Communications on Applied Electronics (CAE) – ISSN : 2394-4714
Foundation of Computer Science FCS, New York, USA
International conference on Computing, Communication and Sensor Network, CCSN 2015

New Proposal of a Hybrid Voltage and Frequency Monitoring System

Amritayan Chatterjee
Student,Department of Electronics and Communication Engineering
West Bengal University of Technology, Kolkata

Dependra Nath Shome
Student,Department of Electronics and Communication Engineering
West Bengal University of Technology, Kolkata

Ramit Kishore Saha, Sourajit Mukhopadhyay
Student,Department of Electronics and Communication Engineering
West Bengal University of Technology, Kolkata

ABSTRACT
The purpose of this project is to design a hybrid voltage and frequency monitoring device which can act as a controlled power source. The whole system which is controlled and monitored by the ATC89c51 microcontroller, provides a perfect monitoring of line voltage and frequency and alerts the user for critical voltage and frequency limits and switches off the electromagnetic relay that act as a Circuit Breaker to switch off the main electrical supply to protect the electrical circuitry. The Relay gets activated whenever the electrical parameters are within the limited predefined acceptable ranges. All the circuit breakers like MCB etc. available in market cuts the power only in the exceeding voltage ranges but this system can cut the power when frequency is exceeded from ±10% of the normal supply frequency (50Hz, AC) as well as upper and lower cutoff voltages 250V and 160V respectively. Thus better protection of electrical circuitry is possible by this system.

General Terms
Introduction, Working Principle, Flowchart, Experiment, Result and Discussion, Conclusion, Further Development, References.

Keywords
Line voltage & frequency, Microcontroller, Circuit breaker, Monitor, Band pass filter.

1. INTRODUCTION
Now a days power supply is one of the most important needs of mankind. In India home power supply is A.C. in nature, where general operating voltage and frequency are 220 Volts and 50 Hz respectively. Most of the home appliances are optimized to run on the mentioned voltage and frequency. But unfortunately the supply voltage is not stable constantly due to improper maintenance and various other reasons. Fluctuating voltage and frequency over an extended period of time can cause damage to many of the home appliances which do not usually come with proper inbuilt countermeasures. So monitoring and controlling of power supply for the protection of sensitive appliances and electrical instruments is becoming more essential.

The system being developed here can measure the input line voltage and frequency, display the corresponding values in an LCD, alerts for predefined high and low voltage and frequency ranges and also act as a circuit breaker beyond a safe limit of frequency and voltage respectively. Thus the system can work both as a monitor and controller. The monitoring system can ensure quicker response time to adverse factors and conditions and better utility of control.

The type of microcontroller used in the system as the monitoring and controlling unit is AT89C51 microcontroller which is a low-power, high-performance CMOS 8-bit microcomputer with 4Kbytes of Flash Programmable and Erasable Read Only Memory. The on-chip Flash allows the program memory to be re programmed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

A Relay is used to operate as a Circuit Breaker to switch off the main electrical supply. Relay is an electrical switch that uses an electromagnet to move the switch from the off to on position instead of a person moving the switch. It takes relatively small amount of power to turn on a relay but the relay can control something that draws more power. The system disconnects the relay in case of predefined voltage and frequency ranges thus protecting electric appliances from damage.

The display unit consists of LCD which shows the line voltage, frequency and also high and low voltage as well as frequency limit alert messages. The LCD module is connected to the microcontroller through its I/O ports.

The system developed here makes the relay on only when the frequency is in the limited acceptable range and relay remain off when the frequency is beyond that limited range. Thus the system can act like a band pass filter which only passes limited range of frequencies and reject frequencies outside that range [1]. However, the Active Band Pass Filter is slightly different. It is a frequency selective filter circuit used in electronic systems to separate a signal at one particular frequency, or a range of signals that lie within a certain "band" of frequencies from signals at all other frequencies. This band or range of frequencies is set between two cut-off or corner frequency points labeled the "lower frequency" (fL) and the "higher frequency" (fH) while attenuating any signals outside of these two points. The whole filtering purpose in this developed system is done by the microcontroller. Thus this system operated and controlled by microcontroller provides sharp lower and upper cut off in the frequency ranges and act as a better band pass filter than normal band pass filter.

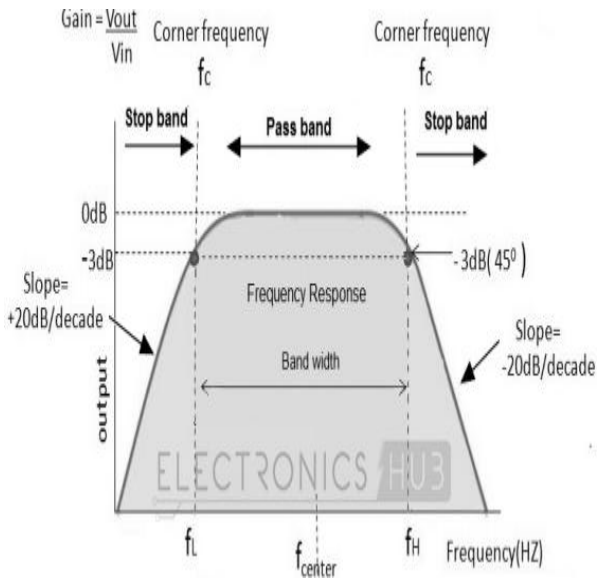


Fig 1: High pass filter Frequency Response[1]

The resonant frequency (point of oscillation) of band pass filter is given as:

$fR=\sqrt{(fL*fH)}$

Where:

fR is the resonant or Center Frequency

fL is the lower -3dB cut-off frequency point

fH is the upper -3dB cut-off frequency point

2. WORKING PRINCIPLE

To provide constant supply voltage to all IC's in the circuit, the A.C. supply voltage (230V, 50Hz), is linearly reduced to equivalent 12V A.C. using a center tapped step down A.C. transformer (rated as 230V A.C. input and 12-0-12V AC output). Then this A.C. voltage is converted to equivalent D.C. with the help of a full wave rectifier circuit by using diode (1N4007). Output of this rectifier is then filtered by a 1000µf electrolytic capacitor and fed to a regulator (7805) that generates 5V D.C. which supplies power to all IC's in the circuit[2][3].

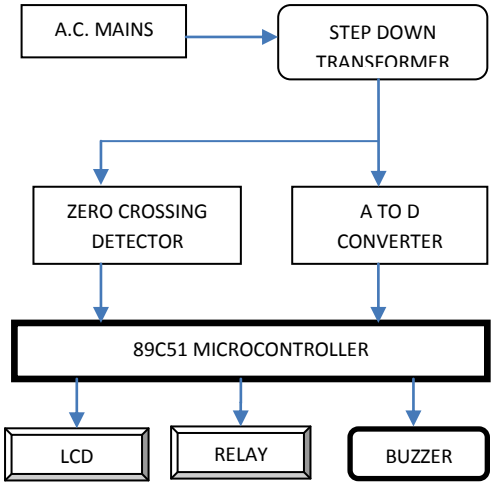
2.1 Voltage Measurement

The A.C. line voltage (230V), which is to be monitored, is first linearly reduced using a 100kΩ resistor. Then this stepped down voltage is converted to equivalent D.C. voltage using a rectifier diode (1N4007). A filter circuit is used to remove the ripple. A multi-turn preset (10kΩ) is used to calibrate the voltage to make it equivalent to A.C. line voltage [4].

Then an 8-bit Analog to Digital Converter (ADC) is used to convert analog signal to its equivalent digital signal. The converted digital data is available on microcontroller.

2.2 Frequency Measurement

For frequency measurement [5], the linearly dropped down A.C. line voltage is collected from secondary winding of transformer and then further dropped using a voltage divider circuit. Then it is fed to an OPAMP (LM324) which is configured as Zero Crossing Detector. The output of zero crossing detector generates pulses, which is connected to counter input of the microcontroller [6].



IV.

Fig 2: Simplified block diagram of the system

2.3 Display, Monitor and Control

A two line alphanumeric LCD with 16 characters per line is used as display. The data is sent to LCD through microcontroller which measures and displays the A.C. line voltage and frequency on the LCD [6].

A relay, with 5V coil [7], is used to control electric appliances, i.e., operate at safe voltage and frequency range and cut the power below the frequency 45Hz and above 55Hz as well as for voltages greater than 250V or less than 160V respectively. It means the devices which are connected to A.C. line are disconnected so that it cannot affect the electrical or electronic devices. The relay is on only when both the frequency and voltage is between 45-55Hz and160-250V respectively [8].

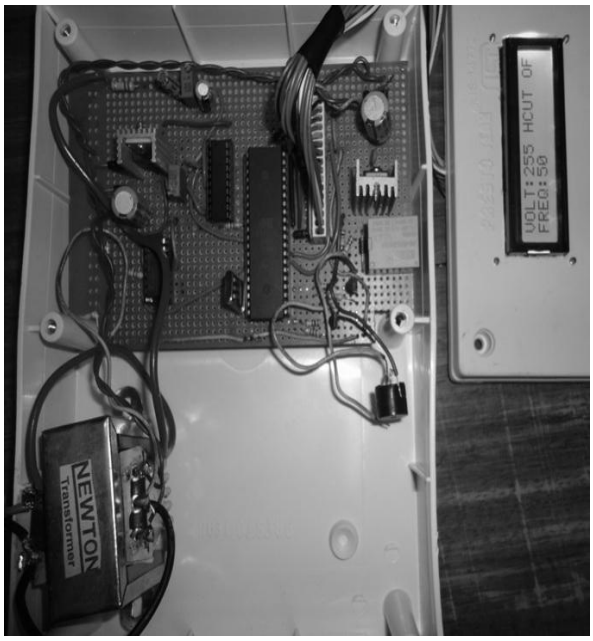
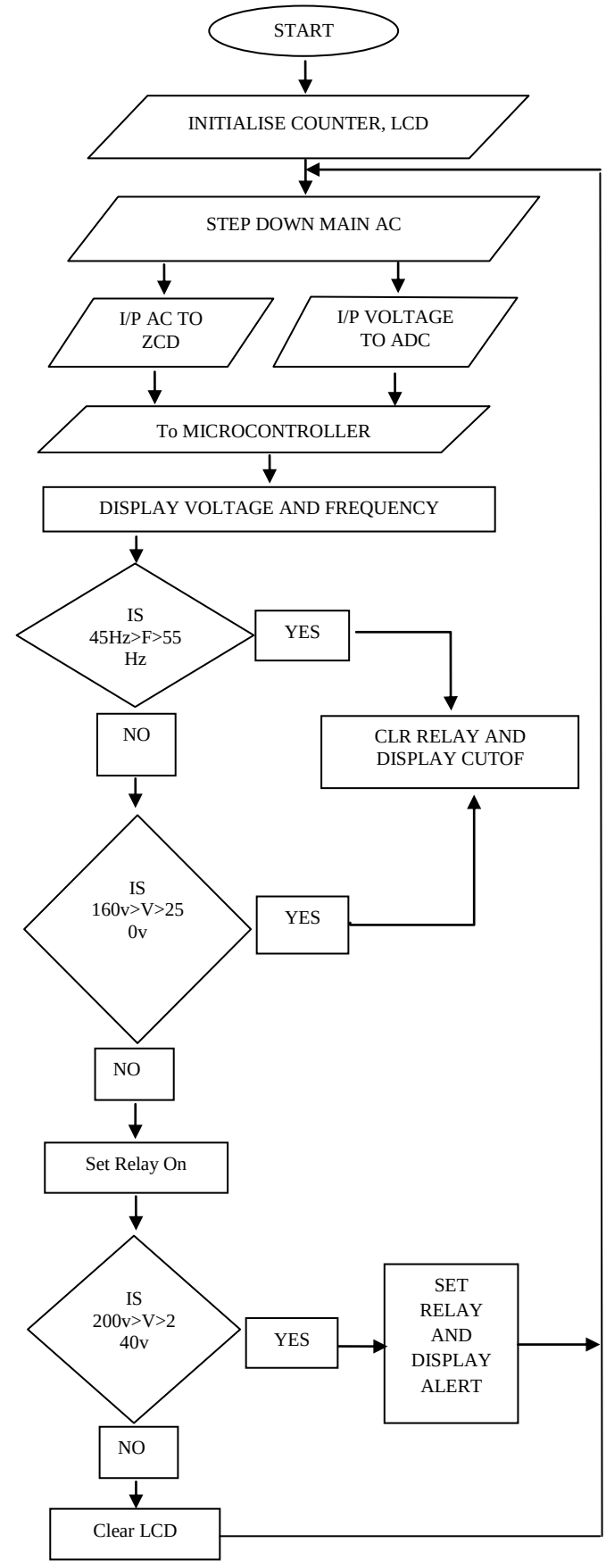


Fig 3: System in working condition

When the voltage is greater than 240V or less than 200V an alert message is displayed on the LCD for warning to turn off the expensive electric devices as shown in Fig.6.

Fig 4: Alert shown for high voltage condition

3. FLOWVHART



4. EXPERIMENT

The system is tested under various voltages and frequencies. The experimental output of the system under the tested voltages and frequencies are given in Table I.

Table 1. Response of the system for different voltages and frequencies

Sl. No.	Original Input to the System		System Output		Condition of Relay
	Voltage	Frequency	Voltage	Frequency	
1	265	50	265	50	Off
2	260	52	260	52	Off
3	255	53	255	53	Off
4	255	54	255	54	Off
5	250	55	250	55	On
6	245	56	245	56	Off
7	240	58	240	58	Off
8	220	60	220	60	Off
9	200	45	200	45	On
10	195	44	195	44	Off
11	190	42	190	42	Off
12	185	46	185.5	46	On
13	180	48	179.5	48	On
14	175	50	175	50	On
15	170	52	170.3	52	On
16	165	54	164.7	54	On
17	160	55	160	55	On
18	155	48	154.6	48	Off
19	150	50	149.7	50	Off
20	140	52	140.7	52	Off

It is clear that the display result's error is less than 5%. which is acceptable in most of the experimental devices.

5. RESULT AND DISCUSSION

From the data sheet it is clear that the system is giving the perfect result for the higher voltage but some distortions are occurring in the lower voltage. The relay is off whenever the voltage is below 160V and above 250V or frequency is below 45Hz and above 55Hz respectively. The relay is on only when both the frequency and voltages are between 45-55Hz and 160-250V. As it is a general purpose system the flexibility of it is made wide. For dedicated machineries and appliances the range of the alert and cut off limit can be varied by modifying the program without changing hardwire.

6. CONCLUSION

The microcontroller based device that has been built is capable of monitoring voltage and frequency continuously and cut off the relay when any of the voltage or frequency is beyond the specified safe range. That was exactly the objective of the project i.e. to design a system that can protect the electrical circuitry from fluctuating line frequency as well as voltage. In MCB the switch is needed to be on by manually after cutoff. But in this system the relay becomes automatically on whenever the frequency and voltage are in the specified safe range. So no manual effort is needed to on the relay. Overall our system provides better means of protection for the electrical appliances than fuse and MCB that are available in market.

7. FURTHER DEVELOPMENT

Some future improvements that can be done in the device:

Due to the processing delay of the microcontroller, the system cannot detect sudden fluctuations (till 1 sec) in the line voltage or frequency. Thus for the sudden impulse changes (change duration shorter than 1 second) in the line the relay won't cut and circuit breaker won't work.Minimization of this delay is one of the major scopes of development of the system.

More features can be attached in the device like data logger; it can be directly connected to the computer with UART and the computer can keep a data log about the variations of voltage and frequency over fixed durations. All the records of a domestic supply line for a period of time can be kept in the database.

Also the line voltage and frequency fluctuation characteristics can be observed from the data log.

The consumption rate of the area at certain times can also be known.

8. ACKNOWLEDGEMENT

With great pleasure we would like to express our profound gratitude and indebtedness to Mr. Nilotpal Halder, Assistant Professor, Department of Electronics and Communication, JIS College of Engineering, for his continuous guidance, valuable advice and constant encouragement throughout the whole period of project work.

We are also grateful to Prof.Dulal Acharjee, Asst. Prof. Swastika Chakroborty, HOD, department of Electronics and Communication, and the rest of the faculty for providing with the necessary facilities and assistance.

Lastly, we express our sincere thanks to our colleagues and friends for roles during our project work. We beg to be excused for not mentioning individual names of them all.

9. REFERENCES

[1] http://www.electronics-tutorials.ws/filter/filter_7.html.

[2] Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson India, Tenth Edition,2009.

[3] Jacob Millman, Christos Halkias, Chetan D Parikh, Millmans's Integrated Electronics, Tata McGraw Hill Education India pvt.Ltd, Second edition.2011.

[4] Md.Imran Hossain Jony, Md.Moshiur Rahman, "Construction of microcontroller based digital voltmeter", International Journal of Science & Research,Vol.3, Issue 1,(Jan 2014).

[5] D.Ibrahim, "Accurate measurement of the mains frequency", IJTPE Journal,Vol.3,Issue 9,No.4,102-105(2011).

[6] Muhammad Ali Majidi and Janice Gillispie Mazidi, The 8051 microcontroller And Embedded Systems Using Assembly & C, Pearson India, Second Editoin,2007.

[7] B.L.Theraja, A.K.Theraja, A Textbook of Electrical Technology in SI Units, Volume 1: Basic Electrical Engineering, S Chand & Co Ltd; 1st edition (July 31, 1999).

[8] Amit Sachan , "Microcontroller based substation monitoring and control system with GSM modem", IOSR Journal of Electrical and Electronics Engineering, Vol.1, Issue 6, PP 13-21, (July-Aug. 2012).

[9] M.A.A. Mashud, M.A.A. Tariq, M. Shamim Hossain, Md. Serajul Islam, "Design and development of a low-cost microcontroller based single phase water-pump controller", International Journal of Information Sciences and Techniques (IJIST) Vol.2, No.4, July 2012.