كتاب تجارب معمل

الأساسيات الإلكترونية

<u>أولاً: بيانات المعمل الأساسية</u>

اسم المعمل: معمل القياسات الإلكترونية

القسم العلمي: هندسة الإلكترونيات والاتصالات

المشرف: أ.د./ محمد عبدالعظيم

مهندس المعمل: د./ مجدي محمد فاضل

أمين المعمل: أ./ محمد يوسف مصطفى

التليفون: 1300

الموقع بالنسبة للكلية: المعامل البحرية بالكلية – الطابق الثاني علوي.

مساحة المعمل: 127 $م^2$

ثانياً: قائمة بالأجهزة والمعدات الموجودة بالمعمل:

Serial Number	العدد	اسم الجهاز	م
	10	Two channel Oscilloscope.	1
	10	Function generator.	2
	10	Dual power supply.	3
	15	Digital multimeter.	4
	20	Test board.	5
	5	Side cutter (قصافة)	6
	5	Pliers (زردية)	7

ثالثاً: قائمة بالتجارب التي تؤدي داخل المعمل:

م	التجربة	الغرض منها
1	How to use Digital Oscilloscope	التعرف على الأجهزة الإلكترونية الأساسية – وسلوك العناصر الإلكترونية الأساسية.
2	Passive Elements of Electric Circuits	
3	Transient Circuits	
4	Nonlinear Resistors	
5	Passive Filters	
6	Passive Resonant Circuits	
7	Linear Circuits Theorems	
8	Semiconductor Diodes and Diode Applications	
9	Special Purpose Diodes	
10	Bipolar Junction Transistor (BJT)	
11	Diode and Transistor based Logic Gates	
12	Power Supplies	

رابعاً: الخدمات المجتمعية التي يؤديها المعمل:

- **عدد المستفيدين من المعمل:** جميع طلاب (مرحلة البكالوريوس والماجستير والدكتوراه) للقسم وأقسام الكلية المختلفة وكذلك بعض الكليات الأخرى.

- **الجهات التي تتعاون مع المعمل:** جميع أقسام الكلية وبعض الكليات الأخرى.

- **الدخل السنوي للمعمل:** لا يتم تحصيل أية رسوم.

- **الجهات الممولة لأنشطة المعمل:** إدارة الكلية.

- **المشاريع التنافسية التي يشارك فيها المعمل:** العديد

خامساً: الخدمات الطلابية التي يؤديها المعمل:

- **عدد الطلاب المستفيدين من المعمل:** جميع طلاب (مرحلة البكالوريوس والماجستير والدكتوراه) للقسم وأقسام الكلية المختلفة وكذلك بعض الكليات الأخرى.

- **الأقسام العلمية المستفيدة من المعمل:** جميع أقسام الكلية وبعض الكليات الأخرى.

- **الفرق الدراسية المستفيدة من المعمل:** جميع طلاب (مرحلة البكالوريوس والماجستير والدكتوراه) للقسم وأقسام الكلية المختلفة وكذلك بعض الكليات الأخرى.

- **المقررات الدراسية التي تستفيد من المعمل:** مقررات القسم والأقسام الأخرى.

- **الأنشطة الطلابية داخل المعمل:** سكاشن ومشاريع تخرج ومشاريع تنافسية وأبحاث ماجستير ودكتوراه.

- **عدد طلاب الدراسات العليا المستفيدين من المعمل:** العديد

- **عدد الرسائل العلمية التي تمت في المعمل:** العديد

- **عدد الدورات التدريبية التي تمت في المعمل:** العديد

- **المسابقات العملية التي شارك فيها طلاب من المستفيدين من المعمل:** العديد

تمهيد

Course Contents

Experiment-0: Overview of laboratory equipment's (Digital Multimeters, Function Generators, Oscilloscope)

Experiment-1: Passive Elements.

Experiment-2: Transient Circuits.

Experiment-3: Nonlinear Resistances.

Experiment-4: Passive Filters.

Experiment-5: Resonant Circuits.

Experiment-6: Circuit Theorems.

Experiment-7: Diodes and Applications.

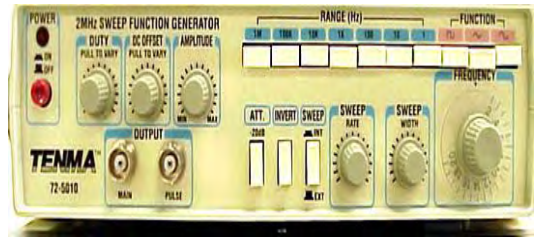
Experiment-8: Special Diodes.

Experiment-9: Bipolar Junction Transistors.

Experiment-10: Logic Gates.

Experiment-11: Power Supplies.

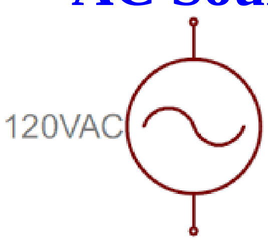
Introduction



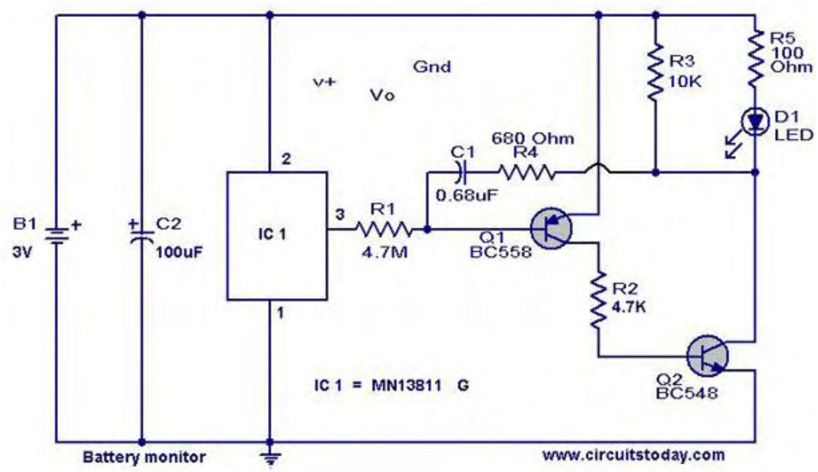
Function Generator

Energy Source → Electric/ Electronic Circuit → Measuring/ Displaying Devices

AC Source



DC Source



Multimeter

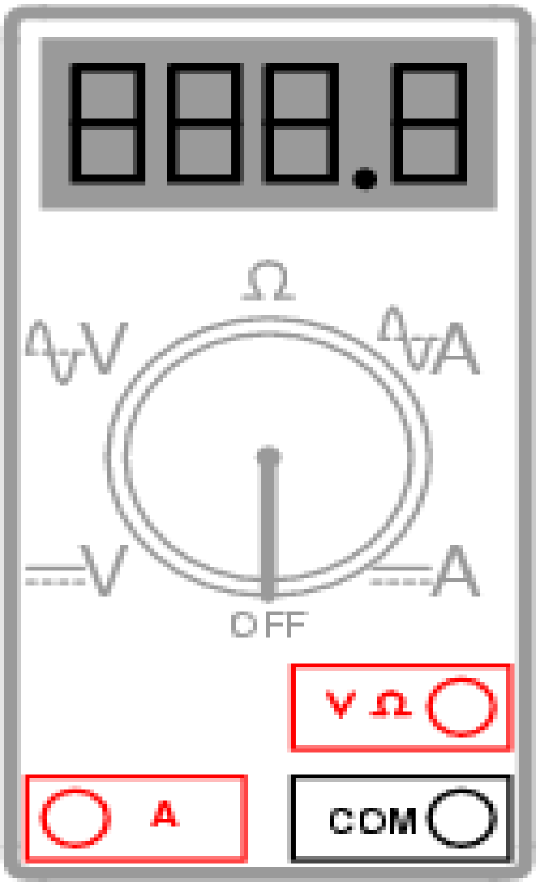
Oscilloscope

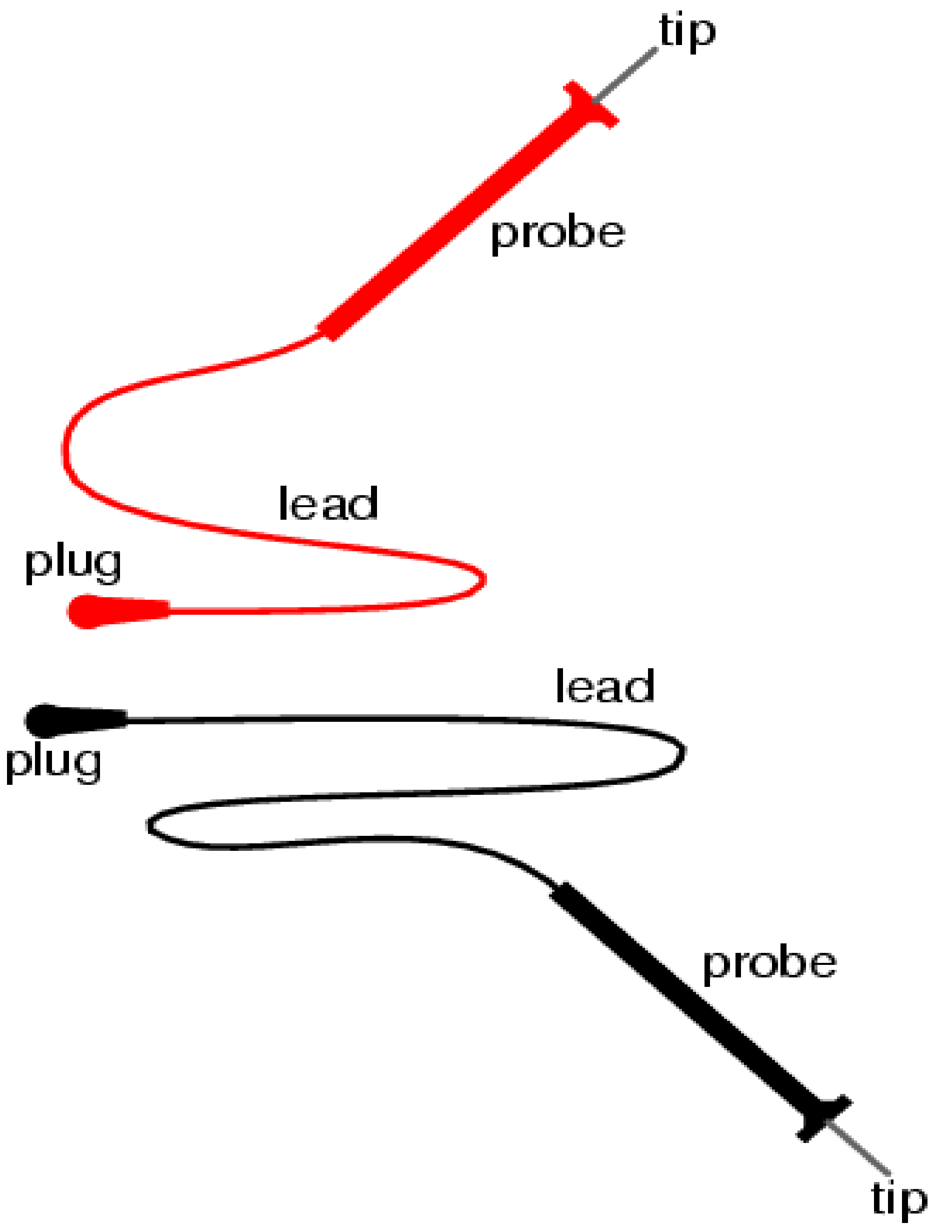
Multimeters

- Multimeters are mainly used to measure three electrical quantities:
  - Voltage: both DC and AC
  - Current: both DC and AC.
  - Resistors.

- There are two types of multimeters:
  - Digital
    - Its outputs are numbers displayed on a liquid crystal display.
  - Analog
    - Its outputs are displayed on a linear or nonlinear scale.

Multimeters (cont'd)

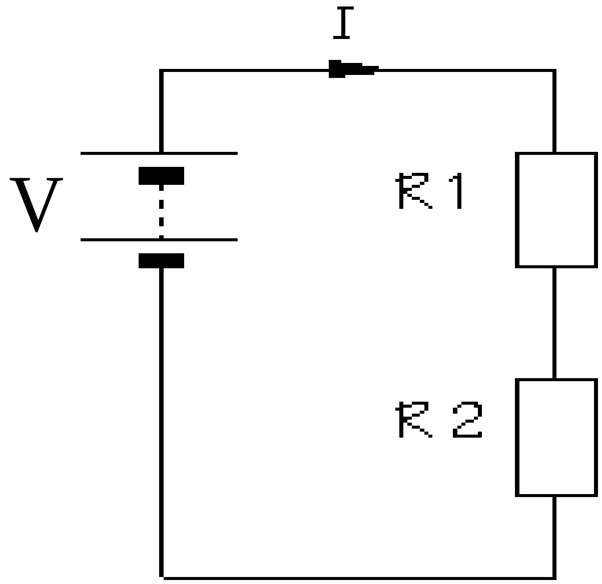




Multimeters: Usage and Functions

- **Ammeter** measures current in a branch or through a circuit element.
- **Voltmeter** measures the potential difference (voltage) between two points (across a circuit element).
- **Ohmmeter** measures resistance.
- **A multimeter** combines all of the above functions, and possibly some additional ones as well, into a single instrument.

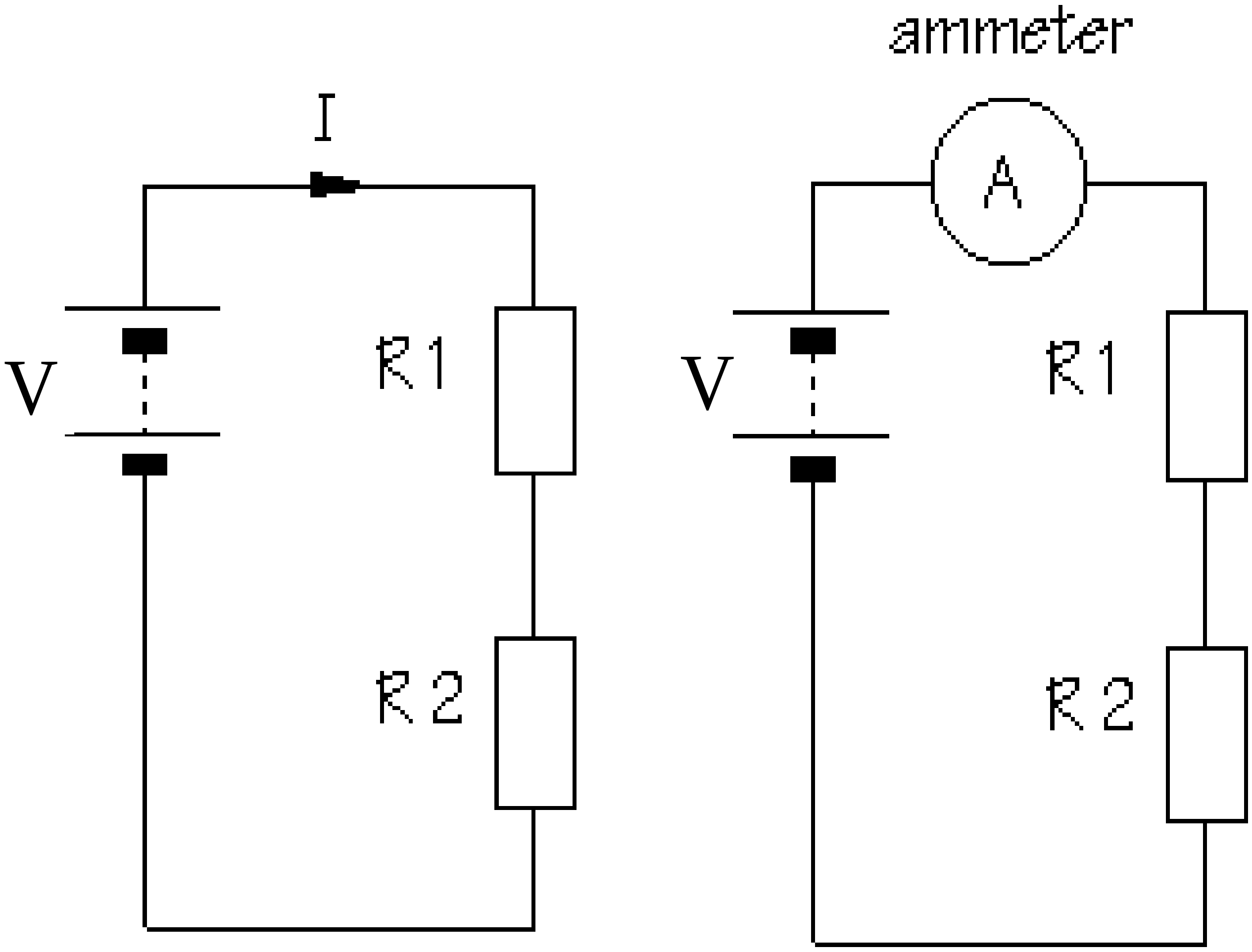
Multimeter as an Ammeter



Procedure (steps)

- Turn **power off** before connecting the multimeter.
- Break the circuit.
- Place multimeter in series with the circuit branch
- **Select highest current scale** and turn the power on
- Measure the required current or currents.
- Turn the power off.
- Disconnect the multimeter and reconnect the circuit.

Multimeter as an Ammeter (cont'd)



$$I_a = \frac{V}{R_1 + R_2}$$

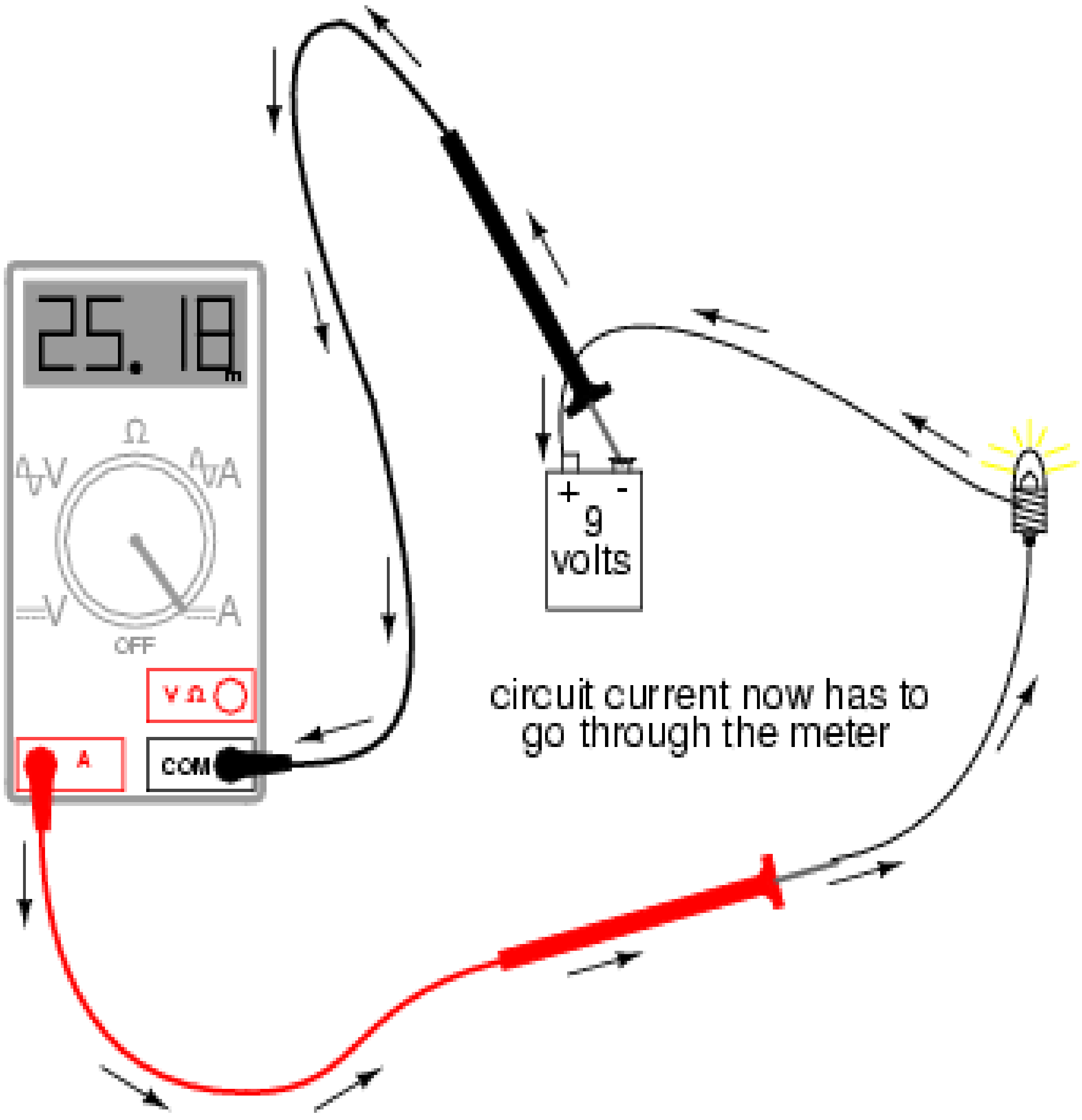
$$I_m = \frac{V}{R_1 + R_2 + R_m}$$

$$I_m \leq I_a$$

The Ammeter is connected as a series device, thus, its internal resistance should be very small (ideally $R_m \approx 0$)

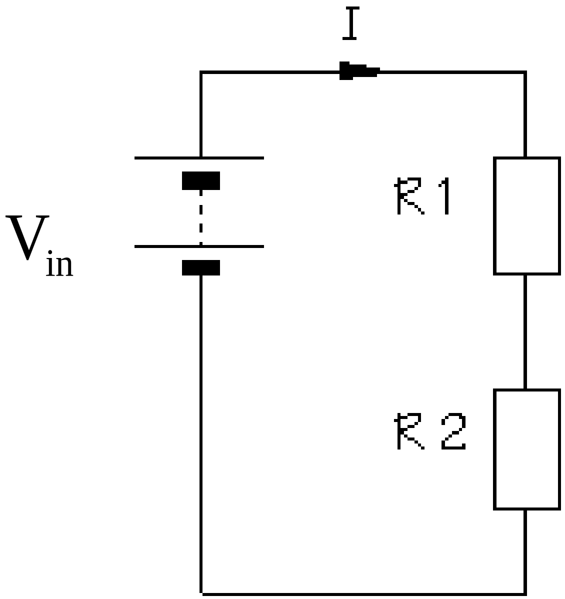
يفضل أن تكون المقاومة الداخلية للأميتر صغيرة جداً حتي تكون قيمة التيار المحسوبة مساوية للتيار المقاس.

Ammeter Snapshot



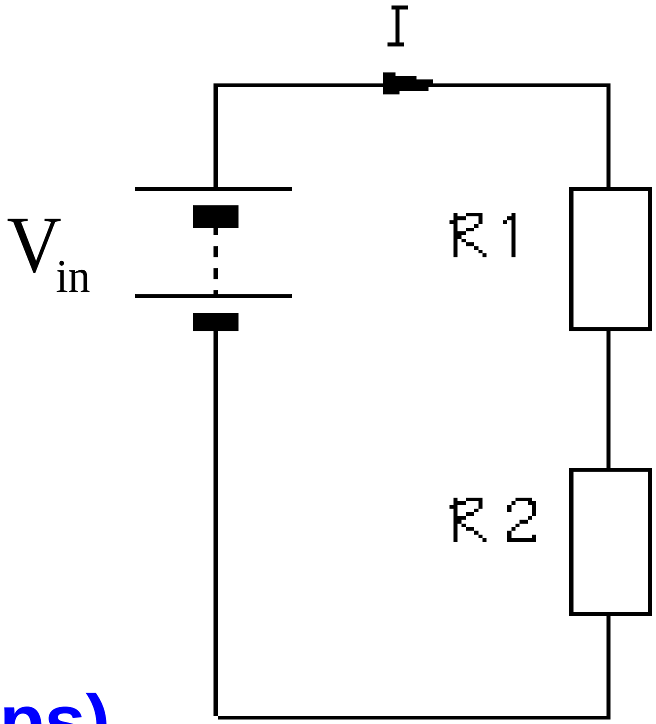
Multimeter as a Voltmeter

- Voltage measurements are the most common measurements.
- Voltage measurements are easy to do because you do not need to change the original circuit.



- To use a multimeter as a voltmeter, it should be connected in parallel between the two points where the measurement is to be made.

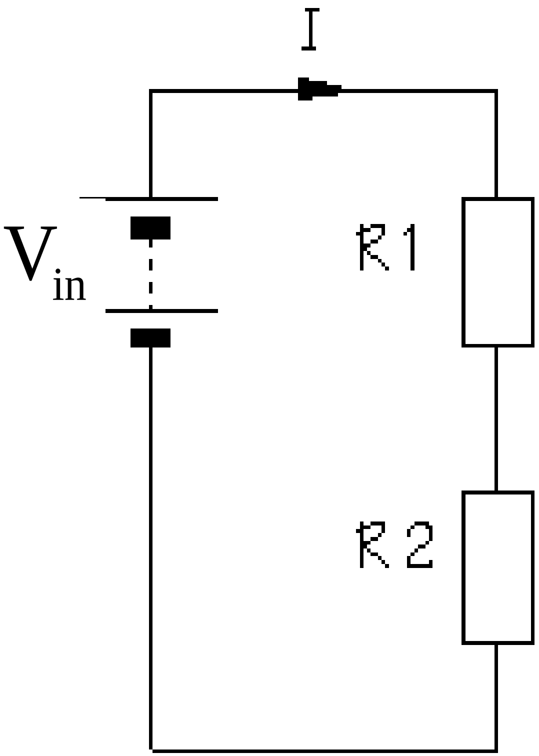
Multimeter as a Voltmeter (cont'd)

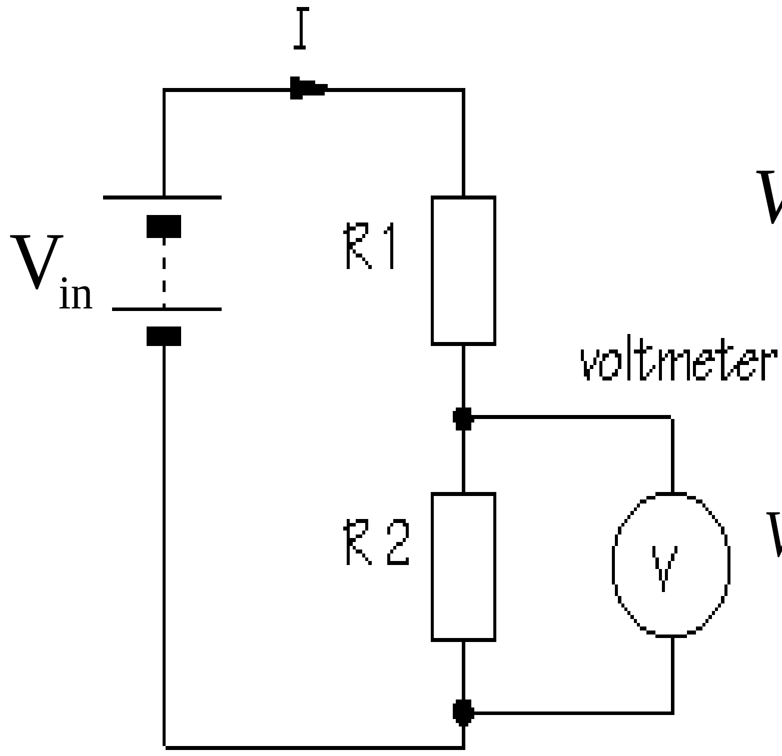


Procedure (steps)

- Select the DC or AC Volts.
- Start at the highest scale (If not a auto-ranging multimeter) and work your way down.
- Do NOT touch any other electronic components within the equipment and do not touch the metal tips.

Multimeter as a Voltmeter (cont'd)





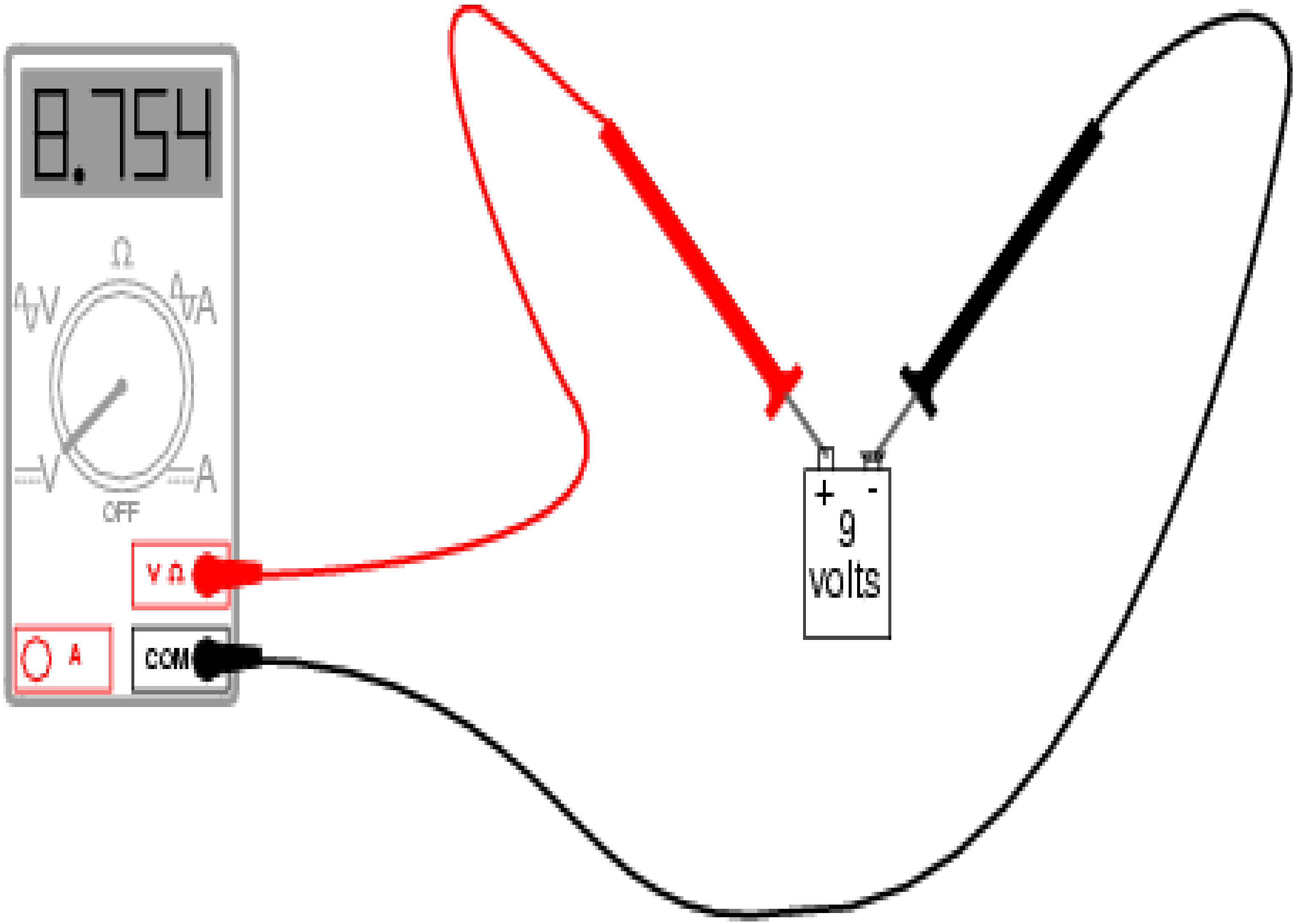
$$V_a = \frac{R_2}{R_1 + R_2} \times V_{in}$$

$$V_m = \frac{R_2 // R_m}{R_1 + R_2 // R_m} \times V_{in}$$

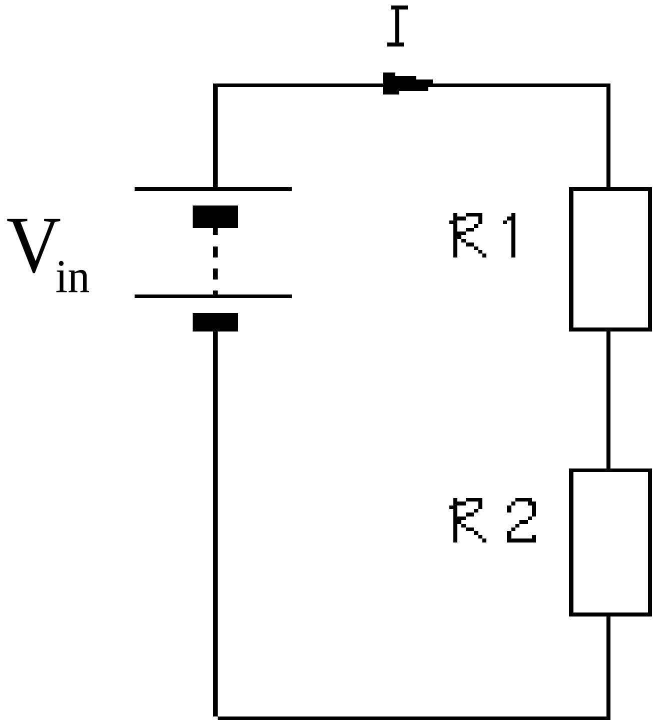
The voltmeter provides a parallel pathway, thus it needs to be of a high resistance (ideally $R_m \approx \infty$)

يفضل أن تكون المقاومة الداخلية للفولتميتر كبيرة جداً حتي تكون قيمة فرق الجهد المحسوب مساوية لفرق الجهد المقاس.

Voltmeter Snapshot



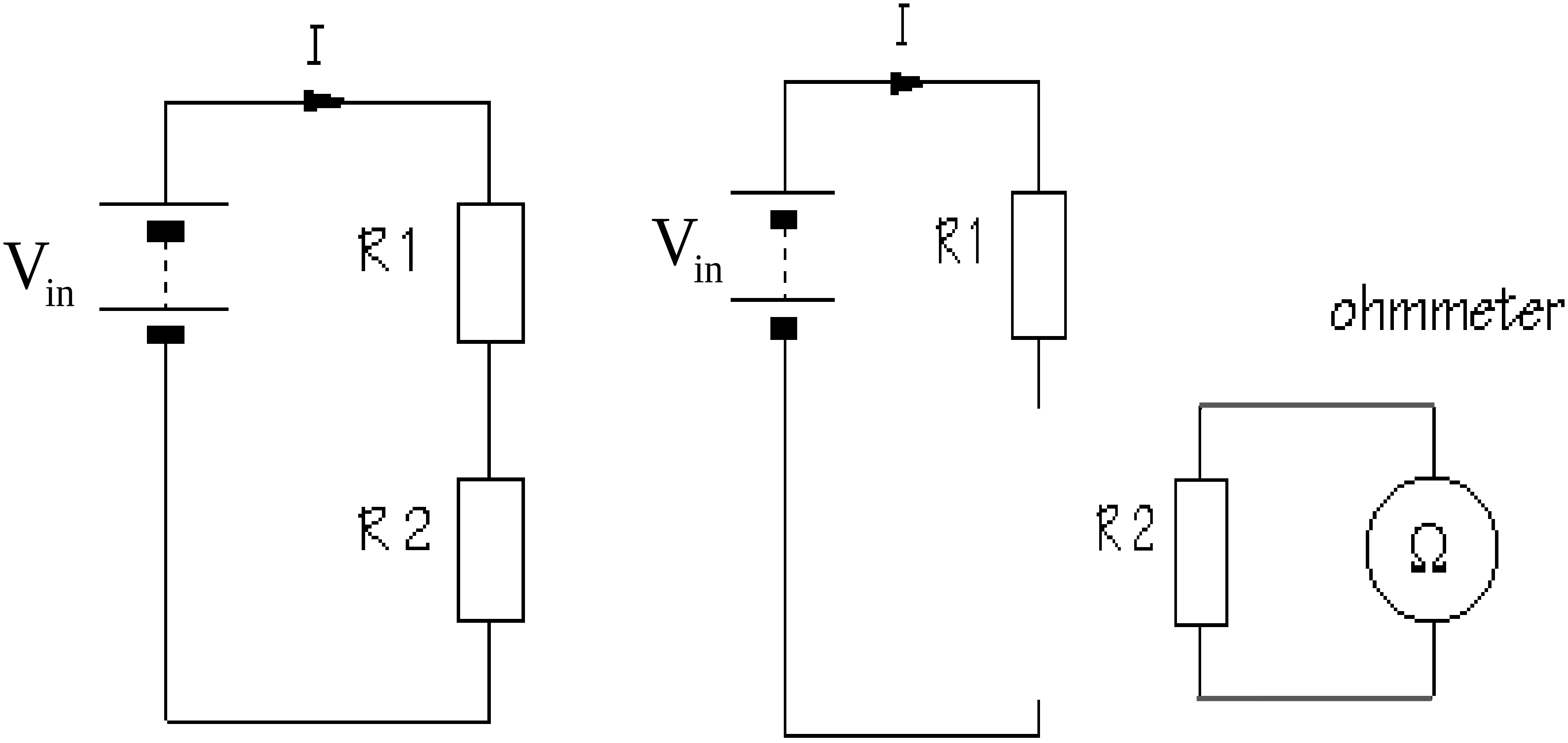
Multimeter as an Ohmmeter



Procedure (steps)

- Turn the **power off** before connecting the multimeter.
- Remove the component from the circuit.
- Start at lowest Ohm setting.

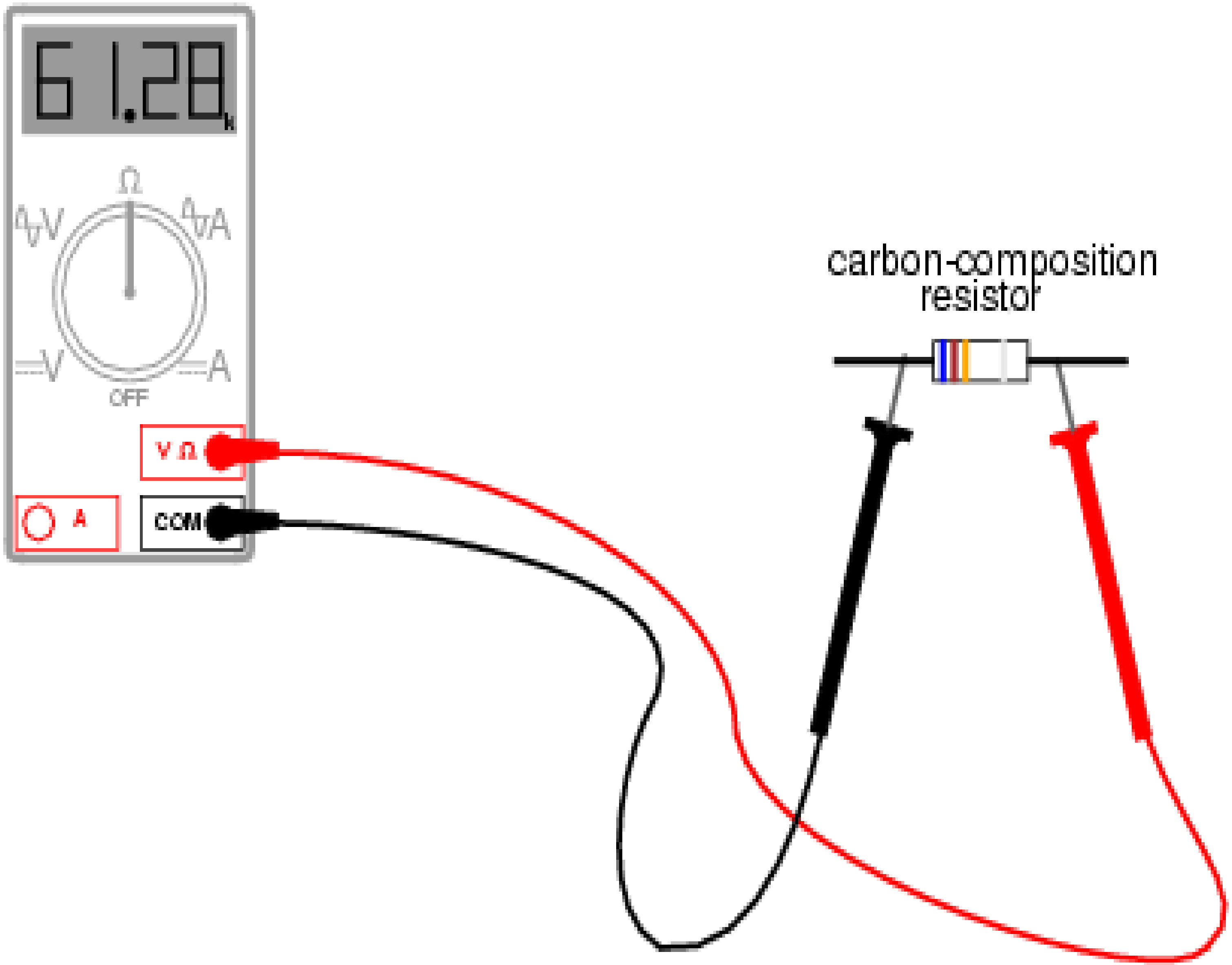
Multimeter as an Ohmmeter (cont'd)



Avoid touching the resistors end tips as the reading reflects the parallel value of the resistor and your body resistance

لايفضل لمس أطراف المقاومـة باليد حيث أن الجسم موصل وبالتـالي تقاس المقاومـة بـالتوازي مـع مقاومـة الجسم.

Ohmmeter Snapshot



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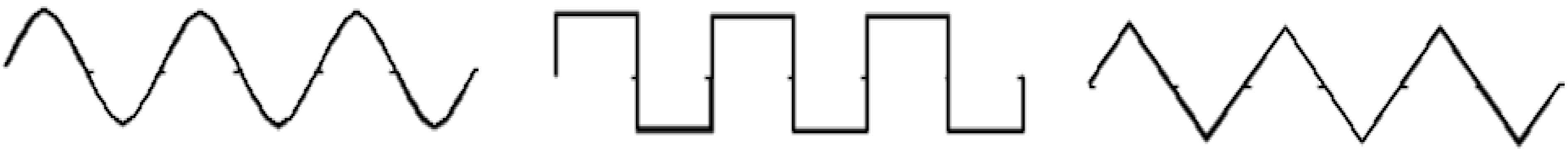
Function Generator

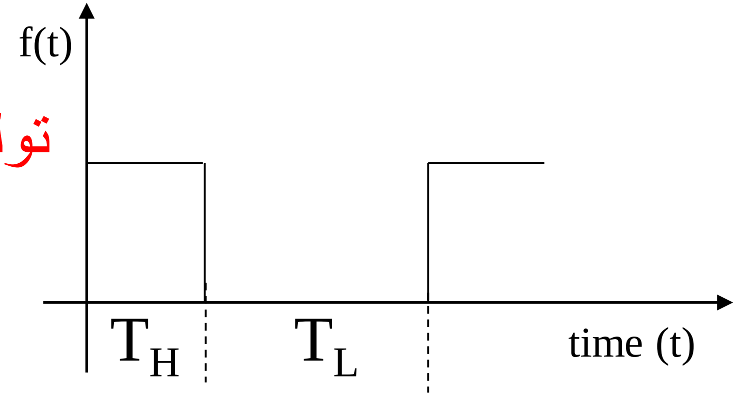
- Function generators can perform the following tasks
  - Fixed signal generation
    - Sinusoidal waves إشارات جيبية
    - Square waves إشارات مربعة
    - Triangular waves إشارات مثلثة



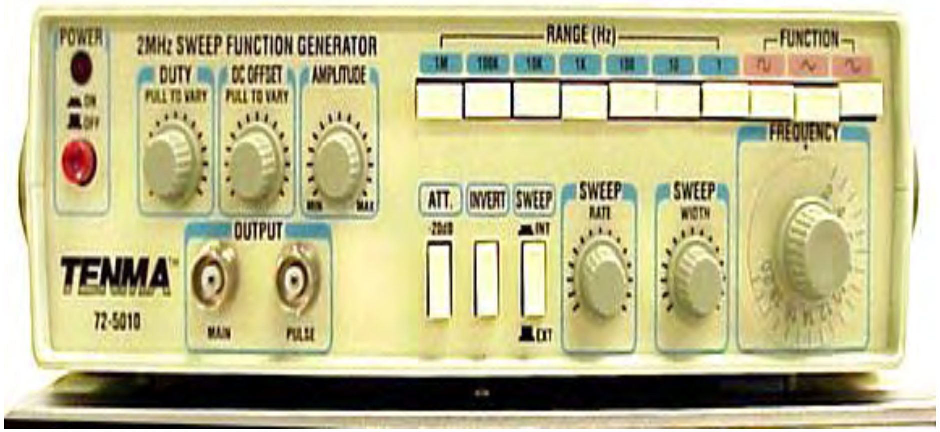
  - Signals with variable amplitude, frequency and duty cycle

توليد إشارات متغيرة القيمة و التردد دورة العمل

$$Duty\,\mathrm{Cycle} = \frac{\mathrm{T_H}}{\mathrm{T_H} + T_L}$$

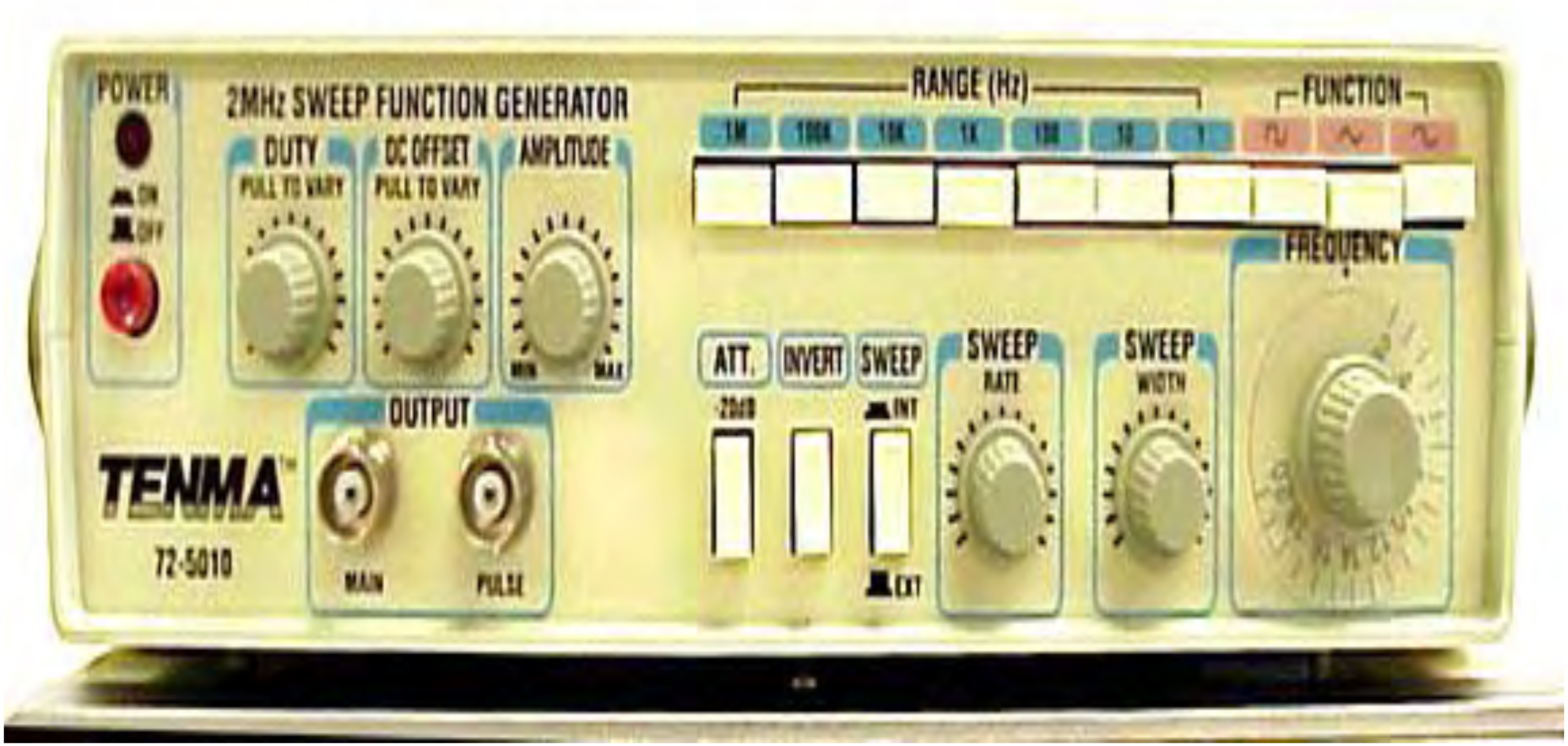


Function Generator Examples



For the class purposes we will discuss the basic equipment keys/features only.

Function Generator: Main Keys



- **Amplitude Dial** مفتاح ضبط إتساع الإشارات
- **ATT Button** مفتاح خافض الإتساع
- **Function Buttons** مفاتيح إختيار الإشارات
- **Frequency Dial and Range Buttons** مفاتيح التحكم في الترددات

Amplitude Dial

- This dial is used to adjust the peak to peak voltage of the AC waveform from 0 to 25.

- Set the amplitude to max by turning the dial completely clockwise.

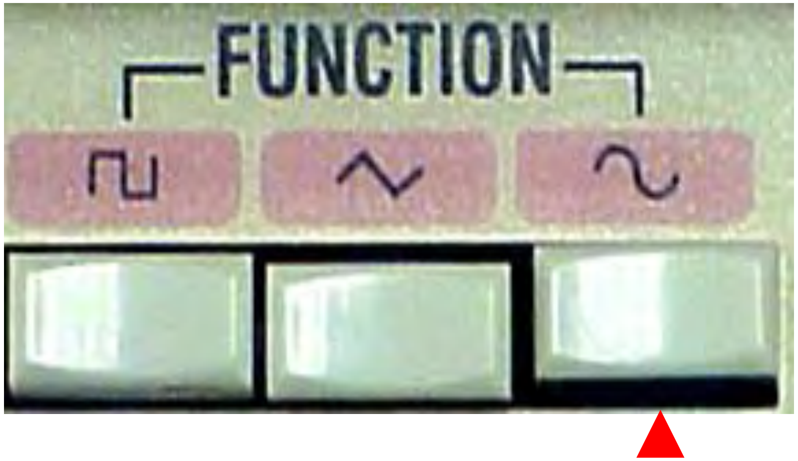
ATT Button

- This button is used to set the amplitude of the signal to a significantly smaller range.

- This button should be in the OUT position unless otherwise directed.

Function Buttons

- Selecting a button sets the type of voltage change over time as a square, triangular or sine wave.



- Press the button for the sine wave.

Frequency Dial and Range Buttons

- The frequency dial and range buttons are used in conjunction to set the required frequency of the generated waveform.

مؤشر التردد

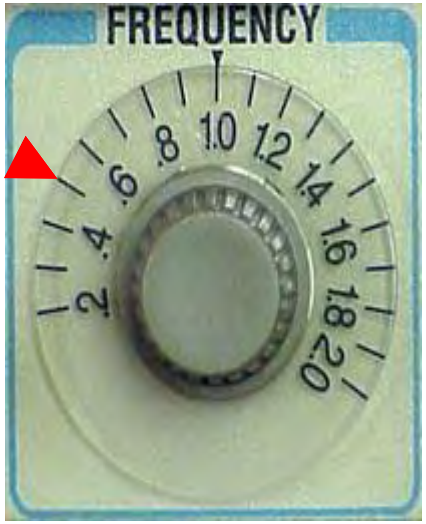
المدي

- Pressing a range button will multiply the value of the frequency dial by its values (the range button value).

التردد= القيمة الموجود عندها المؤشر في المدي المختار

Frequency Example

- Set the FREQUENCY dial to 1.0 and press the RANGE button 10.
- The resulting frequency is 10 cycles/sec (Hz).



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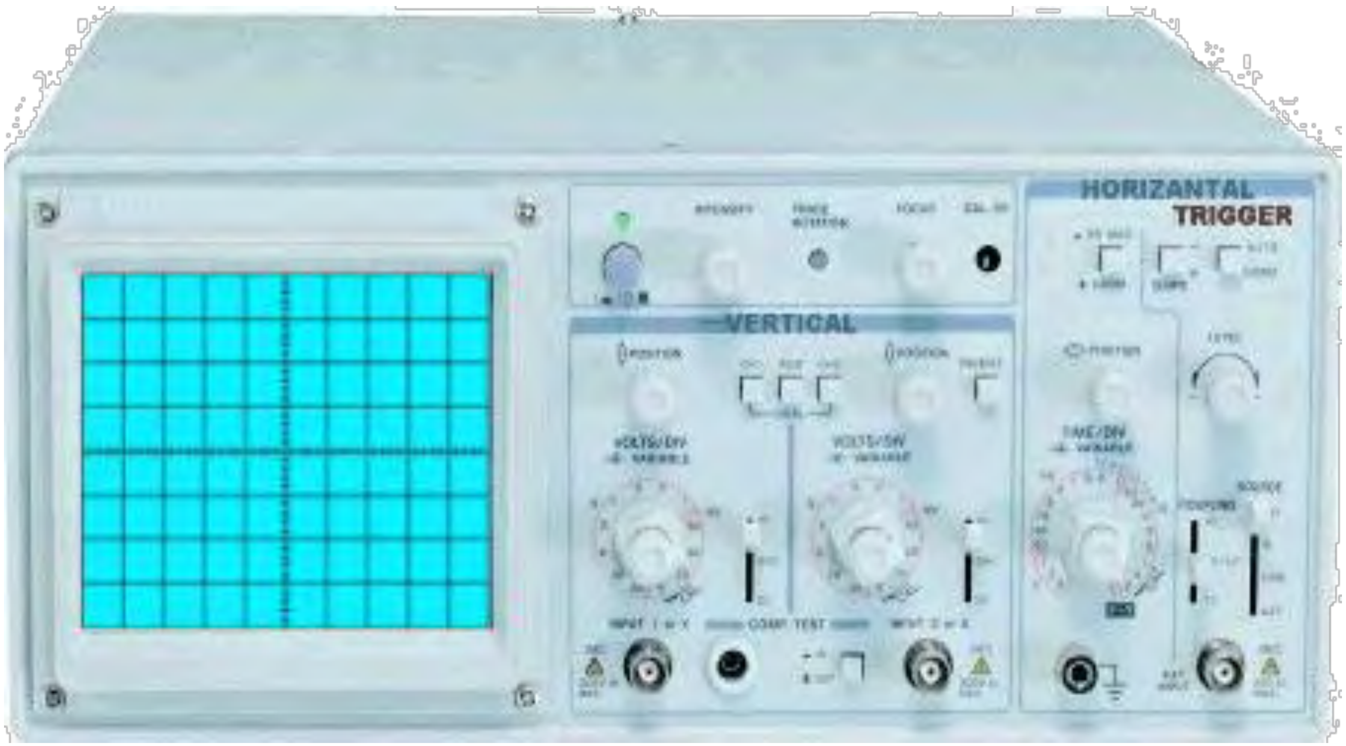
Introduction to Oscilloscope

- One of the most important laboratory equipment.
- It can be used to test/measure/display the circuit signals and; thus, helps in detection of errors/faults.

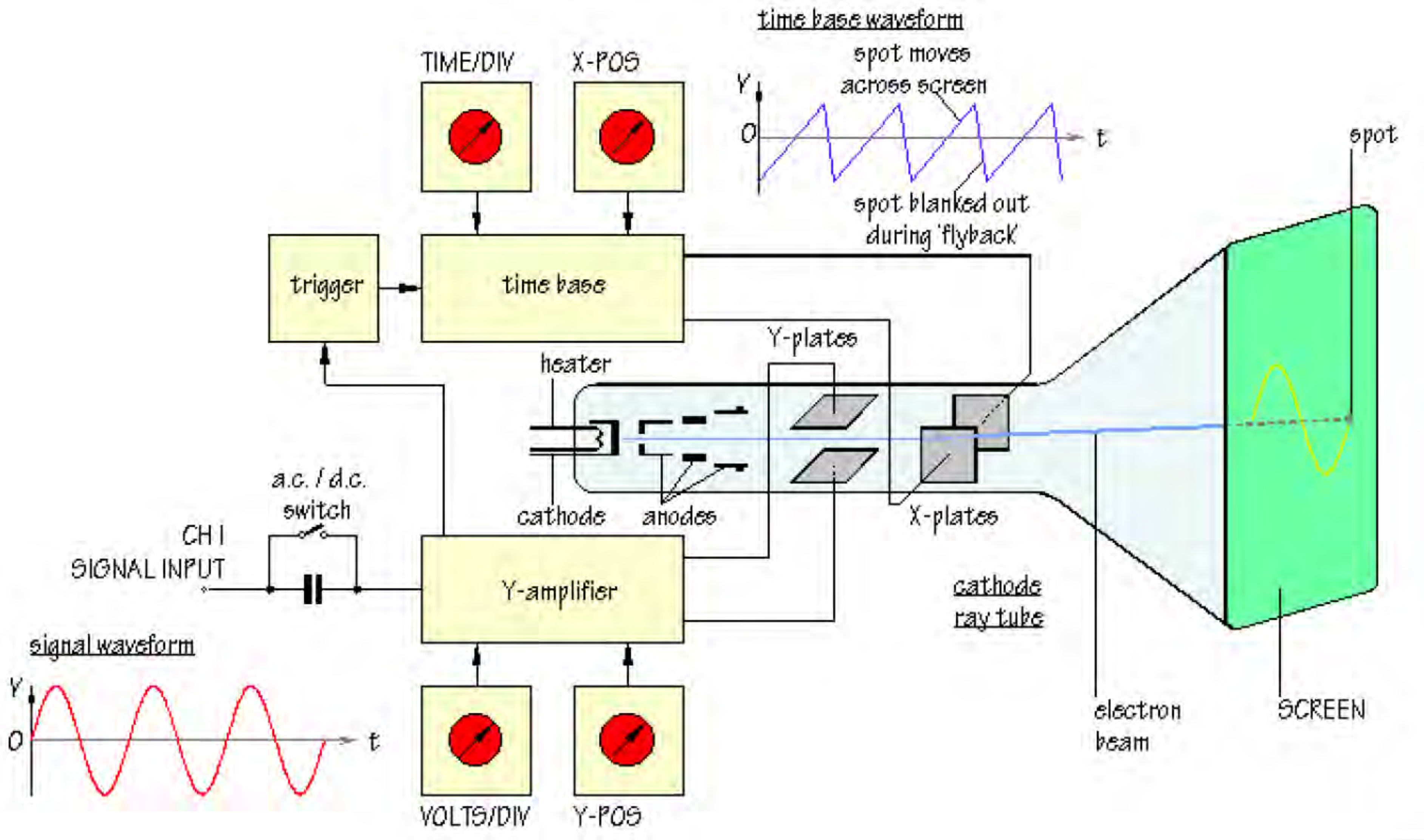


- تختلف أشكال الأوسيليسكوب من جهاز إلى آخر ولكنها جميعاً تحتوي على أزرة تحكم متشابهة.

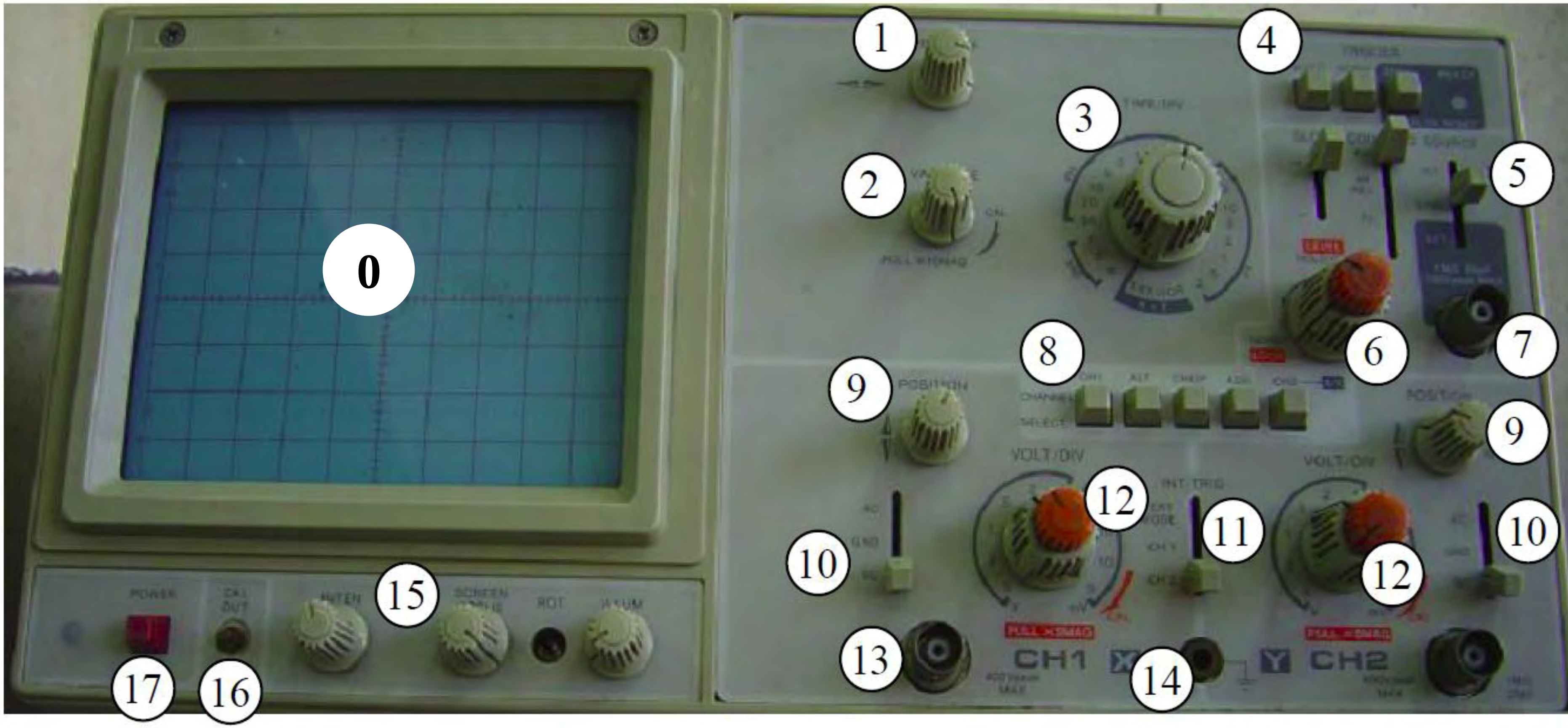
Oscilloscope Main Functions

- Graphs Voltage vs. time دائماً جهاز الأوسيليسكوب يعرض جهد
- Measures the time period of any periodic signal.
- Measures the frequency of any periodic signal.
- Measures signals amplitude; either DC or AC:
  - Peak amplitude.
  - Peak-to-peak amplitude.
- Non-electrical quantities (with some additional modification)

Oscilloscope Blockdiagram



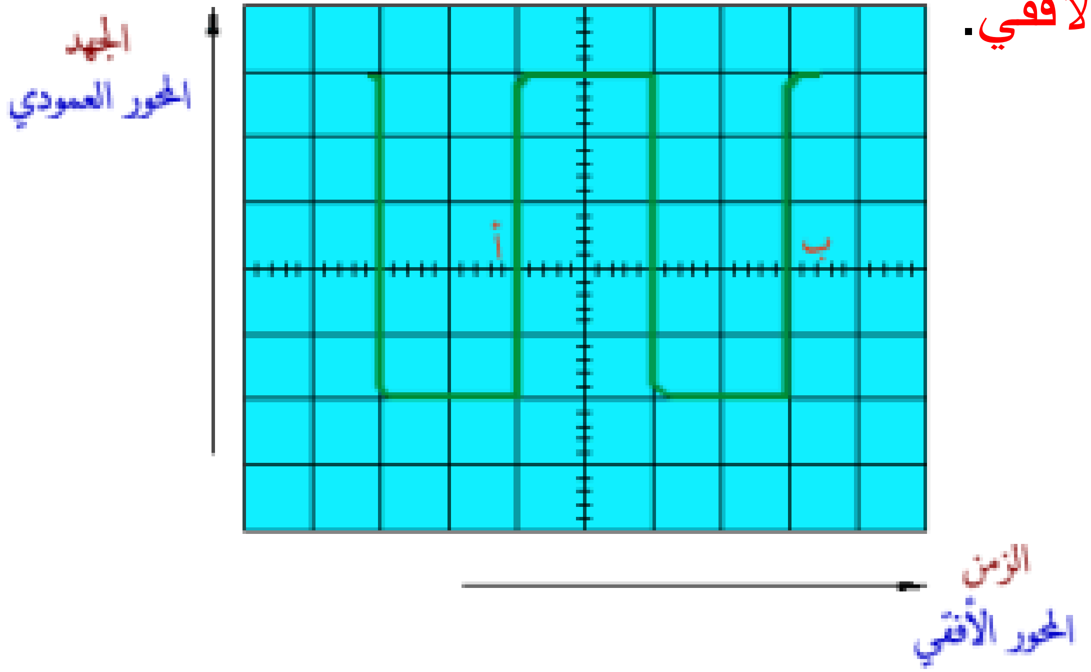
Oscilloscope Controls



Oscilloscope Screen

- The main oscilloscope function is to display voltage

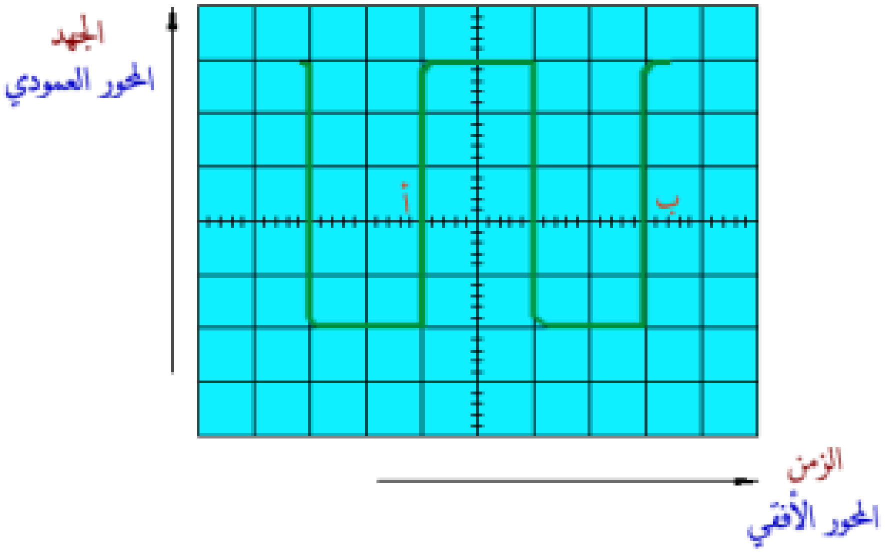
وظيفة الأوسيليسكوب عمل رسم بياني للجهد والزمن حيث يمثل الجهد بالمحور الرأسي و الوقت بالمحور الأفقي.



- Most of the oscilloscopes' screens are 5 inches(Diagonal)
- Screen has ruled divisions both horizontally and vertically

شاشات معظم أجهزة الأوسيايسكوب ٥ بوصة، و كل شاشة مقسمة رأسياً وأفقياً ولها محوران

Oscilloscope Screen: cont’d



- Vertical Axis المحور الرأسي

يمثل الجهد ويحتوي على ثمانية تقسيمات/مربعات. إرتفاع كل مربع ١ سنتيمتر.

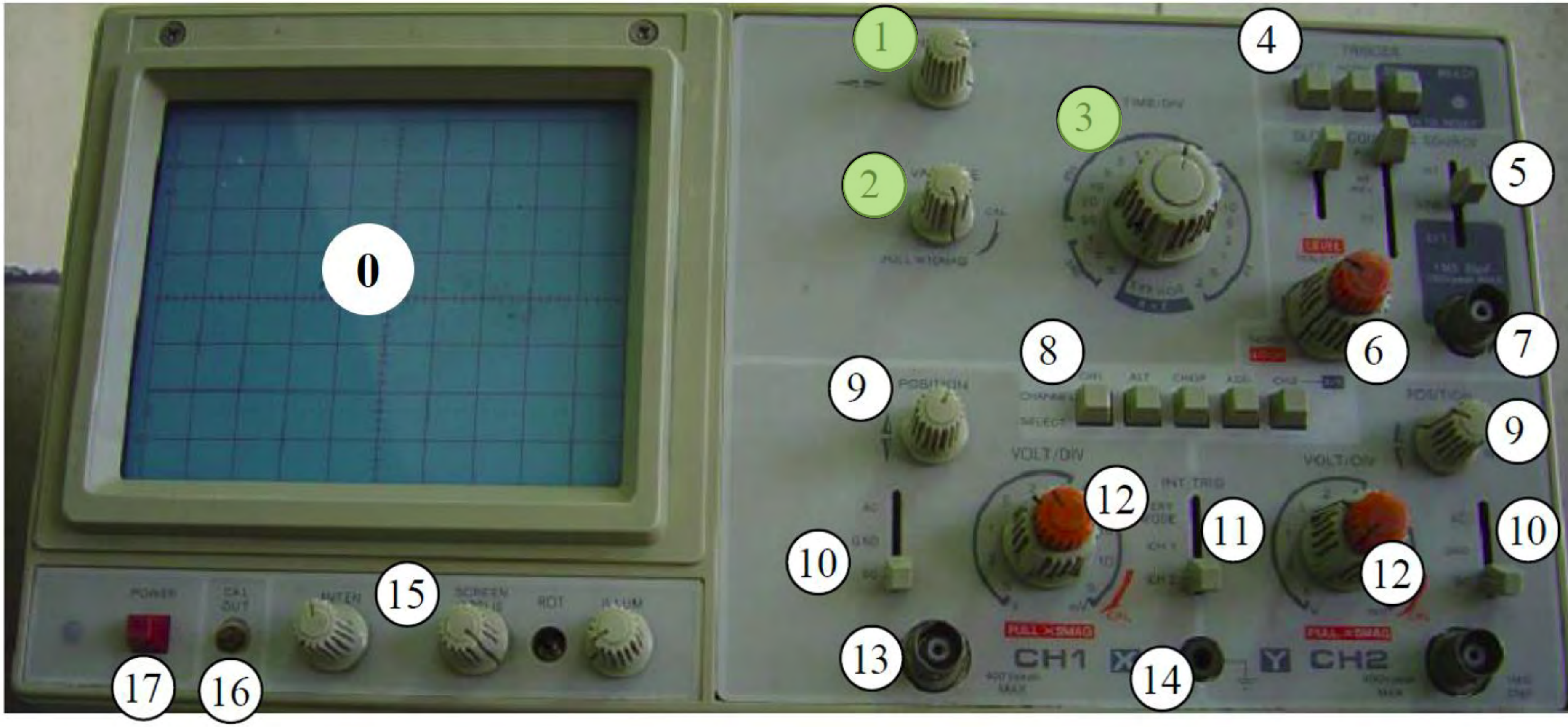
- Horizontal Axis المحور الأفقي

يمثل الزمن ويحتوي على عشرة أقسام/مربعات. عرض كل مربع أفقي ١ سنتيمتر.

- Each vertical or Horizontal division (1 cm) has 5 minor ticks of 0.2 cm

كل مربع رأسي أو أفقي مقسم إلي خمس أجزاء ”قيمة كل منها 0.20 من السنتميتر“.

Oscilloscope Controls: cont’d

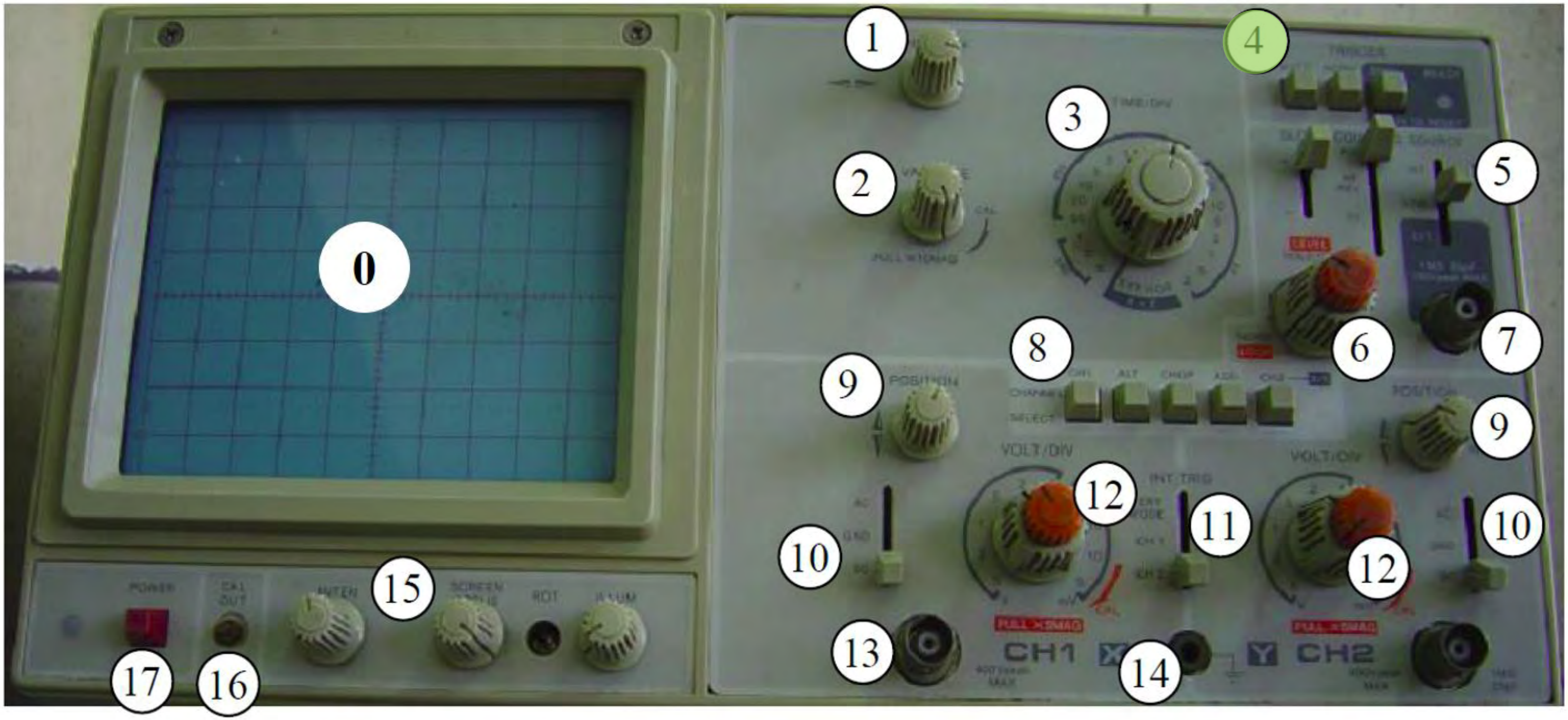


1- Horizontal Position: Moves the trace from side to side

2- Horizontal Axis Calibration: Calibrate TIME/DIV.

3- TIME/DIV: Adjust the pattern width on the screen

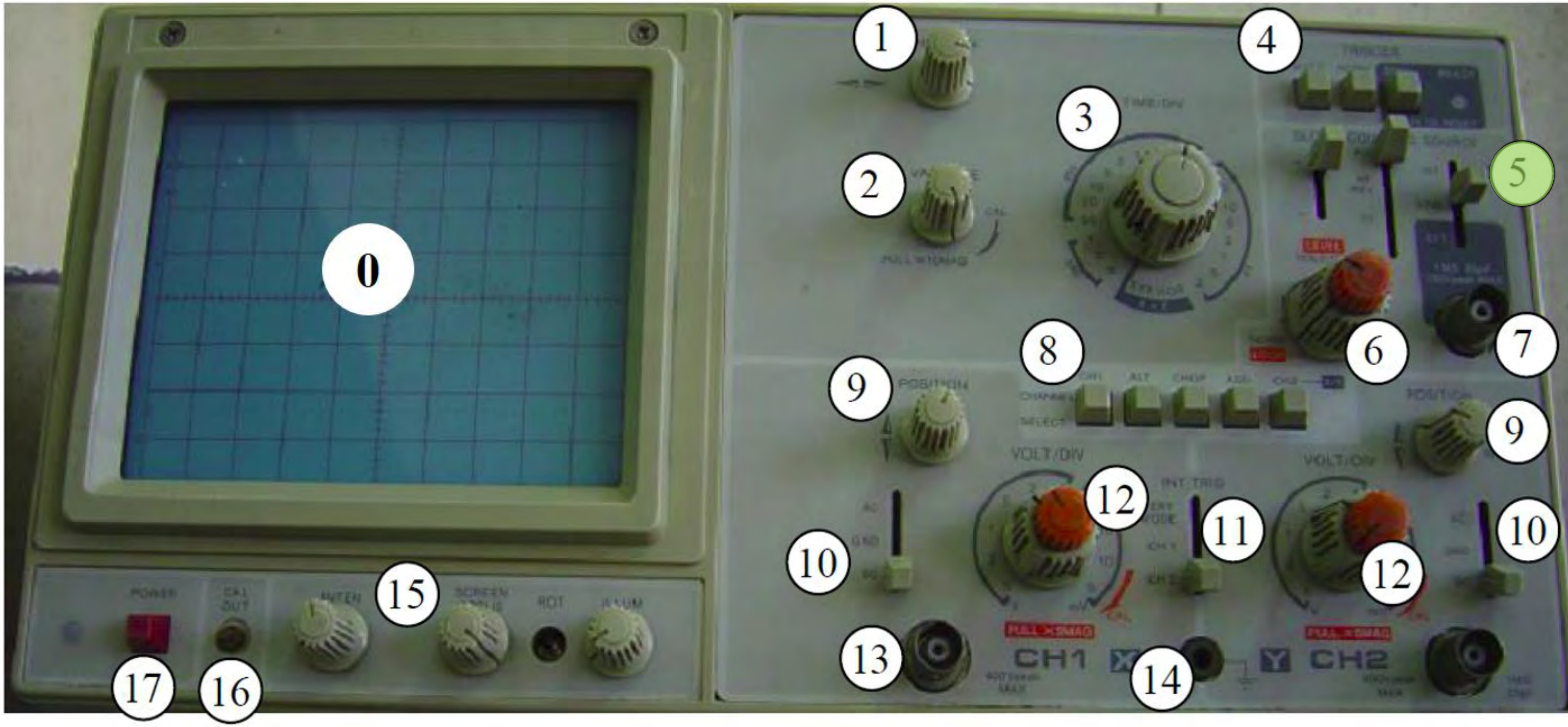
Oscilloscope Controls: cont'd



4- TRIGGER Mode select:

- Auto
- Normal
- Single

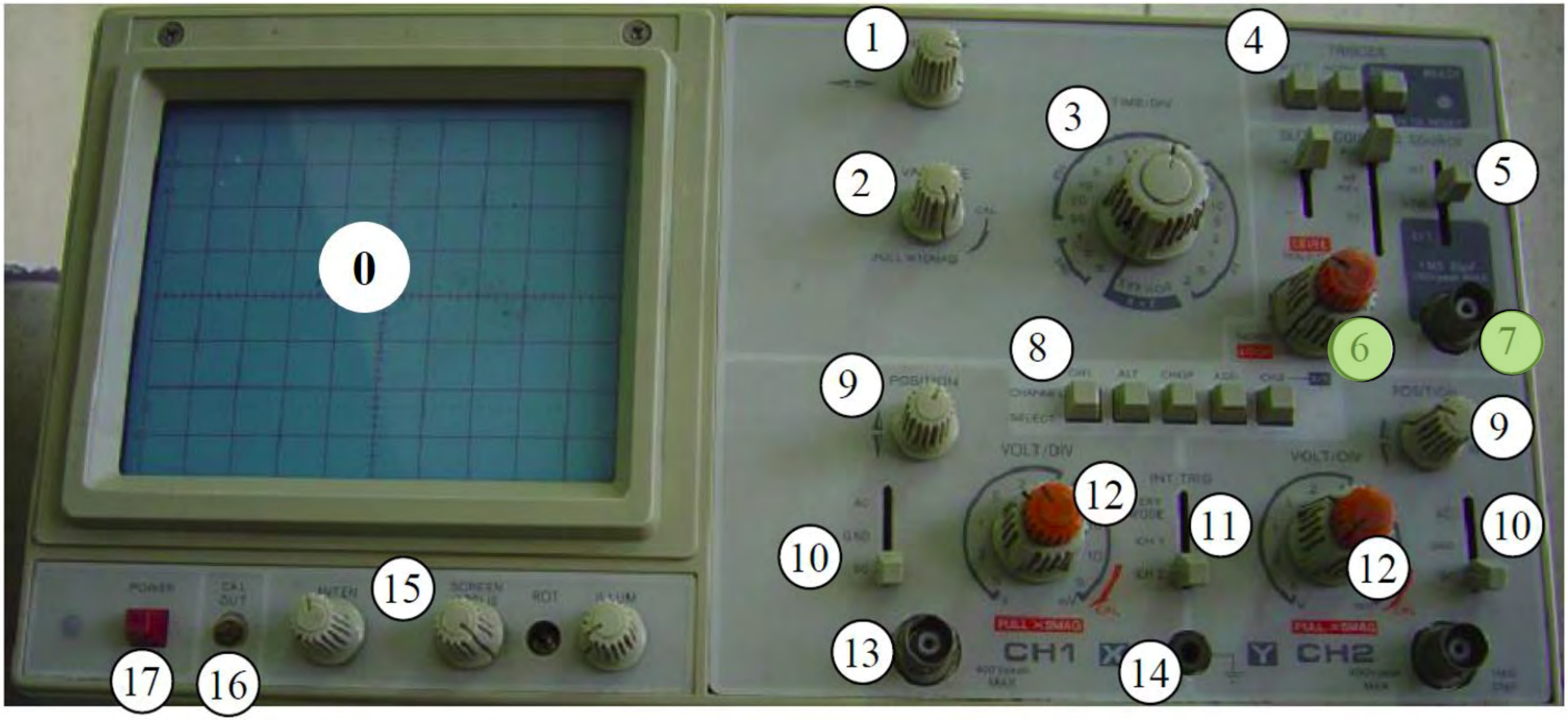
Oscilloscope Controls: cont'd



5- SOURCE, SLOPE, COUPLING select:

- Source: Selects the triggering source (INT, LINE, EXT)
- Slope: Selects the polarity of the trigger signal
- Coupling: The coupling betn the trigger signal and sweep generator

Oscilloscope Controls: cont'd

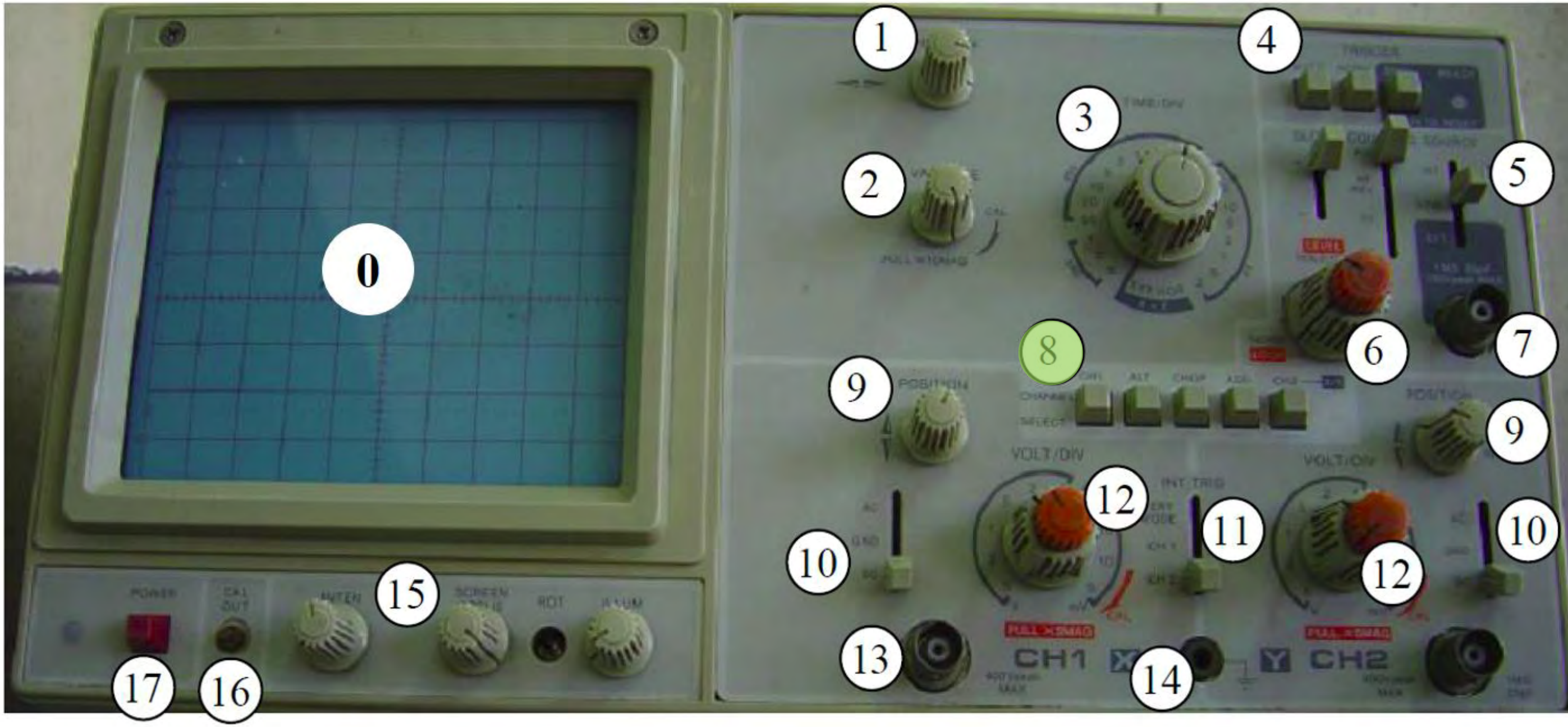


6- TRIGGER LEVEL and HOLD OFF

- Level: the starting point of the waveform for triggering
- HOLD OFF: Adjust the amplitude of the triggering signal

7- EXT input connector: Input for external triggering input

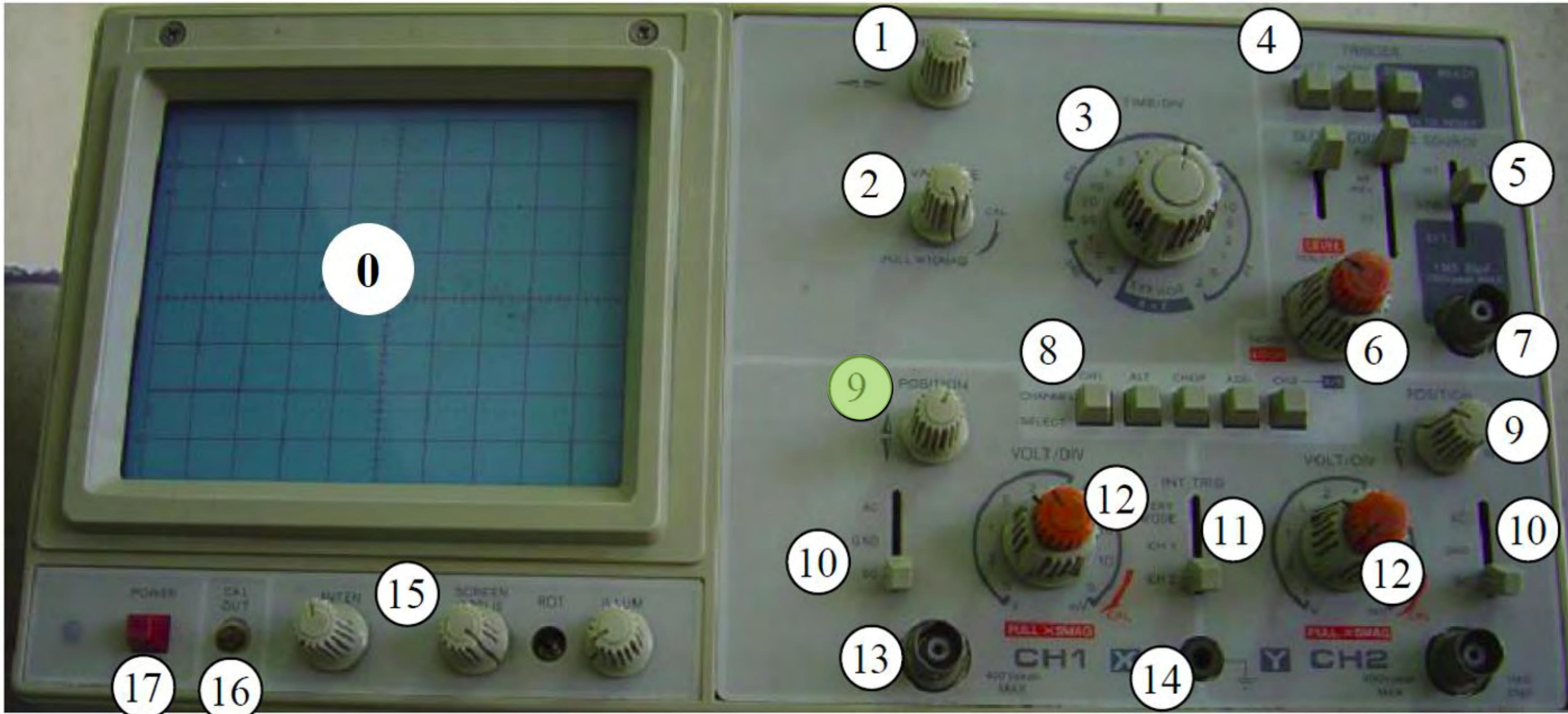
Oscilloscope Controls: cont'd



8- Channel Select: Selects what to display

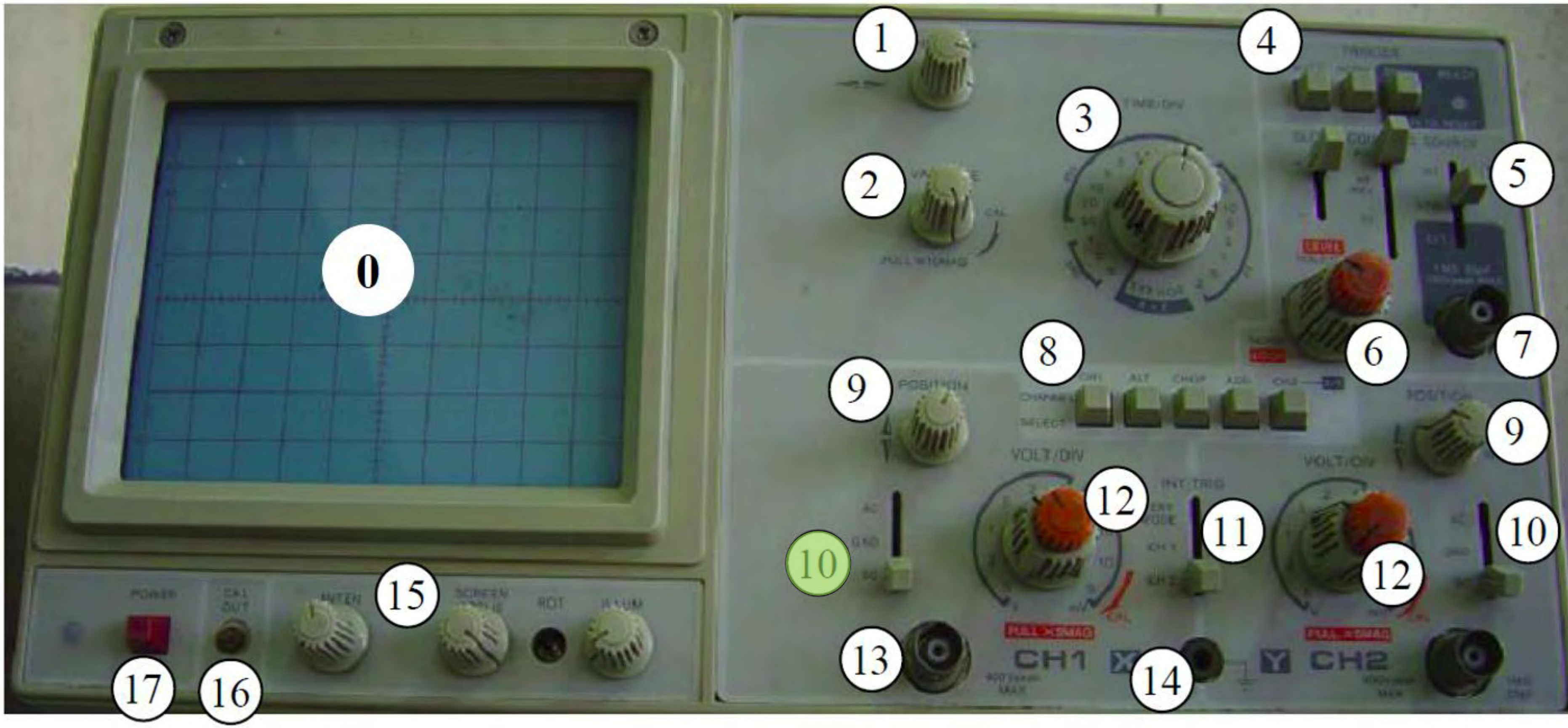
- CH1 or CH2: ONLY one of the input
- ALT, CHOP: Either one or Both
- ADD: Algebraic sum

Oscilloscope Controls: cont'd



9- Vertical Position: Move the signal up and down on the screen

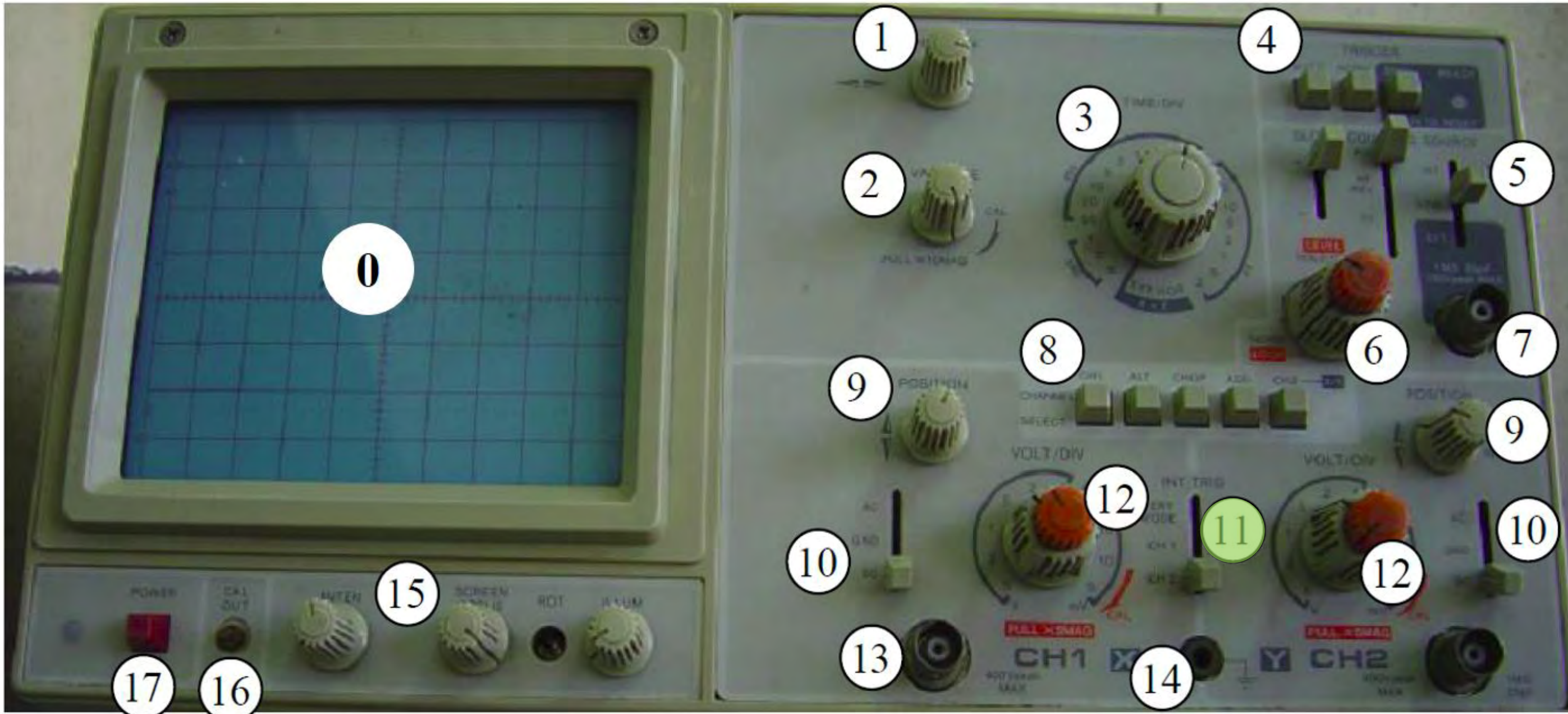
Oscilloscope Controls: cont'd



10- Input Coupling Switch: Selects the coupling between the input signal and the vertical amplifier of the oscilliscope

- AC: ONLY AC component is displayed (Capacitor blocks DC)
- DC: The input wavform is displayed including its DC component
- GND: The input to the vertical amplifier is grounded

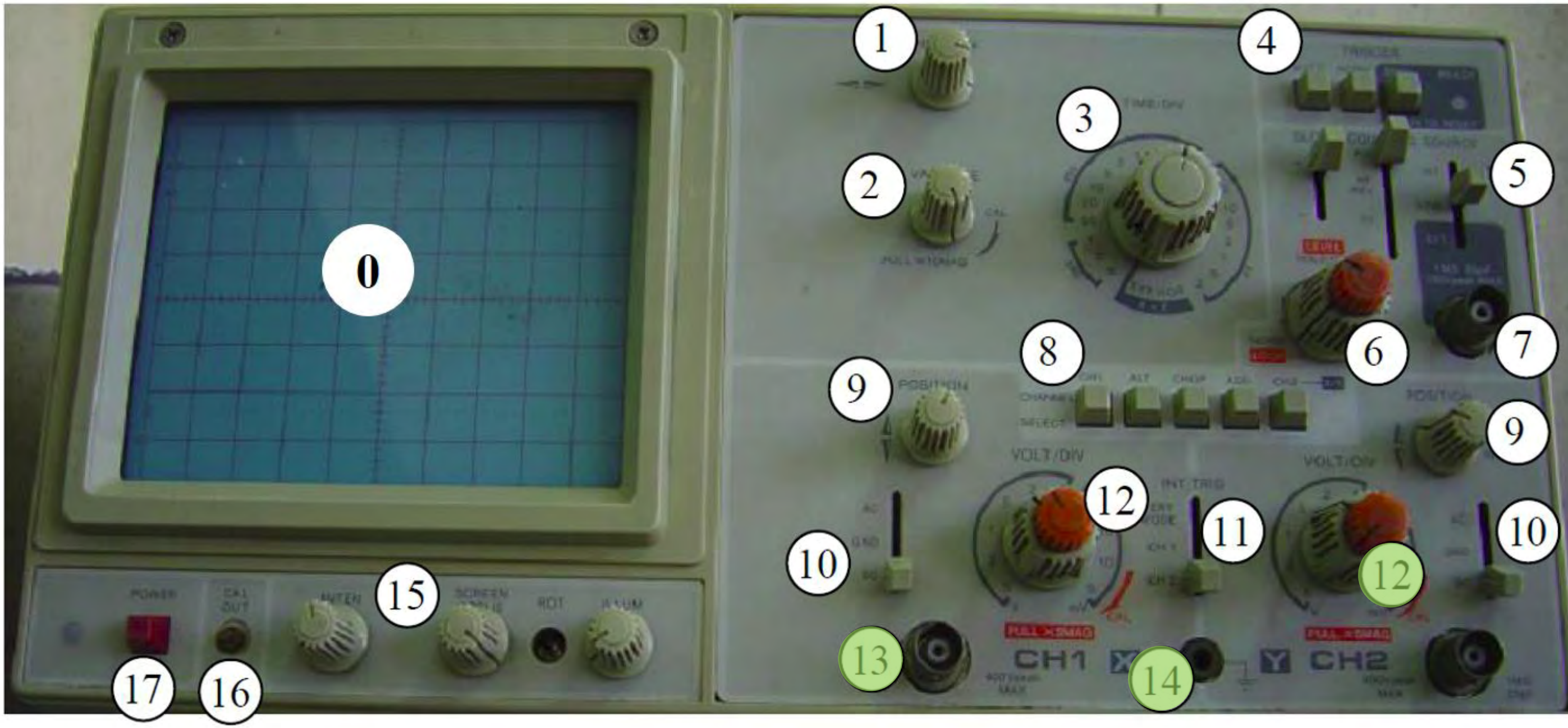
Oscilloscope Controls: cont'd



11- INT trigger switch: Selects the source of the internal trigger (CH1, CH2 or VERT modes)

- CH1 or CH2: Either one of the input waveforms
- VERT: Alternative choice from CH1 and CH2 (for displaying two signals together)

Oscilloscope Controls: cont'd

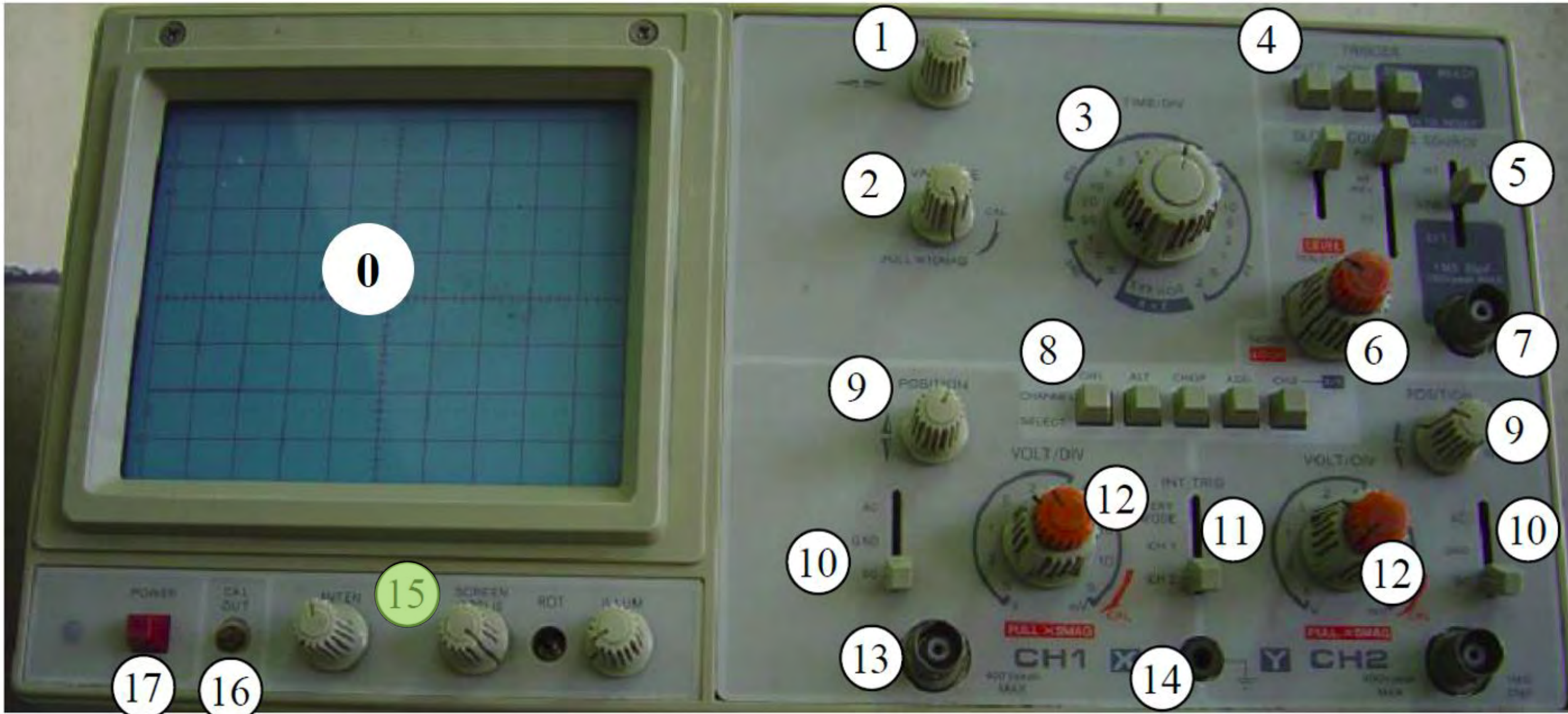


12- VOLT/DIV: Controls the height of the signal on the screen

13- CH1 input connector. In X-Y mode it represents the x-axis waveform

14- The ground of the oscilloscope

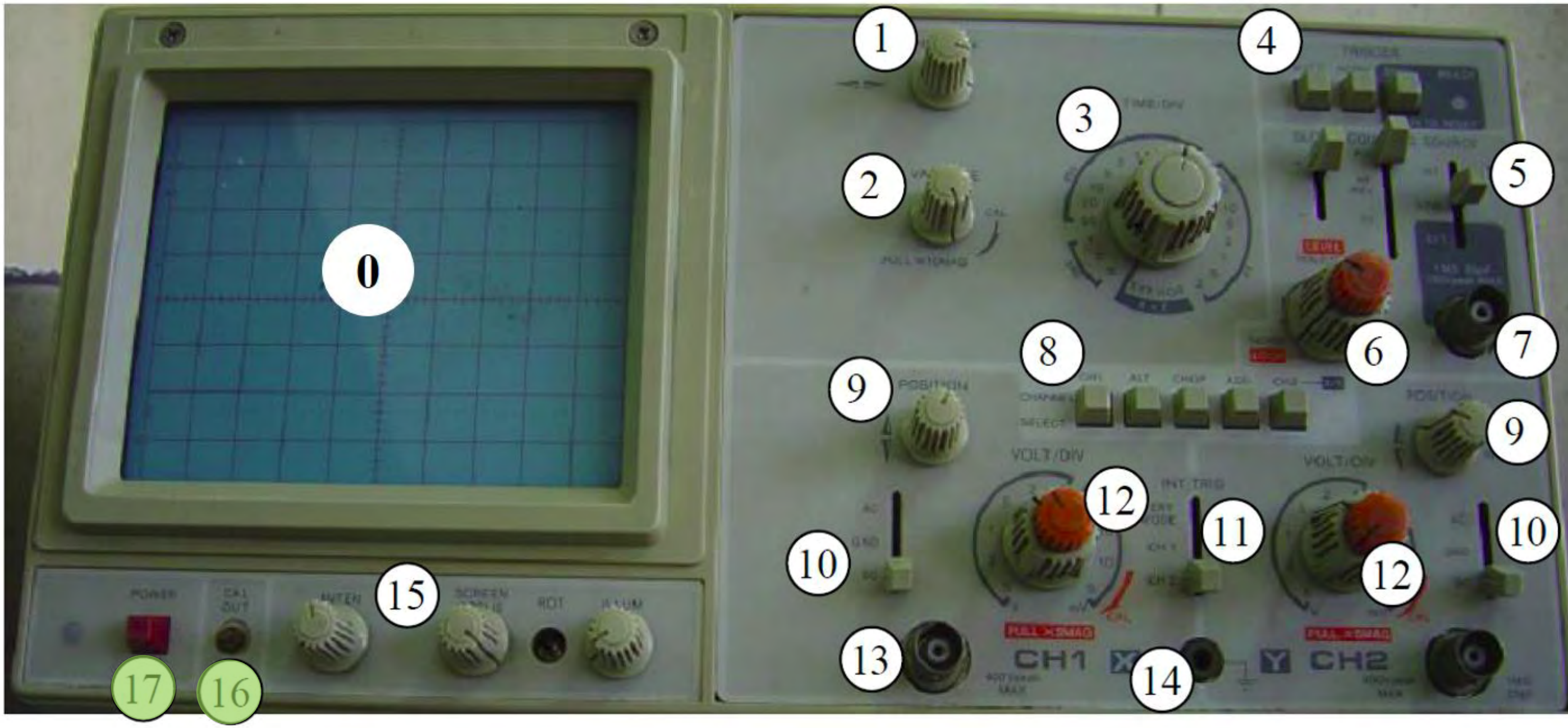
Oscilloscope Controls: cont’d



15- INTENSITY, ROT, FOCUS, ILLUM swiches

- INTENSISTY: Controls the brightness of the trace
- FOCUS: Controls the sharpness of the tracing beam
- ROT: Aligns the trace to be exactly horizontal
- ILUM: Illuminates the graticule to brightens the engraved scale lines

Oscilloscope Controls: cont'd

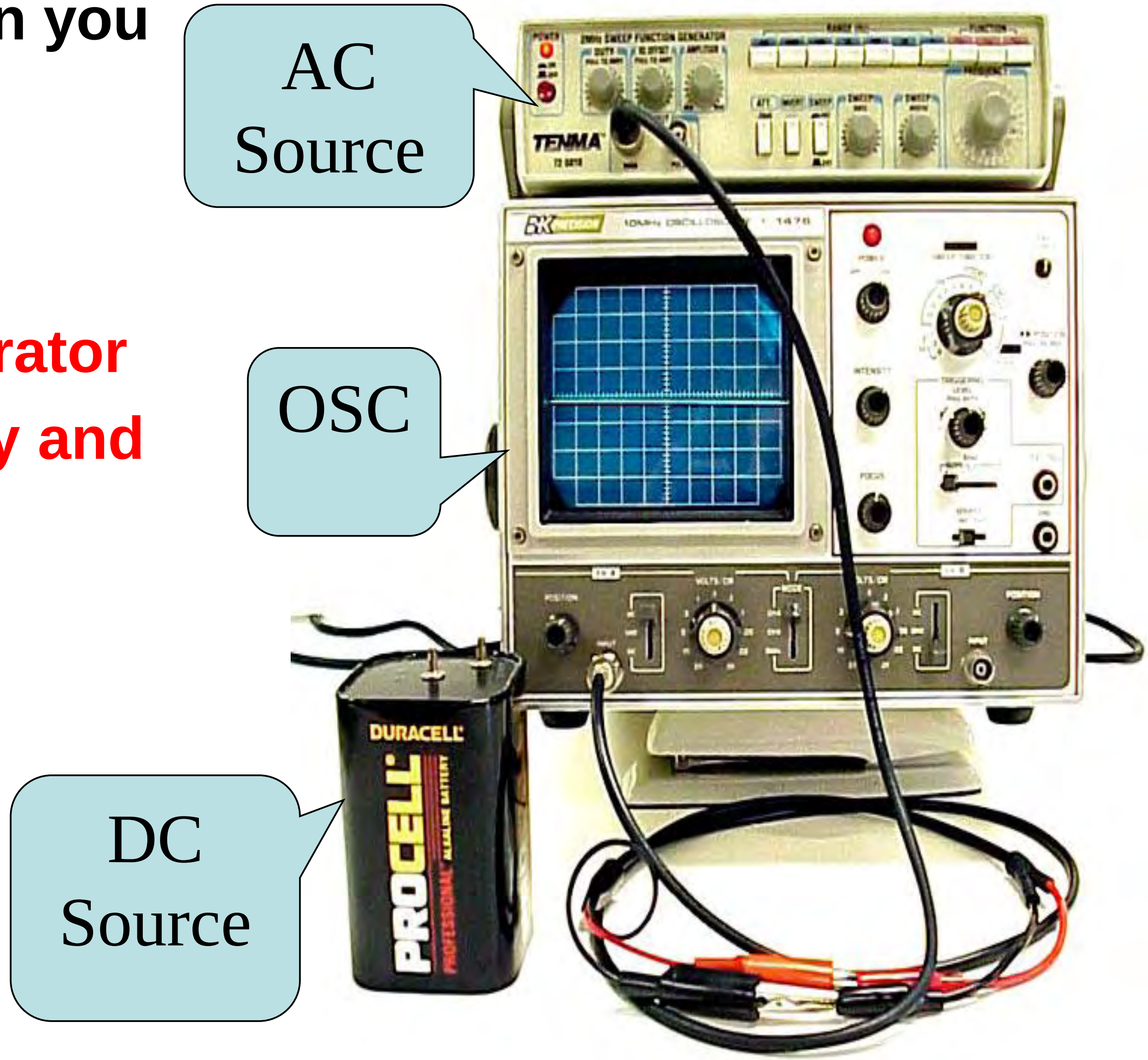


16- CAL OUT: Used to calibrate the oscilloscope using a 1 V peak-to-peak square wave of 1 kHz.

17- POWER switch: Turns the oscilloscope on and off

Using the Oscilloscope

- Before you begin you will need:
  - An oscilloscope
  - A function generator
  - A six volt battery and
  - Two cables



Using the Oscilloscope: cont'd

ملحوظات عامة

- قبل إستخدام الأوسيليسكوب لابد من التأكد من سلامة Probes.
- للابد من ضبط مقياس Volts/Div علي قيمة مناسبة.
- لآبد من ضبط مقياس Time/Div علي قيمة مناسبة.
- التأكد من وضع Trigger علي Auto.
- ضبط Intensity, focus, and illuminance.
- إختيار أحد القناتين علي الأقل.

التجربة الأولى

Course Contents

Experiment-0: Overview of laboratory equipment's (Digital Multimeters, Function Generators, Oscilloscope)

Experiment-1: Passive Elements.

Experiment-2: Transient Circuits.

Experiment-3: Nonlinear Resistances.

Experiment-4: Passive Filters.

Experiment-5: Resonant Circuits.

Experiment-6: Circuit Theorems.

Experiment-7: Diodes and Applications.

Experiment-8: Special Diodes.

Experiment-9: Bipolar Junction Transistors.

Experiment-10: Logic Gates.

Experiment-11: Power Supplies.

Experiement-1 Objectives

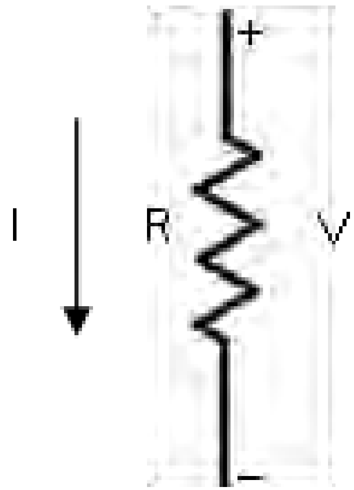
- The student will use the basic passive circuit elements (*R*, *L*, and *C*) and laboratory equipment/Components (Oscilloscope, DMM, Breadboards, Function generators) to make basic measurements.
- The students will also verify Ohm's law for passive elements
- Finally, the students will compare the performance of these components with both DC and AC and check their series and parallel connections of passive elements.

- التمكن من تحديد الأنواع المختلفة من العناصر الخاملة (المقاومات والمكثفات والملفات).
- تحقيق قانون أوم لكل عنصر والتأكد من كيفية تغير الجهد مع التيار
- مقارنة أداء هذه العناصر مع مصادر الطاقة بنوعيها (DC and AC)
- دراسة طريقة توصيل هذه العناصر في الدوائر (توصيل توالي و توصيل توازي)

I- Resistors

- Resistors are two terminal components used to limit the electric current in circuits by producing a voltage drop between its terminals
- A resistor is schematically shown below. Its characteristic equation or "terminal relation" is given by Ohm's Law:

$$V = I \times R$$



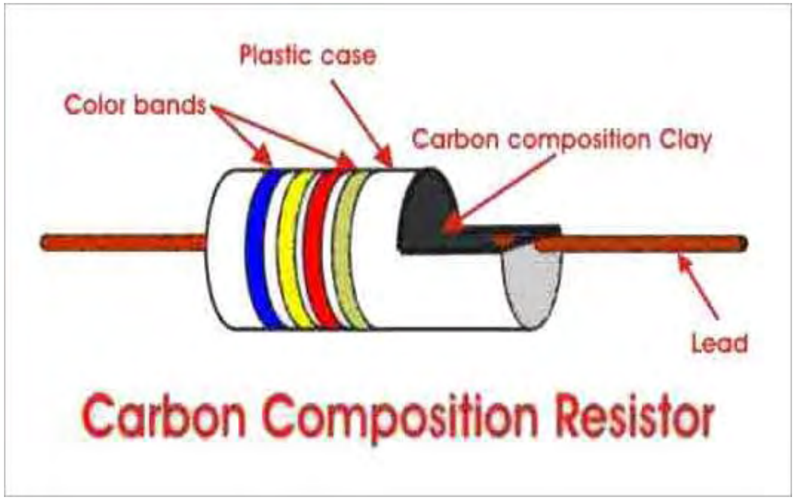
Resistors: cont'd

- Resistors have maximum working voltage and current (power rating) above which the resistance (i) may change (drastically, in some cases) or (ii) the resistor may be physically damaged (overheat or burn up).

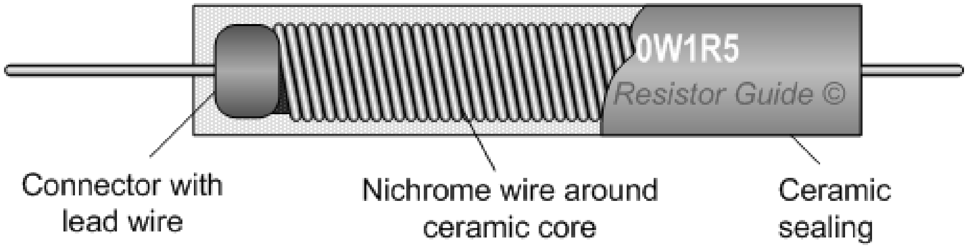
- Common power ratings for carbon composition and metal-film resistors are 1/8 watt, 1/4 watt, and 1/2 watt.

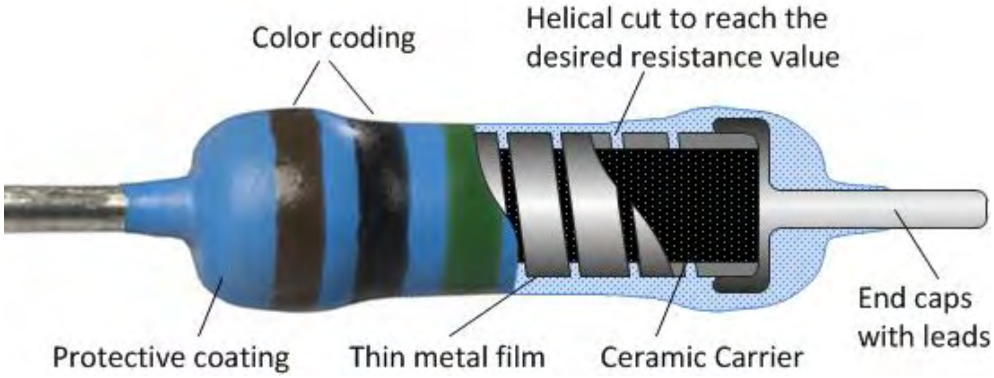
Types of Resistors

- Resistors can be broadly categorized into three types: Fixed resistors, Variable resistors, Special-purpose resistors



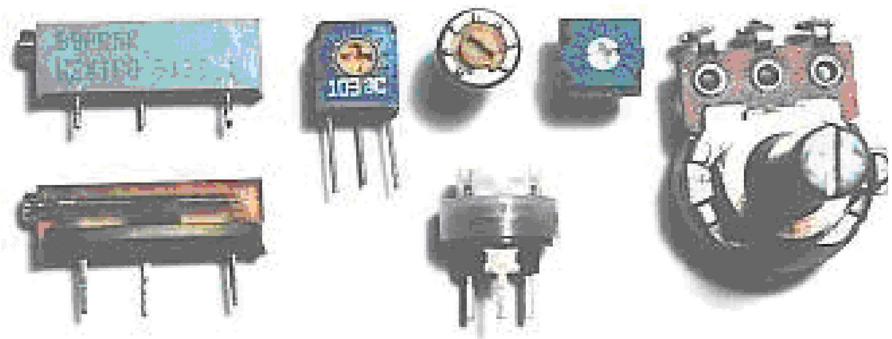
- Fixed resistors are those whose value cannot be varied after manufacture and are classified into:
  - Composition (carbon) resistors,
  - Wire-wound resistors,
  - Metal-film resistors

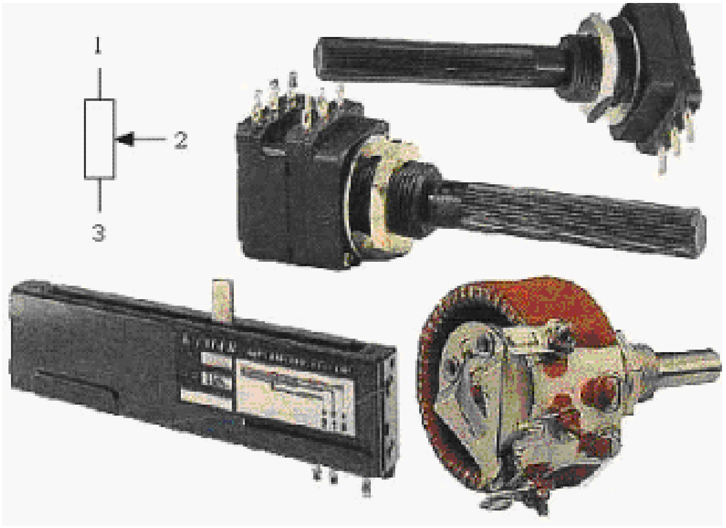


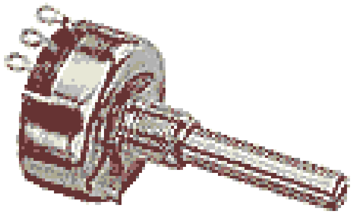


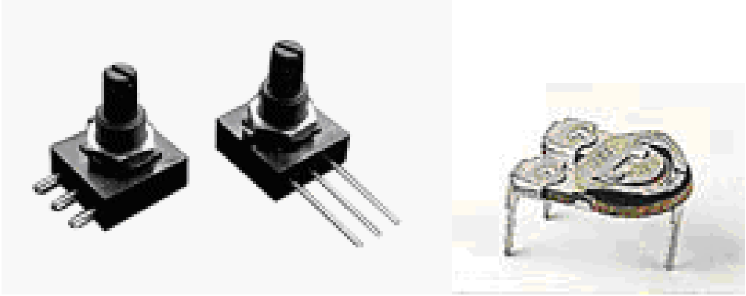
Types of Resistors: Variable resistors

- Variable resistors (Potentiometers or Rheostat) are those whose values can be changed from min to max (*with a hop-off built in resistance*).

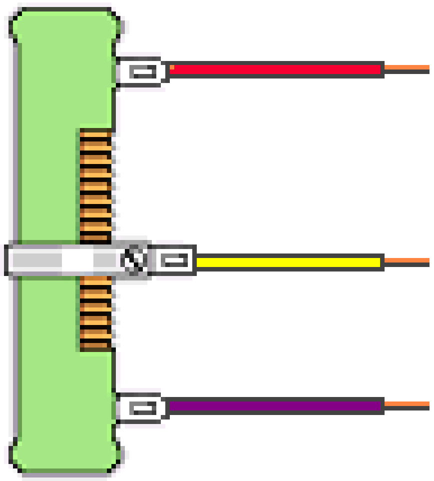




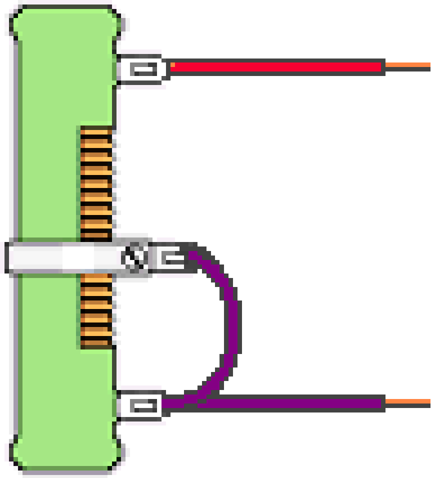




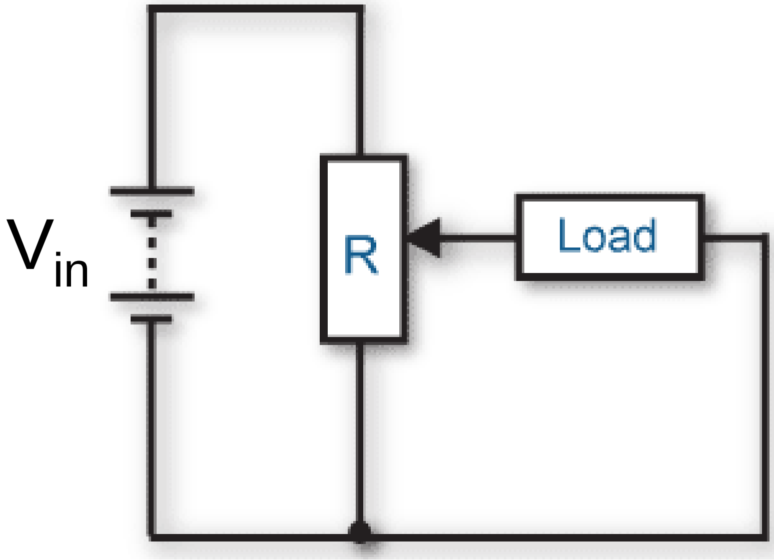
Variable Resistors: cont'd

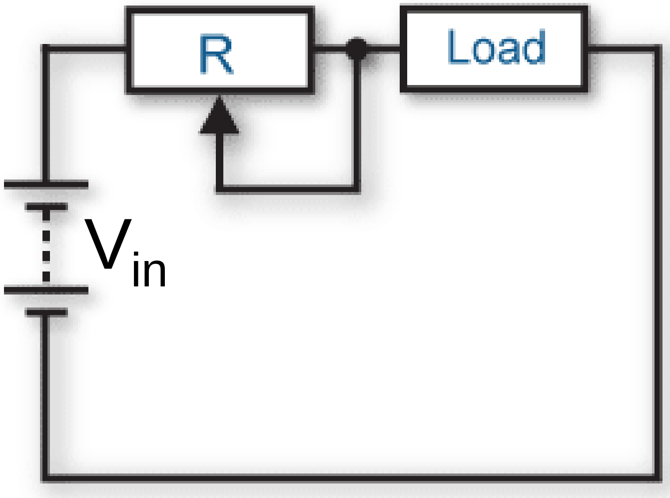


Potentiometer is a 3-terminal component



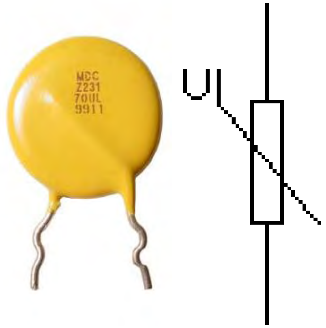
Rheostate: Is a 2-terminal componenet



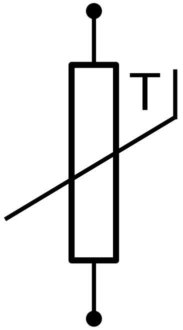


Resistors: Special Purpose Resistors

- **Varistor (Metal Oxide Varistor, MOV)** is a special type of resistor that changes its resistance with rise in voltage.

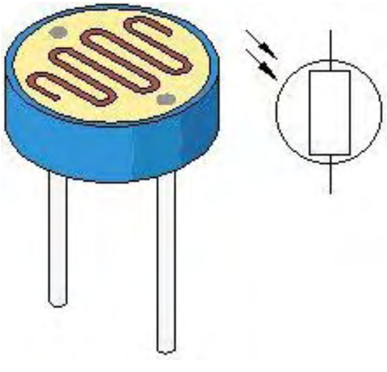


- **Thermistor** is a temperature-dependent resistor:
  - **Positive temperature coefficient** (**PTC**).
  - **Negative temperature coefficient** (**NTC**) .



- **A Sensistor** is a semiconductor-based resistor that depends on temperature (with PTC).

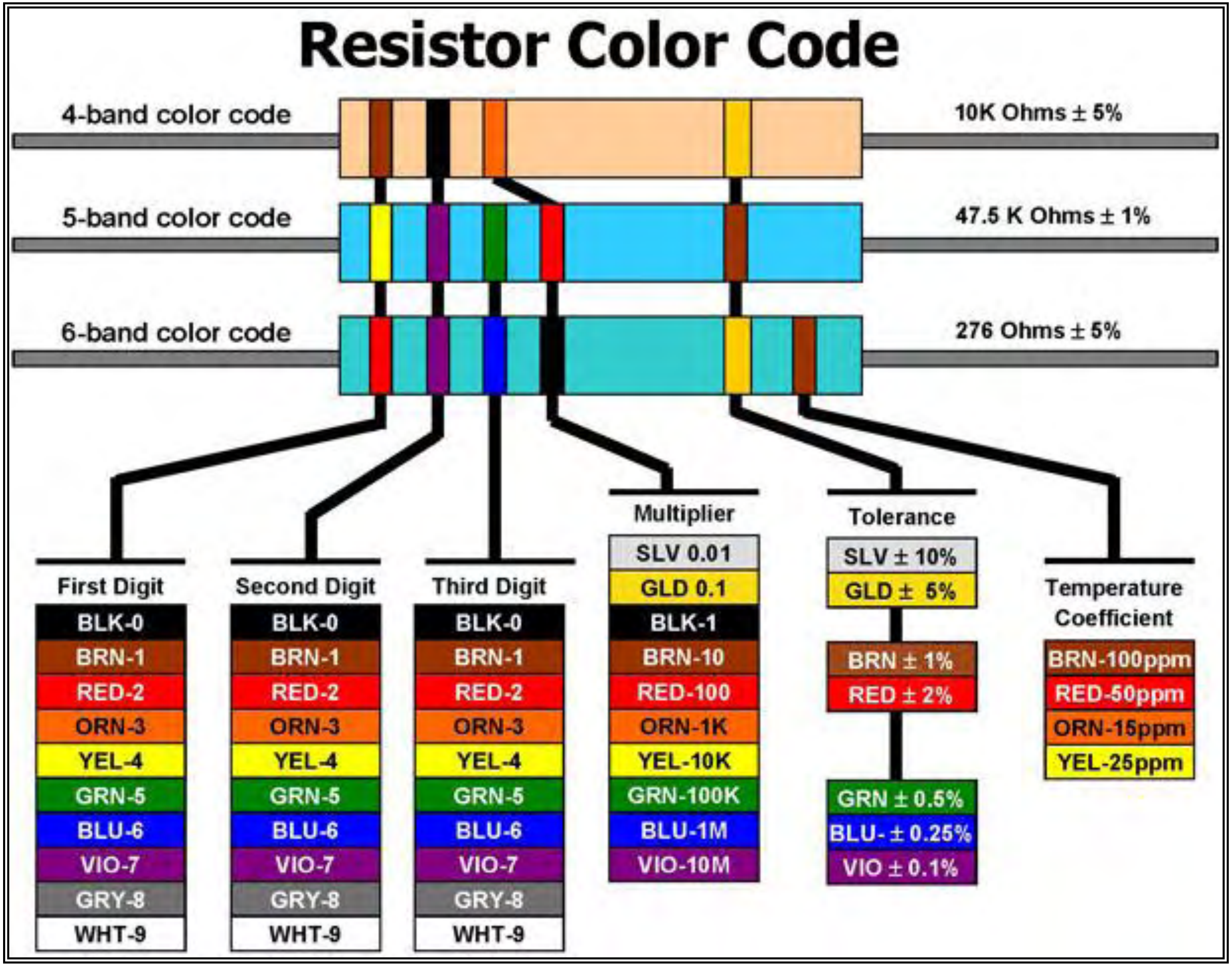
- **Photo resistor (Light dependent resistor, LDR)** an electronic component whose resistance decreases with increasing incident light intensity.



Resistors Color Coding

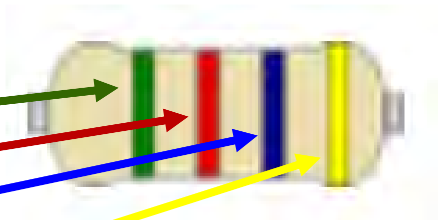
Color	Value	Multiplier	Tolerance (%)
Black	0	0	-
Brown	1	1	±1
Red	2	2	±2
Orange	3	3	±0.05
Yellow	4	4	-
Green	5	5	±0.5
Blue	6	6	±0.25
Violet	7	7	±0.1
Gray	8	8	-
White	9	9	-
Gold	-	-1	±5
Silver	-	-2	±10
None	-	-	±20

Resistors Color Coding: cont'd



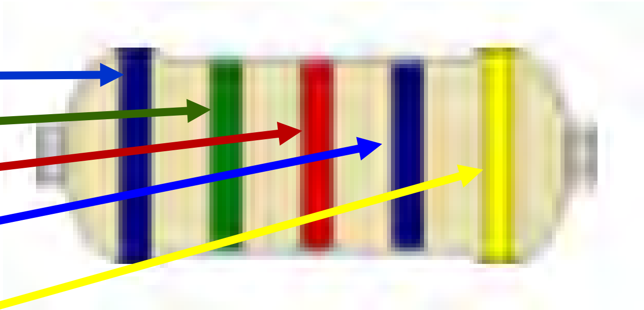
Resistors Color Coding: cont’d

- **<u>4-Band Color Code:</u>**
  - اللون الأول يمثل الرقم X
  - اللون الثاني يمثل الرقم Y
  - اللون الثالث يمثل الأس Z
  - اللون الرابع يمثل نسبة الخطأ المئوية E



$$R = XY \times 10^{Z} + E$$

- **<u>5-Band Color Code:</u>**
  - اللون الأول يمثل الرقم X
  - اللون الثاني يمثل الرقم Y
  - اللون الثالث يمثل الرقم Z
  - اللون الرابع يمثل الأس W
  - اللون الخامس يمثل نسبة الخطأ المئوية E



$$R = XYZ \times 10^{W} + E$$

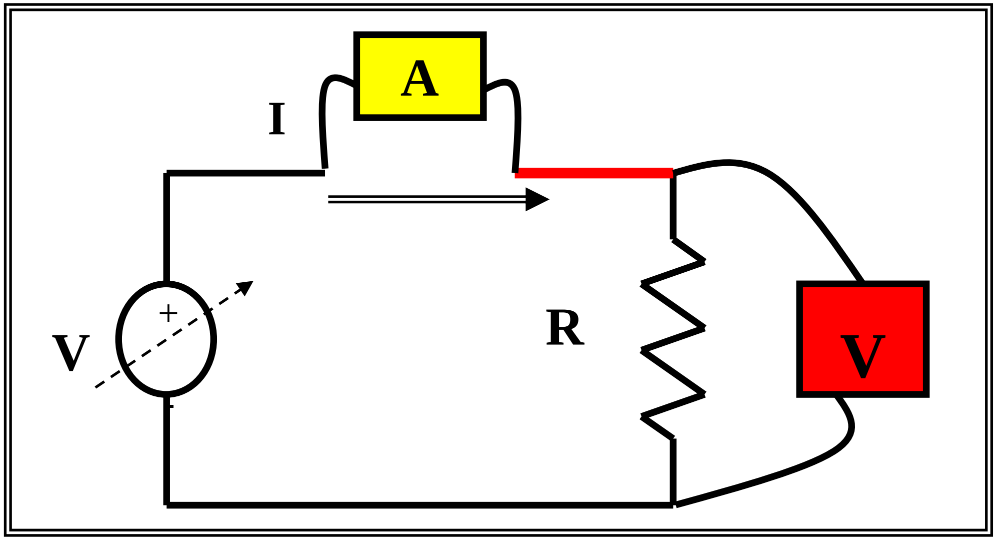
- **<u>6-Band Color Code:</u>** هو نفس الكود الخامس مع إضافة اللون السادس الذي يمثل نسبة التغير مع درجة الحرارة.

$$R = XYZ \times 10^{W} + E + T$$

Ohm's Law

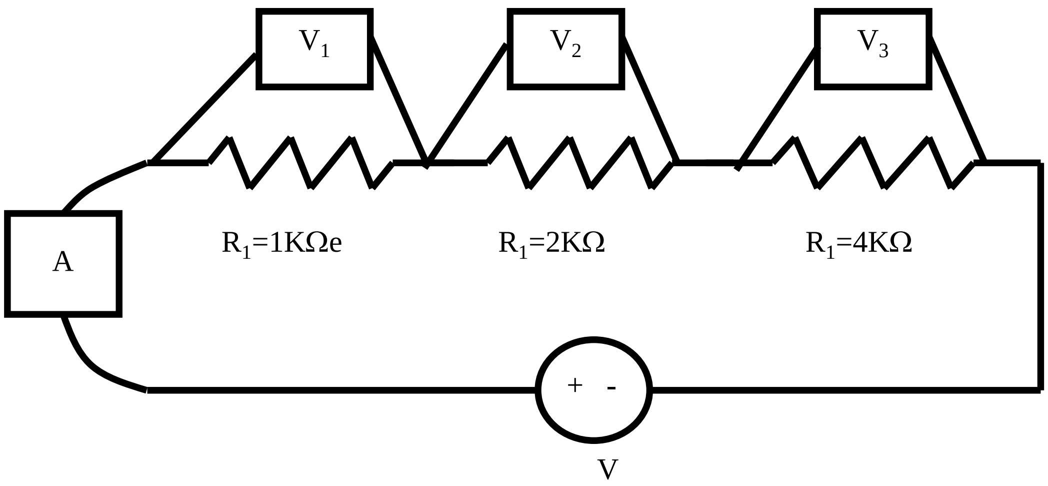
فرق الجهد علي طرفي أي مقاومة خطية يتناسب طردياً مع التيار المار بها.

- **Procedure:** طريقة تحقيق قانون أوم عملياً

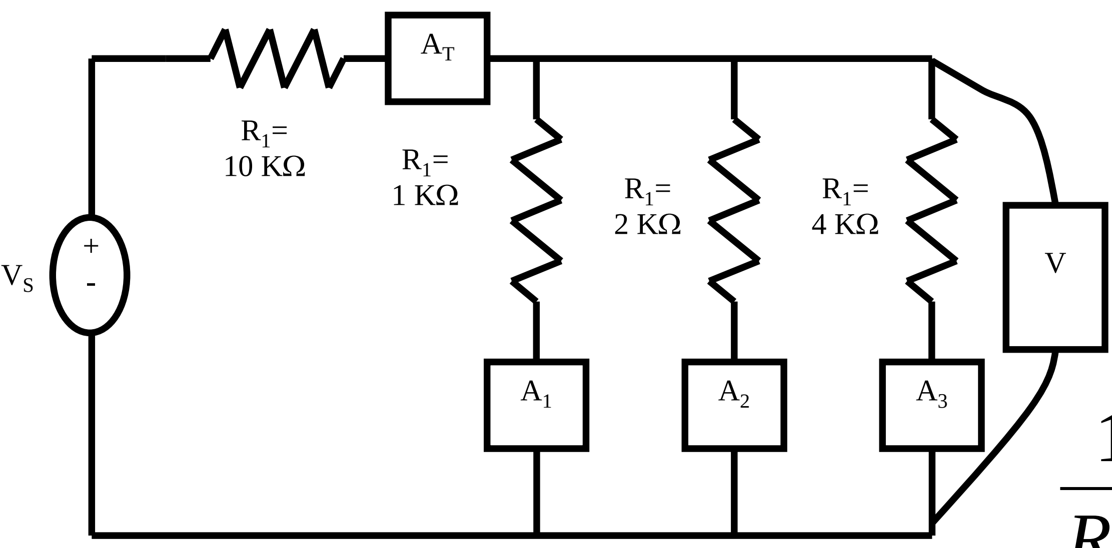


Ohm's Law for Resistors with AC sources											
V (volt)	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
I (Amper)											

Series and Parallel Connection



$$R_{eq} = R_1 + R_2 + R_3 = \sum_{i=1}^{N} R_i$$

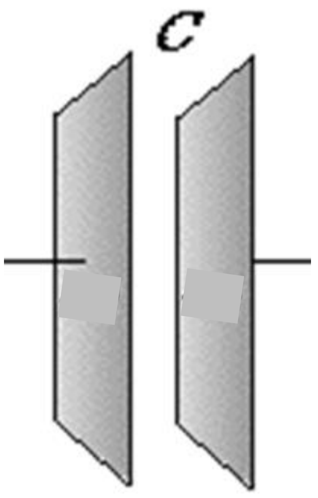


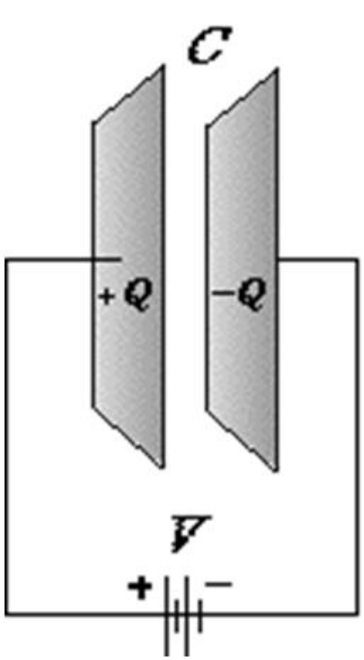
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \sum_{i=1}^{N} \frac{1}{R_i}$$

II- Capacitors

- A *capacitor* is a passive electronic component that stores energy in the form of an electrostatic field between a pair of closely spaced electrode conductors (called ‘plates’) separated by an insulator.
- The unit of capacitance is the farad (coulomb/volt). Practical values usually lie in the Pico farad (1 pF = 10^{-12} F) to microfarad (1 μF = 10^{-6} F) range.
- When voltage is applied to the capacitor, electric charges of equal magnitude, but opposite polarity, build up on each plate. The capacitor relationship:

$$C = \varepsilon \frac{A}{D} \qquad q = Cv \qquad i = c\frac{dv}{dt}$$





Capacitors Characteristics

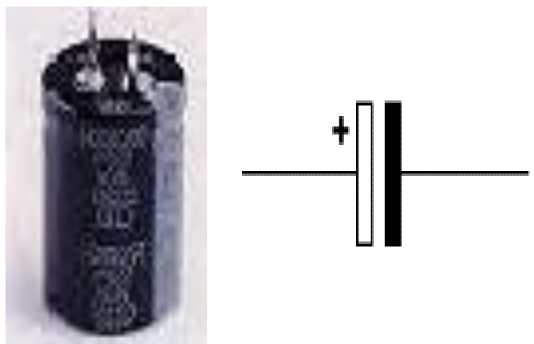
- Capacitors are manufactured as having one of two very basic characteristics, they are either:
  - Polarized are very particular about which side (plate) is connected to a relatively positive voltage. Connecting them the wrong way can damage it.
  - Non-polarized capacitors can normally be connected into a circuit either way round

Capacitor Types

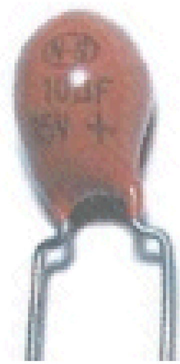
- Capacitors are basically named in respect of the nature of the dielectric material used between the plates

- Polarized
  - Electrolytic Capacitors
  - Tantalum Capacitors
  - Super Capacitors
- Non-polarized
  - Polyester Film
  - Polypropylene Film
  - Polystyrene Film
  - Metalized Polyester Film
  - Epoxy Capacitors
  - Ceramic Capacitors
  - Multi-Layer Ceramic Capacitors
  - Silver Mica Capacitor
  - Trimmer capacitors

Capacitor Types: Examples



Electrolytic Capacitors



Tantalum Capacitor

Super Capacitor

Polyester Capacitor

Polypropylene Film

Polystyrene Film

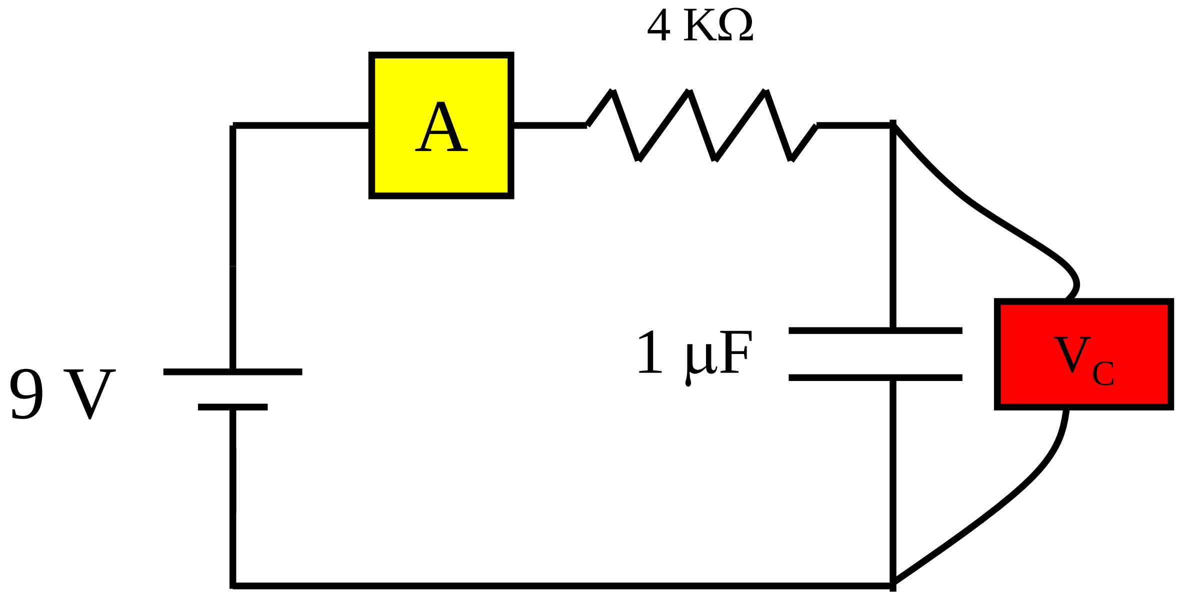
Epoxy Capacitor

Capacitors with DC Voltage

- For circuits with a DC-voltage source, the voltage across the capacitor cannot exceed the voltage of the source.
- Thus, an equilibrium is reached where the voltage across the capacitor is constant and the current through the capacitor is zero.

$$i = c\frac{dv}{dt}$$

- For this reason, it is commonly said that capacitors block DC.



Capacitors with AC Voltage

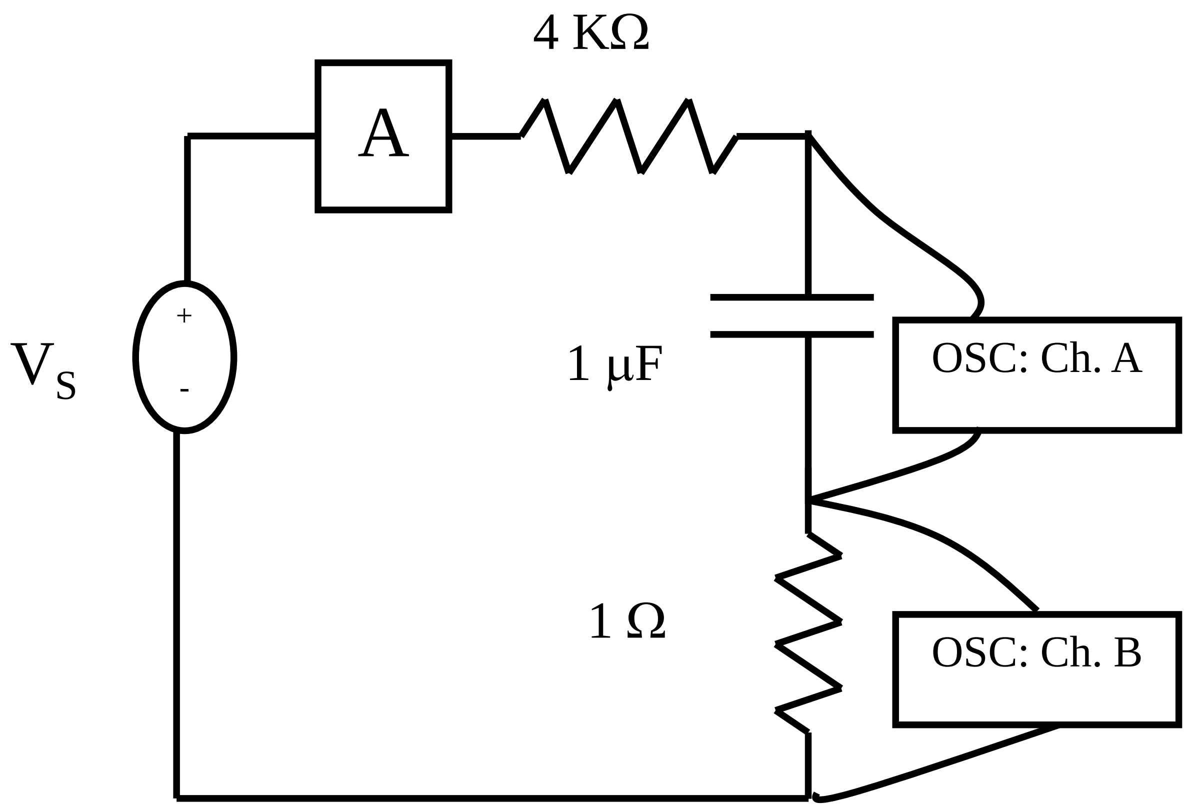
- The current through a capacitor due to an AC-source reverses direction periodically.
- With the exception of the instant that the current changes direction, the capacitor current is non-zero at all times during a cycle. For this reason, it is commonly said that capacitors "pass" AC.

$$i = c\frac{dv}{dt} \quad \Rightarrow \quad v = \frac{1}{c}\int i\,dt$$

Cos Sin

- The capacitor current **leads** its voltage by a 90^{o} phase angle, **i.e., the voltage and current are 'out-of-phase' by a quarter of a cycle.**

Capacitor with AC Voltage: I-V relation

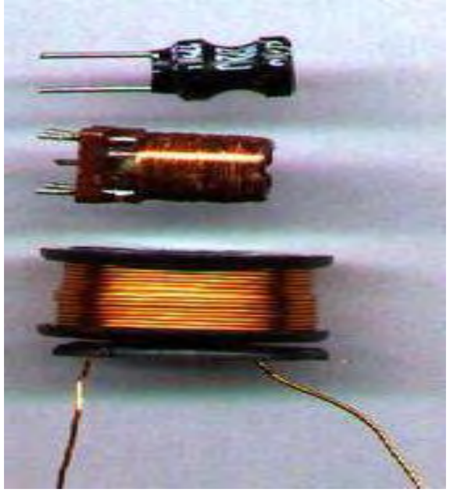


III- Inductors

- When An electric current flows through a conductor, it creates a magnetic field its flux is proportional to the current.

- A change in this current creates a change in magnetic flux that, in turn, generates an electromotive force (*emf*) (Faraday's Law).

- Inductance (measured in Henries) is a measure of the generated emf for a unit change in current.



Inductors with DC Voltage

- In general, the relationship between the time-varying voltage v(t) across an inductor with inductance *L* and the time-varying current i(t) passing through it is described by the differential equation:

$$v = L\frac{di}{dt}$$

- While a capacitor opposes changes in voltage, an inductor opposes changes in current.

- An ideal inductor would offer no resistance to DC current

Inductors with AC Voltage

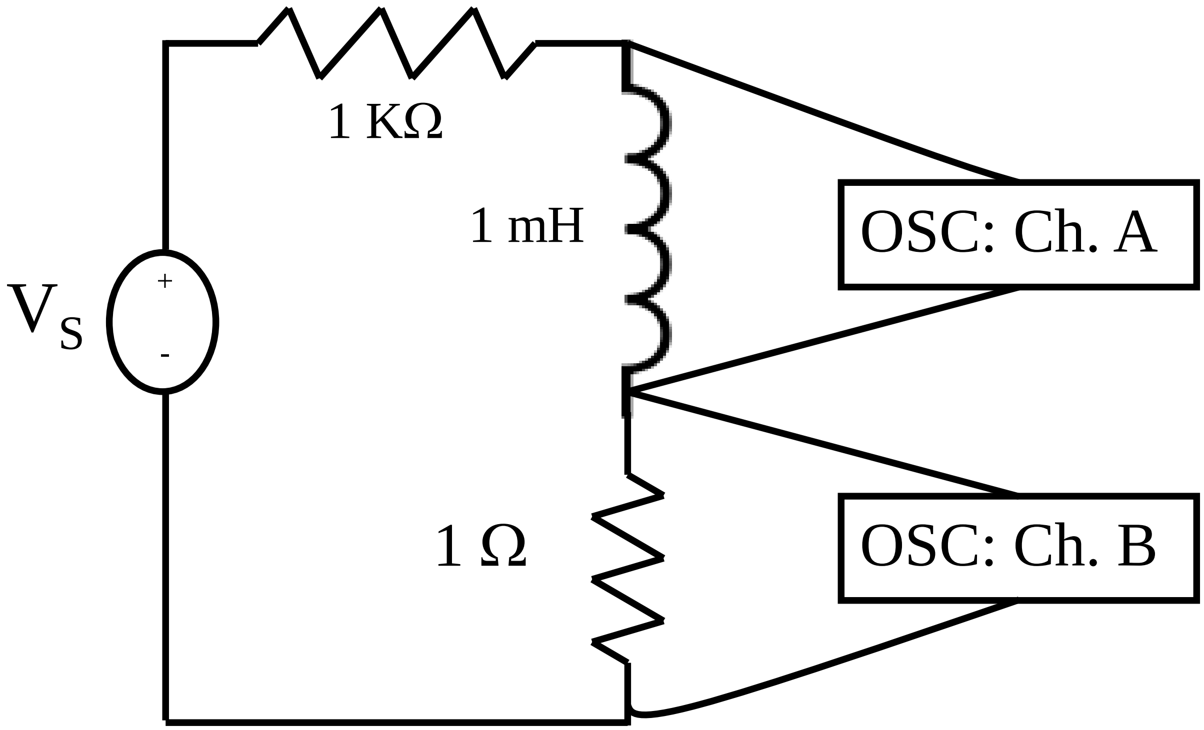
- From the i-v differential equation of the inductor:

$$v = L\frac{di}{dt} \quad \Rightarrow \quad i = \frac{1}{L}\int v\,dt$$

Cos Sin

- The inductor current **lags** its voltage by 90º.

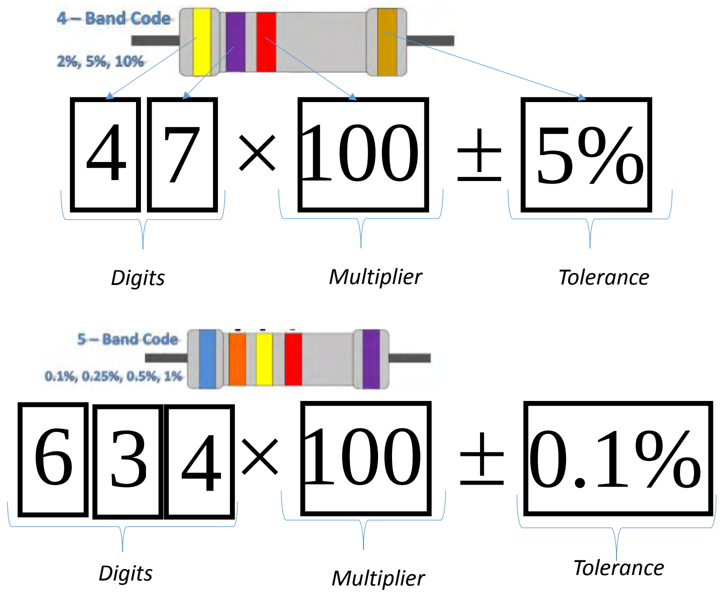
Inductors with AC Voltage: I-V relation



Lab-1 - Overview of Lab Equipment

I. Resistor color codes

Band Color	***Digit***	***Multiplier***	***Tolerance***
Black	0	1Ω	
Brown	1	10Ω	$\pm1\%$
Red	2	100Ω	$\pm2\%$
Orange	3	$1K\Omega$	
Yellow	4	$10K\Omega$	
Green	5	$100K\Omega$	$\pm0.5\%$
Blue	6	$1M\Omega$	$\pm0.25\%$
Violet	7	$10M\Omega$	$\pm0.1\%$
Gray	8		
White	9		
Gold		0.1Ω	$\pm5\%$
Silver		0.01Ω	$\pm10\%$



a) By reading the color code, pick a resistor with a 10K**Ω** ***nominal value*** from your component set.
b) From the <u>tolerance band</u> color, find the expected range of values of the ***actual resistor***.

$$R_{min} \leq R_{actual} \leq R_{max}$$

c) Use the DMM to measure the ***actual resistor value***.
d) Does the measured value fall in the tolerance range (expected range of values of the actual resistor?
e) Repeat the above steps for a 4.7K resistor.

II. Voltage divider circuit

Complete the following steps:

f) Build circuit in Figure 1. R_1, R_2 = 10 KΩ. Input signal settings: 1.0V_{pp}, 500Hz.
g) Turn on the oscilloscope. Adjust the various settings to see signal on the display.
h) On the oscilloscope screen verify the amplitude of the signal across R_2.
i) Use the DMM to measure the signal value.
j) Compare the measured values with the theoretical values.

Repeat the above steps with R1=5 KΩ and R2=1 KΩ (or any other available resistors values in your box)

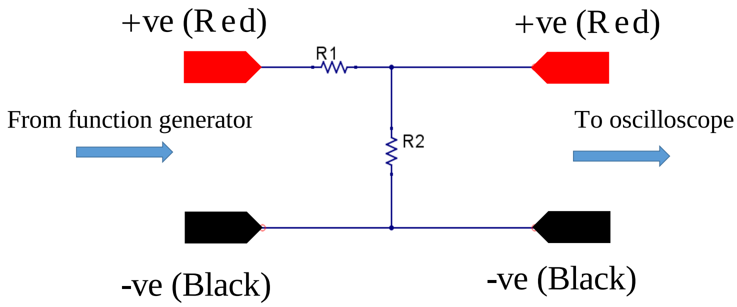


Figure 1: Voltage divider

III. Estimating the value of a variable resistor

Complete the following steps:

a) Build the circuit shown in Figure 2. (Note: R2 now is a variable resistor).
b) Play with the potentiometer arm and set the resistor to some unknown value.
c) Turn on the oscilloscope. Adjust various settings to see the signal on the display.
d) From the oscilloscope, estimate the amplitude of voltage across the potentiometer.
e) Using the values in step 4, can you estimate the value of the potentiometer?
f) Use the DMM to measure the potentiometer value.
g) Compare the values obtained in steps 5 and 6.

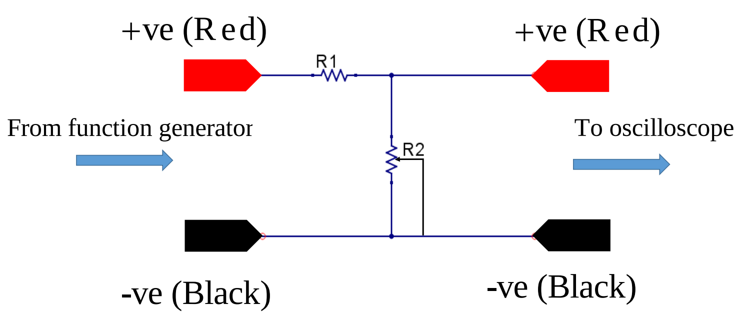


Figure 2: Variable resistor

IV. Displaying signal on oscilloscope

Complete the following steps:

a) Build the circuit of Figure 3 R_L=1 KΩ. Make sure the signal across the resistor is 1.0Vpp, 500 Hz.
b) Turn on the oscilloscope. Adjust the various settings until you can see the signal on the display.
c) Verify the frequency and amplitude of the displayed signal.
d) Now, try to change the frequency of the signal from 500Hz to 1000Hz. **DO NOT CHANGE THE OSCILLOSCOPE SETTINGS**

e) Adjust the horizontal scale (time) using Time/Div knob.
f) Play with vertical and horizontal knobs to center the positioning of the signal on the screen.

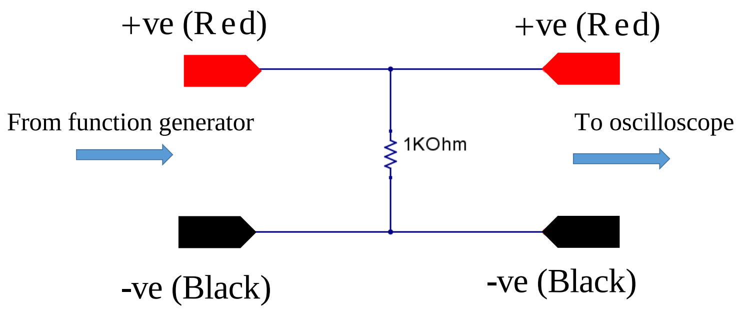


Figure 3: Set-up for viewing signal on scope

V. Frequency dependent circuit behavior

For each of the circuits shown in Figures 4[A-D], do the following:

a) Build the circuit according to the given components.
b) Set the function generator output signal type to sine wave.
c) Connect the function generator signal to the input of the circuit.
d) Using the oscilloscope, view the input of the circuit on Ch1 and the output on Ch2.
e) Using the amplitude knob on the function generator, set the amplitude level 1Vpp.
f) Vary frequency of the function generator signal across the values given in the following table and record the peak-to-peak voltage of the output signal of the circuit.

Frequency	**Peak-to-peak Voltage of Output Signal**
10Hz	
100Hz	
1000Hz	
10000Hz	
100000Hz	

e) Make a rough plot of the peak-to-peak voltage (y-axis) versus frequency (x-axis). Describe what happens to amplitude as you increase frequency for each circuit.

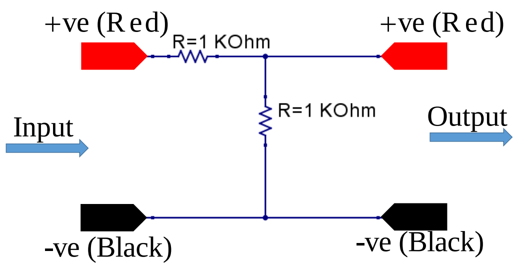


Figure 4A

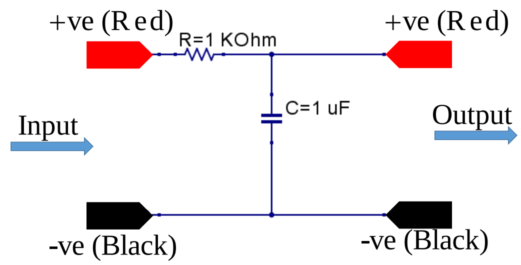


Figure 4B

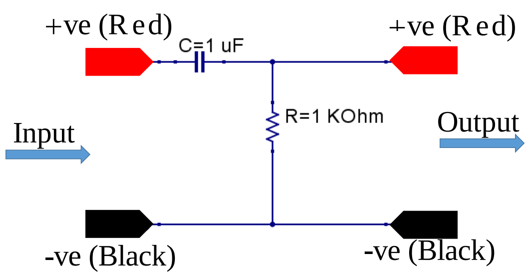


Figure 4C

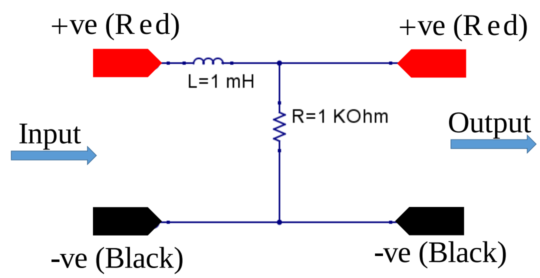


Figure 4D

Objectives:

1.
2.
3.

Q1. For the resistor shown in figure 1.1 answer the below questions:

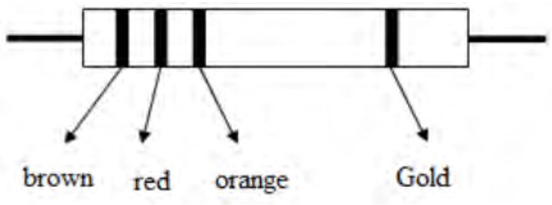


Figure 1.1

a) Calculate the nominal value of the resistor using color-code rule.

b) Which color is indicating the tolerance, and what is the tolerance value?

Q2. For the Wheatstone bridge circuit shown in figure 1.2 derive this formula: $R_x = (R_2 \times R_3)/R_1$

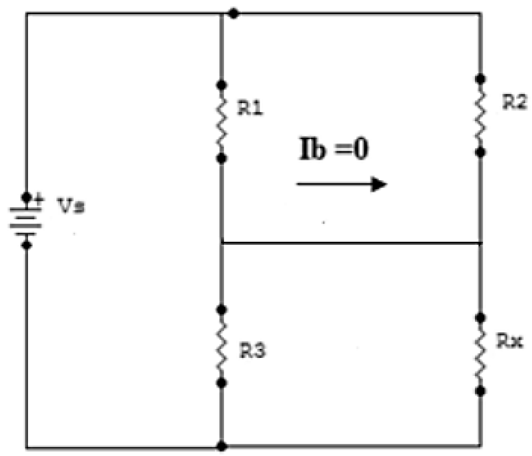


Figure 1.2

Q3. For the circuit shown in figure 1.3, select R_o such that the maximum variation in the current I_o is 5 to 2 mA. (Note: Rs is a rheostat with maximum value 5 kΩ and show all your calculations.)

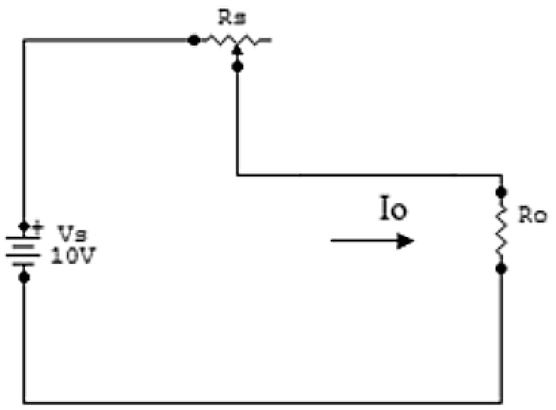


Figure 1.3

1.1 Objectives:

1. Gain familiarity with available types of resistors, potentiometers, and rheostats.
2. Determine the nominal value of resistance using the color code, and the actual value using different types of measurement.
3. Determine the linearity of a potentiometer, and use it as a voltage divider or control element.

1.2 Introduction:

1.2.1 Resistors:

As discrete components, resistors come in various sizes and shapes depending on their power rating and use. The resistive element material may also vary, e.g., metallic wire, carbon, etc. the resistor most commonly used in the laboratory is made of carbon encased in a tubular form with axial leads as shown in Figure 1.1.

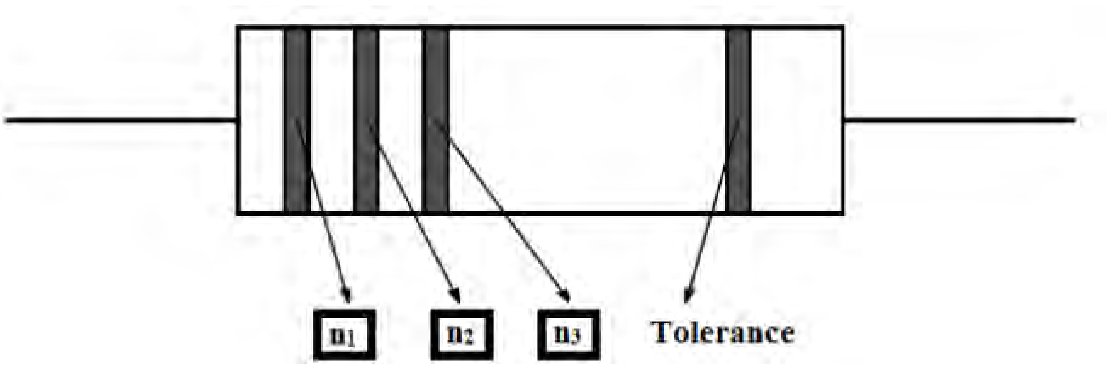


Figure 1.1 Axial-Lead Resistor, Color-Coded

Some resistors may have their nominal ohmic value stamped on the body of the resistor, e.g., 1100 or 2.2M. More often, however, color code is used to indicate the nominal value. Three-color bands are used for this purpose, each having a numerical value between 0 and 9, as shown in Table 1.

Table 1. Numerical Values of Color Codes

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White
0	1	2	3	4	5	6	7	8	9

Starting with the band closest to one end of the resistor, as shown in Figure 1.1, the three represented numbers, n_1, n_2, and n_3 mean:

$$R = \big((10 \times n_1) + n_2\big) \times 10^{n_3} \qquad \Omega.$$

For example, Orange-Blue-Black means $((10 \times 3) + 6) \times 10^{0} = 36\ \Omega$, and Gray-Red-Yellow means $((10 \times 8) + 2) \times 10^{4} = 820\ \text{k}\Omega$. A fourth band according to Table 2 indicates the percent tolerance, around the nominal value. The physical size of a resistor depends on its power rating, and vice versa . To keep its temperature at a safe level, a resistor must be large enough to dissipate its rated power into the surrounding design environment.

Table 2. Percent-Tolerance Color Code

Gold	Silver	No Color
± 5	± 10	± 20

1.2.2 Potentiometers:

Potentiometers provide an adjustable resistance between two points as shown in Figure 1.2. The arrowhead represents a movable contact point. Thus the resistance between the terminals a and b (or c and b) can be varied from 0 to 100 percent of the total resistance between a and c. If this variation is proportional to the physical length of the resistive element, the potentiometer is said to be linear. Otherwise, it is nonlinear, e.g., logarithmic. Two popular shapes of potentiometers are circular and straight-line, as shown in Figure 1.3.

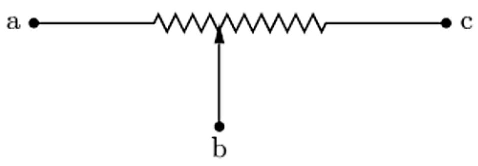
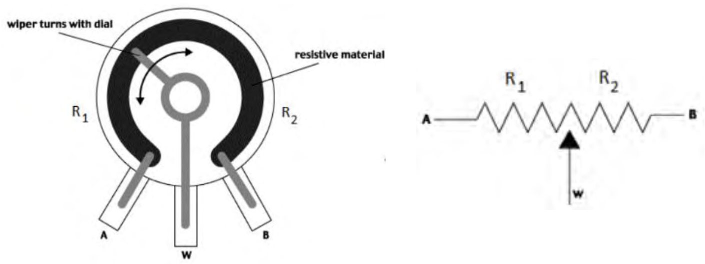


Figure 1.2 Potentiometer Schematic Diagram



(a) Circular Type (b) Straight-line Type

Figure 1.3 Potentiometer Types

A potentiometer is used as a voltage control device to obtain a variable fraction of the potential between two points as shown in Figure 1.4. Here V_o can be varied between zero and V_s.

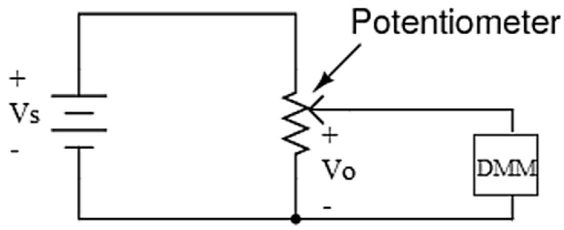


Figure 1.4 Potentiometer Voltage Control

1.2.3 Rheostats:

A rheostat is similar to a potentiometer in structure. However, it differs in its intended use. It is used as a series element to control current as shown in Figure 1.7. Thus, it is usually a higher power device.

1.3 Procedure:

1.3.1 Resistance Measurements:

Several methods will be used to measure resistance. Their results will be compared with each other and with nominal color-code value.

1. Obtain two resistors having arbitrary values between 100 Ω and 100 kΩ.
2. Tabulate their color codes, nominal values, percent tolerances, and power ratings.
3. Use the DMM to measure the value of each resistor directly on the most sensitive range.
4. As an aside, measure and record your body resistance by holding the probes firmly one with each hand.

Resistors	Nominal Value	Tolerance Value	DMM Value
R1			
R2			
Your Body			

5. Construct a measurement circuit as shown in Figure 1.5, where R_x is the resistance to be determined by Ohm's law: $R_x = V_x / I_x$.
6. Increase V_s from 0 to near the highest responsible value. (Within limits that are safe for the resistor R_x)
7. Record the measured values of V_x, I_x, and calculate the value of R_x by the Ohm's law.

V_s	3 V	5 V	10 V
V_x			
I_x			
R_x			

8. A Wheatstone bridge for measuring resistance is shown in Figure 1.6. When the Bridge is balanced, i.e., Ib = 0 A, The following relation holds: $R_x = (R_2 \times R_3)/R_1$.
9. Select reasonable values for R1 and R2, and measure them with the DMM before placing them in the circuit.
10. Use a potentiometer to make an adjustable resistor R3. Use approximately 10 V for Vs.
11. Set the DMM initially to the highest current range and adjust R3 to make Ib approach 0, stop adjusting when a minimum value of Ib is obtained on the lowest possible range. Record this value for reference only.
12. Disconnect R3 and measure it directly with the DMM………………………..
13. Calculate the value of unknown Rx using above formula and compare with the nominal values.

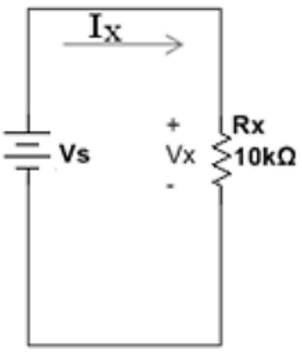


Figure 1.5

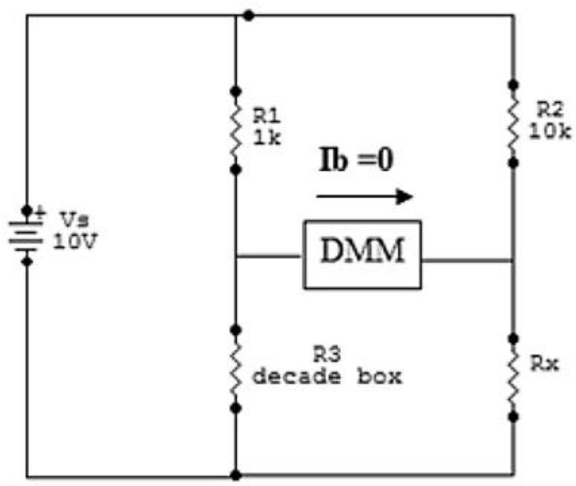


Figure 1.6

1.3.2 Potentiometers and Rheostat:

1. For the circuit shown in Figure 1.7, obtain a Potentiometer; select R_o such that the maximum variation in the current I_o is 5 to 2 mA, then measure and record the value of R_o.
2. Construct the circuit using 10 V for V_s.
3. Measure I_o on the lowest possible range using the 4 marked sections of the potentiometer for R_s, i.e, 0, 25, 50, 75 and 100 percent.

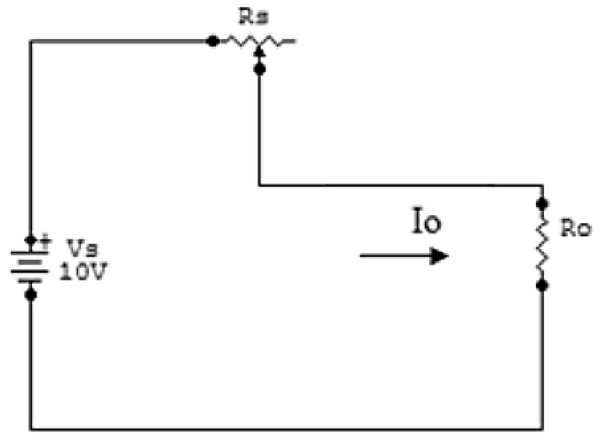


Figure 1.7

R_o = …………………..

R_s (kΩ)	I_o (mA)
5	
4	
3	
2	
1	
0	

1. Resistance Measurements:

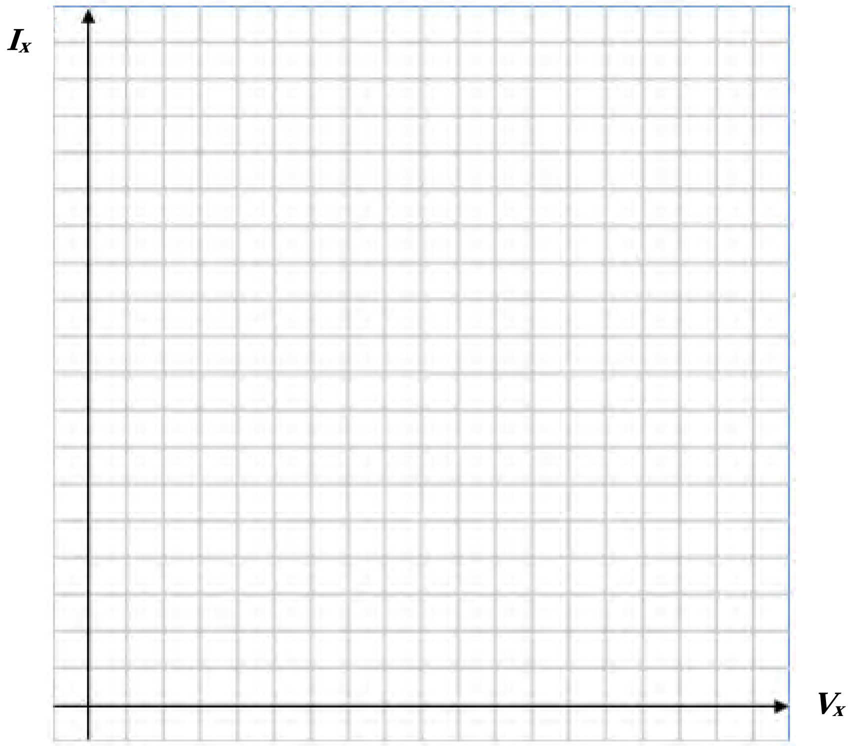
a) ***Ohmmeter Measurements:*** Fill the following table according to what you measured at the laboratory. (Note: you should show your calculations.)

Resistors	Nominal Value	Tolerance Value	DMM Value
R1			
R2			
Your Body			

b) ***Ohm's Law:*** Fill the following table: $R_x = V_x / I_x$.

V_s	3 V	5 V	10 V
V_x			
I_x			
R_x			

c) Plot I_x vs V_x and find the slope of the curve (R_x).



d) ***For Wheatstone Bridge Experiment***, R_3 = __________. Calculate the value of unknown R_x using the balance formula, Compare with the nominal values.

……………………………………………………………………………………………

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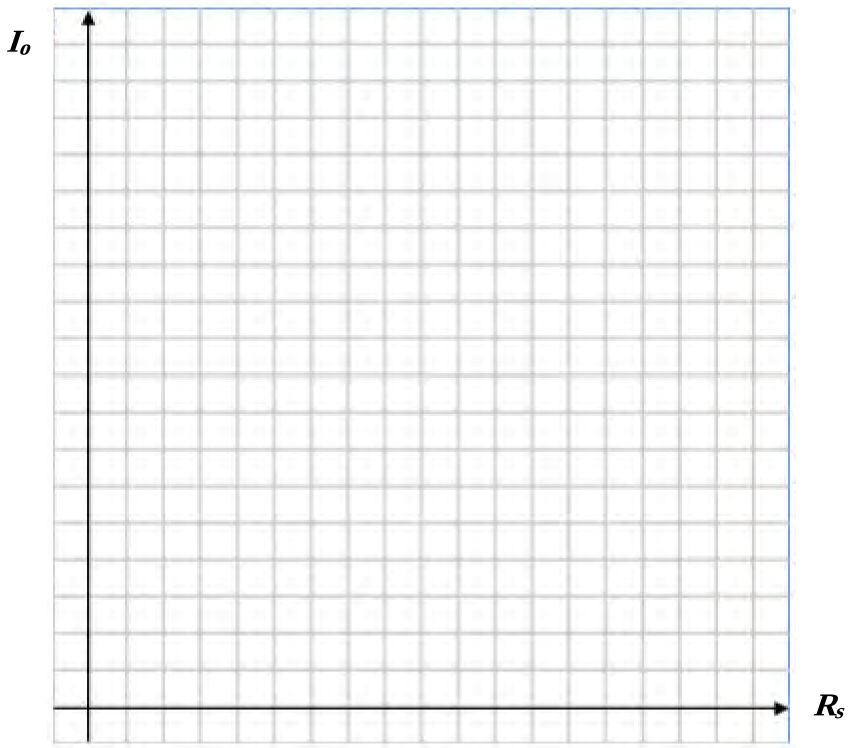
e) ***Potentiometers and Rheostat:*** The selected R_o = ____________. Fill the following table.

R_s (kΩ)	I_o (mA)
5	
4	
3	
2	
1	
0	

f) Plot I_o vs R_s. What functional relation does this plot indicate?



2. Conclusion and Discussion:

List your conclusion about all parts of this experiment, and discuss the results as points:

التجربة الثانية

2.1 Objectives:

Verify Kirchhoff's voltage and current laws and some of their consequences by measurements on dc circuits.

2.2 Introduction:

2.2.1 Series Circuits:

Kirchhoff's Voltage Law (KVL) states that the sum of voltages around a closed path is zero. We can verify this law by measurements on simple series circuits as circuit shown at Figure 2.1.

2.2.2 Parallel Circuits:

Kirchhoff's Current Law (KCL) states that the sum of all currents at any node in a circuit is zero. We can verify this law by measurements on a simple parallel circuit as the circuit shown at Figure 2.2.

2.2.3 Series-Parallel Circuits:

Both KVL and KCL are now verified by measurements in a rather arbitrary circuit containing series and parallel combinations of resistors as shown at Figure 2.3.

2.3 Procedure:

2.3.1 Series Circuits:

1. Construct the circuit shown in Figure 2.1 with the given values of resistors.

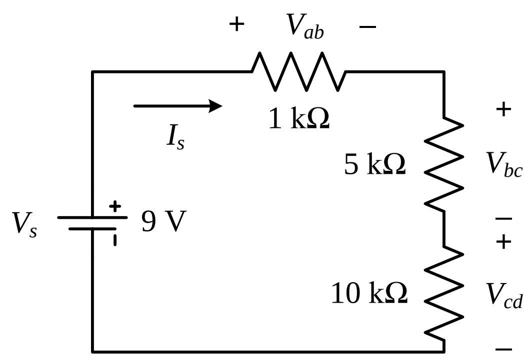


Figure 2.1

2. Measure the value of I_s by using the DMM as an ammeter. $\boldsymbol{I_s}$ = ________________.
3. Move the connection of the voltmeter around the circuit to measure the voltages:

V_s	V_{ab}	V_{bc}	V_{cd}	I_s
9 V				

4. Disconnect the power supply from the circuit, and use the DMM as an ohmmeter to measure the resistances values; (you need to use the measured values of resistances and I_s to calculate the different voltages, and compare the results with the measured values of these voltages.)

Resistor Name	Measured Value
R_1	
R_2	
R_3	

2.3.2 Parallel Circuits:

1. Construct the circuit shown in Figure 2.2 with the given values of resistors.

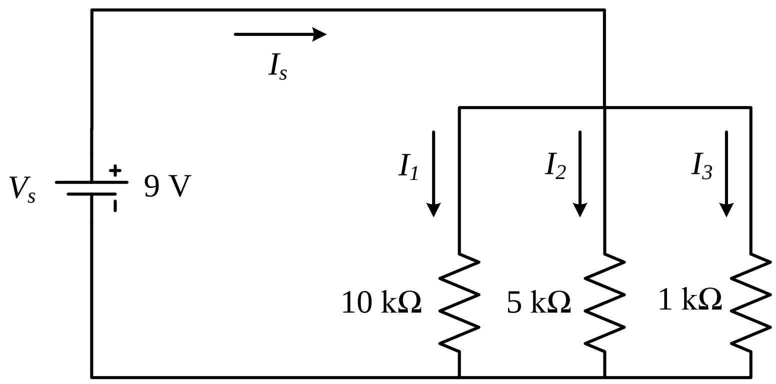


Figure 2.2

2. Measure the value of I_s by using the DMM as an ammeter. $\boldsymbol{I_s}$ = ________________.
3. Now place the ammeter in series with R_1, R_2, and R_3 to measure the values of the different currents:

V_s	I_1	I_2	I_3	I_s
9 V				

4. Disconnect the power supply, and use the DMM as an ohmmeter to measure the parallel combination of R_1, R_2, and R_3, then measure each resistance separately, (you need to use the measured values of resistances and V_s to calculate the different currents, and compare the results with the measured values of these currents.).

Resistor Name	Measured Value
R_1	
R_2	
R_3	
R_{EQ}	

2.3.3 Series-Parallel Circuits:

1. Construct the circuit shown in Figure 2.3 with the given values of resistors.
2. Use the DMM as a voltmeter to measure V_s, and the different voltages across the individual resistors, as indicated:

Voltage Name	Measured Value
V_s	
V_1	
V_2	
V_3	
V_4	
V_5	
V_6	

3. Use the DMM as an ammeter to measure the different currents across the resistors, as below:

Current Name	Measured Value
I_1	
I_2	
I_3	
I_4	
I_5	
I_6	

4. Use the DMM as an ohmmeter to measure the different resistances, as below:

Resistor Name	Measured Value
R_1	
R_2	
R_3	
R_4	
R_5	
R_6	

5. Now, use the measured values of voltages to verify KVL on all closed paths, and use the measured values of currents to verify KCL at all nodes. Finally, use the measured values of resistances with Ohm's law to calculate voltages using measured currents and vice versa, then compare all the measured quantities.

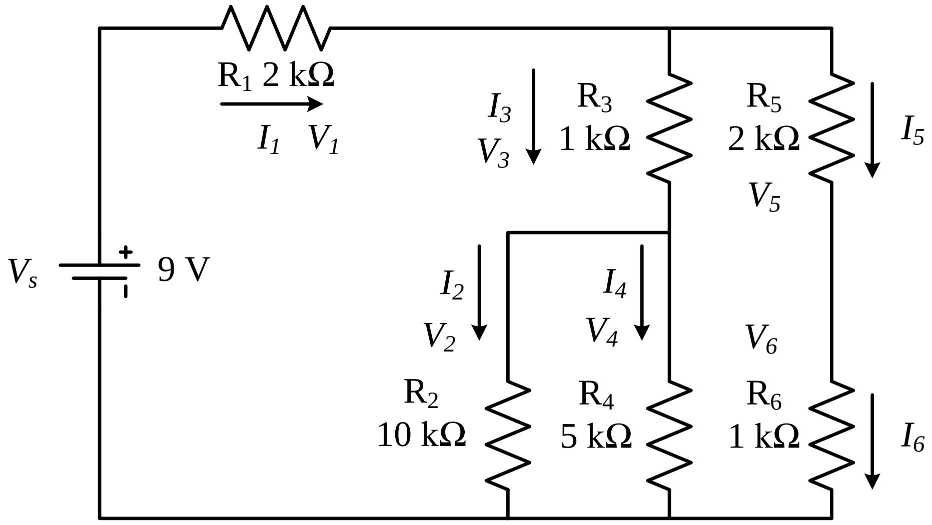

R1 2 kΩ
I1 V1
I3
V3
R3
1 kΩ
R5
2 kΩ
I5
V5
Vs
9 V
I2
V2
I4
V4
V6
R2
10 kΩ
R4
5 kΩ
R6
1 kΩ
I6

Figure 2.3

1. Series Circuits:

After connect the circuit shown in Figure 2.1, fill the below tables and answer the following questions:

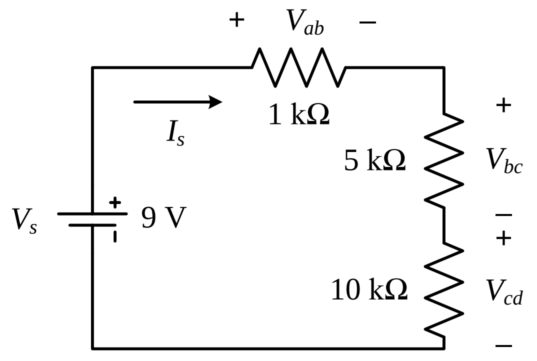


Figure 2.1

V_s	V_{ab}	V_{bc}	V_{cd}	I_s
9 V				

Resistor Name	Measured Value
R_1	
R_2	
R_3	

Q1. Compare the sum of these voltages to V_s.

Q2. Use the above values and the measured value of I_s to calculate different voltages by Ohm's law, and compare them with the values obtained previously.

Voltage Name	Measured Value	Calculated Values Using Ohm's Law
V_{ab}		
V_{bc}		
V_{cd}		

Q3. Now, use voltage division to calculate different voltages, and compare your results with the measured values.

Voltage Name	Calculated Value	Measured Value
V_{ab}		
V_{bc}		
V_{cd}		

2. Parallel Circuits:

After connect the circuit in Figure 2.2, fill the table below and answer the following questions:

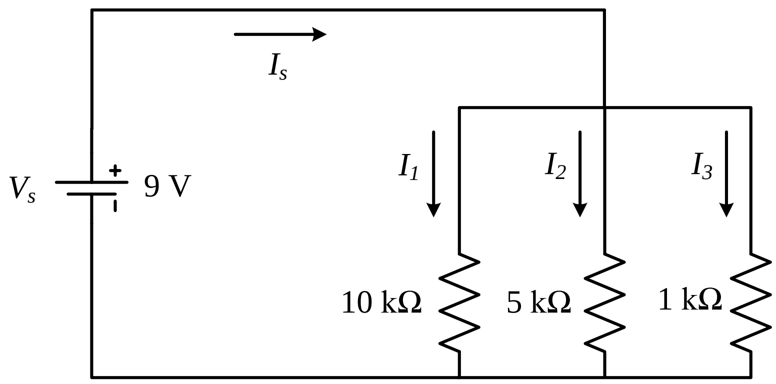


Figure 2.2

V_s	I_1	I_2	I_3	I_s
9 V				

Q4. Compare the sum of the above currents with I_s.

Q5. Use current division to calculate different currents, and compare your results with the measured values.

Current Name	Calculated Value	Measured Value
I_1		
I_2		
I_3		

3. Series-Parallel Circuits:

After connect the circuit in Figure 2.3, record the following results and answer the related question.

Q6. Now, use the measured values of voltages to verify KVL on all closed paths, and use the measured values of currents to verify KCL at all nodes. Finally, use the measured values of resistances with Ohm's law to calculate voltages using measured currents and vice versa, then compare all the measured quantities.

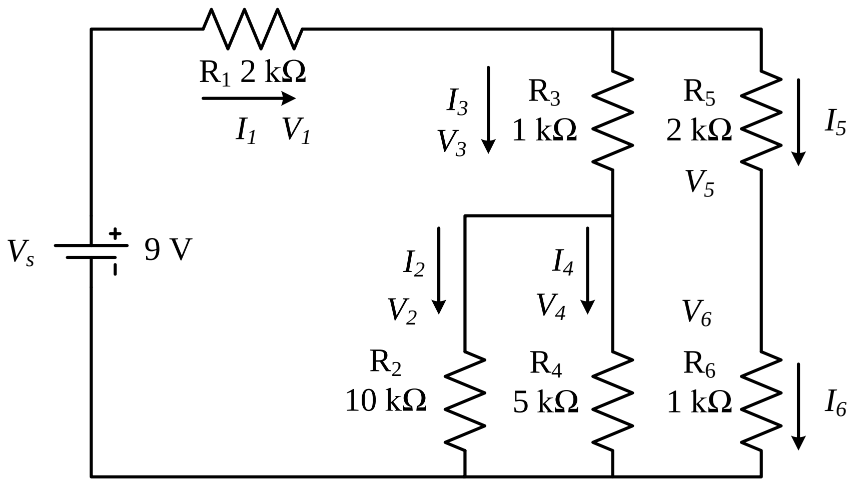


Figure 2.3

Voltage Name	Measured Value
V_s	
V_1	
V_2	
V_3	
V_4	
V_5	
V_6	

Current Name	Measured Value
I_1	
I_2	
I_3	
I_4	
I_5	
I_6	

Resistor Name	Measured Value
R_1	
R_2	
R_3	
R_4	
R_5	
R_6	

Conclusion and discussion:

List your Conclusion about all parts of this experiment, and discuss the results as points:

التجربة الثالثة

Mansoura University
Faculty of Engineering
Pre-lab Experiment (3)

Electronics and Communications Eng.
Electric Circuits Lab (1)
Thevenin's theorem, Norton's theorem's and maximum power transfer

Objectives:

1.
2.
3.

Q1) For the circuit shown in fig. 1, find the current through resistor $R_L = R_1 = 1\Omega$ (I_{ab} branch) using Thevenin's theorem & hence calculate the voltage across the current source (V_{cg}).

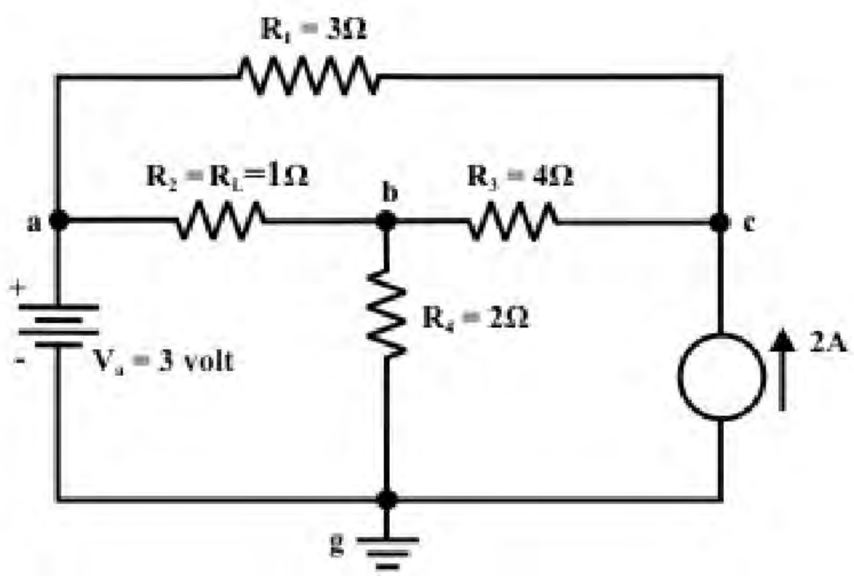


Fig.1

Q2) for the circuit in Fig. 2 below,

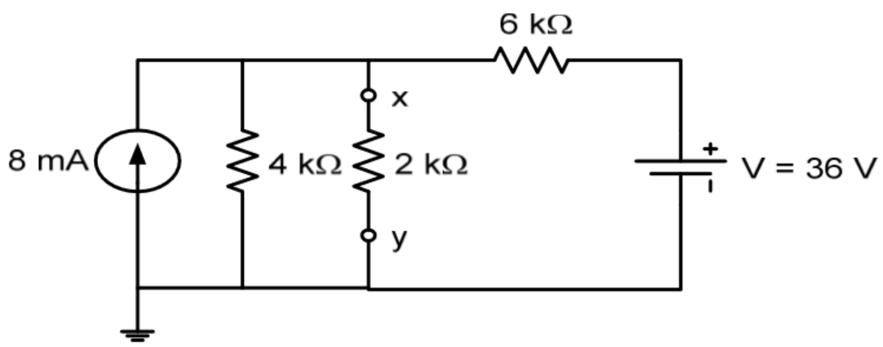


Fig. 2

(a) Determine R_{TH} and V_{TH} for the network external to the 2-kΩ resistor

(b) Determine power delivered to the 2-kΩ resistor using the Thevenin equivalent circuit.

(c) Is the power determined in pat (b) the maximum power that could be delivered to a resistor between terminals x and y? If not, what is the maximum power?

Mansoura University | Electronics and Communications Eng.
Faculty of Engineering | Electric Circuits Lab (1)
Experiment (3) | Thevenin's theorem, Norton's theorem's and maximum power transfer

1.1 Objectives:

1. Validate Thevenin's theorem and Norton's theorem through experimental measurements.
2. Become aware of an experimental procedure to determine V_{TH}, I_N and R_{TH} or R_N. Hence the Thevenin and Norton equivalent circuits.
3. Demonstrate the conditions for maximum power transfer to a load are $R_L = R_{TH}$ and $V_L = V_{TH}/2$.

1.2 Introduction:

Sometimes in circuit analysis we want to concentrate on what happens at a specific pair of terminals. As an example, when we plug a mobile phone charger into an outlet, we are mostly interested in the voltage and current at the terminals of the charger. We have no interest in the effect of the charger on voltages or currents elsewhere in the circuit supplying the outlet. In this laboratory experiment we are going to take a look at Thevenin and Norton equivalent circuits, which are circuit simplifications techniques that focus on terminal behavior.

1.2.1 Thevenin's Theorem:

Any combination of sources and resistances with two terminals can be replaced by a combination of a single voltage source (V_{TH}) in series with a single resistor (R_{TH}). The value of the Thevenin voltage is the open circuit voltage at the output terminals. The value of the Thevenin resistance is the equivalent resistance looking back into the network at the output terminals with all voltage sources replaced by a short and all current sources replaced by an open. In Figure 1 a particular driving circuit with output terminals a and b has been replaced by its Thevenin equivalent circuit, consisting of a Thevenin voltage source V_{TH} in series with the Thevenin resistance R_{TH}.

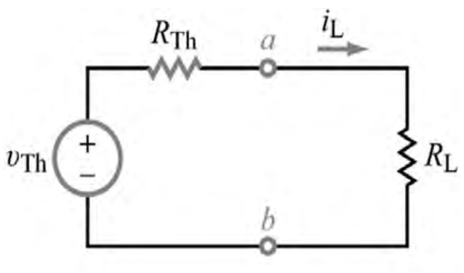


Figure 1 Thevenin equivalent circuit

How to find Thevenin's Equivalent Circuit?

If the circuit contains	You should do
Resistors and independent sources	1) Connect an open circuit between a and b. 2) Find the voltage across the open circuit which is V_{oc}. $V_{oc} = V_{TH}$. 3) Deactivate the independent sources. Voltage source >>> short circuit Current source >>> open circuit 4) Find R_{TH} by circuit resistance reduction
Resistors and dependent sources or independent sources	1) Connect an open circuit between a and b. 2) Find the voltage across the open circuit which is V_{oc}. $V_{oc} = V_{TH}$. ❖ If there are both dependent and independent sources. 3) Connect a short circuit between a and b. 4) Determine the current between a and b. 5) $R_{TH} = V_{oc} / I_{sc}$ ❖ If there are only dependent sources. 3) Connect 1 Ampere current source flowing from terminal b to a. I_t = 1 [A] 4) Then $R_{TH} = V_{oc} / I_t = V_{oc} / 1$

1.2.2 Norton's Theorem:

Any combination of sources and resistances with two terminals can be replaced by a combination of a single current source (I_N) in parallel with a single resistor (R_N). The value of the Norton current is the short circuit current at the at the output terminals. The value of the Norton resistance is the equivalent resistance looking back into the network at the output terminals with all voltage sources replaced by a short and all current sources replaced by an open. In Figure 2 a particular driving circuit with output terminals a and b has been replaced by

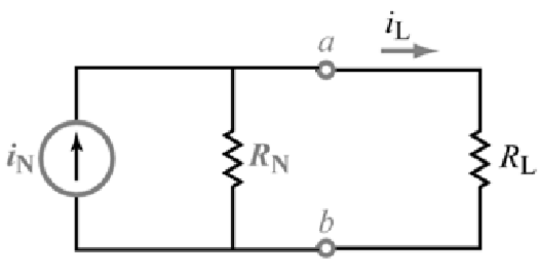


Figure 2 Norton equivalent circuit

its Norton equivalent circuit, consisting of a Norton current source I_N in parallel with the Norton resistance R_N.

How to find Norton's Equivalent Circuit?

If the circuit contains	You should do
Resistors and independent sources	1) Deactivate the independent sources. Voltage source >>>short circuit Current source >>> open circuit 2) Find R_N by circuit resistance reduction 3) Connect a short circuit between a and b. 4) Find the current across the short circuit which is $I_N = I_{sc}$.
Resistors and dependent sources or independent sources	1) Connect a short circuit between a and b. 2) Find the current across the short circuit which is $I_N = I_{sc}$. ❖ If there are both dependent and independent sources. 3) Connect an open circuit between a and b. 4) Determine the voltage between a and b. $V_{oc} = V_{ab}$ 5) $R_N = V_{oc} / I_{sc}$ ❖ If there are only dependent sources. 3) Connect 1 Ampere current source flowing from terminal b to a. I_t = 1 [A] 4) Then $R_N = V_{oc} / I_t = V_{oc} / 1$

Note

1) The theory of source conversion dictates that the Norton and Thevenin circuits be terminally equivalent and related as follows**:**

$$\boxed{R_N = R_{Th}} \qquad \boxed{V_{Th} = I_N R_N} \qquad \text{and} \qquad \boxed{I_N = \frac{V_{Th}}{R_{Th}}} \qquad (3.1)$$

2) If a dc voltage source is to deliver maximum power to a resistive load, the load resistor RL must have a value equal to the Thevenin equivalent resistance, R_{TH} "seen" by the load. For

this value, the voltage across the load will be one-half of the Thevenin voltage. In mathematical expression

$$R_L = R_{Th}, \qquad V_L = \frac{V_{Th}}{2} \qquad and \qquad P_{max} = \frac{V_{Th}^2}{4R_{Th}} \tag{3.2}$$

1.3 Procedure:

1.3.1 THEVENIN'S THEOREM AND NORTON'S THEOREM:

1. Construct the circuit as depicted in Figure 3. Insert the measured resistance values in Table 1.

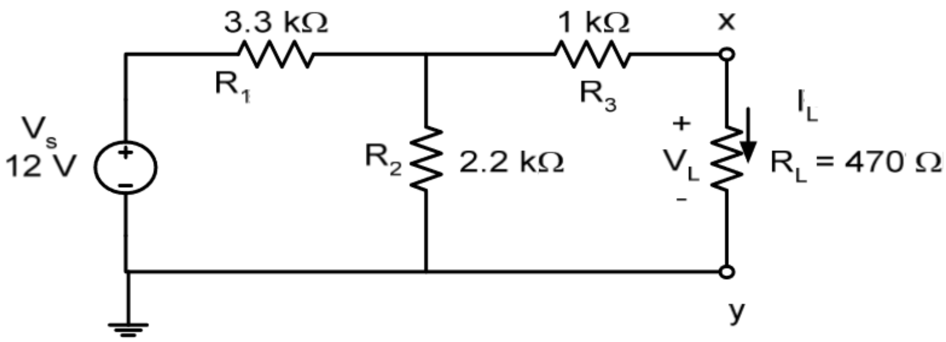


Fig. 3 Circuit diagram for Thevenin's and Norton's theorems application

2. Turn on the supply and measure the voltage V_L. Using ammeter or from Ohm's law, calculate the current I_L. Insert the results in Table 2.

Determining R_{TH} / R_N:

3. Determine R_{TH} / R_N by replacing the voltage source with a short-circuit equivalent and measuring the resistance with ohmmeter between terminal x-y with R_L being removed as depicted in Figure 4.

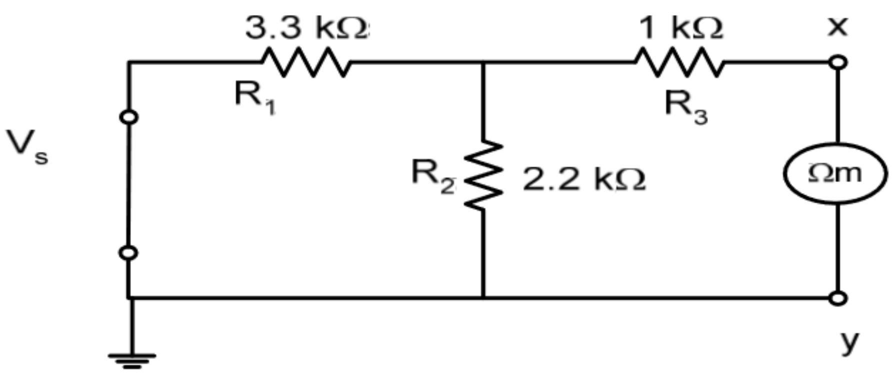


Fig. 4 Determining R_{TH} / R_N

Determining V_{TH}:

4. Determine V_{TH} by constructing the circuit of Figure 5 and measuring the open-circuit voltage between terminal x-y with voltmeter. Insert all results in Table 2.

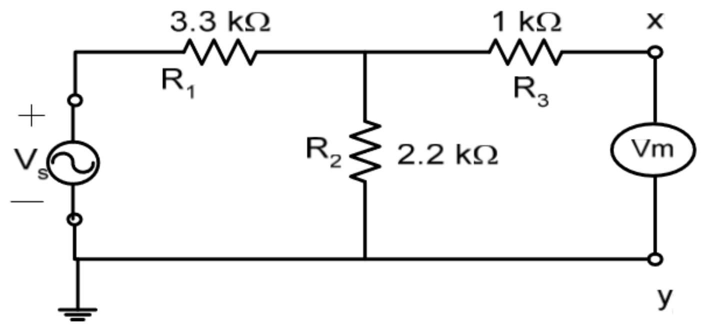


Fig. 5 Circuit connection for determining V_{TH}

Determining I_N:

5. Determine I_N by constructing the circuit depicted in Figure 6 and measuring the short circuit current between terminal x-y with ammeter. Insert the result in Table 2.

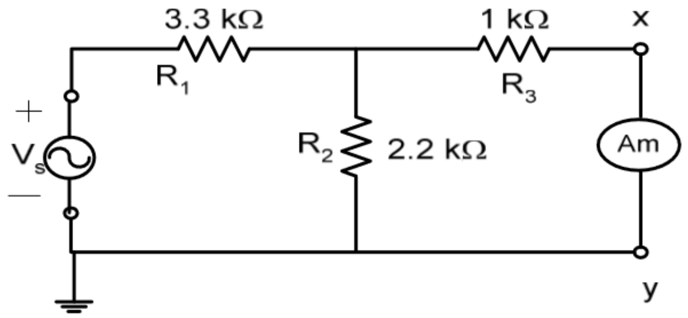


Fig. 6 Circuit connection for determining I_N

Thevenin Equivalent Circuit:

6. Construct the Thevenin equivalent circuit as depicted in Figure 7 using values obtained in parts 3 and 4 respectively. Use ohmmeter to set the potentiometer properly. Then measure the voltage V_L and I_L. Insert the values in Table 2.

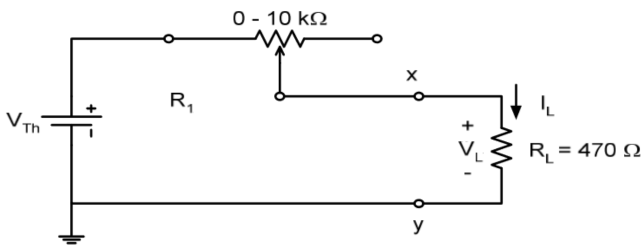


Fig. 7 Constructing Thevenin equivalent circuit

1.3.2 MAXIMUM POWER TRANSFER

1. Replace RL in Figure 3.3 with a 10-kΩ potentiometer without disturbing the previous position of the wiper arm. Measure the load voltage V_L across the potentiometer to check the conditions that at $R_L = R_{TH}$, the load voltage is half the amount of the Thevenin voltage. Record your observation in Table 3.

2. Leave the potentiometer as connected in Figure 8 and measure V_L for all values of R_L appearing in Table 4. Then calculate the resulting power to the load and complete the table. At the very least, remember to disconnect one side of the potentiometer when making the setting.

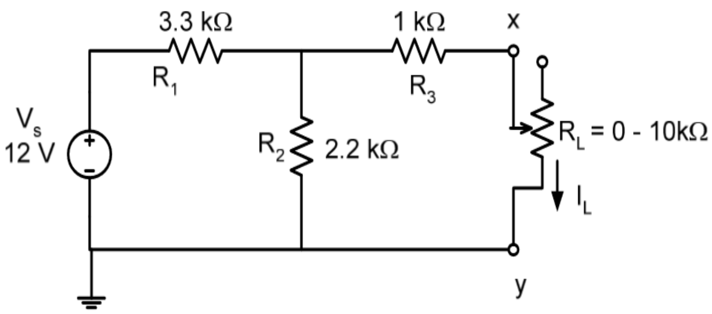


Fig. 8 the maximum power transfer testing circuit

RESULT

Resistor Designation	Measured Value (Ω)
R_1	
R_2	
R_3	
R_L	

Table 1: Measured resistors values.

Param.	Theoretical Result (PRE-LAB)	Experimental Result		Percentage Difference (%)	
		Original Circuit	Thevenin/ Norton Circuit	Original Circuit	Thevenin/ Norton
V_{Th} (V)					
R_{Th} / R_N (kΩ)					
I_N (mA)					
V_L(V)					
I_L (mA)					

Table 2: Thevenin and Norton electrical parameters, voltage and load current.

Load Voltage, V_L (Volt)	Load Resistance, R_L (Ohms)

Table 3: Conditions for maximum power transfer to the load.

R_L	V_L (measured) (Volt)	$P_L = V_L^2 / R_L$ (calculated) (miliWatt)
400 Ω		
800 Ω		
1.2 kΩ		
1.6 kΩ		
2 kΩ		
2.4 kΩ		
2.8 kΩ		
3.2 kΩ		

Table 4: Experimental results to re-confirm the conditions for maximum power transfer to the load.

1. Thevenin Equivalent Circuit:

After connecting the circuit in Figure 3.1, fill the below tables and answer the following questions:

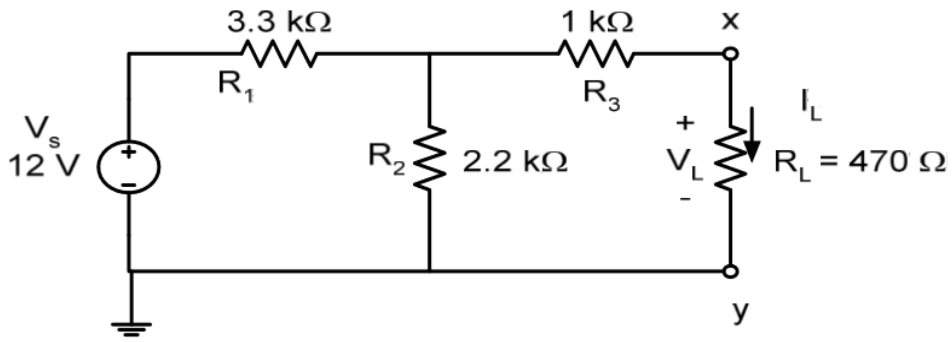


Figure 3.1 Circuit diagram for Thevenin's and Norton's theorems application

Q1. Indicate your employed resistors in Table 1 for the circuit diagram in Figure 3.1

RESULT

Resistor Designation	Measured Value (Ω)
R_1	
R_2	
R_3	
R_L	

Table 1: Measured resistors values.

Q2. Use the circuit analysis (KVL, KCL) to find V_l, I_l and accordingly fill Table 2

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Param.	Theoretical Result (PRE-LAB)	Experimental Result		Percentage Difference (%)	
		Original Circuit	Thevenin/ Norton Circuit	Original Circuit	Thevenin/ Norton
V_{Th} (V)					
R_{Th} / R_N (kΩ)					
I_N (mA)					
V_L(V)					
I_L (mA)					

Table 2: Thevenin and Norton electrical parameters, voltage and load current.

Q3. Explain the condition for the maximum power transfer and fill Table 3,4 to reconfirm experimentally that condition.

Load Voltage, V_L (Volt)	Load Resistance, R_L (Ohms)

Table 3: Conditions for maximum power transfer to the load.

R_L	V_L (measured) (Volt)	$P_L = V_L^2 / R_L$ (calculated) (miliWatt)
400 Ω		
800 Ω		
1.2 kΩ		
1.6 kΩ		
2 kΩ		
2.4 kΩ		
2.8 kΩ		
3.2 kΩ		

Table 4: Experimental results to re-confirm the conditions for maximum power transfer to the load.

2. Conclusion and Discussion:

List your conclusion about all parts of this experiment, and discuss the results as points:

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Objectives:

1. ……………………………………………………………………………………………
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2. ……………………………………………………………………………………………
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Q1. Draw the ideal and the practical circuit model for the inductors and capacitors, then explain briefly the reasons of the differences between ideal and piratical model.

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Q2. For the RL circuit shown in Figure 4.1, plot V_{in} and V_{out} at the same sit of axis. (Note: show only the shape of both signals without the nominal values of the voltages.) Also, calculate the time constant τ for the circuit.

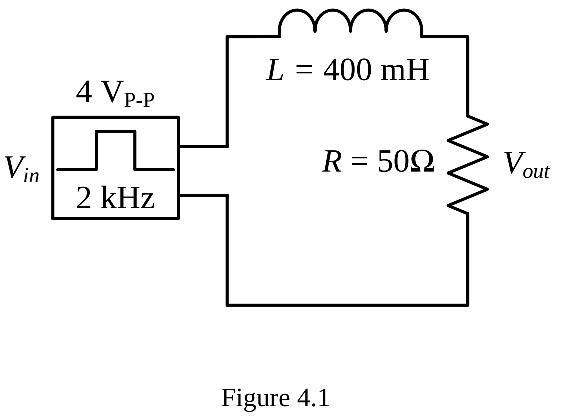

Figure 4.1

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Q3. For the RC circuit shown in Figure 4.2, plot V_{in} and V_{out} at the same sit of axis. (Note: show only the shape of both signals without the nominal values of the voltages.) Also, calculate the time constant τ for the circuit.

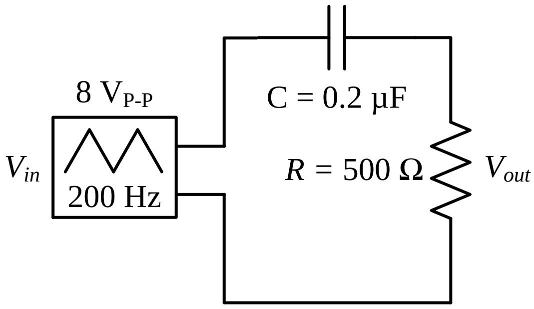

Figure 4.2

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Q4. Derive the below equation

$$\tau = \frac{t_2 - t_1}{\ln(y_f - y_1) - \ln(y_f - y_2)}$$

Note: start from the following formula:

$$y(t) = y_f - (y_f - y_i)e^{-t/\tau}$$

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Q5. Use the same equation of (Q4) to prove that about 63% of the change from y_1 to y_f occurs in one time constant.

4.1 Objectives:

1. Measurement verification of current-voltage (I-V) relations for inductance and capacitance.
2. Measurement verification of RL and RC circuit time constant.

4.2 Introduction:

4.2.1 Inductance and Capacitance Current- Voltage Relations:

Ideal inductors and capacitors can store energy, but their average power loss is zero. Practical components, however, lose a finite amount of energy. Therefore, in addition to inductance and capacitance, their electrical circuit models include resistance as shown in Figure 4.1.

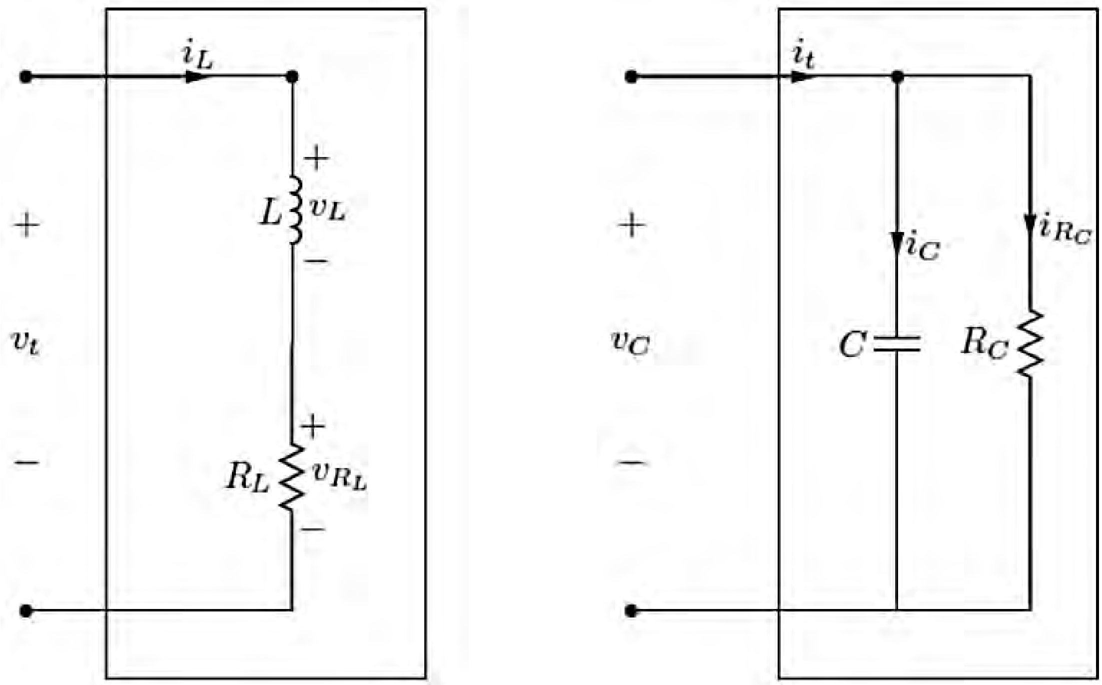


Figure 4.1 Circuit Models for Practical Inductors and Capacitors

From the figure,

$$v_t = v_L + v_{R_L} = L\frac{di_L}{dt} + R_L i_L \tag{1}$$

and

$$i_t = i_C + i_{R_C} = C\frac{dv_C}{dt} + (v_C/R_C) \tag{2}$$

For high quality components, R_L is relatively small and R_C is relatively large. Thus, if di_L/dt and dv_C/dt are large enough, then $v_{R_L} \ll v_L$ and $i_{R_C} \ll i_C$. Consequently,

$$v_t \approx v_L = L\, di_L/dt \tag{3}$$

and

$$i_t \approx i_C = C\, dv_C/dt \tag{4}$$

4.2.2 RL Circuits Transients:

A series RL circuit with a step input voltage is shown in Figure 4.2 (a). For an initial current $i_L(0) = I_0$, which may be positive or negative, the inductor current and voltage transient responses for t ≥ 0 are given by:

$$i_L(t) = \frac{V_m}{R} - \left(\frac{V_m}{R} - I_0\right) e^{-t/\tau} \tag{5}$$

and

$$v_L(t) = (V_m - RI_0)e^{-t/\tau} \tag{6}$$

where $\tau = L/R$ is the circuit time constant. Figures 4.2 (b) and 4.2 (c) depict the responses given by equations (5) and (6) with $V_m > 0$ and $I_0 < 0$.

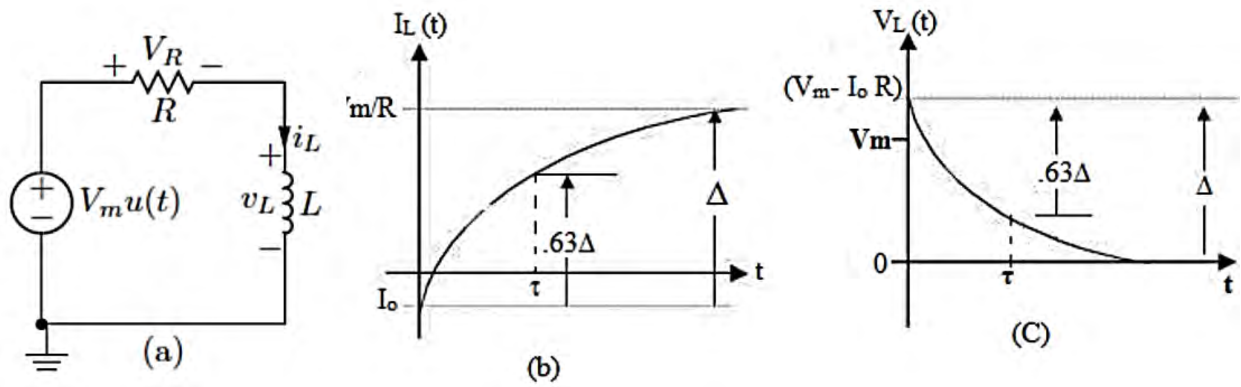


Figure 4.2 RL Circuit and Transient Responses

A basic feature of the exponential function having the general form

$$y(t) = y_f - (y_f - y_i)e^{-t/\tau} \tag{7}$$

where y_f is the final value of y and y_i is its initial value, is that τ can be calculated using any two points, y_1 and y_2, corresponding to t1 and t2, , respectively,

$$\tau = \frac{t_2 - t_1}{\ln(y_f - y_1) - \ln(y_f - y_2)} \tag{8}$$

It is noted that $y_f \approx y(t \geq 5\tau)$. For the special case where $(t_2 - t_1) = \tau$, equation (8) yields:

$$y_2 - y_1 = (1 - e^{-1})(y_f - y_1) = 0.0632(y_f - y_1) \tag{9}$$

That is, about 63% of the change from y_1 to y_f occurs in one time constant. Likewise, one can show that 99.3% of this change occurs in five time constants.

4.2.3 RC Circuits Transients:

Similarly, for the RC circuit shown in Figure 4.3 (a), the transient responses $v_C(t)$ and $i_C(t)$ are shown in Figures 4.3 (b) and 4.3 (c) for an initial capacitor voltage $V_C(0) = V_0 < 0$.

The applicable equations for this case are:

$$v_C(t) = V_m - (V_m - V_0)e^{-t/\tau} \tag{10}$$

$$i_C(t) = ((V_m - V_0)/R)e^{-t/\tau} \tag{11}$$

where $\tau = RC$ is the circuit time constant.

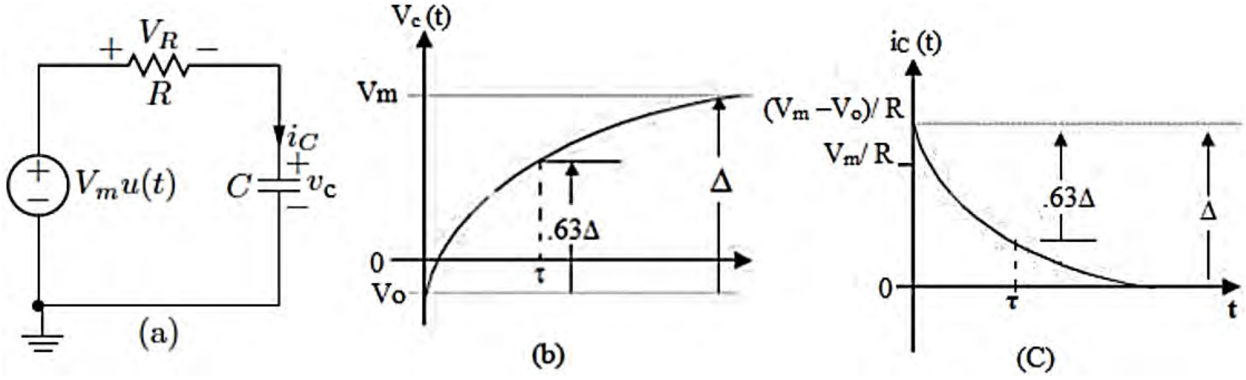


Figure 4.3 RC Circuit and Transient Responses

<u>4.3 Procedure:</u>

<u>*4.3.1 Inductor Test:*</u>

1. Obtain a 400-mH inductor and use DMM to measure the DC resistance R_L.
2. Construct the circuit shown in Figure 4.4, where V_s is 4 V_{p-p} square wave with 2 kHz frequency, and R_s = 47 Ω.

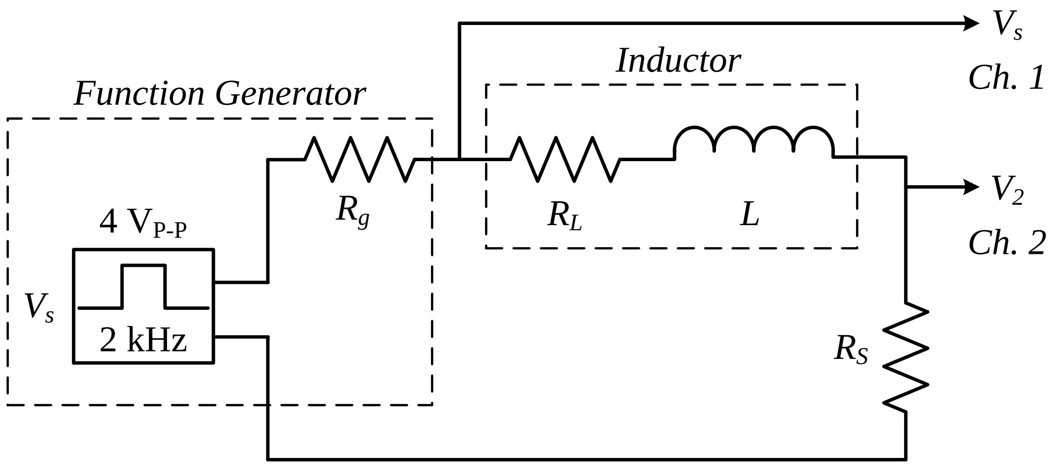


Figure 4.4

3. Display the Function Generator output voltage V_S on *Ch. 1* of the oscilloscope, and V_2 across R_s on *Ch. 2* of the oscilloscope.
4. Make an accurate sketch of both signals showing values of time and amplitude.

R_L =	R_s = 47 Ω	L = 400 mH
Period of I/P Signal $V_s(t)$	T = (1 / F) =	

Ch. 1 of the Oscilloscope	$V_S(t)$

Ch. 2 of the Oscilloscope	*V_2 (t)*

4.3.2 Capacitor Test:

1. Obtain a 0.02-µF capacitor and use DMM to measure the DC resistance R_C = __________.
2. Construct the circuit shown in Figure 4.5, where V_s is 8 V_{p-p} triangular wave with 200 Hz frequency, and R_s = 500 Ω.

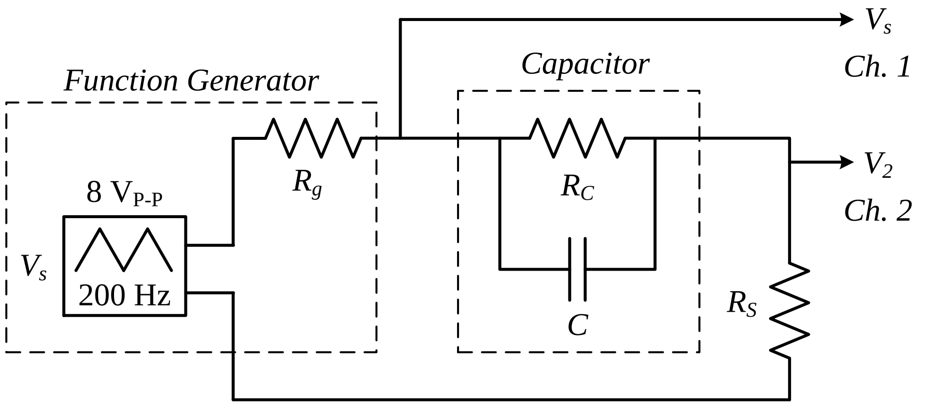


Figure 4.5

3. Display the Function Generator output voltage V_S on *Ch. 1* of the oscilloscope, and V_2 across R_s on *Ch. 2* of the oscilloscope. (Use DC coupling on both Scope channels.)
4. Make an accurate sketch of both signals showing values of time and amplitude.

Ch. 1 of the Oscilloscope	*V_S (t)*
Ch. 2 of the Oscilloscope	*V_2 (t)*

4.3.3 RL-Circuit Transient Tests:

1. Construct the RL circuit shown in Figure 4.6 with R = 1 kΩ and L = 1000 mH.

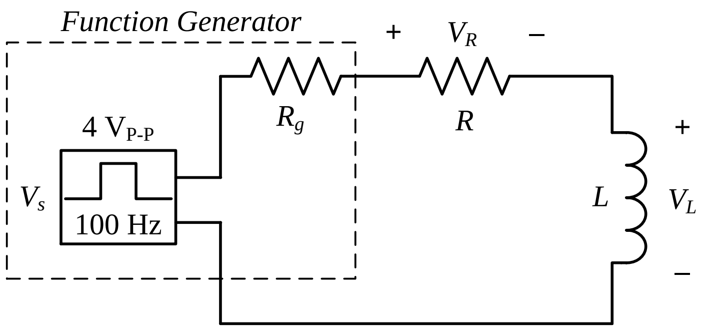


Figure 4.6

2. Use the DMM to measure the DC resistance of the inductor and the actual value of R.

R_g	R_L	$R_{measured}$	$\tau = L / (R_g + R_L + R)$	T / 2
50 Ω				

3. Use a 100-Hz symmetrical square wave from the Function Generator, with V_S = 4 Vp-p.
4. Connect the Oscilloscope to measure $V_L(t)$. (See Figure 4.2.)
5. Make an accurate sketch of $V_L(t)$, and then expand the time scale to make an accurate measurement of τ using the 63% change Criterion.

$V_L(t)$	
Record the Measured Value of τ	……………………………………………..

6. Measure τ using two-point method:

t_1	y_1	t_2	y_2	y_f	τ

7. Exchange the positions of R and L in the circuit to enable the display of V_R by using a common ground between the scope and Function Generator, then sketch V_R.

$V_R(t)$	

4.3.4 RC-Circuit Transient Tests:

1. Construct the RC circuit shown in Figure 4.7 with R = 100 kΩ and C = 10 nF.

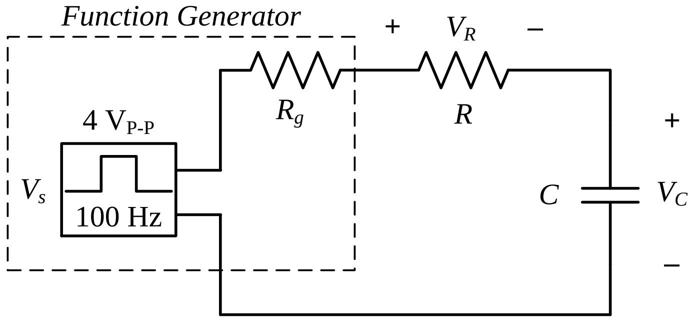


Figure 4.7

2. Use the DMM to measure the DC resistance of the capacitor and the actual value of R.

R_g	R_C	$R_{measured}$	$\tau = C \times (R_g + R)$	T / 2
50 Ω				

3. Use a 100-Hz symmetrical square wave from the Function Generator, with V_S = 4 Vp-p.
4. Connect the Oscilloscope to measure V_C *(t)*. (See Figure 4.3.)
5. Make an accurate sketch of V_C *(t)*, and then expand the time scale to make an accurate measurement of τ using the 63% change Criterion.

V_C *(t)*	
Record the Measured Value of τ	………………………………………………..

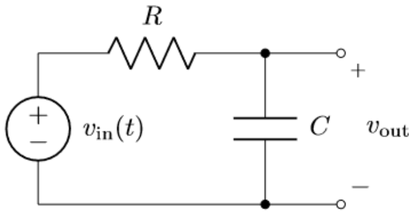
6. Measure τ using two-point method:

t_1	y_1	t_2	y_2	y_f	τ

7. Exchange the positions of R and C in the circuit to enable the display of V_R by using a common ground between the scope and Function Generator, then sketch V_R.

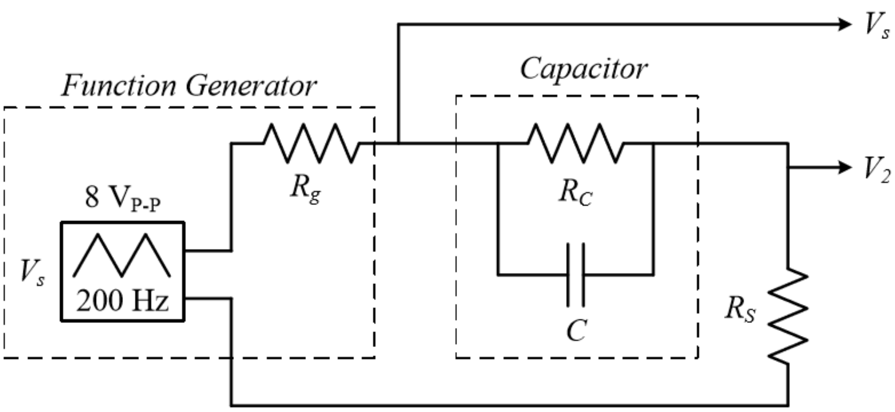
V_R *(t)*	

Q1) Consider the following circuit, whose voltage source provides $v_{in}(t)$= 0 for t < 0, and $v_{in}(t)$ = 10V for t ≥ 0. Write and draw the equation of $v_{out}(t)$

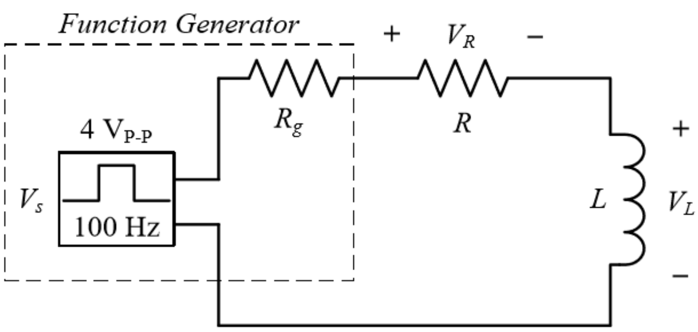


Q2) for the previous circuit, consider R = 100 kΩ and C = 10 nF with $v_{in}(t)$ = 4 Vp-p square wave. Sketch observed pattern of $V_C(t)$ and $V_R(t)$ produced by the RC circuit on top of the Square waveform $v_{in}(t)$. Calculate the error percentage between the measured and calculated time constant.

Q3) for the following circuit, Sketch observed pattern of V_2 produced by the RC circuit on top of the triangle waveform V_s



Q4) for the following RL circuit with R = 1 kΩ and L = 1000 mH, Calculate the error percentage between the measured and calculated time constant. Make an accurate sketch of $V_L(t)$ on top of the Square waveform $v_s(t)$.



Q5) List your conclusion about all parts of this experiment and discuss the results as points.

Answers

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Objectives:

1.
2.
3.

Q1: Derive the transient current and voltage responses for the following circuits to an input step, from -5 to +5 Volts. Then, determine α and ω_0. Calculate the roots of the characteristic equation, $s_{1,2}$ and determine $v_C(0)$, and $v_C(\infty)$, and $\frac{dv_C(0)}{dt}$.

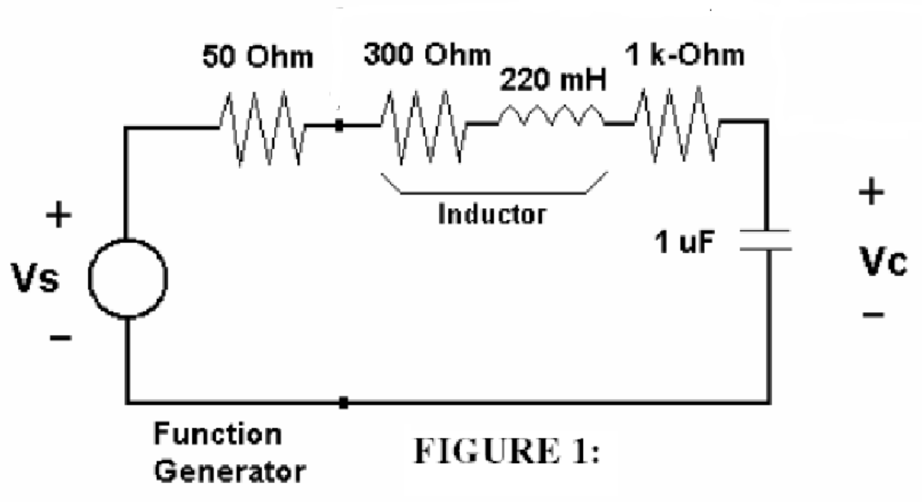


FIGURE 1:

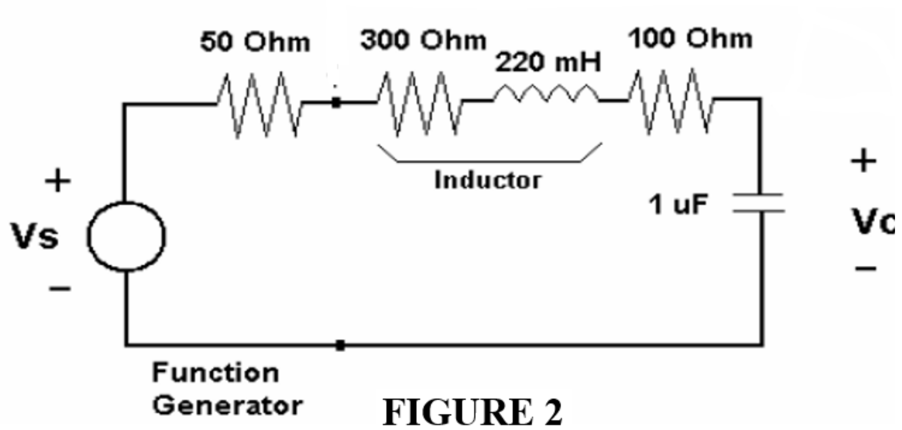


FIGURE 2

5.1 Objectives:

The purpose of this experiment was to observe and measure the transient response of RLC circuits to external voltages.

5.2 Introduction:

5.2.1 Series RLC Circuit Transients:

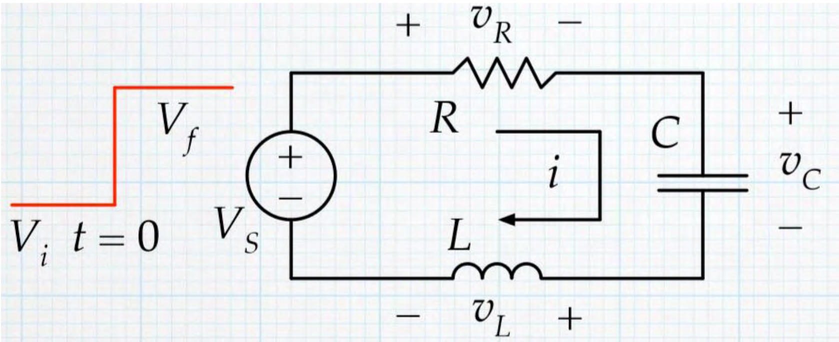


Fig. 5.1 Series RLC circuit

A series RLC circuit is shown in Fig. 5.1. Hence, the governing Equation is $V_s = v_R + v_C + v_L$. Assume a Voltage source makes an abrupt change from V_i to V_f at t = 0. We can conclude the following

t < 0:	$i = 0.$	t >> τ:	$i = 0.$
	$v_R = 0.$		$v_R = 0.$
	$v_L = 0.$		$v_L = 0.$
	$v_C = V_i.$		$v_C = V_f.$

Hence, the question will be: ***What is τ? What happens in between?***

At $t > 0$ $V_f = iR + v_C + L\frac{di}{dt}$, $i = c\frac{dv_C}{dt}$, then we get

$$\frac{d^2 v_C}{dt^2} + \frac{R}{L}\frac{dv_C}{dt} + \frac{v_C}{LC} = \frac{V_f}{LC} \tag{5.1}$$

Eqn. (5.1) is second-order differential equation which have a particular solution (Transient) and a homogenous solution (Steady state). Hence, the solution can be expressed as

$$v_C = v_{tr} + v_{ss}, \quad where \quad v_{ss} = V_f \quad (easy!) \tag{5.2}$$

Now we must find the transient part (homogenous)

$$\frac{d^2 v_{tr}}{dt^t} + \frac{R}{L}\frac{dv_{tr}}{dt} + \frac{v_{tr}}{LC} = 0 \tag{5.3}$$

Assume $v_{tr} = Ae^{st}$, then Eqn. (5.3) can be turned, in S domain, into

$$s^2(A\,e^{st}) + \frac{R}{L}s\,(Ae^{st}) + \frac{1}{LC}\ \ (Ae^{st}) = 0 \tag{5.4}$$

$$\left(s^2 + \frac{R}{L}s + \frac{1}{LC}\right)(A\,e^{st}) = 0 \tag{5.5}$$

$$A\,e^{st} \neq 0, \quad so \ \left(s^2 + \frac{R}{L}s + \frac{1}{LC}\right) = 0$$

$$s = -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}} \tag{5.6}$$

$$s_1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}\ ,\ s_2 = -\frac{R}{2L} - \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}} \tag{5.7}$$

Hence, the transient solution can be expressed as

$$v_{tr} = A\,e^{s_1 t} + B\,e^{s_2 t} \tag{5.8}$$

Accordingly, the final total solution can be expressed as

$$v_C(t) = A\,e^{s_1 t} + B\,e^{s_2 t} + V_f \tag{5.9}$$

Hence, we can conclude that the transient behavior depends on the values of s_1 and s_2. Rename things slightly, $\frac{R}{2L} = \alpha, \frac{1}{LC} = \omega_\circ^2$, then

$$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_\circ^2},\ \ s_2 = \ -\alpha - \sqrt{\alpha^2 - \omega_\circ^2} \tag{5.10}$$

Where α is the damping factor and $\omega_\circ$ is the resonant frequency.

There are three distinct types of solutions depending on whether $\alpha^2 - \omega_\circ^2$ is positive, negative or zero.

1) ***<u>The underdamped case</u>***

If $\omega_\circ > \alpha$ ($\frac{1}{\sqrt{LC}} > \frac{R}{2L}$), the two roots s_1 and s_2, given by Eqn. (5.10), are complex conjugate, so the roots can be expressed as

$$s_1 = -\alpha + j\sqrt{\omega_\circ^2 - \alpha^2} = -\alpha + j\omega_d, \; s_2 = -\alpha - j\sqrt{\omega_\circ^2 - \alpha^2} = -\alpha - j\omega_d \quad (5.11)$$

where $\omega_d = \sqrt{\omega_\circ^2 - \alpha^2}$ is the damped frequency. By substituting in Eqn. (5.9),

$$v_C(t) = Ae^{-\alpha t}\, e^{j\omega_d t} + B\, e^{-\alpha t} e^{-j\omega_d t} + V_f \quad (5.12)$$

$$v_C(t) = e^{-\alpha t}\,[(A+B)\cos\omega_d t + j(A-B)\sin\omega_d t] + V_f \quad (5.13)$$

Using the initial condition of $v_c(0) = v_{c_0} = V_i, \left.\frac{dv_C}{dt}\right|_{t=0} = 0$, Eqn. (5.13) is turned into

$$v_C(t) = (V_i - V_f)e^{-\alpha t}\left[\cos\omega_d t + \frac{\alpha}{\omega_d}\sin\omega_d t\right] + V_f \quad (5.14)$$

There is an oscillation in the response, i.e. it is an exponentially decaying sinusoidal. The voltage changes from V_i to V_f, but wiggles back and forth a few times in the process. The oscillation dies out according to the damping factor over about 5 time constants, where the time constant $\tau = 1/\alpha$. See Fig. 5.2; it shows the Under-damped response $v_C(t)$ at V_i = 5 V, V_f = 20 V, R = 300 Ω, L = 25 mH, and C = 60 nF.

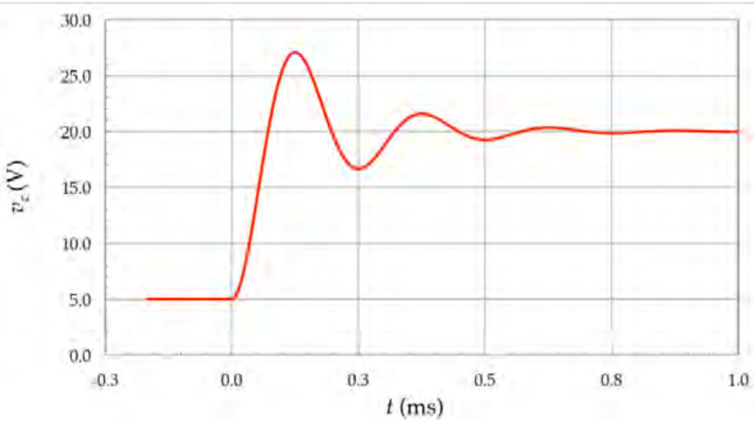


Fig. 5.2 the Under-damped voltage response OF series RLC circuit

For the under-damped current response, apply the equation: $i(t) = C\frac{dv_C(t)}{dt}$. Hence, $i(t)$ is expressed as

$$i(t) = \frac{V_f - V_i}{L\,\omega_d}\, e^{-\alpha t}\sin\omega_d t \quad (5.15)$$

As indicated, in Fig. 5.3, is the amplitude of the exponential envelope, $\pm\frac{V_f - V_i}{L\,\omega_d}\, e^{-\alpha t}$. It is clear form Eqn. (5.15) that the zero crossings of $i(t)$ occur at multiples of T/ 2, where $T = 2\pi/\omega_d$ is the period of oscillation. Thus, ω_d, may be found from a measurement of the period T, i.e., $\omega_d = 2\pi/T$

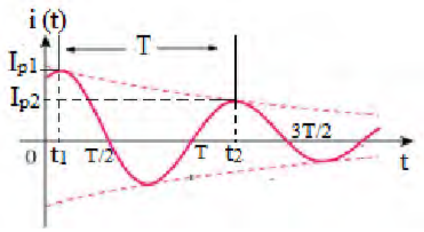


Fig. 5.3 the under-damped current response of series RLC circuit

For small damping , i.e., $\alpha \ << \ \omega_\circ$, the exponential envelope in Fig. 5.3 is tangent to the $i(t)$ curve near the extremum points, which are also separated by T /2. Thus, α may be calculated from peak-current measurements using the relation

$$\alpha = \frac{1}{T} \ln \frac{I_{p_1}}{I_{p_2}} \tag{5.16}$$

2) ***The Critically-Damped Case***

If $\omega_\circ = \alpha$, the two roots s_1 and s_2, given by Eqn. (5.10), are real and equal, so the roots can be expressed as $s_1 = s_1 = -\alpha$. By substituting in Eqn. (5.9),

$$v_C(t) = Ae^{-\alpha t} + B\, e^{-\alpha t} + V_f = Ke^{-\alpha t} + V_f \tag{5.17}$$

This causes a bit of a problem, because we are left with only one term in the general solution, and hence only one coefficient – not enough to satisfy the initial conditions.

This suggests that there must be another solution lurking around in the math. In the special circumstances for the critically damped case, the homogeneous equation can be written as

$$\frac{d^2 v_{tr}}{dt^t} + \frac{R}{L}\frac{dv_{tr}}{dt} + \frac{v_{tr}}{LC} = \frac{d^2 v_{tr}}{dt^t} + 2\alpha \frac{dv_{tr}}{dt} + \alpha^2 v_{tr} = 0 \tag{5.18}$$

To be reformulated to

$$\frac{d}{dt}\left[\frac{dv_{tr}}{dt} + \alpha v_{tr}\right] + \alpha \left[\frac{dv_{tr}}{dt} + \alpha v_{tr}\right] = 0 \tag{5.19}$$

$$\frac{dy}{dt} + \alpha y = 0, \quad \text{where} \;\; y = \frac{dv_{tr}}{dt} + \alpha v_{tr}$$

Then,

$$y = A\, e^{-\alpha t} \;\; \rightarrow A\, e^{-\alpha t} = \frac{dv_{tr}}{dt} + \alpha v_{tr} \tag{5.20}$$

$$A = e^{\alpha t}\frac{dv_{tr}}{dt} + \alpha v_{tr}\, e^{\alpha t} = \frac{d}{dt}\left(v_{tr}\, e^{\alpha t}\right) \tag{5.21}$$

$$At + B = v_{tr}\, e^{\alpha t} \tag{5.22}$$

Hence,

$$v_{tr}(t) = (At + B)e^{-\alpha t} \tag{5.23}$$

Now there are two constants and accordingly, by substituting in Eqn. (5.2),

$$v_C(t) = (At + B)e^{-\alpha t} + V_f \tag{5.24}$$

Using the initial condition of $v_c(0) = v_{c_0} = V_i,\ \left.\frac{dv_C}{dt}\right|_{t=0} = 0$, Eqn. (5.24) is turned into

$$v_C(t) = \left(V_i - V_f\right)(1 + \alpha t)e^{-\alpha t} + V_f \tag{5.25}$$

See Fig. 5.4; it shows the critical case response $v_C(t)$ at V_i = 5 V, V_f = 20 V, R = 1KΩ, L = 15 mH, and C = 60 nF

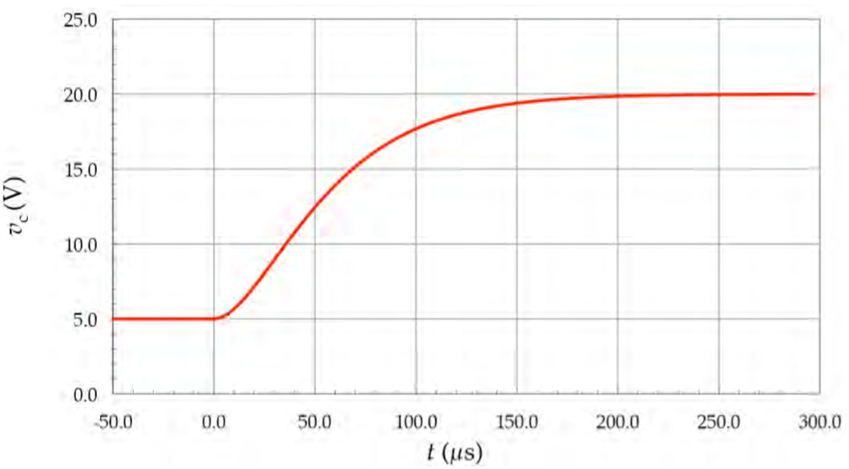


Fig. 5.4 Critically-damped response $v_C(t)$ of series RLC circuit

For the Critically-damped current response, apply the equation: $i(t) = C\frac{dv_C(t)}{dt}$. Hence, $i(t)$ is expressed as

$$i(t) = \frac{V_f - V_i}{L}\, t\, e^{-\alpha t} \tag{5.26}$$

As indicated, in Fig. 5.5, The maximum value of this current occurs at $t_m = \frac{1}{\alpha}$, and equals to $I_m = 2\frac{V_f - V_i}{R}\, e^{-1}$. For calculating α from experimental data, it is expressed as

$$\alpha = \frac{\ln t_2/t_1}{t_2 - t_1} \tag{5.27}$$

where t_1 and t_2 are any two points with $i(t_1) = i(t_2) = I_{12}$.

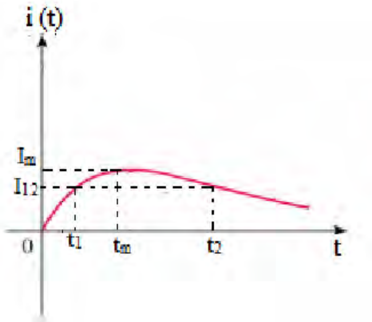


Fig. 5.5 the Critically-damped current response

<u>Note:</u> This case almost never happens. It will be the wildest fluke if the components have exactly the correct ratios to meet the above requirement. For the most part, critical damping is only of academic interest.

3) <u>The Over-Damped Case</u>

If $\omega_\circ < \alpha$, the two roots s_1 and s_2 , given by Eqn. (5.10), are real and unequal, so the roots can be expressed as indicated in Eqn. (5.7)

Using the initial condition of $v_c(0) = v_{c_0} = V_i$, $\left.\frac{dv_C}{dt}\right|_{t=0} = 0$, Eqn. (5.9) is turned into

$$v_C(t) = \left(V_i - V_f\right)\left[\frac{e^{s_1 t}}{1-\frac{s_1}{s_2}} + \frac{e^{s_2 t}}{1-\frac{s_2}{s_1}}\right] + V_f \qquad (5.28)$$

See Fig. 5.6. it shows the over-damped response $v_C(t)$ at V_i = 5 V, V_f = 20 V, R = 1KΩ, L = 15 mH, and C = 0.5 μF. It is the Same as critical case plot of slide 10, except C is larger.

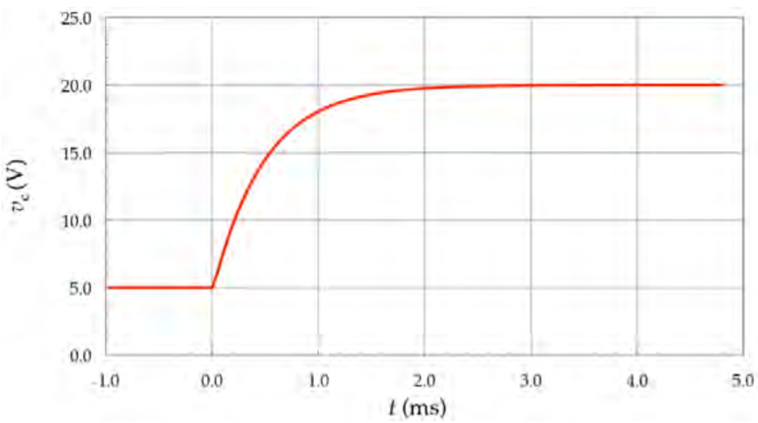


Fig. 5.6 over-damped response $v_C(t)$ of series RLC circuit.

For the over-damped current response, apply the equation: $i(t) = C\frac{dv_C(t)}{dt}$. Hence, $i(t)$ is expressed as

$$i(t) = \frac{V_f - V_i}{2L} \frac{1}{\sqrt{\alpha^2 - \omega_\circ^2}} \left(e^{\left(-\alpha + \sqrt{\alpha^2 - \omega_\circ^2}\right)t} - e^{\left(-\alpha - \sqrt{\alpha^2 - \omega_\circ^2}\right)t} \right) \qquad (5.29)$$

As indicated, in Fig. 5.7, the current response in this case is an exponential pulse However, it settles toward its final value more slowly than the critically damped response, and is said to be overdamped.

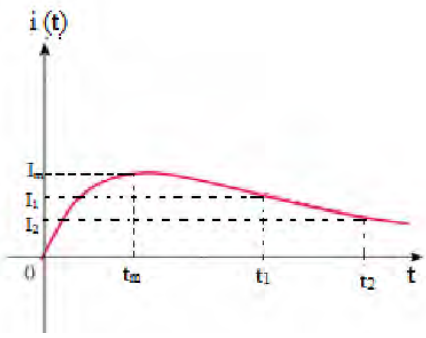


Fig. 5.7 over-damped current response $i(t)$ of series RLC circuit.

5.2.2 Parallel RLC circuit:

A parallel RLC circuit with a current source is the dual of a series RLC circuit with a voltage source, see Fig.5.8. Therefore, all the formulas given previously apply to the parallel circuit provided we replace R with 1 /R, L with C, and C with L.

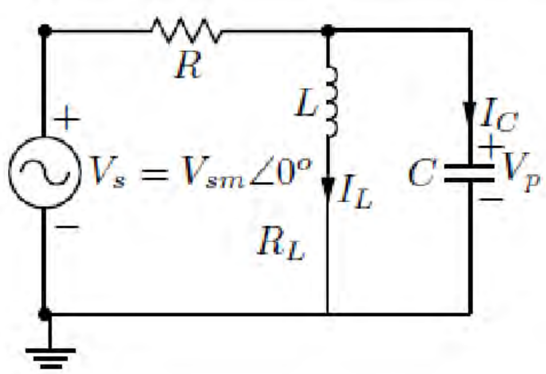


Fig. 5.8 Parallel RLC circuit

5.3 Procedure:

5.3.1 Overdamped case

1. Build the circuit shown in Fig 5.1. use the following R=25KΩ, L=500 mH, C=10 nF, and a square wave input with 4Vp-p (with a peak-to-peak amplitude of -2 to + 2 volts) at 100Hz frequency (If needed, you can change the frequency in order to get clear oscilloscope traces in the following measurements). Then fill Table 1.

5.3.2 Underdamped case

1. similarly, build the circuit shown in Fig 5.1. just replace the resistance in the previous case with R=1.5KΩ. Fill Table 2 which is about the voltage transient response of capacitor.

2. Suppose we want to find the voltage transient response of the 1.5KΩ resistor. The simplest way to solve for the resistor voltage transient is to find the transient circuit current and multiply by the resistor's resistance. Since we are analyzing a series circuit, we will find the transient inductor current and multiply by 1.5KΩ. Accordingly, Fill Table 3 which is about the voltage transient response of the resistor.

5.3.3 Critically-damped case

1. use a 50-kΩ potentiometer for R. Observe the capacitor voltage together with the source voltage on the oscilloscope. Note how you can make the circuit switch back and forth between underdamped and over-damped behavior by adjusting the value of the pot.

2. Display $v_R(t)$ on Oscilloscope, Increase R Gradually until the oscillation just disappears. Then, fill Table 4.

Table 1: Overdamped RLC Circuit

<table>
<tr><th>Quantity</th><th>Calculated Value</th><th colspan="2">Measured, Simulated Value(s)</th></tr>
<tr><td>α</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>ω_0</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>Type of Damping</td><td></td><td colspan="2"></td></tr>
<tr><td>$S_{1,2}$</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>$v_c(0^+)$</td><td></td><td></td><td></td></tr>
<tr><td>$v_c(\infty)$</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">$v_c(t) = v_c(\infty) + A_1 e^{s_1 t} + A_2 e^{s_2 t}$</td></tr>
<tr><td colspan="4">$v_c(0^+) =$

$A_1 + A_2 =$</td></tr>
<tr><td colspan="4">$\frac{dv_c(t)}{dt} = s_1 A_1 e^{s_1 t} + s_2 A_2 e^{s_2 t}$</td></tr>
<tr><td colspan="4">$dv_c(0^+)/dt =$

$A_1 =$ $A_2 =$</td></tr>
<tr><td>$v_c(t)$</td><td colspan="3"></td></tr>
<tr><td>$v_c(0.5\text{ mS})$</td><td></td><td></td><td></td></tr>
<tr><td>$v_c(1\text{ mS})$</td><td></td><td></td><td></td></tr>
<tr><td>$v_c(2\text{ mS})$</td><td></td><td></td><td></td></tr>
</table>

Table 2: Underdamped RLC Circuit

<table>
<tr><th>Quantity</th><th>Calculated Value</th><th colspan="2">Measured, Simulated Value(s)</th></tr>
<tr><td>α</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>ω_0</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>Type of Damping</td><td></td><td colspan="2"></td></tr>
<tr><td>$S_{1,2}$</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>ω_d</td><td></td><td colspan="2">N/A</td></tr>
<tr><td>$v_c(0^+)$</td><td></td><td></td><td></td></tr>
<tr><td>$v_c(\infty)$</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">$v_c(t) = v_c(\infty) + (B_1 \cos \omega_d t + B_2 \sin \omega_d t)e^{-\alpha t}$</td></tr>
<tr><td colspan="4">$v_c(0^+)$ =

B_1 =</td></tr>
<tr><td colspan="4">$\frac{dv_c(t)}{dt} = (B_1 \cos \omega_d t + B_2 \sin \omega_d t)(-\alpha e^{-\alpha t})$
$+ (\omega_d B_1 \sin \omega_d t + \omega_d B_2 \cos \omega_d t)e^{-\alpha t}$</td></tr>
<tr><td colspan="4">$dv_c(0^+)/dt$ =

B_1 = B_2 =</td></tr>
<tr><td>$v_c(t)$</td><td colspan="3"></td></tr>
<tr><td>$v_c(0.5\ mS)$</td><td></td><td></td><td></td></tr>
<tr><td>$v_c(1\ mS)$</td><td></td><td></td><td></td></tr>
<tr><td>$v_c(2\ mS)$</td><td></td><td></td><td></td></tr>
</table>

Table 3: Underdamped RLC Circuit, Resistor Voltage

<table>
<tr><th>Quantity</th><th colspan="2">Calculated Value(s)</th><th colspan="2">Measured, Simulated Value(s)</th></tr>
<tr><td>α, ω_0</td><td></td><td></td><td colspan="2">N/A</td></tr>
<tr><td>Type of Damping</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>$S_{1,2}$</td><td colspan="2"></td><td colspan="2">N/A</td></tr>
<tr><td>ω_d</td><td colspan="2"></td><td colspan="2">N/A</td></tr>
<tr><td>$v_R(0^+)$</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>$v_R(\infty)$</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="5">$i_L(t) = i_R(t) = i_L(\infty) + (C_1 \cos \omega_d t + C_2 \sin \omega_d t)e^{-\alpha t}$</td></tr>
<tr><td colspan="5">$i_L(0)$ =

C_1 =</td></tr>
<tr><td colspan="5">$$\frac{di_L(0^+)}{dt} = \frac{v_L(0^+)}{L} = (C_1 \cos 0 + C_2 \sin 0)(-\alpha e^0) + (\omega_d C_1 \sin 0 + \omega_d C_2 \cos 0)e^0$$</td></tr>
<tr><td colspan="5">$\frac{v_L(0^+)}{L} =$

C_1 = C_2 =</td></tr>
<tr><td>$v_R(t)$</td><td colspan="4"></td></tr>
<tr><td>$v_R(0.5\ \text{mS})$</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>$v_R(1\ \text{mS})$</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>$v_R(2\ \text{mS})$</td><td colspan="2"></td><td></td><td></td></tr>
</table>

Table 4 Critically-damped RLC circuit

Quantity	Calculated Value	Measured, Simulated Value(s)	
α		N/A	
ω_0		N/A	
Type of Damping			
$S_{1,2}$		N/A	
ω_d		N/A	
$v_c(0^+)$			
$v_c(\infty)$			

التجربة السادسة

Course Contents

Experiment-0: Overview of laboratory equipment's (Digital Multimeters, Function Generators, Oscilloscope)

Experiment-1: Passive Elements.

Experiment-2: Transient Circuits.

Experiment-3: Nonlinear Resistances.

Experiment-4: Passive Filters.

Experiment-5: Resonant Circuits.

Experiment-6: Circuit Theorems.

Experiment-7: Diodes and Applications.

Experiment-8: Special Diodes.

Experiment-9: Bipolar Junction Transistors.

Experiment-10: Logic Gates.

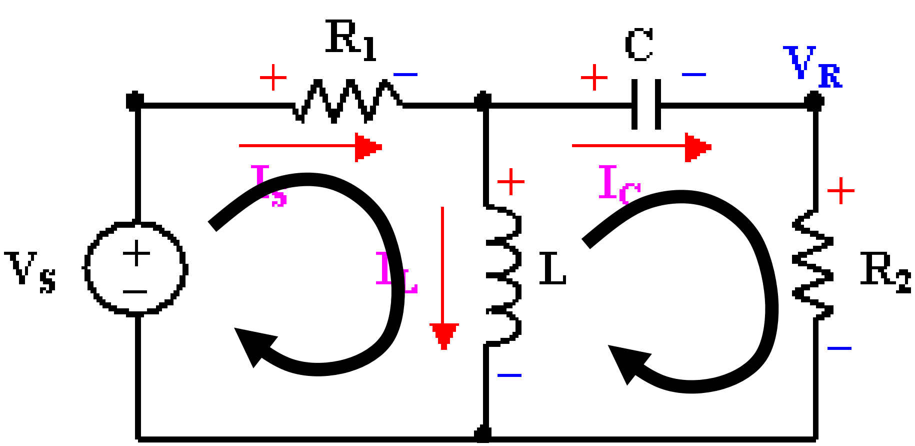
Experiment-11: Power Supplies.

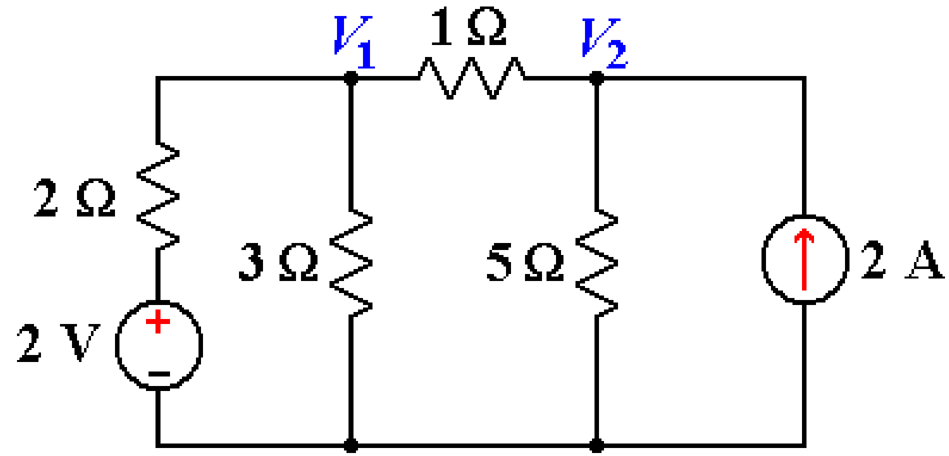
Experiement-4 Objectives

- To verify the linear circuits theorems: Thévenin’s and Norton Theorems, Maximum power transfer, and Superposition.
- Demonstrate the usefulness of the Thévenin’s and Norton theorems to simplify electrical circuits to one that contains three components: a power source, equivalent resistor, and load.

Introduction

- Circuit Analysis Techniques usually employs either mesh (loop, KVL) method or nodal (KCL) method.

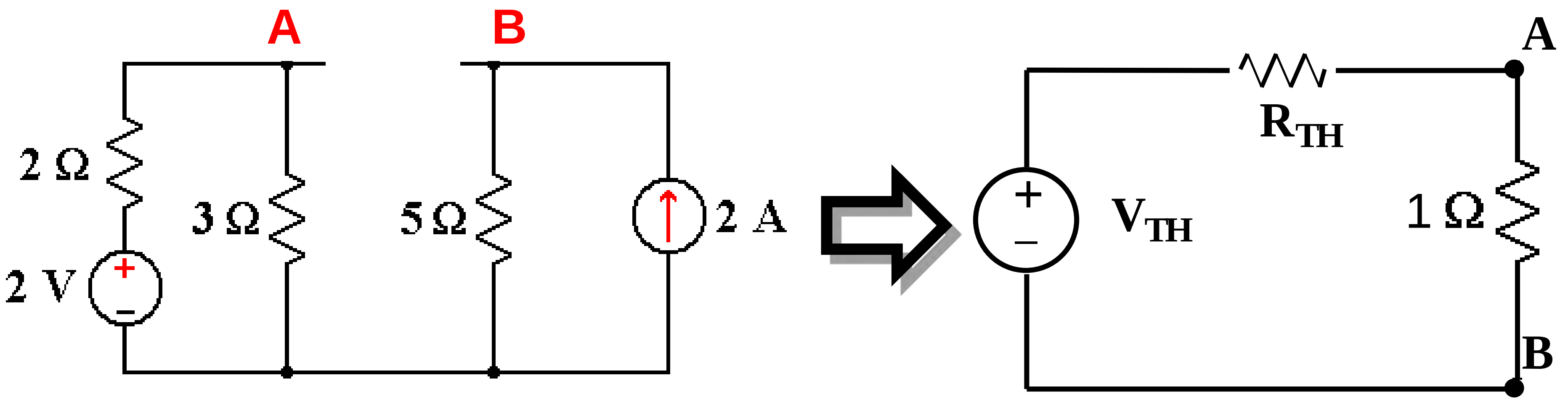




- However, circuits can be **simplified** using some useful theorems, which in turns **facilitates** the analysis.
- Two important simplification techniques are the:
  - Thevenin's Equivalent.
  - Norton's Equivalent.

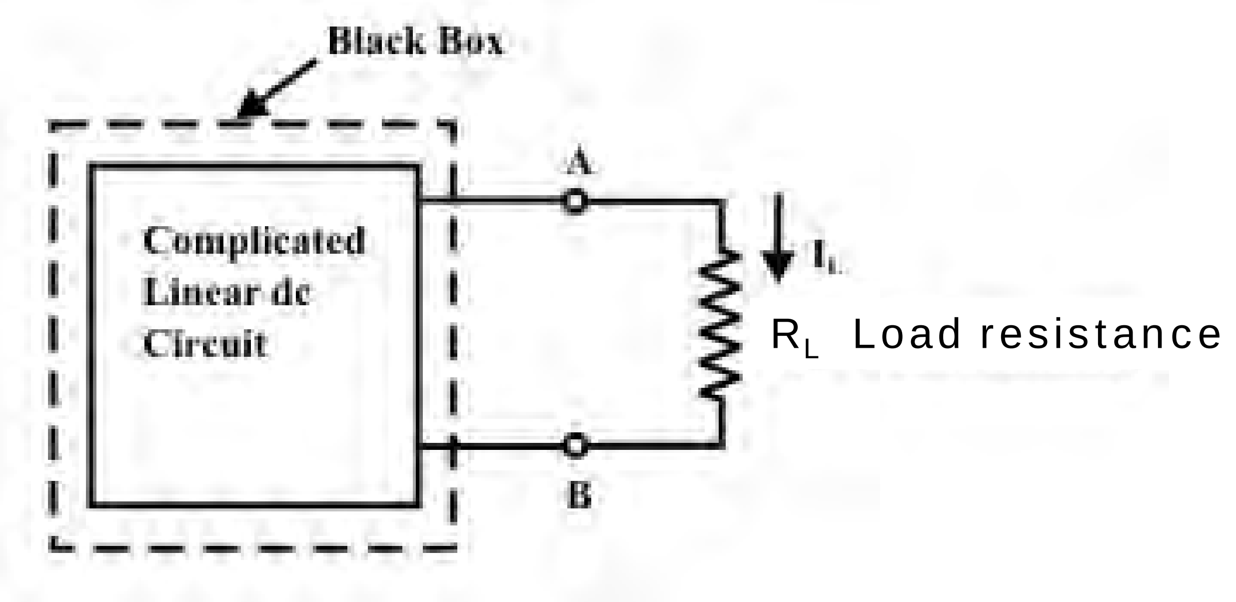
Thévenin's Theorem

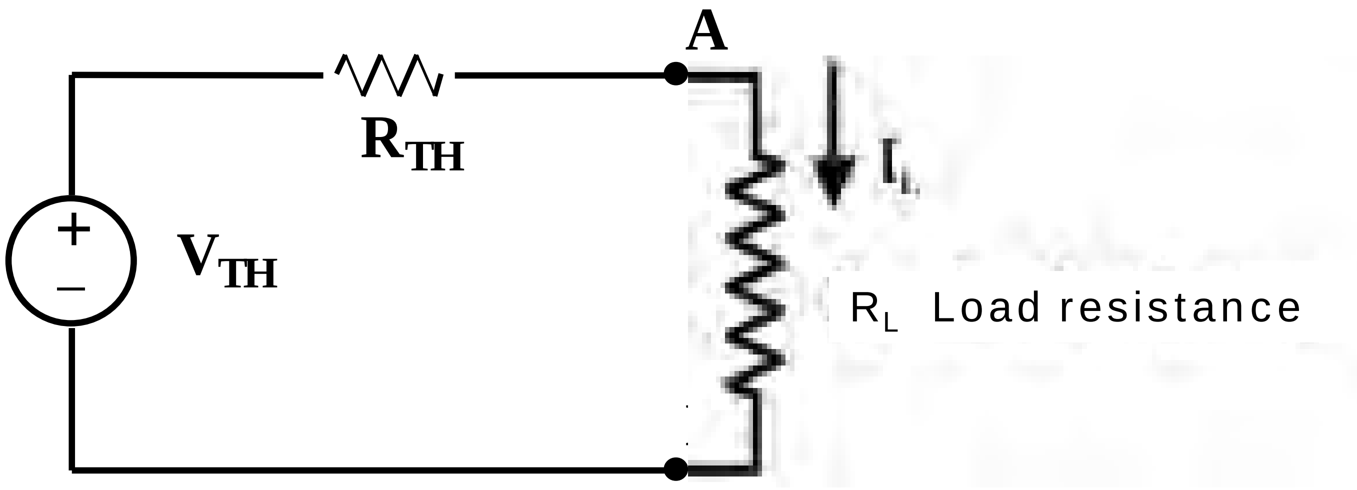
- The theorem was first discovered by German scientist Hermann von Helmholtz in 1853, but was then rediscovered in 1883 by French telegraph engineer Léon Charles Thévenin (1857-1926).
- Thévenin's theorem states that: ***any combination of voltage sources and resistors with two terminals is electrically equivalent to a single voltage source V and a single series resistor R***.



- For single frequency AC systems the theorem can also be applied to general impedances, **not just resistors**.

Thévenin's Theorem: cont'd



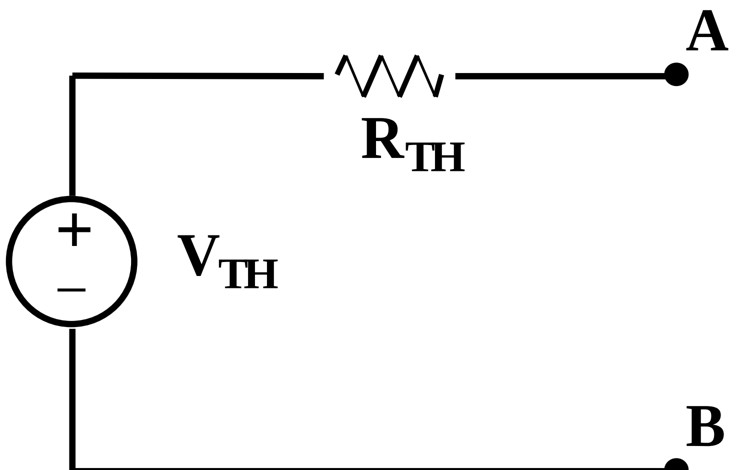


Linear circuit is a circuit where the voltage is directly proportional to the current (i.e., Ohm's Law is followed).

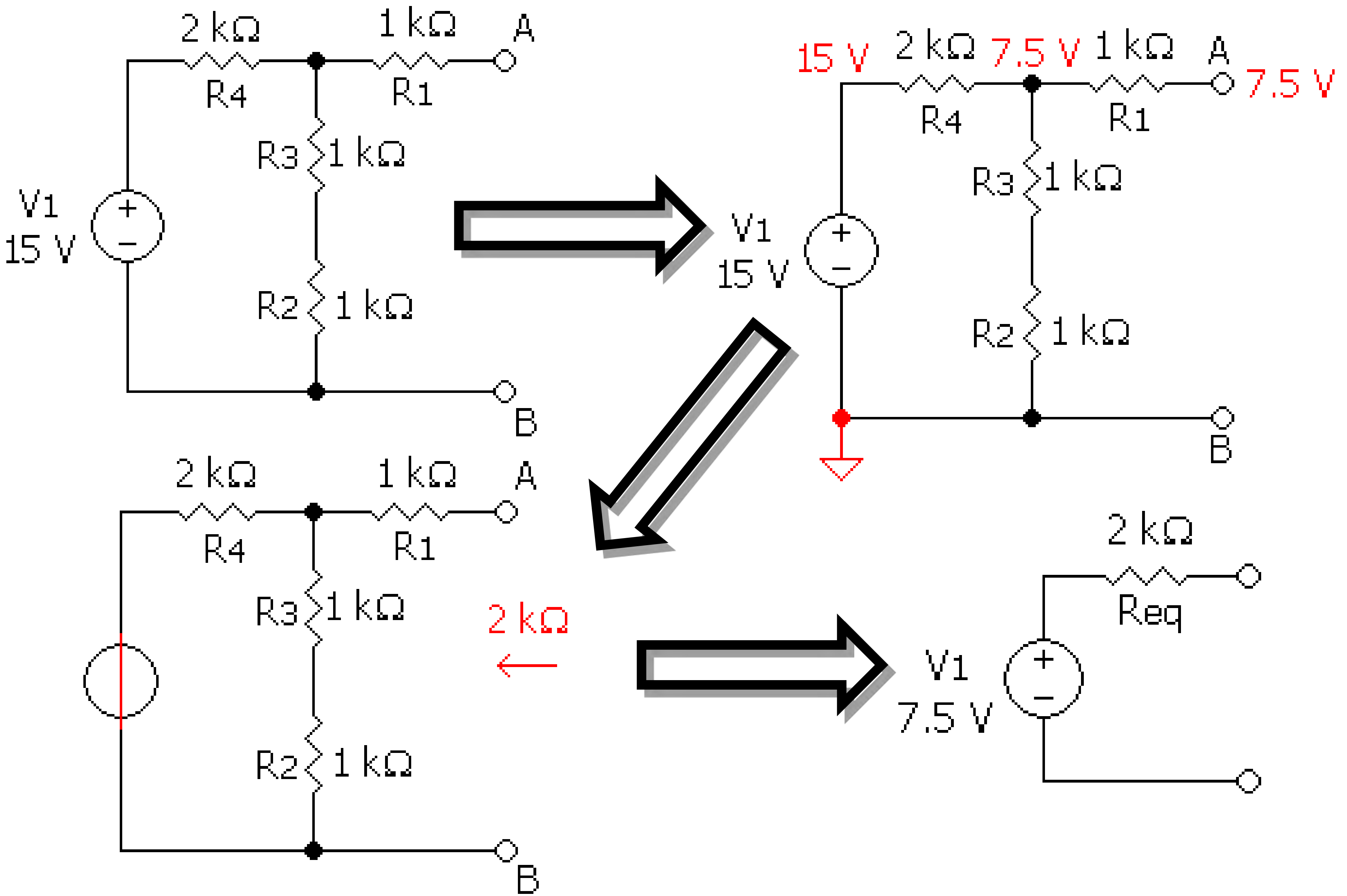
Thévenin's Theorem: cont'd

- Identify the load, which may be a resistor or a part of the circuit.
- Remove the load (replace with an open circuit).
- Calculate the voltage, V, over the gap where the load circuit was (V_{OC} or V_{Th}).
- Turn off all independent voltage and currents sources in the linear 2-terminal circuit (voltage sources with shorts and current sources with open circuits.)
- Calculate the equivalent resistance of the circuit. This is R_{Th}.

The equivalent circuit is a voltage source with voltage V_{Th} in series with a resistance R_{Th} in series with the load.



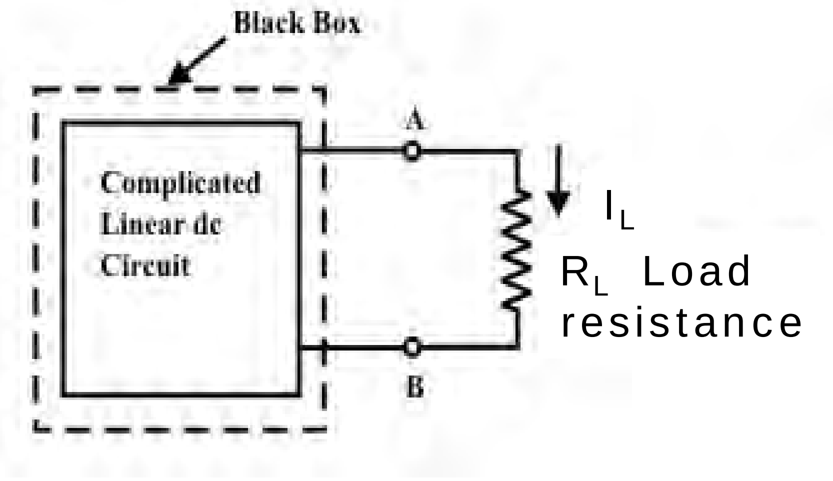
Thévenin's Theorem: cont'd

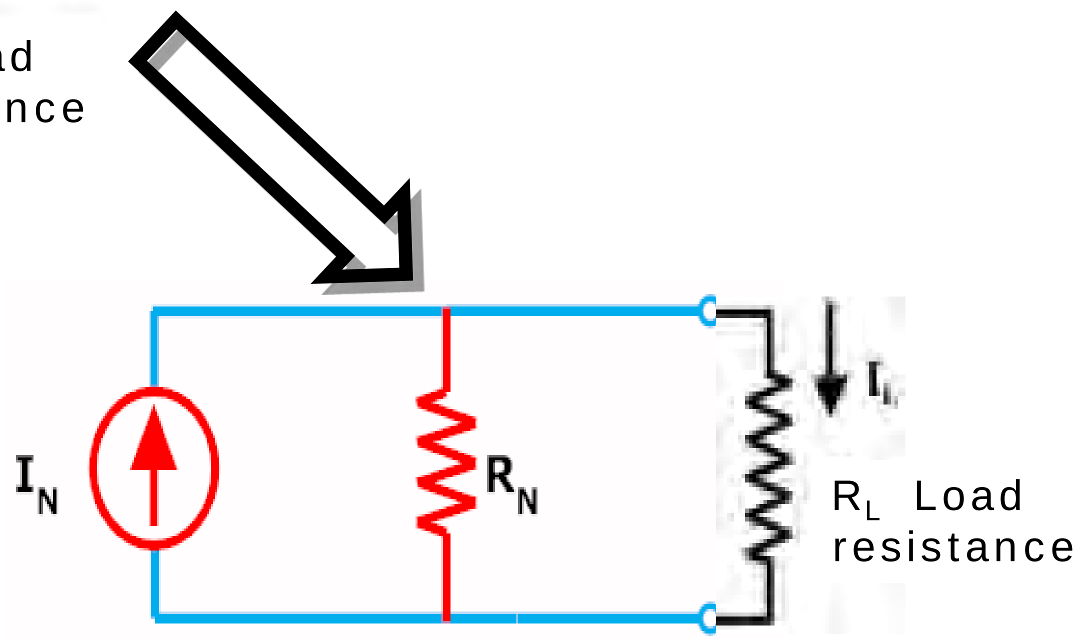


Norton's Theorem

A linear two-terminal circuit can be replaced with an equivalent circuit of an ideal current source, I_N, in parallel with a resistor, R_N.

- I_N is equal to the short-circuit current at the terminals.
- R_N is the equivalent or input resistance when the independent sources in the linear circuit are turned off

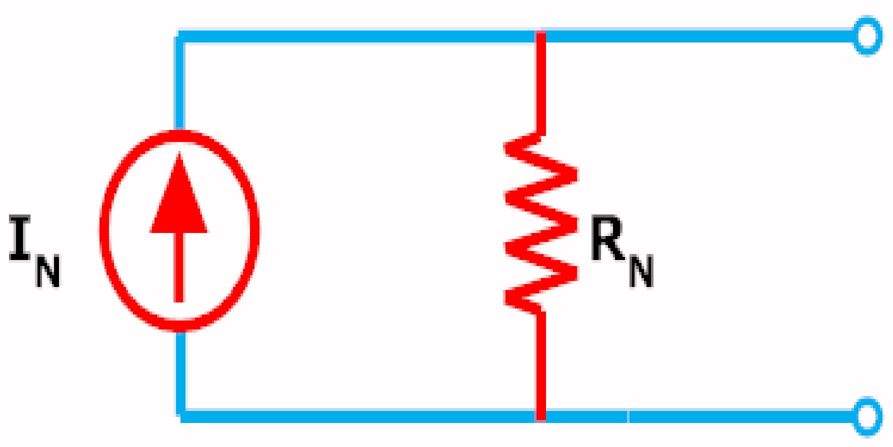




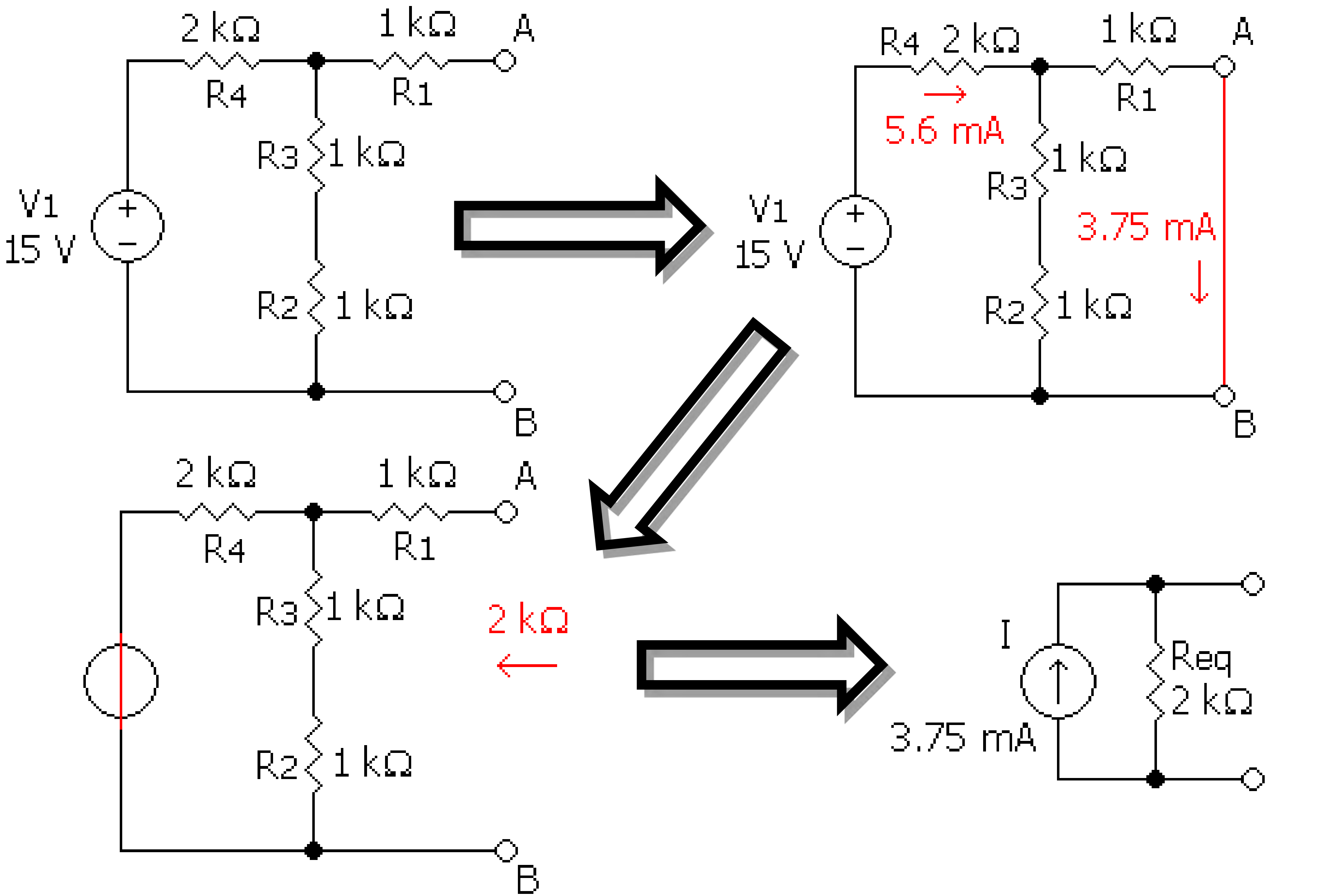
Norton's Theorem: cont'd

- Identify the load (may be a resistor or a part of the circuit).
- Replace the load circuit with a short
- Calculate the current through that short, I, from the original sources.
- Now replace voltage sources with shorts and current sources with open circuits.
- Replace the load circuit with an imaginary ohm meter and measure the total resistance, R, with the sources removed

The equivalent circuit is a current source with current I_{Norton} in parallel with a resistance R_{norton} in parallel with the load.

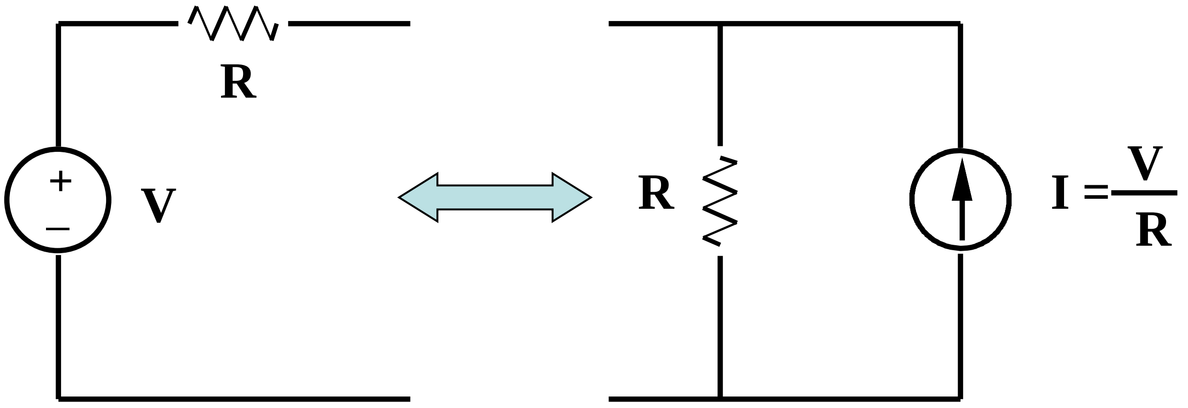


Norton's Theorem: cont'd



Norton's Theorem: cont'd

- We recall the following from source transformations.



- Thus, for any network for which the Thevenin equivalent is calculated, its Norton equivalent can be obtained using source transformation.

Lab Experiment

- Connect the circuit shown in ***Fig.2***; selecting resistors of 1/2 watt power ratings, and choose the value of R_L to be 100Ω.

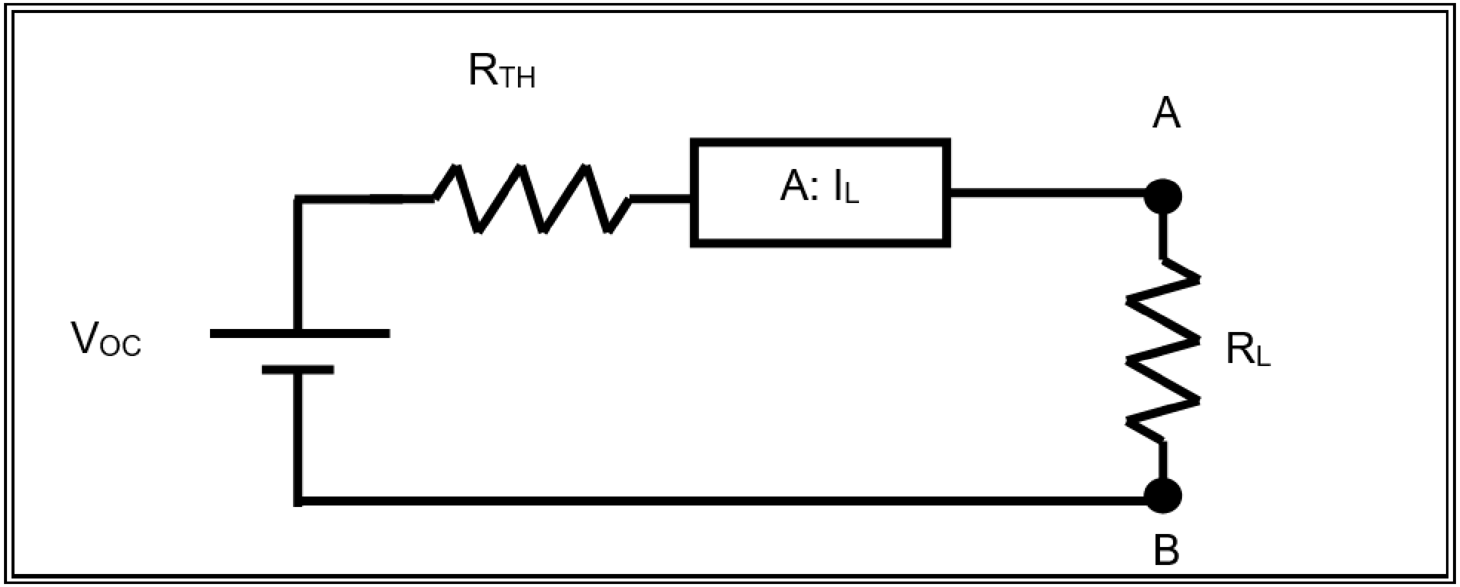
- Measure the load current.
- Compute V_{OC}, after removing load resistor; ***Fig.3***.
- Compute the short circuit current; I_{SC}, after replacing the load resistor by a short circuit; ***Fig.4***.
- Compute the Thevenin equivalent voltage and resistor:

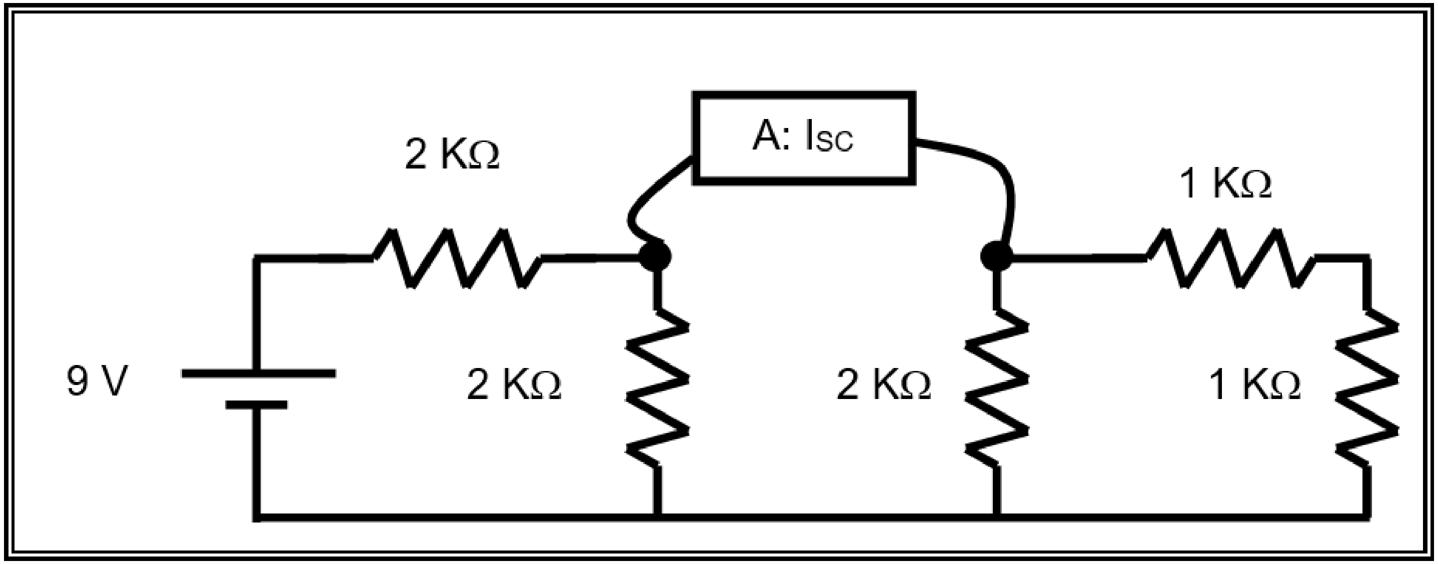
$$V_{TH} = V_{OC} \tag{1}$$

$$R_{TH} = V_{OC} / I_{SC} \tag{2}$$

- Construct the circuit in ***Fig.5***, and compute the load current.
- Compare the two values of the load current.

Lab Experiment

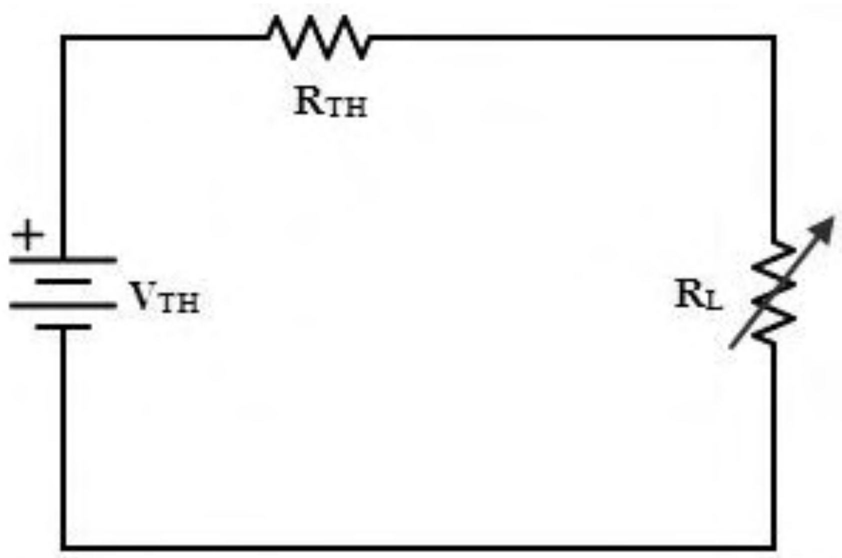


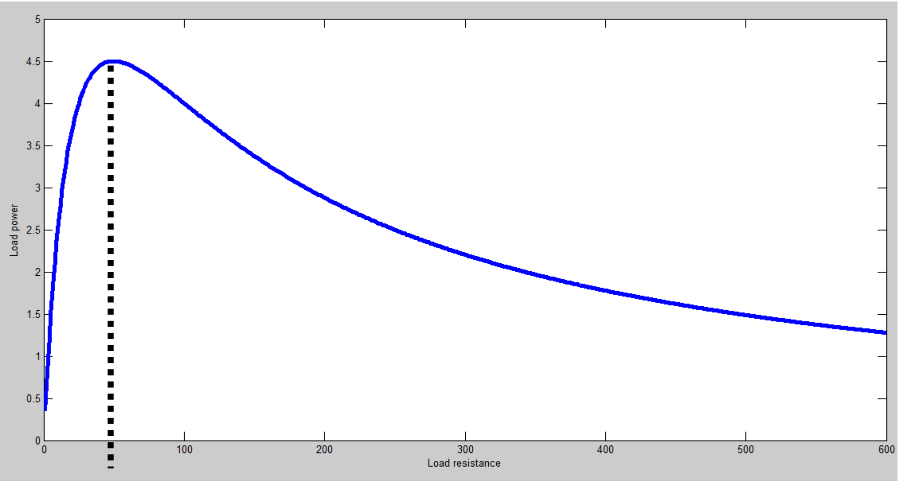


Maximum Power Transfer

- For any power source, the maximum power transferred from the source to the load is when **<u>the resistance of the load R_L is equal to the equivalent or input resistance of the power source</u>** (R_{in} = R_{Th} or R_N).

- The process used to make R_L = R_{in} is called impedance matching.





R_L= R_{Th}

Maximum Power Transfer: **cont'd**

- **If Z_L and Z_{Th}: Resistive**

  $R_L = R_{TH}$

- **If Z_L or Z_{TH}: Resistive**

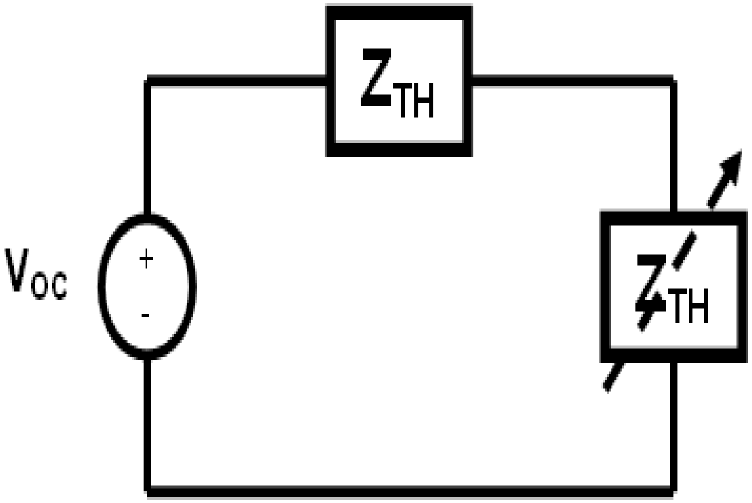
  $|Z_L| = |Z_{TH}|$

- **If Z_L and Z_{TH}: Matched**

  $Z_L = Z_{TH}^*$

- **If Z_L and Z_{TH} are Complex but not Matched**

  $|Z_L| = |Z_{TH}|$



Lab Experiment

- Connect the circuit of ***Fig.6***; resistors of 1/2 watt power ratings.
- Compute V_{OC}, after removing the load resistor; ***Fig.7***.
- Compute the short circuit current; I_{SC}, after replacing the load resistor by a short circuit; ***Fig.8***.
- Compute the Thévenin's equivalent voltage and resistor:

$$V_{Th} = V_{OC}$$

$$R_{Th} = V_{Th}/I_{SC}$$

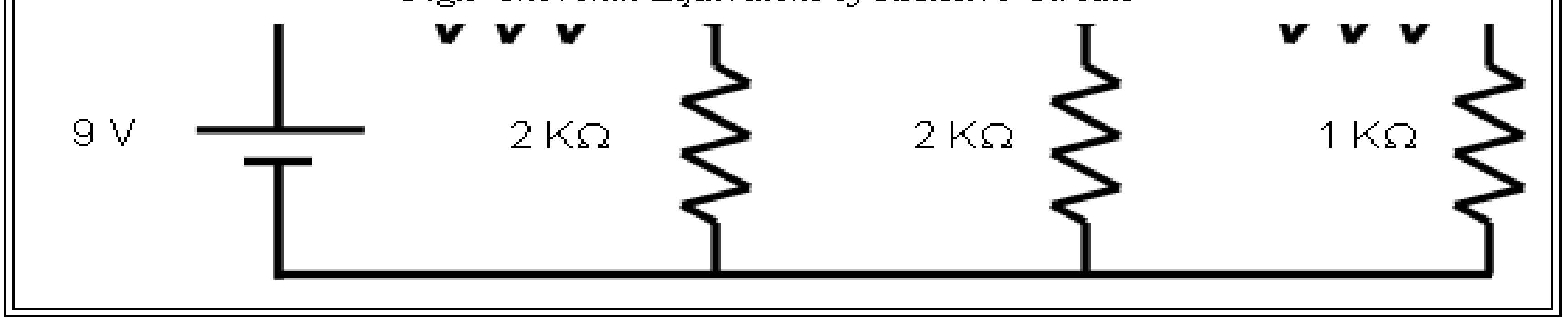
- Construct the circuit in ***Fig.9***, compute the load current (I_L) ; the load voltage (V_L) and hence the load power (P_L) :

$$P_L = I^2_L\ R_L$$

- Change the value of the variable resistor, and complete ***Table.1***.
- Give your comments.

Lab Experiment

- (gs.



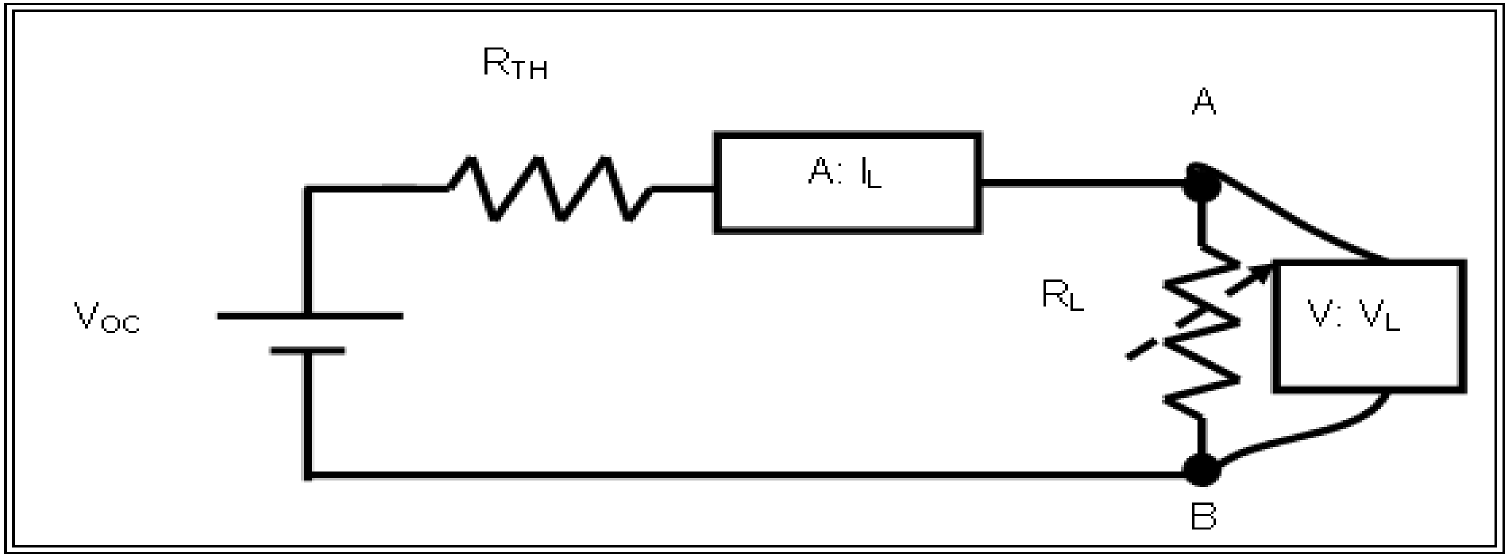


Fig.9 Thevenin Equivalent of Resistive Circuit

Fig.8 Resistive Circuit: I_{SC}

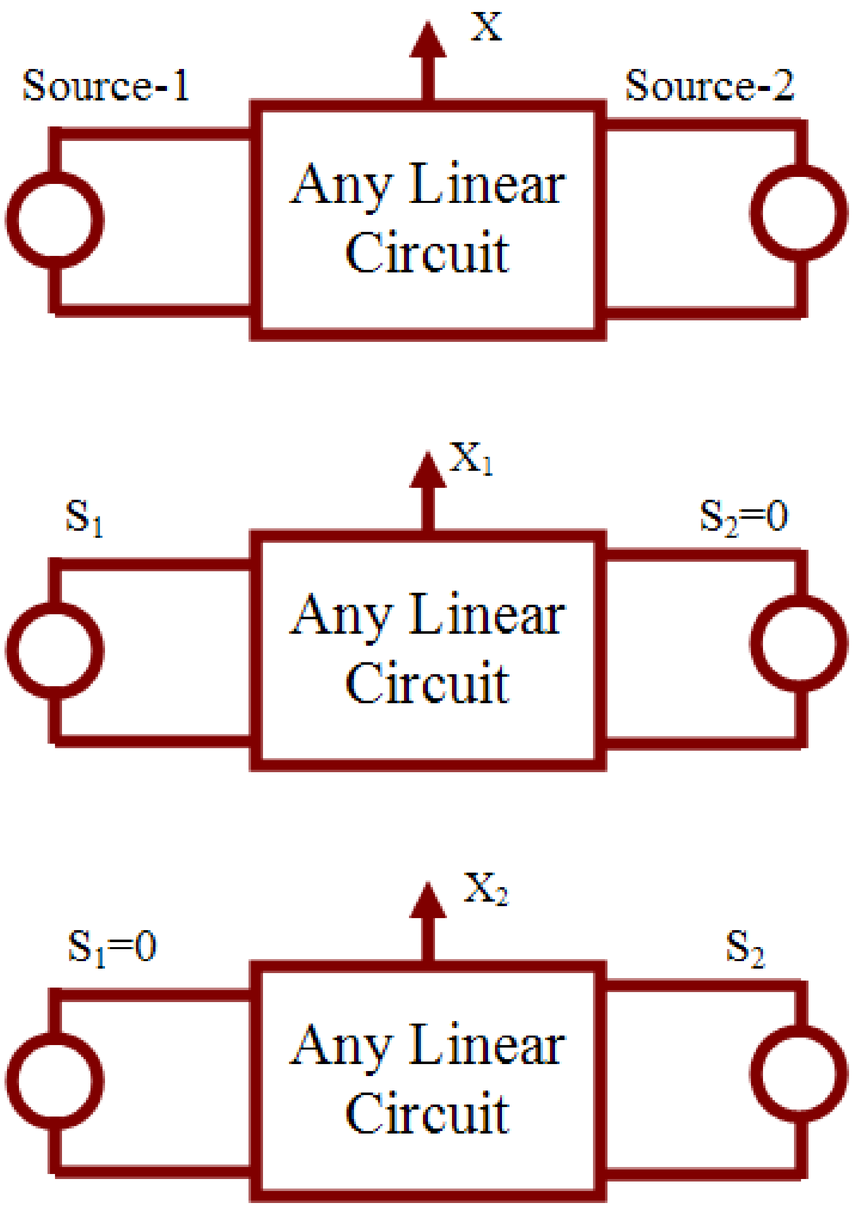
- Give your comments.

Superposition Principal

- The superposition theorem states that for linear circuits, the **total** effect **of several sources** acting simultaneously is equal to the **sum** of the effects of the **individual sources** acting one at a time

  - Optional Case: When all the sources in the circuit have the same frequency.
  - Forced Case: When there exist more than one frequency in the circuit.

Superposition Principal: **cont'd**



Lab Experiment

- Connect the circuit shown in ***Fig.10***, selecting all resistors to be 1/2 watt ratings; and measure the current through the 2 KΩ resistor.
- Remove the *source* V_2; to get the circuit of ***Fig.11***, and *measure* I_1.
- Remove *source* V_1; to get the circuit of ***Fig.12***, and *measure* I_2.
- Compute the overall current through the *2 KΩ* resistor; using:

$$I_{Total} = I_1 + I_2 \qquad (7)$$

- Compare the two values of the required current.

Lab Experiment

- C... stors to be
  1/... the 2 KΩ
  re...

V1

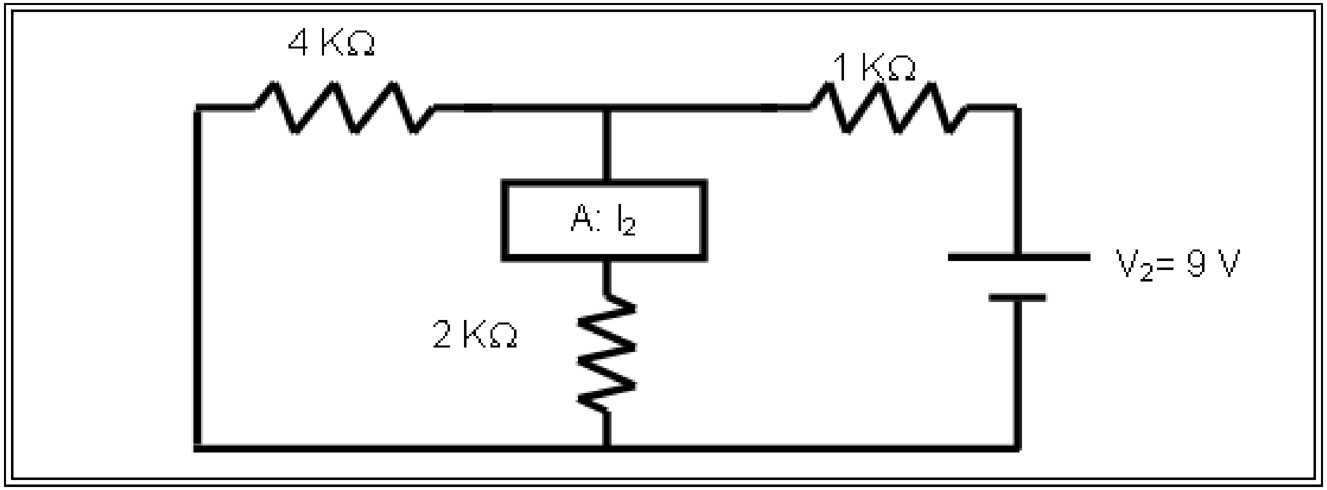


Fig.12 Resistive Circuit: Superposition: $V_1=0$

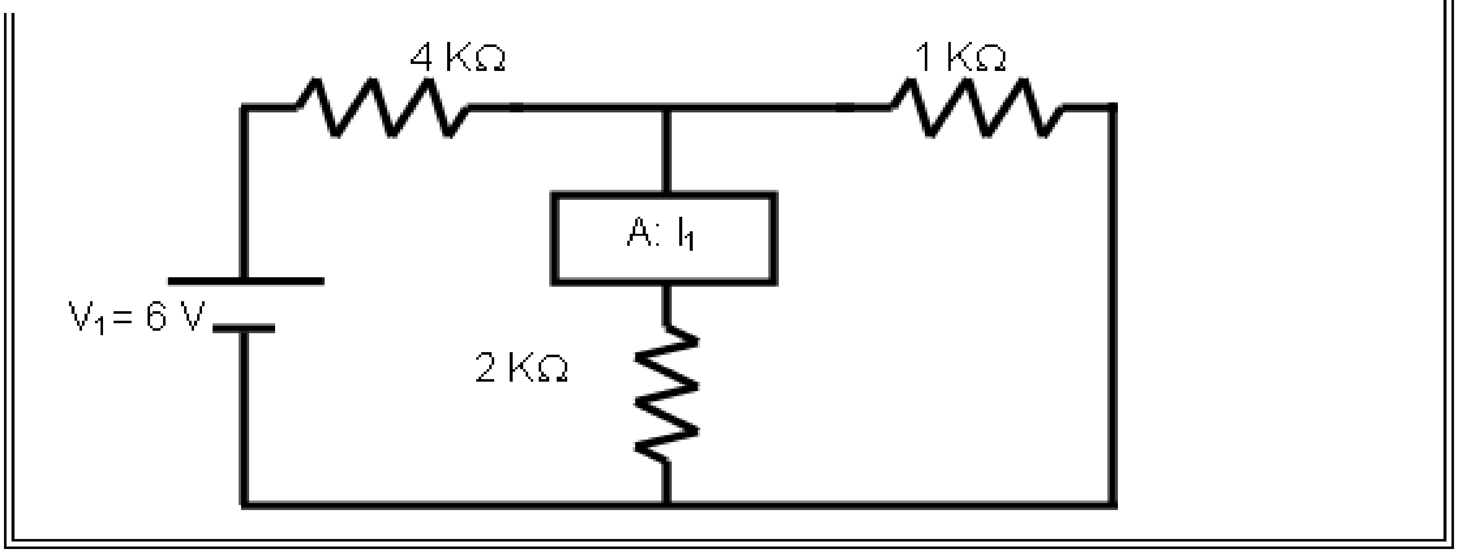


Fig.11 Resistive Circuit: Superposition: $V_2=0$

التجربة السابعة

Course Contents

Experiment-0: Overview of laboratory equipment's (Digital Multimeters, Function Generators, Oscilloscope)

Experiment-1: Passive Elements.

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Experiment-3: Nonlinear Resistances.

Experiment-4: Passive Filters.

Experiment-5: Resonant Circuits.

Experiment-6: Circuit Theorems.

Experiment-7: Semiconductor Diodes and its Applications.

Experiment-8: Special Diodes.

Experiment-9: Bipolar Junction Transistors.

Experiment-10: Logic Gates.

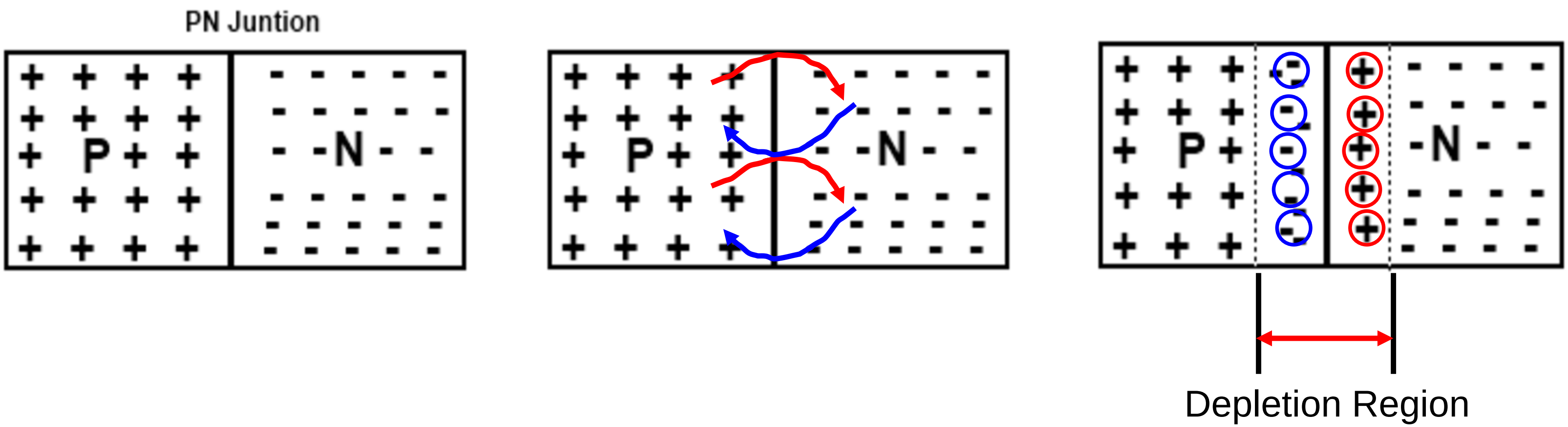
Experiment-11: Power Supplies.

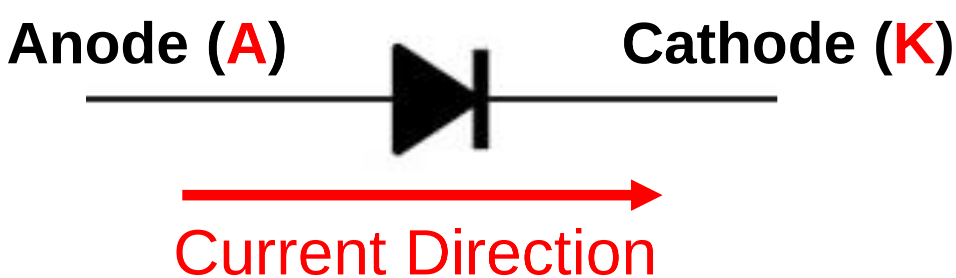
Semiconductor Diodes

A semiconductor diode consists of an *n* material region and a *p* material region separated by a PN junction

– The *n* region has many conduction electrons

– The *p* region has many holes





Experiement-7 Objectives

- Verify the current-voltage (I-V) characteristics of a semiconductor diode.

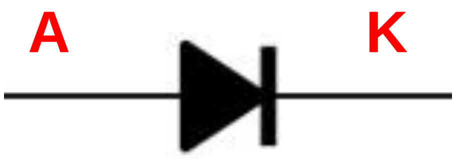
- Study some diode applications; rectifier and logic circuits

- التعرف على الصمام الثنائي (الموحد) و تحقيق منحنى خواصه
- تحديد عمل الصمام الثنائي في الدوائر و إستخداماته في بعض التطبيقات المهمة:
  - توحيد الإشارات المتغيرة.
  - تشكيل الموجات(Clamping, Clipping)
  - الدوائر المنطقية Logic Gates

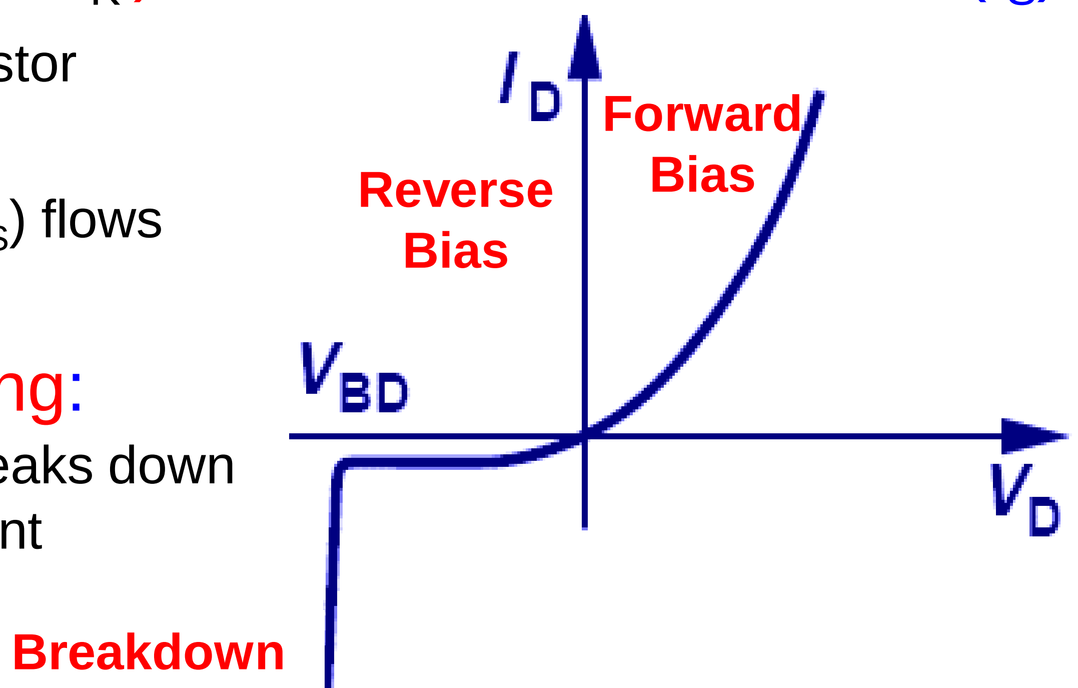
Most of the materials in the upcoming slides are taken from Dr. M. Abdelazim's ppt slides for Electronic Experiment 1", 2011.

Diodes Characteristics

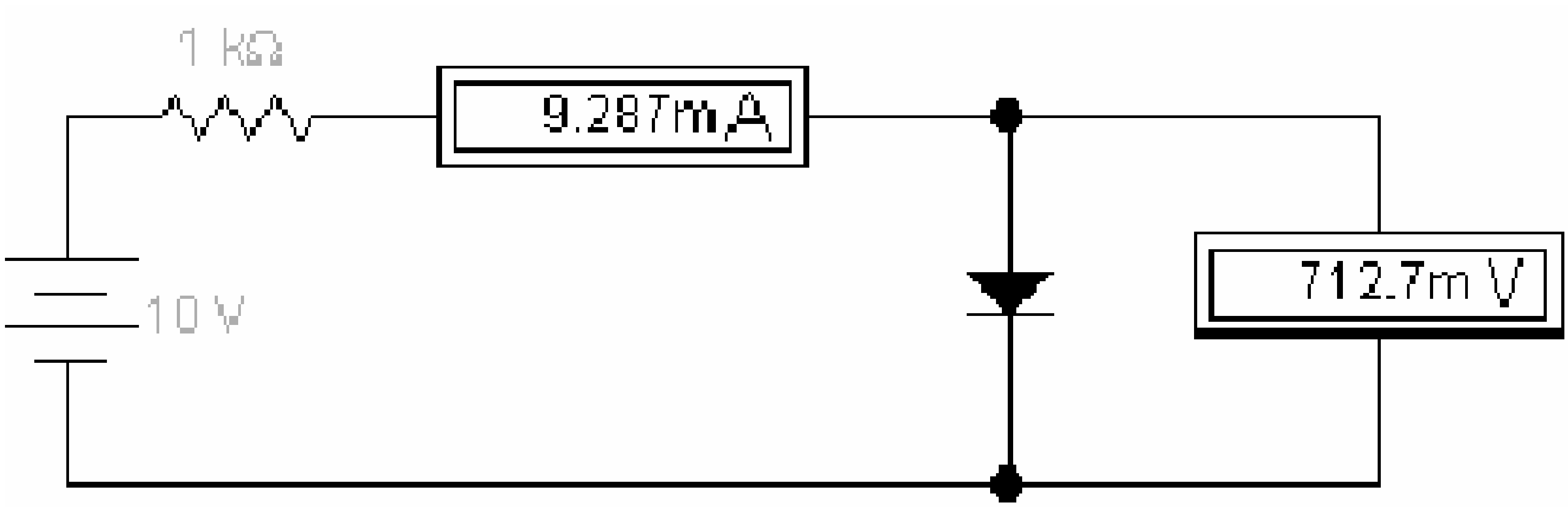
- Represents the relation between the current and voltage of a PN junction
  - Forward biasing ($V_A > V_K$): exponential

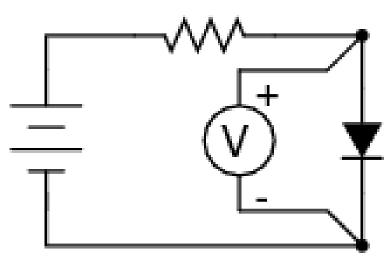


    - $\rightarrow$ $R_{ON} \rightarrow$ Very small resistor
    - $\rightarrow$ Nearly Short Circuit $\rightarrow$ Large current flows $\rightarrow$ Diode turns on
  - Reverse biasing ($V_A < V_K$): almost a constant value (I_S)
    - $\rightarrow$ $R_{OFF} \rightarrow$ Very Large Resistor
    - $\rightarrow$ Nearly Open Circuit
    - $\rightarrow$ Small leakage current (I_S) flows
    - $\rightarrow$ Diodes is OFF
  - Higher reverse biasing:
    - $\rightarrow$ Eventually, the diode breaks down and conducts high current

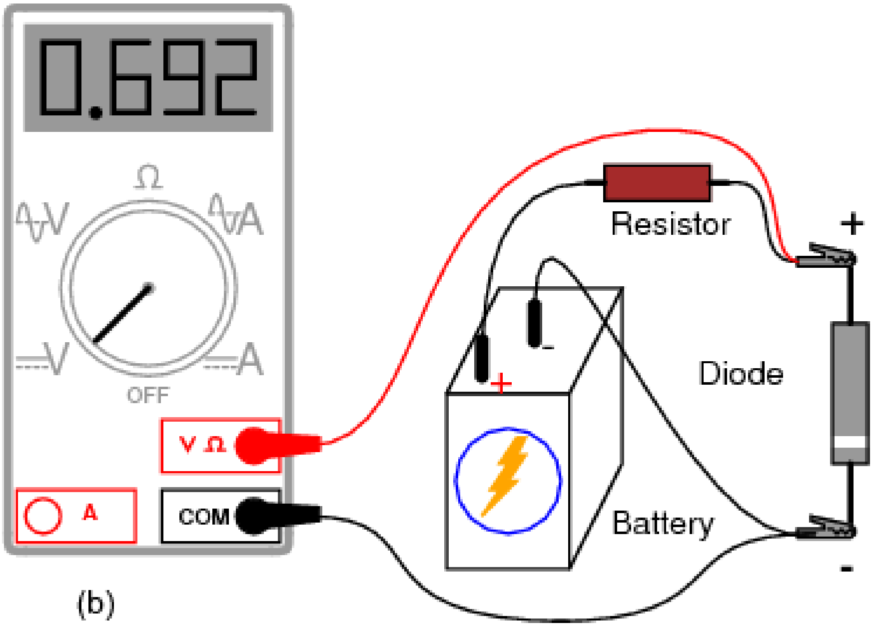


Diodes In Forward Biasing



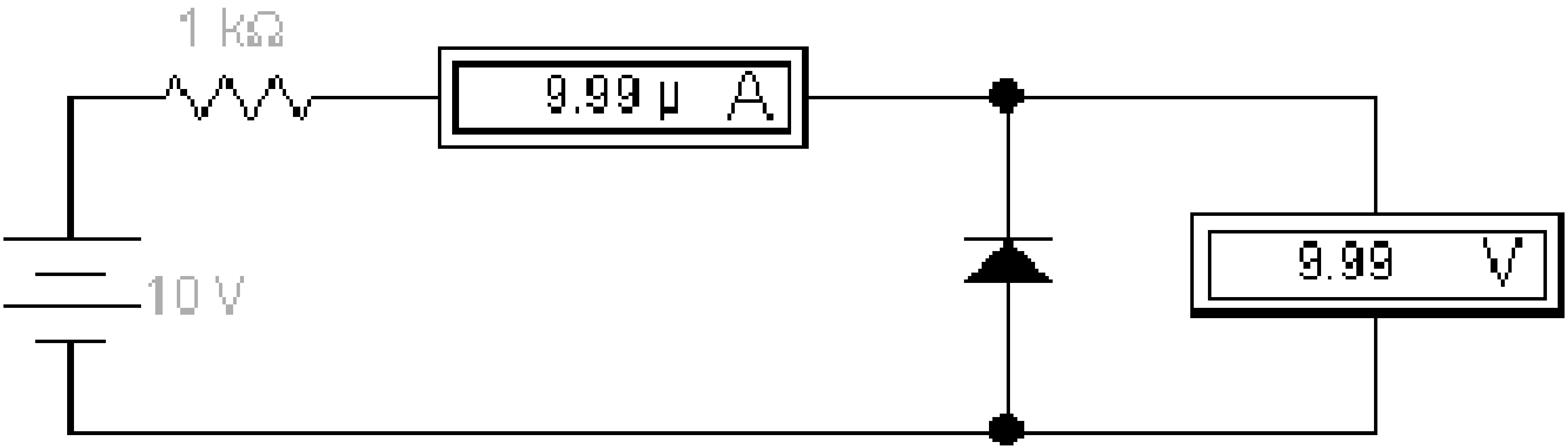


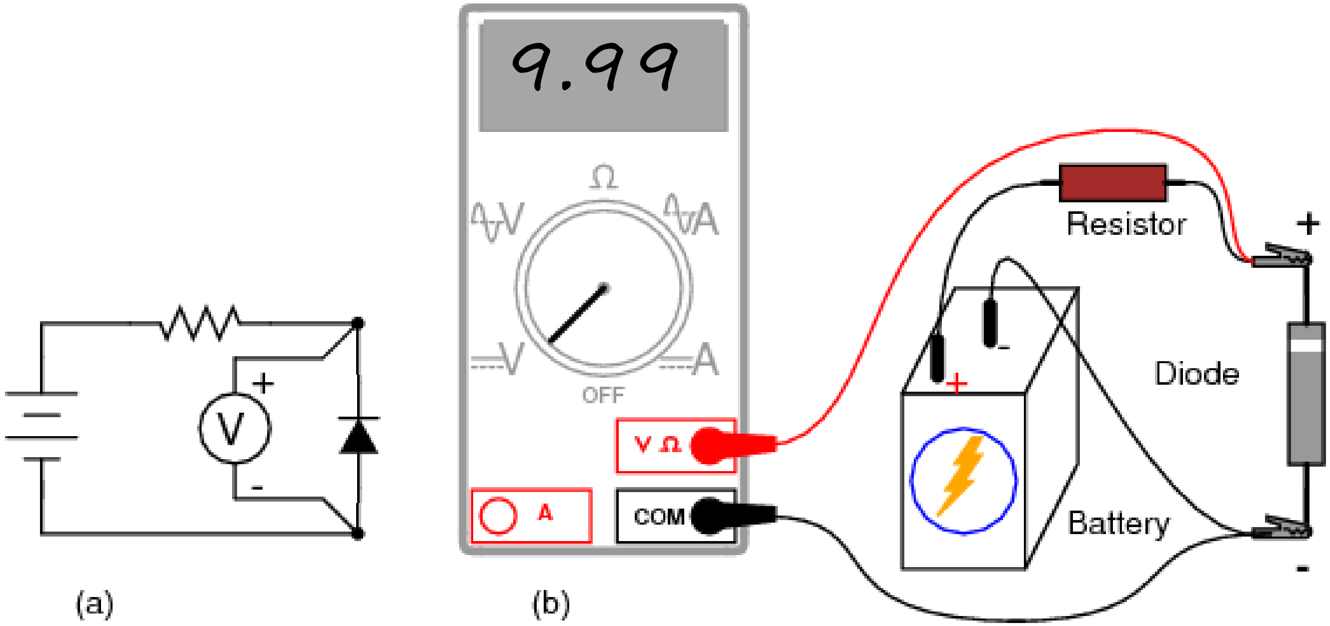
(a)



(b)

Diodes In Reverse Biasing





(a) (b)

Diodes Rating

All the information you will need to know about the Diodes from its data sheet

هي مجموعة البيانات الواجب معرفتها عن الصمام الثنائي من خلال data sheets:

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)				
PARAMETER	**TEST CONDITION**	**SYMBOL**	**VALUE**	**UNIT**
Repetitive peak reverse voltage		V_{RRM}	100	V
Working peak reverse voltage		V_{RWM}	75	V
DC blocking voltage		V_R	75	V
RMS Reverse voltage		$V_{R(RMS)}$	53	V
Forward continuous current		I_F	300	mA
Average rectified current	Half wave rectification with resistive load and f > 50 MHz	$I_{F(AV)}$	200	mA
Non repetitive peak forward surge current	t = 1 s	I_{FSM}	1	A
	t = 1 µs	I_{FSM}	4	A
Power dissipation	l = 4 mm, T_L = 25 °C	P_{tot}	500	mW

THERMAL CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)				
PARAMETER	**TEST CONDITION**	**SYMBOL**	**VALUE**	**UNIT**
Thermal resistance junction to ambient air	l = 4 mm, T_L = constant	R_{thJA}	300	K/W
Junction temperature		T_j	+ 175	°C
Storage temperature range		T_{stg}	- 65 to + 175	°C

الشوائب وعلي نوع شبه الموصل .

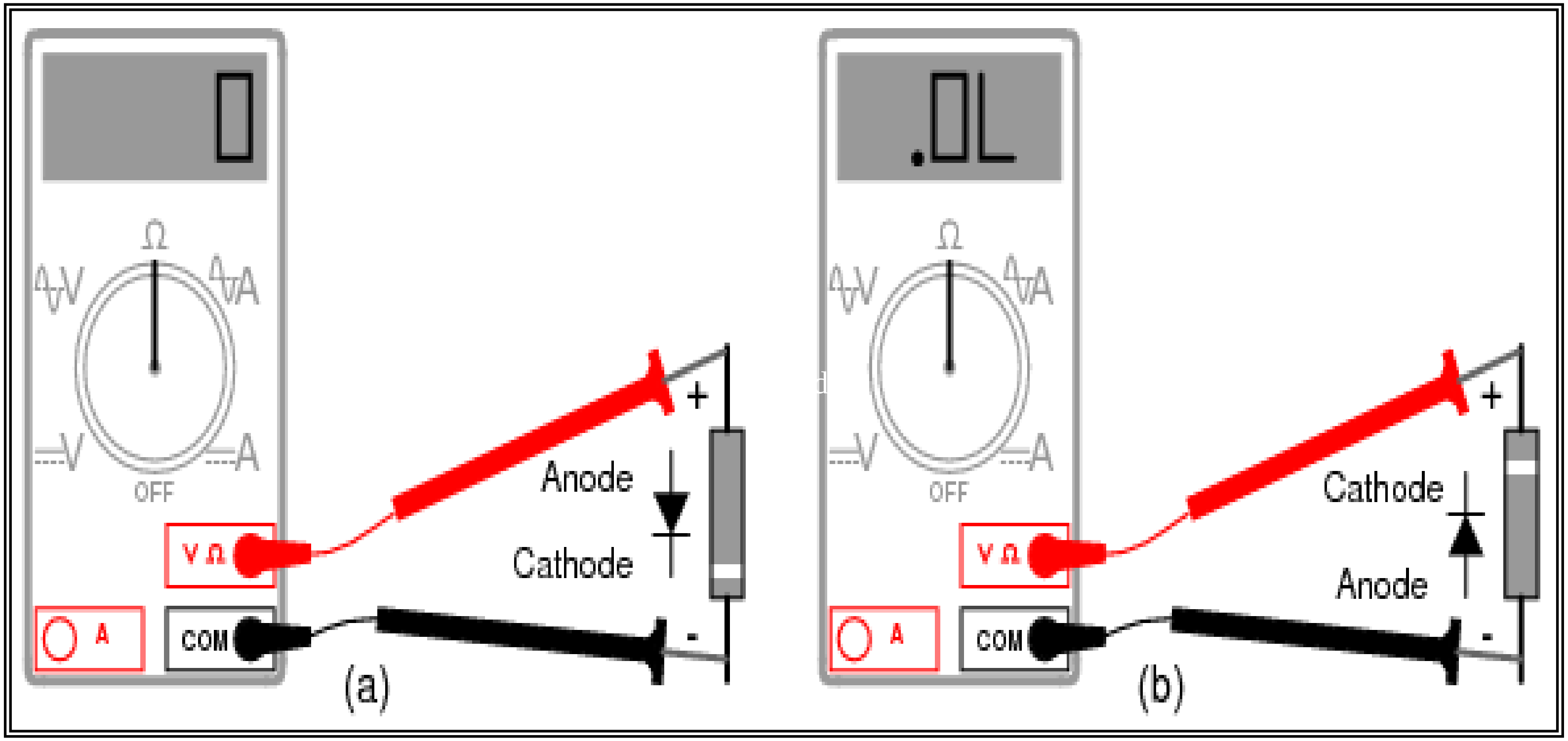
Diodes Checking: Ohm Function

– If D→ F.B. → Positive @A & Negative @K

→ R_{on} → Very small resistance.

– If D→ R.B. → Positive @K & Negative @A

→ R_{oFF} → Very Large resistance.



Diode Forward Bias **Diode Reverse Bias**

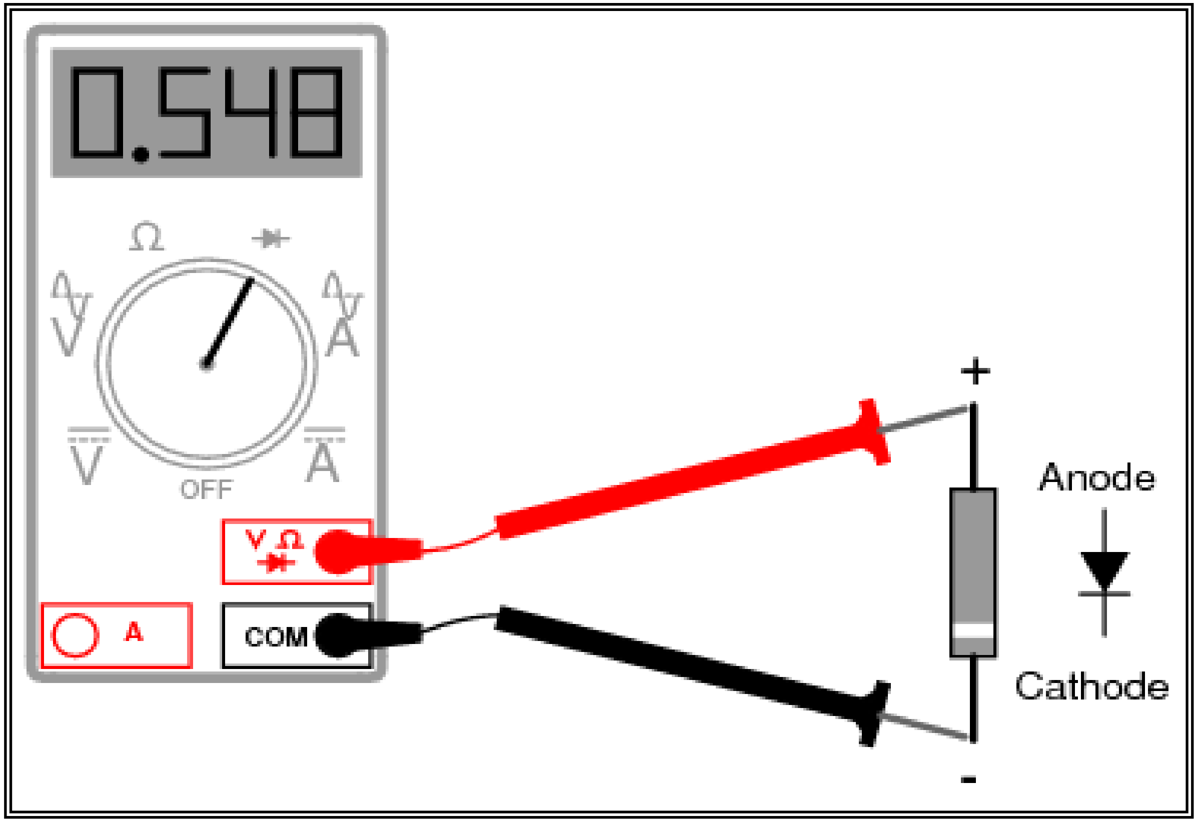
Diodes Checking: Diode Check Function

– If D→ F.B. → Positive @A & Negative @K

→ $V_F \approx 0.65$ for Si and 0.3 for Ge.

– If D→ R.B. → Positive @K & Negative @A

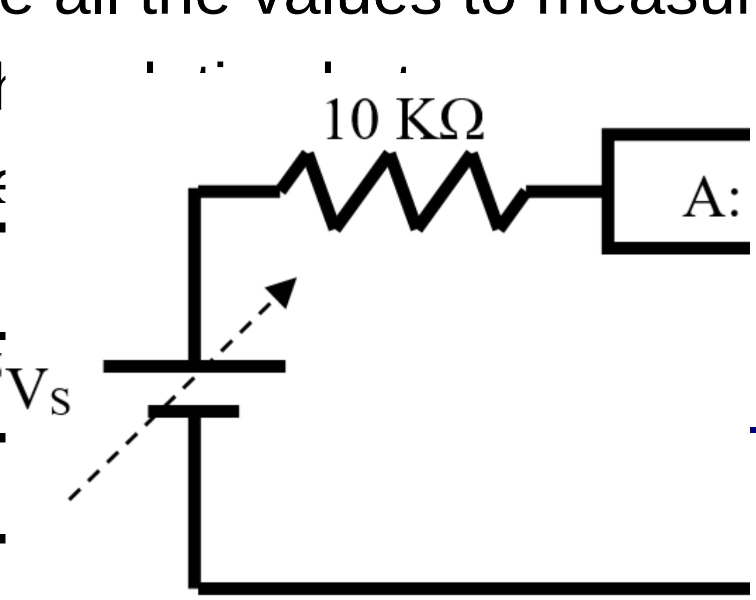
→ O.C (Displays OL)

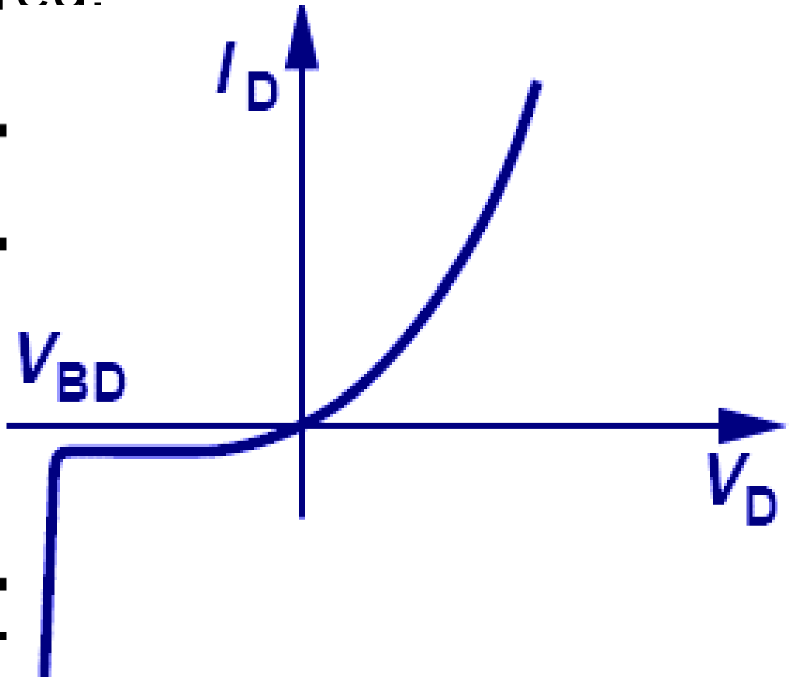


Diodes I-V Characteristics

- Construct the circuit shown in the next figure, with a resistor of 1/2 watt rating.
- Connect a multimeter to get the diode current, and another multimeter to get the diode voltage drop.
- Adjust the DC-supply to get different values of DC volts.
- Complete all the values to measured.
- Sketch th… the diode…

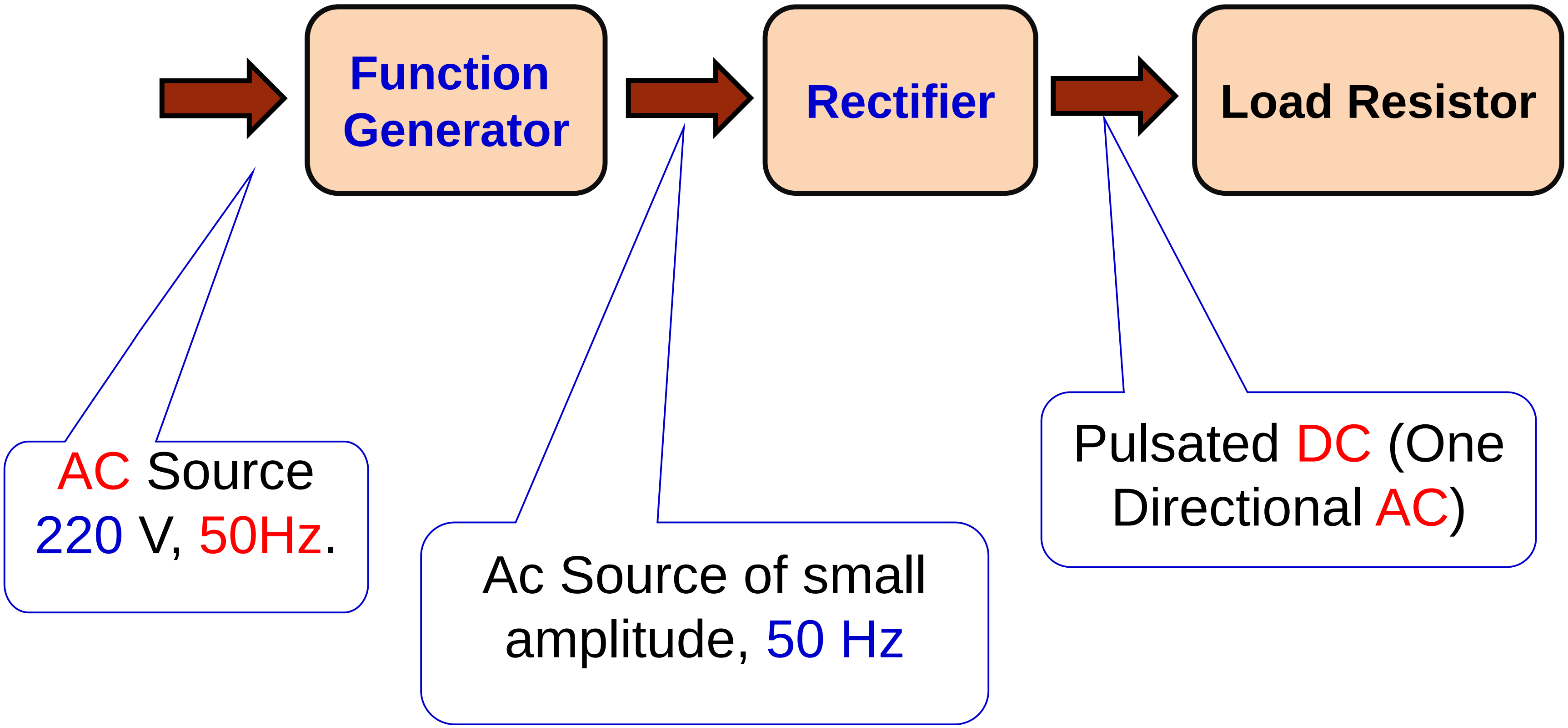
V_S (V)	5
I_D (mA)	
V_D (V)	



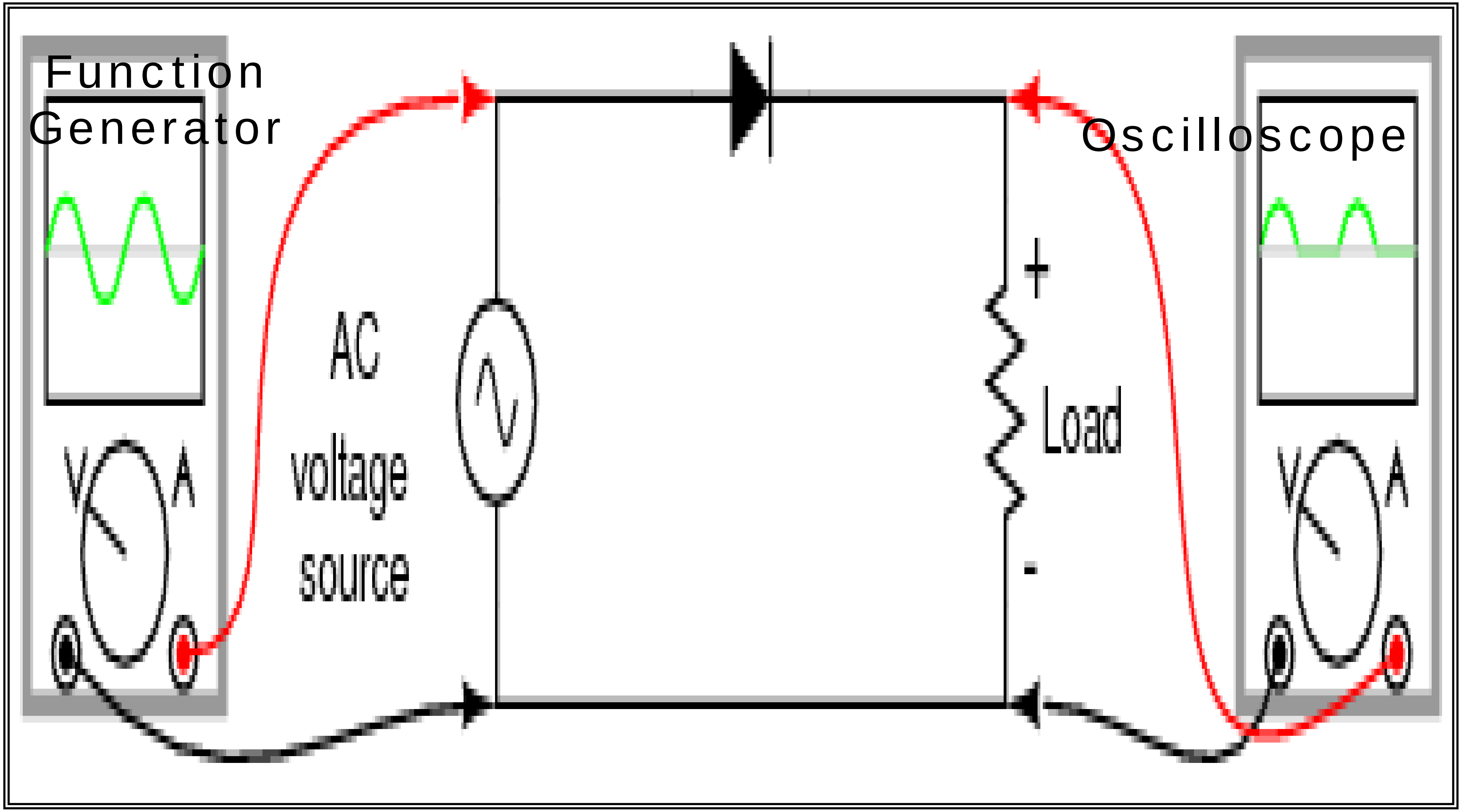


Diodes Applications: Rectification

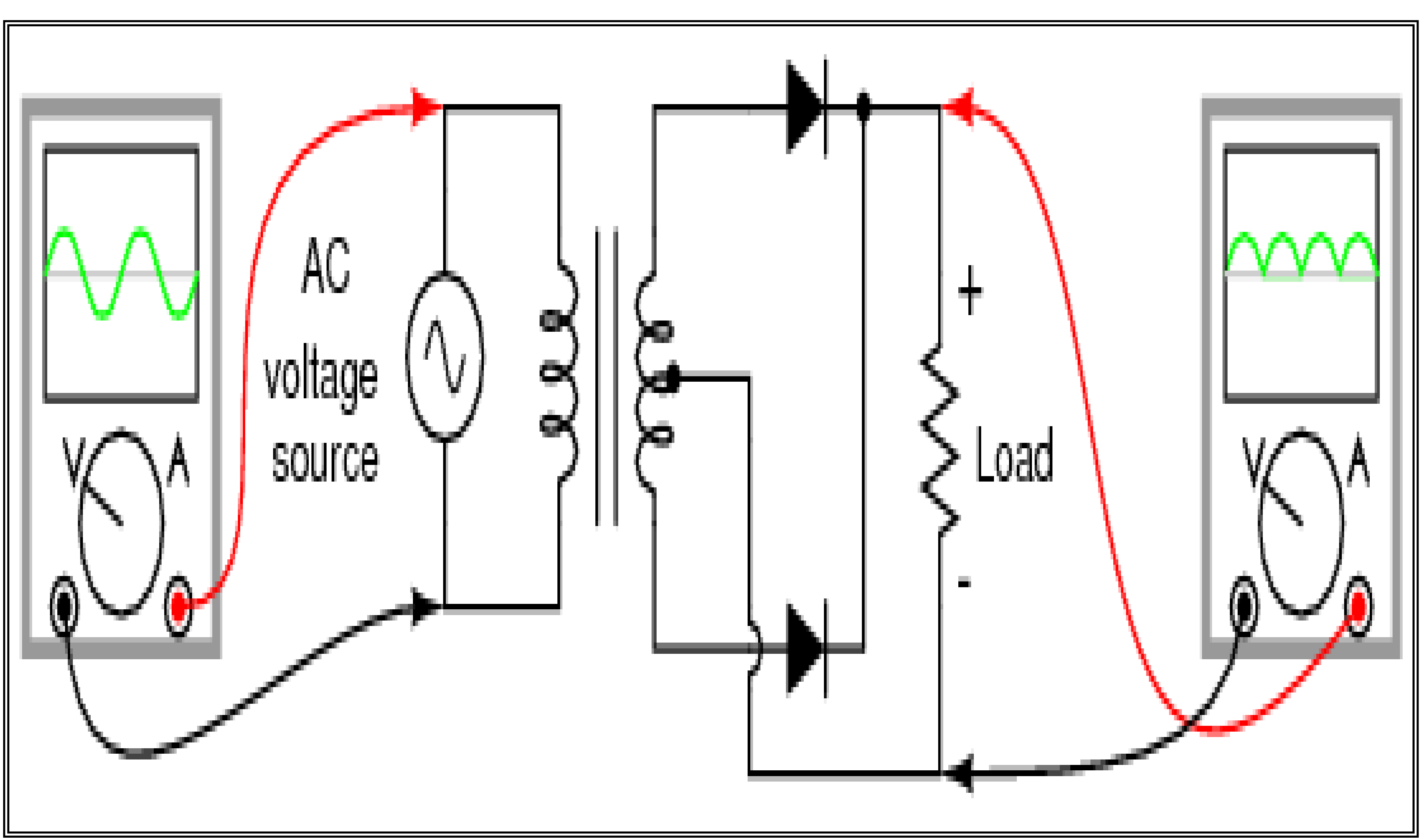
- Rectification: Conversion of alternating current (AC) to pulsated direct current (DC).
  →Allows one-way of electrons flow.
  →This is exactly what a semiconductor diode does.



Half Wave Rectifier Circuit

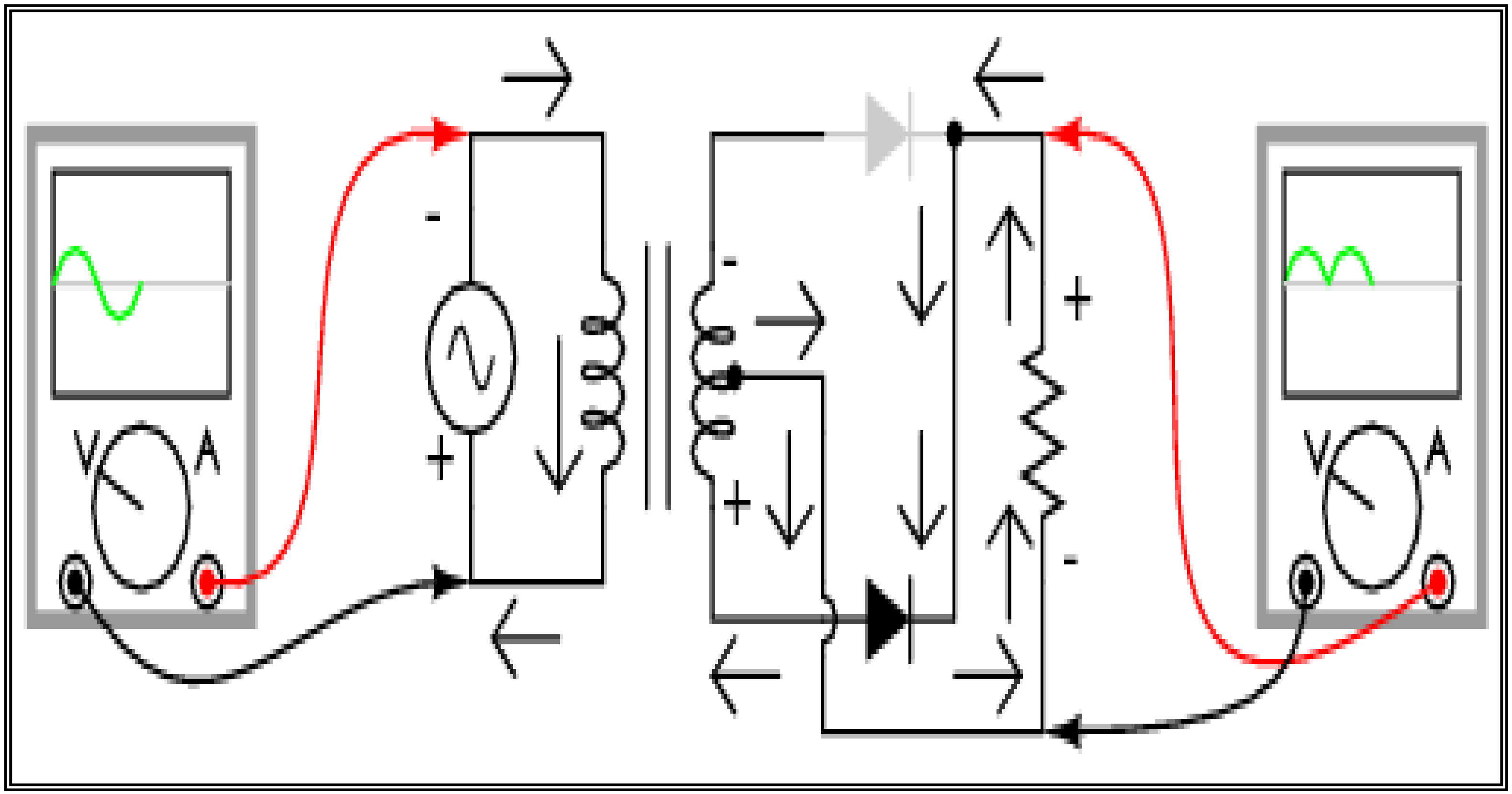


Full Wave Rectifier: Center-tap

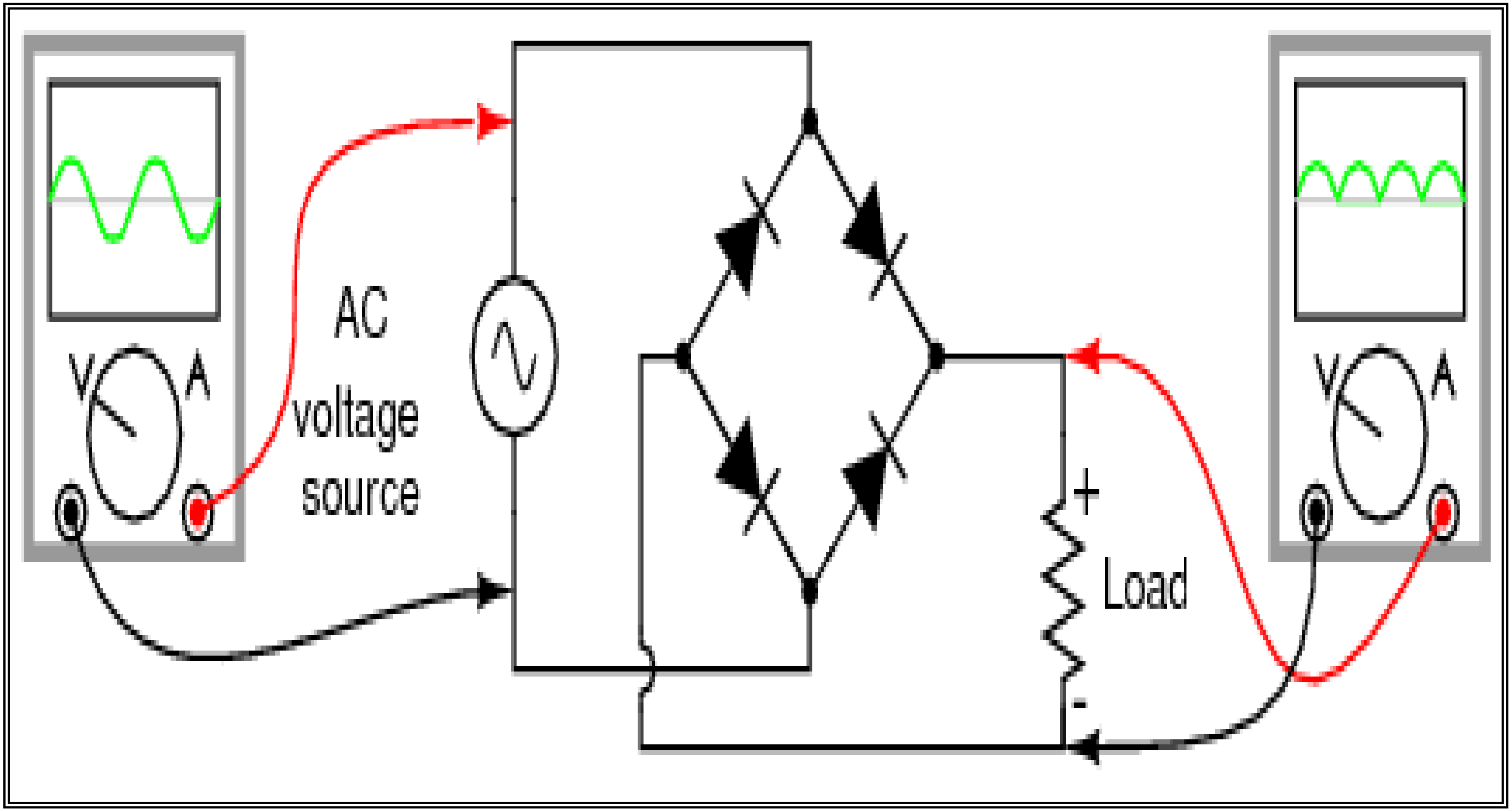


Center-Tap Full Wave Rectifier : cont'd

- Positive half Cycle
- Negative half Cycle

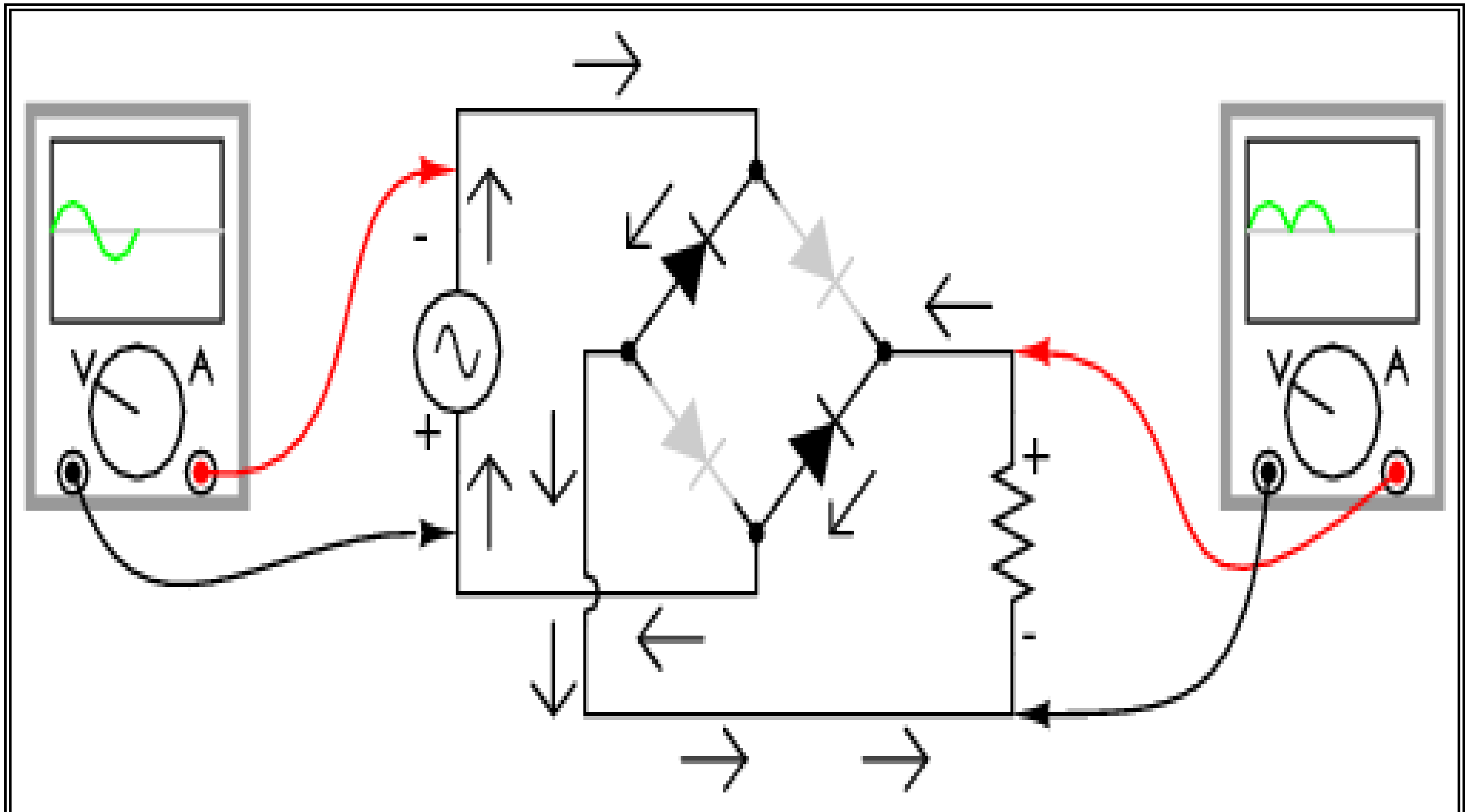


Full Wave Rectifier: Bridge



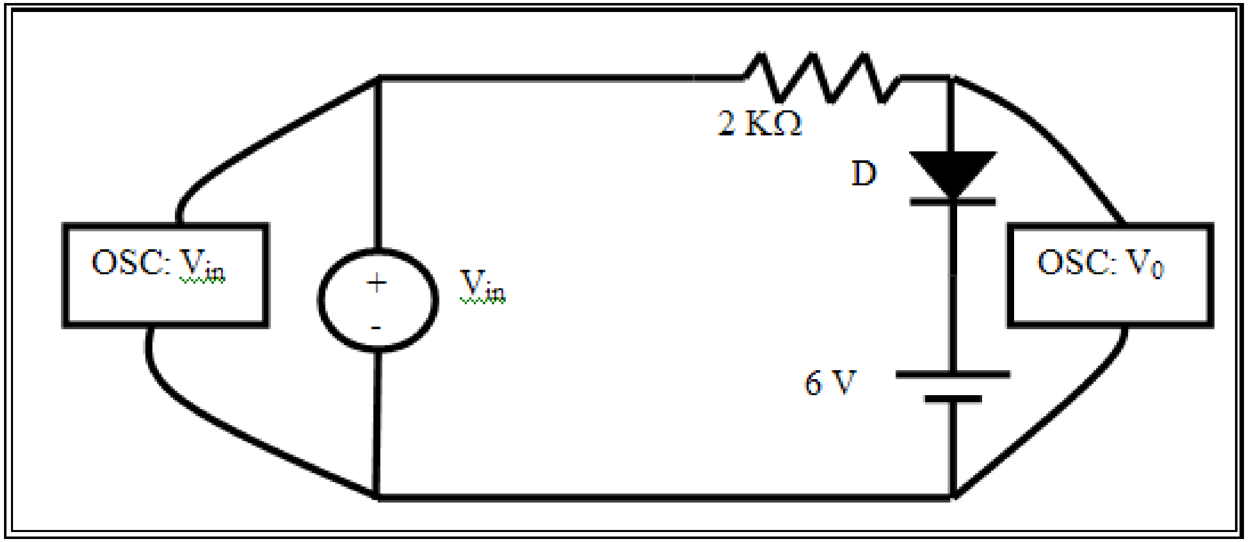
Bridge Full Wave Rectifier: cont’d

- Positive half Cycle
- Negative half Cycle



Diodes Applications: Clipping

- Clipping circuits are used to limit the voltage swing of any signal to a predefined level(s).
- This can be achieved using diode(s)



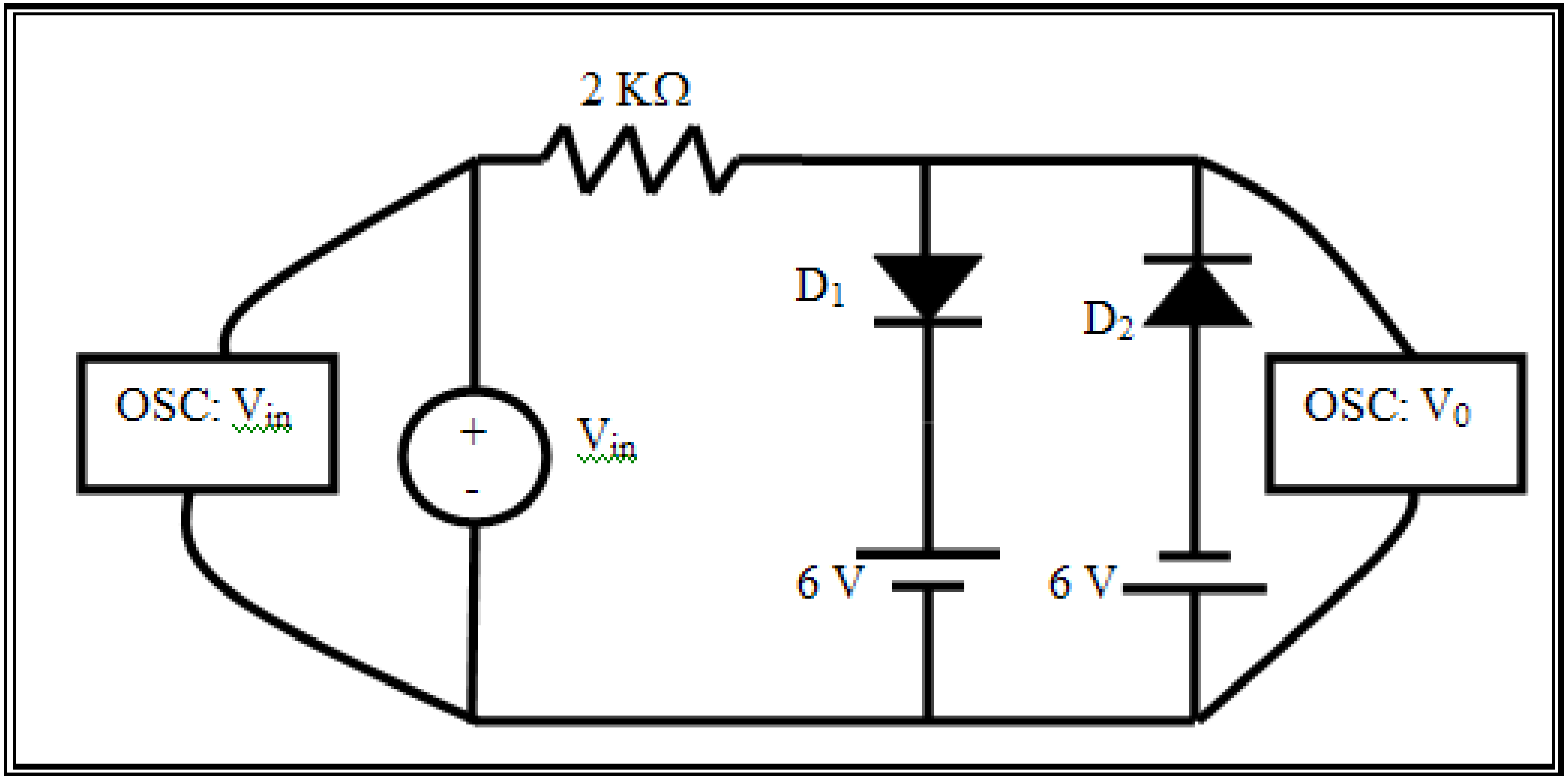
- Positive half Cycle

$$\text{At } V_{in} < 6 \Rightarrow D \Rightarrow R.B. \Rightarrow O.C.\text{; then } V_0 = V_{in}$$

$$\text{At } V_{in} > 6 \Rightarrow D \Rightarrow F.B. \Rightarrow S.C.\text{; then } V_0 = 6$$

- Negative half Cycle $D \Rightarrow R.B. \Rightarrow O.C.;\ V_0 = V_{in}.$

Double (Two-level) Clipping

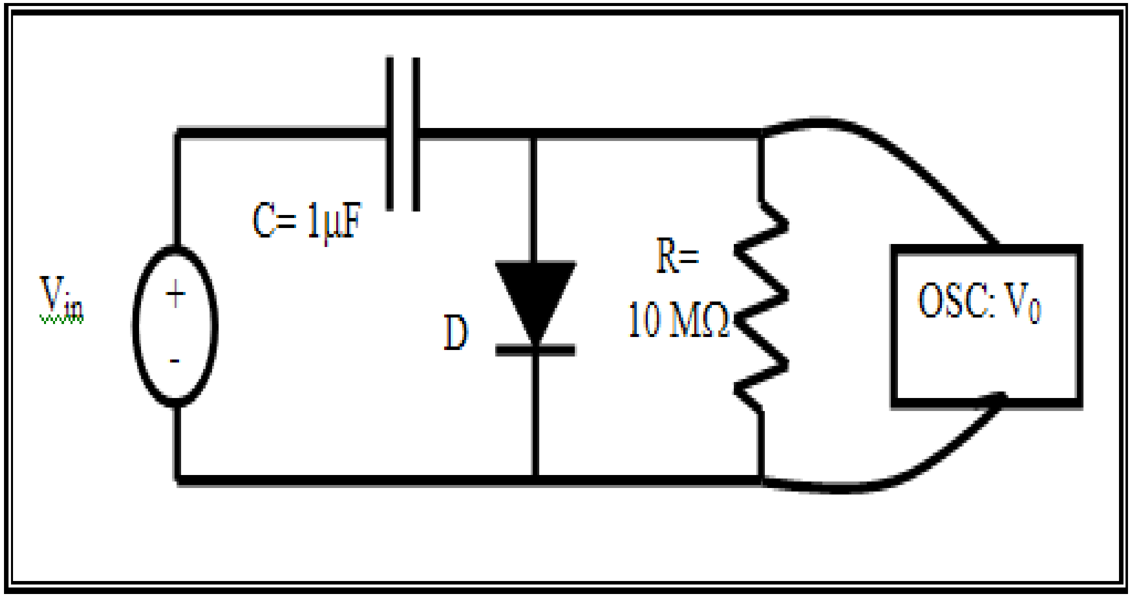


- Positive half Cycle: D1 will do the clipping job
- Negative half Cycle: D2 will do the clipping job

the capacitor will charge up to , and .
the capacitor will charge up to , and .

Diodes Applications: Clamping

- Clamping circuits reproduces the input signal on the output side by shifting it either up or down.
- This can be achieved using diode(s)



- **Positive half Cycle**

  D→F.B. → SC → Capacitor will charge up to $V_C=V_P$

- Negative half Cycle

  D→R.B. → OC → Capacitor will be used as a DC-Supply (DC-Offset) with a small amount od discharge $V_O=V_{in}+V_C$

التجربة التاسعة

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Experiment-10: Logic Gates.

Experiment-11: Power Supplies.

Experiement-9 Objectives

- Transistors are the building block components used in all digital electronics.

- After completing this experiment, the learner will:
  - Utilize a bipolar junction transistor (BJT) as a current-controlled current source
  - Identify the terminals of a BJT
  - Verify V-I (Voltage-Current) characteristics of a typical BJT
  - Identify the cutoff, saturation, and active regions over the BJT operating range .

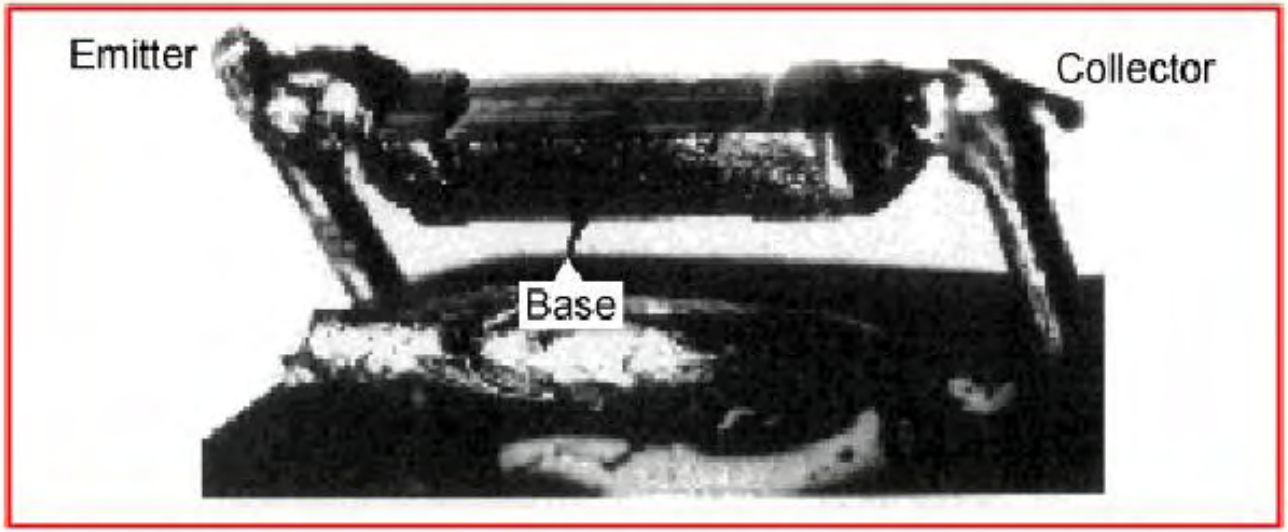
What is a Transistor?

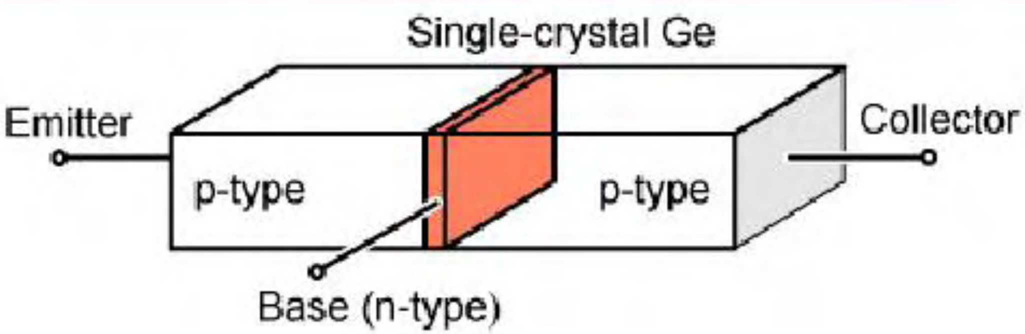
- A transistor is a device which controls the current flowing between a pair of its terminals by another smaller current
- **Integrated circuit (IC)** internally consist of transistors (Core-i7 processor contains ~billion transistors)
- Transistors can be used for **amplification**, **switching**, **voltage stabilization**, **signal modulation** and many other functions.

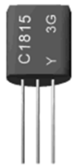
History of Transistor

The First Junction Transistor

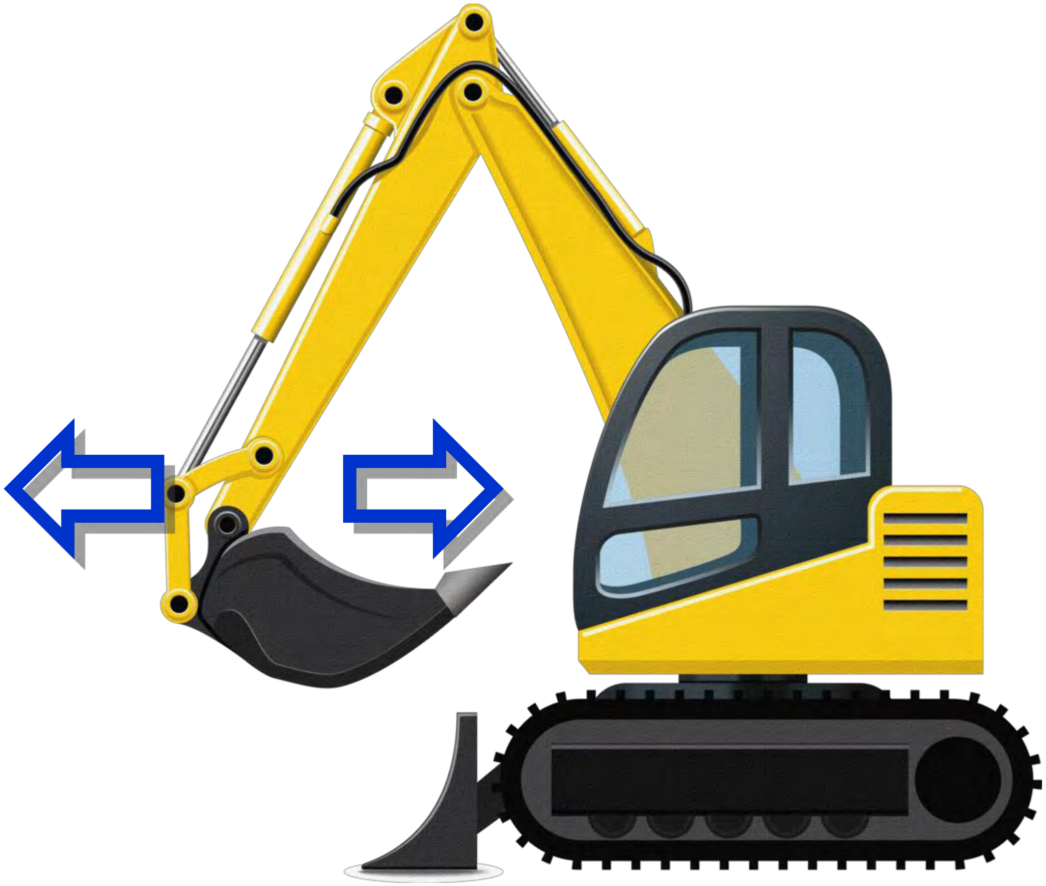
First transistor with diffused pn junctions by William Shockley
Bell Laboratories, Murray Hill, New Jersey (1949)



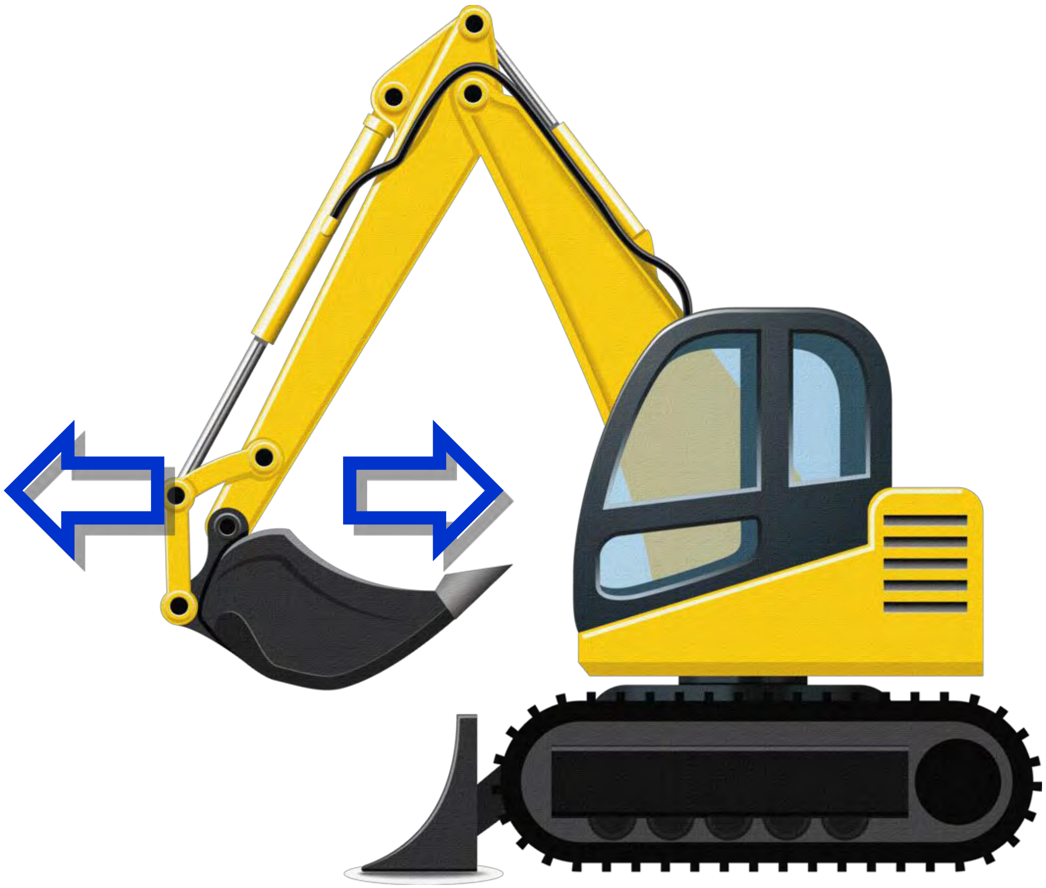


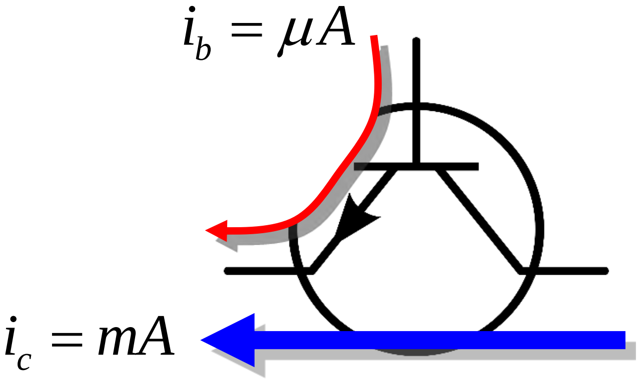


Transistor Amplifier Function

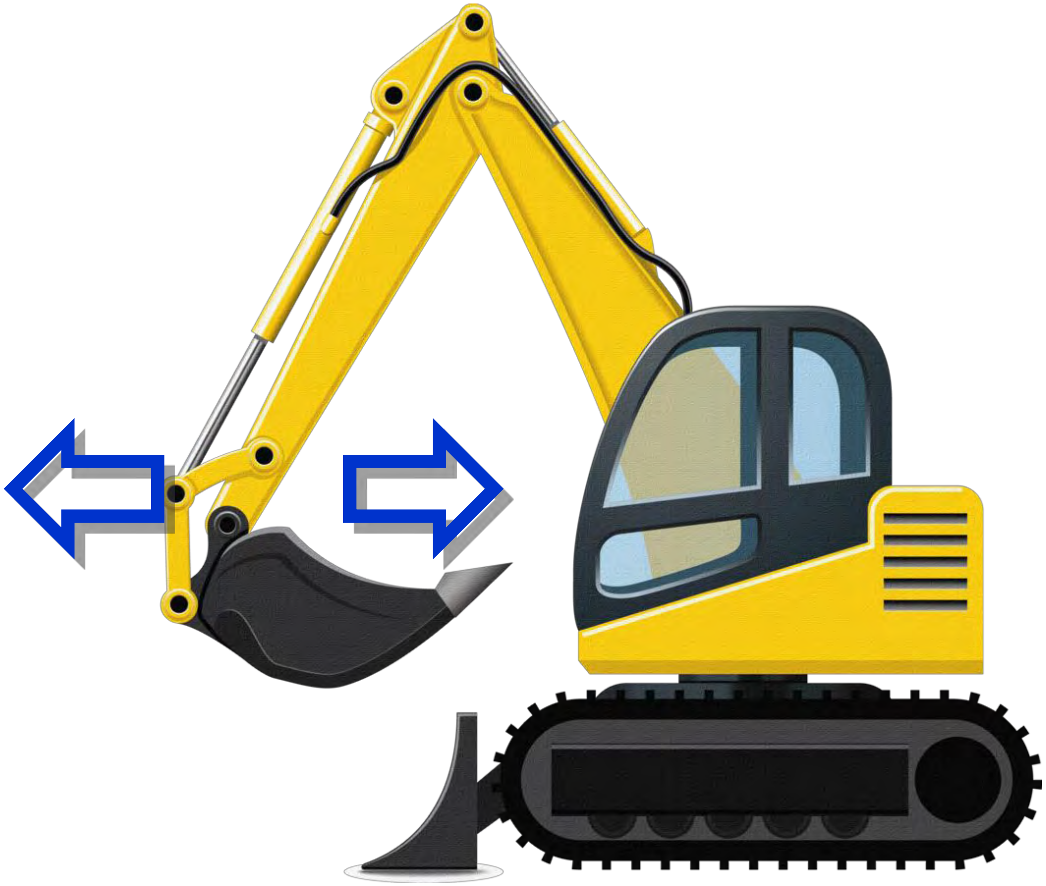


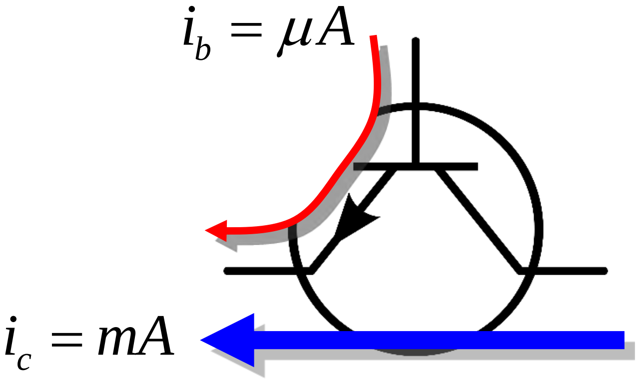
Transistor Amplifier Function





Transistor Amplifier Function





Current <u>controlled</u> current source

Transistors Types

Field Effect Transistors (FET)

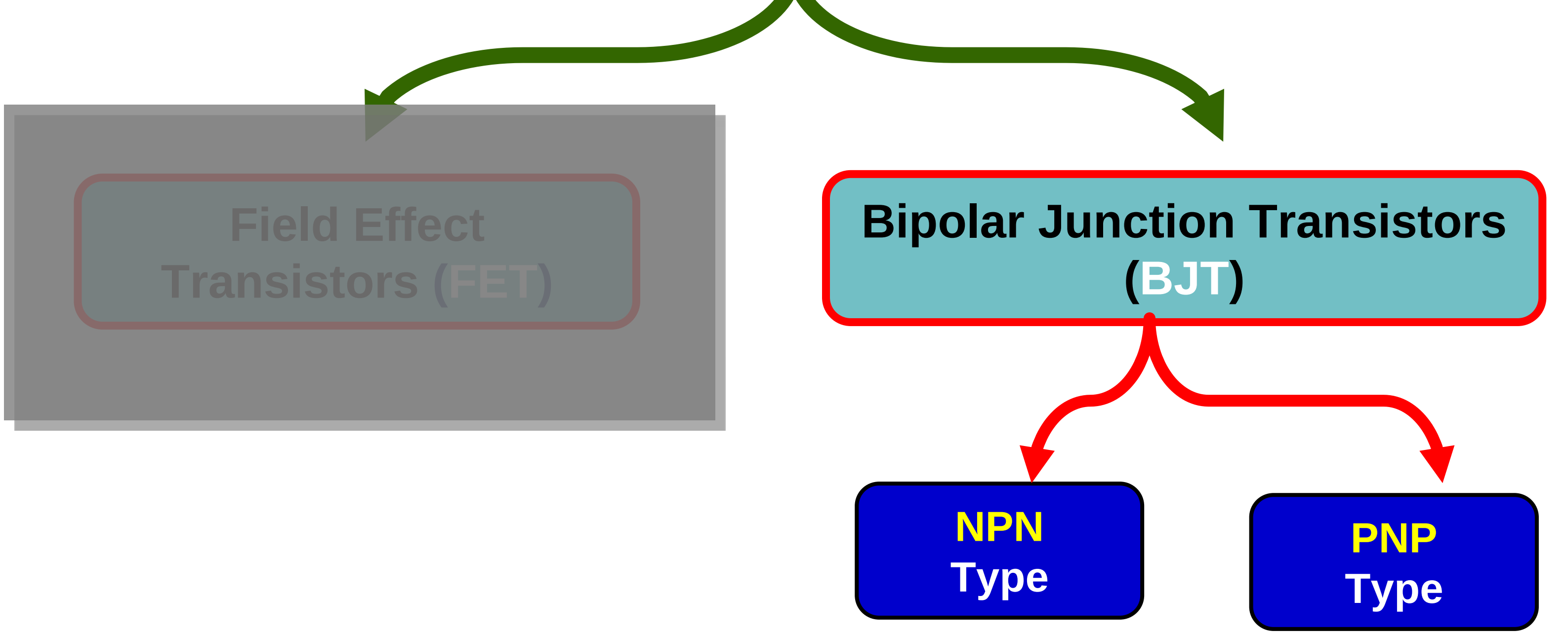
Bipolar Junction Transistors (BJT)

Transistors Types

Field Effect Transistors (FET)

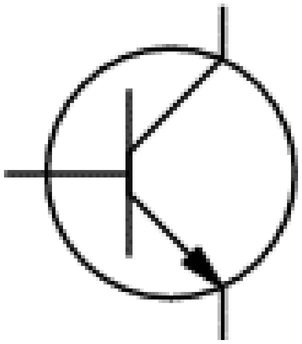
Bipolar Junction Transistors (BJT)

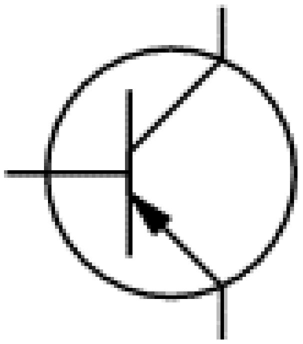
Transistors Types



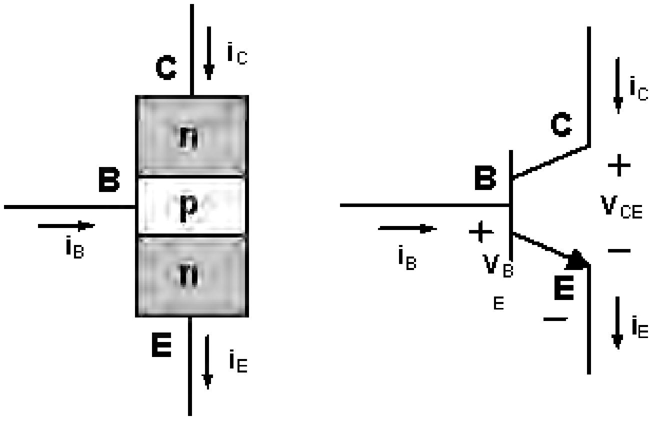
Bipolar Junction Transistor (BJT)

- 3 Terminals:
  - Base
  - Collector
  - Emitter
- 2 types of BJT:
  - NPN.
  - PNP.

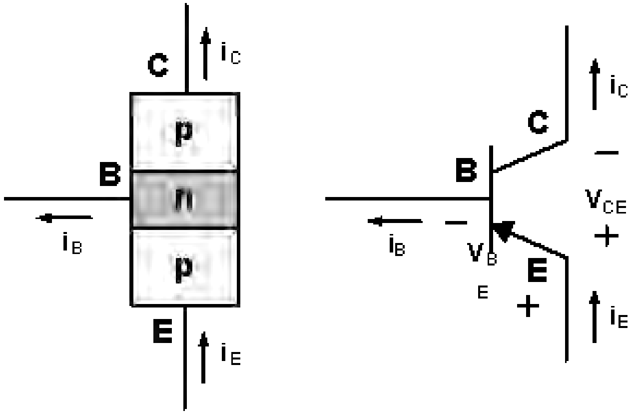




NPN



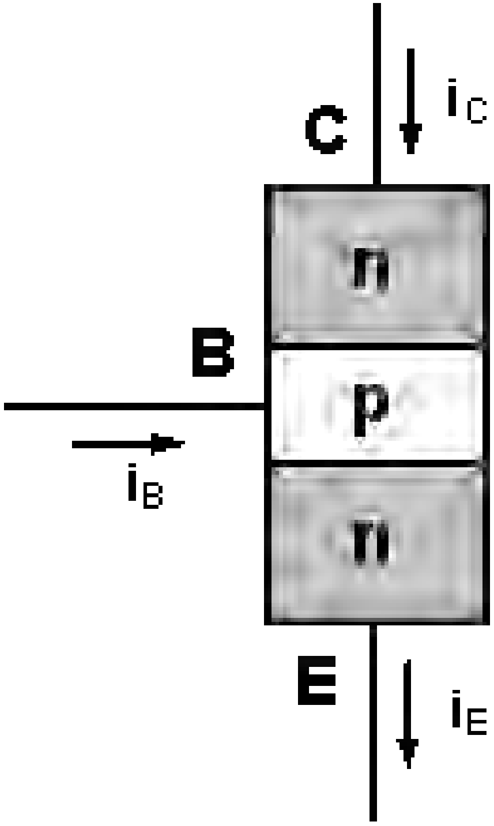
PNP

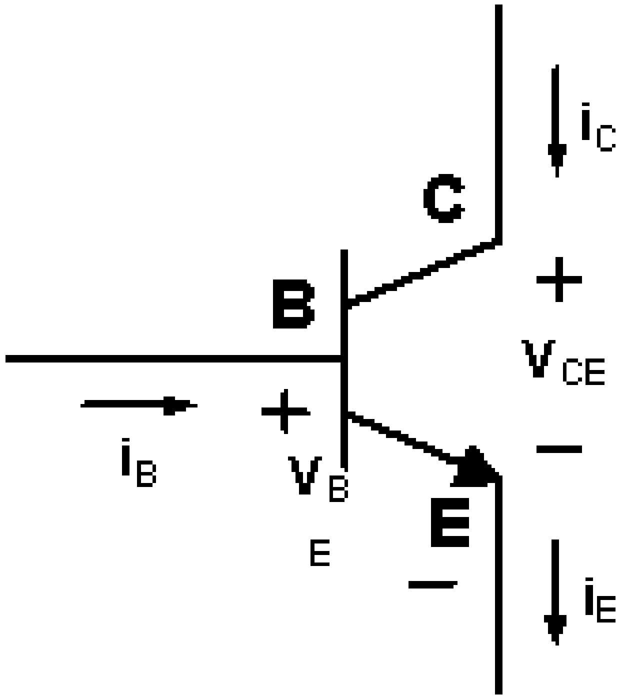


BJT: Configuration

- BJTs are current-controlled devices

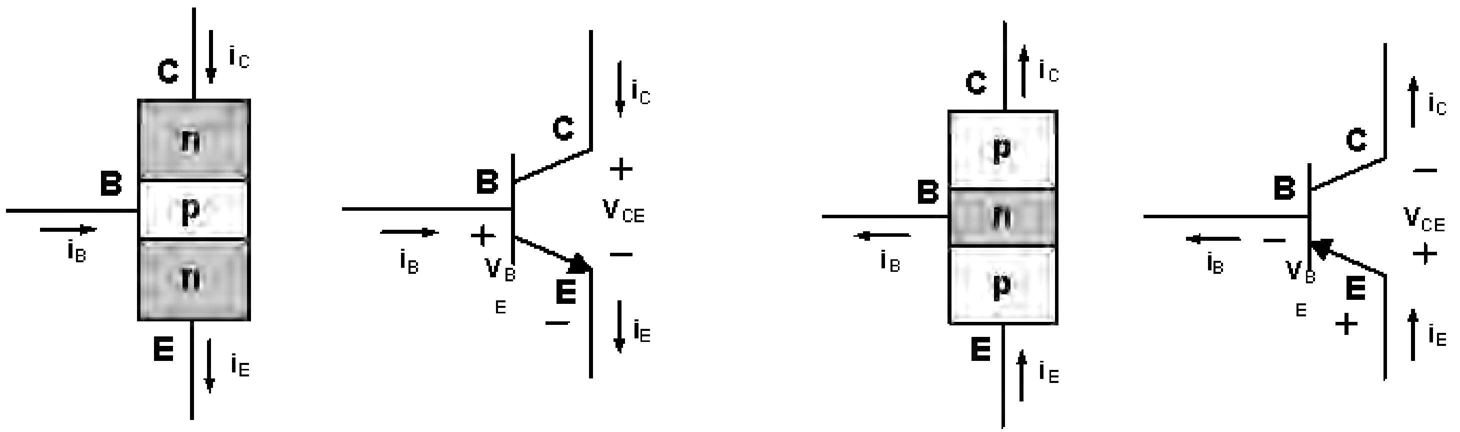
$I_E = I_B + I_C$ ... (KCL)





BJT Checking

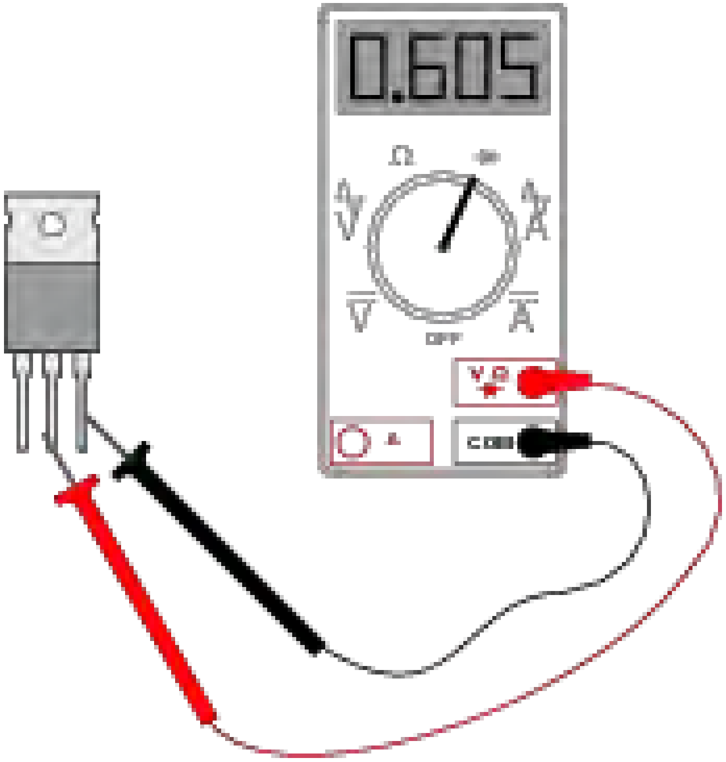
- Bipolar transistors are either NPN or PNP.

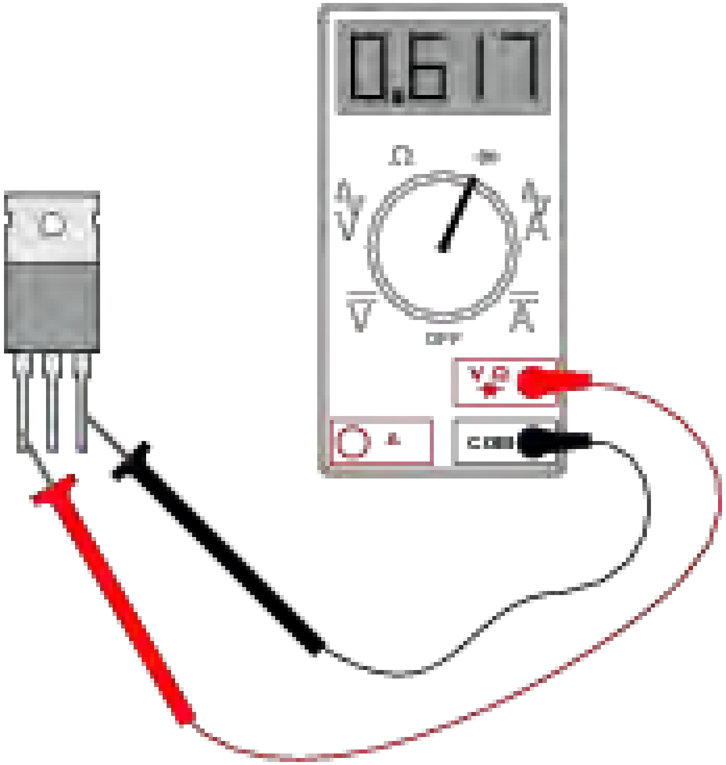


- For purposes of quick testing only, a transistor can be thought of as two back to back diodes.

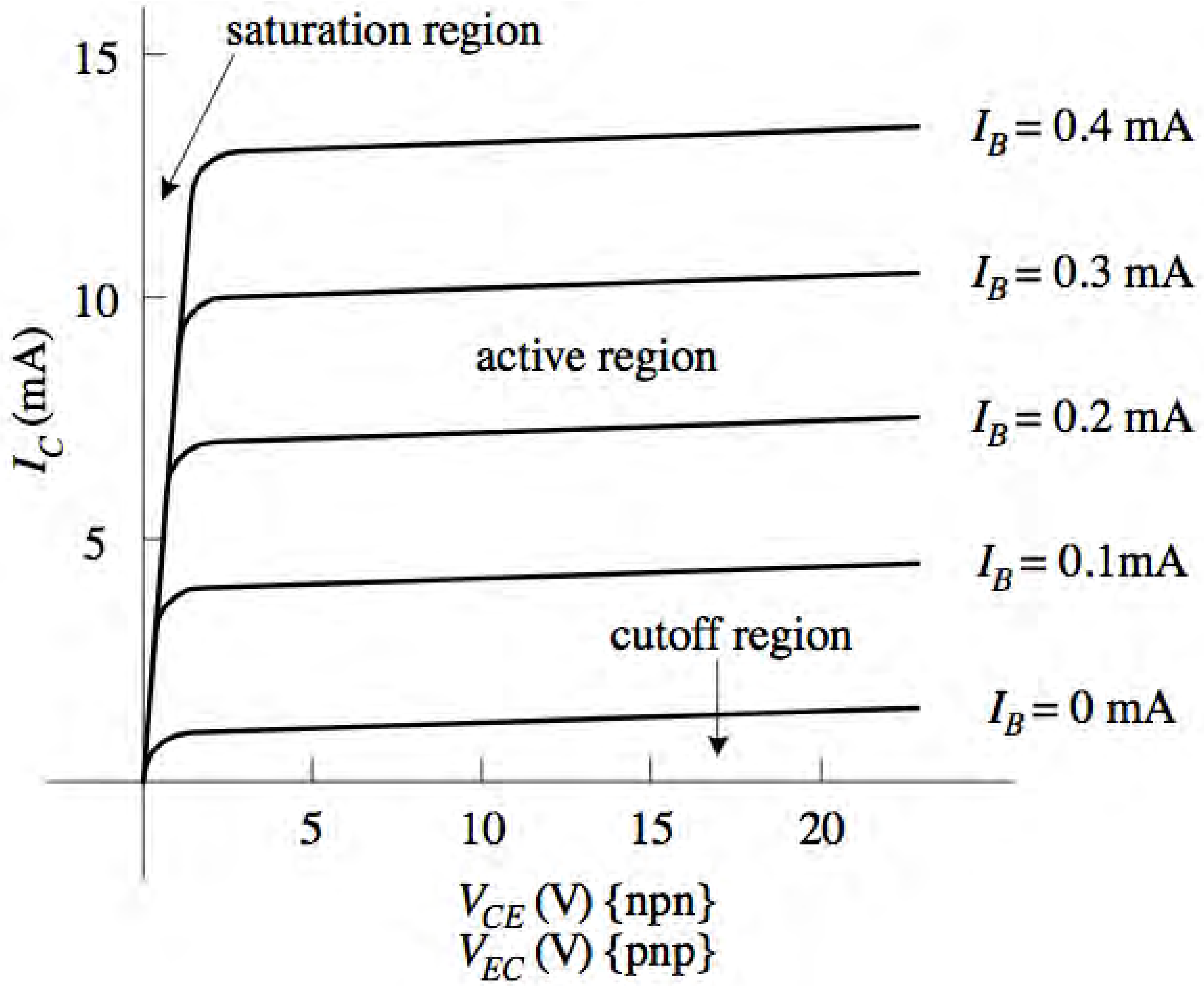
BJT Checking: Known Type

- **Using Ohm Function**:
  Apply the same method used to determine polarity of diode
  .

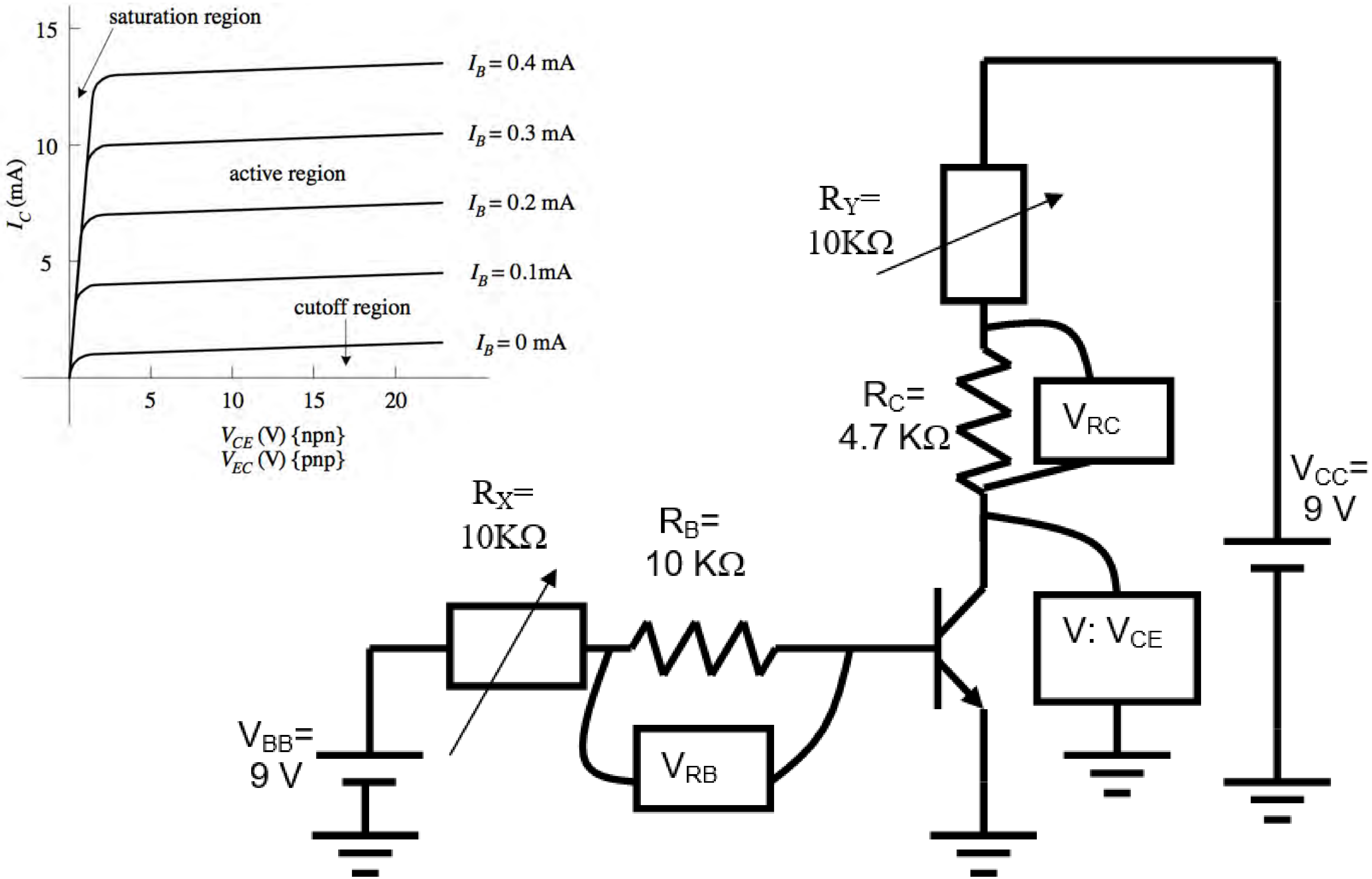




BJT: Output Characteristics

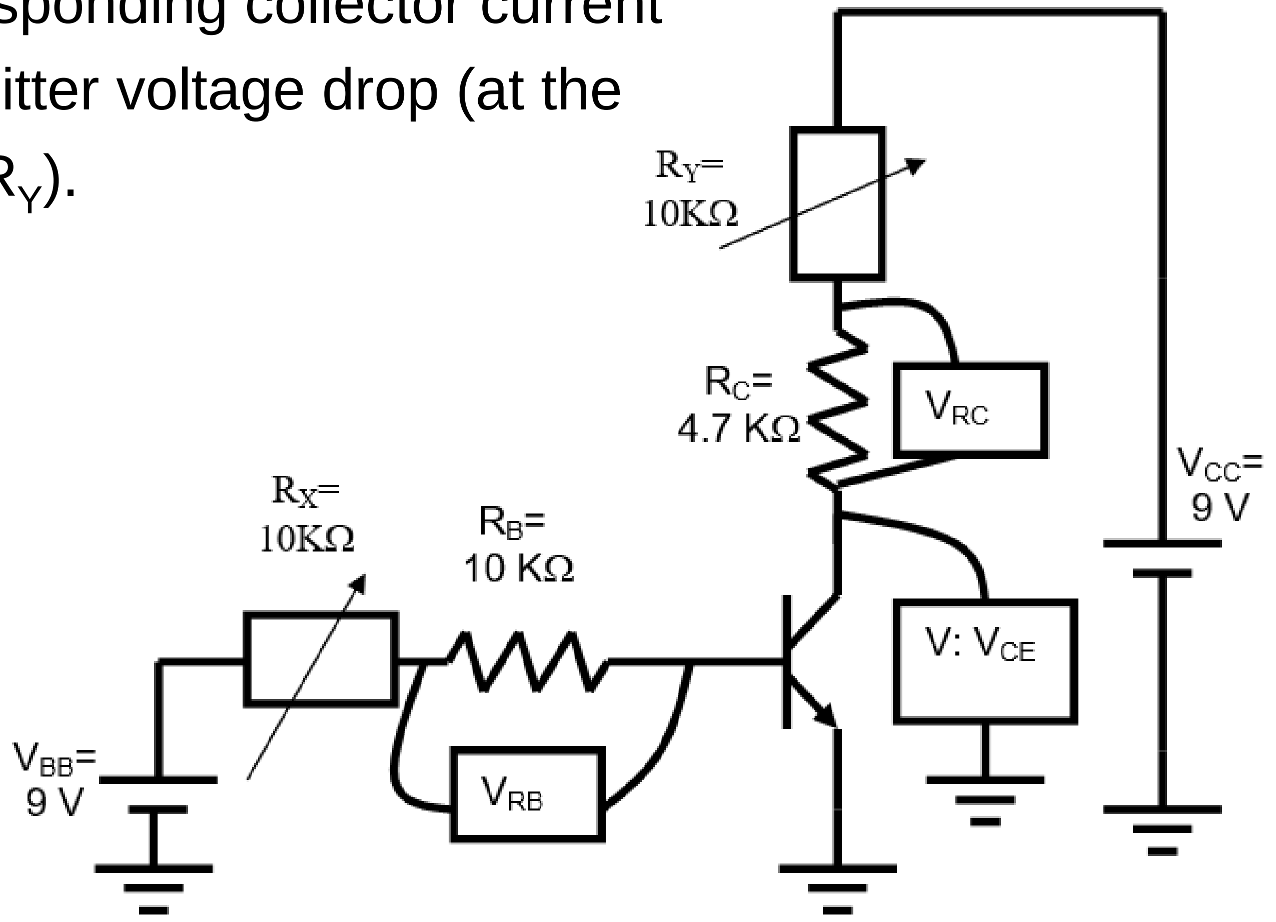


BJT Characteristics: Lab Experiment



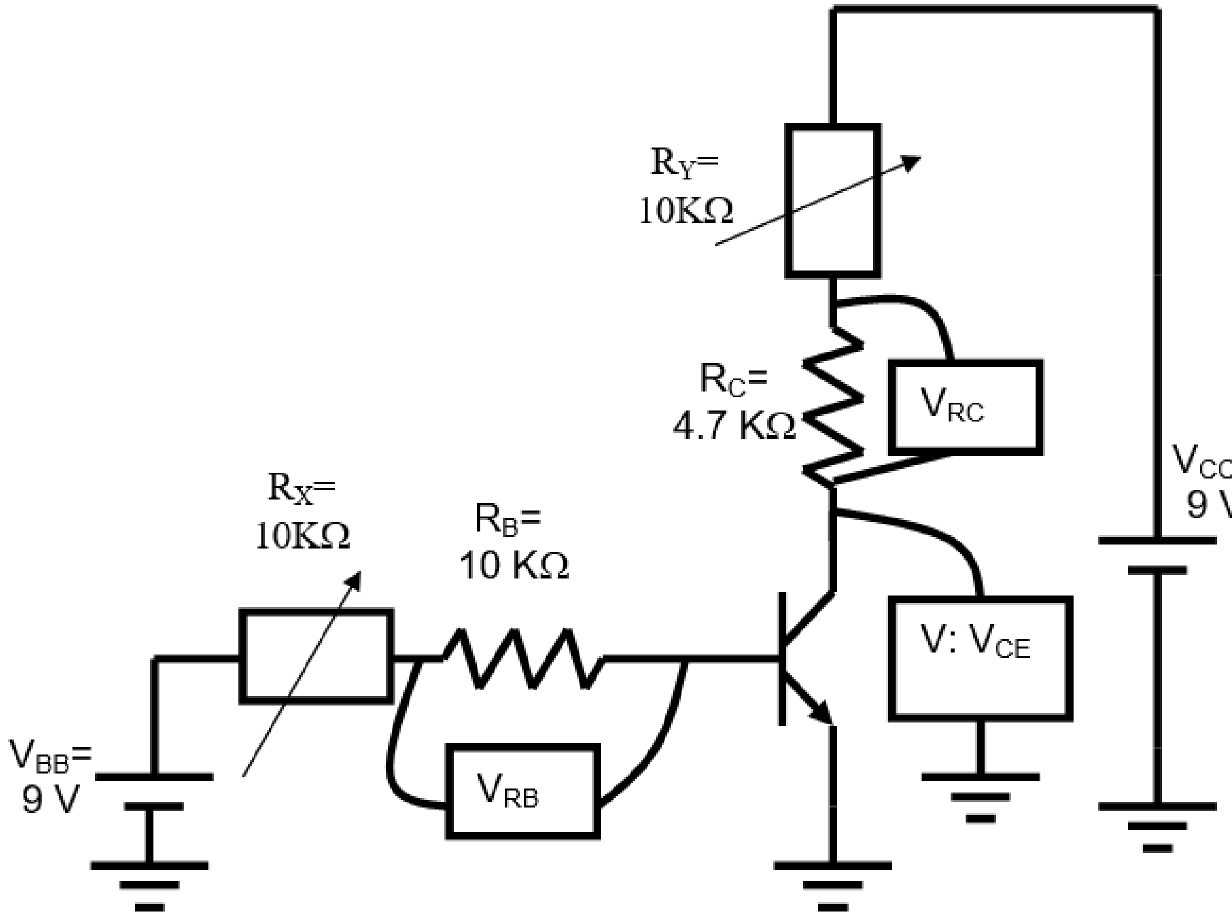
BJT Characteristics: Lab Experiment

1. Connect the circuit in the Figure below.
2. Adjust the variable resistors to provide their minimum values.
3. Adjust the resistance R_X to provide I_B=10μA.
4. Measure the corresponding collector current and collector-to-emitter voltage drop (at the minimum value of R_Y).



BJT Characteristics: Lab Experiment

5. Begin to increase R_Y step-by-step and measure the resulting I_C and V_{CE} at fixed I_B and fill the first two columns of the measurement Table.



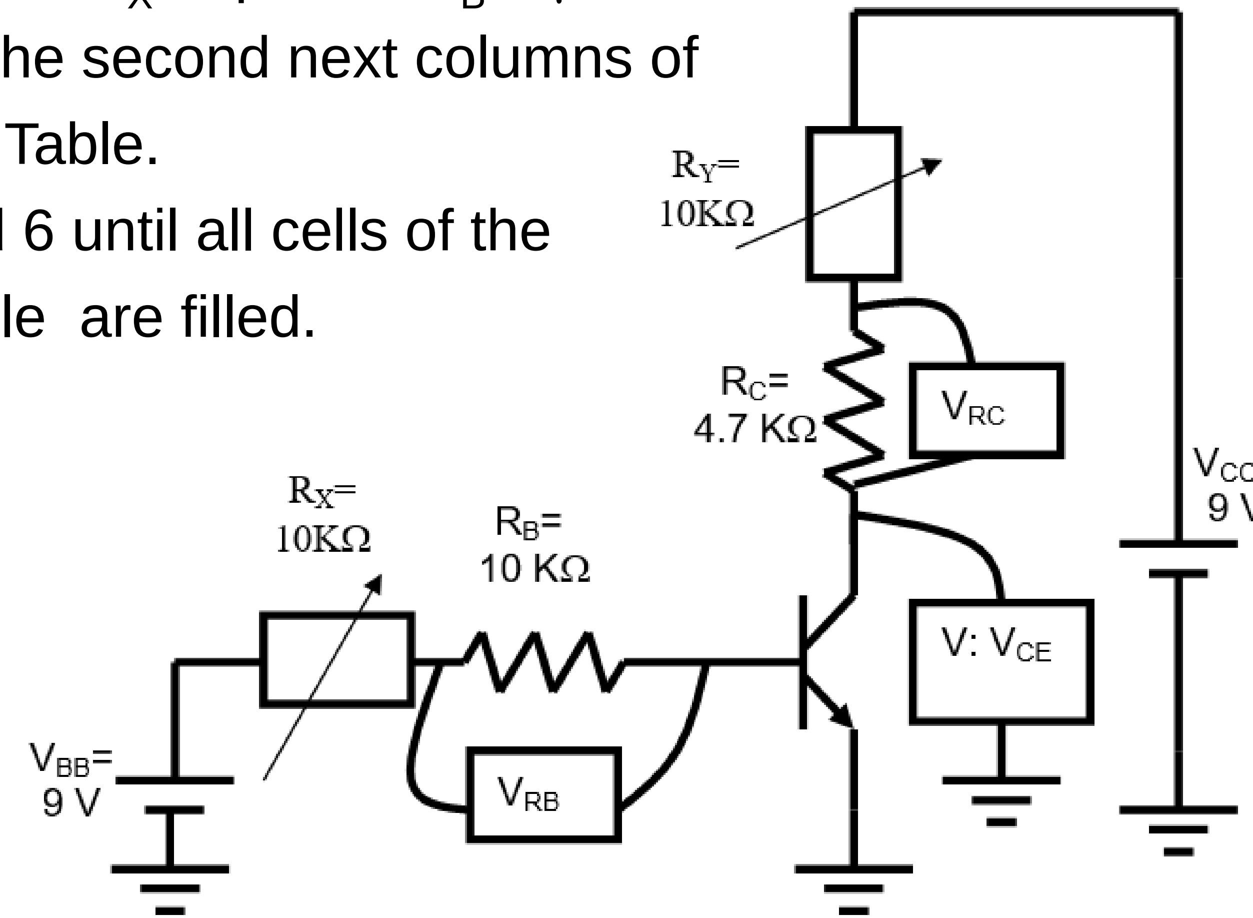
BJT Characteristics: Lab Experiment

5. Begin to increase R_Y step-by-step and measure the resulting I_C and V_{CE} at fixed I_B and fill the first two columns of the measurement Table.

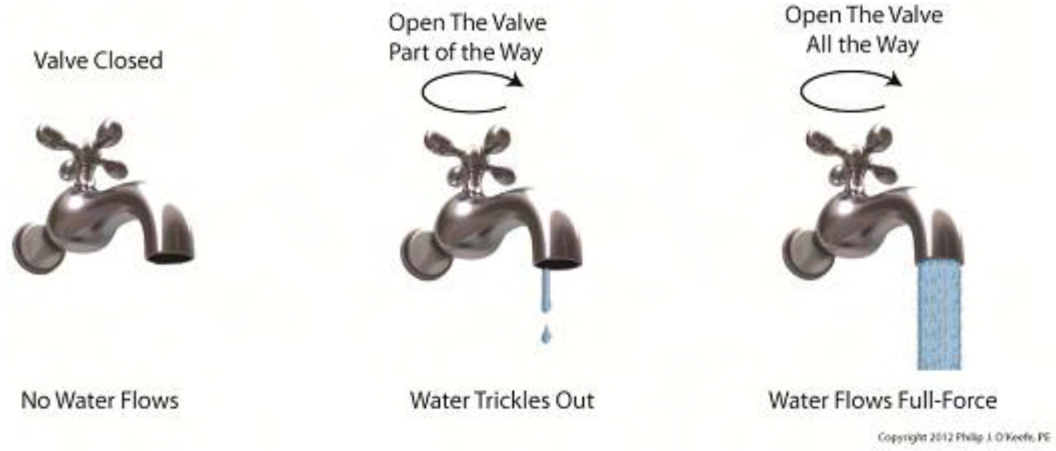
Table.2 BJT Output Characteristics							
$I_B=10\mu A$		$I_B=5\mu A$		$I_B=3\mu A$		$I_B=2\mu A$	
I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)	I_C(mA)	V_{CE}(V)

BJT Characteristics: Lab Experiment

5. Begin to increase R_Y step-by-step and measure the resulting I_C and V_{CE} at fixed I_B and fill the first two columns of the measurement Table.
6. Readjust the resistor R_X to provide I_B=5μA.
7. Repeat step 5 fill the second next columns of the measurement Table.
5. Repeat until 5 and 6 until all cells of the measurement Table are filled.



Transistors Types



التجربة العاشرة

Course Contents

Experiment-0: Overview of laboratory equipment's (Digital Multimeters, Function Generators, Oscilloscope)

Experiment-1: Passive Elements.

Experiment-2: Transient Circuits.

Experiment-3: Nonlinear Resistances.

Experiment-4: Passive Filters.

Experiment-5: Resonant Circuits.

Experiment-6: Circuit Theorems.

Experiment-7: Semiconductor Diodes and its Applications.

Experiment-8: Special Diodes.

Experiment-9: Bipolar Junction Transistors.

Experiment-10: Logic Gates.

Experiment-11: Power Supplies.

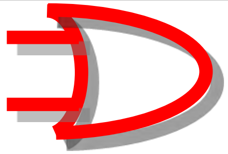
Experiement-10 Objectives

- To experimentally validate standard logic gate functions
- Implement custom (high current/high power) logic switching functions using diodes and transistors

Logic Gate Families

- Logic gate families:
  - Diode Resistor Logic (DRL)
  - Resistor-Transistor Logic (RTL)
  - Diode-Transistor Logic (DTL)
  - Transistor-Transistor Logic (TTL)
  - Emitter-Coupled Logic (ECL)
  - Complementary Metal-Oxide Semiconductors (CMOS)

OR Gate

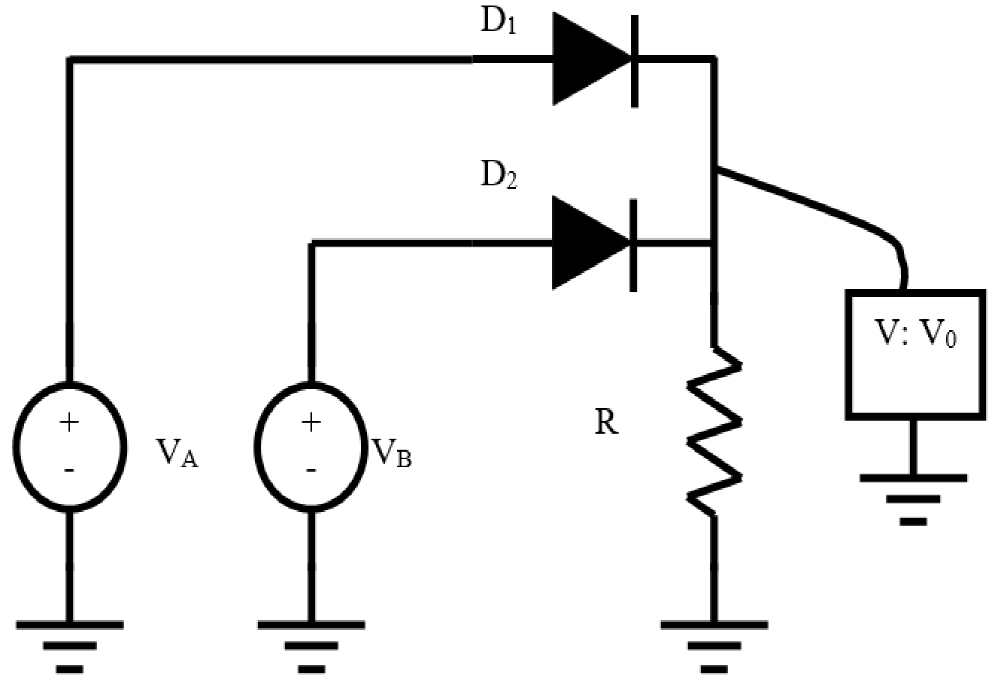


Truth Table

V_A	V_B	V_0
0	0	0
0	1	1
1	0	1
1	1	1

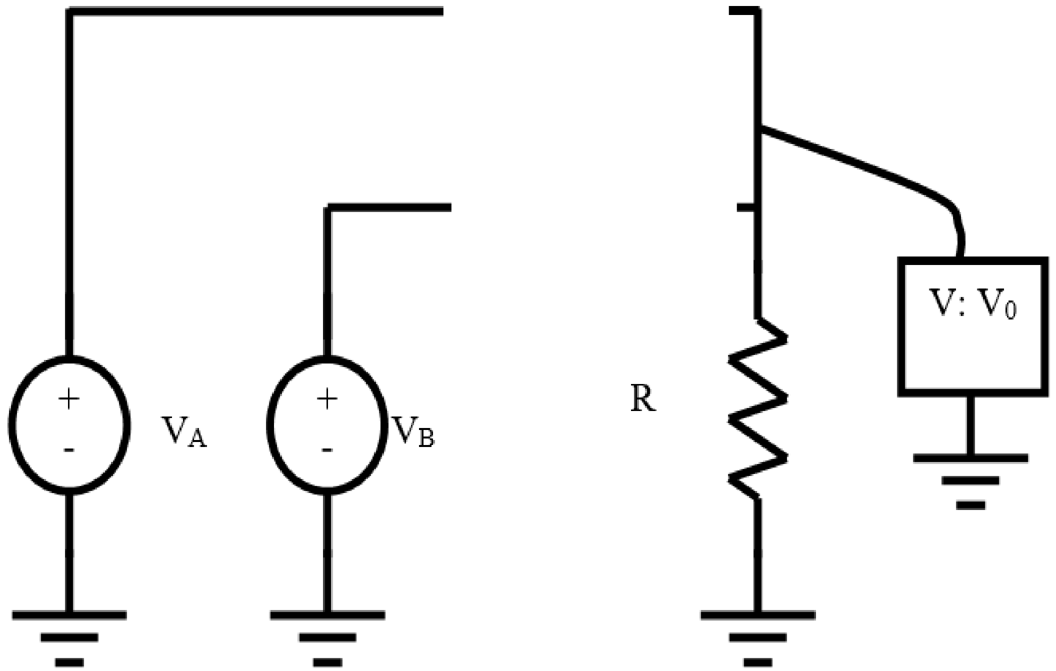
Truth Table

V_A	V_B	V_0
Low	Low	Low
High	Low	High
Low	High	High
High	High	High



Low = 0 Volts
High = 6 volts

OR Gate: **cont'd**

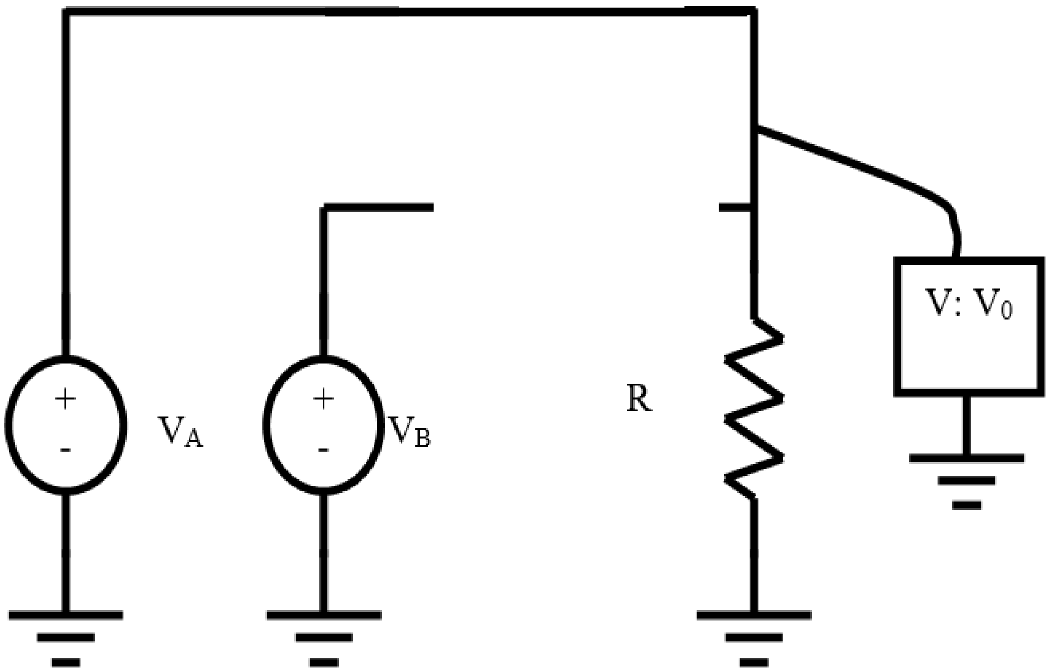


When V_A = Low, and V_B = Low

$$D_1 \Rightarrow R.B. \Rightarrow O.C.$$
$$D_2 \Rightarrow R.B. \Rightarrow O.C.$$

$$V_0 = Low$$

OR Gate: **cont'd**



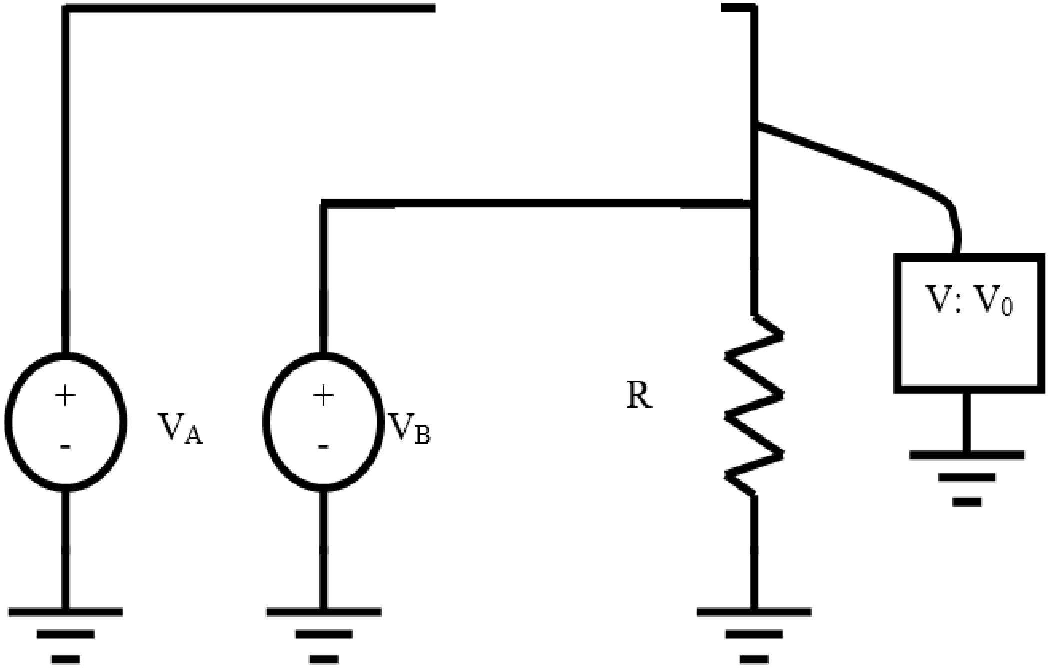
When V_A= High, and V_B = Low

$$D_1 \Rightarrow F.B. \Rightarrow S.C.$$

$$D_2 \Rightarrow R.B. \Rightarrow O.C.$$

$$V_0 = High$$

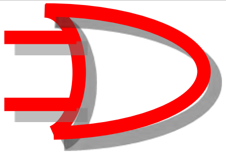
OR Gate: **cont'd**

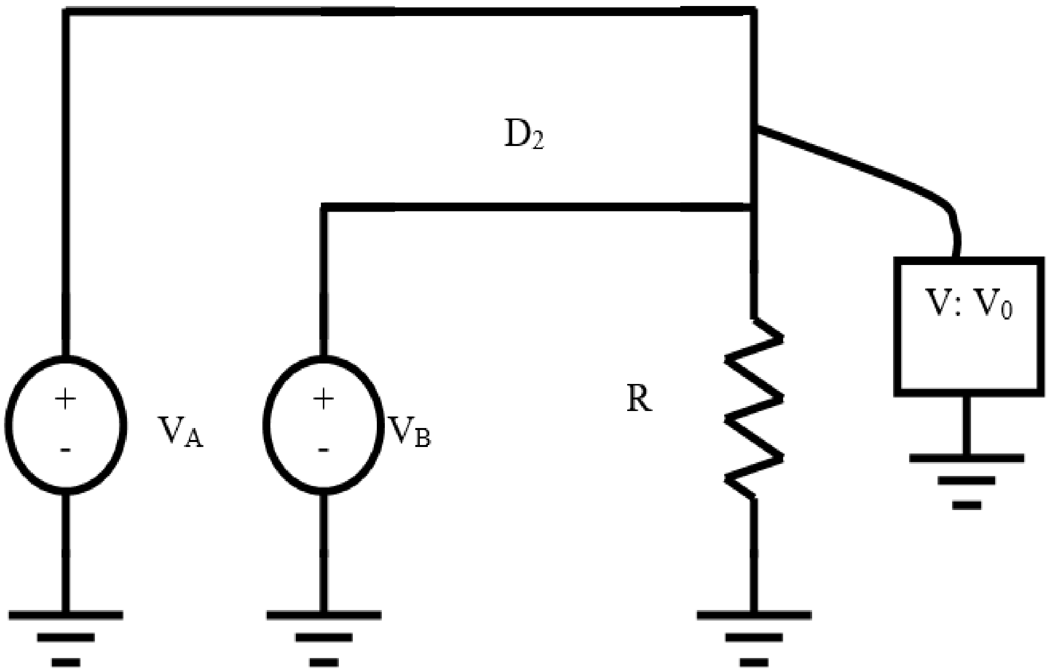


When V_A= Low, and V_B = High

$$D_1 \Rightarrow R.B. \Rightarrow O.C.$$
$$D_2 \Rightarrow F.B. \Rightarrow S.C.$$
$$V_0 = High$$

OR Gate: **cont'd**



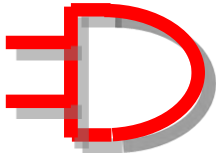


When V_A= High, and V_B = High

$$D_1 \Rightarrow F.B. \Rightarrow S.C.$$
$$D_2 \Rightarrow F.B. \Rightarrow S.C.$$

$$V_0 = High$$

AND Gate

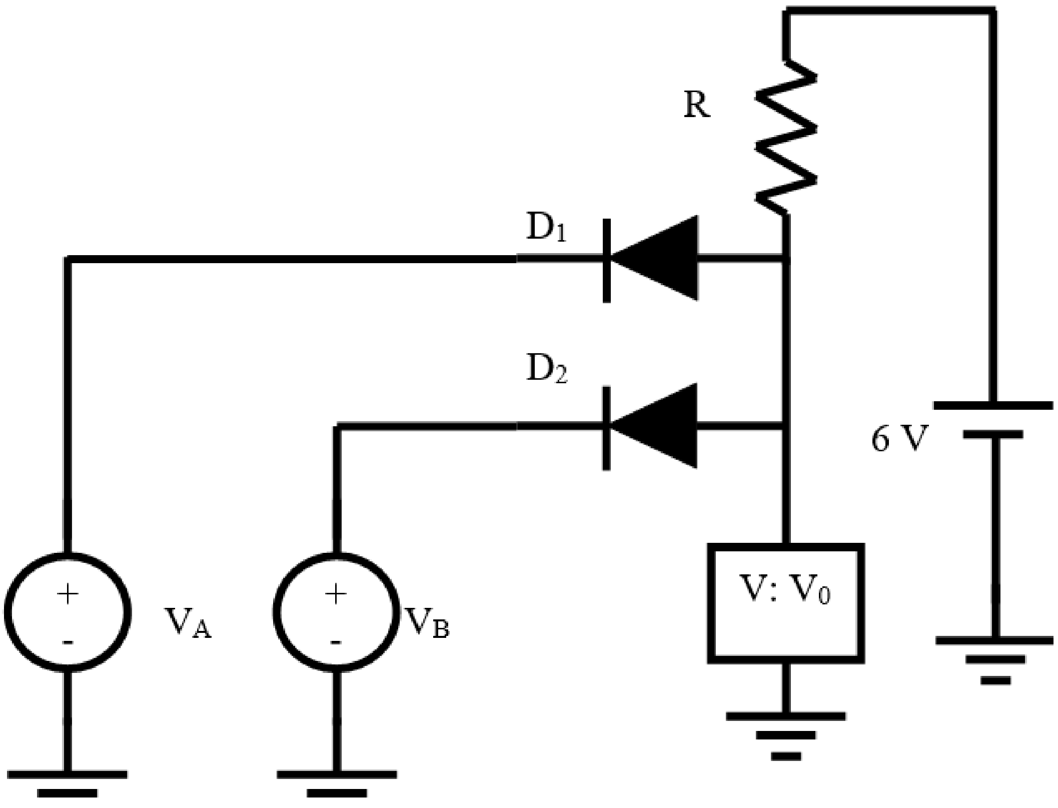


Truth Table

V_A	V_B	V_0
0	0	0
0	1	0
1	0	0
1	1	1

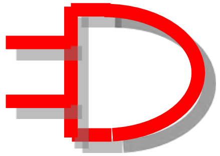
Truth Table

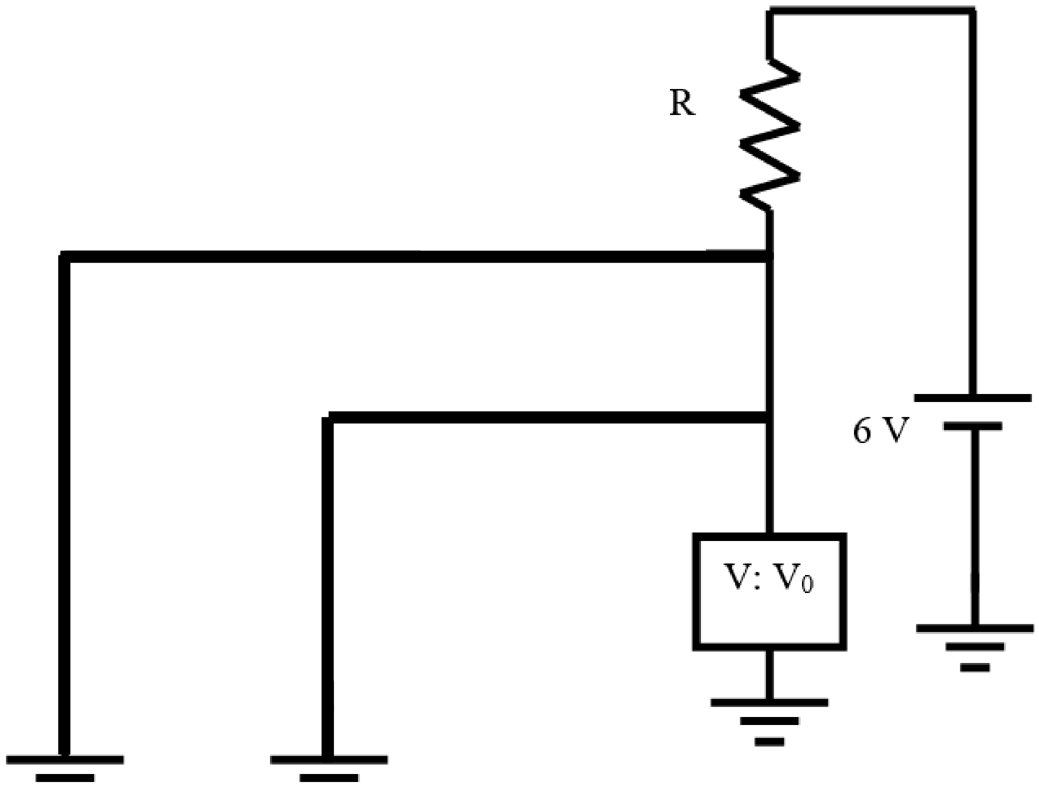
V_A	V_B	V_0
Low	Low	Low
High	Low	Low
Low	High	Low
High	High	High



Low = 0 Volts
High = 6 volts

AND Gate: **cont'd**



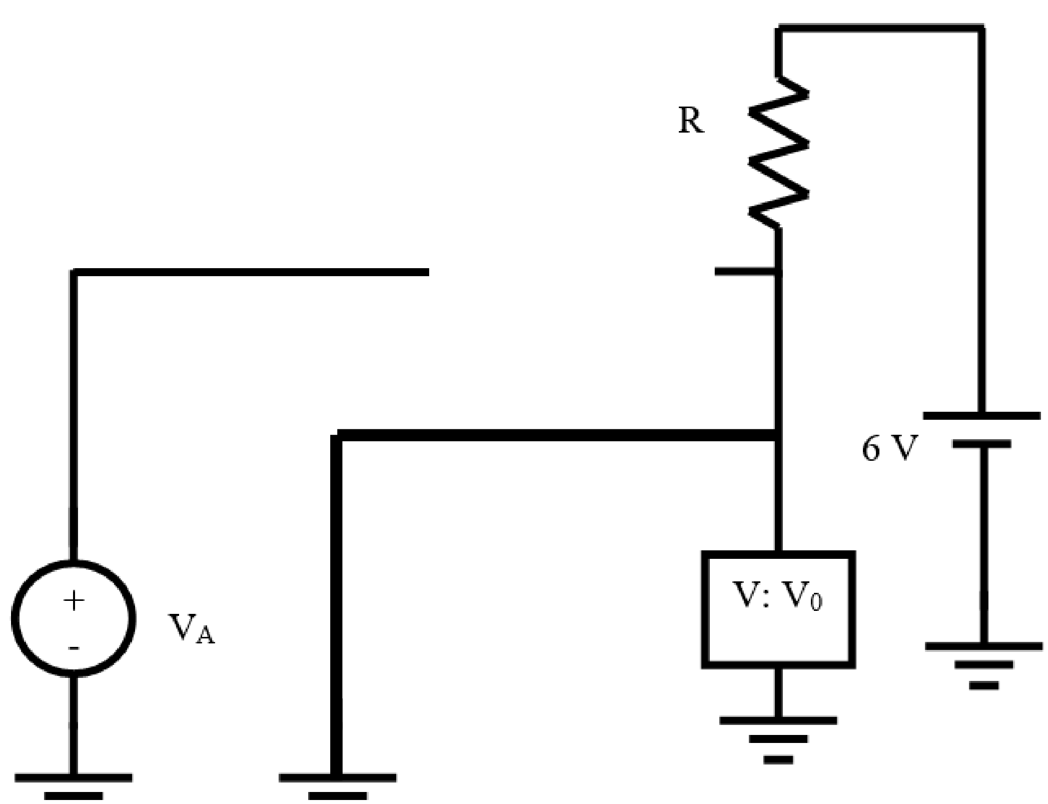


When V_A = Low, and V_B = Low:

$$D_1 \Rightarrow F.B. \Rightarrow S.C.$$
$$D_2 \Rightarrow F.B. \Rightarrow S.C.$$

$$V_0 = Low$$

AND Gate: **cont'd**

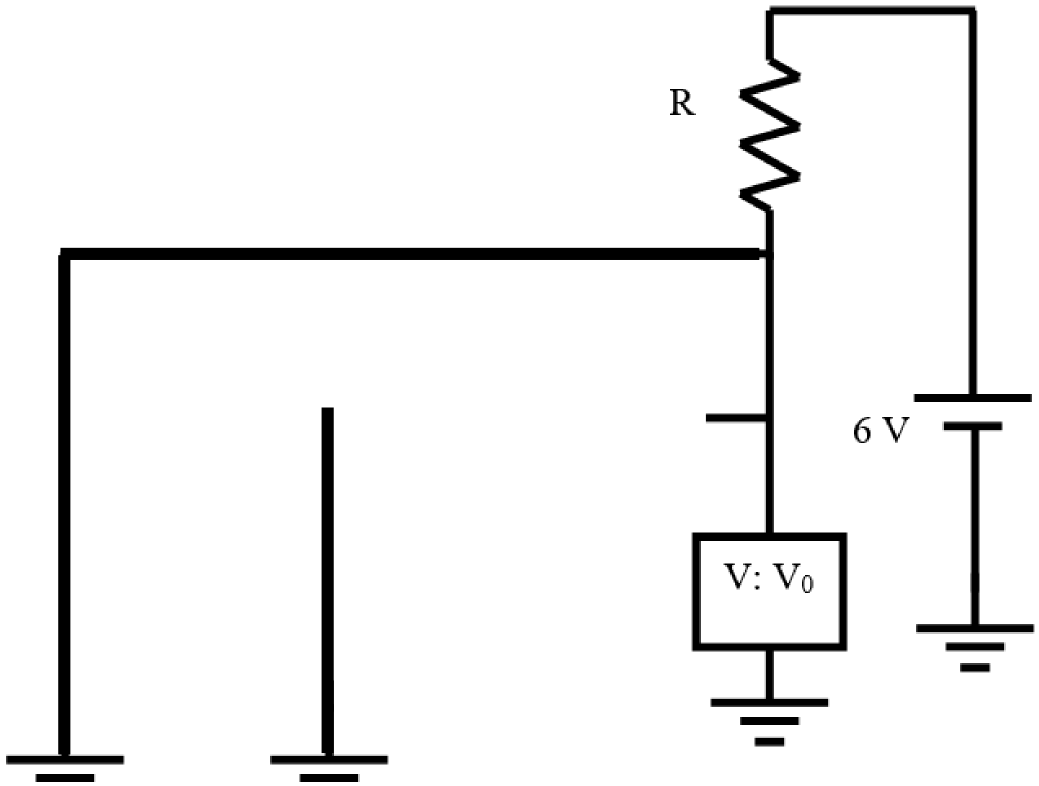


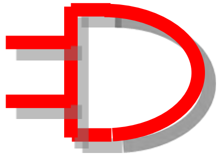
When V_A = High, and V_B = Low

$$D_1 \Rightarrow R.B. \Rightarrow O.C.$$
$$D_2 \Rightarrow F.B. \Rightarrow S.C.$$

$$V_0 = Low$$

AND Gate: **cont'd**





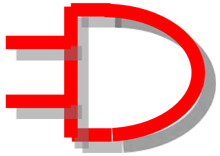
When V_A= Low, and V_B = High

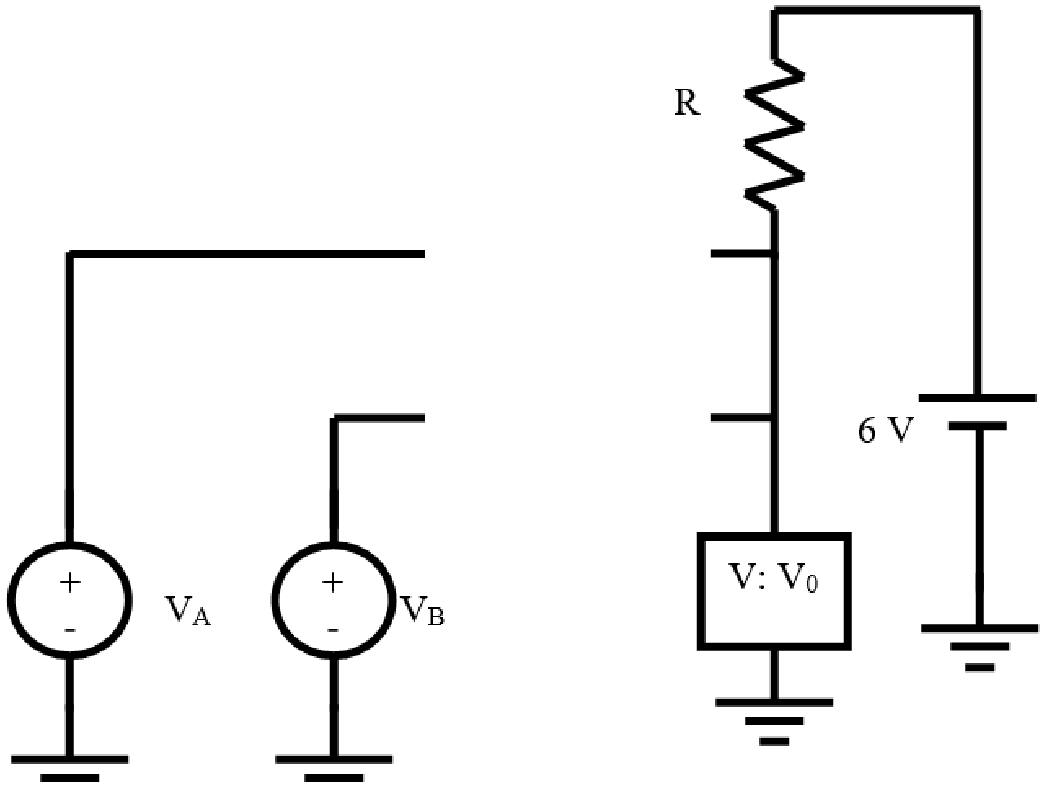
$$D_1 \Rightarrow F.B. \Rightarrow S.C.$$

$$D_2 \Rightarrow R.B. \Rightarrow O.C.$$

$$V_0 = Low$$

AND Gate: **cont'd**





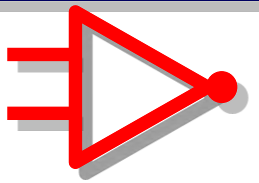
When V_A= High, and V_B = High

$$D_1 \Rightarrow R.B. \Rightarrow O.C.$$

$$D_2 \Rightarrow R.B. \Rightarrow O.C.$$

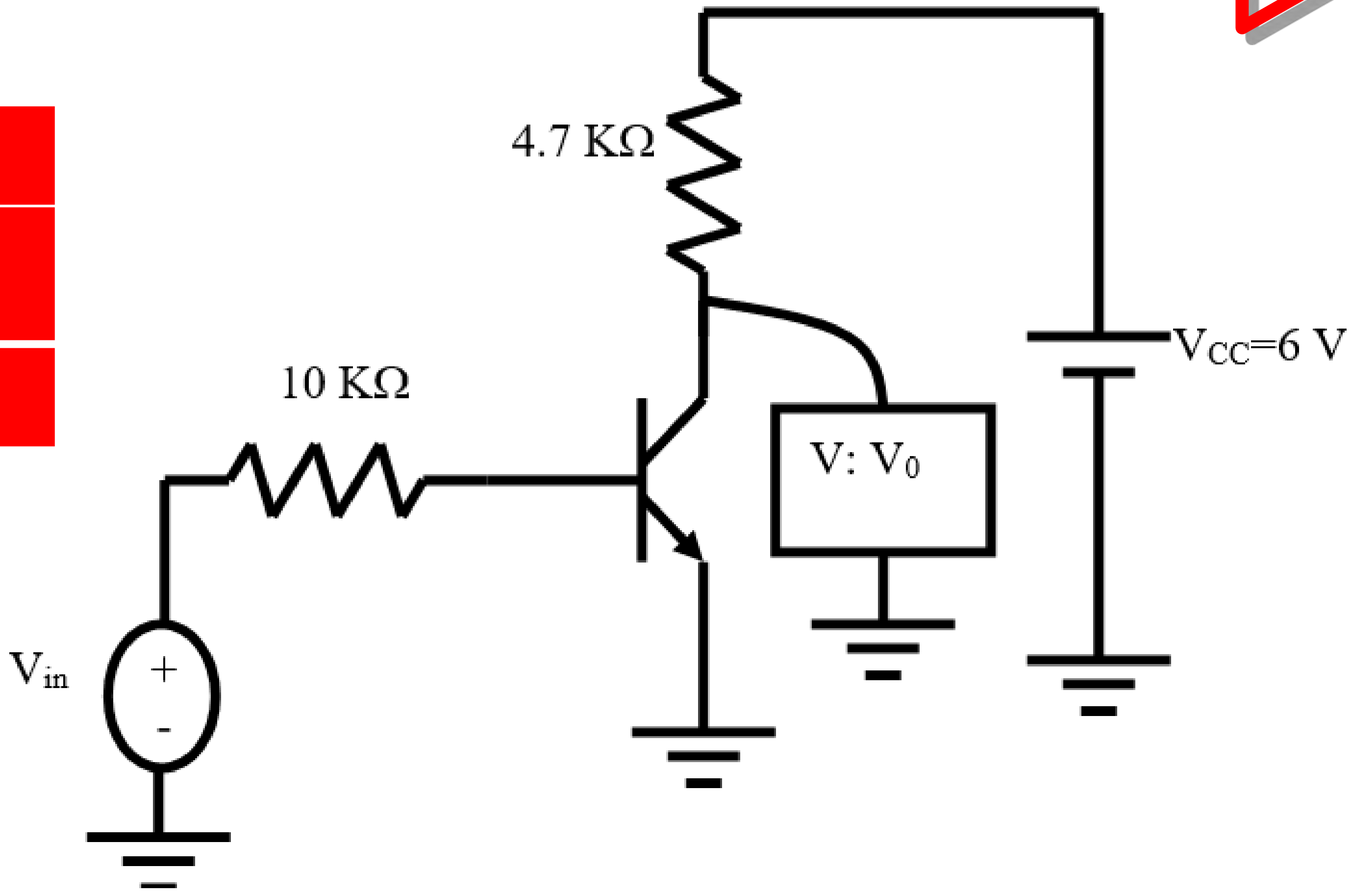
$$V_0 = High$$

Transistor-based Logic Gates: NOT Gate

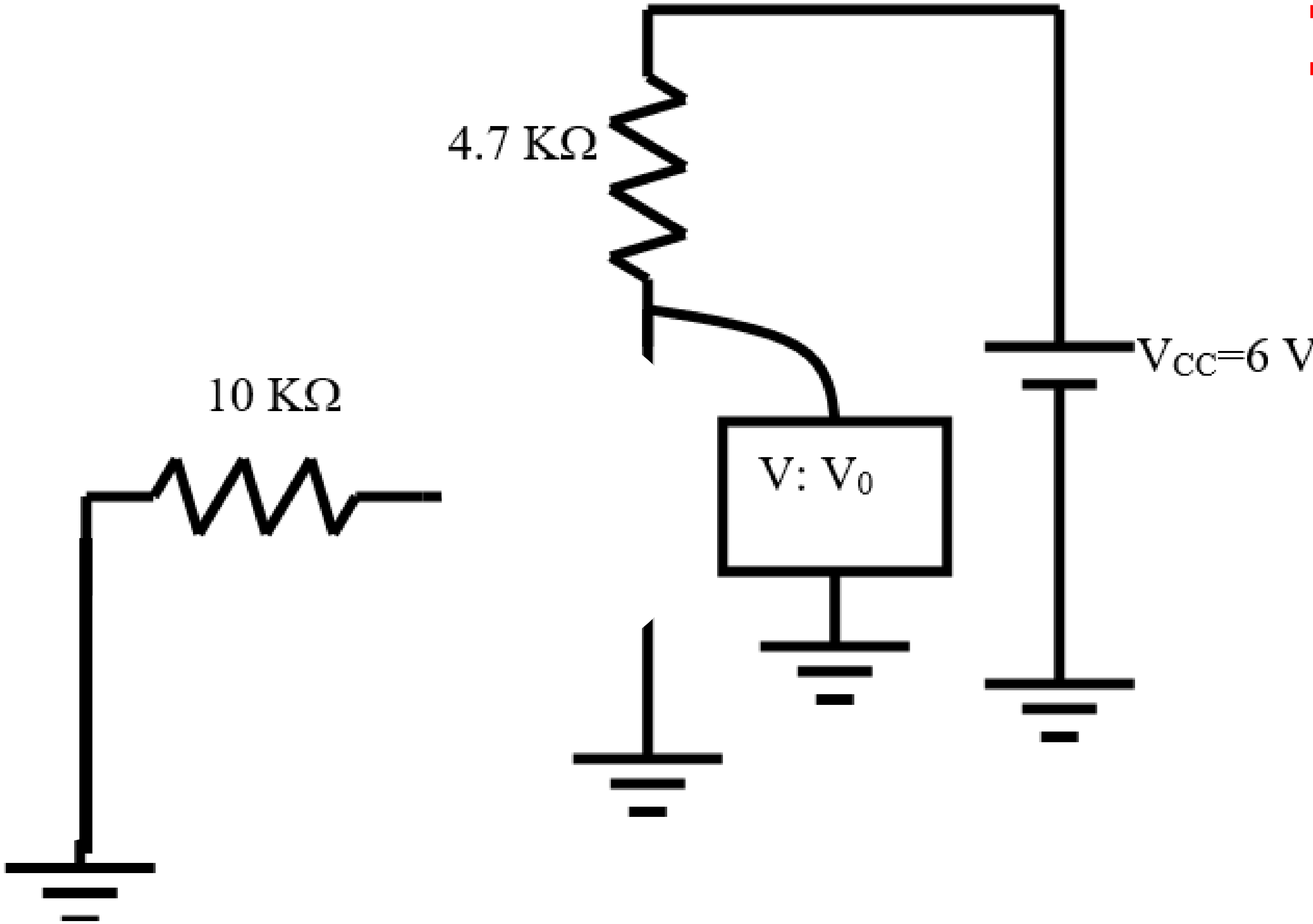


Truth Table

V_A	V_0
0	1
1	0



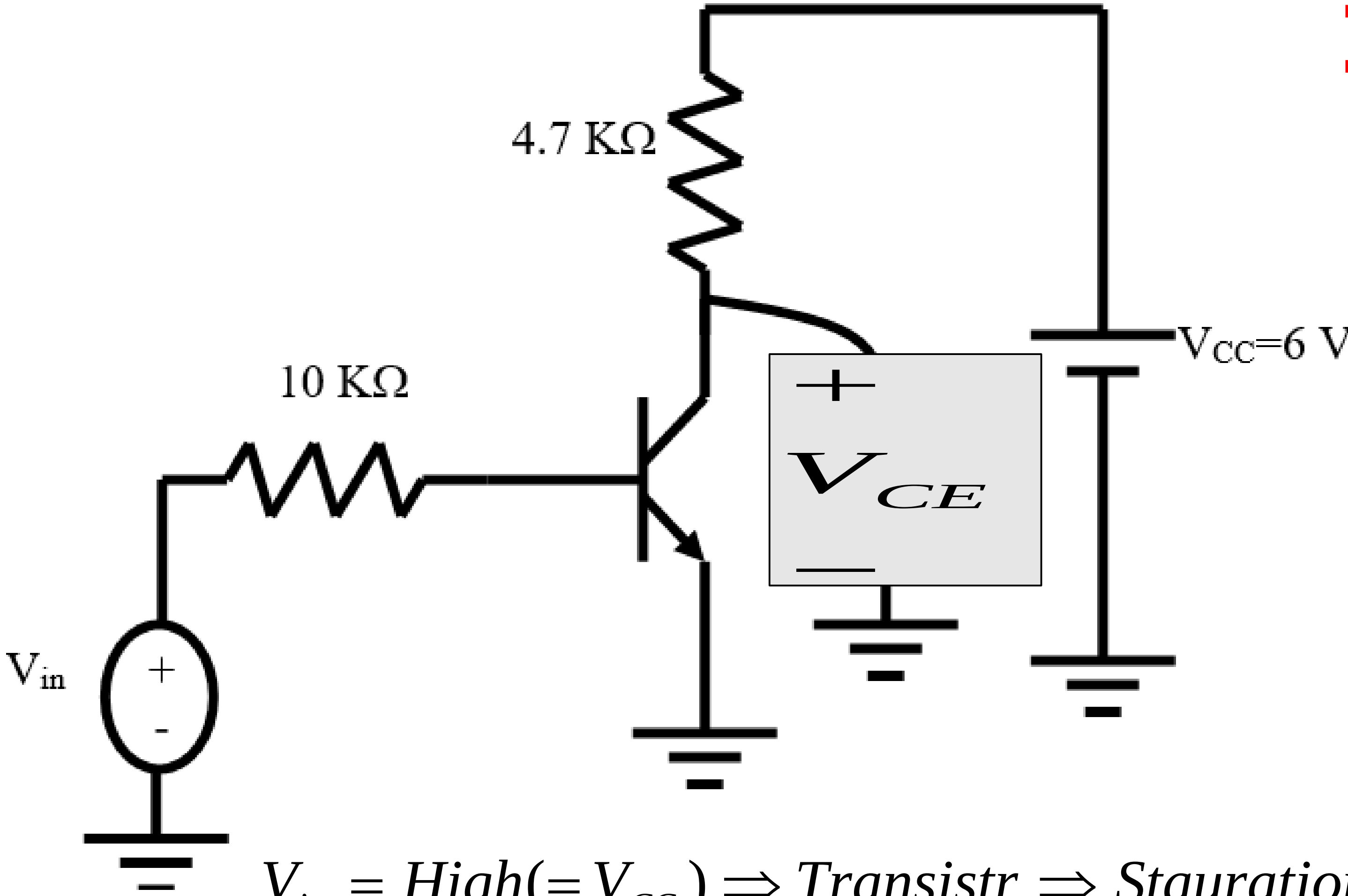
NOT Gate: **cont'd**

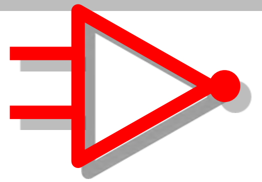


$$V_{in} = 0, \Rightarrow Transistor \Rightarrow CUT\ \ OFF \Rightarrow Open$$

$$V_0 = V_{CC}$$

NOT Gate: **cont'd**





$$V_{in} = High(= V_{CC}) \Rightarrow Transistr \Rightarrow Stauration$$

$$\Rightarrow Closed\ Switch$$

$$\Rightarrow V_{CE} \approx 0$$

$$V_0 = V_{CE} \approx 0$$

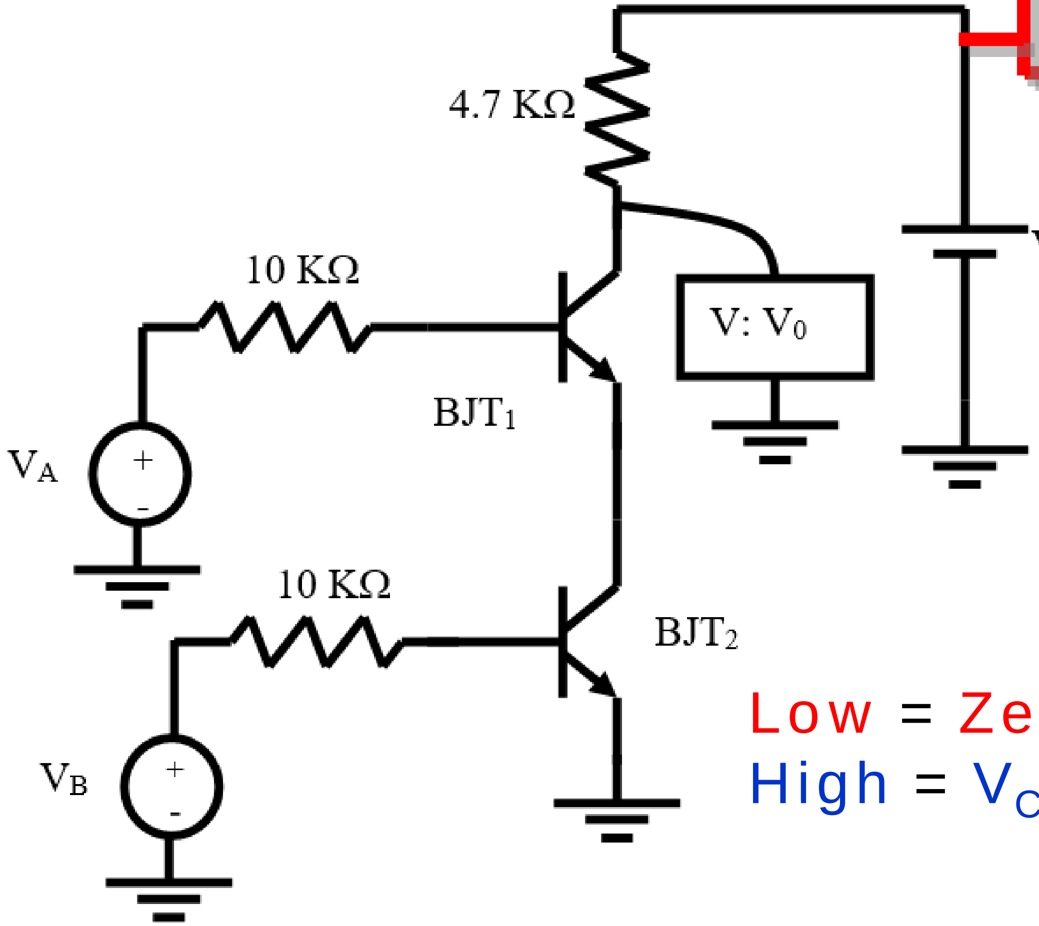
Transistor-based Logic Gates: NAND Gate

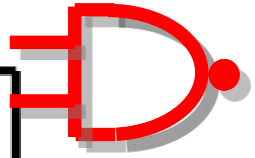
Truth Table

V_A	V_B	V_0
0	0	1
0	1	1
1	0	1
1	1	0

Truth Table

V_A	V_B	V_0
Low	Low	High
High	Low	High
Low	High	High
High	High	Low





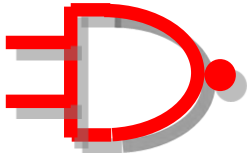
Low = Zero "0"

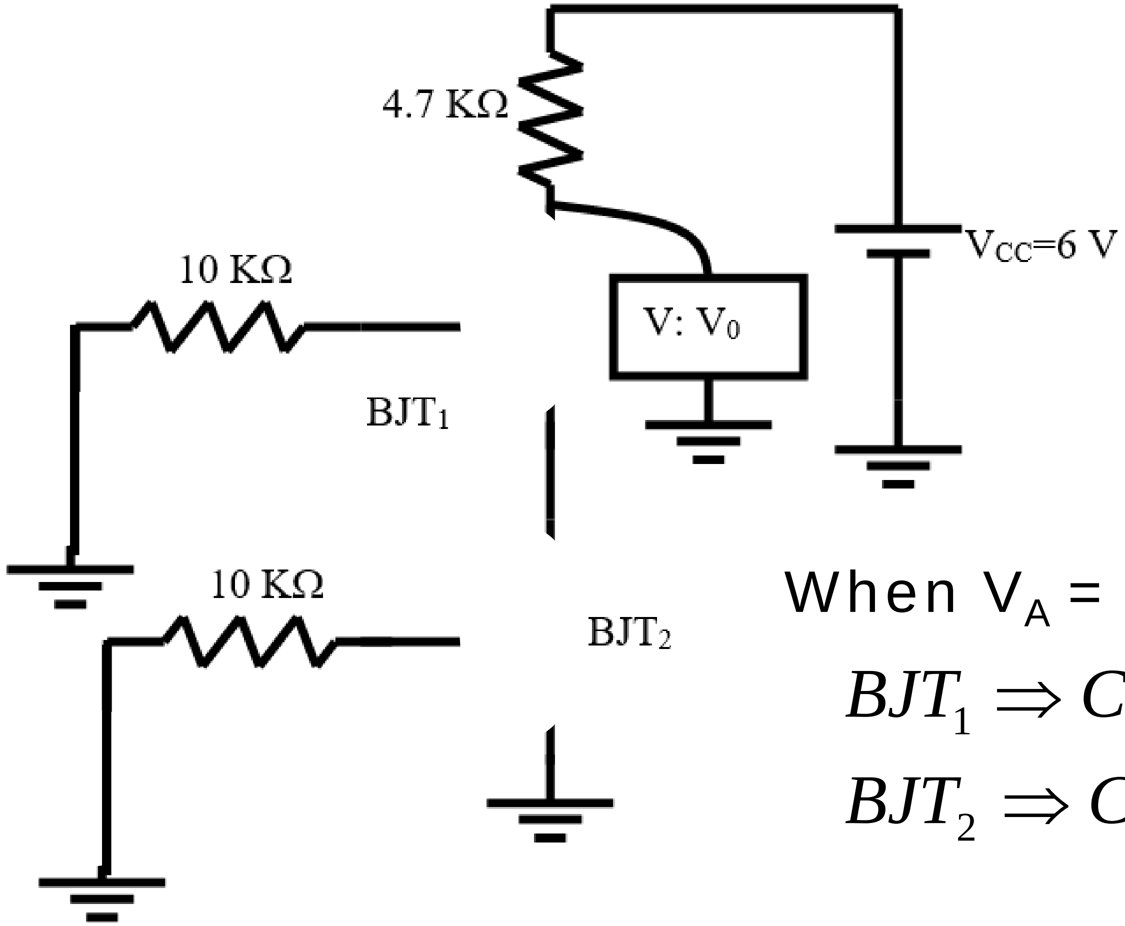
High = V_{CC}

Check this link for illustration

http://www.falstad.com/circuit/e-rtlnand.html

NAND Gate: **cont'd**





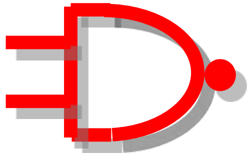
When V_A = Low, and V_B = Low

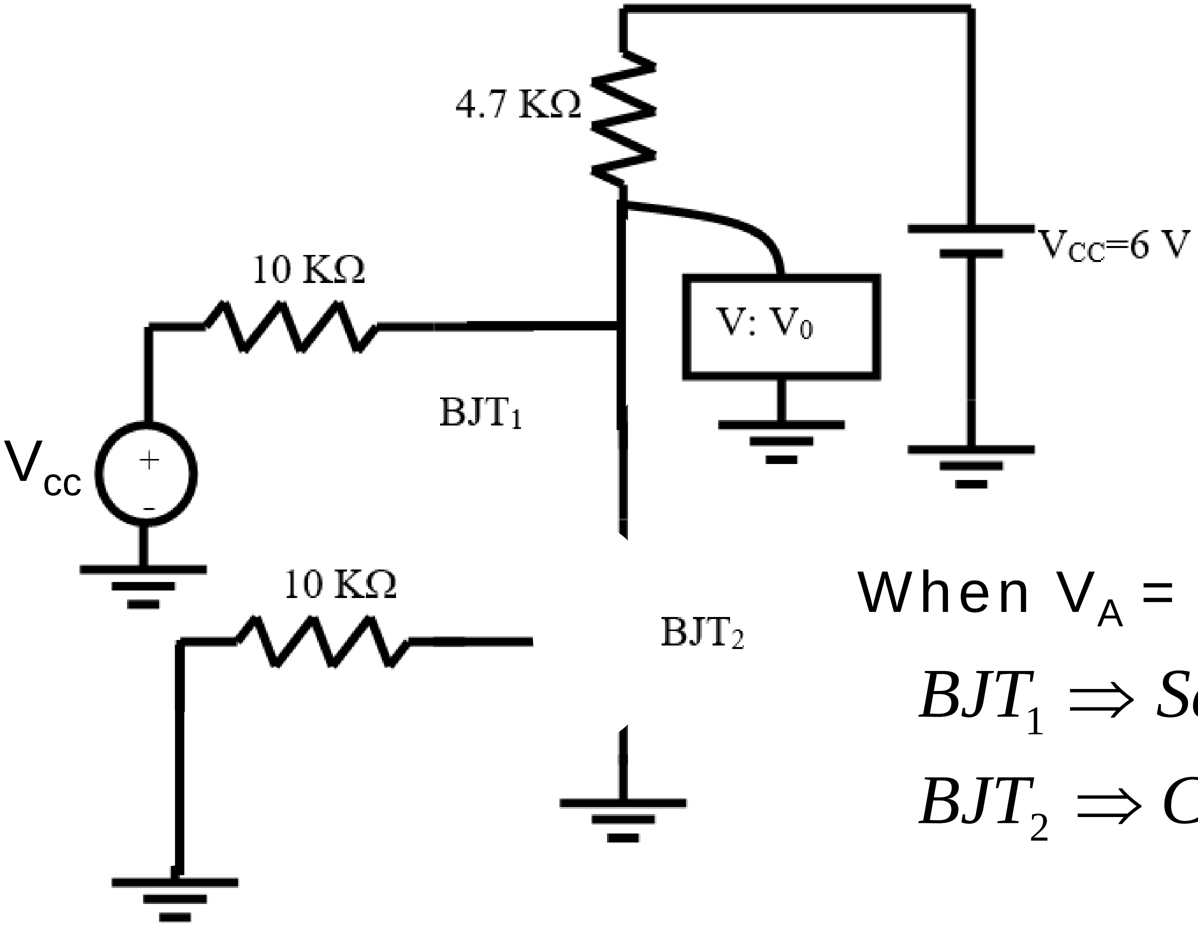
$$BJT_1 \Rightarrow Cut - OFF \Rightarrow O.C.$$

$$BJT_2 \Rightarrow Cut - OFF \Rightarrow O.C.$$

$$V_0 = High = V_{CC}$$

NAND Gate: cont'd





When V_A = High, and V_B = Low

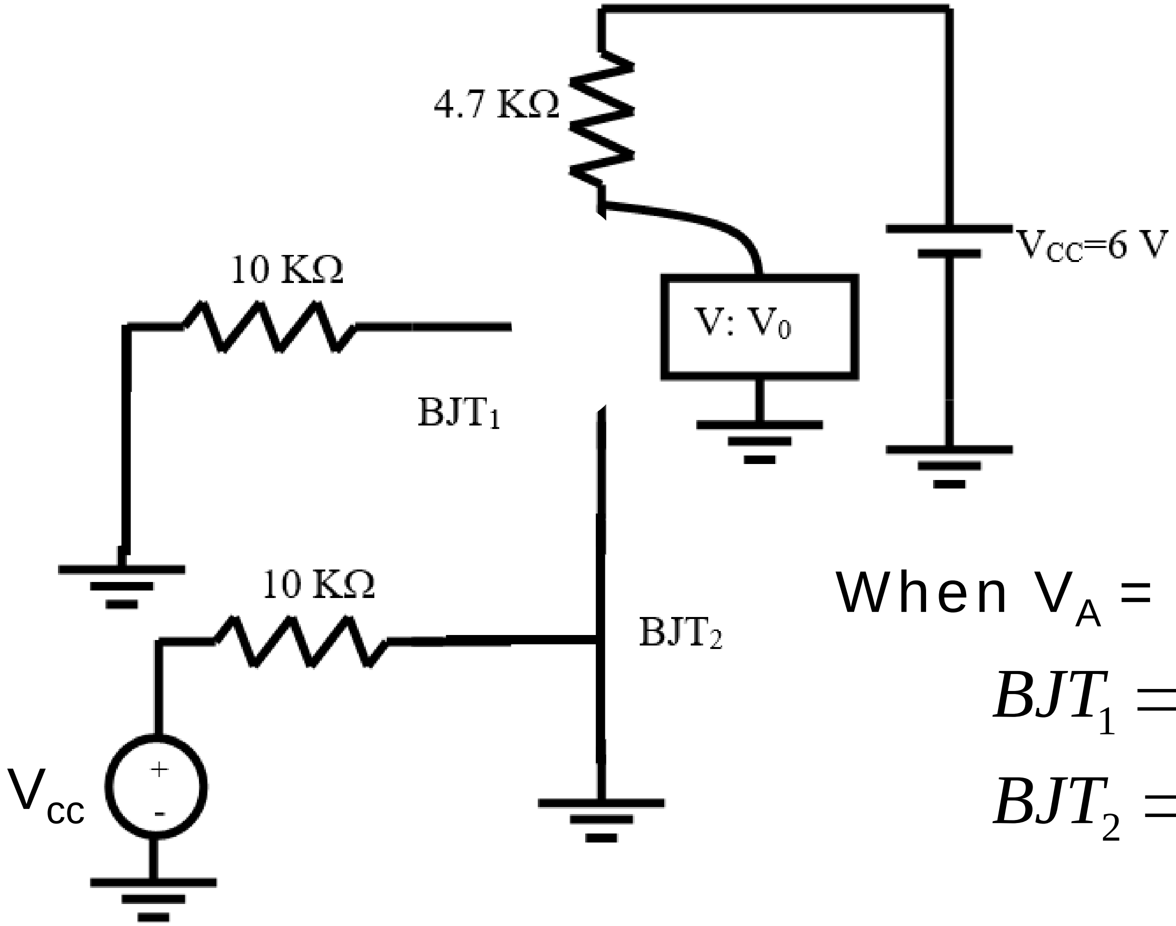
$$BJT_1 \Rightarrow Saturation \Rightarrow S.C.$$

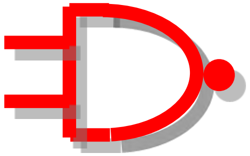
$$BJT_2 \Rightarrow Cut-OFF \Rightarrow O.C.$$

$$V_0 = High$$

In saturation, I_c is low and thus the voltage drop across 4.7 KΩ is small and V_0 will be very close to Vcc (i.e., High)

NAND Gate: **cont'd**





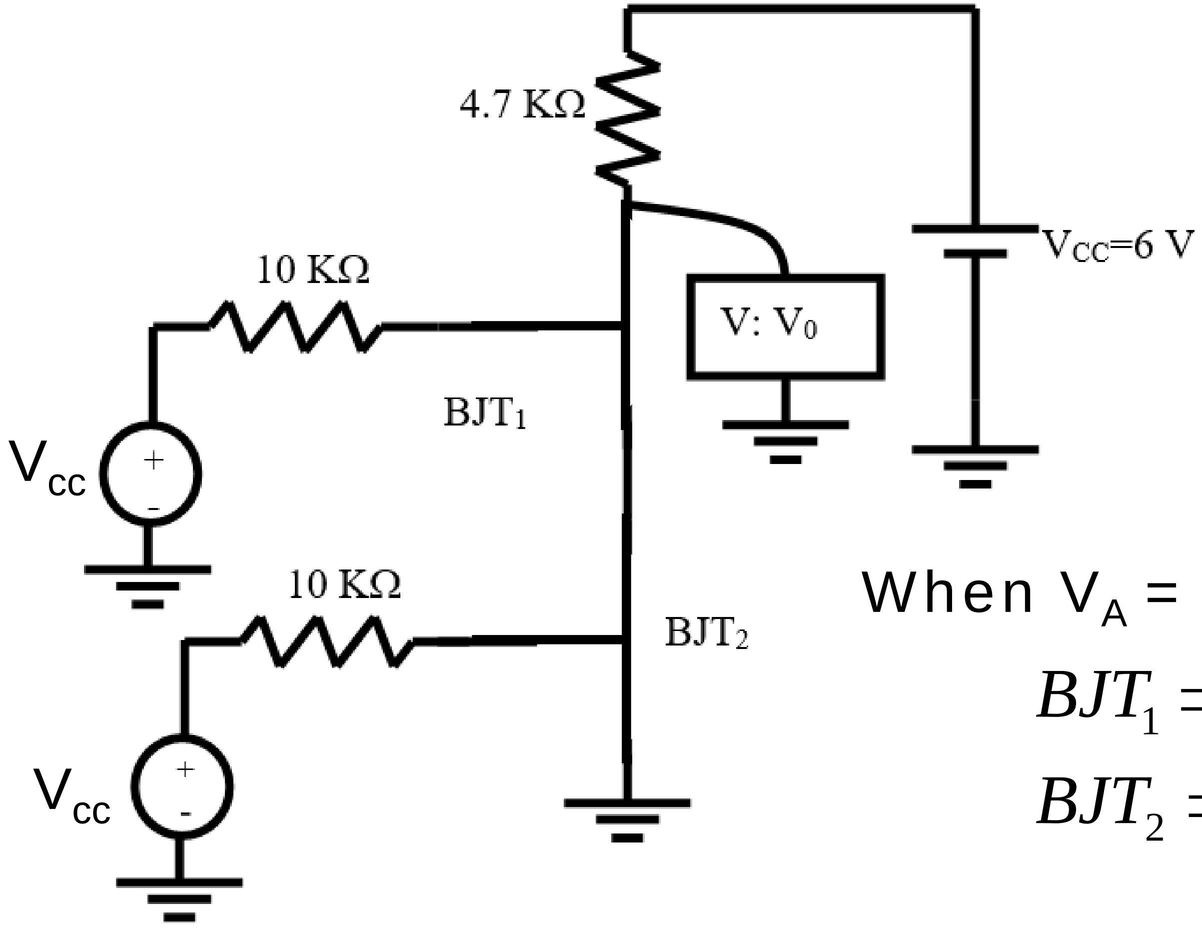
When V_A = Low, and V_B = High

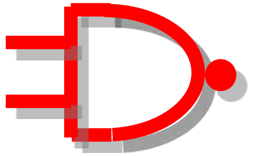
$$BJT_1 \Rightarrow OFF \Rightarrow O.C.$$

$$BJT_2 \Rightarrow ON \Rightarrow S.C.$$

$$V_0 = High$$

NAND Gate: **cont'd**





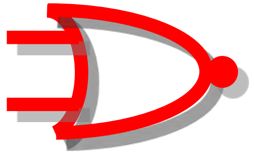
When V_A = High, and V_B = High

$$BJT_1 \Rightarrow ON \Rightarrow S.C.$$

$$BJT_2 \Rightarrow ON \Rightarrow S.C.$$

$$V_0 = Low$$

Transistor-based Logic Gates: NOR Gate

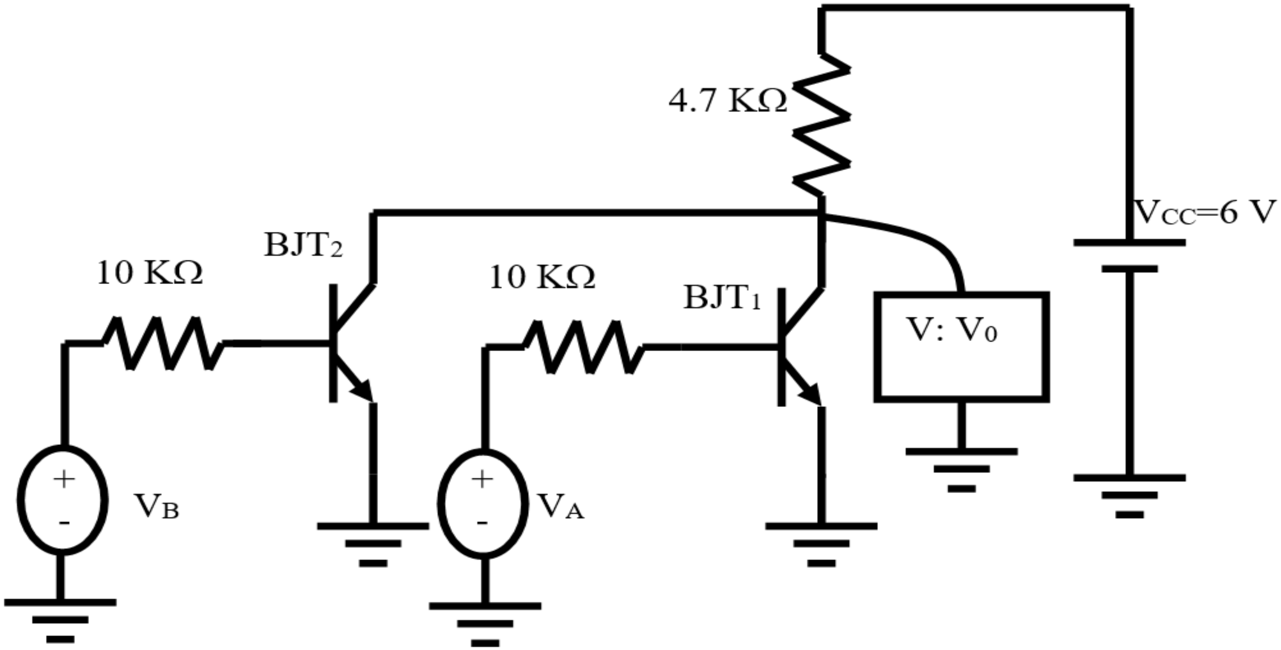


Truth Table

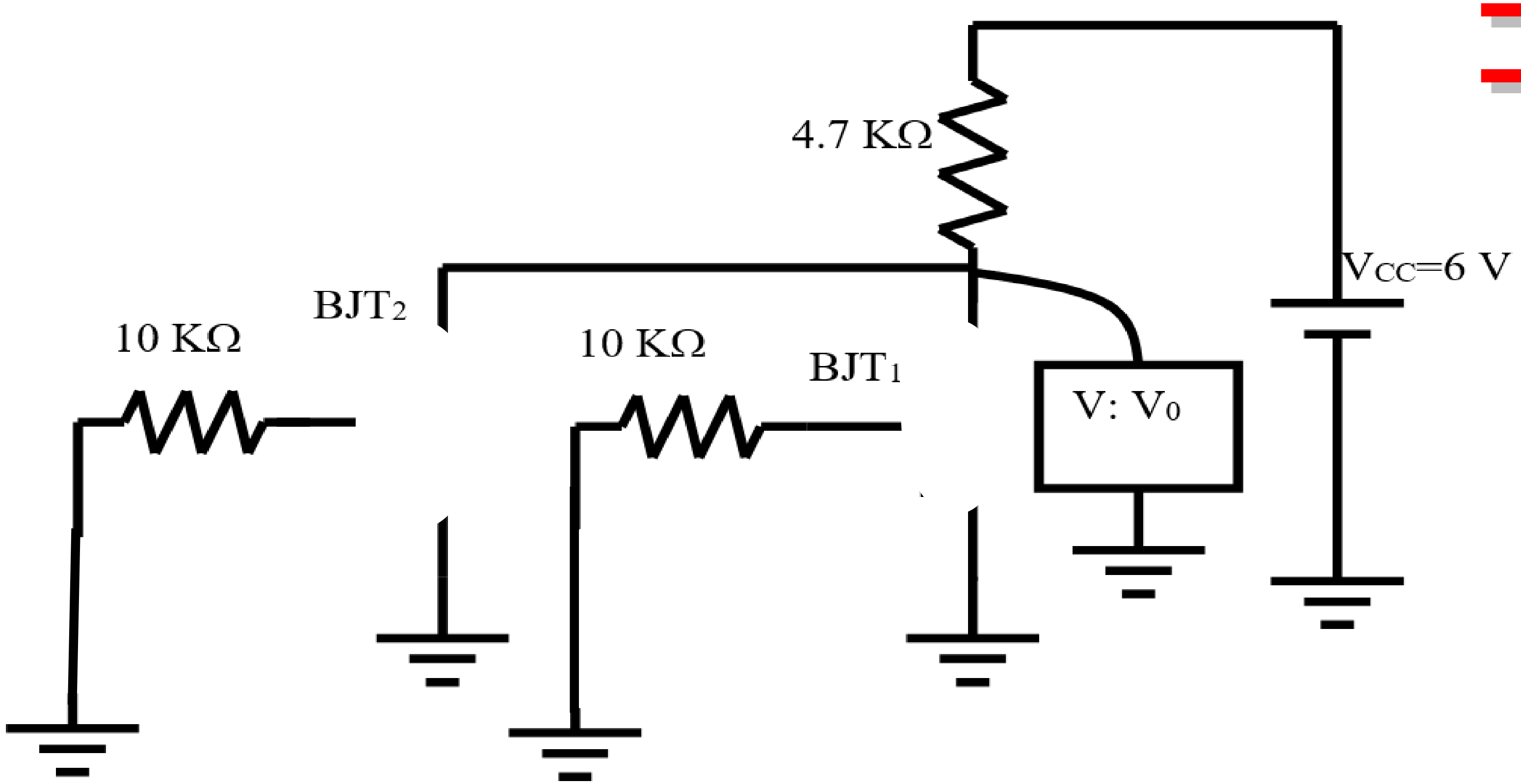
V_A	V_B	V_0
0	0	1
0	1	0
1	0	0
1	1	0

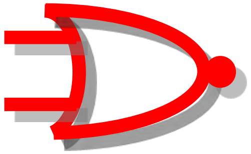
Truth Table

V_A	V_B	V_0
Low	Low	High
High	Low	Low
Low	High	Low
High	High	Low



NOR Gate: **cont'd**





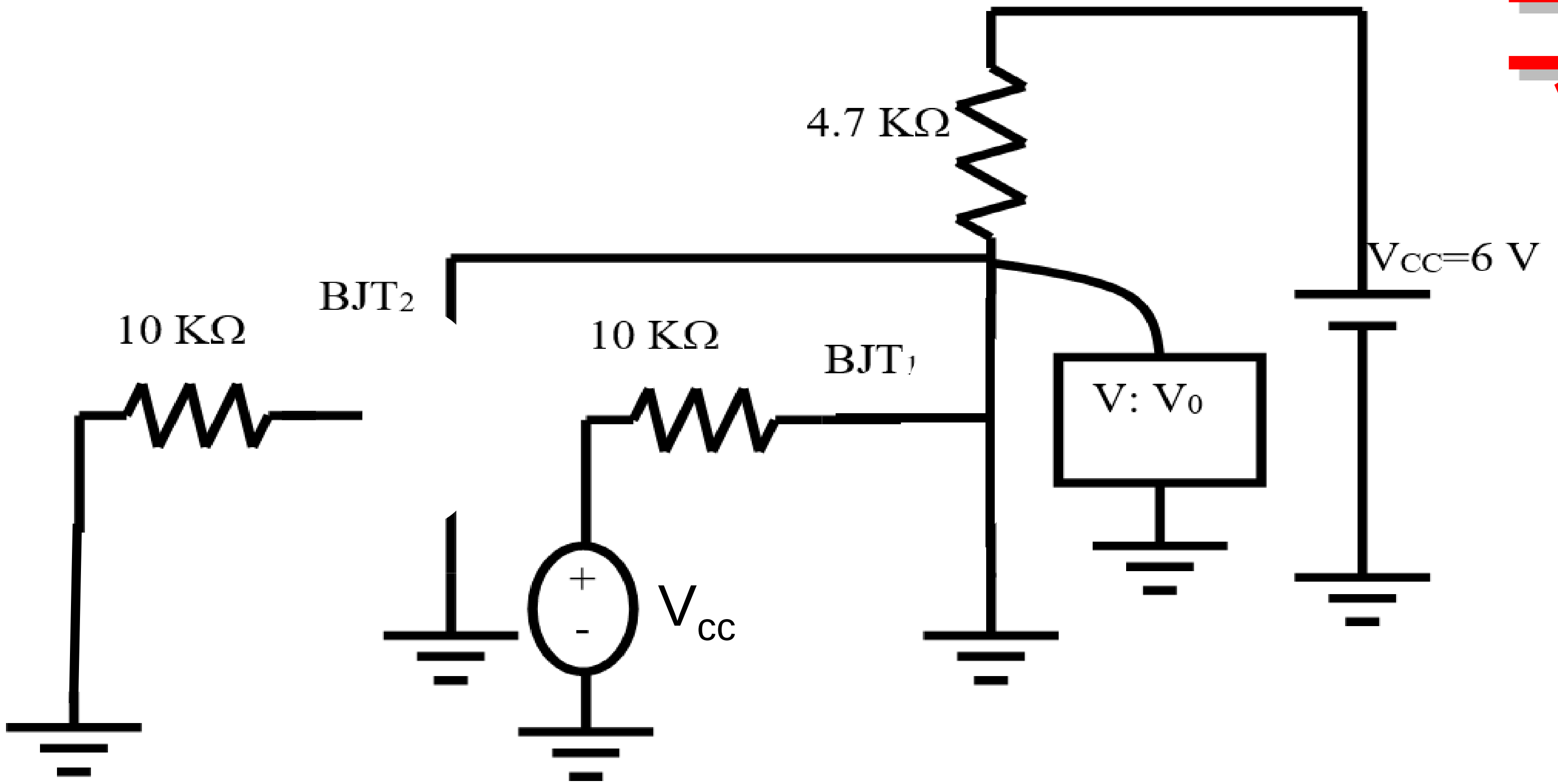
When V_A = Low, and V_B = Low

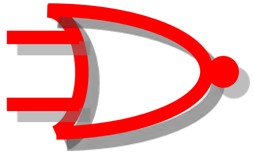
$$BJT_1 \Rightarrow OFF \Rightarrow O.C.$$

$$BJT_2 \Rightarrow OFF \Rightarrow O.C.$$

$$V_0 = High$$

NOR Gate: **cont'd**





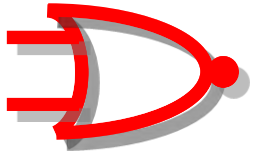
When V_A = High, and V_B = Low

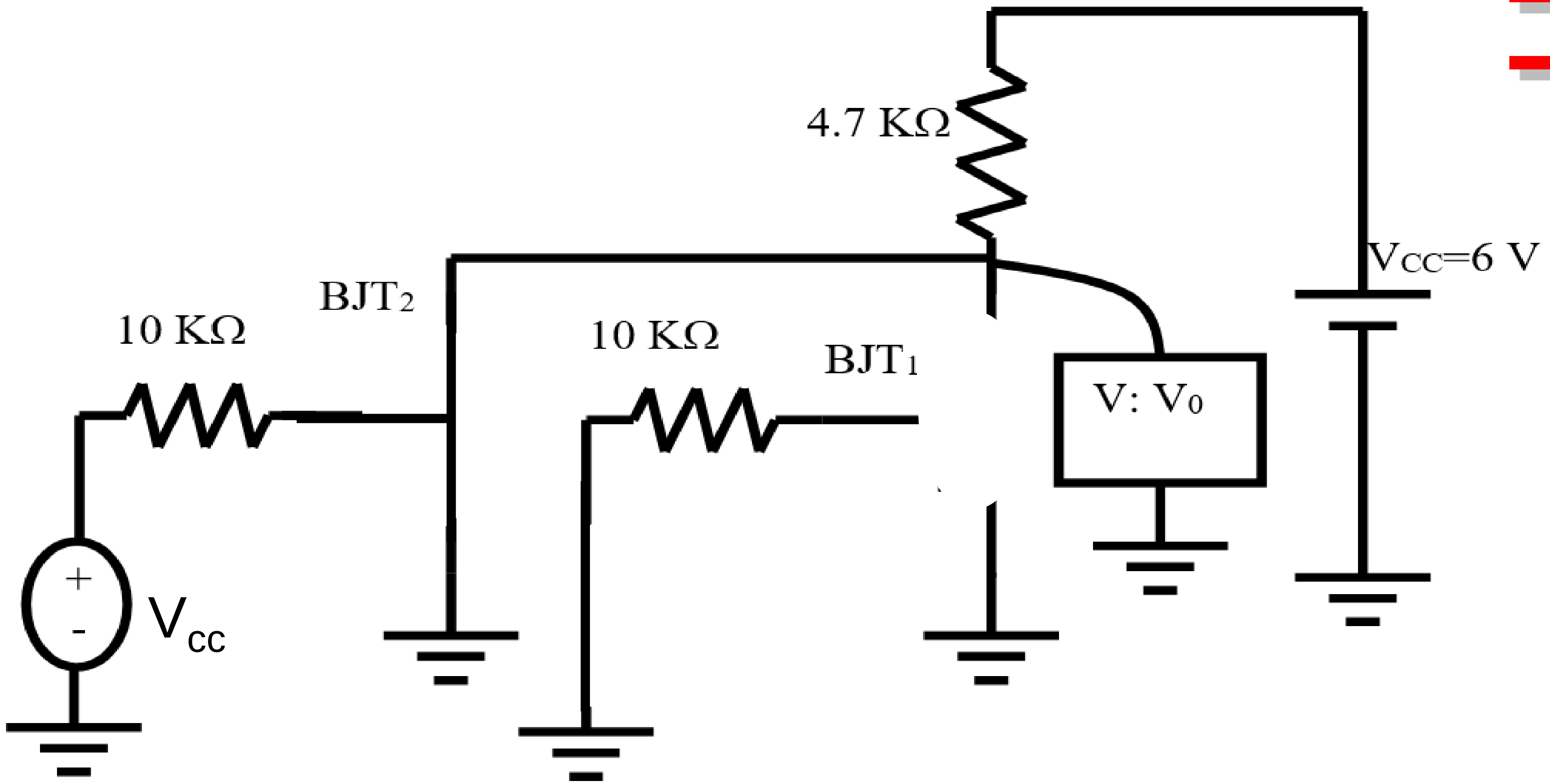
$$BJT_1 \Rightarrow ON \Rightarrow S.C.$$

$$BJT_2 \Rightarrow OFF \Rightarrow O.C.$$

$$V_0 = Low$$

NOR Gate: **cont'd**





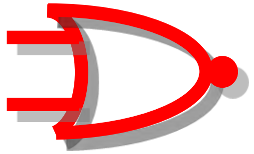
When V_A = Low, and V_B = High

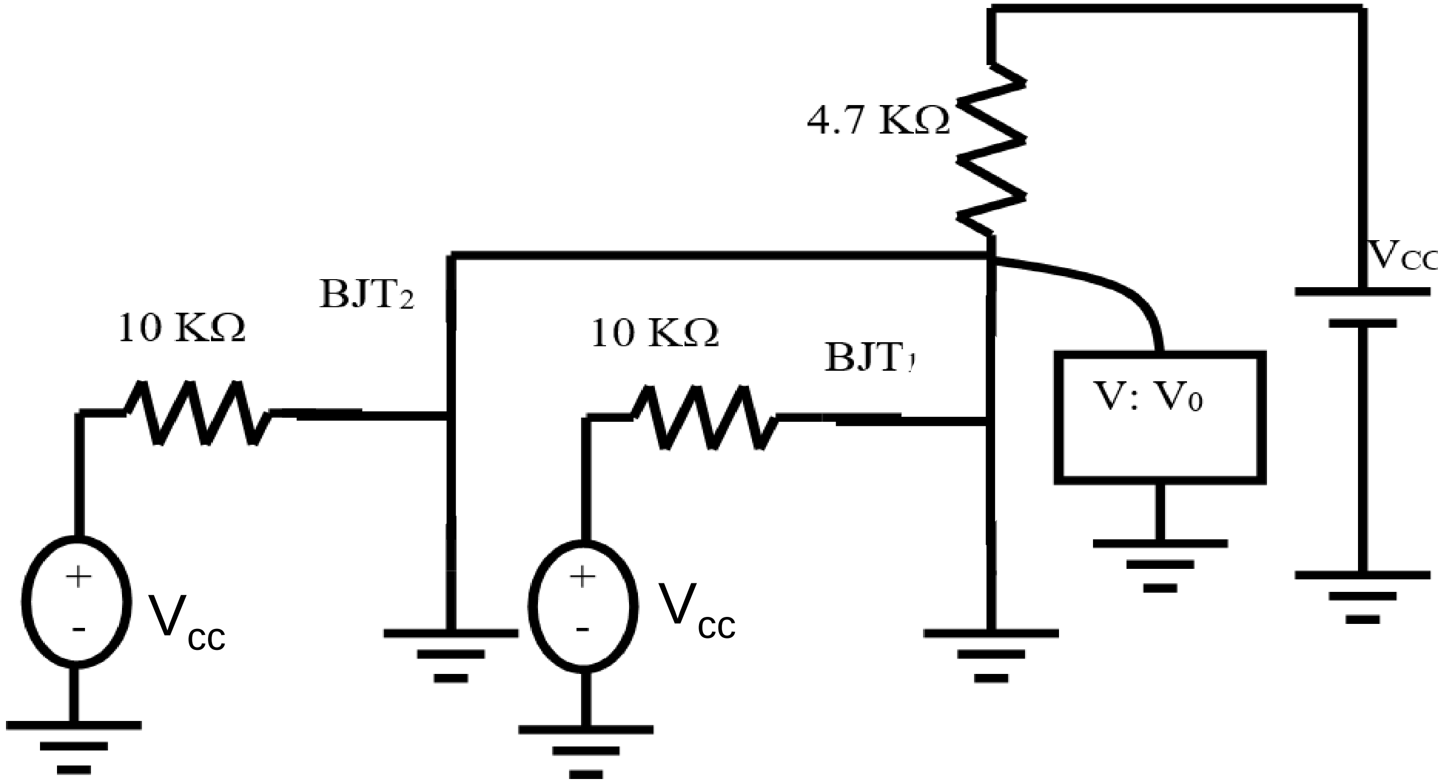
$$BJT_1 \Rightarrow OFF \Rightarrow O.C.$$

$$BJT_2 \Rightarrow ON \Rightarrow S.C.$$

$$V_0 = Low$$

NOR Gate: **cont'd**





When V_A = High, and V_B = High

$$BJT_1 \Rightarrow ON \Rightarrow S.C.$$

$$BJT_2 \Rightarrow ON \Rightarrow S.C.$$

$$\Rightarrow \quad V_0 = Low$$

Q.1 For the circuit shown in Fig.1:

1. The current I is: ....

The voltage V is: ....

2. The power absorbed by the 4KΩ is: ....
3. The power supplied by 9V is: ....

What are the minimum power rating required resistors? ....

4. The ratio of the power absorbed by 4KΩ to the power absorbed by the 8KΩ is: ....
5. The voltage drop across 4KΩ and 8KΩ resistors equals: ....
6. What will happen, when the 8KΩ resistor becomes short circuited:

....

Q.2 For the circuit shown in Fig. 2:

1. The current I is: ....
2. The voltage V_1 is: ....
3. The voltage V_2: ....
4. The capacitor charge is: ....
5. What is the minimum voltage rating of the required capacitor:

....

6. What is the minimum required power rating of the resistor:

....

7. If the dc source is replaced by a square wave of V_{pp}=9V, then the capacitor current will be:

....

8. If the capacitor is replaced by an inductor of 1 mH, then I, V_1, and V_2 will be:

....

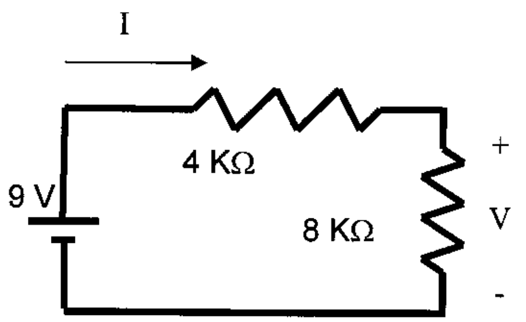


Fig. 1

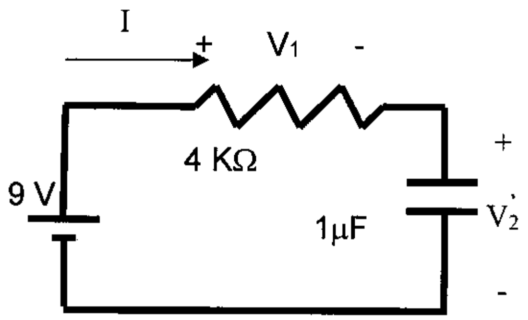


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. If the switch S is placed at "a" for a long time; find I_1, I_2, and V:

   ....

2. Roughly, draw the variation of V as a function of time:

   ....

3. If the switch S is moved to "b"; find the instantaneous values of I_1, I_2, and V:

   ....

4. A long time after S has been moved to "b"; find the steady state value of V, I_2, and I_1:

   ....

5. If the resistor R_2 is replaced by a short circuit, what will happen in the two cases of the switch S?

   ....

Q.2 For the circuit shown in Fig. 2:

1. If the switch S is placed at "a" for a long time; find I_1, I_2, and V:

   ....

2. Roughly, draw the variation of V as a function of time:

   ....

3. If the switch S is moved to b; find the instantaneous values of I_1, I_2, and V:

   ....

4. A long time after S has been moved to "b"; find the steady state value of V, I_2, and I_1:

   ....

5. If the resistor R_2 is replaced by a short circuit, what will happen in the two cases of the switch S?

   ....

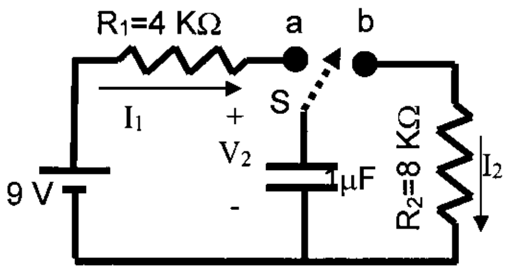


Fig. 1

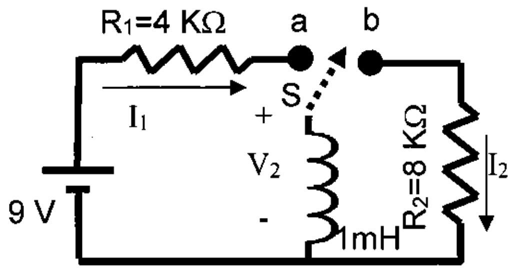


Fig. 2

Q.1 For the circuit shown in Fig. 1

1. If $V_x = 1/I + 1$, find the value of R if the voltage drop across R is the same as V_x: ....
2. For the above case find the power dissipated in the nonlinear element:
....
3. Determine the static resistance of the nonlinear element:
....
4. If R=0.5Ω, find the current I, and the voltage drop across resistor R:
....
5. If the nonlinear element is replaced by a capacitor, what is the minimum rated voltage? ....
6. If R equals 1KΩ, and the nonlinear element is replaced by a short circuit, what is the minimum rated power of that resistor: ....

Q.2 For the circuit shown in Fig. 2:

1. If $V = 1/I_x + 1$, find the value of R if the current through R is the same as the current I_x: ....
2. For the above case find the power dissipated in the nonlinear element:
....
3. Determine the static resistance of the nonlinear element:
....
4. If R=0.5Ω, find the current I_x, and the voltage drop:
....
5. If the nonlinear element is replaced by a capacitor, what is the minimum rated voltage? ....
6. If the R=1KΩ, and the nonlinear element is replaced by a short circuit, what is the minimum rated power of that resistor: ....

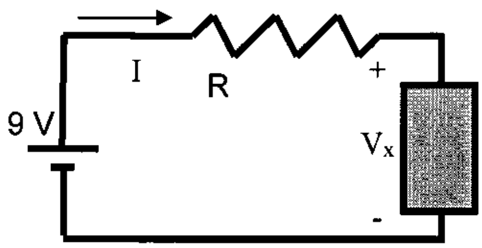


Fig. 1

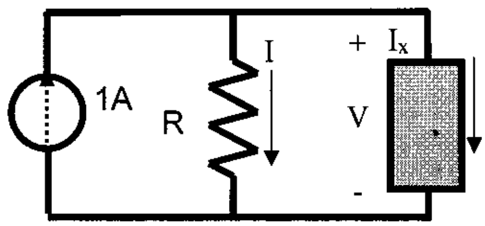


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. The maximum output voltages is:

....

2. The cutoff frequency is given by:

....

3. The maximum output voltage occurs at a frequency of:

....

4. The minimum output voltage occurs at a frequency of:

....

5. The bandwidth is given by:

....

Q.2 If the positions of resistor R and capacitor C; Fig. 1, changed:

1. The maximum output voltages is:

....

2. The cutoff frequency is given by:

....

3. The maximum output voltage occurs at a frequency of:

....

4. The minimum output voltage occurs at a frequency of:

....

5. The bandwidth is given by: ....

Q.3 For the circuit shown in Fig. 2:

1. The maximum output voltages is: ....
2. The cutoff frequency is given by: ....
3. The maximum output voltage occurs at a frequency of:

....

4. The minimum output voltage occurs at a frequency of:

....

5. The bandwidth is given by:

....

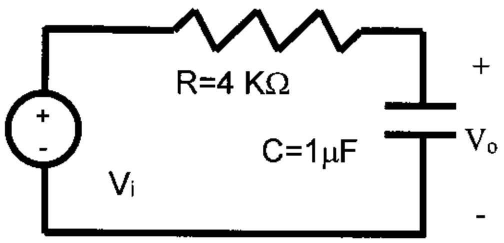


Fig. 1

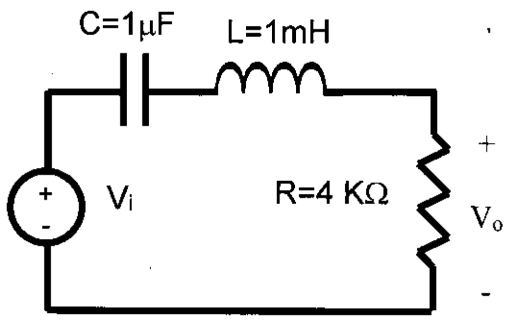


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. Find the resonant frequency:

....

2. Find the minimum impedance:

....

3. Find two expressions for the quality factor:

....

4. Find the circuit bandwidth:

....

5. Find the maximum current through the circuit:

....

6. Find the voltage drop across the capacitor at resonance:

....

7. Find the voltage drop across the inductor at resonance:

....

8. Draw a schematic diagram of the output current vs. frequency:

....

Q.2 For the circuit shown in Fig.2:

1. Find the resonant frequency:

....

2. Find the minimum impedance:

....

3. Find two expressions for the quality factor:

....

4. Find the maximum voltage drop across the circuit:

....

5. Find the overall bandwidth:

....

6. Find the maximum current through the inductor:

....

7. Find the maximum current through the capacitor:

....

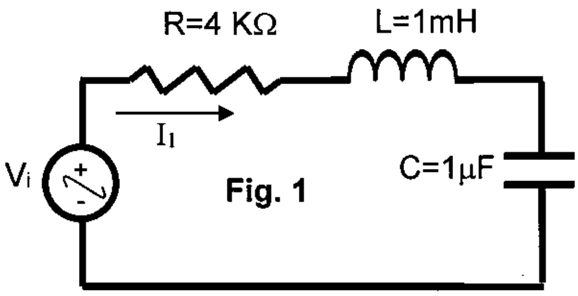


Fig. 1

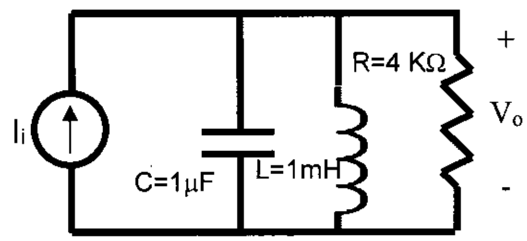


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. Find Thevenin's equivalent:

....

2. Find the resistive load to be connected between x and y for maximum power:...
3. Find the maximum power delivered to the load in case-2:

....

4. Find the ratio of the maximum delivered power to the load with respect to the source: ....
5. If a load of 1Ω is connected between x and y find the load power and give your comments: ....
6. Find Norton's equivalent: ....

Q.2 For the circuit shown in Fig.2:

1. Find the current passing through the 1Ω resistor:

....

2. If the positions of the two sources are exchanged, what is the current through the 1Ω resistor:

....

3. Using superposition principle; find the current passing through the 1Ω resistor in the original circuit:

....

4. If the 1Ω resistor is open circuited, find the equivalent resistance between its terminals:

....

5. If the 2A source is replaced by a 2V source, and the 1Ω resistor is open circuited, find the equivalent resistance between its terminals:

....

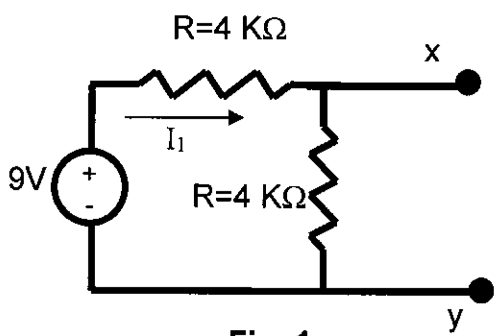


Fig. 1

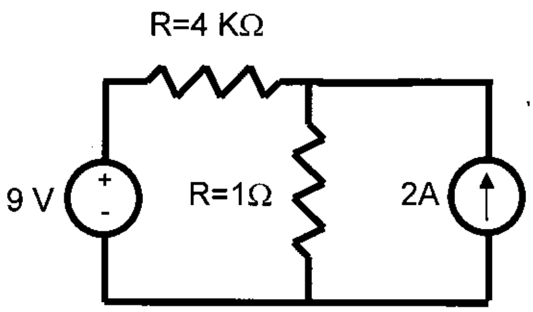


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. If V_{in}=10V, and a Silicon diode was used, find the current passing through the 4kΩ load resistor:

....

2. If V_{in}=-10V, and a Germanium diode was used, find the current passing through the 4kΩ load resistor:

....

3. If V_{in}=10Sin(ωt) V, and a Silicon diode was used, find the current passing through the 4kΩ load resistor, and then draw the output voltage:

....

4. If V_{in} is a symmetric square wave of peak-to-peak 10V, and a Germanium diode was used, find the current passing through the load resistor and hence sketch the output voltage:

....

Q.2 For the circuit shown in Fig.2:

1. If V_1=0V and V_2=0 V, find V_o:

....

2. If V_1=10V and V_2=0 V, find V_o:

....

3. If V_1=0V and V_2=10 V, find V_o:

....

4. If V_1=10V and V_2=10 V, find V_o:

....

5. If V_1=-10V and V_2=10 V, find V_o:

....

6. If V_1=5V and V_2=5 V, D_1 is a Silicon diode and D_2 is a Germanium diode, find V_o:

....

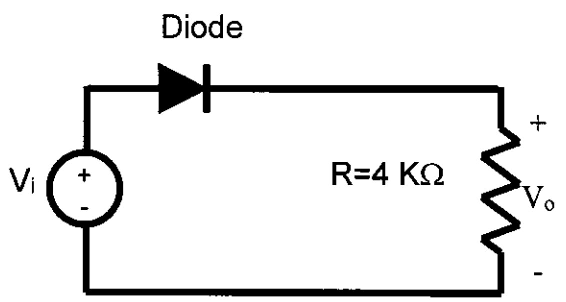


Fig. 1

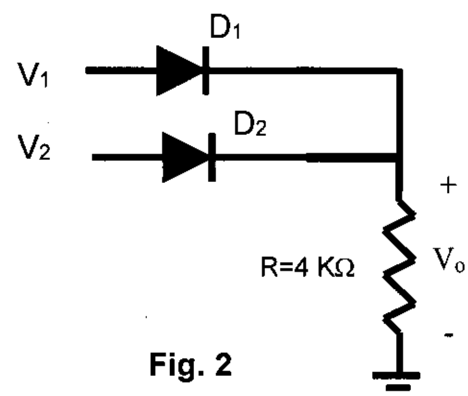


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. If V_{in}=10V and $P_Z(max)$=0.05 Watt, find V_o:

....

2. If V_{in}=20V and $P_Z(max)$=0.05 Watt, find V_o:

....

3. If V_{in}=30V and $P_Z(max)$=0.05 Watt, find V_o:

....

4. If V_{in}=-10V and $P_Z(max)$=0.05 Watt, find V_o:

....

5. If $12 \leq V_{in} \leq 20V$ and $P_Z(max)$=0.05 Watt, find the change in V_o:

....

6. If V_{in}=10Sin(ωt) V, sketch the output waveform:

....

Q.2 For the circuit shown in Fig.2 the LED diode has a forward voltage drop of 3.2V (i.e. during conduction)

1. If V_1=0V and V2=0V, find V_o:

....

2. If V_1=10V and V2=0V, find V_o:

....

3. If V_1=0V and V2=10V, find V_o:

....

4. If V_1=10V and V2=10V, find V_o:

....

5. If V_1=-10V and V2=10V, find V_o:

....

6. If V_1=0V and V2=-10V, find V_o:

....

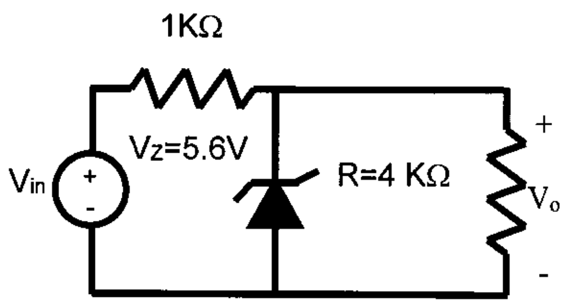


Fig. 1

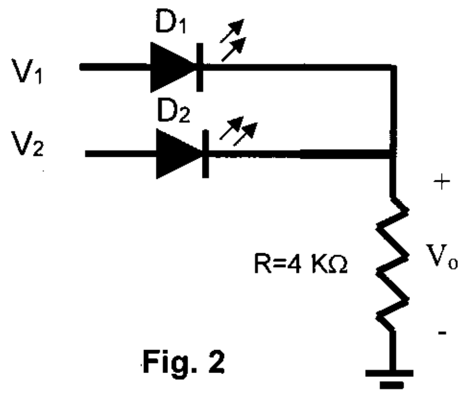


Fig. 2

Q.1 For the circuit shown in Fig. 1:

1. If V_{EB}=0.7V, and V_{CB}=0.5V, determine the BJT operating mode:

....

2. If V_{EB}=-0.7V, and V_{CB}=-0.5V, determine the BJT operating mode:

....

3. If V_{EB}=0.7V, and V_{CB}=-0.5V, Determine the BJT operating mode:

....

Q.2 For the circuit shown in Fig. 2:

4. If V_{BE}=0.7V, and V_{BC}=-0.5V, Determine the BJT operating mode:

....

5. If V_{EB}=-0.7V, and V_{CB}=-0.5V, Determine the BJT operating mode:

....

6. If V_{BE}=0.7V, and V_{BC}=-0.5V, Determine the BJT operating mode:

....

Q.3 For the circuit shown in Fig.3:

1. If V_{CE}=2.5V, Determine the BJT operating mode:

....

2. If V_{CE}=V_{CC} V, Determine the BJT operating mode:

....

3. If V_{CE}=0.05V, Determine the BJT operating mode:

....

4. If V_{CE}=0.2V, Determine the BJT operating mode:

....

5. If V_B=3V, V_C=5V, and V_E=2.3V, Determine the BJT operating mode:

....

6. If V_B=-3V, V_C=10V, and V_E=0V, Determine the BJT operating mode:

....

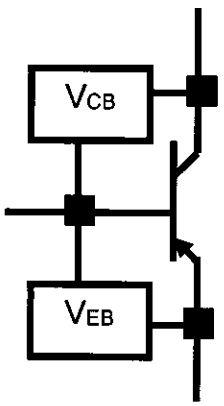


Fig.1

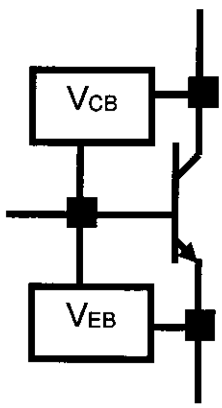


Fig.2

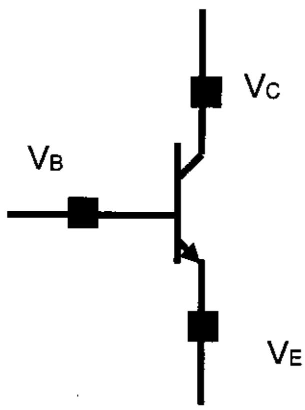


Fig.3

Q.1 For the circuit shown in Fig. 1:

1. If V_1=10 V and V_2=10 V, find V_o: ....
2. If V_1=0 V and V_2=10 V, find V_o: ....
3. If V_1=10 V and V_2=0 V, find V_o: ....
4. If V_1=0 V and V_2=0 V, find V_o: ....

Q.2 For the circuit shown in Fig. 2:

1. If V_1=10 V and V_2=10 V, find V_o: ....
2. If V_1=0 V and V_2=10 V, find V_o: ....
3. If V_1=10 V and V_2=0 V, find V_o: ....
4. If V_1=0 V and V_2=0 V, find V_o: ....

Q.3 For the circuit shown in Fig. 3:

1. If V_1=10 V and V_2=10 V, find V_o: ....
2. If V_1=0 V and V_2=10 V, find V_o: ....
3. If V_1=10 V and V_2=0 V, find V_o: ....
4. If V_1=0 V and V_2=0 V, find V_o: ....

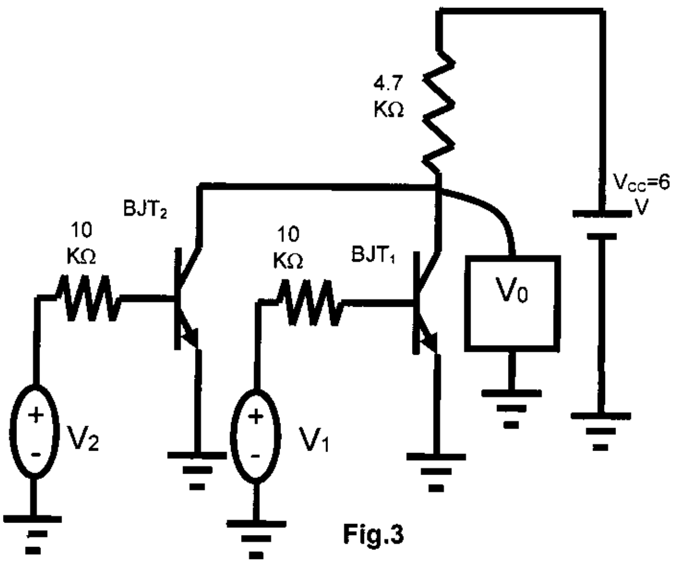


Fig.3

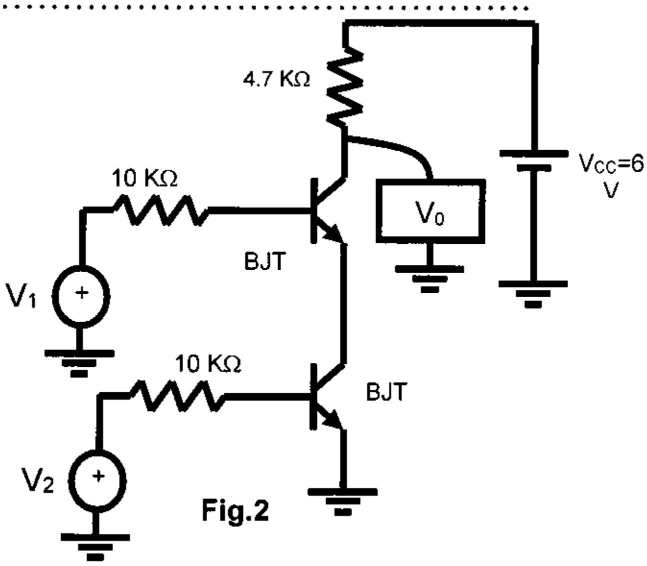


Fig.2

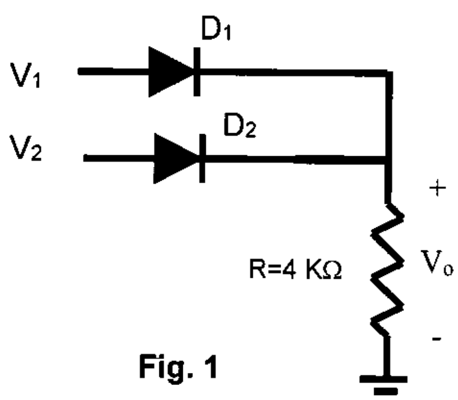


Fig. 1

Q.1 Define the following terms:

1. Stabilized power supply:

....

2. Smoothing circuit(s):

....

3. Voltage regulators:

....

4. The voltage regulator series of type 78xy:

....

5. The voltage regulator series of type 79xy:

....

6. Unipolar voltage supplies:

....

7. Voltage rating of a capacitor:

....

8. Power rating of a resistor:

....

9. Maximum forward current of a general purpose diode:

....

10. Maximum power dissipation of a Zener diode:

....

11. Peak inverse voltage of a diode:

....

Q.2 Specify the following items:

1. Rating parameters of a semiconductor diode:

....

2. Rating parameters of a BJT:

....

3. Rating parameters of a Zener diode:

....

4. Rating parameters of a light emitting diode (LED):

....