

Power Monitoring Technology – Dispelling Metering Myths

Dennis Stewart, Electro Industries/GaugeTech, Westbury, New York

When power quality first became a common issue, concerns were primarily limited to the effects that voltage had on computer and other micro-processor equipment. However, as electronics moved into control, it was discovered that the equipment is more often its own worst enemy because equipment commonly used today is not only susceptible to power quality problems, it often creates the power quality problem.

The result of this increased susceptibility to power quality problems has made power quality monitoring a necessity. Accurate measurement of power quality issues requires that the monitor accurately measure the voltage and current waveforms. Several factors affect this ability, and although sample rate is commonly considered for accurate measurement, other design factors that can affect a monitor's overall performance are often overlooked.

Figure 1 shows approximately 1½ cycles of a voltage waveform. Sample points, shown for reference only, represent a sample rate of 16 samples per cycle. Today, most digital meters sample at

speeds from 64 to as high as 256 samples per cycle. This figure demonstrates the fallacy behind a common meter myth that the sampling rate is a good indicator of the quality and accuracy of a meter, which is only partially true. In reality, if only the sampling rate is known, we really know very little about the meter's accuracy. In order to define a point on the waveform curve it is necessary to establish both an X-value and a Y-value. The X-value is established by the sampling rate. In other words, when we state the sampling rate we can determine the distance between samples on the X-axis and can therefore determine the relative,

and even the exact, location on the X-axis. However, when only the sample rate (the X-value) is known, the Y-value is unknown.

The Y-value is the actual voltage measurement, which identifies the true applied voltage. Without knowing the Y-value nothing is really known about the quantity being measured. The circuitry of a digital meter is designed to measure this value and report it to the processor. However, most meter users never ask how or how well the meter measures the Y-value. The Y-value is determined by the quality and precision of the analog to digital converter. The value coming from the A/D (analog to digital) converter is processed to ultimately become the reported electrical value. Therefore, the accuracy and precision of a digital meter is a function of the sample rate, the A/D converter and the quality of the calculations performed on the measurement. In modern electronic devices, sample rates can vary widely. Some devices used for metering may sample at rates as low as four samples per cycle. At the extreme other end of the spectrum, very

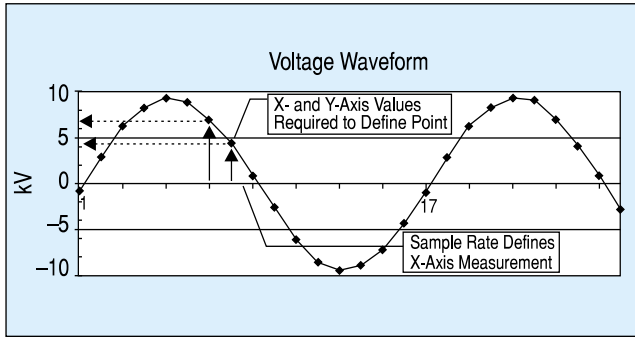


Figure 1. Typical voltage waveform.

accurate, high quality meters may sample as fast as 256 samples per cycle.

The sample rate has a large impact on the ability of a device to correctly identify variations in the wave shape. Low sample rates are not suitable for any measurement where high accuracy is required or where there may be concerns about harmonics, low power factor or any other power quality phenomenon. The quality and performance level of the A/D converter is also a matter of wide variation. Some meters use A/D converters of only 8-bits, but high precision or high accuracy meters may use up to 16-bit A/D converters. At this time, a 16-bit A/D converter is the best technology available. Most modern power quality meters use only twelve or thirteen bits of A/D conversion.

The number of bits of the A/D converter determines the size of the divisions along the Y-axis. To determine the size of the division, the full-scale voltage range and the applied A/D converter need to be known. A typical digital meter may have a full-scale voltage rating of 150V. This means that the A/D converter must measure the corresponding peak-to-peak voltage, resulting in a full-scale measurement range of approximately 424V.

Table 1 gives the number of divisions and the volts per division for various A/D converter ratings. The volts per division are based on the full-scale peak-to-peak readings. The problem of determining measurement is even more severe for current, since full-scale voltage is closely related to normal voltage. However, normal current is usually much less than the required full-scale current because the meter must accommodate faults. So a meter with a nominal 5A input must accommodate an actual full-scale secondary current of at least 10A. Meters designed to record waveforms have typical RMS

A/D Converter	Total Divisions	Volts per Division
8 bit	256	1.656 v/d
10 bit	1024	0.414 v/d
12 bit	4096	0.104 v/d
16 bit	65536	0.0065 v/d

Table 1. Volts per division for typical A/D converters.

Full Scale Peak-to-Peak		28 Amps	141 Amps
A/D Converter	Total Divisions	10 Amp Meter Amps per Division	50 Amp Meter Amps per Division
8 bit	256	0.109 a/d	0.551 a/d
10 bit	1024	0.027 a/d	0.138 a/d
12 bit	4096	0.0068 a/d	0.034 a/d
16 bit	65536	0.0004 a/d	0.0022 a/d

Table 2. Amps per division for typical A/D converters.

full-scale readings of 50A – ten times the nominal full-scale. The effect of RMS measurement must be added on top of this difference (Table 2).

The rating on the A/D converter is a major factor in the ability of a meter to correctly register the shape of the waveform and the correct value of the quantity. All of these impacts flow through the meter to all voltage, current and power quantities. If a meter was sampling at 256 samples per cycle, and it only used an 8-bit A/D converter, it would be unable to provide an accurate indication of the voltage or current. After the reading is taken, it must be processed. Meters use various types of processors to calculate the electrical quantities based on the readings taken. The processor should always be rated higher than the A/D converter. Some meters use 16-bit processors, but high accuracy meters almost universally use 32-bit processors.

Conclusion

Sample rate, A/D converter rating and microprocessor rating all affect the accuracy of a digital meter and therefore its ability to provide accurate power quality measurements. For metering applications where power quality, harmonics measurement, voltage disturbances or fault currents are of concern the user/specifier should carefully consider the degree of measurement required. High sample rates and high value A/D converters are required to clearly measure and interpret these types of power conditions.