**2.0 RESISTIVE NETWORKS**

**a.** intro to KVL and KCL

**b.** Use KVL and KCL to solve circuit

**2.1 TERMINOLOGY**

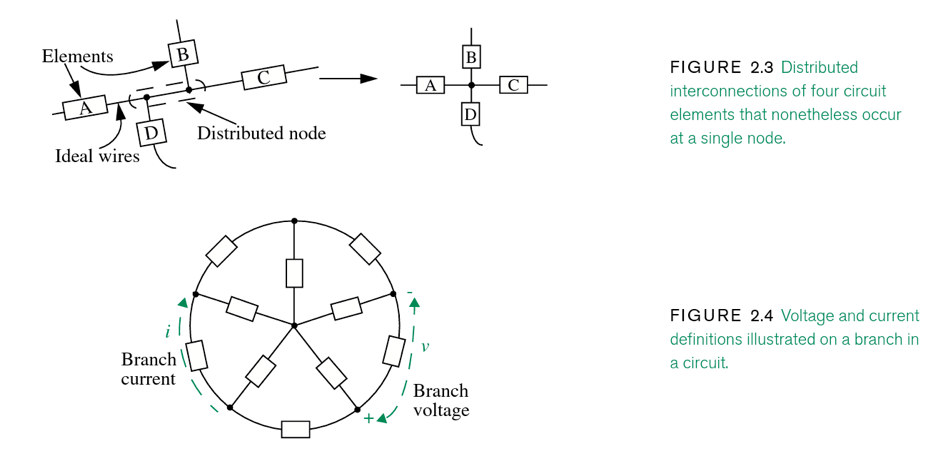
**a.** Junction where 2 + elements are connected = node

**b.** 2 + nodes connected= branch (aka edge)

**c.** Element = branch for only 2 elements

**d.** Since elements and branches are the same for circuits formed of two-terminal

elements, the **branch voltages and currents are the same as the corresponding terminal variables for the elements forming the branches.**

**e. **

**2.2 KIRCHHOFF’S LAWS**

**a.** KVL and KCL derive from Maxwell’s equation.

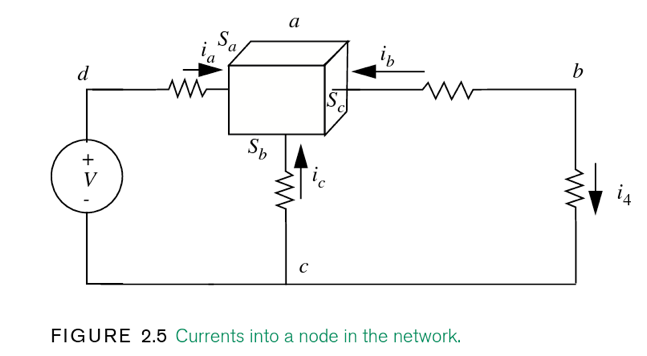
**b.** They are lumped-parameter simplifications into a circuit

**2.2.1 KCL**

**a. What is KCL?** The current flowing out of any node in a circuit must equal the current flowing in. That is, the algebraic sum of all branch currents flowing into any node must be zero.

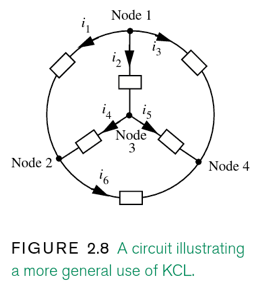
**b.** Current coming in through some branches = current going out through the other branches.

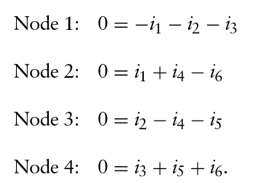
**c.** ia + ib + ic = 0

**d.** 

**in node a:** ia + ib + ic = 0

**in node b:** -ib – ic =0

**e.** 

**f.** 

net current in = net current out. KCL analysis on this closed circuit. As such, adding all those equations sum to 0. A circuit with N node will have N-1 independent statements of KCL.

**2.2.2 KVL**

**a. What is KVL?** The algebraic sum of the branch voltages around any closed path in a network must be zero.

**i.** Voltage between two nodes is independent of the path along which it is accumulated.

**ii.** Like KCL, KVL is an expression of energy conservation.

**b. Look at the chpt book problems**

**2.3 CIRCUIT ANALYSIS: BASIC METHOD**

**a. Basics of circuit analysis:**

**i.** Define the branch and current voltage in the circuit in a CONSISTENT MANNER. IE. + VOLTAGE is CW flow into a + end of voltage.

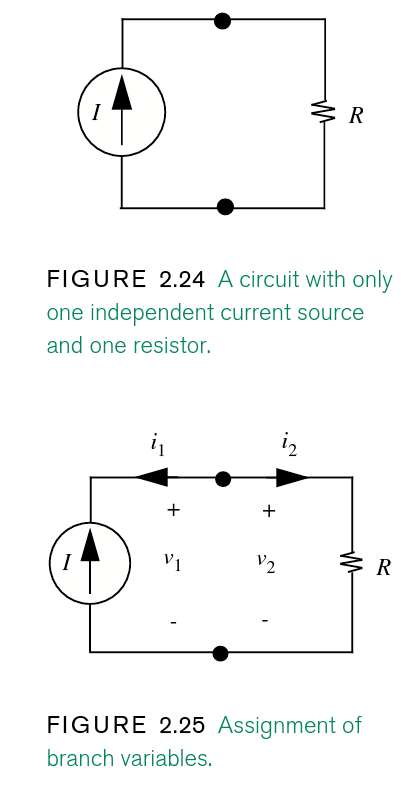
**ii.** Assemble the element laws for the elements.

**iii.** Apply Kirchhoff’s current and voltage laws

**iv.** Jointly solve the equation assembled in Steps 2 and 3 for the branch

**2.3.1 SINGLE-RESISTOR CIRCUITS**

**a. How solve this single-resistor circuits:**

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**i.** label the branch variables (figure 2.25)

**ii.** write the 2-element laws for these elements:

i1 =− I

v2 = Ri(2)

**iii.** i1 + i2 = 0 ; here i1 = -i2 (they are at opp.direction)

**clockwise motion:**

**iv.** v2 − v1 = 0

**Step 4:**

**v.** v1 = v2 = RI

− i1 = i2 = I

take the dots as nodes; see whether current is going away or towards it.

For the circuit in Figure2.25, there are four equations to solve for four unknown branch variables. In general, a circuit having B branches will have 2 B unknown branch variables: B branch currents and B branch voltages. To find these variables, 2 B independent equations are required, B of which will come from element laws, and B of which will come from the application of KVL and KCL. Moreover, if the circuit has N nodes, then N − 1 equations will come from the application of KCL and B − N + 1 equations will come from the application of KVL.

**2.3.3 ENERGY CONSERVATION**

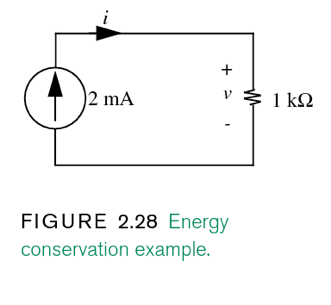
**a.** Power has a (-) sign, current source actually supplies power.

**b.** Energy approaches:

**One energy approach:** equates the energy supplied by a set of elements in a circuit to the energy absorbed by the remaining set of elements in a circuit. Usually, this method involves equating the power generated by the devices in a circuit to the power dissipated in the circuit.

**Another energy approach:** equates the total amount of energy in a system at two different points in time (assuming that there are no dissipative elements in the circuit).

**c.**

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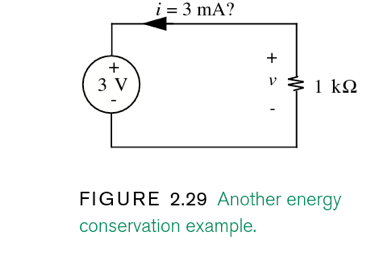
**Since the current source and the resistor share terminals, the voltage v appears across the current source as well.**

power dissipated by the resistor = power into the source

v × (−0.002) =− 0.002 v

v2/1k = 0.002v

Determine if i=3mA is correct:



iv = i2R

i(3) = i2 (1000)

iv = 3(3) = 9mW

power into the source

i2R = 1000ohm x (3x10-3)2

= 9mW

it’s incorrect; power supplied by the source is -9mW; i should be (-):

-9mW + 9mW = 0

Look at chpt1 notes; Energy that is pumped into the source (voltage) is defined as +.

**2.3.4 VOLTAGE AND CURRENT DIVIDERS**

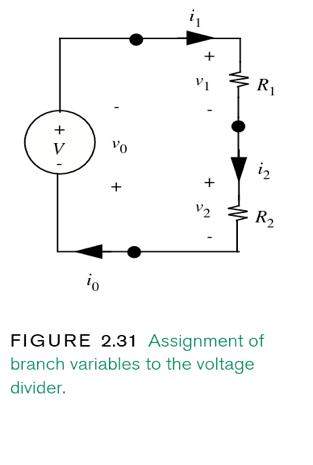
**a.** A divider comprise a single loop and 3 or + elements or two nodes and 3 + elements. Dividers produce fractions of input currents or voltages.

**i.** Useful for decreasing 10% of battery voltage at the terminals, ie v2.

**Voltage Dividers**

1. Voltage divider is an isolated loop that contains 2+ resistors and a voltage source is series.
2. **Deals with Voltages and resistors.**

**Question:**  find the relation between v2 and the battery voltage and resistor values



1. There are 3 elements and branches so there will be 6 branch variable (nodes) \* 2 = number of branch variables. Label the graph.
2. Assemble KVL and KCL and solve them:

**KVL: - just use the internal loops**

v0 = -V

v1 = i1(R1)

v2 = i2(R2)

v0 + v1 + v2 = 0 (from CW direction, all hit + terminals)

**KCL**:

Take each node and see how current is flowing:

From far left:

i0-i1 = 0

i0 = i1

i1 – i2 = 0

i1 = i2

i2 – i0 = 0

i2 = i0

Thus i2 = i1 = i0

V = iR

i = V / R

i = V / R1 + R2 (resis. In series add)

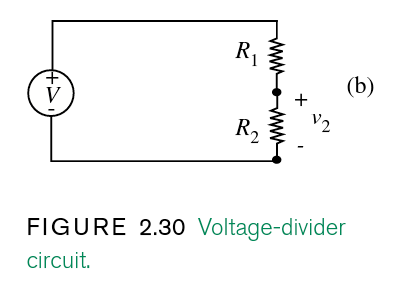
because all I’s are equal, to find v2:

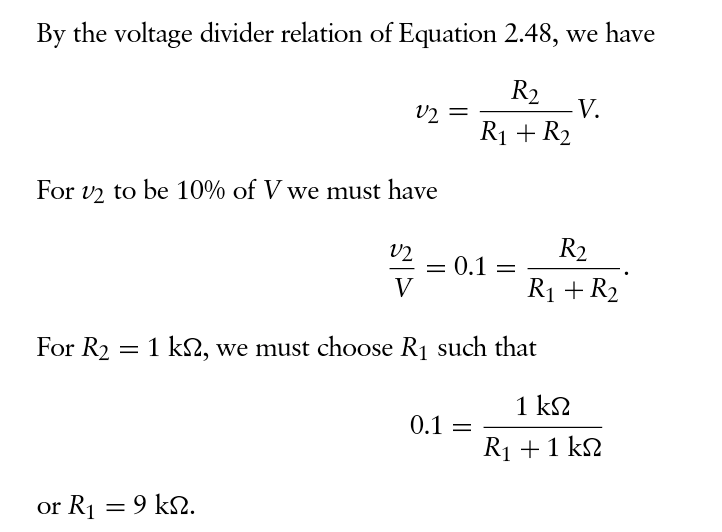
v2 = i2/r2

r2(v2) = V / R1 + R2

v2 = R2 (V) / R1 + R2

Let’s say we want to decrease v2 by 1/10 of the total voltage, R1 > R2 by 9x’s.



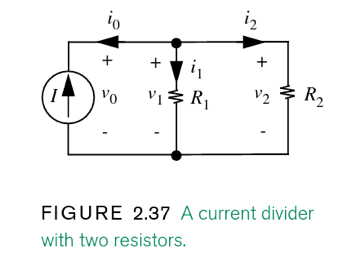


**Resistors in Series**

1. Rs = R1 + R2 + …
2. Conductances: 1/Gs = 1/G1 + 1/G2 + …
3. Problems

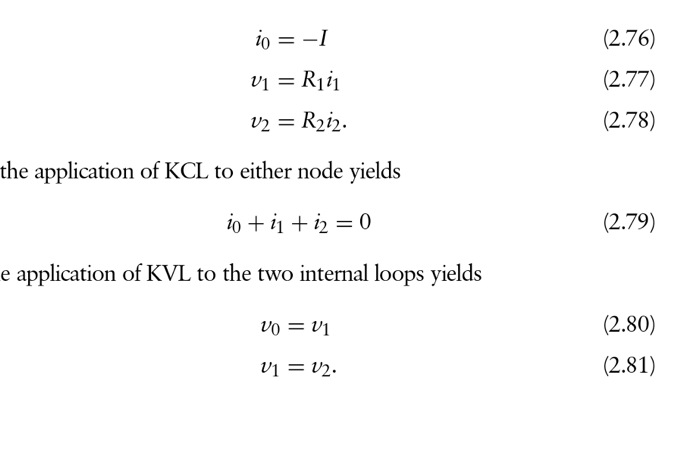
**Current Dividers**

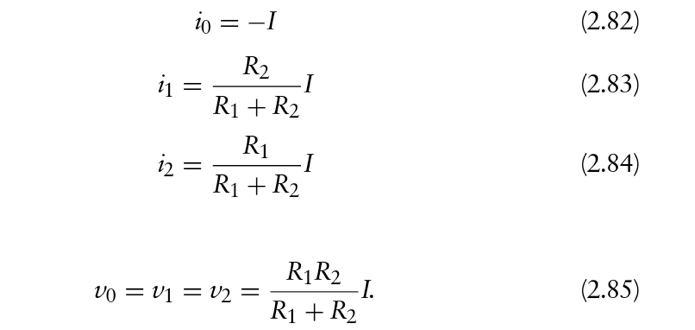
**Current that is dividend proportionally to resistance**

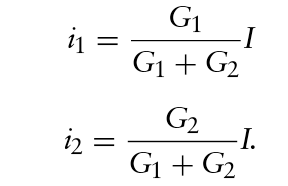
1. Two nodes joining two or more parallel resistors with current going through.
2. **Deals with current and resistors**
3. Conductance:
   1. **i1 = G1/ (G1 + G2) I**
   2. **i2 = G2 / (G1 + G2) I**
4. ****

**-**note about KVL: PICK A current and follow it through. i.e. i2 goes into v2 and (+) terminal and goes into v1 at (-) terminal. v2-v1=0; v2=v1.

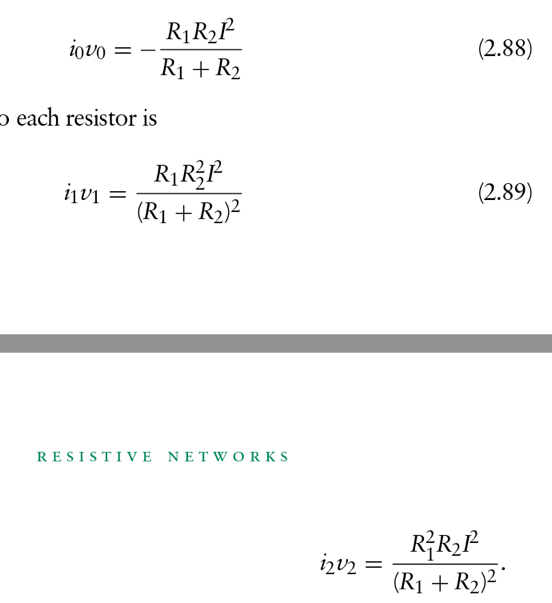
**Analysis of this circuit:**

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****

**Power into each resistor:**

****

**Resistors in Parallel**

**a. v = R1(R2) / R1 + R2**

**b.** Resistors in parallel act as a single resistor and have a conductance of:

Gp = 1/Rp

**c.** Placing resistors in parallel essentially increases their combined

cross-sectional area:

GP = I/v = G1 + G2 .

1. <http://www.learningaboutelectronics.com/Articles/Current-divider-circuit.php>

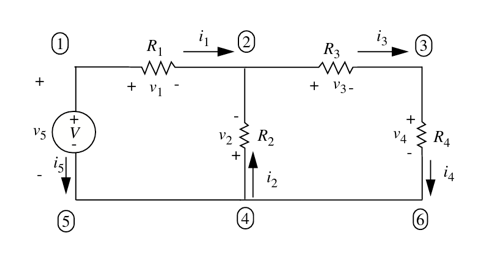
**Differences between resistors in parallel and series:**

Series: The voltage you are trying to find is going to be the numerator of the resistor: V2 = (R2/R1+R2)Vmain\_voltage

Parallel: Current you are trying to find is going to be the opposite of the resistor:

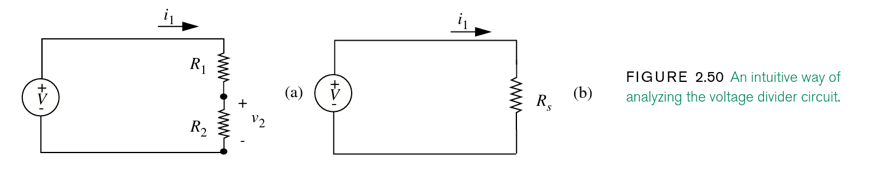
i2 = (R1/R1 + R2)Imain\_current

**2.3.5 A MORE COMPLEX CIRCUIT**

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1. node 5 and 6 are not true nodes; they are just conductors (wire). A node should be
2. 2+ circuit elements, not just conductors, connected. Node 2 is a good example.

**2.4 INTUITIVE METHOD OF CIRCUIT ANALYSIS: SERIES AND PARALLEL SIMPLIFICATION**

1. ****

* we can sum R1 + R2 = Rs
* V = i1Rs

**i1 = V/Rs**

Because i1 is the same for both circuits:

* v2 = i1(R2)

**sub for i1 from eq. above:**

v2 **=** V(R2/R1+R2)

rest of chpt goes over problem of how to expand pg 91 in book.

**2.6 DEPENDENT SOURCES AND THE CONTROL CONCEPT**

**a.** Independent and dependent elements:

Independent: V and i: independent of circuit operations

Dependent: small v and I = dependent on the voltage and resistance (circuit elements); denoted by a diamond symbol.

**b.** MOSFET: in which a control voltage between one pair of terminals of the device determines the MOSFET’s behavior between another pair of terminals. Thus, when the multi-terminal dependent source is connected in a circuit, the behavior of the device can be controlled by a voltage or current in some other part of the circuit.

**c. Types of dependent sources:**

**i VCCS:** voltage controlled current source (open circuit)

**ii.** **VCVS:** voltage controlled voltage source (open circuit)

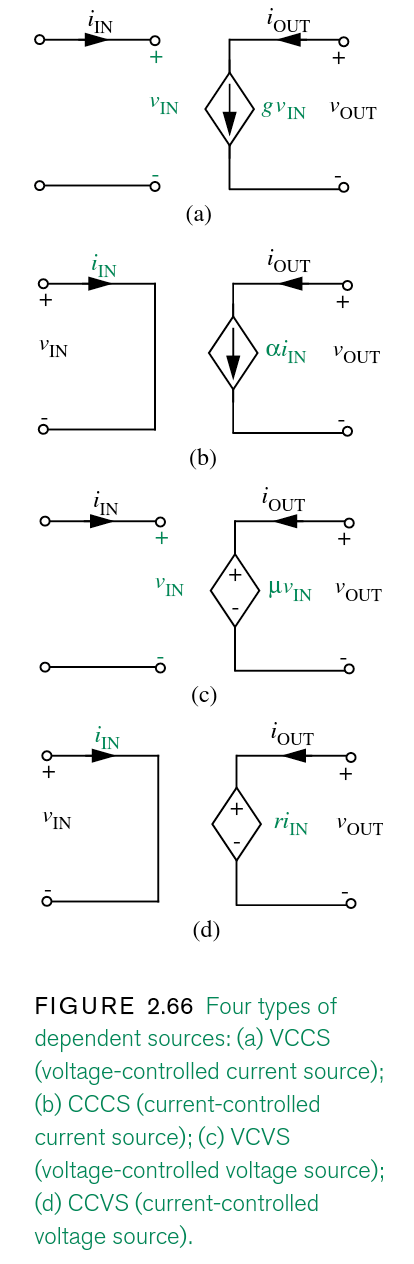
**iii.** **CCCS:** current controlled current source (short circuit)

**iv. CCVS:** current controlled voltage source (short circuit)

**d.** Diagrams:

**i. VCCS AND VCVS: VC:**open terminals

**ii. CCCS AND CCVS:** **CC:** closed terminals



**iii.** On the left diagram ie a) iout = gvin where g=conductance. Each dependent source has different units.

**VCCS:** g(conductance)vin

**VCVS:** miuvin [same=coef] miu = voltage transfer ratio

**CCCS:** alpha(in) [same =coef] alpha=current transfer ratio

**CCVS:** resistance(in) r=transresistance

**iv.** left-side = dependent side

**v.** 2 parts to this circuit: input and output.

**i.** **input (aka control port)=** left-side; independent of the

output (right-side)

**ii. output=**right-side; dependent on the input.

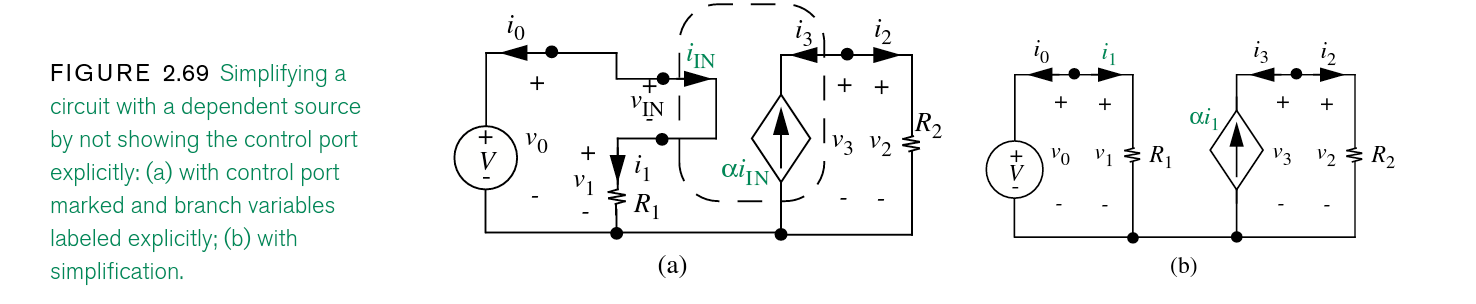
**iii.** you can analyze the circuit as you would normally using

KVL and KCL. For the purpose of analysis, you can treat

each part independently of each other.

**e. Diagram style:**

**i.** The idealized input port is simply present to sample the value of a branch current or voltage ***without changing the value of the existing branch variable***. Therefore, we do not really need to show the input port of the dependent source explicitly, thereby reducing the number of branch variables that we have to deal with. So, you don’t have to write Vin.



**note:**  Always remember that series resistors have the same current and parallel resistors have the same voltage.

**Random notes:**

**Labeling KVL and KCL equations:**

http://engineeringvideolectures.com/video/9975

Number of KCL equations: #Nodes -1

Number of KVL equations: #Branches - #Nodes + 1

***Which KVL equation do you write?***

1. Pick branches that don’t yet form a loop
2. Individually add branches where it will form a loop (see video above)

If you take current (+) moving from +v to –v, then the power consumed by an element (vi) is (+). Also known as associated variable convention.