Manufacturers of Engineering and Production Test Equipment
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AN104
APPLICATION NOTE

Specifying Frequency Response of Amplitude Measurements

This paper serves as a brief primer on specifying frequency response - amplitude only. Specifying phase, watts, power factor, etc. are far more complex.

In XiTRON power analyzers, when there is a user-selected, restricted, frequency range, then there is a frequency range reducing filter; any such filter has a finite frequency response. This is why one will see a "per Hz" portion to the XiTRON accuracy equations. The "per Hz" portion is different depending on the selected frequency range for measurements. The more filtering the user requests, the more error there is in the measurement.

For significantly higher frequencies, there are additional error sources such as analog frequency response issues. In the XiTRON model 2551 for example, for other than the internal current measurement, these are pretty insignificant at low frequencies. This is why the "per Hz" portion doesn't just simply diminish linearly with an increasing upper frequency limit on filtering. The error with a 20Hz upper limit is indeed ten times that for a 200Hz upper limit, but the 100kHz specification is not 20x less than that for a 5kHz upper limit.

This method of specifying frequency response performance is not exactly new, many manufacturers use it these days. This gives a specification which is far more descriptive of the "real world" accuracy. If a product has a specification of 0.1% for frequencies 45-65Hz and 0.2% outside of this range (as an example), is it really twice as inaccurate at 65.00000001Hz than at 64.99999999Hz? Of course not!

If one looks at the specification for the 20Hz-100kHz range of the 2551, the voltage specification adder is 0.02%/kHz. This is pretty much insignificant below a few kHz. The internal current specification adder is significantly larger. This is because of the internal current transducer used. Using an external transducer eliminates this and has the same adder as voltage, but you have to add the performance of the transducer.

In reality, even this "linear" adder is not completely describing the error source properly. Well designed filters, particularly digital ones such as we use, generally have a square law error for small errors (unless they have ripple or resolution limitations, of which ours have very little) so the "real" error added by them should be described as dependent on frequency squared. Generally this is believed to be too complex a way of specifying, so it isn't the industry practice. However, it does mean that one's actual error at frequencies significantly lower than the upper limit are actually better than contained in the specifications.

Analog errors are much less well behaved. Generally, a well designed circuit will still give the simple square law frequency response, but there are usually other effects which mean that a more linear frequency response is more descriptive of the accuracy. Less well designed circuits will have significant ripple in their frequency response, which means that a "frequency range" based specification is sometimes more descriptive in those circumstances.

The user should select the frequency range restriction of the product depending on the compromise between including any unwanted signal content versus additional inaccuracy at the wanted signal frequencies. Generally, if one does not have significant higher frequency unwanted signal components, then there's no need to restrict the instrument's frequency range to eliminate them. Remember, unwanted frequency components "RMS" into the measurements, so there has to be over 10% of unwanted content to produce a 1% difference in the measurement. This is all about any unwanted signal content in the user's signal, and *not* those generated internally in the product. The internally generated *unwanted* signal content is already accounted for in the specification, which is why there is a slight reduction in the floor portion of the specification when a reduced frequency range is selected by the user.

9770-A Carroll Centre Road, San Diego, CA 92126 • Tel: (858) 530-8099 • Fax (858) 530-8077
www.xitrontech.com • sales@xitrontech.com • support@xitrontech.com