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White Paper

Performance Comparison: Solid State Power Controllers vs. Electromechanical Switching

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July 2010

Performance Comparison: SSPCs vs. Electromechanical Switching

Introduction

The design of primary and secondary power distribution systems for modern ground and air platforms entails a number of challenges. These include needs for increased amounts of electrical power for C^4I and other equipment; improved reliability and system availability; reduced weight, volume and thermal footprint; along with capabilities to shed loads, and for enabling system prognostics and diagnostics.

SSPCs (Solid State Power Controllers) provide a number of functional and performance advantages over electromechanical circuit breakers and relays. SSPCs provide accurate measurements, digital processing, low loss switching with controlled rise and fall time for reduced EMI emissions, very rapid short circuit protection, along with I^2t overload protection. I^2t protection protects wiring, loads and the SSPCs themselves against overheating, while reliably avoiding “nuisance trips” when switching into capacitive or incandescent lamp loads.

Relays and breakers present reliability problems, as they are subject to arcing, oxidation, erosion, and welding; along with problems associated with moving parts. The latter include contact bounce, and difficulties operating in environments with high vibration, dust, or sand. Relative to electromechanical switching, SSPCs provide an advantage in reliability (MTBF) of an order or magnitude or more, providing increased vehicle and system availability.

Relative to electromechanical breakers and relays, SSPCs increase electrical energy efficiency by providing lower power dissipation, along with higher power weight and volume densities.

By means of bus or network connectivity, SSPCs provide real time feedback to vehicle diagnostic computers. Data reported from SSPCs can be used for system-level diagnostics and prognostics, enabling predictive, condition-based maintenance, thereby providing increased availability and continued mission readiness. Reported data, which includes the status of the on-board SSPCs, allows management computers to make advance determinations of pending failures of generators, batteries, wiring, connectors, and loads.

Solid State Power Controllers

In addition to basic ON/OFF power switching, typical SSPCs provide a number of protective features, including rapid short circuit protection, enabling circuit deactivation times on the order of 1 mS. The circuit deactivation involves a gradual removal of the channel’s switching MOSFET(s)’ gate drive over a period of 500 µS to 1mS, to minimize EMI emissions. Referring to Figure 1, for overload protection, SSPCs implement an “I-squared t” (I^2t) detection method to protect wires and loads, while still preventing high inrush currents for switching into motors, solenoids, capacitive loads such as electronic power supplies, or incandescent light bulb loads from resulting in “nuisance trips”. With I^2t protection, SSPCs will instantly trip when the measured load current is ten or more times the rated current. For lower values of current, the SSPC’s processor performs a continuous calculation, resulting in longer trip times for overload situations involving load currents of between one and ten times the rated value.

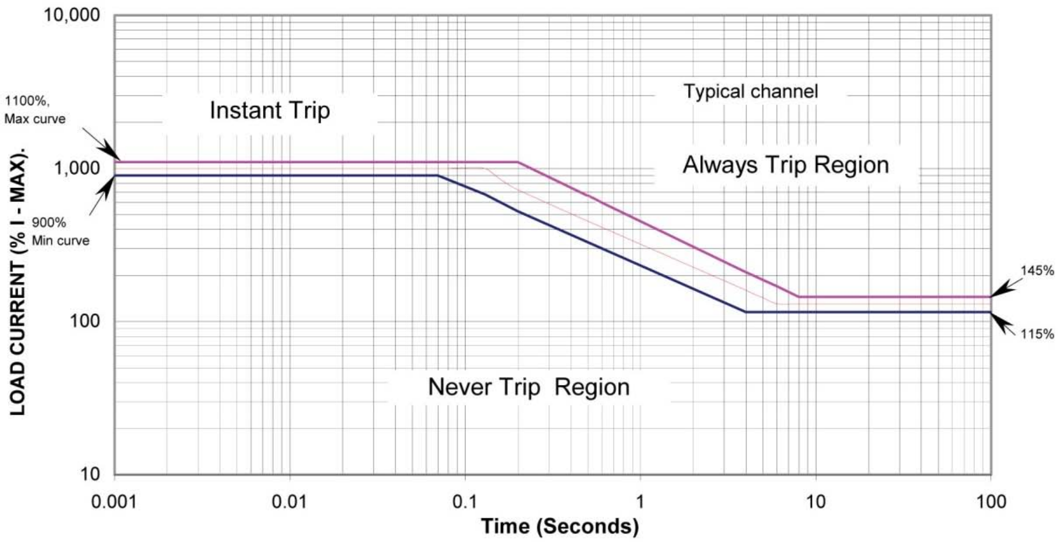


Figure 1. SSPC I²t Trip Curve

Modern SSPC boards are processor-based, providing advantages in the areas of flexibility, measurement and computational accuracy, and connectivity to an external power management computer by means of a data bus or network interface, such as CAN Bus, Ethernet, or MIL-STD-1553. Other features include capabilities for programming different values for the SSPC channels' rated currents to accommodate varying loads, and the capability to parallel multiple SSPC channels, enabling higher current capacities.

To support prognostics, diagnostics, health monitoring, and fault detection and isolation, a power management computer can poll the values of various SSPC parameters over the board's bus or network interface. For each SSPC channel, these parameters include basic on/off and built-in test status, along with output voltage and current; and board rail and/or load temperatures. This data will allow a power management computer to make advance determinations of pending failures of generators, batteries, wiring, connectors, loads, along with the status of the on-board SSPCs.

Figure 2 is an example of a multi-channel 28 volt SSPC board, DDC's RP-26200. This board includes 16 SSPC load channels, with each channel capable of delivering up to 25 amps of current with capability to be paralleled with other channels to support larger loads, and a total capacity of 200 to 300 amps. For load current switching, each SSPC channel includes one or more MOSFETs. For minimizing EMI emissions, in particular for dealing with fault conditions, the SSPCs provide control of their output voltage rise and fall times. For channel activation, controlled rise times reduce the inrush current for switching into loads such as motors, solenoids, electronic power supplies, and incandescent lamps. For the case of incandescent lamps, this provides the added benefit of increasing the lifetime of the light bulbs.

SSPCs provide a number of functional and performance advantages over electromechanical circuit breakers and relays. These advantages are described in the following paragraphs.

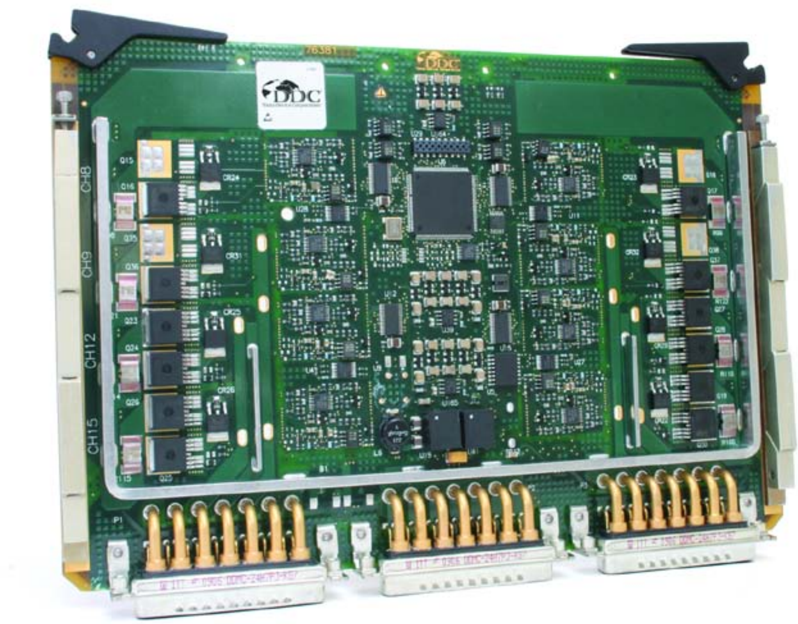


Figure 2. DDC RP-26200 16-Channel Solid State Power Controller Board

Weight and Volume

Relative to electromechanical switching, SSPCs provide advantages in the areas of weight and volume. From a system-level top-down perspective, referring to Figure 3, a representative system providing electromechanical switching of 80 amps of 28V power to 8 loads is 4.25” X 7” X 10.9” or 324 cu. in., and weighs 11.5 pounds. Referring to Figure 4, an SSPC module switching 480 amps of 28V power to 32 loads is 11” X 7.8” X 3.1” or 266 cu. in., and weighs 15 pounds.

Figure 3. Electromechanical Relay/Circuit Breaker System Box

As a matter of comparison and referencing Figure 5, the power-to-volume ratio for the electromechanical switching system shown in Figure 3 is 6.9 watts/cu. in., while that for the SSPC module shown in Figure 4 is 50.5 watts/Cu-in. At a system level, this provides SSPCs an advantage in power-to-volume density of 7.3 to 1. This reduction in volume frees up additional space for crew and/or equipment.

The power to weight ratio for the electromechanical switching system (Figure 3) is 194.8 watts/lb., while that for the SSPC module (Figure 4) is 896 watts/lb. This provides SSPCs an advantage in power-to-weight density of about 4.6 to 1. This reduction in weight translates to fuel savings.

These differences in system volume and weight density are attributable to multiple factors. These include:

- As explained below, solid state components exhibit inherently lower volume and weight relative to electromechanical relays and breakers.
- In addition to directly reducing overall size and weight, the reduced component sizes also reduce the size and weight of the associated PC boards and chasses.
- Solid state components attach directly to printed circuit boards. In some cases, relays and breakers mount on metal frames rather than PC boards, and interconnect by means of discrete wires, rather than PC board traces.

Figure 4. Solid State Power Controller Module

	Electromechanical Switching	DDC SSPC Module
Voltage	28 V	28 V
Current	80A	480 A
Loads	8	32
Dimensions	4.25" x 7" x 10.9"	11" x 7.8" x 3.1"
Volume	324 in^3	266 in^3
Weight	11.5 lbs	15 lbs
Power-to-Volume Density	6.9 W/in^3	**50.5 W/in^3**
Power-to-Weight Density	194.8 W/lb	**896 W/lb**

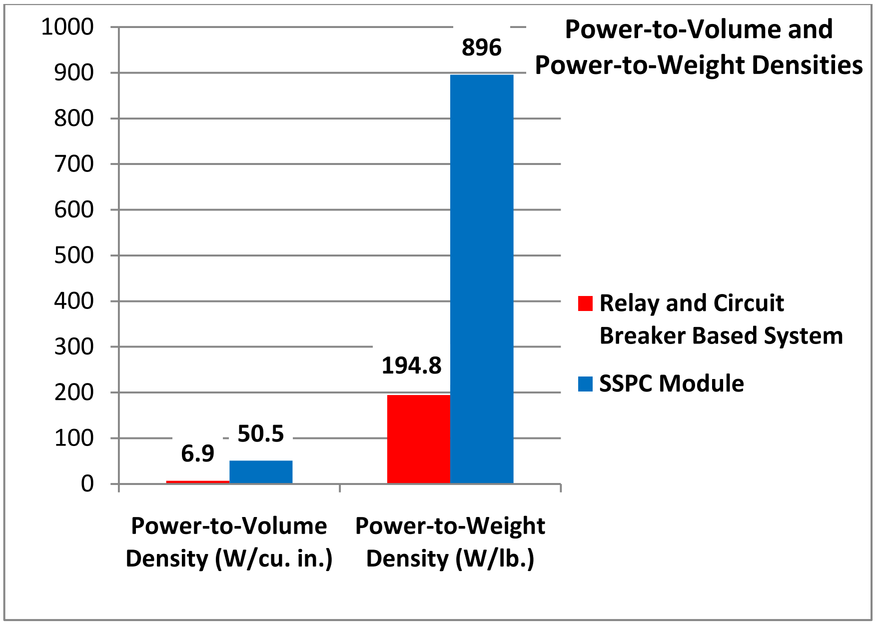


Figure 5. Top-Down, System-Level Comparison: Power to Volume and Weight Densities, Solid State Power Control Module vs. Electromechanical Switching

For comparing the volume, weight, and power dissipation of solid state and electromechanical switching from a bottom-up perspective, Table 1 and Table 2 provide the weight, volume, and power dissipation of commercially available electromechanical relays and breakers, each from multiple suppliers. These tables include the outline dimensions, weight, and power dissipation for five 28V, 25-amp relays; and five 28V, 25-amp circuit breakers. In addition, they include the computed PC board real estate and volume for these components, along with the computed average values for these parameters.

Table 1. Data for 28 V, 25-amp Relays									
28V, 25-amp Relays	**Width (in.)**	**Depth (in.)**	**Height (in.)**	**PC Board Real Estate (sq. in.)**	**Volume (cu. in.)**	**Weight (lbs.)**	**Coil Dissipation (watts)**	**Contact Dissipation (watts)**	**Total Dissipation (watts)**
#1	1.01	0.52	1.00	0.52	0.52	0.10	2.45	N/A (note 1)	6.20
#2	1.71	0.48	1.01	0.82	0.83	0.12	2.45	4.38	6.83
#3	1.72	0.53	1.01	0.90	0.91	0.1	2.45	4.38	6.83
#4	1.53	1.40	1.90	2.14	4.07	0.19	1.44	N/A (note 1)	5.19
#5	2.7	1.39	1.42	3.75	5.33	0.20	0.49	2.50	2.99
AVERAGE	**1.74**	**0.86**	**1.27**	**1.56 (Note 2)**	**2.11 (Note 2)**	**0.14**	**1.86**	**3.75**	**5.60**

Table 2. Data for 28 V, 25-amp Circuit Breakers							
28V, 25-amp Circuit Breakers	**Width (in.)**	**Depth (in.)**	**Height (in.)**	**PC Board Real Estate (sq. in., Width X Depth)**	**Volume (cu. in.)**	**Weight (lbs.)**	**Power Dissipation (watts)**
#1	1.14	0.57	2.53	0.65	1.65	0.09	N/A (note 1)
#2	0.78	0.59	2.09	0.46	0.97	0.05	5
#3	0.70	0.59	2.28	0.41	0.95	0.07	5
#4	1.22	0.45	2.81	0.549	1.54269	0.06	0.48
#5	1.64	0.76	2	1.24	2.48	0.15	2.5
AVERAGE	**1.10**	**0.59**	**2.34**	**0.66 (Note 2)**	**1.52 (Note 2)**	**0.08**	**2.60**

Notes:

1. The contact dissipation data for relay #1 and relay #4, and circuit breaker #1 is not available and therefore not included in the calculations for average dissipation.
2. For both relays and circuit breakers, the average PC board real estate (sq. in.) and volume (cu. in.) are computed as the average of two different methods:
    a. Using the first method, the average PC board real estate is computed as the average PC board real estate of the five relays or circuit breakers. Similarly, the average volume is computed as the average volume of the five relays or circuit breakers.
    b. Using the second method, the average PC board real estate is computed as the average width for the five relays or circuit breakers times the average depth. Similarly, the average volume is computed as the average width for the five relays or circuit breakers times the average depth times the average height.

For relays and circuit breakers, the average real estate per channel = 1.56 + 0.66 = 2.22 sq. in. Assuming that relays and breakers occupy 60% of the total PC board area, the total real estate per channel = 2.22/0.6 = 3.7 sq. in. Using the average circuit breaker height of 2.34 in. and assuming a PC board thickness of 0.093", a top-side clearance of 0.02, and a back-side clearance of 0.25" (similar to a comparable SSPC board assembly), the total assembly height for a relay/breaker board assembly = 2.34 + 0.02 + 0.093 + 0.25 = 2.7 in. The total volume for one channel = (3.7)*(2.7) = 9.99 cu. in., and output power per unit volume = (28)*(25)/(9.99) = 70.1 W/cu. in.

For a 16-channel SSPC board assembly, the board dimensions are 9.2 X 6.3 in., with a maximum component height of 0.54 in., PC board thickness of 0.093", and a back-side clearance of 0.25", for a total height = 0.54 + 0.093 + 0.25 = 0.883". Total volume for 16 channels = 9.2 X 6.3 X 0.883 = 51.18 cu. in. This translates to 51.18/16 = 3.20 cu. in. per channel. For a 25-amp channel, the output power per unit volume = (28)*(25)/3.20 = 219 W/cu. in.

The weight of a typical bare 9.2 X 6.3, 0.093" thick PC board is 0.55 lbs. For such a board, the weight per unit area = .55/((9.2)*(6.3)) = .0095 lbs/sq. in. For one relay + breaker channel, total real estate per channel = 3.7 sq. in., therefore the PC board weight per channel = (.0095)*(3.7) = 0.035 lbs. Total relay + breaker weight per channel = 0.14 + 0.08 + 0.035 = 0.255 lbs. The output power per weight = (28)*(25)/0.255 = 2745 W/lb.

The weight of a typical 16-channel SSPC board assembly is 1.8 pounds. For a 28 volt, 25-amp SSPC channel, the output power per unit weight = ((28)*(25))/(1.8 /16) = 6222 W/lb.

Reduced Wiring

For either an aircraft or a ground vehicle, if load switching is performed using crew-accessible circuit breakers, then these must be located in the vicinity of the pilot or operator. This forces all power wires to be routed both to and from the location of the crew. Since SSPCs can be controlled over a network, their use eliminates the need to run power wires to and from the crew location, thereby saving weight and reducing fuel consumption.

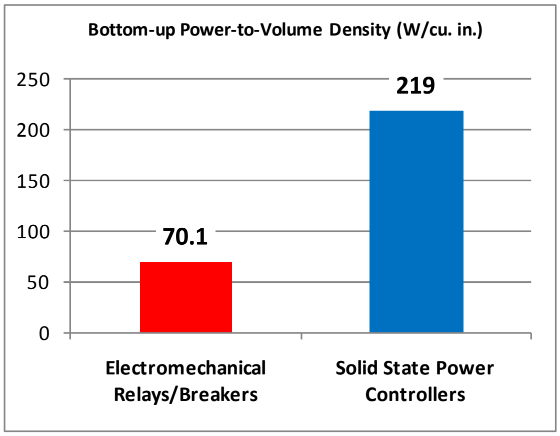
Power Dissipation

SSPCs provide a lower thermal profile than circuit breakers. This is based on the low on-resistance of switching MOSFETs, whose affect can be further reduced by paralleling multiple MOSFETs and/or multiple SSPC channels for switching current to the same load. Further, solid state switching eliminates the power dissipated in the relay coils, solenoids, bimetallic strips, and contact resistances found in circuit breakers and relays. As a result, SSPCs provide a significant advantage in internal power dissipation relative to circuit breakers and relays.

As an example, consider a 28 volt, 25-amp SSPC channel relative to a circuit breaker/relay combination. In each case, assume that the channel is fully loaded.

Referring to Table 1 and Table 2, the average power dissipation for a 28V, 25-amp relay + circuit breaker channel = 5.6 + 2.6 = 8.2 watts. For a typical 28V, 25-amp SSPC channel with a voltage drop of 115 mV, the resulting dissipation is 2.875 watts. Further, it is important to note that the SSPC path dissipation includes the RP-26200 PC board traces and connector contacts, while that for the circuit breakers and relays does not.

	Electromechanical Switching	SSPC Module
Voltage	28V	28V
Current	25 A	25 A
Volume	9.99 in^3	3.20 in^3
Weight	0.255 lbs.	0.113 lbs.
Power-to-Volume Density	**70.1 W/in^3**	**219 W/in^3**
Power-to-Weight Density	**2745 W/lb**	**6222 W/lb**



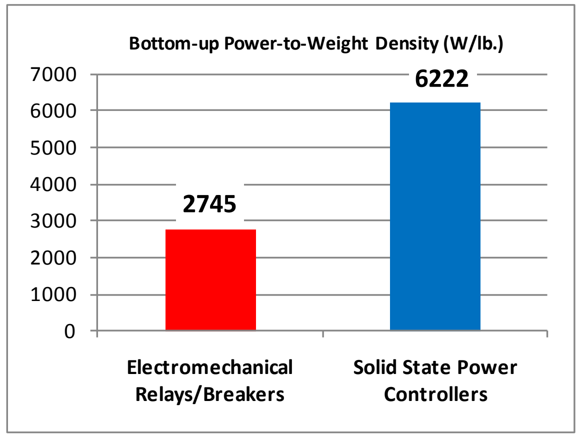


Figure 6. Bottom-Up Comparison: Power-to-Volume and Power-to-Weight Density, SSPC Channel vs. Relay/Breaker Combination

	Electromechanical Relay + Circuit Breaker	SSPC Channel
Voltage	28V	28V
Channel Current	25A	25A
Relay Coil Dissipation	1.86 W	--
Relay Contacts Dissipation	3.75 W	--
Circuit Breaker Dissipation	2.60 W	--
SSPC Voltage Drop	--	0.115V
Total Channel Power Dissipation	**8.2 W**	**2.875 W**

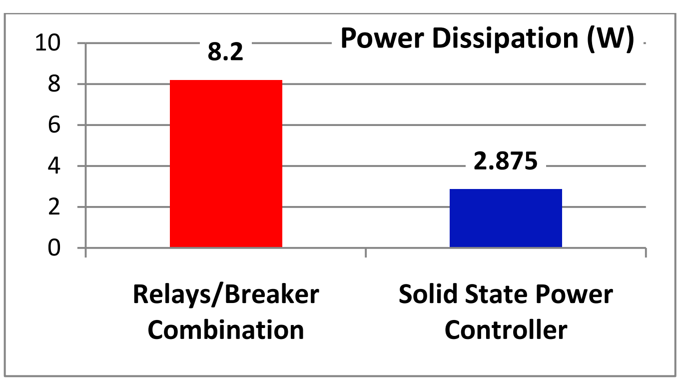


Figure 7. Channel Power Dissipation, SSPC vs. Electromechanical Switching

Reliability

In terms of reliability, SSPCs provide significant advantages over electromechanical circuit breaker/relay-based power distribution. The MTBF of a multi-channel SSPC board is an order of magnitude higher than that of a comparable implementation based on electromechanical circuit breakers and relays. Since SSPCs have no moving parts, they exhibit a far lower number of failure modes than circuit breakers and relays. Figure 8 shows the internal construction of relays.

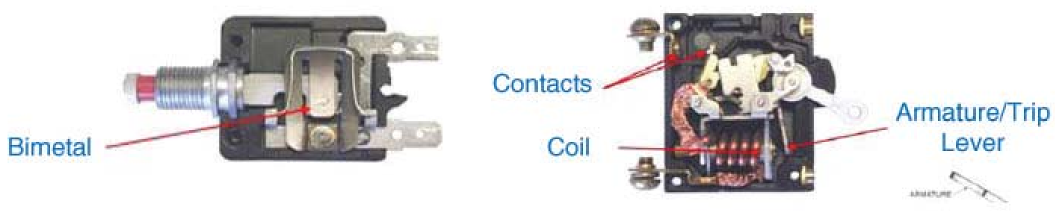


Figure 8. Breaker and Relay Internals

Some of the failure modes specific to electromechanical switching include:

- Contact resistances for relays and circuit breakers are subject to arcing, resulting in oxidation, erosion, and pitting, leading to increased contact resistance.
- The arcing resulting from opening breakers and relays switching into inductive loads can degrade contacts, resulting in contact erosion, and possibly welding. Similarly, contact bounce can affect the operation of loads, and also result in arcing and failures, including contact welding.
- Operation at low load currents can fail to burn off oxidation, resulting in high contact resistance.
- In high-vibration environments, electromechanical switches can chatter, affecting system operation. In addition, vibration can lead to material failure and misalignment.
- The operation of relay and breaker contacts can degrade in salt spray, dusty, or sandy environments.
- Armatures for thermal circuit breakers and relay coils dissipate power, resulting in additional heat and complicating system thermal design.
- Relay coils are subject to long-term damage from humidity, dust, and dirt, resulting in coil wire insulation embrittlement and eventually failures.
- For relays, high on/off cycling rates can lead to wear on moving parts, binding relay armatures, contact erosion, intermittent contact operation, and coil failures.
- Lack of operation can lead to build-up of organic material on relay contacts.[1]

For DDC's RP-26200 28 volt, 16-channel SSPC board, the MIL-STD-217 MTBF for a ground mobile environment is estimated as 415,000 hours at 25° C. The MIL-STD-217 failure rate for a comparable electromechanical contactor at 25° C is $1.00 \cdot 10^{-6}$ events/hour, and for a circuit breaker is 3.3E-6 events/hour. The failure rate of the contactor/breaker combination = $1.00 \cdot 10^{-6} + 3.3 \cdot 10^{-6} = 4.3 \cdot 10^{-6}$, or a

[1] *;* Electric Power Research Institute; Maintenance and Application Guide for Control Relays and Timers Technical Report; December 1993; page 3-7.

combined MTBF of 233,000 hours.[2] For 16 contactor/breaker combinations, the MTBF is 233,000/16 ≈15,000 hours. Referencing Figure 9, this provides SSPCs with an MTBF advantage of a factor of about 27.7 to 1 relative to electromechanical relays and breakers.

Short Circuit Instant Trip

The higher reliability of SSPCs relative to switches and breakers provides an improvement in protection and safety. In addition, following the occurrence of short circuit faults, SSPCs will clear in approximately 1 mS, while breakers and relays take tens of mS to open. This added delay can lead to significant damage to wiring and equipment.

From a system reliability standpoint, the use of SSPCs enables automated redundancy, thereby allowing rapid restoration of power to vehicle and mission-critical loads following failures of generators, wiring, or other power system components.

	16 Contactors and Circuit Breakers	DDC RP-26200, 28V 16 Channel SSPC Board
1 contactor/breaker combination	233,000	N/A
16 contactor/breaker combinations	15,000 hrs	**415,000 hrs**

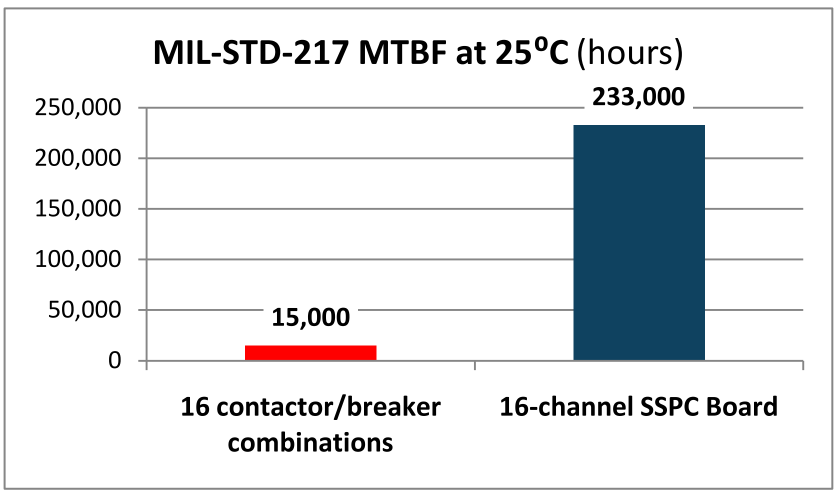


Figure 9. Reliability (MTBF), MIL-STD-217 MTBF for a Ground Mobile Environment at 25°C

[2] Kulkarni, Ashok; A Hidden Reliability Threat in UPS Static Bypass Switches; American Power Conversion; 2006; page 5.

Cost of Ownership

The use of SSPCs can reduce ownership costs based on multiple factors, including:

- The higher reliability of SSPCs relative to electromechanical switching reduces ground vehicle or aircraft downtime and maintenance costs.
- Based on their lower weight and lower power dissipation, SSPCs provide fuel savings relative to circuit breakers and relays.
- SSPCs, by providing real time feedback to on-board diagnostic computers, can facilitate preventive maintenance by predicting failures in equipment and wiring before they occur. This allows maintenance to be performed during scheduled downtimes, rather than following outright failures.
- With regards to maintainability, multi-channel SSPCs consolidate the functions of many circuit breakers and relays on to highly modular circuit boards. Further, since SSPCs include built-in self-test functionality, their operational health may be interrogated continuously over a bus or network. SSPC boards are typically installed into LRU boxes with 38999 connectors. This design and construction minimizes troubleshooting time and therefore mean-time-to-repair. The increased reliability, coupled with lower repair times serves to increase vehicle availability time and reduce maintenance costs.
- By providing a high degree of flexibility, SSPCs enable modular, scalable system design. This allows SSPCs to facilitate incremental vehicle upgrades, such as the installation of additional C4I equipment. In large part, this is due to the fact that individual SSPC channels can be re-programmed to accommodate varying loads. Further, it is possible to parallel the outputs from multiple channels in order to support loads requiring higher currents than the capacity of individual channels. In addition, the use of multi-channel SSPC assemblies can reduce inventory costs, by allowing the same box, including with *the same internal firmware programming*, to be installed in multiple locations in the same vehicle or aircraft. This is feasible by the fact that it's possible to program a multi-channel SSPC with multiple "personalities", the selection of which will be determined by the hardwired bus (e.g., CAN Bus) or network address for a given location in a vehicle.

Load Flexibility

As platforms evolve to more electrical and electronic operation, there will be increased need to support multiple equipment configurations with varying power requirements. The current ratings for electromechanical relays can vary depending on the type of load. For example, a relay rated for 25 amps for resistive loads may be rated for only 12 amps for inductive loads, 10 amps for motors, and 4 amps for lamps.

By comparison (Figure 10), SSPCs can support the same maximum current rating for all types of loads. In addition, the current ratings for SSPCs are typically programmable over a range of at least ten to one. Further, it's possible to support higher load currents by paralleling the outputs from multiple SSPCs. Based on these factors, SSPCs support greater use flexibility than breakers and relays by allowing rapid re-configuration.

Monitoring and Diagnostics

Solid State Power Controllers support multiple aspects of health management for ground vehicle and aircraft power and wiring systems. These include:

- SSPCs provide autonomous circuit protection for faults such as short circuits and overloads. All SSPC trip events may be immediately reported over the board's network interface by means of alarm messages, thus allowing the platform's power management computer to efficiently manage power system redundancies. Alternatively, the power management computer may periodically interrogate the SSPCs' status over the board's bus or network interface.
- SSPCs can provide high accuracy (±5%) measurements of input and load voltages, and load currents. For detected faults such as under- or over-voltage, under-current, and over-temperature, individual channels may be programmed to either trip immediately, or to issue alarms over the network interface. In the latter case, power management computers can log the faults, and possibly make determinations to deactivate SSPCs, depending on other factors. For example, for certain fault conditions for some platform or mission critical loads, circuit deactivation may not be practical.
- SSPCs monitor input voltages, allowing system computers to track generator and/or battery power quality, along with load currents and total power consumption.
- Based on the status and parametric data provided from SSPCs, power management computers can perform continuous analyses of power system operation. This enables determinations of such faults as loss of, or low or high input voltage; short circuits or open circuits in wires or loads; along with failed SSPCs, with either open or shorted switching MOSFETs.

Data reported from SSPCs can be used for system-level diagnostics and prognostics, enabling predictive, condition-based maintenance, thereby helping to provide improved availability and continued mission readiness. For example, if the system management computer records an increase in the current drawn by a pump, this could point to the need for advance maintenance to repair or replace a failing pump.

	Current Rating by Load Type (A)			
	Resistive	**Inductive**	**Motor**	**Lamp**
25A Relay	25	12	10	4
SSPC Channel, Programmable up to 25A	**25**	**25**	**25**	**25**

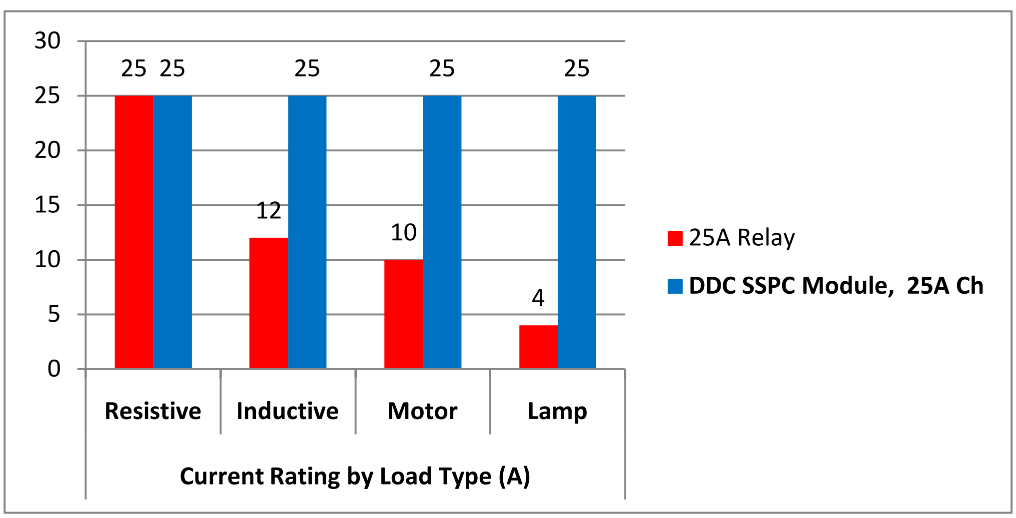


Figure 10. Current Ratings by Load Type, DDC SSPC Module vs. Electromechanical Switching

Survivability and Fault Tolerance

SSPCs provide many features contributing to the survivability and fault tolerance of platform power systems. These include:

- As discussed, SSPCs provide a significant increase in reliability over electromechanical breakers and relays. This contributes substantially to the survivability of ground vehicle or aircraft power systems.
- For some applications, multiple SSPCs can be cascaded. That is, there will be one or more high-current SSPCs connecting between one of the platform's primary power buses and one or more power distribution centers, each of which contain multi-channel SSPCs. This provides fault containment and system survivability by preventing circuit faults on one load (or its wiring) from propagating to other circuits.
- From a system reliability standpoint, the use of SSPCs allows automated redundancy, enabling the restoration of power to platform and mission-critical loads following failures of generators or other power system elements. This includes load shedding, as a means to automatically, quickly, and reliably turn off non-essential loads in emergency situations.
- SSPCs can provide real time, internal and system-level diagnostics, including:
    - Loss of SSPC input voltage, indicating generator, battery, or wire failures.
    - Tripped SSPCs, indicating short circuit faults in load wires or loads.
    - SSPC output voltage activated, but zero load current, indicating open circuit faults in wiring or loads.
    - SSPC output activated when intended to be off or following a TRIP event, indicating a shorted MOSFET.
    - Low output voltage with SSPC intended to be in ON state, indicating a controller failure or MOSFET failed open.

Conclusion

Table 3 provides a comparison between the functionality and performance of SSPCs relative to electromechanical circuit breakers and relays. This comparison is based on DDC's RP-26200 28 volt, 16-channel SSPC board housed in an enclosure, and a comparable system based on electromechanical circuit breakers and relays. As can be seen, SSPCs provide a number of functional and performance advantages. These include higher reliability, lower power dissipation, higher power/weight and power/volume densities, improved operation in high vibration environments, faster clearing of short circuit faults, greater use flexibility, reduced EMI, and increased capability for reporting status.

Table 3. Comparison Summary: SSPCs vs. Breakers and Relays

Parameter	Electromechanical Breakers and Relays	SSPCs	SSPC Advantage
MTBF -- 16 channels (hours)	15,000	415,000	Increased platform power availability, reduced maintenance costs.
Switching power dissipation – one 25-amp channel.	8.2	2.9	Reduced power losses, smaller thermal profile.
System-Level: Power /Volume Density – Load watts per cubic inch	6.9	50.5	Frees up space for crew and/or equipment.
Bottom-up: Power /Volume Density – Load watts per cubic inch	70	219	
System-Level Power/Weight Density – Load watts per pound	194.8	960	Reduced weight translates to fuel savings.
Bottom-up Power/Weight Density – Load watts per pound	2745	6222	
Operation in high vibration environments.	Contacts can chatter, resulting in voltage outages and spikes.	Solid state switching ensures continuity of power to loads.	Improved quality and availability of power to loads.
Time to clear short circuit faults.	Tens of mS.	1 to 2 mS	Fast clearing of short circuits prevents damage to wiring, equipment, and vehicles.
Flexibility	Trip current is fixed. Maximum current varies depending on load type.	10:1 Programmable rated current. The maximum current is the same for all load types. Multiple SSPCs may be paralleled.	Power distribution equipment may be re-programmed for varying load scenarios.
EMI	Abrupt switching of load currents.	Controlled rise and fall times.	Reduced surge currents for switching into inductive or lamp loads. Reduced inductive spikes for power turn-off.
Status reporting.	None or minimal.	Report status, voltages, currents, and temperatures.	Provide inputs to system computers for prognostics, diagnostics, and improved system maintenance.

REFERENCES:

1. Electric Power Research Institute; Maintenance and Application Guide for Control Relays and Timers Technical Report; December 1993.
2. Kulkarni, Ashok; A Hidden Reliability Threat in UPS Static Bypass Switches; American Power Conversion; 2006.

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Data Device Corporation

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Data Device Corporation is recognized as an international leading supplier of high-reliability data interface products for military and commercial aerospace applications since 1964 and MIL-STD-1553 products for more than 25 years. DDC's design and manufacturing facility is located in Bohemia, N.Y.

Data Device Corporation

Leadership Built on Over 45 Years of Innovation

Military | Commercial Aerospace | Space | Industrial

Data Device Corporation (DDC) is the world leader in the design and manufacture of high-reliability data bus products, motion control, and solid-state power controllers for aerospace, defense, and industrial automation applications. For more than 45 years, DDC has continuously advanced the state of high-reliability data communications and control technology for MIL-STD-1553, ARINC 429, Synchro/Resolver interface, and Solid-State Power Controllers with innovations that have minimized component size and weight while increasing performance. DDC offers a broad product line consisting of advanced data bus technology for Fibre Channel networks; MIL-STD-1553 and ARINC 429 Data Networking cards, components, and software; Synchro/Resolver interface components; and Solid-State Power Controllers and Motor Drives.

Product Families

Data Bus | Synchro/Resolver | Power Controllers | Motor Drives

DDC is a leader in the development, design, and manufacture of highly reliable and innovative military data bus solutions. DDC's Data Networking Solutions include MIL-STD-1553, ARINC 429, and Fibre Channel. Each Interface is supported by a complete line of quality MIL-STD-1553 and ARINC 429 commercial, military, and COTS grade cards and components, as well as software that maintain compatibility between product generations. The Data Bus product line has been field proven for the military, commercial and aerospace markets.

DDC is also a global leader in Synchro/Resolver Solutions. We offer a broad line of Synchro/Resolver instrument-grade cards, including angle position indicators and simulators. Our Synchro/Resolver-to-Digital and Digital-to-Synchro/Resolver microelectronic components are the smallest, most accurate converters, and also serve as the building block for our card-level products. All of our Synchro/Resolver line is supported by software, designed to meet today's COTS/MOTS needs. The Synchro/Resolver line has been field proven for military and industrial applications, including radar, IR, and navigation systems, fire control, flight instrumentation/simulators, motor/motion feedback controls and drivers, and robotic systems.

As the world's largest supplier of Solid-State Power Controllers (SSPCs) and Remote Power Controllers (RPCs), DDC was the first to offer commercial and fully-qualified MIL-PRF-38534 and Class K Space-level screening for these products. DDC's complete line of SSPC and RPC boards and components support real-time digital status reporting and computer control, and are equipped with instant trip, and true I^2T wire protection. The SSPC and RPC product line has been field proven for military markets, and are used in the Bradley fighting vehicles and M1A2 tank.

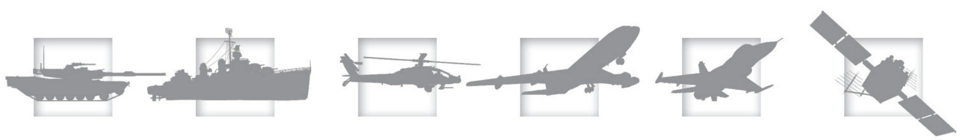
DDC is the premier manufacturer of hybrid motor drives and controllers for brush, 3-phase brushless, and induction motors operating from 28 Vdc to 270 Vdc requiring up to 18 kilowatts of power. Applications range from aircraft actuators for primary and secondary flight controls, jet or rocket engine thrust vector control, missile flight controls, to pumps, fans, solar arrays and momentum wheel control for space and satellite systems.

Certifications

Data Device Corporation is ISO 9001: 2008 and AS 9100, Rev. B certified.

DDC has also been granted certification by the Defense Supply Center Columbus (DSCC) for manufacturing Class D, G, H, and K hybrid products in accordance with MIL-PRF-38534, as well as ESA and NASA approved.

Industry documents used to support DDC's certifications and Quality system are: AS9001 OEM Certification, MIL-STD-883, ANSI/NCSL Z540-1, IPC-A-610, MIL-STD-202, JESD-22, and J-STD-020.



The first choice for more than 45 years—DDC
DDC is the world leader in the design and manufacture of high reliability data interface products, motion control, and solid-state power controllers for aerospace, defense, and industrial automation.

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