

## APPLICATION NOTE - 019

### RMS or Peak range considerations in Precision Power Analysis

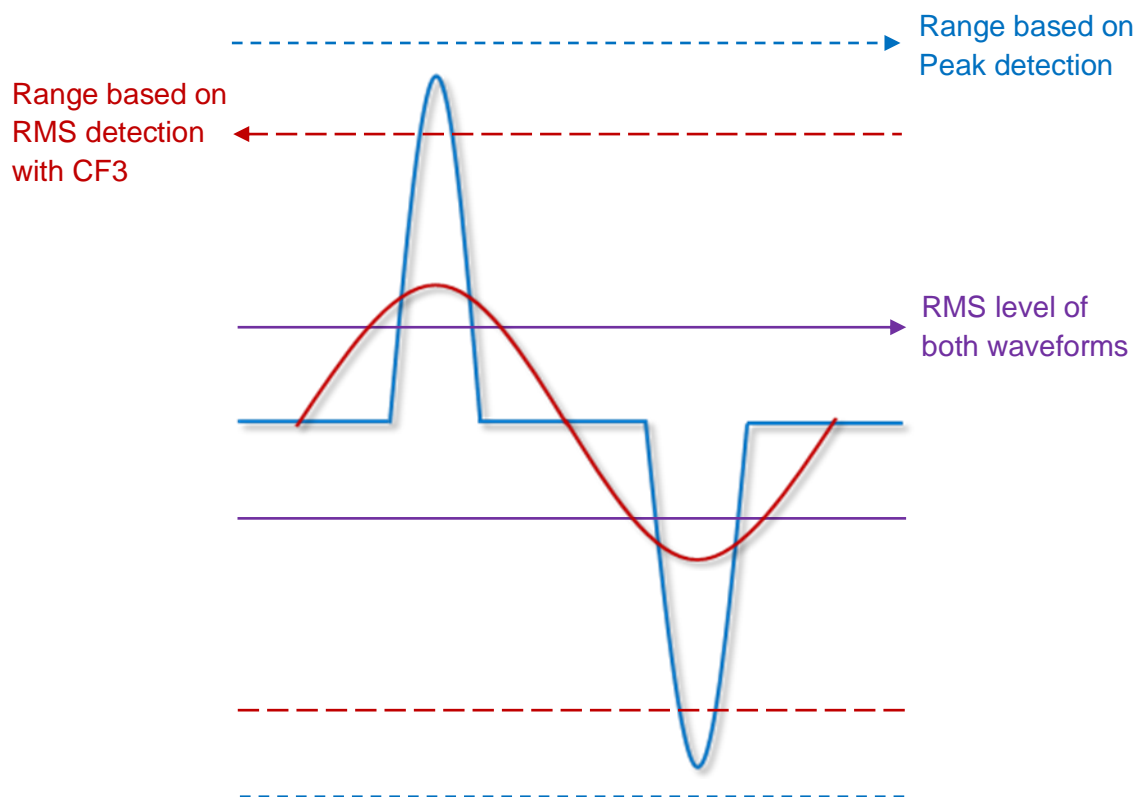
#### Introduction

In the field of power electronics, it is quite common for measurement instruments to utilise voltage and current inputs that select ranges based upon the RMS value of an input signal. Given the common reference in power electronics to RMS values, this technique is not generally questioned. However, the harmonically distorted voltage or current waveforms associated with modern electronic products justify a different approach to range selection.

In this document, we consider the nature of power electronic signals that are not ideally suited to RMS range systems and illustrate the benefit of measurement techniques that select ranges based upon the Peak value of an input signal.

#### How do RMS and Peak Range systems differ?

In order to understand the key difference between RMS or Peak Ranging measurement systems, we can consider the response of these systems to a harmonically distorted signal that has an RMS value equal to that of a sine wave.



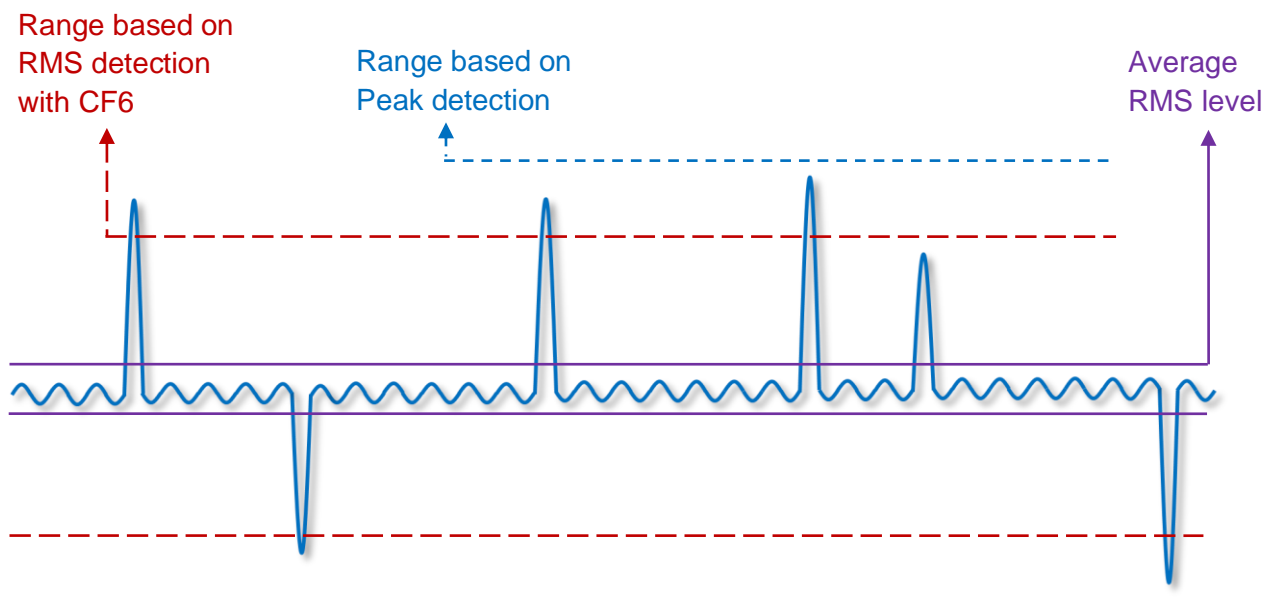
In the diagram on the previous page, we can see that a harmonically distorted waveform may have a considerably different peak value relative to a sine wave of the same RMS level. This ratio of Peak to RMS is called the Crest Factor, which is abbreviated to CF.

The CF of a sine wave is equal to  $\sqrt{2}$  which is approximately equal to 1.414. It follows that if an RMS range system selects a range that accepts a peak value of 1.414 x the RMS value, the complete waveform will be included in the measurement, provided that the signal being measured is sinusoidal or has a CF less than 1.414. However, if a signal having a CF greater than 1.414 is applied to such a measurement system, it would clearly be impossible to make an accurate measurement because the maximum range value would be less than the peak of the input waveform and 'clipping' would occur.

To reduce the chance of incorrect measurements due to range clipping, RMS based range systems will assume a fixed CF or may sometimes offer a selectable CF setting. Such systems commonly use a default CF = 3 and an optional CF = 6.

Unfortunately for such systems, signals that are regularly found in modern power electronic applications are likely to have a peak value that exceeds an arbitrarily selected CF. This is illustrated in the diagram above where the RMS system with CF3 setting does not include the complete waveform. The peaky waveform shown in this example is typical of the input current seen on many modern electronic devices.

Let us now consider another example. In the diagram below, we show the trickle and burst current that maybe seen on the input of an electronic device in low duty-cycle standby mode:



The examples shown above illustrate that modern power electronic applications are likely to involve highly distorted signals that will not be satisfied by assumed values of Crest Factor.

This is not a good situation in any field of metrology and it is easy to recognise that accurate measurements in any application are only possible if the measurement system includes all data associated with the signal of interest.

### **N4L focus on modern applications not traditional techniques**

A large proportion of power measurement instruments available today were developed at a time when power electronic applications mainly involved sinusoidal waveforms. It is partly for this reason that such instruments often use range systems that are based on the measured RMS value plus an assumed crest factor.

However, in modern power electronic conversion where the voltage, current or both are likely to be distorted, the best way to ensure that the complete waveform is analysed correctly is to use a peak range technique and to design the system to accurately measure relatively small RMS values within this range.

N4L measurement instruments have been developed to select the optimum range based on the Peak value of the signal being measured together with input circuits that maintain the full specified accuracy with RMS values down to only 5% of the selected range.

### **Is there a down side to Peak ranging?**

With any two systems that operate in a different way, it is inevitable that the suppliers of each system will argue the benefit of their respective system.

In this document, we have explained why N4L utilise Peak range measurement systems. Equally, suppliers of a system based upon RMS ranging will present arguments supporting that technique. It is also important to recognise that where instruments offer similar nominal levels of accuracy, it will be possible to select measurement conditions under which a particular instrument will appear to offer superior accuracy. So in terms of competitive analysis or marketing documentation, it is possible to select conditions under which a Peak ranging product would appear inferior. However, while such examples may be interesting for marketing purposes, they rarely reflect meaningful application measurements.

### **Conclusion**

N4L continue to focus product design on the basis of real world applications and good metrology practice where 1. The complete waveform is analyzed irrespective of distortion, 2. Wideband accuracy is maintained, since harmonically distorted waveforms include multiple frequency components and 3. Instrument calibration covers the complete frequency range with a good margin of safety. In this way, users can be confident that measurements made with an N4L power analyzer will be accurate, irrespective of the input wave shape.