Application Brief

Performance, Space, and Cost Optimized Protection Using TPS25961

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End equipments (EE) such as set-top box (STB), smart speakers, E-meters and many more, require a power path protection design that is both cost and space optimized. Conventional designs consist of discrete components such as MOSFETs, fuse, PTC, zener diodes,resistors, capacitors, and so on to turn on and off power supply rails. Although simple, these designs are often physically and electrically oversized and can lack protection features. In comparison, an eFuse with integrated FET like TPS25961 can provide similar functionality while providing additional system benefits including inrush current limiting and smaller design size. This application brief highlights benefits of using TPS25961 over a discrete design. TPS25961 is a 19 V 2 A eFuse with overvoltage, overcurrent and short circuit protection in a 2 mm × 2 mm package. This device is well adapted for personal electronics and industrial power path protection trends that require a design that have wide voltage range support, minimum 20 V absolute maximum support to withstand transients and current limiting support for less than 2 A.

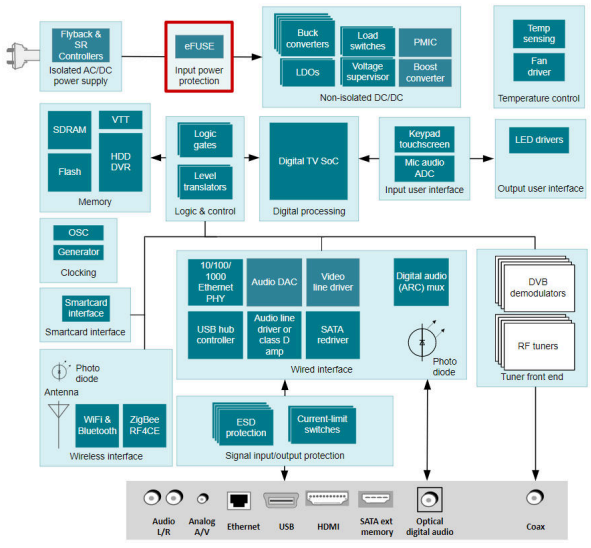


Figure 1. Set-top Box Design

Comparison with Discrete Implementation

Figure 1 shows a typical discrete implementation for application , for example adapter and or USB input protection in end equipments (EE) such as STB, wireless ear buds charging case, and so on. The design is a very basic implementation that provides power path on and off functionality and inrush current control. Advantage of using TPS25961 is the integration of key power path protection features into a simpler, smaller design, including thermal shutdown, controlled rise time, overvoltage, and short circuit protection. Applications requiring additional robust power path protection other than on-off control must add more components to basic discrete implementation which will further increase the design size and complexity. In some instances, such as thermal shutdown, this might not be properly implemented with discrete components. Figure 3 compares the design size of a basic discrete design that offers on-off control and fixed overcurrent protection with TPS25961 configured in most optimized way that provides fixed overvoltage and overcurrent protection. In this example, the discrete FET design consists of 7 components with a total design size of 80 mm^2 . In comparison, the TPS25961 consists of the single IC at 4 mm^2 with a 95 % reduction in design size. TPS25961 can also be configured for a generic use case having programmable overvoltage and overcurrent protection by adding a resistor divider at OVLO pin and one resistor at ILIM pin as shown in Figure 2.

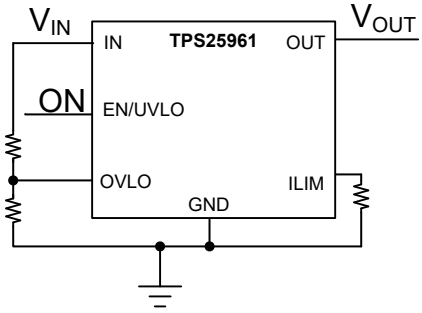
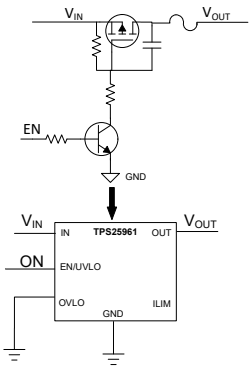


Figure 2. TPS25961 Configured for Programmable OVP and OCP



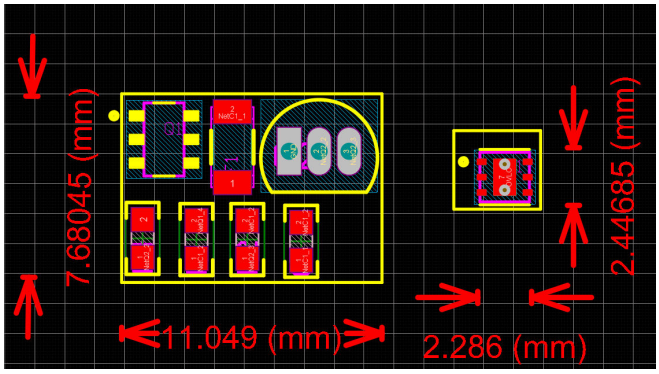


Figure 3. Discrete vs. TPS25961 Design Size

Table 1. Comparison of TPS25961 with Discrete FET Design

	TPS25961		PMOS Discrete Design
	Fixed OVP and OCP	Programmable OVP and OCP	
BOM count	1	4	7
design size	4 mm^2	33 mm^2	80 mm^2
Inrush current control	Linear, Lower inrush current	Linear, Lower inrush current	RC based, Higher inrush current
Thermal shutdown	Yes	Yes	Requires additional components
Short circuit protection	Yes	Yes	
Overvoltage protection	Yes	Yes	

Overvoltage Protection

Some EE such as wireless ear buds charging case have a requirement for fixed overvoltage protection threshold to save on the bill of materials (BOM) count due to resistors used for adjustable overvoltage protection. TPS25961 device comes with an OVLO pin, when pulled low configures device for fixed 6 V overvoltage protection. OVLO pin can also be configured in the usual resistor divider method and the device can provide programmable OVP. Adding overvoltage protection circuitry to basic discrete implementation needs extra components, for example op-amp and resistors that further increase the design size.

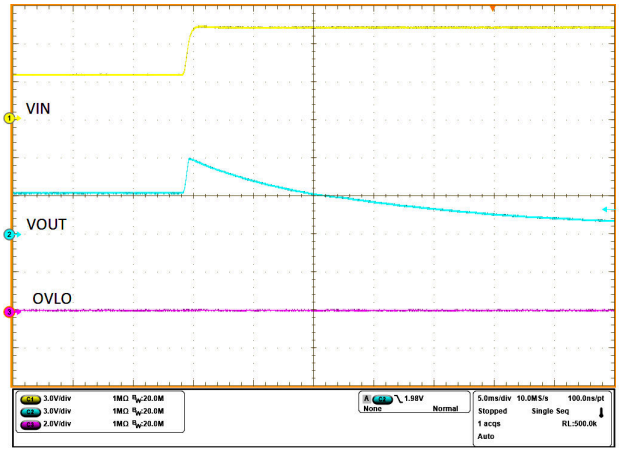


Figure 4. Fixed 6 V OVP Response

Overcurrent Protection

Implementing overcurrent protection features using discrete components can have shortcomings comparable to lesser accuracy, larger size, and slower response time. To reduce inrush current, a discrete implementation uses an RC delay by connecting a capacitor from the source to the gate of the PMOS FET. Although this process helps reduce the inrush current by reducing the switching speed of the PMOS, the RC delay makes it difficult to control the peak value of the current due to the non-linear behavior of the output voltage rise time.

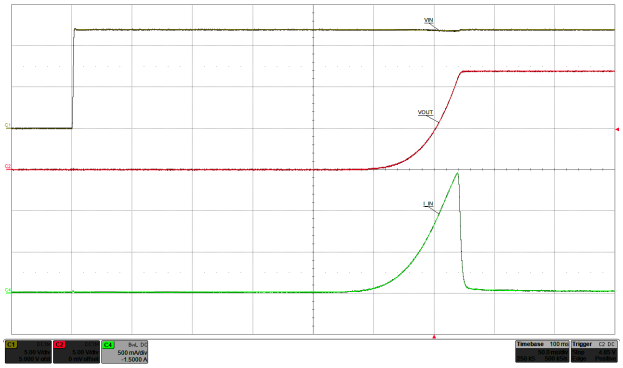


Figure 5. Discrete design Inrush Current Control

TPS25961 offers fast and accurate current control protection features such as inrush current control, configurable current limit, and short at output protection. TPS25961 helps in smart meter applications, for example limiting current drawn from SMPS during overcurrent faults and bulk cap charging events thus prevents input supply from collapsing which is very crucial in an EE such as E-meter.

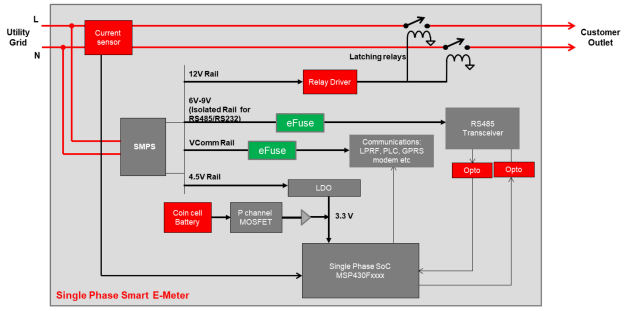


Figure 6. Single Phase Smart E-meter

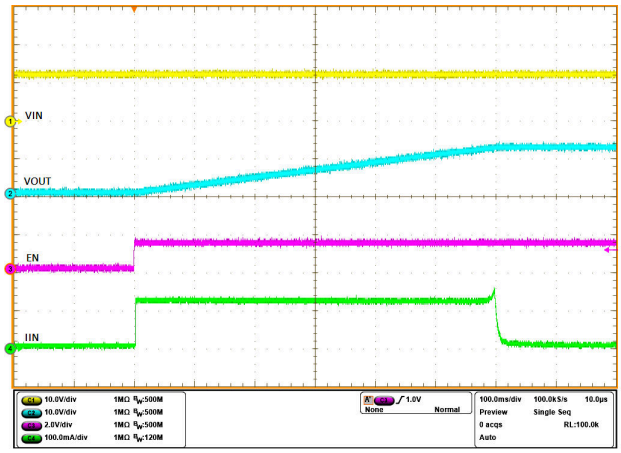


Figure 7. TPS25961 Charging 6400 uF at 0.1 A Current Limit

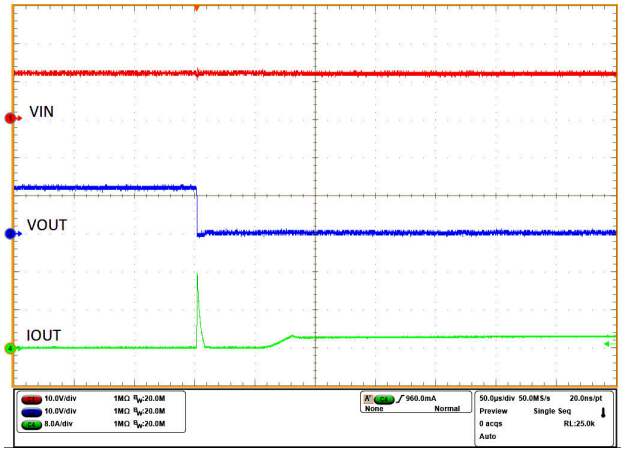


Figure 8. TPS25961 Short at Output Protection

Thermal Shutdown

FET junction temperature can rise due to many factors, including a high current load, large inrush current during startup, or during a fault condition like short at output. Thermal shutdown feature of TPS25961 turns it off when integrated FET junction temperature reaches near a certain threshold thus saving the FET from damage. In comparison, discrete circuits generally do not incorporate thermal protection for the pass FET. If discrete protection is not designed properly, in stress events, the FET can fail in short due to overstress and damage the downstream load or peripheral.

Conclusion

TPS25961 offers higher performance and smaller design size as compared to discrete power path protection designs. TPS25961 offers various system level benefits such as size reduction of wireless ear bud charging case, minimizing over-design, and preventing SMPS from collapsing and ensuring robust, reliable power path in security cameras.

Additional Resources

- Basics of eFuse
- How eFuse Ensures Integrated FET Operation in Safe Operating Area
- eFuse Making Smart Meter Robust and Reliable

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