

INDUSTRIAL ELECTRONICS AND CONTROL OF DRIVES

Unit IV : Thyristor Control of Electric Drives

Topic: AC Drives: Phase Control, Variable Frequency and Constant V/f Control

Important Questions with Answers (5th Semester, Electrical Engg.)

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Short Answer Questions

Q.1 What is an AC drive? State the advantages of an AC drive over a DC drive.

Ans. An AC drive is an electric drive in which an AC motor (usually an induction motor) is controlled by a thyristor converter that changes the voltage and/or the frequency fed to the motor.

Advantages of an AC drive over a DC drive:

1. An AC (squirrel cage) motor is cheaper and lighter than a DC motor of the same rating.
2. It has no commutator and brushes, so the maintenance is very low and there is no sparking.
3. It is rugged and can work in dirty, dusty and explosive places.
4. It can be built for higher speeds and higher power ratings.
5. It has a higher efficiency and a longer life.

Q.2 Differentiate between AC drives and DC drives.

Ans. The differences between AC drives and DC drives are given below.

Point	AC drive	DC drive
Motor	AC (induction) motor	DC motor
Cost and size	Lower cost, smaller and lighter	Higher cost, larger
Maintenance	Very low (no commutator, no brushes)	High (brushes and commutator wear)
Working place	Dusty and explosive places also	Not suitable (sparking)
Speed and power limit	Higher	Lower (commutator limit)
Control circuit	More complex (voltage and frequency)	Simpler (only voltage)
Converter used	AC voltage controller, inverter, cyclo-converter	Controlled rectifier, chopper

Q.3 Explain the phase control of an AC drive.

Ans. Phase control is a stator voltage control. A pair of back-to-back SCRs (or a TRIAC) is connected in each line between the three-phase supply and the induction motor. This is an AC voltage controller.

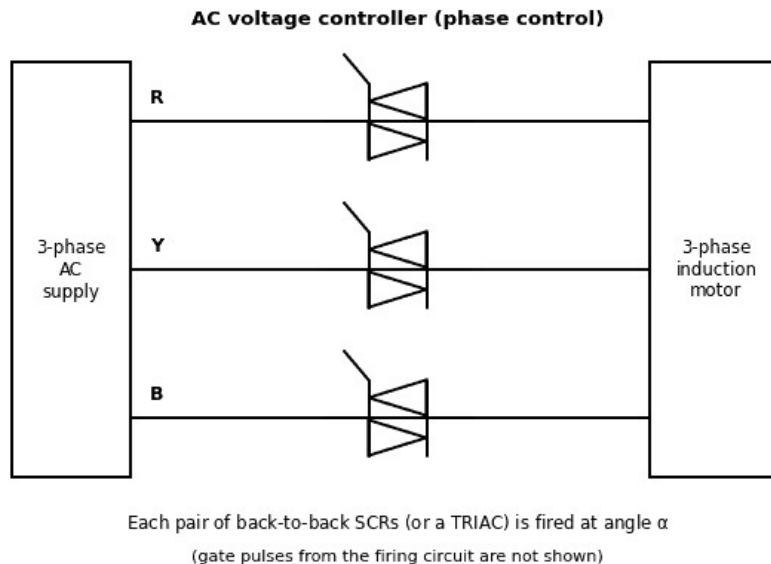


Fig. 1 AC voltage controller for an induction motor (circuit sketch)

Working:

1. The SCRs are fired at the firing angle α in each half cycle. Late firing cuts a part of the wave, so the RMS voltage fed to the motor is reduced.
2. The torque of an induction motor is proportional to the square of the stator voltage (textbook statement). So if the voltage is reduced, the torque falls.
3. For a given load torque, the motor now has to run at a larger slip, so the speed falls.
4. If α is decreased, the voltage and the speed increase.

Advantages, limitations and applications:

The circuit is simple and cheap, and it gives a soft start. But the speed range is small, the efficiency is low at low speed (large slip, high rotor losses), and the wave contains harmonics. It is used for fans, blowers, pumps and small motors.

Q.4 Explain the working of a variable frequency AC drive with a block diagram.

Ans. Since $N_s = 120 f / P$, the speed of an induction motor is nearly proportional to the supply frequency. A variable frequency drive uses a converter that gives a variable frequency, so the speed can be controlled over a wide range, smoothly and efficiently.

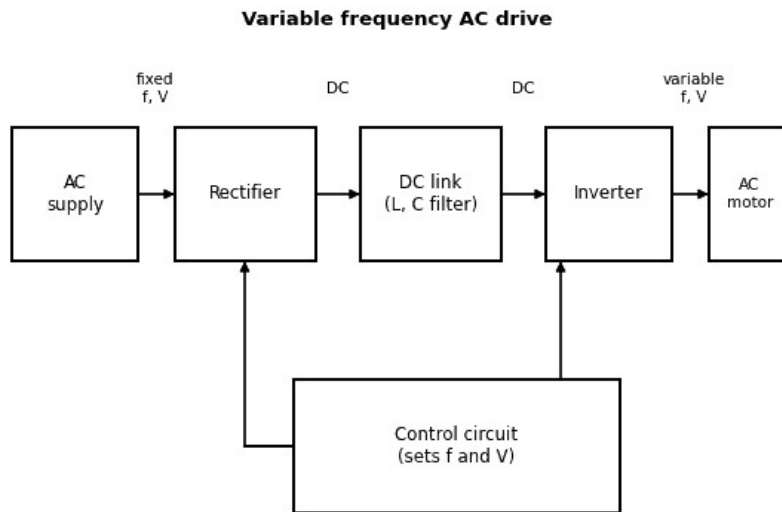


Fig. 2 Variable frequency AC drive (block diagram)

Working:

1. The **rectifier** converts the fixed-frequency AC supply into DC. It may be a controlled rectifier (which can also vary the DC voltage) or a diode rectifier.
2. The **DC link** has an inductor and a capacitor (L-C filter) that smooth the DC.
3. The **inverter** converts the DC into AC of variable frequency and voltage. A pulse width modulated (PWM) inverter is common.
4. The **control circuit** sets the frequency according to the speed command, and changes the voltage along with the frequency so that V / f stays constant.
5. To increase the speed, the frequency is increased. To slow down, the frequency is lowered.

Advantages: Wide and smooth speed control, soft starting, high efficiency and regenerative braking if the converter can return power. **Applications:** Pumps, fans, conveyors, machine tools, lifts and electric vehicles.

Q.5 Explain constant V/f control of an AC drive.

Ans. The flux of an induction motor is proportional to the ratio V / f (from the emf equation, a textbook relation). If the frequency is lowered and the voltage is kept the same, the flux increases and the core saturates. If the frequency is raised and the voltage is kept the same, the flux falls and the torque falls. So, when the frequency is changed, the voltage is changed in the same ratio. This is constant V/f control.

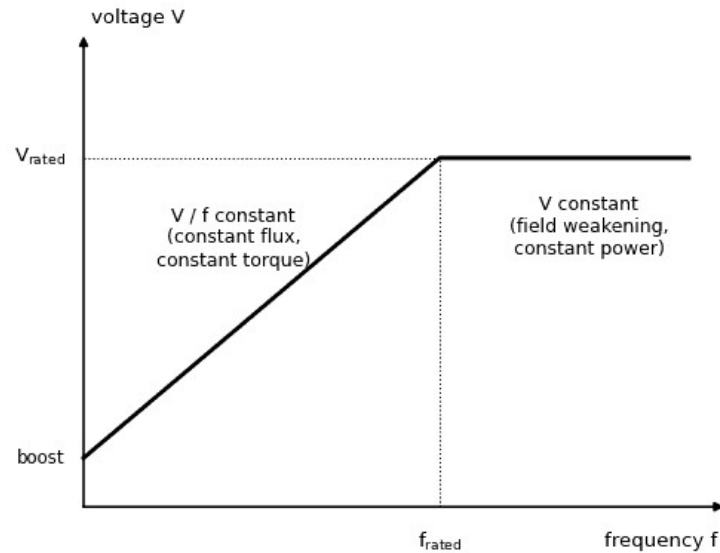


Fig. 3 Constant V/f control characteristic (sketch)

1. **Below the rated frequency:** V / f is kept constant. The flux stays constant and the motor can give its full (constant) torque.
2. **At very low frequency:** The voltage drop in the stator resistance is large compared with the supply voltage, so a small extra voltage (boost) is given.
3. **Above the rated frequency:** The voltage cannot be raised above its rated value, so V is kept constant and f is increased. V / f falls, the flux weakens (field weakening), and the motor works at constant power with a falling torque.

Long Answer Question

Q.6 What is the AC drive control? Explain variable frequency AC drives.

Ans. AC drive control means controlling the speed of an AC motor (usually an induction motor) by changing the voltage and/or frequency fed to it with a thyristor converter. The speed of an induction motor is $N = N_s(1 - s)$, with $N_s = 120 f / P$.

Note: In the exam, draw Fig. 1 (phase control), Fig. 2 (VFD block diagram) and Fig. 3 (V/f characteristic) given in Q.3 to Q.5.

Methods of AC drive control:

Method	What is changed	Remark
Stator voltage control (phase control)	Voltage, so the slip	Simple; small speed range; for fans and pumps
Variable frequency control	Frequency f (and voltage)	Wide, smooth speed range; the best method
Pole changing	Number of poles P	Only a few fixed speeds
Rotor resistance control	Slip (slip-ring motor)	Wasteful

Variable frequency AC drive:

1. The supply is rectified to DC. The DC link (L-C filter) smooths the DC.
2. An inverter changes the DC into AC of variable frequency and voltage.
3. The control circuit changes the frequency for the speed command and keeps V / f constant to keep the flux constant.
4. Speed increases with the frequency, and the speed range is wide.

Advantages: Wide and smooth speed control, soft start, high efficiency and regenerative braking. **Applications:** Pumps, fans, conveyors, machine tools, lifts and electric vehicles.

Points to Remember (for MCQ and True/False)

1. An AC drive controls an AC motor with a thyristor converter.
2. The synchronous speed is $N_s = 120 f / P$.
3. An AC drive has less maintenance than a DC drive, because it has no commutator and brushes.
4. In a variable frequency drive, the voltage is changed along with the frequency (constant V/f).
5. Phase control of an AC drive is done with back-to-back SCRs or a TRIAC in each line.