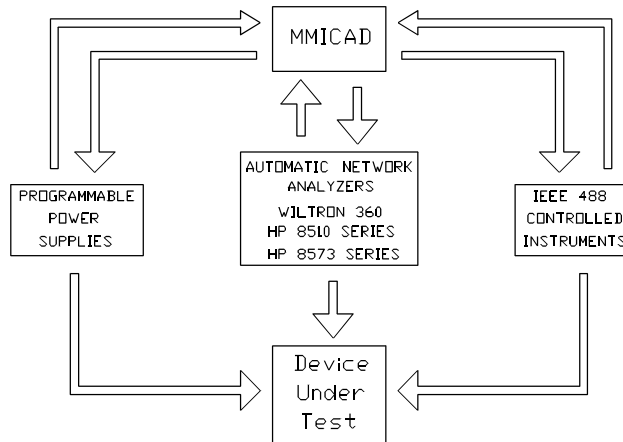


# Computer Aided Testing with MMICAD

## Series #3: Using MMICAD to Control Programmable Power Supplies & Other Control Devices



MMICAD can simultaneously address control devices such as programmable power supplies, attenuators, relays, switches, and other IEEE 488 instruments via user defined commands in the IEEE block of a circuit file. The user should review and perform the configuration and setup as described in application notes #24 and #25.

### IEEE Block Syntax

Five control statements are used: **WRITE**, **READ**, **PAUSE**, **TRIGGER**, and **LOCAL**.

### I WRITE Control Statement Syntax:

[WRITE] <Device Name> <Write String> <Variable> [<Mask>]

where:

**[WRITE]** indicates a write operation of a variable on the bus. This keyword is optional. If the first word on the line is none of **WRITE**, **READ**, **PAUSE**, **TRIGGER**, and **LOCAL**, MMICAD interprets the line as a **WRITE**.

<Device Name> is the device name as defined in the National Instruments IEEE-488 configuration program IBCONF.EXE.

<Write String> is a string of characters enclosed in quotes. This contains the ASCII string to be sent to the <Device Name>, followed by a comma and either %f or %i depending on whether a floating point or integer variable is to be used.

<Variable> is the name of a global variable previously defined in the circuit file's VAR block.

[<Mask>] is an integer constant used by MMICAD to check the status byte of the instrument. Once the string is sent to the device, MMICAD will read the status byte from it; this byte is logically ANDed with the mask value. If the value is nonzero, MMICAD interprets this as a device error and will stop analysis and display an error message. This keyword is optional.

**Example** WRITE DEV14 "VSET1, %f" VD 32

### II READ Control Statement Syntax:

READ <Device Name> <Read String> <Variable>

where:

**READ** indicates a read operation into a variable on the bus.

**<Device Name>** is the device name as defined in the National Instruments IEEE-488 configuration program IBCONF.EXE

**<Read String>** is a string of characters enclosed in quotes. This contains an ASCII string, followed by a comma and either %f or %i depending on whether a floating point or integer variable is to be used. The ASCII string will be printed in a result file besides the value returned into %f or %i from the instrument.

**<Variable>** is the name of a global variable previously defined in the circuit file's VAR block. MMICAD will store the value read from the device into the **<Variable>**.

**Example** READ DEV15 "COLLECTOR CURRENT:, %f" IC

### III PAUSE Control Statement Syntax:

PAUSE **<String>**

where

**PAUSE** is used to pause the operation of MMICAD waiting for a key press.

**<String>** when a **PAUSE** is executed, **<String>** is displayed on the status line of the analysis window.

**Example** PAUSE "CONNECT THE DEVICE"

### IV TRIGGER Control Statement Syntax:

TRIGGER **<Device Name>**

**TRIGGER** is used to trigger **<Device Name>**

**Example** TRIGGER DEV14

### V LOCAL Control Statement Syntax:

LOCAL **<Device Name>**

The **LOCAL** command is used to return **<Device Name>** to local.

**Example** LOCAL DEV14

### Applications

(a) In Example 1, MMICAD acquires data from a low noise 1.15-1.45 GHz amplifier by controlling the Wiltron 360 network analyzer, and two Keithleys DC programmable power supplies. The goal is to find optimal Gate and Drain bias points such that  $S_{21} \geq 15$  dB,  $S_{11} \leq -10$  dB,  $S_{22} \leq -10$  dB, Drain Current,  $I_d < 85$  mA, and DC Power  $< 200$  mW. In the circuit file, the voltages VG and VD are defined in the **VAR** block. The drain and gate currents are defined as well and given initial values which are replaced with measured values when MMICAD begins to sweep. The commands for the programmable power supplies are listed in the **IEEE** block. In the **PROC** block, the drain current ID is assigned to an out variable "IDRAIN" and the DC power is defined. This enables them to be optimized in the **OPT** block. When optimization begins, MMICAD reads at the start of each sweep the sourcing voltages in the **IEEE** block and measures the drain and gate currents, and assigns them to ID and IG respectively. S-parameter data is then acquired from the network analyzer, and the error function is updated. The final optimized values are pasted between the **FREEZE ON** (Start comments) and **FREEZE OFF** (End comments).

Note that the IEEE blocks commands are performed only once at the start of a sweep. In the example, the user can set the variables VG and VD as equations which depend on other global variables. Setting VG and VD to be **FREQ** or **PARAM** dependent will cause MMICAD to use the initial values for the sweep.

(b) Example 2 illustrates how MMICAD can be used to derive an operating point in a MESFET; in this case, half the drain current at saturation ( $I_d = 0.5 * I_{dss}$ ). The sourcing voltages and measured currents are valid MMICAD variables which can be **TUNED** and **OPTIMIZED**. By controlling two Keithley DC power Supplies, MMICAD can optimize the gate bias to obtain the desired drain current. In the circuit file, the voltages VG and VD are defined in the **VAR** block. The drain and gate currents are defined as well and given initial values which are replaced with measured values when MMICAD begins to sweep. The commands for the programmable power supplies are listed in the **IEEE** block. Since the problem is not frequency dependent, a dummy frequency step is assigned to force MMICAD to conduct one sweep. In the **PROC** block, the drain current ID is assigned to an out variable "IDRAIN". This enables this variable to be optimized in the **OPT** block. The optimization statement simply set up IDRAIN to be equal to 0.0325 Amperes. When optimization begins, MMICAD reads the sourcing voltages at the start of each sweep in the **IEEE** block and measures the drain and gate currents, and assigns them to ID and IG respectively. The final optimized values are pasted between the **FREEZE ON** (Start comments) and **FREEZE OFF** (End comments),  $V_G = -0.429V$ .

## Verify IEEE 488 Codes

The user can confirm that the string sent to the instrument is correct by selecting "**Verify Codes**" from the "**C.A.T.**" menu. For Example 1, the screen will show the following:

## IEEE commands:

DEV14 -> VSET1, -0.500000  
DEV14 -> VSET2, 3.000000

```
MMICAD 5.0      LINEAR ANALYSIS AND CIRCUIT DESIGN      OPTOTEK LTD
FILE NAME: APP26.CKT  AUTHOR: MMICAD Authors          04/29/1992
```

### NOTES: Using MMICAD for automated Computer-Aided-Testing of Amplifiers

Find optimal bias point for  $\text{dB}[S_{21}] \geq 15$ ,  $\text{dB}[S_{11}] \leq -10$ ,  $\text{dB}[S_{22}] \leq -10$   
Condition:  $1.15 \leq F \leq 1.45$  GHZ,  $I_d \leq 85$  mA,  $V_d \leq 4$  V, DC Power  $\leq 200$  mW

Network Analyzer: Wiltron 360  
Control Devices: Two Keithleys DC programmable power supplies

```
FILES
WILTRON AMPLFR 75 2P FREQ      ! Read LNA S-parameters from ANA
VAR
VG=? -5 -3 -2 ?              ! Set VG to be optimized
VD=? 1 3 4 ?                  ! Set VD to be optimized
ID=1                           ! Set initial value of ID
IG=1                           ! Set initial value of IG
IEEE
SMU236A "G4,2,0"              ! Command Gate DC Supply to measure
SMU236A "B%f,,1X" VG 32       ! Source bias to Gate DC Supply
READ SMU236A "THE GATE CURRENT : " IG ! Read measured gate current
SMU236B "G4,2,0"              ! Command Drain DC Supply to measure
SMU236B "B%f,,1X" VD 32       ! Source bias to Drain DC Supply
READ SMU236B "THE DRAIN CURRENT:" ID ! Read measured drain current
PROC
IDRAIN=ID*1000                ! Set drain current to milli-Amperes
DCPOWER=IDRAIN*VD*1000       ! Define DC power in milli-Watts
FREQ
SWEEP 1 1.6 .05
OPT
RANGE 1.15 1.45              ! Optimization frequency range
AMPLFR DB[S21] GT 15          ! Optimize for gain
AMPLFR DB[S11] LT -10        ! Optimize for S11
AMPLFR DB[S22] LT -10        ! Optimize for S22
OUTVAR RE[IDRAIN] LT 85      ! Optimize for drain current
OUTVAR RE[DCPOWER] LT 200    ! Optimize for DC Power
OUT
AMPLFR DB[S21] FRAME1
AMPLFR DB[S11] FRAME1
AMPLFR DB[S22] FRAME1
OUTVAR RE[DCPOWER] FRAME1 R
OUTVAR RE[IDRAIN] FRAME1 R
GRID
RANGE 1 1.6 .15
FRAME1 -20 20 5 R 0 400
LABEL
OPTIMAL AMPLIFIER BIAS POINT
!
FREEZE ON
! Final Results shown below
VG=? -5 -4.13151 -3 ?
VD=? 0.1 1.75334 4 ?
ID=0.012525
IG=8.1e-005
FREEZE OFF
```

## Example 1 MMICAD C.A.T. of Low Noise Amplifier

MMICAD 5.0	LINEAR ANALYSIS AND CIRCUIT DESIGN	OPTOTEK LTD
FILE NAME: APP26B.CKT	AUTHOR: MMICAD Authors	04/29/1992
<p>* Use MMICAD's OPTIMIZATION for Computer-Aided-Testing of MESFET parameters *</p> <p>Objective: Determine the Gate bias for ID= 0.5*Idss= +32.5 mA</p> <p>Control Device #1: "SMU236A" KEITHLEY DC Power Supply for Gate Bias</p> <p>Control Device #2: "SMU236B" KEITHLEY DC Power Supply for Drain Bias</p>		
<pre> VAR   VG=? -2.0 -1.0 0.2 ?      ! Gate Bias is optimized   VD=4                      ! Fixed Drain Bias   ID=1                      ! Initial Drain Current Value   IG=1                      ! Initial Gate Current Value IEEE   SMU236A "G4,2,0"          ! Command KEITHLEY #1 to measure current   SMU236B "G4,2,0"          ! Command KEITHLEY #2 to measure current   SMU236A "B%f,0,5X" VG 32  ! Source VG bias and wait 5 milli-seconds   SMU236B "B%f,0,5X" VD 32  ! Source VD bias and wait 5 milli-seconds   READ SMU236A "IG=" IG     ! Read IG from KEITHLEY #1   READ SMU236B "ID=" ID     ! Read ID from KEITHLEY #2 PROC   IDRAIN=ID                 ! Make ID an OUTVAR "IDRAIN" to allow optimization FREQ   STEP 0.1 OPT   OUTVAR RE[IDRAIN] EQ 0.0325 ! Optimize for IDRAIN=32.5mA OUT   OUTVAR RE[IDRAIN] TABLE T LABEL ! FREEZE ON ! Final Results pasted below VG=? -2 -0.429 0.2 ? VD=4 ID=0.032506 IG=2.2e-007 FREEZE OFF </pre>		

**Example #2: MMICAD C.A.T. control two KEITHLEY Power Supplies: Determination of operating point in a MESFET by Optimization**