

PHASORS AND PHASE SHIFT CIRCUITS

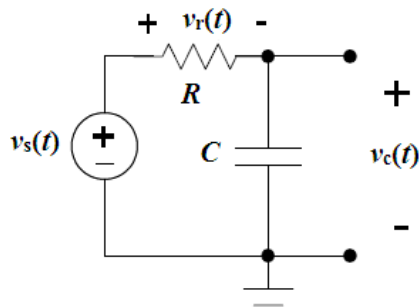
YOUR NAME _____

GTA'S SIGNATURE _____

LAB MEETING TIME _____

PHASOR CIRCUIT

4. Assemble the series RC circuit with the following circuit element values:



$$C = 0.027 \mu\text{F}$$

$$R = 10 \text{ k}\Omega$$

$$v_s(t) = V_m \cos(\omega t)$$

$$V_m = 5 \text{ V}$$

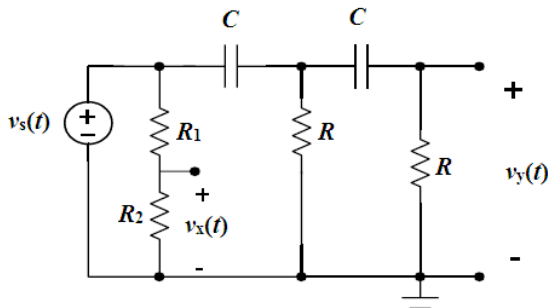
- a) Use the Agilent 33522A function/arbitrary waveform generator and vary the frequency. Connect the input voltage source $v_s(t)$ to ch.1 of the oscilloscope. Use ch.2 for the voltage of interest to measure magnitude and phase (phase with respect to the phase of the source) and fill-in the table below showing both theoretical, Cadence and experimental results at $f = 60 \text{ Hz}$, 500 Hz , 600 Hz , 4 kHz , and 10 kHz for magnitude and phase of $v_r(t)$ and $v_c(t)$. For theoretical and Cadence results, pick one of the team member's results from PreLab homework to enter in this table.

f	$v_r(t)$						$v_c(t)$					
	Magnitude [V]			Phase [deg]			Magnitude [V]			Phase [deg]		
	Theor.	Cad.	Meas.	Theor.	Cad.	Meas.	Theor.	Cad.	Meas.	Theor.	Cad.	Meas.
60 Hz												
500 Hz												
600 Hz												
4 kHz												
10 kHz												

- b) How well do your measurement results match theoretical results and PreLab Cadence simulation?

BALL GENERATION CIRCUIT**5. Stationary ball:**

Assemble the phase shift circuit using the following circuit values:



$$\begin{aligned}
 C &= 1.4 \text{ nF} \\
 R_1 &= 1.2 \text{ k}\Omega \\
 R &= 5 \text{ k}\Omega \\
 R_2 &= 1 \text{ k}\Omega \text{ (potentiometer)}
 \end{aligned}$$

The phase shift between the two voltage phasors V_x and V_y can be displayed on an oscilloscope by connecting the voltages $v_x(t)$ and $v_y(t)$ to the horizontal and vertical inputs, respectively. In fact, this technique is used for special effects in movies and laser light shows!

* *TECH NOTE:* To set the Oscilloscope to X-Y mode:

- Push **Horiz** button under the horizontal section
 - Under **Time Mode** softkey select **XY** mode
- a) A circular figure (i.e., a ball) can be displayed on the scope if:
- a. The phase shift between V_x and V_y is 90° , and
 - b. The phasor magnitudes are identical (i.e. $|V_x| = |V_y|$).

Using values for C , R and R_1 from above and formulas derived in PreLab, estimate initial values for ω and R_2 (theoretical values). Set ω to theoretical value and rotate potentiometer R_2 to adjust to theoretical value (do this before inserting it in the circuit!)

Most likely, you will not get a perfect circle at first.

Adjust the frequency ω and resistor R_2 to obtain a circle on the oscilloscope.

$$\omega = \text{_____ theoretical, _____ experimental}$$

$$R_2 = \text{_____ theoretical, _____ experimental}$$

Explain any difference between the theoretical and experimental values.

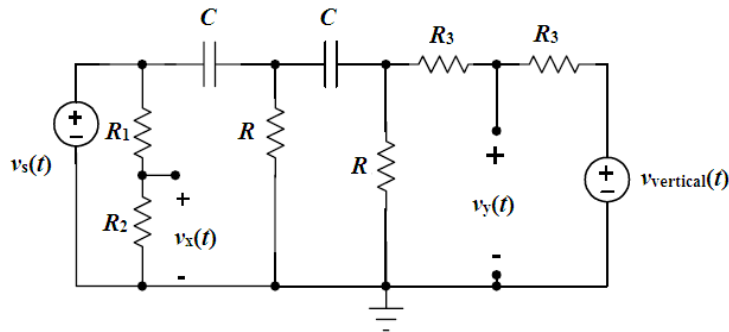
GTA's signature _____

- b) Explain why the resistor R_2 needs to be readjusted from the value obtained in PreLab part 2.d.

- c) Explain what happens to the scope figure, if either condition in part a) is violated.
Hint: experiment to find out!

d) **Bouncing ball:**

The ball can be made to bounce up and down by adding the summing circuit as shown below.
When the circuit works, call GTA to verify.



The bouncing ball circuit

Experiment by initially setting a DC voltage as $v_{\text{vertical}}(t)$ and changing its value. When you think it is working, challenge yourself to set a low-frequency AC signal for $v_{\text{vertical}}(t)$, and then change its magnitude and frequency. What is going on?

Explain in few sentences what happens with the signal as you are changing R_3 and $v_{\text{vertical}}(t)$ (you may write in the space provided below).

Bouncing balls are for playing, so have fun with yours. Try understanding the formulas that are “driving” this circuit, not just connecting and being satisfied with the response, without knowing the physics behind it.

GTA's signature _____

e) **Playing racquetball** ☺

The ball can also be made to move back and forth while it is bouncing up and down. Show how you would modify the last circuit by adding another input signal, so this additional motion is possible.

Hint: Compare the difference between the non-bouncing circle in 5.a to vertically bouncing in 5.d and try adding the same combo of two resistors and additional voltage source between $v_x(t)$ and ground.

Required: Draw the new circuit, with all component values labeled!

Optional: See if this circuit works and call GTA to verify.

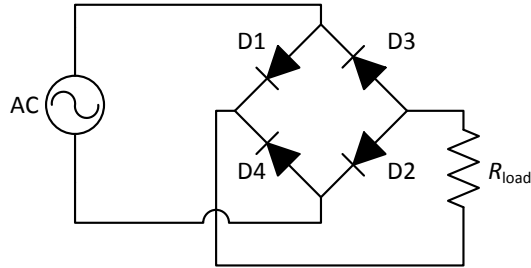
Explain in few sentences what happens with the signal as you are changing values of different circuit elements and/or parameters.

GTA's signature _____

DIODE BRIDGE WITH THE LOAD

6. Bridge followed by a resistor, only:

- a) Connect the diode bridge from part 3.a of the pre-lab using LEDs and a load resistor whose value you have calculated in the PreLab. For the sinusoidal input, set frequency to 1Hz and amplitude to 14 Vpp. Measure current flowing through the circuit and compare with theoretical value.



% error _____

- b) Re-adjusting calculation based on the actual values of parameters:
 One of the potential reasons for different value of current could be the actual vs. theoretical values of a resistance R and voltage on a diode v_{LED} when conducting. Measure these values and re-calculate current flowing through your circuit.

	R [Ω]	v_{LED} [V]	i [A]	Measured current [A]	% error
Theoretical (PreLab values)					
Re-calculated using measured R and v_{LED}					

- c) Using the oscilloscope, look at the voltage over the resistor. Ideally, the output of this configuration would look like the absolute value of a sine wave. What shape is the wave in your circuit? What is the amplitude of the v_R (voltage on the resistor)? Why?

7. Bridge followed by a capacitor in parallel with the resistor:

Now add a capacitor in parallel with the resistor and capture a few cycles of the output signal for different values of a capacitor. Some of the recommended values could be: $1\mu F$ - $10\mu F$
Note: Take extra care when working with larger capacitors, as the deposited charge could be substantial. Take extra care not to touch the capacitor terminals!

REVERSE ENGINEERING PROJECT: THE AC ADAPTER

8. **Purpose:** Analyze a commercial AC adapter by reverse engineering.

Output Observations: Obtain a cheap AC adapter – not a PC power supply, a really cheap one such as those used to run an inexpensive tape recorder or similar.

- a) Observe its output voltage using an oscilloscope.
- b) As a load, connect a power decade resistor box to the output of your AC adapter. Choose a resistance value corresponding to the current rating of your adapter. Observe the output voltage now while under load.

The above are the only measurements you should make on this converter while it is plugged into a power outlet. Do not plug in the converter ever again after you have opened it or removed its case.

Save the screen shot of the output voltage as seen with the oscilloscope, both unloaded and under load. For the adapter with load, measure in both DC and AC modes of the scope (there will be a difference).

“Ripple” is a common specification for AC converters. Define “ripple.”

Reverse Engineering: Open up the AC adapter, identify the circuit elements by basic type (resistor, diode, etc.), and determine how they are connected. Never again plug the converter into a power outlet after opening its case.

Hand-draw circuit schematic. If circuit is very complex, only draw the integral components and explain the rest.

To receive 15 bonus points on this experiment, attach a sheet with explanation how the circuit works. This is a very important circuit that you will learn in the first junior Electronics course (actually, the class will find several variations). You might consult a junior electronics text for explanations.

Remember GTA’s signature!