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APPLICATION NOTE - 021

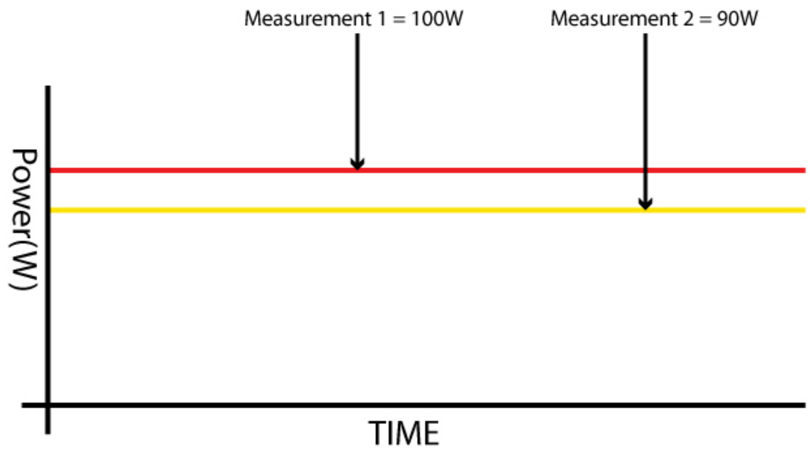
Power Analysis - Master Slave Efficiency Testing

This application note will describe the theory behind the “Master/Slave” concept utilised when measuring efficiency with power analyzers. We will discuss the downfalls encountered with this method of measurement and also the approach we at Newtons4th have taken in order to overcome these problems and provide a truly versatile, reliable and accurate method of efficiency measurement.

The Problem – Dynamic measurement

In a steady state environment in which the input power and output power of a product will be constant, there would be no need to consider master/slave, common windows or any other technique discussed in this application note. This is due to the fact that if the input and output power was constant, the efficiency would always remain the same and as a result the point in time which the measurements are taken on the respective input and output signals would not change the result.

The graph below depicts different measurement points with respect to time, with a constant power measurement for both the input and output of a product, synchronising the windows and measurement points would make no difference and the same result would be obtained. See below measurement 1 is taken before measurement 2, however the same efficiency measurement of 90% would be obtained



As seen above if power is constant for both the output and the input, efficiency measurements are relatively easy and no synchronisation is required. However in modern power electronics, this is rarely the case.

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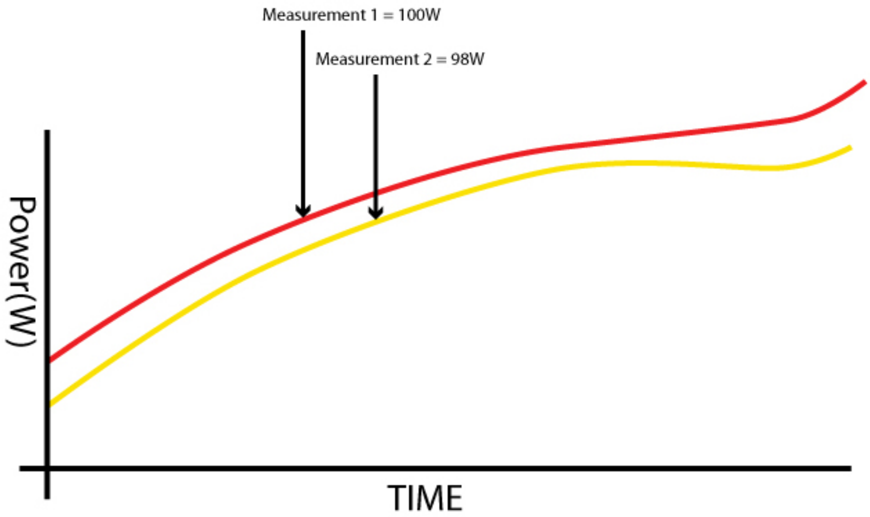
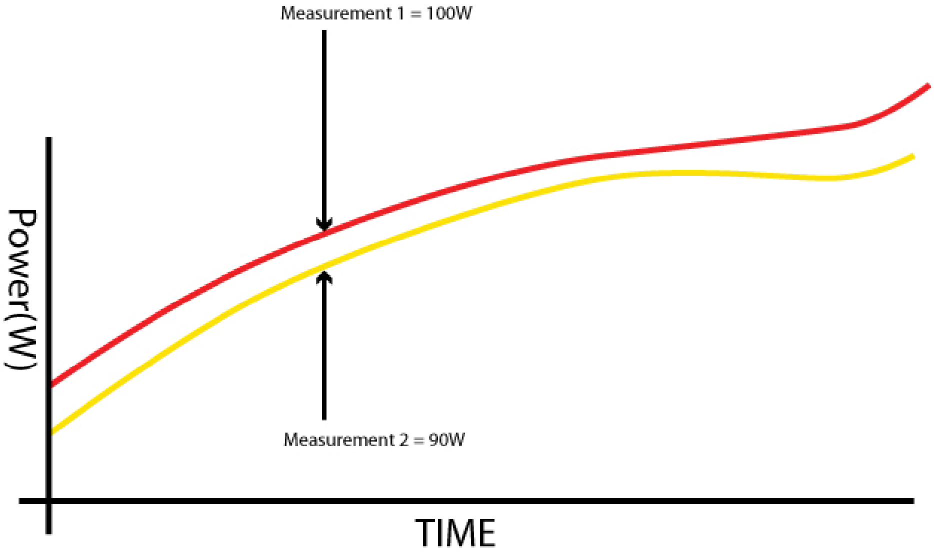
Modern Power Electronics – Dynamic Efficiency measurements

In reality steady state measurements are rare and the need for synchronisation of measurements becomes apparent.



For the graph above, the efficiency measurements 1 and 2 were not taken at the same point in time. As a result, an artificially high efficiency measurement was taken. Measurement 2 was taken as the output power was rising with time, if measurement two was taken at the same point in time as measurement 1 the efficiency measurement would have been lower.



As is depicted in the graph above, with the two measurements for input power and output power being taken simultaneously the correct efficiency figure can be made. This technique poses problems for the power analyzer; these include common windowing between possibly two different frequencies on the input and the output.

Common windowing of different frequencies

As is common place with modern power electronics, the input power and output power will have different frequencies, for example a PWM Motor Drive being fed by 50Hz mains outputting a varied frequency to the motor windings. This provides a challenge to conventional windowing techniques used in many power analyzers.

As we know frequency detection is paramount to accurate power analysis, once the frequency is detected the instrument will select a window size to accommodate such a waveform with respect to the sampling frequency, ideally the window size will be an exact multiple of the fundamental time period, this may be one cycle with no averaging or many cycles with a lot of smoothing.

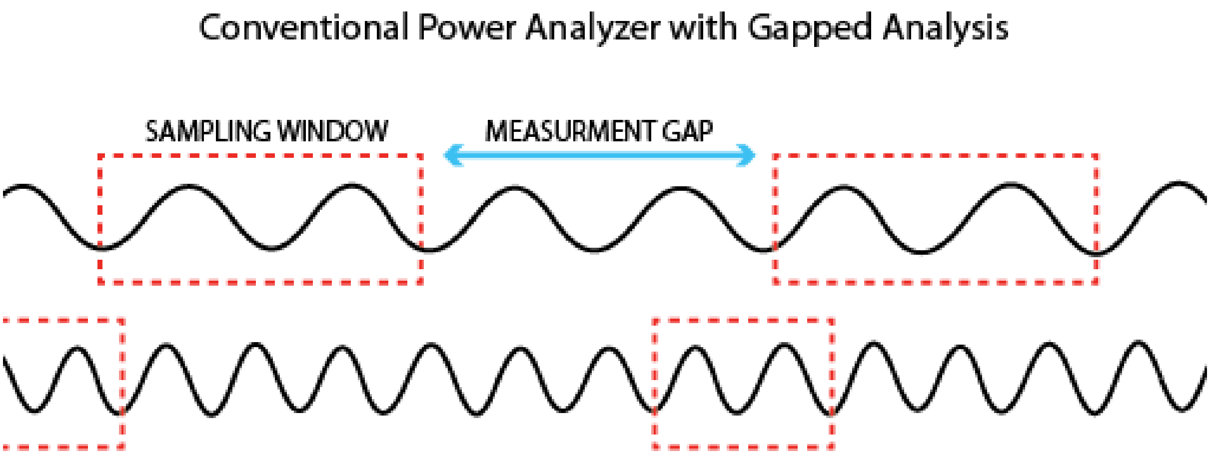


Fig 1.

Firgure 1 illustrates how unsynchronised input and output power analysis can cause problems with efficiency measurements. As the top waveform has a lower fundamental frequency the measurement window is longer, encompassing two cycles. The lower waveform (Output Waveform) has a higher fundamental frequency and as such, the measurement window is shorter. However if an efficiency measurements was taken at any point, a true efficiency measurement would not take place as the windows are not synchronised with each other, ie the power is not being read at the same point in time.

The conventional method of approach to overcome the problems associated with this are synchronisation of measurements windows, this involves the two instruments adopting a master/slave configuration. In this configuration the slave instrument will either synchronise the start time or end time of its measurement window with the master.

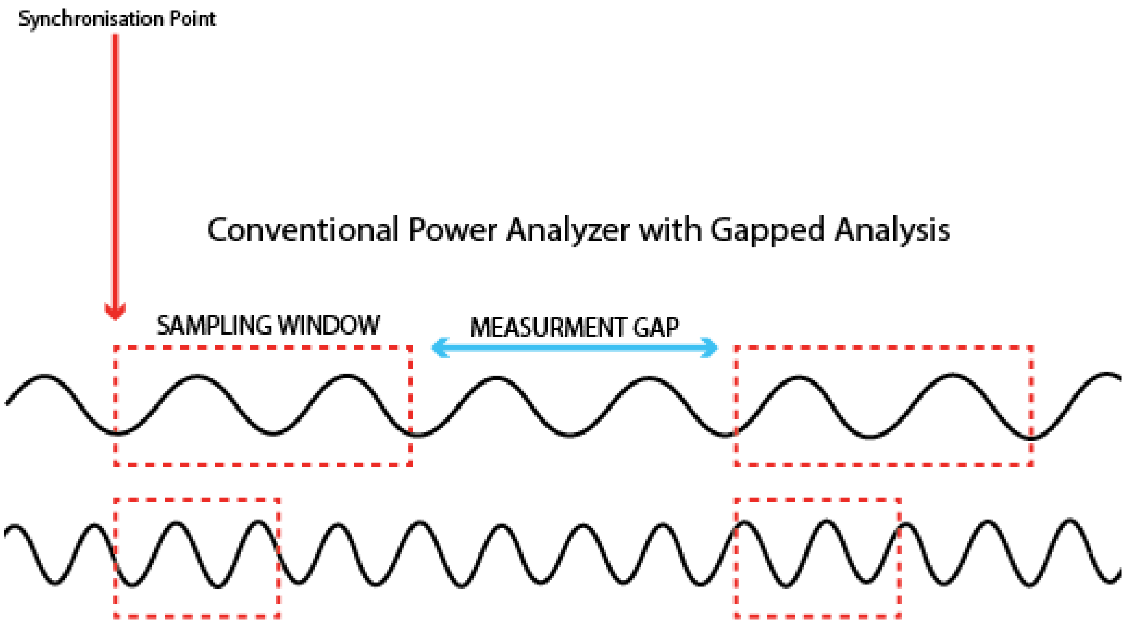


Fig 2.

As seen above, the measurement windows are synchronised to start at the same point, yet the efficiency reading will not take place until both windows have finished. As can be seen, with differing frequencies on the input and the output the measurement windows may be of different sizes and as such after the smaller window has completed the power result may have increased/decreased on that waveform, even with synchronisation false efficiency figures may be indicated by the analyzer as events are being missed with the gapped analysis technique.

This problem has been long encountered in the power analysis industry, Newtons4th have overcome this as a result of implementing a unique measurement technique whereby true real time no gap analysis is utilised.

True Real Time No Gap Analysis

The Newtons4th range of power analyzers benefit from true no gap analysis, which differ slightly from Fig 1. As there is no measurement gap

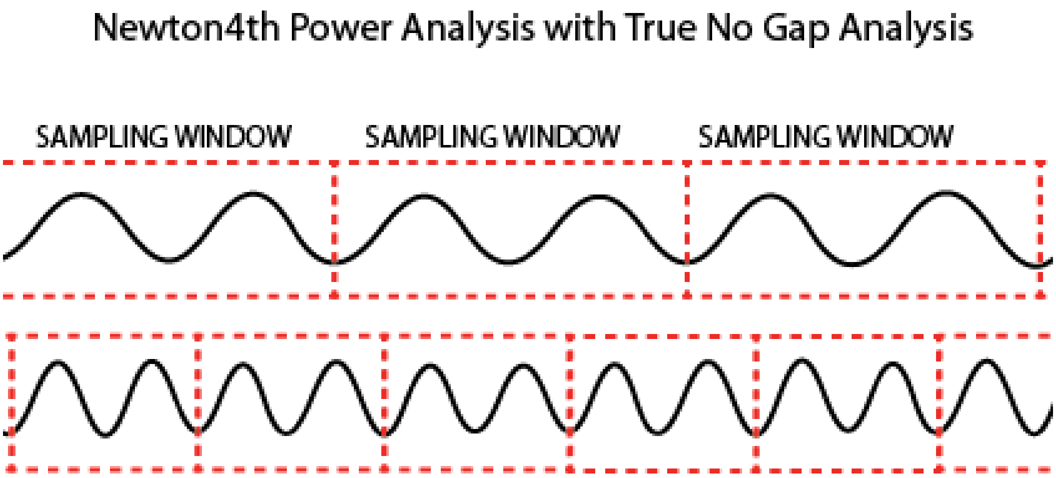


Fig 3.

Figure 3. above illustrates the Newtons4th Power Analysis technique in which a unique True No Gap Measurement is implemented. Where other instruments on the market will be required to utilise a measurement gap in their analysis in which signal processing is performed, the newtons4th PPA series power analyzers all benefit from the simultaneous Read and Write ability of the FPGA used in the Newtons4th design, no gap analysis has many benefits but for this application note we will concentrate on its benefit with regards to efficiency measurements.

The Newtons4th Power analyzers in fact use a “sliding window” with no gap in measurement. Each individual measurement will continually be processing data as it arrives.

For more information on the Newtons4th PPA500, PPA1500 and PPA5500 series power analyzers please go to our website at www.newtons4th.com