Using an Auxiliary High Power Broad Band Amplifier to Test High Power Microwave Components

High power amplifiers are often used to boost power out of signal generators or network analyzers to provide sufficient power to adequately test high power semiconductor amplification devices, limiters, and other components requiring a high drive level for proper operation. Although the implementation of a high power amplifier to augment testing would seem to be straight forward, there are several considerations to keep in mind as the test set up is configured. This application note seeks to address several of those.

Losses

A typical signal source from a network analyzer or synthesized signal source has the capability to source 10 to 15 dBm, operated at its limit. While this power level may appear to be sufficient for many test applications, actual implementation of the test system often significantly reduces the level of power available to the DUT from the signal source, often by as much as 20 dB. Effective levels of useable power at the Device Under Test (DUT) may range from -10 to -5 dBm maximum. This power level will be insufficient to drive mixers, high power amplification stages, limiters, and other components requiring high drive levels.

The losses, virtual, and actual, derive from several sources, including the following:

- Linearity Requirements (Virtual Loss)
- Test System Losses (Couplers, Cables, etc.) (Actual Loss)
- Source VSWR Mismatch Loss (Actual)
- Load VSWR Mismatch Loss (Actual)

Virtual losses derive from the necessity to operate below peak operating capability. For example, many bandwidth efficient modulation formats exhibit high peak-to-average power ratios during their operation. Modulation Schemes such as CDMA, WCDMA, OFDM, and derivatives may require instantaneous power levels that exceed 10-13 dB of their average power level, just to permit the waveform to nominally operate. Typically, an uncorrected device, such as an arbitrary waveform generator, must operate another 10 dB lower so that its nonlinear characteristics are insignificant relative to the component being tested.

Even for unmodulated signals, the source must often be operated significantly below its maximum power level. For broadband operation, harmonic signal content becomes significant. Harmonic filtering is undesirable, as the filters limit operational frequencies, so, again the signal source often must be operated 10-15 dB below its peak capacity.

Use of a broad band solid state power amplifier following the signal source can significantly enhance the test system operation by allowing comparatively greater levels of linear power to impinge upon the DUT significantly making up for virtual losses.

Other, real, losses also limit the amount of power available at the DUT. Cables, Load and Source VSWR, isolators, monitoring couplers, attenuators, even connectors and adapters, all add insertion and reflection mismatch loss to a test system. (See 990054 Effects of External Power Amplifier Impedance on Measurements, CAP Wireless, Inc. CAP Note) Coupled with the effects of virtual loss, significant power

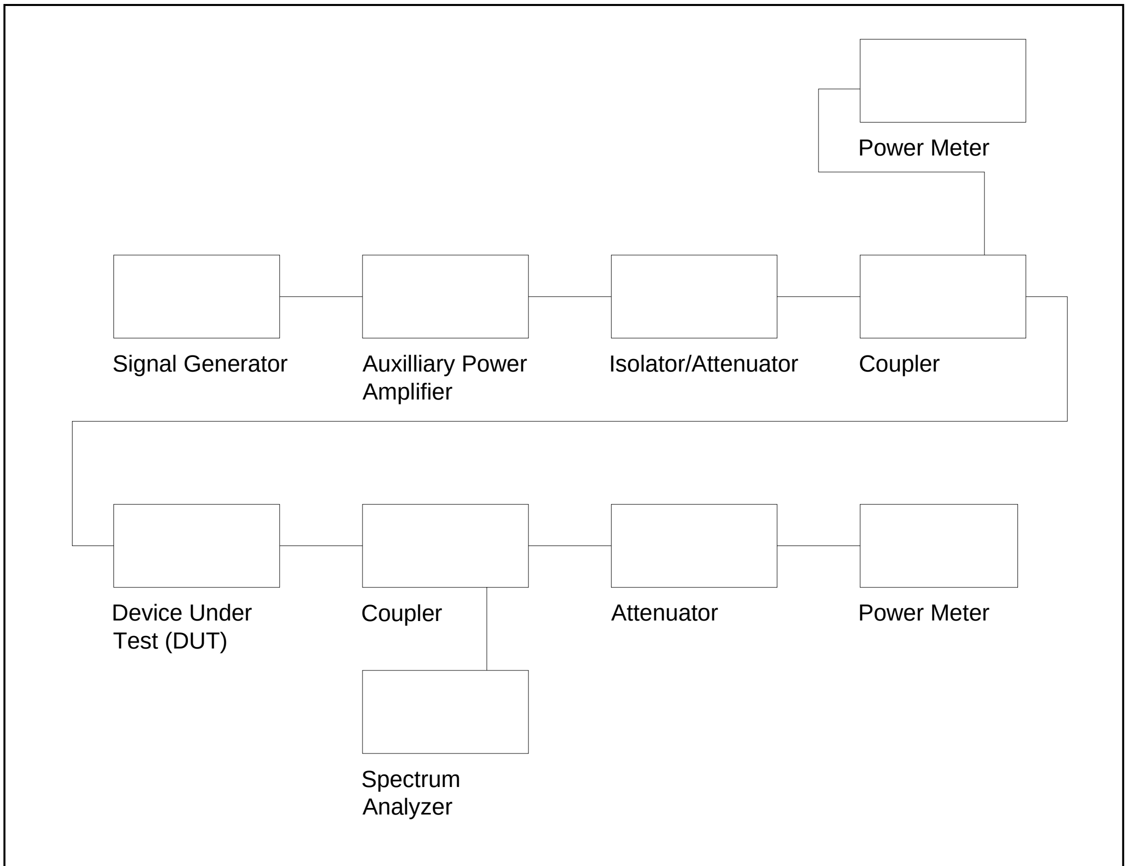

Figure 1

capability is lost that can only be compensated with an external power amplifier. Figure 1 shows a typical block diagram of a test configuration using an auxiliary power amplifier.

Noise Power

Noise power implications of broadband amplifiers is often forgotten or neglected during the initial configuration of auxiliary amplifiers. The output noise power of the amplifier can reasonably be expected to be -174+10*log(amplifier Bandwidth(Hz)) + gain (dB) + noise figure (dB). For a 2-20 GHz amplifier with an 8 dB noise figure and 50 dB gain, this results in an output noise power of -26 dBm as measured on a broadband power meter. Add this to the noise output of a signal generator, and the measured output power level might be 0 dBm without any input signal present! Clearly, one must use caution in measuring and establishing signal levels with a broadband auxiliary amplifier.

Linearity

Amplifier Technology (SSPA or TWTA)

Often, the test engineer has a choice between broad band amplifier technologies. Traveling Wave Tube Amplifiers (TWTAs) have historically dominated the microwave power amplifier offering, but recent advances in solid state power amplifier (SSPA) technologies have challenged vacuum tube technology. TWTAs and SSPAs both provide power amplification, but with substantially different characteristics, as shown in Table 1.

Characteristic	SSPA	TWTA
Noise Power	Low	High
Linearity	Good	Poor
Efficiency	Fair	Good
Reliability	Excellent	Fair
Gain Stability	Excellent	Fair
Warm Up Time	None	Several Minutes
Gain Flatness	Fair to Good	Poor to Fair
Prime Power Supply	Low Voltage (Safe)	High Voltage (Dangerous)
Ruggedness	Excellent	Poor

Table 1

In general, solid state solutions offer a far superior solution for most test applications. Test results are less likely to be significantly noise influenced or corrupted by non-linearities, and more stable and repeatable.

Instantaneous Bandwidth

Frequency coverage of an amplifier is key to the repeatability of measurement. Instantaneous broad frequency coverage means that test results can be taken without switching between amplifiers, or reconfiguring a setup for a new frequency band. Reducing switching and eliminating test set up reconfiguration dramatically improves repeatability, reduces the chances of configuration errors, reduces the number and cost of amplifiers required, and minimizes the amount of calibration /characterization required. Historically, extreme bandwidth operation has been supported by TWTAs, or, alternatively, a single box containing multiple solid state and/or traveling wave tube amplifiers that are selectively switched to the appropriate frequency band. CAP Wireless' Spatium™ amplifiers overcome this limitation by providing instantaneous multi-octave to decade+ bandwidth from a single amplifier without switches, multiplexers, couplers, leading to more consistent measurements.

An Optimum Solution

The ideal auxiliary test amplifier would incorporate the features of low source and load VSWR, moderate to high average power capability, low additive noise, superb stability, excellent ruggedness and robustness, and extended bandwidth operation. CAP Wireless industry leading rack mount and bench top auxiliary power amplifiers exhibit all of these attributes in a compact EIA standard 3 RU configuration. Available in moderate power levels of 10-20 watts covering the 2-20 GHz band, and at higher power levels accommodating specific bandwidth applications, these amplifiers provide the most cost effective high performance amplification available.