dBm Measurements in 600 W Systems

Scaling dBm Power Spectrum readouts for 600 W Systems

The FFT power spectrum outputs are read in dBm, decibels relative to 1 milliWatt (mW). This is common in wide band RF instrumentation designed for 50Ω termination. If measurements are made with different terminations the identical voltage levels will produce different dBm readings unless the FFT power spectrum readings are re-scaled to take the difference in impedance levels into account.

For example, if the oscilloscope input is externally terminated in 600 Ω then the power spectrum readings from the oscilloscope will be 10.8 dBm too high:

$dBm_{600} = dBm_{50} - 10.8$

Lets look at why this occurs- starting with a basic definition of dBm:

$\mathbf{dBm = 10\ LOG_{10} (P_1/P_{ref})}$

$\mathbf{P_1 = V_1^2 / R}$ **and**

$\mathbf{P_{ref} = V_{ref}^{\ 2} / R}$

Where:

P1 is the power of the measured signal in Watts and V1 is the corresponding rms voltage for a termination resistance value R, in Ohms. P_{ref} is 1 mW

For a given reference power level the associated voltage will vary with the square root of the terminating impedance:

$\mathbf{P_{ref} = .001\ Watt = V_{ref600}^{\ 2} / 600}$

$\mathbf{= V_{ref50}^{\ 2}/50}$

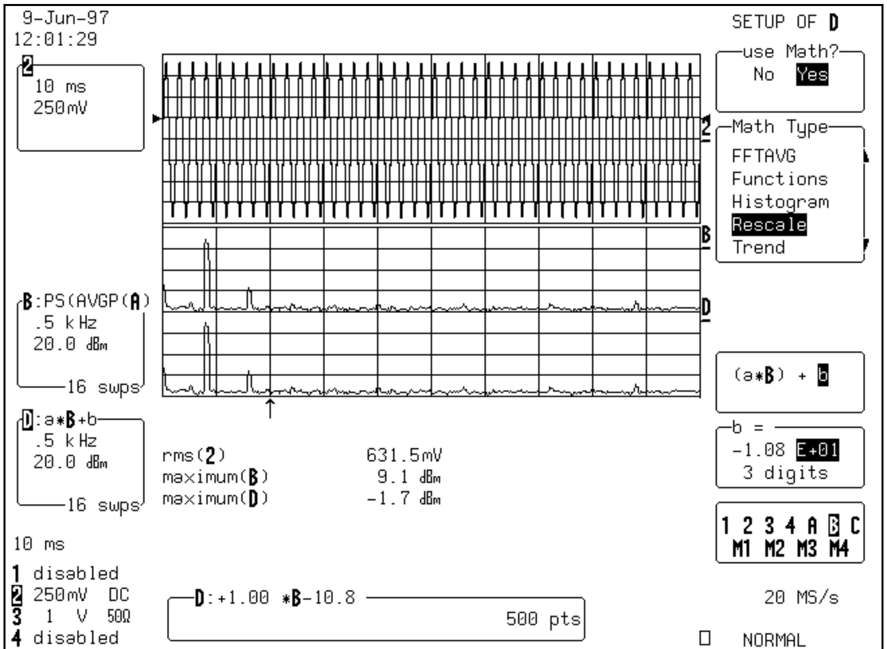

Figure 1 -An example of using the rescale function to calibrate power spectrum dBm readings for 600W termination

Some simple algebra will allow us to determine the dBm reading for 600 Ω in terms of the oscilloscopes readout calibrated for 50Ω:

$\mathbf{dBm_{600} =}$

$\mathbf{10\ LOG_{10}\ [(V_1^{\ 2}) / (V_{ref600}^{\ \ 2})] =}$

$\mathbf{10\ LOG_{10}[(\ V_1^{\ 2}\ ) /(600)(V_{ref50}^{\ \ 2}/50)] =}$

$\mathbf{10\ LOG_{10}[(50/600)\ (V_1^{\ 2}/ (V_{ref50}^{\ \ 2})] =}$

$\mathbf{10\ LOG_{10}[\ (V_1^{\ 2})/(V_{ref50}^{\ \ 2})] + 10\ LOG_{10}(50/600)}$

$\mathbf{dBm_{600} = dBm_{50} - 10.8}$

Figure 1 shows an example where a 0.631 Vrms waveform(Trace 2), terminated with an external 600 Ω load, is analyzed using FFT power spectrum. Using the preceding equations the expected power level in dBm relative to 600 Ω can be calculated:

$\mathbf{dBm_{600} =}$

$\mathbf{10\ LOG_{10}\ [(V_1^{\ 2}) / (V_{ref600}^{\ \ 2})] =}$

$\mathbf{10\ LOG_{10}[(0.631^2) /(.001)(600)] =}$

$\mathbf{10\ LOG_{10}[0.664] = -1.78\ dBm}$

Trace B shows the averaged FFT of the measured waveform. This data is rescaled in trace D. The math menu shows the Trace D setup where the correction factor -10.8 dBm is subtracted from the FFT. The FFT spectrum in trace D is identical to Trace B except that its vertical scaling is in dBm referenced to 600 Ω. Note that the measured spectrum peak in trace D has a value of -1.7 dBm

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Title: Pulse Width Modulated Waveforms
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Change Number: 8
Last Saved On: 7/30/1997 10:32 AM
Last Saved By: Preferred Customer
Total Editing Time: 68 Minutes
Last Printed On: 8/22/2001 2:55 PM
As of Last Complete Printing
Number of Pages: 1
Number of Words: 338 (approx.)
Number of Characters: 1,932 (approx.)