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Why did the fuse interrupt? Basic principles in the selection of miniature fuses



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Introduction

Why did the fuse interrupt?

Miniature fuses are designed to protect electrical installations, equipment and assemblies from unacceptably high current loads. Their application is wide-ranging. Miniature fuses are used to protect power supply systems and power output stages. In industry they are often employed to separate defective assemblies from the power supply whenever a fault arises, before more serious damage can be caused.

When choosing the right miniature fuse a number of factors have to be considered that are crucial for the life expectancy and function of the fuse. The fuse link should only interrupt when a fault occurs, thereby protecting the electronics from more serious damage, and should not result in undesirable system outages simply because someone failed to take all the influencing factors into account when choosing the type of fuse to be used.

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Selection criteria



Classic Cylindrical Fuse



SMD-Fuse

When you think of miniature fuses you usually have a mental image of the conventional 5×20 cylindrical insert. But there are in fact a wide range of fuse types and operating properties to choose from. Cylindrical fuses come in 5×25 mm, 5×30 mm and 6.3×32 mm sizes, and many other different dimensions can also be supplied. There are wired fuses for mounting on printed circuit boards, sub-miniature fuses and of course SMD fuses.



Wired fuse for Printed circuit board mounting



SMD-Fuse with Clip

Their operating characteristics range from superfast fuses (FF), such as those used to protect semiconductors or instruments, to super-time-lag (TT) fuses that do not interrupt, even in the face of very large load pulses or starting currents. Fuses are used in a wide range of instances requiring safe and reliable circuit breaking, from the smallest voltages up to applications of 1,000 V and above, and this in both alternating current and direct current systems. Fuses are usually selected solely on the basis of current rating, voltage rating and characteristic. Here it is generally assumed that the rated current stated on the fuse is able to pass through the fuse unit on a permanent basis. Unfortunately, however, this only applies in the rarest of cases!

When determining the current rating the relevant standards are always based on the optimum operating conditions for that particular fuse (23 °C ambient temperature, unrestricted heat dissipation, continuous current flow...).



This draws our attention to the most important factors influencing the correct choice of fuse, and to those factors which, for the particular application in question, ensure that the fuse will suddenly no longer provide a connecting passage for the current flow.

The ambient temperature affects both the continuous current capacity and the melting integral of the fuse. Starting currents and pulse loads that exceed the current rating of the fuse also play a key role. These influencing factors will be examined below in more detail.



Effects of ambient temperature

Effects on the current rating of the fuse link

Safety fuses operate on a very simple principle. If current is flowing the fusible element in the fuse link will become warm. If the current increases the fusible element will become even warmer until finally the lowest fusing current of the fuse is reached and the temperature in the fusible element is so high that the element melts and interrupts the current flow. It is therefore immediately obvious that while the response behaviour will be affected by the temperatures generated by the load current, the ambient temperature levels will also have an impact on the long-term resilience of the fuse link.

As stated above, fuses are designed in accordance with standard specifications for an ambient temperature of 23 °C. If the ambient temperatures are higher than this, the possible long-term current load will be reduced accordingly. The heat generated in the fusible element can no longer be adequately dissipated and this can result in the fuse being tripped below its current rating. The reverse applies when the temperature is below 23 °C. In such cases the fuse will only respond



at correspondingly higher currents, as it is being 'cooled' from an external source and therefore exhibits better heat dissipation than under normal conditions.

The figure below can be used to determine the 'derating' effect of ambient temperature on the current rating of different fuse types.

If for example a time-lag fuse is required that has to cope with a current flow of 1A and operate at an ambient temperature of 70 °C, the rated current of the fuse can be calculated as shown in the box below.

The chosen fuse should therefore have a current rating of at least 1.28 A so that the load current of 1 A can flow permanently across the fuse at an ambient temperature of 70 °C without the fuse being tripped prematurely and unintentionally. As the next current rating according to the standard is 1.6 A, then a 1.6 A fuse should be selected.



Effects of ambient temperature

Effects on the melting integral of the fuse

Ambient temperature does not just affect the maximum continuous current of the fuse, it also influences the behaviour of the melting integral. Here too the values given in the current data sheets for the melting integral of a fuse link only apply to normal room temperatures. If the latter move into a higher range, which tends to be the case in electronics applications, the melting integral of the fuse, as stated in the data sheets, will be decreased. If the temperatures are below 20 °C, an increased melting integral has to be considered.

The figure below shows the correction factor that has to be used when calculating the melting integral.

The Calculation of the actual melting integral can be found in the box on the right.



Ambient temperature

In actual applications, as the ambient temperature is usually higher than normal, allowance therefore has to be made for a lower melting integral than specified in the fuse data sheets. This corrected melting integral can then be used for all further calculations.

l2ts`=l2t x Keu

I2ts`: actual melting integral I2t: melting integral taken from data sheet

KEU: correction factor determined from the graph

The unintentional tripping of a fuse link is most commonly caused by one-off loads, often of short duration and not originally allowed-for, which exceed the current rating of the fuse. These are frequently starting currents that may only occur a few times, though in many cases they will be generated thousands of times over the lifetime of the electronics.

Such loads can lead to premature damage such that the fuse will interrupt at some point even under normal operating conditions. There are various methods available for assessing the starting current. The method most commonly used for checking whether or not the 'inrush' can be carried by the fuse is to compare the starting current with the time/ current curve of the fuse. Here the amplitude of the starting current and the period of time for which this current flows are both entered into the characteristic curve. From this it is possible to determine very quickly whether or not the inrush current will cause the fuse to trip.

However, if premature fuse damage is to be avoided there must be an adequate margin between the starting current and the actual melting current of the fuse. As a guideline value the starting current should be about 60 % of the tripping current. This correlation can be illustrated clearly in the example on the right.



Inrush: 6 A | Duration: 100 ms

This means that by applying the aforementioned 60% rule it is possible to select a fuse that exhibits a melting current of 10 A at 100 ms. In this case the selected fuse should be rated at 3.15 A.



One possible way of correctly determining the pulse loads and short-duration starting currents is by comparing the load integral with the fuse melting integral. This first involves

establishing the energy yield of the load acting on the fuse, which if no appropriate data is available can be done by using the following approximations.



The pulse integral established here can be compared with the melting integral of the fuse as obtained from the data sheet. If this pulse is present only once, or only a few times over the entire life-cycle of the electronics, it is sufficient if the melting integral of the fuse is greater than the measured pulse integral.

However, if the load is a more frequently recurring event it is necessary to ensure a sufficient margin between the melting integral of the fuse and the pulse integral. The

more frequent is the pulse, the greater this margin has to be. Different types of fuse and fuse-element alloys, with their respective characteristics, will exhibit quite significant differences in the degree of sensitivity to pulse loads. The following graph shows which correction factor to use as a function of the number of pulses.



Calculation of the required melting integral of the fuse as a function of the anticipated number of pulses:

I2tsmin = I2tp / Kp

I2tsmin: min. required melting integral of the fuse as taken from the data sheet

By using the minimum required melting integral as established above you select a fuse that will not interrupt unintentionally at switch-on.



I2tp: pulse integral Kp: correction factor of pulse integral

Summary

Choosing the right miniature fuse depends on more than just the permanent load current, the type of equipment or semiconductor. It is equally important to consider the various factors that have an effect on the fuse link so that the operating life of the fuse is not compromised right from the point of selection. loads come into play at the moment of switchon or will the starting currents be of recurrent frequency?

We do not want you to be asking yourself soon after fitting:

"Why did the fuse interrupt?"

For this reason it is essential to consider the type of ambient temperatures to which the fuse is liable to be exposed. And will particular



What sets SIBA apart

Specialists in fuses and fuse protection technology

Providing customers – their machinery and equipment and of course their personnel – with the highest possible level of protection. And we know that this is good for company profits too: production can continue without suffering lengthy disruptions because if anything untoward should happen our fuses will react immediately to prevent further damage.

Staying close to our customers

Many of our products are the result of highly specialised requests from discerning clients. We therefore know our way around manufacturing and production, and our in-house R&D



capabilities have also helped us face some of industry's major challenges – from digitisation and the DC factory through to e-mobility and the energy transition.

Maintaining a global presence

For us ,made in Germany' means ,selling to the world'. With subsidiaries on every continent and sales partners in practically every country worldwide we can supply you with original SIBA fuses no matter where you are.

How to **reach us...**



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