Steeper Motor :

It is an electrical Actuator which converts Pulsed Electrical Energy into a step-wise mechanical energy.

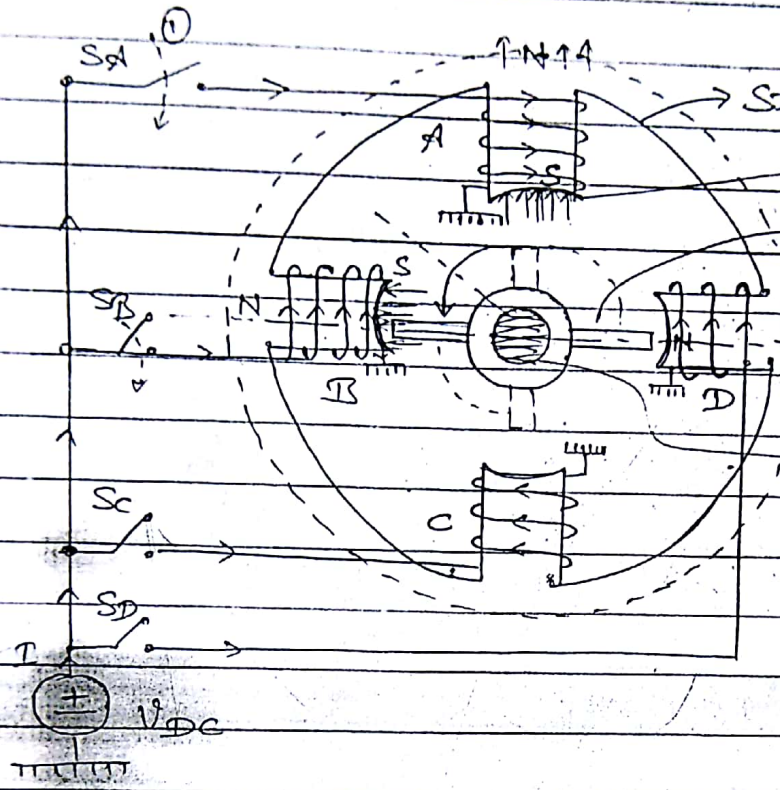
Steeper motors are divided into 3 types :-

(i) Variable Reluctance Type steeper motor,
(ii) Permanent Magnet Type Steeper motor.
(iii) Hybrid type Steeper motor.

(1) Variable Reluctance Type steeper motor

It consist of stator on which poles are arranged and it also

consist Rotor which has teeth made up of magnetic material.



Consider the following type variable Reluctance type stepper motor where 4 windings A, B, C, D are present as shown.

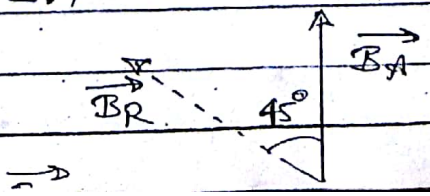
Operation for ACW

⇒ If S_A, S_B, S_C, S_D are opened. $\theta = 0°$
Then $I_A, I_B, I_C, I_D = 0$ Amp.

⇒ If S_A is closed, & S_B, S_C, S_D are opened.
Then $I_A \neq 0$ A ; $I_B, I_C, I_D = 0$ A ; $\theta = 90°$

⇒ If S_B is closed & S_A, S_C, S_D are opened
Then $I_B \neq 0$ A ; $I_A, I_C, I_D = 0$ A. ; $\theta = 180°$

⇒ If S_A, S_B are closed & S_C, S_D are closed.
$I_A, I_B \neq 0$ A & $I_C, I_D = 0$ A ; $\theta = 135°$



☆ { 1 → High Pulsed
  { 0 → Low Pulsed

⇒ If S_A, S_B, S_D are opened & S_C is closed
$I_A, I_B, I_D \neq 0A$ & $I_C \neq 0A$; $\theta = 270°$

⇒ If S_A, S_B, S_C are opened & S_D is closed
$I_A, I_B, I_C = 0A$ & $I_D \neq 0A$; $\theta = 360$

Note: The dir^n of rotation of the shaft can be changed to clockwise by reversing the above sequence.

☆ Switching sequence :-

0 → Open
1 → closed

S_A	S_B	S_C	S_D	θ	
0	0	0	1	0°	→ To get initial excitation.
1	0	0	Φ	90° 45°	→ Full step Angle.
Φ	0	0	0	90°	
Φ	Φ	0	0	270° 135°	
0	Φ	0	0	360° (0°) 180°	
0	1	1	0	225°	
0	0	1	0	270°	
0	0	1	1	315°	
0	0	0	1	360° (0°)	

Half-step Angle.

☆ Stator Pitch (θ_S) :-

The angular separation b/w two successive holes of the stator is called stator Pitch.

Here;

$\theta_S = \frac{360°}{4} = 90°$ $\theta_S = \frac{360°}{\text{No. of Poles of stator}}$

Rotor Pitch (θ_R) :-

The angular separation b/w two successive teeth of the rotor is called Rotor Pitch

Here,

$180^\circ = \frac{360^\circ}{2} = \theta_R = \frac{360^\circ}{\text{Number of teeth of Rotor}}$

Full Step Angle :-

$\theta_{\text{Full step}}$ = The angle rotated by the rotor b/w two successive switching logics, where one switch is activated at a time is called Full step angle.

$$\theta_{FS} = \theta_R - \theta_S$$

Half Step Angle :-

The angle rotated by the rotor b/w two successive switching logics as shown in the table is called Half Step Angle.

$$\theta_{HS} = \frac{\theta_{FS}}{2} = \frac{\theta_R - \theta_S}{2}$$

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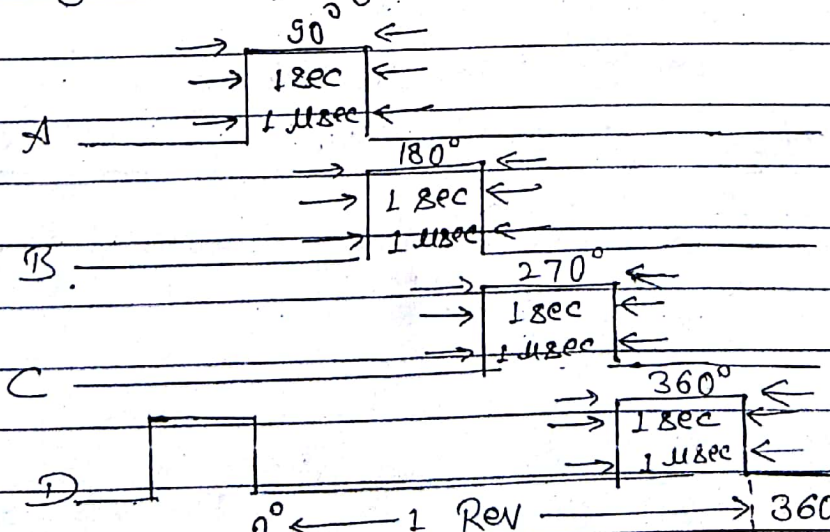
Digital Logic for ACW Rotation :-



★ Pulse Rate → No. of Pulses per sec.

1 Pulse → 1 step

⇒ 4 sec → 4 Pulse → 4 steps → 1 Rev

⇒ 4 sec → 1 Rev

⇒ 1 sec → 1/4 Rev

⇒ 1 min → 15 Rev
(60 sec)

Shaft speed = 15 RPM

1 sec = 1 Pulse

4 usec → 1 Rev

1 usec → 1/4 Rev

1 sec → 1/4 × 10^6 Rev

60 sec → 15 × 10^6 Rev
(1 min)

1 sec → 10^6 Pulses

Note:- Shaft speed can be used by using the Pulse rate.

★ So, a Pulse generator is required before every stepper motor.

Q A stepper motor has 130 step / rev. Find the input digital Pulse rate i.e. required to produce the shaft speed of 10.5 rev/sec.

Sol^n :→ 130 steps → 1 Rev.

1 step ← 1 Pulse

130 Pulses → 1 Rev

1 sec → 10.5 Rev

1 sec ← 10.5 [×130 Pulses]

1 sec ← 1365 Pulses

Pulse rate = 1365 Pulses/sec.

Q A variable reluctance type stepper motor has 8 pole stator & 6 teeth rotor. The full step angle & half step angle respectively are?

Sol^n :→ $\theta_S = \frac{360^\circ}{8 \text{ Poles}} = 45^\circ$

$\theta_R = \frac{360}{6} = 60^\circ$

$\therefore \theta_{FS} = \theta_R - \theta_S = 45^\circ - 60^\circ - 45^\circ = 15^\circ$

$\theta_{HS} = \frac{\theta_{FS}}{2} = \frac{15^\circ}{2} = 7.5^\circ$

☆ No. of diff. Possible current = No. of Phase.

S_1	S_2
4 step / 1 Rev	200 steps / 1 Rev
1 step → 90°	step → $\frac{360^\circ}{200} = 1.8^\circ$
↓	↓
Sudden jerk by large angle.	Smooth rotation.

☆ To Asc the no. of steps:
- ↑se no. of Poles
- ↑se no. of teeth on rotor.

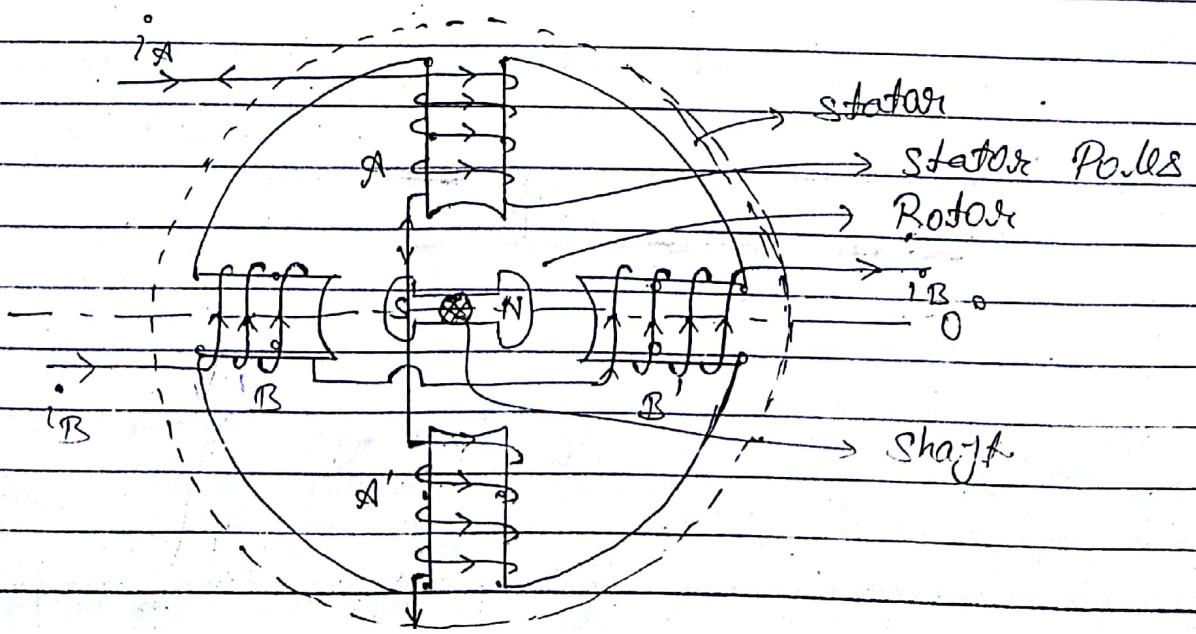
(Q) A stepper motor having a sensitivity of 300 steps/rev and running at 2400 rpm, the req. pulse rate is ?

Sol^n :→ 300 steps / rev.
300 steps → 1 Rev
1 rev. ← 300 steps ← 300 Pulse

1 min → 2400 rev.
1 min → 2400 [× 300 Pulses]
∥
60 sec → 72×10^4 Pulses
1 sec → 12000 Pulses

Pulse rate = 12,000 pulses/sec.

(2) Permanent Magnet Type Stepper Motor :-



Permanent Mag

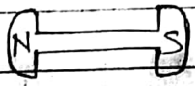
In case of P.M. type stepper motor, the rotor itself it is a magnet.

Consider 2-Phase, 2-Pole rotor Permanent Magnet type stepper motor shown below.

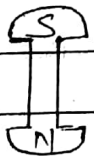
Operation for ACW :-

⇒ If $i_A \neq 0A$ [Current flows from A to A'] & $i_B = 0A$ $\theta = 90°$

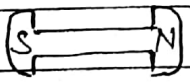
⇒ If $i_A = 0A$ [Current flows from B to B'] & $i_B \neq 0A$ $\theta = 180°$



⇒ $i_B = 0A$ [Current flows from A' to A] & $i_A \neq 0A$ $\theta = 270°$



⇒ $i_A = 0A$ [Current flows from B' to B] & $i_B \neq 0A$ $\theta = 360°$



No. of Phases (N) = 2

No. of Poles stator = 4

No. of Poles of Rotor (m) = 2

This is observation, not derivation.

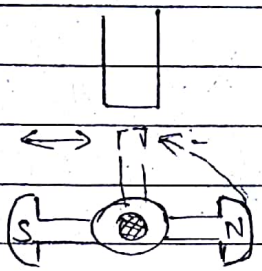
$$\text{Step Angle} = \frac{360°}{2 \times 2} = \frac{360°}{N \times m}$$

The above set up can be used to get Full step

angle as well as Half step angle.

☆ Advantage :-

It requires less power for operation.
In case of Permanent Magnet Type Stepper Motor, the magnet comes to required position earlier compared to variable reluctance type stepper motor (Oscillations about steady state value is very less)



☆ Disadvantage :-
Switching algorithm is very complex in case of P.M. type.

☆ No. of Phases (N) is limited to 4.

Eg

$$\text{Step Angle} = \frac{360^\circ}{N \times m} = \frac{360^\circ}{4 \times 40} = \frac{360^\circ}{160^\circ}$$

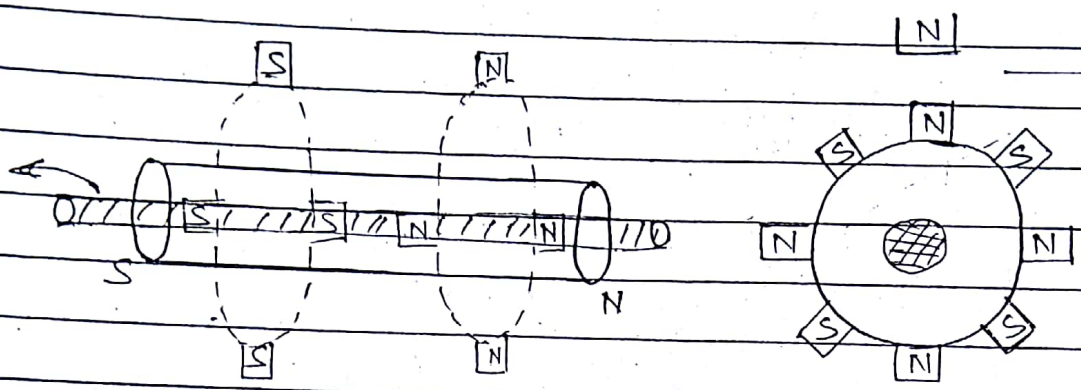
$$= 22.5^\circ$$

$m = 4$ $= 2.5^\circ$

(3) Hybrid Type Stepper Motor :-

To get small step angles, we generally prefer Hybrid Type Stepper Motor.
Hybrid type stepper Motor consist the motor which

has teeth and also Permanent Magnet.
Usually Hybrid type stepper Motor consist of advantages of both variable Reluctance (VR) type stepper Motor as well as Perm Magn type stepper Motor.



Side view

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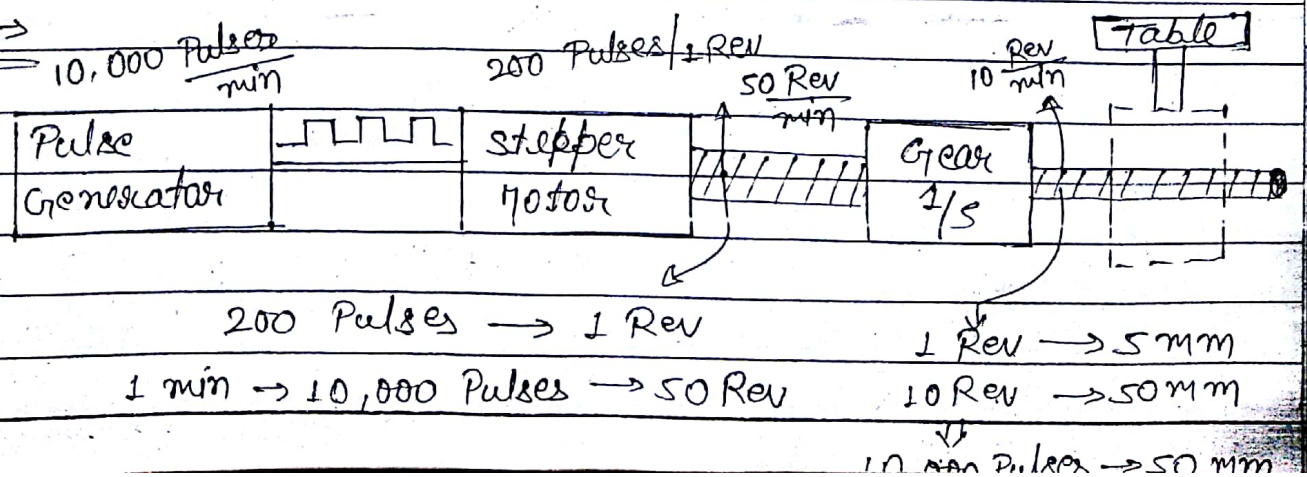
(8) In the feed drive of a point to point open loop CNC drive, a stepper motor rotating at constant speed drives a table through a gear box and screw nut mechanism (Pitch = 5 mm) and gear ratio = 1/5. If the stepper motor is driven by a pulse generator of frequency 10,000 pulses/min. If stepper motor is at the speed of 200 steps/rev. then the basic length unit (BLU), the table movement corresponds to 1 Pulse of the pulse generator is ——

Sol^n :→



1 Pulse → $\frac{50 \times 10^{-3}}{10^4}$

$= 5 \times 10^{-6} m = 5 \mu m$ Ans.