



# APPLICATION INFORMATION FOR HIGH SPEED FUSES

## Fuses In Series

It is important that each fuse should be capable of clearing, on its own, the full voltage that can arise under fault conditions.

In many cases two fuses in series clear the fault e.g. two individual arm fuselinks in a 3 phase bridge with single semiconductors. For the coordination of I<sup>2</sup>t the let-through by the fuse can be determined at a voltage of:

$$\frac{V_f \times 1.3}{2} = 0.65 V_f$$

The 1.3 is an empirical voltage sharing factor and V<sub>f</sub> is the voltage to be cleared in the fault circuit.

## Fuses In Parallel

The use of fuses in parallel can be advantageous.

- To obtain higher current ratings than existing ranges.
- To minimize the variety of fuses stocked.
- To increase the surface area for heat dissipation.

The following aspects should be borne in mind.

## Mechanical Connections

It is desirable to make the connections to the parallel fuses as symmetrical as possible to assist in obtaining good current sharing between fuses. The temperature coefficient of resistance of the fuses does, however, greatly assist in this aspect.

Additional conductors required to make the connections should be of plated copper and of at least the same cross sectional area and surface area as the fuse tags. It is prudent to allow for a 5% de-rating on the maximum current rating for each parallel path, to take account of the proximity of the fuses. Only identical types of fuses should be used in parallel.

## Time Current Characteristics

The time current characteristics of the combination of the fuses can be derived by taking the operating current of specific pre-arcing times for a single fuse and multiplying these currents by the number of parallel paths.

## I<sup>2</sup>t Characteristics

The I<sup>2</sup>t of the combination of fuses is the I<sup>2</sup>t of the single fuse multiplied by the square of the number of parallel fuses i.e.

- by 4 for two fuses in parallel.
- by 9 for three fuses in parallel.

## Fuse Selection In Semiconductor Convertors

### Rectifiers

The majority of applications will be fed from the AC mains supply, the standardized system voltages in various parts of the world are:

Single-Phase	Three-Phase
120	208
220	380
240	415
277	480 (460)
	660

In general for these applications fuses are only exposed to AC fault conditions and the fuse voltage rating is selected to be equal or greater than the supply line-to-line voltage. In the case of the three phase double Wye (star) arrangement with inter-phase transformer, the voltage rating of the fuse must be twice the line to neutral voltage.

For large rectifiers multi-parallel paths are used each with its associated fuse. In such applications the fuselink is used to isolate a faulty semiconductor and the I<sup>2</sup>t of the fuse must be:

- less than the explosion rating of the semiconductor.
- such as not to cause other fuses in the healthy circuits to operate.

## DC Drives

The non regenerative thyristor drive is widely used for variable speed control of motors. In these applications the coordination of fuses and semiconductors is often more critical than for rectifiers. The fuses are usually positioned in each arm of the bridge or the supply lines and will generally only see an AC fault.

In regenerative thyristor DC drives the fuses in the inverter bridge or in the AC input lines can see DC faults in addition to the AC fault, DC faults arise under shoot-through conditions in the inverter bridge or with loss of the AC supply. In addition a combined AC and DC fault occurs with a commutation fault. Due allowance for these conditions must be made in the selection of the voltage rating of the fuses.

## AC Drives

These are becoming increasingly popular and are usually fed from the normal AC mains. Fuses are often used in the DC circuit of the converter and the associated approximate DC circuit voltages for the common 3-phase systems are:

A.C. Systems	D.C. Circuit
380	510
415	560
480 (460)	650 (620)

A very fast fuse is required for this application and the fuse elements should melt before the peak of the fault current. The high rate of rise of the fault current is equivalent to a DC fault with a short time constant.

The Edison E70S range is ideally suited for applications at the above voltages.

## UPS System

The DC circuit voltage in UPS applications is governed by the battery voltage and in 3 phase applications special input transformers are often used. The DC circuit voltage is usually limited to a voltage of approximately 450V DC. Edison E50S semiconductor protection fuses are suitable for applications up to 500V DC circuit voltage.

### Soft Starters

Although soft starters reduce the magnitude of the motor starting current, these currents are still considerably larger than the motor full load current. In such applications the fuse has to be selected to withstand this motor starting current which may be of a repetitive nature. This action defines the fuse rating which in turn may have an  $I^2t$ -let-through approaching that of the power semiconductor.

### Traction Applications

Each application tends to have its specific requirement and full technical details should be forwarded to Edison

Fusegear for evaluation. Third rail d.c. applications are particularly difficult where the time constants sometimes approach 100 m.s.

### Mean and R.M.S. Currents

Care must be taken in coordinating fuse currents with the circuit currents. Fuse currents are always given in r.m.s. values, while it is common practice to treat diodes and thyristors in terms of mean values. In rectifier circuits, fuses are either placed in series with the diodes or thyristors in the a.c. supply lines or least commonly in the d.c. output line. The relationship of the currents in these three positions for commonly used rectifier circuits as shown in the diagrams.

