

A US Coast Guard Study Summarized plus application notes

This article, is to simplify and focus on the Delta Source, Wye Source, and **Phaseback VSGR** affects on System Voltages, system reliability, and safety.

This ship is powered by a Wye Generator. While at shore, it can alternately be powered by a Delta shore power transformer, fed from the utility.

With reliable Voltage, phase to ground, on each phase you can expect the most reliable equipment operation and performance. Voltage SPIKES, Voltage IMBALANCE, and SINGLE PHASE SAGS, will cause equipment problems and malfunction over time. During Voltage events, you can also expect PHASE ANGLE DISPLACEMENT issues, which contribute to control related lockups and further malfunction. By eliminating these rather normal risk conditions system reliability and UPTIME will be optimum.

Plus a look at some other case studies' results showing how stabilizing Voltages Phase/Ground improves UPTIME & SAVES MONEY. This is especially true when Harmonics & other common electrical Power Quality issues are present. See facts on page 5. [Request reports, spreadsheets, originals, from email below.](#)

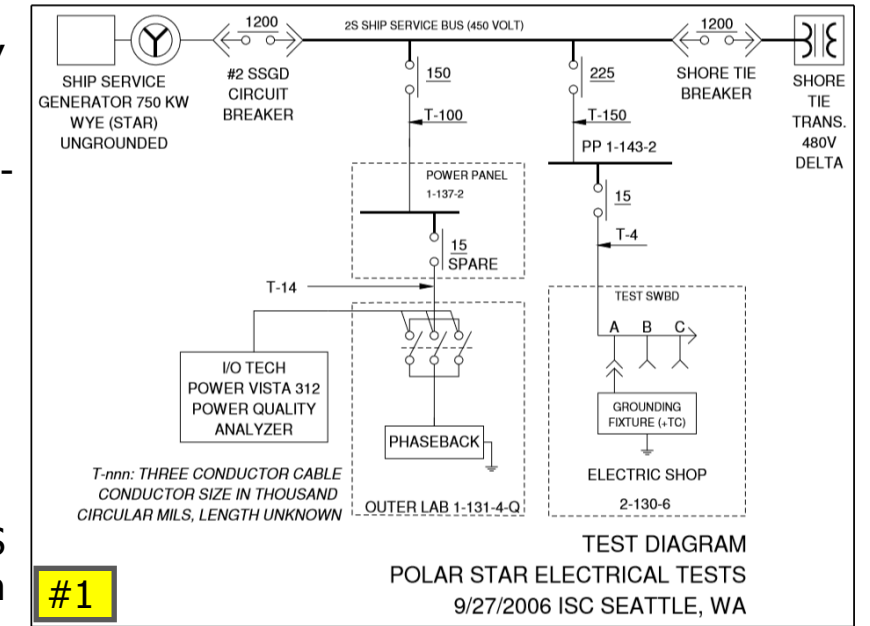


Figure 3 - Test Diagram for Polar Star Electrical Tests

Voltage Wave Forms from the Delta Shore Power System, below, Phase to Phase

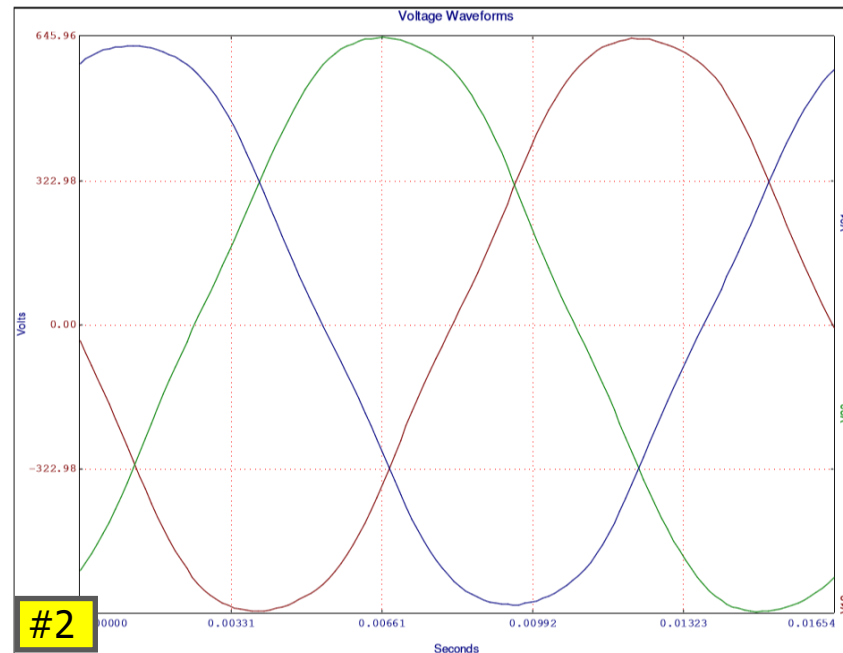


Figure 4 - Shore Tie Voltages, measured line-to-line without induced ground fault

Delta Phase/Phase Wave Form with NO FAULT
Wave Form from Delta Shore Power—Phase to Phase
A 463V B 464V C 453V Imbalance 1.6%

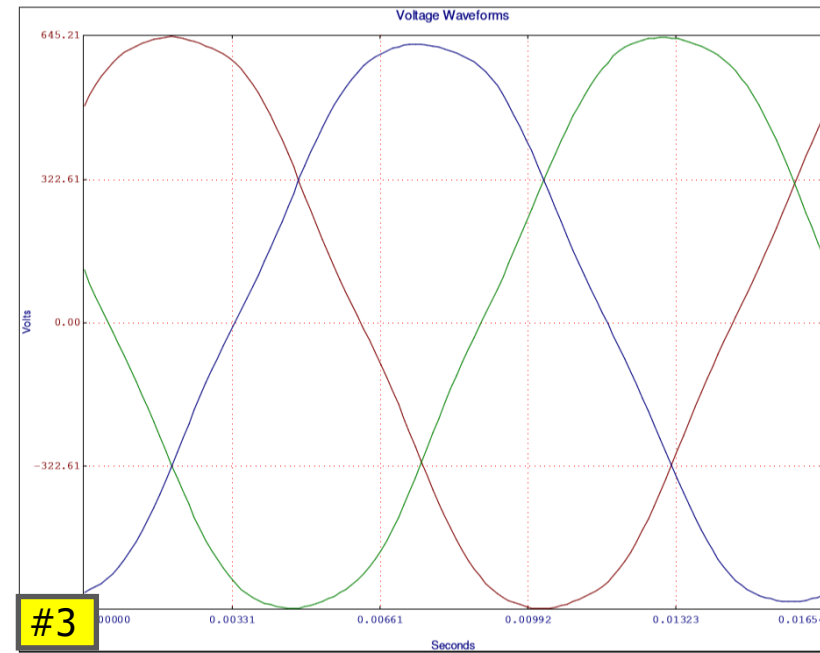


Figure 5 - Shore Tie Voltages, measured line-to-line with induced ground fault

Delta Phase/Phase Wave Form with FAULT
V. Wave Form from Delta Shore Power—Phase to Phase
A 465V B 464V C 454V Imbalance 1.5%
The FAULT cannot be seen Phase/Phase.

Phase to Ground view when Fault occurs

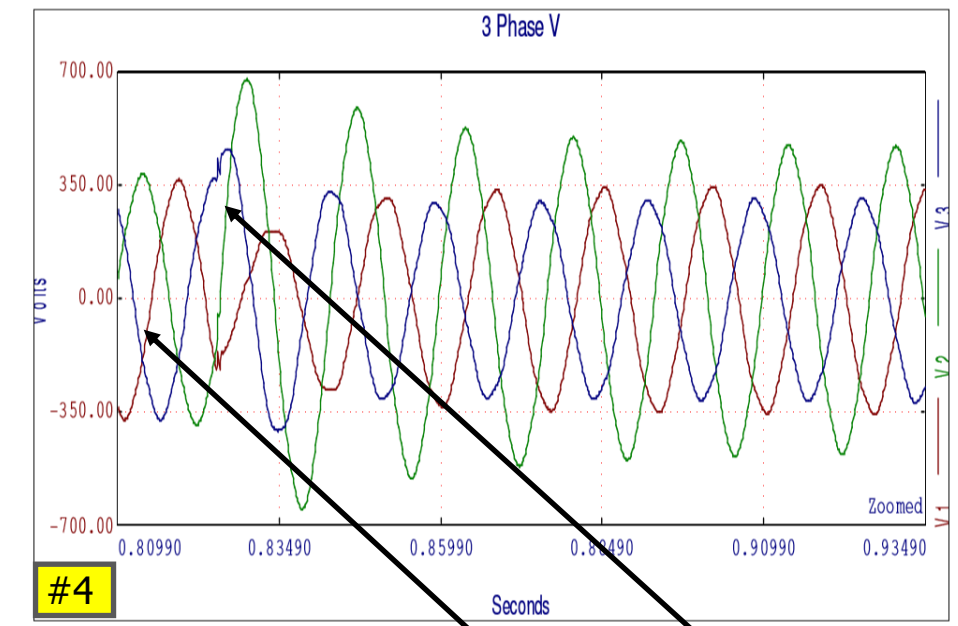


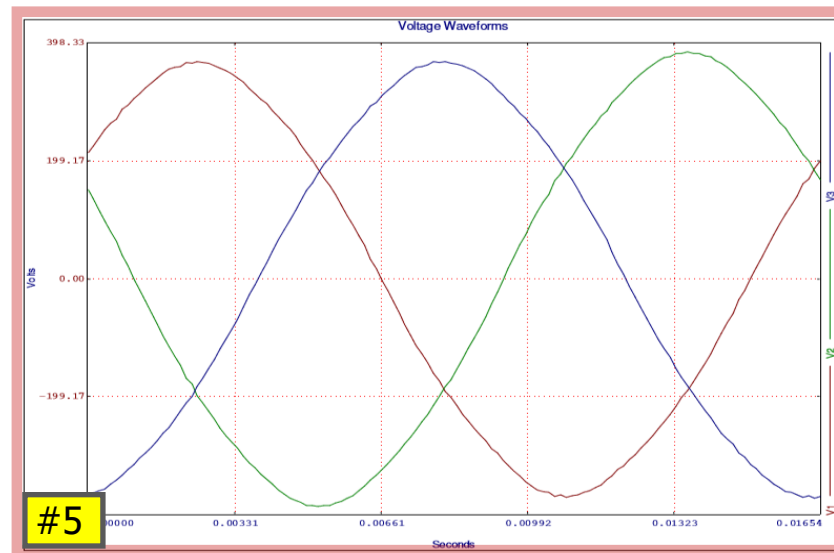
Figure 8 - Ground Fault on Shore Tie Service - Phase C, worst case recorded

Delta Phase/Ground WITHOUT FAULT, WITH FAULT,
The instant the FAULT occurs & beyond—After Fault surge,
A 294V B 264V C 229V Imbalance 12.7%
The Fault is clearly visible, Phase/Ground.

[Request reports, spreadsheets, originals, from email below.](#)

US Coast Guard Study

2 electrical sources, 1. The Delta Transformer Shore Power and 2. The Wye Generator Power, both shown PH/Ground

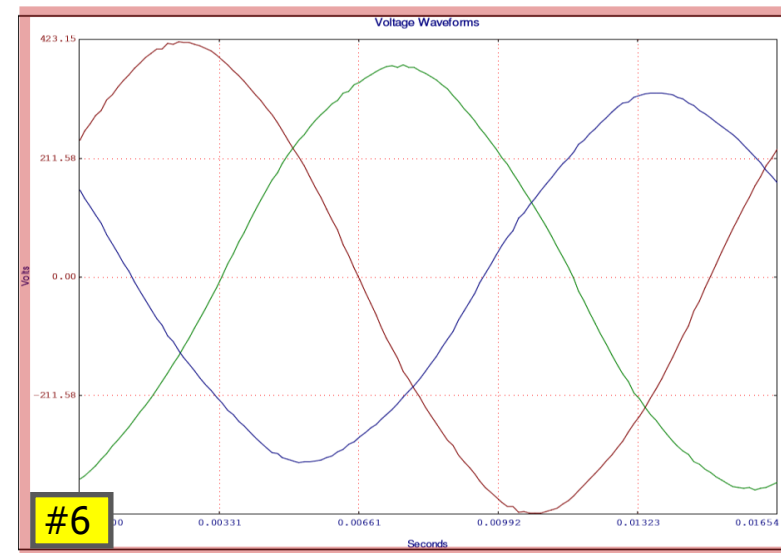


#5 DELTA SHORE POWER Phase/Ground

Phase to Ground without FAULT

A 256V B 268V C 257V

VOLTAGE IMBALANCE 3%

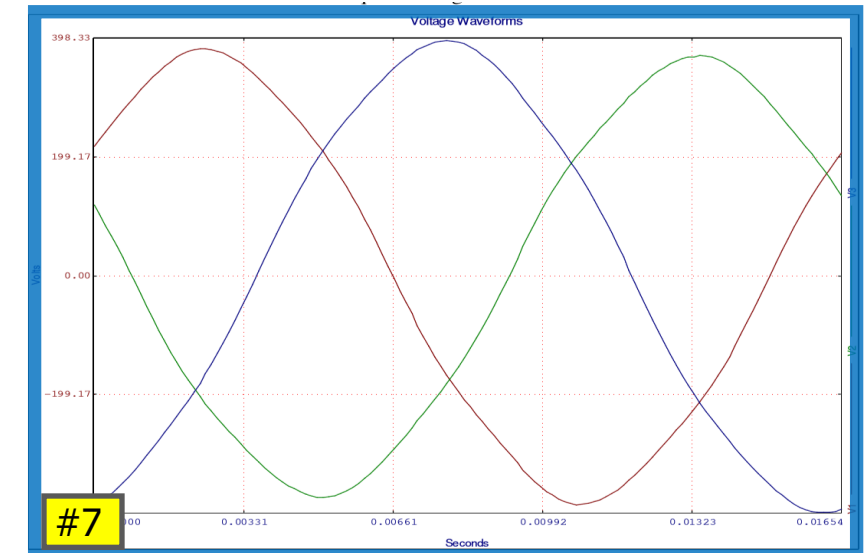


#6 DELTA SHORE POWER Phase/Ground

Phase to Ground **with FAULT**

A 294V B 264V C 229V

VOLTAGE IMBALANCE 13%

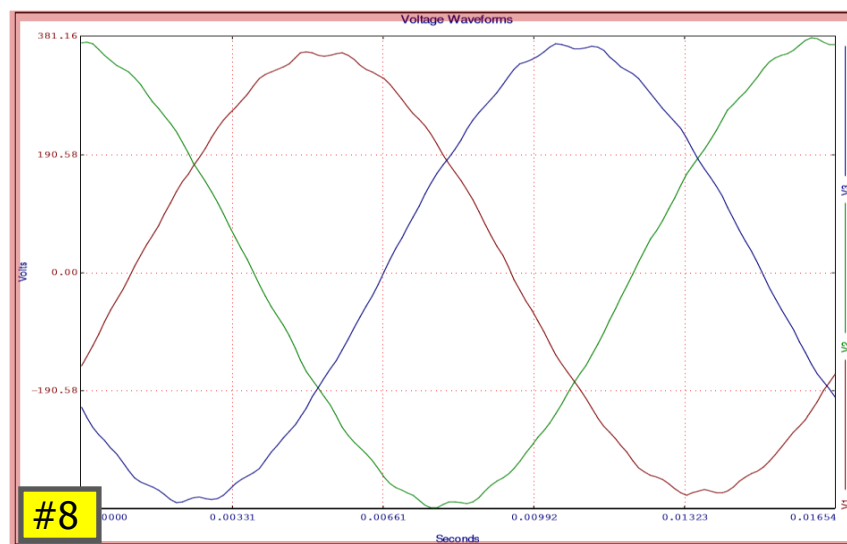


#7 DELTA SHORE POWER Ph/Ground with VSGR

Phase to Ground **V. with FAULT is corrected**

A 265V B 256V C 276V

VOLTAGE IMBALANCE 3.6%

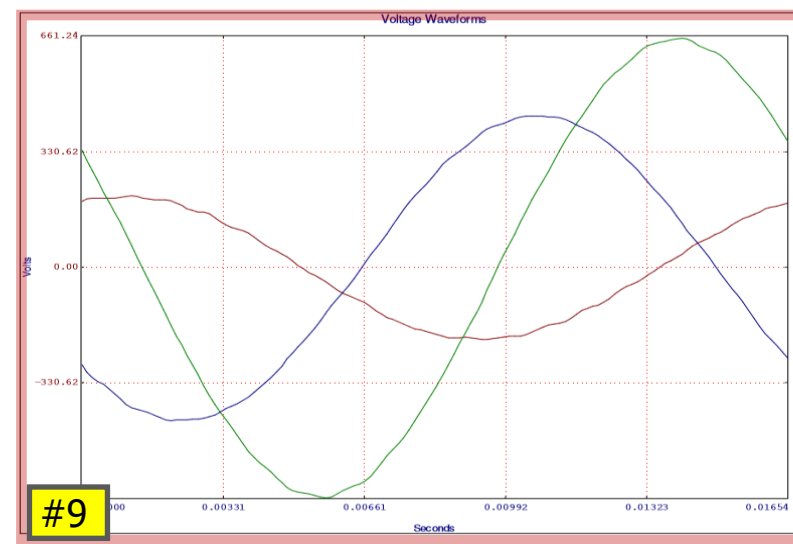


#8 WYE GENERATOR POWER Phase/Ground

Phase to Ground without FAULT

A 253V B 265V C 260V

VOLTAGE IMBALANCE 2.5%

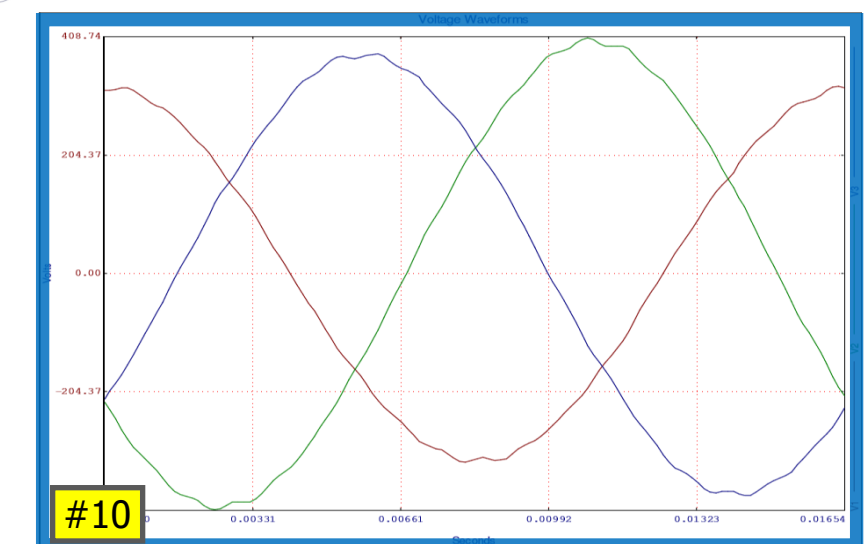


#9 WYE GENERATOR POWER Phase/Ground

Phase to Ground with FAULT

A 144V B 462V C 309V

VOLTAGE IMBALANCE 52.7%



#10 WYE GENERATOR POWER with VSGR

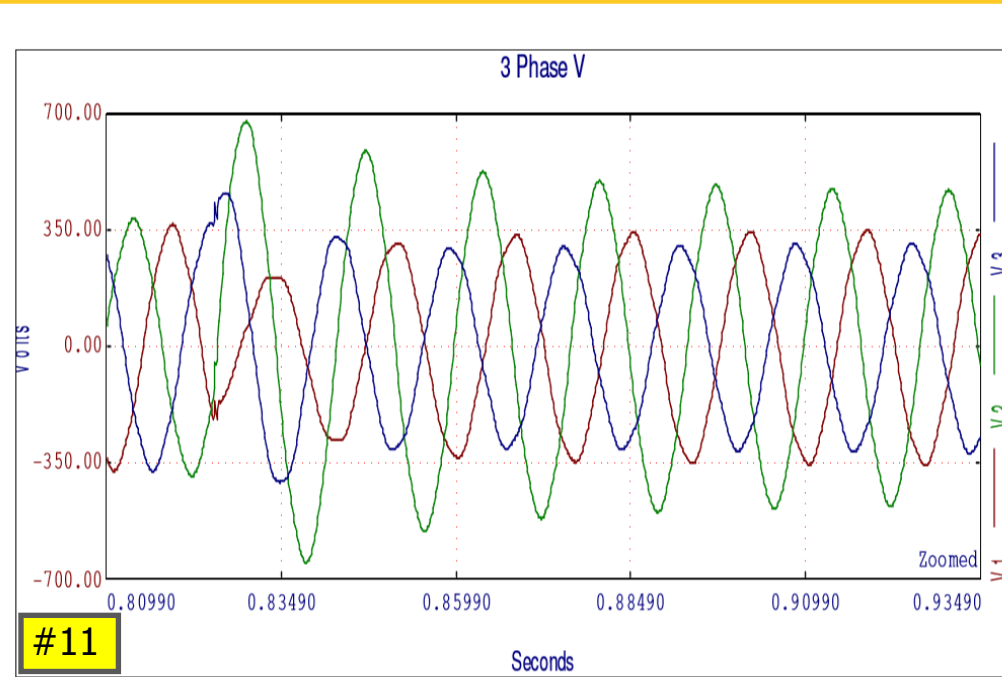
Phase to Ground **V. with FAULT is corrected**

A 229V B 283V C 268V

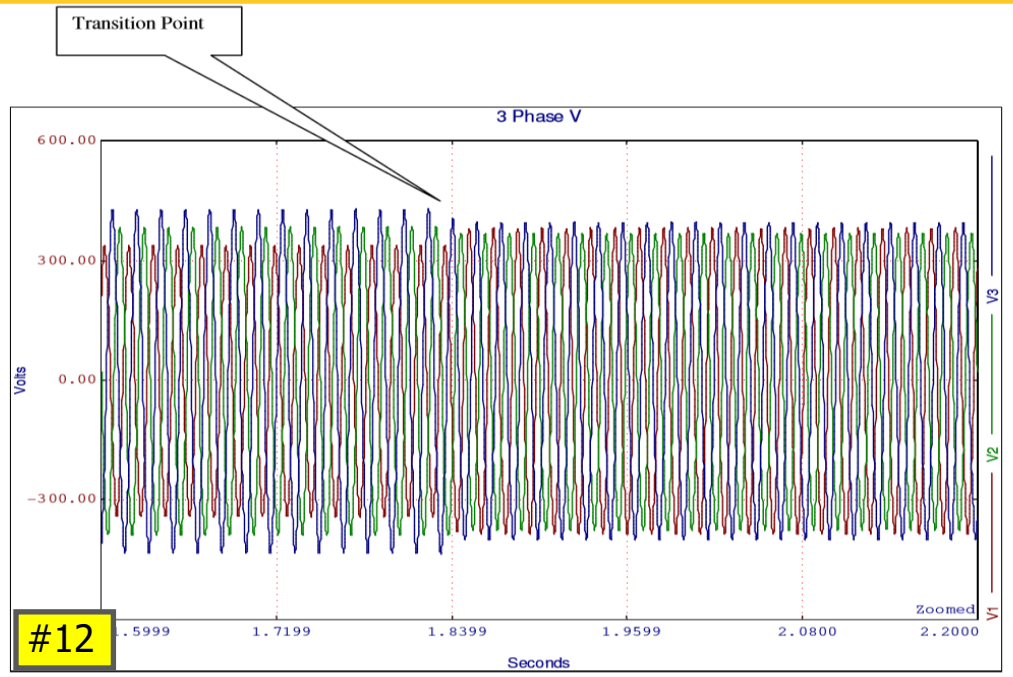
VOLTAGE IMBALANCE 12%

Request reports, spreadsheets, originals, from email below.

Voltage Wave Forms below Focusing on the FAULT CONDITIONS, we can see how each electrical system, one fed from Delta transformer on utility power, and the other fed from Wye Generator deal with developing ground faults. We know that ground faults cause 85% of all Arc Flash events. This report provides 3rd party information.



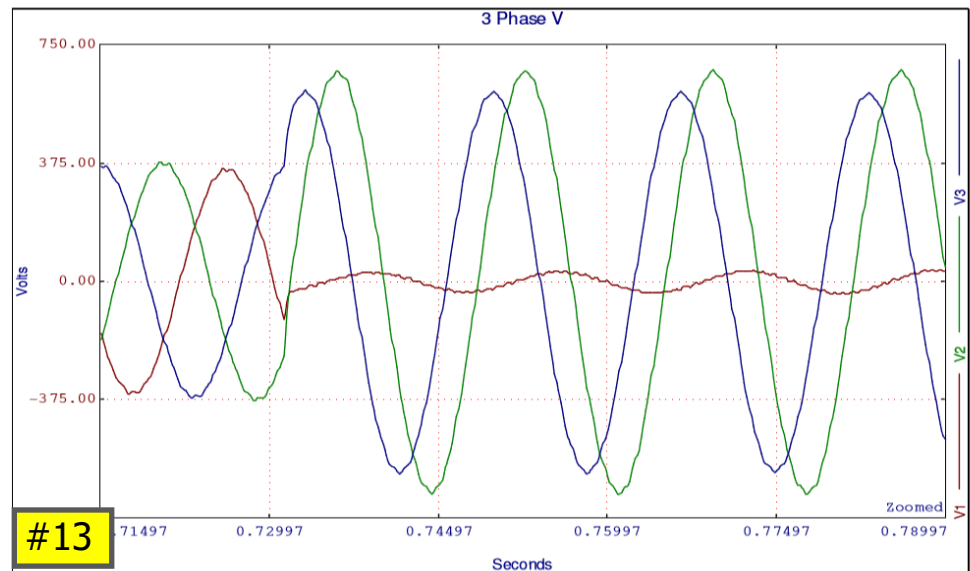
#11
Delta System NORMAL & Fault: 1 Grounded Phase.
 Normal A 256V B 268V C 257V VOLTAGE IMBALANCE 3%
 Fault A 294V B 264V C 229V VOLTAGE IMBALANCE 13%



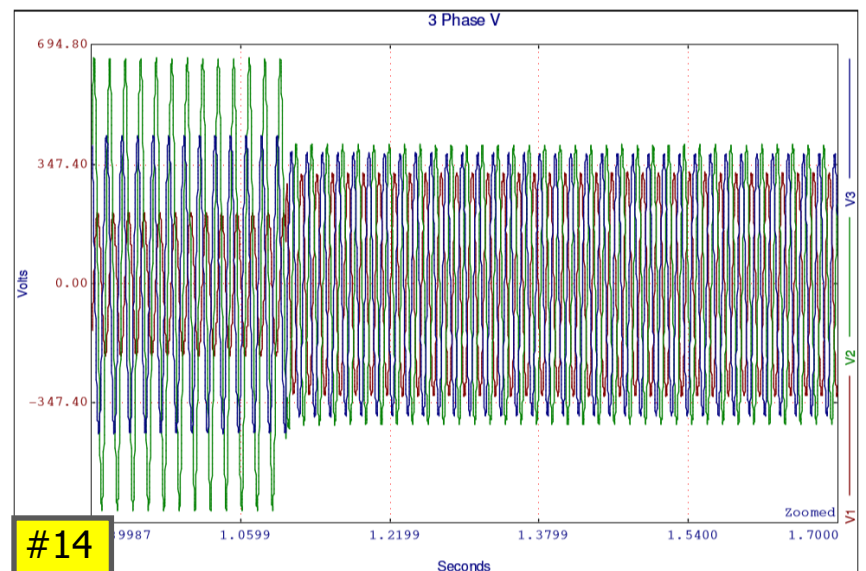
#12
Delta System Fault & **VSGR** switched ON
 Fault A 294 B 264V C 229V V. IMBALANCE 13%
VSGR A 265V B 258V C 276V V. IMBALANCE 3.6%



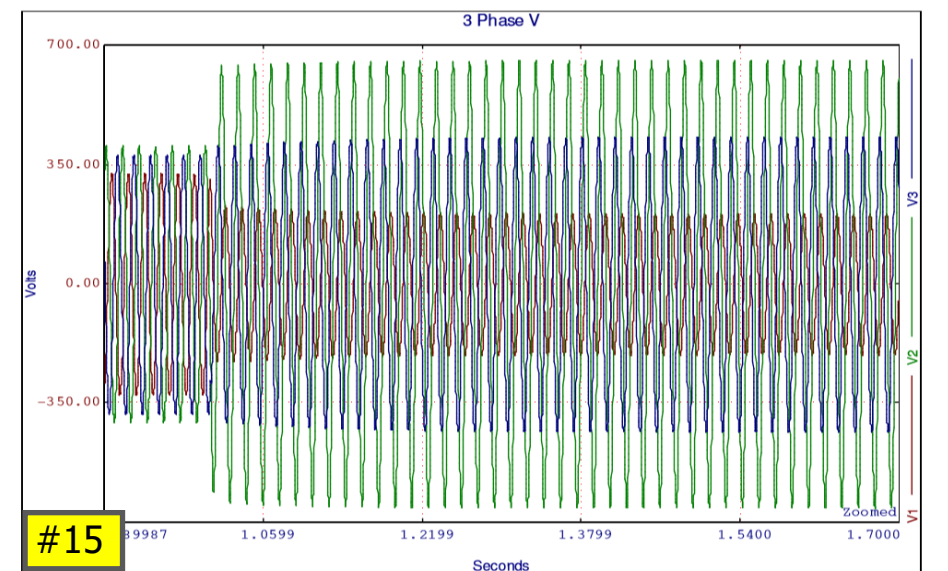
With **Phaseback VSGR**, electrical system are as safe as they can be. Without interfering with other protective equipment, **VSGR** corrects the Arcing Ground Fault & will not allow the Ground Fault to happen. This electromagnetic device acts at the speed of current flow, to correct Voltages Phase / Ground, remove surges, single phase Sags, & more. These features can be demonstrated.



#13
Wye Generator system, Ph/Gr: NORMAL & Fault.
 Normal A 253V B 265V C 260V VOLTAGE IMB. 2.5%
 FAULT A 144V B 462V C 309V VOLTAGE IMB 53%



#14
WYE Generator Fault, **VSGR** OFF & Switched ON.
FAULT A 144V B 462V C 309V V. IMB. 53%
VSGR A 229V B 283V C 268V V. IMB. 12%



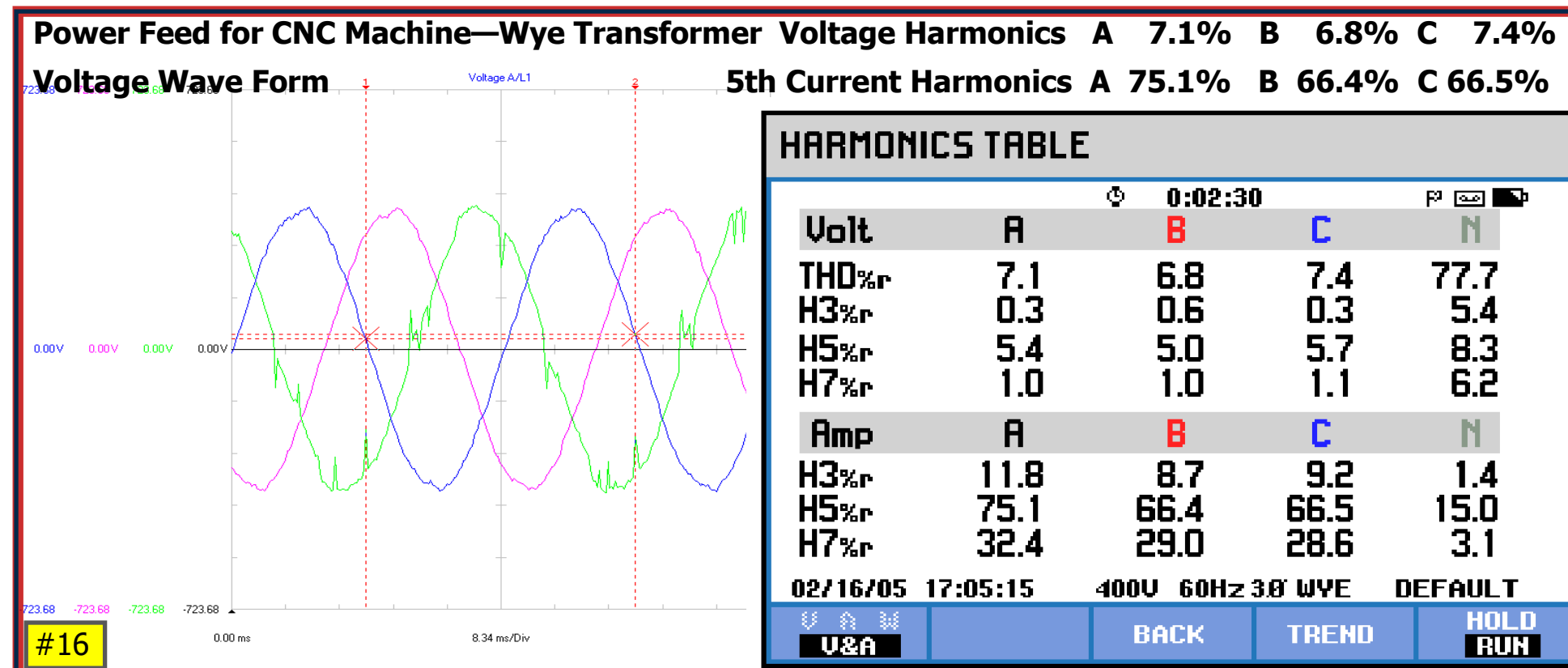
#15
WYE Generator Fault, **VSGR** ON & Switched OFF.
VSGR ON A 229V B 283V C 268V V. IMB. 12%
FAULT A 144V B 462V C 309V V. IMB. 53

This information is from General Dynamics Information Technology Report for USCG, ISC Seattle, Wa, WAGB-10 Polar Star. Call me for a copy of the report.

Request reports, spreadsheets, originals, from email below.

The previous pages were from a Coast Guard Ship, which was having serious downtime issues related to Voltage imbalance, causing equipment faults and unsafe conditions.

Phaseback VSGR corrected those issues and the downtime problem. In many cases, we find Harmonics issues are also part of the problem. The Coast Guard study was not focused on Harmonics. This section uses a manufacturing case study from Michigan, where Downtime was the motivation as Voltage imbalance and Harmonics were affecting control systems, causing lockup and malfunction. [Request reports, spreadsheets, originals, from email below.](#)



Case Study—Automotive plant in Michigan:

Uptime in the plant was 50%, before making some changes. Delta/Wye Isolation Transformers had been installed at each CNC machine, when the machines were purchased. The main power transformer upstream was a Delta / Delta Transformer. **Phaseback VSGR** was installed at the main Power Transformer secondary, which protected all of the 480V system, including the CNC machines. The isolation transformers were then removed to allow the machines to get power from the main transformer protected by **VSGR**.

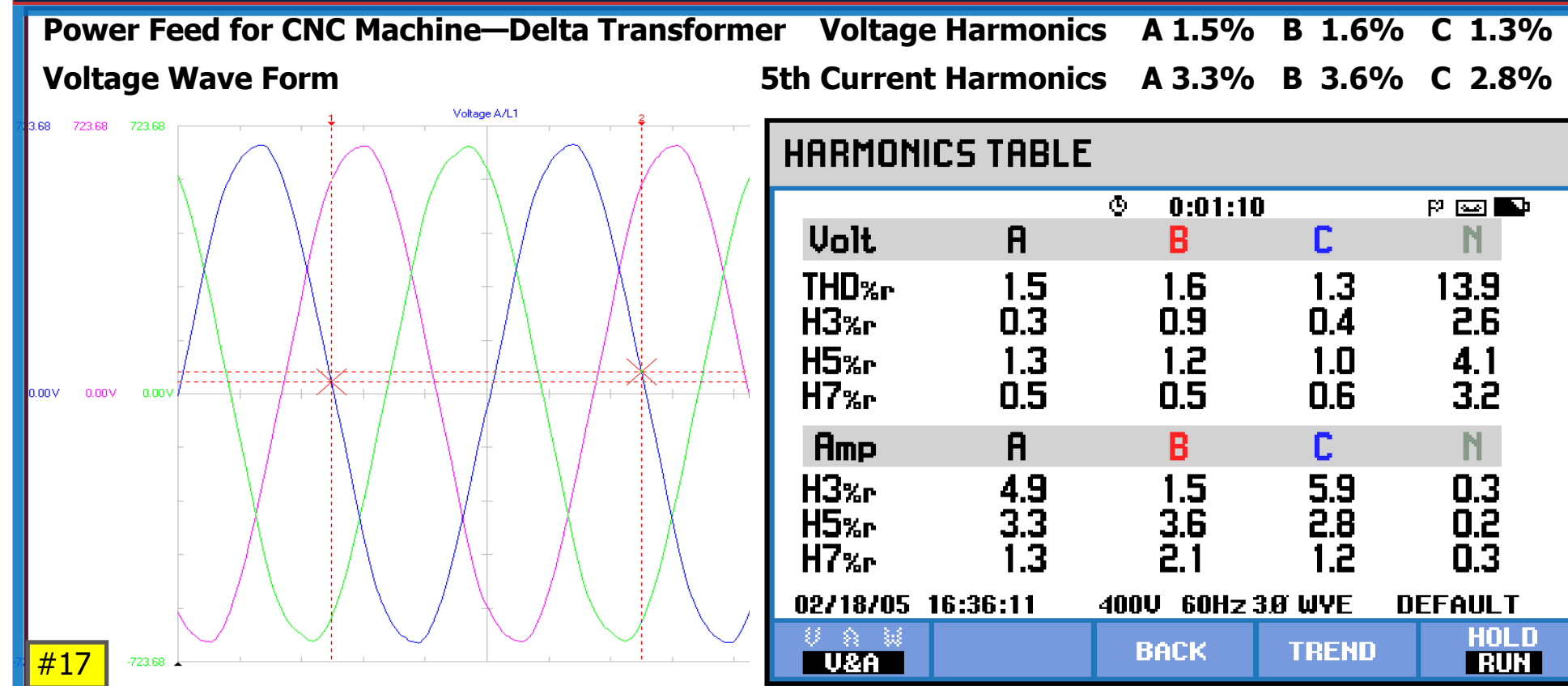
The charts left, show before, when the CNC machines were fed from the Delta/Wye Isolation Transformers.

Upon completion, Uptime went immediately to 85%, optimum for the facility, and stayed at that level. The Table and Chart left lower, shows after, when the CNC machines were fed from the main Delta/Delta Power Transformer with **VSGR**.

In summary:

Harmonics stayed well below IEEE 519 limits, regardless of the load conditions, which frequently change.

1. Current Harmonic filtering, provided by the Delta/Delta Transformer can see in the lower table. A Phase 3rd H went from 11.8 to 4.9, 5th Harmonic went from 75.1% to 3.3%.
2. **Reduction of Current Harmonics > 90%.** The **VSGR** provides excellent Voltage Harmonic filtering, as you can see in the lower table.
3. **Reduction of Voltage Harmonics > 80%** When Lightning destroyed the meter pole just outside the building, it was a non-event inside. No equipment damage occurred and **NO DOWNTIME!**
4. Power Factor Correction was easily managed, with Voltages stabilized & Transients /Harmonics mitigated.
5. Energy Efficiency, which was not the objective, improved significantly. Before these changes were made, the electric bill was \$495,000 per month. Afterwards, it was \$385,000/mo. Savings of more than \$1.2million per year was realized. Management was pleased.



Phaseback VSGR as a Power Quality Solution—Application notes & Facts

Delta / Delta Transformer plus VSGR

1. Harmonics Isolation

*Delta / Delta Transformer effectively filters **CURRENT HARMONICS**. Pg 4 shows full spectrum Current Harmonics reduction, example 5th Harmonic from 75.1% THDC to 3.3%. 90% plus is Typical Current Harmonic reduction, from Delta/Delta Transformer.

*VSGR effectively removes **VOLTAGE HARMONICS**. Chart on pg 4 shows 7.4% VTHD reduced to 1.3%. 80% plus Voltage Harmonic reduction is typical.

*Generator Source –Load reduction approximately **20–30%** (6 pulse VFD Current THD without Reactor / Filter) With Harmonics effectively removed, the generator size can be reduced.

*Harmonics and Transients from the VFDs or other loads will not be shared on the primary side of the transformer.

*Ungrounded Delta with VSGR provides the Safest, most reliable, and most economical electrical system, with all of these benefits.

2. Arc-Flash / Fault prevention

*VSGR corrects Voltage imbalance at the speed of Current Flow, not allowing Ground Faults to develop. The Alarm signals that a grounded phase is developing. The system continues to operate. Additional Alarms are available, to provide Alarm & Trip, for example.

3. Voltage Spikes removed

*VSGR Removes Voltage Transients, whether caused by lightning or normal internal events.

4. Phase Voltage Imbalance corrected

*Phase to Ground Voltage is corrected at the speed of Current Flow. 6000V Spike applied to Phase C, is shared on 3 phases. Imbalance from by Arcing Ground Fault at 61% Voltage Imbalance is corrected to 6% Voltage Imbalance.

*Phase Loss from high impedance grounds fixed.

5. Phase angle differential displacement is corrected by VSGR

continuously at the speed of current flow, which help to solve the control system lockup problems, many of which happen while recovering from outage conditions.

6. Phase voltage instability corrected

*Phase to Ground Voltages are corrected continuously by VSGR, whether caused by Current imbalance or temporary Arcing Ground Faults.

7. Phase voltage Harmonics, THDV is improved by 80%, approximately.

*Waveform distortion corrected as shown on pg 4. IEEE 519 compliance is expected

*Noisy ground reference /frequency corrected

*Arcing ground-faults corrected and alarmed pg 3.

8. Increase Operational efficiency

*Reduce KW & Ground Current. Approximately 1.4% kW reduction per 1% of Voltage Imbalance corrected, saving money on Energy cost. See Pg 4 Summary #5.

*The capacitive charge current, which is normally drained to ground continuously, is used, by Phaseback VSGR (Voltage Stabilizing Ground Reference), to correct the Voltages Ph/Grnd.

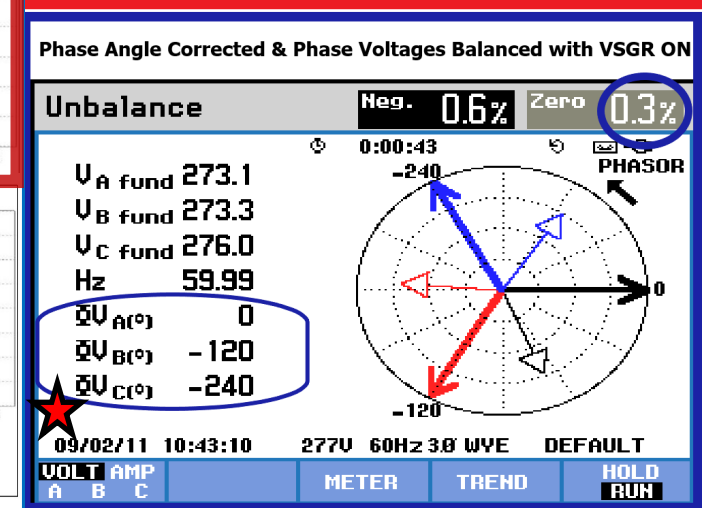
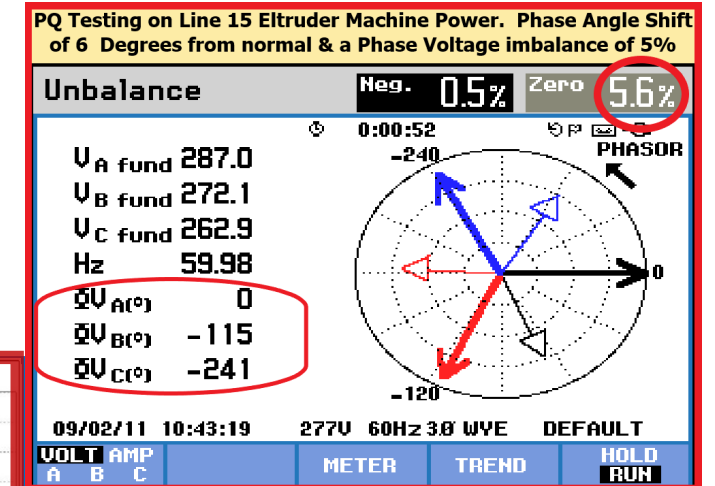
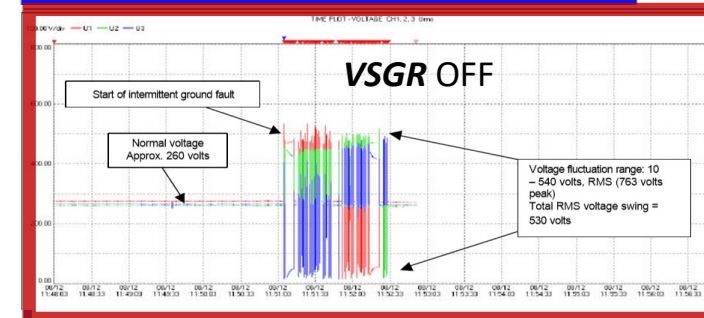
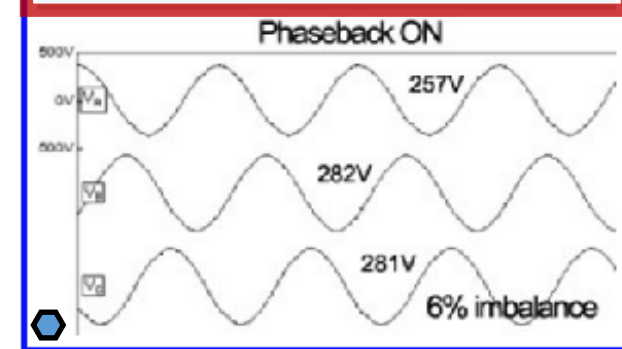
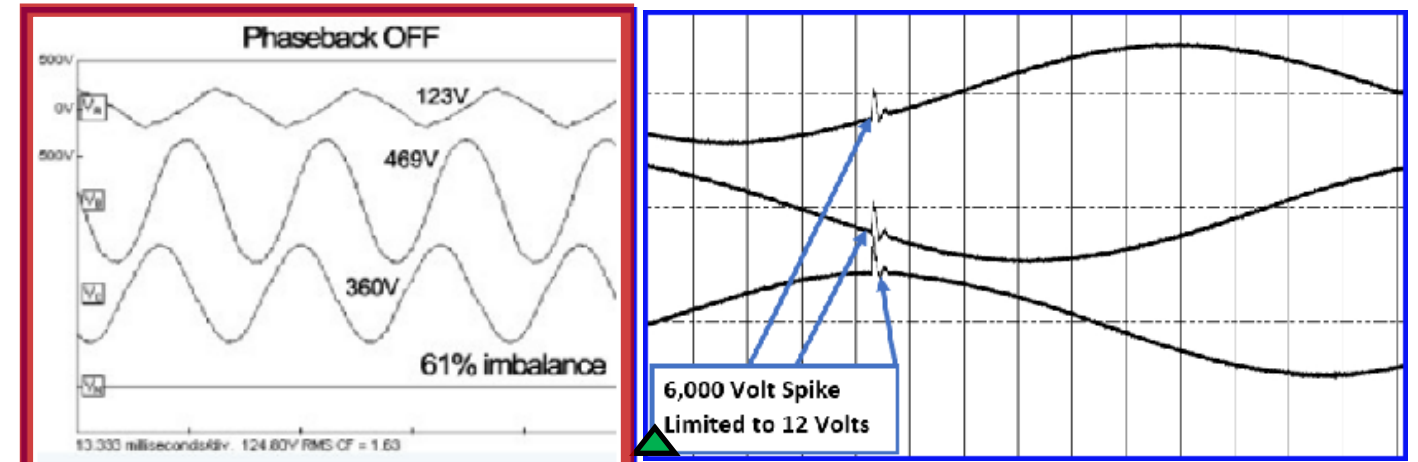
9. For Wye Generator or Wye Transformer secondary with VSGR

*Grounded Wye Transformer secondary gains 2,3,4,5,6, 8, & 10 Benefits. Pg 2.

*Ungrounded Wye or Impedance Grounded Wye gain 2,3,4,5,6,7, 8, & 10 Benefits.

*Ungrounded Delta with VSGR provides the Safest, most reliable, and most economical electrical system, with all of these benefits.

10. Phaseback VSGR limits fault current to less than 1Amp.



Considerations	Grounded				Ungrounded	
	Solid ¹	Low Resist	High Resist	W/VSGR	Ungrdgd	W/ VSGR
System Characteristics	No	No	Yes	Yes	Yes	Yes
Continuity of service/grnd fault	High	Medium	Low	Lowest	Low	Lowest
Propagage multiphase fault	High	Low	Very Low	Lowest	Very Low	Lowest
Equipment damage potential	Highest	400.0 A	5 - 10 A	1.0 A	Low	1.0 A
Ground fault current	2.5X	2.5X	2.5X	1X	≥6X	1X
Transient over-voltage level	1.0X	1	1.73	1	1.73	1
Cable insulation level	High	Medium	Low	Lowest	Low ²	Lowest
Arc Flash Risk Level	5 to 10A	5 to 10A	5 to 10A	.01 to .02A	5 to 10A	0.01 to 0.02A
Continuous energy drained/grnd ±						

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