- One-shot fuses
- Positive Temperature Coefficient (PTC) resettable fuses
- Electronic fuses (eFuses)

Comparison of technologies

One shot fuses, which are based on melting of a metal link, must be replaced after a single high current event. They are commonly found in applications like LED bulbs where a simple device makes sense. For LED bulbs the solution to a blown fuse is just to purchase another bulb. It is a small expense and the fault leading to the open fuse likely requires replacement of the bulb anyway.

PTC resettable fuses are a step-up from one shot fuses. When a short circuit occurs, they heat up and transition from a low resistance state to a high resistance state. Allowing them to cool down (typically by removing the power) resets them to the low resistance state.

PTCs come in both ceramic (CPTC) and polymer (PPTC) types. Ceramic types are used in sensitive application spaces such as telecom where the resistance must not change much after tripping. The polymer type is used in many general electronics applications and is sometimes called alternatively a resettable fuse, or polyswitch. In this article, a polymer type is compared against an eFuse.

eFuses utilize a completely different operating principle than one-shot or PTC fuses. Instead of limiting current based entirely on heating, eFuses actually measure the current and turn off an internal switch if the current exceeds a specified limit.

Also, since eFuses are semiconductor integrated circuit devices they have a rapid (typically less than 10 μs) response to short circuits as well as a plethora of features that may be included:

- Ability to operate over temperature with minimal shift in parameters
- No degradation after a fault; the on resistance does not

eFuse vs. PTC Test Setup

To compare eFuse and PTC fault response an eFuse (ON Semiconductor NIS5132MN2) and a polymer PTC with similar characteristics were chosen to provide fault protection on a 12 V power rail. The eFuse R_{limit} resistor was chosen as 37.4 Ω to match the current limit specifications. Table 1 provides a brief comparison of the devices.

Table 1. PTC AND EFUSE SPECIFICATION COMPARISON

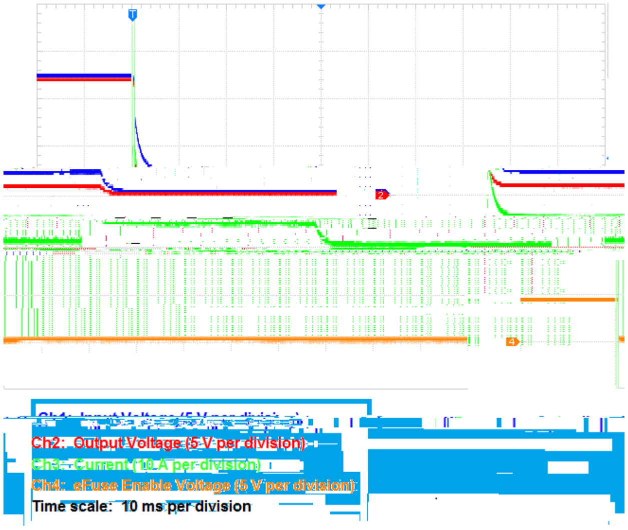
Specification	Polymer PTC	eFuse
Max Voltage	16	25
Hold Current	1.5 A	1.7 A
Trip Current	3.0 A	3.0 A
On Resistance	40 to 110 mΩ	44 mΩ
Package	1210	3 × 3 DFN
Length (mm)	3.2	3
Width (mm)	2.5	3
Height (mm)	0.55	1

The test circuit board is shown in Figure 1. It has coaxial connectors to measure input voltage, output voltage, current (voltage over a 20 mΩ resistor), and eFuse enable pin voltage. It also has a Zener diode and 10 μF input capacitor to suppress inductive spikes due to V = L(di/dt) transients on the power cable.

There are also switches to change between the eFuse and PTC and to short the output to ground. Furthermore, it has an onboard multimeter to read input voltage and output current. Standard eFuse peripheral components such as the R_{limit} and the output capacitor were included too. Generally eFuses do not require output capacitors for functionality, but it is a good idea to have them if large inductive voltage spikes are possible in the application.

Figure 1. The Circuit Board Used for Comparing the eFuse to the PTC

A 12 ohm load is connected from output to ground. Since both the eFuse and PTC have their current limits above 1 A, in normal operation 1 A is allowed to flowuireto1ere7r7(Figur009 Tc[(bo


Ch2: Output Voltage (5 V per division)
Ch3: Current (10 A per division)
Ch4: eFuse Enable Voltage (5 V per division)
Time scale: 10 ms per division

Desktop Computer Power Supply

The high current capability of the desktop computer supply allowed the PTC to trip quickly (see Figure 6). Clearly, the PTC performs much better with this supply than with the others; the input voltage trace is much more stable. As Figure 7 shows, the eFuse responds in a similar manner as with the other supplies, but even in this case the eFuse results in less disruption of the input voltage than with the PTC.

Figure 6. With the desktop computer power supply, there is a dip in the input voltage but the PTC trips in about 3 ms

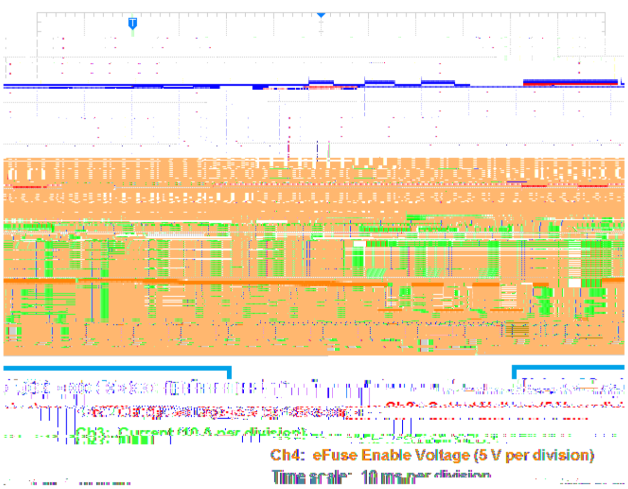


Figure 7. The eFuse responds as it did with the other power supplies. The response is quick and the input voltage stays high

Test Summary

It was observed during the tests that the eFuse responded to faults more quickly than the PTC, allowing the power supply rail to stay up better. The results are summarized in Table 2.

Table 2. FAULT RESPONSE TEST SUMMARY

Supply	PTC Response	eFuse Response
Wall Adapter	Fig 2: Did not trip	Fig 3: ~10 μs
Benchtop	Fig 4: Slow (~30 ms)	Fig 5: ~10 μs
Desktop Computer	Fig 6: Fast (~3 ms)	Fig 7: ~10 μs

Conclusion

In many cases, a PTC may provide adequate protection. Its response should be fast enough to prevent burn damage to wiring. In addition, its ability to maintain voltage levels in response to a fault can be enhanced by choosing a higher current supply, or perhaps even adding decoupling capacitance on the power supply (input) side.

However, in other cases an eFuse is not only a better choice but its superior performance and features are required to satisfy application requirements. The use of an eFuse may also save cost and board space if additional circuitry, needed to prevent inrush currents or to provide overvoltage protection, can be eliminated by using an eFuse. For more information about eFuses, please visit www.onsemi.com or contact your local ON Semiconductor sales representative for evaluation boards and samples.

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