

Drop-In

NON-CATALOG

Monolithic Amplifier

MAR-2+

50Ω

DC to 2000 MHz



Features

- wideband, DC to 2000 MHz
- high gain, up to 32.5 dB @ 100 MHz
- low noise
- MAR-2+ is equivalent to MSA-0285
- cascadable
- protected by US Patent, 6,943,629 (except MAR-6+)

CASE STYLE: VV105

+ RoHS compliant in accordance with EU Directive (2002/95/EC)

The +Suffix has been added in order to identify RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications.

Applications

- cellular
- PCN instrumentation

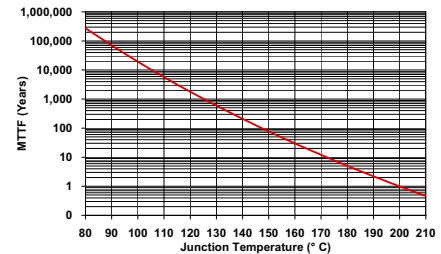
Electrical Specifications *

FREQ. ² (MHz)		GAIN (dB) Typical at MHz				MAXIMUM POWER (dBm)		DYNAMIC RANGE		VSWR (:1) Typ.		ABSOLUTE MAXIMUM RATING ⁵ (25°C)		DC OPERATING POWER ⁷ at Pin 3		THERMAL RESISTANCE ⁵
f _L	f _U	100	1000	2000	Note 1 Min.	Output (1 dB Compr.) Typ.	Input (no dam- age) Typ.	NF (dB) Typ.	IP3 (dBm) Typ.	In	Out	I (mA)	P (mW)	Current (mA)	Device Volt Typ.	°C/W
DC	2000	12.5	12.0	11.0	8.5	+6.0	+13	6.5	+17.0	1.5	1.4	60	325	25	5.0	105

* Test data based on models tested with bent leads per case style WW107

1. Minimum gain over the full frequency range and temperature range.
2. Low frequency cutoff determined by external coupling capacitors.
3. Thermal resistance θ_{jc} is from hottest junction in device to mounting surface of leads.
4. Permanent damage may occur if any of these limits are exceeded. These ratings are not intended for continuous normal operation.
5. Supply voltage must be connected to pin 3 through a bias resistor in order to prevent damage. See "Biasing MMIC Amplifiers" in minicircuits.com/application.html. Reliability predictions are applicable at specified current & normal operating conditions.

MTTF vs. Junction Temp.



Maximum Ratings

Operating Temperature	-40°C to 85°C
Storage Temperature	-55°C to 100°C

Pin Connections

RF IN	1
RF OUT	3
DC	3
GROUND	2,4

Model Identification

Model No.	Marking
MAR-2+	02

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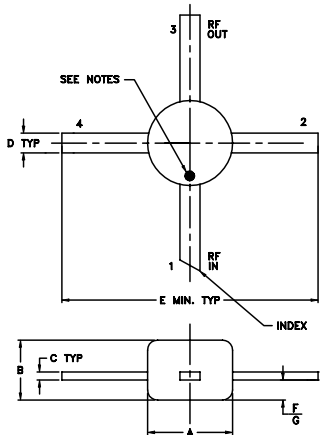
Provides ACTUAL Data Instantly at minicircuits.com

For detailed performance specs
& shopping online see web site

Notes: 1. Performance and quality attributes and conditions not expressly stated in this specification sheet are intended to be excluded and do not form a part of this specification sheet. 2. Electrical specifications and performance data contained herein are based on Mini-Circuit's applicable established test performance criteria and measurement instructions. 3. The parts covered by this specification sheet 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.

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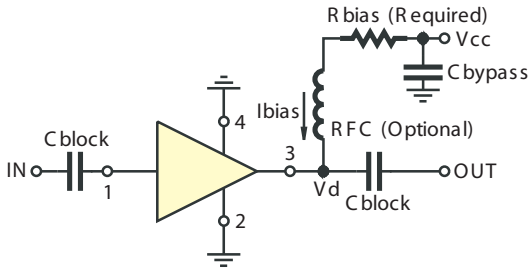
Outline Drawing



Outline Dimensions (inch mm)

A	B	C	D	E	F	G	wt
.085	.060	.008	.020	.250	.012	.025	grams
2.16	1.52	0.20	0.51	6.35	0.30	0.64	.015

Typical Biasing Configuration



Resistor Values ("1%" Res.)	
Vcc	MAR-2+
7	80.6
8	121
9	162
10	200
11	243
12	280
13	324
14	357
15	402

Typical Performance Data

**NOTE: Use PDF Bookmarks to view DATA at required conditions
or to view GRAPHS.**

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 25mA, Vd = 4.82V @Temperature = +25degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.83	18.22	24.31	20.87	1.19	0.54	22.47	8.53	3.63
100	12.80	18.18	24.30	21.34	1.19	0.54	22.56	8.31	3.66
150	12.80	18.23	24.67	21.18	1.20	0.54	23.18	8.48	3.71
200	12.78	18.23	24.33	21.33	1.20	0.54	23.09	8.31	3.71
250	12.76	18.23	24.57	21.37	1.20	0.54	21.97	8.25	3.67
300	12.75	18.20	24.47	21.38	1.20	0.54	23.02	8.37	3.77
350	12.71	18.21	24.53	21.61	1.20	0.54	22.58	8.28	3.77
400	12.71	18.20	24.51	21.50	1.20	0.54	22.76	8.47	3.74
450	12.69	18.21	24.52	21.72	1.20	0.53	22.10	8.15	3.74
500	12.67	18.19	24.71	21.74	1.20	0.53	22.65	8.28	3.73
550	12.63	18.19	24.74	21.97	1.21	0.53	22.05	8.04	3.75
600	12.61	18.19	24.83	22.05	1.21	0.53	22.35	8.28	3.77
650	12.61	18.19	24.89	22.07	1.21	0.53	22.17	8.26	3.77
700	12.55	18.16	24.97	22.44	1.21	0.53	22.31	8.15	3.78
750	12.53	18.15	25.01	22.48	1.21	0.53	22.55	8.30	3.75
800	12.50	18.15	25.41	22.65	1.21	0.52	22.71	8.04	3.79
850	12.47	18.14	25.40	22.72	1.22	0.52	22.60	8.34	3.73
900	12.43	18.13	25.68	23.06	1.22	0.52	22.31	7.91	3.70
940	12.41	18.12	25.83	22.97	1.22	0.52	22.59	8.07	3.70
1000	12.36	18.11	25.81	23.09	1.22	0.52	22.15	8.09	3.69
1050	12.33	18.10	26.50	23.11	1.22	0.52	22.58	8.06	3.67
1100	12.29	18.07	26.24	23.13	1.22	0.51	22.01	8.10	3.73
1150	12.24	18.06	26.27	23.16	1.23	0.51	22.26	7.93	3.80
1200	12.19	18.07	26.86	23.05	1.23	0.51	21.88	8.07	3.77
1250	12.15	18.04	26.85	23.05	1.23	0.51	22.33	7.85	3.76
1300	12.12	18.02	27.03	22.80	1.23	0.51	22.13	7.90	3.81
1350	12.06	18.01	27.38	22.72	1.24	0.50	22.43	7.84	3.79
1400	12.00	17.99	27.26	22.44	1.24	0.50	22.00	7.85	3.81
1450	11.97	17.98	27.65	22.23	1.24	0.50	22.04	7.94	3.85
1500	11.92	17.97	27.55	21.94	1.24	0.50	22.10	7.99	3.91
1550	11.87	17.96	27.70	21.70	1.25	0.49	22.34	7.91	3.82
1600	11.82	17.94	27.61	21.48	1.25	0.49	22.34	7.84	3.86
1650	11.74	17.90	27.71	21.13	1.25	0.49	22.40	7.67	3.81
1700	11.68	17.90	27.54	20.88	1.25	0.49	22.59	7.82	3.87
1750	11.65	17.89	27.50	20.52	1.25	0.48	22.53	7.68	3.77
1800	11.59	17.88	27.46	20.34	1.26	0.48	22.32	7.88	3.80
1850	11.51	17.84	27.39	19.94	1.26	0.48	21.71	7.69	3.84
1900	11.46	17.83	27.23	19.67	1.26	0.48	21.58	7.82	3.77
1950	11.41	17.82	27.11	19.41	1.27	0.47	21.70	7.70	3.73
2000	11.36	17.81	26.77	19.14	1.27	0.47	21.52	7.50	3.74

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 20mA, Vd = 4.75V @Temperature = +25degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.35	17.92	20.98	18.24	1.20	0.54	18.16	5.05	3.66
100	12.36	17.91	21.12	18.48	1.20	0.54	18.11	4.91	3.69
150	12.31	17.91	21.28	18.40	1.21	0.53	18.60	4.90	3.71
200	12.32	17.95	21.27	18.35	1.21	0.53	18.43	5.00	3.75
250	12.28	17.94	21.30	18.64	1.21	0.53	17.59	5.03	3.71
300	12.29	17.95	21.10	18.58	1.21	0.53	18.41	5.06	3.79
350	12.27	17.96	21.36	18.68	1.21	0.53	18.03	4.87	3.78
400	12.22	17.93	21.22	18.72	1.21	0.53	18.26	4.93	3.75
450	12.24	17.96	21.41	18.76	1.21	0.53	17.66	4.72	3.79
500	12.21	17.93	21.37	19.08	1.21	0.53	18.20	5.15	3.73
550	12.19	17.93	21.47	18.99	1.22	0.53	17.64	4.86	3.78
600	12.17	17.92	21.64	19.22	1.22	0.52	17.94	4.82	3.75
650	12.15	17.90	21.49	19.32	1.22	0.52	17.78	4.91	3.78
700	12.14	17.91	21.72	19.59	1.22	0.52	17.94	4.86	3.76
750	12.10	17.89	21.77	19.53	1.22	0.52	18.10	5.06	3.78
800	12.06	17.88	21.95	19.97	1.22	0.52	18.24	4.91	3.78
850	12.03	17.87	21.78	20.00	1.22	0.52	18.18	5.10	3.73
900	12.03	17.87	22.18	20.29	1.22	0.52	17.95	4.89	3.73
940	11.97	17.84	22.36	20.40	1.23	0.51	18.26	4.95	3.74
1000	11.95	17.83	22.32	20.46	1.23	0.51	17.86	4.86	3.69
1050	11.89	17.80	22.49	20.79	1.23	0.51	18.36	4.78	3.72
1100	11.87	17.81	22.35	20.86	1.23	0.51	17.84	4.78	3.77
1150	11.86	17.80	22.64	20.98	1.23	0.51	18.20	4.60	3.83
1200	11.78	17.79	23.06	21.17	1.24	0.50	17.81	4.72	3.83
1250	11.74	17.76	22.77	21.46	1.24	0.50	18.29	4.51	3.81
1300	11.73	17.73	22.85	21.32	1.24	0.50	18.17	4.65	3.84
1350	11.68	17.73	23.40	21.33	1.24	0.50	18.47	4.47	3.81
1400	11.63	17.72	23.31	21.44	1.24	0.50	18.15	4.57	3.85
1450	11.56	17.70	23.35	21.51	1.25	0.49	18.18	4.72	3.81
1500	11.53	17.68	23.27	21.40	1.25	0.49	18.31	4.69	3.91
1550	11.49	17.65	23.44	21.34	1.25	0.49	18.53	4.49	3.84
1600	11.43	17.65	23.44	21.25	1.25	0.49	18.52	4.61	3.85
1650	11.38	17.63	23.69	21.03	1.26	0.48	18.65	4.78	3.86
1700	11.34	17.62	23.61	21.02	1.26	0.48	18.85	5.05	3.85
1750	11.28	17.60	23.53	20.74	1.26	0.48	19.03	4.70	3.77
1800	11.20	17.56	23.48	20.67	1.26	0.48	18.88	5.07	3.79
1850	11.17	17.55	23.61	20.44	1.26	0.47	18.64	4.78	3.81
1900	11.14	17.57	23.65	20.19	1.27	0.47	18.43	4.82	3.77
1950	11.05	17.54	23.51	19.99	1.27	0.47	18.80	4.76	3.71
2000	10.98	17.51	23.28	19.77	1.27	0.47	18.55	4.78	3.74

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 30mA, Vd = 4.88V @Temperature = +25degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	13.06	18.38	26.83	23.21	1.19	0.55	25.76	10.51	3.67
100	13.06	18.35	26.90	23.38	1.19	0.55	26.13	10.44	3.68
150	13.03	18.38	27.22	23.43	1.19	0.54	26.93	10.53	3.71
200	13.04	18.36	26.96	23.39	1.19	0.54	27.15	10.42	3.73
250	13.00	18.37	27.19	23.58	1.19	0.54	25.51	10.48	3.67
300	13.00	18.38	27.00	23.52	1.19	0.54	26.90	10.47	3.74
350	12.97	18.37	27.13	23.61	1.20	0.54	26.42	10.35	3.76
400	12.95	18.36	27.00	23.69	1.20	0.54	26.62	10.53	3.74
450	12.95	18.36	27.12	23.72	1.20	0.54	25.76	10.29	3.76
500	12.91	18.36	27.35	23.91	1.20	0.54	26.30	10.40	3.75
550	12.88	18.36	27.40	24.01	1.20	0.53	25.67	10.30	3.79
600	12.86	18.35	27.46	24.08	1.20	0.53	25.92	10.33	3.77
650	12.84	18.34	27.60	24.17	1.20	0.53	25.63	10.31	3.80
700	12.80	18.34	27.79	24.36	1.21	0.53	25.81	10.24	3.75
750	12.77	18.31	27.73	24.28	1.21	0.53	26.14	10.34	3.77
800	12.73	18.31	28.28	24.54	1.21	0.53	26.29	10.17	3.77
850	12.70	18.29	28.30	24.46	1.21	0.53	26.10	10.36	3.74
900	12.67	18.29	28.66	24.59	1.21	0.52	25.73	10.12	3.73
940	12.63	18.28	28.87	24.48	1.22	0.52	25.91	10.03	3.74
1000	12.60	18.27	28.90	24.37	1.22	0.52	25.41	10.10	3.72
1050	12.54	18.24	29.70	24.30	1.22	0.52	25.66	10.08	3.71
1100	12.51	18.24	29.48	24.10	1.22	0.52	25.10	10.03	3.81
1150	12.47	18.24	29.52	23.99	1.22	0.51	25.17	9.89	3.82
1200	12.41	18.23	30.34	23.65	1.23	0.51	24.84	9.93	3.76
1250	12.36	18.21	30.29	23.55	1.23	0.51	25.25	9.79	3.78
1300	12.33	18.18	30.62	23.10	1.23	0.51	24.90	9.74	3.81
1350	12.28	18.18	31.14	22.87	1.23	0.51	25.06	9.65	3.85
1400	12.22	18.15	30.87	22.45	1.23	0.50	24.58	9.80	3.85
1450	12.17	18.14	31.35	22.15	1.24	0.50	24.65	9.67	3.87
1500	12.13	18.14	31.23	21.73	1.24	0.50	24.62	9.78	3.93
1550	12.07	18.12	31.37	21.44	1.24	0.50	24.90	9.64	3.85
1600	12.01	18.12	31.10	21.13	1.25	0.49	24.82	9.50	3.87
1650	11.95	18.10	31.13	20.76	1.25	0.49	24.84	9.49	3.87
1700	11.90	18.07	30.87	20.45	1.25	0.49	24.94	9.47	3.86
1750	11.84	18.05	30.63	20.02	1.25	0.49	24.61	9.32	3.77
1800	11.77	18.02	30.41	19.82	1.26	0.48	24.24	9.36	3.82
1850	11.71	18.01	30.34	19.43	1.26	0.48	23.48	9.27	3.81
1900	11.65	17.99	29.87	19.14	1.26	0.48	23.40	9.16	3.81
1950	11.60	17.97	29.53	18.84	1.26	0.48	23.31	9.17	3.75
2000	11.53	17.96	29.05	18.59	1.27	0.47	23.19	8.98	3.75

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 25mA, Vd = 5.09V @Temperature = -45degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.99	18.22	24.80	21.39	1.18	0.55	22.40	8.27	2.97
100	12.98	18.26	23.78	21.16	1.19	0.55	22.32	8.13	2.99
150	12.97	18.27	23.32	20.54	1.19	0.55	22.81	8.25	3.00
200	12.95	18.30	23.28	20.62	1.19	0.55	22.62	8.08	3.05
250	12.93	18.30	23.68	21.00	1.19	0.54	21.69	8.08	3.01
300	12.96	18.28	24.44	21.67	1.19	0.55	22.57	8.16	3.16
350	12.92	18.27	25.19	22.36	1.19	0.54	22.19	8.02	3.07
400	12.91	18.27	25.66	22.63	1.19	0.54	22.41	8.37	3.06
450	12.90	18.26	26.15	22.93	1.19	0.54	21.81	8.01	3.05
500	12.88	18.26	25.88	22.84	1.19	0.54	22.34	8.13	3.03
550	12.85	18.25	25.95	22.91	1.20	0.54	21.81	7.92	3.07
600	12.83	18.24	25.87	22.90	1.20	0.54	22.10	8.09	3.05
650	12.83	18.24	26.16	23.12	1.20	0.54	21.90	8.06	3.05
700	12.78	18.22	26.36	23.48	1.20	0.54	22.08	7.95	3.08
750	12.75	18.21	26.49	23.38	1.20	0.54	22.27	8.12	3.03
800	12.73	18.20	26.45	23.34	1.20	0.53	22.42	7.85	3.05
850	12.71	18.20	26.40	23.24	1.20	0.53	22.33	8.16	3.04
900	12.68	18.17	26.47	23.32	1.20	0.53	22.10	7.90	3.02
940	12.64	18.17	26.63	23.27	1.20	0.53	22.40	7.97	3.04
1000	12.61	18.14	27.14	23.54	1.21	0.53	21.99	8.00	2.98
1050	12.57	18.14	27.40	23.59	1.21	0.53	22.45	7.89	3.00
1100	12.55	18.12	27.56	23.65	1.21	0.53	21.95	7.98	3.05
1150	12.50	18.09	27.86	23.66	1.21	0.53	22.29	7.83	3.11
1200	12.45	18.10	28.22	23.39	1.21	0.52	21.89	7.93	3.10
1250	12.43	18.08	28.10	23.39	1.21	0.52	22.38	7.75	3.05
1300	12.40	18.05	28.90	23.14	1.21	0.52	22.20	7.83	3.08
1350	12.34	18.01	29.68	23.04	1.21	0.52	22.54	7.73	3.10
1400	12.28	18.02	29.15	22.74	1.22	0.52	22.14	7.79	3.11
1450	12.24	18.00	29.29	22.50	1.22	0.51	22.18	7.89	3.14
1500	12.22	17.97	29.45	22.13	1.22	0.51	22.26	7.94	3.18
1550	12.15	18.01	29.89	21.96	1.23	0.51	22.47	7.88	3.12
1600	12.10	17.96	29.53	21.58	1.23	0.51	22.52	7.83	3.12
1650	12.05	17.92	29.79	21.17	1.23	0.51	22.60	7.75	3.11
1700	11.99	17.93	29.29	20.92	1.23	0.50	22.83	7.95	3.10
1750	11.94	17.90	29.08	20.52	1.23	0.50	22.91	7.62	3.07
1800	11.89	17.89	29.20	20.36	1.23	0.50	22.77	8.03	3.06
1850	11.83	17.86	29.29	19.96	1.24	0.50	22.35	7.62	3.06
1900	11.78	17.84	28.96	19.64	1.24	0.49	22.21	7.88	3.02
1950	11.72	17.81	28.67	19.30	1.24	0.49	22.43	7.86	3.03
2000	11.68	17.80	28.30	18.97	1.24	0.49	22.19	7.74	3.02

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 20mA, Vd =5.01V @Temperature = -45degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.57	18.13	21.74	18.91	1.20	0.54	17.59	4.83	2.96
100	12.60	18.06	21.14	18.62	1.19	0.54	17.48	4.61	2.97
150	12.55	18.07	20.68	18.23	1.20	0.54	17.91	4.81	3.03
200	12.56	18.05	20.70	18.37	1.20	0.54	17.73	4.77	3.08
250	12.53	18.07	20.97	18.53	1.20	0.54	17.00	4.63	3.01
300	12.54	18.04	21.60	19.08	1.20	0.54	17.72	4.83	3.16
350	12.55	18.05	22.12	19.52	1.20	0.54	17.36	4.64	3.07
400	12.51	18.02	22.28	19.90	1.20	0.54	17.63	4.85	3.05
450	12.52	18.02	22.78	20.13	1.20	0.54	17.07	4.54	3.05
500	12.49	18.03	22.58	19.94	1.20	0.54	17.64	4.77	3.04
550	12.47	18.01	22.64	20.21	1.20	0.54	17.09	4.55	3.08
600	12.45	18.02	22.54	20.14	1.21	0.53	17.38	4.63	3.07
650	12.42	17.98	22.74	20.40	1.20	0.53	17.22	4.60	3.06
700	12.42	17.99	23.04	20.58	1.21	0.53	17.39	4.58	3.09
750	12.39	17.97	22.99	20.82	1.21	0.53	17.49	4.72	3.07
800	12.35	17.96	22.99	20.72	1.21	0.53	17.68	4.53	3.08
850	12.32	17.93	22.98	20.78	1.21	0.53	17.62	4.90	3.04
900	12.33	17.94	23.05	20.82	1.21	0.53	17.39	4.57	3.00
940	12.27	17.93	23.10	20.91	1.21	0.53	17.72	4.64	3.05
1000	12.24	17.91	23.41	21.34	1.21	0.52	17.33	4.62	2.98
1050	12.20	17.88	23.51	21.49	1.21	0.52	17.86	4.59	2.98
1100	12.18	17.86	23.76	21.70	1.21	0.52	17.35	4.68	3.05
1150	12.16	17.86	24.01	21.91	1.21	0.52	17.79	4.36	3.10
1200	12.11	17.87	24.13	21.83	1.22	0.52	17.36	4.46	3.08
1250	12.07	17.82	24.06	21.91	1.22	0.52	17.85	4.29	3.08
1300	12.04	17.79	24.60	21.99	1.22	0.52	17.74	4.33	3.10
1350	11.99	17.79	25.08	22.17	1.22	0.51	18.03	4.40	3.09
1400	11.96	17.77	24.79	22.10	1.22	0.51	17.75	4.48	3.07
1450	11.90	17.75	24.99	22.02	1.22	0.51	17.77	4.51	3.14
1500	11.86	17.72	25.18	21.90	1.22	0.51	17.93	4.45	3.20
1550	11.83	17.75	25.38	21.90	1.23	0.50	18.12	4.50	3.13
1600	11.76	17.69	25.23	21.66	1.23	0.50	18.14	4.59	3.12
1650	11.74	17.67	25.44	21.38	1.23	0.50	18.27	4.49	3.08
1700	11.70	17.67	25.30	21.33	1.23	0.50	18.46	4.78	3.11
1750	11.64	17.65	25.20	20.98	1.23	0.50	18.71	4.41	3.06
1800	11.56	17.63	25.20	20.88	1.24	0.49	18.60	4.86	3.05
1850	11.53	17.61	25.43	20.60	1.24	0.49	18.49	4.42	3.04
1900	11.51	17.60	25.54	20.36	1.24	0.49	18.26	4.88	3.02
1950	11.43	17.58	25.31	20.04	1.24	0.49	18.74	4.68	2.99
2000	11.36	17.55	25.06	19.71	1.24	0.48	18.44	4.71	3.00

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 30mA, Vd = 5.15V @Temperature = -45degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	13.19	18.34	26.88	23.29	1.18	0.56	25.92	10.59	2.98
100	13.20	18.38	25.71	22.94	1.18	0.55	25.90	10.46	3.03
150	13.18	18.37	25.38	22.27	1.18	0.55	26.52	10.53	3.04
200	13.17	18.43	24.97	22.24	1.18	0.55	26.30	10.45	3.05
250	13.15	18.43	25.64	22.85	1.19	0.55	25.10	10.49	3.02
300	13.14	18.42	26.53	23.53	1.19	0.55	26.12	10.49	3.15
350	13.14	18.42	27.50	24.36	1.19	0.55	25.73	10.37	3.06
400	13.12	18.40	28.30	24.80	1.19	0.55	25.94	10.57	3.07
450	13.11	18.39	28.61	24.94	1.19	0.55	25.26	10.36	3.09
500	13.09	18.39	28.55	24.94	1.19	0.54	25.80	10.43	3.09
550	13.05	18.38	28.50	24.77	1.19	0.54	25.25	10.29	3.06
600	13.05	18.37	28.51	24.87	1.19	0.54	25.48	10.37	3.10
650	13.02	18.36	28.88	25.02	1.19	0.54	25.26	10.39	3.11
700	12.99	18.35	28.93	25.23	1.19	0.54	25.44	10.30	3.09
750	12.96	18.34	29.02	24.98	1.20	0.54	25.69	10.39	3.06
800	12.93	18.34	29.28	24.97	1.20	0.54	25.86	10.16	3.09
850	12.89	18.33	29.12	24.63	1.20	0.54	25.76	10.40	3.01
900	12.89	18.31	29.19	24.65	1.20	0.54	25.43	10.16	3.04
940	12.85	18.29	29.60	24.57	1.20	0.53	25.70	10.26	3.05
1000	12.80	18.28	29.91	24.62	1.20	0.53	25.31	10.19	2.99
1050	12.76	18.27	30.73	24.59	1.20	0.53	25.64	10.15	3.00
1100	12.72	18.24	30.76	24.39	1.20	0.53	25.12	10.19	3.07
1150	12.70	18.24	30.97	24.26	1.21	0.53	25.32	9.98	3.12
1200	12.64	18.24	31.82	23.83	1.21	0.52	24.94	10.09	3.10
1250	12.60	18.21	31.85	23.73	1.21	0.52	25.43	9.90	3.06
1300	12.56	18.19	32.86	23.27	1.21	0.52	25.17	9.93	3.12
1350	12.51	18.18	33.49	23.09	1.21	0.52	25.44	9.89	3.12
1400	12.47	18.16	32.91	22.62	1.22	0.52	24.99	10.00	3.15
1450	12.42	18.13	33.11	22.26	1.22	0.52	25.02	9.97	3.16
1500	12.37	18.12	33.00	21.81	1.22	0.51	25.08	9.97	3.20
1550	12.32	18.15	34.01	21.58	1.23	0.51	25.24	9.95	3.15
1600	12.27	18.10	32.89	21.19	1.22	0.51	25.28	9.86	3.14
1650	12.21	18.08	32.84	20.74	1.23	0.51	25.36	9.77	3.15
1700	12.18	18.06	32.18	20.47	1.23	0.51	25.58	9.86	3.15
1750	12.12	18.03	31.82	20.00	1.23	0.50	25.41	9.66	3.06
1800	12.06	18.02	31.68	19.80	1.23	0.50	25.17	9.85	3.09
1850	12.01	18.00	31.61	19.44	1.23	0.50	24.52	9.63	3.09
1900	11.95	17.99	30.87	19.12	1.24	0.50	24.44	9.72	3.08
1950	11.89	17.95	30.48	18.72	1.24	0.50	24.40	9.64	3.06
2000	11.83	17.95	29.74	18.42	1.24	0.49	24.22	9.60	3.07

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 25mA, Vd = 4.57V @Temperature = +85degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.61	18.05	24.02	20.27	1.20	0.54	22.06	8.56	4.17
100	12.60	18.08	24.33	20.98	1.20	0.54	22.18	8.38	4.21
150	12.60	18.03	25.46	21.51	1.20	0.54	22.84	8.53	4.26
200	12.57	18.04	25.66	21.54	1.20	0.54	22.73	8.40	4.27
250	12.55	18.06	25.70	21.76	1.20	0.53	21.52	8.38	4.27
300	12.54	18.06	25.31	21.37	1.20	0.53	22.58	8.44	4.30
350	12.49	18.08	24.47	21.14	1.21	0.53	22.17	8.30	4.32
400	12.50	18.06	24.09	20.77	1.21	0.53	22.32	8.64	4.34
450	12.46	18.08	23.92	20.65	1.21	0.53	21.65	8.16	4.32
500	12.44	18.07	23.81	20.79	1.21	0.53	22.15	8.35	4.32
550	12.40	18.07	23.86	20.83	1.21	0.53	21.60	8.18	4.32
600	12.39	18.06	23.72	20.98	1.21	0.53	21.84	8.30	4.33
650	12.38	18.07	24.02	21.11	1.22	0.52	21.62	8.37	4.35
700	12.30	18.05	23.92	21.28	1.22	0.52	21.78	8.15	4.35
750	12.28	18.04	23.81	21.19	1.22	0.52	21.99	8.35	4.32
800	12.26	18.02	23.94	21.48	1.22	0.52	22.15	8.11	4.37
850	12.21	18.02	23.92	21.43	1.22	0.52	22.03	8.25	4.31
900	12.18	18.02	23.79	21.66	1.23	0.51	21.70	7.97	4.29
940	12.16	18.00	23.85	21.75	1.23	0.51	21.97	8.17	4.33
1000	12.10	18.01	23.96	21.83	1.23	0.51	21.51	8.10	4.27
1050	12.08	17.96	24.33	22.13	1.23	0.51	21.86	8.10	4.31
1100	12.02	17.96	24.44	22.17	1.24	0.51	21.33	8.04	4.36
1150	11.98	17.97	24.46	22.32	1.24	0.50	21.48	7.92	4.42
1200	11.93	17.95	24.70	22.37	1.24	0.50	21.14	8.01	4.43
1250	11.89	17.93	24.93	22.69	1.24	0.50	21.56	7.82	4.39
1300	11.84	17.93	25.41	22.48	1.25	0.50	21.30	7.91	4.45
1350	11.79	17.90	25.67	22.49	1.25	0.49	21.55	7.76	4.41
1400	11.73	17.88	25.48	22.40	1.25	0.49	21.14	7.92	4.47
1450	11.69	17.86	26.04	22.26	1.25	0.49	21.14	7.88	4.47
1500	11.64	17.84	26.40	21.96	1.26	0.49	21.17	7.84	4.54
1550	11.58	17.85	26.38	21.94	1.26	0.48	21.39	7.76	4.48
1600	11.52	17.82	26.62	21.54	1.26	0.48	21.35	7.76	4.48
1650	11.45	17.80	26.57	21.16	1.27	0.48	21.42	7.59	4.49
1700	11.38	17.79	26.41	21.01	1.27	0.47	21.54	7.69	4.47
1750	11.34	17.78	26.51	20.52	1.27	0.47	21.40	7.51	4.39
1800	11.28	17.77	26.62	20.36	1.28	0.47	21.16	7.72	4.41
1850	11.19	17.73	26.54	20.00	1.28	0.47	20.59	7.54	4.46
1900	11.13	17.73	26.18	19.69	1.28	0.46	20.47	7.38	4.45
1950	11.08	17.69	25.93	19.38	1.28	0.46	20.50	7.46	4.39
2000	11.03	17.69	25.58	19.14	1.29	0.46	20.31	7.34	4.44

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 20mA, Vd = 4.50V @Temperature = +85degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.13	17.82	20.64	17.50	1.21	0.53	17.91	5.43	4.21
100	12.10	17.77	20.85	18.02	1.21	0.53	17.90	5.01	4.24
150	12.09	17.74	21.80	18.48	1.21	0.53	18.42	5.28	4.26
200	12.07	17.75	21.80	18.44	1.21	0.53	18.23	5.25	4.32
250	12.05	17.78	21.89	18.64	1.22	0.53	17.31	5.03	4.27
300	12.07	17.79	21.49	18.38	1.21	0.53	18.15	5.35	4.28
350	11.99	17.79	21.01	18.26	1.22	0.52	17.78	5.07	4.34
400	11.99	17.79	20.88	18.08	1.22	0.52	18.00	5.22	4.33
450	11.97	17.81	20.67	17.86	1.22	0.52	17.40	5.05	4.33
500	11.95	17.78	20.66	18.05	1.22	0.52	17.92	5.18	4.34
550	11.92	17.78	20.62	18.10	1.22	0.52	17.38	4.96	4.34
600	11.87	17.77	20.67	18.26	1.23	0.52	17.66	5.22	4.37
650	11.89	17.77	20.83	18.34	1.22	0.52	17.48	5.00	4.38
700	11.83	17.76	20.64	18.46	1.23	0.51	17.64	5.01	4.36
750	11.81	17.78	20.65	18.49	1.23	0.51	17.79	5.28	4.36
800	11.77	17.75	20.78	18.80	1.23	0.51	17.94	5.00	4.36
850	11.76	17.73	20.63	18.78	1.23	0.51	17.89	5.36	4.37
900	11.70	17.72	20.59	19.02	1.24	0.51	17.62	5.03	4.33
940	11.67	17.72	20.81	19.15	1.24	0.51	17.95	5.15	4.37
1000	11.64	17.72	20.75	19.22	1.24	0.50	17.53	5.05	4.30
1050	11.61	17.66	21.10	19.70	1.24	0.50	18.01	4.95	4.35
1100	11.60	17.67	21.00	19.74	1.24	0.50	17.50	5.09	4.39
1150	11.53	17.67	21.11	19.88	1.25	0.50	17.82	4.80	4.40
1200	11.46	17.65	21.40	20.18	1.25	0.49	17.44	4.76	4.40
1250	11.45	17.62	21.49	20.64	1.25	0.50	17.89	4.42	4.41
1300	11.44	17.62	21.72	20.57	1.25	0.49	17.73	4.68	4.44
1350	11.35	17.59	21.92	20.70	1.26	0.49	18.00	4.58	4.47
1400	11.28	17.57	21.82	20.98	1.26	0.49	17.68	4.82	4.44
1450	11.27	17.55	22.23	21.12	1.26	0.49	17.69	4.92	4.47
1500	11.25	17.55	22.36	21.01	1.26	0.48	17.81	5.00	4.54
1550	11.16	17.53	22.49	21.24	1.27	0.48	18.03	4.99	4.51
1600	11.13	17.52	22.67	21.06	1.27	0.48	18.03	4.90	4.48
1650	11.05	17.49	22.64	20.88	1.27	0.47	18.19	4.83	4.50
1700	10.98	17.48	22.48	21.00	1.28	0.47	18.33	4.95	4.49
1750	10.95	17.46	22.72	20.66	1.28	0.47	18.45	4.81	4.43
1800	10.89	17.45	22.92	20.61	1.28	0.47	18.30	5.11	4.46
1850	10.81	17.43	22.79	20.41	1.28	0.46	18.01	4.88	4.45
1900	10.76	17.41	22.53	20.15	1.29	0.46	17.83	4.98	4.43
1950	10.70	17.37	22.58	19.96	1.29	0.46	18.08	4.99	4.36
2000	10.64	17.36	22.47	19.75	1.29	0.45	17.85	4.76	4.42

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Typical Performance Data

Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Icc = 30mA, Vd = 4.64V @Temperature = +85degC

FREQ	Gain	Isolation	Input Return Loss	Output Return Loss	Stability		IP3 Output	1dB Comp. Output	Noise Figure
(MHz)	(dB)	(dB)	(dB)	(dB)	K	Delta	(dBm)	(dBm)	(dB)
50	12.89	18.25	26.62	22.39	1.19	0.54	25.23	10.46	4.21
100	12.89	18.22	27.27	23.26	1.19	0.54	25.57	10.41	4.24
150	12.87	18.22	28.84	24.02	1.19	0.54	26.39	10.38	4.29
200	12.85	18.23	29.12	24.23	1.20	0.54	26.54	10.34	4.30
250	12.82	18.25	29.14	24.34	1.20	0.54	24.85	10.39	4.25
300	12.82	18.25	28.41	23.71	1.20	0.54	26.22	10.33	4.33
350	12.78	18.25	27.45	23.34	1.20	0.53	25.72	10.26	4.35
400	12.76	18.24	26.78	22.97	1.20	0.54	25.89	10.37	4.32
450	12.74	18.24	26.57	22.78	1.20	0.53	25.00	10.21	4.34
500	12.70	18.24	26.43	22.81	1.21	0.53	25.49	10.27	4.33
550	12.69	18.24	26.56	22.92	1.21	0.53	24.91	10.15	4.32
600	12.65	18.23	26.36	23.02	1.21	0.53	25.10	10.16	4.36
650	12.63	18.22	26.63	23.15	1.21	0.53	24.77	10.24	4.37
700	12.59	18.22	26.61	23.16	1.21	0.53	24.97	10.20	4.39
750	12.55	18.21	26.44	23.15	1.22	0.52	25.22	10.13	4.33
800	12.51	18.21	26.53	23.32	1.22	0.52	25.39	10.05	4.40
850	12.48	18.20	26.51	23.22	1.22	0.52	25.17	10.17	4.37
900	12.45	18.18	26.43	23.39	1.22	0.52	24.76	10.01	4.35
940	12.41	18.19	26.45	23.40	1.22	0.52	24.89	9.98	4.36
1000	12.35	18.18	26.58	23.45	1.23	0.51	24.40	9.94	4.31
1050	12.32	18.14	27.07	23.57	1.23	0.51	24.59	9.88	4.34
1100	12.28	18.15	27.20	23.51	1.23	0.51	24.03	9.84	4.39
1150	12.23	18.14	27.26	23.54	1.23	0.51	24.01	9.65	4.45
1200	12.17	18.12	27.65	23.40	1.24	0.50	23.70	9.71	4.43
1250	12.13	18.10	27.85	23.53	1.24	0.50	23.98	9.53	4.41
1300	12.09	18.09	28.48	23.16	1.24	0.50	23.64	9.47	4.47
1350	12.02	18.07	28.97	23.04	1.25	0.50	23.81	9.44	4.51
1400	11.96	18.06	28.76	22.67	1.25	0.49	23.33	9.46	4.45
1450	11.92	18.05	29.46	22.34	1.25	0.49	23.34	9.37	4.53
1500	11.88	18.03	29.89	21.89	1.25	0.49	23.30	9.41	4.53
1550	11.80	18.03	29.97	21.75	1.26	0.49	23.49	9.21	4.50
1600	11.74	18.01	30.07	21.27	1.26	0.48	23.44	9.14	4.49
1650	11.68	17.99	30.16	20.82	1.26	0.48	23.42	9.04	4.53
1700	11.62	17.98	29.90	20.59	1.27	0.48	23.46	9.06	4.51
1750	11.55	17.96	29.73	20.07	1.27	0.47	23.20	8.93	4.41
1800	11.49	17.95	29.75	19.84	1.27	0.47	22.83	8.85	4.46
1850	11.42	17.91	29.63	19.43	1.28	0.47	22.13	8.85	4.48
1900	11.36	17.90	28.92	19.15	1.28	0.47	22.06	8.67	4.44
1950	11.29	17.87	28.48	18.82	1.28	0.46	21.89	8.72	4.41
2000	11.23	17.86	27.87	18.54	1.28	0.46	21.75	8.48	4.44

REV. X1

MAR-2+

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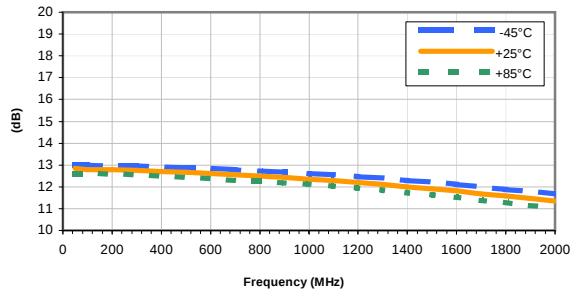
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Typical Performance Curves

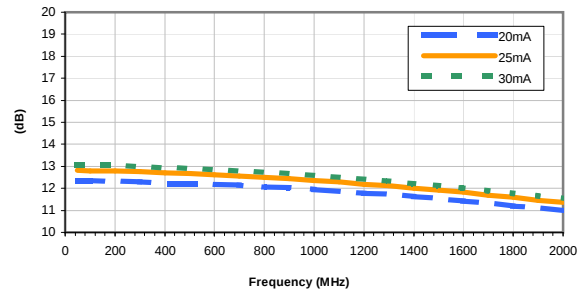
GAIN vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



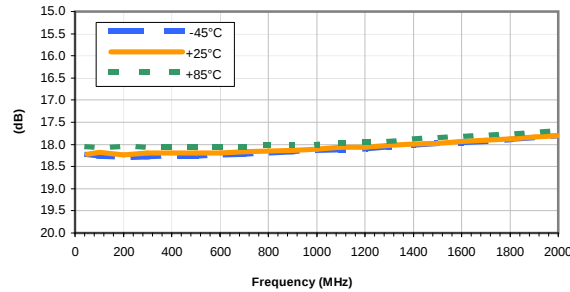
GAIN vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



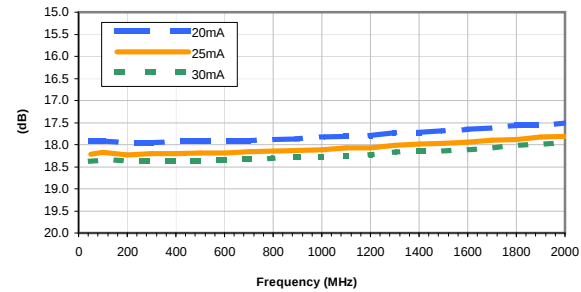
ISOLATION vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



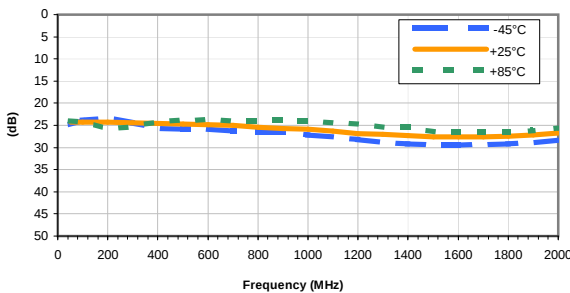
ISOLATION vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



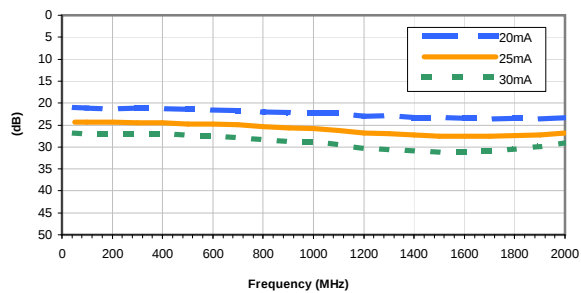
INPUT RETURN LOSS vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



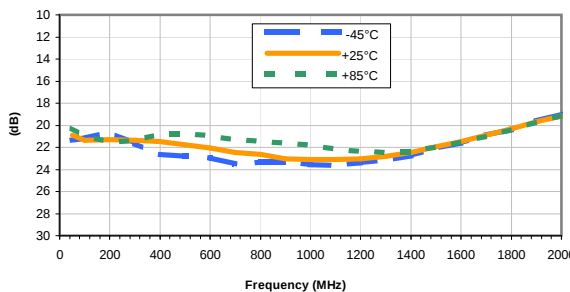
INPUT RETURN LOSS vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



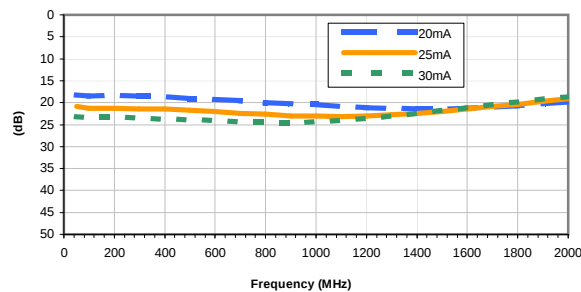
OUTPUT RETURN LOSS vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



OUTPUT RETURN LOSS vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



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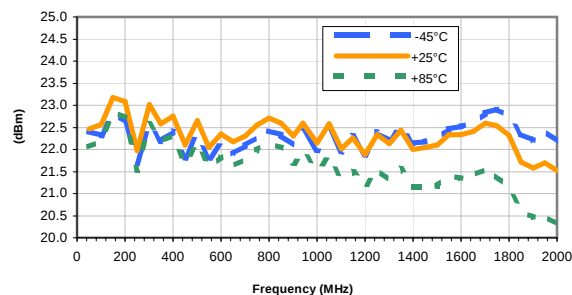
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Typical Performance Curves

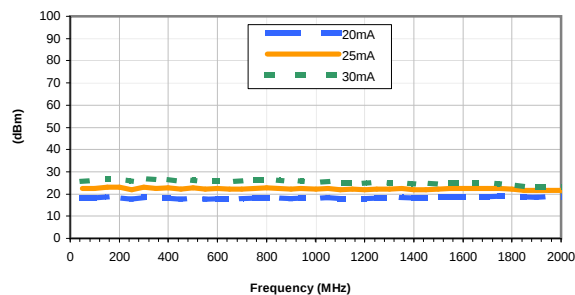
OUTPUT IP3 vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



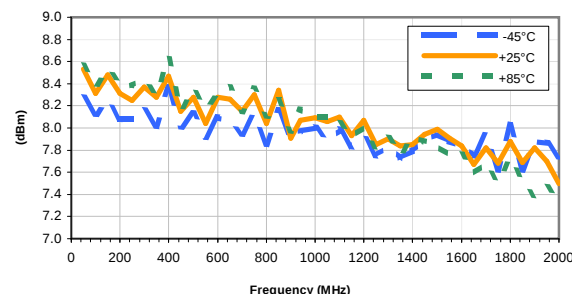
OUTPUT IP-3 vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



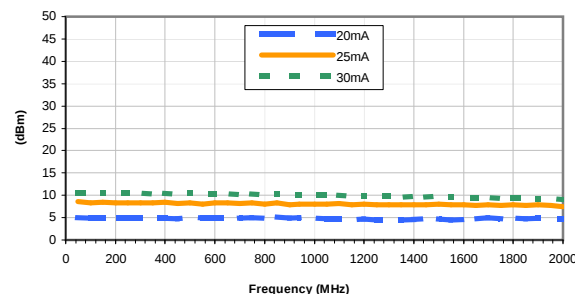
OUTPUT POWER at 1dB Compression vs. TEMPERATURE

CURRENT = 25mA



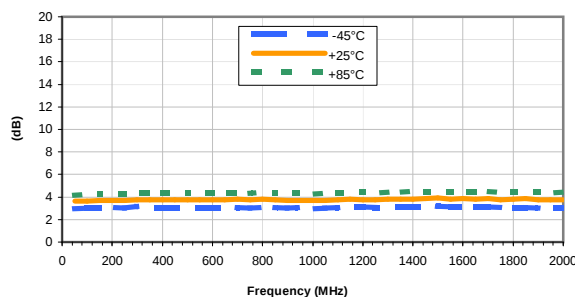
OUTPUT POWER at 1dB Compression vs. CURRENT

Temperature = +25°C



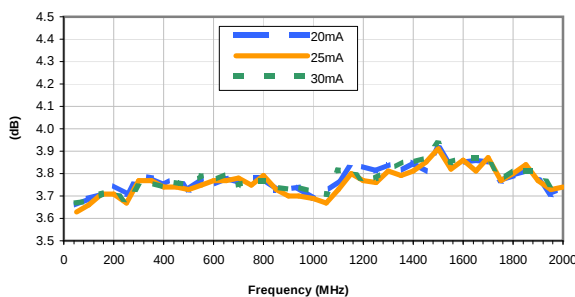
Noise Figure vs. TEMPERATURE

CURRENT = 25mA



Noise Figure vs. CURRENT

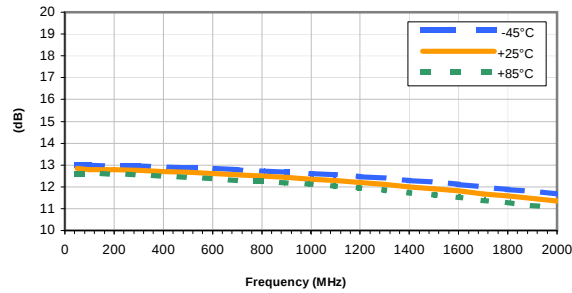
Temperature = +25°C



Typical Performance Curves

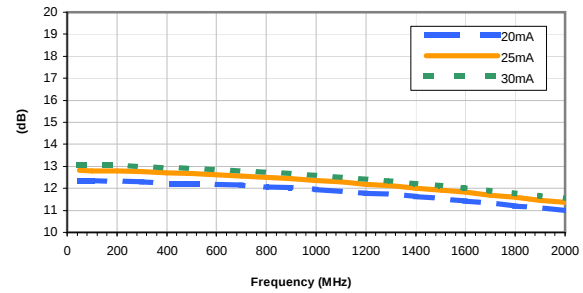
GAIN vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



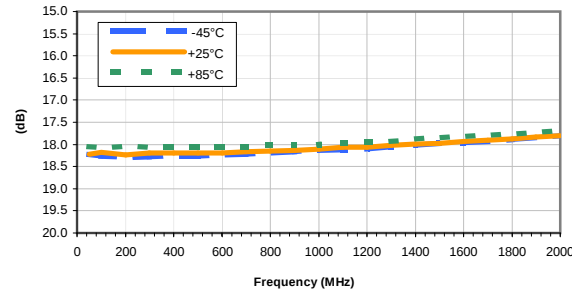
GAIN vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



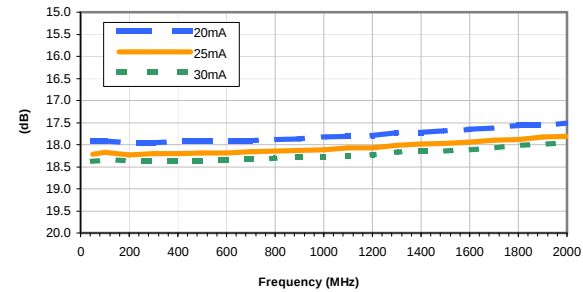
ISOLATION vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



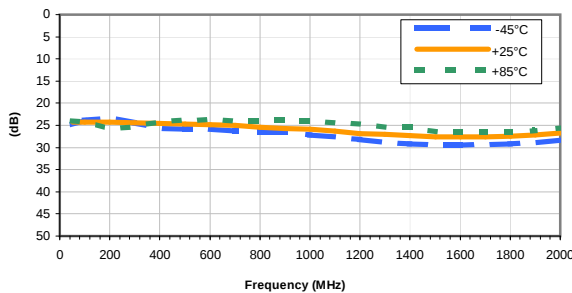
ISOLATION vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



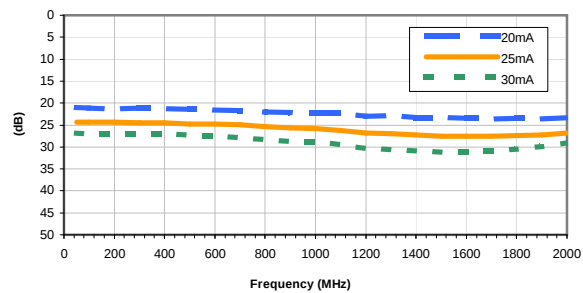
INPUT RETURN LOSS vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



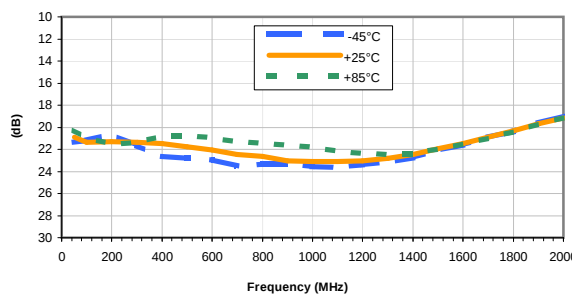
INPUT RETURN LOSS vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



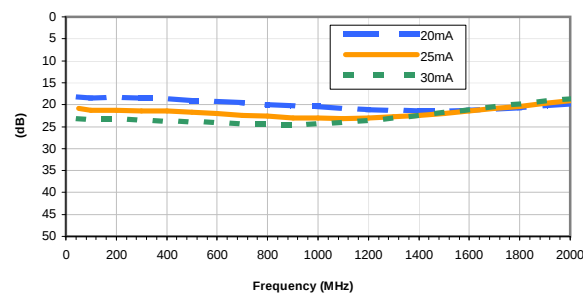
OUTPUT RETURN LOSS vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



OUTPUT RETURN LOSS vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



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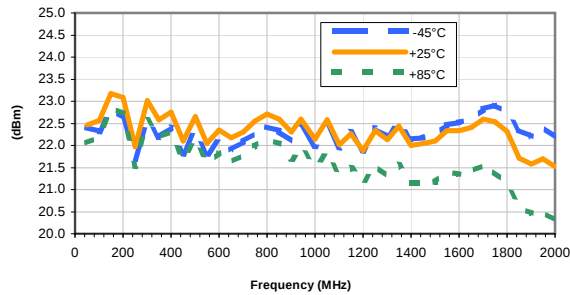
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Typical Performance Curves

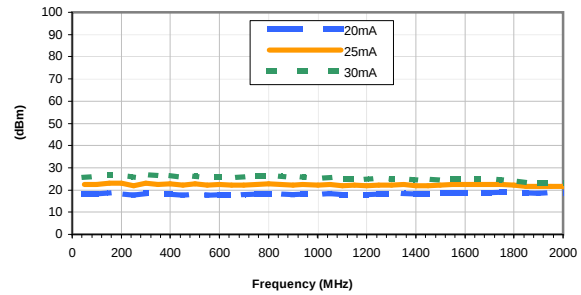
OUTPUT IP3 vs. TEMPERATURE

INPUT POWER = -20dBm, CURRENT = 25mA



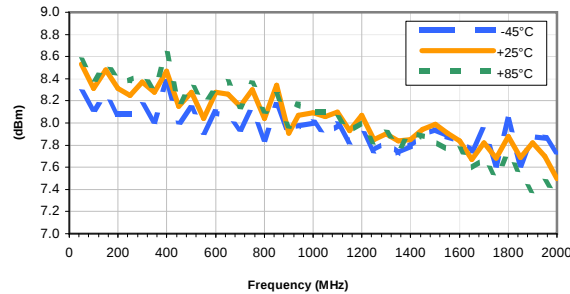
OUTPUT IP-3 vs. CURRENT

INPUT POWER = -20dBm, Temperature = +25°C



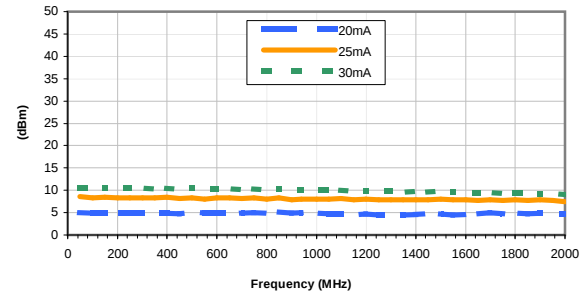
OUTPUT POWER at 1dB Compression vs. TEMPERATURE

CURRENT = 25mA



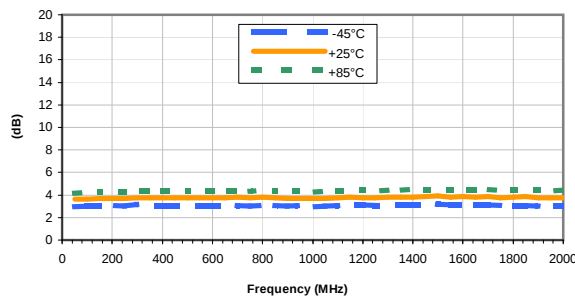
OUTPUT POWER at 1dB Compression vs. CURRENT

Temperature = +25°C



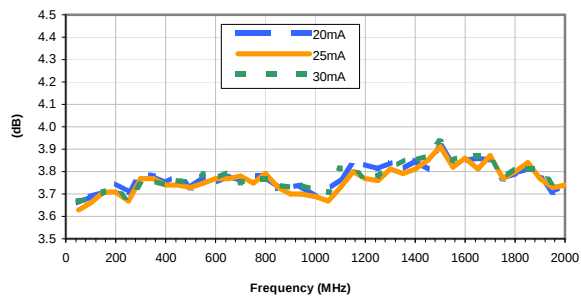
Noise Figure vs. TEMPERATURE

CURRENT = 25mA

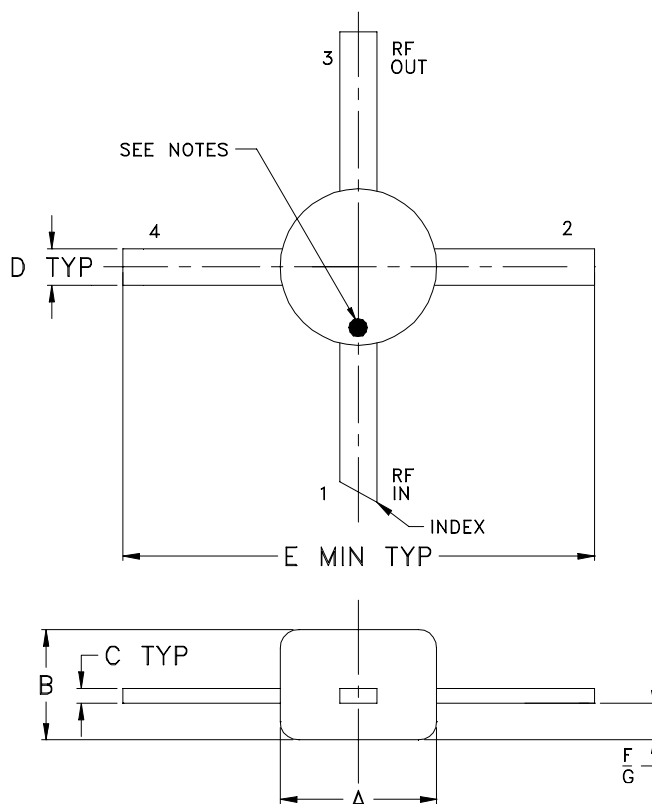


Noise Figure vs. CURRENT

Temperature = +25°C



Outline Dimensions



CASE#	A	B	C	D	E	F	G	WT.GRAMS
VV105	.085 (2.16)	.060 (1.52)	.008 (0.20)	.020 (0.51)	.250 (6.35)	.012 (0.30)	.025 (0.64)	.015

Dimensions are in inches (mm). Tolerances: 2 Pl. $\pm .03$; 3 Pl. $\pm .015$

Notes:

- Case material: Plastic.
- Termination finish:
For RoHS Case Styles: Tin-Silver alloy plate over Nickel barrier.
For RoHS-5 Case Styles: Tin-Lead plate.
- RF input termination (1) identified by one or both of the following at factory option:
 - diagonally cut termination, which be 45° (ref) in either direction;
 - orientation mark on the case. Model dash number is identified by color dot or alphanumeric code on case. See specification data sheet.
- Special Tolerances: Termination width $\pm .005$ inch, termination thickness $\pm .003$ inch.



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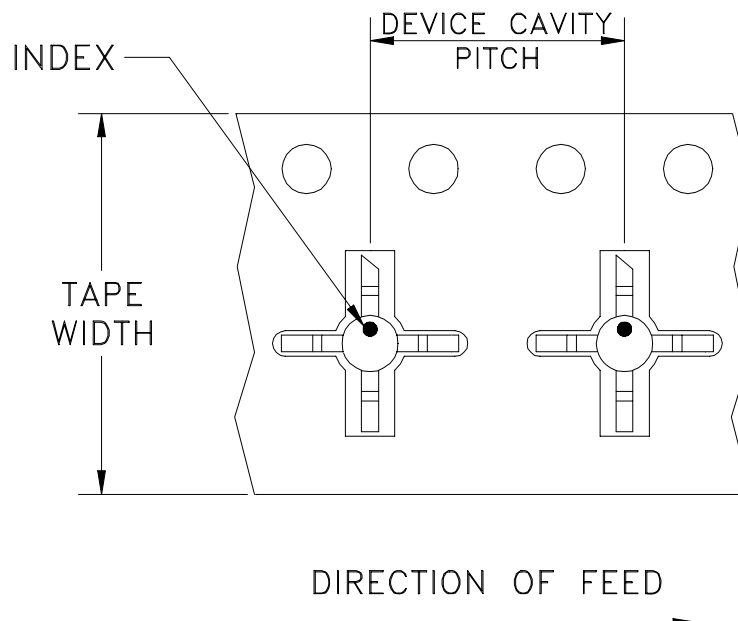
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Tape & Reel Packaging TR-F4

DEVICE ORIENTATION IN T&R



Tape Width, mm	Device Cavity Pitch, mm	Reel Size, inches	Devices per Reel	
12	8	7	Small quantity standards (see note)	20
				50
				100
				200
				500
		7	Standard	1000

Note: Please Consult individual model data sheet to determine device per reel availability.

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



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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	-20° to 85°C Ambient Environment	Individual Model Data Sheet
Storage Temperature	-55° to 100° C Ambient Environment	Individual Model Data Sheet
Thermal Shock	-55° to 100°C, 100 cycles	MIL-STD-202, Method 107, Condition A-3, except +100°C
Mechanical Shock	1.5Kg, 0.5 ms, 5 shock pulses, Y1 direction only	MIL-STD-883, Method 2002, Condition B, except Y1 direction only
Vibration (Variable Frequency)	50g peak	MIL-STD-883, Method 2007, Condition B
Autoclave	15 psig, 100% RH, 121°C, 96 hours	JESD22-A102, Condition C
HAST	130°C, 85% RH, 96 hours	JESD22-A110
Solderability	10X Magnification	J-STD-002, Para 4.2.5, Test S, 95% Coverage
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 260°C peak	J-STD-020
Marking Resistance to Solvents	Isopropyl alcohol + mineral spirits at 25°C; terpene defluxer at 25°C; distilled water + proylene glycol monomethyl ether +	MIL-STD-202, Method 215



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
	monoethanolamine at 63°C to 70°C	