To our valued customers:

Since 1987, EMP Connectors has provided advanced transient suppression and EMI filter connectors for both military and commercial applications. We specialize in custom-built, high-powered designs within compact connector envelopes to fit your particular power handling, clamping voltage and package requirements. Although our connectors are specifically designed for your application, we are often able to provide them at a significant cost savings over the typical board mounted configurations.

In addition to delivering to you the highest quality connectors, EMP promotes and maintains a positive workplace for its employees. Each EMP team member is treated with respect and is encouraged to pursue professional as well as personal growth. Long term employee relationships are the key to our success that culminates in your complete satisfaction.

This catalog and design guide has been created to aid you in selecting the right connector series to meet your interconnection needs. Although comprehensive in nature, this is just a sampling of what we have to offer. If your application calls for a connector or connection system that is not represented here, please give us a call. We'll do our best to assist you in every way possible.

We look forward to serving you in the near future.

Sincerely,

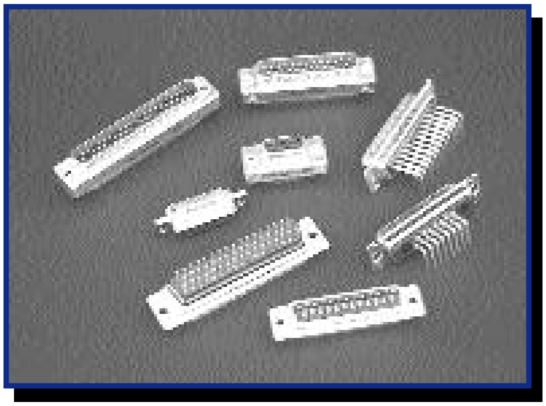
EMP Connectors

14251 Franklin Avenue • Tustin • California • 92680
Phone (714) 665-2080 • Fax (714) 665.2099

TABLE OF CONTENTS

CYLINDRICAL CONNECTORS

RECTANGULAR CONNECTORS



EMP Connectors, Inc. makes no representation that the use of the information described herein will not infringe on existing or future patent rights, nor do the descriptions contained herein imply the granting of licenses to make, use or sell equipment constructed in the accordance therewith.

NOTE: The information presented in this section is believed to be accurate and reliable. However, no responsibility is assumed by EMP Connectors, Inc. for its use.

GENERAL INFORMATION

EMP Connectors, Inc. was founded in 1987 with the mission of providing the highest quality solutions for military and commercial electronic interference problems. Specializing in the science of eletromagnetic compatibility (EMC), EMP Connectors is in the unique position of being able to supply both EMI filtering and EMP transient surge protection in the same compact connector package. By incorporating both types of protection into this single device, we have developed a proven space and cost saving solution over traditional protection methods.

Located in Banning, California, EMP supplies customers throughout the world with the highest quality products that meet or exceed all military and customer specifications. Our extensive facility is fully equipped to meet stringent quality and delivery demands:

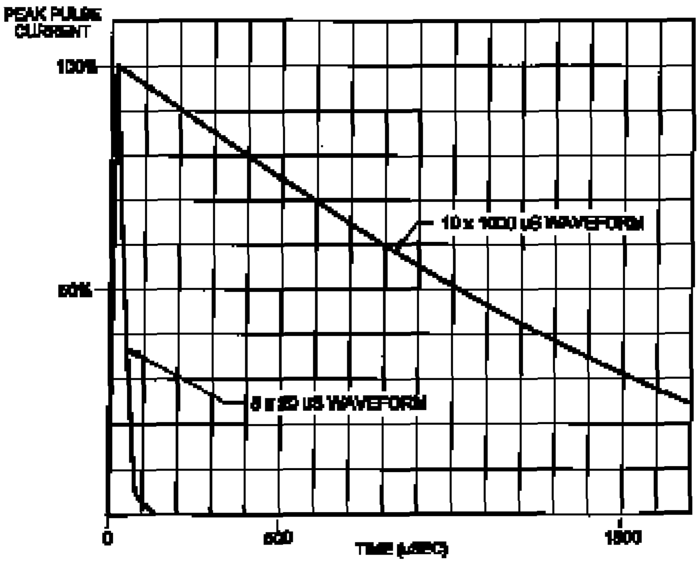
- Machine shop utilizing state-of-the art CNC equipment
- Design engineering staff with full CAD capabilities
- Quality control department operating to Mil Spec I-45208A
- Production and testing staff with over 30 years of experience
- Environmentally-controlled electronic assembly department

To support EMP's position as the leader in high-quality EMI filtering and EMP transient suppression connector design and manufacture, our engineering and test capabilities are among the most advanced in the industry today. The reliability and performance of every component and system is assured by a battery of tests performed under carefully controlled conditions. Prototyping techniques simulate and further validate performance prior to volume production and testing. All this to assure that parts leaving our plant can be utilized with confidence in the most complex and sophisticated electronic systems in the world today.

For further information on products, or for special application assistance, please contact our experienced staff of product or engineering specialists at our Tustin, California facility.

WHAT IS EMP OR EMI PROTECTION?

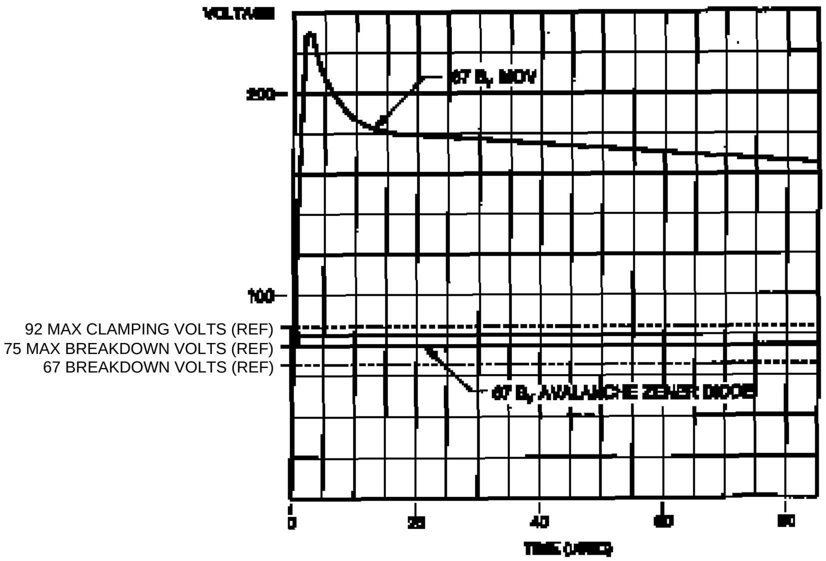
8 x 20 vs 10 x 1000 MICRO SECOND PULSE
(EXPONENTIALDECAY PULSE)



EMP Connectors incorporates proprietary technology, enabling us to offer much greater power handling ability than otherwise available in the industry. Many transient suppression companies express their power handling ability (in watts) using an 8 x 20 microsecond pulse waveform. At EMP Connectors, we rate our power handling ability to a 10 x 1000 microsecond pulse waveform - a much more stringent standard - requiring 6 times the power handling ability of the 8 x 20 standard. EMP Connectors can provide over 1000 watts of protection per line, testing to the 10 x 1000 pulse waveform, establishing a new standard in the industry for EMP protection within a connector. A quick glance at the energy envelope of each waveform indicates the higher standards established at EMP Connectors.

Current diode and traditional MOV technologies respond very quickly to transient voltage surges. However, the inherent inductance introduced by the two different devices after breakdown has a profound effect on the settling time of each. This phenomenon is indicated in the chart to the right. In this example, both devices share a nominal breakdown voltage of 67 volts. However, using a 60 amp square wave pulse with a 2 nsec rise time, the MOV has yet to settle to its maximum clamping voltage, even after 80 µsec of time has passed. By comparison, with the same 60 amp pulse, the Avalanche Zener diode has settled in to its maximum clamping voltage after only 5 nsec. As a result, the protected line will see a much smaller amount of energy when protected by a diode as compared to an MOV.

RESPONSE CHARACTERISTICS (DIODE vs METALOXIDE VARISTOR-MOV)
60 AMP SQUARE WAVE PULSE WITH 2nS RISE TIME



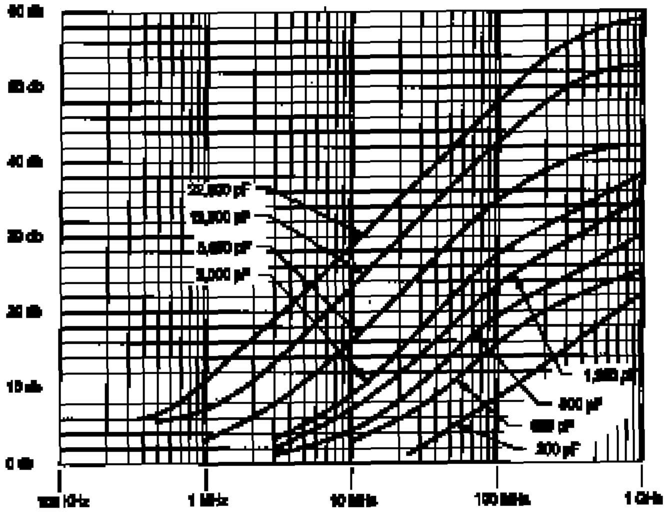
This phenomenon may be verified by comparing the maximum clamping voltage of a diode with that of an MOV. An MOV with a breakdown voltage of 38 volts has a maximum clamping voltage of 100 volts when pulsed with a 5 amp, 8 x 20 µsec exponential decay pulse. An EMP Connectors Avalanche Zener diode with a similar rating of 39 volts has a maximum clamping voltage of 54 volts when pulsed with a 19 amp, 10 x 1000 µsec exponential decay pulse.

FILTER PERFORMANCE CURVES

TYPICAL ATTENUATION CURVES

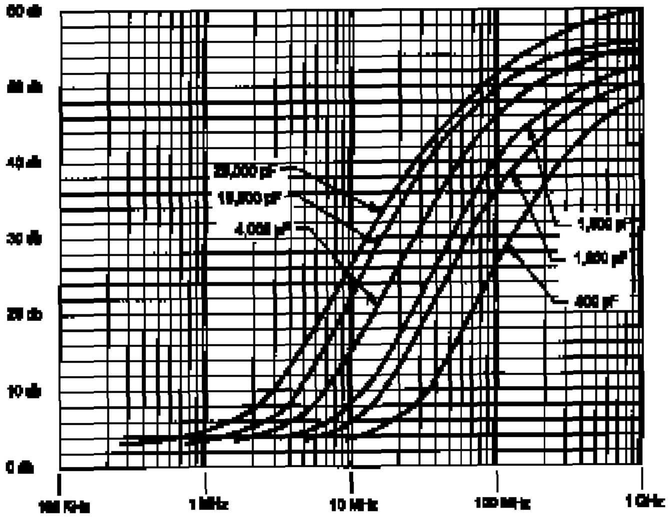
Straight "C" Filter Configurations

(per MIL-STD-220 @ 25°C with 50 Ohm system)



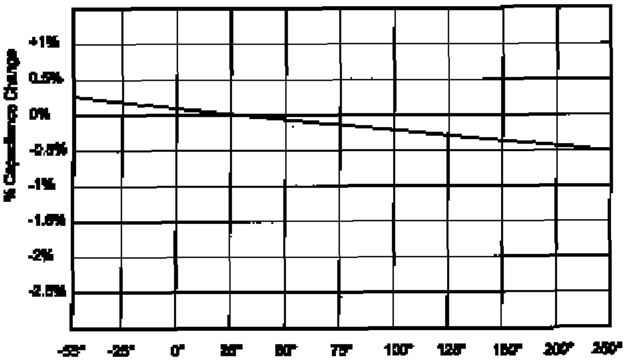
"Pi" Filter Configurations

(per MIL-STD-220 @ 25°C with 50 Ohm system)



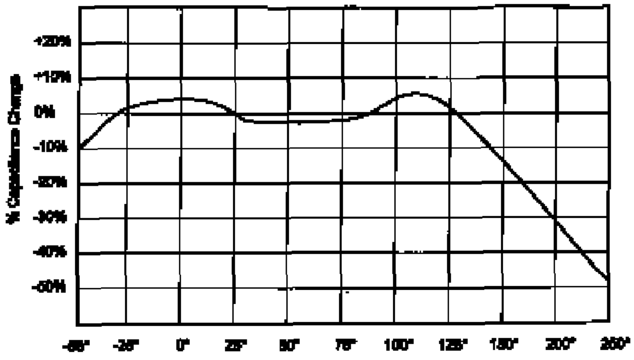
CAPACITANCE CHANGE VS. TEMPERATURE

NPO Low "K" Value Material



Low "K" value materials offer less capacitance in a given amount of space, however, lower "K" value materials are much more stable over a wide temperature range than higher "K" value materials. This chart does not reflect the impact of voltage and frequency on capacitance.

X7R High "K" Value Material



High "K" value materials offer more capacitance in the same amount of space, however, higher "K" value materials are less stable over a wide temperature range than lower "K" value materials. This chart does not reflect the impact of voltage and frequency on capacitance.

Part Numbering Guide

A 2 1 F F 53 P N - C 01

CLASS DESCRIPTION

CONNECTOR
A=38999
B=26482
G=28840
K=5015

SERIES
0
1
2
3
4

STYLE
1=SQ. Flange/Wall Mount
2=Box Mount
3=Jam-Nut
4=Feed Thru
5=Adapter
6=Plug
7=Back Panel Mount
8=Solder Mount
9=Receptacle

PLATING
A=Tin
C=Clear CAD
D=Fused Tin
E=Nickel
F=Electroless Nickel
G=Gold
H=Passivation
W=O.D. CAD
M=Composite (Plating recorded in -#)
Y=Yellow CAD

MODIFICATION CODE
Manufacturer's Code
to Identify Pin Values

TERMINATION STYLE
C=Crimp
S=Solder
T=Extended Pin
(PCBD or Flex Cable)
A=Pin/Socket

CLOCKING/KEYING
SEE MIL-STDS

CONTACT STYLE
P=Pin
S=Socket
A=P/S Pin on Plug Side

ADAPTER/FEED THRU
A=P/S Pinion Plug Side
B=S/P Socket on
Plug Side
C=P/P
D=S/S

INSERT ARRANGEMENT
SEE MIL-STDS

SHELL SIZE

A=8-9	G=20-21
B=10-11	H=22-23
C=12-13	J=24-25
D=14-15	K=1
E=16-17	L=2
F=18-19	M=3

SHELL SIZE (28840)

A=11	G=25
B=13	H=29
C=15	J=33
D=17	
E=19	
F=23	

MIL-C-38999 CONTACT ARRANGEMENTS

LEGEND

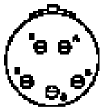
∘ #22D CONTACTS

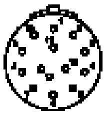
⊖ #20 CONTACTS

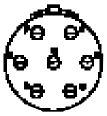
⦶ #16 CONTACTS

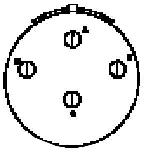
⊕ #12 CONTACTS

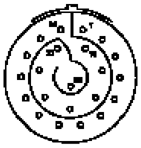
(FRONT FACE OF PIN INSERT SHOWN)

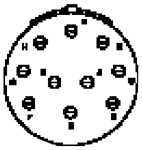

INSERT 11-5
5 #20 CONTACTS

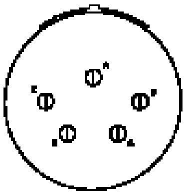

INSERT 11-35
13 #22D CONTACTS

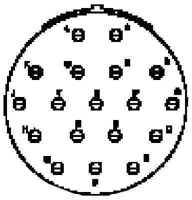

INSERT 11-99
7 #20 CONTACTS

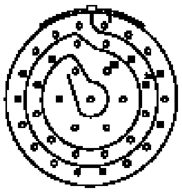

INSERT 13-4
4 #16 CONTACTS

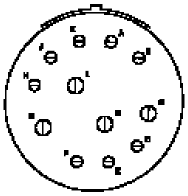

INSERT 13-35
22 #22D CONTACTS

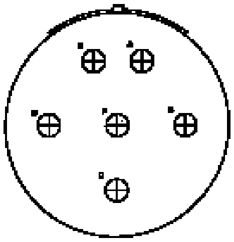

INSERT 13-98
10 #20 CONTACTS

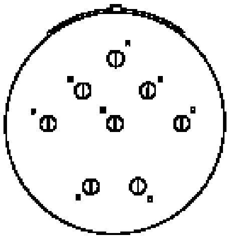

INSERT 15-5
5 #16 CONTACTS

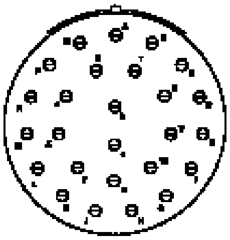

INSERT 15-18
18 #20 CONTACTS

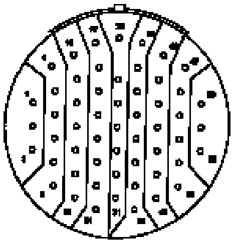

INSERT 15-35
37 #22D CONTACTS

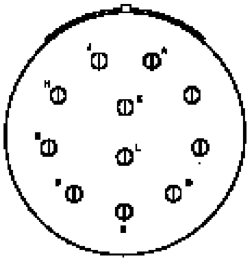

INSERT 15-97
8 #20 CONTACTS
4 #16 CONTACTS

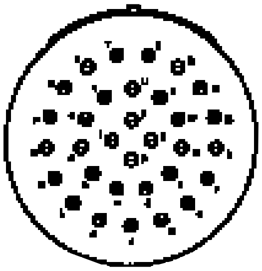

INSERT 17-6
6 #12 CONTACTS

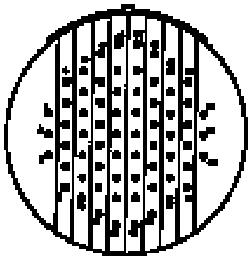

INSERT 17-8
8 #16 CONTACTS

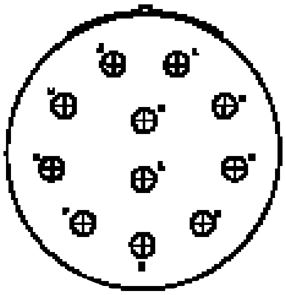

INSERT 17-26
26 #20 CONTACTS

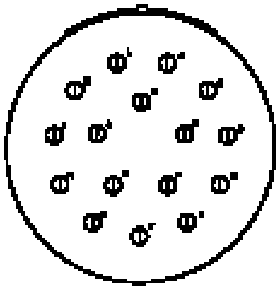

INSERT 17-35
55 #22D CONTACTS

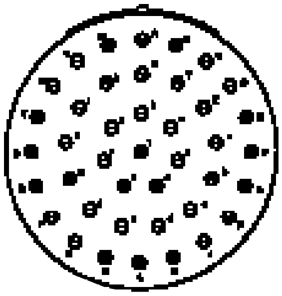

INSERT 19-11
11 #16 CONTACTS

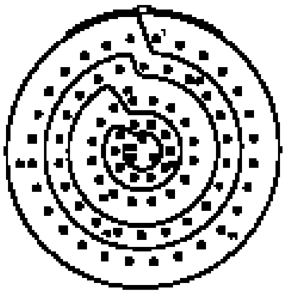

INSERT 19-32
32 #20 CONTACTS

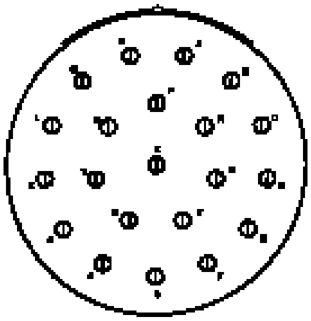

INSERT 19-35
66 #22D CONTACTS

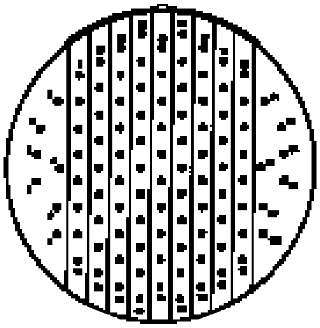

INSERT 21-11
11 #12 CONTACTS

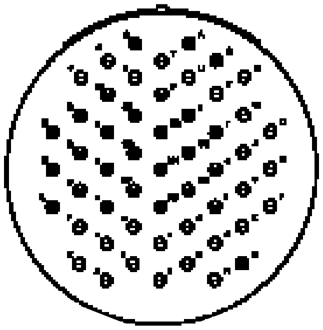

INSERT 21-16
16 #16 CONTACTS

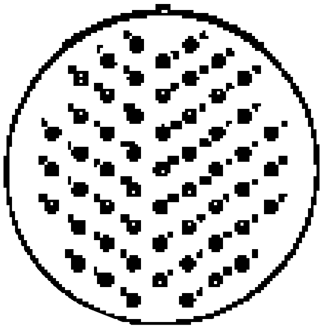

INSERT 21-41
41 #20 CONTACTS

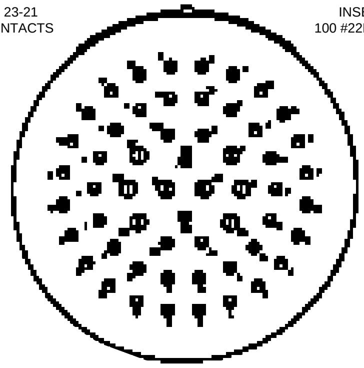

INSERT 21-35
79 #22D CONTACTS

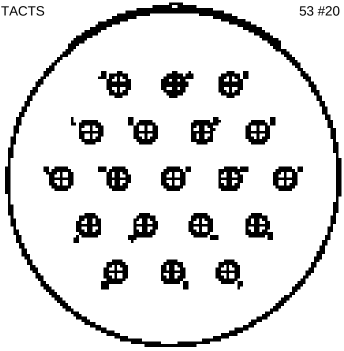

INSERT 23-21
21 #16 CONTACTS


INSERT 23-35
100 #22D CONTACTS


INSERT 23-53
53 #20 CONTACTS


INSERT 23-55 55 #20 CONTACTS

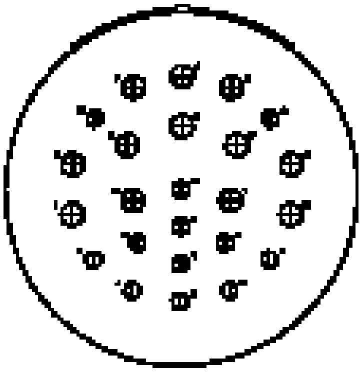

INSERT 25-4 48 #20 CONTACTS 8 #16 CONTACTS


INSERT 25-19 19 #12 CONTACTS

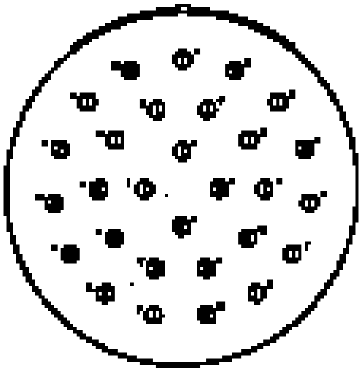
MIL-C-38999 CONTACT ARRANGEMENTS (CONTINUED)

LEGEND	
∘	#22D CONTACTS
⊖	#20 CONTACTS
⦶	#16 CONTACTS
⊕	#12 CONTACTS

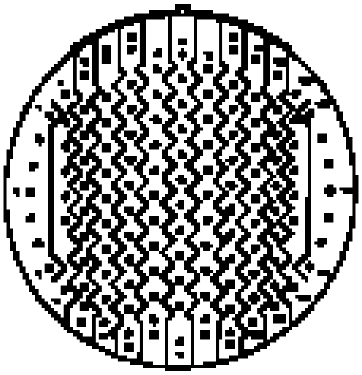
(FRONT FACE OF PIN INSERT SHOWN)



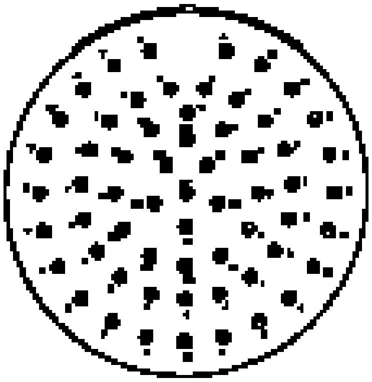
INSERT 25-24
12 #16 CONTACTS
12 #12 CONTACTS



INSERT 25-29
29 #16 CONTACTS



INSERT 25-35
128 #22D CONTACTS

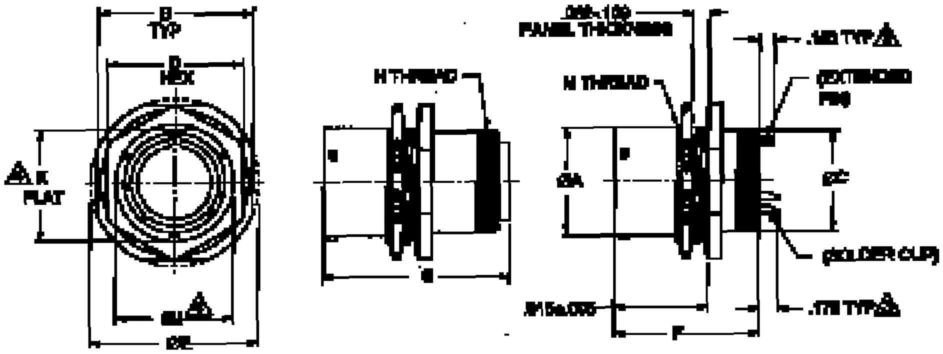


INSERT 25-61
61 #20 CONTACTS

INSERT NUMBER	SERVICE RATING	TOTAL CONTACTS	CONTACTSIZE			
			22D	20	16	12
11-5	I	5		5		
11-35	M	13	13			
11-99	I	7		7		
13-4	I	4			4	
13-35	M	22	22			
13-98	I	10		10		
15-5	II	5			5	
15-18	I	18		18		
15-35	M	37	37			
15-97	I	12		8	4	
17-6	I	6				6
17-8	II	8			8	
17-26	I	26		26		
17-35	M	55	55			
19-11	II	11			11	
19-32	I	32		32		

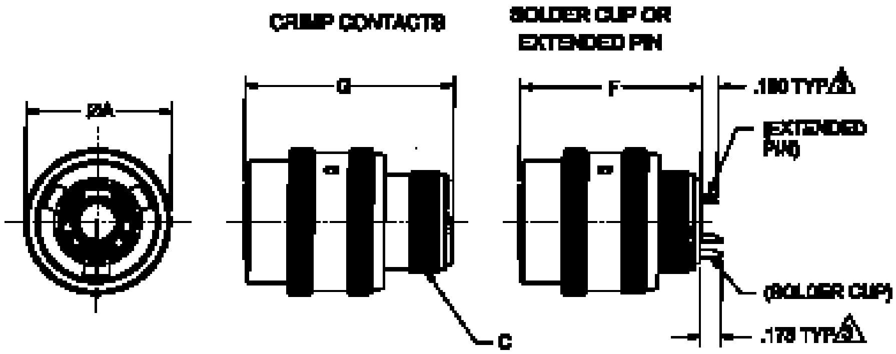
INSERT NUMBER	SERVICE RATING	TOTAL CONTACTS	CONTACTSIZE			
			22D	20	16	12
19-35	M	66	66			
21-11	I	11				11
21-16	II	16			16	
21-41	I	41		41		
21-35	M	79	79			
23-21	II	21			21	
23-35	M	100	100			
23-53	I	53		53		
23-55	I	55		55		
25-4	I	56		48	8	
25-19	I	19				19
25-24	I	24			12	12
25-29	I	29			29	
25-35	M	128	128			
25-61	I	61		61		

JAM-NUT RECEPTACLE



SHELL SIZE	ØA +.001 -.005	B +.016 -.015	ØC +.001 -.006	D +.017 -.016	ØE +.011 -.010	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H UNEF-2A THREAD	ØJ +.010 -.000	K +.000 -.010	M CLASS 2A THREAD
						F MAX	G MAX	F MAX	G MAX				
9	.572	1.062	.436	.875	1.188	1.400	2.050	1.650	2.300	7/16-28	.697	.669	11/16-24
11	.700	1.250	.560	1.000	1.375	1.400	2.050	1.650	2.300	9/16-24	.822	.769	13/16-20
13	.850	1.375	.686	1.188	1.500	1.400	2.050	1.650	2.300	11/16-24	1.007	.955	1-20
15	.975	1.500	.810	1.312	1.625	1.400	2.050	1.650	2.300	13/16-20	1.134	1.084	1 1/8-18
17	1.100	1.625	.936	1.438	1.750	1.400	2.050	1.650	2.300	15/16-20	1.259	1.208	1 1/4-18
19	1.207	1.812	1.060	1.562	1.938	1.400	2.050	1.650	2.300	1 1/6-18	1.384	1.333	1 3/8-18
21	1.332	1.938	1.186	1.688	2.062	1.400	2.050	1.650	2.300	1 3/16-18	1.507	1.459	1 1/2-18
23	1.457	2.062	1.310	1.812	2.188	1.400	2.050	1.650	2.300	1 5/16-18	1.634	1.580	1 5/8-18
25	1.582	2.188	1.436	2.000	2.312	1.400	2.050	1.650	2.300	1 7/16-18	1.759	1.709	1 3/4-18

STRAIGHT PLUG



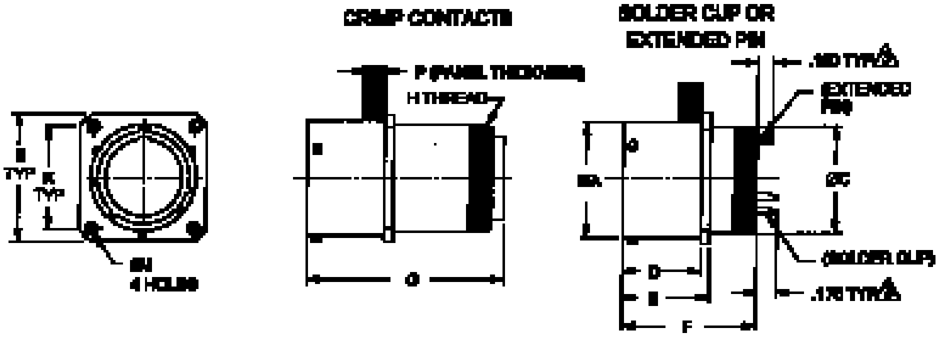
SHELL SIZE	ØA	C		F MAX	G MAX
		CLASS 2A THREAD	MODIFIED MAJOR DIA		
9	.734	7/16-28	.421-.417	1.234	1.634
11	.844	9/16-24	.542-.538	1.234	1.634
13	1.016	11/16-24	.667-.663	1.234	1.634
15	1.141	13/16-20	.791-.787	1.234	1.634
17	1.265	15/16-20	.916-.912	1.234	1.634
19	1.391	1 1/16-18	1.034-1.030	1.234	1.634
21	1.500	1 3/16-18	1.158-1.154	1.234	1.634
23	1.625	1 5/16-18	1.283-1.279	1.234	1.634
25	1.750	1 7/16-18	1.408-1.404	1.234	1.634

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

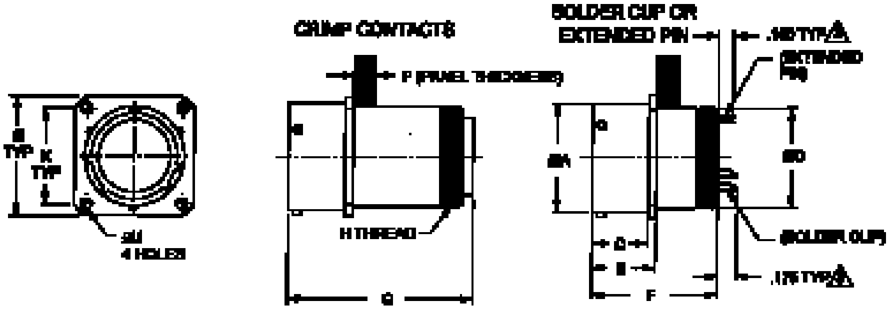
△4 “D” SHAPED MOUNTING HOLE DIMENSIONS.

WALL MOUNT RECEPTACLE (REAR PANEL MOUNTING)



SHELL SIZE	ØA +.001 -.005	B +.011 -.010	ØC +.001 -.006	D +.000 -.006	E +.005 -.000	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H UNEF-2A THREAD	J +.004 -.002	K ±.005	P MAX
						F MAX	G MAX	F MAX	G MAX				
9	.572	.938	.436	.820	.905	1.400	2.050	1.650	2.300	7/16-28	.128	.719	.234
11	.700	1.031	.560	.820	.905	1.400	2.050	1.650	2.300	9/16-24	.128	.812	.234
13	.850	1.125	.686	.820	.905	1.400	2.050	1.650	2.300	11/16-24	.128	.906	.234
15	.975	1.219	.810	.820	.905	1.400	2.050	1.650	2.300	13/16-20	.128	.969	.234
17	1.100	1.312	.936	.820	.905	1.400	2.050	1.650	2.300	15/16-20	.128	1.062	.234
19	1.207	1.438	1.060	.820	.905	1.400	2.050	1.650	2.300	1 1/6-18	.128	1.156	.234
21	1.332	1.562	1.186	.790	.905	1.400	2.050	1.650	2.300	1 3/16-18	.128	1.250	.204
23	1.457	1.688	1.310	.790	.905	1.400	2.050	1.650	2.300	1 5/16-18	.147	1.375	.204
25	1.582	1.812	1.436	.790	.905	1.400	2.050	1.650	2.300	1 7/16-18	.147	1.500	.193

WALL MOUNT RECEPTACLE (FRONT PANEL MOUNTING)

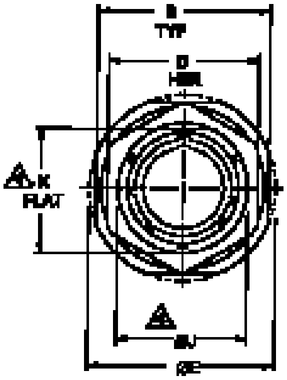


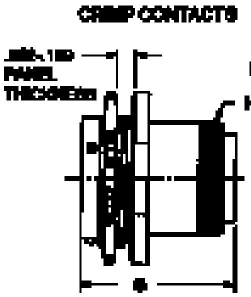
SHELL SIZE	ØA +.001 -.005	B +.011 -.010	ØC +.001 -.006	D +.000 -.006	E +.005 -.000	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H UNEF-2A THREAD	J +.004 -.002	K ±.005	P MAX
						F MAX	G MAX	F MAX	G MAX				
9	.572	.938	.436	.632	.717	1.400	2.050	1.650	2.300	7/16-28	.128	.719	.234
11	.700	1.031	.560	.632	.717	1.400	2.050	1.650	2.300	9/16-24	.128	.812	.234
13	.850	1.125	.686	.632	.717	1.400	2.050	1.650	2.300	11/16-24	.128	.906	.234
15	.975	1.219	.810	.632	.717	1.400	2.050	1.650	2.300	13/16-20	.128	.969	.234
17	1.100	1.312	.936	.632	.717	1.400	2.050	1.650	2.300	15/16-20	.128	1.062	.234
19	1.207	1.438	1.060	.632	.717	1.400	2.050	1.650	2.300	1 1/6-18	.128	1.156	.234
21	1.332	1.562	1.186	.602	.717	1.400	2.050	1.650	2.300	1 3/16-18	.128	1.250	.204
23	1.457	1.688	1.310	.602	.717	1.400	2.050	1.650	2.300	1 5/16-18	.147	1.375	.204
25	1.582	1.812	1.436	.602	.717	1.400	2.050	1.650	2.300	1 7/16-18	.147	1.500	.193

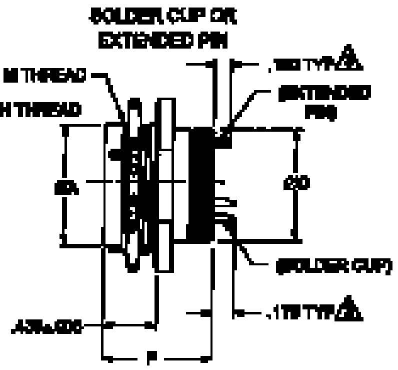
1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

⚠3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

JAM-NUT RECEPTACLE

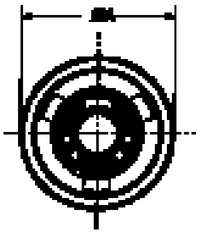


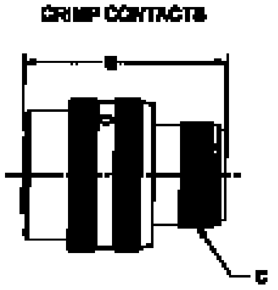


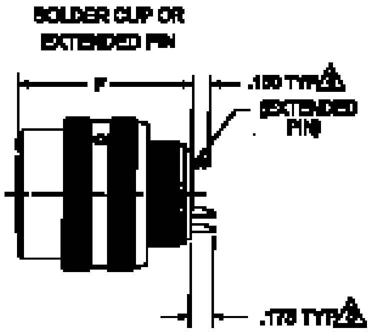


SHELL SIZE	ØA +.001 -.005	B ±.010	ØC +.001 -.006	D +.017 -.016	ØE +.011 -.010	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H UNEF-2A THREAD	ØJ +.010 -.000	K +.000 -.010	M CLASS 2A THREAD
						F MAX	G MAX	F MAX	G MAX				
8	.473	1.250	.436	1.062	1.375	1.050	1750	1.300	2.000	7/16-28	.884	.830	7/8-20
10	.590	1.375	.560	1.188	1.500	1.050	1750	1.300	2.000	9/16-24	1.007	.955	1-20
12	.750	1.500	.686	1.312	1.625	1.050	1750	1.300	2.000	11/16-24	1.134	1.084	1 1/8-18
14	.875	1.625	.810	1.438	1.750	1.050	1750	1.300	2.000	13/16-20	1.259	1.208	1 1/4-18
16	1.000	1.781	.936	1.562	1.938	1.050	1750	1.300	2.000	15/16-20	1.384	1.333	1 3/8-18
18	1.125	1.890	1.060	1.688	2.016	1.050	1750	1.300	2.000	1 1/6-18	1.507	1.459	1 1/2-18
20	1.250	2.016	1.186	1.812	2.141	1.050	1750	1.300	2.000	1 3/16-18	1.634	1.576	1 5/8-18
22	1.375	2.140	1.310	2.000	2.265	1.050	1750	1.300	2.000	1 5/16-18	1.759	1.701	1 3/4-18
24	1.500	2.265	1.436	2.125	2.390	1.050	1750	1.300	2.000	1 7/16-18	1.884	1.826	1 7/8-16

STRAIGHT PLUG







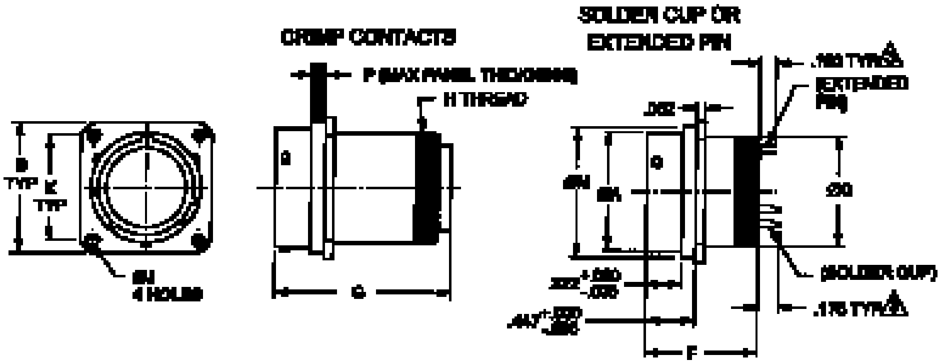
SHELL SIZE	ØA	C CLASS 2A THREAD	F MAX	G MAX
8	.734	7/16-28	1.009	1.409
10	.844	9/16-24	1.009	1.409
12	1.016	11/16-24	1.009	1.409
14	1.141	13/16-20	1.009	1.409
16	1.265	15/16-20	1.009	1.409
18	1.391	1 1/16-18	1.009	1.409
20	1.500	1 3/16-18	1.009	1.409
22	1.625	1 5/16-18	1.009	1.409
24	1.750	1 7/16-18	1.009	1.409

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

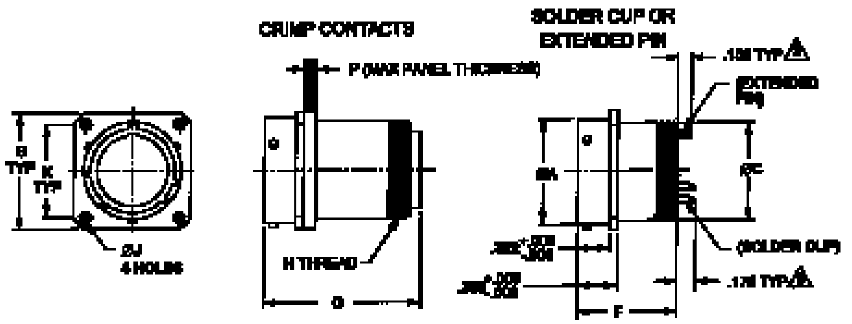
△4 “D” SHAPED MOUNTING HOLE DIMENSIONS.

WALL MOUNT RECEPTACLE (REAR PANEL MOUNTING)



SHELL SIZE	ØA +.001 -.005	B +.011 -.010	ØC +.001 -.006	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H UNEF-2A THREAD	J ±.005	K ±.005	ØM +.001 -.005	P
				F MAX	G MAX	F MAX	G MAX					
8	.473	.812	.436	1.050	1.750	1.300	2.000	7/16-28	.120	.594	.516	.147
10	.590	.938	.560	1.050	1.750	1.300	2.000	9/16-24	.120	.719	.633	.152
12	.750	1.031	.686	1.050	1.750	1.300	2.000	11/16-24	.120	.812	.802	.152
14	.875	1.125	.810	1.050	1.750	1.300	2.000	13/16-20	.120	.906	.927	.152
16	1.000	1.219	.936	1.050	1.750	1.300	2.000	15/16-20	.120	.969	1.052	.152
18	1.125	1.312	1.060	1.050	1.750	1.300	2.000	1 1/6-18	.120	1.062	1.177	.152
20	1.250	1.438	1.186	1.050	1.750	1.300	2.000	1 3/16-18	.120	1.156	1.302	.179
22	1.375	1.562	1.310	1.050	1.750	1.300	2.000	1 5/16-18	.120	1.250	1.427	.179
24	1.500	1.688	1.436	1.050	1.750	1.300	2.000	1 7/16-18	.147	1.375	1.552	.179

WALL MOUNT RECEPTACLE (FRONT PANEL MOUNTING)

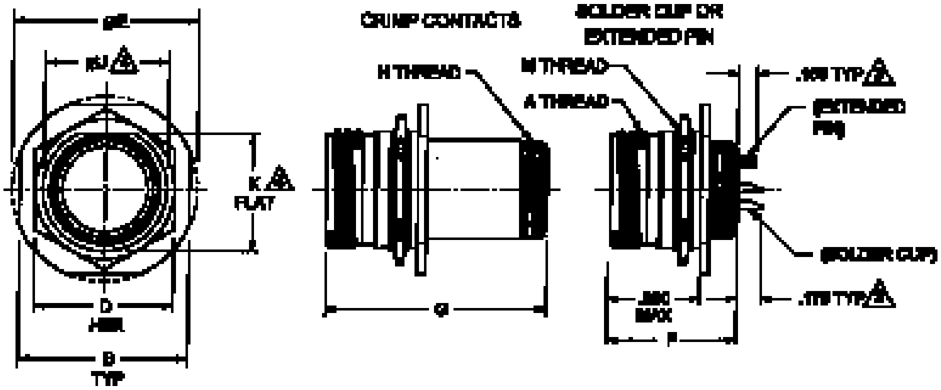


SHELL SIZE	ØA +.001 -.005	B +.011 -.010	ØC +.001 -.006	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H UNEF-2A THREAD	J ±.005	K ±.005	P
				F MAX	G MAX	F MAX	G MAX				
8	.473	.812	.436	1.050	1.750	1.300	2.000	7/16-28	.120	.594	.147
10	.590	.938	.560	1.050	1.750	1.300	2.000	9/16-24	.120	.719	.152
12	.750	1.031	.686	1.050	1.750	1.300	2.000	11/16-24	.120	.812	.152
14	.875	1.125	.810	1.050	1.750	1.300	2.000	13/16-20	.120	.906	.152
16	1.000	1.219	.936	1.050	1.750	1.300	2.000	15/16-20	.120	.969	.152
18	1.125	1.312	1.060	1.050	1.750	1.300	2.000	1 1/6-18	.120	1.062	.152
20	1.250	1.438	1.186	1.050	1.750	1.300	2.000	1 3/16-18	.120	1.156	.179
22	1.375	1.562	1.310	1.050	1.750	1.300	2.000	1 5/16-18	.120	1.250	.179
24	1.500	1.688	1.436	1.050	1.750	1.300	2.000	1 7/16-18	.147	1.375	.179

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

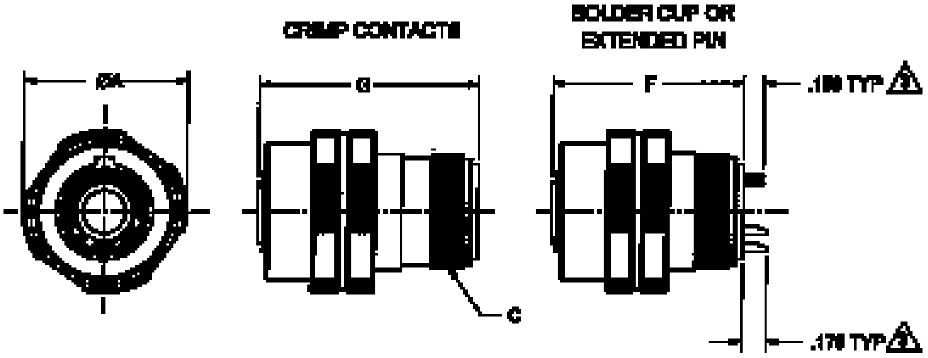
△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

JAM-NUT RECEPTACLE



SHELL SIZE	ØA THREAD CLASS 2A 0.1P-0.3L-TS (PLATED)	B +.016 -.015	D +.017 -.016	ØE +.011 -.010	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H METRIC THREAD (PLATED)	ØJ +.010 -.000	K +.005 -.006	M METRIC THREAD (PLATED)
					F MAX	G MAX	F MAX	G MAX				
9	.625	1.062	.875	1.188	1.300	1.800	1.650	2.050	M12X1-6g0.100R	.697	.651	M17X1-6g0.100R
11	.750	1.250	1.000	1.375	1.300	1.800	1.650	2.050	M15X1-6g0.100R	.822	.751	M20X1-6g0.100R
13	.875	1.375	1.188	1.500	1.300	1.800	1.650	2.050	M18X1-6g0.100R	1.007	.938	M25X1-6g0.100R
15	1.000	1.500	1.312	1.625	1.300	1.800	1.650	2.050	M22X1-6g0.100R	1.134	1.062	M28X1-6g0.100R
17	1.188	1.625	1.438	1.750	1.300	1.800	1.650	2.050	M25X1-6g0.100R	1.259	1.187	M32X1-6g0.100R
19	1.250	1.812	1.562	1.938	1.300	1.800	1.650	2.050	M28X1-6g0.100R	1.384	1.312	M35X1-6g0.100R
21	1.375	1.938	1.688	2.062	1.300	1.800	1.650	2.050	M31X1-6g0.100R	1.507	1.437	M38X1-6g0.100R
23	1.500	2.062	1.812	2.188	1.300	1.800	1.650	2.050	M34X1-6g0.100R	1.634	1.562	M41X1-6g0.100R
25	1.625	2.188	2.000	2.312	1.300	1.800	1.650	2.050	M37X1-6g0.100R	1.759	1.687	M44X1-6g0.100R

STRAIGHT PLUG



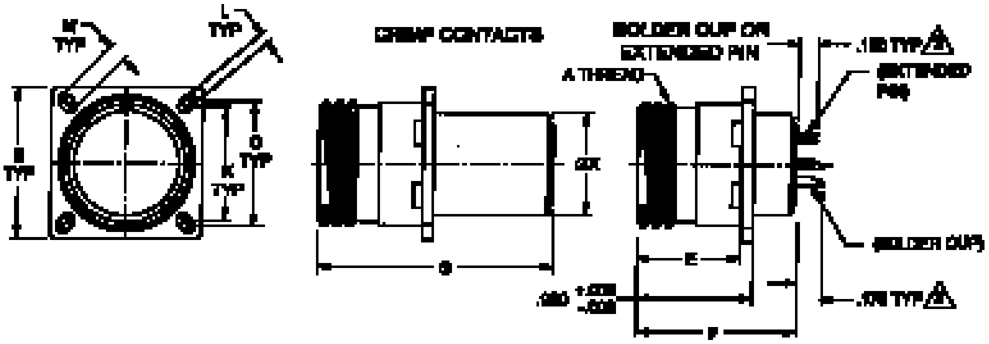
SHELL SIZE	ØA MAX	C CLASS METRIC	F MAX	G MAX
9	.859	M12X1.6g	1.234	1.634
11	.969	M15X1.6g	1.234	1.634
13	1.141	M18X1.6g	1.234	1.634
15	1.266	M22X1.6g	1.234	1.634
17	1.391	M25X1.6g	1.234	1.634
19	1.500	M28X1.6g	1.234	1.634
21	1.625	M31X1.6g	1.234	1.634
23	1.750	M34X1.6g	1.234	1.634
25	1.875	M37X1.6g	1.234	1.634

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

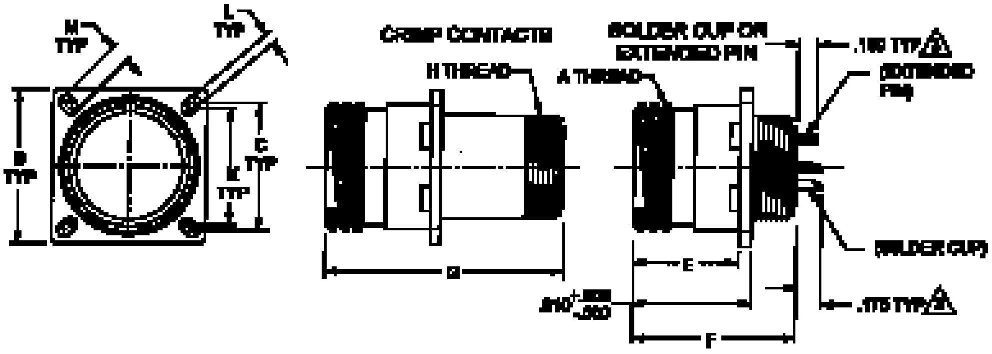
△4 "D" SHAPED MOUNTING HOLE DIMENSIONS.

BOX MOUNT RECEPTACLE



SHELL SIZE	A THREAD CLASS 2A 0.1P-0.3L-TS (PLATED)	B ±.010	C TYP	E +.000 -.005	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H METRIC THREAD (PLATED)	K TYP	L +.004 -.002	M +.004 -.002	ØX MAX
					F MAX	G MAX	F MAX	G MAX					
9	.625	.938	.719	.842	1.300	1.800	1.650	2.050	M12X1-6g0.100R	.594	.128	.216	.469
11	.750	1.031	.812	.842	1.300	1.800	1.650	2.050	M15X1-6g0.100R	.719	.128	.194	.594
13	.875	1.125	.906	.842	1.300	1.800	1.650	2.050	M18X1-6g0.100R	.812	.128	.194	.719
15	1.000	1.219	.969	.842	1.300	1.800	1.650	2.050	M22X1-6g0.100R	.906	.128	.173	.844
17	1.188	1.312	1.062	.842	1.300	1.800	1.650	2.050	M25X1-6g0.100R	.969	.128	.194	.969
19	1.250	1.438	1.156	.842	1.300	1.800	1.650	2.050	M28X1-6g0.100R	1.062	.128	.194	1.078
21	1.375	1.562	1.250	.842	1.300	1.800	1.650	2.050	M31X1-6g0.100R	1.156	.128	.194	1.203
23	1.500	1.688	1.375	.842	1.300	1.800	1.650	2.050	M34X1-6g0.100R	1.250	.154	.242	1.328
25	1.625	1.812	1.500	.842	1.300	1.800	1.650	2.050	M37X1-6g0.100R	1.375	.154	.242	1.453

WALL MOUNT RECEPTACLE

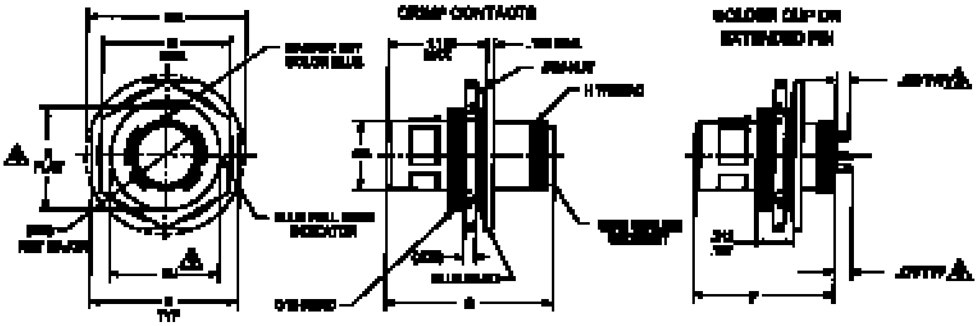


SHELL SIZE	A THREAD CLASS 2A 0.1P-0.3L-TS (PLATED)	B ±.010	C TYP	E +.000 -.005	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H METRIC THREAD (PLATED)	K TYP	L +.004 -.002	M +.004 -.002
					F MAX	G MAX	F MAX	G MAX				
9	.625	.938	.719	.820	1.300	1.800	1.650	2.050	M12X1-6g0.100R	.594	.128	.216
11	.750	1.031	.812	.820	1.300	1.800	1.650	2.050	M15X1-6g0.100R	.719	.128	.194
13	.875	1.125	.906	.820	1.300	1.800	1.650	2.050	M18X1-6g0.100R	.812	.128	.194
15	1.000	1.219	.969	.820	1.300	1.800	1.650	2.050	M22X1-6g0.100R	.906	.128	.173
17	1.188	1.312	1.062	.820	1.300	1.800	1.650	2.050	M25X1-6g0.100R	.969	.128	.194
19	1.250	1.438	1.156	.820	1.300	1.800	1.650	2.050	M28X1-6g0.100R	1.062	.128	.194
21	1.375	1.562	1.250	.790	1.300	1.800	1.650	2.050	M31X1-6g0.100R	1.156	.128	.194
23	1.500	1.688	1.375	.790	1.300	1.800	1.650	2.050	M34X1-6g0.100R	1.250	.154	.242
25	1.625	1.812	1.500	.790	1.300	1.800	1.650	2.050	M37X1-6g0.100R	1.375	.154	.242

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

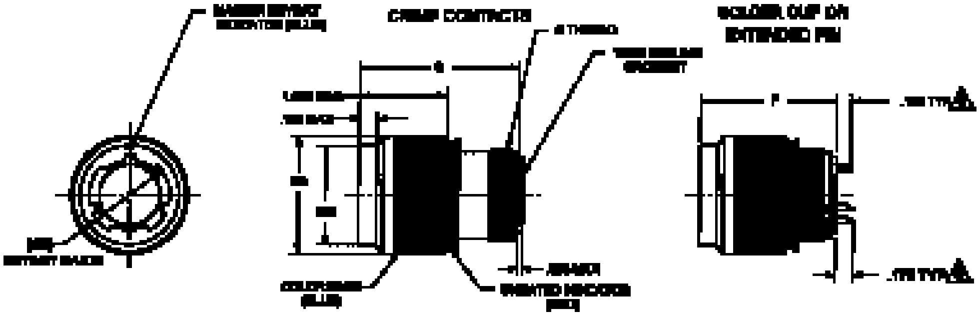
△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

JAM-NUT RECEPTACLE



SHELL SIZE	ØA MAX	B +.016 -.015	C METRIC THREAD	D +.017 -.016	ØE +.011 -.010	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H METRIC THREAD	ØJ +.010 -.000	K FLAT MAX	ØQ REF
						F MAX	G MAX	F MAX	G MAX				
9	.381	1.062	M22x1.0-6g0.100R	.875	1.188	1.300	1.800	1.650	2.050	M12X1-6g0.100R	.697	.651	.461
11	.509	1.250	M25x1.0-6g0.100R	1.000	1.375	1.300	1.800	1.650	2.050	M15X1-6g0.100R	.822	.942	.589
13	.634	1.375	M28x1.0-6g0.100R	1.188	1.500	1.300	1.800	1.650	2.050	M18X1-6g0.100R	1.007	1.066	.720
15	.759	1.500	M31x1.0-6g0.100R	1.312	1.625	1.300	1.800	1.650	2.050	M22X1-6g0.100R	1.134	1.191	.844
17	.885	1.625	M34x1.0-6g0.100R	1.438	1.750	1.300	1.800	1.650	2.050	M25X1-6g0.100R	1.259	1.321	.969
19	1.009	1.812	M38x1.0-6g0.100R	1.562	1.938	1.300	1.800	1.650	2.050	M28X1-6g0.100R	1.384	1.441	1.088
21	1.134	1.938	M41x1.0-6g0.100R	1.688	2.062	1.300	1.800	1.650	2.050	M31X1-6g0.100R	1.507	1.566	1.213
23	1.259	2.062	M44x1.0-6g0.100R	1.812	2.188	1.300	1.800	1.650	2.050	M34X1-6g0.100R	1.634	1.691	1.342
25	1.384	2.188	M47x1.0-6g0.100R	2.000	2.312	1.300	1.800	1.650	2.050	M37X1-6g0.100R	1.759	1.816	1.469

STRAIGHT PLUG



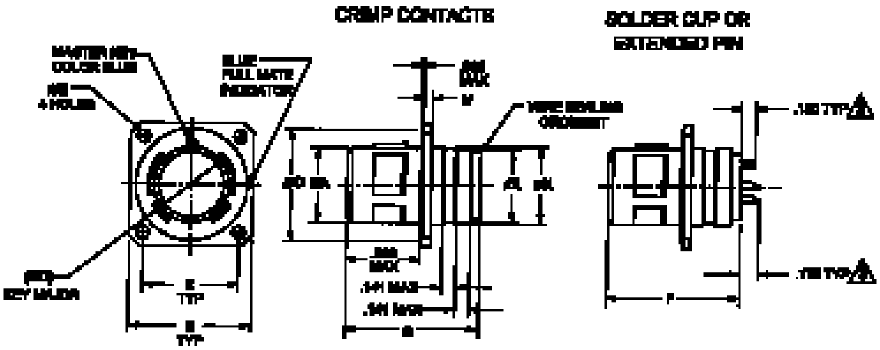
SHELL SIZE	ØA MAX	C METRIC THREAD	F		G		ØM MAX
			MAX MATED	MAX UNMATED	MAX MATED	MAX UNMATED	
9	.935	M12x1.0-6g0.100R	1.437	1.531	1.837	1.931	.650
11	1.054	M15x1.0-6g0.100R	1.437	1.531	1.837	1.931	.775
13	1.226	M18x1.0-6g0.100R	1.437	1.531	1.837	1.931	.901
15	1.351	M22x1.0-6g0.100R	1.437	1.531	1.837	1.931	1.039
17	1.476	M25x1.0-6g0.100R	1.437	1.531	1.837	1.931	1.149
19	1.566	M28x1.0-6g0.100R	1.437	1.531	1.837	1.931	1.275
21	1.711	M31x1.0-6g0.100R	1.437	1.531	1.837	1.931	1.401
23	1.836	M34x1.0-6g0.100R	1.437	1.531	1.837	1.931	1.527
25	1.964	M37x1.0-6g0.100R	1.437	1.531	1.837	1.931	1.649

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

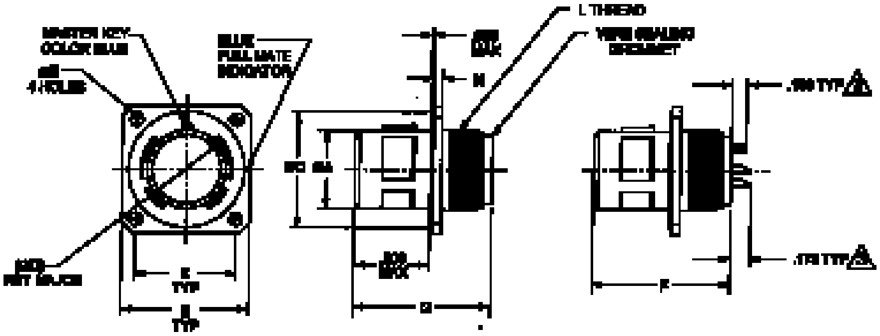
△4 “D” SHAPED MOUNTING HOLE DIMENSIONS.

BOX MOUNT RECEPTACLE



SHELL SIZE	ØA MAX	B MAX	ØC BOSS MAX	ØD REF	ØE MIN	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		K	ØL MAX	ØX MAX	N MAX REF
						F MAX	G MAX	F MAX	G MAX				
9	.384	.948	.668	.464	.122	1.300	1.800	1.650	2.050	.656	.412	.453	.102
11	.509	1.051	.793	.589	.122	1.300	1.800	1.650	2.050	.812	.535	.578	.102
13	.634	1.146	.919	.720	.122	1.300	1.800	1.650	2.050	.906	.649	.692	.102
15	.759	1.240	1.044	.844	.122	1.300	1.800	1.650	2.050	.968	.771	.818	.102
17	.885	1.335	1.170	.969	.122	1.300	1.800	1.650	2.050	1.062	.897	.944	.102
19	1.009	1.461	1.294	1.088	.122	1.300	1.800	1.650	2.050	1.156	1.003	1.051	.102
21	1.134	1.583	1.419	1.213	.122	1.300	1.800	1.650	2.050	1.250	1.129	1.173	.133
23	1.259	1.709	1.544	1.342	.142	1.300	1.800	1.650	2.050	1.375	1.255	1.299	.133
25	1.386	1.835	1.669	1.469	.142	1.300	1.800	1.650	2.050	1.500	1.377	1.425	.133

WALL MOUNT RECEPTACLE

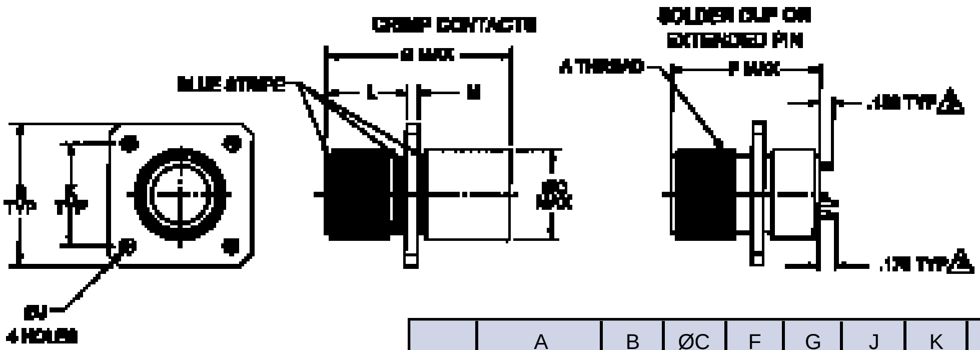


SHELL SIZE	ØA MAX	B MAX	ØC BOSS MAX	ØD REF	ØE MIN	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		K	L THREAD METRIC	N MAX REF
						F MAX	G MAX	F MAX	G MAX			
9	.384	.948	.668	.464	.122	1.300	1.800	1.650	2.050	.656	M12x1.0-6g0.100R	.102
11	.509	1.051	.793	.589	.122	1.300	1.800	1.650	2.050	.812	M15x1.0-6g0.100R	.102
13	.634	1.146	.919	.720	.122	1.300	1.800	1.650	2.050	.906	M18x1.0-6g0.100R	.102
15	.759	1.240	1.044	.844	.122	1.300	1.800	1.650	2.050	.968	M22x1.0-6g0.100R	.102
17	.885	1.335	1.170	.969	.122	1.300	1.800	1.650	2.050	1.062	M25x1.0-6g0.100R	.102
19	1.009	1.461	1.294	1.088	.122	1.300	1.800	1.650	2.050	1.156	M28x1.0-6g0.100R	.102
21	1.134	1.583	1.419	1.213	.122	1.300	1.800	1.650	2.050	1.250	M31x1.0-6g0.100R	.133
23	1.259	1.709	1.544	1.342	.142	1.300	1.800	1.650	2.050	1.375	M34x1.0-6g0.100R	.133
25	1.386	1.835	1.669	1.469	.142	1.300	1.800	1.650	2.050	1.500	M37x1.0-6g0.100R	.133

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-38999.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

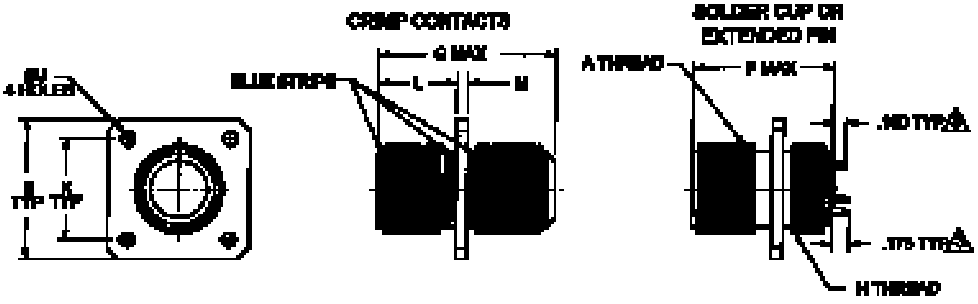
BOX MOUNT RECEPTACLE (MS3452)



SHELL SIZE	A THREAD CLASS 2	B +.031 -.031	ØC MAX	F MAX	G MAX	J +.010 -.005 CLASS DLUW	K +.005 -.005	L +.031 -.000	M +.015 -.015
10S	.625-24UNEF	1.000	.625	1.925	2.325	.120	.719	.562	.083
10SL	.625-24UNEF	1.000	.625	1.925	2.325	.120	.719	.562	.083
12S	.750-20UNEF	1.094	.750	1.925	2.325	.120	.812	.562	.083
12	.750-20UNEF	1.094	.750	1.925	2.325	.120	.812	.750	.083
14S	.875-20UNEF	1.188	.875	1.925	2.325	.120	.906	.562	.083
14	.875-20UNEF	1.188	.875	1.925	2.325	.120	.906	.750	.083
16S	1.000-20UNEF	1.281	1.000	1.925	2.325	.120	.969	.562	.083
16	1.000-20UNEF	1.281	1.000	1.925	2.325	.120	.969	.750	.083
18	1.125-18UNEF	1.375	1.062	1.925	2.325	.120	1.062	.750	.125
20	1.250-18UNEF	1.500	1.187	1.950	2.350	.120	1.156	.750	.125
22	1.375-18UNEF	1.625	1.312	1.950	2.350	.120	1.250	.750	.125
24	1.500-18UNEF	1.750	1.437	1.950	2.350	.147	1.375	.812	.125
28	1.750-18UNS	2.000	1.750	1.950	2.350	.147	1.562	.812	.125
32	2.000-18UNS	2.250	2.000	1.950	2.350	.173	1.750	.875	.125
36	2.250-16UN	2.500	2.250	1.950	2.350	.173	1.938	.875	.125
40	2.500-16UN	2.750	2.500	1.950	2.350	.173	2.188	.875	.125
44	2.750-16UN	3.000	2.750	1.950	2.350	.173	2.375	.875	.125

SHELL SIZE	A THREAD CLASS 2	B +.031 -.031	F MAX	G MAX	H THREAD CLASS 2A	J +.010 -.005 CLASS DLUW	K +.005 -.005	L +.031 -.000	M +.015 -.015
10S	.625-24UNEF	1.000	1.925	2.325	.625-24UNEF	.120	.719	.562	.083
10SL	.625-24UNEF	1.000	1.925	2.325	.625-24UNEF	.120	.719	.562	.083
12S	.750-20UNEF	1.094	1.925	2.325	.750-20UNEF	.120	.812	.562	.083
12	.750-20UNEF	1.094	1.925	2.325	.750-20UNEF	.120	.812	.750	.083
14S	.875-20UNEF	1.188	1.925	2.325	.875-20UNEF	.120	.906	.562	.083
14	.875-20UNEF	1.188	1.925	2.325	.875-20UNEF	.120	.906	.750	.083
16S	1.000-20UNEF	1.281	1.925	2.325	1.000-20UNEF	.120	.969	.562	.083
16	1.000-20UNEF	1.281	1.925	2.325	1.000-20UNEF	.120	.969	.750	.083
18	1.125-18UNEF	1.375	1.925	2.325	1.062-18UNEF	.120	1.062	.750	.125
20	1.250-18UNEF	1.500	1.950	2.350	1.187-18UNEF	.120	1.156	.750	.125
22	1.375-18UNEF	1.625	1.950	2.350	1.312-18UNEF	.120	1.250	.750	.125
24	1.500-18UNEF	1.750	1.950	2.350	1.437-18UNEF	.147	1.375	.812	.125
28	1.750-18UNS	2.000	1.950	2.350	1.750-18UNS	.147	1.562	.812	.125
32	2.000-18UNS	2.250	1.950	2.350	2.000-18UNS	.173	1.750	.875	.125
36	2.250-16UN	2.500	1.950	2.350	2.250-16UN	.173	1.938	.875	.125
40	2.500-16UN	2.750	1.950	2.350	2.500-16UN	.173	2.188	.875	.125
44	2.750-16UN	3.000	1.950	2.350	2.750-16UN	.173	2.375	.875	.125

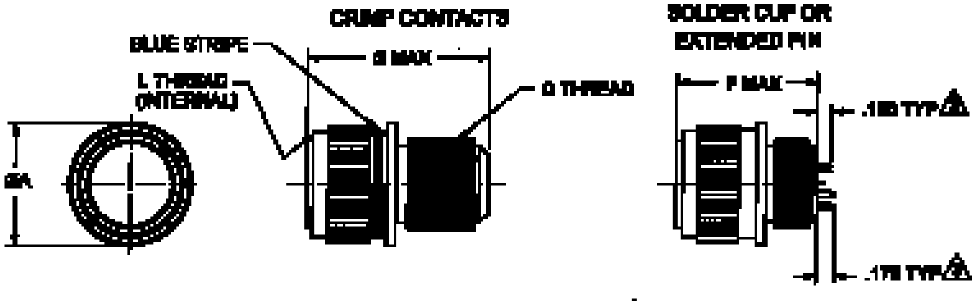
WALL MOUNT RECEPTACLE (MS3450)



1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-5015.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

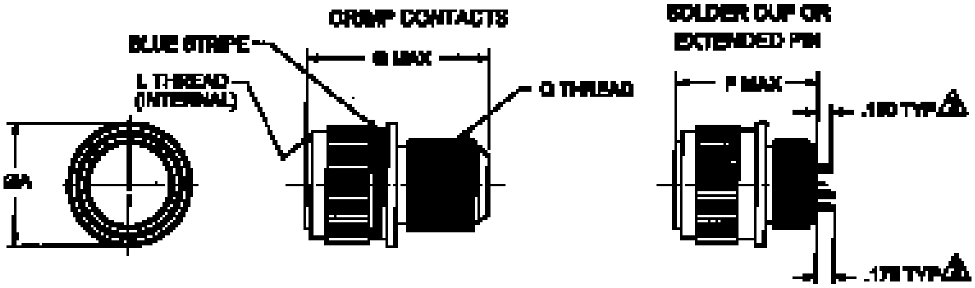
STRAIGHT PLUG (MS3456)



SHELL SIZE	ØA MAX	C THREAD CLASS 2	F MAX	G MAX	L THREAD CLASS 2
10S	.969	.625-24UNEF	1.925	2.325	.625-24UNEF
10SL	.969	.625-24UNEF	1.925	2.325	.625-24UNEF
12S	1.062	.750-20UNEF	1.925	2.325	.750-20UNEF
12	1.062	.750-20UNEF	1.925	2.325	.750-20UNEF
14S	1.156	.875-20UNEF	1.925	2.325	.875-20UNEF
14	1.156	.875-20UNEF	1.925	2.325	.875-20UNEF
16S	1.250	1.000-20UNEF	1.925	2.325	1.000-20UNEF
16	1.250	1.000-20UNEF	1.925	2.325	1.000-20UNEF
18	1.344	1.062-18UNEF	1.925	2.325	1.125-18UNEF
20	1.469	1.187-18UNEF	1.950	2.350	1.250-18UNEF
22	1.594	1.312-18UNEF	1.950	2.350	1.375-18UNEF
24	1.719	1.437-18UNEF	1.950	2.350	1.500-18UNEF
28	1.969	1.750-18UNS	1.950	2.350	1.750-18UNS
32	2.219	2.000-18UNS	1.950	2.350	2.000-18UNS
36	2.469	2.250-16UN	1.950	2.350	2.250-16UN
40	2.719	2.500-16UN	1.950	2.350	2.500-16UN
44	2.969	2.750-16UN	1.950	2.350	2.750-16UN

SHELL SIZE	ØA MAX	C THREAD CLASS 2	F MAX	G MAX	L THREAD CLASS 2
10S	1.088	.625-24UNEF	1.925	2.325	.625-24UNEF
10SL	1.088	.625-24UNEF	1.925	2.325	.625-24UNEF
12S	1.213	.750-20UNEF	1.925	2.325	.750-20UNEF
12	1.213	.750-20UNEF	1.925	2.325	.750-20UNEF
14S	1.358	.875-20UNEF	1.925	2.325	.875-20UNEF
14	1.358	.875-20UNEF	1.925	2.325	.875-20UNEF
16S	1.463	1.000-20UNEF	1.925	2.325	1.000-20UNEF
16	1.463	1.000-20UNEF	1.925	2.325	1.000-20UNEF
18	1.588	1.062-18UNEF	1.925	2.325	1.125-18UNEF
20	1.713	1.187-18UNEF	1.950	2.350	1.250-18UNEF
22	1.788	1.312-18UNEF	1.950	2.350	1.375-18UNEF
24	1.963	1.437-18UNEF	1.950	2.350	1.500-18UNEF
28	2.213	1.750-18UNS	1.950	2.350	1.750-18UNS
32	2.463	2.000-18UNS	1.950	2.350	2.000-18UNS
36	2.713	2.250-16UN	1.950	2.350	2.250-16UN
40	2.963	2.500-16UN	1.950	2.350	2.500-16UN

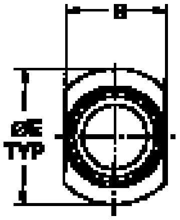
STRAIGHT PLUG (MS3459)

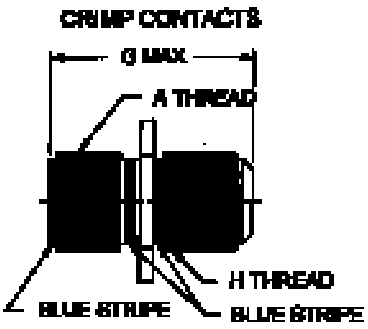


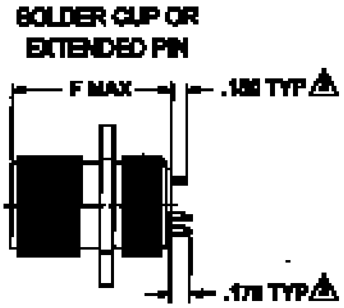
1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-5015.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

CABLE CONNECTING RECEPTACLE (MS3456)



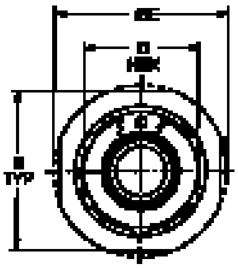


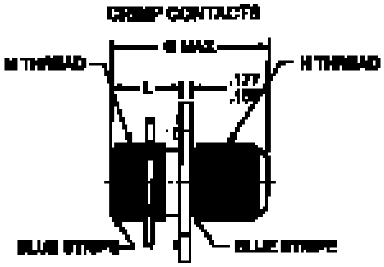


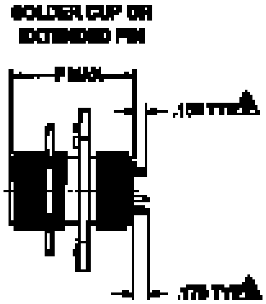
SHELL SIZE	A THREAD CLASS 2	B +.004 -.004	ØE +.015 -.015	F MAX	G MAX	H THREAD CLASS 2A
10S	.625-24UNEF	.625	.854	1.925	2.325	.625-24UNEF
10SL	.625-24UNEF	.625	.854	1.925	2.325	.625-24UNEF
12S	.750-20UNEF	.750	.974	1.925	2.325	.750-20UNEF
12	.750-20UNEF	.750	.974	1.925	2.325	.750-20UNEF
14S	.875-20UNEF	.875	1.099	1.925	2.325	.875-20UNEF
14	.875-20UNEF	.875	1.099	1.925	2.325	.875-20UNEF
16S	1.000-20UNEF	1.000	1.224	1.925	2.325	1.000-20UNEF
16	1.000-20UNEF	1.000	1.224	1.925	2.325	1.000-20UNEF
18	1.125-18UNEF	1.125	1.349	1.925	2.325	1.062-18UNEF
20	1.250-18UNEF	1.250	1.479	1.950	2.350	1.187-18UNEF
22	1.375-18UNEF	1.375	1.599	1.950	2.350	1.312-18UNEF
24	1.500-18UNEF	1.500	1.715	1.950	2.350	1.437-18UNEF
28	1.750-18UNS	1.750	1.974	1.950	2.350	1.750-18UNS
32	2.000-18UNS	2.000	2.224	1.950	2.350	2.000-18UNS
36	2.250-16UN	2.250	2.474	1.950	2.350	2.250-16UN
40	2.500-16UN	2.505	2.724	1.950	2.350	2.500-16UN
44	2.750-16UN	2.755	2.974	1.950	2.350	2.750-16UN

SHELL SIZE	B +.005 -.005	D +.010 -.010	ØE +.005 -.005	F MAX	G MAX	H THREAD CLASS 2A	L +.005 -.005	M THREAD CLASS 2
10S	1.312	.812	1.397	1.925	2.325	.625-24UNEF	.720	.625-24UNEF
10SL	1.312	.812	1.397	1.925	2.325	.625-24UNEF	.720	.625-24UNEF
12S	1.437	.937	1.522	1.925	2.325	.750-20UNEF	.720	.750-20UNEF
12	1.437	.937	1.522	1.925	2.325	.750-20UNEF	.970	.750-20UNEF
14S	1.562	1.125	1.647	1.925	2.325	.875-20UNEF	.720	.875-20UNEF
14	1.562	1.125	1.647	1.925	2.325	.875-20UNEF	.970	.875-20UNEF
16S	1.687	1.250	1.772	1.925	2.325	1.000-20UNEF	.720	1.000-20UNEF
16	1.687	1.250	1.772	1.925	2.325	1.000-20UNEF	.970	1.000-20UNEF
18	1.812	1.375	1.897	1.925	2.325	1.062-18UNEF	.970	1.125-18UNEF
20	1.937	1.500	2.022	1.950	2.350	1.187-18UNEF	.970	1.250-18UNEF
22	2.156	1.625	2.241	1.950	2.350	1.312-18UNEF	.970	1.375-18UNEF
24	2.281	1.750	2.366	1.950	2.350	1.437-18UNEF	.970	1.500-18UNEF
28	2.531	2.000	2.616	1.950	2.350	1.750-18UNS	.970	1.750-18UNS
32	2.781	2.375	2.866	1.950	2.350	2.000-18UNS	.970	2.000-18UNS
36	3.031	2.625	3.116	1.950	2.350	2.250-16UN	.970	2.250-16UN
40	3.281	2.875	3.366	1.950	2.350	2.500-16UN	.970	2.500-16UN
44	3.656	3.125	3.741	1.950	2.350	2.750-16UN	.970	2.750-16UN

JAM-NUT RECEPTACLE (MS3454)



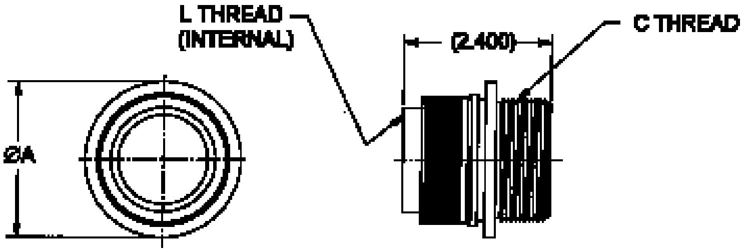




1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-5015.
2. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND ARE FOR REFERENCE ONLY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

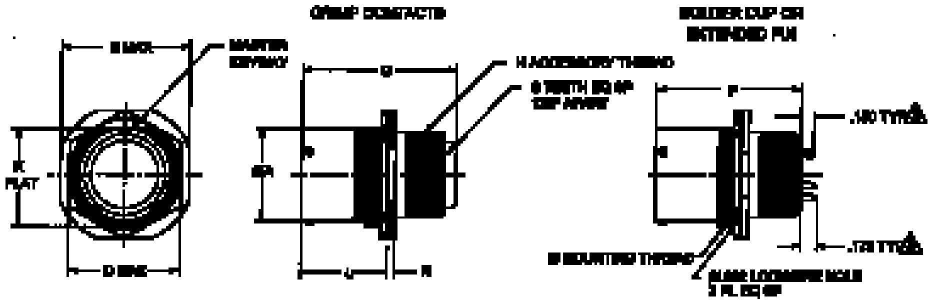
INLINE ADAPTER



SHELL SIZE	ØA MAX	C THREAD CLASS 2	L THREAD CLASS 2
10S	1.088	.625-24UNEF	.625-24UNEF
10SL	1.088	.625-24UNEF	.625-24UNEF
12S	1.213	.750-20UNEF	.750-20UNEF
12	1.213	.750-20UNEF	.750-20UNEF
14S	1.358	.875-20UNEF	.875-20UNEF
14	1.358	.875-20UNEF	.875-20UNEF
16S	1.463	1.000-20UNEF	1.000-20UNEF
16	1.463	1.000-20UNEF	1.000-20UNEF
18	1.588	1.125-18UNEF	1.125-18UNEF
20	1.713	1.250-18UNEF	1.250-18UNEF
22	1.788	1.375-18UNEF	1.375-18UNEF
24	1.963	1.500-18UNEF	1.500-18UNEF
28	2.213	1.750-18UNS	1.750-18UNS
32	2.463	2.000-18UNS	2.000-18UNS
36	2.713	2.250-16UN	2.250-16UN
40	2.963	2.500-16UN	2.500-16UN

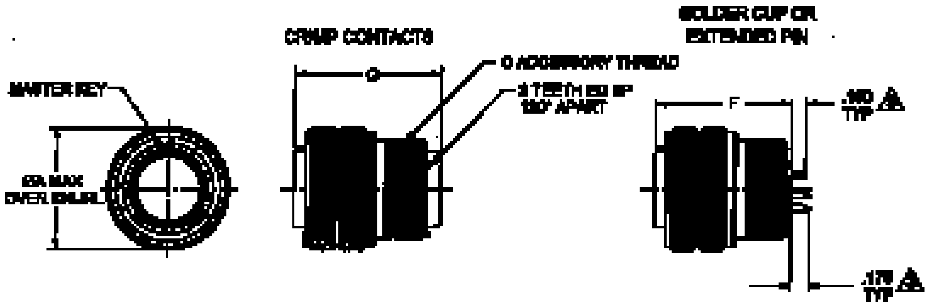
1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-5015.
2. ALLDIMENSIONS FOR REFERENCE ONLY.

JAM-NUT RECEPTACLE



SHELL SIZE	ØA +.006 -.006	B	D	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H CLASS 2A ACCESSORY THREAD	K +.005 -.005	L	M CLASS 2A MOUNTING THREAD	N
				F MAX	G MAX	F MAX	G MAX					
8	.468	.954	.767	1.300	2.000	1.550	2.250	.500-20UNF	.525	.707 .658	.562-24UNEF	.113 .086
10	.585	1.078	.892	1.300	2.000	1.550	2.250	.625-24UNEF	.650		1.062-24UNEF	
12	.745	1.266	1.079	1.300	2.000	1.550	2.250	.750-20UNEF	.813		.875-20UNEF	
14	.870	1.391	1.205	1.300	2.000	1.550	2.250	.875-20UNEF	.937		1.000-20UNEF	
16	.995	1.516	1.329	1.300	2.000	1.550	2.250	1.000-20UNEF	1.061		1.125-18UNEF	
18	1.220	1.641	1.455	1.300	2.000	1.550	2.250	1.062-18UNEF	1.186		1.250-18UNEF	
20	1.245	1.828	1.579	1.300	2.000	1.550	2.250	1.187-18UNEF	1.311	.772 .721	1.375-18UNEF	.148 .096
22	1.370	1.954	1.705	1.300	2.000	1.550	2.250	1.312-18UNEF	1.436		1.500-18UNEF	
24	1.495	2.078	1.829	1.300	2.000	1.550	2.250	1.437-18UNEF	1.561		1.625-18UNEF	

STRAIGHT PLUG

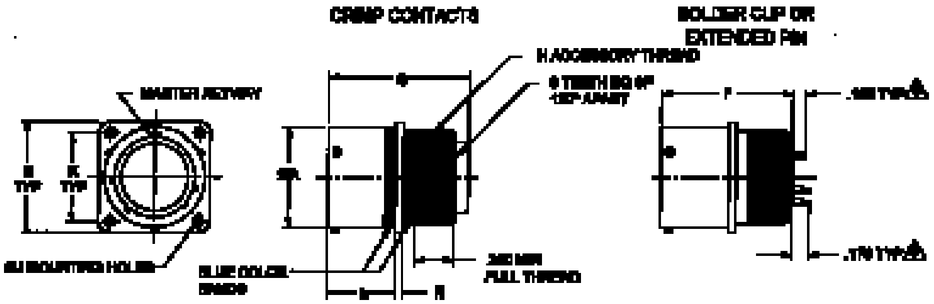


SHELL SIZE	ØA	C CLASS 2A ACCESSORY THREAD	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER	
			F MAX	G MAX	F MAX	G MAX
8	.782	.500-20UNF	1.500	2.000	1.750	2.250
10	.926	.625-24UNEF	1.500	2.000	1.750	2.250
12	1.043	.750-20UNEF	1.500	2.000	1.750	2.250
14	1.183	.875-20UNEF	1.500	2.000	1.750	2.250
16	1.305	1.000-20UNEF	1.500	2.000	1.750	2.250
18	1.391	1.062-18UNEF	1.500	2.000	1.750	2.250
20	1.531	1.187-18UNEF	1.500	2.000	1.750	2.250
22	1.656	1.312-18UNEF	1.500	2.000	1.750	2.250
24	1.777	1.437-18UNEF	1.500	2.000	1.750	2.250

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-26482.
2. ALLDIMENSIONS FOR REFERENCE ONLY.

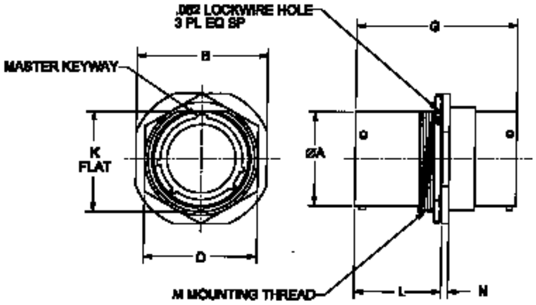
△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

SQUARE FLANGE RECEPTACLE



SHELL SIZE	ØA ±.006	B MAX	TRANSIENT SUPPRESSION OR EMI FILTER		TRANSIENT SUPPRESSION AND EMI FILTER		H CLASS 2A ACCESSORY THREAD	J ±.005	K ±.005	L ±.031	N ±.016
			F MAX	G MAX	F MAX	G MAX					
8	.468	.828	1.300	2.000	1.550	2.250	.500-20UNF	.120	.594	.431	.062
10	.585	.954	1.300	2.000	1.550	2.250	.625-24UNEF	.120	.719	.431	.062
12	.745	1.047	1.300	2.000	1.550	2.250	.750-20UNEF	.120	.812	.431	.062
14	.870	1.141	1.300	2.000	1.550	2.250	.875-20UNEF	.120	.906	.431	.062
16	.995	1.234	1.300	2.000	1.550	2.250	1.000-20UNEF	.120	.969	.431	.062
18	1.120	1.328	1.300	2.000	1.550	2.250	1.062-18UNEF	.120	1.062	.431	.062
20	1.245	1.453	1.300	2.000	1.550	2.250	1.187-18UNEF	.120	1.156	.556	.094
22	1.370	1.578	1.300	2.000	1.550	2.250	1.312-18UNEF	.120	1.250	.556	.094
24	1.495	1.703	1.300	2.000	1.550	2.250	1.437-18UNEF	.147	1.375	.556	.094

FEEDTHRU ADAPTER

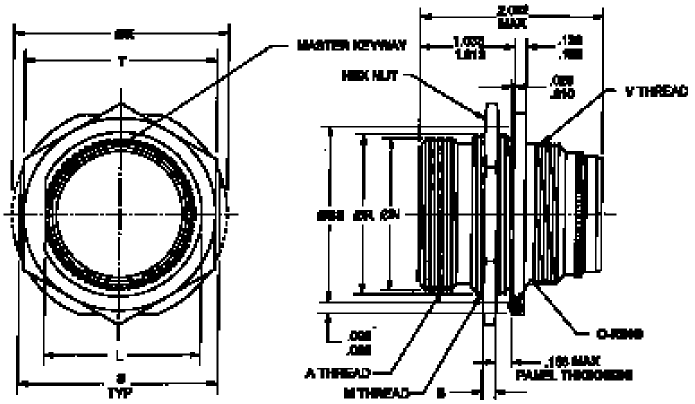


SHELL SIZE	ØA ±.006	B MAX	D MAX	G REF	K ±.005	L	M CLASS 2A MOUNTING THREAD	N
8	.468	.954	.767	2.120	.525	.707 .658	.562-24UNF	.148 .086
10	.585	1.078	.892	2.120	.650		1.062-24UNEF	
12	.745	1.266	1.079	2.120	.813		.875-20UNEF	
14	.870	1.391	1.205	2.120	.937		1.000-20UNEF	
16	.995	1.516	1.329	2.120	1.061		1.125-18UNEF	
18	1.220	1.641	1.455	2.120	1.186		1.250-18UNEF	
20	1.245	1.828	1.579	2.120	1.311	.772 .721	1.375-18UNEF	.148 .096
22	1.370	1.954	1.705	2.120	1.436		1.500-18UNEF	
24	1.495	2.078	1.829	2.120	1.561		1.625-18UNEF	

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-26482.
2. ALLDIMENSIONS FOR REFERENCE ONLY.

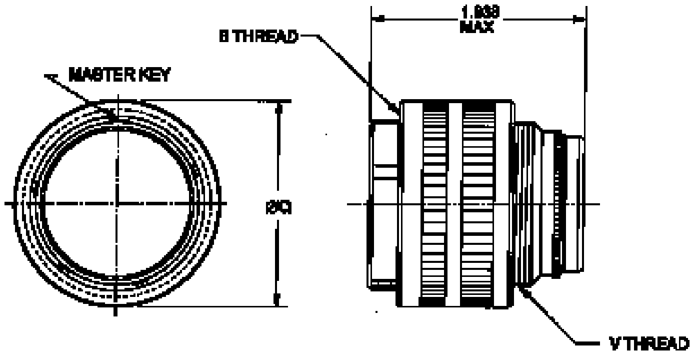
△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

JAM-NUT RECEPTACLE



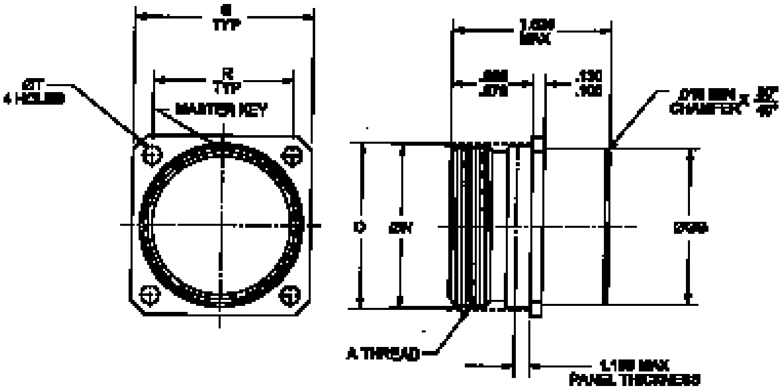
SHELL SIZE	A THREAD CLASS 2A	V THREAD CLASS 2A	M THREAD CLASS 2A	G ±.031	ØK ±.005	L ACROSS FLAT	ØN ±.031	ØR ±.016	ØBB ±.031	S NOM	T ±.017
11	.750-.1P-.2L-D.S.	3/4-20 UNEF	7/8-20 UNEF	1.274 1.254	1.368 1.348	.841 .832	.750	.875	.979 .969	.125	1.062
13	.875-.1P-.2L-D.S.	7/8-20 UNEF	1-20 UNEF	1.399 1.379	1.508 1.488	.966 .957	.875	1.000	1.104 1.094	.125	1.188
15	1.062-.1P-.2L-D.S.	1-20 UNEF	1 3/16-18 UNEF	1.587 1.567	1.681 1.661	1.153 1.144	1.062	1.188	1.292 1.282	.125	1.375
17	1.125-.1P-.2L-D.S.	1 1/8-18 UNEF	1 1/4-18 UNEF	1.649 1.629	1.743 1.723	1.216 1.207	1.125	1.250	1.354 1.344	.125	1.438
19	1.312-.1P-.2L-D.S.	1 1/4-18 UNEF	1 7/16-18 UNEF	1.837 1.817	1.931 1.911	1.403 1.394	1.312	1.438	1.542 1.532	.125	1.625
23	1.500-.1P-.2L-D.S.	1 7/16-18 UNEF	1 5/8-18 UNEF	2.024 2.004	2.118 2.098	1.591 1.582	1.500	1.625	1.729 1.719	.125	1.812
25	1.625-.1P-.2L-D.S.	1 9/16-18 UNEF	1 3/4-18 UNS	2.149 2.129	2.243 2.223	1.716 1.701	1.625	1.750	1.854 1.844	.189	2.000
29	1.812-.1P-.2L-D.S.	1 7/8-16 UN	1 15/16-16 N	2.337 2.317	2.435 2.415	1.903 1.894	1.812	1.938	2.042 2.032	.189	2.188
33	2.000-.1P-.2L-D.S.	2 1/16-16 N	2 1/8-16 UN	2.524 2.504	2.618 2.598	2.091 2.082	2.000	2.125	2.229 2.219	.189	2.375

STRAIGHT PLUG



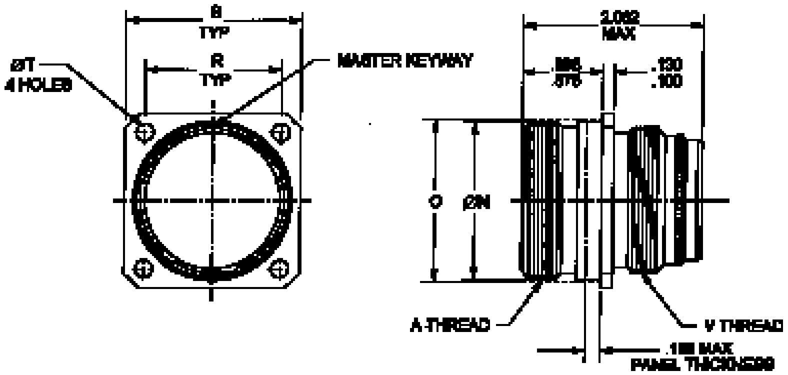
SHELL SIZE	B THREAD CLASS 2A	V THREAD CLASS 2A	ØQ MAX
11	.750-.1P-.2L-D.S.	3/4-20 UNEF	1.028
13	.875-.1P-.2L-D.S.	7/8-20 UNEF	1.141
15	1.062-.1P-.2L-D.S.	1-20 UNEF	1.263
17	1.125-.1P-.2L-D.S.	1 1/8-18 UNEF	1.387
19	1.312-.1P-.2L-D.S.	1 1/4-18 UNEF	1.513
23	1.500-.1P-.2L-D.S.	1 7/16-18 UNEF	1.703
25	1.625-.1P-.2L-D.S.	1 9/16-18 UNEF	1.825
29	1.812-.1P-.2L-D.S.	1 7/8-16 UN	2.143
33	2.000-.1P-.2L-D.S.	2 1/16-16 N	2.329

BOX MOUNT RECEPTACLE



SHELL SIZE	A THREAD CLASS 2A	ØN MAX	O REF MTG HOLE	R T.P. ℄ TO ℄	S	T	ØGG MAX
11	.750-.1P-.2L-D.S.	.750	.812	.750	1.043 1.003	.130 .115	.758
13	.875-.1P-.2L-D.S.	.875	.937	.843	1.158 1.118	.130 .115	.880
15	1.062-.1P-.2L-D.S.	1.062	1.124	.968	1.278 1.238	.130 .115	1.005
17	1.125-.1P-.2L-D.S.	1.125	1.187	1.015	1.403 1.363	.130 .115	1.130
19	1.312-.1P-.2L-D.S.	1.312	1.374	1.140	1.528 1.488	.130 .115	1.255
23	1.500-.1P-.2L-D.S.	1.500	1.562	1.281	1.738 1.698	.130 .115	1.443
25	1.625-.1P-.2L-D.S.	1.625	1.687	1.392	1.838 1.798	.157 .142	1.567
29	1.812-.1P-.2L-D.S.	1.812	1.937	1.568	2.158 2.118	.157 .142	1.880
33	2.000-.1P-.2L-D.S.	2.000	2.124	1.734	2.348 2.308	.183 .168	2.067

WALL MOUNT RECEPTACLE



SHELL SIZE	A THREAD CLASS 2A	V THREAD CLASS 2A	ØN MAX	O REF MTG HOLE	R T.P. ℄ TO ℄	S	T
11	.750-.1P-.2L-D.S.	3/4-20 UNEF	.750	.812	.750	1.043 1.003	.130 .115
13	.875-.1P-.2L-D.S.	7/8-20 UNEF	.875	.937	.843	1.158 1.118	.130 .115
15	1.062-.1P-.2L-D.S.	1-20 UNEF	1.062	1.124	.968	1.278 1.238	.130 .115
17	1.125-.1P-.2L-D.S.	1 1/8-18 UNEF	1.125	1.187	1.015	1.403 1.363	.130 .115
19	1.312-.1P-.2L-D.S.	1 1/4-18 UNEF	1.312	1.374	1.140	1.528 1.488	.130 .115
23	1.500-.1P-.2L-D.S.	1 7/16-18 UNEF	1.500	1.562	1.281	1.738 1.698	.130 .115
25	1.625-.1P-.2L-D.S.	1 9/16-18 UNEF	1.625	1.687	1.392	1.838 1.798	.157 .142
29	1.812-.1P-.2L-D.S.	1 7/8-16 UN	1.812	1.937	1.568	2.158 2.118	.157 .142
33	2.000-.1P-.2L-D.S.	2 1/16-16 N	2.000	2.124	1.734	2.348 2.308	.183 .168

Part Numbering Guide

H D L B 25 P 01

HIGH DENSITY

Use as Required

D-SUB SERIES

CODE

A=Adapter
C=Crimp Termination
F=Feed Thru
I=IDC Termination
L=Right Angle Board Mount
S=Solder Cup Termination
T=Through Hole Extended Pin

SHELL SIZE

E=1
A=2
B=3
C=4
D=5
M=Microminiature

NUMBER OF CONTACTS

PIN or SOCKET

P=Pins
S=Sockets

ADAPTER

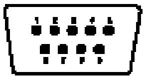
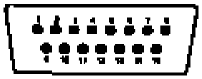
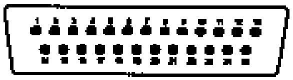
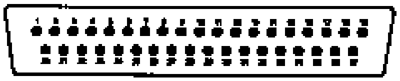
A=Pin/Socket
B=Pin/Pin
C=Socket/Socket

MODIFICATION CODE

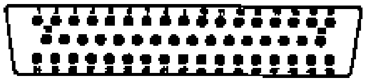
Manufacturer’s Code
to Identify Pin Values

CONTACT ARRANGEMENTS (FACE VIEW PIN INSERT)

BASIC ARRANGEMENTS

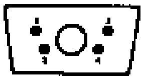
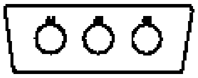
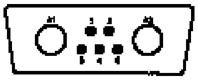
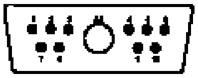
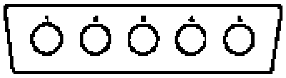





SHELL SIZE	E	A	B	C
NO. OF CONTACTS	9	15	25	37
CONTACT SIZE	#20	#20	#20	#20

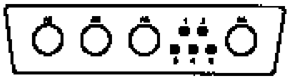


SHELL SIZE	D
NO. OF CONTACTS	50
CONTACT SIZE	#20

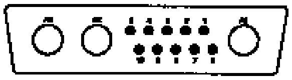
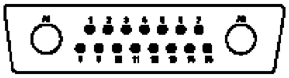
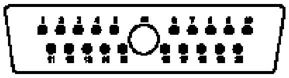
COMBINATION ARRANGEMENTS (WILL ACCOMMODATE REMOVEABLE COAX POWER AND/OR HIGH VOLTAGE CONTACTS)

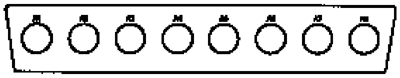
SHELL SIZE	E	A	A	A	B
ARRANGEMENT	5W1	3W3	7W2	11W1	5W5
NO. OF CONTACTS	4	0	5	10	0
CONTACT SIZE	#20	—	#20	#20	—
COAX OR HV CAVITIES	1	3	2	1	5



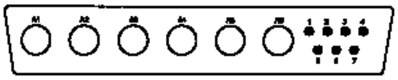
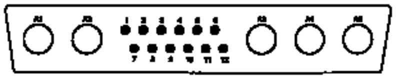
SHELL SIZE	B
ARRANGEMENT	9W4
NO. OF CONTACTS	5
CONTACT SIZE	#20
COAX OR HV CAVITIES	4

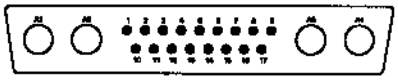
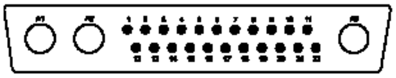
SHELL SIZE	B	B	B
ARRANGEMENT	13W3	17W2	21W1
NO. OF CONTACTS	10	15	20
CONTACT SIZE	#20	#20	#20
COAX OR HV CAVITIES	3	2	1



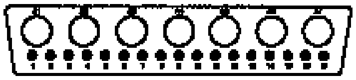
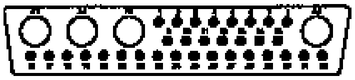
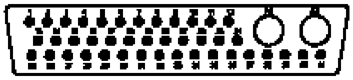
SHELL SIZE	C
ARRANGEMENT	8W8
NO. OF CONTACTS	0
CONTACT SIZE	—
COAX OR HV CAVITIES	8

SHELL SIZE	C	C
ARRANGEMENT	13W6	17W5
NO. OF CONTACTS	7	12
CONTACT SIZE	#20	#20
COAX OR HV CAVITIES	6	5

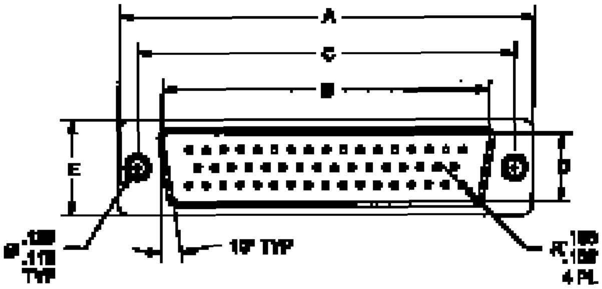



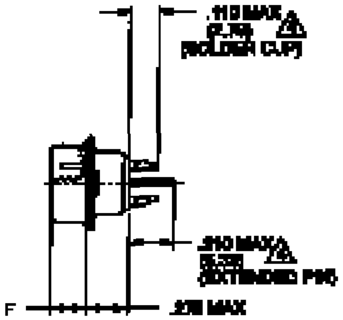
SHELL SIZE	C	C
ARRANGEMENT	21WA4	25W3
NO. OF CONTACTS	17	22
CONTACT SIZE	#20	#20
COAX OR HV CAVITIES	4	3

SHELL SIZE	D	D	D
ARRANGEMENT	24W7	36W4	43W2
NO. OF CONTACTS	17	32	41
CONTACT SIZE	#20	#20	#20
COAX OR HV CAVITIES	7	4	2

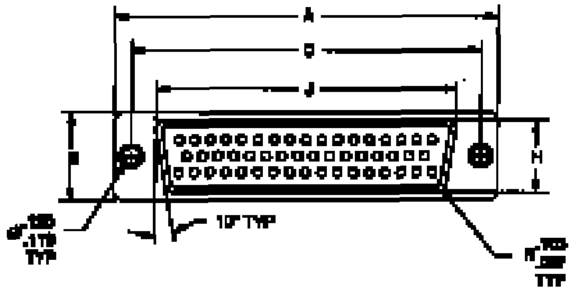
PIN RECEPTACLE

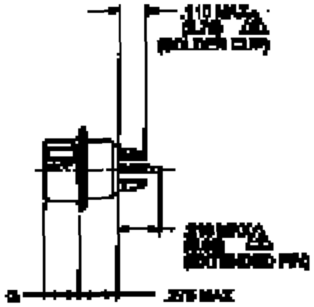




SHELL SIZE	NO. OF PINS	A	B	C	D	E	F
1	9	1.213 (30.81)	.666 (16.92)	.984 (24.99)	.329 (8.36)	.494 (12.55)	.233 (5.92)
2	15	1.541 (39.14)	.994 (25.25)	1.312 (33.32)	.329 (8.36)	.494 (12.55)	.233 (5.92)
3	25	2.088 (53.03)	1.534 (38.96)	1.852 (47.04)	.329 (8.36)	.494 (12.55)	.228 (5.79)
4	37	2.729 (69.32)	2.182 (55.42)	2.500 (63.50)	.329 (8.36)	.494 (12.55)	.228 (5.79)
3	44	2.088 (53.03)	1.534 (38.96)	1.852 (47.04)	.329 (8.36)	.494 (12.55)	.228 (5.79)
5	50	2.635 (66.93)	2.079 (52.81)	2.406 (61.11)	.436 (11.07)	.605 (15.37)	.228 (5.79)
4	62	2.729 (69.32)	2.182 (55.42)	2.500 (63.50)	.329 (8.36)	.494 (12.55)	.228 (5.79)

SOCKET PLUG



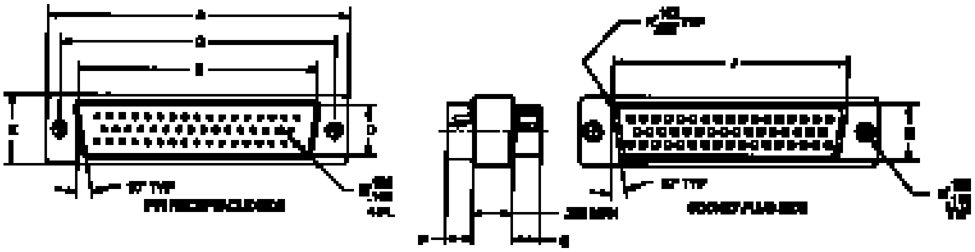


SHELL SIZE	NO. OF PINS	A	C	E	G	H	J
1	9	1.213 (30.81)	.984 (24.99)	.494 (12.55)	.243 (6.17)	.311 (7.90)	.643 (16.33)
2	15	1.541 (39.14)	1.312 (33.32)	.494 (12.55)	.243 (6.17)	.311 (7.90)	.971 (24.66)
3	25	2.088 (53.03)	1.852 (47.04)	.494 (12.55)	.243 (6.17)	.311 (7.90)	1.511 (38.38)
4	37	2.729 (69.32)	2.500 (63.50)	.494 (12.55)	.243 (6.17)	.311 (7.90)	2.159 (54.84)
3	44	2.088 (53.03)	1.852 (47.04)	.494 (12.55)	.243 (6.17)	.311 (7.90)	1.511 (38.38)
5	50	2.635 (66.93)	2.406 (61.11)	.605 (15.37)	.243 (6.17)	.423 (10.74)	2.064 (52.54)
4	62	2.729 (69.32)	2.500 (63.50)	.494 (12.55)	.243 (57.71)	.311 (7.90)	2.159 (54.84)

1. INTERMATEABLE AND INTERMOUNTABLE WITH MIL-C-24308.
2. ALLDIMENSIONS FOR REFERENCE ONLY.
3. DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.

△4 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

PIN/SOCKET ADAPTER



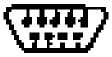
SHELL SIZE	NO. OF PINS	A	B	C	D	E	F	G	H	J
1	9	1.213 (30.81)	.666 (16.92)	.984 (24.99)	.329 (8.36)	.494 (12.55)	.233 (5.92)	.243 (6.17)	.311 (7.90)	.643 (16.33)
2	15	1.541 (39.14)	.994 (25.25)	1.312 (33.32)	.329 (8.36)	.494 (12.55)	.233 (5.92)	.243 (6.17)	.311 (7.90)	.971 (24.66)
3	25	2.088 (53.03)	1.534 (38.96)	1.852 (47.04)	.329 (8.36)	.494 (12.55)	.228 (5.79)	.243 (6.17)	.311 (7.90)	1.511 (38.38)
4	37	2.729 (69.32)	2.182 (55.42)	2.500 (63.50)	.329 (8.36)	.494 (12.55)	.228 (5.79)	.243 (6.17)	.311 (7.90)	2.159 (54.84)
3	44	2.088 (53.03)	1.534 (38.96)	1.852 (47.04)	.329 (8.36)	.494 (12.55)	.228 (5.79)	.243 (6.17)	.311 (7.90)	1.511 (38.38)
5	50	2.635 (66.93)	2.079 (52.81)	2.406 (61.11)	.436 (11.07)	.605 (15.37)	.228 (5.79)	.243 (6.17)	.423 (10.74)	2.064 (52.54)
4	62	2.729 (69.32)	2.182 (55.42)	2.500 (63.50)	.329 (8.36)	.494 (12.55)	.228 (5.79)	.243 (57.71)	.311 (7.90)	2.159 (54.84)

1. INTERMATEABLE AND INTERMOUNTABLE WITH MIL-C-24308.
2. ALLDIMENSIONS FOR REFERENCE ONLY.
3. DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.

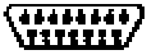
CONTACT ARRANGEMENTS

(FACE VIEW PIN INSERT - USE REVERSE ORDER FOR SOCKET SIDE)

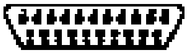
BASIC ARRANGEMENTS



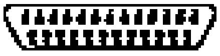
[illegible]



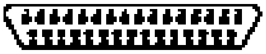
[illegible]



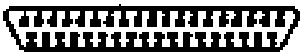
[illegible]



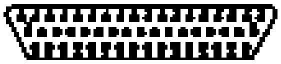
[illegible]



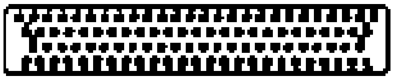
[illegible]



[illegible]

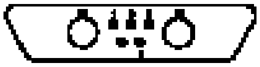


[illegible]

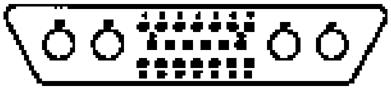


[illegible]

COAXIAL



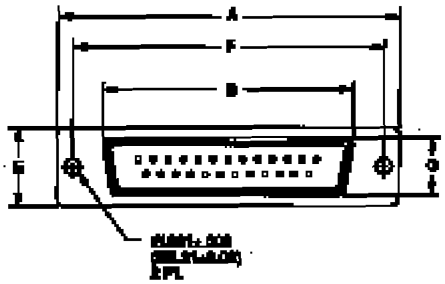
[illegible]

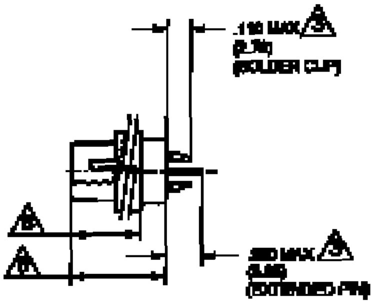


[illegible]

NOTE: CONTACT IDENTIFICATION NUMBERS ARE FOR REFERENCE ONLY AND DO NOT APPEAR ON INSULATOR OR CONNECTOR BODY.

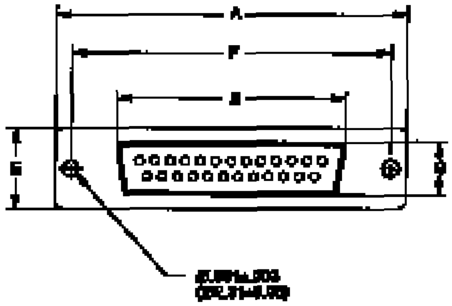
RECEPTACLE
(SOCKET CONTACTS)

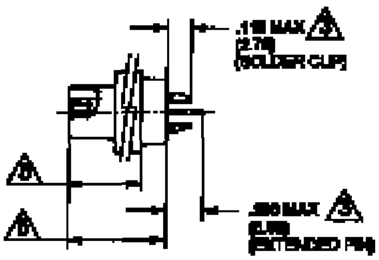




NO. OF PINS	A MAX	B MAX	E MAX	F ±.0015 (0.13)	G MAX
9	.785 (19.94)	.402 (10.21)	.308 (7.83)	.565 (14.35)	.253 (6.43)
15	.935 (23.75)	.552 (14.02)	.308 (7.83)	.715 (18.16)	.253 (6.43)
21	1.085 (27.56)	.702 (17.83)	.308 (7.83)	.865 (21.97)	.253 (6.43)
25	1.185 (30.10)	.802 (20.37)	.308 (7.83)	.965 (24.51)	.253 (6.43)
31	1.335 (33.91)	.952 (24.18)	.308 (7.83)	1.115 (28.32)	.253 (6.43)
37	1.485 (37.72)	1.102 (27.99)	.308 (7.83)	1.265 (32.13)	.253 (6.43)
51	1.435 (36.45)	1.052 (26.72)	.351 (8.92)	1.215 (30.86)	.296 (7.52)
100	2.170 (55.12)	1.452 (36.88)	.394 (10.01)	1.800 (45.72)	.399 (8.61)

PLUG
(PIN CONTACTS)



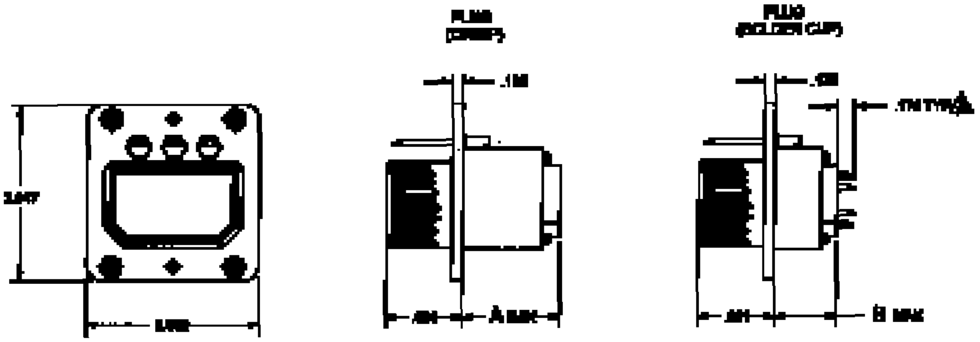


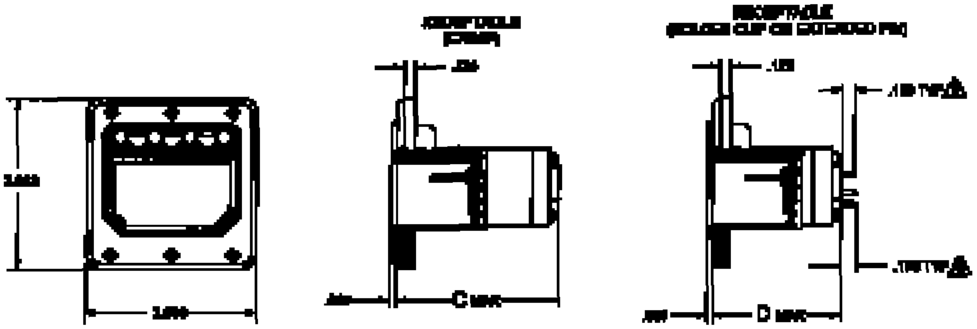
NO. OF PINS	A MAX	B MAX	E MAX	F ±.0015 (0.13)	G MAX
9	.785 (19.94)	.334 (8.48)	.308 (7.83)	.565 (14.35)	.185 (4.70)
15	.935 (23.75)	.484 (12.29)	.308 (7.83)	.715 (18.16)	.185 (4.70)
21	1.085 (27.56)	.634 (16.10)	.308 (7.83)	.865 (21.97)	.185 (4.70)
25	1.185 (30.10)	.734 (18.64)	.308 (7.83)	.965 (24.51)	.185 (4.70)
31	1.335 (33.91)	.884 (22.45)	.308 (7.83)	1.115 (28.32)	.185 (4.70)
37	1.485 (37.72)	1.034 (26.26)	.308 (7.83)	1.265 (32.13)	.185 (4.70)
51	1.435 (36.45)	.984 (24.99)	.351 (8.92)	1.215 (30.86)	.228 (5.79)
100	2.170 (55.12)	1.384 (35.15)	.394 (10.01)	1.800 (45.72)	.271 (6.88)

1. INTERMATEABLE AND INTERMOUNTABLE WITH MIL-C-83513.
2. ALLDIMENSIONS FOR REFERENCE ONLY.

3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.
4. DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.
5 CONSULT FACTORY FOR DIMENSIONS.

ARINC 404 SHELL SIZE I



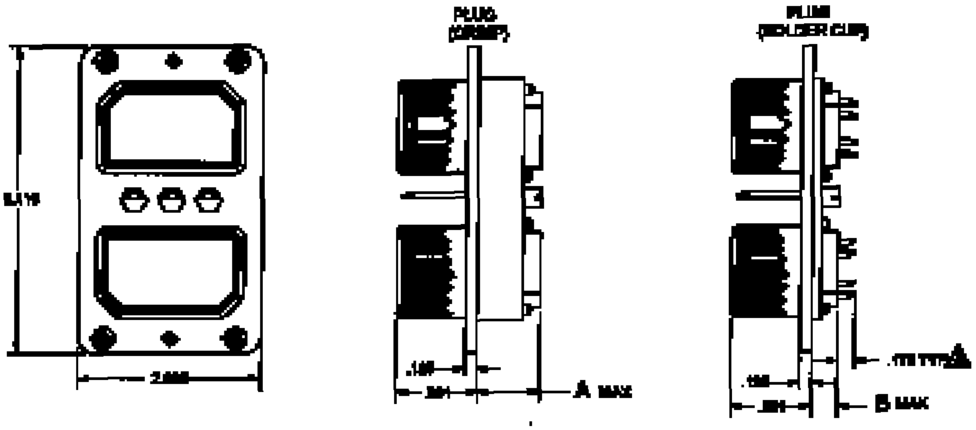


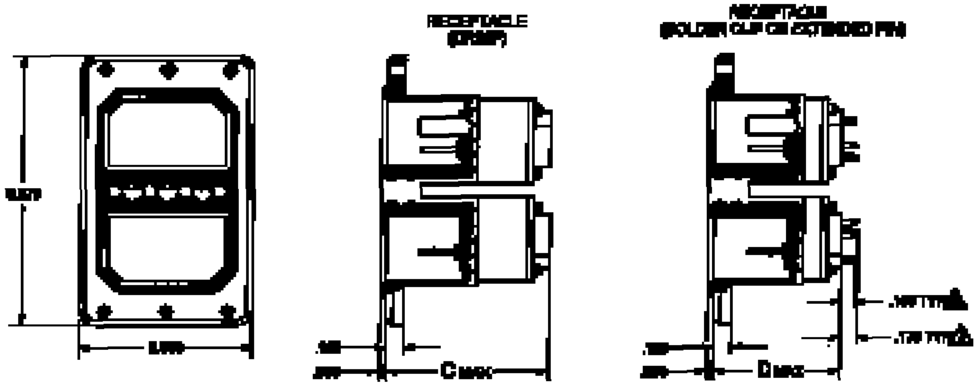
CONTACT ARRANGEMENT	TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
	A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
C2	.475	.075	1.416	1.016	.725	.325	1.666	1.266
C3	.475	.075	1.416	1.016	.725	.325	1.666	1.266
8	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
C8	---	---	---	---	---	---	---	---
D8	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
26	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
32C2	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
33C4	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
40	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
40C1	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
45	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
57	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
67	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
106	.679	.279	1.619	1.219	.929	.529	1.869	1.469

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULT FACTORY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

ARINC 404 SHELL SIZE II



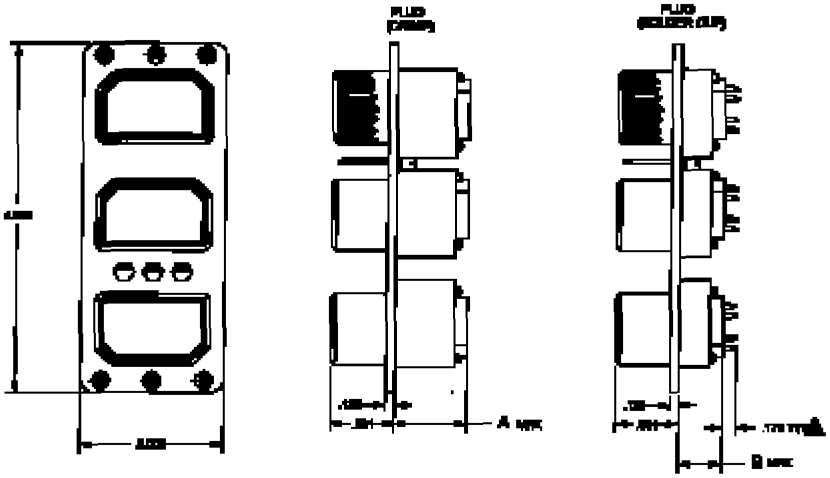


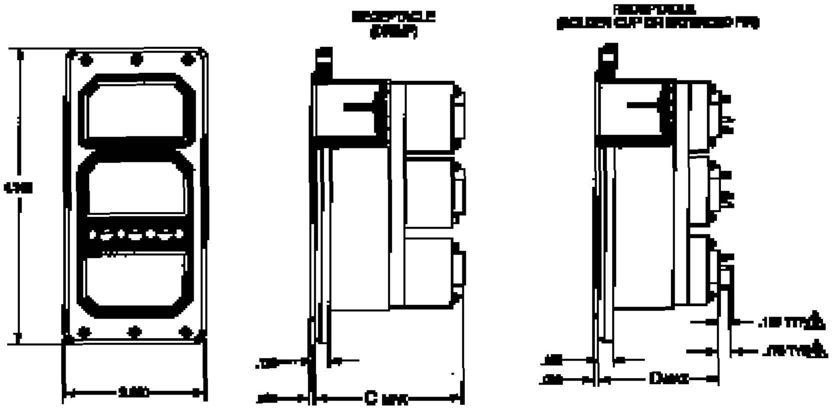
CONTACT ARRANGEMENT	TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
	A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
C2	.475	.075	1.416	1.016	.725	.325	1.666	1.266
C3	.475	.075	1.416	1.016	.725	.325	1.666	1.266
8	.714	.314	1.653	1.253	.964	.564	1.903	1.503
C8	.912	.512	1.852	1.452	1.162	.762	2.102	---
D8	.714	.314	1.653	1.253	.964	.564	1.903	1.503
26	.714	.314	1.653	1.253	.964	.564	1.903	1.503
32C2	.929	.529	1.865	1.465	1.179	.779	2.115	1.715
33C4	.929	.529	1.865	1.465	1.179	.779	2.115	1.715
40	.714	.314	1.653	1.253	.964	.564	1.903	1.503
40C1	.929	.529	1.865	1.465	1.179	.779	2.115	1.715
45	.714	.314	1.653	1.253	.964	.564	1.903	1.503
57	.714	.314	1.653	1.253	.964	.564	1.903	1.503
67	.714	.314	1.653	1.253	.964	.564	1.903	1.503
106	.475	.075	1.416	1.016	.725	.325	1.666	1.266

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULT FACTORY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

ARINC 404 SHELL SIZE III



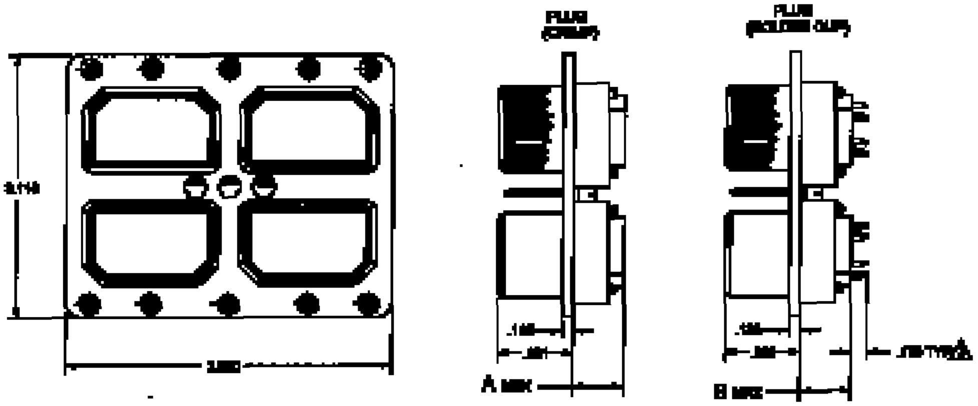


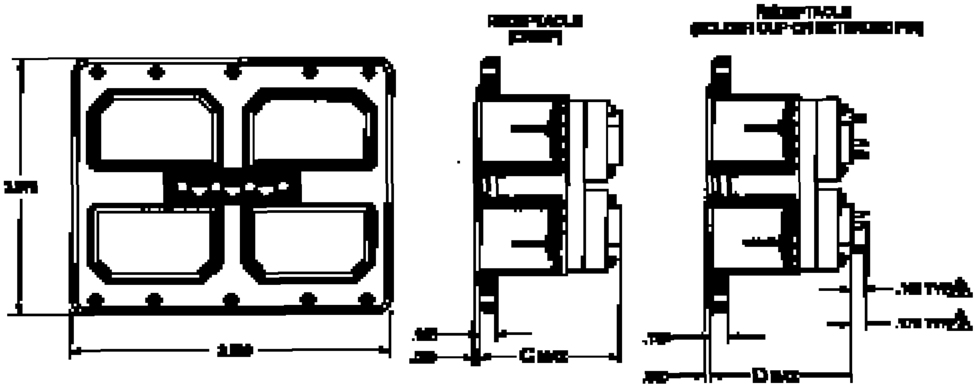
CONTACT ARRANGEMENT	TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
	A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
C2	.475	.075	1.416	1.016	.725	.325	1.666	1.266
C3	.475	.075	1.416	1.016	.725	.325	1.666	1.266
8	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
C8	---	---	---	---	---	---	---	---
D8	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
26	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
32C2	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
33C4	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
40	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
40C1	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
45	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
57	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
67	.934	.534	1.865	1.465	1.184	.784	2.115	1.715

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULT FACTORY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

ARINC 404 SHELL SIZE IV

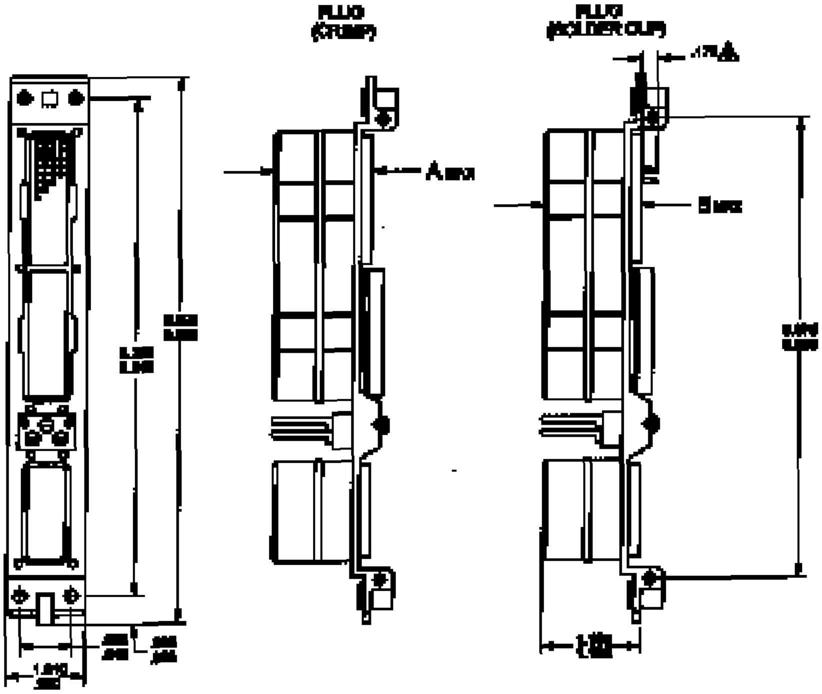


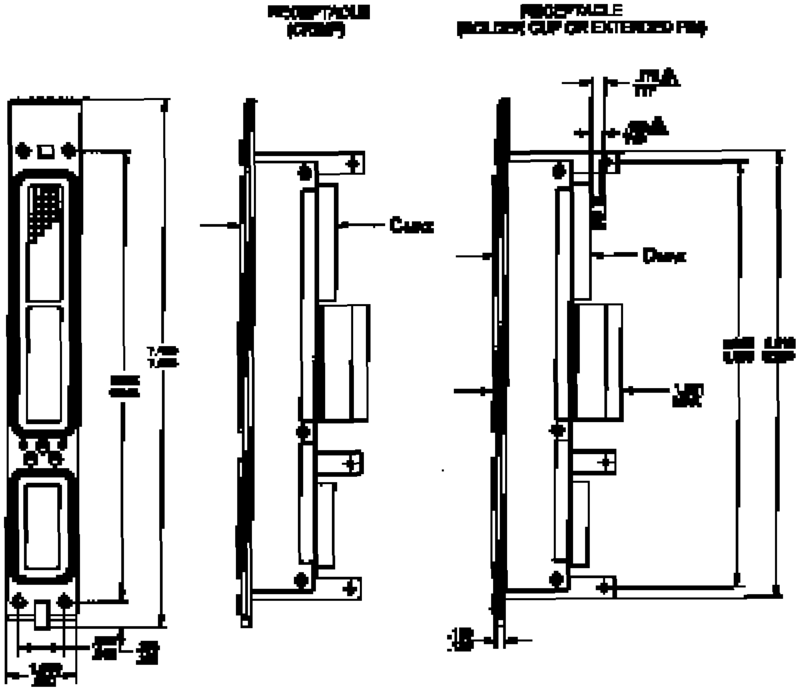


CONTACT ARRANGEMENT	TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
	A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
C2	.475	.075	1.416	1.016	.725	.325	1.666	1.266
C3	.475	.075	1.416	1.016	.725	.325	1.666	1.266
8	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
C8	---	---	---	---	---	---	---	---
D8	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
26	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
32C2	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
33C4	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
40	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
40C1	1.134	.734	2.065	1.665	1.384	.984	2.315	1.915
45	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
57	.934	.534	1.865	1.465	1.184	.784	2.115	1.715
67	.934	.534	1.865	1.465	1.184	.784	2.115	1.715

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULT FACTORY.

△3 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.



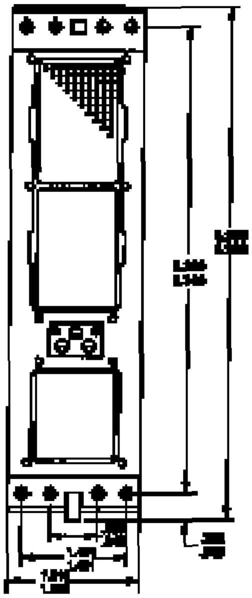


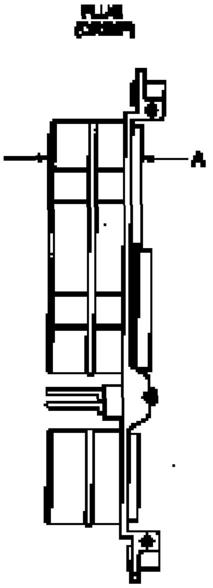
TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
1.252	1.252	1.371	1.371	1.502	1.502	1.621	1.621

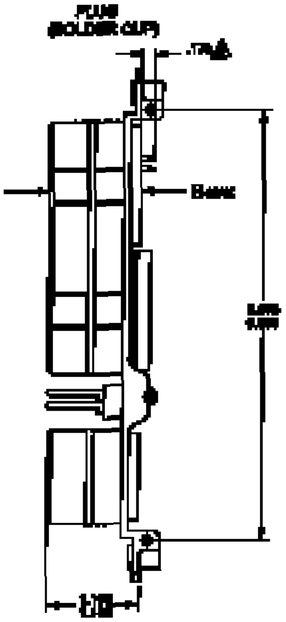
1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULTFACTORY.

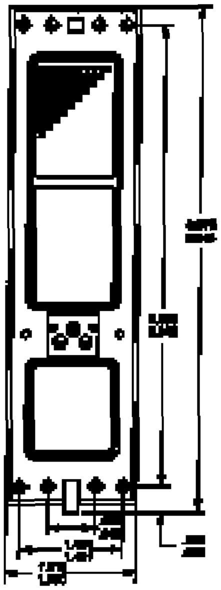
△2 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

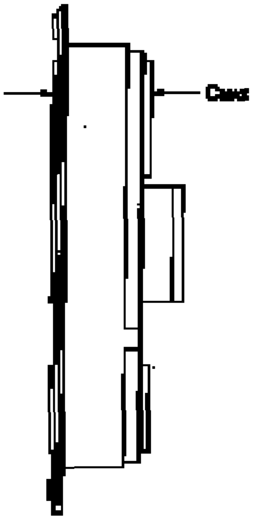
ARINC 600 SHELL SIZE II

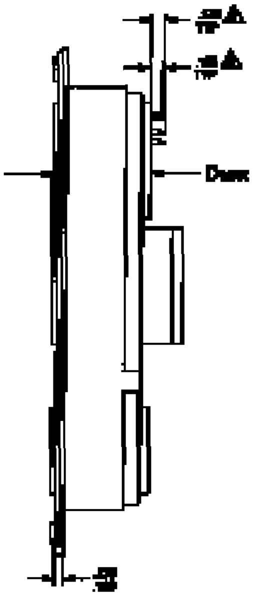










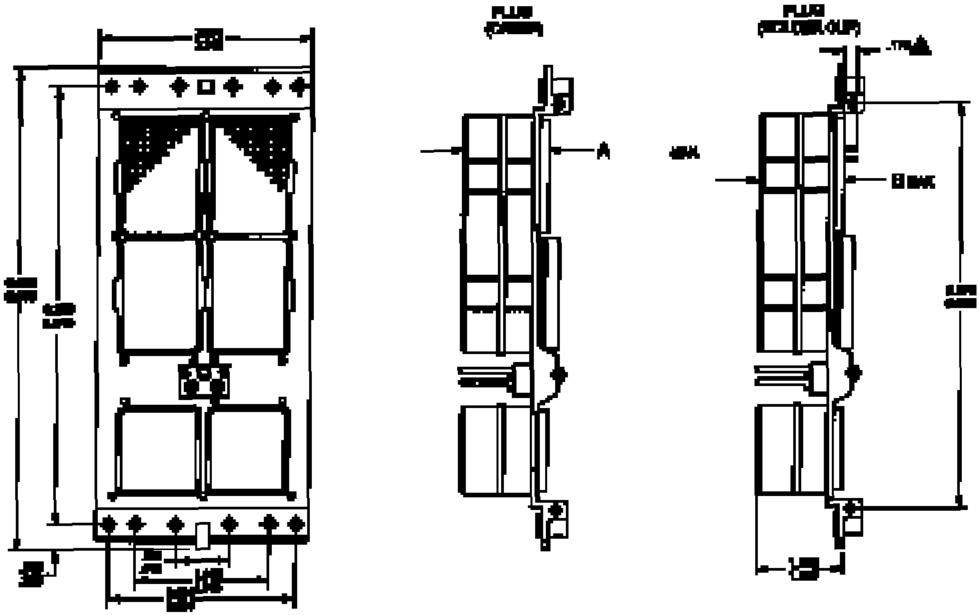


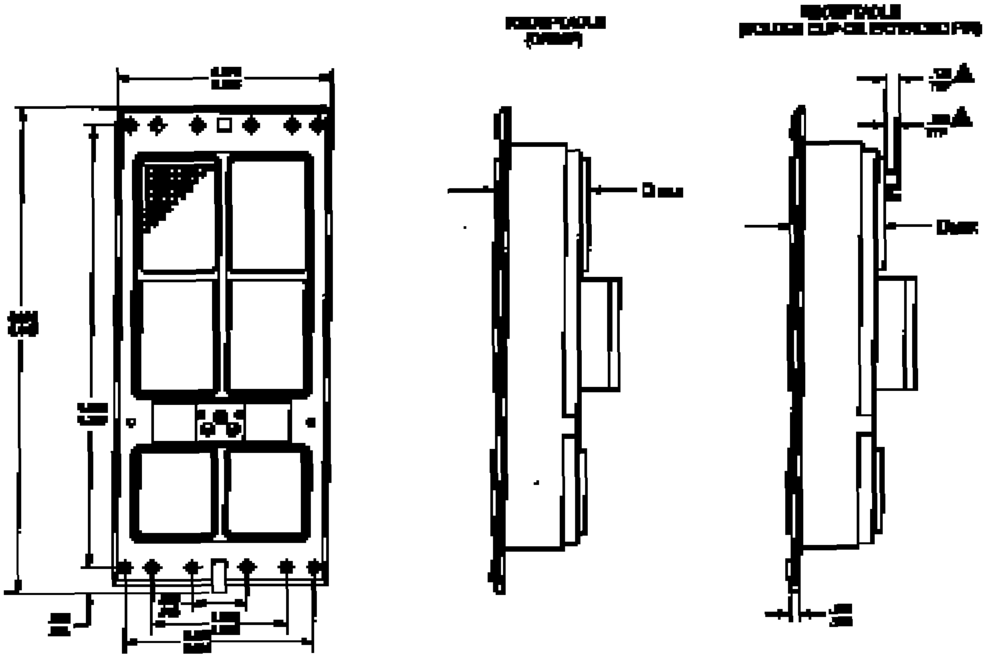
TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
1.252	1.252	1.371	1.371	1.502	1.502	1.621	1.621

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULT FACTORY.

⚠2 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

ARINC 600 SHELL SIZE III





TRANSIENT SUPPRESSION OR EMI FILTER				TRANSIENT SUPPRESSION AND EMI FILTER			
A MAX	B MAX	C MAX	D MAX	A MAX	B MAX	C MAX	D MAX
1.252	1.252	1.371	1.371	1.502	1.502	1.621	1.621

1. FOR DIMENSIONS NOTSHOWN, SEE MIL-C-81659.
2. ALLDIMENSIONS ARE FOR REFERENCE ONLY. FOR ARINC PART NUMBERS, CONSULT FACTORY.

△2 THESE DIMENSIONS MAY BE MODIFIED TO SUIT.

DESIGN GUIDELINES FOR SPECIFYING EMP/EMI CONNECTORS

by
Ed Meelhuysen, P.E.
EMP Connectors, Inc., Tustin, California

Introduction

‘A nuclear device which is detonated above the atmosphere produces an extremely high power Electromagnetic Pulse (NEMP). Semiconductor devices are quite vulnerable to this fast rise-time pulse with destruct threshold values in the microjoule range.’ Another source producing fast rise-time transients is Electrostatic Discharge (ESD). Lightning or inductive switching transients have slower rise times than NEMP or ESD, but contain more energy since the pulses extend over longer periods of time.

Various devices have been used for surppressing transient voltages such as transient suppression avalanche diodes, zener diodes, metal oxide varistors (MOV’s), capacitors and gas surge suppressors. The article “NEMP Transient Suppression Using the TransZorb®” by O. Melville Clark in the General Semiconductor Industries’ Product Data Book has an excellent comparison of the various devices. All remarks surrounded by single quotes (‘ ‘), such as the one above, are taken from the same product book.

Transient suppression diodes have gained strong support due to their rapid response times, current handling capability and reliablity. Combining the transient suppression abilities of the diodes with the connector interfaces required on most electronics enclosures results in a number of benefits to the user.

- Reduces space requirements.
- Saves weight.
- Saves design time of the circuit board assembly.
- Reduces parts handling during assembly.
- Eliminates radiated noise due to diode activation.
- Eliminates increased clamping voltages due to grounding lead inductance contrbutions.
- EMP hardening on retrofits can often be accomplished by using a transient suppression connector, saving costs and time on product redevelopment.

EMP Connectors, Inc. has developed the highest power handling capability of any transient suppression diode type connector on the market today, handling up to 1,000 watts of peak power (10 x 1000 µs pulse) on a 22 gauge contact (compare vs. the 75 to 200 watt units commonly found). Even higher peak power ratings are available on larger guage contacts.

Each connector is customized to the user’s particular application, with each cavity permitting a unique breakdown voltage. Popular connectors such as the MIL-C-38999 circular connector lines do not require length extensions for extended pin, wire wrap or solder cup type terminations. For crimp type applications, the commonly used piggy back method using short sockets per MIL-C-39029/22 requires minimal additional length.

Commercial connectors such as D-subminiatures, DIN or IEEE-488 standars can have transient suppression added to them to withstand the electrical transients found in industrial or office environments.

(Continued on page 40)

ELECTRICAL CHARACTERISTICS AT 25° C

DIODE P/N BASED ON BV Nom.	NOMINAL BREAKDOWN VOLTAGE BV Nom.	VOLTAGES BASED ON JEDEC TYPE NUMBER (REF. ONLY)	REVERSE STANDOFF VOLTAGE V r	BREAKDOWN VOLTAGE			MAX REVERSE LEAKAGE I r (μA) at V r					MIN. IMPEDANCE Z (MΩ) at V r					MAXIMUM CLAMPING VOLTAGE V c (Volts)	MAXIMUM CLAMPING CURRENT - I p (A) (10 x 1000 μ pulse-per R.E.A.)					MAX. VOLTAGE TEMP. VARIATION OF BV mV/°C	CAPACITANCE-pF (Typical at V r Rated Standoff Voltage)				
				MIN. BV	MAX. BV	at I mA	200	300	600	1000	2000	200	300	600	1000	2000		200	300	600	1000	2000		200	300	600	1000	2000
006	6.8	1N5629A	5.8	6.45	7.14	10	200	300				.029	.019				10.5	19.0	28.6				5.0	844	1267			
007	7.5	1N5630A	6.4	7.13	7.88	10	100	150				.064	.043				11.3	17.7	26.5				5.0	738	1106			
008	8.2	1N5631A	7.0	7.79	8.61	10	40	60				.176	.117				12.1	16.5	24.8				6.0	650	975			
009	9.1	1N5632A	7.8	8.7	9.6	1	10	15				.78	.52				13.4	14.9	22.4				7.0		846			
010	10.0	1N5633A	8.6	9.5	10.5	1		3					2.9				14.5		20.7				8.0		744			
011	11.1	1N5634A	9.4	10.5	11.6	1		2					6.3				15.6		19.2				9.0		653			
012	12.0	1N5635A	10.2	11.4	12.6	1		2					6.8				16.7		18.0				10		584			
013	13.1	1N5636A	11.1	12.4	13.7	1		2					7.4				18.2		16.5				11			1040	1733	
015	15.1	1N5637A	12.8	14.3	15.8	1			3	5				4.3	2.6		21.2			28.3	47.2		12			855	1425	
016	16.0	1N5638A	13.6	15.2	16.8	1			3	5				4.5	2.7		22.5			26.7	44.4		14			787	1311	
018	18.0	1N5639A	15.3	17.1	18.9	1			3	5				5.1	3.1		25.2			23.8	39.7		19			669	1116	
020	20.0	1N5640A	17.1	19.0	21.0	1			3	5				5.7	3.4		27.7			21.7	36.1		19			575	958	
022	22.0	1N5641A	18.8	20.9	23.1	1			3	5				6.3	3.8		30.6			19.6	32.7		20			505	841	
024	24.0	1N5642A	20.5	22.8	25.2	1			3	5				6.8	4.1		33.2			18.1	30.1		23			448	747	
027	27.1	1N5643A	23.1	25.7	28.4	1			3	5				7.7	4.6		37.5			16.0	26.7		25				634	
030	30.0	1N5644A	25.6	28.5	31.5	1				5					5.1		41.4				24.2		28				551	
033	33.1	1N5645A	28.2	31.4	34.7	1				5					5.6		45.7				21.9		30				482	
036	36.0	1N5646A	30.8	34.2	37.8	1				5					6.2		49.9				20.0		31				427	
039	39.1	1N5647A	33.3	37.1	41.0	1				5					6.7		53.9				18.6		36				384	
043	43.1	1N5648A	36.8	40.9	45.2	1				5					7.4		59.3				16.9		44				335	
047	47.1	1N5649A	40.2	44.7	49.4	1				5					8.0		64.8				15.4		48				296	
051	51.1	1N5650A	43.6	48.5	53.6	1				5					8.7		70.1				14.3		51				265	
056	56.0	1N5651A	47.8	53.2	58.8	1				5					10		77.0				13.0		56				234	
062	62.0	1N5652A	53.0	58.9	65.1	1				5					11		85.0				11.8		62				203	
068	68.0	1N5653A	58.1	64.6	71.4	1				5					12		92.0				10.9		69				179	
075	75.1	1N5654A	64.1	71.3	78.8	1				5					13		103.0				9.7		76				156	
082	82.0	1N5655A	70.1	77.9	86.1	1				5					14		113.0				8.8		86				138	
091	91.0	1N5656A	77.8	86.5	95.5	1				5					16		125.0				8.0		94				120	
100	100.0	1N5657A	85.5	95.0	105.0	1				5					17		137.0				7.3		104				105	
111	110.5	1N5658A	94.0	105.0	116.0	1				5					19		152.0				6.6		115				92	
120	120.0	1N5659A	102.0	114.0	126.0	1				5					20		165.0				6.1		125				83	
131	130.5	1N5660A	111.0	124.0	137.0	1				5					22		179.0				5.6		136				74	
151	150.5	1N5661A	128.0	143.0	158.0	1				5					26		207.0				4.8		157				61	
160	160.5	1N5662A	136.0	152.0	168.0	1				5					29		219.0				4.6		167				56	
171	170.5	1N5663A	145.0	162.0	179.0	1				5					30		234.0				4.3		188				51	
180	180.0	1N5664A	154.0	171.0	189.0	1				5					32		246.0				4.1		188				47	
200	200.0	1N5665A	171.0	190.0	210.0	1				5					34		274.0				3.6		209				41	
2000 WATT UNITS COMBINE TWO 1000 WATT UNITS IN SERIES ON THE CONTACT. MAY BE USED ON 20 GAUGE OR LARGER CONTACTS.																												
054	54.1	027 x 3	46.2	51.4	56.8	1					5					9	75.0					26.7	50					317
060	60.0	030 x 3	51.2	57.0	63.0	1					5					10	82.8					24.2	56					275
066	66.1	033 x 2	56.4	62.8	69.4	1					5					11	91.4					21.9	60					241
072	72.0	036 x 2	61.6	68.4	75.6	1					5					12	99.8					20.0	62					214
078	78.1	039 x 2	66.6	74.2	82.0	1					5					13	107.8					18.6	72					192
086	86.1	043 x 2	73.6	81.8	90.4	1					5					15	118.6					16.9	88					167
094	94.1	047 x 2	80.4	89.4	98.8	1					5					16	129.6					15.4	96					148
102	102.1	051 x 2	87.2	97.0	107.2	1					5					17	140.2					14.3	102					133
112	112.0	056 x 2	95.6	106.4	117.6	1					5					19	154.0					13.0	112					117
124	124.0	062 x 2	106.0	117.8	130.2	1					5					21	170.0					11.8	124					101
136	136.0	068 x 2	116.2	129.2	142.8	1					5					23	184.0					10.9	138					89
150	150.1	075 x 2	128.2	142.6	157.6	1					5					26	206.0					9.7	152					78
164	164.0	082 x 2	140.2	155.8	172.2	1					5					28	226.0					8.8	172					69
182	182.0	091 x 2	155.6	173.0	191.0	1					5					31	250.0					8.0	188					60
200	200.0	100 x 2	171.0	190.0	210.0	1					5					34	274.0					7.3	208					53
221	221.0	111 x 2	188.0	210.0	232.0	1					5					38	304.0					6.6	230					46
240	240.0	120 x 2	204.0	228.0	252.0	1					5					40	330.0					6.0	250					41
261	261.0	131 x 2	222.0	248.0	274.0	1					5					44	358.0					5.5	272					37
301	301.0	151 x 2	256.0	286.0	316.0	1					5					51	414.0					4.7	314					30
320	320.0	160 x 2	272.0	304.0	336.0	1					5					58	438.0					4.1	334					28
341	341.0	171 x 2	290.0	324.0	358.0	1					5					60	468.0					3.8	376					25
360	360.0	180 x 2	308.0	342.0	378.0	1					5					64	492.0					3.6	376					23
400	400.0	200 x 2	342.0	380.0	420.0	1					5					68	548.0					3.4	418					20

NOTES:
1. SPECIFY DIODES BY THE NOMINAL BREAKDOWN VOLTAGE LEVEL AND THE POWER RATING. CONSULT DESIGN GUIDE FOR ADDITIONAL INFORMATION ON HOW TO SPECIFY DIODES.

Rev. 11/03/88

ELECTRICAL CHARACTERISTICS AT 25° C

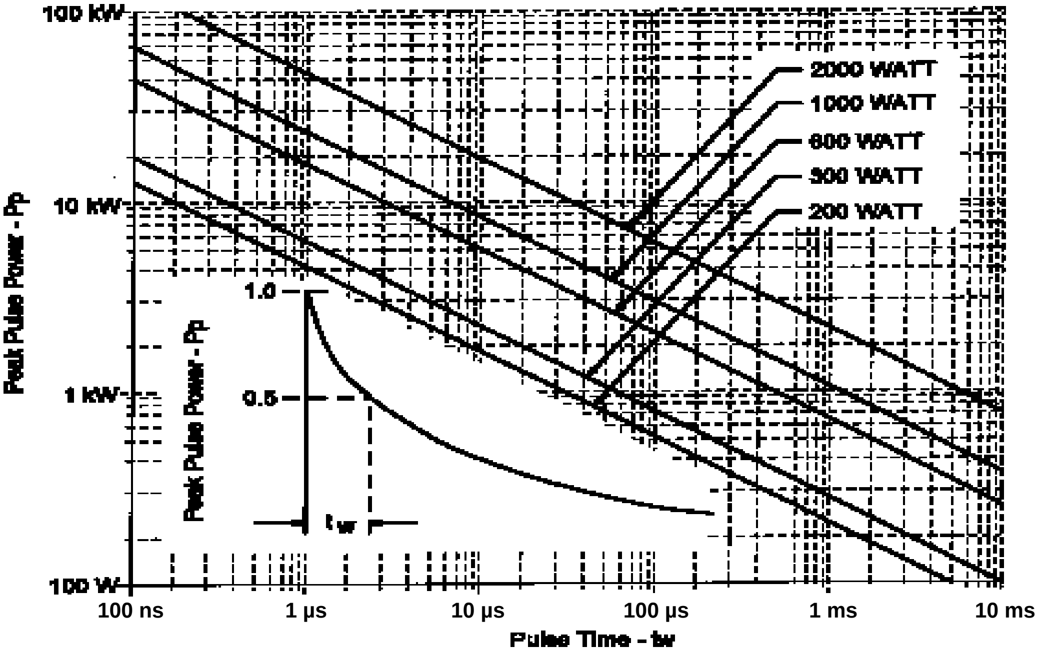
DIODE P/N BASED ON BV Nom.	NOMINAL BREAKDOWN VOLTAGE BV Nom.	VOLTAGES BASED ON JEDEC TYPE NUMBER (REF. ONLY)	REVERSE STANDOFF VOLTAGE V r	BREAKDOWN VOLTAGE			MAX REVERSE LEAKAGE I r (μA) at V r					MIN. IMPEDANCE Z (MΩ) at V r					MAXIMUM CLAMPING VOLTAGE V c (Volts)	MAXIMUM CLAMPING CURRENT - I p (A) (10 x 1000 μ pulse-per R.E.A.)					MAX. VOLTAGE TEMP. VARIATION OF BV mV/°C	CAPACITANCE-pF (Typical at V r Rated Standoff Voltage)				
				MIN. BV	MAX. BV	at I mA	200	300	600	1000	2000	200	300	600	1000	2000		200	300	600	1000	2000		200	300	600	1000	2000
006	6.8	1N6138A	5.2	6.46	7.14	10	100	150				.052	.035				10.5	19.0	28.6				5.0	769	1153			
007	7.5	1N6036A	6.0	7.13	7.88	10	200	300				.030	.020				11.3	17.7	26.5				5.0	629	943			
008	8.2	1N6037A	7.0	7.79	8.61	10	100	150				.070	.047				12.1	16.5	24.8				5.0	506	759			
009	9.1	1N6038A	7.5	8.7	9.6	1	40	60				.19	.13				13.4	14.9	22.4				7.0	460	689			
010	10.0	1N6039A	8.5	9.5	10.5	1		15					.6				14.5		20.7				7.0		578			
011	11.1	1N6040A	9.0	10.5	11.6	1		3					3.0				15.6		19.2				8.0		534			
012	12.0	1N6041A	10.0	11.4	12.6	1		2					6.7				16.7		18.0				9		460			
013	13.1	1N6042A	11.0	12.4	13.7	1		2					7.3				18.2		16.5				10		403			
015	15.1	1N6043A	12.0	14.3	15.8	1			3	5				4.0	2.4		21.2			28.3	47.2		12			713	1188	
016	16.0	1N6044A	13.0	15.2	16.8	1			3	5				4.3	2.6		22.5			26.7	44.4		13			637	1062	
018	18.0	1N6045A	15.0	17.1	18.9	1			3	5				5.0	3.0		25.2			23.8	39.7		15			521	868	
020	20.0	1N6046A	17.0	19.0	21.0	1			3	5				5.7	3.4		27.7			21.7	36.1		18			437	728	
022	22.0	1N6047A	18.0	20.9	23.1	1			3	5				6.0	3.6		30.6			19.6	32.7		20			403	672	
024	24.0	1N6048A	20.0	22.8	25.2	1			3	5				6.7	4.0		33.2			18.1	30.1		24			348	580	
027	27.1	1N6049A	22.0	25.7	28.4	1			3	5				7.3	4.4		37.5			16.0	26.7		28			304	507	
030	30.0	1N6050A	25.0	28.5	31.5	1				5					5.0		41.4				24.2		31				424	
033	33.1	1N6051A	28.0	31.4	34.7	1				5					5.6		45.7				21.9		34				361	
036	36.0	1N6052A	30.0	34.2	37.8	1				5					6.0		49.9				20.0		37				328	
039	39.1	1N6053A	33.0	37.1	41.0	1				5					6.6		53.9				18.6		40				287	
043	43.1	1N6054A	36.0	40.9	45.2	1				5					7.2		59.3				16.9		43				254	
047	47.1	1N6055A	40.0	44.7	49.4	1				5					8.0		64.8				15.4		47				219	
051	51.1	1N6056A	43.0	48.5	53.6	1				5					8.6		70.1				14.3		51				198	
056	56.0	1N6057A	47.0	53.2	58.8	1				5					9		77.0				13.0		56				175	
062	62.0	1N6058A	53.0	58.9	65.1	1				5					11		85.0				11.8		62				148	
068	68.0	1N6059A	58.0	64.6	71.4	1				5					12		92.0				10.9		68				130	
075	75.1	1N6060A	64.0	71.3	78.8	1				5					13		103.0				9.7		75				113	
082	82.0	1N6061A	70.0	77.9	86.1	1				5					14		113.0				8.8		82				100	
091	91.0	1N6062A	75.0	86.5	95.5	1				5					15		125.0				8.0		86				91	
100	100.0	1N6063A	82.0	95.0	105.0	1				5					16		137.0				7.3		94				80	
111	110.5	1N6064A	94.0	105.0	116.0	1				5					19		152.0				6.6		104				66	
120	120.0	1N6065A	100.0	114.0	126.0	1				5					20		168.0				6.0		115				61	
131	130.5	1N6066A	110.0	124.0	137.0	1				5					22		182.0				5.5		125				53	
151	150.5	1N6067A	128.0	143.0	158.0	1				5					26		213.0				4.7		136				43	
171	170.5	1N6068A	145.0	162.0	179.0	1				5					29		245.0				4.1		157				36	
180	180.0	1N6069A	150.0	171.0	189.0	1				5					30		261.0				3.8		167				34	
191	190.5	1N6070A	160.0	181.0	200.0	1				5					32		278.0				3.6		188				31	
200	200.0	1N6071A	170.0	190.0	210.0	1				5					34		294.0				3.4		188				29	
220	220.0	1N6072A	185.0	209.0	231.0	1				5					37		328.0				3.0		209				26	
2000 WATT UNITS COMBINE TWO 1000 WATT UNITS IN SERIES ON THE CONTACT. MAY BE USED ON 20 GAUGE OR LARGER CONTACTS.																												
054	54.1	027 x 3	44.0	51.4	56.8	1					5					9	75.0					26.7	56					254
060	60.0	030 x 3	50.0	57.0	63.0	1					5					10	82.8					24.2	62					212
066	66.1	033 x 2	56.0	62.8	69.4	1					5					11	91.4					21.9	68					181
072	72.0	036 x 2	60.0	68.4	75.6	1					5					12	99.8					20.0	74					164
078	78.1	039 x 2	66.0	74.2	82.0	1					5					13	107.8					18.6	80					144
086	86.1	043 x 2	72.0	81.8	90.4	1					5					14	118.6					16.9	86					127
094	94.1	047 x 2	80.0	89.4	98.8	1					5					16	129.6					15.4	94					110
102	102.1	051 x 2	86.0	97.0	107.2	1					5					17	140.2					14.3	102					99
112	112.0	056 x 2	94.0	106.4	117.6	1					5					19	154.0					13.0	112					87
124	124.0	062 x 2	106.0	117.8	130.2	1					5					21	170.0					11.8	124					74
136	136.0	068 x 2	116.0	129.2	142.8	1					5					23	184.0					10.9	136					65
150	150.1	075 x 2	128.0	142.6	157.6	1					5					26	206.0					9.7	150					57
164	164.0	082 x 2	140.0	155.8	172.2	1					5					28	226.0					8.8	164					50
182	182.0	091 x 2	150.0	173.0	191.0	1					5					30	250.0					8.0	172					45
200	200.0	100 x 2	164.0	190.0	210.0	1					5					33	274.0					7.3	188					40
221	221.0	111 x 2	188.0	210.0	232.0	1					5					38	304.0					6.6	208					33
240	240.0	120 x 2	200.0	228.0	252.0	1					5					40	336.0					6.0	230					30
261	261.0	131 x 2	220.0	248.0	274.0	1					5					44	364.0					5.5	250					26
301	301.0	151 x 2	256.0	286.0	316.0	1					5					51	426.0					4.7	272					21
341	341.0	171 x 2	290.0	324.0	358.0	1					5					58	490.0					4.1	314					18
360	360.0	180 x 2	300.0	342.0	378.0	1					5					60	522.0					3.8	334					17
381	381.0	191 x 2	320.0	362.0	400.0	1					5					64	556.0					3.6	376					16
400	400.0	200 x 2	340.0	380.0	420.0	1					5					68	588.0					3.4	376					14
440	440.0	220 x 2	370.0	418.0	462.0	1					5					74	656.0					3.0	418					13

NOTES:
1. SPECIFY DIODES BY THE NOMINAL BREAKDOWN VOLTAGE LEVEL AND THE POWER RATING. CONSULT DESIGN GUIDE FOR ADDITIONAL INFORMATION ON HOW TO SPECIFY DIODES.

Rev. 11/03/88

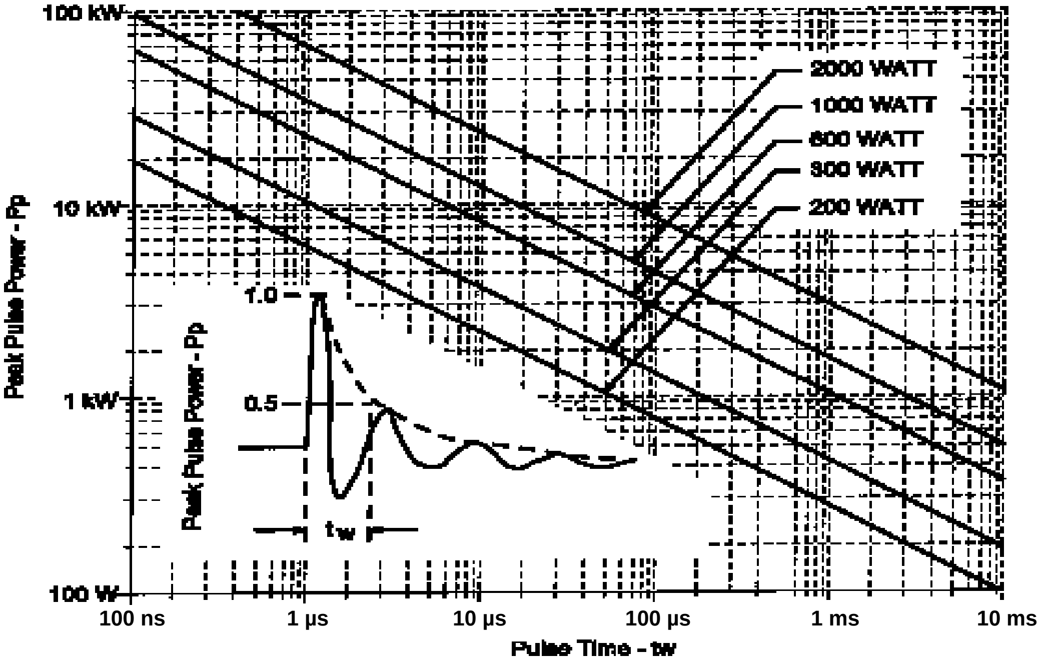
PEAK PULSE POWER VS. PULSE TIME CHARTS
EXPONENTIAL DECAY PULSE

Electrical Surge Characteristics at 25° C



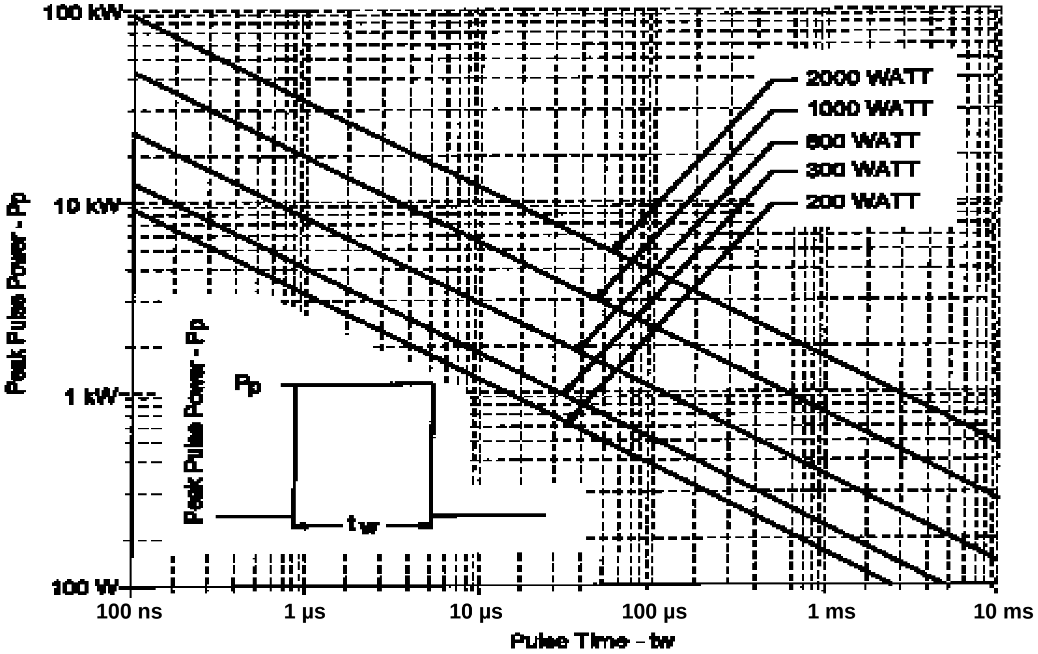
DAMPED SINE WAVE PULSE

Electrical Surge Characteristics at 25° C



SQUARE WAVE PULSE

Electrical Surge Characteristics at 25° C



This guide shows how to determine and choose the proper diode voltage and power ratings, answers potential questions regarding filter selection, connector grounding and cost considerations, and provides a number of examples to help make the guide easier to understand. If you have any question or comments, please contact the factory or your local EMP Connector representative. Your feedback is greatly appreciated.

DIODE CONSIDERATIONS

Voltage Rating

- Determine the maximum DC or peak AC operating voltage, which is the nominal circuit voltage plus its tolerance on the high side. For AC voltages given in RMS values, multiply the maximum RMS value by 1.414 to determine the peak value.

- Select a transient suppression diode which has a reverse standoff voltage equal to or greater than the maximum circuit voltage. This selection will allow for operation over the temperature range of -65° to +175°C.

- Example: What is the peak operating voltage for a 115 ± 7 V RMS AC line? What diode voltage rating should be chosen?

  115 + 7 = 122 V rms 122 (1.414) = 173 volts peak

  Chose a diode which has a reverse standoff voltage greater than 173 volts. From the Electrical Characteristics tables on pages 37 and 38, a good choice would be the 220 Volt (Nominal Breakdown Voltage) diode. Since AC power is specified, a bi-directional diode is selected.

Pulse Rating

- 'Define the waveshape or source of the transient and duration of the pulse. Determine the peak pulse power of the transient' and determine the pulse time for decay to 50% of the crest value (tw). On pages 39 and 40 are charts showing the peak pulse power vs. the pulse time for several common waveforms used to simulate EMP transients.

  The pulse time, tw, is equal to the rise time, tr, plus the decay time, td.

  $$tw = tr + td \qquad [1]$$

  However, for most pulses, td is much greater than tr such that tw = td. Thus, the following simplified formulas can be used. Where tr is significant, add tr to the ~tw calculated to determine the actual pulse time.

  An expoential decay pulse, has the formula:

  $$V = V_o\ e^{(-xt)} \qquad [2]$$

  and has a pulse time of:

  $.5\ V = V_o\ e^{(-xt)}$ $-xt = \ln\ (.5) = -.693$ **$tw = t = .693/x$ [3]**

  An exponential damped sine wave pulse, has the formula:

  $$V = V_o\ e^{(-\pi ft/Q)}\ \sin(2\pi ft) \qquad [4]$$

  where: f = frequency of the sine wave, and
  Q= damped factor

  Typical values of Q range from 6 to 24. The actual Q factor is dependent on the resonant frequency of the system. This is a function of the length of the electrical lines, type of object involved such as antenna, missile, ship, aircraft, etc, and other factors. Several of the services specify the value of Q called for in MIL-STD-461. For most applications, the Navy uses a Q of 15, and the Air Force a Q of 20. The greater the Q value, the longer the pulse time, and the greater the power handling ability required.

  The exponentially damped sine wave pulse has a pulse time of:

  $.5\ V_o = V_o\ e^{(-\pi ft/Q)}$ $-\pi ft/Q = \ln\ (.5) = -.693$ **$tw = t = .221\ Q/f$ [5]**

  A nonrepetitive square wave of a pulse frequency, f, has a pulse time of:

  $$tw = 1/f \qquad [6]$$

  For example, a 20 MHz square wave pulse has a pulse time of:

  $$tw = 1/(20\ \text{MHz}) = 50\ \text{ns}.$$

  If the pulse is a nonrepetive one-half sine wave, use the exponential decay waveform chart and derate the suppressor peak pulse power to 75% of the maximum value under exponential decay conditions. The pulse time for a one-half sine wave pulse where f is the frequency of the full sine wave is:

  $$tw = 1/(3f) \qquad [7]$$

- The peak pulse requirements are usually specified by the equipment purchaser. If no pulse is specified, or the designer must choose the requirements, the following table may furnish ideas of typical transients used by the government and industry. The table does not include all the categories that a given spec might have. These categories have different requirements based on the location of the equipment and frequency of pulse exposure. Obtain the required specification for additional information.

  Companies A and B are both aircraft manufacturers. Company C had an electronics enclosure protected by the metallic aircraft skin. The pulse testing equipment listed shows the damped sine wave pulse capability of the commonly used IRT Corporation test equipment using the IFI amplifier. (EMP Connectors' product was able to withstand repeated pulses at these settings; actual capability of a particular diode may be higher or lower depending on the voltage and power ratings used). Other pulse testing equipment may have reduced pulse capability. Where the information is in italics, the values are commonly used numbers and not given in the specification.

Waveform Specification	Peak Pulse Type	Pulse (Vp or Ip)	Source Time (tw)	Impedance (Zs)
DOD-STD-1399 Section 300	Exponential Decay	2500 V	50 µs	*20 Ω*
MIL-STD-461	Damped Sine Wave	.16 A @ 10 KHz 10 A @ .63 MHz	530 µs (Q = 24) 8.4 µs (Q = 24)	100 Ω
IEEE 587-1980 (AC power lines)	Damped Sine Wave	6000 V @ 100 Hz	12 µs	30 Ω (Cat. A) 12 Ω (Cat. B)
A	Damped Cosine Wave	800 V @ 1 MHZ (Cat. A) 400 V @ 1 MHZ (Cat. B)	5 µs	20 Ω
B	Damped Sine Wave	25 A from 10 KHz to 100 MHz	*530 µs max.*	100 Ω
C	Square Wave	500 V @ 5 MHz	200 ns	100 Ω
IRT Corp. Pulse Testing Equipment	Damped Sine Wave	26 A @ 10 KHz 34 A @ 100 MHz	530 µs 53 ns	100 Ω

- Another excellent source defining pulse requirements for aircraft is the RTCA Paper No. 473-87/SC135-207, Section 22. It defines a number of tests to "determine the ability of equipment to withstand the induced effects of lightning. . ." A description of the categories follows the table.

CATEGORIES AND TEST LEVELS

	-- TEST LEVELS --					
	Long Exponential Decay (tw = 70 µs)		Short Exponential Decay (tw = 6.4 µs)		Damped Sine Wave (tw = 2 µs)	
Category	Vp	Ip	Vp	Ip	Vp	Ip
J	125	25	125	25	250	10
K	300	60	300	60	600	24
L	750	150	750	150	1500	60
M	1600	320	1600	320	3200	128
X			No Testing Required			

Vp = Peak Open Circuit Voltage (Volts)
Ip = Peak Test Limit Current (Amps)

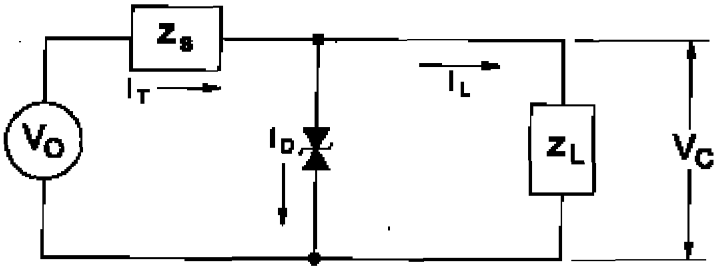
“Category J is intended for equipment and interconnect wiring that will be installed in a partially protected environment, such as an enclosed avionics bay in an all-metallic aircraft.”

“Category K is intended for equipment and interconnect wiring that will be installed in a moderate environment, such as the more electromagnetically open areas (e.g. cockpit) of an aircraft composed principally of metal.”

“Categories L & M are for equipment and interconnect wiring that will be installed in a severe electromagnetic viroment. Such levels might be found in all-composite aircraft or other exposed areas in metallic aircraft.”

“Category X is intended for equipment for which lightning effects are insignificant or are not applicable.”

- Determine the peak pulse power requirements of the transient suppression device. For the simplified circuit shown, use the following formulas.



$$\frac{V_O - V_C}{Z_S} = I_T \qquad [8]$$

$$I_T - \frac{V_C}{Z_L} = I_D \qquad [9]$$

$$I_D V_C = P_P \qquad [10]$$

Where: V_C is the maximum clamping voltage of the diode (see diode electrical characteristics tables), and
V_O is the maximum transient voltage
Z_S is the source impedance
Z_L is the load impedance
I_T is the current flowing through the source impedance
I_D is the current flowing through the diode
I_L is the current flowing through the load impedance

If the peak pulse current I_{MAX} is given such as in MIL-STD-461C, start with formula [9] where $I_{MAX} = I_T$. From the appropreate “Peak Pulse Power vs. Pulse Time” chart, locate the intersection of the P_P and the pulse time tw. Choose a diode power rating that has the diagonal line above the intersection point.

Example

Choose a transient suppression diode for a 12 VDC electrical circuit where the nominal voltage can vary ± 3 volts, the source impedance is 25 Ω and the load impedance is 100 Ω. The circuit is subject to a damped sine wave transient pulse of 1000 volts peak at a frequency of 10 KHz and a damping factor of 24. The circuit powers a DC motor that when reversed, generates a counter EMF, temporarily producing a -12 VDC line voltage.

From formula [5], the pulse width is:

$$tw = .221\ Q/f = .221\ (24/10k) = 530\ \mu sec$$

The maximum normal operating voltage is:

12 v + 3 v = 15 v (reverse standoff voltage)

Since the circuit is subject to reverse voltages, choose a bi-directional diode. Look at the bi-directional diode electrical characteristics table on page 38 and find the diode with a reverse standoff voltage equal to or greater than 15 volts. The 18 volt nominal diode is the best choice. The maximum clamping voltage for this diode is 25.2 volts.

$$\frac{V_O - V_C}{Z_S} = I_T \qquad \frac{1000 - 25.2}{25} = 39.0\ A$$

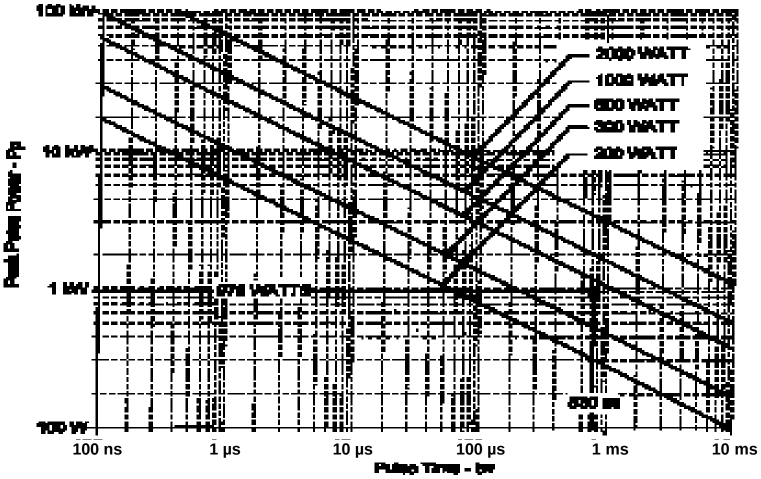
$$I_T - \frac{V_C}{Z_L} = I_D \qquad 39.0 - \frac{25.2}{100} = 38.7\ A$$

$$I_D V_C = P_P \qquad 38.7\ (25.2) = 976\ \text{watts}$$

From the peak pulse power chart for the damped sine wave pulse, locate the intersecion of the 530 µs pulse time and the 976 watts peak pulse power (see the next figure). The diode line directly above that point is the 600 watt device.

DAMPED SINE WAVE PULSE

Electrical Surge Characteristics at 25° C



From the chart, we can see that the 600 watt device at 530 µs has a rating of around 1.1 kW at 25°C for a factor of safety of:

$$\frac{1100}{976} = 1.13$$

A factor of safety of 1 indicates no reserve for overload conditions. If the above factor of safety is inadequate, choose a higher rated diode such as the 1000 watt device, which has a peak pulse power rating of 1.9 kW at 530 µs. It's factor of safety would be:

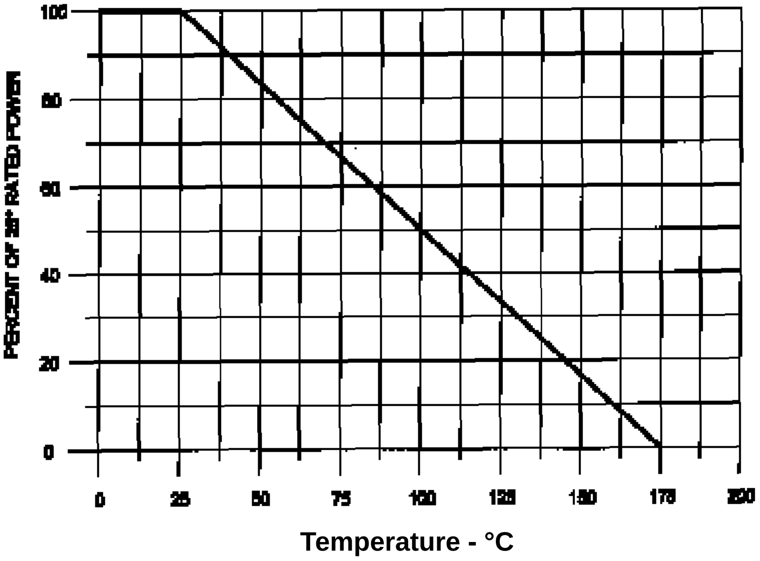
$$\frac{1900}{976} = 1.95$$

or almost 2 to 1. Using a 1000 watt device would also reduce the maximum clamping voltage from 25.2 volts to around 22 volts for the 38.7 amps of transient current.

Temperature Considerations

- If the operating temperature of the system is higher than 25°C (room ambient temperature), then the semiconductor devices must be derated per the following graph.

Power Derating Curve



If the circuit in the previous example had an operating temperature of 100°C (212°F), then from the above chart, the device must be derated to 50% of its 25°C power rating or to:

.5 (1900) = 950 watts

Since this is less than the 976 watts required, one should use the 2000 watt device which is rated at 3.8 kW at 25°C or 1900 watts at 100°C.

Contact to Ground Isolation

- Most connector specifications call out a contact isolation of 5,000 MΩ. In a transient suppression diode connector, the maximum isolation between one contact and another is the sum of the two minimum impedances listed in the electrical characteristics tables for the diodes involved. The individual impedances vary from 20 kΩ to greater than 50 MΩ. This impedance is determined by dividing the reverse standoff voltage by the leakage current. Average values of resistance are 2 to 3 times higher than the minimum values listed. If the leakage current is too high, as may be the case for a high impedance input circuit, consider using a higher voltage rated diode. Especially for the lower voltage diodes, a 1 or 2 volt increase in rating can result in significant impedance increases without increasing the clamping voltage much.

- At the 175°C rating, the leakage current may increase by 2-5 times. This is a function of the silicon diode material and not of the connector package. For temperatures in between, figure a linear increase in leakage between the 25°C and the 175°C endpoints.

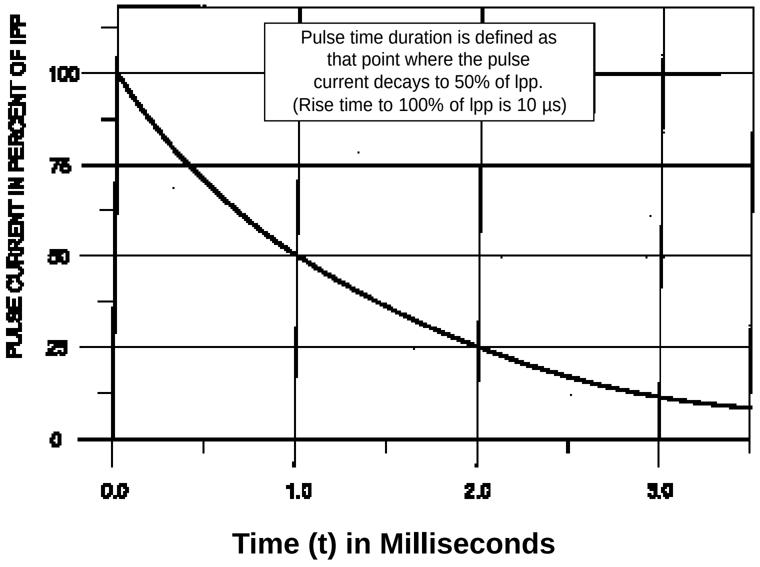
Stacking Transient Suppression Diodes for Higher Power (Patent Pending)

- ‘If the incident P_p is greater than the rating of the transient suppression diodes, devices may be stacked in series to increase the power rating.’ Thus, two 1000 watt diodes may be stacked in series on a 22 gauge contact to reach the 2000 watt maximum rating. An example of this could be a 1000 watt, 100 volt diode, which is inadequate for a given application where 2000 watts of peak power dissipation is required. Specifying the 102 volt, 2000 watt diode gives the user two 51 volt, 1000 watt diodes, stacked in series on the contact. If even higher power ratings are required, or operating voltage levels above 370 volts are being used, then the user should consider a larger gauge contact. Additional diodes may be stacked in series as well as a larger diode active area may be used on larger gauge contacts. Consult the factory for your specific requirements.

- Paralleling of Diodes (not recommended) - While discrete transient suppression diodes may be placed in parallel for voltages below 40 volts in order to further increase the overall power rating, close matching, about 100 millivolts or less between each device, is necessary to assure even loading of the transient power between the devices. This is usually done at the semiconductor manufacturer’s factory for optimum results. Connecting contacts in parallel to raise the power rating of the diodes is **not** recommended due to the additional imbalances caused by contact location, grounding and inductive factors. These imbalances could cause the diode with the lower breakdown voltage to carry the bulk of the transient current, potentially resulting in degradation or failure of that diode.

Clamping Voltages

10 x 1000 µs Current Impulse Waveform



Pulse time duration is defined as that point where the pulse current decays to 50% of Ipp. (Rise time to 100% of Ipp is 10 µs)

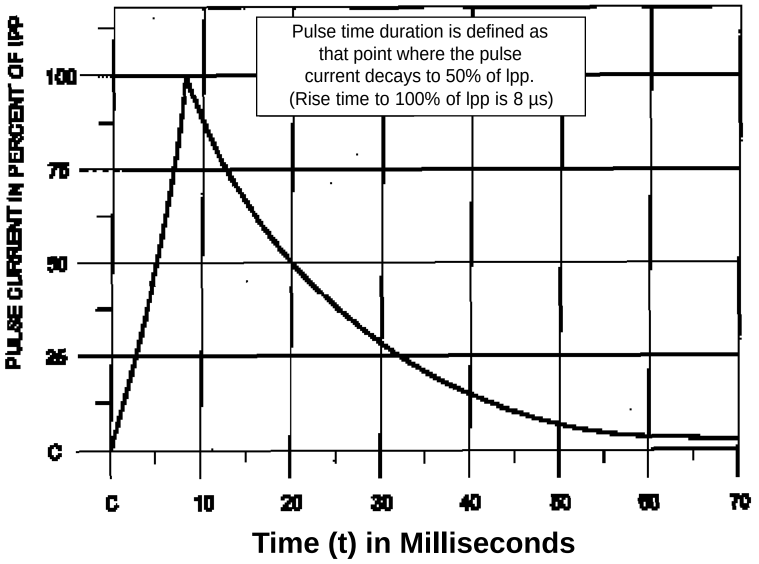
- The maximum clamping voltage given in the electrical characteristic tables on pages 37 and 38 are for the 10 x 1000 µs exponential decay pulse shown above. The actual clamping voltage experienced will depend on the circuit parameters and the nature of the transient pulse.

- Note ‘that the maximum clamping voltage is approximately 1.33 times the breakdown voltage.’ If this maximum clamping voltage exceeds the circuit limitations, higher powered devices can be used to reduce the clamping factor. For example, a 2000 watt device has a clamping factor of approximately 1.2 as compared to the clamping factor of 1.3 for a 1000 watt device at the 1000 watt device’s maximum current level.

Power Rating Comparisons

- Sometimes, to make a low powered device look like it can absorb a greater amount of power, the device is rated for a shorter pulse, such as the 8 x 20 µs pulse shown in the next figure.

8 x 20 µs Current Impulse Waveform



In order to truly compare the power rating of a device rated for a 10 x 1000 µsec device with a device rated for a 8 x 20 µsec pulse, the 10 x 1000 µs device’s power rating should be increased by a factor of 6, as indicated by the exponential decay graph on page 39.

10 x 1000 µs Rating		8 x 20 µs Rating
200 watt	=	1200 watt
300 watt	=	1800 watt
600 watt	=	3600 watt
1000 watt	=	6000 watt
2000 watt	=	12000 watt

Transient Rise Times

- Typical rise times and pulse durations are given in the following table:

Description	Field Density or Magnitude	Rise Time	Pulse Duration
NEMP	50 kV/m at 500 km	5 kV/ns	1 µs
Static Discharge	20 kV at Impact Point	2 kV/ns	55 µs
Lightning	3 V/m at 10 km	600 V/µs	500 µs

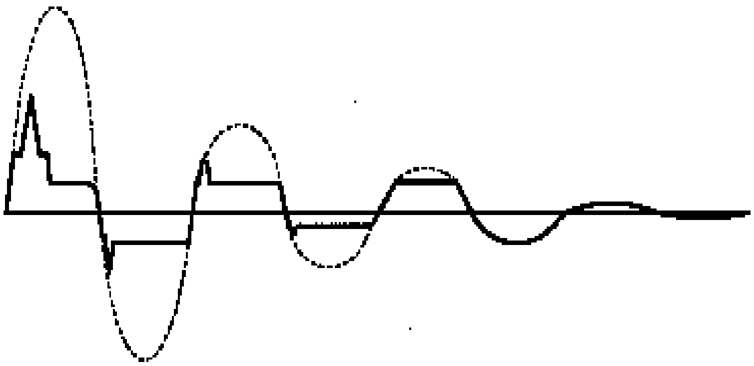
Device Response Times

- The theoretical response time of various configurations are as follows:

Uni-directional	1 psec
Bi-directional	5 nsec
Uni-directional stacked configurations	5-10 nsec
Bi-directional stacked configurations	5-10 nsec
Low Capacitance	5-10 nsec
Gas Surge Suppressor (Spark Gap)	5-nsec

Voltage Overshoot

- Volatge overshoot occures when the transient suppression circuit does not have a fast enough response time to adequately clamp the transient signal to the device’s maximum clamping voltage. This overshoot is shown in the figure below.



Factors that contribute to reduce response time are 1) impedance in series with the transient suppression device (especially inductance), 2) the internal inductance of the diode (typically 10 nH, 3) the number of PN junctions in the device assembly that require turn on, 4) the arc over voltage (such as in a spark gap surge arrestor) 5) ond others. This overshoot is especially observed for square wave pulses and combination high frequency/high voltage damped sine wave pulses.

Example: How much time is needed for a 500 volt maximum, 100 MHz damped sine wave pulse to reach the 10.5 “maximum clamping level” of a 6.8 volt Diode? Assume that the contribution from the exponential term is negligible for the initial peak.

$$V = V_o \sin(2\pi f t) \qquad 10.5 = 500 \sin (2\pi(100 \times 10^6)t]$$

$$t = \frac{\underline{\arcsin}\ \underline{(V/V_o)}}{2\pi f} \qquad t = \frac{\underline{\arcsin}\ \underline{(10.5/500)}}{2\pi(100 \times 10^6)} = 33 \text{ psec}$$

From the above device response list, it is apparent that while a uni-directional device may clamp the transient, a bi-directional or stacked device would allow some overshoot to occure. The energy contained in this overshoot would not normally be sufficient to cause damage to the electronics to be protected, but it could cause erroneous data or memory states, also known as “upset”. This is especially true for bi-directional or stacked diode configurations. Therefore, uni-directional devices are recommended for DC applications in which upset is to be prevented (typically 5 VDC data lines).

One way to reduce the overshoot is by slowing the rise time of the transient pulse. This can be done by placing a filter in front of the suppression circuitry or using lossy filter line wire.

Bi-directional or Uni-Directional?

- Alternating Current (AC) applications require the use of bi-directional devices.
- Applications in which the line has both positive and negative DC voltages require bi-directional devices.
- Direct Current (DC) applications may use either uni-directional or bi-directional devices. Some factors to consider in choosing the type of device are:

Condition	Bi-directional Recommended	Uni-directional Recommended
Upset Prevention	No	Yes
Long Opposite Going Voltage	Yes	No
Capacitance to be Minimized	Better (Low Cap Best)	OK

- For very high (25 - 200 amp and up) long duration (> 8.4 ms) transient current applications, gas surge suppression type connectors are being developed, as well as blends of the two technologies, combining the gas surge suppression devices and the diode suppression devices within the same connector. Gas surge suppression devices are bi-directional in nature. Consult the factory if your application requires such a device.

Space Applications

- The diodes are hermetically sealed (1 x 10^{-8} cc/sec; tracer flow) for reliability and long life with a material approved by NASA per their outgassing specifications. Materials with the appropriate outgassing specifications can be provided in place of the normally used connector materials. Please give application and outgassing requirements on the connector specification sheet.

Filtering/Transient Suppression Combinations

- Capacity filtering can be easily added to the transient suppression connector without increasing the overall length. Following are the standard capacitances offered, as well as the approximate cutoff frequency for systems having a relatively low impedance (≤ 50 Ω):

Capacitance	50 Ω Load	1000 Ω Load
1000 pF	6.4 MHz	3.3 MHz
2000 pF	3.2 MHz	1.7 MHz
5000 pF	1.3 MHz	.67 MHz

Due to the inductance of the wires entering and exiting the connector, the filtering effect of the feedthru capacitive filter is around 40 db/decade (see Filter Performance section following). The filtering contribution from the capacitance of the transient suppression diode can be considerable, depending on the capacitance of the diode, (See electrical characteristics tables on pages 37 and 38 for typical capacitance values). This filtering effect is most effective from 1 MHz - 1 GHz.

Above 1 GHz, the diode's internal inductance of about 10 nH, reduces the filtering effect. Additional capacitive filtering in parallel with the diode assures good signal attenuation above 1 GHz.

- Feedthru capacitance also minimizes the **Q** of the transient protected line. This **Q**, which is the ratio of the reactive impedance over the resistive impedance, is not to be confused with the previously defined damping factor Q. Both the reactive impedance and resistive impedances are measured from contact end to end. Since the inductive impedance is the major portion of the reactive component, minimizing the inductance improves the circuit **Q** and reduces the additional voltage produced by the inductive effect. This term is expressed as:

$$V(t) = L\, di/dt$$

where L is the inductance in Henry's and di/dt is the time rate of change of current. If there is any inductance behind the diode (circuit side), the additional inductive voltage contribution may significantly increase the peak transient voltage across the diode, resulting in underrating the diode and subsequent premature diode failure. If inductance is to be added to the connector line, such as in a Pi network, or LC network, it should be in front of the diode (mating side of the connector) in order to prevent this additional inductive voltage contribution.

- If a Pi network, or LC network filter (which both contain inductive elements) is required in light of the above, these can be provided by EMP Connectors. These types of networks will add to the overall length and complexity of the connector.

Filter Temperature Ratings

- Filter Operating Temperatures:
  - Low Capacitance (≤ 1000 pF) filter components: -65°C to + 175°C.
  - High Capacitance (≥ 1000 pF) filter components: -65°C to + 125°C.

Filter Storage Temperatures (all): -65°C to + 175°C.

- The capacitance of the filter is a function of the dielectric constant K of the ceramic material used, as well as the geometry of the filter. This K value is temperature dependent. It typically remains constant up to a given temperature, then begins to increase, peaking at the "Curie temperature." Above this temperature, the K value quickly drops off. For the high K value materials used in the high capacitance filters, the Curie temperature is around 125°C to 130°C. Above this temperature, the capacitance drops off and the filtering effect becomes negligible. Therefore, the maximum operating temperature for these is 125°C. The K value will return to the original values as the capacitor cools.

The low capacitance materials have Curie temperatures of 175°C and higher. Therefore, their maximum operating temperatures can be rated at the connector's maximum operating temperature of 175°C.

- If the operating temperature is lower than 125°C, higher K valued materials can be used to increase the capacitance and provide a greater filtering effect.

High Frequency Applications

- 'If the suppressor is used on DC or low frequency signal lines, the capacitance of the suppressor will not attenuate or alter the circuit conditions significantly. However, if the frequency is quite high, and insertion loss occurs, the capacitance of the transient suppression diode should be considered.' For digital signals, a cutoff frequency 5-10 times the digital frequency is recommended to prevent signal degradation.

- Methods of effectively reducing capacitance by placing low capacitance diodes in series with the transient suppression diodes have been developed by EMP Connectors (patent pending). Each of the following methods should be evaluated in the light of the application requirements.

  Low Capacitance Diodes - Paralleling two low capacitance diodes in opposite conduction directions reduces the system capacitance to around 50 pF. These diodes, when placed in series with the standard transient suppression diodes, add only a couple of volts to the maximum clamping voltage for currents up to 40 A. The additional PN junction may reduce the response time as indicated in the device response time list.

  PIN Diodes - PIN diodes have capacitances in the order of 1-2 pf each or 2-4 pF for bi-directional clamping. Due to the higher resistivity of these units, these diodes add about 2-3 volts to the maximum clamping voltage for each 10 A of peak pulse current. For 5 volt high frequency digital data lines, this would raise the peak clamping voltage from 10.5 volts to around 15 volts for a 20 A transient spike. The power contained within this transient spike should be calculated and compared verses the energy absorption capabilities of the electronic devices to be protected. The additional PN junction may reduce the response time, as indicated in the device response time list.

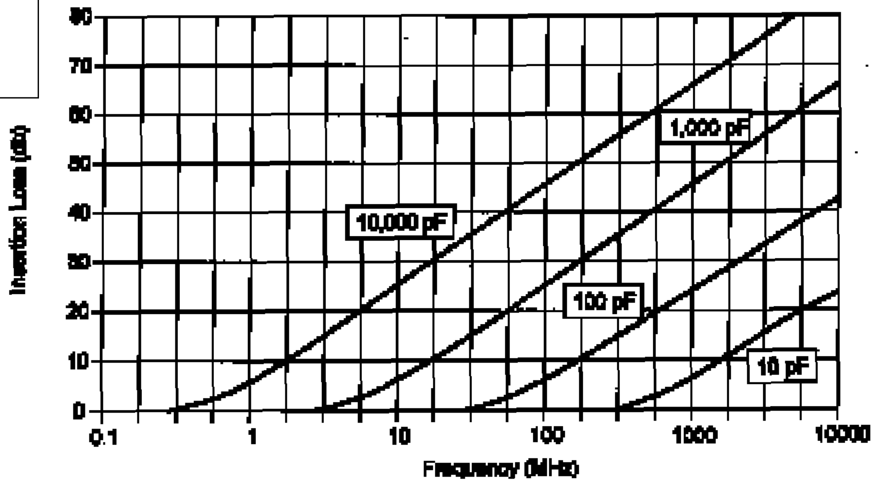
- For antenna or RF connectors, gas spark gap type connectors are currently under development which would have capacitances of less than 2 pF and have high surge current capability. Contact the factory for additional information.

Filter Performance

- The filter performance expected from several different configurations are demonstrated in the following graphs. The first is the theoretical filter curve of a purely capacitive filter. The graph demonstrates the typical 20 db per decade slope for capacitance values ranging from 10 pF to 10,000 pF with source and load resistances of 50 Ω.

Capacitance Effects on Signal Attenuation
without Cable Inductance Considerations

Feedthru Capacitance as shown	
Source Impedance:	50 Ω
Load Impedance:	50 Ω
Cable Inductance:	0 nH

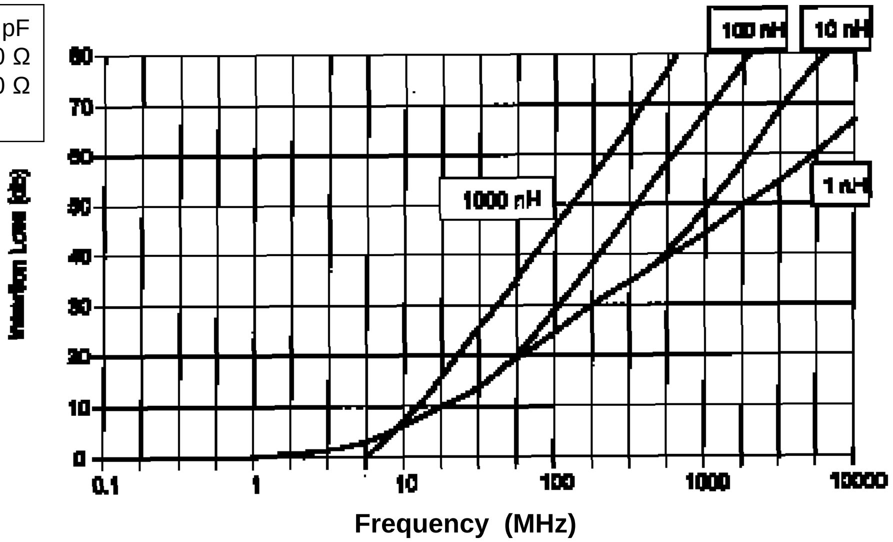


- The last chart is not real world though, when considering filtering within the context of a filter connector. This is due to the contributions of the inductance of the wires entering and exiting the connector.

- Cable inductance has a pronounced effect on the filtering curve of the capacitive filter as the next chart shows. The slopes of the curves begin at 20 db per decade and increase to 40 db per decade. The chart is for a 1000 Pf capacitive filter with various values of input and output line inductances. The effect of mismatched inductances is shown in a later example.

Cable Inductance Effects on Capacitance Filtering

Feedthru Capacitance: 1000 pF
Source Impedance: 50 Ω
Load Impedance: 50 Ω
I/O Inductance as Shown



- Values of inductance per unit length for various types of cables are shown in the following table. Six foot or longer cables are not unusual, producing line inductances greater than 1000 nH.

  The higher the rated impedance of the cable, the higher the inductance. Consult wire manufacturer for the actual values of inductance of the cables you will be using.

TYPICAL WIRE INDUCTANCES

CABLE TYPE	INDUCTANCE PER UNIT LENGTH
Between single conductors in a bundle	180 nH/ft (585 nH/M)
Singles Conductors within an overall shielded wire bundle	187 nH/ft (608 nH/m)
Coax - 50 Ω	75 nH/ft (244 nH/m)
Coax - 75 Ω	115 nH/ft (374 nH/m)
Twinax - 78 Ω	120 nH/ft (390 nH/m)
Twinax - 100 Ω	155 nH/ft (504 nH/m)

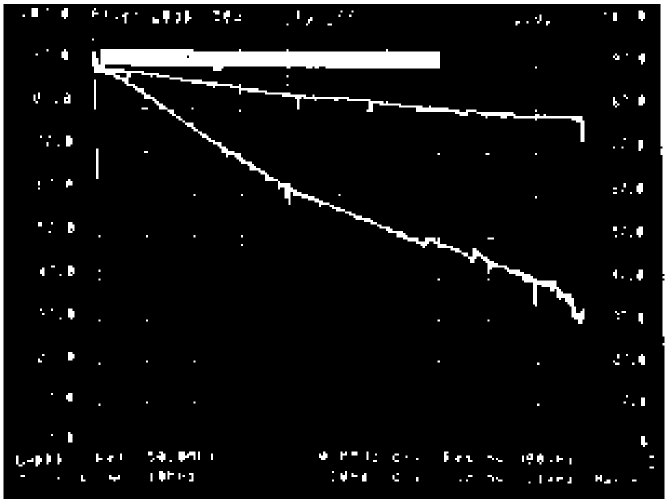
- To determine the actual filtering characteristics of the capacitive filter, use the following formula:

$$\text{Attenuation (db)} = 20 \log \left\{ 1 + \frac{1\ (Z_S\ Z_L)}{X_C\ (Z_S+Z_L)} \right\}$$

where X_C, Z_S and Z_L are complex variables.

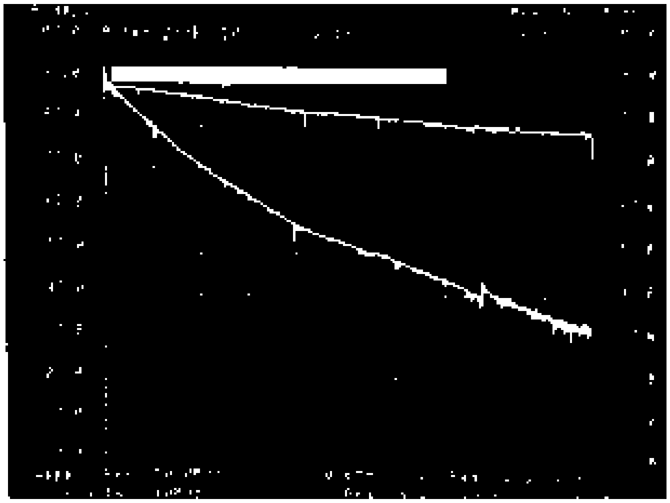
- This inductive effect is shown in the two following photographs. These photographs are of oscilloscope recordings showing the filtering effect of a ceramic capacitor element and the filtering effect due to the capacitance of a transient suppression diode. The filter connector was tested with MIL-STD-220 equipment. The upper curve in both photographs is a reference level from a straight feedthru contact. The lower curve is the output of the “filtered” contact. In both cases, the source and the load impedances are 50 Ω and the oscilloscope range shown is from 0 to 100 MHz per division. The inductance of the lines on either side of the connector (~1000 nH) causes the filter to exhibit a filtering effect around 40 db per decade.

Photograph 1. Insertion Loss from Ceramic Capacitor



Insertion loss due to the ~1000 pF capacitance of the ceramic capacitor element. The insertion loss at 10 MHz is 95 - 91 = 4 db. The insertion loss at 100 MHZ is 85 - 39 = 46 db. The slope is ~42 db per decade between 10 MHz and 100 MHz.

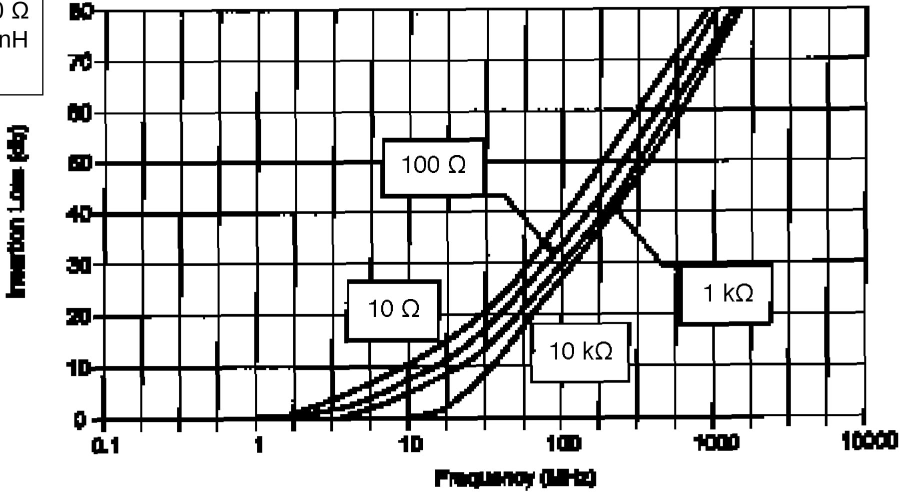
Photograph 2. Insertion Loss from Transient Suppression Diode



Insertion loss due to the ~1000 pF capacitance of a transient suppression diode. The insertion loss at 10 MHz is 95 - 87 = 8 db. The insertion loss at 100 MHZ is 85 - 39 = 46 db. The slope is ~38 db per decade between 10 MHz and 100 MHz.

Load Impedance Effects on Capacitance Filtering with 100 nH Cable Inductance

Feedthru Capacitance: 1000 pF
Source Impedance: 50 Ω
Cable Inductance: 100 nH
Load Impedance as shown



- Load impedance has an effect on the filtering curve as shown in the previous figure for load impedances of 10 Ω, 100 Ω, 1kΩ and 10 kΩ. These have differing cutoff frequencies (3 db points). The attenuation curves do not vary much above 30 db as the curves converge along a 40 db per decade slope.

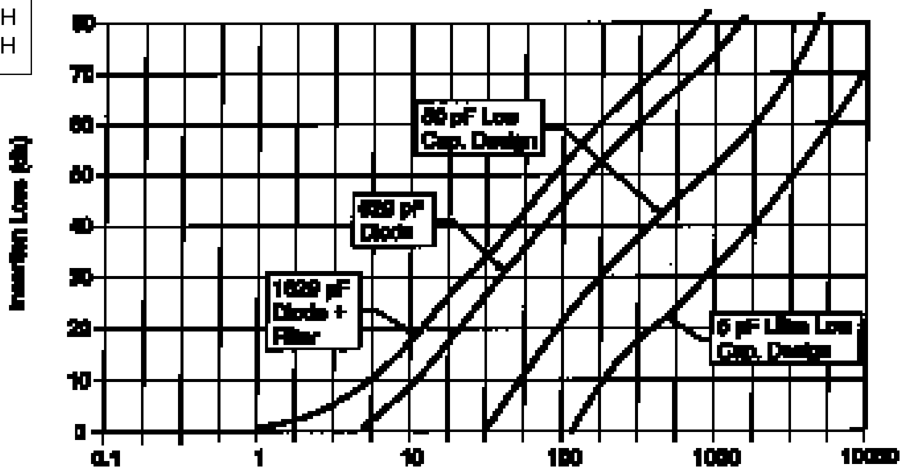
- If the line carries a high frequency digital signal, signal degradation may be minimized by designing in a cutoff frequency a decade (10 x's) above the operating frequency. The filtering effect due to the capacitance of a 6.8 v, 200 watt bi-directional diode (629 pF typical) is shown in the following example along with the increased filtering effect of adding a 1000 pF capacitive filter, and the reduced filtering effect achieved using the low capacitance and ultra low capacitance techniques developed by EMP Connectors.

  Example:

  In this example, a 5 foot cable is used for the input line (5 ft x 188 nH/ft = 940 nH) and a 1.1 foot line for the output line within the box (1.1 ft x 180 nH/ft = 198 nH). The input line has a nominal impedance of 50 Ω's, while the 1000 Ω load impedance is similar to a high impedance TTL circuit.

Feedthru Capacitance as shown	
Source Impedance:	50 Ω
Load Impedance:	1000 Ω
Input Cable Inductance:	940 nH
Output Cable Inductance:	198 nH

Various Designs Effect on the Filtering Effect of a 6.8 Volt, 200 Watt Diode



CONNECTOR CONSIDERATIONS

Designing Around Cost Factors

- A number of factors should be considered when designing connectors:

  The greater the number of cavities in the connector, the lower the cost per line, amortizing the cost of the connector shell and inserts over a greater number of cavities.
  The lower the power rating of the diodes specified, the lower the cost per line. All diode voltage ratings listed in the electrical characteristics table are available in all the power ranges shown, even though their clamping currents are not shown (i.e. all voltage ratings can be ordered in the 200 watt version if the current requirements permit their use).
  The addition of capacitive filtering marginally affects the cost per line.
  The addition of Pi network or LC type filtering affects the cost per line noticeably more than capacitance filtering.
  The greater the quantity of connectors the program will use, the lower the cost. Develop a standard connector for use throughout a program if feasible.

Receptacles are less expensive than plugs (fewer shell components).
Square flange receptacles provide more stable shell to ground conductivities than jam nut receptacles, and are less costly.
Pin contacts for the connector interface are less expensive than socket type contacts.

Connector Grounding

- A good connector ground is vital to proper operation of the transient clamping circuitry. A good bond between the connector shell and case is usually considered to be less than 2 mΩ, but the exact grounding resistance should be evaluated in terms of the clamping requirements. If used, conductive sealing gaskets between the mounting flange and panel should be capable of carrying the required total peak pulse current. This current can be calculated as:

Number of contacts in the connector:	100
Peak pulse current:	x 20 A
Grounding conductor current requirements:	2000 A

Another consideration is the inductance of the grounding pathway. 'Static discharge has a rise time of the order of 1 to 2 kV per nanosecond. This fast rise time voltage front presents some unique problems in providing adequate protection due to the grounding pathway. What would seem to be a relatively short length of wire in the transient suppression diode circuit between the protected line and ground may produce a large secondary or overshoot voltage. Voltage produced by the inductive effect is expressed as:

$$V(t) = L\, di/dt$$

where L is the inductance in Henrys and di/dt is the time rate of change of current.' The inductance between the diode and the ground plane/connector shell has been minimized in EMP Connectors' design. However, good connector shell grounding techniques must be applied by the user.

Where grounding cables are utilized between the connector and a central vehicular grounding system, such as for composite aircraft or where the metallic substrate is coated, use of a flat conductor, such as flattened braid is recommended to reduce the inductance. The conductor should be large enough to carry the total peak pulse current as shown above.

If the connector is a high density arrangement, the additional voltage drop across the grounding path that occurs during transient clamping should be determined in light of the circuit characteristics. For example, if:

Grounding resistance:	$R = .002\ \Omega$
Total pulse current:	$I_T = 2000$ A

$$V(\text{additional}) = I_T \times R = 2000 \times .002 = 4 \text{ volts}$$

The electronic system and the connector shell should share a common grounding point to minimize any additional voltage contributions from long line impedances.

Dielectric Withstanding Voltage (DWV)

- The Dielectric Withstanding Voltage given in most connector specifications is not applicable for transient suppression connectors. The maximum withstanding voltage between any two contacts is the sum of the two diode breakdown voltages.

System Testing

- Testing of a system with an in-line transient suppression connector is similar to testing a system with circuit board mounted suppression circuitry. An important item to note is that the suppression circuitry is designed to suppress transients of short duration (< 8.4 msec). If a high voltage is to be applied for any length of time to the line to locate defects in the line insulation (such as the 500 volt test for many Navy applications), a current limited voltage source should be used (< 10 mA).

Electrically Inspecting a Transient Suppression Connector

- EMP Connectors' products are 100% tested prior to leaving the factory to ensure that the proper electrical characteristics are preset. However, there will be times when a connector needs to be electrically inspected.

- Since the mode of failure of transient suppression diodes is the shorted mode, a quick check of diode integrity can be done. A resistance meter that has an open circuit voltage less than the minimum breakdown voltage of the diode circuit to be checked, should be connected between the contact and the connector shell. A low resistance reading indicates a damaged diode. A high resistance reading indicates a good diode. Use of a high voltage meter will cause the diode to conduct, giving it the erroneous appearance of being shorted.

- Clamping voltage check - Apply a current limited sine wave (10 mA at a frequency of ~10 KHz) across the contact and connector shell, observing the waveform on an oscilloscope. The sine wave should be clamped at a level between the minimum breakdown voltage level and the maximum clamping level. The sine wave input should have a greater voltage than the maximum clamping voltage to guarantee clamping. Do not apply the signal for extended periods of time, as overheating of the diode may occur.

- For slow rise time pulses, such as for the clamping voltage check above, the current may be injected and observed at the mating end of the connector. However, for testing of the connector with fast rise time pulses (such as high frequency, high voltage combination pulses), the input pulse must be applied at the connector mating end and the output clamping voltage must be read at the rear end. The circuit capacitance becomes significant for higher rise time signals and the results differ depending at which end the reading is taken.