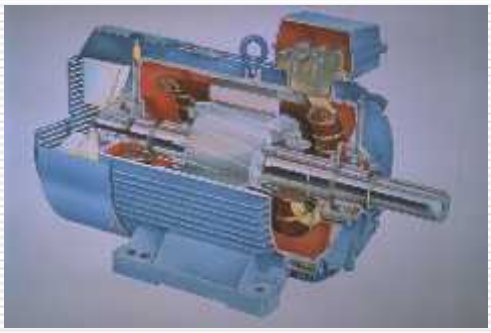
Module 4

# AC MOTOR CONTROL

Lecture 2

## Induction Motor Speed Control



Shameer A Koya

## Induction motor speed

- So, the IM will always run at a speed lower than the synchronous speed

$$N_S = 120 * f / P$$

- The difference between the motor speed and the synchronous speed is called the *Slip*

$$n_{slip} = n_{sync} - n_m \qquad n_m = n_s - s * n_s$$

Where $n_{slip}$= slip speed

$n_{sync}$= speed of the magnetic field

$n_m$ = mechanical shaft speed of the motor

## The Slip

$$s = \frac{n_{sync} - n_m}{n_{sync}}$$

Where ***S*** is the *slip*

$$n_m = n_s - s * n_s$$

*Hence,*

$$N_m = \frac{120 * f}{P}(1 - s)$$

## Introduction to speed control

$$N_m = \frac{120 * f}{P}(1 - s)$$

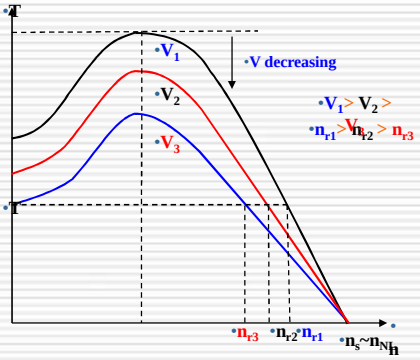
- Speed can be changed by,
  - Changing frequency, *f*
  - Changing no. of poles, P
  - Changing slip, *s*
- *Terminal voltage*
- *Rotor resistance*

# Speed control techniques

- Frequency
  - Change in synchronous speed,
  - Need variable frequency supply.
- Change no. of poles
  - Put two or more sets of winding in stator
  - Limited speeds
    - 2 / 4 pole – speed available are 3600 / 1800 for 60 hz
- Terminal voltage
  - Torque proportional to square of voltage
  - Variation is very little, Reduces starting torque
- Rotor control
  - For Wound rotor motor
  - Rotor resistance, reactance or injecting voltage to rotor.

# Stator voltage control

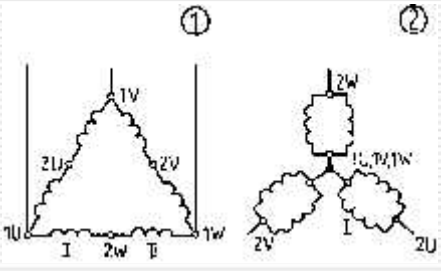
- Suitable for constant torque load,
- low starting torque, narrow speed range.
- Maximum torque changes
- uses power electronics circuit for voltage controller
  - AC voltage controller or PWM inverters can be used to change voltage



# Stator multi-winding control

- Changing Number of Poles
- Inversely proportional
- Discrete speeds (step) - suited to application that does not require continuous (step-less) adjustments.
- Use two separate windings,
- One for less number of poles and other for more.
- One of them will be idle when other is energized.
- Disadvantages
  - High cost,
  - Large size,
  - Reduced performance characteristics.

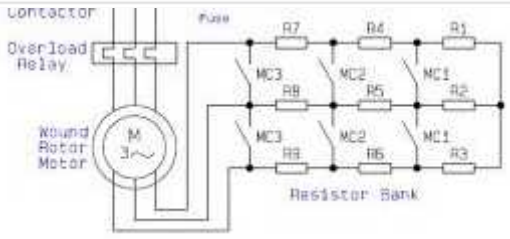
# Stator multi-winding control
## consequent pole

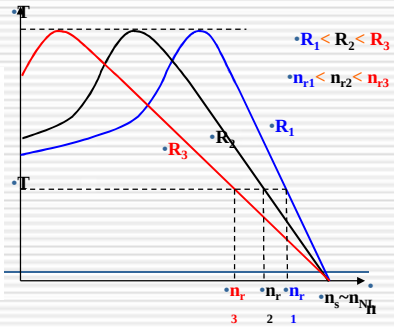



- Use single winding, whose connection can be changed.
  - Speed is the double the other
- Reversing the polarity of one winding to get 'consequent pole'
  - Net effect is providing twice no. of poles

# Rotor Control

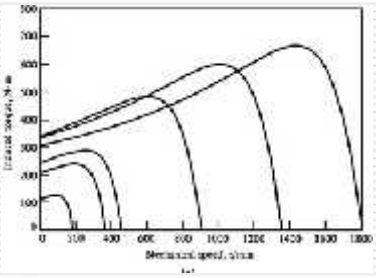
- External three phase resistor is connected to slip rings.
- Speed can be adjusted for a wide range
- Involve power loss in resistor
- Control is possible in either direction
- Speed above Ns is possible by reversing power flow to the rotor. (voltage injection)




# Frequency control

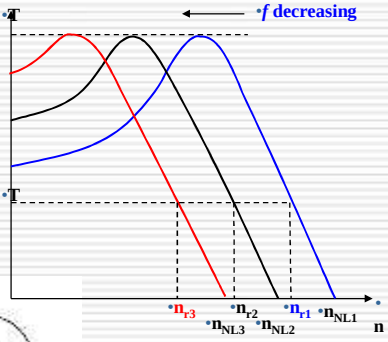
- Supply from variable frequency source.
- If voltage kept constant.
  - Frequency reduced, XL will reduce, current will increase and hence flux will increase – saturation
  - Frequency increased, XL will increase, current will decrease and hence flux will decrease – torque reduce.

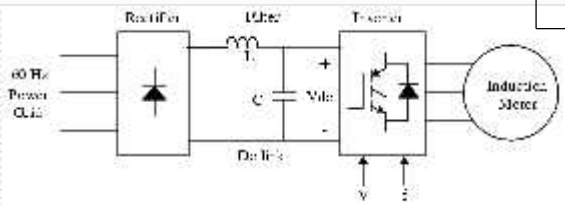


# V / *f* Control

- Ratio of Voltage to frequency is kept constant
- Three phase cyclo-converter
- PWM inverter

$$V = 4.44 N \phi_m f$$



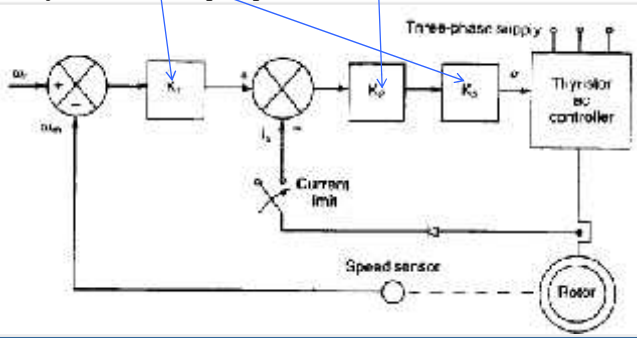




# Closed-loop Control

- to satisfy the steady-state and transient performance requirement of an ac drive
- control strategy can be
  - scalar control - the control variables are dc quantities only their magnitudes are controlled
  - vector control - both magnitude and phase of controlled variables are controlled
  - adaptive control - parameters of the controller are continuously varied to adapt to the variations of the output variables

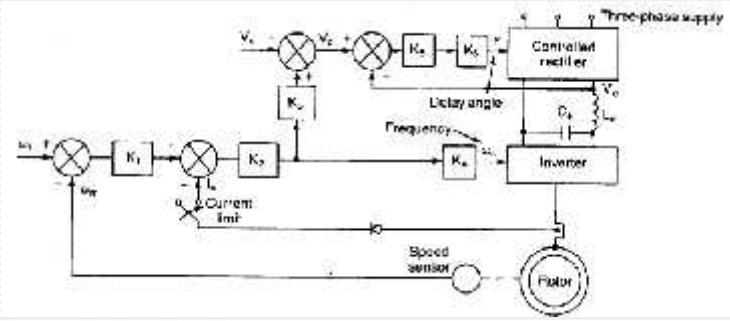
# stator voltage control

- The speed controller, K1, processes the speed error and generates the reference current Is(ref). K2 is the current controller. K3 generates the delay angle of thyristor converter.
- characterized by poor dynamic and static performance
- generally used in fans, pumps, and blower drives




# volt/hertz control

- additional controlled rectifier and dc voltage control loop
- same signal generates the inverter frequency and provides input to the dc link gain controller
- The dc voltage *Vd acts as* the reference for the voltage control of the controlled rectifier



Next Lecture – Braking and Reversing of AC Motors

# THANK YOU