# Important Information:

(Constant Current, Placement, 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 in operation.

## 2. Placement in Circuits:

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

## 3. Rated Current, Rated Voltage Selection:

Different manufacturers may specify SSC's ratings differently. For example, some manufacturers may specify ratings based on transistors' performance at 25°C. Other manufactures may specify the transistor ratings that far exceed the packaging or terminal limits; both cases require further deratings. MAXQ™/M1™ SSC specifications are based on a more practical approach, which is when the terminal limit, when the contactors are in continuous operation with a baseplate temperature of 100°C.

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 transient suppression. While selecting SSC ratings, you must consider parameters such as total inductance, inrush current, transients, environmental temperatures, and other variables.

**General Selection Guidelines for Mach1/MAXQ- Solid State Contactors Only**

| Load Type | Suggested Rated Voltage (multiples of the operating voltage) | Suggested Rated Current (multiples of the operating current) |
|---|---|---|
| General Resistive | ≥1.5x | ≥2x |
| Mildly Inductive Loads (inductive heater) | ≥2x (BEMF suppressed), ≥3x (BEMF unsuppressed) | ≥2x (BEMF suppressed), ≥3x (BEMF unsuppressed) |
| Moderately Inductive Loads (DC motors, coils) | ≥3x (BEMF suppressed), ≥5x (BEMF unsuppressed) | ≥3x (BEMF suppressed), ≥5x (BEMF unsuppressed) |
| Capacitive Loads | ≥3x | ≥3x, or ≥1.5x peak surge current |
| Electromagnets | ≥5x | ≥8x |

- Solid state switches in general, should be used at no more than 75% of its maximum transistor ratings.
- For mission-critical applications, increase above margins by 25% or more.
- The above table is a general guideline only. Selection requirements may increase/decrease depending on the exact load and operating conditions.

### 3.1 Rated Current Selection:

For all applications, the SSC's rated current must be higher than the circuit's worst-case peak current. It is important to recognize, for example, the peak current of DC motor circuits may be the initial inrush current or the stall current that's likely 5x or higher. Similarly, the peak current of capacitive circuits may be the initial short circuit current.

**Helpful Tips**

- Choose SSCs with higher rated current, enhances both reliability and thermal performances.
- For most of our models, multiple units can be connected in parallel to share continuous current and/or to reduce power loss. However, to ensure that peak current is also shared, both units must be customized. Contact us for more details.
- For general overcurrent protection, use a quick fuse or air circuit breaker.

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 of our SSC models, you may connect multiple units in series to increase rated voltage. Contact us for more details.

*Regarding di/dt and Inductive Loads

MAXQ™/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 ratings and make external clamping decisions based on the potential energy stored in the inductor ($E = \frac{1}{2} * L * i^2$). Naturally, BEMF voltage should not exceed the SSC's rated voltage; however, for applications where the overall energy released by the inductor is low when compared to SSC's switching power, external inductive clamping may not be required.

**Helpful Tips**

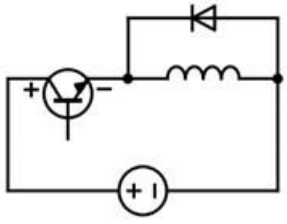
For applications with high di/dt or with high inductance, consider the following:

- Choose SSCs with higher current and voltage ratings
- Choose SSCs with internal TVS protection. If not available, add suppression devices externally (e.g. RC snubbers and MOVs)
- Choose full-bridge, forward, and reversing SSCs
- Clamp 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 use MOV nor RC snubbers for operating high inductance load, because MOV is not intrinsically reliable, and the RC snubber not be sufficient.

#1) Freewheel Diode/Catch Diode Method

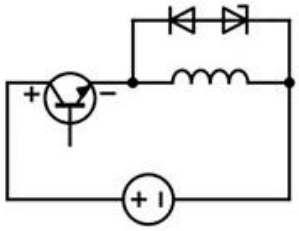


This is the most common and effective method. The reverse-biased rectifier diode would exponentially decay the flyback energy by looping it back to the load, dissipating energy through the resistance of the wires and the load. The duration of the decay, depending on the load characteristics, may only last for 10's of milliseconds.

Freewheel Diode Selection:

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

#2) Freewheel Diode + TVS/Zener Diode Method

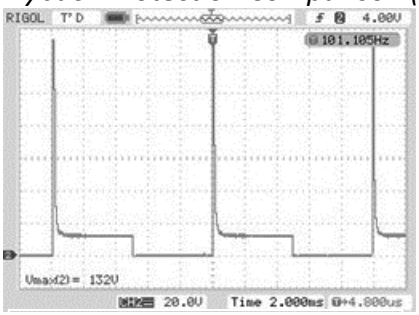


For high-frequency inductive applications requiring faster dissipation of the magnetic field, adding a TVS/zener diode in conjunction with a freewheel diode is recommended. This shortens the duration of the flyback kick, typically by a factor of 5 at the cost of slightly higher peak transient voltage.

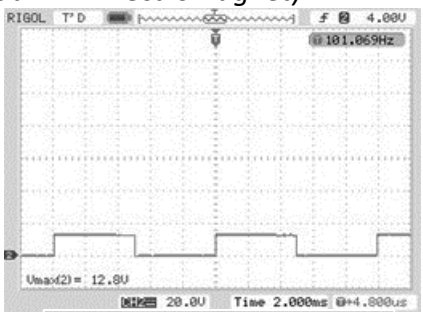
Freewheel Diode Selection:
*Same as "Freewheel Diode Selection" above.*
TVS Diode Selection:

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

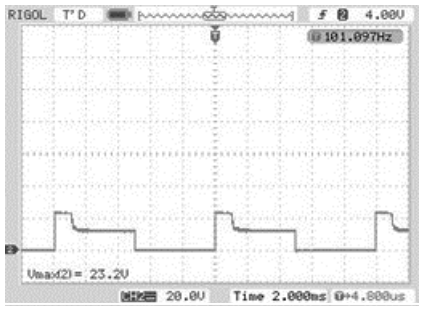
*Flyback Protection Comparison (Load: 12V Electromagnet)*




*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 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/parallel to add redundancy

**6. PWM/Switching Frequency:**

- 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.

- Rapid switching will also generate additional heat. Therefore, at higher PWM frequencies (typically >3kHz), user may need to de-rate the operating current, improve the heatsink, or clamp the load against BEMF.
- For applications operating at higher frequencies, the SSC's output duty cycle may be marginally different from the programmed input. Measure and compensate for this change if necessary.

## 7. Heatsink/Cooling Requirement:

Cooling must be carefully considered for all solid state switches. A minimum thermal derating table is provided on the side label of each SSC. It should also be noted that SSC's long-term reliability falls with an increase in operating temperature. For some SSCs, you can reduce the total heat dissipation by wiring multiple units in parallel.

Cooling requirements are determined by both the "maximum allowable baseplate temperature", as well as the "maximum allowable junction temperature". If a maximum allowable baseplate temperature is not provided, consider using the value of 100°C for MAXQ- Series and 90°C for Mach1- Series, respectively. The following calculation can be used to estimate the minimum thermal resistance required of the heatsink.

$$\text{Heatsink } R_{SA} = (T_{\text{Max allowable baseplate}^\circ C} - T_{\text{Ambient}^\circ C}) \,/\, \text{Power Loss} - 0.1^\circ C/W$$

However, for MAXQ- Series solid state contactors operating at less 40% of rated current, you may use the following method of calculation.

$$\text{Heatsink } R_{SA} = (T_{\text{Max allowable junction}^\circ C} - T_{\text{Ambient}^\circ C}) \,/\, \text{Power Loss} - R_{\text{jc junction-case thermal resistance}} - 0.1^\circ C/W$$

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

## 8. Storage/Handling:

- The SSC's long term storage condition should be at an ambient temperature of 0 to 40°C with a relative humidity of 45 – 85%.
- 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, dust, or metallic dust.
- Do not store or use the relay in environments directly exposed to oil and chemicals.
- Always ensure proper working knowledge and safety precautions, and handle all electrical components with care.

| | | |
|---|---|---|
|  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. |