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Automated Monitoring System for Transmission System Laboratory Model

MN Mohtar[1,2] and MA Osman[1], MM Ramli[3]

[1]Department of Electrical and Electronic Engineering , Faculty of Engineering , Universiti Putra Malaysia 43400 UPM Serdang, Selangor Darul Ehsan

[2]Institute of Advance Technology, Universiti Putra Malaysia 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

[3]School of Microelectronic Engineering, Universiti Malaysia Perlis, Pauh Putra Campus, 02600 Arau, Perlis, Malaysia

ABSTRACT

Transmission System Laboratory Model (TSLM) is a model of power transmission systems use to facilitate the studies of power system. TSLM replicates a power transmission system mimicking the real transmission line. The input and output voltage reading on the current TSLM requires a manual measurement using multimeter. The lack of real time monitoring is rectify in this work. This works propose an automated real time measurement and display system for real time voltage input and output monitoring on the TSLM. An imbedded custom made digital voltmeter and a digital display is used for real time monitoring

INTRODUCTION

Transmission System Laboratory Model (TSLM) is a model of power transmission systems use to facilitate the studies of power system. TSLM replicates a power transmission system as if it is the real transmission line. An accurate model of power system related studies and experiments is important so that it reflects the nature of the system under study. Even though nowadays there are many personal computers available and they can be used to perform power system analysis, students still cannot understand well something that does not involve hands on activity. Modern personal computers can be used to find information, ask questions, involve in online forum and many more regarding the power system analysis. These methods can provide some information only on facts but hands on activity is important to get a better understanding. So, real system model that can be experimented with, do some testing and setting and many more different kinds of learning process that involve hands on is much needed. This hardware system is important to enhance the learning process for students that taking the related subjects on power as long as the laboratory model is accurate and the obtained information from it is also accurate.

A laboratory model that is suitable in size and portability to ease the students with their experimental activities has been built and named as Transmission System Laboratory Model

(TSLM). Software implementation is important at the early stage and the software used is MATLAB SIMULINK. Then the parameter involved in every components such as transmission lines, transformers and protection devices are selected well in order to produce an accurate result prior the hardware implementation. Then the results of both software and hardware are recorded and compared to determine the accuracy of the model.

This model is basically to conduct the studies on power transmission system. It is a single-phase transmission system with two buses. One of the buses is connected directly from the power source which is 240V and another bus is connected to the load. From this prototype, power can be transmitted in maximum transmission voltage level of 1000V from the sending end to the receiving end for high voltage transmission purpose. Specifications of step-up transformer is 230V/1000V and specifications for step-down transformers is 1000V/230V. Power transmission line parameter model is built in between the transformer with four main types of parameter that represent the real life power transmission line which are resistance, capacitance, inductance and conductance that are represented as R, C, L and G respectively. The selected parameters of transmission model are resistance, capacitance and inductance. Different length of transmission line is represented with different resistance and inductance value. Short and medium length transmission line are determined by capacitances. For short length transmission lines, capacitance value is neglected but for medium length, capacitance is in connection with the resistance and inductance.

Load system is made up of three incandescent lights with 60W each which means a total of 180W can be connected maximally. Protective devices such as switches, fuses and circuit breakers are installed in the model to provide extra safety precaution. All the required connections are made using safe jacks and flexible conductors.

This model is tested with two stages which are software and hardware. In software stages, the circuit consist of voltage source, transformers, transmission line parameter model and load. Voltage source is connected to the single-phase transformer and then stepped up for the transmission purpose. Then the high voltage is stepped down before it reaches the load. The transmission performances is tested using MATLAB SIMULINK by varying the transmission voltage value, load and transmission line parameter. The performances is tested by taking the current and voltage measurement at both side of the line.

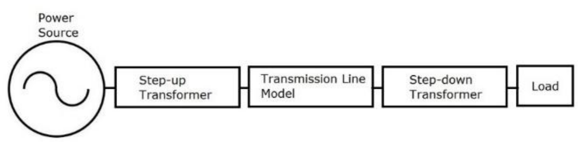

FIGURE 1: Concept idea of connection transmission system model.

Hardware implementation is basically as described in Figure 1 which consist of four different case box each with different functionality. Both of the transformers and the transmission line model are installed with protective devices such as fuse box and circuit breaker for as the protection whereas load box is only installed with circuit breaker. Step-up transformer has the turn ratio of 230/1000 and step down transformer has the turn ratio of 1000/230. The transmission line parameter model are resistance, inductance and capacitance which can be varied via mechanical rotation switch. The load is made of three incandescent light bulb giving a total of 180W as the maximum load that can be connected.

A prototype of Transmission System Laboratory Model is successfully developed based on the principle of transporting the electrical energy from electrical source to the loads. This model can be used as teaching tool by conducting some experiments related to power study to improve the undergraduates learning process. However some improvements need to be done on the model to further improve it. Currently the model used analog voltmeter to get the voltage value which is lack in real time monitoring. There are problems in term of work repetition such that in order to observe the voltage reading, measurement need to be done. This process will consume some time, so an automated real time voltage monitoring system need to be installed on the model to show the voltage readings at the sending end and receiving end of the transmission line.

The objectives of this project is based on the following:

1. To develop a display system using a custom made digital voltmeter.
2. To integrate the design into the TSLM.

Methodology

The process of automated monitoring system for Transmission System Laboratory Model is shown in project flowchart at Figure 2.

Voltage source is taken from the regular voltage supply which is 230V AC voltage. Using a transformer of 230V/12V, the voltage is stepped down to 12V. The output voltage of 12V is still in AC so it must be converted to DC before entering the PIC. AC to DC conversion is done by using the bridge rectifier and capacitor. After the conversion, the 12V is further reduced using voltage divider circuit because the maximum voltage that can be handled by the PIC is up to 5V only. Any voltage greater than that will damage the PIC. Then, PIC will perform the mathematical process as being programmed. It will do the calculation to get the output voltage. Finally, LCD will display the output voltage value which is the value of the regular voltage source.

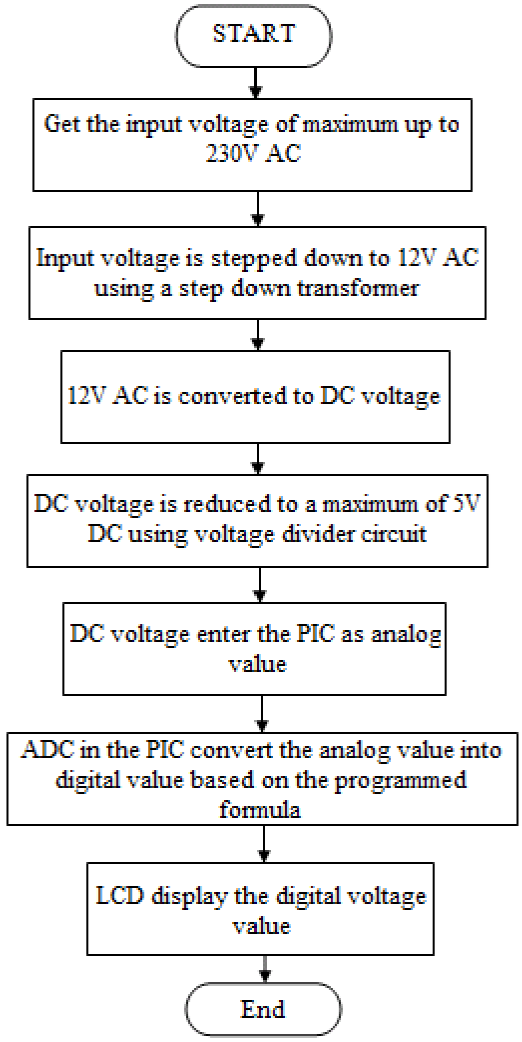

FIGURE 2: Project Flowchart

Two voltage readings have been extracted in this project, namely the calculated reading and measured reading.

1. PIC16F877A.

PIC 16F877A is a microcontroller of 40 pins with 8 input channels which means it is a 10 bit microcontroller.

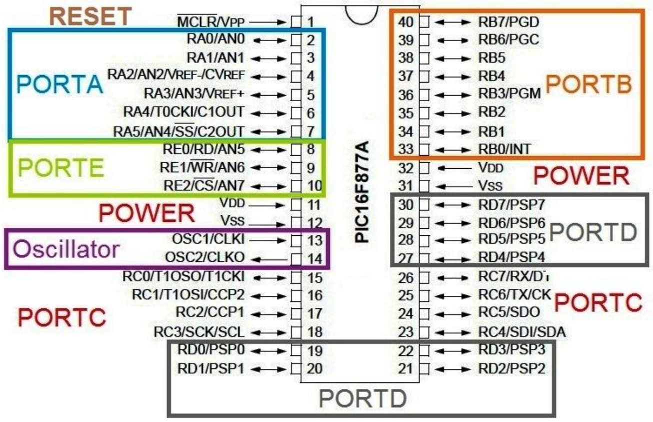

FIGURE 3: PIC 16F877A pin diagram [1].

Figure 3 shows the pin configurations of PIC 16F877A. Every pin has its own function. Pin VDD which is 5V and VSS which is Ground or 0V are to supply power to the microcontroller. Pin 13, OSC1 and pin 14, OSC2 are connected with oscillator to provide clock for the microcontroller. MCLR pin which is Master Clear Input is the reset pin. It is an active low input and should be connected to VDD for normal operations. Port A, B, C, D and E are the input/output ports. Port A is used for analog inputs. Port B is used for data transmission. Port C is used for control registers such as serial communication, I2C functions and serial data transfer. Port D is used as data port. Port E is generally used for controlling purposes. Every port has two registers which are TRIS and PORT. TRIS which is Tri-state is used to determine the behaviour of the pin. Logic 1 at TRIS register makes the corresponding pin Input while Logic 0 at TRIS register makes the corresponding pin Output [5]. PORT register can be used to read input pins or to write status of output pins [5]. For an Output Pin, Logic 1 at PORT register makes the corresponding pin HIGH state (VDD) while Logic 0 at PORT register makes the corresponding pin LOW state (VSS) [5]. Reading PORT register reads the actual voltage levels on input/output pins, if the actual voltage level is near to HIGH Level (VDD), corresponding PORT bit will be 1 and if the voltage level is near to LOW Level (VSS), corresponding PORT bit will be 0 [5].

The time required to execute one instruction is called instruction cycle or machine cycle [4]. One machine cycle is equals to four time periods, 4T [4]. So the time required to execute one instruction for PIC 16F877A is 1μs which can be assumed as very fast.

2. LCD LM016L

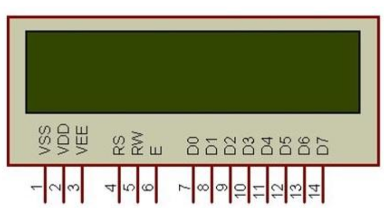

FIGURE 4: LCD 16 x 2 (LM016L) [2].

Figure 4 shows the pins of LCD 16 x 2 (LM016L) which consist of 14 pins. Pin 1 is VSS which acts as Power Supply (GND). Pin 2 is VCC which acts as Power Supply (+5V). Pin 3 is VEE which is the contrast adjust of the LCD display. Pin 4 is RS which can be instruction or command input if it is

LOW and can be data input if it is HIGH. Pin 5 is RW. If it is LOW, it will write to LCD Module and if it is HIGH, it will read from LCD Module. Pin 6 is EN which is to enable signal. Pin 7 to pin 14 is the data bus line which started from data bus line 0 (LSB) to data bus line 7 (MSB). This LCD has two other pins which are pin 15 and 16 that are used to control the background light of the LCD. It is controlled using the potentiometer.

3. Transformer 230V / 12V.

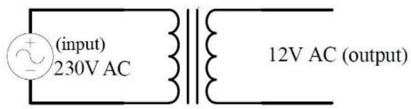

FIGURE 5: Step-down transformer [3].

Figure 5 shows the step-down transformer used in the circuit. Input of 230V AC is stepped down to 12V AC. This transformer has six terminals, three for input terminals and the other three are for output terminals. For input terminals, the first terminal is grounded, the second terminal is connected to step down 115V and the last terminal is connected to step down 230V. This project only use the first and third terminal only because the voltage that is going to be stepped down is 230V. For the output part, the first, second and third terminals are 12V, 0V and 12V respectively. To get an output of 12V, the connection can be made at first terminal or third terminal. If both terminal are being used, the output voltage will be 24V. The second terminal is the compulsory terminal that must be connected to ground. The power output of this transformer is 5VA.

4. Diode 1N4007.

FIGURE 6: General-Purpose Rectifiers 1N4007.

Figure 6 shows the diode 1N4007 which is used as bridge rectifiers to convert the 12V AC voltage to DC voltage. Four diodes are connected with each other in diamond shape forming the rectifiers. It have features like low forward voltage drop and high surge current capability. This diode has a grey colour band at one side of its body which indicates the cathode part. Figure 7 below shows the function of this rectifiers on the sinusoidal waveform.

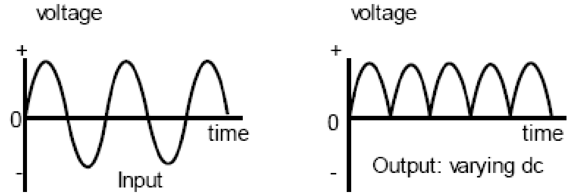

FIGURE 7: Sinosoidal waveform is converted to half wave [4].

Figure 7 above shows the function of the bridge rectifiers. AC source produce a sinusoidal waveform. After the sinusoidal waveform passed through the bridge rectifiers, it will be converted to a DC waveform with the peak magnitude of the AC waveform. The full wave of sinusoidal waveform is converted to half wave and all the negative region of the waveform are inverted upwards.

5. Capacitor.

FIGURE 8: General Purpose Capacitor 100µF 50V.

Figure 8 shows the capacitor that is used to stabilize the DC waveform. It will smoothen the varying DC waveform and gives out a steady DC waveform. It is a 100µF capacitor with the rated working voltage range is from 10V to 100V. If a bigger voltage passed through, it will be blown and damaged.

6. Voltage Divider Circuit.

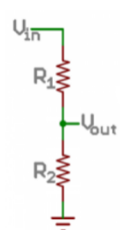

FIGURE 9: Voltage divider schematics.

Figure 9 shows a voltage divider circuit that will be used in the project. Voltage divider is a simple circuit that divide the large voltage into a smaller value just by using two resistors in series and an input voltage. By applying a voltage source across the two resistors in series, an output voltage by a fraction of the input voltage can be obtained [5]. The operation is based on the formula below.

$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2} \quad 1)$$

From formula above, the output voltage, Vout is directly proportional to the input voltage, Vin and ratio of R1 and R2 [5].

Results and Discussion

The results obtained from both methods are compared.

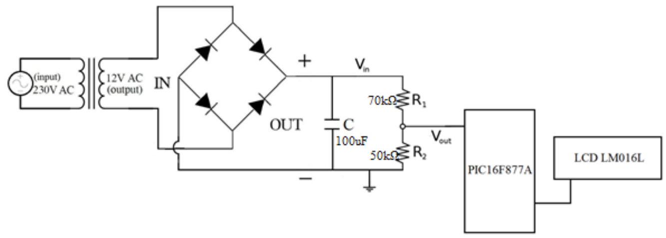

FIGURE 10: Circuit Schematic of the Digital Voltmeter

Voltage source is taken from the regular voltage supply which is 230V AC voltage. Using a transformer of rating 230V/12V, the voltage is then stepped down to 12V. The output voltage of 12V is still in AC so it must be converted to DC before entering the PIC. AC to DC conversion is done by using the bridge rectifier and capacitor. After the conversion, the 12V is then further reduced using voltage divider circuit which consist of resistors in series and the output is taken at a point in between the resistors. The output voltage from the voltage divider must have a maximum value of 5V because any voltage greater than that will damage the PIC. The 5V enter the PIC at pin 2 which is the AN0 pin. Pin 13 and 14 of the PIC is for clock in and clock out. Clock is generated using crystal oscillator and capacitor. Pin 1 is the master clear reset pin which is active low. This pin is connected with switch to reset the voltmeter reading. It is also connected with resistor and supplied with VDD of 5V. Output part of the PIC is connected with LCD. Pin 21 of pic is connected with pin 4 of LCD, pin 22 of pic is connected to pin 6 of LCD, pin 27 of PIC is connected to pin 11 of LCD, pin 28 of pic is connected to pin 12 of LCD, pin 29 of pic is connected to pin 13 of LCD and lastly, pin 30 of PIC is connected to pin 14 of LCD. Finally, LCD will display the voltage value.

PIC 16F877A get an input voltage in the range of 0V to 5V. This input voltage is mapped with 0V to 230V of output voltage. The comparison is shown in the table below:

Table 1: Comparison of Input Voltage to Output Voltage.

Input Voltage into PIC (V)	Output Voltage Displayed at LCD (V)	
	Calculated	Measured
0	0	0
1	46	50.13
2	92	98.25
3	138	146.36
4	184	195.82
5	230	230

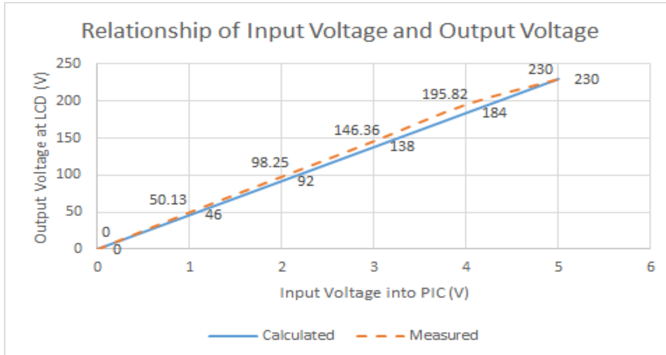

FIGURE 11: Relationship of Input Voltage and Output Voltage.

Input voltage is directly proportional to output voltage. As input voltage increases, output voltage also increases. The maximum voltage that is displayed is 230V which is the mapped value of 5V input voltage to the PIC16F877A. For the measured value, the final value is not exceed than 230V because it is the maximum value that is set in the PIC to be displayed. Any voltage bigger than 230V will not be displayed. Safety features to be taken care is that the input voltage to the PIC must not exceed 5V because it will damage the PIC.

Conclusion

Digital voltmeter give an accurate and precise reading when compared to analog voltmeter as the parallax error can be avoided. Analog voltmeter used pointer and scale to show the measured voltage using the concept of magnetic field. As time passed, the magnets will wear out thus reducing the accuracy of the analog voltmeter to measure the voltage reading.

Digital voltmeter using PIC16F877A and LCD LM016L gives a good performance and the cost to build it is also cheap. Most of the mini projects at the end of each semester in UPM used the PIC and LCD. Then, after the semester finished, students do not used the PIC and LCD anymore. These components can be reused to make this voltmeter and it is cost saving.

There is slight difference between the calculated and measured value. The difference occur due to the errors in the formula set in the PIC and the components used such as breadboard, capacitor, resistor, LCD and the PIC itself. The formula need to be more precise. The difference between calculated and measured value is less than 10% so it is acceptable. The system is successfully developed. The system can be adopted by the TSLM with minor changes.

This voltmeter only can measure up to 230V. In the future, the measurement limit can be increased higher. TSLM require a voltage measurement up to 1000V, so this criteria can be set as priority to improve this digital voltmeter. Also, further improvement can be done in terms of the voltage supply to circuit, to the PIC and to the LCD so that these components are supplied with the right voltage. It is because slight error in supply voltage can affect the output voltage reading.

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