User Defined Outputs and Optimization Goals in MMICAD

This application note shows how easy it is for designers to define customized outputs or optimization goals in MMICAD.

Creating User Defined Outputs or Optimization Goals

MMICAD supports a powerful PROC block which allows the user to define variables that are vectors as a function of frequency. In other words, PROC block variables do not contain a single real or complex number (like VAR block variables) but reference a list of numbers that vary as a function of either parameter or frequency. This allows their use as optimization goals (user-defined optimization goals), and permits the display of their values in the OUT block against frequency or parameter (user-defined outputs).

Example 1 User Defined Outputs

Consider the circuit file shown in Figure 1 overleaf. The FRIIS equation is used to calculate the noise figure contribution of each stage of a two stage amplifier, storing the results in PROC block variable nft, which is displayed in the OUT block. Obviously any output that can be expressed mathematically may be defined.

Example 2 User Defined Optimization Goals

The goal of any optimization statement can be a PROC block variable. For example, an amplifier could be designed to match a theoretical performance curve.

Consider the MMICAD circuit file segment below:

```
PROC
  GOAL = 30 -3*LOG10(FREQ)
OPT
  LNA dB[S21] EQ GOAL
```

During optimization the gain response of the amplifier will be optimized to agree with 30-3LOG(f) (the GOAL variable).

Over...

Figure 1 User-Defined Outputs

CIRCUIT FILE

```
!******************************************* ********************************************************************************
! A LOW-NOISE AMPLIFIER DESIGN EXAMPLE
! THIS EXAMPLE ALSO ILLUSTRATES THE USE OF A USER DEFINED MODEL & THE IN-LINE PROCESSOR BLOCK
! MMICAD SETTINGS: FREQUENCY MODE; NOISE ON
!******************************************* ********************************************************************************

FILES
 \MMICAD\EXAMPLES\NEC710.S2P NEC710 101 2P FREQ

VAR
 LRFB=? 60 100 120 ?
 LIN1=? 500 1000 5000 ?
 LOUT1=? 100 500 1000 ?
 LBIAS=? 2000 4000 6000 ?
 LIN2=? 800 1000 3000 ?
 LOUT2=? 100 100 2000 ?
 LSOURCE=? 200 700 2000 ?
 CSQ=330
 RSQ=100
 W1=2
 W2=1.3

CKT
 MSUB ER=12.8 H=200 T=3 RHO=1.3 TAND=0 @SUB0

 MODVAR W=10 L=10
 RES 1 2 R={ L/W*RSQ }
 MTRLND 2 3 W=W L=L @SUB0
 DEF2P 1 3 TFRES ( W L )

 MTRL 1 2 W=20 L=LIN1 @SUB0
 RES 1 0 R=5000

 NEC710 2 31 10 M=W1
 MTRL 10 0 W=20 L=LSOURCE @SUB0
 MTRL 31 3 W=12 L=LOUT1 @SUB0
 TFRES 2 21 0 W=20 L=LRFB
 TFC 3 21 W=250 L=250 CS=CSQ @SUB0
 TFRES 3 34 0 W=10 L=10
 MTRL 34 0 W=20 L=LBIAS @SUB0
 DEF2P 1 3 STAGE1

 MTRL 1 2 W=20 L=LIN2 @SUB0
 RES 2 0 R=5000
 NEC710 2 3 0 M=W2
 MTRL 3 4 W=20 L=LOUT2 @SUB0

TFRES 4 44 0 W=10 L=10
 MTRL 44 0 W=20 L=LBIAS @SUB0
 DEF2P 1 4 STAGE2 ZOUT1

 STAGE1 1 2 0 M=1
 STAGE2 2 3 0 M=1
 DEF2P 1 3 TCW100

 STAGE1 1 2 0 M=1
 RES 1 0 R=50
 DEF1P 2 ZOUT1

FREQ
 SWEEP 1 2 .1

TERM
 Z0=50
 stage2 zout1 Z0

PROC
 gain1=stage1 mag[s21]
 s1out=stage1 mag[s22]
 gav1=(gain1*gain1)/(1-s1out*s1out)
 nf1=stage1 mag[nf]
 nf2=stage2 mag[nf]
 nft=10.*log10(nf1+(nf2-1)/gav1)

OUT
 tcw100 db[nf] NFIG T
 outvar mag[nft] NFIG

LABEL
COMPARISON OF CALCULATED AND MEASURED NF
```

READ THE NEC710 S-PARAMETERS, STORE THE RESULT IN THE NETWORK. (FILES)

DEFINE CIRCUIT VARIABLES. (VAR)

DEFINE MODEL FOR A THIN FILM RESISTOR. THE MODEL IS A TWO PORT AND CAN BE CALLED WITH TWO PARAMETERS: W AND L. THE MODEL CONSISTS OF A RESISTOR R=RSQ*L/W (RSQ IS DEFINED IN THE VAR BLOCK ABOVE) AND A NON-DISPERSIVE MICROSTRIP LINE MTRLND WITH W=W AND L=L. THE SHEET RESISTANCE RSQ IS DEFINED AS A VARIABLE. W=10 AND L=10 ARE THE DEFAULT VALUES FOR THE MICROSTRIP WIDTH AND LENGTH. PLEASE NOTE THAT WE COULD HAVE PASSED THE VALUE OF THE SHEET RESISTANCE AS A PARAMETER TO THE USER DEFINED MODEL AS WELL. (MODVAR W=10 L=10)

CONNECT THE MEASURED MESFET, NOTE THE USE OF A VARIABLE SCALING FACTOR FOR THE MESFET (W1). (NEC710 2 31 10 M=W1)

CONNECT THE USER DEFINED MODEL. NOTE THAT IT IS CONNECTED JUST LIKE A BUILT-IN MODEL. (TFRES 4 44 0 W=10 L=10)

DEFINE A ONE-PORT AS THE OUTPUT OF STAGE ONE. THIS WILL BE CONNECTED TO THE INPUT OF STAGE TWO FOR THE NOISE FIGURE CALCULATION (SEE THE (STAGE1 1 2 0 M=1)

CALCULATE THE NOISE FIGURE OF STAGE ONE AND STAGE TWO SEPARATELY, USE THE FRIIS EQUATION TO CALCULATE THE TOTAL NOISE FIGURE OF THE AMPLIFIER (CALLED nft BELOW). (PROC)

OUTPUT THE CALCULATED NOISE FIGURE nft. (OUT)

RESULTS

```
! MMICAD -- Tue Dec 1 11:31:14 1990
! COMPARISON OF DIRECTLY
! CALCULATED AND PROC BLOCK
! CALCULATED NF
! FREQ    TCW100   OUTVAR
          DB[NF]   MAG[NFT]
  1.000   2.423    2.423
  1.100   2.416    2.416
  1.200   2.408    2.408
  1.300   2.400    2.400
  1.400   2.391    2.391
  1.500   2.381    2.381
  1.600   2.370    2.370
  1.700   2.359    2.359
  1.800   2.347    2.347
  1.900   2.335    2.335
  2.000   2.321    2.321
```

Note that the calculated and measured noise figure agree.

REMARKS

This design example illustrates several features of MMICAD:

- Utilizing data files in analysis (**FILES** block)
- User defined models (TFRES - **CKT** block)
- Network scaling ("NEC710 2 31 10 M=W1")
- Frequency dependent terminations (**TERM** block)
- User defined measurements (**PROC** block)