Accuracy Uncertainty

How Powerful are Your Measurements?

In power measurement, power analyzer accuracy is one of the most important specifications to consider. It is easy to understand the importance of accuracy but to respect it's role in power measurements, one must first understand error.

Accuracy is Error

Error is a measurement's proximity to the true value, a measurement value accepted as standard. True values vary and can include government-mandated standards or manufacturers' calibration standards.

Accuracy is characterized by the amount of error present in the measurement- its proximity to the true value. The cause of error is either *random*, with no identifiable root cause, or *systematic*, introduced by components of the measurement system.

Systematic Errors

Systematic errors can categorized as either *gross* or *measurement*.

Unknowingly created by a user, *gross errors* occur as a result of improperly configuring or analyzing the results of a measurement system. Engineers working with a power analyzer could cause a gross error by choosing an inappropriate line filter (see Figure 1).

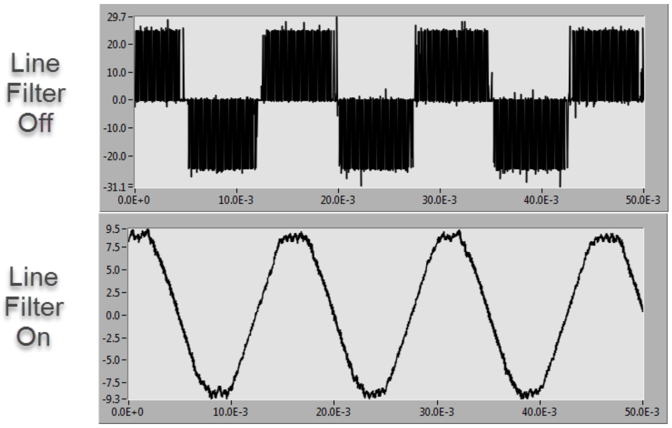

Figure 1: Failing to turn on a required line filter could cause a gross error. In this example, the lack of a filter (top image) results in a signal that is difficult to synchronize.

The second type of systematic error, *measurement error*, is introduced by the power instrument or system itself. Measurement errors can be caused by a lack of calibration, limited instrument accuracy, or measurements that have been altered by the measurement system. A shunt resistor used in a power analyzer will introduce a small measurement error due to the change in voltage it introduces to the system.

Once the error type and source are identified, the next step toward precision is to quantify the accuracy.

Accuracy Quantified

Defined previously, accuracy is the difference between a measured value and a true value. This difference can be expressed as an absolute error - an "error band" surrounding the true value.

For example, the absolute error for a voltage measurement might be expressed as:

X [Volts] +/- Y [Volts], where **X** is the true value and **Y** is the absolute error.

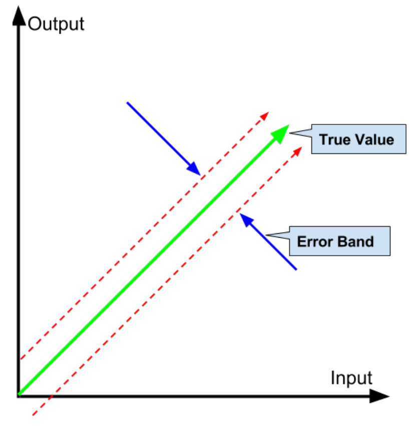

Figure 2: Error band surrounding a true value

Absolute error is useful because the total accuracy of a components system is equal to the sum of absolute errors.

It is common to express absolute error levels in parts per million (PPM), which specifies the accuracy relative to one million.

1 PPM/V = an error band that is +/- 0.000001V

Relative Error

Power analyzer datasheets typically specify voltage, current, and power accuracies as relatively. Relative errors are simply percentages relative to the measurement and to the full-scale range of the input. For example, the WT3000E Power Analyzer specifies a power accuracy of 0.01% f reading +/- 0.03# of range at 60HZ.

Putting it all Together

Before the total system error can be calculated, it is necessary to convert the power analyzer's relative error to an absolute error.

Total System Error = ∑(Absolute Errors)

Rather than manually converting relative error to absolute error, an uncertainty calculator can be utilized.

Uncertainty Calculator

Entering the following relative errors into the Uncertainty Calculator yields the corresponding absolute error value.

- Voltage Reading & Range
- Current Reading & Range
- Frequency (kHz)
- Power Factor (between 0 and 1)

Once entered, the Uncertainty Calculator provides the corresponding accuracies:

- Voltage Uncertainty (Volts)
- Current Uncertainty (Amps)
- Power Uncertainty (Watts / Element)
- Power Uncertainty for 3-phase, 3-wire configuration (Watts)
- Power Uncertainty for 3-phase, 4-wire configuration (Watts)

Figures 3 and 4 demonstrate how to use Yokogawa's Uncertainty Calculator.

Remember- simply measuring power does not ensure accuracy or precision. If you struggle with accuracy uncertainty, try an Uncertainty Calculator today.

Input the Voltage & Current Readings and Ranges, Frequency and Power Factor: **Input Data**

Voltage:	Reading	7		
	Range	15		
Current:	Reading	15		
	Range	30		
		1P-2W	3P-3W	3P-4W
Watt:	Reading	105	181.86	315
	Range	450	900	1350
Frequency:	kHz	0.06	Power Factor	1

Figure 3: Simply entering relative errors in the Yellow cells yields the corresponding absolute error values

Accuracy Uncertainty

30 Amp Input Element, and 2 Amp Input Element Ranges 50, 100, 200, 500 mA, 1A, 2A					
Frequency	Voltage Uncertainty Volts	Current Uncertainty Amps	Watt Uncertainty Watts/Element	Watt Uncertainty 3P-3W	Watt Uncertainty 3P-4W
DC 30A Input Element	0.0110	0.0225	0.5025	N/A	N/A
DC 2A Input Element	0.0110	0.022502	0.5025	N/A	N/A
0.1≤ f < 30 Hz	0.0096	0.0195	0.5340	1.0455	4.6800
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45 ≤ f ≤ 66 Hz	0.0052	0.0105	0.1455	0.2882	0.4365
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 kHz < f ≤ 10 kHz	0.0145	0.0300	0.6075	1.1728	1.8225
10 kHz < f ≤ 50 kHz	0.0360	0.0750	1.2150	2.3456	3.6450
50 kHz < f ≤ 100 kHz	0.0301	0.0601	1.3509	2.7015	4.0526
100 kHz < f ≤ 500 kHz	0.0750	0.1501	4.5008	9.0013	13.5023
500 kHz < f < 1 MHz	-0.3399	-0.7498	-10.9470	-16.5482	-32.8409

Figure 4 - After entering values in the yellow fields, locate the row that corresponds to the appropriate frequency range to read off the absolute uncertainties for voltage, current and power.