# Important Information:

(Constant-Current, Circuits, Rating Selections)

## 1. Switching Constant Current Loads:

DO NOT use solid state contactors (SSCs) to switch constant current without ensuring open-circuit voltage is within limits of SSC's operation.

## 2. Placement in Circuits:

M1™ SSCs can switch either the high side or the low side. The switching of the high side is preferred as it is deemed safer.

## 3. SSC Rating Selections:

Different manufacturers may specify SSC's ratings differently. For example, some manufacturers use SSC's peak current as the "rated current", other manufacturers may specify ratings based on transistor's performance at 25°C; both cases require further user deratings. M1™ SSC's ratings are specified based on a more realistic approach, which is typically when the transistors are in operation and well heated.

Tolerances need to be considered in the design of all electrical applications. Most semiconductor failures are the result of misuse, improper selection, or the lack of clamping. While selecting SSC ratings, you must consider parameters such as inrush current, transients, and other circuit variables.

### 3.1 Rated Current Selection:

For all applications, the SSC's rated load current must be higher than circuit's worst-case peak current. It is important to recognize, for example, the peak current of resistive circuits may be 1.4x higher than the nominal current due to reduced resistance at a cold-start. The peak current of DC motor circuits may be the initial inrush current or the stall current that's likely 6-8x higher. Similar, the peak current of capacitive circuits may the short circuit current.

**Helpful Tips**

- Choose M1™ SSCs with higher rated current, enhances both reliability and thermal performances.
- For some M1™ SSC models, multiple units can be connected in parallel to share continuous current and/or to reduce power loss. However, in order to ensure that instantaneous peak current is also shared, both units must be customized. Contact us for more details.
- For general overcurrent protection, add a quick fuse or air circuit breaker in your circuit to protect your load. Although neither device will act fast enough to protect the SSC from surge current damages, they will stop the SSC from generating excessive heat due to overcurrent.

### 3.2 Rated Voltage Selection:

Consider choosing a rated voltage 2x higher than the nominal voltage for resistive loads and even higher for inductive loads. For some M1™ SSC models, you may connect multiple units in series to increase rated voltage. Contact us for more details.

*Regarding di/dt and Inductive Loads

M1™ SSC can open a circuit within 10s of µS. As a result, a significant back EMF may be generated when opening high currents. SSC's opening time may be customized to improve EMI behaviour during inductive switching, however, this is not always ideal. For high current, high frequency, or inductive switching, it is essential to choose SSC ratings and make external clamping decisions based on the estimated BEMF ($-V = L * di/dt$) and inductive energy potential ($E = \frac{1}{2} * L * i^2$). Naturally, BEMF voltage should not exceed the SSC's rated voltage; however, for applications where the overall energy released by the inductor is negligible when compared to SSC's "power rating", external inductive clamping may not be required.

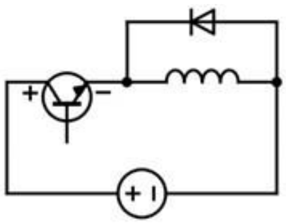
**Helpful Tips**

- For applications with high di/dt or inductance, consider:
  - Choosing M1™ SSCs with higher overall ratings
  - Choosing M1™ SSCs with internal TVS protection
  - Choosing full-bridge forward and reversing SSC
  - Clamping the circuit externally with one of the methods described in section 4. below

**4. Managing Inductive Kicks:**

When switching inductive loads, high energy inductive kicks could damage the SSC. Even if damages do not occur immediately, it may affect SSC's long term reliability. For switching inductive loads, clamp the load with one of the two methods described below. It is not recommended to solely rely on MOV nor RC snubbers for protection because MOV is not intrinsically reliable, and the RC snubber circuit may not be effective.

#1) Freewheel Diode/Catch Diode Method

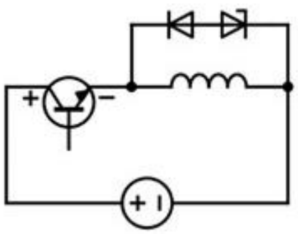


This is the most common and effective method. The reverse-biased rectifier diode would exponentially decay the flyback energy by looping it back to the inductive load through the resistance of the wires and the load. The duration of the decay, depending on the load characteristics, may last a few milliseconds.

Freewheel Diode Selection:

- *"DC Blocking Voltage" should be ≥2x the operating voltage.*
- *"Repetitive Peak Current" should be much larger than the operating current.*
- *Choose diodes with faster recovery and higher ratings for high-frequency applications.*

#2) Freewheel Diode + TVS/Zener Diode Method



For high frequency inductive applications requiring faster dissipation of the magnetic field, adding a TVS/zener diode in conjunction with a freewheel diode is recommended. This shortens the duration of flyback kick typically by a factor of 5 at the cost of slightly higher peak transient voltage.

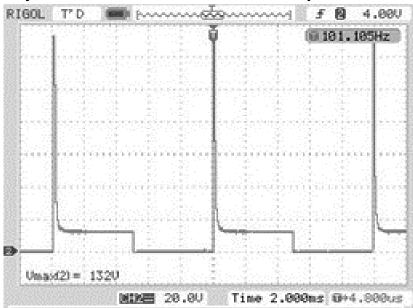
Freewheel Diode Selection:

*Same as "Freewheel Diode Selection" above.*

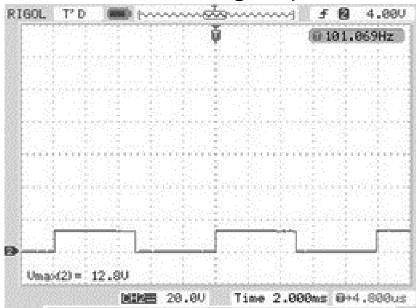
TVS Diode Selection:

- *"Vrwm" or "working voltage" ≥ operating voltage.*
- *"Ipp" ≥ expected transient peak.*
- *"Vc" ≤ maximum voltage rating of the protected component.*

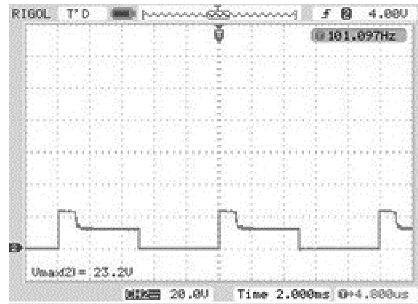
*Flyback Protection Comparison (Load: 12V Electromagnet)*




*A: Without External Clamping*




*B: Freewheel Diode Only*




*C: Freewheel Diode + Zener Diode*

## 5. Applications Requiring Extra Reliability:

Should the SSC operate more frequently than usual, or if reliability is of a greater concern over cost, consider the following:

- Clamp the circuit against any transients
- Choose SSCs with higher overall ratings
- Improve cooling to ensure SSC stays at a much lower temperature
- Switch with two SSCs in series to add redundancy
- Have an emergency disconnect switch in the event of a short circuit

## 6. PWM/Switching Frequency:

- Rapid switching will also generate additional heat and EMF. At high frequencies, the operating current should be de-rated, and EMF clamped.
- For applications operating at higher switching frequencies, the SSC's output duty cycle may be marginally different from the programmed input. Measure and compensate for this change if necessary.
- Do not exceed the rated max switching frequency of the contactor. This may cause SSC's duty cycle to increase until SSC no longer turns OFF.

## 7. Heatsink & Fan Requirement:

Cooling must be carefully designed for all solid state switches. It should also be noted that SSC's long term reliability falls with an increase in operating temperature. For QSDM/QADM SSCs only, you can reduce the total heat dissipation by 50% by wiring two units in parallel.

The following formula can be used to estimate the required thermal resistance of a heatsink without a fan:

$$(T_{\text{Max Junction Temp. °C}} - T_{\text{Ambient°C}}) / \text{Power Loss} - R_{\text{jc junction to case thermal resistance}} - R_{\text{ch case to heatsink thermal resistance}}$$

To maximize heat dissipation through the heatsinks, apply a thin layer of thermal paste *(1W/mK or greater)* and tighten all panel mount screws to ensure very close contact.

## 8. Storage/Handling:

- The long term storage condition of the SSC should be at an ambient temperature of 0 to 40°C with a relative humidity of 45 – 85%.

# Important Information:

(Precautions)

- Do not drop the relay or subject it to a hard impact.
- Do not subject the relay to excess vibration
- Do not store or use the relay in environments exposed to salt, dusts, or metallic dusts.
- Do not store or use the relay in environments directly exposed to oil and chemicals.
- Always ensure proper working knowledge and safety precautions, as well as handle all electrical components with care.

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| Do not touch SSC's output terminations when power is ON or immediately after power is switched OFF. | Conduct wiring only when power and input control signals are completely CUT OFF. | SSC and heatsink may likely be hot and cause burns. Do not touch them until power is OFF, and surfaces are cooled. |