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DESIGN AND IMPLEMENTATION OF PROGRAMMABLE (USER SELECTABLE) MAINS MONITOR WITH SURGE PROTERTOR

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ABSTRACT
Power irregularities and fluctuations are major problems in Nigeria. To prevent and control these abnormalities, the need for mains monitor with surge protector is necessary. Voltage fluctuation is a critical problem for electrical and electronics equipment which could damage power equipment either at low or high voltage. This paper therefore presents the design and construction of programmable (user selectable) mains monitor with surge protector. The paper discusses the design, construction and operation of a programmable (user selectable) mains monitor with surge protector. The design is meant to automatically monitor the mains voltage to ensure that it is within the selected permitted voltage range of 170 – 240VAC. LCD interface was used for the output display. PIC16F689A microcontroller was used to implement the control program. The design is recommended for both household and industrial power equipment protection.
Keywords: Mains monitor; Surge Protector; Programming; LCD; User selectable

1. INTRODUCTION
Researches in the field of Electrical Electronics have led to tremendous discoveries and inventions especially in the area of automation and power control. These inventions have been useful in solving the ever-increasing problems posed by power generation, distribution and control, which have been a cause of concern especially in third world countries. The quality of power supplied in Nigeria is so poor that in a day, the power supplied could be as low as 170volts with several spikes (fluctuations) and this situation causes damage to most appliances.

The programmable (user selectable) mains monitor with surge protector is an electronic circuit designed to automatically monitor the mains voltage to ensure that it is within the selected permitted voltage range of 170 – 240VAC. The mains monitor also features a transient voltage arrestor which provides a means to protect home appliance from damaged caused by transient voltages.

Surge protection devices (SPD) are designed to protect against transient surge conditions. Transient surges can reach values of hundreds of thousands of volts or instantaneous current flow of ten thousands of amperes, but typically last than one hundred microseconds in duration. Transient surges generated within a facility typically accounts for 80% of the surge activity. These internally generated transients can be caused by switching power supplies (computers), electronic ballasts (building lighting) and variable frequency drives (air handlers, elevators, etc). The most destructive transient voltage surges can be attributed to lightning and utility load switching; however, experts predict that these two events account for 20% of all transient surge activity.

Electronic systems are designed to refine, extend or supplement the human ability to observe, perceive, communicate, remember, calculate, or reason. A power electronic device, like the programmable (user selectable) mains monitor with surge protector, extends and supplements the human ability to monitor, protect and control. The incorporation of this power electronic device in the home or the office will reduce the electrical hazards and loss of electrical devises posed when mains voltage is erratic and transient condition occur.

2. LITERATURE REVIEW

Design and implementation of microcontroller based programmable power changeover (Obasi *et al*, 2015). The paper deals with the design and implementation of microcontroller based programmable power changeover.
Transient: it is a change in the steady state condition of voltage, current, or both. In fact, transients vary widely in current and voltage wave shapes as well as magnitudes. Technically, transient is a sub-cycle disturbance in the AC waveform that is evidenced by a sharp brief discontinuity of the waveform. Transients may be of either polarity and may be of addictive or subtractive energy to the nominal waveform.

Transients are divided into two categories which are easy to identify; impulsive and oscillatory. If the mains signal is removed, the remaining waveform is the pure component of the transient. The transient is classified in the impulsive category when 77% of the peak-to-peak voltage of the pure component is of one polarity. Each category of transient is subdivided into three types related to the frequencies contained. Each type of transient can be associated with a group of phenomena occurring on the power system.

The impulsive low frequency transient rises in 0.1ms and last more than 1ms. Its companion, the oscillatory low-frequency transient, contains frequency

components up to5kHz. These types are the most common transients recorded on a power system. They are not only easily propagated but they can also be amplified by a power system resonance phenomenon. Measurement of these types of transients should be useful for all classes of application (benchmarking, legal, trouble shooting and laboratory).

The medium-frequency impulsive transient lasting between 50ns to 1ms and oscillatory transients between 5 and 500 kHz are less frequent than the low-frequency types but have much higher amplitude. These transients may not propagate as easily as the low-frequency types but may cause arching faults on the power distribution system which result in voltage sag on many user power systems. It is most appropriate to measure these types of transients for trouble shooting and laboratory classes.

High-frequency types with high amplitude can be observed only near where the phenomenon occurs. The high-frequency impulsive transient has duration below 50ns and the frequency of the high frequency oscillatory type ranges between 0.5 and 5MHz. These measurements are useful for laboratory and troubleshooting classes of application.

Sources of Transient Voltages: Transients can be generated internally, or they can come into a facility from external sources. The least common of the two are externally generated transients. They have been described as "electronic rust"

External sources: Lightning is the most well know of the externally generated transients. Most lightning transients are not actually the result of direct lightning strikes; they are most often "induced" onto conductors as lightning strikes near the power line. The large electric fields generated during a discharge can couple into the power system, creating induced transients. A cloud-to-cloud discharge can generate a 70volts per meter electric field. Other externally generated transients may also be imposed on power lines through normal utility operations. Switching of facility loads, opening and closing of disconnects on energized lines, switching of capacitor banks; re-closure operations and tap changing on transformers can all cause transients.

Internal sources: The vast majority of transients are produced within your own facility. The main culprits are device switching, static discharge, and arching. Each time you turn on off load or unload an inductive, you produce a transient. Inductive devices are those devices that use "magnetic mass" to function. Examples of inductive loads are motors and transformers.

Microcontrollers: A microcontroller (also microcomputer, MCU or μC) is a small computer on a single integrated circuit consisting internally of a relatively simple CPU, clock, timers, I/O ports, and memory. A program memory in the form of NOR flash or OTP (one time programmable) ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for small or dedicated applications. Thus, in contrast to the microprocessors, used in personal computers and other high-performance or general purpose applications, simplicity is emphasized. Some microcontrollers may use four-bit words and operate at clock rate frequencies as low as 4 kHz, as this is adequate for many typical applications, enabling low power consumption (milliwatts or microwatts).

Embedded Design: A microcontroller can be considered a self-contained system with a processor, memory and peripherals and can be used with an embedded system. (only the software needs be added). The majority of microcontrollers in use today are embedded in other machinery, such as automobiles, telephones, appliances, and peripherals for computer systems. These are called embedded systems. While some embedded systems are very sophisticated, many have minimal requirements for memory and program length, with no operating system, and low software complexity. Typical input and output devices include switches, relays, solenoids, LEDs, small or custom LCD displays, radio frequency devices, and sensors for data such as temperature, humidity, light level etc. embedded systems usually have no keyboard, screen, disks, printers, or other recognized I/O devices of a personal computer, and may lack human interaction devices of any kind.

Transistors: Transistors are active components used basically as amplifiers and switches. The two main types of transistors are: The bipolar transistors whose operation depends on the flow of both minority and majority carriers, and the unipolar or field effect transistors (called FET) in which current is due to majority carriers only (either electrons or holes). The transistor as a switch operates in class A mode. In this mode of bias, the circuit is designed such that current flows without any signal present. The value of bias current is either increased or decreased about its mean value by the input signal (if operated as an amplifier) or ON and OFF by the input signal if operated as a switch.

3. METHODOLOGY

Principle of operation; the programmable (user selectable) mains monitor with surge protector is built around a microcontroller, PIC16F689A, programmed to

handle the whole mains monitoring unit. It has a user selected permissible input voltage range of 170V - -240V which the microcontroller monitors to ensure that voltages outside this range are not allowed to get to the load. A step-down transformer is designed to take in input as high as 300VAC to provide 12V and 20V output. The 12V output is rectified to power the transistor-relay switching stage and further regulated to 5V to power the microcontroller circuitry. The 20V output is used for the transient eliminator and mains voltage monitoring stage. The microcontroller is programmed to ensure that when the input voltage exceeds 240VAC the output to load is cut-off and an "UNUSUAL" message is displayed on the liquid crystal display (LCD). When a transient condition occurs, the transient eliminator stage, which hitherto has been "ON", goes "OFF" prompting the microcontroller to disable the output to load via the relay switching stage and display a "TRANSIENT CONDITION" message on the LCD. And when the input voltage is below 170VAC, the LCD displays an "UNUSUAL" message and no voltage is supplied to the load.

The power supply stage generates a regulated voltage to power the active components and also create a stable reference voltage to enable proper calibration of the programmable (user selectable) mains monitor with surge protector. The power supply stage is a linear power supply type that has the step-down transformer, rectifier filter and regulator stages.

A step-down transformer is designed to take in maximum input of 300VAC to provide 12V and 20V output. The 12V output is rectified to power the transistor relay switching stage and further regulated to 5V to power the microcontroller circuitry. The 20V output is used for the transient eliminator and mains voltage monitoring stage. Using a 300V transformer on a 50Hz supply and transformer secondary r.m.s voltage output is 12V.

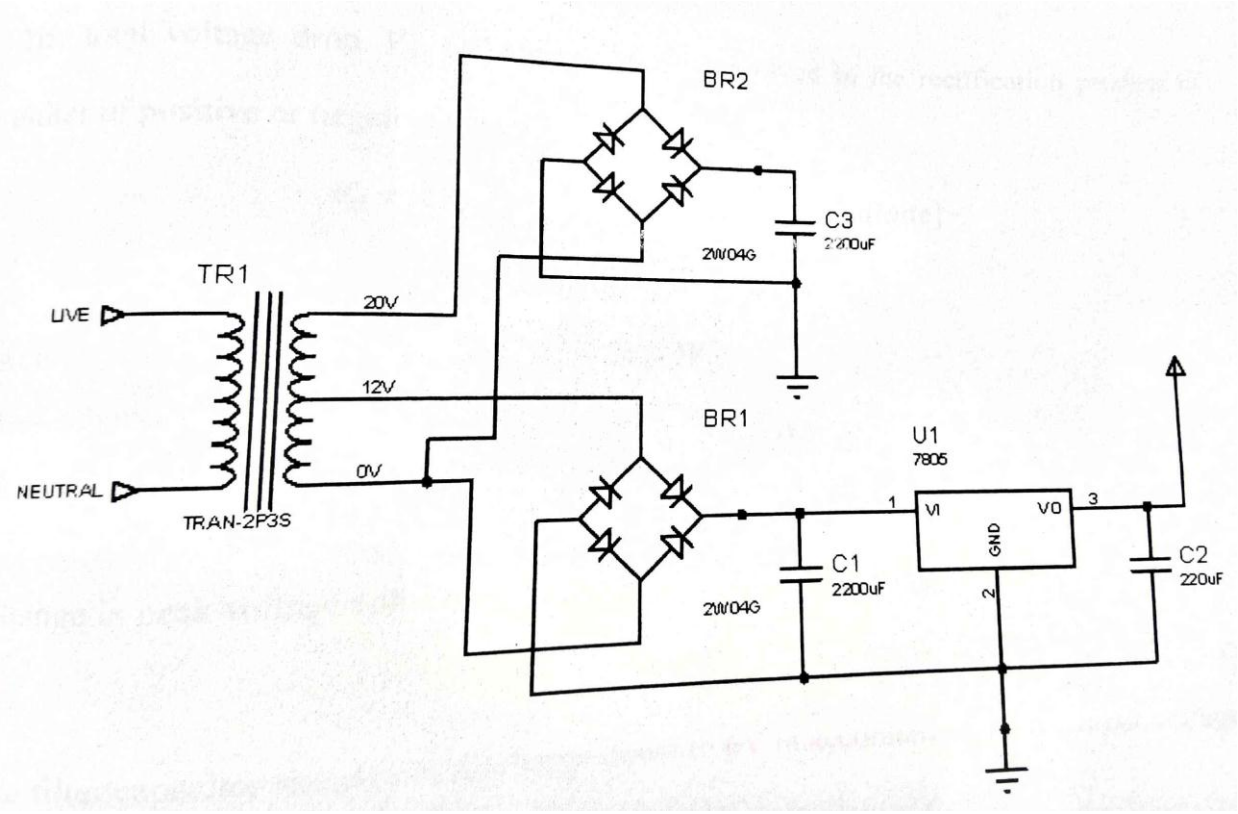

Figure 1: Power Supply Circuit

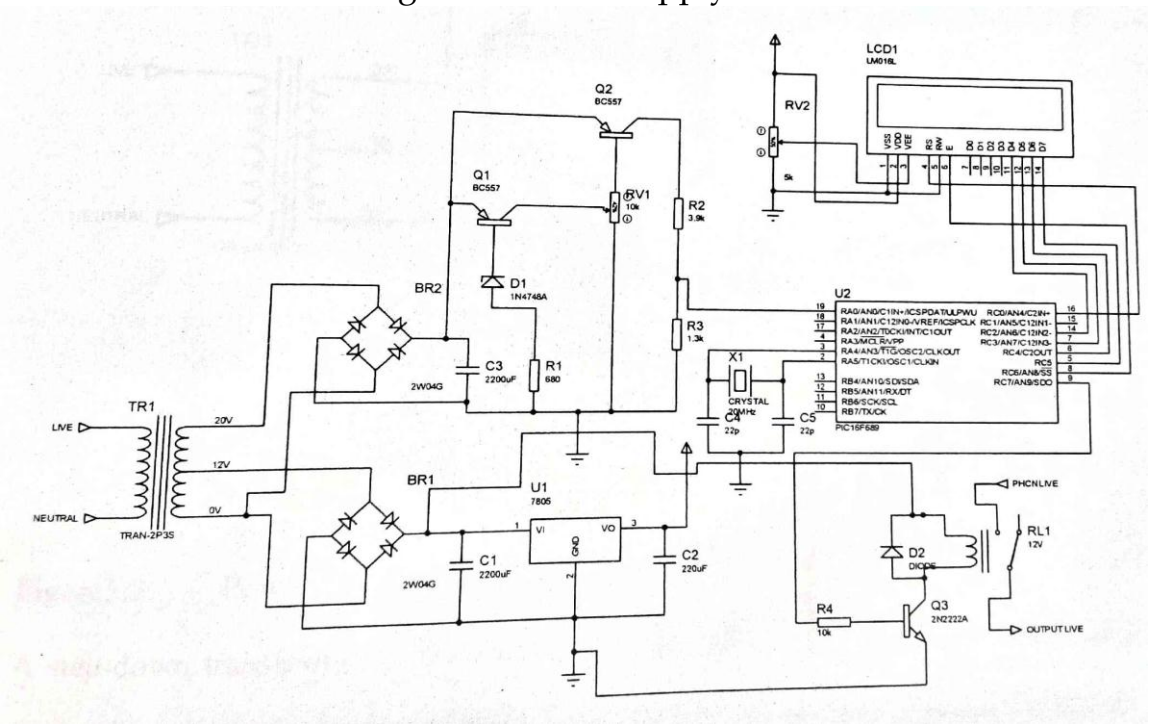

Figure 2: Circuit Diagram

The microcontroller stage, PIC16F689A: It belongs to a class of 8-bit microcontroller of RISC architecture. It is an 18 pin dual in-line package chip. The PIC16F689A is a tiny but complete computer. It has a CPU (central processing unit), program memory (PROM), working memory (RAM), and two input-ports. The CPU is the "brain" of the computer. It reads and executes instructions from the program memory. As it does so, it can store and retrieve data in working memory (RAM). CPUs make a distinction between "registers" located within the CPU and "RAM" outside it; the PIC does not, and its general-purpose working RAM is also known as registers. On the F689, there are 68 bytes of general-purpose RAM, located at addresses C to hex 4F. Besides the general-purpose memory, there is a special "working register" or "register" where the CPU holds the data its working on. There are also several special function registers each of which controls the operation of the PIC in some way. The program memory of the F689 consists of flash EPROM; it can be recorded and erased electrically, and it retains its contents when powered off. Program memory (FLASH) for storing a written program. Since memory made in FLASH technology can be programmed and cleared more than once, it makes this microcontroller suitable for device development. EEPROM - data memory that needs to be saved when there is no supply. It is usually used for storing important data must not be lost if power supply suddenly stops.

4. RESULTS AND DISCUSSIONS

The physical realization of the project is very vital. The paper work is transformed into a finished hardware. After carrying out all the paper design and analysis, the work was implemented, constructed and tested to ensure its working ability. The construction of this work was done in three different stages: the implementation of the whole work on a solder-less experiment board, the soldering of the circuits on vero-boards and the coupling of the entire work to the casing.

The implementation of this work was done on the breadboard. The power supply was first derived from a bench power supply in the electronics laboratory. To confirm the workability of the circuits before the power supply stage was soldered. The implementation of the project on bread board was successful and it met the desired design aims with each stage performing as designed.

Testing of programmable (user selectable) mains monitor is done with the use of variac (device used to vary voltage). The mains supply is fed to the input of the

variac and the output of the variac is connected to the input protective device and then to the isolator of the household or the machine. When the voltage is varied through the variac, the input protective device would only allow the permissible voltage to flow to the load and such protecting the load. Meanwhile any voltage out of range would be cut off from entering the load and be seen as no voltage supply.

Stage by stage testing was done according to the block representation on the breadboard, before soldering of circuit commenced on vero board. The process of testing and implementation involved the use of some test and measuring equipment's stated below; bench power supply, oscilloscope and digital multi-meter.

5. CONCLUSION

The design and implementation of programmable (user selectable) mains monitor with surge protector has been implemented in this paper. It was designed considering some factors such as economic application, design economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the work after test met design specifications. However, the general operation of the work and performance is dependent on the user who is prone to human error such as entering wrong timing. The design of the programmable mains monitor involved research in both digital and microelectronics.

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