DC MOTOR SPEED CONTROL

$$E_b = \frac{\phi Z N}{60} \times \frac{P}{a}$$

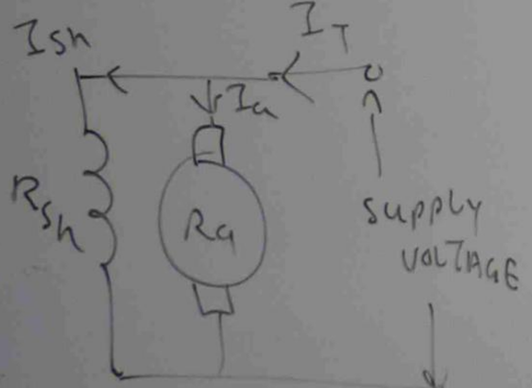
ϕ = flux

Z = ARMATURE CONDUCTORS

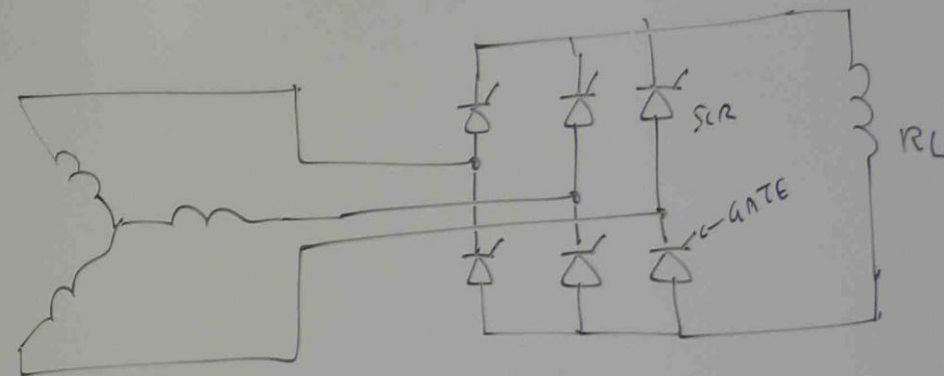
N = SPEED

P = NO. OF POLES

a = NO. OF ARMATURE PARALLEL PATHS

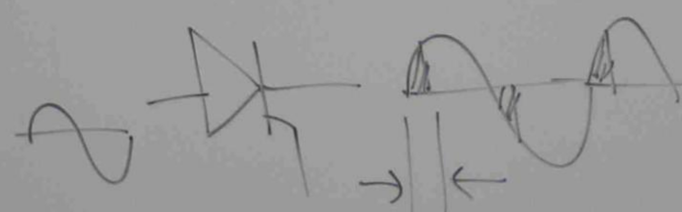


BY ADJUSTING FIELD CURRENT, DC MOTOR SPEED CAN BE CONTROLLED



SCR (SILICON CONTROLLED RECTIFIER)

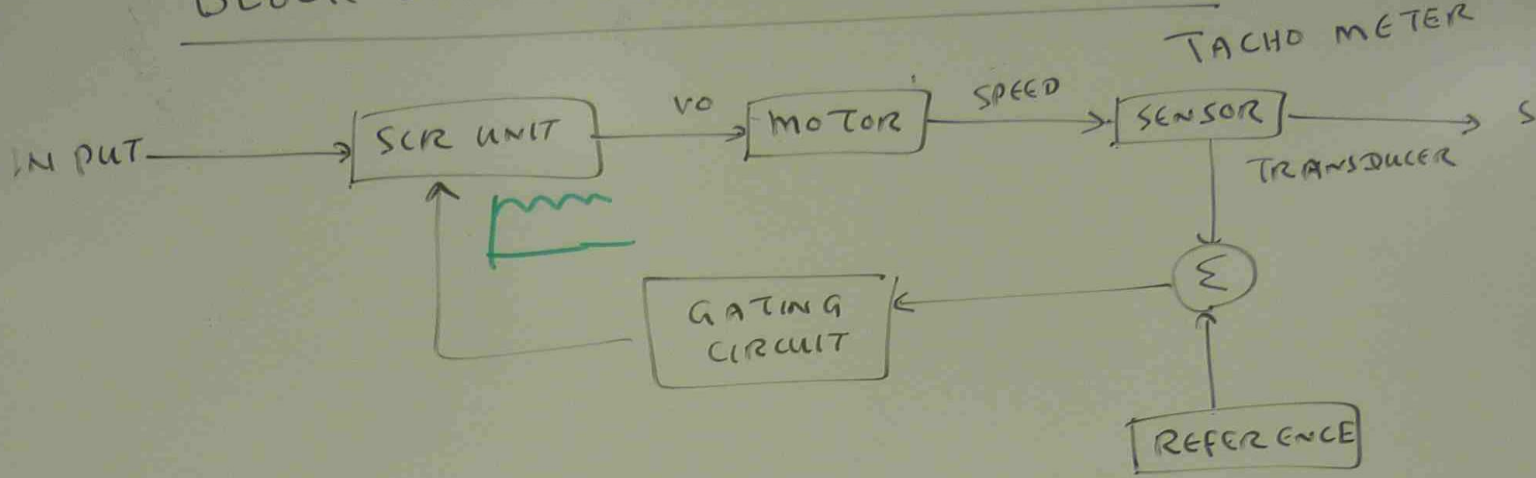
- AC MOTOR SPEED CONTROL
- DC MOTOR SPEED CONTROL



α FIRING ANGLE

LLED

BLOCK DIAGRAM OF SCR CONTROLLED MOTOR



HEATING EFFECT OF RIPPLE

RIPPLE → HEATING

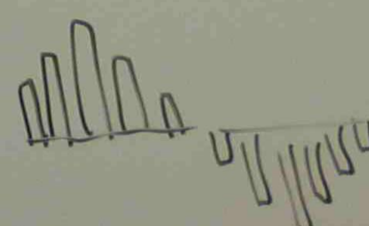
RIPPLE → HARMONIC — NEED TO BE ELIMINATED BY FILTER

RIPPLE → VIBRATION

→ DERATE THE MACHINE

→ DERATE INSULATION

PRODUCED BY
HIGH FREQUENCY
SWITCHING CIRCUITS
PWM DRIVES



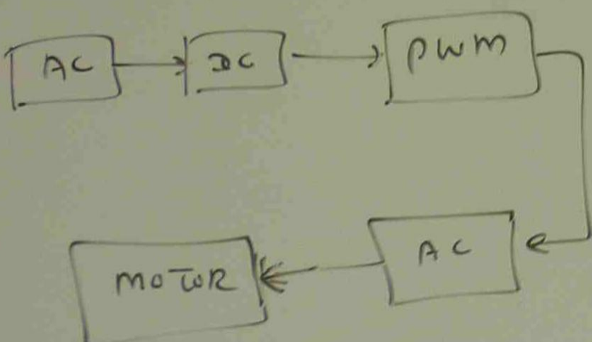
PWM - PULSE WIDTH MODULATION

S.

SPEED CONTROL

AC

$$N = \frac{120f}{P}$$



DC

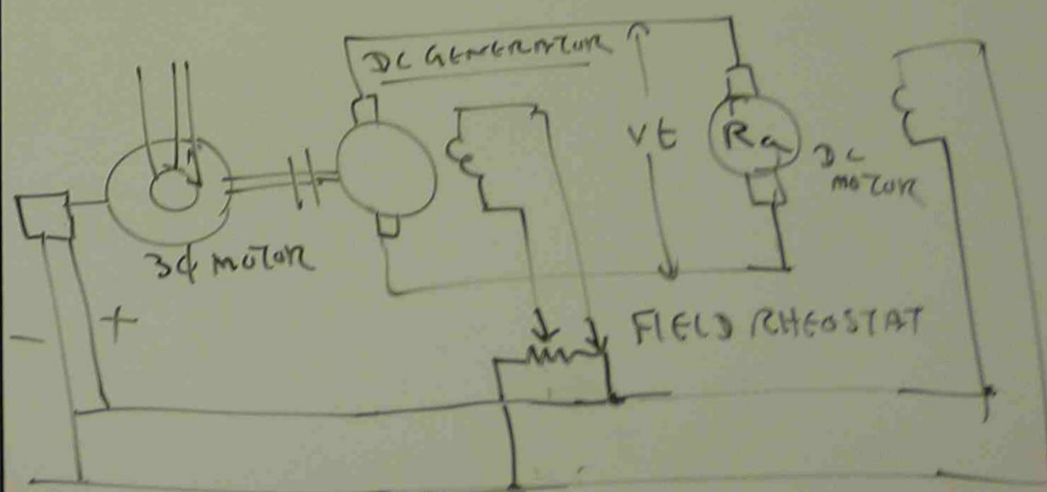
SHUNT FIELD CURRENT/ FLUX CONTROL

ARMATURE CURRENT/ FLUX CONTROL

WARD LEONARD CONTROL

WARD LEONARD SYSTEM

EXCITER



EXCITATION

ON

WARD LEONARD SYSTEM

DC GENERATOR GENERATED VOLTAGE IS SUPPLIED TO DC MOTOR ARMATURE.

DC GENERATOR FIELD EXCITATION IS VARIED BY FIELD RHEOSTAT.

GENERATED VOLTAGE DEPENDS ON DC GENERATOR FIELD EXCITATION.

GENERATED VOLTAGE INDUCES THE VARIABLE CURRENT SUPPLIED TO DC MOTOR ARMATURE AND MOTOR SPEED IS VARIED

DC MOTOR TORQUE-SPEED RELATIONSHIP

$$\boxed{T = k_t \phi I_a}$$

T = TORQUE, (N-m) ; ϕ = FLUX (wb) ; I_a = ARMATURE CURRENT (Amp)

$$k_t = \frac{PZ}{2\pi a}$$

P = NO. OF POLES

Z = NO. OF CONDUCTORS IN ARMATURE

a = NO. OF ARMATURE PARALLEL PATHS

$$\boxed{E_g = k_e \phi N}$$

E_g = GENERATED VOLTAGE

$$k_e = \frac{PZ}{60a}$$

$$\boxed{T = \frac{K_t \phi \, V_t}{R_a} - \frac{K_e K_t \phi^2 N}{R_a}}$$

pb A 4 POLE WAVE WOUND ARMATURE OPERATING IN A FIELD OF FLUX 0.01 Wb IN WOUND WITH 360 ARMATURE CONDUCTORS.

DETERMINE THE EXPRESSION OF TORQUE AS A FUNCTION OF SPEED IF $V_t = 250V$ AND $R_a = 0.1\Omega$.

$$T = \frac{K_t \phi V_t}{R_a} - \frac{K_e K_t \phi^2 N}{R_a}$$

$$K_t = \frac{PZ}{2\pi a}$$

$a = Pn$ FOR LAP

$2n$ FOR WAVE

$$= \frac{4 \times 360}{2 \times 3.1416 \times 2}$$

ASSUME SIMPLEX WAVE

$n = 1$

$$= 114.5$$

$a = 2 \times n = 2 \times 1 = 2$

$$K_e = \frac{PZ}{60a} = \frac{4 \times 360}{60 \times 2} = 12$$

$$T = \frac{114.5 \times 0.01 \times 250}{0.1} - \frac{12 \times 114.5 \times (0.01)^2 \times N}{0.1}$$

$$T = 2800 - 1.38\,N$$

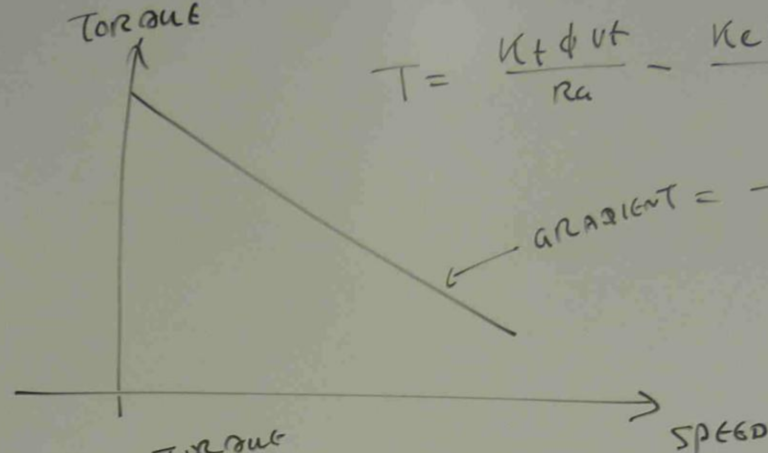
NO LOAD $\rightarrow T = 0$

$$0 = 2800 - 1.38N$$

$$1.38N = 2800$$

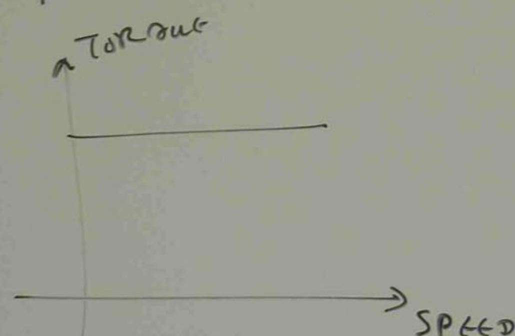
$$N = \frac{2800}{1.38} = 2028 \text{ RPM}$$

DC MOTOR TORQUE & SPEED RELATIONSHIP

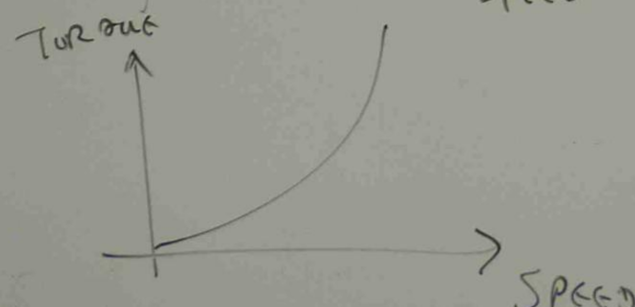


$$T = \frac{K_t \phi V_t}{R_a} - \frac{K_e K_t \phi^2 N}{R_a}$$

$$\text{GRADIENT} = -\frac{K_e K_t \phi^2}{R_a}$$



CONSTANT TORQUE



SERIES MOTOR

MATH THE MOTOR AND DRIVE SYSTEM.

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pb FOR MOTOR $T = 2860 - 1.38N$

FOR LOAD (i) $T = 50 + 1.25N$

(ii) $T = 50 + 0.625 \times 10^{-4} N^2$

TO MATCH THE MOTOR AND LOAD, CALCULATE THE EQUILIBRIUM SPEED IN EACH INSTANCE.

MOTOR & LOAD $T = 50 + 1.25N$

MOTOR TORQUE = LOAD TORQUE

$$2860 - 1.38N = 50 + 1.25N$$

$$2860 - 50 = 1.38N + 1.25N$$

$$2.63N = 2810$$

$$N = \frac{2810}{2.63} = 1087 \text{ RPM}$$

MOTOR & LOAD $T = 50 + 0.625 \times 10^{-4} N^2$

MOTOR TORQUE = LOAD TORQUE

$2860 - 1.38N = 50 + 0.625 \times 10^{-4} N^2$

$0.625 \times 10^{-4} N^2 + 1.38N - 2810 = 0$

$Ax^2 + Bx + C = 0$

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$x = N$, $A = 0.625 \times 10^{-4}$, $B = 1.38$, $C = -2810$

$$N = \frac{-1.38 \pm \sqrt{(1.38)^2 - 4 \times 0.625 \times 10^{-4} \times (-2810)}}{2 \times 0.625 \times 10^{-4}}$$

$$N = \frac{-1.38 \pm 1.622}{1.25 \times 10^{-4}}$$

$$= \frac{-1.38 + 1.622}{1.25 \times 10^{-4}}$$

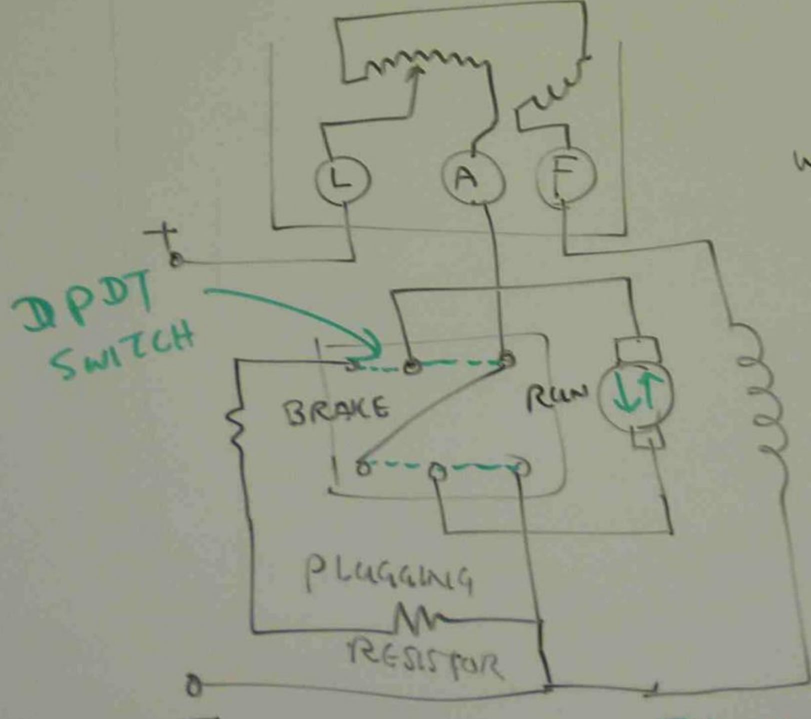
$= 1930$ RPM

DC MOTOR BRAKING

AC / DC

- PLUGGING
- DYNAMIC BRAKING
- MECHANICAL BRAKE

BRAKING BY PLUGGING

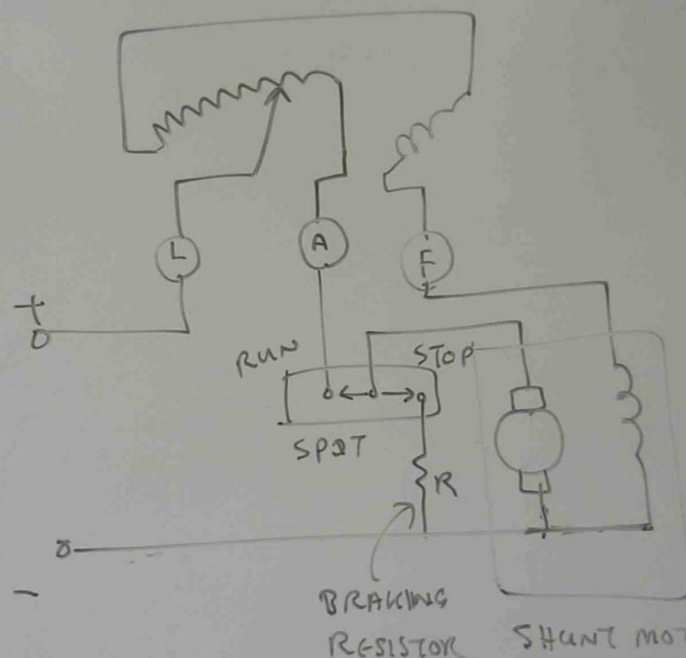


SHUNT MOTOR

WHEN THE STOP SWITCH IS PRESSED, MOTOR TERMIAL CONNECTIONS IS REVERSED.

REVERSED SUPPLY CANCELS THE MOTOR ROTATIONAL INERTIA AND MOTOR IS STOPPED IMMEDIATELY. THEN MOTOR IS CUT OFF FROM SUPPLY.

BRAKING BY DYNAMIC BRAKING



WHEN STOP BUTTON IS PRESSED, MOTOR TERMINAL IS CONNECTED TO EXTERNAL DYNAMIC BRAKING RESISTOR. THE STORED ENERGY IN MOTOR ARMATURE IS DISSIPATED IN DYNAMIC BRAKING RESISTOR AND MOTOR IS STOPPED.