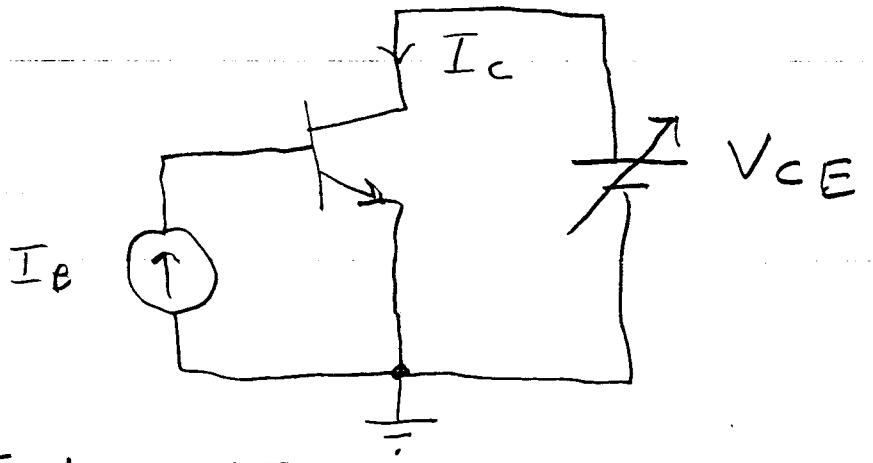
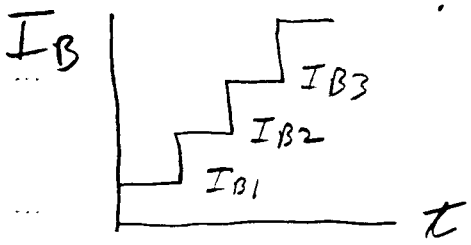
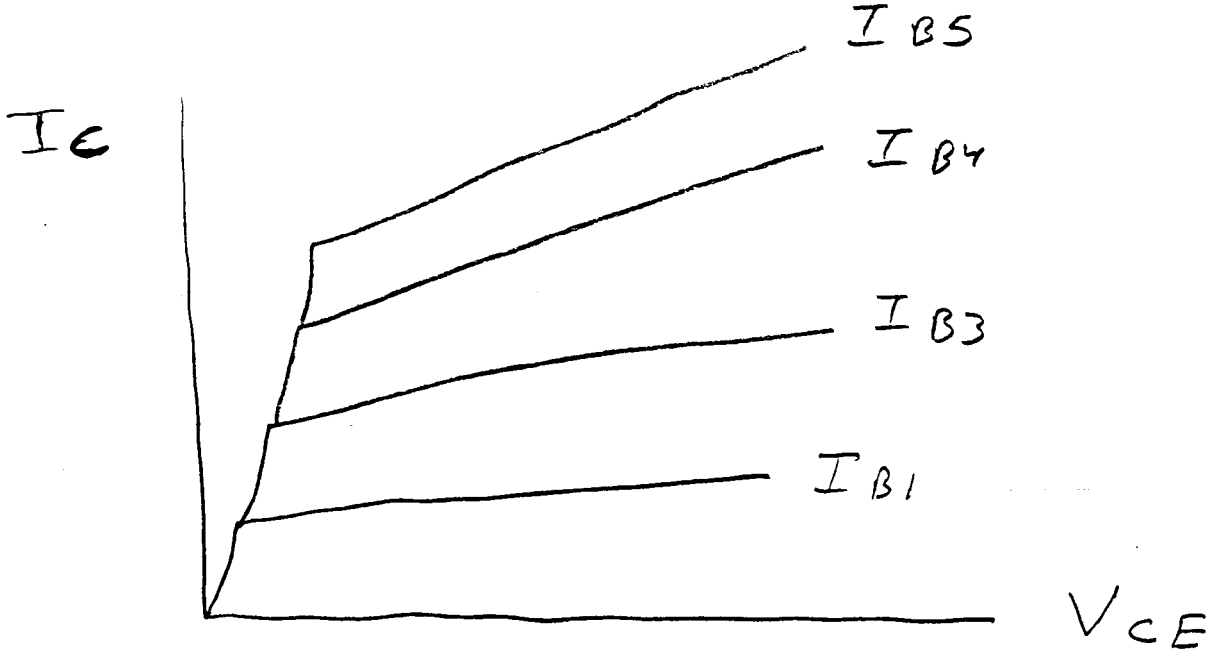
Terminal Characteristics of Active Devices

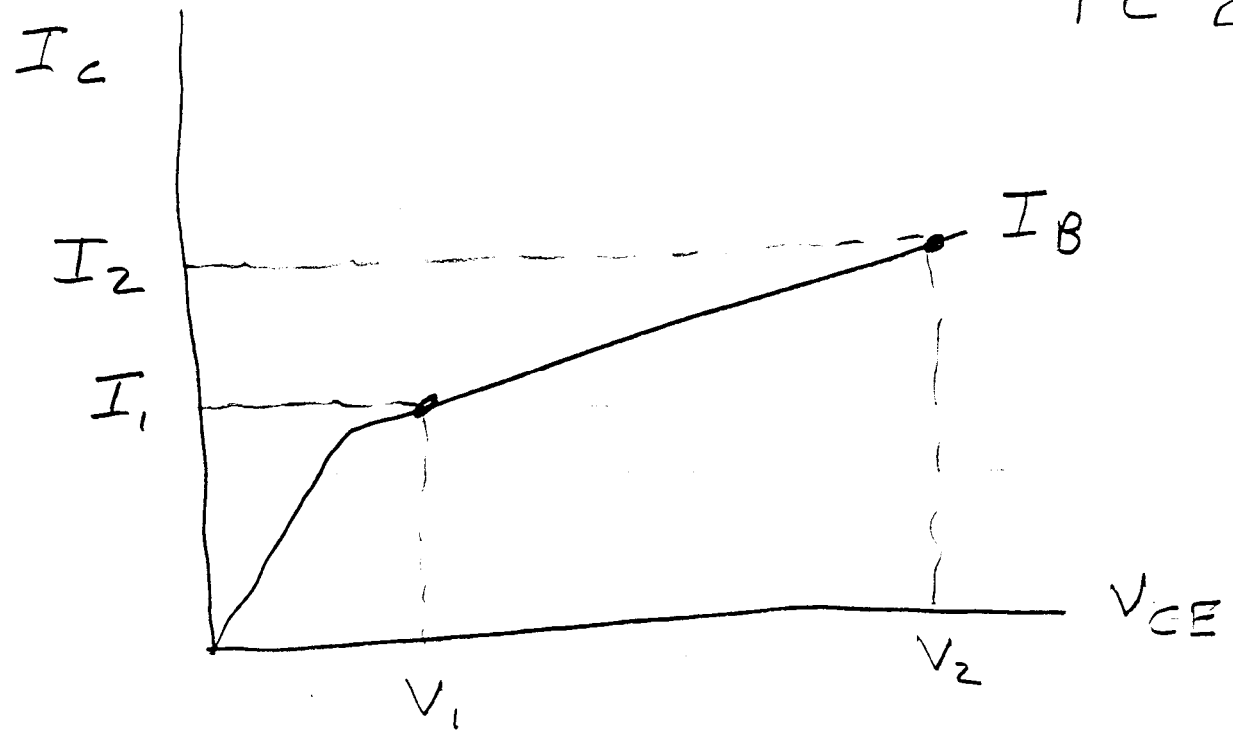
NPN BJT







Output Characteristic



$$m = \frac{\Delta I_C}{\Delta V_{CE}} = \frac{I_2 - I_1}{V_2 - V_1} \qquad (7.41)$$

Early Voltage

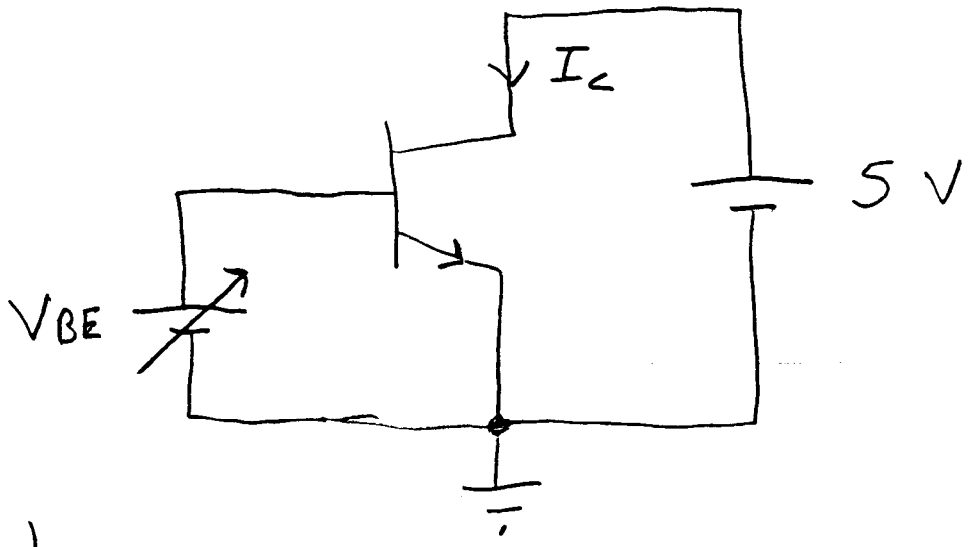
$$V_A \doteq \frac{I_C}{m} - (V_{CE} - V_{BE}) \qquad (7.42)$$

$$I_C = \frac{I_1 + I_2}{2}, \quad V_{CE} = \frac{V_1 + V_2}{2}$$

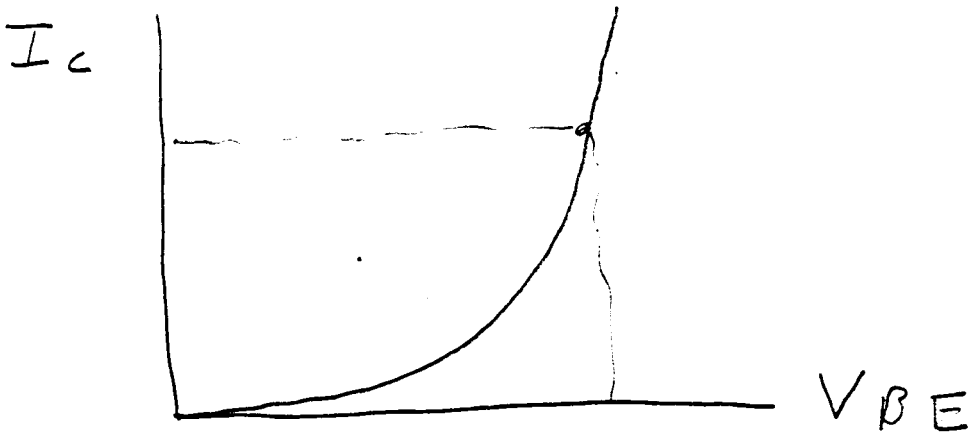
V_A is the SPICE parameter VA

$$\beta_0 = \frac{I_C / I_B}{1 + (V_{CE} - V_{BE})/V_A} \qquad (7.43)$$

β_0 is the SPICE parameter BF



Transfer Characteristic

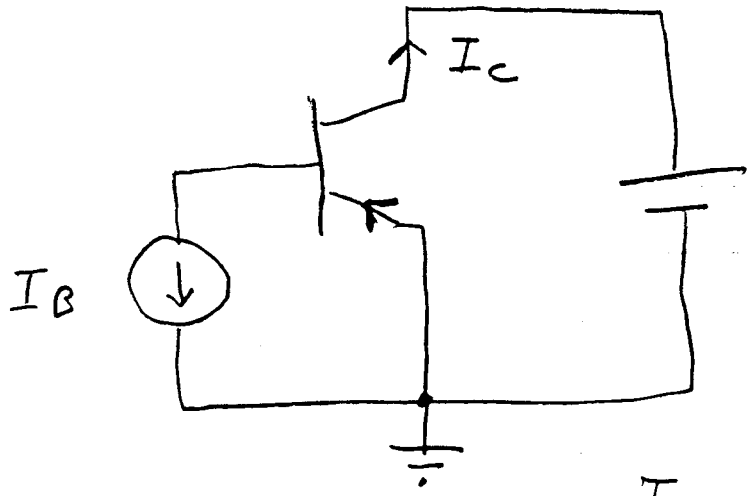


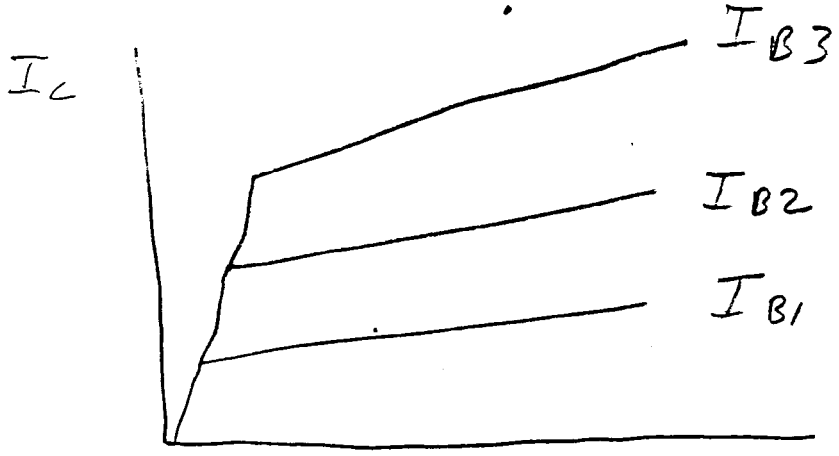
$$I_{SO} = \frac{I_C}{1 + (V_{CE} - V_{BE})/V_A} e^{-\frac{V_{BE}}{V_T}}$$

I_{SO} is the SPICE parameter IS

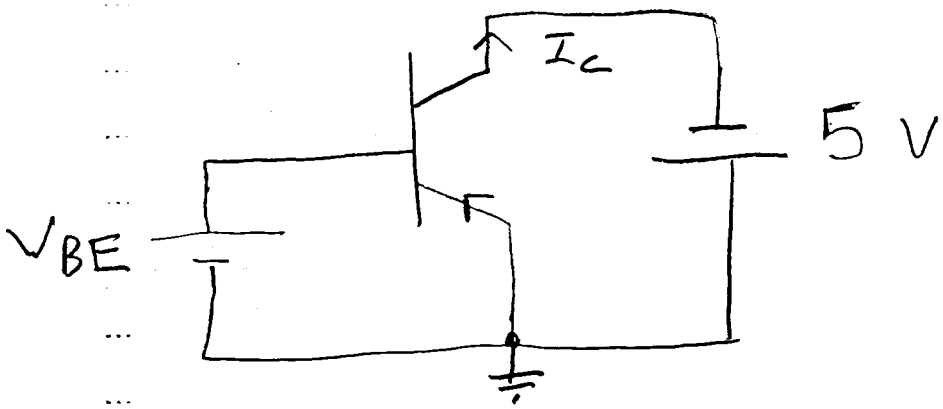
Use SPICE code on page 6 to obtain Output & Transfer Characteristics

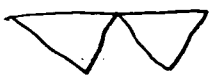
PNP BJT



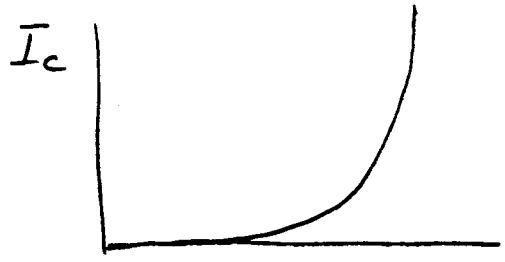


Output Characteristics

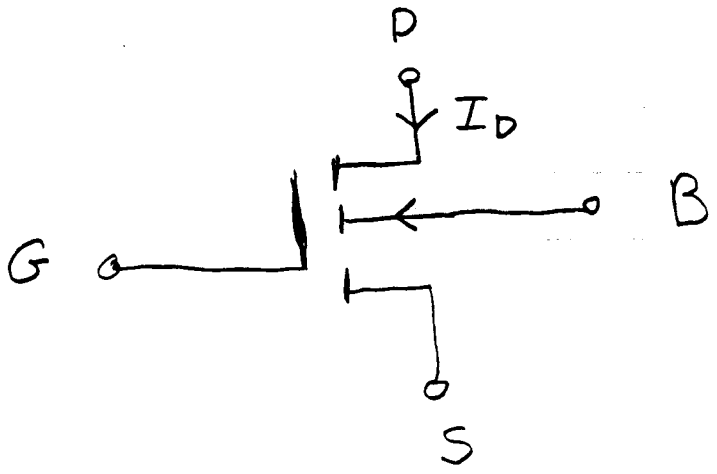




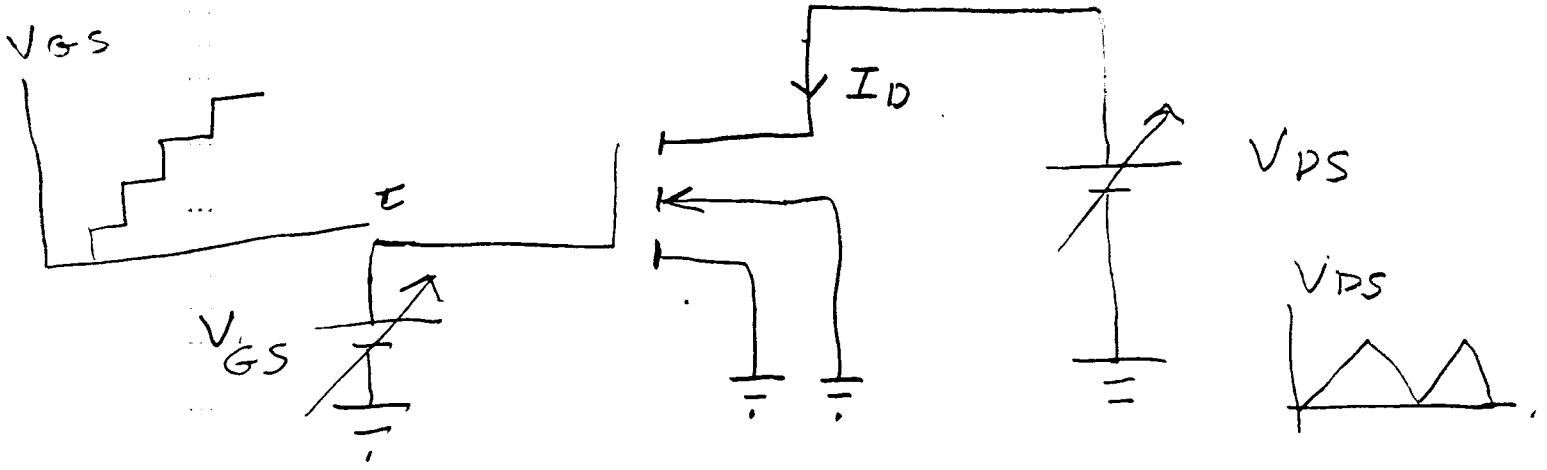
Transfer Characteristic

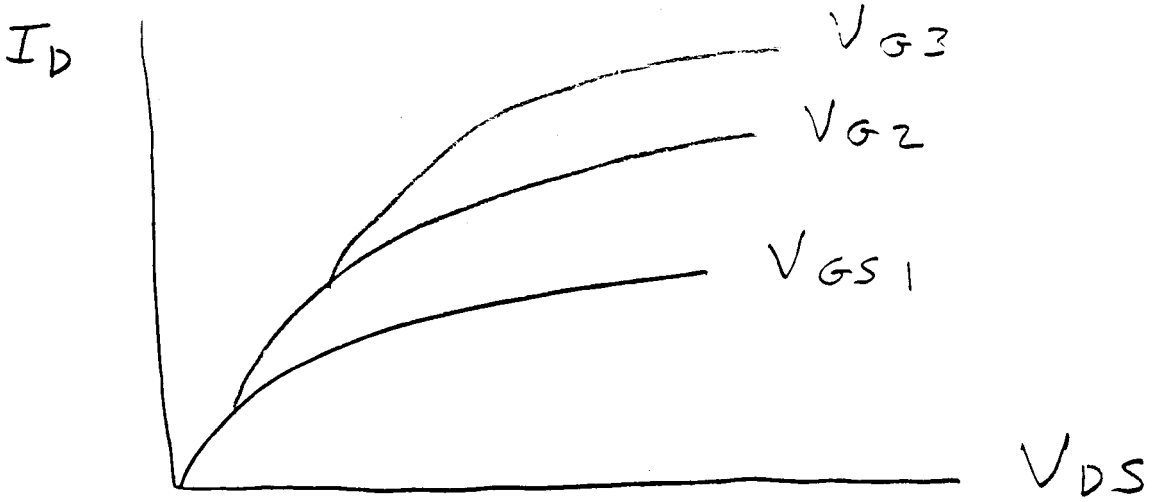


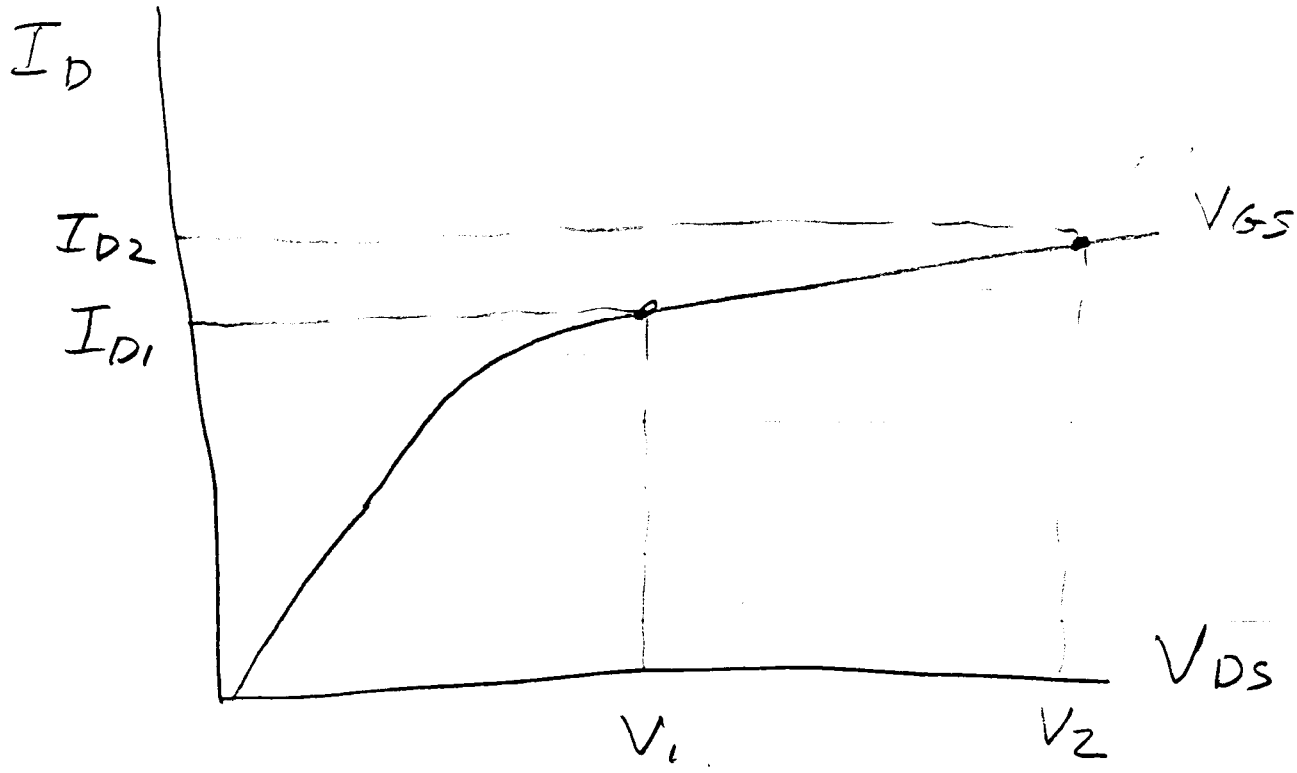
N Channel Enhancement Mode MOSFET



Output characteristic







$$m = \frac{\Delta I_D}{\Delta V_{DS}} = \frac{I_{D2} - I_{D1}}{V_{D2} - V_{D1}}$$

$\lambda \equiv$ the channel length modulation factor

$$\lambda = \frac{1}{\frac{I_D}{m} - V_{DS}} \qquad (7.50)$$

$$I_D = \frac{I_{D1} + I_{D2}}{2}$$

$$V_{DS} = \frac{V_1 + V_2}{2}$$

λ is the SPICE parameter LAMBDA

$$I_D = K \left[V_{GS} - V_{TO} \right]^2$$

$$\sqrt{I_D} = \sqrt{K} \left[V_{GS} - V_{TO} \right] \quad (7.51)$$

straight line with slope $\sqrt{K}$ & y intercept $-\sqrt{K} V_{TO}$

Find V_{TO} & K

$$K_0 = \frac{K}{1 + \lambda V_{DS}} \quad , \quad K' = 2K_0 \quad (7.52)$$

K' is the SPICE parameter KP

& V_{TO} is the SPICE parameter VTO

LSQ Curve Fitting for MOSFET Drain Current in mA

$$V_{gs} := \begin{pmatrix} 2 \\ 2.5 \\ 3 \\ 3.5 \\ 4 \\ 4.5 \\ 5 \end{pmatrix}$$

Insert Matrix

with 1 column
and 7 rows

$$I := \begin{pmatrix} 0.05127 \\ 0.2013 \\ 0.4513 \\ 0.8013 \\ 1.251 \\ 1.801 \\ 2.451 \end{pmatrix}$$

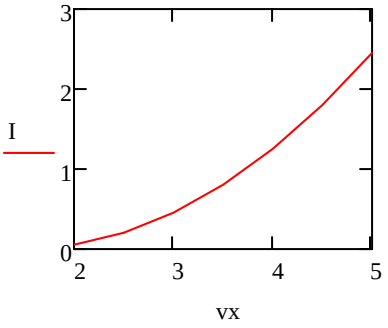
$vx := V_{gs}$

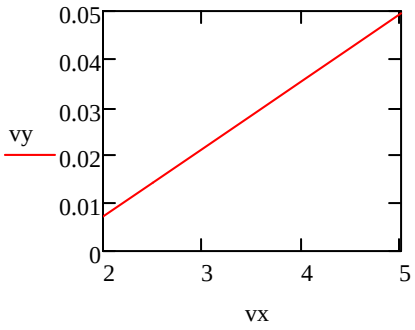
$vy := \mathrm{Re}\left(\sqrt{I \cdot 0.001}\right)$

$m := \mathrm{slope}(vx, vy)$ $b := \mathrm{intercept}(vx, vy)$ $K := m^2$ $V_{TO} := \frac{-b}{m}$

$K = 1.993 \times 10^{-4}$

$V_{TO} = 1.494$



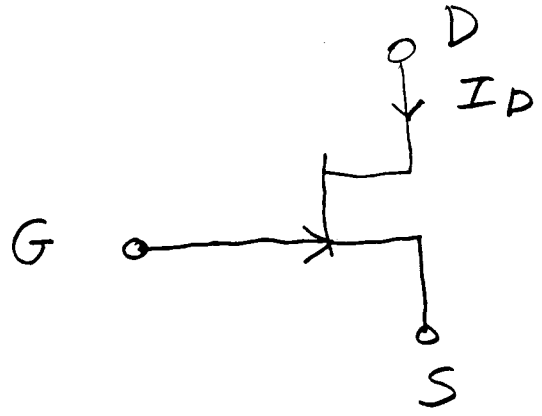


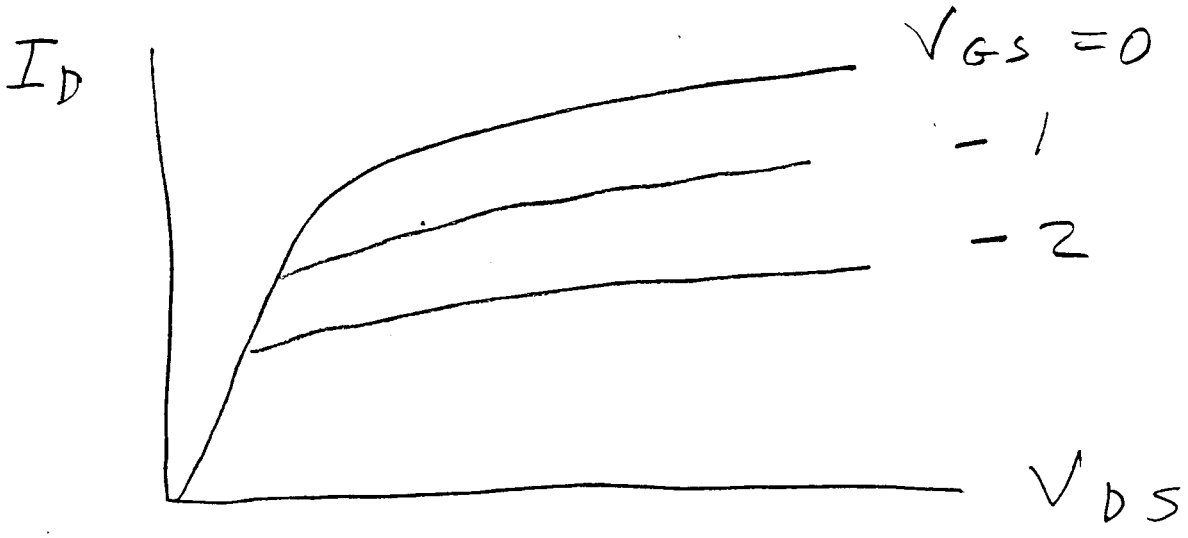
Note that slope and intercept are built in MathCad functions.

If a CSV file of data from the curve tracer is desired do the following:

- Get the desired display on the screen of the curve tracer either manually or with the LabVIEW program.
- Press Local on the physical Tektronix 370B Curve Tracer. This returns control of the instrument to the knobs and buttons.
- Insert a formatted high quality double density floppy disk into the floppy disk drive on the curve tracer.
- Simultaneously press the buttons: SHIFT, ADDR, & BMP FILE. The display should indicate that a CSV file is being printed to the floppy disk.
- When the LED on the drive goes out remove the floppy disk.
- Press the RUN button on the LabVIEW program to return control of the instrument to the pc.

N Channel JFET





Depletion Mode

Device

Georgia Institute of Technology

School of Electrical and Computer Engineering

ECE 3042 Microelectronic Circuits Laboratory Verification Sheet

NAME:_____ SECTION:_____

GT NUMBER:_____ GTID:_____

Experiment 7: Terminal Characteristics of Active Devices

Procedure	Time Completed	Date Completed	Verification (Must demonstrate circuit)	Points Possible	Points Received
1. NPN BJT Output				14	
2. NPN BJT Transfer				14	
3. PNP BJT Output				14	
4. PNP BJT Transfer				14	
5. N MOSFET Output				14	
6. P MOSFET Output				14	
7. JFET Output				16	

To be permitted to complete the experiment during the open lab hours, you must complete at least **four** procedures during your scheduled lab period or spend your entire scheduled lab session attempting to do so. A signature below by your lab instructor, Dr. Brewer, or Dr. Robinson permits you to attend the open lab hours to complete the experiment and receive full credit on the report. Without this signature, you may use the open lab to perform the experiment at a 50% penalty.

SIGNATURE:_____ DATE:_____

ECE 3042 Check-off Requirements for Experiment 7

Make sure you have made all required measurements before requesting a check-off. For all check-offs, you must demonstrate the circuit or measurement to a lab instructor.

- A labview program is used to control the curve tracer.
- For each transfer characteristic, use a cursor to obtain one (Ic, Vbe) point on the curve.
- For each output characteristic, use cursors to find five (I, V) points on five separate curves for a constant Vce or Vds. For a constant Vce or Vds, the cursors should be on the same vertical line. Also, determine the slope of one of the upper characteristic curves.

For the report, determine the dominant SPICE parameters for the devices from the measured curves and simulate the characteristic curves. Compare the simulated curves to the measured curves by creating a table that displays the points measured in lab on the curve tracer to the corresponding points on the simulated curves. Use the same x axis voltage as was used in lab and measure the simulated current. In the report, group together the measured curve, calculations of the device parameters, the table comparing the measured and modeled values, and the simulated curve for each device.