

## 71-76GHz Medium Power Amplifier

### GaAs Monolithic Microwave IC

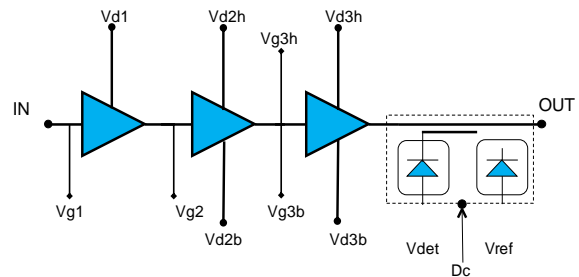
#### Description

The CHA3080-98F is a three-stage monolithic Medium Power Amplifier. This circuit includes a power detector which integrates a directional coupler, a detection diode and a reference diode to be used in differential mode.

It is dedicated to E-band telecommunication, particularly well suited for the new generation of high capacity Backhaul.

The circuit is manufactured with a pHEMT process, 0.1 $\mu$ m gate length, via holes through the substrate, air bridges and electron beam gate lithography.

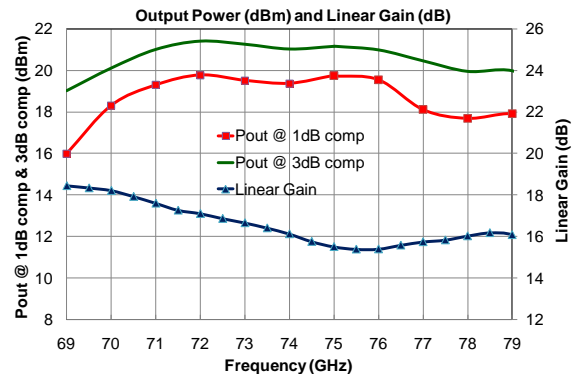
It is available in chip form with BCB layer protection.



Functional diagram

#### Main Features

- Broadband performances: 71-76GHz
- 16dB linear gain
- 19dBm power at 1dB compression
- 20dB power detector dynamic range
- BCB layer protection
- DC bias: Vd=3.5V@Id=280mA
- Chip size 3.96x1.78x0.07mm



#### Main Electrical Characteristics

Tamb.= +25°C

| Symbol | Parameter   | Min | Typ | Max | Unit |
|--------|---|-----|-----|-----|------|
| Freq   | Frequency range   | 71  |     | 76  | GHz  |
| Gain   | Linear Gain   |     | 16  |     | dB   |
| P1dB   | Output Power @1dB comp.   |     | 19  |     | dBm  |
| Psat   | Saturated Output Power  |     | 21  |     | dBm  |
| Dr     | Detection dynamic range (for output power detection up to Psat) |     | 20  |     | dB   |

## Electrical Characteristics

Tamb.= +25°C, Vd = Dc = 3.5V, Id (quiescent) = 280mA

| Symbol                         | Parameter   | Min | Typ              | Max | Unit |
|--------------------------------|---|-----|------------------|-----|------|
| Freq                           | Frequency range   | 71  |                  | 76  | GHz  |
| Gain                           | Linear Gain   |     | 16               |     | dB   |
| P1dB                           | Output power @ 1dB compression                                  |     | 19               |     | dBm  |
| Psat                           | Saturated Output Power  |     | 21               |     | dBm  |
| Dr                             | Detection dynamic range (for output power detection up to Psat) |     | 20               |     | dB   |
| Vdetect                        | Voltage detection Vref-Vdet up to Psat                          |     | 50<br>to<br>1400 |     | mV   |
| RLin                           | Input Return Loss   |     | 12               |     | dB   |
| RLout                          | Output Return Loss  |     | 12               |     | dB   |
| Gain ctrl                      | Gain control range with Vg1&Vg2 tuning (with Vd fixed at 3.5V)  |     | 10               |     | dB   |
| NF                             | Noise Figure  |     | 4.3              |     | dB   |
| Vd1, Vd2h, Vd3h,<br>Vd2b, Vd3b | Drain supply voltage  |     | 3.5              |     | V    |
| Id                             | Supply quiescent current  |     | 280              |     | mA   |
| Vg1, Vg2, Vg3b,<br>Vg3h        | Gate supply voltage   |     | 0.15             |     | V    |
| Dc                             | Detector supply voltage   |     | 3.5              |     | V    |
| IDc                            | Detector bias current   |     | 240              |     | μA   |

These values are representative of on-wafer measurements that are made without bonding wires at the RF ports but with 10kΩ resistor in parallel on pads Vdet and Vref.

A ribbon (75μm wide) connection at the input and the output of the MMIC amplifier (See chapter recommended chip assembly) should improve the performances.

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

Tamb.= +25°C

| Symbol | Parameter                      | Values      | Unit |
|--------|--------------------------------|-------------|------|
| Vd     | Drain bias voltage             | 4V          | V    |
| Id     | Drain bias current             | 350         | mA   |
| Vg     | Gate bias voltage              | -2 to +0.4  | V    |
| Pin    | Maximum continuous input power | +12         | dBm  |
| Tj     | Junction temperature           | 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 on-wafer Sij parameters

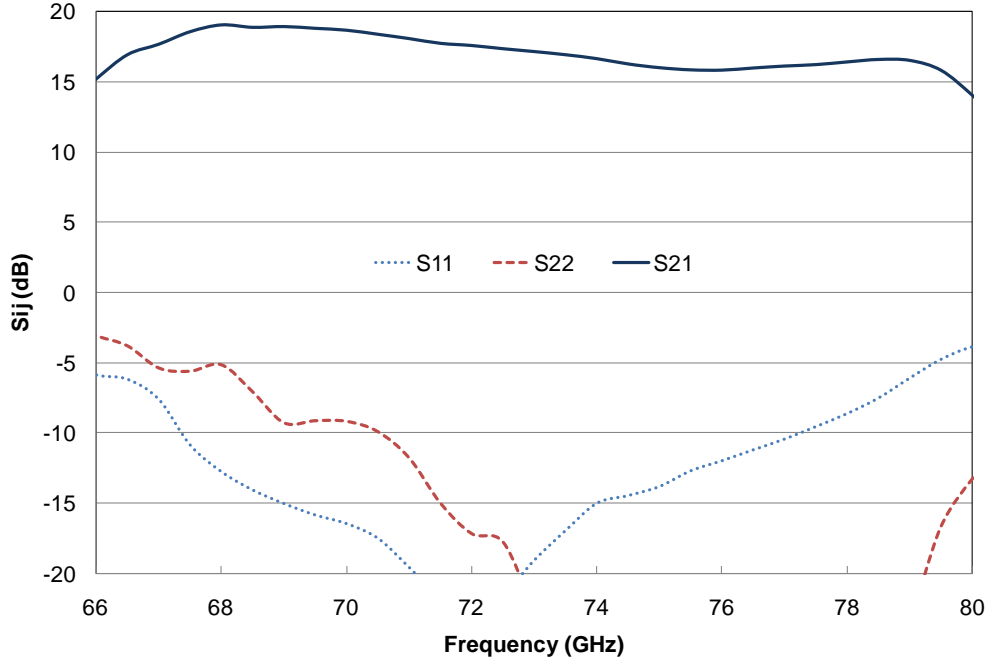
Tamb.= +25°C, Vd = Dc = 3.5V, Id (quiescent) = 280mA

| Freq (GHz) | S11 (dB) | PhS11 (°) | S21 (dB) | PhS21 (°) | S12 (dB) | PhS12 (°) | S22 (dB) | PhS22 (°) |
|------------|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| 55         | -2.46    | 132.0     | -18.06   | 88.2      | -38.27   | -59.1     | -3.1     | 154.1     |
| 56         | -2.15    | 130.4     | -14.57   | 64.0      | -46.79   | -110.3    | -3.86    | 136.3     |
| 57         | -2.08    | 124.3     | -10.74   | 45.9      | -47      | -90.7     | -5.15    | 120.0     |
| 58         | -2.11    | 117.7     | -6.58    | 16.0      | -56.14   | 173.2     | -8.11    | 96.1      |
| 59         | -2.24    | 109.3     | -3.93    | -17.5     | -48.75   | -83.7     | -13.05   | 55.6      |
| 60         | -2.46    | 100.8     | -1.3     | -49.8     | -44.01   | 179.0     | -18.18   | -34.7     |
| 61         | -2.70    | 93.3      | 1.51     | -84.4     | -47.31   | -144.5    | -12.31   | -109.5    |
| 62         | -2.97    | 80.9      | 3.03     | -112.9    | -48.68   | -148.7    | -8.32    | -135.7    |
| 63         | -3.10    | 59.9      | 5.28     | -144.3    | -44.74   | 147.4     | -6.44    | -155.0    |
| 64         | -4.00    | 37.4      | 7.81     | -176.8    | -58.68   | 41.4      | -5.04    | -175.9    |
| 65         | -4.79    | 13.9      | 11.13    | 151.2     | -46.69   | -106.8    | -4.4     | 168.1     |
| 66         | -5.95    | -3.8      | 14.36    | 111.5     | -43.75   | -70.0     | -2.98    | 154.8     |
| 67         | -7.25    | -50.7     | 16.74    | 61.9      | -39.35   | -109.3    | -5.84    | 114.3     |
| 68         | -12.65   | -125.9    | 18.02    | 5.0       | -37.08   | -155.6    | -5.06    | 95.4      |
| 69         | -15.54   | 167.5     | 17.96    | -44.2     | -36.92   | 165.9     | -9.55    | 81.9      |
| 70         | -18.12   | 116.8     | 17.84    | -89.5     | -37.08   | 130.1     | -8.88    | 53.1      |
| 71         | -21.43   | 105.4     | 17.31    | -132.3    | -37.51   | 95.1      | -11.49   | 30.3      |
| 72         | -23.63   | 138.6     | 16.86    | -172.1    | -38.17   | 56.3      | -16.38   | -29.7     |
| 73         | -18.57   | 150.3     | 16.32    | 145.1     | -39.03   | 15.9      | -20.6    | -72.6     |
| 74         | -14.93   | 142.7     | 15.79    | 104.0     | -39.58   | -22.7     | -25.62   | -167.6    |
| 75         | -14.01   | 124.4     | 15.19    | 66.1      | -40.28   | -58.2     | -24.88   | 140.9     |
| 76         | -11.98   | 115.7     | 15.05    | 29.2      | -39.71   | -96.2     | -25.01   | 38.3      |
| 77         | -10.37   | 102.9     | 15.43    | -12.2     | -39.19   | -135.3    | -24.05   | 21.1      |
| 78         | -8.42    | 88.3      | 15.76    | -59.2     | -38.74   | -176.8    | -23.41   | -22.1     |
| 79         | -5.87    | 68.3      | 15.85    | -114.1    | -38.67   | 135.9     | -24.16   | 37.4      |
| 80         | -4.00    | 36.6      | 13.32    | -178.6    | -40.65   | 81.3      | -13.51   | 21.1      |
| 81         | -4.09    | 0.4       | 8.78     | 127.1     | -45.06   | 31.7      | -9.22    | -24.3     |
| 82         | -5.32    | -27.5     | 3.04     | 83.7      | -50.27   | -31.9     | -7.24    | -49.4     |
| 83         | -6.17    | -53.8     | -1.89    | 53.5      | -52.02   | -136.3    | -6.7     | -73.0     |
| 84         | -7.18    | -76.6     | -6.21    | 26.8      | -51.33   | 149.9     | -6.31    | -91.1     |
| 85         | -8.67    | -97.1     | -10.46   | 5.8       | -52.71   | 100.1     | -6.34    | -105.9    |
| 86         | -9.94    | -116.1    | -13.65   | -12.5     | -52.42   | 90.9      | -6.78    | -115.8    |
| 87         | -11.29   | -131.7    | -15.77   | -35.6     | -50.5    | 36.0      | -6.32    | -126.7    |
| 88         | -12.33   | -148.4    | -18.17   | -56.9     | -48.64   | -30.4     | -6.31    | -138.3    |
| 89         | -13.22   | -162.5    | -19.99   | -81.0     | -49.99   | -117.4    | -6.47    | -150.8    |
| 90         | -13.92   | -175.1    | -21.67   | -109.9    | -49.76   | 179.0     | -6.82    | -164.2    |
| 91         | -14.52   | 169.6     | -23.45   | -140.9    | -48.91   | 148.2     | -7.47    | -178.6    |
| 92         | -15.11   | 154.1     | -25.76   | -174.2    | -48.04   | 113.4     | -8.69    | 163.1     |
| 93         | -14.60   | 141.8     | -28.46   | 151.7     | -47.25   | 86.4      | -10.51   | 136.2     |
| 94         | -13.52   | 125.1     | -30.15   | 119.1     | -43.54   | 74.3      | -14.36   | 83.5      |
| 95         | -12.99   | 102.5     | -30.87   | 49.4      | -36.3    | 6.8       | -14.84   | -18.6     |

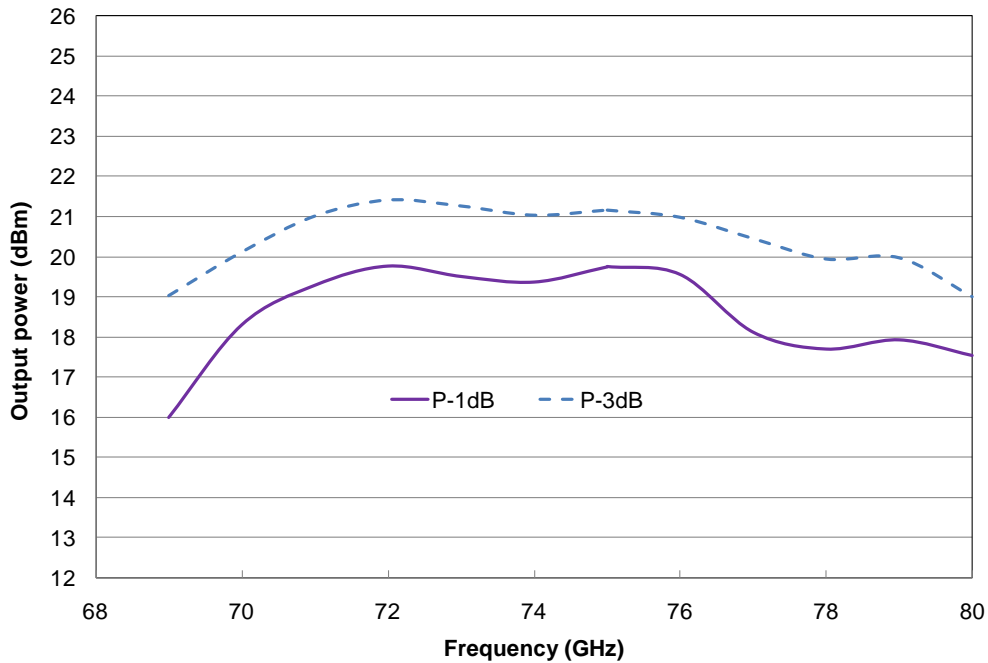
## Typical on wafer Measurements

Tamb.= +25°C, Vd = Dc = 3.5V, Id (quiescent) = 280mA

### Gain & Return loss versus frequency



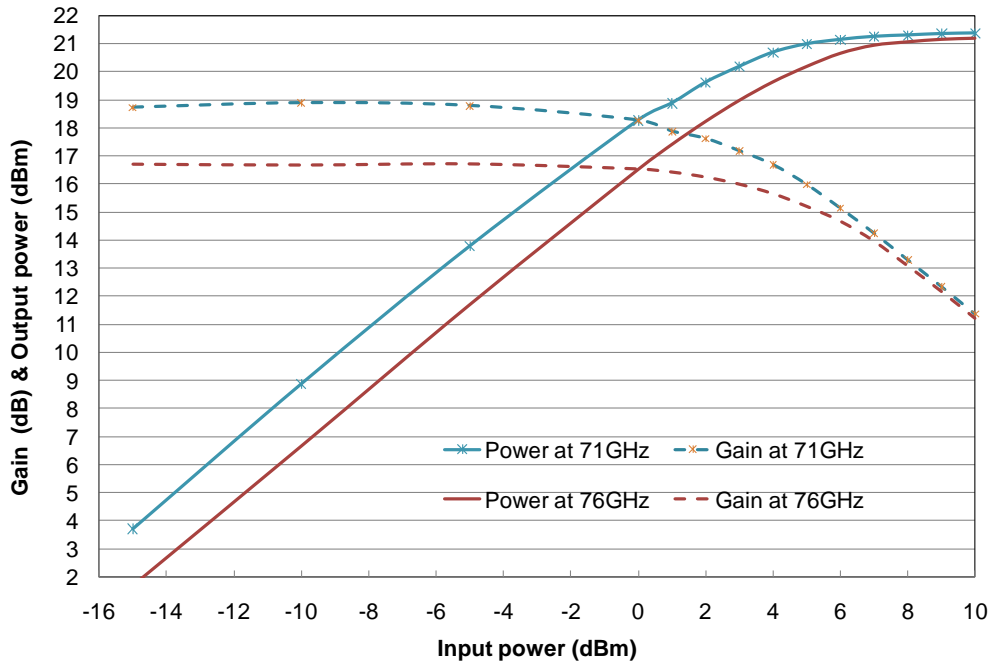
### Output power at 1 & 3 dB compression



Typical on wafer Measurements

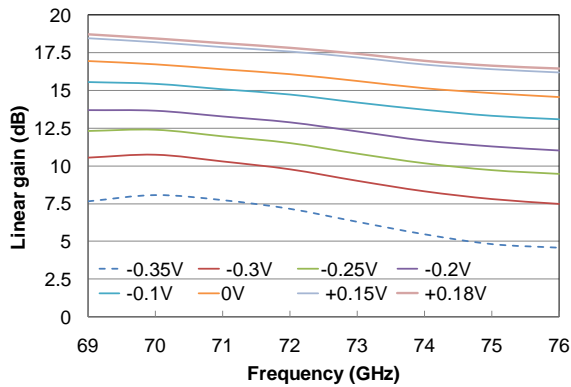
Tamb.= +25°C, Vd = Dc = 3.5V, Id (quiescent) = 280mA

Gain & output power versus input power



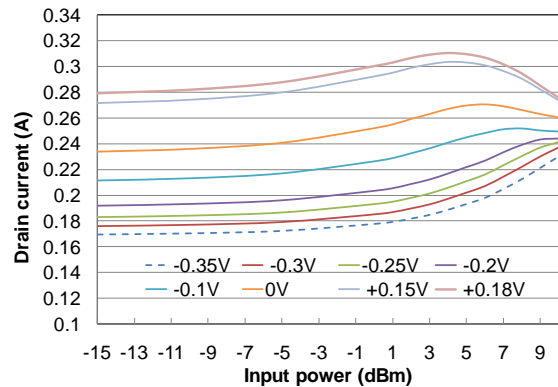
Linear Gain versus gate voltage

Vg3 fixed at +0.18V, Vg1=Vg2 variable



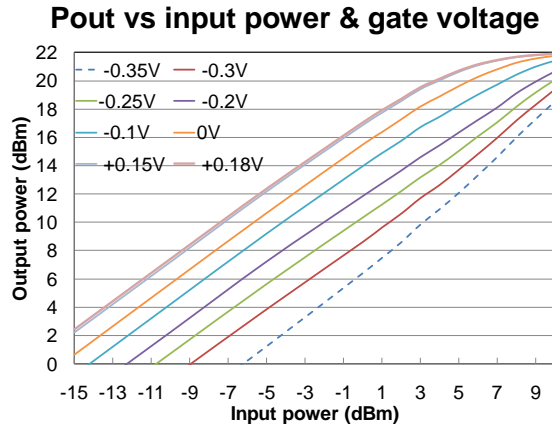
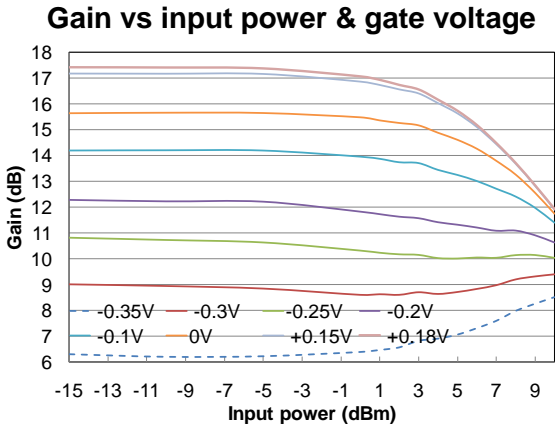
Drain current versus gate voltage & Pin

Vg3 fixed at +0.18V, Vg1=Vg2 variable



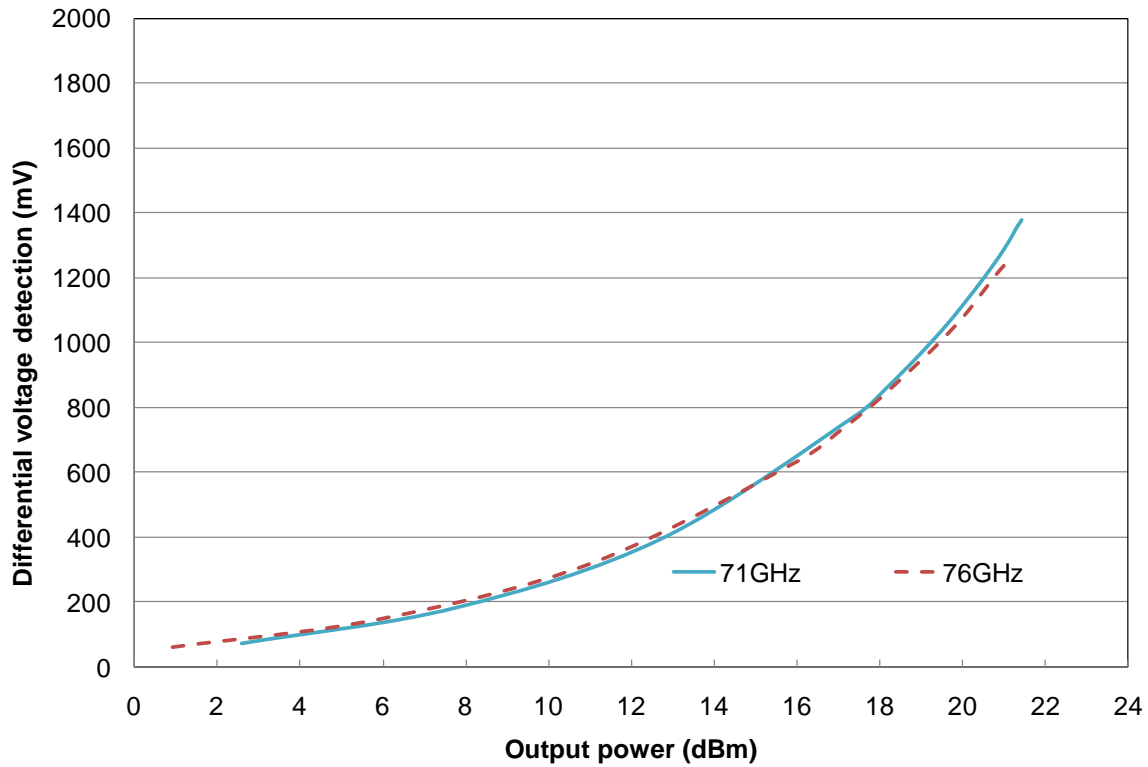
## Typical on wafer Measurements

T<sub>amb</sub>. = +25°C, V<sub>d</sub> = D<sub>c</sub> = 3.5V, I<sub>d</sub> (quiescent) = 280mA



## Power detection versus output power

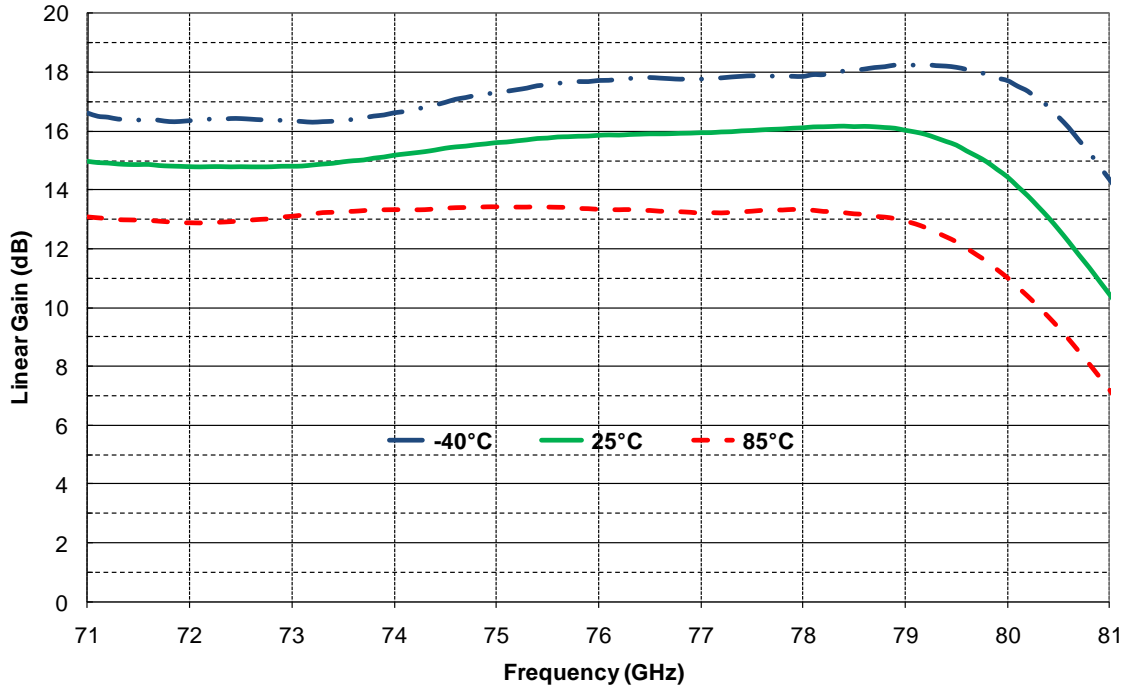
Differential voltage



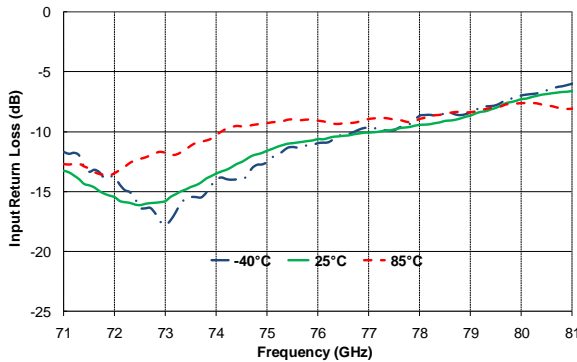
**Typical Test Fixture Measurements**

Tamb.= -40°C / +25°C / +85°C, Vd = +3.5V, Vg = +0.15V  
 Id= 340 mA @ -40°C / 280 mA @ +25°C / 250mA @ +85°C  
 Measurements are given in the test fixture access plans

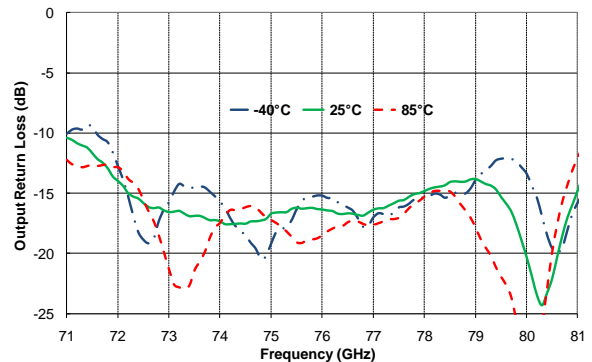
**Linear Gain versus Temperature**



**Input Return Loss versus Temperature**



**Output Return Loss versus Temperature**

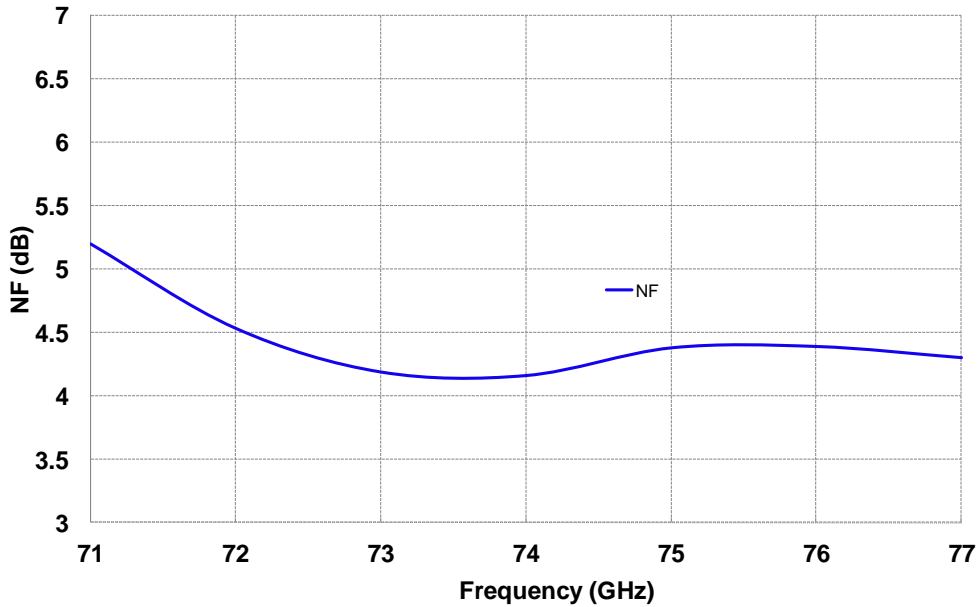


## Typical Test Fixture Measurements

Tamb.= 25°C, Vd = +3.5V ; Id= 280 mA

Measurements are given in the test fixture access plans

### Noise Figure versus Frequency

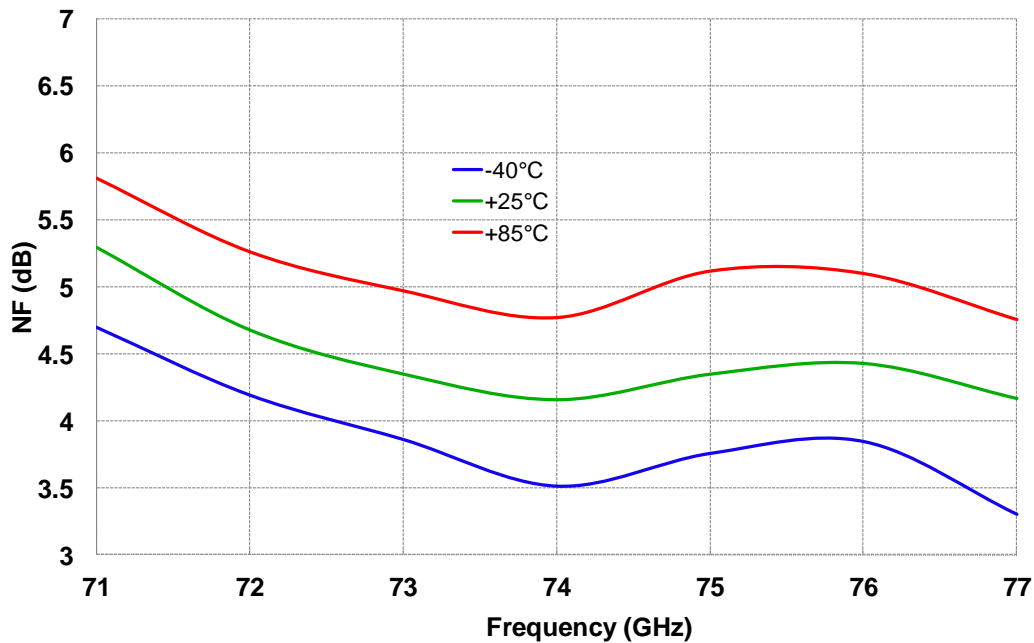


Temp.= -40°C / +25°C / +85°C, Vd = +3.5V

Id= 340 mA @ -40°C / 280 mA @ +25°C / 250mA @ +85°C

Measurements are given in the test fixture access plans

### Noise Figure versus Frequency & Temperature



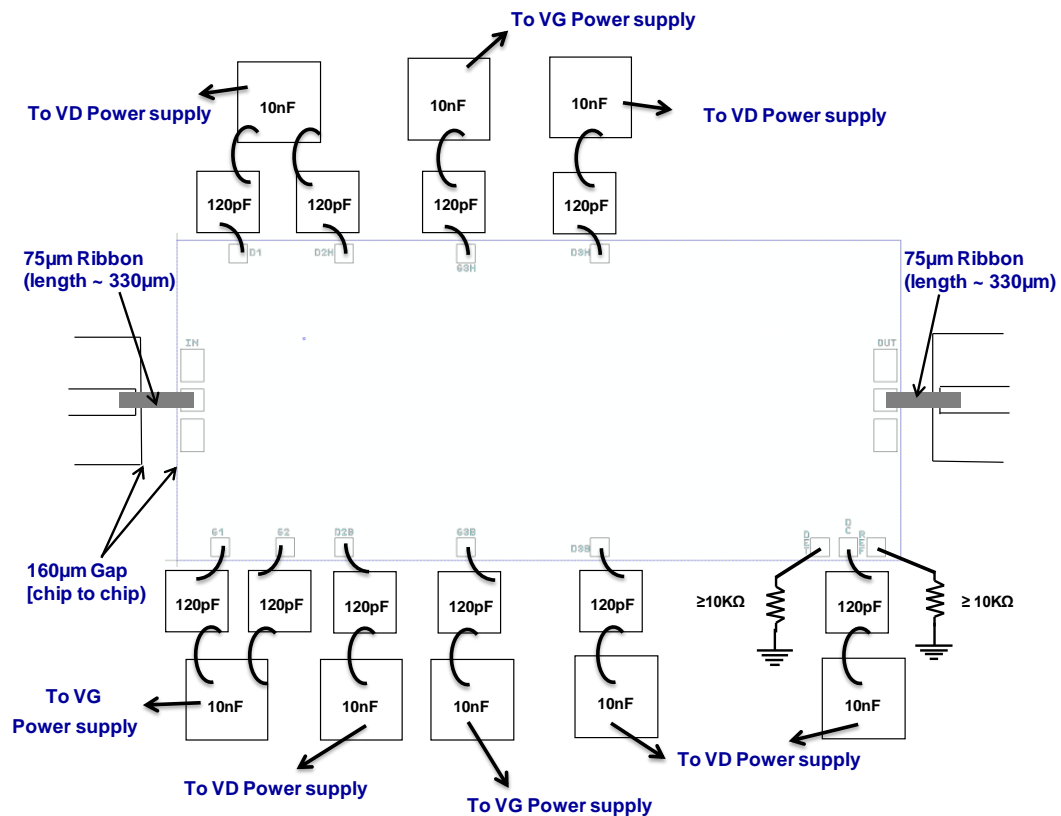




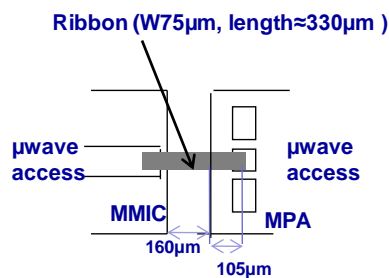
**Recommended circuit bonding table**

| Pad number | Pad name        | Description                             |
|------------|-----------------|---|
| 1, 3, 6    | D1; D2H; D3H    | Drain voltage (3.5V, 160mA)             |
| 16, 19     | D3B, D2B        | Drain voltage (3.5V, 120mA)             |
| 5          | G3H             | Gate voltage (0.15V)                    |
| 17, 20, 21 | G3B, G2, G1     | Gate voltage (0.15V)                    |
| 14         | DET             | Detector output                         |
| 12         | REF             | Detector reference output               |
| 13         | DC              | DC voltage detector (3.5V, 240 $\mu$ A) |
| 22         | IN              | RF in                                   |
| 11         | OUT             | RF out                                  |
| 2, 4, 7    | D1M; D2HM; D3HM | Not connected                           |
| 15, 18     | D3BM, D2BM      | Not connected                           |
| 8, 9, 10   | DETH, DCH, REFH | Not connected                           |
|            | GND             | Not connected                           |

## Recommended assembly plan



The design of the circuit integrates a half ribbon (75µm wide) connection at the input and the output of the MMIC amplifier compliant with a 50 Ohm line on GaAs MMIC. The circuits have to be as close as possible to each other; the ribbon length must be as short as possible: typically 160µm gap between two chips is considered, and the loop height must also be the smallest possible (80µm).

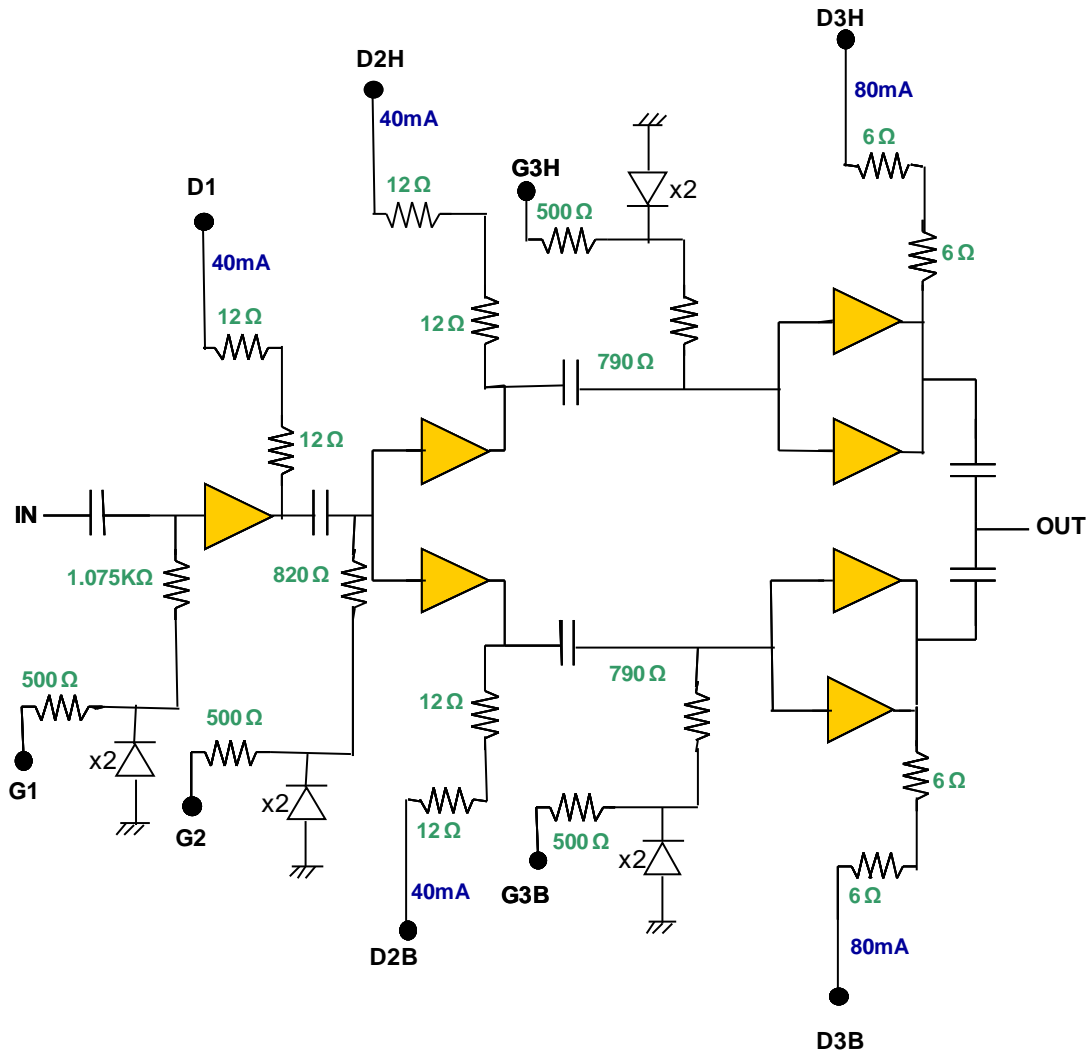


A second solution is to use wires ( $\varnothing$  25µm). In this case a minimum of two wires together with the same chip to chip distance mention above are necessary to reduce the inductance effect. Nevertheless, simulations show an improvement of RF performance for E-band frequency range with the use of ribbon connection instead of wire.

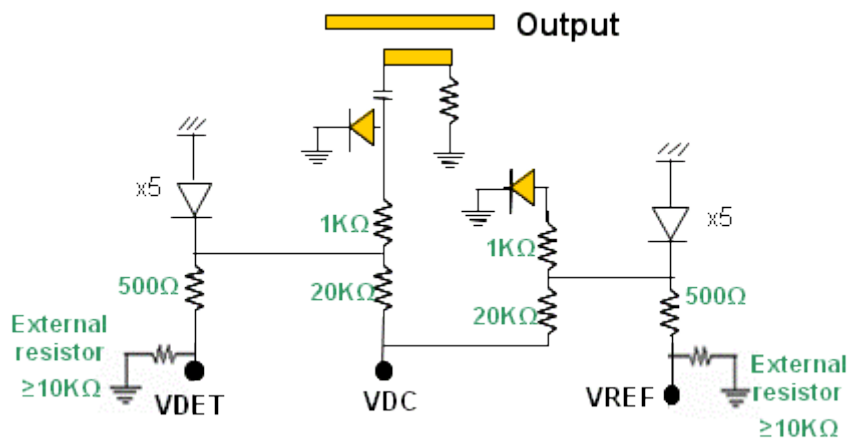
For DC connection (DC pads), a 25µm bonding is preferred. Due to BCB coating on the chip, qualification domain requires the chip to be glued.

## DC Schematic

3.5V, 280mA



### Detector



**Notes**

## 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 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 <http://www.ums-gaas.com>.

## Ordering Information

Chip form:

CHA3080-98F/00

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