Bowthorpe EMP, TVC Transient Voltage Clampers

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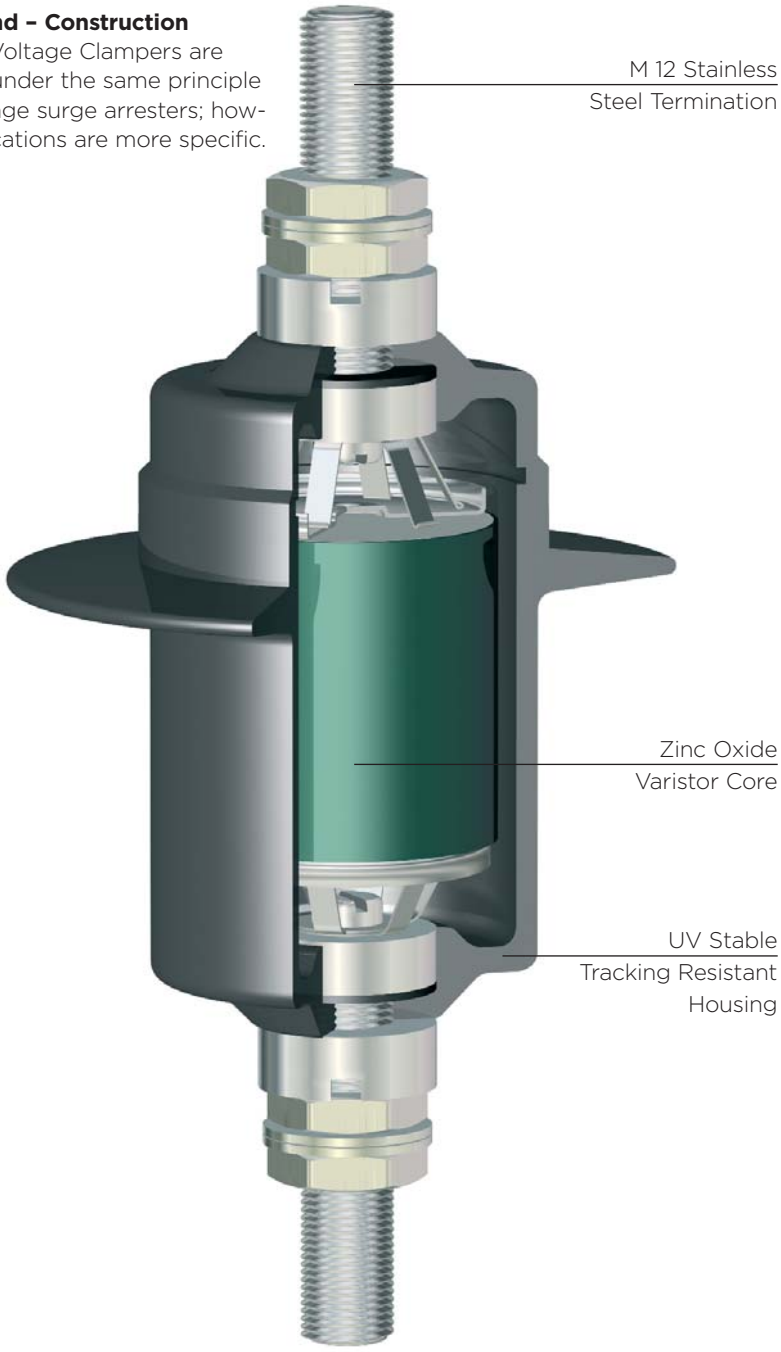
Introduction
In the UK where severe lightning is often accompanied by poor pole earthing resistance, the secondary LV distribution system is subjected to high voltage surges due to lightning current seeking alternate ground paths through the low-voltage circuits. The typical mode of failure of a pole mounted transformer is for the low voltage winding to flash over to the transformer tank due to the relatively high voltage developed across the pole earth resistance. The high voltage arrester does not prevent this type of failure. However, to remove this source of failure (or back flashover) a TVC may be placed between the neutral bushing and the tank.

What is a Transient Voltage Clamper, TVC?
A TVC is used to protect against the internal failure of a pole mounted transformer (PMT) due to "back flashover" between the transformer tank and the LV winding bushing. A "back flashover" on a PMT will cause permanent damage to the transformer internal solid insulation.

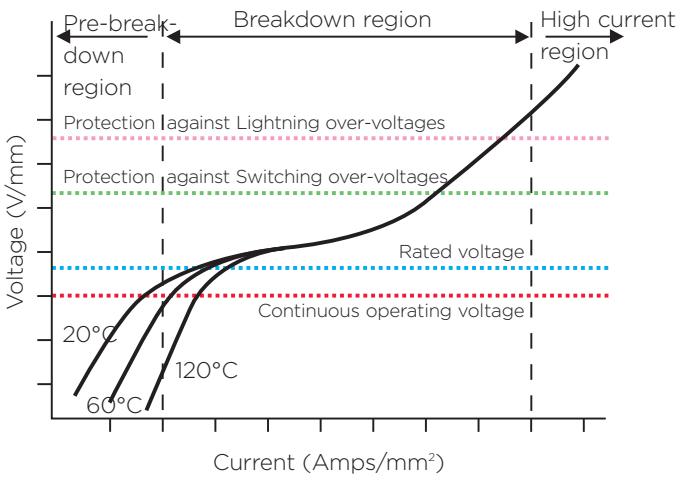
Conditions of Use?
1) TVC's are useful when there is very high resistivity pole grounding conditions e.g. hot, sandy, rocky ground. Under these soil conditions an earth resistance of 10 ohms or less may be difficult to achieve; resistance maybe variable throughout the year.
2) TVC's are useful when the LV earth "downstream" from the PMT is lower than at the pole earth resistance.
3) Best used in conjunction with HV and LV surge arresters (cannot be used instead).

Principle of Operation
TVCs incorporate a gapless metal oxide varistor, MOV design that under steady state conditions maintains the line-to-ground voltage across the TVCs terminals. When overvoltages occur, the TVC conducts current to earth, limiting the overvoltage to below the required protection levels. Upon passage of the overvoltage condition, the TVC returns to a highly non-linear steady state condition that conducts very minimal 10's of Hz power current.

Background – Construction
Transient Voltage Clampers are designed under the same principle as LV voltage surge arresters; however applications are more specific.



Current-voltage characterisitc for Zno varistor



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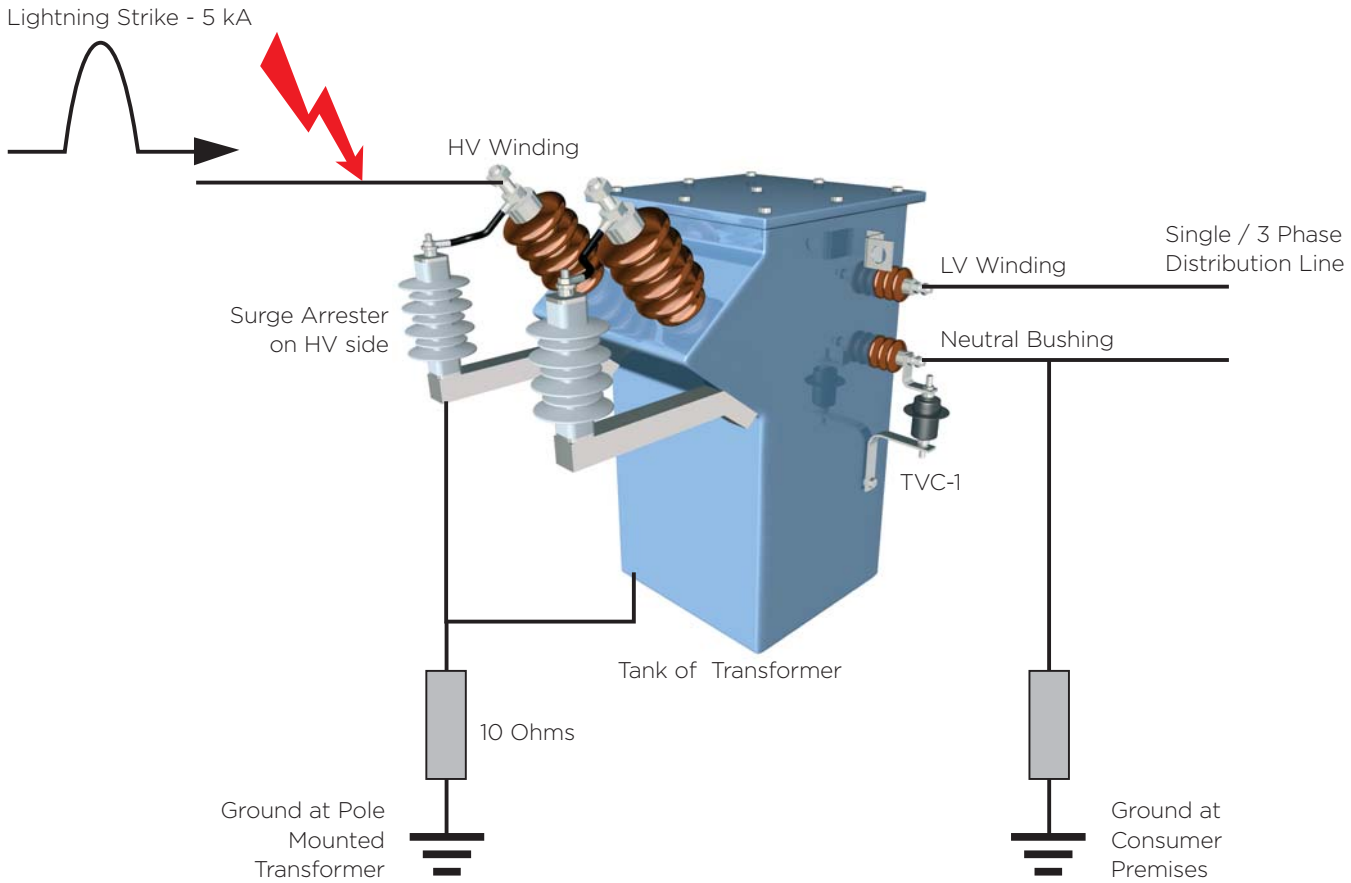
Application Diagram



Example Problem: A moderate lightning current of 5kA flowing to earth into a resistance of 10 ohms will raise the tank of the transformer to 50kV as V = IR. Typically the impulse breakdown voltage of the LV winding to the transformer case is 30kV. The tank voltage due to 10 ohms earth resistance can cause a breakdown between the tank and a low voltage bushing of the transformer. Any back flashover will drive high current through the low voltage windings when striking the phase connections. These high currents are driven by the power frequency flow current.

Solution: To remove the back flashover a suitable device must be connected between the neutral bushing and the tank of the transformer, hence a TVC should be installed. In order to be compatible with standard auto recloser operations in the event of a fault, the device must be able to withstand the phase to earth voltage for at least 10 seconds.
LV and HV surge arresters cannot be used instead of a TVC.
LV Surge arresters: The LV arrester should be used in lightning prone exposed areas to give additional protection. They should be installed on the low voltage system, on the first pole down stream from the transformer.

HV Surge arresters: The HV arrester should be fitted to the high voltage bushings (connections under 300mm in length to limit voltage drop). The installation of the HV arrester prevents damage to the insulation on the HV winding and the transformer case.
Note: The HV arrester will not stop back flashovers across the low voltage bushings, but will limit the power follow-current, hence this is the reason why TVC's should be used.
Tips: To reduce the voltage on the tank of the transformer, it is advisable to have low values of earthing resistance connected to the tank, approximately 5 ohms or less. To achieve an optimum overvoltage protection, connecting leads should be as short as possible.