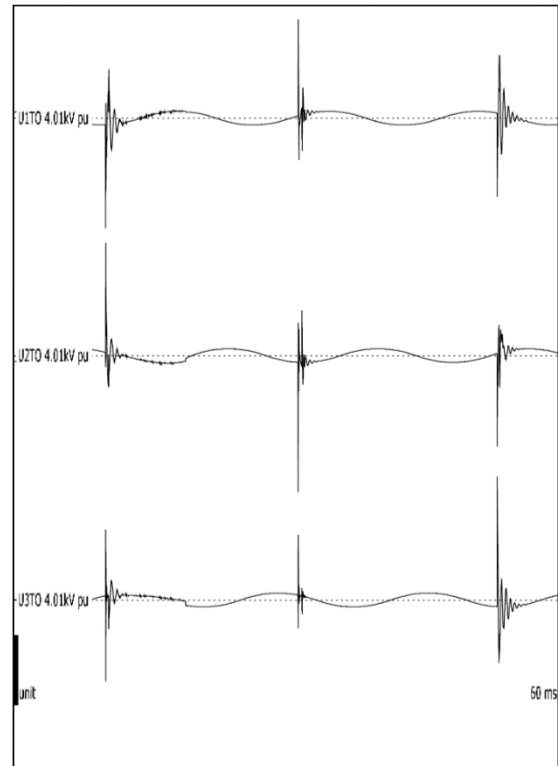


Phaseback VSGR Arc-Flash Prevention Testing Summary

From October 2019 and January 2017

Test number: 191010-3006

Phase		A	B	C
Current	A _{peak}	-51.2	51.2	-50.7
Current, a.c. component	A _{RMS}	36.2	36.5	36.2
Current, a.c. component, three-phase average	A _{RMS}	36.3		
Duration, current	s	0.500	0.500	0.500
1st Discharge Pk	kV	1.56	1.76	1.65
2nd Discharge Pk	kV	2.38	2.59	0.825
3rd Discharge Pk	kV	3.62	1.84	3.63
1st Event Dur.	ms	1.90		
2nd Event Dur.	ms	1.61		
3rd Event Dur.	ms	2.67		



Gas pressure at 20 °C - MPa

Observations: No visible disturbance.

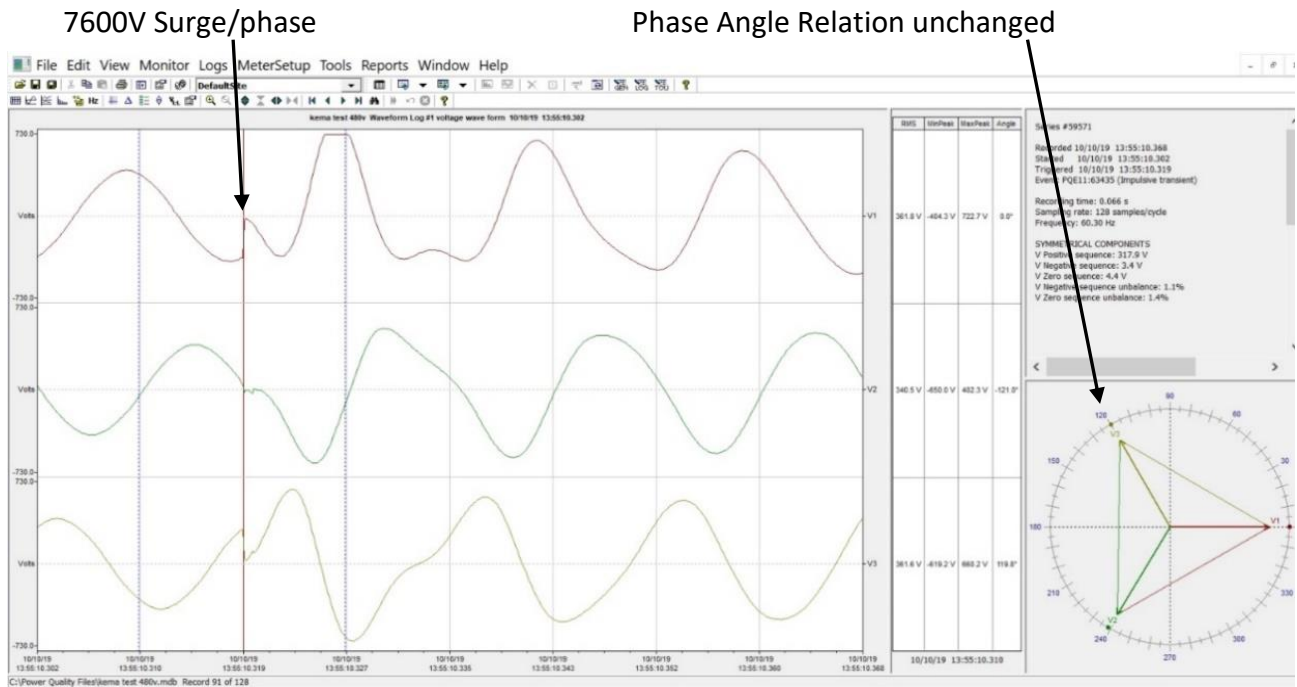
October 8 -11, 2019- The Phaseback VSGR unit was tested in a high-power test lab. ¹

The goal of the battery of tests was to test the withstand capacity and see how well VSGR performs in preventing a high voltage flash-over. With 7600V minimum impulses applied to each of 3 phases of a 480V system, potentially causing 3phase fault events. With VSGR, we expected to see no fault, no flash-over and no Arc Flash.

Notes:

1. The standards require phase spacing for 600v Feeder Circuits 1" or more to prevent a flash over, phase to ground or phase to phase.
2. For 600V systems, flashover may or may not happen with a 2500V Voltage surge but will certainly occur with a 6000V or higher surge.
3. SPD, surge suppressor, test standards information for perspective:
 - a. B3/C1, calls for 6,000 volts for 8 x 20 μs (millionths of a second).

- b. The harshest test standard for SPD devices include up to 350 μ s for class 1. Over-voltage events beyond these times may cause MOV devices to overheat and fail (some will fail catastrophically). The SPD will then need to be replaced.
- 4. This 600V 3000kVA VSGR was tested and proven to withstand 8,400 volts/phase without a flashover or disruption of any kind. Voltage distortion would also be minimized if a 3000kVA or smaller Transformer was upstream.
- 5. The Test source was a High Voltage high-power Laboratory generator, which is many times larger than 3000kVA.
- 6. The duration of Voltage surge was 6.18ms, between 6 and 10 times longer than SPD test duration.
- 7. The test charge energy was 1800% higher than SPD, surge suppressor test.

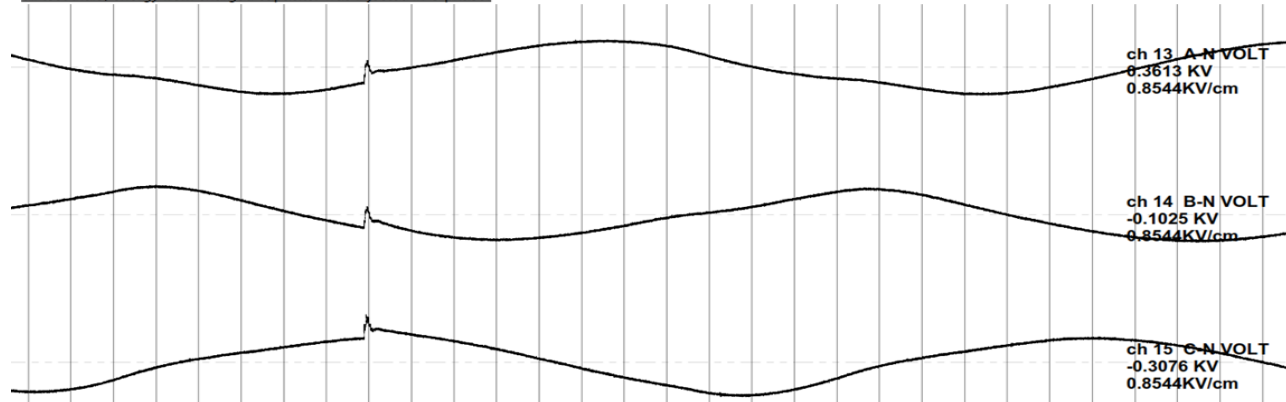


- 8. **The 2019 Arc Flash test** included a battery of 12 extreme tests. For these tests, the VSGR is undersized by 20 times, according to Phaseback VSGR instruction manual.
 - a. No flashover occurred.
 - b. No Arc-Flash occurred.
 - c. No increase in peak current occurred.
 - d. No surge or noise energy was conducted to ground, during these tests.
 - e. No noticeable damage occurred to the test circuit, power source or VSGR during these tests as the VSGR protected them all including itself.
 - f. No change occurred to Phasors.
- 9. **Half of the 2019 tests** (8400V per phase) included:
 - a. Hitting (2) phases (A and B) each with 8400V surge at the same time.
 - b. Followed by the third phase (C)8400V approximately ¼ cycle later.
 - c. Popular opinion is that 480V systems cannot survive (2) phases being hit with >7,000 volts at the same time. With VSGR there is no Fault or Flashover.
 - d. The test results are similar for 3 wire and 4 wire systems.

10. **Phase Angle relationships did not change**, which helps to explain why there is no flash-over, as the path of least resistance does not change during the test.
11. **Previous Test from 2017**, Source included a Transformer, appropriately sized for 3000kVA rated VSGR. The example below shows how a typical electrical system, with properly sized VSGR, will not experience damage from a 6000V surge on one phase. In fact, the resulting voltage distortion, shared on 3 phases, is less significant than a motor start. ²

Trial	Sample	Test Duty	O.C.V. (V)	Phase	Total (A)	Sym (A)	Peak (A)	Total @ End (A)	Sym @ End (A)	TD Gnd I pk (A)	Curr. Dura. (ms)	Transient Duration (μs)	Phase	C.C. Volts (V)	Transient Peak (V)	Remarks
10	6.0kV charge	With	480.00	A	34.40	27.84	60.40	-	25.60	-	390	296	A-N	280	-	2,3
	TD connected			B	34.09	26.67	58.59	-	25.51	-	390	296	B-N	275	-	
				C	48.53	28.08	80.08	-	25.53	-5.33	390	296	C-N	281	727	
				AVG	39.01	27.53	-	-	25.55	-	-	-	AVG L-L	483	-	

Remarks: 1) Ground on power source thru wye transformer. 2) Ungrounded system. 3) Test device distorts voltage for duration of ~200ms during switching on of load current. 4) For all test trials, energy from charged capacitor was injected in C phase.



There was no interruption, no outage, no surge in current, no Arc-flash or Flash-over, which confirms that the VSGR is the best device to protect the power system and provide superior quality voltage. These are important attributes which are unachievable without VSGR. This battery of tests proves that VSGR will take the hit and continue to protect the power system. ³

Thank you,

William Hinton

William Hinton
 Director of Engineering
www.Phaseback.com

¹ 2019 Arc Flash Test. A copy of Test report is available upon request, to 'William Hinton (bill@applied-energy.us)'. Test includes 3 wire and 4 wire systems.

² 2017 Arc Flash Test. A copy of Test report is available upon request, to 'William Hinton (bill@applied-energy.us)'. Test includes 3 wire and 4 wire systems.

³ We are pleased with the performance of our VSGR in the 2019 tests. We requested (**191011-3008** and **191011-3009**) in a test circuit, like the test parameters of the previous test from Jan 2017 (Project # 17013-R). We consider the previous tests in this report to be calibration, baseline and withstand tests as indicated in the test report.