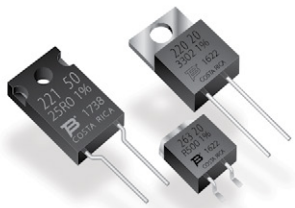
APPLICATION NOTE

Understanding the Importance of Resistive Components in Switched-Mode Power Supplies

Thick Film Resistors

Metal Foil and Strip Chip Resistors


High Power Resistors


Current Sense Resistors


Trimpot® Trimming Potentiometers

Introduction

Switched-Mode Power Supplies (SMPS) offer a highly efficient power technology that enables systems to operate with a wider input voltage range and a longer output voltage holding time compared to conventional linear power supplies. The result is that customers can build smaller and lighter applications. Supporting SMPS-based designs are new, smaller form factor transformers and resistors (such as the 0201 or 01005 size components shown in Figures 1 and 2).

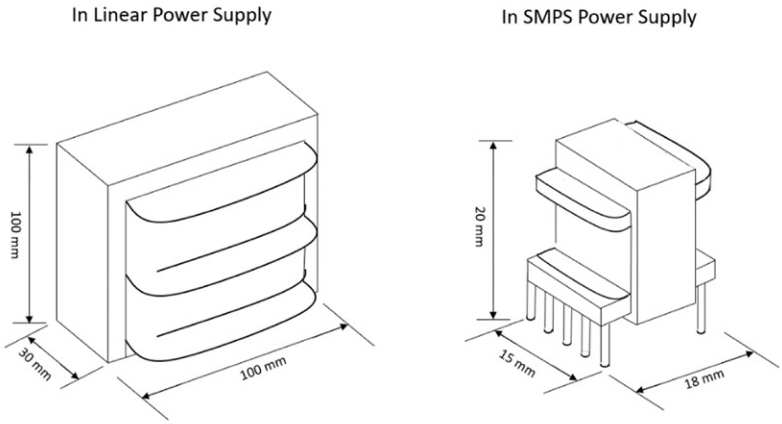


Figure 1. | *Transformer size comparison between a conventional power supply and an SMPS power supply.*

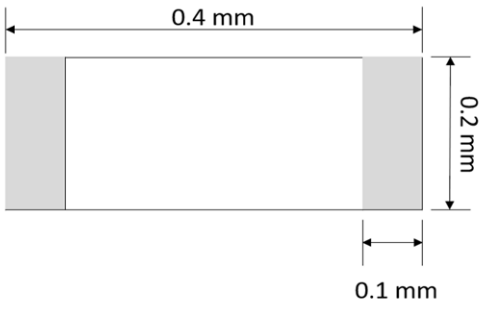
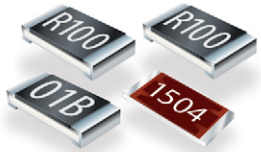


Figure 2. | *Resistor footprint in 01005 size.*

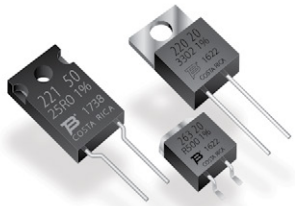
There are many different topologies used in SMPS designs including forward, flyback, boost, buck, buck-boost, half-bridge and full-bridge. The flyback topology is the most popular and is commonly used in consumer and industrial SMPS-based applications, such as mobile phone chargers, portable power banks, laptop chargers or in AC-DC converter applications.

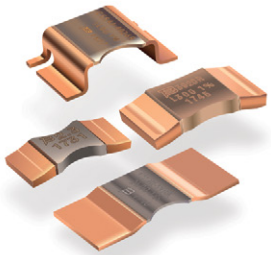
Understanding the Importance of Resistive Components in Switched-Mode Power Supplies



Thick Film Resistors

Metal Foil and Strip Chip Resistors


High Power Resistors


Current Sense Resistors


Trimpot® Trimming Potentiometers

Resistor Functions for Flyback Topology

As shown in Figure 3, resistors play an important role in SMPS. The example below shows a flyback topology with resistors in snubber circuitry to be placed ahead of the transformer to protect it. The snubber resistor in circuitry helps protect the transformer by discharging the capacitor.

This paper will provide tips on how to select the right resistive products for a flyback power topology SMPS design. It will present how and why resistors are selected and used in this type of electronic circuitry. Figure 3 below illustrates a schematic for a typical flyback topology.

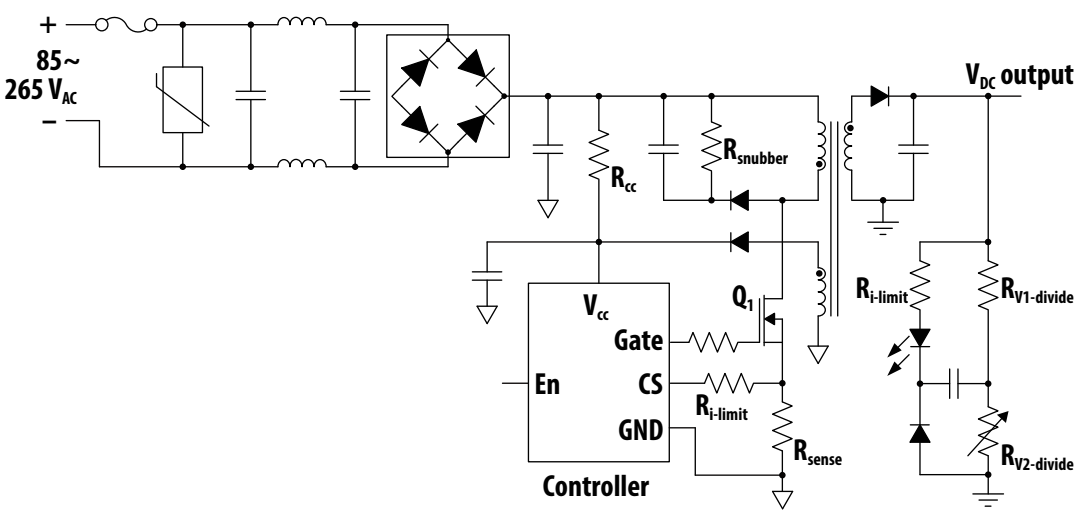
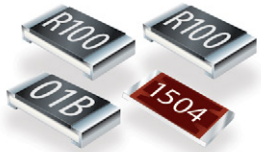


Figure 3. | *Illustration of flyback power topology.*

Figure 3 illustrates that there are many resistors used in a flyback design and how each resistor has its own function which must be considered for the circuit to perform properly.

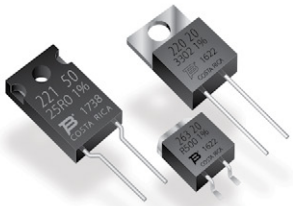
For example, resistor R_{CC} is in place to withstand high voltage from the bridge rectifier and is used in the pre-charging phase to protect the controller. For this function, the Bourns® Model CHV and CHV-A Series feature high voltage withstanding capability, up to 3 kV operating voltage and compliance with UL 1676 and UL 62368-1 standards that help ensure higher reliability.

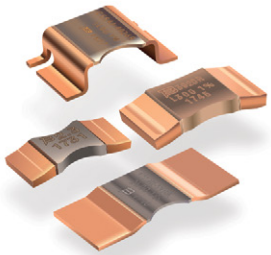
Understanding the Importance of Resistive Components in Switched-Mode Power Supplies



Thick Film Resistors

Metal Foil and Strip Chip Resistors


High Power Resistors


Current Sense Resistors


Trimpot® Trimming Potentiometers

Resistor Functions for Flyback Topology (Continued)

Resistors for $R_{snubber}$ are employed to protect the transformer due to countless continuous large surge voltages generated when MOSFET Q_1 is in switching mode. The resistance value of the $R_{snubber}$ function needs to be determined by the leakage inductance of the transformer's switching frequency, clamped voltage of the MOSFET flyback voltage, and the current flow going through the primary side of the transformer, which are all dependent on the customer's requirements. Bourns® Model CMP, CMP-A, CHP and CHP-A Series offer high surge capability, low TCR and a wide resistance range suitable for the snubber function. For instance, the maximum surge capability of the Model CHP Series in 100 µs is 800 W and the Model CMP Series supports up to 1 kW in 100 µs. If a higher surge voltage capability is required, Bourns® Model PWR163, PWR263S, PWR220T or PWR221T Series are good options for this application as the maximum peak pulse power of the PWR Series is up to 5 kW in 100 µs.

The R_{sense} function resistors are used for monitoring current flow through the primary side of the transformer during MOSFET Q_1 switching. Depending upon how the controller is designed for the application, it will sense voltage from R_{sense} and determine when to turn Q_1 ON or OFF to protect the AC-DC converter and load connected with the output terminal. The resistance value and power rating are determined by the current flow through the transformer, switching frequency, duty cycle of the MOSFET and the controller's sense capability.

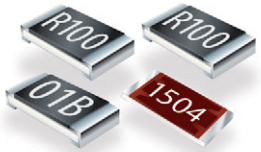
Bourns® Model CRM, CRM-A, CST0612, CRE2512, CRA2512 and CRF Series are offered in SMD packages and feature low resistance values under 1 Ω. The lower resistance tolerance, down to 0.5 %, and their small package size range, from 0603 to 2512, makes these resistor model series ideal solutions to sense the current flow. For higher current flow sensing, or if a very low resistance value is required (1 mΩ or lower), Bourns offers the Model CSS2H-2512, CSS2H-3920, CSS2H-5930 and CSS4J-4026 Series, which are Electron Beam (EB) welded, fully metal current sense resistors that offer low inductance, low thermal EMF, low TCR, low thermal resistance, and AEC-Q200 compliancy.

Resistors for the $R_{i\text{-}limit}$ function limit input current for protecting the controller, and thus require an accurate resistor to help ensure the most effective protection. To fill this need, Bourns offers 0.5 % tolerance resistors such as the thick film Model CRM Series.

In addition, $R_{v1\text{-}divide}$ and $R_{v2\text{-}divide}$ resistors are utilized to divide output voltage feedback to the controller, which also requires more accurate resistors. Again, Bourns® Model CRM Series, providing 0.5 % resistance tolerance with 100 PPM/˚C in a small 0603 package size, is an excellent choice for $R_{v1\text{-}divide}$ and $R_{v2\text{-}divide}$. If the engineer is designing for user flexibility, the $R_{v2\text{-}divide}$ can be a variable resistor to cater to different controllers. Ideal solutions are the Bourns® Model 3313 and 3314 Series Trimpot® Trimming Potentiometers offered in a single-turn, AEC-Q200 compliant compact SMD footprint, with 0.1 % adjustability of the voltage divider to meet the requirements for this application.

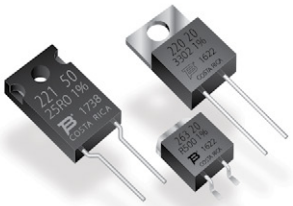
APPLICATION NOTE

Understanding the Importance of Resistive Components in Switched-Mode Power Supplies



Thick Film Resistors

Metal Foil and Strip Chip Resistors


High Power Resistors


Current Sense Resistors


Trimpot® Trimming Potentiometers

Conclusion

Based on the functional requirements of flyback topology SMPS, this paper has shown that resistors are essential design components that can aid in delivering the higher reliability demanded in today's consumer devices, industrial applications, motor control or automotive applications. The Bourns® resistive products highlighted in this paper are provided as a resource for engineers to help improve their design's performance, quality and safety.

Additional Resources

For more detailed information on the resistor series presented, please see:
https://www.bourns.com/products/resistors
https://www.bourns.com/products/resistors/thick-film-chip-resistors
https://www.bourns.com/products/trimpot-trimming-potentiometers/trimpot-trimming-potentiometers-single-turn

Bourns® Resistive Products for Switched-Mode Power Supply Designs :
https://www.bourns.com/docs/product-datasheets/chp.pdf
https://www.bourns.com/products/resistors/current-sense-resistors
https://www.bourns.com/products/resistors/high-power-resistors

www.bourns.com

BOURNS®

Americas: *Tel* +1-951 781-5500
Email americus@bourns.com

EMEA: *Tel* +36 88 520 390
Email eurocus@bourns.com

Asia-Pacific: *Tel* +886-2 256 241 17
Email asiacus@bourns.com