SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

POWER SYSTEM ANALYSIS
UNIT – I
PERMANENT MAGNET BRUSHLESS DC MOTOR

CLASSIFICATION of PMBLDC motor.

PMBLDC motor is classified on the basic of flux density distribution in the air gap of the motor.

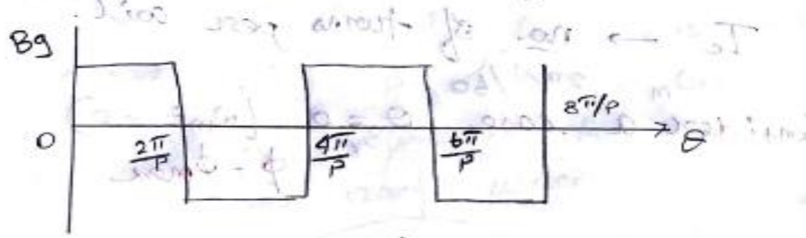
They are

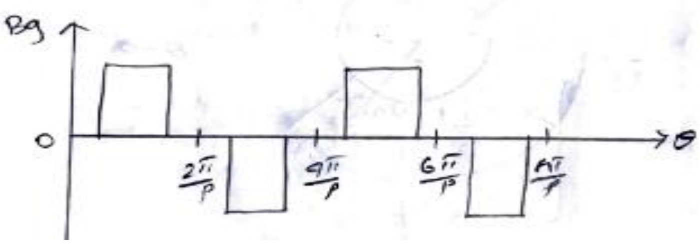
* PMBL square wave DC motor.
* PMBL SNW motor (sine wave).

PMBL square wave DC motor

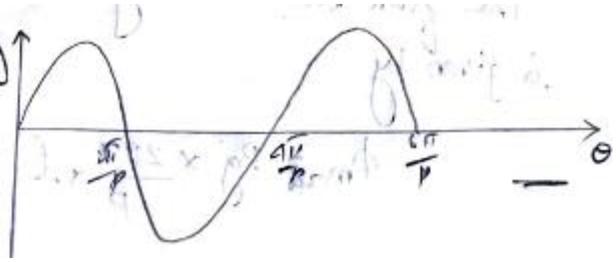
Two types

* 180° pole arc PMBL SQW dc motor
* 120° pole arc PMBL SQW dc motor.





PMBL SNW



EMF equation for PMBL SQW DC Motor

The basic emf equation results to Conventional DC motor.

Let us assume that,

P → No. of poles

Bg → flux density in the airgap of the motor (Wb/m²)

Bg is assumed to be constant throughout entire air gap

r → radius of the airgap (in m)

L → length of the armature (in m)

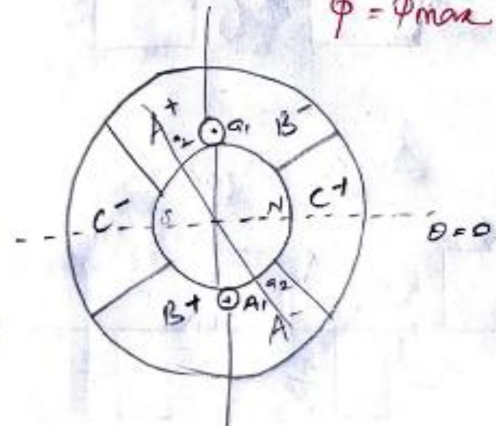
ω_m → angular velocity in mech. rad/sec

T_c → no. of turns per coil.

$\omega_m = 2\pi N/60$

Consider a case $\theta = 0$ $(\omega_m t = 0)$

$\phi = \phi_{max}$



The flux enclosed by the coil per pole is given by

$$\phi_{max} = B_g \times \frac{2\pi r}{p} \times l \quad \text{Area}$$

$$\phi_{max} = rl \int_0^{\pi} B_g(\theta)\, d\theta$$

$$= B_g r l [\theta]_0^{\pi}$$

$$\boxed{\phi_{max} = B_g r l \pi}$$

The same condition, the flux linkage of the coil is, flux linkage = φ × Turns

$$\lambda_{max} = \left(B_g \frac{2\pi r l}{p}\right) \cdot T_c \quad Wb\text{-}T$$

Let us consider rotor rotates in counter clockwise direction and when $\omega_m t = \frac{\pi}{2}$ (90°)

The flux enclosed by the coil is $\phi = 0$

flux linkage $\lambda = 0$

The flux linkage of the coil varies with rotor position θ.

The flux linkage of coil changes from maximum value.

$\boxed{B_g \cdot \frac{2\pi r l}{p} \cdot T_c}$ at $\omega_m t = 0$ to $\boxed{\text{Zero}}$

at $t = \frac{\pi}{p\omega_m}$ (time)

Calculate rate of change of flux linkage with respect to time.

$$\frac{\Delta\lambda}{\Delta t} = \frac{\text{Final flux linkage} - \text{Initial flux linkage}}{\text{Time taken}}$$

$$= \frac{0 - B_g \cdot \frac{2\pi r l T_c}{P}}{\pi / p\omega_m}$$

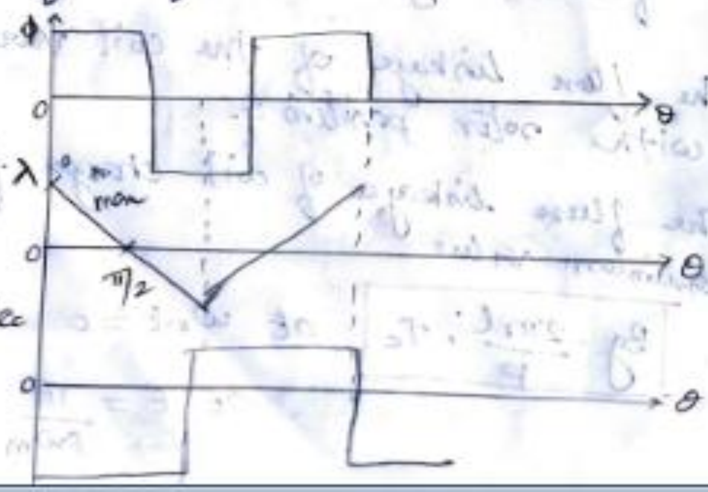
$$\boxed{\frac{\Delta\lambda}{\Delta t} = -2 B_g r l T_c \omega_m}$$

The EMF induced in coil can be determined using Electromagnetic induction law

$$e_c = -\frac{d\lambda}{dt} = 2 B_g r l T_c \omega_m$$

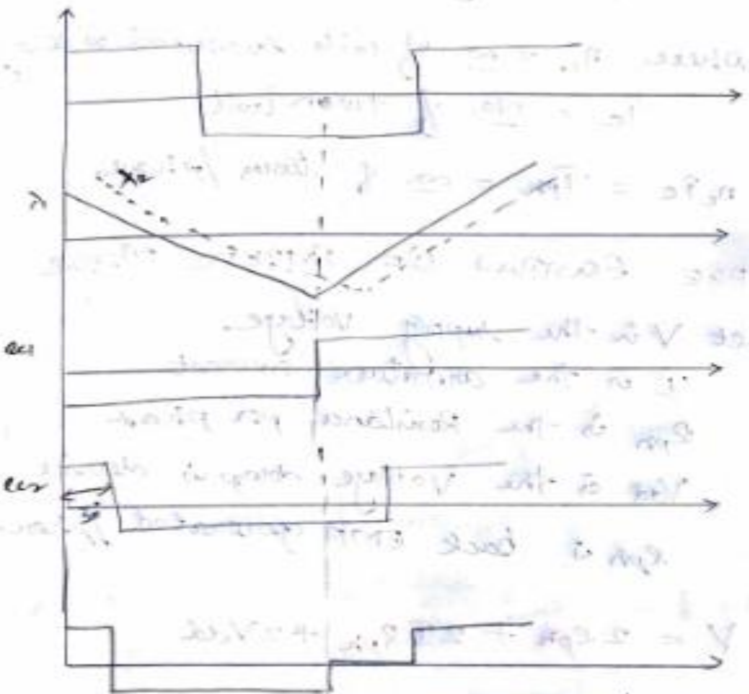
(emf induced in coil)

This emf is for single coil



Consider two coils A_1a_1 and A_2a_2.

The angle b/w two coils $30°$



The magnitude of EMF induced in coil A_1a_1 is

$$e_{c1} = 2 B_g r l T_c \omega_m \text{ Volts}$$

The magnitude of EMF induced in coil A_2a_2 is

$$e_{c2} = 2 B_g r l T_c \omega_m.$$

The sum of 2 coil voltages.

$$e_{c1} + e_{c2} = 4 B_g r l T_c \omega_m. \text{ Volts}$$

Resultant emf when all coils are connected in series.

$$e_{ph} = 2 B_g r L T_{ph} \omega_m \text{ Volts}$$

where n_c = no. of coils connected in series/ph

T_c = No. of turns/coil

$n_c T_c = T_{ph}$ = no. of turns/phase

VOLTAGE EQUATION OF PMBLDC MOTOR

Let V is the supply voltage

I is the armature current

R_{ph} is the Resistance per phase

V_{dd} is the voltage drop in device

e_{ph} is back EMF generated /phase

$$V = 2e_{ph} + 2IR_{ph} + 2V_{dd} \text{ (negligible)}$$

$$I = \frac{V - 2e_{ph}}{2R_{ph}} = \frac{V - E}{R}$$