

Potential Manufacturers for Hi-Rel Solid-State Relays

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Preface

The purpose of this survey is to provide a reference to engineers to aid in the selection of solid state power switching devices: solid-state relays (SSR), solid-state power controllers (SSPC) etc.

The survey was conducted using the internet. A search for “solid-state relays” found 100 possibilities, the vast majority were eliminated for various reasons: not being a solid state relay manufacturer but a company which integrates them into their systems, form factor (hockey puck), low current, commercial use only, etc. Of the remaining, 11 manufacturers were found which produce products with attributes desirable to the space community.

Section 1 contains the selected list of manufacturers with a short company overview, as provided by the manufacturer, and a list of tests and screens they will perform.

Section 2 contains a list of component series in matrix format. The matrix is not intended to be a comprehensive list containing each component produced but rather a reference of component “series” along with the range of the various characteristics for that series. It’s intended to help narrow the search.

Section 3 contains, from the Johnson Space Center (JSC) community, uses and issues with using SSRs for space flight.

Section 4 briefly discusses changes that may be expected in SSRs and SSPCs within the next few years.

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1.1

Aeroflex Circuit Technology

Aeroflex Plainview

35 South Service Road
P.O. Box 6022
Plainview , NY 11803-0622
Phone: (516) 694-6700
Toll Free: 1-800-843-1553
www.aeroflex.com

Aeroflex Plainview manufactures advanced microelectronic multi-chip modules (MCMs) for airborne, space, shipboard, ground based and commercial avionics and telecom systems. Avionic products encompass MIPs microprocessors, SRAM/FLASH memories, MIL-STD-1553/1760/1397 databus, and transceivers. Space application products include power modules, analog multiplexer modules, solid-state relays and voltage regulators, DC-DC converters using chip on board technology for MIL and space applications, and single board computers for military applications using MIPs based microprocessors. They also offer a variety of broadband, RF and microwave products and filters for commercial and aerospace applications.

Note: Chip on Board is not normally good for high temperature extremes.
Chip on Board is usually an epoxy covered die on FR4.

1.2

Agilent Technologies, Inc.

395 Page Mill Rd.
Palo Alto, CA 94306
(800) 235 0312
www.agilent.com

Agilent Technologies is the worlds leading manufacturer of hermetically sealed optocouplers and offers a wide variety of functions and package solutions with a guaranteed performance over the full military temperature range of -55 to +125°C.

Services/Capabilities:

- Performs qualification testing per the requirements of MIL-PRF-38534
- Reports life testing in mean time between failure (MTBF) and failures in time (FIT)
- Can provide hermetic packaging
 - Hermetically sealed ceramic package
 - Cavity filled with silicone gel potting
 - Lids are gold plated
 - Leads are available with either gold plate or lead-tin solder finish.
- Components are screened to the requirements of MIL-PRF-38534
- Processes to MIL-STD-883
- Has not built specifically “space rated” product, however, supplied a part specially screened to the Class K level of MIL-PRF-38534
- Now offer a Mil-PRF-38534, Class E part, intended for space use
- Can build to source control documents (SCDs) in small volume

1.3

Ametek Aerospace & Defense Headquarters

50 Fordham Road
Wilmington, Massachusetts 01887
Phone: 978-988-4771
www.ametekaerospace.com

AMETEK's AMPHION solid-state power controller (SSPC) combines circuit breaker, load monitoring and relay functions in a small, cost-effective, plug-in package. The SSPC can be used directly in an application circuit or combined with other AMPHION SSPC components into a power distribution system.

1.4

Data Device Corporation

105 Wilbur Place
Bohemia, New York 11716
(800) 332-5757
www.ddc-web.com

DDC offers a line of COTS/MOTS card, component and software products. DDC continues to expand its offerings in ruggedized, test and simulation cards. DDC also supplies ARINC-429 cards and components for use on commercial aircraft. DDC is a supplier of solid-state remote power controllers, for replacing electromechanical relays in power management systems.

Services/Capabilities:

- Performs qualification testing on solid state remote power controllers
- Reports life testing in MTBF or others per customer requirements
- Can provide hermetic packaging
- Component packages made of Kovar
- Can solder dip leads per customer request
- DDC tests all products. Depending on product, the customer can select the level of testing
- Processes to MIL-STD-883. Standard DDC processing to Methods 2009, 2010, 2017, 2032, 1014 condition A and C, 1010 condition C, 2001 condition A and 1015 Table 1, also to MIL-STD-704
- Has experience fabricating and testing space rated components
Government tested to 30k rad total dose and single event upset (SEU) testing
- Can build to SCDs in small volume

1.5

International Rectifier

233 Kansas St.
El Segundo, CA 90245
(310) 252-7105
www.irf.com

International Rectifier Hi-Rel Products Group is a recognized leader in the fabrication of power (hybrid) modules. We have been developing custom and standard power modules at our Leominster facility since 1986 and are committed to providing power products of the highest quality and reliability. Our facilities provide total capability to design, develop and manufacture custom and standard power modules serving the defense, aerospace, communications and high-end industrial market segments. We are qualified to provide custom and standard Hi-Rel screening according to MIL-PRF-38534 in our Class K certified facility. Our design engineers have extensive experience in power packaging, semiconductor circuit design and thermal modeling techniques.

All power module products are carefully designed to meet the electrical, thermal, mechanical and environmental requirements of our customers. Our product designers and application engineers are ready to work with you to design custom products that specifically meet your application needs. Your designs will be manufactured in our state-of-the-art Class 10,000 clean room facilities.

Services/Capabilities:

- Will perform qualification testing per the customers request
- MTBF calculations per MIL-HDBK-217 are on the data sheets
- Can provide both hermetic and environmental packaging
- Can provides a triple encapsulant in what is termed “near hermetic” packaging
- Lead plating options include Nickel, nickel with gold flash, and nickel with thick gold along with solder dip
- Components are generally screen in accordance to the requirements of the performance spec, MIL-PRF-38534
- Processes to MIL-STD-883. Standard processing to methods 2009, 2010, 2017, 2032, 1014 condition A and C, 1010 condition C, 2001 condition A and 1015 Table 1
- Have 15+ years of experience providing custom product to the Hi-Rel marketplace
- Can build to SCDs in small volume

1.6

Leach International

6900 Orangethorpe Ave.
P.O. Box 5032
Buena Park, CA 90622-5032
(714) 736-7598
www.leachintl.com

Designed for applications as diverse as civil and military aviation, satellites and railway systems. Leach International's extensive line of products includes a full selection of hermetically sealed relays. Leach contactors are available with single or multi-pole contacts in latching or non-latching configurations. A variety of complementary devices provide time delay and power measurement functions. The majority of these products are available in different mounting styles and terminals. Comprehensive lines of push-button indicators, solid state power controllers and limit switches also play important roles in the company's product mix.

Services/Capabilities:

- Performs qualification testing
- Provides life testing results in MTBF
- Can provide both hermetic and sealed devices
- Coating options for packaging include painting or tin plating
- Lead plating options include gold and tin plating
- Provides screening to MIL-STD-883 or customer specific
- All products are built to Leach Specification Control Drawings

1.7

Micropac Industries, Inc.

905 E. Walnut St.
Garland, TX 75040
(972) 272-3571
www.micropac.com

Micropac Industries, Inc. has supplied space level components since the 1970s. The company is qualified to the highest level for the military specifications that apply to the components and modules manufactured by Micropac. Micropac is qualified to MIL PRF 38534 Class K and MIL PRF 28750, and MIL PRF 19500 JAN S. We are ISO 9001(2000) registered. NASA has used Micropac standard and custom devices including relays for multiple programs.

Micropac supplies solid-state relays, including radiation tolerant designs to many companies in the space community. Besides relays Micropac supplies space level custom multi chip modules.

Services/Capabilities:

- Micropac performs qualification – Group A, B, D and Group C Life Test to both H level and K Level
- Provides life testing results in the data pack supplied with the parts when qualification testing is performed
- Can provide both hermetic and environmental packaging
- Lead plating options include nickel, gold along with solder dip
- MIL-PRF-38534, Class H & K qualified and MIL-PRF-28750 qualified
- Has space rated components to MIL-PRF-38534, Class K for Relays, Hybrids, and MIL-PRF-19500 JANS for Semiconductors
- Can build to SCDs in small volume
- Standard off-the-shelf space level radiation tolerant designs

1.8

National Hybrid, Inc.

2200 Smithtown Ave,
Ronkonkoma, NY 11770
(631) 981-2400
www.nationalhybrid.com

Services/Capabilities:

- Performs qualification testing
- Can provide both hermetic and environmental packaging
- Plating options for packaging include typically nickel and gold
- Lead plating options include gold and solder dip
- Provides screening to MIL-PRF-38534
- MIL-PRF-38534, Class H+
- Has fabricated space rated components to MIL-PRF-38534 H+
- Can build to SCDs in small volume

1.9

Semitronics

64 Commercial St.
Freeport, N.Y. 11520
516-623-9400
www.semitronics.com

Semitronics is approved to supply military products to Raytheon, Hughes, General Dynamics, Northrop, Lockheed Martin, Rockwell International Varo, Texas Instruments, United Technologies/Hamilton Standard, Hazeltine, BAE, Kearfott Guidance and Navigation and many other military contractors.

The Semitronics quality program is approved by a number of government agencies and contractors

Services/Capabilities:

- Performs qualification testing
- Most relays supplied are fabricated with all metal hermetic packages with glass to metal seals
- Epoxy potting is available for industrial relays
- Plating options for packaging include typically nickel, and gold 200 μ in. minimum
- Lead plating option includes gold only
- Provides screening to MIL-PRF-28750
- Fabrication of space rated components limited to insulated gate bipolar transistors (IGBTs) , and diodes in Hi-Rel packaging to source control drawings
- Can build to SCDs in small volume

1.10

Teledyne Technologies Inc.

12333 West Olympic Boulevard

Los Angeles, CA 90064

(800) 284-7007

www.teledynereleys.com

For more than 40 years, Teledyne Relays has been recognized as an innovator and industry leader in manufacturing electromechanical and solid-state switching products. With headquarters in Hawthorne, California, Teledyne Relays maintains six factories in California, Mexico, Taiwan and France. The company's comprehensive product line meets a wide range of switching solutions for applications in RF& microwave; wireless & high-speed digital; instrumentation & test; aviation, military & space; motor, heating & lighting control.

Services/Capabilities:

- Performs qualification testing per MIL-PRF-28750 or MIL-PRF-38534
- Provides life testing per MIL-PRF-28750 or MIL-PRF-38534, MTBF & FIT per MIL-HDBK-217
- Can provide both hermetic and environmental packaging
- Can provide encapsulated designs
- Plating options for packaging include electroless Nickel Plating and Gold Plating with Nickel underplating
- Lead plating options include electroless Nickel Plating and Gold Plating with Nickel underplating
- Provides screening to MIL-PRF-28750, MIL-PRF-38534, MIL-STD-883 or customer requirements
- MIL-PRF-38534, Class H & K qualified and MIL-PRF-28750 qualified (also are qualified to MIL-PRF-19500, Jan S). These specs send you to MIL-STD-883
- Components to MIL-PRF-38534, Class K
- Can build to SCDs in small volume but acceptance of such request will depend on design and cost

1.11

Tyco Electronics

CII Product line
P.O. Box 3608
Harrisburg, PA 17105
(800) 522-6752
www.tycoelectronics.com

CII high performance signal level and mid-range relays are designed to perform in a wide range of extreme environments in aerospace, military electronics and commercial applications.

The line includes: solid-state relays including versions with built-in circuit protection and other intelligent functions.

Both MIL-SPEC and commercial versions of these hermetically-sealed relays are offered. Many optional terminal and mounting styles, including surface mount are offered.

The CII product line includes one of the industry's largest listings of QPL products. CII relays are currently qualified to MIL-R-39016, MIL-R-28776, MIL-R-28750, MIL-R-5757, MIL-R-83726, MS27245, MS27247, MIL-R-6106 and MIL-R-83536.

Our rigid quality assurance program exceeds MIL-STD-790. We perform a wide range of tests on a continual basis in our U.S. government approved testing laboratories. Included are: environmental testing, electrical characteristic testing, visual and mechanical inspection and quality assurance testing

Services/Capabilities:

- Performs qualification testing
- Most relays supplied are fabricated with all metal hermetic packages with glass to metal seals, some are available encapsulated in lieu of hermetic sealing
- Lead plating option includes gold or solder dip
- Provides screening to MIL-PRF-28750
- Has fabricated space rated components but none were solid-state
- Can build to SCDs in small volume

Solid State Relay Survey Components Matrix

Part No.	Manufacturer	Temp. Range (°C)	Control Signal		Output						Package Style				Testing Specs.	Notes	
			Signal Voltage Range	Current mA	Load Voltage Range			Load Current (A)	R _{ds} (mΩ)	Isolation		Lead Config.	Surface mount	Sealing			
					DC (V)	AC	DC			Both	Optical			Xformer			Hermetic
CT2100-400	Aeroflex Circuit Technology	-55 to +125	5.0			60		1.0	600	600V		40 Pin DIP			Processed & Screened to MIL-STD-883	Quad Solid State Relay http://ams.aeroflex.com/ProductPages/PH_switch.cfm?pmenuum=8_3#datasheets	
HSSR-7110 HSSR-7111 HSSR-7112 5962-9314001 5962-9314002 5962-04204 596204205	Agilent Technologies	-55 to +125	5.0	5.0 to 20.0	24	28 48		0.8 AC 1.6 DC	40.0 AC 12.0 DC	1500VDC		8 Pin DIP		Yes	MIL-PRF-38534 Class H	Power MOSFET Optocoupler http://we.home.agilent.com/cgi-bin/bvpub/agilent/Industry/cp_Industry.jsp?NAV_ID=-536893204.0.00&LANGUAGE_CODE=eng&ID=m1&COUNTRY_CODE=US	
10676B01Exx series	Ametek Aerospace	-55 to +125				10 to 36		0.1 30.0	30.0 6.0			28 Pin DIP			DO-160 Testing	Solid State Power Controller http://www.ametekaerospace.com/product.asp?product_id=23	
RP-210xx series	Data Device Corporation	-55 to +125	2.0 to 5.5	0.050		9.0 to 40.0		2.0 to 25.0	100.0 to 12.0			10 Pin DIP			MIL-STD-704 MIL-PRF-38534	28 VDC Solid State Power Controller http://www.ddc-web.com/products/Components/mdpc.asp	
SSP-2116-010-X SSP-2116-015-X	Data Device Corporation	-55 to +125	2.0 to 5.5	0.050		60.0 to 300.0		10.0 15.0	85.0			16 Pin DIP			MIL-PRF-38534 but w/o QCI testing	270 VDC Solid State Power Controller http://www.ddc-web.com/products/Components/mdpc.asp	
RP-212xx series	Data Device Corporation	-55 to +100	2.0 min	0.10		0.0 to 40.0		1.0 to 25.0	100.0 to 12.0			20 Pin DIP	Yes		MIL-STD-704	28 VDC Solid State Power Controller http://www.ddc-web.com/products/Components/mdpc.asp	
SSP-21120	Data Device Corporation	-55 to +85	2.0 to 5.5	0.050		9.0 to 40.0		80.0	3.2						MIL-STD-704 MIL-PRF-38534 but w/o QCI testing	28 VDC Solid State Power Controller Module http://www.ddc-web.com/products/Components/mdpc.asp	
OMR970x series odd	International Rectifier	-55 to +125	3.3 to 5.0	25.0		100.0		10.0	70.0	1500VDC		8 Pin SIP	Yes	Yes	MIL-PRF-38534 Class K	Dual 10A Solid State Relay http://www.irf.com/product-info/hi-rel/hirelcustpms.html	
OMR970x series even	International Rectifier	-55 to +125	3.3 to 5.0	25.0		130.0		10.0	80.0	1500VDC		8 Pin SIP	Yes	Yes	MIL-PRF-38534 Class K	Dual 10A Solid State Relay http://www.irf.com/product-info/hi-rel/hirelcustpms.html	
PV series	International Rectifier	-40 to +85	< 2.0	5.0 to 25.0	60 (AC peak)	0 to 100.0	0 to ±60.0 (DC or AC peak)	1 - 2.5 (ac) 2 - 4.5 (dc)	500.0 40.0	4000V _{RMS}		4 Pin DIP & 6 Pin DIP	Yes	No	Plastic package UL recognized	HEXFET Power MOSFET Photovoltaic Relay http://ec.irf.com/v6/en/US/adirect/ir?cmd=catNavigateFrame	
P110 series	Leach International	-55 to +105	3.3 to 28.0	12.0		32		2.0		500 V _{RMS}		4 Pin DIP			MIL-STD-704D, category 3, Curve 1	Solid State Power Controller http://www.leachintl2.com/english/english1/sframe.html	
P111 series	Leach International	-25 to +70	5.0 to 32.0	14.0 to 16.0	250			25.0		1500V _{RMS}		6 Pin Flange		Yes	MIL-R-28750 C/10	Solid State AC Relay http://www.leachintl2.com/english/english1/sframe.html	
P140 through P600	Leach International	-25 to +125 range	5.0 to 33.0 range	10.0 to 30.0 range		28 P152 = 270		1 to 80 range		500 to 750 V _{RMS} range		6 to 8 Pin Dip, 10Pin Flange, Can		Yes P600 = No	Various	Solid State Power Controller http://www.leachintl2.com/english/english1/sframe.html	
53012, 53024, 53200, 53203, 53204, 53209, 53210, 53211, 53262, 53267 53270	Micropac Industries, Inc.	-55 to +125 range	CMOS/ TTL	5.0 to 16.0 range	80 to 180	60 to 400 range		0.2 to 8.2 range	200.0 to 1500.0 range	1000VDC 1000 V _{RMS} to 1500 V _{RMS} range		various dip & flange		Yes	Various	Solid State Relay http://www.micropac.com/ssr_ss_pc_pmo.html	

Part No.	Manufacturer	Temp. Range (°C)	Control Signal		Output						Package Style				Testing Specs.	Notes	
			Signal Voltage Range	Current mA	Load Voltage Range			Load Current (A)	R _{ds} (mΩ)	Isolation		Lead Config.	Surface mount	Sealing			
					AC	DC	Both			Optical	Xformer			Hermetic			Encap.
53111, 53124, 53246, 53250, 53253, 53254, 53255, 53257, 53258, 53259	Micropac Industries, Inc.	-55 to +125 range		5.0 to 20.0 range		±90 to 400 & 40 to 400 ranges		0.08 to 10.0 range	25.0 to 12,000 range	1000 VDC to 1500 VDC range		8 pin dip & 6 pin flange	4 Pin dip	Yes		Various	Solid State Mosfet Driver http://www.micropac.com/ssr_ss_pc_pmo.html
53217, 53248, 53248-102	Micropac Industries, Inc.	-55 to +125 range		2.0 to 3.0		33 to 400		3.0 to 10.0	35.0 to 500.0 range	Yes	1000 V _{RMS}	10 Pin flange	4 pin Dip	Yes		Various	Solid State Power Controller http://www.micropac.com/ssr_ss_pc_pmo.html
90000 series	National Hybrid, Inc.	-55 to +125 range	4.5 to 5.5			28 to 270		10.0 to 20.0	15.0 to 25.0	1000VDC		8 Pin flange		Yes		Various	Solid State Power Controller http://www.nationalhybrid.com/
90240-25AC	National Hybrid, Inc.	-55 to +125	5.0	25.0		80 to 240		25.0		Yes		9 Pin flange		Yes		MIL-STD-704 & MIL-H-38534 compliant	Solid State AC Power Controller http://www.nationalhybrid.com/
CT101/102/103 series	Semitronics Corporation	-55 to +120	5.0	25.0		± 80 to ±350		0.35 to 1.0	400.0 to 7,200	Yes		6 Pin mini-dip		Yes		MIL-R-28750	Solid State Relay http://www.semitronics.com/solid%20state%20relays.htm
CT400/402/522	Semitronics Corporation	-55 to +120 to -40 to +90	5.0 to 28.0	30.0 to 50.0		60 to 200		2.0 to 8.0	100.0	500 V _{RMS}		6 Pin Dip, 6 Pin flange, 8 Pin Dip		Yes 400 & 402		Various	Solid State Relay http://www.semitronics.com/solid%20state%20relays.htm
SR75-1-2-3 series	Teledyne Technologies, Inc.	-55 to +105	3.8 to 32.0	11.0		60 to 400		0.5 to 1.5	500.0 to 2400	Yes		8 Pin Dip		No Plastic Package		MIL-STD-202 Method 210	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
CD series	Teledyne Technologies, Inc.	-55 to +105	CMOS or TTL	14.0		60		2.0	160.0 to 360.0	Yes		6 Pin Dip		Yes Ceramic		MIL-PRF-28750	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
HD series	Teledyne Technologies, Inc.	-55 to +105	CMOS or TTL	14.0		60		2.0	150.0	Yes		6 Pin Dip		Yes Kovar		MIL-PRF-28750	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
FR75-1	Teledyne Technologies, Inc.	-40 to +85	5.0	15.0		60		1.0	320.0	Yes		4 Pin Dip		No Kovar			Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
M33-2N	Teledyne Technologies, Inc.	-55 to +125	5.0	16.0		60		7.0	90.0		Yes	6 Pin Dip		Yes		MIL-PRF-28750	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
KD/LD KD44CF	Teledyne Technologies, Inc.	-55 to +105	CMOS or TTL	15.0		60		2.0 to 10.0	75.0 to 100.0	Yes		6 Pin Dip & 6 Pin Dip with flange		Yes cold rolled steel		MIL-PRF-28750	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
PC0280X series	Teledyne Technologies, Inc.	-55 to +105	5.0	45.0		28		2.0 to 25.0	14.0 to 80.0	Yes		7 Pin with flange		did not specify		MIL-PRF-28750	Solid State Power Controller http://www.teledynereleys.com/militaryaerospace.asp
PC2700X	Teledyne Technologies, Inc.	-55 to +105	5.0	45.0		270		1.0 to 10.0	100.0 to 640.0	Yes		7 Pin with flange		did not specify		MIL-PRF-28750	Solid State Power Controller http://www.teledynereleys.com/militaryaerospace.asp
FB series	Teledyne Technologies, Inc.	-55 to +120	5.0	10.0 to 25.0		±80.0 to ±350.0		0.25 to 1.0	150.0 to 2,000	Yes		6 Pin Dip		did not specify		MIL-PRF-28750	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
QB00FM series	Teledyne Technologies, Inc.	-55 to +105	5.0	38.0		±150		±7.5	100.0	Yes		6 Pin with flange		Yes		MIL-PRF-28750	Solid State Relays http://www.teledynereleys.com/militaryaerospace.asp
DS9, 11, 13 series	Tyco Electronics Corporation	-55 to +110 range	TTL & CMOS	15.0		250 V _{RMS}	60	1.0 to 2.0	150.0 to 450.0	Yes		4 to 6 Pin Dip		Yes Kovar Ceramic		MIL-R-28750	Solid State Relay http://relays.tycoelectronics.com/
JPS10	Tyco Electronics Corporation	-55 to +110	TTL	16.0		250 V _{RMS}		25.0		Yes		"HOT TIN DIPPED"		did not specify		MIL-R-28750C	Solid State Relay http://relays.tycoelectronics.com/
MS18-1006	Tyco Electronics Corporation	-55 to +120		10.0		80		2.0	400.0	Yes		6 Pin Dip		Yes		MIL-R-28750	Solid State Relay http://relays.tycoelectronics.com/
PC2.5D10-2B	Tyco Electronics Corporation	-55 to +105	3.8 to 32.0 range	15.0		60		2.5	140.0	Yes		6 Pin Dip		Yes 1010 CRS		MIL-PRF-28750 Y level	Solid State Relay http://relays.tycoelectronics.com/
PS12	Tyco Electronics Corporation	-55 to +95	TTL	16.0		250 V _{RMS}		10.0		1500 V _{RMS}		Screw Terinal			Epoxy filled Plactic	MIL-R-28750C & Tyco specs.	Solid State Relay http://relays.tycoelectronics.com/

Solid State Relay Uses and Issues

Mechanical Switches

Solid-state relays are an attractive solution to switching 120VDC power for International Space Station (ISS). A conventional 120VAC mechanical switch poses long-term reliability problems for switching 120VDC loads primarily due to localized heating of contacts. There are special switches built for higher voltages that can handle 120VDC, but they tend to be significantly larger in size and more expensive than a solid-state solution. Mechanical switches also have a wear out mechanism that will predictably lead to failure after a predetermined number of cycles. Solid-state switches avoid the predictable wear out mechanism, and are immune to contact bounce as well.

Solid State Relays

Solid-state relays have their own disadvantages for ISS use. The switching element is usually either a Field Effect Transistor (FET) or an Silicon Controlled Rectifier (SCR). The EEE parts group discourages the use of SCR's for flight, and they suffer from a relatively large forward drop (in comparison to FET's), which increases heat dissipation. On the other hand, a FET has problems with deterioration after exposure to ionizing radiation. This can eventually lead to junction burn-out. They are also susceptible to inductive voltage spikes that exceed their limits when interrupting currents, so it is important to avoid such transient voltages.

Another drawback of solid-state relays is that they don't provide a "deadface", or complete open circuit, when disconnected from a power source. There is always a possible leakage of a few microamps. Additional problems are that the gate drive circuit on some solid state switches may generate an AC current, which may require EMI filtering, and most SSR's are operated from logic level control voltages, which may require a separate low level voltage source referenced to the 120VDC return line.

SSR's on ISS

Some of the Remote Power Controllers (RPC's) used to control 120VDC power to the Utility Output Panels (UOP's) in the ISS use solid state switches. The Intravehicular Portable Power Supply (IPPS) power distribution box in the Portable Electrical Equipment Kit (PEEK) equipment group uses a version of a solid-state switch with built-in circuitry (also called by the manufacturer an RPC, remote power controller) to switch 120VDC bus power to portable loads. The built-in circuits add soft-start and over current protection capabilities. Obviously the SSR selected must meet derating criteria for the application, and it should be a proper JANTXV part, or it may require screening tests.

What to look forward to in the future

A questionnaire was distributed to the twelve manufacturers represented in this survey. One of the questions asked was, “*What trends do you see steering the solid state relay market/product development in the next few years?*” Not all of the manufacturers queried responded to the questionnaire, of those that did respond, no two provided the same answer to this question. Some of the “product developments” listed below are presently available in some product lines.

Responses:

Lower costs

Reduced R_{ds}

Increased package density

Additional features

Increased speed

Multi-channels per package

Higher radiation tolerance

Diagnostics; Arc Fault/Arc Location detection

More Solid-State Power Controllers

Custom packaging

Smart options (status, short circuit protection, etc)

Technical Articles/Notes

Agilent

Application Note 1036 “Small Signal Solid State Relays”

<http://cp.literature.agilent.com/litweb/pdf/5965-5980E.pdf>

Introduction:

Traditionally, isolated control of signal paths has been provided by the Electro-Magnetic Relay (EMR). The purpose of this application note is to present an alternative, the Solid State Relay (SSR), and to describe some of the ways in which the SSR can be used.

Application Note 1047 “Low On-Resistance Solid-State Relays For High-Reliability Applications”

<http://cp.literature.agilent.com/litweb/pdf/5091-4502E.pdf>

Introduction:

In military, aerospace, and commercial applications, the high performance, long lifetime, and immunity to shock and vibration give solid state relays distinct advantages over electromechanical relays. The HSSR-7110 family of hermetically sealed power MOSFET optocouplers operate exactly like single-pole, normally-open, solid-state relays (SSR). Therefore, from here on, they will be referred to as SSRs. Each SSR in the HSSR-7110 family contains a light-emitting diode (LED) optically coupled to a high voltage circuit. When a control current flows through the input terminals of the SSR, the LED emits light onto a photodiode array. This photodiode array, illustrated in Figure 1, generates sufficient voltage and current to operate a FET driver circuit and also to drive the gate-to-source voltages above the thresholds of the two output MOSFETs. This application note describes the main characteristics of the HSSR-7110, suggests various control drive circuits, and discusses the use of this SSR with different types of loads. Additional information regarding SSRs and their applications can be found in Agilent Technologies' Application Notes 1036 and 1046.

Application Note 1074 “Optocoupler Input-Output Endurance Voltage”

<http://cp.literature.agilent.com/litweb/pdf/5965-5977E.pdf>

Introduction:

A major concern of circuit designers is the reliability of an optocoupler when subjected to repeated and long-term, high-voltage stress between its input and output. Most of the technical data on optocouplers adequately address the capability of an optocoupler to withstand one-time high-voltage transients, but they do not adequately address the issues of: a) how long one can apply a steady state ac or dc voltage between the input and output of the optocoupler before degrading the semiconductors or the insulation inside the optocoupler, and b) how often one can apply high-voltage transients before degrading the optocoupler.

Application Note 1399
“Maximizing the Life Span of Your Relays”

<http://cp.literature.agilent.com/litweb/pdf/5988-6917EN.pdf>

Introduction:

Electromechanical relays can be used as actuators, as switches to route power to electrical devices, or for signal routing within a device or between different instruments. In data acquisition applications, relays are used to connect multiple transducers to a single measuring device. Most electromechanical relays are driven electromagnetically. A magnetic flux is generated by passing current through a coil. This magnetic flux causes an armature to move, and the movement causes isolated electrical contacts to open or close, thus making or breaking electrical connections. As with all mechanical devices, relays eventually wear out. If you use the right relays for the type of measurements you are making and derate them appropriately, you can protect your relays against early failure and prevent damage to your test instruments.

International Rectifier

Application Note AN-1068
“Considerations for Designs Using Radiation-Hardened Solid State Relays”

<http://www.irf.com/technical-info/appnotes/an-1068.pdf>

Introduction:

Manufacturers of satellites, satellite launch vehicles, and tactical weapon systems face many challenges when designing electro-mechanical relays (EMR) into their systems. Some method of “cushioning” must be employed in order to prevent false relay operation when encountering shock and vibration. In addition, “hash filters” are sometimes necessary to debounce the contacts, thus adding space and weight. However, Solid State Relays (SSR) are immune to the shock and vibration levels normally encountered, and do not need contact filters. Hence, the use of Solid State Relays in place of the mechanical type leads to a more reliable end product.

**“The Hermetic Surface Mount Device (SMD),
Its Advantages and Solutions to Assembly Integration”**

<http://www.irf.com/technical-info/whitepaper/hermeticsmd.pdf>

Introduction:

Hermetic surface mount packages have been in existence for more than 15 years. While the leaded packages (TO-257, TO-254, etc.) continue to find their use in many current designs, a vast majority of new electronic equipment designs have been integrating the SMD packages due to smaller size, lighter weight, and the excellent thermal performance that the surface mount devices offer. Design engineers for

high frequency applications particularly enjoy the inherently low inductance and low resistance these packages provide. In many instances, the SMD's are the absolute requirement. Successful assembly integration of plastic SMD devices is well established because of the temperature coefficient of expansion (TCE) of the package is comparable to the industry's standard board materials, FR-4 and polyimide to which the devices are mounted. Additionally, the environments where most plastic SMD's are used are generally benign. Unlike the plastic SMD, the popularity of the hermetic SMD devices has been somewhat hindered by the TCE incompatibility of the SMD package and the board materials, and significantly wider operating temperature demands. The soldered interface of the assembly can crack when it is subjected to temperature extremes, i.e., after a soldering operation or after temperature cycling screens. Solutions to the hermetic SMD assembly integration will be presented in this article. With the availability of low TCE (temperature coefficient of expansion) board materials, advances in materials, innovative SMD carrier designs, and maturity of the Power Module technology, the hermetic SMD devices can be now successfully and economically integrated in most of system designs. This article will focus on the new generation and more thermally efficient hermetic surface mount packages hereafter referred to as 'SMD'.

Solid State Optronics

Application Note 040 "Solid State Relays vs. Electromechanical Relays"

<http://www.ssousa.com/appnote040.asp>

Introduction:

In a relay's most basic function, the switching of a load circuit is controlled by a low power, electrically isolated input signal. In the past, Electromechanical Relays (EMRs) have been the component of choice, largely due to price, function, and availability. Now, however, the emergence of semiconductor technology has provided the means to manufacture solid state relays (SSRs) which in many applications, outperform their predecessors.

Acronyms and Abbreviations

°C	Degrees Centigrade
μin	Microinch
A	Ampere
AC	Alternating Current
ARINC	Aeronautical Radio, Incorporated
CMOS	Complementary Metal-Oxide Semiconductor
COTS	Commercial Off The Shelf
CRS	Cold Rolled Steel
DC	Direct Current
DC-DC	Direct Current to Direct Current
DIP	Dual Inline Pin
EEE	Electrical Electronic and Electromechanical
EMI	Electro Magnetic Interference
EMR	Electro Magnetic Relay
FET	Field Effect Transistor
FIT	Failures In Time
HI-REL	High Reliability
IGBT	Insulated Gate Bipolar Transistor
Inc.	Incorporated
IPPS	Intravehicular Portable Power Supply
ISO	International Standards Organization
ISS	International Space Station
JANS	Joint Army Navy Class S
JANTXV	Joint Army Navy, extra screening and testing with requirement of precapsulation visual examination
JSC	Johnson Space Center
LED	Light Emitting Diode
mA	Milliampere
MCM	Multi-Chip Module
MIL	Military
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
MOTS	modified or modifiable off-the-shelf
MTBF	Mean Time Between Failures
mΩ	Milliohm
NASA	National Aeronautics And Space Administration
PEEK	Portable Electrical Equipment Kit
PRF	Performance
QCI	Quality Conformance Inspection
QPL	Qualified Products List
rad	Radiation Absorbed Dose
R _{ds}	Channel Resistance Between Drain and Source
RF	Radio Frequency
RPC	Remote Power Controller
SCD	Source Control Drawing
SCR	Silicon Controlled Rectifier
SEU	Single Event Upset
SIP	Single Inline Pin

SMD	Surface Mount Device
SPEC	Specification
SRAM	Static Random Access Memory
SSPC	Solid State Power Controller
SSR	Solid State Relay
STD	Standard
TCE	Thermal Coefficient of Expansion
TTL	Transistor Transistor Logic
UOP	Utility Outlet Panel
VAC	Voltage Alternating Current
VDC	Volts Direct Current
V_{RMS}	Volts, Root Mean Square
w/o	Without