



Abstract from White Paper

“Concerning PRC-024-1 and PRC-024-2 Under Voltage Ride-Through Requirements the VDH/GSMI supports Differentiation between Internal and External Faults”

November 2017

INTRODUCTION: STANDARD PRC-024-2 REQUIREMENTS

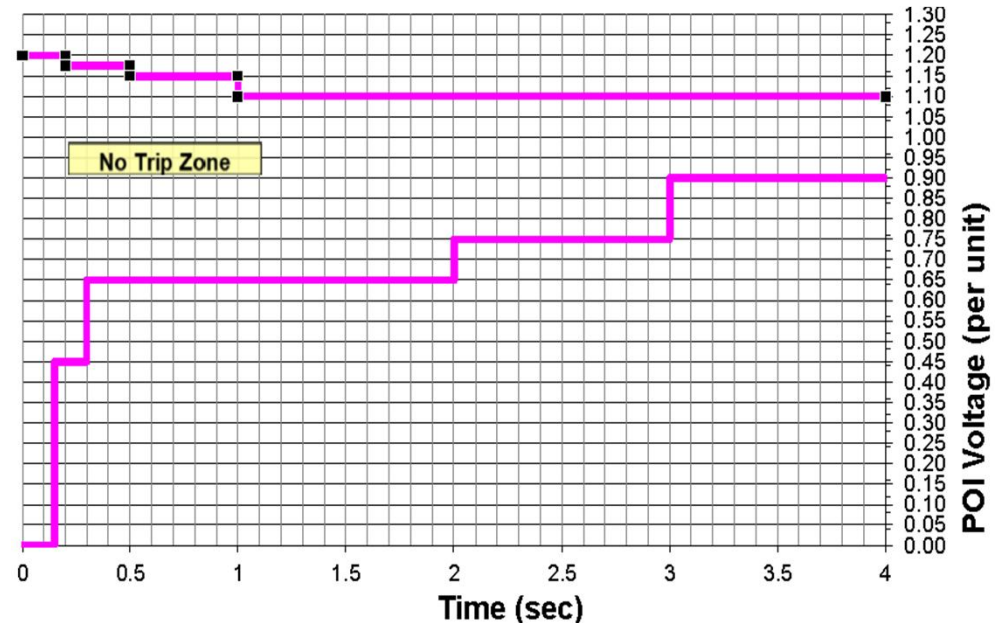
- On march 2014 Federal Energy Regulatory Commission (FERC) approved Reliability Standard PRC-024-1. Relay settings in wind and solar power plants must comply with said Standard.
- PRC-024-1 states that each Generator Owner that has generator voltage protective relaying activated to trip its applicable generating unit(s) shall set its protective relaying such that the generator voltage protective relaying does not trip the applicable generating unit(s) as a result of a voltage excursion (at the point of interconnection) caused by an event on the transmission system external to the generating plant that remains within a “**no trip zone**” of a time duration curve.
- Point of interconnection means the transmission (high voltage) side of the generator step-up transformer or collector circuit transformer.
- The **VDH/GSMI** can help wind or solar power plant designers and engineers provide the functionality required by NERC, **allowing generators to differentiate between internal faults and external faults.**

Ride-Through Duration

■ High Voltage Duration ■ Low Voltage Duration

High Voltage Ride Trough Duration		Low Voltage Ride Trough Duration	
Voltage (pu)	Time (sec)	Voltage (pu)	Time (sec)
≥1.20	Instantaneous trip	<0.45	0.15
≥1.175	0.20	<0.65	0.30
≥1.15	0.50	<0.75	2.00
≥1.10	1.00	<0.90	3.00

Voltage Ride-Through Time Duration Curve



PSCAD SIMULATION TO EVALUATE VDH/GSMI vs. PRC-024-2 REQUIREMENTS

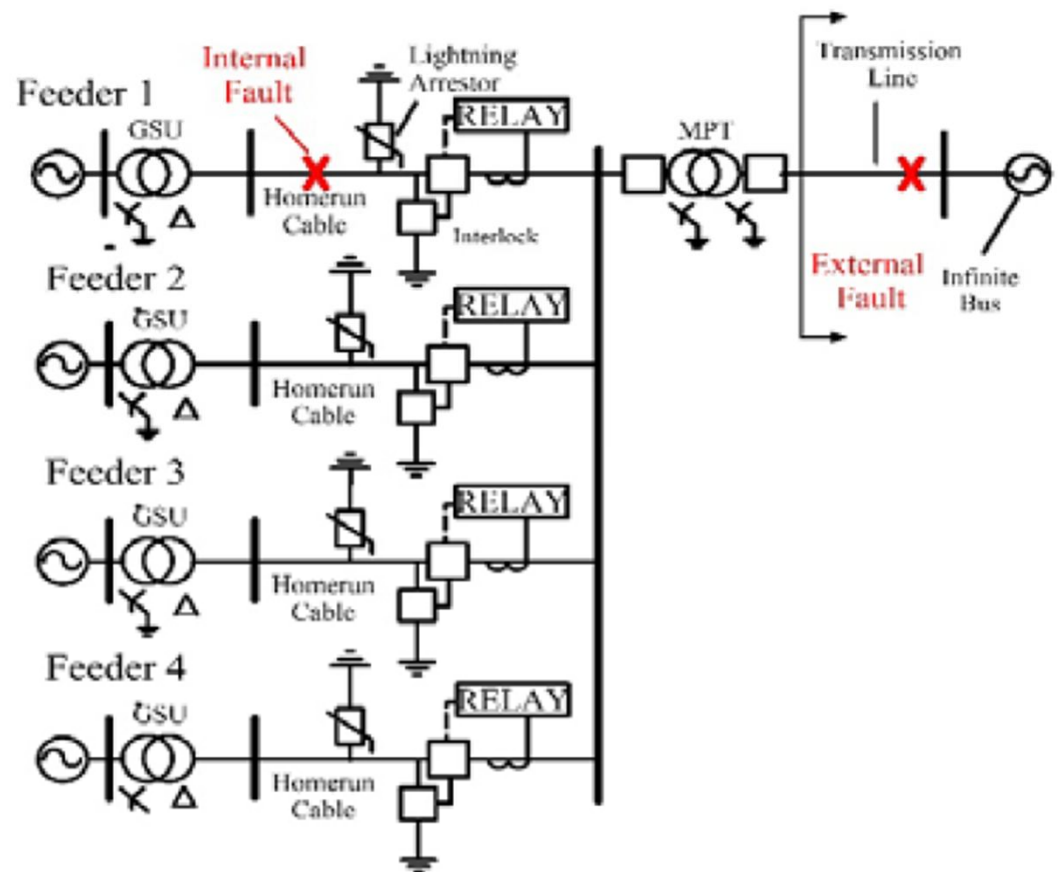
- PSCAD models show that VDH/GSMI allows generators to differentiate between internal faults and external faults.
- FERC PRC-024-1's written purpose is to ensure generator owners set their generator protective relays such that generating units remain connected during defined voltage excursions and operate down to zero percent voltage at the point of interconnect (POI) for nine cycles (150 ms).
- PSCAD simulations show the VDH/GSMI when it opens, clears the fault and then closes to ground causing the voltage at the mains of each generator on the affected circuit to go below 9% which is significantly below 15% concerning certain ride through requirements. (*)

- PRC-024-1 requires power plants set their relays so that the plant remains connected during voltage excursions, such that the generator voltage protective relaying does not trip within the “no trip zone” as measured at the POI; the no trip zone in part includes nine cycles at zero volts.

- PSCAD simulations, performed for **inverter-based generation**, indicate that **VDH/GSMI can help engineers** provide such required PRC-024-1 functionality.

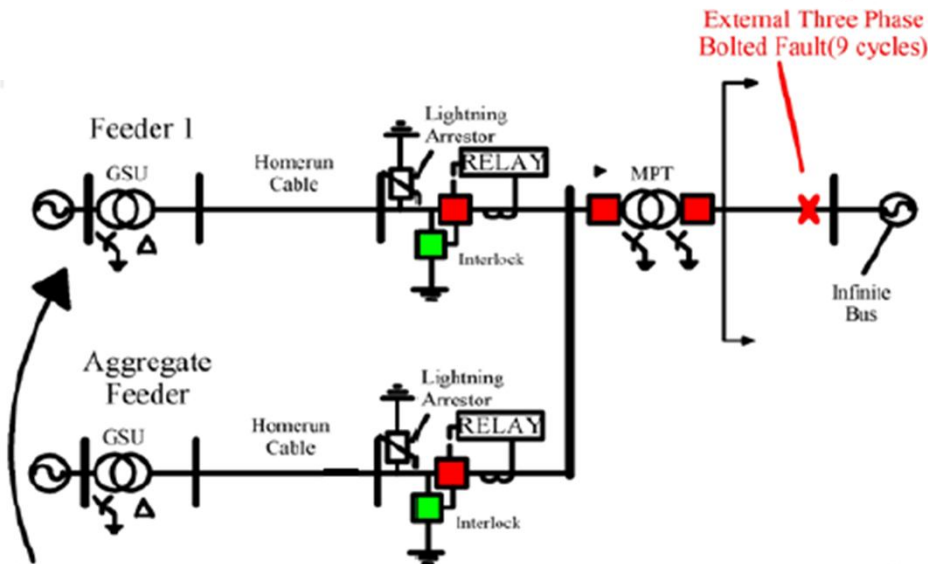
- Many types of faults can occur, within or outside a wind or solar power plant. For PSCAD simulation purposes, **the internal fault is considered as a single line fault to ground while the external fault is a three phase bolted fault.**

Feeder Breakers with VDH/GSMI



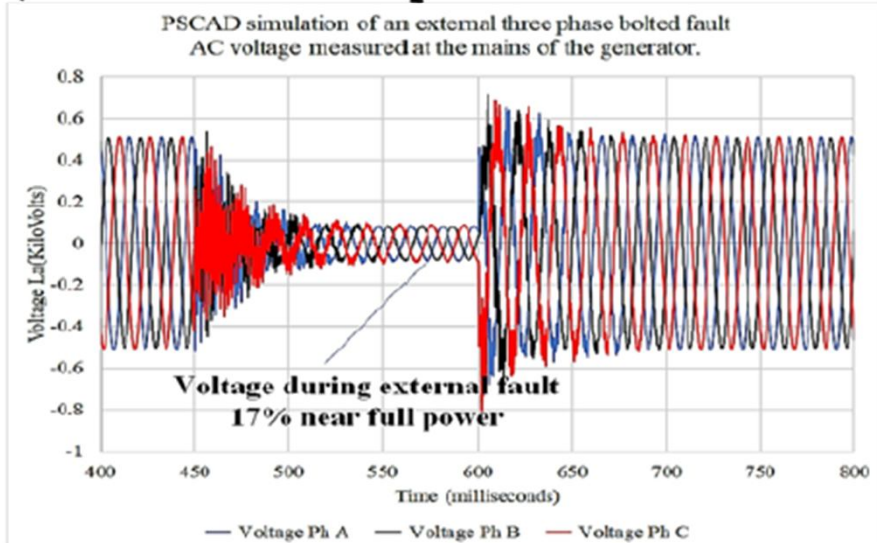
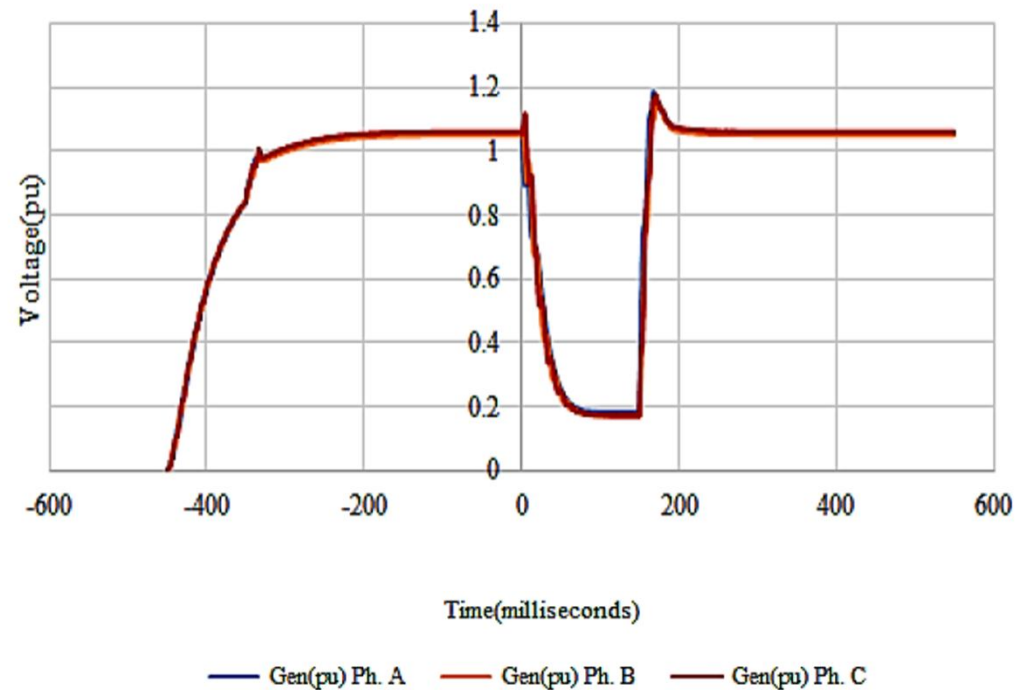
(*) Values are results of the PSCAD simulation of the White Paper.

PSCAD SIMULATION: EXTERNAL 3-PHASE FAULT AT HIGH SIDE OF MAIN TRANSFORMER



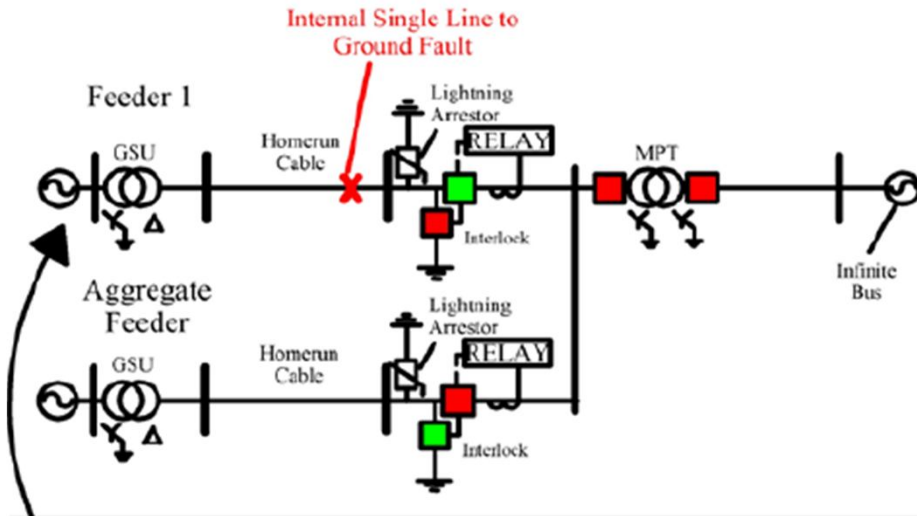
EXTERNAL 3-PHASE FAULT AT HIGH SIDE OF MAIN TRANSFORMER

Plant production approx. 80 MW
Voltage measured at the generator terminals



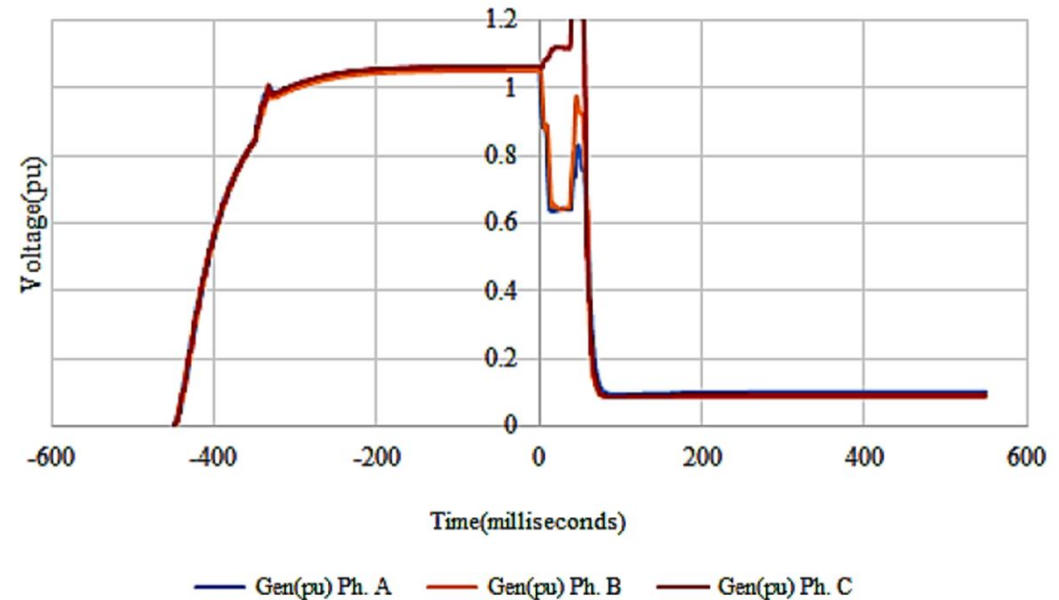
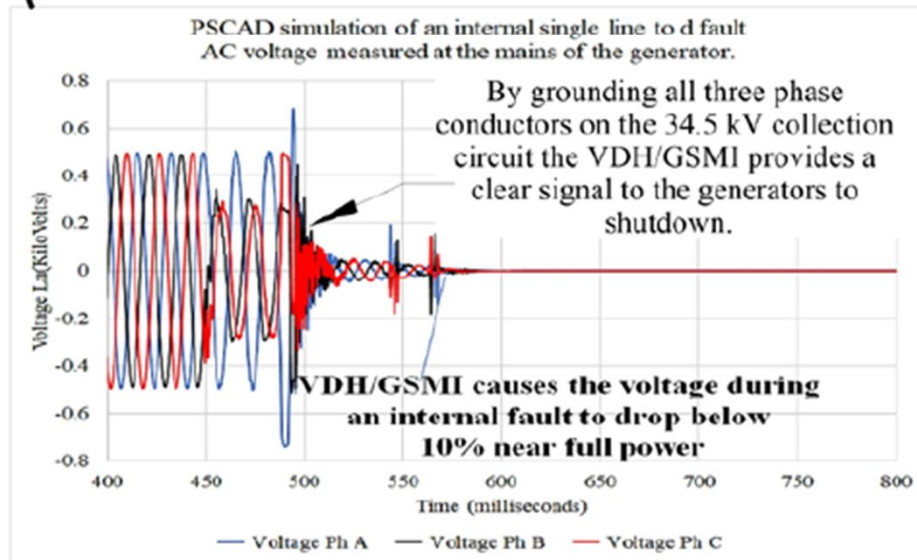
*A fault that occurs on a transmission line near a wind or solar power plant could cause the voltage at that point to drop to zero, however, generators **ride through** and stay connected as long as the voltage remains within the “no trip zone” of the PRC-024-1.*

PSCAD SIMULATION: INTERNAL SINGLE LINE TO GROUND FAULT ON A COLLECTION CIRCUIT



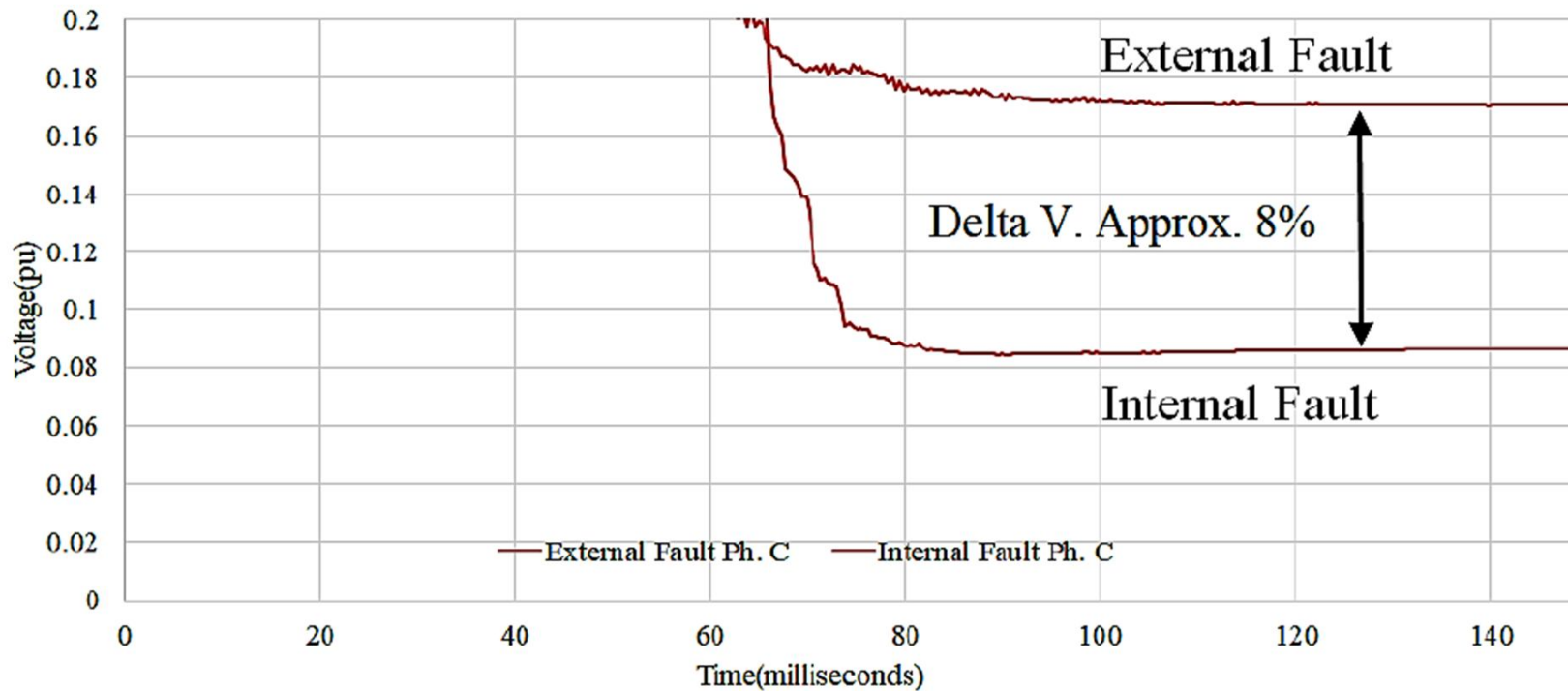
INTERNAL SINGLE LINE TO GROUND FAULT ON A COLLECTION CIRCUIT

Plant production approx. 80 MW
Voltage measured at the generator terminals



*VDH/GSMI signals the generators that the fault is inside the plant and shuts them down for events that the generators **should not ride through**, therefore providing a valuable discriminatory function that standard circuit breakers do not.*

*This “zoomed in” graph is an overlay of the two previous graphs, it shows the **difference in voltage between the external and internal faults at the generator terminals (e.g. low side of the padmount transformer)***



Note: Generation protection disabled for graphic purposes

CONCLUSIONS

- Concerning PRC-024-1 and PRC-024-2, the VDH/GSMI signals the wind generators in a fraction of the 150 ms required by the standard, that the fault is inside the plant, providing the generators with a valuable information to take the decision to shut down.
- Concerning PRC-024-1 and PRC-024-2, the VDH/GSMI signals the generators that the fault is inside the plant and shuts them down for events that the turbines should not ride through, therefore providing a valuable discriminatory function that standard circuit breakers do not.
- The VDH/GSMI forms a three-phase bolted ground and provides a zero reference closer to the generators than the zero reference that forms with the three-phase bolted ground at the point of interconnection; the difference in impedance between internal faults and external faults is basically the impedance of the main plant transformer.
- At near full power for the wind or solar power plant the delta in voltage between the two fault locations is 8%. As a result, each generator could detect and discriminate between each fault location.
- Because the VDH/GSMI can help differentiate between internal and external faults, generators will know via the voltage measured at their terminals that the fault is outside the plant and keep running, to meet PRC-024-1 and PRC-024-2 voltage ride-through requirements, having zero volts at the point of interconnection.
- Consequently, **VDH/GSMI provides designers and engineers the ability to distinguish between external and internal faults**, where generators may be set to trip if the fault is in the plant or ride through if the fault is outside the plant.
- **VDH/GSMI do not require the use of the fiber optic installation** that links the sub station with the turbines to send the shut down signal to the Generator, **making it the most cyber-secure device in case of normal and emergency operation**.
- The shut down signal goes from the VDH/GSMI (located at the sub-station) to all the Generators of the collection circuit faster than any other mean, and gets to all of them at the same time.





*Concerning PRC-024-2 the VDH/GSMI Supports
Differentiation between
Internal and External Faults*

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The VDH/GSMI is essential element for meeting over/under voltage ride through requirements such as those found in PRC-024-2
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http://emaelectromechanics.com/wp/wp-content/uploads/2017/09/EMA_WP3_VDH_GSMI_vs_Low-Voltage_Ride_Through.pdf

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