EE 320 L ELECTRONICS I

LABORATORY 8: MORE BJT AMPLIFIERS

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF NEVADA, LAS VEGAS

1. OBJECTIVE

Enhance the understanding of BJT characteristic under various DC bias scenarios. Compare the differences among common-emitter BJT amplifiers, common-base BJT amplifiers, common-collector BJT amplifiers.

2. COMPONENTS & EQUIPMENT

Power Supply	Breadboard & Jump wires
Function Generator	Resistors & Capacitors
Multimeter	BJT (2N2222A, 2N3904)
Oscilloscope	

3. BACKGROUND

A BJT can work as a **current control current source** when it is turned on (i.e. V_{BE} exceeds the threshold voltage). To illustrate, the current flowing through collector-base junction is proportional to the current through the base-emitter junction.

Key knowledges and formulas related to BJT amplifiers.

Model parameters in terms of DC bias current

$$g_m = \frac{I_C}{V_T} \qquad r_e = \frac{V_T}{I_E} = \alpha \frac{V_T}{I_C} \qquad r_\pi = \frac{V_T}{I_B} = \beta \frac{V_T}{I_C} \qquad r_o = \frac{|V_A|}{I_C}$$

In terms of g_m

$$r_e = \frac{\alpha}{g_m} \qquad r_\pi = \frac{\beta}{g_m}$$

In terms of r_e

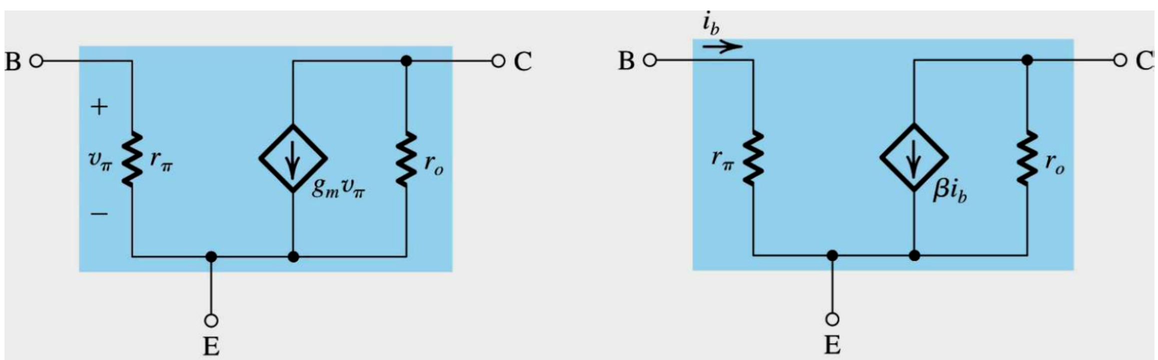
$$g_m = \frac{\alpha}{r_e} \qquad r_\pi = (\beta + 1) r_e \qquad g_m + \frac{1}{r_\pi} = \frac{1}{r_e}$$

Relationship between α and β

$$\beta = \frac{\alpha}{1 - \alpha} \qquad \alpha = \frac{\beta}{\beta + 1} \qquad \beta + 1 = \frac{1}{1 - \alpha}$$

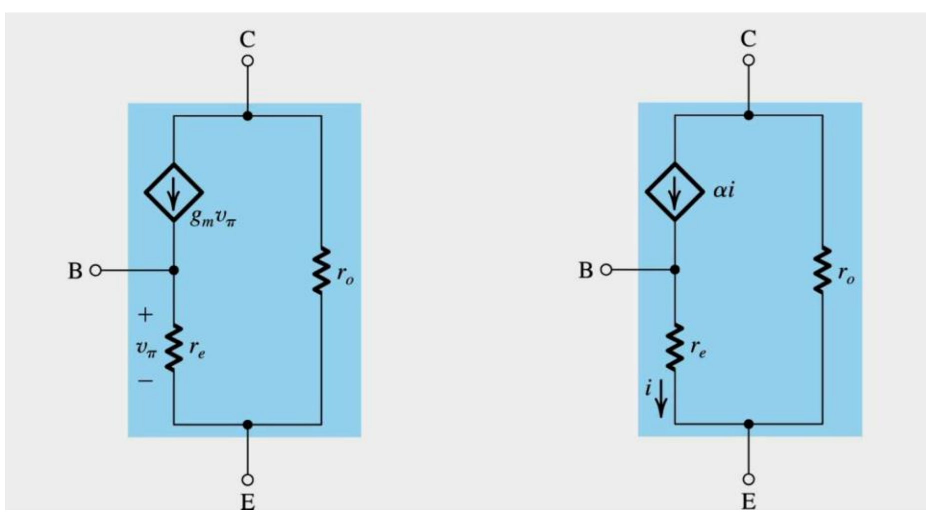
Hybrid-π Model

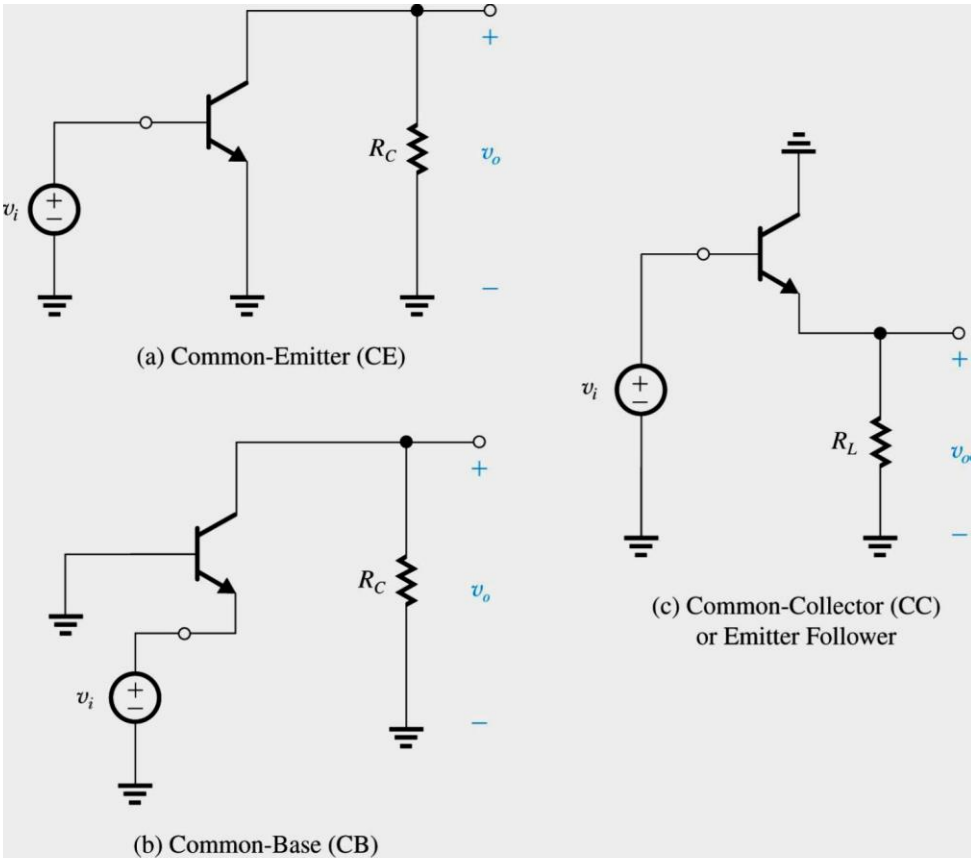
($g_m v_\pi$) Version (βi_b) Version



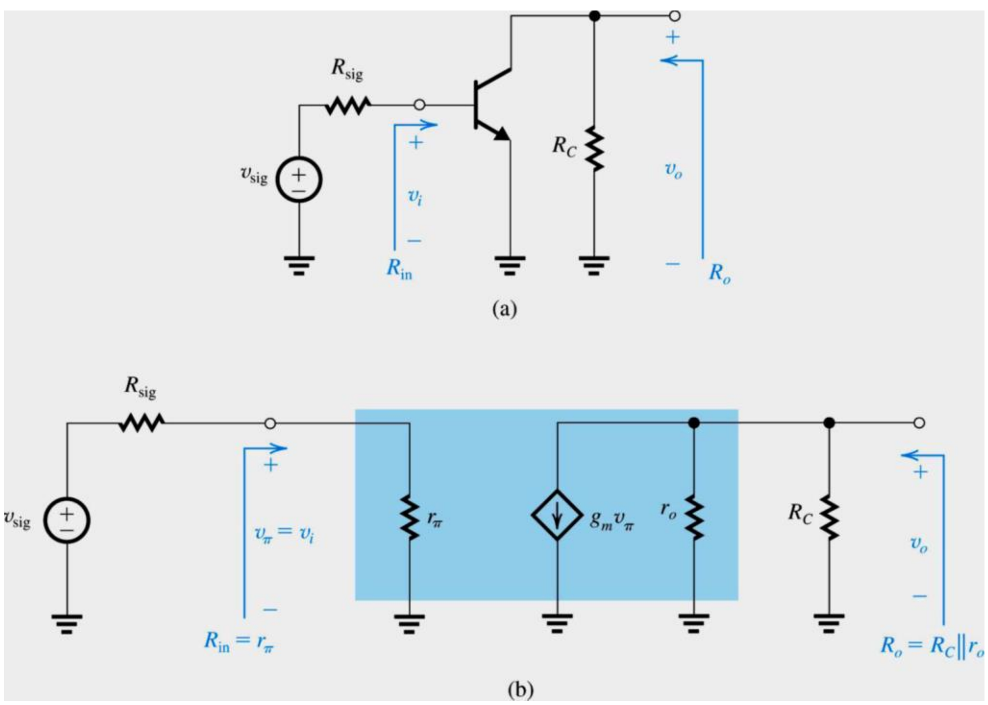
T Model

($g_m v_\pi$) Version (αi) Version

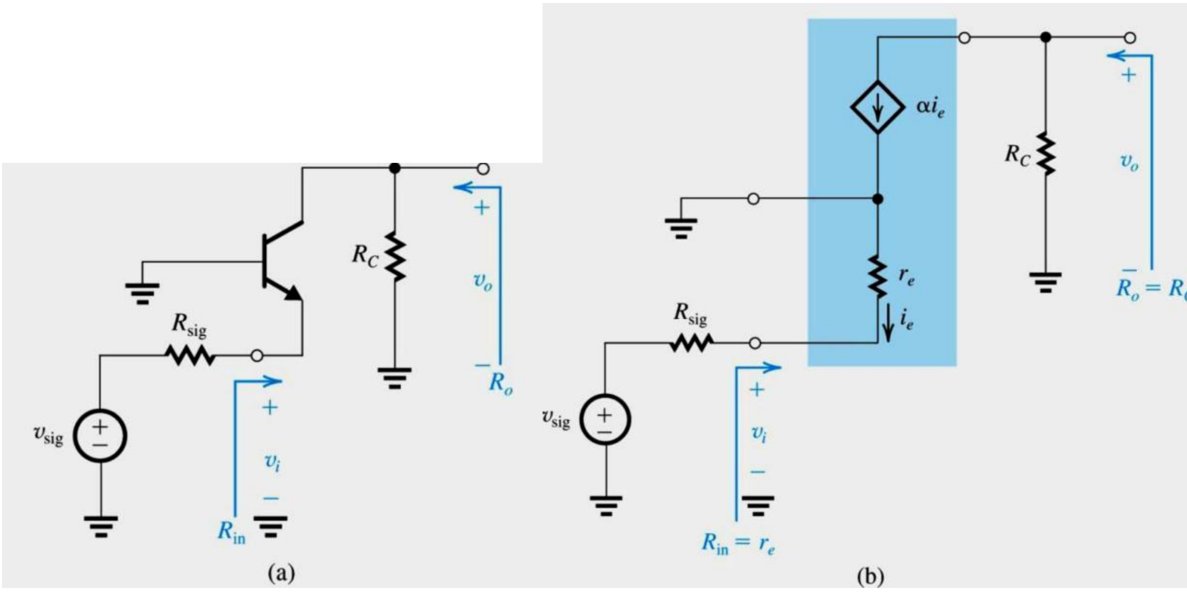




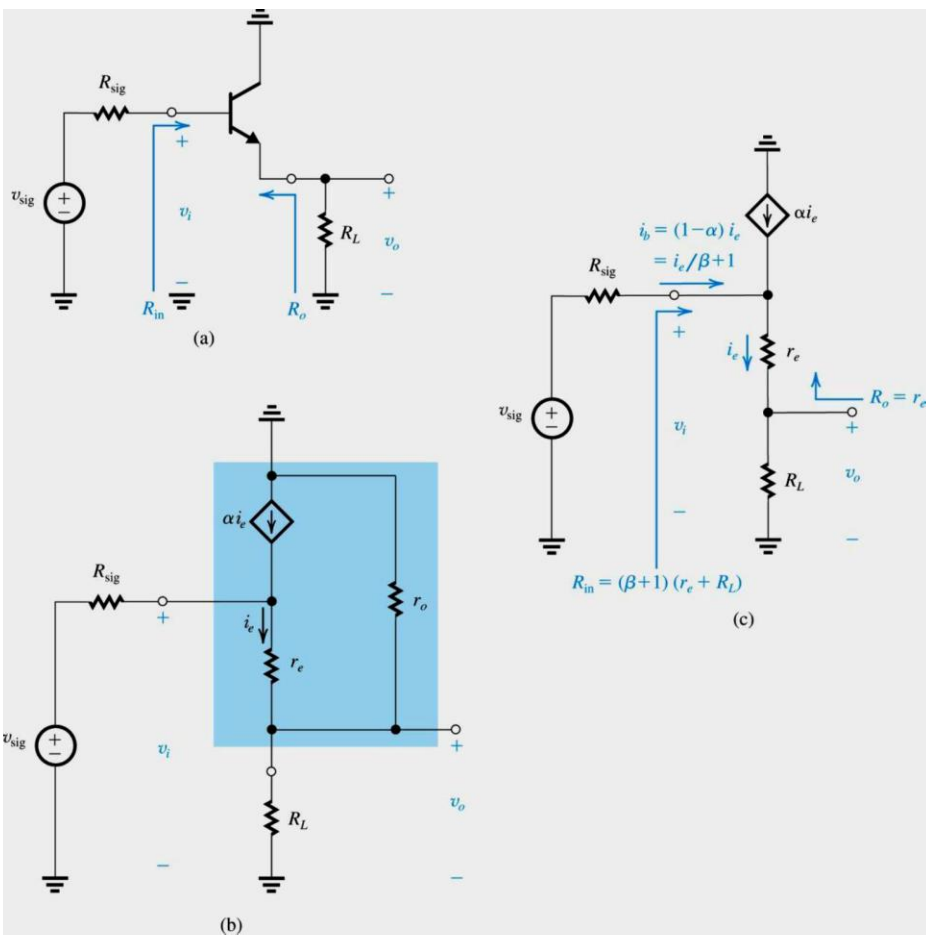
CE Amplifier



CB Amplifier



CC (Emitter Follower) Amplifier



4. LAB DELIVERIES

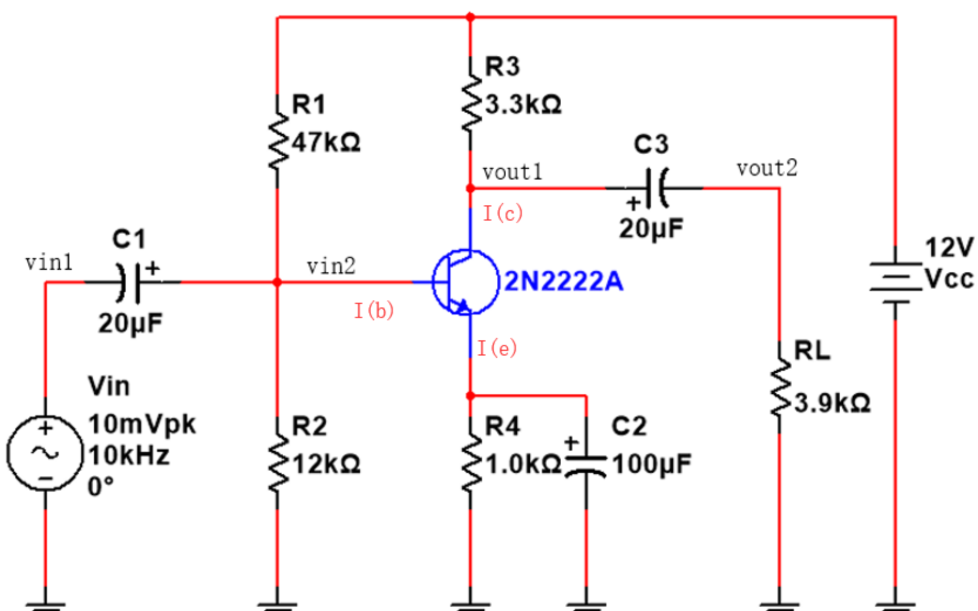
PRELAB:

1. **Review the various configurations of BJT amplifiers, and the IV relationship in each scheme. Part of key knowledge are listed in the previous section.**

2. **Overview the key character of diodes in their datasheets.**

2N2222A	https://www.onsemi.com/pub/Collateral/P2N2222A-D.PDF
2N3904	https://www.onsemi.com/pub/Collateral/2N3903-D.PDF

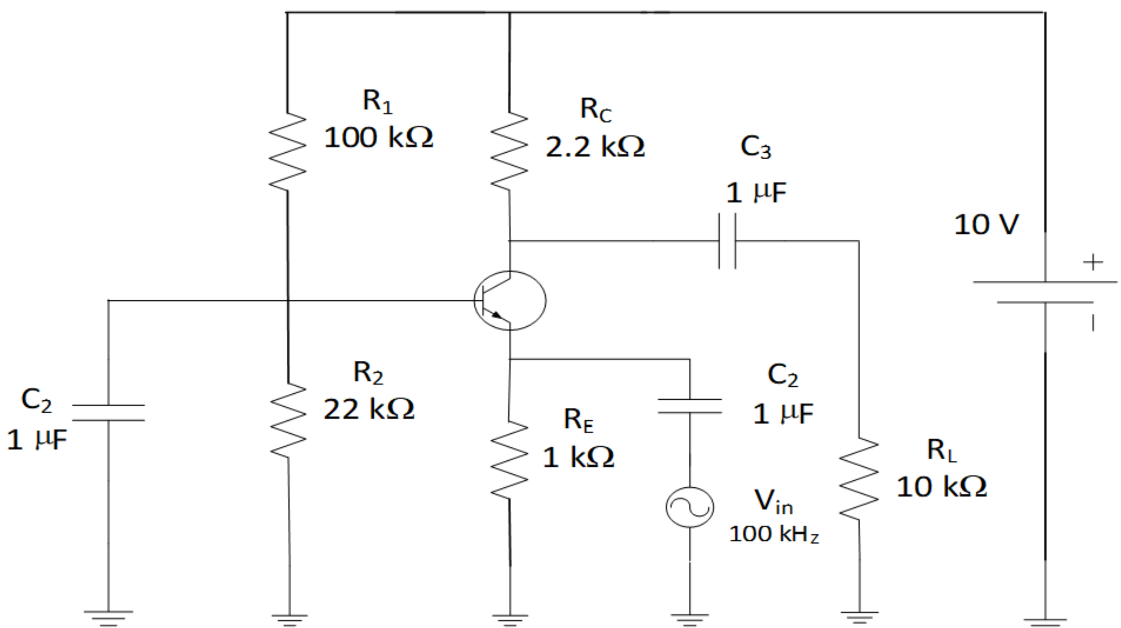
3. **Use LTspice to simulate Circuit 1.**
   1) Observe the voltage at "vin1" and "vout1". Write down the peak voltage (V_p) and peak-to-peak voltage (V_{pp}) of "vout1". Compute $A_V = V_{out1,pp}/V_{in1,pp}$.
   2) Observe the current of I(b), I(c) and I(e), and compute $A_i = I_{pp}(c)/I_{pp}(b)$.
   3) Compute the input impedance by using $Z_{in} = V_{pp}(b)/I_{pp}(b)$, where V(b) = vin2. Note that there may be phase difference between V(b) and I(b), but does not affect V_{pp} or I_{pp}.
   4) Run ac analysis with AC input from 10Hz to 1MHz to draw the Bode plot.
   5) Remove/Short R_L, and repeat 1) ~ 4). Observe the changes in voltages, currents and frequency responses, if any.
   6) Compute the output impedance using $Z_{out} = V_{pp}(c)/I_{pp}(c)$.



Circuit 1

4. Use LTspice to simulate Circuit 2.

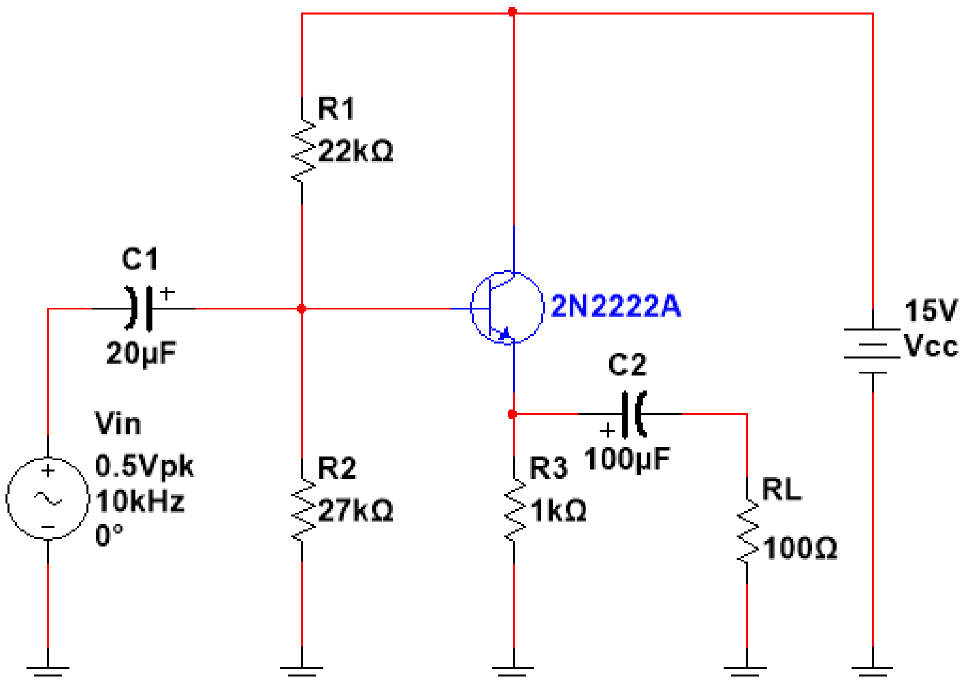
1) Observe the voltages and currents at b, c, e nodes of the BJT. Write down the peak voltage (V_p) and peak-to-peak voltage (V_{pp}) of V(c). Computer $A_v = V_{pp}(c)/V_{pp}(e)$ and $A_i = I_{pp}(c)/I_{pp}(e)$.
2) Compute the input impedance by using $Z_{in} = V_{pp}(e)/I_{pp}(e)$. Note that there may be phase difference between V(e) and I(e).
3) Run the ac analysis for the Bode plot of the AC input from 10Hz to 1MHz.
4) Short/Remove R_L to re-measure and compute $Z_{out} = V_{pp}(c)/I_{pp}(c)$.



Circuit 2

5. Use LTspice to simulate Circuit 3.

1) Observe the voltages and currents at b, c, e nodes of the BJT. Write down the peak voltage (V_p) and peak-to-peak voltage (V_{pp}) of V(c). Computer $A_v = V_{pp}(e)/V_{pp}(b)$ and $A_i = I_{pp}(e)/I_{pp}(b)$.
2) Compute the input impedance by using $Z_{in} = V_{pp}(b)/I_{pp}(b)$. Note that there may be phase difference between V(b) and I(b).
3) Run the ac analysis for the Bode plot of the AC input from 10Hz to 1MHz.
4) Disconnect R_L to re-measure and compute $Z_{out} = V_{pp}(e)/I_{pp}(e)$.



Circuit 3

LAB EXPERIMENTS:

1. **Implement and measure Circuit 1 in Prelab Experiment 3 on breadboard, and compare with LTspice results.**
   - Use frequencies of 10Hz, 100Hz, 1KHz, 10KHz, 100KHz, and 1MHz for Bode plot.

2. **Implement and measure Circuit 2 in Prelab Experiment 4 on breadboard, and compare with LTspice results.**
   - Use frequencies of 10Hz, 100Hz, 1KHz, 10KHz, 100KHz, and 1MHz for Bode plot.

3. **Implement and measure Circuit 3 in Prelab Experiment 5 on breadboard, and compare with LTspice results.**
   - Use frequencies of 10Hz, 100Hz, 1KHz, 10KHz, 100KHz, and 1MHz for Bode plot.

POSTLAB REPORT:

Include the following elements in the report document:

<table>
<tr><th>Section</th><th colspan="2">Element</th></tr>
<tr><td>1</td><td colspan="2">Theory of operation
Include a brief description of every element and phenomenon that appear during the experiments.</td></tr>
<tr><td>2</td><td colspan="2">Prelab report
1. Hand calculation results of Prelab Experiment 3~5.
2. LTspice schematics and simulation results of Prelab Experiment 3~5.</td></tr>
<tr><td rowspan="5">3</td><td colspan="2">Results of the experiments</td></tr>
<tr><th>Experiments</th><th>Experiment Results</th></tr>
<tr><td>1</td><td>Screenshots of LTspice simulations and oscilloscope waveforms, and V_p, V_{pp} values.</td></tr>
<tr><td>2</td><td>Screenshots of LTspice simulations and oscilloscope waveforms, and V_p, V_{pp} values.</td></tr>
<tr><td>3</td><td>Screenshots of LTspice simulations and oscilloscope waveforms, and V_p, V_{pp} values.</td></tr>
<tr><td rowspan="4">4</td><td colspan="2">Answer the questions</td></tr>
<tr><th>Questions</th><th>Questions</th></tr>
<tr><td>1</td><td>Which type of amplifiers does each circuit belong to, respectively?</td></tr>
<tr><td>2</td><td>What A_v range can you conclude for each type of BJT amplifier?</td></tr>
<tr><td>5</td><td colspan="2">Conclusions
Write down your conclusions, things learned, problems encountered during the lab and how they were solved, etc.</td></tr>
<tr><td>6</td><td colspan="2">Images
Paste images (e.g. scratches, drafts, screenshots, photos, etc.) in Postlab report document (only .docx, .doc or .pdf format is accepted). If the sizes of images are too large, convert them to jpg/jpeg format first, and then paste them in the document.

Attachments (If needed)
Zip your projects. Send through WebCampus as attachments, or provide link to the zip file on Google Drive / Dropbox, etc.</td></tr>
</table>

5. REFERENCES & ACKNOWLEDGEMENT

1. Adel S. Sedra & Kenneth C. Smith, "Microelectronic Circuit", 6th Ed.
2. Previous lab instructions.
3. Related circuit component datasheets.

I appreciate the help from faculty members (e.g. Dr. Wen Shen, etc), and TAs during the composing of this instruction manual. I would also thank students who provide valuable feedback so that we can offer better higher education to the students.