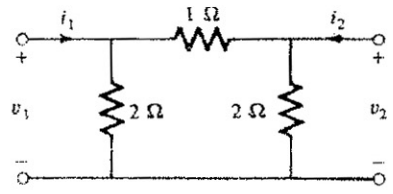
HOMEWORK SET 12

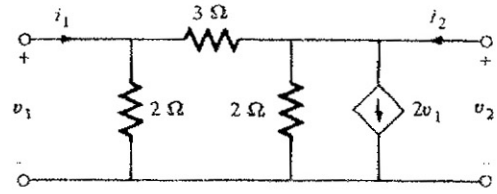
Issued: November 22, 2004 Due: November 29, 2004

Problem 1.

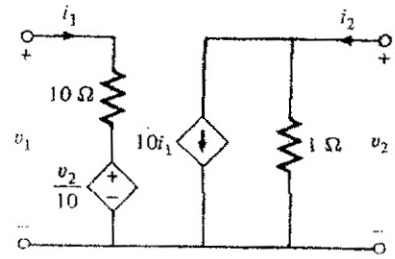
Find the six equivalent 2-port representations of the following 4 2-ports (whenever they exist).



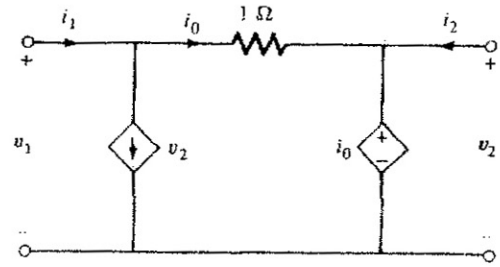
(a)



(b)



(c)



(d)

Problem 2.

Using only linear resistors and linear controlled sources, find an equivalent circuit for the 2-ports described by the following 6 sets of 2-port parameters corresponding to the 6 equivalent representations for a linear 2-port.

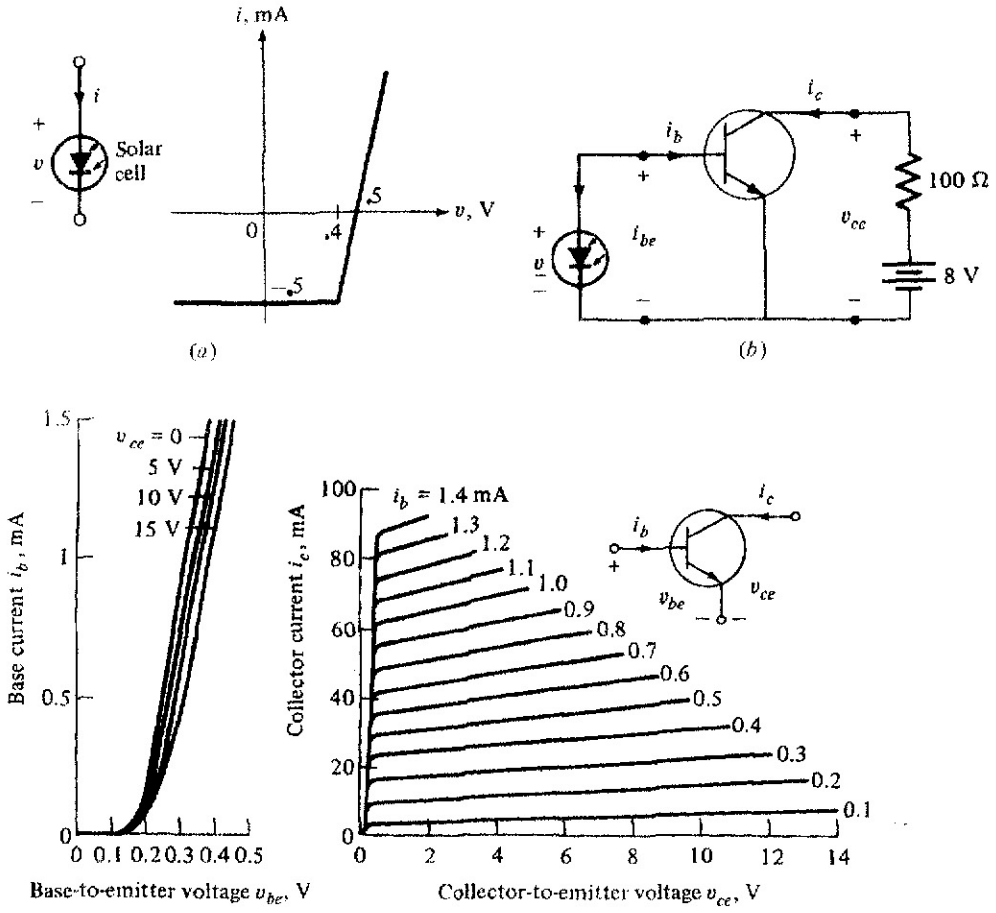
$$(a)\ \mathbf{R} = \begin{bmatrix} 3 & 1 \\ 2 & 5 \end{bmatrix} \qquad (d)\ \mathbf{H}' = \begin{bmatrix} 1 & -1 \\ 2 & 3 \end{bmatrix}$$

$$(b)\ \mathbf{G} = \begin{bmatrix} 3 & -2 \\ -1 & 2 \end{bmatrix} \qquad (e)\ \mathbf{T} = \begin{bmatrix} 0 & 0 \\ 1 & -1 \end{bmatrix}$$

$$(c)\ \mathbf{H} = \begin{bmatrix} 2 & 5 \\ -2 & \frac{1}{2} \end{bmatrix} \qquad (f)\ \mathbf{T}' = \begin{bmatrix} 1 & -1 \\ -2 & 1 \end{bmatrix}$$

Problem 3.

Using the v-i characteristic of the solar cell shown in Fig. 3(a) and the npn transistor characteristics shown in Fig. 3(c), find the operating point of the circuit shown in Fig. 3(b).



(c)

Figure 3

Problem 4.

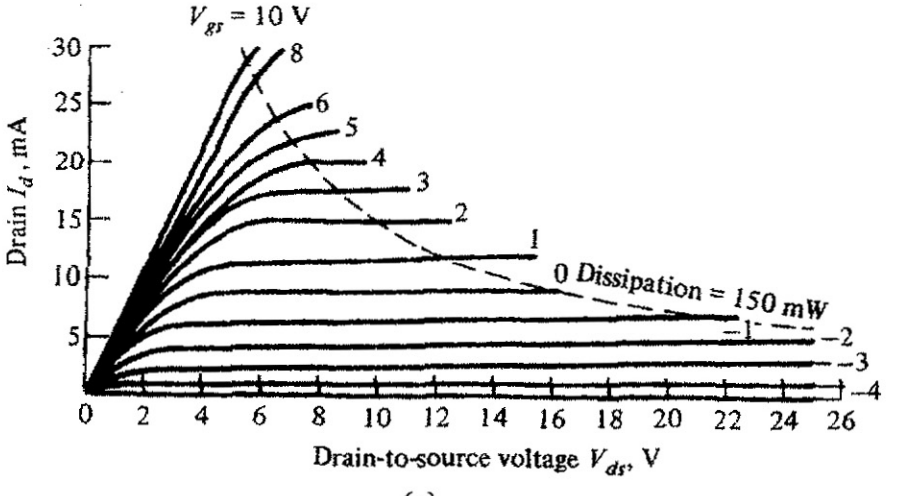
The characteristic of a typical MOS transistor is shown in Fig. 4(a) For the circuit shown in Fig. 4(b)

(*a*) Find the operating point Q.

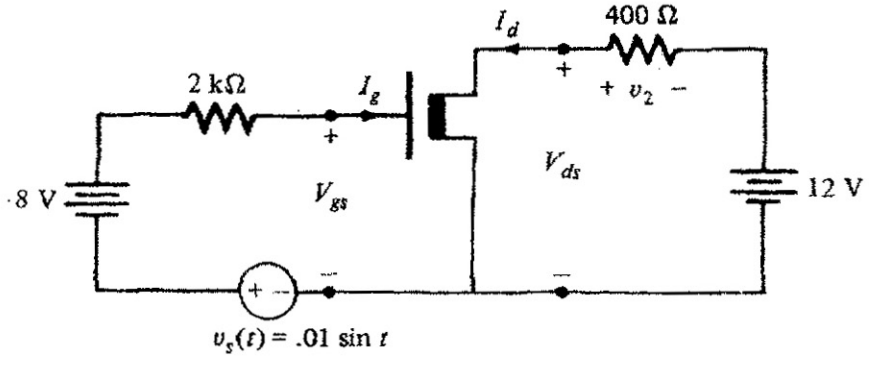
(*b*) Synthesize a small-signal circuit model for the transistor about the operating point Q using only one linear resistor and one linear controlled source. Assume the following model parameters: $\beta = 0.64\ \text{mA/V}^2$ $V_{th} = -5\ \text{V}$

(*c*) Draw the small-signal equivalent circuit.

(*d*) Calculate the small-signal voltage $\tilde{v}_2(t)$.



(*a*)



(*b*)

Fig. 4

Hint: Verify your operating point from (a) is in the "linear region" and use Equation (5.3) on page 151 of the materials on MOS transistor (handout).

Problem 5.

The MOSFET in VLSI circuits can be modeled as a three-terminal resistor by the two families of v-i characteristics shown in Fig. 5 Over the normal operating region, the current I_d at each breakpoint is related to the voltage V_{gs} by $I_d = 10\,V_{gs}^2$ mA.

(a) Using only linear resistors, ideal diodes, and a nonlinear controlled source synthesize a circuit model for this transistor.

(b) Transform your model from (a) into one containing only linear resistors, linear controlled sources, ideal diodes, and at most one nonlinear two-terminal resistor.

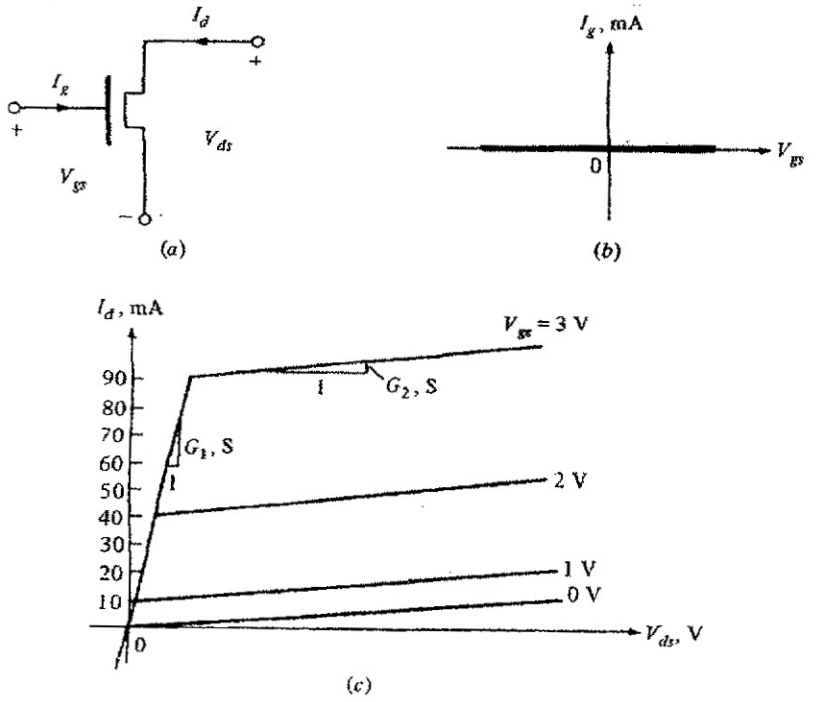


Fig. 5