Test 1 (02/06/17)

Total # Pages 4
Total # Problems 4

1. (10 points) __________
2. (25 points) __________
3. (35 points) __________
4. (25 points) __________

Total (100 points) __________

GOOD LUCK
1. A diode circuit and voltage waveform $v_s(t)$ are shown. (10 points).

\[ \text{List which diodes are ON (i.e., forward biased and conducting current) and which are OFF for } 0 < t < 2. \text{ Assume ideal diodes.} \]

\begin{align*}
\text{ON Diodes:} & \quad D_1, D_3 \\
\text{OFF Diodes:} & \quad D_2, D_4
\end{align*}

\[ \text{List which diodes are ON and which are OFF for } 2 < t < 4. \text{ Assume ideal diodes.} \]

\begin{align*}
\text{ON Diodes:} & \quad D_2, D_4 \\
\text{OFF Diodes:} & \quad D_1, D_3
\end{align*}

2. Consider the diode circuit shown below with a signal voltage waveform $v_s(t)$ as shown. Draw the specified voltage waveforms in the table below. (25 points).

\[ \text{Sketch the voltage waveform for } v_o(t) \text{ assuming an ideal diode. Label the time axes and the signal values.} \]

\[ \text{Sketch the voltage waveform for } v_o(t) \text{ assuming a constant voltage drop model for the diode (the diode voltage is at 0.5V when conducting). Label the time axes and the signal values.} \]
3. Answer the following questions. $|V_{BE}| = 0.7V$ for an ON transistor and $|V_{CE}| = 0.2V$ when the transistor is in saturation.

a) For the bipolar transistors and conditions shown in the following table calculate the missing entries. (15 points).

<table>
<thead>
<tr>
<th>Device</th>
<th>$I_C$ (mA)</th>
<th>$I_B$ (mA)</th>
<th>$I_E$ (mA)</th>
<th>$\alpha$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1</td>
<td>0.02</td>
<td>1.02</td>
<td>0.98</td>
<td>50</td>
</tr>
<tr>
<td>b</td>
<td>1.96</td>
<td>0.04</td>
<td>2</td>
<td>0.98</td>
<td>49</td>
</tr>
<tr>
<td>c</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>0.8</td>
<td>4</td>
</tr>
</tbody>
</table>

b) In the circuit shown, calculate the collector current ($I_C$), the base voltage ($V_B$), and the emitter voltage ($V_E$) assuming $\beta = 100$. (15 points).

$I_C = 1\ mA$ \\
$V_B = 1.7V$ \\
$V_E = 1V$

$I_C = \beta I_B = 100 \times 10\ \mu A = 1mA$

$I_E \approx I_C = 1mA \Rightarrow V_E = 1k\Omega \times 1mA = 1V$

$V_B = V_E + V_{BE(on)} = 1.7V + 0.7V = 1.7V$

c) For the circuit shown determine the region of operation (cutoff, active, or saturation) for the transistor with $\beta = 49$. (10 points).

Transistor is on; Assume active

$I_B = \frac{I_E}{\beta + 1} = \frac{1mA}{50} = 0.02\ mA$

$V_B = 2V - (10)(0.02) = 1.8V$

Since $V_B > V_C = 0V \Rightarrow CB$ junction forward biased

$\Rightarrow$ saturation region
4. Calculate the labeled dc node voltages \( V_1, V_2, V_3, V_4, \) and \( V_5 \) in the circuit below.
\[ \beta_{\text{pnp}} = 4, \beta_{\text{nnp}} = \infty \text{ and } |V_{BE}| = 0.7V \text{ for an ON transistor.} \] (25 points)

\[
\begin{align*}
V_1 &= 1V \\
V_2 &= 1.7V \\
V_3 &= -1V \\
V_4 &= 3V \\
V_5 &= -1.7V
\end{align*}
\]

Since \( \beta_{\text{nnp}} = \infty \Rightarrow I_b, nnp = 0 \Rightarrow \text{the two circuits can be solved independently} \)

KVL: \[ 5 - 3.3I_{E1} - 0.7 - 5I_B1 = 0 \]

\[
I_{B1} = \frac{I_{E1}}{\beta + 1} = \frac{I_{E1}}{5}
\]

\[
5 - 3.3 \cdot \frac{I_{E1}}{5} - 0.7 - 5 \cdot \frac{I_{E1}}{5} = 0
\]

\[
4.3I_{E1} = 4.3 \Rightarrow I_{E1} = 1mA
\]

\[
I_{E1} = 0.2mA, I_{C1} = 0.8mA
\]

\[
V_1 = 5 \times 0.2 = 1V \quad V_2 = V_1 + 0.7 = 1.7V
\]

\[
V_3 = -5 + 5I_{C1} = -5 + 5 \times 0.8 = -1V
\]

\[
V_5 = -1 - 0.7 = -1.7V
\]

\[
I_{E2} = \frac{-1.7 - (-5)}{6.6} = 0.5mA
\]

Since \( \beta_{\text{pnp}} = \infty \Rightarrow I_{C2} = 0.5mA \)

\[
V_4 = 5 - 4 \times 0.5 = 3V
\]