Lab 1

Introduction to laboratory equipment

Objective

- Gain hands-on experience with basic laboratory equipment used in electrical engineering.
- Learn how to measure voltage, current, and resistance using a Digital Multimeter (DMM).
- Practice using a DC power supply, function generator, oscilloscope, and breadboard.
- Understand the process of verifying output from lab instruments and interpreting real measurements.

Introduction

This lab introduces essential tools and methods for working with electronic circuits in a lab environment. Students are exposed to solderless breadboards, DMMs, power supplies, function generators, and oscilloscopes. They learn how to properly connect and use these instruments to build, test, and measure various circuit components and behaviors. This lab emphasizes safety, accurate data collection, and good engineering practices such as resetting instruments after use and confirming measurements with multiple methods.

Equipment Used

- Breadboard (solderless)
- Digital Multimeter (Fluke 87 or similar)
- DC Power Supply (Agilent E3630A)
- Function Generator
- Oscilloscope
- Jumper Wires and Alligator Clips
- Various Resistors (for measurement tasks)
- IC555 and IC741 for circuit implementation

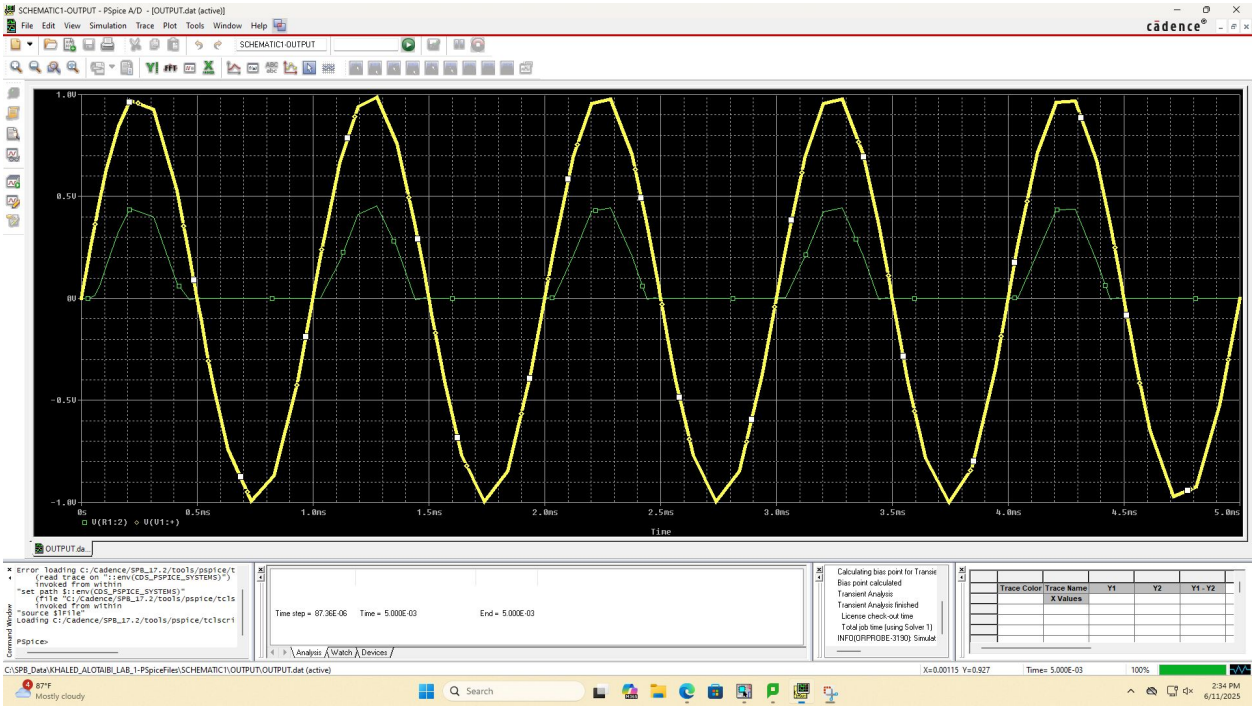
Experiment (Tasks)

Part 1 – Resistance Measurement

- Measured five different resistors using DMM.
- Compared measured values to color code (nominal) values.
- Verified meter accuracy by shorting leads.

Part 2 – Power Supply Verification

- Verified voltage output of +6V, +20V, and -20V terminals.
- Recorded minimum and maximum voltages using the DMM.



Part 3 – Software: PSpice Simulation

- Identified components like 2N222, AD741, and D1N4153.
- Simulated a basic diode rectifier circuit and then added a 1uF capacitor.
- Ran transient analysis and captured voltage waveforms.
- Observed ripple voltage and rectification behavior.

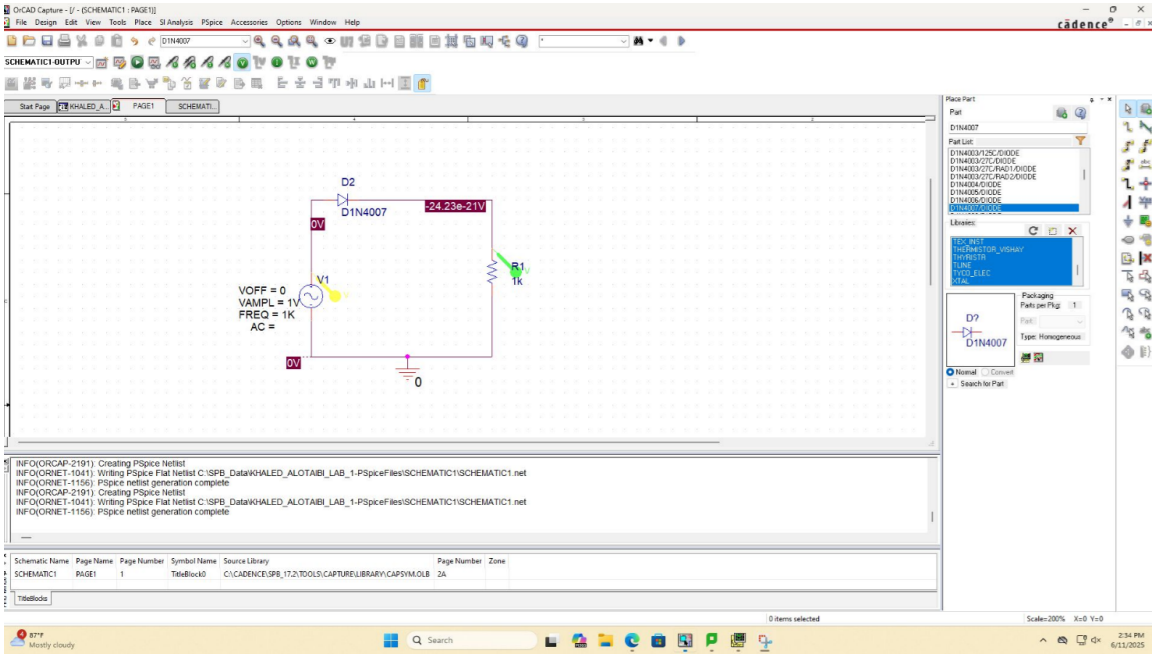


Figure 1. Basic diode rectifier

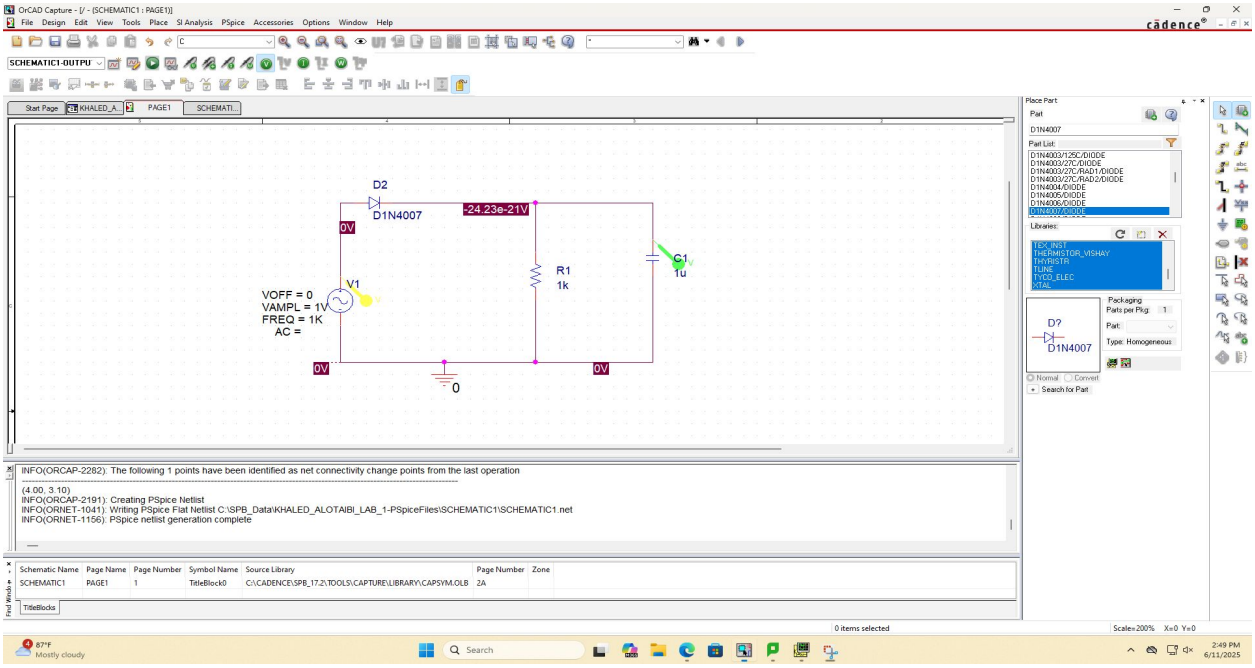
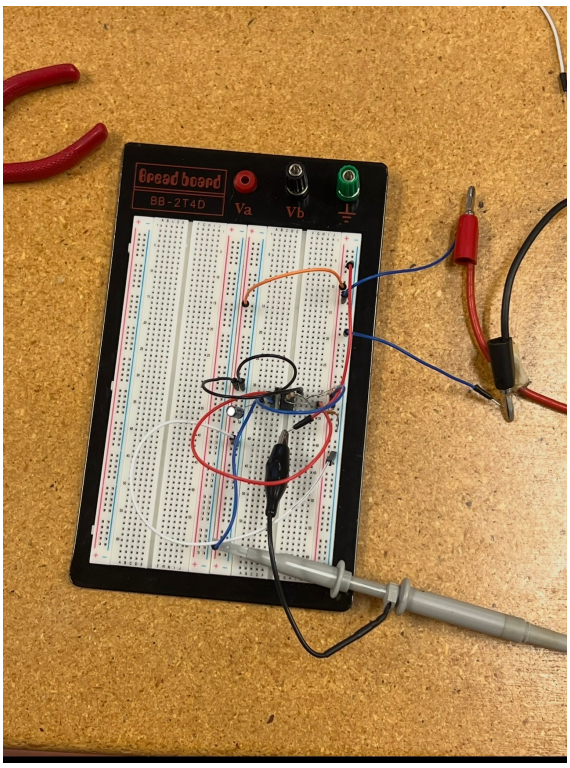
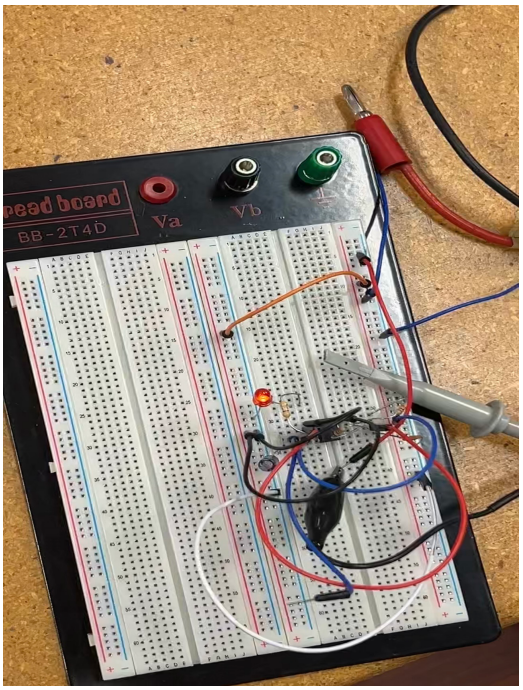
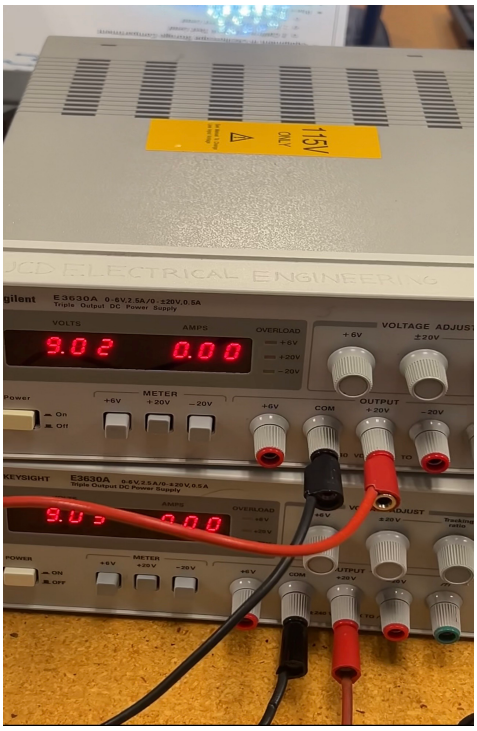


Figure 2. Diode rectifier with capacitor




STATION #15
KEYSIGHT
InfiniiVision DSOX3024A
Digital Storage Oscilloscope
200 MHz
4 GSa/s
Channel 2 Menu


Va
Vb



Part 4 – Square Wave Generator (NE555)

- Built a square wave generator circuit using NE555.
- Calculated T1 and T2 using provided formulas.
- Connected an LED with a resistor to verify output visually.
- Used oscilloscope to view waveform and adjust settings.

Part 5 – Inverting Amplifier (Op-Amp 741)

- Constructed an inverting amplifier on a breadboard.
- Verified phase inversion and gain using oscilloscope.
- Used function generator for input and measured output signal properties.
- Compared theoretical gain (Av = -R2/R1 * Vin) with actual output.

Data and Analysis

Task 1: Resistance Measurement Table

Color code	Nominal	Measure value	Tolerance %	% diff
Red, black, brown, gold	200	196.2	5%	1.9
Brown, blue, yellow, gold	160k	159.7k	5%	0.63

Brown, green, gold, gold	1.5	2.1	5%	40
Red, blue, brown, gold	260	259.6	5%	0.153

Task 2: Power Supply Output

Power supply	Maximum output	Minimum output
+6V	6.96	6.94
+20V	23.23	23.2
-20V	-22.8	-22.76

Task 3: PSpice Observations

- With only diode: Half-wave output observed.
- With capacitor: Output becomes smoother with reduced ripple.
- Application: Filtering in power supplies.

Task 4: 555 Circuit

- Measured waveform frequency matched calculated T1 and T2.
- LED blinked visibly with 470Ω resistor and red LED.
- Circuit acted as a basic astable multivibrator.

$$R_1 = 1k\ ohms, R_2 = 4.7k\ ohms, C = 10uF$$

$$T_1 = 0.693 * (R_1 + R_2) * C$$

$$T_1 = 0.693 * (1000 + 4700) * 10 * 10^{-6}$$

$$T_1 = 0.39501\ s$$

$$T_2 = 0.032571$$

$$T = 0.4276$$

$$f = 2.34Hz$$

Questions:

1. List all the pin function/names for the IC 555 used from the data sheet.

Pin no	Function
1	GND
2	Trigger
3	Output
4	Reset
5	Control voltage
6	Threshold
7	Discharge
8	Vcc (power)

2. From the data sheet, write all the values for the following Electrical Characteristics:

Supply Voltage: 4.5V to 16V

Input Voltage: 0V to Vcc

Output Current: 200 mA max

Operating Temperature: 0°C to 70°C (commercial) or -40°C to 125°C (industrial)

3. What is the name/type of the circuit we have implemented other than the name "Square Wave Generator"?

This circuit is also known as an Astable Multivibrator.

4. What will happen if we attach a resistor of 470Ω and a red LED in series to the output terminal? Explain your output in detail.

The LED will blink on and off as the output toggles between high and low. The 470Ω resistor limits current to a safe level (~20mA) to prevent damage to the LED. When the output is high (~Vcc), current flows through the LED-resistor combo, lighting it. When low, the LED turns off.

Task 5: Op-Amp Circuit

- Input: 1Vpp, 100Hz sine wave.
- Output: Inverted sine wave, ~5× gain observed.
- Phase shift: 180°, as expected from an inverting amplifier.

$$A_v = -\frac{R_2}{R_1}$$

$$V_{out} = A_v * V_{in}$$

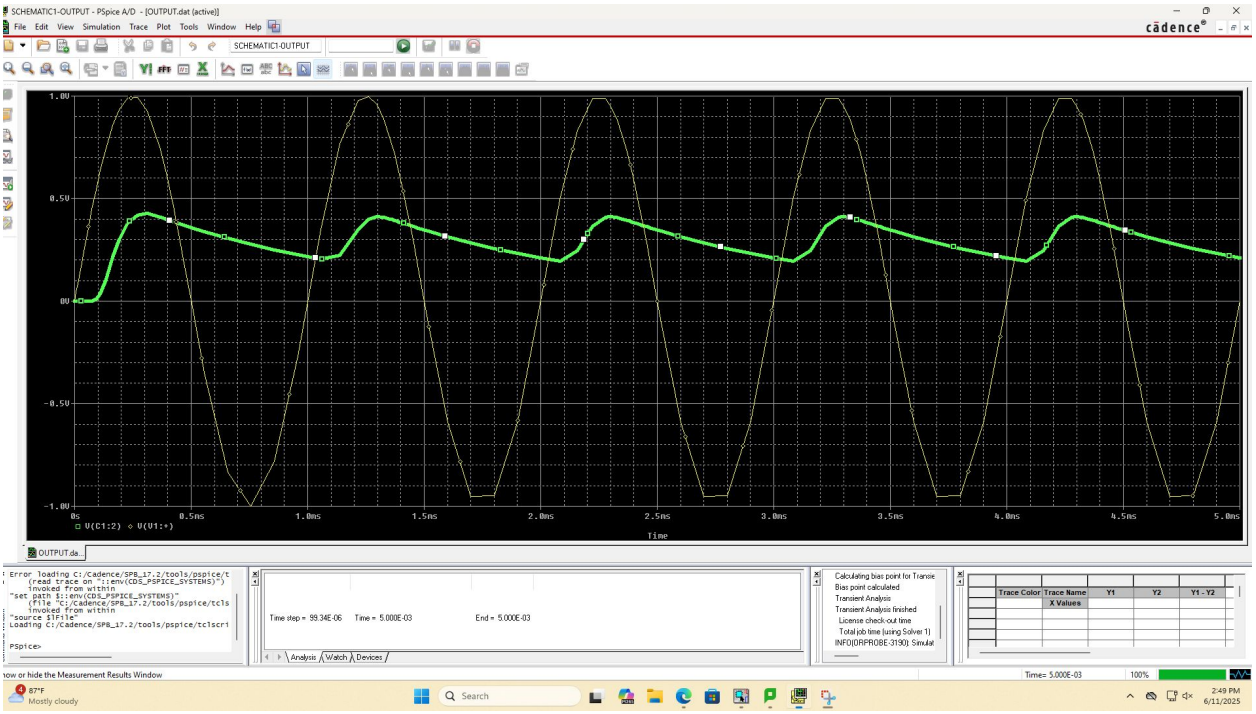
$$R_1 = 1k\ ohms, R_2 = 4.7k\ ohms, V_{in} = 0.5V_{pp}$$

$$A_v = -\frac{4700}{1000}$$

$$A_v = -4.7$$

$$V_{out} = -4.7 * 0.5$$

$$V_{out} = -2.35V_{pp}$$



Questions:

1. List all the pin function/names for the IC 741 used from the data sheet:

Pin no	Function
1	Offset NULL
2	Inverting input
3	Non-inverting input
4	V-
5	Offset NULL
6	Output
7	V+
8	Not connect

2. From the data sheet, write all the values for the following Electrical Characteristics:

Supply Voltage: ±15V typical

Input Voltage Range: ±13V max

Output Current: 25 mA typical

Operating Temperature: 0°C to 70°C

3. Write down the values of the input and output waveform from the oscilloscope. Also, write the theoretical values you obtain from the formula used. Explain in detail, the difference between both the values.

Input voltage: 1V

Theoretical gain: $A_V = -\frac{R_2}{R_1} = -\frac{4.7k}{1k} = -4.7$

Theoretical output: -4.7*1=-4.7

Measured Output (from scope): ~ -4.5V (slight drop due to real component tolerance)

Difference Explanation: Minor differences due to resistor tolerance, op-amp internal limitations, and slight voltage drops.

4. Compare the phase of the output signal to the input signal. What do you observe, and why?

The output signal is 180° out of phase with the input. This is expected in an inverting amplifier, where the output waveform flips relative to the input.

Results

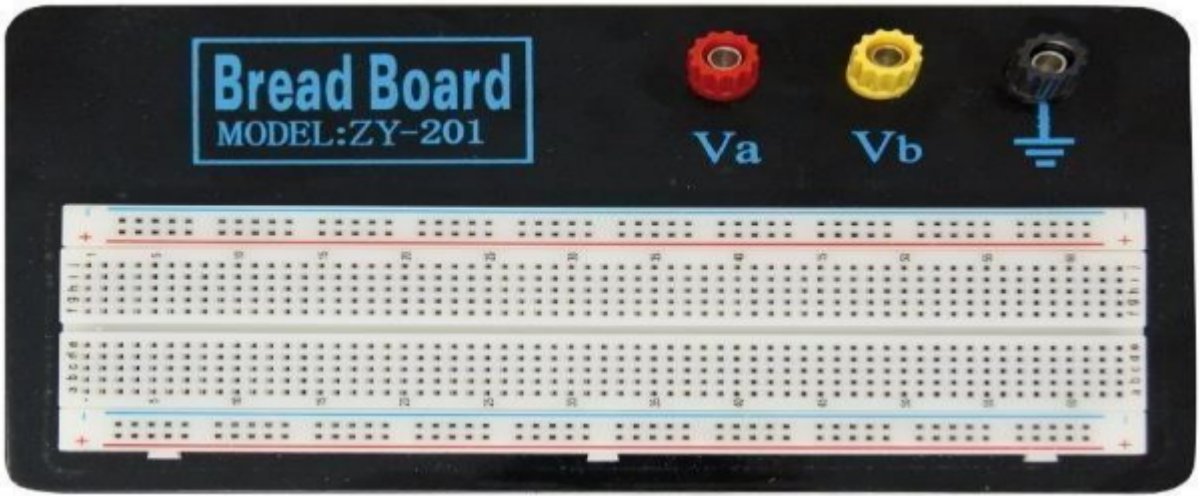
- All instruments functioned as expected.
- Resistance measurements were within tolerance.
- Power supply voltages were adjustable and matched specs.
- PSpice simulations confirmed theoretical behavior.
- The 555 timer generated a proper square wave output.
- The Op-Amp circuit inverted the input and showed correct gain and phase shift.

Conclusion

This lab provided a strong foundation in using key lab instruments for circuit building and measurement. Students successfully measured electrical parameters, verified equipment operation, and analyzed signal behavior both practically and through simulation. The hands-on activities reinforced theoretical knowledge, ensuring better preparedness for advanced labs. Proper use of DMMs, oscilloscopes, and simulation tools like PSpice was achieved, along with safe and effective circuit prototyping on breadboards.

Appendix:

Breadboard:



Alligator clips: