United Monolithic Semiconductors

CHA5659-98F

36-43.5GHz Power Amplifier

GaAs Monolithic Microwave IC in bare die

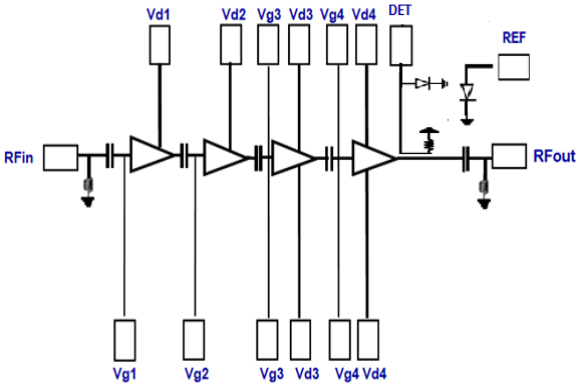
Description

The CHA5659-98F is a four stage monolithic GaAs High Power Amplifier producing 1.3 Watt output power. It is highly linear, with possible gain control and integrates a power detector. ESD protections are included.

It is designed for Point To Point Radio or K-band SatCom applications.

The CHA5659-98F is recommended with the CHA3398-98F as a driver.

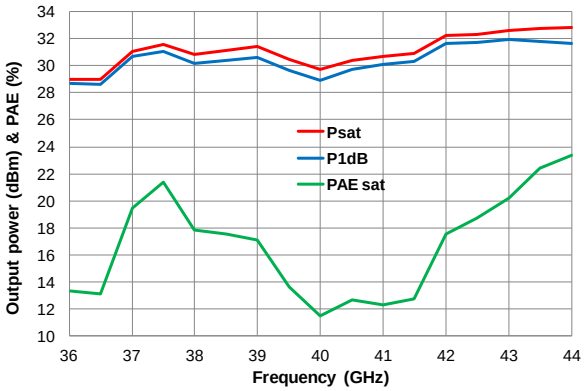
The circuit is manufactured with a pHEMT process, 0.15µm gate length.



Main Features

- Broadband performances: 36-43.5GHz
- 31dBm saturated power
- 38dBm OIP3
- 22dB gain
- Gain control up to 15dB
- DC bias: Vd = 6.0Volt @ Idq = 0.8A
- Chip size 3.60x3.00x0.07mm

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		22		dB
Psat	Saturated output power		31		dBm
OIP3	Output IP3		38		dBm

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Specifications

Tamb.= +25°C, Vd = +6.0V

Symbol	Parameter	Min	Typ	Max	Unit
Fop	Operating frequency range	36.0		43.5	GHz
Gain	Small Signal Gain		22		dB
ΔG	Gain variation in temperature		± 0.04		dB/°C
Psat	Saturated Output Power		31		dBm
OIP3	Output IP3		38		dBm
P1dB	Pout at 1dB of compression		30		dBm
PAE	PAE at saturation		15		%
CG	Gain control range		15		dB
Rlin	Input Return Loss		8		dB
Rlout	Output Return Loss		10		dB
Dr	Detection dynamic range(for output power detection up to Psat)		30		dB
Vdetect	Voltage detection V_{REF}- V_{DET} up to Psat		20 to 2000		mV
Vg	DC gate Voltage		-0.65		V
Idq	Total drain current		0.8		A

These values are representative of on-board measurements.
Electrostatic discharge sensitive device observe handling precautions!

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Absolute Maximum Ratings [1, 2]

Tamb.= +25°C

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	8	V
Id	Drain bias current	1900	mA
Vg	Gate bias voltage	-2 to 0	V
Vdg	External drain-gate excursion	12	V
Pin	Maximum Input Power	+15	dBm
Tj	Maximum Junction temperature	175	°C

[1] Operation of this device above anyone of these parameters may cause permanent damage.

[2] These are stress rating only, and functional operation of the devices at these conditions is not implies.

Recommanded Operating Range [3, 4]

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	5 to 6	V
Id	Drain bias current	640 to 800	mA
Vg	Gate bias voltage	-2 to 0	V
Pin	Maximum peak input power overdrive	15	dBm
Ta	Operating temperature range	-40 to 95	°C

[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	6V	V
Vd2	DC Drain voltage 2nd stage	6V	V
Vd3	DC Drain voltage 3rd stage	6V	V
Vd4	DC Drain voltage 4th stage	6V	V
Vg1	DC Gate voltage 1st stage	-0.65	V
Vg2	DC Gate voltage 2nd stage	-0.65	V
Vg3	DC Gate voltage 3rd stage	-0.65	V
Vg4	DC Gate voltage 4th stage	-0.65	V

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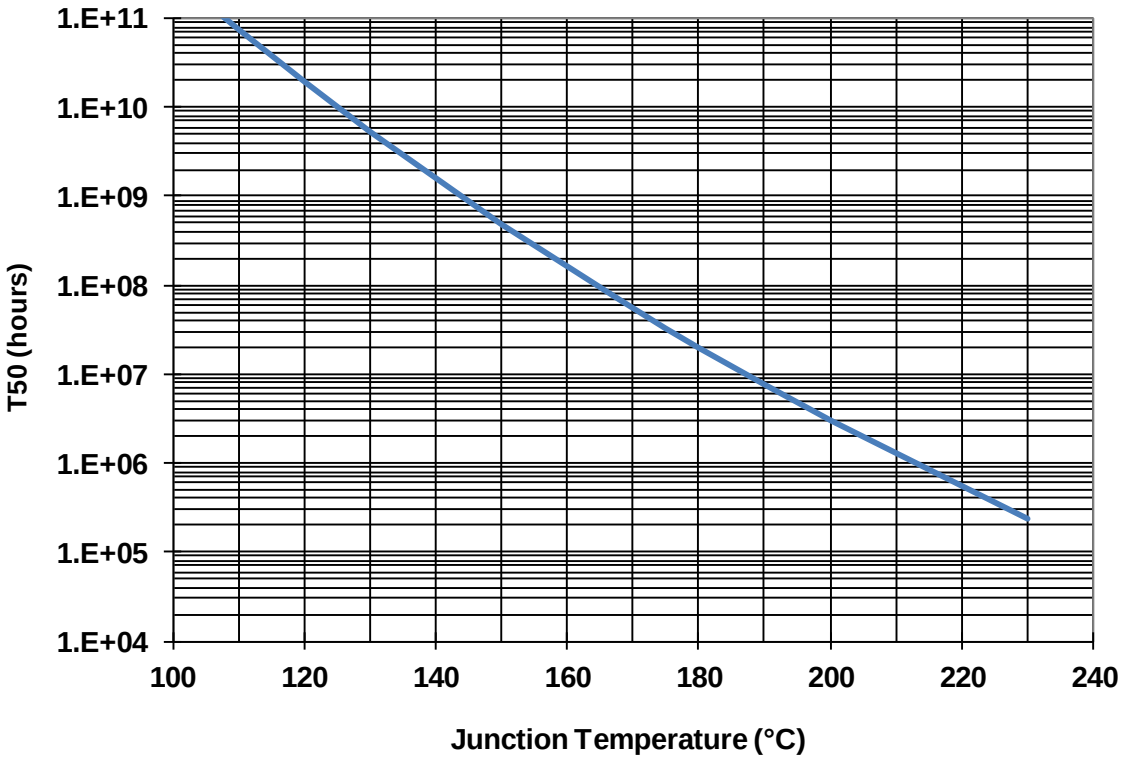
Device thermal performances

The device thermal performances below are based on UMS rules to evaluate the junction temperature.
The temperature Tb_{chip} is defined as the chip back side 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.
So, 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 (Back of the chip)	Vd= 6V Idq = 800mA Pdiss= 4.8W	170	17.8	5.3E+07
R_{TH} (1) Thermal Resistance (Back of the chip)	Vd= 5V Idq = 640mA Pdiss= 3.2W	125	12.5	9.0E+09

(1) Assuming 85°C Tb_{chip}



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Typical on-wafer Sij parameters (Pulsed mode)

Tamb.= +25°C, Vd = +6.0V, Id = 800mA, Pulse width = 25µs, Duty cycle = 10%

Freq (GHz)	S11 (dB)	PhS11 (°)	S12 (dB)	PhS12 (°)	S21 (dB)	PhS21 (°)	S22 (dB)	PhS22 (°)
5	-0.6	138.1	-77.6	-84	-92.5	129.1	-0.2	164.4
6	-0.7	124.1	-80.1	99.6	-72.7	-61.7	-0.3	160.7
7	-1.1	103	-90.3	61.3	-59.4	-79.1	-0.3	156.6
8	-1.7	68.1	-80.7	-44	-45.7	-109.1	-0.4	151.8
9	-2.8	7.6	-87.2	-163.2	-34.5	-168.6	-0.6	145.5
10	-2.6	-67.9	-86.5	177.9	-25.6	129.5	-1	136.6
11	-1.9	-119.5	-73	-128.7	-17.3	62.6	-2	120.5
12	-1.6	-149.4	-65.2	-110.2	-9.1	-21.5	-7.7	76.4
13	-1.7	-167.8	-55.8	-160	-6.5	-134.5	-5.1	-137.1
14	-2	-179.7	-56.2	160.2	-9.8	143.6	-1.2	-176.8
15	-2.2	171.6	-56.4	110.6	-13.2	78.2	-0.6	167.3
16	-2.4	165.3	-57.7	92	-16.9	30.3	-0.5	157.7
17	-2.4	159.6	-56.6	49	-20.9	-5.6	-0.5	151
18	-2.3	153.7	-58.3	22.3	-23.5	-28.7	-0.4	145
19	-2.3	147.7	-62	-45.8	-24.7	-52.8	-0.5	139.4
20	-2.4	142	-67.5	166.1	-26.1	-72.9	-0.6	133.5
21	-2.4	135.7	-65.7	132.3	-27	-95.1	-0.6	127.5
22	-2.5	129	-58.7	83.6	-28.5	-104.7	-0.6	121.2
23	-2.7	122.9	-60.9	67.9	-27	-100.7	-0.7	114.7
24	-2.7	115.8	-60.6	34.6	-22.6	-109.5	-0.8	106.6
25	-2.7	108.4	-76.2	95.1	-18.1	-126.1	-0.9	97.7
26	-3	99.9	-58.4	19.3	-13.9	-154.3	-1	87.1
27	-3.2	90.6	-56.4	21.2	-9.9	-179	-1.3	73.6
28	-3.2	81	-57.1	-27.8	-4.4	152.8	-1.5	56.4
29	-3.4	69.6	-54.6	-28.9	1.1	116	-2.3	34.1
30	-3.6	57.2	-54.1	-29.3	7.2	73.3	-4	2.9
31	-3.8	43.5	-58.6	-47.7	13.2	21.4	-7	-42.1
32	-4.2	28.7	-52.4	-39.3	18.9	-43.1	-12	-108.4
33	-4.8	15.7	-51.4	-64	23	-114.3	-16.8	177.4
34	-5.3	4	-54.3	-93.7	25.4	169.1	-20.4	126.4
35	-5.3	-13.2	-51.2	-96.8	25.9	93.6	-21.4	135.1
36	-5.5	-28.1	-52	-118.8	25.9	29.1	-21.1	114.7
37	-6.4	-46.5	-59.7	178.5	26	-38.8	-20.5	120.2
38	-7.3	-57.2	-58.5	139.4	25.5	-97.5	-20.7	108.3
39	-8.4	-70	-71.3	-131.3	25.2	-157.6	-20.8	100.9
40	-9.9	-80.9	-57.4	9.4	25.4	141.4	-19.1	93.6
41	-11.7	-84.3	-61.6	130.4	25.3	78	-16.7	73.3
42	-14.5	-78.7	-58.6	-45.4	25.7	12.3	-13.4	48.5
43	-14.3	-62.6	-58.6	88.4	25.8	-61.7	-9.7	27.9
44	-14.3	-35.4	-56.5	73.4	25.8	-150.1	-5	-2.6
45	-6.5	-27.2	-60.1	-99.9	20.5	110.3	-3.5	-41.2

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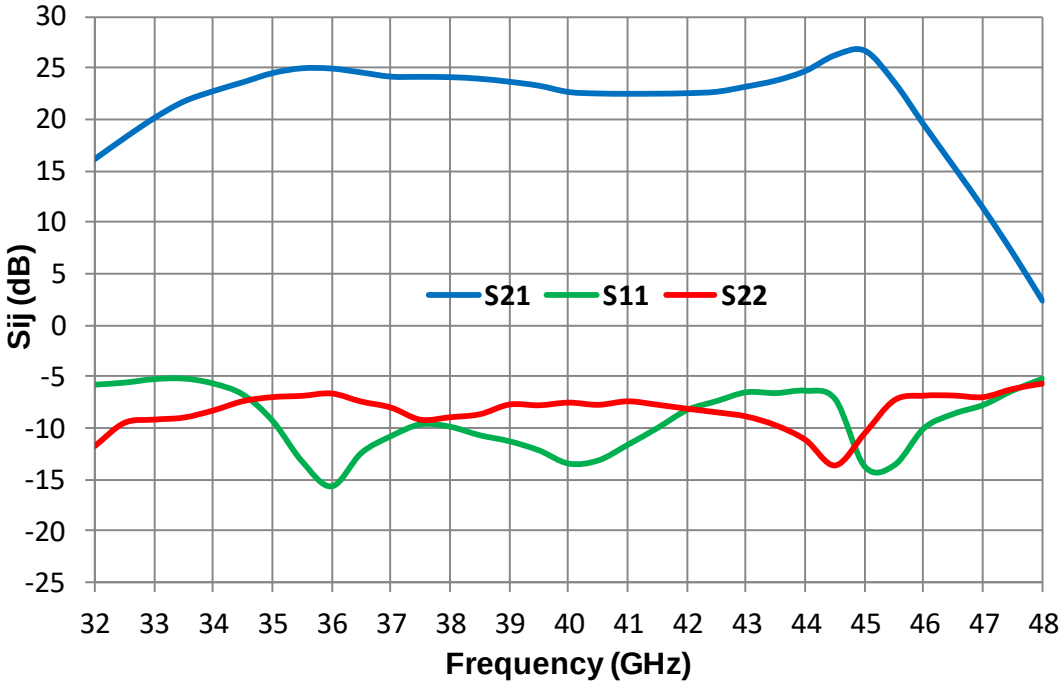
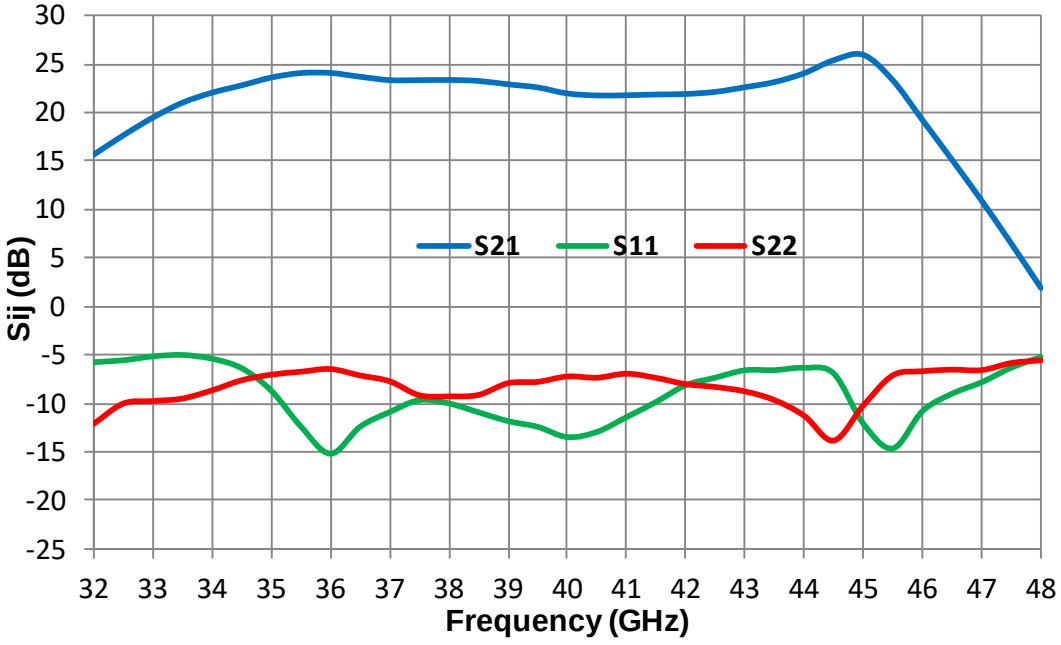
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +6V, Idq = 800mA & Vd = +5V, Idq = 640mA
Measurement performed in the access plans of the die.

Gain & Return Losses versus Frequency
Vd = +6V, Idq = 800mA



Gain & Return Losses versus Frequency
Vd = +5V, Idq = 640mA



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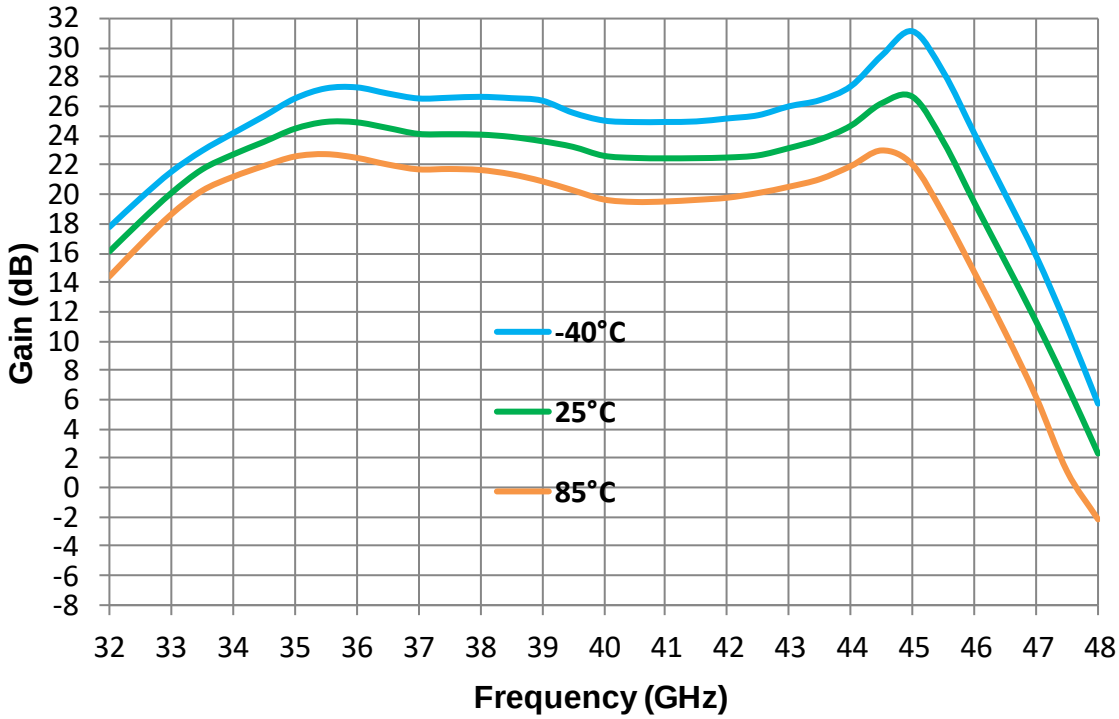
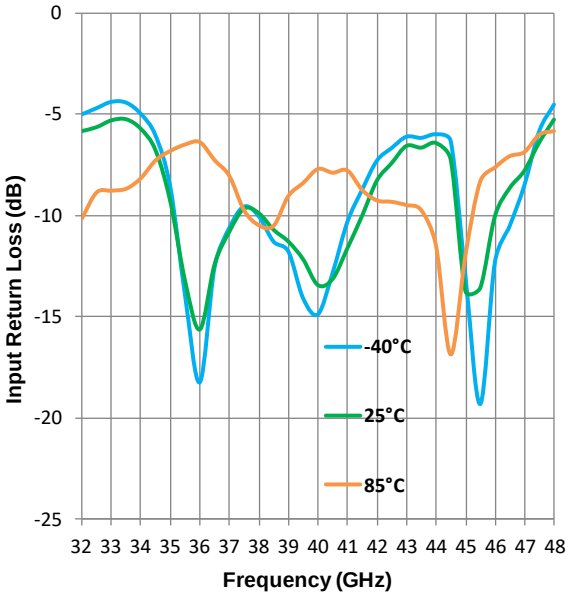
Typical Measurements on a probe compatible Board (CW)

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA
Measurement performed in the access plans of the die.

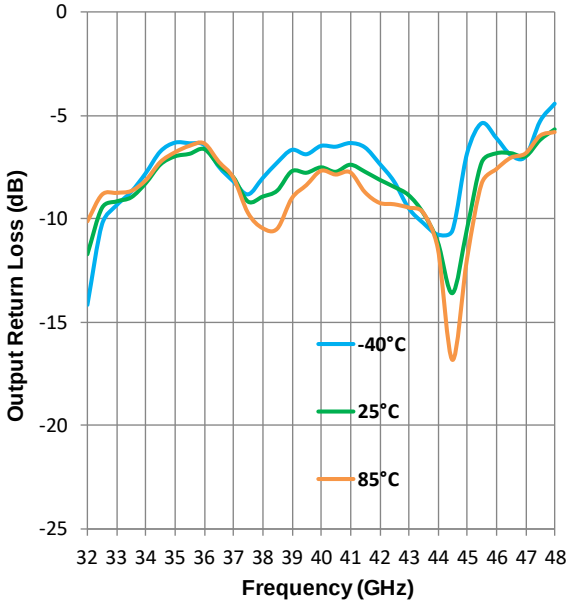
Gain versus Frequency in Temperature



Input Return Losses versus Frequency in Temperature



Output Return Losses versus Frequency in Temperature



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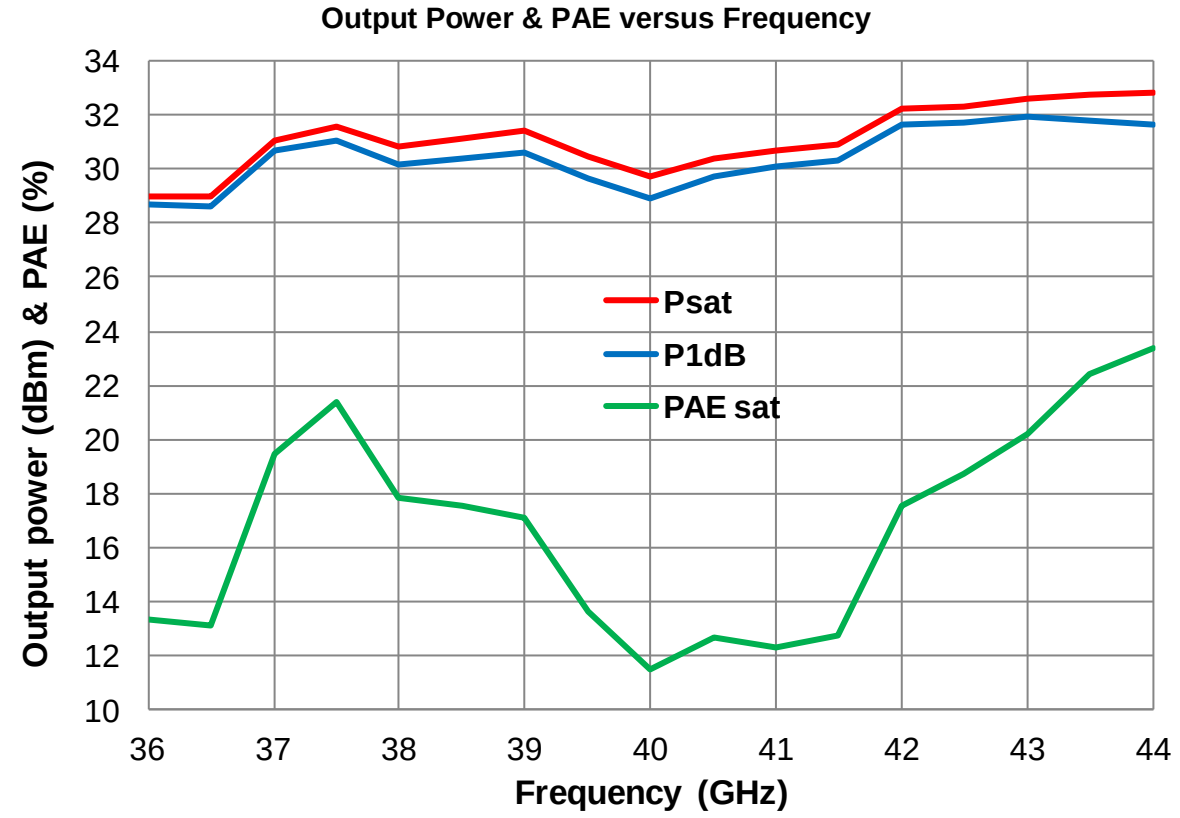
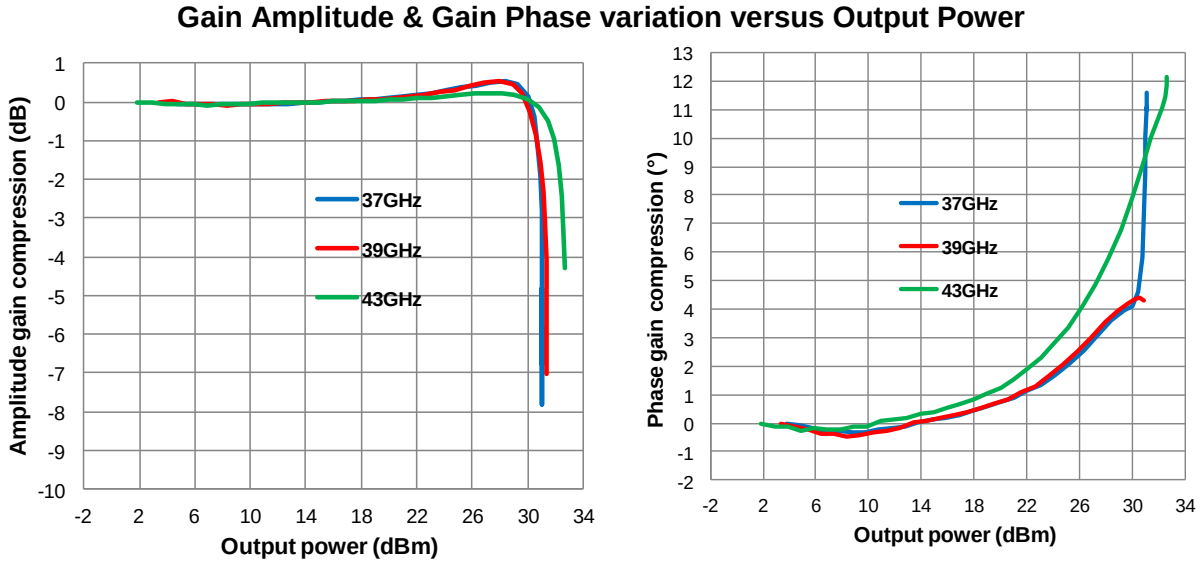
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA
Measurement performed in the access plans of the die.





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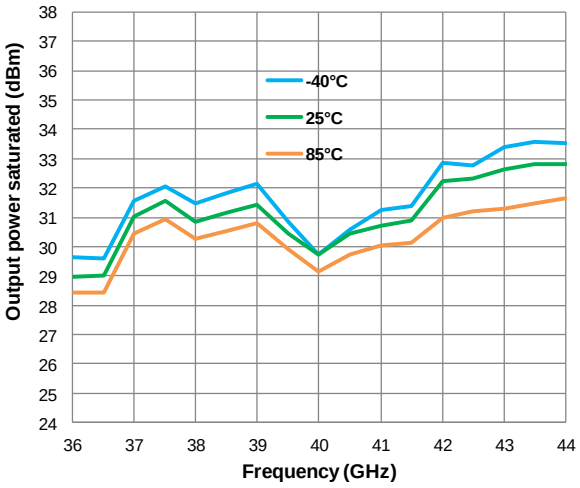
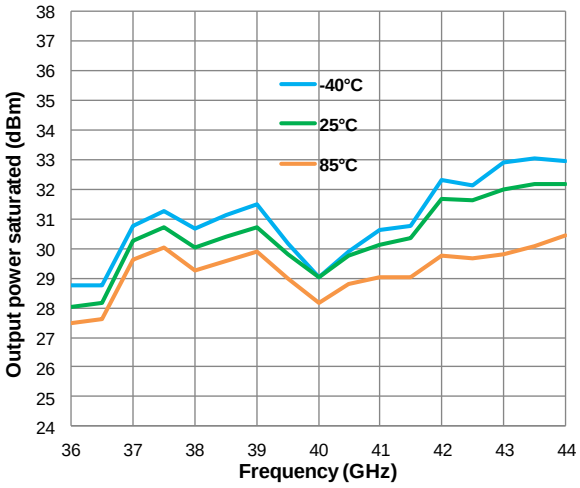
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA & Vd = +5V, Idq = 640mA

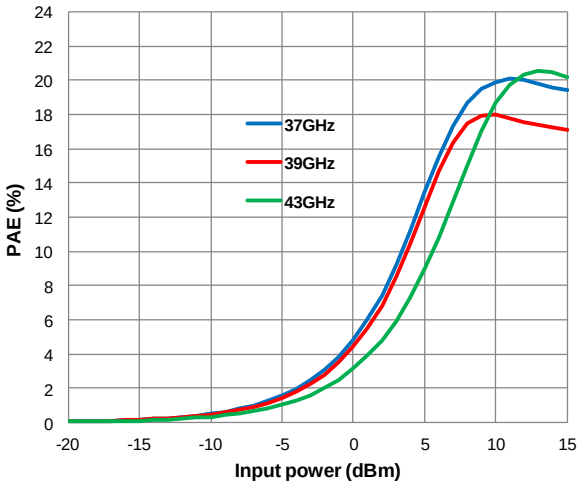
Saturated Power versus Frequency in Temperature
Vd = +6V, Idq = 800mA



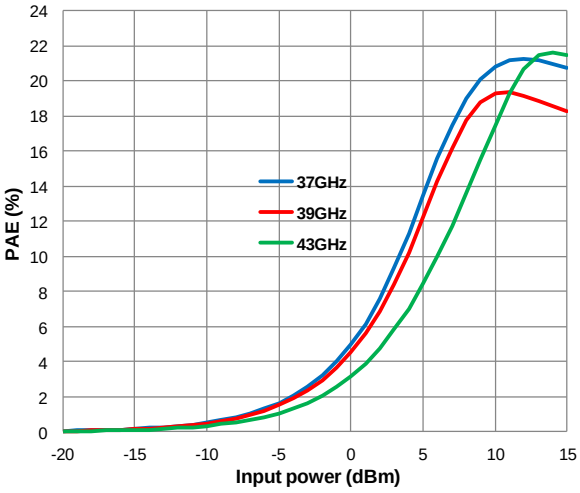
Saturated Power versus Frequency in Temperature
Vd = +5V, Idq = 640mA



PAE versus Input Power
Vd = +6V, Idq = 800mA



PAE versus Input Power
Vd = +5V, Idq = 640mA



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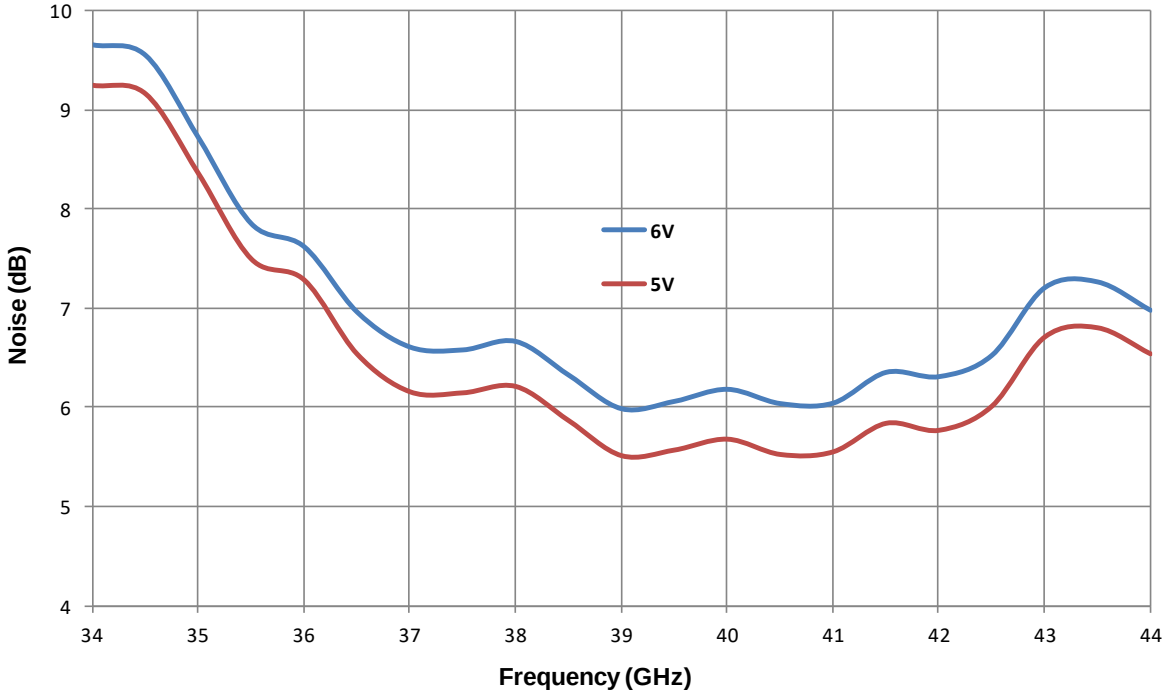
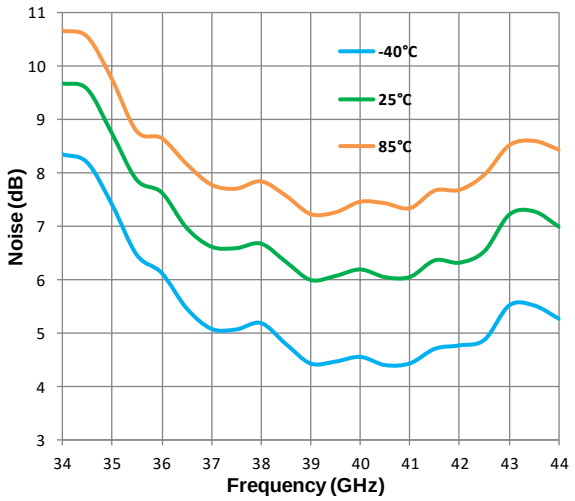
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA & Vd = +5V, Idq = 640mA

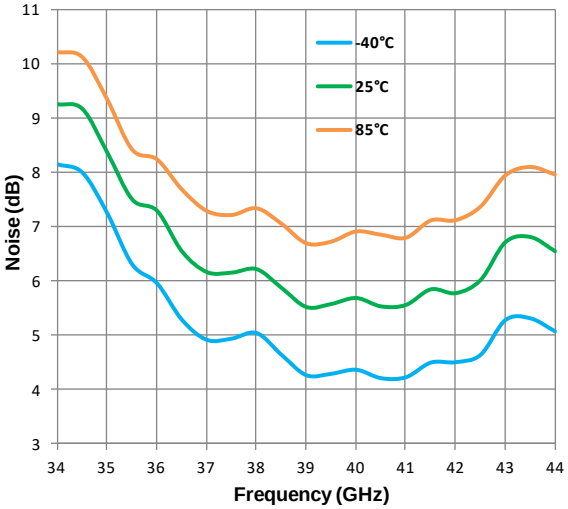
Noise Figure versus Frequency
Vd = +6V, Idq = 800mA
Vd = +5V, Idq = 640mA



Noise Figure versus Frequency in Temperature
Vd = +6V, Idq = 800mA



Noise Figure versus Frequency in Temperature
Vd = +5V, Idq = 640mA



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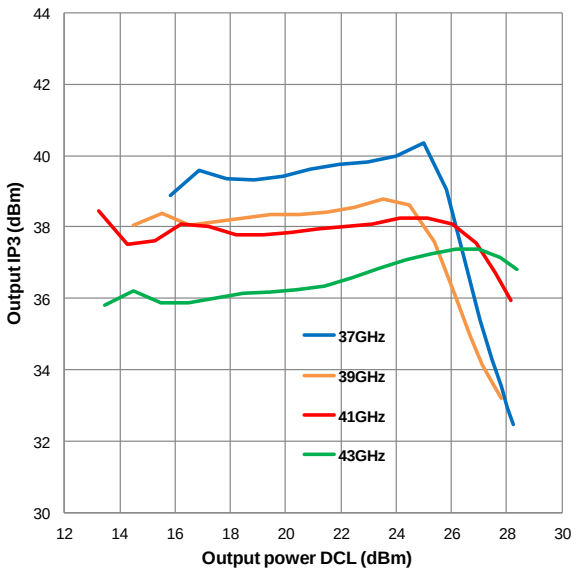
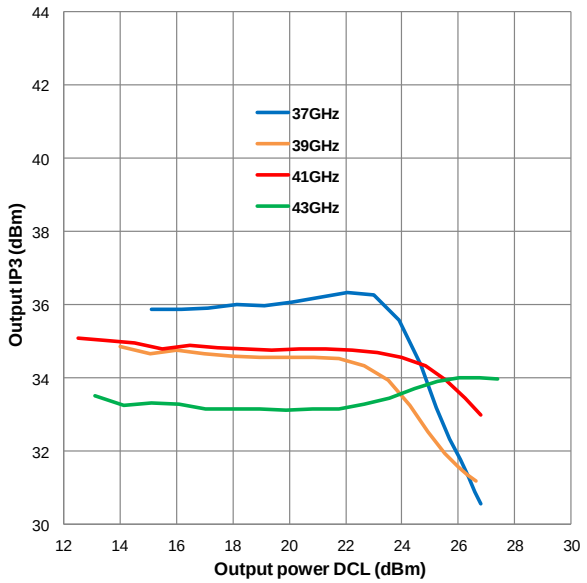
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA & Vd = +5V, Idq = 640mA

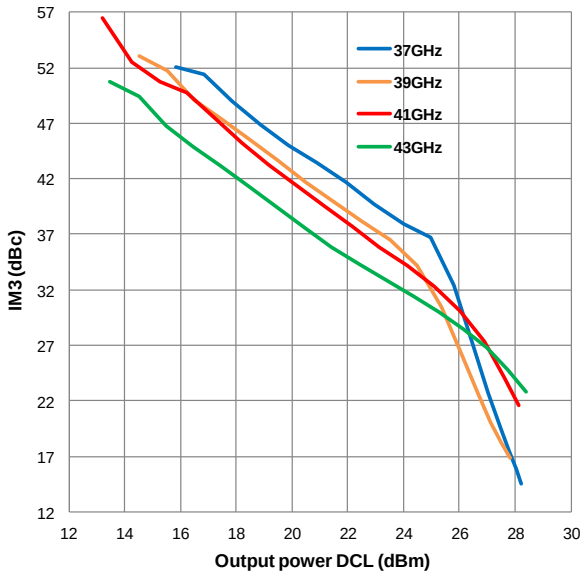
Output IP3 versus Output Power
Vd = +6V, Idq = 800mA



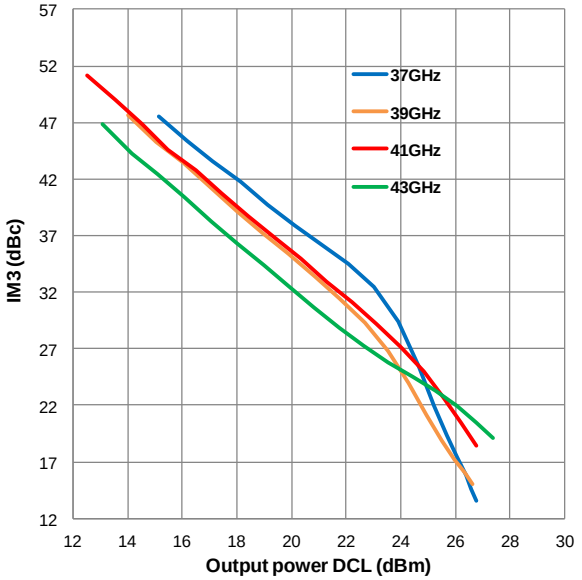
Output IP3 versus Output Power
Vd = +5V, Idq = 640mA



Output IM3 versus Output Power
Vd = +6V, Idq = 800mA



Output IM3 versus Output Power
Vd = +5V, Idq = 640mA



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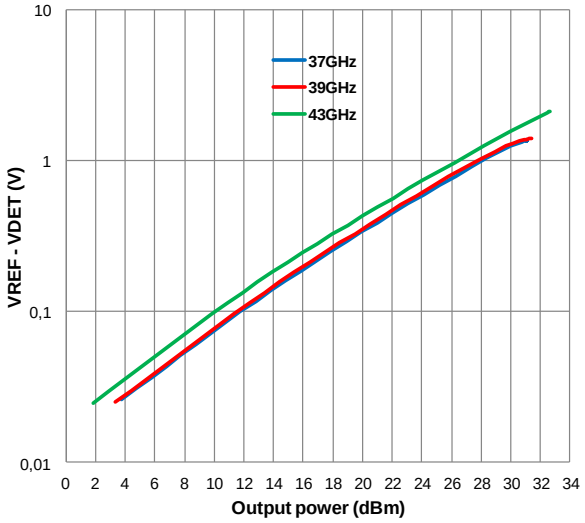
Typical Board Measurements (CW)

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA & Vd = +5V, Idq = 640mA

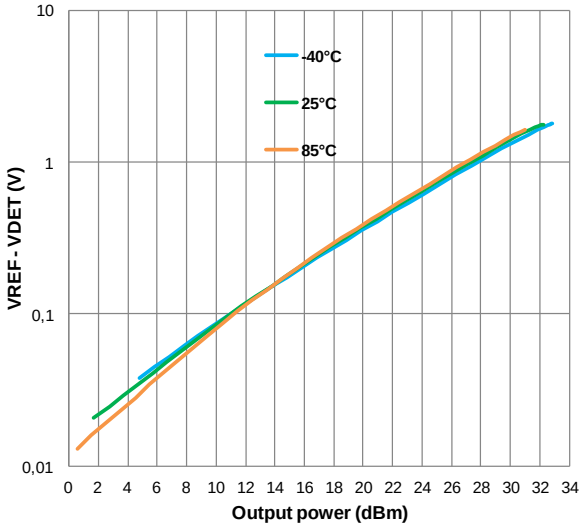
Power Detector versus Output Power

Vd = +6V, Idq = 800mA



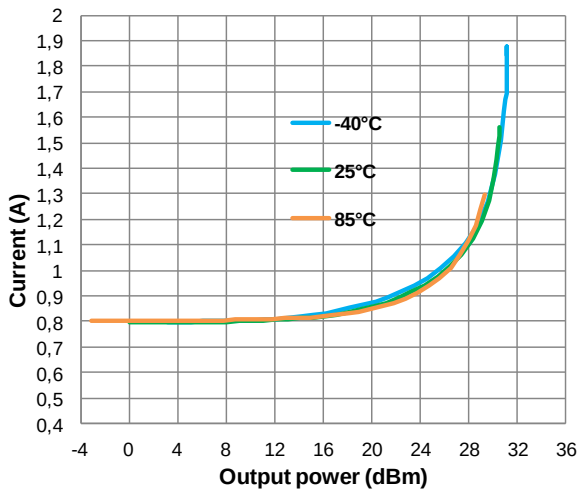
Power Detector versus Output Power & Temperature at 42GHz

Vd = +6V, Idq = 800mA



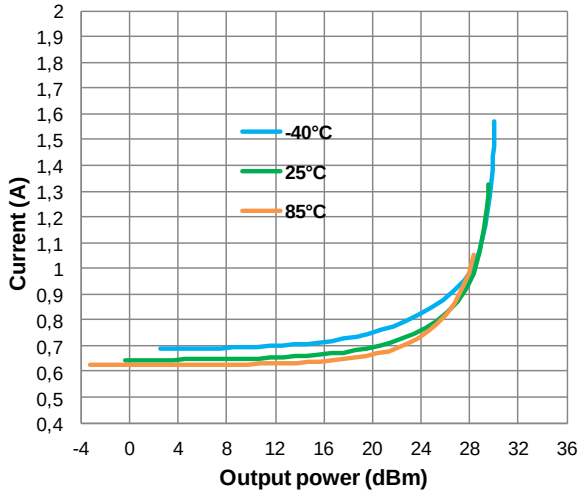
Total Drain Current versus Output Power at 42GHz

Vd = +6V, Idq = 800mA



Total Drain Current versus Output Power at 42GHz

Vd = +5V, Idq = 640mA



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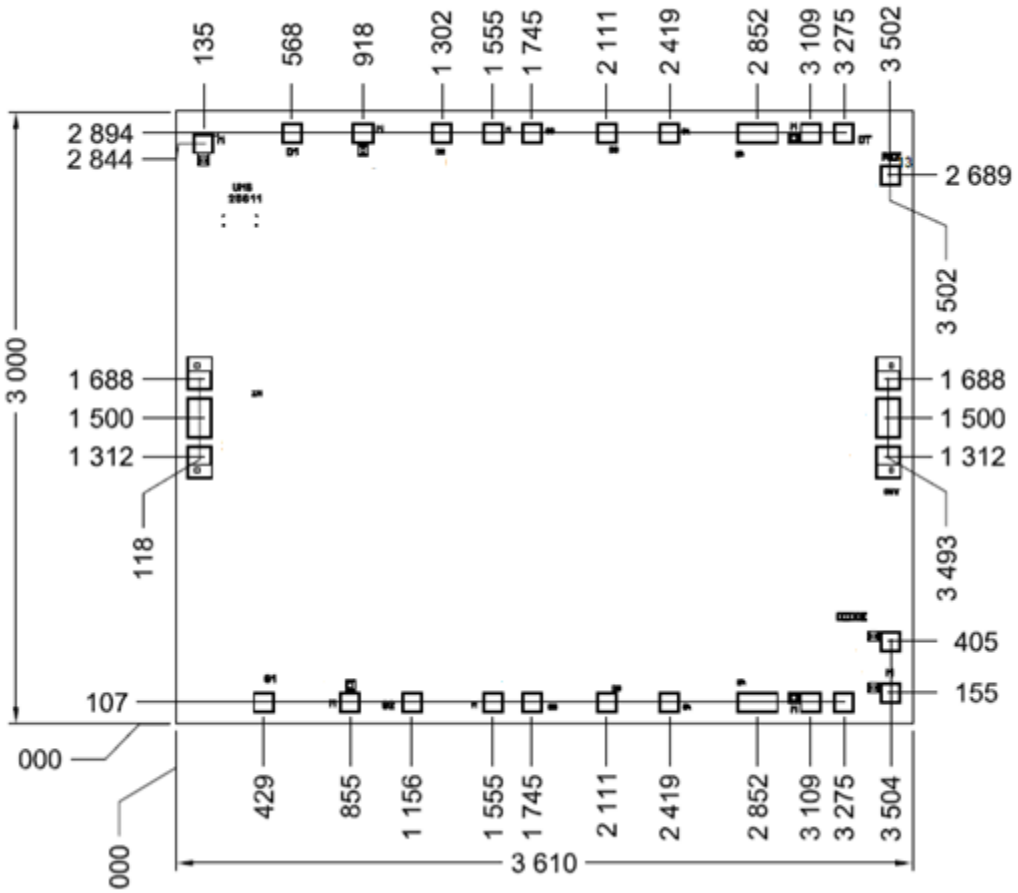
Mechanical data



Chip thickness: 70µm.
All dimensions are in micrometers
DC pad size: 83um x 83 um (BCB opening)
RF pad size: 105um x 186 um (BCB opening)

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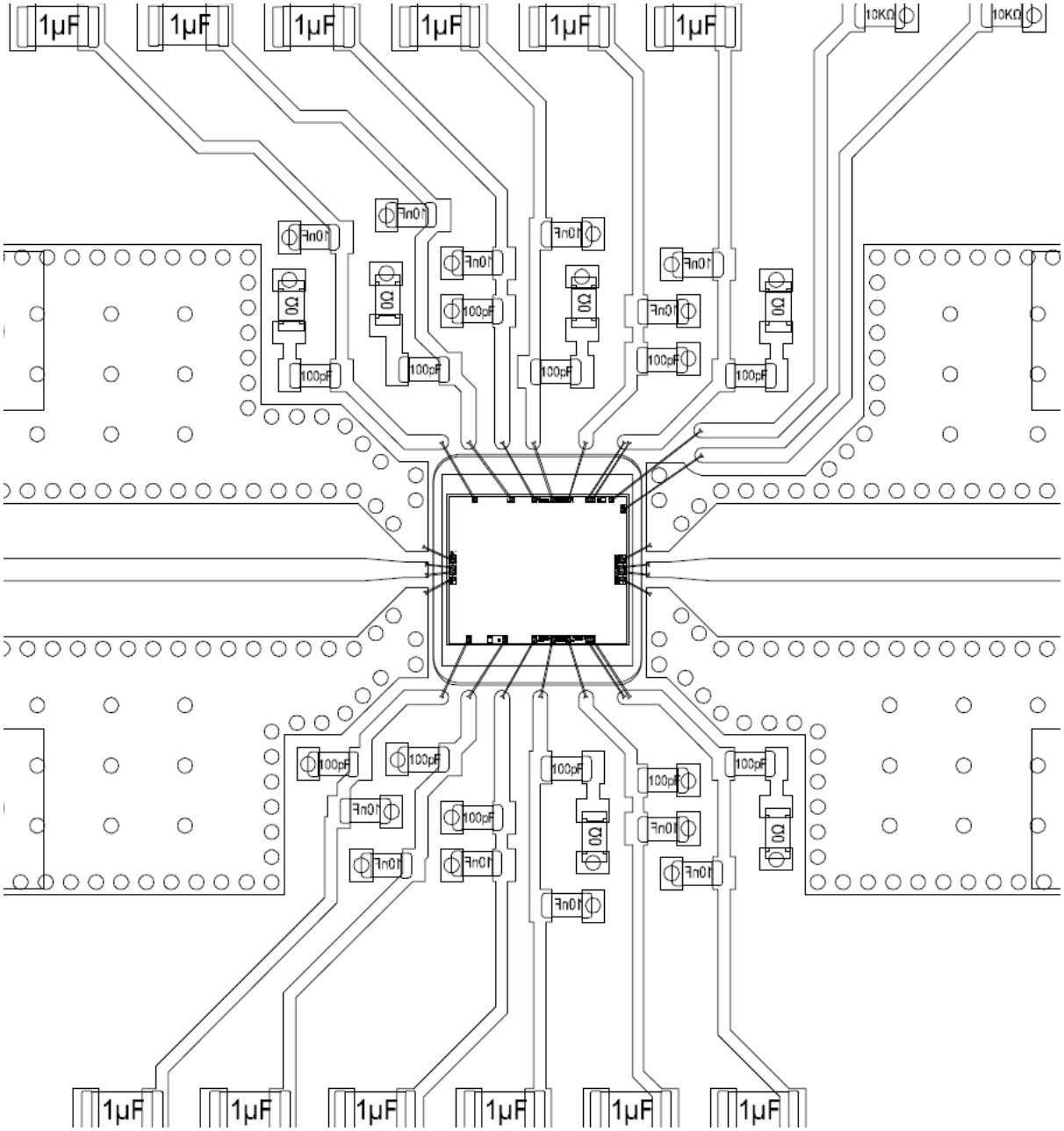
Recommended assembly plan



Decoupling capacitors: 100pF, 10nF & 1µF (on gate & drain access)

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

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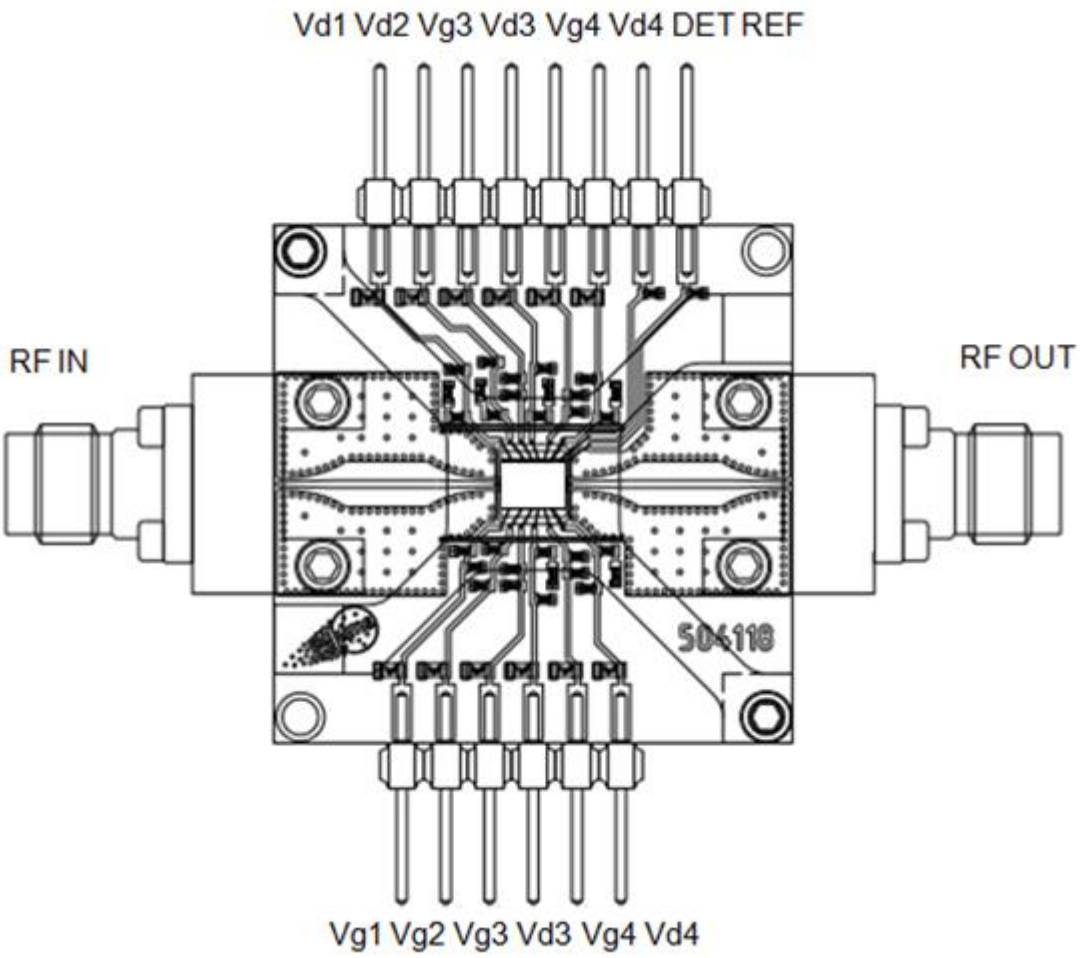
Evaluation mother board

- Compatible with the proposed footprint.
- Based on typically RF35P / 8mils 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.
- A 10KΩ resistor is recommended on VREF & VDET accesses for the detector
- Note: All board measurements are performed using shielded cables, even for DC bias, to ensure safe operation.



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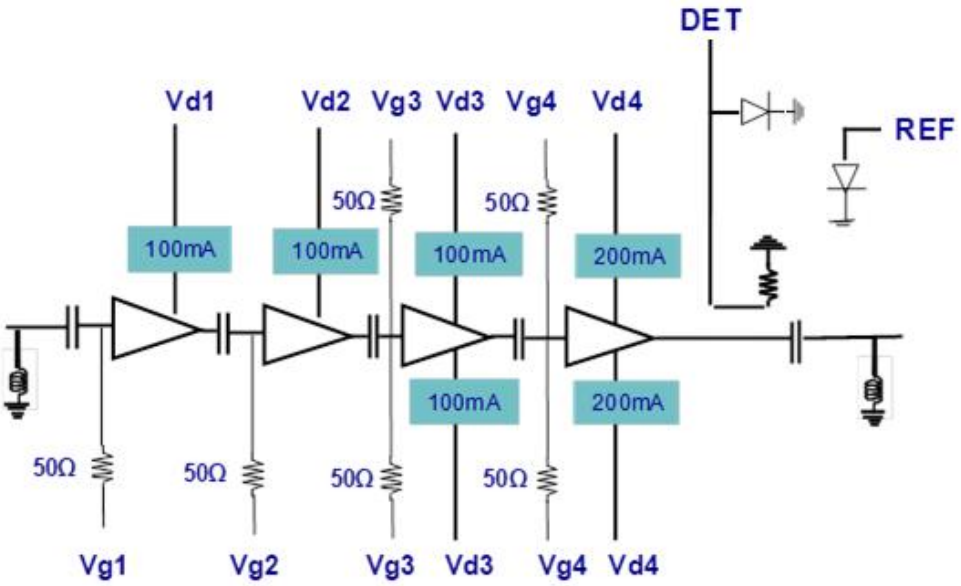
DC Schematic

HPA : 6V, 800mA



Biasing procedure

Device Power Up instructions:

1. Ground the device
2. Bias HPA gate voltage at Vgs close to Vpinch-off (example: Vg ≈ -2V)
3. Apply Vds quiescent bias voltage (Example: Vd = 6V)
4. Increase slowly Vgs up to quiescent bias drain current Idq (pulsed applied on the gate)
5. Apply RF input power

Device Power Up instructions:

1. Remove RF input power
2. Decrease HPA gate voltage up to Vgs -2V
3. Decrease drain voltage up to 0V

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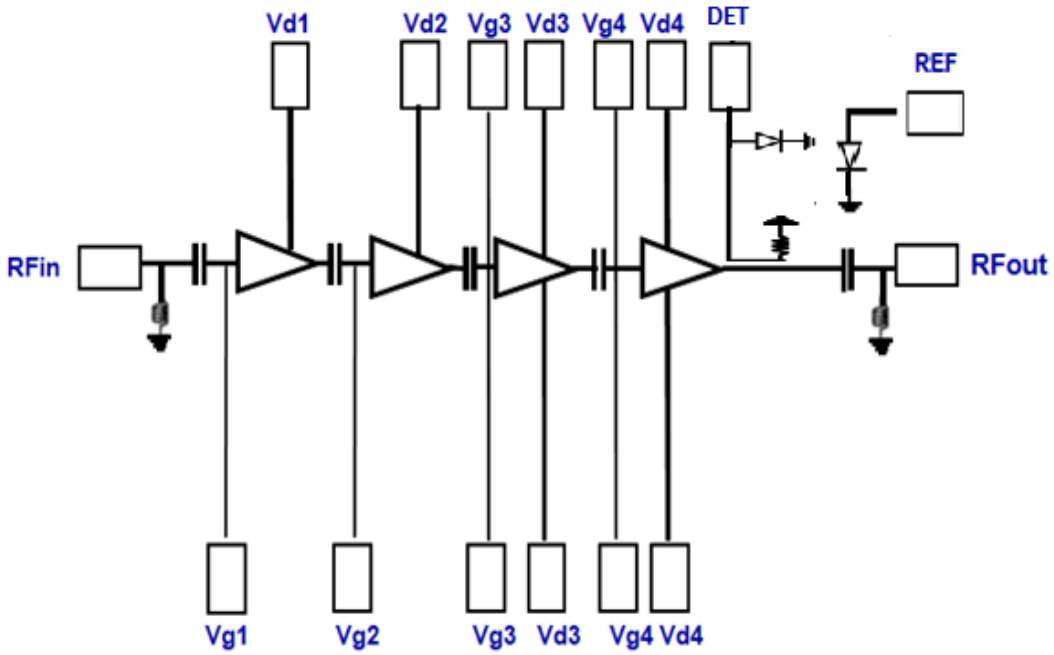
Notes

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



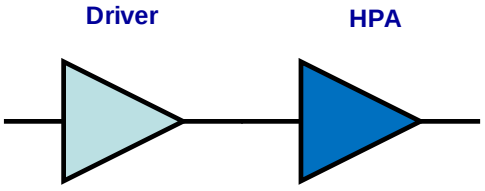
Limited DC decoupling is implemented on chip. Additional external DC decoupling (100pF, 10nF, 1µF) on the PC Board, as close as possible to the bare die, is required.

A 10KΩ resistor is recommended in parallel to VDET, and VREF accesses.

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

Recommended UMS Power chain

The CHA3398-98F is recommended with the CHA5659-98F as driver.
Total Gain: 42dB
Gain control: 30dB with the both amplifiers.



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

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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:	CHA5659-98F/00

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