QPA1010

7.9 – 11 GHz 25 Watt GaN Power Amplifier

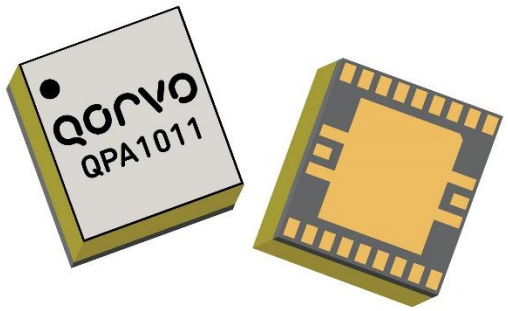
Product Overview

Qorvo's QPA1010 is a X-band high power MMIC amplifier fabricated on Qorvo's production 0.15um GaN on SiC process (QGaN15). The QPA1010 operates from 7.9 – 11 GHz and typically provides 15 W saturated output power with power-added efficiency of 38% and large-signal gain of 18 dB. This combination of wideband performance provides the flexibility designers are looking for to improve system performance while reducing size and cost.

QPA1010 can also support a variety of operating conditions to best support system requirements. With good thermal properties, it can support a range of bias voltages and will perform well under both CW and pulse operations.

The QPA1010 is matched to 50Ω with integrated DC blocking capacitors on both RF I/O ports simplifying system integration. The wideband performance and operational flexibility allow it support satellite communication and data links, as well as military and commercial radar systems.

Lead-free and RoHS compliant.



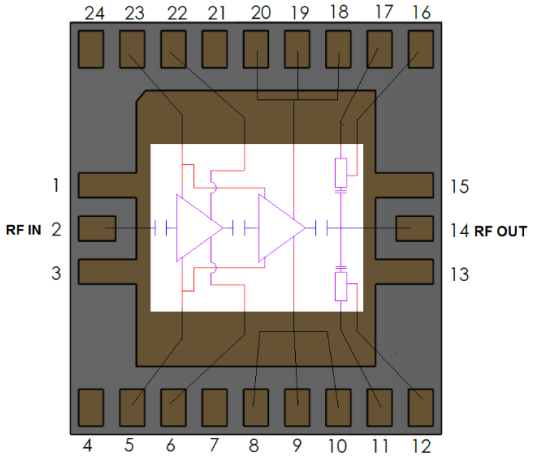
24-Lead 4.5 x 5.0 x 1.64 mm Air Cavity Laminate Package

Key Features

- Frequency Range: 7.9 – 11 GHz
- P_{OUT} (P_{IN} = 24 dBm): 42 dBm
- PAE (P_{IN} = 24 dBm): 38 %
- IM3 (P_{OUT}/Tone = 35 dBm): -20 dBc
- Small Signal Gain: 25 dB
- Integrated Power Detector
- Bias: Pulsed V_D = 24 V, I_{DQ} = 600 mA, V_G = -2.1 V typ. range, PW = 100 uS, DC = 10%
- Package Dimensions: 4.5 x 5.0 x 1.64 mm

Performance is typical across frequency. Please reference electrical specification table and data plots for more details.

Functional Block Diagram



Applications

- Satellite Communications
- Data Links
- Military and commercial Radar

Ordering Information

Part No.	Description
QPA1010TR7	250 Piece 7" Reel
QPA1010PCB4B01	Evaluation Board

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Absolute Maximum Ratings

Parameter	Value / Range
Drain Voltage (V_D)	29.5 V
Gate Voltage Range (V_G)	-6 V to 0 V
Drain Current (I_{D1}), T_{BASE} = 85 °C max (bias 1 side vs. 2 sides)	1 side: 672 mA 2 sides: 1344 mA
Drain Current (I_{D2}), T_{BASE} = 85 °C max	1440 mA
Drain Current Total (I_D), T_{BASE} = 85 °C max (bias 1 side vs. 2 sides)	1 side: 2112 mA 2 sides: 2780mA
Gate Current (I_G)	See p. 21
Power Dissipation (P_{DISS}), T_{BASE} = 85 °C, CW	70 W
Input Power (P_{IN}), 50 Ω, Pulsed V_D = 28 V or CW V_D = 24 V, I_{DQ} = 600 mA, T_{BASE} = 85 °C	30 dBm
Input Power (P_{IN}), 3:1 VSWR, Pulsed V_D = 28 V or CW V_D = 24 V, I_{DQ} = 600 mA, T_{BASE} = 85 °C	28 dBm
Mounting Temperature (30 seconds)	260 ºC
Storage Temperature	-55 to +150 ºC

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied.

Recommended Operating Conditions

Parameter	Min	Typ.	Max	Unit
Drain Voltage (V_D)		24	28	
Drain Current Total, Quiescent (I_{DQ} = I_{D1} + I_{D2})		600		mA
Gate Voltage Typ. Range (V_G)	−1.5 to -2.9			V
Drain Current Total, RF (I_{D_Drive})	See plots page 4 - 13			mA
Gate Current, RF (I_{G_Drive})				
Input Power @ Saturation (P_{IN}) (2)	T_{BASE} -40ºC: 24			dBm
	T_{BASE} +25ºC: 24			
	T_{BASE} +85ºC: 26 (1)			
Operating Temp. Range (T_{BASE}) (3)	−40		+85	ºC

1. CW, V_D > 24 V @ T_{BASE} +85C requires thermal consideration, recommended 24 dBm P_{IN} max.
2. See P_{IN} vs. T_{BASE} plots page 6, 11
3. T_{BASE} is back side of QPA1010

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.

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Electrical Specifications

Parameter	Conditions (1) (2)		Min	Typ.	Max	Units
Operational Frequency Range			7.9		11	GHz
Output Power at Saturation, P_{SAT}	P_{IN} = 24 dBm Pulsed V_D	7.9, 8.4, 9, 10 GHz	40.5	42		dBm
		11.0 GHz	40	41.5		
		11.5 GHz	39.5	41.5		
Power Added Efficiency, PAE	P_{IN} = 24 dBm Pulsed V_D	7.9, 8.4, 9, 10 GHz	30	35		%
		11.0 GHz	25			
		11.5 GHz	25			
3RD Intermodulation Products, IM3	P_{OUT}/Tone = 38 dBm, CW ΔF = 1 MHz			-20		dBc
5RD Intermodulation Products, IM5				-35		
Small Signal Gain, S21	P_{IN} = -25 dBm, CW			25		dB
Input Return Loss, IRL				15		
Output Return Loss, ORL				10		
P_{SAT} Temperature Coefficient	T_{DIFF} = 25 ºC to 85 ºC; P_{IN} = 24 dBm			-0.01		dBm/ºC
S21 Temperature Coefficient	T_{DIFF} = 25 ºC to 85 ºC			-0.05		dB/ºC
Gate leakage	V_D = 10 V, V_G = -4 V		-6.6		0.1	mA

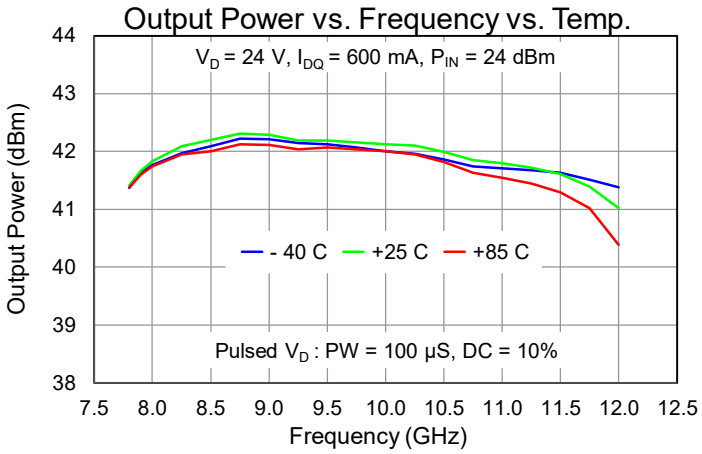
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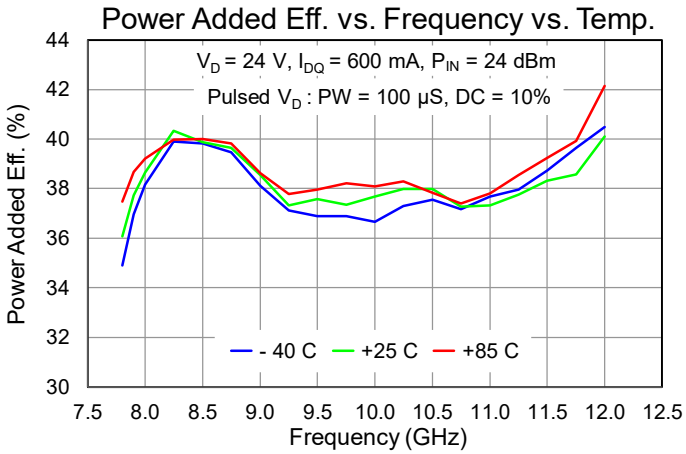
1. Test conditions unless otherwise noted: Pulsed V_D = 24 V, I_{DQ} = 600 mA, V_G = -2.2 V +/- 0.7 V typical, PW = 100 us, DC = 10%, T_{BASE} = 25ºC, Z_0 = 50 Ω
2. T_{BASE} is back side of QPA1010

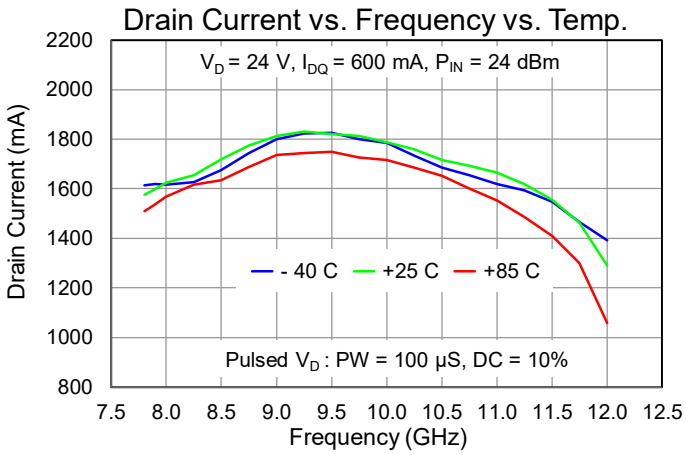
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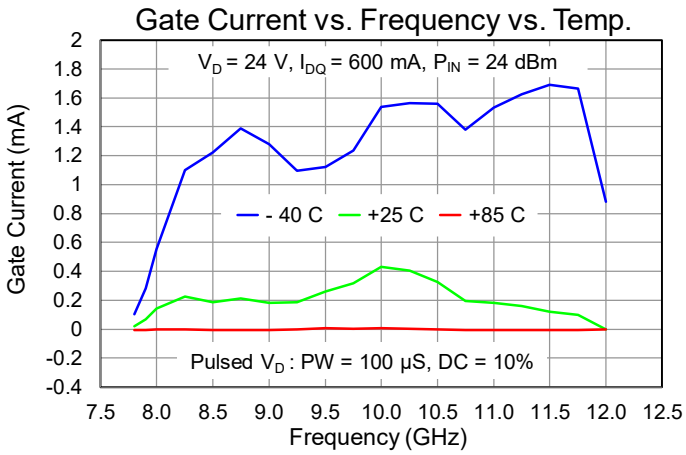
Performance Plots – Large Signal (Pulsed)

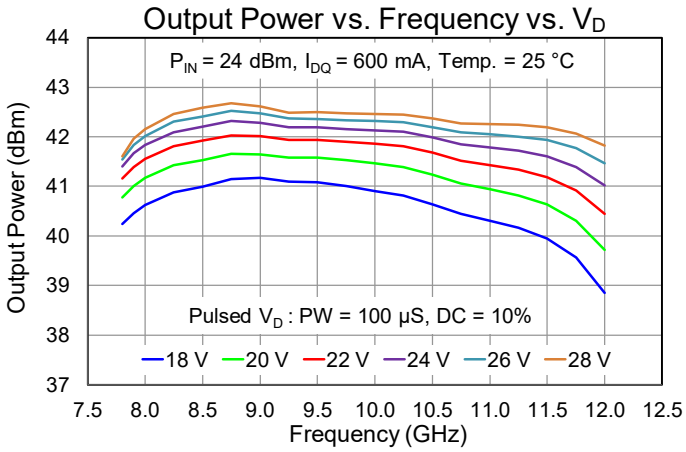
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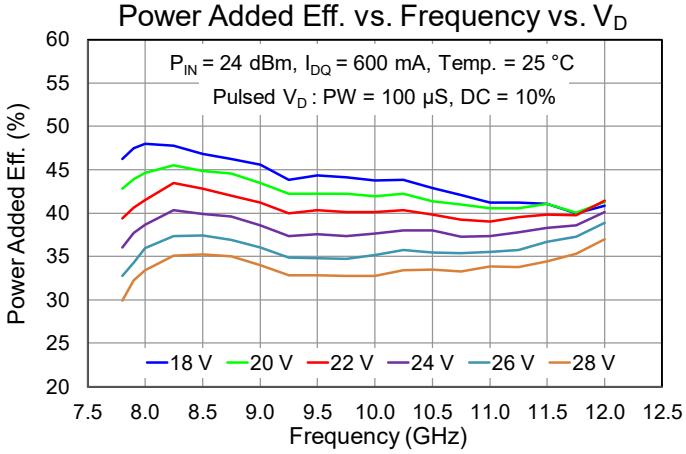








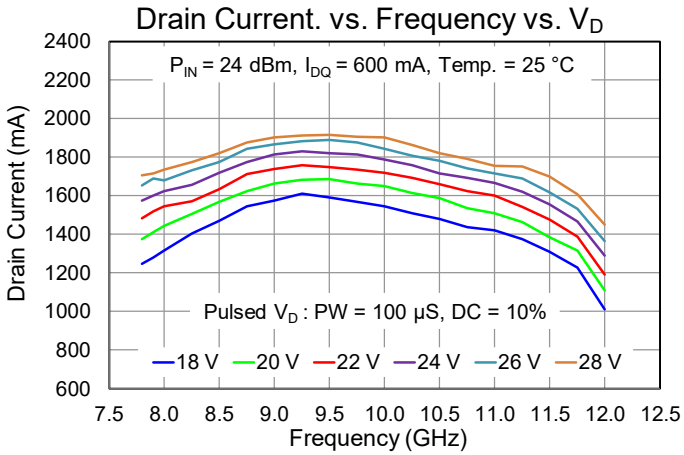


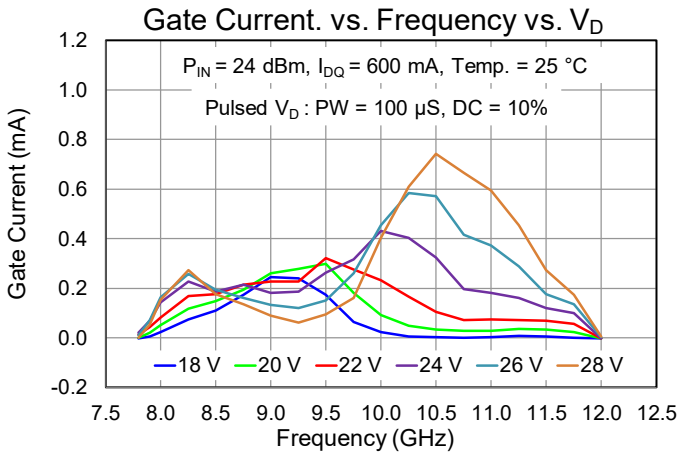


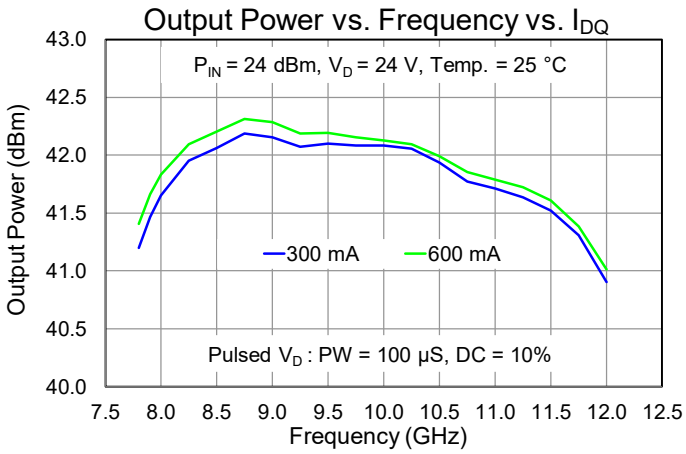
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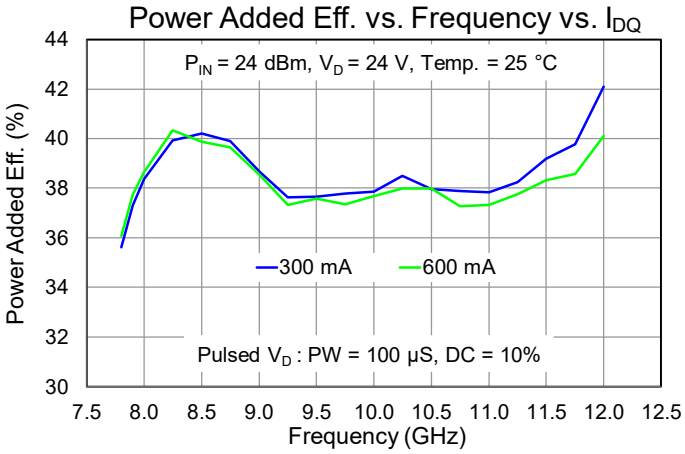
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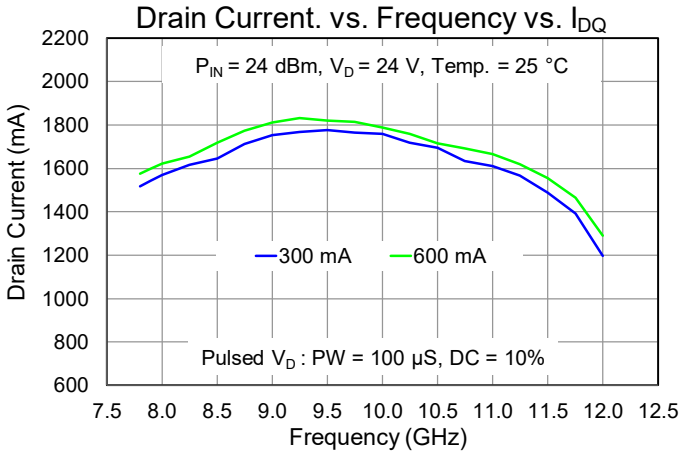
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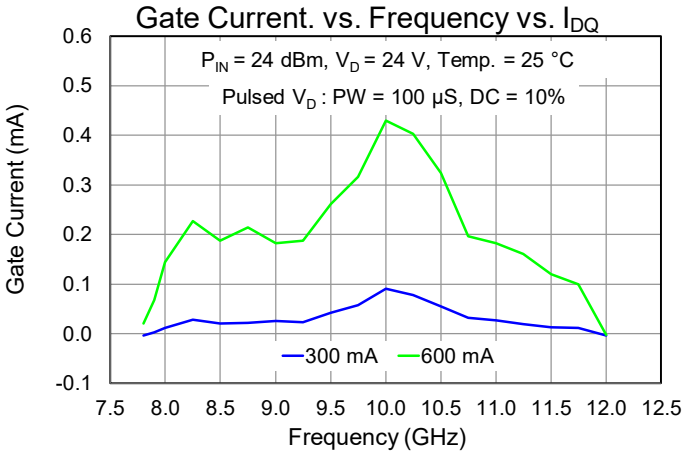








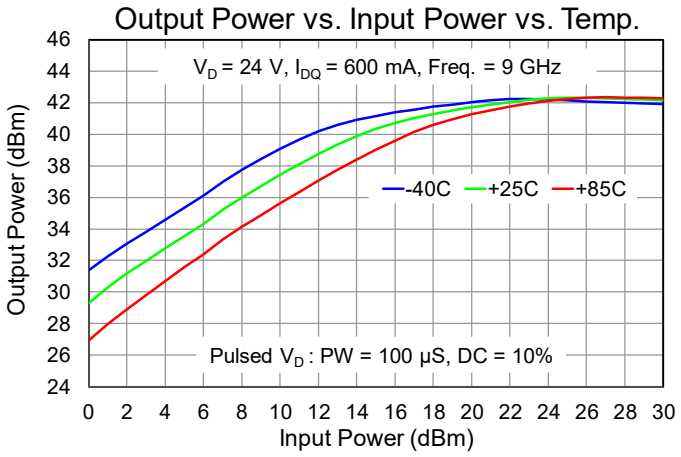


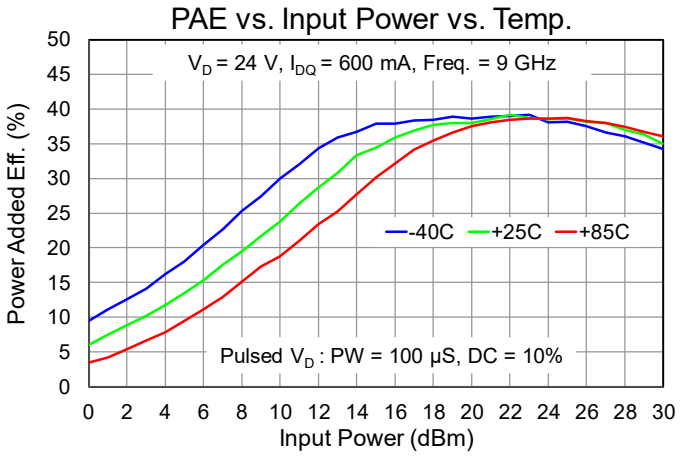


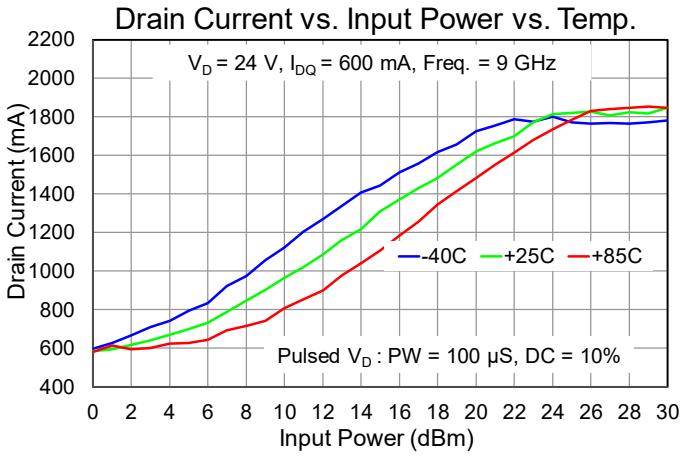
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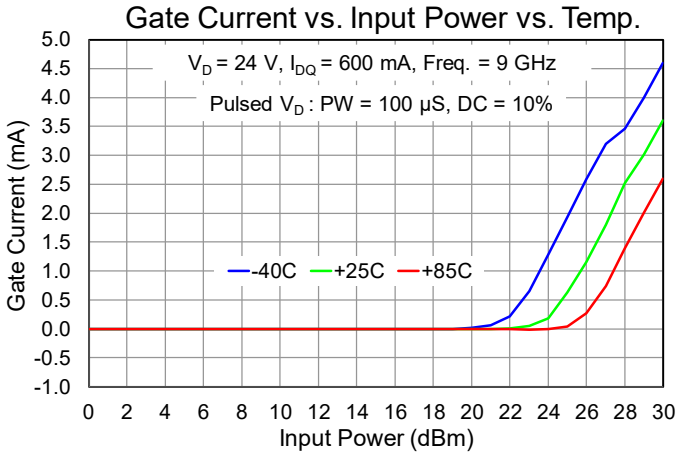
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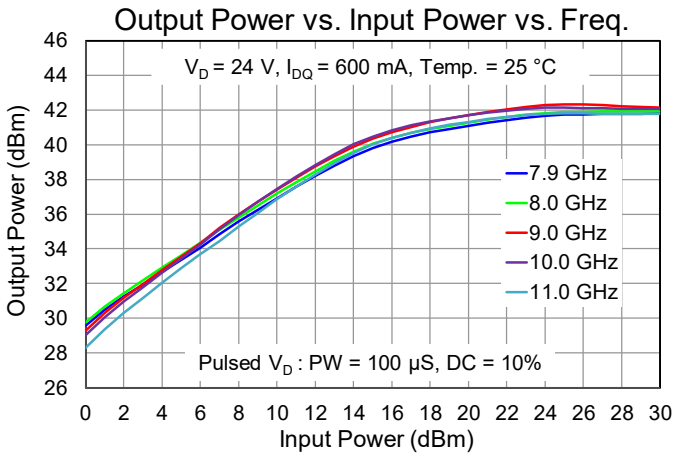
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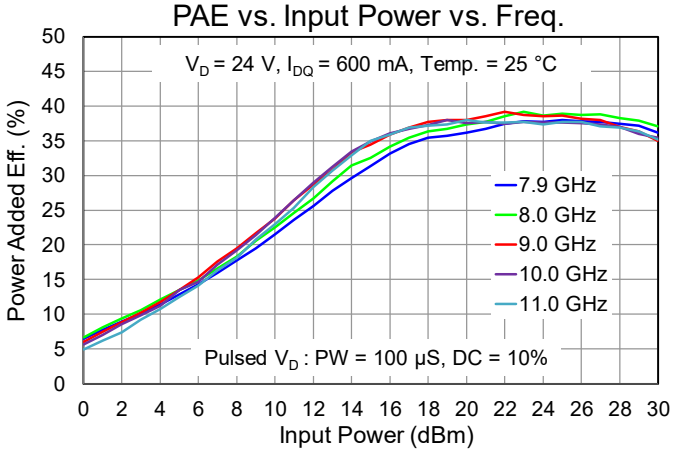










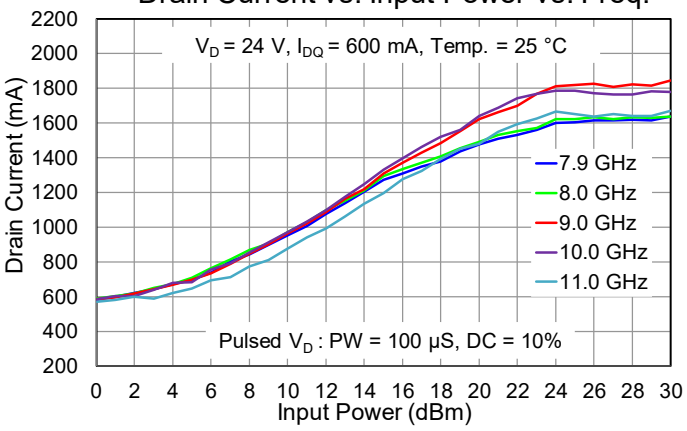


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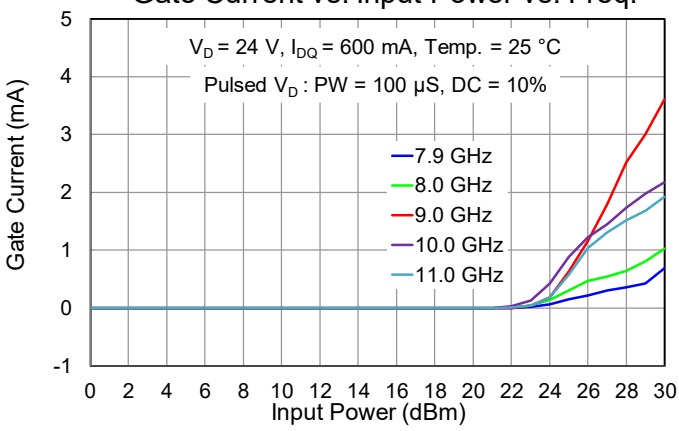
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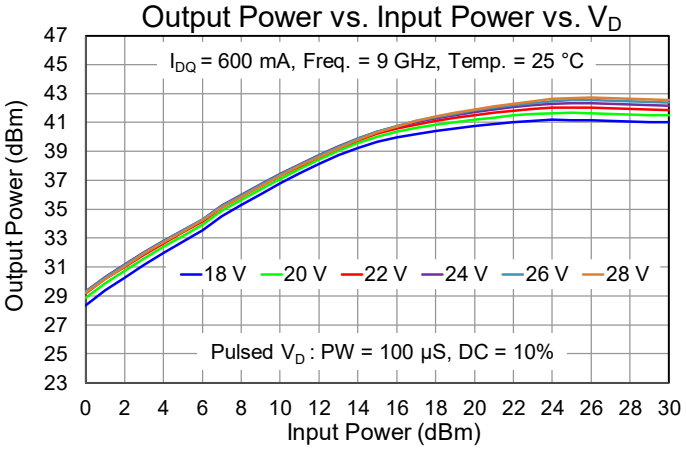
Drain Current vs. Input Power vs. Freq.



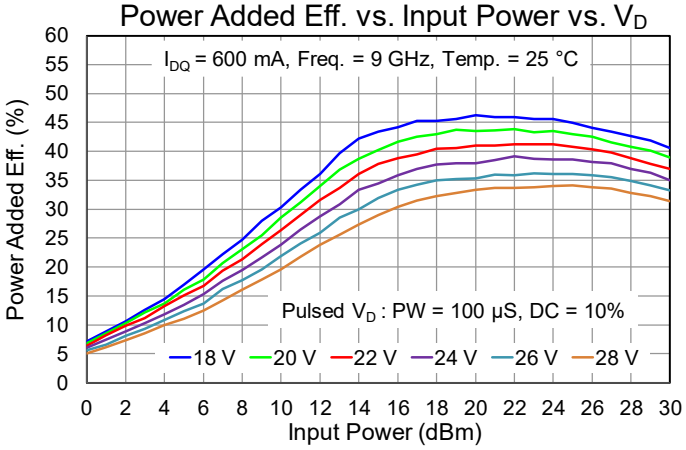
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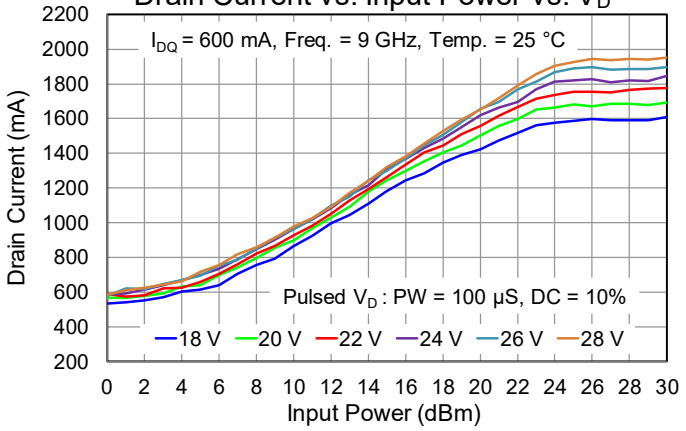
Output Power vs. Input Power vs. V_D



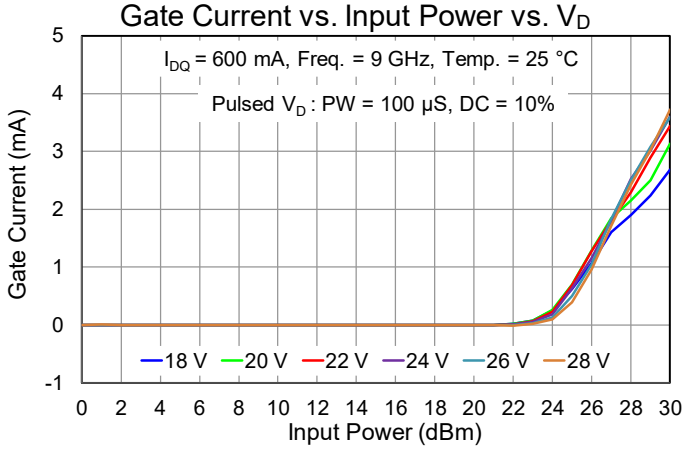
Power Added Eff. vs. Input Power vs. V_D



Drain Current vs. Input Power vs. V_D



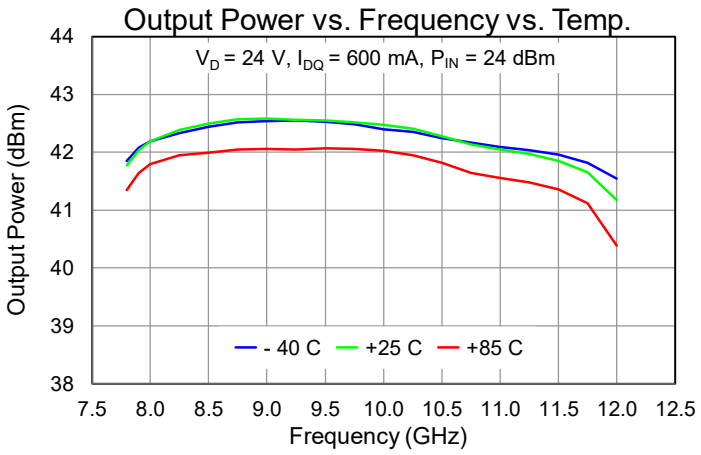
Gate Current vs. Input Power vs. V_D

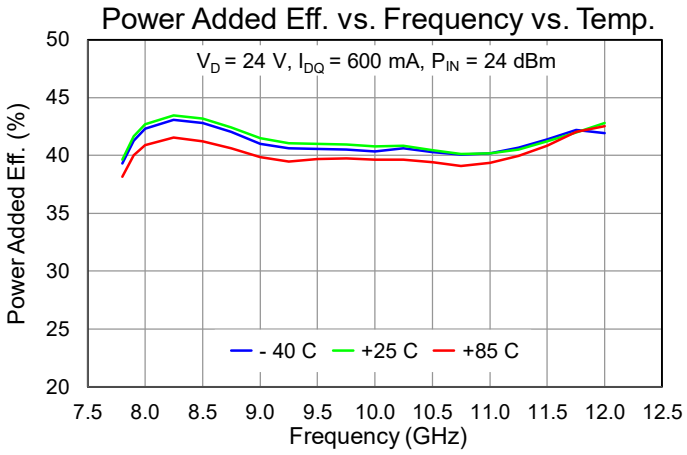


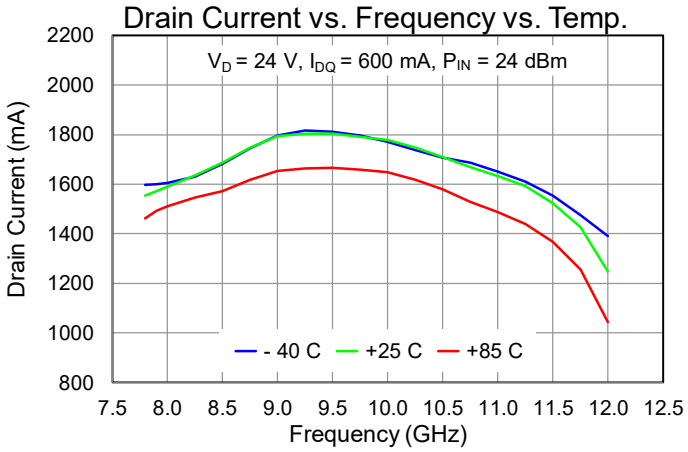
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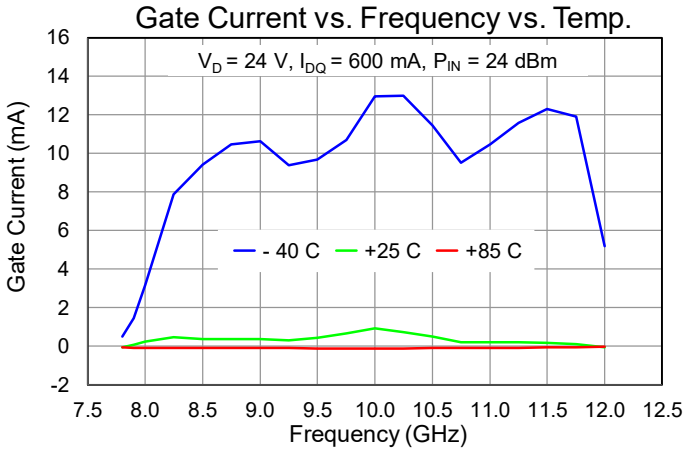
Performance Plots – Large Signal (CW)

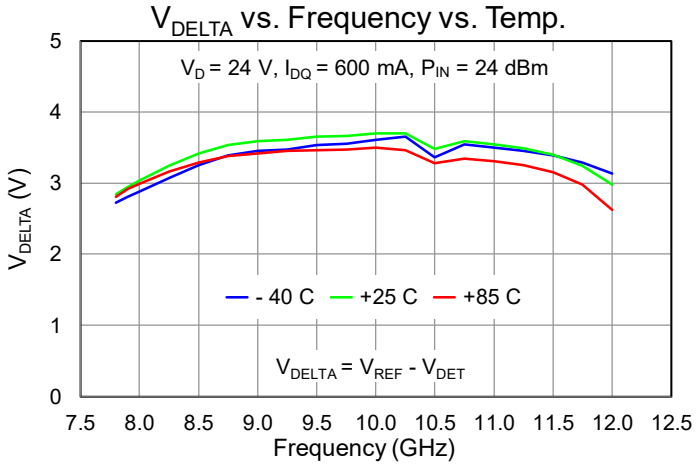
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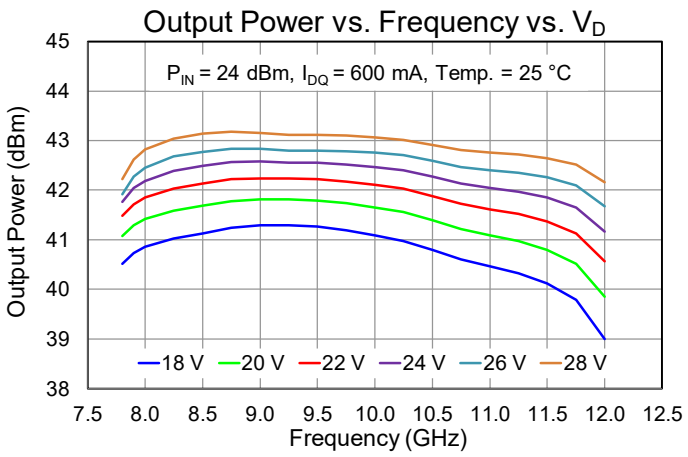


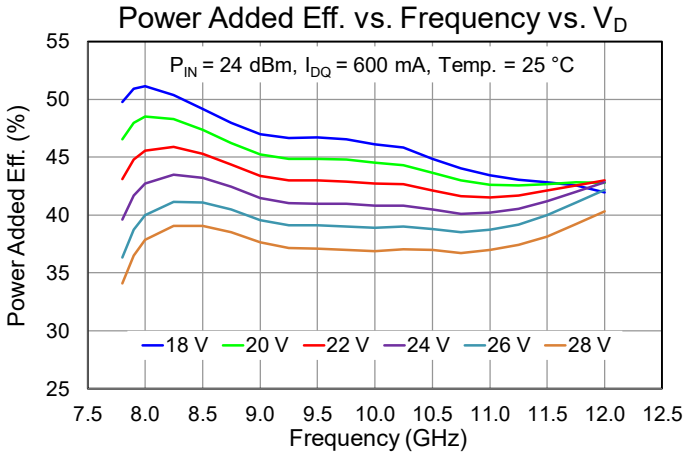


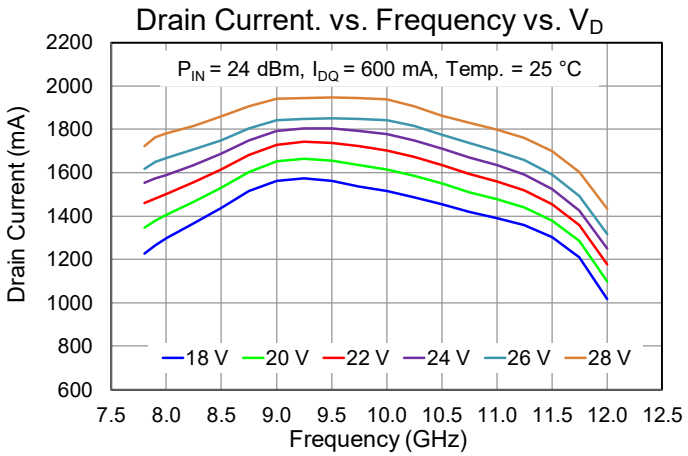
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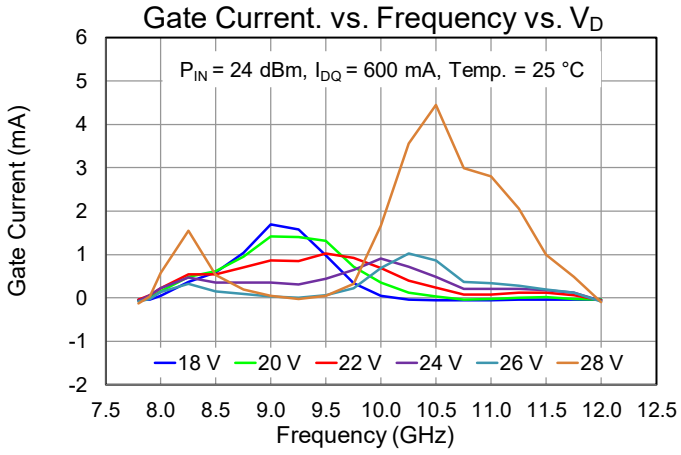
Performance Plots – Large Signal (CW)

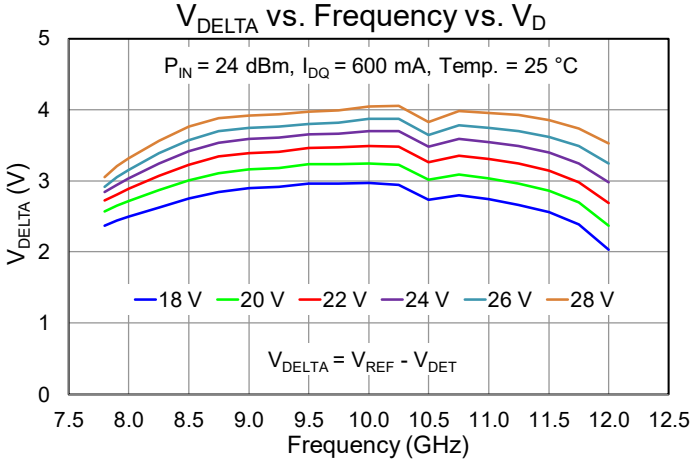
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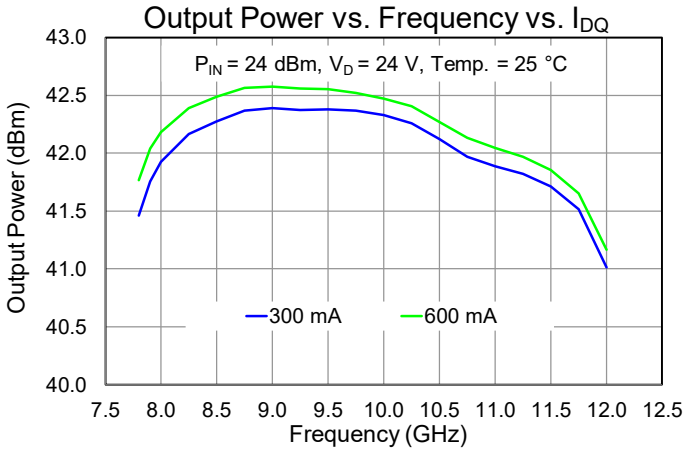


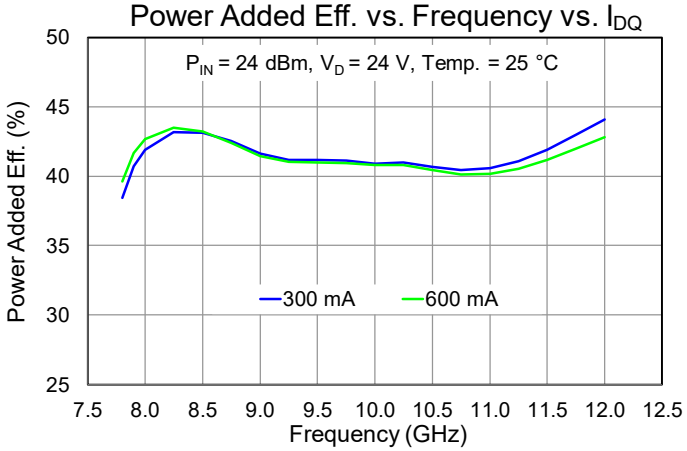


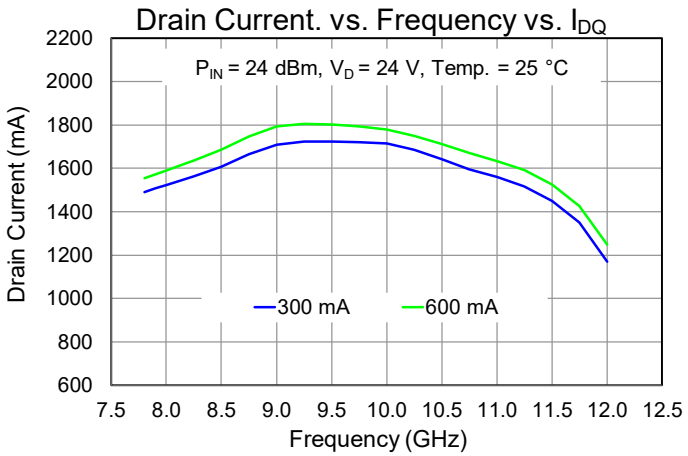
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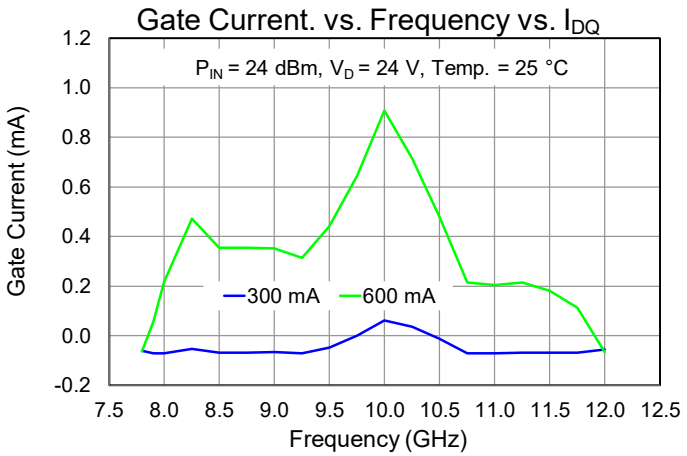
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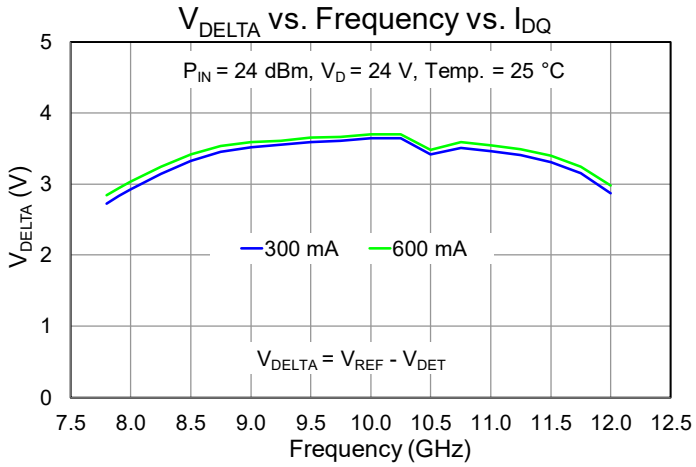
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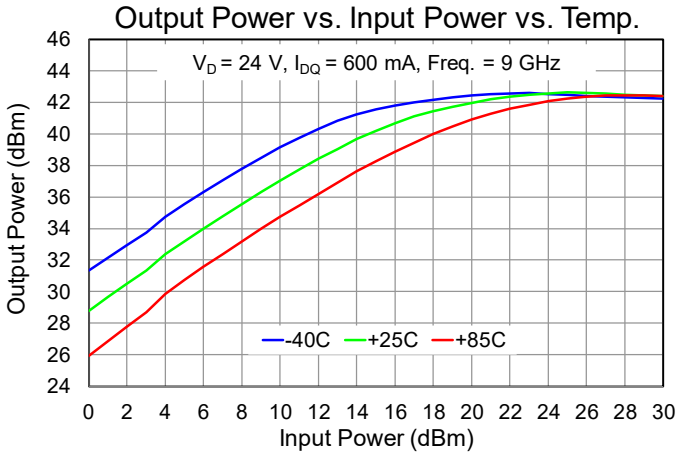


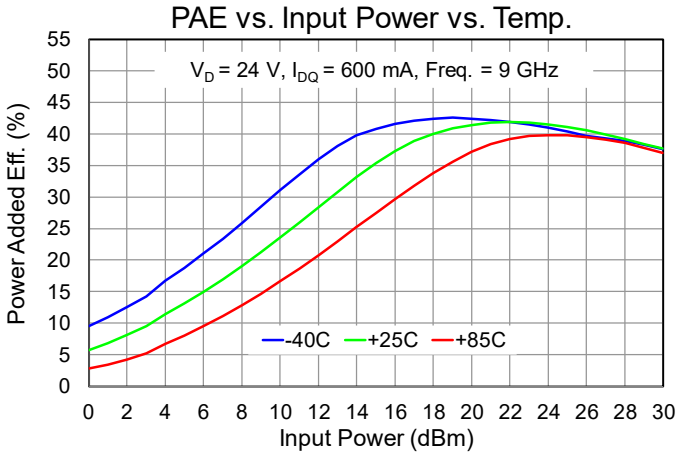


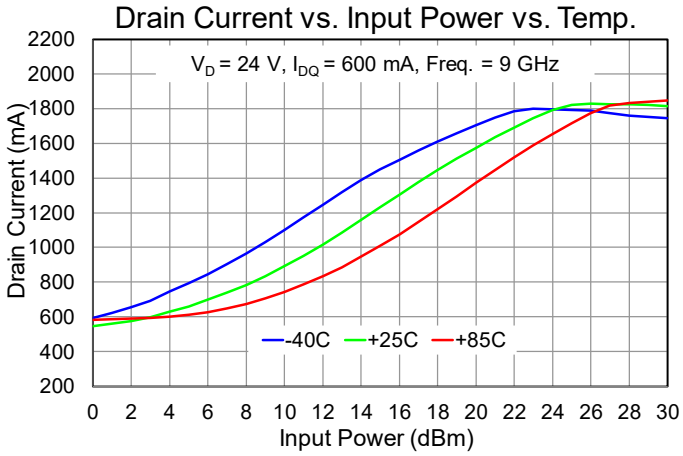
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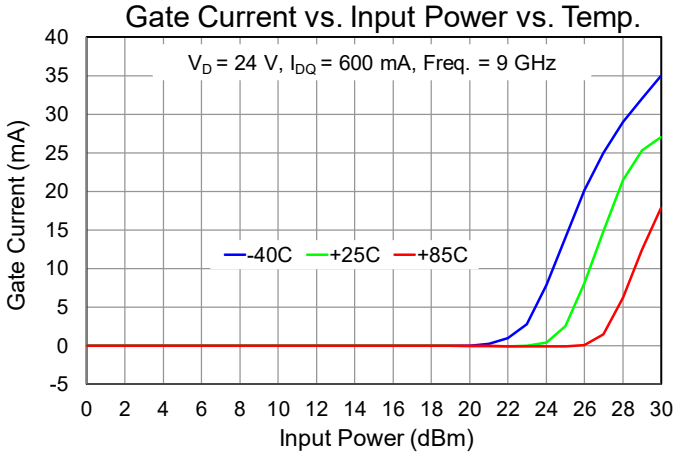
Performance Plots – Large Signal (CW)

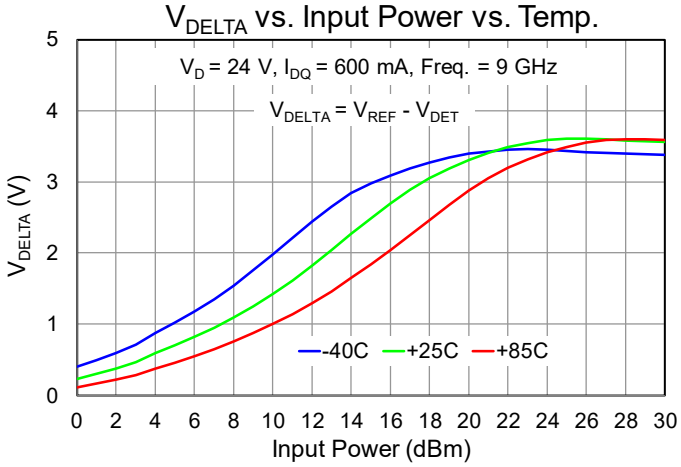
Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, P_{IN} = 24 dBm, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).







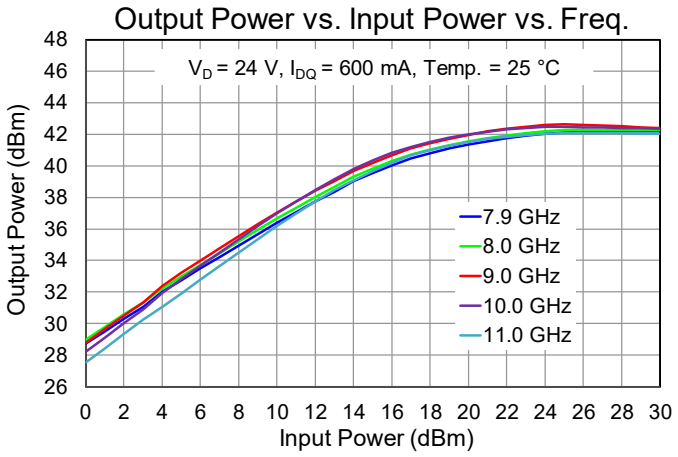


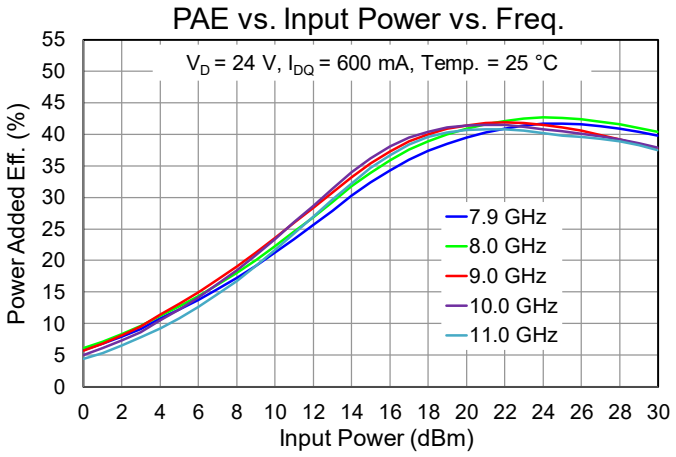


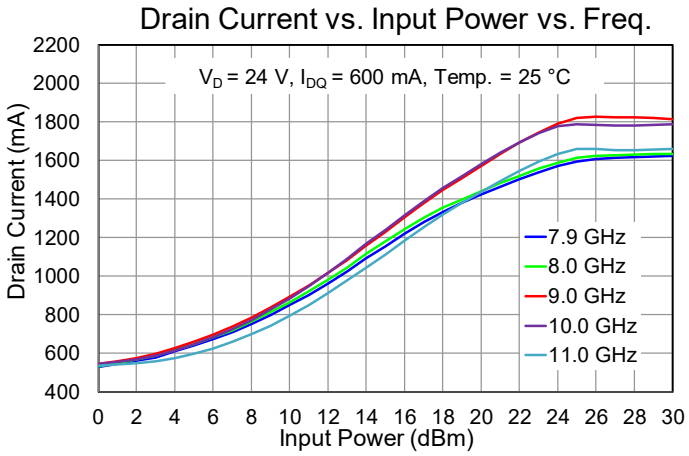
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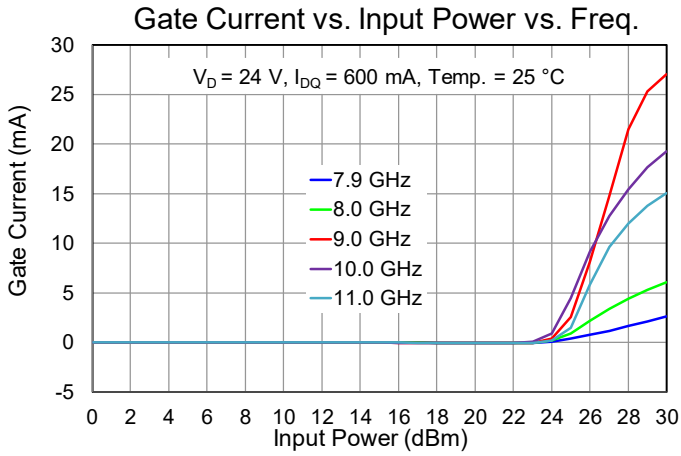
Performance Plots – Large Signal CW)

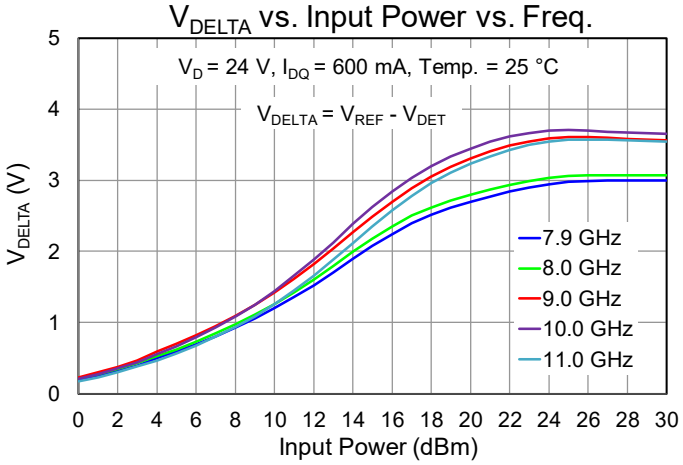
Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, P_{IN} = 24 dBm, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).







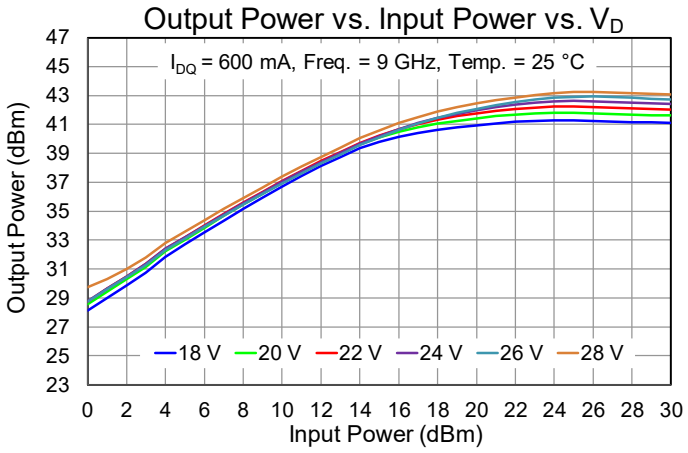


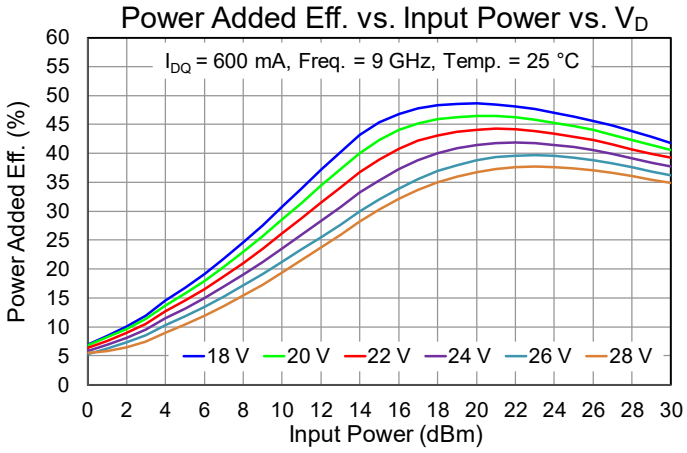


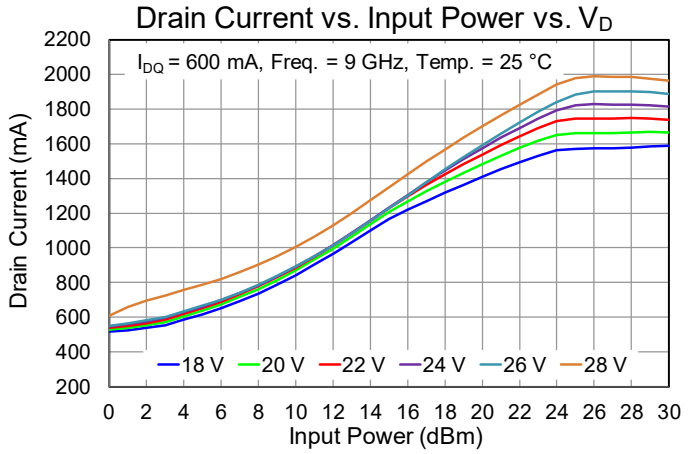
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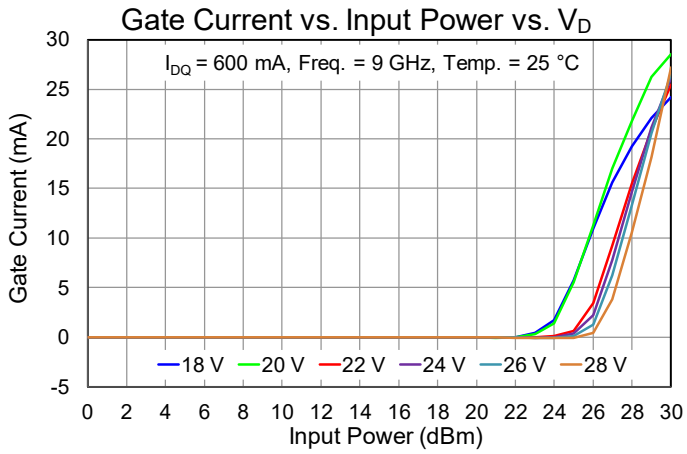
Performance Plots – Large Signal (CW)

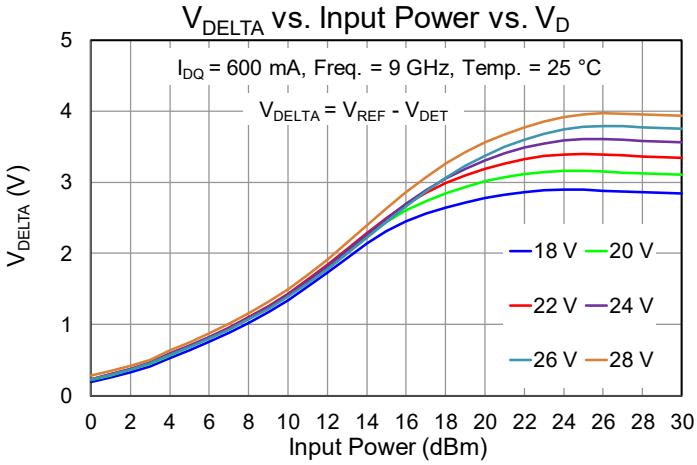
Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, P_{IN} = 24 dBm, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).







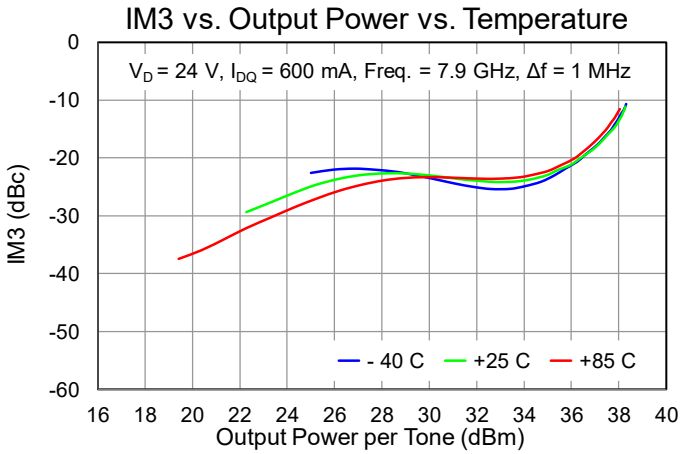


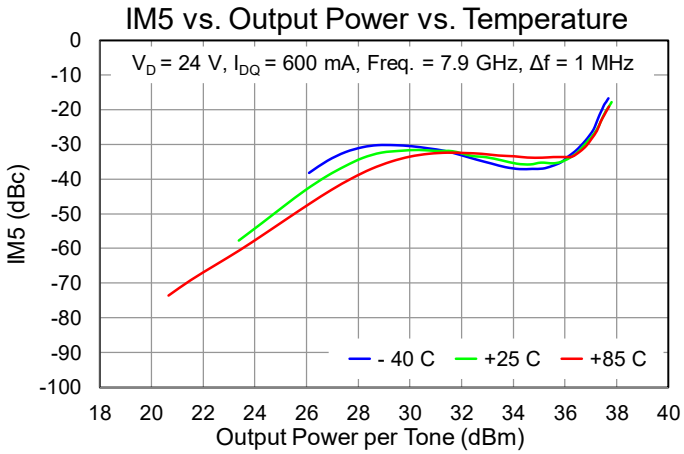


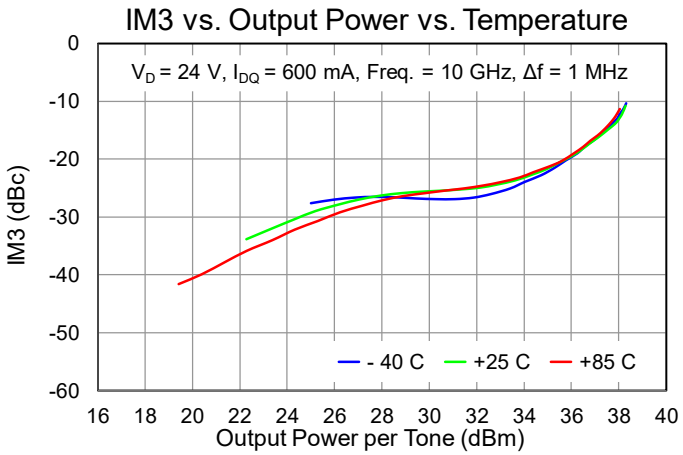
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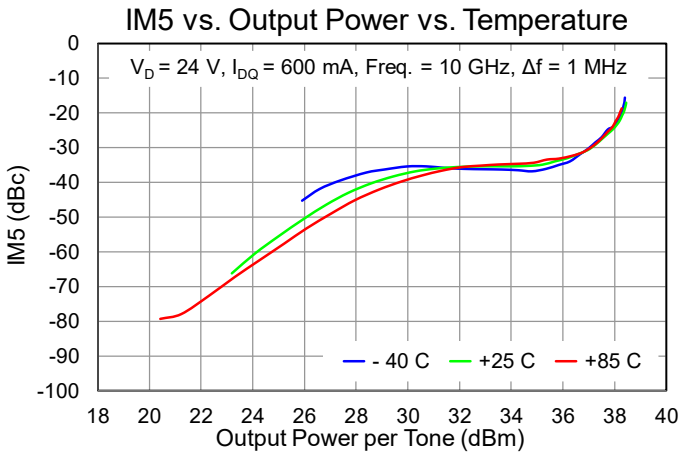
Performance Plots – Linearity (CW)

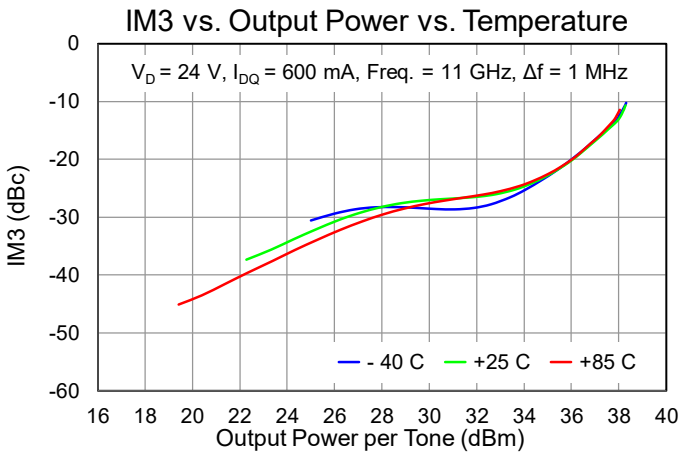
Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, Δf = 1 MHz, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).

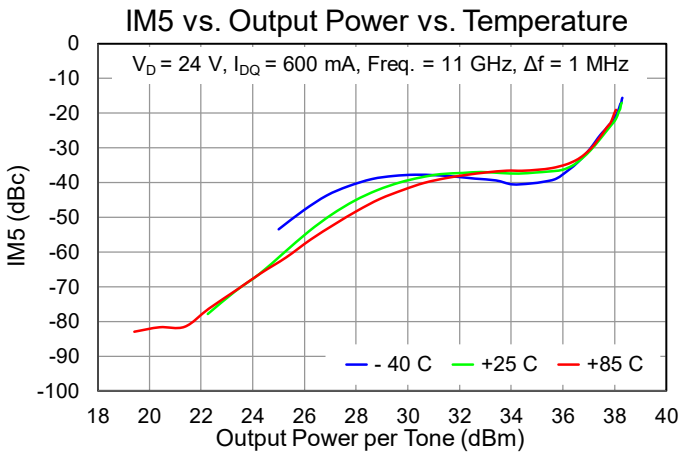








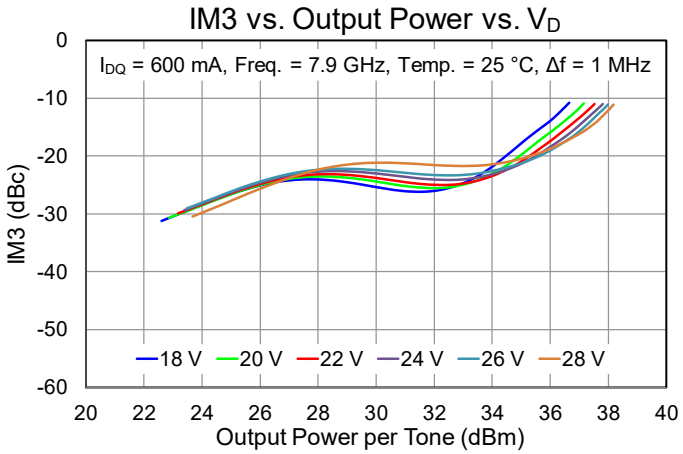


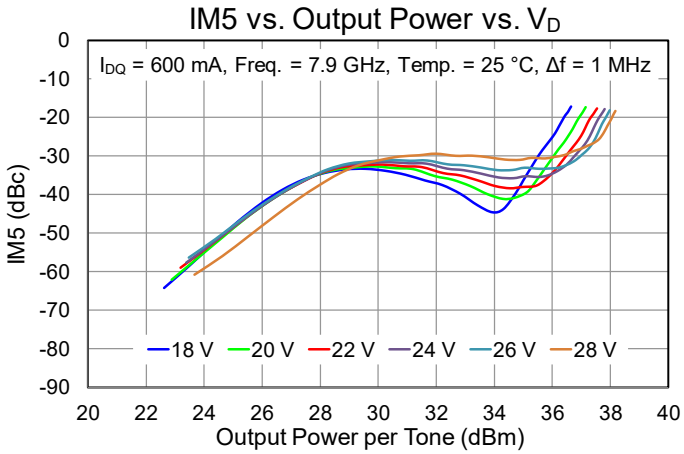


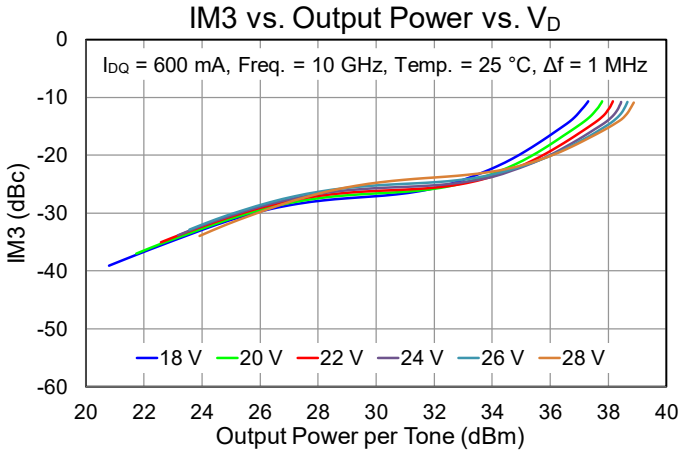
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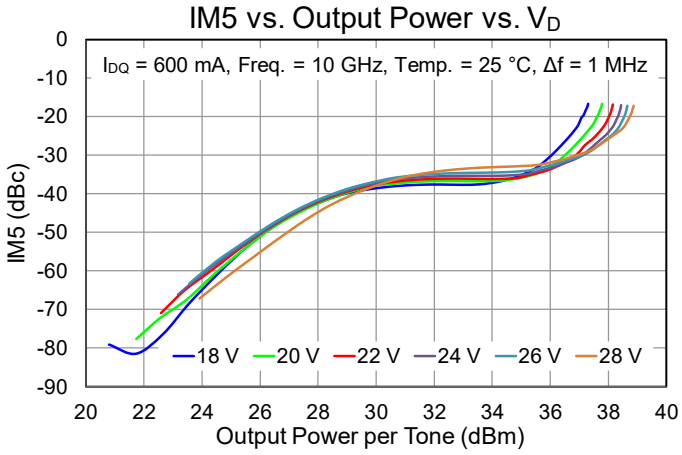
Performance Plots – Linearity (CW)

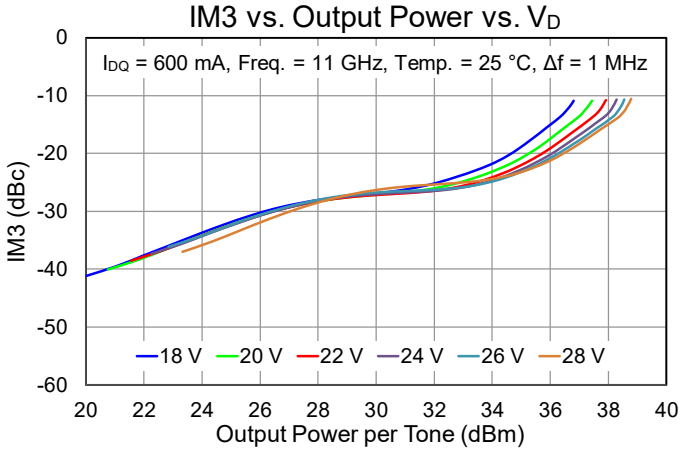
Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, Δf = 1 MHz, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).

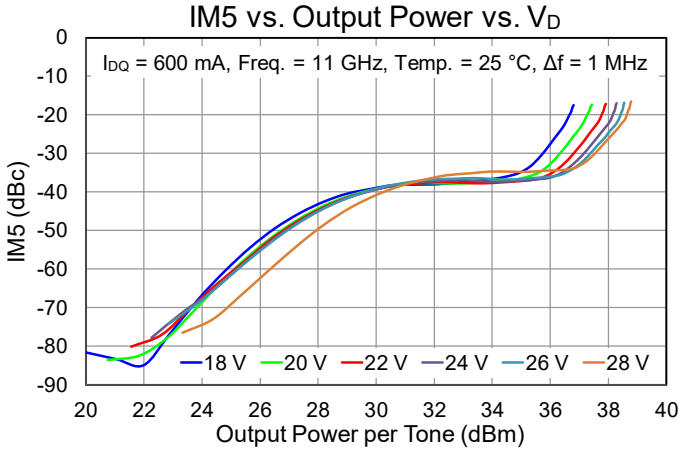








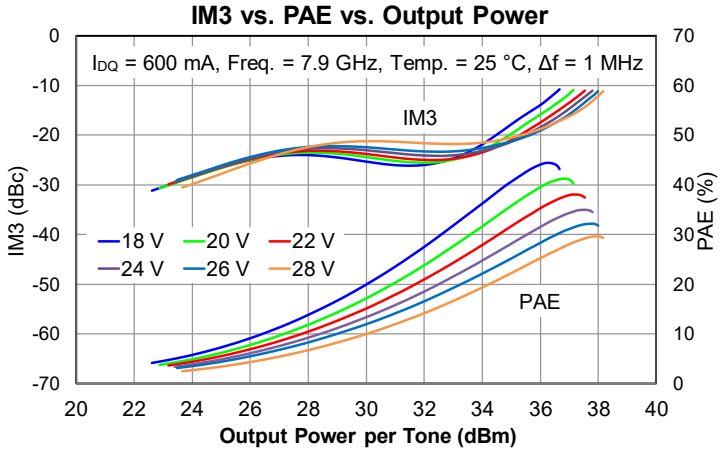




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Performance Plots – Linearity (CW)

Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, Δf = 1 MHz, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).

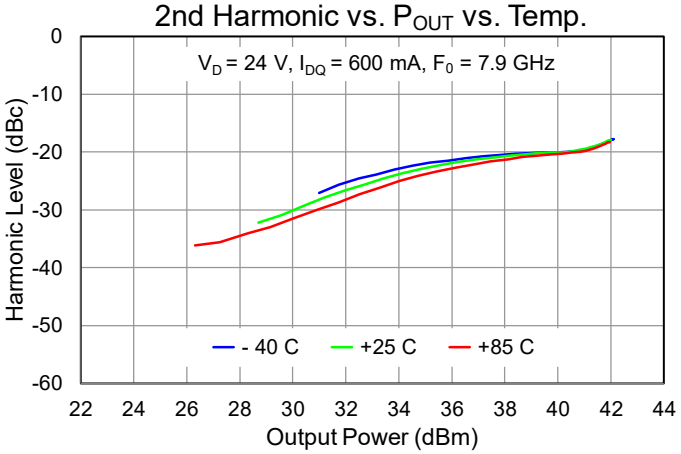


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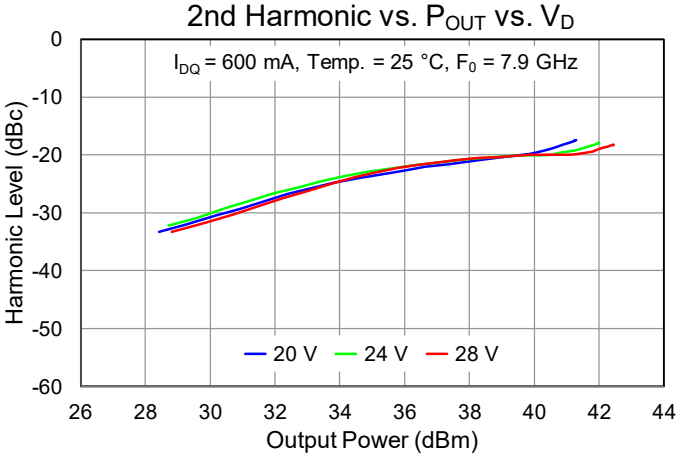
Performance Plots – Harmonics (CW)

Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, Δf = 1 MHz, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).

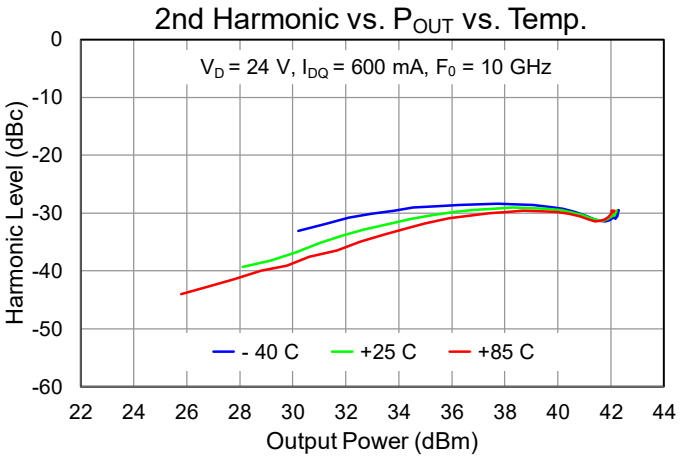
2nd Harmonic vs. P_{OUT} vs. Temp.



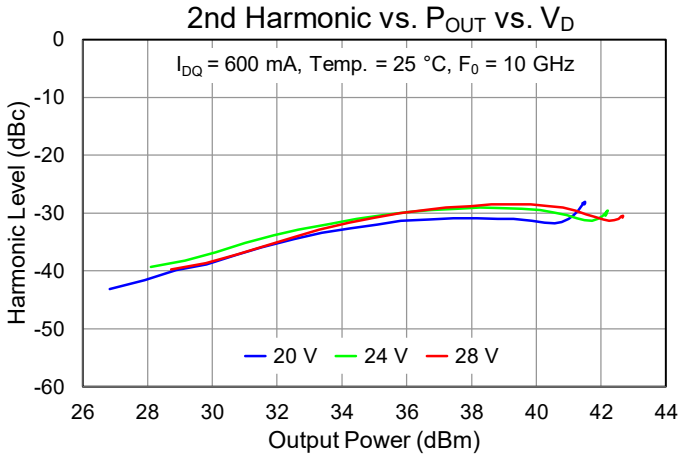
2nd Harmonic vs. P_{OUT} vs. V_D



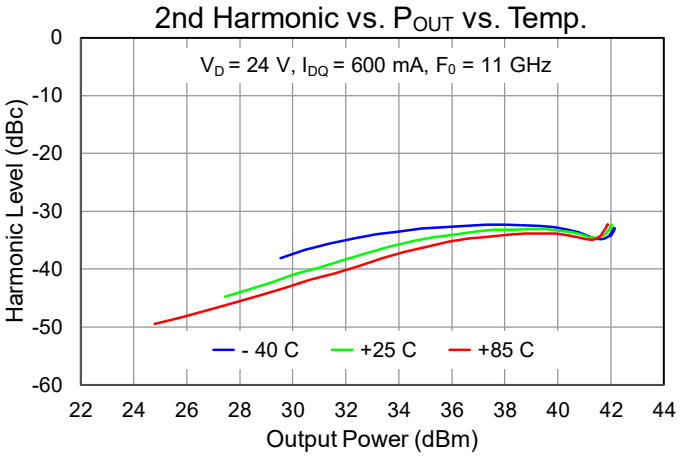
2nd Harmonic vs. P_{OUT} vs. Temp.



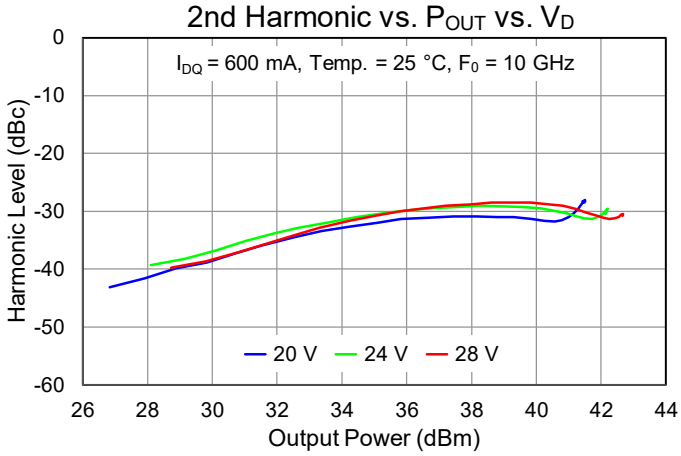
2nd Harmonic vs. P_{OUT} vs. V_D



2nd Harmonic vs. P_{OUT} vs. Temp.



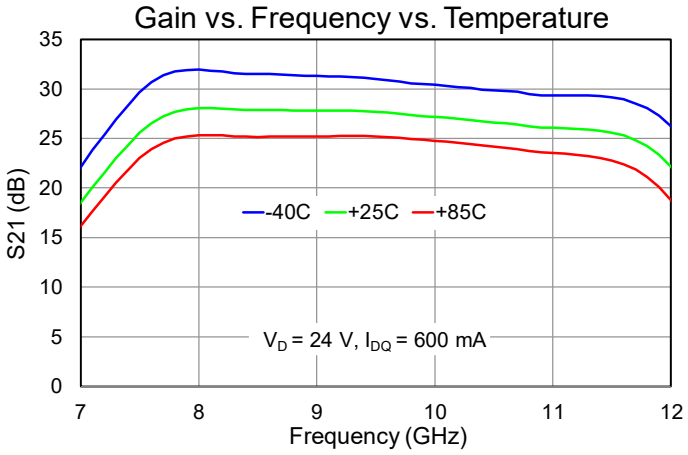
2nd Harmonic vs. P_{OUT} vs. V_D

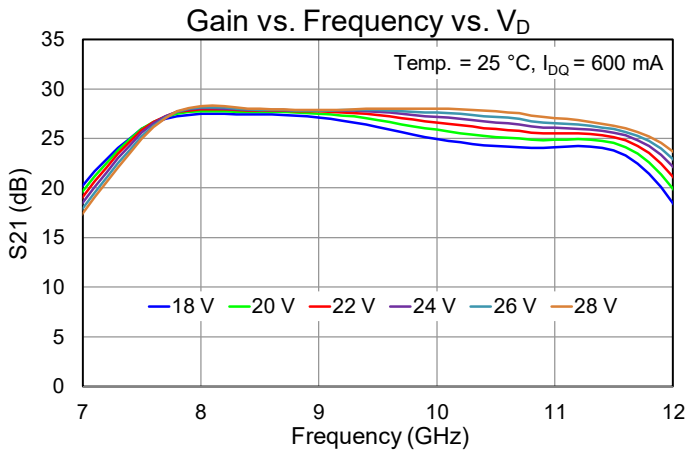


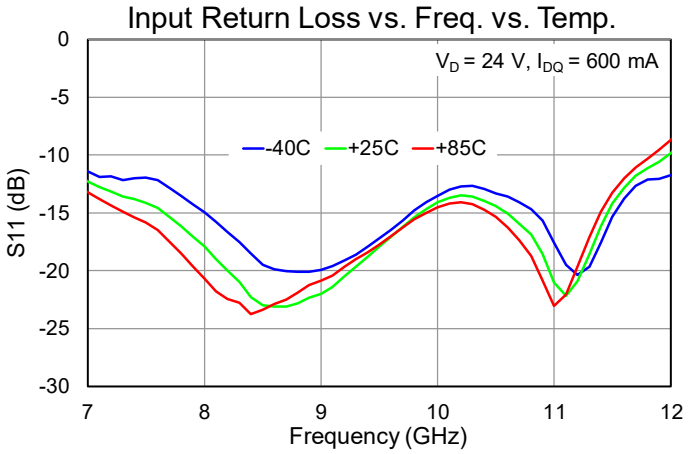
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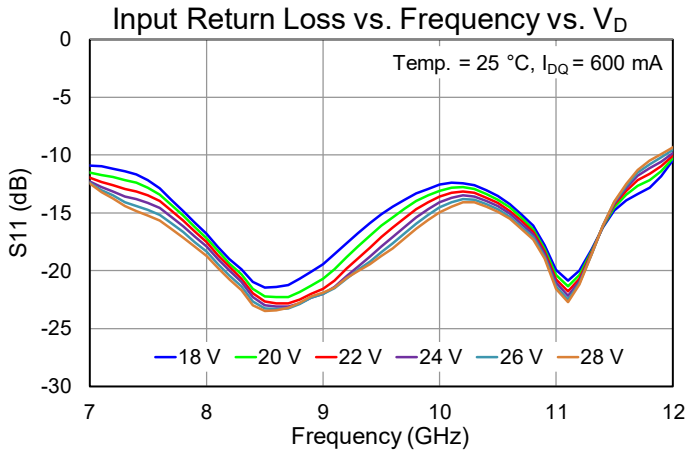
Performance Plots – Small Signal (CW)

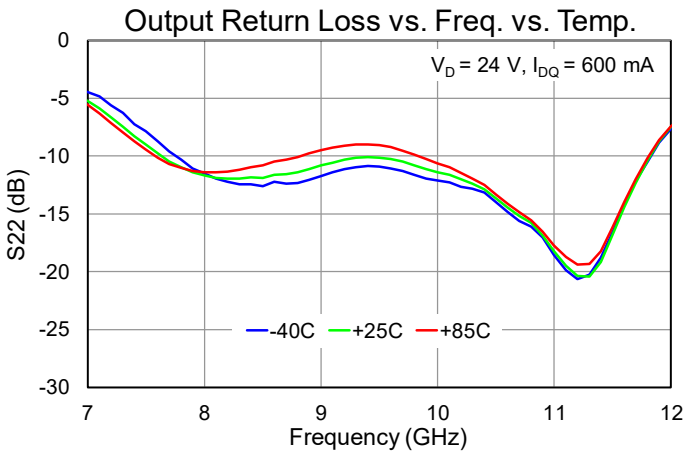
Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).

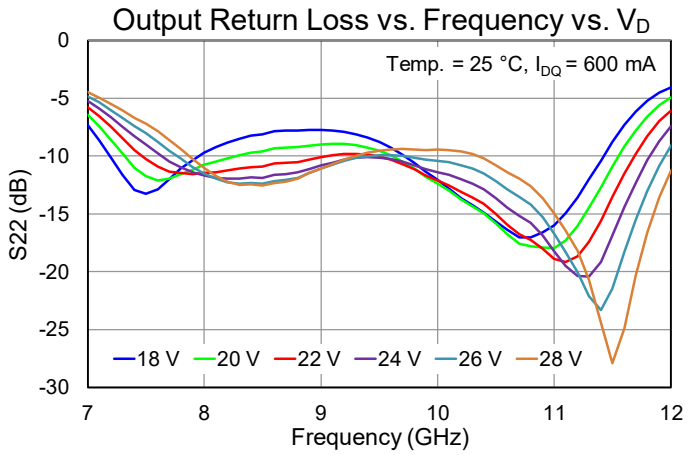








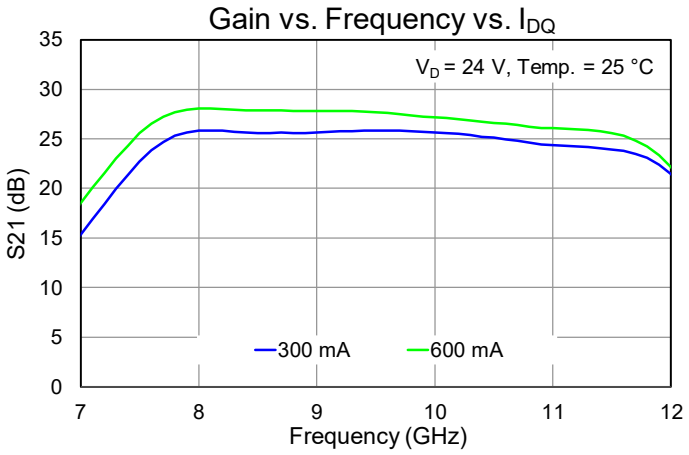


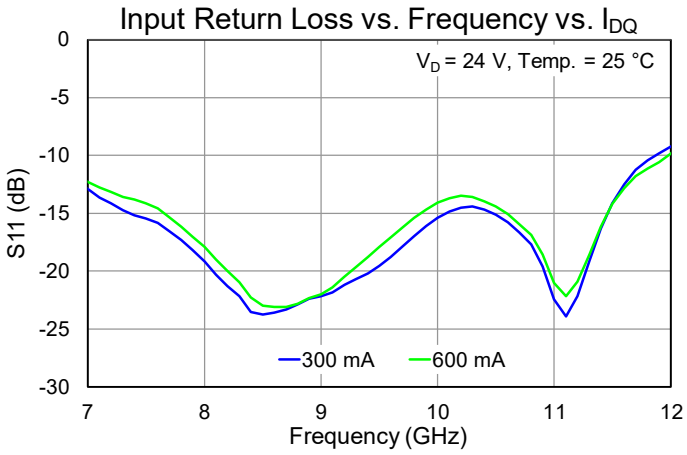


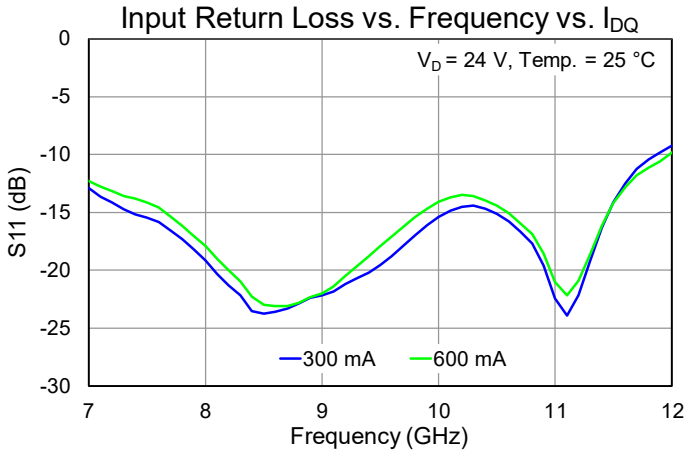
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Performance Plots – Small Signal (CW)

Test conditions, unless otherwise noted: CW, V_D = 24 V, I_{DQ} = 600 mA, T_{BASE} = +25 ºC (T_{BASE} is backside of QPA1010).







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Thermal and Reliability Information

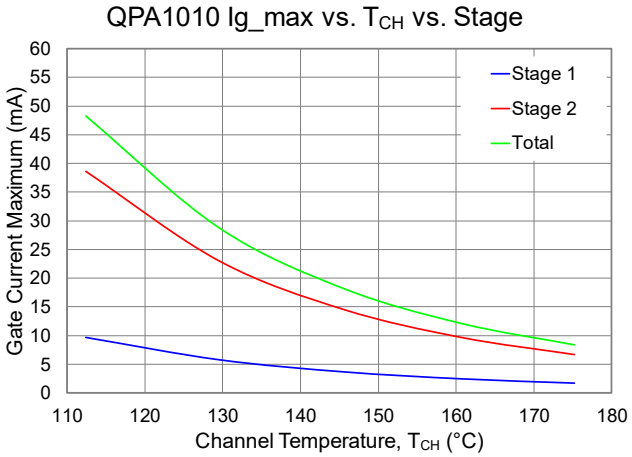
Parameter	Test Conditions	Value	Units
Thermal Resistance, θ_{JC} (1)	CW, T_{BASE} = 85°C, V_D = +24V, I_{DQ} = 600 mA, no RF, P_{DISS} = 14.4 W	2.9	°C/W
Channel Temperature, T_{CH} (No RF) (2)		126	°C
Thermal Resistance, θ_{JC} (1)	Pulsed, T_{BASE} = 85 °C, V_D = +24 V, I_{DQ} = 600 mA, V_D (100 us/10%), Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.7 A, P_{OUT} = 42 dBm, P_{DISS} = 25.9 W	2	°C/W
Channel Temperature, T_{CH} (Under RF drive) (2)		137	°C
Thermal Resistance, θ_{JC} (1)	CW, T_{BASE} = 85 °C, V_D = +24 V, I_{DQ} = 600 mA, Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.7 A, P_{OUT} = 42 dBm, P_{DISS} = 24.2 W	2.7	°C/W
Channel Temperature, T_{CH} (Under RF drive) (2)		150	°C
Thermal Resistance, θ_{JC} (1)	CW, T_{BASE} = 85°C, V_D = +20V, I_{DQ} = 600 mA, no RF, P_{DISS} = 12 W	2.8	°C/W
Channel Temperature, T_{CH} (No RF) (2)		119	°C
Thermal Resistance, θ_{JC} (1)	Pulsed, T_{BASE} = 85 °C, V_D = +20 V, I_{DQ} = 600 mA, V_D (100 us/10%), Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.6 A, P_{OUT} = 41.3 dBm, P_{DISS} = 18.5 W	1.9	°C/W
Channel Temperature, T_{CH} (Under RF drive) (2)		120	°C
Thermal Resistance, θ_{JC} (1)	CW, T_{BASE} = 85 °C, V_D = +20 V, I_{DQ} = 600 mA, Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.56 A, P_{OUT} = 41.4 dBm, P_{DISS} = 17.7 W	2.6	°C/W
Channel Temperature, T_{CH} (Under RF drive) (2)		131	°C

Notes:

1. Thermal resistance determined to T_{BASE} (T_{BASE} is backside of package QPA1010)
2. Channel temperature indicated is an IR scan equivalent temperature. Thermal resistance is calculated using this value. Additional information can be found in the Qorvo Applications Note “GaN Device TCHMAX Theta-JC and Reliability Estimates,” located here https://www.qorvo.com/products/d/da006480

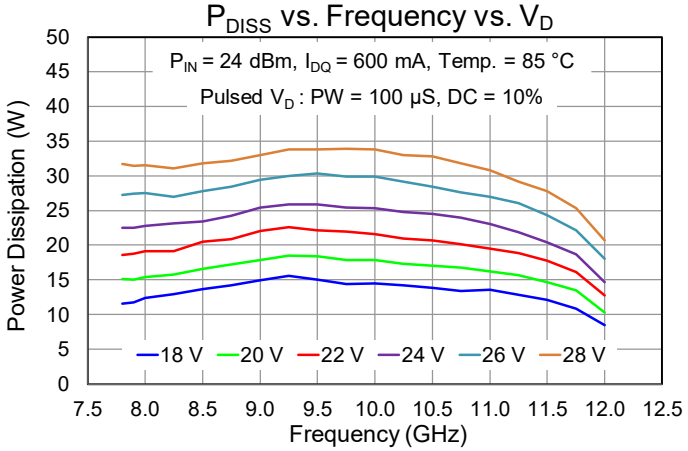
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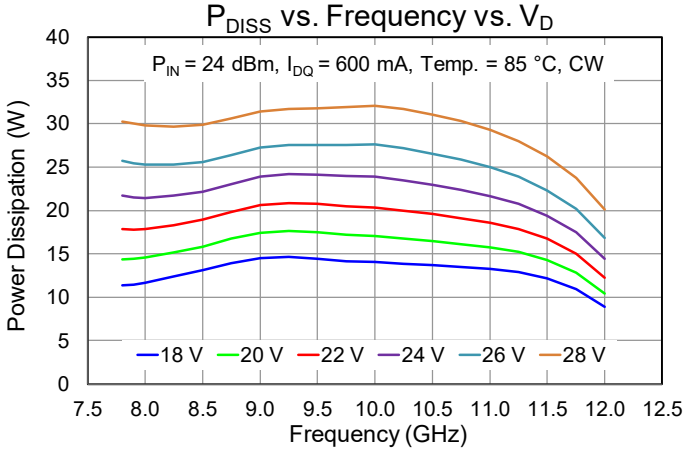
Maximum Gate Current



Channel Temperature is an IR scan equivalent

Dissipated Power

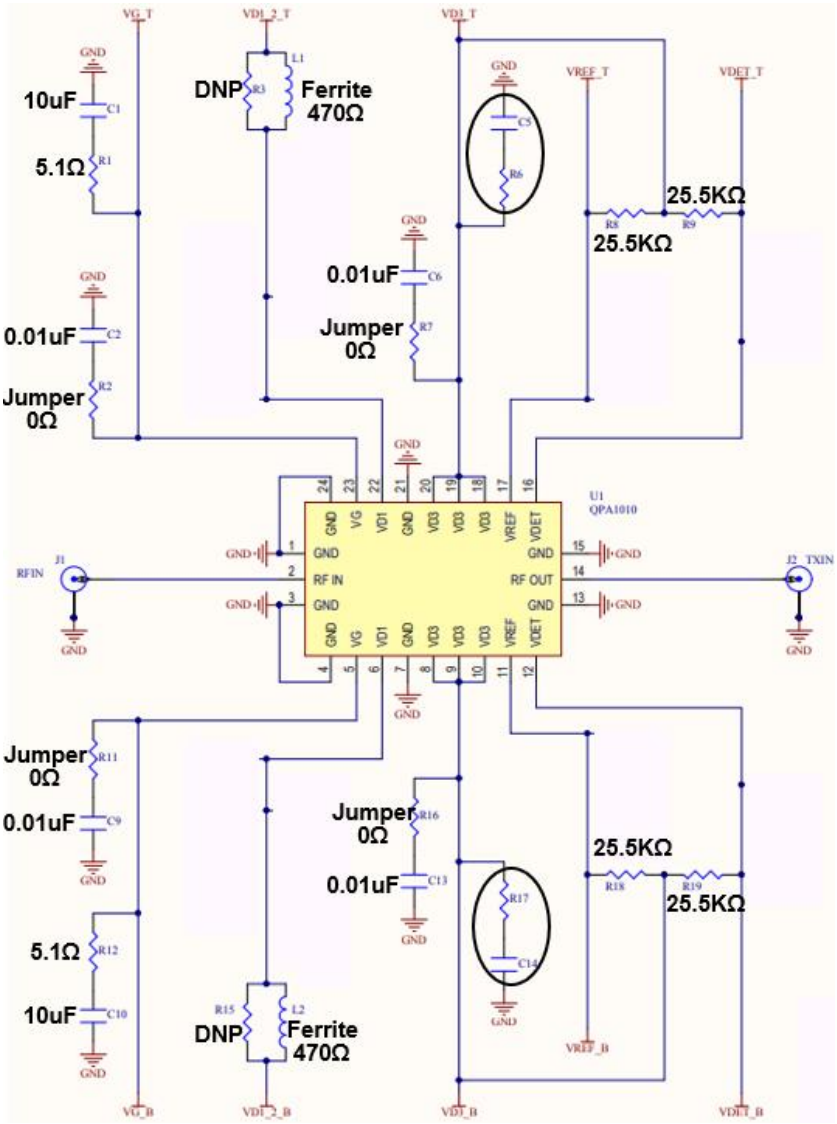




T_{BASE} = 85 ºC (T_{BASE} is back side of QPA1010)

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Applications Information for Pulsed and Linear Operations



- Tie all V_D's (V_{D1}, V_{D2}, top, bottom) together at the harness level to form V_D; tie the same for V_G (top, bottom) to form V_G
- The extra bypassing components R6, R17, C5 and C14 are required for optimum linearity
- If not using power detector function: recommended terminate V_{REF} and V_{DET} (pin 11, 12, 16, 17) with 50 Ohm (R8, R9, R18, R19 not needed)

Bias-Up Procedure

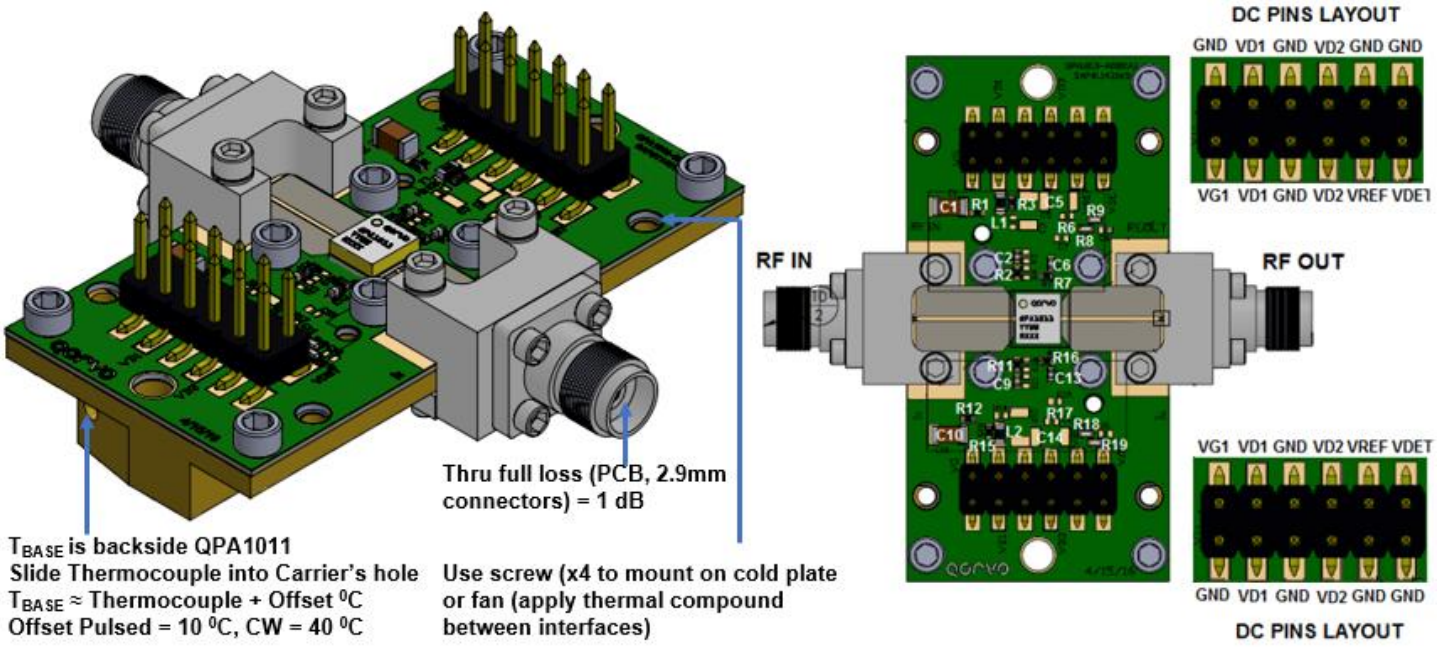
1. Set limit: I_D = 2000 mA, I_G = 20 mA
2. Turn on V_G = −5 V
3. Turn on V_D to 24 V. Ensure I_{DQ} ~ 0 mA
4. Adjust V_G until I_{DQ} = 600 mA (V_G ≈ -2.2 +/- 0.7 V typical)
5. Turn on RF signal

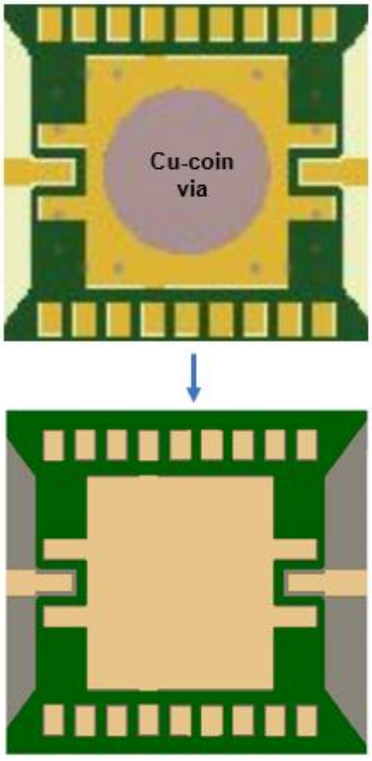
Bias-Down Procedure

1. Turn off RF signal
2. Reduce V_G to −5 V. Ensure I_{DQ} ~ 0 mA
3. Set V_D to 0 V
4. Turn off V_D
5. Turn off V_G

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Evaluation Board (EVB) Layout for Pulsed and Linear Operations





Layer	Name	Material	Thickness	Constant	Board Layer Stack
1	SILKSCREEN_TOP				
2	SOLDERMASK_TOP	Solder Resist	0.40mil	0	
3	METAL1_TOP	Copper	0.70mil		
4	DIELECTRIC 1	ROGERS 4003C	8.00mil	3.38	
5	METAL2_GND	Copper	0.70mil		
6	DIELECTRIC 2	370HR	6.00mil	3.82	
7	METAL3_GND	Copper	0.70mil		
8	DIELECTRIC 3	370HR	6.00mil	4.14	
9	METAL4_BOT	Copper	0.70mil		

PCB is a multilayer:
1. Total thickness: 25 3 mil
2. Via, 98 mil round, is Cu-coined required for optimum thermal management
3. Other vias, 8 mil round, is non-conductive epoxy filled

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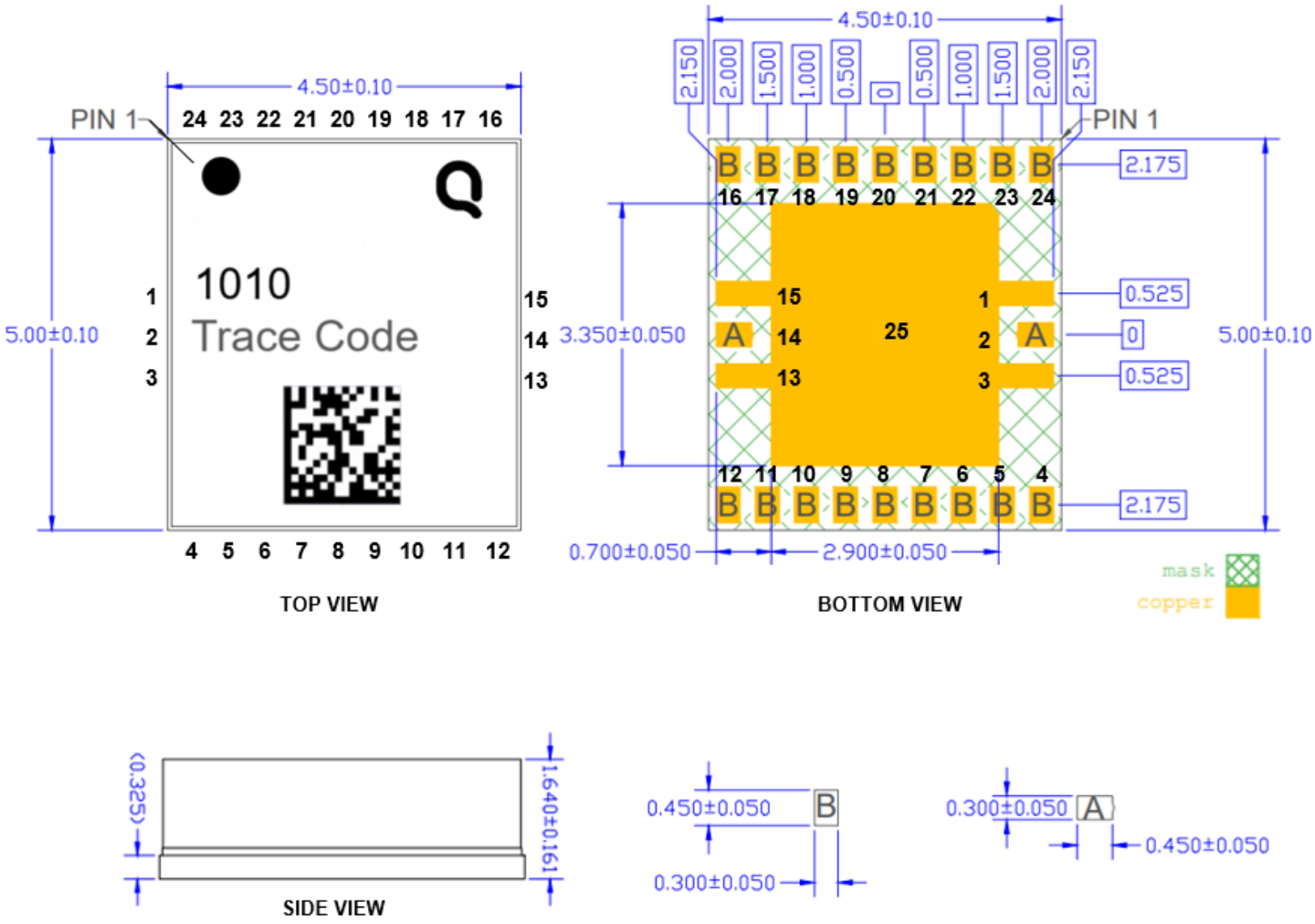
Bill of Materials

Reference Des.	Qty	Value	Description	Part Number
C1, C10	2	10 uF	CAP, 10uF, ±20%, 50V, X5R, 1206	
C2, C6, C9, C13	4	0.01 uF	CAP, 0.01uF, ±10%, 50V, X7R, 0402	
R1, R12	2	5.1 Ω	RES, 5.1 Ohm, ±5%, 50V, 0402	
R2, R7, R11, R16	6	0 Ω	RES, 0 Ohm, Jumper, 0402	
R8, R9, R18, R19	4	25.5K Ω	RES, 25.5K Ohm, ±1%, 1/16W, 0402	
Optional for CW and optimum linearity (These 4 components are not included in Qorvo EVB – pulsed):				
C5, C14	2	10 uF	CAP, 10uF, ±20%, 50V, X5R, 1206	
R6, R17	2	0 Ω	RES, 0 Ohm, Jumper, 0402	
L1, L2	2	470 Ω	Ferrite Bead, 470 Ohm, 1A, 0603	
PCB	1		PCB	Qorvo, Custom
H1, H2	2		DC Header, 2x6, 0.100”, SMD	
J1, J2	2		RF Connector, 2.92mm, F, Pin 0.005, Diel 0.029	Southwest Microwave
H-Block	1		H-Block, Copper C110, 0.990 x 2.000 x 0.275 in	Qorvo, Custom
S1 – S8	8		Screw, Cap, Socket Head, 2-56X1/8”	
Solder Preform			Solder, Preform, SAC305, 1 x 1 x 0.002 in	
Solder Paste			Paste, solder, Sn63/Pb37	

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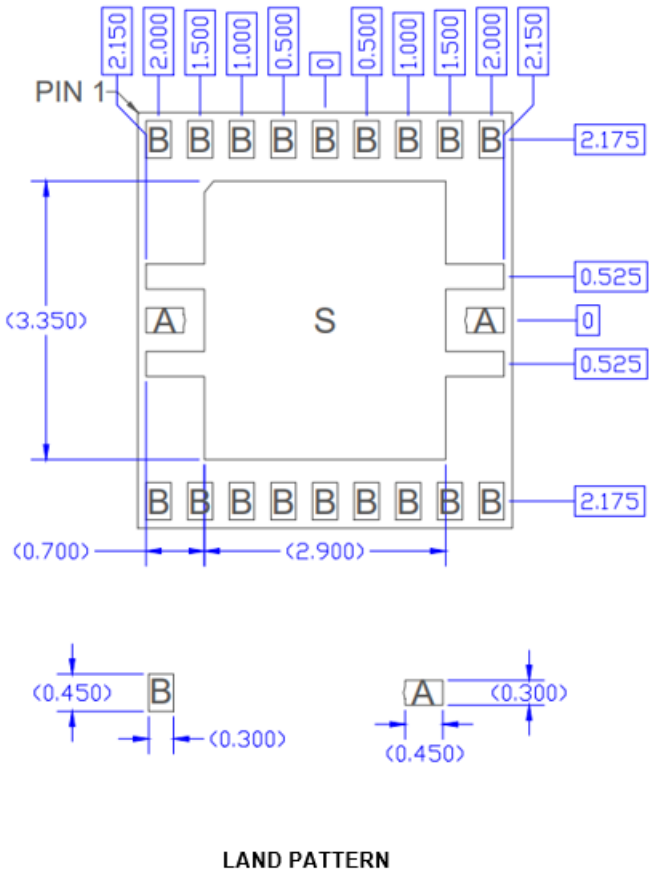
Mechanical Information



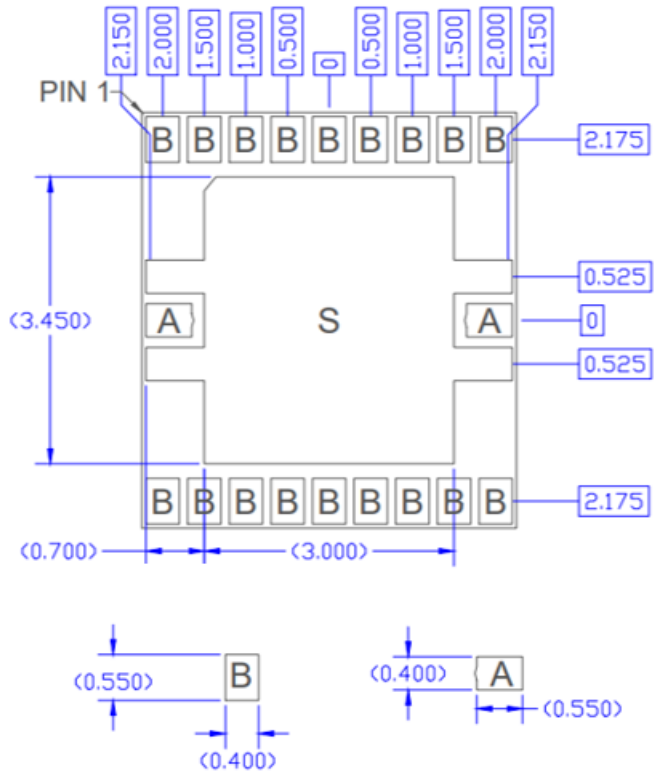
Dimensions (unless otherwise specified) are in millimeters
0.000 no tolerance; minimum precision
Pin 1 Indicator; 2D Matrix – 16P (1.5mm x 1.5mm); Trace Code to be assigned for each part
Package is air-cavity and non-hermetic
Base is laminate; Lid is FR4; all metalized features are gold plated; part is epoxy sealed

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Recommended Land Pattern & Mask



LAND PATTERN



LAND PATTERN MASK

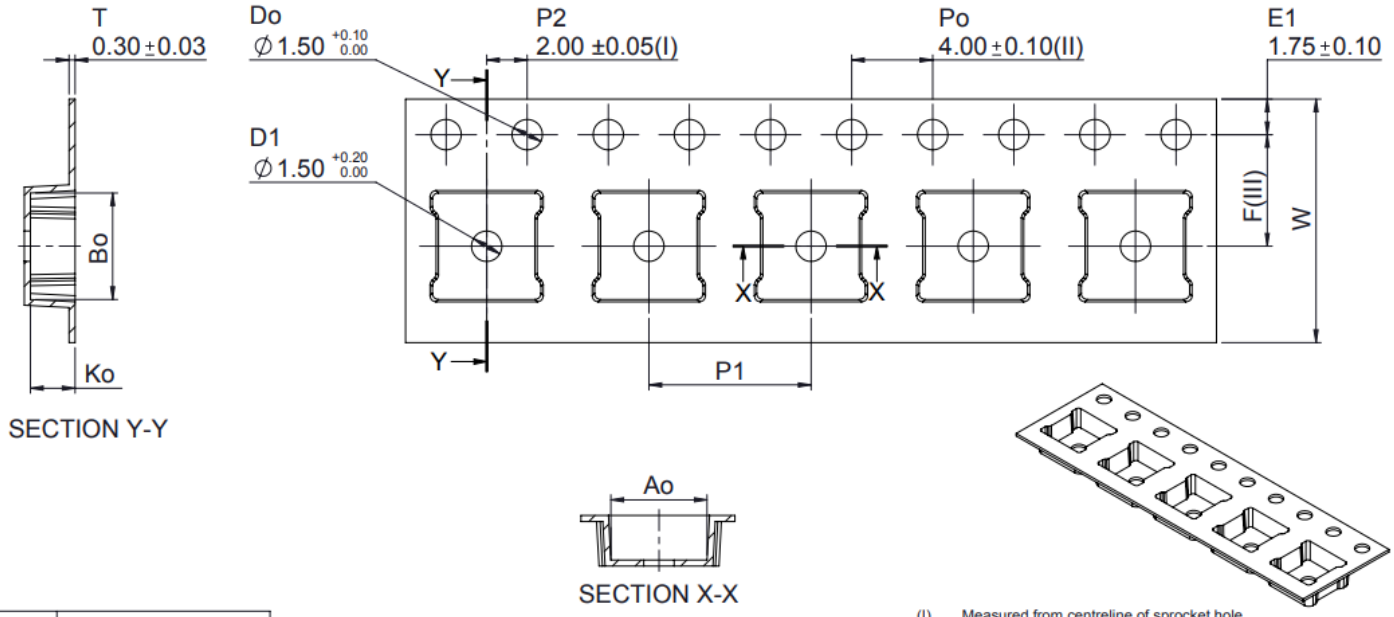
Pin Description

Pin Number	Symbol	Description
1, 3, 13, 15	GND	Ground; recommend grounding on PCB
2	RF_{IN}	RF Input; matched to 50 Ω; DC blocked
4, 7, 21, 24	N/C	No internal connection; recommend grounding on PCB
5, 23	V_G	Gate voltage for stage 1 and 2; external bypassing required (page 28)
6, 22	V_{D1}	Drain voltage for stage 1; external bypassing required (page 28)
8 – 10, 18 – 20	V_{D2}	Drain voltage for stage 2; external bypassing required (page 28)
11, 17	V_{REF}	Reference output voltage
12, 16	V_{DET}	Detector diode output voltage; varied with RF output power
14	RF_{OUT}	RF Output; matched to 50 Ω; DC blocked
25	GND	Ground (backside paddle); grounded on PCB; Cu-coin via should be employed to minimize inductance and thermal resistance

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Tape & Reel Information

Standard T/R size: 250 pieces on a 7” reel
Dimensions unless otherwise noted: millimeters (mm)
Tolerances unless otherwise noted: ± 0.1



Ao	4.75	+/- 0.05
Bo	5.25	+/- 0.05
Ko	2.20	+/- 0.05
F	5.50	+/- 0.05
P1	8.00	+/- 0.10
W	12.00	+0.30 / -0.10

(I) Measured from centreline of sprocket hole to centreline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centreline of sprocket hole to centreline of pocket.
(IV) Other material available.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

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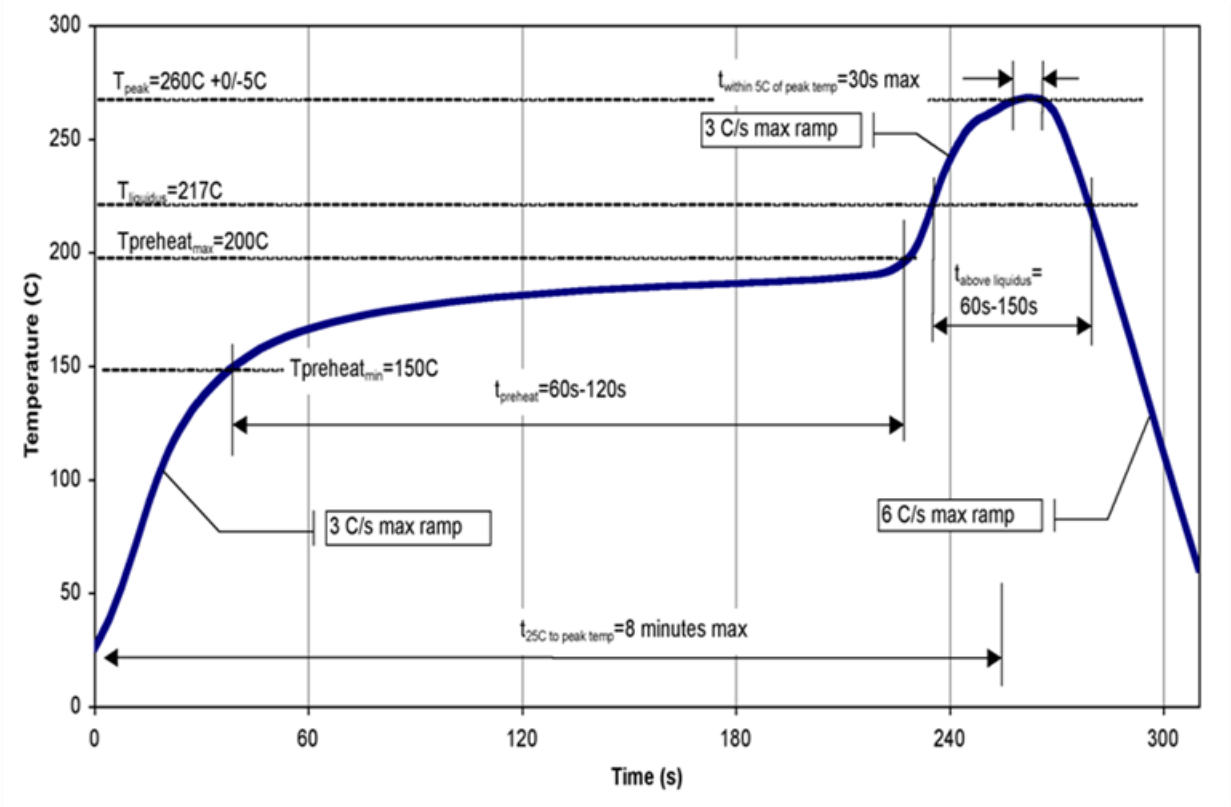
Assembly Notes

Compatible with lead-free soldering processes with 260°C peak reflow temperature.

This package is air-cavity and non-hermetic and therefore cannot be subjected to aqueous washing. The use of no-clean solder to avoid washing after soldering is highly recommended.

Contact plating: Ni-Au

Solder rework not recommended



Recommended Soldering Temperature Profile

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Handling Precautions

Parameter	Rating	Standard
ESD – Human Body Model (HBM)	0B	ANSI/ESD/JEDEC JS-001
ESD – Charged Device Model (CDM)	C3	ANSI/ESD/JEDEC JS-002
MSL – Moisture Sensitivity Level	3	IPC/JEDEC J-STD-020



Caution!

ESD-Sensitive Device

RoHS Compliance

This part is compliant with 2011/65/EU RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) as amended by Directive 2015/863/EU.

This product also has the following attributes:

- Lead Free
- Antimony Free
- TBBP-A ($C_{15}H_{12}Br_4O_2$) Free
- PFOS Free

Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

Web: www.qorvo.com

Tel: 1-844-890-8163

Email: customer.support@qorvo.com

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