

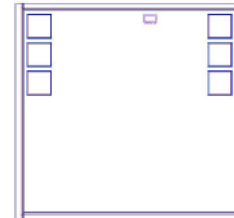
MMIC

# 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



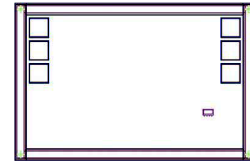
# Reflectionless Low Pass Filter Die

## XLF-14-D+

50Ω DC to 10000 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

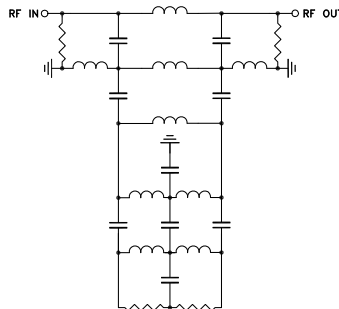
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Ordering Information: Refer to Last Page

### General Description

Mini-Circuits' XLF-14-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-10000		1.6		dB
	Frequency Cut-off	F2	13200		3.0		dB
	VSWR	DC - F1	DC-10000		1.3		:1
Stop Band	Rejection	F3 - F4	15800 - 17000		16		dB
		F4 - F5	17000 - 24200		20		dB
	VSWR	F3 - F4	15800 - 17000		1.3		:1
		F4 - F5	17000 - 24200		2.2		: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-844-14+

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

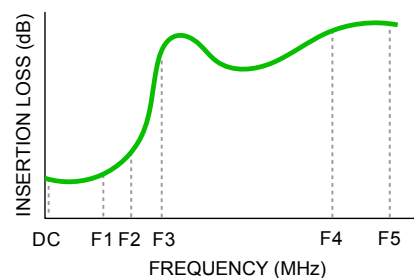
Parameter	Ratings
Operating Temperature	-55°C to +105°C
RF Power Input, Passband (DC-F1) <sup>2</sup>	2W at 25°C
RF Power Input, Stopband (F2-F5) <sup>3</sup>	50mW at 25°C

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

<sup>3</sup> Stopband rating derates linearly to 25mW at 105°C ambient

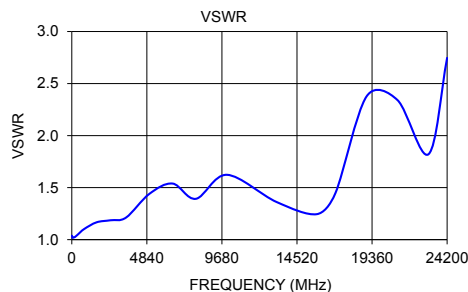
<sup>4</sup> Permanent damage may occur if any of these limits are exceeded.

**Specification Definition**



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

Frequency (MHz)	Insertion Loss (dB)	VSWR (:1)
10	0.41	1.04
50	0.39	1.02
100	0.39	1.02
200	0.39	1.03
400	0.39	1.05
800	0.42	1.10
1600	0.49	1.17
2500	0.55	1.19
3500	0.61	1.21
5000	0.79	1.44
6500	0.94	1.54
8000	1.00	1.39
10000	1.46	1.62
13200	2.97	1.36
15800	15.92	1.25
17000	30.74	1.45
19000	24.05	2.38
21000	20.45	2.34
23000	24.70	1.82
24200	27.43	2.75



**Die Layout**



Fig 1. Die Layout

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

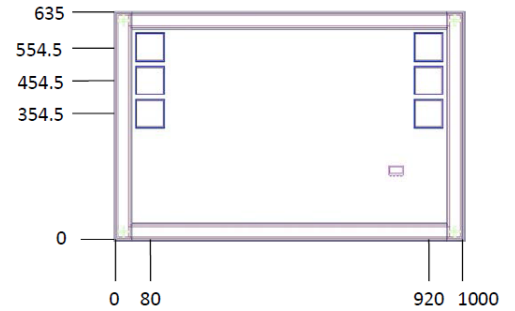


Fig 2. Bonding Pad Positions

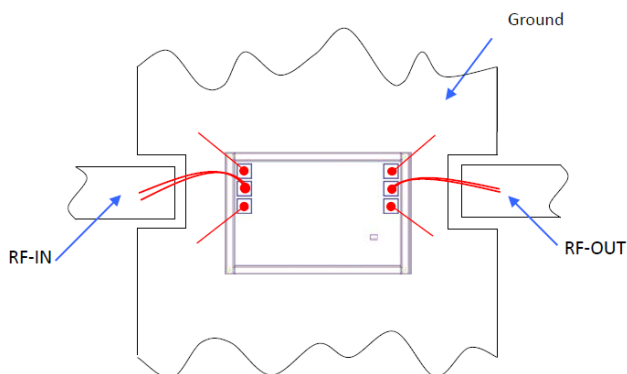
**Critical Dimensions**

Parameter	Values
Die Thickness, $\mu\text{m}$	100
Die Width, $\mu\text{m}$	1000
Die Length, $\mu\text{m}$	635
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	0.38	0.36	0.39	0.43	0.43	0.09	0.09	0.13	0.13	0.13
50	0.32	0.34	0.38	0.40	0.40	0.06	0.06	0.08	0.08	0.08
100	0.33	0.34	0.38	0.40	0.41	0.05	0.05	0.05	0.05	0.05
500	0.31	0.33	0.41	0.44	0.45	0.05	0.05	0.04	0.04	0.04
1000	0.31	0.33	0.45	0.48	0.50	0.05	0.05	0.04	0.04	0.04
1500	0.34	0.37	0.49	0.54	0.55	0.04	0.04	0.04	0.04	0.04
2000	0.36	0.38	0.53	0.57	0.59	0.04	0.04	0.04	0.04	0.04
2500	0.37	0.41	0.57	0.60	0.63	0.04	0.04	0.04	0.04	0.04
3000	0.37	0.41	0.58	0.63	0.65	0.04	0.04	0.04	0.04	0.04
3500	0.38	0.43	0.61	0.67	0.70	0.04	0.04	0.04	0.04	0.04
4000	0.41	0.45	0.66	0.73	0.76	0.05	0.04	0.04	0.04	0.04
4500	0.44	0.49	0.72	0.80	0.85	0.05	0.05	0.04	0.04	0.04
5000	0.49	0.54	0.79	0.89	0.94	0.05	0.04	0.04	0.04	0.04
5500	0.56	0.61	0.87	0.97	1.03	0.05	0.04	0.04	0.04	0.04
6000	0.62	0.67	0.92	1.03	1.08	0.05	0.04	0.04	0.04	0.04
6500	0.65	0.71	0.96	1.05	1.10	0.04	0.04	0.04	0.04	0.04
7000	0.63	0.69	0.97	1.08	1.13	0.05	0.05	0.04	0.04	0.04
7500	0.59	0.66	0.98	1.12	1.18	0.05	0.05	0.04	0.04	0.04
8000	0.57	0.65	1.00	1.17	1.24	0.05	0.05	0.05	0.05	0.04
8500	0.60	0.68	1.06	1.25	1.33	0.06	0.06	0.05	0.05	0.05
9000	0.68	0.76	1.14	1.34	1.43	0.06	0.06	0.05	0.05	0.05
9500	0.82	0.90	1.29	1.48	1.57	0.06	0.06	0.05	0.05	0.05
10000	0.98	1.06	1.43	1.63	1.72	0.06	0.06	0.05	0.05	0.05
10500	1.13	1.23	1.62	1.84	1.92	0.06	0.06	0.05	0.06	0.06
11000	1.21	1.32	1.80	2.06	2.16	0.06	0.06	0.06	0.06	0.06
11500	1.27	1.39	1.95	2.27	2.39	0.07	0.07	0.06	0.06	0.06
12000	1.40	1.52	2.11	2.47	2.61	0.08	0.08	0.07	0.07	0.07
12500	1.62	1.75	2.34	2.73	2.88	0.09	0.09	0.08	0.08	0.08
13000	1.94	2.08	2.70	3.14	3.31	0.10	0.10	0.09	0.10	0.10
13200	2.11	2.26	2.91	3.37	3.54	0.10	0.11	0.10	0.10	0.11
13500	2.44	2.60	3.31	3.83	4.03	0.12	0.12	0.11	0.11	0.11
14000	3.26	3.47	4.35	5.01	5.26	0.13	0.13	0.13	0.13	0.13
14500	4.73	4.98	6.13	7.00	7.29	0.15	0.15	0.14	0.14	0.14
15000	7.09	7.42	8.84	9.93	10.33	0.16	0.16	0.15	0.14	0.14
15500	10.69	11.05	12.68	13.96	14.42	0.16	0.16	0.14	0.14	0.13
15800	13.48	13.89	15.60	17.00	17.46	0.15	0.15	0.13	0.13	0.12
16000	15.60	16.03	17.82	19.27	19.76	0.14	0.14	0.13	0.11	0.11
16500	21.86	22.37	24.25	25.66	26.12	0.09	0.09	0.06	0.05	0.05
17000	28.39	28.68	29.78	30.43	30.56	-0.02	-0.02	0.02	0.04	0.07
17500	30.16	30.02	30.35	30.55	30.89	0.11	0.11	0.13	0.16	0.17
18000	28.20	28.32	28.39	28.42	28.50	0.17	0.12	0.15	0.17	0.17
18500	25.69	25.73	26.03	26.10	26.17	0.15	0.15	0.11	0.13	0.12
19000	23.46	23.48	24.14	24.33	24.43	0.12	0.13	0.10	0.09	0.10
19500	21.79	21.89	22.75	23.05	23.26	0.12	0.11	0.08	0.08	0.06
20000	20.84	20.88	21.52	21.95	22.20	0.09	0.09	0.07	0.07	0.07
20500	20.25	20.31	20.65	21.02	21.27	0.09	0.10	0.09	0.08	0.08
21000	19.80	19.89	20.06	20.48	20.71	0.10	0.09	0.10	0.10	0.09
21500	19.68	19.77	20.03	20.47	20.70	0.11	0.11	0.10	0.12	0.11
22000	19.89	20.07	20.67	21.29	21.58	0.12	0.12	0.12	0.14	0.14
22500	20.75	21.00	22.06	23.01	23.34	0.15	0.15	0.15	0.14	0.14
23000	22.56	22.87	24.50	25.59	25.98	0.18	0.20	0.19	0.20	0.21
23500	25.25	25.77	27.16	28.36	28.82	0.19	0.21	0.23	0.29	0.26
24000	25.52	25.98	27.53	28.42	28.72	0.25	0.26	0.27	0.27	0.26
24200	25.10	25.51	26.95	27.59	27.79	0.27	0.27	0.24	0.23	0.25
24500	24.08	24.35	25.73	26.32	26.38	0.23	0.23	0.18	0.17	0.16
25000	22.48	22.63	23.49	23.98	24.20	0.15	0.14	0.12	0.11	0.11
25500	21.32	21.36	21.59	22.06	22.32	0.12	0.11	0.09	0.08	0.08
26000	20.40	20.38	20.07	20.33	20.53	0.06	0.06	0.07	0.08	0.07
26500	19.07	19.11	18.77	18.91	19.00	0.06	0.06	0.07	0.07	0.07
27000	17.51	17.65	17.81	17.83	17.84	0.04	0.04	0.08	0.06	0.08
27500	15.61	15.89	17.02	17.34	17.36	0.08	0.08	0.05	0.05	0.05
28000	14.47	14.72	16.30	16.99	17.21	0.10	0.09	0.04	0.03	0.04
28500	14.36	14.48	15.82	16.62	17.00	0.07	0.07	0.04	0.04	0.02
29000	14.80	14.83	15.28	16.14	16.56	0.04	0.05	0.04	0.04	0.04
29500	15.18	15.19	14.90	15.48	15.85	0.03	0.04	0.05	0.03	0.03
30000	15.02	15.10	14.70	14.82	15.00	0.02	0.02	0.04	0.05	0.04
30500	14.41	14.60	14.61	14.42	14.33	0.03	0.03	0.04	0.05	0.06
31000	13.39	13.66	14.62	14.43	14.24	0.04	0.03	0.03	0.04	0.04
31500	12.60	12.90	14.59	14.75	14.64	0.07	0.06	0.03	0.04	0.04
32000	12.23	12.46	14.51	15.09	15.17	0.11	0.10	0.02	0.02	0.02
32500	13.14	13.14	14.36	15.31	15.70	0.04	0.03	0.03	0.01	0.01
33000	13.86	13.83	14.22	15.38	15.95	0.01	0.01	0.02	-0.01	0.00
33500	14.56	14.51	13.78	15.07	15.75	-0.01	-0.01	0.03	0.01	0.00
34000	14.50	14.47	13.46	14.29	14.99	0.00	0.00	0.03	0.04	0.02
34500	14.18	14.24	13.15	13.58	14.10	-0.01	-0.01	0.02	0.01	0.01
35000	13.41	13.50	12.93	12.94	13.16	0.00	0.00	0.01	0.02	0.03



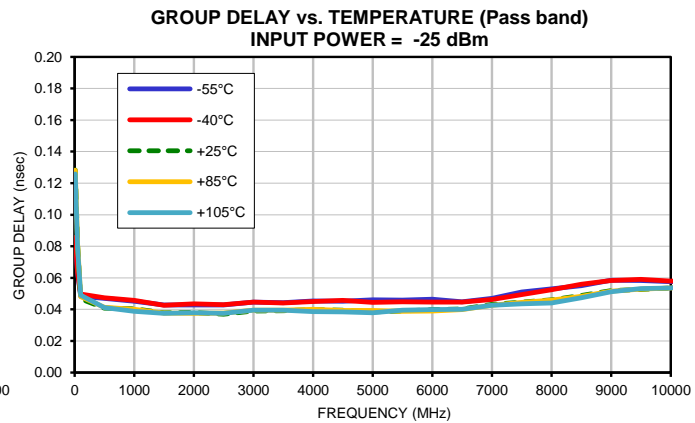
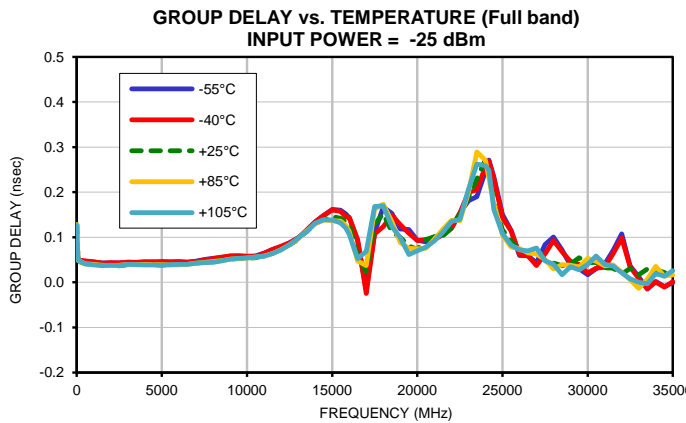
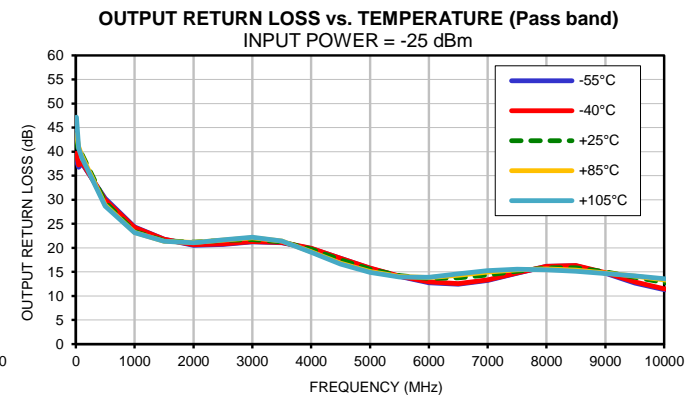
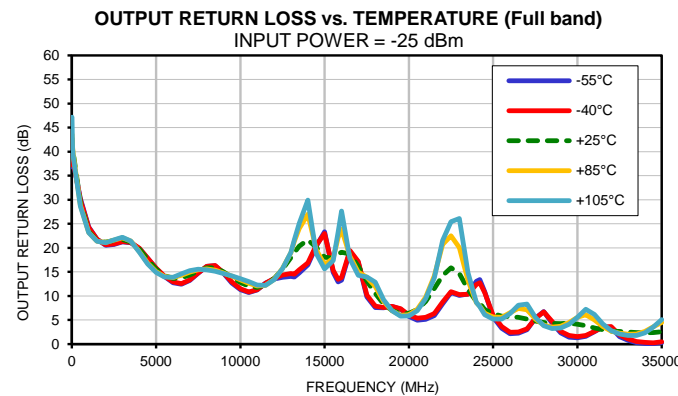
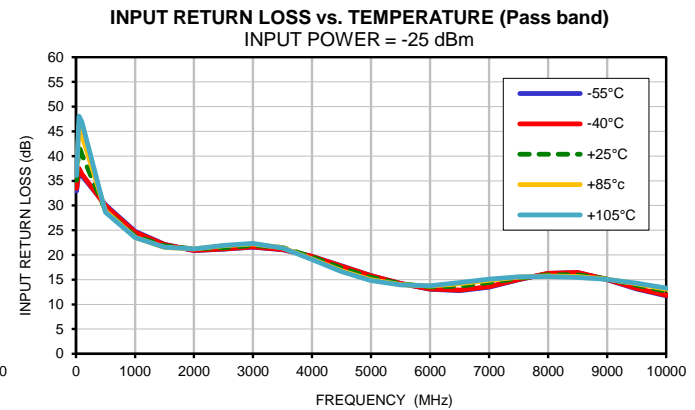
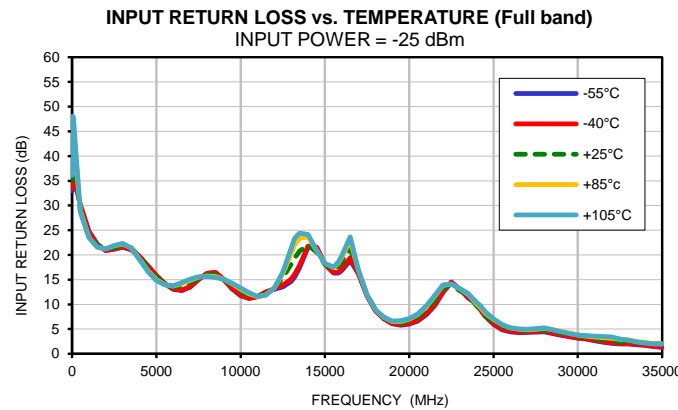
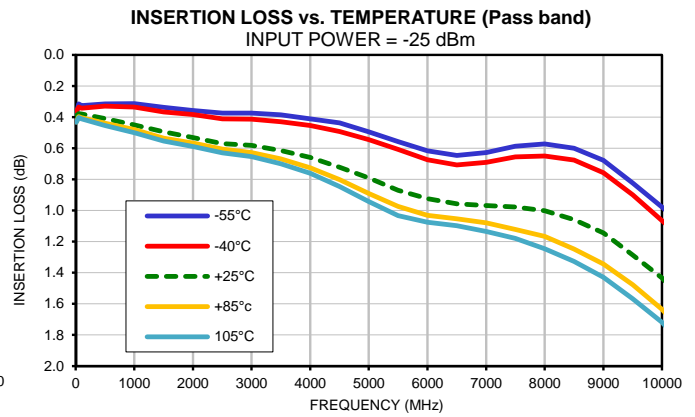
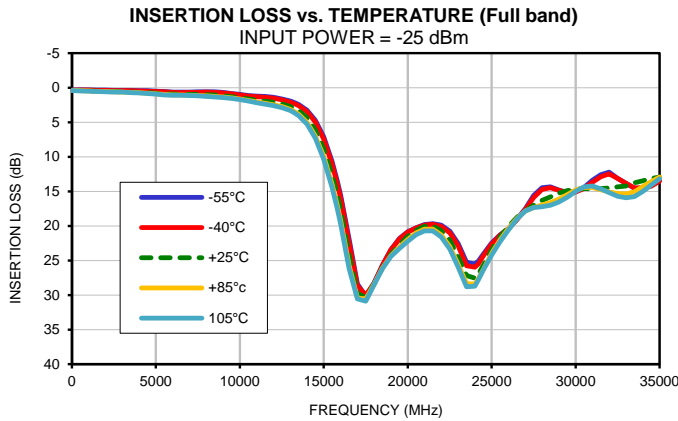
Typical Performance Data

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	32.95	33.48	35.08	36.37	36.10	38.07	39.66	42.76	43.59	47.17
50	37.13	37.52	42.12	46.33	48.08	36.73	37.22	39.56	41.01	40.61
100	36.00	36.37	40.34	44.16	46.89	37.58	37.79	39.53	39.14	38.72
500	30.15	29.99	28.97	28.92	28.59	30.29	29.98	29.51	28.91	28.67
1000	24.75	24.62	23.84	23.57	23.51	24.34	24.25	23.42	23.25	23.17
1500	22.14	22.10	21.88	21.54	21.55	21.78	21.79	21.48	21.38	21.34
2000	20.89	20.94	21.23	21.20	21.20	20.55	20.65	21.22	21.16	21.08
2500	21.15	21.20	21.43	21.85	21.91	20.70	20.83	21.54	21.62	21.68
3000	21.55	21.61	21.93	22.22	22.31	21.22	21.30	21.71	22.10	22.20
3500	21.07	21.10	21.51	21.43	21.39	21.08	21.13	21.28	21.42	21.41
4000	19.71	19.72	19.61	19.19	19.06	19.90	19.90	19.72	19.23	19.08
4500	17.79	17.76	17.33	16.82	16.64	17.84	17.82	17.51	16.84	16.64
5000	15.80	15.78	15.43	15.01	14.84	15.77	15.79	15.54	15.08	14.89
5500	14.26	14.25	14.20	13.99	13.92	14.07	14.13	14.25	14.04	13.97
6000	13.07	13.13	13.54	13.72	13.79	12.77	12.91	13.67	13.82	13.88
6500	12.76	12.86	13.68	14.16	14.43	12.43	12.58	13.79	14.28	14.58
7000	13.49	13.58	14.39	14.88	15.11	13.20	13.32	14.39	14.98	15.28
7500	15.01	15.06	15.26	15.48	15.55	14.73	14.78	15.14	15.46	15.57
8000	16.28	16.30	15.98	15.75	15.60	16.17	16.15	15.86	15.60	15.44
8500	16.43	16.43	15.96	15.65	15.47	16.29	16.34	15.83	15.39	15.17
9000	14.97	15.06	15.16	15.10	15.05	14.70	14.85	15.03	14.81	14.65
9500	13.11	13.25	13.86	14.18	14.29	12.71	12.94	13.91	14.14	14.16
10000	11.73	11.85	12.65	13.07	13.30	11.29	11.48	12.79	13.33	13.57
10500	11.18	11.23	11.81	12.13	12.34	10.70	10.82	12.01	12.61	13.00
11000	11.55	11.53	11.54	11.57	11.64	11.27	11.31	11.80	12.08	12.29
11500	12.50	12.46	12.07	11.89	11.84	12.67	12.66	12.31	12.20	12.21
12000	13.07	13.18	13.35	13.37	13.35	13.52	13.67	13.62	13.38	13.38
12500	13.55	13.89	15.39	16.22	16.55	13.91	14.36	15.58	15.73	15.67
13000	14.61	15.12	18.15	20.31	21.35	14.06	14.65	17.94	18.99	19.04
13200	15.53	16.07	19.35	22.04	23.36	13.95	14.55	19.06	21.39	21.68
13500	17.35	17.86	20.76	23.39	24.45	14.81	15.42	20.36	23.98	25.06
14000	21.64	21.80	21.99	23.68	24.16	16.43	16.88	21.68	27.00	29.90
14500	21.59	21.57	20.56	20.94	20.96	20.34	20.53	20.11	19.62	18.85
15000	18.14	18.21	18.11	18.31	18.28	23.36	23.01	18.10	16.51	15.64
15500	16.33	16.43	17.05	17.48	17.56	14.89	15.34	17.83	17.83	17.35
15800	16.34	16.59	17.73	18.38	18.63	12.93	13.45	18.71	22.08	23.23
16000	16.84	17.14	18.63	19.52	19.91	13.28	13.81	19.07	23.86	27.63
16500	18.88	19.40	21.30	22.93	23.66	19.24	19.46	18.75	18.26	17.74
17000	16.14	16.24	16.65	16.86	16.86	17.01	17.17	16.17	14.98	14.31
17500	11.65	11.68	11.85	11.91	11.89	9.80	10.18	13.10	13.86	13.93
18000	8.72	8.76	8.91	8.93	8.92	7.63	7.89	10.51	11.99	12.88
18500	7.05	7.11	7.32	7.35	7.41	7.51	7.63	8.29	8.86	9.23
19000	6.07	6.14	6.44	6.54	6.63	7.84	7.83	7.00	6.93	6.95
19500	5.81	5.93	6.26	6.56	6.69	7.23	7.34	6.33	5.97	5.78
20000	5.99	6.13	6.61	7.01	7.12	5.76	6.05	6.41	6.13	5.86
20500	6.58	6.76	7.46	7.96	8.07	4.99	5.39	7.15	7.23	6.94
21000	7.87	8.06	8.93	9.54	9.67	5.15	5.56	8.83	9.75	9.48
21500	9.68	9.85	10.86	11.58	11.76	5.91	6.37	11.56	14.19	13.77
22000	12.40	12.50	13.27	13.80	13.96	8.40	8.74	14.27	20.74	21.56
22500	14.52	14.47	14.12	14.09	14.13	10.70	10.89	15.86	22.50	25.41
23000	13.04	12.90	12.73	13.13	13.18	10.13	10.30	14.68	20.07	26.08
23500	11.25	11.67	12.14	12.02	12.21	10.40	10.34	11.40	13.25	14.85
24000	10.07	9.97	9.70	10.09	10.40	13.05	12.40	8.89	8.62	8.70
24200	9.05	9.04	8.93	9.45	9.79	13.40	12.74	8.51	7.87	7.78
24500	7.63	7.68	7.83	8.31	8.56	10.88	10.73	7.18	6.38	6.11
25000	5.95	6.05	6.50	6.92	7.04	5.60	5.96	6.34	5.62	5.22
25500	4.87	4.99	5.58	5.87	5.93	3.29	3.66	5.82	5.54	5.18
26000	4.42	4.54	5.09	5.25	5.27	2.17	2.48	5.67	6.49	6.34
26500	4.27	4.38	4.82	4.95	5.02	2.28	2.53	5.56	7.45	8.11
27000	4.35	4.42	4.76	4.85	4.95	2.98	3.17	5.24	7.14	8.34
27500	4.40	4.48	4.74	4.96	5.08	5.38	5.33	4.80	5.20	5.55
28000	4.44	4.53	4.78	5.14	5.23	6.76	6.72	4.48	3.94	3.84
28500	4.09	4.19	4.57	4.90	4.85	4.37	4.72	4.33	3.52	3.25
29000	3.77	3.85	4.29	4.58	4.47	2.30	2.66	4.22	3.71	3.34
29500	3.43	3.52	3.97	4.19	4.07	1.45	1.76	4.35	4.51	4.11
30000	3.16	3.24	3.60	3.80	3.79	1.31	1.56	4.13	5.55	5.55
30500	2.98	3.04	3.32	3.56	3.68	1.61	1.77	3.81	6.13	7.22
31000	2.65	2.73	3.03	3.37	3.60	2.56	2.62	3.37	5.01	6.19
31500	2.36	2.45	2.85	3.29	3.53	3.60	3.55	3.02	3.67	4.16
32000	2.13	2.21	2.61	3.17	3.39	3.50	3.68	2.72	2.70	2.84
32500	1.98	2.06	2.43	2.91	3.01	1.57	1.91	2.61	2.25	2.12
33000	1.97	2.05	2.39	2.79	2.78	0.75	1.05	2.30	2.05	1.80
33500	1.83	1.92	2.28	2.49	2.41	0.30	0.56	2.36	2.11	1.80
34000	1.68	1.78	2.17	2.26	2.20	0.12	0.35	2.35	2.62	2.35
34500	1.46	1.54	2.04	2.06	2.00	0.08	0.26	2.38	3.58	3.54
35000	1.30	1.41	1.96	2.01	2.00	0.33	0.50	2.55	4.50	5.09





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)	