded applications.

General Description:

The Microchip Technology Inc. ENC28J60 is a standalone Ethernet controller with an industry standard Serial Peripheral Interface (SPI™). It is designed to serve as an Ethernet network interface for any microcontroller equipped with SPI. The ENC28J60 meets all of the specifications for IEEE 802.3. It incorporates a number of packet filtering schemes to limit incoming packets.

It also provides internal DMA for fast data throughput and support for hardware assisted IP checksum calculation. Communication with the microcontroller is implemented via SPI, with data rates up to 10 Mbit/s.
Dedicated pins are used for LED link and activity indication and for transmit and receive interrupts.

Features of ENC28J60 :
- IEEE 802.3 Compatible Ethernet Controller
- Integrated MAC and 10BASE-T PHY
- 8-Kbyte Transmit/Receive Packet Dual Port
- Buffer SRAM
- Receiver and Collision Squelch Circuit
- Supports one 10BASE-T Port with Automatic
- Polarity Detection and Correction
- Programmable Automatic Retransmit on Collision
- Programmable Padding and CRC Generation
- Programmable Automatic Rejection of Erroneous
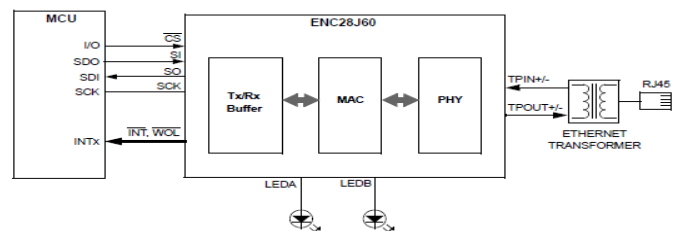- 10 Mbit/s SPI™ Interface

Block Diagram of ENC28J60:
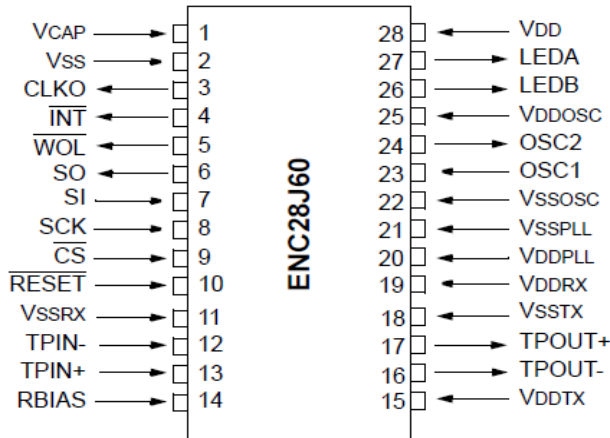

Figure 7. Block diagram of ENC28J60 controller I

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Pin Diagram:

Figure 8. 28-pin SSOP, SOIC and SPDIP

Figure 10. Ethernet Interface Board

Features:

- Ethernet Controller – Microchip's ENC28J60 with SPI interface
- Supports Data Transfer up to 10 Mb/s
- LINK/STATUS LEDs for indication/debugging

Figure 9. 28-pin QFN package

Figure 11. Ethernet Interface Board with power connector

F. Ethernet Interface Board

It contains the Ethernet Controller ENC28J60 with SPI support and Ethernet Jack – MAG Jack (RJ45). The Ethernet Interface Board v1.0 helps to connect a particular embedded device to the network. If a particular embedded device is connected to the network, command or data for that particular embedded device can be provided from any of the devices connected to that network.

The Ethernet Interface Board can be connected to the uNiBoard (which will be the heart of that particular device) and by using SPI pins of the Ethernet controller (ENC28J60) the Ethernet Interface Board communicates with the uNiBoard.
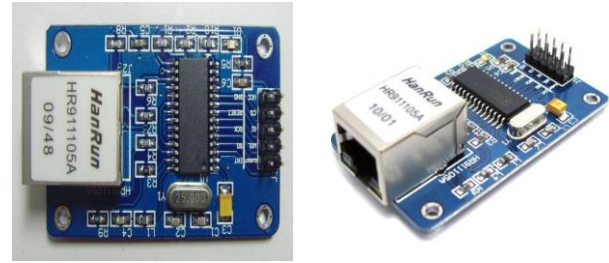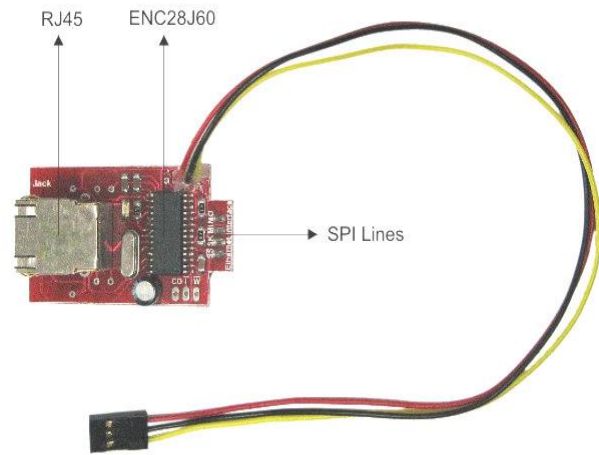
Setting up the Connection:

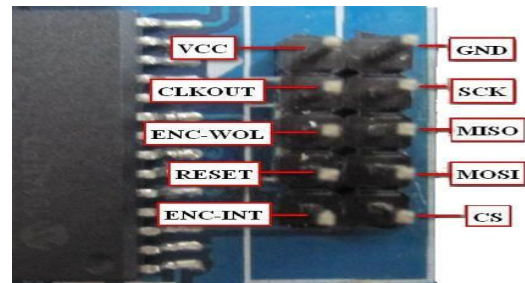Connect the pins of the Ethernet Interface board with the Development Board (uNiBoard) accordingly.

Figure 12. Interfacing of ENC28J60 with PIC16F877A

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MOSI < - > MOSI
MISO < - > MISO
SCK < - > SCK
CS < - > SS
WOL < - > NC (LAN interrupt o/p pin)
INT < - > NC (Interrupt o/p pin)
CLK0 < - > NC(Programmable clock o/p pin)
RST < - > PB7 (in case of uNiBoard)
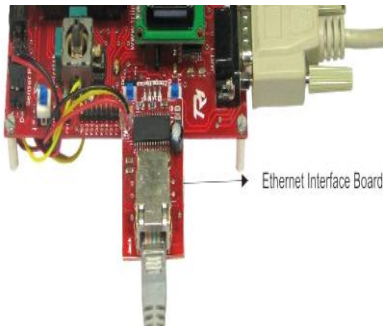GND < - > GND
3V3 < - > VCC (in case of uNiBoard

Figure 13. Ethernet Interface Board interfaced with uNiBoard

Configurations:

There are two different configurations that you can have with the board as shown below of which the first configuration can be used for testing and development purposes while the second one would be used for application purposes.
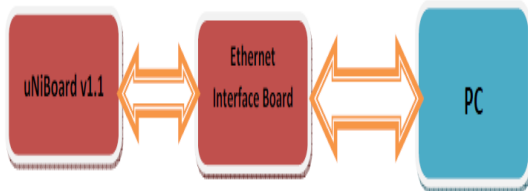
Connecting uNiBoard directly to the PC:

Figure 14. Connecting uNiboard directly to PC

Connection between the uNiBoard and Ethernet Interface Board is done as described above and PC is interfaced with the Ethernet Interface Board using the network cable.

Connecting uNiBoard directly on to the Network:

Connection between the uNiBoard and Ethernet Interface Board is done as described above and Ethernet Interface Board is connected to the network directly.
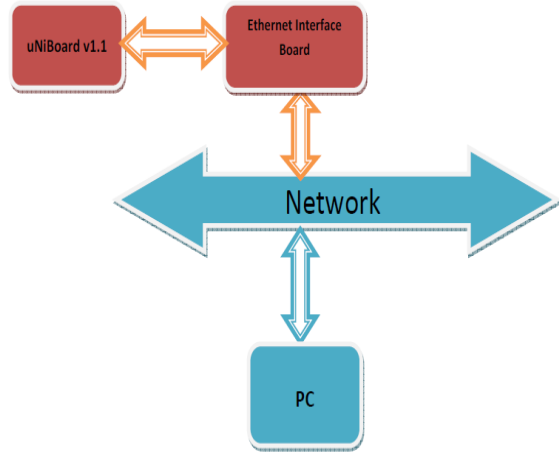

Figure 15. Connecting uNiboard directly to the network
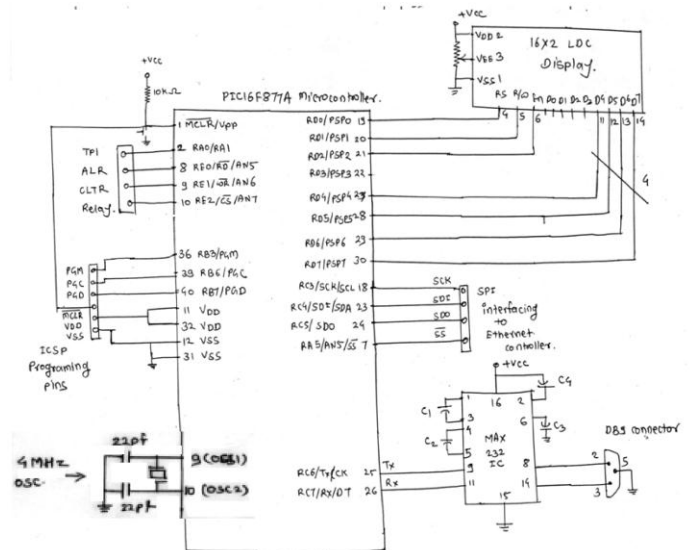
III. CIRCUIT DIAGRAM OF A SYSTEM

Figure 16. Circuit diagram of a system
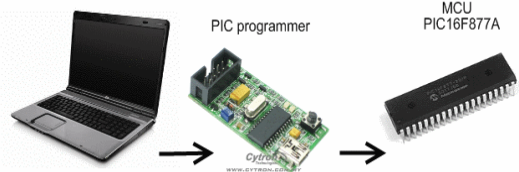
IV. SOFTWARE DESCRIPTION

Figure 17. Programming the PIC16F877A

The software code is written in 'C' language and compiled using Hi-tech C cross compiler in MPLAB IDE. The software performs the following operations in an infinite loop:

1. Initiate analogue-to-digital conversion and obtain the result
2. Calculate the equivalent voltage value from the ADC result
3. Calculate the temperature in degree Celsius from the voltage value
4. Display the temperature on the LCD

The voltage output (in volts) of the sensor is:
$$= (ADC\ result \times 5)/1023 \qquad \ldots(2)$$

The temperature in degree Celsius is:
$$= (Sensor\ output \times 1000)/10$$
$$= Sensor\ output \times 100 \qquad \ldots(3)$$

MPLAB IDE and Hitech C compiler:

MPLAB IDE is a very powerful software development tool for Microchip products (microcontrollers). It is available for download at 'www.microchip.com' free of cost. It consists of tools like text editor, cross-assembler, cross-compiler and simulator. Hitech C cross compiler is meant for Microchip PIC10/12/16 series of microcontrollers. Its Lite edition comes free with newer versions of MPLAB IDE like MPLAB v8.2 and v8.3. It can also be downloaded for free from www.htsoft.com.

V. CONCLUSION

Any microcontroller based system can be connected with the Ethernet interface card and the whole system can be connected to the internet by which we can communicate with the system. The heart of the entire system is the Ethernet controller ENC28J60 which communicates with the MCU through its SPI interface. So MCU only need to have the SPI.

This Ethernet Interface can be used to develop different applications like embedded web server, Ethernet based Data acquisition system, internet controlled robot (Telepresence robot) etc.

If your embedded device is a robot and you want to control that from a remote place you just need a PC which is connected to the network. From the PC you can send commands to the robot though your Ethernet network.

REFERENCES

[1] http://thinklabs.in
[2] http:// www.DatasheetCatalog.com
[3] http://www.microchip.com
[4] http://www.embeddedmarket.com
[5] http://www.robotics.com
[6] The 8051 Microcontrollers and Embedded Systems Using Assembly and C, Second Edition, Muhammad Ali Mazidi, Janice Gillispie, Rolin D. McKinlay.
[7] PIC Microcontrollers and Embedded Systems Using Assembly and C for PIC18, Pearson International Edition, Muhammad Ali Mazidi, Rolin D. McKinlay, Danny Causey.