APPLICATION NOTE

Using High Pulse Resistors for Precharge and Discharge of Capacitors

Bourns® High Pulse Resistors

INTRODUCTION

A capacitor is a passive electrical component which stores electrical energy in the dielectric field between its two plates. The charging and discharging process of the capacitor can cause high energy pulses that have the potential to damage the circuit. Therefore, it is recommended that designers use a resistor to absorb these pulses.

This application note outlines the various types of resistors and how they are used in capacitor-based designs. It presents an optimal resistor solution along with what features designers should consider when selecting the right resistor to help mitigate precharge and discharge high energy pulses. Finally, it provides a list of Bourns® advanced high pulse resistor products that are designed to help protect against the issues associated with capacitor charging and discharging.

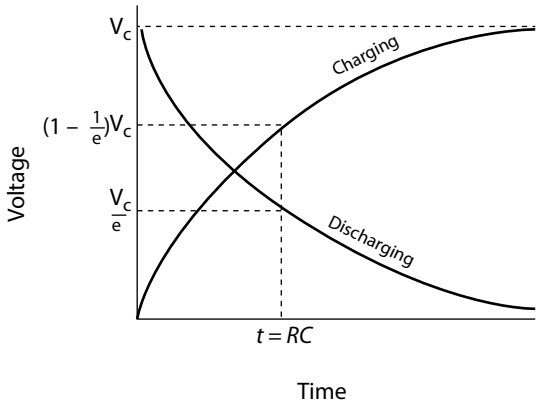

Figure 1. The typical charging and discharging process in a capacitor

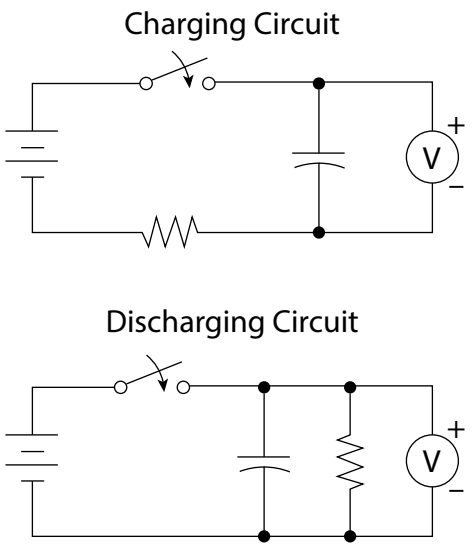

Figure 2. Precharge resistor

Figure 2 illustrates how a precharge resistor absorbs the energy peak of inrush current caused by a capacitor being charged after the circuit is switched on.

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COMMON RESISTOR TYPES AND THEIR USES

Bleeder or discharge resistors are mainly necessary for safety reasons. The common placement is for the resistor to be connected in parallel to the filter capacitor so it absorbs the electrical energy remaining in the capacitor after the power is switched off.

Filter or smoothing capacitors are widely used for 'smoothing' or evening out the output voltage of commercial, industrial and automotive power supplies and inverters. It is common in AC-DC converters to use a rectifier to convert the AC signal into DC power. The rectifier provides pulsating DC output with a frequency of 50 Hz. The switching mode used by the DC-DC converter's rectified output voltage is also pulsating with the converter's switching frequency, which is normally hundreds of kilohertz or megahertz.

A filter capacitor is typically connected to the rectified signal and charged by the pulse energy of the halfwave. Then, the energy stored in the capacitor is discharged while the voltage falls, thus smoothing the DC output voltage. The capacitance value of the filter or smoothing capacitor should be high enough to effectively reduce ripple voltage.

Even after devices are turned off, filter capacitors in the power supply circuit can still store an electrical charge. This electrical energy that remains in capacitors is a safety issue as it can potentially cause an electrical shock to operators or can result in damage to the surrounding components. By connecting bleeder or discharge resistors in parallel with the capacitor, they are able to dissipate the energy stored in the capacitor to help prevent injuries and/or system damage.

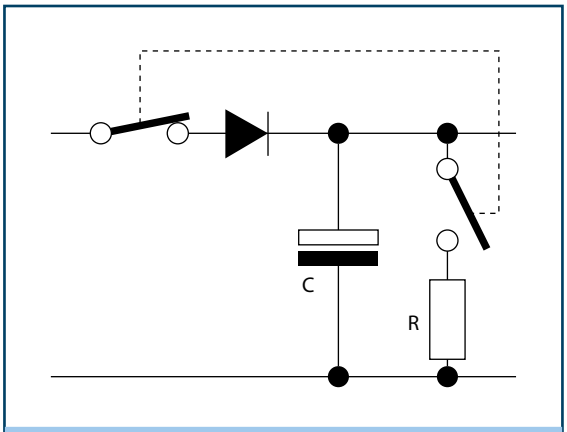

Figure 3. Bleeder resistors connected in parallel to the capacitor controlled by a switching circuit

In addition, a bleeder resistor can also be used to improve voltage regulation. It provides a minimum load for the output, lowering the no load voltage and helps to minimize the difference between no load voltage and the rated load voltage.

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IDEAL SOLUTION FOR CAPACITOR PRECHARGE/DISCHARGE PULSES

The optimum solution to safeguard against capacitor precharge and discharge high energy pulses is to specify a bleeder resistor that has high pulse power and short time overload capabilities in order to effectively dissipate charge energy of the filter capacitor.

The following characteristics need to be evaluated when selecting a bleeder resistor:

- C Capacitance value of the filter capacitor to be discharged
- V_o Initial voltage of the capacitor
- V_t Safety threshold voltage level to be achieved in Δ_t
- t Required maximum duration while capacitor discharged for V_o to V_{min}
- R Resistance value of bleeder resistor

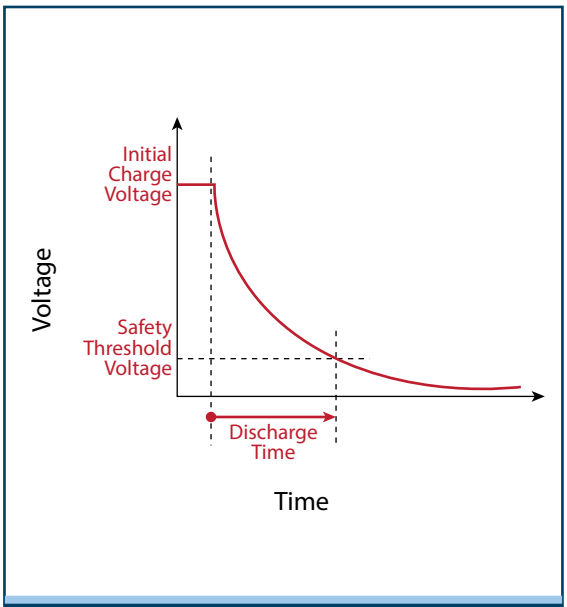

Figure 4. The voltage change of the capacitor during discharge

Discharge voltage after t time:
$V_t = V_{oe}^{-(t/RC)}$

Resistance of bleeder resistor:
$R = t/(e^{-(V/Vo)} * C)$

Discharge energy:
$E = ½ C*V^2$

The discharge energy level cannot exceed the pulse capability of the resistor.

The lower the resistance value, the higher the current flows through the resistor and the higher the pulse dissipation capability required from the resistor. On the other hand, the higher the bleeder resistance value, the more time that is required to discharge the capacitor.

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BOURNS® HIGH PULSE RESISTORS

Bourns offers a variety of high pulse resistor solutions designed with features to match a wide range of application requirements. A key example is Bourns® CMP Series pulse withstand thick film resistors which are designed to absorb high pulse peak power. In addition, the Bourns® CRS Series pulse power resistors are tested for 1.2/50 µs surge, and the Bourns® CHP Series pulse power resistors feature an extremely high rated power up to 3 watts. Bourns® CHV Series is able to handle high working and overload voltage and is UL 1676 recognized. These advanced high power thick film chip resistors can be used as a single solution or connected into an array to absorb capacitor charge and discharge energy.

Model	Feature	Size	Rated Power
CRM CRM-Q CRM-A	High Power AEC-Q200 compliant, automotive grade and sulfur-resistant models available	0603 to 2512	up to 2 W
CRS CRS-Q CRS-A	Surge withstand IEC 61000-4-5; 1.2/50 µs AEC-Q200 compliant, automotive grade and sulfur-resistant models available	0603 to 2512	up to 2 W
CMP CMP-Q CMP-A	High Pulse AEC-Q200 compliant, automotive grade and sulfur-resistant models available	0603 to 2512	up to 1.5 W
CHP CHP-Q CHP-A	Ultra-High Power AEC-Q200 compliant, automotive grade and sulfur-resistant models available	0603 to 2512	up to 3 W
CHV CHV-Q CHV-A	High Voltage UL 1676 compliant AEC-Q200 compliant and automotive grade models available	0603 to 2512	up to 2 W

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Bourns® High Pulse Resistors

BOURNS® HIGH PULSE RESISTORS (Continued)

Bourns® PWR series high power thick film resistors feature excellent pulse capability and are available in DPAK and D²PAK for SMD mounting and in a TO-220 housing for through-hole soldering.

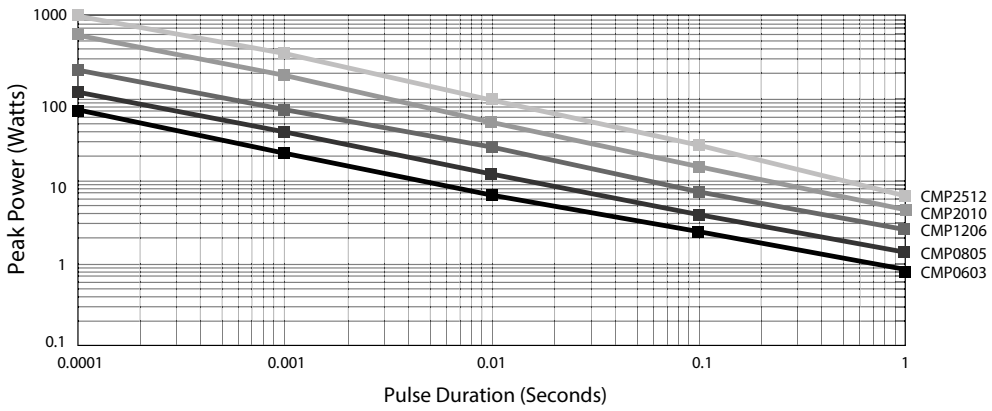

Figure 5. Pulse power graph for CMP Series pulse withstand thick film chip resistors

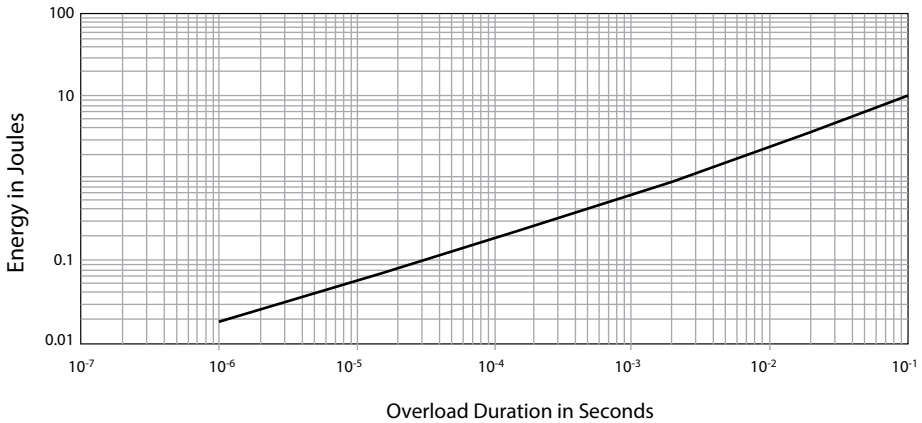

Figure 6. Pulse energy graph for Bourns® Model PWR263S-35 Series high power thick film resistors

Model	Package	Mounting	Rated Power
PWR163	DPAK	SMD	25 W
PWR263	D²PAK	SMD	20 and 35 W
PWR 220	TO-220	Through-hole	20 to 50 W

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CONCLUSION

Bleeder resistors are essential design elements in various electronic devices where voltage is converted between different forms and levels. They are also required when output voltage needs to be filtered by a filter capacitor such as in AC-DC, DC-DC converters, motor drives, and traction inverters that are commonly employed in a wide range of commercial, industrial and automotive market applications.

With the comprehensive range of high pulse resistors offered by Bourns, designers are able to source the right solutions for their particular application. Higher power densities, wider operating temperatures, lower temperature coefficients, and elevated operating voltages are just a few of the challenges that Bourns® resistive products are continually being designed to meet.

BOURNS®

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