

3.3 CONSTRUCTION OF MECHANICAL COMMUTATOR

COMMUTATOR SEGMENT

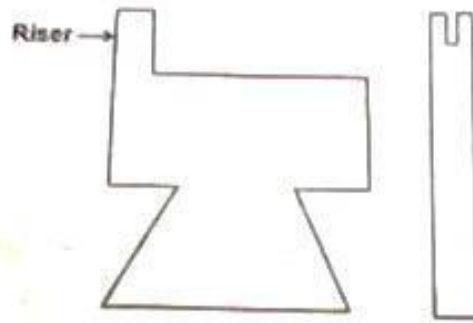


Figure 2.1.1 Commutator Segment

[Source: "special electric machines" by R.Srinivasan page:4.3]

Commutator is made up of specially shaped commutator segments made up of copper. These segments are separated by thin mica sheets (ie) Insulation of similar shape. The commutator segments are tapered such that when assembled they form a cylinder.

These segments are mechanically fixed to the shaft using V – shaped circular steel clamps, but are isolated electrically from the shaft using suitable insulation between the clamps and the segment.

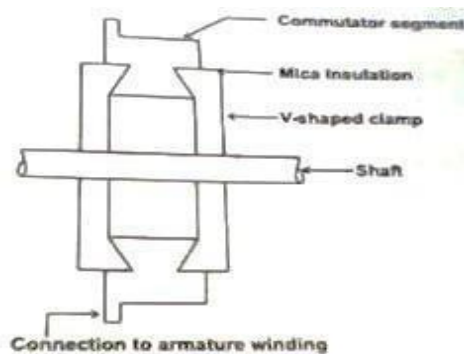


Figure 3.3.2 connection of commutator segments to shaft

[Source: "special electric machines" by R.Srinivasan page:4.3]

MECHANICAL COMMUTATOR AND BRUSHES ARRANGEMENT

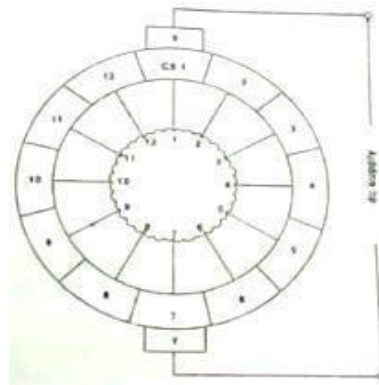


Figure 3.3.3 Mechanical Commutator and Brushes

[Source: "special electric machines" by R.Srinivasan page:4.4]

It represents a case with 2poles and 12 commutator segments. To start with the brush X contacts with CSI and brush Y with 7. A dc supply is connected across the brushes X and Y. The dc current I passes through brush X, CSI, tapping 1, tapping 7 and brush Y. There are two armature parallel paths between tapping's 1 and 7. The current passing through the armature winding sets up a magneto motive force whose axis is along the axes of tapping 7 and 1 of the brush axes Y and X.

Allow the armature to rotate by an angle in a counter clockwise direction. Then the brush X contacts CS2 and the tapping's a and the brush Y. Contact CS8 and tapping 8. The dc current passes through the tapping's 2 and 8 there are two parallel paths.

- (i) 2-3-4-5-6-7-8
- (ii) 2-1-12-11-10-9-8

Now the mmf set up by the armature winding is from tapping 8 to 2 along the brush axis YX. Thus the armature mmf direction is always along the brush axis YX, even though the current distribution in the armature winding gets altered. In a normal dc

machine brushes are kept in the interpolar axis. Therefore, the axis of the armature mmf makes an angle 90° elec with the main field axis. The function of commutator and brushes arrangement in a conventional dc machine is to set up an armature mmf always in quadrature with the main field mmf respectively of the speed of rotation of the rotor.

ELECTRONIC COMMUTATOR

The armature winding which is in the stator has 12 tapping's. Each tapping is connected to the positive of the dc supply node and through 12 switches designate as S_1, S_2, \dots, S_{12} and negative of the supply at node Y through switches $S'_1, S'_2, \dots, S'_{12}$.

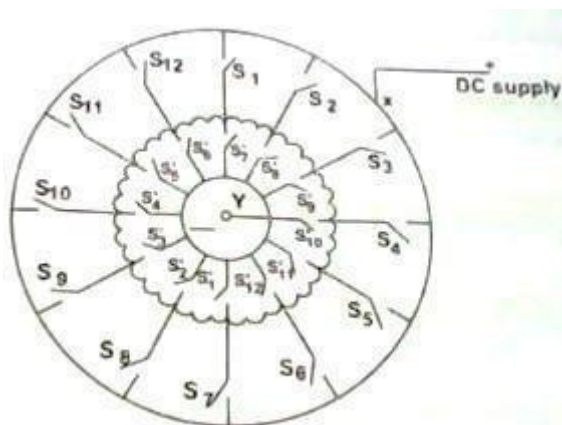


Figure 3.3.4 Electronic Commutator
 [Source: "special electric machines" by R.Srinivasan page:4.5]

When S_1 and S'_1 are closed the others are in open position, the dc supply is given to the trappings 1 and 7. there are two armature parallel path.

- (i) 1-2-3-4-5-6-7
- (ii) 1-12-11-10-9-8-7

They set up armature mmf along the axis 7 to 1. After a small interval S1 and S'1 are kept open and S2 and S'2 are closed. Then dc current passes from tapping 2 to 8 sets up mmf in the direction 8 – 2.

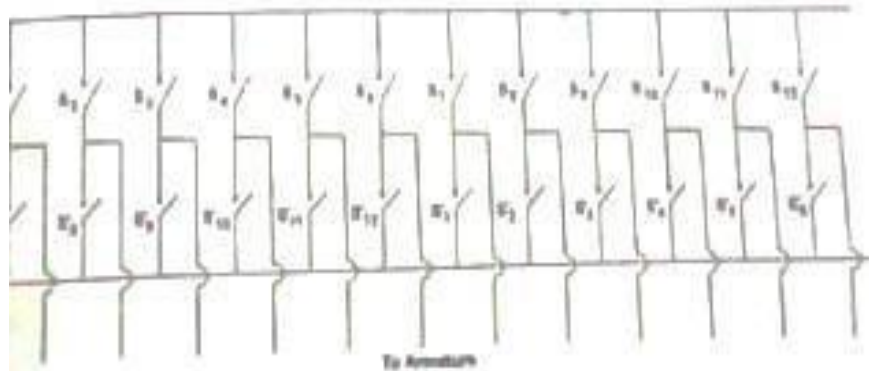


Figure 3.3.5 switching circuit of Electronics commutator

[Source: "special electric machines" by R.Srinivasan page:4.6]

Thus by operating the switch in a sequential manner it is possible to get a revolving mmf in the air gap. The switches S1 to S12 and S'1 to S'12 can be replaced by power electronic switching devices such as SCR's MOSFET's IGBT's, power transistor etc.

When SCR's are used suitable commutating circuit should be included. Depending upon the type of forced commutated employed, each switch requires on or two SCRs and other commutating devices. As number of devices is increased, the circuit becomes cumbersome.

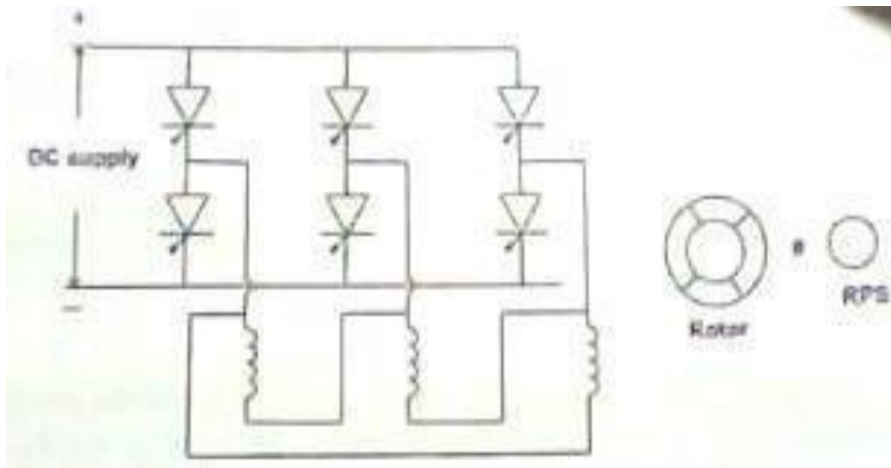


Figure 3.3.6 Delta Connected Stator Armature Winding

[Source: "special electric machines" by R.Srinivasan page:4.6]

For normal electronic commutator, usually six switching devices are employed. Then the winding should have three tapping's. Therefore the winding can be connected either in star or in delta.

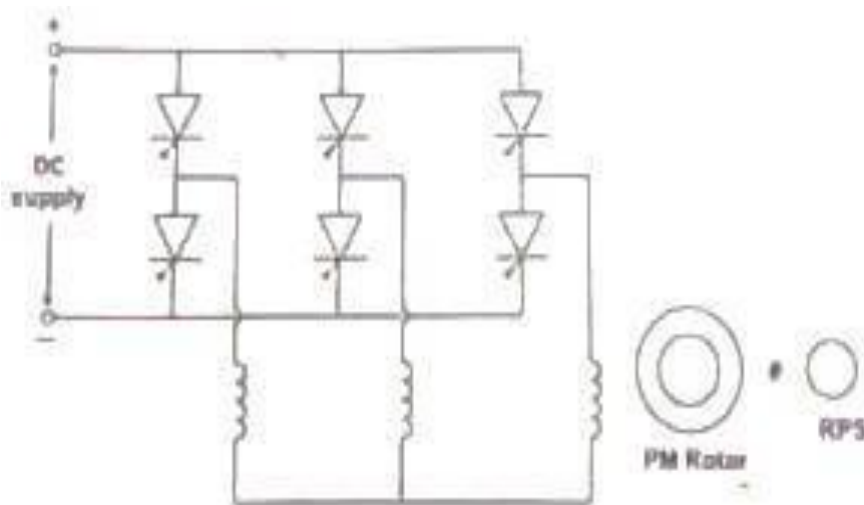


Figure 3.3.7 Star Connected Armature Winding

[Source: "special electric machines" by R.Srinivasan page:4.6]

COMPARISON BETWEEN MECHANICAL COMMUTATOR AND BRUSHES AND ELECTRONIC COMMUTATOR

S. No	Mechanical Commutator	Electronic Commutator
1.	Commutator is made up of copper segment and mica insulation. Brushes are of carbon or graphite.	Power electronic switching device is used in the commutator. It requires a position sensor.
2.	Commutator arrangements are located in the rotor.	It is located in the stator.
3.	Shaft position sensing is inherent in the arrangement	Separate rotor position sensor is required.
4.	Numbers of commutator segments are very high.	Number of switching devices is limited to 6.
5.	Highly reliable.	Reliability is improved by specially designing the devices and protective circuits.
6.	Difficult to control the voltage available across the tappings.	The voltage available across armature tappings can be controlled by employing PWM techniques.
7.	Interpole windings are employed to have sparkless commutation.	By suitable operating the switching devices, better performance can be achieved.



3.4 TORQUE- SPEED CHARACTERISTICS OF BLPM SQM DC MOTOR

Let the supply voltage V be constant. A family of torque speed characteristics for various constant supply voltages is as shown in figure 3.4.1

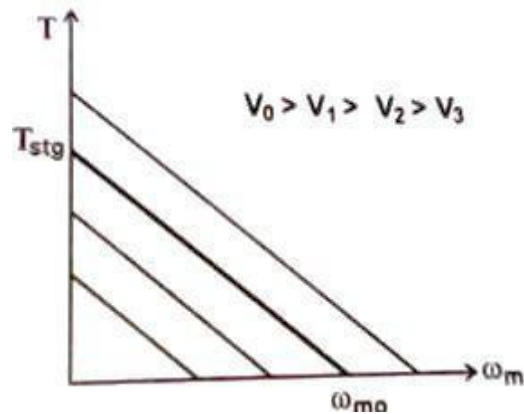


Figure 3.4.1 T- ω_m curve for various supply voltages

[Source: "special electric machines" by R.Srinivasan page:4.57]

Permissible region of operation in T- ω_m plane

Torque speed characteristics of BLPM square wave motor is shown in fig.3.4.1. The constraints are

1. The continues current should not exceed the permissible current limit I_n
(i.e) Torques should not exceed $K_t I_n$.
2. The maximum permissible supply voltage = V_n .
3. The speed should not exceed ω_{mn} .

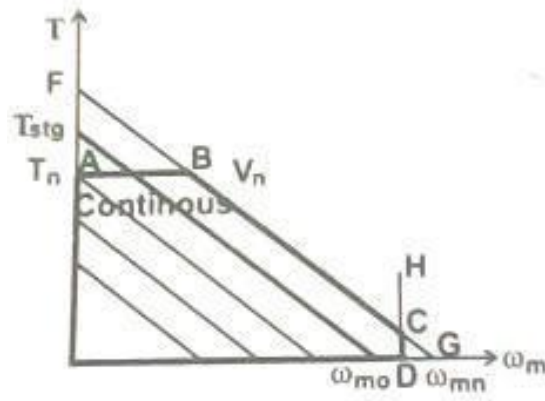


Figure 3.4.2 Torque-speed characteristics

[Source: "special electric machines" by R.Srinivasan page:4.58]

LINE AB

Parallel to X-axis represents maximum permissible torque line which corresponds to maximum permissible current I_n .

Line FG

It represents $T-\omega_m$ characteristics corresponding to the maximum permissible V_n . B and C are points in Fig. B is the point of intersection between AB and FG.

Line DH

It represents constant maximum permissible speed line (i.e) ω_{mn} is constant. DH intersects FG and x axis at D.

The area OABCDO is the permissible region of operation. To obtain a particular point P corresponding to given load-torque and speed condition the only way to operate the motor at P is by suitably adjusting the supply voltage fed to the motor.

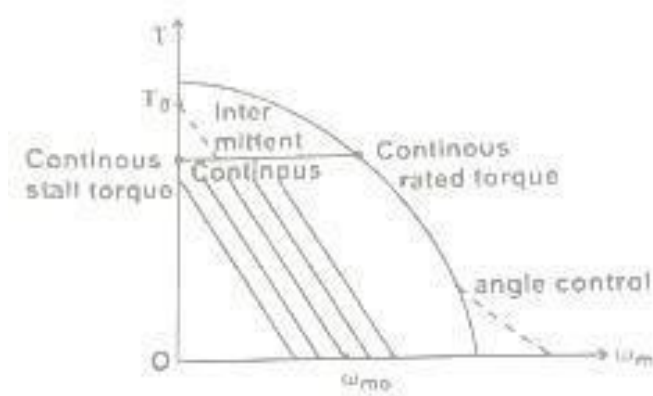


Figure 2.1.1 Torque speed characteristics of ideal brushless DC motor

[Source: "special electric machines" by R.Srinivasan page:4.58]

If the phase resistance is small as it should be in an efficient design, then the characteristics to that of a shunt dc motor. The speed is essentially controlled by the voltage V and may be changed by changing the supply voltage. Then the current drawn just to drive the torque at its speed. As the load torque is increased, the speed drops and the drop is directly proportional to the phase resistance and the torque. The voltage is usually controlled by chopping or PWM.

This gives rise to a family of torque speed characteristics as shown in fig. 4.5.8. The boundaries of continuous and intermittent limits are shown. Continuous limit - determined by the heat transfer and temperature rise. Intermittent limit – determined by the maximum ratings of semiconductor devices in circuit. In practice the torque speed characteristics deviates from the ideal form because of the effects of inductance and other parasitic influences. Also the speed range can be extended by increasing the dwell of conduction period relative to the rotor position.

