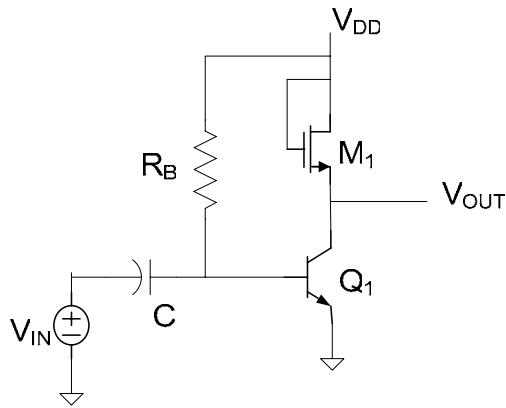


Instructions: There are 8 short questions and 5 problems. The points allocated to each of the questions are as indicated. The problems are all equally weighted with an assigned weight of 16 points each. All work should be included on the exam itself. Attach additional sheets only if you run out of space on a problem. Students may bring 4 pages of notes to the exam. Calculators are permitted but can not be shared.

Questions:

1. (2pts) What advantage does the precision rectifier circuit offer over the simple diode rectifier circuit?
2. (2pts) In what region of operation is the MOSFET usually used when building amplifier circuits?
3. (2pts) How many parameters are there in a small-signal model of a 3-terminal device?
4. (3pts) Draw a small-signal equivalent circuit for a BJT in terms of the small-signal model parameters.
5. (4pts) If you measure the quiescent drain current of a MOSFET to be 500 μ A with a quiescent drain to source voltage of 3V and a quiescent gate to source voltage of 3V, give a small-signal model of the MOSFET. Assume the device is characterized by process parameters $V_T=1V$, $\lambda=0$, and $\mu C_{OX}=100\mu A/V^2$.

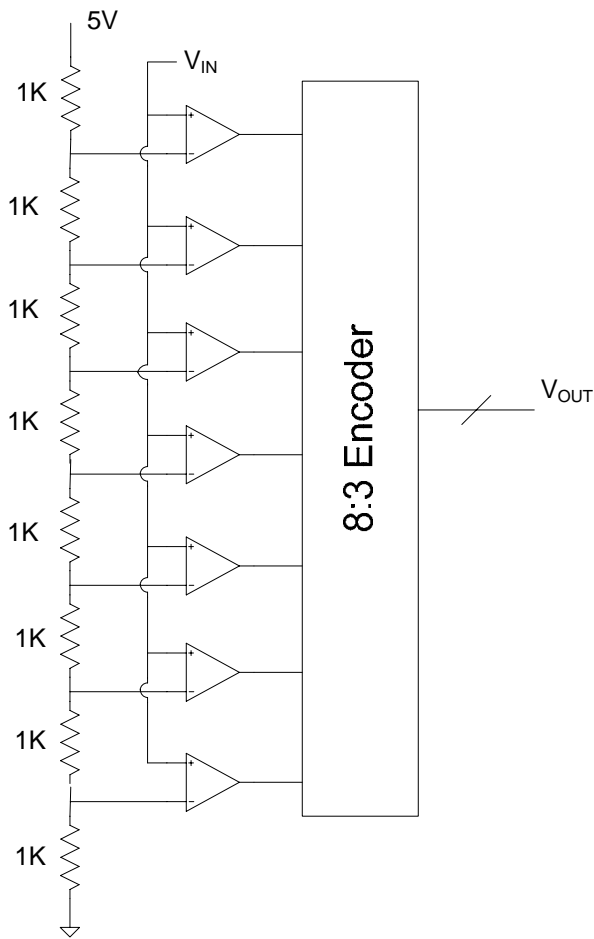
6. (2pts) For some input values, an ADC fails to make a decision in a finite time T . When the ADC fails to make a decision in a given time interval, we say it is operating in a special mode, what is this mode called?
7. (2pts) There are two inherent limitations associated with any data converter, even when it is ideal. Give one of these two.
8. (3pts) Draw the small-signal equivalent circuit. Assume the MOSFET is operating in the saturation region, the BJT is operating in the forward active region, C is very large, and that V_{IN} is a small-signal source.



Problem 1

A flash ADC is shown

- a) What is the resolution
- b) What is an LSB of the input voltage?
- c) Plot the transfer characteristics of this ADC explicitly showing all transition points
- d) What will be V_{OUT} if $V_{IN}=0.78V$?

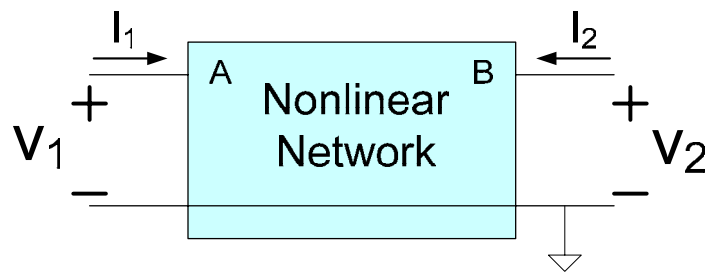


Problem 2

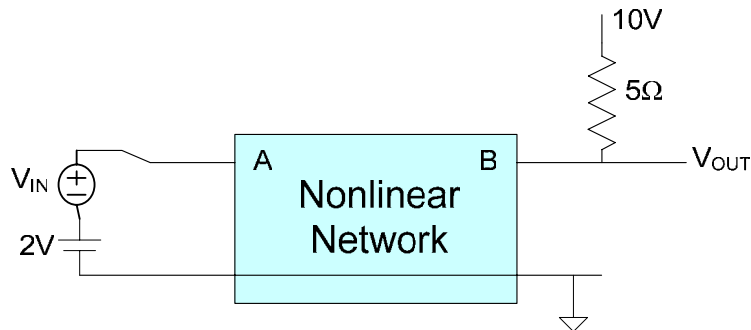
Assume the Nonlinear Network shown is characterized by the equations

$$I_1 = 5e^{\frac{V_1}{2}} V_2$$

$$I_2 = \frac{V_1 V_2}{10}$$



- Determine a small signal model for the device at the Q-point defined by the $V_{1Q}=2V$, $V_{2Q}=5V$
- Draw a small-signal equivalent circuit
- If this nonlinear network is connected in the circuit shown below, determine the quiescent voltages V_{1Q} , V_{2Q} , I_{1Q} and I_{2Q} where these variables are defined as indicated in the previous figure
- Determine the small-signal voltage gain

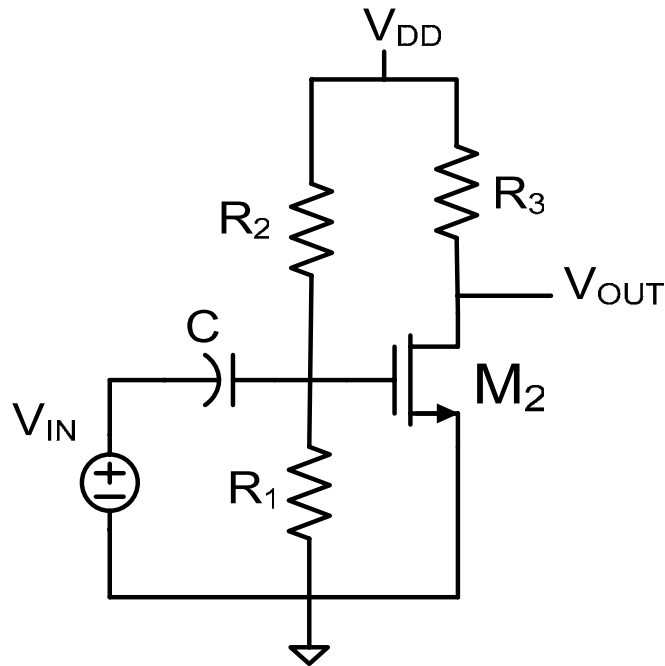


(Provide Solutions on the Following Page)

Solution for Problem 2 goes here

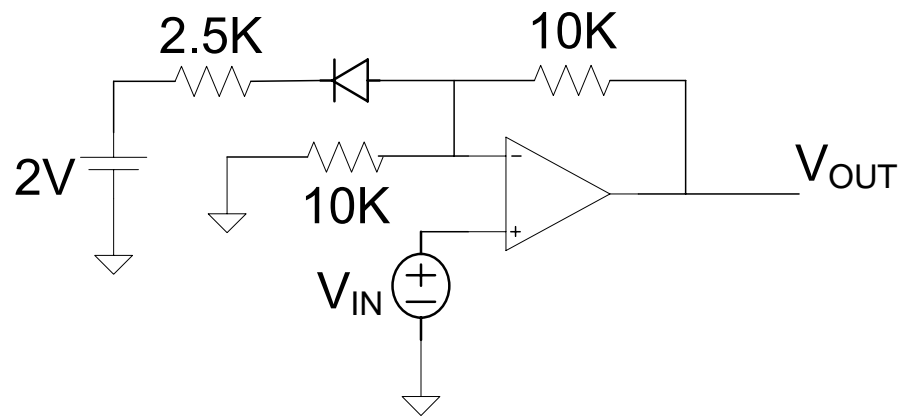
Problem 3 Assume the transistor is characterized by model parameters

$\mu C_{ox} \frac{W}{L} = 100 \mu A/V^2$ and $V_T = 1V$. Assume V_{IN} is a small-signal input, C is large, $R_1 = 100K$, $R_2 = 300K$, $R_3 = 10K$ and $V_{DD} = 12V$.



- Determine the quiescent output voltage
- Obtain a small-signal model for M_2 at the operating point determined by this circuit
- Draw a small-signal equivalent circuit for the whole circuit.
- What is the small signal voltage gain for this circuit?

Problem 4 Obtain an expression for and plot the transfer characteristics for the following circuit. Assume the diode and the op amp are ideal.



Problem 5 The circuit shown has been proposed as a sinusoidal oscillator.

- a) Determine the value of k needed to put the poles on the imaginary axis
- b) With the value of k determined in part a), obtain an expression for the frequency of oscillation (in Hz)

