TECHNICIAN NOTE 003

Martin Jones
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RF Power Definitions

Manufacturers and customers do not always use the same power definitions for their applications. MicroSemi, for example, uses the term *peak power* when characterizing its components; this makes its components appear better than the competition, since most use *DC power* for characterization. So, the first question that should be asked is whether the requirement is for peak power or DC power.

Average Power without Modulation (DC Power)

As most commonly used, the word *power* refers to the DC component of the power product. Power is defined as the energy transfer per unit time averaged over many periods of the lowest frequency. In the case used here, the highest and lowest frequencies are the same – a mode of operation commonly referred to as CW. CW is a continuous wave with no modulation. The formula for power is:

$$P = V_{RMS} \bullet I_{RMS} \bullet \cos q$$

Here is an example for the IXZ2210N50L: Assume the resistance is 50 Ω, the peak voltage is 173.17892 V, and the peak current is 3.4635785 A. Determine the voltage and current RMS values by multiplying each by 0.707, which yields 122.47449 V and 2.44875 A. Multiply these two values to get power (cosq can be dropped because its value is 1). The result, 300 W, is the value that a power meter would read and is the most common measurement for power.

RF Pulse Power without Modulation

For *pulse power*, the energy transfer rate is averaged over the pulse width. For example, consider a single 100 ns pulse of 1 kV into a 10 Ω resistor. Using $P = E^2/R$, the power is 100 kW, but it is only delivered for one 100 ns pulse. A series of 100 ns pulses at a 1 kHz rate results in a duty cycle of 100 ns/1 ms = 0.01%. The average power, or DC equivalent, is 100000 W • 0.0001 = 10 W.

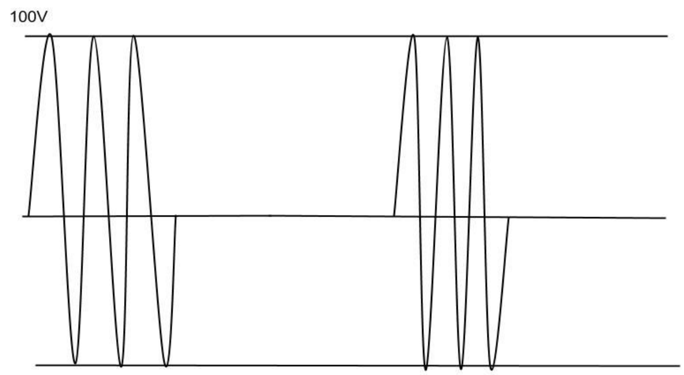
Conversely, if you know the power delivered to the load and the duty cycle, it is simple to determine the pulse power: $P_P = P_{AVG}$ / duty cycle. Using the values in the previous example, 10 W delivered to the load at a duty cycle of 0.01% yields 10 W / 0.0001 = 100000 W per pulse.

RF Peak power without Modulation

Peak power is the power delivered at the highest amplitude of the waveform. For example, the unmodulated RF sinusoidal waveform shown below has a peak voltage of 100 V. This is the point at which the peak power is delivered.

There are several ways to determine peak power. For continuous RF, a standard power meter can be used to measure the DC power being delivered to the load. Because the duty cycle of a sine wave is 50%, the DC power divided by the duty cycle yields peak power.

The other method to use the standard power formula $P = V^2 / R$. Assuming a 50 Ω load for the following waveform, plugging the numbers into the power formula produces 200 W peak. To determine the DC power of the signal, multiply the peak power by the duty cycle, 50%, to get the result of 100 W. This answer can be checked by determining the RMS voltage ($V_{RMS} = V_{PEAK}$ • 0.707) and using the same formula for power as before.



RF Peak Pulsed Power

Peak pulse power is the same as pulsed power except that we use an unmodulated RF signal. In the image below the peak voltage is 200 V. With a load resistance of 50 Ω, the peak power is 800 W for a single pulse. The RF Pulse signal is outlined in red. This type of pulsing is used in radar and MRI applications. For MRI the RF frequency is 64 MHz or 125 MHz pulsed at 10 Hz with a 10% duty cycle. As was calculated, each pulse has a peak power of 800 W. Because the signal has a 50% duty cycle, the peak power is divided by the duty cycle to yield a DC power of each pulse of 400 W. The average power to the load is 40 W since $P_{AVG} = P_P$ • duty cycle