Detecting Harmonics in an AC Signal

Application Note

Introduction

Harmonic distortion has become increasingly prevalent in today's world due to the expanded use of equipment and machinery. Because these devices can malfunction or fail in the presence of high harmonic voltage and/or current levels, harmonic distortion has become a growing concern for facility managers, users of automation equipment, and engineers. The presence of harmonics may not impede a factory's or office's ability to run properly, however, it depends on the withstand capability of the power distribution system and the susceptibility of the equipment. In this application note, you will learn some basics about harmonics and how to perform a quick check for harmonics in electrical power systems using the harmonic ratio function of the Agilent U1242B handheld digital multimeter (DMM).

Agilent Technologies

What are Harmonics?

Harmonics are electric voltages and currents that appear on the electric power system with frequencies that are integer multiples of the fundamental supply frequency, which is 50 Hz for European countries and 60 Hz for North America. For example, if the fundamental supply frequency is 60 Hz, then the second order harmonic is 120 Hz, the third order is 180 Hz, the fourth order is 240 Hz, and so on.

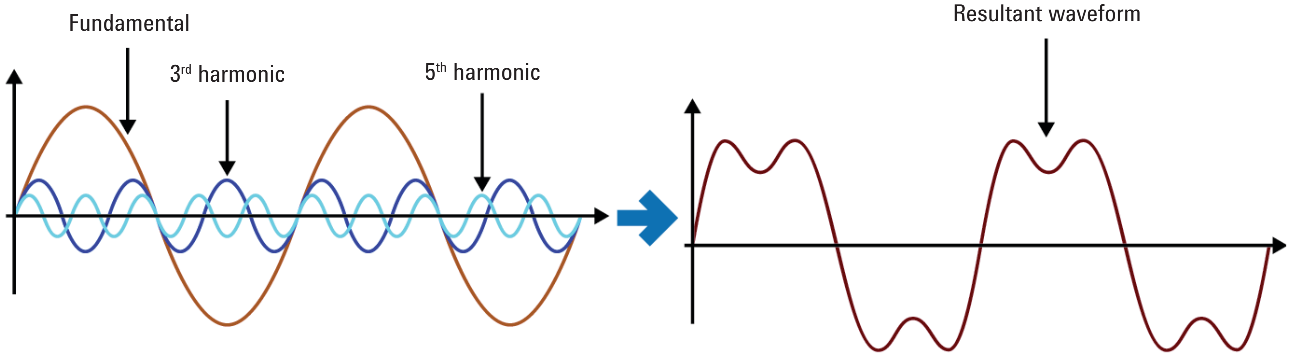

Figure 1. The resultant waveform of a sine wave with the presence of third and fifth order harmonics

What Causes Harmonics?

Harmonics are caused by modern electronic equipment having a non-linear load. These non-linear loads create harmonics by drawing current in abrupt short pulses. The short pulses cause distorted current waveforms which in turn causes harmonic currents to flow back into other parts of the power system. Harmonics are especially prevalent where there are a large number of personal computers, laser printers, fax machines, copiers, medical test equipment, fluorescent lighting, uninterruptible power supplies (UPSs), and variable speed drives.

Harmonics degrade the level of power quality and its efficiency, particularly in a commercial building or industrial facility. In general, most buildings can withstand non-linear loads of up to 15% of the total electrical system capacity without concern. If the non-linear loads exceed 15%, some non-apparent negative consequences can be expected.

Problems Caused by Harmonics

The following are some of the common problems caused by harmonics. The actual problems of any building will vary, depending on the types and number of installed harmonic-producing loads.

Overloading of neutral conductors

The three-phase system consists of three individual phase conductors and a neutral conductor. If all the phase conductors carry the same current, the phase currents tend to cancel out one another provided there is a balanced load. This balanced load makes it possible to reduce the size of the neutral conductor. Unfortunately, switched mode power supplies used in computers have very high third harmonic current. While harmonic currents cancel out on the neutral wire, the third harmonic current is additive in the neutral. In buildings with a large number of installed personal computers, the neutral wire can carry much higher currents than the wire was designed to accommodate, creating a potential fire hazard.

Overheating of transformers and increased associated losses

For transformers feeding harmonic-producing loads, the eddy current loss in the windings is the most dominant loss component in the transformer. This eddy current loss increases proportional to the square of the product's harmonic current and its corresponding frequency. The total transformer loss to a fully loaded transformer supplying to a non-linear load is twice as high as for an equivalent linear load. This causes excessive transformer heating and degrades the insulation materials in the transformer, which eventually leads to transformer failure.

Nuisance tripping of circuit breakers

All circuits containing capacitance and inductance have one or more resonant frequencies. When any of the resonant frequencies correspond to the harmonic frequency produced by non-linear loads, harmonic resonance can occur. Voltage and current during resonant frequency can be highly distorted. This distortion can cause nuisance tripping in an electrical power system, which can ultimately result in production losses.

Detecting Harmonics with the U1242 Series Handheld Multimeter

A harmonics analyzer is the most effective instrument for performing detailed analysis of power quality to determine the wave shapes of voltage and current on respective frequency spectrums. A harmonic analyzer is also useful in instances where the lack of obvious symptoms prevents you from determining if harmonics are a cause for concern.

To help technicians or electricians quickly indentify if harmonics are present in the source, Agilent has introduced a new U1240 Series DMM feature called harmonic ratio. A harmonic analyzer is used to provide a detailed analysis of the suspect source. Using this data, the harmonic ratio function calculates a value from 0% to 100% to indicate the deviation of non-sinusoidal and sinusoidal waveform. This value indicates the presence of harmonics. A pure sinusoidal waveform without harmonics has a harmonic ratio of 0%. Measurements with a higher harmonic ratio show that more harmonics are present in the signal. Typically, a harmonic ratio of 5% is not much of a concern; anything above 10% will almost always cause you problems.

Figure 2 illustrates how the harmonic ratio is derived.

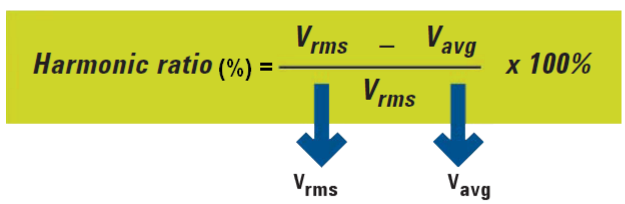

Figure 2. The harmonic ratio calculation

Table 1 shows the harmonic ratio derived based on an accuracy comparison of harmonic readings obtained using a true RMS DMM and an average responding-type DMM.

Table 1. Differential for true RMS, average responding, and the harmonic ratio

Waveform	True RMS	Average responding	Harmonic ratio
Pure sine wave	Accurate	Accurate	0%
Square wave	Accurate	10% higher	–10%
1-phase diode rectifier	Accurate	40% lower	40%
3-phase diode rectifier	Accurate	5 to 30% lower	5 to 30%
Sawtooth	Accurate	13.3% higher	–13.3%

Conclusion

With the built-in harmonic ratio function, the Agilent U1242 Series handheld DMM helps technicians and engineers quickly verify the presence of harmonics in AC signals. This information can be used to prevent or reduce equipment downtime and repair costs.

www.agilent.com

Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

Agilent Channel Partners

www.agilent.com/find/channelpartners
Get the best of both worlds: Agilent's measurement expertise and product breadth, combined with channel partner convenience.

Agilent Advantage Services

Agilent Advantage Services is committed to your success throughout your equipment's lifetime. We share measurement and service expertise to help you create the products that change our world. To keep you competitive, we continually invest in tools and processes that speed up calibration and repair, reduce your cost of ownership, and move us ahead of your development curve.

www.agilent.com/find/advantageservices

Agilent Electronic Measurement Group
KEMA Certified
ISO 9001:2008
Quality Management System

www.agilent.com/quality

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas	
Canada	(877) 894 4414
Brazil	(11) 4197 3500
Mexico	01800 5064 800
United States	(800) 829 4444

Asia Pacific	
Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 375 8100

Europe & Middle East	
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
	*0.125 €/minute
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
United Kingdom	44 (0) 118 9276201

For other unlisted Countries:
www.agilent.com/find/contactus

Revised: October 14, 2010

Product specifications and descriptions in this document subject to change without notice.

Printed in USA, April 4, 2011
5989-7687EN

Agilent Technologies