1,2,3
WEEK

# Drive Notebook

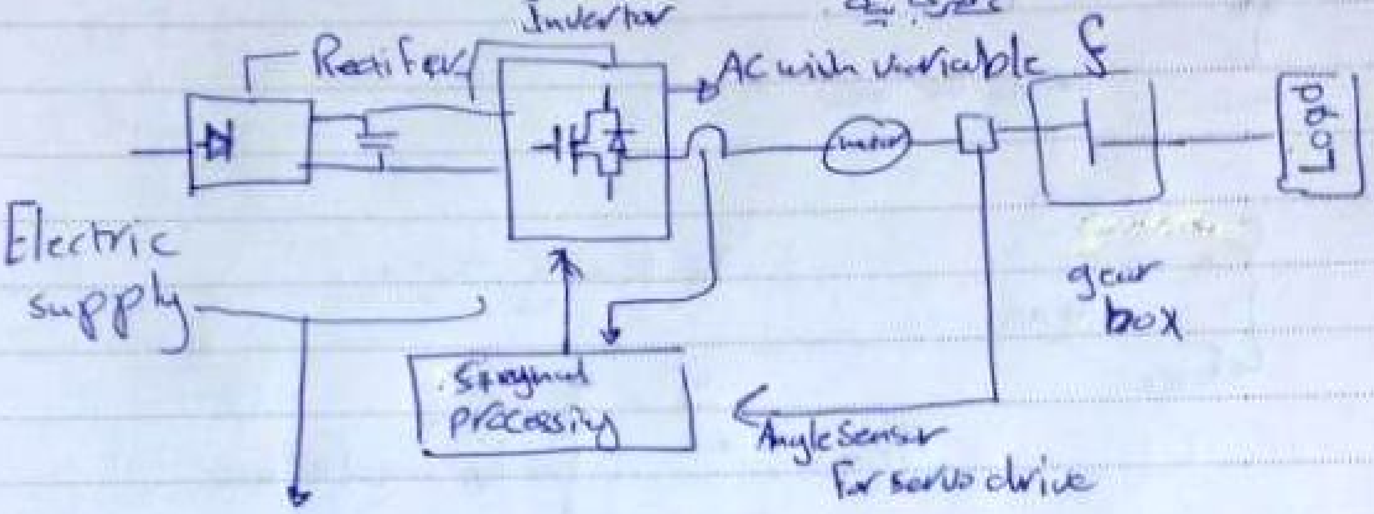
**DR. MHMD ZAKI KHADER**

**BY : NOOR ALKHATIB**

6. oct. 2015

Drives:

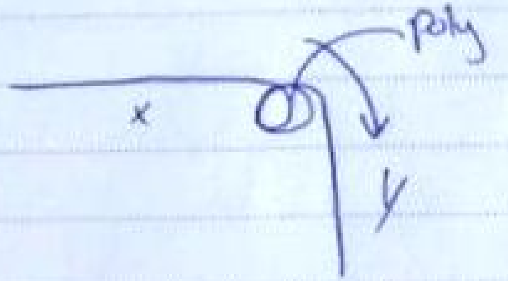
عملية الإستفادة من الحركة الميكانيكية و تحويلها إلى طاقة كهربائية



Inverter

↑ Automation system

| Linear | in Rotor |
|---|---|
| displacement | angular displacement |
| velocity | angular velocity |
| accelration | angular accelration |



$V = \frac{dx}{dt}$ $a = \frac{dv}{dt} = \frac{d^2x}{dt}$

$$. \overset{\text{liner speed}}{V} = \underset{\text{angular velocity}}{\omega} r .$$

$$\underset{\text{acc}}{a} = \underset{\text{angular acc}}{\alpha} r .$$

$$. \underset{\text{Force}}{F} = \overset{\text{mass}}{m} \underset{\text{acc}}{a} .$$

In Rotary sys:

$$. \underset{\text{" Troque "}}{T} = \underset{\text{(( moment of inertia ))}}{J} \underset{\text{angular acc}}{\alpha} .$$

* Fundamental of electrical drives . محمد الشرقاوي *
الكتاب ↑

. $\text{Energy} = \frac{1}{2} m V^2$ .

. $E = \frac{1}{2} J \omega^2$ .

Subject: 8 /oct/2015

## Work, Power and energy:

work

$w = F . s$ ↳ distance

$P = \frac{dw}{dt} = F . \frac{dx}{dt} = F \cdot V$ ↳ velocity

↱ power

$P = \tau w$

↙ Torque ↳ angular speed

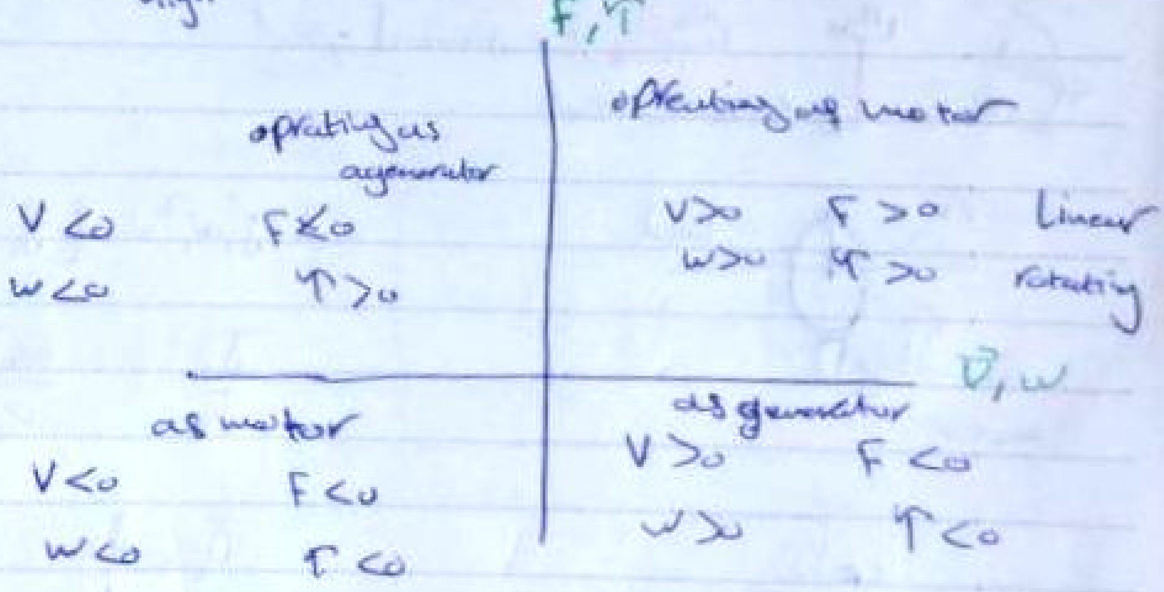
$E_{ke} = \frac{1}{2} m V^2 = \frac{1}{2} J \omega^2$ ↳ moment of inerita

kinetic energy

$E_{pe} = F \Delta h = mg \Delta h$

mass ↑ (m), ↑ high (h)

Potential energy



$J = \iiint \rho \vec{r}\, r^2\, dV$ → Volume

$\rho$ ↓ تغيرالكتلة

$r^2$ ↳ radius

$J = \frac{1}{2} m r^2$

↳ for cylinder.

$\frac{1}{2} m v^2 = \frac{1}{2} J \omega^2$ ⟸ conservation of energy

$m v^2 = \omega^2 \left(\frac{v}{r}\right)^2$

$J = m r^2$ ⟵ in rotary drive.

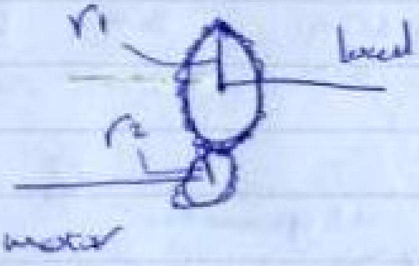
Gear box: وسيلة لنقل الحركة or higer speed from low speed motor

$i = \frac{n_1}{n_2} = \frac{\omega_1}{\omega_2}$

$i$ ↖ speed ratio

$\omega_2$ ↳ rotational speed

$n_2$ ↳ Linear speed



$\frac{1}{2} J_1 \omega_1^2 = \frac{1}{2} J_2 \omega_2^2$

$\frac{J_1}{J_2} = \frac{\omega_2^2}{\omega_2}$

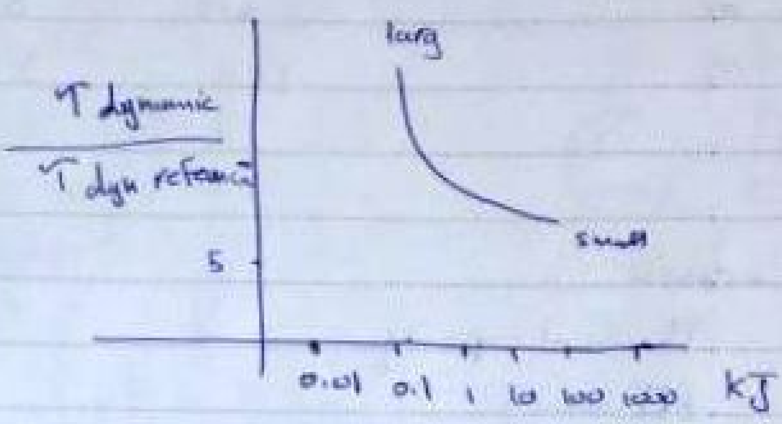
$i = \sqrt{\frac{J_1}{J_2}}$

$J_1 = \frac{J_2}{i2}$

# Loading matching factor

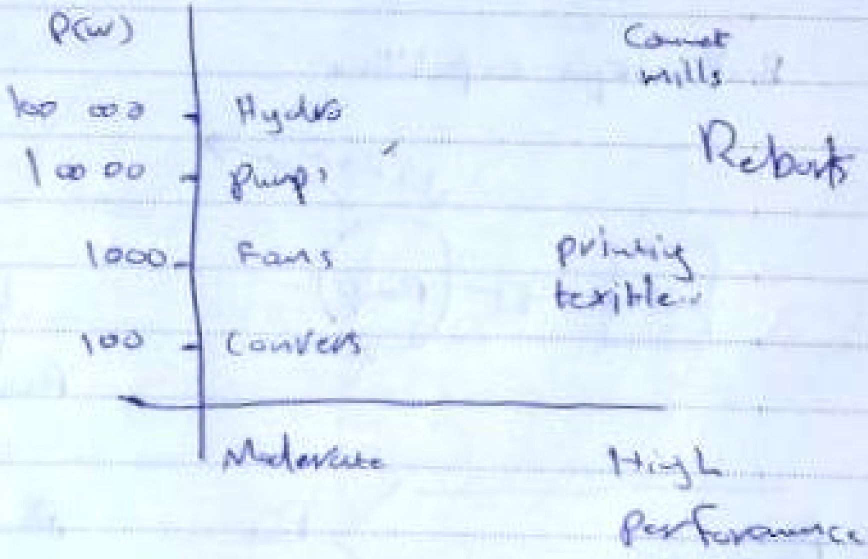
$$k_J = \frac{J_{load}}{i^2 J_{motor}} = 1$$

↑ gear box ratio



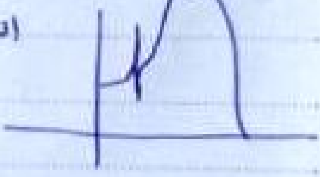
$$\frac{T_{dyn}}{T_{dyn\,refe}} = 1 + \frac{1}{k_J}$$

$$i_{opt} = \sqrt{\frac{J_{load}}{J_{motor}}}$$

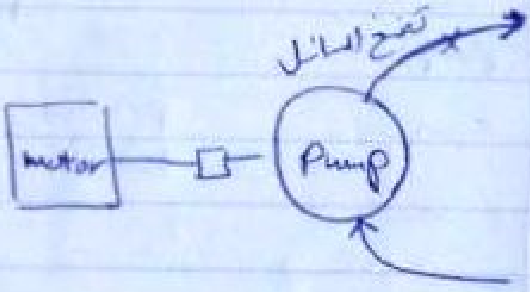


| drive | 1990 | 2005 |
|---|---|---|
| dc | 40% | 20% |
| ac | 60% | 80% |
| $\eta$ | 15% | 27% |

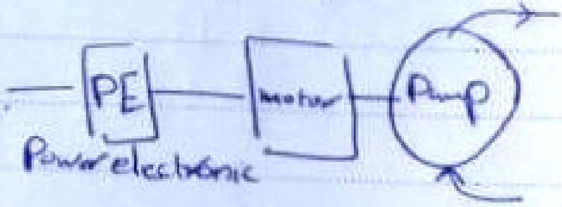
- cost
- Thermal capacity .
- Efficiency
- Torque speed profile
- accelration
- power density (volume of the motor)
- Ripple and cogging torque التغير اللحظي للعزم

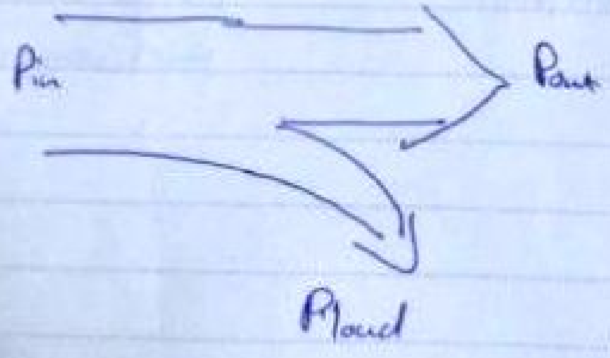


Peak torque capability

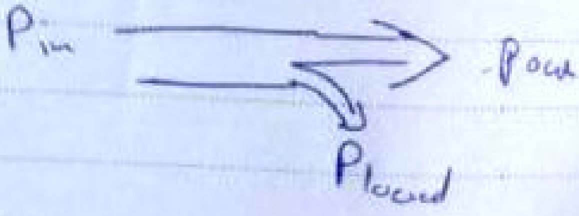


Variable speed drive

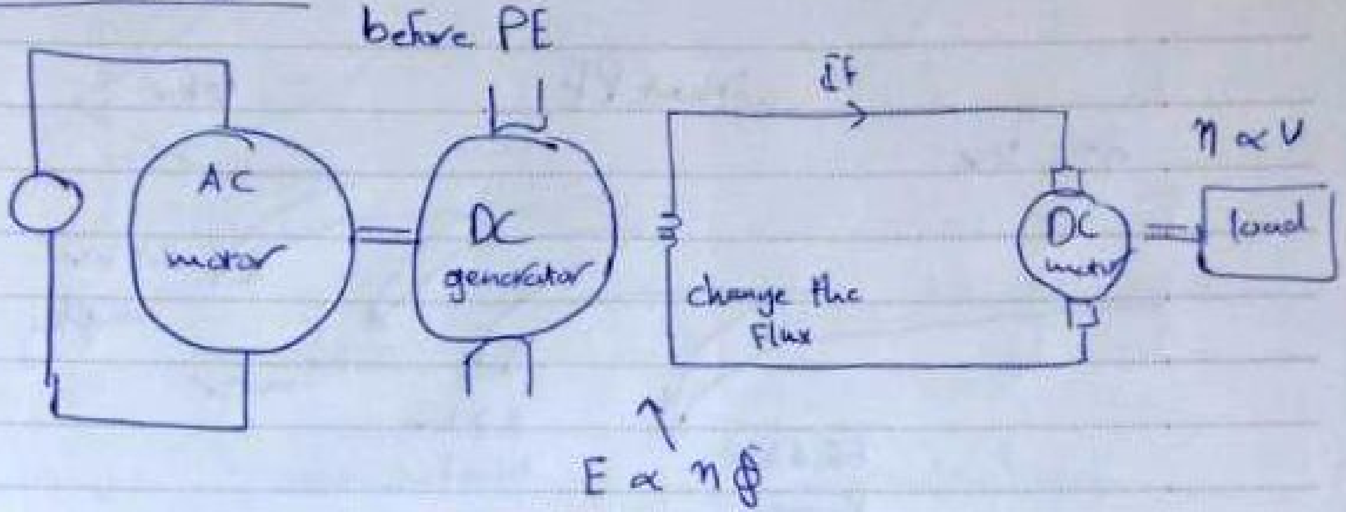




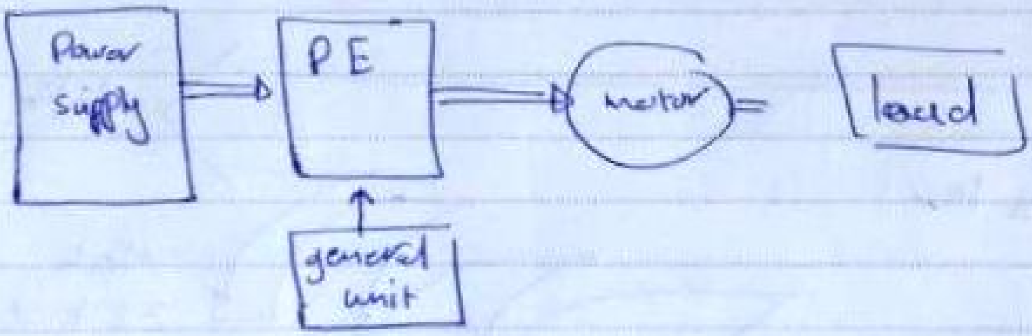
Power input is less than



لتقليل سرعة ال motor :

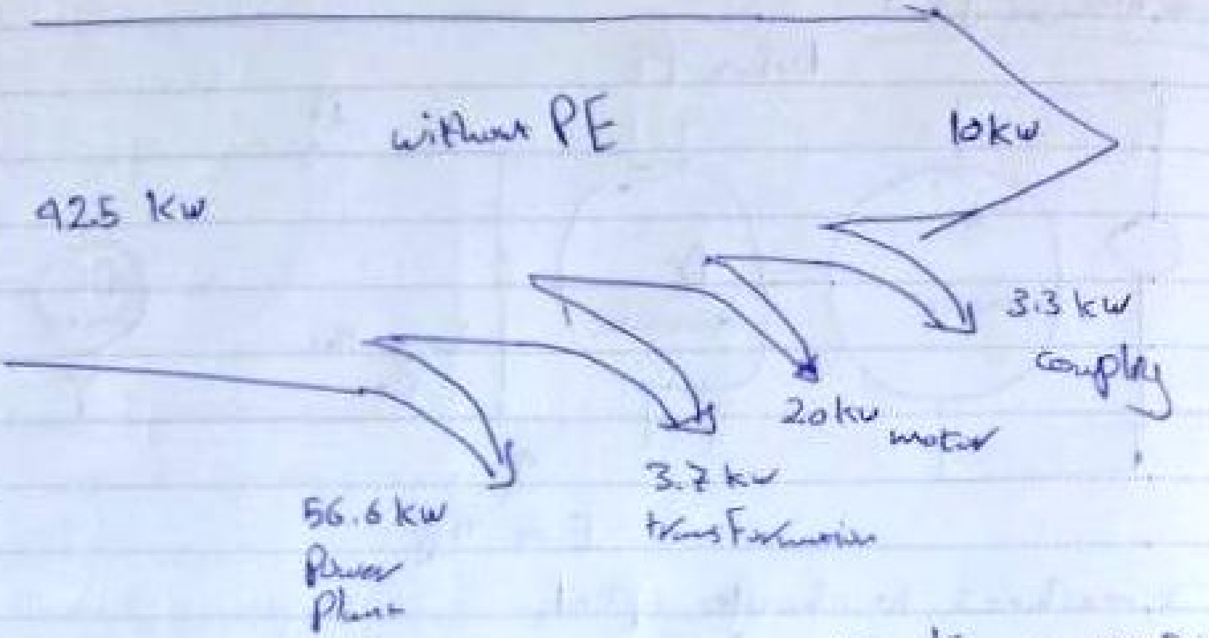


3 machines to change speed.

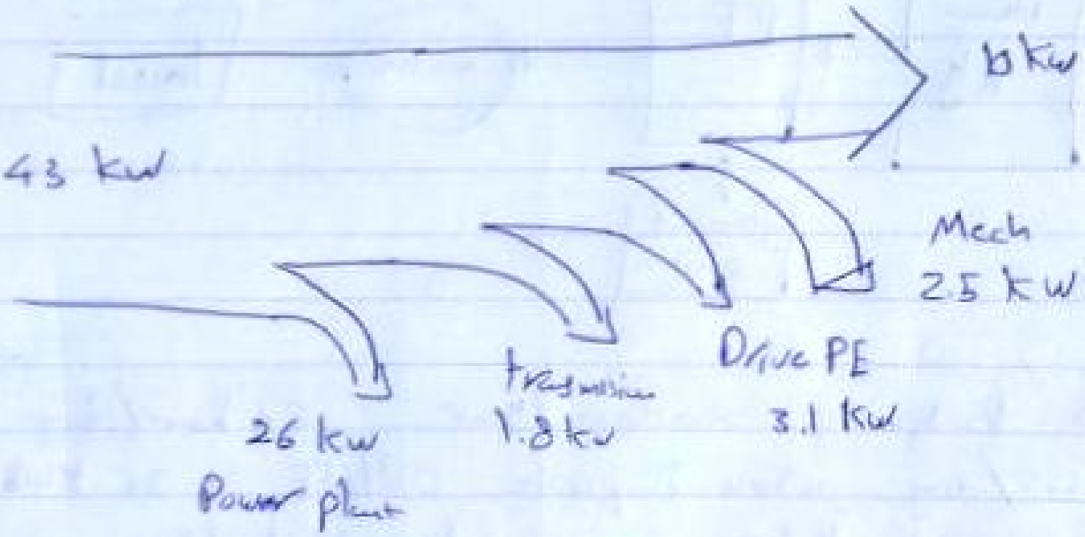


Pump 15 kw 300 days / year 24 hour/day
1200 m² / day when I opriate ON/OFF 0.36 kwh / m³
. PE 0.28 kwH / m³ ← on variable speed drive
1 kwH → 40 Fils

$$1200 * 300 * (0.36-0.28) * 0.04 = 1152 \text{ JD / year}$$



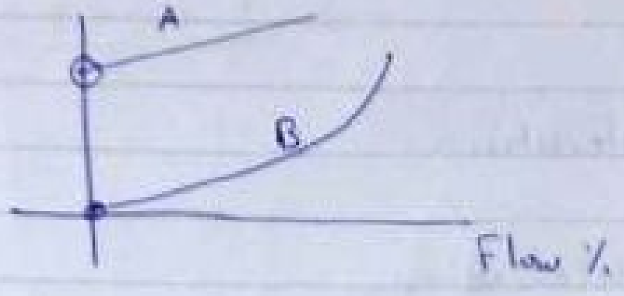
$\eta = \frac{10}{92.5} = 10.8\%$



$\eta = \frac{10}{43} = 23\%$

Subject: ............ / /

Power consumtion



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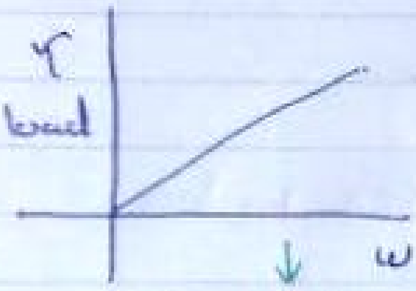
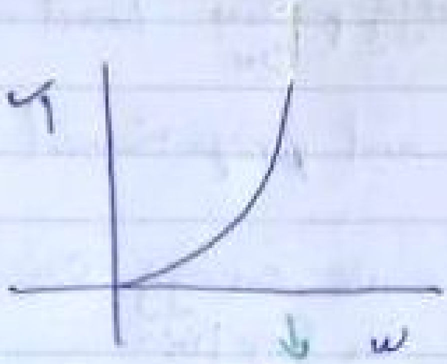
$T \propto \omega^n$

torque    rotational speed    T depend on load.



Frictional systems



Fans

For system:    $F = M \frac{dv}{dt}$

$T = J \frac{dw}{dt}$

$T \propto w$ always
[illegible]

$T_e = T_L + J \frac{dw}{dt}$
└ electromagnetic

$$T_e - T_L = J \frac{dw}{dt} = J \frac{d^2\theta}{dt}$$

$\Longrightarrow$ ④

Subject: ............ / /

$T_e - T_L = J \frac{d\omega}{dt}$

$T_e - T_L > 0$ $\Longrightarrow$ acceleration.

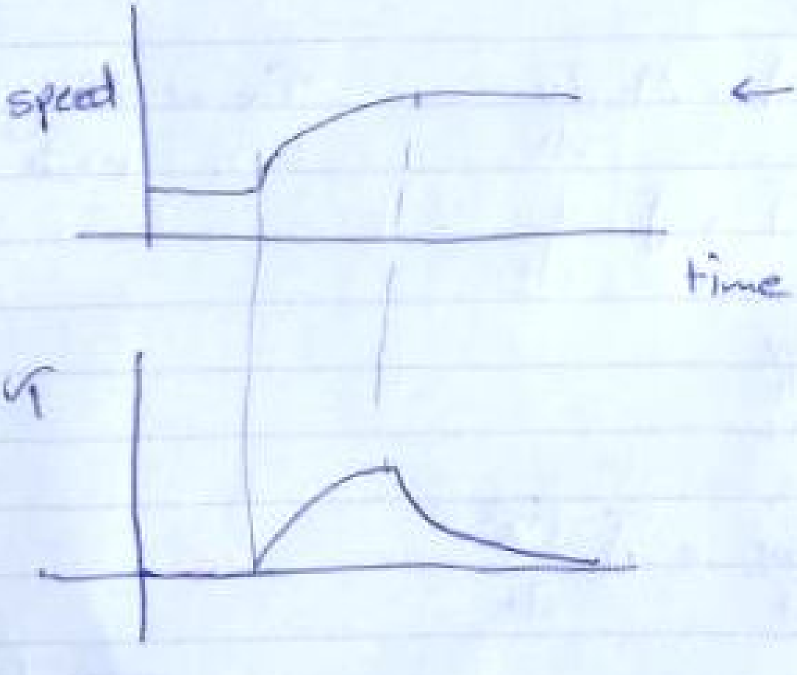
$T_e - T_L < 0$ $\Longrightarrow$ deceleration.

$T_e = T_L$ $\Longrightarrow$ constant speed.

energy منتقلة بين load and system.

and proportional with $\underline{\underline{\omega}}$.

we save energy from system not to lose it in friction.



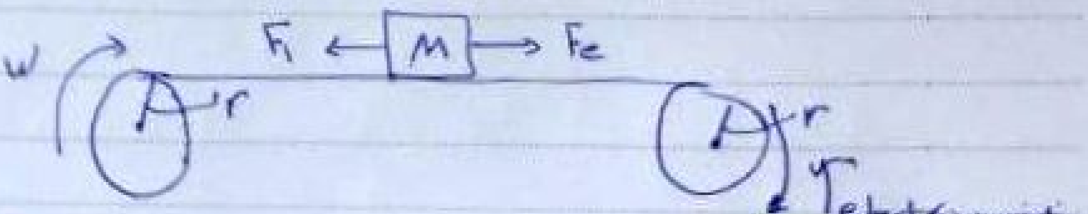
← car walk in specific speed.

Scanned by CamScanner

$\boxed{V = wr}$ ←

علاقة ال linear
مع
rotational.

System



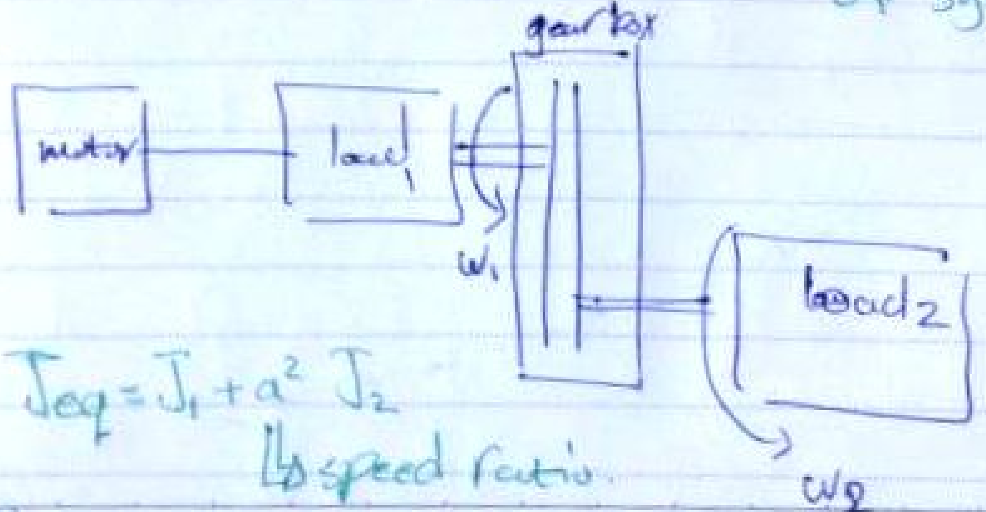
⟹ Here both linear and rotational.

$$F_e - F_L = \boxed{M}\frac{dv}{dt}$$

From linear to rotational

$$T_e - T_L = \boxed{r^2M}\frac{dw}{dt}$$

↳ $J$ ⟹ equivalent moment of inertia of system.



$$J_{eq} = J_1 + a^2 J_2$$

↳ speed ratio.

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# Drive Notebook

POWER UNIT

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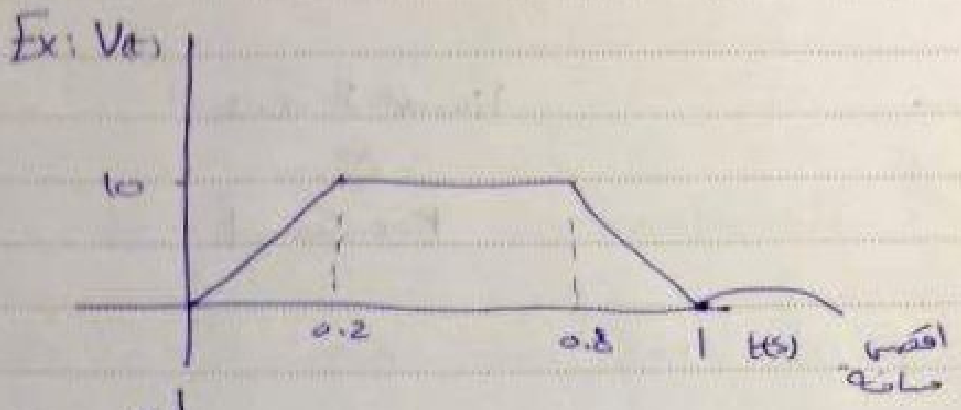
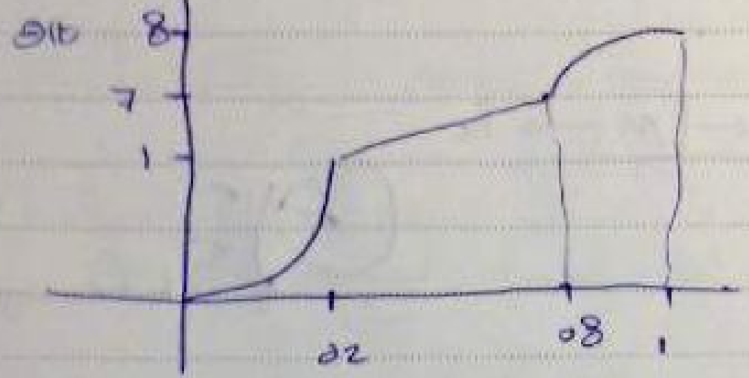
Ex:





$V_1(t) = \frac{10t}{0.2} = 50\ t$

$\theta_1(t) = \int 50t\,dt = \frac{50t^2}{2} + k = 25t^2 \Big]_0^{0.2}$

$\theta(0.2) = 25 \times 0.2^2 = 1$

$V_2(t) = 10$

$\theta_2(t) = 10t + k_2$

$1 = 10t + k_2 \qquad 1 = 10 \times 0.2 + k_2 \qquad k_2 = -1$

$\theta_2(0.8) = 10 \times 0.8 - 1 = 7$

$V_3(t) = At + B \qquad B = -A$

$10 = 0.8A + B \qquad 10 = 0.8A - A$

$A + B = 0 \qquad A = -50$

$B = 50$

①

Subject:

21 /oct/ 2015

$V_3(t) = -50t + 50$

$\theta_3(t) = -\frac{50t^2}{2} + 50t + k_2$

$7 = 25 \times (0.8)^2 + 30 \times 0.8 + k_2$

$k = -17$

$\theta_3(1) = -25 \times - 50 \times 1 = 8$

**Subject:**

28 / oct / 2015

Standards:

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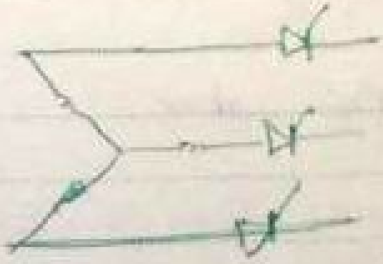
earthing : protecting for system and human

earth-leakage circuit breaker

Ambient conditions.

* controlled rectifier :.

* Three Phase controlled rectifier.



* rectifire will work only in 1st quard.
due to Freewheeling rectifier added to RL load.

* Three Phase semiconverters :
3 diodes - 3 thyristors.

* Three phase full converter :
6 thyristors.

* dual converter ⇒ work on 4 quadrant

* DC to AC Invertor :

de-rated ⇒ devise work on 10KVA in pure sine
with harmonic case should decrease
rated to : .sth

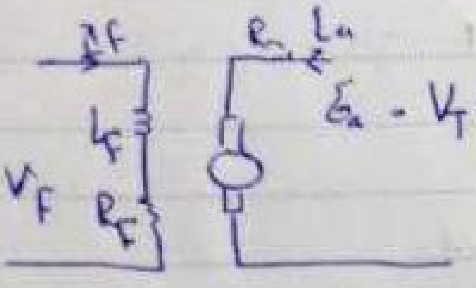
3 / Nov

Half bridge inverter.

Three phase inverter.

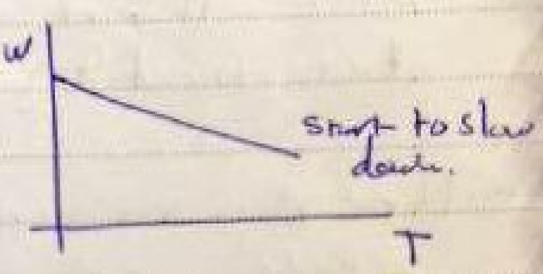
NOOR

seprately exited DC motor :



$E_a = V_T - I_a R_a$

$T = k_a \phi \underline{I_a}$



$$w = \frac{V_T}{k_a \phi} - \frac{T}{(k_a \phi)^2} R_a$$

$$k \phi w = V_T - \frac{T}{k_a \phi} R_a$$

$E_a = K \phi w$

decrease in Flux leads to change Ea

So $\underline{\underline{I_a}}$ rise

much more effective than decreasing in flux

speed control of shunt dC motor.

5 / Nov /

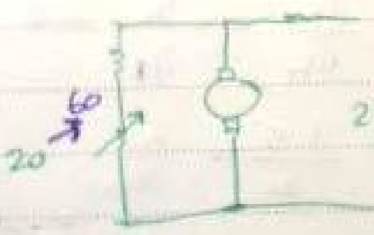
Ex

$I_a = 200$ A

$R_a = 0.1\,\Omega$

$R_{sh} = 100\,\Omega$

$R_{ext} = 20\,\Omega$



shunt motor

$E_A = 240 - 200 * 0.1 = 220$ V at full load    n = 2000 rpm

torque.

$I_f = \frac{240}{100+20} = 2A$

$T = \frac{E_a I_a}{\omega} = \frac{220 \times 100}{2000 * \frac{2\pi}{60}}$

by changing load

change ⇒ $I_f$

and T

$I_{f_2} = \frac{240}{100+60} = 1.5A$

$\frac{T_2}{T_1} = 1.25$

$T = k\phi I_a$

$\frac{T_1}{T_2} = \frac{I_{f1}}{I_{f2}} \cdot \frac{I_{a1}}{I_{a2}}$

$\frac{1}{1.25} = \frac{2}{1.5} \times \frac{200}{I_{a2}}$

$I_{a2} = 333.3$ A

$E_{a2} = 240 - 333.3 \times 0.1 = 206$ V

$\frac{E_{a2}}{E_{a1}} = \frac{I_{F2}}{I_{F1}} \times \frac{n_2}{n_1}$

$n_2 = 2504$ rpm

$\frac{206.6}{220} = \frac{1.5}{2} \times \frac{n_2}{2000}$

load torque ∝ speed

$R_{ext}$ 20 → 60 Ω

$$\frac{E_{a2}}{E_{a1}} = \frac{I_{f2}}{I_{f1}} * \frac{n_2}{n_1}$$

$$* \frac{E_{a2}}{280} = \frac{1.5}{2} * \frac{n_2}{2000}$$ ②

③ $* E_a = 240 - 0.1 I_a$

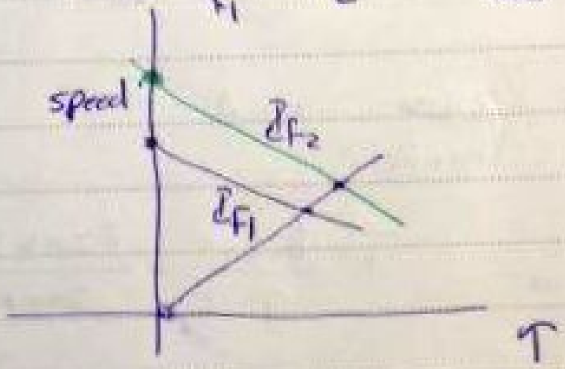
④ $* \frac{T_2}{T_1} = \frac{n_2}{2000}$ .

$$E_a = k_a \phi \omega$$

$$T = k_a \phi I_a$$

$$\frac{T_2}{T_1} = \frac{I_{f2}}{I_{f1}} * \frac{I_{a2}}{I_{a1}}$$

① $* \frac{T_2}{T_1} = \frac{1.5}{2} * \frac{I_{a2}}{200}$



$$\frac{n_2}{2000} = 0.75 * \frac{I_a}{200}$$

$$\frac{E_{a2}}{220} = 0.75 * \left(0.75 * \frac{I_a}{200}\right)$$

$$220 \times (0.75)^2 \frac{I_a}{200} = 240 - 0.1 I_a$$

$$\frac{23}{32} I_a =$$

$n_2 = 2510$ rpm

$I_{a2} = 333.61$ A

$E_a = 207$ V

$T_2 = 1.255 T_1$

permenent magnet - DC motor.

In: series DC motor $I_a = I_f$

$E_a = V_t - I_a(R_a + R_s)$

$k_a w = V_T - k_1\sqrt{T}\,(R_a + R_s)$ $T \propto I_a^2$

$I_a = k\sqrt{T}$

$$w = \frac{V_T}{k_a \phi} - \frac{I_a(R_a + R_s)}{k_a \phi} = \frac{V_T}{k\sqrt{T}} - k_2(R_a + R_s)$$

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