Prelab
Part I: Wired Diode OR Gate LTspice use 1N4002

1. Design a diode OR gate, Figure 1 in which the maximum current thru R1 $I_{R1} = 9mA$
assume $V_{in} = 5Vdc$. Design the R1 resistor with a single diode on such that the current thru the diode is 9ma assume the forward diode voltage drop $V_D = 0.6 Vdc$. Show all work including the LTspice schematic and plots.
   a. Use two 1N4002 diodes.
      Remember to place on the schematic (.LIB 1N4002.sub) for LTspice.
   b. Verify your design using LTspice $V_{in}A = 5Vdc$ and $V_{in}B = 0vdc$, use a diode 1N4002 and the closes standard resistor value for R1. Include LTspice schematic.
   c. Plot the voltage transfer function (DC Sweep) by varying the input voltage on Pin A while holding the voltage at Pin B to 0V.
   d. Assume the $V_{in}A$ sweeps from 0V to 5V. Turn in the plot.
   e. Verify that the maximum current thru diode is within specification from LTspice.

![Diode OR Gate Schematic](image)

FIGURE 1

2. Simulate the circuit again after substituting D1N914 diodes for the 1N4002 diodes.
   a. Plot the voltage transfer function by sweeping the input voltage from 0v to 5v on Pin A while holding the voltage at Pin B to 0V.
   b. Determine the maximum diode current.
Part II: Prelab Clipping Circuit (use 1N4002 diodes)

Given the circuit in Figure 2, **sketch by hand** (do not use LTspice) the input $v_{in}$ and output $v_{out}$ signals expected. Assume diode forward voltage drop is 0.6V.

1. $v_{in} = 8 \text{ V}_{pp}$, 5 kHz sine + 2 V DC offset.

2. $v_{in} = 8 \text{ V}_{pp}$, 5 kHz sine – 2 V DC offset.

![FIGURE 2](image)

Given the circuit in Figure 3, **sketch by hand** (do not use LTspice) the input $v_i$ and output $v_o$ signals expected. Assume diode forward voltage drop is 0.6V.

3. $v_{in} = 8 \text{ V}_{pp}$, 5 kHz sine + 2 V DC offset.

4. $v_{in} = 8 \text{ V}_{pp}$, 5 kHz sine – 2 V DC offset.

![FIGURE 3](image)
5. Design a clipping circuit as shown below, Figure 4, so that the waveform will be clipped at +2V and -4V. Use R1 = 3.3kΩ, C1 = 0.1uF, 1N4002 diodes for D1, and D2. Show all work. Verify your design using LTspice include schematic and plot of Vin and Vout. Vin = 8Vp, 5kHz sinewave for plot 2 to 5 cycles. Assume diode forward voltage drop is 0.6V.

![Clipping Circuit Diagram](image)

**FIGURE 4**

R = 3.3k, D1,D2 = 1N4002

Your design:

Vneg = ________________

Vpos = ________________

Why might the circuit not clip at exactly -4V and +2V?
Prelab work sheet

CRN# _____________ Date:_______________ Bench: _________
Name: ____________________  Instructor: ___________________

Part I: Diode OR Gate (use 1N4002 diodes)
1. Assume a voltage drop of 0.6V across the diode and Vin = 5Vdc. Maximum current allowed through resistor is about 9 mA. Solve for value of R1.

   R1 = ____________

   For 1N4002 $I_{\text{max}}$ from LTspice = ____________

2. For 1N914 $I_{\text{max}}$ from LTspice = ____________

Part II: Clipping Circuit (use 1N4002 diodes)

Given the circuit in Figure 2, sketch by hand (do not use LTspice) the input $v_{\text{in}}$ and output $v_{\text{out}}$ signals expected if

1. $v_{\text{in}} = 8\, V_{\text{pp}}, 1\, \text{kHz sine} + 2\, \text{V DC offset.}$

   $v_{\text{out}} = __________\text{ when } v_i \geq 0.7V$
   $v_{\text{out}} = __________\text{ when } -0.7V < v_i < 0.7V$
   $v_{\text{out}} = __________\text{ when } v_i \leq -0.7V$

2. Repeat part 1 with $v_{\text{in}} = 8\, V_{\text{pp}}, 1\, \text{kHz sine} - 2\, \text{V DC offset.}$

   $v_{\text{out}} = __________\text{ when } v_i \geq 0.7V$
   $v_{\text{out}} = __________\text{ when } -0.7V < v_i < 0.7V$
   $v_{\text{out}} = __________\text{ when } v_i \leq -0.7V$
Given the circuit in Figure 3, sketch by hand (do not use LTspice) the input \( v_i \) and output \( v_o \) signals expected if

3. \( v_{in} = 8 \ V_{pp}, 1 \text{kHz sine} + 2 \ V \text{ DC offset} \)
   \( v_{out} = \) ______ when \( v_i \geq 0.7V \)
   \( v_{out} = \) ______ when \(-0.7V < v_i < 0.7V \)
   \( v_{out} = \) ______ when \( v_i \leq -0.7V \)

4. Repeat part 3 with \( v_i = 8 \ V_{pp}, 1 \text{kHz sine} - 2 \ V \text{ DC offset} \).
   \( v_{out} = \) ______ when \( v_i \geq 0.7V \)
   \( v_{out} = \) ______ when \(-0.7V < v_i < 0.7V \)
   \( v_{out} = \) ______ when \( v_i \leq -0.7V \)

5. Verify figure 4 results with LTspice. Turn in with Pre-Lab
   
   Your design:
   
   \( V_{neg} = \) ______________
   \( V_{pos} = \) ______________

   Why might the circuit not clip at exactly -4V and +2V?

Required Graphs
1. Part I 1.b LTspice schematic
2. LTspice DC sweep of diode ‘or’ circuit with 1N4002.
3. LTspice DC sweep of diode ‘or’ circuit with 1N914.
4. Sketch of Part II.1
5. Sketch of Part II.2
6. Sketch of Part II.3
7. Sketch of Part II.4
8. Part II.5 LTspice Transient of -4V and 2V clipping circuit figure 4
LAB EXERCISE
DIODE GATE AND CLIPPING CIRCUIT

Part I. Diode OR GATE:

1a. Build an OR gate (Figure 1) using 1N4001 diodes. Fill in the function table; use the multimeter to measure Vout.

1b. Use the Signal Express Basic DC sweep to plot the output voltage Vout. Sweep one input from 0 to 5V while **grounding the other input** 100mv increments. (Label your graph to be turned in).

1c. On the same plot write the scale factor for current thru the resistor. (current = voltages across a known resistance / resistance) Write the scale factor (ma/v) on the plot above. Compare the maximum value for the output current with that obtained from your simulation.

**Red LED**

2a. Build the circuit below and DC sweep the Vsupply from 0Vdc to 5Vdc. Use a multimeter to measure the voltage across the resistor (Rlimit). Use a resistor Rlimit = 270Ω. Plot this voltage as a current in mA. The scale factor to convert the voltage across the resistor to current (mA/V). Plot the Iled the LED current in mA not amps.

Add formula data step to output section of the Sweep loop.

Load BaicDCSweep > open Step Setup Tab > Open Add Step Tab > Add Step >

Processing > Analog Signal > Formula.

Divide voltage across VRlimit by Rlimit this will be in **amps**. You must scale to mA.

Drag this new step into the sweep loop just below the DMM step (Voltage across Rlimit).

Open the sweep step > Sweep Output Tab > Add > Processed Data (LED current) vs. Voltage X-Axis.

At what Vdiode does the Red LED begin to conduct? What is the Vdiode if the current is 9mA? Use the digital voltmeter to measure Vdiode with the Vsupply = 5Vdc.
2b. Using the curve tracer to produce the forward-biased characteristic of your Red LED. Set the maximum voltage to 5V and the maximum current to 10mA. Determine $V_D$ at the maximum current of your design from the graph. Turn in your curve tracer graph. Compare with your results of your DC sweep.

**Part II. Clipping Circuits: (use 1N4001 diodes)**

1. Build the clipping circuit Figure 2 of the pre-lab with an 1kHz 8Vpp sinewave input with a offset of 2V. Capture the input (Vin) and output (Vout) waveforms from the oscilloscope.

2. Change the offset of the vi to -2v.

3. Change the direction of the diode Figure 3 change the offset to 2V.

4. Change the offset to -2V and repeat.

5. Build your design for the clipping circuit in Figure 4. Place a probe in order to view $V_{OUT}$, the waveform produced. Capture the waveform and print out the waveform to be turned in.

   a. Does the circuit clip at exactly +2V and -4V? Does it clip at the same values from your LTspice simulation? If not, why would there be differences between the LTspice simulation results and the real life results?

   b. Now that you know the voltage drop across the diodes you are using in lab, design your circuit so that the source is a 5kHz 16V pp square wave that after clipping is approximately a 0 to 5V square wave. Build your circuit, capture the waveform and save it to disk to print later. **Draw your design schematic on your answer sheet.**
DATA SHEET CRN# _____________ Date:_______________ Bench: ________
Name: ____________________ Name: ____________________________

DIODE GATE & CLIPPING CIRCUIT

PART I. (use 1N4001)
Diode Gate figure 1

1a. Fill in the function table; use a multimeter to measure Vout.

<table>
<thead>
<tr>
<th>Vb</th>
<th>Va</th>
<th>Vout</th>
</tr>
</thead>
<tbody>
<tr>
<td>0Vdc</td>
<td>0Vdc</td>
<td></td>
</tr>
<tr>
<td>0Vdc</td>
<td>5Vdc</td>
<td></td>
</tr>
<tr>
<td>5Vdc</td>
<td>0Vdc</td>
<td></td>
</tr>
<tr>
<td>5Vdc</td>
<td>5Vdc</td>
<td></td>
</tr>
</tbody>
</table>

1b. Print out DC sweep 0V to 5V of one of the inputs using a power supply and turn in with data sheet (ground the unused input).

1c. Maximum current in circuit ____________ Calculate from voltage across a resistor.
Include a scale factor on your plot (ma/v)

   Maximum current in LTspice ____________ from prelab

Red LED

2a. DC sweep of Red LED and resistor (Rlimit = 270Ω). Turn in plot with scale factor to mA.
   At what Vdiode does the LED begin to conduct? ____________
   What is the Vdiode if the current is 9mA from plot? ________________

   Vdiode = Vsupply - VRlimt

2b. Print out forward-bias characteristics curve on the curve tracer for the LED. The x-axis should be scaled according to the typical voltage drop across a LED diode (5V). The y-axis should be scaled according to the current that will be flowing through the diode in the circuit (10mA).

   VD (graph) = ____________
   VD (measured) = ________

   Any difference? Why?

PART II. Clipping Circuits (use 1N4001 diodes)

1-4. Compare the differences in circuit behavior between having a forward and reverse-biased diode, include scope capture of input (Vin) plot 2 to 5 cycles and output (Vout) to turn in with lab.
5. Turn in waveform.
   a. Does the circuit clip at exactly –4V and +2V? 
   Why would there be differences between the LTspice simulation results and the real life results?

   b. turn in waveform plot 2 to 5 cycles.

Schematic Drawing:

Required Graphs
   1. DC Sweep of OR gate, voltage Part I.2
   2. DC Sweep of OR gate, current (write on voltage plot #1 the scale factor mA/V to read current) Part I.3
   3. DC sweep I-V Characteristic of LED diode Part I.4
   5. Scope capture of Part II.1 Vin nand Vout
   6. Scope capture of Part II.2 Vin and Vout
   7. Scope capture of Part II.4 Vin and Vout
   8. Scope capture of Part II.5a Vin and Vout
   9. Scope capture of Part II.5b Vin and Vout