Name_____ Lab Section_____ Date_____

INTRODUCTION :

In this laboratory the student will investigate the operation of the function generator and the oscilloscope. The Agilent 33120A Function Generator will be used to produce DC and AC time varying waveforms. The GW Instek GDS-2064 Digital Storage Oscilloscope (DSO) will be used to display and measure the waveforms. The Agilent 34401A bench-top DMM will be used to take both voltage and current measurements.

PRELAB:

1. Using PSpice, build the circuit in Figure 1 and run the simulation (F11). The parts needed are: Vdc, r, GND_Earth. To rotate the component use Ctrl-R. Use the V and I buttons to display the voltage and current. Record the DC voltages at the nodes labeled Ch.1, Ch.2, and the current Is in Table 8.1.
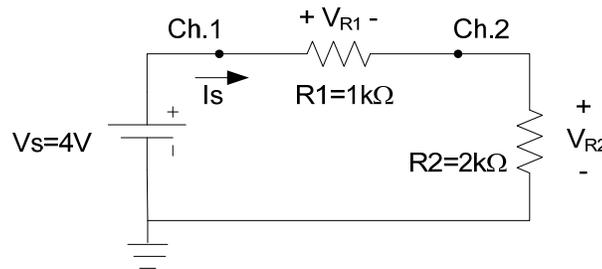
Figure 8.1: DC Series Circuit.

2. Perform a Transient Analysis in PSpice on the circuit in Figure 8.1 by doing the following steps. From the pull down menu select Markers → Mark Voltage/Level (Ctrl+M). Place markers at Ch.1, Ch.2, and GND. Again from the pull down menu select Analysis → Setup → Transient (Check Box). Set the Print Step to 0ns and the Final Time to 1ms. Check the box beside the "Skip initial transient solution". Save the file and run a simulation (F11). A Probe Plot will automatically pop up displaying the voltages at each marker as a function of time. Record the DC voltages at the nodes labeled Ch.1 and Ch.2 in Table 8.1.

3. On the same PSpice schematic beside the previous circuit, build the circuit shown in Figure 8.2. The parts needed are: VSIN, r, GND_Earth. Double-click on the VSIN component and set the DC=0, AC=0, VOFF=0, VAMPL=6, and Freq=1k.
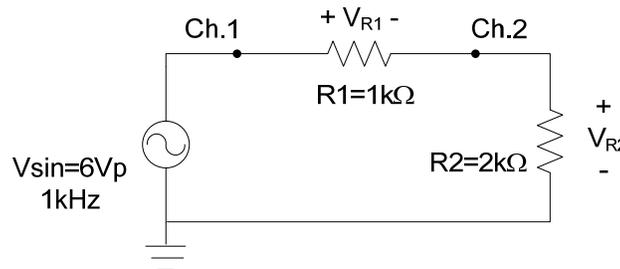
Figure 8.2: AC Series Circuit.

4. Perform a Transient Analysis in PSpice on the circuit in Figure 8.2 by doing the following steps. From the pull down menu select Markers → Mark Voltage/Level (Ctrl+M). Place markers at Ch.1 and Ch.2. Again from the pull down menu select Analysis → Setup → Transient (Check Box). Set the Print Step to 0ns and the Final Time to 1ms. Check the box beside the "Skip initial transient solution". Save the file and run a simulation (F11). A Probe Plot will automatically pop up displaying the voltages at each marker as a function of time. Record the peak voltages at the nodes labeled Ch.1 and Ch.2 in Table 8.1. Return to the schematic where the V and I display buttons should still be pressed. Record the DC voltages at Ch.1 and Ch.2 in Table 8.1. Remove all markers in the PSpice schematic.
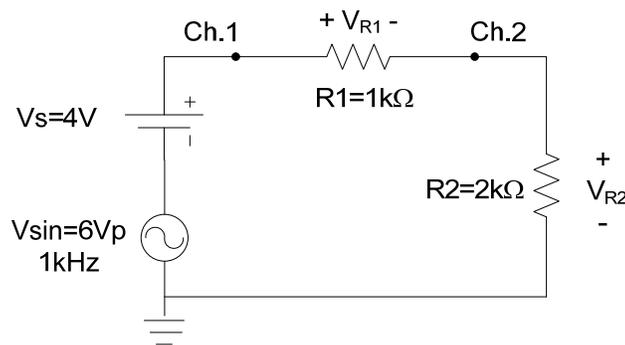
Figure 8.3: AC+DC Series Circuit.

5. On the same PSpice schematic, build the circuit shown in Figure 8.3. (Figures 8.1 and 8.2 should still be intact). Use the same settings as in the previous circuits.

6. Perform a Transient Analysis in PSpice on the circuit in Figure 3 by doing the following steps. From the pull down menu select Markers → Mark Voltage/Level (Ctrl+M). Place markers at Ch.1 and Ch.2. Again from the pull down menu select Analysis → Setup → Transient (Check Box). Set the Print Step to 0ns and the Final Time to 1ms. Check the box beside the "Skip initial transient solution". Save the file and run a simulation (F11). A Probe Plot will automatically pop up displaying the voltages at each marker as a function of time. Record the peak voltages at the nodes labeled Ch.1 and Ch.2 in Table 8.1. Return to the schematic and press the V and I buttons, record the DC values in Table 8.1.

7. Return to the PSpice circuit of Figure 8.2. Double-click on the VSIN component and set the DC=4, AC=0, VOFF=4, VAMPL=6, and Freq=1k. Again place markers at Ch.1 and Ch.2 and run a simulation. Record in Table 1 the peak voltages for each waveform. Return to the schematic and press the V and I buttons. Record the DC values in Table1. How do the waveforms of Figure 8.2 with DC=4 compare to the waveforms of the circuit with AC and DC sources in Figure 8.3?

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8. Save the PSpice schematics to your flash drive.

PROCEDURE:

1. Construct the circuit shown in Figure 8.1.

2. Use an Agilent E3612A Power Supply as the DC source voltage in Figure 8.1. Accurately set the voltage to 4.0V and confirm the source voltage value using a digital multimeter.

3. Use the multimeter to measure the voltages across each resistor and each of the node voltages. Record the results in Table 8.2.

4. Use the multimeter to measure the series current flowing in the circuit. Record the result in Table 8.2.

5. Identify the GW Instek GDS-2064 Digital Storage Oscilloscope (DSO) at your lab station. The four silver connectors at the bottom right are BNC connectors. Get two BNC-to-Alligator (scope) cables from the cable holders at the end of the lab bench. The BNC-to-Alligator cable will be referred to as a 1-to-1 probe because it does not scale the voltage measurement.

6. Connect the BNC connector of one scope cable to CH1 on the scope. Connect the red alligator clip of that scope cable to the node labeled Ch.1 on the circuit of Figure 8.1 and connect the black alligator clip of the cable to the circuit ground.

7. Use a second scope cable to connect CH2 of the scope to the Ch.2 and ground nodes of the circuit.

8. Press the **ON/STBY** button to turn on the scope. Once the scope has booted-up, press the yellow-lighted **CH1** button. On the screen, a grey softmenu option will pop up.

9. Press the **F1** key repeatedly until the DC symbol $\overline{-----}$ is shown. Press the **F4** key repeatedly until the Probe setting is x1. The setting x1 matches the BNC-to-Alligator cable to the voltage scaling ratio of 1-to-1. Both the Invert and BW Limit options should be off.

10. Press the blue-lighted **CH2** button and set up CH2 with the same settings as CH1.

11. Press the blue **Auto Set** button to the lower right of the power button. This causes the DSO to search for the signals on both channels. The yellow and blue lighted CH1 and CH2 buttons should be on. On the screen should be displayed two horizontal lines: the top line is the yellow CH1 trace and the bottom line is the blue CH2 trace.

12. Rotate the **VOLT/DIV** knob below the CH1 so that the display setting in the lower left of the screen is set at CH1 $\overline{-----}$ 2V. Likewise, set CH2 to the same 2V per division setting. If either or both horizontal trace lines have disappeared, use the **POSITION** knobs above the lighted CH1 and CH2 buttons to find the traces.

    For example: Rotate the CH1 **POSITION** knob so that the Position (1)=0.00V is displayed in the lower left of the screen. Do the same for the CH2 trace. The 1 and 2 arrows on the left side of the screen will overlap in the center of the display

13. Count the vertical square grid divisions from the center horizontal grid where the 1 and 2 arrows overlap to each of the CH1 and CH2 traces. Multiply the total divisions for each trace by the 2V/division setting to determine the voltage. Record your results in Table 8.3.

14. Press the **Cursor** button to the right of the power button. On the right of the screen is a gray pop up menu with the title of CURSOR at the top. Cycle the **F1** key so that the Source is CH1. Cycle the **F3** Vertical key so that the lower line is solid and the upper line is dashed.

15. Use the **VARIABLE** knob just below the power button to move the lower cursor line to the center grid of the screen. Doing so will display **V₂:0.00V** in the lower right of the screen.

16. Cycle the **F3** key again so the top line is now solid and the lower line is dashed. Adjust the **VARIABLE** knob so the upper cursor line is centered in the yellow CH1 horizontal trace.

17. The voltage level of the upper cursor (compared to that of the lower cursor) will be displayed in the lower right of the screen. Record your measurement in Table 8.4.

18. Cycle the **F1** key to CH2 and repeat the cursor measurement of the blue horizontal CH2 trace. Record your measurement in Table 8.4.

19. Turn OFF the DC power supply. Remove DC power supply from the circuit and replace it want an Agilent 33120A (or 33220A) Function Generator. You will need to utilize another BNC-to-Alligator cable that is connected to the BNC terminal on the far right of the function generator labeled "**Output**". Note that the oscilloscope leads should still be connected to the circuit.

20. Press the power button on the function generator to turn it on. Once the generator has booted-up, press the **Utility** button on the bottom row in the center of the device.

21. Press the blue softkey under the **Output Setup** option that is displayed on the screen. Press the blue softkey on the far left of the screen to switch to **High Z**. Then press **DONE**. (Note that each time the function generator's power is cycled off/on, this process must be repeated)

22. Press the **Sine** button to the right of the power button. The frequency should be set to 1 kHz by default. If not, press the blue softkey on the left of the screen to highlight **Freq.** and enter "1" (using the numeric key pad) so 1 kHz is displayed on the blue softkey.

23. Set the amplitude of the sine wave by highlighting **Ampl** using the second blue softkey. On the numeric key pad press "**1**" "**2**" followed by the blue softkey **Vpp** to set the voltage to 12Vpp, which provides the required 6Vp shown in Figure 8.2.

24. Press the **Output** button on the generator to activate or "turn-on" the generator's output (i.e. – to send the sine wave signal to the circuit).

25. On the scope, press the blue **Auto Set** button. Both CH1 and CH2 traces should be displayed on the screen. Use the **POSITION** knobs to adjust the traces towards the center of the screen so that each Position(CHx)=0.00V. Also adjust the **VOLTS/DIV** to **2V** for each channel.

26. Count the vertical divisions on the screen for each waveform to determine the peak-to-peak voltage. Record the voltages in Table 8.5. Using a USB flash drive, save the screen image by pressing **Save/Recall** → **Save Waveform (F4)** → **Save Waveform (F1)** → **Destination USB (F3)**.

27. Since the oscilloscope only measures voltages, determine a method to measure the series-current using the oscilloscope and record the value in Table 8.5.

28. Use a multimeter to measure the AC voltages at each node along with the AC series current. Record the values in Table 8.6.

29. Press the **Measure** button right beside the Cursor button. In the gray pop up menu area MEASURE should be displayed. Press the **F1** key repeatedly to select CH 1. Press the **F2** key repeatedly to select CH 2. Press the **F3** key repeatedly to select Voltage. Press the **F4** key repeatedly to measure Vpp. Then press **F5** to go back to the Previous Menu.

30. Press the **F2** button and repeat the process so that Vamp is selected, and then press **F5** to go back.

31. Press the **F3** button and repeat the process so that Vrms is selected, and then press **F5** to go back.

32. Press the **Run/Stop** button just below the blue Auto Set and the screen will freeze at that time instant. Record in Table 8.7 the voltages displayed. Press the **Run/Stop** button again and the scope will go back to the Run mode.

33. Adjust the function generator so that it has a 4V DC offset by pressing the blue softkey and highlighting the **Offset** selection. Press "**4**" on the keypad followed by V_{DC}. Using a USB flash drive, save the screen image. Measure by any method above the peak-to-peak voltages, the DC offset, and the RMS voltages. Record the values in Table 8.8.

34. Use the multimeter to measure the AC and DC voltages of the circuit in Step 10 along with the AC and DC currents. Record the values in Table 8.9. This steps completes the procedure.

REPORT GUIDE:

1. Discuss any differences between the calculated and measured results.

Table 8.1: Prelab PSpice Values

Prelab Step	DC Values			AC Values			
	$V_{Ch.1}$	$V_{Ch.2}$	I_S	$V_{Ch.1}$ Upper Peak	$V_{Ch.1}$ Lower Peak	$V_{Ch.2}$ Upper Peak	$V_{Ch.2}$ Lower Peak
Step 1				----	----	----	----
Step 2				----	----	----	----
Step 4							
Step 6							
Step 7							

Table 8.2: DC Series Circuit Measured Values using Multimeter

	$V_{Ch.1}$	$V_{Ch.2}$	V_{R1}	V_{R2}	I_S
Measured					

Table 8.3: DC Series Circuit Measured Values using Scope by Divisions

	$V_{Ch.1}$	$V_{Ch.2}$	V_{R1}	V_{R2} (Same as Ch.2)	I_S (Calculated)
Measured					

Table 8.4: DC Series Circuit Measured Values using Scope and Cursors

	$V_{Ch.1}$	$V_{Ch.2}$	V_{R1}	V_{R2} (Same as Ch.2)	I_S (Calculated)
Measured					

Table 8.5: AC Series Circuit Measured Values using Scope

	$V_{Ch.1}$ Upper Peak	$V_{Ch.1}$ Lower Peak	$V_{Ch.2}$ Upper Peak	$V_{Ch.2}$ Lower Peak	I_S (Calculated)
Measured					

Table 8.6: AC Series Circuit Measured Values using Multimeter

	$V_{Ch.1}$	$V_{Ch.2}$	V_{R1}	V_{R2}	I_S
Measured					

Table 8.7: AC Series Circuit Measured Values using Scope with Measure Button

	$V_{Ch.1}$	$V_{Ch.2}$	V_{R1}	V_{R2}	I_S
Measured					

Table 8.8: DC+AC Series Circuit Measured Values using Scope

	$V_{Ch.1}$	$V_{Ch.2}$	V_{R1}	V_{R2}	I_S
Measured					

Table 8.9: DC+AC Series Circuit Measured Values using Multimeter

	DC Values			AC Values		
	$V_{Ch.1}$	$V_{Ch.2}$	I_S	$V_{Ch.1}$	$V_{Ch.2}$	I_S
Measured						

Approved by: _____   Date: _____