

## 12.5-30GHz Low Noise Amplifier

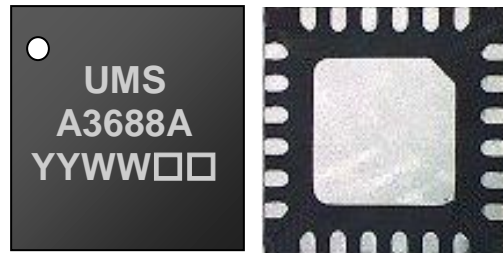
### GaAs Monolithic Microwave IC in SMD leadless package

#### Description

The CHA3688aQDG is a three-stage self-biased wide band monolithic low noise amplifier monolithic circuit.

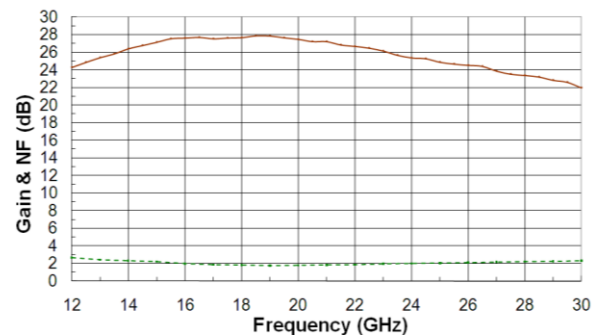
The circuit is manufactured with a pHEMT process, 0.25 $\mu$ m gate length, via holes through the substrate, air bridges and electron beam gate lithography.

It is supplied in RoHS compliant SMD package.



#### Main Features

- Broadband performances: 12.5-30GHz
- 2.1dB noise figure
- 26dB gain
- 26dBm Output IP3
- DC bias: Vd = 4V @ Id = 85 / 115mA
- 24L-QFN4x4
- MSL1



#### Main Characteristics

Tamb.= +25°C

| Symbol | Parameter                              | Min  | Typ | Max | Unit |
|--------|--|------|-----|-----|------|
| Freq   | Frequency range                        | 12.5 |     | 30  | GHz  |
| Gain   | Linear Gain                            | 21   | 26  |     | dB   |
| NF     | Noise Figure                           |      | 2.1 | 2.5 | dB   |
| OIP3   | 3rd order intercept point (16 - 30GHz) | 24   | 26  |     | dBm  |

## Main Characteristics (low current configuration)

Tamb = +25°C, Vd1=Vd2=Vd3= +4V and Pads B, D not connected

| Symbol     | Parameter  | Min  | Typ       | Max   | Unit |
|------------|--|------|-----------|-------|------|
| Freq       | Frequency range  | 12.5 |           | 30    | GHz  |
| Gain       | Linear Gain (12.5 - 24GHz)                                   | 22   | 25        |       | dB   |
|            | Linear Gain (24.5 - 30GHz)                                   | 20   | 23        |       | dB   |
| $\Delta G$ | Gain flatness (12.5 - 24GHz)                                 |      | $\pm 1.5$ |       | dB   |
|            | Gain flatness (24.5 - 30GHz)                                 |      | $\pm 2$   |       | dB   |
| NF         | Noise figure (12.5 - 16GHz)                                  |      | 2.3       | 2.6   | dB   |
|            | Noise figure (16.5 - 24GHz)                                  |      | 2.0       | 2.3   | dB   |
|            | Noise figure (24.5 - 30GHz)                                  |      | 2.2       | 2.5   | dB   |
| S11        | Input return loss (12.5 - 16GHz) (27 – 30GHz)                |      | 2.5:1     | 3.0:1 | dB   |
|            | Input return loss (16.5 - 26.5GHz)                           |      | 2.0:1     | 2.5:1 | dB   |
| S22        | Output return loss   |      | 2.0:1     | 2.5:1 | dB   |
| OIP3       | 3rd order intercept point @ Pout SCL < 8dBm from 16 to 30GHz | 23   | 25        |       | dBm  |
| P1dB       | Output power at 1dB gain compression                         | 13   | 14        |       | dBm  |
| Id         | Drain bias current   |      | 85        | 115   | mA   |
| Vd         | Drain bias voltage   |      | 4         |       | V    |

These values are representative of onboard measurements as defined on the drawing in paragraph "Evaluation mother board".

## Main Characteristics (high current configuration)

Tamb = +25°C, Vd1=Vd2=Vd3= +4V and Pads B, D Grounded

| Symbol     | Parameter  | Min  | Typ     | Max   | Unit |
|------------|--|------|---------|-------|------|
| Freq       | Frequency range  | 12.5 |         | 30    | GHz  |
| Gain       | Linear Gain (12.5 - 24GHz)                                   | 23   | 26      |       | dB   |
|            | Linear Gain (24.5 - 30GHz)                                   | 21   | 24      |       | dB   |
| $\Delta G$ | Gain flatness  |      | $\pm 2$ |       | dB   |
| NF         | Noise figure (12.5 - 16GHz)                                  |      | 2.3     | 2.6   | dB   |
|            | Noise figure (16.5 - 24GHz)                                  |      | 2.0     | 2.3   | dB   |
|            | Noise figure (24.5 - 30GHz)                                  |      | 2.2     | 2.5   | dB   |
| S11        | Input return loss (12.5 - 16GHz) (27 – 30GHz)                |      | 2.5:1   | 3.0:1 | dB   |
|            | Input return loss (16.5 - 26.5GHz)                           |      | 2.0:1   | 2.5:1 | dB   |
| S22        | Output return loss   |      | 2.0:1   | 2.5:1 | dB   |
| OIP3       | 3rd order intercept point @ Pout SCL < 8dBm from 16 to 30GHz | 24   | 26      |       | dBm  |
| P1dB       | Output power at 1dB gain compression                         | 14   | 15      |       | dBm  |
| Id         | Drain bias current   |      | 115     | 150   | mA   |
| Vd         | Drain bias voltage   |      | 4       |       | V    |

These values are representative of onboard measurements as defined on the drawing in paragraph "Evaluation mother board".

**Absolute Maximum Ratings** <sup>(1)</sup>

Tamb.= +25°C

| Symbol | Parameter                           | Values      | Unit |
|--------|-------------------------------------|-------------|------|
| Vd     | Drain bias voltage                  | 4.5V        | V    |
| Pin    | RF input power                      | 10          | dBm  |
| Tj     | Junction temperature <sup>(2)</sup> | 175         | °C   |
| Ta     | Operating temperature range         | -40 to +85  | °C   |
| Tstg   | Storage temperature range           | -55 to +150 | °C   |

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

**Typical Bias Conditions**

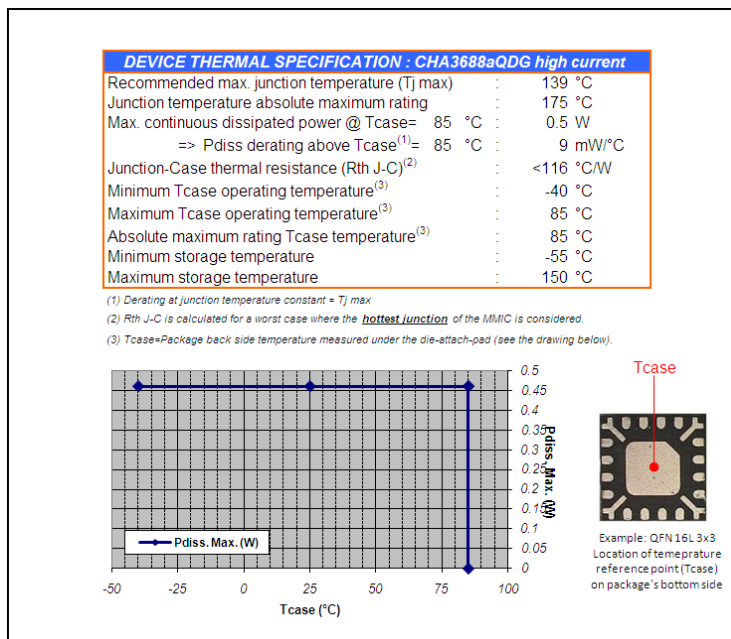
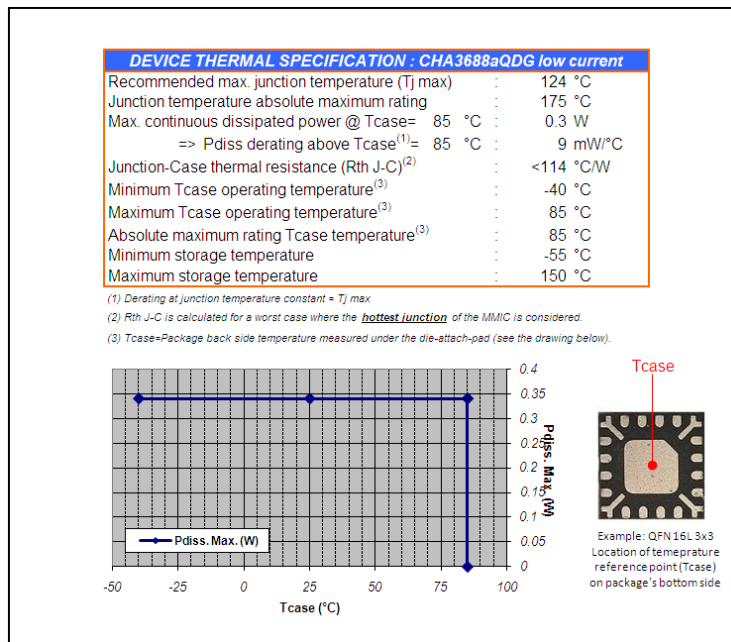
Tamb.= +25°C

| Symbol | Pad N° | Parameter        | Values                     | Unit |
|--------|--------|------------------|----------------------------|------|
| Vd1    | 23     | DC Drain voltage | 4                          | V    |
| Vd2    | 21     | DC Drain voltage | 4                          | V    |
| Vd3    | 19     | DC Drain voltage | 4                          | V    |
| B      | 9      | DC Gate voltage  | Connected to ground or not |      |
| D      | 11     | DC Gate voltage  |                            |      |

## Device thermal performances

All the figures given in this section are obtained assuming that the QFN device is cooled down only by conduction through the package thermal pad (no convection mode considered). The temperature is monitored at the package back-side interface (Tcase) as shown below. The system maximum temperature must be adjusted in order to guarantee that Tcase remains below than the maximum value specified in the next table. So, the system PCB must be designed to comply with this requirement.

A de-rating must be applied on the dissipated power if the Tcase temperature cannot be maintained below than the maximum temperature specified (see the curve P<sub>diss. Max</sub>) in order to guarantee the nominal device life time (MTTF).



**Typical Package Sij parameters for low current configuration**

Tamb = +25°C, Vd1=Vd2=Vd3= +4V, Id = 90mA and Pads B, D not connected

| Freq (GHz) | S11 (dB) | PhS11 (°) | S12 (dB) | PhS12 (°) | S21 (dB) | PhS21 (°) | S22 (dB) | PhS22 (°) |
|------------|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| 2.0        | -1.3     | 66        | -63.8    | -33       | -67.2    | -134      | -1.4     | 61        |
| 3.0        | -1.2     | 14        | -62.8    | 61        | -57.0    | 24        | -1.5     | 0         |
| 4.0        | -1.1     | -34       | -62.9    | 140       | -57.9    | 30        | -1.7     | -60       |
| 5.0        | -1.0     | -79       | -68.4    | 99        | -31.8    | -63       | -2.4     | -120      |
| 6.0        | -0.9     | -124      | -61.8    | -70       | -13.3    | -143      | -4.8     | -178      |
| 7.0        | -1.3     | -178      | -59.6    | 71        | 1.2      | 118       | -9.9     | 126       |
| 8.0        | -2.6     | 117       | -61.0    | -1        | 9.1      | 24        | -19.3    | 87        |
| 9.0        | -4.8     | 42        | -62.0    | -111      | 15.9     | -62       | -23.9    | -14       |
| 10.0       | -5.6     | -27       | -59.3    | 164       | 19.5     | -144      | -14.5    | -159      |
| 11.0       | -5.3     | -83       | -53.6    | 134       | 22.0     | 142       | -12.9    | 136       |
| 12.0       | -4.8     | -128      | -52.4    | 94        | 23.7     | 74        | -14.1    | 89        |
| 13.0       | -4.8     | -167      | -55.4    | 43        | 24.8     | 13        | -15.3    | 58        |
| 14.0       | -5.2     | 157       | -51.0    | 33        | 25.8     | -44       | -15.3    | 27        |
| 15.0       | -6.1     | 122       | -56.9    | 36        | 26.8     | -101      | -13.7    | -6        |
| 16.0       | -7.6     | 91        | -57.5    | 176       | 27.0     | -157      | -12.2    | -40       |
| 17.0       | -9.4     | 56        | -47.2    | -157      | 27.0     | 151       | -10.3    | -70       |
| 18.0       | -12.0    | 26        | -51.8    | 92        | 27.1     | 101       | -9.0     | -111      |
| 19.0       | -14.5    | -6        | -49.0    | 67        | 27.3     | 49        | -8.8     | -149      |
| 20.0       | -17.2    | -28       | -58.8    | 30        | 26.8     | 0         | -9.6     | -179      |
| 21.0       | -20.2    | -34       | -49.9    | 34        | 26.4     | -46       | -10.4    | 149       |
| 22.0       | -16.7    | -69       | -49.0    | 40        | 25.9     | -93       | -13.6    | 130       |
| 23.0       | -14.6    | -107      | -47.2    | 20        | 25.3     | -140      | -15.7    | 125       |
| 24.0       | -13.3    | -146      | -48.4    | -5        | 24.7     | 176       | -15.7    | 117       |
| 25.0       | -12.2    | -175      | -48.2    | -3        | 24.2     | 129       | -17.2    | 122       |
| 26.0       | -10.5    | 161       | -50.6    | -12       | 23.7     | 86        | -15.7    | 118       |
| 27.0       | -8.6     | 130       | -47.7    | 2         | 23.2     | 38        | -13.7    | 102       |
| 28.0       | -7.7     | 91        | -45.5    | -17       | 22.9     | -9        | -13.2    | 79        |
| 29.0       | -7.7     | 53        | -47.8    | 47        | 22.0     | -60       | -13.4    | 39        |
| 30.0       | -6.4     | 2         | -37.9    | -51       | 21.1     | -116      | -14.9    | -5        |
| 31.0       | -4.9     | -55       | -42.9    | -24       | 18.5     | -176      | -14.0    | -55       |
| 32.0       | -4.4     | -106      | -37.5    | -65       | 14.5     | 134       | -11.3    | -96       |
| 33.0       | -3.1     | -141      | -44.7    | -110      | 10.9     | 84        | -7.8     | -133      |
| 34.0       | -2.1     | -172      | -43.4    | -69       | 6.4      | 38        | -5.1     | -162      |
| 35.0       | -1.2     | 162       | -46.5    | 27        | 1.3      | -6        | -3.5     | 173       |
| 36.0       | -1.2     | 139       | -34.6    | -70       | -4.4     | -44       | -2.3     | 150       |
| 37.0       | -1.2     | 122       | -33.9    | -90       | -10.7    | -73       | -1.6     | 131       |
| 38.0       | -1.2     | 105       | -32.7    | -103      | -17.8    | -98       | -1.3     | 113       |
| 39.0       | -1.6     | 90        | -38.1    | -114      | -24.8    | -113      | -1.6     | 93        |
| 40.0       | -2.6     | 71        | -39.0    | -118      | -32.8    | -85       | -2.8     | 75        |

## Typical Package Sij parameters for high current configuration

Tamb = +25°C, Vd1=Vd2=Vd3= +4V, Id = 115mA and Pads B, D Grounded

| Freq (GHz) | S11 (dB) | PhS11 (°) | S12 (dB) | PhS12 (°) | S21 (dB) | PhS21 (°) | S22 (dB) | PhS22 (°) |
|------------|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| 2.0        | -1.3     | 66        | -75.4    | 159       | -77.1    | 115       | -1.4     | 61        |
| 3.0        | -1.2     | 14        | -62.1    | -168      | -56.8    | 7         | -1.5     | 0         |
| 4.0        | -1.1     | -34       | -74.0    | 65        | -57.0    | 6         | -1.7     | -61       |
| 5.0        | -1.0     | -79       | -79.6    | -146      | -30.6    | -61       | -2.6     | -120      |
| 6.0        | -0.9     | -124      | -84.9    | 160       | -12.4    | -144      | -5.0     | -178      |
| 7.0        | -1.3     | -178      | -63.2    | 24        | 1.8      | 118       | -9.8     | 128       |
| 8.0        | -2.7     | 117       | -64.3    | 31        | 9.9      | 23        | -20.6    | 92        |
| 9.0        | -4.9     | 42        | -73.9    | 84        | 16.6     | -62       | -27.6    | -18       |
| 10.0       | -5.7     | -27       | -56.5    | -150      | 20.2     | -145      | -13.9    | -168      |
| 11.0       | -5.3     | -83       | -57.7    | 126       | 22.7     | 142       | -12.4    | 130       |
| 12.0       | -4.8     | -128      | -54.9    | 86        | 24.3     | 74        | -13.5    | 84        |
| 13.0       | -4.7     | -167      | -55.2    | 30        | 25.4     | 13        | -14.8    | 53        |
| 14.0       | -5.1     | 158       | -53.6    | 116       | 26.4     | -44       | -15.4    | 21        |
| 15.0       | -6.2     | 122       | -48.5    | -47       | 27.2     | -100      | -13.0    | -8        |
| 16.0       | -7.4     | 91        | -57.7    | 140       | 27.6     | -156      | -11.6    | -44       |
| 17.0       | -9.4     | 54        | -55.6    | 135       | 27.6     | 152       | -9.8     | -75       |
| 18.0       | -11.6    | 27        | -51.6    | 119       | 27.7     | 103       | -8.7     | -112      |
| 19.0       | -14.0    | -5        | -51.0    | 75        | 27.9     | 52        | -8.5     | -150      |
| 20.0       | -16.4    | -29       | -48.8    | 58        | 27.5     | 2         | -9.0     | 179       |
| 21.0       | -19.3    | -48       | -49.5    | 59        | 27.2     | -44       | -10.0    | 148       |
| 22.0       | -16.8    | -72       | -48.5    | 29        | 26.7     | -92       | -13.0    | 128       |
| 23.0       | -15.0    | -109      | -47.6    | 25        | 26.2     | -139      | -15.5    | 117       |
| 24.0       | -13.7    | -149      | -49.0    | -17       | 25.4     | 177       | -15.9    | 112       |
| 25.0       | -12.0    | -176      | -47.4    | 3         | 24.9     | 131       | -18.0    | 116       |
| 26.0       | -10.3    | 158       | -48.6    | 2         | 24.5     | 87        | -16.6    | 113       |
| 27.0       | -9.0     | 129       | -47.1    | -24       | 23.9     | 38        | -14.4    | 102       |
| 28.0       | -8.3     | 91        | -38.4    | -21       | 23.4     | -7        | -14.2    | 75        |
| 29.0       | -7.5     | 51        | -42.0    | 16        | 22.8     | -58       | -14.2    | 39        |
| 30.0       | -6.3     | 2         | -40.8    | -34       | 22.0     | -115      | -14.9    | -6        |
| 31.0       | -5.1     | -57       | -41.5    | -56       | 19.4     | -175      | -14.6    | -54       |
| 32.0       | -4.5     | -107      | -37.7    | -58       | 15.3     | 134       | -11.4    | -98       |
| 33.0       | -3.0     | -142      | -43.9    | -115      | 11.8     | 84        | -7.8     | -133      |
| 34.0       | -2.1     | -173      | -50.3    | -135      | 7.2      | 38        | -5.2     | -163      |
| 35.0       | -1.2     | 162       | -39.6    | -15       | 2.1      | -6        | -3.6     | 172       |
| 36.0       | -1.2     | 139       | -34.6    | -45       | -3.9     | -45       | -2.3     | 148       |
| 37.0       | -1.4     | 122       | -32.7    | -105      | -10.2    | -74       | -1.6     | 129       |
| 38.0       | -1.3     | 105       | -38.2    | -109      | -16.9    | -92       | -1.4     | 112       |
| 39.0       | -1.7     | 90        | -38.3    | -142      | -22.1    | -91       | -1.8     | 92        |
| 40.0       | -2.4     | 70        | -39.4    | -105      | -25.1    | -73       | -2.1     | 75        |

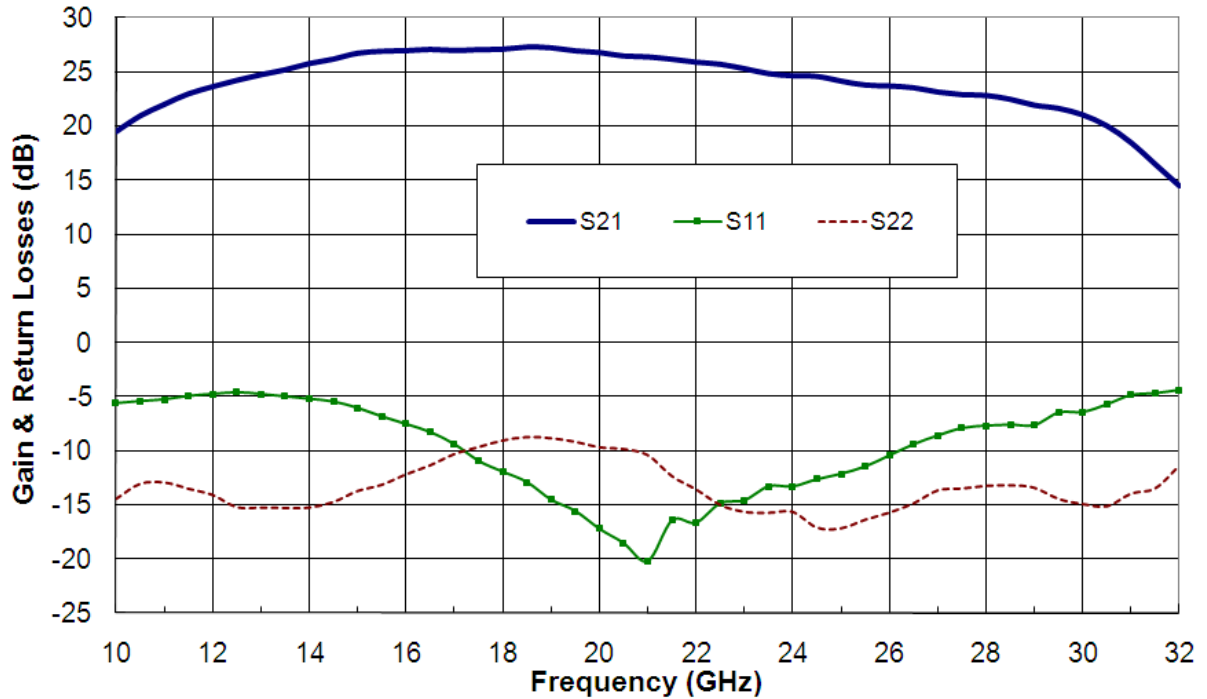
**Typical Board Measurements**

Tamb = +25°C, Vd1=Vd2=Vd3= +4V Id = 85mA

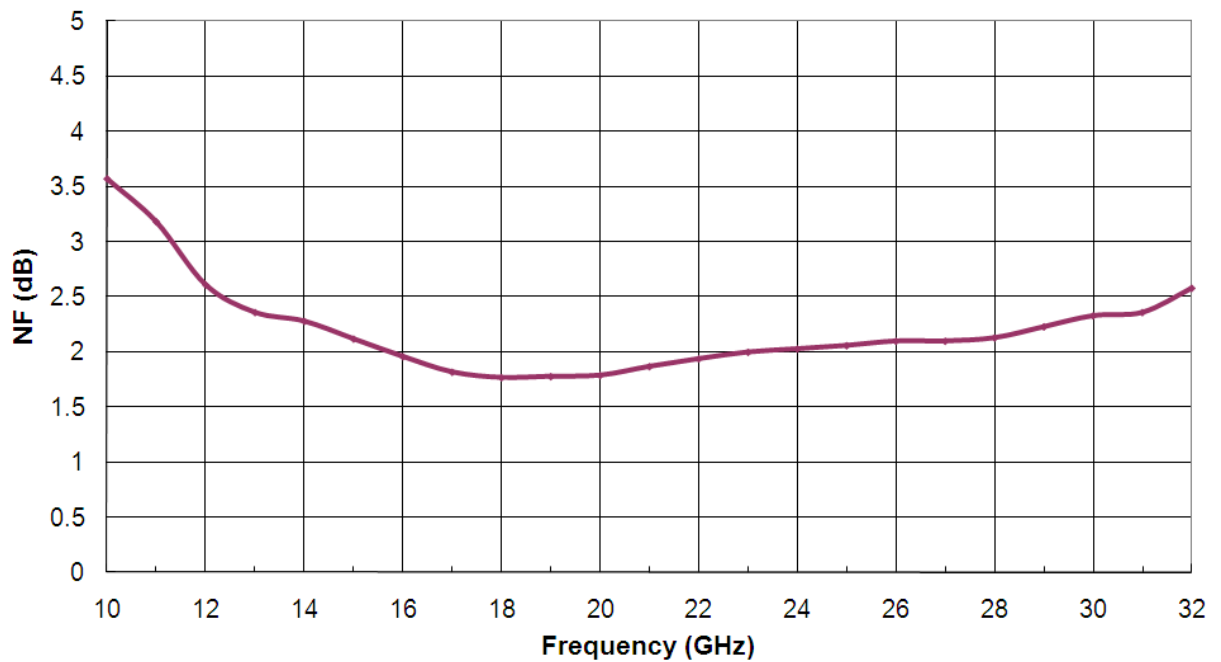
Pads B, D not connected (low current configuration)

Measurements are given in the package access planes. Losses are de-embedded.

**Gain and return losses versus frequency**



**Noise figure versus frequency**



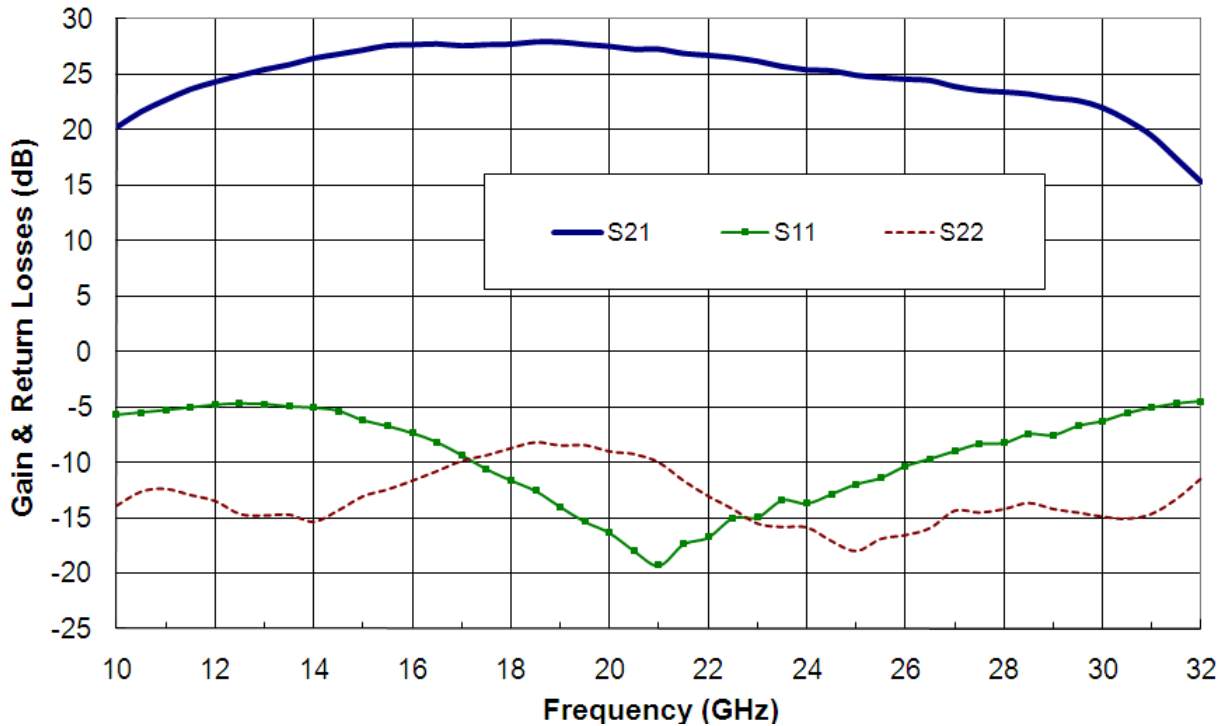
## Typical Board Measurements

Tamb = +25°C, Vd1=Vd2=Vd3= +4V Id = 115mA

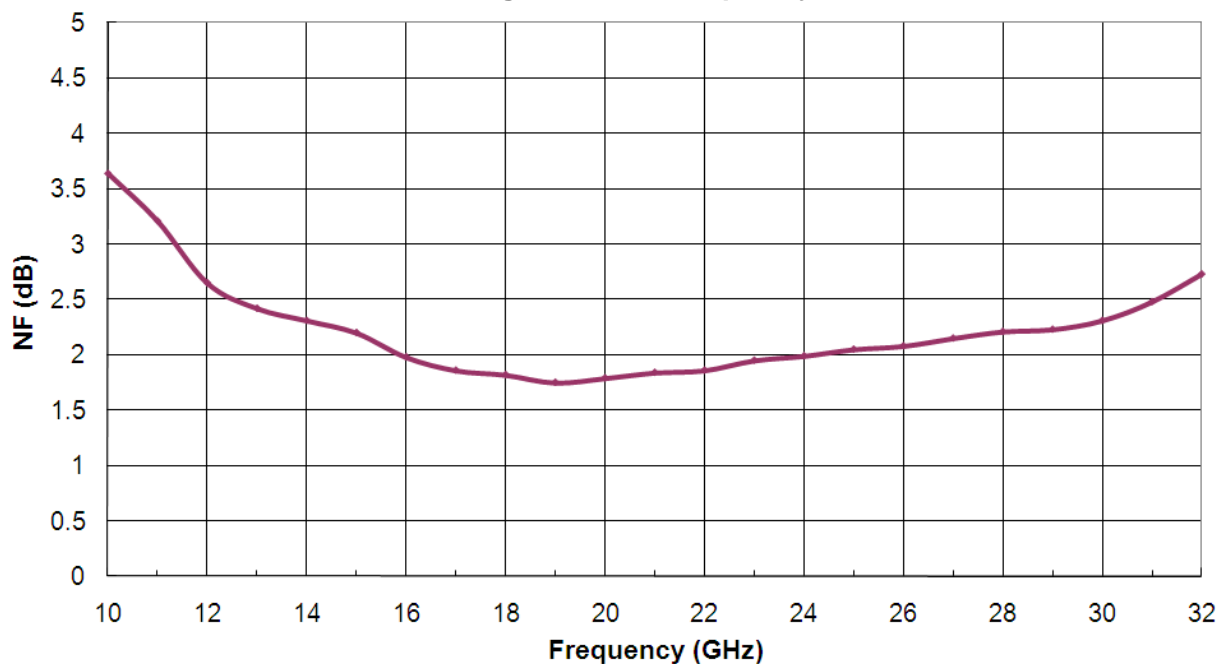
Pads B, D Grounded (high current configuration)

Measurements are given in the package access planes. Losses are de-embedded.

Gain and return losses versus frequency



Noise figure versus frequency

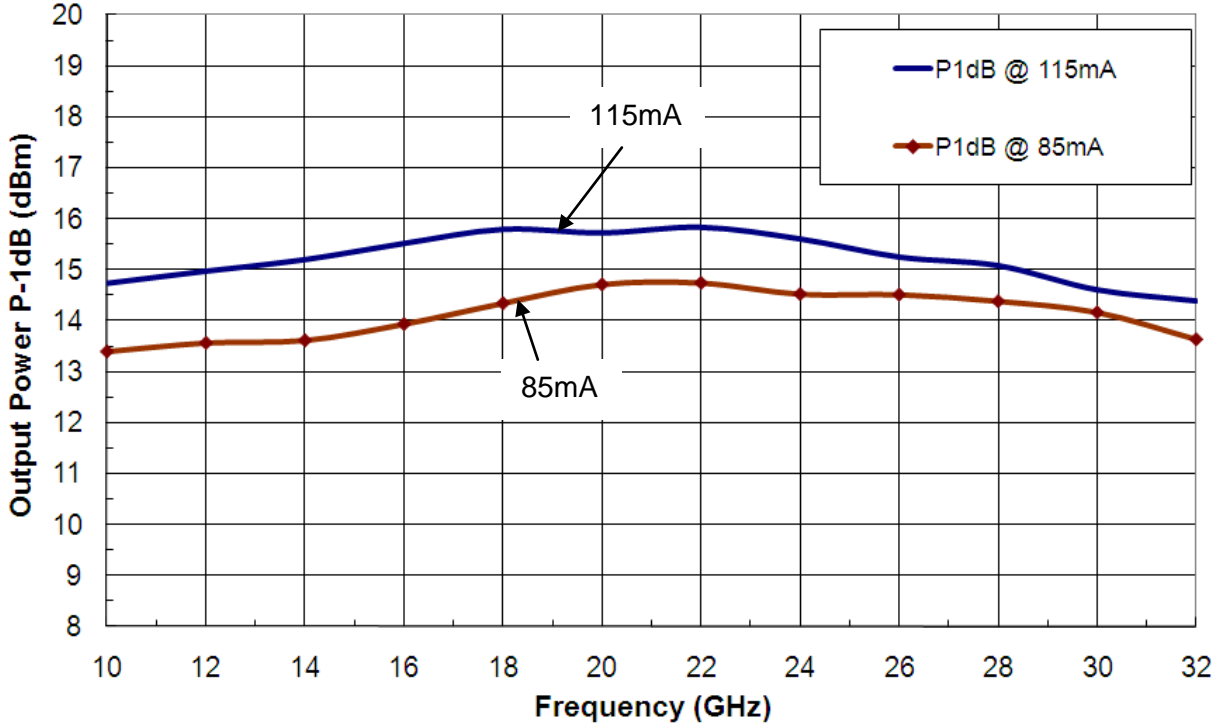




**Typical Board Measurements**

Measurements are given in the package access planes. Losses are de-embedded.  
 Tamb = +25°C, Vd1=Vd2=Vd3= +4V Id = 85/115mA

**Output power -1dB for low and high current configurations**

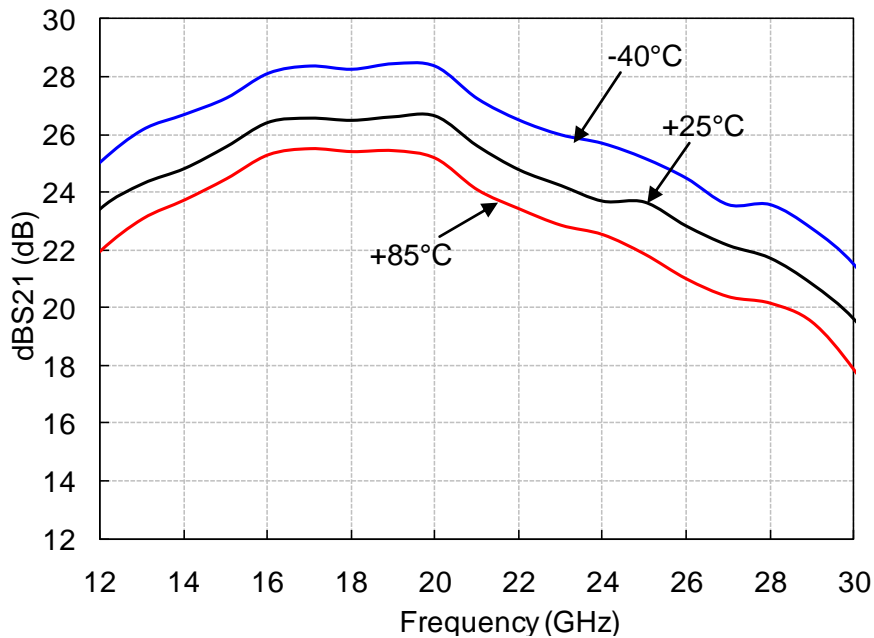


## Typical Board Measurements

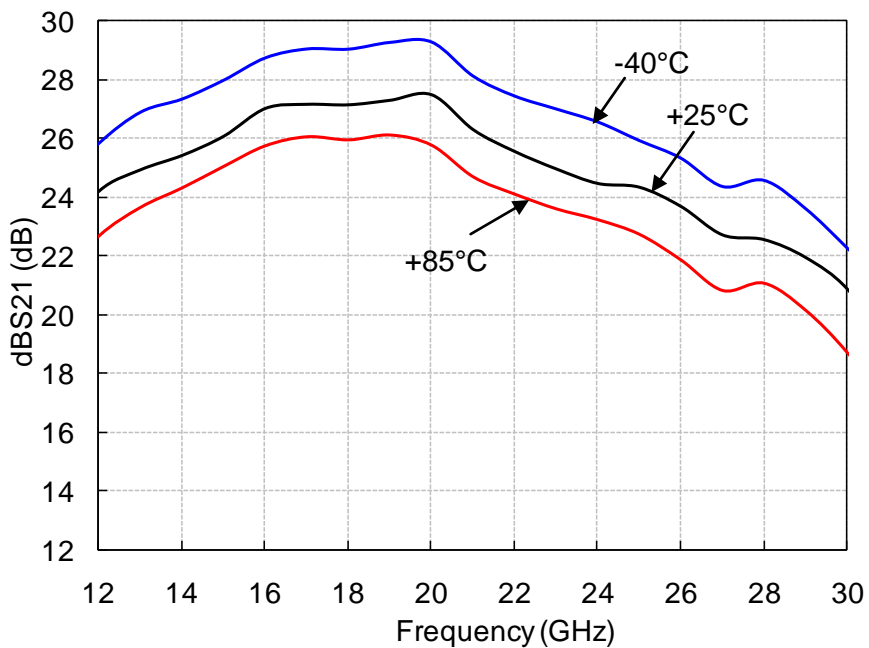
Tamb = -40°C / +25°C / +85°C, Vd1=Vd2=Vd3= +4V

Measurements are given in the package's access plans. Losses are de-embedded.

**Gain measurement for low current configuration  
Pads B, D not connected**



**Gain measurement for high current configuration  
Pads B, D Grounded**

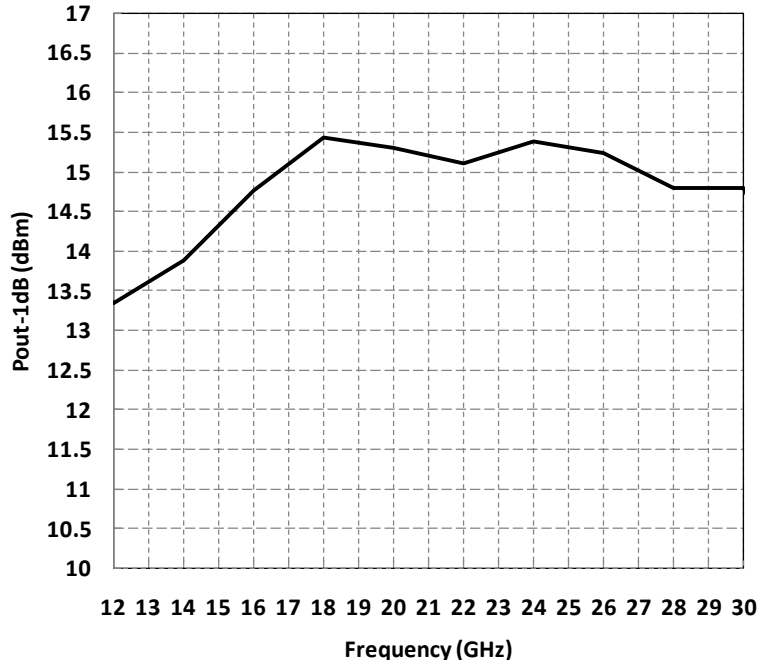


**Typical Board Measurements**

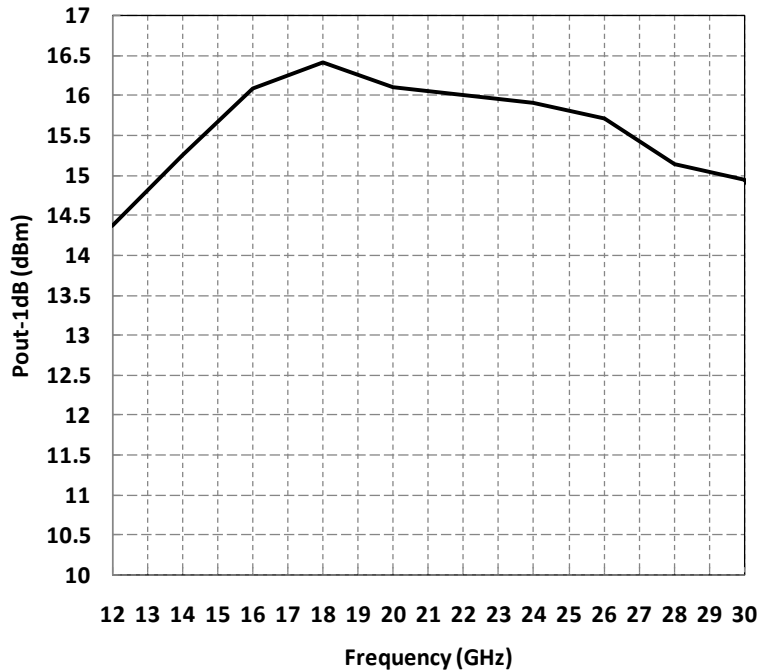
Tamb = -40°C / +25°C / +85°C, Vd1=Vd2=Vd3= +4V

Measurements are given in the connectors' access plans. Losses are not de-embedded.

**Output power -1dB measurement for low current configuration  
Pads B, D not connected**



**Output power -1dB measurement for high current configuration  
Pads B, D Grounded**



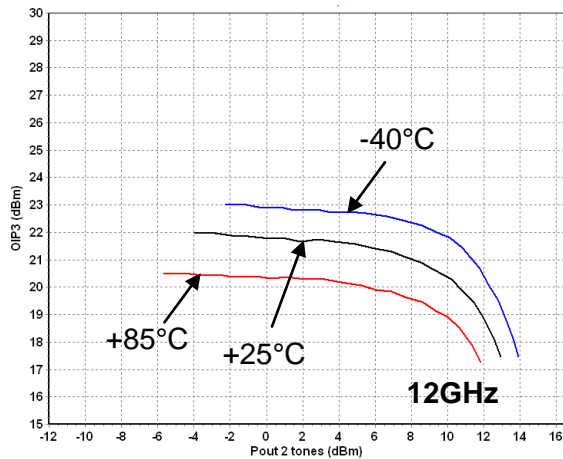
## Typical Board Measurements

Tamb = -40°C / +25°C / +85°C, Vd1=Vd2=Vd3= +4V Id = 85mA

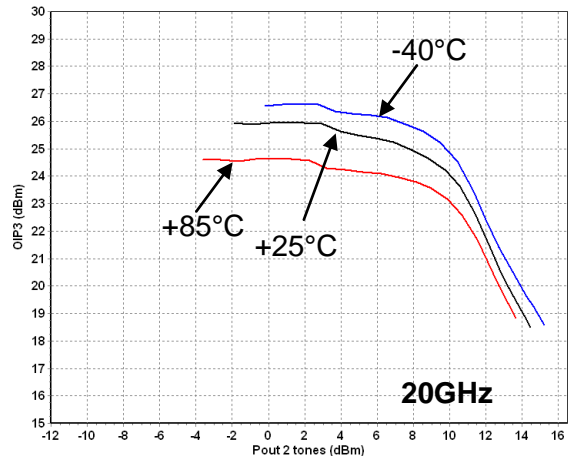
Pads B, D not connected (low current configuration)

Measurements are given in the connectors' access plans. Losses are not de-embedded.

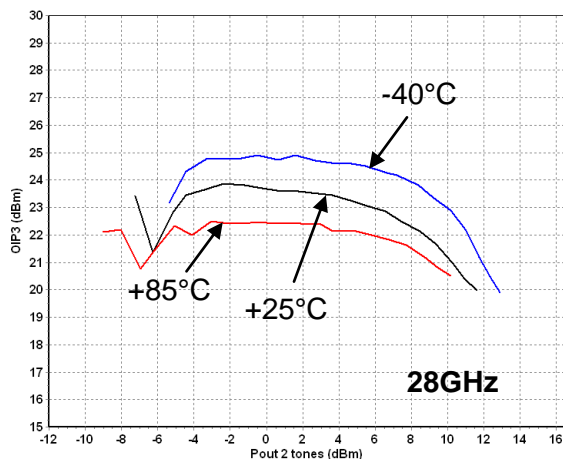
**Output IP3 versus input power @ 12GHz**



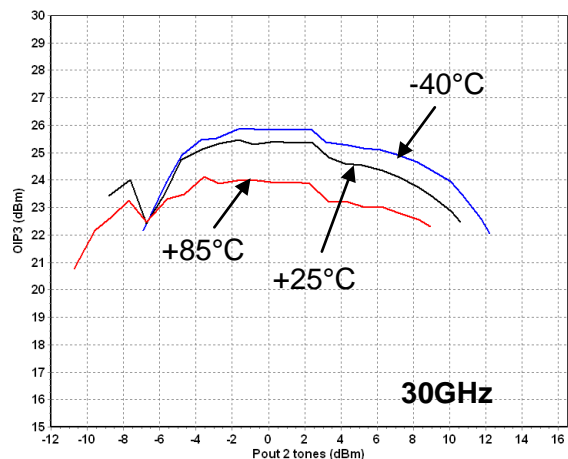
**Output IP3 versus input power @ 20GHz**



**Output IP3 versus input power @ 28GHz**



**Output IP3 versus input power @ 30GHz**



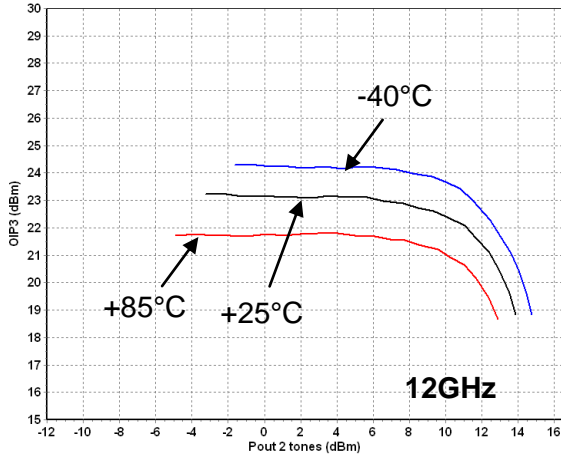
**Typical Board Measurements**

Tamb = -40°C / +25°C / +85°C, Vd1=Vd2=Vd3= +4V Id = 115 mA

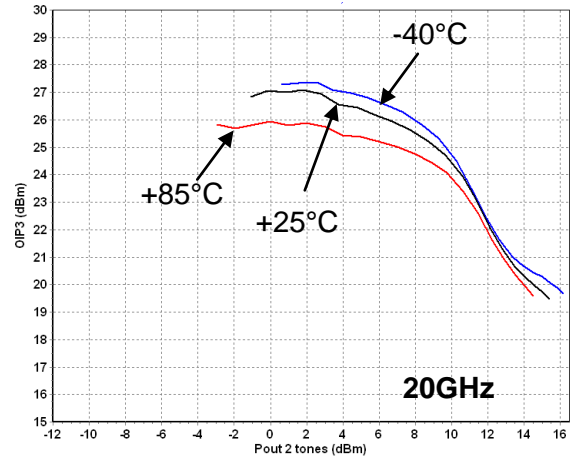
**Pads B, D = GND (high current configuration)**

Measurements are given in the connectors' access plans. Losses are not de-embedded.

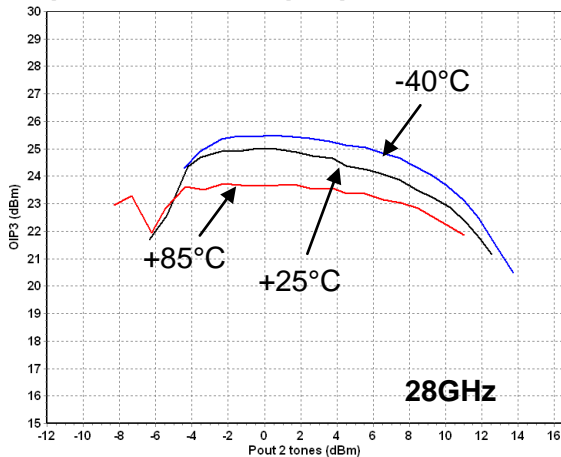
**Output IP3 versus input power @ 12GHz**



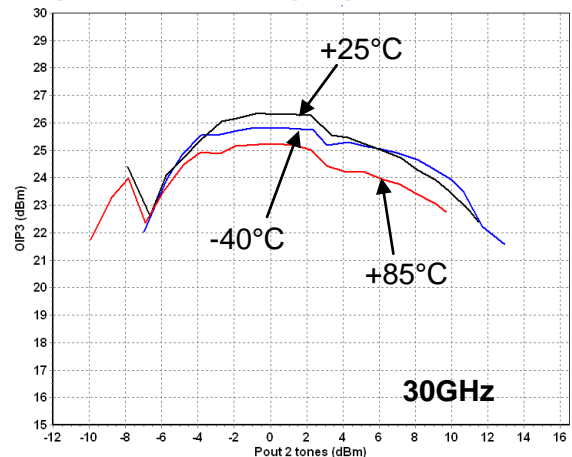
**Output IP3 versus input power @ 20GHz**



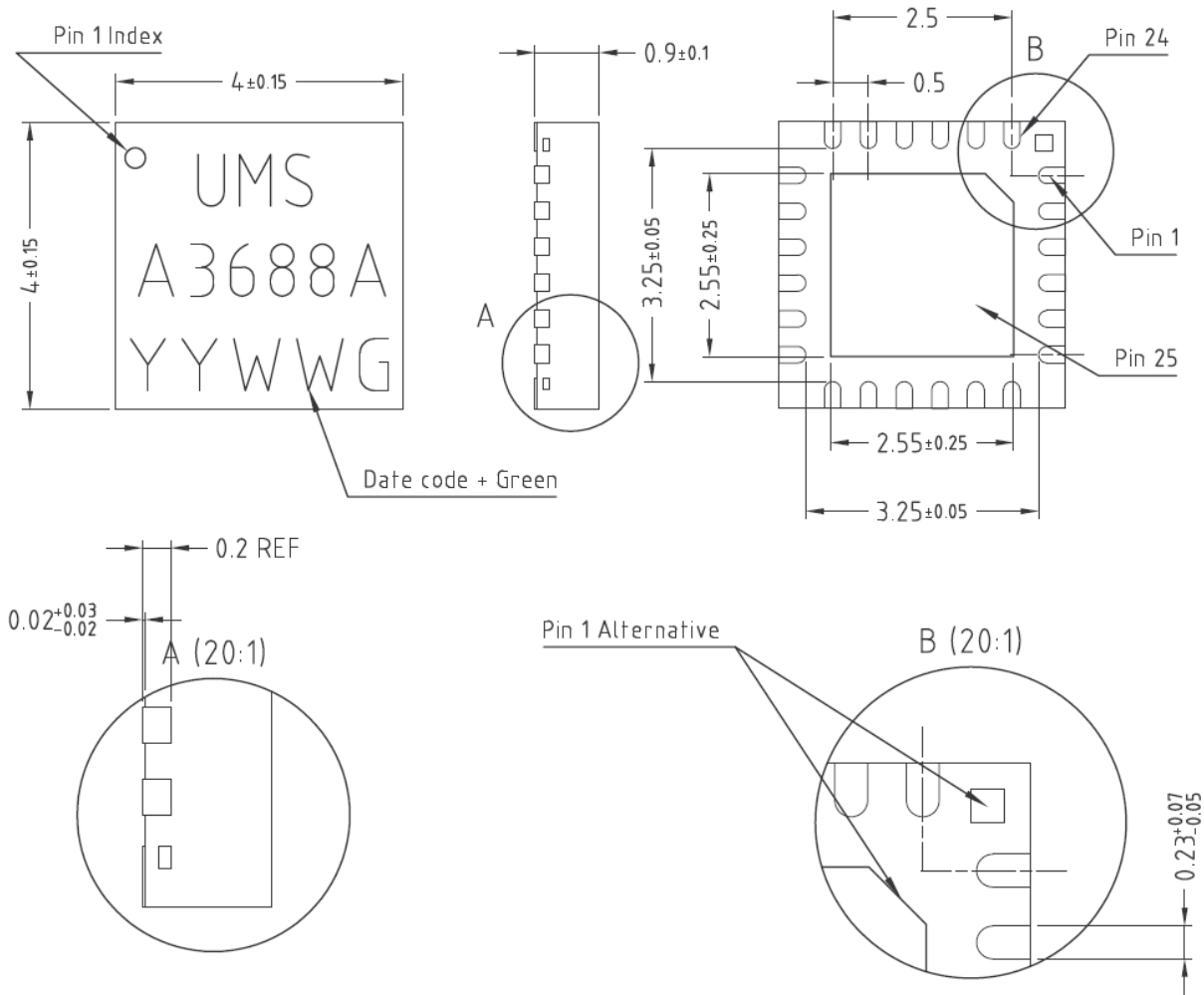
**Output IP3 versus input power @ 28GHz**



**Output IP3 versus input power @ 30GHz**



## Package outline (1)



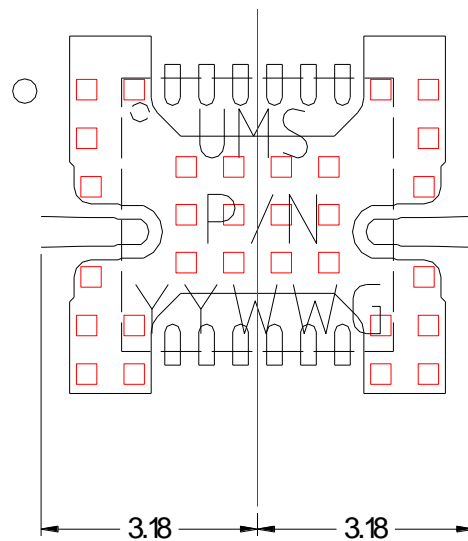
|   |          |            |         |
|---|----------|------------|---------|
| Matt tin, Lead Free (Green)             | 1- Nc    | 9- B       | 17- GND |
| Units : mm                              | 2- GND   | 10- Nc     | 18- Nc  |
| From the JEDEC MO-220 standard : (VGGD) | 3- GND   | 11- D      | 19- Vd3 |
| 25- GND                                 | 4- RF in | 12- Nc     | 20- Nc  |
|   | 5- GND   | 13- GND    | 21- Vd2 |
|   | 6- GND   | 14- GND    | 22- Nc  |
|   | 7- Nc    | 15- RF out | 23- Vd1 |
|   | 8- Nc    | 16- GND    | 24- Nc  |

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

(2) 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.

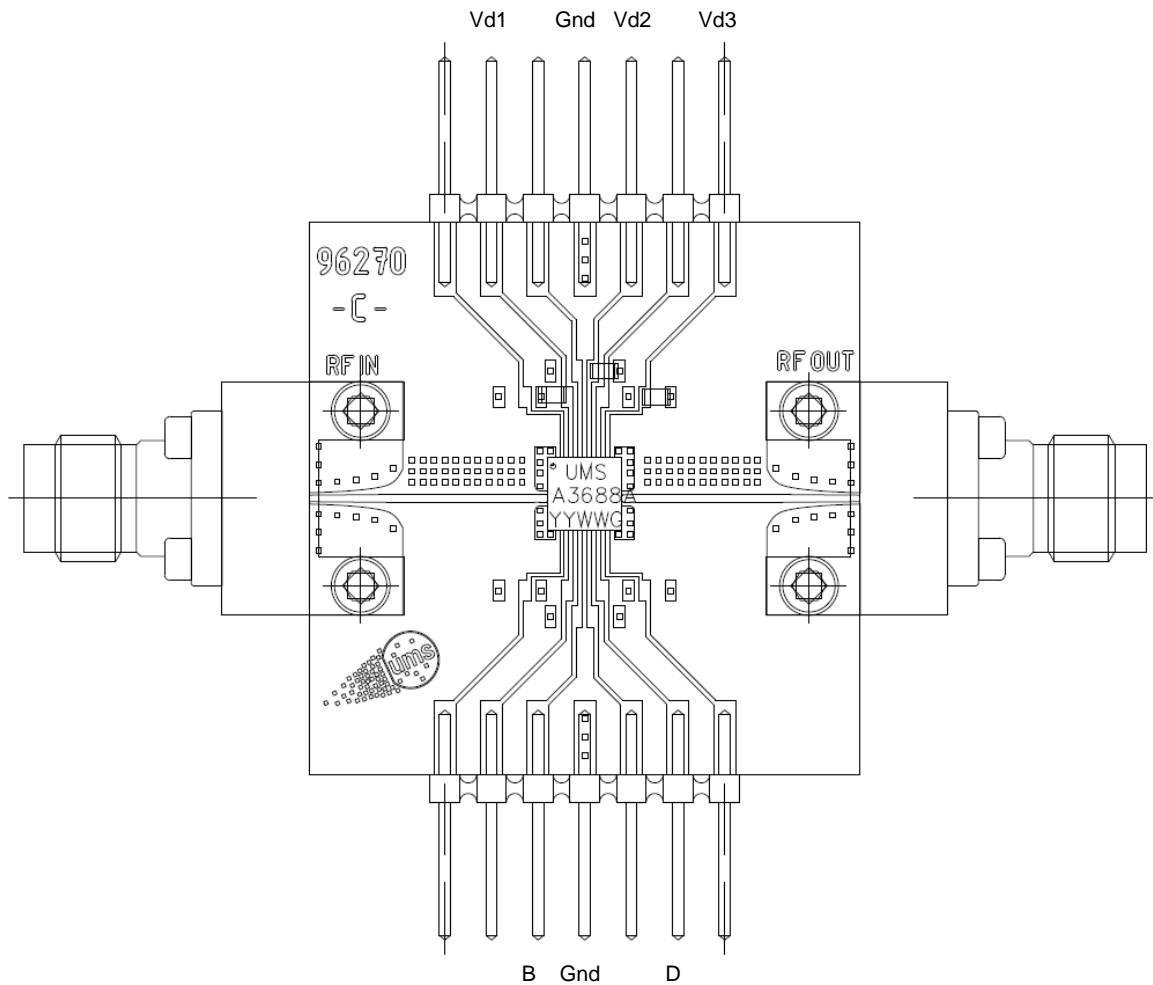
### Definition of the Sij reference planes

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 3.18mm 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".



## Evaluation mother board

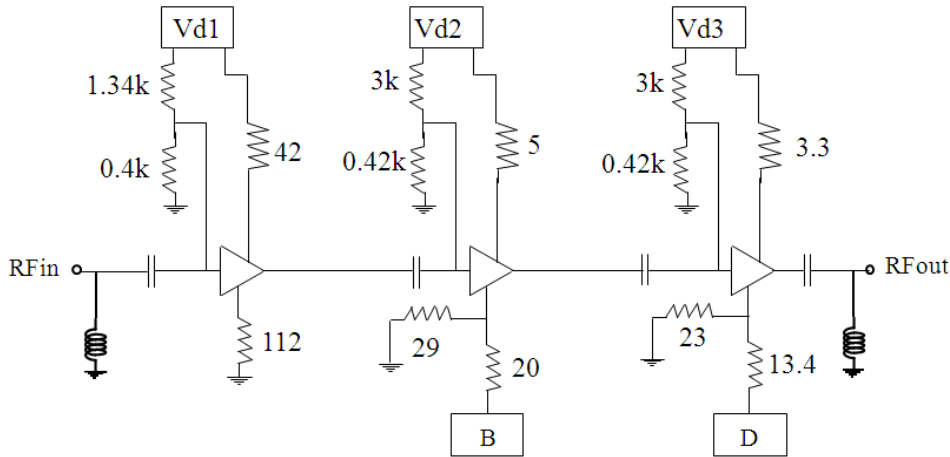
- Compatible with the proposed footprint.
- Based on typically Ro4003 / 8mils or equivalent.
- Using a micro-strip to coplanar transition to access the package.
- Recommended for the implementation of this product on a module board.
- Decoupling capacitors of 10nF  $\pm$ 10% are recommended for all DC accesses.
- See application note AN0017 for details.





## Chip Biasing options

This chip is self-biased, and flexibility is provided by the access to number of pads. The internal DC electrical schematic is given in order to use these pads in a safe way.



The requirement is not to exceed  $V_{ds} = 3.5\text{V}$  (internal Drain to Source voltage).

We propose two standard biasings:

- Low Noise and low consumption:  $V_d = 4\text{V}$  and B & D leads non connected (NC).  
 $I_{dd} = 85\text{mA}$  &  $P_{out-1\text{dB}} = 14\text{dBm}$  Typical.
- Low Noise and higher output power:  $V_d = 4\text{V}$  and B, D grounded  
 $I_{dd} = 115\text{mA}$  &  $P_{out-1\text{dB}} = 15\text{dBm}$  Typical.

## Note

Due to ESD protection circuits, RFin and RFout are DC grounded and an external capacitance might be requested to isolate the product from external voltage that could be present on the RF accesses.

The DC connections (Vd1, Vd2 and Vd3) do not include any decoupling capacitor in package, therefore it is mandatory to provide a good external DC decoupling (typically 10nF) on the PC board, as close as possible to the package.

## Recommended package footprint

Refer to the application note AN0017 available at <http://www.ums-gaas.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

Refer to the application note AN0019 available at <http://www.ums-gaas.com> for environmental data on UMS package products.

## Recommended ESD management

Refer to the application note AN0020 available at <http://www.ums-gaas.com> for ESD sensitivity and handling recommendations for the UMS package products.

## Ordering Information

QFN 4x4 RoHS compliant package:

CHA3688aQDG/XY

Stick: XY = 20

Tape & reel: XY = 21

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