High/Low Voltage Protection Device System for Appliances

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Abstract

The project is a high/low voltage protection device system for appliances specifically for home appliance. The device is low-cost making it more affordable for the countryside and in response to the abnormal input voltage condition in rural Philippines. The apparatus is an innovation ofthe existing high/low voltage protector device using the architecture development vee model. Testing of the device shows that it has a very high switching efficacy index comparable to existing similar devices.

Keywords: High/low voltage protection, power surge control, fluctuating current control device

I. INTRODUCTION

The geographical location of the Philippines entails erratic climate changes. It indirectly affects the power line distribution of the country for it causes fluctuations of line voltage that often causes serious problems to sophisticated electrical and electronic home appliances. According to Islam and Zulquarnian (1991), during Storm season, it is observed that the line voltages of some phases divert to a low level and remain at the level for several hours until some corrective measures are taken by the concerned authority. Under these conditions of line voltage, a rewireable fuse or circuit breaker are normally used to protect different households and the corresponding appliances from under and over –voltage conditions that are apparent at that time.

Consequently, in spite of the above situation, the number of appliances continues to grow, so does the corresponding energy consumption. In fact, a significant number of innovative electrical fluctuation projects have been made and implemented to secure all electrical components and systems. It is because power line fluctuations and cut-offs cause damages to electrical appliances connected to the line. Note that unexpected appliance failures can be inconvenient and worse, they can be costly.

Therein, Surge protection has become a more complex and important issue to look into considering that the value of electronic equipment in a typical house has increased enormously. Protective devices were developed for ensuring a dependable and effective protection to small households. Some of these devices are developed by Islam (1991), Islam (1992) and Mashud (1994).

Though a significant number of devices have already been developed, but an alternative approach which is being done within the context of this study has been made. This project aimed to develop a low cost and more reliable system with the integration of time delay in order to establish and ensure reliable damage protection of equipment.

II. MATERIALS AND METHODS

System Concept Development

Figure 1 shows the general concept idea of the project. The figure indicates the necessary infrastructure and components needed in the system development vis-à-vis system operations.

As reflected on the figure, the developed device/system is to be placed in between the power source and the electronic component/appliance to be protected. Note that the protector input voltage should only be connected to the source of 220 VAC and the output voltage should be to the appliances.

The development of the High/Low Voltage Protection Device uses the Vee Model. The Vee Model is a system development method defined and elaborated by Forseberg and Mooz (2005) which addresses development issues of decomposition, definition, integration and verification as shown in figure 2.

Based on the Vee Model, the following summary of device development has been made: (1) Designing of Complete electronic circuit diagram based on the low cost locally available materials; (2) Fabrication of the design in a Printed Circuit Board (PCB) based on the schematic diagram, with the inclusion of trial and revisions to eliminate errors; (3) Fabrication of plastic housing and installation of other components in the chassis was made to set the project ready for operation and evaluation; (4) Test and evaluation of device system performance in the following areas is done as to its safety, durability and efficiency compared the existing developed gadget in the market.

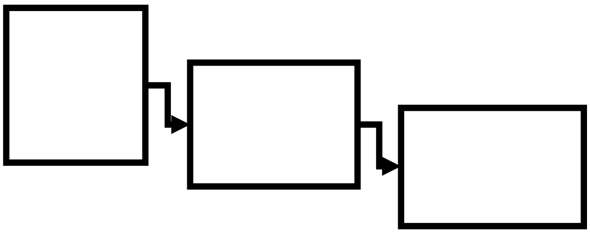

Figure 1. Conceptual Development Diagram

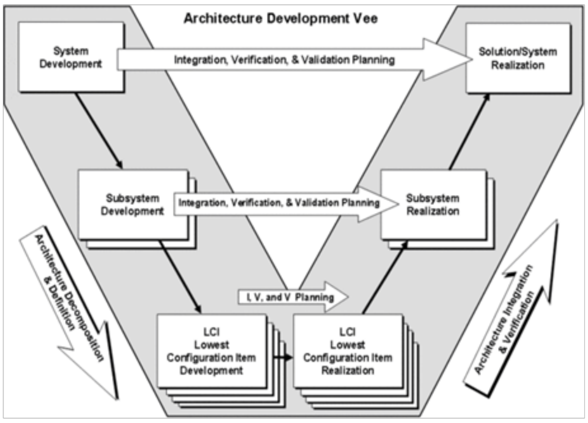

Figure 2. Architecture Development Vee Model (Provides What, Why, and Who). Source – Kevin Forsberg and Hal Mooz 2006

Device testing and Evaluation

Test and Evaluation is focused only to the switching action efficiency of the developed device in three areas – (1) switching action during normal input voltage condition, (2) switching action during low input voltage conditions and (3) switching action during the high voltage conditions. Note that for this particular study, a switching action efficacy index is set to 3 minutes and 15 seconds based on the established device switching action standard of the Philippine Electrical Code. Further, the low and high voltage value was also based on the plus and minus 20% of the standard input voltage of 230 volts AC.

In addition, durability test was made to ensure that device's operability once utilized in actual setting. Comparative analysis was made out of the laboratory test result and actual test result in order to determine the device's durability index in a three trial period.

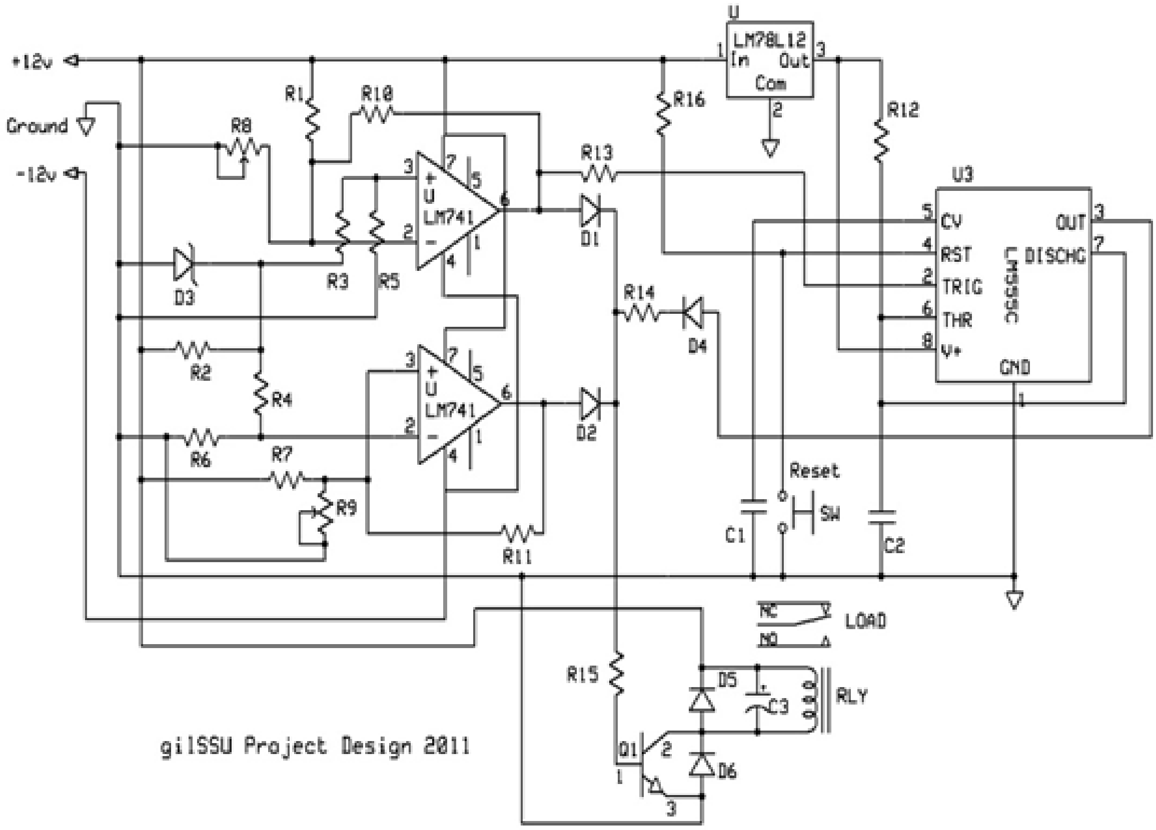

Figure 3. Circuit Lay out of the Device

III. RESULTS AND DISCUSSIONS

High/Low Voltage Protection Device

In consonance with the Methodology, the Circuit Diagram of the system as shown in the figure has been made

Figure 3 indicates the entire circuit layout of the device. As reflected, it is composed of several electronics and electrical components. These are: (1) Low Voltage Cut Off Amp, (2) High Voltage Cut Off Amp, (3) Time Delay Circuit, (4) High Ampere Relay, (5) Fuse and (6) 250 VAC Cord.

Specifically, an omp-amp 741 component in fig. 4 is used as a low voltage comparator. Low Voltage Cutoff Amp circuit made use of the Zener diode D3 and the associated resistor R3 are connected to the non-inverting terminal (+ve) of 741 to give the suitable reference voltage. The DC voltage from the sensor is given to the inverting (-ve) terminal through the pre-set resistor R8. It is used to set the input level. When the sensor input is less than the Zener voltage, the output from the Op-amp remains high. When it is greater than the Zener voltage, the output goes low. When the sensing voltage is equal to the Zener voltage, the output of the op-amp is approximately zero. This phenomenon is used as a decision for switching the relay and gives cutoff in a low voltage situation.

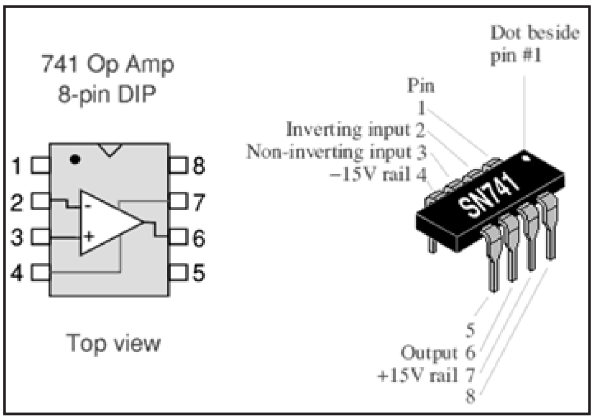

Figure 4. The op amp 741 used in the circuit

Consequently, the high voltage cutoff Amp circuit utilizes LM741 op-amp as an inverted amplifier. Zener and resistor network gives reference voltage to the inverting terminal (-ve) of op-amp. Sensing voltage derived through the resistor R9, pre-set is given to the non-inverting (+ve) terminal and this sets a high-level cut. When the input DC from the sensor has a lesser zener voltage, the output of the Op-amp is low and vice-versa. When the input DC voltage is equal to the zener voltage, the op-amps output is approximately zero. Thus, no voltage output will be sensed by the relay causing the relay to de-energized.

Integration of time Delay circuit is one of the innovations of the project. The time delay circuit made use of LM555 timer that is wired as a monostable multivibrator (fig. 5) with a pulse width of 10ms. When the power comes back after a cutoff, a negative voltage is obtained at the trigger pin which triggers the IC LM555. The transistor Q1 gets forward biased, and it drives the relay to switch ON the load that indicates power resumption. Also, this will activate LM741 that in turn makes the transistor Q1 to OFF condition. As a result, the relay will remain de-activated for 10ms that will provide the sufficient delay and in turn protect the equipment.

In addition, a high Ampere relay was used

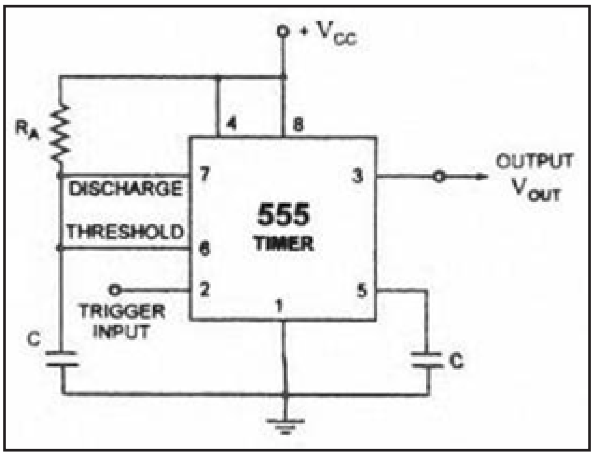

Figure 5. Circuit of the timer 555 as monostable multivibrator

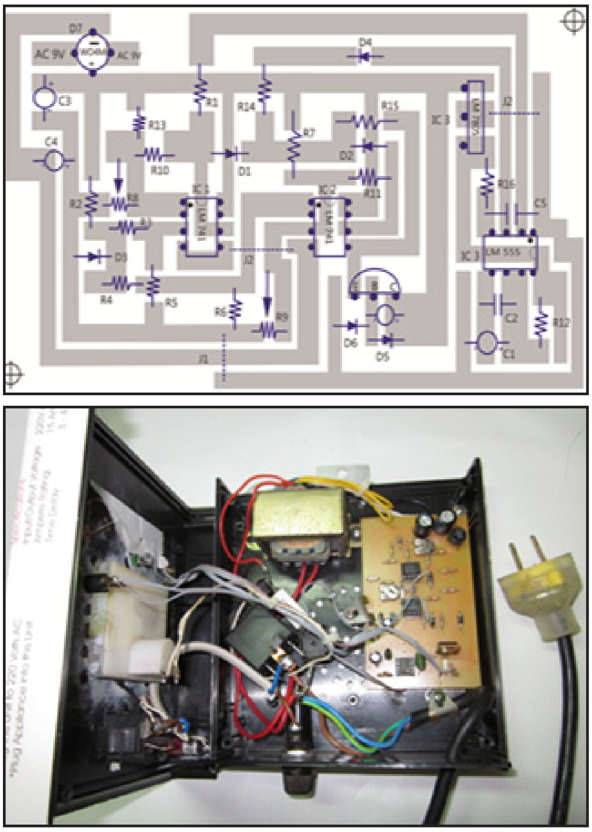

Figure 6. PCB Layout and Internal Structure of the Device

which can hold voltage and current to a maximum of 250 VAC/30 Ampere. This particular component is used as an ON-OFF switch of the electronic equipment/ appliances connected to the device. Another component utilized is the fuse with a 10 ampere rating. Its primary function is to protect the appliances from excessive flow of high current. The PCB layout, as well as the internal structure of the developed project, is shown in figure 6.

Device Test and Evaluation Result

A series of laboratory tests was conducted in evaluating the performance of the project specifically the device's switching efficiency.

Table 1 shows the safety test result of the developed device. The first efficiency test is focused on the average power ON time efficiency of the device in normal voltage operation. Table 1 shows the result of the laboratory based on observation. Note

Table 1. Power on Time Efficiency under Normal Condition

Trials	Voltage Rating	Time Delay	Power ON time
1	223V	Off	1.0 sec.
2	223V	Off	1.3 sec.
3	223 V	Off	0.8 sec.
Average			1.03 sec.

Table 2.. Low Voltage Cut-off Efficiency

Trials	Voltage Rating	Time Delay	Power ON time
1	200V	Off	0.90 sec.
2	200V	Off	1.3 sec.
3	200V	Off	0.8 sec.
Average			1.0 sec.

that the average power on time efficiency of the gadget as it is being subjected to variable transformer voltage with a setting range of 223 VAC is at 1.03 minutes. Note further that the device's switching action efficacy index is 3.15 minutes. Since the computed switching action of the device is 1.03, it is less than the preset efficacy index of 3.15. Therefore it can be concluded that the device is efficient enough to protect the appliances in power surges when it is being switched on under normal voltage conditions, especially if frequent voltage fluctuation occurs.

Table 2 reflects the Low Voltage Cut-Off Operation of the system. Note that a presence of abnormal voltage situation was set to the variable voltage transformer to 200 volts. The 220 volts AC which is considered as low voltage based on the plus and minus computation of the average input power supply as reflected in the Philippines electrical code (as mentioned in the methodology) which can cause damages to electrical appliances if situation occurred for a long period of time. The result shows from the three trials conducted that the average cut-off time of the device to disconnect the appliances from the power source is about 1 second which is less than the preset efficacy index of 3.15 minutes from the time that the low voltage occurred

Table 3. High Voltage Cut-Off Efficiency

Trials	Voltage Rat-ing	Time Delay	Power ON time
1	250 – 260 V	Off	0.5 sec.
2	250 – 260 V	Off	1.0 sec.
3	250 – 260 V	Off	0.7 sec.
Average			0.73 sec

which is considerably safe for appliances operating in abnormal voltage.

On the other hand, table 3 shows the laboratory test results of the device as it is being subjected to high voltage power source. As reflected on the table, the average cut-off time is 0.73 seconds which is considerable enough in automatically disconnecting the appliance during the presence of this particular voltage input condition. Again the result of 0.73 seconds is less than the preset efficacy index of 3.15 minutes; hence the device has a high efficiency level.

High/Low Voltage Protection Device Parts, Descriptions and Functions

Figure 7 shows the different parts of the developed High/Low Protection Device. These include (a) High Voltage Indicator, which emits light when there is a presence of high voltage at around 250 – 260 Volts AC and consequently disconnect the

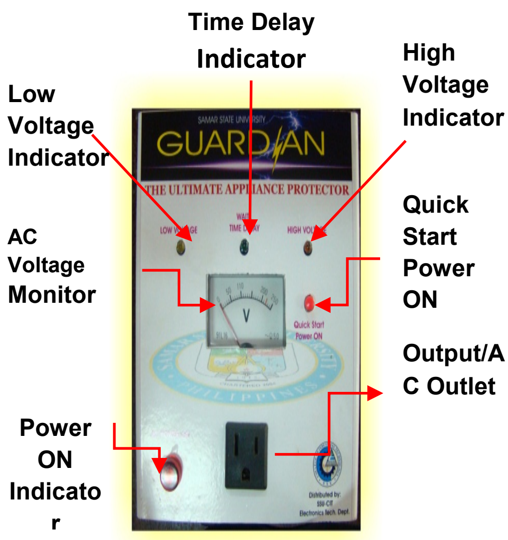

Figure 7. Different Parts of the High/ Low Protection Device

device or appliances that are connected to avoid damage.; (b) Low Voltage Indicator operates in the same manner with the high voltage indicator however it only activates when there is a presence of low input voltage at around 180 – 200 volts AC; (c) Time delay circuit that emits light during the transition period of either turning On or OFF the device when there is a presence of abnormal input voltage. Note that based on the efficiency result, the average observed time-delay switching action of the developed device is less than the predefined time index of 3 minutes and 15 seconds, which indicated the high efficiency index of the device.

Other parts of the device are (1) AC voltage indicator which is used to display the actual input voltage of the system, (2) Quick Start Power On which is used to quickly power ON the appliances without waiting the time delay, and (3) Power on indicator that indicates the presence and absence of the input voltage source signal.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the foregoing results, it can be deduced that the developed device has a very high switching efficacy index which is very important in protecting electronic appliances and devices. The device covers possible occurrences of over and under voltage supply which in most cases, causes damage to electrical equipment.

Based on the device's high efficacy index and robustness test, the device is recommended to be immediately utilized in real life application and that a massive production be carried over.

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