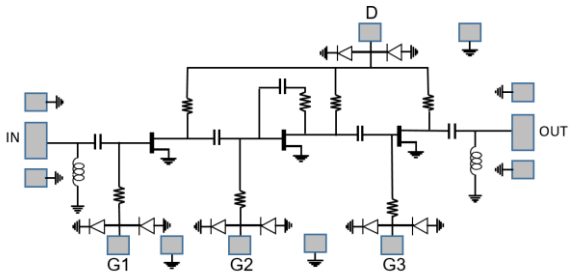
46-52GHz Low Noise Amplifier with AGC

GaAs Monolithic Microwave IC

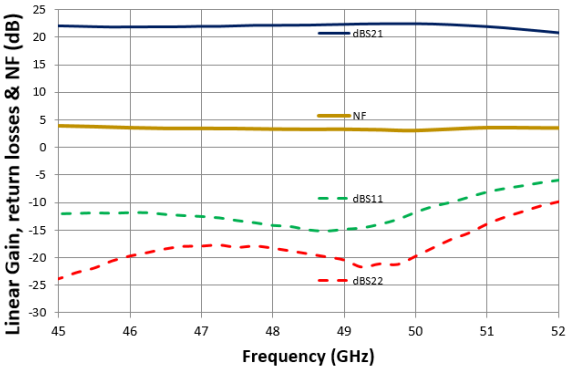
Description

The CHA2352-98F is a three stage monolithic Low Noise Amplifier, which produces 21dB linear gain with 20dB Adjustable Gain Control (AGC) and 3.5dB Noise Figure in the frequency band 46-52GHz. It includes ESD protections on each RF access and DC pads.
This amplifier is designed for a wide range of applications, from Commercial to Space communication systems.
It is manufactured with a pHEMT process, 0.1µm gate length, via holes through the substrate, air bridges and electron beam gate lithography and is available in bare die with BCB layer protection.



Main Features

■Broadband performances: 46-52GHz
■Low Noise Figure: 3.5dB
■12dBm Pout@1db compression for input power ≥-10dBm
■High Gain: 21dB
■BCB Layer protection
■Typical DC bias: Vd=3.3V@Id=55mA
■Chip size 2x1.2x0.07mm



Typical S parameters and Noise Figure

Main Electrical Characteristics

Tamb.= +25°C, Vd(D) = 3.3V,VG(G1=G2=G3) =0V

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	46		52	GHz
Gain	Linear Gain		21		dB
NF	Noise Figure		3.5		dB
Pout	Output Power @1dB comp.		12		dBm

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Electrical Characteristics

Tamb.= +25°C, Vd(D) = 3.3V,VG(G1=G2=G3) set in order to get Idq = 55mA (≈0V)

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	46		52	GHz
Gain	Linear Gain		21		dB
NF	Noise Figure		3.5		dB
IRL	Input return loss		13		dB
ORL	Output return loss		16		dB
Gain ctrl	Gate control voltage to gain sensitivity		20		dB
IP-1dB	Input power at 1dB gain compression		-8		dBm
OP-1dB	Output power at 1dB gain compression		12		dBm
Vd	Drain bias voltage		3.3		V
Id	Drain bias current		55		mA

These values are representative of on-board measurements as defined on the drawing in paragraph "Evaluation board".
A bonding wire of typically 0.1 to 0.15nH will improve the matching at the RF accesses.

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Absolute Maximum Ratings (1)

Tamb.= +25°C

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	4V	V
Vg	Gate bias voltage	-1.5 to +0.4	V
Pin	Maximum peak input power overdrive (2)	2	dBm
Tj	Junction temperature	175	°C

(1) Operation of this device above anyone of these parameters may cause permanent damage.

(2) Thermal Resistance channel to ground paddle

Recommended Operating Range 3, 4

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	3.0 to 3.6	V
Id	Drain bias current	54 to 70	mA
Vg	Gate bias voltage	-0.5 to +0.1	V
Pin	Input power range	-20 to -2	dBm

(3) Electrical performances are defined for specified test conditions

(4) Electrical performances are not guaranteed over all recommended operating conditions

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Temperature Range

Ta	Operating temperature range	-40 to +95	°C
Tstg	Storage temperature range	-55 to +150	°C

Typical Bias Conditions

Tamb.= +25°C

Symbol	Pad Nº	Parameter	Values	Unit
VG1	9	Gate voltage tuned for Idq ~55mA	+0	V
VG2	7			
VG3	5			
VD	2	Drain Voltage	3.3	V

"Power ON" sequence

1. Ground the device
2. Bias LNA gate voltage at Vgs close to Vpinch-off (G1=G2=G3=0.5V -1.5V)
3. Apply Vds quiescent bias voltage (Vd = 3.3V)
4. Increase slowly Vg1 up to 0V and 2nd & 3rd stage Vgs up to quiescent bias drain current Idq (100mA for total Idq current)
5. Apply RF input power

"Power OFF" sequence

1. Remove RF input power
2. Bias LNA gate voltage at Vgs close to Vpinch-off (G1=G2=G3=0.5V -1.5V)
3. Set drain voltage to 0V
4. Set gate voltage to 0V

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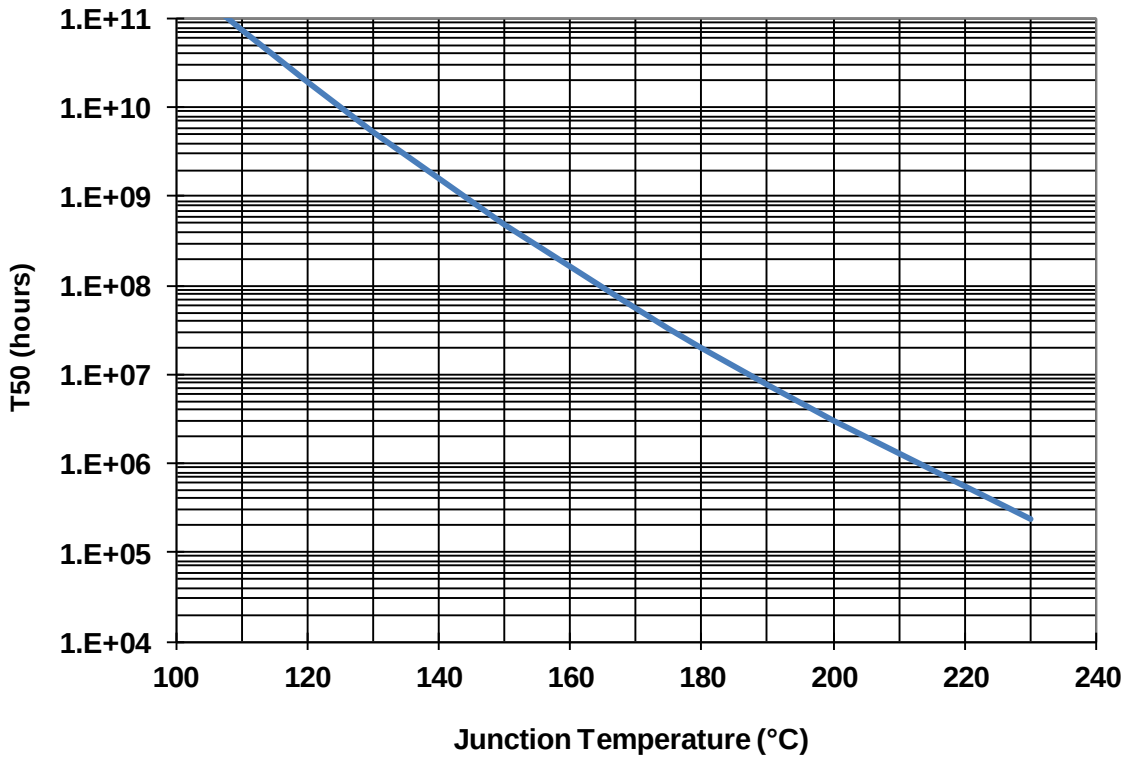
Device thermal performances

The device thermal performances below are based on UMS rules to evaluate the junction temperature.
The temperature Tb_{chip} is defined as the chip backside temperature.
The system maximum temperature must be adjusted in order to guarantee that Tjunction remains below the maximum value specified in the Absolute Maximum Ratings table.
Therefore, the PCB system must be designed to comply with this requirement.

Parameter	Biasing conditions	Tjunction (°C)	R_{TH} (°C/W)	T50 (hours)
R_{TH} (1) Thermal Resistance (Junction to Case)	Vd = 3.3V Id = 55mA P_{diss} = 0.18W	130	250	$5x10^9$

(1) Assuming 85°Tb_{chip}



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Typical on-board Sij parameters

Tamb.= +25°C, Vd = +3.3V, Id = 55mA

Freq (GHz)	S11 (dB)	PhS11 (°)	S12 (dB)	PhS12 (°)	S21 (dB)	PhS21 (°)	S22 (dB)	PhS22 (°)
38	-1.67749	-96.036	-47.114	87.7094	13.9391	-74.2987	-6.88755	64.5732
38.5	-1.73018	-108.734	-48.8004	56.4504	15.59	-90.6353	-6.74418	63.1019
39	-1.73452	-122.177	-46.6783	43.4578	17.2140	-107.415	-6.52361	60.5373
39.5	-1.89709	-136.170	-45.4142	28.4421	18.7485	-125.506	-6.2604	56.853
40	-2.09373	-150.807	-47.3335	9.20285	20.2068	-144.381	-6.13741	50.9982
40.5	-2.61484	-166.878	-46.3137	-32.2792	21.4799	-165.334	-6.06872	43.2920
41	-3.59895	177.374	-46.6791	-53.4724	22.3849	173.052	-6.30426	34.1858
41.5	-4.89870	163.067	-45.0936	-84.4821	23.0158	150.830	-7.05945	23.8043
42	-6.76324	151.392	-44.7473	-109.094	23.2725	129.286	-8.34997	14.0730
42.5	-8.86111	145.597	-44.7096	-143.93	23.2299	108.804	-10.1036	4.81448
43	-10.8047	144.846	-44.3887	-157.113	23.0782	89.6807	-12.5217	1.59073
43.5	-11.9769	148.553	-42.5701	-170.154	22.7850	72.0930	-15.4041	5.04522
44	-12.5339	153.926	-42.4812	177.299	22.4920	55.8298	-19.1655	0.42092
44.5	-12.5015	157.142	-42.2134	152.693	22.2378	40.507	-22.9304	17.7235
45	-12.1	156.506	-41.8905	153.985	21.9976	26.1521	-23.8848	57.1862
45.5	-11.9154	154.905	-41.6972	129.311	21.8434	12.2224	-21.9389	72.9923
46	-11.8727	152.314	-41.8068	120.351	21.7937	-1.77690	-19.7483	81.2896
46.5	-12.1994	150.26	-41.4248	117.649	21.8048	-15.0545	-18.44	83.6011
47	-12.5702	147.127	-41.7006	110.658	21.9071	-28.8998	-17.9479	80.9778
47.5	-13.3167	146.625	-41.3435	111.913	21.9962	-43.3212	-18.1674	79.0382
48	-14.2019	149.710	-40.3601	94.6982	22.0845	-57.9207	-18.3228	80.2910
48.5	-15.0261	157.276	-40.3571	77.0632	22.1242	-72.9191	-19.3552	83.9594
49	-14.9065	168.995	-39.4624	70.8862	22.2605	-88.3616	-20.4752	94.1548
49.5	-13.992	-177.182	-40.0593	55.4913	22.367	-104.304	-21.1717	115.428
50	-11.8201	-170.887	-40.5868	44.2668	22.3891	-121.264	-19.7946	140.802
50.5	-9.97835	-170.031	-39.5234	36.3902	22.1969	-139.006	-16.7205	148.463
51	-8.12079	-172.892	-43.7888	40.5748	21.8641	-156.689	-13.9417	155.872
51.5	-6.97242	-176.598	-40.9078	22.2075	21.343	-173.461	-11.6747	151.727
52	-5.96315	177.725	-42.4501	15.0076	20.7440	170.071	-9.88788	147.062
52.5	-5.12289	171.977	-45.5365	20.7047	20.1329	154.214	-8.60512	140.205
53	-4.64018	166.917	-44.4545	-4.51717	19.4296	138.942	-7.73785	136.17
53.5	-4.32110	162.131	-45.7384	-27.7450	18.8101	123.816	-6.95694	131.267
54	-4.13959	157.282	-47.6817	-16.5407	18.2538	109.532	-6.60429	127.692
54.5	-4.1182	154.144	-48.0400	-38.7317	17.7025	95.1413	-6.26805	124.362
55	-4.06388	151.152	-45.8591	-29.9386	17.3264	80.1205	-6.02584	122.518
55.5	-4.18498	149.291	-47.4718	-60.1957	17.0563	63.9622	-5.78532	120.872
56	-4.22860	149.126	-50.4657	-67.5044	16.8286	46.2012	-5.66691	119.598
56.5	-4.32142	150.070	-49.9819	-74.2336	16.4732	24.5301	-5.18517	120.041
57	-3.93906	153.181	-49.1521	-123.746	15.68	-0.53281	-4.70936	120.051
57.5	-2.97766	153.936	-51.9424	27.999	14.0355	-28.3576	-3.85940	118.336
58	-1.98765	151.352	-51.9208	149.893	11.1055	-54.894	-3.38075	115.402

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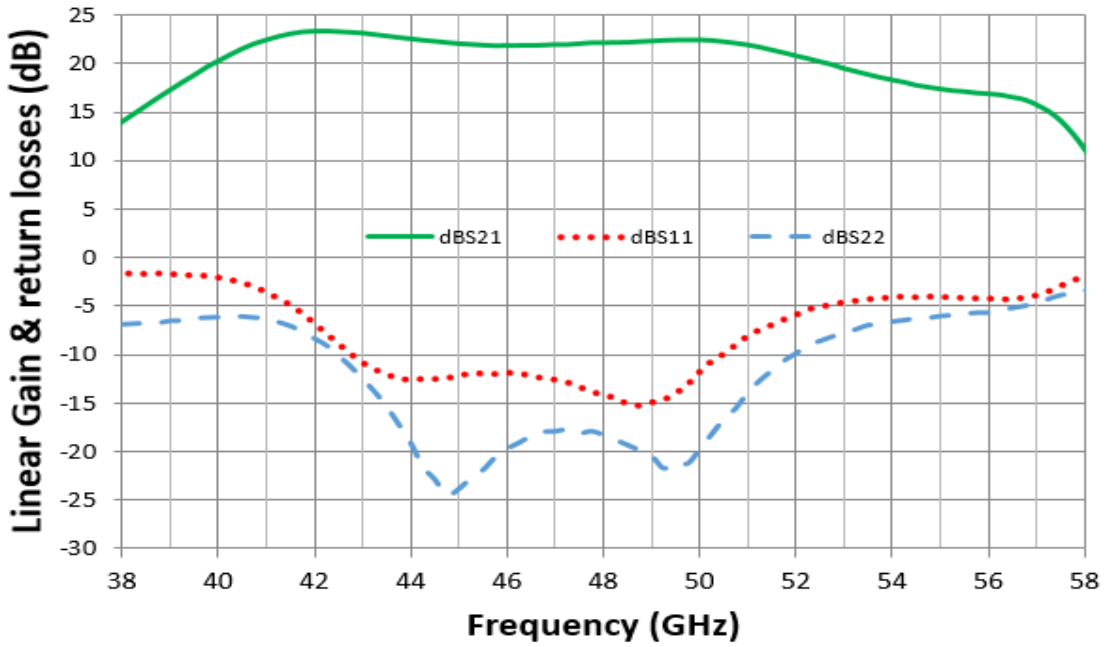
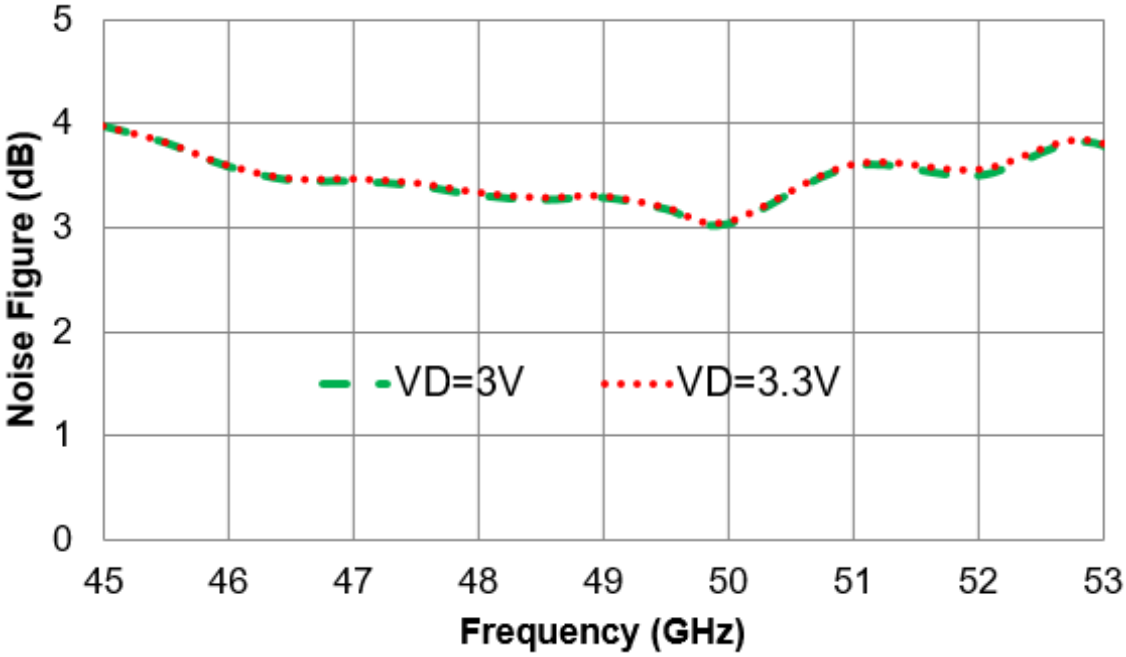
Typical on board Measurements

Tamb.= +25°C, Vd = +3.3V, Id = 55mA, Typical
Losses due to board are de-embedded. Measurements are given in the die access planes

Linear Gain & return losses versus Frequency



Noise Figure versus VD & Frequency



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Typical on board Measurements

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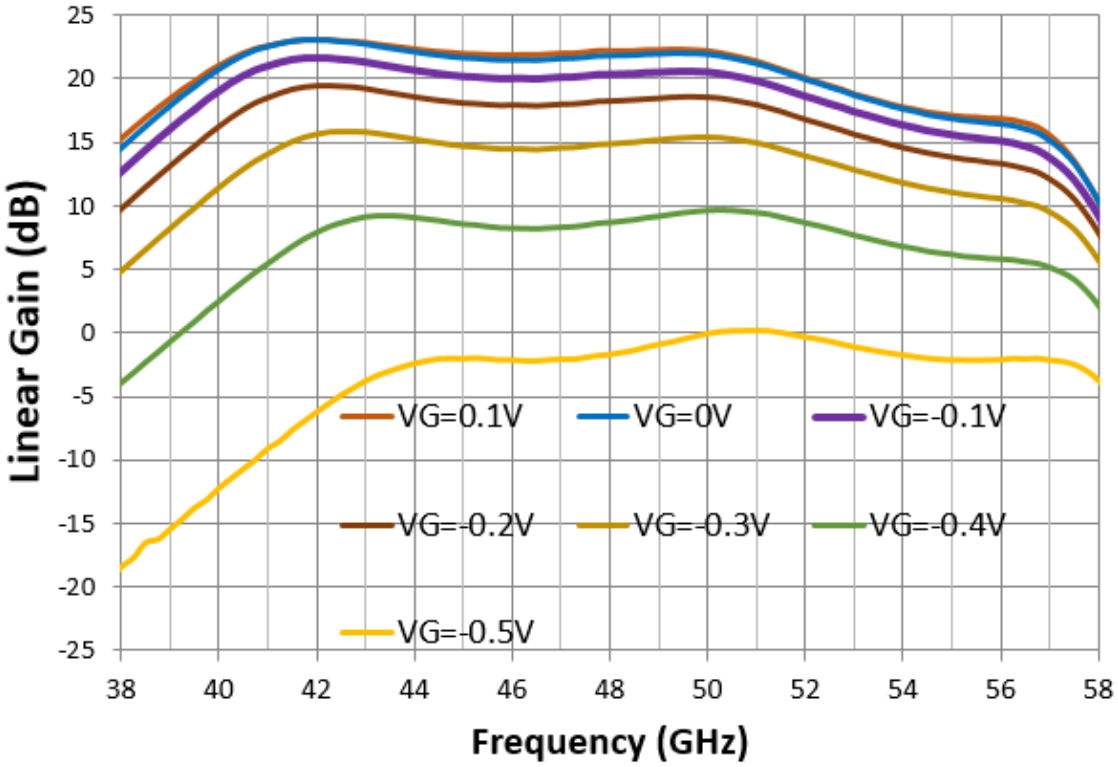
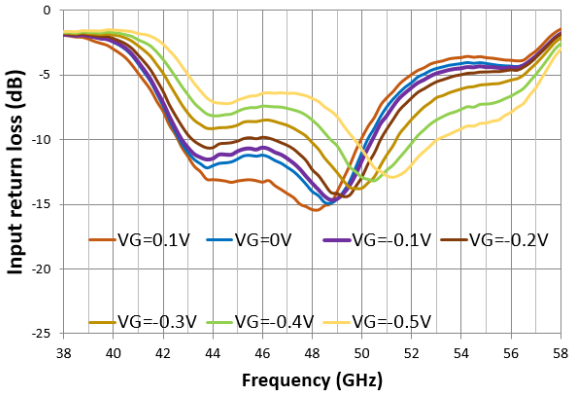
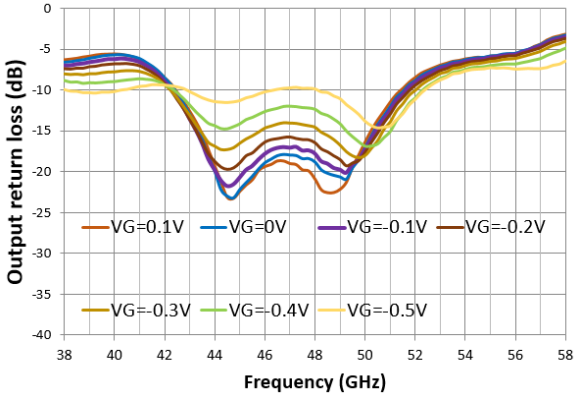
Linear Gain versus VG & Frequency



Input return loss versus VG & Frequency



Output return loss versus VG & Frequency



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Typical on board Measurements

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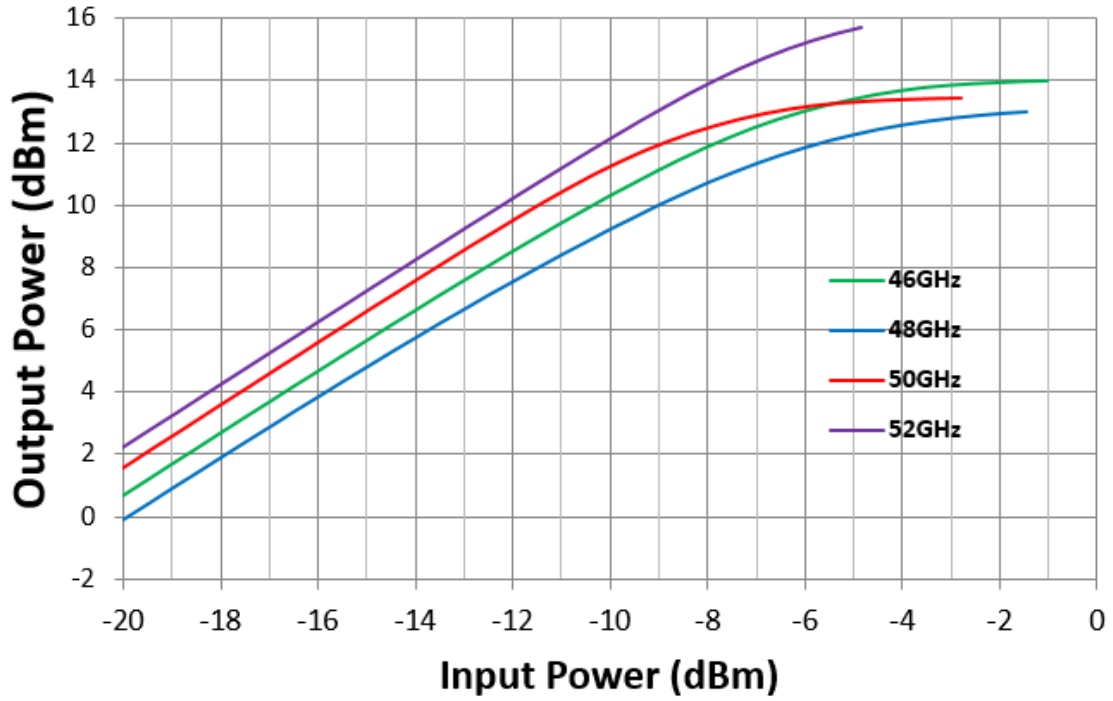
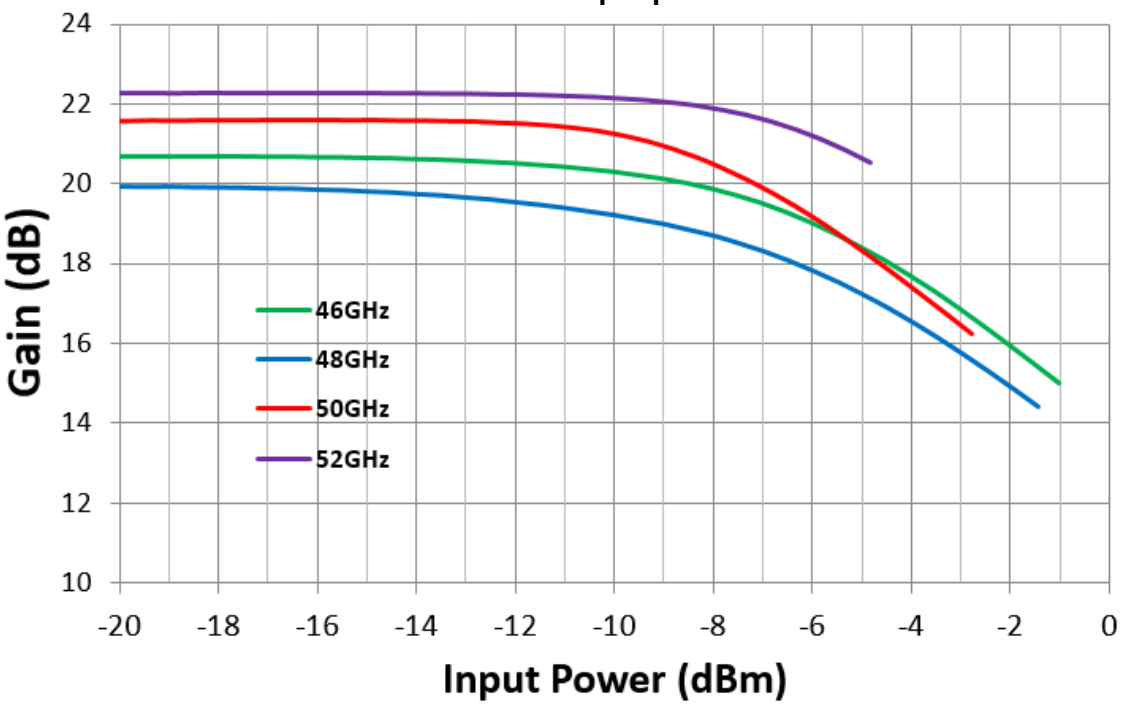
Losses due to board are de-embedded. Measurements are given in the die access planes

Output power versus Input power



Gain versus Input power



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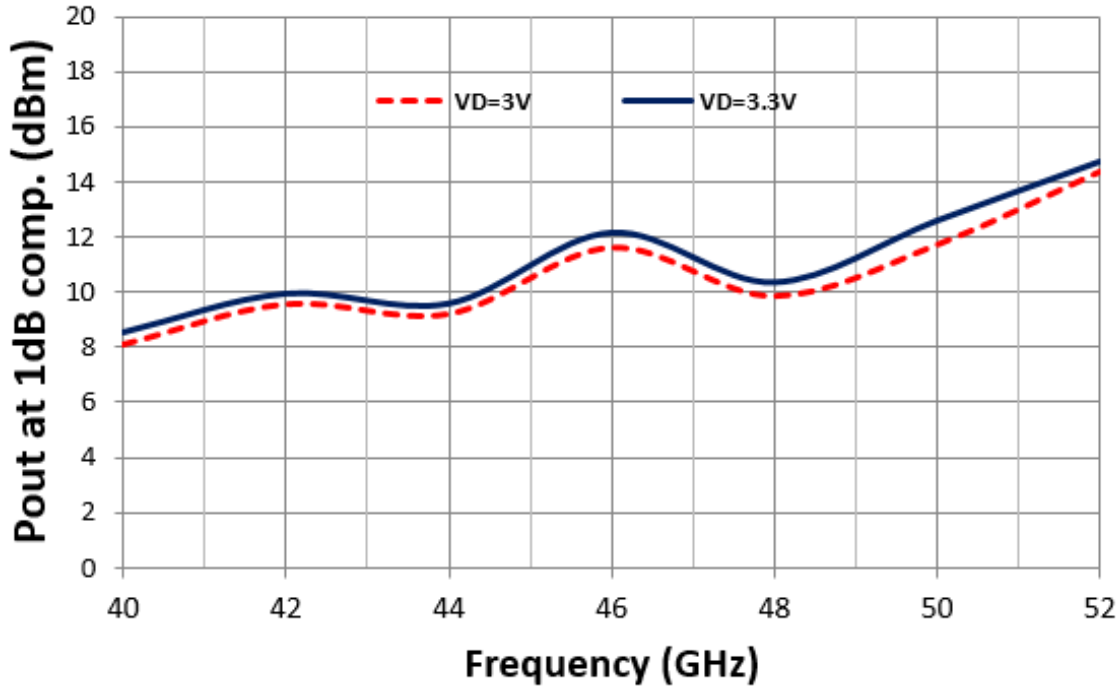
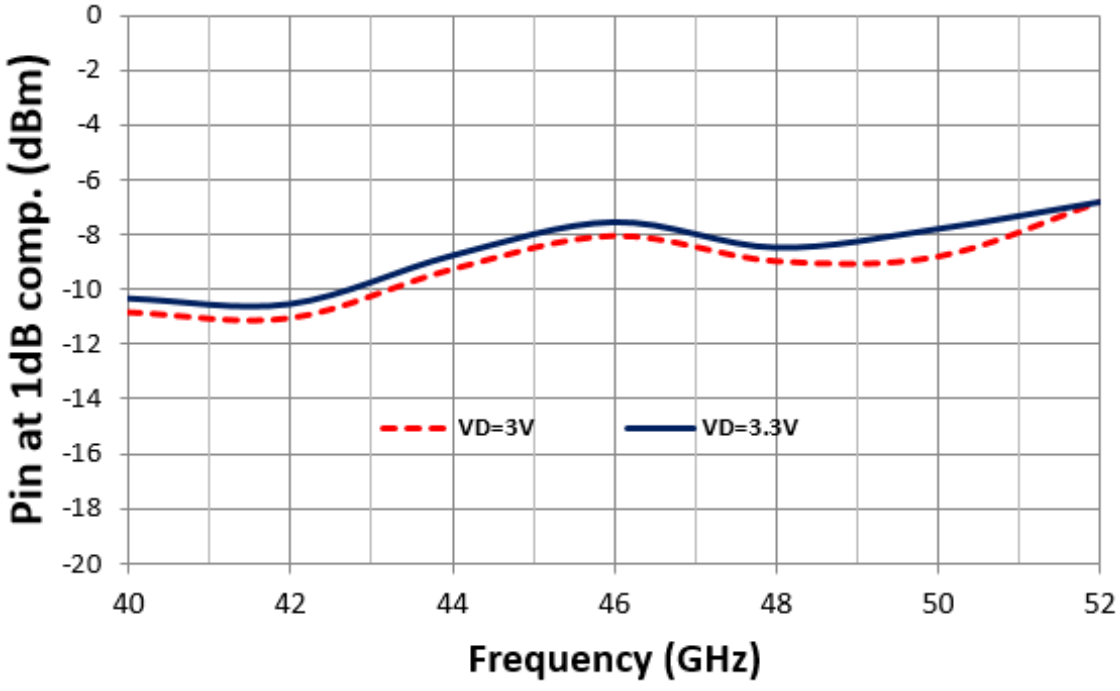
Typical on board Measurements

Tamb.= +25°C, Vd = +3.3V, Id = 55mA, Typical
Losses due to board are de-embedded. Measurements are given in the die access planes

Output power at 1 dB compression versus VD & Frequency



Input power at 1 dB compression versus VD & Frequency



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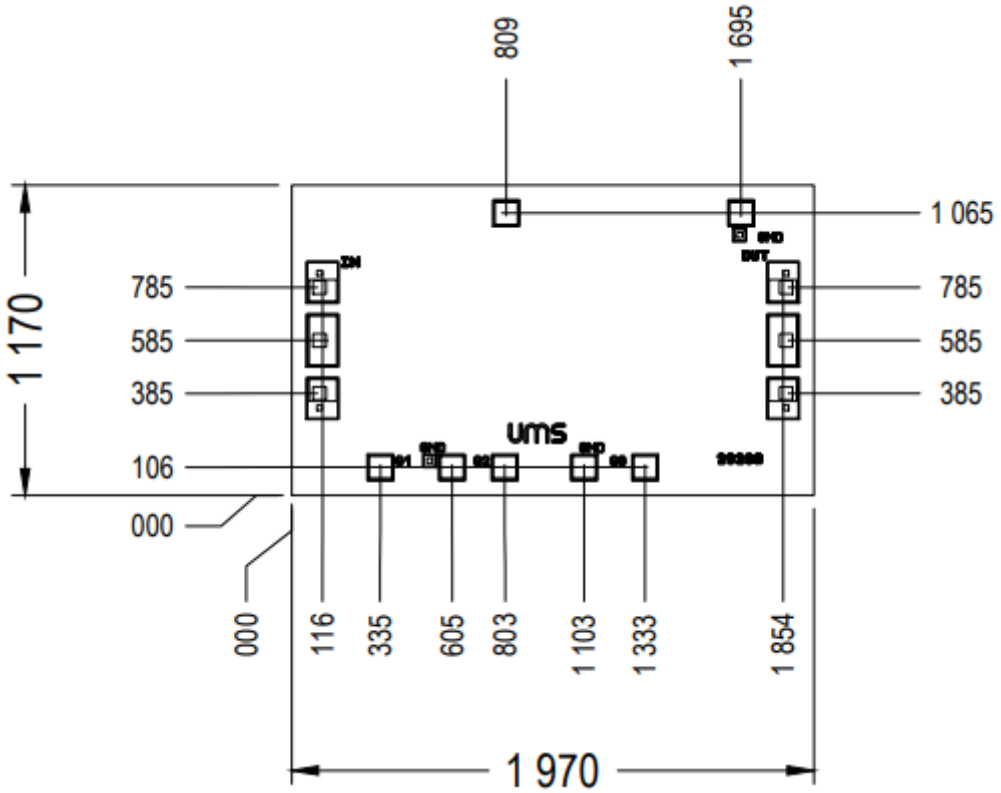
Mechanical data

Chip thickness: 70µm
Chip size: 1970µmx1170µm ±35µm
All dimensions are in micrometers



PAD Number	Name	Description	Pad size (BCB Opening)
1	RF IN	Input RF port	186µm x 105µm
2	D	DC Drain voltage all stages	86µm x 83µm
9	G1	DC Gate voltage 1st stage	86µm x 83µm
7	G2	DC Gate voltage 2nd stage	86µm x 83µm
5	G3	DC Gate voltage 3rd stage	86µm x 83µm
3,6,8	GND	Ground not connected	86µm x 83µm
4	RF OUT	Output RF port	186µm x 105µm

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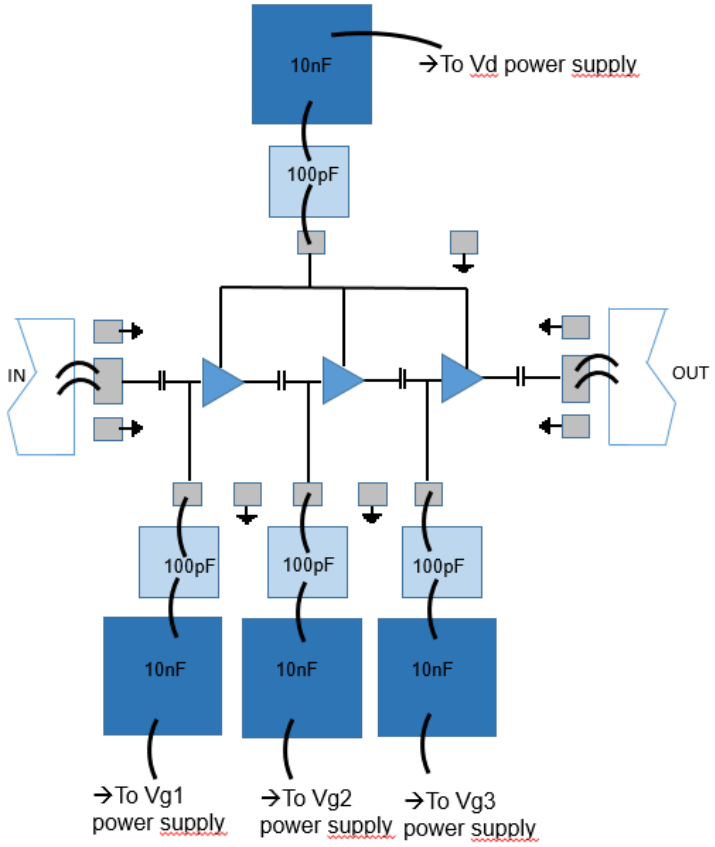
Recommended assembly plan



25µm wedge bonding is preferred

Note: Supply feed should be bypassed. 25µm diameter gold wire is to be preferred.

Connection RF accesses: Circuits having to be as close as possible to each other, the ribbon length(75µm wide) must be reduced to the achievable minimum (160µm gap between two chips is considered) and the loop height must also be the smallest realizable (80µm).

A second solution is the use of double wires (Ø 25µm), wedge bonded. In this case, a minimum of two wires and the same chip-to-chip distance than ribbon solution are necessary to reduce the inductance effect. Nevertheless, simulations have demonstrated an improvement of RF performance for Q-band frequency range with the use of ribbon connection instead of wire.

2 levels of decoupling capacitor have been used:

First level of capacitor is 100pF, second level is 10nF. First level of capacitors decoupling must be close to the chip.

Recommended circuit bonding table

Label	Type	Decoupling	Comment
IN / OUT	RF access	Not required	as close as possible
D	Vd	100pF/ 10nF	Drain Supply: 100pF as close as possible the circuit
G1/G2/G3	Vg	100pF/ 10nF	Gate Supply: 100pF as close as possible the circuit

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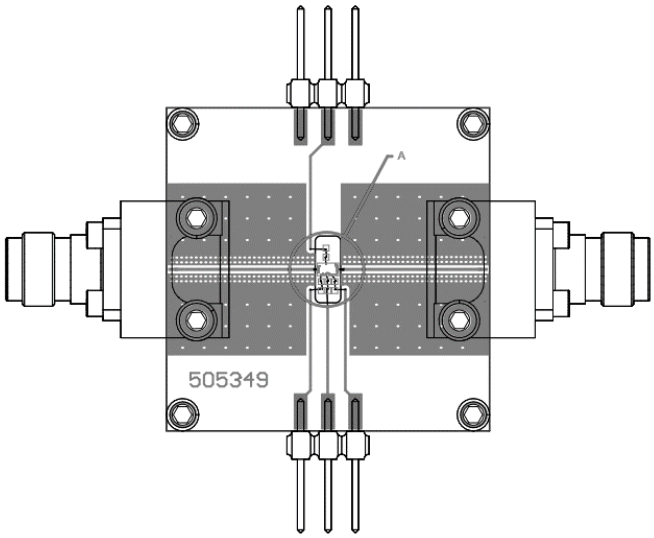
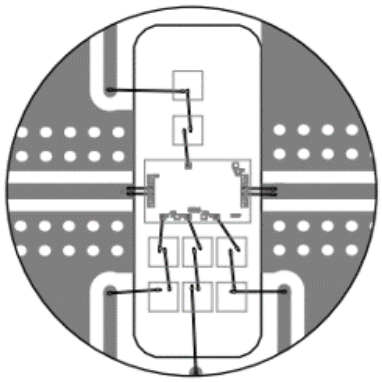
Evaluation mother board

- Based on typically Ro4003 / 8mils or equivalent.
- Decoupling capacitors of 100pF and 10nF ±10% are recommended for all DC accesses.
- Note: All board measurements are performed using shielded cables, even for DC bias, to ensure safe operation.





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Recommended ESD management

Refer to the application note AN0020 available at https://www.ums-rf.com for ESD sensitivity and handling recommendations for the UMS products.

Recommended environmental management

UMS products are compliant with the regulation in particular with the directives RoHS N°2011/65 and REACh N°1907/2006. More environmental data are available in the application note AN0019 also available at https://www.ums-rf.com.

Ordering Information

Chip form:	CHA2352-98F/00

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