Tutorial Sheet 4

Ques 1. What are fundamental principles of overvoltage protection? Illustrate these principles with suitable diagram.

Ans 1. Principles of Overcurrent Protection:

Done in Tutorial Sheet 3, Ques 4.

Ques 2. Discuss the following devices used for overvoltage protection:

(1) Crowbar devices
(2) Clamping devices
(3) Isolation transformers
(4) Low Pass filters
(5) Low Impedance Power Conditioners

Ans 2. (1) Crowbar Devices:

Crowbar devices are normally open devices that conduct current during overvoltage transients. Once the device conducts, the line voltage will drop to nearly zero due to the short circuit imposed across the line. These devices are usually manufactured with a gap filled with air or special gas. The gap arcs over when a sufficiently high-voltage transient appears. Once the gap arcs over, usually power frequency or "follow current", will flow continuously in the gap until the next current zero. Thus, these devices have a disadvantage that the power frequency voltage drops to zero or to a very low

value for atleast one half-cycle. This will cause some loads to drop-off unnecessarily.

(2) Clamping Devices:

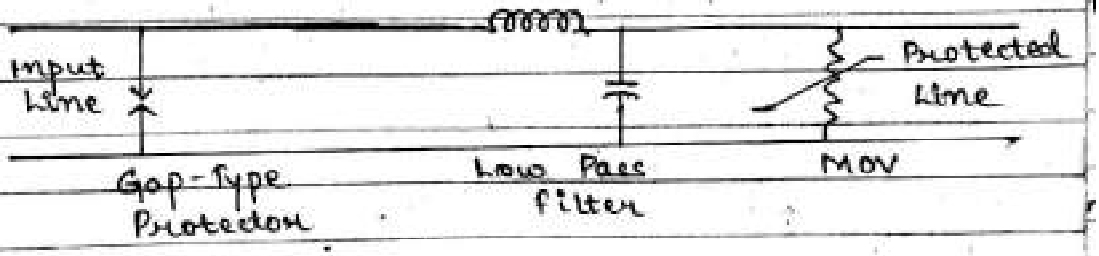
Clamping Devices for ac circuits are commonly non-linear resistors (varistors) that conduct very low amounts of currents until an overvoltage occurs. Then they start to conduct heavily, and their impedance drops rapidly with increasing voltage. These devices effectively conduct increasing amounts of current (and energy) to limit the voltage rise of a surge. They have an advantage over gap-type devices that the voltage is not reduced below the conduction level when they begin the conduction of surge current. Zener diodes are also used in this conduction application.

(3) Isolation Transformers:

The chief characteristics of isolation transformers for electrically isolating the load from the system for transients is their leakage inductance. Therefore, high-frequency noise and transients are kept from reaching the load, and any load-generated noise and transients are kept from reaching the rest of the power system. Voltage notching due to power electronic switching can be limited to the load side by an isolation transformers. Capacitor switching and lightning transients coming from the utility system can be attenuated, thereby preventing nuisance tripping of equipment.

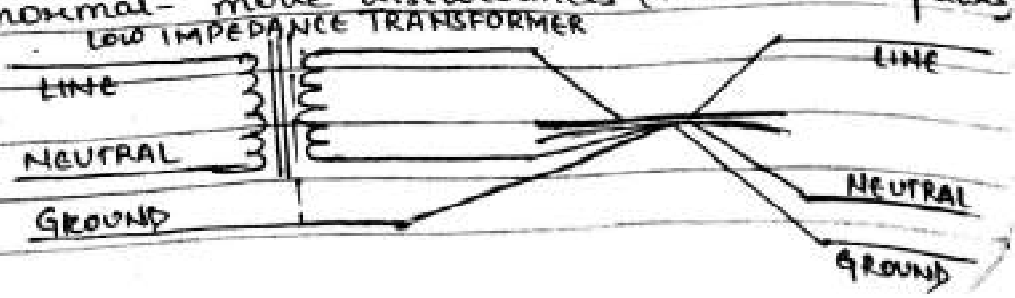
(4) Low Pass Filters :

Low pass filters use the pi- circuit principle to achieve even better protection for high-frequency transients. For general usage in electric circuits, low pass filters are composed of series inductors and parallel capacitors. This LC combination provides a low-impedance path to ground for selected resonant frequencies. In surge protection usage, voltage clamping devices are added in parallel to the capacitors. In some designs, there are no capacitors.



(5) Low Impedance Power Conditioners :

Low Impedance Power conditioners (LIPCs) are used primarily to Interface with the switch-mode power supplies found in electronic equipment. LIPCs differ from isolation transformers in that these conditioners have a much lower Impedance and have a filter as a part of their design. The filter is on the output side and protects against high-frequency, source-side, common-mode and normal-mode disturbances (noise and impulses)

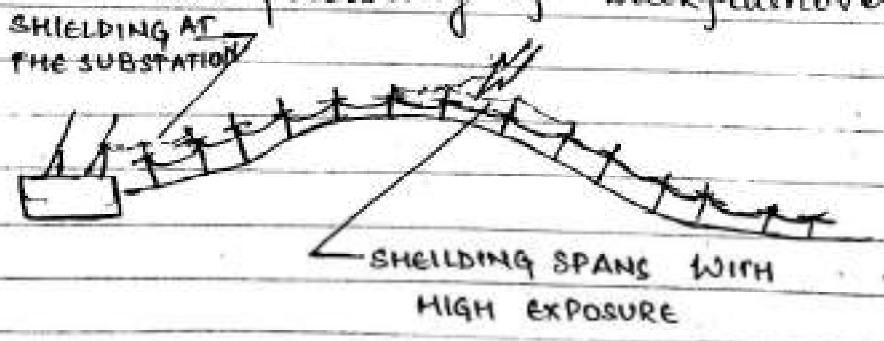


Ques 3. Explain the various strategies for utilities to use to decrease the impact of lightning.

Ans 3. Strategies to Decrease the Impact of Lightening:

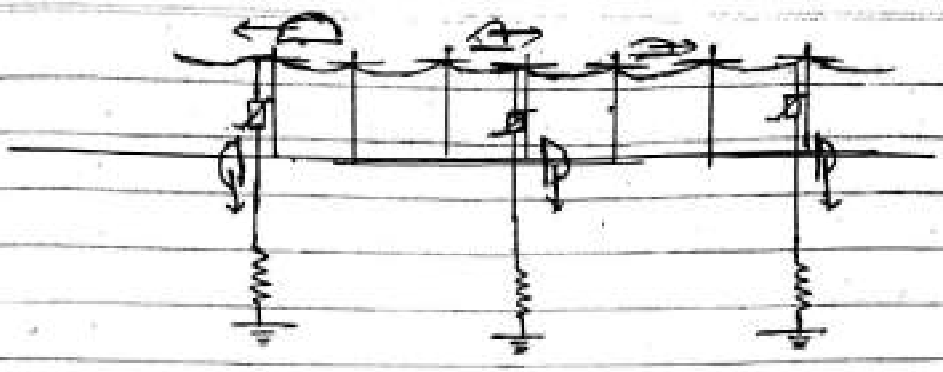
(1) Shielding:

One of the strategies open to utilities for lines that are particularly susceptible to lightening strikes is to shield the line by installing a grounded neutral wire over the phase wires. This will intercept most lightning strokes before they strike the phase wires. This can help, but will not necessarily prevent line flashovers because of the possibility of backflashovers.



(2) Line Arresters:

Another strategy for lines that are struck frequently is to apply arresters periodically along the phase wires. Normally, lines flashover first at the pole insulators. Therefore, preventing insulator flashover will reduce the interruption and sag rate significantly. This is more economical than shielding and results in fewer line flashovers. The arresters bleed off some of the stroke current as it passes along the line, depending on the ground resistance



(3) Cable Protection:

As a cable ages, the insulation becomes progressively weaker and a moderate transient overvoltage causes breakdown and failure. Many utilities are exploring ways of extending the cable life by arrester protection. Some other options are:

(1) Add an open-point arrester if one is not installed.

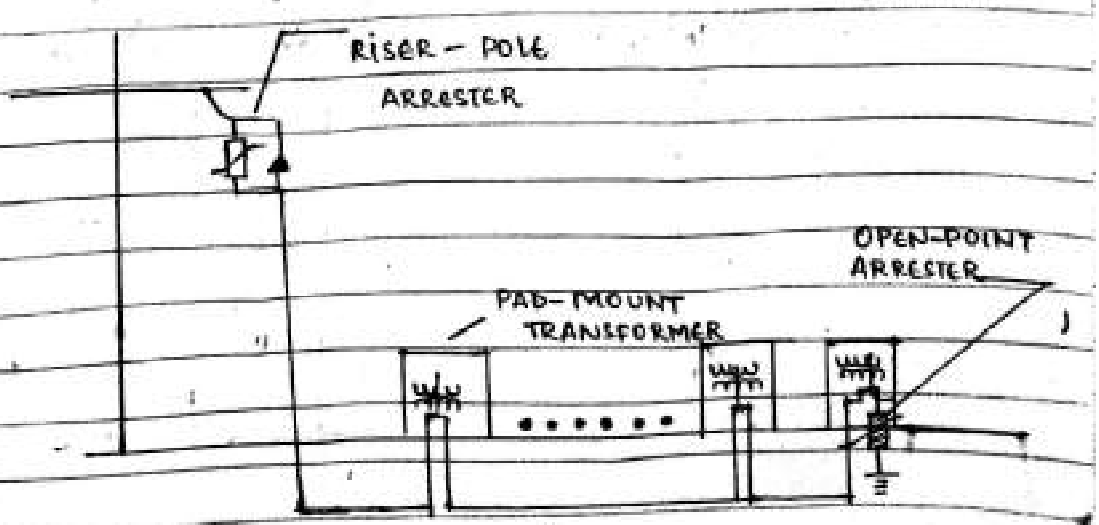
(2) Add a third arrester on the next-to-last transformer.

(3) Add arresters at every transformer.

(4) Add special low-discharge voltage arresters.

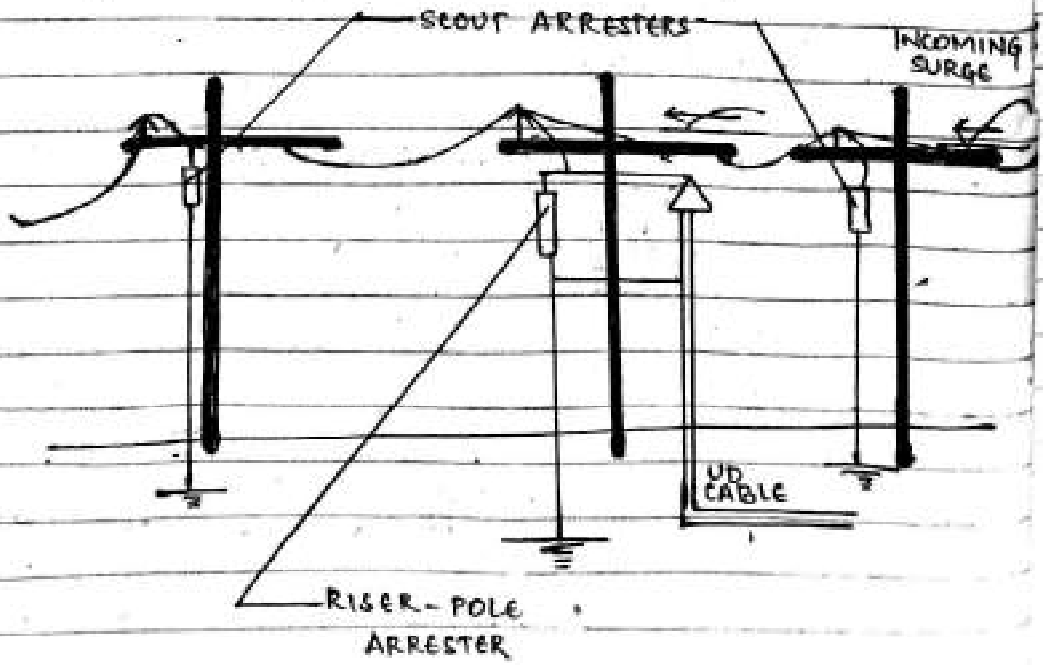
(5) Inject an insulation-restoring fluid into the cable.

(6) Employ a secondary arrester scheme on the primary.



(4) Scout Arrester Scheme:

In this scheme, arresters are placed on either side of the riser-pole arrester to reduce the lightning energy that can enter the cable. The incoming lightning surge current from a strike down-line first encounters a scout arrester. A large portion of the current is discharged into the ground at that location. A smaller portion proceeds on to the riser-pole arrester, which now produces a smaller discharge voltage. It is this voltage that is impressed upon the cable. To further enhance the protection, the first span on either side of the riser pole can be shielded to prevent direct strokes to the line. The greatest benefit of the scout scheme may be that it greatly reduces the rate of rise of surge voltages entering the cable. The scout scheme practically eliminates these from the cable.

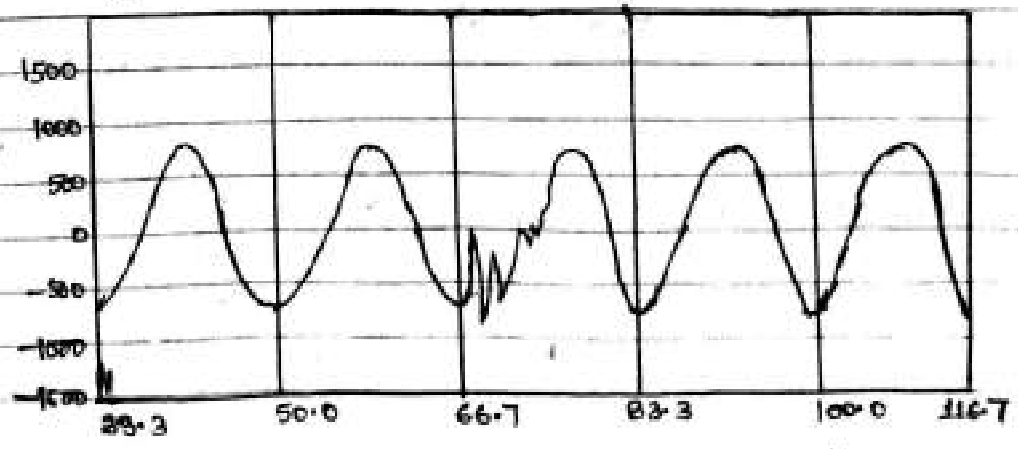


Ques 4. Describe load switching transients. Also discuss different protections needed to overcome the load switching transient problems.

Ans 4. **Load switching transients:**

De-energizing inductive switching circuits with air gap switches, such as relays and contactors, can generate bursts of high-frequency impulses. There is very little energy in these types of transients due to the short duration, but they can interfere with the operation of electronic loads.

Such electrical fast transient (EFT) activity, producing spikes upto 1 kV, is frequently due to cycling motors, such as air conditioners and elevators. Transients as high as 3 kV can be caused by operation of arc welders and motor starters. The duration of each impulse is short compared to the travel time of building wiring, thus the propagation of these impulses through the wiring can be analysed with travelling wave theory. The impulses attenuate very quickly as they propagate through the building.



Protection from Load Switching Transients

(1) In most cases, the only protection needed is electrical protection, through separation. Physical separation is also required because the high rate of rise allows these transients to couple into nearby sensitive equipment.

(2) EFT suppression may be required with extremely sensitive equipment in close proximity to a disturbing load, such as a computer room. High frequency filters and isolation transformers can be used to protect against conduction of EFTs on power cables. Shielding is required to prevent coupling into equipment and data ~~test~~ lines.

Ques 5. Explain the effect of following a.c. sources of transient overvoltages :

(1) Capacitor switching
(2) Magnification of capacitor switching transients
(3) Lightning

Ans 5. (1) Capacitor Switching :

Done in Tutorial Sheet 3, Ques 3, Part (1)

(2) Magnification of capacitor Switching Transients:

(1) Transient overvoltages on the end-user side may reach as high as 3.0 to 4.0 p.u on the low voltage bus on magnification, with

potentially damaging consequences for all types of customer equipment.

(2) Magnification may lead to a rise of approximately 1.8 times in the normal peak voltage (1.8 pu), causing heavy damage to sensitive equipments that might only have a withstand capability of 1.75 p.u.

(3) In many cases, there are only a small number of load devices, such as adjustable-speed motor drives, that are adversely affected by the transient.

(3) Lightning :

Done in Tutorial Sheet 3, Ques 3, Part (2).