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A Novel Over Voltage and Under Voltage Protecting Systemfor Industrial and Domestic Applications

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Abstract:-This paper presents a novel system to protect the industrial and domestic loads from over voltage and under voltage in AC mains supply. The proposed system monitors the voltage and provides a breakpoint based over voltage and under voltage tripping mechanism and protects the load. The proposed system consists of a tripping mechanism that monitors the supply voltage and trips according to the limits provided. A lamp load is used in this research work to test the effective working of proposed system.

Keywords:-*Over Voltage, Under Voltage, Industrial Applications, Domestic Applications, Protecting System.*

I. INTRODUCTION

Different domestic and industrial uses require variations in the availability of AC mains. There is a risk of electronic devices and electrical loads being affected, which are very susceptible to these fluctuations. There is, therefore, a need for a tripping device that prevents these loads from being damaged.

Allowing voltage to set limits is suggested for the satisfactory operation of all devices. Voltage fluctuations in the supply of electric power undoubtedly have detrimental effects on various loads. There are many causes that can cause these voltage fluctuations, such as voltage spikes, overload, lightning, etc. Over voltages are the voltages that beat the standard values that cause electrical equipment to lose insulation, resulting in short circuits. Similarly, under-voltage causes the apparatus to overload.

A Power Electronics based medium voltage prototype of Traction Transformer can be designed and protected by a protecting system [1].

A microcontroller can be used to protect the three phase appliances when one of the phases of three phase AC power supply is disconnected. A relay and comparator based protecting system which can be used to trip the control circuit can be simulated by using PSIM software.

A microcontroller PIC16F877A and some discrete components based Over Voltage and Under Voltage protecting system can be designed and simulated [2]. A relay based on an Arduino microcontroller can be used to secure the solid state transformer branch of the Future Renewable Electrical Energy Distribution and Management System System. [3].

The main objective of this research work is to make an indicator of low voltage and high voltage. The proposed device would save costly electrical and electronic equipment from the opposing effects of protection against over voltage and under voltage. This system's circuit features an auto reset and uses components that are readily accessible. Inside the 555 timer ICs, it utilises the comparators available. The main component of this research work includes 555 timer. There are various protecting techniques to protect the electrical and electronics equipment from various unexpected voltages such as over voltage, under voltage, common mode voltage and Electro Magnetic Interference based voltage [4-9].

The voltage across the capacitors and switches in the multi-level inverters and other inverters can also be protected from the unexpected voltages and makes the voltage balancing in the inverter circuit [10].

This paper presents the basics of over voltage and under voltage, causes of over voltage and under voltage, effects of over voltage and under voltage on power system. This paper also presents the complete details of the proposed protecting system.

II. OVER VOLTAGE

Increase in voltage for the very short time is called as the over voltage. It is also known as the voltage surge or voltage transients. The voltage stress caused by over voltage can damage the supply mains. This over voltage can damage the electrical loads, electronic devices and circuits, electrical and electronic equipment connected to the supply mains. Transient over voltages will be generated at high frequency (load switching and lightning), medium frequency (capacitor energizing) or low frequency.

The AC supply voltage waveform with over voltage is shown in Fig.1.

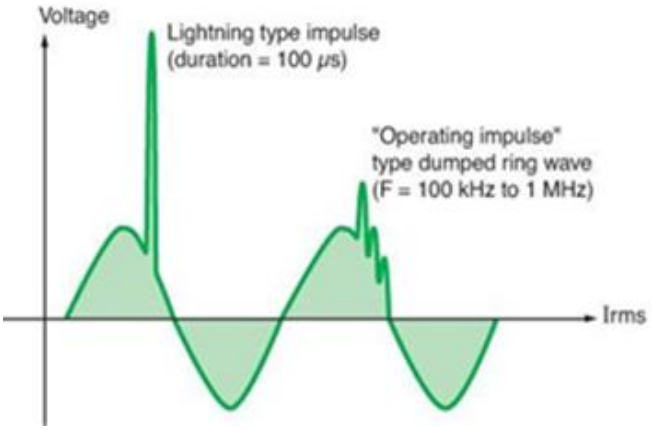

Fig.1. Supply Voltage Waveform with Over Voltage

The possible causes of over voltage are of two types. They are (i) external causes (ii) internal causes.

In the clouds, the lightning strokes are the main cause of over voltage. Due to the lightning strokes, the electric charges will be accumulated in clouds. Also, due to some bad atmosphere, the electric charges will be increased. Hence, the lightning in the atmospherecreates some unwanted charges in the electrical supply. The unwanted electric charges will be in the form of a surge. The surges may occur due any of the following causes:

(a) Direct lightening Stroke.
(b) Generated voltages due to changes in the environment along the length of the line.
(c) Due to lightning discharge taking place near the line, dubbed 'side stroke', electromagnetically induced over voltages.
(d) The presence of charged clouds nearby induces electrostatically induced voltages.
(e) Owing to the frictional effects of small particles such as dust or dry snow in the atmosphere or due to changes in the altitude of the line, electrostatically induced over voltages.

When the potential gradient becomes 5000V to 10000V per cm or when the voltage between cloud and earth is 5 million volts to 20 million volts, lightning strokes takes place.

The change in the operating conditions in an electrical system causes the internal over voltages. These can be divided into two groups as below.

(a) Transient over operation voltages or Switching over voltages of high frequency.
(b) Temporary over voltages.

The Switching over voltage is caused when switching operation is carried out under normal conditions or when fault occurs in the network. When an unloaded long line is charged, due to Ferranti Effect the receiving end voltage is increased considerably resulting in over voltage in the system. Similarly when the primary side of the transformers or reactors is switched on, over voltage of transient nature occurs.

The temporary overvoltage is induced under usual or steady state conditions when any big load is disconnected from the long line. Over voltage continues to stress the electrical equipment's insulation and is likely to cause harm to them as it happens regularly. Surge-induced overvoltage will result in spark over and flash over at the weakest point in the network between phase and field.

III. UNDER VOLTAGE

Under voltage is defined as a condition where the applied voltage drops to 90% of ratedvoltage, or less, for at least 1 minute. Low - voltage conditions occur when a facility asks for more power than the line can deliver. The AC supply voltage waveform with under voltage is shown in Fig.2.

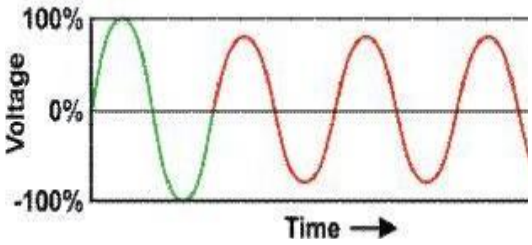

Fig.2. Supply Voltage Waveform with Under Voltage

There are various causes of under voltage in the AC supply mains. They are

(a) Closing and Opening of CircuitBreakers.
(b) Due toFault.
(c) Due to Motor Starting.
(d) Due to Transformer Energizing.
(e) EquipmentFailure.
(f) Bad Weather and Pollution like flash over and Lightning strikes.
(g) Damage to undergroundcables.

Due to the under voltage, the resistive loads will run less effectively. Also, Loads with controllers to do a job - i.e. thermostats to maintain A/C, refrigerators, ovens, etc will run longer and harder and end up usingthe same power until the voltage is way too low and the units is running 100% of the time, then temperature regulation will fall off and start not to work.

Motors with loads that are not reduced - say pumps and conveyors - will attempt to use the same power to meet their mechanical loads. As a result current will increase to keep power the same. If the motor is was originally running at 100% of its rated power, then the current in a brown out will exceed its design current and the motor will overheat and eventually short out as the insulation fails.

Electronics devices - units with modern switching supplies will probably work OK with lower voltages but take more current to supply the same power required to

operate the device. Older devices may not operate correctly on low voltage.

IV. PROPOSED PROTECTING SYSTEM

The proposed protecting system to protect the loads from over voltage and under voltage consists of various electrical and electronic components and devices such as step down transformer, rectifier, filter, voltage regulator, LM358 IC, resistors, capacitors, LEDs, diodes etc.

The input of the transformer is connected to the mains i.e, 230VAC. The input can also be given to a variac which is variable AC power source. The output of transformer is 12V AC and it is fed to the input of 12VAC connector of the PCB. The principle of working of the circuit lies in the working of the Op amp IC. There is a potential divider network along with a zenor diode used for controlling the tripping of the power to the AC load connected to the system. The working range of voltage is set into the system with the help of the potential divider network.

This set voltage range is for a working range of 180VAC up to 240VAC at the input of the 12VAC step down transformer. Whenever the voltage goes below 180VAC at the input of the transformer, it will trip down the relay and thus the load will automatically get disconnected in the under voltage condition. Similarly, at voltages higher than 240VAC, the over voltage sensing Op amp IC will trip down the relay, hence protecting it from over voltage condition.

There is also a pot provided on the PCB. This is to demonstrate manually the change in voltages so that demonstration of this system can also be shown without the variac connected at the input of the transformer. The transformer in such case will directly be connected to AC supply and variations in AC will be simulated by varying the pot on the project thus demonstrating tripping of load relay in case of over and under voltages.

The figures of various components are shown from Fig. 3 to Fig.9.

Fig.3. Step Down Transformer

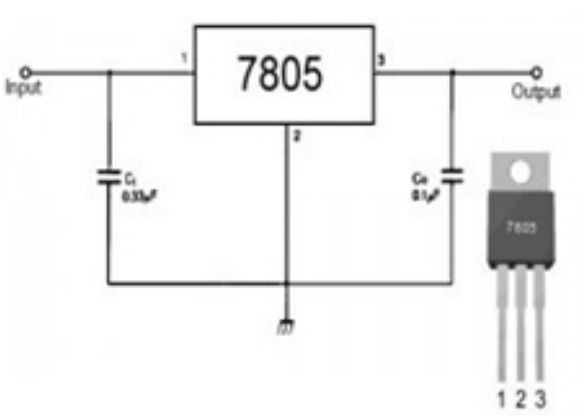

Fig.4. Voltage Regulator

Fig.5. Rectifier

Fig.6. Transistor

Fig.7. Relay

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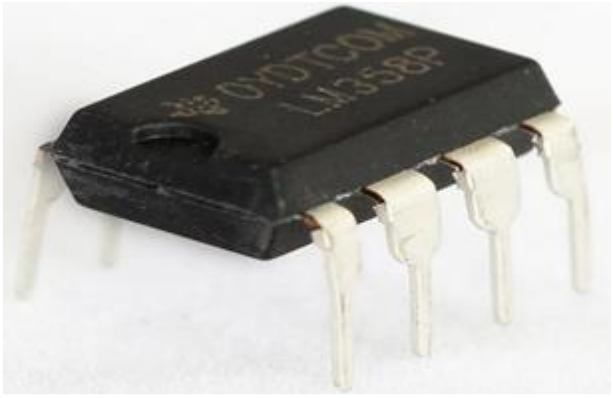

Fig.8. LM358 IC

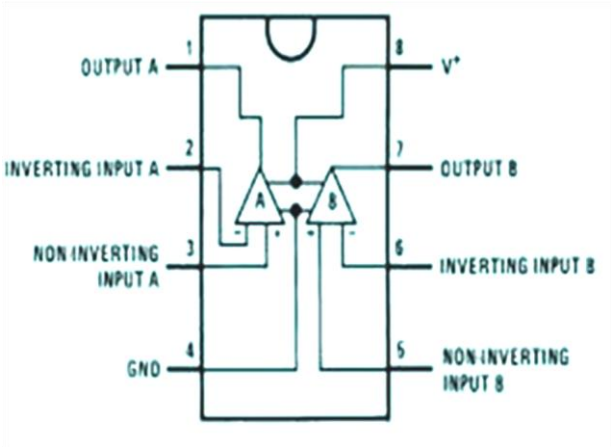

Fig.9. Pin Diagram of LM358 IC

The working of proposed protecting system when there is no over voltage and under voltage is shown in fig.10.

Fig.10. Proposed System when there is no over voltage and under voltage in AC supply mains

The working of proposed protecting system when there is an over voltage in the AC supply mains is shown in fig.11. Here, the proposed system trips the circuit and protects the lamp load.

Fig.11. Proposed System when there is an over voltage in AC supply mains

V. CONCLUSION

In this paper, a novel system is proposed to protect the industrial and domestic loads from over voltage and under voltage in AC mains supply. The proposed system is designed, fabricated and tested for two conditions. The first condition is the normal AC supply without any over voltage and under voltage. The second condition is the over voltage in AC supply. The proposed system worked satisfactorily with the lamp load. Hence, it is concluded that the proposed system protects the industrial and domestic applications from the supply over voltage and supply under voltage. The proposed system can be further fabricated for three phase AC supply for three phase loads.

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