An Experiment on Internet Based Telemetry

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Abstract: This experiment is to develop and implement an Internet Based Telemetry system. Telemetry is a science of automatically measuring or recording data from one or more instruments and transmitting them over a distance. The transmission of the data can be done over wires or radio waves but this experiment is implementing transmission of the data through the Internet. The system is consisting of Local Portion and Remote Portion. In the Local Portion, data are collected from external measuring devices (EMD) and interfaced to be stored into a Local Computer, which is connected to the Internet and functions as a Server. In the Remote Portion, it consists of any Remote Computer that can access to the Internet and are able to access to the data from the Local Computer (the Server) through the Internet. Hardware comprising a PIC Microcontroller applied in Interfacing Circuits is developed to enable communication between the EMD and the Local Computer. Software programs are also developed for getting data and presenting Web Pages to the user at both the Local and Remote computers. With the Internet Based Telemetry system, measured data can be accessed globally.

Key-Words: - Telemetry, Data acquisition, Internet, Electronic measuring devices, Remote control, Microcontroller applications

1 Introduction

On-line monitoring system is on the rise especially for monitoring the condition of certain equipment or system. Monitoring the condition of Station Cable [1] partial discharge (PD) in generator [2] and the Pollution Levels on Solid Insulators

[3] are applying on-line monitoring system as well. Telemetry system is a type of on-line monitoring system that can be applied for such cases. Telemetry system can use Power Line Carrier (PLC) [4] or Sonic Radio wave [5] as the transmission medium. The Internet Based Telemetry system however will use the Internet as the communication medium.

The work to be described here will implement the Internet Based Telemetry system both on the hardware and software. The layout of the whole system is illustrated in Figure 1. The Local Portion is made up of the external measuring device (EMD), the Interfacing Circuits and the Local Computer, which is connected to the Internet and acting as the Server. Meanwhile the Remote portion is made up of any remote personal computers, with access to the Internet.

The hardware implementations are at the Local Portion only, which involve the interfacing between the Local Computer and the EMD. For this work, the current of a DC Motor will be measured and the EMD is a Hall effect based Current Transducer, LEM HY05-P. The Interfacing Circuits are another hardware implementation. It basically consists of a PIC Microcontroller, DC Power Supply, Voltage Regulator and Connectors. It is able to transfer the measurement data from the EMD to and stored into the Local Computer.

Most software implementation of the work are programs that were written for presenting Web .

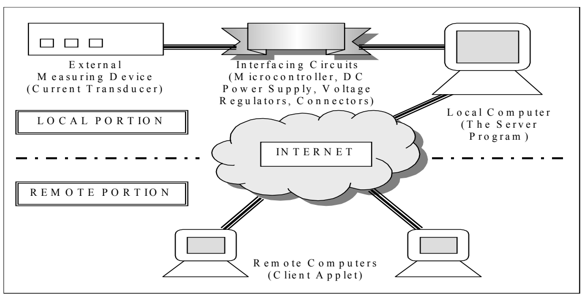

Fig 1: The Layout of the Internet Based Telemetry system

Some of the benefits of Internet Based Telemetry are:

1. Cheap implementation: The cost involving the transmission of the data is cut down whereby only the relatively lower Internet access fee, compared to the transmission using wires or radio waves, where huge cost is needed in the building and maintenance of the interval stations and transmission lines along the distance.

2. Convenient system: As the Internet is widely used throughout the world, this system can also be implemented and accessed globally, contributing to the improvement of R&D field where several researches may be conducted concurrently at various part of the globe, with all the data can be accessed and shared.

Pages displaying the data at both the Local and Remote computers. Provided with these programs and Internet connection, the measurement data can be accessed at any time with any remote computer, with authorization control being enabled where only user who has the IP address of the Local Computer (as the Server) can get access to the Web Pages. Security features such as Username and Password verifications for accessing the Web Pages can also be included. Besides, a precise program containing the appropriate instruction sets required for the effective operations of the PIC Microcontroller are written and then stored into the internal memory of the PIC Microcontroller

3. Safe system: Security restriction can be enforced where only user with valid Username and Password verified by the system can get access to the web pages.

2 Hardware Design

The hardware developments are involved in the stage of External Measuring Device (EMD), Interfacing Circuits and Local PC. The EMD main role is to obtain the measurement data, which is the current of the running DC Motor.

The EMD used is a Current-to-Voltage Transducer; with model name LEM HY05-P. The rating of this transducer is 5A primary nominal rms current (IPN), ±15A primary current measuring range (IP) and ±4V output voltage, powered by ±15V supply and with accuracy ±1%. The Data sheet for this LEM HY05-P Current Transducer can be downloaded from Reference [6].

The HY05-P transducer is connected in series with the motor at its Pin 5 (Primary-In) and Pin 6 (Primary-Out). It will measure the running current and produce the equivalent voltage signal at its Output pin (Pin 3). The voltage signal is next passed as input to the PIC Microcontroller in the Interfacing Circuits stage. The connection between the DC Motor and the HY05-P Transducer is as shown in Fig.2.

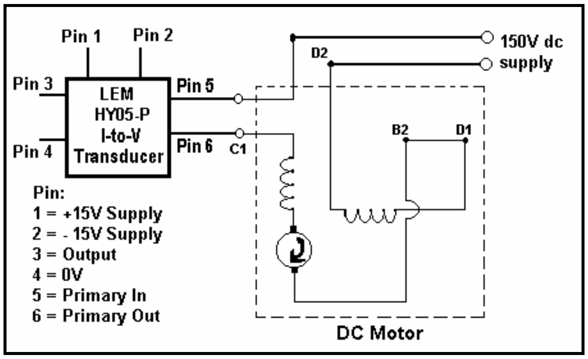

Fig.2: The connection between the DC Motor and the HY05-P Transducer

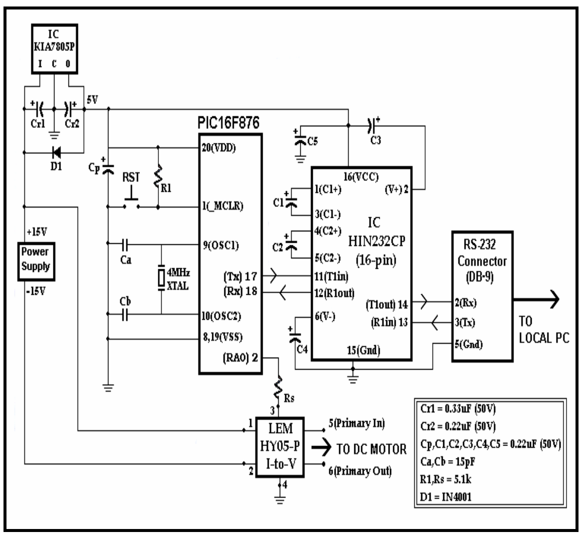

Fig.3: The schematic of the Interfacing Circuits and its peripherals

The Interfacing Circuits transfers the interfaced data through the transducer to the Local PC. This circuit consists of a PIC16F876 Microcontroller manufactured by Microchip™ Technology Incorporated, Power Supply, 5V Voltage Regulator (IC7805P), RS-232 Transmitters/Receivers Interface Circuits (IC232) and RS-232 connector. The chosen PIC16F876 Microcontroller has 8K of FLASH Program Memory (14-bit words), 368 bytes of Data Memory (RAM) and 256 bytes of EEPROM Data Memory capacities. It also provides other main features specifically used in this Interfacing Circuits like 5 channels of 10-bit Analog-to-Digital Converter (ADC) module, USART module for serial communications and 3 I/O ports (Port A, B and C). The Data Sheets for this PIC can be downloaded from Reference [7]. The schematic diagram of the Interfacing Circuits and its connection to the Transducer and Local PC is as shown in Fig.3.

Both the Transducer and the Interfacing Circuits can use the same Power Supply, which supplies ±15V to the Transducer, but only supplies 5V to the Interfacing Circuits after passing through the IC7805P. The 5V Voltage Regulator (IC KIA7805P) is to ensure a stable 5V voltage supply provided to the PIC16F876 Microcontroller so that it can operate effectively. The relevant part of the Data Sheet for this IC can be downloaded from Reference [8]. The diode D1 connected to the IC KIA7805P acts as a protector against terminals connections error [8].
This basic core circuit connection needed for the PIC to operate consists of a pull-up resistor R1 (5.1k), filtering capacitor Cp and it is driven by the 4MHz crystal (XTAL) and capacitors Ca and Cb, generating clock signal for the PIC operation [9]. Meanwhile, the RESET push switch (RST) is inserted for manual resetting of the PIC when necessary.

The RS-232 Transmitters/Receivers Interface Circuits (IC HIN232CP) acts as a converter to change the TTL signal (0V-5V) to the RS-232 signal (-15V-15V). The Data Sheet about the usage for this IC can be downloaded from Reference [10]. Meanwhile, the RS-232 connector used is a DB-9 type, which has only 9 pins. However, only 3 out of the 9 pins are used. They are Pin 2 (Receive Data, Rx), Pin 3 (Transmit Data, Tx) and Pin 5 (Ground, Gnd).

The ADC and the USART modules in the PIC16F876 Microcontroller are applied and playing the main roles. The output voltage signal at Pin 3 of the Transducer is connected as input signal to the PIC ADC module through an analog source resistor, Rs at its Pin 2 (RA0). This pin is configured in the programming of the PIC.

The Local PC will function as the Server for the Internet Based Telemetry system. The Server Programs in it receives interfaced data from the EMD and then sends them to be displayed at any remote computer connected to the Local Computer through the Internet. Therefore, the Local PC is a relatively high-performance PC with the following minimum requirements:

1. With Pentium CPU and 64MB RAM
2. Minimum 0.5 MB Hard Disc Memory for storing software program for both the Local (as Server) and Remote computers (as Clients)
3. Unused communication port (COM port) for connecting to Interfacing Circuits
4. Internet connection ready

The PIC needs to be programmed to determine its appropriate operation. The program written will be stored in the PIC EEPROM. The MPLAB® Integrated Development Environment (IDE) by Microchip™ is used to edit, assemble, compile and link source code, simulate and debug the program of the PIC. The program written, in form of a hex file is downloaded into the PIC EEPROM with the PICSTART® Plus device programmer.

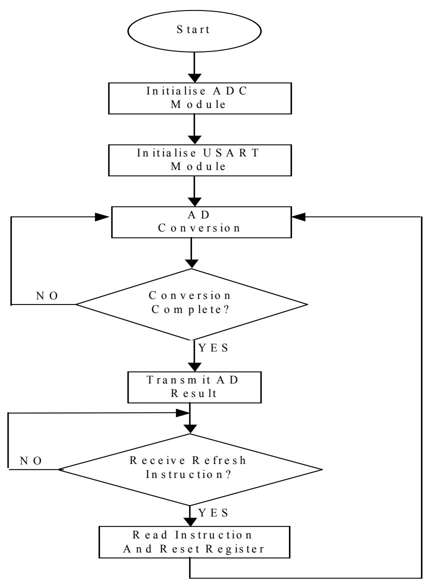

Fig.4: The Flow of Data A/D conversion in the PIC

The configurations of ADC module involved are Pin 2 (RA0) as analog input, the supply voltage of 5V as the A/D reference voltages, A/D conversion clock set as 8 Tosc (2 us), A/D conversion result format set as "Right justified" and also the start and stop instruction of the A/D conversion. The PIC is supplied with a 4MHz clock signal from the 4MHz crystal. Thus the Tosc is equivalent to 1/4*106 = 2.5*10-7seconds. Therefore 8 Tosc equals 8*2.5*10-7 = 2.0*10-6 seconds Meanwhile, the configurations of the USART module are 19kb Baud rate setting, Asynchronous Transmission Mode, Pin 17 (RC6/Tx) and Pin 18 (RC7/Rx) are enabled as serial port pins for serial communication.

The flow of the data A/D conversion in the PIC can be illustrated as in Figure 4. The main function of the PIC is to convert the analog voltage signal received from the Transducer into digital signal and then send the data to the Local PC. Therefore, the PIC ADC and USART modules are applied and need to be configured initially.

The A/D conversion is through successive approximation and the conversion time needed is 13 A/D Conversion Clock (TAD), as specified in the Data Sheet of the PIC16F876 [7]. Thus, a loop instruction is programmed to keep checking if the A/D conversion of the analog signal has completed. Otherwise, the conversion will be resumed. Once completed, the result of the A/D conversion will be loaded to the USART module, where it will be transmitted to the Local PC, through the RS-232 connector.

After the transmission of data, the PIC will keep waiting for a "Refresh" instruction from the Local PC. This "Refresh" instruction can be just a string sent out by the Server Program at the Local PC in order to get a new data from the PIC in the Interfacing Circuits. Once the "Refresh" instruction is received, the PIC will read the instruction and then reset the Receive register of the USART. Then, the A/D module will be invoked again to get the new analog signal, do the A/D conversion and transmit the data again.

3 Software Design

The software developments involve writing the Server Programs for the Local PC and the Client Applet for the Remote PC. Visual Basic (VB) 6.0 Programming Language and a few software applications are used to develop these programs.

The main objective of the Server Programs at Local PC is to get the measured data from the PIC in the Interfacing Circuits through a COM port of the Local PC. This data will then be stored into a database so as it can be retrieved for display in the Client Applet at the Remote PC. The programs involved are a Local Program written with VB and the Microsoft® Personal Web Server 4.0 software application.

The Local Program can be written with Visual Basic, which is an object-oriented, user-friendly and easy-to-use programming language. The Microsoft® Visual Basic 6.0 in an Integrated Design Environment (VB IDE) is used to develop the Local Program. It is the program to get data from the COM port of Local PC and send it to a database file stored in the Local PC too. As part of security features for this experiment, the Local Program is written to demand for Username and Password verification before it can be executed at the Local PC. The IDE provides compilation that transforms the source code of the program into a normal Windows executable (.EXE) file whereby, making the program able to be run independently of the VB IDE [11]. It also provides a Package and Deployment Wizard, a wizard that can bundle all the dependencies together with the program EXE file, including a SETUP.EXE file and create compressed (.CAB) files. These CAB files can be copied into any computer and the Local Program can be installed into the computer by using the SETUP.EXE file, making the Local Program portable and can be installed easily for implementing part of this experiment.

As mentioned earlier, part of the Local Program is a database file that has to be created too and saved in the Local PC for storing the data sent from the Local Program. It can be created using either the Microsoft® Access or the Visual Data Manager utility in the VB IDE. The database file created for this experiment is named readLst.mdb and contains two fields of data, the Reading and the Time, which store the measurement data and the date and time it is taken respectively.

The Microsoft® Personal Web Server 4.0 (PWS) is the software application to be installed in the Local PC. It can turn the Local PC into a low-volume server. Thus, the data stored the database file in the Local PC can be published onto the Internet with this application. Once installed, there will be a default Web publishing home directory in the Local PC with the path C:\Inetpub\wwwroot. Subdirectory can also be created within this home directory to distinguish different experiment being published using the same PWS. A new subdirectory named FKEE has been created for this experiment. All the Web Pages and files of the experiment for publishing are copied into this folder. Subsequently, the home directory path to be set in the PWS for this experiment is C:\Inetpub\wwwrootFKEE. With this, the Local PC can be connected through the Internet with the Universal Resource Locator (URL), which is its name in the network, as set by the Domain Name Server (DNS) it is connected or its Internet Protocol (IP) address.

The Remote Computer can be any personal computers located anywhere. The minimum requirements of the Remote Computer are:

1. Internet connection ready
2. Installed with Internet Browser software

The Client Applets in this experiment are in fact Web Pages stored in the Server (Local PC), which can be browsed through the Internet with a Web Browser at the Remote PC. These web pages can be developed using Microsoft® FrontPage® 2000, which is also a user-friendly and easy-to-use software application. These web pages are to be published onto the Internet with the PWS from the Local PC.

When browsed at the Remote PC, the web pages will demand for Username and Password verification before access is provided to the page displaying the data measured from the EMD. This is another security feature of the project, where only an authorized user who knows the IP address of the Local PC and has the correct Username and Password can get access to the web page displaying the measured data.

4 Results

The flow of Motor Current measured data within the Hardware and Software implementation is as shown in Fig.5.

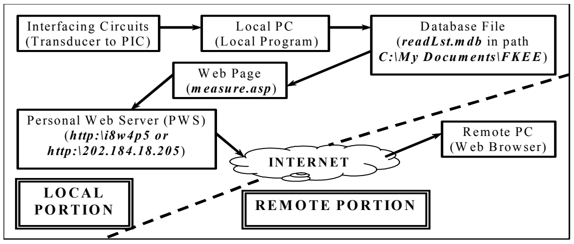

Fig.5: The flow of Data in Hardware and Software Implementation

In Hardware Implementations, the results presented in this section include the EMD (the LEM HY05-P Current Transducer) and the Interfacing Circuits connected to the Local PC. All the components of the Interfacing Circuits, which consists of the IC KIA7805P, IC HIN232CP, the PIC16F876, resistors, capacitors, connector and even the EMD can be connected to the Interfacing Circuits in a same Project Board or PCB too.

By referring to the HY05-P Transducer's Data Sheet, at an input of ±5 A Primary Nominal rms current (IPN), the output voltage will be ±4V. Since the motor used in this project is a DC Motor, the current measured is a DC current too and the '±' sign does not apply in the evaluation of the Im This in turn gives a conversion factor of 1.25 A/V, where the measured current, Im can be evaluated using the equation as follows:

$$I_m = (Vsig \times 1.25)\ A$$

With Vsig is the output voltage from the Transducer. This conversion factor is used in the Local Program in order to convert the A/D converted voltage signal received from the PIC Transducer, back into the equivalent current measured. The evaluated reading of the current is then sent to and stored in the database file, readLst.mdb within the Local PC.

In Software implementations, the results presented in this section include the Server Programs at the Local PC and the Client Applet for the Remote PC. The Server Programs results consists of the Local Program and the Microsoft® Personal Web Server software application results, while the Client Applet are the Web Sites and Web Pages developed for displaying the measurement at the Remote PC.

The Visual Basic (VB) code or the source code of the Local Program consists of five files, telemetry.bas, frmSplash.frm, frmLogin.frm, COMsetup.frm and Local.frm. The .frm files are designed Forms, which are the layout that the user will see exactly when the program being written is executed. On the other hand, the .bas file is a Module file, which is for writing program subroutines or declaring variables that can be used in all the forms.
Before executing the Local Program at the Local PC, a database file, readLst.mdb is created first and must be stored in the following path: C:\My Documents\FKEE. The 'FKEE' folder must be created in the above path in the Local PC, as this path has been programmed in the Local Program as where the database file will be located. Otherwise, the Local Program cannot be executed. Furthermore, a system name called an Open Database Connectivity (ODBC) Data Source Name (DSN) have to be created and assigned to the database file readLst.mdb in the Local PC for faster access when it is needed [12].

When the Local Program is executed, the first screen displayed is a Splash screen (results of frmSplash.frm) as in Figure 6, which is just an introduction screen about the Internet Based Telemetry project. As prompted in the screen, the program will be continued when any Click of the Mouse or Key is pressed. The next screen will be the Login dialog box (results of frmLogin.frm) screen as in Figure 7(a), where the user will be demanded to enter the correct Username and Password. If the Username or the Password entry is incorrect, a message will be prompted informing about the error, as shown in Figure 7(b) and 7(c). The Username and Password are already set within the programming of the Local Program.

After entering the correct Username and Password, the COM Port Setup dialog box (results of COMsetup.frm) will be displayed, as in Figure 8. It is for the user to select the COM port, either COM1 or COM2 that is being used to connect the Local PC with the Interfacing Circuits. If the port selected does not match, an error message will be prompted and the program has to be exited. Whereas, after selecting the correct port and the 'OK' button is clicked, the Local Program will proceed to the screen that displays the Measurement.

Fig. 9 is the screen that displays the Measurement (results of Local.frm). This Local Program is already programmed to refresh and get the data from the Interfacing Circuits (the PIC16F876) at every 5 seconds interval. Therefore, in this screen, the Motor Current reading 0.5183 A will be changing according to the varying current being measured. Simultaneously, the time and date (11:33:28 AM 31/08/2002) displayed will also change every 5 seconds. It is the exact time when the measurement is taken. Besides refreshing automatically, the reading can also be refreshed manually by clicking the 'Refresh' button. There are procedures programmed in the Local Program where both the Motor Current reading and the Time and Date data are then sent and stored in the database file readLst.mdb in the Local PC's path C:\My Documents\FKEE after every refreshing of the data. The 'Exit' button is to end the Local Program.

The screen in Fig.9 is with the connection to the Motor at Active status, where a Green indicator button is displayed within the screen and means that the Interfacing Circuits is switched on and operating. In the case that the Interfacing Circuits is switched off while the Local Program is running, and thus no connection established between it and the Local PC, the indicator button will change to RED with a label that states the connection to the Motor is Inactive.

Fig.6: The Splash screen when the Local Program is executed

In this Inactive status, the Motor Current reading and the time displayed will not change although the Local Program is keep refreshing automatically to get the data. They will neither change even if the 'Refresh' button is clicked. The Inactive status of the connection can also be detected by the user by observing the time displayed is not within 5 seconds in difference from the real current time. When the Interfacing Circuits is switched back on, the indicator will change back to Green The Motor Current reading and the Time and Date displayed are then refreshed and updated.

When the Microsoft® Personal Web Server software application is executed at the Local PC, the Personal Web Manager Main page will be displayed. The home directory of the experiment is C:\Inetpub\wwwroot\FKEE, which can be set in the Advanced Options page by clicking the 'Advanced' tab button in this Main page. After doing all the settings and return to the Main page, the Publishing services of the Web Pages can be started by just clicking the 'Start' button. With this, the Local PC can be connected from other Remote PC through the Internet by using its IP address as the URL of the web Browser. The IP address of the Local PC can be detected by running the 'winipcfg' at the Run option in the Start Menu tab of the Windows toolbar. For this experiment, the IP address of the Local PC is 202.184.18.205,but it is a dynamic IP address, which may change during each new Internet connection made.

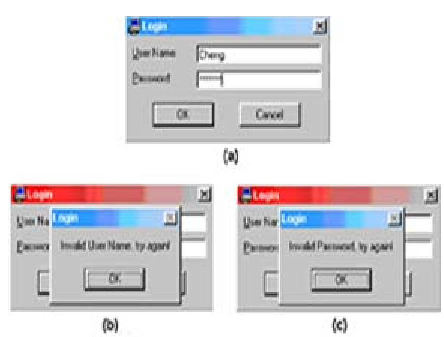

Fig.7: The Login screen during the execution of Local Program

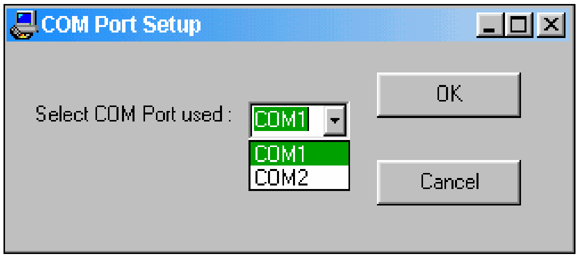

Fig.8: The COM Port Setup dialog box screen in Local Program

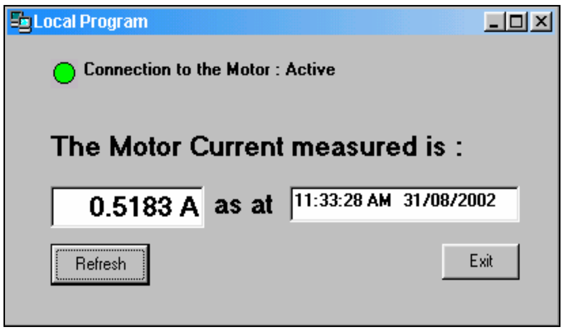

Fig.9: The Local Program screen that displays the Measurement with connection to the

Motor at Active statusBesides the IP address, a reliable method to connect to the Local PC is the URL **http://i8w4p5**, the name of the Local PC as set by the DNS it is connected to. This name is seldom changed by the DNS. This URL is also displayed at the Main page of the PWS when the Publishing services have been started.

The Client Applets, which are the Internet Based Telemetry Web Site with Web Pages developed using the Microsoft® FrontPage® 2000 and stored in the Local PC. There are only four web pages, the Home Page, Overview, Enter and The Measurement pages. Besides these four web pages, there is also an applet named verify.asp written in developing the Web Sites.

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When the Web Site URL http://i8w4p5 is browsed at the Remote PC Web Browser, the Home Page will be displayed first by default. The navigation of the Web Sites is as shown in Fig.10, while the Home Page, Overview, Enter and The Measurement pages are as in Fig. 11, 12, 13 and 14 respectively.
The Home Page is an introduction page for this Internet Based Telemetry Web Site. There are hyperlinks that link to the *Overview* and *Enter* pages. The *Overview* page contains an introduction text about the Internet Based Telemetry and the explanation on how the Web Site works. Hyperlinks to the *Home Page* and *Enter* pages are also included in this page. The *Enter* page provide the security feature at the Remote PC where the user have to submit the correct Username and Password before getting access into *The Measurement* page to view the measurement.

When the Username and Password are submitted, the *verify.asp* applet will be called to run. The *verify.asp* applet is written using VB scripts and is for verifying the Username and Password being submitted and then directing the *The Measurement* page to be displayed at the web browser. However, if the Username, Password or both are incorrect, the *verify.asp* applet will direct back to the *Enter* page and prompt the errors made, letting the user to reenter the Username and Password. Besides that, there are also hyperlinks that link to the *Home Page* and *Overview* pages.

The *The Measurement* page is the one that displays the Motor Current data measured at the Local PC. It displays the Motor Current reading as well as the date and time at when the measurement is taken. VB scripts are added in the source codes file of this page to make it self-refresh every 5 seconds in order to get the new reading stored in the database file *readLst.mdb*. The time displayed will not be updated if the connection to the Motor is in Inactive status at the Local Program

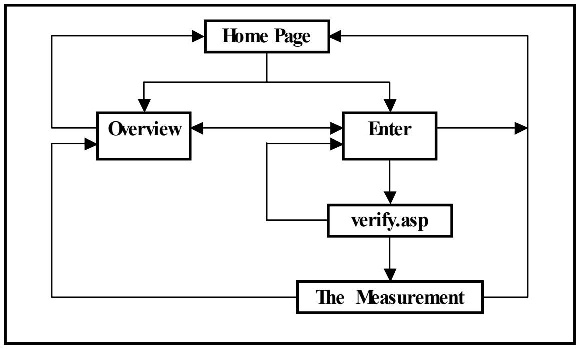

Fig. 10: The navigation of the Internet Based Telemetry Web Sites

Fig.11: The *Home Page* as viewed in a Web Browser

Fig.12: The *Overview* page as viewed in a Web Browser

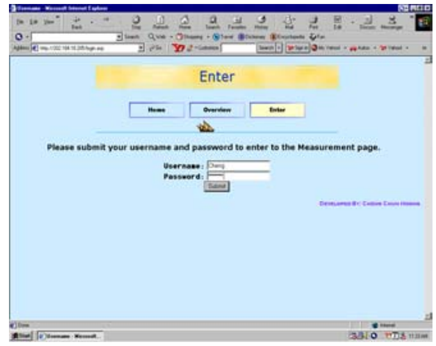

Fig.13: The *Enter* page as viewed in a Web Browser

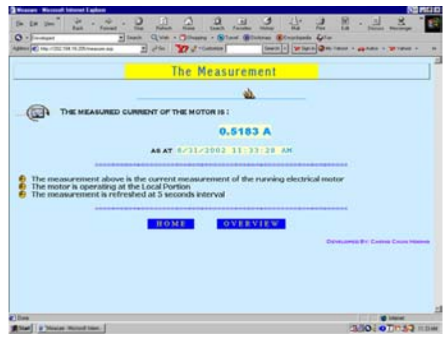

Fig.14: *The Measurement* page as viewed in a Web Browser

5 Discussion

There are a few limitations for this telemetry system. The reference voltage used for the ADC module in the PIC16F876 Microcontroller is 5V, which is also the V_{DD} for the PIC. The A/D conversion technique used is Successive Approximation. Thus, the analog signal that feeds as input into the ADC module cannot be greater than 5V or else, the A/D conversion will not be accurate. In such case that the current measured generates voltage signal higher than 5V, external voltage supply instead of the 5V PIC V_{DD} may be needed to feed the ADC module through pin RA3 of the PIC16F876 as the Reference Voltage.

The measurement made in this work is a DC Motor Current. Thus the parameter measured is a DC parameter. The HY05-P I-to-V Transducer used is capable for measuring both AC and DC current. However, in the Interfacing Circuits, the ADC module in the PIC Microcontroller that deals only with DC signal is used for converting the analog signal into digital signal. Thus, measurement of AC parameter may not be made directly with the circuits and system developed in this project. For enabling the measurement of AC parameter, such as AC Motor Current instead of a DC Motor, a Rectifier circuit may be added at the stage before the Interfacing Circuits that will rectify the AC signal into equivalent DC signal before it is being fed into the Interfacing Circuits. Some filter circuits may also be needed to filter out the noise signal to increase the accuracy of the measurement.

In implementing the Internet Based Telemetry system in this experiment, the Microsoft® Personal Web Server (PWS) is used to turn the Local PC into a low-volume server only. Thus, the concurrent connections to the Local PC are limited to only 10 at a time. For large-volume usage, a domain should be applied from a local Internet Service Provider (ISP) so that the domain can be used to run as the Web Server that can support large volume of connections. However, this is done in the expense of some cost charged by the ISP for providing the domain.

In the implemented experiment, only one motor is being dealt with in the measuring task. In fact, further improvement can be made to add parameter from more equipment to be measured. This issue may come in when considering that there are normally more than one equipment are running at the same time in an industrial plant. Thus, the measurement parameters of all these equipments, which can be the current, voltage, temperature or power consumed, should be available for monitoring purposes. The Telemetry system in this experiment may be upgraded as suggested as follows:

1. Each equipment to be measured should has its own transducer that provides output in voltage signal equivalent to its parameter being measured
2. A Multiplexer circuit is included to select which equipment to be measured and connect its Transducer output to the PIC ADC module analog input Pin 2 (RA0) in the desired order
3. The Local Program, the database file and the Web Pages are modified so as to get and display all the parameters measured from all the equipments

Such improvement of the system will make it more reliable and cost saving, since only one Local PC needed in a plant to get the parameters measurement of all running equipments in that plant. Yet, more convenience is added as the monitoring job can be done at a remote distance from the plant through the Internet.

6 Conclusion

The objective of this research project to perform internet based measurements was implemented successfully. The current of a DC Motor is measured and displayed at real time with scan rate of 5 seconds in the Local Program at the Local PC as well as in the Web Page when browsed through the Internet with Web Browser at a Remote PC. Both hardware and software implementation of this project are also accomplished successfully.

References:

[1] S. Bomben, H. G. Sedding, S. Rizzetto, "*Assessment of Station Cable Condition Using Wireless Telemetry and Diagnostic Tests*", IEEE Electrical Insulation Magazine Vol. 18, No. 4, pp.24-29, 2002.
[2] Chengjun Huang Weiyong Yu, Wei Wei, "*Development of PD On-line Monitoring System for Large Turbine Generators*", Conference Record of the 2002 IEEE International Symposium on Electrical Insulation, pp. 23-26, April 2002.
[3] C.J Bennoch, M.D. Judd, J.S. Pearson, "*System for On-line Monitoring of Pollution Levels on Solid Insulator*", Conference Record of the 2002 IEEE International Symposium on Electrical Insulation, pp. 237-240, April 2002.
[4] J. Michael Silva, Bruce Whitney, "*Evaluation of the Potential for Power Line Carrier (PLC) to Interfere With The Use of the Nationwide Differential GPS Network*", IEEE Transaction On Power Delivery, Vol. 17, No. 2, pp. 348-352, 2002.
[5] Yoshiharu Yonezawa, W. Murton Caldwell, "*A Miniaturized Radio Telemetry Two Channel Ultrasonic Cardiac Dimension Gauge*", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Vol. 5, pp. 1449-1450, Nov. 1989.
[6] http://www.lem.com - LEM official websites.

[7] http://www.microchip.com Microchip Technology official websites.
[8] http://www.kec.co.kr - KEC official data sheets websites.
[9] Myke Predko, "*Programming and Customizing the PIC Microcontroller*", McGraw Hill, 1998.
[10] http://www.intersil.com - Intersil Americas Inc. official websites.
[11] Richard Mansfield, "Visual Basic 6 Weekend Crash Course", M&T Books, 2000.
[12] Bill Hatfield, "Active Server Pages for Dummies 2nd Edition", IDG Books Worldwide Inc, 1999.
[17] D. Patranabis, "Telemetry Principles", Tata McGraw Hill Publishing, 1999.
[18] George Smith, "Computer Interfacing", Newnes, 2000.
[19] Gilbert Held, "Understanding Data Communications: From Fundamentals to Networking", John Wiley & Sons, 2000.
[20] Alan M. Cohen, "A guide to Networking", Boyd & Fraser Publishing Company, 1991.
Gilbert Held, "Internetworking LANs and WANs – Concepts, Techniques and Methods", John Wiley & Sons, 1993.
[21] Raymond Greenlaw, Ellen Hepp, "Introduction to the Internet for Engineers", McGraw Hill, 1999.
[22] Gilbert Held, "Managing TCP/IP Networks: Techniques, Tools and Security Considerations", John Wiley & Sons Ltd, 2000.
[23]. http://www.studiodeluxe.net/pws - Studio Deluxe International websites for downloading Personal Web Server software application.
[24] Sherry London, "FrontPage 2000 - Get Professional Results", Osborne McGraw-Hill, 2000.
[25] Peter G. Aitken, "Visual Basic 65 Programming BLUE Book", The Coriolis Group, 1998.
[26] C. Goodchild, D. Kerr, "An Unmanned Underwater Vehicle Navigation and Guidance System", IEE Colloquium on Control and Guidance of Remotely Operated Vehicles, pp. 5/1-5/4, 1995.
[27] Mohammad Modarreszadeh, Robert N. Schmidt, "Wireless, 32-Channel, EEG and Epilepsy Monitoring System", Proceedings of the 19th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Vol.3, pp. 1157-1160,1997
[13] Azlim Bin Zamberi, "Internet Based Control and Monitoring of Utility Substation", Department of Electric and Electronic, Faculty of Engineering, UPM, 2000.
[14] Tan Eng Hau, "Web Based Device Monitoring and Control", Department of Electric and Electronic, Faculty of Engineering, UPM, 2000.
[15] Affendi Bin Alias, "Internet Based SCADA System", Department of Electric and Electronic, Faculty of Engineering, UPM, 2001.
[16] Foo Siang Wang, "Remote Monitoring via Internet", Department of Electric and Electronic, Faculty of Engineering, UPM, 1999.