United Monolithic Semiconductors

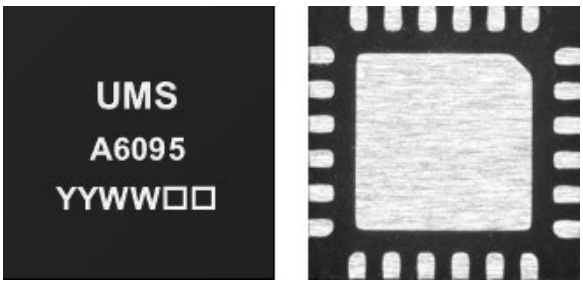
# CHA6095-QKB

# 35-42.5GHz 4W Packaged Power Amplifier

## GaN Monolithic Microwave IC in SMD leadless package

## Description

The CHA6095-QKB is a GaN packaged Power Amplifier operating over 35-42.5GHz frequency band. It typically exhibits 36dBm saturated output power with 25dB small signal gain. For 256QAM modulation signal & 120MHz channel spacing the linear power is 31dBm with ACPR below -30dBc and it is 29dBm with EVM below 3.5%.
The CHA6095-QKB is designed for telecom applications such as 5G active phased array antennas, Satcom and Radar systems. It is manufactured on a robust GaN-on-SiC HEMT technology and packaged in a standard surface mount 4x4 plastic QFN which is RoHS compliant. RF input and output are 50Ω matched and integrate ESD RF protections.

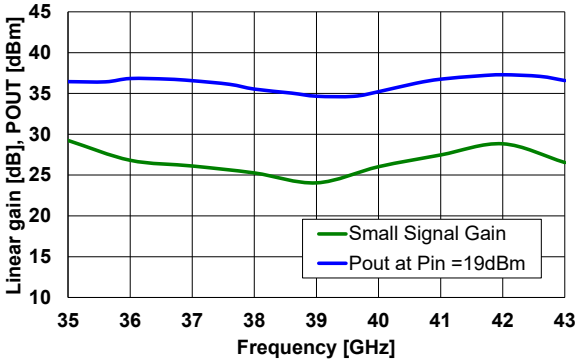



## Main Features

- Frequency range: 35-42.5GHz
- Pout = 36dBm @ 20dBm input power
- Linear Gain = 25dB
- ACPR < -30dBc at 31dBm Average Pout(1)
- EVM < 3.5% at 29dBm Average Pout(1)
- DC bias: Vd=25V @ Idq=300mA
- 24L-QFN RoHS plastic package 4x4mm²
- MSL3

*(1) 120MHz modulation bandwidth, 256QAM*

**Small Signal Gain & Output Power at Pin = 20dBm vs. Frequency, T°= 25°C**




## Main Electrical Characteristics

Tcase = +25°C (Tcase: QFN backside temperature)

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Freq | Frequency range | 35.0 | | 42.5 | GHz |
| Gain | Linear Gain | | 25 | | dB |
| ACPR | ACPR @ $P_{AVG}$ = 27dBm with 256QAM & 120MHz modulation bandwidth | | -33 | | dBc |
| $P_{MAX}$ | Maximum Output Power at $PAE_{MAX}$ | | 36 | | dBm |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## Specifications

Tcase = +25°C, Vd = +25V (QFN reference plans)

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Freq | Frequency range | 35.0 | | 42.5 | GHz |
| Gain | Linear Gain | | 25 | | dB |
| IRL(*) | Input Return Losses | | 10 | | dB |
| ORL(*) | Output Return Losses | | 10 | | dB |
| $PAE_{MAX}$ | Maximum Power Added Efficiency | | 12 | | % |
| $P_{MAX}$ | Output Power at $PAE_{MAX}$ | | 36 | | dBm |
| ACPR | Transmit ACPR@ $P_{AVG}$=27dBm, 256QAM 120MHz modulation bandwidth | | -33 | | dBc |
| EVM | Transmit EVM @ $P_{AVG}$=27dBm for 256QAM, 120MHz modulation bandwidth | | -31 | | dB |
| Vd | CW Drain Voltage | | 25 | | V |
| Vg | CW Gate Voltage | | -2.9 | | V |
| Idq | Quiescent Drain bias current | | 300 | | mA |

These values are representative of measurements performed on evaluation board - see paragraph "Evaluation board".

(*) Input and Output Return Loss are given at RF reference plan of Evaluation board (see Definition of the board reference planes section).



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## Absolute Maximum Ratings (1)

Tcase = +25°C

| Symbol | Parameter | Values | Unit |
|---|---|---|---|
| Vd | Drain bias voltage | 27 | V |
| Idq | Quiescent Drain bias current | 400 | mA |
| Vg | Gate bias voltage | -7 to -2 | V |
| Pin | Maximum Input Power | 23 | dBm |

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

## Recommended Operating Range (2), (3)

| Symbol | Parameter | Values | Unit |
|---|---|---|---|
| Vd | Drain bias voltage | 20 to 25 | V |
| Id | Quiescent Drain bias current | 140 to 300 | mA |
| Vg | Gate bias voltage | -5 to-2.8 | V |
| Pin | Maximum Input Power | 21 | dBm |
| Tj | Maximum Junction temperature (4) | 200 | °C |

(2) Electrical performances are defined for specified test conditions

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

(4) See Device thermal performances section

## Temperature Range

| | | | |
|---|---|---|---|
| Tcase | Operating temperature range | -40 to +85 | °C |
| Tstg | Storage temperature range | -55 to +150 | °C |

## Typical Bias Conditions

Tcase=+25°C

| Symbol | Pad N° | Parameter | Values | Unit |
|---|---|---|---|---|
| VG12N | 1 | North 1st Gate bias voltage | -2.9 | V |
| VG3N | 23 | North 2nd Gate bias voltage | -2.9 | V |
| VG4N | 22 | North 3th Gate bias voltage | -2.9 | V |
| VD12N | 21 | North 1st Drain bias voltage | 25 | V |
| VD3N | 20 | North 2nd Drain bias voltage | 25 | V |
| VD4N | 18 | North 3th Drain bias voltage | 25 | V |
| VG12S | 7 | South 1st Gate bias voltage | -2.9 | V |
| VG3S | 8 | South 2nd Gate bias voltage | -2.9 | V |
| VG4S | 9 | South 3th Gate bias voltage | -2.9 | V |
| VD12S | 10 | South 1st Drain bias voltage | 25 | V |
| VD3S | 11 | South 2nd Drain bias voltage | 25 | V |
| VD4S | 12 | South 3th Drain bias voltage | 25 | V |



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## "Power ON" sequence

1. Bias HPA gate voltage Vg (VG12N, VG3N, VG4N, VG12S, VG3S, VG4S) close to Vpinch-off (Typically: Vg ≈ -5V)
2. Apply drain bias voltage Vd (VD12N, VD3N, VD4N, VD12S, VD3S, VD4S) (Typically: Vd = 25V)
3. Increase gate voltage Vg (VG12N, VG3N, VG4N, VG12S, VG3S, VG4S) up to quiescent bias drain current Idq
4. Apply RF signal

## "Power OFF" sequence

1. Turn off RF signal
2. Bias HPA gate voltage Vg (VG12N, VG3N, VG4N, VG12S, VG3S, VG4S) close to Vpinch-off (Typically: Vg ≈ -5V)
3. Check that quiescent bias drain current Idq is close to 0mA
4. Turn drain bias voltage Vd (VD12N, VD3N, VD4N, VD12S, VD3S, VD4S) to 0V
5. Check that quiescent bias drain current Idq is close to 0mA
6. Turn gate voltage Vg (VG12N, VG3N, VG4N, VG12S, VG3S, VG4S) to 0V



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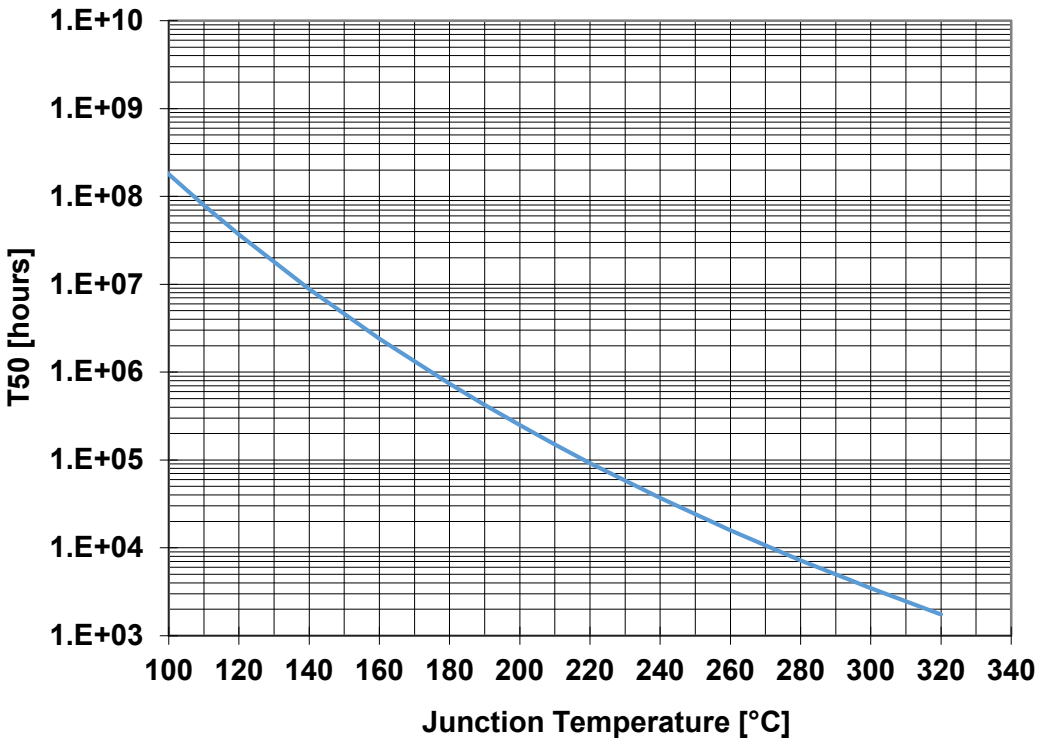
## Device thermal performances

All figures given in this section are obtained assuming the QFN device is only cooled down by conduction through the package thermal pad (no convection mode is 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 Recommended Operating Range table.
The system PCB must be designed to comply with this requirement

| Parameter | DC & RF conditions | Tjunction (°C) | RTH (°C/W) | T50 (hours) |
|---|---|---|---|---|
| RTH (1) Thermal Resistance (Junction to Case) | Vd= 25V<br>Id= 300mA<br>Pout= 26dBm<br>Pdiss= 12.7W | 137 | 4.1 | 8.8E+06 |
| | Vd= 25V<br>Id= 300mA<br>Pout= 33dBm<br>Pdiss= 21.7W | 200 | 5.3 | 2.5E+05 |

(1) Assuming 85°C Tcase



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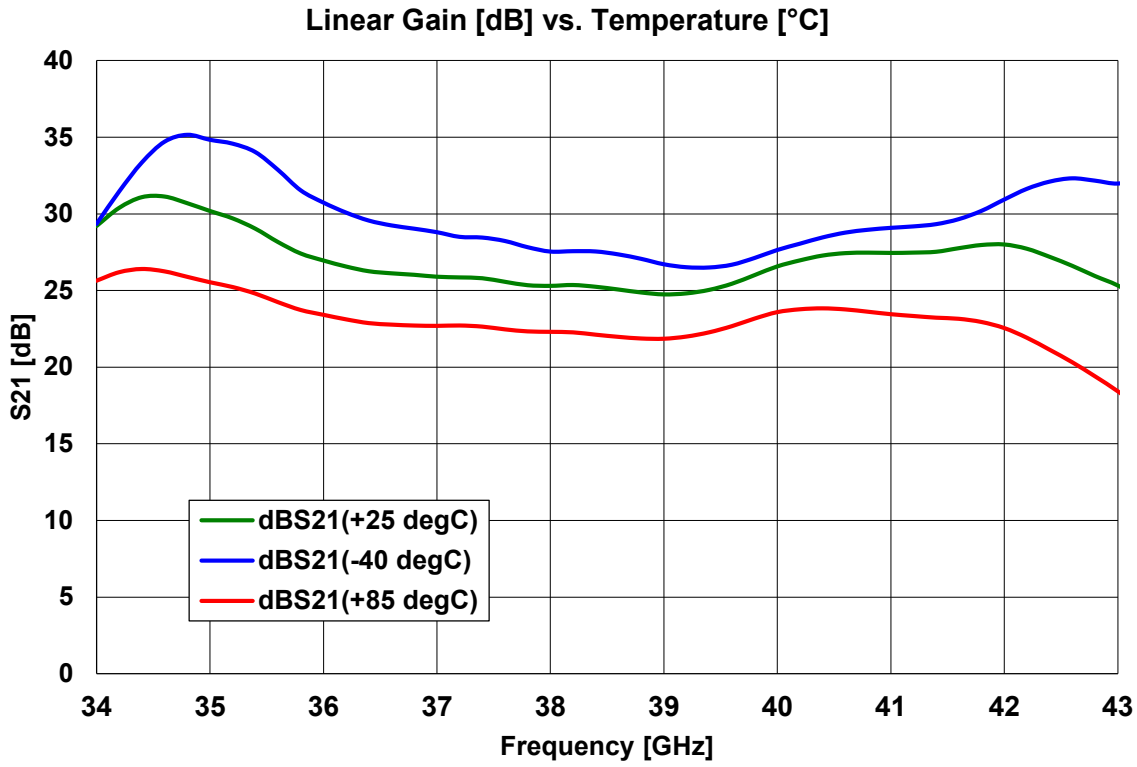
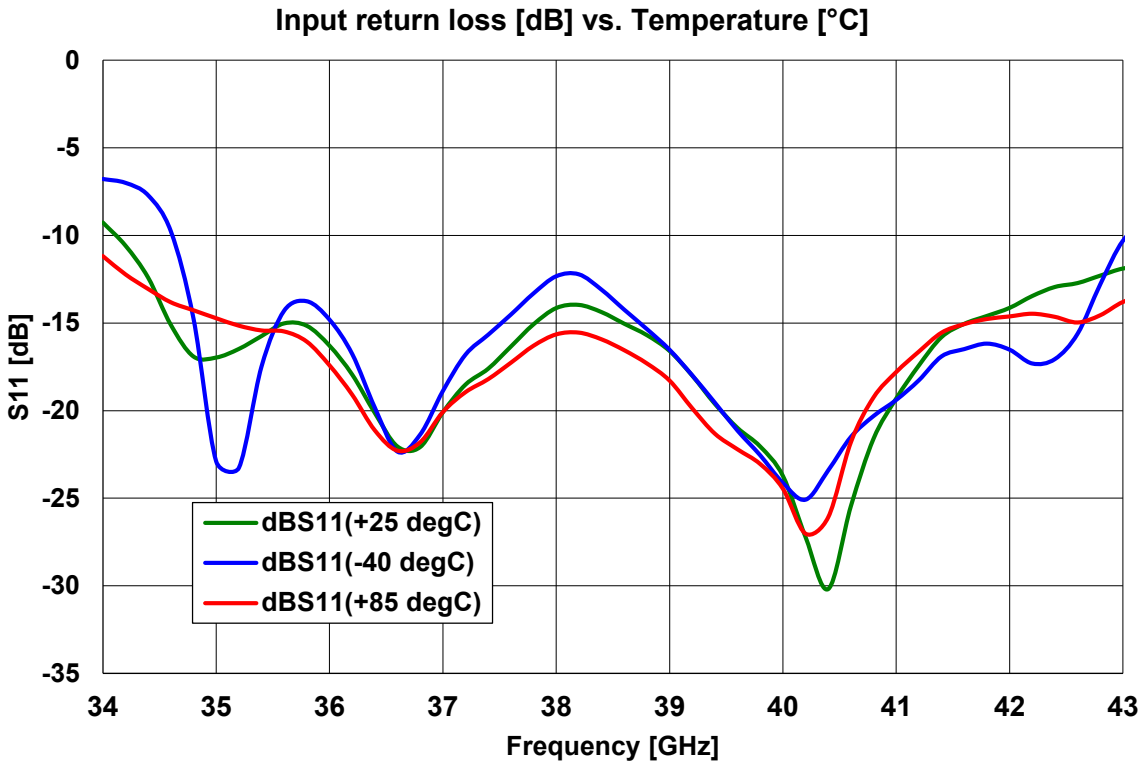
## Typical on board Measurements: Small signal performance

Tcase=-40°C/+25°C/+85°C (QFN backside), Vd = +25V, Idq = 300mA



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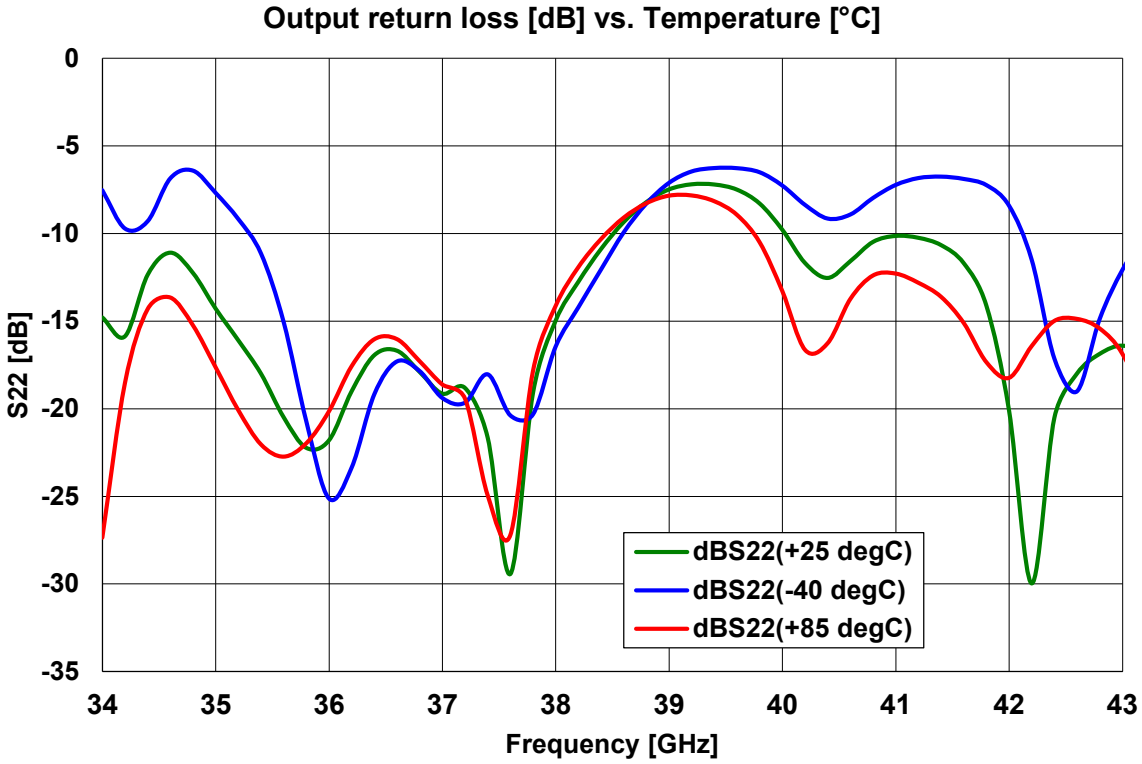
## Typical on board Measurements: Small signal performance

Tcase=-40°C/+25°C/+85°C (QFN backside), Vd = +25V, Idq = 300mA



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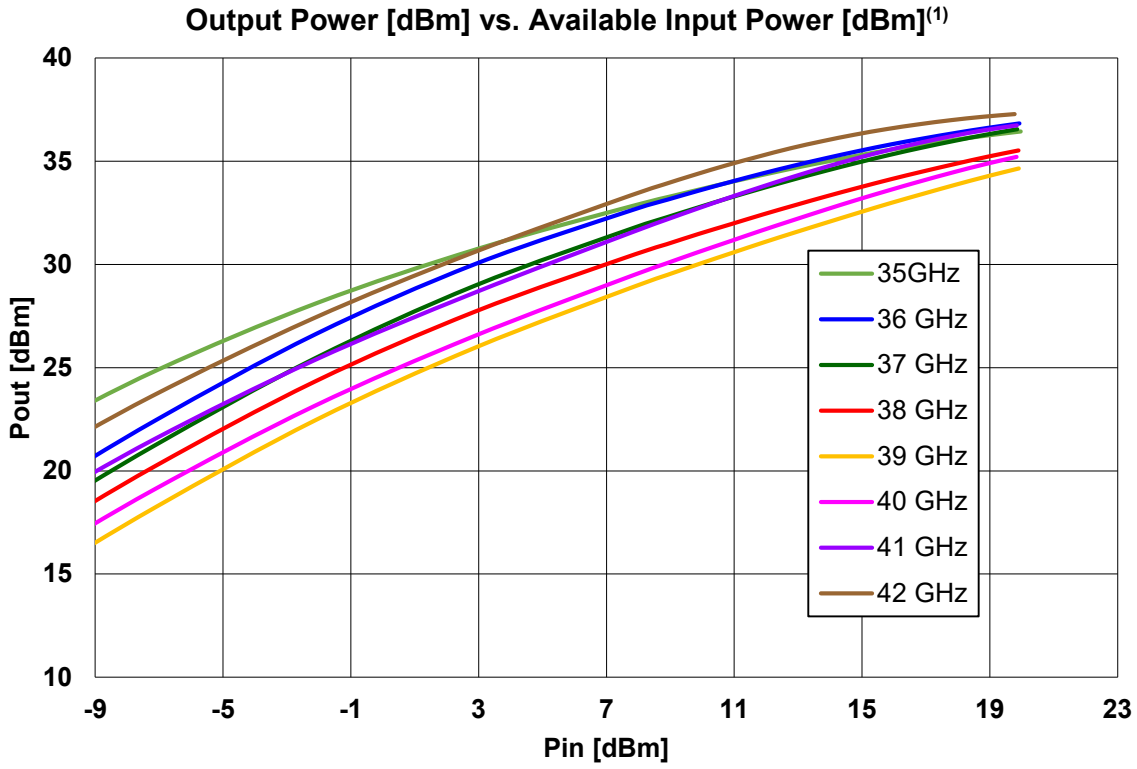
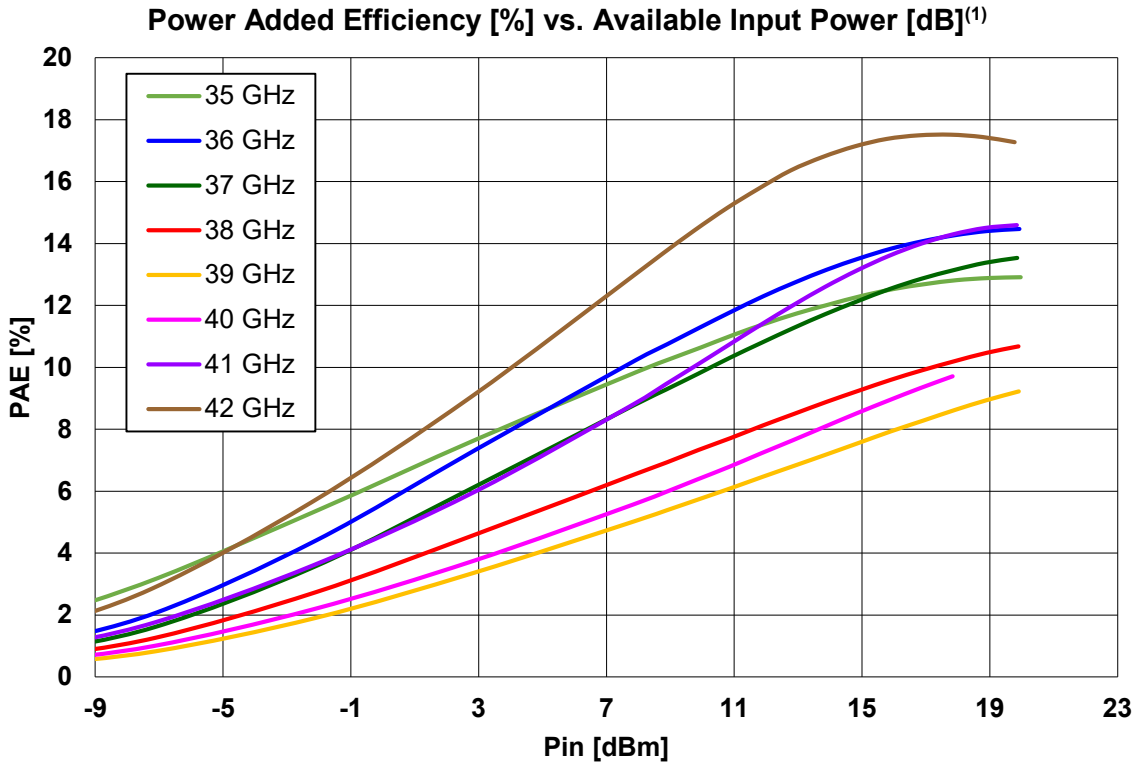
## Typical on board Measurements: Large signal performance

Tcase=+25°C (QFN backside), Vd = +25V, Idq = 300mA




(1) The temperature is fixed at Tcase = 25°C with Pout = 36dBm.



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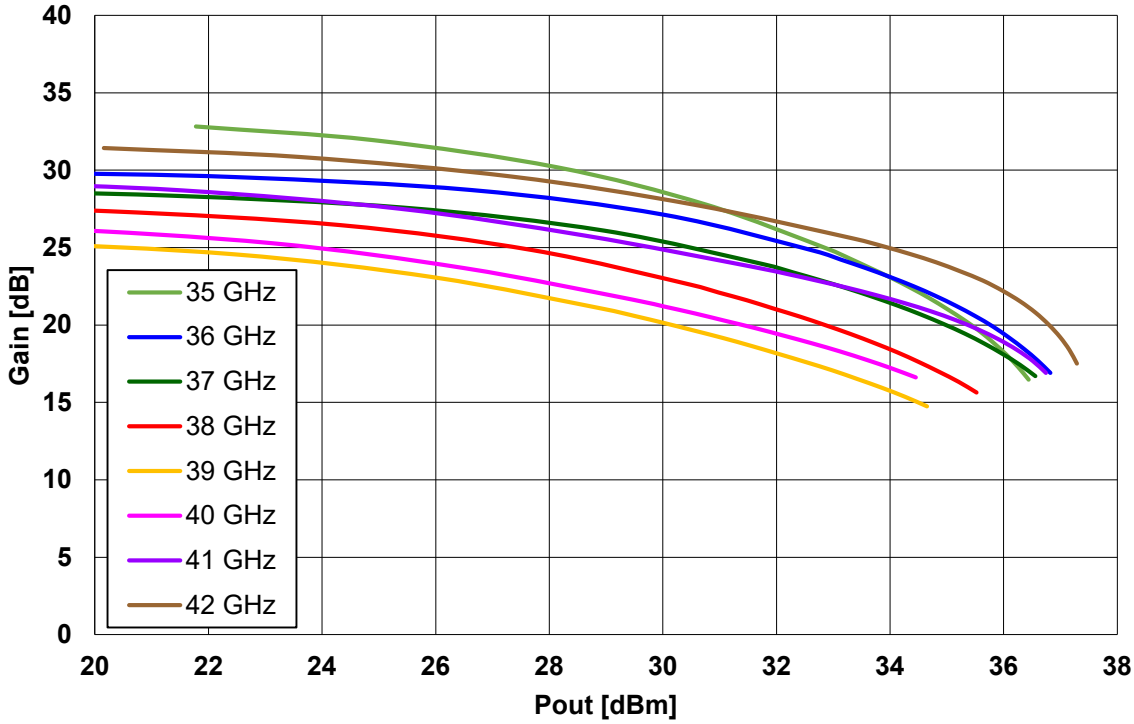
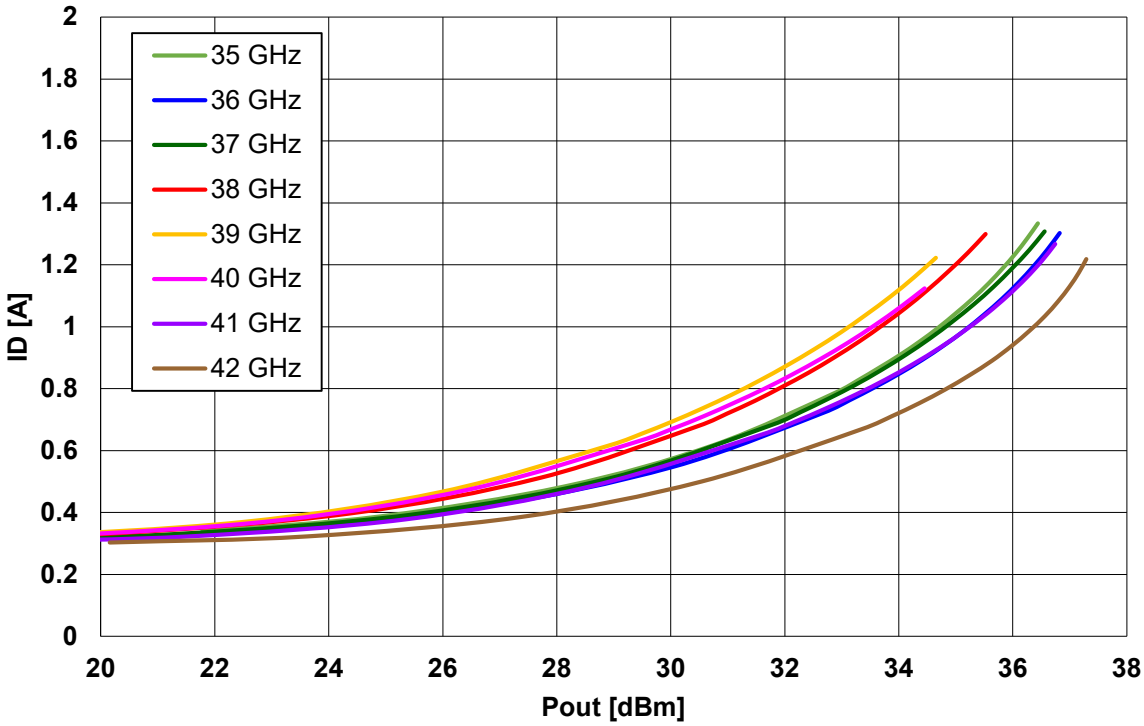
## Typical on board Measurements: Large signal performance

Tcase=+25°C (QFN backside), Vd = +25V, Idq = 300mA

**Gain [dB] vs. Output Power [dBm](1)**




**Drain current [A] vs. Output Power [dBm](1)**




(1) The temperature is fixed at Tcase = 25°C with Pout = 36dBm.



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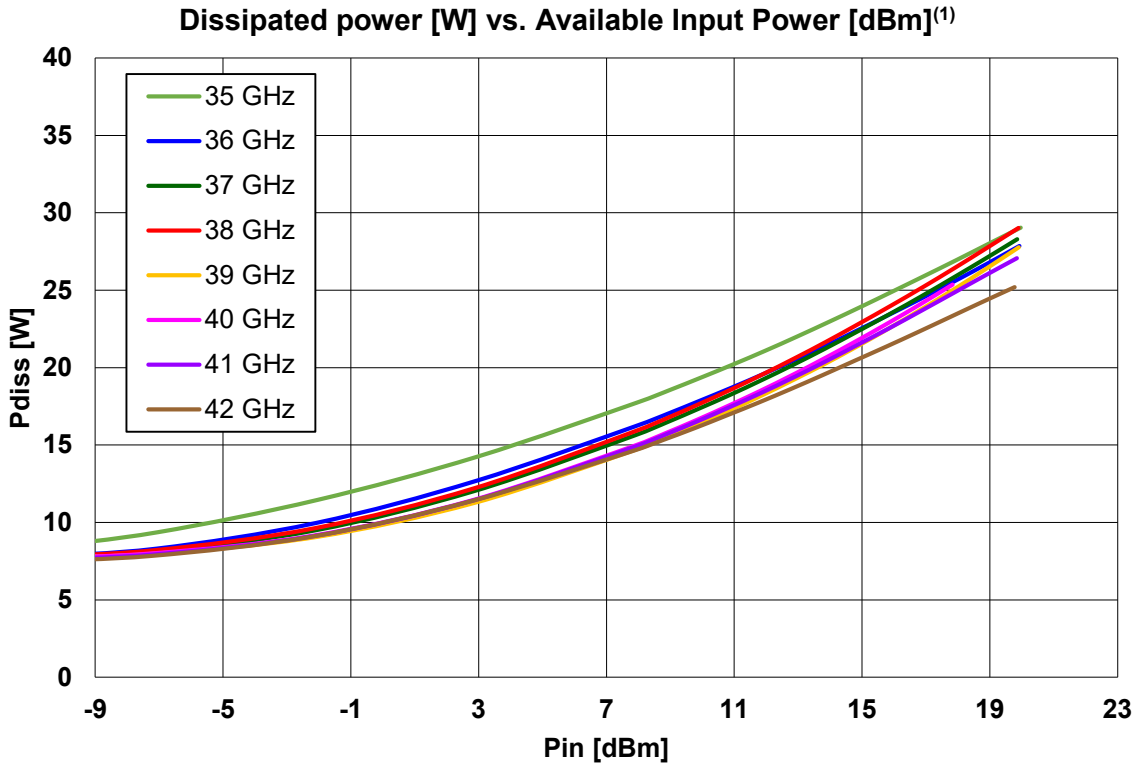
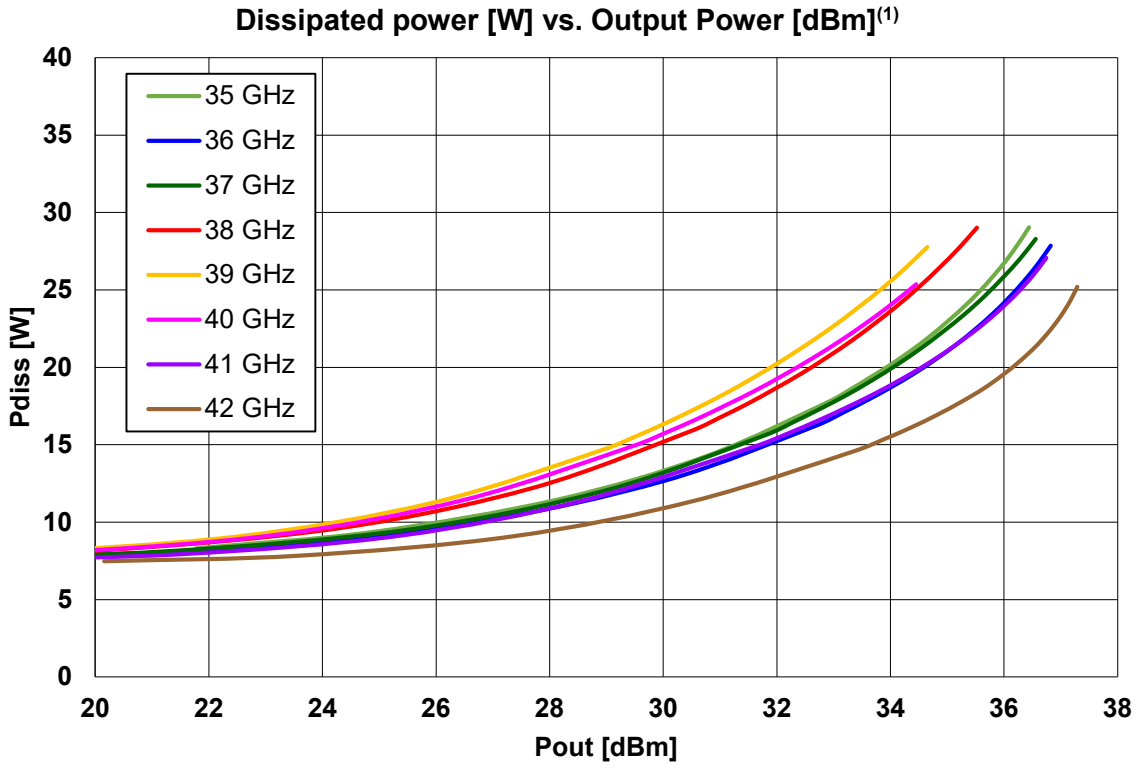
## Typical on board Measurements: Large signal performance

Tcase=+25°C (QFN backside), Vd = +25V, Idq = 300mA




(1) The temperature is fixed at Tcase = 25°C with Pout = 36dBm.



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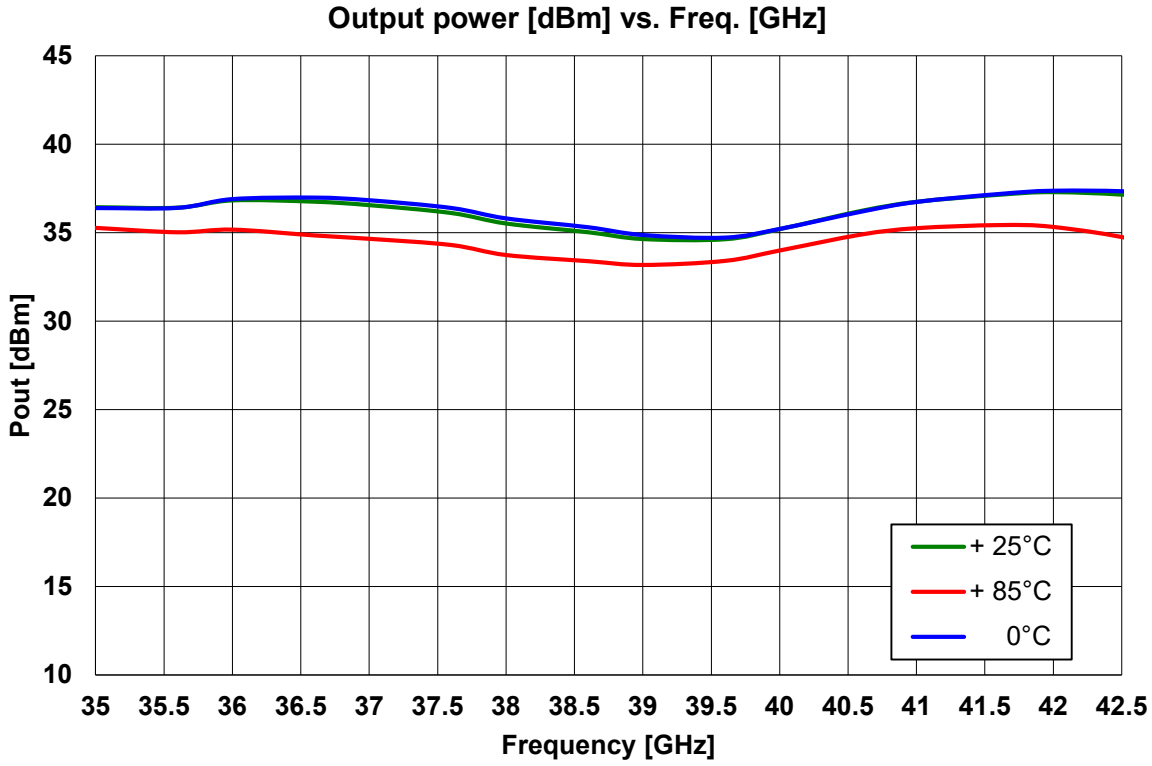
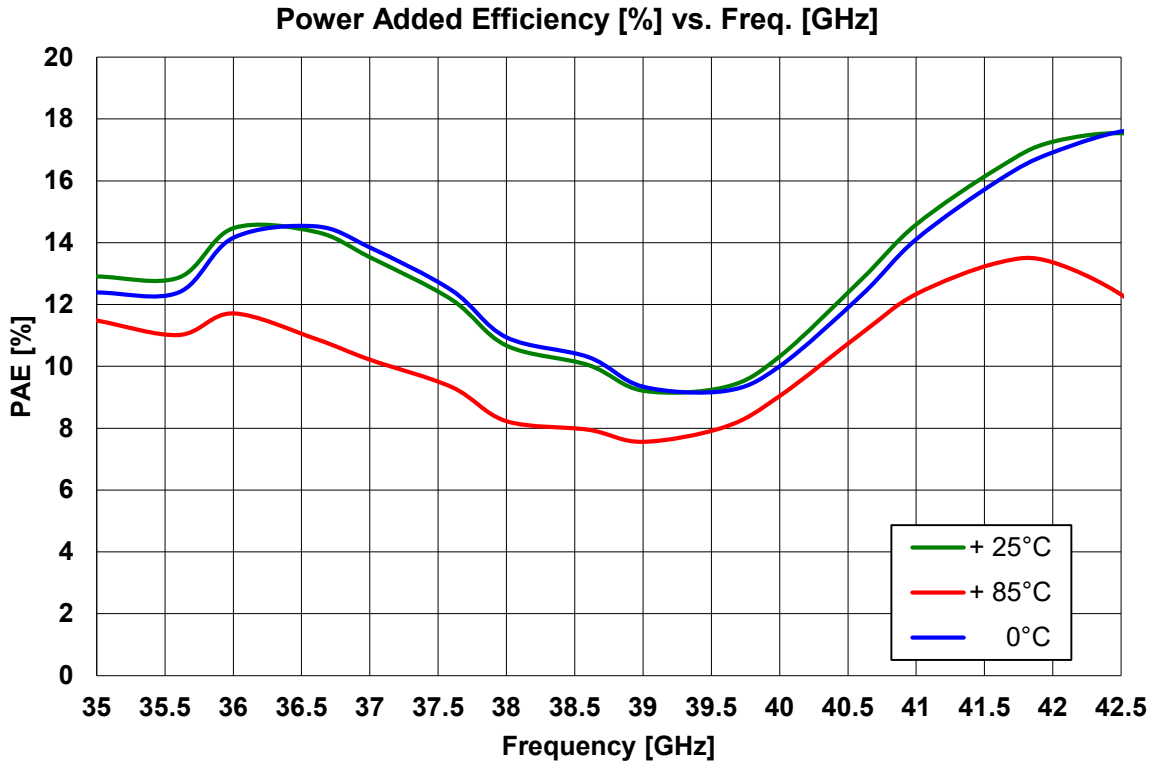
## Typical on board Measurements: Large signal performance

Tcase= 0°C/+25°C/85°C (QFN backside), Vd = +25V, Idq = 300mA, Pin = 20dBm



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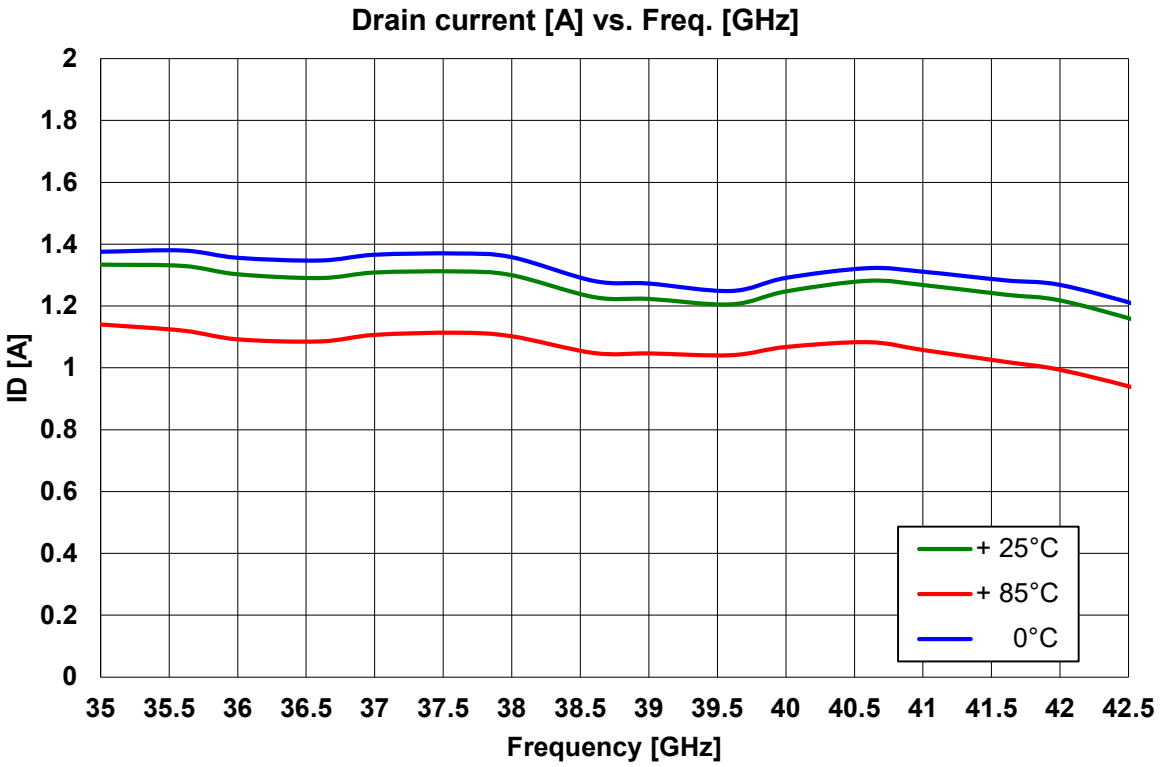
## Typical on board Measurements: Large signal performance

Tcase= 0°C/+25°C/85°C (QFN backside), Vd = +25V, Id = 300mA, Pin= 20dBm



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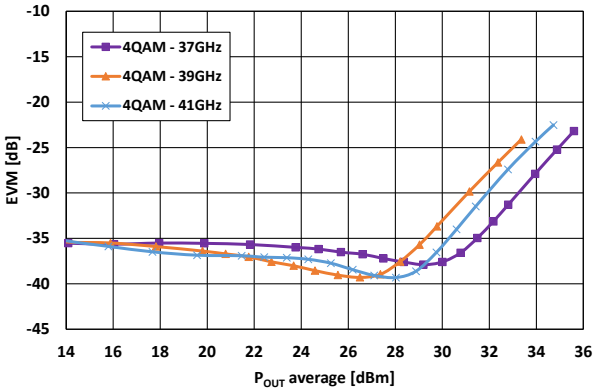
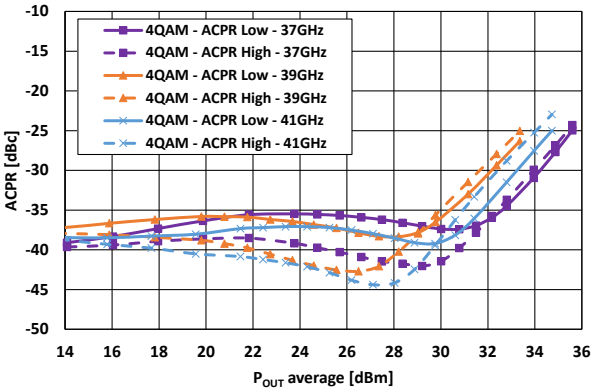
## Typical Board Measurements: Linearity performance with modulated signals

**Tcase = +25°C**, Vd = +25V, Idq = 150mA, 4QAM (PAPR ~ 5.2dB) / 64QAM (PAPR ~ 7.3dB) / 256QAM (PAPR ~ 7.3dB), **SR = 50MSym/s**, Roll-Off = 0.2, $f_{CARRIER}$ = 37/ 39/ 41GHz, Evaluation board decoupling : 10Ω+100pF / 10Ω+1nF/ 10Ω+1µF, QFN reference planes

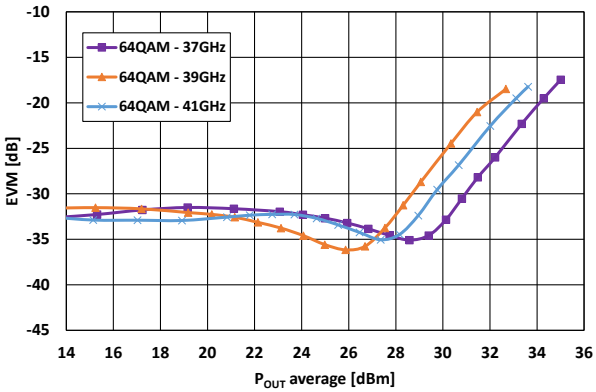
**4QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C**



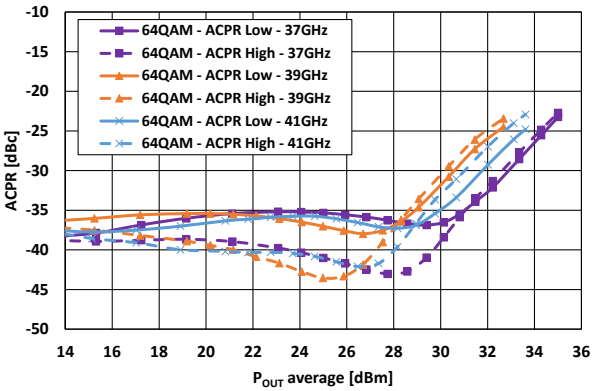

**4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C**



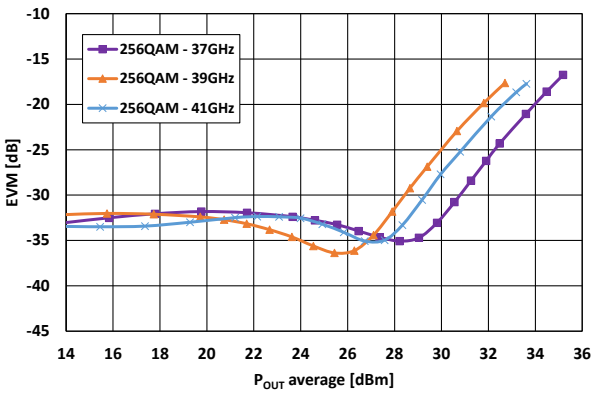

**64QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C**



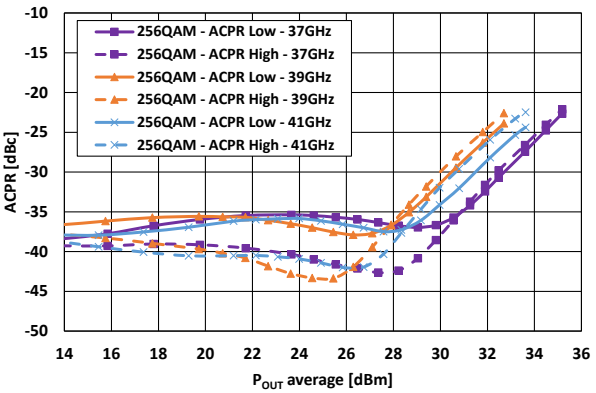

**64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C**




**256QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C**




**256QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C**



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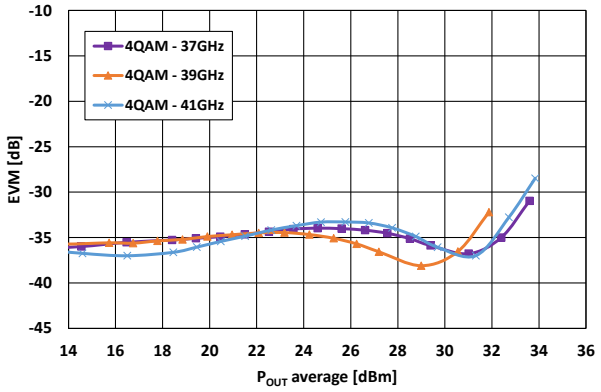
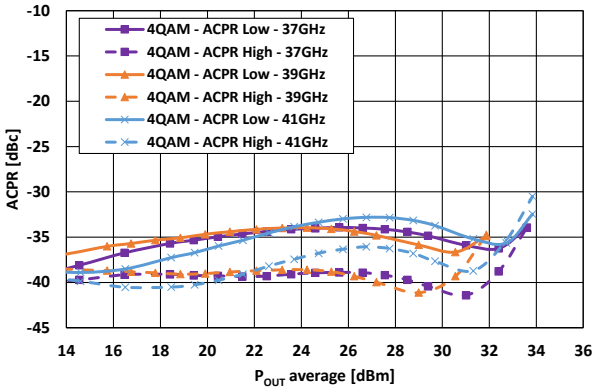
## Typical Board Measurements: Linearity performance with modulated signals

**Tcase = +85°C**, Vd = +25V, Idq = 150mA, 4QAM (PAPR ~ 5.2dB) / 64QAM (PAPR ~ 7.3dB) / 256QAM (PAPR ~ 7.3dB), **SR = 50MSym/s**, Roll-Off = 0.2, $f_{CARRIER}$ = 37/ 39/ 41GHz, Evaluation board decoupling : 10Ω+100pF / 10Ω+1nF/ 10Ω+1µF, QFN reference planes

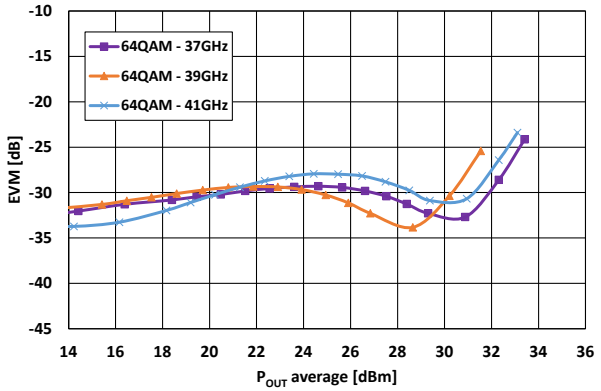
### 4QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



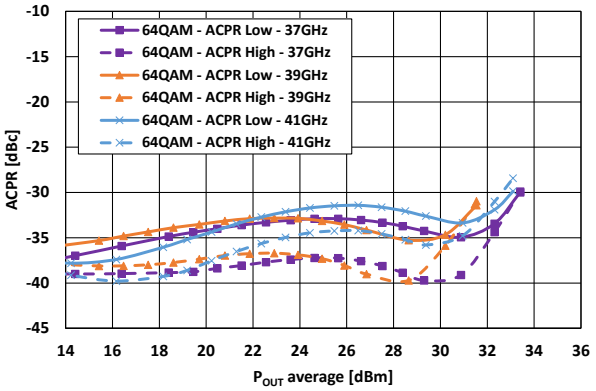

### 4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



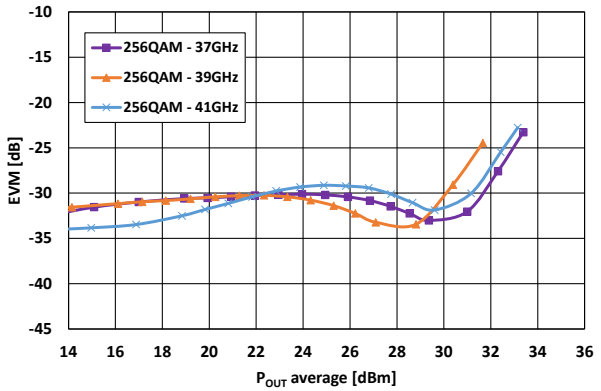

### 64QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



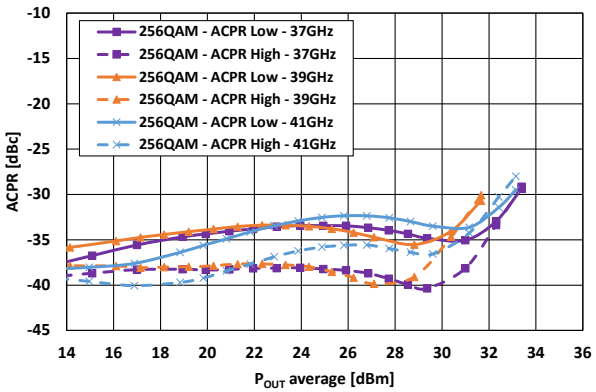

### 64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C




### 256QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C




### 256QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



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## Typical Board Measurements: Linearity performance with modulated signals

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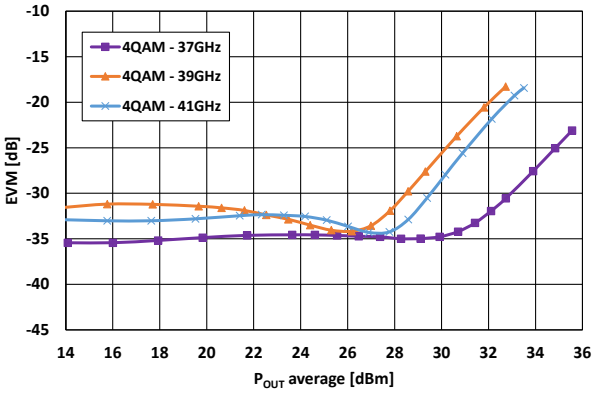
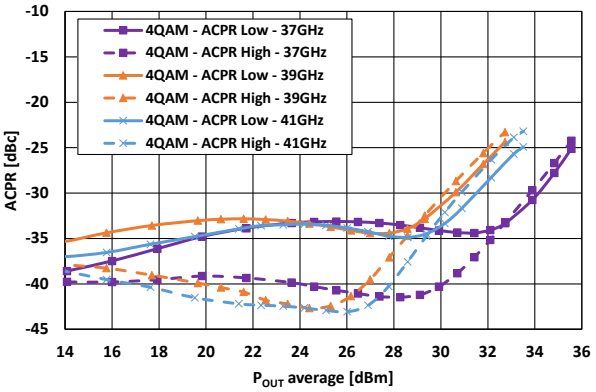
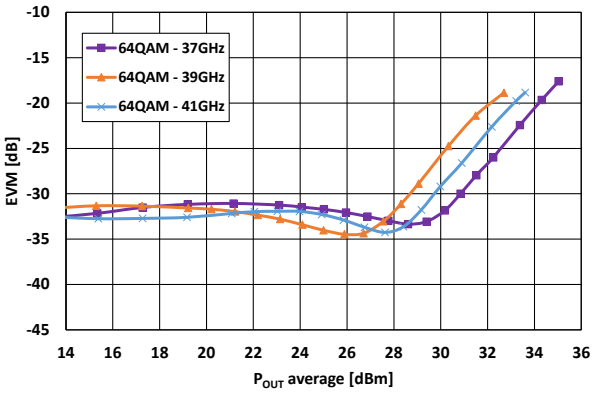
### 4QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C



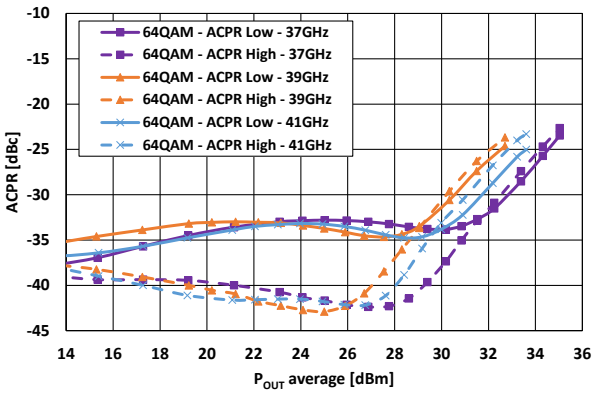

### 4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C



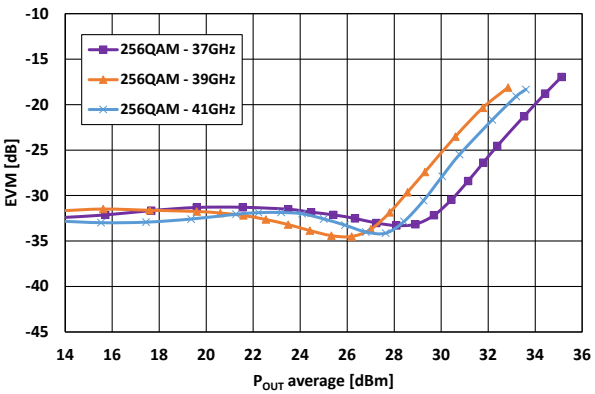

### 64QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C



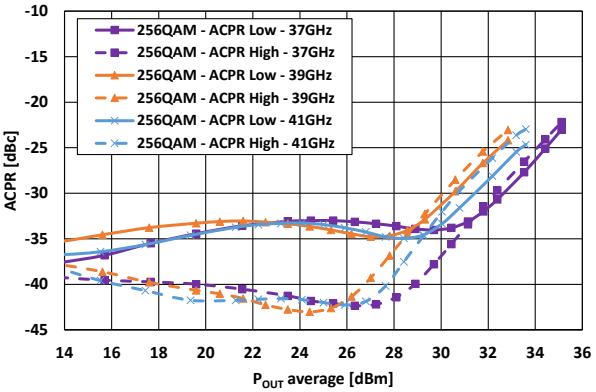

### 64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C




### 256QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C




### 256QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C



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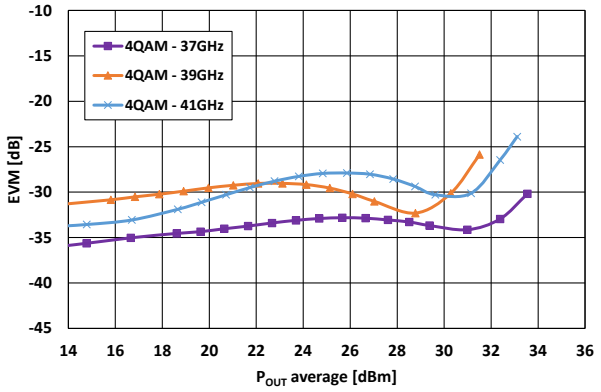
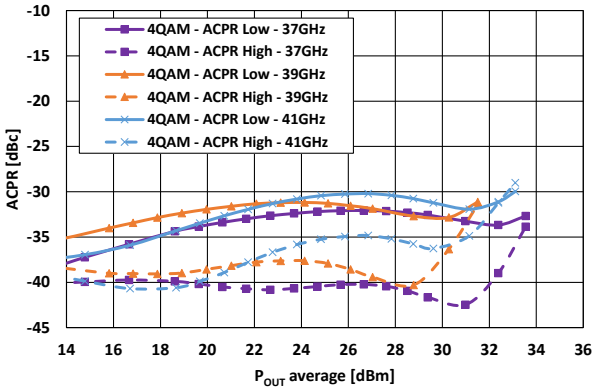
## Typical Board Measurements: Linearity performance with modulated signals

**Tcase = +85°C**, Vd = +25V, Idq = 150mA, 4QAM (PAPR ~ 5.2dB) / 64QAM (PAPR ~ 7.3dB) / 256QAM (PAPR ~ 7.3dB), **SR = 100MSym/s**, Roll-Off = 0.2, $f_{CARRIER}$ = 37/ 39/ 41GHz, Evaluation board decoupling : 10Ω+100pF / 10Ω+1nF/ 10Ω+1µF, QFN reference planes

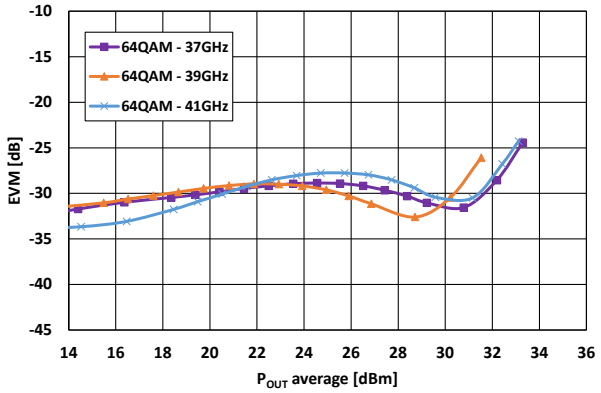
### 4QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



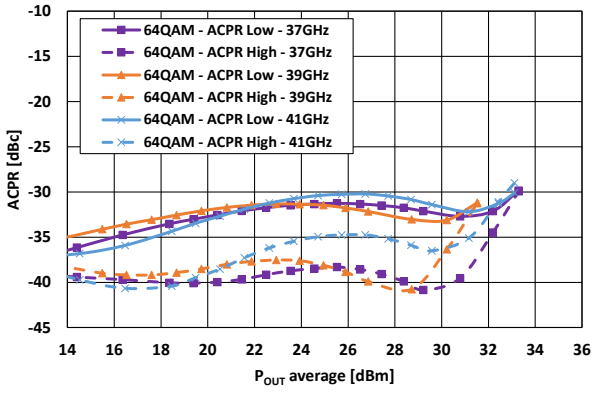

### 4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



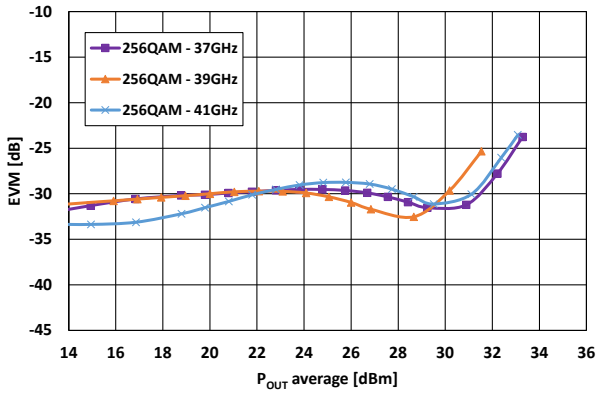

### 64QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



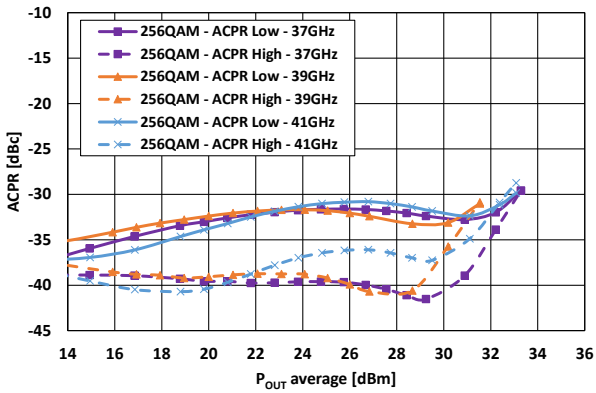

### 64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C




### 256QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C




### 256QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



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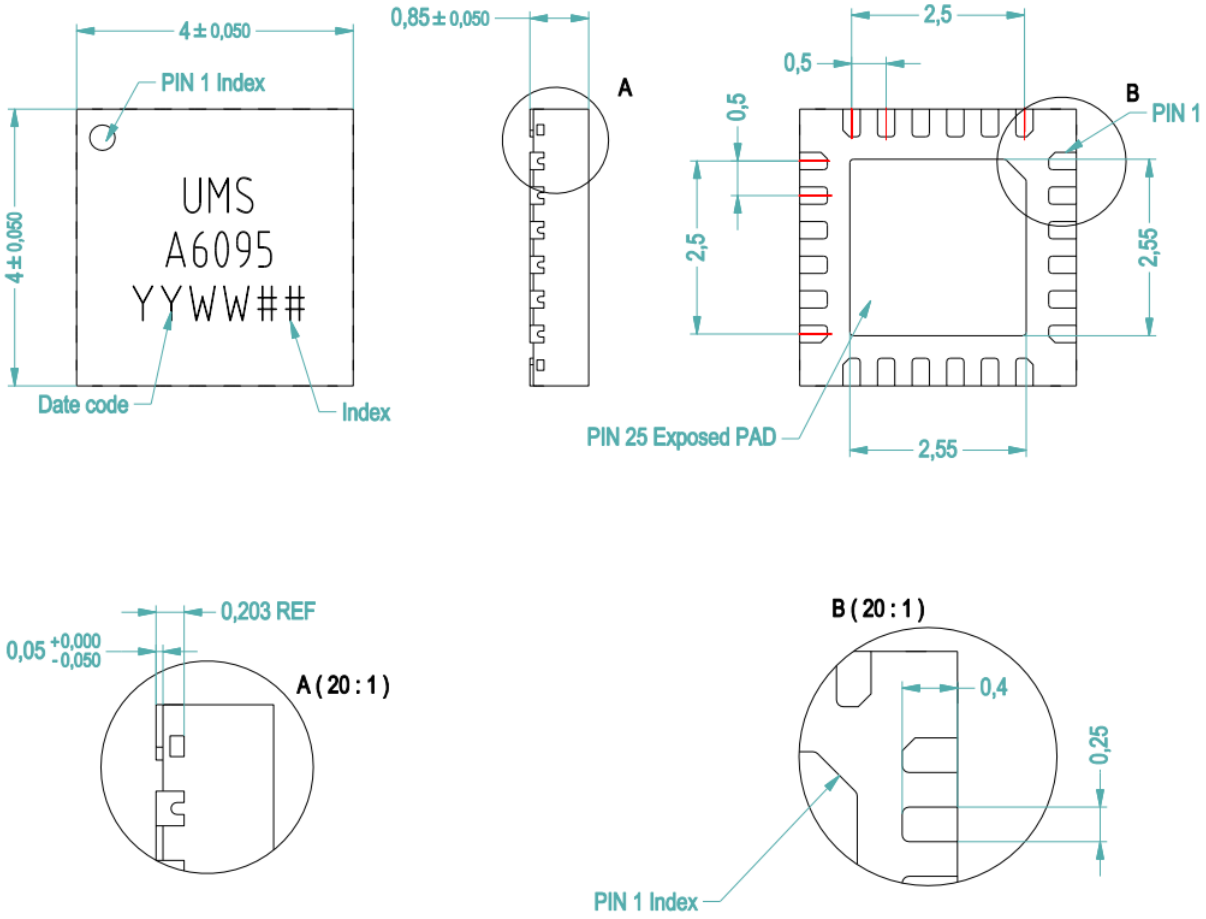
## Package outline (1)




## Package pinout

| | | | | |
|---|---|---|---|---|
| Ni-Pd-Au-Ag, Lead Free (Green) | 1- VG12N | 9- VG4S | 17- NC |
| Units : mm | 2- NC | 10- VD12S | 18- VD4N |
| From the standard : JEDEC MO-220 | 3- GND(2) | 11- VD3S | 19- GND(2) |
| (VGGD) | 4- RF in | 12- VD4S | 20- VD3N |
| 25- GND(2) | 5- GND(2) | 13- NC | 21- VD12N |
| NC : Not Connected | 6- NC | 14- GND(2) | 22- VG4N |
| | 7- VG12S | 15- RF out | 23- VG3N |
| | 8- VG3S | 16- GND(2) | 24- GND(2) |

(1) Refer to the application note AN0017 (https://www.ums-rf.com) for general consideration and recommendations for Molded Plastic QFN/DFN packages.
(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.
See application note AN0017 for details.



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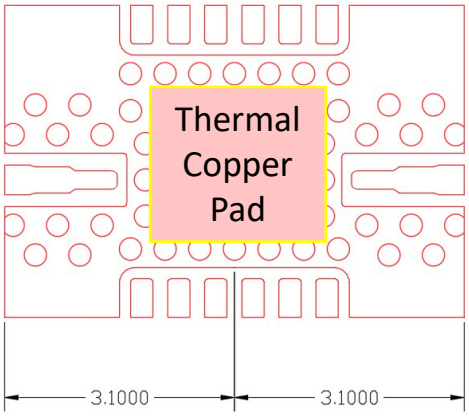
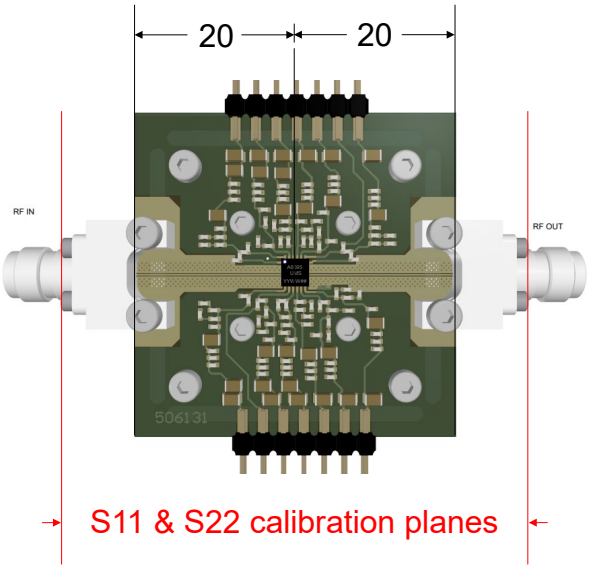
## Definition of the QFN reference planes

Reference planes used for S21 and Power measurements are symmetrical from the central axis of the package (see drawing beside). Input and output reference planes are located at 3.1mm offset (input wise and output wise respectively) from this axis.




## Definition of the evaluation board reference planes

Reference planes used for S11 and S22 measurements are symmetrical from the central axis of the package (see drawing beside also called calibration planes). Input and output reference planes are located at 20mm offset from the central axis. S11 and S22 measurements include this given PCB pattern,RF lines of the evaluation board and RF connectors.



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## ESD sensitivity

| Parameter | Classification | Standard |
|---|---|---|
| Human Body Model (HBM) | 1A | ANSI/ESDA/JEDEC - JS-001 |

## Package Information

| Parameter | Value |
|---|---|
| Package body material | RoHS-compliant |
| | Low stress Injection Molded Plastic |
| Lead finish | 100% Ni-Pd-Au-Ag |
| MSL Rating | MSL3 |



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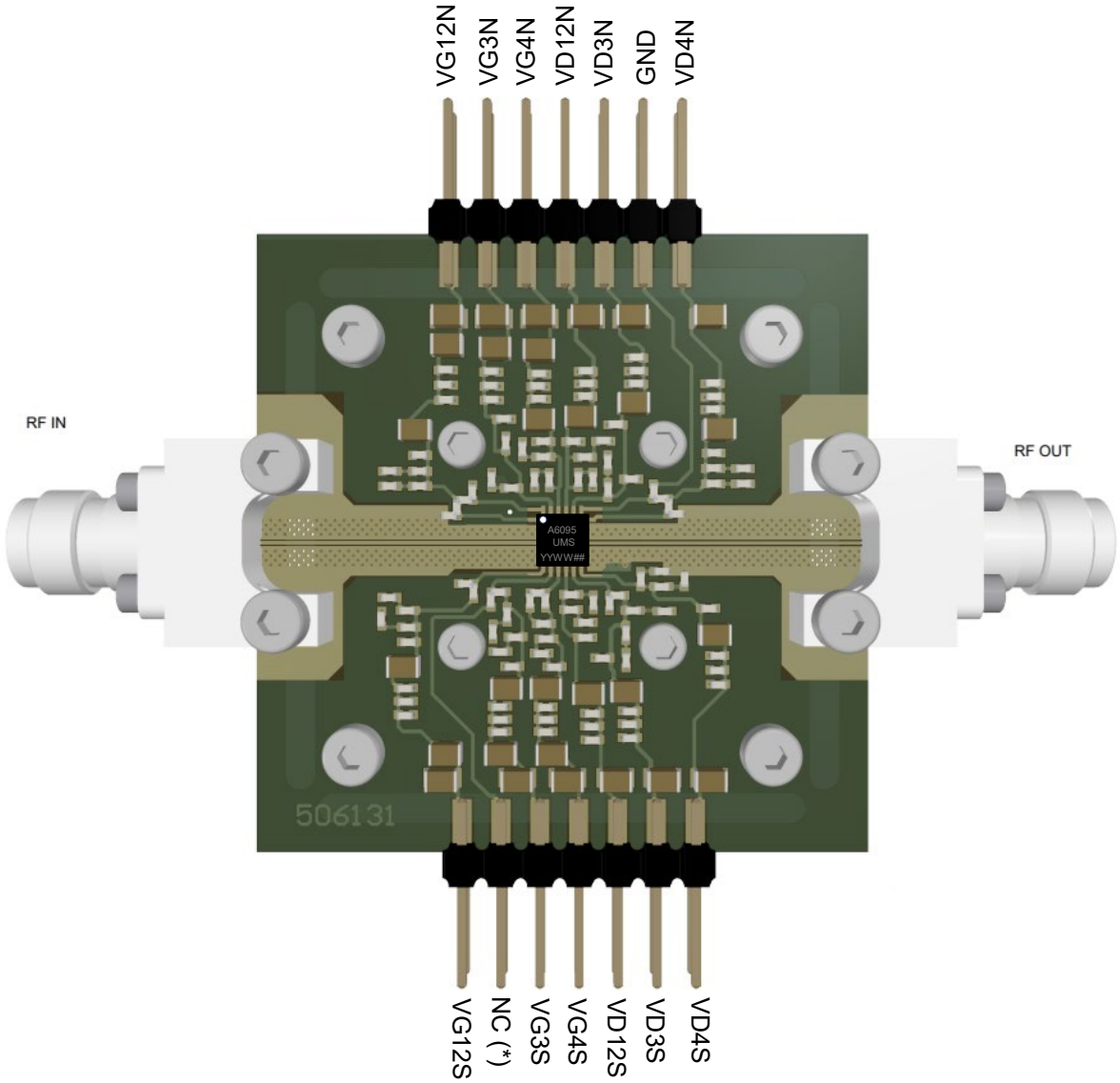
## Evaluation board

- Compatible with the proposed footprint.
- Based on typically MT77 / 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.
- Low frequency decoupling circuit of 10Ω ±10% resistor in series with 100pF ±5% capacitor, 10Ω ±10% resistor in series with 1nF ±10% capacitor and 10Ω ±10% resistor in series with 1µF ±10% capacitor are recommended for each DC access.
- To ensure safe operation, all measurements must be performed using **shielded cables**, **even for DC bias**.




(*) Pins not connected.



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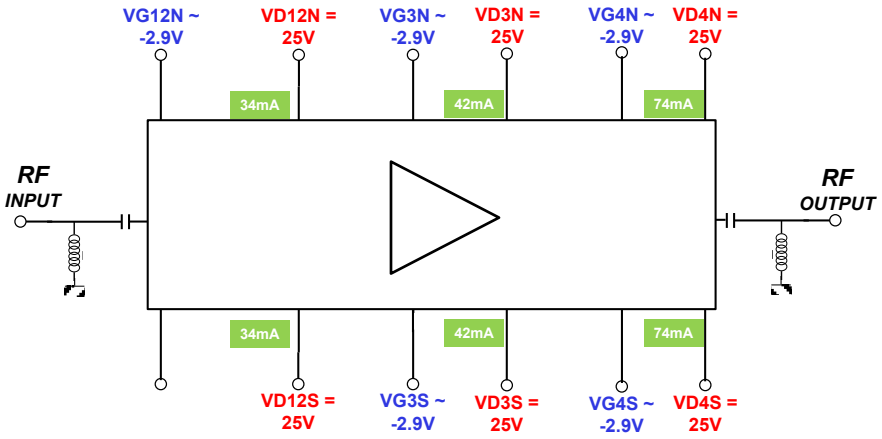
## DC Schematic




The DC pins do not include any decoupling capacitor in package, therefore it is mandatory to provide a good external DC decoupling (10Ω ±10% resistor in series with 100pF ±5% capacitor, 10Ω ±10% resistor in series with 1nF ±10% capacitor and 10Ω ±10% resistor in series with 1µF ±10% capacitor) on the PCB as close as possible to the QFN package.



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## Recommended package footprint

Refer to the application note AN0017 available at https://www.ums-rf.com for package foot print 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 at https://www.ums-rf.com.

## 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.

## Description of Evaluation Board

Refer to the application note AN0031 available at https://www.ums-rf.com for the description of Evaluation Board for Packaged Die and recommendations for this UMS package product.

## Ordering Information

| | | |
|---|---|---|
| QFN 4x4 package: | CHA6095-QKB/XY | |
| | Stick: XY = 20 | Tape & reel: XY = 21 |





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