Measurement and Monitoring System With Real Time Data Logging Based on Microcontroller

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ABSTRACT

This article presents a microcontroller-based system for measurement and monitoring voltage of a three-phase electrical system with real-time data logging abilities. The proposed system uses voltage signals and time data as input. The output is an LCD and data files. The system accurately records abnormal voltage variations which have occurred on the system. A PC software is developed to receive and save data in two spreadsheet files through a serial port. Ihe log file contains the measured voltage, which is recorded periodically with a predefined time interval, and the second file contains the type of the fault. The proposed system is first simulated by ISIS-Proteus and then realized and implemented on an electronic board. It is beneficial to make detailed, scientific judgments and analysis for the voltage system to be supplied to a load. Because of the very simple circuit, it finds applications in industrial facilities. It is also useful in applying final circuits for both investigation and monitoring purposes.

KEYWORDS

Data Logging, Microcontroller, Monitoring, Real Time Clock, Voltage

INTRODUCTION

Nowadays, microcontrollers are considered the main parts in modern electronics because of the simplicity and flexibility of handling by the software; they are employed in the most of electronic systems that need inputs and outputs. Performance improvement at low price makes microcontrollers highly adequate for vast applications (Jaanus, Udal, Kukk, & Umbleja1, 2013). Generally, large series of microcontrollers have built-in analog to digital converters, these converters are employed and used for analog data acquisition (Krejcar, Spicka, & Frischer, 2011). Most of built-in converters have ten bit resolution which is enough for simple purposes, while in some applications in which the accuracy is very important, analog to digital converters with higher resolution is needed (Jaanus, Udal, Kukk, & Umbleja1, 2013). Among the applications that use microcontroller and introduce analog to digital converters is voltage measurement, it is considered the most main parameters in electrical systems and engineering. However, to measure voltage that is the difference of electrical potential between two points in electric circuits, voltmeter is the instrument commonly used for this purpose (Imran & Moshiur, 2014; Abraham, Thekkekara, Sajana, Sandeep, & Sandeep, 2014).

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Another application that employs microcontroller is data logger, it is used to record or capture by time and date measurements by means of peripheral sensors over a period of time (Al Mamun et al., 2013), there are times when it may need to analyze a complex situation, process large amounts of data, diagnose an error, or perhaps need an automated way to run an experiment or just record data for storage or for future analysis. These devices are normally connected to a personal computer. Such data can either be analyzed online or offline.

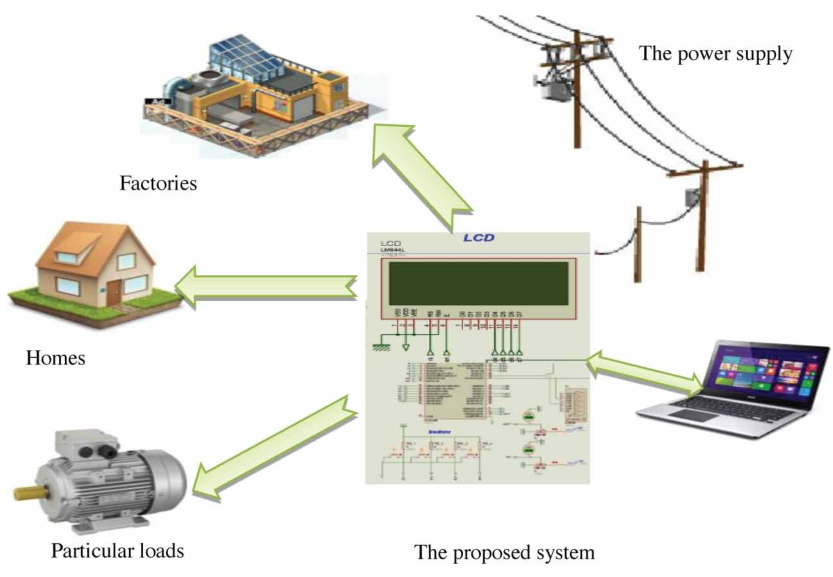
In other side, simulation can improve design efficiency and reduce considerably the cost of product development. Actually there are many software of simulation such as Matlab which have strong and efficient functions of simulation in many kinds of systems, but design in electronic applications needs to analyze relationship of variety output signals and understanding real time signal behaviors in the designed circuits (Liping & Weiguo, 2012), for this purpose, Proteus ISIS as simulation platform has been chosen to design and develop voltage measurement and monitoring system with real time data logging based on low cost microcontroller. In addition, Proteus ISIS is widely used (Heribertus, Catur, Samiul, & Adrin, 2015) and provides vast functions such as graphical display, showing signal changes in graphic form and, the designers can observe the results of simulation directly.

The present paper takes Proteus ISIS software as simulation platform to design a combination of the two systems in one, voltage measurement system and real time data logging based on microcontroller PIC 18F4550, it will be ideally suited to local monitoring of voltage electrical installations in industrial facilities, commercial buildings, particular loads, utility networks or critical power environments. Voltage measurement and monitoring system with real time data logging based on microcontroller and its typical application has been shown in Figure 1.

SYSTEM OVERVIEW

The entire system was designed to sense voltage from three phase electrical power system using voltage sensors, by using of an rms-to-dc converter chip with high accuracy even with distorted or non-sinusoidal voltage wave form to get measurable dc signal, the sensed values witch are analog values then sent to the built-in analog to digital converter (ADC) of PIC 18F4550 microcontroller and converted to digital values, at the same time the PIC microcontroller receives data from a real

Figure 1. Typical application of the proposed system



time clock (RTC) PCF8583 through I2C communication protocol, this data contains the current date and time. All the data generated by voltage sensors and RTC is considered as inputs of the proposed system, a firmware developed using Proton Basic language and implemented on the PIC18F4550 to handle these data, performing the necessary processing and calculations. As outputs of the proposed system a Liquid Crystal Display (LCD) is used to show the current date, time and the measured voltage of each phase with its state on real time, for data logging, a communication between the microcontroller and personal computer through serial port using RS232 protocol is used. Generally the block diagram of the whole system is shown in Figure 2, a Graphical User Interface as software has been developed using MS Visual Basic 6 for showing the measured values, date, time and logged data, this software allows the user to set up the time interval for logging data, predefined range of allowed min and max voltage values and, automatically when it is connected to the proposed system generates two spreadsheet files, first called log file contains recorded values of each phase voltage with time and date, second called error file contains the faulty phase voltage values, time of its occurrence and the type of the fault or error, all these events are saved on real time, the two files could be open using MS Excel or using the data for graphic representation in Matlab for offline exploitation or statistical purposes.

DESIGN METHODOLOGY

The design of the proposed system is divided into two parts: hardware and software.

Hardware Design

The circuit of the proposed system is made of the following units: power supply unit; processing unit; sensing unit; display unit; real time clock unit, and communication unit. The power supply unit will not be discussed in this paper because it is considered basic part. Figure 3 shows the block diagram of units of the proposed system.

Processing Unit

The processing unit is considered the brain of this system. It is used to collect, control and manage all the data coming from the other units and synchronizes all the module operations. A microcontroller

Figure 2. Block diagram of the proposed system

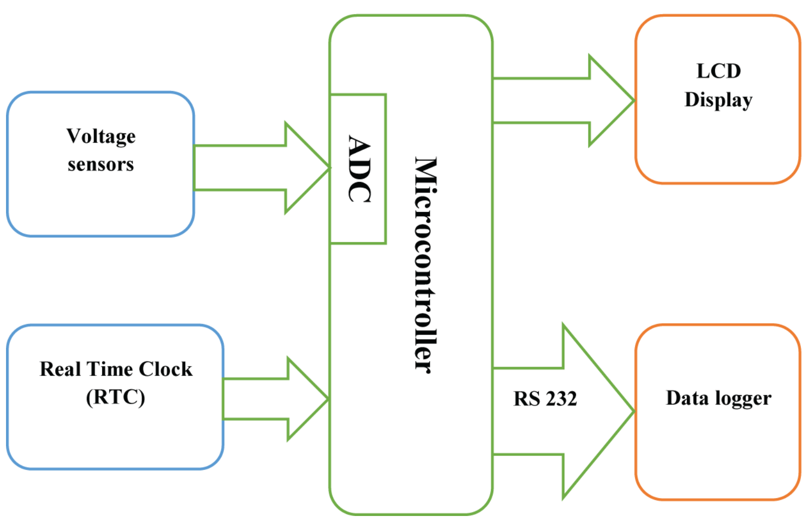
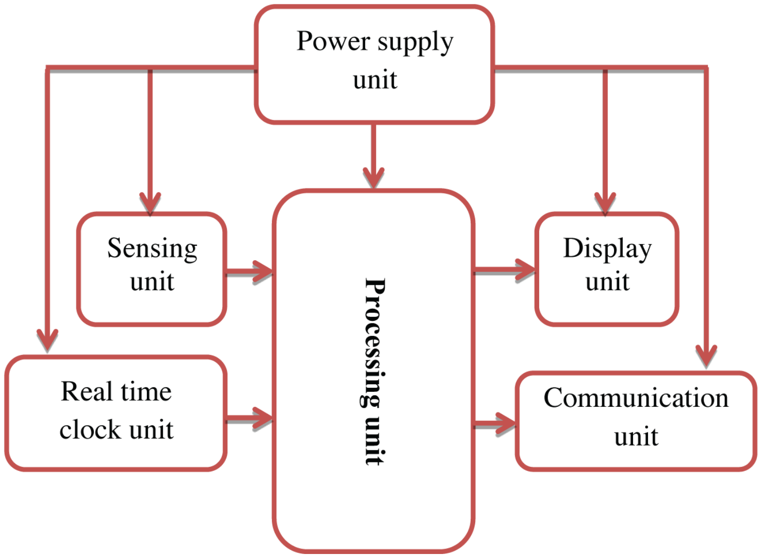


Figure 3. Units of the proposed system

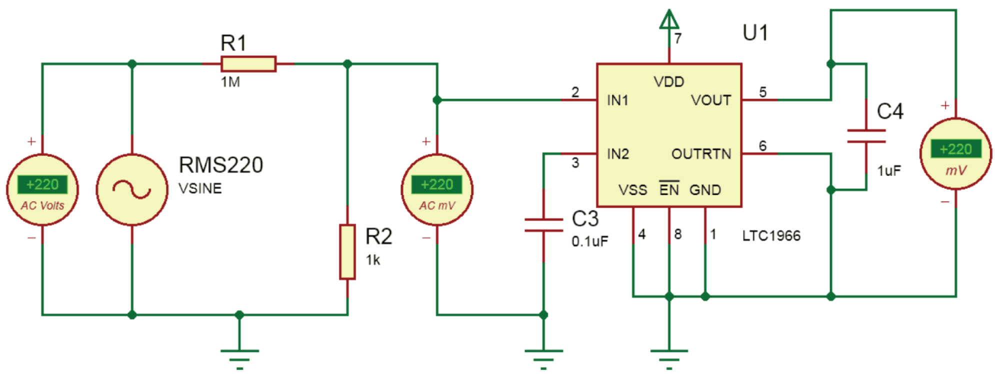


PIC18F4550 from MicroChip has been chosen for a variety of features including: eight-bit microcontroller has 40 pins with 33 input/ output lines divided into five ports: A, B, C, D and E, so future tasks for the proposed system can be introduced. Also supports four crystal mode up to 40 MHz, has USART module for the serial communication with RS232 and, has 10bit ADC converter and one of the main advantages is that it can be write-erase as many times as possible because it uses flash memory technology. In addition, this microcontroller is widely available in the markets with low cost. All these features of PIC18F4550 microcontroller make it a logical choice for many power sensitive and high performances applications (Arul Jai Singh, Raviram, & Shanthosh Kumar, 2014; Aniket. Sanket. & Jagtap, 2014; Vikram & Anand, 2016; Bharathkumar, Irshad, Gowtham, & Geethamani, 2017).

Sensing Unit

Voltage is defined as the electrical potential difference between two points in a circuit (Heribertus, Catur, Samiul, & Adrin, 2015), the measurement of this parameter is essential in this system. In order to obtain data about voltage it is necessary to use a sensor. A voltage divider has been used to provide a measurable voltage signal that will be proportional to the line voltage (Mustafa, 2017), it is composed of a combination of 1 MΩ and 1 kΩ resistors that means that the impedance of voltage sensor has an input of 1.01 MΩ which is suitable to measure AC voltage up to 1000 V RMS in this system. The output voltage across the 1 kΩ resistor is up to 1000 mV RMS. To reduce the calculation of RMS by the software an integrated circuit from linear technology has been introduced LTC1966, it is an RMS to DC converter designed for electrical measurement, this circuit utilizes an innovative delta sigma computational technique providing an accurate amplitude information that is true RMS value whatever the shape factor (LTC1966 Datasheet, 2001; Manel, Aktham, & Jean-Paul, 2015) then, the output of the voltage divider has been linked to this integrated circuit as illustrated in Figure 4. The output of LTC1966 is an analog quantity linearly proportional to the RMS of the measured voltage providing accuracy less than 1% for an input level of 10mV to 1000mV, this method provides the RMS directly (Manel, Aktham, & Jean-Paul, 2015) in DC form from the hardware, equation (1) shows the transfer function of LTC1966, and then sent to the port A and transformed to digital value by the ADC of the microcontroller. By using of this design in the proposed system, a true RMS voltage of the three phases is assured regardless the voltage waveform even distorted sine wave:

Figure 4. Sensing unit circuit scheme



$$V_{out} = \sqrt{\overline{\left(V_{in}\right)^2}} = RMS\left(V_{in}\right) \tag{1}$$

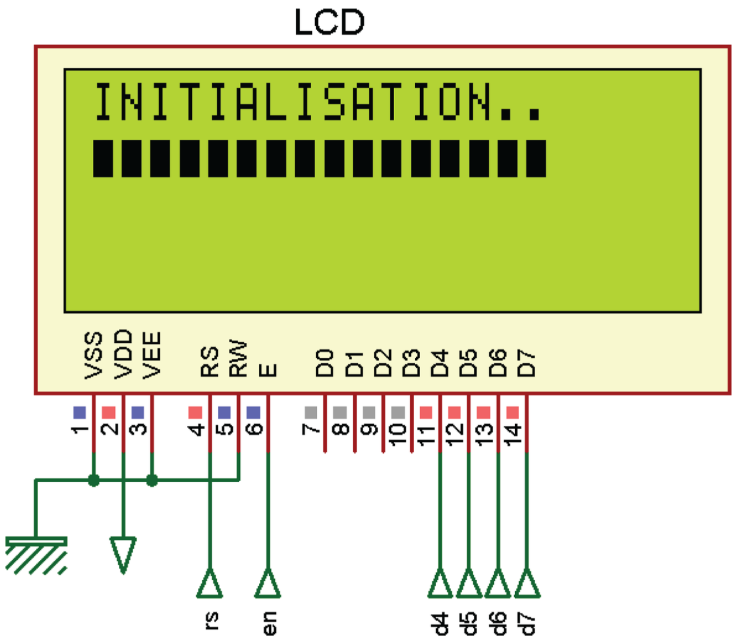
Display Unit

Displaying values and events on real-time locally in the proposed system is indispensable for this purpose an LCD module has been used as shown in Figure 5. The module is a thin, flat display device, has built-in display controller that means that the main microcontroller will be free from generating dot matrix character display with manual manner. The module is composed of 20×4 dot matrix. Alphanumeric LCD means it can display 20 characters per line and there are 4 such lines. In this type of LCD, character is displayed in 5×7-pixel matrix; it has two registers, namely, data and command. The command register stores the instructions of command given to the screen. A command is an instruction given to LCD to perform a predefined task like clearing or initializing its screen, setting the position of the cursor, controlling display and so on. The data register memorizes the data to be displayed on the screen. The data is the ASCII character (American Standard Code for Information Interchange) value to be displayed on the screen. It is capable to display any character with ASCII values ranging from 0 to 255. The module is configured with read-write control (WR) pin grounded in 4-bit mode. Typically, such configuration requires only 6 input/output pins of microcontroller (Heribertus, Catur, Samiul, & Adrin, 2015; Arul Jai Singh, Raviram, & Shanthosh Kumar, 2014; Nhivekar & Mudholker, 2011).

Real Time Clock Unit

To maintain and to keep trucking of accurate current time, even when there is no power supply introducing separate chip for doing this job is needed, which is here PCF8583. This operation can be performed by the main microcontroller but using separate RTC relives the processing unit for time critical tasks and, because of its lower power consumption. Figure 6 shows the scheme of PCF8583 interfacing with PIC18F4550 (Saidu, Momoh, & Mindaudu, 2013). Communication between the chip and the processing unit is carried out through simple serial interface bus protocol. By using of lithium battery to provide an alternative power supply source to the RTC, this yields the operation of RTC without interruption in the event of failure in main power source (Nhivekar & Mudholker, 2011). The PCF8583 is working as a slave device through I2C bus (Anuj, Indu, & Suresh, 2010). We are using RTC PCF which has these features as mentioned in its datasheet: operating supply voltage: 2.5 V to 6 V, Clock operating supply voltage 1.0 V to 6.0 V at 0° C to +70° C, 240 × 8-bit low-voltage RAM, Data retention voltage: 1.0 V to 6.0 V, Operating current (at f_{SCL} = 0 Hz): max 50 µA, Clock function with four year calendar, Universal timer with alarm and overflow indication, 24 hour or 12

Figure 5. Display unit (LCD) circuit scheme



hour format, 32.768 kHz or 50 Hz time base, Serial input and output bus (I2C-bus), Automatic word address incrementing, Programmable alarm, timer, and interrupt function and Slave addresses: A1h or A3h for reading, A0h or A2h for writing (PCF8583 Datasheet, 2010).

Communication Unit

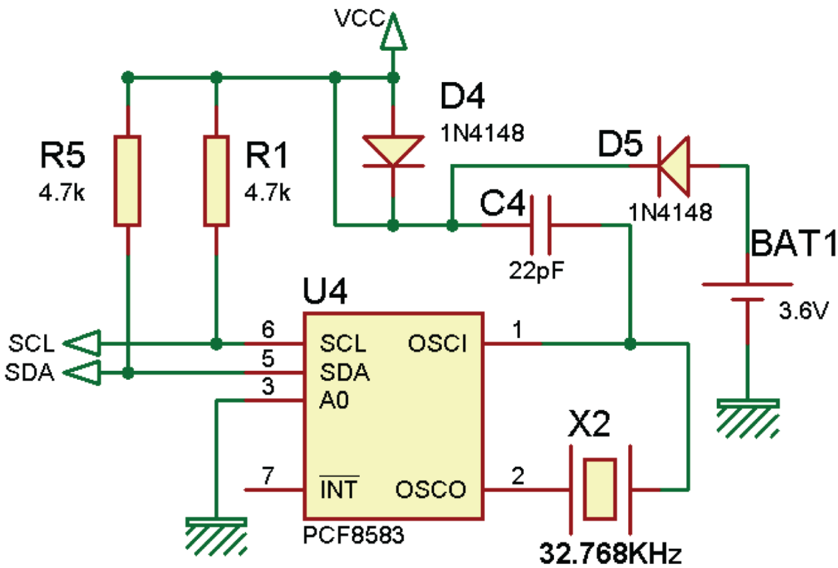
In order to create data link between processing unit and standard PC to perform data logging and remote monitoring tasks, a communication protocol is needed which is here serial communication. The microcontroller has a module called USART (Universal Synchronous Asynchronous Receiver Transmitter)/ UART (Universal Asynchronous Receiver Transmitter) this requires only two pins from the microcontroller to send and receive data serially: TX and RX. TX is the pin which the microcontroller data is transmitted through, and RX is responsible for data received by the microcontroller.

This serial communication is called RS232 (Recommended Standard 232) it supports as full duplex both of transmission types; synchronous and asynchronous. It is widely used in personal computers and known as serial ports. The RS232 device is considered as Data Terminal Equipment (DTE) or Data Communication Equipment (DCE). A connected device to the RS232 interface is called Data Communication Equipment and the device to which it connects is called as Data Terminal Equipment (Ramya & Palaniappan, 2012).

Software Design

Software design includes developing algorithm for the system, allocating memory blocks, writing the separate routines for different interfacing devices and testing them on the designed hardware. Interfacing of the microcontroller with the peripherals; RTC, LCD and sensing unit has been carried out using the software modules. The software section is composed of four software involved namely Proteus ISIS 7.8, Proton IDE 1.0, Mikroprog Suite For Pic V2.34 and Visual Basic6.

Figure 6. Real time clock unit circuit scheme



Proteus ISIS

The software design has been constructed based on Proteus ISIS which is a Virtual System Modelling, complete simulation platform (Jie & Qinfang, 2015) developed by Labcenter and, it has been chosen because of the ability to simulate the interaction between software running on a microcontroller and any analog or digital electronics connected to it, professional software for embedded designers. It enables the user to build circuits with a variety of elements which are available in its library. This can simulate in real time and shows real time outputs the modeled circuit. It is even possible to connect Proteus with third party software debugger, and watch animated schematic diagram at work as if it was real hardware. There is much software available but no one user friendly and simple. Proteus ISIS offers a user-friendly environment. It also offers the simulation of large number of single chip microcontrollers (Jie & Qinfang, 2015), electrical, electronic and other connecting components. Proteus ISIS offers the platform where different components are arranged or connected according to the circuit diagram and PCB layout can be created as per the proposed system. After the arranging the component the simulation operation perform and the errors are identified and rectified. The architecture of the Proteus has been made according to different user. There is no requirement of extra equipment and lab facilities because it is implemented these facilities itself. The graphical view and the different wave form can be seen in this software (Ishaan, Prerna, Shubham, & Sheila, 2015; Shakti & Saxena, 2014; Subrata, Rafiul, Samiul, Robiul, & Tanzila, 2013).

Development Software

In order to make working hardware with embedded system of this system, three software have been used: programming language with compiler for microcontroller; software for introducing the firmware and; programming language for PC software to communicate with the hardware for monitoring and data logging purposes. In this system the microcontroller's program was been written and compiled using Proton IDE, it has been chosen because it is the one of the most easy and popular language intended for PIC microcontrollers programming. The Figure 7 shows the graphical user interface of Proton IDE.

The constructed Proton IDE program can be uploaded to the PIC as a hexadecimal file by using MikroProg_Suite_For_Pic, software intended for uploading firmware to PIC microcontroller family.

It is not only for intoducing the firmware to microcontroller but, also for reading, verifying erasing or even blanking the microcontroller flash memory. The graphic interface of this program is clear and easy-to-use, which makes the use of this program faster. The program main window includes basic options for programming microcontrollers as shown in the Figure 8. In addition, there are advanced programming options that enable experienced users to set configuration bits on their own. The program includes views providing basic information about the selected MCU, voltage monitoring.

The computer software that allows data transfer from the microcontroller to the PC was developed using MS Visual Basic6 as shown in Figure 9. In the standard serial communication, MSCOMM which is the power communication control provided by Visual Basic, it can set the serial communication of data sent and received, and the serial communication port status, message formats and protocols are set, directly send data by PC's RS232 serial port. In order to realize PC reliable communication with the proposed system, and ensure that both sides have the same data format and baud rate, this design uses RS232 communications, a 10 bits data format, 9600bit per second baud rate. This developed software allows monitoring and showing trending measurement data of voltage in real time and, stored in a CSV file, users can easily view and analyze the collected data for verification then retrieval the data can be handled and analyzed easily by any mathematical software such as MS Excel or MATLAB, taken both online and offline (Mustafa, 2017; Handoko, Agus, Arwinda, & Nana, 2016; Mousam, Suman, & Pradip, 2016).

SIMULATION

As mentioned before, Proteus ISIS is the software used for simulation of the whole system that is the electronic components or hardware parts; the Figure 10 illustrates the Proteus ISIS scheme.

Figure 7. Graphical user interface of the programming language (Proton IDE) that used to develop the firmware of the proposed system

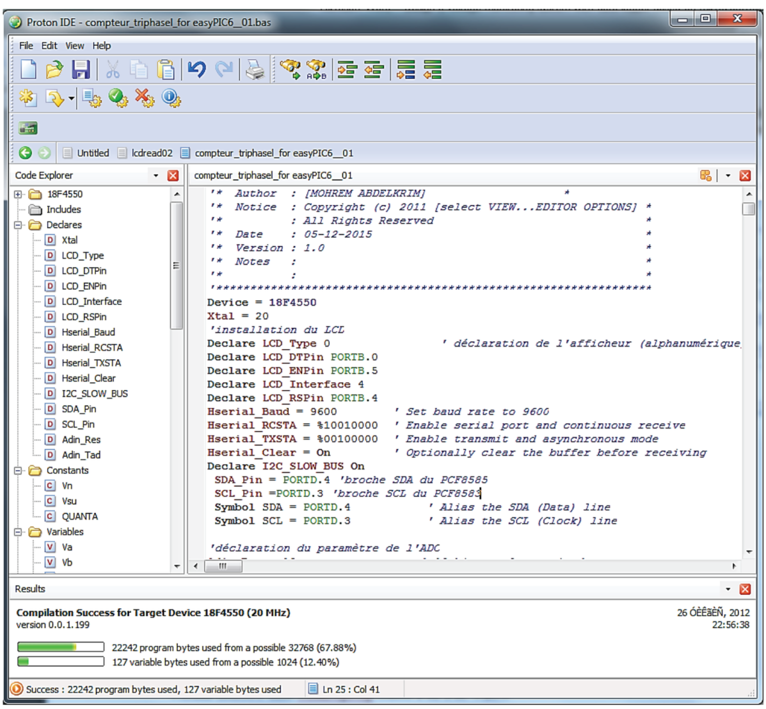


Figure 8. MikroProg_Suite_For_Pic graphical user interface used to program the MCU

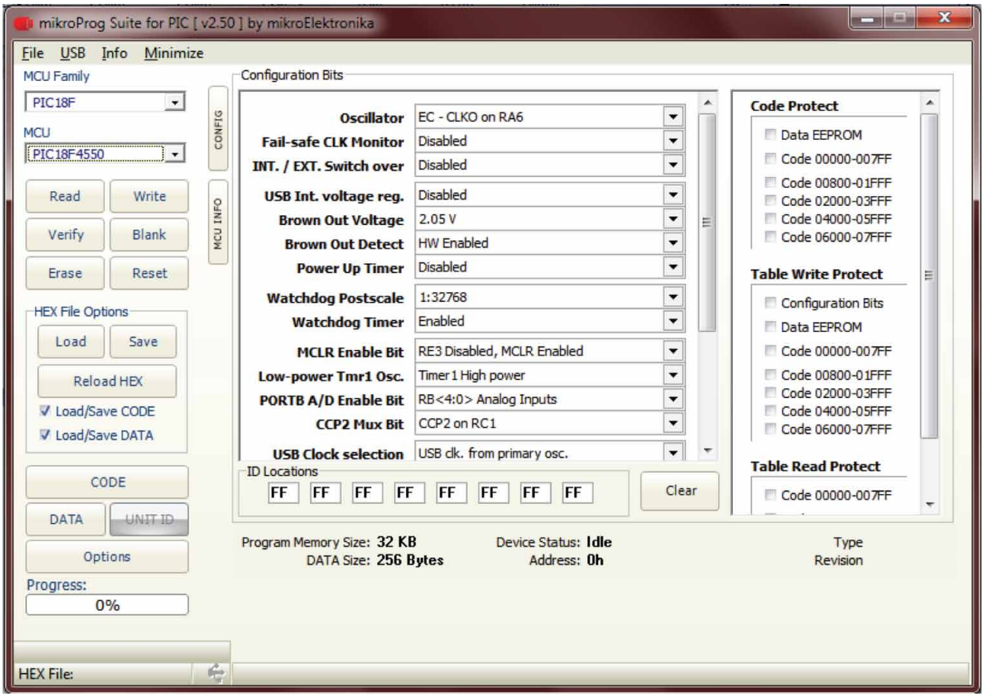


Figure 9. MS Visual Basic6 graphical user interface in which the software of communication to PC has been developed

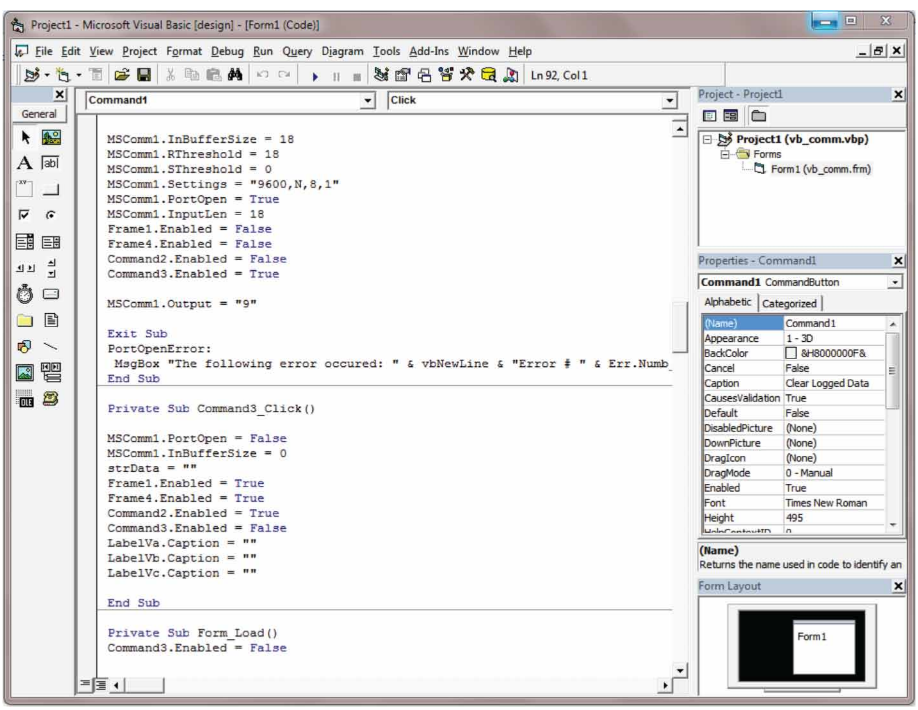
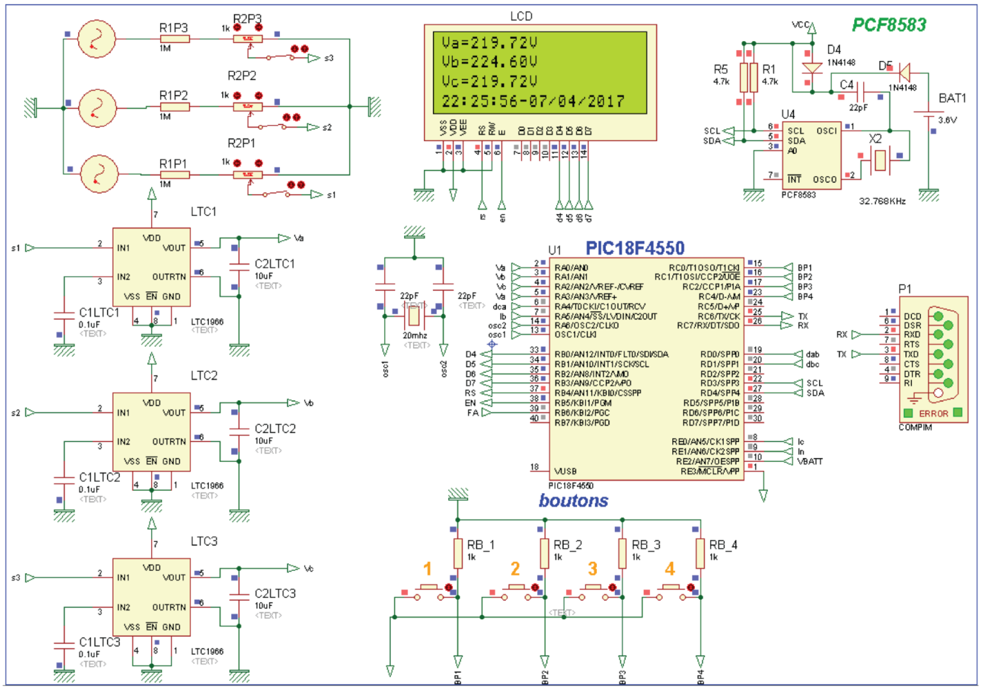


Figure 10. Proteus ISIS simulation scheme of the proposed system



For simulation, the variation of voltage in each phase, three potentiometers have been used, these make the simulation of the two cases overvoltage and undervoltage. For simulation of the case of lost voltage phase, three switches have been used, opening the switch makes the voltage sensor reads zero volt which means that the voltage in the corresponding phase is missing or lost.

By using the com components in Proteus ISIS, virtual serial communication based on RS232 standards can be performed, this makes the communication between the simulated microcontroller in Proteus ISIS and the designed software based on Visual Basic6 as shown in Figure 11.

In case of any abnormal voltage variations the LCD displays a code corresponding to the type of the fault, the Table 1 shows the fault type and the codes used in the proposed system.

As shown in the Table 1, there are three possible cases: overvoltage, undervoltage and missing phase voltage which represent a zero voltage in one of any phase.

Simulation Results

In simulation, the threshold value of over voltage is set to 260 V phase to neutral, this means that any value of voltage exceeds this threshold leads to display a code of overvoltage in the LCD beside the corresponding phase. In the same manner the threshold of undervoltage is set to 200 V phase to neutral which means that any value below it leads to display a code of undervoltage in the LCD. The missing phase voltage is set to zero (0V). To simulate the variations, three potentiometers have been introduced and, to simulate missing phase voltage, three switches have been used as shown in Figure 13.

Figure 12b shows an overvoltage in phase B and Er_1B in the LCD, the value is about 288V which is bigger than the threshold.

Figure 12c shows an undervoltage in phase A and Er_2A in the LCD, the value is about 161V which is smaller than the preprogrammed threshold that is 200 V.

Figure 12d shows the case of missing voltage in phase C and Er_0C in the LCD, which is zero volt.

Figure 11. Graphical user interface of communication PC software with proposed system

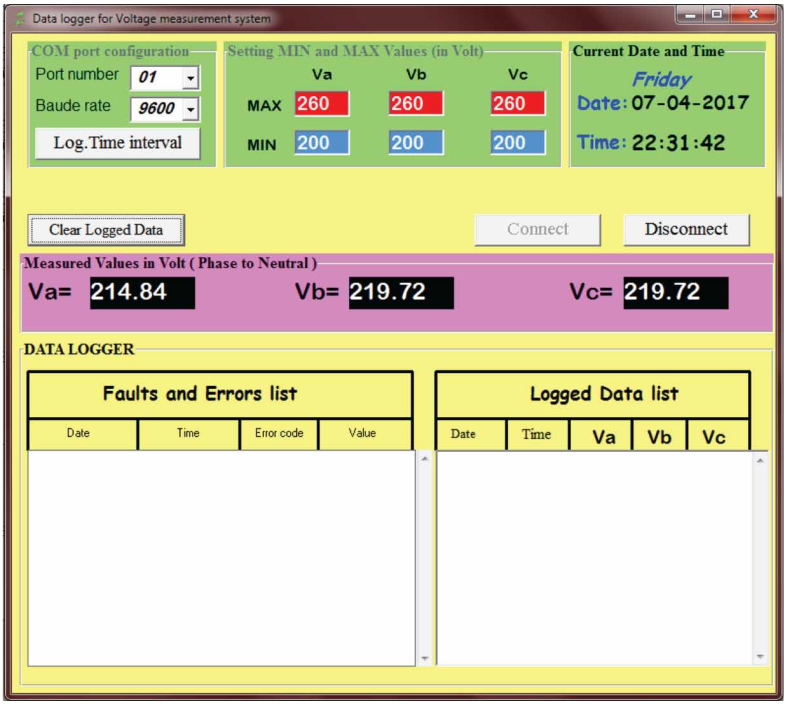


Table 1. Fault type with its corresponding phase and code

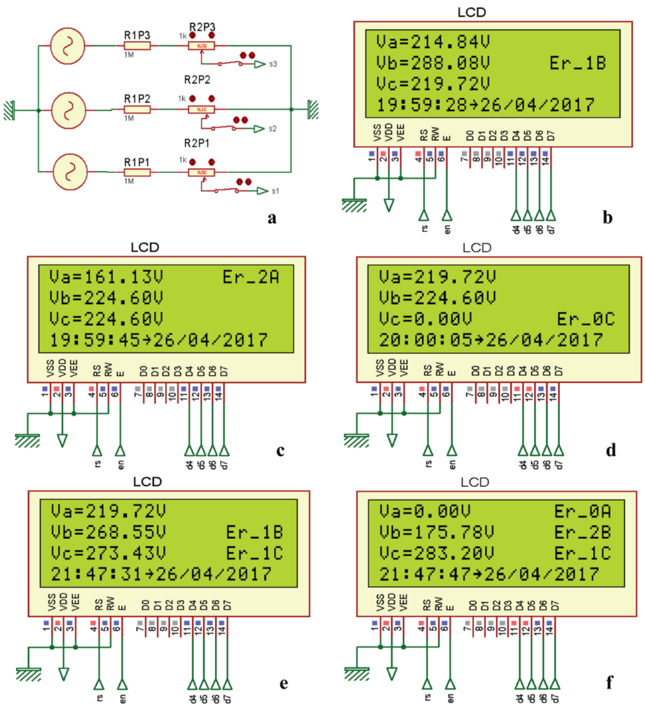
Fault Code	Corresponding Phase	Fault Type
Er_1A	Phase A	Overvoltage
Er_1B	Phase B	
Er_1C	Phase C	
Er_2A	Phase A	Undervoltage
Er_2B	Phase B	
Er_2C	Phase C	
Er_0A	Phase A	Missing phase
Er_0B	Phase B	
Er_0C	Phase C	

Figure 12e and Figure 12f show the case of mixed three types of faults between overvoltage, undervoltage and missing voltage and the corresponding codes beside each phase.

Using virtual communication between serial port of the microcontroller and the PC side graphical user interface, serial communication can be established, online monitoring and data recording is started as shown in Figure 13.

The developed PC software generates automatically in real time a list of logged data containing the voltage values in each phase every predefined time interval as shown in Figure 14, and automatically generates a CSV file on the hard disk of the PC as shown in Figure 15, data in the generated file is updated and saved in real time, such file can be opened using MS Excel for offline analysis.

Figure 12. Simulation results under Proteus ISIS environment. a. Voltage divider with potentiometers and switches for simulation of voltage variations purposes. b. Overvoltage in phase B with the corresponding code under Proteus ISIS. c. Undervoltage in phase A with the corresponding code under Proteus ISIS. d. Missing voltage in phase C with the corresponding code under Proteus ISIS. e. Mixed faults in phase B and C overvoltage and undervoltage in Proteus ISIS. f. Mixed faults, missing voltage in phase A, undervoltage in phase B and overvoltage in phase C under Proteus ISIS.



In case of any abnormal variation of voltage that is outside the predefined interval in any phase the PC software detect it as shown in the Figure 16 and generates automatically the error.csv file as shown in the Figure 17.

PRACTICAL REALIZATION RESULTS

For practical realization, EasyPic 6 development board is used which includes an on-board programmer, for simulating voltage variations in each phase three potentiometers have been used, Figure 18 shows a real photo of the board and the peripherals of the proposed system.

Figure 19a shows the normal working of the realized system the LCD shows the neutral to phase voltages values of each phase, the current time and date.

In case of an overvoltage, under voltage or missing voltage in one, two or even three phase the error codes can be displayed beside the corresponding phase voltage. Figure 19b shows an overvoltage in the phase C with the error code Er_1C, and it is clear that the voltage value in this case is 307.61 V, which is higher than the preprogrammed threshold (260 V).

In case of mixing faults, the proposed system as in Figure 19c detects and displays in real time the error code beside each phase voltage (missing phase voltage in phase A and C, undervoltage in phase B).

When the proposed system is connected to the PC through the serial port and using of the developed software, it starts automatically logging data as shown in the Figure 20.

Figure 13. Virtual communication using RS232 protocol and developed PC software

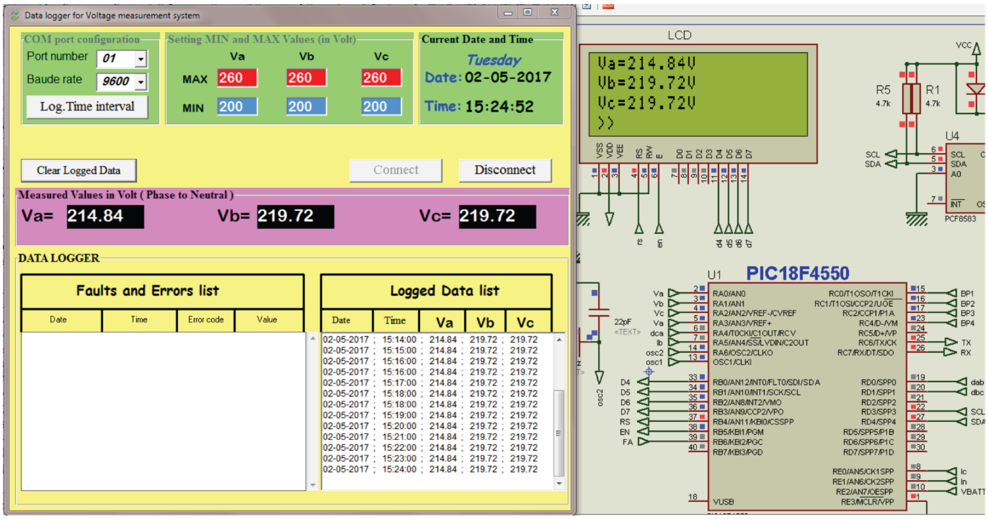
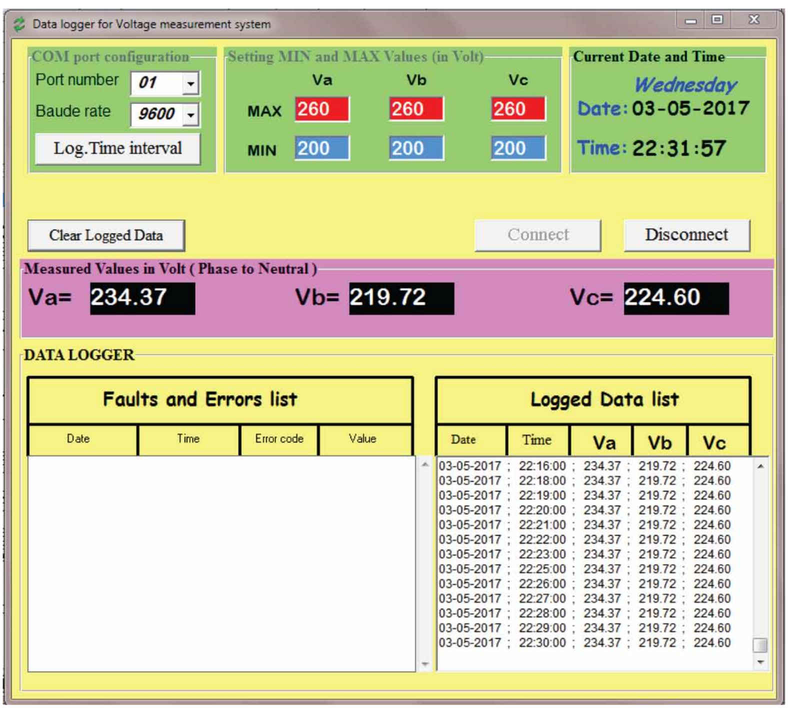


Figure 14. Logged data list in the PC software



In real time the Log.csv file is generated automatically accumulating and saving voltage values every preprogrammed time interval as shown in Figure 21 (1 minute logging time interval) the file contains five colons for date, time, phase A voltage, phase B voltage, and phase C voltage, this file is used for further offline analysis.

Figure 15. The content of (log.csv) file generated by the PC software containing date, time and voltage of the three phases

Date	Time	Va (Volt)	Vb(Volt)	Vc(Volt)
01/06/2017	21:00:00	219.72	214.84	219.72
01/06/2017	21:01:00	219.72	209.96	214.84
01/06/2017	21:02:00	219.72	214.84	219.72
01/06/2017	21:03:00	219.72	214.84	219.72
01/06/2017	21:04:00	219.72	209.96	219.72
01/06/2017	21:05:00	219.72	219.72	224.60
01/06/2017	21:06:00	229.49	209.96	219.72
01/06/2017	21:07:00	219.72	214.84	219.72
01/06/2017	21:08:00	219.72	214.84	219.72
01/06/2017	21:09:00	224.60	214.84	219.72
01/06/2017	21:10:00	224.60	214.84	219.72
01/06/2017	21:11:00	224.60	214.84	219.72
01/06/2017	21:12:00	229.49	214.84	214.84
01/06/2017	21:13:00	224.60	214.84	219.72
01/06/2017	21:14:00	219.72	209.96	214.84
01/06/2017	21:15:00	219.72	219.72	214.84
01/06/2017	21:16:00	219.72	214.84	214.84
01/06/2017	21:17:00	224.60	214.84	219.72
01/06/2017	21:18:00	219.72	214.84	219.72
01/06/2017	21:19:00	219.72	209.96	219.72
01/06/2017	21:20:00	219.72	219.72	219.72
01/06/2017	21:21:00	224.60	214.84	219.72
01/06/2017	21:22:00	219.72	214.84	219.72
01/06/2017	21:23:00	219.72	209.96	219.72
01/06/2017	21:24:00	219.72	214.84	219.72
01/06/2017	21:25:00	224.60	214.84	224.60
01/06/2017	21:26:00	224.60	214.84	219.72
01/06/2017	21:27:00	219.72	219.72	214.84
01/06/2017	21:28:00	224.60	214.84	219.72
01/06/2017	21:29:00	219.72	214.84	214.84
01/06/2017	21:30:00	219.72	214.84	214.84

Figure 16. Faults and errors list in the PC software

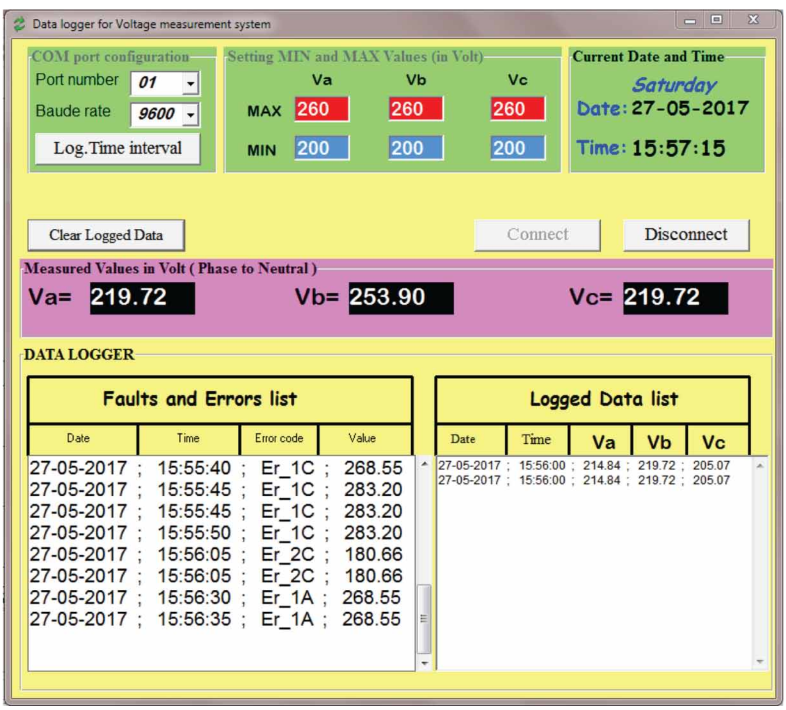
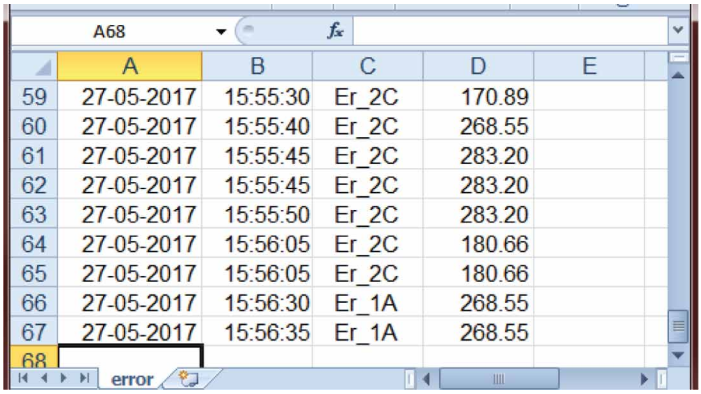
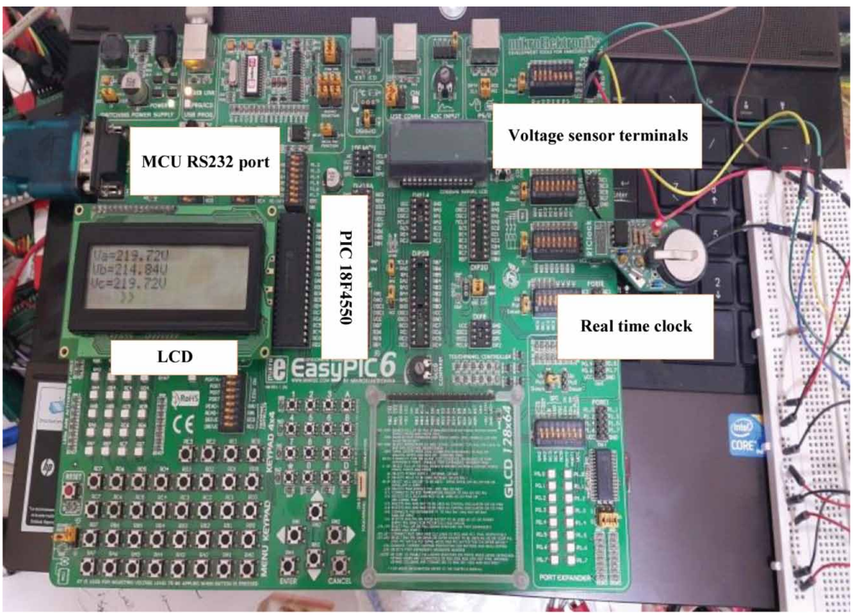


Figure 17. Generated error.csv file by the PC software under MS Excel containing date, time and code error with its voltage value



	A	B	C	D	E
59	27-05-2017	15:55:30	Er_2C	170.89	
60	27-05-2017	15:55:40	Er_2C	268.55	
61	27-05-2017	15:55:45	Er_2C	283.20	
62	27-05-2017	15:55:45	Er_2C	283.20	
63	27-05-2017	15:55:50	Er_2C	283.20	
64	27-05-2017	15:56:05	Er_2C	180.66	
65	27-05-2017	15:56:05	Er_2C	180.66	
66	27-05-2017	15:56:30	Er_1A	268.55	
67	27-05-2017	15:56:35	Er_1A	268.55	
68					

Figure 18. The development board EasyPic 6 with the peripherals of the proposed system



If any abnormal voltage variation in any phase, the system also automatically generates error.csv file and accumulates all abnormal values the file which contains four colons: date, time, error code and the value as shown in the Figure 22. This can help in the investigation or monitoring purposes.

For offline analysis of logged data the log.csv file can be used as shown in the Figure 23 which represents a graphical representation of phase A voltage variation in the function of time, this can be used for statistical purposes.

CONCLUSION

In the proposed system, it has been introduced an idea of cheaper and simple way to measure, monitoring and logging three phase voltage system. The entire system has been simulated, and compiled in Proteus environment. Apart from this work, many different software and tools have

Figure 19. (a) Normal working of proposed system; (b) Real time overvoltage detection with the corresponding code in phase C. (c) Real time mixed faults detection with the corresponding code in each phase

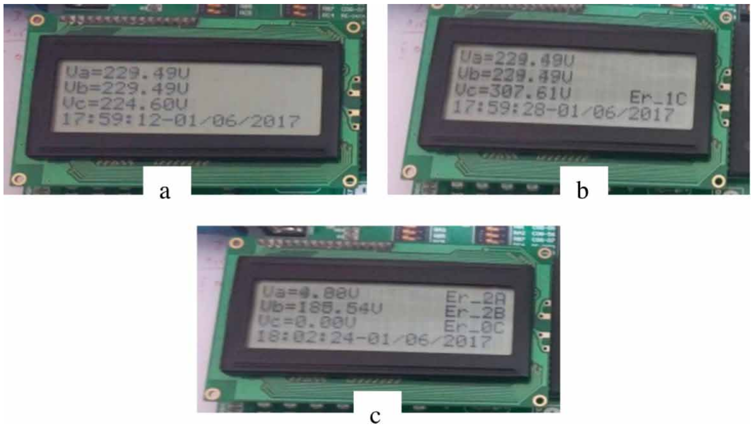
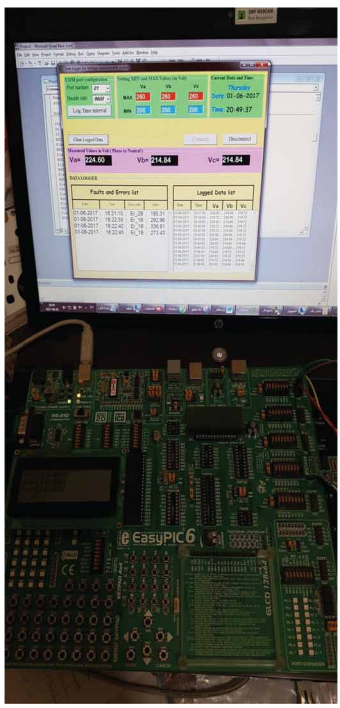


Figure 20. Connection of the proposed system with PC to communicate with the developed software for data logging



been employed to construct this system, which are either costly or unavailable for the commercially or for a small industry. The proposed system performed according to the desired parameter, and easily has been implemented and realized in EasyPic 6 development board by using additional peripherals. The realization results were exactly as expected and were as the simulation results. Real time measurement and detection of abnormal values, accumulating and saving data in the generates files, all these features can help in service utility voltage and statistical study based on the data logger report generated by the system.

Figure 21. The generated Log.csv file content after linking the board to the PC software with time interval of 1 minute

A1320 | 01-06-2017

	A	B	C	D	E	F
1359	01-06-2017	22:03:00	219.72	214.84	214.84	
1360	01-06-2017	22:04:00	219.72	214.84	219.72	
1361	01-06-2017	22:05:00	219.72	214.84	219.72	
1362	01-06-2017	22:06:00	224.60	214.84	214.84	
1363	01-06-2017	22:07:00	224.60	209.96	219.72	
1364	01-06-2017	22:08:00	219.72	209.96	219.72	
1365	01-06-2017	22:09:00	224.60	214.84	219.72	
1366	01-06-2017	22:10:00	219.72	214.84	219.72	
1367	01-06-2017	22:11:00	224.60	214.84	219.72	
1368	01-06-2017	22:12:00	219.72	219.72	219.72	
1369	01-06-2017	22:13:00	219.72	214.84	219.72	
1370	01-06-2017	22:14:00	219.72	214.84	219.72	
1371	01-06-2017	22:15:00	224.60	209.96	219.72	
1372	01-06-2017	22:16:00	219.72	219.72	214.84	
1373	01-06-2017	22:17:00	224.60	209.96	219.72	
1374	01-06-2017	22:18:00	224.60	209.96	219.72	
1375	01-06-2017	22:19:00	224.60	214.84	219.72	

log

Figure 22. The generated Error.csv file content after linking the board to the PC software

F9

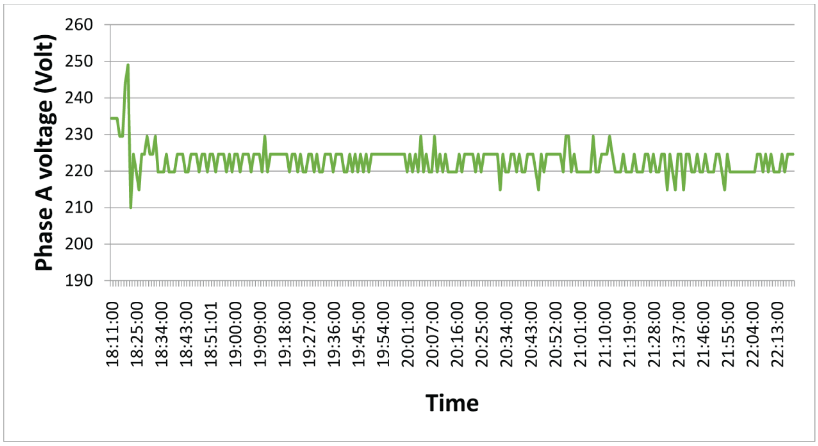
	A	B	C	D	E
1	01-06-2017	18:21:10	Er_2B	195.31	
2	01-06-2017	18:22:35	Er_1B	292.96	
3	01-06-2017	18:22:40	Er_1B	336.91	
4	01-06-2017	18:22:45	Er_1B	273.43	
5					
6					
7					
8					

error

Future Work

This system has been developed with the idea to measure and monitoring online three phase voltage system and logging its values. The future work in this field would require giving the system more efficiency so that it can be implemented commercially. These improvements will include addition of memory card for saving the generated files locally in the same board that would eliminate the using of the PC in every logging need. To protect the load to be supplied, adding relay to switch off the power supply in case of harmful faults can be added also. Introducing another measurements ability such as current in each phase, frequency and power factor and adding these measured values to the logged data for further statistical and analysis purposes.

Figure 23. Offline analysis of logged data by the proposed system shows voltage in phase A vs time



REFERENCES

Abraham, D., Thekkekara, R., Sajana, M., Sandeep, S., & Sandeep, T. (2014). Development of a High Precision Digital Volt Meter. International Journal of Advanced Research in Electrical. *Electronics and Instrumentation Engineering*, *3*(2), 7608–7611.

Al Mamun, M., Sundaraj, K., Ahmed, N., Matiur, R., Mijanur, R., & Ahamed, N. U. (2013). Design And Development Of A Pc-Based Automated Data Logging System For Measuring Temperature. *Journal of Engineering and Applied Sciences (Asian Research Publishing Network)*, *8*(11), 960–968.

Aniket, V. K., Sanket, A.B. & Jagtap, S.R. (2014). Design Of PIC Microcontroller-Based Data Acquisition Module With Lab View. In *International Conference on Communication and Signal Processing*, India (pp. 858-861).

Anuj, K., Indu, P.S. & Suresh, K.S. (2010). Development of Multi- Channel Data Logger for Indoor. *Scientific research journal*, *2*, 690-697.

Bharathkumar, V., Irshad, S.M., Gowtham, S. & Geethamani. R. (2017). Microcontroller Based Digital Meter With Alert System Using GSM. In *11th International Conference on Intelligent Systems and Control (ISCO)*, India (pp. 444-448).

Biswas, S., Bhuiyan, R. H., Hoque, S., Hasan, R., & Khan, T. N. (2013). Pressure sensed fast response anti-collision system for automated railway gate control. American Journal of Engineering Research, 2(11), 163–173.

Ghosh, M., Ghosh, S., Saha, P., & Panda, G. (2016, January). Design and Implementation of PIC16F877A Microcontroller Based Data Acquisition System with Visual Basic Based GUI. In *2016 7th International Conference on Intelligent Systems, Modelling and Simulation (ISMS)* (pp. 419-423). IEEE.

Heribertus, H., Catur, S., Samiul, H. & Adrin, T. (2015). Design of Prepaid Energy Meter Based on Proteus. In *2nd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, Indonesia (pp. 239-243). IEEE.

Imran, M., & Moshiur, M. (2014). Construction of Microcontroller Based Digital Voltmeter. *International Journal of Science and Research.*, *3*(1), 84–87.

Ishaan, D., Prerna, C., Shubham, S., & Sheila, M. (2015). Microcontroller Based Data Acquisition And Supervision. *International Journal Of Scientific & Technology Research.*, *4*(5), 95–99.

Iskandar, H. R., Purwadi, A., Rizqiawan, A., & Heryana, N. (2016, November). Prototype development of a low cost data logger and monitoring system for PV application. In *2016 3rd Conference on Power Engineering and Renewable Energy (ICPERE)* (pp. 171-177). IEEE.

Jaanus, M., Udal, A., Kukk, V., & Umbleja, K. (2013). Umbleja1, K.: Using Microcontrollers for High Accuracy Analogue Measurements. *Elektronika ir Elektrotechnika*, *19*(6), 51–54. doi:10.5755/j01.eee.19.6.4559

Jie, S. & Qinfang, S. (2015). Design And Simulation Of PWM DC Motor Speed Regulator Based On Proteus. In *International Conference on Fluid Power and Mechatronics (FPM)*, China (pp. 1210-1213).

Krejcar, O., Spicka, I., & Frischer, R. (2011). Micro Operation System for Microprocessor Applications. *Elektronika ir Elektrotechnika*, *8*, 83–88.

Liping, M., & Weiguo, Z. (2012). Design and Simulation of Digital Frequency Meter Based on Proteus. In *International Conference on Electrical and Computer Engineering Advances in Biomedical Engineering* (pp. 207–211).

LTC1966 Datasheet. (2001). *Precision Micropower ΔΣ RMS-to-DC Converter*. Linear Technology Corporation.

Manel, Z., Aktham, A., & Jean-Paul, Y. (2015). RMS-to-DC Converter for GMI Magnetic Sensor. *IEEE Transactions on Magnetics*, *51*(1), 1210–1213.

Mustafa, E. (2017). Open Source Embedded Data Logger Design For PV System Monitoring. In *6th Mediterranean Conference on Embedded Computing (MECO)*, Montenegro (pp. 1-5).

Nhivekar, G.S. & Mudholker, R.R. (2011). Data logger and remote monitoring system for multiple parameter measurement applications. *e-Journal of Science & Technology*, *3*, 55–62.

PCF8583 Datasheet. (2010). *Clock and calendar with 240 x 8-bit RAM*. NXP Semiconductors.

Ramya, V., Palaniappan, B., & Embedded, P. H. (2012). Data acquisition and logging. *Advanced Computing An International Journal*, *3*(1), 45–63. doi:10.5121/acij.2012.3104

Saidu, I. G., Momoh, M., & Mindaudu, A. S. (2013). Temperature monitoring and logging system suitable for use in hospitals, incorporating GSM text messaging. *International Journal of Information Sciences and Techniques.*, *3*, 11–26. doi:10.5121/ijist.2013.3102

Shakti, K., & Saxena, V. K. (2014). Microcontroller Based Switching Control of Dc Motor Using GSM modem. *Journal of Electrical and Electronics Engineering (Oradea)*, *9*(3), 39–44.

Singh, A.J.S., Raviram, P., & Shanthosh Kumar, K. (2014). Embedded Based Green House Monitoring System Using Pic Microcontroller. In *International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE)*, India. doi:10.1109/ICGCCEE.2014.6922290

Vikram, P. & Anand, N. (2016). Design Of PIC Real Time Smart Home Automation Based On PIC Microcontroller, Bluetooth And Android Technology. In *3rd International Conference on Computing for Sustainable Global Development*, India (pp. 1478-1484).

APPENDIX

List of acronyms:

AC: Alternating Current
ADC: Analog to Digital Converter
ASCII: American Standard Code for Information Interchange
CSV: Comma-Separated Values
DC: Direct Current
DCE: Data Communication Equipment
DTE: Data Terminal Equipment
I2C: Inter-Integrated Circuit
LCD: Liquid-Crystal Display
MHz: Megahertz
mV: milliVolts
MΩ: Megaohm
PC: Personal Computer
PCB: Printed Circuit Board
PIC: Programmable Interface Controllers
RAM: Random Access Memory
RMS: Root Mean Square
RS232: Standard for serial communication transmission of data
RTC: Real-Time Clock
RX: Receiving pin
TX: Transmitting pin
UART: Universal Asynchronous Receiver/Transmitter
USART: Universal Synchronous/Asynchronous Receiver/Transmitter
V: Volts
V_{in}: Input AC voltage of the LTC1966
V_{out}: Output DC voltage of the LTC1966
WR: Write