Power supply design

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Having a 5 volt DC power supply around in your workspace can be very useful. Many op amps, micro controllers, and other digital ICs {integrated circuits} run off 5 volts (although most now take a range of 3-15 volts) . Here is how to build a very simple 5 volt DC power supply that can deliver up to 1.5A of current. You will need to solder together the various components.

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POWER SUPPLY DESIGN

AIM: Design the 5V and 1.5 amp DC power supply using 230V AC supply

APPARATUS:

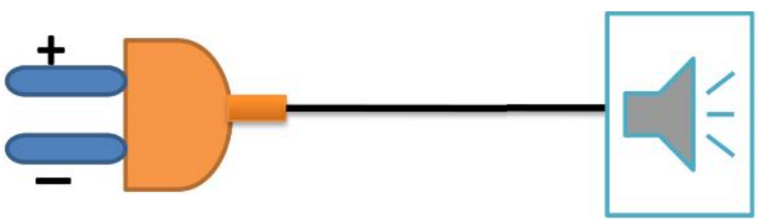
1. Step down Transformer 230V/5V AC = 1
2. 1N4007 Diode = 4
3. Capacitor = 330uF/50V
4. Regulator LM7805=1

Alternating current:

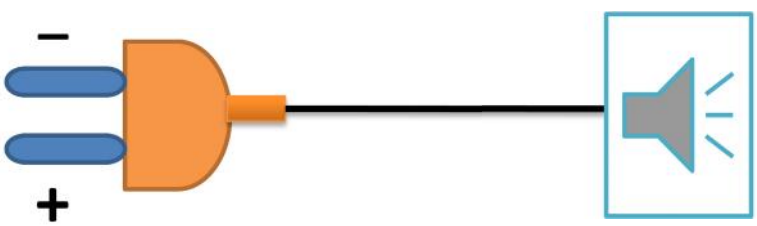
It is bidirectional current.

Why it is called as bidirectional current?

Example: Practically



One direction



Another direction

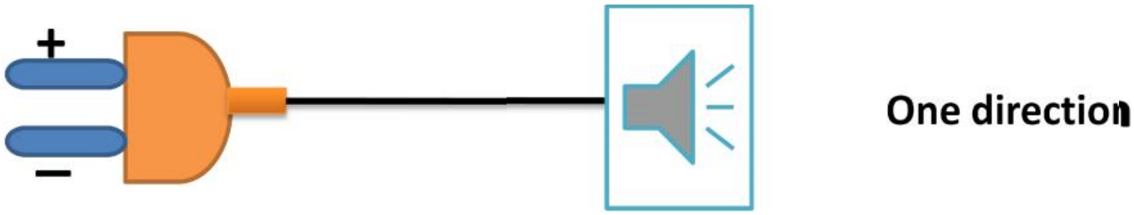
In the above figure the 2 pin plug when it is plugged into 230V AC then the blub glows even by changing the polarities of the 2 pin plug the blub glows

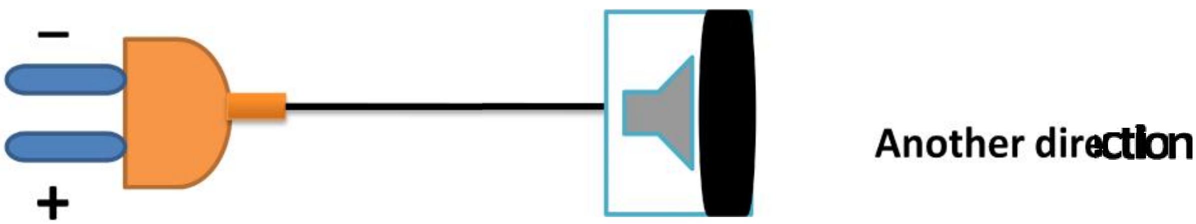
Direct current:

It is unidirectional current

Why it is called as unidirectional current

Example: Practically





In the above figure the 2 pin plug when it is plugged into 5V DC then the LED glows when you change the polarities of the 2pin plug the LED doesn't glow.

Procedure:

Step1: Convert 230V/AC to 5V AC using step down transformer

- Transformer consists of two input terminals and two output terminals
- In transformer one side it contain two terminals and other side it contains two terminals to find out input and output terminals, find the resistance of the both sides using multimeter. The resistance is high for input terminals and low for output terminals.
- Now input terminals are connected to 2 pin plug to 230V AC.
- The output terminals output voltage is 5V AC.
- Now first step is completed

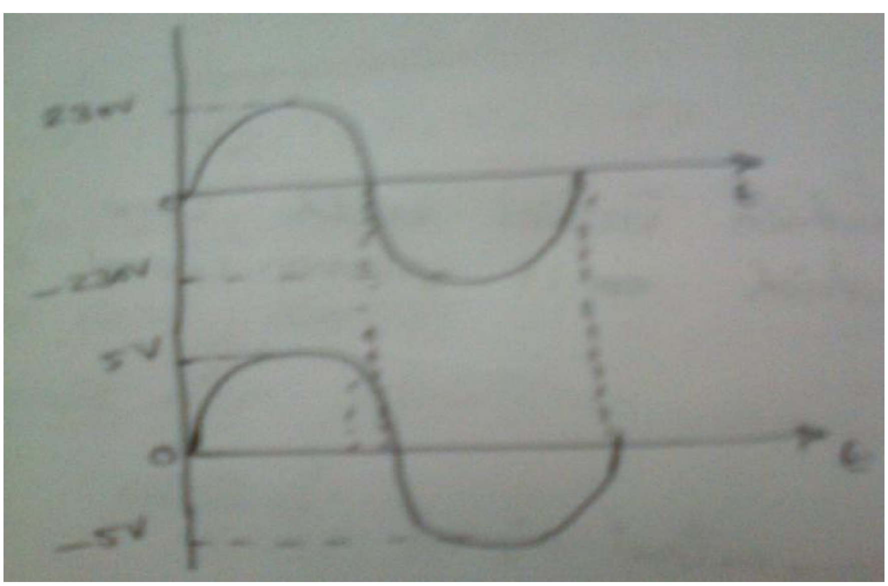


Figure 5V AC wave form

Step 2: Convert 5V AC to 5V pulsating DC

- To convert 5V AC to 5V pulsating DC we need a rectifier. Rectifier means which convert AC to pulsating DC
- Here I use bridge rectifier. Bridge rectifier output is full wave form. It contains four diodes D1, D2, D3, and D4.

What is diode?

Diode is two terminals device which consists of anode and cathode. It conducts in only one direction.

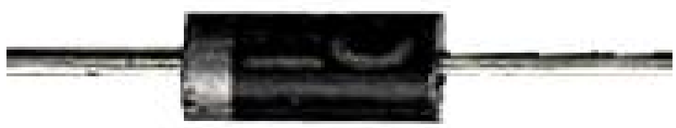
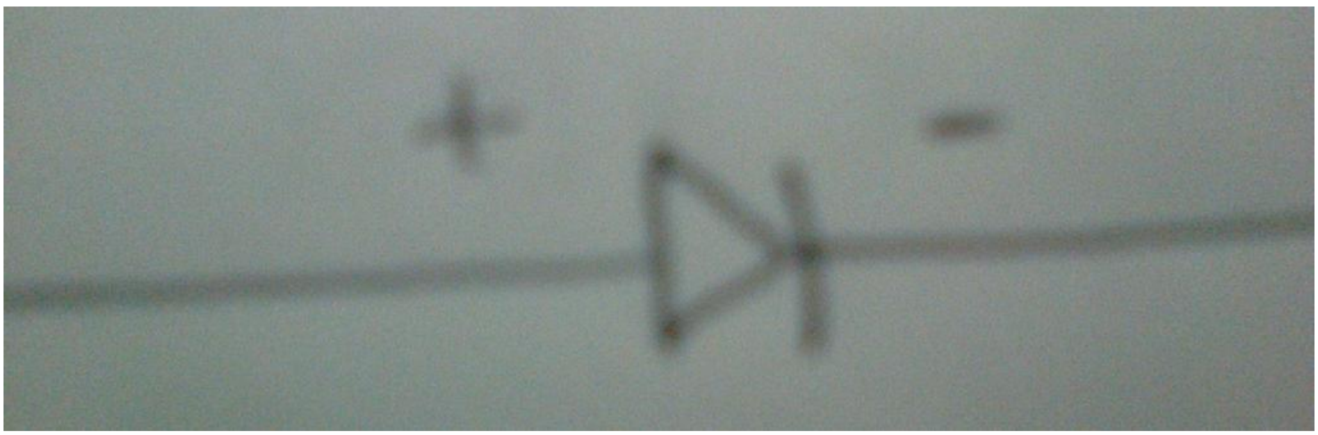


Figure diode



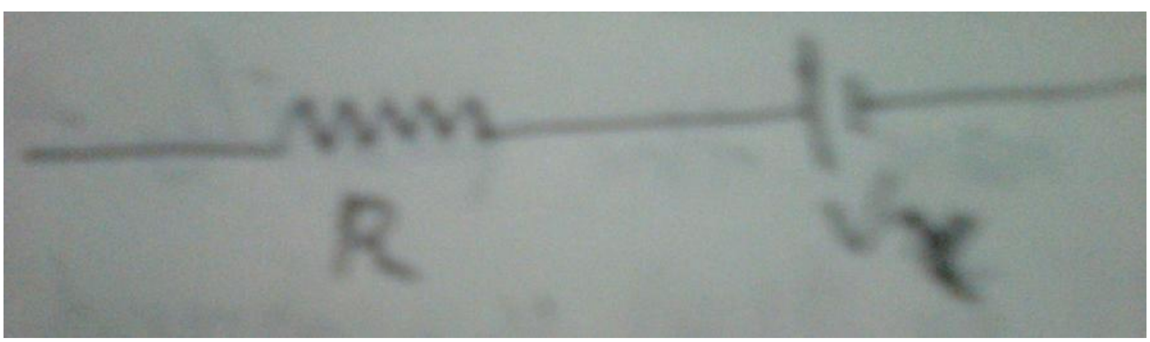
Symbol of diode

Why it is uni-directional?

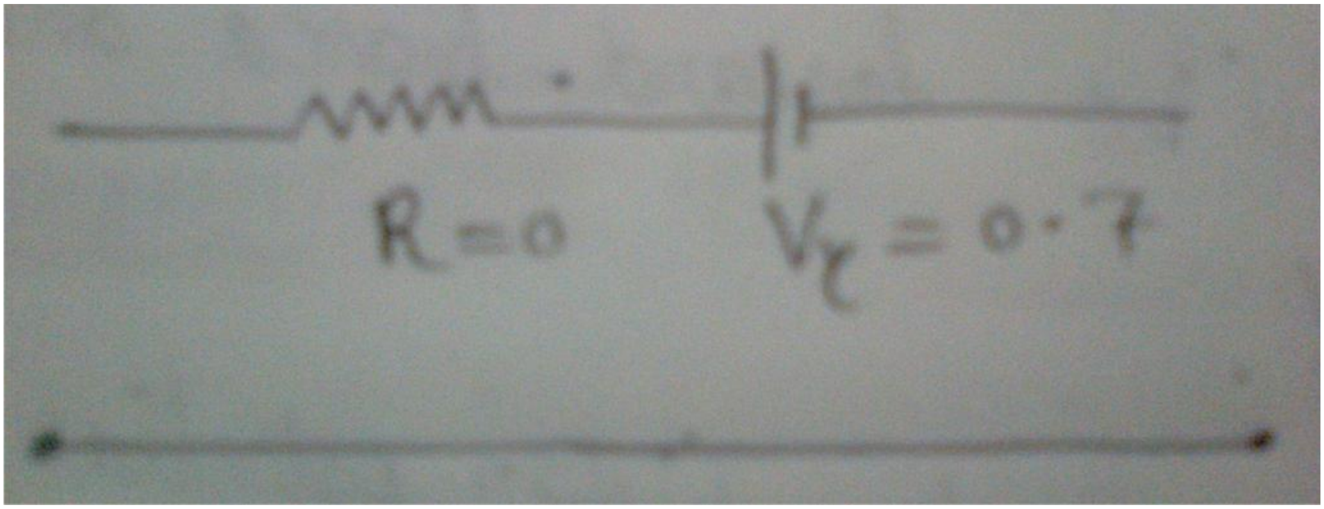
The ideal characteristics of the diode is

1. In forward bias the input resistance R is zero
2. In reverse bias the input resistance R is infinite

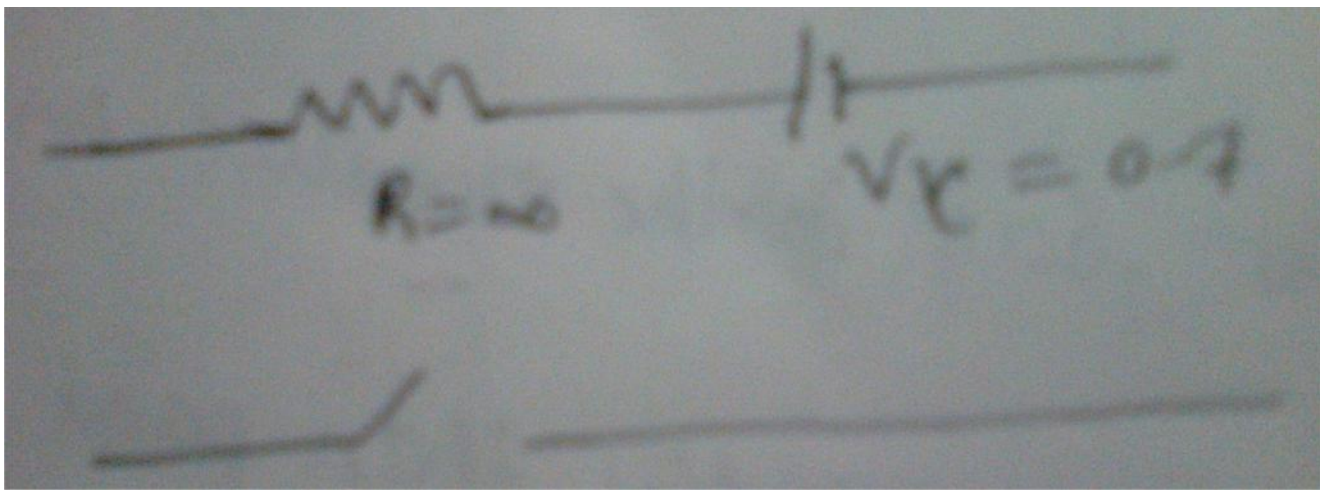
Equivalent circuit diagram of diode



Circuit: Diode in forward bias



Circuit: Diode in reverse bias



In forward bias the diode is short circuited because input resistance of diode is zero. When resistance is zero then it becomes short circuit. So diode conducts

In reverse bias the diode is open circuited because input resistance is infinite. When resistance is infinite then it becomes open circuit. So diode does not conduct.

So diode conducts in only one direction i.e. in forward bias. So diode is a unidirectional device.

What is forward bias?

When positive terminal of power supply is connected to positive terminal of diode and negative terminal of diode is connected to negative terminal of power supply then this bias is called forward bias. In this bias diode allows only positive voltages. It does not allow negative voltage.

What is reverse bias?

When negative terminal of the power supply is connected to positive terminal of diode and negative terminal of diode is connected to positive terminal of power supply then this bias is called reverse bias. In this bias diode neither allows positive voltage nor negative voltage.

The unidirectional behavior of the diode is called rectification. It is used to convert alternating current into direct current

Generally for normal operating current the forward voltage drop is 0.65V-0.7V, but it varies with current.

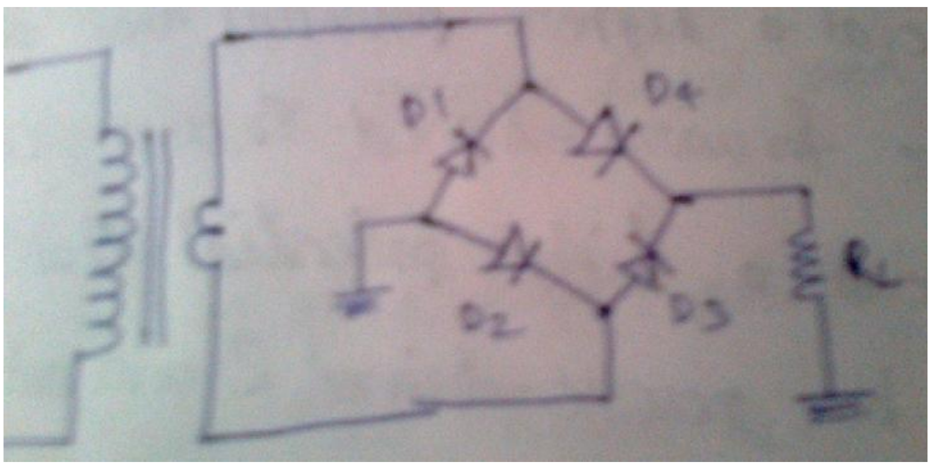
To convert AC to DC we need to arrange the diodes such that it should convert both positive and negative voltages of AC into positive voltages. This can be done using only full wave rectifier or bridge rectifier.

Rectifier means which converts bi-directional signal into unidirectional signal.

- In this we use bridge rectifier to convert AC to pulsating DC

Bridge rectifier:

- The full wave bridge rectifier is designed to convert an AC sine wave to an full wave pulsating DC signal
- The bridge is normally connected to the secondary terminals of the transformer
- Current will flow from a point with a higher potential to a point of lower potential.



During Positive Half cycle

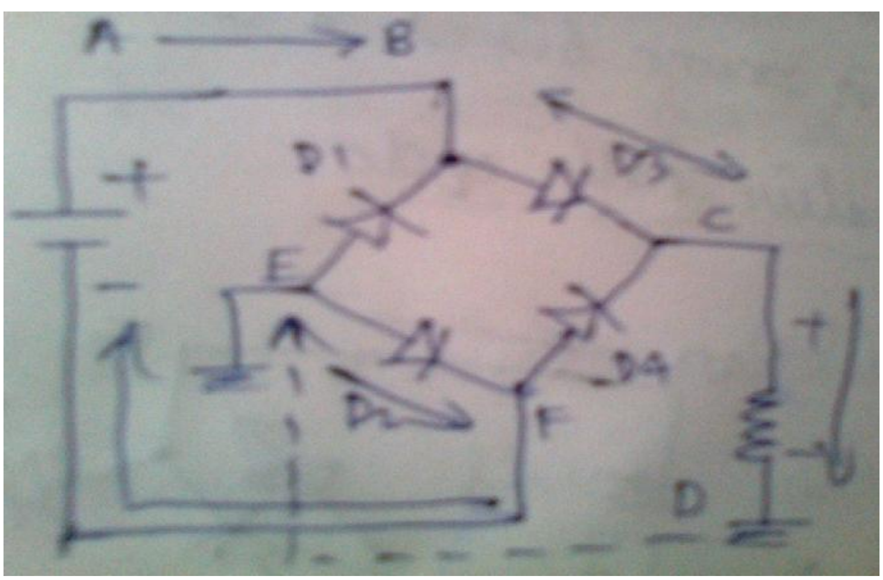


Figure: positive half cycle

- The Top of the battery is positive
- Current flows from point A to point B
- Point B will be at a higher potential than point C
- Diode D3 will be forward biased and will conduct current
- Point E will be at lower potential than point B
- Diode D1 will be reverse biased and will not conduct current
- Point C will be at higher potential than point D
- Current will be flow through R
- The load contain polarities +ve and -ve
- The current will flow through the ground connection from point D to point E
- Point E will be at higher potential than point F
- Diode D2 will be forward biased and will conduct current
- Point B will be at a higher potential than point E
- Diode D1 will be reverse biased and will not conduct current
- Current will flow back to the negative terminal of the battery
- Point F is at low potential than point C
- Diode D4 is reverse biased and will not conduct current

During Negative Half cycle

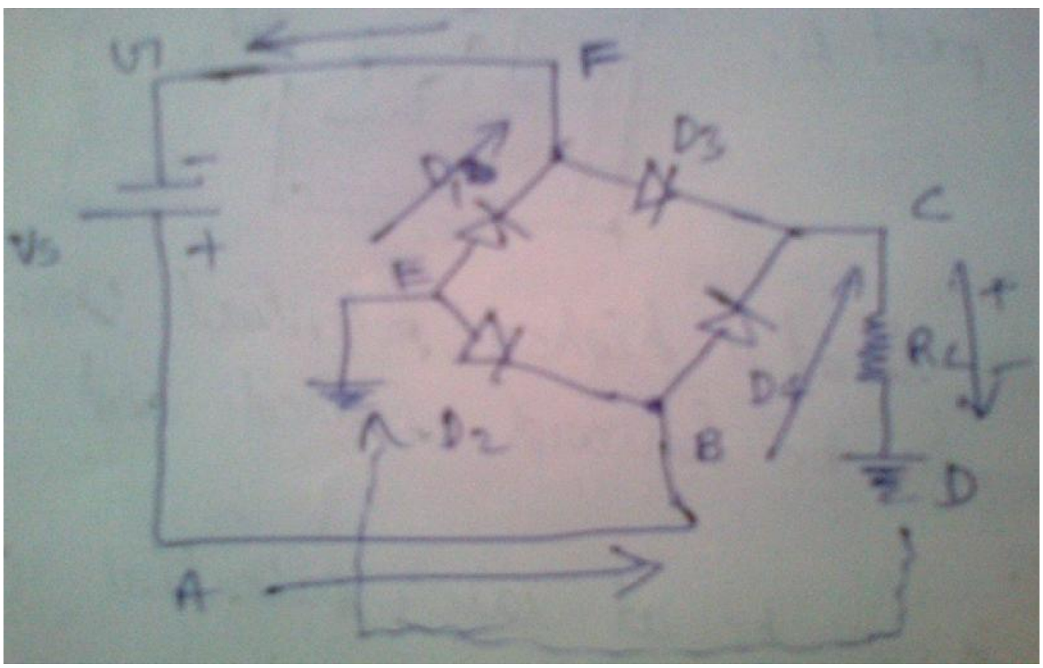
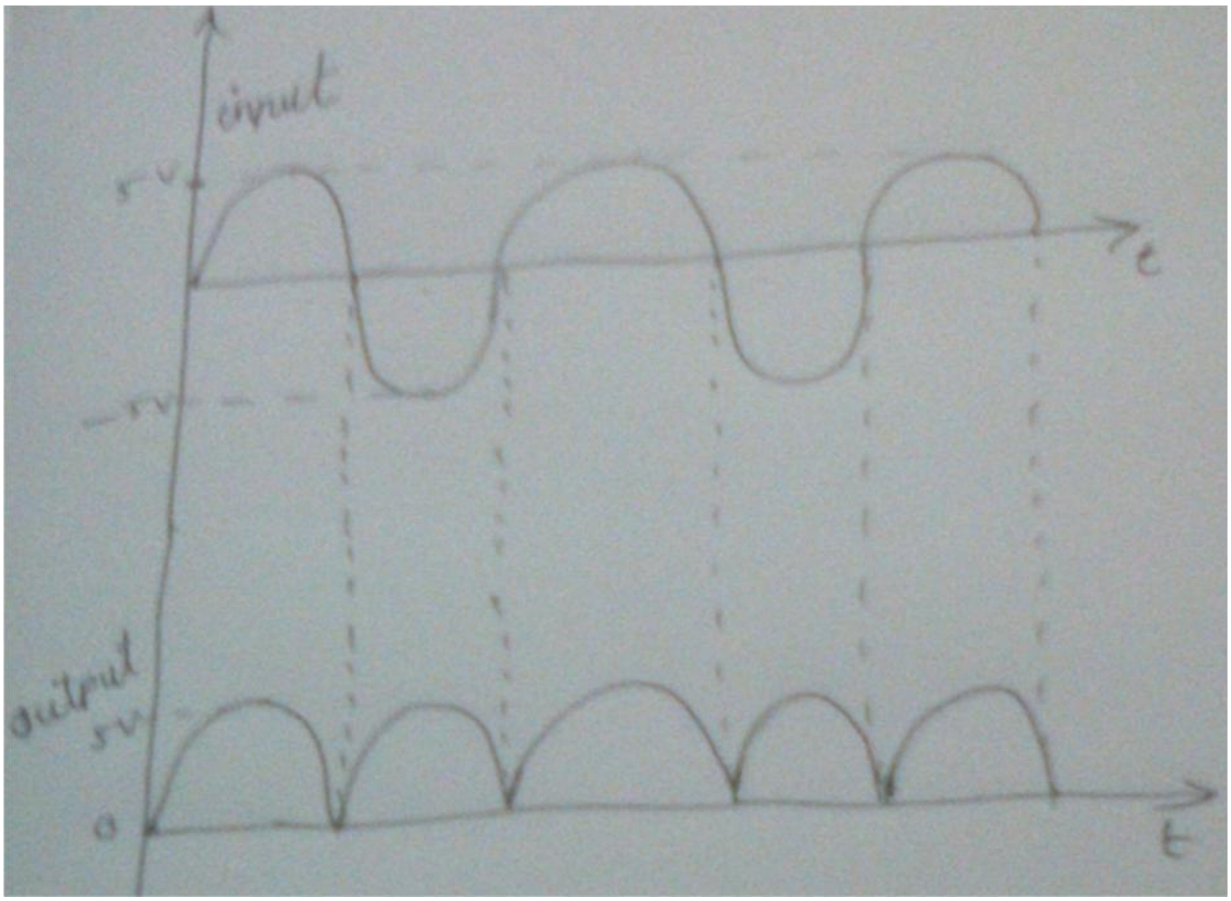


Figure: Negative Half cycle

- Current flows from point A to Point B
- Point B will be at a higher potential than point C
- Diode D4 will be forward biased and will conduct current
- Point E will be at a lower potential then point B.
- Diode D2 will be reverse biased and will not conduct current
- Point C will be at a higher potential than Point D
- Current will flow through R.

- The load voltage will have the polarity +ve and –ve
- The current will flow through the ground connections from point D to point E
- Point E will be at higher potential than point F
- The diode D1 will be forward biased and will conduct current
- The point B will be at higher potential than point E
- Diode D2 will be reverse biased and will not conduct current
- Current will flow back to the negative terminal of the battery
- Point F is at lower potential than point C
- Diode D3 is reverse biased and will not conduct current

Bridge rectifier wave forms



Why we prefer bridge rectifier?

- For a given center tapped transformer bridge rectifier produces a voltage output is twice that of the conventional full wave circuit.

Why we use bridge rectifier instead of Full wave rectifier for center tap transformer?

- Consider a center tapped transformer of 12V-0-12V AC.
- If we use full wave rectifier for rectification the output voltage of full wave rectifier is 12V DC. Because in full wave only one diode conduct during each cycle.
- If we use bridge rectifier for rectification the output voltage of bridge rectifier is 24V DC. It is twice that of the full wave rectifier output. Because in bridge rectifier two diodes conducts during each cycle.

- For only center tapped transformer we use bridge rectifier for higher voltage, for lower voltage we can use either bridge rectifier or full wave rectifier
- For normal transformer the output of full wave rectifier and bridge rectifier is same. So we can use either full wave rectifier or bridge rectifier.
- Full wave rectifier produces lower voltage and bridge rectifier produces higher voltage for center tapped transformers
- We can generate either higher voltage or lower voltage by using bridge rectifier for center tapped transformer

Why we use 1N4007 Diodes?

1N400X diodes are used as rectifiers for low frequency having big capacitance at the junction, other diodes have less capacitance value therefore they have quick ON –OFF time.

These 1N4007 diodes are usually slow. To measure the voltage drop across the diode connect a load resistance across the cathode terminal and other terminal of the load is connected to negative terminal of the battery. Then the drop across the diode is 0.7 volts.

Filtering:

The output of the rectifier is pulsating DC. This pulsating DC is converted into pure DC using filter. The filter used in this circuit is LC filter, but practically we won't use inductor because it is bulky. The value of capacitor depends upon the output voltage and output current. To calculate the value of capacitor the following formulae is used

$$Q = C \times V \longrightarrow \text{equation (1)}$$

$$Q = C \times IR$$

$$Q = I \times RC$$

$$Q = I \times T \longrightarrow \text{equation (2)}$$

Substitute equation (2) in equation (1)

$$I \times T = C \times V$$

$$C = (I \times T) / V$$

Here output voltage is V = 5 DC

Here output current is I = 1.5 amps

Here the input voltage is AC 230V, 50 Hz. The output of the transformer is 5V AC, 50 Hz, here in transformer output of the frequency is 50 Hz because transformer frequency remains constant. So f = 50 Hz,

$$T = 1/2\pi f$$

$$= 1 / 2 \times 3.14 \times 50 \text{ Hz}$$

$= 3.184713376 \times 10^{-3}$

Here output current is I = 1.5 amps

$C = (1.5 \times 3.184713376 \times 10^{-3}) / 5$

$C = 9.554140128 \times 10^{-4}$

$C = 955.41 \times 10^{-6}$

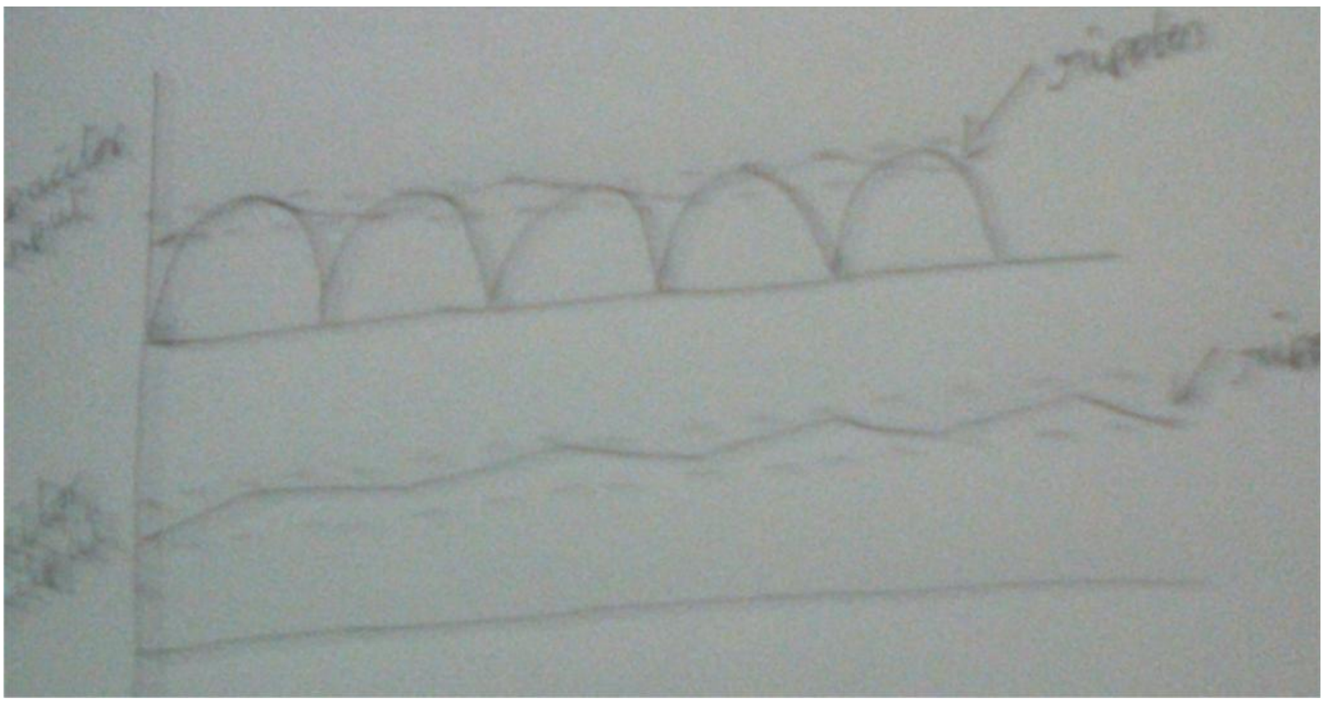
C = 955 uF

The value of capacitor is 955 uF at this value of capacitor are not available so that we have to select the value nearer to it so we use C =1000 uF.

If V = 5V DC and f =100 Hz, I=1.5 then C = 477 uF.

If V = 7V DC and f = 100 Hz, I = 1.5 then C = 330 uF.

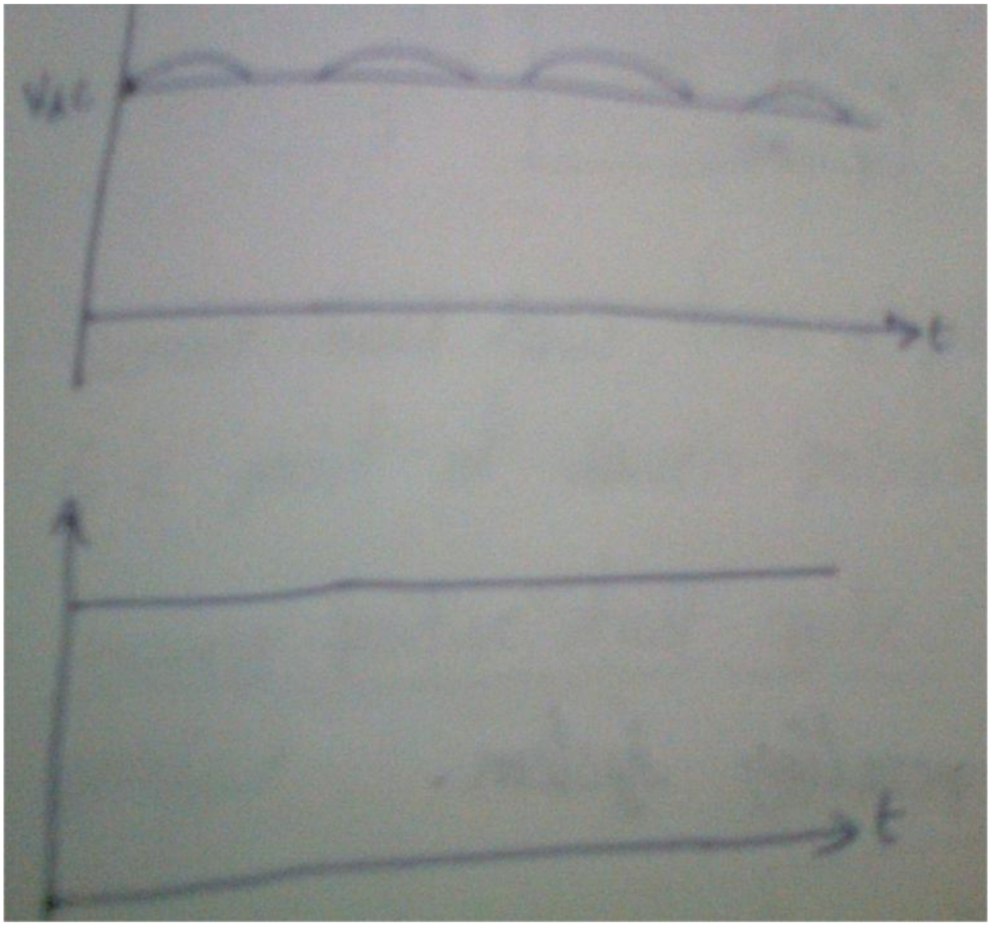
Capacitor input and output wave forms:



Regulator:

The purpose of regulator is to maintain constant voltage. For positive voltage output use LM78XX, XX indicates value of output voltage and 78 indicates positive output. For negative voltage output use LM79XX, 79 indicate negative voltage and XX indicates value of output. To get positive 5V regulated output use LM7805. To get negative 5V regulated output use LM7905.

Input and output wave forms



LM7805 IC:

Circuit diagram: