

## **DC Solid State Power Controller Module**

### **Description:**

The Solid State Power Controller (SSPC) Module is a microcontroller-based Solid State Relay rated upto 25A designed to be used in Army, Air force and Navy in 28V DC applications. This module has integrated current sensing with no derating over the full operating temperature range. The module is the electronic equivalent to an electromechanical circuit breaker with isolated control and status.

This series is supplied in 3 product families covering 9 current ranges:

### **SPD5D28 Family:**

- SPD5D28-1: 1A
- SPD5D28-3: 3A
- SPD5D28-5: 5A

### **SPD15D28 Family:**

- SPD14D28-7: 7A
- SPD14D28-10: 10A
- SPD14D28-14: 14A

### **SPD25D28 Family:**

- SPD25D28-15: 15A
- SPD25D28-20: 20A
- SPD25D28-25: 25A

### **Compliant Documents & Standards:**

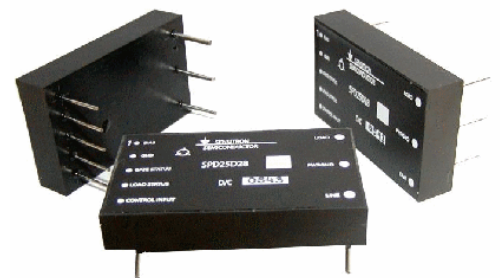
MIL-STD-1275B, Notice1	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles-4/20/04
MIL-STD-704F	Aircraft Electrical Power Characteristics 12 March 2004
MIL-STD-217F, Notice 2	Reliability Prediction of Electronic Equipment 28 Feb 1995

### **Module Features:**

- Epoxy Shell Construction
- Solid State Reliability; Low Weight (20 gms) - High Power Density
- Same Pin Out as Industry Standard SSPCs in a Smaller Outline
- Extremely Low Power, No Derating Over the Full Temperature Range

### **Electrical Features (SPDXXD28 Series):**

- 28VDC Input with Very Low Voltage Drop; 60mV, typ. @15A
- True  $I^2t$  Protection from 32A to 250A with Nuisance Trip Suppression
- Instant Trip Protection (50  $\mu$ sec typ) for Loads Above 250A
- Unlimited Interrupt Capability; Repetitive Fault Handling Capability
- Thermal Memory
- Internally Generated Isolated Supply to Drive the Switch
- Low Bias Supply Current: 20 mA typ @ 5V DC
- High Control Circuit Isolation: 750V DC Control to Power Circuit
- Soft Turn-On to Reduce EMC Issues
- EMI Tolerant
- Module Reset with a Low Level Signal; Reset Circuit is Trip-Free
- TTL/CMOS Compatible, Optically Isolated, Input and Outputs
- Schmitt-Trigger Control Input for Noise Immunity



**TECHNICAL DATA**  
**DATASHEET 4310, Rev B**

**Table 1 - Electrical Characteristics** (at 25 °C and  $V_{bias} = 5.0V$  DC unless otherwise specified)

<b>Control &amp; Status (TTL/CMOS Compatible)</b>	
BIAS ( $V_{cc}$ )	5.0V DC Nominal, 6.5V DC Absolute Maximum 4.5V to 5.5 VDC
BIAS ( $V_{cc}$ ) Current	20 mA typ 25 mA, max
GATE Status, Load Status Signals	$V_{oh}=3.7V$ , min, at $I_{oh}=-20mA$ $V_{ol}=0.4V$ , max, at $I_{ol}=20mA$
CONTROL Signal $V_{T+}$ (Positive-going input threshold voltage) $V_{T-}$ (Negative-going input threshold voltage) $\Delta V_T$ Hysteresis ( $V_{T+} - V_{T-}$ )	2.0V, min, 3.5V, max 1.2V, min, 2.3V, max 0.6V, min, 1.4V, max
Reset	Cycle CONTROL Signal

<b>Power</b>	
Input Voltage – Continuous – Transient	0 to 40V DC, 50V DC Absolute Maximum +600V or -600V Spike ( $\leq 10 \mu s$ )
Power Dissipation	See Table 4
Current	See Table 4 See Trip Curve
Max Voltage Drop	See Table 4
Max current without tripping	110% min

Trip time	See Trip Curve
Output Rise Time (turn ON)	110 $\mu s$ typ
Output Fall Time under normal turn-off	110 $\mu s$ typ
Output Fall Time under Fault	50 $\mu s$ typ
Min Load Requirement	Nil

<b>Protection</b>	
Short Circuit Protection	Unlimited
Instant Trip	800%, min; 1200%, max

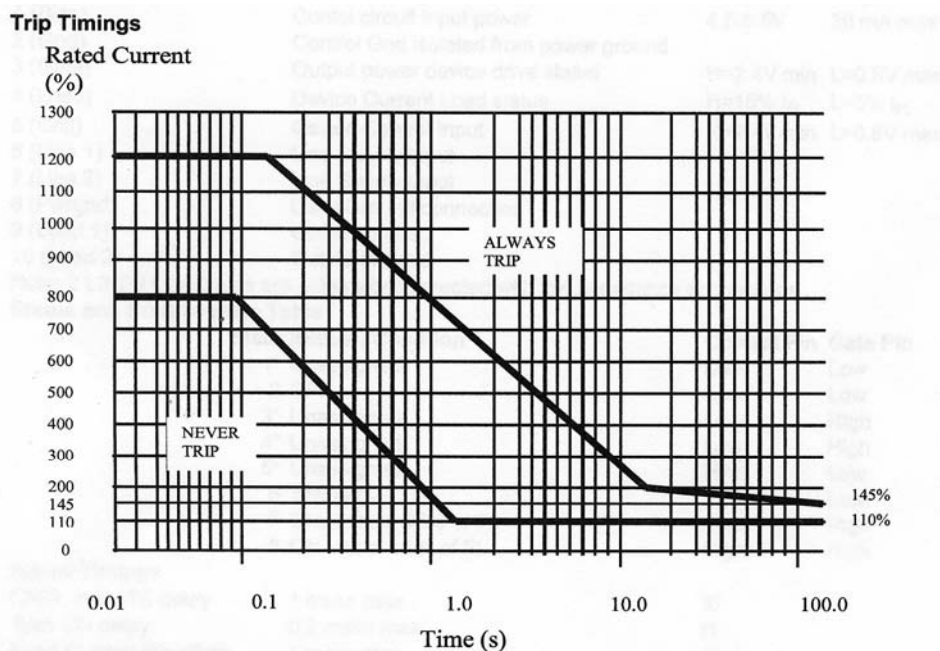
**Physical Characteristics**

<b>Temperature</b>	
Operating Temperature	$T_A = -55^\circ C$ to $+100^\circ C$
Storage Temperature	$T_A = -55^\circ C$ to $+125^\circ C$

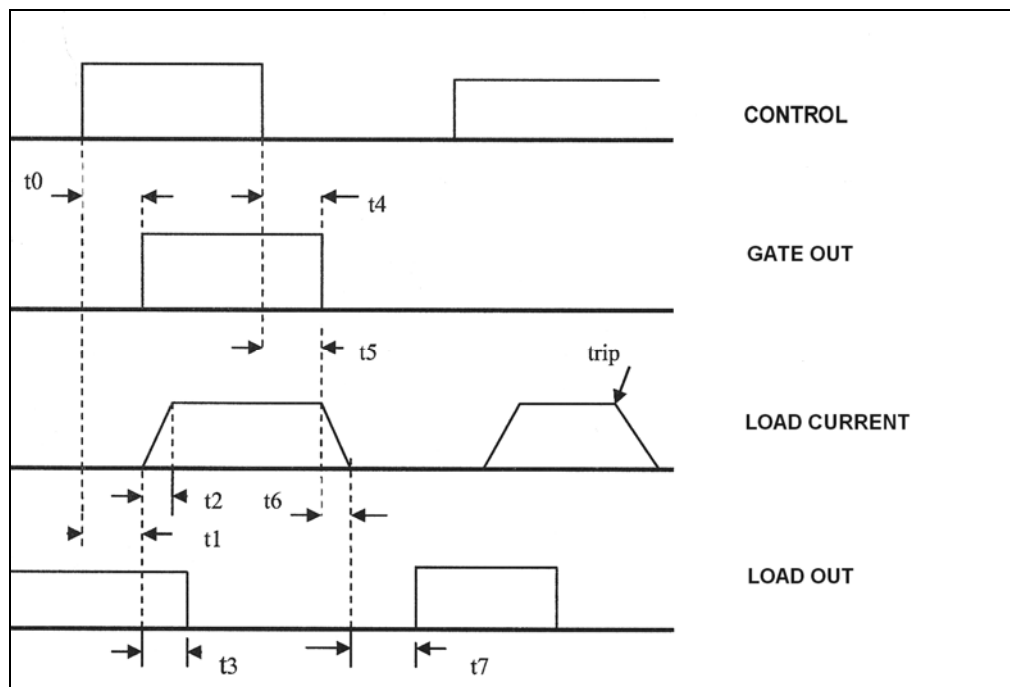
<b>Environmental</b>	
Altitude	Up to 30,000 ft Can be installed in an unpressurized area
Case Dimensions	1.825"L x 1.25"W x 0.38"H
Operating Orientation	Any
Weight	20 grams typ
MTBF (Estimate: MIL STD 217F)	1.1 Mhrs at 25°C Full load

**TECHNICAL DATA**  
**DATASHEET 4310, Rev B**

**Figure 1 - Trip Curve**



**Figure 2 - Timing Diagram**



**TECHNICAL DATA**  
**DATASHEET 4310, Rev B**

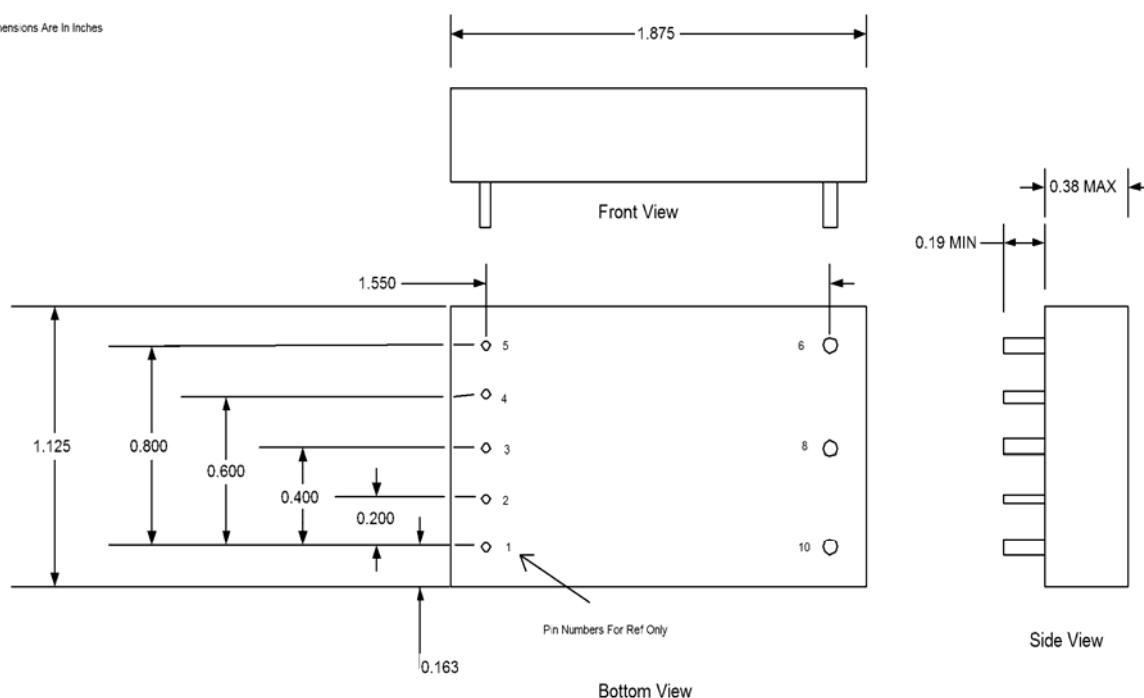
**Table 2 - Signal Timing – (-55 °C to 100 °C @ LINE = 28V DC)**

Parameter	Symbol	Min	Max	Units
CONTROL to GATE Status Delay for Turn On	t0		1	ms
Turn ON Delay	t1		200	μs
Load Current Rise Time	t2	50	200	μs
Turn ON to LOAD Status Delay	t3		1	ms
CONTROL to GATE Status Delay for Turn Off	t4		1	ms
Turn OFF Delay	t5		200	μs
Load Current Fall Time	t6	50	200	μs
Turn OFF to LOAD Delay	t7		1	ms

Note: Current Fall Time from trip dependent on magnitude of overload

**Figure 3 - Mechanical Dimensions**

All Dimensions Are In Inches



**Table 3 - Pin Definitions**

Pin Number	Pin Name	Function
1	BIAS	+5V DC Supply
2	GND	5V Return
3	GATE Status	Switch Status
4	LOAD Status	Load Current Detection
5	CONTROL Input	On/Off Control
6	LINE	+28V DC Supply
7	---	No Pin
8	PWRGND	28V Return
9	---	No Pin
10	LOAD	Load Connection

**TECHNICAL DATA**  
**DATASHEET 4310, Rev B****Table 4 – Individual Model Ratings****SPD5D28 Family**

Model	SPD5D28-1	SPD5D28-3	SPD5D28-5
Current Rating @ 100°C	1A	3A	5A
Power Dissipation	0.01W typ @ 0.6A 25°C 0.035W max @ 1A 25°C 0.04W max @ 1A 100°C	0.04W typ @ 1.8A 25°C 0.14W max @ 3A 25°C 0.16W max @ 3A 100°C	0.09W typ @ 3A 25°C 0.30W max @ 5A 25°C 0.36W max @ 5A 100°C
Max Voltage Drop	18mV typ @ 0.6A 25°C 35mV max @ 1A 25°C 40mV max @ 1A 100°C	23mV typ @ 1.8A 25°C 46mV max @ 3A 25°C 53mV max @ 3A 100°C	30mV typ @ 3A 25°C 60mV max @ 5A 25°C 71mV max @ 5A 100°C

**SPD14D28 Family**

Model	SPD14D28-7	SPD14D28-10	SPD14D28-14
Current Rating @ 100°C	7A	10A	14A
Power Dissipation	0.15W typ @ 4.2A 25°C 0.49W max @ 7A 25°C 0.60W max @ 7A 100°C	0.26W typ @ 6A 25°C 0.87W max @ 10A 25°C 1.10W max @ 10A 100°C	0.48W typ @ 8.4A 25°C 1.61W max @ 14A 25°C 2.06W max @ 14A 100°C
Max Voltage Drop	35mV typ @ 4.2A 25°C 70mV max @ 7A 25°C 86mV max @ 7A 100°C	43mV typ @ 6A 25°C 87mV max @ 10A 25°C 110mV max @ 10A 100°C	57mV typ @ 8.4A 25°C 115mV max @ 14A 25°C 147mV max @ 14A 100°C

**SPD25D28 Family**

Model	SPD25D28-16	SPD25D28-20	SPD25D28-25
Current Rating @ 100°C	16A	20A	25A
Power Dissipation	0.41W typ @ 9.6A 25°C 1.44W max @ 16A 25°C 1.73W max @ 16A 100°C	0.60W typ @ 12A 25°C 2.11W max @ 20A 25°C 2.56W max @ 20A 100°C	0.90W typ @ 15A 25°C 3.15W max @ 25A 25°C 3.86W max @ 25A 100°C
Max Voltage Drop	43mV typ @ 9.6A 25°C 90mV max @ 16A 25°C 108mV max @ 16A 100°C	50mV typ @ 12A 25°C 105mV max @ 20A 25°C 128mV max @ 20A 100°C	60mV typ @ 15A 25°C 126mV max @ 25A 25°C 154mV max @ 25A 100°C

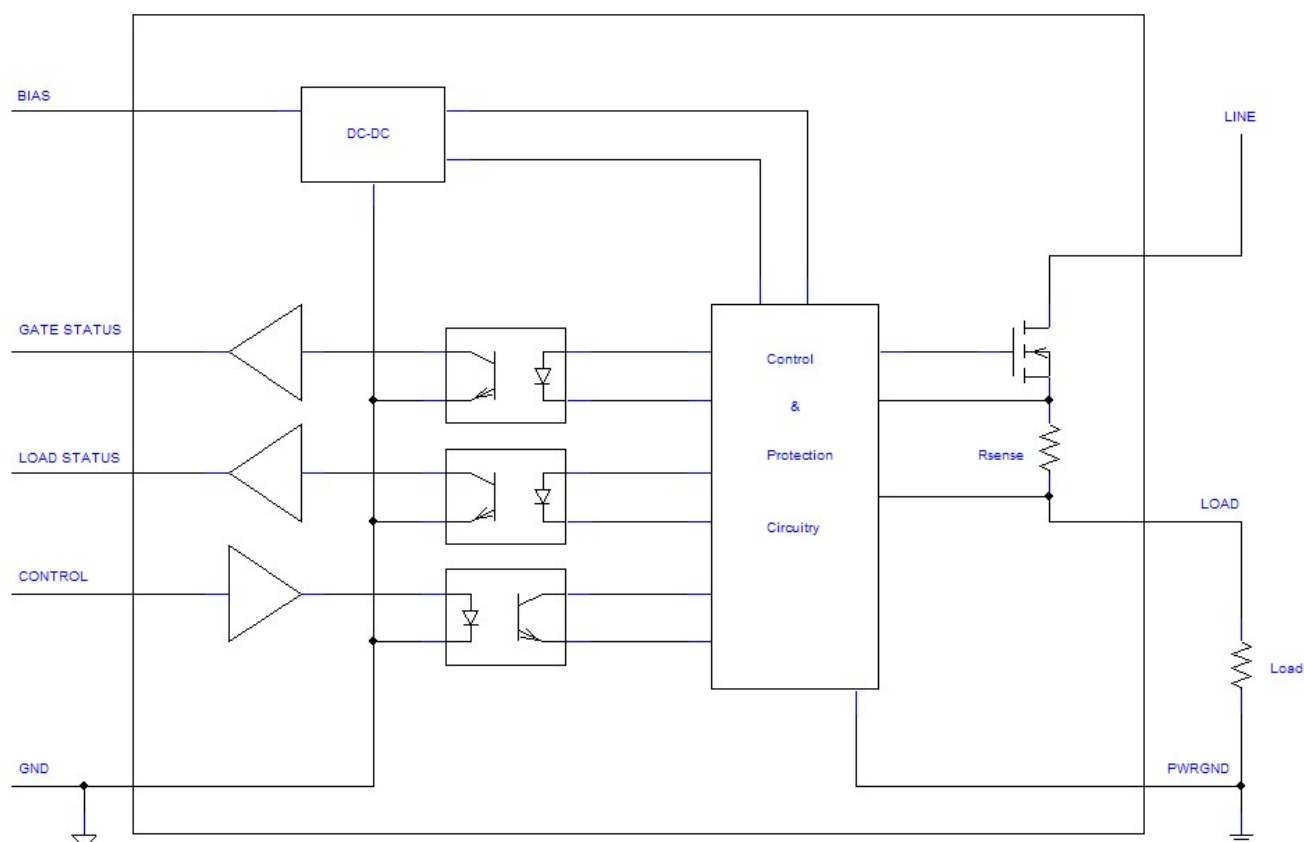
**TECHNICAL DATA**  
**DATASHEET 4310, Rev B****Figure 4 - Electrical Block Diagram****Description**

Figure 4 shows the block diagram of the SPDXXD28 SSPC Series. It uses a SN74LVC3G14 device for digital I/O. This TTL compatible device has a Schmitt-Trigger input to minimize the effects of noise on the input. Its outputs can each drive more than 10 standard TTL loads. It's also compatible with CMOS inputs and outputs. The SN74LVC3G14 is isolated from the remainder of the module circuitry by three optocouplers.

The block labeled "Control & Protection Circuitry" gets power from the DC-DC converter and is referenced to the output of the SSPC. This block contains an amplifier to gain up the voltage developed across the sense resistor. It also contains a microcontroller with on-board timers, A/D converter, clock generator and independent watchdog timer. The microcontroller implements a precision  $I^2t$  protection curve as well as an Instant Trip function to protect the wiring and to protect itself. It performs all of the functions of multiple analog comparators and discrete logic in one high-reliability component.

The code programmed in the microcontroller acquires the output of the internal A/D converter, squares the result and applies it to a simulated RC circuit. It checks the output of the simulated circuit to determine whether or not to trip (turn off the power Mosfets). Because the microcontroller simulates an analog RC circuit, the SSPC has 'thermal memory'. That is, it trips faster if there had been current flowing prior to the overload than if there hadn't been current flowing. This behavior imitates thermal circuit breakers and better protects the application's wiring since the wiring cannot take as much an overload if current had been flowing prior to the overload.

**TECHNICAL DATA**  
**DATASHEET 4310, Rev B**

The watchdog timer operates from its own internal clock so a failure of the main clock will not stop the watchdog timer. The code programmed in the microcontroller will periodically reset the watchdog timer preventing it from timing out. If the code malfunctions for any reason, the watchdog timer is not reset and it times out. When the watchdog timer times out, it resets the microcontroller. Since the code is designed to detect levels and not edges, the output of the module, and therefore the output of the SPDXXD28, immediately reflects the command on its input.

The Power Mosfets used in the SPDXXD28 Series have been selected for very low  $R_{ds(on)}$  and results in low voltage drop and low power dissipation. In most applications, the SPDXXD28 will be operated at 50 – 60% of rated current to provide a safety margin. As can be seen in Table 1, when the SPD25D28 is operated at 15 Amps, 60% of rated current, it only dissipates 1.0 Watt at room temperature. No heatsinking is required for this condition. However, if the SPD25D28 is to be operated at maximum rating and/or at elevated temperatures, the dissipation can exceed 4 Watts and heatsinking is required. Some heatsinking can be accomplished by adding copper area to the LINE and LOAD pins, a heatsink can be epoxied to the surface of the module or a flat copper or aluminum heatsink can be sandwiched between the SPD25D28 and the printed circuit board using a thermal pad to maximize heat transfer. Each application should be evaluated at maximum expected constant current.

For overloads, no heatsinking is required provided the SPDXXD28 Series is allowed some time to cool down. The SPDXXD28 has sufficient thermal mass that the temperature will rise only a few degrees under the worst-case overload. Repetitive overloads should be avoided. When the SPDXXD28 reports a trip condition, the controller driving the SPDXXD28 should allow no more than four repetitions and then allow thirty seconds to cool down before trying to turn on again.

The SPDXXD28 will trip on overloads in the ALWAYS TRIP region shown in Figure 1 and will never trip when in the NEVER TRIP region. The SPDXXD28 can be reset by bringing the CONTROL pin to a logic low. When the CONTROL pin is brought back to logic high, the SPDXXD28 will turn back on. If the overload is still present, the SPDXXD28 will trip again. Cycling the 5 Volt BIAS power will also reset the SPDXXD28. If the CONTROL pin is at logic high when the BIAS power is cycled, the SPDXXD28 will turn back on when the BIAS power is re-applied.

**Status Outputs**

The LOAD and GATE status outputs of the SPDXXD28 show whether or not the load is drawing current and whether or not the SPDXXD28 Power Mosfet switch is on. A logic high on the LOAD status output shows that the load draws  $\leq 5\%$  of rated load and a logic low shows that the load draws  $\geq 15\%$  of rated current. A load that draws between 5% and 15% of rated current could result in either a high or low logic level on the LOAD status output. A logic high on the GATE output indicates that the Power Mosfet switch is on while a logic low indicates that the switch is off.

As can be seen in Table 4, of the 8 possible states for the combination of CONTROL, LOAD and GATE, only 3 states represent valid SSPC operation. The other 5 states indicate either a failed SSPC or, more likely, a short to ground or a short to the BIAS supply of one of the logic outputs. By comparing the CONTROL input with the LOAD and GATE outputs, the user can determine whether or not the load is supposed to be ON (GATE), whether or not it's drawing current (LOAD) and whether or not the LOAD and GATE outputs are valid responses to the CONTROL input.

**Table 4 – CONTROL, LOAD & GATE Truth Table**

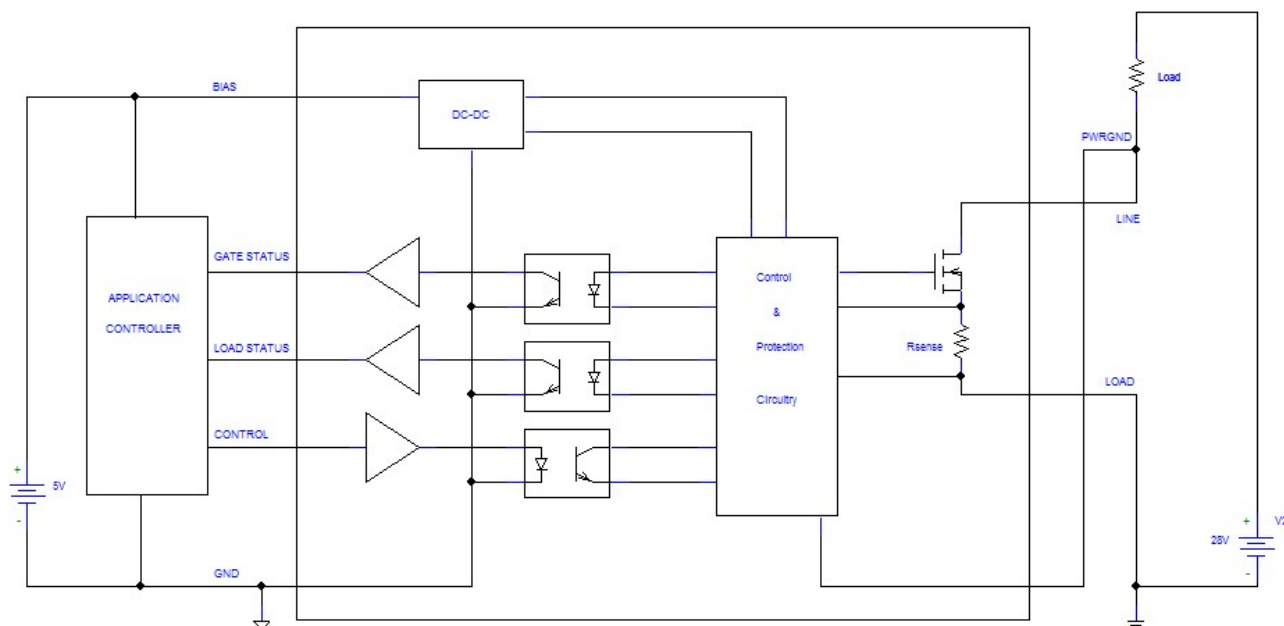
State	CONTROL	LOAD	GATE	Comments
1	L	L	L	SSPC failure or shorted LOAD output to ground
2	L	L	H	SSPC failure
3	L	H	L	Normal OFF condition
4	L	H	H	SSPC failure or shorted GATE output to BIAS supply
5	H	L	L	SSPC failure or shorted GATE output to ground
6	H	L	H	Normal ON condition with load current > 15% rated current
7	H	H	L	Tripped
8	H	H	H	Normal ON condition with load current < 5% rated current

- ### Wire Size



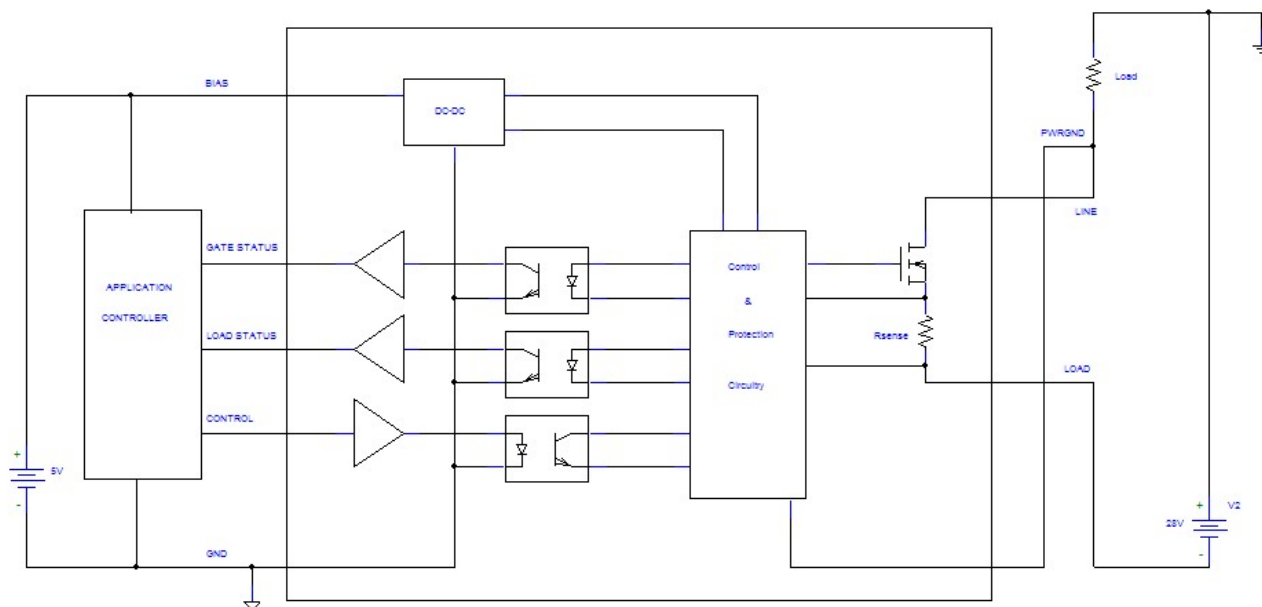
**TECHNICAL DATA**  
**DATASHEET 4310, Rev B**

Figure 6 shows a low-side switch with a negative power supply. Note that the PWRGND pin is now connected to the LINE pin (see Rise/Fall Time paragraph below for more information on the PWRGND pin).



**Figure 6 – Low-Side Switch, Positive Supply**

Figures 7 and Figure 8 show negative supply high-side switch and low-side switch implementations. Again, note the connection of the PWRGND pin.



**Figure 7 – High Side Switch, Negative Supply**



**TECHNICAL DATA**  
**DATASHEET 4310, Rev B**

**Board Layout**

The current-carrying power circuit should be kept well away from the control circuit and other low-level circuits in the system. It's unlikely, but possible, that magnetic coupling could affect the control circuit when turning normal loads on and off. However, in the case of an overload, the magnetic coupling could be 10 times greater than with normal loads. Effects of such coupling could cause 'chattering' when turning on and off, oscillation, and the possibility of turning the SPDXXD28 back on after an overload. The SPDXXD28 Series is a Trip-Free device. Once tripped it will not turn back on until reset and commanded on again. Reset is accomplished by bringing the CONTROL pin low and turning the SSPC back on is accomplished by bringing the CONTROL pin high. Sufficient magnetic coupling between the current-carrying power circuit and the control circuit can negate the Trip-Free characteristic.

**MIL-STD-704F and MIL-STD-1275B**

These standards cover the characteristics of the electrical systems in Military Aircraft and Vehicles. The SPDXXD28 Series meets all of the requirements of MIL-STD-704F including Normal, Emergency, Abnormal and Electric Starting conditions with the Ripple, Distortion Factor and Distortion Spectrum defined in the standard. The SPDXXD28 Series also meets all of the requirements of MIL-STD-1275B including operation with Battery and Generator, Generator Only and Battery Only for all of the conditions described in the standard including Cranking, Surges, Spikes and Ripple.

In addition, the SPDXXD28 Series can withstand  $\pm 600$  V spikes for 10uS. This capability is beyond that required by the standards cited above.

**DISCLAIMER:**

- 1- The information given herein, including the specifications and dimensions, is subject to change without prior notice to improve product characteristics. Before ordering, purchasers are advised to contact the Sensitron Semiconductor sales department for the latest version of the datasheet(s).
- 2- In cases where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, medical equipment, and safety equipment), safety should be ensured by using semiconductor devices that feature assured safety or by means of users' fail-safe precautions or other arrangement.
- 3- In no event shall Sensitron Semiconductor be liable for any damages that may result from an accident or any other cause during operation of the user's units according to the datasheet(s). Sensitron Semiconductor assumes no responsibility for any intellectual property claims or any other problems that may result from applications of information, products or circuits described in the datasheets.
- 4- In no event shall Sensitron Semiconductor be liable for any failure in a semiconductor device or any secondary damage resulting from use at a value exceeding the absolute maximum rating.
- 5- No license is granted by the datasheet(s) under any patents or other rights of any third party or Sensitron Semiconductor.
- 6- The datasheet(s) may not be reproduced or duplicated, in any form, in whole or part, without the expressed written permission of Sensitron Semiconductor.
- 7- The products (technologies) described in the datasheet(s) are not to be provided to any party whose purpose in their application will hinder maintenance of international peace and safety nor are they to be applied to that purpose by their direct purchasers or any third party. When exporting these products (technologies), the necessary procedures are to be taken in accordance with related laws and regulations.