Solid Aluminum Capacitors with Organic Semiconductor Electrolyte

EXPLANATION OF THE RUSH CURRENT SUPPRESSION METHODS

There is the chance that an excessive amount of rush current will flow through the Vishay OS-CON capacitor when it is used in the following circuits because its ESR is exceedingly low. Therefore, careful consideration and measures must be taken with regard to design and production equipment. Use the Vishay OS-CON capacitor so the rush current value does not exceed 10 A.
In case that 10 times the allowable ripple current value exceeds 10 A, the Vishay OS-CON capacitor can be used within that value.

1. DC-DC Converter Input Circuits

a. DC-DC converter circuits are usually a PC board block shape and use a low ESR capacitor in the input section for high performance and miniaturization.

b. Consideration must be given to the rush current that flows the equipment when DC-DC converter is adjusted and inspected.

- There is the possibility that an extremely large amount of rush current will flow through the Vishay OS-CON capacitor during voltage adjustment or inspection of the DC-DC converter's circuit block when the power impedance supplied from the equipment being adjusted or inspected is exceedingly low and the current suppression function of the current limiter and such is provided.

  (Refer to the example in Figure 1.)

- Rush current suppression measures must be taken for DC-DC converter adjustment and inspection equipment.

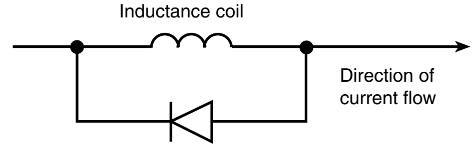
2. Circuits Driven by Chargeable Batteries

b. Circuit power lines equipped with batteries or rechargeable batteries use capacitors such as the Vishay OS-CON with very low ESR to increase performance and facilitate miniaturization.

- There is the possibility of an extremely large amount of rush current flowing through the low ESR capacitors arranged along the power line when the power is turned on for circuits driven by nickel cadmium chargeable batteries and such that have a very low internal resistance.

  (Refer to the example in Figure 1.)

- A protection circuit like that is shown at the top of the next column is usually used to suppress rush current of charging battery.



The main points to be aware of are listed here.

- Normally, an inductance coil with a magnetic core is used; however, inductance sometimes drops depending on the frequency, so it must be checked.
- The peak current value of the diode when absorbing counter electromotive force.

3. No Protection Resistance Rush Current

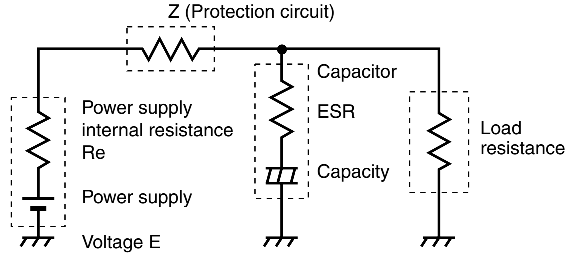
When there is no protection, Resistor Z as shown in Figure 1 and the power supply has Re = 0 Ω, the Vishay OS-CON capacitor's rush current is as follows.

$$\text{Rush current (A)} = \frac{\text{Supplied DC voltage (E)}}{\text{ESR} + \text{Re} + \text{Z}\ (\Omega)}$$

Example:
For type 94SC106X0025C
ESR = Less than 90 mΩ, and
supplied DC voltage = 20 V,

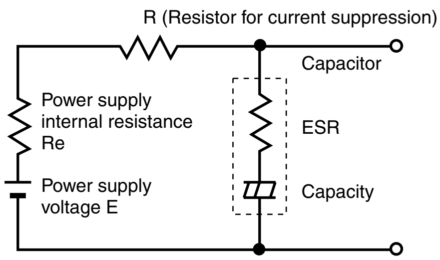
$$\frac{\text{Then } 20\text{ V}}{\text{Less than } 0.09\ \Omega} = \text{more than } 222\text{A}$$

Figure 1



EXAMPLE OF RUSH CURRENT SUPPRESSION METHODS

1. Resistor Method

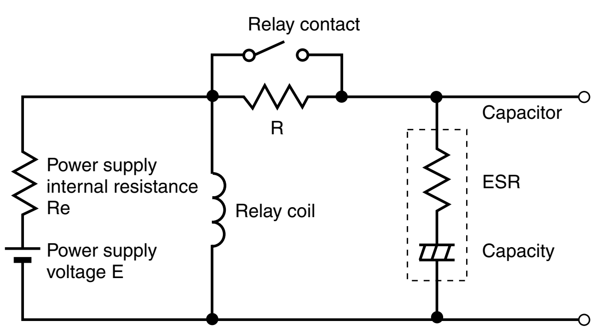


- Rush Current is as shown below.

$$\text{Rush current (A)} = \frac{E\ (V)}{Re + ESR + R\ (\Omega)}$$

- Rush Current is usually determined mainly by R, as Re and ESR are low.
- Although the current is simply and clearly suppressed with this method, resistor R is suppressing current causes the voltage to drop.

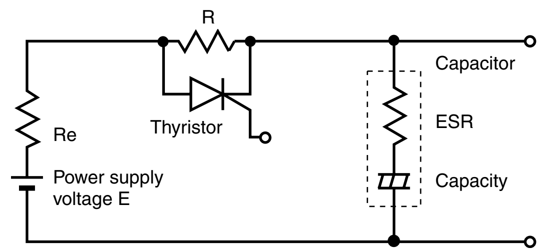
2. Resistor and Relay Method



- The Rush Current is exactly the same as in the resistor method, however, there is almost no voltage drop caused by the current suppression resistor from the time the relay contact goes ON.
- Note that the relay MUST be changed depending on the voltage of the supplied power.

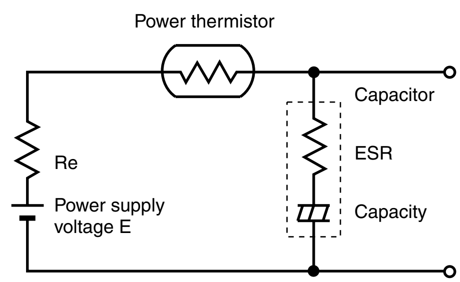
  This is mainly because the relay coil's specifications differ depending on the voltage.

3. Resistor and Thyristor Method



- Rush Current is exactly the same as in the resistor method, however, there is almost no voltage drop caused by R after rushing, the same as the resistor and relay method.

4. Power Thermistor



- Taking an example of a power thermistor sold on the market, the value is 8 Ω at + 25 °C, but becomes - 0.62 Ω at + 130 °C.
- When the power thermistor is connected as shown in the above diagram, rush current is suppressed due to the large resistor value at the moment the switch is turned on.

  After this, the output loss (voltage drop) is reduced.

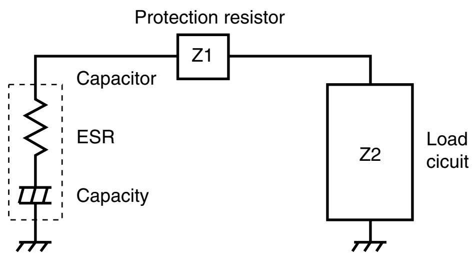
  However, the power thermistor has a heat constant, meaning that the large resistor value in the initial state cannot be regained the moment the switch is turned off.

  As a result, the ability to suppress current is lost when the switch is turned off and on quickly.

SUDDEN DISCHARGE CURRENT SUPPRESSION METHODS

Since the Vishay OS-CON capacitor has an exceedingly low ESR and when the load impedance during discharge is extremely low, there is the chance that it allows a large amount of discharge current to flow for an instant.
Please note the following points when using Vishay OS-CON capacitor in sudden discharge operations.

The discharge equivalent circuit is as shown below.



As shown in the above example, there is the chance an extremely large amount of discharge current will flow when electric charge is discharged with 0 Ω loading. When the Vishay OS-CON capacitor is to be used in sudden discharge operations, use the above mentioned formula to estimate the discharge current.

Use the Vishay OS-CON capacitor so the peak discharge current value does not exceed 10 A. In case that 10 times of the allowable ripple current value exceeds 10 A, the Vishay OS-CON capacitor can be used within the value.

The formula for estimating discharge current is given below.

$$\text{Discharge current (A)} = \frac{\text{Charging voltage (V)}}{\text{ESR + Z1 + Z2 } (\Omega)}$$

Example:

For type 94SC106X0025C
ESR = Less than 90 mΩ
Charging voltage = 20 V
Z1, Z2 = 0 Ω
is set, then

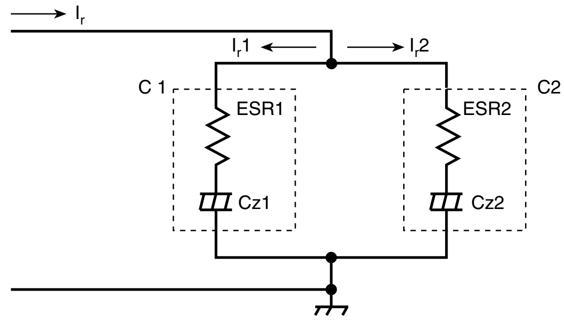
$$\text{Discharge current (A)} = \frac{\text{Charging voltage (V)}}{\text{ESR + Z1 + Z2 } (\Omega)}$$

$$= \frac{\text{Then 20 V}}{\text{Less than 0.09 } \Omega} = \text{more than 222 A}$$

CONNECTING A VISHAY OS-CON AND AN ALUMINUM ELECTROLYTIC CAPACITOR IN PARALLEL

Aluminum electrolytic capacitors and Vishay OS-CON capacitors are often connected in parallel to improve the space factor and cost performance of ripple absorbing capacitors. Please give full consideration to the following.

Figure 1

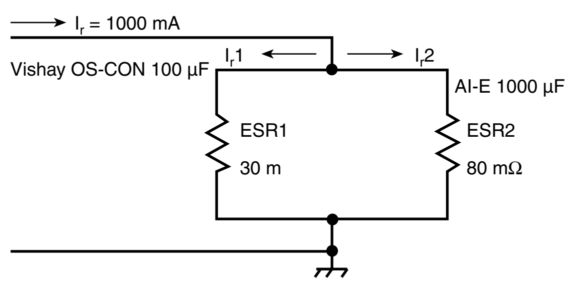


I_r = Total Ripple Current
ESR = Capacitor's Equivalent Series Resistance
Cz = Impedance of the capacitor's capacitive components

Ripple current flowing through each parallel connected capacitor can be found by using the values symbolized in the reference equivalent circuit in Figure 1.

The equivalent circuit in Figure 1 can be simplified as shown in Figure 2 when it is to be used for frequencies between 100 kHz and a few MHz. (Assuming the capacitor's capacity is more than 10 µF.)

Figure 2



Since impedance becomes exceedingly low when the capacity is more than 10 µF, and frequencies higher than 100 kHz, each Cz in Figure 1 can be omitted changing the actual ripple current value to that shown figure 2.

$$\text{Ir 1} = \text{Ir} \times \frac{\text{ESR2}}{\text{ESR1 + ESR2}}$$

$$= 1000 \text{ mA} \times \frac{80 \text{ m}\Omega}{30 \text{ m}\Omega + 80 \text{ m}\Omega} = 727 \text{ mA}$$

As shown here, although the Vishay OS-CON capacitor has 1/10th of the capacity of that the mated capacitor, it allows 73 % of the ripple current flow.

As explained here, when a Vishay OS-CON capacitor and an aluminum electrolytic capacitor are to be used in parallel connection, select the appropriate type of Vishay OS-CON capacitor that has an extra margin of capacity since a large amount of ripple current flows through it.