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Microprocessor based AC line Voltage Recorder

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Abstract: *This paper presents the design and development of microprocessor based AC line voltage recorder. It can keep the record of line voltage for twelve hours at an interval of an half minute. Variac with half-wave rectifier and a Z-80 microprocessor based trainer kit is used as the sensor and interfacing the circuit respectively. It can sense the line voltage from 0-250V. The product would be handy portable and commercially viable.*
Key words: *Voltage Recorder, 8 bit Microprocessor, Sensor, ADC*

I. Introduction

AC line voltage recorder is an electronic instrument which is used for measurement of AC line voltage. In Bangladesh AC line voltage should be 220V rms and line frequency 50 Hz. Though it is an ideal voltage but normally the lines have voltages above or below this level. Besides some lines are defective and different types of distortion like sag, swell , under voltage, over voltage, Power failure, black out, transients, spike due to lightening etc are found there. These defective lines are very harmful for electronic devices and instruments [1]. Some lines are having more distortions some have less and some are distortion free. For the safety of electronic instruments and devices some extra safety devices are used for their protection. For example, refrigerators and air conditioners have compressors and spikes are very harmful for them [2]. So for safety we need voltage protectors. Distortion in voltage is also harmful for computers. Slowing down of computers and data loss may occur, so we need UPS for its protection [3]. In some lines due to over voltage and under voltage no instrument or device will operate. We need voltage stabilizer for proper operation of instrument or device will operate [4]. These extra precautions take lot of money and we cannot spend so much money for every line. For this reason we need to know what the condition of AC line is. Here we are motivated to develop new instrument for this purpose is called AC Line Voltage Recorder, AC Line Data Logger, and AC Line Power Recorder etc. AC Line Voltage Recorder is a microprocessor based instrument which can store a large number of samples in a specific period of time.

II. Circuit Design And Implementation

2.1 Block diagram of the developed system

Block diagram is the only simple pictorial way to explain any complex electronic circuit. The block diagram of the developed system is shown in fig.1 that represents the entire major section of the microprocessor based AC line voltage recorder.

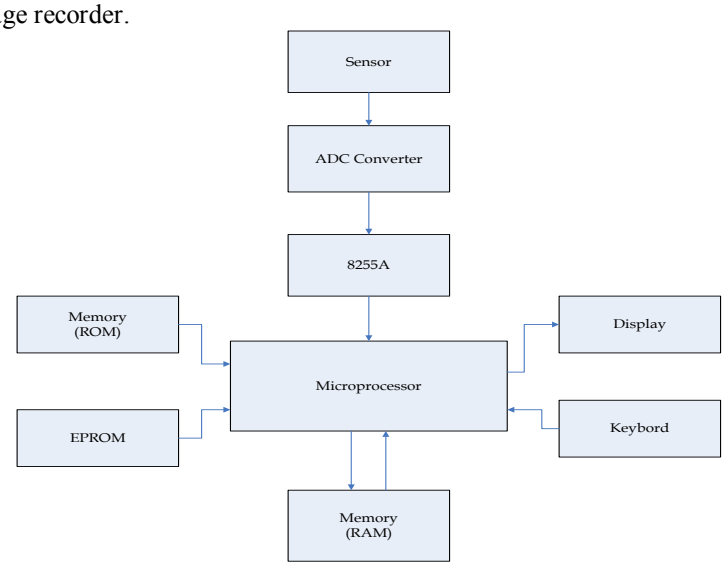


Fig. 1 Block diagram of the Developed System

2.2 Low Voltage Power Supply

In the microprocessor based AC line voltage recorder, a dc voltage (+5V) is required [5]. A regulated dc power supply is designed for this purpose. The complete circuit of a regulated dc power supply is shown in Fig.2 using a 7805 IC and 7905IC as a voltage regulating device.

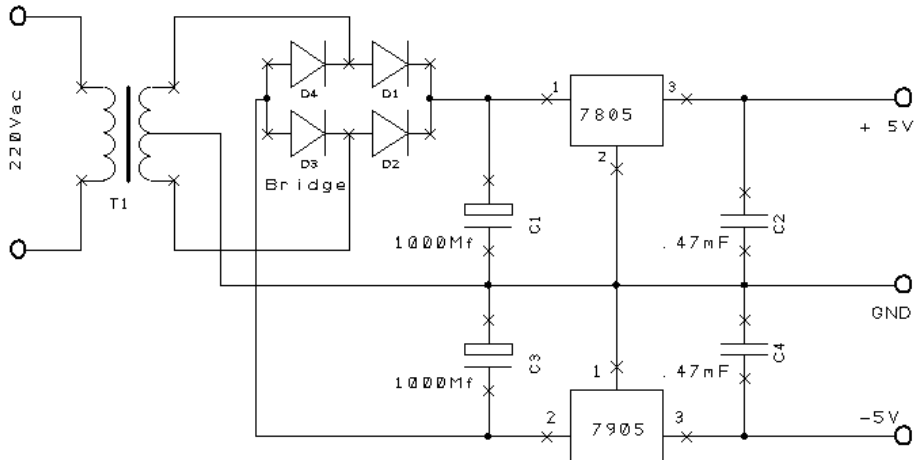


Fig. 2 Schematic Diagram ± 5V power supply

The bridge rectifier contains four diodes D_1, D_2, D_3, and D_4 connected to form bridge as shown in Fig.2 The ac supply to be rectified is applied to the diagonally opposite ends of the bridge through the transformer. The bridge rectifier converts the step-down transformer's secondary ac voltage into pulsating dc voltage. The pulsating dc voltage is applied to the capacitor filter. This filter circuit reduces the pulsations of the rectifier dc output voltage and the output voltage is 9V.The IC Voltage regulator provides regulated output and C_2 is used to improve transient response. Although voltage regulators can be designed using op-amp, it is quicker and easier to use IC voltage regulators [6]**.** In this design a positive fixed voltage regulator L7805 is used. The L7805 of three terminal positive regulators is available in T0-220 fixed 5V output voltage, making it useful in a wide range of applications [7]**.** This regulator can provide local on card regulator, eliminating the distribution problems associated with single point regulator. This employs internal current limiting, thermal shut down and safe area protection, making it essentially indestructible. If adequate heat sinking is provide, it can deliver over 1Amp output current. This fixed voltage regulator device can be used with external components to obtain adjustable voltages and currents. The pin connection of L7805 is shown in Fig.3.The IC 7905 has the similar parts combination of 7805 IC.

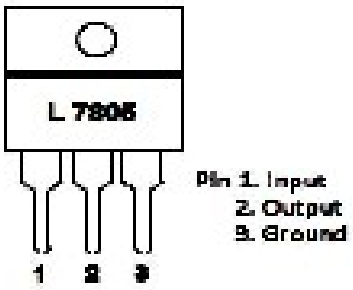


Fig. 3 Pin Connection of L7805

2.3 Sensing unit

In the microprocessor based AC line voltage line voltage recorder sensing unit is required. A sensing unit is design for this purpose. The complete circuit of sensing unit of the AC line voltage recorder is shown in Fig .4

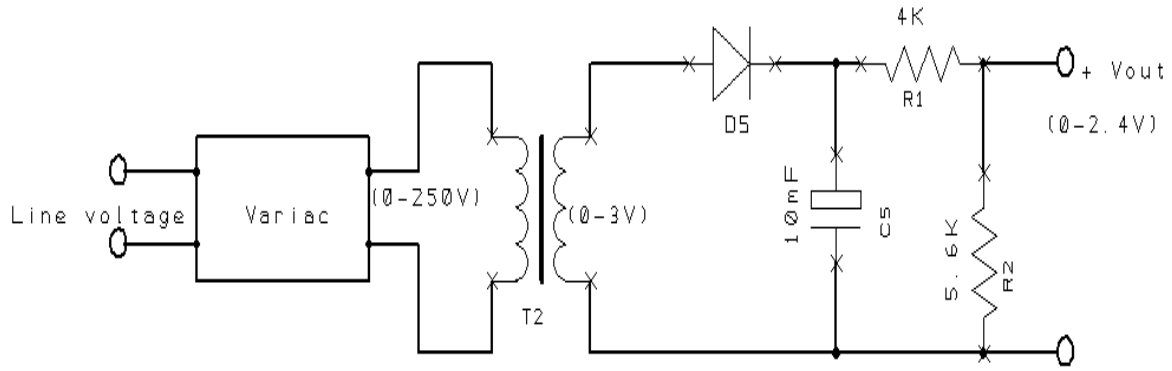
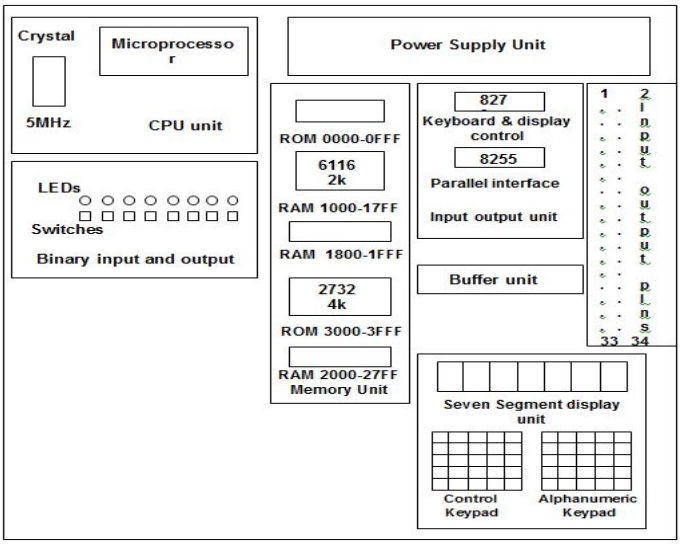


Fig. 4 Schematic diagram of AC line voltage sensing unit Circuit

Fig.4 shows the circuit where a variac and a diode are used. The diode acts as a half wave rectifier. A step down transformer is used in this circuit. Generally, AC supply line voltage is given through a transformer. The use of transformer permits two advantages. Firstly, it allows the step down AC line voltage as input. Secondly, the transformer isolates the rectifier circuit from power line and thus reduces the risk of electric shock. The capacitor is used as filter capacitor. During the positive half cycle of input AC voltage, the upper end of the secondary winding becomes positive with respect to lower end of secondary winding. This makes the diode forward biased and hence it conducts current. During the negative half-cycle, the upper end of the secondary winding is negative with respect to lower end. Under this condition, the diode is reverse biased and it conducts no current. Therefore, current flows through the diode during positive half-cycle of input AC voltage only; it is blocked during the negative half-cycle. Hence, D.C. output is obtained having pulsating D.C. [8].
The pulsating direct voltage of the rectifier is applied across the capacitor. As the rectifier voltage increases, it charges the capacitor and also supplies current to the resistors R_1 and R_2. The direct output voltage V_{DC} is obtained using regulator. This output V_{DC} voltage is maximum 2.4V.

2.4 Z-80 Microprocessor based single board microcomputer
Different section of a Z80 microprocessor based single board microcomputer is shown below.



2.4 Keyboard
The keyboard consists of two sets of keypads. One lies on the right side and it consists of alphanumeric values. The other lies on the left side and it contain the control keys.

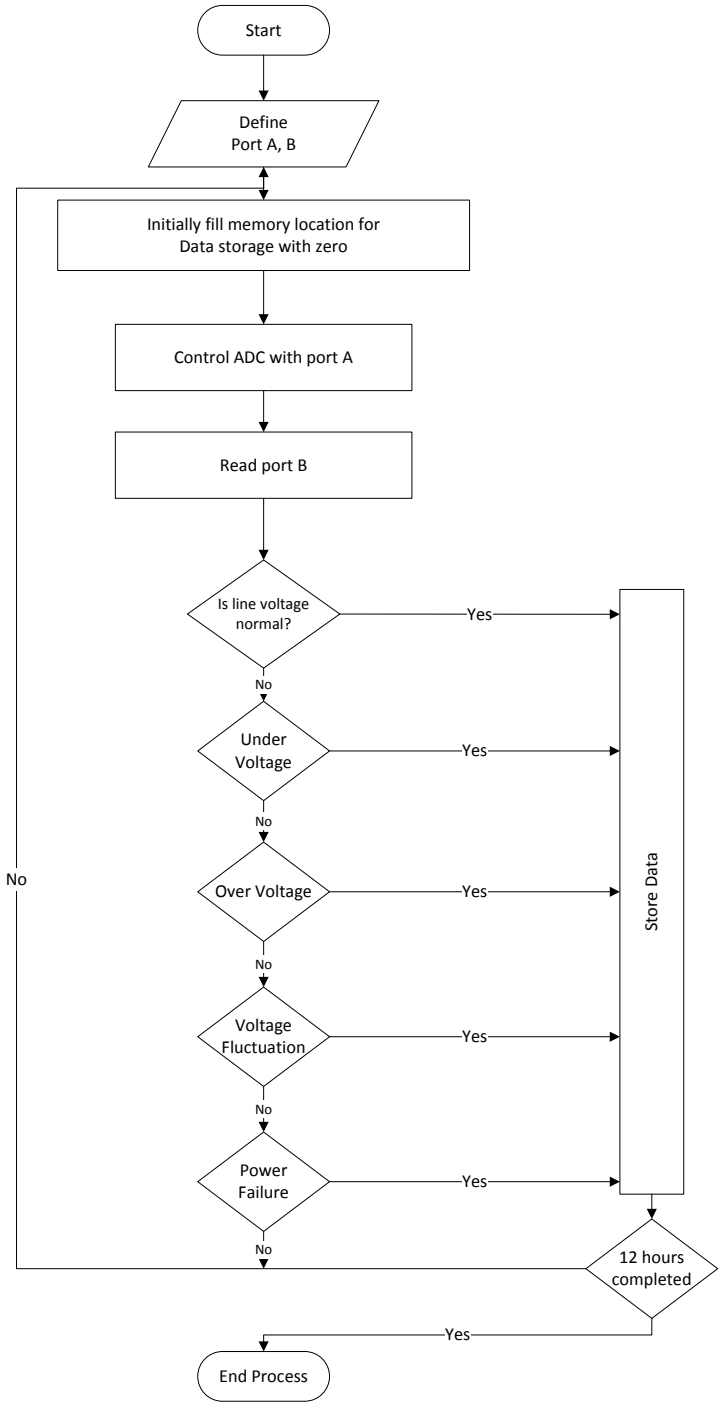
Alphanumeric Keypad

IS C	FL D	FL E	F
IX 8	IY 9	PC A	SP B
AF 4	BC 5	DE 6	HL 7
AF 0	BC 1	DE 2	HL 3

Control Keypad

RS	SS	RN	MM
XE	BP	TW	TR
RL	IN	—	+
RG	EN	SA	SD

Flow chart of the AC line voltage recorder



Software of the design and development of microprocessor based AC line voltage recorder

Address	Instruction	Object Code	Commentary
1000	LD C, 00	0E 00	Load register C with 00
1002	LD A , 82	3E 82	Define port B as input
1004	OUT 07	D3 07	Address of command register
1006	LD HL, 1200	21 00 12	Load pair register HL with memory location 1200
1009	INPORT 0B	DB 05	Read input port B
100B	OUTPORT 0C	D3 0C	Show output to port C
100D	LD (HL), A	77	Store the data from A in HL
100E	CALL 1100	CD 00 11	Call delay subroutine
1011	INC, L	2C	Increment lower byte of pair register HL
1012	LD A, L	7D	Store the content of L into A
1013	CP 00	FE 00	Compare A with 00
1015	JPNZ, 1300	C2 00 13	Jump if not zero to location 1300
1018	HALT	76	Break point

Delay Subroutine

Address	Instruction	Object Code	Commentary
1100	LD C, 1E	0E 1E	Load register C with 1E
1102	LD B, FF	O6 FF	Load register B with FF
1104	CALL 000D	CD 0D 00	Call delay subroutine whose address is 000D
1107	DEC, C	0D	Decrement the content of C
1108	JPNZ, 1102	C2 02 11	Conditional jumping at 1102
110B	RET	C9	Return to main program
1300	LD A, FF	3E FF	Load register A with FF
1302	AND 01	E6 1E	Accumulator content is ANDed with 01 to test the D0 bit
1304	OUTPORT 0A	D3 04	Address of command register
1306	CALL 1100	CD 00 11	Call delay subroutine
1309	LD A, 00	3E 00	Load register A with 00
130B	OUTPORT 0A	D3 04	Address of command register
130D	LD C, 1E	0E 1E	Load register C with 1E
130F	JP 1102	CD 02 11	Jump to memory location 1102
1312	LD A, FF	3E FF	Load register A with FF
1314	AND 01	E6 01	Accumulator content is ANDed with 01 to test the D0 bit
1316	OUTPORT 0A	D3 04	Show output to port C
1318	JP 1009	C3 09 10	Jump to memory location 1009

III. 3. Operation Of AC Line Voltage Recorder

The line voltage sensor used here is half-wave rectifier at the output of variac. High value resistance is used at the output of the rectifier so that it can sense any change at the line voltage. This rectifier gives the dc value which is proportional to the ac line voltage. In the circuit diagram the output of this rectifier is connected to analog input of ZN448 ADC (fig.5). Any variation in line voltage is sensed by the voltage sensor and through this ADC is converted from Analog to Digital value. The input output curve is a linear one. This digital output enters the Z-80 trainer kit. Z-80 trainer kit is a single board microcomputer based on Z-80 microprocessor. This microcomputer is supplied by the International Atomic Energy Agency. It has eight (8) seven segment display units, two sets of keypads each of sixteen (16) keys. One is the hex keypad and the other is control keypad. For interfacing Z-80 based Trainer Kit has thirty four (34) pins. It communicates to the external world through these pins. These pins represent the three I/O ports of 8255 IC, Port A (P_a), Port B (P_b) and Port C (P_c). Besides, there are +5V at ground points. There is a two kilo RAM and provision for RAM extension for writing software and storing data. The Z-80 based microcomputer (Trainer's Kit) has also a ROM where the Monitor program of the computer is stored. There is also a 4K EPROM were lookup tables in the software has been stored. A single bit from port A controls the write signal of the ADC. The digital signals from the output of analog to digital converter IC ZN 448 enters the accumulator through port B(P_b) and stored in the memory (RAM). At the same time the equivalent line voltage in hexadecimal value is displayed in the display unit. The subsequent data are also stored in the RAM and displayed in the display unit in the same way.

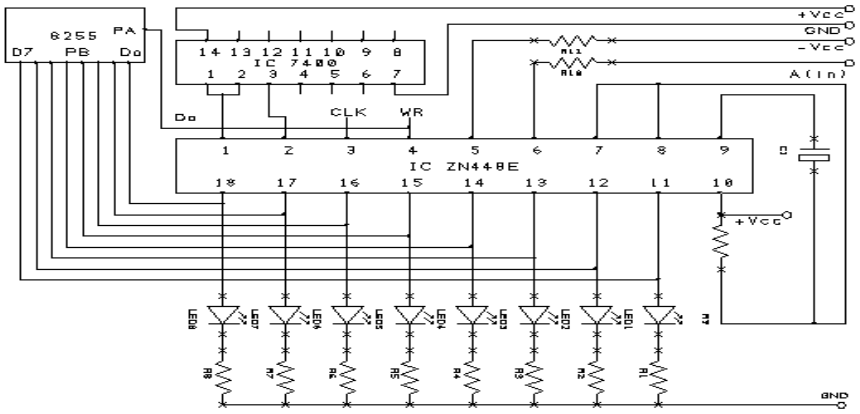


Fig. 5 Schematic Diagram of AC Line Voltage recorder

IV. Result And Discussion

The circuit has been designed and developed successfully as shown in the fig.5. The variac, half-wave rectifier for line voltage sensing and IC's which have been used here in the complete design. The IC's are ZN 448 (ADC) and inverter 7404. The detail operation of this circuit has been explained above. The circuit was calibrated by giving input voltage as shown in the table below.

Line Voltage in Volt	ADC input Value in Volt
175	1.60
180	1.63
185	1.68
190	1.75
195	1.81
200	1.86
205	1.90
210	1.95
215	2.00
220	2.06
225	2.93
230	2.17
235	2.24
240	2.29
245	2.33

The experimental values of AC line voltage are drawn against the ADC voltage as shown in fig.6

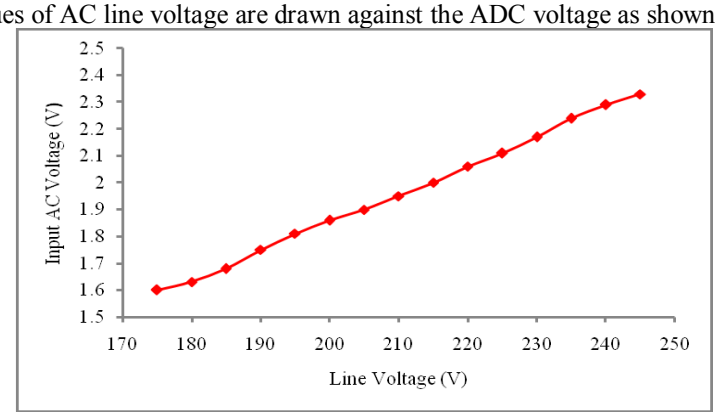


Fig. 6 Curve of ADC input Value VS Line Voltage

It is seen that the ADC input value increases linearly with increasing the AC line voltage. So any values of line voltage are recorded as ADC input voltage.

V. Conclusion

In conclusion it may be said that the design and development of microprocessor based AC Line Voltage Recorder system has been successfully designed and implemented. A voltage recording process records the voltages from AC line. In AC lines due to over voltage and under voltage, no instruments or devices will

operate. So, mills, industries, essential public services (paramedics, hospitals) etc. are disrupted due to under voltage, over voltage and voltage fluctuation. So, this device can be used to record the AC line voltage. As a result by knowing the condition of the AC line, we can take measures to overcome these problems.

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