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Microcontroller Based Active and Reactive Power Measurement

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ABSTRACT

The work presented in this paper introduces a simple method for the measurement of active and reactive power digitally using microcontroller. Three signal values are generated, the first is proportional to the peak value (V_m) of the line voltage v(t), the second and third signals are proportional to the instantaneous values of the line current i(t) at the instants of v(t)=0 and v(t)=V_m, i.e. $I_m$sinø and $I_m$cosø respectively, where I_m is the peak value of the line current and ø is the phase angle. These signals are inserted in to PIC16F877A by means of analog circuit. The active and reactive power are calculated by the algorithm written on the PIC16F877A. The calculated values by multiplications and digitization will provide a realizable and displayable form on LCD screen.

Keywords: *Microcontroller, Active and Reactive Power, Microcontroller, Measurements.*

I. INTRODUCTION

Rapid advances in the technology of solid state devices have provided many inexpensive and powerful means of implementation in the various fields of instrumentations, measurements, control….etc. thus measuring instruments, based on this new technology are replacing the conventional types of measuring equipment especially in the fields of electrical and electronics measurements. However, constant research and development are still bringing new, more flexible and simpler to use equipment.

In the past many years many researchers have been able to provide good and accurate designs for the measurement of the electrical power digitally (Banks and Majithia 1976 [1], Filipski 1980 [2], Hafeth and Abdul-Karim 1984 [3], Ibrahim and Abdul-Karim 1984 [4], Prokic 1986 [5], Bascifti and Hatay 2010 [6]. Their attempts were based on different methods, e.g. using microprocessor, linear or non-linear ADC,…, etc. In this work a simple approach has been tried to realize active and reactive power digitally. This approach is based on the generation of three values by means of analog circuit, these values are proportional to V_m, $I_m$cosø and $I_m$sinø, thus multiplication by using microcontroller will result in V_m $I_m$cosø, i.e. active power and V_m $I_m$sinø, i.e. reactive power.

II. PRINCIPLE OF OPERATION

Consider a normal three wire power system, where voltage and current signals under steady-state conditions are of sinusoidal nature. Thus the instantaneous voltage *v(t)* and current *i(t)* are given as follows:

$$v(t) = V_m \sin(\omega t) \quad (1)$$

$$i(t) = I_m \sin(\omega t + \phi) \quad (2)$$

Where V_m is the peak value of the line voltage, I_m is the peak value of line current, and ø is the phase angle between line voltage and line current (leading or lagging).

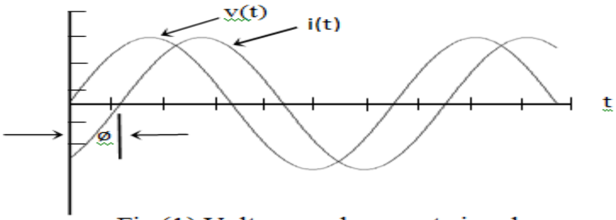

Fig (1) Voltage and current signals

From Fig (1) : at $\omega t = \pi/2$, then

$$v(t) = V_m \quad (3)$$

$$i(t) = I_m \sin(\pi/2 + \phi)$$

$$i(t) = I_m \cos \phi \quad (4)$$

at $\omega t = 0$, then

$$i(t) = I_m \sin(0 + \phi)$$

$$i(t) = I_m \sin \phi \quad (5)$$

Thus multiplication of eqns. (3) and (4) will give V_m I_m cos ø, i.e. active power, and multiplication of eqns. (3) and (5) will give V_m I_m sin ø, i.e. reactive power.

III. HARDWARE DESCRIPTION

The design aim is to monitor active and reactive power on LCD display continuously. The circuit diagram and corresponding timing waveforms of the system are shown in Figs. 2 and 3 respectively. The basic point in the proposed technique is to generate three values using ADC contained in the microcontroller; these values are proportional to V_m, $I_m$cosø and $I_m$sinø. This has been achieved by taking the ADC values from voltage and current signals at the instants of peak voltage V_m and 0 voltage, i.e. at the instant when the voltage signal crosses the zero line. To achieve this aim electronically. The current and voltage signals are acquired from the main AC line by using current transformer and potential transformer. The acquired voltage signal V_1 is shifted 90^o, squared V_2 and reduced ON time with monostable V_3. Both V_1 and current signal I_1 are read by the microcontroller, at the positive edge of V_3, both signal values are taken, providing two components V_m and $I_m$cosø. The two components if multiplied will result in ($V_m I_m$cosø) a value proportional to the active power P. For the realization of reactive power, the same procedure is used except that the 90^o phase shift is bypassed by using SPDT switch, thus the acquired current signal value is taken at the instant of zero voltage, producing value proportional to $I_m$sinø. Thus multiplication will result in (V_m $I_m$sinø) a value is proportional to reactive power Q. The required multiplication has been achieved with microcontroller PIC16F877A. The active and reactive power are calculated by the algorithm written on the PIC16F877A, the output of which is displayed on LCD accordingly.

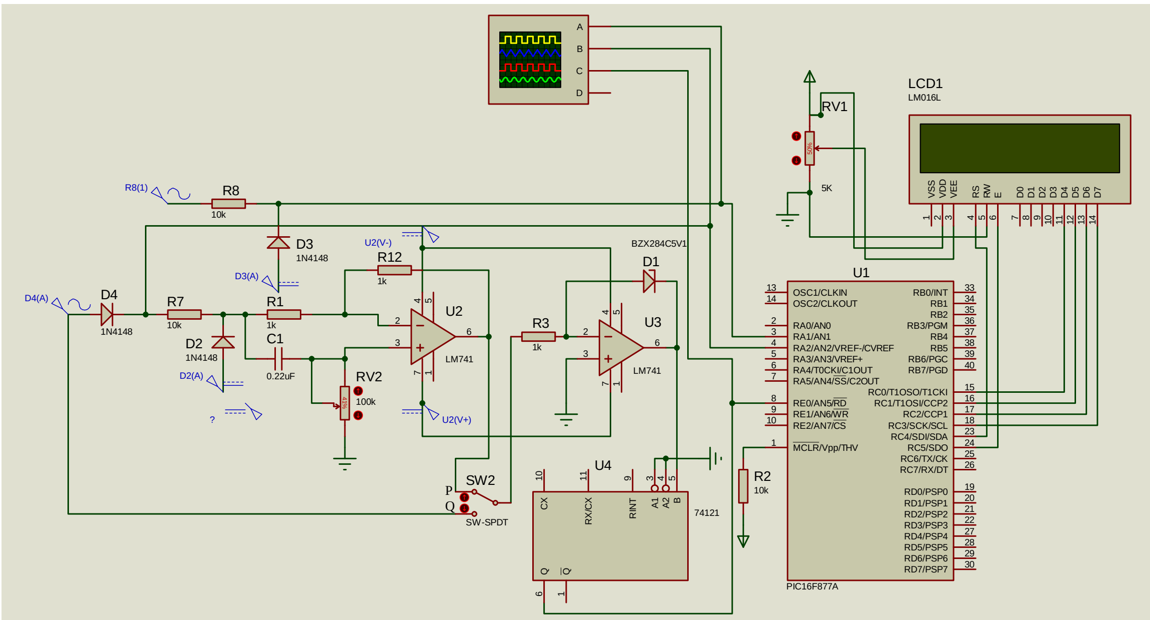

Fig (2) Schematic diagram of measuring system

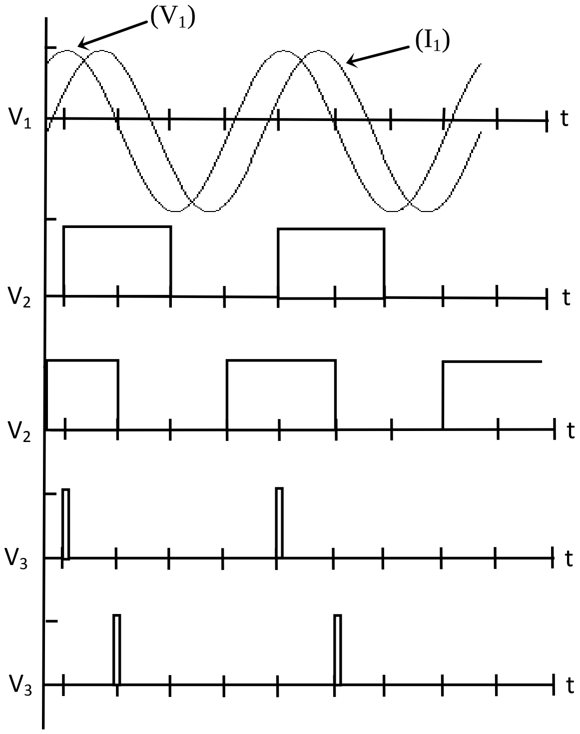

Fig (3) Timing waveforms

PIC16F877A Microcontroller

The PIC16F877A is a microcontroller from Microchip in a chip type of 40-pin DIP packages. The principal characteristics by which this PIC was used are: digital I/O ports, analog inputs, analog to digital converter of 10 or 8-bit resolution, serial communication USART, memory storage EEPROM [7]. The PIC16F877A, has programmed routines process or features, such as analog to digital conversion to get the values from the sensors, storage of historic data in the internal EEPROM when an alert happened generates a detection range of values which can determinate whether the system suffered acceleration that cause an alert [8]. The circuit used in this work operates of 20 MHz clock frequency and runs each instruction as fast as 200 ns.

The program for the PIC16F877A microcontroller is written in Micro C and is compiled into Hex program. Microcontroller is programmed to calculate active and reactive power. The flow chart of this calculation in Hex is shown in Fig. 4. The input of the current and voltage signals are connected to pins 3,4 and 8 as shown in Figs. 5 (a) and 5 (b).

IV. SOFTWARE COMPONENTS

This section presents the software's used in the design of the measuring system

A. **Micro C:** Micro C is powerful, feature rich development tool for PIC micros. It designed to provide the programmer with the easiest possible for developing applications for embedded systems, without compromising performance or control [8].

B. **Proteus 7 Professional:** is an interactive system level simulator. Which combines mixed mode circuit simulation, micro-processor models and interactive component models to allow the simulation of complete micro-controller based designs [8].

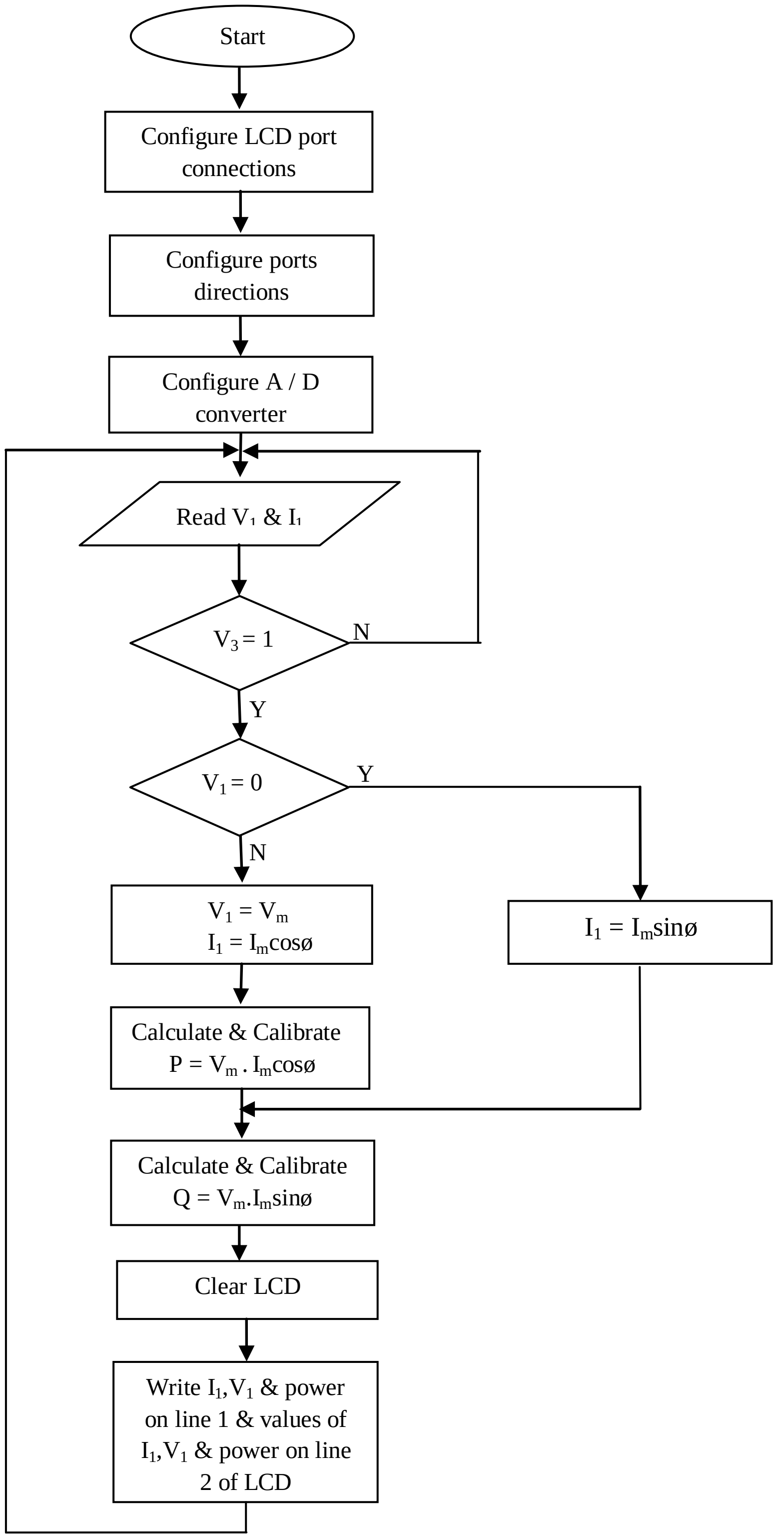

Fig (4) Flowchart of active and reactive power measurement . Hex program

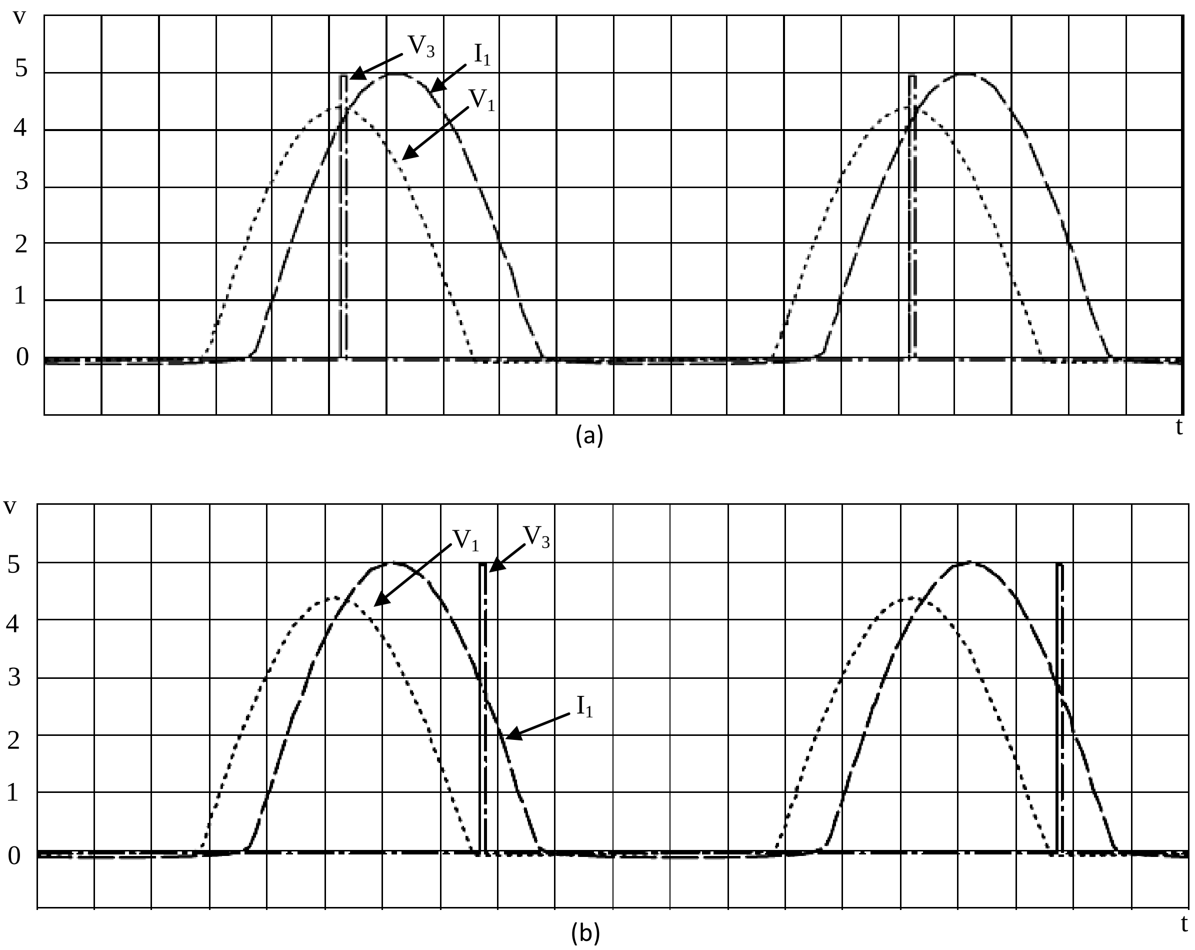

Fig (5) The microcontroller inputs of the current and voltage signals
(a) Active power. (b) Reactive power

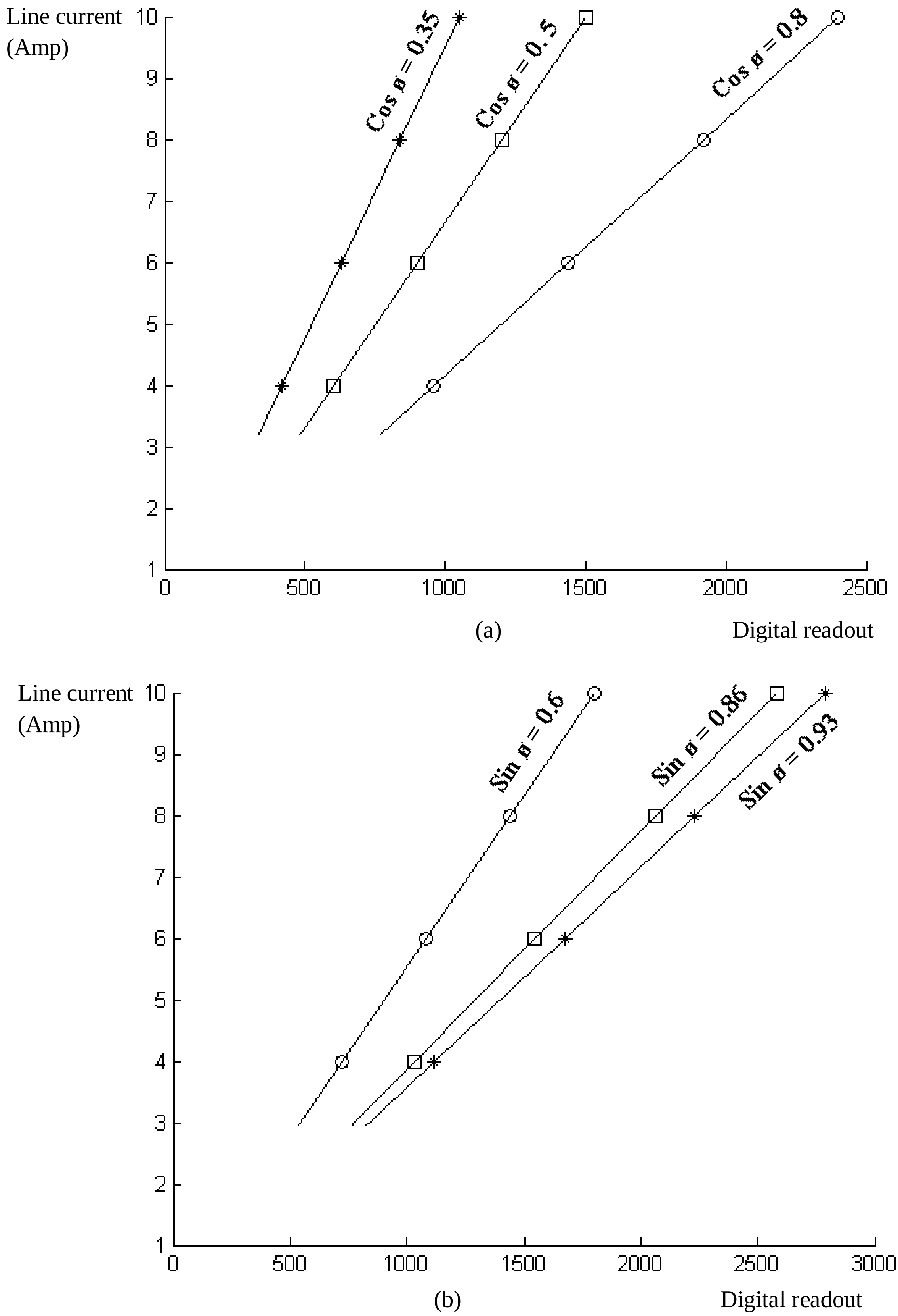

Fig (6) System linearity curves. (a): Active power. (b): Reactive power.

IV. CONCLUSION

The technique presented in this paper provides a very simple means for the digital measurement of active and reactive power. Which can be implemented in the various fields of industry and education. The circuit is designed to display active and reactive power of the load connected the network. Calculation process is achieved by PIC16F877A. This approach is so straight forward that the hardware is very simple.

The system has been tested under different loading conditions using proteus simulator and has shown linear behavior under those conditions, as shown in Fig.6 (a) and (b)

References

[1] Banks, W., and Majithia, J.C., 1976, Microprocessors: Design and applications in digital instrumentation and control. IEEE Trans. on Instrumentation and Measurement, IM-25, No. 3.

[2] Filipski, P., 1980, A new approach to reactive current and reactive power measurement in nonsinusoidal systems. IEEE Trans. on Instrument and Measurement, IM-29, No.4.

[3] Hafeth, B. A., and Abdul-Karim, A. H., 1984, Digital power meter using non-linear ADC. International Journal of Electronics, 57,179-186.

[4] Ibrahim, K. M., and Abdul-Karim, A. H., 1984, A novel phase measurement method. International Journal of Electronics, 56, 217-221.

[5] Prokik, D., 1986, A concept for measurement of electric power on the basis of Mass measurement, Rev. Roum. Phys. Tome, 31, 275-279.

[6] Fatih B., and Omer F. H., 2010, Microcontroller-controlled reactive power measurement and saving circuit design for residences and small scale enterprises, Scientific Research and Essays Vol. 5(16), pp. 2312-2317.

[7] Microchip 2001, PIC 16F87X Data Sheet, USA.

[8] Basil A., 2012, Alerting system design using PIC16F877a for power distribution system, The 4th International Engineering Conference –Towards engineering of 21st century.