SELECTING SURGE PROTECTIVE DEVICES FOR ELECTRICAL SYSTEMS WITH HIGH RESISTANCE GROUNDING

SURGE PROTECTION NOTE 4

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INTRODUCTION

The awareness of electrical safety has increased over the past 10-15 years which has caused many companies to consider different electrical system designs in an attempt to control or eliminate the hazards that their employees are potentially exposed to. Companies also have to consider the reliability of their electrical power system in an attempt to limit unnecessary or unscheduled stoppages in production, which could cost the company thousands of dollars in lost revenue. The use of high resistance grounding (HRG) systems is one of the tools that plant engineers have used over the years to limit the magnitude of phase to ground faults, but also allow process equipment to continue functioning until scheduled maintenance can isolate and resolve the issue.

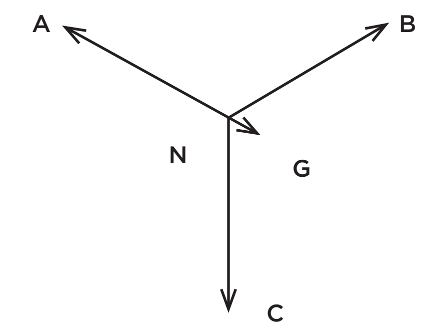
Plant engineers also use surge protective devices (SPDs) to protect sensitive process equipment from prolonged exposure to electrical system voltage transients that can shorten the life of this equipment, halt production and cause costly downtime. The tech topic is intended to assist plant engineers and maintenance professionals with determining the best SPD for transient protection when HRG systems are applied within their facilities.

HIGH RESISTANCE GROUNDING:

High resistance grounded (HRG) electrical systems are typically designed such that the fault-current during an initial phase-ground fault is limited to 10 amps or less. This is accomplished by placing a resistor between the transformer neutral and system ground. The relatively low amount of fault current allows the plant owner to keep the electrical system running until the initial fault can be located and maintenance scheduled to clear the fault or a second phase-ground fault occurs which would require protective device opening.

TERMS

- **HRG:** High Resistance Grounded
- **TPMOV:** Thermally Protected Metal Oxide Varistor
- **SPD:** Surge Protective Device
- **MOV:** Metal Oxide Varistor

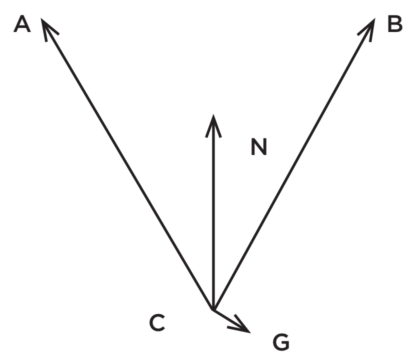


Unfaulted Condition:

$V_{ag}=V_{bg}=V_{cg}$

$V_{ac}=V_{bc}=V_{ab}$

$V_{ng}=0$



Faulted Condition:

$V_{cg}=0$

$V_{ag}=V_{ac}$

$V_{bg}=V_{bc}$

Figure 1: HRG systems during unfaulted and faulted conditions

HRG systems do have pitfalls to be aware of. First, no line-neutral loads can be served in these systems. The neutral is not distributed in HRG systems. Second, system capacitive reactance must be higher than the resistance value of the resistor to avoid transient overvoltage issues. Last, during the time the initial phase-ground fault is on the system, the un-faulted phase's potential with respect to ground will rise to the phase-phase potential. Any equipment insulation ratings and Maximum Continuous Operating Voltage (MCOV) ratings to ground must be rated for the full line-line voltages of the system. This would include items such as cables, L-G filtering systems, and L-G Surge Protective Devices. See figure 1 to further understand voltage levels of HRG systems during unfaulted and faulted conditions.

SPD TECHNOLOGY:

There are many different types of devices that make up the core component of SPD technology; however, for this particular application guide we will discuss the metal oxide varistor (MOV) since it has been used by a large majority of SPD manufacturers for many years. The MOV is essentially two metal plates with granular zinc oxide separating them and has a specific voltage rating determined by the overall thickness of the device (figure 2).

The device passes current from phase to ground when it is subjected to voltage transients that exceed its predefined rating thus preventing important loads from being exposed to voltage transients that could cause expensive repairs or replacement. These devices work exceptionally well; however they are inherently flawed because as they operate to protect equipment each operation causes the MOV to approach its "end-of-life". This "end of life" is the MOV's thermal runaway point in which the device fails closed (shorted) as many semi-conductor components do. This event can quickly become a dangerous electrical hazard as the system fault current rushes to the resulting phase-ground fault created and can quickly become a 3-phase fault provided there is not adequate disconnecting means.

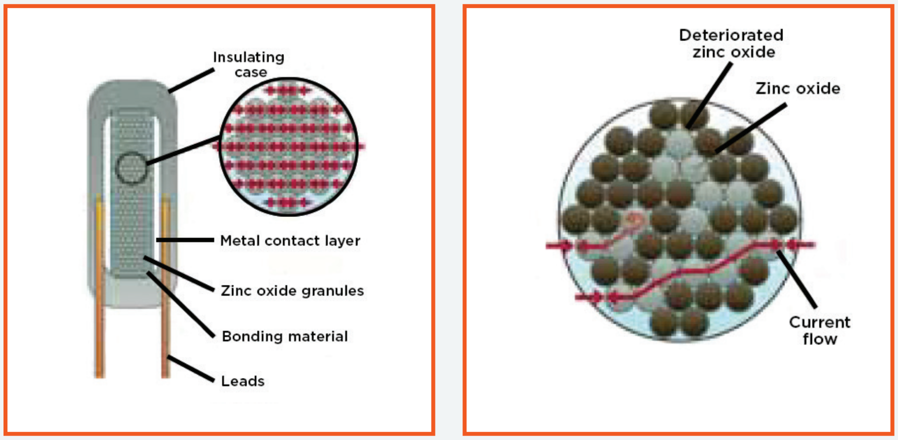


Figure 2: Cross Section of MOV

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It is this potential electrical hazard that led Mersen to develop the thermally protected MOV (TPMOV®) which completely disconnects the MOV from the electrical system prior to its thermal runaway point thus preventing catastrophic system failures and unnecessary downtime. See the TPMOV performance video by clicking here

APPLYING SPD TO HRG SYSTEMS:

As explained earlier, HRG Systems require that a resistor is installed between the Neutral and Ground on a 480/277V transformer secondary essentially making the 3-phase 4-wire wye transformer secondary a 480V 3-phase 3-wire system since no neutral will be carried out of the service entrance to downstream loads. The mistake that could be made is installing a SPD device that is designed for 480/277V wye systems because the secondary is technically a grounded wye. This misapplication would cause the SPD to prematurely reach its end-of-life. An example is that it is very common to use a MOV or TPMOV with a 320V MCOV because the line-ground voltage in a 480V grounded wye system is 277V. The 320V MCOV would be the appropriate sized device for a traditional 480V grounded wye system; however, when a HRG is applied to the 480V grounded wye system the line-ground potential will equal the line-line potential (480V) when a line-ground fault occurs as illustrated in figure 1. Since HRG systems are employed to keep 3-phase loads operating for extended periods of time with a sustained line-ground fault the difference in voltage from 277V to 480V would be seen as a sustained over voltage to the 320V MCOV MOV or TPMOV thus causing the device to rapidly reach its end-of-life. The proper protection for a HRG system would be a device with a MCOV that is 115-135% larger than the 480V nominal line-line voltage on the system which would prevent the SPD from having an express end of life. Typically, 550V MCOV MOVs or TPMOVs are used. Note: the example above can also be applied to 600V systems that are high resistance grounded. The MCOV values would change from 420V to 690V in those applications.

RECOMMENDATIONS:

It is critically important with SPD application to 3-phase power systems, that the system grounding configuration is known before specifying or choosing a SPD. The most common failure modes of SPDs are due to misapplication. To avoid issues with failure of the SPD, the MCOV ratings should be such that they exceed the system line-line voltages. For HRG systems, most SPD manufacturers supply a device that is dual-rated for Delta and HRG systems. These devices will have the higher MCOV ratings necessary. Utilizing correctly rated equipment can help to increase SPD component life as well as system safety. Always consult the device manufacturer for proper application.

For Service Entrance Panels: Mersen's STXP, STXT, or STZ series products rated 480V Delta 3P-3W configurations (part builder code 480D). Web Link

For Distribution/Branch Panels: Mersen's STXR, STXP, or STXT series products in 480V Delta 3P-3W configurations (part builder code 480D). Web Link

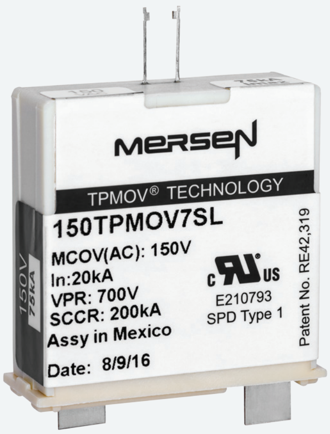

Figure 3: Mersen's Patented Thermally Protected MOV (TPMOV)

SURGE PROTECTION PRODUCTS FROM MERSEN

TPMOV®

Mersen's patented TPMOV (Thermally Protected Metal Oxide Varistor) eliminates common destructive failure modes associated with standard MOVs. Comprised of a voltage clamping device and a disconnecting apparatus that monitors the status of the metal oxide disk inside the TPMOV, the device is securely disconnected in the event of an overvoltage by an arc shield. Upon failure, the TPMOV is also equipped with a visual pin indicator as well as a normally open microswitch providing remote indication, if applicable.

TPMOV

Surge-Trap® NEMA Type 1 SPDs

Mersen's Surge-Trap NEMA Type 1 SPD line includes six surge protection products designed and manufactured by Mersen with the latest materials, layouts, and components, including the industry-leading TPMOV Technology. All are NEMA devices for ANSI/UL 1449 Type 1 and 2 applications, indoor and outdoor use, and provide UL96A lightning protection plus a variety of other features and benefits to meet clients' needs. To aid partners offering Mersen products, the company designed an intuitive cataloging system and partner portal that makes it easy to compare features and quickly find the right product for customers. For more information regarding Mersen's surge protection products, visit: ep-us.mersen.com/surge-trap.

Surge-Trap® NEMA Type 1 SPDs

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ADDITIONAL RESOURCES

Surge Protection Note 1: Introduction to Specifying Surge Protection

Surge Protection Note 2: Surge-Trap® and the Different kA Ratings

These and other Tech Topics are available on ep.mersen.com.

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