A Review Paper on Simulation of Overvoltage and Undervoltage Protection

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Abstract: ***Energy insistence goes on increasing and will be still continuing also the risk of energy distribution will be the great factor. There are many cases in which fault occurred due to over voltage or under voltage and hence equipment gets damaged. This paper emphasizes modeling and simulation of overvoltage and undervoltage protection system. This method is based on the operation of relay overvoltage and undervoltage faults. A power as an input is given to the system and specific limits are set for the overvoltage protection and undervoltage protection. If the input voltage fluctuates above or below the limit the relay will trip accordingly and hence there is less chances of damaging equipment. This model has been designed for 230V, 50Hz.***

Keywords: Power quality, over voltage, under voltage

1. Introduction

The electric power system subsists of various units like alternators, transformers, station bus-bars, transmission lines, mechanical support, etc. The most relevant thing to be considered is the stability of all those equipments installed in the system. The main unbiased of any power system is to provide constant power supply. For this, the system has to be guarded from various faults that take place in any of the parts of the system and the functional framework like current, voltage are to be maintained. Industries face a major problem that is sudden overvoltage in the system which further results in power quality and damages the equipments. Industries have to deal with crores of losses due to power interruption. Cost of alternate damaged apparatus costs very high. [1]

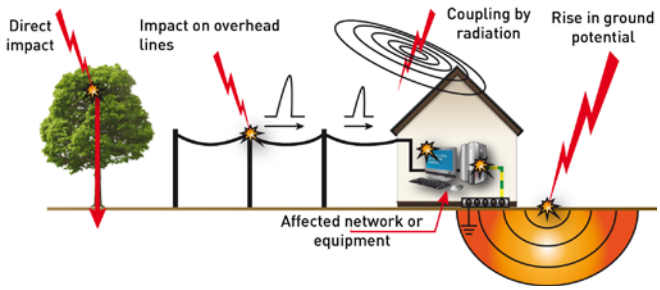

Figure 1: Transient voltage due to lightening

This paper primarily affirms for the protection of the electrical appliances from overvoltage and under voltage system. There are two types of transient voltages. First which is consistently generated due to lightening is called Natural overvoltage. A lightning stroke can produce much more energy than we previously thought possible. A lightning stroke can bear nearly 3 billion kW at approximately 125 million volts. During lightening very huge amount of current is discharged (10,000 to 90,000A.) Second, this is caused by human beings by using low power factor machines and using local electrical appliances. Transient over voltages are surges that reach value of tens of kilovolts with a duration of the order of micro seconds. Despite their short duration they cause the destruction of equipment connected to the network, causing serious damage, service interruption. The major reason of overvoltage is sudden changes in the operating conditions of an installation such as switch in, switch-out or sudden change in load, the opening of circuits with large inductance or capacitance. The interruption of a short circuit current, the appearance of an arc fault between one phase and ground, as well as other circuit disturbances are responsible for the voltage fluctuation.

2. Power quality and its problem

Power quality determines the fitness of electric power to consumer devices. In the past the equipment made were especially for the heating, lighting and motoring purposes. As such there was no equipment for sensing the voltage fluctuation. But from the recent past few decades' power quality has become a big issue. There are many such semiconductor devices which sense the voltage variation. [2]

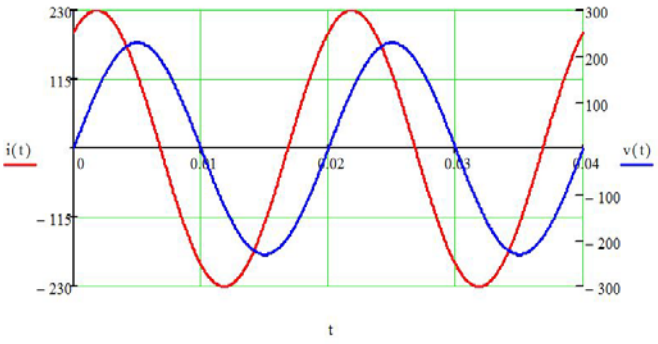

Figure 2 Voltage and Current waveform under normal condition

Causes of power quality problem:

A. Internal causes
- Switching surges
- Insulation failure or breakdown
- Arcing ground
- Sudden loss of load
- Sudden drooping of load results in generator overspeed.
- Excitations of induction motors by shunt capacitor banks.

B. External causes
- Mainly due to atmospheric conditions i.e. lightening.
- Snow formation on transmission line and storm.

Short circuit occurring in the distribution side is the major cause of power quality problem. This results in the increase in current and large voltage drop in the impedance of the supply system. [3]

Effects of power quality problem:

Power quality plays a vital role in the electrical equipment. Different equipment has different power ratings and works on different voltage. Any change in the supplied power to the equipment results in damage. If there is no occurrence of failure, there will be possibility of heating and losses in the equipment.
- Harmonics are added to the supply voltage which is responsible for the rise in voltage and may be susceptible to the equipment failure.
- The performance of the transformer, rotating machines, capacitors, and fuses is poor and noise is produced.
- Poor power quality results in heating of equipments.
- Failure of power system equipment and customer load is caused due to sudden rise in voltage. [4]

3. Undervoltage

An undervoltage is the decrease in rms ac voltage to less than 90% at the power frequency foe a duration longer than 1 minute. Undervoltage is that voltage which is below the optimum operational value of the equipment. This voltage may produce a malfunction of customer equipment. For example, data losses in the computer are due to undervoltage. A sudden drop in the root mean square (R.M.S.) voltage is called under voltage. It is mainly due to short circuits, starting of large motors and equipment failure. [5]

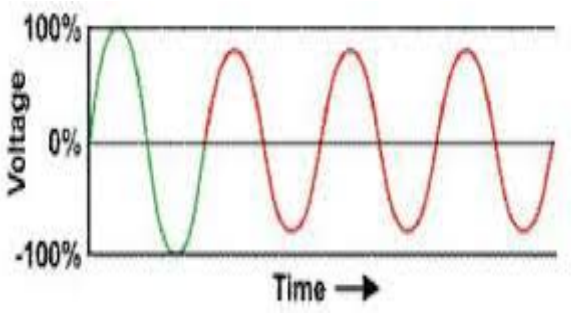

Figure 3: Under voltage waveform of voltage with respect to time

Table: 1 Types of under voltage

Type of undervoltage	Duration	Magnitude
Instantaneous	0.5 – 30 cycles	0.1 – 0.9 pu
Momentary	30 cycles – 3secs	0.1 – 0.9 pu
Temporary	3 secs – 1 min	0.1 – 0.9 pu

Causes of under voltage:

Undervolatge causes quite severe disturbances in the power system such as failure of sensitive components and production losses. There are many causes which are responsible for the undervoltage in the system.
- When there is sudden opening of circuit breaker, the feeding line is disconnected from the load and other feeder line is connected to the load. In this case the changing of the feeder is acting as undervoltage. Hence closing and opening of circuit breakers acts as a undervoltage in the power system
- Due to fault the magnitude of the voltage can be reduced which result in the failure of the plant equipment.
- Transformer energizing is the cause of undervoltage and this is unsymmetrical in nature.
- Insulation breakdown and short circuits cause failure of electrical components.
- Due to lightening strike the power line causes undervoltage.

Prevention of undervoltage:

An undervoltage relay is used which is specially designed for the protection of the electrical components from the undervoltage system. An undervoltage relay is operates when the voltage decreases to below the limit and closes its contact. Hence the equipment is protected from being undervoltage.

4. Overvoltage

An overvoltage is the increase in rms ac voltage from 1.1 pu to 7.8 pu at the power frequency ranging from half cycle to 1 minute. Overvoltage is that voltage which is above the optimum operational value of the equipment.
Undervoltage is more common than overvoltage and both occur due to the fault in the system. Single line to ground fault causes overvoltage in the system which in turn raises the voltage in the other phases. Disconnection of the heavy loads or switching on the capacitors banks results in overvoltage.

Causes of overvoltage:

- A phase to ground fault on the system may results in rise in the phase to ground voltage on other phase. The magnitude depends upon the system characteristics, type of system neutral earthing and the system connecting when the fault occurs.
- Sudden loss of load generally results in a rise in system voltage, since the impedance drops in generators, transformer, and lines suddenly disappear.
- The sudden dropping of load results in generator overspeed.
- Overvoltage is caused due to switching transients.
- Excitations of induction motors by shunt capacitors banks causes overvoltage in the power system.
- Employing salient pole machines without damper windings.

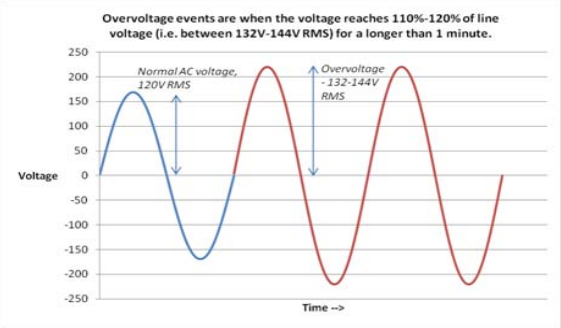

Figure 4: Overvoltage waveform of voltage with respect to time.

Energization of capacitor bank is the main reason of overvoltage. It can be also cause by sudden load deduction. Due to disconnection of the load from the supply the current decreases which further gives rise to the voltage.

V = L (di/dt) where L = inductance of the line.

Table: 2 Types of overvoltage

Type of overvoltage	Duration	Magnitude
Instantaneous	0.5 – 30 cycles	1.1 – 1.8 pu
Momentary	30 cycles – 3secs	1.1 – 1.4 pu
Temporary	3 secs – 1 min	1.1 – 1.2 pu

The effects of overvoltage are more severe and destructive than undervoltage. In this case the equipment gets overheated and cause to the failure and which are not repaired, so they can only be replaced. [6]

Prevention of overvoltage:

An overvoltage relay is used which is specially designed for the protection of the electrical components from the overvoltage system. An overvoltage relay is operates when the voltage increases beyond the limit and closes its contact. Hence the equipment is protected from being overvoltage.

5. Features of Relay

Whenever the fault occurs in the system the relay sense the fault and accordingly operates and isolate the faulty part of the system from the healthy part. The protection activities are considered capable when the protection operates its function accordingly. The under voltage and over voltage relay should have features as:

- Reliability- The relay should be reliable. It must operate when it is required. There are many units which go into activity before a relay operates, for example, lack of suitable current and voltage transformer may result in unreliable operation.
- Selectivity- It is the primitive requirement of the relay. The relay should have the capability of sensing the faulty part and removing from the healthy part.
- Speed- A protective relay must operate at the required speed. It should neither be too slow which may result in damage to the equipment, nor should it be too fast which may result in undesired operation during transient faults. [6]
- Sensitivity- A relay should be adequately sensitive is that it perform its operation reliably when required under the actual conditions in the system which procedure the least tendency for operation.
- Economy- The relay used in the system should cost less than the installed equipment. [7]

6. Modeling and its Control Strategy

The circuit delineated is over voltage and under voltages protection system. If the applied input voltage is more than the required input then the overvoltage relay operates and disconnects the appliances from the supply or if less than the required voltage then the undervoltage relay gets operated

and disconnect the electrical appliance from the supply.
This voltage protection circuit is arranged to develop a low voltage and high voltage tripping instrument to protect a load from voltage variation.

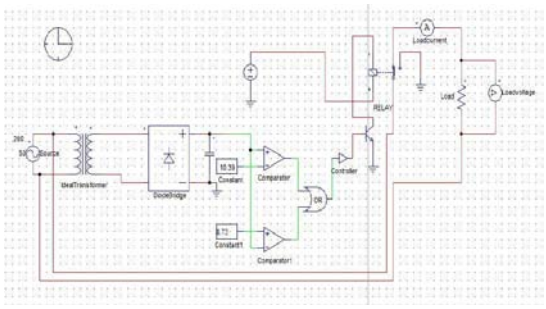

Figure 5: Overvoltage protection systems

Fluctuations in AC supply takes place frequently in homes and industries. Due to fluctuation electronic devices get easily damaged. To eliminate this problem, we can implement a tripping mechanism of under/over voltage protection circuit to protect the loads from damage. Table shows the specification of the system. In this system a comparator is used which compares the set value and the actual value. Accordingly it operates the relay for the protection of load. For operating overvoltage relay the applied voltage should be greater than the set value whereas for operating undervoltage relay the applied voltage should be less than the set value.

Table 3 : Specification of Test systems

Source	230 V, 50 Hz,
Single phase transformer	Ideal, K=23:1
Single phase diode bridge	Ideal
Capacitor	0.019 mF
Resistive load	120 Ω
D.C. voltage source (Relay operation)	12 V
Relay with 1 NO and 1 NC Changeover switches.	Coil voltage= 12 V, Operating voltage= 10 V

A 230 V AC supply is provided to the system and the load is connected.

A. Simulated Results:

Normal voltage (230 V)

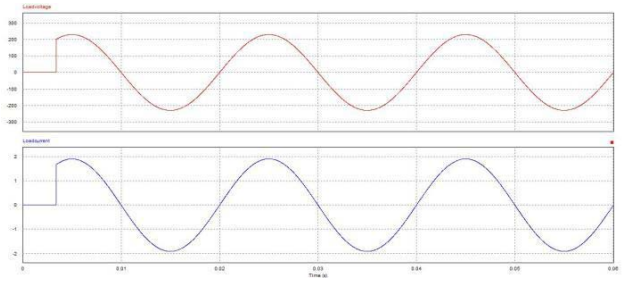

Figure 6 : Voltage and current output during normal working condition

The waveform shown above is for the load voltage and load current during normal working condition. When the supply voltage is 230 V, the control circuit sees that there is no undervoltage and overvoltage problem. So the relay allows the supply voltage to be fed to the load.

Undervoltage Condition (200 V)

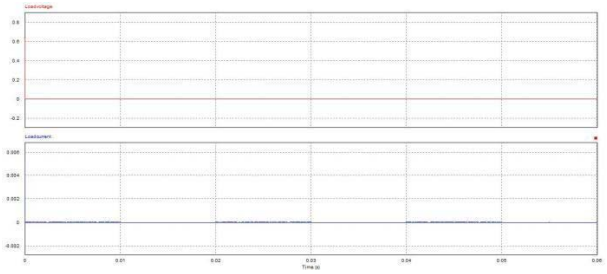

Figure 7: Voltage and current output during undervoltage condition

As it can be easily depicted from the waveform that as soon as the supply voltage is less than the lower limit of the circuit which is 200 V, is falls in undervoltage region. So it disconnects the supply to the load.

Overvoltage Condition (240 V)

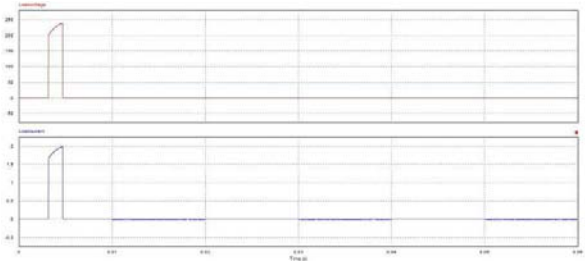

Figure 8 : Voltage and current output during overvoltage condition

In this waveform the supply voltage is 240 V, which crosses the upper voltage limit. So it falls in overvoltage criteria. The relay will see this overvoltage problem and disconnect the supply from the load. Thus saves the electrical appliances.

7. Conclusion

A power system composed of various components such as transformer, generator, transmission line, bus bar etc. Each component needs different protection as per their rating,

size etc. Both in industries and homes the protection regarding electrical component is different. The variation in the AC power supply is numerous in homes as well as industries. As we know that under voltage and overvoltage problem are very common and can create problem for consumer goods and industrial application. So the protective relays are used in homes and industries. If a fault occurs in the system then such as over voltage then this overvoltage relay operates and disconnect the load from the circuit in this way the electrical component is protected by being damaged. [8]

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8. Author Profile

Vishal Sinha pursuing in final year in Electrical Engineering from Parthivi College of Engineering & Management in 2012.

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