



Chip Fuse Developments for Secondary Circuit Protection

Surface-mount fuse links enable designers to implement circuit protection measures now obligatory in many electronic products. Next-generation fuses are combining advanced materials with construction techniques from precision chip resistor manufacture, to further reduce footprint, enhance long-term stability, and meet international standards covering fuse links.

Product safety standards are mandating secondary over-current protection for many battery powered instruments and their associated battery chargers and low-voltage power supplies. Further mains-connected units requiring secondary protection include power inverters, motion-control units, and dc-to-dc converters, which are widely used throughout electronic equipment markets.

The majority of these instruments are destined for use by today's mobile consumers, including cellphones, PDAs, portable media players, notebook PCs, flat-screen televisions and sensor-rich in-car electronics. Other modern essentials, such as portable medical devices, also require space-efficient secondary protection. In addition to general circuit protection requirements, integrated display and storage subsystems such as TFT-LCD displays and 2.5" HDD drives must also be protected from harmful over-currents.

The levels of miniaturization typically demanded by these end user groups place a premium on every square millimeter of board space. Designers need to minimize the real estate devoted to secondary over-current protection. Conventional wire fuses in SMD packages display a number of strong features: they are robust, have high breaking capacity, are available in ratings up to 10 A, and the technology also supports fast acting or time delay type fuse operation. They can address a wide range of applications, including over-current protection of power lines. On the other hand, package sizes are not likely to reduce below the industry-standard 2410 SMT outline. In consumer applications where low rated currents and breaking capacities are required, chip fuses (figure 1) are emerging to satisfy designers' demands for the next level of component miniaturization.

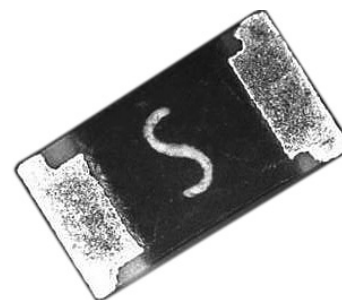


Figure 1.

Chip fuses feature a conductive fuse element that is typically deposited as a thick-film, electroplated, or thin-film layer onto a ceramic substrate. Using these basic technologies, secondary over-current protection is able to migrate into smaller SMT packages including 1206, 0603, and even 0402. However, two further imperatives are the need for long-term stability of the fusing characteristic and a low unit price to enable a cost-effective solution.

Stability is heavily dependent on the accuracy of the fabrication technique used to create the fuse element. Traditionally, a thick-film element for a chip fuse is deposited using a screen printing process, while most fuse elements are electroplated. Both of these techniques enable quite accurate control over the dimensions of the fuse element in order to achieve the desired fusing characteristic. However, the homogeneous crystal structure of the metal layer has an important influence over the long-term stability, due to aging factors such as power dissipation or external high temperatures in combination with thermal cycles. To simultaneously improve control over the dimensions and crystal structure of the fuse element, Vishay Beyschlag MFU-series chip fuses are created using a thin film sputtering process in place of screen printing or electro-plating. This process leverages precision chip resistor manufacturing knowledge and assembly capacity.

In addition, a special protective coating comprising layers of glass and epoxy lacquer also now raises the capability of chip fuses to withstand harsh thermal shocks and wide-ranging humidity requirements. Benchmark tests on MFU series chip fuses demonstrate superior performance in this respect due to this special protective system.

TECH NOTE

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Leveraging the manufacturing technology established for chip resistors in this way presents a fast solution to migrating surface mount fuses to smaller form factors while also meeting applicable performance standards and long-term stability. Manufacturers of chip resistors have a clear advantage here: Because chip fabrication capacity is already in place and operational, large numbers of chip fuses can be produced quickly.

Applicable Standards and Figures of Merit

The main international standards applying to all surface-mount fuses, including SMD fuses and chip fuses, are UL248-14 and IEC60127-4. The IEC60127-4 Standard Sheet 2 defines SMD devices of rated voltage 12.5 V, 25 V, 32 V, 50 V, 63 V, 125 V, or 250 V, depending on the minimum distance between the contacts. MFU chip fuses in the standard 1206, 0805 and 0603 outlines fulfill the requirements of the IEC 60127-4 Standard Sheet 2.

IEC60127-4 also defines several time/current characteristics applicable to chip fuses, SMD fuses, and through-hole fuse links. Among these, the technology that enables the very small and flat component dimensions also allows chip fuses to meet the IEC specifications for very quick-acting (type FF) fuses as well as quick-acting (type F) fuses. Type FF fuses must open within 0.001 seconds at ten times the rated current, while type F must open from 0.001 seconds up to 0.01 seconds.

At lower levels of excess current, the acting time requirements laid down in IEC60127-4 are longer. For example, at 1.25 times the rated current the fuse cannot open within one hour, and at two-times rated current the time-to-open must not exceed two minutes.

Among the requirements for UL248-14, UL ampere rating tests for chip fuses (microfuses) are conducted at 100 % and 200 % of rated current. The fuse must carry 100 % of its ampere rating and must stabilize at a temperature rise that does not exceed 75 K. The fuse must open at 200 % of rated current within 2 minutes for ampere ratings up to 30 A.

To deliver the circuit protection required for small loads such as consumer products or medical handheld instruments, the MFU chip fuses are rated from 500 mA to 3.15 A at 32 V in 0402, 500 mA to 5.0 A at 32 V in 0603 and 0805 outline, and 500 mA to 6.3 A at 63 V in 1206 outline. Figure 2 shows the current versus time characteristics for very fast acting chip fuses in 0603 outline rated from 0.5 A

to 5.0 A, illustrating that each device meets the requirements of IEC60127-4 type FF fuses. Since the MFU series complies with both the UL and IEC safety standards (figures 3a and 3b), designers have the opportunity to develop only one electronic design for the global market instead of two designs. The MFU series is suitable in applications for the American market (UL) as well as for applications designed for the rest of the world (IEC). In terms of costs of ownership the MFU series reduces the costs of procurement, logistic, production, and spare part supply.

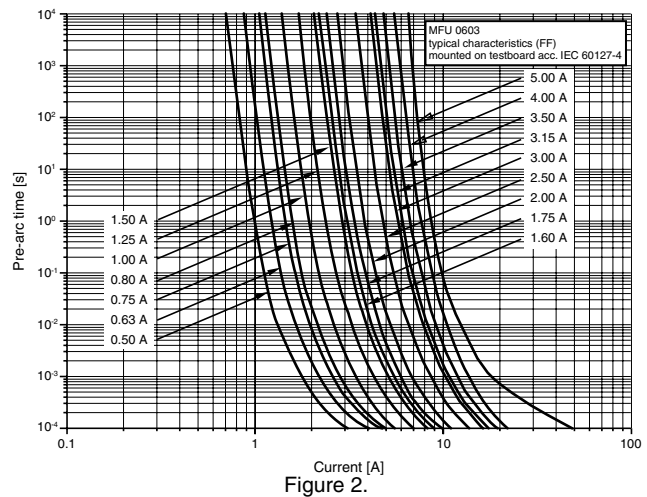


Figure 3a.



Figure 3b.

Endurance Testing

Both the UL and IEC standards call for endurance tests to be performed on compliant fuses. For instance, IEC60127-4 requires 100 cycles of exposure to full rated current, at an ambient temperature of 23 °C, followed by one full hour exposed to 1.25 times the rated current. The fuse must show no visible signs of damage upon completion of this test, and any measured increase of the voltage drop must be less than 10 % of the value measured before the test. The dissipation during exposure to 1.25 times rated current is also subject to specified limits, and the temperature of the fuse link must not rise excessively; this is detected by measuring for a greater than 85 K rise in temperature at the terminals.



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In addition, those requirements of the IEC 60068 Environmental Testing standard that apply to SMD resistors have also been added to the specification of the MFU Series. These include as some examples IEC 60068-2-78 (Cab) exposure to damp heat at a nominal 40 °C and 93 % relative humidity, applied for up to 56 days, IEC 60068-2-14 (Na) exposure to rapid temperature rise tests, and IEC 60068-2-6 (Fc) vibration testing for 6 hours duration. After each of these tests, any resistance change must be within 10 % of the nominal cold resistance of the fuse.

However, designers also need to be sure the fuse will remain stable throughout its intended lifetime, and will break under the conditions as described in the datasheet. Since neither aging characteristics nor construction techniques for chip fuses are stipulated in the published standards, designers will welcome additional measures that boost confidence in the device.

Long-Term Protection

Fuses performing secondary protection act as a virtually transparent element in the circuit for almost their entire lifetime, simply conducting current normally. But they must work as expected in the event of an over-current above its rated limit. The tests called for in the IEC and UL standards provide some assurance that this will be the case.

Techniques to enhance accuracy and control over the physical characteristics of the fuse element, such as thin film sputtering in chip fuse fabrication, allow fuse breaking characteristics to remain consistent over a longer lifetime than conventional chip fuse technologies. Hence chip fuses evolved from thin film chip resistor design and fabrication technology deliver an advantage. This technology provides a valuable extra degree of certainty that the device will perform its intended purpose when the time comes.

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