ELECTRO MECHANICS

Abstract from White Paper

“Interlocked Combined Breaker Grounding Switch (VDH/GSMI) provides better protection for insulation coordination than a grounding transformer. We present the reasons why”

November 2017

INTRODUCTION

- While both the VDH/GSMI and the grounding transformer provide protection for insulation coordination in wind and solar power plants, **the VDH/GSMI provides better protection by reducing incident energy and eliminating temporary over voltage (TOV)**

- During single line to ground faults, the VDH/GSMI provides a clear signal for the WTGs to turn off, whereas the grounding transformer provides a source for zero sequence current, a path to ground **that does not pass active power**.

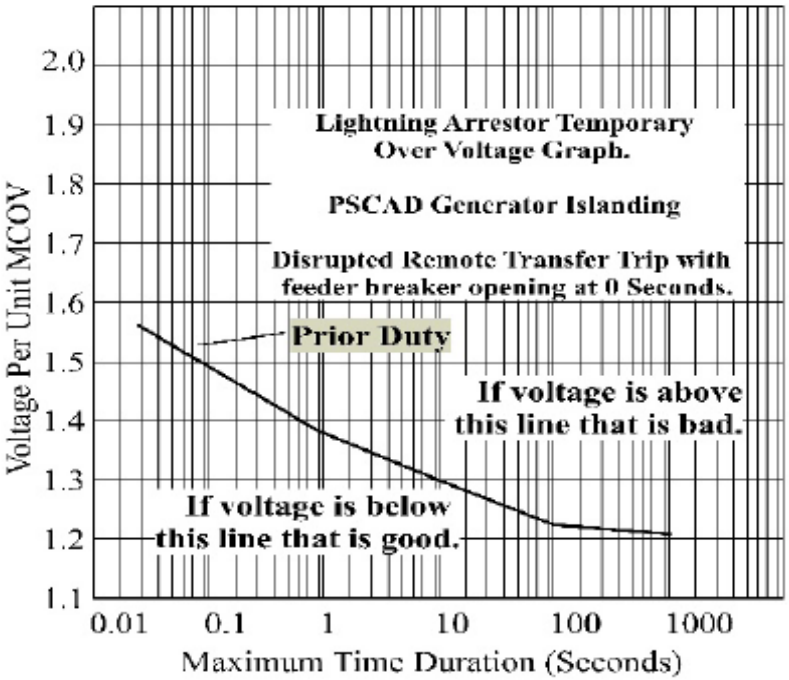
- The impedance to ground included with a grounding transformer causes a loss of insulation coordination and diminishes the safety and reliability of the collection circuit over time.

- VDH/GSMI overcomes the grounding transformer's limitations and provides a superior very low impedance path to ground.

- The lightning arrestor and duty curve are critical for protecting wind and solar power plants. If the lightning arrestor fails, a voltage rise on the collection circuit will damage any equipment that is connected electrically.

- **PSCAD simulations** show that when a feeder is separated from the grid with the generators still running and attempting to produce power, the TOV duty curve of lightning arrestor is typically exceeded, and change its I-V characteristic; as a result, it may fail to open, close, or reduce its current conducting characteristics, depending on failure mode.

- When TOV is eliminated during opening of the circuit breaker and subsequent very fast connection to ground provided by the VDH/GSMI, the lightning arrestors are operated below their duty curve, insulation coordination of the feeder circuit is maintained, and equipment is more reliable.



SLG FAULT IN COLLECTION FEEDERS AND GROUNDING TRANSFORMERS

- When a single line to ground (SLG) fault occurs, there are basically two objectives with protecting the collection circuit.

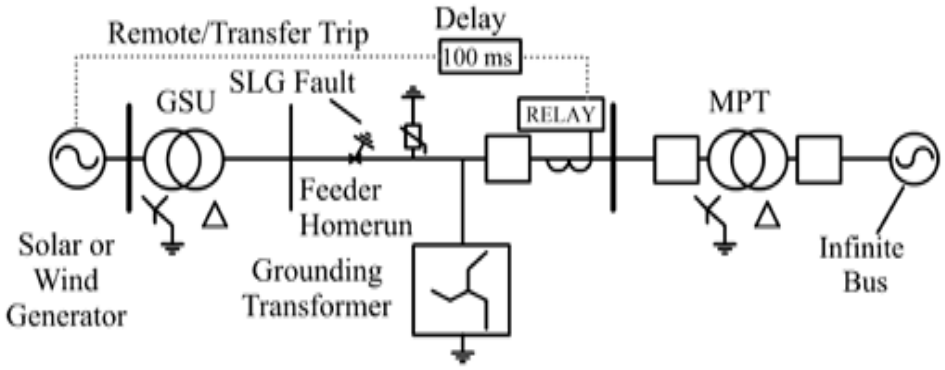
- First objective is **clearing the fault from the grid** to reduce both the incident energy and the time that personnel and equipment are exposed to the huge fault currents sourced from the transmission system. When the feeder breaker operates first and clears the plant from the fault, high current from the transmission system is limited in time, and that is good. However, TOV in the collection circuit can present a problem, since the generators may be islanding.

- Second objective is to **get the generators to shut down without islanding**; this objective competes with the first objective of quickly opening the feeder breaker. It could take 200 milliseconds for the signal to reach the generators and order them to shut down.

- **Islanding** occurs when all or a portion of the power generated by a power plant becomes electrically isolated from the remainder of the electric power system. For example, when a collection circuit producing power at 24 MW separates **severe islanding occurs**.

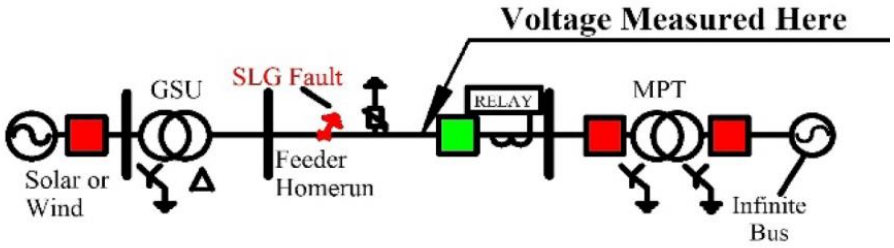
- Some designers place a **grounding transformer** on the collection circuit when trying to avoid TOV. In certain cases, however, the grounding transformer will not be effective when it comes to reducing TOVs and subsequent damage to the lightning arrestors.

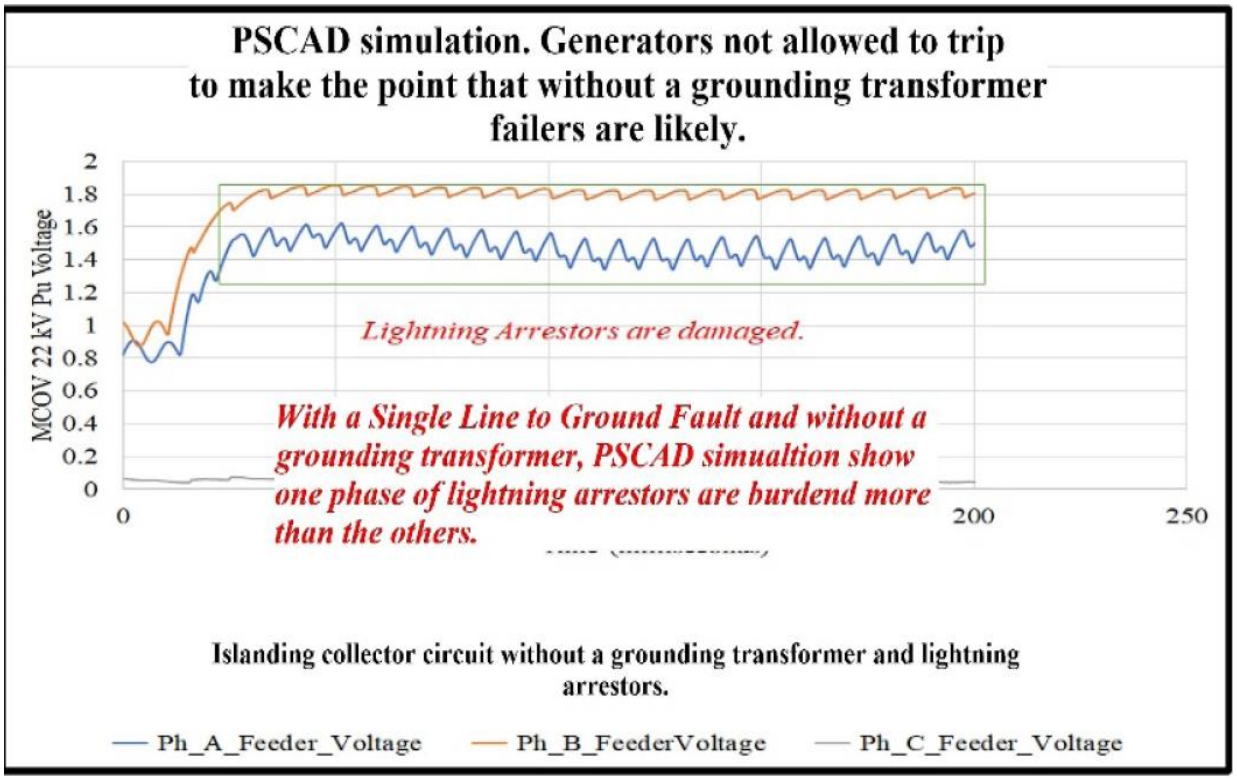
- Grounding transformers connected to collection circuits provide a zero sequence path to ground **but do not provide a positive or negative sequence path to ground**.



- Grounding transformers provide a relatively low zero sequence impedance, however, the **impedance is not low enough** to prevent a severe voltage rise during a fault followed by a severe islanding event, **as shown in the PSCAD simulations**.

PSCAD SIMULATION: ISLANDING WITHOUT GROUNDING REFERENCE

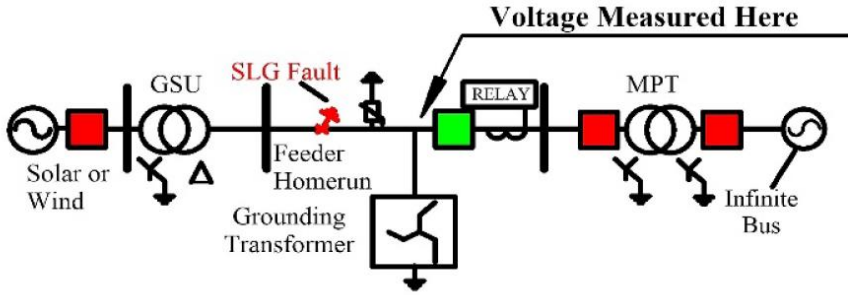


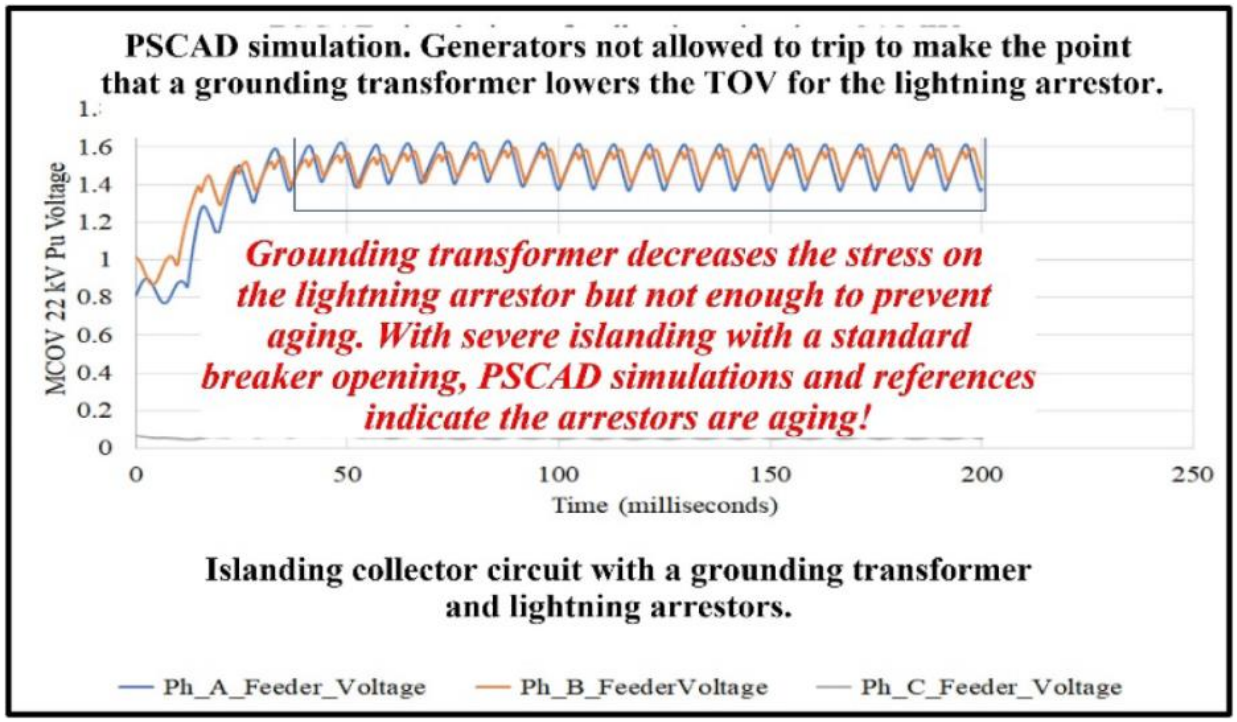


TOV is really bad and dangerous

PSCAD simulations show that with a SLG fault and without a grounding reference, lightning arrestors are quickly damaged due to stress.

PSCAD SIMULATION: ISLANDING WITH GROUNDING TRANSFORMER

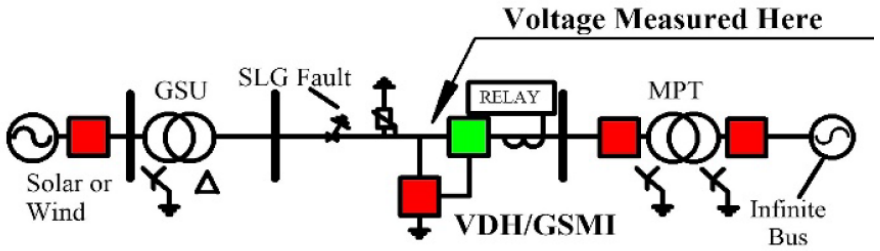


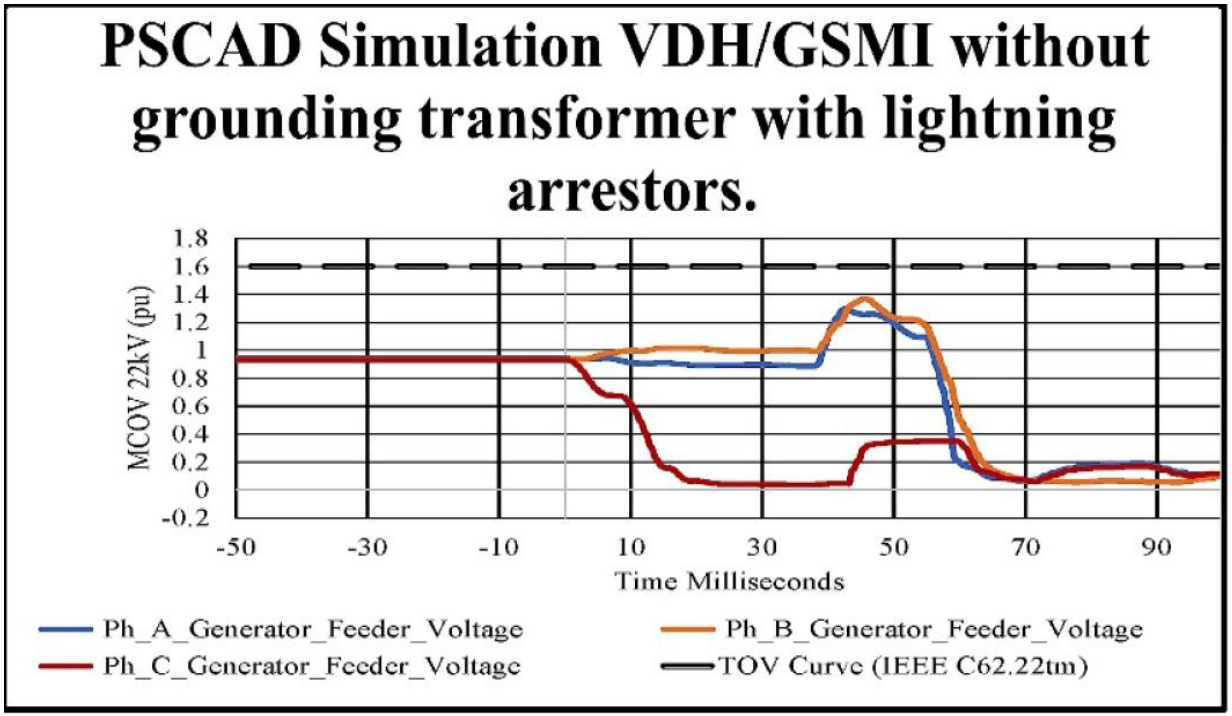


TOV is present but reduced. Anticipate accelerated aging

PSCAD simulations show that with a standard circuit breaker and a grounding transformer, severe islanding occurs and an insufficient path to ground to shunt the islanding power is created. This results in TOV and loss of insulation coordination, which in turn results in damage to the lightning arrestors.

PSCAD SIMULATION: ISLANDING WITH VDH/GSMI





No observed TOV, coordinates well with lightning arrestors and other protection.

PSCAD simulations show that the VDH/GSMI coordinates well with lightning arrestors and maintains the collection circuit's insulation coordination by keeping switching transients and temporary over voltages within the operating specifications of the lightning arrestors.

CONCLUSIONS

- During severe islanding, where the generators have not received a trip signal and shut down, the grounding transformer on the separated collection circuit **will not shunt the active power to ground and will not keep the voltage below the MCOV of the lightning arrestor**.

- The grounding transformer **splits the current and energy burden between lightning arrestors** during a fault where the feeder breaker has opened and allows the energy to be shared.

- Grounding transformers limit voltage spikes concerning transient overvoltage. However, when it comes to islanding, **they do not limit TOV**. In addition, the voltage spikes they produce may exceed the BIL of equipment connected electrically to the separated collection circuit

- PSCAD simulations show that the **VDH/GSMI resolves both issues of TOV and incident energy** where delays are not needed for clearing the fault from the plant. The VDH/GSMI completely operates within nearly 50 milliseconds to open, clear the fault, close, and ground the affected collection circuit, and thus it collapses the voltage.

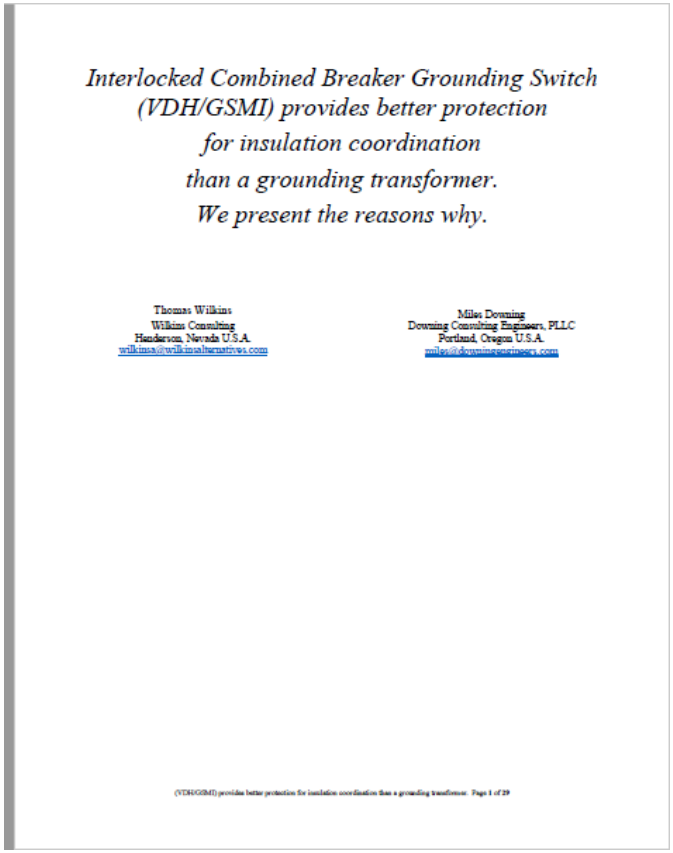
- When closed to ground, the VDH/GSMI results in a **very low impedance of the cable**. VDH/GSMI demonstrates a clear change in impedance as it operates. Generators can detect such a change and act on it.

- TOV duration is minimized by the combination of the VDH/GSMI's fast transition state and the lightning arrestors. **VDH/GSMI significantly lowers the energy burden** on lightning arrestors and protects them.

- The VDH/GSMI relieves the lightning arrestor and **keeps the resulting TOV below the duty curves**. Without a VDH/GSMI, the arrestors can be destroyed by other protection schemes. After that, if the arrestor is not replaced, expensive collection circuit equipment is damaged thereafter.

- The use of the VDH/GSMI in the design and construction of wind and solar generating projects constitutes a **best practice**.

EMA ELECTRO MECHANICS



Interlocked Combined Breaker Grounding Switch (VDH/GSMI) provides better protection for insulation coordination than a grounding transformer. We present the reasons why.

Thomas Wilkins
Wilkins Consulting
Henderson, Nevada U.S.A.
wilkinsa@wilkinsalternatives.com

Miles Downing
Downing Consulting Engineers, PLLC
Portland, Oregon U.S.A.
miles@downingengineers.com

(VDH/GSMI) provides better protection for insulation coordination than a grounding transformer. Page 1 of 29

EMA Electromechanics, Inc.
16 Industrial Drive, Sweetwater, Texas 79556, USA
+ 1 325 235 8000
info@emaelectromechanics.com
www.emaelectromechanics.com

http://emaelectromechanics.com/wp/wp-content/uploads/2017/09/EMA_WP2_VDH_GSMI_vs_Grounding_Transformers.pdf

November 2017