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Electric Circuit Experiments

2020380029

RAIHAN MD RAKIBUL ISLAM

ELECTRIC CIRCUIT EXPERIMENTS

Preview 02

Superposition theorem and homogeneity theorem

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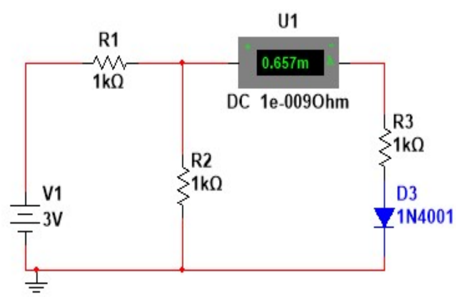
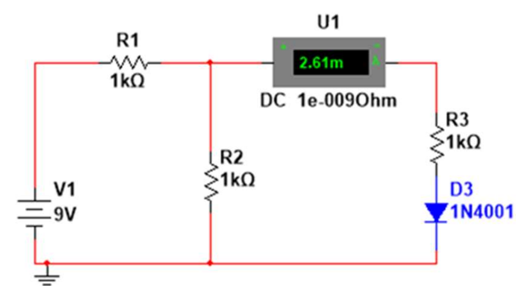
1. Under what condition does the homogeneity theorem not hold true?
Describe two possibilities:
1) we need to replace element
2) we don't need to replace elements to satisfy homogeneity, design an experiment to prove that.

Answer:

Under non liner condition homogeneity theorem does not hold true.

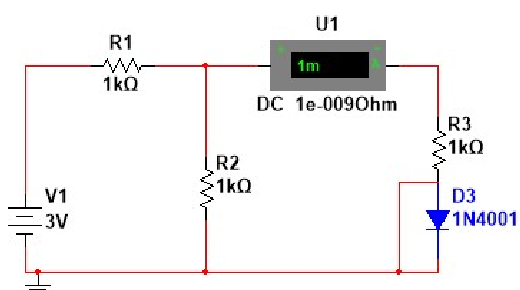
1. We need to change the non-linear element (in this case, it's a diode) with something that is linear.

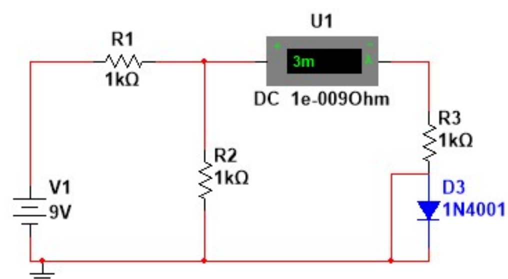




From the circuits above it is evident that if we use nonlinear item in the circuit the current flow will not be linear even though we change the source voltage source.
Here we change the voltage source 3times but the current flow doesn't change 3times.
One way to make the circuit linear is to replace the non-linear item (the diode).

2. We can also make the same circuit linear by shorting the diode without replacing it.

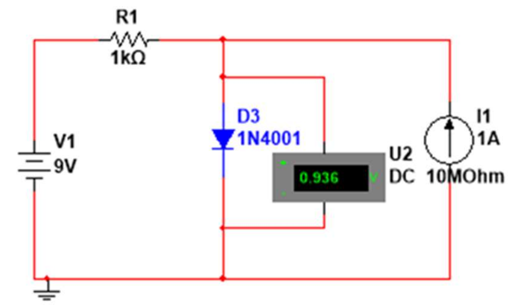


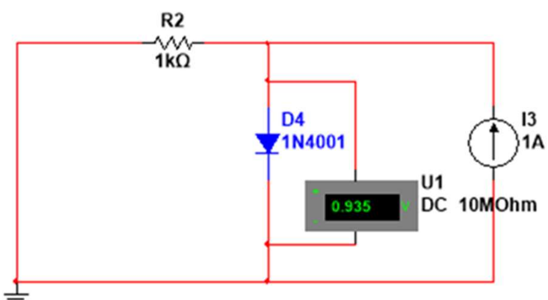


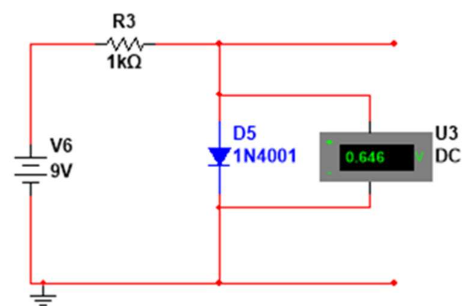
From the circuit above we can see shorting the diode changes the nonlinear circuit into a linear circuit; no need to replace element. As the current flowing through the R_3 has become directly proportional to the source voltage.

2. Under what condition does the superposition theorem not hold true?
Describe two possibilities:
1) we need to replace element
2) we don't need to replace elements to satisfy homogeneity, design an experiment to prove that.

Answer: *Super position theorem doesn't work on nonlinear circuit.*







If we sum up the last two circuit's voltage, it doesn't equal to the 1st circuit's voltage.

3. List the reasons of the inaccuracy of the experiment data. How to guarantee the accuracy of experiment? Elaborate your methods and use them in your design.

 # The reasons of the inaccuracy of the experiment data:
Common causes of errors include equipment, environment, procedures, and personnel. All of these errors can occur randomly or systematically, depending on their impact on the results. If the equipment used is inaccurate, such as when the balance is not working, an equipment error will occur.

 # Guarantee the accuracy of experiment:
1. Compare the measured value with the expected value of a single measurement theory.
2. Compare the tolerance of the final experimental result with the overall experimental result.

Elaborate my methods and use them in my design: Unfortunately, I don't know the how can I express it.

ELECTRIC CIRCUIT EXPERIMENTS

Preview 03

Power Source Transformation and Equivalent Power Source Theorem

Design a circuit to test the voltage-current relation of 1KΩ resistor.

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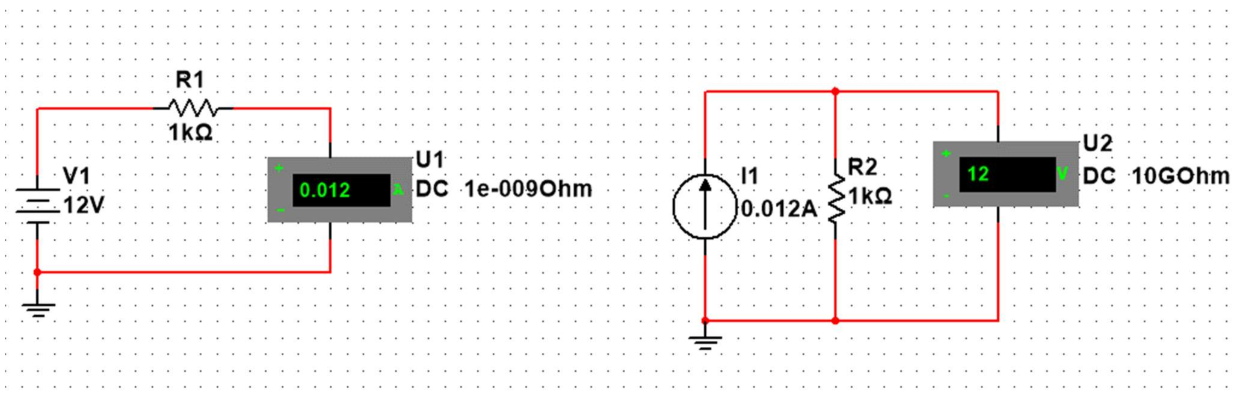
Experiment principle:

A source transformation is the process of replacing a voltage source in series with a resistor by a current source is in parallel with a resistor, or vice versa.

The objective of this experiment is to prove that this source transformation indeed works. The equivalent resistance and short circuit current should be equal for the both circuit for the transformation to be proved.

Circuit:



Simulation Steps:

1. A circuit with a 12V source in series with 1k-ohm resistor as the internal resistance of the voltage source is drawn in NI Multicim 14.0.
2. An ammeter is attached in series with the resistor to measure the short circuit current.
3. At the other side, another circuit is created with a current source (with the short circuit current value from the first circuit) in parallel with a 1k-ohm resistor.
4. A volt meter is attached in parallel with the resistor to measure the voltage.

Simulation Data:

Source Type	Resistance	Current	Voltage
Voltage source (Left Ckt)	1k-Ohm	$I_{sc}=V_s/R$ $=0.012A$	$12V(V_s)$
Current Source (Right Ckt)	1k-Ohm	$0.012A(I_s)$	$V= I_{sc} . R$ $=12V$

Analysis and conclusion:

From the simulation data table it is evident that the voltage and current both sources have the same equivalent resistance (1k-Ohm; if the sources are withdrawn; voltage source as short circuit and current source as open circuit) and the short circuit current for both circuit is equal ($I_{sc} = I_s$=0.012A) which testifies the authenticity of the source transformation.

Remarks and Grade (by the instructor)

Instructor Signature:
Grading Date:

Electric Circuit Experiments

Preview 04

Power Factor Improvement

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Question 1

 # What is the significance of power factor?

The power factor is the cosine of the phase difference between voltage and current. It is also, the cosine of the angle of the load impedance. the power factor may be seen as that factor by which the apparent power must be multiplied to obtain the real or average power. The value of pf ranges between zero and unity.

For a purely resistive load, the voltage and current are in phase, so the power factor = 1. For a purely reactive load (inductive and capacitive), the voltage and current are 90 degrees out of phase. The angle between the voltage and current can be either +90 degree or -90 degree. So, the Power Factor= 0; as no current will flow through the circuit.

Power factor is said to be leading or lagging. Leading power factor means that current leads voltage, which implies a capacitive load. Lagging power factor means that current lags voltage, implying an inductive load.
Power factor affects the electric bills consumers pay the electric utility companies. Loads with low power factors are costly to serve because they require large currents. The ideal situation would be to draw minimum current from a supply. A load with low power factor draws more current as additional current flows back and forth between the load and the source which rises additional power losses.

For this reason, power companies often encourage their customers to have power factors closer to unity as possible and penalize some customers who do not improve their load power factors.

 # What is the improvement principle of power factor?

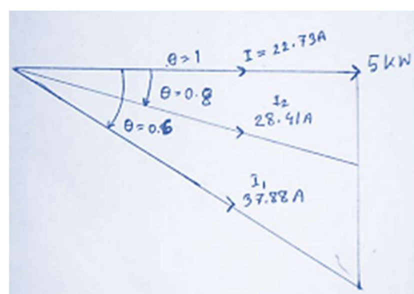
(Analyze this problem from physical and mathematical perspective).

If a 5kw induction motor runs at 220V ac.
At 0.6 power factor, the current draw would be

I1= P/ (V * Cos θ) = 5kw/ (220 * 0.6) = 37.88A
But it we improve the power factor to 0.8,

The current draw would be
I2= P/ (V * Cos θ) = 5kw/ (220 * 0.8) = 28.41A

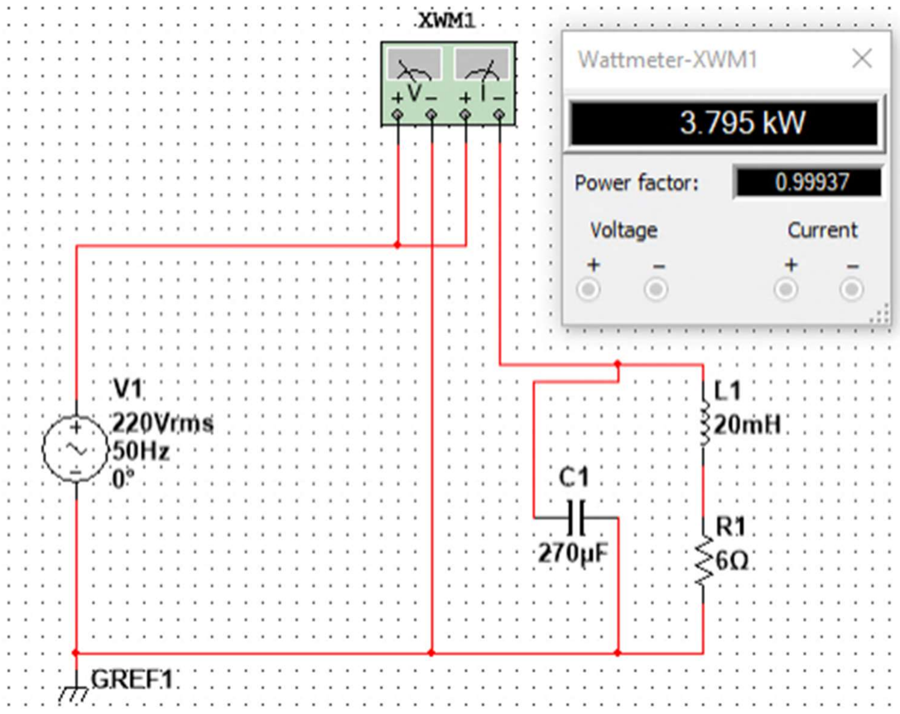
And if we improve the power factor to unity,
The current draw would be,
I= P/ (V * Cos θ) = 5kw/ (220 * 1) = 22.73A



From above calculation it is quite obvious that improving power factor to unity reduces current flow for the same amount of power thus reduces additional power losses. Since most loads are inductive, one or more capacitors are connected in parallel to improve the power factor.

Question 2

Design a circuit to measure power and power factor. You can use necessary elements and instruments in Multisim



Remarks and Grade (by the instructor)

Instructor Signature:

Grading Date:

ELECTRIC CIRCUIT EXPERIMENTS

Preview 05

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Given Data:

R=10Ω,

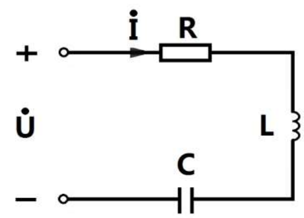
L=30mH= 30 x 10^{-3}H

C=1uF= 1x 10^{-6} F

U=1.414V

f_1& f_2 are frequencies of half-power points

f_1=? f_0=? f_2=?



we know,

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{30\times10^{-3}\times1\times10^{-6}}} = 918.88 \approx 919 \text{ Hz}$$

$$f_1 = f_0 - \frac{R}{4\pi L} = 919 - \frac{10}{4\pi\times30\times10^{-3}} = 892.47 \text{ Hz}$$

$$f_2 = f_0 + \frac{R}{4\pi L} = 919 + \frac{10}{4\pi\times30\times10^{-3}} = 945.52 \text{ Hz}$$

f/H_Z	f_1	f_0	f_2
U_R/V	892.47Hz	919Hz	945.52Hz

ELECTRIC CIRCUIT EXPERIMENTS

Preview 06

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1.What is transient response? What is first order circuit? What is second order circuit? What is Zero-Input response, Zero-State response and full response?

Transient Response:

The transient response is the circuit's temporary response that will die out with time. The transient response essentially dies out after five-time constants. At that time, the inductor becomes a short circuit, and the voltage across it is becomes zero.

First Order Circuit:

First order circuits are circuits that contain only one energy storage element (capacitor or inductor), and that can, therefore, be described using only a first order differential equation. The two possible types of first-order circuits are:

RC (resistor and capacitor)
RL (resistor and inductor)

Second-Order Circuit:

A second-order circuit is characterized by a second-order differential equation. It consists of resistors and the equivalent of two energy storage elements.

Zero-Input response, Zero-State response & Full response:

When it comes to solving a circuit, it is possible to split up the solution into two parts, the Zero-Input response, and the Zero-State Response to get the Full Response of the given circuit.

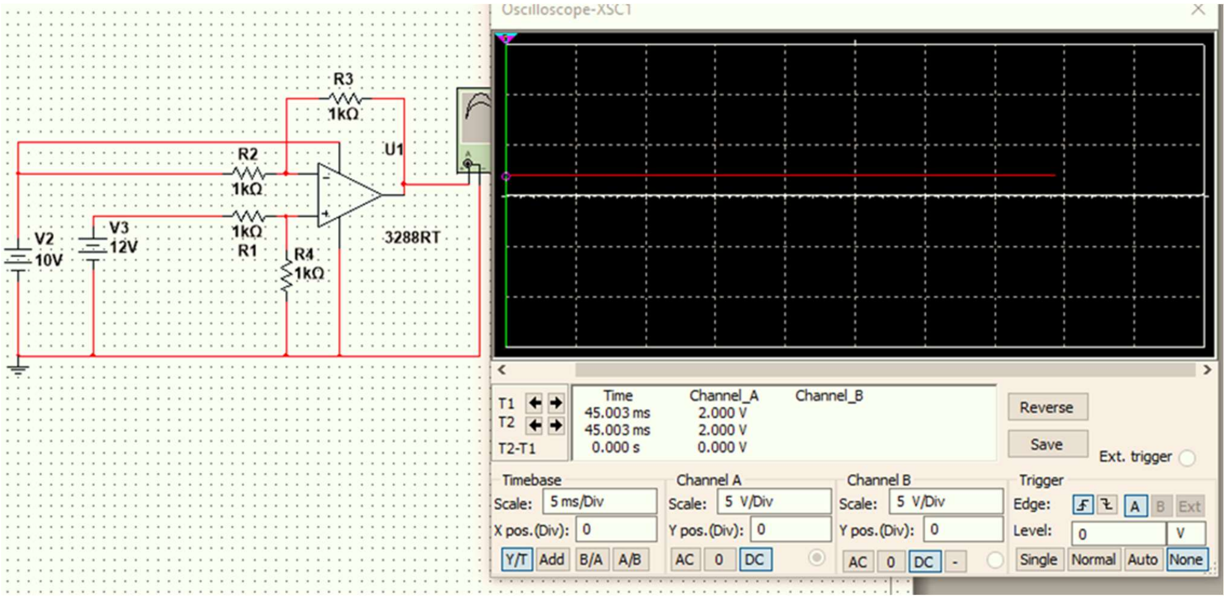
The Zero-Input response is the response of the system to the initial conditions, with the input set to zero.

The Zero-State Response is the response of the system to the input, with initial conditions set to zero.

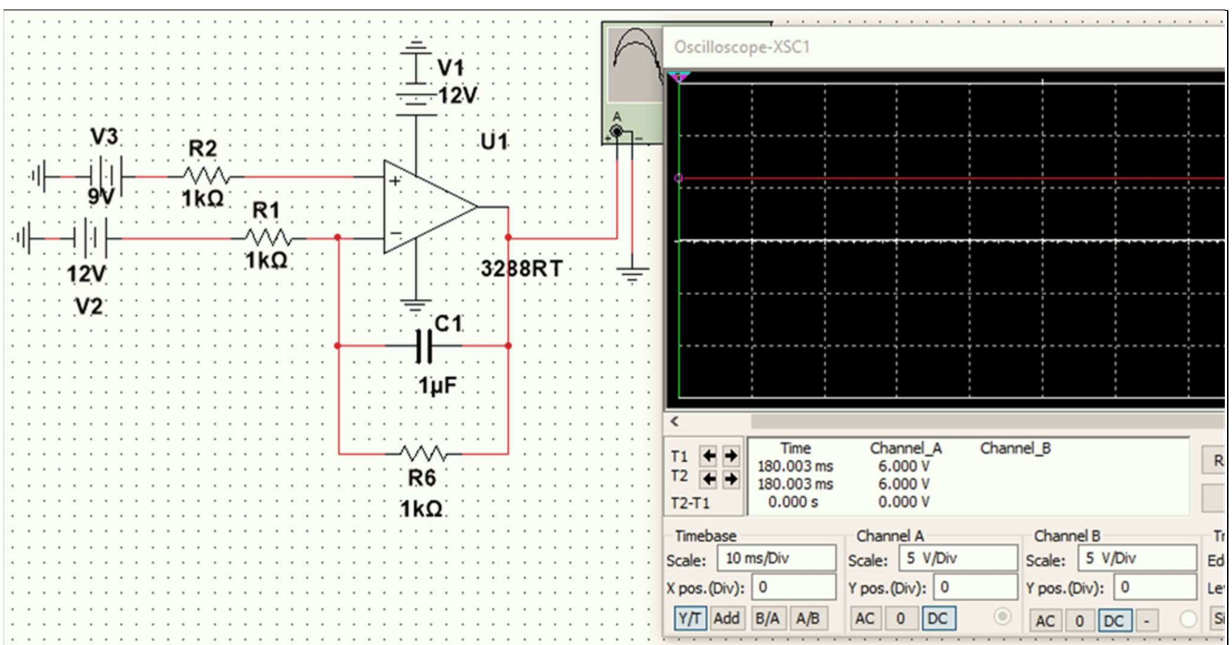
The complete or Full Response is simply the sum of the Zero-Input response and Zero-State response.

2. Draw a differential circuit and an integral circuit separately, and use an oscilloscope to observe differences between two waves.

Rc: Differential circuit



Rc: An integral circuit



Electric Circuit Experiments

Basic Concept and Laws

Preview 07 Operational amplifier

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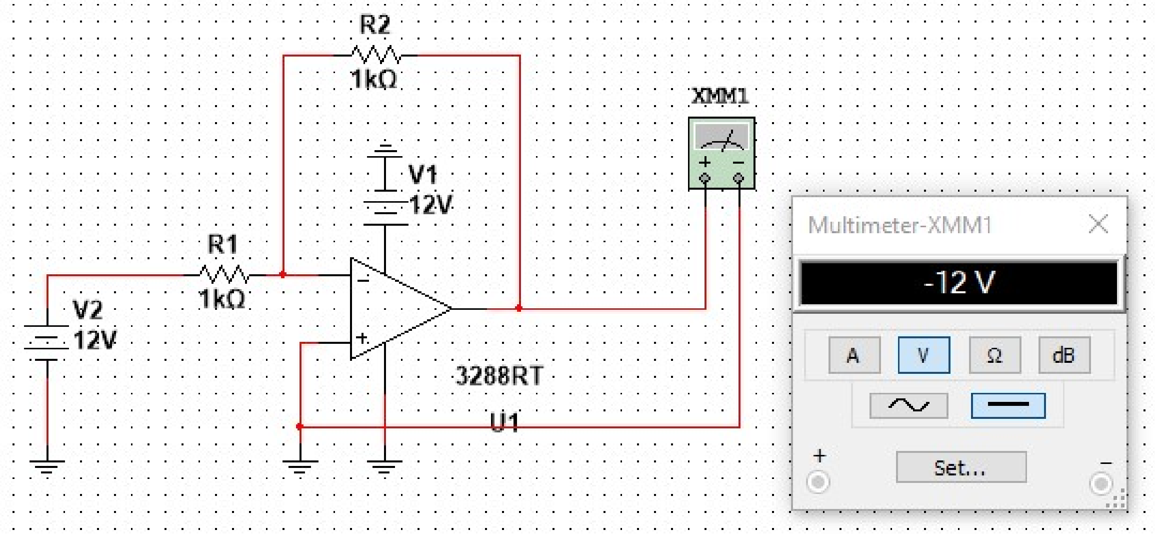
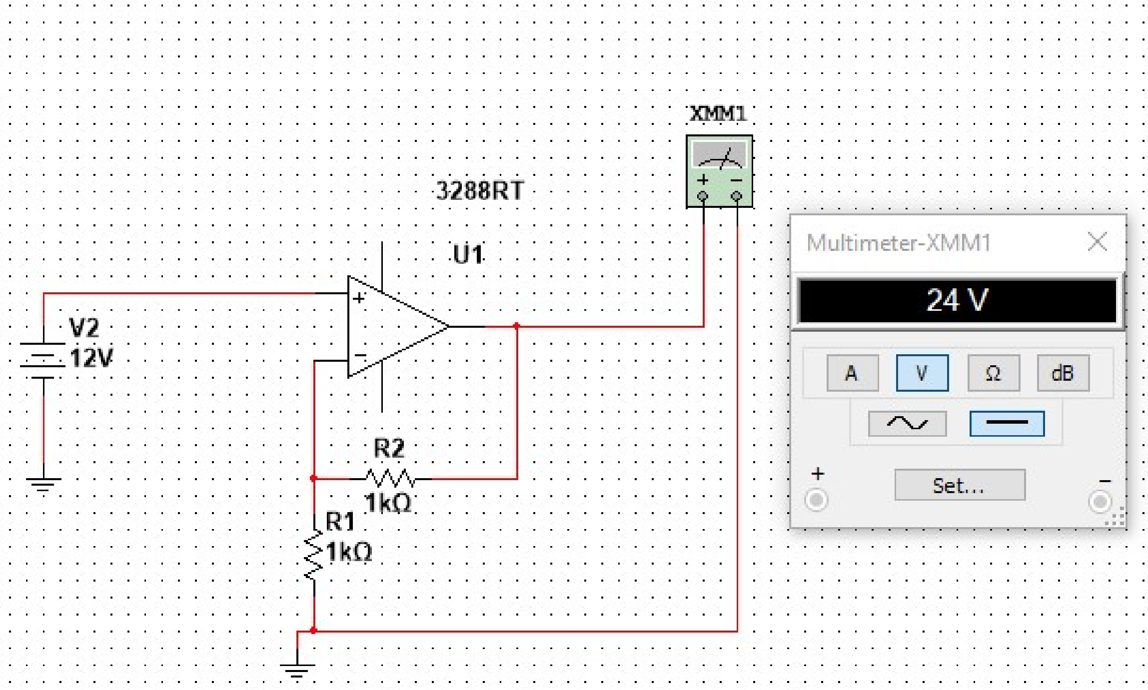
Draw the basic circuits and write the gain expressions of:

Inverting proportional amplifier: An inverting amplifier reverses the polarity of the input signal while amplifying it.



Gain Expression: As $R_{in} = R_f$. So, $V_{out} = -V_{in}$. The gain is -1.

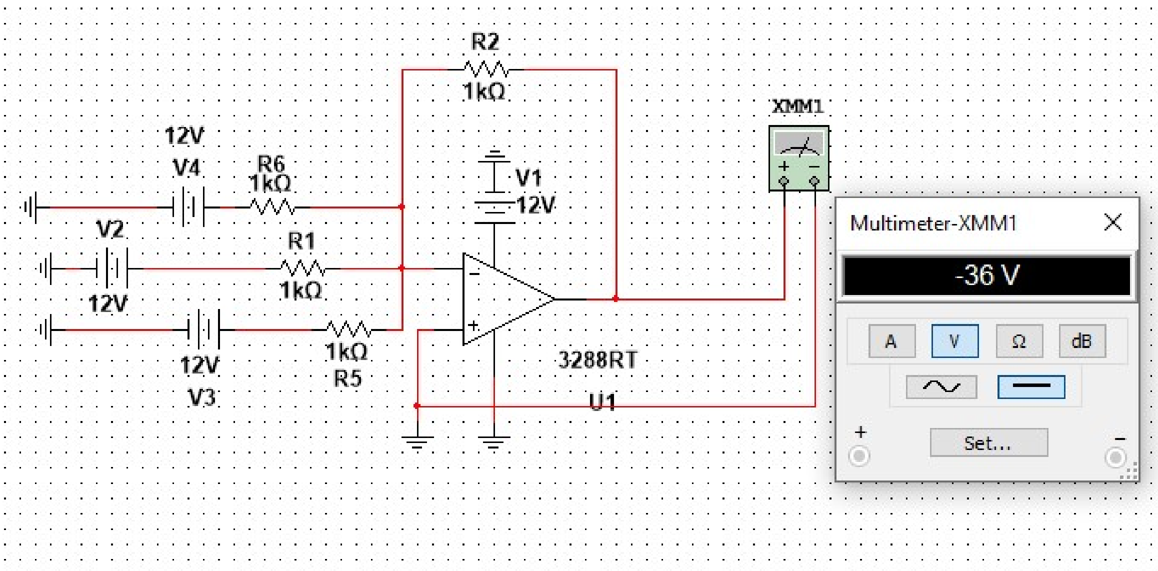
Noninverting proportional amplifier: A noninverting amplifier is an op amp circuit designed to provide a positive voltage gain. Which means it provides positive signal at the output.



Gain Expression:

For the circuit above, Gain = 1 + (R2/R1) = 2,

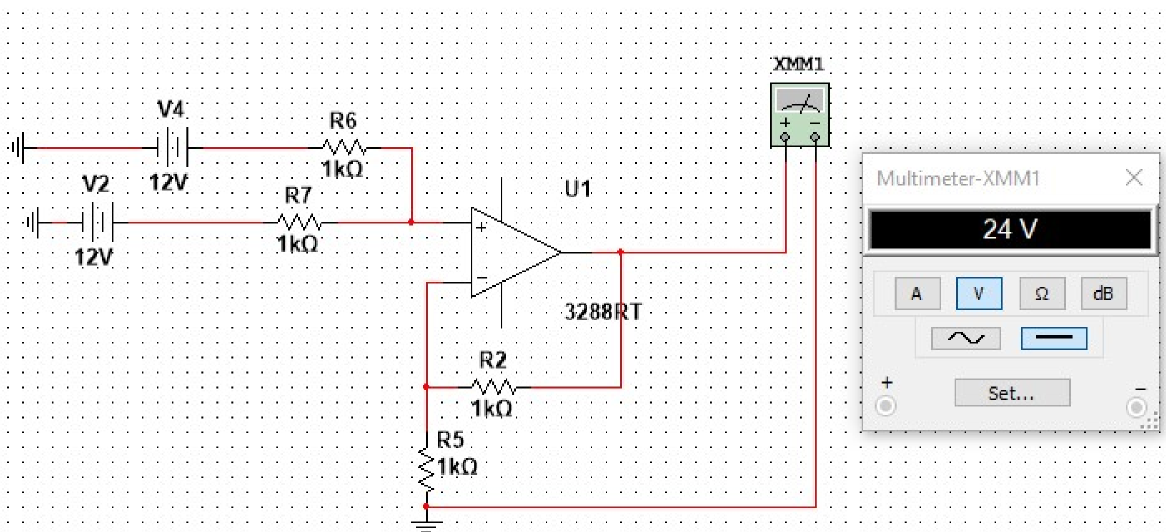
Inverting summing amplifier:



Gain Expression:

V_{out} = -(V1+ V2+V3) = -36v. So, the gain is 3.

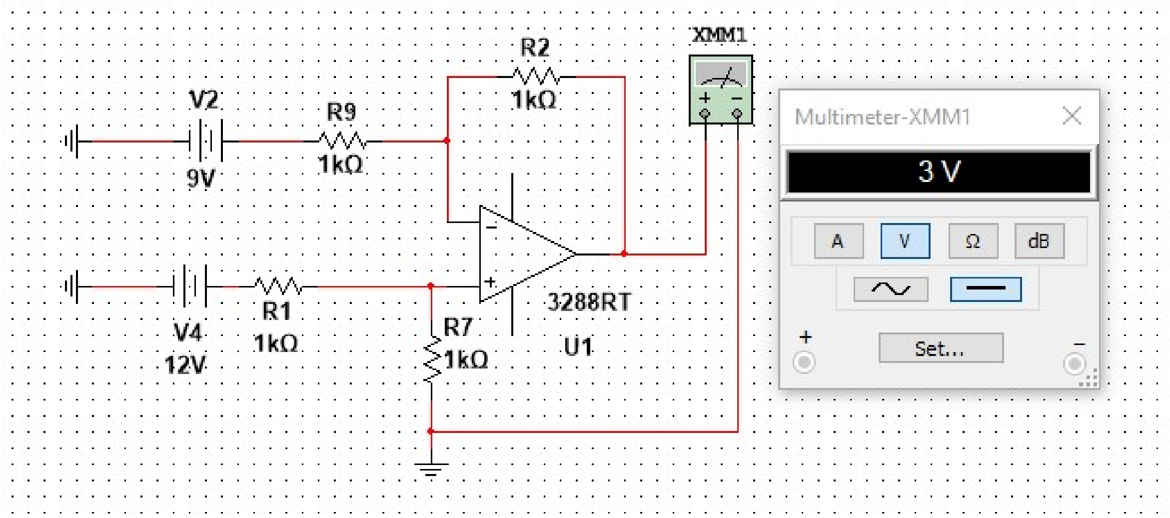
Non inverting summing:



Gain Expression:

V_{out}= V1+ V2 = 24V, as the resistors R_1 and $R_2(R_f)$ are the same. Here the gain is 2.

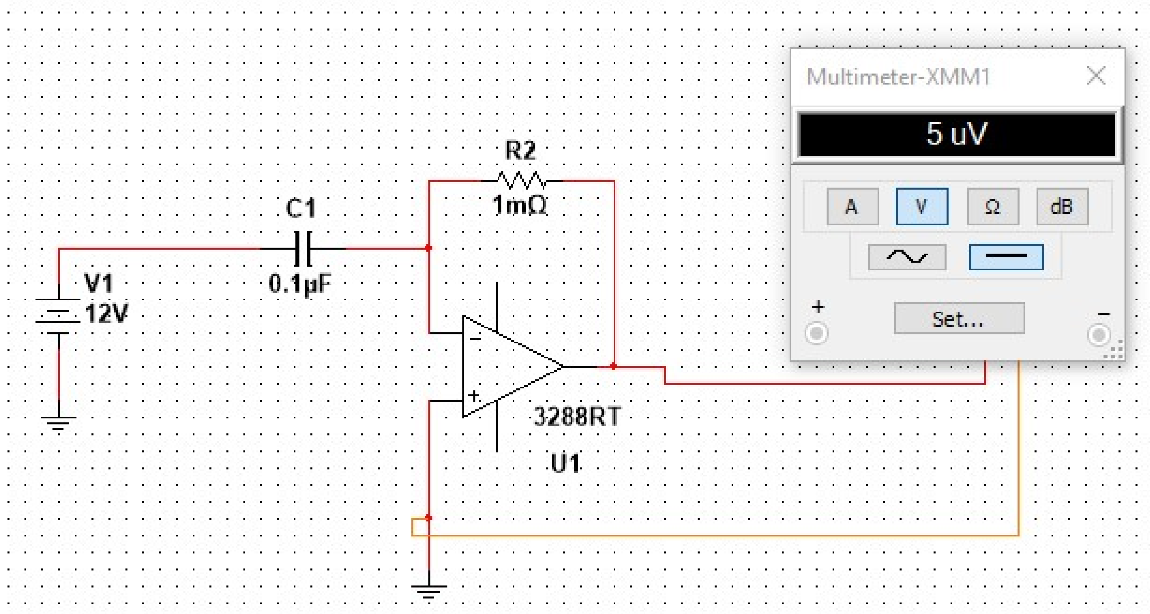
Difference Amplifier:



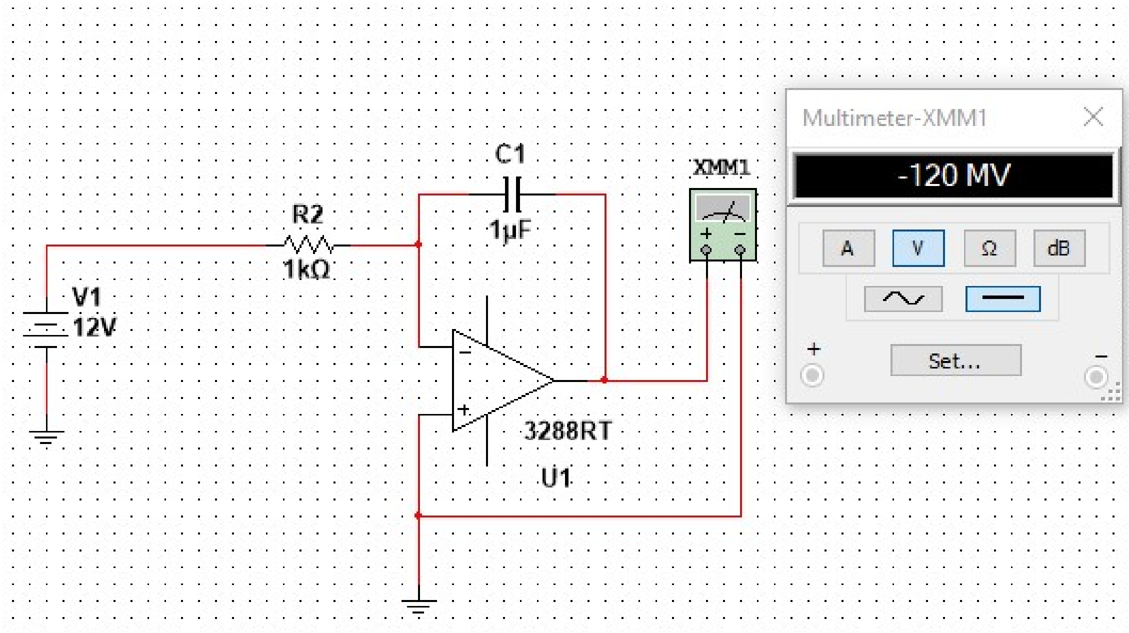
Output value is difference between two voltage sources.

V4 - V2= 12V-9V = 3V.

Differentiator:



Integrator:



Multimeter-XMM1
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A
V
Ω
dB
Set...
+
−
XMM1
C1
1µF
R2
1kΩ
V1
12V
3288RT
U1