

## Parameter Mode in MMICAD

One of MMICAD's most useful features is its ability to sweep a parameter other than frequency. The value of a circuit variable can be set to the parameter, which can then be swept. This feature is extremely valuable in circuit analysis.

### Example:

A simple example circuit will clarify circuit file structure and usage. Consider the circuit shown in Figure 1 along with the circuit file (Figure 2) for a phase shifter:

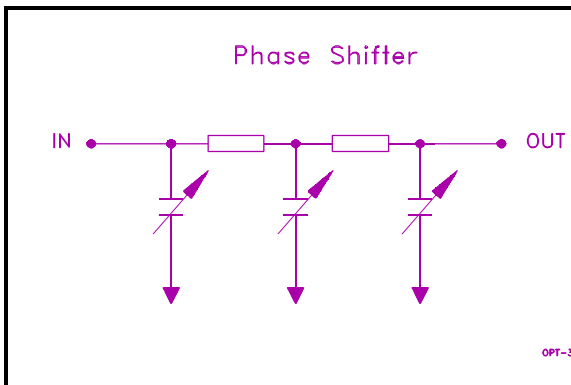


Figure 1 Phase Shifter

```

VAR
VCON=PARAM                                !Varactor control voltage!
CV={4*(1-EXP(-2/(0.8-3*VCON)))}           !Varactor capacitance!

CKT
DIM FREQ=1E9 CAP=1E-12 LNG=1E-6           !First,define
                                         units
                                         and set GaAs
substrate                                  parameters!
MSUB ER=12.4 H=200 T=2.5&
RHO=1.3 TAND=0 @GAAS

!Now define the varactor !network. The varactor is !modelled as a bias -
!dependent series RC !impedance (1-port).

RES 1 2 R={0.2-VCON}                      !Varactor series
                                         !resistance
CAP 2 0 C=CV                               !Varactor series
                                         !capacitance
DEF1P 1 VARAC                              !Complete varactor
                                         !network
    
```

```

!Now define the network for a two-port phase shifter

VARAC 1 0                                  !Use the varactor in a network

MTRLND 1 2 W=25 L=800 @GAAS               !Nondispersive microstrip

VARAC 2 0 M=2                              !Connect a scaled varactor
!to the ref. node

MTRLND 2 3 W=25 L=800 @GAAS

VARAC 3 0

DEF2P 1 3 SHIFT                            !Now define a two-port
!network call SHIFT.
!Node 1 is port 1; node
!3 is port 2.

PARAM
SWEEP -2 0 0.001                          !Sweep the parameter
!from -2 to 0 volts.

FREQ
FIXED 5
SWEEP 5 10 .1                             !Sweep the frequency
!from 5 to 10 GHz

!
OUT
SHIFT ANG[S21] PHASE
SHIFT DB[S21] LOSS
!
GRID
PHASE 5 10 -180 180
LOSS 5 10 -10 0
    
```

Figure 2 Circuit File for a Phase Shifter

The **VAR** block at the start defines variables for the control voltage and the varactor capacitance. Please note that the control voltage variable **VCON** is assigned the current value of the **PARAM**. This parameter is set in the **PARAM** block, and is swept from -2 to 0 volt in steps of 0.1 volts. In the **CKT** block, a one-port varactor network is defined first. In this network, the resistance value is set using a mathematical expression while the capacitance value is set with the variable **CV**. This was done for illustrative purposes. Either variables defined in a **VAR** block or in-line expressions could be used. The circuit block completes with the description and definition of a two-port phase shifter network. The **FREQ** block defines a frequency sweep. The **OUT** block defines two graphical output frames, in which the phase shift (in degrees) and the insertion loss (in dB) will be plotted vs frequency. The **GRID** block defines the scaling for the output frames.

## Analysis and Output

Once a circuit file has been typed in, analysis can be performed with several options. These options are found in the Run menu, or can be invoked using function keys. When analysis is started by pressing the F4 key or choosing **Analyze** from the Run menu, MMICAD goes through the lines of the circuit file sequentially. For each network in the **CKT** blocks, it calculates the matrix representation. It then generates output as defined in the **OUT** blocks. A sample graphical output is shown in Figure 3 for the phase shifter example.

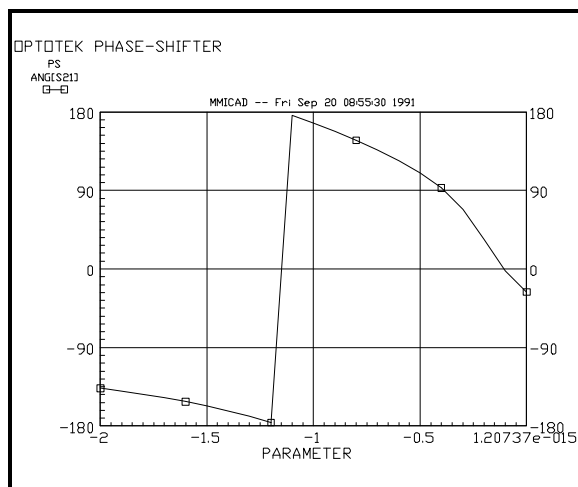


Figure 3 Phase Shifter Response

## Applications of Parameter Mode

A frequently used application of parameter mode is to display the network sensitivity to a technological parameter. For example, the sheet capacitance in a circuit could be swept over the technological range to determine whether the network would meet specs, and if not, to estimate the yield and determine the need for a change of topology.

Under some situations, it is useful to vary both the frequency and the parameter. For example, it might be useful in the above example to view the phase shift as a function of frequency for different values of the control voltage. This can be done using the **Variational Analysis** selection from the Run menu. In **FREQ** mode, MMICAD will set the parameter to the first value of the parameter sweep and perform the calculations at each frequency point, displaying results. The program then repeats this

for the second value of the parameter, the third and so on, generating a family of frequency response curves for different values of the parameter.

Another commonly used application for parameter sweeps is to plot an error function, defined as the discrepancy between desired and actual network measurements in the circuit file's **OPT** blocks.