Experiment 6: Transistor Inverters

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Purpose:

To determine the voltage range over which a transistor acts as a linear amplifier, and to measure the voltage gain.

Method:

Voltage-transfer plots (v_{OUT} vs v_{IN}) for BJT and MOSFET inverters will be produced, and the dependence of the curve shapes on component values and input conditions will be determined. The input voltage to the base or gate will be incremented at a fixed V_{CC} or V_{DD}, and the corresponding v_{CE} or v_{DS} will be measured. Observed voltage gains will be compared with calculated values.

A simple gain expression for the BJT is obtained by equating the transistor current with the current through R_C.

$$i_C = \beta_F i_B = \beta_F \left[\frac{v_{IN} - V_f}{R_B} \right] = \frac{V_{CC} - v_{OUT}}{R_C} \quad \text{for } v_{IN} > V_f \qquad (6\text{-}1).$$

Therefore

$$v_{OUT} = -\frac{\beta_F R_C}{R_B} v_{IN} + \left[V_{CC} + \frac{\beta_F R_C}{R_B} V_f \right] \qquad (6\text{-}2),$$

and

$$\text{voltage gain} = \frac{dv_{OUT}}{dv_{IN}} = -\frac{\beta_F R_C}{R_B}. \qquad (6\text{-}3)$$

Doing the same for the MOSFET in the constant-current region gives

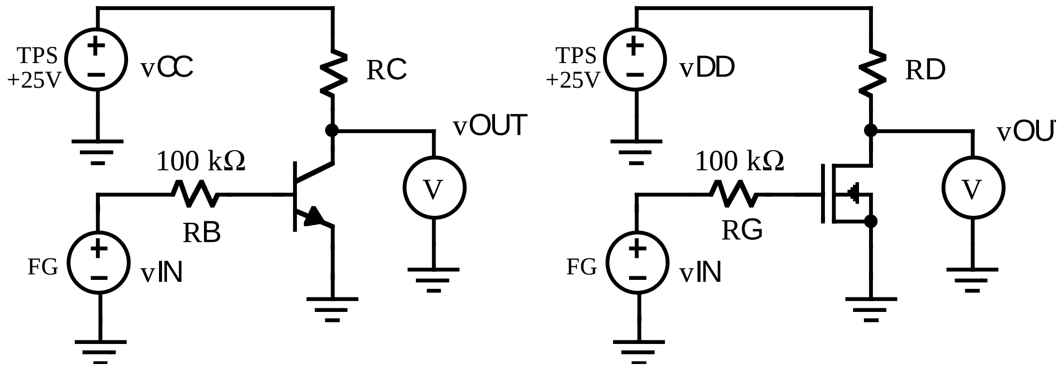
$$i_D = K(v_{IN} - V_{TR})^2 = \frac{V_{DD} - v_{OUT}}{R_D} \quad \text{for } v_{IN} > V_{TR} \qquad (6\text{-}4),$$

which leads to

$$\text{voltage gain} = -2KR_D(v_{IN} - V_{TR}) \qquad (6\text{-}5)$$

Hardware Setup:

The circuits for the BJT and the MOSFET are shown below. As in Experiment 4, the 100 kΩ resistor need not be removed for the MOSFET. Use transistors for which you measured the i-v characteristics in Experiment 4, and begin with R_C (R_D) = 10 kΩ and V_{CC} (V_{DD}) around 15 V.



Software Setup:

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

Use a knob or slider to set the +25 V power supply to the desired V_{CC} value, and a For Range object to set the range of input voltages, using the offset feature of the function generator. The offset output from the function generator (or directly from the input) provides the X input to an XY plotter, and the multimeter output provides the Y input.

Procedure:

Before running the experiments, predict the range of v_{IN} values over which the BJT and MOSFET will remain in the forward active or constant-current region, respectively. Then run the program for each, recording the approximate values for V_f and V_{TR}, and measuring the voltage gains with the use of the markers on the v_{OUT} vs v_{IN} plots. You must use a small enough increment in v_{IN} to obtain meaningful readings from the curves.

Repeat the experiments with a different value of V_{CC} or V_{DD}. Should the gains change? Do they? Now run the experiments with a 1 kΩ pullup resistor. Do the gains change as you would expect?

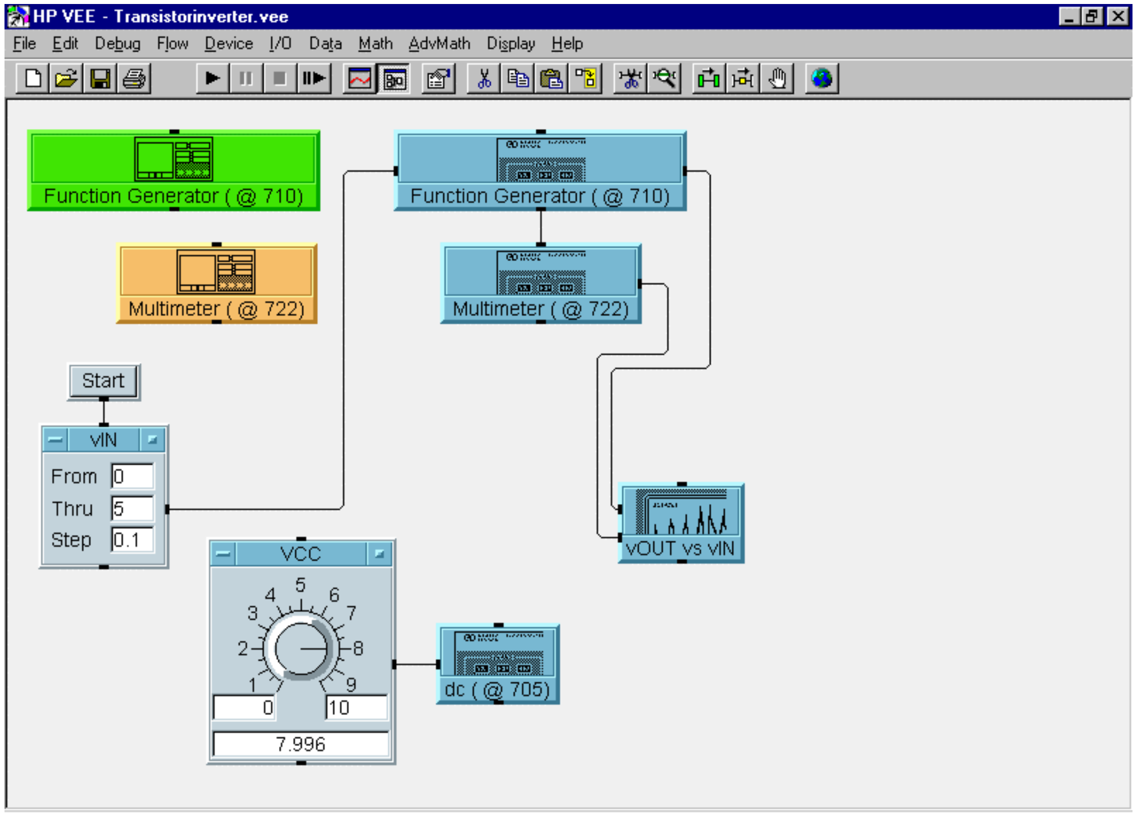


Fig. 6-6 Agilent VEE Setup