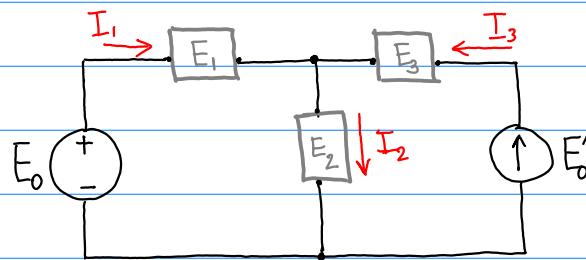


Lecture # 01Electric Circuits: Circuit Elements

Electric Circuits: An electric circuit (or network) is an interconnection of electrical circuit elements linked together in a closed path so that an electric current may continuously flow.



Electric circuit →  
Sources & Sinks.

here,  $E_0$  = Voltage Source

$E'$  = Current Source

$E_1, E_2, E_3$  = Elements (Resistor, Capacitor, Inductor...  
...)

Circuit Elements   
Sources  
Sinks

We define two kinds of ckt. elements

1) Active Elements

2) Passive Elements

1) Active Elements : Capable to supply non-zero average power to the ckt (ext'l/int.) over an infinite time interval.

Examples :

1) Sources : Voltage source, Current Source

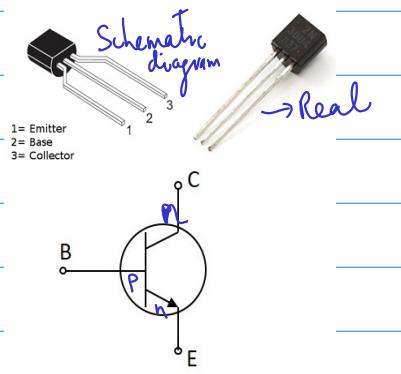


Battery

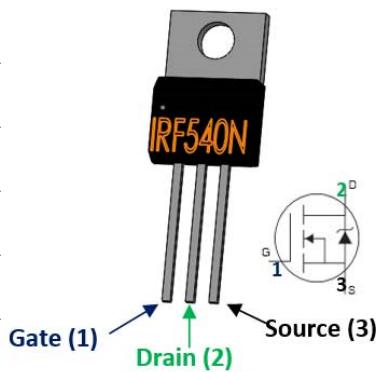
DC power Supply (Lab.)

2) Semiconductor Devices : Transistors (BJTs, MOSFETs)  
Op-Amp. etc.

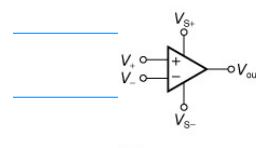
- Power gain in the ckt.



BJTs



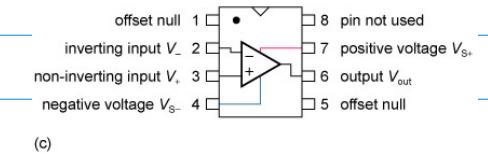
MOSFETs



(a)



(b)

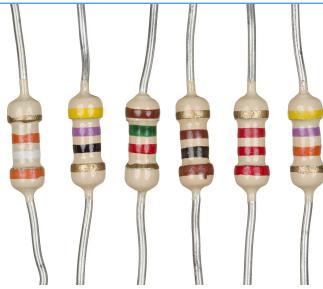


Op-Amp.

2) Passive Elements : Not capable to supply non-zero average power to the ckt. over an infinite time interval.

- No power gain.

## Examples :

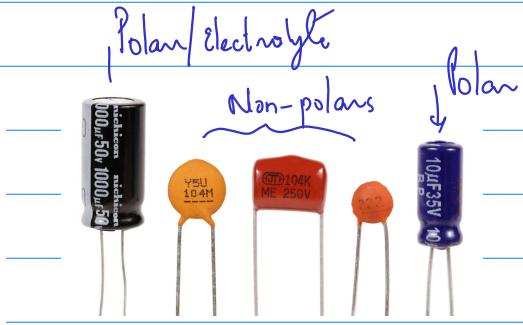


## Resistors

$$\underline{I^2R}$$



## Transformers



# Capacitors

$$\frac{1}{2} CV^2$$



## Inductors

$$\frac{1}{2} LI^2$$

$$P_{in} = P_{out} \quad (\text{ideal})$$

$$I_p V_p = I_s V_s \quad - \text{ideal transformer}$$

ACTIVE	PASSIVE
Transistor	 
Diode	 
LED	 
Photodiode	 
Integrated Circuit	 -
Operational Amplifier	 
Seven Segment Display	 
Battery	 
	Resistor  
	LDR  
	Thermistor  
	Capacitor  
	Inductor  
	Switch  
	Variable Resistor  
	Transformer  

## Active and Passive Ckt. Elements :

1) Judgement based on power activity.

Active Element : Those which outsource electric energy

- Sources — Voltage / Current sources

They provides electrical power to the ckt. continuously.

- Amplifiers : They amplify low power signals to high power signals. at the cost of bias power.  
— Power gain.

Passive Elements : Consumes electrical power or,  
stores electrical power

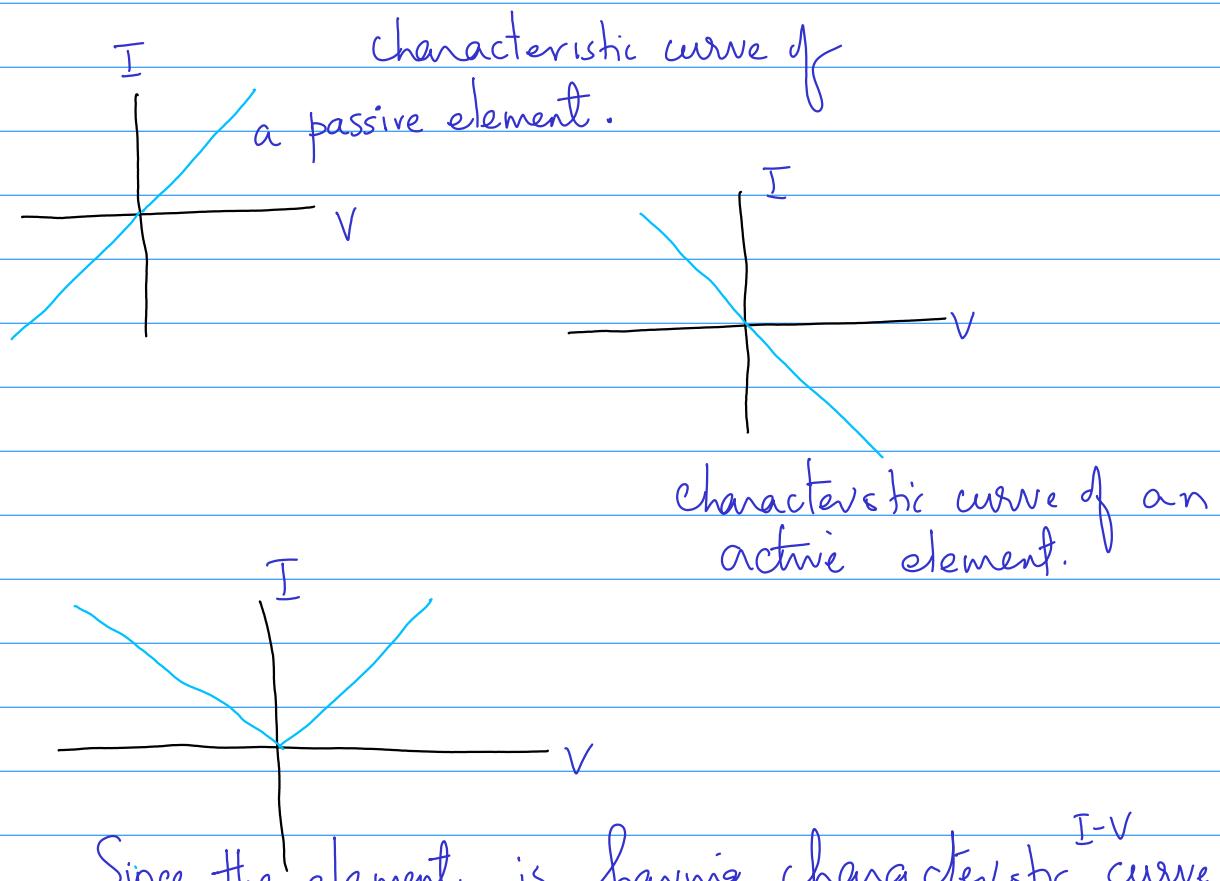
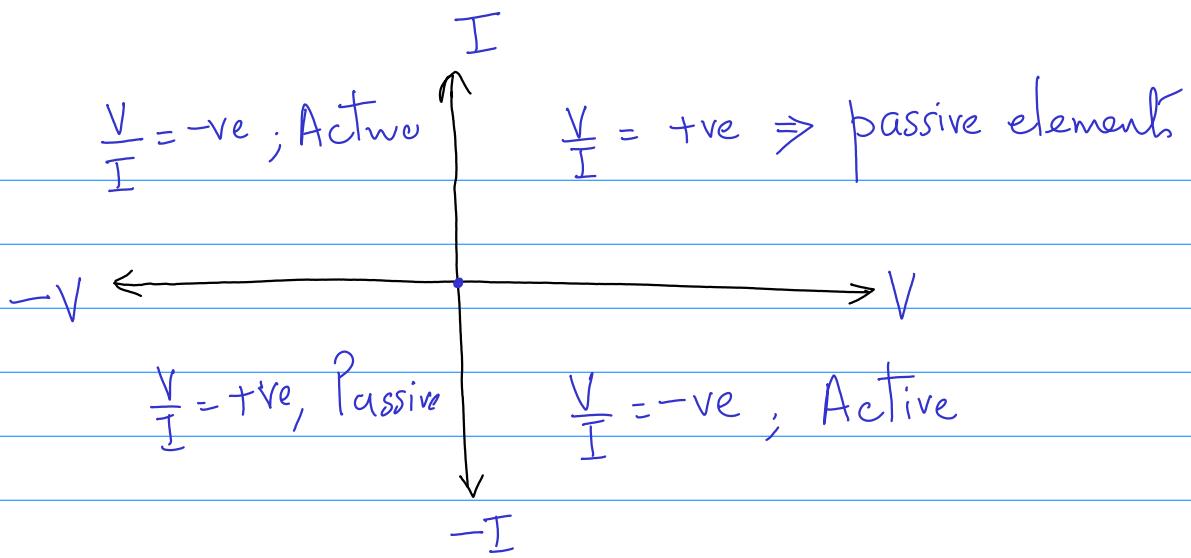
- Resistors, capacitors, Inductors, Transformer.

Any element behaving as an electric "SOURCE" is active and any element behaving as electric "SINK (LOAD)" is passive.

(2)

Judgement based on the sign of  $\frac{V}{I}$  ratio:

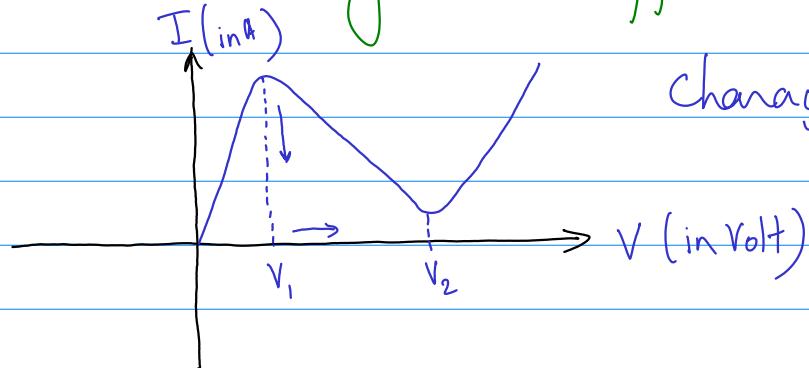
- We know that electric current is driven out from the +ve terminal of the Sources, therefore,  $\frac{V}{I}$  ratio is Negative, hence, it is active element.
- Similarly, the electric current is entered into the +ve terminal of the "SINK (LOAD)", therefore,  $\frac{V}{I}$  ratio is positive, hence they are passive element.



Since the element is having characteristic curve  
 in second quadrant, we can say it is an  
 Active element.

## Special Cases :

③ Devices with negative differential resistance.



characteristic of a "Tunnel Diode".

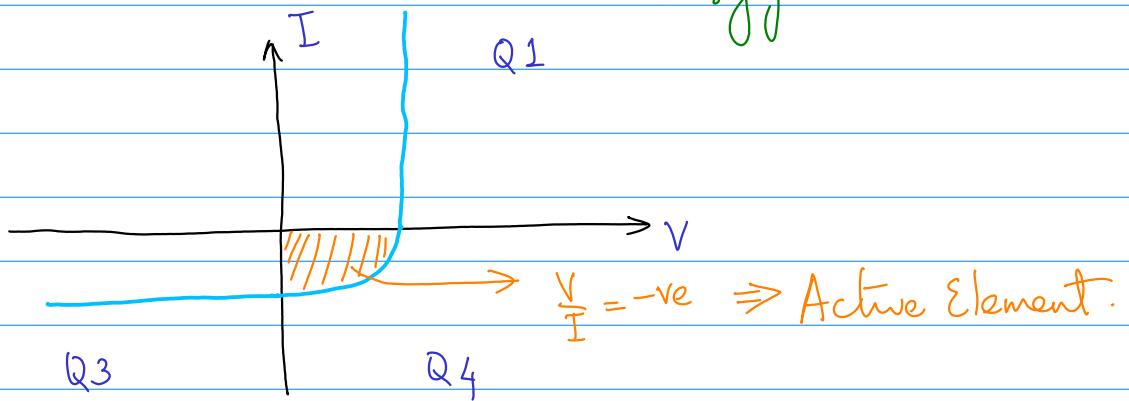
$$\text{Slope} = -ve$$

$$R = \frac{1}{\text{Slope}} = -ve \Rightarrow \text{Source}$$

Therefore, we categorize such element as "Active Element"

⇒ Application : As an amplifiers or oscillators.

④ Characteristic curve of a solar cells (power generation)  
Solar energy to useful electrical energy.

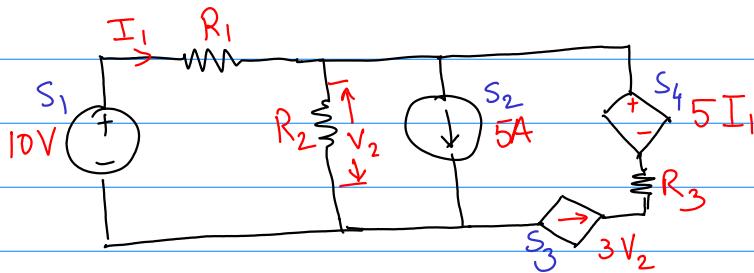


Sources : Independent Sources

Dependent Sources

Independent Sources : The element for which both voltage and current don't depend on the voltage or current elsewhere in the ckt.

Dependent Sources : The element for which both voltage & current depend on the voltage & current elsewhere in the ckt.

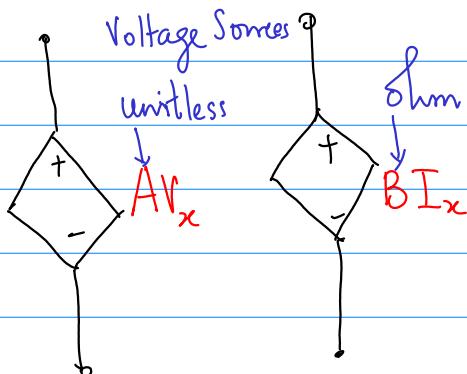


$S_1$  = Independent Source

$S_2$  = "

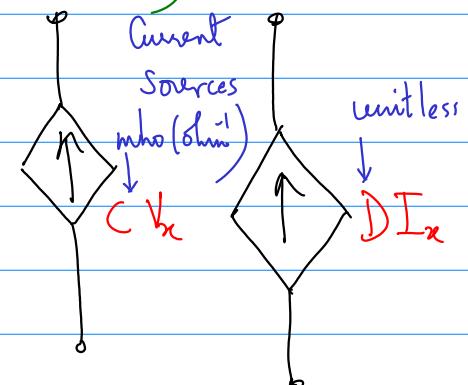
$S_3$  } Dependent Sources  
 $S_4$

Dependent Sources (Controlled Sources)



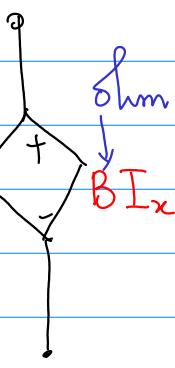
VCVS

Voltage Controlled voltage Source



CCCS

Current controlled current source



CCVS

Current controlled voltage source

Current controlled voltage source



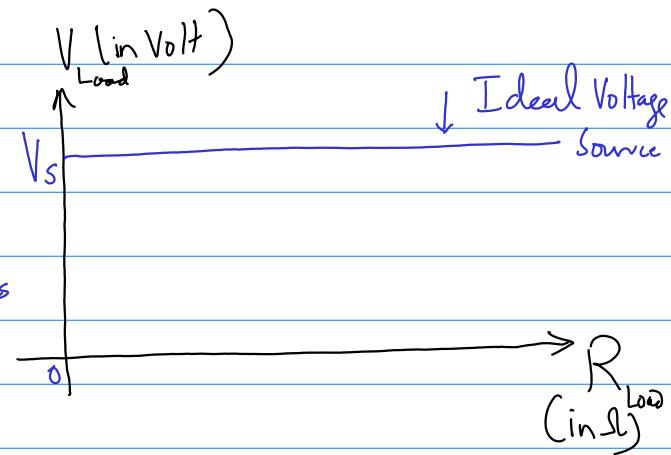
VCCS

Voltage controlled current source

## Ideal Voltage Source :

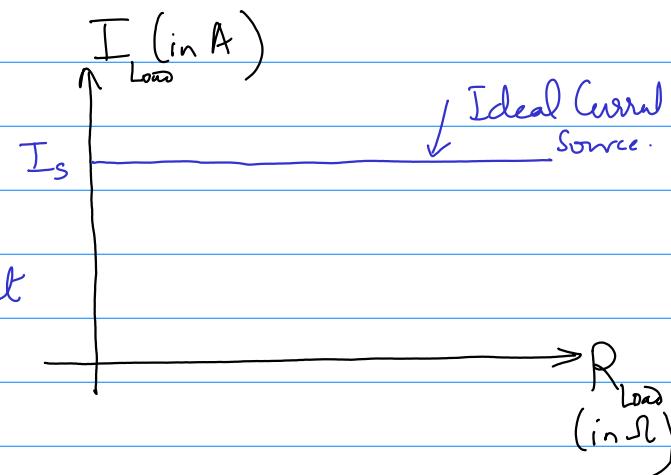
⇒ Voltage drop across

the load resistance remains constant with varying the value of load resistance.

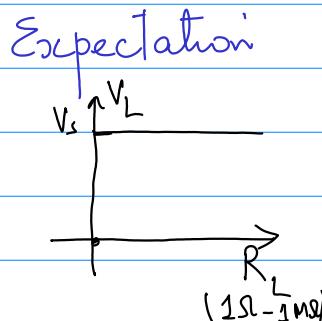
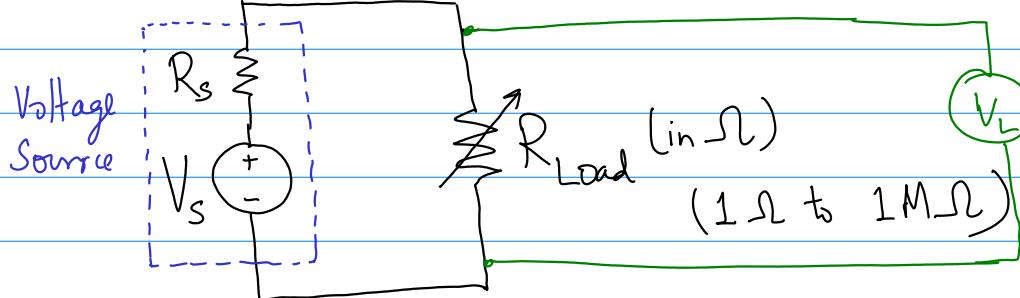


## Ideal Current Source :

Current passing through the load resistance remains constant with varying the value of load resistance.



However, in practice, we have real voltage source and real current source.



Reference : Chapter 1 (Malvino & Bates)