Chapter 1 Voltage, Current, Circuit Laws

(Selected contents from Chapter 1-3 in the text book)

1. What are the following instruments? Draw lines to match them to their cables:

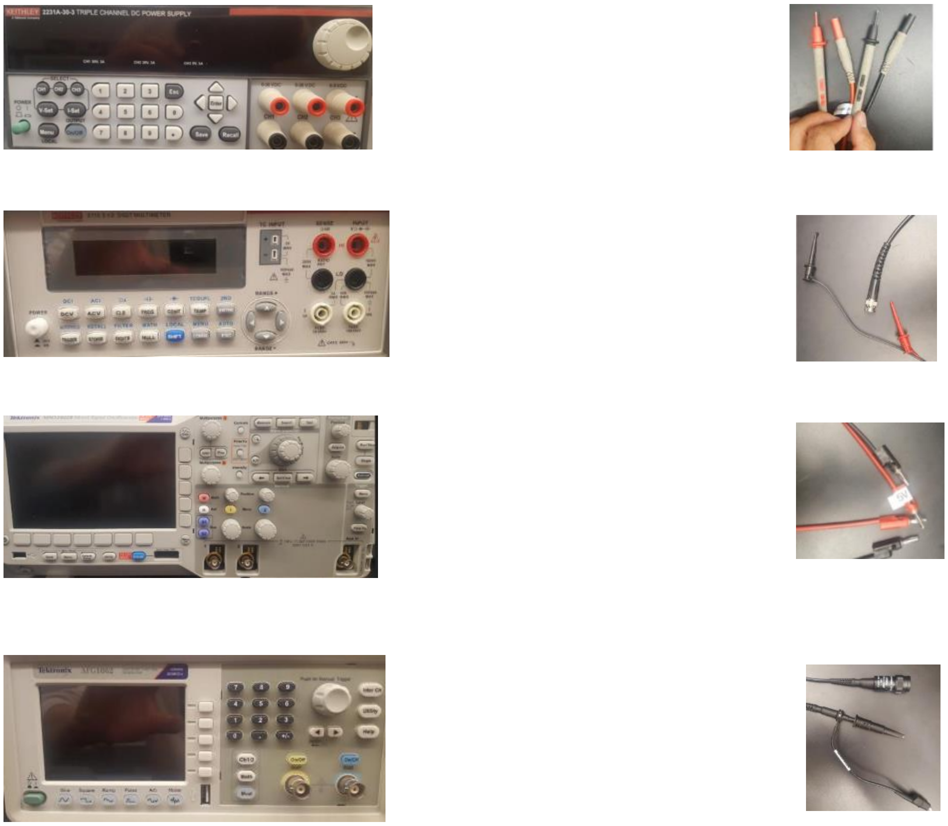


Fig. 1-1

2. Complete the circuits to test the voltage at node Vout using the multimeter in Fig. 1-2(a) and test the current flows in the circuit in Fig. 1-2(b).

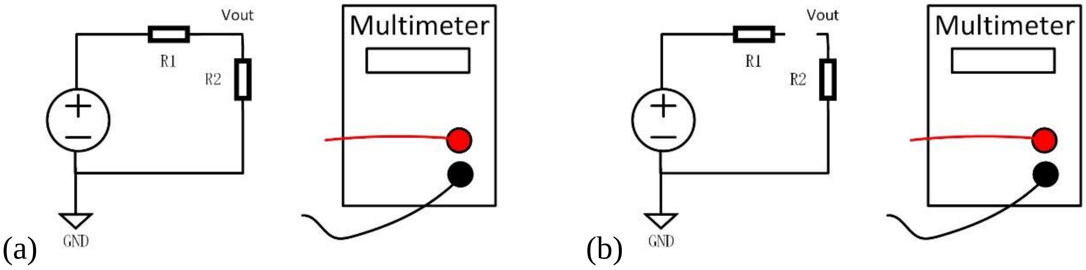


Fig. 1-2 Voltage and Current testing

3. Label the voltages at the nodes showing in the following figures:

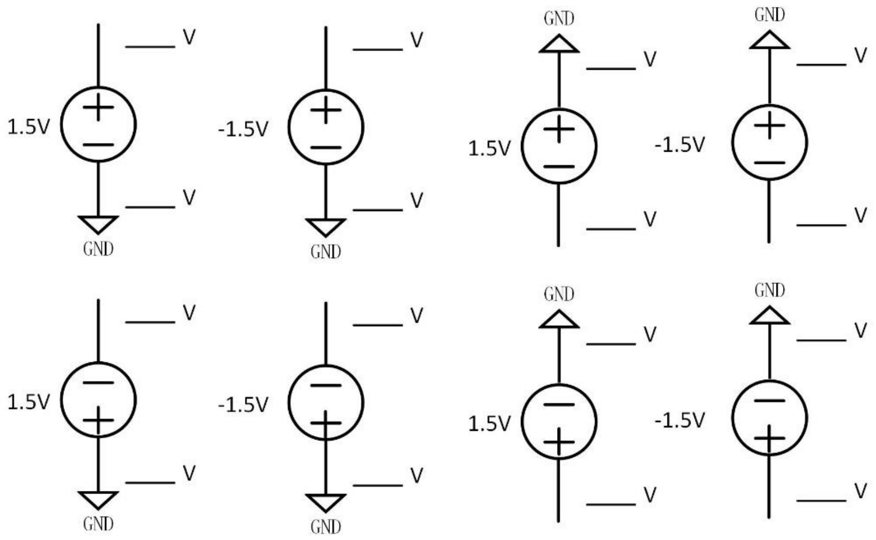


Fig. 1-3

4. Complete the following circuit to provide a +5 and -5 power supply:

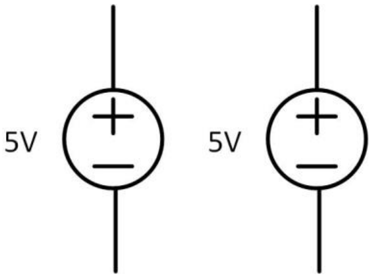


Fig. 1-4

5. What is VR? What is the current flow from the left to the right of R1?

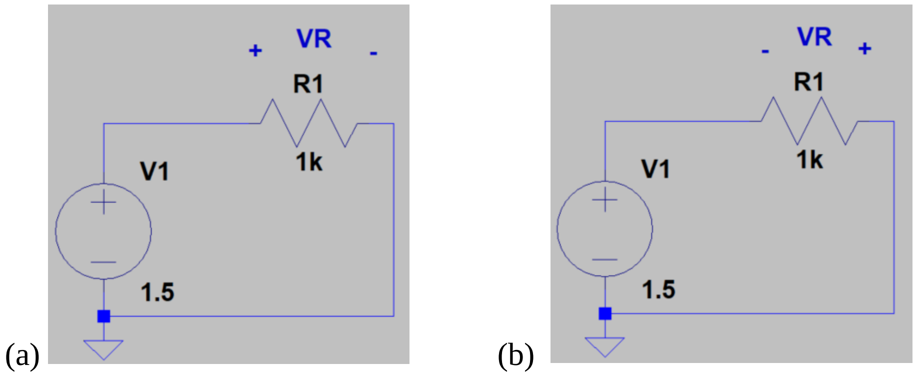
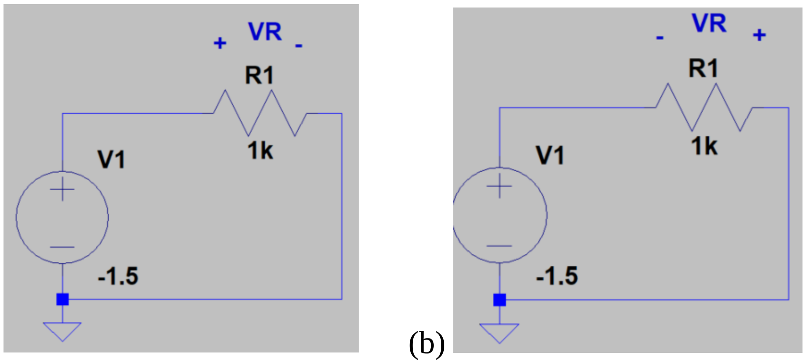


Fig. 1-5

6. The same question as above, work on the following ones:

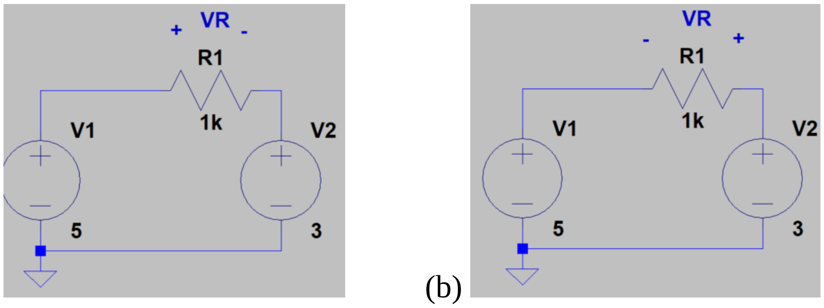


(a) (b)

Fig. 1-6

7. Write the Spice code for all the circuits in Problem 5 and 6, use Transient analysis, simulate from Time 1s to Time 10s, plot every point for every 0.01s.

8. Calculate VR. Draw the direction of the current and calculate the current value:



(a) (b)

Fig. 1-8

9. Solve the Vout of the following 'Voltage Divider'. Instead of calculating the current first, what is the express way to calculate it if you know it is a Voltage Divider?

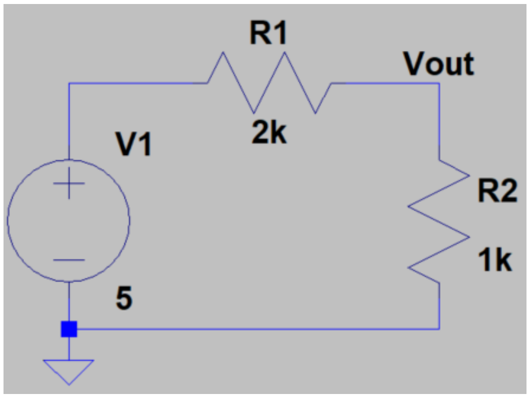


Fig. 1-9

10. Find the voltages Vx and Vs in each of the following circuits. Verify your hand calculations using LTspice.

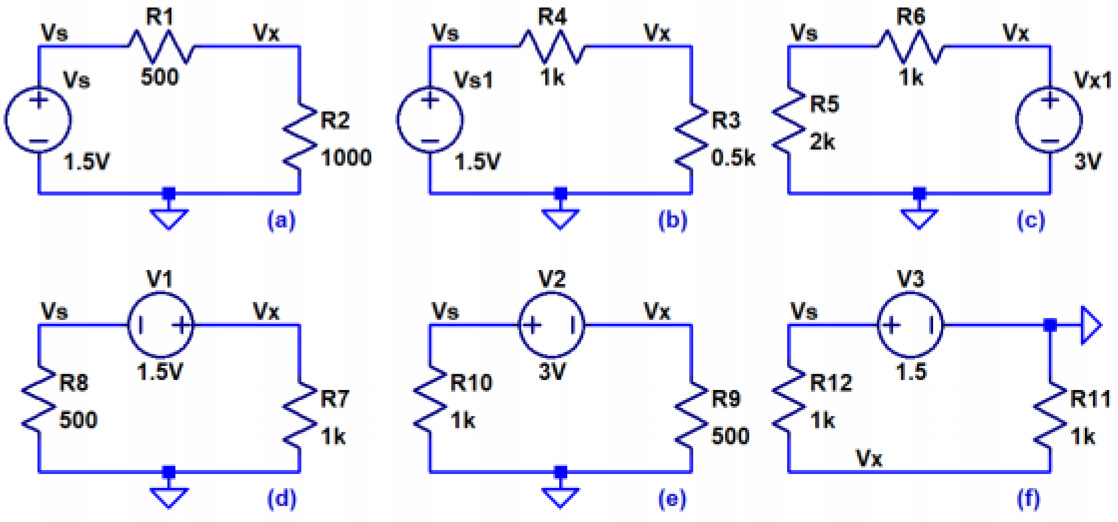


Fig. 1-10

11. Find the voltages in the following circuit. Verify your hand calculations using LTspice.

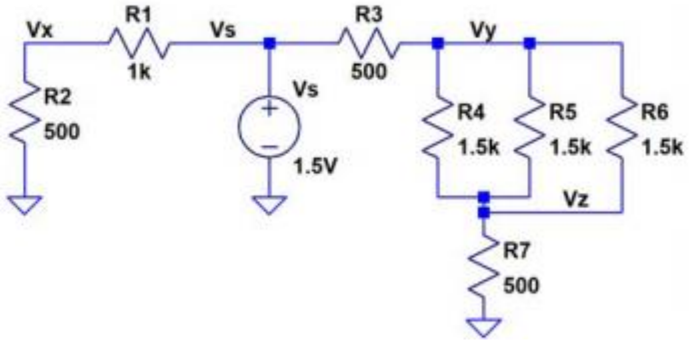


Fig. 1-11

12. Show how to derive the voltage divider equation and the current divider equation for a two resistor circuit. Ensure your derivation includes the two schematics you are using. Provide an example for each derivation.

13. Calculate Vs, Vx, and the current that flows in R2 and R3. Verify your hand calculations using LTspice.

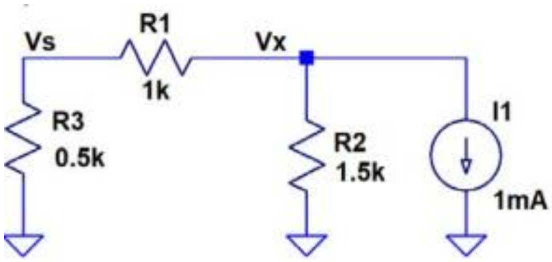


Fig. 1-13

14. Find the voltages Vx and Vs in each of the following circuits. Verify your hand calculations using LTspice.

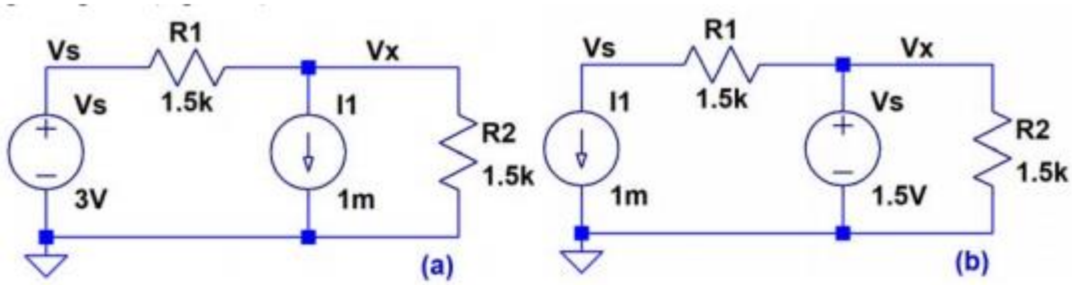


Fig. 1-14

15. Find the voltages Vx and Vs and the current through Vs in each of the following circuits. Verify your hand calculations using LTspice.

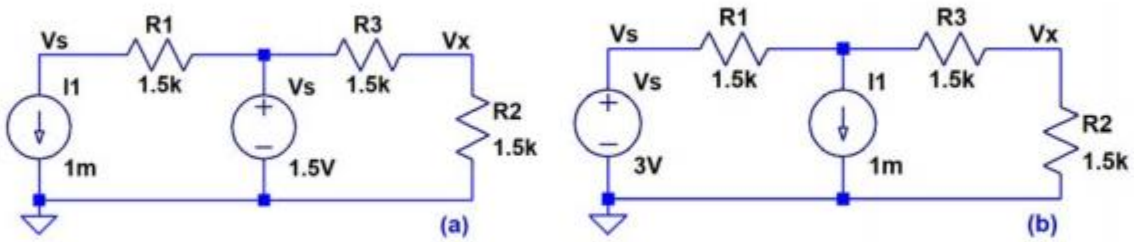


Fig. 1-15

16. Find the voltages Vx and Vy in each of the following circuits. Verify your hand calculations using LTspice.

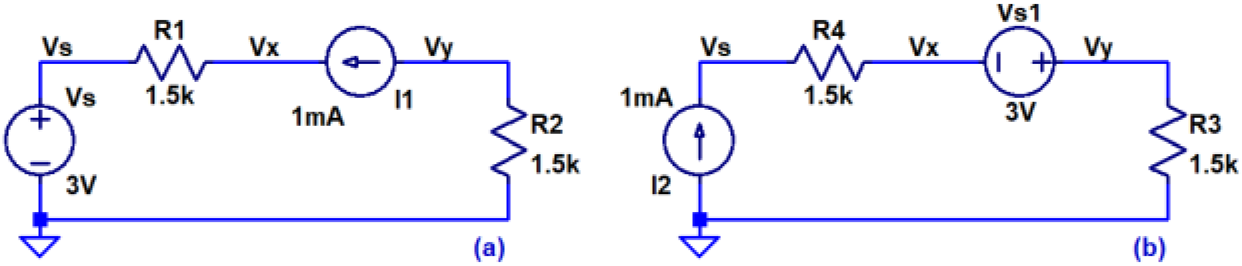


Fig. 1-16

17. Find the voltages Vs and Vx and the current through R2 and R5 in each of the following circuits. Verify your hand calculations using LTspice.

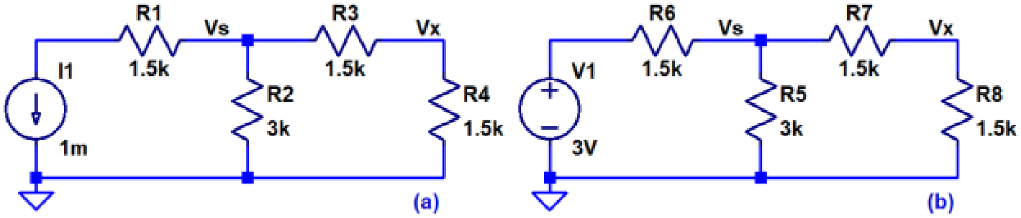


Fig. 1-17

18. What is the equivalent resistance of the marked area in the following circuit?

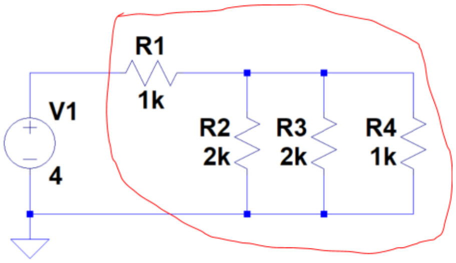


Fig. 1-18

19. What is the current in each branch in the following circuit? Using the equations for a current divider to calculate this.

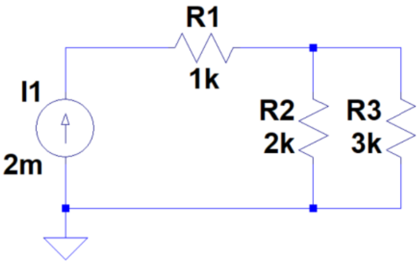


Fig. 1-19

Chapter 2 Analysis Methods

1. Using **superposition** show how to find Vx in the following circuits. Verify your hand calculations using LTspice.

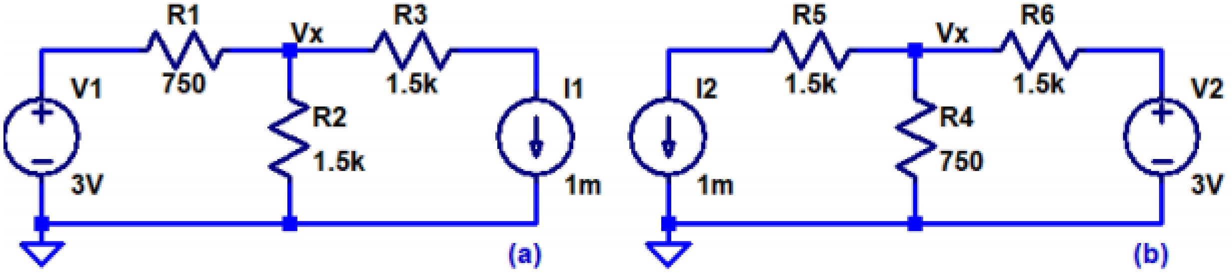


Fig. 2-1

2. Find the voltages and currents in each of the following circuits using **superposition**.

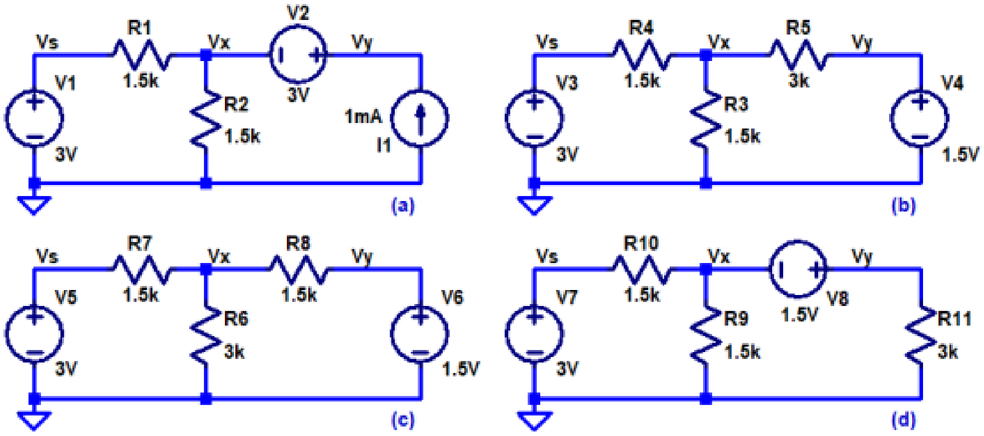


Fig. 2-2

3. Find the voltages and currents in each of the following circuits using mesh analysis. Verify your hand calculations using LTspice.

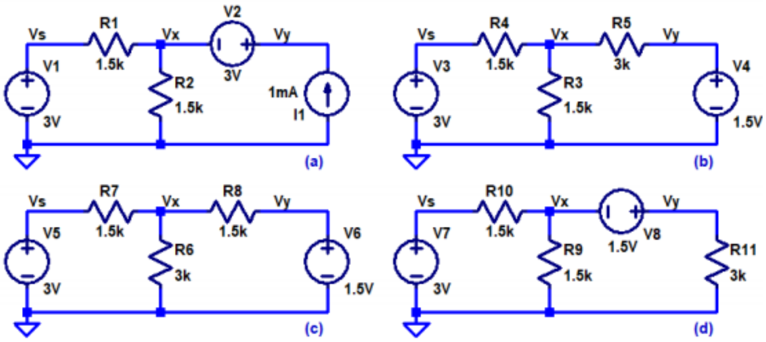


Fig. 2-3

4. Determine the currents and voltages in the following circuit using mesh analysis. Verify your hand calculations using LTspice.

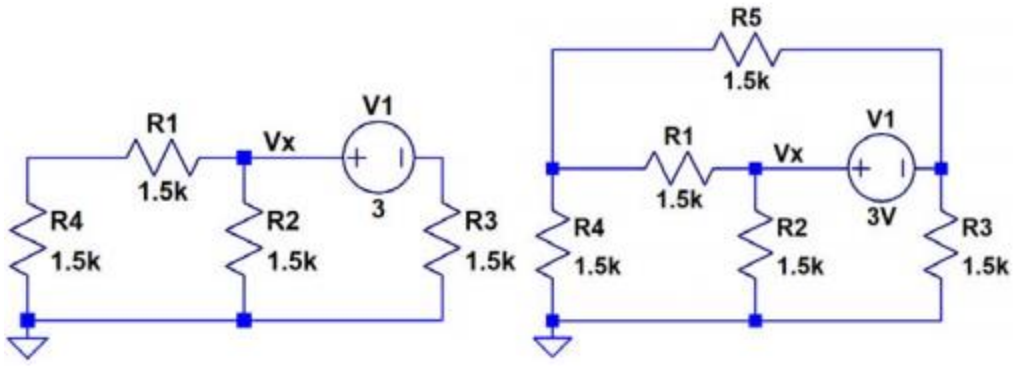


Fig. 2-4

5. Find all voltages in the following circuit. Verify your hand calculations using LTspice. As always, show your work for credit.

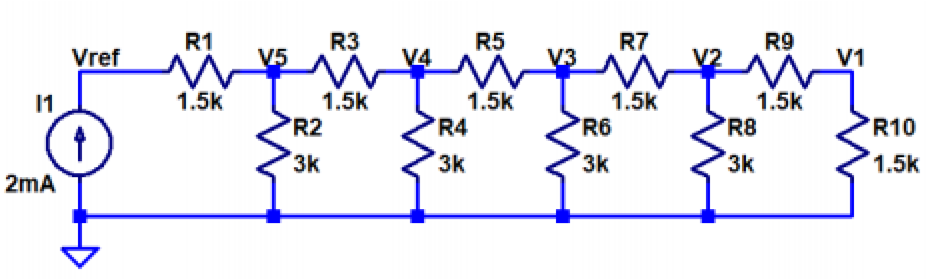


Fig. 2-5

6. Find all voltages in the following circuit (Use the Super Mesh Current Method). Verify your hand calculations using LTspice. As always, show your work for credit.

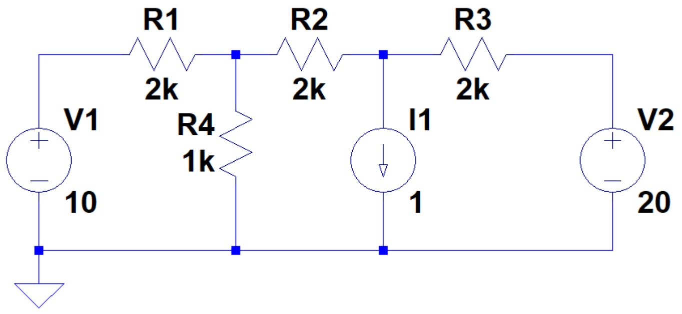


Fig. 2-6

7. **Convert** the following circuit into it’s **Thevenin’s equivalent circuit**, then **calculate** the current flows through the load resistor.

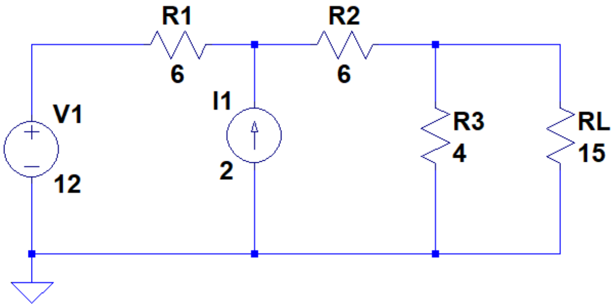


Fig. 2-7

8. **Convert** the following circuit into it's **Thevenin's equivalent circuit**, then **calculate** the current flows through the load resistor.

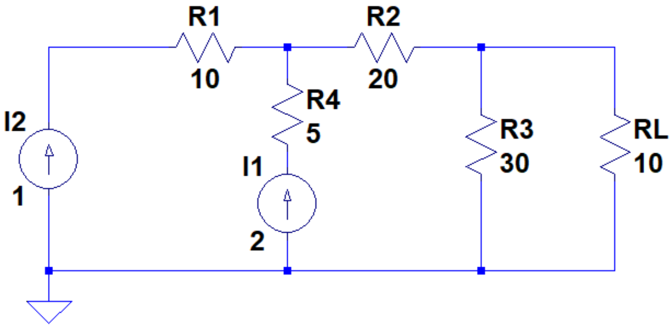


Fig. 2-8

9. **Convert** the following circuit into it's **Norton's equivalent circuit**, then **calculate** the current flows through the load resistor.

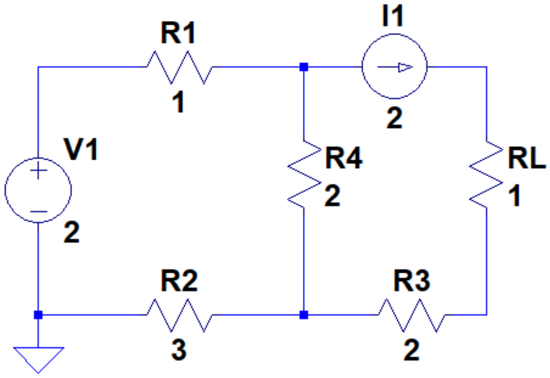


Fig. 2-8

10. **Convert** the following circuit into it's **Norton's equivalent circuit**, then **calculate** the current flows through the load resistor.

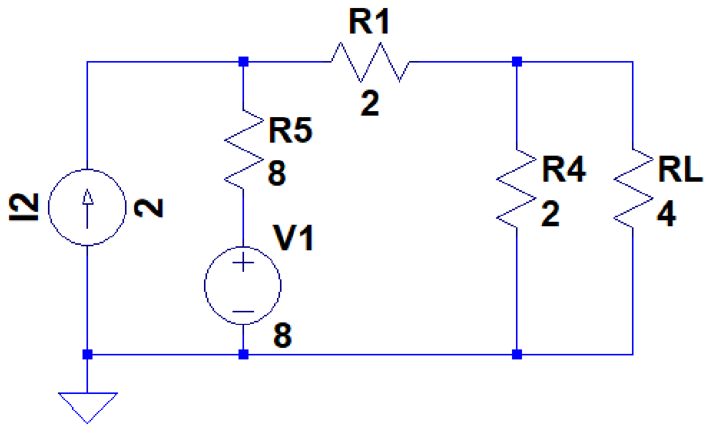


Fig. 2-10

Chapter 3 Amplifiers and Operational Amplifiers

1. Find all the mesh current in the circuit and the power dissipated (P=V*I) by the 4 Ohm resistor on the right side of the circuit.

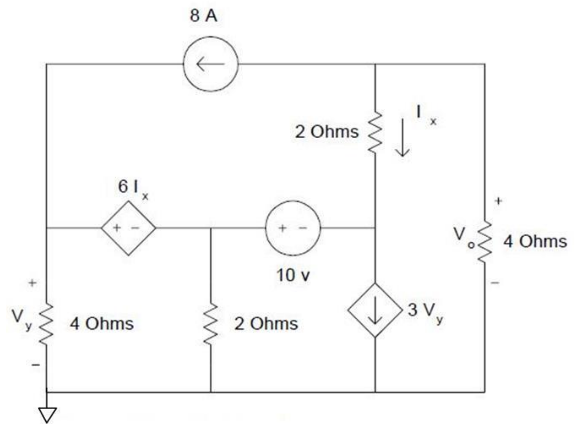


Fig. 3-1

2. Find Vout in each of the following circuits. Verify your hand-calculated answers using LTspice.

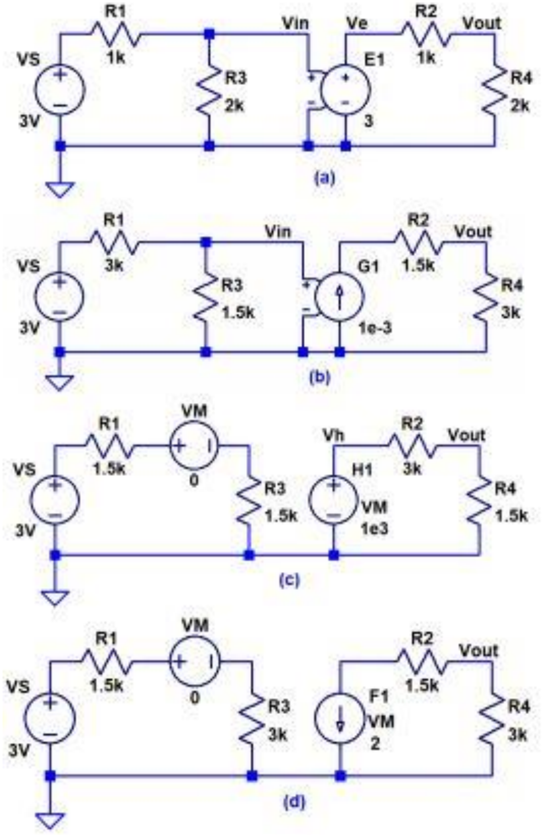


Fig. 3-2

3. Calculate the voltage across R4 in the below circuits. Next find the Thevenin and Norton equivalent circuits at the port indicated by the red dots in the below schematics (this means without R4 in the circuit). Show that your equivalent circuits are correct and then verify with LTspice.

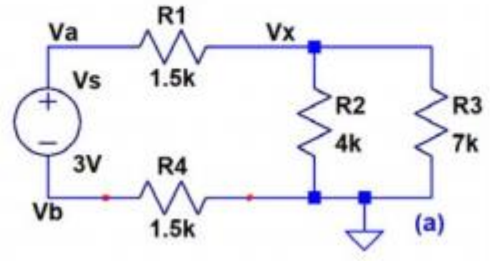


Fig. 3-3

4. Find the voltage VB in the following circuit. Verify your answer with LTpsice.

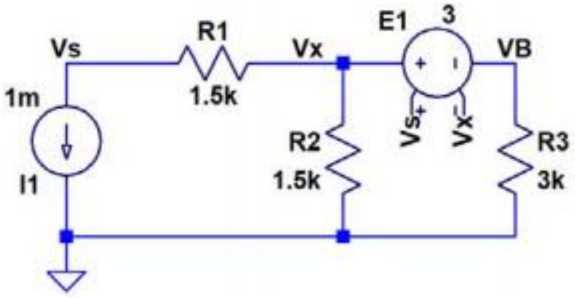


Fig. 3-4

5. Find Vout in the following circuit. For all intents and purposes you can assume the gain of the VCVS is infinite.

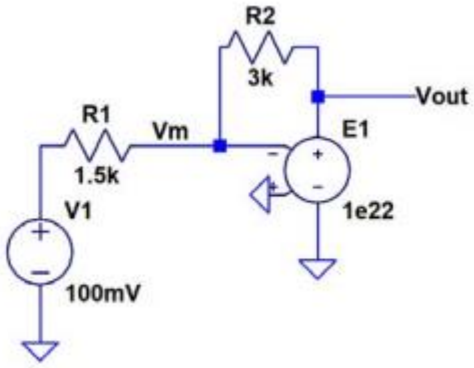


Fig. 3-5

6. 1) Use LTSpice, use the E1 voltage amplifier, create a symbol to make it in the standard OpAmp triangle shape like I showed in the lecture. 2) Use this OpAmp to build an inverting amplifier and a non-inverting amplifier. 3) Derive the voltage gain for these two amplifiers, and use LTSpice to verify the gain.

7. (1) Create a symbol of an Op Amp in LTSpice and complete the following circuits. (2) Derive the voltage gains of the following Op Amp configurations. (3) Plot Vout if Vin varies from -1 to 1 V in each circuit, using a DC sweep in LTspice. (4) If Vin is a 1V Vp-p, 0 offset, and 1 kHz sine wave, plot the input and output for the two circuits and explain if the results are correct.

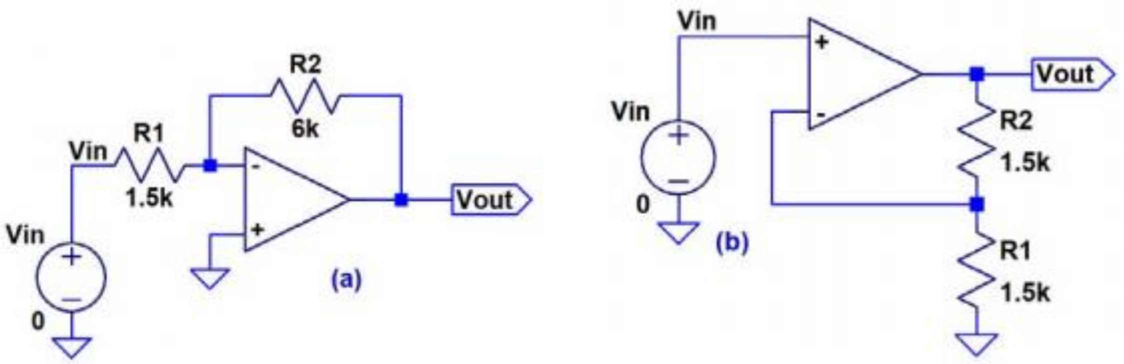
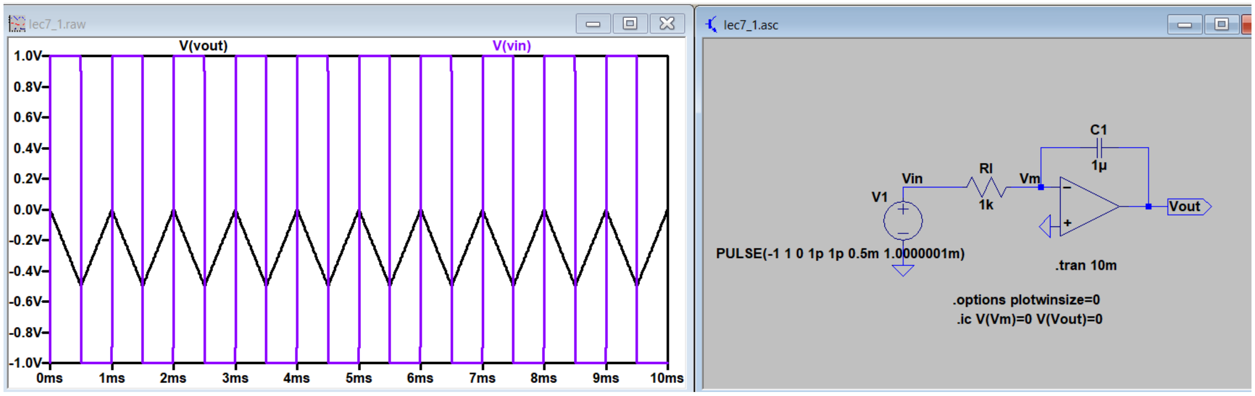


Fig. 3-7

8. In the following integrator, Vo is charged to -0.5 V – 0 V. Modify the value of the resistor or the capacitor, to make the Vo swings between -1 V – 0V. (Do not change anything about the voltage source).

(Show the calculations and the simulations for credit).



PULSE(-1 1 0 1p 1p 0.5m 1.0000001m)

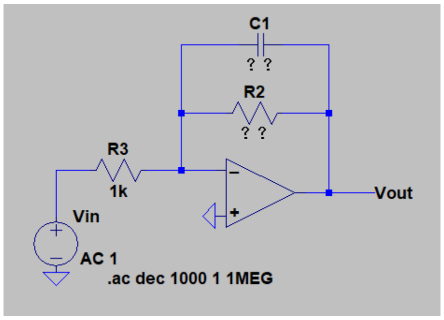
.tran 10m

.options plotwinsize=0

.ic V(Vm)=0 V(Vout)=0

Fig. 3-8

9. Based on the following circuit, design the values of the capacitor and the resistor to make the cutoff frequency to be 5 kHz. Use LTSpice to verify the cutoff frequency.



AC 1

.ac dec 1000 1 1MEG

Fig. 3-9

10. Derive the voltage gain of both the inverting OpAmp and the non-inverting OpAmp when the open-loop gain of the OpAmp is not infinite (a finite gain of ***A***).

11. Derive the differential gain and the common mode gain of the following difference amplifier. Then, show the common-mode rejection ratio (CMRR, which is the differential gain over the common-mode gain). (Assume R2=R4, R1=R3).

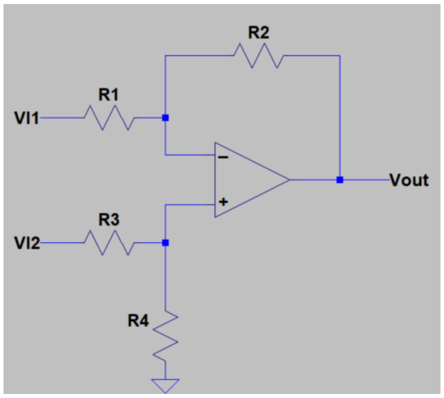


Fig. 3-11

12. Derive the voltage gain of the following instrumentation amplifier.

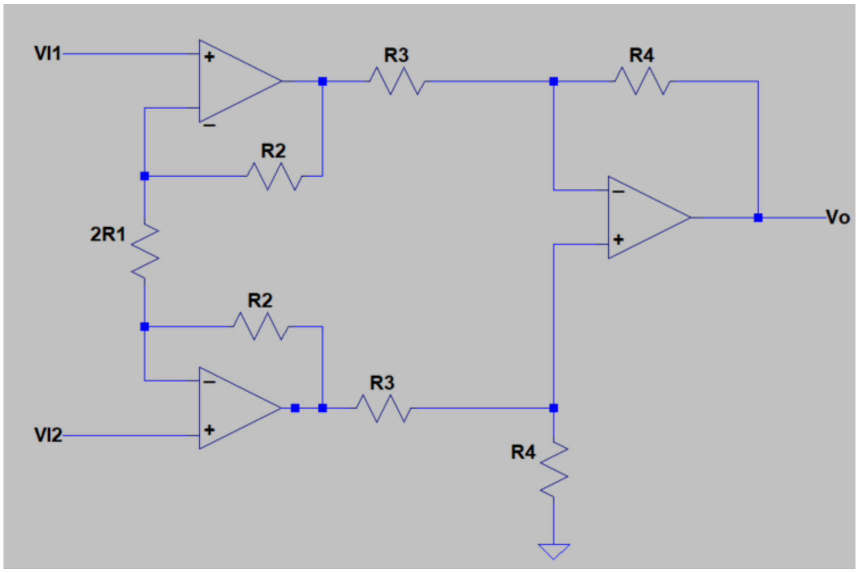


Fig. 3-12

13. Find an equation for Vout in terms of Vb0, Vb1, and Vb2. Pick values for these later voltages and show, using hand calculations and a simulation, that your equation is correct. Please don't focus on, or get confused by, the values I picked for Vb0, Vb1, or Vb2 below when I simulated. You pick a DC value for these in this problem.

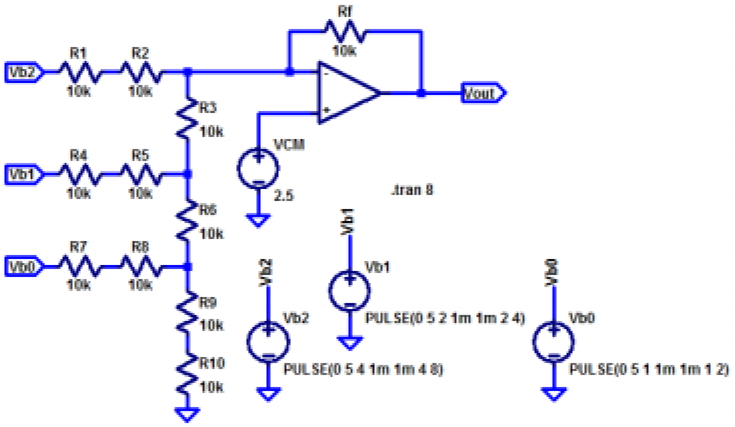


Fig. 3-13

14. An infrared (light at longer wavelengths than the visible spectrum so you can't see it) lightemitting diode (LED) may be used in a remote control to send infrared light to the TV, game console, cable box, etc. to control operation. In these receiving devices there is a photodiode, a device that converts the received light into current. Modeling the diode below as a current source that may vary from 0 to 1 uA in the direction shown, design, using a single ideal opamp and single resistor, a circuit that converts this current to a voltage that varies from 0 to –1 V (0 input current then 0 V output voltage, 1 uA input current then –1 V output, 0.5 uA input then – 500 mV output). Simulate, using a DC sweep of the input current, the operation of your circuit. The circuit you design is often called a transresistance, or transimpedance amplifier, since its output is voltage and its input is current (Votlage/Current = Resistance).

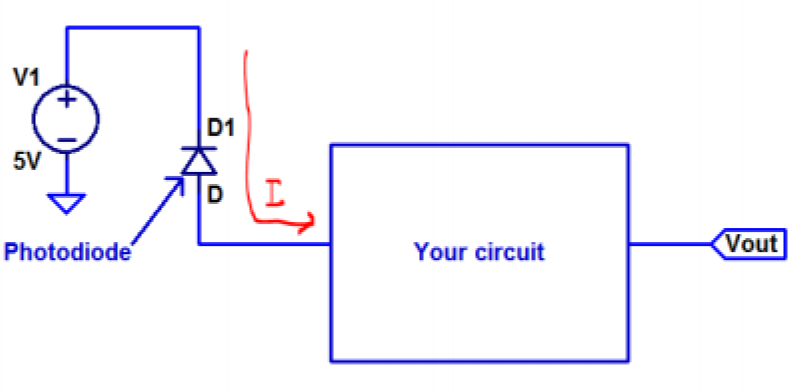


Fig. 3-14

Chapter 4 First Order Circuits

1. Suppose a 1 uF capacitor is charged to 1V. How much charge is stored on the capacitor?

2. Show the equation for the definition of capacitance in physics and show how the plate area and the gap between the two plates will affect the capacitance.

3. Show the equation that represents the relationship among Charge Q, Current I, and Time t.

4. At t=0, show the relationship between I and Vc(t) in the form of I=f(Vc(t)). Also show Vc(t) in terms of I. Will Vc(t) be a linear curve? Why?

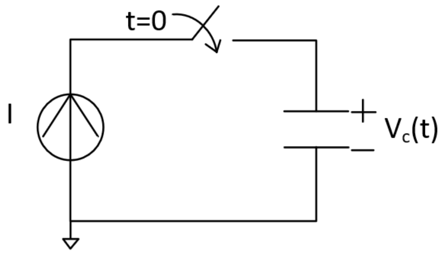


Fig. 4-4

5. At t=0, the switch is closed. What is the voltage across the resistor and the current flows through the resistor in terms of time t.

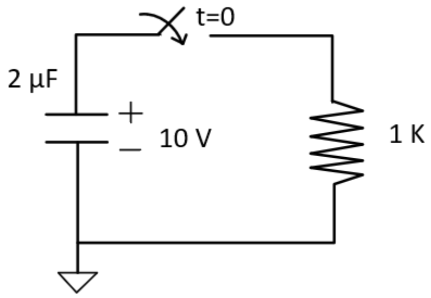


Fig. 4-5

6. Replace the resistor in the circuit above with a current source, how long does it take to drain out all the charges in the cap?

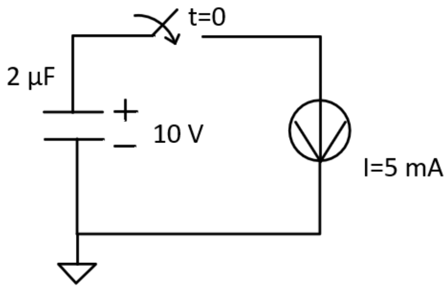


Fig. 4-6

7. (1) Explain the parameters in the PULSE() function. (2) Hand calculate the delay of the following circuit and verify it using LTSpice.

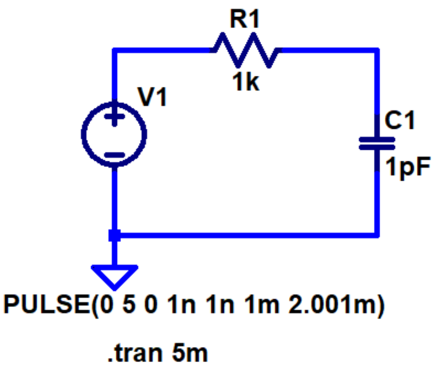


Fig. 4-7

8. At t=0, the switch is closed. What is the voltage across the cap and the current flows through the cap in terms of time t.

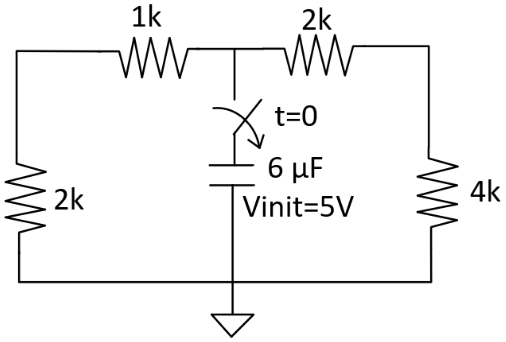


Fig. 4-8

9. Calculate for Vc(t) and I in terms of t for the following circuit:

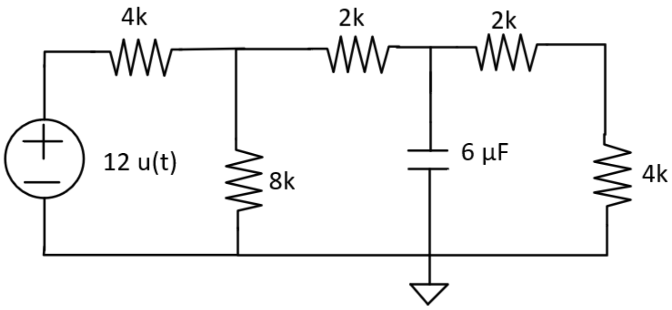


Fig. 4-9