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Focus
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Application Note 28

Macro File Operation of CCMT System

The CCMT load pull system performs complex measurement tasks, like automatic source or load impedance optimization or load and source pull at constant or regulated input power, control the bias of transistors, measure saturation characteristics and tune to any impedance on the Smith Chart.
Macro File operation is the capability of the CCMT system to make all these measurements automatically, driven by the ASCII code included in a User defined script file (Macro file).

Introduction

Automatic Load Pull measurement setups are being used in laboratories, but yet mostly for R&D and exploratory transistor testing. One of the reasons for this is that load pull measurements cannot be carried through fully automatically, but require frequent inputs from the operator, in order to select and set different parameters, run the tests and decide which step is next to be carried through.
This approach is used if the devices to be tested are new, not well known and the task is to establish their state of the art performances, or, to generate some data to be used in circuit (power amplifier) design. This is the typical R&D or prototyping laboratory environment.

In a production type environment, however, the characteristics of the devices are established and load pull tests are needed in order to classify them according to their performance to class A, B or C etc. following a number of criteria. This type of measurement is repeating and should not need human interference.

The first step in this direction is the possibility to run the complete set of load pull tests fully automatically. This has been done for the CCMT system and is being described in the following sections of this note.

A further, important step, is the automatic replacement of the devices in the test fixture. This can be done either using a motorized or pneumatic test fixture [1] or an automatic wafer probe station that can both be driven by the same system controller as the CCMT system.

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MACRO File Operation

The Macro file operation of the CCMT system consists of three steps:

Step 1: **Preparation and Setup**: Calibrate the tuners and the setup components, assemble and verify the accuracy of the load pull setup, as in normal load pull. Start the programm, load tuner calibration and setup file and deembed.

Step 2: **Generate the Macro file**: This can be done either from the POWER menu of the load pull software, or from the CCMT shell using one of the available ASCII editors (like EDIT.COM of Microsoft).

Step 3: **Execute the Macro file**: This can be done **either from the CCMT shell or from the POWER menu of the load pull software**. Once started from the CCMT shell the software will recall the initial state of the system, load tuner and setup calibrations and execute all commands as listed in the Macro file through to the end of the file.

There is no limitation to the length of a Macro file. As this file may also include the names of other Macro files this operation may be expanded to include all imaginable tests.

The Macro file execution will be stopped either by a syntax error or by the operator by pressing the 'Esc' key.

MACRO File Commands

Summary

The following table summarizes the commands that may be included in a Macro file and executed by the CCMT tuner system:

Command	Arguments (Symbol | means 'or')
SOURCE	none
LOAD	none
INIT	1 | 2
TUNE	SOURCE | LOAD G|Z Gamma/Phi | Real(Z)/Imag(Z)
PIN	1 | 2 power delta.freq (dBm , MHz)
PSIGNAL	1 | 2 power delta.freq (dBm , MHz)
POWER	1 | 2 ON | OFF
FREQ	frequency (GHz)
PEAK	SOURCE | LOAD [Gamma Phase] (Mag / Degrees)

PIN_POUT	Pmin Pmax Pstep Filename (all in dB, dBm)
LOAD_PULL	1 | 2 | 3 | 4 Filename
REGLP_P	1 | 2 | 3 | 4 Filename Target Pmin Pmax Tolerance (dB)
REGLP_ID	1 | 2 | 3 | 4 Filename Target Pmin Pmax Tolerance Sensitivity
GPIB	Address Command-String
WAIT	time (milliseconds)
BIAS	A|F value1 value2
P1DB	[Pmin, Pmax, Pstep, Compression] (all dB)
FILE	name (type ASCII in C:\CCMT)

Syntax and Operation of Macro Commands

The exact syntax and action of each macro command are as follows:

Command   Action   (Remark: Symbol | means "or")

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- **SOURCE**   = Activate Source Side Tuner (2) (use always when you want to
operate on the source side = Input side of the setup)

- **LOAD**   = Activate Load Side Tuner (1) (use always when you want to operate   on the
load side = Output side of the setup)

- **INIT 1|2**   = Initialize Tuner 1(Input) or 2(Output),
example: INIT 1 or INIT 2 (or init 1 , init 2)

- **PSIGNAL 1|2 power delta-frequency** = Set **Signal Source** 1 or 2 to power [dBm] with an
Offset Frequency of delta-freq [MHz]. **For Source 1: ALWAYS enter delta-freq=0.**
example: PSIGNAL 1 12.7 0 or PSIGNAL 2 20.5 4.5 (sets source 2
at 20.5 dBm and 4.5 MHz off the operation frequency).

- **PIN 1|2 value delta-frequency** = Set the signal power of source 1 or 2 to a value [dBm] so that
the available (injected) power at the input of the device becomes =value. This is
possible by adding the loss of the input section of the setup (including the cable to the
source and the tuner) to the signal power setting.

- **POWER 1|2 ON|OFF** = Switches RF power of source 1 or 2 ON or OFF
- **PEAK SOURCE|LOAD [GAMMA PHASE]** = Search Maximum Gain|Power at Source or
Load side. Starting point of the Search is the actual tuner position if you

do not specify Gamma/Phi(degrees).

- FREQ value (value in GHz) = Load Tuner Calibration and Setup Data to the specified frequency and de-embed to the DUT reference plane for both sides (tuners) of the setup.

- **TUNE SOURCE|LOAD G|Z Gamma|Real(Z) Phi|Imag(Z)** = Tune with Source or Load tuner to Gamma or Z specified in Gamma/Phi[degr] or Real(Z)/Imag(Z) [Ohms]. Specify G (or g) if you enter the data in Gamma/Phi and Z (or z) if you enter the data in R / jX .

- **PIN_POUT Pmin Pmax Pstep Filename** (all values in dBm) = Sweep Source Power, measure Input Power, Output Power and Gain and save the result in a text (ASCII) file with the name "Filename". The file will be automatically saved in the DATA Directory of the CCMT operation. We recommend to use the extension .SAT.

- **GPIB Adr Command** = Sends directly commands to a GPIB instrument connected to the bus at address "Adr".

- LOAD_PULL 1|2|3|4 Filename(.LPD) (file extension optional) = Performs full Load (or Source) Pull. The numbers 1,2,3,4 have the following signification: 1=Measure at all tuner calibration points, 2=measure at 50% of cal points, 3=measure every third calibration point. 4=Use only the points on the Pattern File **MACROFIL.PTN.** Only this file name can be used and it has to be generated before the measurement using the Alt-P soft-key combination. The load (source) pull data measured will be saved in the ASCII file "Filename.LPD" in the directory of the data. You do not have to define this directory in the filename. If you do there will be an error.

- **REGLP_P 1|2|3|4 Filename(.LPD) Target Ps-min Ps-max Tolerance** (all in dB) = Performs full Load (or Source) Pull. The numbers 1,2,3,4 have the following signification: 1=Measure at all tuner calibration points, 2=measure at 50% of cal points, 3=measure every third calibration point. 4=Use only the points on the Pattern File **MACROFIL.PTN.** Only this file name can be used and it has to be generated before the measurement using the Alt-P soft-key combination. The load (source) pull data measured will be saved in the ASCII file "Filename.LPD" in the directory of the data. You do not have to define this directory in the filename. If you do there will be an error.
During the measurement the source power will be regulated between the values Ps-min and Ps-max so that the output power becomes equal to
Target +/- Tolerance. If this target value is not reached, either because the tolerance is too tight, or the source power not sufficient or the gain of the device too low, the corresponding impedance on the Smith Chart will be marked and the point will not be saved in the data file.

- **REGLP_ID 1|2|3|4 Filename(.LPD) Target Ps-min Ps-max Tolerance Sensitivity**
Dimensions: Target,Tolerance [ma], Ps..[dBm], Sensitivity [dB/mA]

= Performs full Load (or Source) Pull. The numbers 1,2,3,4 have the following signification: 1=Measure at all tuner calibration points,   2=measure at 50% of cal points, 3=measure every third calibration point.

4=Use only the points on the Pattern File **MACROFIL.PTN.** Only this file name can be used and it has to be generated before the measurement using the Alt-P soft-key combination. The load (source) pull data measured will be saved in the ASCII file "Filename.LPD" in the directory of the data. You do not have to define this directory in the filename. If you do there will be an error.

During the measurement the source power will be regulated between the values Ps-min and Ps-max so that the Output DC Current becomes equal to **Target +/- Tolerance**. The correction in input power is proportional to the difference to the target value **multiplied by the factor Sensitivity**. If this target value is not reached, either because the tolerance is too tight, or the source power not sufficient or the gain of the device too low, the corresponding impedance on the Smith Chart will be marked and the point will not be saved in the data file.

- **WAIT value**   (milli-seconds)= Holds programm execution for "value" milliseconds. This command may be useful in order to wait the termination of some GPIB commands, such as DC bias setting or frequency sweeps etc..

- **P1DB [Pmin Pmax Pstep Compression]** (dB) = Sweeps the source power between given limits and determines the value for which the Gain of the device has dropped by 'Compression' dB. If the arguments are omitted the system takes values from the default file [2].

- **BIAS A|F value1 value2** = Drives the selected power supply to set the DC bias of the device either to a fixed value (F) or to automatically adjust for the target value2.

- **FILE filename** = Causes execution of all Macro commands included in the file "filename". This enables the creation of subroutines for specific tests. The subroutine "filename" is of type ASCII (same as the original macro file) and may include all macro commands listed above, except the command "FILE filename" itself, in order to avoid recursive loops and file sharing problems.

Measurement Parameters

At Macro file execution the CCMT software measures and saves in files a number of parameters of the DUT. These parameters include DC and RF measurement quantities which are computed from GPIB instrument readings and corrected to the DUT reference plane. These parameters are marked in the **Measurement Macro File** and may be activated when **Load Pull, Mouse or Macro file measurements are executed.**

The Measurement Macro File may include the following parameters:

PIN	Input Power (Injected) at DUT input port

POUT	Output Power (delivered) at DUT output port
GAIN	Transducer Gain
IMD	Two Tone Intermod
ICPT	Intercept Power Level
ACP	Adjacent Channel Power Ratio (2 sidebands)
GCOMPR	Output Power at Compressed Gain (user defined)
EFF	RF/DC Efficiency (PadEff, Total Eff or Collector Eff)
DCPOWER	DC Power of the DUT (V1·I1 + V2·I2)
PHI21	Transmission Phase (use a network analyzer)
I1	Input Port DC Current (Gate, Base)
I2	Output Port DC Current (Drain, Collector)
V1	Input Port DC Voltage (Gate, Base)
V2	Output Port DC Voltage (Drain, Collector)

Macro file Operation in CCMT Power Menu

The Macro file measurements can be activated using key **F8 MACRO** in POWER-1 menu (press F5 MORE to activate POWER-1 menu).
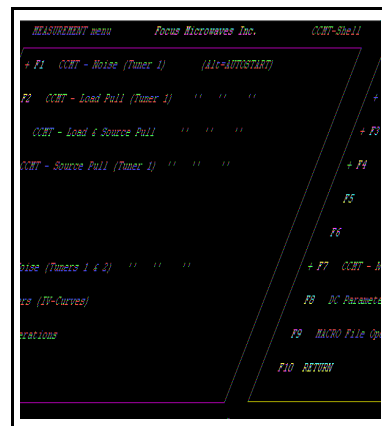Once activated this routine gives the possibility to generate, verify, edit and execute any Macro File.
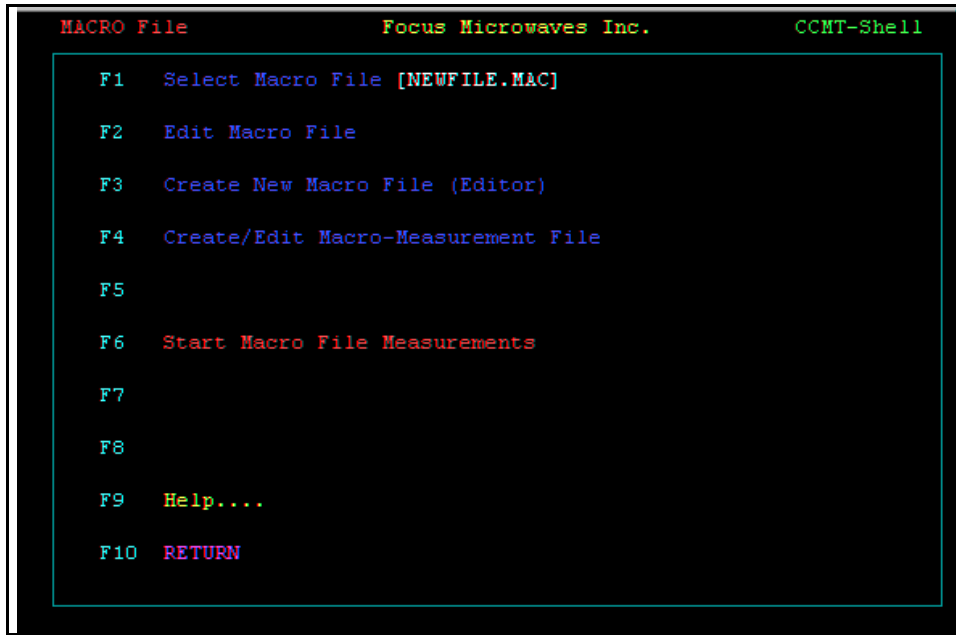The View Macro File option is a "read-only" option that does not allow to modify the file.

There are two ways to generate a Macro File:

1- Through key option F1 in the menu besides.
2- Using an external Editor programm (like EDIT.COM of Microsoft) and write the text file yourself.
When you activate the option **F1 Create Macro File** the following menu appears (the text on the left hand side is a summary of the command syntax):

```
MACRO File                 Focus Microwaves Inc.              CCMT-Shell

      F1    Select Macro File [NEWFILE.MAC]

      F2    Edit Macro File

      F3    Create New Macro File (Editor)

      F4    Create/Edit Macro-Measurement File

      F5

      F6    Start Macro File Measurements

      F7

      F8

      F9    Help....

      F10   RETURN
```

The list of commands on the left side of the screen remains displayed as long as the "Create File" option is active in order to simplify the user's work in entering the commands. The commands can be entered in <u>small or capital letters</u> but the syntax MUST be respected. At execution the software will check the number of arguments of each command and refuse execution if this number is not correct, with a warning message on which command contains the error. The programm execution will stop at this point.

Examples

<u>User defined MACRO file:</u>

! This is a test	Comment line, optional
INIT 1	set tuner 1 to zero
INIT 2	
FREQ 0.84	load tuner cal and setup cal at 840 MHz
LOAD	
PIN 1 20 0	set signal 1 so that Pin=20 dBm at 840 MHz at DUT reference plane.
POWER 1 ON	
POWER 2 OFF	
PEAK LOAD 0.5 175	search the max pout starting at 0.5/175 degr
PEAK SOURCE	search the maximum Gain starting at the **actual position** of the source tuner.
LOAD	switch to load side
LOAD_PULL 1 test_lp.lpd	run load pull at 50% of cal points, save in file test_lp.lpd
INIT 1	
INIT 2	
LOAD	
REGLP_P newfile 1 20 -5 15 0.2	

this command will cause a load pull operation at all calibrated points (1), while trying to keep the output power at 20 dBm by regulating the source power between -5 and +15 dBm, the tolerance of the regulation loop being set to +/- 0.2 dB. The result of the load pull measurement will be saved in the file "newfile.lpd" in the data directory. Points at which the target output power could not be reached will be marked on the Smith Chart and will not be saved in the file as data points.

<u>Macro Measurement file: MEASURE.CNF</u>

PIN
POUT
GAIN
EFF
I2
V2
DCPOWER

References

[1] Intercontinental Microwave, Device Handling System, DHS

[2] CCMT Operation Manual, Section 4, Focus Microwaves.