EE42 Introduction to Electronics for CS

Course content:

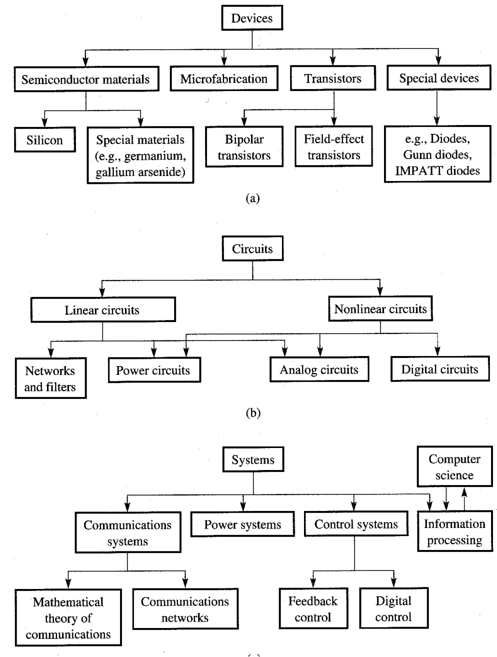
- Basic circuit theory
- Emphasize digital circuits
- Performance limitation of digital circuits

(see syllabus for details)

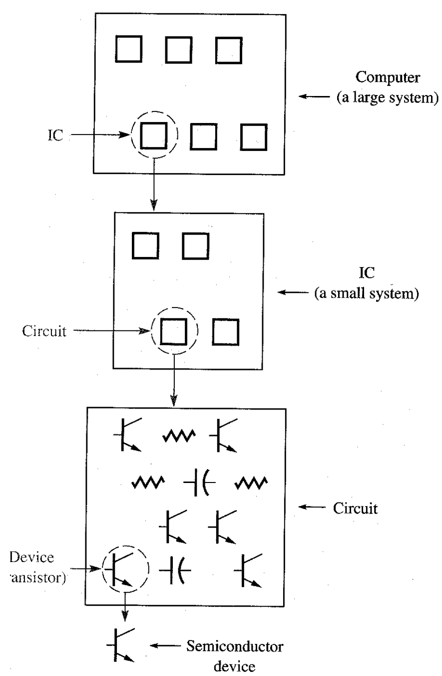
Course web page:

http://www-inst.eecs.berkeley.edu/~ee42

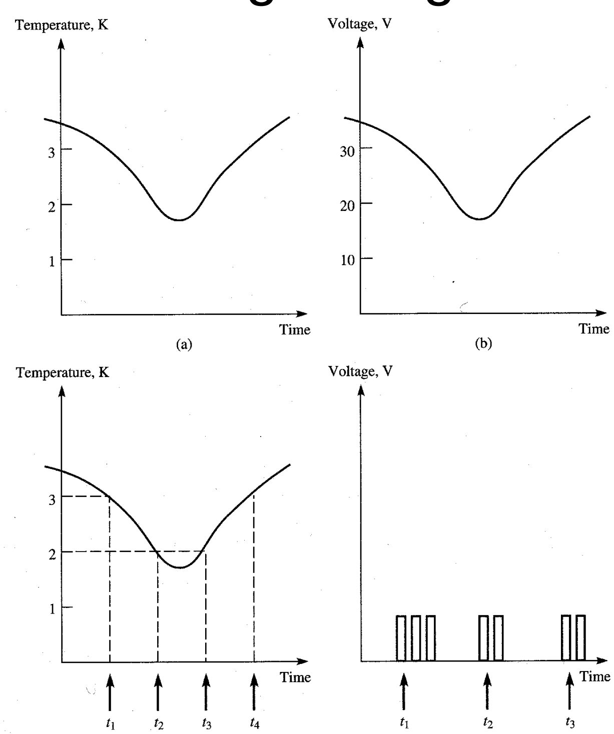
Electrical Engineering



Systems, Circuits, Devices (transistors)

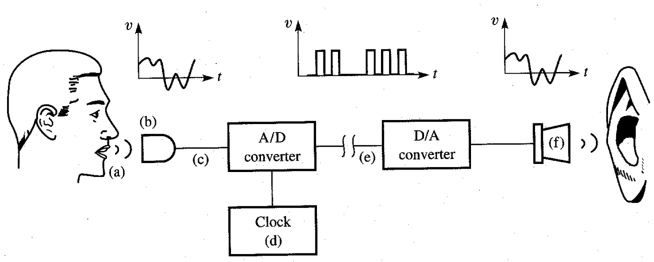


Analog vs Digital

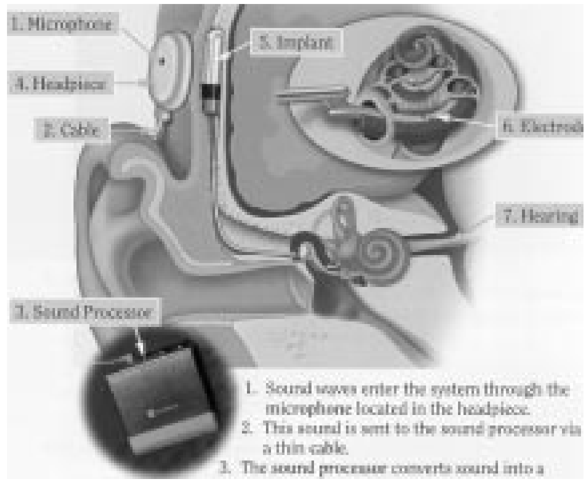


2 bits: 11 10 10 11

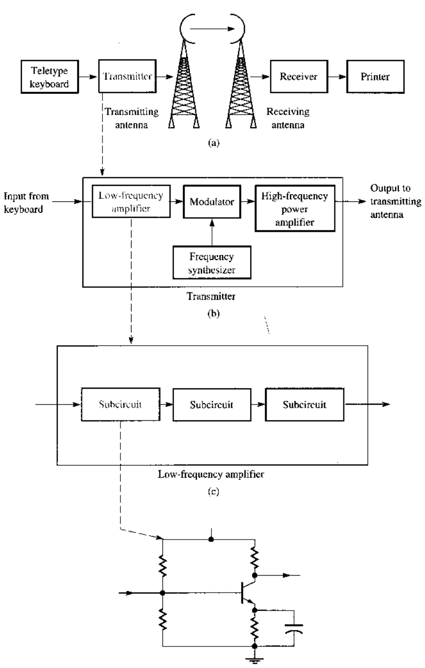
Analog to Digital
Digital to Analog



Cochlear Implant



Building blocks Approach



Electrical Quantities (SI units)

Quantity	Symbol	Unit	Abr of unit
Length	*l*	meter	m
Mass	m	kilogram	kg
Time	t	second	sec
Energy	E	joule	J
Force	F	newton	N
Power	P	watt	W
Charge	Q	coulomb	C
Current	I or I	Ampere	A
Potential	V or v	volt	V
Resistance	R	ohm	Ω
Capacitance	C	farad	F
Inductance	L	henry	H

Electrical Quantities

Prefix	Abr.	Multiplies Unit by
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Symbols Used in Circuit Diagram

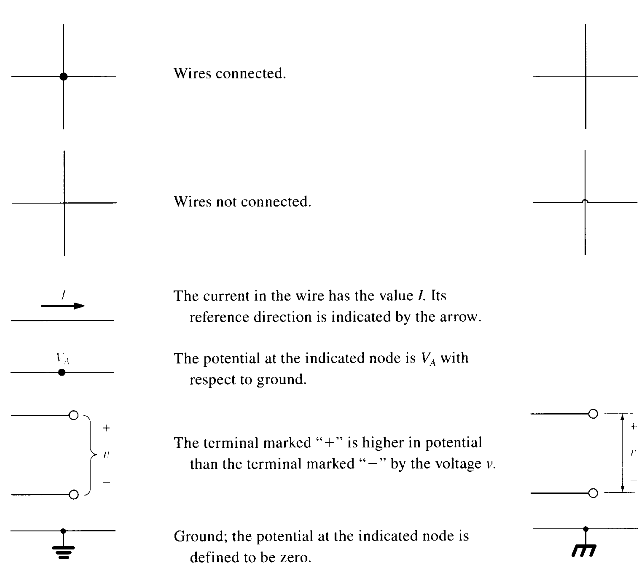
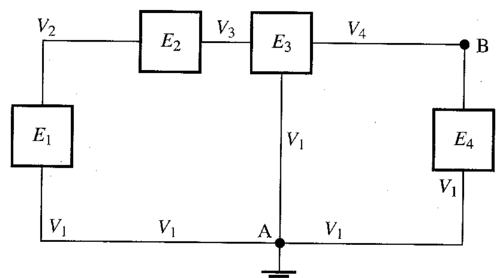


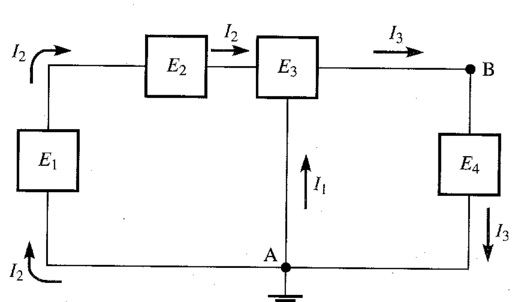
TABLE 1.2 Symbols Used in Circuit Diagrams

Symbols Used in This Book	Meaning	Alternate Symbol
	Wires connected.	
	Wires not connected.	
I	The current in the wire has the value I. Its reference direction is indicated by the arrow.	
V_A	The potential at the indicated node is V_A with respect to ground.	
+ v −	The terminal marked "+" is higher in potential than the terminal marked "−" by the voltage v.	+ v −
	Ground; the potential at the indicated node is defined to be zero.	

Ground

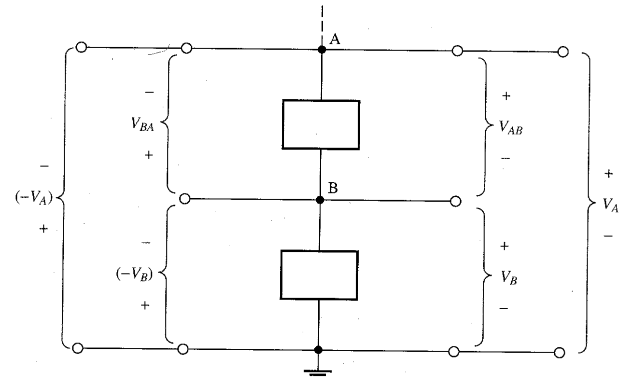


(a)



(b)

Voltage Symbols

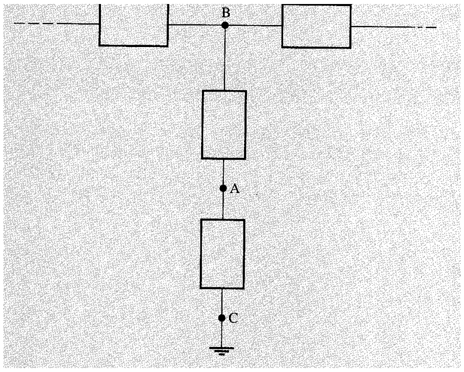


Use the same convention consistently:

$V_{AB} = -V_{BA}$
$V_{AB} = V_A - V_B$
$V_{BA} = V_B - V_A$

$V_{B0} = - (V_{0B})$
$V_B - V_0 = - (V_0 - V_B) = V_B = - (- V_B)$

Exercise



V_A (the potential at A with respect to ground (node C) is 4V, and V_{BA}=-7V. What is V_B? V_C?

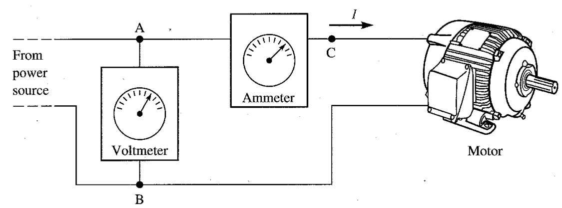
$$V_{BC}=V_B - V_C = V_B$$
$$= V_{BA} + V_{AC}$$
$$= (V_{BA}) + (V_A - V_C)$$
$$= -7V + 4V = -3\ V$$
$$V_C = 0V.$$

Example

From measurement a direct current (dc) produces a mechanical output of 41.3 hp. The voltmeter indicates V_{AB}=442 v. and the ammeter tells us that a current of 83.1 A in the direction of I. (1hp=746W)

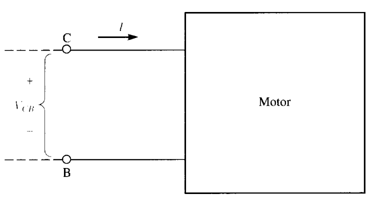
(a) what is the efficiency of the motor if we assume V_{AC} = 0?

(b) Efficiency if V_{AC} = 20v?



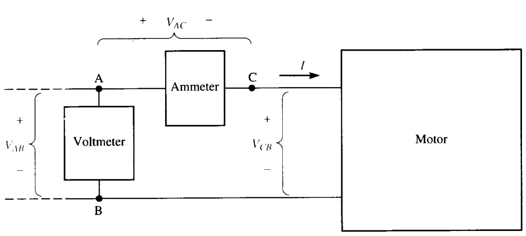
(a)

Example (cont.)



(b)

Power entering the motor = $V_{CB}\ I$



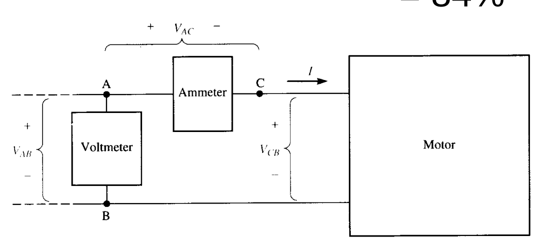
(c)

(a) $V_{AB}=V_{AC}+V_{CB}$, but we assume V_{AC}=0
$V_{AB}=V_{CB}$

PIN = (442)(83.1) = 36700W=36.7kW
= 36700W (1 hp/746W) = 49.2 h.p.

Example (cont.)

Efficiency E = P_{in}/P_{out}
= 41.3/49.2 = 0.84
= 84%



(c)

(b) $V_{AB}=V_{AC}+V_{CB}$

$\Rightarrow V_{CB}=V_{AB}-V_{AC}$

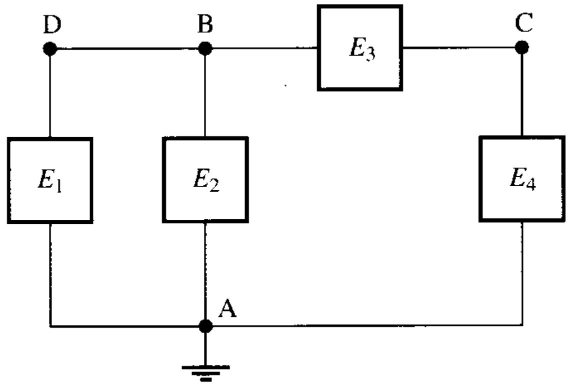
V_{AC}=20v.

$E = P_{out}/P_{in} = P_{out}/[(V_{AB}-V_{AC})I]$

= 41.3/[(442-20)(83.1)(746)]

=0.88 or 88% (why higher efficiency?)

Circuit Nodes & Branches



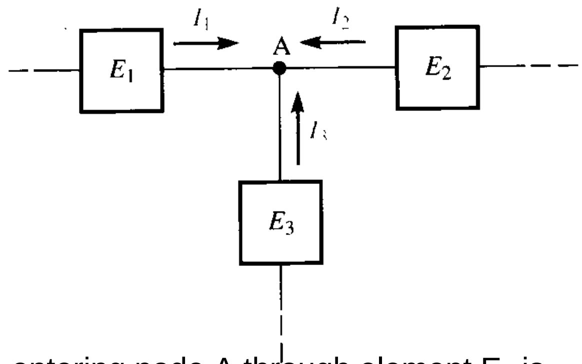
Points A, B, C, D (or nodes A, B, C, D)

Branches E_1, E_2, E_3, E_4

Nodes A is the reference node or ground (notice the ground symbol). Point D and B are located in the same node.

Kirchhoff's Current Law

- Whatever current flows in one end must flow out the other end of a wire.
- **The sum of all currents entering a node is zero.**



I_1 entering node A through element E_1 is +15mA, I_2 equals +32mA, what is I_3?
According to KCL: sum of all current entering node A is zero $I_1+I_2+I_3 = 0$ or $I_3 = -I_1-I_2$
I_3 = -15mA - 32mA = -47mA.

KCL (cont.)

KCL can be stated as:

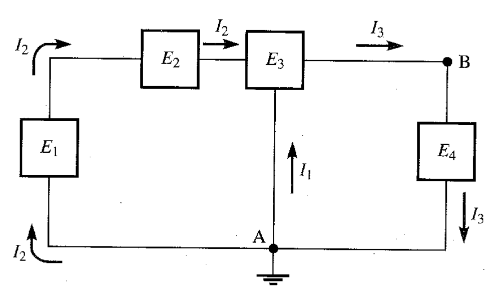
the sum of all currents leaving a node is zero.

$- I_1 - I_2 - I_3 = 0$

$- (I_1+I_2+I_3) = 0$

$- (0) = 0$

Exercise



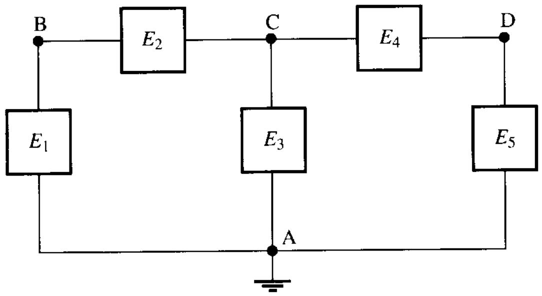
I_2 = 4.7mA, I_3 = 3.3mA
What is I_1?

Apply KCL: Sum of all current entering E_3 = 0

$I_1+I_2 - I_3 = 0$
$I_1 = - I_2 +I_3$ = -4.7mA + 3.3mA = -1.4mA

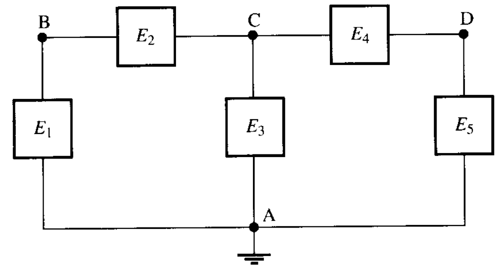
Kirchhoff's Voltage Law

KVL: the sum of all the voltage drops around a complete loop



Voltage at node A, B, C, D is V_A, V_B, V_C, V_D respectively. Write an equation expressing KVL for the loop A$\rightarrow$ B $\rightarrow$ C $\rightarrow$ D $\rightarrow$ A.

KVL (cont.)

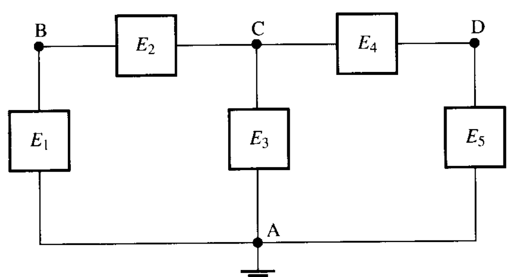


We shall add the "voltage drop" as we move around the loop.

Because of the ground symbol, node A has 0 V.

The drop from node A to B is :
$V_{AB} = V_A\text{-}V_B = 0 - V_B = -V_B$
Voltage drop from B to C is:
$V_{BC} = V_B\text{-}V_C$

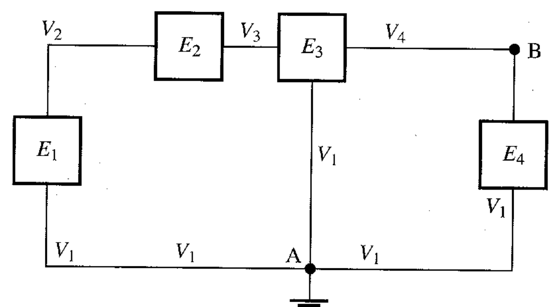
KVL (cont.)



Voltage drop across E_1 + voltage drop across E_2 + voltage drop across E_4 + voltage drop across E_5 = 0

$-V_B + (V_B - V_C) + (V_C - V_D) + (V_D\text{-}0) = 0$

Exercise 1.4

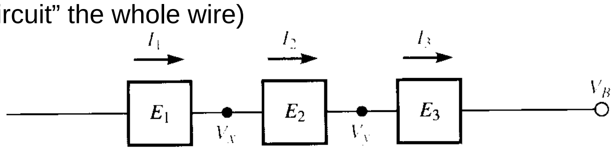


Let $V_1 - V_2 = 6.1V$
$V_3 - V_1 = 4.4V$
$V_3 - V_2 = ?$

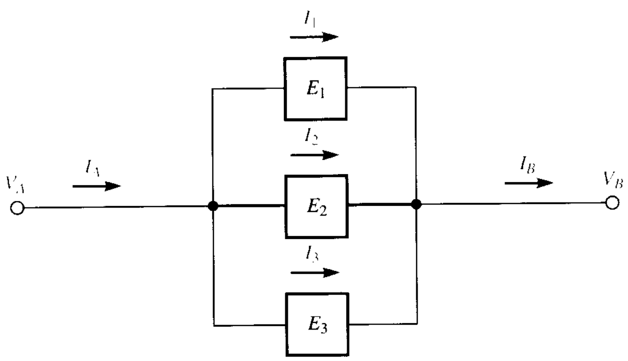
$V_1 - V_2 + V_3 - V_1 = 6.1 + 4.4V$
$V_3 - V_2 = 10.5V$

Series and Parallel

Series connection (take out one will "open circuit" the whole wire)

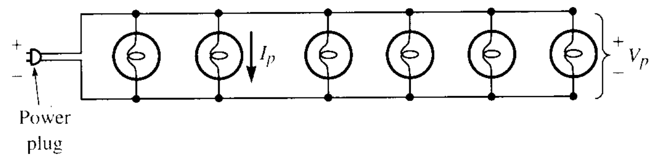


Parallel connection (take out one circuit element would not affect the whole circuit)

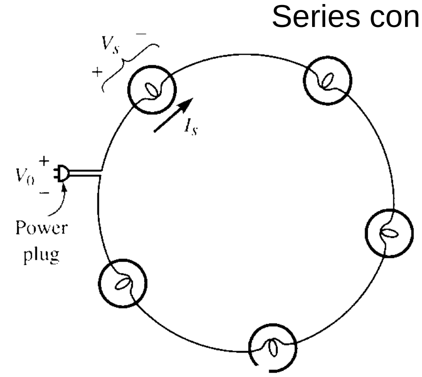


Series and Parallel (cont.)

Parallel connection

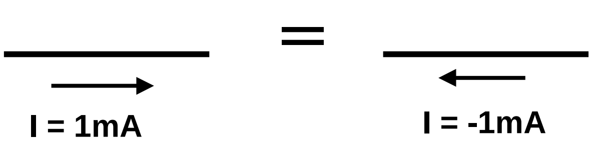


Series connection



Summary

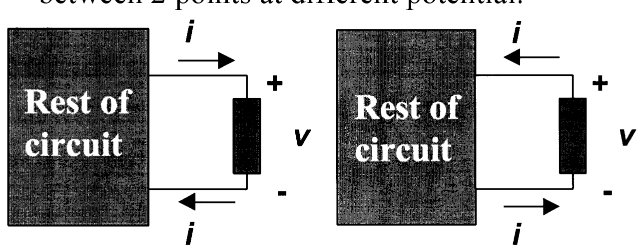
- The current at a point is equal to the amount of charge passing through that point each second. In SI, charge is in coulombs and current in amperes. Current can be positive or negative, but you have to stick to the convention:



- A voltage is a difference in electrical potential between two points.
- It is possible to designate any single point in a circuit as "ground, " meaning that by definition the potential at that point is zero.

Summary (cont.)

- Power is transferred from one part of the circuit to another whenever a current flows between 2 points at different potential.



By using the "associated reference direction", when the product of VI (= Power) > 0, the circuit element is absorbing.

When VI < 0, the circuit element is releasing power.

Kirchoff's Current law states that the sum of all current entering a node is zero.

Kirchoff's voltage law states that the sum of all voltage "drop" around any closed loop is zero.