

INDUSTRIAL ELECTRONICS AND CONTROL OF DRIVES

Unit IV : Thyristor Control of Electric Drives

Topic: Cyclo-Converter Controlled AC Drives and Electric Braking

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

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Short Answer Questions

Q.1 Explain the concept of a cyclo-converter controlled AC drive.

Ans. A three-phase to three-phase cyclo-converter converts the fixed-frequency AC supply directly into a variable, lower-frequency AC supply, without any DC link. This supply is given to an AC motor (induction or synchronous motor). Since the speed of the motor is proportional to the frequency, the motor speed is controlled by changing the output frequency of the cyclo-converter.

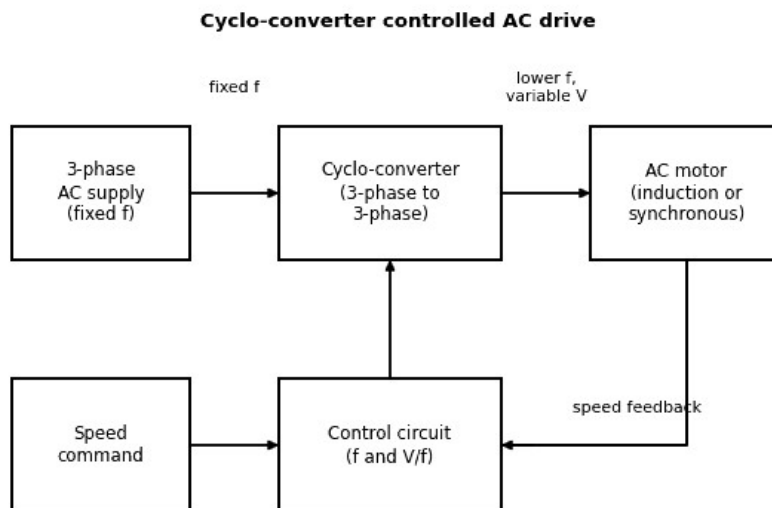


Fig. 1 Cyclo-converter controlled AC drive (block diagram)

Working:

1. The control circuit takes the speed command and the speed feedback from the motor.
2. It sets the output frequency of the cyclo-converter. It also sets the output voltage in proportion to the frequency, so that V / f is constant (constant flux).
3. The cyclo-converter makes the output wave from pieces of the three-phase supply, by firing its positive and negative groups of SCRs in the right order. The SCRs are turned OFF naturally by the supply.
4. The motor runs at a speed that depends on the output frequency. The output frequency is limited to about one-third to one-half of the supply frequency (textbook statement).

5. Power can flow in both directions, so the motor can return energy to the supply during braking.

Applications:

1. Large low-speed drives for cement mills, rolling mills, mine hoists and ship propulsion
2. Gearless drives, where the motor is connected directly to the load

Q.2 State the advantages and limitations of a cyclo-converter controlled AC drive.

Ans. The advantages and limitations of a cyclo-converter controlled AC drive are given below.

Advantages	Limitations
Single-stage conversion with no DC link, so the efficiency is high	The output frequency is limited to a fraction of the supply frequency, so the speed range is limited
Natural commutation, so no commutation circuit is needed	A large number of SCRs and a complex firing circuit are needed, so the cost is high
Power can flow both ways (regenerative braking)	The supply power factor is poor, and the supply gets harmonics
Smooth torque at very low speeds	Not suitable for high-speed motors

Q.3 Explain the basic concept of electric braking for an AC drive.

Ans. Braking means slowing down a rotating machine or bringing it to rest quickly, or holding a load at a constant speed against a force that tries to speed it up (for example, a lowering lift). In electric braking, the braking torque is produced by the motor itself.

Basic idea:

In motoring, the motor takes electrical energy and gives mechanical energy. In braking, the motor works as a generator: it takes the mechanical (kinetic) energy of the load and either returns it to the supply or wastes it as heat in a resistor or in the motor.

Why electric braking is used:

1. It is smooth and quick.
2. There is no wear of brake shoes.
3. In regenerative braking, the energy is returned to the supply.

Q.4 Explain regenerative, plugging and dynamic (DC injection) braking of an AC drive.

Ans. The three main types of electric braking of an AC drive are given below.

(a) Regenerative braking:

If the motor is driven above its synchronous speed (for example, by an overhauling load) or if the supply frequency is reduced quickly in a variable frequency drive, the induction motor works as an induction generator. The power is returned to the supply through a converter that can pass power in both directions. If the converter cannot return power, the energy is wasted in a braking resistor. It saves energy and gives smooth braking, but it works only above a certain speed.

(b) Plugging (reverse current braking):

Two of the three stator supply leads are interchanged. The rotating field reverses, and the torque opposes the rotation of the rotor. The motor stops very quickly. But the current is very large, so resistances are connected in series, and the supply must be cut off at zero speed. Otherwise, the motor would start in the reverse direction. Much energy is lost as heat.

(c) Dynamic braking (DC injection braking):

The AC supply is disconnected from the stator, and a DC supply is connected to two of the stator terminals. This produces a stationary magnetic field. The rotor conductors cut this field, so the motor works as a generator and gives a braking torque. The energy is wasted as heat in the rotor circuit. The braking is smooth and can bring the motor to rest, but the braking torque is small at low speed.

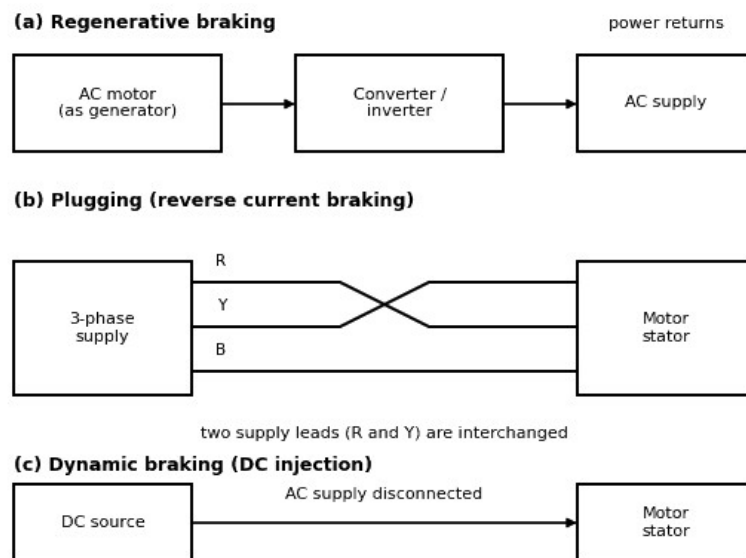


Fig. 2 Methods of electric braking of an AC motor (sketch)

Point	Regenerative braking	Plugging	Dynamic (DC injection) braking
Method	Motor works as a generator and returns power to the supply	Two supply leads are interchanged	DC is fed to the stator, with the AC disconnected

Energy	Returned to the supply	Wasted as heat	Wasted as heat
Stopping	Slow down only (above a certain speed)	Very quick; the supply must be cut at zero speed	Smooth stop to zero speed

Long Answer Question

Q.5 Explain a cyclo-converter controlled AC drive and the types of electric braking used for AC drives.

Ans. A cyclo-converter controlled AC drive feeds an AC motor directly with low-frequency AC from a three-phase to three-phase cyclo-converter, without a DC link. Electric braking makes the motor work as a generator during braking.

Note: In the exam, draw Fig. 1 (drive) and Fig. 2 (braking) given in Q.1 and Q.4.

(A) Cyclo-converter controlled AC drive:

1. The three-phase supply feeds a cyclo-converter, which gives AC of a lower, variable frequency and a voltage proportional to it (constant V/f).
2. The AC motor (induction or synchronous) runs at a speed that depends on the output frequency. The output frequency is limited to about one-third to one-half of the supply frequency.
3. The control circuit uses the speed command and the speed feedback to set the frequency.
4. It is used for large, low-speed drives (cement mills, rolling mills, mine hoists, ship propulsion). The efficiency is high and power can flow both ways, but the number of SCRs is large and the supply power factor is poor.

(B) Electric braking of an AC drive:

Point	Regenerative braking	Plugging	Dynamic (DC injection) braking
Method	Motor works as a generator and returns power to the supply	Two supply leads are interchanged	DC is fed to the stator, with the AC disconnected
Energy	Returned to the supply	Wasted as heat	Wasted as heat
Use	Variable frequency and cyclo-converter drives, trains	Machine tools, quick stopping	Fans, centrifuges, hoists

Points to Remember (for MCQ and True/False)

1. A cyclo-converter converts AC to AC of a lower frequency without a DC link.

2. In a cyclo-converter drive, the motor speed is controlled by the output frequency.
3. In regenerative braking, the motor works as a generator and returns energy to the supply.
4. In plugging, two supply leads of the motor are interchanged.
5. In dynamic (DC injection) braking, a DC supply is connected to the stator.
6. Cyclo-converter drives are used for large low-speed machines such as cement mills and rolling mills.