EXPERIMENT X1: INTRODUCTION TO BASIC ELECTRICAL COMPONENTS AND BREADBOARD

OBJECTIVES:
To familiarise with basic electrical components and breadboard / protoboard

EQUIPMENT:
Universal power supply; breadboard / protoboard; resistors: 1kΩ (2 units), 470Ω (2); light emitting diodes (LED) (2); ICs: 74XX32 (2) (XX can be HC, LS or AC); wires/jumpers

INSTRUCTIONS:
1. Record all your results and observations in a log book or on a piece of paper
2. Follow the demonstrator's instructions throughout the experiment
3. Before leaving the lab, make sure that you show all of your answers recorded (either on this sheet or separate sheet) to the lab demonstrator or lecturer

REFERENCE(S):
Refer to the main references of KIE1003 (Digital System) and KIE1005 (Circuit Analysis I)

TESTS:
TEST 1: READING RESISTOR VALUES
TEST 2: READING NON-POLARISED CAPACITOR VALUES
TEST 3: CONNECTING A SIMPLE CIRCUIT ON A BREADBOARD
TEST 4: CONNECTING IC AND COMPONENTS ON A BREADBOARD

INTRODUCTION:

Table 1 shows Metrix prefix, which shows the equivalent number and its corresponding symbol. Metrix prefix is commonly used in expressing the values of basic electrical components such as resistors, capacitors and inductors.

Table 1: Metrix prefix

Number	Powers of ten	Symbol	Name
1 000 000 000 000 000 000	10^{18}	E	Exa
1 000 000 000 000 000	10^{15}	P	Peta
1 000 000 000 000	10^{12}	T	Tera
1 000 000 000	10^{9}	G	Giga
1 000 000	10^{6}	M	Mega
1 000	10^{3}	k	kilo
100	10^{2}	h	hecto
10	10^{1}	da	deca
1	10^{0}	-	-
0.1	10^{-1}	d	deci
0.01	10^{-2}	c	centi
0.001	10^{-3}	m	mili
0.000 001	10^{-6}	µ	micro
0.000 000 001	10^{-9}	n	nano
0.000 000 000 001	10^{-12}	p	pico
0.000 000 000 000 001	10^{-15}	f	femto
0.000 000 000 000 000 001	10^{-18}	a	atto

TEST 1: READING RESISTOR VALUES

A resistor is a passive two-terminal electrical component that implements electrical resistance to reduce current flow, adjust signal levels and divide voltage. Resistors are made of carbon film, metal film or metal oxide film. The resistive film is deposited on a cylindrical insulating material between two terminals of a resistor. The electrical function of a resistor is specified by its resistance, which is measured in Ohm (Ω) or Volt per Ampere (V/A). Resistors are usually labelled as *R* in a circuit. Figure 1 shows a resistor and its symbol.

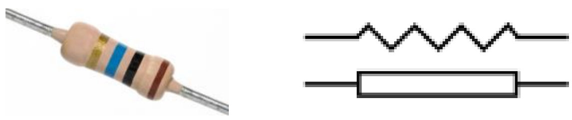


Figure 1: A resistor and its symbol

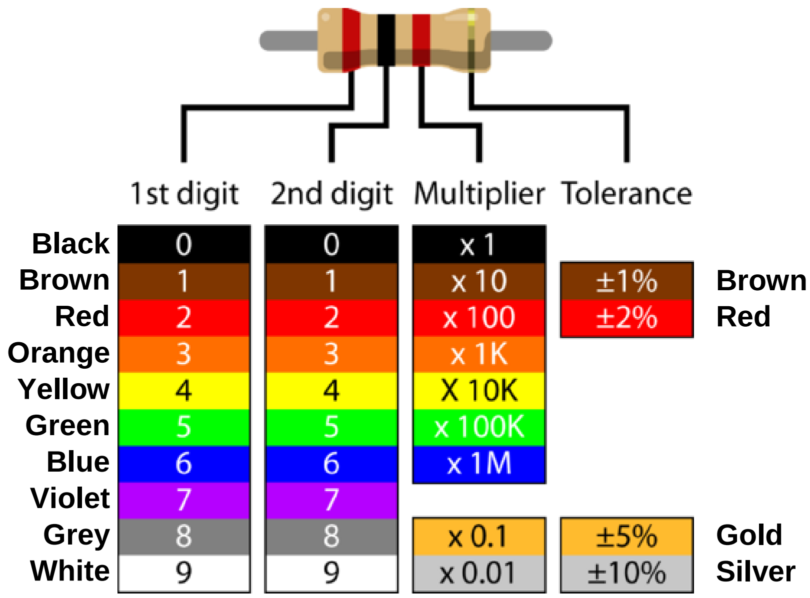


Figure 2: RESISTOR COLOUR CODE

Figure 2 shows the resistor colour code. For example, if the first band is brown (value is 1), the second band is black (value is 0) and the third band is red (value is x100), the resistor value is 10x100=1000 Ω or 1kΩ. The fourth band is a tolerance band. Tolerance is the percentage of error in the resistance value, or how much we can expect a resistor's actual resistance to be from its stated resistance. The tolerance band is usually positioned slightly far from the other 3 bands. If the fourth band is brown, the tolerance is ±1% of the resistor value, which is ±1% x 1000Ω = ±10Ω. Hence, the actual value of this resistor is 1000±10Ω or between 990Ω and 1010Ω.

Referring to the Resistor Colour Code in Figure 2, determine the resistor values in Table 2.

Table 2

First band	Second band	Third band	Fourth band	Resistor value (Ω)	Tolerance (Ω)
Brown	Black	Red	Brown	10x100 = 1000 Ω or 1kΩ	±1% x 1000Ω = ±10Ω
Red	Brown	Orange	Silver		
Green	Violet	Blue	Red		
Green	Red	Violet	Gold		
Brown	Black	Red	Gold		
Blue	Red	Brown	Brown		
Red	Orange	Yellow	Red		

TEST 2: READING NON-POLARISED CAPACITOR VALUES

A capacitor is a passive two-terminal electrical component that stores electrical energy in an electric field. Figure 3 shows a basic structure of a capacitor, which consists of two electrical conductors in the form of metallic plates, with cross-sectional area of *A*, separated by a dielectric material of thickness *d*. A conductor can be a foil, thin film or metal. The non-conducting dielectric increases the capacitor's charge capacity. Materials commonly used as dielectrics are glass, ceramic, plastic film, paper, mica and oxide layers.

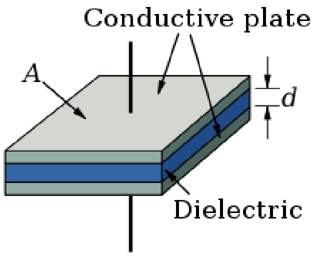


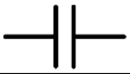
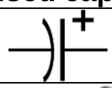
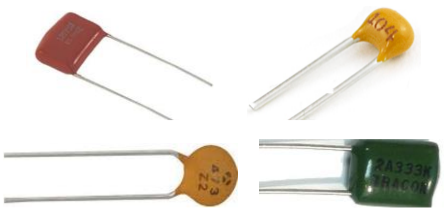
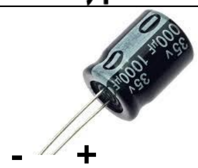
Figure 3: Basic structure of a capacitor

Electric current is the flow of electric charge. When current flows into a capacitor, the charges get "stuck" on the plates because they cannot pass through the insulating dielectric. Electrons (negatively charged particles) stuck into one of the plates and it becomes overall negatively charged. The large mass of negative charges on one plate pushes away charges on the other plate, making it positively charged. The positive and negative charges on each of these plates attract each other. However, with the dielectric between them, the charges will be stuck on the plate. The stationary charges on these plates create an electric field, which influence the electric potential energy and voltage. When charges group together on a capacitor, the capacitor is storing electric energy.

Capacitors are widely used in electronic circuits for blocking direct current (DC) while allowing alternating current (AC) to pass. In analog filter circuits, they smooth the output of power supplies. In resonant circuits, capacitors tune radios to particular frequencies. In power transmission systems, they stabilize voltage and power flow.

The effect of a capacitor is known as capacitance (SI unit: Farad (F)). Capacitance *C* is the ratio of the electric charge *q* on each conductor to the potential difference *V* between them.

Table 3: Types of capacitor

	Non-polarised capacitor	**Polarised capacitor**
Symbol		
Physical appearance		 Negative polarity is marked by a light colour stripe
Examples	Ceramic capacitors	Electrolytic capacitors
How to read capacitance value (Farad)	If the third digit is 0 to 6, add that many zeroes to the end of the first two numbers. (e.g. 453 → 45 x 1000 = 45,000 pF) If the third digit is 8, multiply by 0.01. (e.g. 278 → 27 x 0.01 = 0.27 pF) If the third digit is 9, multiply by 0.1. (e.g. 309 → 30 x 0.1 = 3.0 pF)	Read the printed value on the capacitor body directly
Applications	In AC applications, loudspeaker	In DC applications, to reduce DC voltage ripple
Connection	Does not matter which way	+ polarity to + power supply, - polarity to - power supply or ground

In Table 4, determine the value of capacitance for each number on non-polarised capacitors.

Table 4

Number on non-polarised capacitor	Capacitance value (in pF)	Capacitance value (in nF)	Capacitance value (in µF)
455			
101			
102			
103			
104			
206			
328			
471			

TEST 3: CONNECTING A SIMPLE CIRCUIT ON A BREADBOARD

A. LIGHT EMITTING DIODE (LED)

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a PN junction diode, which emits light when activated. When a suitable voltage is applied to its terminals, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the colour of the light is determined by the energy band gap of the semiconductor. Figure 4 shows a LED and its symbol. In a simple circuit, the anode (+) of the LED must be connected to positive polarity of the power supply so that the LED can emit light while cathode (-) to negative polarity of the power supply or ground or 0V.

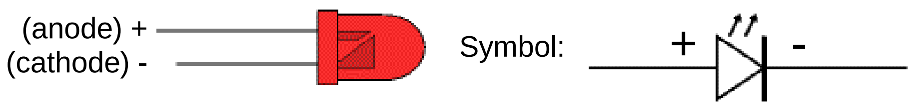


Figure 4: LED and its symbol

B. INTEGRATED CHIP (IC)

An integrated circuit (IC) is a set of electronic circuits on one small flat piece of semiconductor material, normally silicon. The integration of large numbers of tiny transistors into a small chip resulted in circuits that are smaller, cheaper and faster than those constructed of discrete electronic components. Figure 5 shows an example of OR gate IC and its corresponding internal circuit. In this IC, pin 14 (VCC) must be connected to the power supply (typically +5V DC) and pin 7 (GND) must be connected to the ground or 0V. The input pins for this IC are pin 1, 2, 4, 5, 9, 10, 12 and 13 while the output pins are pin 3, 6, 8 and 11. The input voltage for the input pins is +5V DC or 0V.

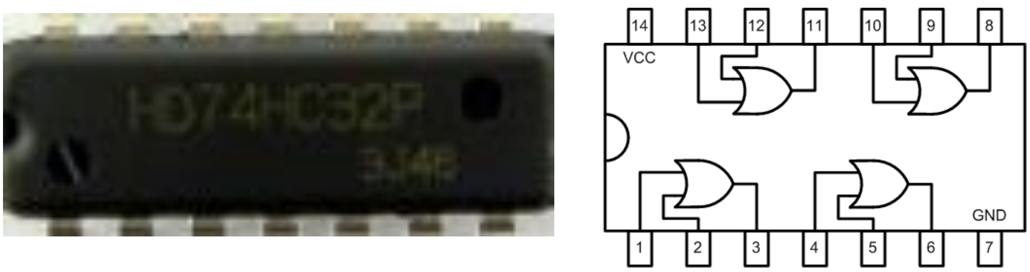


Figure 5: OR gate (74HC32) IC and its corresponding internal circuit

C. BREADBOARD / PROTOBOARD

A breadboard is a construction base for prototyping of electronics. Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. Figure 6 shows a photo of an actual breadboard available in the lab (64 columns).

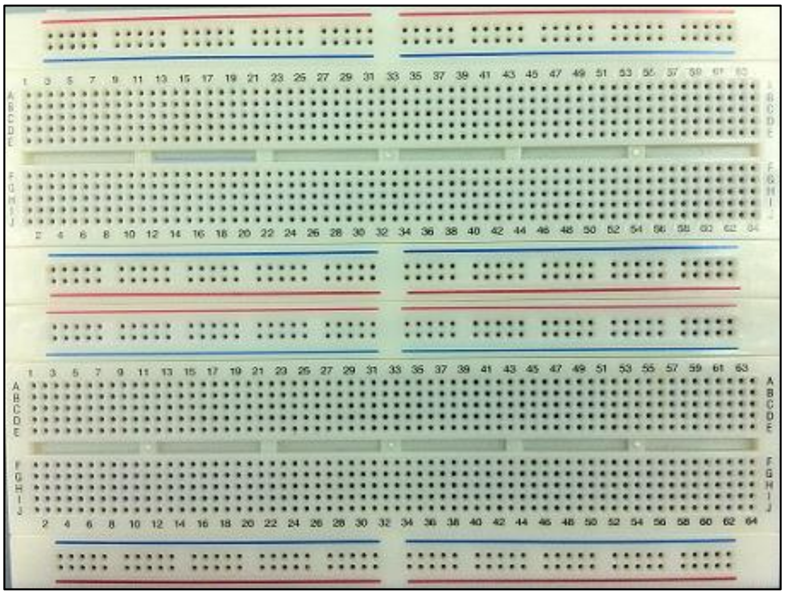


Figure 6: Photo of an actual breadboard / protoboard in the lab

Figure 7 shows the internal wiring of a breadboard, which shows wire connections between different holes or points. The rows between blue and red lines are called common lines, where one line is usually used to connect to a power supply and the other to the ground, 0 Volt or negative voltage.

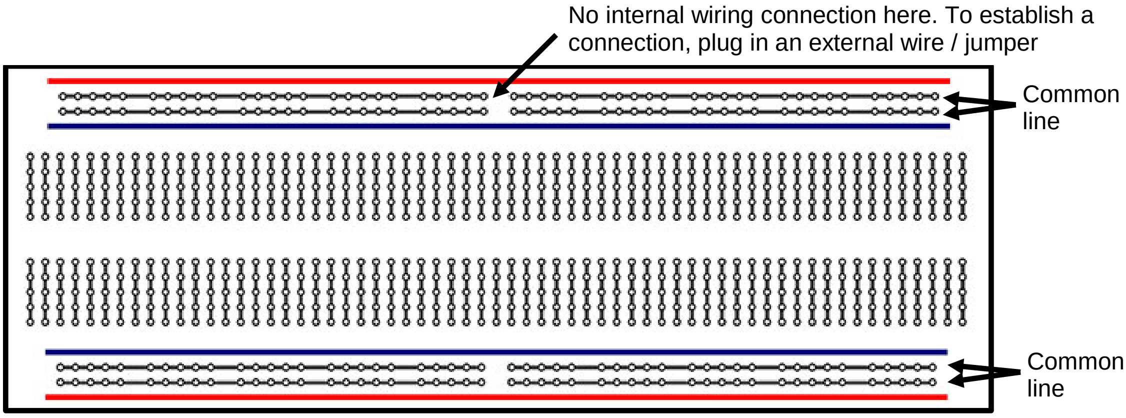


Figure 7: Internal wiring of a breadboard / protoboard

D. UNIVERSAL POWER SUPPLY

A universal power supply consists of AC-supply, DC-supply and function generator. A universal power supply available in the lab is shown in Figure 8 (LM4500). For the DC-supply, it can supply fixed +5V, +15V and -15V and variable DC voltage between 0 and 15V. For the AC-supply, it can supply 50Hz at 6V, 12V, 24V and 42V.

Figure 8: Universal power supply (LM4500)

Figure 9 shows connection of components in series on a breadboard while Figure 10 shows connection of components in parallel on a breadboard. **CAUTION:** Do not touch the pins of the LED while placing it on a breadboard. Do the following steps:

1. Connect the circuit as shown in Figure 9 on a breadboard.
2. Switch ON the DC power supply and observe the brightness of the LED.
3. Connect the circuit as shown in Figure 10 on a breadboard.
4. Switch ON the DC power supply and observe the brightness of the LED.
5. In Figure 10, remove any one 1kΩ resistor and observe the brightness of the LED.
6. Again, remove another 1kΩ resistor from the circuit in Figure 10. What happens to the brightness of the LED and why? To answer why, calculate the current that flows across the LED (assume that the voltage drop across the LED is 2.0 V).

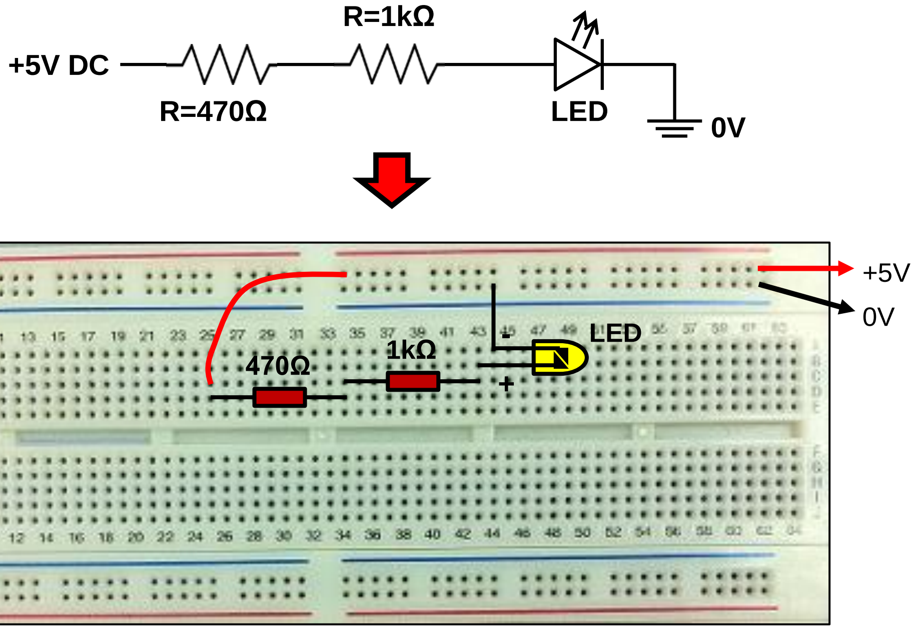


Figure 9: Series connection of a circuit

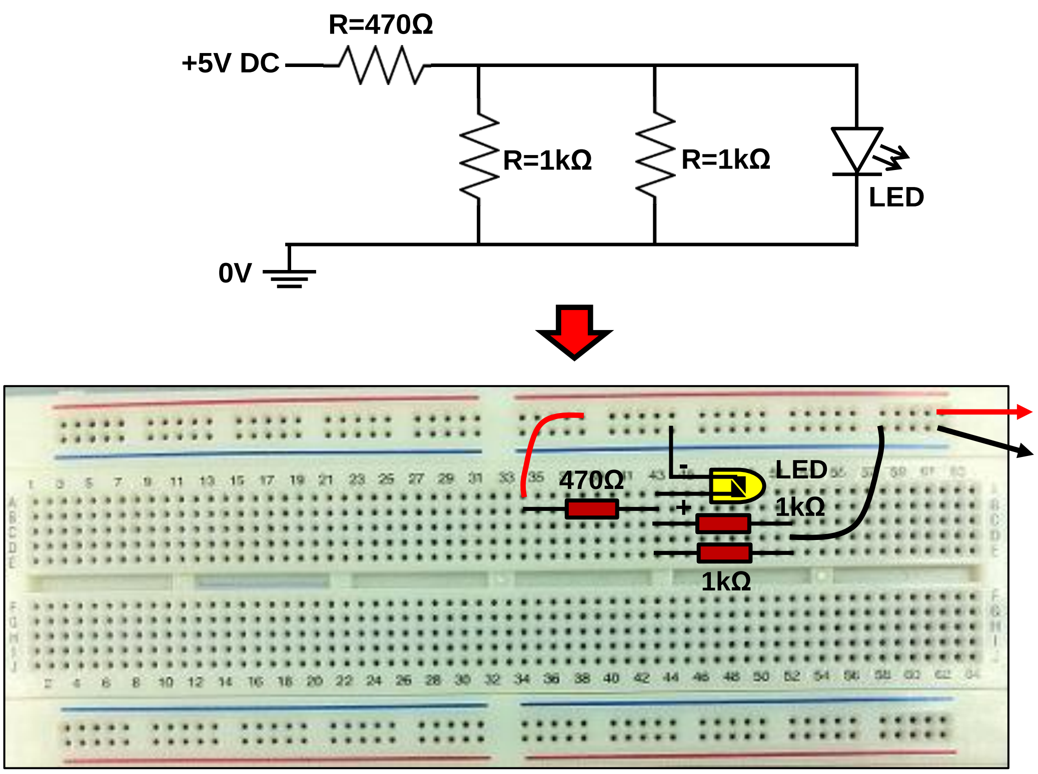


Figure 10: Parallel connection of a circuit

TEST 4: CONNECTING IC AND COMPONENTS ON A BREADBOARD

1. Place the components and wires/jumpers on a breadboard as shown in Figure 11. Note: 74XX32 is an OR gate chip, where XX can be HC, LS or AC. **CAUTION:** Do not touch the pins of the LED while placing it on the breadboard. Otherwise, the pins may break.
2. Connect pin 14 of the OR gate chip to +5V DC of the DC power supply through a 470Ω resistor and pin 7 to 0V or ground of the DC power supply.
3. Switch ON the DC power supply.
4. Connect pin 12 and pin 13 according to Table 5 and observe whether the LED is ON or OFF. The results must be similar to the OR gate truth table.
5. Switch OFF the DC power supply.
6. Change the input pin to 9 and 10. Change the output pin to 8. Record the results in Table 5.
7. Switch OFF the DC power supply. Remove all components from the breadboard and leave the components nicely on the table. **CAUTION:** Remove the IC from the breadboard gently and carefully. Otherwise, some of its pins may break.

Table 5

Input		**Output (pin 11)**
Pin 12	**Pin 13**	**LED ON / OFF?**
To 0V	To 0V	
To 0V	To +5V	
To +5V	To 0V	
To +5V	To +5V	

Input		**Output (pin 8)**
Pin 9	**Pin 10**	**LED ON / OFF?**
To 0V	To 0V	
To 0V	To +5V	
To +5V	To 0V	
To +5V	To +5V	

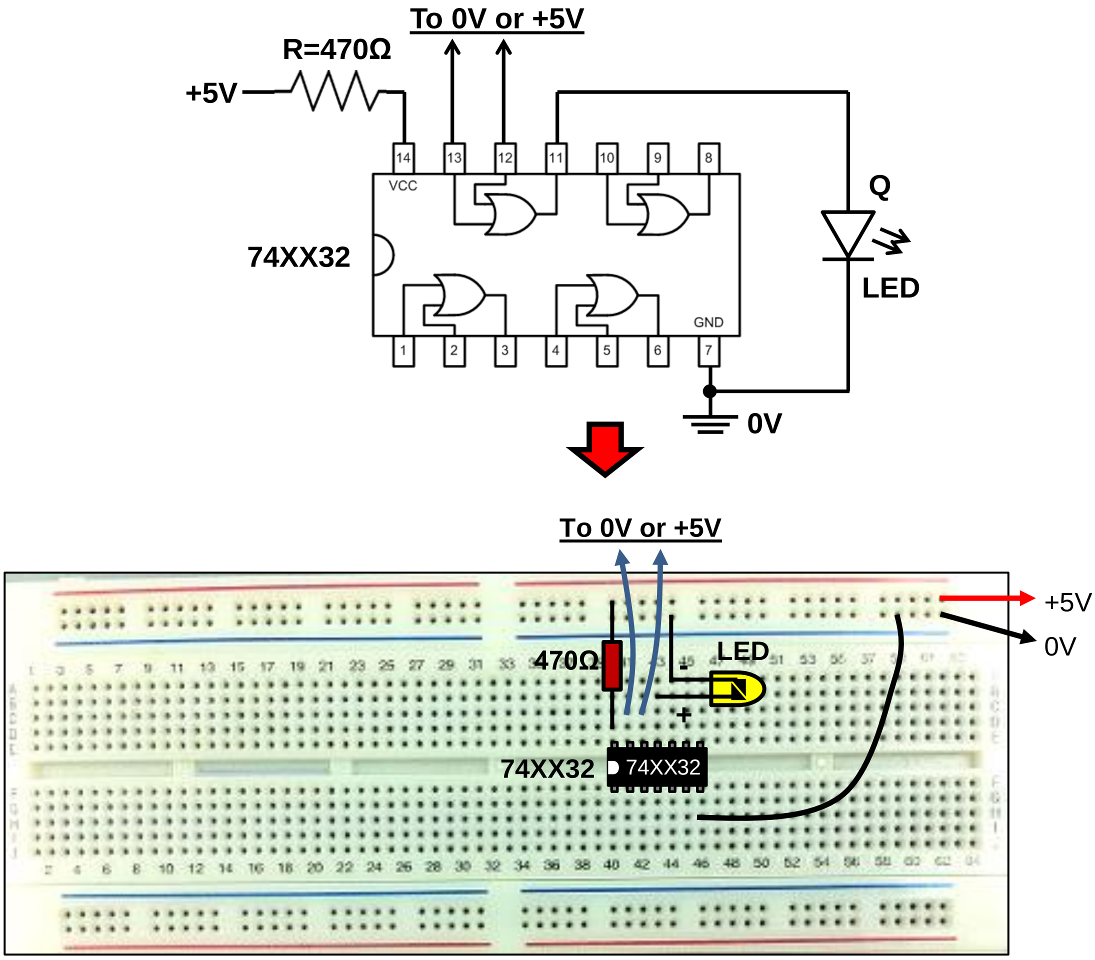


Figure 11

Notes: If your circuit is not working as expected, follow these steps:

1. Check whether the DC power supply has been turned ON and is working or not.
2. Check whether the output voltage of the DC power supply is 5V or not by using a multimeter.
3. Check whether the LED has been connected to the right polarity or not. If not, change the LED connection.
4. Check whether the LED is working or not. If not, change the LED with a new unit.
5. Check whether the wires have been connected to the right pins of the IC or not.
6. Change the IC with a new unit.
7. Move the position of each component to another position on the same breadboard.
8. Use a different breadboard.
9. If none of these methods work, consult the lab demonstrator or technician.

END OF EXPERIMENT