Experiment 5:   Mosfet Parameters

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Purpose:
To measure the threshold voltage V_{TR}, the scale factor K, and the substrate, or body-effect coefficient γ of the MOSFET.

Method :
The i_D-v_{GS} relationship for an enhancement-mode NMOS transistor in the constant-current region will be measured for different values of the body-to-source voltage v_{BS}. The values of V_{TR}, K, and γ will be extracted from the data, using the following two equations:

$$i_D = K(v_{GS} - V_{TR})^2 \qquad (5\text{-}1) \qquad \text{and}$$
$$V_{TR} \approx V_{TR0} + \gamma\sqrt{v_{BS}} \qquad (5\text{-}2)$$

where V_{TR0} is the threshold voltage with no substrate bias. Taking the square root of both sides of (5-1) gives

$$\sqrt{i_D} = \sqrt{K}\,v_{GS} - \sqrt{k}\,V_{TR} \quad (5\text{-}3).$$

Therefore, a plot of $\sqrt{i_D}$ vs v_{GS} should be a straight line whose slope yields the value of K and whose v_{GS}-intercept ($i_D = 0$) yields V_{TR} . If a family of these curves is generated for different values of v_{BS} and their intercepts measured, the body coefficient γ can be calculated from (5-2).

Hardware Setup :
The following circuit maintains the enhancement-mode NMOS transistor in the constant-current region because $v_{GS} \approx v_{DS}$ (the voltage drop across the ammeter is negligible). The substrate, or body, is maintained at zero or negative potential relative to the source to insure that the source-body junction is never forward biased. Use the same NMOS transistor that you studied in Experiment 4.
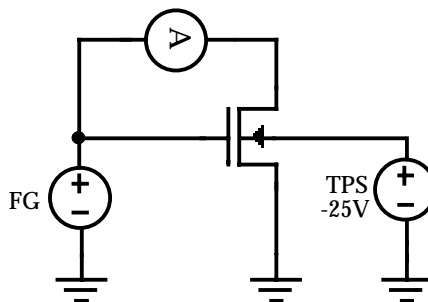
Software Setup:

Following the customary procedure, create instrument panels for configuring the function generator and multimeter, and component drivers for all dynamic interactions with them. A direct I/O driver will be needed for the triple power supply.

Nested FOR loops will be used as they were in Experiment 4 to step the offset voltage of the function generator through a sequence of v_{GS} values for each of a sequence of v_{BS} values, set by the -25 V component of the triple power supply. Refer to Experiment 4 to arrange the components on the screen.

The multimeter, operating in DC Amps mode, gives the current values, which will be fed to a Formula object to extract the square root. You should use the expression **sqrt(mag(a))** (or whatever variable name you choose) to prevent overflow at very low current values, some of which may appear negative because of noise.

Plot $\sqrt{i_D}$ vs v_{GS} for each value of v_{BS} on an X vs Y display, using the control input terminal as you did in Experiment 4 to suppress the retrace lines.

Procedure:

Begin with the v_{GS} range from 0 to 3 V in 0.1 V steps, and the v_{BS} range from 0 to -4 V in -0.5 V steps. Open the display and run the program, executing Auto Scale to keep the curves on the screen. When execution is completed, if not all the traces are usable, you may have to adjust the voltage ranges. When you have an acceptable set of curves, use the markers to determine the slope and the v_{GS} intercept of each curve. Use equation (5-1) to obtain V_{TR0} and K from the first curve (v_{BS} = 0). Then use (5-2) to find γ. Record these values for future use.

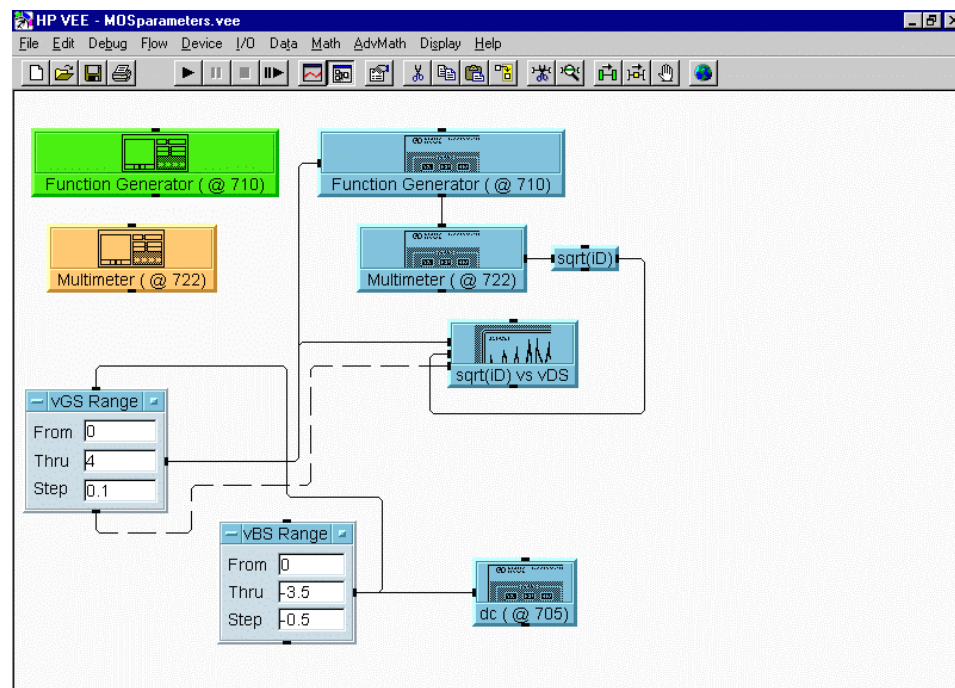If you have time, repeat the experiment using the remaining 4-terminal NMOS on the CD4007 chip, and compare your results.

Fig. 5-4 Agilent VEE Setup