Load Pull Measurements for GSM and CDMA Power Modules

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Abstract

A load pull system that has CDMA and GSM stimulus and response capability is presented. This novel system performs fundamental and harmonic tuning using a single, solid-state, impedance tuner without a multi-plexer or harmonic loops. Measurements of power, efficiency and spectral re-growth are obtained. Special consideration is made for the burst requirements of GSM. This paper presents the measurement system, harmonic tuning, CDMA and GSM examples.

Measurement System

This measurement approach uses an ATN Microwave LP2 Harmonic load pull system [1]. This approach has been reported before and has some distinguishing characteristics. It is based around a network analyzer. This provides in-situ calibration, 100dB dynamic range and voltage sampler as opposed to thermal detection measurement speed. In addition it utilizes solid state impedance tuners. These have repeatability on the order of 2 parts in 10^5 or -94 dB residual for accuracy [2]. They also provide virtually instantaneous switching, increasing measurement throughput.

For harmonic tuning measurements, the system is unique in that it can control harmonic terminations without a diplexer and multiple tuners. This allows enhanced reflection coefficient and simple system architecture [3].

The Digitally modulated CDMA and GSM waveforms are from an HP ESG-D signal generator and received by an HP 89441 vector signal analyzer. The vector signal analyzer can measure true RMS power. This enhances the power measurement accuracy of "noise like" modulated signals that typically would have been measured with a spectrum analyzer.

GSM Measurement Issues

For GSM, special attention is needed to analyze the device performance during the "on" portion of the GSM duty cycle (Figure 1). This is required for both the DC and RF characteristics. For the DC parameters a transient bias supply is used. It has the capability to return the "on " values for voltage and current when the GSM burst is present. For the RF parameters, the vector signal analyzer is used to time-sample the device output waveform. This allows characterization exclusively during the GSM burst without compensation factors for duty cycle. Once the waveform during the burst is captured, the required parameters of power and ACPr can be calculated. These instruments are synchronized and controlled automatically by the ATN LP measurement system

Harmonic Tuning

The harmonic tuning capability is a result of tuner's 390,625 calibrated settings. The system has the ability to select settings based on their impedance at a given frequency. It is therefore possible to select many states that all have similar fundamental termination at 900 MHz. Due to the nature of the tuner, they will have a pseudo-random distribution at 1.8 GHz (Figure 7, Figure 8). This allows harmonic tuning without a diplexer and the resultant loss and degradation of reflection coefficient. In addition, this property of harmonic "dispersion" is what enables a single tuner system to provide enough information for this modeling approach.

Experiment

1.) A device was characterized for its single tone and CDMA tone performance. Fundamental contours of Power, Efficiency, CDMA power (integrated in 1.23MHz BW), CDMA efficiency [(CDMA output power-CDMA input power) divided by CDMA DC power], and ACPr were created.

2.) Harmonic tuning was performed for ACPr and CDMA efficiency. These results then verify a behavioral model taken from the initial measurements.

3.) A second device was characterized for GSM performance, during the GSM burst. Pin/Pout at Optimum power terminations, Fundamental contours of GSM Power, GSM Efficiency are presented

Experiment 1 Fundamental Load Pull

A Fujitsu FLL101 FET was utilized as a DUT for CDMA. It was biased at 5.8V Vds, 50mA Ids. The fundamental frequency was 900MHz. Conventional load pull was performed with a source match set to maximize delivered power (at output gamma Pmax) and contours for power (Figure 2), efficiency (Figure 3), CDMA power (Figure 4), CDMA efficiency (Figure 5) and CDMA ACPr (Figure 6) are presented. Note CDMA power and efficiency are different than the CW values. Comparing the contours for CDMA ACPr and CDMA power, a compromise fundamental termination of (0.345, -19°) was selected. This was used as the fixed fundamental for experiment 2.

Experiment 2, Harmonic Tuning

The same device was then measured at 201 states with a constant fundamental termination of (0.345, -19°) (Figure 7) and a varying second harmonic (Figure 8).

From these 201 fixed fundamental measurements, contours of CDMA ACPr (Figure 9) and CDMA efficiency (Figure 10) were generated. The total time for the 201-point measurement of all the values, single tone and CDMA, was 7 minutes.

Experiment 3 GSM Load Pull

A Bosch Telecom GSM PA Module was used as the DUT. The module had pre-matching elements. Measurements were made at 800 MHz. The device was controlled by a 3 V pulse at the gate that was at 12% duty cycle, 577 μsec pulse width.

The module was iteratively tuned for maximum output power at the input and output for optimum fundamental terminations, then measured versus power (Figure 11). A second measurement generated power (Figure 12) and efficiency (Figure 13) contours vs. output termination.

Acknowledgment

The authors would like to thank Wayne Kennan at Fujitsu Semiconductor and Per Dahlgaard Pedersen and Peter Bundgaard Jensen at Bosch/Dancall Telecom A/S for assistance with test devices and measurement specifications.

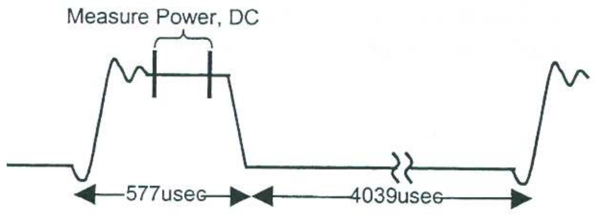

Figure 1 GSM measurement timing

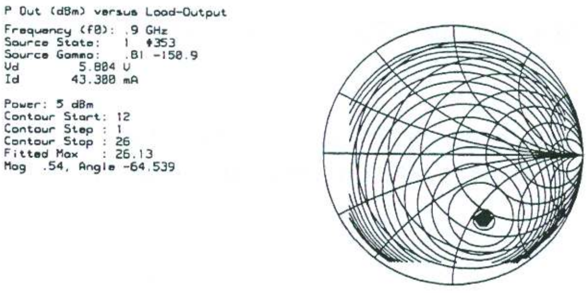

Figure 2 Output power vs. fundamental

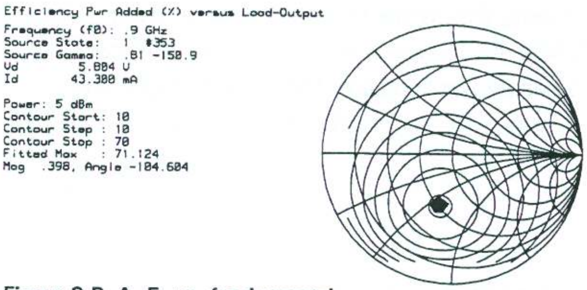

Figure 3 P. A. E. vs. fundamental

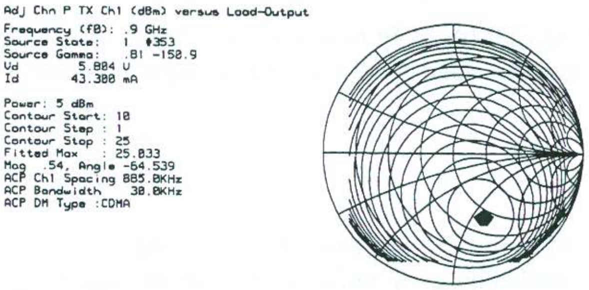

Figure 4 CDMA output power vs. fundamental

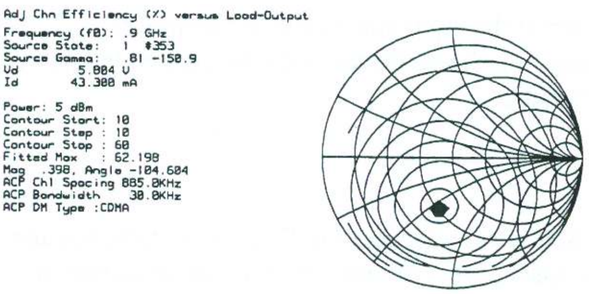

Figure 5 CDMA efficiency vs. fundamental

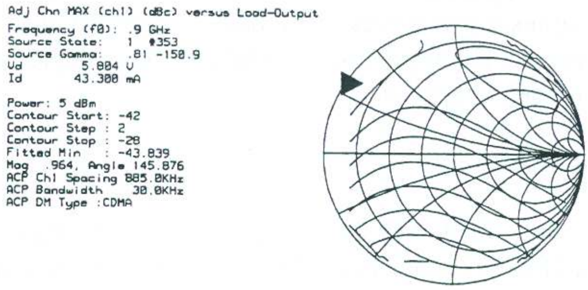

Figure 6 CDMA ACPr vs. fundamental

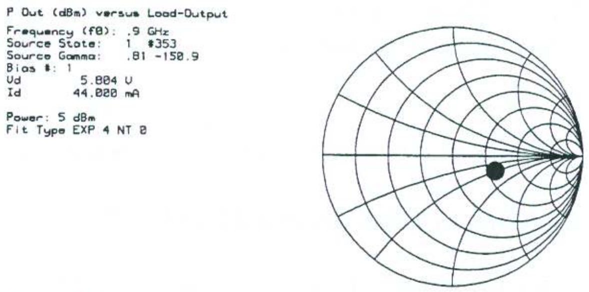

Figure 7 Fundamental termination for harmonic tuning

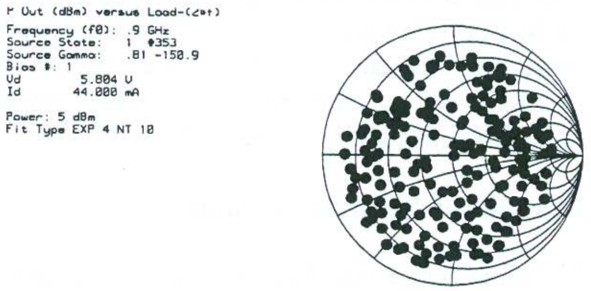

Figure 8 Second harmonic distribution for harmonic tuning

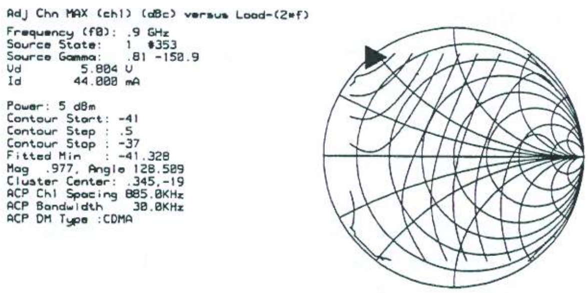

Figure 9 CDMA ACPr from harmonic tuning

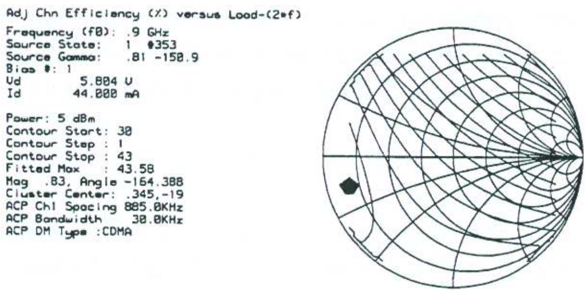

Figure 10 CDMA efficiency from harmonic tuning

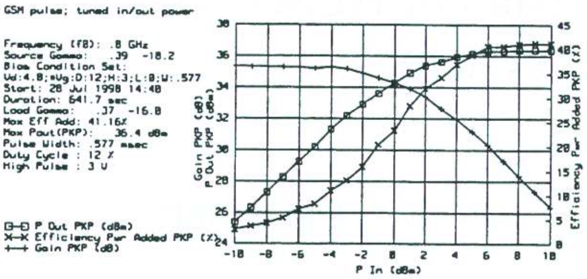

Figure 11 Pin vs. Pout for GSM burst

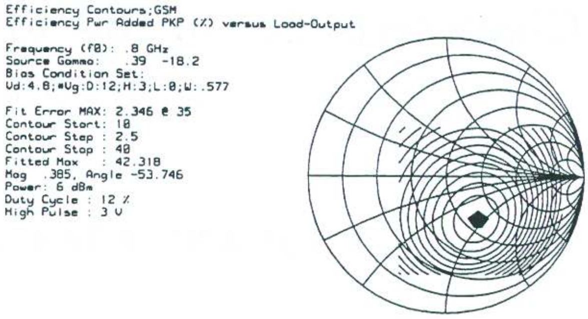

Figure 13 Efficiency contours for GSM burst

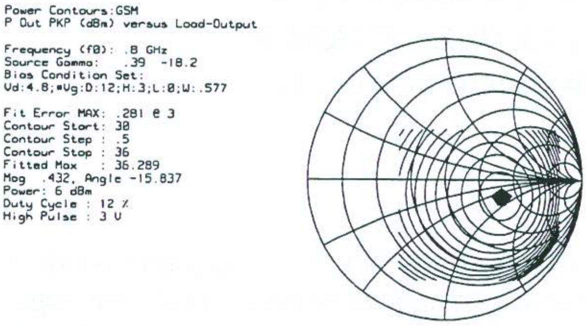

Figure 12 Power contours for GSM Burst

References

[1] ATN Microwave, "A Load Pull System with Harmonic Tuning", Microwave Journal, pp. 128-132, March 1996.

[2] G. Engen, R. Judish, J. Juroshek, "The Multi-State Two Port: An Alternative Transfer Standard, ARFTG Digest, Spring 1993.

[3] D. Kinzel, M. Fennelly, D. Wandrei "Measurement Based Behavioral Modeling of Impedance Dependent Transistor Non-Linearity" 1997 Wireless Communications Conference Digest, pp 114-116.