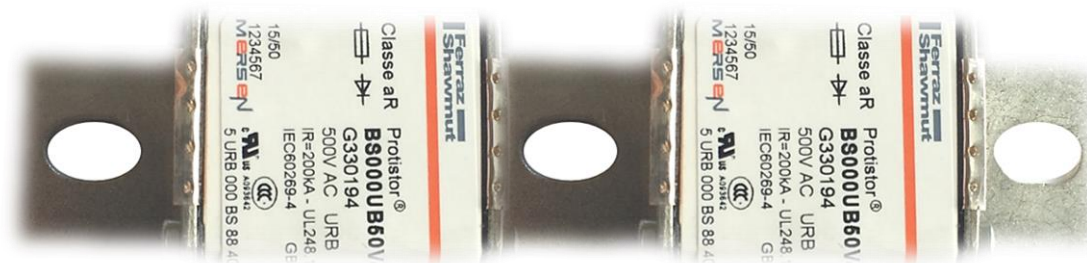


FUSES IN SERIES

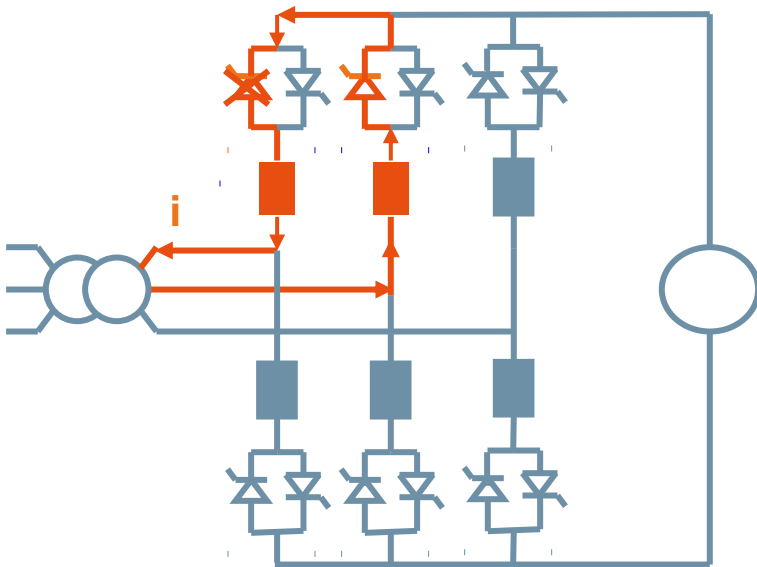
EDUPACK TRAINING MODULE

2012

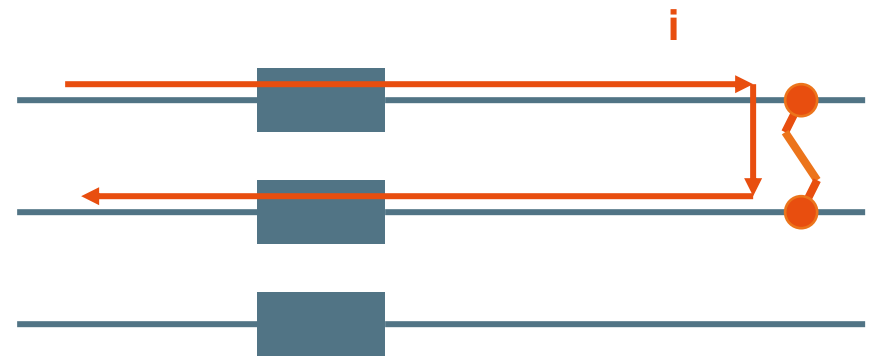


VOLTAGE RATING

In many applications 2 fuses in series are involved when a fault occurs. But they do not always share perfectly the fault voltage. Perfect sharing of the voltage will depend on the circuit and the on magnitude of the fault.



Internal fault inside a 3 phase bridge



Line to line fault in 3 phases feeder

VOLTAGE RATING

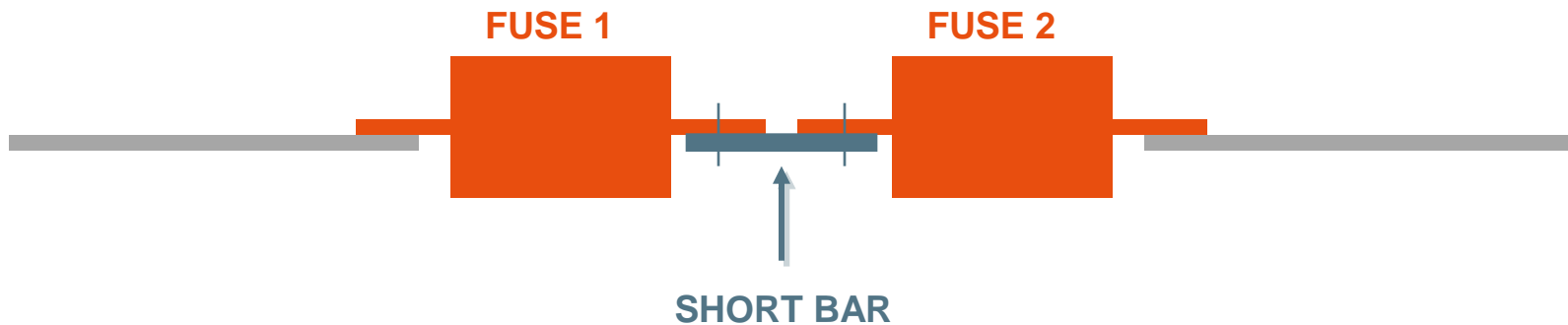
When the fuse needs more than 10 milliseconds to melt there are 2 possibilities:

- When the prearc time is long it is possible that only one fuse melts : this fuse will see the full voltage of the circuit and must be rated accordingly.
- The 2 fuses operate but one fuse melts several milliseconds before the second one: since the arc duration inside the fuse is typically 5 milliseconds, the fuse melting first will get most of the interruption energy and may explode or let go out ionized gases.

The maximum operating voltage of each fuse should be higher than the maximum circuit voltage.

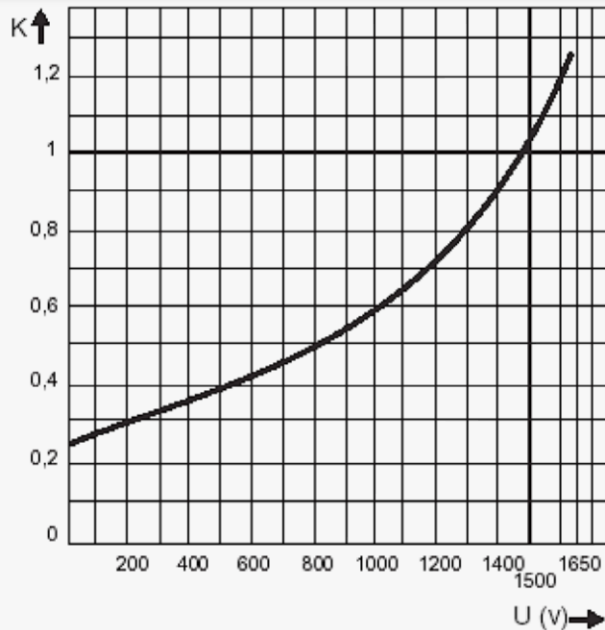
CURRENT RATING

When 2 fuses are in series the current rating is simply the current rating of each fuse. However if 2 fuses are purposely mounted in series (in order to reduce the I^2t) a derating is may be necessary when there is a very short copper bar between the fuses.



I²t corrective K factor

URF / URG / URK



U: R.M.S. working voltage V

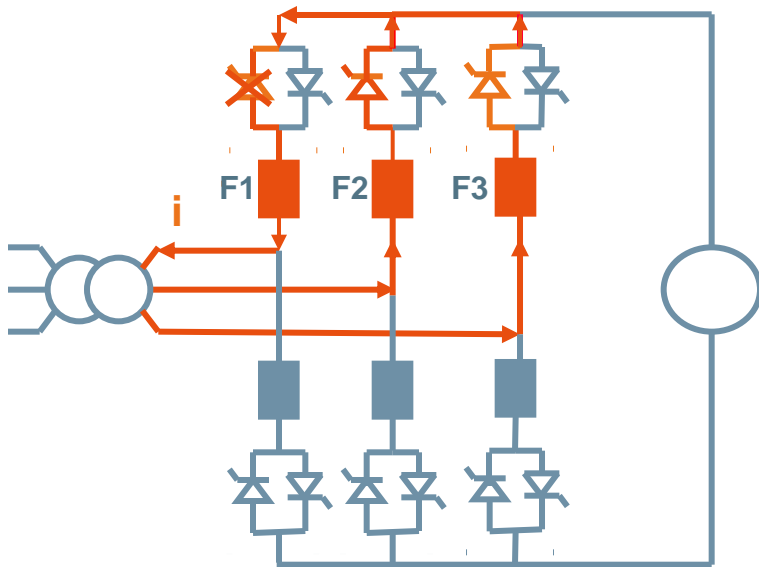
K: I²t corrective coefficient versus U

The curve $K = f(U)$ allows the calculation of the total i^2t for voltages lower than the rated voltage of the fuse.

- Prearc time of the fuse is less than 10 milliseconds
- Fuse $I^2t <$ semiconductor silicon die I^2t
- Fuse $I^2t <$ semiconductor case explosion I^2t
- I^2t helps to evaluate the discrimination (selectivity) between different fuses

The I^2t of 2 fuses in series is smaller than the I^2t of a single fuse.

I^2t WHEN THE FAULT IS LARGE: CASE 1

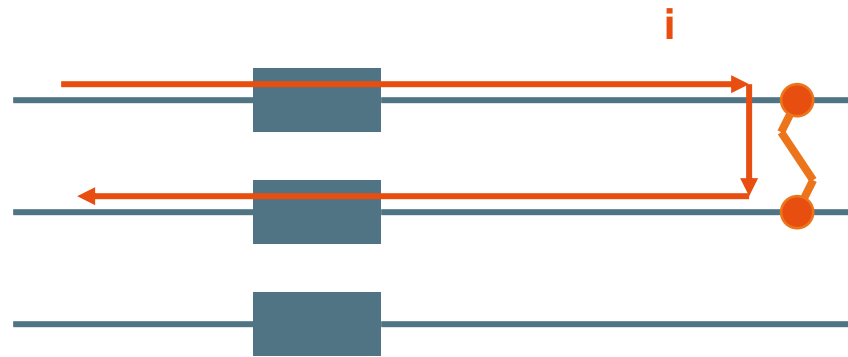


The short circuit current due to the failure of the diode in arm 1 starts between lines 1 and 2 but may end between lines 1 and 3 due to the commutation of the semiconductors.

Preaming time of fuse F1 is slightly smaller than the preaming time of F2 or F3.

The I^2t is calculated for 65 % of the full voltage of the circuit.

I²T WHEN THE FAULT IS LARGE: CASE 2



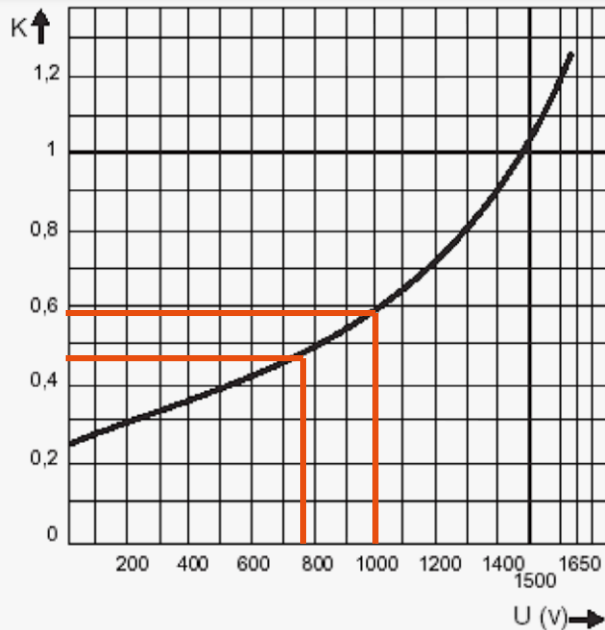
In this case the fault totally remains in lines 1 and 2 only.

The I^2t can be calculated considering the fuses will see 55% only of the circuit voltage (the use of 50 % is possible when the prearcing time is less than 2 milliseconds).

I²T WHEN THE FAULT IS LARGE: CALCULATION EXAMPLE

I²t corrective K factor

URF / URG / URK



U: R.M.S. working voltage V

K: I²t corrective coefficient versus U

Fuse: 1500 V URH 630 A

Maximum voltage of the circuit 1400 V + 10% i.e. 1540 V maximum

The short circuit current is such that the fuse prearcing time is only 1 millisecond

The fuse I²t under 1500 V is 1 570 000 A²S

- When the fuse is protecting a 3 phase bridge the i²t of the fuse is calculated for U = 1540 x 0.65 = 1000 V

The curve gives k = 0.59 , then the fuse I²t is: 1570 000 x 0.59 = 926 300 A²S i.e. 926 000 A²S

- When the fuse is protecting a 3 phases circuit without three phases electronic equipment, the i²t of the fuse can be calculated for U = 1540 x 0.50 = 770 V

The curve gives k = 0.47 , then the fuse I²t is: 1570 000 x 0.47 = 737 900 A²S i.e. 738 000 A²S



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