Why Directional Couplers Are Better for High Power Measurements vs. Attenuators

by MECA Electronics

Day-to-day field measurements of base station power has frustrated engineers and technicians alike because of the instability and uncertainty of measurement caused by using high power fixed attenuators to reduce the signal level into sensitive power meters. Why? Attenuators de-rate as input power increases and their case temperature rises, so full-power measurements are far different from the initial calibration point. Directional couplers have very low insertion loss and high directivity so the sampled power (at the coupled port) is extremely stable and isolated from changes in temperature or reflections as power levels increase. The unused power (and subsequent heat) is passed to the termination which is attached to the output of the coupler and away from your measurement path.

Directional Coupler Theory

When power is introduced at the input port of a directional coupler, all of the power appears at the output port except for the portion intended to be sampled. If power is reflected back from the output port, the ideal directional coupler does not allow any of the reflected power to appear on the secondary line. Regrettably, the ideal directional coupler does not exist in our world. Consequently, a small amount of backward power will be coupled to the secondary line 180° out of phase from the incident wave canceling power on the secondary line and adding uncertainty to the measurement. The term directivity (Figure 1) denotes the ratio of forward to backward coupling and is defined as 10 times the common log of the ratio of forward and backward power D = 10 log10(Pr/Pb). The higher the value of directivity, the less backward power is sampled and measurement uncertainty is significantly improved. Directivity is the qualitative benchmark by which couplers are compared.

Since we are on the subject of measurement errors, we should also deal with the importance of Voltage Standing Wave Ratio (VSWR) because reflections will add and subtract to the incident signal causing uncertainty in the coupling factor. VSWR is defined as the ratio of incident to reflected signals and is ideally 1.00:1, meaning these signals are in phase and will not cancel. The better the VSWR, the less return loss is encountered. Unsatisfactory coupler VSWR will degrade measurement accuracy and is usually attributable to lesser quality connectors or inadequate design techniques.

Attenuator De-rating

As discussed in the introduction, attenuators will handle the specified power ratings at ambient temperatures. Most attenuators are convection cooled meaning no forced air (fan) is required to cool the unit. As the ambient and case temperature of the unit rises due to increased input power, the attenuator de-rates linearly to zero at 150 deg C. For instance, a 50w attenuator is rated for full power at 25 deg C and 0 watts at 150 deg C. If plotted on graph paper, you will find that the attenuator will dissipate 25w at 88 deg C (midpoint) which is far different from the initial calibration point. (See Figure 2)

MECA Power Measurement Kit

MECA has designed the MFK-PMK-1 Power Measurement Kit to replace high power attenuators as a means of reducing signal levels into sensitive power meters. The kit features a 500w, 30 dB, 0.800 – 2.200 GHz, Directional Coupler (MECA 715-30-1.500V) furnished with albaloy plated connectors, gold plated contact pins, and a rugged aluminum housing for long lasting performance. Different directional couplers can also be specified for many frequency band specific measurements such as TETRA/Public Safety (400 – 800 MHz) and WiMAX (2.000 – 4.000 GHz) applications.

For the output of the coupler, MECA has included a 100w, N-Male Termination (MECA 490-1) which will provide a 2X safety margin for full power BTS measurements at 46 dBm. The termination has an albaloy plated N-Male connector, silver contact pins and a black anodized convection cooled heatsink. The kit also contains 1 each of a 2w, N-Type Attenuators in 6, 10 and 20 dB (MECA 605-dB-1). The additional attenuators can be added to the coupled port to optimize the input signal level into the power meter.

All of the components are furnished in a hard-shell case with form-fitting foam inserts that eliminate concerns of damaging the RF components in transit. These sturdy cases can be stored in technician’s vehicle or remote switch locations and are rugged enough to be stored among toolboxes and cable spools.

MECA Electronics, Inc.

Since 1961, MECA has designed and manufactured an extensive line of RF/Microwave components with industry leading performance including Fixed Attenuators, Directional and Hybrid Couplers, Isolators/ Circulators, Power Divider/Combiners, RF Loads, DC Blocks and Bias Tees. MECA serves all areas of the RF and Microwave industries including world class network providers and supporting supply chain infrastructure, and has long been the “backbone” of high performance wired and air-interfaced networks such as in-building applications, satellite communications, radar, radio communications, telemetry applications, mobile radio, aviation and air traffic communications.