
Application Note No 12

AM/PM Distortion Load Pull of Power Transistors

The CCMT Software Version 4.01 includes the option to measure Saturation Characteristics and Load Pull of the AM/PM Distortion of Power Transistor or Amplifiers under high power conditions.

The measurement requires a Vector Network Analyzer connected to the setup together with two power meters for simultaneous Gain and Efficiency measurements.

Description of the Setup

The setup required for the Load Pull measurement of the AM/PM distortion of power transistors is shown in figure 1.

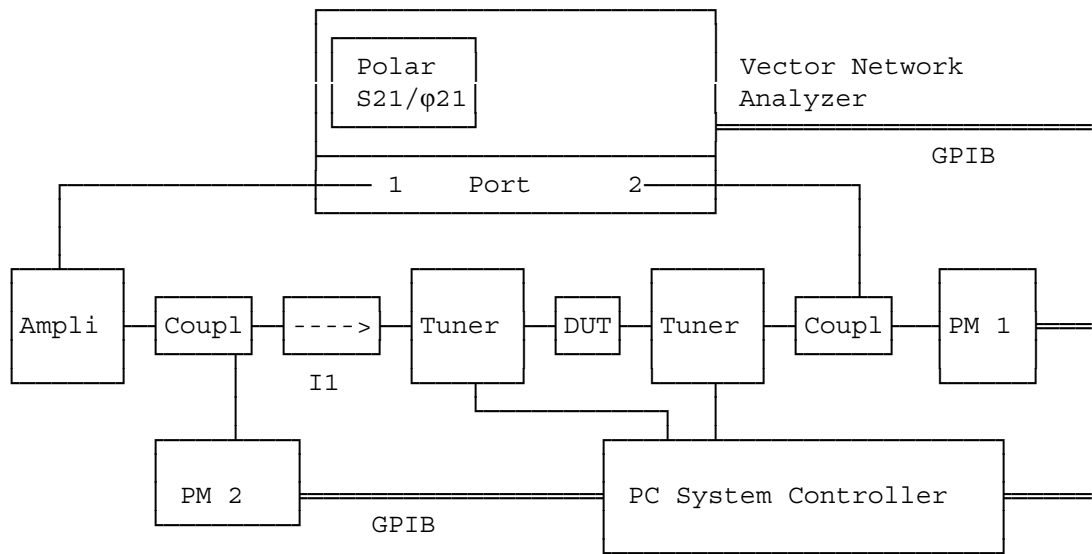
The RF signal of the network analyzer's synthesizer is injected into the input booster amplifier of the setup. The amplified signal is sampled using a directional coupler at the output of the DUT and recovered at the test port 2 of the testbox of the analyzer. The injected and output power are measured using two GPIB programmable power meters or a dual channel power meter. The software also supports most peak power meters.

A pre-calibration of all passive components of the setup permits simultaneous measurements of Gain, Power, Efficiency and Transmission Phase at the DUT reference plane using standard De-Embedding techniques.

The AM/PM distortion of the booster amplifier is calibrated out using an input power sweep within the required Pmin/Pmax limits and a Through-Line standard inserted in the test fixture instead of the DUT itself. The residual AM/PM data are saved in a CAL file and retrieved for corrections during the actual measurement.

The CCMT software permits to make two types of AM/PM measurements:

- 1- Transmission Phase as a function of Input Power to the transistor
- 2- Load (Source) Pull of AM/PM for a user selected input power step.



PM = Power Meter
 Supported Analyzers: Wiltron 360, HP 8510, 8720

Figure 1: Automatic Load Pull Setup for AM/PM Distortion Characteristics

Isolator I1 ensures that the input coupler is always loaded with 50Ω and that the AM/PM residual characteristics of the booster amplifier is the same whether the DUT is inserted or not in the test fixture (in which case the impedance before the input tuner is going to change).

Efficiency can also be measured if a programmable power supply or two programmable DMMs (not shown) are connected in addition to the setup and read by the software via the GPIB.

Measurement Examples

The following figures show measurement examples of transmission phase and AM/PM Distortion of power transistors as a function of input power and load impedance.

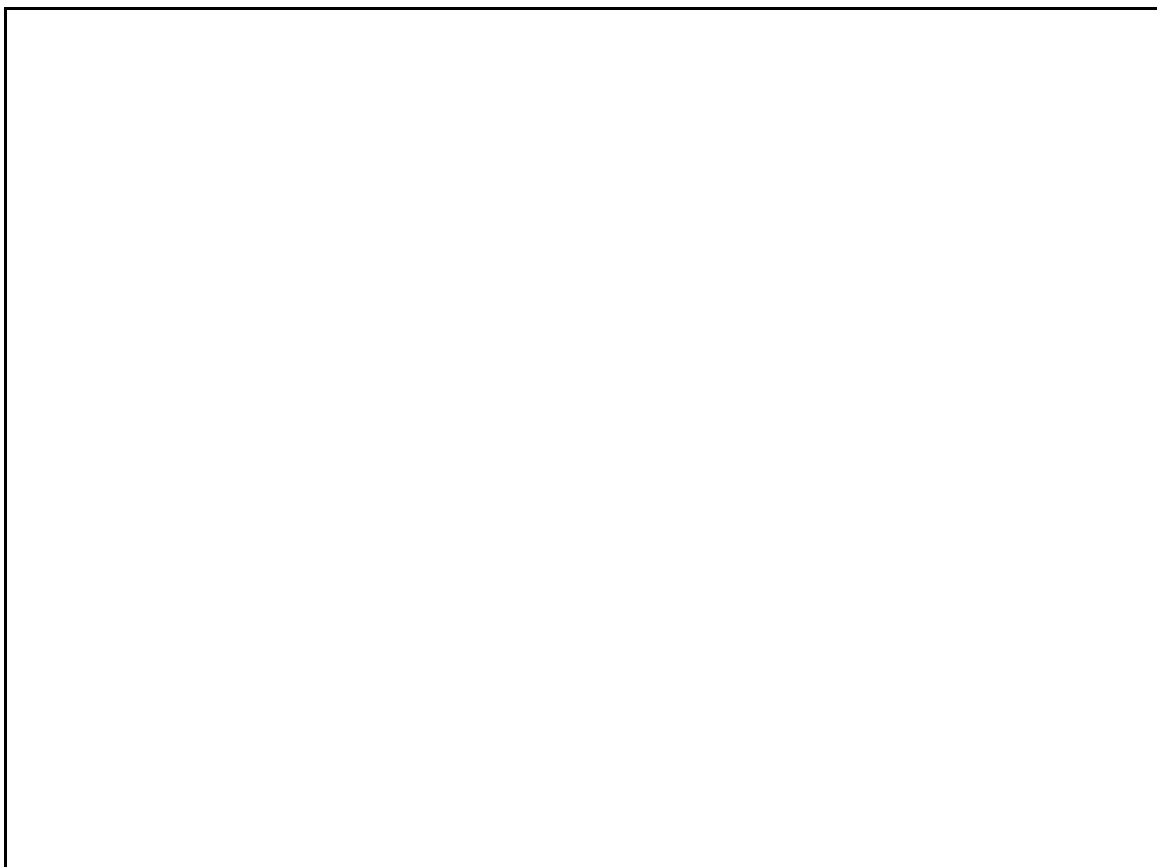


Figure 2: Transmission Phase as a function of Input Power at matched input and output impedance conditions.

AM/PM Distortion L/P

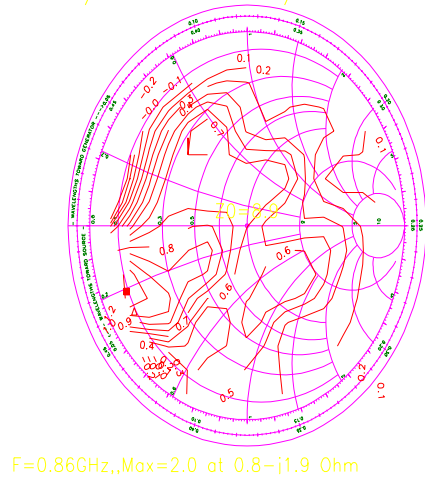


Figure 3: AM/PM Distortion Load Pull. The Source is matched for Maximum Gain.

The data show the normalized transmission phase change of a transistor when its input power is switched between a low and a high power value for each load impedance. The data are expressed in Degrees/dB. The 0 contour signifies that if the transistor is loaded with this impedance the total AM/PM distortion will be 0, for the specific Input Power step.

As figure 2 shows the Input Power step may be selected such as to obtain a 'worst case' Phase Modulation to make a selection of the optimum impedance easier.

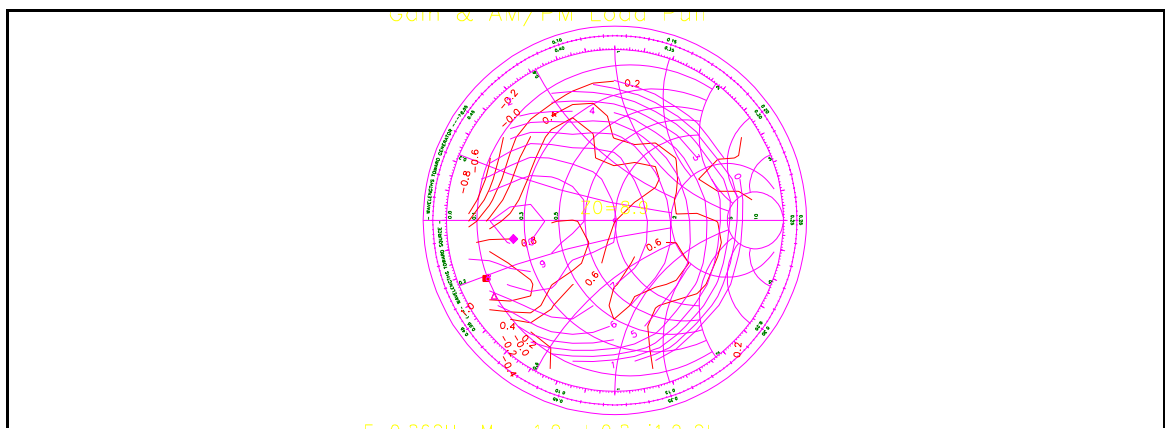


Figure 4: AM/PM against GAIN Load Pull, showing the Optimum Matching for Gain (=best case) and the maximum point for AM/PM (=worst case).

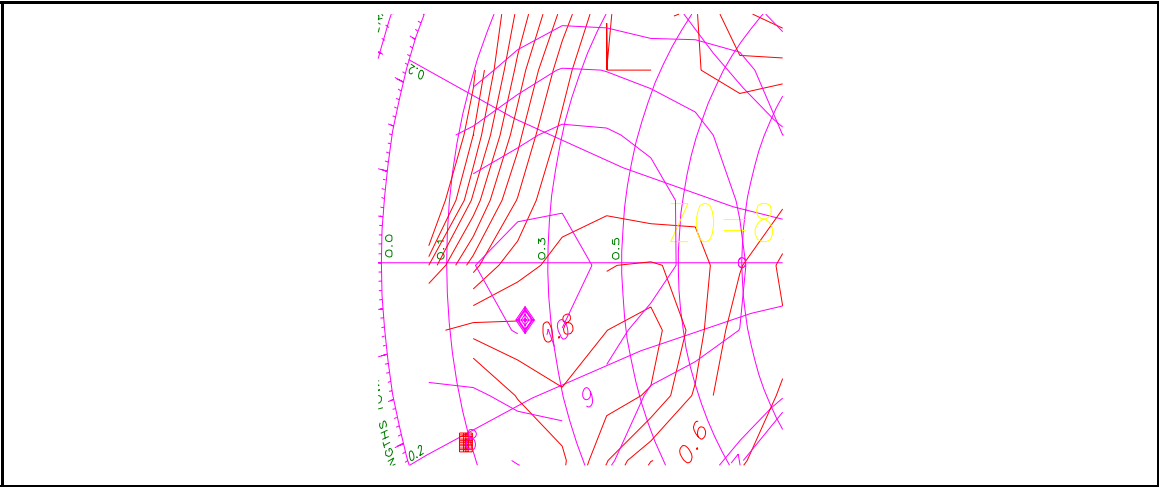


Figure 5: Zoomed detail of figure 4 showing that if the transistor is tuned to 9dB gain the AM/PM distortion may become 0 (point X).

The CCMT Graphics software permits to extract contour points from the ISO contours and save them in a file. If we do this for the above case the ASCII file of figure 6 can be generated. It shows that the transistor can be tuned such as to have 0 °/dB AM/PM for 9dB Gain (points BEST) or for up to 1.2°/dB for the same gain (point WORST)

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! User generated Contour file 'CONTOUR.023'
!-----
! File 'FMI2F1SL.DAT':Freq=0.86GHz, ,AM/PM,pmax=33
!
! Characteristic Impedance = 8.90 Ohm
!-----
!  Γ          φ          R          jX          -AM/PM [°/dB] Gain [dB]
!-----
0.806    171.0        1.0        0.7    -    0.07 <== 9.00 <==BEST
0.806    171.0        1.0        0.7    -    0.07    9.00
0.742    166.1        1.3        1.1    -    0.34    9.71
0.742    166.1        1.3        1.1    -    0.34    9.71
0.689    162.7        1.7        1.3    -    0.57    9.46
0.607    157.0        2.3        1.7    -    0.41    9.07
0.499    149.0        3.2        2.2    -    0.67    8.75
0.396    144.4        4.2        2.3    -    0.56    8.48
0.274    144.7        5.4        1.8    -    0.57    8.89
0.173    162.2        6.4        0.7    -    0.91    8.91
0.228   -168.5        5.6       -0.5    -    0.82    9.28
0.325   -158.7        4.7       -1.2    -    0.56    9.18
0.444   -151.8        3.6       -1.9    -    0.42    9.43
0.531   -149.5        2.9       -2.2    -    0.86    8.87
0.621   -151.6        2.2       -2.1    -    0.89    9.37
0.699   -157.3        1.6       -1.7    -    0.94    8.54
0.782   -161.9        1.1       -1.4    -    1.03 <== 9.21<==WORST
0.818   -165.6        0.9       -1.1    -    1.00    9.13
0.836   -171.0        0.8       -0.7    -    0.89    9.08
0.771    167.7        1.2        0.9    -    0.28    9.04
0.771    167.7        1.2        0.9    -    0.28    9.04
0.804    172.0        1.0        0.6    -    0.09 <== 8.98 <==BEST

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Figure 6: ISO contour ASCII file showing possible tuning for optimization of AM/PM for the same overall gain.

Conclusion

The AM/PM measurement routines of the CCMT software permit to obtain quantitative data on the Phase Linearity behaviour of the transistors and an optimized design of power amplifier stages used in phase modulated transmission applications.