

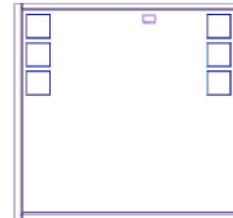
MMIC

# 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-221-D+

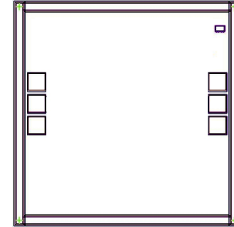
50Ω DC to 220 MHz

### 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
- Wideband Matching
- Transmitters / Receivers



#### +RoHS Compliant

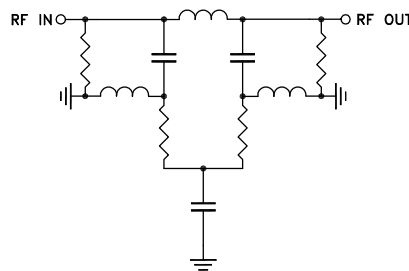
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Ordering Information: Refer to Last Page

### General Description

Mini-Circuits' XLF-221-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 - 220		1.4		dB
	Frequency Cut-off	F2	370		3.0		dB
	VSWR	DC - F1	DC - 220		1.2		:1
Stop Band	Rejection	F3 - F4	570 - 3500		15		dB
		F4 - F5	3500 - 12000		26		dB
	VSWR	F3 - F4	570 - 3500		1.2		:1
		F4 - F5	3500 - 12000		1.7		: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-844-221+

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

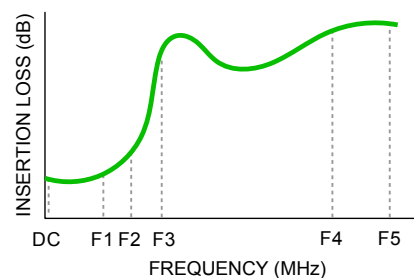
Parameter	Ratings
Operating Temperature	-55°C to +105°C
RF Power Input, Passband (DC-F1) <sup>2</sup>	2W at 25°C
RF Power Input, Stopband (F2-F5) <sup>3</sup>	0.5W at 25°C

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

<sup>3</sup> Stopband rating derates linearly to 0.25W at 105°C ambient

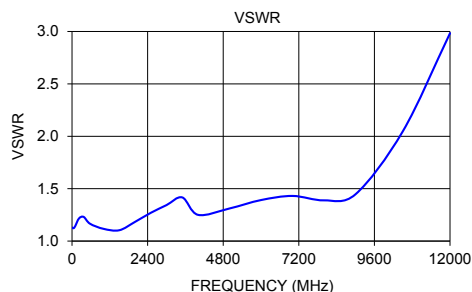
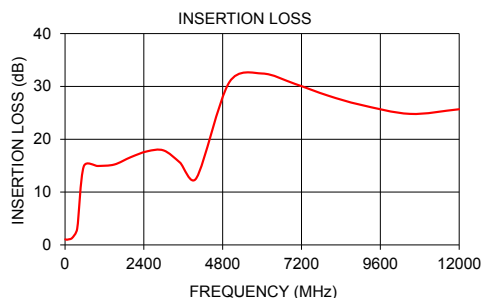
<sup>4</sup> Permanent damage may occur if any of these limits are exceeded.

**Specification Definition**



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

Frequency (MHz)	Insertion Loss (dB)	VSWR (:1)
10	1.07	1.13
50	0.99	1.12
100	1.04	1.14
220	1.34	1.22
370	3.05	1.23
570	14.85	1.17
1000	14.94	1.12
1500	15.21	1.10
2000	16.61	1.18
2500	17.71	1.27
3000	17.89	1.34
3500	15.59	1.42
4000	12.65	1.25
5000	30.78	1.31
6000	32.44	1.39
7000	30.47	1.43
8000	28.27	1.39
9000	26.52	1.45
10500	24.80	2.05
12000	25.68	2.98



**Die Layout**

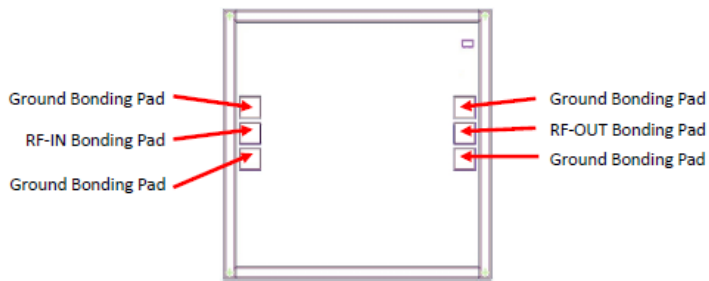


Fig 1. Die Layout

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

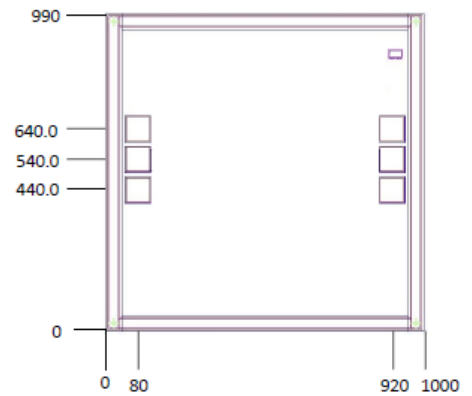


Fig 2. Bonding Pad Positions

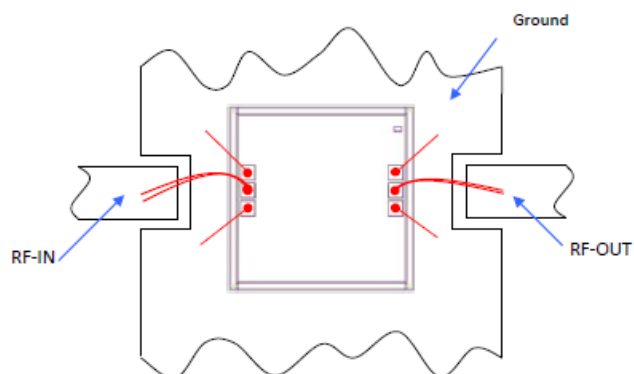
**Critical Dimensions**

Parameter	Values
Die Thickness, $\mu\text{m}$	100
Die Width, $\mu\text{m}$	1000
Die Length, $\mu\text{m}$	990
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

<b>Additional Detailed Technical Information</b> <i>additional information is available on our dash board.</i>	
<b>Performance Data</b>	Data Table
	Swept Graphs
	S-Parameter (S2P Files) Data Set with and without port extension(.zip file)
<b>Case Style</b>	Die
<b>Die Ordering and packaging information</b>	Quantity, Package                      Model No. Small, Gel - Pak: 10,50,100 KGD*      XLF-221-DG+ Medium†, Partial wafer: KGD*<5K      XLF-221-DP+
	†Available upon request contact sales representative  Refer to <a href="#">AN-60-067</a>
<b>Environmental Ratings</b>	ENV-80

\*Known Good Dice ("KGD") means that the dice are taken from PCM good wafer and visually inspected according to Mini-Circuits inspection criteria. While this is not definitive, it does help to provide a higher degree of confidence that dice are capable of meeting typical RF electrical parameters specified by Mini-Circuits.

## ESD Rating\*\*

Human Body Model (HBM): Class 1A (250V) in accordance with ANSI/ESD STM 5.1 - 2001

\*\* Tested in industry standard MCLP 3x3mm 12 lead package.

### 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-Circuit's 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)
- Mini-Circuits does not warrant the accuracy or completeness of the information, text, graphics and other items contained within this document and same are provided as an accommodation and on an "As is" basis, with all faults.
- Purchasers of this part are solely responsible for proper storing, handling, assembly and processing of Known Good Dice (including, without limitation, proper ESD preventative measures, die preparation, die attach, wire bonding and related assembly and test activities), and Mini-Circuits assumes no responsibility therefor or for environmental effects on Known Good Dice.
- Mini-Circuits and the Mini-Circuits logo are registered trademarks of Scientific Components Corporation d/b/a Mini-Circuits. All other third-party trademarks are the property of their respective owners. A reference to any third-party trademark does not constitute or imply any endorsement, affiliation, sponsorship, or recommendation by any such third-party of Mini-Circuits or its products.

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	0.86	0.88	1.06	1.19	1.24	0.55	0.53	0.53	0.52	0.54
20	0.80	0.83	1.00	1.12	1.17	0.54	0.53	0.52	0.52	0.54
30	0.81	0.86	1.00	1.15	1.20	0.54	0.53	0.53	0.52	0.54
40	0.79	0.82	0.99	1.12	1.17	0.54	0.53	0.53	0.53	0.54
50	0.80	0.84	1.00	1.15	1.19	0.53	0.53	0.53	0.53	0.54
60	0.80	0.83	1.00	1.15	1.20	0.53	0.53	0.53	0.53	0.54
70	0.81	0.85	1.02	1.17	1.21	0.53	0.53	0.53	0.54	0.54
80	0.81	0.86	1.02	1.17	1.21	0.53	0.53	0.53	0.54	0.54
90	0.83	0.87	1.03	1.18	1.24	0.53	0.53	0.54	0.54	0.54
100	0.84	0.87	1.04	1.19	1.24	0.54	0.53	0.54	0.54	0.55
110	0.85	0.89	1.06	1.21	1.28	0.54	0.54	0.54	0.55	0.55
120	0.85	0.90	1.07	1.23	1.28	0.54	0.54	0.55	0.55	0.55
130	0.88	0.92	1.09	1.25	1.31	0.55	0.55	0.55	0.56	0.56
140	0.87	0.92	1.09	1.26	1.32	0.55	0.56	0.55	0.56	0.56
150	0.89	0.94	1.12	1.28	1.34	0.56	0.56	0.56	0.57	0.57
160	0.92	0.96	1.15	1.32	1.38	0.57	0.57	0.57	0.57	0.58
180	0.95	0.99	1.19	1.37	1.43	0.59	0.59	0.59	0.59	0.59
200	0.99	1.04	1.25	1.43	1.50	0.61	0.61	0.61	0.61	0.61
210	1.02	1.07	1.29	1.48	1.54	0.62	0.62	0.62	0.62	0.62
220	1.06	1.11	1.33	1.53	1.60	0.63	0.63	0.63	0.63	0.63
230	1.09	1.16	1.38	1.59	1.65	0.64	0.64	0.64	0.65	0.65
240	1.13	1.19	1.42	1.63	1.71	0.65	0.65	0.65	0.65	0.65
250	1.18	1.24	1.48	1.69	1.77	0.67	0.67	0.67	0.67	0.67
260	1.24	1.30	1.54	1.77	1.84	0.69	0.69	0.68	0.68	0.68
270	1.31	1.37	1.63	1.85	1.93	0.70	0.71	0.70	0.70	0.70
280	1.38	1.44	1.71	1.95	2.03	0.72	0.72	0.72	0.71	0.71
290	1.45	1.51	1.79	2.04	2.12	0.74	0.74	0.73	0.72	0.72
300	1.55	1.61	1.90	2.15	2.24	0.76	0.76	0.75	0.74	0.74
310	1.65	1.72	2.01	2.28	2.37	0.77	0.77	0.76	0.75	0.75
320	1.76	1.83	2.14	2.41	2.50	0.79	0.79	0.78	0.77	0.77
330	1.89	1.96	2.28	2.56	2.66	0.81	0.81	0.79	0.78	0.78
340	2.03	2.11	2.43	2.73	2.83	0.83	0.83	0.81	0.80	0.79
350	2.20	2.28	2.62	2.92	3.03	0.85	0.84	0.82	0.81	0.81
360	2.39	2.47	2.82	3.13	3.24	0.86	0.86	0.83	0.82	0.81
370	2.60	2.68	3.05	3.37	3.49	0.88	0.87	0.85	0.83	0.82
380	2.83	2.92	3.30	3.63	3.75	0.89	0.88	0.86	0.83	0.83
390	3.10	3.19	3.58	3.91	4.03	0.89	0.89	0.86	0.84	0.83
400	3.39	3.48	3.88	4.23	4.34	0.90	0.90	0.86	0.84	0.83
450	5.37	5.47	5.91	6.28	6.42	0.87	0.86	0.81	0.77	0.76
500	8.34	8.45	8.88	9.25	9.37	0.69	0.68	0.62	0.56	0.55
510	9.07	9.17	9.60	9.96	10.07	0.63	0.62	0.55	0.50	0.48
520	9.82	9.93	10.35	10.70	10.81	0.56	0.55	0.48	0.41	0.40
530	10.65	10.76	11.17	11.51	11.61	0.49	0.46	0.39	0.32	0.30
540	11.51	11.62	12.02	12.34	12.44	0.40	0.37	0.29	0.22	0.20
550	12.42	12.53	12.92	13.22	13.31	0.28	0.26	0.16	0.09	0.08
560	13.40	13.48	13.85	14.12	14.21	0.14	0.12	0.02	-0.05	-0.07
570	14.43	14.51	14.86	15.08	15.17	-0.02	-0.05	-0.15	-0.22	-0.24
600	17.83	17.89	18.05	18.10	18.10	-0.73	-0.76	-0.82	-0.84	-0.84
700	22.73	22.54	21.86	21.33	21.12	-1.73	-1.68	-1.48	-1.33	-1.28
800	17.70	17.66	17.56	17.46	17.42	-0.07	-0.07	-0.08	-0.09	-0.09
900	15.71	15.71	15.72	15.72	15.73	0.13	0.13	0.12	0.11	0.11
1000	14.87	14.88	14.93	14.98	15.00	0.15	0.15	0.15	0.14	0.14
2000	16.44	16.49	16.61	16.70	16.73	0.09	0.09	0.08	0.09	0.09
2200	16.98	17.02	17.12	17.20	17.23	0.08	0.08	0.08	0.08	0.08
2400	17.40	17.43	17.55	17.62	17.65	0.08	0.08	0.08	0.08	0.08
2600	17.71	17.74	17.85	17.91	17.94	0.08	0.08	0.08	0.08	0.09
2800	17.87	17.89	17.98	18.04	18.05	0.08	0.08	0.08	0.08	0.08
3000	17.79	17.80	17.87	17.91	17.93	0.09	0.09	0.09	0.10	0.10
3500	15.67	15.66	15.57	15.47	15.44	0.17	0.18	0.20	0.22	0.23
4000	11.16	11.43	12.63	13.71	14.05	0.85	0.83	0.73	0.65	0.63
5000	30.17	30.33	30.71	31.12	31.24	0.02	0.05	0.03	0.03	0.04
6000	32.34	32.39	32.56	32.57	32.58	0.02	0.08	0.03	0.04	0.04
7000	30.35	30.34	30.44	30.48	30.47	0.04	0.05	0.03	0.03	0.04
8000	28.15	28.18	28.26	28.30	28.32	0.05	0.04	0.04	0.05	0.04
9000	26.44	26.44	26.53	26.64	26.64	0.05	0.05	0.05	0.05	0.05
10000	25.12	25.15	25.31	25.36	25.41	0.04	0.05	0.03	0.04	0.05
11000	23.90	23.88	24.13	24.19	24.25	0.06	0.07	0.06	0.08	0.09
12000	23.88	24.23	25.68	26.65	27.04	0.21	0.19	0.15	0.24	0.28
13000	17.57	17.76	18.35	18.74	18.81	0.59	0.56	0.44	0.36	0.34
14000	16.85	17.01	17.57	17.96	18.09	0.13	0.12	0.10	0.10	0.10
15000	17.30	17.40	17.77	18.02	18.11	0.07	0.07	0.07	0.06	0.07
16000	17.13	17.22	17.55	17.77	17.86	0.06	0.06	0.06	0.07	0.06
17000	16.91	16.97	17.34	17.64	17.78	0.07	0.08	0.07	0.08	0.08
18000	17.37	17.51	18.18	18.67	18.83	0.08	0.08	0.09	0.08	0.08
19000	19.68	19.95	20.99	21.84	22.10	0.07	0.07	0.06	0.05	0.05
20000	24.55	24.85	25.76	26.29	26.42	-0.01	-0.03	-0.04	-0.06	-0.08



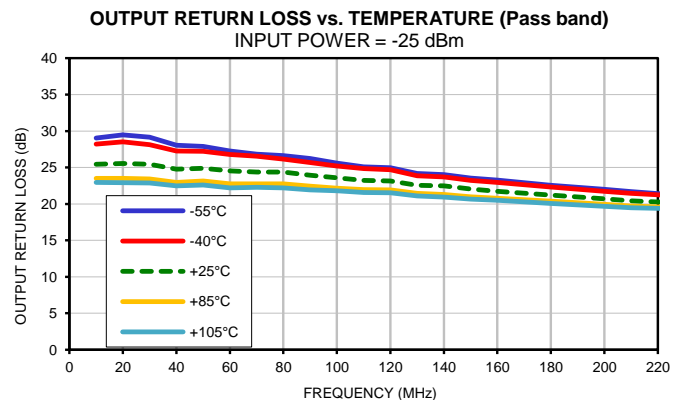
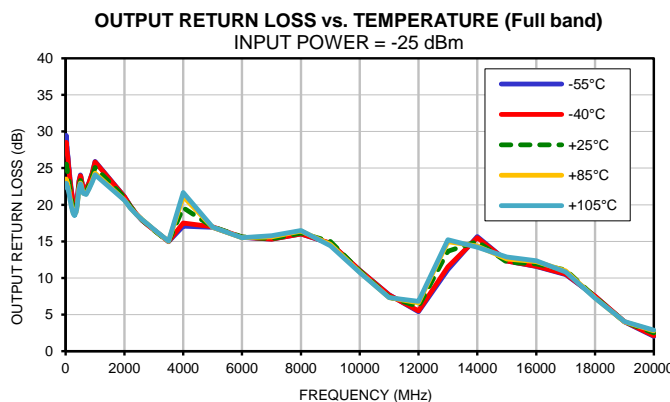
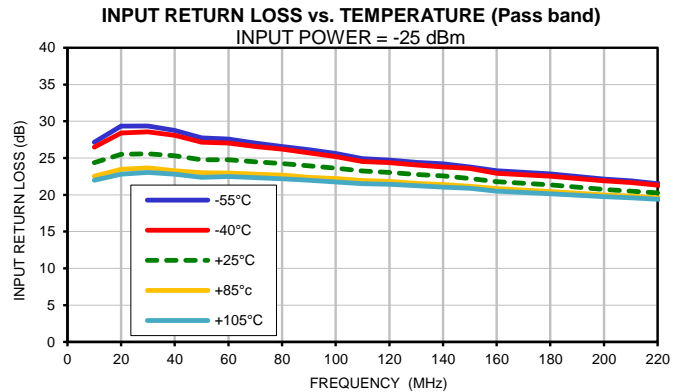
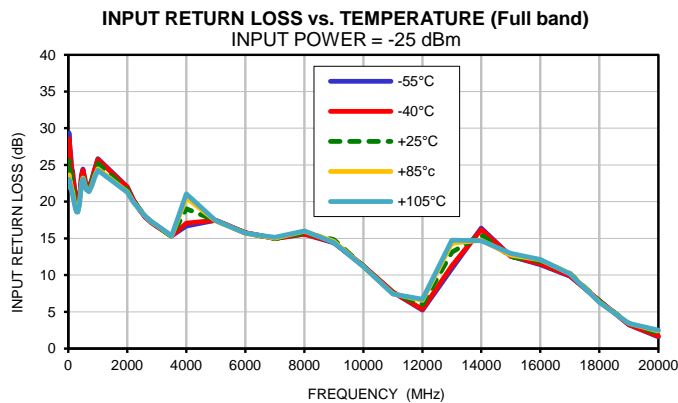
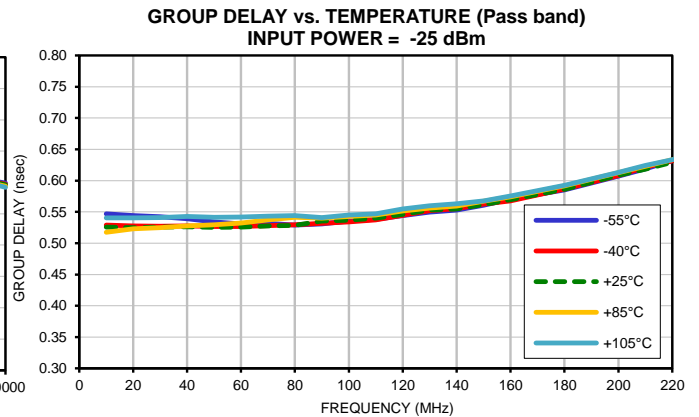
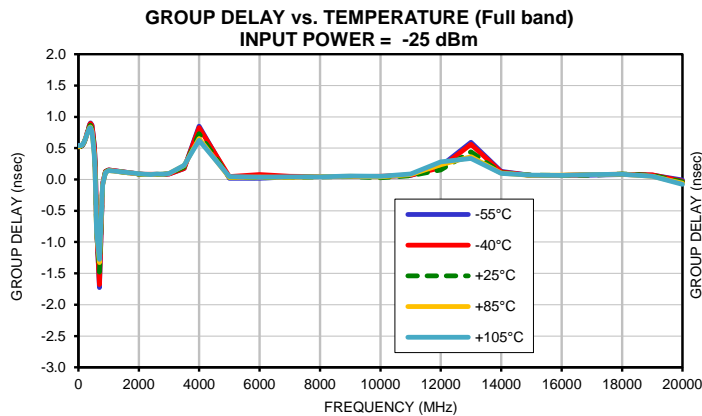
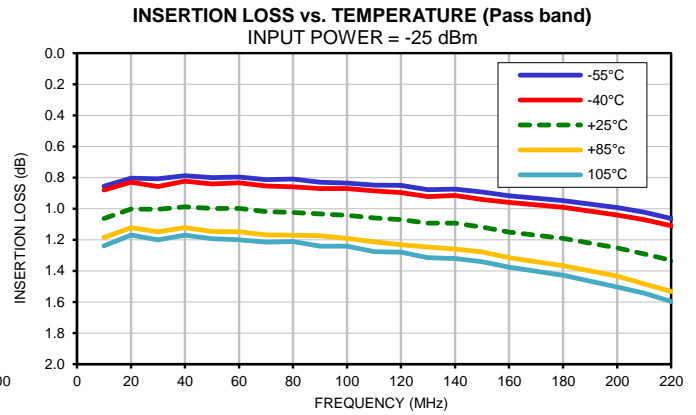
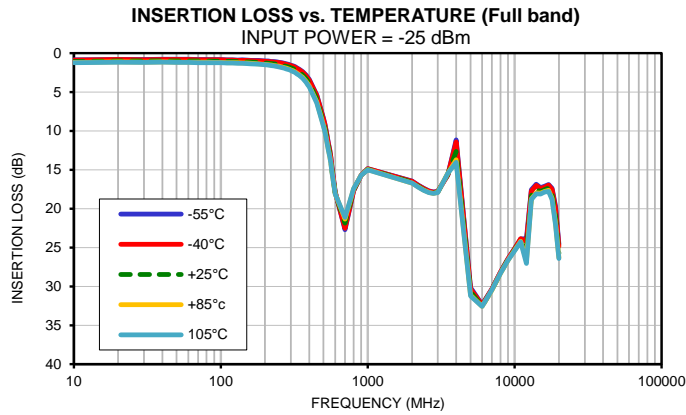
Typical Performance Data

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	27.17	26.48	24.39	22.52	21.98	29.05	28.20	25.45	23.52	22.95
20	29.36	28.42	25.50	23.48	22.81	29.47	28.52	25.55	23.49	22.93
30	29.36	28.56	25.58	23.67	23.06	29.16	28.11	25.44	23.44	22.86
40	28.74	28.08	25.30	23.27	22.81	28.05	27.26	24.78	22.97	22.49
50	27.74	27.17	24.76	22.99	22.40	27.89	27.23	24.87	23.16	22.58
60	27.58	27.03	24.78	22.96	22.51	27.25	26.80	24.52	22.76	22.21
70	27.03	26.56	24.49	22.81	22.34	26.84	26.53	24.37	22.77	22.27
80	26.58	26.23	24.26	22.68	22.17	26.63	26.15	24.37	22.74	22.21
90	26.13	25.72	23.96	22.39	22.00	26.23	25.69	23.94	22.46	21.93
100	25.62	25.21	23.64	22.24	21.73	25.61	25.20	23.60	22.18	21.79
110	24.91	24.52	23.25	21.93	21.51	25.09	24.84	23.24	21.97	21.57
120	24.75	24.37	23.05	21.85	21.43	24.98	24.69	23.17	21.95	21.52
130	24.43	24.08	22.77	21.55	21.23	24.18	23.85	22.57	21.43	21.12
140	24.21	23.78	22.56	21.39	21.05	24.01	23.70	22.47	21.30	20.95
150	23.81	23.60	22.22	21.15	20.87	23.54	23.22	22.03	21.00	20.64
160	23.27	22.91	21.78	20.85	20.49	23.28	22.96	21.74	20.78	20.49
180	22.84	22.54	21.35	20.44	20.16	22.55	22.32	21.20	20.40	20.08
200	22.15	21.90	20.75	19.98	19.76	22.02	21.73	20.69	19.95	19.67
210	21.91	21.67	20.51	19.82	19.59	21.69	21.45	20.44	19.72	19.49
220	21.52	21.33	20.27	19.60	19.39	21.43	21.24	20.25	19.58	19.39
230	21.36	21.13	20.08	19.44	19.23	21.22	20.99	20.05	19.44	19.17
240	20.97	20.80	19.79	19.22	19.05	20.85	20.59	19.71	19.17	19.06
250	20.80	20.64	19.65	19.09	18.92	20.69	20.49	19.63	19.10	18.93
260	20.68	20.51	19.58	19.06	18.87	20.45	20.23	19.43	18.92	18.79
270	20.30	20.14	19.34	18.80	18.67	20.26	20.10	19.30	18.85	18.73
280	20.22	20.07	19.33	18.87	18.68	20.11	20.01	19.23	18.80	18.66
290	20.13	19.98	19.30	18.81	18.71	19.95	19.79	19.06	18.71	18.59
300	19.87	19.72	19.10	18.70	18.59	19.84	19.70	19.01	18.72	18.53
310	19.69	19.58	19.03	18.63	18.55	19.77	19.66	19.05	18.72	18.63
320	19.71	19.60	19.11	18.71	18.64	19.71	19.63	19.01	18.71	18.62
330	19.61	19.55	19.10	18.77	18.64	19.76	19.64	19.09	18.82	18.72
340	19.73	19.65	19.17	18.91	18.84	19.79	19.69	19.19	18.91	18.84
350	19.83	19.72	19.34	19.06	18.99	19.86	19.74	19.27	19.02	18.95
360	20.01	19.88	19.53	19.27	19.18	20.00	19.92	19.44	19.22	19.18
370	20.14	20.05	19.69	19.47	19.41	20.21	20.04	19.65	19.42	19.32
380	20.42	20.37	19.99	19.75	19.69	20.40	20.32	19.90	19.69	19.60
390	20.76	20.65	20.29	20.07	19.99	20.70	20.58	20.15	19.94	19.89
400	21.31	21.18	20.78	20.53	20.41	21.11	21.01	20.59	20.34	20.27
450	23.63	23.47	22.82	22.49	22.39	23.24	23.14	22.54	22.20	22.11
500	24.46	24.30	23.59	23.24	23.13	24.08	23.97	23.33	22.99	22.85
510	24.34	24.22	23.53	23.22	23.07	24.01	23.88	23.25	22.90	22.78
520	24.02	23.95	23.32	23.03	22.90	23.83	23.76	23.12	22.81	22.68
530	23.81	23.74	23.20	22.88	22.80	23.65	23.49	22.97	22.67	22.57
540	23.60	23.54	22.97	22.73	22.63	23.38	23.25	22.74	22.47	22.37
550	23.30	23.27	22.75	22.54	22.44	23.14	23.09	22.57	22.33	22.19
560	23.05	22.95	22.52	22.28	22.23	22.99	22.91	22.37	22.12	22.07
570	22.78	22.71	22.27	22.11	22.05	22.79	22.72	22.19	21.98	21.89
600	22.22	22.21	21.90	21.71	21.65	22.34	22.29	21.84	21.59	21.55
700	21.99	21.95	21.70	21.45	21.36	22.19	22.15	21.78	21.47	21.42
800	23.04	22.98	22.64	22.26	22.17	23.05	23.00	22.66	22.25	22.14
900	24.44	24.41	23.99	23.45	23.32	24.32	24.28	23.83	23.26	23.07
1000	25.85	25.74	25.18	24.48	24.28	25.93	25.83	25.10	24.31	24.09
2000	22.04	21.99	21.61	21.34	21.27	21.11	21.08	20.99	20.65	20.60
2200	20.29	20.25	20.17	19.98	19.95	19.85	19.85	19.80	19.61	19.55
2400	18.96	18.99	19.10	18.99	18.98	18.72	18.75	18.78	18.74	18.68
2600	17.92	17.94	18.10	18.05	18.06	17.85	17.88	17.94	17.99	17.99
2800	17.21	17.23	17.30	17.32	17.34	17.20	17.21	17.23	17.29	17.31
3000	16.61	16.64	16.69	16.78	16.79	16.58	16.57	16.51	16.61	16.66
3500	15.34	15.33	15.25	15.32	15.34	14.95	14.97	14.95	15.00	15.02
4000	16.69	17.09	19.03	20.51	21.08	17.08	17.51	19.59	21.13	21.67
5000	17.47	17.48	17.42	17.40	17.42	16.93	16.98	16.98	16.91	16.95
6000	15.79	15.80	15.74	15.69	15.70	15.54	15.56	15.62	15.50	15.51
7000	14.99	15.01	14.97	15.06	15.17	15.28	15.32	15.33	15.61	15.76
8000	15.57	15.60	15.76	15.96	16.04	16.01	16.01	16.13	16.41	16.49
9000	14.43	14.49	14.82	14.59	14.45	14.70	14.74	15.00	14.60	14.40
10000	11.25	11.28	11.22	11.17	11.14	11.06	11.06	10.96	10.80	10.75
11000	7.71	7.69	7.54	7.45	7.42	7.72	7.69	7.40	7.32	7.32
12000	5.24	5.37	6.03	6.55	6.74	5.40	5.52	6.11	6.62	6.81
13000	10.86	11.26	13.13	14.34	14.75	11.13	11.52	13.66	14.93	15.21
14000	16.41	16.22	15.47	14.76	14.69	15.67	15.50	14.99	14.35	14.19
15000	12.55	12.57	12.50	12.74	12.97	12.30	12.32	12.16	12.60	12.87
16000	11.45	11.53	11.95	12.10	12.13	11.56	11.61	11.91	12.25	12.33
17000	9.86	9.94	10.26	10.23	10.16	10.45	10.53	11.10	10.97	10.83
18000	6.51	6.51	6.47	6.34	6.30	7.51	7.52	7.40	7.26	7.24
19000	3.23	3.28	3.42	3.42	3.44	4.02	4.04	4.00	4.01	4.04
20000	1.60	1.69	2.10	2.38	2.51	2.02	2.11	2.50	2.78	2.87





## 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)	