

## 40-43.5GHz Power Amplifier

### GaAs Monolithic Microwave IC in SMD leadless package

#### Description

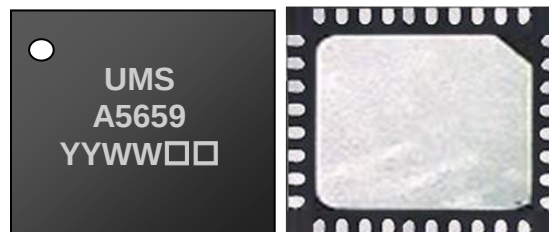
The CHA5659-QXG is a four stage monolithic GaAs high power amplifier producing 1 Watt output power. It is highly linear, with possible gain control and integrates a power detector. ESD protections are included.

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

The CHA5659-QXG is recommended with the CHA3398-QDG as a driver.

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

It is supplied in RoHS compliant SMD package.

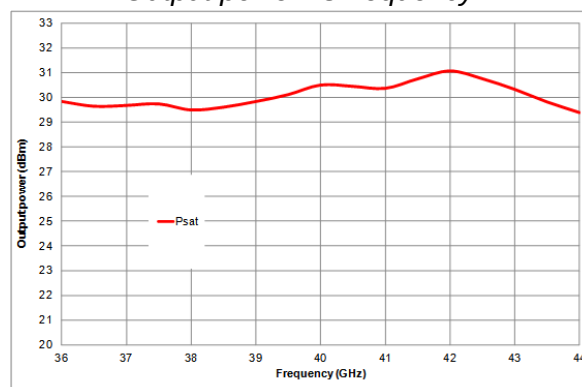


36 leads 6x5mm QFN package

#### Main Features

- Broadband performances: 40-43.5GHz
- 30dBm saturated power
- 38.5dBm OIP3
- 20dB gain
- DC bias:  $V_d = 6.0\text{V}$  @  $I_{dq} = 0.8\text{A}$
- QFN5x6
- MSL3

Output power vs frequency



#### Main Electrical Characteristics

$T_{amb.} = +25^{\circ}\text{C}$

| Symbol | Parameter              | Min  | Typ  | Max  | Unit |
|--------|------------------------|------|------|------|------|
| Freq   | Frequency range        | 40.0 |      | 43.5 | GHz  |
| Gain   | Linear Gain            |      | 20   |      | dB   |
| Psat   | Saturated output power |      | 30   |      | dBm  |
| OIP3   | Output IP3             |      | 38.5 |      | dBm  |

**Electrical Characteristics**

Tamb.= +25°C, Vd = +6.0V

| Symbol     | Parameter                                                      | Min  | Typ        | Max  | Unit  |
|------------|----------------------------------------------------------------|------|------------|------|-------|
| Fop        | Operating frequency range                                      | 40.0 |            | 43.5 | GHz   |
| Gain       | Small Signal Gain                                              |      | 20         |      | dB    |
| $\Delta G$ | Gain variation in temperature                                  |      | $\pm 0.04$ |      | dB/°C |
| Psat       | Saturated Output Power                                         |      | 30         |      | dBm   |
| OIP3       | Output IP3                                                     |      | 38.5       |      | 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!

**Absolute Maximum Ratings** <sup>(1)</sup>T<sub>amb.</sub> = +25°C

| Symbol          | Parameter                                   | Values  | Unit |
|-----------------|---------------------------------------------|---------|------|
| V <sub>d</sub>  | Drain bias voltage                          | 8       | V    |
| I <sub>d</sub>  | Drain bias current                          | 1000    | mA   |
| V <sub>g</sub>  | Gate bias voltage                           | -2 to 0 | V    |
| P <sub>in</sub> | Maximum Input Power                         | +15     | dBm  |
| T <sub>j</sub>  | Maximum Junction temperature <sup>(2)</sup> | 171     | °C   |

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

<sup>(2)</sup> Thermal Resistance channel to ground paddle

**Temperature Range**

|                  |                             |             |    |
|------------------|-----------------------------|-------------|----|
| T <sub>a</sub>   | Operating temperature range | -40 to +95  | °C |
| T <sub>stg</sub> | Storage temperature range   | -55 to +150 | °C |

**Typical Bias Conditions**T<sub>amb.</sub> = +25°C

| Symbol          | Pad N° | Parameter                              | Values | Unit |
|-----------------|--------|----------------------------------------|--------|------|
| V <sub>d1</sub> | 7      | DC Drain voltage 1 <sup>st</sup> stage | 6.0    | V    |
| V <sub>d2</sub> | 6      | DC Drain voltage 2 <sup>nd</sup> stage | 6.0    | V    |
| V <sub>d3</sub> | 4, 23  | DC Drain voltage 3 <sup>rd</sup> stage | 6.0    | V    |
| V <sub>d4</sub> | 2, 25  | DC Drain voltage 4 <sup>th</sup> stage | 6.0    | V    |
| V <sub>g1</sub> | 19     | DC Gate voltage 1 <sup>st</sup> stage  | -0.65  | V    |
| V <sub>g2</sub> | 21     | DC Gate voltage 2 <sup>nd</sup> stage  | -0.65  | V    |
| V <sub>g3</sub> | 5, 22  | DC Gate voltage 3 <sup>rd</sup> stage  | -0.65  | V    |
| V <sub>g4</sub> | 3, 24  | DC Gate voltage 4 <sup>th</sup> stage  | -0.65  | V    |

## Device thermal performances

All the figures given in this section are obtained assuming that the QFN device is only cooled down by conduction through the package thermal pad (no convection mode considered).

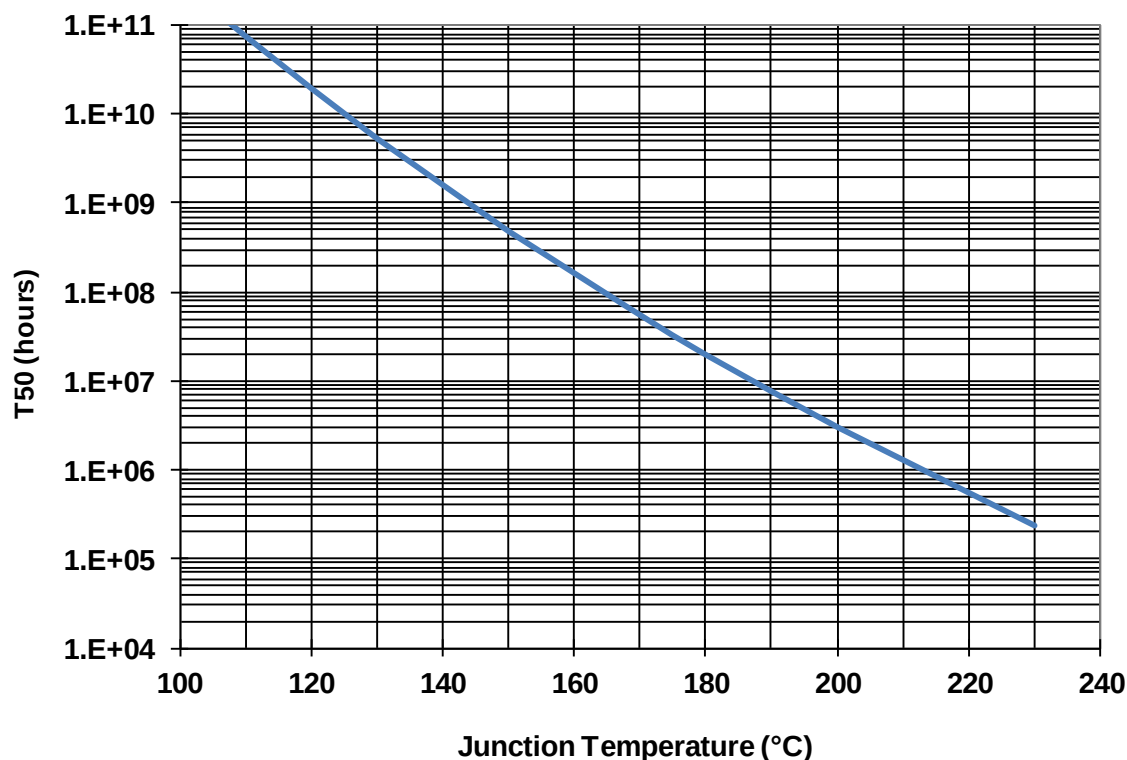
The temperature is monitored at the package back-side interface (Tcase).

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 system PCB must be designed to comply with this requirement.

| Parameter                                                                | Biasing conditions                   | Tjunction (°C) | R <sub>TH</sub> (°C/W) | T50 (hours) |
|--------------------------------------------------------------------------|--------------------------------------|----------------|------------------------|-------------|
| R <sub>TH</sub> <sup>(1)</sup><br>Thermal Resistance ( Junction to Case) | Vd= 6V<br>Idq = 800mA<br>Pdiss= 4.8W | 171            | 17.8                   | 5.3E+07     |

<sup>(1)</sup> Assuming 85°C Tcase



**Typical Package Sij parameters**

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA

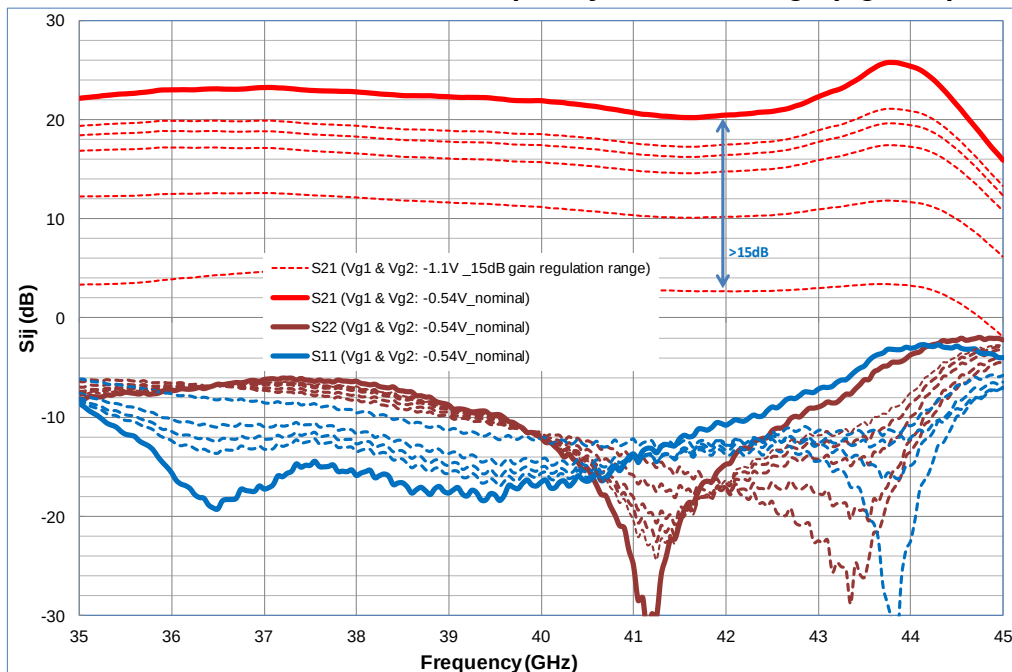
| Freq<br>(GHz) | S11<br>(dB) | PhS11<br>(°) | S21<br>(dB) | PhS21<br>(°) | S12<br>(dB) | PhS12<br>(°) | S22<br>(dB) | PhS22<br>(°) |
|---------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|
| 5             | -0.52       | 74.54        | -67.53      | -1.52        | -66.88      | 11.34        | -0.33       | 102.43       |
| 6             | -0.70       | 49.57        | -64.16      | -60.52       | -65.02      | -17.56       | -0.37       | 85.86        |
| 7             | -1.03       | 18.03        | -62.40      | -146.10      | -70.02      | -67.49       | -0.46       | 68.64        |
| 8             | -1.74       | -28.09       | -48.01      | 145.09       | -77.24      | -129.52      | -0.60       | 49.77        |
| 9             | -2.75       | -101.44      | -35.46      | 81.03        | -62.86      | 62.15        | -0.82       | 29.97        |
| 10            | -2.63       | 171.22       | -26.22      | 4.83         | -62.75      | -36.60       | -1.26       | 6.52         |
| 11            | -1.91       | 108.89       | -17.90      | -78.92       | -62.71      | -138.28      | -2.57       | -26.75       |
| 12            | -1.69       | 67.34        | -10.25      | -175.87      | -53.97      | 86.92        | -9.21       | -102.14      |
| 13            | -1.89       | 35.65        | -7.70       | 65.79        | -51.97      | -12.79       | -4.85       | 66.80        |
| 14            | -2.31       | 10.88        | -9.88       | -29.09       | -60.03      | -54.67       | -1.45       | 11.93        |
| 15            | -2.59       | -10.89       | -12.61      | -105.14      | -78.68      | -143.36      | -0.84       | -19.54       |
| 16            | -2.69       | -31.29       | -15.55      | -172.76      | -64.51      | -24.71       | -0.67       | -44.35       |
| 17            | -2.68       | -51.13       | -19.10      | 134.08       | -66.10      | 150.90       | -0.63       | -66.35       |
| 18            | -2.57       | -70.36       | -21.26      | 88.39        | -54.87      | 67.67        | -0.65       | -86.97       |
| 19            | -2.50       | -88.87       | -22.77      | 47.85        | -50.71      | -3.88        | -0.69       | -106.37      |
| 20            | -2.50       | -107.28      | -23.90      | 6.03         | -55.28      | -60.13       | -0.70       | -125.57      |
| 21            | -2.42       | -125.23      | -25.05      | -27.64       | -51.50      | 31.84        | -0.81       | -144.84      |
| 22            | -2.43       | -142.67      | -25.75      | -63.86       | -50.44      | 2.85         | -0.81       | -163.70      |
| 23            | -2.58       | -159.63      | -27.14      | -97.27       | -47.40      | -19.96       | -0.85       | 176.72       |
| 24            | -2.53       | -177.83      | -27.71      | -120.16      | -43.84      | -74.27       | -0.98       | 157.38       |
| 25            | -2.60       | 164.64       | -28.21      | -130.86      | -43.17      | -81.25       | -1.02       | 137.41       |
| 26            | -2.81       | 145.53       | -23.97      | -132.07      | -42.83      | -83.24       | -1.24       | 115.95       |
| 27            | -3.05       | 125.62       | -17.60      | -161.53      | -43.21      | -126.16      | -1.43       | 91.49        |
| 28            | -3.23       | 104.16       | -11.46      | 157.21       | -42.85      | -145.58      | -1.84       | 64.22        |
| 29            | -3.36       | 81.73        | -5.38       | 111.75       | -44.04      | -170.00      | -2.58       | 31.65        |
| 30            | -3.28       | 57.64        | 1.57        | 57.06        | -48.90      | -170.91      | -3.97       | -12.59       |
| 31            | -3.29       | 34.13        | 8.32        | -10.10       | -46.55      | -165.68      | -7.09       | -75.15       |
| 32            | -3.41       | 7.21         | 13.99       | -88.67       | -42.25      | 177.51       | -10.56      | -169.32      |
| 33            | -4.07       | -18.31       | 18.40       | -171.69      | -48.89      | 172.38       | -9.43       | 111.92       |
| 34            | -5.33       | -48.24       | 20.92       | 99.60        | -54.68      | 178.74       | -8.88       | 75.44        |
| 35            | -8.04       | -75.60       | 21.80       | 15.26        | -47.71      | -154.02      | -7.61       | 49.55        |
| 36            | -14.39      | -84.46       | 22.72       | -65.77       | -43.83      | -170.15      | -6.98       | 28.93        |
| 37            | -14.30      | -53.69       | 22.78       | -146.65      | -39.52      | -174.93      | -5.79       | 6.59         |
| 38            | -15.07      | -72.87       | 22.43       | 134.96       | -38.54      | 158.26       | -5.97       | -19.48       |
| 39            | -19.08      | -85.29       | 22.09       | 58.12        | -39.62      | 135.69       | -7.86       | -42.64       |
| 40            | -20.44      | -178.75      | 21.76       | -19.97       | -37.14      | 144.47       | -11.06      | -63.27       |
| 41            | -13.55      | 87.64        | 20.56       | -98.81       | -34.53      | 127.15       | -21.82      | -64.28       |
| 42            | -9.79       | 26.41        | 20.13       | -169.60      | -32.42      | 117.13       | -13.81      | 4.03         |
| 43            | -7.06       | -28.15       | 22.02       | 114.81       | -28.47      | 97.79        | -8.21       | -41.42       |
| 44            | -3.66       | -174.16      | 25.54       | -12.67       | -23.21      | 37.94        | -2.72       | 165.93       |
| 45            | -3.60       | 69.27        | 15.59       | -140.93      | -27.82      | -7.55        | -2.16       | 40.20        |

### Typical Board Measurements on a probe compatible Board

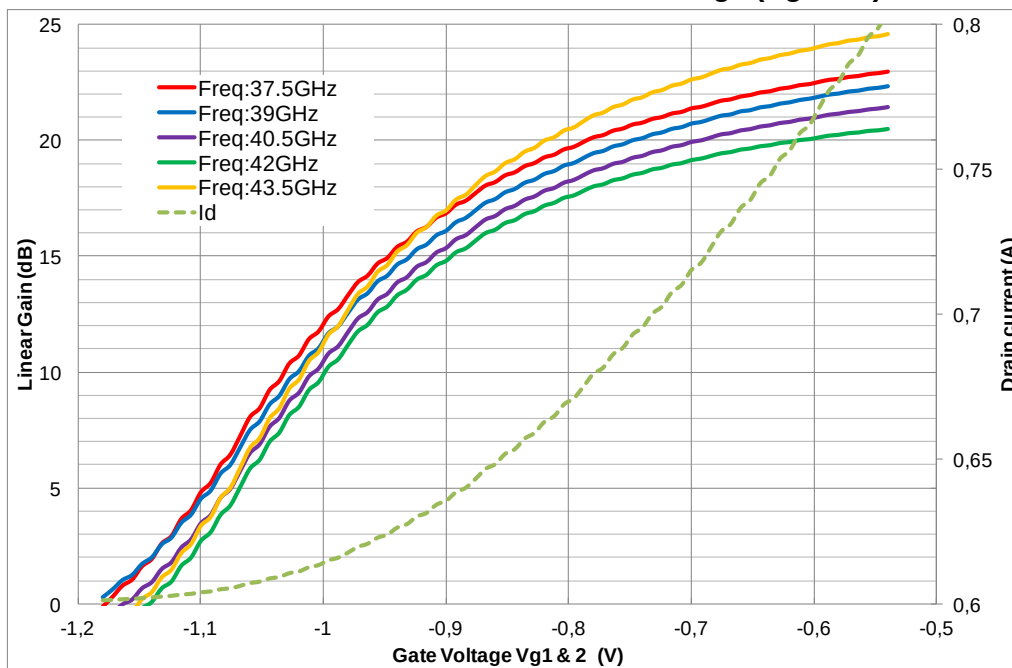
Tamb.= +25°C, Vd = +6.0V, Idq = 800mA

Measurement in the plan of the QFN, using the proposed land pattern & board, as defined in paragraph "Evaluation mother board"

**Gain & Return Loss versus Frequency & Gate Voltage (Vg1 & 2)**



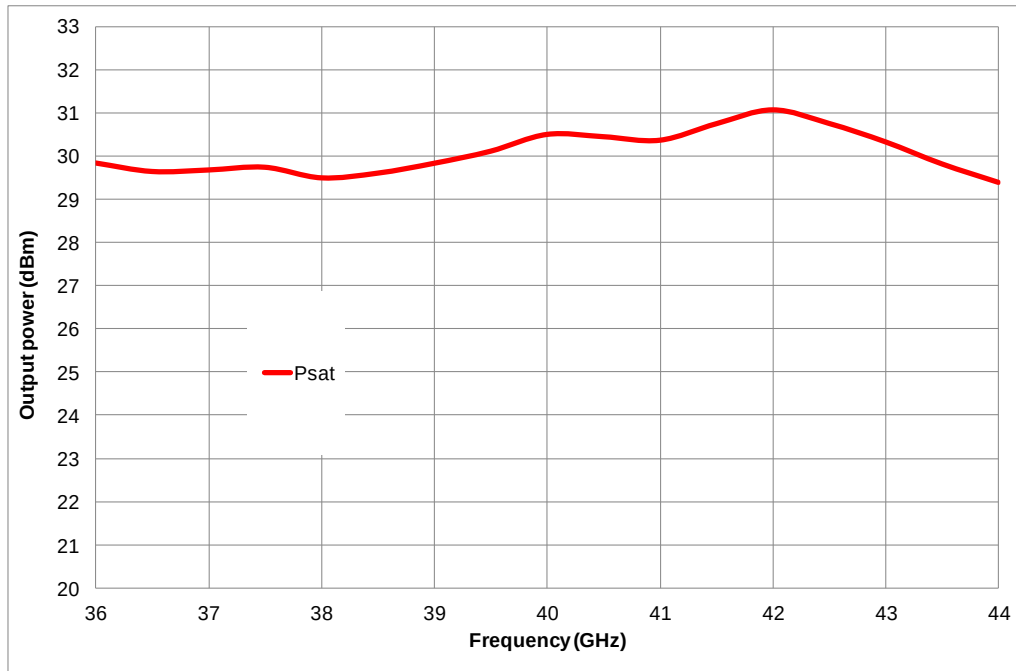
**Gain control & current versus Gate Voltage (Vg1 & 2)**



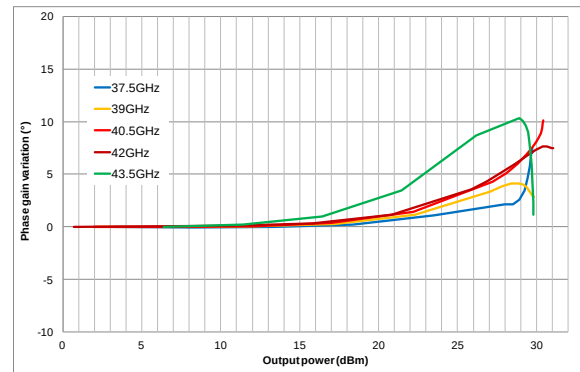
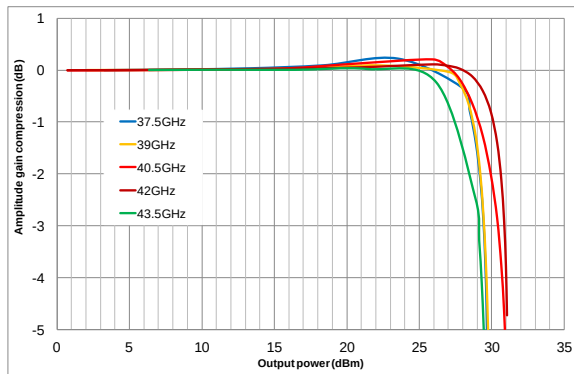
## Typical Measurements on a probe compatible Board

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA

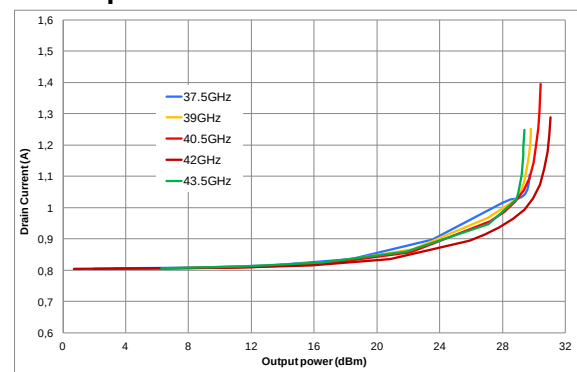
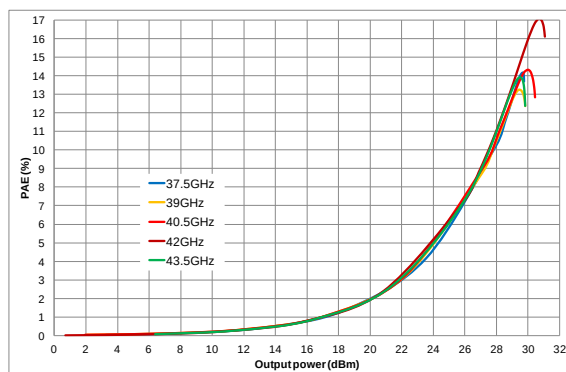
### Output Power versus Frequency



### Amplitude & Phase variation versus Output Power



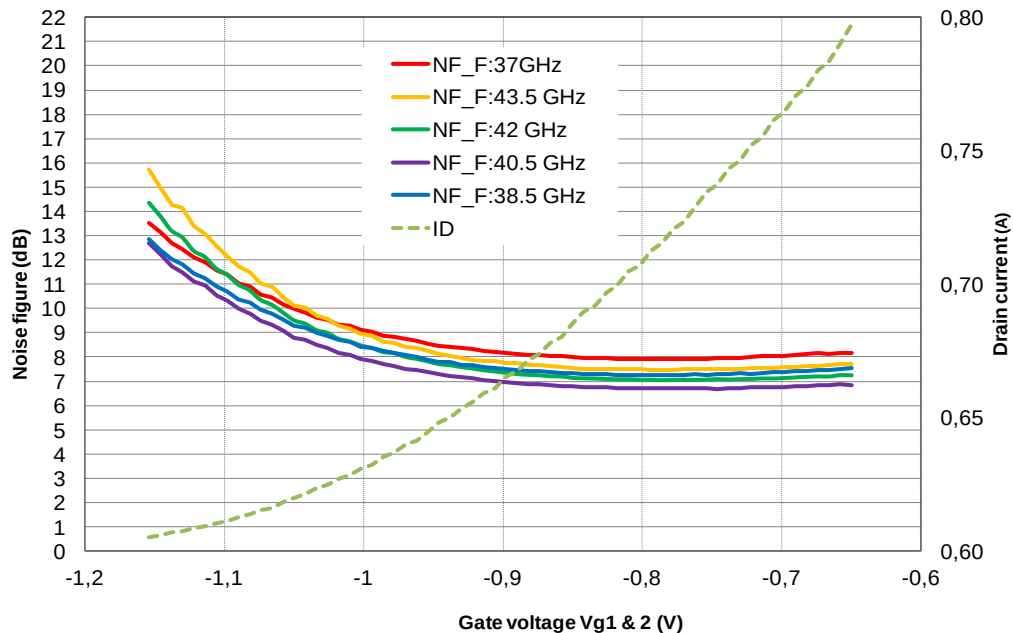
### PAE & Drain Current versus Output Power



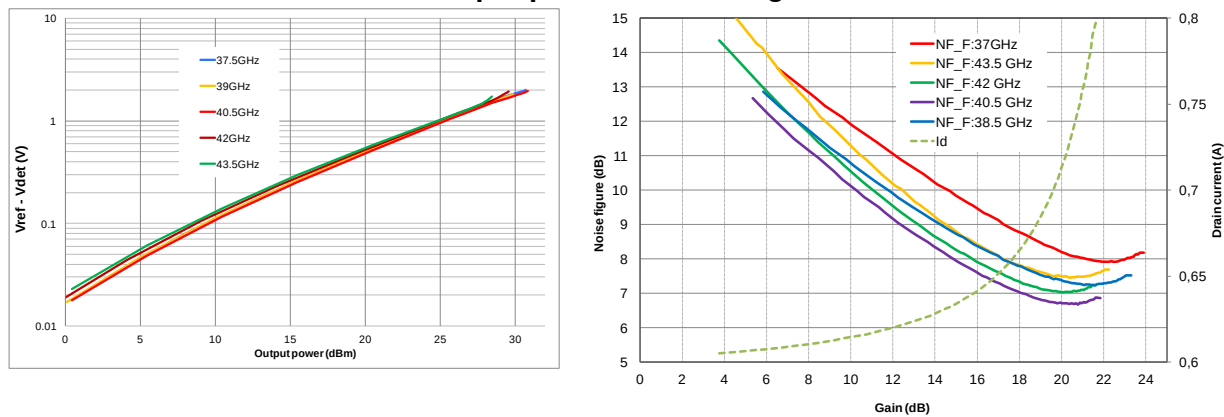
## Typical Board Measurements

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA

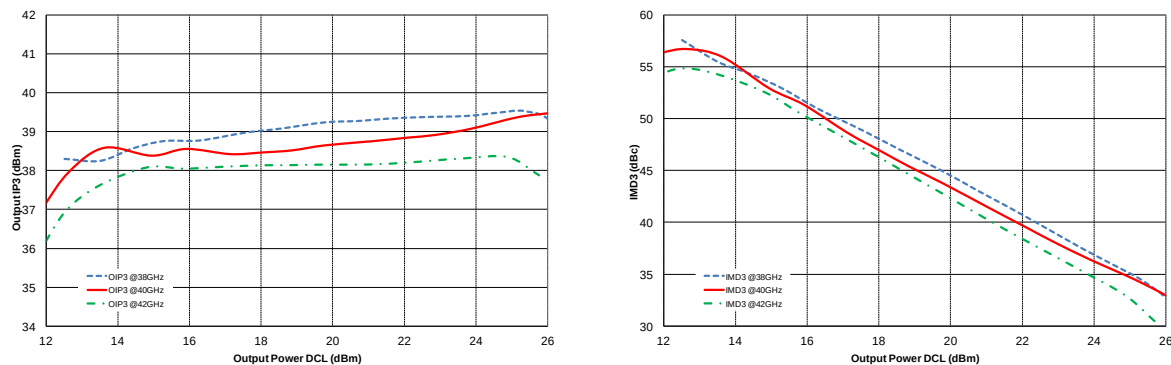
### Noise Figure variation versus Gate Voltage



### Power Detector versus Output power & Noise Figure versus Gain Control



### Output IP3 & IMD3 versus Output Power

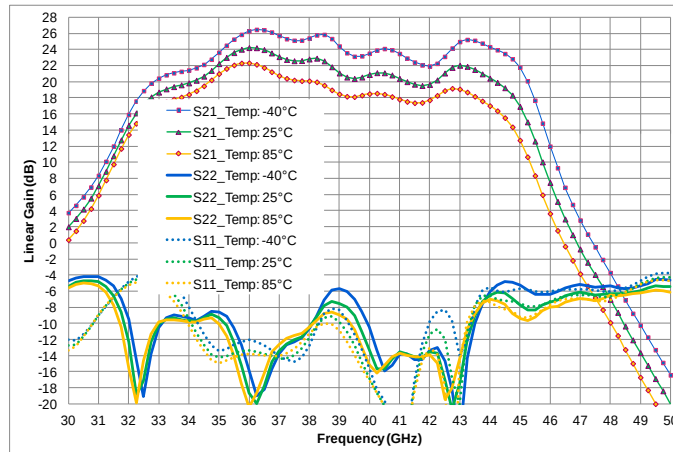




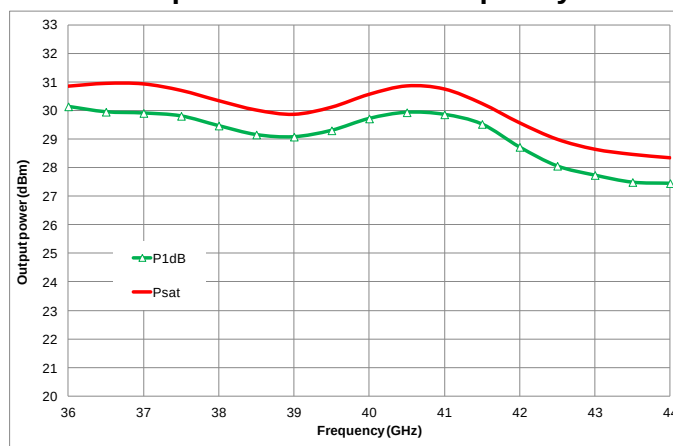
## Typical Board Measurements

Tamb.= +25°C, Vd = +6.0V, Idq = 800mA

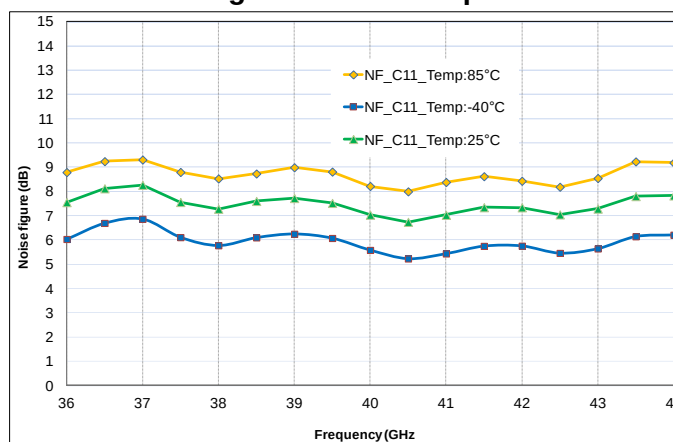
### Gain variation versus Temperature



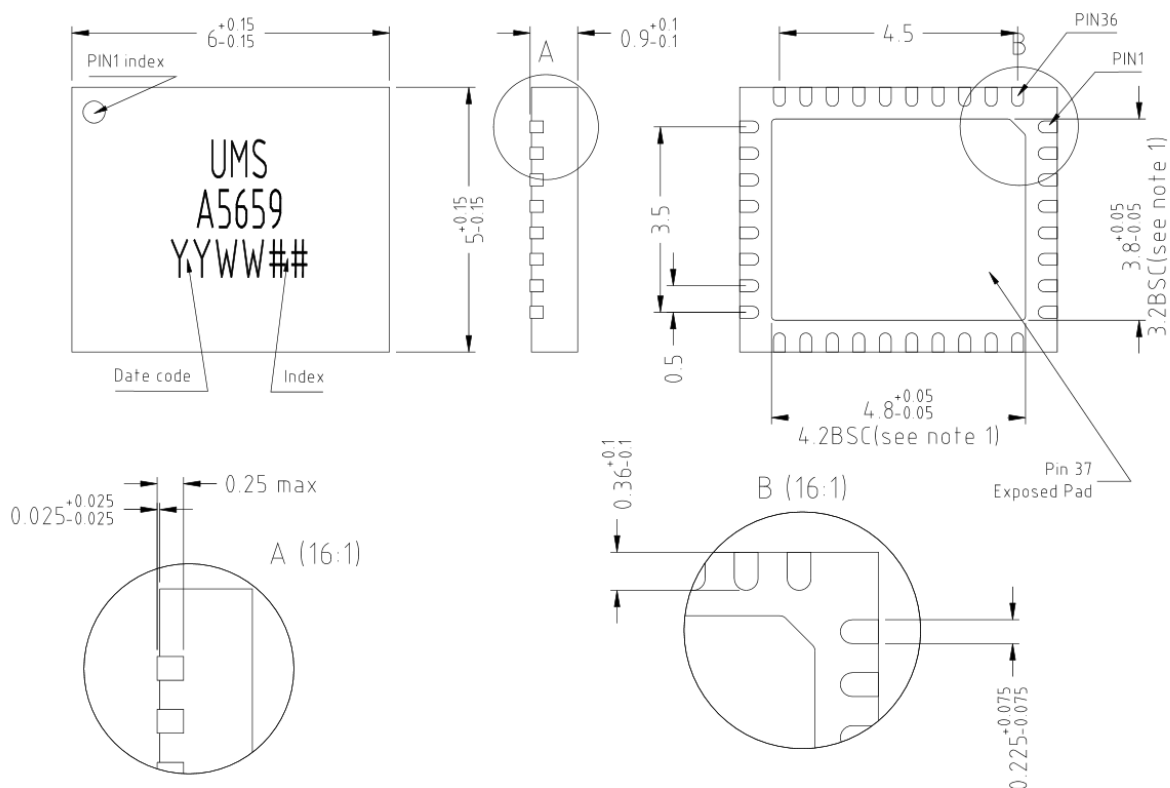
### Output Power versus Frequency



### Noise Figure versus Temperature



### Package outline <sup>(1)</sup>



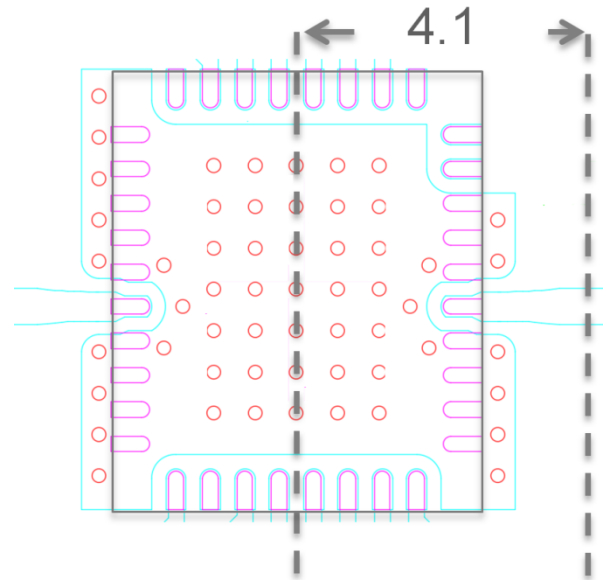
|                      |              |        |                        |                        |
|----------------------|--------------|--------|------------------------|------------------------|
| Matte tin, Lead Free | (Green)      | 1- DET | 13- Gnd <sup>(2)</sup> | 25- Vd4                |
| Units :              | mm           | 2- Vd4 | 14- RF in              | 26- NC                 |
| From the standard :  | JEDEC MO-220 | 3- Vg4 | 15- Gnd <sup>(2)</sup> | 27- Gnd <sup>(2)</sup> |
|                      | (VGGD)       | 4- Vd3 | 16- NC                 | 28- NC                 |
|                      | 37- GND      | 5- Vg3 | 17- NC                 | 29- NC                 |
|                      |              | 6- Vd2 | 18- NC                 | 30- Gnd <sup>(2)</sup> |
|                      |              | 7- Vd1 | 19- Vg1                | 31- RF out             |
|                      |              | 8- NC  | 20- NC                 | 32- Gnd <sup>(2)</sup> |
|                      |              | 9- NC  | 21- Vg2                | 33- NC                 |
|                      |              | 10- NC | 22- Vg3                | 34- NC                 |
|                      |              | 11- NC | 23- Vd3                | 35- NC                 |
|                      |              | 12- NC | 24- Vg4                | 36- REF                |

<sup>(1)</sup> The package outline drawing included to this data-sheet is given for indication. Refer to the application note AN0017 (<https://www.ums-rf.com>) for exact package dimensions.

<sup>(2)</sup> It is strongly recommended to ground all pins marked "Gnd" through the PCB board. Ensure that the PCB board is designed to provide the best possible ground to the package.

## Definition of the Sij reference planes

The reference planes used for Sij measurements given above are symmetrical from the symmetrical axis of the package (see drawing beside). The input and output reference planes are located at 4.1mm offset (input wise and output wise respectively) from this axis. Then, the given Sij parameters incorporate the land pattern of the evaluation motherboard recommended in paragraph "Evaluation motherboard".



## ESD sensitivity

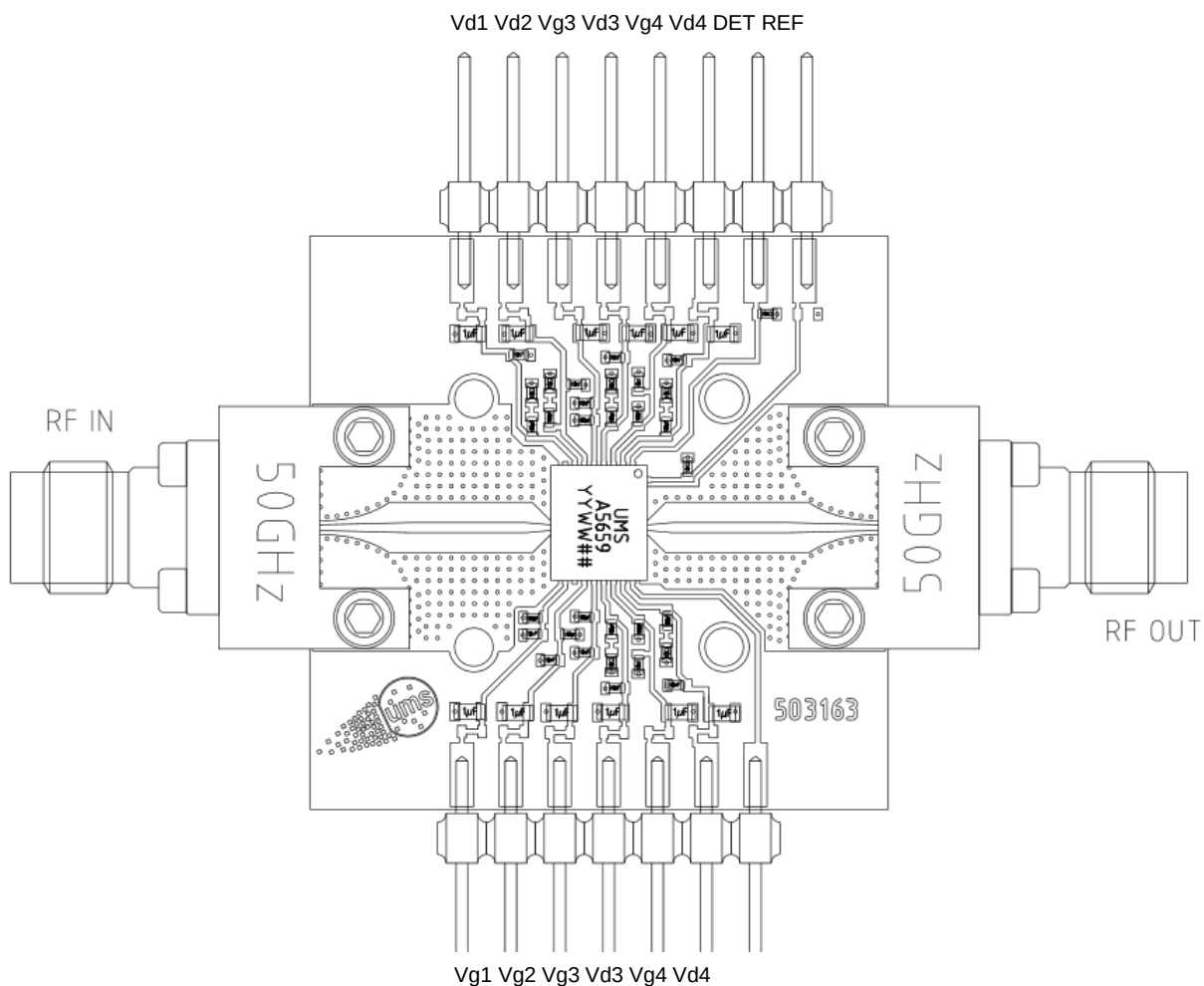
| Standard      | Value                |
|---------------|----------------------|
| MIL-STD-1686C | HBM Class 1 (<2000V) |

## Package Information

| Parameter             | Value                               |
|-----------------------|-------------------------------------|
| Package body material | RoHS-compliant                      |
|                       | Low stress Injection Molded Plastic |
| Lead finish           | 100% matte tin (Sn)                 |
| MSL Rating            | MSL3                                |

### Evaluation mother board

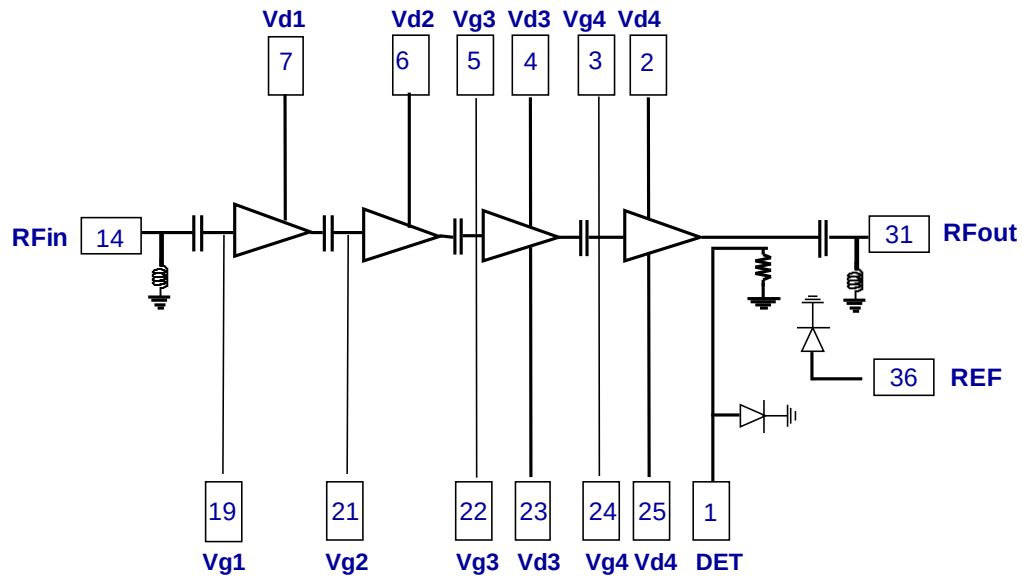
- Compatible with the proposed footprint.
- Based on typically Ro4350B / 10mils or equivalent.
- Using a micro-strip to coplanar transition to access the package.
- Recommended for the implementation of this product on a module board.
- Decoupling capacitors of 100pF  $\pm 5\%$ , 10nF  $\pm 10\%$  and 1 $\mu$ F  $\pm 10\%$  are recommended for the gate accesses.
- Decoupling capacitors of 100pF  $\pm 5\%$  in series with 10ohms  $\pm 1\%$ , 10nF  $\pm 10\%$  and 1 $\mu$ F  $\pm 10\%$  are recommended for the drain accesses.
- A 10K $\Omega$  resistor is recommended on VREF & VDET accesses for the detector
- See application note AN0017 for details.



Note: All board measurements are performed using shielded cables, even for DC bias, to ensure safe operation.

## 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.

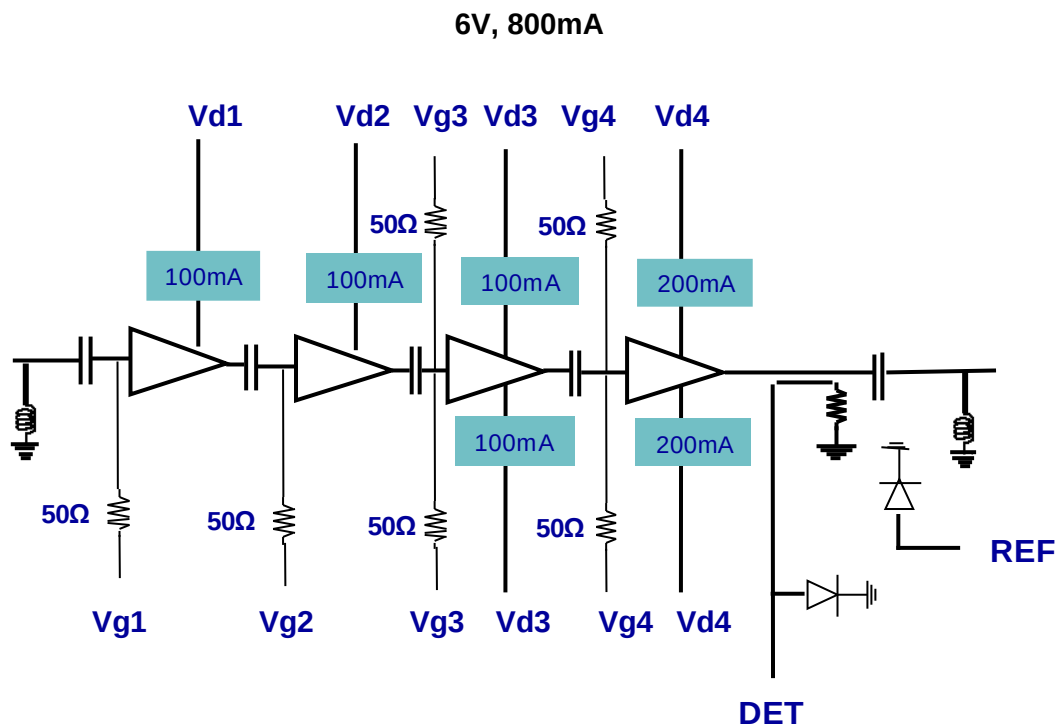


The DC connections do not include any decoupling capacitor in package, therefore it is mandatory to provide a good external DC decoupling (100pF, 10nF, 1μF) on the PC board, as close as possible to the package.

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

The circuit includes ESD protections on all RF and DC leads

### DC Schematic



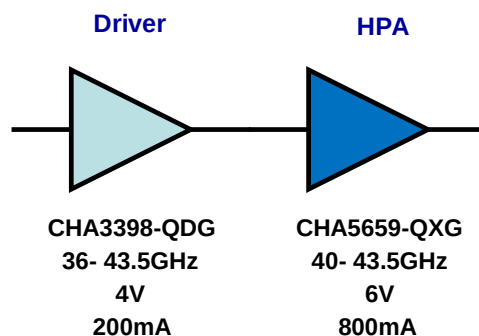
### Recommended UMS Power chain

The CHA5659-QXG is recommended with the CHA3398-QDG as driver.

Total Gain: 42dB

Gain control: 30dB with the both amplifiers.

For more information about CHA3398-QDG, see our web site.



**Notes**

### Recommended package footprint

Refer to the application note AN0017 available at <https://www.ums-rf.com> for package footprint recommendations.

### SMD mounting procedure

For the mounting process standard techniques involving solder paste and a suitable reflow process can be used. For further details, see application note AN0017.

### 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>.

### 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 package products.

## Ordering Information

QFN 6x5 package:

CHA5659-QXG/XY

Stick: XY = 20

Tape & reel: XY = 21

Information furnished is believed to be accurate and reliable. However **United Monolithic Semiconductors S.A.S.** assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of **United Monolithic Semiconductors S.A.S.**. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. **United Monolithic Semiconductors S.A.S.** products are not authorised for use as critical components in life support devices or systems without express written approval from **United Monolithic Semiconductors S.A.S.**