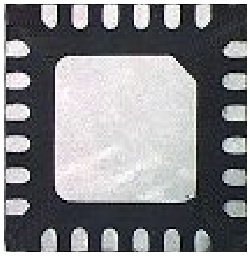
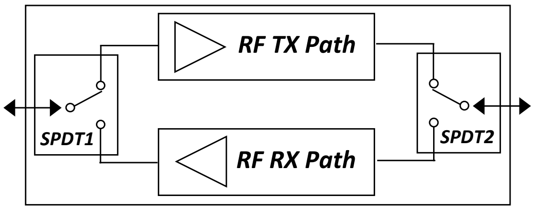
2W RF Front-End 37-41 GHz

GaN Monolithic Microwave IC in SMD leadless package

Description

The CHC6094-QKB is a multi-function monolithic packaged front-end operating in 37-41GHz band with a low noise high linearity amplifier, input/output switches and a linear efficient High Power Amplifier. It suits well for 5G terrestrial networks, high-throughput Fixed Wireless Access and phased array antennas. The transmit channel includes SWin+PA+SWout that provide 2W maximum power and 23dB linear Gain. SWout+LNA+SWin on the receive channel provide 4.8dB Noise Figure with 23dB Gain. This circuit is manufactured on a robust GaN-on-SiC HEMT technology. It is available in a standard surface mount 24 leads QFN4x4 internally matched to 50Ω.



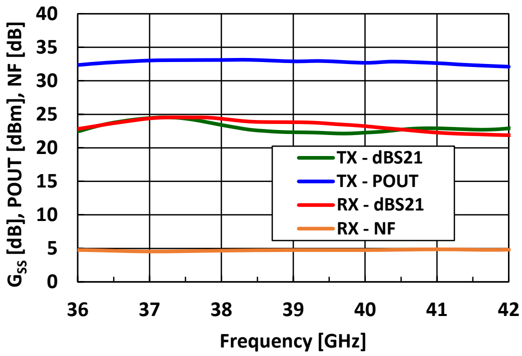


Main Features

- ■ Frequency range: 37-41GHz
- ■ Transmit linear Gain: 23dB
- ■ Transmit Pout: 33dBm @ 21dBm Pin
- ■ ACPR = -33dBc at 25dBm Average Pout(1)
- ■ Transmit DC bias: Vd=23V @ Idq=60mA
- ■ Receive linear Gain: 23dB
- ■ Receive Noise Figure : 4.8dB
- ■ Receive DC bias: Vd=12V @ Idq=40mA
- ■ 24L-QFN RoHS plastic package 4x4mm²
- ■ MSL3

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

Tx Max Output Power and Linear Gain
Rx Noise Figure and Gain at Tcase = 25°C



Main Electrical Characteristics

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

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	37		41	GHz
Tx P_{MAX}	Transmit Maximum Output Power at PAE_{MAX}		33		dBm
Tx Gain	Transmit Linear Gain		23		dB
Rx NF	Receive Noise Figure		4.8		dB
Rx Gain	Receive Linear Gain		23		dB

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Specifications – Tx Mode [1]

Tcase = +25°C, Vd,Tx = +23V, Tx turned ON / Rx turned OFF, (QFN reference planes)

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	37		41	GHz
Gain	Linear Gain		23		dB
IRL [2]	Input Return Loss		14		dB
ORL [2]	Output Return Loss		8		dB
P_{MAX}	Output Power at PAE_{MAX}		33		dBm
PAE_{MAX}	Maximum Power Added Efficiency		13		%
Tx ACPR	Transmit ACPR@ P_{AVG}=25dBm, 256QAM 120MHz modulation bandwidth		-33		dBc
Tx EVM	Transmit EVM @ P_{AVG}=25dBm for 256QAM, 120MHz modulation bandwidth		-31		dB
Vd	Drain bias Voltage		23		V
Vg	Gate bias Voltage		-3		V
Idq	Quiescent Drain bias current		60		mA

Specifications – Rx Mode [1]

Tcase = +25°C, Vd,Rx = +12V, Rx turned ON / Tx turned OFF, (QFN reference planes)

Symbol	Parameter	Min	Typ	Max	Unit
Freq	Frequency range	37		41	GHz
Gain	Linear Gain		23		dB
IRL [2]	Input Return Loss		12		dB
ORL [2]	Output Return Loss		10		dB
NF	Noise Figure		4.8		dB
Pin1dB	Input power at 1dB compression		-12		dBm
P_{MAX}	Maximum Output Power		19		dBm
Vd	Drain bias Voltage		12		V
Vg	Gate bias Voltage		-3		V
Idq	Quiescent current		40		mA

[1] These values are representative of on-board measurements as defined on the drawing in paragraph "Evaluation board".

[2] Input and Output Return Loss are given at RF reference planes of Evaluation board (see Definition of the evaluation board reference planes section).

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Absolute Maximum Ratings – Tx Mode [1]

Tcase = +25°C

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	27	V
Idq	Drain bias current	100	mA
Vg	Gate bias voltage	-7 to -2.6	V
VCN	Tx Switch bias voltage	27	V
Pin	Input Power	24	dBm

Absolute Maximum Ratings – Rx Mode [1]

Tcase = +25°C

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	15	V
Idq	Drain bias current	100	mA
Vg	Gate bias voltage	-7 to -2	V
VCS	Rx Switch bias voltage	27	V
Pin	Input Power	13	dBm

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

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Recommended Operating Range – Tx Mode (1), (2)

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	23	V
Id	Drain bias current	60 - 75	mA
Vg	Gate bias voltage	-5 to -3	V
VCN	Tx Switch bias voltage	23	V
Pin	Input Power	7 - 22	dBm
Tj	Maximum Junction temperature (3)	200	°C

Recommended Operating Range – Rx Mode (1), (2)

Symbol	Parameter	Values	Unit
Vd	Drain bias voltage	12	V
Id	Drain bias current	40 - 60	mA
Vg	Gate bias voltage	-5 to -2.8	V
VCS	Rx Switch bias voltage	23	V
Pin	Input Power	13	dBm
Tj	Maximum Junction temperature (3)	150	°C

(1) Electrical performances are defined for specified test conditions

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

(3) See Device thermal performances section

Temperature Range

Tcase	Operating temperature range	-30 to +85	°C
Tstg	Storage temperature range	-55 to +150	°C

Typical Bias Conditions

Tcase = +25°C

Symbol	Pad N	Parameter	Tx mode	Rx mode	Unit
VG12	24	1st HPA Gate bias voltage	-3	0	V
VG3	23	2nd HPA Gate bias voltage	-3	0	V
VG4	22	3th HPA Gate bias voltage	-3	0	V
VD12	21	1st HPA Drain bias voltage	23	0	V
VD3	20	2nd HPA Drain bias voltage	23	0	V
VD4	19	3th HPA Drain bias voltage	23	0	V
VCN	8	Tx Switch bias voltage	23	0	V
VCS	7	Rx Switch bias voltage	0	23	V
VGL	9	LNA Gate bias voltage	0	-3	V
VDL	11	LNA Drain bias voltage	0	12	V
Id,Tx	21,20,19	Total HPA Drain current	60	0	mA
Ig,Tx	24,23,22	Total HPA Gate current	0	0	mA
Id,Rx	11	Total LNA Drain current	0	40	mA
Ig,Rx	9	Total LNA Gate current	0	5	mA

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Biasing procedure – Tx Mode

"Power ON" sequence

1. Bias LNA Drain voltage VDL at 0V (Ground), Id,Rx=0mA
2. Bias LNA Gate voltage VGL at 0V (Ground), Id,Rx=0mA
3. Set Rx Switch voltage VCS to 0V
4. Set Tx Switch voltage VCN to 23V
5. Bias HPA Gate voltage Vg,Tx close to Vpinch-off (Typically: Vg ≈ -5V), Id,Tx=0mA
6. Apply HPA Drain voltage Vd,Tx (Typically: Vd = 23V), Id,Tx=0mA
7. Increase HPA Gate voltage Vg,Tx up to quiescent HPA bias drain current Idq,Tx
8. Apply RF signal

"Power OFF" sequence

1. Turn off RF signal
2. Bias HPA Gate voltage Vg,Tx close to Vpinch-off (Typically: Vg ≈ -5V), Id,Tx=0mA
3. Turn HPA Drain voltage Vd,Tx to 0V, Id,Tx=0mA
4. Turn HPA Gate voltage Vg,Tx to 0V, Id,Tx=0mA
5. Set Tx Switch voltage VCN to 0V

Biasing procedure – Rx Mode

"Power ON" sequence

1. Bias HPA Drain voltage Vd,Tx at 0V (Ground), Id,Tx=0mA
2. Bias HPA Gate voltage Vg,Tx at 0V (Ground), Id,Tx=0mA
3. Set Tx Switch voltage VCN to 0V
4. Set Rx Switch voltage VCS to 23V
5. Bias LNA Gate voltage VGL close to Vpinch-off (Typically: Vg ≈ -5V), Id,Rx=0mA
6. Apply LNA Drain voltage VDL (Typically: Vd = 12V), Id,Rx=0mA
7. Increase LNA gate voltage VGL up to quiescent LNA bias drain current Idq,Rx
8. Apply RF signal

"Power OFF" sequence

1. Turn off RF signal
2. Bias LNA Gate voltage VGL close to Vpinch-off (Typically: Vg ≈ -5V), Id,Rx=0mA
3. Turn LNA Drain voltage VDL to 0V, Id,Rx=0mA
4. Turn LNA Gate voltage VGL to 0V, Id,Rx=0mA
5. Set Rx Switch voltage VCS to 0V

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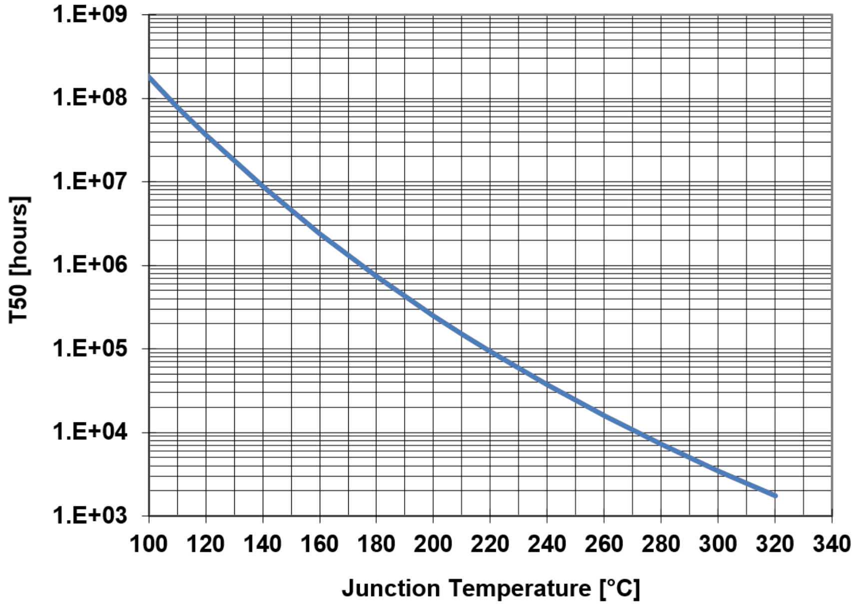
Device thermal performances – Tx Mode

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	DC & RF conditions	Tjunction (°C)	RTH (°C/W)	T50 (hours)
RTH (1) Thermal Resistance (Junction to Case)	Vd= 23V Idq= 60mA Pout= 23dBm Pdiss= 6W	135	8.33	1E+07
	Vd= 23V Idq= 60mA Pout= 31.5dBm Pdiss= 10.8W	200	10.64	2.5E+05

(1) Assuming 85°C Tcase



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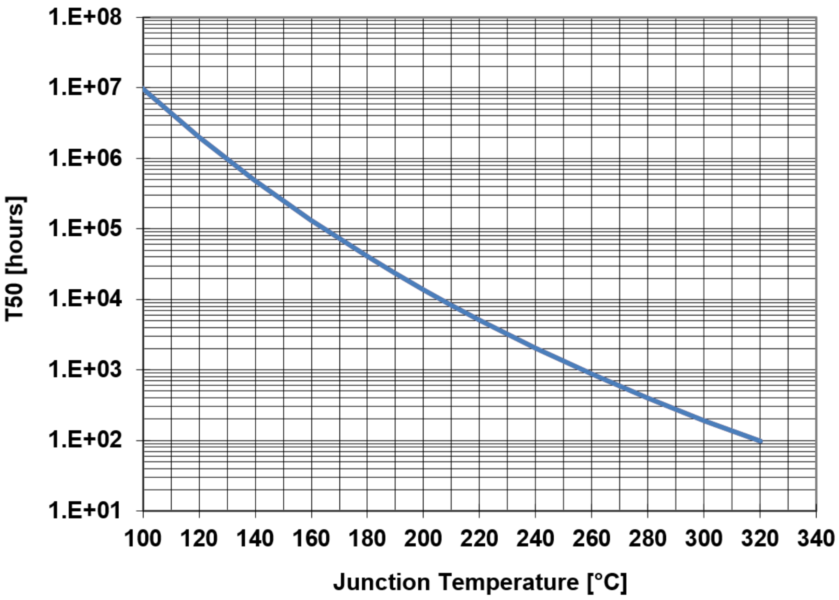
Device thermal performances – Rx Mode

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	DC & RF conditions	Tjunction (°C)	R_{TH} (°C/W)	T50 (hours)
R_{TH} [1] Thermal Resistance (Junction to Case)	Vd= 12V Idq= 40mA Pout= 19dBm Pdiss= 0.82W	133	58.5	7.5E+05

[1] Assuming 85°C Tcase



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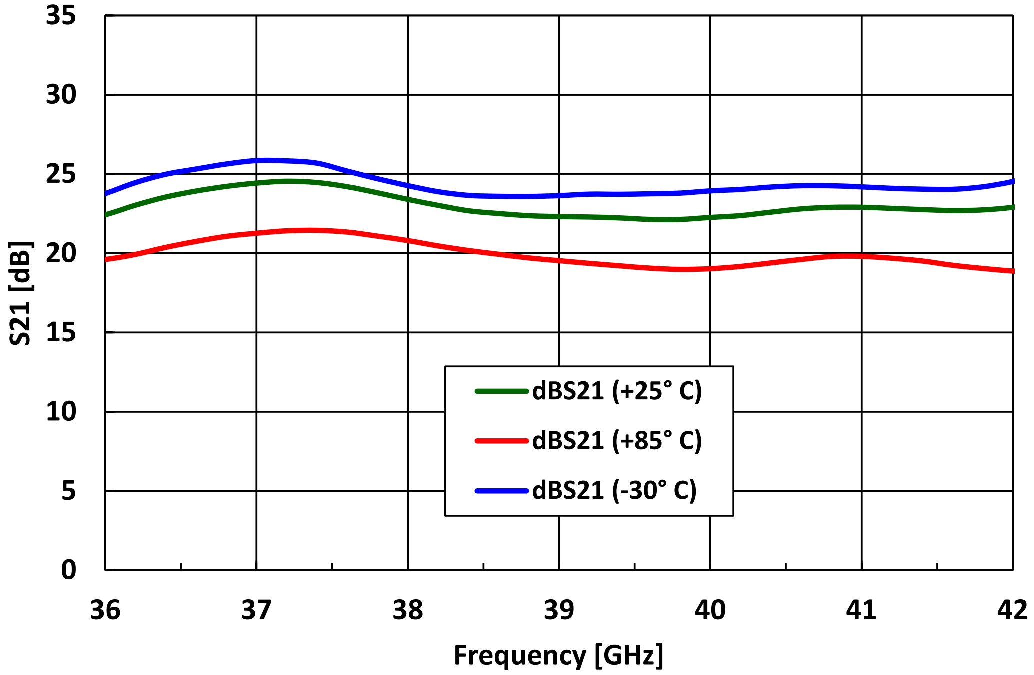
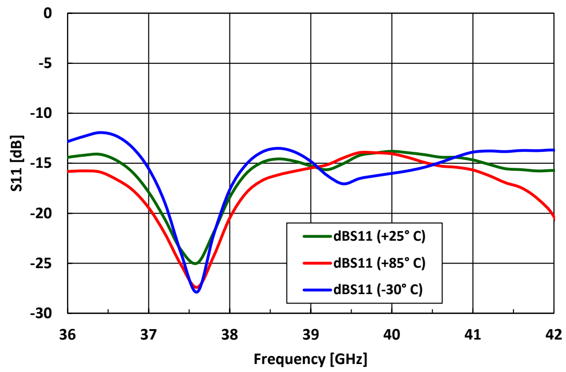
Typical Board Measurements: Small signal performance – Tx mode

Tcase = -30 / +25 / +85°C, Vd = +23V, Idq = 60mA; CW mode

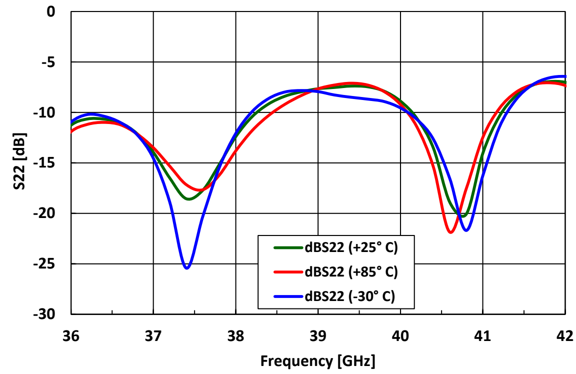
Linear Gain [dB] vs. Freq [GHz] (1)



Input Return Loss [dB] vs. Freq [GHz](2)



Output Return Loss [dB] vs. Freq [GHz](2)



(1) QFN reference planes
(2) Evaluation board reference planes

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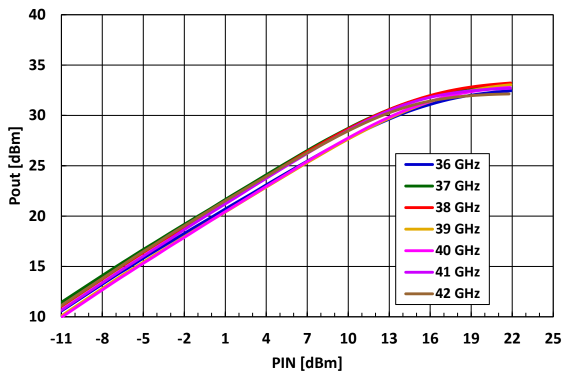
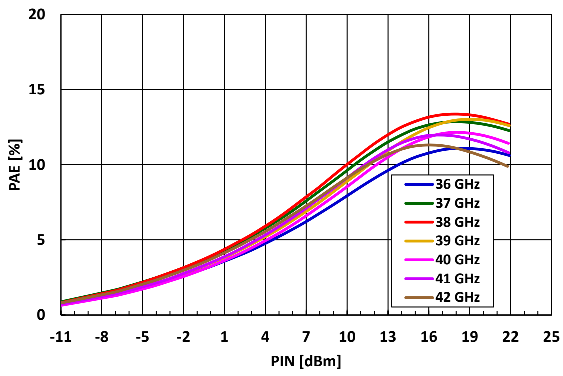
Typical Board Measurements: Large signal performance – Tx Mode

Tcase = +25°C, Vd = +23V, Idq = 60mA, CW mode, QFN reference planes

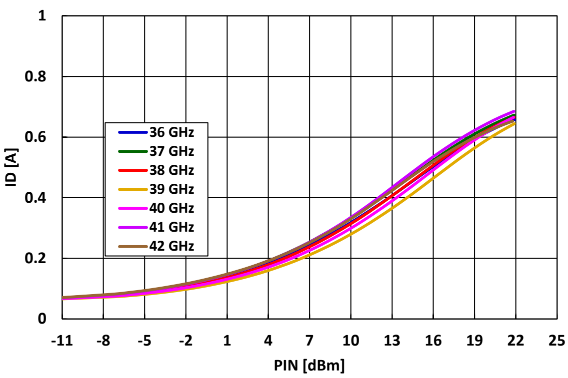
Output Power [dBm] vs. Input Power [dBm]



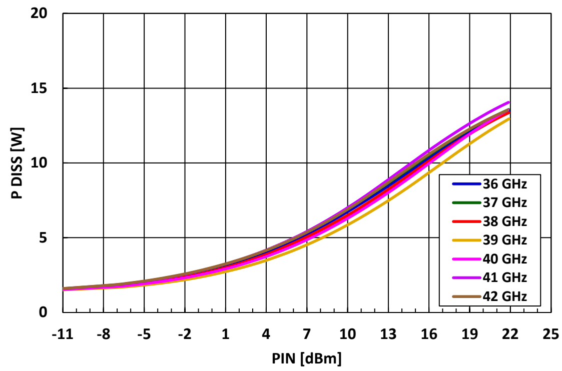
Power Added Efficiency [%] vs. Input Power [dBm]



Drain current [A] vs. Input Power [dBm]



Dissipated power [W] vs. Input Power [dBm]



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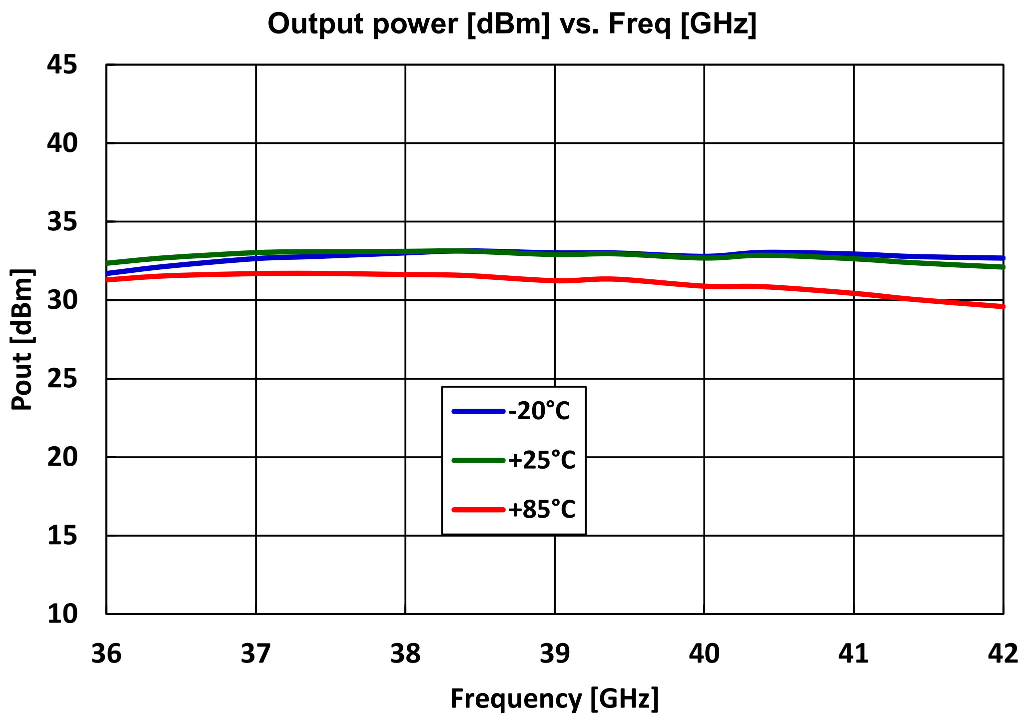
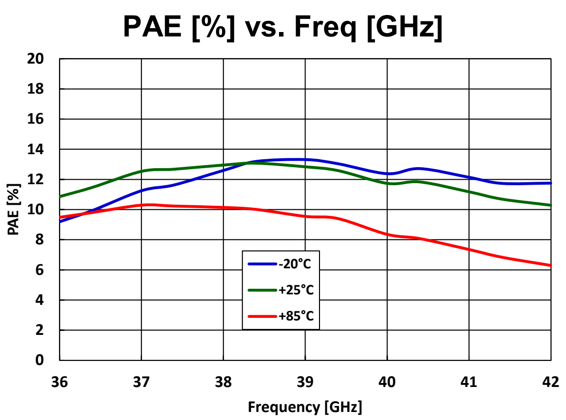
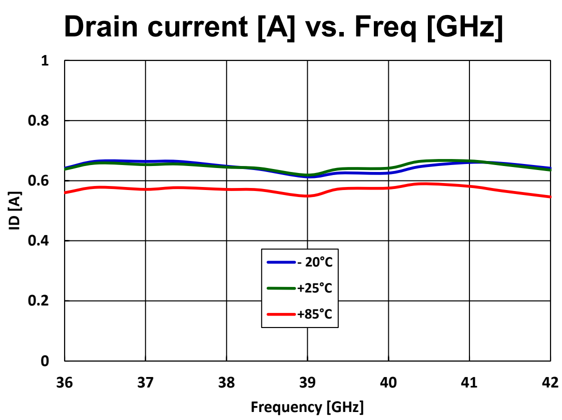
Typical Board Measurements: Large signal performance – Tx Mode

Tcase = -20/ +25 / +85°C, Vd = +23V, Idq = 60mA, Pin = 21dBm, CW mode, QFN reference planes







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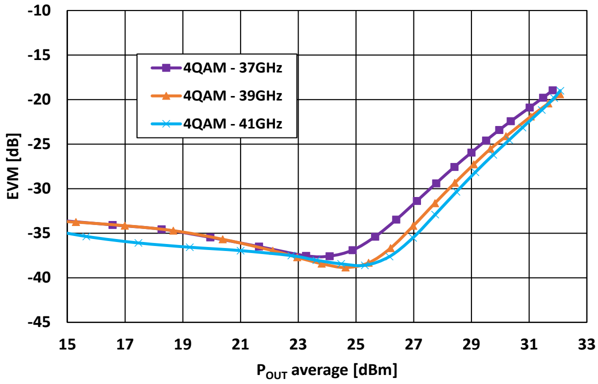
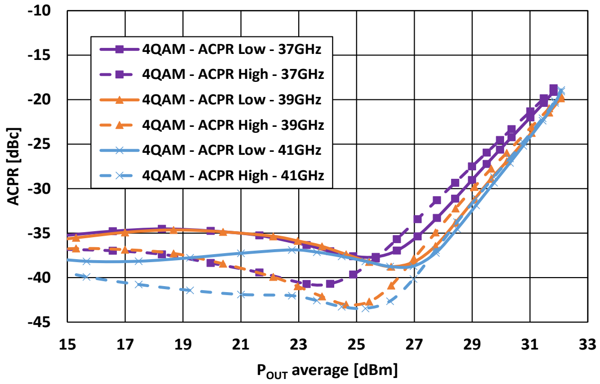
Typical Board Measurements: Linearity performance with modulated signals – Tx Mode

Tcase = +25°C, Vd = +23V, Idq = 60mA, 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

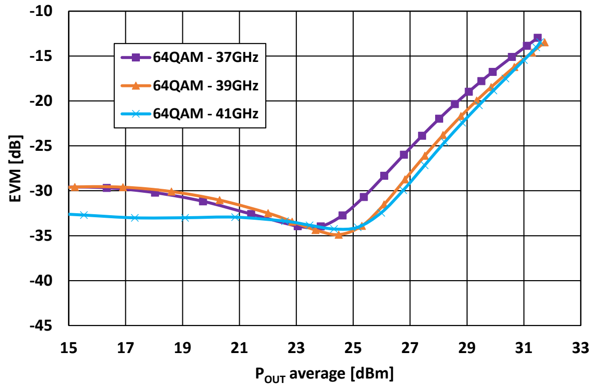
4QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C



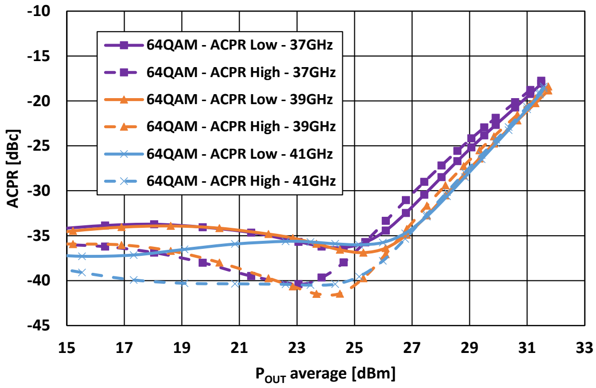
4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C



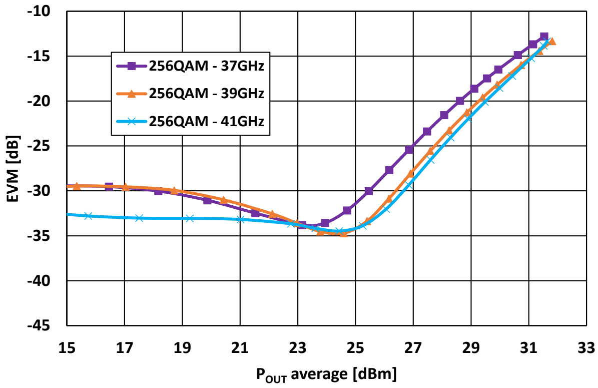
64QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C



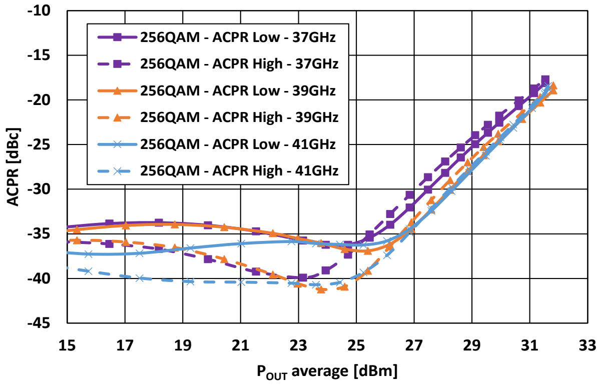
64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C



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



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



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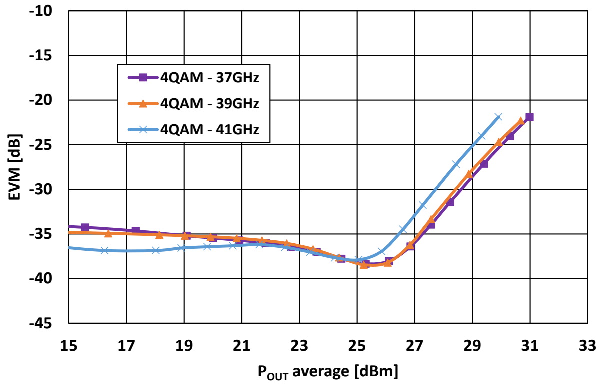
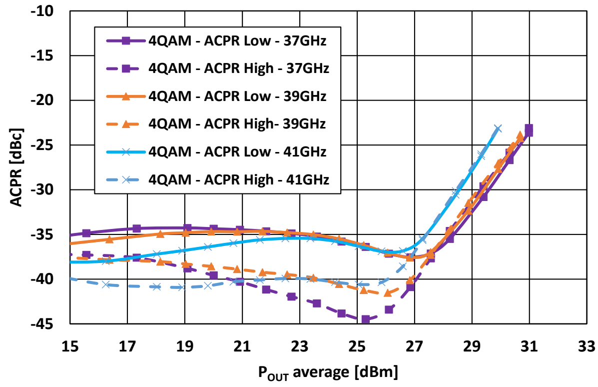
Typical Board Measurements: Linearity performance with modulated signals – Tx Mode

Tcase = +85°C, Vd = +23V, Idq = 60mA, 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

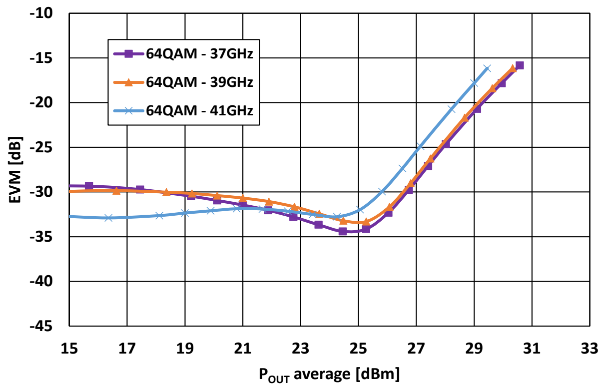
4QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



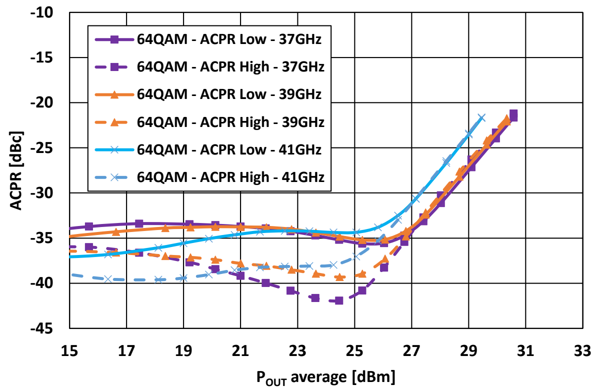
4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



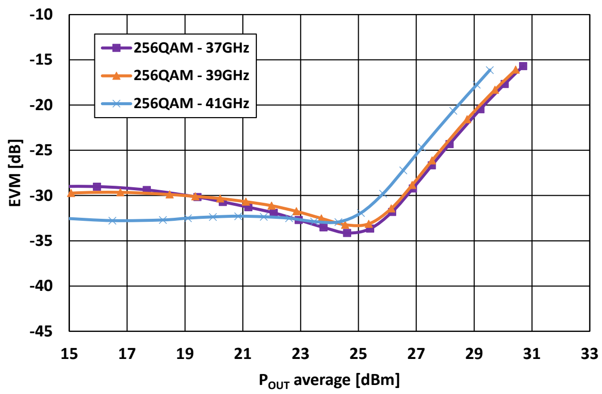
64QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



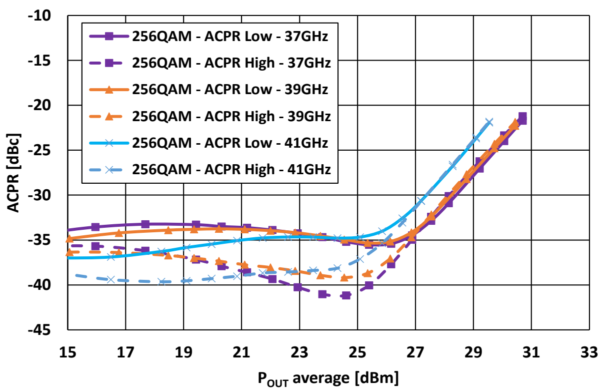
64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



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 – Tx Mode

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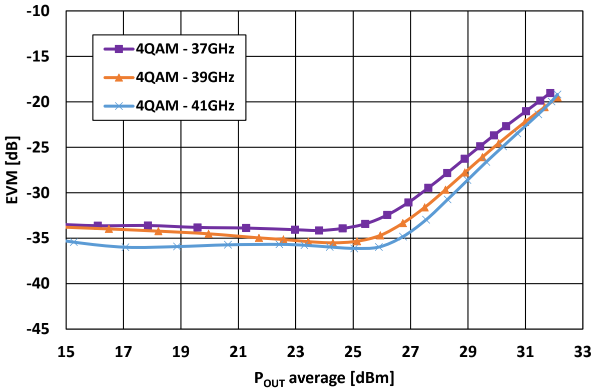
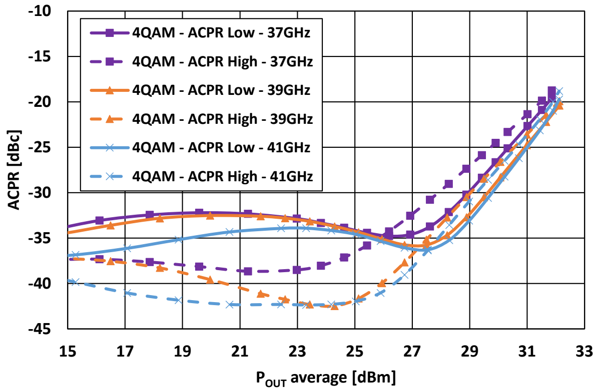
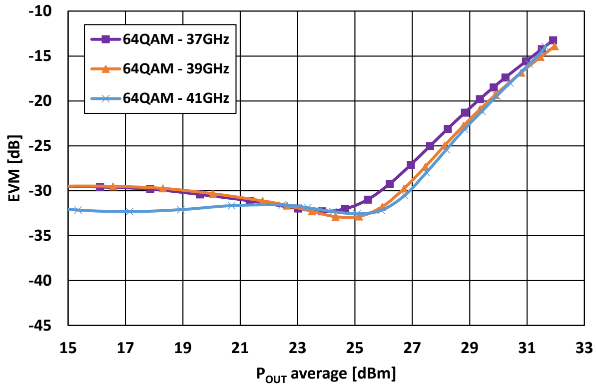
4QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C



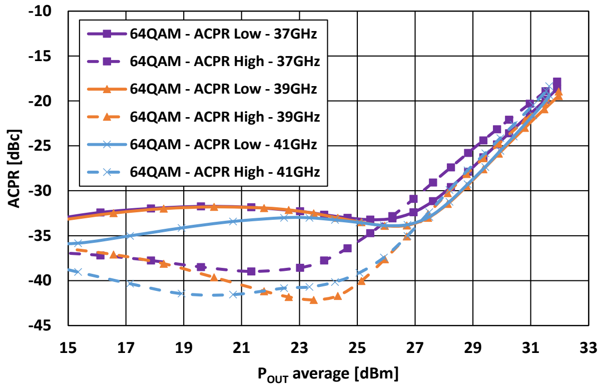
4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C



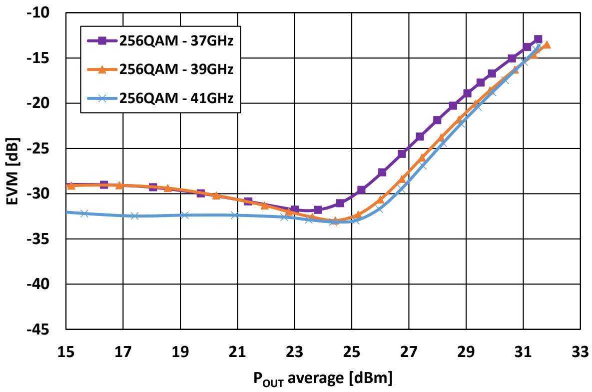
64QAM: EVM [dB] vs. Average Output Power [dBm] @ 25°C



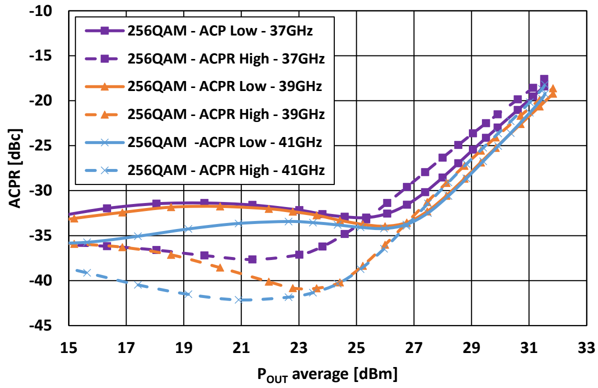
64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 25°C



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



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



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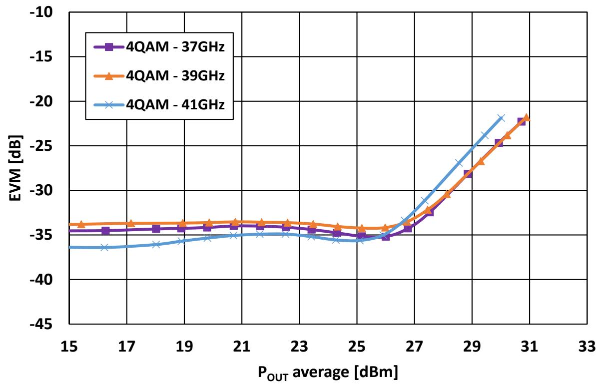
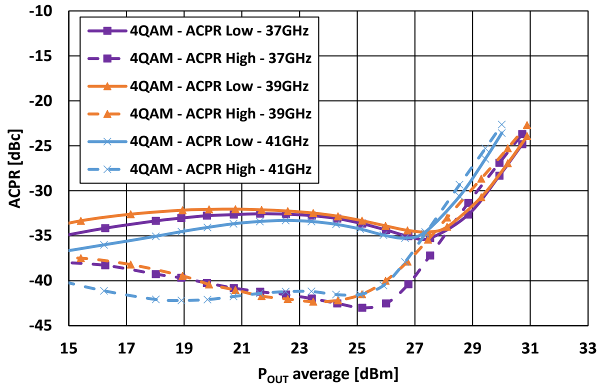
Typical Board Measurements: Linearity performance with modulated signals – Tx Mode

Tcase = +85°C, Vd = +23V, Idq = 60mA, 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

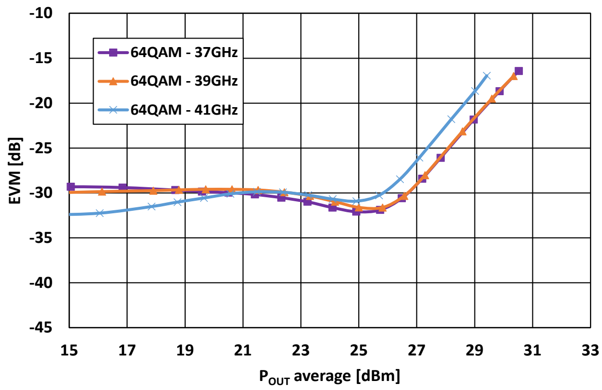
4QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



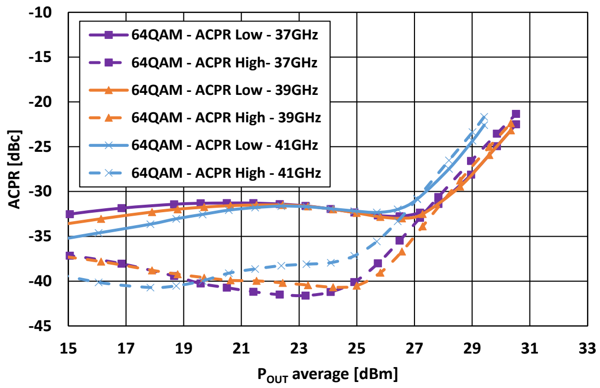
4QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



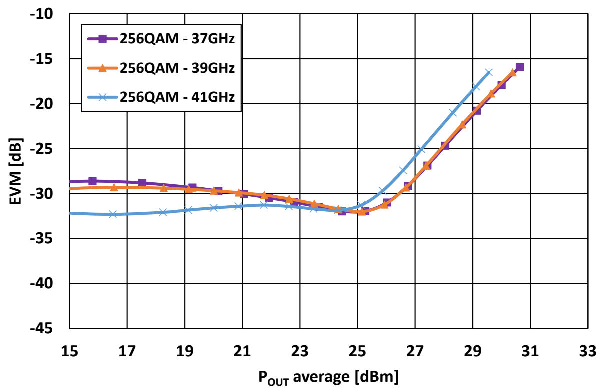
64QAM: EVM [dB] vs. Average Output Power [dBm] @ 85°C



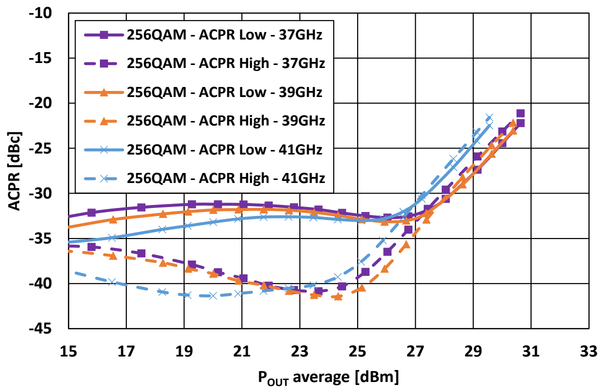
64QAM: ACPR [dBc] vs. Average Output Power [dBm] @ 85°C



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



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



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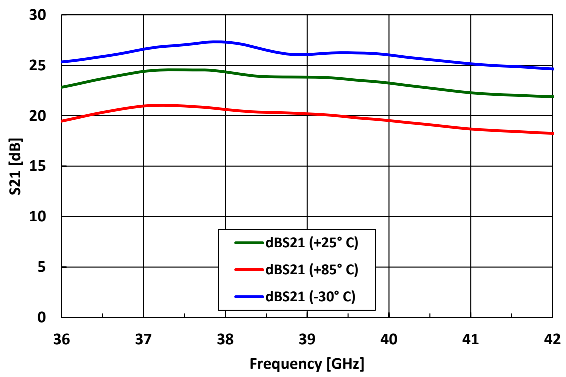
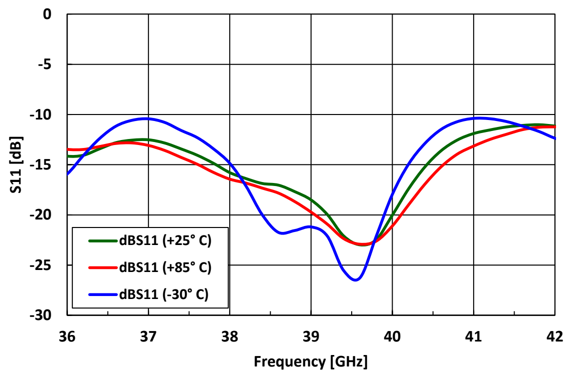
Typical Board Measurements: Small signal performance – Rx Mode

Tcase = -30/ +25/ +85°C, Vd = +12V, Idq = 40mA; CW mode

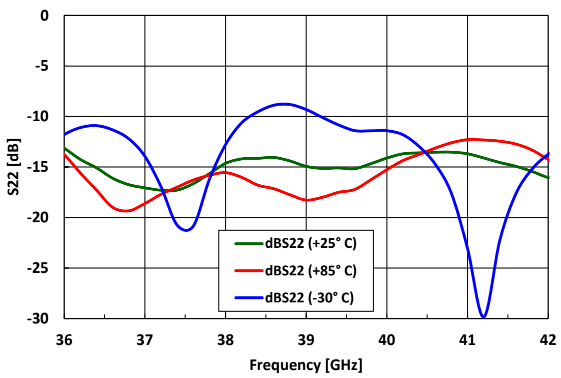
Linear Gain [dB] vs. Freq [GHz][1]



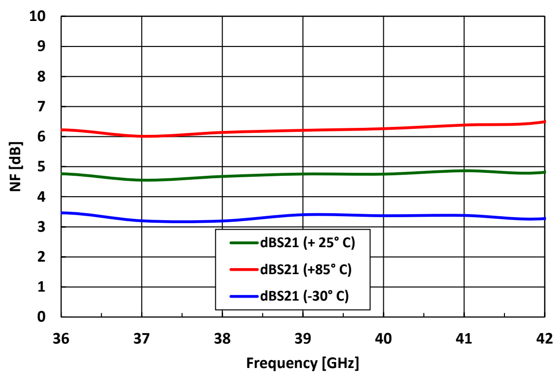
Input Return Loss [dB] vs. Freq [GHz][2]



Output Return Loss [dB] vs. Freq [GHz][2]



Noise Figure [dB] vs. Freq [GHz][1]



(1) QFN reference planes
(2) Evaluation board reference planes

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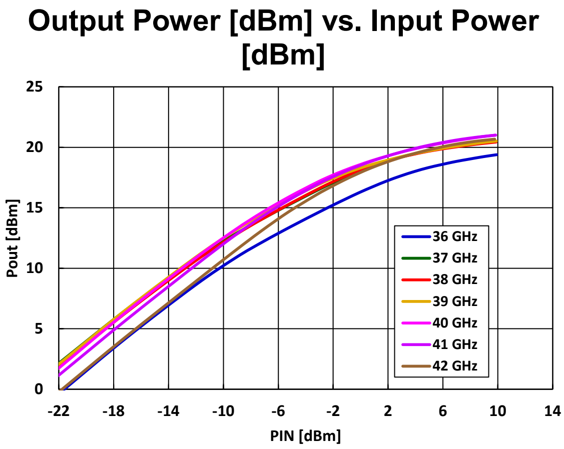
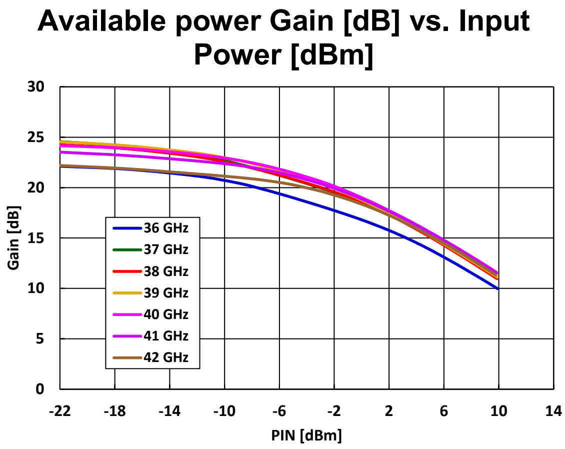
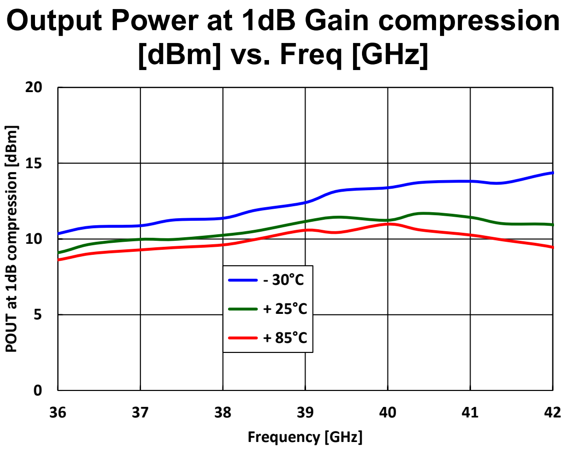
Typical Board Measurements: Large signal performance – Rx Mode

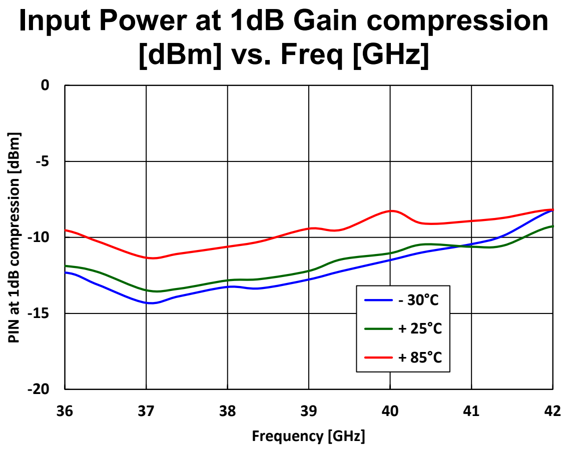
Tcase = +25°C, Vd = +12V, Idq = 40mA, CW mode, QFN reference planes





Tcase = -30 / +25 / +85°C, Vd = +12V, Idq = 40mA, CW mode, QFN reference planes





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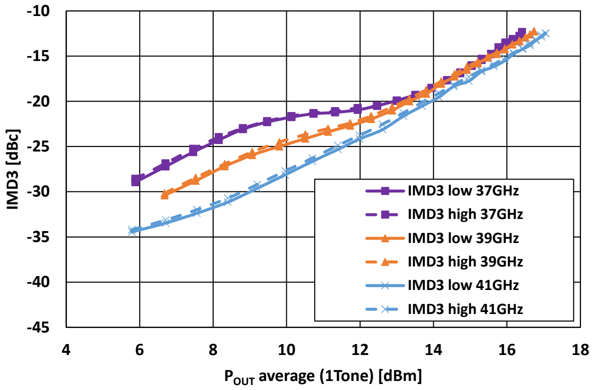
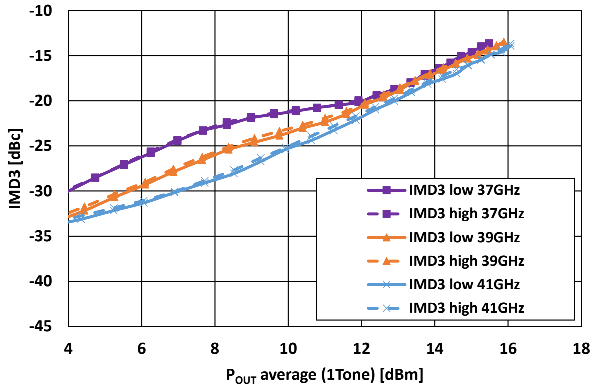
Typical Board Measurements: Large signal 2Tone – Rx Mode

Tcase= +25/ 85°C, Vd = +12V, Idq = 40mA, $f_{CARRIER}$ = 37/ 39/ 41GHz, Δf = 1/ 10/ 100MHz, QFN reference planes

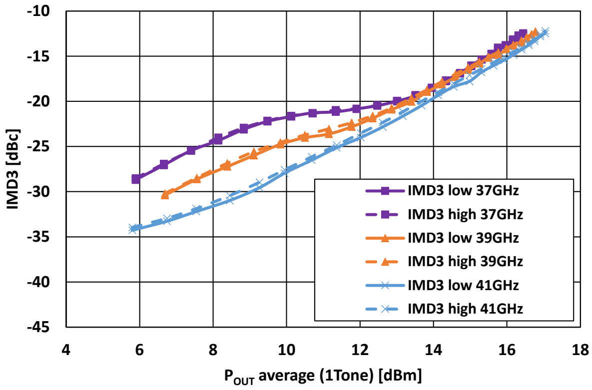
Δf = 1MHz / 25°C : IMD3 [dBc] vs. Average Output Power / tone [dBm]



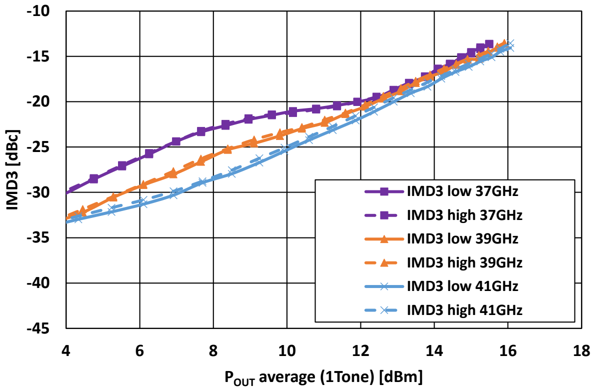
Δf = 1MHz / 85°C : IMD3 [dBc] vs. Average Output Power / tone [dBm]



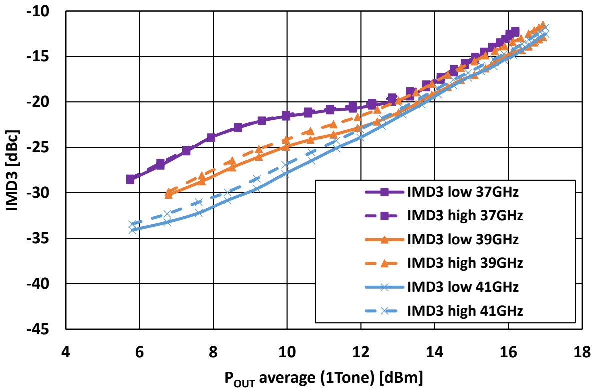
Δf = 10MHz / 25°C : IMD3 [dBc] vs. Average Output Power / tone [dBm]



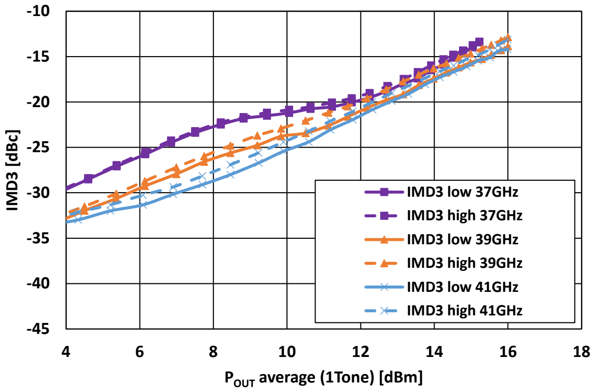
Δf = 10MHz / 85°C : IMD3 [dBc] vs. Average Output Power / tone [dBm]



Δf = 100MHz / 25°C : IMD3 [dBc] vs. Average Output Power / tone [dBm]



Δf = 100MHz / 85°C : IMD3 [dBc] vs. Average Output Power / tone [dBm]



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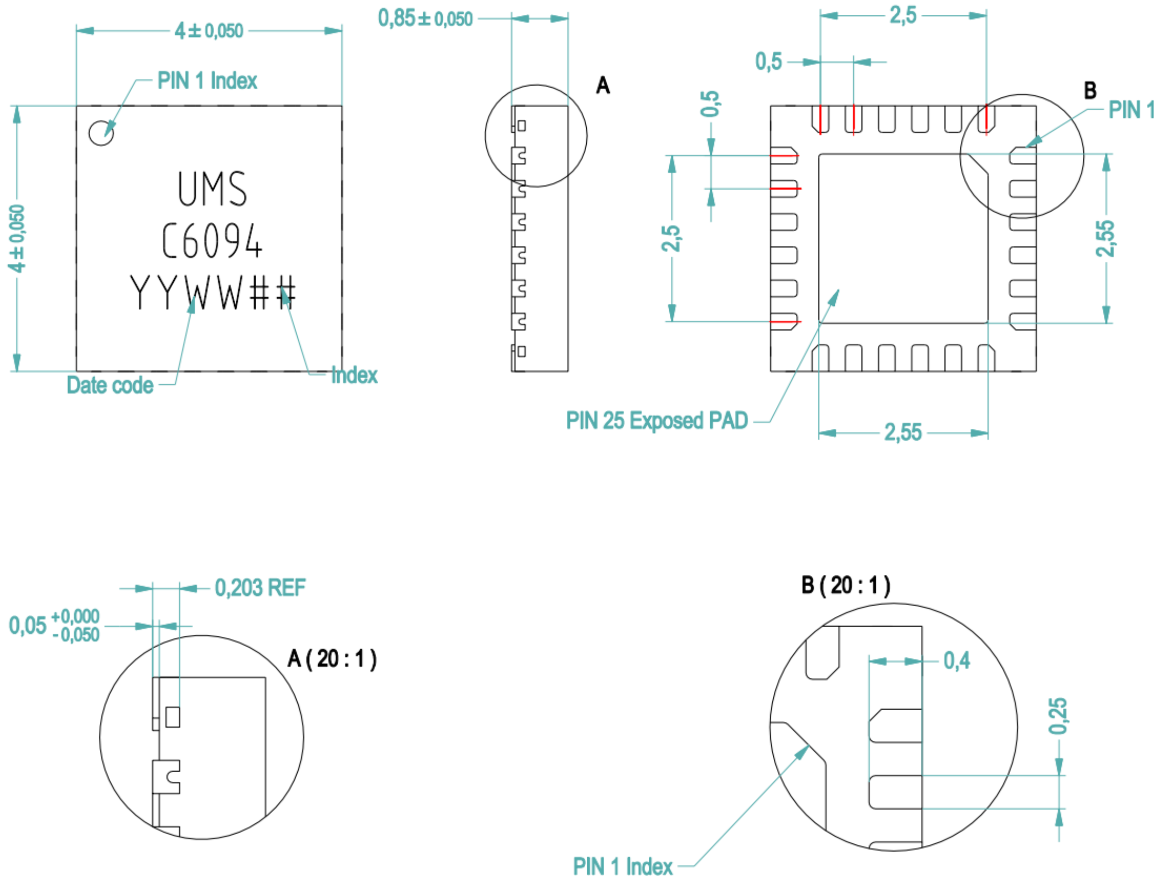
Package outline (1)



Package pinout

Ni-Pd-Au-Ag, Lead Free	(Green)	1- NC	9- VGL	17- NC
Units :	mm	2- NC	10- GND (2)	18- NC
From the standard :	JEDEC MO-220	3- GND (2)	11- VDL	19- VD4
	(VGGD)	4- RF IN	12- GND (2)	20- VD3
NC :	Not Connected	5- GND (2)	13- NC	21- VD12
25-	GND (2)	6- NC	14- GND (2)	22- VG4
		7- VCS	15- RF OUT	23- VG3
		8- VCN	16- GND (2)	24- VG12

(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.

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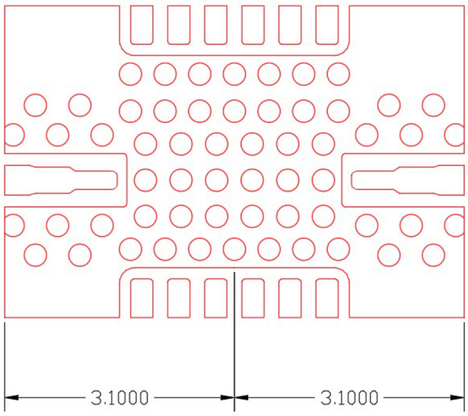
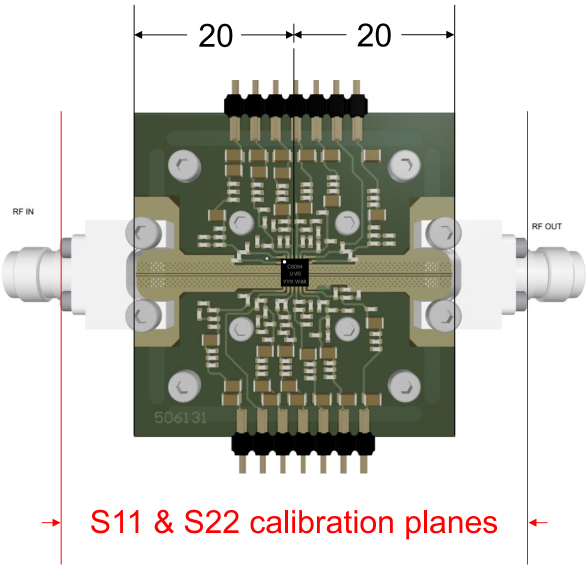
Definition of the QFN reference planes

The reference planes used for S21 and Power measurements are symmetrical from the central axis of the package (see drawing beside). The 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

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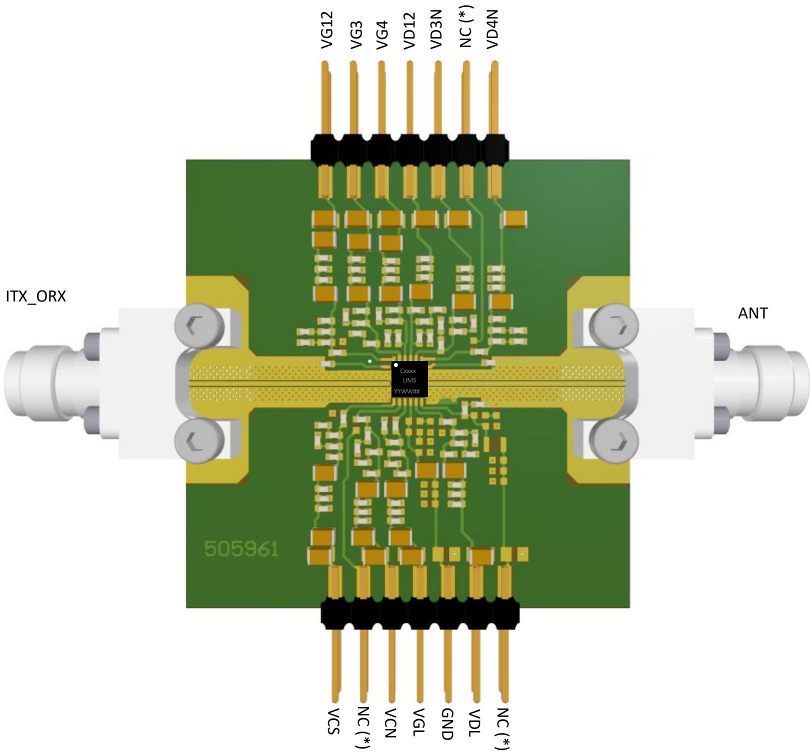
Evaluation board

■ 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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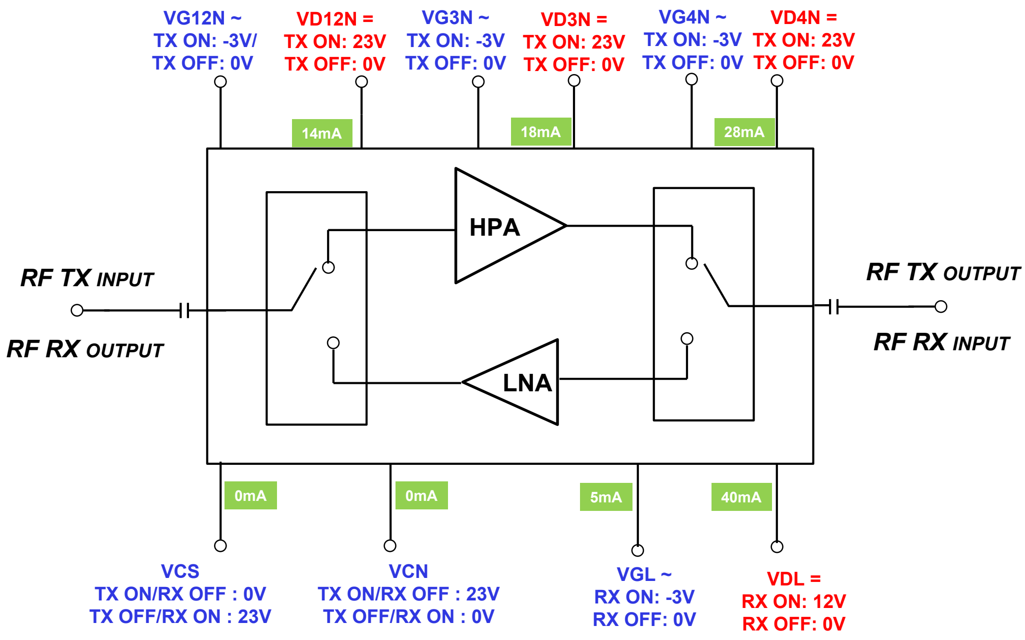
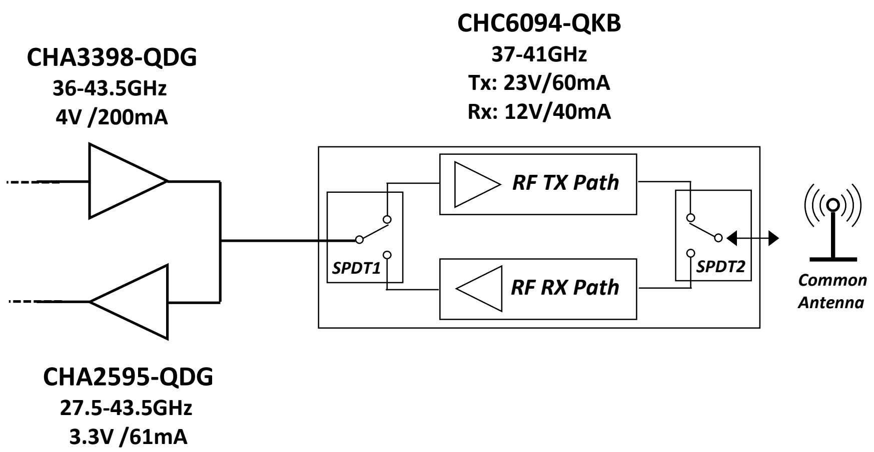
DC Schematic



The DC connections 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 package.

Recommended UMS Power Chain

The CHC6094-QKB is recommended with the CHA3398-QDG as driver for a total linear gain of 44dB and CHA2595-QDG as LNA for a total linear gain of 42dB or adequate beamformer chip.



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Notes

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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.

Ordering Information

QFN 4x4 package:	CHC6094-QKB/XY	
	Stick: XY = 20	Tape & reel: XY = 21

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