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SIBA technical background information:
Know-how on electrical fuses

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A rule of thumb that does not always apply

Miniature fuses in
direct current applications



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A rule of thumb that does not always apply

Geräteschutzsicherungen in Gleichstrom-Anwendungen

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1 Introduction

Often one hears the following: „A 250-V AC fuse can safely be used in 125-V DC applications.“ Is that really true? And if not, why not?

Let us put it this way: This statement is not generally correct; it is roughly true, however, of part of the miniature fuses offered on the market. But let us begin by looking at the problems fuses may encounter in interrupting direct currents.

If a short-circuit current flows through a fuse, after a certain time the fuse-element inside the fuse will have molten. Depending on the applied voltage and the height of the short-circuit current, an arc develops in the fuse. This arc enables the current flow to be maintained, resulting in the short circuit lasting longer than is desirable. In alternating-current applications, the zero current „helps“ to extinguish the arc. Since there is no such zero current in DC applications, in cases of the permissible rated DC voltage being exceeded the arc may „stop“ between the two fuse caps, burn holes into them or even cause the fuse body to burst as it cannot withstand these extremely high temperatures and pressures. This results in the unhindered leakage of metallized material from inside of the fuse which, in turn, can cause new short circuits on the printed circuit board. Often, in such cases, one finds charring on the printed circuit board. In extreme cases it may even lead to fire.

2 When are fuses suitable to be used with direct current?

The way fuses actually behave when interrupting direct currents, however, depends on their construction and characteristic.

The above illustration of a fuse not properly interrupting the current could be an example of, among others, fuses without an extinguishing filler. The term extinguishing filler designates the substance the fuse body is filled with and which contributes to prevent the arc from developing unhindered inside the fuse. Among the most commonly used extinguishing fillers are quartz sand and glass beads.

It is these unfilled fuses to which the assumption given at the beginning applies: „A fuse can operate at direct currents with voltages of half the voltage stated for AC“ – at least, the assumption applies roughly. But be careful – under certain circumstances, even half the voltage may be critical for the fuse!



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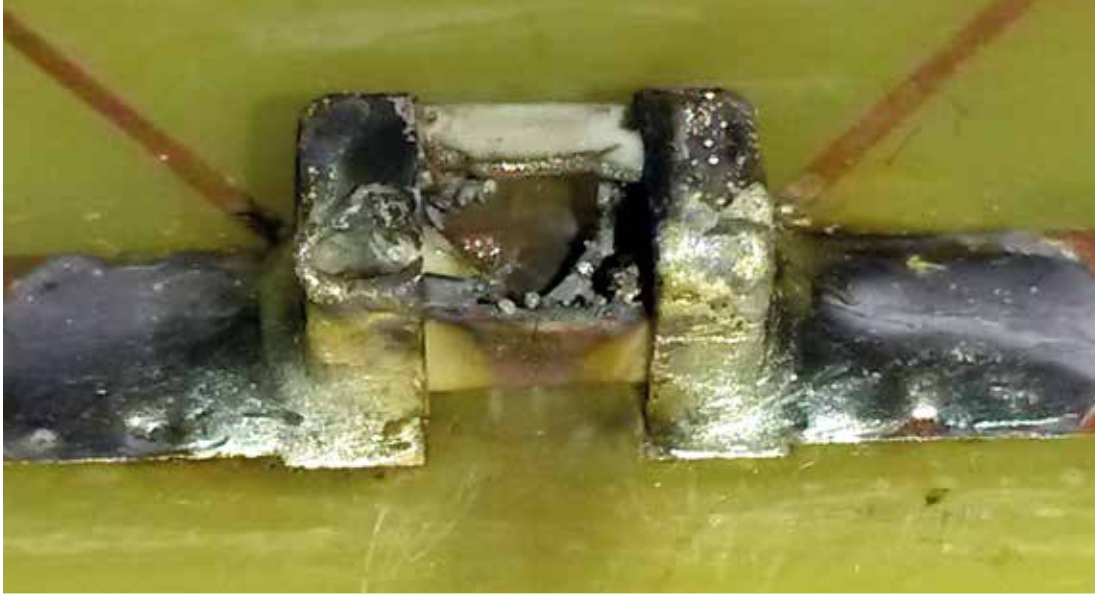


Figure 1: SMD fuse which had not properly interrupted the current.

So, let us rather turn to fuses which are suitable for direct current applications. There is a large variety of such fuses available, particularly for applications with extra-low voltages of up to approximately 65VDC. This is due to the fact that only low-energy arcs form over this voltage range, enabling safe operation with even very small fuses.

It gets interesting, however, with voltages exceeding 100 V. For such voltages, usually fuses with a ceramics body and the relevant filler are used. Then the maximum permissible height of the driving voltage for the fuse to be able to properly interrupt the current depends on the size, the material, the rated current and also the characteristic of the miniature fuse.

While very quick-acting (FF) fuses – being only suitable for mere short-circuit protection – are often suitable for high DC voltages, the values that can be reached with time-lag (T) fuses of the same construction are much lower than those achieved with the very quick-acting ones.

If you are already a little familiar with the topic of fuses, you may have asked yourself why there are fuses, in the first place, whose rated DC voltage is stated to be higher than their rated AC voltage. Can this be correct!? Yes, it can be correct! The fuse suitable for DC is able to extinguish the arc but has to cope with the peak value in the case of an AC application.

Thus, it is clear that the peak voltage plays a major role. But it is not only the height of the DC voltage that has an impact on the fuse's breaking performance. Another decisive factor is the time constant of the shorted circuit. The time constant is calculated from L/R , with the reactances of the components in the short-circuited branch having to be taken into consideration. For most applications the time constant does not exceed 10 ms and it is even lower than 3 ms in battery-operated circuits. The higher the time constant is, the lower is the DC voltage at which the fuse-link may be used. For example, time constants of 100 ms may also result in the rated AC voltage having to be reduced by more than 50 % for applications in DC voltage circuits. Due to the vibration characteristics in the intermediate DC voltage circuit of a frequency inverter, on the other hand, the maximum DC voltage may exceed the rated AC voltage (r.m.s. value) of the fuse-link.

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3 What about the concrete capacity of the fuses?

So, what are SIBA's miniature fuses actually capable of? Well, this varies considerably depending on the construction; but 6,3 x 32 mm fuses may definitely be used for short-circuit protection in the case of low rated currents with up to 1 000 V DC.

Below you will find a brief list of different fuses which are also suitable for DC applications.

	<p>Series 151000 to 154000 (FF) Construction types 0402 to 1206 Rated currents of 250 mA to 6,3 A Rated breaking capacities of 50 A@DC 32 – 125 V</p>
	<p>Series 157000 (F) Construction types 2,6 x 6,1 mm Rated currents of 62 mA to 15 A Rated breaking capacities of 50 A@DC 65 – 125 V</p>
	<p>Series 158000 (T) Construction types 2,6 x 6,1 mm Rated currents of 250 mA to 6,3 A Rated breaking capacities of 50 A@ DC 125 V</p>
	<p>Series 160016 (T) Construction types 4,5 x 16 mm Rated currents of 80 mA to 10 A Rated breaking capacities of 1500 A@ DC 250 V</p>
	<p>Series 179200 (T) Construction types 5 x 20 mm Rated currents of 80 mA to 10 A Rated breaking capacities of 1500 A@ DC 125 to 300 V</p>
	<p>Series 7018040 (FF) Construction types 5 x 20 mm Rated currents of 100 mA to 500 mA Rated breaking capacities of 100 kA@ DC 660 V</p>

	<p>Series 189140 (T) Construction types 6,3 x 32 mm Rated currents of 100 mA to 32 A Rated breaking capacities of 1500 A to 6000 A @ DC 300 to 400 V</p>
	<p>Serie 189020 (F) Construction types 6,3 x 32 mm Rated currents of 160 mA to 16 A Rated breaking capacities of 1500 A @ DC 125 to 450 V</p>
	<p>Series 7012540 (FF) Construction types 6,3 x 32 mm Rated currents of 100 mA to 6,3 A Rated breaking capacities of 20 kA @ DC 500 V</p>
	<p>Series 7017240 (FF) Construction types 6,3 x 32 mm Rated currents of 100 mA to 2 A Rated breaking capacities of 30 kA @ DC 1000 V</p>
	<p>Series 7018509 (F) Construction types 8 x 65 mm Rated currents of 2 A to 3,15 A Rated breaking capacities of 30 kA @ DC 1,500 V</p>

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4 Concrete applications

A very typical field of application for fuses are the DC voltage circuits of emergency current supplies or emergency light systems. Very often, such systems are special in another way – in the normal operating mode, the systems are supplied with the typical mains voltage of 230 V AC, which, as such, does not present the fuses with a special challenge. It is only when the plant has to operate in the



Figure 2: In emergency illumination systems (in the background you see a corridor in the Landesgymnasium für Musik Dresden (Dresden-based music high school of the state of Saxony)); the technology was supplied by Klett Ingenieur GmbH) systems of high-capacity common batteries are applied; on the left side you see Inotec's CPS220/64. When, in the case of a mains failure, these batteries have to stand in by supplying emergency power, the fuses may have to be able to cope with high DC short-circuits

emergency current mode and is fed by common batteries of very high capacity, that a fuse being able to safely interrupt also direct currents becomes necessary. Unfortunately the fuse cannot be exchanged as needed, so it is obvious that it has to be suitable for operation in both the direct- and the alternating current modes.

Especially in cases of such emergency current applications one should additionally take into consideration the height of any potential short-circuit current. It is not uncommon for the batteries applied to cause short-circuit currents of 6 000 A or more in the systems; now, at the latest, it becomes obvious that the fuse to be applied in such situations should be selected with great care. By no means are all fuses able to properly interrupt such high direct currents, and the damage resulting from faults can be considerable.

We would be glad if, after having read this brief article, you will be very careful when it comes to selecting your next fuse, taking into consideration both what the fuse is able to achieve, but also what it is not able to achieve!

We will be pleased to support you based on our experience. Please do not hesitate to contact us!

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