



White Paper PQube vs. Fluke 1750 On a Mobile MRI System

Background

A medical imaging OEM has installed a PQube power monitor in an MRI system, which has been installed in a mobile trailer. This system typically is used during daytime hours, and in the evening, travels to a different site. During the transit process, the trailer is removed from facility power (typically, a concrete pad with a large plug-in power source) and transferred to an on-board generator. Once arriving at the new site, the power is transferred back to facility power at the new site.

The intention of the PQube system is to send an email alert when the system experiences a power disturbance, to permit service to quickly identify power issues and address these pre-emptively.

PowerLines was consulted because the PQube at one site was sending a large number of "disturbance event" emails, and service engineers were getting swamped. The OEM provided a sampling of the PQube disturbance emails, and several weeks of power monitoring with a Fluke 1750 power quality analyzer.

Findings

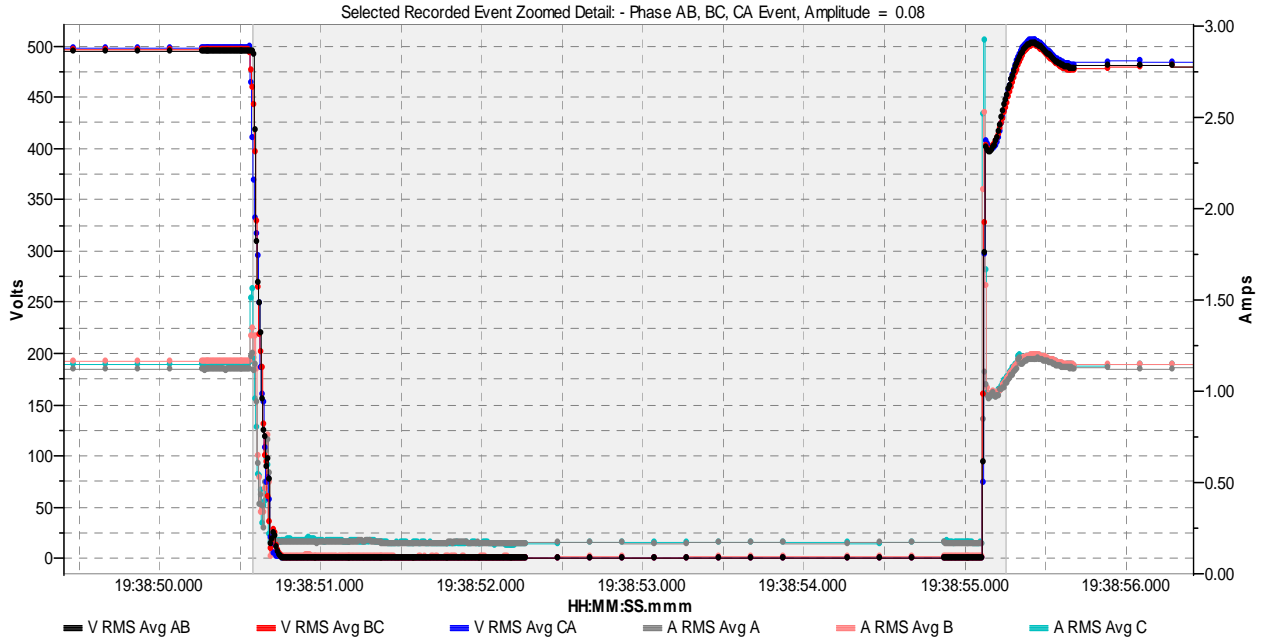
- All of the PQube events that were provided were correlated to Fluke 1750 events. Since the PQube data that was provided was a sampling or selection (there were 220 significant sag / outage events captured on the Fluke 1750 monitoring, only 37 PQube events were provided), it was not possible to determine if the PQube captured all events.
- The medical imaging system is protected by an on-board power conditioner, based on rock solid voltage levels during both facility power and on-board generator power.
- During a typical "trailer move" there was a significant (and rather ragged) voltage outage during transition to the generator and transfer back to shore power.
- During generator power, there was a periodic severe voltage sag (perhaps 10-20 per hour), which was causing the large number of PQube disturbance emails. It appears that there is a large, cycling load (chiller, compressor, or the trailer HVAC system) operating from the on-board generator, and causing a severe voltage sag when it cycles on (inrush current) that the power conditioner is unable to correct.
- The PQube does a good job of documenting the individual events, although the large number of these events and lack of a "big picture" (the OEM does not have the expertise or program in place to download the full PQube data set, including RMS logs and all disturbance events) makes analysis difficult.

All in all, a very interesting project: the PQube appears to be a handy tool in the power quality kit!

Voltage Disturbance Events During Mobile System Move

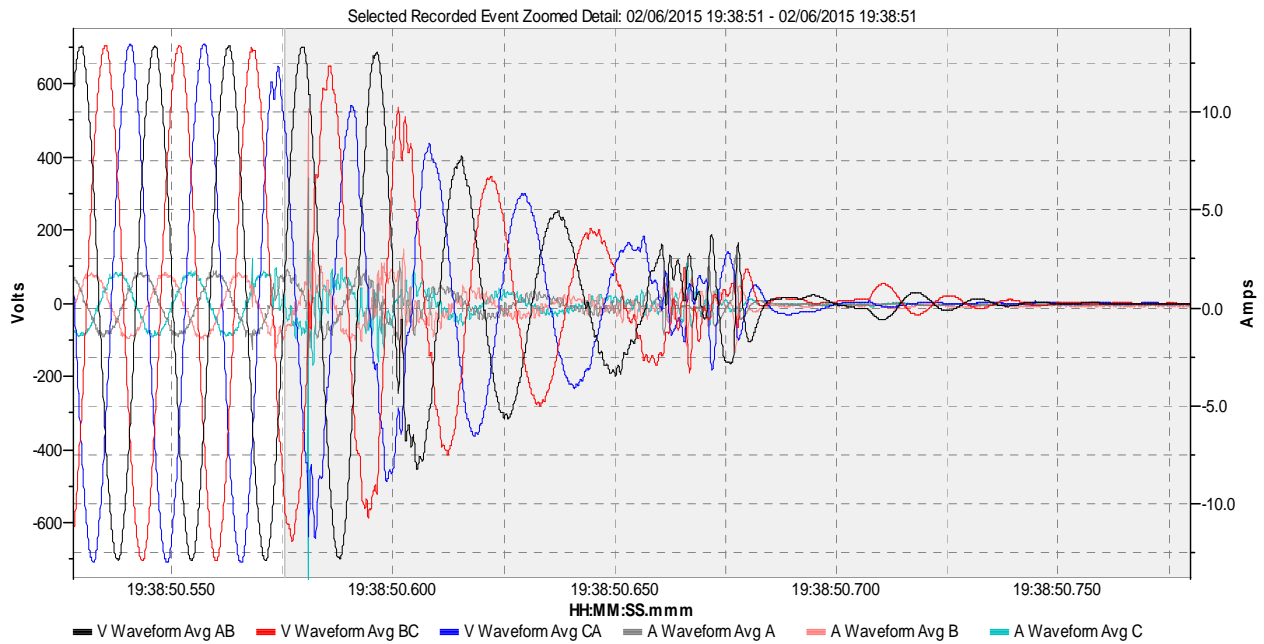
#	Date/Time	Type	Duration (Days - Hrs:Min:Sec)	% of Nominal	Absolute	Triggered Phase
1	02/06/2015 19:38:50.575.635	Dip	0 - 00:00:04.676178800	0.03%	0.08 V	AB, BC, CA
2	02/06/2015 19:38:50.732.558	Interruption	0 - 00:00:04.390470400	0.03%	0.08 V	AB, BC, CA
3	02/06/2015 19:41:19.766.989	Dip	0 - 00:00:00.118524600	76.05%	365.05 V	AB, BC, CA
4	02/06/2015 19:44:07.411.967	Dip	0 - 00:00:00.118755100	75.86%	364.15 V	AB, BC, CA
5	02/06/2015 19:47:51.665.948	Dip	0 - 00:00:00.118350800	76.57%	367.53 V	AB, BC, CA
6	02/06/2015 19:51:36.921.925	Dip	0 - 00:00:00.118574800	76.61%	367.73 V	AB, BC, CA
7	02/06/2015 19:55:19.001.292	Dip	0 - 00:00:00.118402500	76.65%	367.93 V	AB, BC, CA
8	02/06/2015 19:58:42.531.849	Dip	0 - 00:00:00.067681100	82.35%	395.27 V	AB, BC, CA
9	02/06/2015 19:59:05.279.141	Dip	0 - 00:00:00.118365900	76.70%	368.15 V	AB, BC, CA
10	02/06/2015 20:00:16.736.377	Dip	0 - 00:00:00.101729700	80.79%	387.81 V	AB, BC, CA
11	02/06/2015 20:04:13.749.360	Dip	0 - 00:00:00.101601600	81.00%	388.78 V	AB, BC, CA
12	02/06/2015 20:12:34.393.121	Dip	0 - 00:00:00.101329600	80.46%	386.18 V	AB, BC, CA
13	02/06/2015 20:16:43.083.113	Dip	0 - 00:00:00.101701200	80.57%	386.74 V	AB, BC, CA
14	02/06/2015 20:21:32.297.122	Dip	0 - 00:00:00.101605600	80.83%	387.96 V	AB, BC, CA
15	02/06/2015 20:30:26.970.928	Dip	0 - 00:00:00.101734900	80.70%	387.34 V	AB, BC, CA
16	02/06/2015 20:41:07.102.000	Dip	0 - 00:00:00.110161900	80.41%	385.97 V	AB, BC, CA
17	02/06/2015 20:47:26.891.850	Dip	0 - 00:00:00.101594300	80.88%	388.21 V	AB, BC, CA
18	02/06/2015 20:52:17.045.882	Dip	0 - 00:00:00.101599400	80.93%	388.47 V	AB, BC, CA
19	02/06/2015 20:56:30.893.844	Dip	0 - 00:00:00.101460200	80.51%	386.48 V	AB, BC, CA
20	02/06/2015 21:01:06.051.088	Dip	0 - 00:00:00.101665600	81.04%	388.99 V	AB, BC, CA
21	02/06/2015 21:04:29.917.875	Dip	> 0 - 00:05:01.638833700	0.03%	0.08 V	AB, BC, CA
22	02/06/2015 21:04:30.520.191	Interruption	> 0 - 00:05:01.036517000	0.03%	0.08 V	AB, BC, CA
	(Unshaded)	Fluke 1750 Dip / Sag Events				
	(Shaded Green)	Fluke 1750 Interruption events (no PQube event data provided)				
	(Shaded Red)	Fluke 1750 Dip / Sag Events with corresponding PQube Event documented				

Voltage Disturbance Events During Mobile System Move



**Outage
 Event #
 1 - 2**

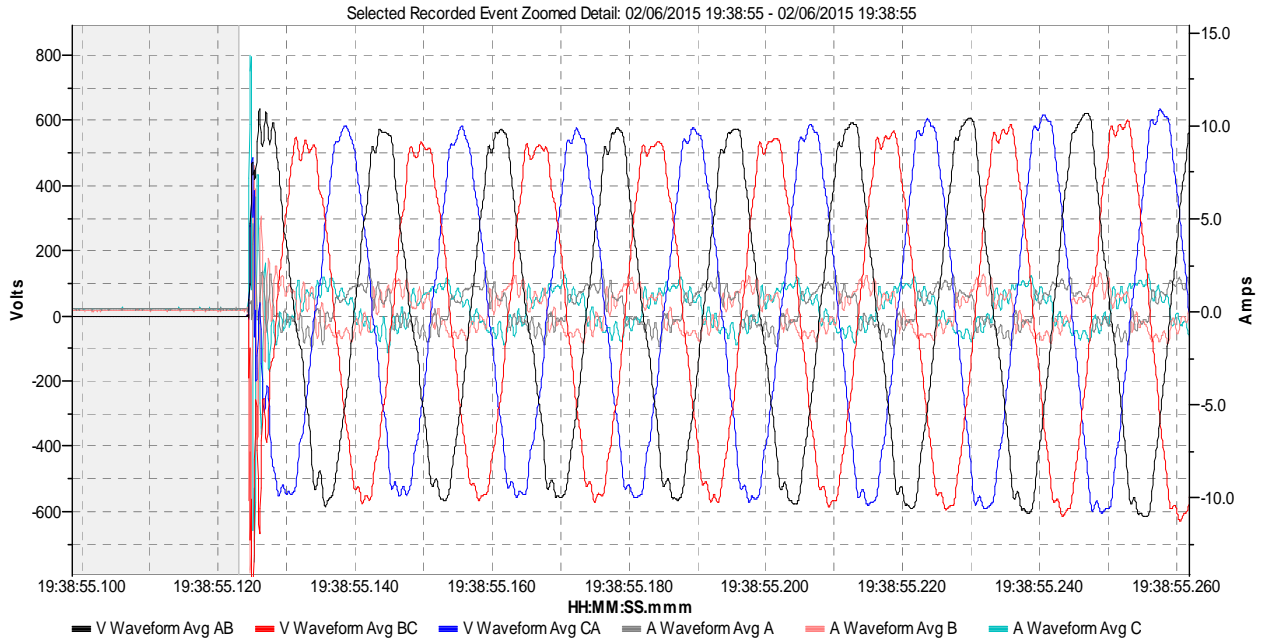
Outage related to transfer from facility power to on-board generator. Note instability / fluctuation of voltage while operating on generator.



**Outage
 Event #
 1 - 2**

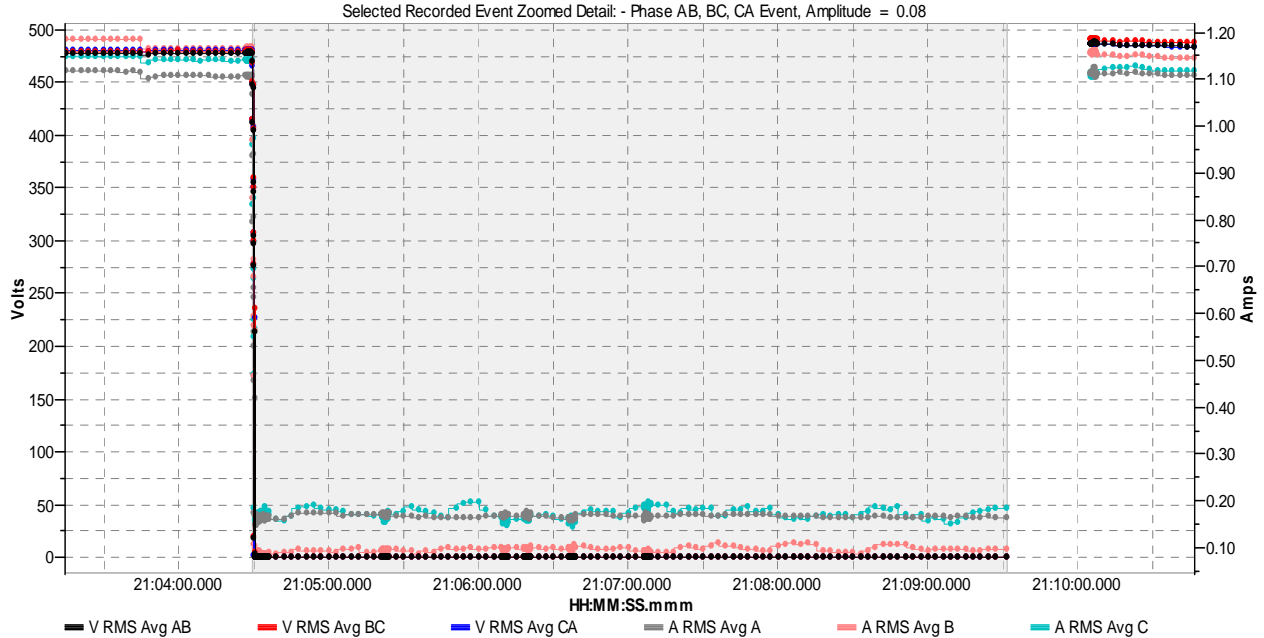
Slow decay of voltage during outage, probably related to power conditioner discharge of DC bus. Recommend switching sensitive equipment off during transfers to/from the on-board generator.

Voltage Disturbance Events During Mobile System Move



Outage
 Event #
 1 - 2

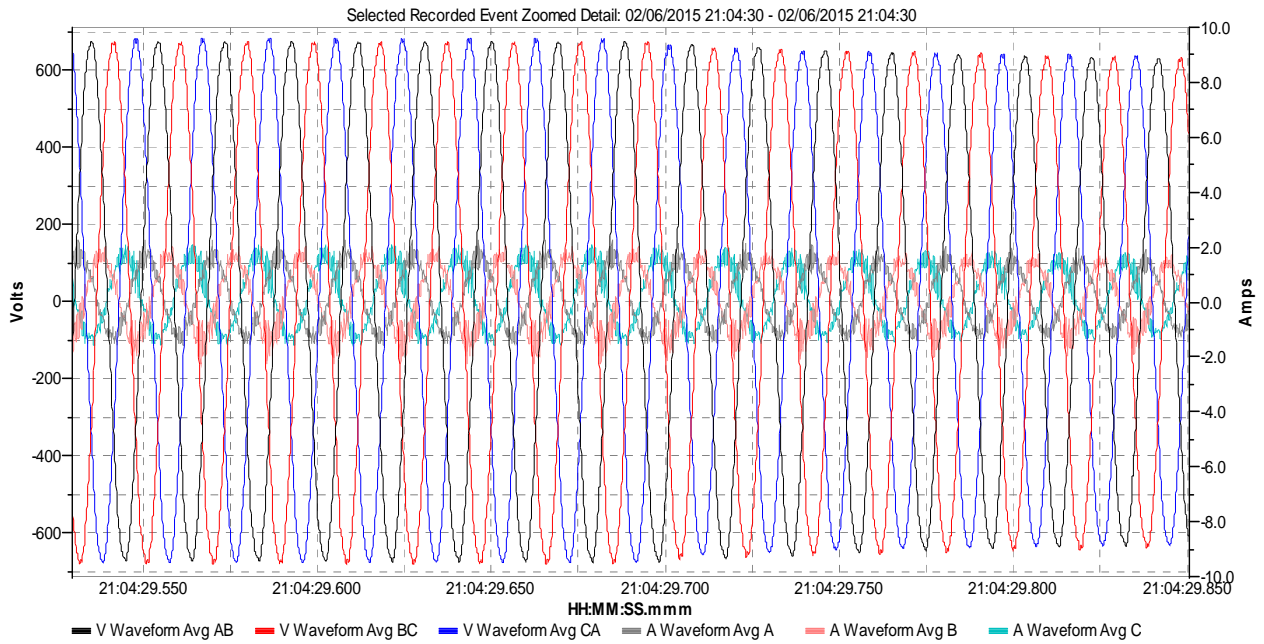
Voltage transfer to on-board generator, with transients, voltage instability, and voltage distortion. Suspect that on-board power conditioner is struggling to correct generator voltage instability.



Outage
 Event #
 21 - 22

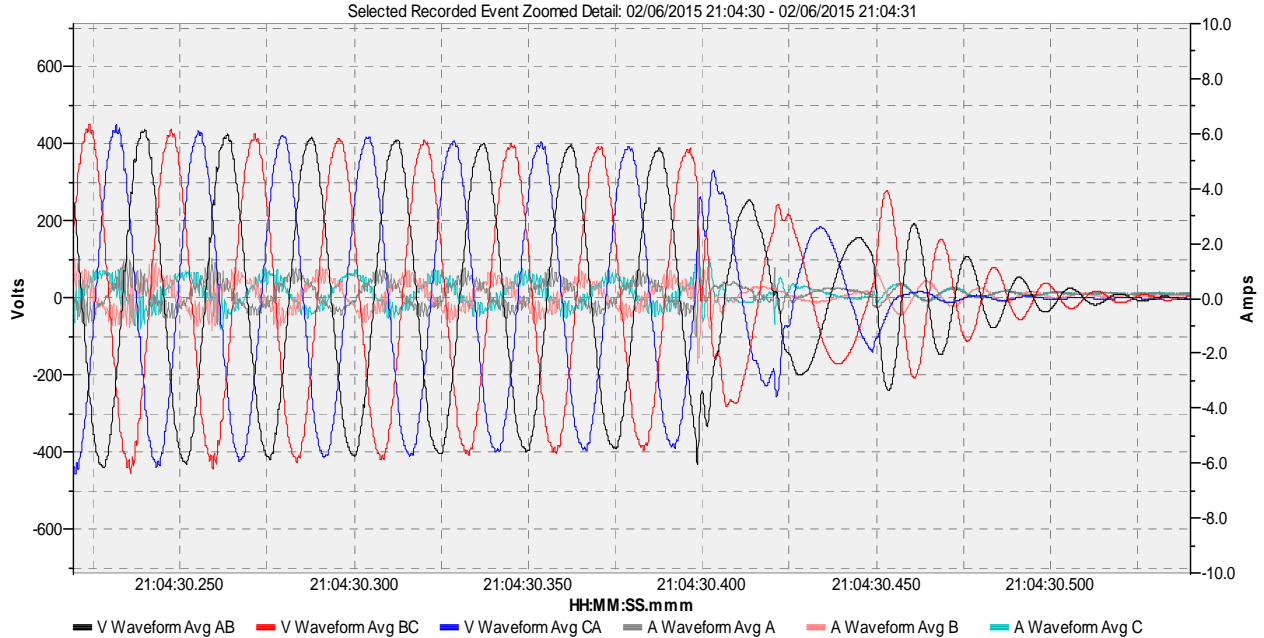
Voltage outage associated with transfer from on-board generator back to facility power.

Voltage Disturbance Events During Mobile System Move



Outage
Event #
21 - 22

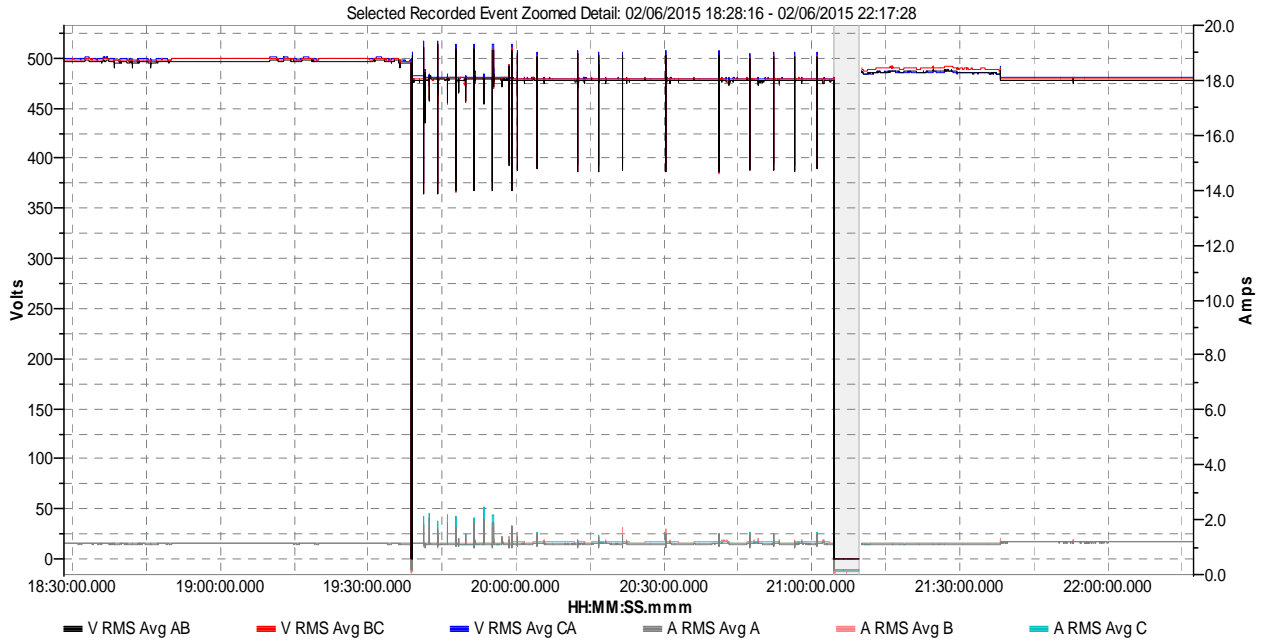
Long voltage decay, probably related to generator being switched off and allowed to run down over time. Best practice would be to switch power conditioner and/or medical imaging system off rather than allowing the generator to spin down over many cycles.



Outage
Event #
21 - 22

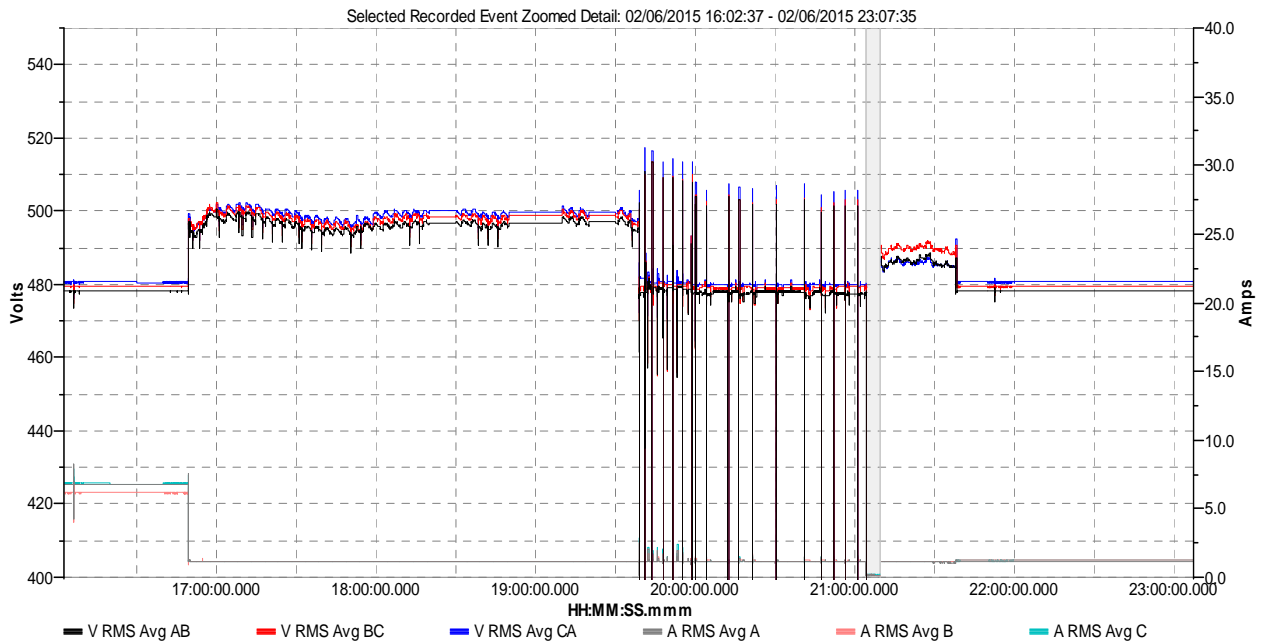
Slow decay of voltage during outage, probably related to power conditioner discharge of DC bus. Recommend switching sensitive equipment off during transfers to/from the on-board generator.

Voltage Disturbance Events During Mobile System Move



**Outage
Event #
1 - 22**

Mobile system move event: transfer from facility power to generator, generator operation, and a subsequent transfer back to facility power. During generator, voltage is well regulated (power conditioner) but many sag events were captured. Suspect generator is being overloaded by a cycling load (chiller, compressor, HVAC, etc.) and resultant sags are too severe for power conditioner to correct.



**Outage
Event #
1 - 22**

Power conditioner is switched to bypass mode before and after power transfers. Note higher and less regulated RMS voltage: 500 VAC before move, 490 VAC after.

PQube Header Information

Voltage Sag – MEDICAL IMAGING OEM Mobile MRI Site

PQube Information

Location: MEDICAL IMAGING OEM Mobile MRI Site

PQube ID: 010356

Note 1: XXX=XXXXXX

Note 2: XXX.XXX.XXX.XXX

PQube Serial Number: P010356

Model Number: PQube 02-0000

Firmware Version: 2.1.4 #2893

Configuration

Power Configuration: Delta

Nominal Line-to-Line Voltage: 480V

Nominal Frequency: 60Hz

Clock Sync

Time Offset: 58:32 (subtract from PQube for Corresponding Fluke 1750 Event)

Filename

PQube - 2015/02/06 20:58:48 - Voltage Dip - MEDICAL IMAGING OEM Mobile MRI Site

Event

Event Type: Voltage Sag

Event Magnitude: 80.39%

Event Duration in Seconds: 0.117

Trigger Date: 2015/02/06

Trigger Day of Week: Friday

Trigger Time: T 20:58:48.321 EST

Trigger Channel: L1-L2

Trigger Threshold: 90.0% of nominal

Min Max Readings

L1-L2

Min: 385.9V

Max: 504.8V

Min (During Event Only): 385.9V

Max (During Event Only): 442.8V

L2-L3

Min: 389.6V

Max: 504.2V

Min (During Event Only): 389.6V

Max (During Event Only): 444.7V

L3-L1

Min: 395.0V

Max: 507.4V

Min (During Event Only): 395.0V

Max (During Event Only): 454.0V

L1 Amp

Min: 0.01A

Max: 0.01A

Min (During Event Only): 0.01A

Max (During Event Only): 0.01A

L2 Amp

Min: 0.01A

Max: 0.01A

Min (During Event Only): 0.01A

Max (During Event Only): 0.01A

L3 Amp

Min: 0.01A

Max: 0.01A

Min (During Event Only): 0.01A

Max (During Event Only): 0.01A

Frequency

Min: 59.371Hz

Max: 59.991Hz

Min (During Event Only): 59.887Hz

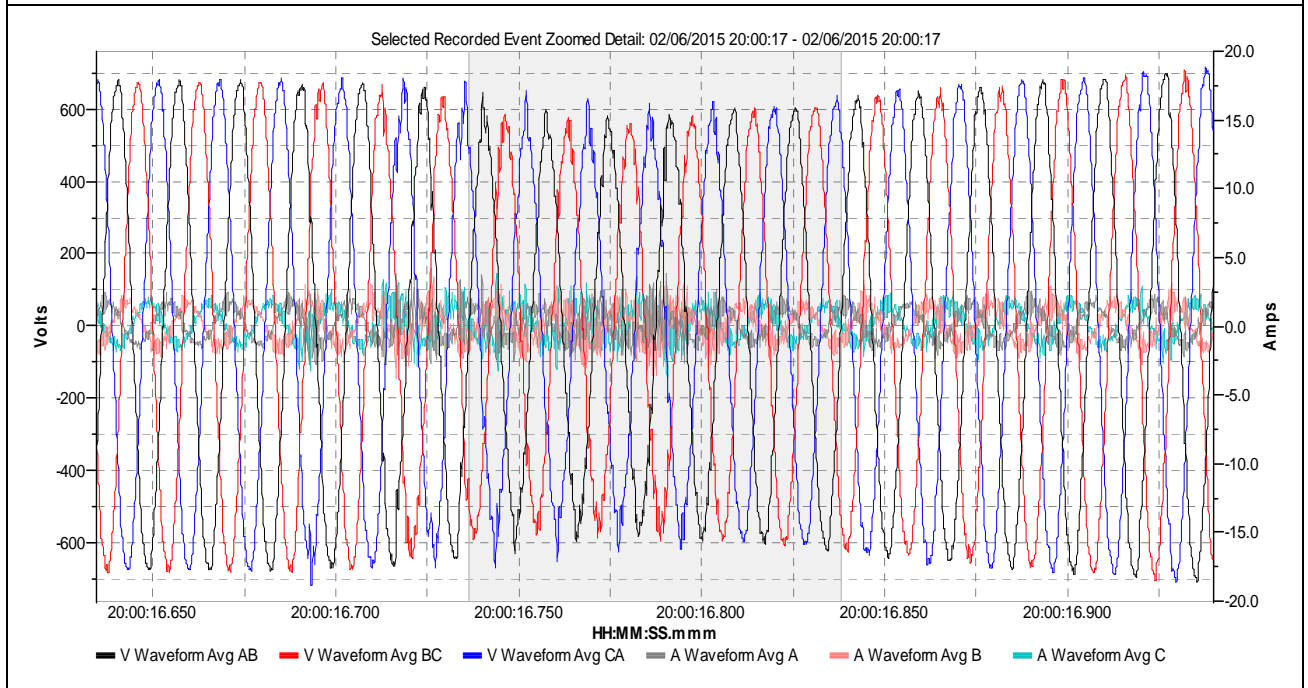
Max (During Event Only): 59.963Hz

Made with the PQube(R) by Power Standards Lab
(www.PowerStandards.com)



Above: PQube waveform graphs of a serious voltage sag, captured during operation from the on-board generator. A large number of similar sags were captured during each period of generator operation.

Below: Fluke 1740 documents severe voltage sag / collapse. Unusual for the output of a power conditioner, unless the source voltage collapse or instability is too great for the device to compensate. (Event #10)





Above: PQube RMS logs of a serious voltage sag, captured during operation from the on-board generator. A large number of similar sags were captured during each period of generator operation.

Below: Fluke 1750 RMS sag / swell event - with severe voltage sag / dip, followed by an overvoltage swell (less severe) related to generator and/or power conditioner regulation characteristics. (Event #10)

