Squirrel cage induction motors are the prime movers of Indian industry. With increasing automation all around, our dependence on a reliable protection system is increasing. In the event of a fault, it is expected that the protective circuit acts rapidly and clears the fault such that the healthy control devices are unaffected and can be put back into operation with minimum downtime.

To achieve this, detailed study of the total system is essential. The system designer must ensure proper coordination among various equipment and cables. The protective device should operate quickly so that the energy let through the circuit during the fault is restricted to a level lower than the withstand capability of other devices and cables.

In Indian industry, fuses are predominantly used as short circuit Protective device. They have a proven track record and they provide reliable coordination with downstream equipment.

However, some of the customers have started using Moulded Case Circuit Breakers (MCCBs) as a short circuit protective device. MCCBs have mechanical limitation of minimum operating time. Hence, let-through energy of MCCBs is much more as compared to that of fuses. This necessitates detailed engineering during system design. Since all switchgear manufacturers do not have complete range of fuses, contactors, overload relays and MCCBs, coordination and selection of components becomes complex. Only a manufacturer having consistent quality and total range of products will be in a position to offer a reliable coordinated system.

In this issue of L&T Current Trends, we bring you the considerations involved in selecting a suitable short circuit protective device for a motor circuit.

Forthcoming Product

High Performance MCCB

Larsen & Toubro Limited is shortly adding a high performance moulded case circuit breaker (MCCB) to its existing product range. Designated as Type DH 100, it offers 25kA breaking capacity, low let-through energy and allows termination of both copper and aluminium cables of size up to 50 sq. mm.

It is suitable for operation at 415 V. This MCCB comes with 3 poles and different current carrying capacities of 16, 20, 25, 32, 40, 50, 63, 80 and 100 amps. Accessories available are: shunt release, undervoltage release, auxiliary contact block (1 NO + 1 NC), trip alarm contact, door interlock and interlock defeat facility. To make it convenient to use, a rotary operating handle is provided. A red trip push button helps check the operation of MCCB.

Type DH 100 is designed for the utilisation Category A, and has a magnetic threshold capacity of 9 times the rated current. During short circuits, it disconnects the supply within 10 milliseconds. This MCCB conforms to IEC 947-2 and IS 13947 Part 2.
Industrial processes are becoming progressively sophisticated and the cost of downtime is increasing. With a large number of induction motors in use, the protection system for them has become an important aspect in order to have minimum downtime of the plants. So designing a cost effective motor supply circuit and ensuring its safety under all operating conditions is of paramount importance.

Motor circuit designers have a lot to think about in selecting control components and in providing adequate protection. The need for more precise protection is heightened by another factor. There is a trend towards installing motor starters in Motor Control Centres (MCCs). This has led users to size motor feeder cables economically. When a short-circuit occurs, the Short Circuit Protective Device (SCPD) takes a finite time to interrupt the fault. During this time, the current rises rapidly and certain energy is let through is higher than the withstand capacity of the downstream equipment, it can cause damage to the equipment. So achieving proper co-ordination means matching the characteristics of SCPD and the downstream equipment including cables to ensure that the let-through energy and peak cut-off current do not rise above the levels that the circuit can withstand.

Types of Co-ordination

IEC 947-4-1: 1990 and IS 13947 (Part 4/Section 1) : 1993 standards on starters and contactors define two types of co-ordination: Type 1 and Type 2.

Type 1 co-ordination requires that, under short-circuit conditions, the contactor or the starter shall cause no danger to persons or installations and may not be suitable for further service without repair and replacement of parts.

Type 2 co-ordination requires that under short-circuit conditions, the contactor or starter shall cause no danger to persons or installations and shall be suitable for further use. The risk of contact welding is recognized.

These standards replace the three types of co-ordination defined by the earlier standards on starters - IEC 292-1: 1969 and IS 8544 (Part 1): 1977.

Type 1 co-ordination is easy to achieve but in the event of a short-circuit, the user has to check all the starter components and replace them if found necessary. This works out to be very expensive. Type 2 co-ordination has a major advantage. After the fault is cleared, the user needs just to reset the breaker or replace the blown fuse and check for contact welding. Type 1 co-ordination is cheaper during installation but Type 2 will prove to be economical in the long run.

Fuses as SCPDs

Fuses are traditionally used as SCPDs because of the low initial capital cost and their capability to interrupt faults faster. Fuses have excellent current limiting characteristics and can be applied safety on systems having high fault levels. They have been the undisputed champions in the area of circuit protection for a long time. Using fuses for short-circuit protection is found to be the easiest and most effective way of achieving Type 2 co-ordination.
The principle strength of a fuse is its ability to reduce energy let-through at high fault levels. At high currents, the fuse element gets hot and melts (pre-arcing period). This is followed by arcing which persists until the resistance across the fuse builds up to a sufficiently high value to reduce the current to zero (arcing period). Both actions take place very quickly - about 2 msec for pre-arcing period and 4 msec for arcing period - making the total operating time of about 6 msec in the event of short circuit. The combination and high speed operation and high arc resistance limits the peak fault current and reduces the let-through energy.

**MCCBs as SCPDs**

- **Conventional MCCBs:**

MCCBs as SCPDs have been compared, not always favourably, with the fuses ever since they were introduced. The first generation of MCCBs had low short-circuit breaking capacity and high operating time. The breaking capacity offered by the earlier MCCBs was limited to 30-35 kA with an operating time of 15-20 msec. The traditional MCCB was a zero-point device, that is to say, in the event of a short circuit, it was unable to clear the fault till it completed the first half-cycle. During this half-cycle, the entire circuit would undergo tremendous stress, at times resulting in damage to the downstream equipment.

Still, MCCBs were considered as SCPDs since they offered features like remote tripping, remote signalling, reusability after the interruption of fault, protection against single phasing and undervoltage.

- **Current Limiting MCCBs**

Introduction of current limiting MCCBs has resulted in a big breakthrough in the reduction of let-through energy in a system and getting very high breaking capacity (even of the order of 200 kA). Current limiting MCCBs can reduce both the peak fault current and energy that reach downstream equipment to a tolerable level. Thus, motors and cables connected to the system will not be exposed to high Let-through energy. With this, the current limiting MCCB helps in using lower size devices and cables, resulting in cost efficient control system.

The standards on circuit breakers - IEC 947-2: 1989 and IS 13947 (Part 2): 1993 define current limiting breaker as the one with a break time short enough to prevent the short-circuit current reaching its prospective peak value. As per UL standard, a current limiting breaker when operating within its current limiting range, limits the let-through energy to a value less than the energy of 1/2-cycle wave of the symmetrical prospective current.

Final requirement for current limiting operation is that the trip mechanism must operate quickly enough to co-ordinate with the rapidly moving contacts. The mechanism must trip the breaker before the spring loaded contacts can re-close on the fault.

Figure 2 shows how a typical current limiting MCCB restricts the let-through energy and peak current compared to conventional MCCB. On a prospective short-circuit current of 70 kA, the installation protected by the current limiting MCCB would get less than 15% of the prospective current.

To meet these stipulated requirements, the current limiting MCCB must respond quickly in case of a fault. To achieve high speed contact separation, closely spaced contact fingers carrying current in opposite directions create a strong magnetic repulsion between the conductors (see Figure 1). High speed contact separation is actually produced by electromagnetic repulsion forces generated by the fault current itself. The higher the current, the greater is the force pushing the contacts apart. Although rapid contact opening is important, just opening the contact quickly is not enough. The next concern is to control the arc voltage across the contacts to ensure proper arc extinction. This is accomplished by forcing the arc into the arc chute and stretching the arc. The elongated arc is cooled and broken into segments in the arc chute until it is de-ionized and ceases to conduct current, thus being extinguished.
peak current and thermal energy compared to that experienced by the installation protected by a conventional MCCB.

**MCCB Selection Criteria**

In selecting MCCBs for motor protection, the following points are to be taken care of (Figure 3):

1. The thermal rating of MCCB should be greater than or equal to the motor full load current.
2. The breaking capacity of the MCCB should be greater than or equal to the prospective fault current at its installation point.
3. The magnetic threshold of the MCCB should be selected in such a way so as to avoid nuisance tripping during starting of the motor.
4. The best protection can be provided by selecting a current limiting MCCB with only magnetic protection and a suitable thermal overload relay with matching motor characteristics.
5. The thermal characteristics of MCCB (if provided) should be such that it falls above the overload relay characteristics up to the magnetic threshold of the MCCB.
6. The contactor should be able to break any currents up to the magnetic threshold of the breaker.
7. The starter should be able to withstand the let-through energy of the breaker.

**Comparison of Fuses with MCCBs**

One constraint against the acceptance of MCCB is the initial cost when compared to the cost of the switch-fuse unit (SFU). But for more complete comparison of costs, one must also consider the other aspects like ease of maintenance, downtime, simplicity of operation, recurring costs, etc. To sum up, current limiting MCCBs do have a number of practical advantages over fuses if one considers these to be worth the extra cost. These advantages will have to be weighed against the advantages offered by fuses like low initial cost, very high breaking capacity, very low peak cut-off current and let-through energy, etc.

A fuse is better than a current limiting MCCB in providing protection against the effects of short circuits at very high fault levels. But in most of the cases, the short-circuit currents are limited by the contactor, relay and cable impedance, generally up to 30 times the rated current of the motor. In such events, the MCCB acts faster than any other type of protective device available.

While comparing fuses with MCCBs, it is essential to compare the systems. MCCB results in a higher let-through than a fuse, so it is usually necessary to use a bigger size of contactor and/or a CT operated relay. This occupies larger panel space resulting in increased costs.

**Selection of Equipment**

The only way to ensure Type 2 co-ordination, is to carry out exhaustive tests of particular fuse + relay and MCCB + relay combinations with the contactor. While individual protection devices may perform to a given set of characteristics, their behaviour in combination affects the way the circuit reacts to a fault.

Selection of equipment becomes very important here. To complicate the matter further, in most of the cases, not all devices are available from a single manufacturer. For example, if the fuse/MCCB manufacturer does not make relays or contactors, he has to depend on other makes to offer complete protection system. It is likely that the relay or the contactor undergoes some design changes which can affect the selection combination with the fuse/MCCB.

Thus it is very important that all protective equipment are available from a single source to offer proper co-ordination. Alternatively, such tests are required to be carried out periodically.

**Conclusion**

The argument which centres around short-circuit protection is the choice between fuses and current limiting MCCBs. The reasons being put forward are both technical and commercial. Since each has its own merits, there is no clear-cut answer. So, the choice depends on the application and the user requirement. However, everyone will agree that:

1. It is possible to achieve Type 2 co-ordination with the help of either fuses or MCCBs.
2. MCCBs result in a higher let-through than a fuse so it may be necessary to use a larger contactor and/or a CT operated relay.
3. MCCBs have the advantage that they can be reset, whereas blown fuses have to be replaced, which means keeping stock of fuses. In certain applications, where the cost of downtime is very high, this point is very important.
4. Though the popularity of MCCBs is on the rise, the Indian market is dominated by fuses.
5. Use of fuses result - in cost savings directly and indirectly - savings through lower initial costs, usage of lower sized contactors and directly operated relays, and less panel space.
6. To ensure reliable co-ordination, it is important that all protective equipment are available from a single manufacturer.

---

**L&T’s Excellent Half-year Results**

Larsen & Toubro Limited has produced excellent results for the half year ended September 30, 1994. Sales and service revenues were Rs. 1,450 crores as against Rs. 1,242 crores in the corresponding period last year - an increase of 17%. Profit before Tax has gone up to Rs. 144.6 crores from Rs. 112.4 crores - showing an increase of 29% due to improvement in the operating margins. The provision for tax is higher at Rs. 32 crores as against Rs. 27 crores in the corresponding period last year. Profit After Tax has gone up substantially from Rs. 85.4 crores to Rs. 112.6 crores - an increase of 32%. Based on the share capital as at September 30, 1994, the annualised EPS works out to Rs. 10.62 as against Rs. 8.09 as at September 30, 1993.