

# Speed Control of Three Phase Induction Motor by Stator Voltage Control

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**Abstract – This paper presents the method of speed control of three phase induction motor by varying the stator voltage. Three phase induction motors are very popular in industrial, appliances and heavy industry applications. Induction motors are constant speed motors, hence if we desire to use these motors for variable speed applications, the speed can be vary by using AC power controllers. As the torque is directly proportional to the square of the voltage, the torque can be varied with stator voltage, so, in turn, the speed. Also the energy saving is achieved as the input voltage is controlled.**

**Index Terms – AC power controller, Three phase Induction Motor.**

## 1. INTRODUCTION

Induction motors are low cost, reliable, robust, cheaper, lighter, and efficient motors (efficiency about 95%) . these motors can operate in dirty and explosive environments as compared to DC motor drives. Induction motor fulfills the requirements of constant speed drives, however complex for variable speed applications. Hence by using semiconductor devices, we can achieve this purpose also.

There are various methods of speed control of 3-phase IM from the stator side as follows.

1. Stator voltage control
2. Frequency control
3. v/f control
4. Rotor resistance control
5. Slip energy recovery control

## 2. METHOD OF OPERATION

We are discussing here the stator voltage control method.

## STATOR VOLTAGE CONTROL:

Stator voltage control of an induction motor is used generally for three purposes-(a) to control the speed of the motor (b) to control the starting and braking behavior of the motor (c) to maintain optimum efficiency in the motor when the motor load varies over a large range. Here we are discuss about speed control of motor.

At a given load, if the voltage applied to the motor decreases, keeping the frequency constant, air gap flux decreases. This results in a reduction in torque or power developed. The rotor speed decreases, increasing the value of slip at which the torque developed will balanced the load torque. Thus the variation of voltage results in a variation of slip frequency and speed control of the motor. For speed control in a reasonably wide range, the rotor should have a large resistance.

The torque equation is given by:

$$T_e = \frac{3}{\omega_s} \cdot \frac{(KV_1)^2}{\left(r_1 + \frac{r_2}{s}\right)^2 + (x_1 + x_2)^2} \cdot \frac{r_2}{s}$$

From the torque equation of the induction machine given above, we can see that the torque depends on the square of the applied voltage. A reduction in the supply voltage will reduced the motor torque and therefore the speed of the drive.

For the purpose of varying the voltage applied to a 3 phase IM so as to achieve a speed control, a 3-phase AC voltage controller is usually employed. The figure below shows a 3-phase voltage controller feeding a 3-phase IM. By controlling

the firing angle of the thyristors connected in anti-parallel in each phase, the rms value of stator voltage can be regulated. As a consequence, motor torque and thus speed of the drive is controlled.

The Torque-Speed Characteristics of the three phase Induction motors for varying supply voltage and also for the fan load are shown.

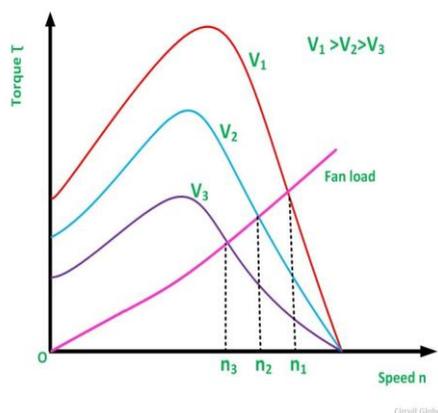


Fig. Torque speed Characteristics

This method gives a speed control only below the normal rated speed as the operation of the voltages if higher than the rated voltage is not admissible. This method is suitable where the intermittent operation of the drive is required and also for the fan and pump drives. As in fan and pump the load torque varies as the square of the speed. These types of drives required low torque at lower speeds. This condition can be obtained by applying lower voltage without exceeding the motor current.

In case of a three phase induction, motor three pairs of Thyristor are required which are connected back to back. Each pair consists of two Thyristor. The diagram below shows the Stator Voltage Control of the three phase induction motors by Thyristor Voltage Controller.

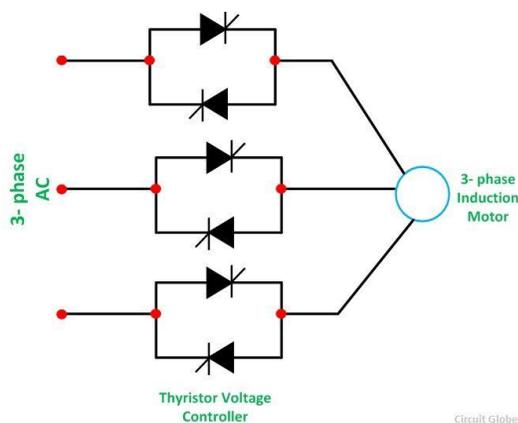


Fig. AC voltage controller

Speed control is obtained by varying the firing angle of the Triac. These controllers are known as Solid State fan regulators. As the solid state regulators are more compact and efficient as compared to the conventional variable regulator. Thus, they are preferred over the normal regulator.

Each pair of the Thyristor controls the voltage of the phase to which it is connected. Speed control is obtained by varying the conduction period of the Thyristor. For lower power ratings, the back to back Thyristor pairs connected in each phase is replaced by Triac.

### 3. CONCLUSION

A smooth speed variation can be achieved by stator voltage control method using triac. This method also called as phase angle control method as we are varying the voltage by controlling the firing angle of the thyristors connected in anti-parallel in each phase. Energy consumption can also be controlled by controlling ac power.

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