United Monolithic Semiconductors

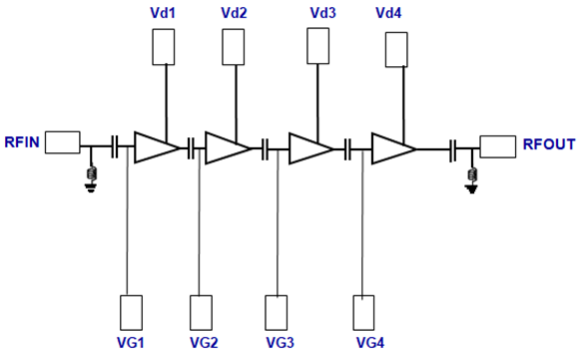
CHA3398-98F

36-43.5GHz Medium Power Amplifier

GaAs Monolithic Microwave IC in bare die

Description

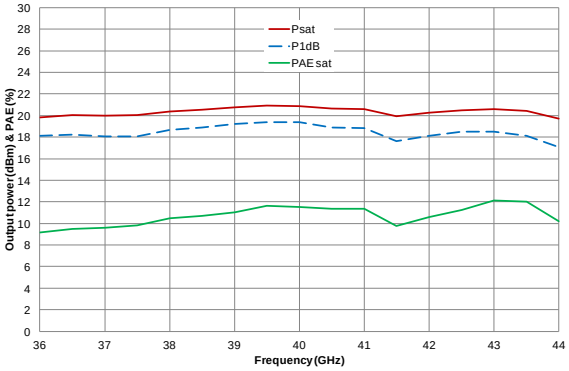
The CHA3398-98F is a 4 stage monolithic Medium Power Amplifier, which produces 24dB gain for 20dBm output power.
It is well suited for a wide range of application from military to commercial communication systems.
This circuit is highly linear and compatible with the last generation of Digital Pre-Distortion. Its versatile biasing condition helps to tune the performances. In addition, the circuit is fully protected against ESD.
This product is manufactured with a pHEMT process, 0.15µm gate length, via holes through the substrate, air bridges and electron beam gate lithography.
It is available in bare die.



Main Features

- Broadband performances: 36-43.5GHz
- 18dBm Pout at 1dB compression
- 29dBm OTOI
- 24dB gain
- Gain control up to 15dB
- DC bias: Vd=4.0Volt @ Id=200mA
- Chip size 1.25x2.41x0.1mm

Output power & PAE vs frequency



Main Electrical Characteristics

Tamb.= +25°C

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	36.0		43.5	GHz
Gain	Linear Gain [1]		24		dB
P-1dB	Output Power @1dB comp.		18		dB
OTOI	3rd order Intercept point		29		dBm

(1) See specifications on evaluation board

United Monolithic Semiconductors S.A.S.
Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Specifications (On Wafer)

Tamb=+25°C, Vd=+4.0V

Symbol	Parameter	Min	Typ	Max	Unit
Fop	Operating frequency range	36		43.5	GHz
Gain	Linear Gain		20		dB
P_{-1dB}	Output power @ 1dB in 36.0-40.0GHz Output power @ 1dB in 40.5-43.5GHz		17 18		dBm
Psat	Saturated Output Power		19		dBm
PAE	PAE at saturation in 36.0-40.0GHz PAE at saturation in 40.5-43.5GHz		8 10		%
RLin	Input Return Loss		8		dB
RLout	Output Return Loss		8		dB
CG	Gain control range		15		dB
Id	Quiescent Drain current		200		mA
Vg	Gate voltage		-0.35		V

These values are representative of on-wafer measurements that are made without bonding wires at the RF ports.

Specifications (On Board)

Tamb=+25°C, Vd=+4.0V

Symbol	Parameter	Min	Typ	Max	Unit
Fop	Operating frequency range	36		43.5	GHz
Gain	Linear Gain		24		dB
ΔG	Gain variation in temperature		± 0.03		dB/°C
P_{-1dB}	Output power @ 1dB gain compression		18		dBm
Psat	Saturated Output Power		20		dBm
PAE	PAE at saturation in 36.0-40.0GHz PAE at saturation in 40.5-43.5GHz		10 12		%
RLin	Input Return Loss		10		dB
RLout	Output Return Loss		11		dB
CG	Gain control range		15		dB
NF	Noise figure		5.5		dB
OIP3	Output IP3		29		dBm
Id	Quiescent Drain current		200		mA
Vg	Gate voltage		-0.35		V

These values are representative of measurement in test fixture with a bonding wire of typically 0.25 to 0.3nH.

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Absolute Maximum Ratings [1]

Tamb.= +25°C

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	4.5	V
Id	Drain bias current	330	mA
Vg	Gate bias voltage	-2 to 0	V
Vdg	External drain-gate excursion	5	V
Pin	Maximum peak input power overdrive [2]	5	dBm
Tj	Maximum Junction temperature	175	°C

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

(2) Duration < 1s.

Recommended Operating Range [3, 4]

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	3.3 to 4	V
Id	Drain bias current	100 to 200	mA
Vg	Gate bias voltage	-2 to 0	V
Pin	Maximum peak input power overdrive	5	dBm

(3) Electrical performances are defined for specified test conditions

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

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	Parameter	Values	Unit
Vd1	DC Drain voltage 1st stage	4	V
Vd2	DC Drain voltage 2nd stage	4	V
Vd3	DC Drain voltage 3rd stage	4	V
Vd4	DC Drain voltage 4th stage	4	V
Vg1	DC Gate voltage 1st stage	-0.35	V
Vg2	DC Gate voltage 2nd stage	-0.35	V
Vg3	DC Gate voltage 3rd stage	-0.35	V
Vg4	DC Gate voltage 4th stage	-0.35	V

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Device thermal information

The device thermal performances below are based on UMS rules to evaluate the junction temperature.
The temperature Tb_{chip} is defined as the chip back side temperature. The thermal resistance (Rth_eq) is given for the full circuit, and assumes CW operation mode in the table

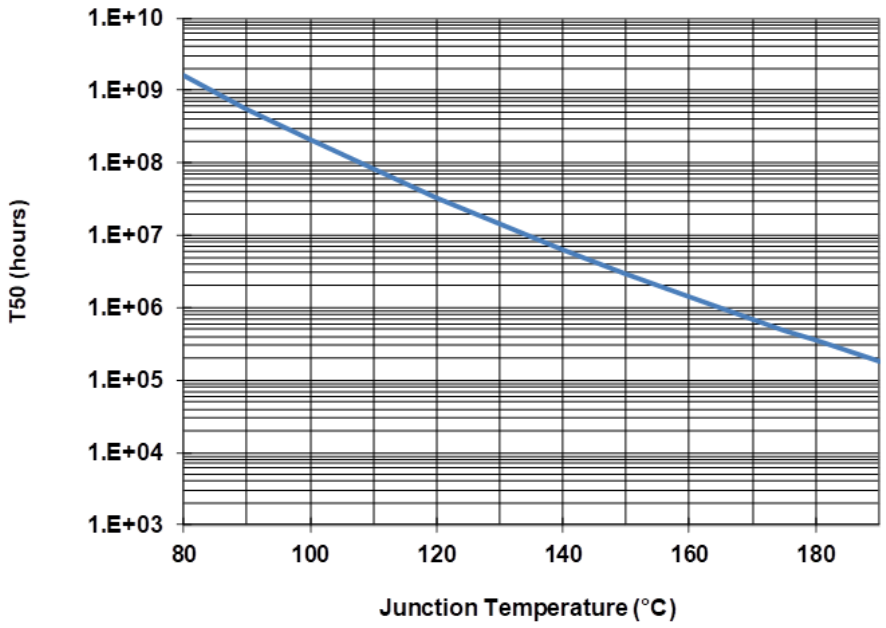
Thermal Resistance(1)	Rth_eq	Tb_{chip} =85°C, Vd=4V, Idq=200mA Pin=5dBm Pout_sat=19dBm Pdiss=860mW, Freq. = 42.0GHz	89.5	°C/W
Junction Temperature	Tj		162	°C
Median Life	T50		$1.5x10^6$	Hrs

(1) Thermal resistance simulated to back of the chip

Thermal Resistance(1)	Rth_eq	Tb_{chip} =85°C, Vd=4V, Idq=200mA Pin=5dBm Pout_sat=18.5dBm Pdiss=900mW, Freq. = 43.5GHz	84.5	°C/W
Junction Temperature	Tj		161	°C
Median Life	T50		$1.5x10^6$	Hrs

(1) Thermal resistance simulated to back of the chip. Thermal analysis is highly recommended, more details are available on request.

Median Life Time versus Junction Temperature



Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Typical on wafer Sij parameters

Tamb.= +25°C, Vd = +4.0V, Id = 200mA

Freq (GHz)	S11 (dB)	PhS11 (°)	S12 (dB)	PhS12 (°)	S21 (dB)	PhS21 (°)	S22 (dB)	PhS22 (°)
15.0	-0.74	98.7	-43.5	64.4	-23.34	67.9	-8.30	136.4
16.0	-0.69	92.9	-46.9	64.2	-21.77	74.3	-8.60	128.3
17.0	-0.58	86.5	-44.2	18.2	-16.87	73.9	-8.88	120.6
18.0	-0.46	79.0	-47.4	-11.6	-11.25	65.1	-9.26	113.1
19.0	-0.40	70.2	-51.2	-19.4	-4.58	44.2	-9.62	106.5
20.0	-0.76	59.9	-56.4	-55.3	1.90	6.0	-10.08	99.9
21.0	-1.66	53.4	-60.7	-137.4	5.69	-43.6	-10.51	92.2
22.0	-1.95	50.5	-53.4	115.0	7.31	-87.6	-11.40	89.1
23.0	-1.77	46.1	-51.3	59.6	8.83	-121.6	-11.15	88.4
24.0	-1.60	39.0	-52.6	17.0	10.69	-155.9	-10.69	79.2
25.0	-1.60	31.2	-57.2	27.5	12.18	170.6	-11.07	71.8
26.0	-1.67	23.2	-58.4	44.7	12.96	135.0	-10.96	64.2
27.0	-1.89	15.1	-60.4	69.8	13.72	104.2	-11.65	57.6
28.0	-2.35	7.4	-56.6	90.1	14.44	72.7	-11.56	53.7
29.0	-2.56	0.9	-49.3	80.8	15.24	45.2	-11.86	48.4
30.0	-2.85	-6.9	-49.9	57.2	16.39	14.2	-11.53	44.7
31.0	-3.45	-15.3	-45.9	55.5	17.50	-17.1	-11.89	44.1
32.0	-4.31	-21.7	-44.5	35.0	18.16	-52.9	-10.12	42.5
33.0	-4.99	-24.0	-44.9	8.4	17.76	-84.7	-8.73	30.2
34.0	-5.70	-28.4	-44.9	10.3	18.07	-114.4	-8.58	22.3
35.0	-6.30	-32.5	-46.8	-7.5	17.83	-140.0	-8.36	13.0
36.0	-7.21	-29.3	-45.9	-3.7	18.64	-163.6	-7.39	6.5
36.5	-7.14	-29.7	-45.2	-6.7	19.49	-176.7	-6.95	-0.5
37.0	-7.43	-28.5	-44.5	-13.3	20.37	165.7	-7.06	-7.8
37.5	-7.01	-28.5	-44.1	-22.8	20.90	146.4	-7.38	-14.1
38.0	-7.12	-30.2	-45.2	-36.4	20.91	126.0	-7.73	-17.7
38.5	-7.19	-33.2	-46.2	-29.7	20.88	109.9	-7.59	-21.7
39.0	-7.88	-31.3	-46.1	-32.6	20.95	90.8	-8.04	-26.7
39.5	-7.69	-29.0	-45.6	-32.2	20.72	72.8	-8.43	-27.8
40.0	-7.55	-27.9	-44.6	-43.1	20.43	55.3	-9.00	-29.6
40.5	-7.39	-28.2	-45.3	-47.9	20.23	39.6	-9.12	-31.1
41.0	-7.41	-27.8	-45.5	-51.0	20.25	22.2	-9.39	-29.9
41.5	-7.20	-24.5	-46.4	-54.9	19.95	2.5	-8.80	-28.6
42.0	-6.41	-22.6	-45.3	-50.5	19.31	-15.2	-8.11	-31.5
42.5	-5.48	-25.2	-44.6	-58.5	18.95	-30.4	-7.91	-38.7
43.0	-5.13	-27.9	-44.2	-69.7	18.61	-48.2	-8.18	-43.1
43.5	-4.39	-29.3	-43.2	-64.0	17.94	-65.0	-8.53	-45.6
44.0	-3.73	-37.3	-42.1	-77.8	17.88	-78.8	-8.32	-48.4
45.0	-4.76	-49.0	-41.0	-109.4	17.70	-119.8	-8.45	-68.1
46.0	-4.71	-49.0	-41.9	-146.4	16.12	-161.2	-12.74	-85.6
47.0	-4.96	-56.8	-43.3	-168.2	14.11	160.7	-25.09	-86.9
48.0	-5.71	-63.0	-43.6	168.8	12.51	116.8	-14.01	41.5
49.0	-6.94	-61.2	-45.8	135.1	8.74	65.3	-7.63	15.0
50.0	-6.51	-57.0	-53.4	129.7	2.76	28.2	-5.26	-7.1

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Typical on wafer Sij measurements

Tamb.= +25°C, Vd = +4.0V, Id = 200mA
Measurement performed in the access plans of the die.

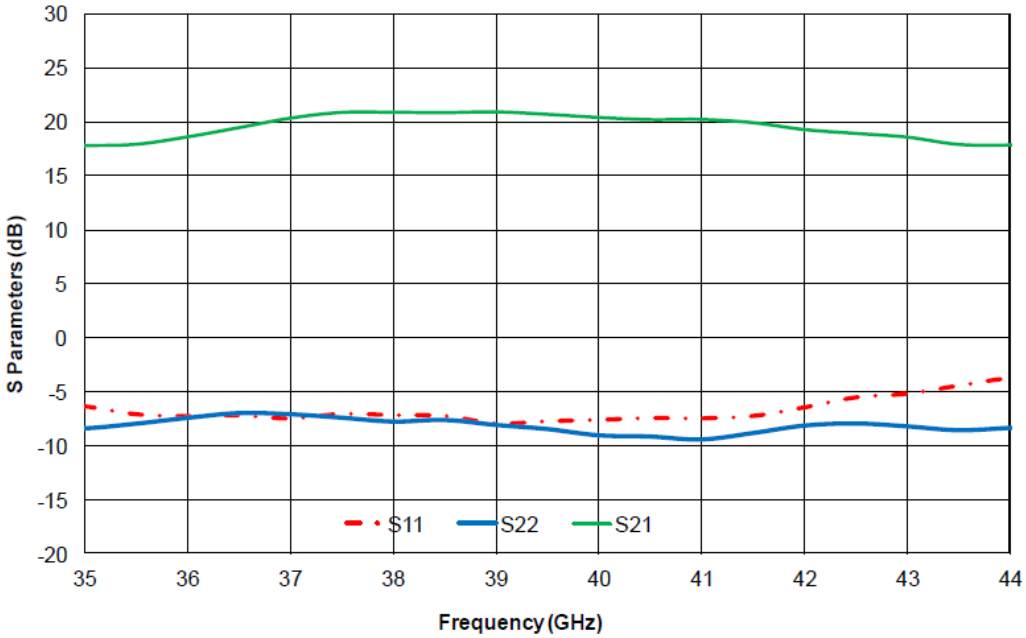


Fig.1: Small Signal Gain (dB) and Input and Output Return Losses based on wafer measurements

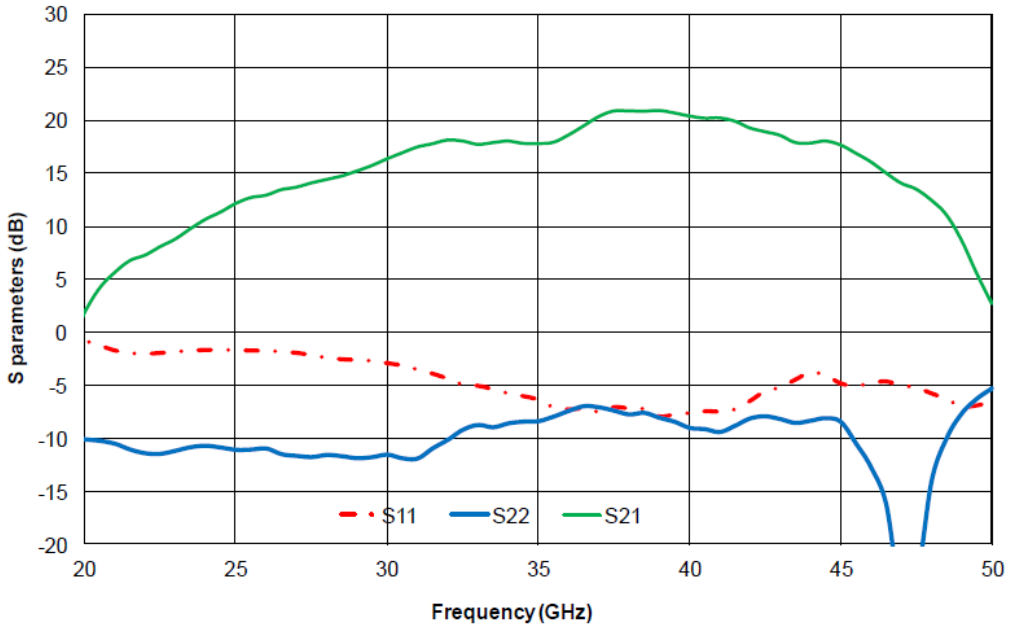


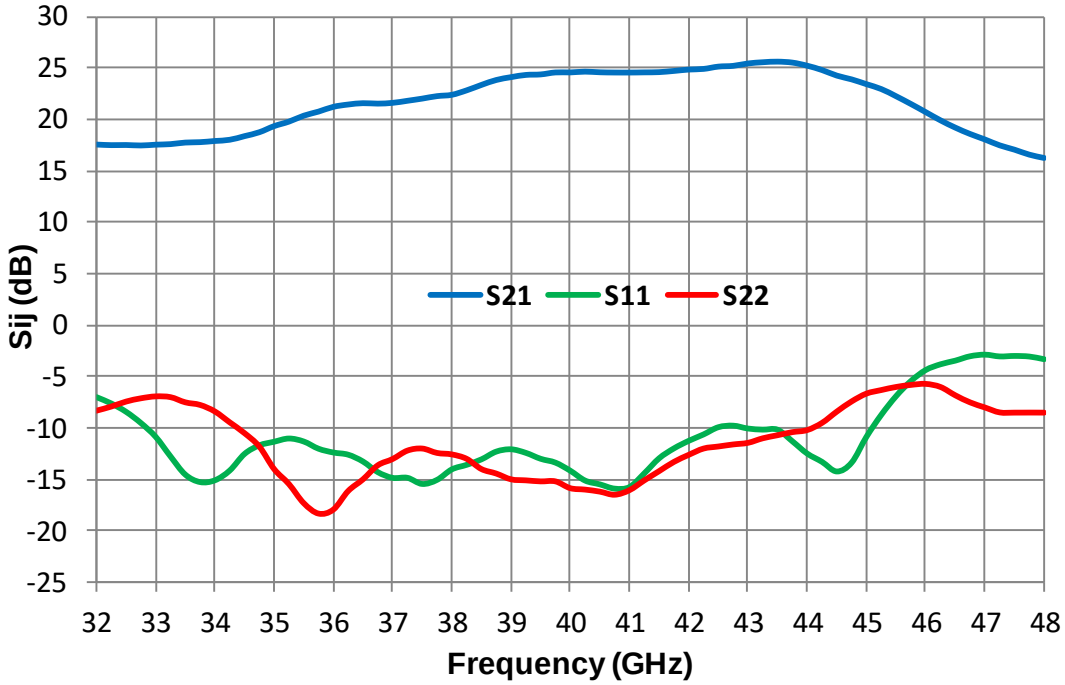
Fig.2: Small Signal Gain (dB) and Input and Output Return Losses based on wafer measurements; wide band

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

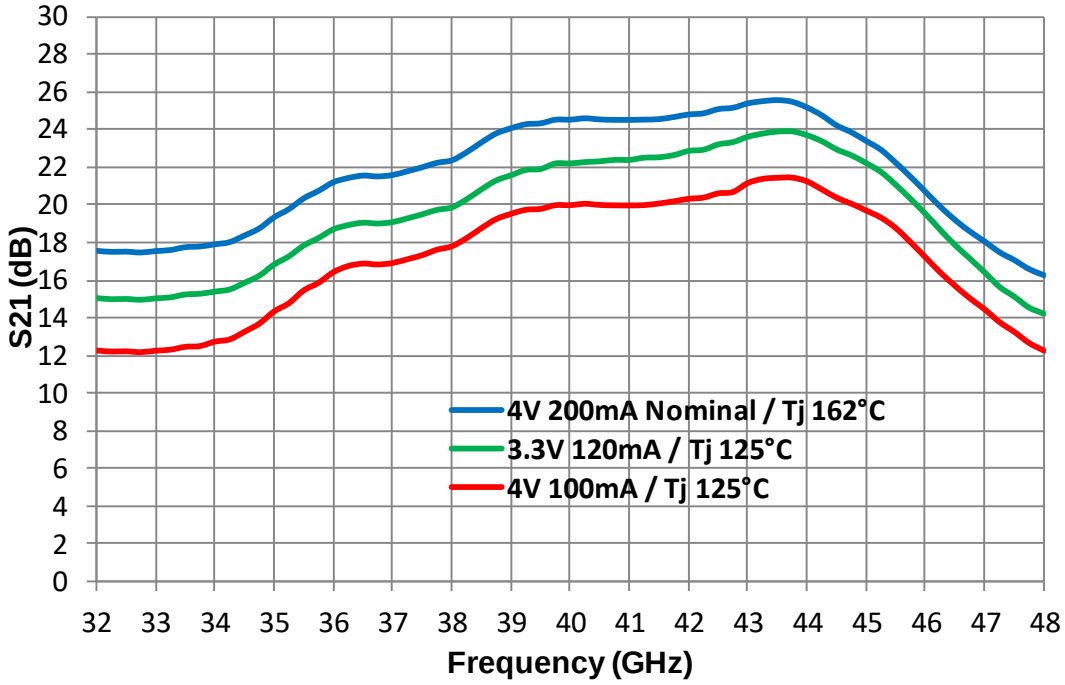
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +4V, Idq = 200mA & 100mA & Vd = +3.3V, Idq = 120mA
Measurement performed in the access plans of the die.

Gain & Return Losses versus Frequency
Vd = +4V, Idq = 200mA



Gain versus Frequency

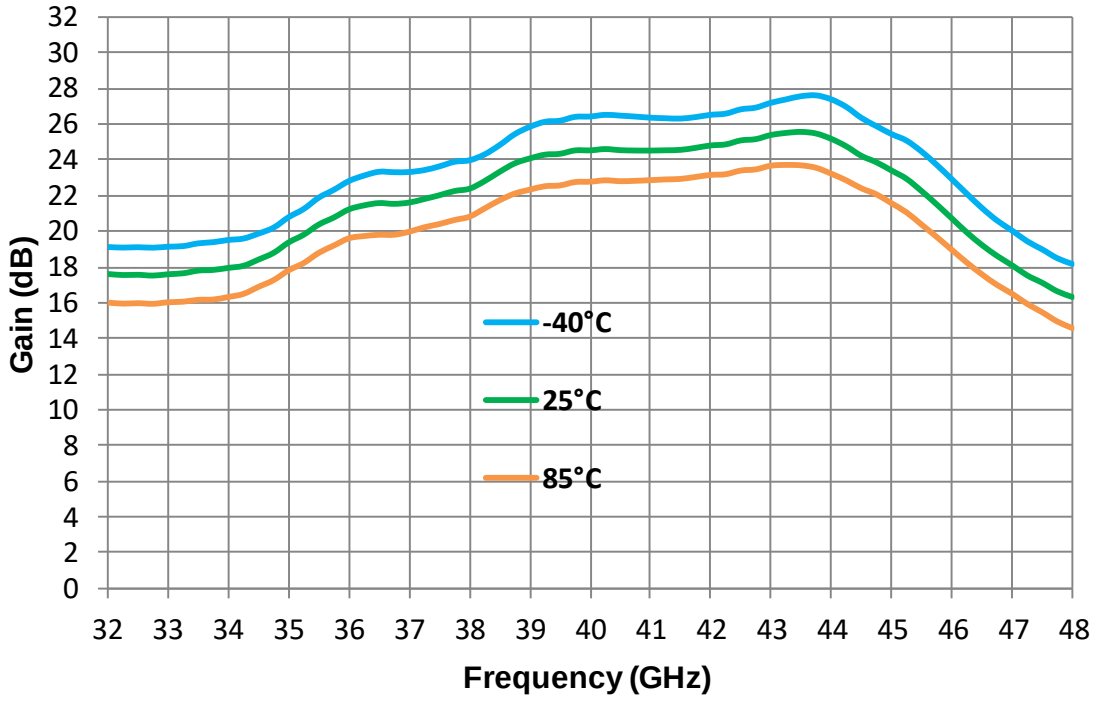


Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

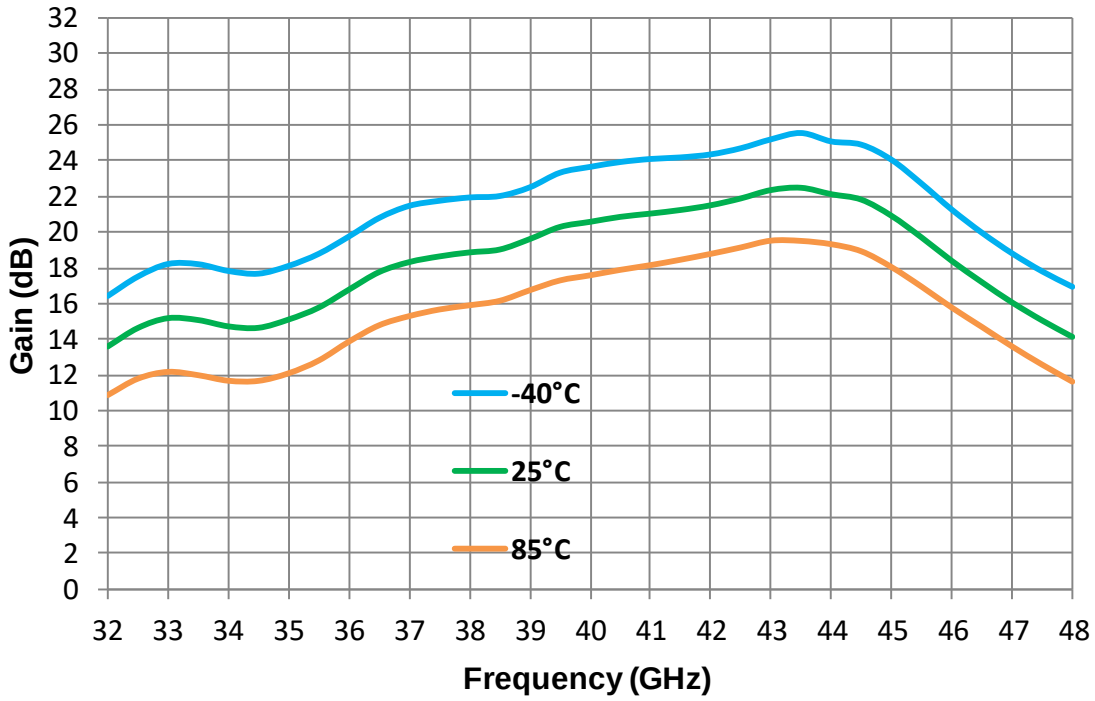
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +4V, Idq = 200mA & Vd = +3.3V, Idq = 120mA

Gain versus Frequency in Temperature
Vd = +4V, Idq = 200mA



Gain versus Frequency in Temperature
Vd = +3.3V, Idq = 120mA

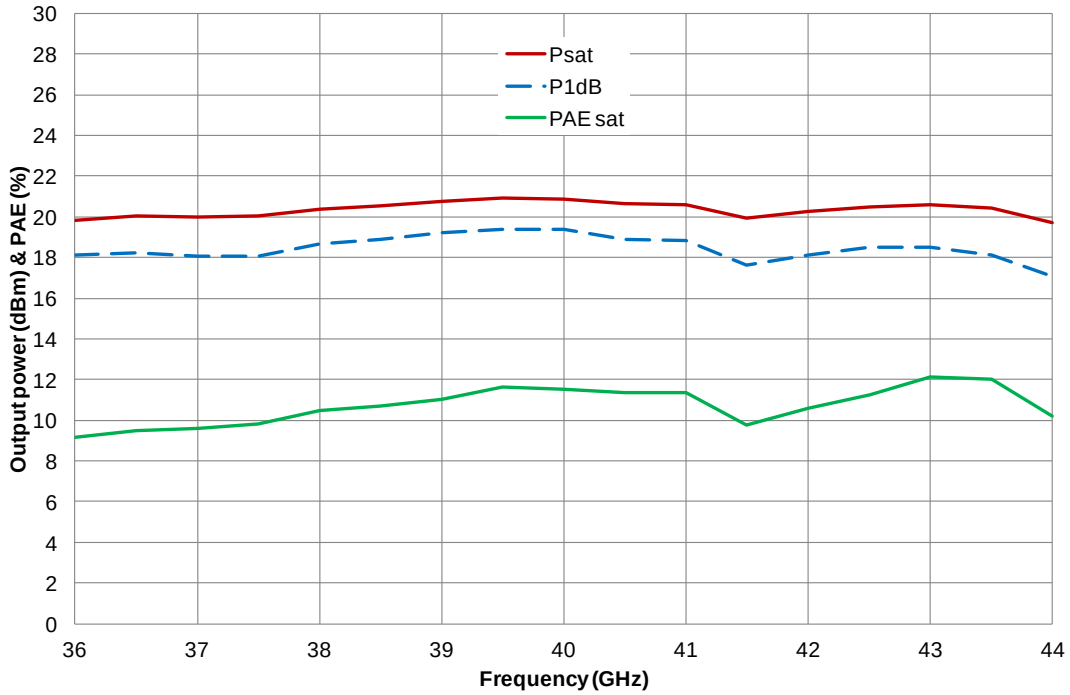


Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

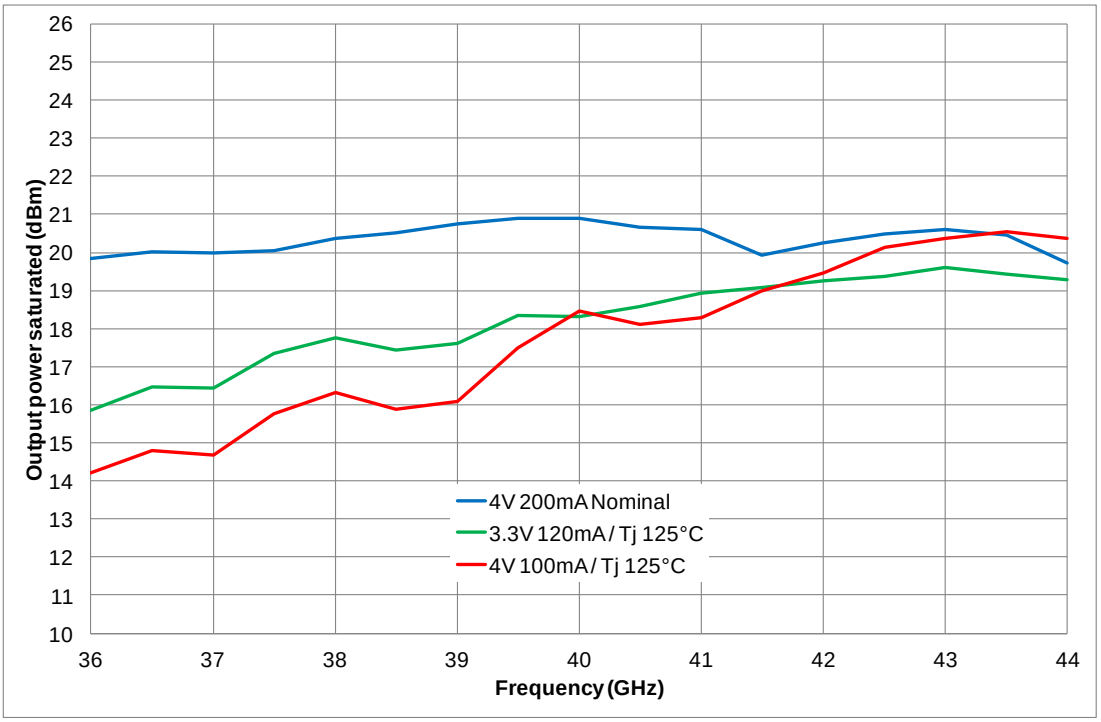
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +4.0V, Idq = 200mA

Output Power & PAE versus Frequency



Output Power versus Frequency

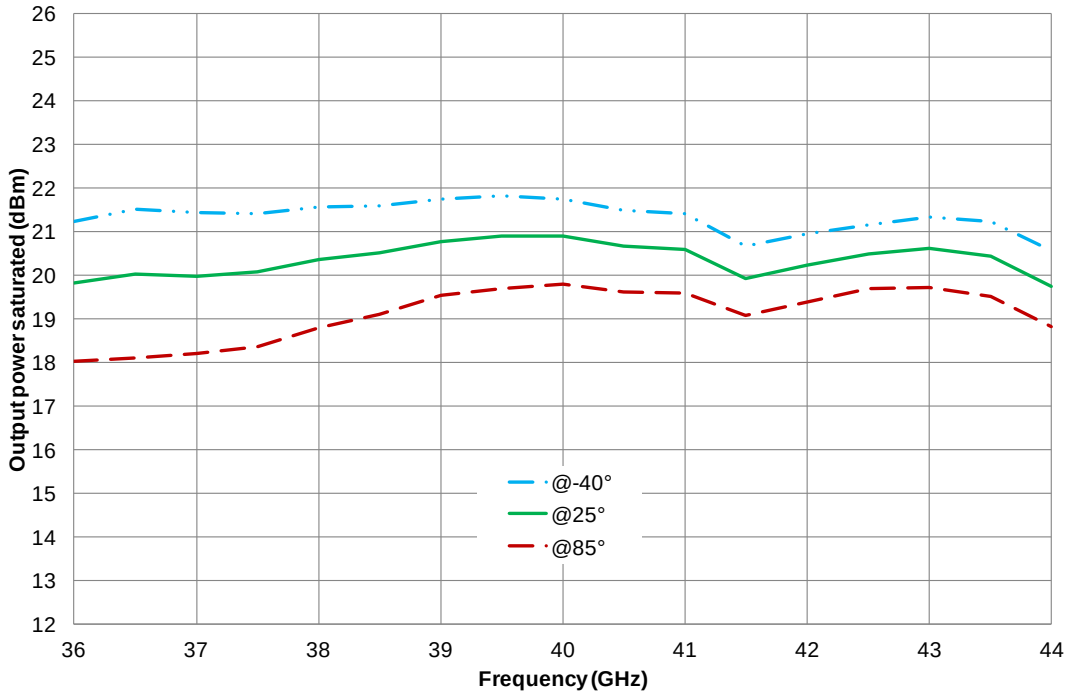


Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

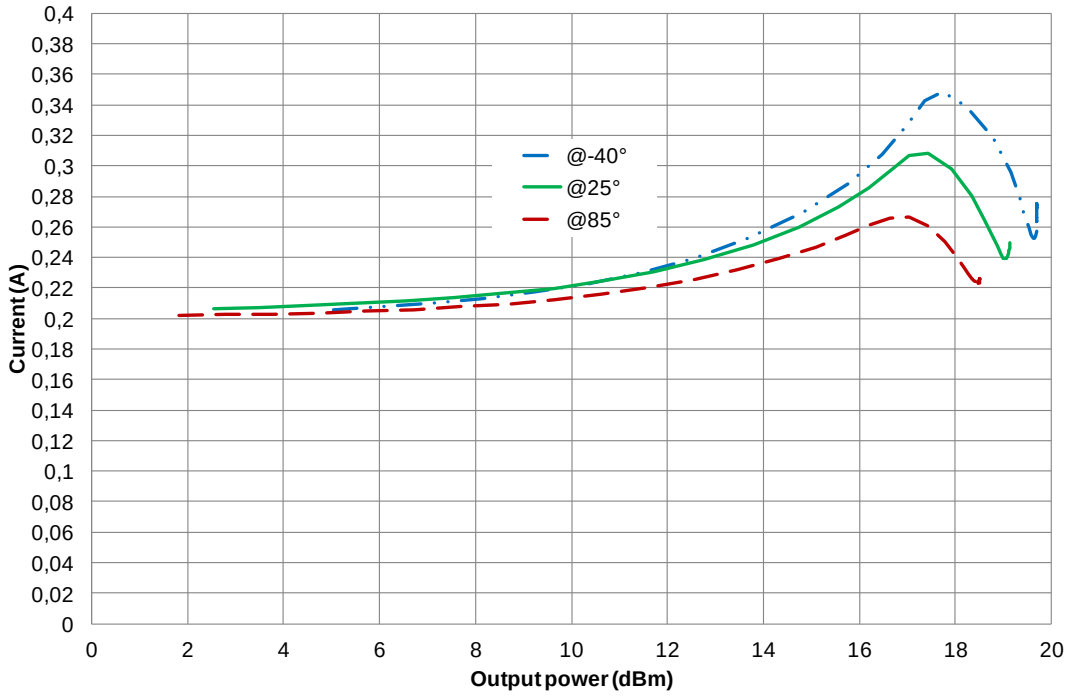
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +4.0V, Idq = 200mA

Saturated Power versus Frequency in Temperature



Total Drain Current versus Output Power at 42GHz

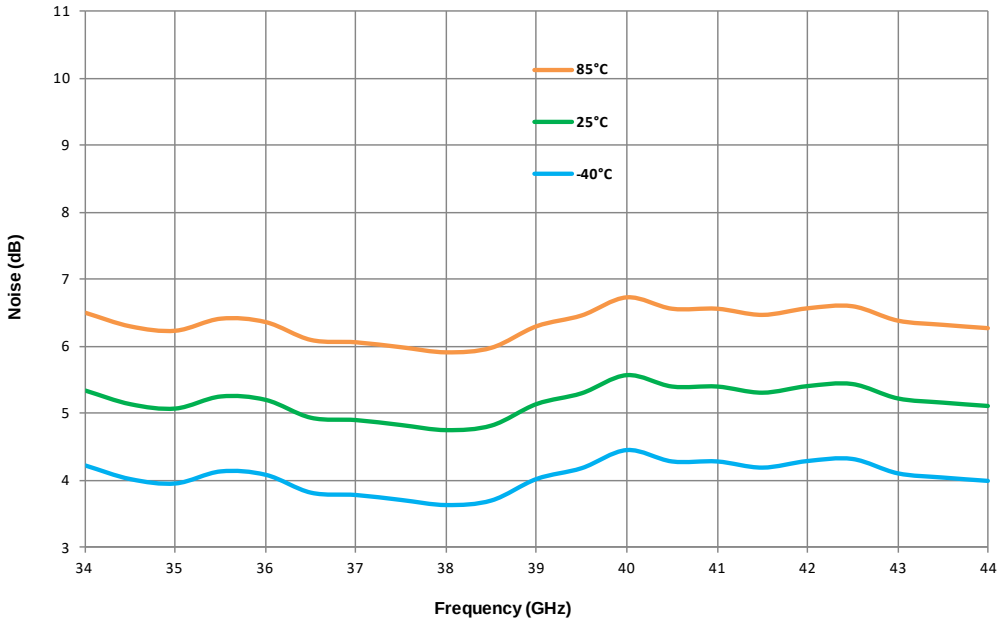


Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

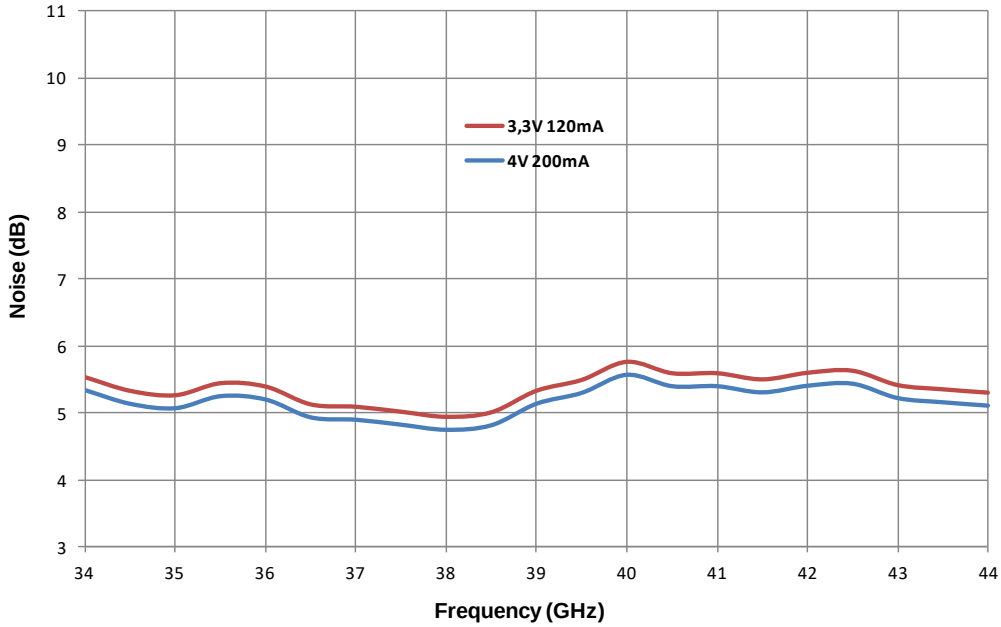
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +4.0V, Idq = 200mA & Vd = +3.3V, Idq = 120mA

Noise Figure versus Frequency in Temperature
Vd = +4V, Idq = 800mA



Noise Figure versus Frequency
Vd = +3.3V, Idq = 120mA
Vd = +4V, Idq = 200mA

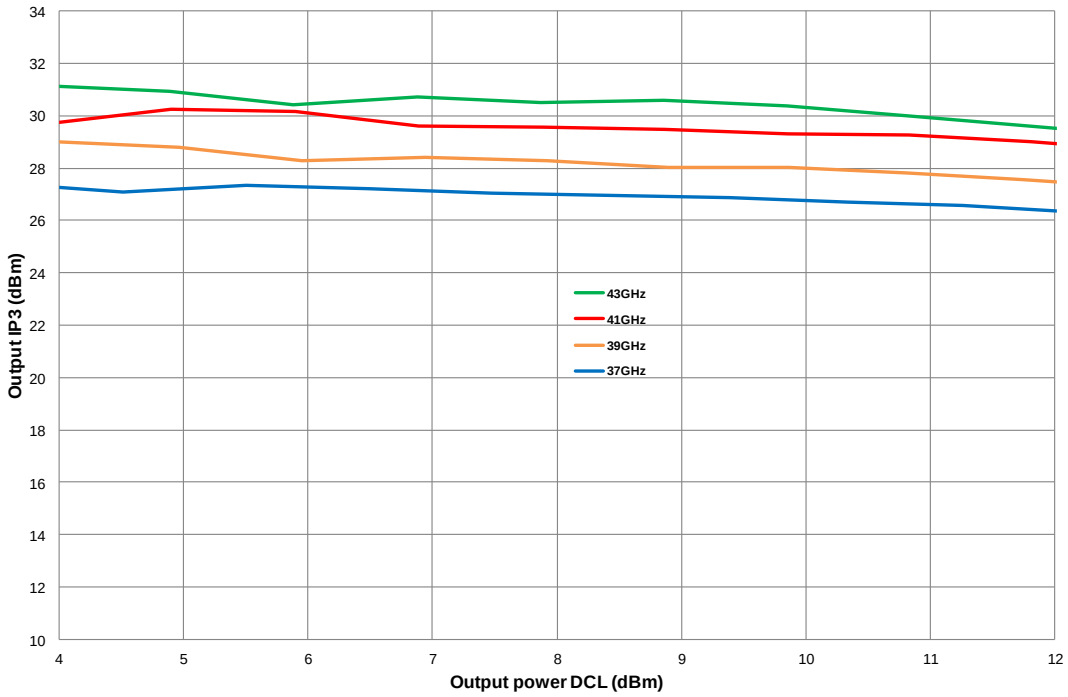


Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

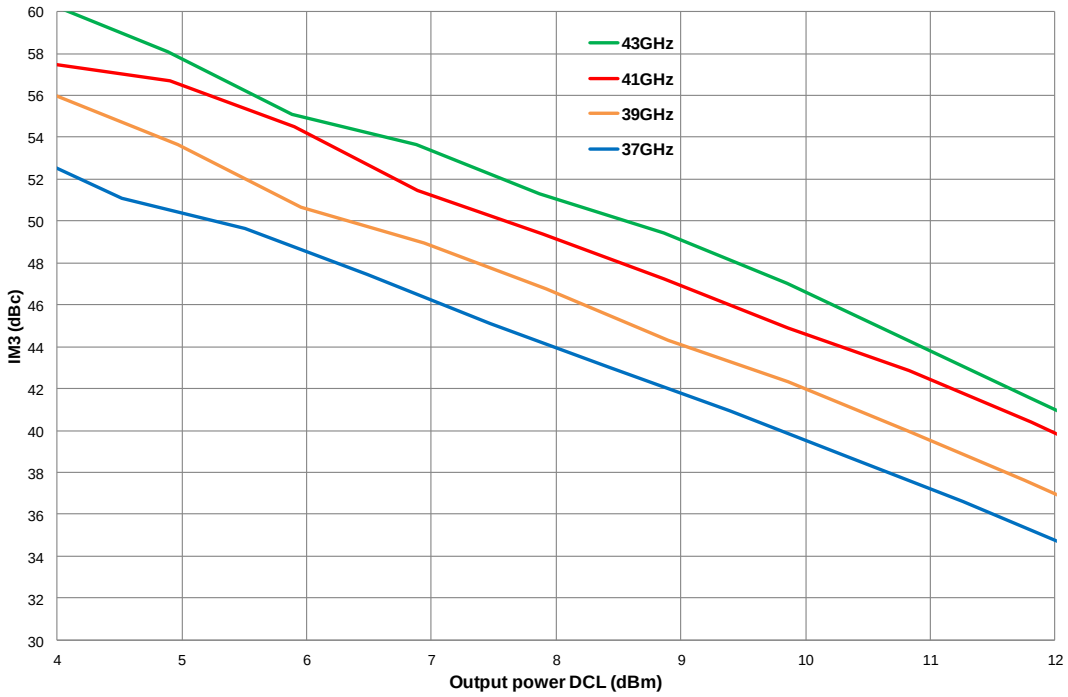
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +4.0V, Idq = 200mA

Output IP3 versus Output Power

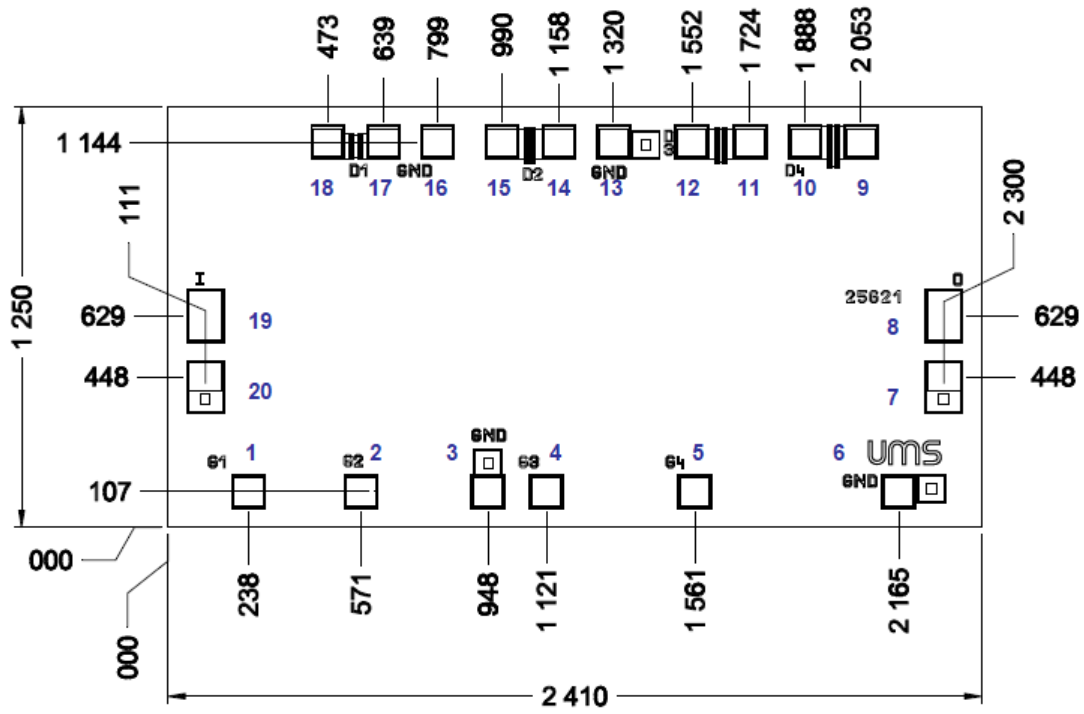


Output IM3 versus Output Power



Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Mechanical data



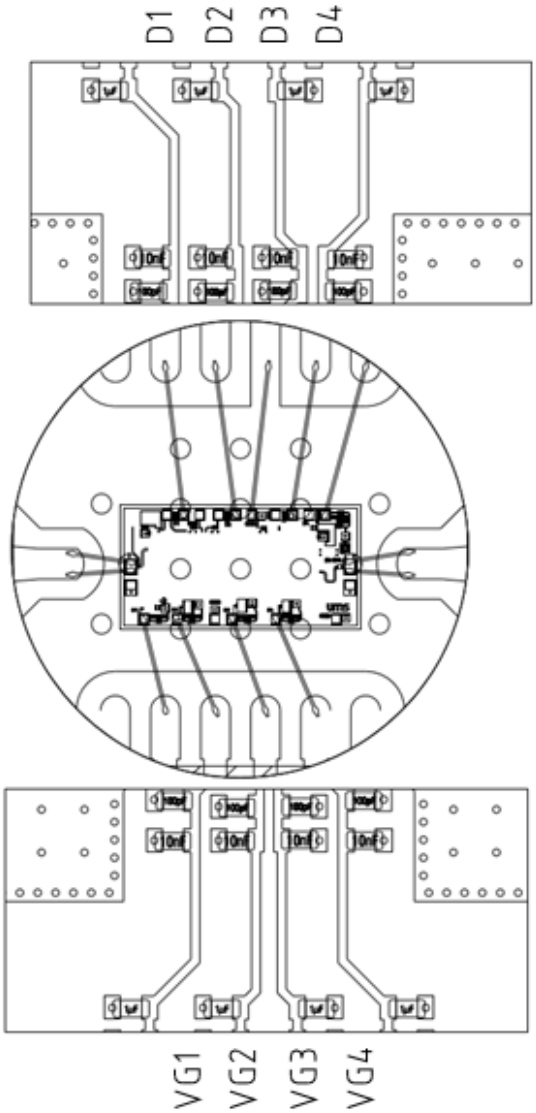
Chip thickness: 100µm.
DC pad size: 83um x 86 um (BCB opening)
RF pad size: 97um x 146 um (BCB opening)
All dimensions are in micrometers

PAD Number	Name	Description
1	Vg1	DC Gate voltage 1st stage
2	Vg2	DC Gate voltage 2nd stage
4	Vg3	DC Gate voltage 3rd stage
5	Vg4	DC Gate voltage 4th stage
8	RF IN	Input RF port
9, 10(1)	Vd4	DC Drain voltage 4th stage
11, 12(1)	Vd3	DC Drain voltage 3rd stage
13	GND	Ground
14, 15(1)	Vd2	DC Drain voltage 2nd stage
17, 18(1)	Vd1	DC Drain voltage 1st stage
19	RF OUT	Output RF port

(1) Option: Biasing at 3.3V; Connect both pads together is not recommended

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Recommended assembly plan



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

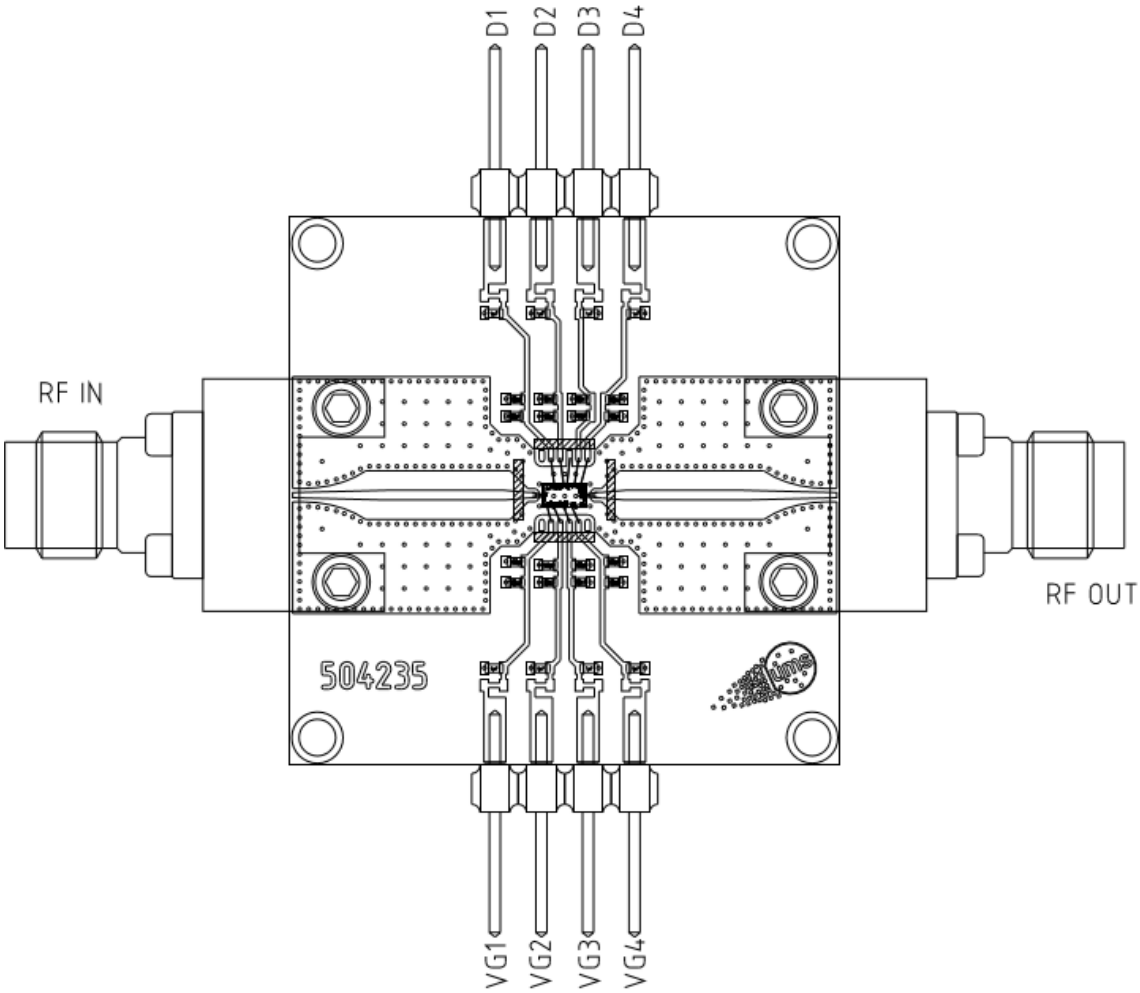
Recommended circuit bonding table

Label	Type	Decoupling	Comment
D1, D2, D3, D4	Vd	100pF & 10nF & 1µF	Drain Supply
VG1, VG2, VG3, VG4	Vg	100pF & 10nF & 1µF	Gate Supply

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Evaluation mother board

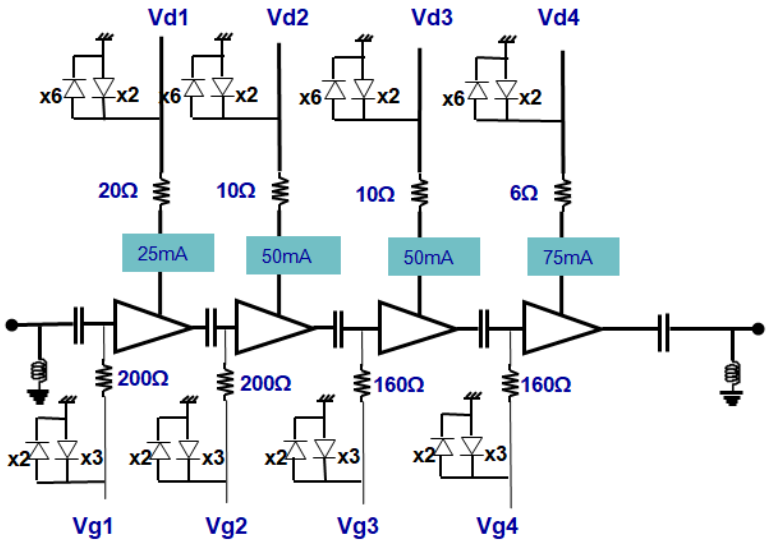
- Compatible with the proposed footprint.
- Based on typically Ro4350 / 10mils or equivalent.
- Using a micro-strip to coplanar transition to access the chip.
- Recommended for the implementation of this product on a module board.
- Decoupling capacitors of 100pF ±5%, 10nF ±10% and 1µF ±10% are recommended for the gate and drain accesses.
- Note: All board measurements are performed using shielded cables, even for DC bias, to ensure safe operation.



Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

DC Schematic

MPA: 4V, 200mA



Notes

Due to ESD protection circuits on RF input and output, an external capacitance might be requested to isolate the product from external voltage that could be present on the RF accesses.

The DC connections do not include any decoupling capacitor, therefore it is mandatory to provide a good external DC decoupling (100pF, 10nF, 1µF) on the PC board, as close as possible to the bare die.

The circuit includes ESD protections on all RF and DC accesses.

Biasing procedure

Device Power Up instructions:

1. Ground the device
2. Bias MPA gate voltage at Vgs close to Vpinch-off (example: Vgs ≈ -1.5V)
3. Apply Vds quiescent bias voltage (Example: Vd = 4V)
4. Increase slowly Vgs up to quiescent bias drain current Idq
5. Apply RF input power

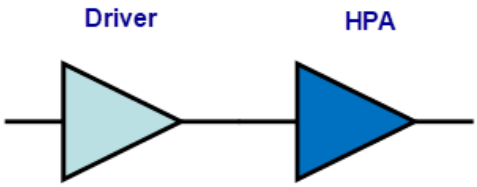
Device Power Down instructions:

1. Remove RF input power
2. Decrease MPA gate voltage down to Vgs -1.5V
3. Decrease drain voltage down to 0V

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

Recommended UMS Power chain

The CHA5659-98F is recommended with CHA3398-98F as driver.
Total Gain: 46dB
Gain control: 30dB with both amplifiers.



CHA3398-98F	CHA5659-98F
36- 43.5GHz	36- 43.5GHz
4V	6V
200mA	800mA

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com

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:	CHA3398-98F/00

Bât. Charmille - Parc Mosaic - 10, Avenue du Québec - 91140 VILLEBON-SUR-YVETTE - France
Tel.: +33 (0) 1 69 86 32 00 - Fax: +33 (0) 1 69 86 34 34 - www.ums-rf.com