

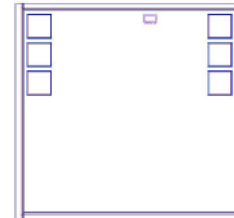
MMIC

# REFLECTIONLESS FILTER DICE

50Ω DC to 21 GHz

## The Big Deal

- Patented design eliminates in band spurs
- Pass band cut-off up to 21 GHz
- Stop band up to 35 GHz
- Excellent repeatability through IPD\* process
- Unpackaged Die Form



**X-Series**

Available in Low Pass, High Pass and Band Pass designs

## Product Overview

Mini-Circuits' X-Series reflectionless filters employ 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 which interact with neighboring components and often result in intermodulation 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 isolators, isolation amplifiers or attenuators.

### Key Features

Easy integration with sensitive reflective components, e.g. mixers, multipliers

Enables stable integration of wideband amplifiers

Cascadable

Excellent power handling in a tiny surface mount device

Excellent repeatability of RF performance

Excellent stability over temperature

Operating Temperature up to 105°C

Unpackaged Die form

### Advantages

Reflectionless filters absorb unwanted signals, 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.

Because reflectionless filters maintain good impedance in the stop band; they can be integrated with high gain, wideband amplifiers without the risk of creating instabilities in these out of band regions.

Reflectionless filters can be cascaded in multiple sections to provide sharper and higher attenuation, while also preventing any standing waves that could affect pass band signals.

High power handling extends the usability of these filters to the transmit path for inter-stage filtering.

Through semiconductor IPD process, X-series filters are inherently repeatable for large volume production.

With  $\pm 0.3$  dB variation over temperature ideal for use in wide temperature range applications without the need for additional temperature compensation.

Suitable for operation close to high power components

Enables direct integration into customer hybrids

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



# Reflectionless Low Pass Filter Die

## XLF-962-D+

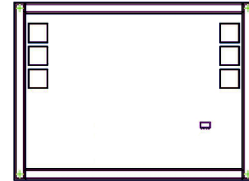
50Ω DC to 9600 MHz

### Features

- Match to 50Ω in the stop band, eliminates undesired reflections
- Cascadable
- Excellent Power handling
- Protected by US Patent No. 8,392,495

### Applications

- Harmonics Rejection
- Satellite
- Radar
- Military & Space



#### +RoHS Compliant

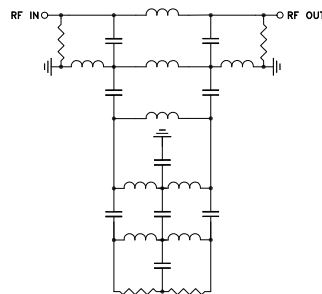
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Ordering Information: Refer to Last Page

### General Description

Mini-Circuits' XLF-962-D+ reflectionless filter die 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



Pad	Description
RF-IN	RF Input Pad
RF-OUT	RF Output Pad
Ground	Ground Bonding Pad

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

Parameter		F#	Frequency (MHz)	Min.	Typ.	Max.	Unit
Pass Band	Insertion Loss	DC - F1	DC-9600		1.4		dB
	Frequency Cut-off	F2	12400		3.0		dB
	VSWR	DC - F1	DC-9600		1.2		:1
Stop Band	Rejection	F3 - F4	14800 - 16000		14		dB
		F4 - F5	16000 - 25200		20		dB
	VSWR	F3 - F4	14800 - 16000		1.3		:1
		F4 - F5	16000 - 25200		2.4		:1

<sup>1</sup> Measured on Mini-Circuits Characterization test board. Die packaged in 3mm x 3mm, 12-lead MCLP package and soldered on TB-844-962+

**Absolute Maximum Ratings<sup>1,4</sup>**

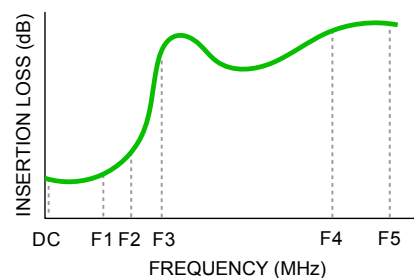
Parameter	Ratings
Operating Temperature	-55°C to +105°C
RF Power Input, Passband (DC-F1) <sup>2</sup>	2W at 25°C
RF Power Input, Stopband (F2-F5) <sup>3</sup>	80mW at 25°C

<sup>2</sup> Passband rating derates linearly to 1W at 105°C ambient

<sup>3</sup> Stopband rating derates linearly to 40mW at 105°C ambient

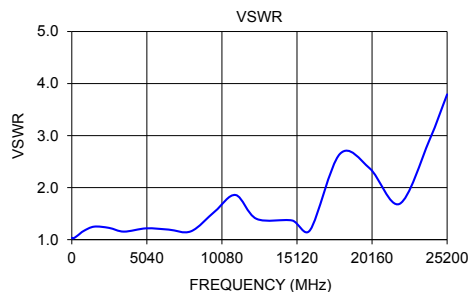
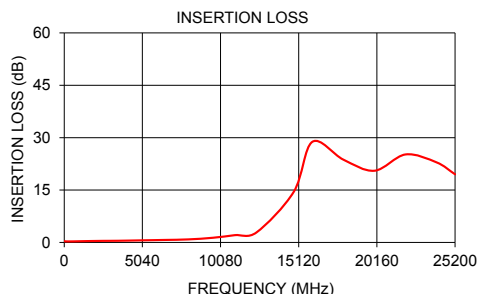
<sup>4</sup> Permanent damage may occur if any of these limits are exceeded.

**Specification Definition**



**Typical Performance Data at 25°C<sup>1</sup>**

Frequency (MHz)	Insertion Loss (dB)	VSWR (:1)
10	0.38	1.04
100	0.31	1.02
400	0.30	1.08
800	0.33	1.17
1500	0.39	1.25
2500	0.46	1.23
3500	0.49	1.16
5000	0.61	1.22
6500	0.72	1.19
8000	0.88	1.16
9600	1.35	1.54
11000	2.10	1.86
12400	2.89	1.40
14800	14.50	1.37
16000	28.82	1.18
18000	23.70	2.65
20000	20.53	2.37
22000	25.19	1.69
24000	22.94	2.90
25200	19.51	3.79



**Die Layout**

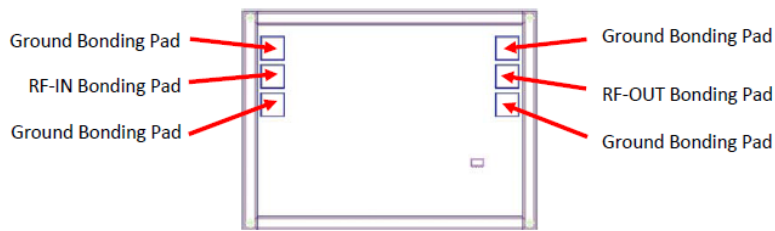


Fig 1. Die Layout

**Bonding Pad Position**  
(Dimensions in  $\mu\text{m}$ , Typical)

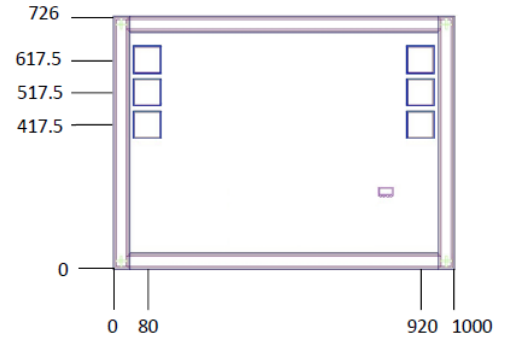


Fig 2. Bonding Pad Positions

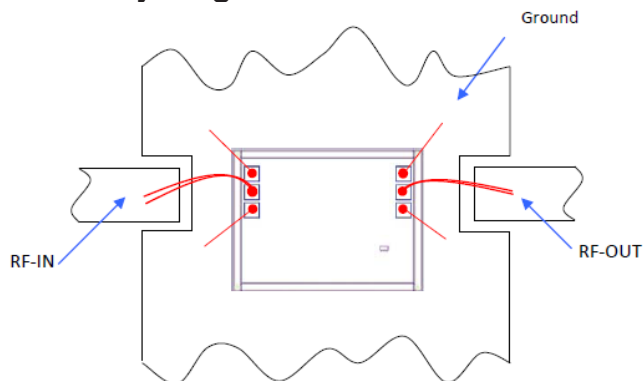
**Critical Dimensions**

Parameter	Values
Die Thickness, $\mu\text{m}$	100
Die Width, $\mu\text{m}$	1000
Die Length, $\mu\text{m}$	726
Bond Pad Size (Ground pad), $\mu\text{m}$	75 x 75

## Assembly and Handling Procedure

1. Storage  
Dice should be stored in a dry nitrogen purged desiccators or equivalent.
2. ESD  
MMIC Gallium Arsenide (GaAs) filter dice are susceptible to electrostatic and mechanical damage. Die are supplied in antistatic protected material, which should be opened in clean room conditions at an appropriately grounded anti-static workstation. Devices need careful handling using correctly designed collets, vacuum pickup tips or sharp antistatic tweezers to deter ESD damage to dice.
3. Die Attach  
The die mounting surface must be clean and flat. Using conductive silver filled epoxy, recommended epoxies are DieMat DM6030Hk-PT/H579/H579 or Ablestik 84-1LMISR4. Apply sufficient epoxy to meet required epoxy bond line thickness, epoxy fillet height and epoxy coverage around total die periphery. Parts shall be cured in a nitrogen filled atmosphere per manufacturer's cure condition. It is recommended to use antistatic die pick up tools only.
4. Wire Bonding  
Bond pad openings in the surface passivation above the bond pads are provided to allow wire bonding to the dice gold bond pads. Thermosonic bonding is used with minimized ultrasonic content. Bond force, time, ultrasonic power and temperature are all critical parameters. Suggested wire is pure gold, 1 mil diameter. Bonds must be made from the bond pads on the die to the package or substrate. All bond wires should be kept as short as low as reasonable to minimize performance degradation due to undesirable series inductance.

## Assembly Diagram



### Recommended Wire Length, Typical

Wire	Wire Length (mm)	Wire Loop Height (mm)
All wires	1.0	0.15

Note: Use double bond wire at RF IN & RF OUT



Typical Performance Data

FREQ.  (MHz)	INSERTION LOSS					GROUP DELAY				
	(dB)					(nsec)				
	@-55°C	@-40°C	@+25°C	@+85°C	@+105°C	@-55°C	@-40°C	@+25°C	@+85°C	@+105°C
10	0.34	0.33	0.38	0.41	0.40	0.12	0.13	0.09	0.09	0.11
50	0.28	0.29	0.33	0.34	0.36	0.08	0.08	0.06	0.06	0.07
100	0.26	0.28	0.32	0.34	0.35	0.05	0.05	0.05	0.05	0.05
200	0.25	0.26	0.31	0.33	0.34	0.05	0.05	0.04	0.05	0.05
300	0.23	0.24	0.31	0.33	0.34	0.05	0.05	0.04	0.04	0.04
400	0.22	0.23	0.30	0.32	0.34	0.05	0.05	0.04	0.04	0.04
500	0.22	0.24	0.31	0.35	0.35	0.05	0.05	0.04	0.04	0.04
600	0.22	0.24	0.32	0.35	0.36	0.05	0.05	0.04	0.04	0.04
700	0.23	0.25	0.34	0.37	0.38	0.05	0.05	0.04	0.04	0.04
800	0.22	0.25	0.35	0.38	0.39	0.05	0.05	0.04	0.04	0.04
900	0.23	0.25	0.36	0.39	0.40	0.05	0.05	0.04	0.04	0.04
1000	0.23	0.25	0.37	0.39	0.42	0.05	0.05	0.04	0.04	0.04
1200	0.24	0.27	0.39	0.42	0.44	0.05	0.05	0.04	0.04	0.04
1400	0.25	0.28	0.41	0.45	0.46	0.04	0.04	0.04	0.04	0.04
1600	0.26	0.29	0.43	0.47	0.48	0.04	0.04	0.04	0.04	0.04
1800	0.28	0.30	0.44	0.47	0.49	0.05	0.04	0.04	0.04	0.04
2000	0.27	0.31	0.45	0.48	0.50	0.04	0.04	0.04	0.04	0.04
3000	0.28	0.32	0.50	0.54	0.55	0.05	0.05	0.04	0.04	0.04
4000	0.29	0.33	0.54	0.61	0.63	0.05	0.05	0.04	0.04	0.04
5000	0.33	0.38	0.63	0.72	0.76	0.05	0.05	0.04	0.04	0.04
6000	0.39	0.45	0.71	0.82	0.87	0.05	0.05	0.05	0.04	0.04
7000	0.42	0.49	0.78	0.92	0.96	0.05	0.05	0.05	0.05	0.05
8000	0.46	0.54	0.89	1.06	1.13	0.06	0.06	0.05	0.05	0.05
8200	0.49	0.56	0.92	1.10	1.17	0.06	0.06	0.05	0.05	0.05
8400	0.52	0.59	0.97	1.15	1.22	0.06	0.06	0.05	0.05	0.05
8600	0.55	0.63	1.01	1.20	1.27	0.06	0.06	0.05	0.05	0.05
8800	0.59	0.68	1.06	1.26	1.33	0.06	0.06	0.06	0.06	0.05
9000	0.65	0.73	1.12	1.32	1.40	0.06	0.06	0.06	0.06	0.06
9200	0.72	0.80	1.19	1.39	1.47	0.06	0.06	0.06	0.06	0.06
9400	0.81	0.89	1.27	1.47	1.55	0.06	0.06	0.06	0.06	0.06
9600	0.90	0.99	1.35	1.56	1.64	0.07	0.06	0.06	0.06	0.06
9800	1.01	1.09	1.46	1.67	1.75	0.06	0.06	0.06	0.06	0.06
10000	1.10	1.19	1.57	1.78	1.86	0.06	0.06	0.06	0.06	0.06
10500	1.33	1.43	1.84	2.09	2.17	0.06	0.06	0.06	0.06	0.06
11000	1.47	1.58	2.10	2.40	2.49	0.07	0.07	0.07	0.07	0.07
11500	1.59	1.71	2.31	2.68	2.80	0.08	0.08	0.08	0.07	0.07
12000	1.78	1.92	2.56	2.97	3.11	0.09	0.10	0.09	0.09	0.09
12400	2.06	2.20	2.87	3.33	3.49	0.11	0.11	0.10	0.10	0.11
13000	2.82	2.99	3.76	4.35	4.55	0.13	0.13	0.13	0.13	0.12
13500	4.01	4.22	5.18	5.94	6.18	0.15	0.15	0.14	0.14	0.14
14000	6.10	6.39	7.63	8.62	8.94	0.16	0.16	0.15	0.15	0.15
14200	7.28	7.60	8.98	10.07	10.45	0.17	0.16	0.15	0.15	0.14
14400	8.70	9.04	10.57	11.76	12.17	0.17	0.16	0.15	0.14	0.14
14600	10.36	10.72	12.37	13.67	14.08	0.16	0.16	0.14	0.13	0.13
14800	12.30	12.70	14.43	15.82	16.23	0.16	0.16	0.14	0.13	0.11
15000	14.54	14.95	16.72	18.14	18.60	0.15	0.14	0.12	0.10	0.09
15100	15.80	16.19	17.97	19.42	19.92	0.13	0.13	0.10	0.08	0.08
15200	17.07	17.49	19.29	20.74	21.16	0.13	0.11	0.09	0.07	0.06
15300	18.47	18.91	20.67	22.06	22.50	0.11	0.10	0.08	0.05	0.05
15400	19.92	20.35	22.08	23.41	23.83	0.09	0.08	0.06	0.04	0.03
15500	21.43	21.87	23.48	24.74	25.10	0.06	0.06	0.03	0.01	0.01
15600	22.95	23.34	24.86	25.93	26.35	0.03	0.03	0.01	0.00	-0.02
15700	24.48	24.78	26.14	27.06	27.38	-0.01	-0.01	-0.03	-0.02	-0.01
15800	25.86	26.12	27.29	28.03	28.25	-0.05	-0.04	-0.03	-0.03	-0.02
15900	27.08	27.30	28.16	28.65	28.91	-0.06	-0.06	-0.03	0.00	0.02
16000	27.93	28.10	28.76	29.20	29.40	-0.06	-0.06	-0.03	0.03	0.04
17000	27.10	27.17	27.74	28.04	28.14	0.21	0.21	0.21	0.21	0.21
18000	23.34	23.43	23.67	23.74	23.80	0.13	0.13	0.11	0.11	0.11
19000	20.51	20.62	21.50	21.86	22.04	0.10	0.09	0.08	0.08	0.07
20000	19.51	19.61	20.44	20.99	21.26	0.11	0.11	0.10	0.09	0.08
21000	20.19	20.37	21.20	21.97	22.24	0.13	0.14	0.13	0.13	0.13
22000	23.61	24.02	25.33	26.48	26.91	0.19	0.21	0.20	0.22	0.23
23000	26.14	26.42	27.15	27.59	27.82	0.25	0.25	0.28	0.24	0.27
24000	21.50	21.68	22.87	23.08	23.10	0.13	0.14	0.11	0.10	0.10
25000	19.07	19.14	19.92	20.48	20.71	0.08	0.07	0.06	0.05	0.05
25200	18.87	18.86	19.38	19.97	20.20	0.06	0.06	0.05	0.05	0.05
26000	17.81	17.81	17.38	17.75	18.00	0.03	0.03	0.06	0.06	0.06
27000	15.34	15.47	15.69	15.74	15.78	0.05	0.05	0.07	0.06	0.08
28000	12.91	13.13	14.75	15.42	15.61	0.09	0.09	0.04	0.03	0.03
29000	13.34	13.37	13.79	14.66	15.09	0.04	0.04	0.04	0.04	0.02
30000	13.44	13.52	13.11	13.32	13.51	0.04	0.03	0.06	0.05	0.05
31000	12.11	12.34	13.31	13.19	13.02	0.05	0.05	0.03	0.05	0.05
32000	11.22	11.47	13.67	14.32	14.45	0.11	0.11	0.02	0.02	0.03
33000	12.98	12.99	13.77	15.11	15.67	0.02	0.01	0.02	0.00	0.01
34000	14.26	14.27	13.36	14.54	15.24	-0.01	0.00	0.02	0.02	0.01
35000	13.73	13.86	13.10	13.19	13.43	0.00	0.00	0.03	0.01	0.01



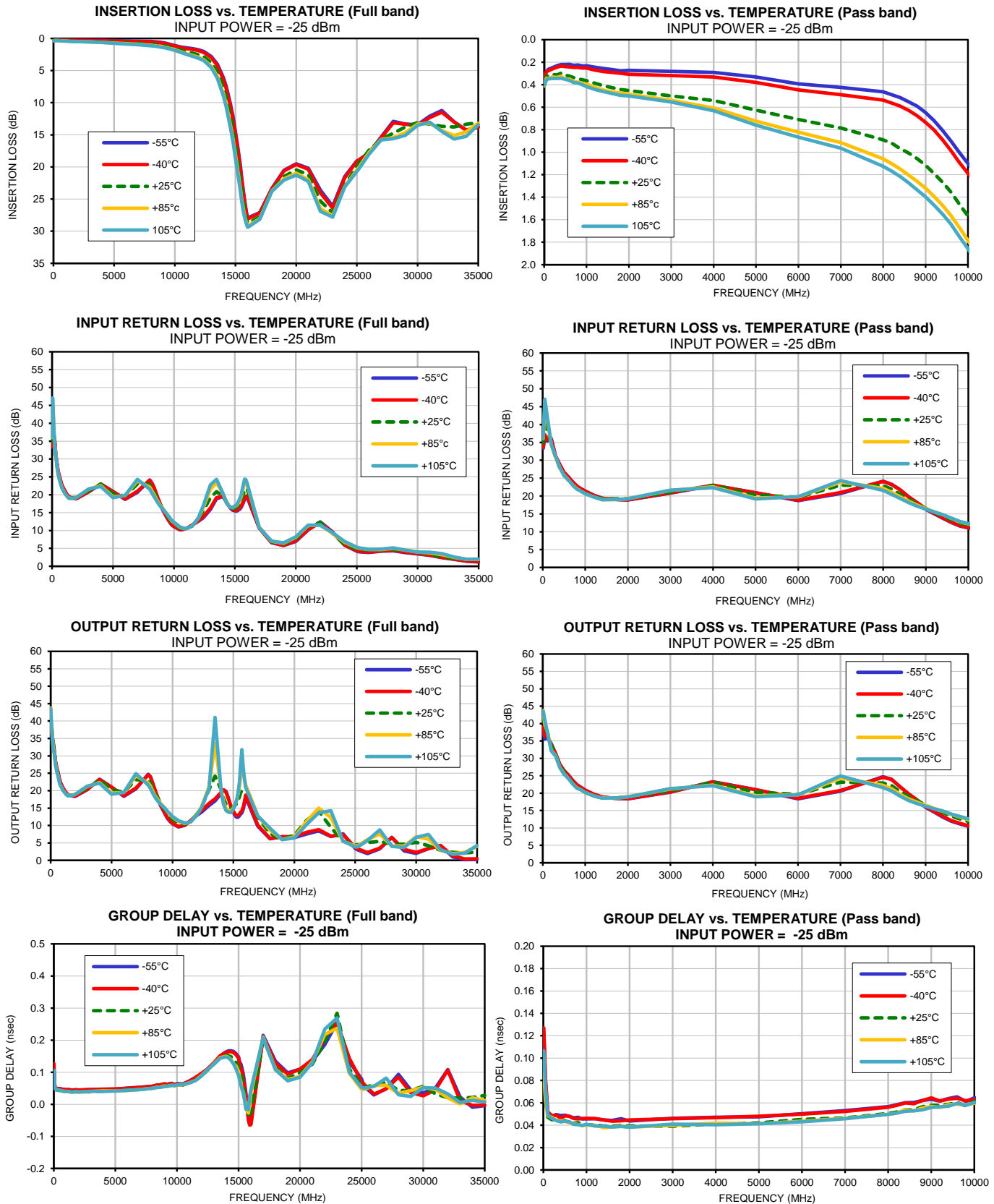
Typical Performance Data

FREQ.  (MHz)	INPUT RETURN LOSS					OUTPUT RETURN LOSS				
	(dB)					(dB)				
	@-55°C	@-40°C	@+25°C	@+85°C	@+105°C	@-55°C	@-40°C	@+25°C	@+85°C	@+105°C
10	33.32	33.62	34.90	36.09	36.27	37.43	38.99	42.14	43.76	43.55
50	36.46	37.17	41.60	45.11	47.08	35.58	36.31	38.42	39.71	41.00
100	35.34	35.72	38.81	41.82	42.93	36.04	36.55	37.74	38.11	37.82
200	36.06	35.79	34.73	34.42	34.37	34.18	33.97	33.64	32.40	32.12
300	31.22	31.24	30.88	31.01	31.13	31.35	31.26	31.21	30.74	30.66
400	28.74	28.80	27.86	27.91	28.00	28.33	28.20	27.80	27.44	27.38
500	26.65	26.57	25.93	25.90	25.68	26.54	26.45	26.06	25.64	25.45
600	25.38	25.30	24.42	24.56	24.55	25.23	25.10	24.40	24.26	24.22
700	24.03	23.92	23.08	23.12	23.08	23.79	23.66	22.95	22.72	22.71
800	22.76	22.78	22.03	22.01	21.90	22.42	22.36	21.78	21.56	21.44
900	22.02	21.95	21.34	21.35	21.36	21.65	21.61	21.05	20.97	20.95
1000	21.38	21.32	20.76	20.67	20.67	20.87	20.81	20.23	20.17	20.14
1200	20.23	20.19	19.84	19.69	19.69	19.71	19.68	19.23	19.22	19.21
1400	19.36	19.34	19.25	18.99	18.94	18.90	18.91	18.63	18.66	18.58
1600	19.18	19.18	19.27	19.01	19.01	18.63	18.64	18.63	18.61	18.59
1800	18.98	19.00	19.22	19.04	19.04	18.45	18.50	18.72	18.66	18.67
2000	18.86	18.94	19.20	19.25	19.25	18.38	18.46	19.00	18.97	18.92
3000	20.81	20.89	21.13	21.56	21.65	20.32	20.35	20.74	21.22	21.34
4000	22.99	23.00	22.98	22.54	22.33	23.31	23.22	23.03	22.16	22.16
5000	20.94	20.89	20.30	19.42	19.16	21.04	21.02	20.28	19.26	18.98
6000	18.71	18.84	19.62	19.74	19.84	18.36	18.58	19.61	19.53	19.53
7000	20.73	21.00	23.03	23.92	24.30	20.56	20.78	23.17	24.33	24.93
8000	24.13	24.10	22.90	22.14	21.54	24.72	24.54	22.93	22.24	21.61
8200	23.26	23.20	21.90	21.07	20.47	24.03	23.95	21.90	21.29	20.62
8400	21.76	21.70	20.45	19.79	19.32	21.86	21.82	20.49	19.70	19.14
8600	19.77	19.73	19.05	18.54	18.16	19.77	19.84	19.08	18.35	17.89
8800	18.10	18.15	17.78	17.44	17.13	17.89	18.05	17.88	17.42	17.02
9000	16.29	16.42	16.57	16.50	16.35	15.91	16.09	16.55	16.43	16.22
9200	15.00	15.10	15.41	15.59	15.53	14.58	14.77	15.51	15.64	15.53
9400	13.76	13.89	14.42	14.77	14.78	13.18	13.39	14.50	14.77	14.88
9600	12.60	12.73	13.39	13.77	13.84	11.97	12.17	13.41	13.92	14.02
9800	11.59	11.72	12.43	12.80	12.92	11.17	11.34	12.61	13.18	13.34
10000	11.06	11.15	11.82	12.18	12.31	10.47	10.62	11.84	12.39	12.60
10500	10.18	10.23	10.63	10.85	10.98	9.60	9.69	10.66	11.14	11.41
11000	10.48	10.50	10.46	10.45	10.50	10.07	10.10	10.40	10.44	10.74
11500	11.48	11.50	11.33	11.24	11.23	11.39	11.41	11.19	11.06	11.05
12000	12.62	12.78	13.30	13.50	13.61	12.95	13.17	13.34	13.17	13.06
12400	13.55	13.85	15.44	16.39	16.86	13.89	14.33	15.45	15.45	15.23
13000	15.89	16.32	19.17	21.56	22.79	15.73	16.38	20.32	21.13	20.69
13500	18.88	19.17	20.85	23.38	24.34	17.07	17.66	24.17	33.49	41.07
14000	19.51	19.61	19.71	20.47	20.54	19.26	19.58	20.18	19.93	19.36
14200	18.69	18.82	18.58	18.92	18.86	20.22	20.23	17.78	16.69	16.08
14400	17.36	17.45	17.28	17.39	17.31	19.80	19.52	16.06	14.92	14.28
14600	16.38	16.49	16.48	16.63	16.59	17.65	17.55	15.36	14.36	13.84
14800	15.68	15.84	16.10	16.38	16.41	15.21	15.38	14.86	14.16	13.71
15000	15.50	15.70	16.26	16.73	16.87	13.81	14.13	15.37	15.06	14.69
15100	15.41	15.63	16.43	16.93	17.10	13.15	13.54	15.77	15.82	15.59
15200	15.54	15.77	16.69	17.24	17.52	12.57	13.00	16.00	16.64	16.62
15300	15.75	15.99	17.00	17.83	18.22	12.33	12.81	16.43	17.74	17.93
15400	16.00	16.29	17.49	18.51	19.02	12.45	12.97	17.23	19.40	20.07
15500	16.47	16.80	18.30	19.37	19.87	12.90	13.44	18.40	21.60	22.90
15600	17.03	17.40	19.26	20.59	21.28	13.30	13.85	19.44	24.47	27.74
15700	17.80	18.21	20.17	21.98	22.92	13.67	14.23	20.00	26.25	31.76
15800	18.78	19.21	21.31	23.37	24.38	14.61	15.20	20.46	25.03	26.82
15900	19.15	19.60	21.76	23.63	24.26	16.17	16.74	20.97	23.49	23.48
16000	19.28	19.69	21.69	22.94	23.26	18.19	18.78	21.26	21.70	20.97
17000	10.66	10.71	10.90	10.87	10.81	9.85	10.16	12.48	12.91	12.76
18000	6.61	6.69	6.89	7.00	7.05	6.17	6.33	7.70	8.67	9.25
19000	5.76	5.86	6.23	6.45	6.57	6.81	6.82	6.09	6.01	5.98
20000	6.95	7.10	7.74	8.11	8.24	6.55	6.87	7.19	6.74	6.41
21000	10.14	10.28	11.22	11.39	11.47	7.55	8.04	11.44	11.13	10.29
22000	12.43	12.22	12.22	11.55	11.48	8.47	8.81	14.15	14.98	13.65
23000	9.62	9.50	9.22	9.25	9.37	6.85	6.98	9.47	12.38	14.26
24000	5.91	5.98	6.15	6.69	6.94	7.61	7.40	5.51	5.45	5.53
25000	4.21	4.32	4.82	5.22	5.35	3.45	3.75	4.45	4.14	3.89
25200	4.01	4.13	4.67	5.02	5.14	3.02	3.35	4.44	4.15	3.86
26000	3.87	3.98	4.57	4.69	4.73	1.94	2.23	5.13	5.97	5.72
27000	4.23	4.32	4.59	4.71	4.78	3.35	3.53	5.49	7.56	8.76
28000	4.32	4.43	4.69	5.03	5.14	6.59	6.58	4.62	4.14	4.05
29000	3.80	3.89	4.37	4.53	4.52	2.75	3.12	4.65	4.11	3.69
30000	3.48	3.56	3.91	3.98	3.99	2.02	2.28	5.20	6.79	6.59
31000	3.02	3.10	3.37	3.75	3.90	3.38	3.41	4.22	6.12	7.45
32000	2.42	2.49	2.72	3.24	3.49	4.23	4.28	2.92	2.91	3.08
33000	1.95	2.02	2.20	2.46	2.57	0.99	1.28	2.34	1.94	1.73
34000	1.42	1.50	1.93	1.94	1.96	0.22	0.42	2.17	2.33	2.08
35000	1.20	1.29	1.84	1.95	1.99	0.27	0.44	2.35	4.06	4.28





## Typical Performance Curves



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	-40° to 85° C or -40° to 105° C or -55° to 105° C or -45° to 105° C Ambient Environment	Refer to Individual Model Data Sheet
Storage Environment (Die)	-65° to 150°C	Individual Model Data Sheet
Storage Environment(Packaging)	-40° to 70°C and 40 to 60% humidity (In Factory Shipped Package)	