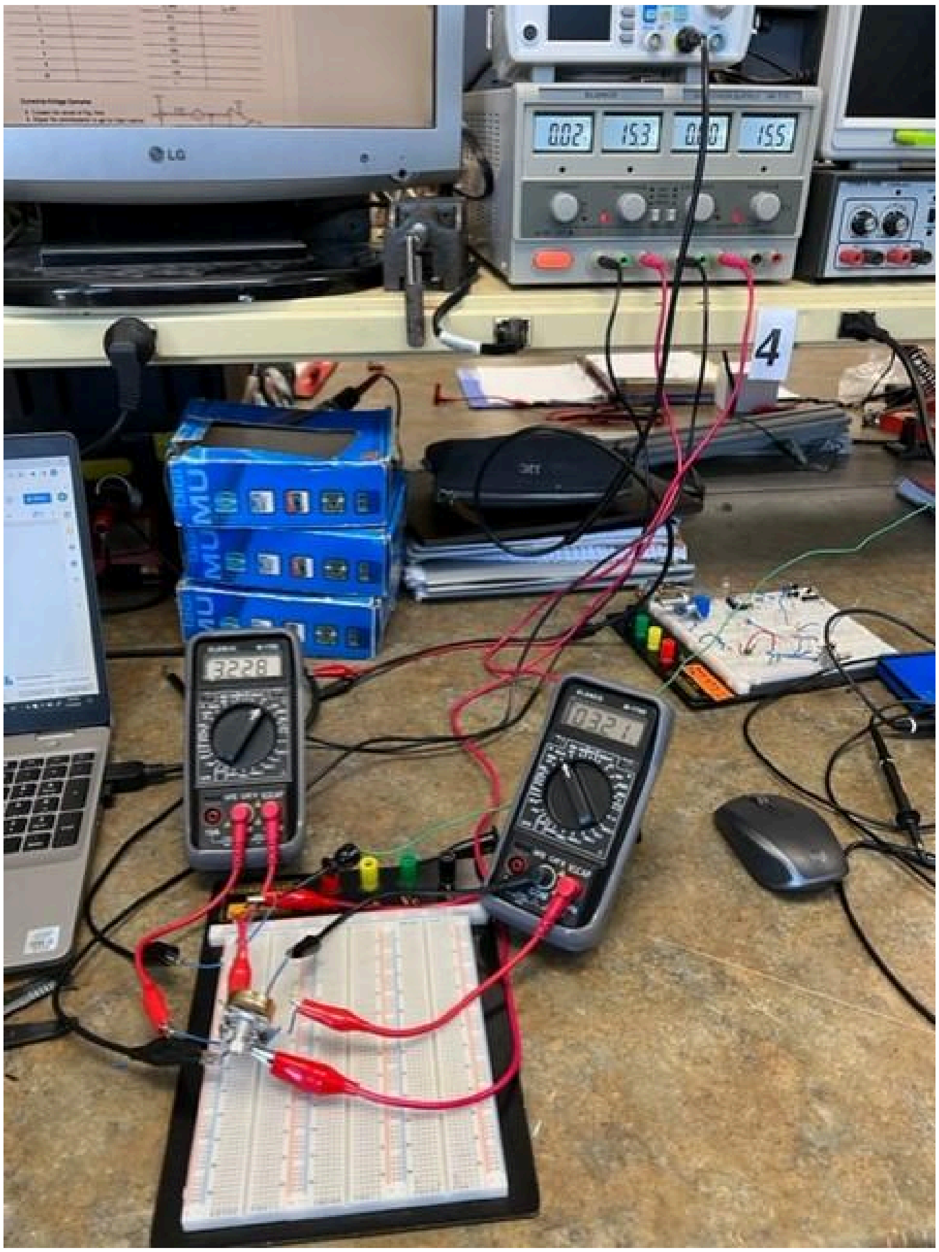
Experiment 30- OP Amp Basic Circuits



By: Jason Cardente, Sidney Laden, Aidan McGrail, Colin Medeiros, and Henry Warfield

4/5/22

Objectives:

- To test a voltage-to-current converter
- To test a current-to-voltage converter
- To test a current amplifier

Materials Required:

- Oscilloscope
- Dual power supply
- Sine-wave generator
- Digital multimeter
- 2 1-kΩ resistors
- 2 10-kΩ resistors
- 1-kΩ potentiometer
- 741C Semiconductor

Procedure:

1. We constructed the circuit shown in figure 30-1
2. We adjusted the potentiometer until we got an input voltage of 1
3. We read the output current from the ammeter and recorded the data in table 30-1
4. We repeated this process for every voltage in table 30-1 and recorded the currents in the table

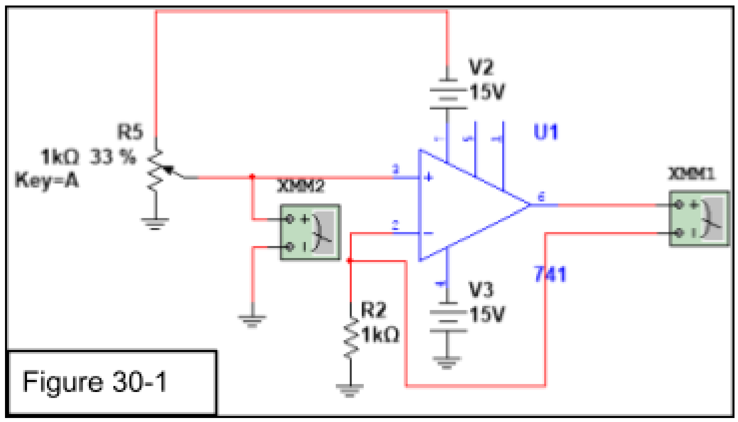


Figure 30-1

V_{in}, V	I_{Out}, mA
1	1.048
2	2.025
3	3.000
4	4.051
6	6.052
8	8.029
10	10.053

Table 30-1M

V_{in}, V	I_{Out}, mA
1	0.985
2	1.980
3	2.990
4	3.900
6	6.280
8	7.970
10	9.980

Table 30-1B

5. We constructed the circuit shown in figure 30-2
6. We adjusted the potentiometer until we got 1 mA of input current
7. We then measured the voltage on the output and recorded the value in table 30-2
8. We repeated this process for every input current in the table and recorded the output voltage in table 30-2.

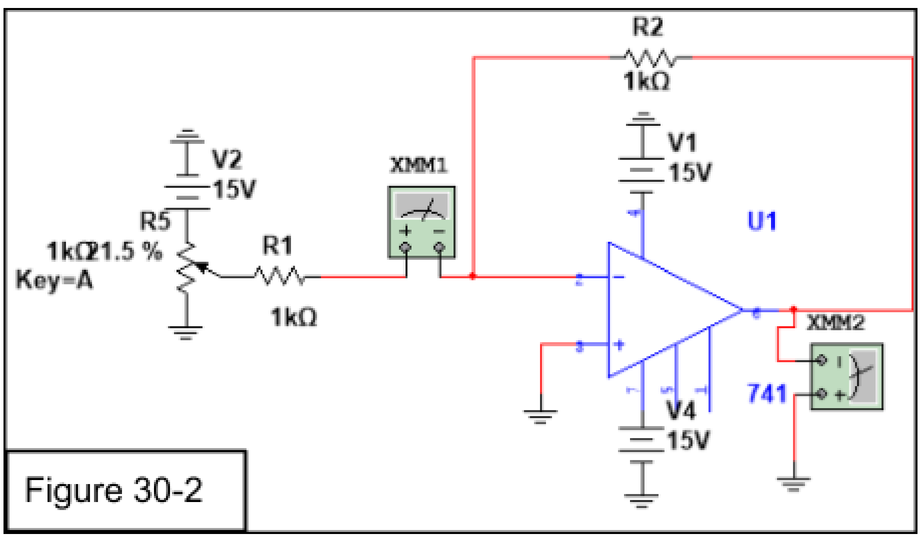


Figure 30-2

I_{in}, mA	V_{Out}, V
1	1.050
2	2.054
3	3.043
4	4.053
6	6.058
8	8.012
10	10.073

Table 30-2M

I_{in}, mA	V_{Out}, V
1	0.98
2	1.96
3	2.94
4	3.92
6	5.91
8	7.83
10	9.79

Table 30-2B

9. We constructed the circuit shown in figure 30-3.
10. We adjusted the potentiometer until we got an input current of 0.1 mA
11. We then recorded the output current in table 30-3, and repeated this process for all the input currents on the table.

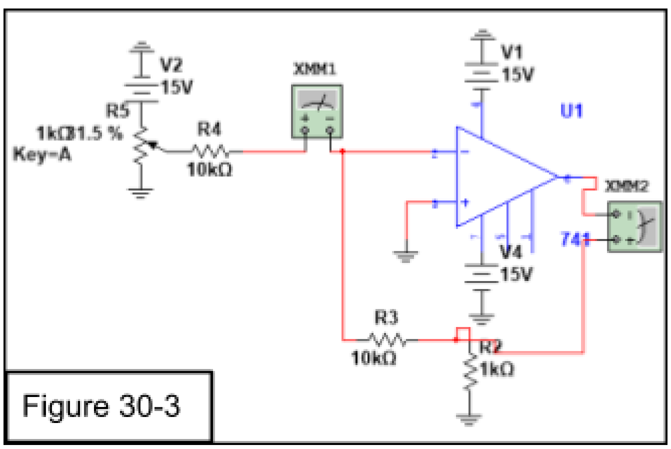


Figure 30-3

I_{in}, mA	I_{out}, mA
0.1	1.145
0.2	2.199
0.3	3.325
0.4	4.366
0.6	6.682
0.8	8.853
1	11.061

Table 30-3M

I_{in}, mA	I_{out}, mA
0.1	1.9
0.2	2.9
0.3	3.9
0.4	5.1
0.6	7.1
0.8	9.3
1	11.2

Table 30-3B

Observations:

1. *Ideally, the currents in Table 30-1 should be 1, 2, 3, 4, 6, 8, and 10 mA. Give three reasons why the measured currents were different.*
    a. The most plausible reasons for why the measured currents were different are because of the slight current outputs inside of the op amp, the tolerance of the resistors, and imperfect resistances of the potentiometer.

2. *After removing the potentiometer and voltmeter at the input of Figure 30-1, the circuit that remains can be used as an electronic voltmeter. Why is this true?*
    a. The remaining circuit can be used as an electronic voltmeter because with the removal of the voltmeter and potentiometer on the input, we can

replace the ammeter on the end with a current driven gauge. Each different input voltage will produce a different amount of current from the OP-Amp which can drive the gauge to different places and be used to measure voltage.

3. *Suppose we want 1 V to produce 2 mA of current in Figure 30-1. What change can we make?*
    a. If we place a 2k-ohm resistor between the negative end of the ammeter and the inverting input, we can change the gain to a factor of 2 which will result in 2 mA out at 1v instead of 1mA.

4. *In Figure 30-2, what is the ideal value of output voltage when the input current is 5mA?*
    a. The ideal value of output voltage when the input current is 5mA is 5V . This can be found using the equation $V_{out} = I_{in} * 10$ which can be synthesized from the data in table 30-2.

5. *After removing the potentiometer, 1kOhm resistor, and ammeter from the input of Figure 30-2, the converter acts like an electronic ammeter. Why is this true?*
    a. The converter acts like an ammeter because once you remove these components the OP-Amp will output a specific amount of voltage for each amount of current which allows us to figure out the current based on the input vs output ratio.

6. *What change can we make in Figure 30-2 to get an output voltage of 2V when the input current is 1mA?*
    a. To get an output voltage of 2V at an input current of 1mA we would need to change R2 to be worth 2kOhm instead of 1kOhm which would increase the gain of the circuit so that the output voltage would double.

7. *What is the theoretical current gain in Figure 30-3?*
    a. The theoretical current gain in Figure 30-3 is 11. This can be found by doing I_{out}/I_{In} and an example is in table 30-3 when we had an input current of 1 mA and an output current of 11 mA so we did 11/1 to get a gain of 11.

8. *What is the current gain in Table 30-3 for an input current of 4mA*
    a. The current gain in Table 30-3 for an input current of 4mA is 44mA because we figured out that the theoretical gain would be 11 so if it was measured it would be around 44mA.

Discussion:

Problem: *We smelled and saw smoking around our circuit leading to us immediately shutting the power off.*

Troubleshooting: We started by checking our multimeter fuses to see if they were blown and after coming up with no problems, checked the edges of other components to see if they were damaged. Next we used our multimeters to value check each individual component, excluding the chip. Finally, to test the chip we set up a basic op amp circuit with a signal flowing into the inverting input and observed the output on the oscilloscope. We found the op amp was damaged and produced a distorted signal so we checked our circuits wiring to see if we may have miswired a component.

Solution: We identified that we had set our circuit up incorrectly due to the op amp chip being reversed, meaning we had connections set to the wrong pins. We borrowed a new op amp 348-chip from another group, however this also meant that our values changed. With the new chip, the values measured on the breadboard had lower rates and values compared to that of the previous chip.

Conclusion:

To test a voltage-to-current converter

- We tested a voltage-to-current converter in **Table 30-1** using **circuit 30-1** we were able to see that at each input voltage we were able to obtain a direct relationship of mA on the output where at an input of **1V** we saw an output current of **1mA** and with an input of **2V** we saw an output of **2mA**

To test a current-to-voltage converter

- We tested a current-to-voltage converter in **Tables 30-2** using **circuit 30-2** we were able to see that an input voltage in mA directly resulted in an output voltage in volts. This can be seen with an input current of **1mA** resulting in an output voltage of **1V** and another input current of **2mA** resulting in an output voltage of **2V**.

To test a current amplifier

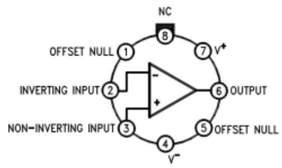
- We were able to test an op amp current amplifier in **Table 30-3M** using **circuit 30-3** when we were able to measure a current gain of **11** for each input and output current, for example, with a input current of **1mA** we obtained an output current of about **11mA**, and with an input current of **.3mA** we obtained an output current of about **3.3mA**

Datasheet:

741C:

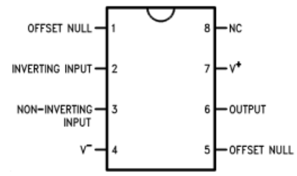
5 Pin Configuration and Functions

LMC Package
8-Pin TO-99
Top View



LM741H is available per JM38510/10101

NAB Package
8-Pin CDIP or PDIP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, should be left floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V–	4	I	Negative supply voltage

LM741
SNOSC25D – MAY 1998 – REVISED OCTOBER 2015 www.ti.com

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[(1)(2)(3)]

		MIN	MAX	UNIT
Supply voltage	LM741, LM741A		±22	V
	LM741C		±18	
Power dissipation [(4)]			500	mW
Differential input voltage			±30	V
Input voltage [(5)]			±15	V
Output short circuit duration		Continuous		
Operating temperature	LM741, LM741A	–50	125	°C
	LM741C	0	70	
Junction temperature	LM741, LM741A		150	°C
	LM741C		100	
Soldering information	PDIP package (10 seconds)		260	°C
	CDIP or TO-99 package (10 seconds)		300	°C
Storage temperature, T_{stg}		–65	150	°C

6.5 Electrical Characteristics, LM741[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		$R_S \le 10\ k\Omega$	$T_A = 25°C$		1	5	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			6	mV
Input offset voltage adjustment range		$T_A = 25°C$, $V_S = \pm 20\ V$			±15		mV
Input offset current		$T_A = 25°C$			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$			85	500	
Input bias current		$T_A = 25°C$			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				1.5	µA
Input resistance		$T_A = 25°C$, $V_S = \pm 20\ V$		0.3	2		MΩ
Input voltage range		$T_{AMIN} \le T_A \le T_{AMAX}$		±12	±13		V
Large signal voltage gain		$V_S = \pm 15\ V$, $V_O = \pm 10\ V$, $R_L \ge 2\ k\Omega$	$T_A = 25°C$	50	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	25			
Output voltage swing		$V_S = \pm 15\ V$	$R_L \ge 10\ k\Omega$	±12	±14		V
			$R_L \ge 2\ k\Omega$	±10	±13		
Output short circuit current		$T_A = 25°C$			25		mA
Common-mode rejection ratio		$R_S \le 10\ \Omega$, $V_{CM} = \pm 12\ V$, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		$V_S = \pm 20\ V$ to $V_S = \pm 5\ V$, $R_S \le 10\ \Omega$, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	$T_A = 25°C$, unity gain			0.3		µs
	Overshoot				5%		
Slew rate		$T_A = 25°C$, unity gain			0.5		V/µs
Supply current		$T_A = 25°C$			1.7	2.8	mA
Power consumption		$V_S = \pm 15\ V$	$T_A = 25°C$		50	85	mW
			$T_A = T_{AMIN}$		60	100	
			$T_A = T_{AMAX}$		45	75	