

How Is RF Power Detected?

In today's wireless world, RF signals are transmitted and received to effectively send data and facilitate wireless communications. Among all the parameters to consider in RF design, power measurements remain one of the most critical metrics for designers and operators. With today's complex modulation schemes, pulsed communication modes, and increased popularity of wireless devices, the need to accurately and efficiently measure RF power has become crucial to obtaining optimum performance from communication systems and components. For example, proof-of-design, satisfying regulatory specifications, adhering to safety limits to protect against the dangers of high-power RF radiation, system efficiency, and component protection, among others, are all situations reliant upon accurate RF power measurements.

Since RF power measurements are a top priority for the design and development of wireless technology, it's important to understand how test instruments actually measure RF power. Well, it all starts with electrical components known as diodes, which are defined as semiconductor devices or components that allow the current to flow easily in one direction, but severely restrict the flow of current in the other direction. Diode-based RF power sensors use high-frequency semiconductor diodes to detect the RF voltage developed across a terminating load resistor. The diode sensors directly perform an AC to DC conversion that is then relayed to a power meter, which measures and scales the DC voltage to produce a power readout (see Figure 1).

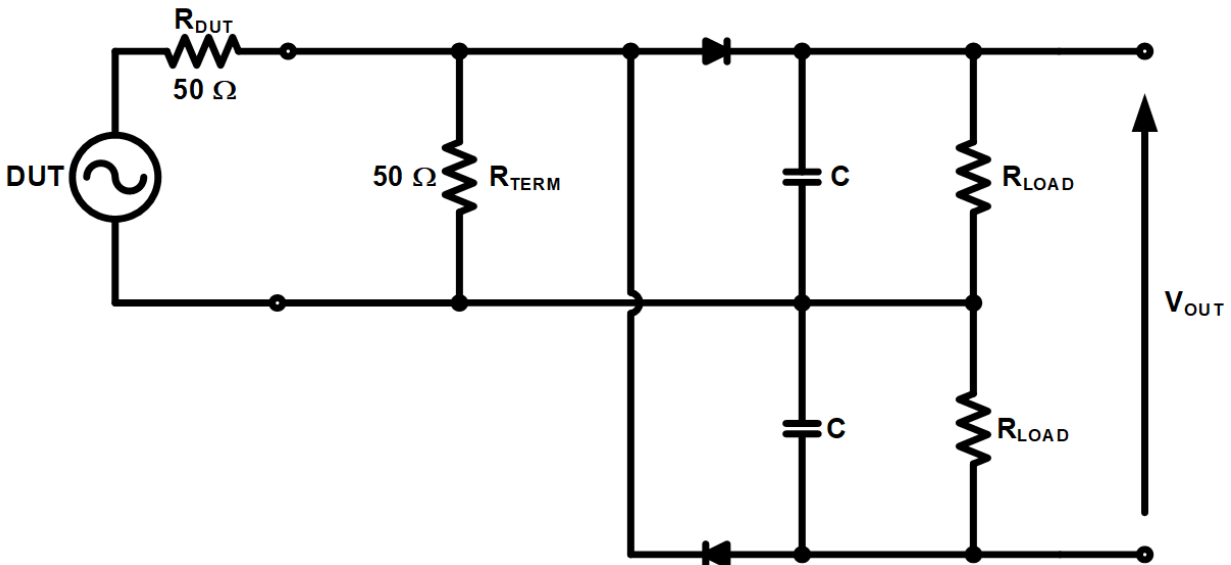


Figure 1: An RF detection circuit.

The relations to the DC voltage to the power measured is dependent on the diode region of operation, which is commonly broken up into three areas – square-law, transition, and linear (see Figure 2).

Square-Law – At levels below about -20 dBm, the diodes produce a DC voltage output that is closely proportional to the square of the applied RF voltage, and therefore is referred to as the “square-law” region of the diode sensor. This occurs because the RF input is not high enough to cause the diodes to fully conduct in the forward direction, which causes them to behave as non-

linear resistors. This region is also modulation independent, meaning the average DC output voltage will be proportional to the average RF power, even if modulation is present. Therefore, a diode sensor can be used to measure the average power of a modulated signal, provided the envelope (peak) power remains within the square-law region of the diodes at all times. Sensors operating solely in this region are called true-average or RMS power sensors.

Transition – The transition region of a diode sensor exists between the square-law and linear regions, ranging from approximately -20 dBm to 0 dBm. Accurate power readings in this transitional area depend on careful characterization of the diode response.

Linear – Above 0 dBm, the linear (or “peak detecting”) region exists where the DC output voltage is proportional to the RF voltage. The diodes go into forward conduction on each cycle of the carrier, and the peak RF voltage is held by the smoothing capacitors. In this region, the sensor is behaving as a peak detector (also called an envelope detector), and the DC output voltage will be equal to the peak-to-peak RF input voltage minus two diode drops.

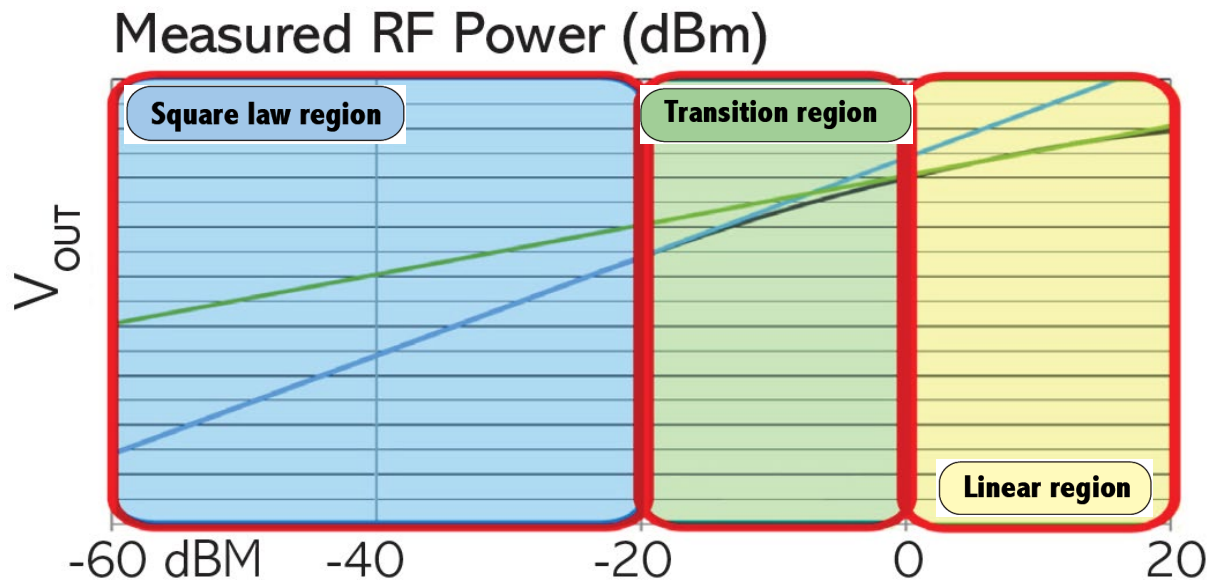


Figure 2: The diode regions of operation.

RF product design, system integration, and maintenance rely on accurate and reliable RF power measurements. In addition to wireless communications, RF test equipment plays a vital role in the semiconductor, military, aerospace, and medical industries in applications involving radar, avionics, electronic warfare, satellite networks, and EMI/EMC, among others. A leader in high-performance RF and microwave test and measurement solutions, Boonton can enable the essential power metrics necessary in RF design with its product portfolio of peak and average RF power meters, real-time USB power sensors, and connected USB power sensors. To learn more, visit www.boonton.com.