

**NEW!**  
Two & Three  
Section Models

# MMIC REFLECTIONLESS FILTERS

50Ω DC to 21 GHz

## The Big Deal

- High Stopband rejection, up to 50 dB
- Patented design terminates stopband signals
- Pass band cut-off up to 11 GHz
- Stop band up to 26 GHz
- Excellent repeatability through IPD\* process



**X-Series**

Available in Low Pass  
& High Pass designs

## Product Overview

Mini-Circuits' **X-Series** of reflectionless filters now includes 2- and 3-section models, giving you ultra-high rejection in the stopband – up to 50 dB! Reflectionless filters employ a patented filter topology which absorbs and terminates stopband signals internally rather than reflecting them back to the source. This new capability enables unique applications for filter circuits beyond those suited to traditional approaches. Traditional filters are reflective in the stopband, sending signals back to the source at 100% power. These reflections interact with neighboring components and often result in intermodulation and other interferences. By eliminating stopband reflections, reflectionless filters can readily be paired with sensitive devices and used in applications that otherwise require circuits such as isolation amplifiers or attenuators.

### Key Features

### Advantages

Easy integration with sensitive reflective components, e.g. mixers, multipliers	Reflectionless filters absorb unwanted signals falling in filter stopband, preventing reflections back to the source. This reduces generation of additional unwanted signals without the need for extra components like attenuators, improving system dynamic range and saving board space.
High stopband rejection, up to 50 dB	Ideal for applications where suppression of strong spurious signals and intermodulation products is needed.
Enables stable integration of wideband amplifiers	Because reflectionless filters maintain good impedance in the stopband; they can be integrated with high gain, wideband amplifiers without the risk of creating instabilities in these out of band regions.
Cascadable	Reflectionless filters can be cascaded in multiple sections to provide sharper and higher attenuation, while also preventing any standing waves that could affect passband signals. Low & highpass filters can be cascaded to realize bandpass filters.
Excellent power handling in a tiny surface mount device up to 7W in passband	High power handling extends the usability of these filters to the transmit path for inter-stage filtering.
Small size, 3x3mm/ 4x4 mm/ 5x5mm QFN	Allows replacement of filter/attenuator pairs with a single reflectionless filter, saving board space.
Excellent repeatability of RF performance	Through semiconductor IPD process, X-series filters are inherently repeatable for large volume production.
Excellent stability over temperature	With ±0.3 dB variation over temperature ideal for use in wide temperature range applications without the need for additional temperature compensation.
Operating temperature up to 105°C	Suitable for operation close to high power components.

\*IPD – Integrated Passive Device, is a GaAs semiconductor process



# Reflectionless High Pass Filter

## XHF-721M+

50Ω 700 to 5000 MHz

### Features

- Match to 50Ω in the stop band, eliminates undesired reflections
- Cascadable
- Good stopband rejection, 35 dB typ.
- Temperature stable, up to 105°C
- Small size, 5 x 5 mm
- Protected by US Patents 8,392,495; 9,705,467, additional patent pending
- Protected by China Patent 201080014266.1
- Protected by Taiwan Patent I581494



Generic photo used for illustration purposes only  
CASE STYLE: DG1847

### +RoHS Compliant

The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

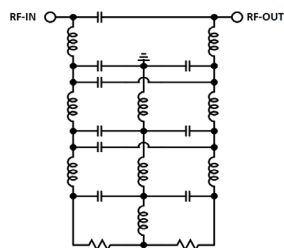
### Applications

- Cellular
- WiFi, WiMAX
- PCS, AWS, LTE B42/B43
- GPS

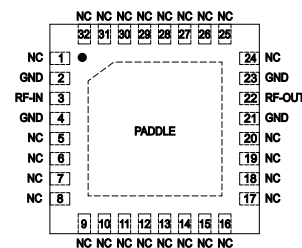
### General Description

Mini-Circuits' XHF-721M+ two-section reflectionless filter employs a novel filter topology which absorbs and terminates stop band signals internally rather than reflecting them back to the source. This new capability enables unique applications for filter circuits beyond those suited to traditional approaches. Traditional filters are reflective in the stop band, sending signals back to the source at 100% of the power level. These reflections interact with neighboring components and often result in inter-modulation and other interferences. Reflectionless filters eliminate stop band reflections, allowing them to be paired with sensitive devices and used in applications that otherwise require circuits such as isolation amplifiers or attenuators.

### simplified schematic and pad description



(each section)



Function	Pad Number	Description
RF-IN	3	RF Input Pad
RF-OUT	22	RF Output Pad
GND	2,4,21,23	Connected to ground
NC (GND Externally)	1,5-20,24-32 & paddle	No internal connection



Electrical Specifications<sup>1</sup> at 25°C

Parameter	F#	Frequency (MHz)	Min.	Typ.	Max.	Unit
Stop Band	Rejection	DC - F'	DC - 300	28	35	—
		F' - F1	300 - 450	17	30	—
	Frequency Cut-off	F2	600	—	3.0	—
	VSWR	DC - F1	DC - 450	—	1.4	—
Pass Band	Insertion Loss	F3 - F5	700 - 5000	—	0.7	2.3
	VSWR	F3 - F4	700 - 2000	—	1.1	—
		F4 - F5	2000 - 5000	—	1.7	—

<sup>1</sup> Measured on Mini-Circuits Characterization Test Board TB-944-721M+

Absolute Maximum Ratings<sup>4</sup>

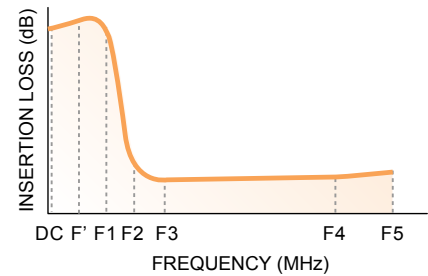
Parameter	Ratings
Operating Temperature	-55°C to +105°C
Storage Temperature	-65°C to +150°C
RF Power Input, Passband (F3-F5) <sup>2</sup>	32 dBm at 25°C
RF Power Input, Stopband (DC-F3) <sup>3</sup>	35 dBm at 25°C

<sup>2</sup> Passband rating derates linearly to 29 dBm at 105°C ambient

<sup>3</sup> Stopband rating derates linearly to 32 dBm at 105°C ambient

<sup>4</sup> Permanent damage may occur if any of these limits are exceeded.

SPECIFICATION DEFINITION

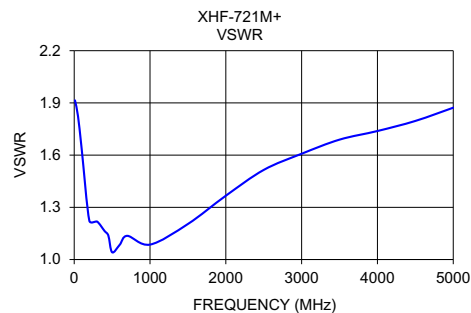
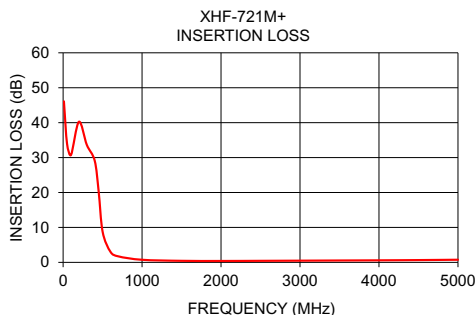


ESD rating

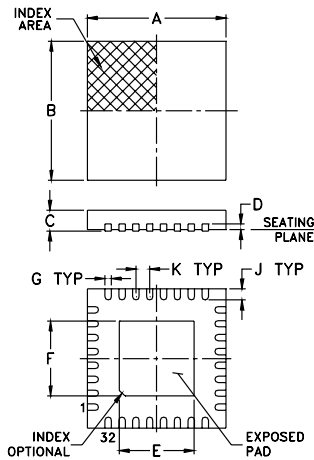
Human body model (HBM): Class 2(Pass 2000V) in accordance with ANSI/ESD 5.1-2001

Typical Performance Data at 25°C

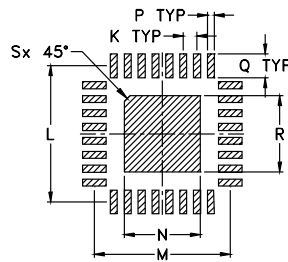
Frequency (MHz)	Insertion Loss (dB)	VSWR (:1)
10	46.11	1.91
50	33.91	1.82
100	30.74	1.63
200	40.26	1.22
300	33.64	1.22
400	29.11	1.16
450	20.33	1.14
500	8.78	1.04
600	3.01	1.08
700	1.71	1.14
1000	0.74	1.09
1500	0.44	1.20
2000	0.40	1.37
2500	0.44	1.51
3000	0.49	1.61
3500	0.54	1.69
4000	0.58	1.74
4500	0.65	1.80
5000	0.75	1.87



Outline Drawing

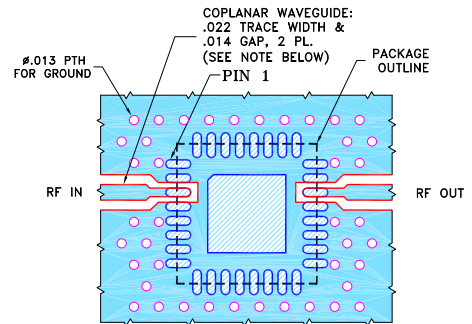


PCB Land Pattern



Suggested Layout, Tolerance to be within ±.002

Demo Board MCL P/N: TB-944-721M+  
Suggested PCB Layout: PL-518



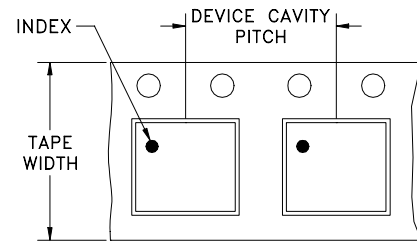
- NOTES:
- TRACE WIDTH & GAP ARE SHOWN FOR ROGERS R04350B WITH DIELECTRIC THICKNESS .010" ± .001"; COPPER: 1/2 OZ. EACH SIDE. FOR OTHER MATERIALS TRACE WIDTH MAY NEED TO BE MODIFIED.
  - BOTTOM SIDE OF THE PCB IS CONTINUOUS GROUND PLANE.
- DENOTES PCB COPPER LAYOUT WITH SMOBC (SOLDER MASK OVER BARE COPPER)
  - DENOTES COPPER LAND PATTERN FREE OF SOLDER MASK

Outline Dimensions ( inch / mm )

A	B	C MAX	C MIN	D	E	F	G	H	J
.197	.197	.039	.031	.008	.142	.142	.009	-	.016
5.00	5.00	0.99	0.79	0.20	3.61	3.61	0.23	-	0.41
K	L	M	N	P	Q	R	S		wt
.020	.193	.193	.110	.012	.035	.110	0.008		grams
0.51	4.90	4.90	2.79	0.30	0.89	2.79	0.20		0.05

Tape & Reel Packaging, F68

DEVICE ORIENTATION IN T&R



DIRECTION OF FEED

Product Marking



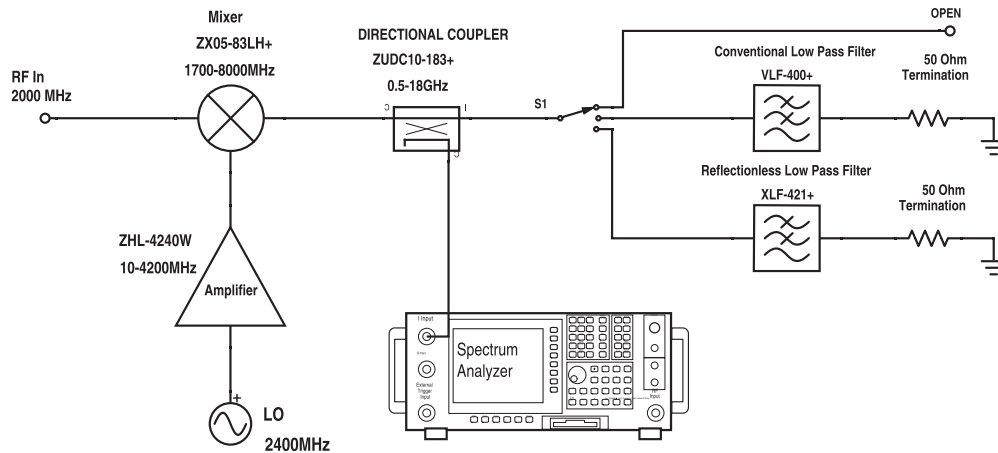
← black body  
← model family designation

Tape Width, mm	Device Cavity Pitch, mm	Reel Size, inches	Devices per Reel see note
12	8	7	Small quantity standard
			20
			50
		13	Standard
			1000
			2000
			4000

Lead Finish: Matte-Tin

## Application Circuit Example

Pairing mixers with reflectionless filters to improve system dynamic range



Test block diagram: IF output reflection spectrum with single input frequency

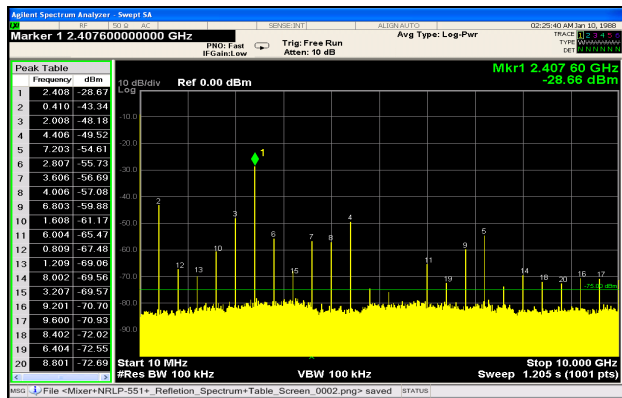


Figure 1. IF output reflection spectrum without filter

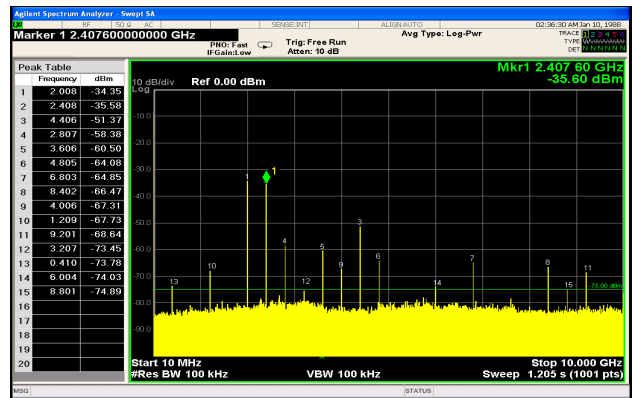


Figure 2. IF output reflection spectrum with conventional filter

An application circuit was assembled to measure the IF reflection spectrum at the output of a mixer when the mixer was paired with a conventional filter versus a reflectionless filter.

While the conventional filter reduces the reflections present when the mixer is used alone (no filter), the reflectionless filter virtually eliminates those reflections altogether.

The reflected signal at marker 1 in the figures above exhibits a reduction of more than 20 dB from -28.7 dBm to -50.3 dBm when the reflectionless filter is used as compared to the conventional filter, thus eliminating unwanted spurious mixing products and improving system dynamic range.

For more information, refer to application note [AN-75-007](#)

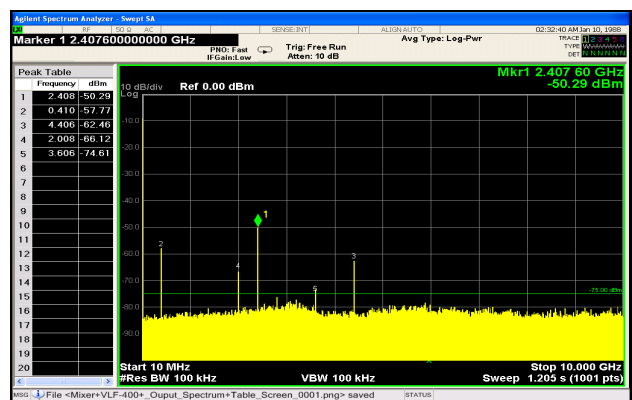


Figure 3. IF output reflection spectrum with reflectionless filter

### Additional Notes

- Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.
- Electrical specifications and performance data contained in this specification document are based on Mini-Circuits' applicable established test performance criteria and measurement instructions.
- The parts covered by this specification document are subject to Mini-Circuits standard limited warranty and terms and conditions (collectively, "Standard Terms"); Purchasers of this part are entitled to the rights and benefits contained therein. For a full statement of the Standard Terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at [www.minicircuits.com/MCLStore/terms.jsp](http://www.minicircuits.com/MCLStore/terms.jsp)

# MMIC Reflectionless High Pass Filter

# XHF-721M+

## Typical Performance Data

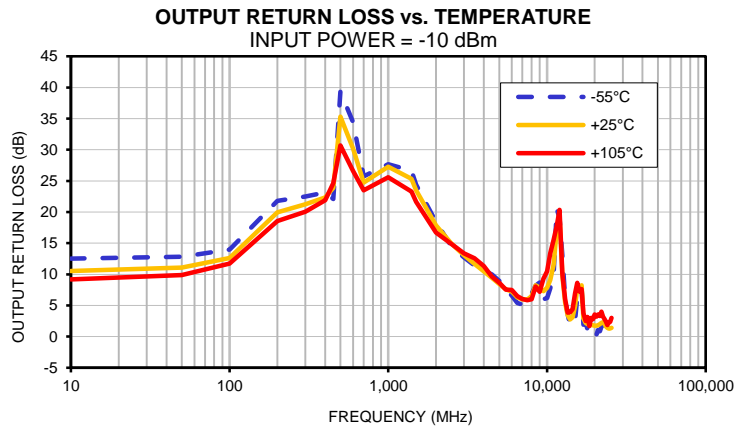
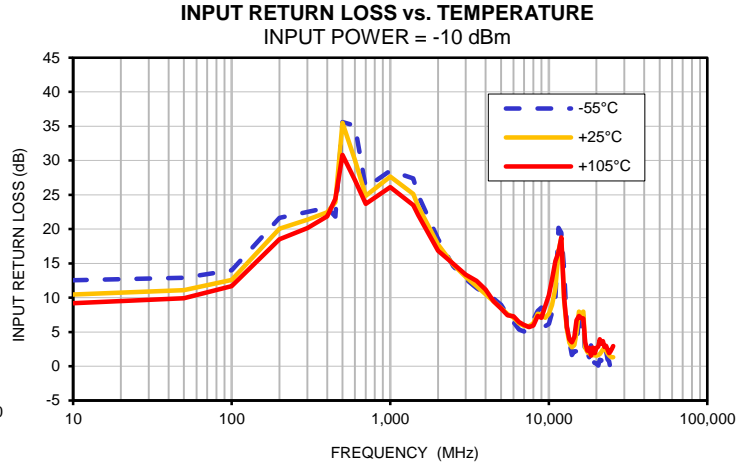
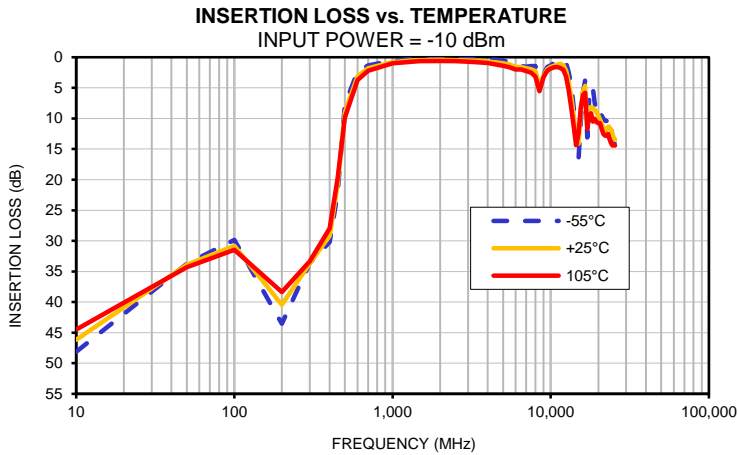
FREQ. (MHz)	INSERTION LOSS			INPUT RETURN LOSS			OUTPUT RETURN LOSS		
	(dB)			(dB)			(dB)		
	@-55°C	@25°C	@+105°C	@-55°C	@+25°C	@+105°C	@-55°C	@+25°C	@+105°C
10	48.13	46.16	44.50	12.54	10.48	9.19	12.53	10.53	9.19
50	33.72	33.92	34.32	12.88	11.07	9.90	12.83	11.06	9.89
100	29.83	30.82	31.48	13.99	12.60	11.68	13.99	12.61	11.71
200	43.54	40.43	38.35	21.63	20.07	18.51	21.80	19.97	18.56
300	33.57	33.70	33.35	22.48	21.38	20.17	22.49	21.26	20.05
400	30.22	29.21	27.98	23.13	22.47	21.88	23.12	22.33	21.88
450	22.13	20.71	19.71	21.81	23.92	24.39	22.07	23.89	24.65
500	7.75	9.00	9.86	35.62	35.50	30.82	39.32	35.31	30.69
600	2.37	3.09	3.73	35.10	30.09	27.17	34.38	30.15	26.58
700	1.32	1.78	2.18	26.03	24.85	23.70	25.74	24.73	23.47
1000	0.54	0.78	1.00	28.52	27.68	26.13	27.69	27.29	25.56
1400	0.29	0.49	0.67	27.40	25.12	23.49	26.61	25.31	23.30
1500	0.26	0.47	0.65	24.93	23.32	22.06	24.37	23.50	21.65
2000	0.20	0.42	0.61	18.56	17.75	16.86	18.42	17.86	16.72
2500	0.23	0.45	0.65	14.59	14.82	14.95	14.44	14.91	14.87
3000	0.28	0.52	0.72	12.71	13.03	13.37	12.74	13.05	13.36
3500	0.34	0.60	0.81	11.43	11.69	12.47	11.42	11.68	12.55
4000	0.39	0.71	0.94	10.51	10.49	11.19	10.56	10.49	11.33
4500	0.44	0.84	1.16	9.89	9.45	9.45	9.98	9.41	9.65
5000	0.53	1.00	1.39	8.97	8.46	8.44	8.94	8.42	8.63
5500	0.78	1.19	1.63	7.46	7.62	7.41	7.56	7.60	7.54
6000	1.22	1.57	2.01	6.42	7.11	7.29	6.61	7.23	7.50
6500	1.42	1.61	2.00	5.35	6.24	6.43	5.41	6.28	6.49
7000	1.55	1.78	2.27	5.07	5.90	6.03	5.14	5.97	6.04
7500	1.46	1.94	2.50	5.57	5.82	5.72	5.54	5.93	5.86
8000	1.43	2.27	3.19	6.77	6.26	5.94	6.87	6.48	5.99
8500	3.39	4.80	5.55	8.06	7.66	7.34	8.17	8.23	8.02
9000	2.86	2.95	3.27	8.54	7.53	7.08	8.69	7.85	7.17
9500	1.60	1.93	2.20	5.83	7.08	8.75	6.02	7.29	9.28
10000	1.35	1.60	1.84	6.15	7.64	10.35	6.20	7.84	10.48
10500	0.94	1.37	1.66	7.77	8.93	12.62	7.72	9.10	13.37
11000	0.66	1.17	1.61	9.83	11.39	15.35	10.09	11.60	15.56
11500	0.33	1.07	1.75	20.19	16.81	16.63	20.48	17.21	17.75
12000	0.52	1.29	2.07	19.49	18.72	18.78	19.04	19.30	20.33
12500	0.92	2.19	3.22	14.09	9.69	9.99	13.01	9.78	10.11
13000	2.48	4.01	5.33	5.70	5.40	5.72	6.16	5.44	5.97
13500	4.72	6.65	8.51	3.62	3.43	3.93	3.65	3.46	3.85
14000	8.59	9.85	11.54	1.62	2.76	3.47	1.78	2.78	3.91
14500	12.18	13.40	14.39	2.18	3.08	4.25	2.16	3.10	4.41
15000	16.50	14.10	12.43	2.15	4.94	6.68	2.61	4.92	6.94
15500	10.41	8.74	8.29	7.77	7.99	7.35	6.30	7.81	8.65
16000	5.79	5.67	6.23	5.84	7.57	7.02	6.52	7.46	7.25
16500	3.78	4.68	5.80	7.36	7.97	6.99	7.94	8.26	7.65
17000	13.09	11.38	11.68	1.21	2.72	3.46	1.91	2.88	3.73
17500	6.82	8.36	9.62	1.84	2.08	2.28	2.24	2.20	2.49
18000	6.97	8.12	9.16	1.32	1.84	2.67	1.16	2.01	3.16
18500	5.04	8.27	10.53	3.07	1.71	1.54	1.74	1.90	1.68
19000	7.47	8.60	10.05	0.78	1.63	2.70	1.41	1.84	3.00
19500	8.97	9.04	10.61	0.45	1.56	1.91	0.50	1.79	2.78
20000	10.13	9.56	10.75	0.40	1.56	2.66	0.47	1.75	3.57
20500	10.49	10.14	10.78	0.09	1.62	2.87	0.33	1.75	3.19
21000	9.52	10.80	11.65	0.94	1.78	3.92	1.05	1.80	3.53
21500	10.06	11.55	12.55	0.82	2.10	3.25	0.87	2.00	3.30
22000	10.35	12.16	12.80	1.90	2.47	3.66	1.62	2.22	4.00
22500	10.41	11.88	12.86	2.72	2.66	2.81	1.88	2.31	3.19
23000	9.75	11.34	12.54	2.33	2.35	2.98	1.87	2.01	2.78
23500	10.22	11.39	13.27	0.99	1.90	2.47	1.42	1.65	2.44
24000	11.40	11.85	13.98	0.74	1.56	1.90	0.38	1.40	1.88
24500	13.34	12.49	14.43	-0.24	1.39	2.11	0.29	1.28	2.28
25000	13.82	13.09	14.38	0.17	1.30	2.54	0.21	1.29	2.35
25500	14.21	13.51	14.41	0.07	1.32	2.93	0.13	1.41	2.99
26000	14.00	13.56	13.83	0.07	1.51	3.60	0.05	1.72	4.05



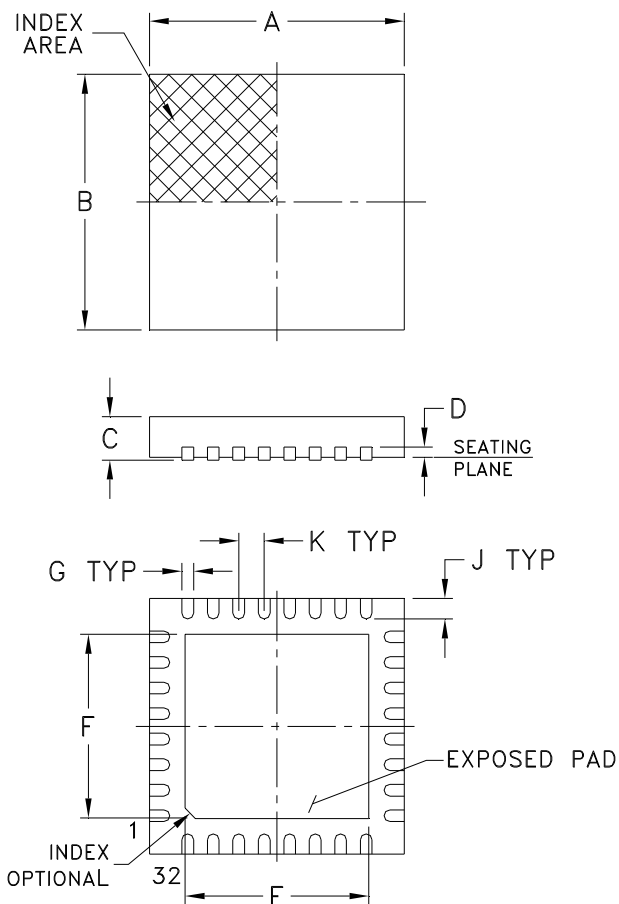
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 • Fax (718) 332-4661 For detailed performance specs & shopping online see Mini-Circuits web site  
 The Design Engineers Search Engine Provides ACTUAL Data Instantly From MINI-CIRCUITS At: [www.minicircuits.com](http://www.minicircuits.com)

REV. OR  
 XHF-721M+  
 7/14/2017  
 Page 1 of 1

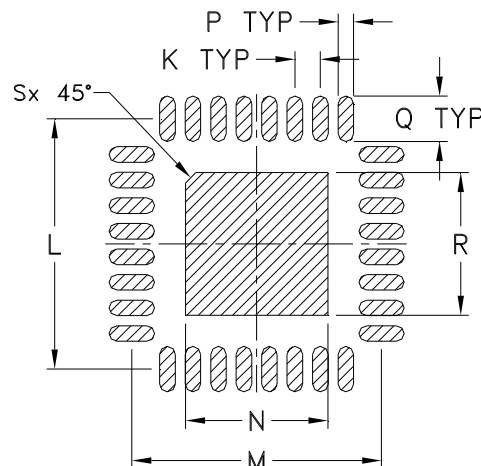
## Typical Performance Curves



### Outline Dimensions



### PCB Land Pattern



Suggested Layout,  
Tolerance to be within  $\pm .002$

CASE #	A	B	C MAX	C MIN	D	E	F	G	H	J
DG1677-2	.197 (5.00)	.197 (5.00)	.039 (1.00)	.031 (0.80)	.008 (0.20)	.142 (3.60)	.142 (3.60)	.009 (0.23)	- -	.016 (0.40)
CASE #	K	L	M	N	P	Q	R	S	WT. GRAM	
DG1677-2	.020 (0.50)	.193 (4.90)	.193 (4.90)	.110 (2.79)	.012 (0.30)	.035 (0.89)	.110 (2.79)	.008 (0.20)	.05	

Dimensions are in inches (mm). Tolerances: 2 Pl.  $\pm .01$ ; 3 Pl.  $\pm .005$

#### Notes:

- Case material: Plastic.
- Termination finish:

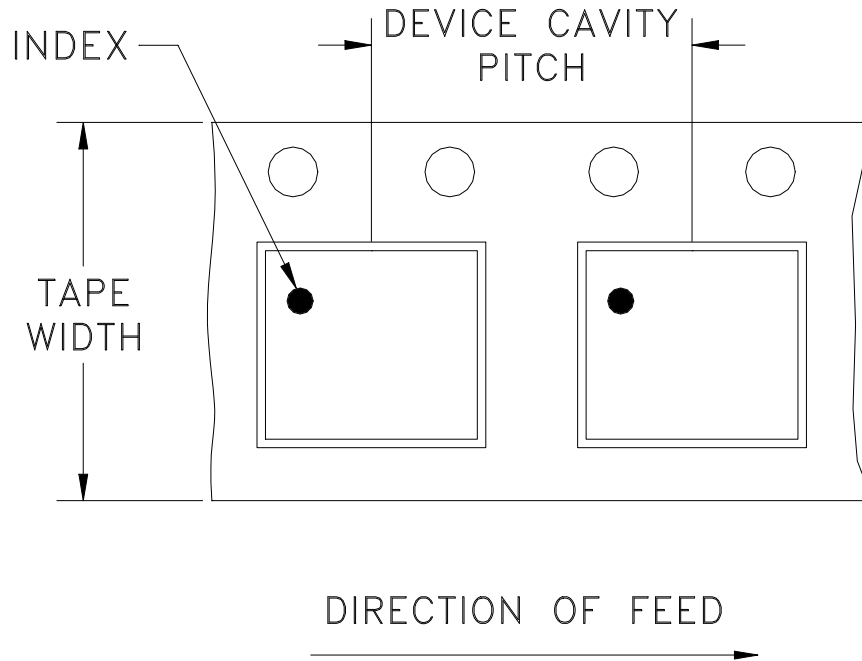
For RoHS Case Styles: Tin-Silver alloy plate over Nickel barrier transitioning to Matte-Tin.  
All models, (+) suffix. See Data sheet.

For RoHS-5 Case Styles: Tin-Lead plate. All models, no (+) suffix.



# Tape & Reel Packaging TR-F68

## DEVICE ORIENTATION IN T&R



Tape Width, mm	Device Cavity Pitch, mm	Reel Size, inches	Devices per Reel see note	
12	8	7	Small quantity standard	20
				50
				100
				200
				500
		7	Standard	1000
		13	Standard	2000
				3000
				4000

Mini-Circuits carrier tape materials provide protection from ESD (Electro-Static Discharge) during handling and transportation. Tapes are static dissipative and comply with industry standards EIA-481/EIA-541.

Go to: [www.minicircuits.com/pages/pdfs/tape.pdf](http://www.minicircuits.com/pages/pdfs/tape.pdf)



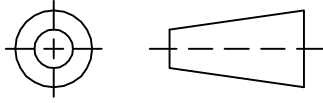
INTERNET <http://www.minicircuits.com>

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Distribution Centers NORTH AMERICA 800-654-7949 • 417-335-5935 • Fax 417-335-5945 • EUROPE 44-1252-832600 • Fax 44-1252-837010

Mini-Circuits ISO 9001 & ISO 14001 Certified

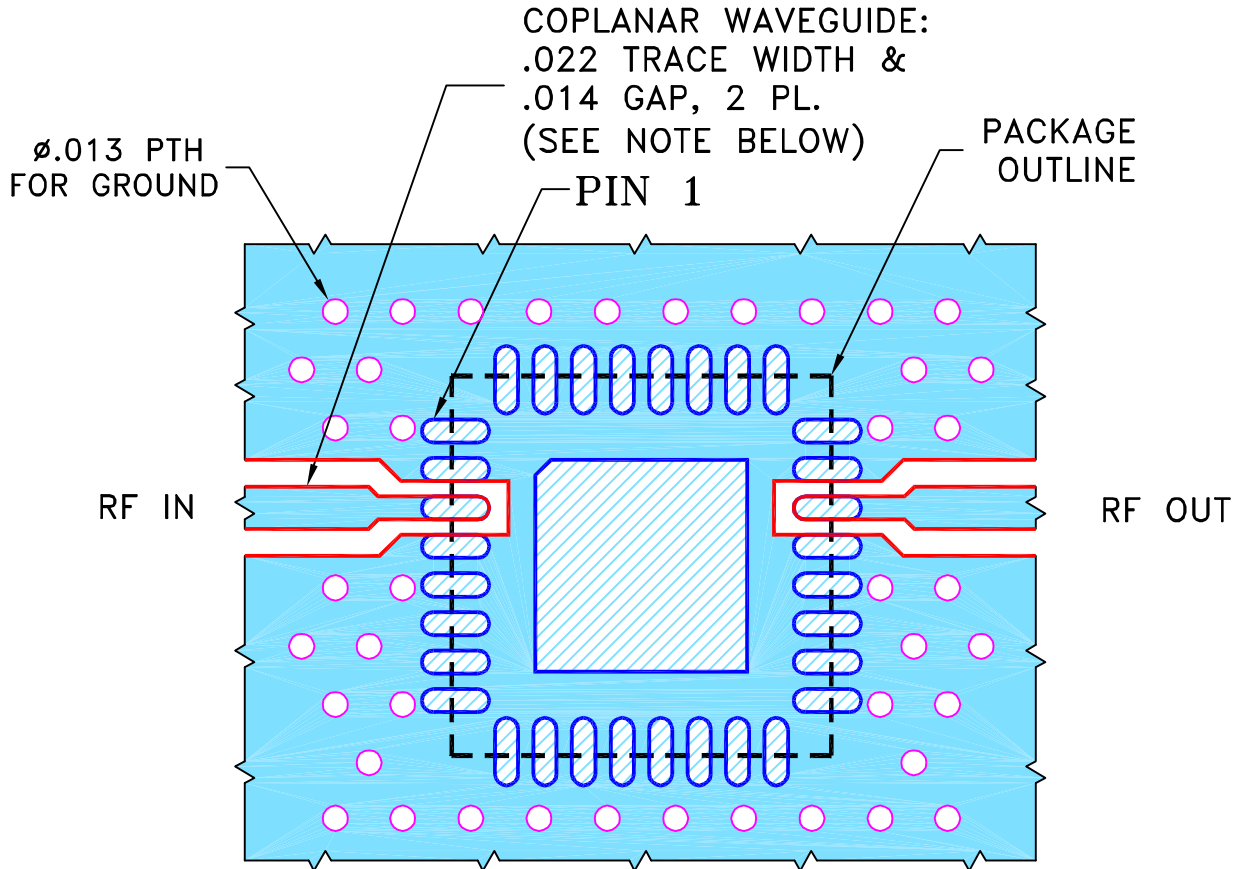
THIRD ANGLE PROJECTION



REVISIONS

REV	ECN No.	DESCRIPTION	DATE	DR	AUTH
OR	M162495	NEW RELEASE	06/15/17	GF	RS

SUGGESTED MOUNTING CONFIGURATION FOR  
DG1677-2 CASE STYLE, "32FL01" PIN CONNECTION



**NOTES:**

- TRACE WIDTH & GAP ARE SHOWN FOR ROGERS RO4350B WITH DIELECTRIC THICKNESS .010" ± .001"; COPPER: 1/2 OZ. EACH SIDE. FOR OTHER MATERIALS TRACE WIDTH MAY NEED TO BE MODIFIED.
- BOTTOM SIDE OF THE PCB IS CONTINUOUS GROUND PLANE.

- DENOTES PCB COPPER LAYOUT WITH SMOBC (SOLDER MASK OVER BARE COPPER)
- DENOTES COPPER LAND PATTERN FREE OF SOLDER MASK

UNLESS OTHERWISE SPECIFIED	INITIALS	DATE
DRAWN	GF	06/14/17
CHECKED	IL	06/15/17
APPROVED	RS	06/15/17

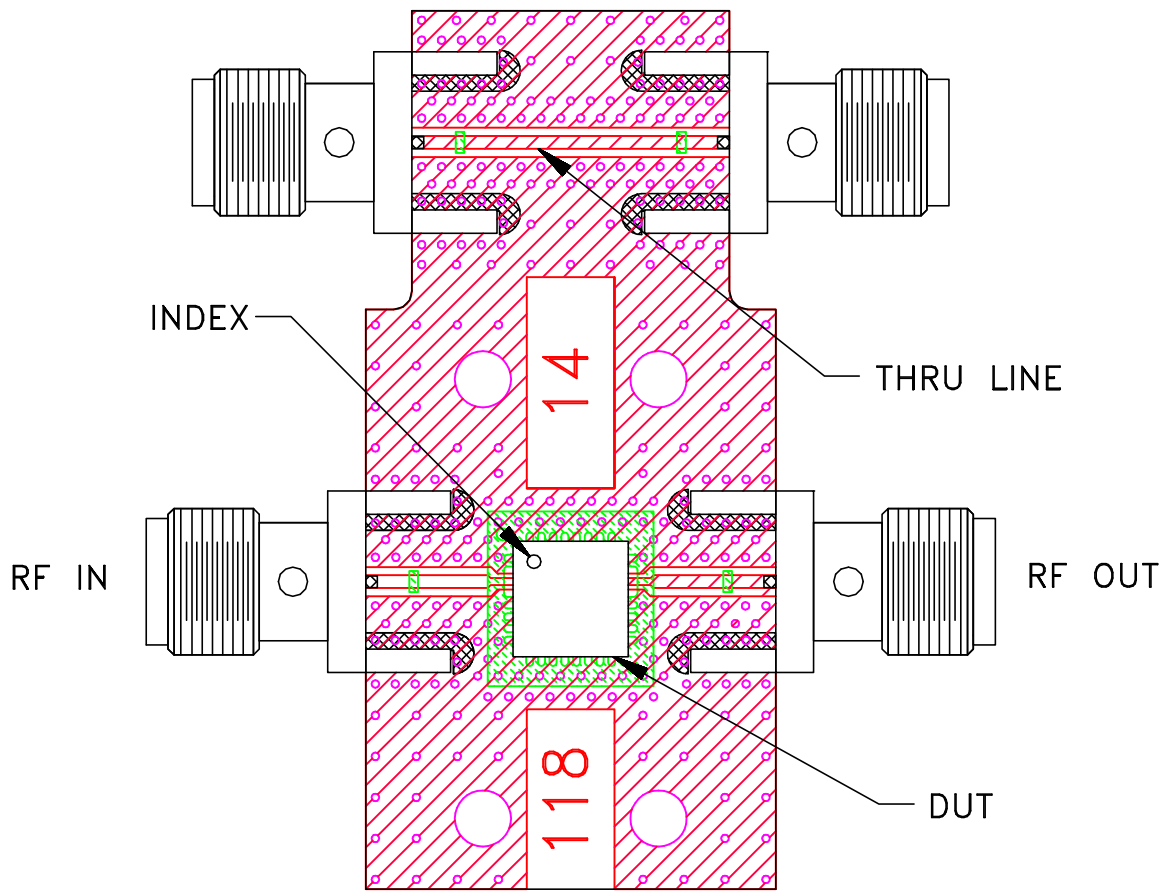
**Mini-Circuits®** 13 Neptune Avenue  
Brooklyn NY 11235

PL, 32FL01, DG1677-2, TB-944+

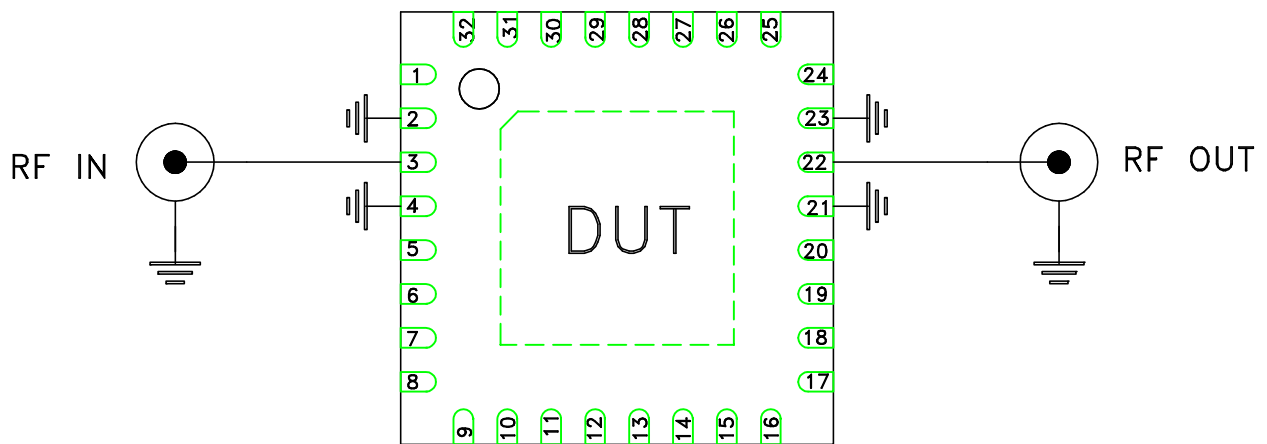
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SIZE	CODE IDENT	DRAWING NO:	REV:
A	15542	98-PL-518	OR
FILE:	98PL518	SCALE:	10:1
SHEET:	1	OF	1

# Evaluation Board and Circuit



TB-944-721M+




PINS 1,5-8,9-20,24-32 - NOT CONNECTED.

Schematic Diagram

## Notes:

1. 50 Ohm SMA Female connectors.
2. PCB Material: R04350 or equivalent,  
Dielectric Constant=3.5, Thickness=.010 inch.

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All Mini-Circuits products are manufactured under exacting quality assurance and control standards, and are capable of meeting published specifications after being subjected to any or all of the following physical and environmental test.

Specification	Test/Inspection Condition	Reference/Spec
Operating Temperature	-55° to 105°C Ambient Environment	Individual Model Data Sheet
Storage Temperature	-65° to 150° C Ambient Environment	Individual Model Data Sheet
Autoclave	15 psig, 100% RH, 121°C, 96 hours	JESD22-A102-C, Condition C
Temperature Cycling	-65° to 150°C, 100 cycles	JESD22-A104
Temperature Humidity	85°C/ 85% RH, 168 hours	JESD22-113
Solder Reflow Heat	Sn-Pb Eutetic Process: 240°C peak Pb-Free Process: 260°C peak	J-STD-020, Table 4-1, 4-2 and 5-2; Figure 5-1
Moisture Sensitivity: Level 1	Bake at 125°C for 24 hours Soak at 85°C/85% RH for 168 hours, Reflow 3 cycles at 240°C peak (Non-RoHS) or 260°C (RoHS)	J-STD-020C
Solderability	10X magnification, 95% coverage	JESD22-B102, Method 1: Dip and Look Test
Marking Resistance to Solvents	Isopropyl alcohol + mineral spirits at 25°C; terpene defluxer at 25°C; distilled water + proylene glycol monomethyl ether + monoethanolamine at 63°C to 70°C	MIL-STD-202, Method 215