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RP-21200 *STAR* Series™

SOLID-STATE ADVANCED REMOTE POWER CONTROLLERS

FEATURES

- Low Cost
- Continuously Programmable and Preset Ranges
- EMI Tolerant
- I^2T & Instant Trip Protection
- MIL-STD-704 Compliant
- Opto-Isolated Control Circuitry
- No Thermal Derating
- Low Power Dissipation
- Thermal Memory
- Coordinated Tripping Characteristics

DESCRIPTION

The RP-21200 STAR Series of 28 Vdc Solid-State Power Controllers (SSPCs) replace electromagnetic circuit breakers and solid-state relays rated from 1 through 25 amperes. These SSPCs provide status outputs and logic input control so that they may be remotely located near the load. The 28 Vdc SSPCs are available in three programmable current ranges; 1-3 amperes, 3-9 amperes, and 8.3-25 amperes. Each of these ranges offer four preset current settings and allow the user to set other ranges.

The primary function of the SSPC is to protect the wire from I^2R heating. The SSPC uses standard logic I/O, "on/off" logic input controls, provides isolation between the control side and power side, and has status outputs. The device is contained in a non-flammable housing and is electrically shock proof. It has self contained SSPC functions including thermal memory. The RP-21200 STAR Series are PC board through-hole or surface-mountable lightweight encapsulated devices that are impervious to moisture.

Using power MOSFET switches, these power controllers offer low "ON" resistance, low voltage drop, high "OFF" impedance, and low power dissipation. Built using the latest plastic and epoxy technologies, they offer small size, low power, and high reliability.

APPLICATIONS

Designed to replace circuit breakers in land, air, sea, and space vehicles, these SSPCs provide status outputs, which show switch state and minimum load current. An optional analog current monitor can report load current. Fault tolerant systems can be configured using these SSPCs with a remote or local CPU.

Data Device Corporation
105 Wilbur Place
Bohemia, New York 11716
631-567-5600 Fax: 631-567-7358
www.ddc-web.com

FOR MORE INFORMATION CONTACT:

Technical Support:
1-800-DDC-5757 ext. 7771

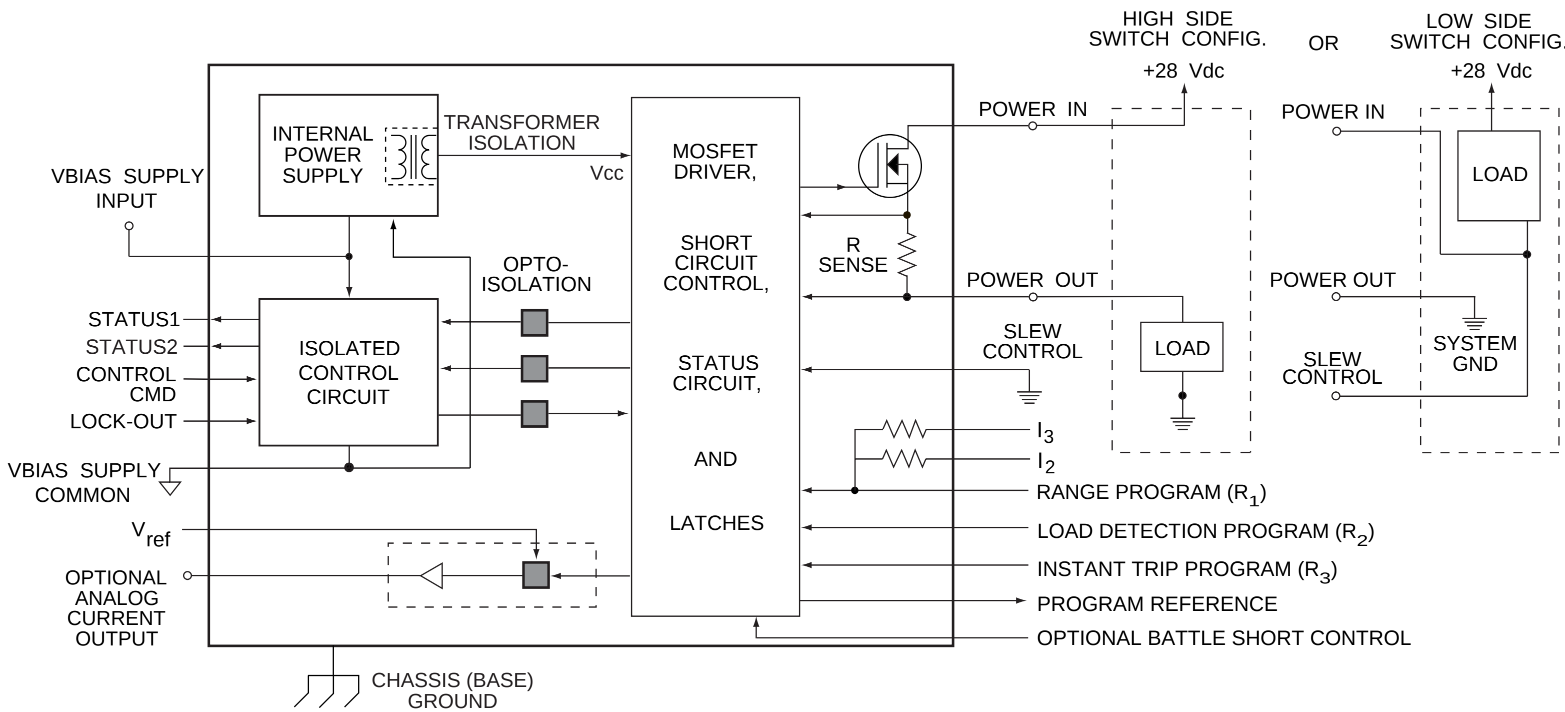


FIGURE 1. *STAR* Series BLOCK DIAGRAM

TABLE 1. ABSOLUTE MAXIMUM RATINGS

PARAMETER	UNIT	VALUE
Power In to Power Out	Vdc	70 continuous 90 transient
Power Out to Slew Control	Vdc	100 continuous
Control Input to Signal Ground [1]	Vdc	-0.5 to 7.0
Lock-Out Input to Signal Ground [1]	Vdc	-0.5 to 7.0
Power Out to Signal Ground	Vdc	-100 to +100
VBias voltage	Vdc	-0.5 to +6.0
Lead Temperature (soldering)	°C	+260 (within 10 sec.)
Junction Temperature	°C	125

Note: 1. This input shall not exceed VBias by more than 0.5V.

TABLE 2. RECOMMENDED OPERATING CONDITIONS

PARAMETER	UNIT	VALUE
Power In to Power Out	Vdc	+0.0 to +40.0
Control Input to Signal Ground[1]	Vdc	+4.5 to +5.5
Lock-Out Input to Signal Ground [1]	Vdc	+4.5 to +5.5
Power Out to Signal Ground	Vdc	-40 to +40
VBias voltage	Vdc	+4.5 to +5.5

Note: 1. This input shall not exceed VBias by more than 0.5V.

TABLE 3. RP-212XX SPECIFICATIONS

PARAMETER	CONDITION	UNIT	VALUE
Logic Type	See FIGURE 2 See Note 2	—	TTL/CMOS Compatible
Vbias Supply Current[8]	V_{Bias}=4.5-5.5 V_{DC} RP-212XXF0	mA	20 typ. 30 max.
	V_{Bias}=4.5-5.5 V_{DC} RP-212XXF1	mA	50 typ., 75 max.
Control Turn-On Voltage[2]	-55°C to +100°C	V	2.0 min.
Control Turn-Off Voltage[2]	-55°C to +100°C	V	0.8 max.
Lockout Disable Voltage[2]	-55°C to +100°C	V	2.0 min.
Lockout Enable Voltage[2]	-55°C to +100°C	V	0.8 max.
Control/Lockout Input Current[2]	Control = 5 V Lockout = 0 V -55°C to +100°C	µA µA	100 max. -100 min.
Control/Lockout Input Current[2]	Control = 0 V Lockout = 5 V -55°C to +100°C	µA µA	1.0 max. -1.0 min.
Status Output Voltage Low	V_{Bias} = 4.5 V I_{OL} = 2.5 mA -55°C to +100°C	V	0.4 max.
Status Output Voltage High	V_{Bias} = 4.5 V I_{OH} = -0.4 mA -55°C to +100°C	V	3.5 min.
Status Truth Table	See TABLE 6	—	—
'On' Resistance	See TABLE 4	—	—
Power Dissipation	See TABLE 4	—	—
Power Input Leakage Current to Power Out RP-21203	Power In = 0-40 V -55°C to +100°C See Note 5	mA	0.3 max.

TABLE 3. RP-212XX SPECIFICATIONS (CONT.)

PARAMETER	CONDITIONS	UNIT	VALUE
Power Input Leakage Current to Power Out RP-21209	Power In = 0-40 V -55°C to +100°C See Note 5	mA	2 max.
Power Input Leakage Current to Power Out RP-21225	Power In = 0-40 V -55°C to +100°C See Note 5	mA	4 max.
Load Capacitance RP-21203	See Note 3 -55°C to +100°C	µF	700 min.
Load Capacitance RP-21209	See Note 3 -55°C to +100°C	µF	1400 min.
Load Capacitance RP-21225	See Note 3 -55°C to +100°C	µF	6800 min.
Control to Power Output Isolation Resistance	Control to Power Output = 50V	Ω	10^8 min.
Output Capacitance RP-21203	Power in to Power Output = 28V	pF	900 typ.
Output Capacitance RP-21209	Power in to Power Output = 28V	pF	3300 typ.
Output Capacitance RP-21225	Power in to Power Output = 28V	pF	6600 typ.
Trip Reset Time	See Note 4	ms	1 max.
Rupture Capacity		A	Unlimited
Output Reverse Continuous Current All Models	Power Out Voltage > Power In Voltage	A	1x max. rated current
Output Reverse Pulsed Current All Models	Pulse Width ≤100 µs	A	4x max. rated current
Output Reverse Voltage at Rated Current	Power Out Voltage > Power In Voltage	V	1.8 max.
Output Voltage Drop at 25°C	See Note 3 See TABLE 4	V	0.2 max.
Output Voltage Drop at 100°C	See Note 3 See TABLE 4	V	0.3 max.
Trip Characteristics	See FIGURE 5 -55°C to +100°C	—	—
Response Time	See FIGURE 6 -55°C to +100°C	—	—
I^2t Max Rating Calculation	Instant Trip=3000% See FIGURE 5	A^2-sec	10.6 x I_{rated} current^2
	Instant Trip=1000% See FIGURE 5	A^2-sec	4.2 x I_{rated} current^2
	Instant Trip=200% See FIGURE 5	A^2-sec	1.4 x I_{rated} current^2
Total Gamma Dose (Note 6)	RP-212XX"F0"	rad(si)	10K
Neutron Fluence (Note 6)	RP-212XX"F0"	n/cm^2	3.2 x 10^{12}
Gamma Dose Rate (Note 6)	RP-212XX"F0"	rad(si) /sec	<10^{12} (Note 7)
Instant Trip Level Without External Programming Resistor	See Figures 3 and 4	% of Rated Current	190 min. 210 max.

TABLE 3. RP-212XX SPECIFICATIONS (CONT.)			
PARAMETER	CONDITIONS	UNIT	VALUE
Instant Trip Level With External Programming Resistor Shorted	See Figures 3 and 4	% of Rated Current	2845 min. 3155 max.
Load Detection Level Without External Programming Resistor	See Figures 3 and 4	% of Rated Current	89 min. 101 max.
Load Detection Level With Ext. Programming Resistor Shorted	See Figures 3 and 4	% of Rated Current	5 min. 15 max.
Thermal Resistance Junction-to-Case RP-21203	Hottest die to base	°C/W	3 max.
Thermal Resistance Junction-to-Case RP-21209	Hottest die to base	°C/W	1 max.
Thermal Resistance Junction-to-Case RP-21225	Hottest die to base	°C/W	0.5 max.
Thermal Resistance Base-to-Sink RP-21203	—	°C/W	1.8 max.
Thermal Resistance Base-to-Sink RP-21209	—	°C/W	0.9 max.
Thermal Resistance Base-to-Sink RP-21225	—	°C/W	0.5 max.
Thermal Resistance Base-to-Ambient RP-21203	Free Air	°C/W	25 max.
Thermal Resistance Base-to-Ambient RP-21209	Free Air	°C/W	20 max.
Thermal Resistance Base-to-Ambient RP-21225	Free Air	°C/W	15 max.
Size	See Figure 8	—	—
Weight RP-21203	—	oz (g)	1.24 (35)
Weight RP-21209	—	oz (g)	1.59 (45)
Weight RP-21225	—	oz (g)	2.12 (60)
Operating Case Temperature Range	—	°C	-55 to +100
Storage Temperature	—	°C	-55 to +125
Mounting Torque	—	in-lbs	5

TABLE 3 notes:
1. All specifications are at 25°C unless otherwise specified. Maximum Rated Current is defined as the current when the R1 current range programming pin is shorted to the programming reference pin.
2. Control and Lockout operate the input optocoupler. They may be interchanged which will invert their function. See FIGURE 2 for a schematic of this input structure.
3. Limits are shown when programmed to maximum instant trip level, and at the maximum current rating setting. Limits are 33% of those shown when there are no connections to R1, I2, and I3 programming pins (when at minimum current range, but maximum instant trip range).
4. This means that the SSPC may be reset 1 ms after a trip has occurred. However, if the cause of the trip has not been removed, the second trip will occur faster than the first trip. This is an example of how the internal 'thermal memory' protects the wire. Also, repeated resetting and tripping must not occur faster than 30 ms after the first reset in order to prevent overheating of the SSPC.
5. DDC recommends using an external bleed resistor in situations that may not tolerate leakage currents that will permit power-in VDC at the load.
6. Analytical Radiation Tolerance Estimate.
7. The STAR Series design incorporates series power supply resistors to protect against latch-up damage.
8. During initial power-on @ Vbias ~ 3.5Vdc, a transient current pulse of up to 100mA above the Vbias Supply Current may be observed.

FUNCTIONAL DESCRIPTION

The RP-21200 *STAR* Series of programmable Solid-State Power Controllers (SSPCs) are electronic circuit breakers and, as such, are primarily intended to protect the wiring between the power source and the load. They are designed to replace electro-mechanical or thermal circuit breakers while providing the reliability of solid-state electronics. Unlike circuit breakers, SSPCs can easily interface with TTL/CMOS signals associated with solid-state controllers, such as embedded microprocessors.

The Block Diagram in FIGURE 1 shows the various functional blocks within the RP-212XXF1 series. The control side employs buffers for the logic signals, which are isolated and level shifted from the power side by optical isolation. On the power side are the analog and digital circuits which drive the power MOSFET switch, sense the switch's current and provide programmability. An internal DC-DC converter, powered by the control side 5 Volt bias supply provides isolated power to the power side circuitry. An optional analog Current Monitor output uses optical isolation, and provides an analog voltage signal on the control side which is proportional to the switch's (load) current.

The *STAR* Series has two TTL/CMOS compatible inputs. One input is the Control Command. A logic high on the Control Command will turn on the power switch and a logic low will turn it off. The other input is a Lockout Input which can be used to provide safety during system maintenance. When the Lockout Input is at a logic high, the SSPC is disabled and always off, regardless of the state of the Control Command input. When the Lockout input is at a logic low, the SSPC follows the state of the Control Command.

The two TTL/CMOS compatible outputs, Status 1 and Status 2, provide status information on the switch current (load current) and switch state, respectively. Status 1 will be at a logic high when the switch current is less than the programmed Load Detection value - see FIGURE 4 for programming information. When the switch current is greater than the programmed Load Detection value, Status 1 will be at a logic low. Status 2 reflects the state of the switch. When the switch is closed, Status 2 will be at a logic high and when the switch is opened, Status 2 will be at a logic low. The combination of the states of the Control Command, Lockout Input, Status1 and Status 2 outputs provide Built-In-Test (BIT) capability. TABLE 6 shows the possible status combinations.

As in a circuit breaker, the SSPC will carry continuous current up to a certain level without tripping. For the RP-21200 series, the SSPC will not trip as long as the continuous current is less than 110% of the programmed current - see FIGURE 4 and TABLE 5 for programming information. The *STAR* Series are guaranteed to trip if the continuous current is greater than 145% of the programmed value. Again, like a circuit breaker, the RP-21200 series can handle short duration overloads without tripping. The I^2t curve shows that time to trip is inversely proportional to the square of the current. This means that short overloads can be large without tripping but longer overloads must be small to avoid tripping. FIGURE 5 shows a typical set of I^2t curves. Operation

TABLE 4. POWER DISSIPATION					
PART NUMBER	"ON" RESISTANCE (OHMS)	MIN. RATED CURRENT		MAX. RATED CURRENT	
		VOLTAGE DROP (V)	POWER DISSIPATION (W)	VOLTAGE DROP (V)	POWER DISSIPATION (W)
RP-21203	0.100	0.1	0.25	0.3	1.05
RP-21209	0.033	0.1	0.45	0.3	2.85
RP-21225	0.012	0.1	0.98	0.3	7.65

TABLE 4 notes:
1. Values shown are maximum over the case temperature range of -55°C to +100°C; typical values at 25°C are typically 67% of the maximums shown above.
2. Voltage drop is approximately 0.6% per °C improved below the100°C limit.
3. Power Dissipation data includes 150 mW contribution of VBIAS, but doesn't include the analog current monitor (see TABLE 3). "F1" is another 45 mA maximum.

in the area between the minimum and maximum curves is ambiguous; the SSPC may or may not trip.

A hot wire cannot withstand as great an overload as a cool wire. The *STAR* Series of SSPCs incorporate 'Thermal Memory' to protect a wire that is hot from a previous overload.

The Instant Trip Characteristic ranges shown in FIGURE 5 are programmable as detailed in FIGURE 4. If the overload exceeds the upper Instant Trip level, the SSPC will trip regardless of the duration of the overload. The main reason for an Instant Trip level is to protect the switch from excessive short-term power dissipation but can be programmed for system considerations, if necessary.

The RP-21200 *STAR* Series are available in three current ranges. As shown in TABLE 5, they are programmable over a three-to-one range. The ranges are: 1 - 3 Amps, 3 - 9 Amps and 8.3 to 25 Amps. TABLE 4 shows the Maximum "on" resistance and voltage drops over the temperature range.

The rise and fall times of the output voltage are controlled to be approximately 500µS. Fast rise times minimize the power dissipation in the switch during turn-on and turn-off. Slow rise times minimize EMI, voltage spiking due to line inductance and allow starting up into higher capacitive loads. The 500µS rise and fall times in the *STAR* Series represent a compromise. While the switch can handle the power dissipation during occasional changes of state, rapidly switching the SSPC on and off will lead to overheating. These SSPCs should not be cycled at greater than a 30ms rate.

To control the rise and fall time, the Slew Control Input must be returned to Chassis Ground. The load return is the ideal Chassis Ground; the Chassis Ground can also be used as a ground but, if there is noise between Chassis Ground and load return, some of this noise may appear on the output. An alternative Chassis Ground is the Power In but, if the Power In is turned on abruptly, such as through a switch or contactor, the output may exhibit a small transient although the SSPC is commanded off.

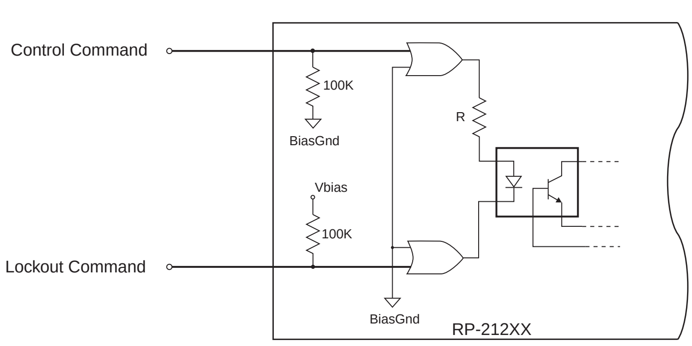


FIGURE 2. RP-212XX SERIES CONTROL/LOCKOUT FUNCTIONAL SCHEMATIC

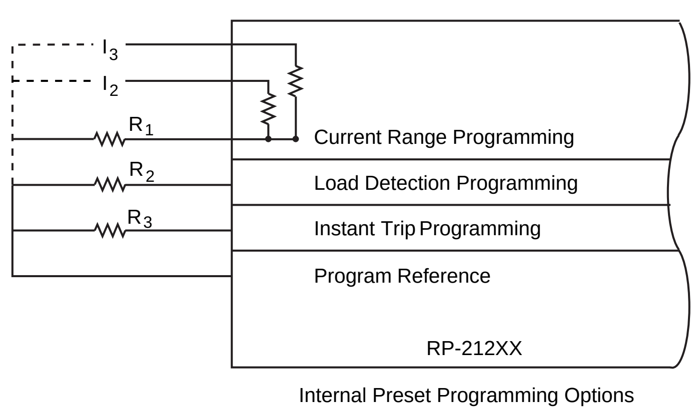


FIGURE 3. RP-212XX SERIES PROGRAMMING CONNECTIONS

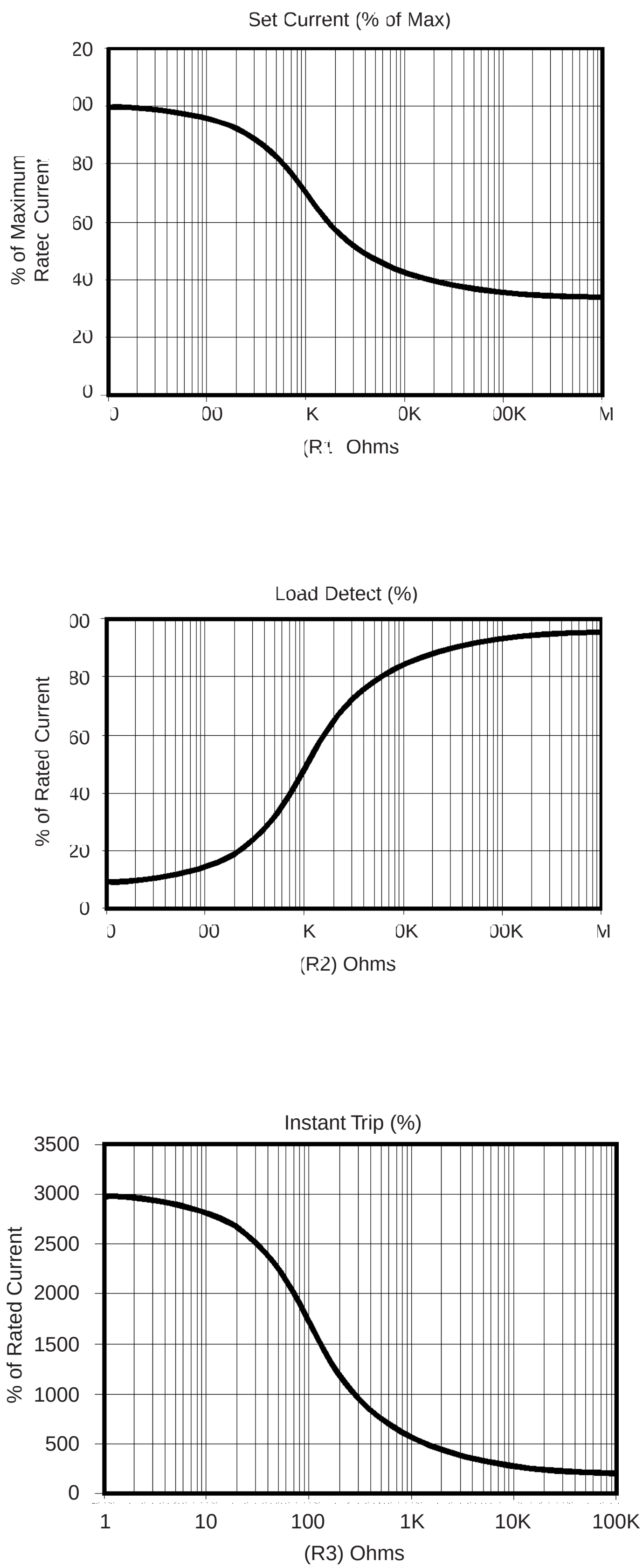


FIGURE 4. *STAR* Series PROGRAMMING CURVES

APPLICATIONS INFORMATION

PROGRAMMING OVERVIEW

The three standard programmable devices of the RP-212XX STAR Series are the RP-21203 (1-3 amp), RP-21209 (3-9 amp), and RP-21225 (8-25 amp). Each supports a 3:1 current rating range. Please refer to FIGURE 3 (RP-212XX Series Programming Connections), FIGURE 4 (STAR Series Programming Curves), and TABLE 5 (Preset Current Ratings for further details).

The Instant Trip level is independently programmable from a nominal 200% to 3000% of the SSPCs programmed current rating. Using the RP-21203 as an example, if the current rating range is programmed for 3 Amps [by using external R1 = 0 (shorted)], then the instant trip will be programmed from 6 to 90 Amps. On the other hand, if R1 = 4 (left open), the instant trip can be programmed from 2 to 30 Amps. Therefore, the Instant Trip level remains a fixed percentage of the current rating range.

The Status 1 load detect programming works the same way as the Instant Trip level programming. The range for the Status 1 Load detect is 10% to 95% of the SSPCs programmed current rating.

PROGRAMMING

The STAR Series can be programmed for Current Rating, Instant Trip level and Load Detection Level. Figures 3 and 4, TABLE 5 and the Programming Explanation give detailed information on how to program these SSPCs.

The Current Rating for each of the RP-21200 series SSPCs can be varied over a three-to-one range to tailor each application for the wire's I2t rating as described above. The Current Rating can be programmed for any value in the range by using an external resistor. Additionally, preset programmed Current Ratings of 50%, 80% and 100% of Maximum Rated Current can be imple-

TABLE 5. PRESET PROGRAMMED CURRENT RATINGS

Preset Current Settings (amperes): See Note 2				
RP Unit	**OPEN** Note 1a	**I3** Note 1b	**I2** Note 1c	**R1** Note 1d
RP-21203	1	1.5	2.4	3
RP-21209	3	4.5	7.2	9
RP-21225	8.3	12.5	20	25

Notes:
1) The RP-212XX series current rating programming is as follows:
a) Minimum current is set by not connecting R1, I2, or I3.
b) The first quarter program rating requires connecting I3 to the program reference pin.
c) The third quarter program rating requires connecting I2 to the program reference pin.
d) The Maximum Current Rating is programmed by connecting the R1 programming pin to the program reference pin directly.
2) An external resistor connected between the R1 input range programming pin and program reference pin will provide infinite resolution current setting. Reference FIGURE 4 (*STAR* Series Current Programming curves).

mented by simply connecting together the appropriate pins. A Current Rating of 33% of Maximum Rated Current occurs with no programming connections.

The Load Detection Level determines the current which will control the Status 1 output. When the load current is below the Load Detection level, the Status 1 output is at a logic high and goes low when the load current rises above the Load Detection level. Therefore, the Status 1 output can be used to determine if the load is drawing more or less than a preset amount of current. The Load Detection level can be programmed from >10% to <95% of Rated Current using an external resistor connected between the Programming Reference pin and Load Detection Program pin. The 10% level can be achieved by simply connecting the Programming Reference pin and the load Detection Program pin together. The 95% level occurs when no connection is made to the Load Detection Program pin.

The *STAR* Series have been designed with a maximum Instant Trip level of 3000% of Rated Current in order to protect the internal MOSFET switches from exceeding their rated junction temperatures. In most cases, the user will elect to set the Instant Trip level to the maximum by connecting the Instant Trip Program pin to the Programming Reference pin. This will allow the greatest possible inrush current without tripping for charging capacitive loads, starting motors or energizing incandescent lamps.

In some applications, where there is no need to support high inrush currents, the Instant Trip level can be set lower by adding a resistor between the Instant Trip Program pin and the Programming Reference pin. The lowest Instant Trip level of 200% can be set by leaving the Instant Trip Program pin open. The most likely reason for setting a low Instant Trip level is to minimize short-term voltage drops at the load due to high source impedances. In other cases, the generator has its own circuit breaker for protection and it's better to trip an SSPC than the generator.

When an SSPC is turned on into a short circuit, the output voltage cannot rise. However, the output current will rise rapidly until the Instant Trip level is reached. Then the SSPC will turn off. The maximum transient current will not exceed the Instant Trip level, even if there is no circuit inductance, since the turn on time of the MOSFET is controlled. Since the output voltage is still zero, the output current will begin to decay as soon as the Instant Trip level is reached. The time for the current to decay is determined by the total circuit inductance and resistance. This is difficult to predict since the resistance of the internal MOSFET switch changes as it turns off. In any case, the turn off time is always fast enough to ignore for purposes of damaging the wire.

If there is considerable circuit inductance when an SSPC is turned on into a short circuit, the risetime of the current will be much slower than without inductance. Large load inductance can stretch the risetime of the current to the point where the current does not reach the Instant Trip level but intersects the I^2t curve instead. Again, this cannot damage the wire as the SSPC will trip at that point to protect the wire.

If the SSPC is already on and a short circuit occurs, the SSPC will trip, but the short circuit current will likely overshoot the Instant Trip level. Again, the rate of rise of the current depends on total circuit inductance. Since the SSPC is already on, the current can, theoretically, rise in zero time if there is no inductance. In the real world, there is always inductance which will limit the risetime of the current although it can be quite fast.

As soon as the current reaches the Instant Trip level, the SSPC will begin to turn off. However, since the SSPC is already on, there is a delay until the gate-to-source voltage in the internal MOSFET switch is reduced to the point where they begin to turn off. As a result, the current keeps rising during that delay. How much the current rises above the Instant Trip level is determined by the delay and the risetime of the current. The RP-21200 Series of SSPCs contain circuitry to reduce the delay at high currents. But, with lit-

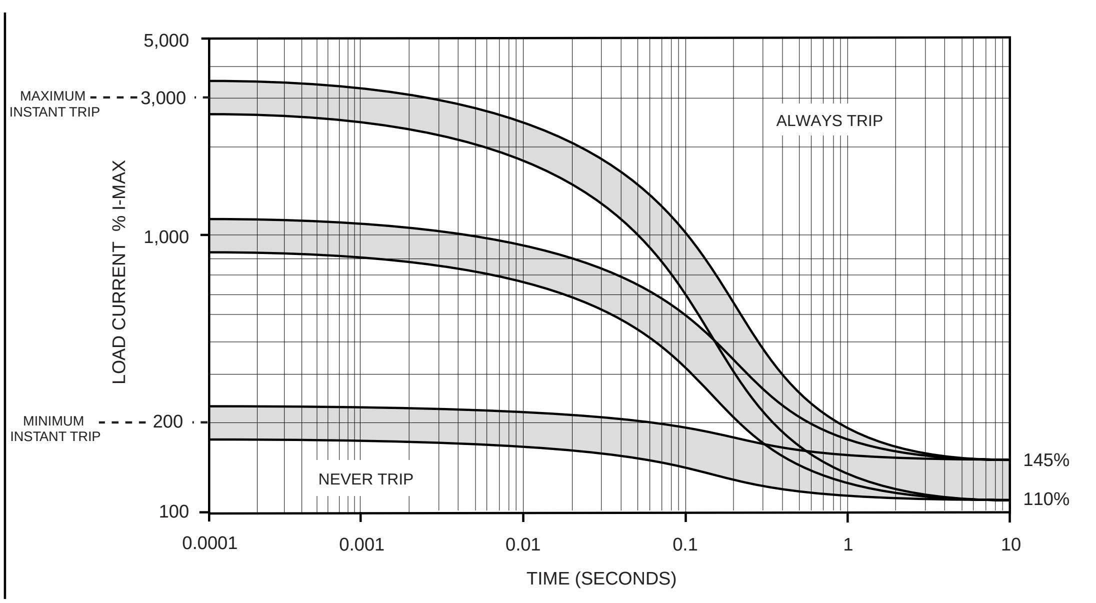


FIGURE 5. TYPICAL TRIP CHARACTERISTIC SETTINGS

tle circuit inductance, the current can reach up to 4000% of rated current even if the Instant Trip level is set as low as 200%!

This possible high level of transient current is short-term. The lower the circuit inductance, the higher the transient current but the shorter the transient lasts. In all cases, the wire is protected since the wire can withstand large overloads for short durations. The only concern is possible system effects of having large, short-term transient currents. Generator tripping is unlikely since the transients are so fast.

HIGH SIDE AND LOW SIDE SWITCHING

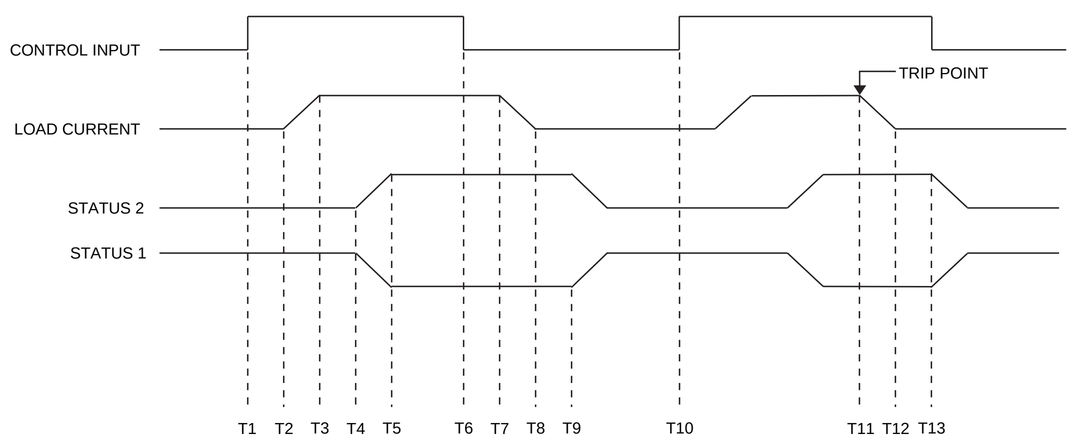
Most applications place the circuit breaker in the wire supplying power to the load, not in the load return wire; this is the 'High Side Switch' configuration. The RP-21200 series are designed to be placed in either 'High Side' or 'Low Side' switch configurations. FIGURE 1 shows both configurations. Additionally, because the *STAR* Series SSPCs have complete isolation between the control and power sides, these SSPCs can be used with either positive (as shown in FIGURE 1), or negative power.

To use these SSPCs with negative power, the configurations in FIGURE 1 are swapped. That is, the configuration of FIGURE 1 showing 'High Side Switch' would be used for low side switching for negative input power and the configuration in FIGURE 1 showing 'Low Side Switch' would be used for high side switching for negative input power. For either high side or low side switch configurations, the 'ground' symbol in FIGURE 1 would be replaced with the negative power input, -28VDC for instance, and the '+28VDC' symbol would be replaced with ground.

SELECTION

All wires carrying current have both continuous and transient ratings for maximum safe operating current. Continuous ratings are usually expressed in Amps and are dependent on the size of the wire as well as physical conditions around the wire such as whether or not the wire is in a bundle. Transient ratings are expressed as an I^2t product, which is a constant. Sometimes, transient ratings are expressed as a pulse of current for a specified duration. The I^2t constant can be calculated from that data. Both continuous and transient ratings depend on the allowable temperature rise of the wire which is dependent upon the type of insulation on the wire as well as overall system requirements.

Since the STAR Series main function, like a circuit breaker, is to protect the wire and prevent fire damage, the SSPC must have lower continuous and transient ratings than the wire's ratings. The user must verify that the SSPC's trip curve falls below the



SOLID-STATE POWER CONTROLLER TIMING AT 28 VDC				
TIME	**DESCRIPTION**	**MINIMUM**	**MAXIMUM**	**UNIT**
T1-T2	TURN-ON DELAY		350	µs
T2-T3	VOLTAGE RISE TIME *	300	700	µs
T1-T4	STATUS 1 & STATUS 2 TURN ON DELAY		7.5	ms
T4-T5	STATUS 1 & STATUS 2 RISE AND FALL TIME		50	ns
T6-T7	TURN OFF DELAY		900	µs
T7-T8	VOLTAGE FALL TIME *	300	700	µs
T6-T9	STATUS 1 & STATUS 2 TURN OFF DELAY		5.0	ms
T10-T11	TRIP TIME AFTER TURN-ON		see Fig 5	s
T11-T12	VOLTAGE FALL TIME AFTER TRIP*	300	700	µs
T11-T13	TRIP TURN-OFF STATUS 1 DELAY		5.0	ms

Note: *Voltage rise/fall time is specified for maximum rated current.

FIGURE 6. SOLID-STATE POWER CONTROLLER TIMING

wire's safe operating curve for all values of time. For the RP-21200 series and continuous currents, this is simple. Just specify the SSPC's rated current to be below the wire's continuous current rating by the required safety factor times 1.45. The 1.45 comes from the fact that the RP-21200 series is guaranteed to trip at 145% of rated current. Since the RP-21200 series are available in three programmable ranges, it's easy to tailor the STAR Series to the wire.

It's even easier to select an RP-21200 series SSPC for transient ratings. The *STAR* Series I^2t ratings are tailored to the continuous ratings so that, except for rare cases, the SSPC I^2t ratings will be below the wire's ratings. This can be verified by comparing the RP-21200 series I^2t rating in TABLE 3 against the wire's I^2t rating. Since the Instant Trip level has an effect on the shape of the I^2t curves as shown in FIGURE 5, TABLE 3 shows the *STAR* Series I^2t rating for three levels of Instant Trip. Simply select the RP-21200 series I^2t rating for the Instant Trip level being used and multiply by the programmed Rated Current squared to obtain the I^2t rating for the application.

PRECAUTIONS

While circuit inductance reduces current transients when a short circuit occurs with the *STAR* Series of SSPCs already on, it will create voltage transients as the SSPC turns off. The voltage transient is caused by the rapid change in current in the inductance. If the inductance is on the power input side of the SSPC, the voltage at the Power In pin will rise when the SSPC turns off. Similarly, when the inductance is on the output side, the Power Out pin will swing negative when the SSPC turns off.

In the RP-21200 series, internal circuitry slows the turn off time of the SSPC to minimize this voltage transient until the inductance, in microhenries, exceeds a critical inductance of 10,000 divided by the Maximum Rated Current. (For an RP-21225 SSPC with a Maximum Rated Current of 25 Amps, this equates to 400µH.) At that level of inductance, the transient voltage will be about 45 V. For larger circuit inductances, the voltage transient will grow linearly with inductance.

In most cases, the inductance on the Power In side of the SSPC will be, at most, a few microhenries. Therefore, the Power In side will have only small transient voltages. On the other hand, the Power Out side can have considerable inductance from loads. A prime example is a motor. To protect the SSPC with large inductive loads, a power diode should be placed between the SSPC Power Out pin and the load return to prevent the SSPC Power Out from swinging negatively. This diode should be rated to handle the same maximum transient current as described above for short circuit conditions. It should be connected with short leads; otherwise, the inductance of its leads will negate its benefits.

Since short circuits can create large transient currents, it's possible to magnetically couple those transients to the control side if wiring or circuit board traces of the power side run near those of the control side. It's not impossible to couple many volts to the control side with poor layout. This will cause improper operation and possibly oscillation of the SSPC which could damage the SSPC. After all, coupling the output current to the control circuit is a form of feedback. Since there is no control of the phase of the feedback, oscillation is possible. This may be hard to trace since, when there is no short circuit, everything appears normal but as soon as a short circuit occurs, the SSPC fails. Good layout practice will prevent this.

Likewise, large transient currents could magnetically couple voltage transients elsewhere in the system causing hard-to-trace system faults. Large voltage transients could couple into high impedance system circuits, another possible system problem. Also, these transients could radiate elsewhere; while the system seems to pass its EMI tests, it may only do so under certain conditions and fail under other conditions. Routing of high current wiring and control signals must always be made while considering these effects.

CAPACITIVE LOADS

Applying a voltage to a capacitor causes an inrush current to flow which depends on the rate-of-rise of the voltage and the value of the capacitor. Since the *STAR* Series has a typical risetime of 500µS, the charging current will never intersect the I^2t portion of the trip curve, but can intersect the Instant Trip level. If it does, the SSPC will trip. TABLE 3 specifies the capacitive load that the RP-21200 series can handle without tripping with 28 Volt power input. Higher power input voltage will proportionally reduce that capacitive load capability since the risetime is independent of voltage. By carefully controlling the risetime of the output voltage, the RP-21200 series provide a form of current limiting for capacitive loads.

However, if an SSPC is already on and an uncharged capacitive load is applied, i.e., through a switch, the SSPC will trip. If, due to system requirements, this possibility exists, the solution is to use another SSPC to switch the capacitive load. The risetime control of the second SSPC will limit the current. As described earlier, the Slew Control must be connected to AC ground for this current limiting to function.

In some situations, there may be a critical system load that must have power if the primary power bus fails. In that case, a second SSPC may be used to switch power from a secondary power bus when the primary power bus drops. If the load cannot withstand the time for the second SSPC to rise, the Slew Control on the second SSPC may be left open which will speed up its risetime to about 75µS. However, this will reduce the second SSPC's capacitive drive capability by a factor of approximately 7. Risetimes between 75µS and 500µS can be programmed by using a voltage divider between the Power Out pin and "AC" ground and connecting the Slew Control to the mid-point of the voltage divider. The calculated resistance of the two resistors of the voltage divider in parallel must be less than 1000 ohms. The capacitive load capability of an SSPC used this way will be reduced by the same factor as the speed-up of risetime.

RESET

When 5 Volt bias power is applied, internal circuits are automatically reset. As a result, the SSPC will correctly respond to the Control Command input and Lockout Input.

When a trip occurs, the RP-21200 series are latched off. To reset the SSPC, simply bring the Control Command input to a logic low. Subsequently bringing the Control Command input to a logic high will turn the SSPC on again.

THERMAL MEMORY

The I^2t rating of a wire is based on the heating effect of current passing through the wire with the assumption that the wire was initially cool (unpowered). If a wire is already hot, its I^2t rating is lower and, if the wire is already at its maximum temperature, its I^2t rating is zero. The RP-21200 series has circuitry to create a 'thermal memory' to protect the wire under these conditions. The I^2t ratings of the *STAR* Series shown in TABLE 3 apply only when the load current prior to the overload is zero, such as when the SSPC is first turned on. If the load was drawing current prior to the overload, the trip time will be faster. If the SSPC tripped due to an overload and the SSPC is commanded to turn back on immediately, the trip will be almost instantaneous. However, if the SSPC tripped due to an overload and sufficient time elapses for the wire to cool, the trip time will once again be the same as if the wire were initially unpowered. In this way, the 'thermal memory' protects the wire from repetitive overloads.

STATUS CODES

This section contains a fuller explanation of the conditions and meaning of the status codes shown in TABLE 6. Each paragraph number corresponds to the STATE in TABLE 6.

The first four conditions show the control input has commanded the SSPC to be off:

1) The SSPC has failed or shorted to ground. STATUS 1 indicates the load is drawing current but the SSPC should be off.

2) The SSPC has failed. STATUS 1 indicates the load is drawing current; STATUS 2 indicates the power MOSFET switch is on; the SSPC should be off.

3) Normal off condition. STATUS 1 indicates the load is not drawing current; STATUS 2 indicates the power MOSFET switch is off.

4) The SSPC has failed or STATUS 2 has shorted to the bias supply. STATUS 1 indicates the load is not drawing current; STATUS 2 indicates the power MOSFET is on; the SSPC should be off.

The next four conditions show the control input has commanded the SSPC to be on:

5) The SSPC has failed or there is a short to ground on the STATUS 2 output. STATUS 1 indicates the load is drawing current but STATUS 2 indicates the power MOSFET switch is off.

6) Normal on condition. STATUS 1 indicates the load is drawing current and STATUS 2 indicates the power MOSFET switch is on.

7) Tripped condition. STATUS 1 indicates the load is not drawing current and STATUS 2 indicates the power MOSFET switch is off. The SSPC can be turned back on by cycling the input control to a logic low and then back to a logic high. If the excessive load has not been removed, the SSPC will trip again.

8) No load current. STATUS 1 indicates the load is not drawing current; STATUS 2 indicates the power MOSFET switch is on.

HEATSINKING

The *STAR* Series are designed so that the junction temperature of its components can never exceed their maximum ratings if the baseplate temperature is held to 100°C or less. Heat sinking may be required at high ambient temperatures. The maximum ambient temperature (Ta) for operation without a heat sink is 100 - Pd x θ_{CA} (where Pd is the power dissipation and θ_{CA} is the thermal resistance from case-to-ambient from TABLE 3). Note that TABLE 4 specifies maximum power dissipation assuming maximum baseplate temperature and a current equal to Rated Current. Since all systems are designed for the maximum load current to be less than the SSPC's Rated Current (for margin), the actual power would be less than shown in TABLE 4. For example, an SSPC with a Rated Current of 25 Amps, operated at a maximum load current of 20 Amps would actually dissipate 4.95 Watts (20 x 20 x 0.012 + 0.15). This is almost 36% less than the maximum specified in TABLE 4.

Similarly, if the maximum baseplate temperature will be less than 100°C, the MOSFET switch's 'on' resistance will be less than the maximum, thereby reducing the power dissipation. As a result, in many cases, a heat sink will not be required. But, operating at maximum load currents and maximum baseplate temperatures will always require a heat sink. The maximum baseplate temperature with a heat sink can be calculated using the same formula as for without a heat sink, except that θ_{CA} is replaced by the sum of the thermal resistance from junction-to-baseplate and baseplate-to-heat sink.

TABLE 6. STATUS CODES

STATE	INPUT CONTROL (see note 4)	OUTPUT STATUS 1 (see note 1)	OUTPUT STATUS 2 (see note 2)	POWER CONTROLLER AND LOAD STATUS
1	L	L	L	SSPC failure or short to ground.
2	L	L	H	Load "on"; showing SSPC failure.
3	L	H	L	Load "off"; showing normal "off" condition.
4	L	H	H	SSPC failure or STATUS 2 shorted to bias supply
5	H	L	L	SSPC failure or short to ground on STATUS 2 line.
6	H	L	H	Load "on"; showing normal "on" condition.
7	H	H	L	Load "off"; showing "trip" (see note 3).
8	H	H	H	Normal power out with load less than programmed load detection value

Notes:
1) STATUS 1 indicates a logic low when the load is greater than programmed load detection value. See FIGURE 4.
2) STATUS 2 indicates a logic high when the Power MOSFET switch is on.
3) Any trip condition per FIGURE 5.
4) Input Control=Control Command and $\overline{\text{Lockout}}$ Input.

COORDINATION

Coordination requires that in a system using multiple levels of SSPCs in a 'tree' configuration, the lowest level SSPC will trip leaving the other SSPCs untripped. For example, suppose a system has a 25 Amp RP-21225 series SSPC powering a bus which has multiple lower current RP-21200 series SSPCs attached to it. If one of the lower current SSPCs is rated at 10 Amps and has an overload of 50 Amps, the 10 Amp SSPC should trip but no other SSPC should trip even though 50 Amps exceeds the ratings of both SSPCs. The *STAR* Series of SSPCs are designed to guarantee coordination. Note that coordination is guaranteed for a system that uses RP-21200 series, exclusively.

LOCKOUT

One of the concerns in using SSPCs instead of electromechanical circuit breakers is maintenance safety. Electromechanical circuit breakers give a visible indication that they are off allowing safe maintenance of a system. The concern is that when using SSPCs, there is no such visible indication that the SSPC is off and the possibility that a malfunctioning controller could leave on SSPCs which should be off, thereby creating a safety hazard during maintenance.

To address this concern, the *STAR* Series of SSPCs are designed with a Lockout Input. When the Lockout Input is brought to a logic high, the SSPC will be off, regardless of what is commanded on the Control Command input. In a system, the Lockout Inputs of all of the SSPCs can be brought to a switch which can give a visible indication that the SSPC is, in fact, in a safe, off state. There should be no concern that the Lockout Input must be brought to a logic high to guarantee the SSPC is off; the logic high voltage should be the 5 Volt bias power. That way, if the 5 Volt bias power is lost, although the Lockout Input is no longer high, the SSPC will still be off since it cannot operate without 5 Volt bias power and is always off when that occurs.

For additional safety, the Control Command has an internal pull-down resistor and the Lockout Input has an internal pull-up resistor (see FIGURE 2). If either input is left unconnected, the RP-21200 series of SSPCs will default to the off state.

ADVANTAGES OF THE RP-21200 SERIES

The RP-21200 series use power MOSFET technology as the switch. Power MOSFETs have many advantages over electro-mechanical devices and over bipolar transistors used as switches. Most important is the fact that, when the switch opens, there is no arcing. Arcing wears out mechanical contacts since material is transferred from one contact to the other. In some cases, the very high temperatures caused by arcing can actually weld the contacts together, in which case the electromechanical device cannot open the circuit and the wire will overheat and fail, possibly causing a fire. Arcing also causes high levels of EMI.

Bipolar transistors are not as rugged as power MOSFETs. They exhibit 'secondary breakdown' which limits the current they can handle at maximum voltage without failing. Power MOSFETs do not exhibit secondary breakdown and are limited only by their junction temperature rating. Bipolar transistors also exhibit an offset due to their saturation voltage, $V_{CE(sat)}$. Power MOSFETs appear as simple resistors and their voltage drop is simply proportional to their operating current.

The STAR Series of SSPCs are superior to solid-state relays. Most solid-state relays have no protection feature; they are simply switches. Some solid-state relays will protect against short circuits but cannot protect against smaller overloads because they have no I^2t circuits.

Since the RP-21200 series of SSPCs have TTL/CMOS-compatible inputs and outputs they are easy to interface to embedded microprocessor control. This allows automatic load control and automatic load shedding in emergency situations and allows for remote control.

Because the *STAR* Series of SSPCs have tighter trip tolerances than electromechanical circuit breakers, it's not necessary to use as large a wire with these SSPCs as with circuit breakers. This can save considerable weight which is especially important in airborne and space applications.

TABLE 7. OPTIONAL ANALOG CURRENT OUTPUT (SEE NOTES)

PARAMETER	CONDITIONS	UNIT	VALUE
Input Offset Current	I_{load} = 50% rated current	% of Rated Current	2.0, max.
Gain	—	Volts per % of Rated Current	Vref/100, typ.
Gain Error	—	% of Output	2.0, max.
Linearity Error	—	% of Maximum Output	0.5, max.
Reference Voltage Input Current	—	mA	0.26, typ.; 2.0, max.
Reference Voltage Input Range (2)	—	V	4.0 to V_{BIAS} max.
Positive Output Swing	I_{load} = 200% of Rated Current	V	V_{BIAS} -0.5, min.
Negative Output Swing	I_{load} = 0	V	0.02, typ.; 0.05, max.
Output Resistance	—	Ohm	0.33, typ.; 0.46, max.
Slew Rate	I_{load} = 20% to 80% of Rated Current Step	V/µs	0.24, typ.; 0.072, min.
Bandwidth	I_{load} = 80% of Rated Current	kHz	30.0, typ.; 15.0, min.

Notes: 1. All Typical values are at 25°C; all Minimum and Maximum values apply from -55°C to +100°C.
2. Must be supplied externally between 4.0V min. to V_{BIAS} max.

Isolation of the control circuit from the power circuit allows the RP-21200 series to be used in high-side and low-side and negative as well as positive switching applications. Isolation also prevents faults in the power side from propagating into the control side thereby preventing damage to other system components. Isolation also eliminates 'ground loop' problems which can result in false operation.

PARALLELING OF RP-21200 SERIES

While the *STAR* Series takes advantage of the fact that power MOSFETs can be easily paralleled, it is not recommended that RP-21200 series SSPCs be paralleled to obtain higher current ratings unless severe derating or attention to matching is observed.

Since the switches used in the *STAR* Series are power MOSFETs which, when on, look simply like resistors, if two SSPCs are placed in parallel, the current will divide between them. If the 'on' resistances of the MOSFETs in both units are not identical, the current will not divide equally. Therefore, they cannot trip at the same point; the one with the lower 'on' resistance will carry a higher current and will trip first. As soon as the first SSPC trips, the second SSPC will be carrying all of the current and it will trip. As a result, the two SSPCs in parallel will not behave as one SSPC with double the current rating. The current rating will be higher than one SSPC alone, but it will be unpredictable.

Likewise, the trip curves vary from one SSPC to the next. Again, this will result in one SSPC tripping before the other and an unpredictable trip point. While the programmability feature of the *STAR* Series would allow the user to match the trip curves, this would not necessarily guarantee matching over the full temperature range.

OPTIONAL CURRENT MONITOR

An optional Analog current monitor, used for reporting the load current, can be special ordered from the factory. Monitor details are shown in TABLE 7.

The optional Current Monitor provides a voltage output which is proportional to the load current. This Current Monitor contains an Analog-to-Digital converter, optical isolation and a Digital-to-Analog converter. The Reference is brought out to a separate pin. This Reference pin can be simply connected to the 5 Volt bias pin. If the user attaches an external Analog-to-Digital converter to the Current Monitor output pin, then the best accuracy can be obtained by using the external converter's reference for the Current Monitor's Reference.

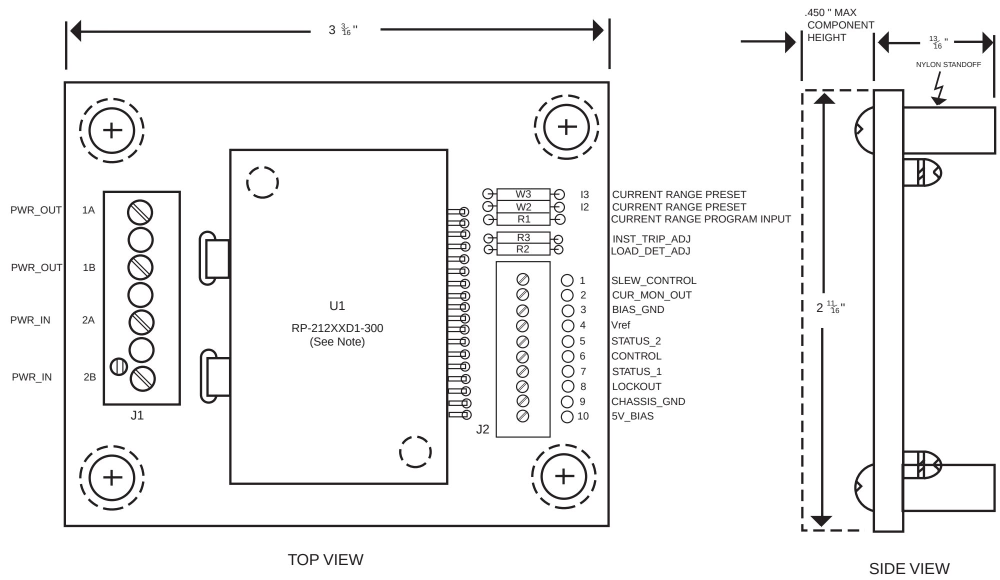
Due to saturation characteristics of the output amplifier in the Current Monitor, the Current Monitor output cannot swing all of the way to ground or to the power supply (5 Volt bias). Therefore, it cannot monitor very low currents (1% of Rated Current) nor can it monitor very high currents (90%) when the 5 Volt bias is used as the Reference. When a Reference voltage of 5 Volt bias less 0.5 Volts is used, the Current Monitor can monitor currents up to 100% of Rated Current; however, the lower limit remains.

OPTIONAL BATTLE SHORT

An optional Battle Short Control (Pin 5) is available on the RP-21225X2/3 and RP-21209X2/3 *STAR* Series devices. The pin used for this option is normally a no connect for all other versions of the *STAR* Series. The Battle Short can be enabled by grounding the Battle Short Control pin to Vbias supply common. To disable the function the pin should be left floating or pulled high to Vbias.

OPTIONAL EVALUATION BOARD

An optional evaluation board is available and is outlined in FIGURE 7. Contact factory for ordering information.



SKT-90110

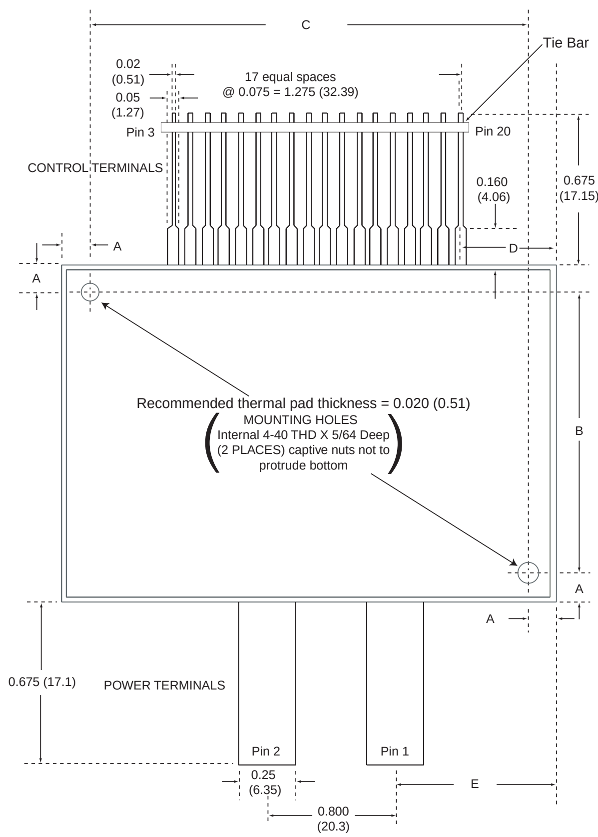
SKT-90110 EVALUATION BOARD AND RP-21225D1 PIN-OUT CROSS REFERENCE				
SKT-90110 PIN NUMBER	**SKT-90110 CONNECTOR**	**RP-21225D1 PIN NUMBER**	**FUNCTION**	**COMMENT**
1A, 1B	J1	1	Power_Out	
2A, 2B	J1	2	Power_In	
10	J2	3	Vbias supply input	
9	J2	4	Chassis ground	
NC	NC	5	No connection	
8	J2	6	Lock-out input	
7	J2	7	Status 1 output	
6	J2	8	Control command input	
5	J2	9	Status 2 output	
4	J2	10	Reference voltage input for optional current monitor	
3	J2	11	Bias supply common input	
2	J2	12	Optional current monitor output voltage	
1	J2	20	Slew control	
NC	NC	13	No connection	
R2*		14	Load detection program input (R2)	Open = 95%, Short = 10%
R3*		15	Instant trip program input (R3)	Open = 200%, Short = 3000%
R2,R3,R1,W2,W3		16	Programming reference	
R1*		17	Current range program input (R1)	Open = 8.3A, Short = 25A
W2*		18	I2 current range preset input	Short = 20A
W3*		19	I3 current range preset input	Short = 12.5A

* Please refer to FIGURE 3, FIGURE 4, and TABLE 5 in data sheet for programming information.

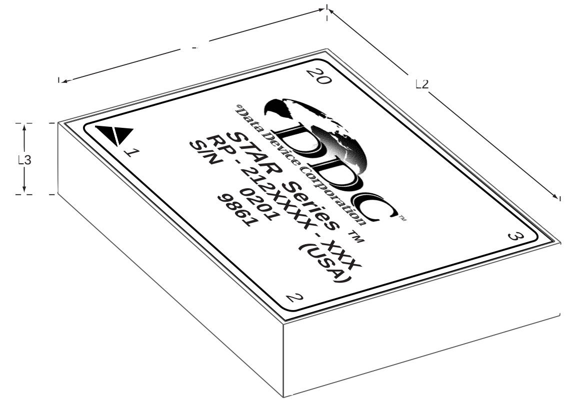
Note: SKT-90110 = Evaluation Board without SSPC supplied
SKT-90110-1 = Evaluation Board with RP-21225D1 supplied
SKT-90110-2 = Evaluation Board with RP-21209D1 supplied
SKT-90110-3 = Evaluation Board with RP-21203D1 supplied

FIGURE 7. OPTIONAL EVALUATION BOARD OUTLINE

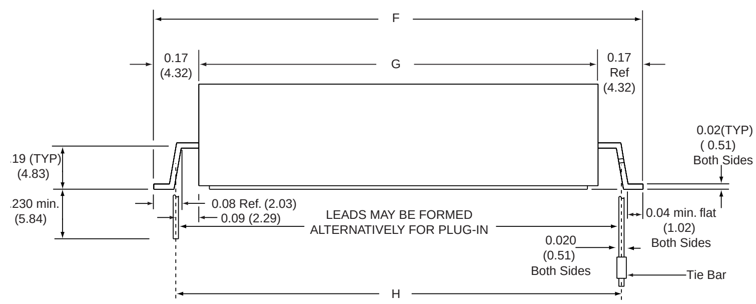
BOTTOM VIEW
[FLAT PACKAGE (F) SHOWN]



ISOMETRIC TOP VIEW
[FLAT PACKAGE (F) SHOWN]



ALTERNATE LEAD CONFIGURATIONS
[GULL LEAD (G) AND
THROUGH HOLE (D) PACKAGES SHOWN]



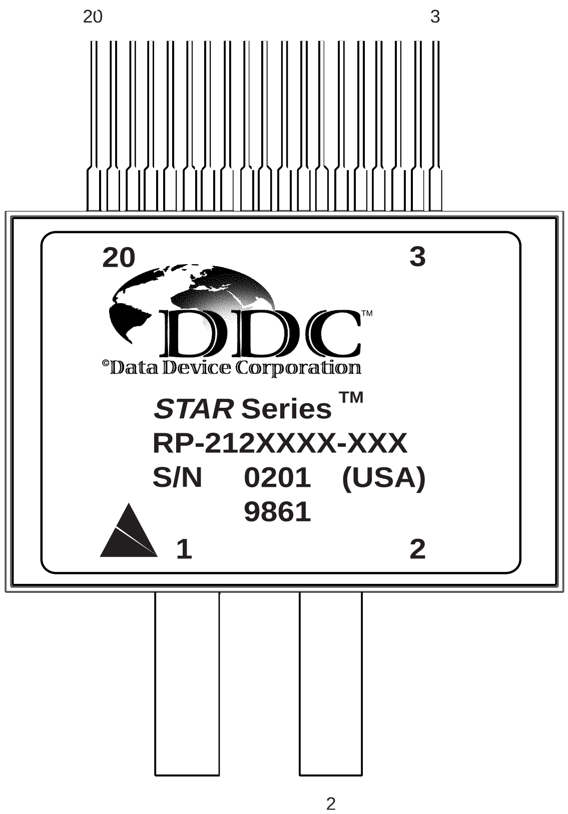
PACKAGE DIMENSIONS			
SSPC MODEL	RP-21203	RP-21209	RP-21225
L1 (see Note 1)	1.205 (30.61)	1.500 (38.10)	1.505 (38.23)
L2 (see Note 1)	1.505 (38.23)	1.500 (38.10)	2.205 (55.88)
L3 (see Note 2)	0.460 (11.68)	0.460 (11.68)	0.460 (11.68)
A	0.262 (6.65)	0.262 (6.65)	0.125 (3.18)
B	0.630 (16.00)	0.930 (23.62)	1.250 (31.75)
C	0.930 (23.62)	0.930 (23.62)	1.950 (49.53)
D	0.115 (2.92)	0.112 (2.84)	0.425 (10.80)
E	0.260 (6.60)	0.260 (6.60)	0.505 (12.83)
F	1.54 ±0.01 (39.12)	1.84 ±0.01(46.74)	1.84 ±0.01 (46.74)
G	1.205 (30.61)	1.50 (38.10)	1.505 (38.10)
H	1.38 ±0.01 (35.05)	1.68 ±0.01 (42.67)	1.68 ±0.01 (42.67)

Notes:

- The models listed above are available with and without the analog current output option.
- Dimensions are in inches (mm).

1. Typical dimensions; tolerance is ± 0.005 in (±0.127).
2. Max. dimensions.

FIGURE 8. RP-21200 SERIES MECHANICAL OUTLINE



Pin #	Function
1	Power out
2	Power in
3	VBias supply input
4	Chassis ground (base)
5	Not connected (Battle Short option)
6	Lock-out input
7	Status 1 output
8	Control command input
9	Status 2 output
10	Reference voltage input for optional current monitor
11	Bias supply common input
12	Optional current monitor output voltage
13	Not connected
14	Load detection program input (R2)
15	Instant Trip (R3) program Input
16	Programming reference
17	Current range program input (R1)
18	I2 current range preset input
19	I3 current range preset input
20	Slew control input

NOTES:
1. Prototype units S/N 100-104 RP-21225F1-300P have pins numbered clockwise. Reference RP-212XX data sheet 01/16/99 or earlier.
2. Figure 9 is now effective for all RP-21225 after S/N 104.

FIGURE 9. PIN-OUT DETAILS

GLOSSARY

Bias Supply- External 5V power supply used to power the SSPC internal circuitry.

BIT- Built In Test.

Coordination- If one or more SSPC's are placed in a series circuit, the SSPC with the lowest rated current will trip first during an over current condition.

Dielectric Strength- The breakdown voltage rating, in Vrms, of an electrical isolation barrier.

EMI- Electromagnetic Interference.

I^2T- Expression that evaluates to a constant value. This constant defines the trip time of the SSPC for any over current except those that would cause an instant trip.

Instant Trip- Condition where the SSPC trips immediately without following the I^2T curve. This occurs when the SSPC load current exceeds a predefined value.

Isolation- The D.C. resistance of an electrical isolation barrier, measured with a known D.C. potential.

Leakage Current- The current that flows into the load when the SSPC is in the off state.

Lockout Control- Provides safe maintenance. When the lockout control is in the active state, the SSPC must be off and shall not respond to the control input.

Max Load Capacitance- Exceeding this load capacitance value may cause unwanted tripping.

MOSFET- Metal Oxide Semiconductor Field Effect Transistor.

On Resistance- Effective resistance in ohms of the SSPC between the Power In and Power Out pins when the SSPC is turned on.

Power Dissipation- Power in watts dissipated by the SSPC. Measured as (VBias x IBias) + (Voltage Drop x Load Current).

Rated Current- Maximum load current where the SSPC will operate continuously without tripping.

SSPC- Solid-State Power Controller

Sympathetic Tripping- Where any SSPC in a system can cause any other SSPC in the system to trip abnormally. (ie. Path through FET parasitic diode or induction transients) Sympathetic tripping is not desirable.

Thermal Resistance- A measure of resistance to heat transfer. Allows calculation of a device's temperature rise above its mounting surface. Specified in °C/W.

Thermal Memory- The ability of an SSPC to account for the thermal energy retained in a wire or device.

Voltage Drop- Maximum voltage measured between the Power In and Power Out pins with the Power Controller operating at its Rated Current.

ORDERING INFORMATION

RP-212XXXX-XX0

Process Requirements:
- 0 = Standard DDC Processing, no Burn-In (See table below)
- 2 = Standard DDC Processing, with Burn-In (See table below)
- 7 = Standard DDC Processing, with Burn-In, Solder Dip
- 9 = Standard DDC Processing with Solder Dip, no Burn-In (See table below)

Temperature Grade/Data Requirements:
- 1 = -55°C to +100°C
- 2 = -40°C to +85°C
- 3 = 0°C to +70°C
- 4 = -55°C to +100°C with Variables Test Data
- 5 = -40°C to +85°C with Variables Test Data
- 8 = 0°C to +70°C with Variables Test Data

Options:
- 0 = Standard Product
- 1 = Analog Current Monitor
- 2 = Battle Short without Monitor
- 3 = Battle Short with Monitor

Package:
- D = Through Hole
- F = Flat Package
- G = Gull Lead (contact factory for availability)

Current Ranges:
- 03* = 1 to 3 Amp Programmable range
- 09 = 3 to 9 Amp Programmable range
- 25 = 8.3 to 25 Amp Programmable range

*RP-21203XX-XX0 is not available with Battle Short.

ADDITIONAL ORDERING INFORMATION

SKT-XXXXX

Evaluation Board:
- 90110 = Evaluation Board without SSPC Supplied
- 90110-1 = Evaluation Board with RP-21225D1-300 Supplied
- 90110-2 = Evaluation Board with RP-21209D1-300 Supplied
- 90110-3 = Evaluation Board with RP-21203D1-300 Supplied

STANDARD DDC PROCESSING FOR DISCRETE MODULES/PC BOARD ASSEMBLIES		
TEST	**METHOD(S)**	**CONDITION(S)**
INSPECTION / WORKMANSHIP	IPC-A-610	Class 3
ELECTRICAL TEST	DDC ATP	—

NOTES:

NOTES:

NOTES:

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105 Wilbur Place, Bohemia, New York, U.S.A. 11716-2482

For Technical Support - 1-800-DDC-5757 ext. 7771

Headquarters, N.Y., U.S.A. - Tel: (631) 567-5600, Fax: (631) 567-7358
Southeast, U.S.A. - Tel: (703) 450-7900, Fax: (703) 450-6610
West Coast, U.S.A. - Tel: (714) 895-9777, Fax: (714) 895-4988
United Kingdom - Tel: +44-(0)1635-811140, Fax: +44-(0)1635-32264
Ireland - Tel: +353-21-341065, Fax: +353-21-341568
France - Tel: +33-(0)1-41-16-3424, Fax: +33-(0)1-41-16-3425
Germany - Tel: +49-(0)8141-349-087, Fax: +49-(0)8141-349-089
Japan - Tel: +81-(0)3-3814-7688, Fax: +81-(0)3-3814-7689
World Wide Web - http://www.ddc-web.com