UNIT- II.

2 - Marks.

1.) What is stepper motor ?

A stepper motor is a digital actuator whose i/p is in the form of Programmed energization of the stator windings and whose o/p is in the form of discrete angular rotation.

2.) Define step angle.

Step angle is defined as the angle through which the stepper motor shaft rotates for each command pulse. It is denoted as β.

$$\beta = \frac{N_s - N_r}{N_s \cdot N_r} \times 360^\circ.$$

$$\beta = 360^\circ / m N_r$$

where

N_s = No. of stator poles

N_r = No. of rotor poles.

m = No. of stator Phases.

3.) Define Slewing :-

The stepper motor may be operate at very high stepping rate. i.e) 25,000 steps per second. A stepper motor operates at high speeds is called 'slewing'.

4.) Define Resolution:-

It is defined as the number of steps needed to complete one revolution of the rotor shaft.

$$\text{Resolution} = \frac{\text{Number of steps}}{\text{revolution}} = \frac{360°}{\beta}$$

5.) State some applications of stepper motor:

1.) Floppy disk drives
2) Quartz watches
3) Camera shutter operation
4) Dot matrix and line Printers
5) Machine tool applications.
6) Robotics.

6) Classify the different types of stepper motor.

1) Variable reluctance stepper motor

2) Permanent magnet stepper motor

3) Hybrid stepper motor.

7.) What are the different modes of exitation in a stepper motor?

i) 1-Phase on (or) full-step operation

ii) 2-Phase on mode

iii) Half step operation

iv) Micro stepping operation.

8.) What is meant by full-step operation?

It is the one-phase ON mode operation. It means, at that time only one winding is energized. By energizing one stator winding, the rotor rotates some angle. It is the full-step operation.

9.) What is meant by half-step operation?

It is the alternate one-phase and 2-phase on mode of operation. Here, the rotor rotate an each step angle is half of the full-step angle.

10.) what is meant by micro stepping in stepper motor?

Micro stepping means, the step angle of the VR stepper motor is very small. It is also called mini-stepping. It can be acheived by two phase simultaneously as in 2-phase on mode but with the two current deliberately made unequal.

UNIT - II.

2 - Marks:

1.) What are the type of power controllers used for Switched Reluctance motor?

i) using 2 power semiconductor & 2 diodes per phase.

ii) (n+1) power switching devices & (n+1) diode per φ

iii) Phase winding using Bifilar wires.

iv) Dump - C converter

v) Split power supply converter.

2.) Why rotor position sensor is essential for the Operation of Switched Reluctance motor?

It is normally necessary to use a rotor Position Sensor for commutation and Speed feed back. The turning ON and OFF operation of the various devices of Power Semiconductor Switching Circuits are influenced by Signals obtained from rotor Position Sensor.

3.) List the disAdvantages of Switched Reluctance motor ?

i) Stator phase winding should be capable of carrying magnetizing current.

ii) It requires a position sensors.

iii) For high speed operation, the developed torque produce acoustic noices.

4.) What are the advantages of Switched Reluctance Motor ?

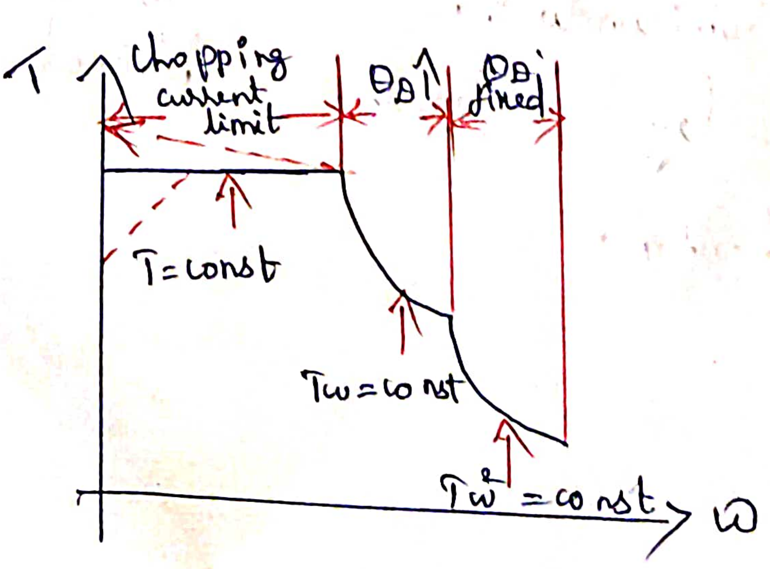
i) Construction is simple and robust

ii) Rotor carries no windings, no sliprings, no brushes -

iii) less maintainance.

iv) There is no permanent magnets.

5.) Draw the Speed - Torque characteristics of Switched Reluctance motor :-



6.) What are the application of SRM ?

1) Washing Machines
2) Vacum Cleaners
3) Fans
4) Automobile Applications
5) Robotics.

7.) What is Switched Reluctance Motor ?

The Switched reluctance motor is a double salient, singly-exited motor. This means that it has salient pole on both the rotor and the stator, but only one member carries windings. The rotor has no windings & magnets. It works on variable reluctance Principle.

8.) Write the Torque- Equation of SRM ?

$$T = \frac{1}{2} i^2 \, \partial L / \partial \theta$$

where,

T = motor torque

i = Current

$\partial L / \partial \theta$ = change of inductance with respect to rotor angle.

9.) What is the significance of closed loop control in SRM?

Switched Reluctance motor is always operated with closed loop control. Normally, we have to use a rotor sensor for Commutation and speed feedback. Here, the Phase windings are energized by using power Semiconductor circuit. The turning ON & OFF operation of the various power Semiconductor devices are influenced by ~~Singts~~ signals obtained from rotor position sensor. It is the main significance of closed loop control in SRM..

10.) What is the need of Sensorless operation (control) in SRM drive?

To avoid additional cost size, and unreliability associated with external Position sensors, developing a reliable, Precise and low-cost Position sensorless control seem necessary.

UNIT-IV (2 Marks).

(1) What are the advantages of brushless dc motor drives :-

i) Regenerative braking is possible
ii) Speed can be easily controllable
iii) It is possible to have very high speed.
iv) There is no-field winding so that field copper loss is neglected.

2) What are the advantages of brushless dc motor drives ?

i) Motor field cannot be controlled
ii) It requires a rotor position position.
iii) It requires a power semiconductor switching circuit.

3.) List the various PM materials:-

1) Alnico
2) Rare earth material
3) Ceramic magnet
4) NdFeB - magnet.

4.) Mention the Application of PMBLC :-

1) Power Alternators
2) Automotive Applications.
3) Computer & robotics application
4) Textile and glass industries.

5.) why is the PMBLDC motor called electronically commutated motor?

The phase windings of PMBLDC motor is energized by using Power Semiconductor Switching circuits.

Here, the power semiconductor switching circuits act as a commutator.

6.) Classification of PMBLDC Motor:-

1) BLPM Square wave motor
2) BLPM Sine wave motor.

7.) What is Hall sensor?-

A sensor is operated with photo transistor. It is called optical sensor. It is mainly used to sense the rotor position of the BLPM-DC motor.

UNIT-IV (2 Marks)

4) what are the features of PM Synchronous motor?

* Robust, Compact
* No field current (or) rotator current in PMSM
* High efficiency

5) what are the advantages of load Commutation?

* It does not require commutation circuits.
* Frequency of operation can be higher.
* It can be operate power level beyond the capability of forced Commutations.

(3.) Write the application of PMSM :-

* Used as direct drive traction motor.
* Used as high speed and High power drives for compression, blowers.
* Fiber spinning mills.

(4.) what are the merits of PMSM :-

* It runs at constant speed
* No field winding, no field loss, better efficiency.
* No Sliding contacts.

(5.) what is load Commutation :-

commutation of thyristors by induced voltage of load is known as Load commutation. Here frequency.

of operation is Higher and it does not require commutation circuits.

(6) What is meant by self control?

As the rotor speed changes the armature supply frequency is also changes proportionally so that the armature field always moves at the same speed as the motor. The armature and rotor field move in synchronism for all operating points. Here accurate tracking of speed by frequency is realized with the help of rotor position sensor.

7) what is brushless DC. motor ?

The Sinusoidal current fed motor, which has distributed winding on the stator inducing sinusoidal voltage is known as brushless a.c motor.

8) State the power controllers for PMSM :-

* PWM inverter using power "MOSFET" with microprocessor control.
* PWM inverter using BJT's with microprocessor control (up to 100 kW).

9) when does a PM Synchronous motor operates as a SyRM :-

If the cage winding is induced in the rotor and the magnets are left out (or) demagnetized.

UNIT-V 2 Marks:

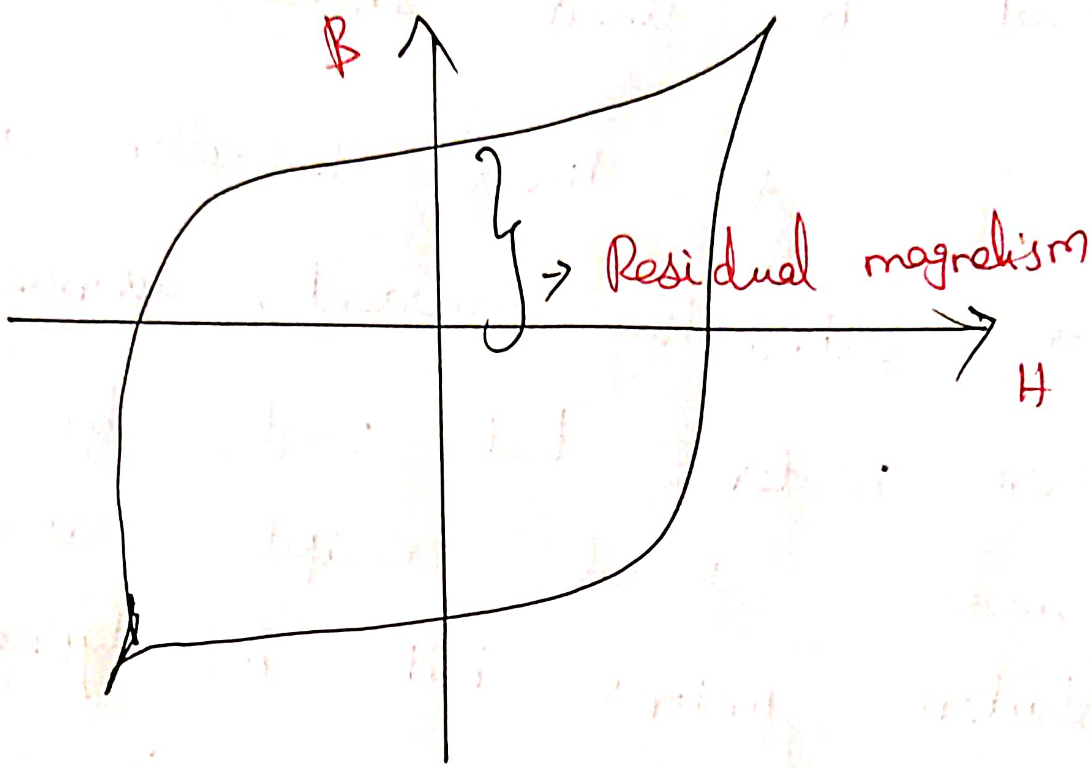
1. what is linear Induction Motor :-

A linear Induction motor is an alternating current, asynchronous linear motor that works by the same general principles as other induction motors but is typically designed to directly produce motion in a straight line.

2. what is Hysteresis Motor :-

A Hysteresis motor is a single-phase synchronous motor whose operating principles is based on the effect of "magnetic Hysteresis".

3. Draw the Hysteresis Loop :-



4. Write down the torque Equation of the synchronous Reluctance motor :-

$$T = \frac{3}{\omega_s} V^2 \left[\frac{X_{sd} - X_{sq}}{2 X_{sd} X_{sq}} \right] \sin 2\delta .$$

5.) Write the Application of linear Induction motor :-

i) Automatic sliding doors.

ii) Pumping of liquid metal.

iii) mechanical handling Equipment.

iv) Propulsion of a train of tubs

6.) Advantages of Hysteresis motor :-

* It's operation is noisless.
* There is no vibration.
* multi-speed can be operate.
* Give higher efficiency.

7.) Define repulsion motor :-

A repulsion motor is a type of electric motor which runs on alternating current. It was formerly used as a traction motor for electric trains. but has been superseded by other types of motors.

UNIT-I - Problems.

(1). A stepper motor driven by a bipolar drive circuit has the following parameters: Winding inductance = 20 mH, rated current = 2 A, DC supply = 45 V, total resistance in each phase = 15 Ω. When the transistors are turned off, determine (i) the time taken by the phase current to decay to zero and (ii) the proportion of the stored inductive energy returned to the supply.

Given Data:-

Winding inductance $L_m = 20\ mH$

Rated Current $I_{ph} = 2\ A$

DC Supply $V_{dc} = 45\ V$.

Total resistance in each Phase $R_m = 15\ \Omega$

To find,

i) The time taken by the phase current to decay to zero,

ii) The stored inductive energy returned to supply.

Solution:

i) The time taken by the phase current to decay to zero,

$$t' = \frac{1}{2}\tau_{e1}$$

$$\tau_{e1} = \frac{L_m}{R_m}$$

$$= \frac{30\times10^{-3}}{15}$$

$$= 2ms.$$

$$t' = \frac{2\times10^{-3}}{2} = 1ms.$$

ii) The stored inductive energy return to supply.

$$\frac{1}{2}L_m I_{ph}^2 = \frac{1}{2}\times 30\times10^{-3}\times 3^2$$

$$= 135mW.$$

Q.) What is the step angle of a 4-phase stepper motor with 12 stator teeth and 3 rotor teeth?

Solution:

It is a VR stepper motor,

Step angle $\beta = \frac{N_s - N_r}{N_s N_r}\times 360° \Rightarrow 4.$

$N_s = 12$, $N_r = 3$,

$$\beta = \frac{12-3}{12\times3}\times 360° \Rightarrow 90°.$$

2.) A single stack, 3-φ VR motor has a step angle of 15°. Find the number of its rotor and stator poles.

Solution:

$$\beta = \frac{360^\circ}{m N_r}$$

$$N_r = \frac{360^\circ}{m\beta} = \frac{360^\circ}{3 \times 5}$$

$$\boxed{N_r = 8.}$$

For finding the value of N_s, we use the relation,

$$\beta = \frac{N_s \sim N_r}{N_s \cdot N_r} \times 360^\circ$$

i) when $N_s > N_r$

$$\beta = \frac{N_s - N_r}{N_s \cdot N_r}$$

$$\beta = \frac{N_s - 8}{N_s \cdot 8} \times 360^\circ$$

$$\boxed{N_s = 12}$$

ii) when $N_s < N_r$

$$15 = \frac{N_r - N_s}{N_s \cdot 8} \times 360^\circ.$$

$$= \frac{8 - N_s}{8 \cdot N_s} \times 360^\circ.$$

$$\boxed{N_s = 6}$$

4.) what is the motor torque T_m required to accelerate an initial load of 2×10^{-4} kg m^2 from 500 Hz to 1500 Hz in 50 ms. The frictional torque is 0.03 N-m and step angle is 1.18 deg.

Given Data:

$J = 2 \times 10^{-4}$ kg m^2, $f_1 = 500$ Hz

$f_2 = 1500$ Hz, $\Delta t = 50$ m sec

$T_f = 0.03$ Nm, $\beta = 1.18^\circ$

Solution:-

Step angle in radians $= \beta \times \pi / 180^\circ$

$= 1.18 \times \pi / 180$

$= 0.0205$ rad.

$\omega_1 = \theta_s \times f_1 = 0.0205 \times 500$

$= 10.25$ rad/sec.

$\omega_2 = \theta_s \times f_2 = 0.0205 \times 1500$

$= 30.75$ rad/sec.

$$\frac{d\omega}{dt} = \frac{\omega_2 - \omega_1}{\Delta t}$$

$$= \frac{30.75 - 10.25}{50 \times 10^{-3}}$$

$$\boxed{d\omega/dt = 411.9 \text{ rad/sec}}$$

Motor torque $T_m = J\frac{d\omega}{dt} + T_f$

$$= 2 \times 10^{-4} \times 411.9 + 0.02$$

$$\boxed{T_m = 0.112 \text{ N-m}}$$

5.) A stepper motor has a step angle of ~~1.08°~~ 1.8° and is driven 4000 pps. Determine (i) resolution (ii) Motor speed (iii) Number of pulses required to rotate the shaft through 54°.

Solution:

(i) Resolution $= \frac{360°}{\beta} = \frac{360}{1.8} = 200$ steps/rev

(ii) Motor speed $n = \frac{\beta \times f}{360°}$

$$= \frac{1.8 \times 4000}{360°} = 20 \text{ rps.}$$

UNIT-II Problems:

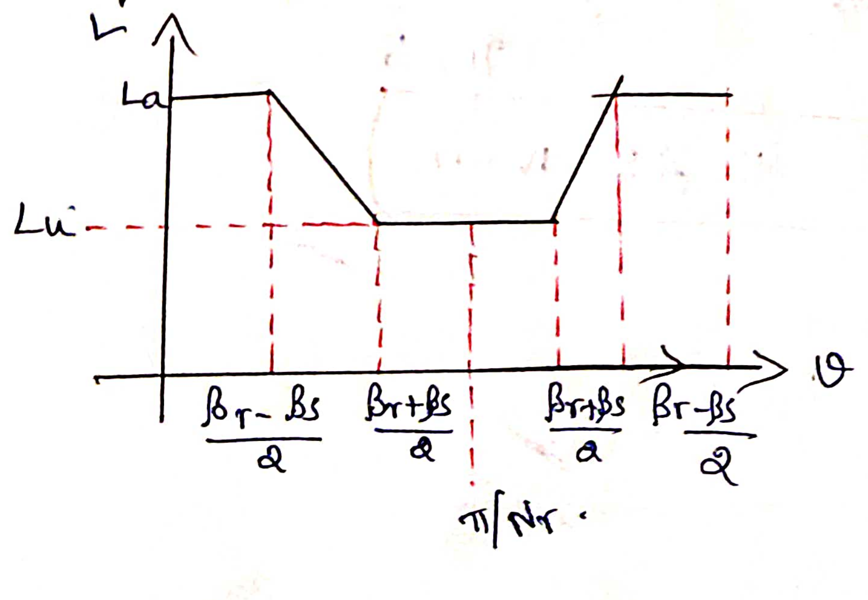
(1). A switched reluctance motor with 6 stator poles and 4 rotor poles has a stator pole arc of 30° and rotor pole arc of 32°. The aligned inductance is 10.7 mH and un-aligned inductance is 1.5 mH. Saturation can be neglected. Calculate the instantaneous torque when the rotor is 30° before the aligned position and the phase current is 7A. Neglect fringing.

Solution:

$N_s = 6$, $N_r = 4$, $\beta_s = 30°$, $\beta_r = 32°$

$L_a = 10.7\,mH$, $L_u = 1.5\,mH$, $i = 7A$.

$$\text{Torque} = \frac{1}{2} i^2 \, \partial L/\partial \theta$$



$\partial L = L_a - L_u$

$= 10.7\times10^{-3} - 1.5\times10^{-3}$

$\boxed{\partial L = 9.2\times10^{-3}\ H}$

$\partial\theta = \theta_1 - \theta_2$

$= \left[\frac{2\pi}{N_r} - \left(\frac{\beta_r - \beta_s}{2}\right)\right] - \left[\frac{2\pi}{N_r} - \left(\frac{\beta_r + \beta_s}{2}\right)\right]$

$= \left[\frac{2\pi}{4} - \left(\frac{32-30}{2}\right)\right] - \left[\frac{2\pi}{4} - \left(\frac{32+30}{2}\right)\right]$

$= 89^\circ - 59^\circ$

$\boxed{\partial\theta = 30^\circ \text{ or } \pi/6}$

Torque $T = \frac{1}{2} i^2 \frac{\partial L}{\partial\theta}$

$= \frac{1}{2}\times 7^2 \times \frac{9.2\times10^{-3}}{\pi/6}$

$\boxed{T = 0.43\ N\text{-}m}$

Q. what is the flux linkage, the aligned position
X. La = 10.7 mH, un-aligned position Lu = 1.5 mH, when the phase current is 7A? if the flux linkages is maintained constant while the rotor rotates from the un-aligned position to aligned position at low-speed. Determine the energy conversion per stroke and the average torque.

Solution:

$L_a = 10.7$ mH , $L_u = 1.5$ mH

$i = 7$ A , $N_r = 4$, $q = 3$

flux linkage $\lambda_a = L_a \times i$

$= 10.7 \times 10^{-3} \times 7 = 0.0749$ wb/t

$\lambda_a = \lambda_u$

$0.0749 = L_u \times i_2$

$0.0749 = 1.5 \times 10^{-5} \times i_2$

$$i_2 = \frac{0.0749}{1.5 \times 10^{-5}}$$

$$\boxed{i_2 = 49.93 \text{ A}}$$

energy conversion per stroke,

$$W_m = \frac{1}{2}(i_2 - i_1) \times \lambda$$

$$= \frac{1}{2}(49.98 - 7) \times 0.0749$$

$$W_m = 1.607 \text{ Joules}$$

Average Torque,

$$T = \frac{W_m \, q \, N_r}{2\pi}$$

$$= \frac{1.607 \times 3 \times 4}{2\pi}$$

$$T = 3.07 \text{ N-m}$$

(3.) (X.) what is the step angle of a 3-ϕ SRM having 12 stator poles and 8 rotor poles. what is commutation frequency at each phase at the speed of 6000 rpm.

Solution:

$N_s = 12$, $q = 3$, $N_r = 8$, $N = 6000$ rpm

i) Step angle $= 2\pi / qN_r \Rightarrow \frac{360°}{3 \times 8} = 15°$

ii) Commutation frequency at each Phase $= \frac{N_r \times N}{60} \Rightarrow \frac{8 \times 6000}{60}$