DC Motor Control Regions and Principles of Power Electronics

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20CSE050

Permanent Magnet DC Machines (PMDC)

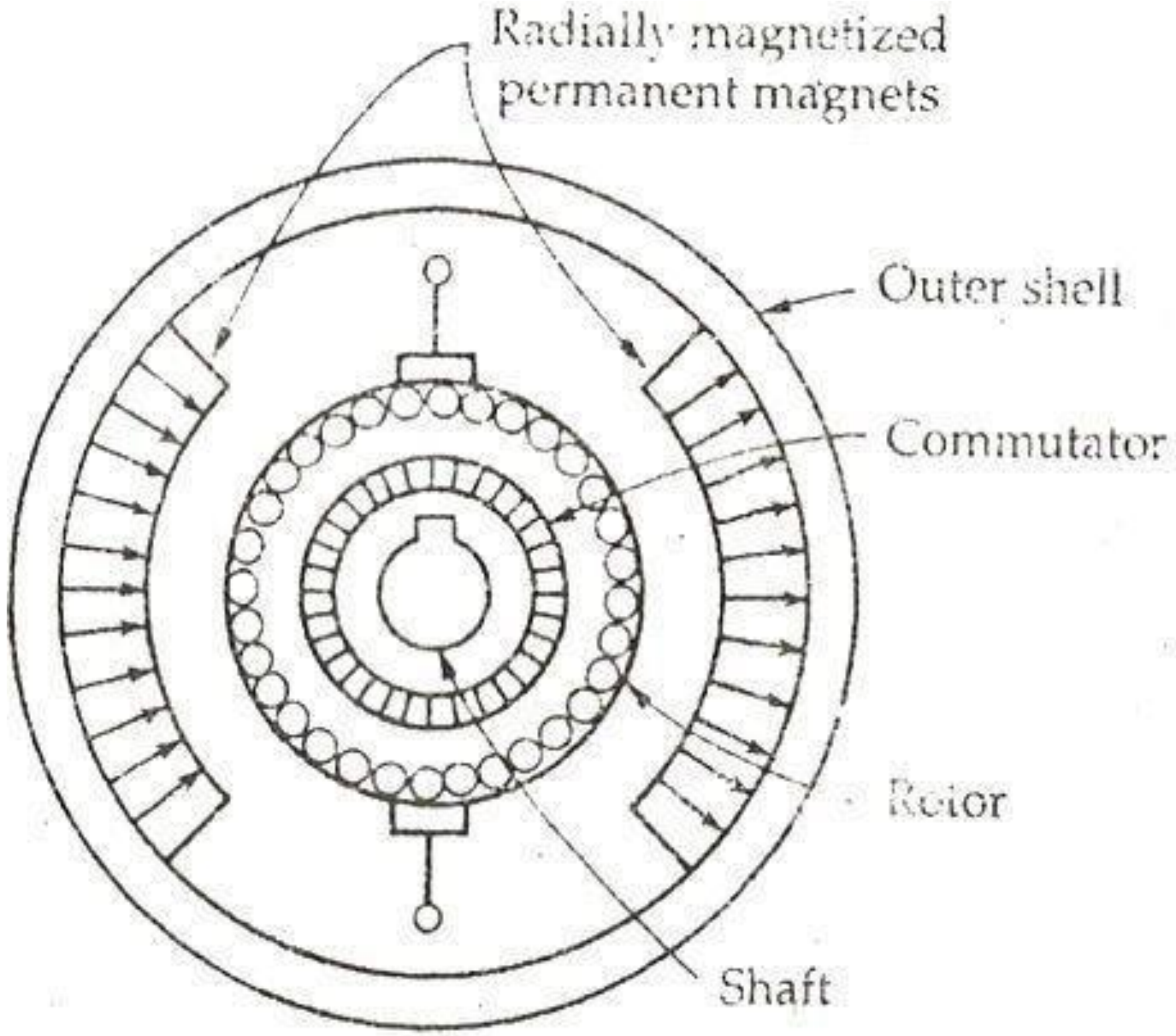
i. Magnet Produce

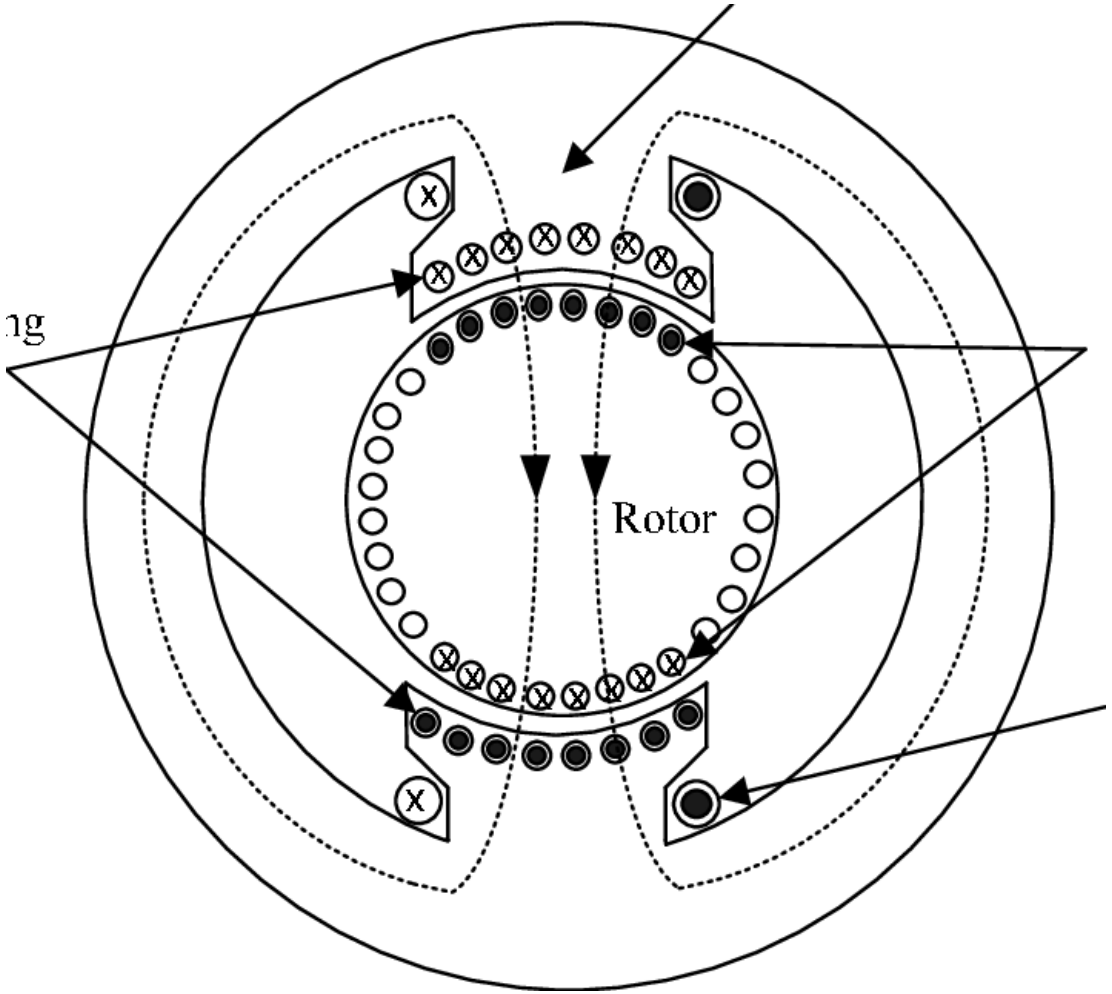
   Magnetic Field Fixed

   Magnet

ii. No Adjustment

iii. Generate Fixed Magnetic Field





Wound Field DC Machine

i. Magnetic Field is Generated by Flow of Current

ii. Rotor Rotate at the Speed of ω

iii. Magnetic Fields are Adjustable

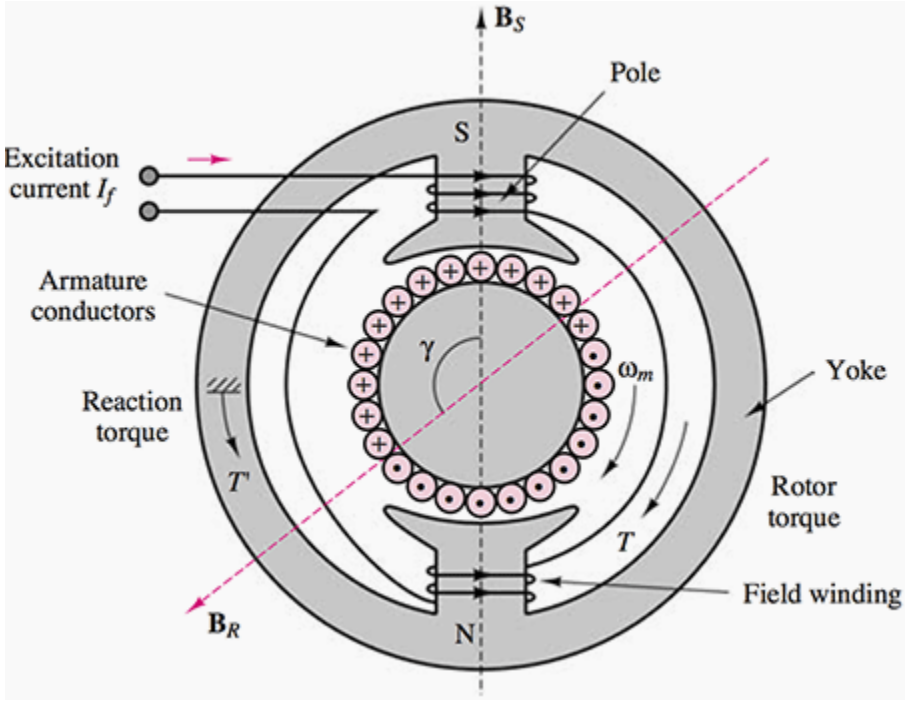
iv. Speed and Torque Depend on Each Other

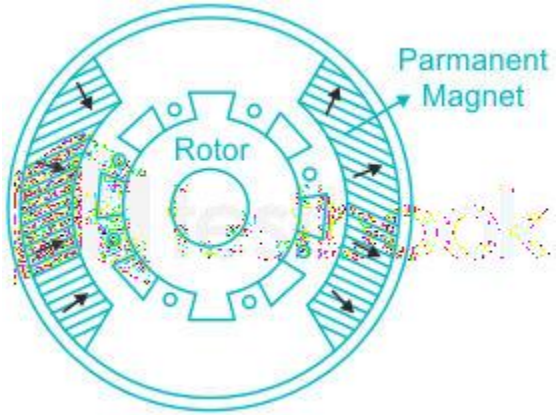
Comparison

I. Wound Field is Bigger than PMDC

II. In Wound Field Magnetic Field can be Modified while in PMDC it's not possible to change Magnetic Field

III. Wound Filed Machine is Made of Soft Magnetic Material and PMDC is Made of Hard Magnetic Material





Formula

Generated Electromagnetic Torque ∞ B(Magnetic Field) × i(Electric Current)

Generated Electromagnetic Field (EMF) ∞ B(Magnetic Field) × ω(Speed)

Torque = Bi

EMF = Bω

Output Mechanical Power = Torque × Speed = Biω

Input Power = Voltage (EMF) × Electric Current (i)

Example 1

Let,
Magnetic Field, B = 1 Wb/m^2 Max
Voltage, EMF = 100 Volt
What will be the maximum speed then?

We know,

$$EMF = B\omega$$

$$\text{Or, } \omega = EMF / B = 100/1 = 100 \text{ rad/s}$$

So, the maximum speed is 100 rad/s.

Example 2

Let,
Magnetic Field, B = 1 Wb/m^2 Max
Voltage, EMF = 100 Volt
Also, assume that Max Electric Current, i = 5 A
What will be the Torque now?

We know,

Torque = Bi = 1×5 = 5 Nm

So, the Torque is 5 Nm.

Example 3

We got the Torque is 5 Nm.
What if we want 4 Nm of Torque?

4 Nm of Torque is possible if,

B = 0.5 when i = 8;
B = 2 when i = 2;
B = 8 when i = 0.5;
B = 16 when i = 0.25.

But which one should we choose?

Example (Continued)

4 Nm of Torque is possible
if, B = 0.5 when i = 8;
B = 2 when i = 2;
B = 8 when i = 0.5;
B = 16 when i = 0.25.

We can not choose any one of them because we have a limitation that we assumed B = 1 Wb/m^2 and i = 5 A. So, the Maximum Magnetic Field can be 1 Wb/m^2 and the Maximum Electric Current can be 5 A.

So, the only possible combination will be B = 1 Wb/m^2 and i = 4 A.

Example (Continued)

Now if we want speed 300 radian per second, What will happen?

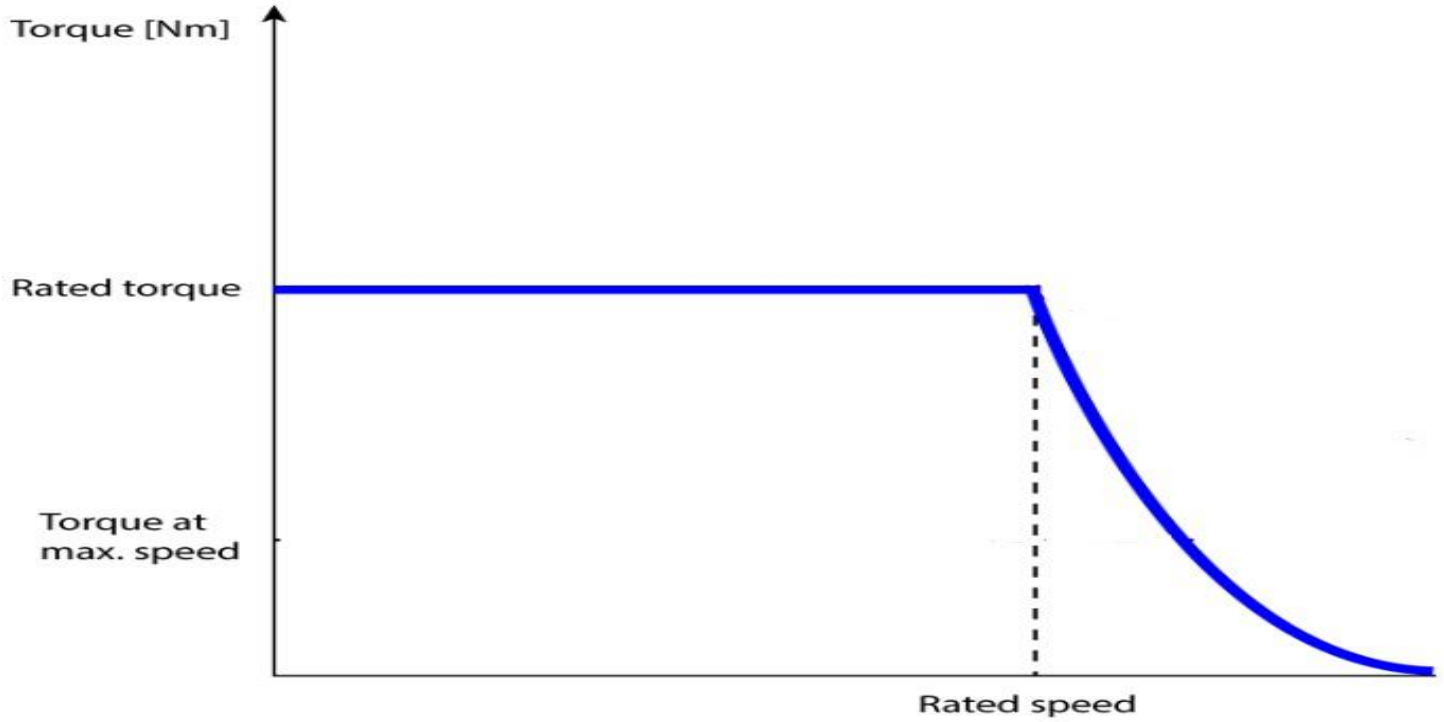
Here,
Electric power input to machine = V*I
[limited by rating]
So, it is 100*5 = 500 watt

Output power (Mechanical) = Torque * Speed
So, it is 5*300=1500 watt

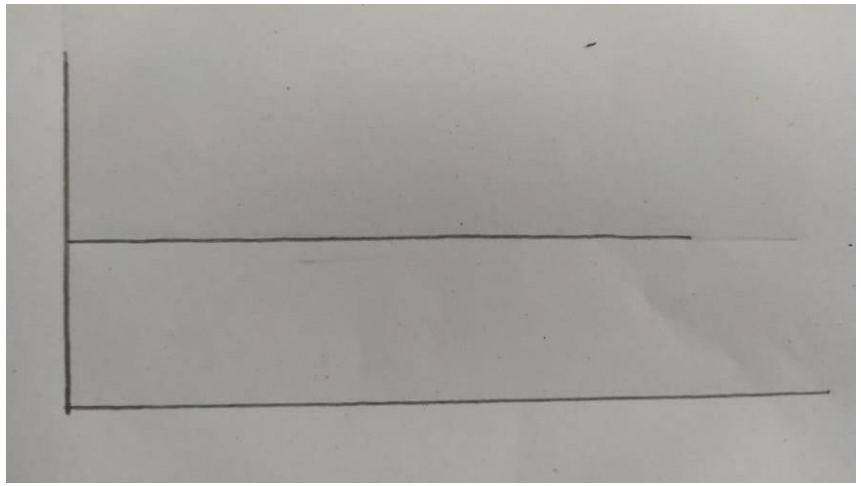
Is it possible?

FIELD WEAKENING OPERATION

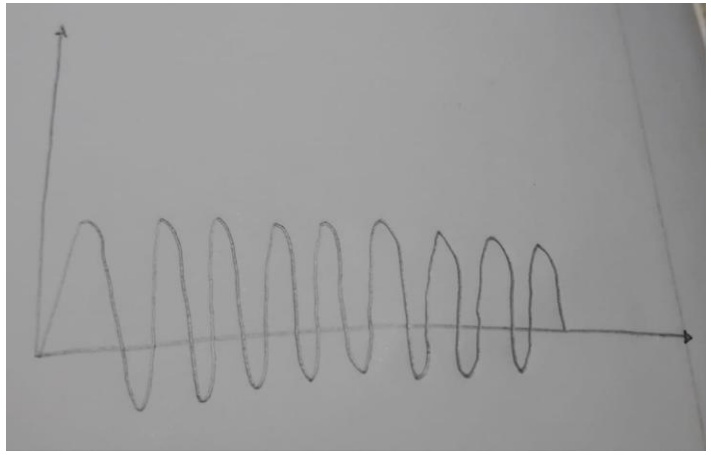
Max torque that can be allowed to generate reduces with speed



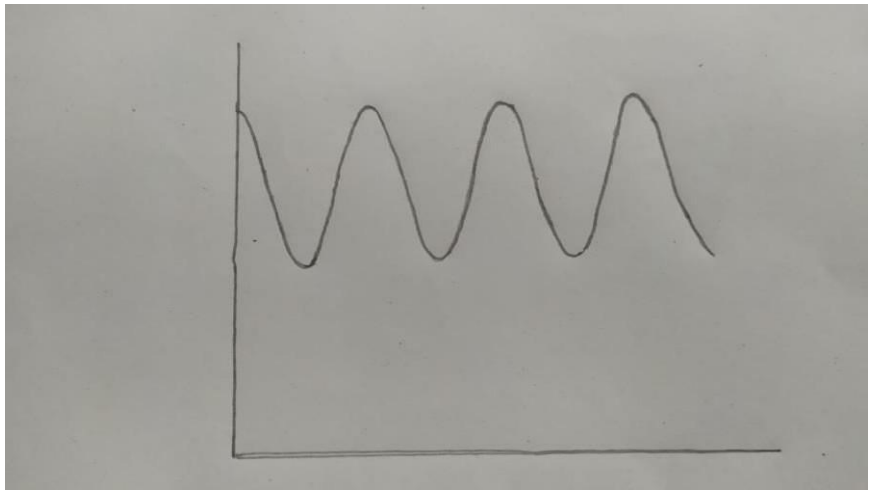
Pure DC Vs Average DC



Pure DC



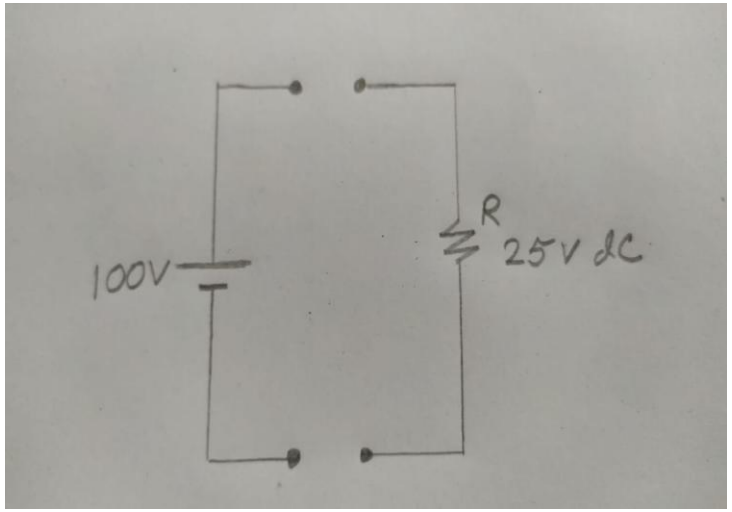
Rippled DC



Pulsed DC

Avg DC Contains ripples

POWER ELECTRONICS



Simple resistor voltage divider causes high losses.

Problem with Ripple Current

i)In a Motor:

Ripple in Voltage -> ripple in current -> ripple in torque

ii) Unacceptable for consistent motor performance

Is there a circuitry that can put in between that gives me 100% efficiency?

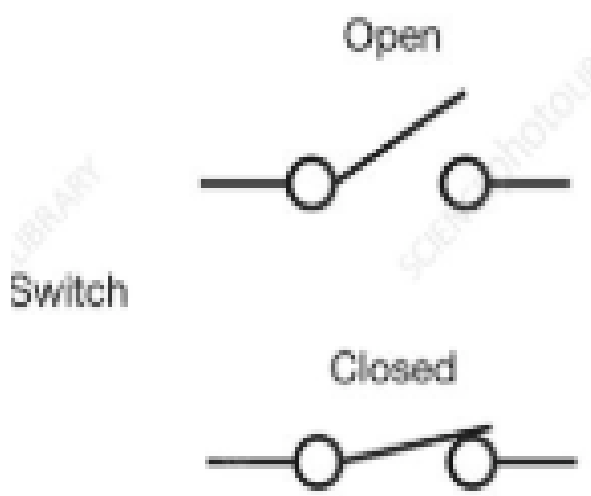
Elements in Power Circuits

i) Resistor(R) : Dissipative

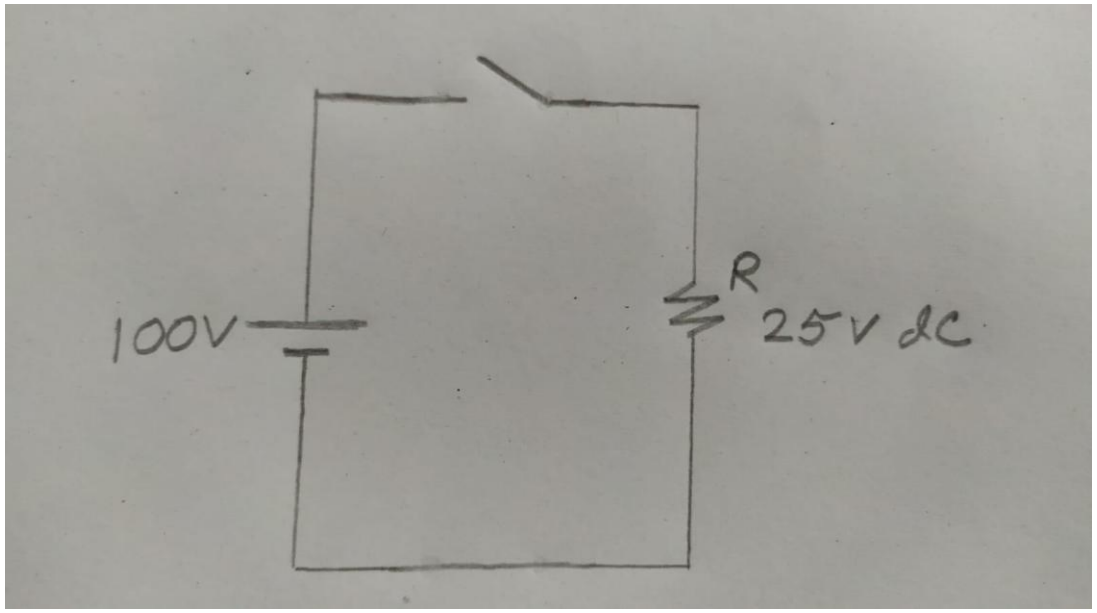
ii) Inductor(L): Energy Storing

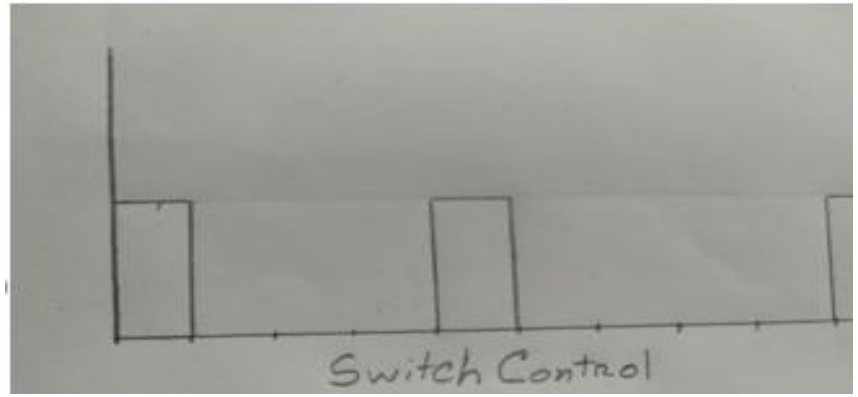
iii) Capacitor(C) : Energy Storing

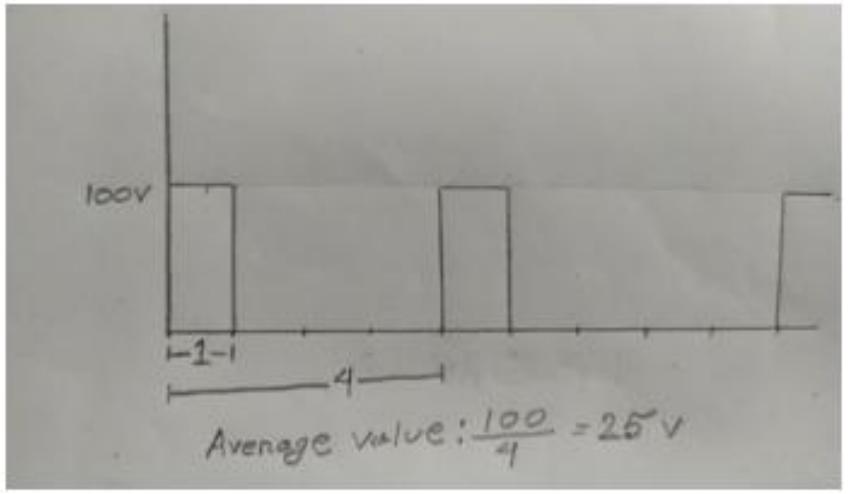
iv) Switch: Zero power loss when fully on or off



BASIC SWITCHING CIRCUIT

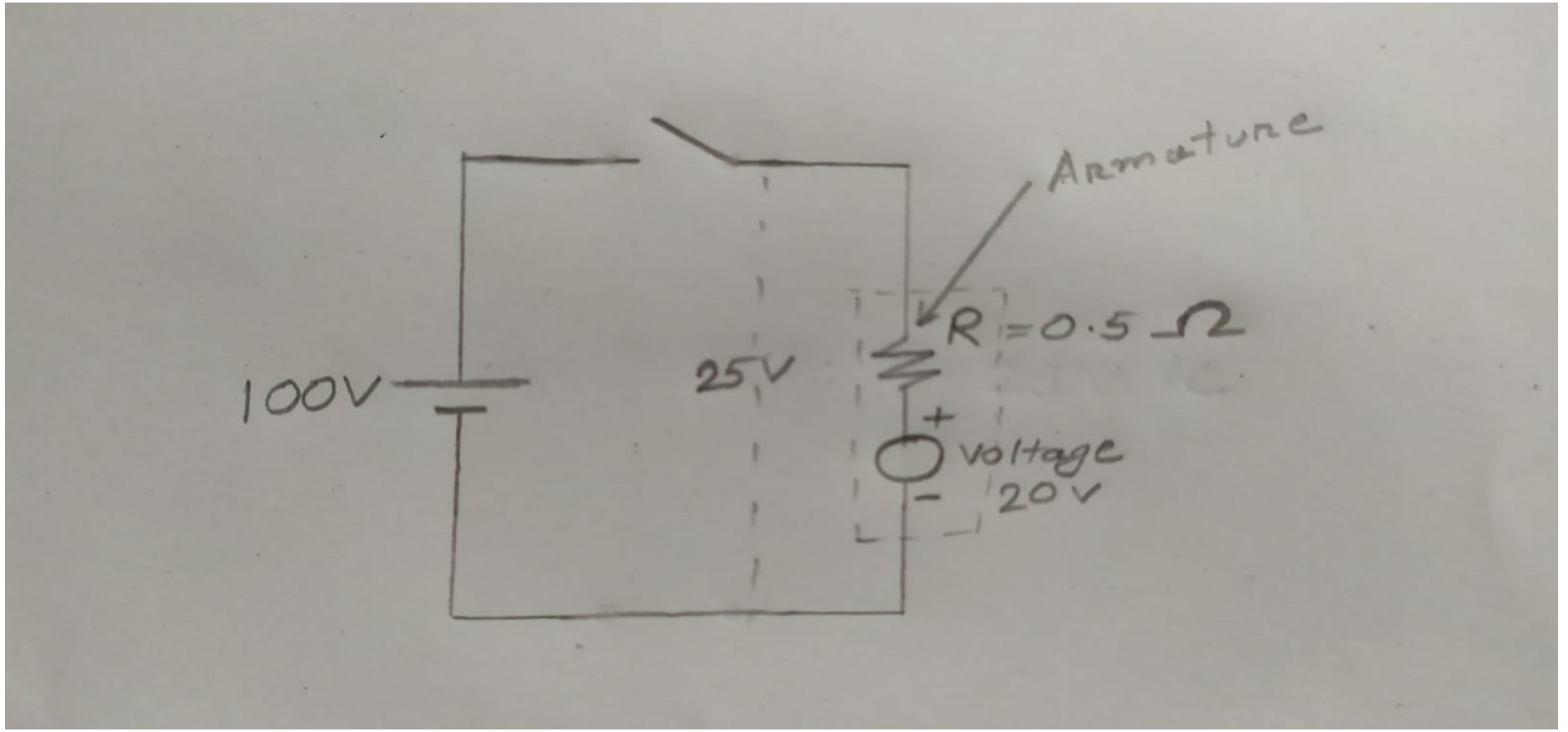






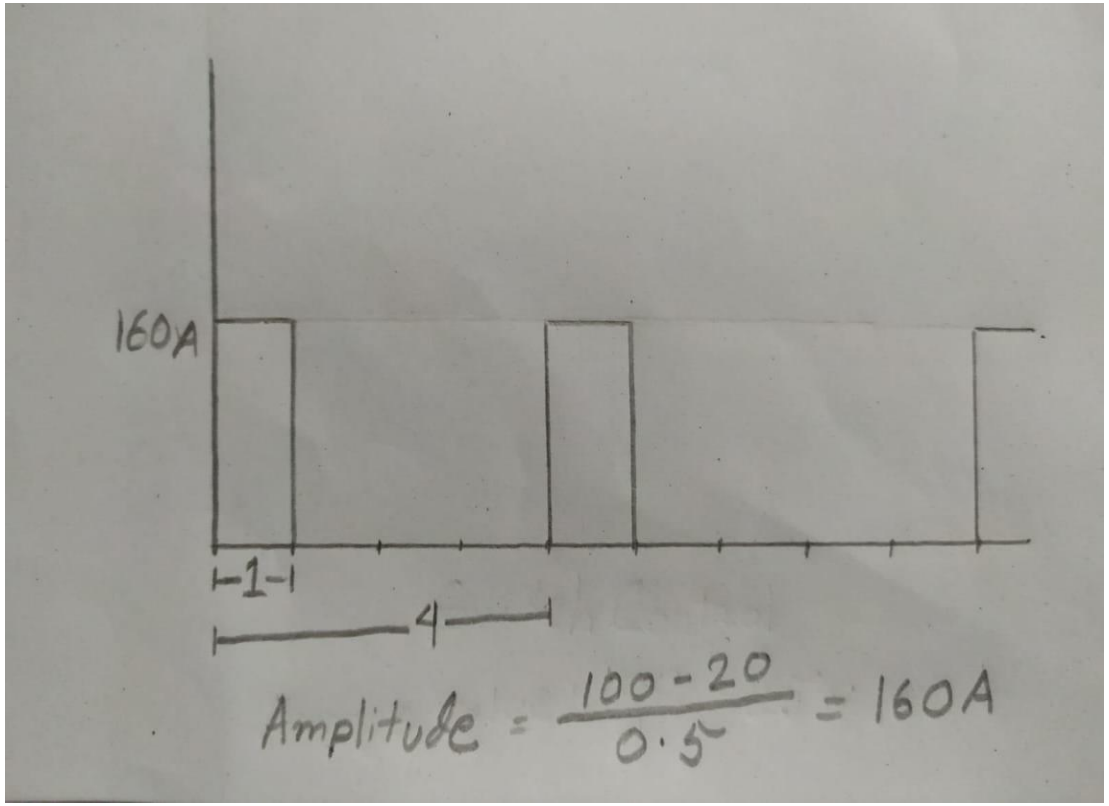
Here, we have to control to get desired average DC (e.g., 25V)

What will happen if we use DC motor instead of register?



If we use DC motor instead of register

- -We want need constant current.
- -Motor will generate an electromagnetic torque which is dependent on waveform.
- -A scaled value of this waveform is electromagnetic torque and you do not want to apply this kind of torque to the Load, it is a huge ripple Torque, you do not know what the load will do.
- -Therefore, this waveform is not acceptable.



This waveform is not acceptable

THANK YOU