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Procedures for High Power Swept Compression Measurements

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High power measurements require care to provide isolation of external amplifiers and maintain signal levels that do not cause damage, and are within the instrument's optimum measurement range.

HP (now Agilent) vector network analyzers have been an RF laboratory staple since the cold war. They have enhanced precision, simplified measurements, and have been configured in seemingly endless applications. One of the more common configurations in amplifier design has been the "amplifier swept set-up." This outdated the sweep oscillator set-up consisting of a cavity wave meter, and crystal detectors with performance displayed on an oscilloscope.

The 8753 series network analyzers, models D & E, unlike earlier models, provide uncoupled channels and independent sweep drive levels. These two features permit independent arbitrary drive levels, which enable relative swept compression measurements. Here a small signal sweep is used as an active uncompressed gain reference; the alternate sweep is set to a user defined drive level such as a 1 dB gain compression sweep (P_{1dB}).

A typical screen shot is shown in Figure 1. The lower screen displays small and large signal gain (S_{21}) over frequency. Input return loss in both phase and magnitude are displayed on the polar chart. In this power application an external driver amplifier is required to drive the device under test (DUT) into compression. Unfortunately, this driver isolates the analyzer's incident port from the DUT's input return loss. Refer to Figure 2 where circulators CC1 and CC2 (Alcatel 9C78) provide a reflection path for input return loss measurements (S_{11}).

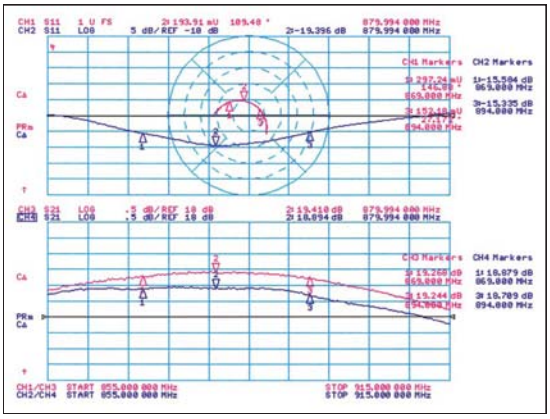

Figure 1 · Typical display, class A/B 60W power amplifier.

Operation

The incident wave from port 1 of the VNA propagates out though CC1's port 1 to port 2 and then is amplified with PA1. The output of PA1 travels to the reference source plane through CC2's port 1 to port 2, then through AT2. The reflection wave propagates back to the VNA's port 1 through AT2 to CC2's port 2 to port 3, through AT1 to CC1's port 3 to port 1. It is by way of CC1 & CC2 the reflected energy is by-passed around PA1. Without this by-pass, the reflected energy would be isolated from the VNA by PA1, thus prohibiting reflection (S_{11}) measurements.

AT3 must maintain VNA port 2 levels below 26 dBm to prevent damage and below 6 dBm to prevent saturation of the VNA's receiver.

High-Power Calibration

It is important to confirm that the source drive is leveled in amplitude as it is swept in

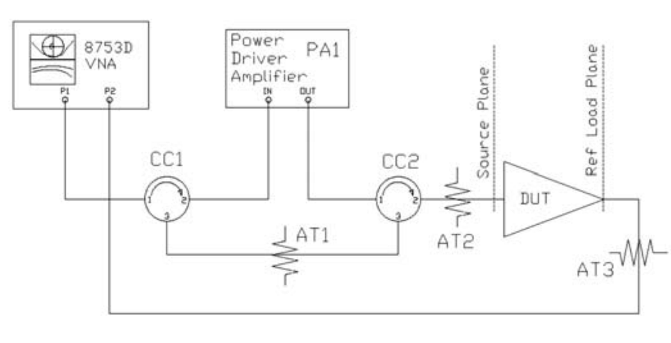

Figure 2 · System includes two circulators for high-power reflection (S_{11}) measurements.

frequency. An unleveled source drive from the VNA or gross source system gain flatness will distort device compression measurements. Decrease the sweep rate to several seconds and then simply measure the source power from AT2 to validate a leveled source.

VNA power calibration procedures can be performed and other leveling techniques can be implemented in this system, however they fall outside of the scope of this discussion.

During the enhanced response calibration, using a high-power calibration standard is essential since the factory calibration load standard is intended for the lower output levels of the analyzer. For example the HP85033C 3.5 mm cal kit load standard has a maximum power rating of 2-watt average (reference HP 909D). The calibration is referenced at the source plane of the high-power DUT and therefore appropriate attenuation is required for the 3.5 mm calibration load standard, or a high-power quality load termination can be used.

The attenuation of AT1 should exceed the gain of the driver amplifier (PA1). AT1 absorbs the reflected energy,

Appendix A: System Configuration Procedure

Starting from a factory preset (8753E):

Key	Soft Key or Data Entry	Description and comments
Start	885 MHz	
Stop	915 MHz	
Markers		Set up Frequency markers as needed
Display	DUAL | QUAD SETUP	
	DUAL ON	
	AUX ON	
CH2	AUX ON	
	Split Disp 2X	Important for Independent drive level control
	CHANNEL POSITION	
	2X [1&2] [3&4]	
	RETURN	
	RETURN	
CH1		Select CH1
Meas	Refl: FWD S11 (A/R)	
CH2	Refl: FWD S11 (A/R)	Select CH2 and configure as CH1
CH2	Trans: FWD S21 (B/R)	Select CH4 and configure as S21
CH1		Select CH1
Format	POLAR	
CH1	LOG MAG	CH3
CH2	LOG MAG	
CH2	LOG MAG	CH4
Menu	POWER	
	PWR RANGE MAN	
	POWER RANGES	
	RANGE 2 –35 TO –10	Set Test Port Power to –30 dBm Select an appropriate drive level to prevent saturation of PA1 and from damaging the DUT.
	RETURN	
	RETURN	

preventing regeneration into an unstable high-power condition in PA1. Consider during the calibration, though, a typical driver amplifier with a gain of 50 dB: when using the reflection cal standards connected at the source plane, the isolation of CC1 would be insufficient with respect to the 50 dB driver amplifier gain. Additionally, this attenuator renormalizes the reflected magnitude preventing saturation or damage to the analyzer's port 1 receiver. AT2 provides additional isolation at the source plane for harmonics and spurious instabilities outside of the circulator's bandwidth.

AT3 serves as the DUT power load; it does not provide regenerative isolation nor does it provide DC isolation to the analyzer. Ensure that AT3 provides enough isolation to prevent damage to port 2 of the analyzer. The damage level of ports 1 and 2 are specified at +26 dBm. Operating at 20 dB below this level and above the noise floor of the network analyzer will ensure accurate measurements.

Conclusion

This paper has presented a high-power measurement technique that incorporates uncoupled trace sweeps for evaluating gain compression over a broad bandwidth. Two common circulators are utilized providing large signal input return loss measurements in phase and magnitude. Refer to Appendix A for system configuration procedure. The Enhanced Response calibration procedure is detailed in Appendix B.

Author Information

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Appendix B: The Enhanced Response Calibration

Caution: Use a high-power quality load terminator such as Weinschel's WA1425 or WA 1428 where VSWR = 1.1. The HP85033C 3.5 mm load standard is rated for low output drive levels only, not to exceed 33 dBm. Turn on the drive amplifier and allow a one-minute warm up period to stabilize the thermal gain drift of the system.

Key	**Soft Key or Data Entry**	**Description and comments**
Cal	CAL KIT	
	SELECT CAL KIT	
	3.5 mm C HP85033C	Select appropriate calibration kit
	RETURN	
	RETURN	
	CALIBRATE MENU	This calibration combines a one-port calibration and
	ENHANCED RESPONSE	a response calibration for source match correction
	S11/S21 ENH. RESP	during transmission measurements.
	REFLECTION	
	FORWARD:	
	OPEN	With open standard connected to source plane
	SHORT	With short standard connected to source plane
	LOAD	With high power load standard connected
	STANDARDS DONE	
	TRANS-MISSION	With Source Plane connected to DUT Plane
	FWD TRANS THRU	
	STANDARDS DONE	Disconnect DUT reference plane
	ISOLATION	
	FWD ISOL'N=	
	ISOLATION DONE	
	DONE FWD ENH RESP	
Menu	COUPLED CH <u>OFF</u>	
	POWER	
	CHAN POWER [UNCOUPLED]	
	RETURN	

Verify calibration with a known through standard. Set up scaling as desired.
To re-calibrate, channels should be coupled or they must be calibrated independently.