

ELC 4350 – Principles of Communication

Project 3

Due Thursday, February 19 at the Beginning of Class

Description

In this project, PSPICE is used to simulate an envelope detector. The role of modulation index in allowing a message to be successfully demodulated is examined. The effects of different circuit components on the ability of the circuit to demodulate the signal are observed.

Deliverables

Your deliverable will be in the form of a hard-copy report with the following clearly labeled sections:

- Cover sheet including your name, the name and number of the course, and the project number (1).
- Brief Description of Project (1 to 2 paragraphs recommended)
- PSPICE Circuit Schematic
- Description of results and answers to questions organized as given below with plots included as numbered figures (“Figure 1”, “Figure 2”, etc.). The Figures should be placed at appropriate places within the body of your descriptions.
- Conclusions (likely a 1 paragraph summary)

Failure to adhere to this format will result in deduction of points.

Project Summary:

In this project, you will construct an AM envelope detector for simulation in PSPICE using a given schematic. Using a transient simulation, you will view the results of the demodulation for different values of μ , the modulation index. Recall that the AM signal corresponding to the message $m(t)$ is given by

$$\varphi_{AM}(t) = [A + m(t)]\cos(\omega_c t) \quad (1)$$

The modulation index μ is defined as

$$\mu = \frac{m_p}{A}, \quad (2)$$

where m_p is the negative of the minimum amplitude of the signal. For the special case of tone modulation (that is, the message is a cosine), the message $m(t)$ is given by

$$m(t) = b \cos(\omega_m t). \quad (3)$$

$m_p = b$ in this case. Thus the message signal can be written as

$$m(t) = \mu A \cos(\omega_m t) \quad (4)$$

Thus, for a sinusoid, the modulation index is given by the ratio of the message tone amplitude to the carrier amplitude. Theoretically (for a diode with a 0 V turn-on), the message should be fully recoverable if $\mu < 1$; however, in the real-life case, the diode turn-on is 0.7 V. Furthermore, the use of different values of the capacitors and resistors may alter the ripple caused in the circuit. You will explore some of the effects of the variations of both modulation index and the circuit component values on the ability of the circuit to correctly demodulate the message signal using transient analysis in PSPICE.

Project Description and Assignment

You will use Orcad PSPICE to create the circuit schematic and perform the simulations.

First, open the program. Open "OrCAD Capture CIS Lite Edition." Choose the New Project option, as shown in Figure 1. As shown in Figure 2, name your project, designate the path to the file, and select "Analog or Mixed A/D". Click "OK" and then select the option to create a blank project. After the blank schematic opens, go to "Place → Part, as shown in Figure 3. After the window pops up, select "Add Library" and add all of the available libraries in the folder, as shown in Figure 4.

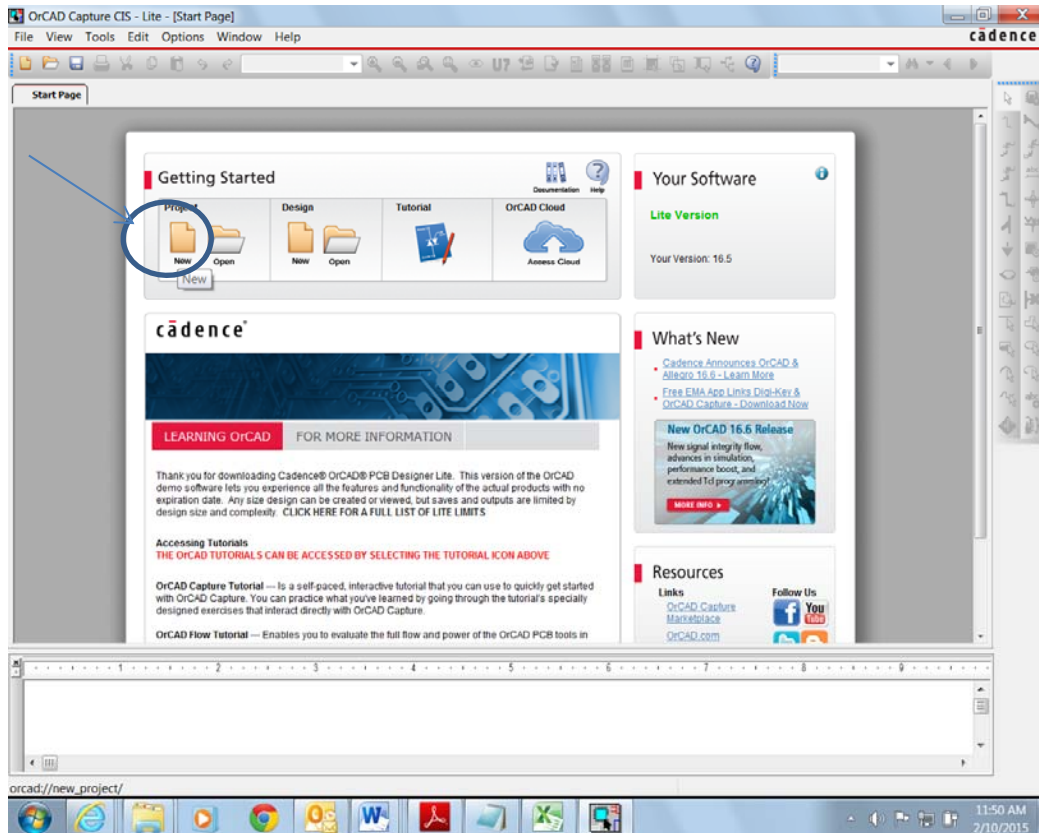


Figure 1. Selecting a New Project in PSPICE

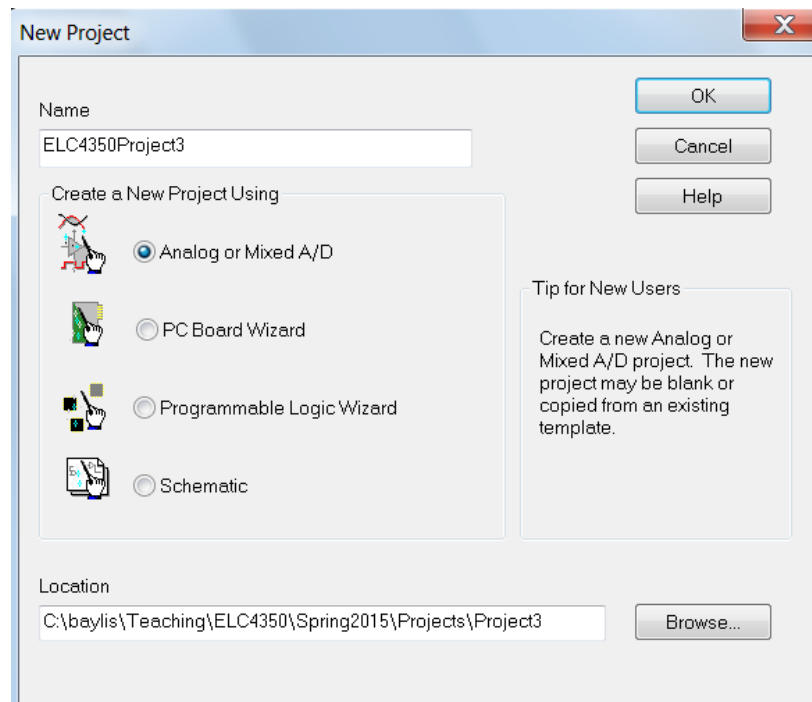


Figure 2. New Project Settings

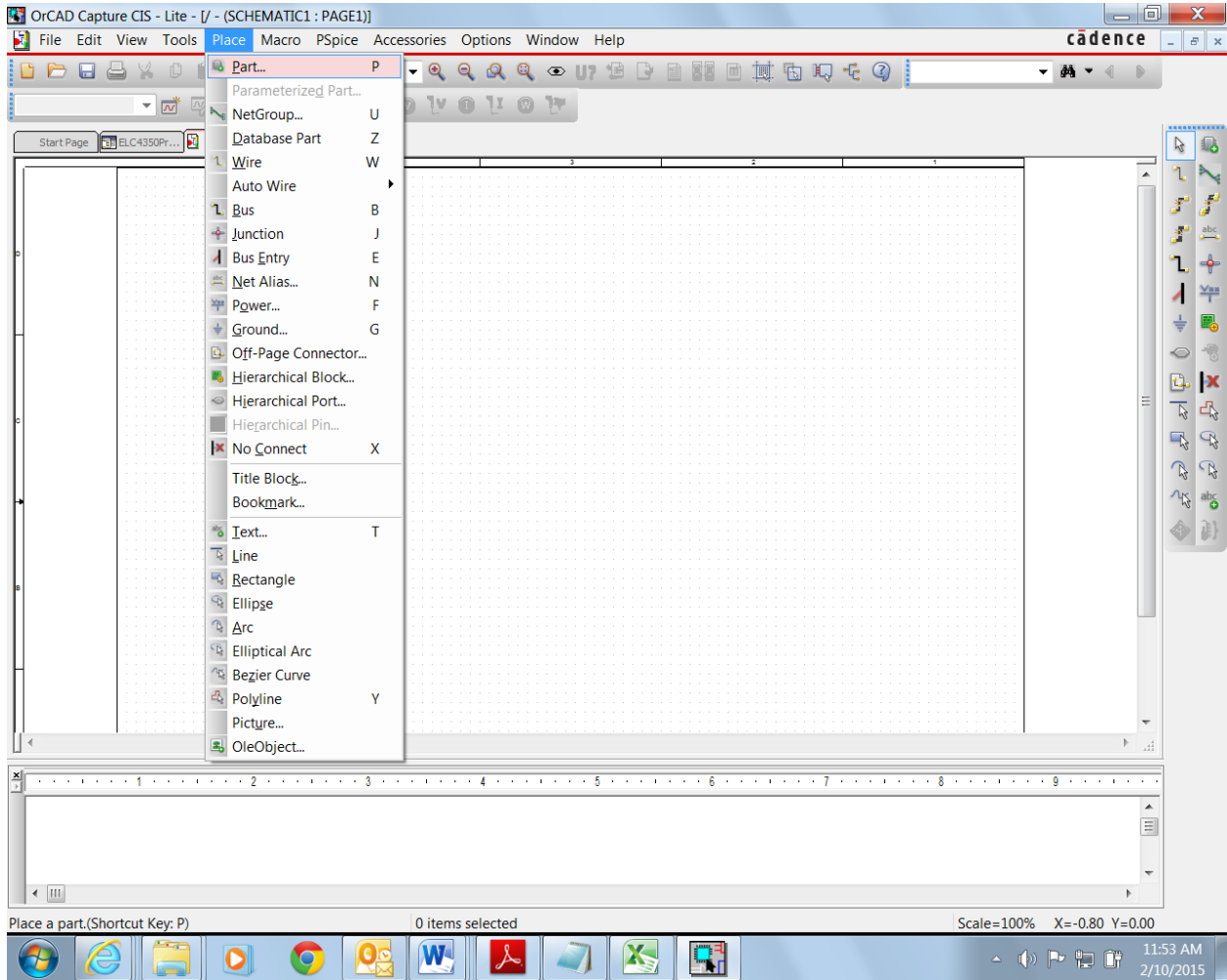


Figure 3. Selecting the Option to Place a Part in the Schematic

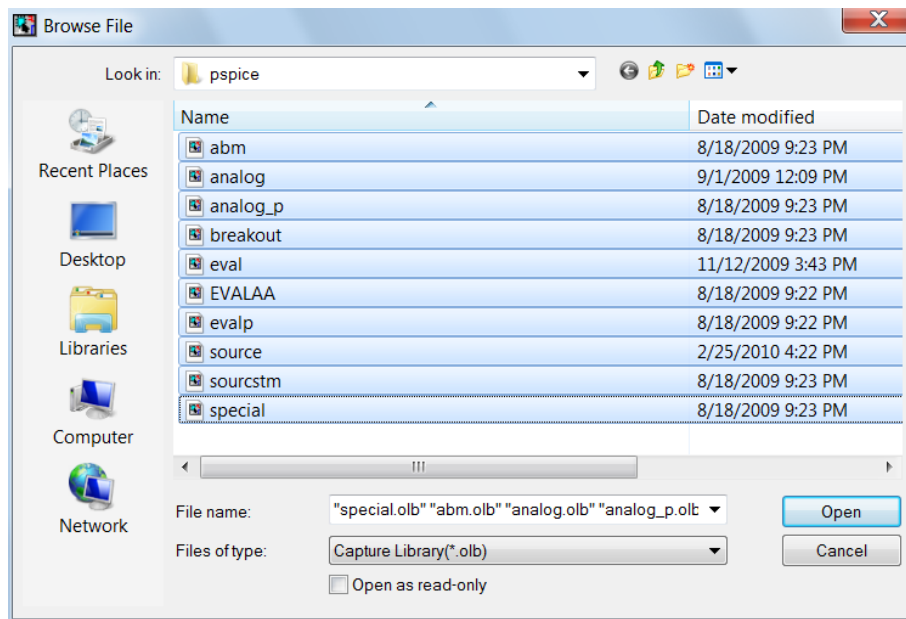
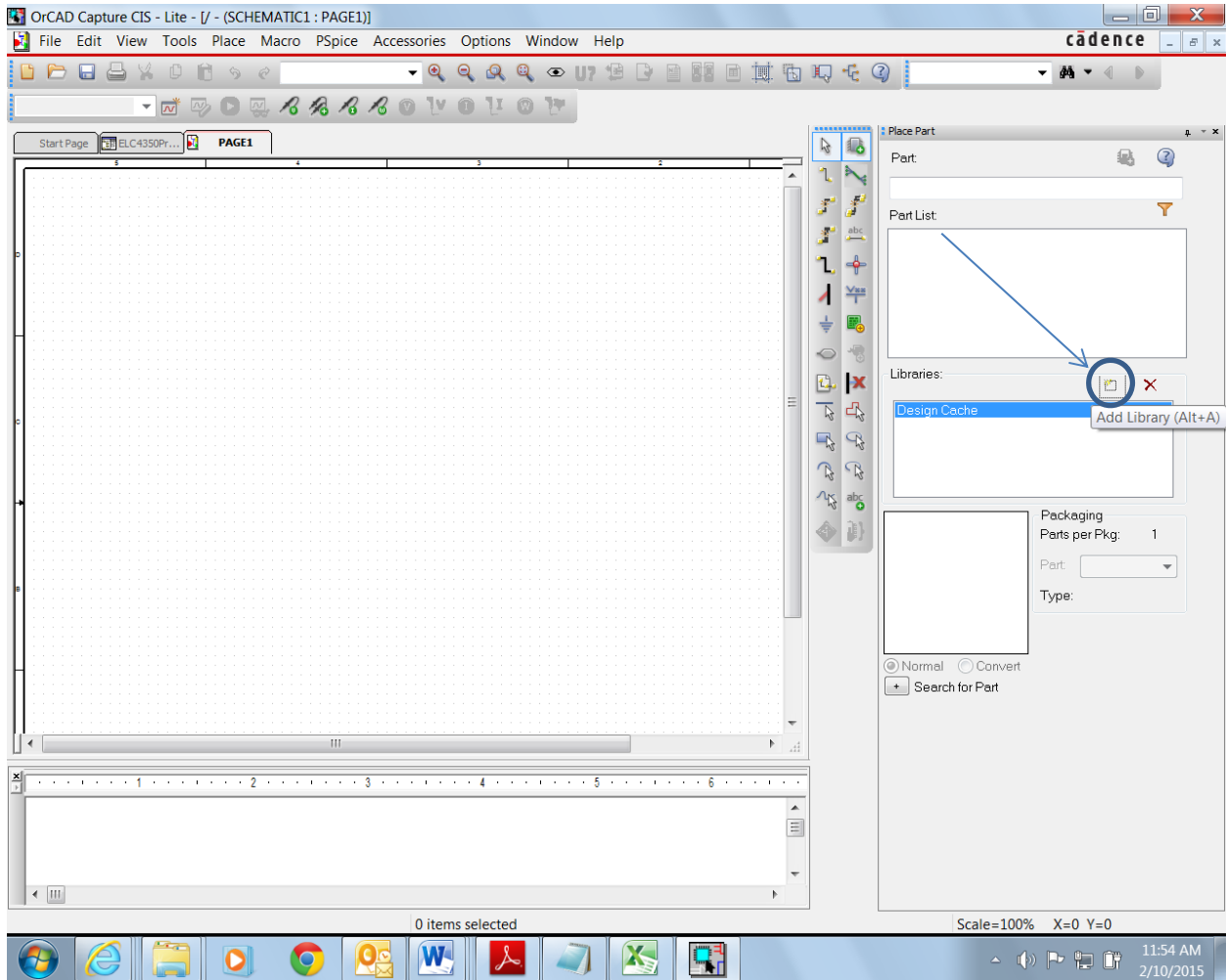


Figure 4. Adding the Available Libraries

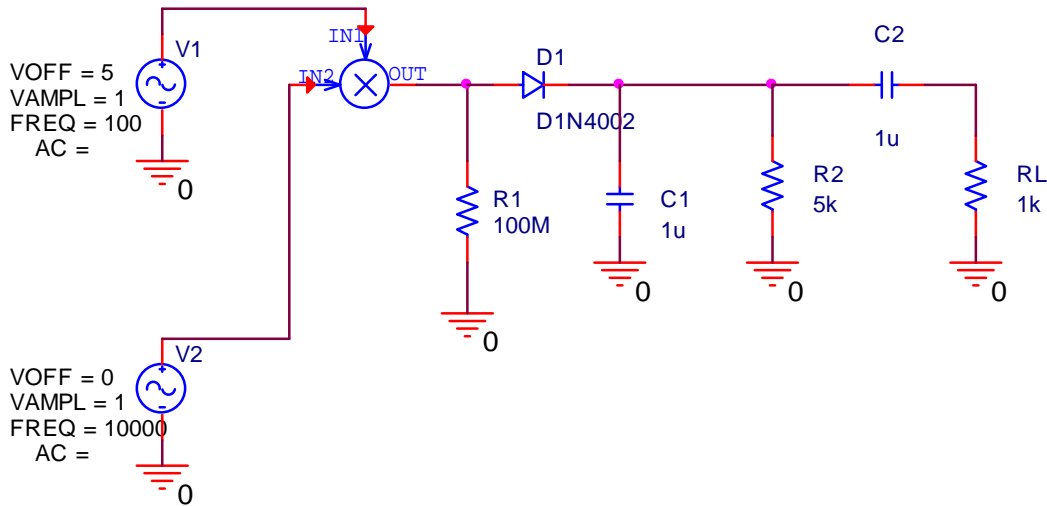


Figure 5. Demodulator Circuit Schematic

Assemble the demodulator circuit schematic of Figure 5 by going to the “Place Part” option again. You will use Vsin for the sources. The source with a frequency of 10 kHz serves as the carrier, while the signal ($A + m(t)$) (the modulating signal) is represented by the source with a frequency of 100 Hz. In this case, the message is

$$m(t) = 1 \sin(2\pi * 100t)$$

$A = 5$, so $A+m(t)$ is the 100 Hz sine wave with a DC offset of 5 V. This is modulated onto a carrier of frequency 10 kHz using the multiplier. Use component “R” for the resistors and “C” for the capacitors. Use MULT/ABM for the multiplier. The diode should be D1N4002. Make sure that the grounds used are selected using the following process: Select Place→Ground, and select “0/SOURCE” as the component to be placed. This is the ground you must use.

After the circuit is constructed and the values are adjusted, the simulation can be configured and run. Go to PSpice → New Simulation Profile, as shown in Figure 6. Name the simulation, and then click “OK”. Fill out the Simulation Settings sheet as shown in Figure 7 and click “OK.” When back in the schematic window, place voltage “V” probes at the three locations shown in Figure 8. After the probes are in place, press the forward arrow on the toolbar to begin the simulation (it looks like a “Play” button). The simulation should pop up with a graph of the transient analysis. The plot appears as in Figure 9 (with the colors inverted). It is apparent that one plot shows the modulated signal, a second plot shows the voltage waveform after the diode, and the third waveform is the envelope after passing it through the DC blocking capacitor.

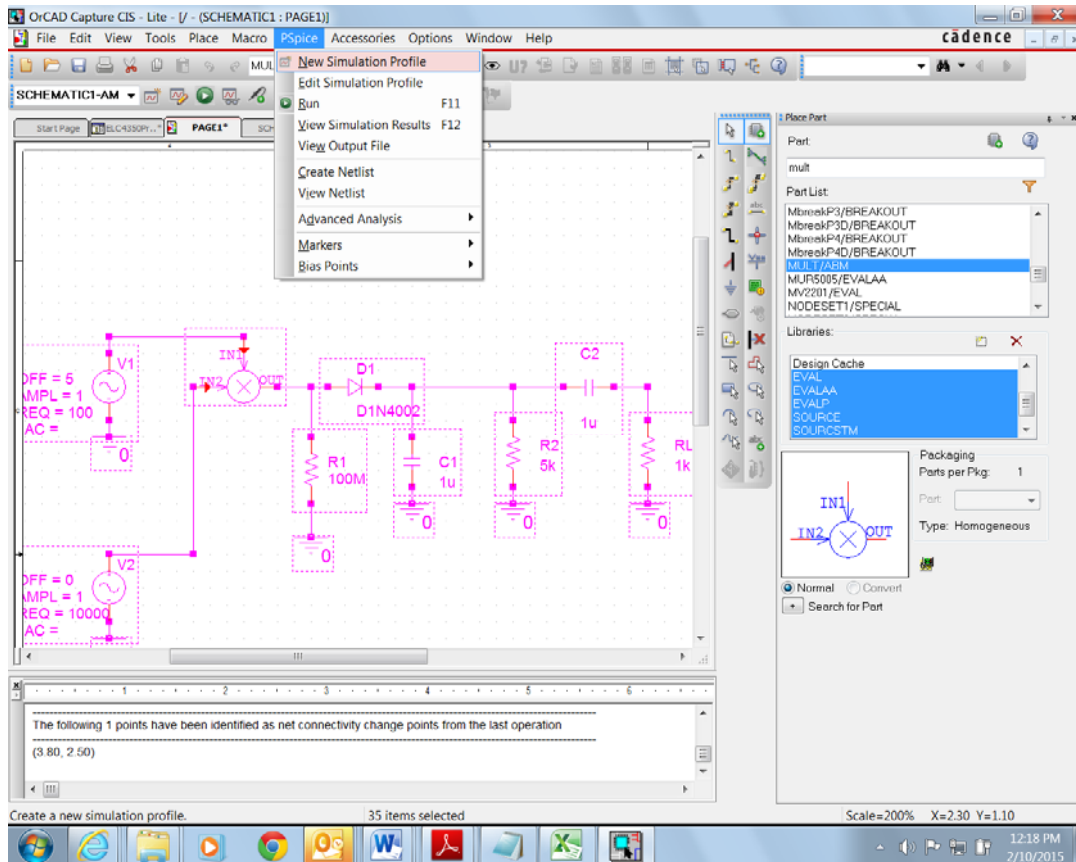


Figure 6. Selecting the Setup for a New Simulation Profile

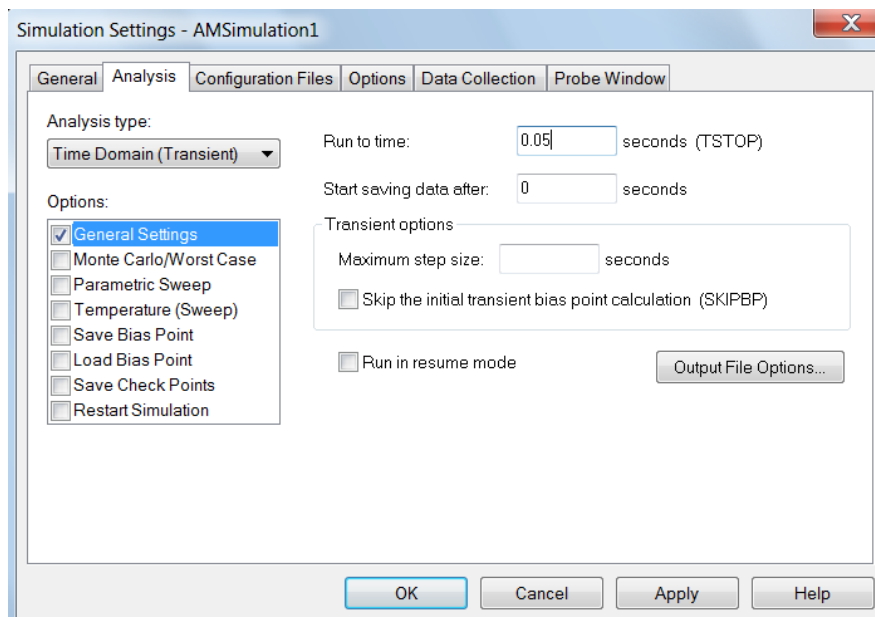


Figure 7. Simulation Settings

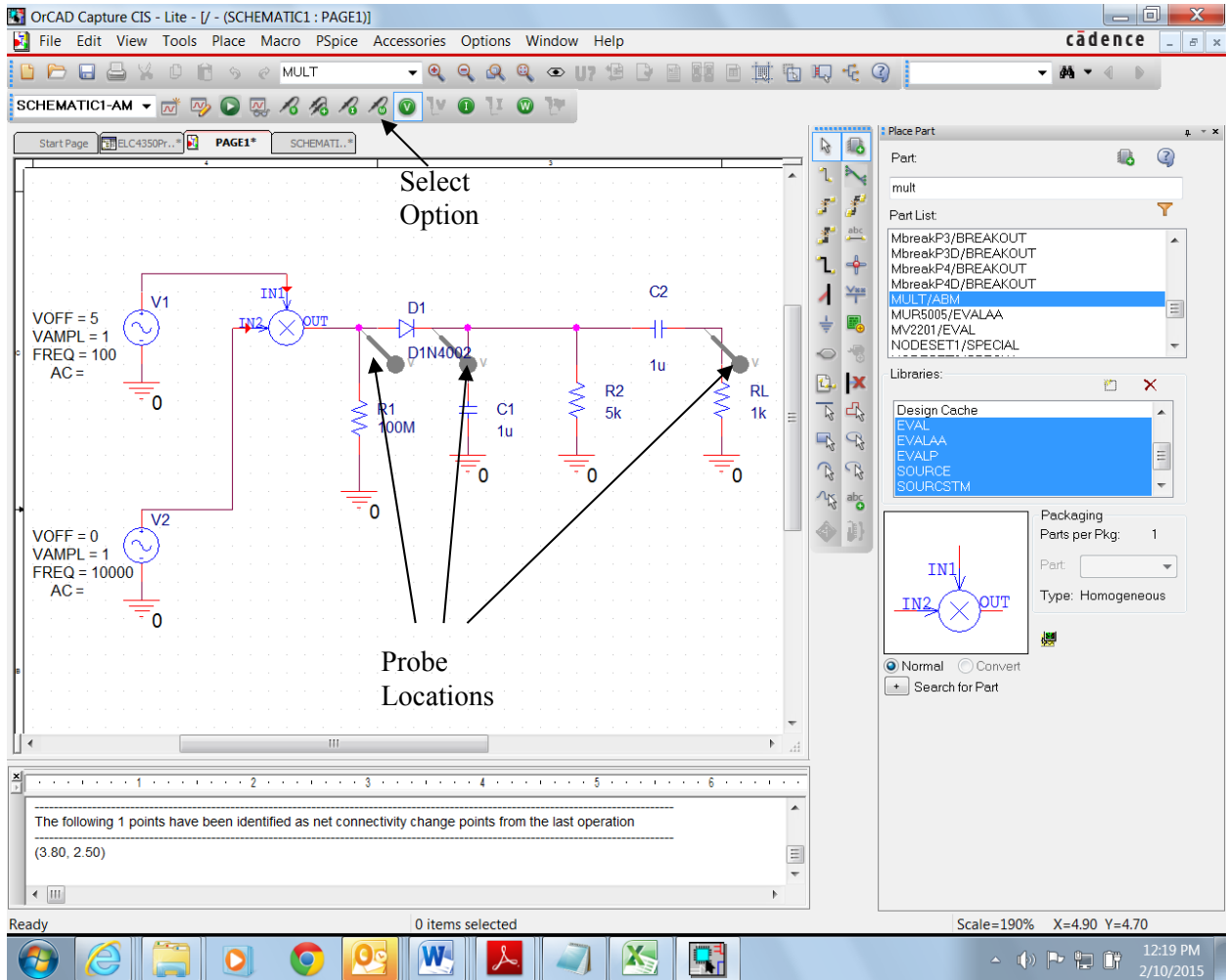


Figure 8. Placement of Voltage Probes

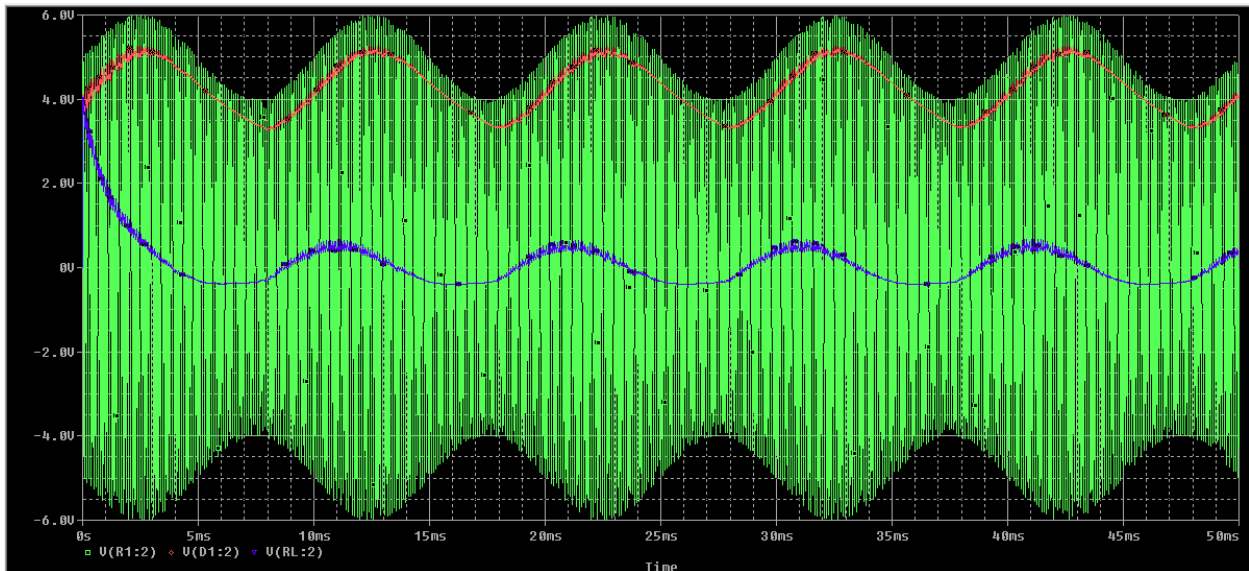


Figure 9. Plot of Results

Procedure and Report

1. Run the analysis of the Figure 5 schematic and show the schematic as Figure 1 and the plot as Figure 2. Comment on the results. Does the demodulation occur as desired?
2. Calculate the time constant of the parallel RC network (the time constant is the product of the parallel resistance and capacitance R2 and C1). What is this time constant (in seconds)? What is the value of $1/\omega_c$ for this problem. What is the frequency of the message tone $m(t)$? Ideally, the inverse of the time constant should be between the radian frequencies of the carrier and the message signal (p. 168-169 of your textbook). Is this the case here? If not, is the RC time constant too high or too low?
3. Modify the time constant by changing the resistor and capacitor values until the envelope is optimally demodulated. Calculate the time constant. What values of R2 and C1 provide optimal results? Explain why this is the case. Plot the results for your optimal combination (Figure 3). Also, find a case where the RC time constant is too short and plot the results as Figure 4. Finally, find a case where the RC time constant is too long and plot the results as Figure 5.
4. Now set the values of R2 and C1 to their optimal values as found in the above step. Plot the results for different values of the modulation index μ . What is the modulation index for the initial setup? Now change the modulation index. Adjust the DC offset of the 100 Hz sine source to the desired value of A to accomplish this. Plot the results for $\mu = 0$ (Figure 6) and $\mu = 1$ (Figure 7). Does $\mu = 1$ allow the signal to be correctly detected? Find the maximum value for μ that allows correct envelope detection and provide a plot (Figure 8). If this value is different from $\mu = 1$, comment as to why (consider the fact that the turn-on voltage of this diode will not be 0 V).

As stated in the first page of this assignment, be sure to include a section containing your conclusions regarding this project.