ac Motor

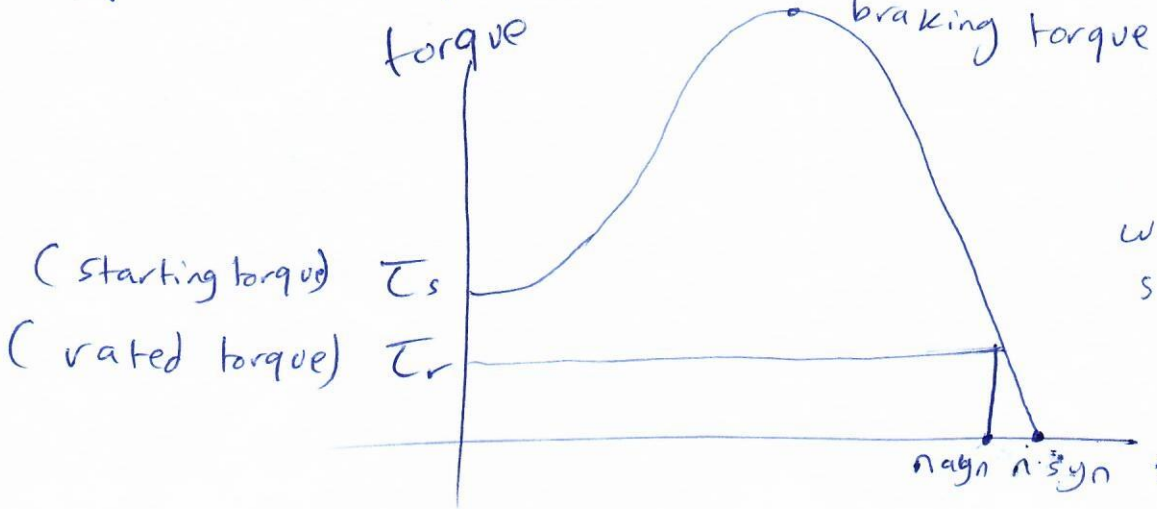
- single phase
- three phase
  - synchronous
  - asynchronous (induction)
    - squirrel cage
    - slip ring

speed Control of induction Motor

1- change the electrical frequency
2- change the terminal voltage
3- change the number of poles
4- slip control using variable resistor in slip ring Motor

$$n_{syn} = \frac{120 f}{P}$$

speed torque charactristic of IM



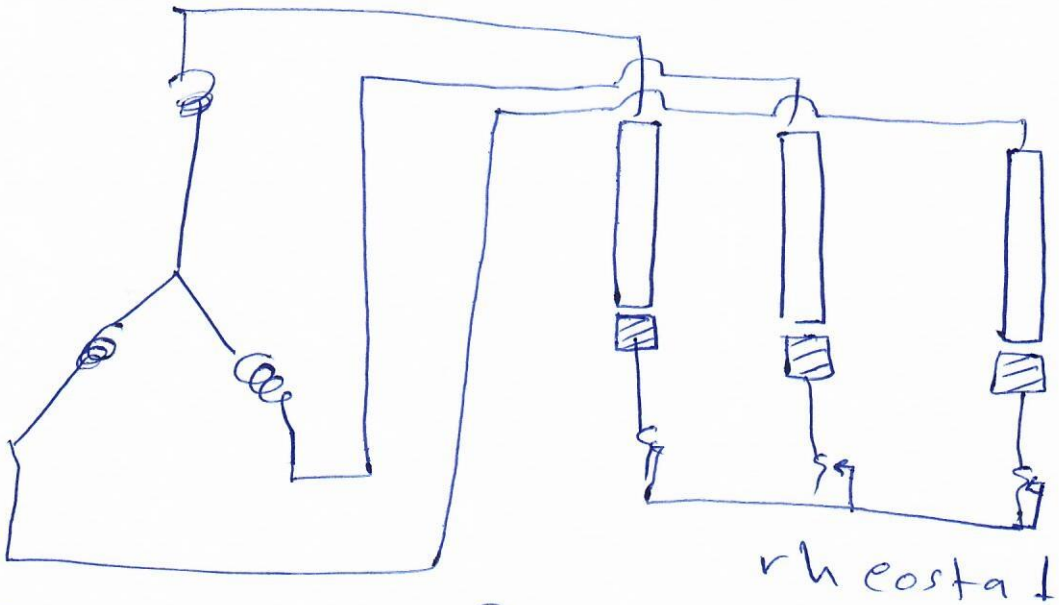
$\tau_s \approx 2\tau_r$

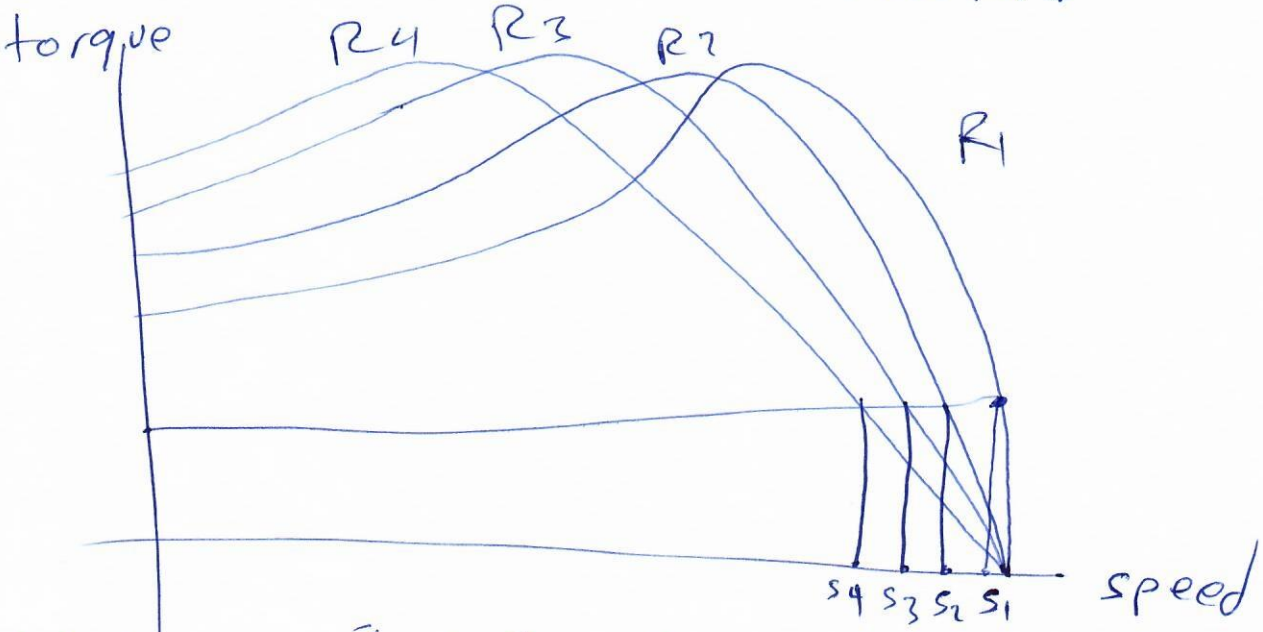
we need high starting torque to accelerate the masses

$$n_{asy} = (1 - s)\, n_{syn}$$

$$S\ (slip) = \frac{\text{Synchronous speed} - \text{Mechanical sp}}{\text{synchronous speed}}$$

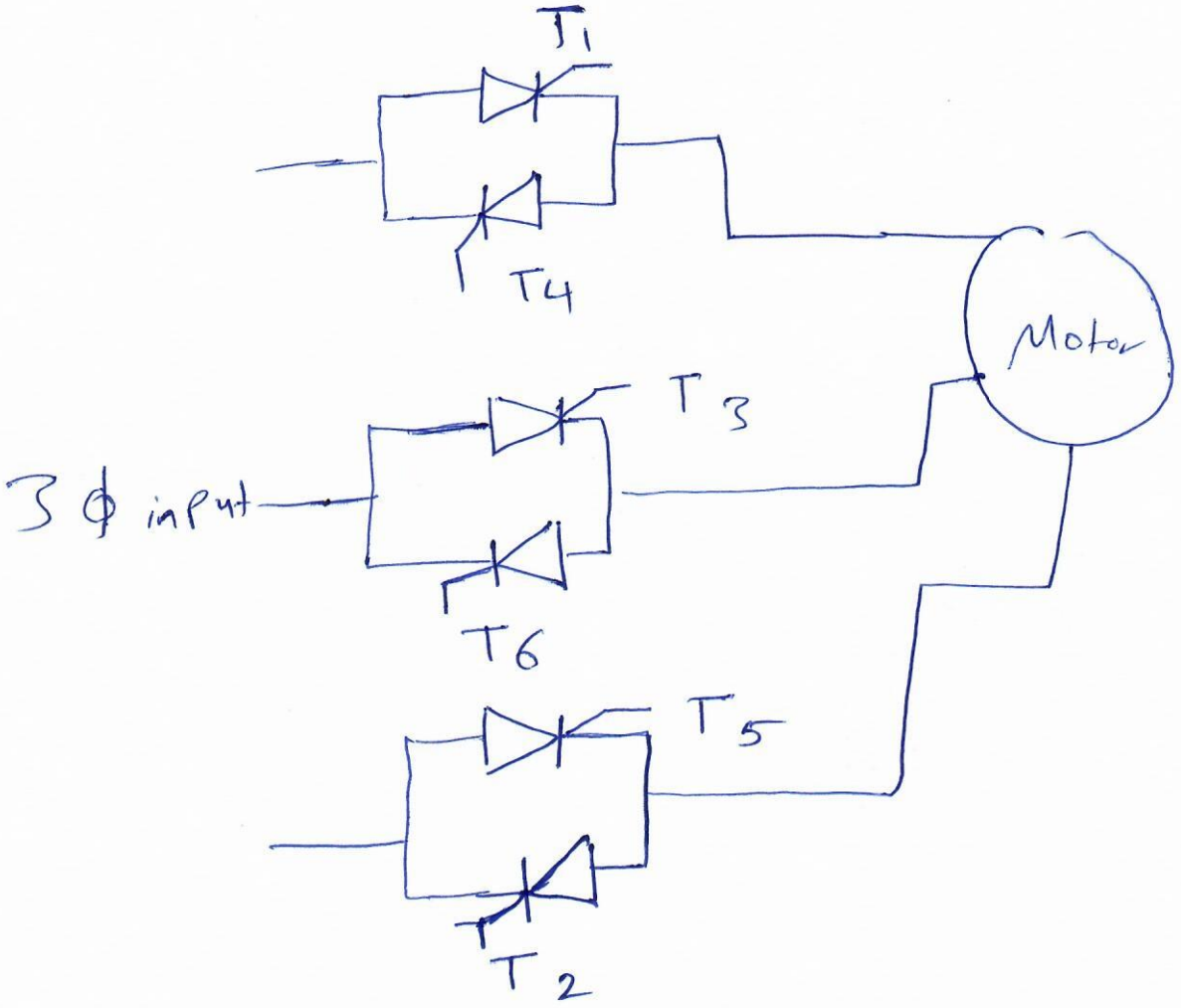
* speed control of slip ring Motor using slip control





كلما زادت قيمة المقاومة قلت السرعة وأيضاً زيادة العزم الابتدائي
ولكن سبب ذلك تخفيض كفاءة المحرك سبب المقاومات

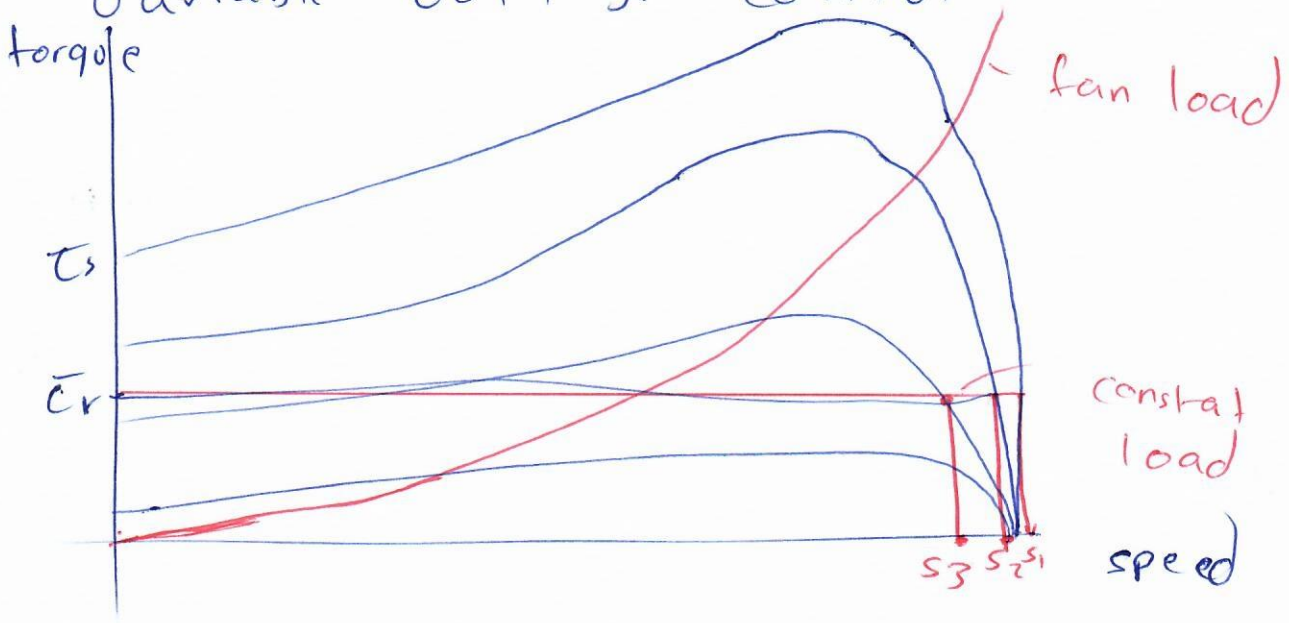
* Variable Voltage Control and soft starter



Thyristor	firing angle	firing angle in Time
T_1	α	$\alpha * \frac{0.02}{360}$
T_4	$\alpha + 180^\circ$	$\alpha + 180 * \frac{0.02}{360}$
T_3	$\alpha + 120$	$\alpha + 120 * \frac{0.02}{360}$
T_6	$\alpha + 300$	$\alpha + 300 * \frac{0.02}{360}$
T_5	$\alpha + 240$	$\alpha + 240 * \frac{0.02}{360}$
T_2	$\alpha + 60$	$\alpha + 60 * \frac{0.02}{360}$

α $(0 \rightarrow 150^\circ)$ مجال التحكم

* speed torque charatristic for Uariable Uoltage Control



disadvatages of Uariable Voltage Control

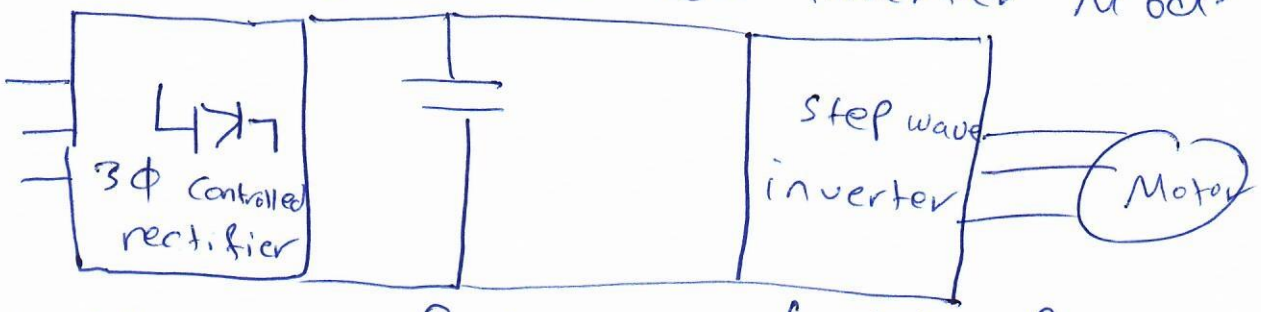
1- Limitid speed control
2. high copper losses
3- huge harmonic due to thyristor switching
4 - poor Power factor
5. not suitable for constant load torque

appli cation : small fans of pumb drive

* speed control of IM using variable voltage variable frequency

* 180° inverter Mode

* Block diagram for 180° inverter Mode



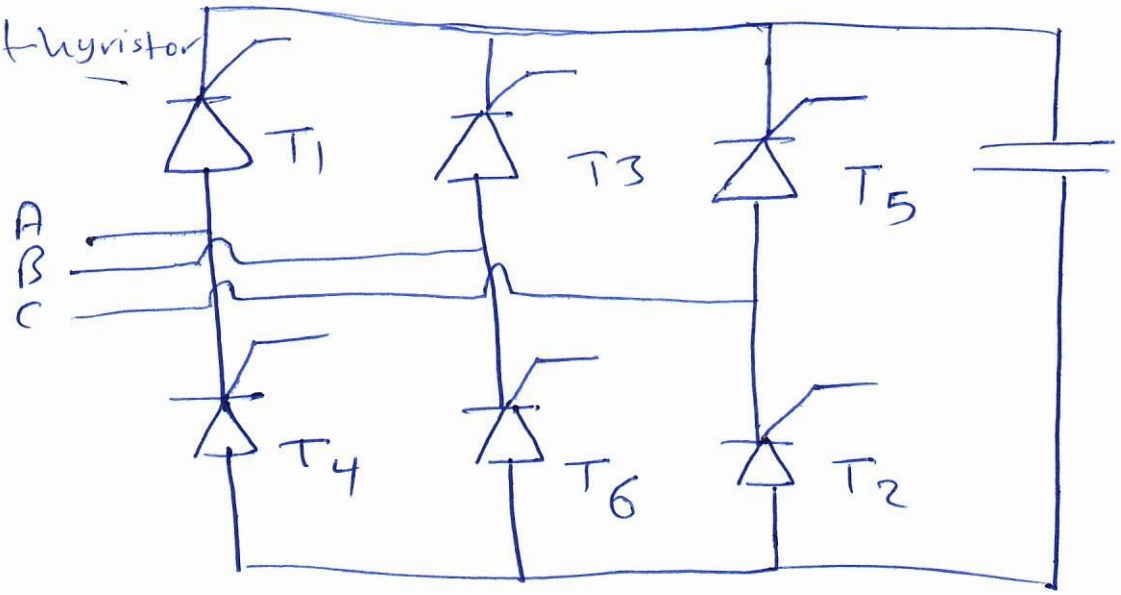
variable voltage filter variable frequency

disadvantages for this Method

1- poor power factor

2- high harmonic

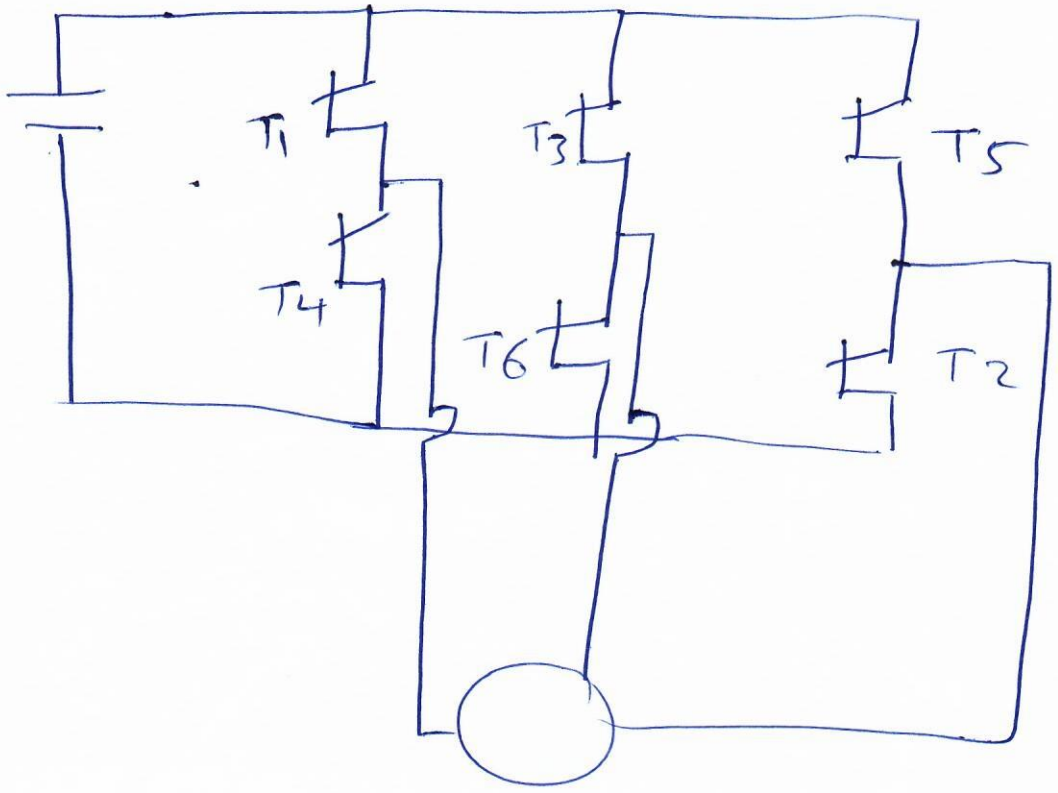
3ϕ controlled rectifier circuit



thyristor	firing angle	firing angle in Time
T_1	$\alpha + 30$	$\alpha+30 * \frac{0.02}{360}$
T_3	$\alpha + 150$	$\alpha+150 * \frac{0.02}{360}$
T_5	$\alpha + 270$	$\alpha+270 * \frac{0.02}{360}$
T_2	$\alpha + 90$	$\alpha+90 * \frac{0.02}{360}$
T_4	$\alpha + 210$	$\alpha+210 * \frac{0.02}{360}$
T_6	$\alpha + 330$	$\alpha+330 * \frac{0.02}{360}$

α (0 — 120°) العلاقة عكسية 120 كحد

* Three phase inverter 180° degree

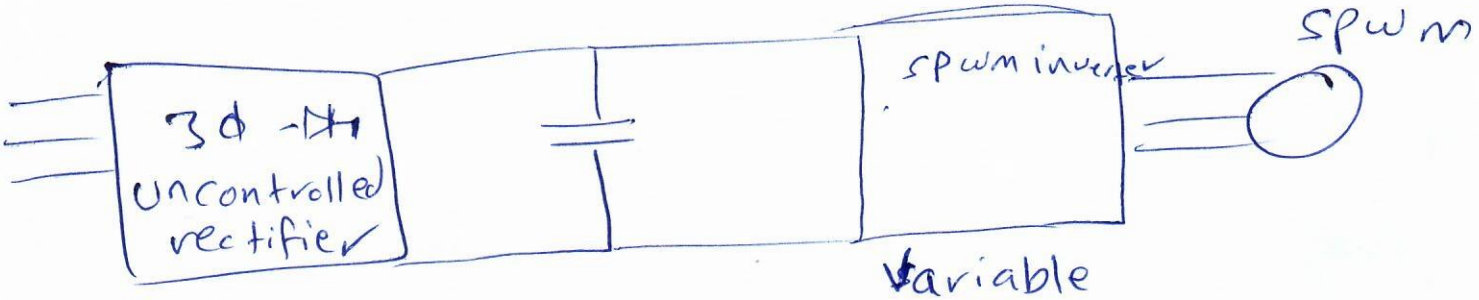


(Mosfet) or IGBT

Mosfet	firing angle	firing angle in Time
T_1	0	0
T_4	180°	$\frac{180}{360} * 0.02$
T_3	120	$\frac{120}{360} * 0.02$
T_6	300	$\frac{300}{360} * 0.02$
T_5	240	$\frac{240}{360} * 0.02$
T_2	60	$\frac{60}{360} * 0.02$

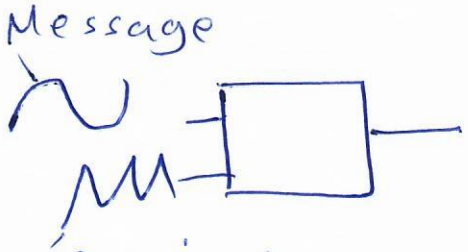
* sine pulse width Modulation (SPWM)

* Block diagram



Constant Voltage

Variable Voltage Variable frequency



frequency 1000Hz

sin A > carrier → 1 on / 4 off

sin A < carrier → 1 off / 4 on

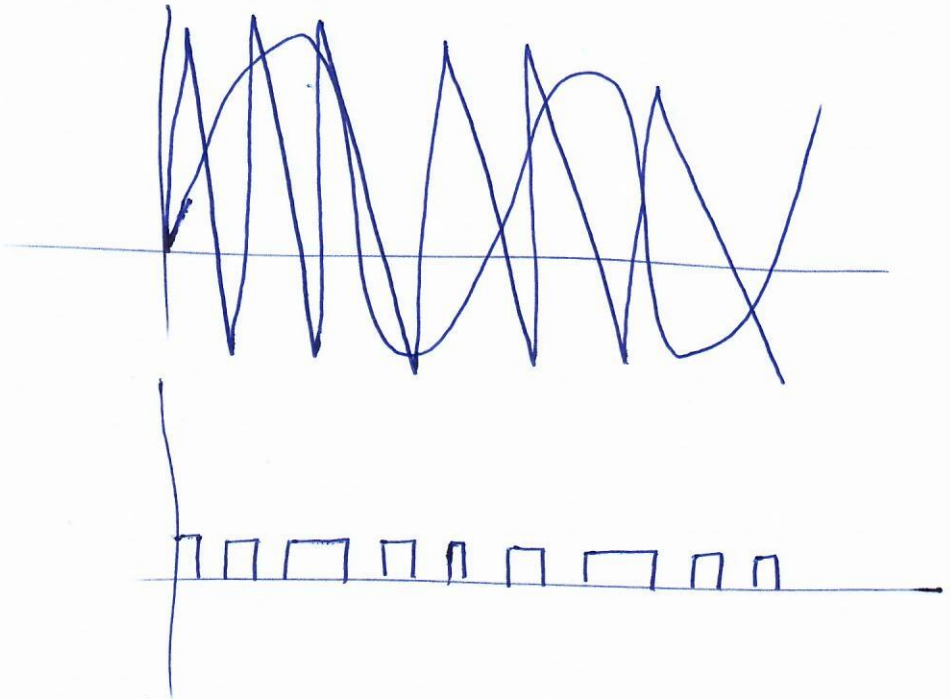
sin B > carrier → 3 on / 6 off

sin B < carrier → 3 off / 6 on

sin C > carrier → 5 on / 2 off

sin C < carrier → 5 off / 2 on

output signal from comparator

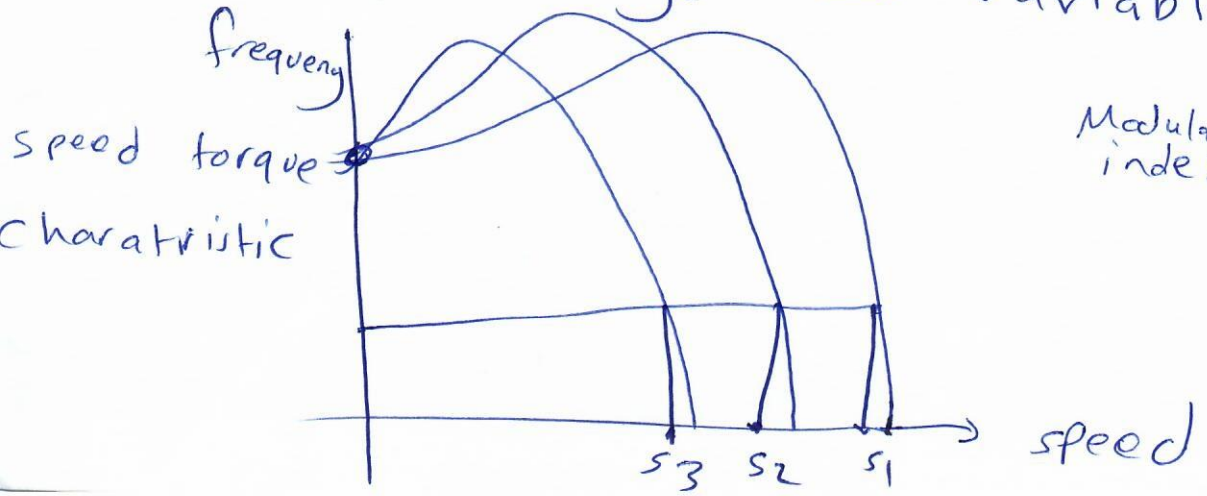


Carrier frequency ↑ ⇒ harmonic ↓

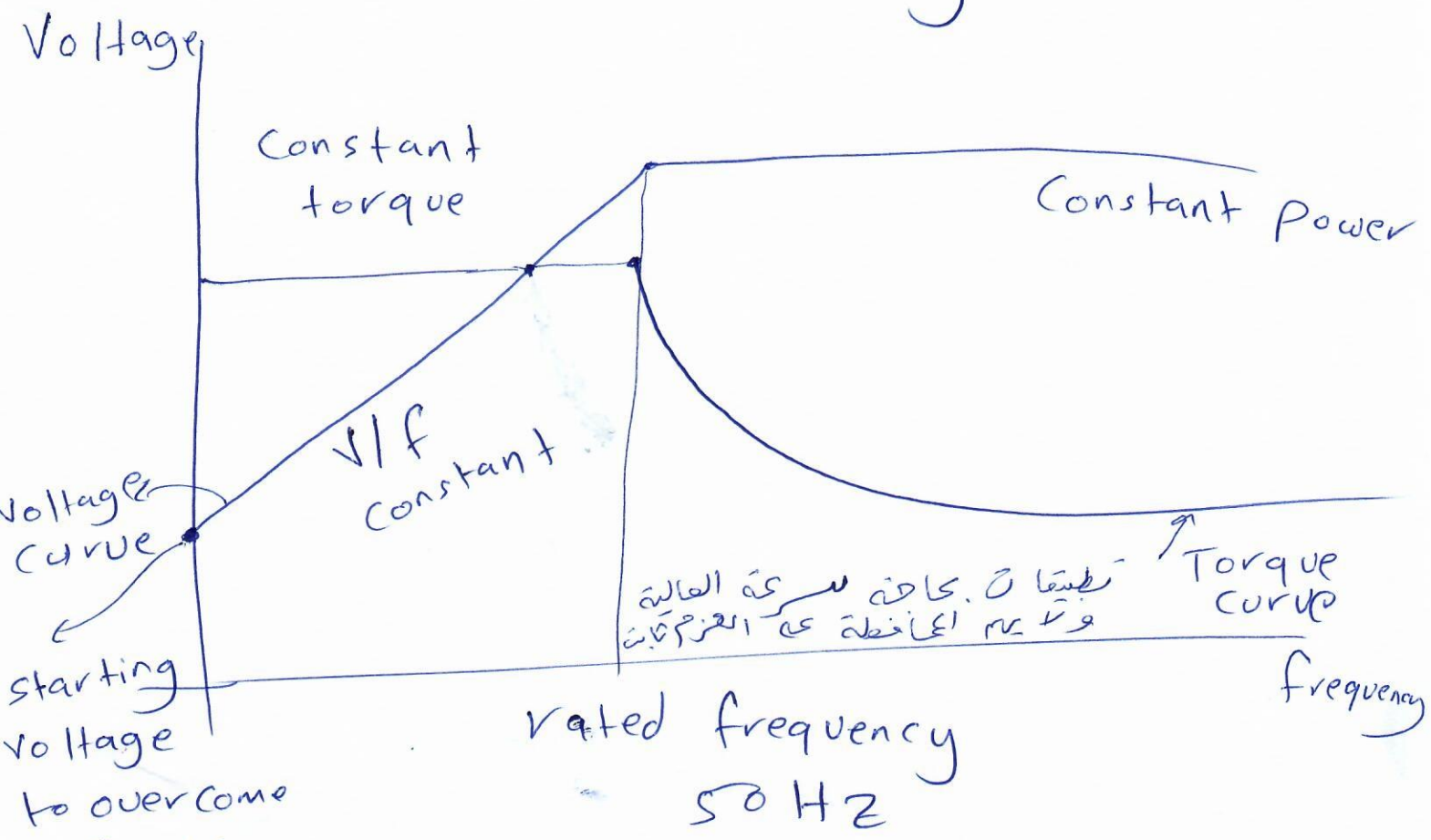
Viariable frequency ⇒ Variable frequency output

Variable Voltage ⇒ variable Modulation index

Modulation index = $\frac{Am}{Ac}$



Voltage frequency Charactristic



$\rightarrow P = \omega T$

Constant $f \uparrow \downarrow$