

## 5kW Dynamic Braking Shunt Regulator



Roboteq's SR5K Shunt Regulator is a protection subsystem for dissipating the regenerative energy when braking or drastically reducing the speed of electric motors. The SR5K has been designed to work in conjunction with a wide variety of power sources and motor controllers. During braking, the regenerative voltage can equal to or even exceed the supply voltage in some cases depending on the rotational inertia of the mechanical system, causing system failures or permanent damage to the power supply or/and the motor controller. The SRK5K works by monitoring the system's supply's voltage and instantly applying a two-level resistive load during overvoltage conditions to absorb up to 5 kilowatt of excess energy and bring voltages back to safe levels.

### Applications

- Automatic Guided Vehicles
- Small Electric Vehicles, Electric Bikes
- Police and Military Robots
- Hazardous Material Handling Robots
- Automated Delivery Robots
- Motorized Factory Machinery

### Features

- Dissipates Excess Back-EMF and Regeneration voltage to prevent system failure or damage.
- 5000 Watt instantaneous, 200 Watts continuous load capability
- Dual Brake Resistor design.
- Simple adjustment of nine preset shunt voltages thresholds from 12V to 100V
- Automatic threshold voltage detection in Auto-mode
- Overheat protection. Automatically disconnects when resistors are too hot.
- Fast easy connection to unit using Fast-On type connectors and standard crimp style lugs.
- Voltage loop through connections makes the use of "Y" cables unnecessary.
- Solid aluminum base plate for easy mounting and conduction heatsinking.
- Flashing Status Lamp to indicate the operational mode including Overheat, Overvolt, Normal Monitoring, Load On.
- Compact, Low Cost with Simple Operation.

### Ordering Information

Reference	Watts	Volts	Max Load
SR5K100V25R	200	100	2.5 Ohm

## Operation

When a motor is spinning faster than it would normally at the applied voltage, such as when moving downhill or decelerating, the motor acts like a generator. In such cases, the current will flow in the opposite direction, back to the power source.

In battery operated system, this current will be absorbed by the battery and recharge it. If a power supply is used instead, the current will attempt to flow back in the power supply during regeneration, potentially damaging it and/or the controller.

Regeneration can also cause potential problems if the battery is disconnected while the motors are still spinning. In such a case, the energy generated by the motor will keep the motor controller On, and depending on the command level applied at that time, the regenerated current will attempt to flow back to the battery. Since none is present, the voltage will rise to potentially unsafe levels.

The safe technique for slowing the motor in these conditions is to place a resistive load in parallel with the power supply, with a circuit to enable that load during regeneration.

The SR5KW Shunt Regulator is connected across the DC power source. It works by monitoring the line continuously, and when the voltage exceeds a preset level, the microcontroller activates MOSFET switches which connects the shunt resistors across the load. The resistors remains connected and absorb the regenerated energy as long as the measured voltage exceeds the preset value. When the voltage levels drop below the threshold value, the resistors disconnect.

Constant monitoring of the shunt resistor temperature ensures that long term shunting does not exceed the thermal limits of the two 100W load resistors. To ensure that the proper braking load is applied at the correct time, the Shunt Regulator uses a Dual Resistor configuration. As the voltage rises, the first 100W load resistor is made active, then the second resistor about 2 volts higher. This allow more accurate control of the overvoltage condition.

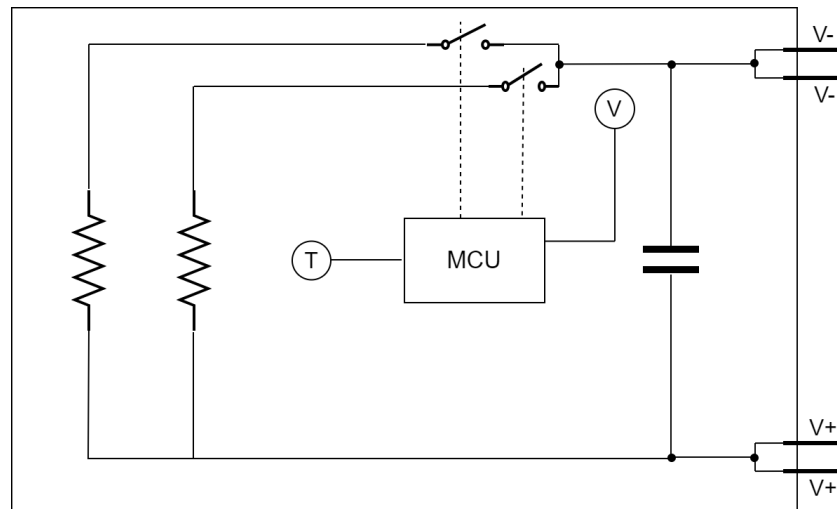


FIGURE 1. Simplified Block Diagram of Shunt Regulator Assembly

## Wiring

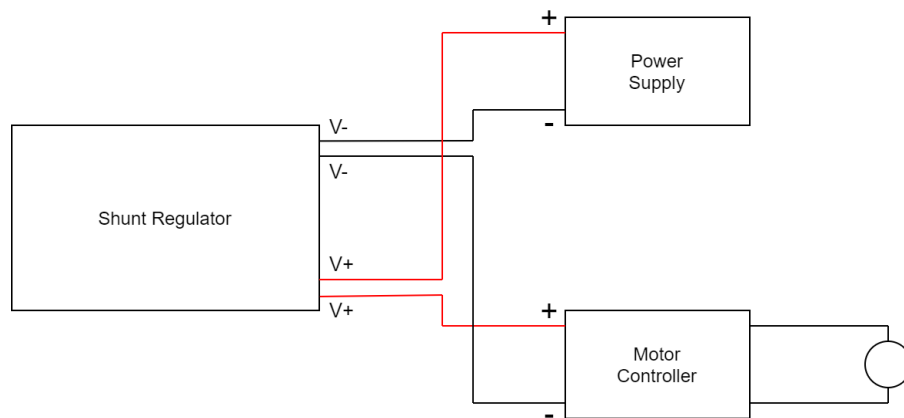


FIGURE 2. Connection Diagram

Connection to the shunt regulator is accomplished by looping through the Fast-On connections as shown. Two sets of Fast-On connections are provided to simplify system integration. The Shunt Regulator's two positive terminals are connected to each other on the board, and so are the two negative terminals. Always observe the correct polarities to avoid system damage.

The SR5KW Shunt Regulator module is fully compatible with all brushed, brushless and Induction Roboteq motor controllers. Loop through connections on the Shunt Regulator allow for easy power pass through connections.

## Setup

The figure below shows the location of the SR5KW's various switches, LED and connectors.

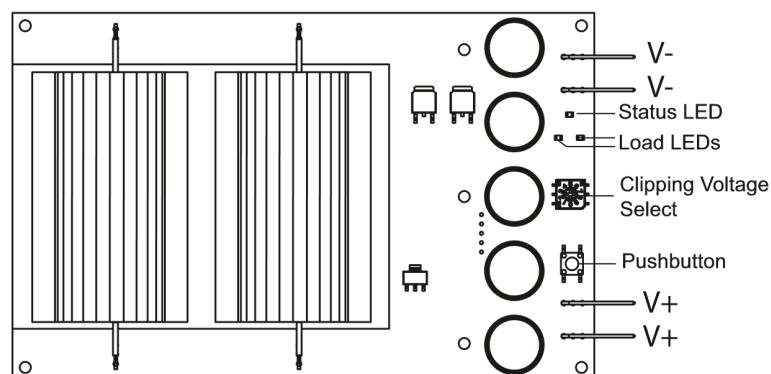


FIGURE 3. Various switches, LED and connectors of SR5K

## Shunt Controller Mounting

When the resistors are active and absorbing energy, they will generate heat that must be evacuated. The published amps rating can only be fully achieved if adequate cooling is provided. Good conduction cooling can be achieved by having the bottom edges of the case making contact with a metallic surface (chassis, cabinet).

## Selecting the Clipping Voltage

Voltage selection is accomplished by setting a rotary PCB mounted switch. The following shunting voltages are preset:

Switch	Clip Voltage
0	AUTO
1	20V
2	25V
3	30V
4	35V
5	40V
6	60V
7	80V
8	100V
9	120V

The *preset voltages* for shunting can be set at any time during operation. The selection of a proper shunt clip voltage above the power supply voltage is crucial for proper operation. Standard shunting voltages from 20 volts to 120 volts maximum are available on the switch.

*Auto Mode* is active when switch position "0" is selected. The processor reads the power line voltage upon power up and sets a fixed preset threshold (about 5v) above that value. This will allow for intermediate values to be obtained for shunting.

## Important Note

**The momentary push button on the status area of the PCB is not currently used and will become available at a future time to implement additional features.**

## LED Indicators

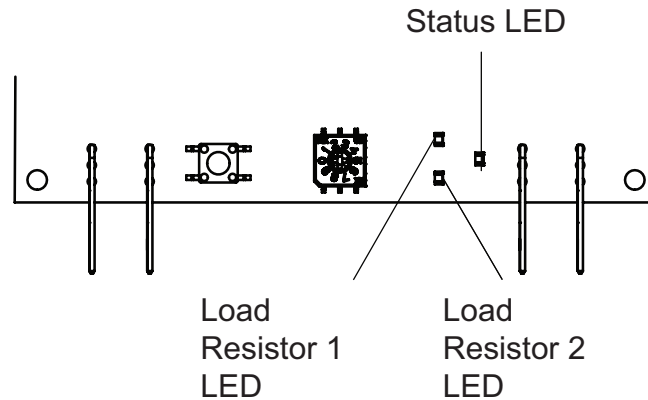


FIGURE 4. Various switches, LED and connectors of SR5KW's

The SR5K is fitted with three LEDs: One Status LED, and two Load indicator LEDs.

Upon power up the Status LED's will remain off for 3 seconds. During the initial power up delay, the input voltage applied across the Shunt Regulator is measured and if it exceeds the maximum of 120Vdc, the Controller halts execution, enters Overvoltage mode, and flashes the Status LED with a constant half second on-off pattern. The unit will remain disabled until the power is cycled again and the overvoltage condition is corrected.

If the input voltage is below 120V during the 3s power up time, input the controller samples the power line and saves the Voltage value for later use as the threshold level Auto Mode. The controller then goes into Monitor mode, ready to activate the load if an overvoltage condition occurs. The Status LED flashes once every 4 seconds during Monitor mode when there is no overload and conditions are nominal.

When an over voltage condition occurs, the Status LED extinguishes and one or both of the load switches becomes active, with the corresponding Load LEDs will flash at 10 Hz alternately, sharing the load between both power resistors. These will stay lit during the overvoltage condition as long as the resistors do not exceed their power rating.

If the the over voltage condition lasts a long time and the load resistor temperature exceeds 70o C., the controller automatically turns off the loads to prevent damage to the Shunt Regulators electronics. Both Load LED's will then turn off, and the Status LED will show a double flash spaced at one second intervals to indicate the unit is in the Overheat Shutdown mode. Depending on heat sink of the base metal plate of the Shunt Regulator, this may take up to a minute or more to recover and for the temperature of the load resistors to return to a safe level. The double flash will stop and at that point the loads will be turned back on if needed.

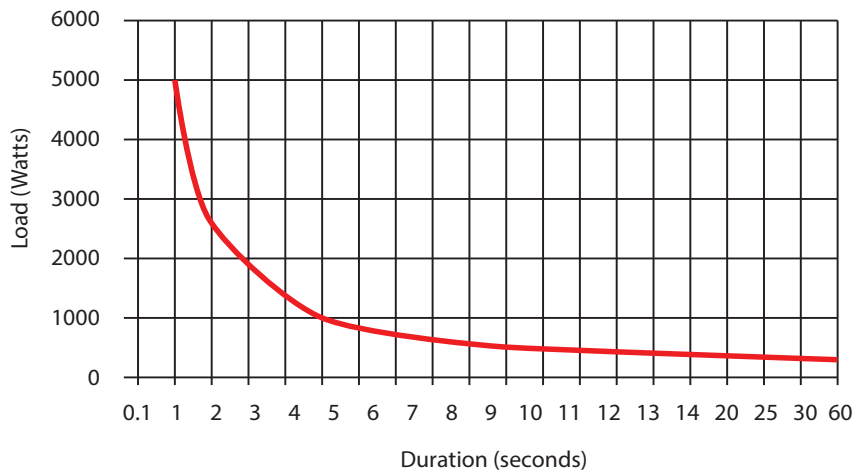
Load Indicator LEDs	
LED Status	State
On	Load Resistor is Active
Off	Load Resistor is Inactive

Status Indicator LEDs	
LED Status	State
Off	Power up or Load Active
Slow flashing	Overvoltage Condition upon start up
Momentary flash every 4 seconds	Normal operation. Voltage monitoring
Double Flashing	Overheat condition. Loads disconnected.

## Electrical Specifications

<b>Absolute Maximum Voltage input range</b>	12 – 120vdc
<b>Typical operating input voltage</b>	20 – 100vdc
<b>Auto Mode input voltage range</b>	12 – 110vdc
<b>Current Consumption at 50vdc</b>	25 mA
<b>Current Consumption at 25vdc</b>	12 mA
<b>Filter Capacitance</b>	1650uF
<b>Maximum Cont. Power Dissipation</b>	200W
<b>Total Load Resistance</b>	2.5 Ohms 200W
<b>SCAN mode Sampling rate</b>	Every 1.0 mS

## Overload vs. Duration for the Shunt Regulator Loading Profile



## Max Amperage at various clip level settings

### Case 1: Single 5 ohm primary loading

Clip Voltage	Amperage	Watts
20	4	80
30	6	180
40	8	320
50	10	500
60	12	720
70	14	980
80	16	1280
90	18	1620
100	20	2000

### Case 2: Dual Load 2.5 ohm loading

Clip Voltage	Amperage	Watts
20	8	160
30	12	360
40	16	640
50	20	1000
60	24	1440
70	28	1960
80	32	2560
90	36	3240
100	40	4000

## Mechanical Specifications

Size (H x W x D)	35mm x 100mm x 159mm
Weight	0.54 kg

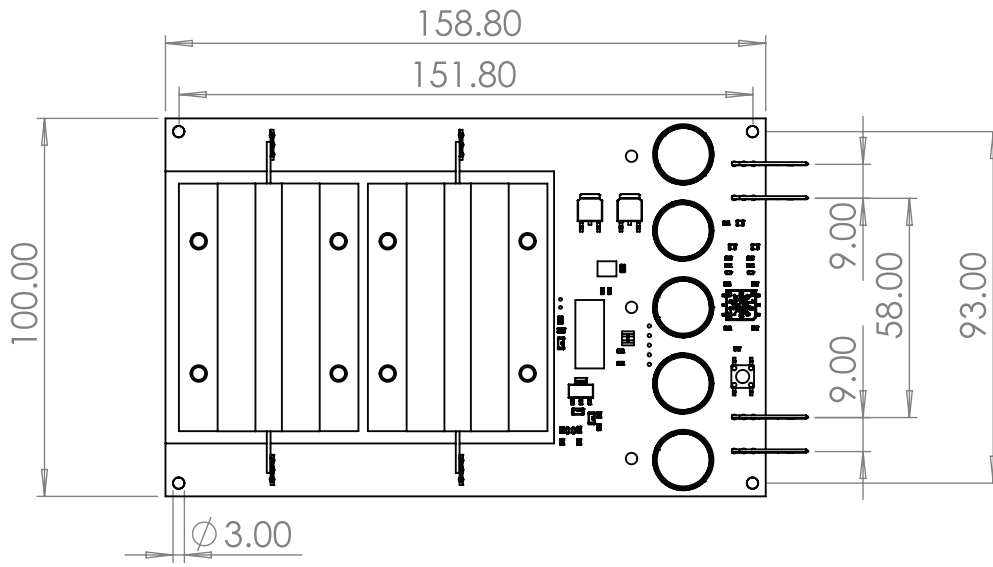


FIGURE 5. Top Mechanical view and dimensions

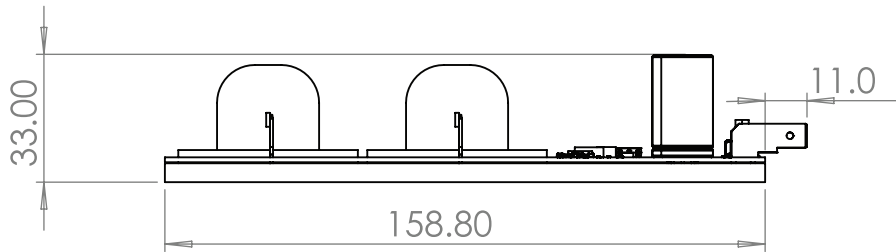


FIGURE 6. Side Mechanical view and dimensions