Comparison of Power Quality Analyzers

SER: 20MGD09231

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Introduction

Not all power quality analyzers are created equal. The standard power quality analyzer is capable of analyzing up to the 50th harmonic. The Fluke 1750 represents a high-quality, 3-phase power quality analyzer that is capable of analysis up to the 50th harmonic. As with any 50th harmonic capable analyzer, it is adequate for verifying compliance with IEEE-519 but is unable to analyze harmonic content above approximately 3KHz. For analyzing the output of variable frequency drives, it is preferred to utilize a power quality analyzer that is at least capable of analyzing harmonic content to the 100th harmonic for 6-step drives and to the 500th harmonic for FPWM drives.

6-Step Example

The example below was collected on a 6-step drive and is typical.

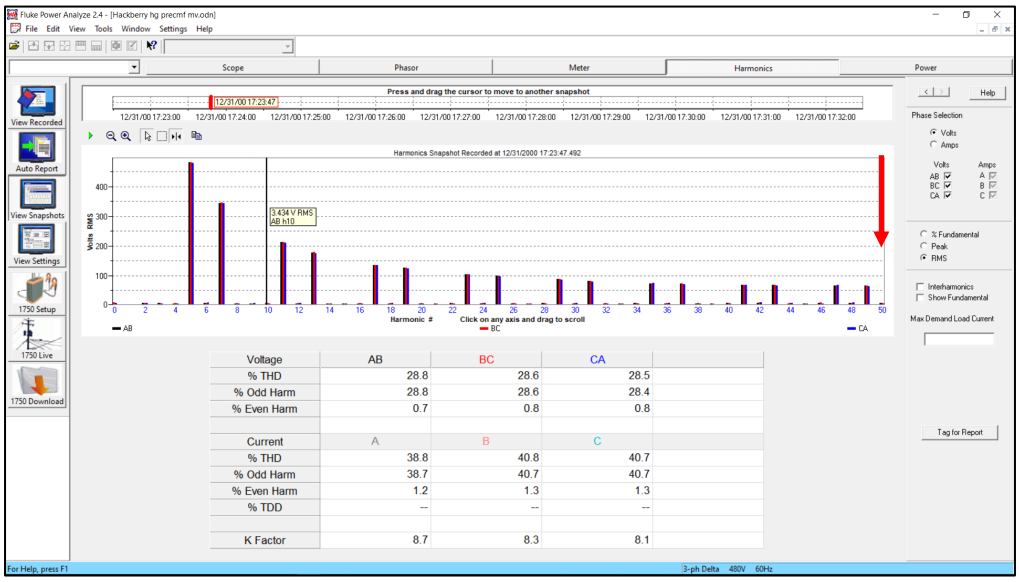


Figure 1: Voltage Harmonic Scale (Fluke 1750). Red arrow indicates 50th Harmonic.

As can be seen in Figure 1, the voltage harmonic content has a general dissipation toward the 50th harmonic which gives the impression that this downward trend continues beyond the horizontal scale.

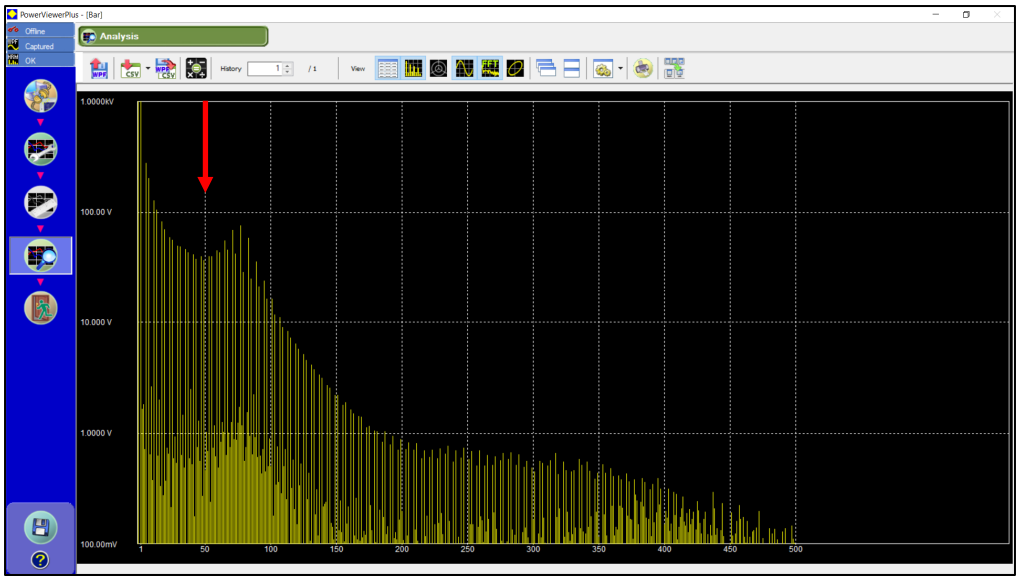


Figure 2: Voltage Harmonic Scale (PX8000). Red arrow indicates 50th Harmonic.

Figure 2 as collected simultaneously with the data in Figure 1, shows that there is an upward trend in harmonic magnitude that occurs after the 50th harmonic. Harmonics at this magnitude in this range are damaging.

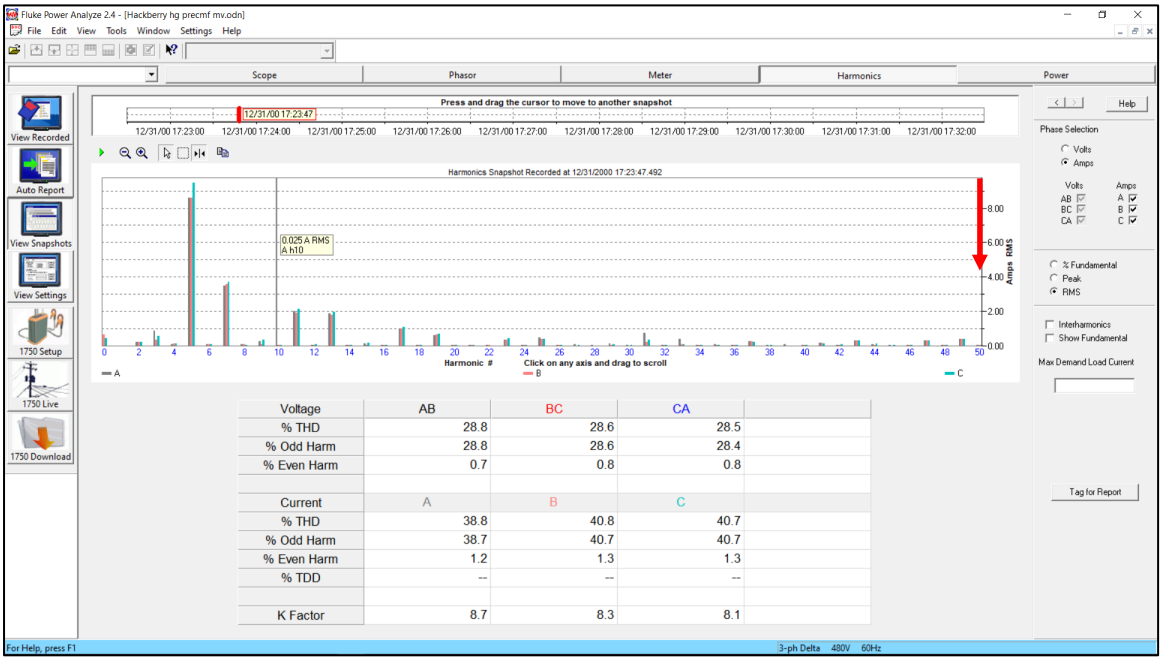


Figure 3: Current Harmonic Scale (Fluke 1750). Red arrow indicates 50th Harmonic.

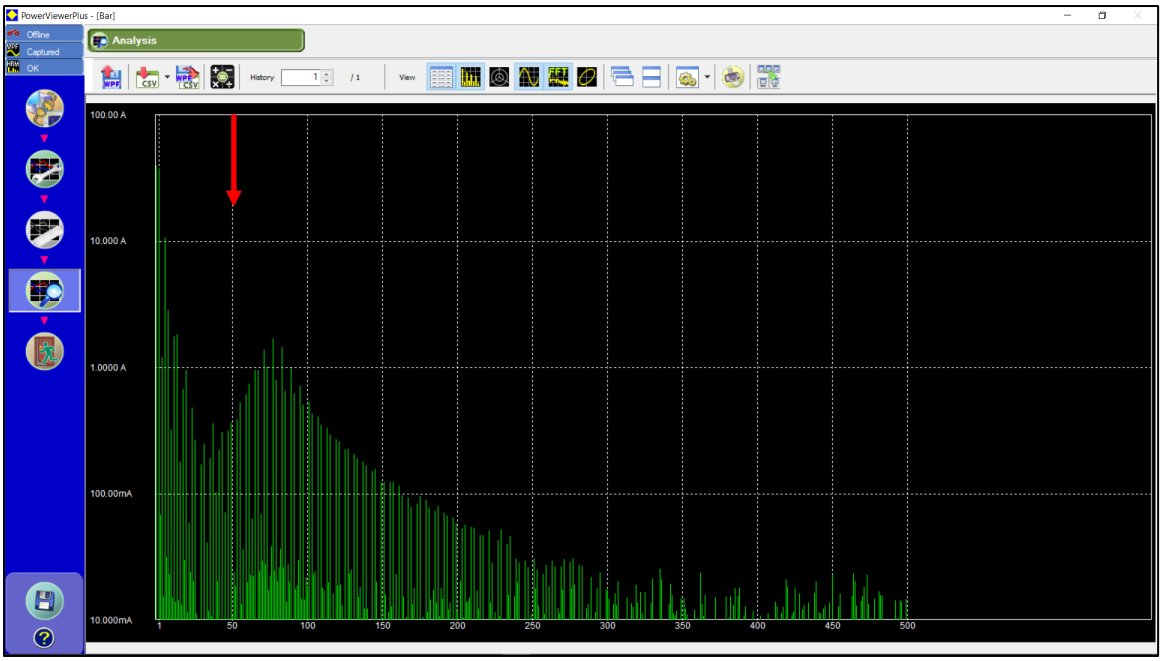


Figure 4: Current Harmonic Scale (PX8000). Red arrow indicates 50th Harmonic.

The current harmonic scales shown in Figures 3 and 4 display the same phenomenon. The current harmonics in the vicinity of the 80th harmonic over 1 amp are damaging and are unrecorded by a standard power analyzer as represented here in the Fluke 1750 (Figure 3).

FPWM Example with Carrier Frequency Below 3KHz

When analyzing the output of FPWM drives, it is recommended to use a power quality analyzer that is capable of analyzing up to the 500th harmonic. Further, the sample rate of the scope should also be considered as a lower sample rate can make the output appear more sinusoidal than actual.

The example below was collected on an FPWM drive with a carrier frequency below 3KHz and is typical.

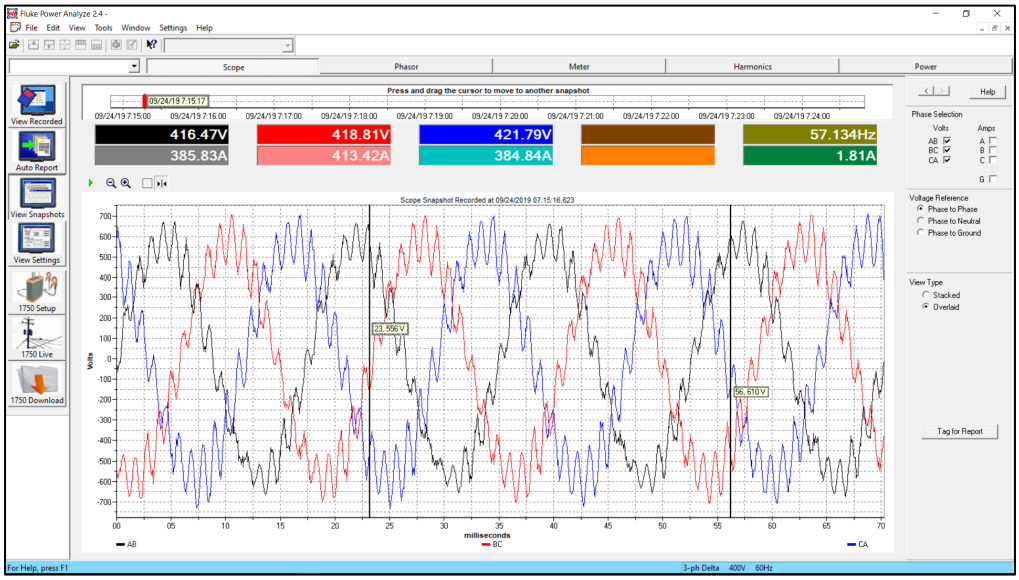


Figure 5: Voltage Waveforms FPWM Output (Fluke 1750)

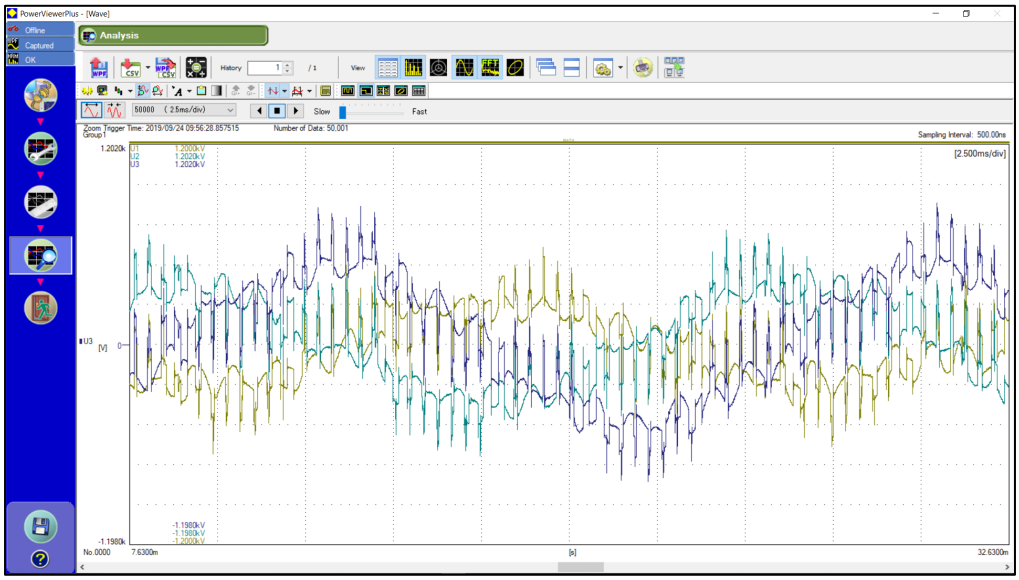


Figure 6: Voltage Waveforms FPWM Output (PX8000)

Figures 5 and 6 were collected simultaneously at the output of an FPWM drive. Figure 5 displays waveforms that appear fairly sinusoidal while Figure 6 displays the remnant of the PWM carrier frequency that has not been properly filtered.

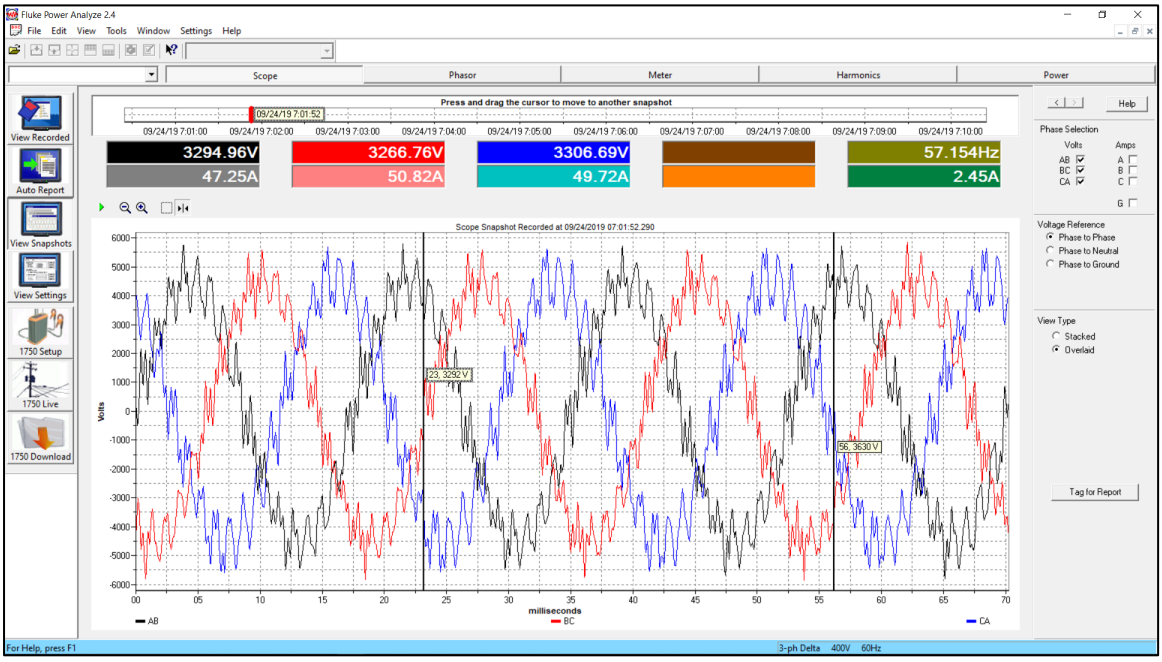


Figure 7: Voltage Waveforms FPWM Output as collected at the SUT secondary (Fluke 1750)

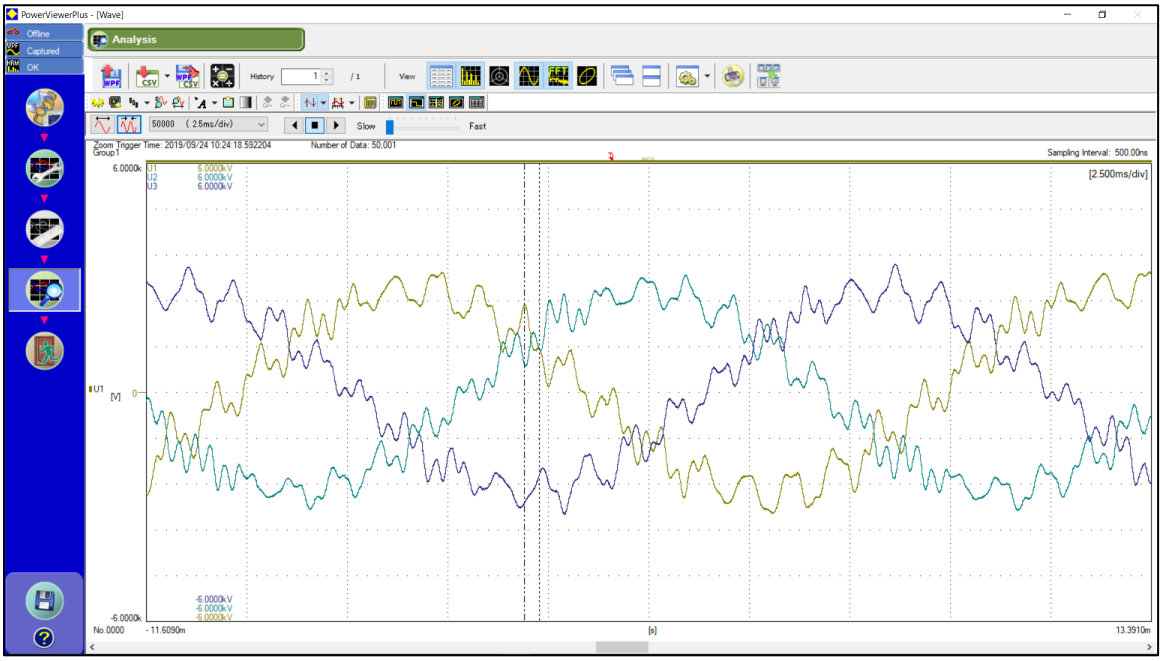
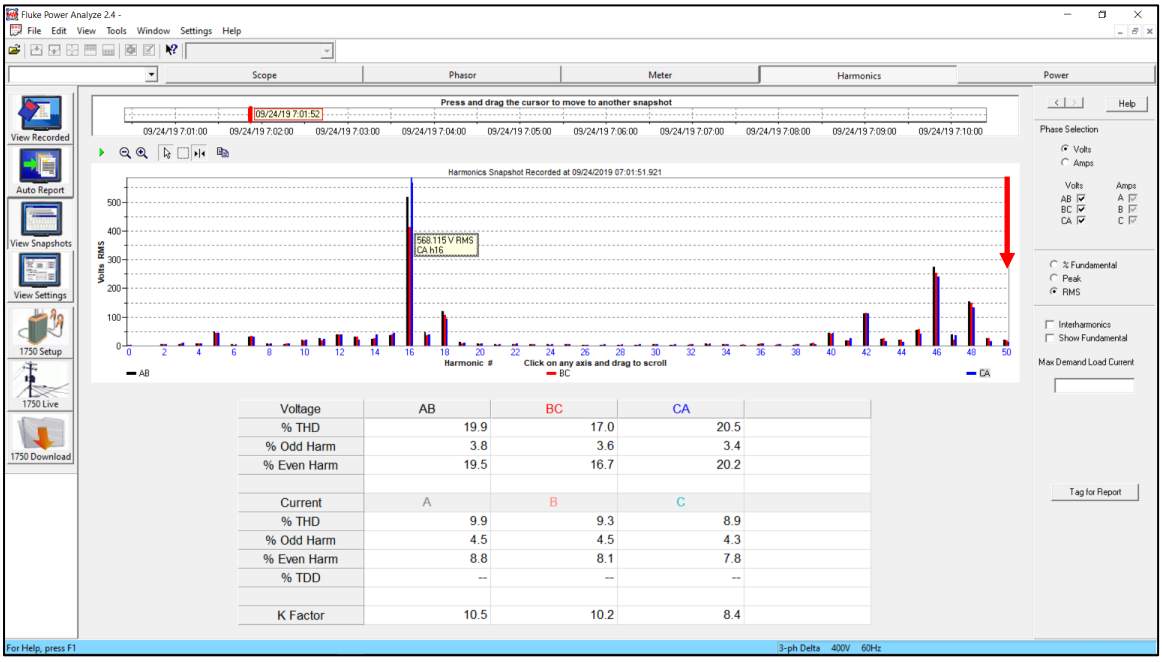


Figure 8: Voltage Waveforms FPWM Output as collected at the SUT secondary (PX8000)

Figures 7 and 8 show the FPWM voltage waveforms as collected simultaneously at the secondary of the step-up transformer. A comparison of Figures 6 and 8 demonstrates the filtering effect of the step-up transformer.



Voltage	AB	BC	CA
% THD	19.9	17.0	20.5
% Odd Harm	3.8	3.6	3.4
% Even Harm	19.5	16.7	20.2
Current	A	B	C
% THD	9.9	9.3	8.9
% Odd Harm	4.5	4.5	4.3
% Even Harm	8.8	8.1	7.8
% TDD	--	--	--
K Factor	10.5	10.2	8.4

Figure 9: Voltage Harmonic Scale (Fluke 1750). Red arrow indicates 50th Harmonic.

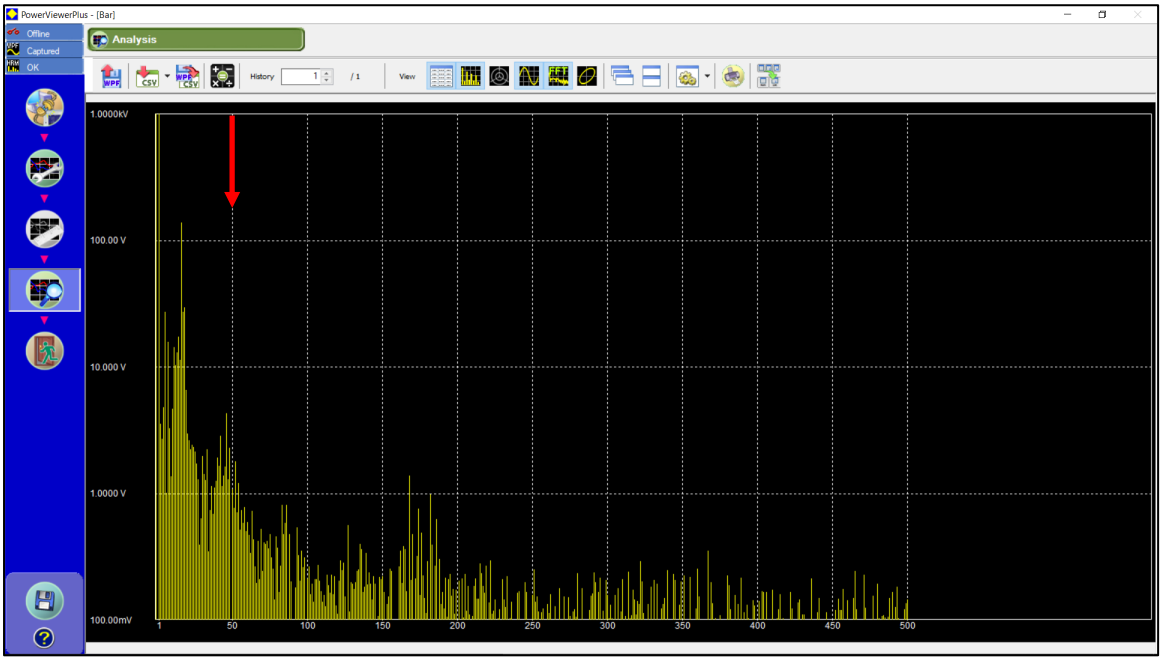
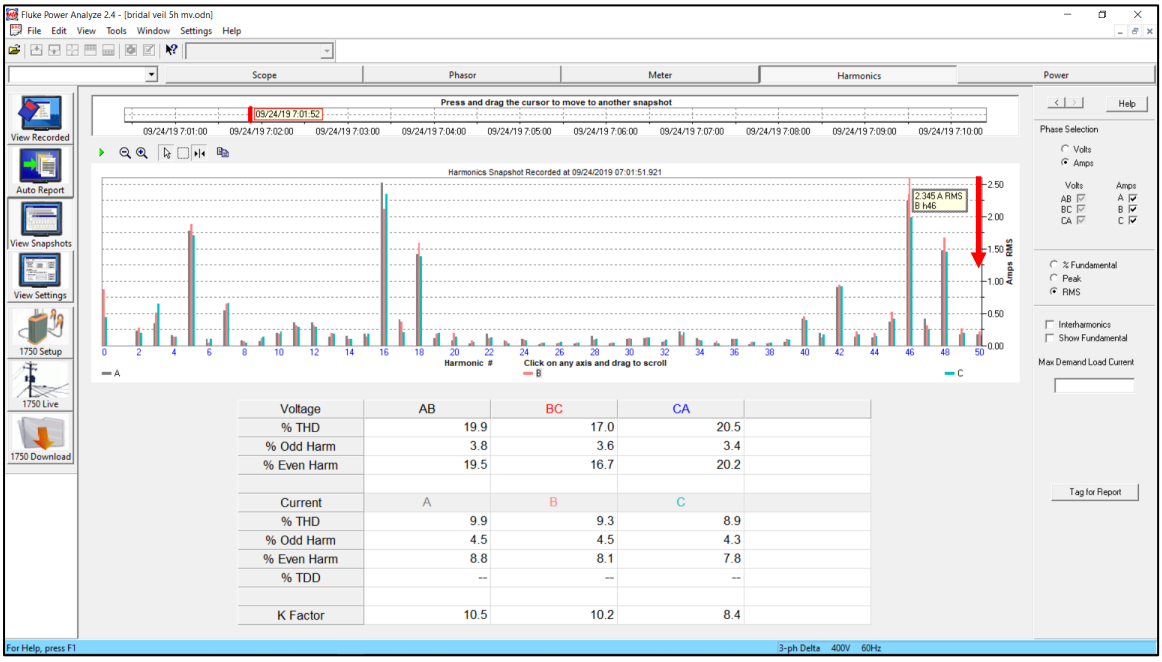


Figure 10: Voltage Harmonic Scale (PX8000). Red arrow indicates 50th Harmonic.



Voltage	AB	BC	CA
% THD	19.9	17.0	20.5
% Odd Harm	3.8	3.6	3.4
% Even Harm	19.5	16.7	20.2
Current	A	B	C
% THD	9.9	9.3	8.9
% Odd Harm	4.5	4.5	4.3
% Even Harm	8.8	8.1	7.8
% TDD	--	--	--
K Factor	10.5	10.2	8.4

Figure 11: Current Harmonic Scale (Fluke 1750). Red arrow indicates 50th Harmonic.

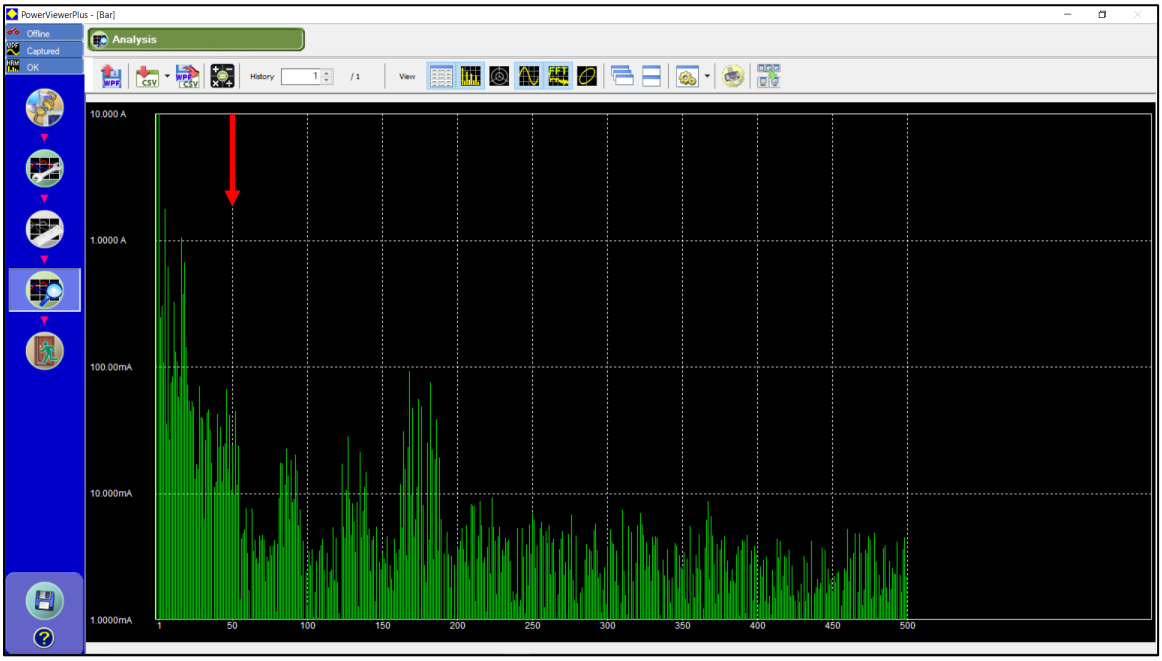


Figure 12: Current Harmonic Scale (PX8000). Red arrow indicates 50th Harmonic.

FPWM Example with Carrier Frequency Above 3KHz

A carrier frequency above 3KHz can make the waveforms appear more sinusoidal and yield a lower Total Harmonic Distortion, however the increased frequency is more damaging to the wire run and downhole equipment if not properly filtered.

The example below was collected on an FPWM drive with a carrier frequency above 3KHz and is typical.

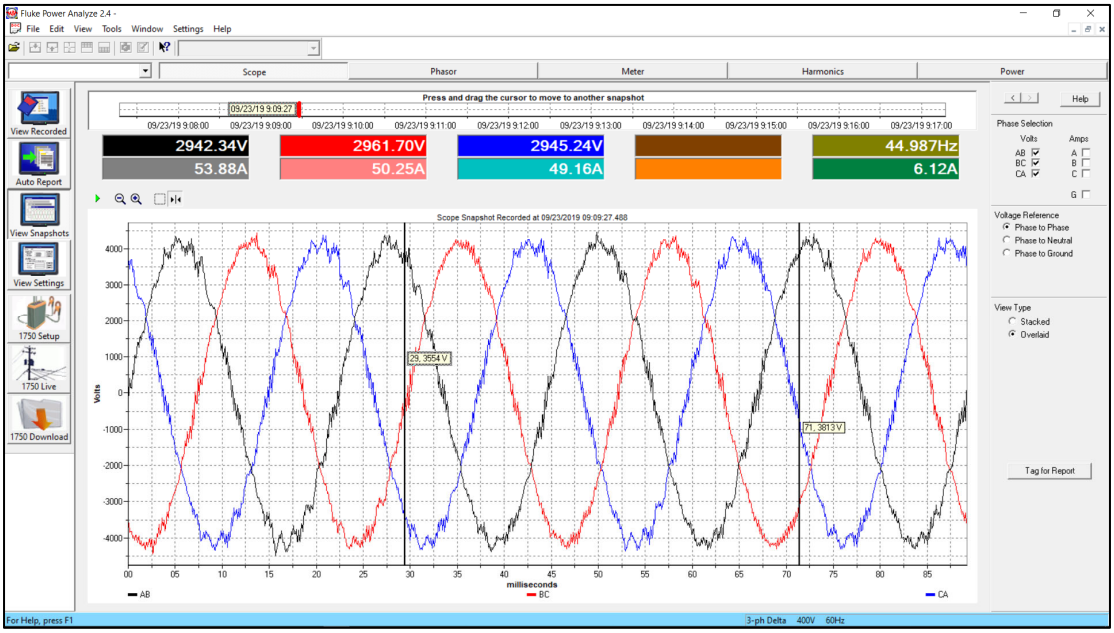


Figure 13: Voltage Waveforms FPWM Output as collected at the SUT secondary (Fluke 1750)

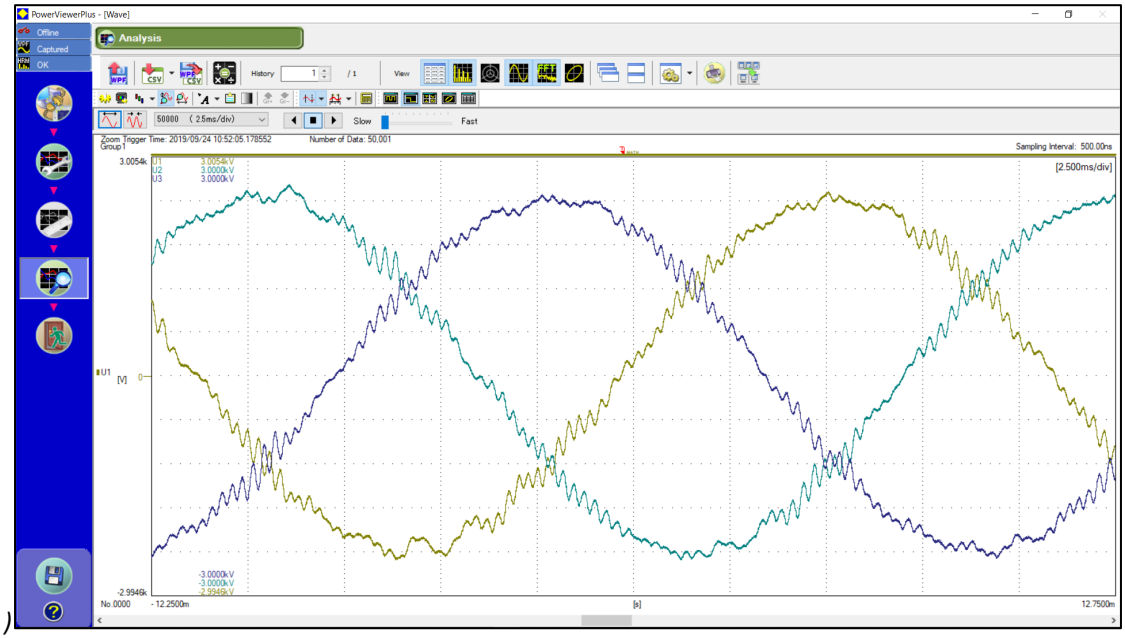


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Figure 14: Voltage Waveforms FPWM Output as collected at the SUT secondary (PX8000)

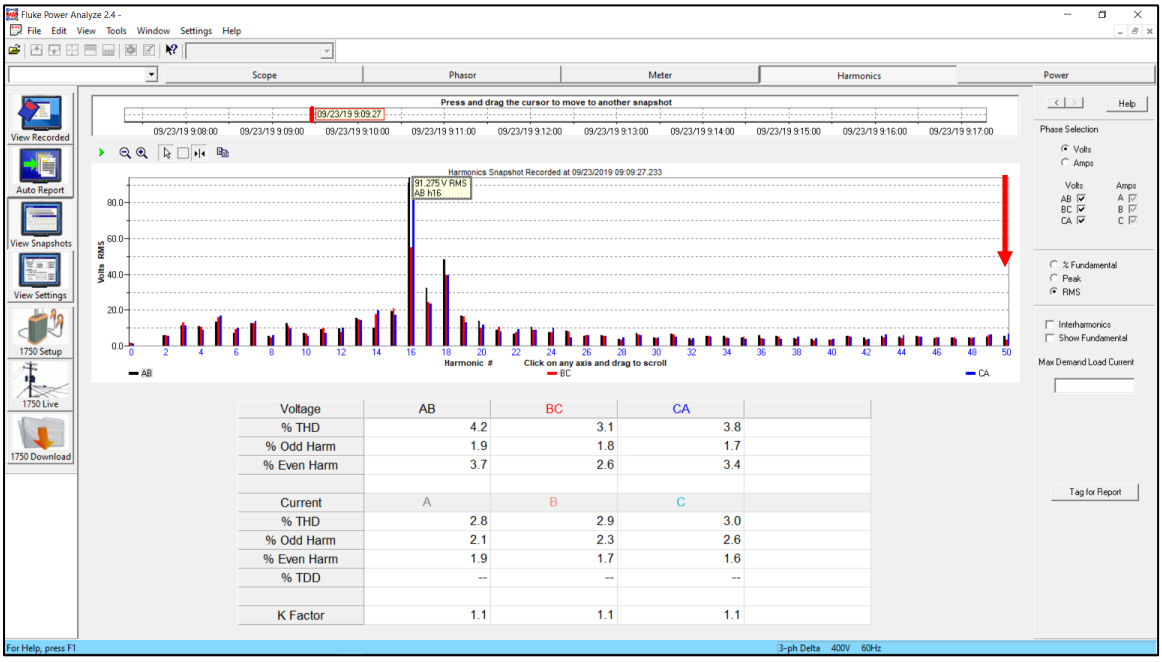

Figure 15: Voltage Harmonic Scale (Fluke 1750). Red arrow indicates 50th Harmonic.

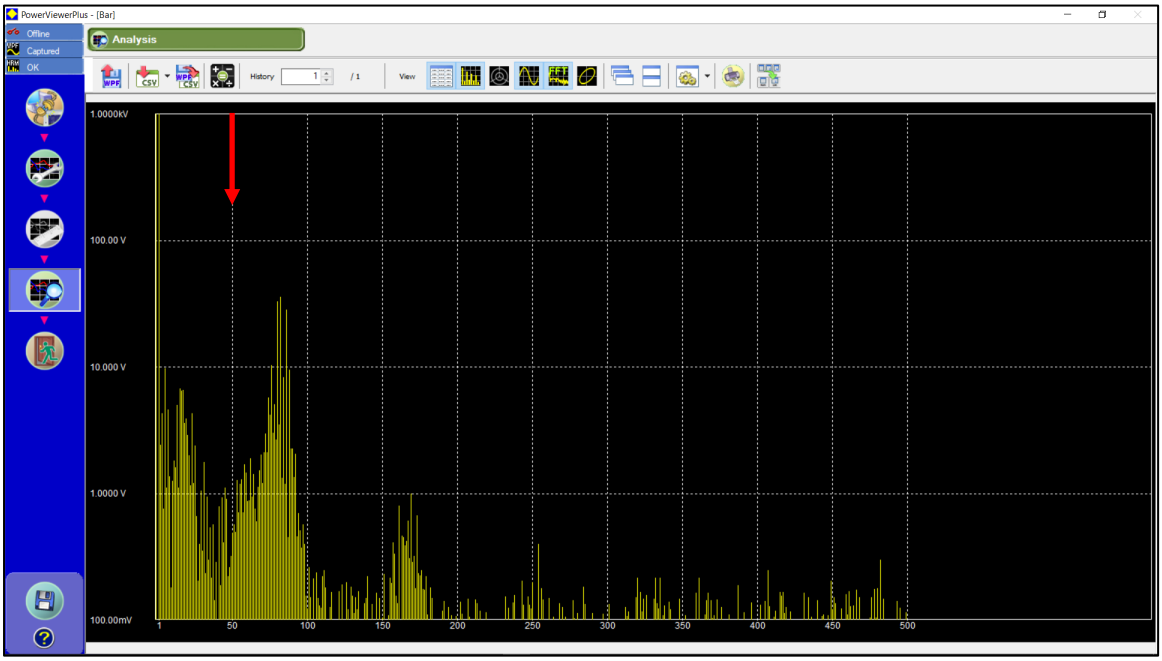

Figure 16: Voltage Harmonic Scale (PX8000). Red arrow indicates 50th Harmonic.

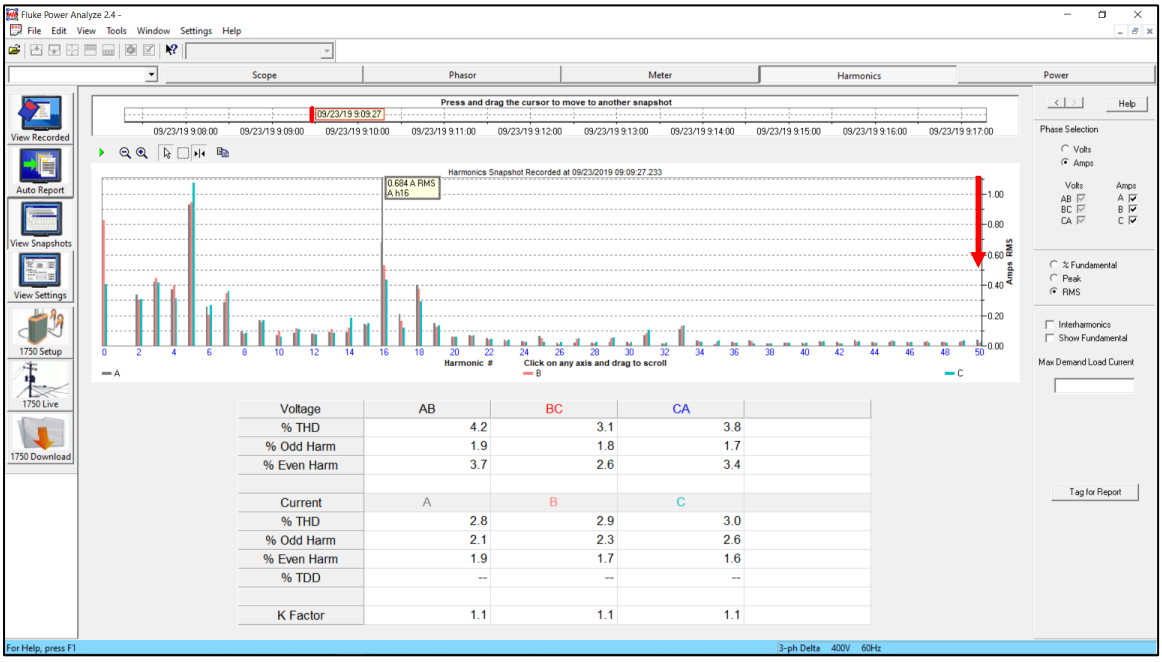

Figure 17: Current Harmonic Scale (Fluke 1750). Red arrow indicates 50th Harmonic.

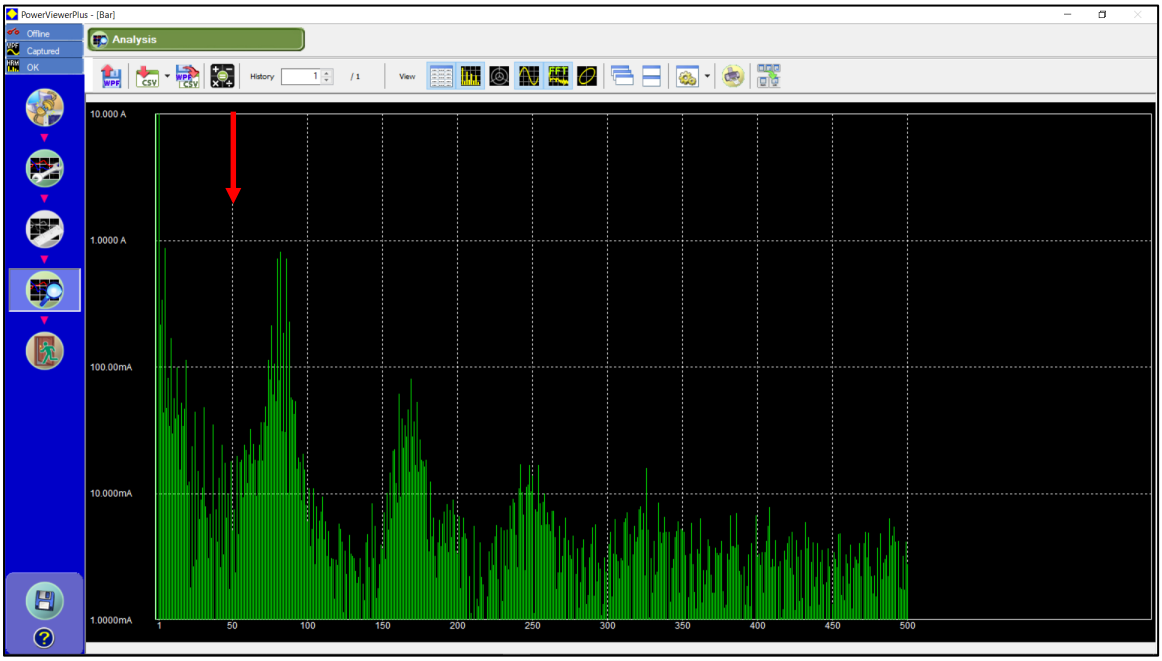

Figure 18: Current Harmonic Scale (PX8000). Red arrow indicates 50th Harmonic.

Figure 15 displays that there is virtually no harmonic content above the relatively small spikes at the 16th and 18th harmonics. Figure 16 demonstrates that the worst of the harmonic content occurs in the vicinity of the carrier frequency which is around the 75th harmonic placing well outside the measurement range of the standard power quality analyzer. This is also visible in the current harmonic scales displayed in Figures 17 and 18.

Summary

A power quality analyzer is a useful tool if it is properly applied. Power quality analyzers that are capable of analyzing to the 50th harmonic are useful for verifying compliance with IEEE-519. When analyzing the output of a 6-step drive, an analyzer that is capable of at least the 100th harmonic is preferred to permit analysis of the upward trend that occurs beyond the 50th harmonic and peaks in the vicinity of the 80th harmonic. When analyzing the output of FPWM drives, it is preferred to use an analyzer that is capable to the 500th harmonic to permit analysis of the carrier frequency and the harmonics of the carrier frequency.