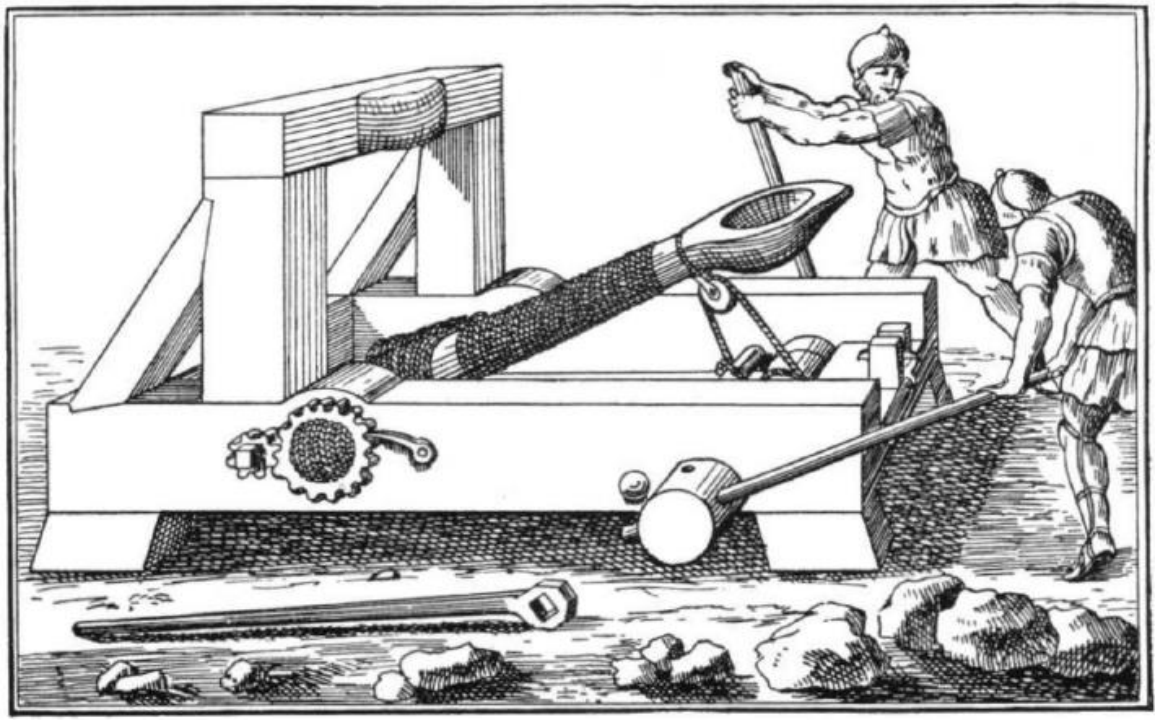
Engineering Design Project I
UTA013

Dr. Poonam Verma
Assistant Professor
ECED, TIET, Patiala

Engineering Design Project-I: Mangonel

- In Engineering Design Project-I, Mangonel (Roman catapult) is to be designed and implemented.



Mangonel: Electronics Part

The Electronic Part is divided into 4 sections:

- Programming of Arduino Digital I/O pins for various applications.
- Sensing any activity through Arduino and instructing accordingly. Also, data capturing through sensors.
- Interfacing of hardware and software to do a specific task (using 7-segment display)
- Develop a micro-electronic circuit to determine and display the angular velocity of the throwing arm.

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Assignment 2

Exercise 1

- To verify the function tables of CD4027 and CD4081 ICs.

Exercise 2

- Demonstrate the working of IR sensors and receiver and display output using LED.

Digital Circuits

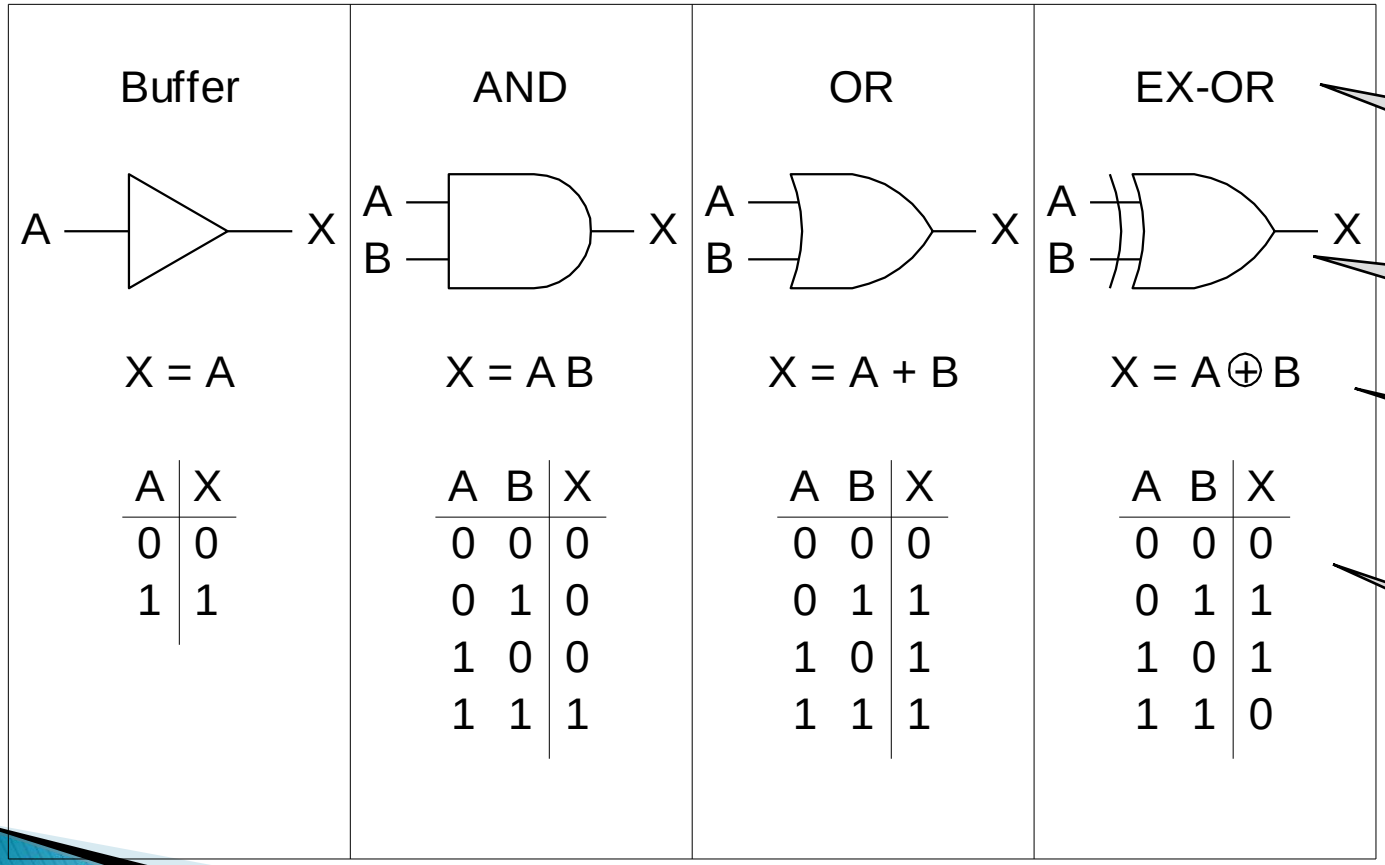
- Digital circuits are of two types
  - Combinational circuits
  - Sequential circuits

- Combinational circuit: The digital circuit in which output depends only of the present input is called as combinational circuits. These circuits do not contain any memory elements.

- Sequential circuit: The digital circuit in which output depends not only on the present input but also the past output is called as sequential circuits. These circuits exhibits memory to remember the previous outputs and are synchronized by clock signal.

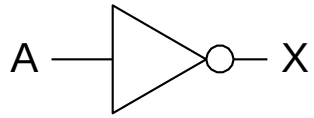
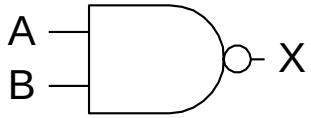
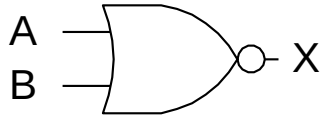
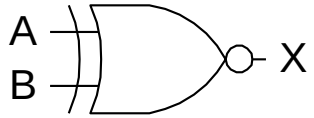
Basic Logic Gates

- Non-inverting logic gates are shown below



Basic Logic Gates with Inverted Output

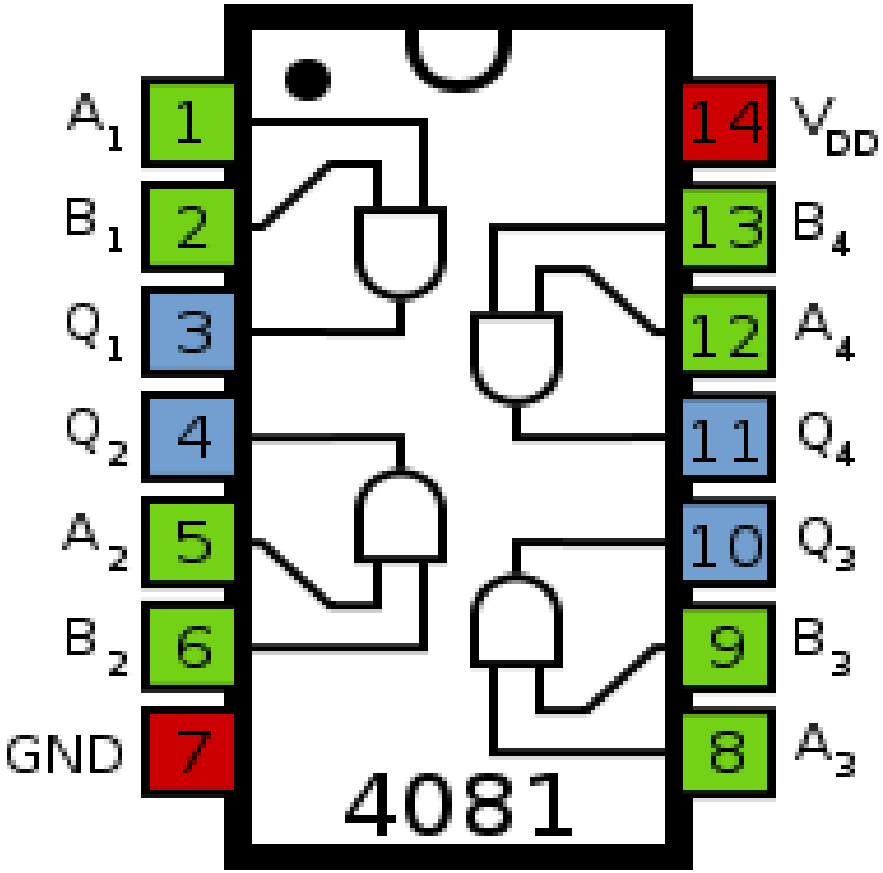
- Logic gates with inverting outputs are shown below.

NOT	NAND	NOR	EX-NOR
			
$X = \overline{A}$	$X = \overline{A\,B}$	$X = \overline{A + B}$	$X = \overline{A \oplus B}$
A X 0 1 1 0	A B X 0 0 1 0 1 1 1 0 1 1 1 0	A B X 0 0 1 0 1 0 1 0 0 1 1 0	A B X 0 0 1 0 1 0 1 0 0 1 1 1

Datasheet of CD4081 IC

- Quad 2-input AND Gate
- 2-input AND gates can be used to combine signal to generate a single signal.

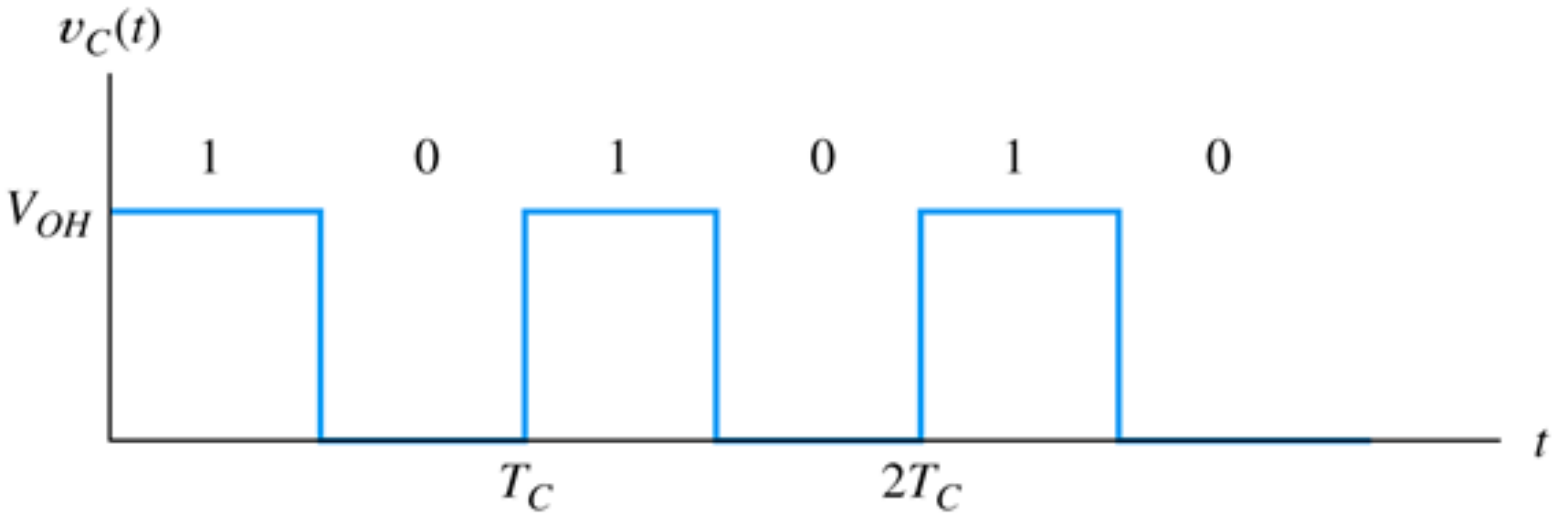
Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1



Sequential Circuits

Clock

- The sequential logic circuits have memory
- Output is a function of input and present state
- Sequential circuits are synchronized by a periodic “clock” signal.

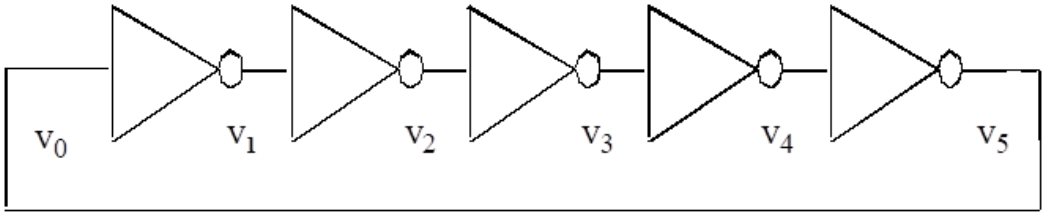


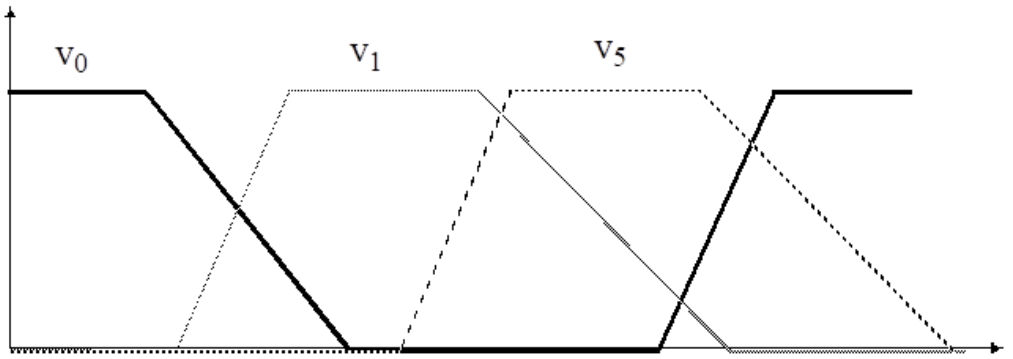
Clock Generator Circuit

- The clock signal can be generated by connecting odd number of inverter in feedback chain.

- The time period of the clock will depends on the propagation delay of inverter and the number of inverters in the chain.

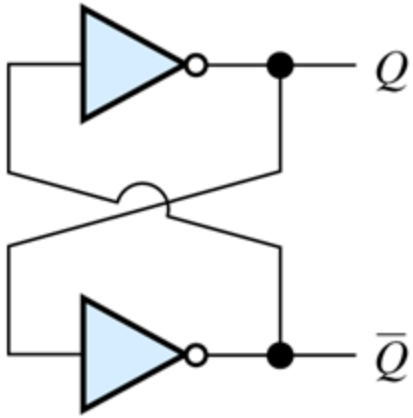
$$T = 2 \times t_p \times N$$





Flip-flop

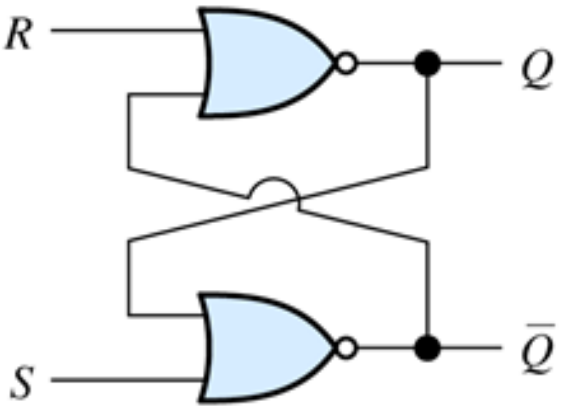
- A basic sequential circuit is a flip-flop.
- Flip-flop has two stable states of complementary output values
- No controlling input



SR flip-flop

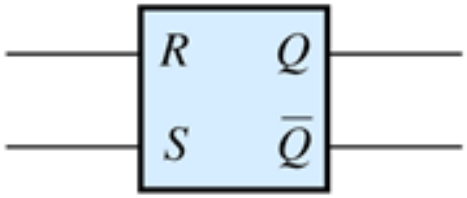
- SR (set-reset) flip-flop based on two NOR gates

- An SR flip-flop can be implemented by cross coupling two NOR gates



R	S	Q_n
0	0	Q_{n-1}
0	1	1
1	0	0
1	1	Not allowed

(a) Truth table

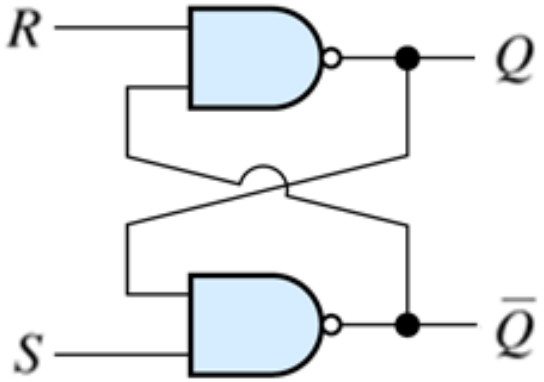


(b) Circuit symbol

Figure The truth table and symbol for the SR flip-flop.

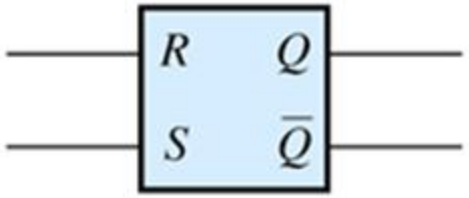
SR flip-flop

- SR (set-reset) flip-flop based on two NAND gates
- An SR flip-flop can be implemented by cross coupling two NAND gates



R	S	Q_n
0	0	Not allowed
0	1	1
1	0	0
1	1	Q_{n-1}

(a) Truth table

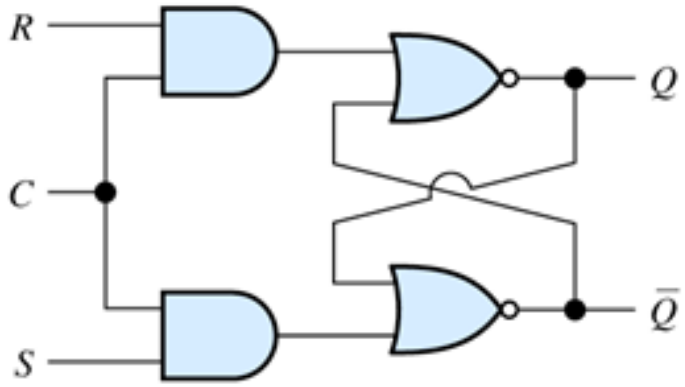


(b) Circuit symbol

Figure The truth table and symbol for the SR flip-flop.

Clocked SR flip-flop

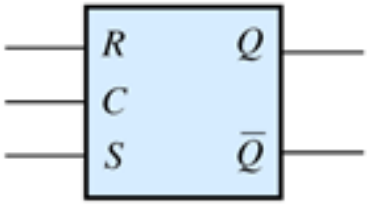
- Clock controlled flip-flop changes its state only when the clock C is high.



(a) Circuit diagram

R	S	C	Q_n
0	0	×	Q_{n-1}
0	1	1	1
1	0	1	0
1	1	1	Not allowed
×	×	0	Q_{n-1}

(b) Truth table

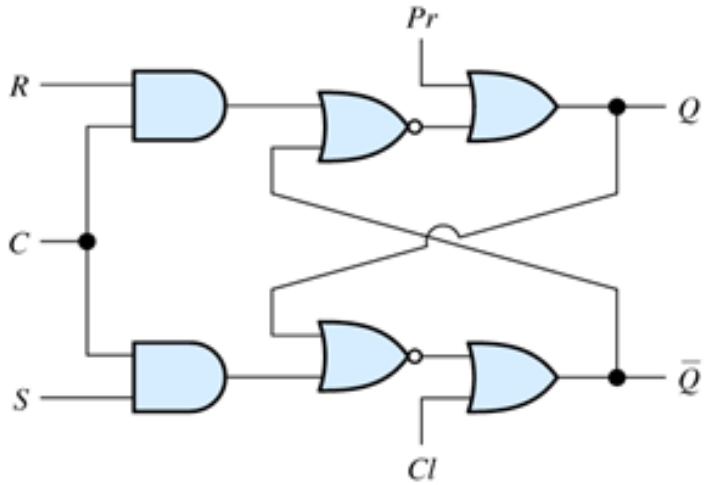


(b) Circuit symbol

Figure A clocked SR flip-flop.

Clocked SR flip-flop with Reset

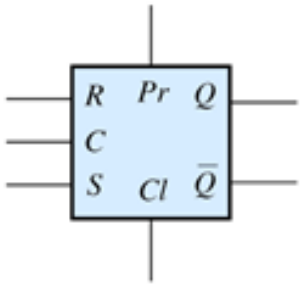
- Some flip-flops have asynchronous preset Pr and clear Cl signals.
- Output changes once these signals change, however the input signals must wait for a change in clock to change the output



(a) Circuit diagram

Pr	Cl	R	S	C	Q_n
0	0	0	0	×	Q_{n-1}
0	0	0	1	1	1
0	0	1	0	1	0
×	×	1	1	1	Not allowed
0	1	×	×	×	0
1	0	×	×	×	1
1	1	×	×	×	Not allowed

(b) Truth table



(c) Circuit symbol

Figure A clocked SR flip-flop with asynchronous preset and clear inputs.

Edge triggered flip-flop

- Edge triggered flip-flop changes only when the clock changes.

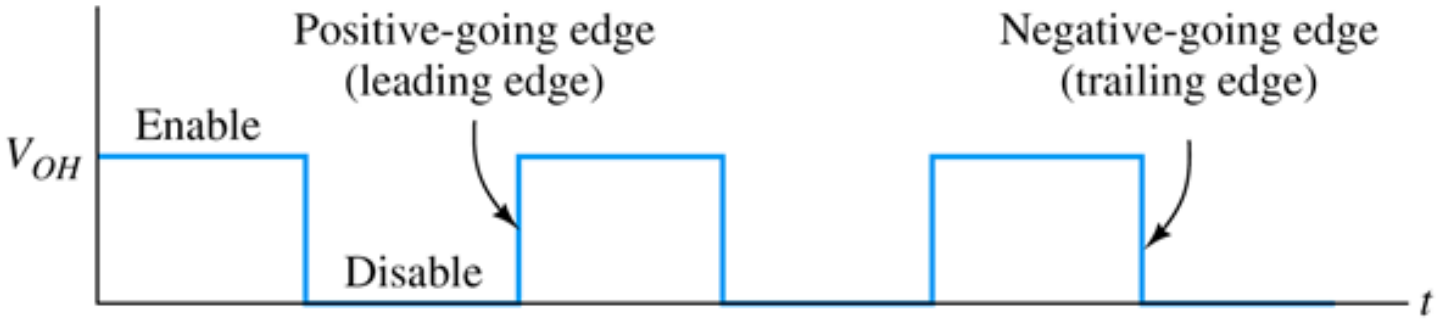
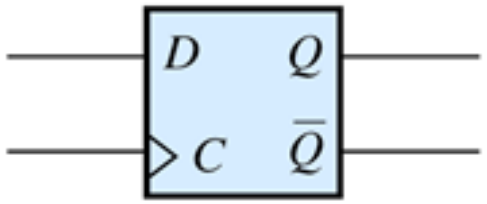


Figure Clock signal.

Positive edge triggered flip-flop

- Positive-edge triggered flip-flop changes only on the rising edge of the clock.



(a) Circuit symbol

C	D	Q_n
0	×	Q_{n-1}
1	×	Q_{n-1}
↑	0	0
↑	1	1

(b) Truth table

↑ indicates a transition from low to high

Figure A positive-edge-triggered D flip-flop.

Example

- The input D to a positive-edge triggered flip-flop is shown
- Find the output signal Q.

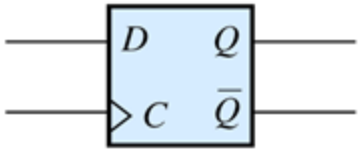
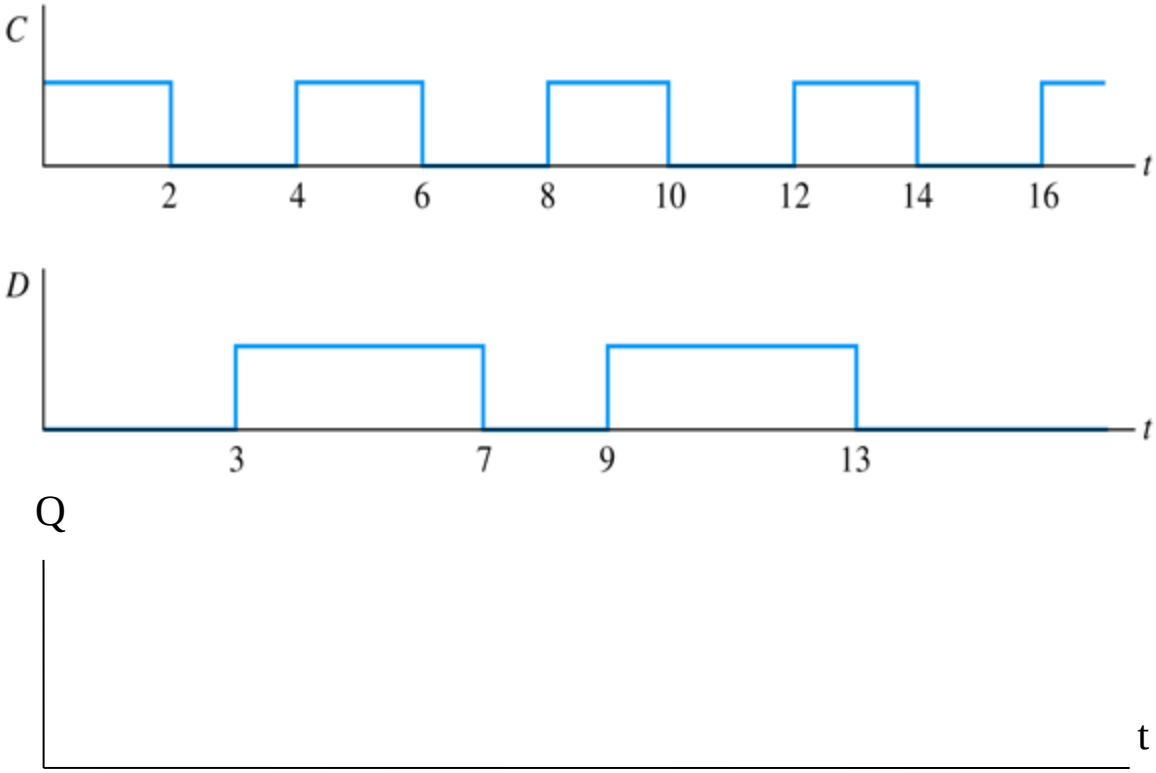


Figure A positive-edge-triggered D flip-flop.



Example

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- Find the output signal Q.

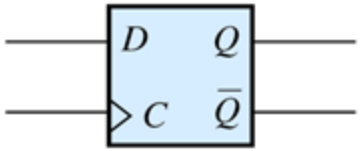


Figure A positive-edge-triggered D flip-flop.

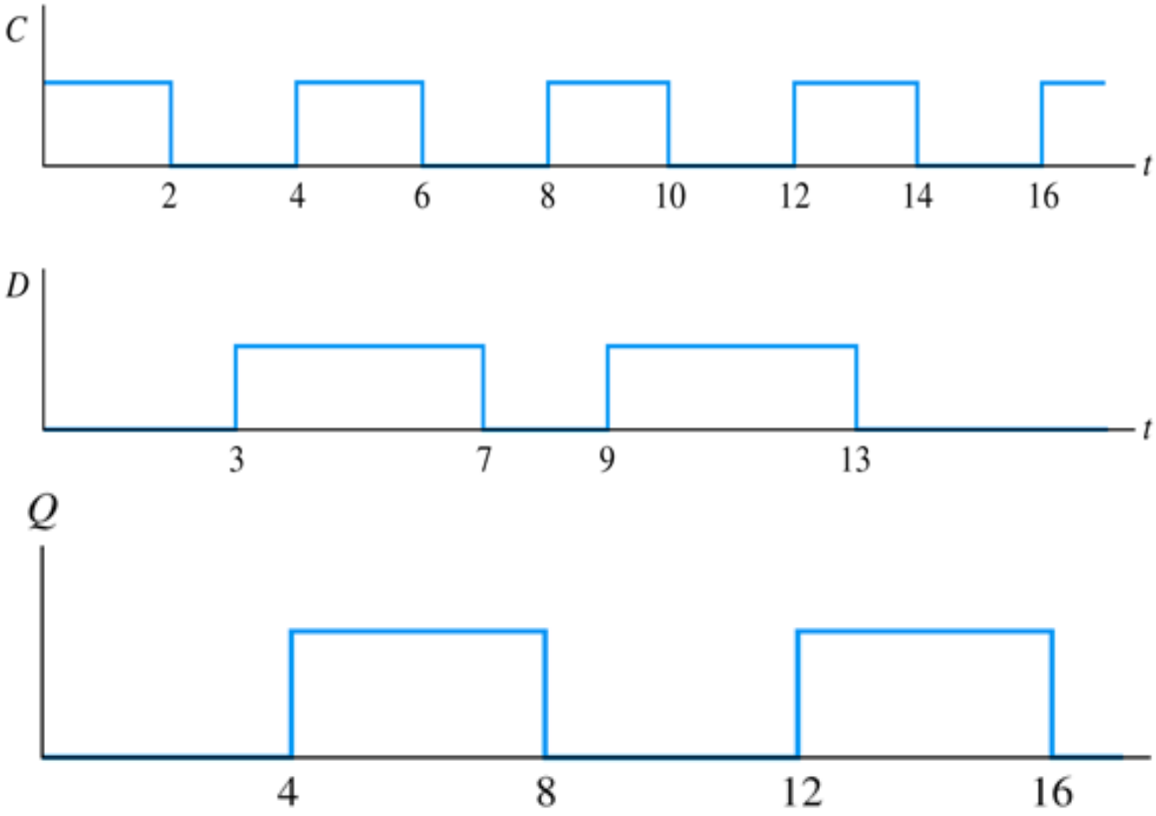
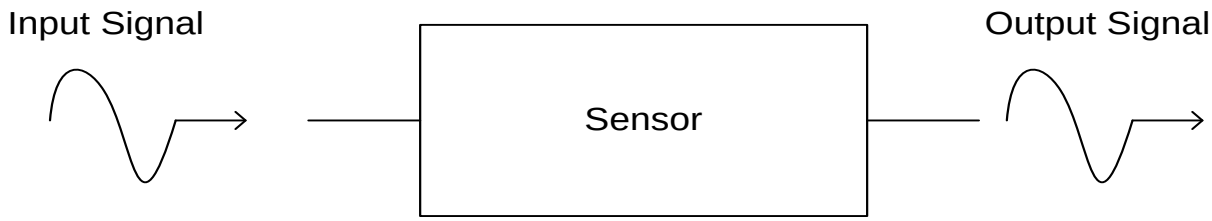


Figure Answer for Exercise

Sensors

- American National Standards Institute (ANSI) Definition: A device which provides a usable output in response to a specified measured.



- A sensor acquires a physical parameter and converts it into a signal suitable for processing (e.g. optical, electrical, mechanical)
- A transducer
  - Microphone, Loud Speaker, Biological Senses (e.g. touch, sight,…etc.)

What is sensing

- Sensor - an electrical/mechanical/chemical device that maps an environmental attribute to a quantitative measurement
- Each sensor is based on a transduction principle -conversion of energy from one form to another
- Also known as transducers

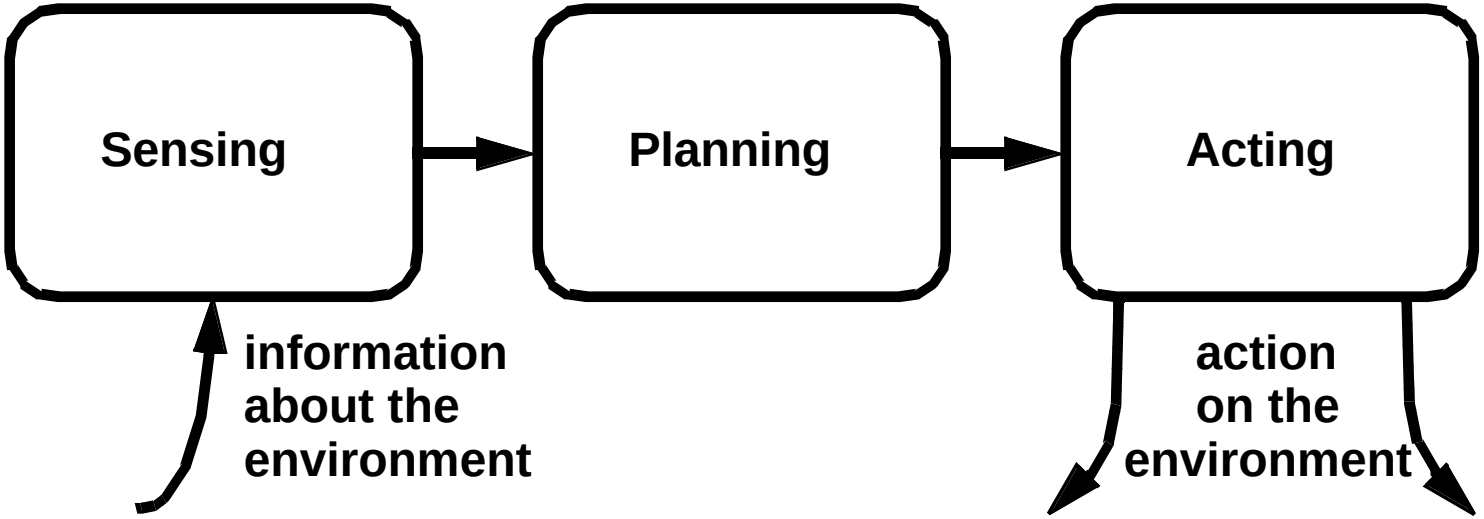
- Why do we need sensors?

Need of Sensors

- Sensors are omnipresent. They embedded in our bodies, automobiles, airplanes, cellular telephones, radios, chemical plants, industrial plants and countless other applications.

- Without the use of sensors, there would be no automation possible !!

What makes a machine a robot?



Example

- Where is the cropline?

Autonomous harvesting

- Where is the face?

Will I hit anything?

Detectable Phenomenon

Stimulus	Quantity
Acoustic	Wave (amplitude, phase, polarization), Spectrum, Wave Velocity
Biological & Chemical	Fluid Concentrations (Gas or Liquid)
Electric	Charge, Voltage, Current, Electric Field (amplitude, phase, polarization), Conductivity, Permittivity
Magnetic	Magnetic Field (amplitude, phase, polarization), Flux, Permeability
Optical	Refractive Index, Reflectivity, Absorption
Thermal	Temperature, Flux, Specific Heat, Thermal Conductivity
Mechanical	Position, Velocity, Acceleration, Force, Strain, Stress, Pressure, Torque

Types of sensors

- Active
  - send signal into environment and measure interaction of signal w/ environment e.g. radar, sonar
- Passive
  - record signals already present in environment e.g. video cameras
- Classification by medium used
  - Based on electromagnetic radiation of various wavelengths
  - Vibrations in a medium
  - Concentration of chemicals in environment
  - By physical contact

Selection of suitable sensor

Environmental Factors	Economic Factors	Sensor Characteristics
Temperature range	Cost	Sensitivity
Humidity effects	Availability	Range
Corrosion	Lifetime	Stability
Size		Repeatability
Overrange protection		Linearity
Susceptibility to EM interferences		Error
Ruggedness		Response time
Power consumption		Frequency response
Self-test capability		

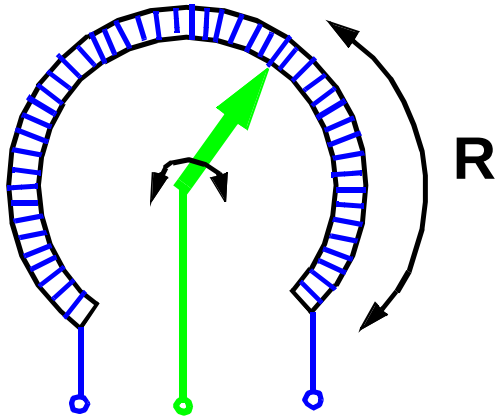
Examples

Resistance variation based sensors

- Light sensor
  - Photo-resistor- resistance changes with light intensity

- Temperature sensor
  - Thermistor- resistance changes with temperature

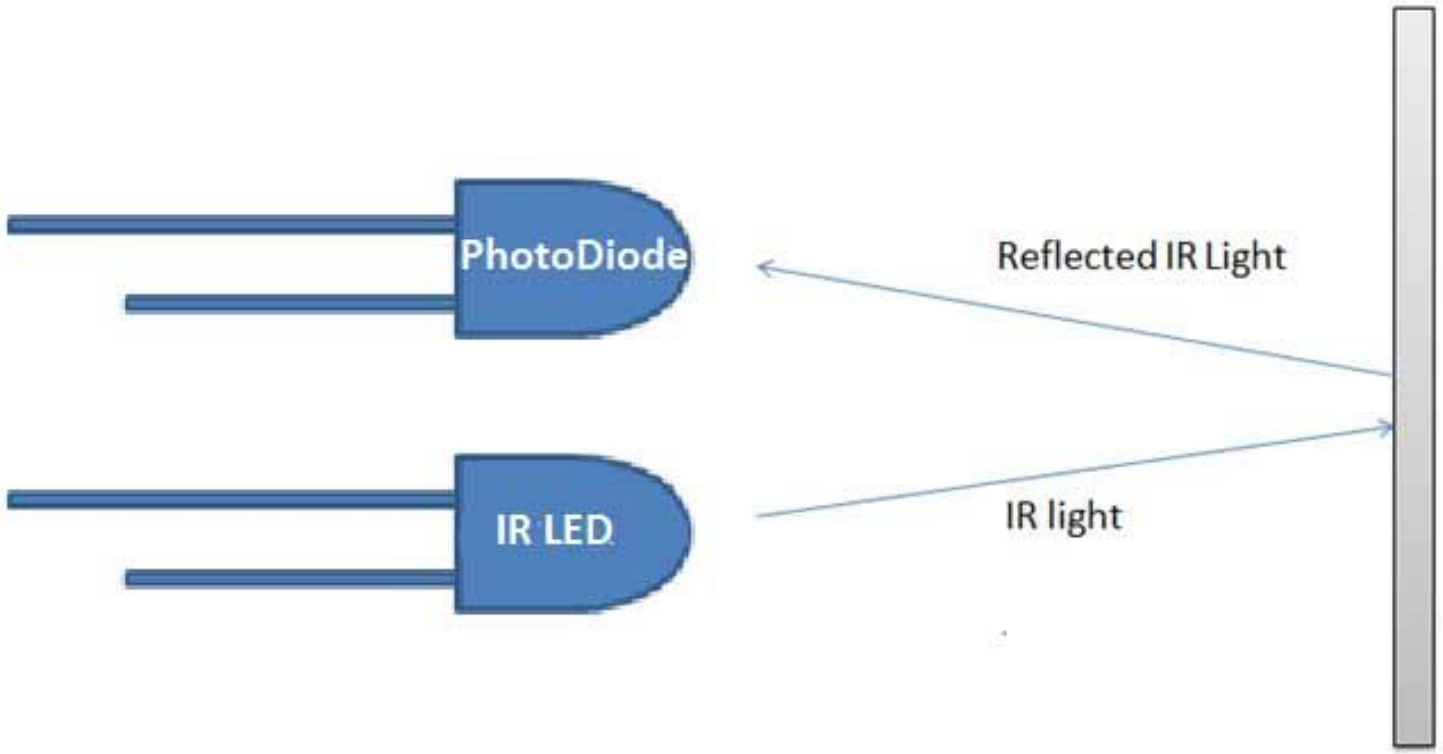
- Rotation sensor
  - Potentiometer- resistance changes with position of dial.



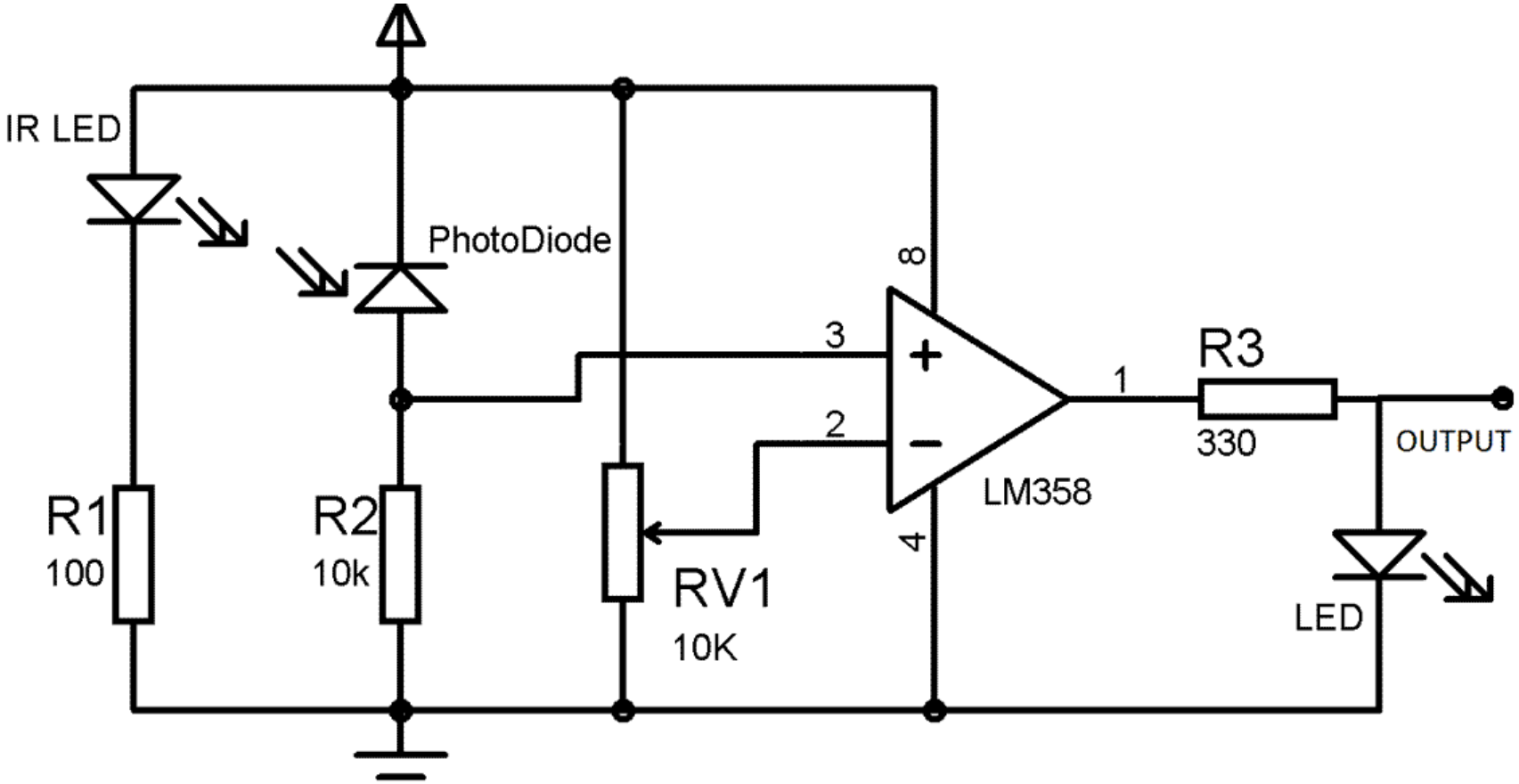
Infrared sensors

- It is an electronic instrument that is used to sense certain characteristics of its surroundings.
- It does this by either emitting or detecting infrared radiation.
- Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion.

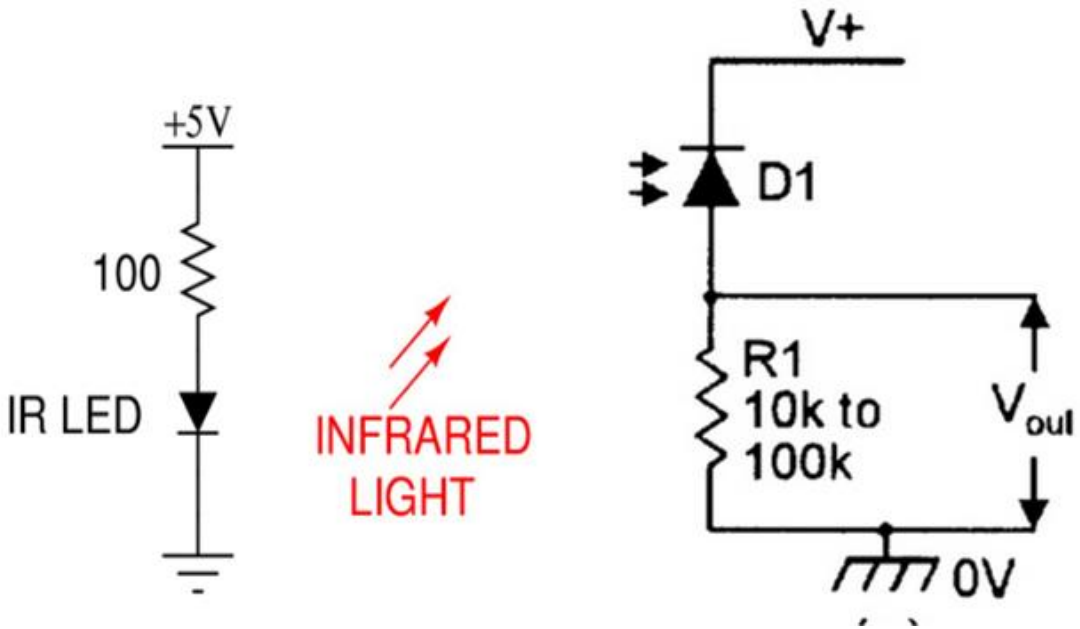
Infrared sensors



Infrared sensors



Example 2



Thanks