AN1944

Generating Temperature-Dependent IV Curves Using ADS

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INTRODUCTION

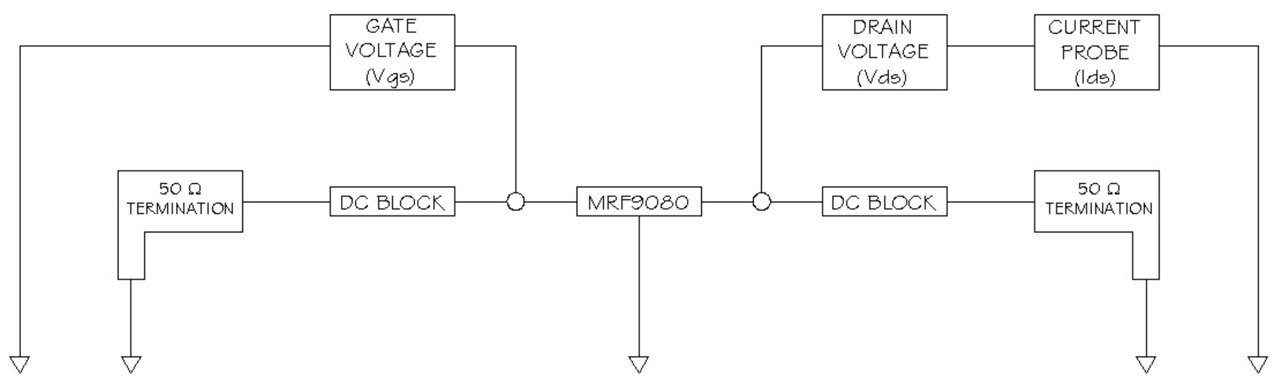
This application note outlines a basic procedure for generating temperature–dependent IV curves using data exported from the Agilent® Eesof® EDA Advanced Design System (ADS). Temperature–dependent IV curves are measured for the MRF9080 and compared to the simulated data of the MRF9080 Motorola Electro Thermal (MET) model.

CURRENT PROBE VERSUS TEMPERATURE AND GATE VOLTAGE

SIMULATION SETUP

In the following simulation, a data set is generated that includes current probe (I_{DS}) as the dependent variable and gate voltage (V_{GS}) and temperature (T) as the independent variables.

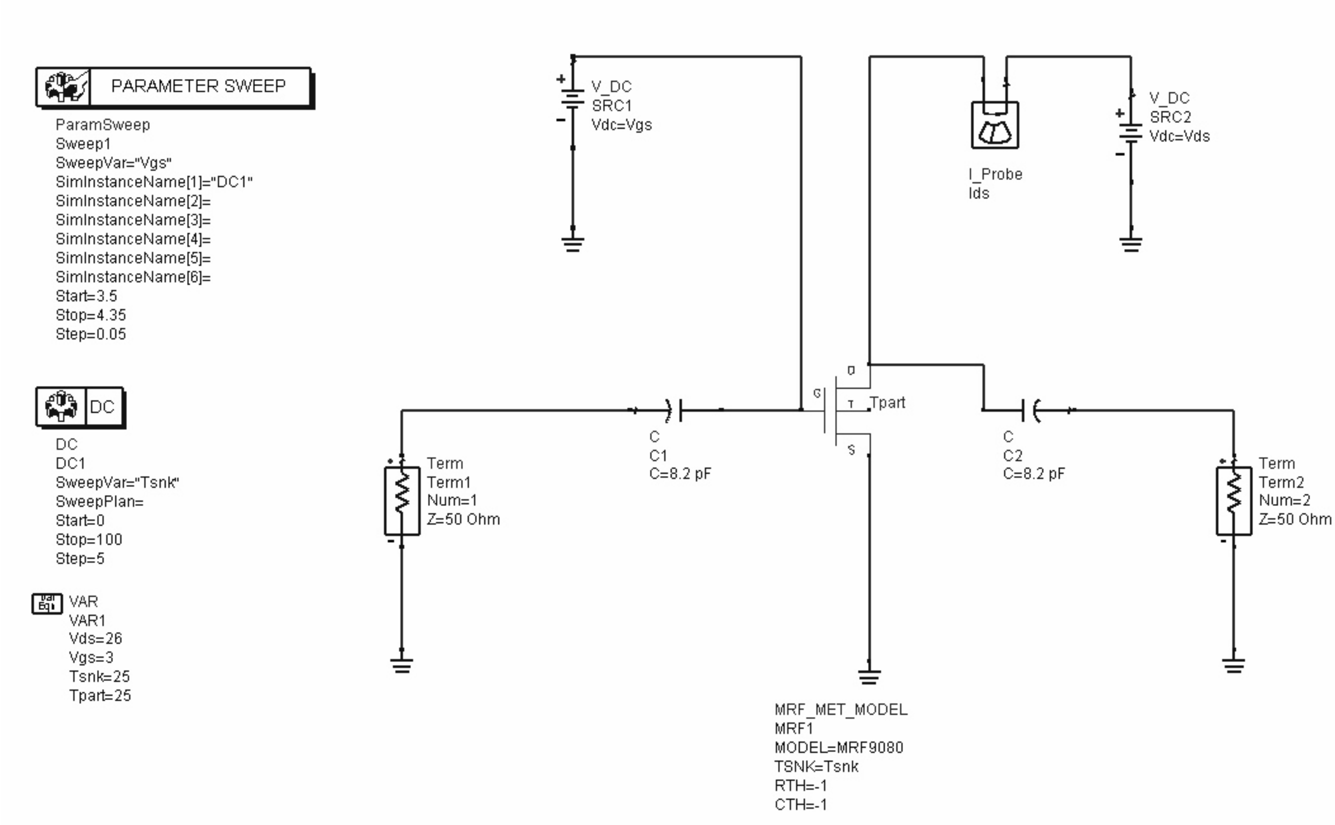
- Variables are defined as I_{DS}, V_{GS}, V_{DS} and T_{SNK}.
- The DUT is terminated with 50 Ω termination ports.
- DC blocking caps with values appropriate for the band of operation are used.
- Parameter Sweep is set up with the variable V_{GS} defined as the global sweep variable.
- DC1 calls on a separate simulation named Sweep1, which then sweeps T_{SNK}.



NOTE: For better viewing on the Web, click on link for larger version of graphic.

Figure 1. Basic Block Diagram of the MRF9080 Setup Simulation

The actual ADS schematic should resemble Figure 2. The choice of independent variable to use for the global sweep variable is irrelevant and is at the user's discretion. There is no added benefit to decreasing the increment value of T_{SNK} from 5°C.



NOTE: For better viewing on the Web, click on link for larger version of graphic.

Figure 2. ADS Design Window of IV Curve Simulation

After the simulation is run, ADS outputs a data set consisting of the following information: drain source current (I_{DS}), temperature (T) and gate source voltage (V_{GS}). See Figure 3.

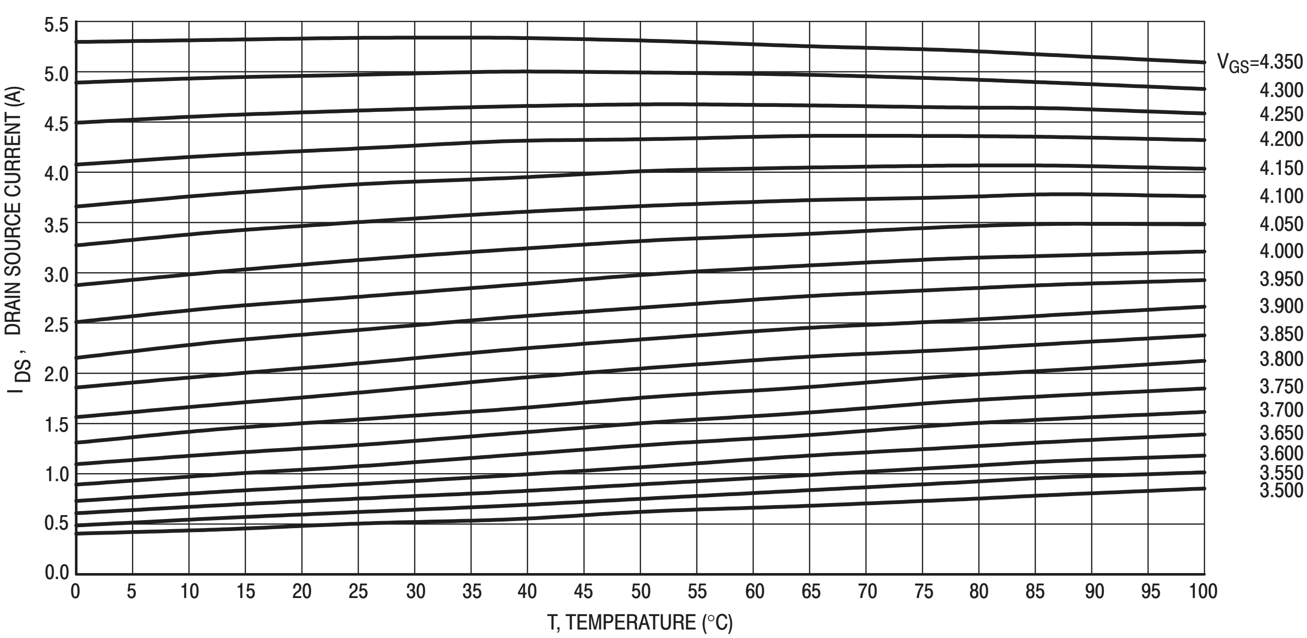


Figure 3. MRF9080 Simulated Drain Source Current versus Temperature versus Voltage

The data gathered from the simulation shown in Figure 3 is useful. However, a more useful method of illustrating the temperature dependence of IV curves is illustrated in Figure 4.

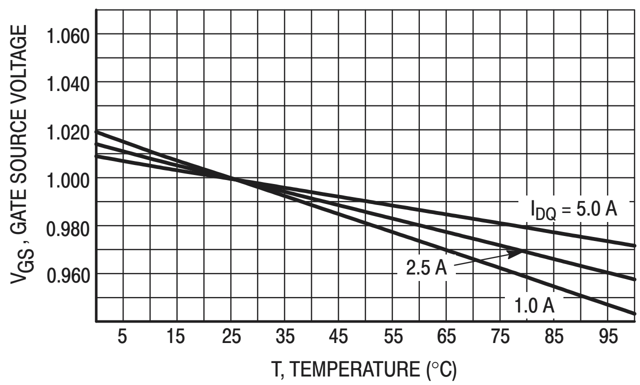


Figure 4. Generic Plot of Gate Source Voltage (Normalized to 25°C) versus Temperature at Parametric Values of I_{DQ}

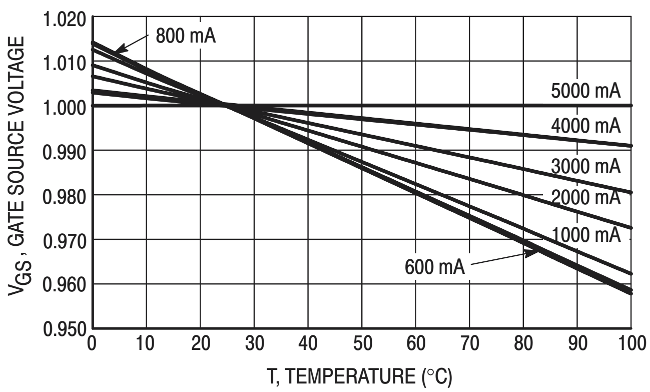


Figure 5. MRF9080 Simulated IV–Temperature Data (Normalized to Gate Source Voltage @ 25°C)

The data set shown in Figure 5 was generated using a macro in Microsoft Excel. This macro tests all values of I_{DQ} (simulated) and compares them against desired values to graph (600 mA, 800 mA and so on). When a tested I_{DQ} value is within +/– 1% of the desired I_{DQ}, the temperature and V_{GS} are recorded. This process is repeated for all V_{GS} and T_{SNK}.

Figure 6 shows the IV–Temperature data measured from an MRF9080 device. This data was taken under DC pulse conditions in a controlled temperature environment. Each measurement was performed quickly enough so that P_{diss} did not contribute to the $T_{(device)}$.

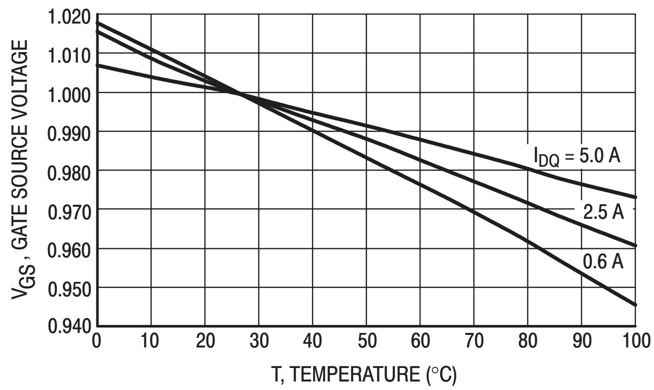
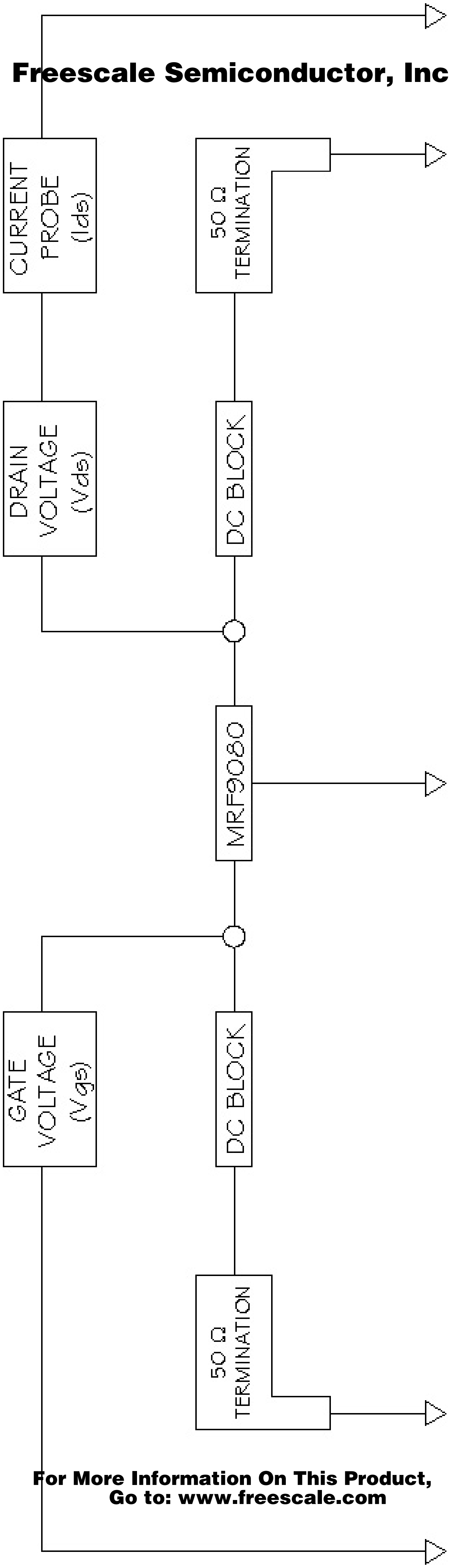
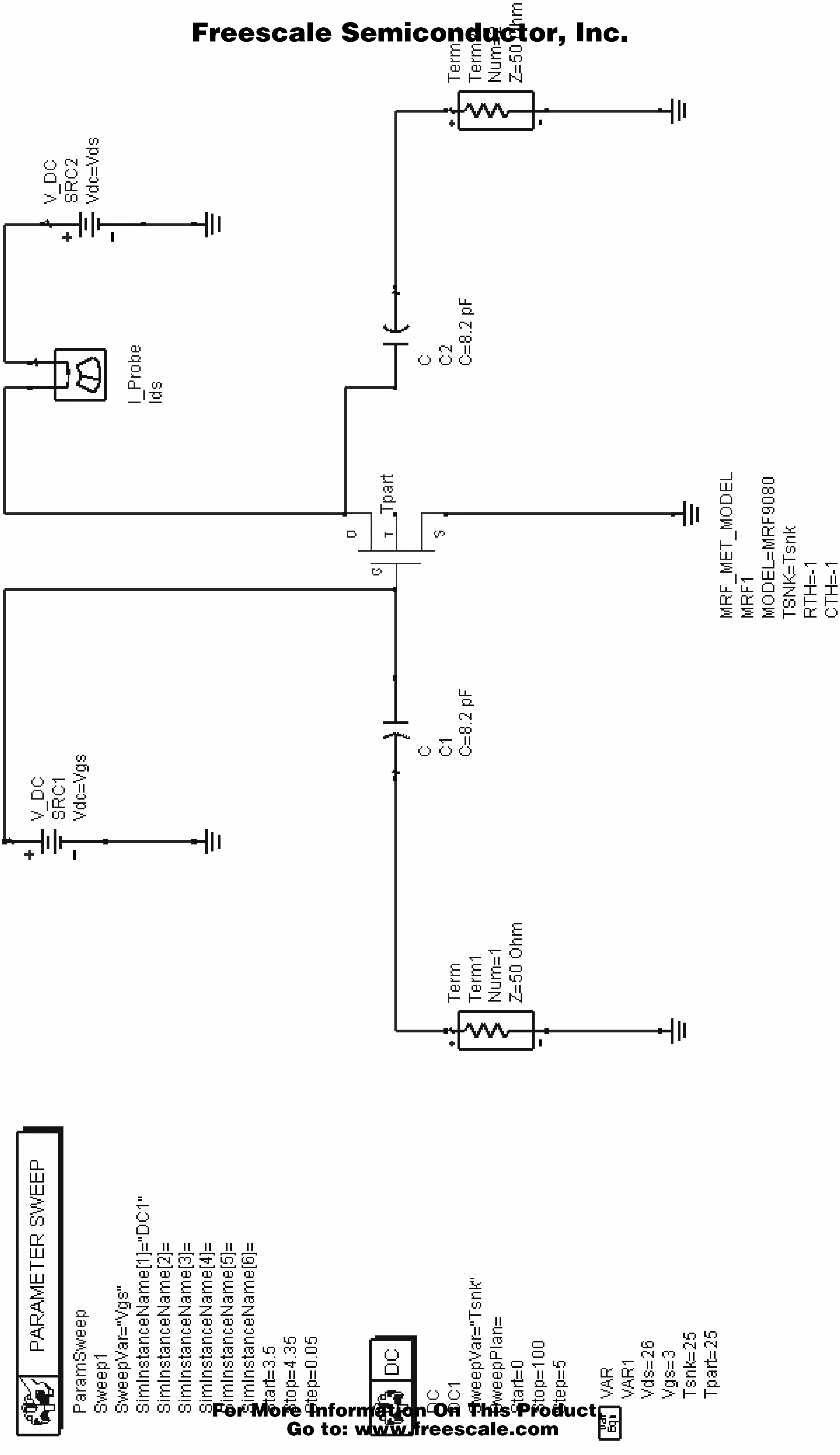


Figure 6. MRF9080 Measured IV–Temperature Data (Normalized to Gate Source Voltage @ 25°C)

MEASURED VERSUS MODELED

A comparison of Figures 5 and 6 show a strong correlation between measured and simulated IV–Temperature behavior from 600 mA to 3000 mA. At higher quiescent currents, the correlation is not as strong. When designing temperature compensation circuits, it is recommended that a circuit similar to that shown in Figure 7 should be used.


CURRENT PROBE (Ids)
50 Ω TERMINATION
DRAIN VOLTAGE (Vds)
DC BLOCK
MRF9080
GATE VOLTAGE (Vgs)
DC BLOCK
50 Ω TERMINATION


Term
Term2
Num=2
Z=50 Ohm
V_DC
SRC2
Vdc=Vds
I_Probe
Ids
C
C2
C=8.2 pF
Tpart
D
T
S
G
MRF_MET_MODEL
MRF1
MODEL=MRF9080
TSNK=Tsnk
RTH=-1
CTH=-1
C
C1
C=8.2 pF
V_DC
SRC1
Vdc=Vgs
Term
Term1
Num=1
Z=50 Ohm
PARAMETER SWEEP
ParamSweep
Sweep1
SweepVar="Vgs"
SimInstanceName[1]="DC1"
SimInstanceName[2]=
SimInstanceName[3]=
SimInstanceName[4]=
SimInstanceName[5]=
SimInstanceName[6]=
Start=3.5
Stop=4.35
Step=0.05
DC
DC
DC1
SweepVar="Tsnk"
SweepPlan=
Start=0
Stop=100
Step=5
VAR
VAR1
Vds=26
Vgs=3
Tsnk=25
Tpart=25

CONCLUSION

This application note shows a step–by–step method for constructing an accurate I–V–T behavior for any of Motorola's modeled LDMOS devices. With this data, a good first–order approximation of the device's ∆V versus temperature (at constant I_{DQ}) will aid in the design of a temperature compensation circuit similar to the one shown in Figure 7.

Figure 7 is an example of a simple DC simulation with a parameter sweep of temperature of any device in Motorola's LDMOS Model Library that will yield useful IV–T data. This data can then be used to generate a plot similar to the one in Figure 5. This data is useful in first revision designs of temperature compensation circuits. Refer to AN1643, "RF LDMOS Power Modules for GSM Base Station Application: Optimum Biasing Circuit," for more details on temperature compensation design.

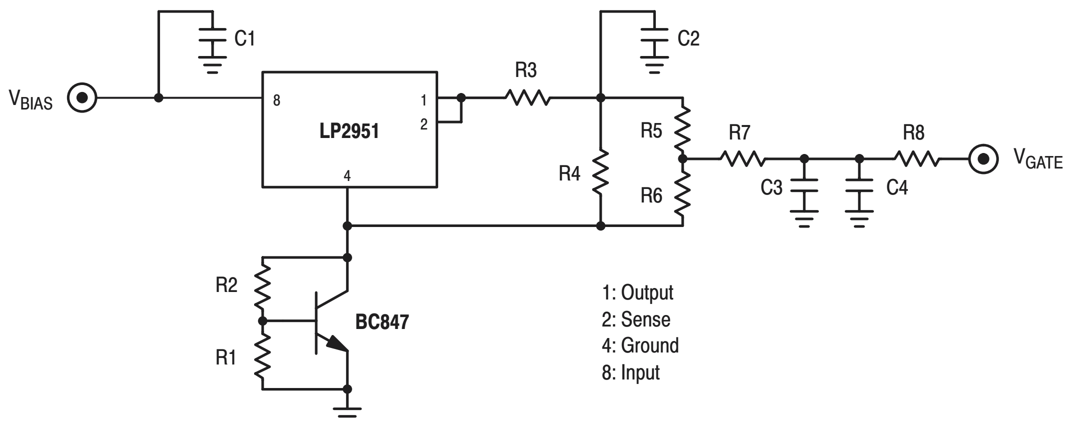


Figure 7. Bias Circuit Schematic

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