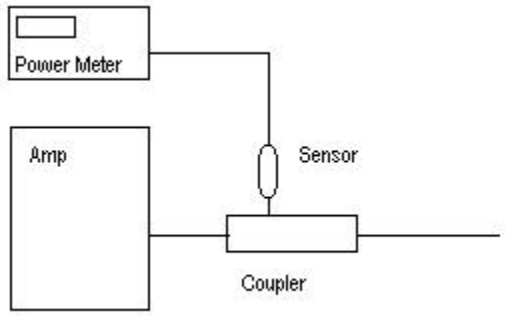
RF Power Measurements

Power measurements can be made several ways, using several different types of instruments. This document will discuss making power measurements of RF signals using a RF power meter.

A typical setup will include a power meter to which is attached one or two power sensors. Lets first discuss making a typical forward-power measurement. This only requires one power sensor, as well as a directional coupler. Below is a drawing of this setup.



The sensor connects to the forward (or Incident) port of the directional coupler. The power from the amplifier passes through the coupler, and the forward port of the coupler provides a way to sample the power being delivered by the amp.

It is important to match the ranges of the components so accurate measurements can be made. Power sensors have a limited range of power in which they can be used. A common range for power sensors is -30 to +20 dBm, which is 1uW to 100mW. A signal higher than this can damage the sensor, and a signal lower than this can't be measured.

Directional couplers will have a "coupling factor" associated with the measurement port. This factor will determine how the signal from the measurement port relates to the actual forward power from the amp. This factor is always expressed in dB, and will usually be a number from 20 to 60 dB. Select a directional coupler and sensor that will allow proper measurements to be made. Always try to make measurements in the upper part of the power sensor's dynamic range since most sensors are more accurate when used in the upper half of their dynamic range.

Example: Lets assume the amplifier above is rated for 100w output. 100w power equates to 50dBm. Lets say our power sensor has a range from -30 to +20 dBm. We would have to pick a directional coupler that has at least at 30dB coupling factor (50-20=30). Keep in mind, however, that the amp has a RATED output of 100w, and in most cases the amp can put out slightly more than this. So, you might want to get a directional coupler with a 40 dB coupling factor, or you could use a 3dB attenuator between the directional coupler and the power sensor. The latter method would probably be preferred since it will have 7dB more dynamic range than a setup with a 40dB coupler.

Lets say we picked the 30dB coupler and used a 3dB attenuator between the coupler and sensor. In terms of power, 3dB is double, so we would be able to measure up to 200w forward power. (Remember, our sensor can go up to +20 dBm, and we now have a 33 dB coupling factor, so we can measure up to 53 dBm, or 200 watts). The sensor can measure down to -30 dBm levels, so we will be able to measure forward power from the amp as low as 2 mW. (-30dBm + 33 = 3 dBm, or 2mW).

Most power meters allow a correction factor to be entered, which will automatically be added to the power level measured by the sensor. This allows the actual forward power to be displayed on the power meter.

In our case, we would enter a 33dB correction factor. If the sensor sees a +10dBm signal, the power meter will internally add the 33 dB to this, which will equate to a +43 dBm power level. The power meter will also allow the power to be displayed in either linear or log format. In this case, the log format would be 43 dBm, while the linear format would be 20 watts.

Measuring reverse power is very similar to the above. The same coupler COULD be used by turning it around, but it would be much more convenient to use a dual-directional coupler which would allow measuring the forward and reverse power simultaneously. This is also where a two-channel power meter would be handy, since two power sensors could be connected and read at one time, although using two separate power meters could be used. One power meter with two channels would have the advantage of being able to do math on the two power readings, such that net-power or VSWR could be displayed.

If you decide to purchase a directional coupler, keep in mind there IS a difference between "dual-directional" and "bi-directional" couplers. Either one can be used to make forward and reverse power measurements. However, bi-directional couplers depend on each port being terminated into a 50 ohm load for accurate measurements to be made. A dual-directional coupler does not, since it already has built-in 50 ohm terminations for each measurement port.

Also, note that there are different types of power sensors. If making true average power readings is important, then pick a sensor that makes this type of measurement, usually a thermocouple sensor. There are also diode sensors, but they typically are non-linear in response so they usually are not able to measure true RMS power of modulated signals. The advantage of diode sensors is that they usually have a wider dynamic range. If all you will be measuring is an unmodulated carrier, then a diode sensor might be considered. However, if you will be measuring pulsed or amplitude modulated signals, you might want a thermocouple sensor to measure average power. There are also peak sensors, which are good for measuring the peak of the modulation envelope, probably the best way to measure a pulsed signal with a very short duty cycle.

