Fuse Selection Guide

Fuse is a safety protection component for preventing fault current from causing hazards or serious damage in electric equipment. There are different types of fuses designed to meet different application requirements. To select an appropriate fuse for a particular application, several parameters should be considered.

1. Amperage rating (A)

Amperage rating indicates the current carrying capacity of a fuse. Normally, a fuse can hold continuously a current equal to or less than its amperage rating without blowing, at a standard environment specified by the relevant testing standards. However, since the actual current flows through the fuse may vary due to variations of other componenets and working environment, an allowance is usually provided when selecting the amperage rating of a fuse in order to avoid nuisance blowing. In other words, the amperage rating of a fuse should always be greater than the normal working current. An minimum allowance of around 20 to 25 percents is usually considered acceptable. The upper limit of amperage rating on the other hand is usually determined by the level of overload protection required. Although it is sometime difficult to obtain exact information, the amplitude of expected fault current and maximum allowed period within which a fuse must clear the fault current are very important in deciding the highest amperage rating to be used.

2. Voltage rating (V)

The voltage rating of a fuse states the maximum supply voltage that the fuse can safely clear. The most popular types of voltage ratings are 125V and 250V. A fuse should only be used at supply voltage less than or equal to its rated voltage. For example, a 125V fuse can be used at 110V supply voltage but not 220V while a 250V fuse can be used at both 110V and 220V supply voltages.

	110V equipment	220V equipment
125V fuse	Acceptable	Not acceptable
250V fuse	Acceptable	Acceptable

3. Blowing characteristics

Basically, fuses can be divided into two blowing characteristics, quick acting and slow blow. Quick acting fuses will react quickly to clear fault current for protecting delicate circuit. Slow blow fuses on the other hand can withstand surge current for a short period and blow when the overload current sustains. It is used mainly in applications where surge current is anticipated in normal operation, for example, the switch-on surge current of motors. A quick acting fuse may blow easily in those cases and require frequent replacement. Slow blow fuses are designed to solve this problem.
However, there is no universally accepted criteria for classifying quick acting/slow blow fuses. Different manufacturers may have different terminologies and specifications. Their products while have similar descriptions (slow blow or time lag), may have different degree of slow blow characteristics. The descriptions "quick acting" and "slow blow" only provide a rough indication of blowing characteristics. In order to get a more detail picture, the time-current characteristic curve and I^2t value should be studied.

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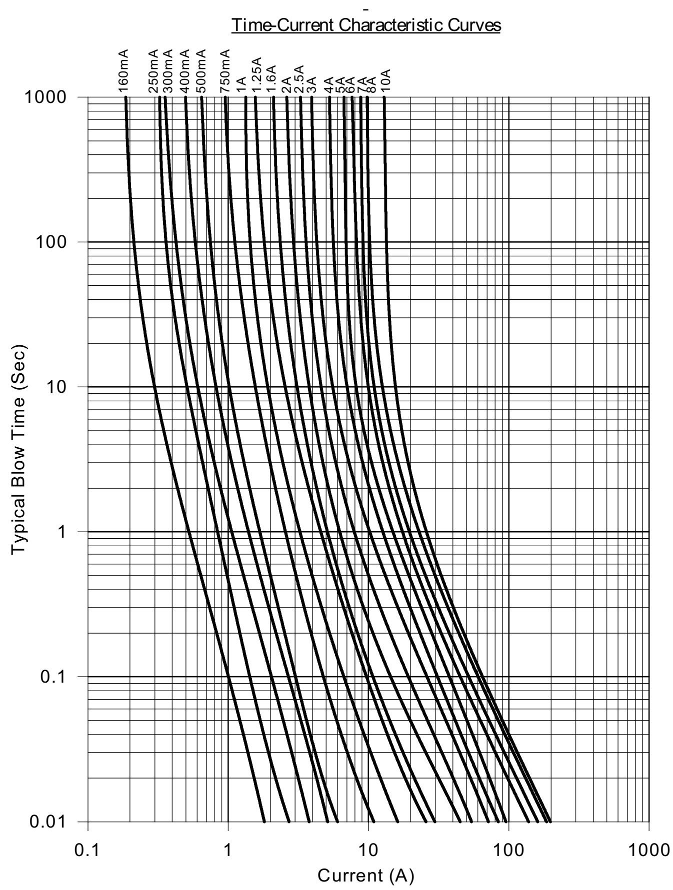
- **Time-Current Characteristic Curve**

It is a curve of blow time plotted against current, usually on a log-log scale graph paper. From this curve, the relationship between current and blow time of a fuse can be easily revealed. The typical blow times corresponding to different overload currents can be estimated from the curves. Slow blow fuses will have longer blow time especially at high current region (the lower right end of the curve will be higher compared with that of a quick acting fuse with same amperage rating). Slow blow fuses from different manufacturers may show different shapes of time-current characteristic curve. The appropriateness of using a fuse in a specific application should be justified by checking whether the corresponding time-current characteristic curve can fulfill both the overload protection and long term reliability requirements.



- **I^2t value**

The time-current characteristic curves usually only provide data down to 10 milliseconds. For blow time less than 8-10 msec (which is ½ cycle of 50Hz or 60Hz AC current), the actual blow time will be significantly affected by the phase angle at which the current is switched on. I^2t is a more meaningful value to represent the blowing characteristic of a fuse at such a short blow time. It is a value proportional to the let-through energy (the integral of square of current against time, with unit A^2sec) of a fuse before it blows at high overload current with blow time less than 8-10ms.

$$\int I^2 dt$$

where I is the current value at time t.

The I^2t value of a fuse should be greater than that of a surge current if the fuse is required to withstand the surge. The greater the I^2t value, the better the fuse surge resistance will be. However, unnecessarily great I^2t value may lead to safety problem if the fuse fails to clear a high fault current fast enough to avoid causing hazardous situation or damage to other more delicate components. A fuse chosen should have I^2t value between the desired surge resistance and maximum allowable fault current I^2t value.

I^2t value of surge current < I^2t value of fuse < Maximum allowable fault current I^2t

4. Safety approvals

Fuse is a safety protection component. Many countries require fuses to be approved by specified safety agencies. The most popularly accepted safety approval agencies are : Underwriters' Laboratories (UL) of U.S.A.; Canadian Standards Association (CSA) of Canada; Swedish Institute of Testing and Approvals of Electrical Equipment (SEMKO) of Sweden and VDE of Germany. UL and CSA have the same requirements which are stipulated in harmonized standards. The European approvals, like Semko and VDE basically follow the same relevant IEC standards.

- North America - UL, CSA
  The harmonized standards of UL and CSA for miniature and micro fuses are UL 248-1 and -14 (or CSA-C22.2 No. 248.1 and No. 248.14). Their fusing characteristic requirements are summarized at the table below.

Percentage of rated current	Blow time	
	Miniature fuses	Micro fuses
100%	Not blow	Not blow
135%	1 hour maximum	Not applicable
200%	2 minutes maximum	1 minute maximum

- Europe - SEMKO, VDE
  The European approvals follow the standards issued by International Electrotechnical Commission (IEC). The standard for miniature fuses is IEC127-2. There are different standard sheets in this standard for different fuse types. The fusing characteristic requirements of two of the standard sheets are summarized at the table below for comparison with that of UL/CSA.

Percentage of rated current	**IEC127-2, Standard sheet II** 5x20mm, quick acting, Low breaking capacity	**IEC127-2, Standard sheet III** 5x20mm, time lag, Low breaking capacity
150%	1 hour minimum	1 hour minimum
210%	30 minutes maximum	2 minutes maximum
275%	50ms minimum, 2 sec maximum	600ms minimum, 10 sec maximum
400%	10ms minimum, 300ms maximum	150ms minimum, 3 sec maximum
1000%	20ms maximum	20ms minimum, 300ms maximum

Note : The specification of UL/CSA and IEC127-2 stipulated above is just a brief representation. The corresponding standards should be referred for the exact details.

5. Mounting methods

Depending on the fuse construction and other installation constrains or requirements, fuses can be installed for use by different mounting methods.

Fuse construction	Cartridge	Leaded	SMD
Mounting methods	- Fuse clip - Fuse holder	- Direct soldering - Crimping	- Surface mount

Cartridge fuses installed in fuse clips or fuse holders offer the advantage of easy replacement but the material and installation cost will be higher. The leaded fuses can be directly inserted into printed circuit board and soldered by automated soldering processes to reduce assembly labor cost. Crimping connection allows leaded fuses to be installed in some areas where other mounting methods will not be feasible. SMD fuses are specially designed for SMD assembly and soldering processes, usually of smaller size comparing with cartridge and leaded fuses.

6. Size

There are two most popular sizes of miniature fuses - 5mm diameter x 20mm length and 1/4" diameter x 1-1/4" length. Appropriate size should be selected to match the fuse clips/holders or the space available. If only limited space is available, micro fuse can be considered.

7. Derating characteristic

Fuse is a thermal sensitive device. The ambient temperature will affect heat transfer from the fuse to the surrounding and hence the current carrying capacity of the fuse. The nominal amperage rating of a fuse is usually established at ambient temperature of 25°C. The higher the ambient temperature, the lower the current carrying capacity will be. Appropriate allowance should be given when deciding the amperage rating of a fuse used at temperature significantly higher or lower than 25°C. Fuses of different constructions and materials may be affected differently by the ambient temperature. The typical relationship of ambient temperature and current carrying capacity is illustrated below.