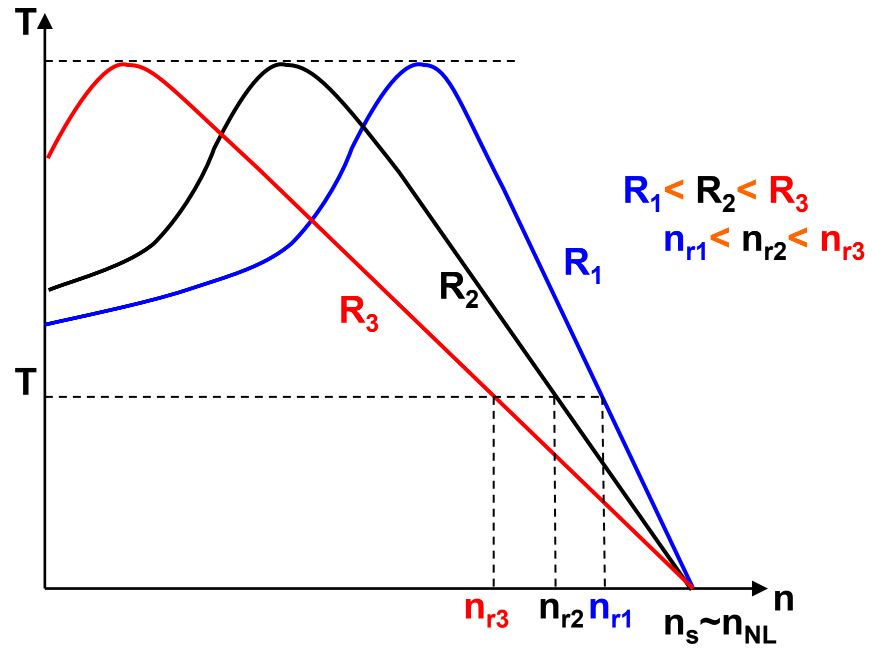
LECTURE 4

Speed Control

- There are 3 types of speed control of 3 phase induction machines
    i. **Varying rotor resistance**
    ii. **Varying supply voltage**
    iii. **Varying supply voltage and supply frequency**

Varying rotor resistance

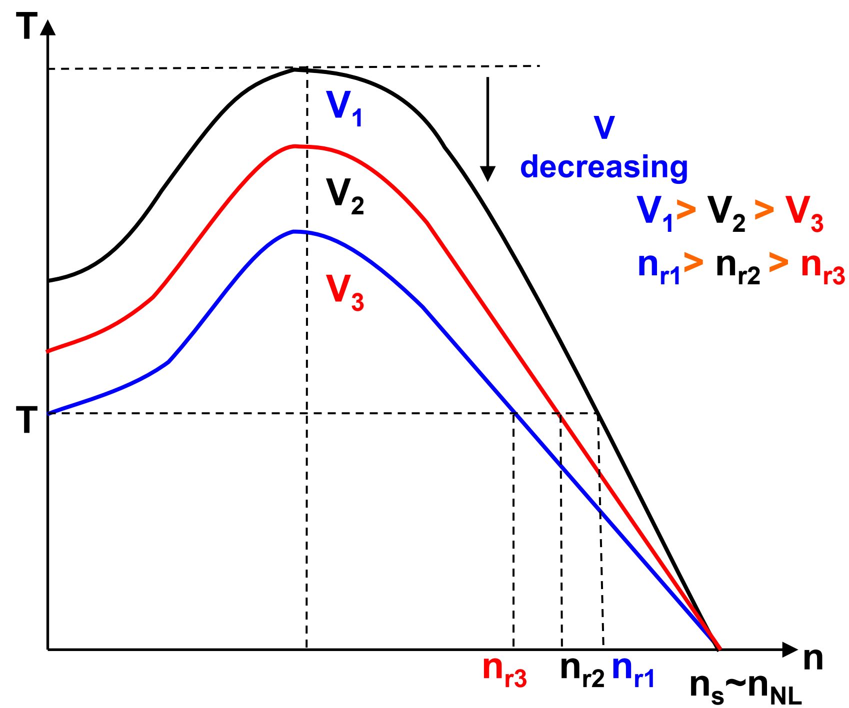
- For wound rotor only
- Speed is decreasing
- Constant maximum torque
- The speed at which max torque occurs changes
- Disadvantages:
  - large speed regulation
  - Power loss in R_{ext} – reduce the efficiency



Varying supply voltage

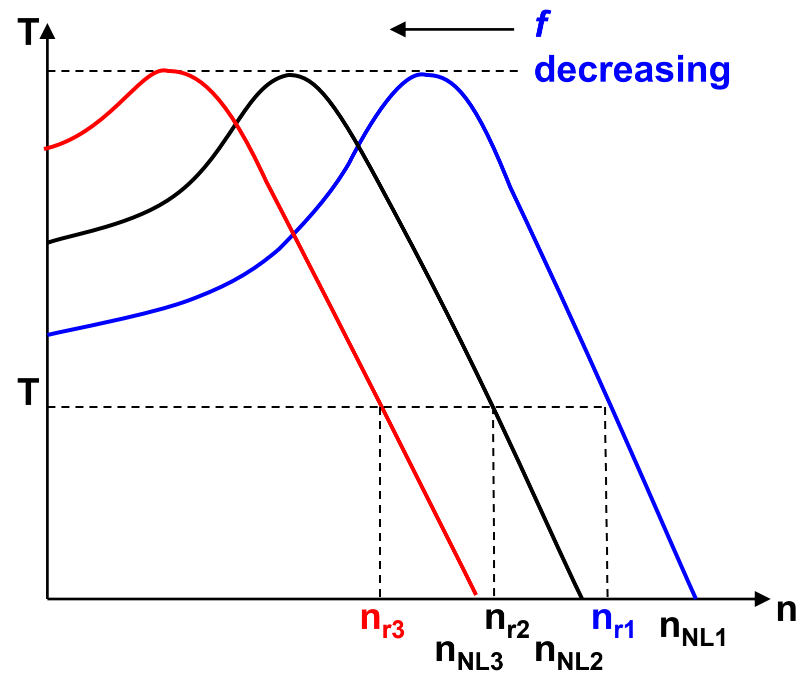
- Maximum torque changes

- The speed which at max torque occurs is constant (at max torque, $X_R = R_R/s$
- Relatively simple method – uses power electronics circuit for voltage controller
- Suitable for fan type load
- Disadvantages :
  - Large speed regulation since ~ n_s



Varying supply voltage and supply frequency

- The best method since supply voltage and supply frequency is varied to keep V/f constant
- Maintain speed regulation
- uses power electronics circuit for frequency and voltage controller
- Constant maximum torque



Torque-Equation

- **Note that, Mechanical torque can written in terms of circuit parameters. This is determined by using approximation method**

$$P_m = 3 I_R'^2 \frac{R_R'}{s}(1-s) \; and \; P_m = \omega_r T_m$$

$$\therefore T_m = \frac{P_m}{\omega_r} = \left[\frac{3 I_R'^2 \frac{R_R'}{s}(1-s)}{\omega_r} \right]$$

...

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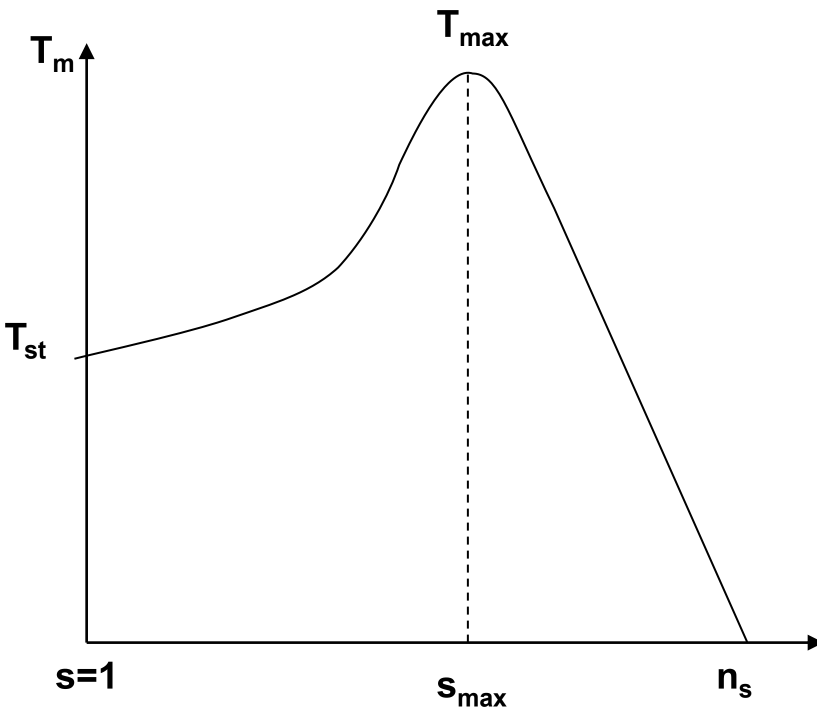
$$\therefore T_m = \left[\frac{3(V_{RM\phi})^2}{2\pi n_s} \right] \left[\frac{s R_R'}{(R_R')^2 + (s X_R')^2} \right]$$

Hence, Plot T_m vs s



s_{max} is the slip for T_{max} to occur

Power Flow Diagram

- **Ratio:**

P_{ag}	P_{rcu}	P_m
$3I_R'^2 \dfrac{R_R'}{s}$	$3I_R'^2 R_R'$	$3I_R'^2 R_R'\left(\dfrac{1-s}{s}\right)$
$\dfrac{1}{s}$	1	$\dfrac{1}{s}-1$
1	s	$1-s$

Ratio makes the analysis simpler to find the value of the particular power if we have another particular power. For example:

$$\frac{P_{rcu}}{P_m} = \frac{s}{1-s}$$

Torque-Equation

$Starting\ Torque, s = 1$

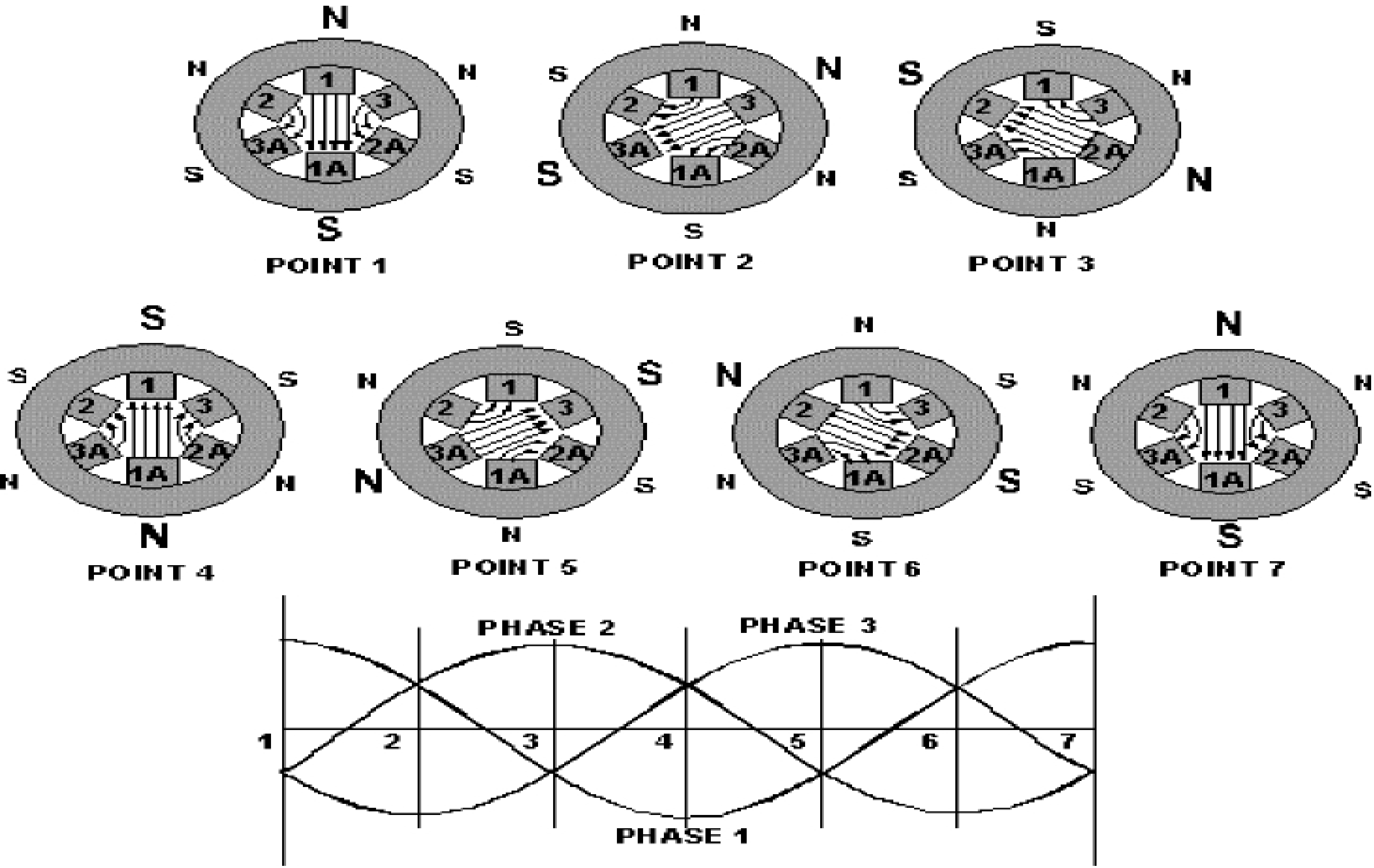
$$\therefore T_{st} = \left[\frac{3(V_{s\phi})^2}{2\pi\left(\frac{n_s}{60}\right)}\right]\left[\frac{R_R'}{(R_s + R_R')^2 + (X_s + X_R')^2}\right]$$

$$s_{\max} = \pm\left[\frac{R_R'}{\sqrt{(R_s)^2 + (X_R')^2}}\right]$$

$$T_{\max} = \left[\frac{3(V_{s\phi})^2}{2\left[2\pi\left(\frac{n_s}{60}\right)\right]}\right]\left[\frac{1}{R_s + \sqrt{(R_s)^2 + (X_s + X_R')^2}}\right]$$

COGGING AND CRAWLING

- When rotor bars are made to run parallel with stator , the torque rises & falls correspondingly causing more pulsations. This is termed as cogging in other words magnetic locking. This is reduced by making the rotor bars run at an angle to the stator i.e crawling in order to make the torque uniform. Crawling on the other hand signifies running of motor at almost one seventh of the rated spped due to interference of seventh harmonics.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