A new level of circuit protection: The e-fuse

Steve Taranovich - January 03, 2014

Protecting the precious designs, that engineers create with their blood, sweat and tears, is a must and should be integrated as one of the foremost specifications and features of the design itself.

In this product review, I am highlighting the e-fuse features, specifically the Texas Instruments solution. Of course, fuses are adequate circuit protectors for so many designs and are good enough for many, many applications.

What is circuit protection?

Some key features that define circuit protection are:

- Short circuit protection
- Current limiting
- Hot swap
- Soft start
- Electronic circuit breaker
- Hot plug
- Inrush control
- Load power limiting
- Over voltage protection (OVP)
- FET SOA limiting (i.e. protecting the protector)
- Reverse current protection (ORing)

The first seven of these are encompassed in Texas Instruments’ e-fuse.

Agency ratings
Protection, as mentioned above, is frequently required in order to meet Agency ratings such as with IEC/UL60950, IEC/UL60730 and many more.

European agencies were the first to ask for an electronic fuse for appliances where conventional fuses were too slow, lossy, leave a load un-powered after an event and are inaccurate.

Aside from the agency ratings which force safe design methods, as designers we want to prevent fires, minimize damage by quickly isolating a failure and prevent disruptive power bus disturbances. The supply, connectors, power FETs and the load all need adequate protection.

**Designing protection into your creation**

A good designer will not just look over their circuit design and extensively test it to ensure that it meets all of the specifications over the temperature and other environmental conditions, but will employ some level of protection as needed like a fuse, PTC (Polyfuse) or maybe an e-fuse.

**The e-fuse**

The e-fuse is an active, rather than passive, circuit protector that always provides inrush current limiting, prevents load or source damage open circuit conditions, and has an internal FET to control the load current. An e-fuse may also provide fixed or adjustable OVP, adjustable fault time and/or current limit, indicator lights for such conditions as Fault, PG (Power good), and more, control of turn on slew rate, a load current indicator output, protection on the source or load side of a connector or wherever else it is needed or can be remote from the connector if desired.

**What’s in an e-fuse?**

**Most Common Elements**

- Element for modulating current
- Element for sensing current
  - (RSENSE is shown, but typically a senseFET)
- Element for controlling the FET

**Location..**

- Sometimes on the Load Side of the Connector
- Sometimes on the Supply Side of the Connector

TPS2592 e-fuse
Some e-fuse applications

Applications in the industry that call for e-fuses are Enterprise class and m-sata SSD (Solid state drives), SAS (Serial attached SCSI) HDD (Hard disk drives), Storage server chassis, Set-top box, Internet TV, DVD player, and appliances.

Trip time vs. current in a fuse vs. an e-fuse

Inaccuracies in time and trip limits lead to the need for larger power supplies

What about a Polyfuse vs. the e-fuse?
• **eFuse (USB power switch)**
  - Current based \( I_{\text{LIMIT}} \)
  - Stable, accurate (20% - 30%) \( I_{\text{LIMIT}} \)
  - Fixed or Programmable \( I_{\text{LIMIT}} \)
  - Repeatable \( I_{\text{LIMIT}} \)
  - Fast (< 1.5 ms typ)
  - Wide temp range
    - -40 °C to +125°C

• **Polyfuse**
  - Temp based \( I_{\text{LIMIT}} \)
  - Sloppy, variable \( I_{\text{LIMIT}} \)
  - No Programmable \( I_{\text{LIMIT}} \)
  - \( R_{\text{ON}} \) increases with each event
  - Slow to trip (several ms)
  - Not usable above 85°C
  - Auto—resets after trip event

Plus polyfuses (PTC devices) require de-rating.

For more information please visit Texas Instruments’ [website](http://www.ti.com).