Induction Motor Protection

The abnormal conditions of induction motor

Prolonged overloading:

It is caused by mechanical loading, short time cyclic overloading. Overloading results in temperature rise or winding and deterioration of insulation resulting in winding fault. Hence motor should ob provided with overload protection.

Single phasing:

One of the supply lines gets disconnected due to blowing of a fuse or open circuit in one of the three supply connections. In such cases the motor continues to run on a single phase supply. If the motor is loaded to its rated full load, it will draw excessive current on sigle phasing. The winding get overheated and damage is caused. The single phasing causes unbalanced load resulting in excessive heating of rotor due to negative sequence component of unbalanced current. Static single phasing relays are becoming very popular.

Stalling:

If the motor does not start due to excessive load, it draws heavy current. It should be immediately disconnected from supply.

Stator earth fault:

Fault in motor winding are due to enough insulation between phases. Earth faults are relatively more likely.

Inter-turn fault:

These grow into earth faults. No separate protection is generally provided against inter-turn faults.

Rotor faults:

These are likely to occur in wound rotor motors, due to insulation failure.

Failure of bearing:

This cause locking up of rotor. The motor should be disconnected, bearing should be replaced.

Unbalance supply voltage:

This cause heating up rotor due to negative sequence currents in stator winding.

Supply under voltage:

The under voltage supply cause increase in motor current for the same load.

Fault in starter of associated circuit:

The choice of protection for a motor is depends upon the size of the motor, its importance in the plant, nature of load.

The motor protection circuit that is designed should be simple in operation and economically feasible. Its cost should be less than 5% of the motor cost. It should also be kept in mind that during starting and permissible overload conditions, the protection circuit should not operate. The choice of motor protecting circuit is based on various factors such as rated voltage, rated kW, size of motor, type of induction motor, type of starter, type of switchgear used, cost of motor, type of load, starting current possibility of occurrence of abnormal conditions etc.

6.3 Protection Circuit for Induction Motor

The protection circuit along with its single line diagram is shown in the Fig. 6.1.

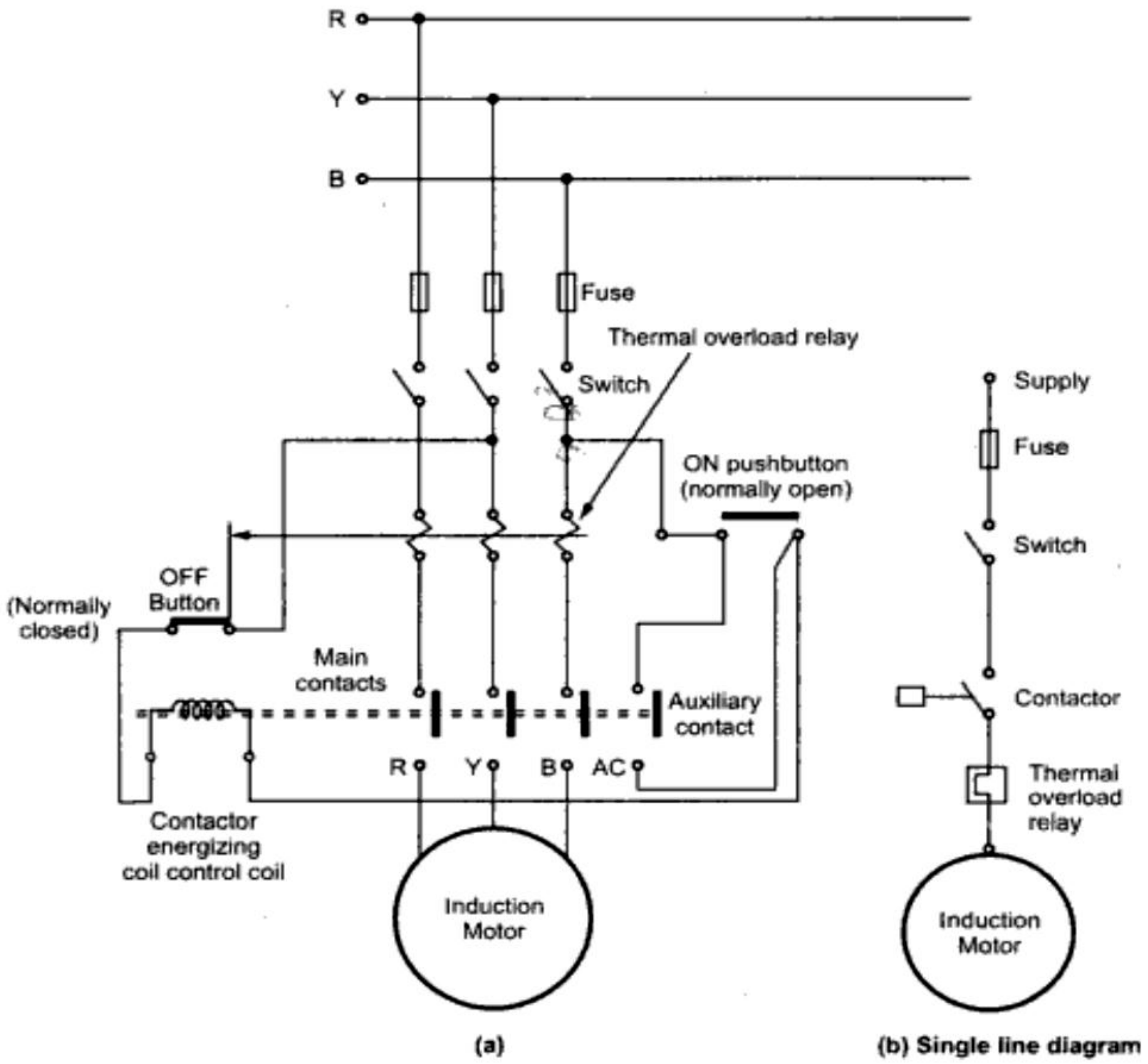

Fig. 6.1

The three phase supply is given to the motor through various elements such as fuse, switch, contactor and thermal overload relay. The control circuit of contactor consists of energizing coil, start and stop buttons. The start (ON) push button is normally open green switch while the stop (OFF) push button is normally closed red switch.

When the start button is pressed then the contactor coil is energized as it gets supply voltage. The coil attracts the plunger when excited and the main contacts are closed along with the auxiliary contact. Even if the ON push button is released, the contactor coil remains energized as it gets supply through auxiliary contacts. Thus motor starts running.

The OFF push button which is normally closed when pressed cuts the supply of the contactor coil and hence the main as well as auxiliary contacts are open so motor eventually stops. If supply voltage fails, control coil is de-energized which opens the contactor and motor stops.

During overload condition, the thermal overload relay operates. Thermal overload relay consists of bimetallic strips. Because of bending of one or more bimetallic strip results in operation of common lever which operates the trip contacts to de-energize the coil and disconnects the supply to the motor.

The bimetallic strips are either heated directly by flow of current or with the help of special heater coil through which motor current flows. For large motors, these relays are connected in secondary of current transformers. The bimetallic strips can be of self setting type or hand resetting type in which mechanical reset is required as the trip mechanism locks itself in operated condition. It should be observed that the rating of thermal relay should be such that it should not operate during normal starting conditions. A setting range is provided for adjustment for various load conditions. Protection against short circuit is provided with the help of HRC fuses.

6.4 Single Phasing Preventer

If one of the supply line is disconnected due to open circuit or improper contact in switch then still the motor continues to run. The power is then supplied to the remaining windings. The current in the other phases increases to about $\sqrt{3}$ times its normal value. This is called single phasing which results in unbalanced stator currents. The component which is present in this unbalanced current called negative sequence component causes magnetic flux rotating in opposite direction to the main flux. This results in double frequency currents to induce in the rotor to cause its heating. Thus major damage to motor may take place due to single phasing if proper precaution is not taken. As the phase overcurrent relays react slowly, they cannot give the instantaneous protection against single phasing.

For small motors separate protection against single phasing is normally not provided as thermal relays sense the increased current in remaining phases due to single phasing and provides the sufficient protection.

A separate single phasing protection circuit is required in case of large induction motors as even a small unbalance can cause damage to motor winding and rotor. The single phasing preventer is shown in the Fig. 6.2.

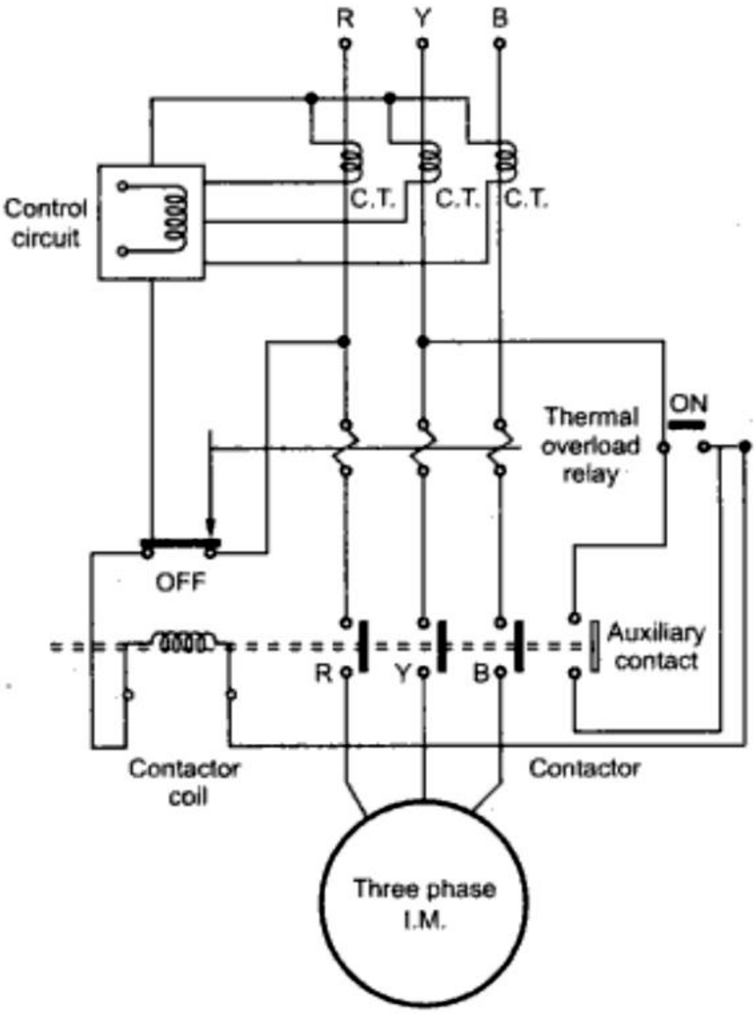

Fig. 6.2

As shown in the figure, it consists of C.Ts connected in each phase. The output of control circuit is fed to the level detector which sense the magnitude of unbalance. Depending on this output from the control circuit the tripping command to the starter or the circuit breaker is given when negative sequence current exceeds its preset limit.

6.5 Ground Fault Protection

The ground fault protection is achieved using earth leakage circuit breaker (ELCB). When the fault current or leakage current flows through earth return path then it forms the earth fault. These faults are relatively frequent and hence protection is required against these which is provided with the help of Earth leakage circuit breaker.

Consider an example of a person whose finger sticks into the socket. Even though the metal enclosure is securely earthened, the person will receive a severe shock. Under such case there must be certain device that will cut the supply. This can be done with the help of ELCB which will typically trip in around 25 ms if current exceeds its preset value.

The schematic of ELCB is shown in Fig. 6.3.

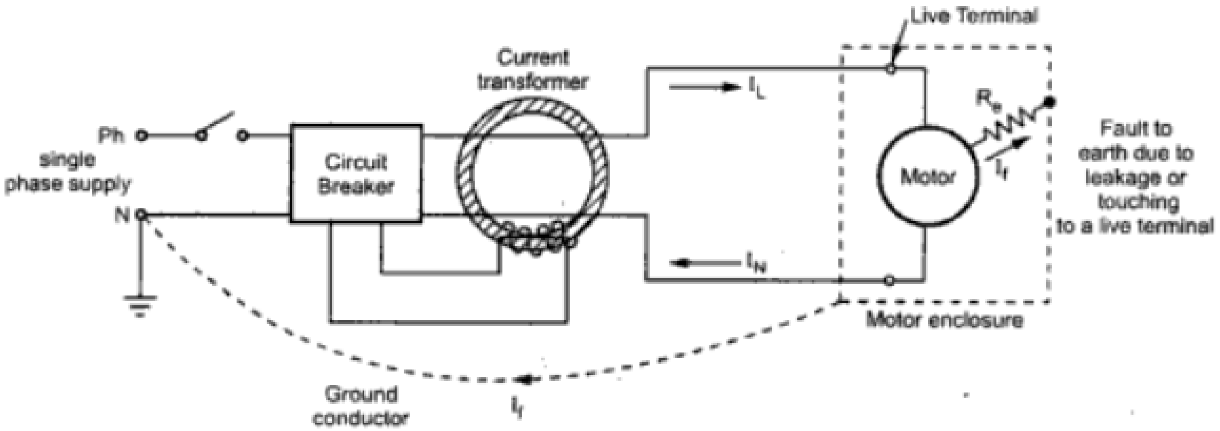

Fig. 6.3

As shown in the Fig. 6.3 ELCB consists of a small current transformer surrounding live and neutral wire. The secondary winding of current transformer is connected to relay circuit which can trip the circuit breaker which is connected in the circuit.

Under normal conditions, the current in line and neutral conductor is same so the net current $(I_L - I_N)$ flowing through the core is zero. Eventually there will not be any production of flux in the core and no induced emf. So the breaker does not trip.

If there is a fault due to leakage from live wire to earth or a person by mistake touching to the live terminal then the net current through the core will no longer remain as zero but equal to $I_L - I_N$ or I_f which will set up flux and emf in C.T. As per the preset value the unbalance in current is detected by C.T. and relay coil is energized which will give tripping singal for the circuit breaker. As C.T. operates with low value of current, the core must be very permeable at low flux densities.

In case of three phase circuits, single ring shaped core of magnetic material, encircles the conductor of all three phases as shown in the Fig. 6.4. A secondary is connected to relay circuit. Under normal condition, the component of fluxes due to fields of three conductors are balanced and secondary carries negligible current.

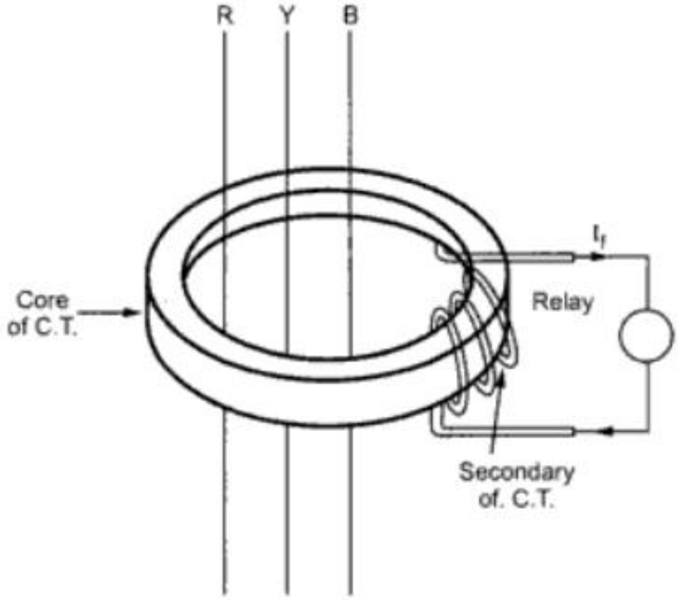

Fig. 6.4

During faulty condition, the balance is disturbed and current is induced in the secondary to trip the circuit breaker through relay.

This method to provide **earth fault protection** is called core balance type protection or **zero sequence current transformer** (ZSCT) protection. In case of earth faults, to avoid burning of coils and stampings the motor must be disconnected as quickly as possible from the supply.

The Fig. 6.5 shows ZSCT protection scheme. It is preferred for the systems with neutral earthed via resistance. (See on next page)

6.6 Phase Fault Protection

This protection is also called short circuit protection. At the time of such a fault, the current increases by 8 to 10 times the full load current of the motor. Attracted armature type relay unit is connected in each phase with a current setting of 4-5 times the full load current. This is because starting current can be 4-5 times full load current.

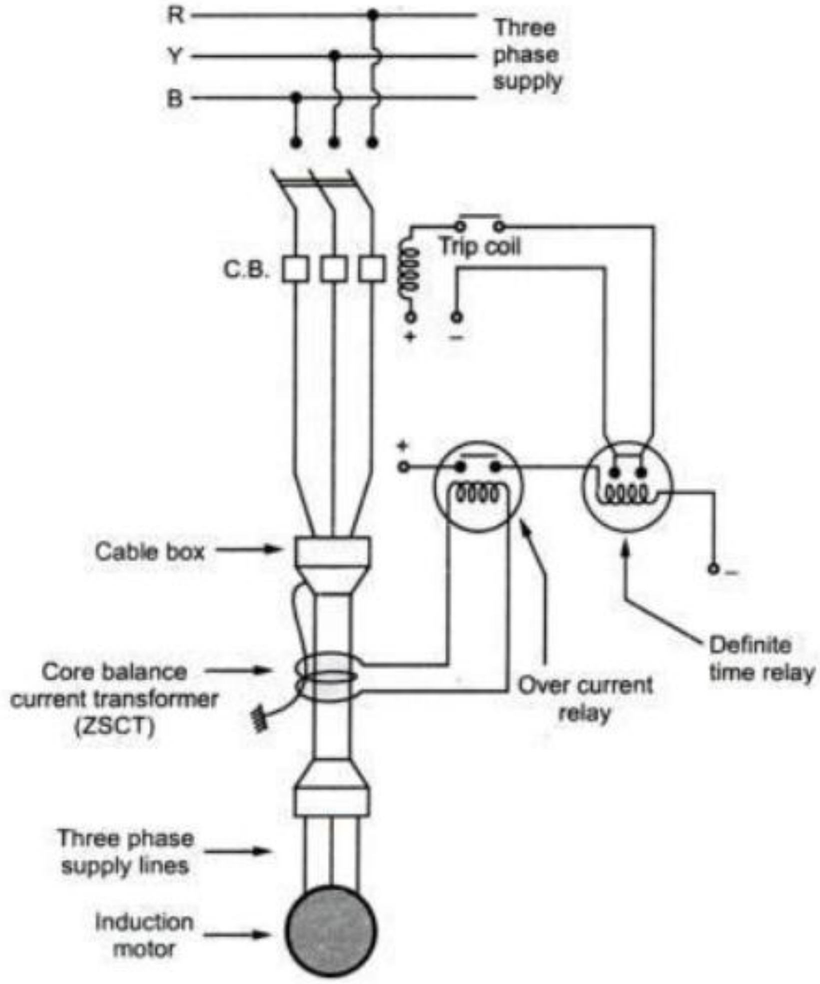

Fig. 6.5 Earth fault protection by ZSCT

Hence to operate the relay only under fault condition such a setting is necessary. Such a protection is shown in the Fig. 6.6.

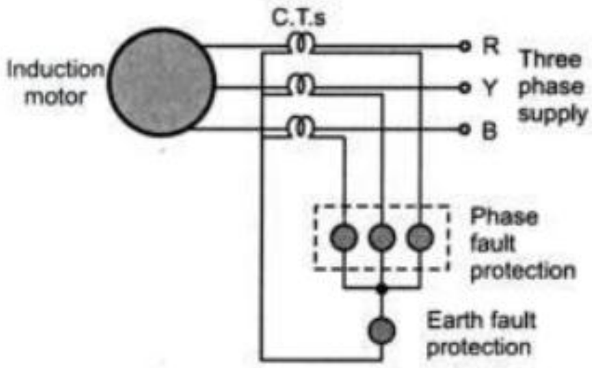

Fig. 6.6 Phase and earth fault protection

The phase faults can cause burn out of coils and stampings and hence motor should be disconnected as quickly as possible when fault occurs. Fast over current relays also are used to provide phase fault protection.

As mentioned above to avoid relay functioning during starting, the short circuit protection current setting must be just above the maximum starting current of the motor.