7.9 – 11.0 GHz 15 W GaN Power Amplifier

Product Description

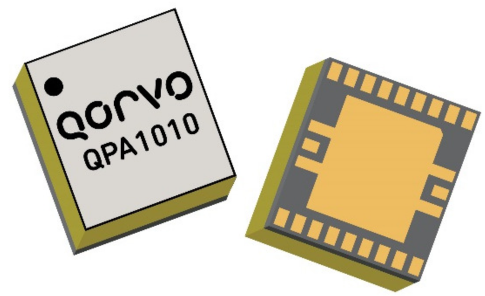
Qorvo's QPA1010 is a X-band high power MMIC amplifier fabricated on Qorvo's production 0.15um GaN on SiC process (QGaN15). The QPA1010 operates from 7.9 – 11 GHz and typically provides 15 W saturated output power with power-added efficiency of 38% and large-signal gain of 18 dB. This combination of wideband 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 allows it support satellite communication and data links, as well as, military and commercial radar systems.

Lead-free and RoHS compliant.

Evaluation boards are available upon request.

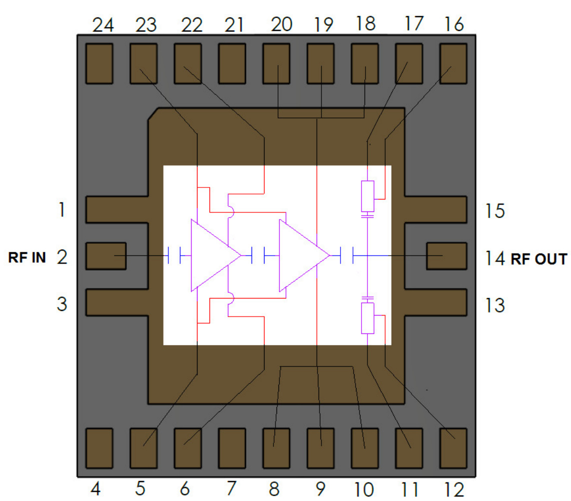


Product Features

- Frequency Range: 7.9 – 11 GHz
- P_{OUT}: 42 dBm at P_{IN} = 24 dBm
- PAE: 38 % at P_{IN} = 24 dBm
- Large Signal Gain: 18 dB at P_{IN} = 24 dBm
- Small Signal Gain: 25 dB
- Integrated Power Detector
- Bias: V_D = 24 V, I_{DQ} = 600 mA, V_G = –1.8 V Typical
- Pulsed V_D: PW =100 µS, DC = 10%
- Package Dimensions: 4.5 x 5.0 x 1.72 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.	ECCN	Description
QPA1010	3A001.b.2.b.2	7.9 – 11 GHz 15 W GaN Power Amplifier

Absolute Maximum Ratings

Parameter	Value / Range
Drain Voltage (V_D)	29.5 V
Gate Voltage Range (V_G)	–8 to 0V
Drain Current (I_{D1}/I_{D2})	672 mA / 1440 mA
Gate Current (I_G)	See chart, pg. 20
Power Dissipation (P_{DISS}), 85°C, CW	38 W
Input Power (P_{IN}), CW, 50Ω, V_D=28 V, I_{DQ}=600 mA, 85 °C	30 dBm
Input Power (P_{IN}), CW, VSWR 3:1, V_D=28 V, I_{DQ}=600 mA 85 °C	30 dBm
Channel Temperature (T_{CH})	275 °C
Mounting Temperature (30 seconds)	260 °C
Storage Temperature	–55 to 150 °C

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	Value / Range
Drain Voltage (V_D)	24 V
Drain Current (I_{DQ})	600 mA
Gate Voltage (V_G), Typical	–1.8 V

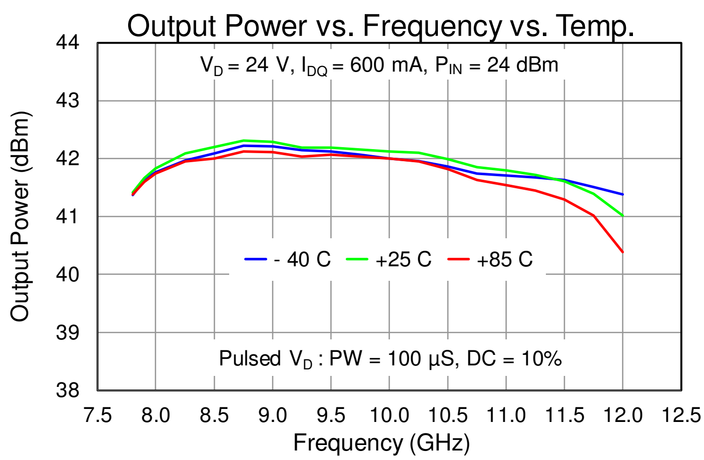
Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.

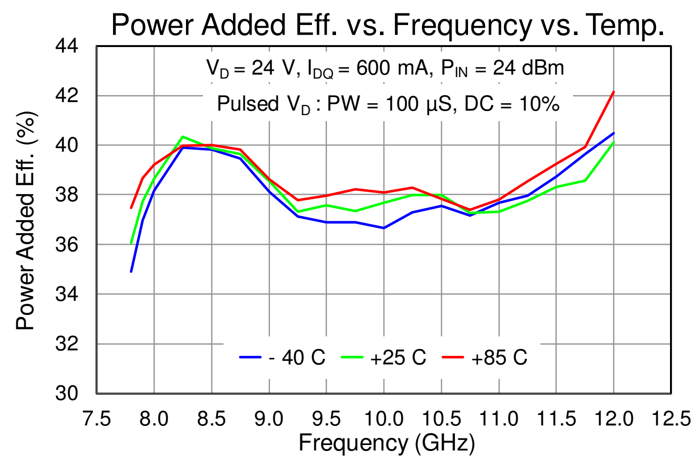
Electrical Specifications

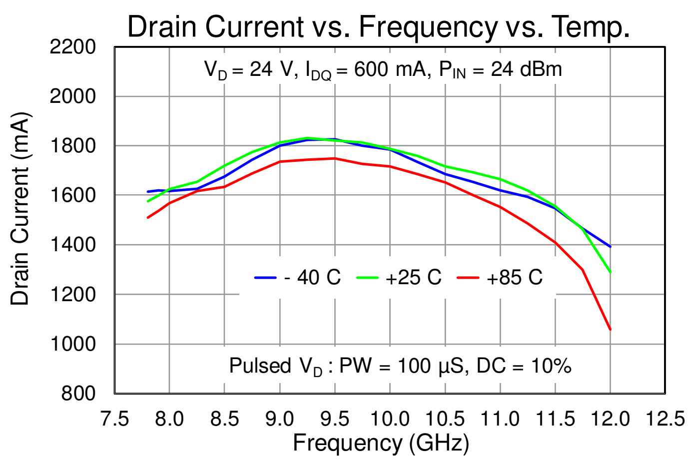
Parameter		Min	Typ	Max	Units
Operational Frequency Range		7.9		11	GHz
Output Power (P_{IN} = 24 dBm)	7.9 GHz 9.0 GHz 11.0 GHz		41.7 42.3 41.8		dBm dBm dBm
Power Added Efficiency (P_{IN} = 24 dBm)	7.9 GHz 9.0 GHz 11.0 GHz		37.7 38.6 37.3		% % %
3rd Order Intermodulation Level (P_{OUT}/Tone= 35 dBm)	7.9 GHz 10.0 GHz 11.0 GHz		–21 –21 –22		dBc dBc dBc
Small Signal Gain	7.9 GHz 9.0 GHz 11.0 GHz		27.9 27.8 26.0		dB dB dB
Input Return Loss	7.9 GHz 9.0 GHz 11.0 GHz		17 22 21		dB dB dB
Output Return Loss	7.9 GHz 9.0 GHz 11.0 GHz		11 11 18		dB dB dB
Output Power Temperature Coefficient (25 – 85 °C) (P_{IN} = 24 dBm)			–0.003		dB/°C
Small Signal Gain Temperature Coefficient (25 – 85 °C)			–0.044		dB/°C
Recommended Voltage Operations			24	28	V

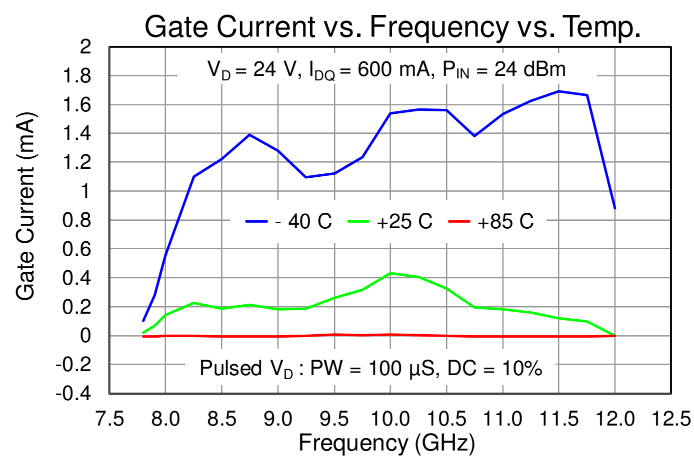
Test conditions, unless otherwise noted: 25 °C, Pulsed V_D: PW = 100 µS, DC = 10%, V_D = 24 V, I_{DQ} = 600 mA, V_G = –1.8 V Typical

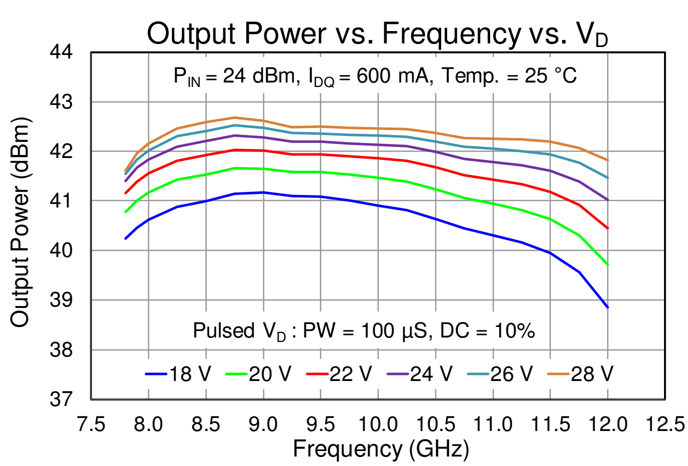
Performance Plots – Large Signal (Pulsed)

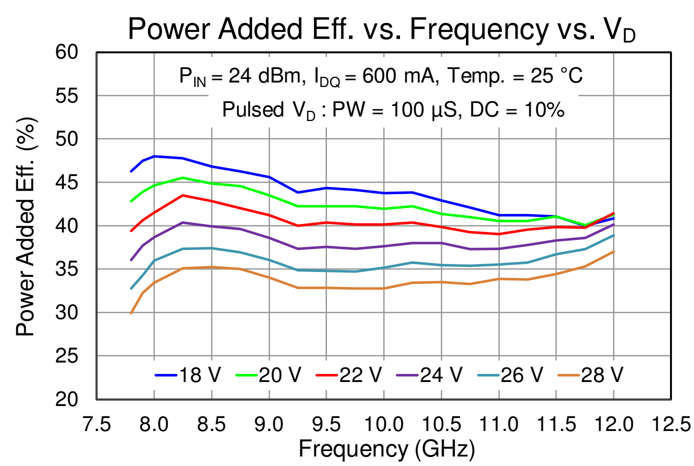












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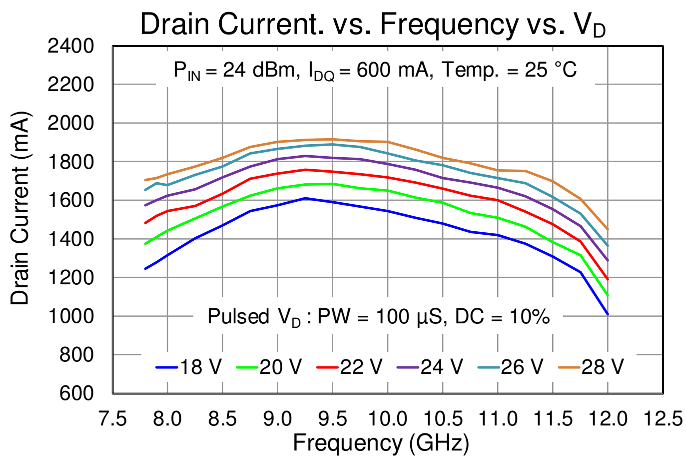

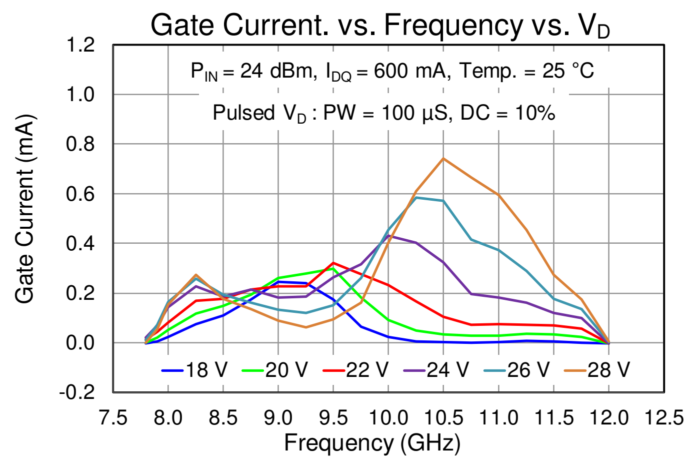

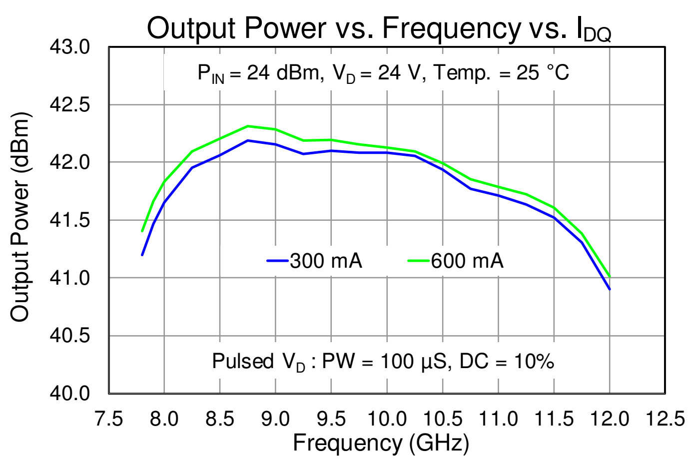

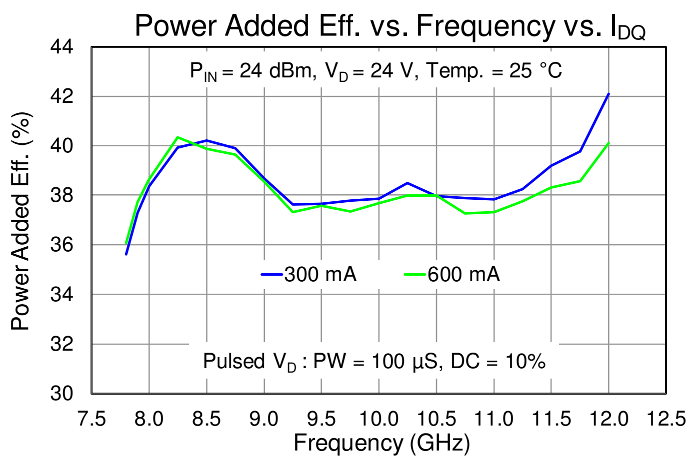

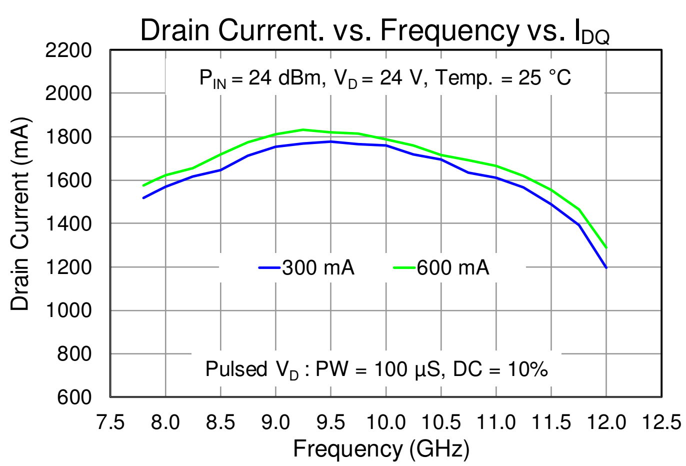

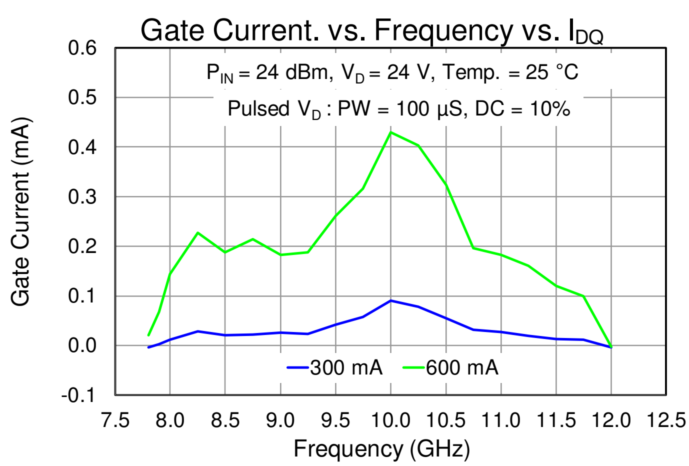

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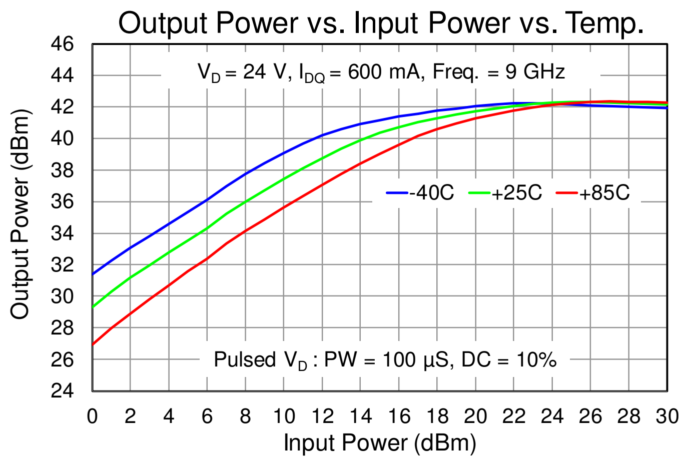

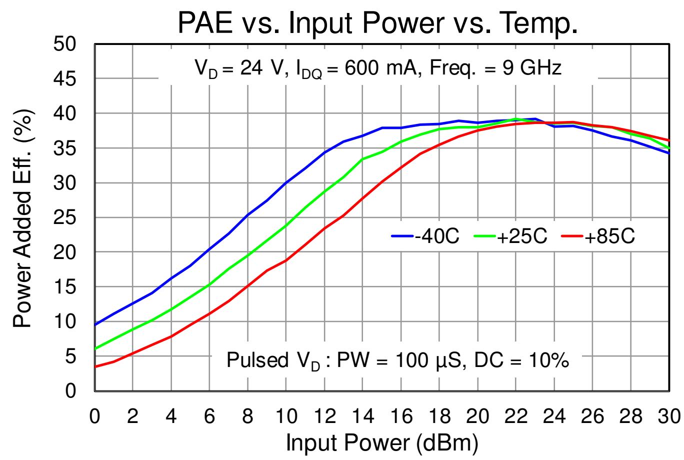

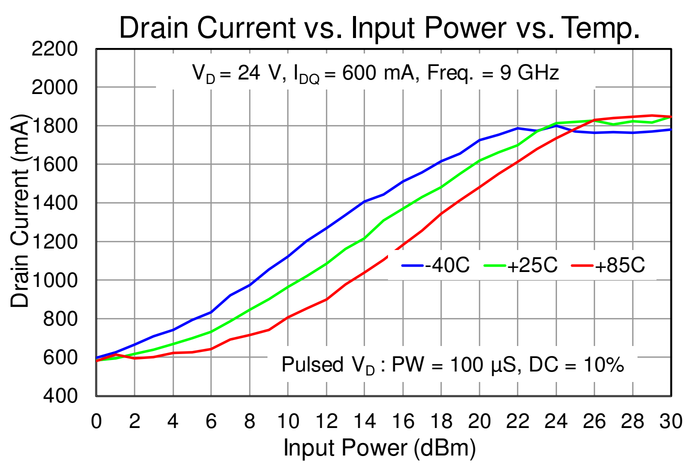

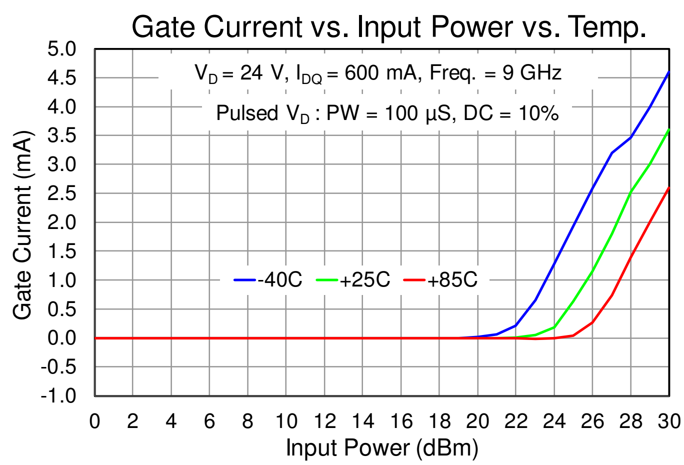

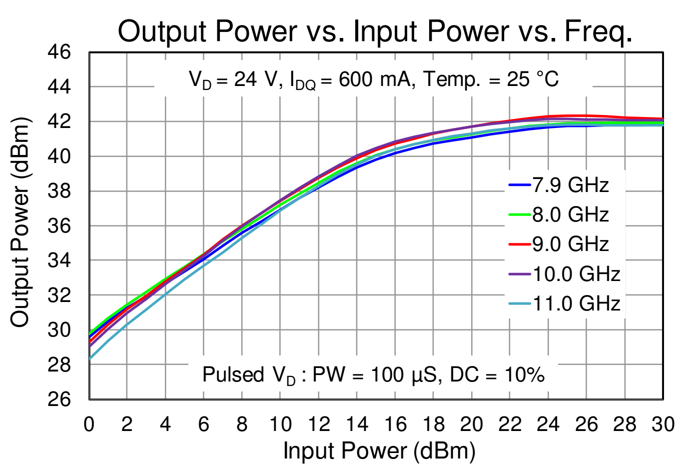

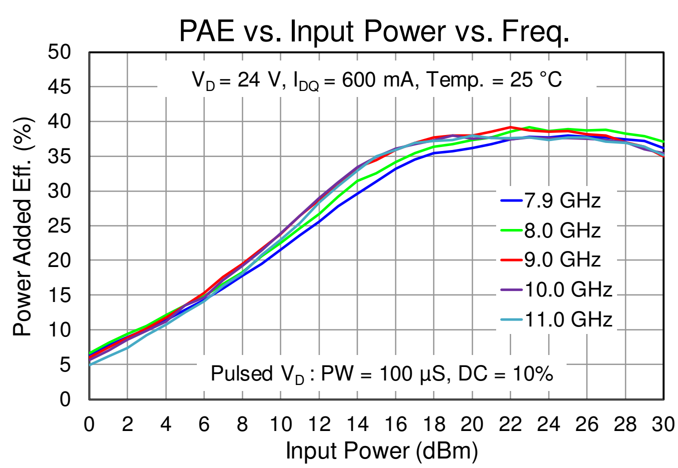

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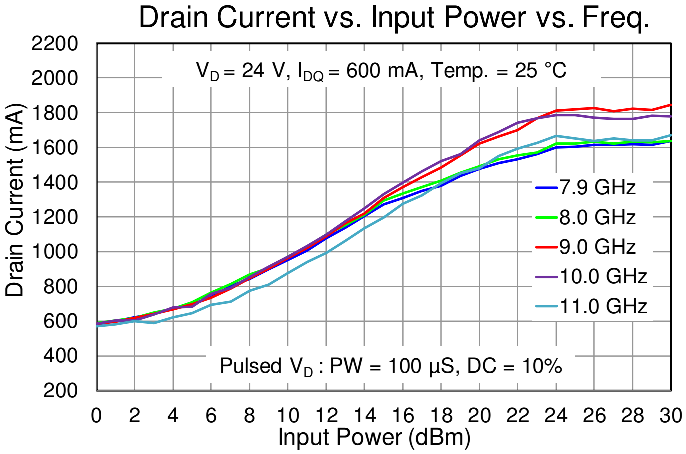
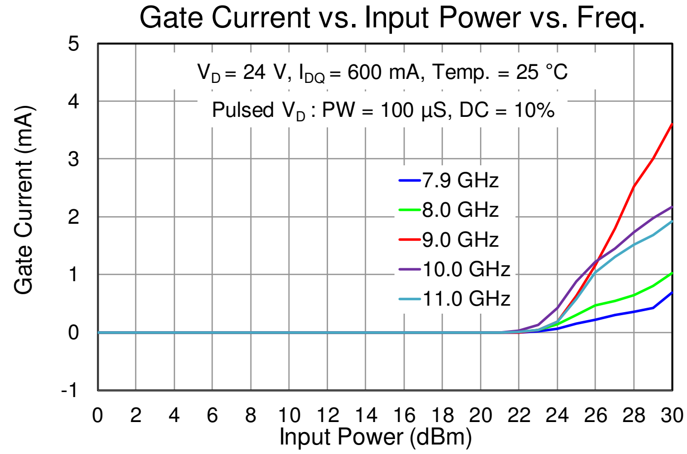
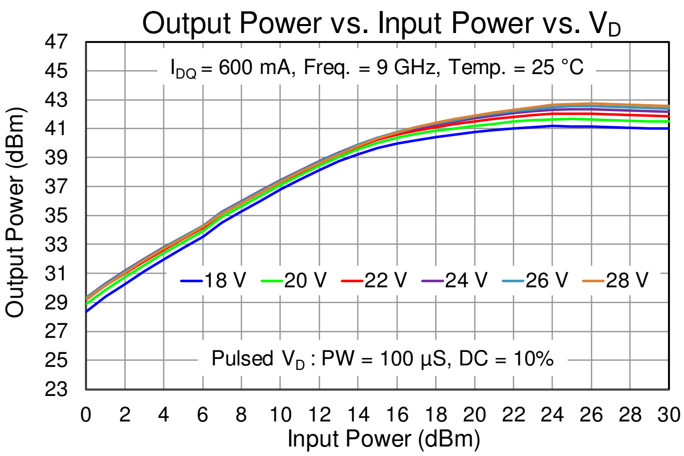
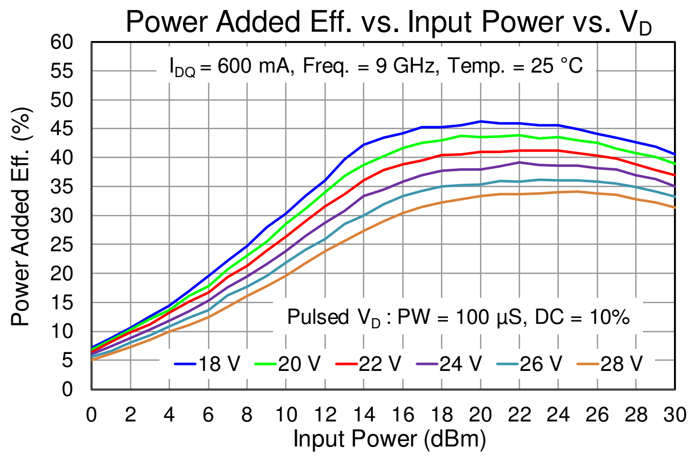
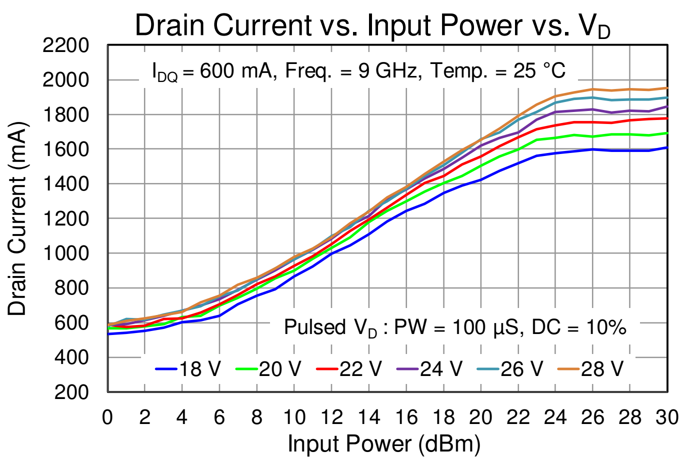
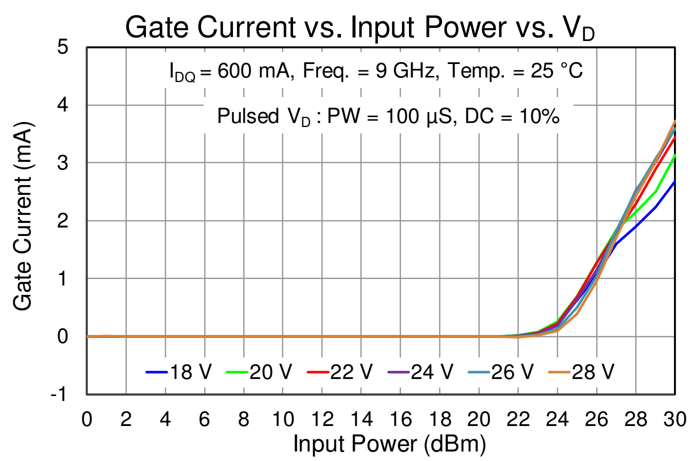




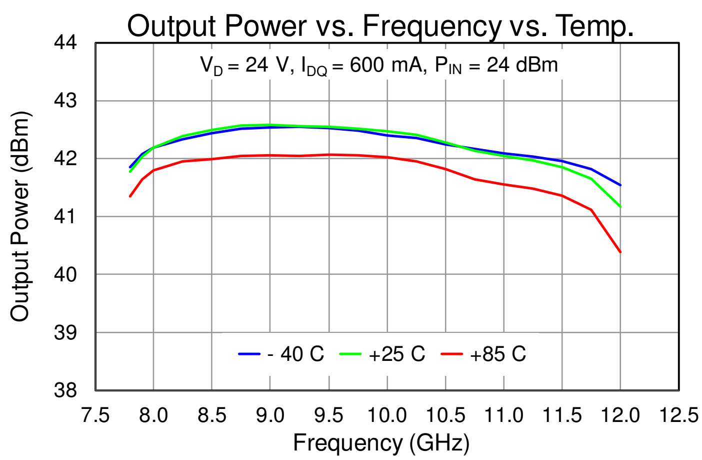


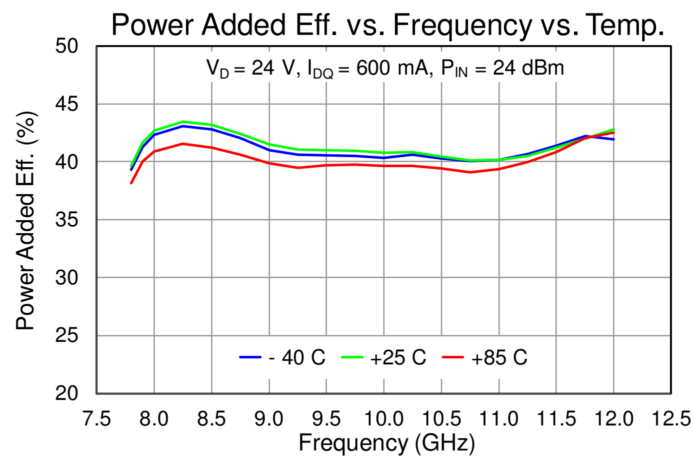


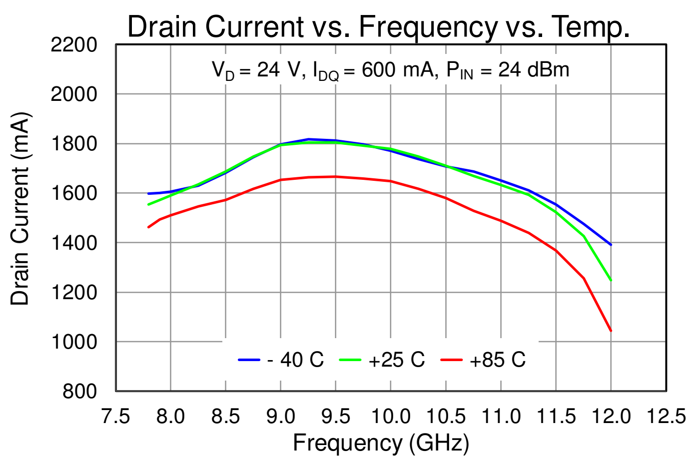


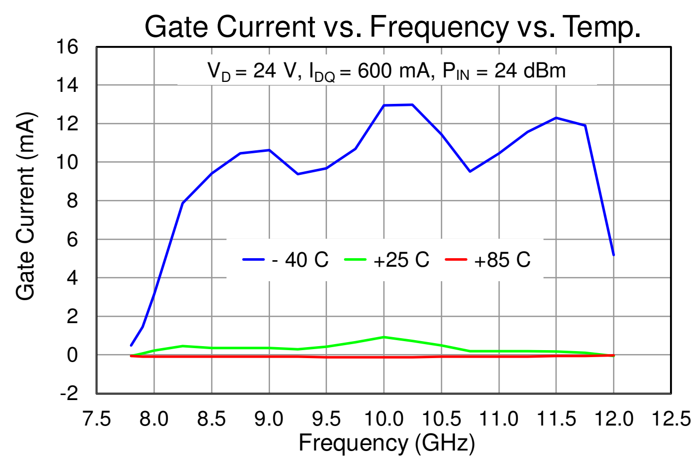


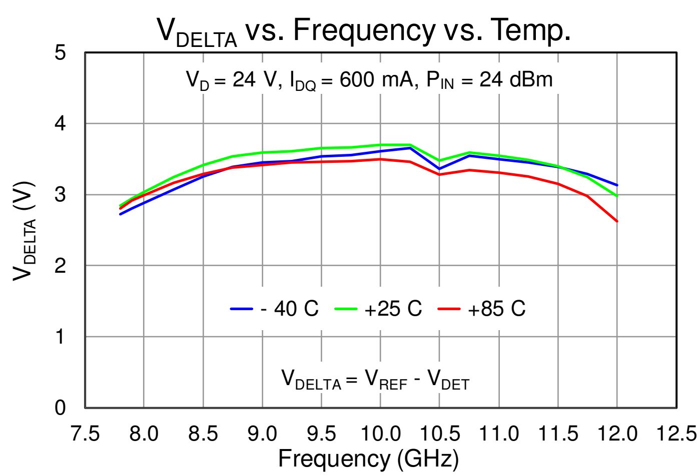
Performance Plots – Large Signal (CW)



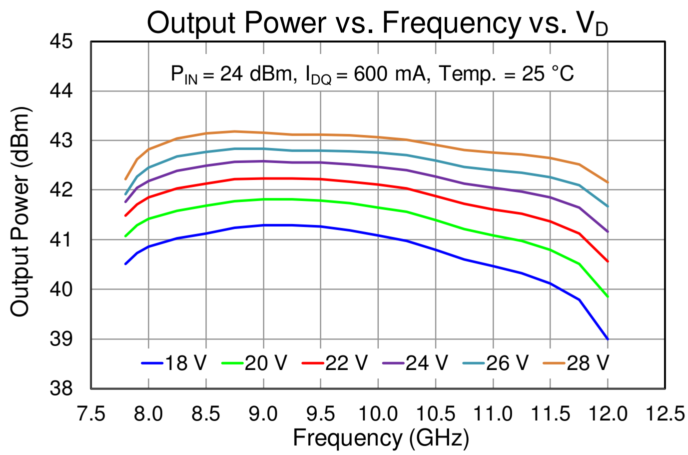


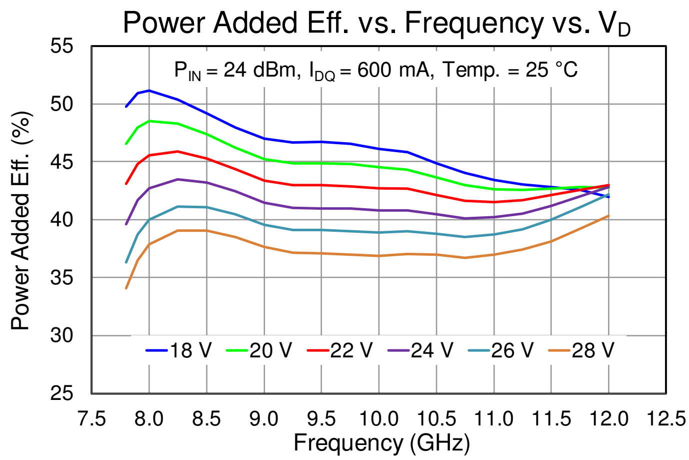


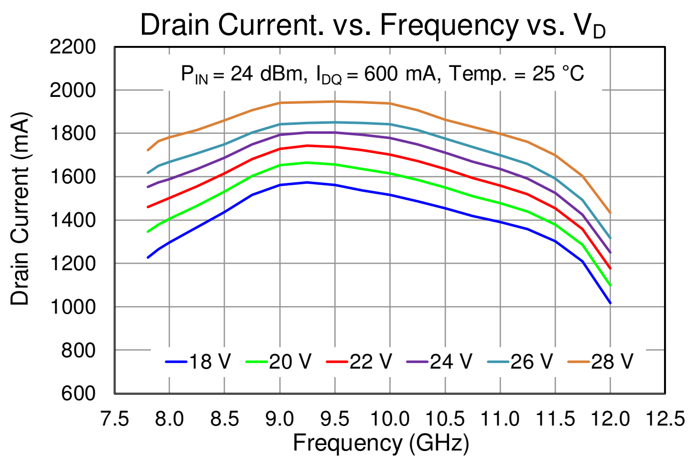


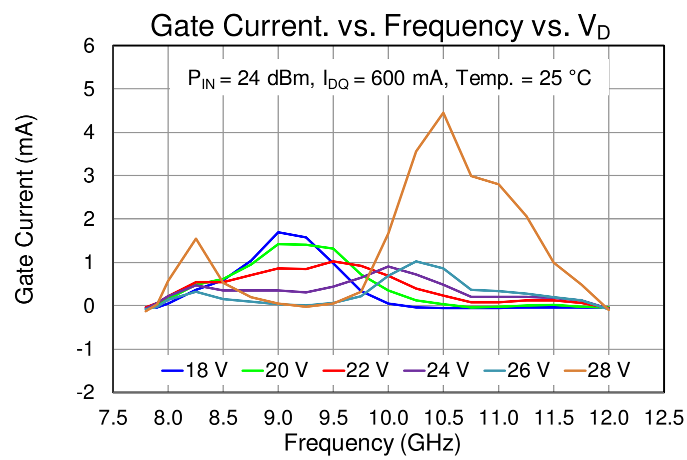


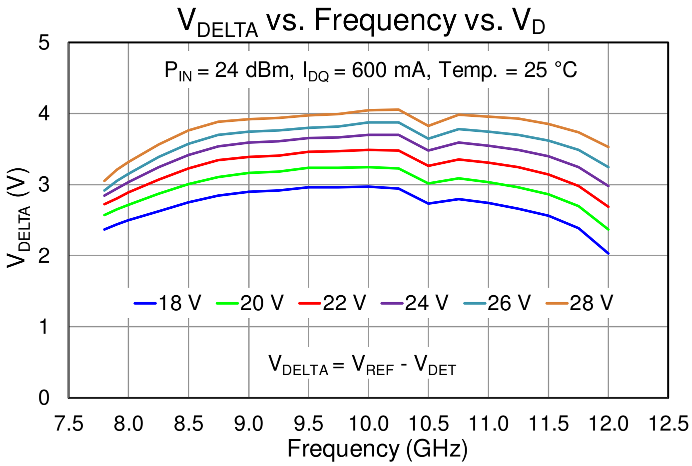
Performance Plots – Large Signal (CW)











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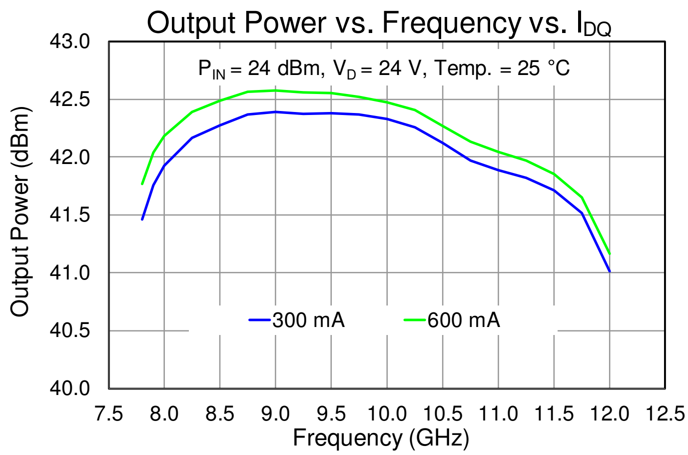

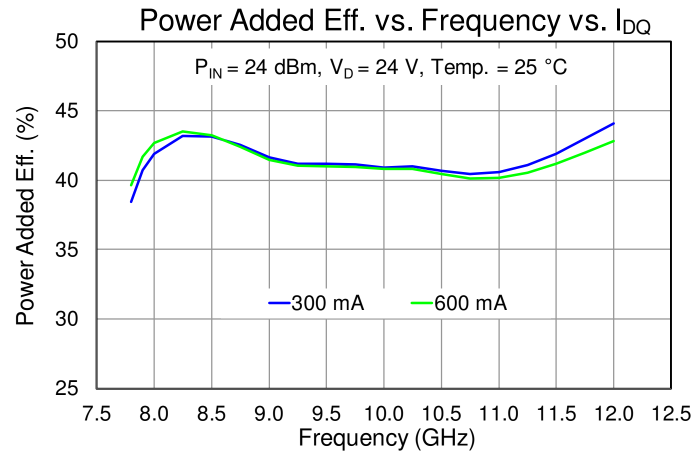

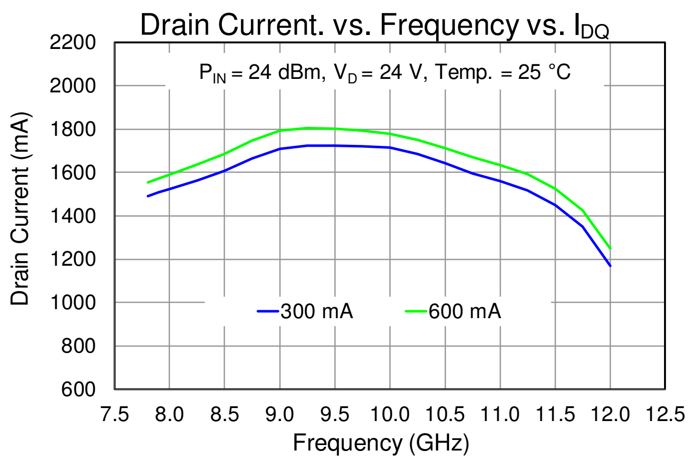

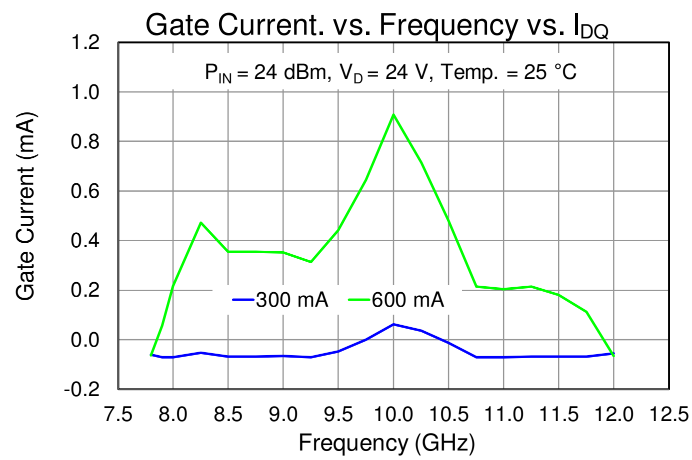

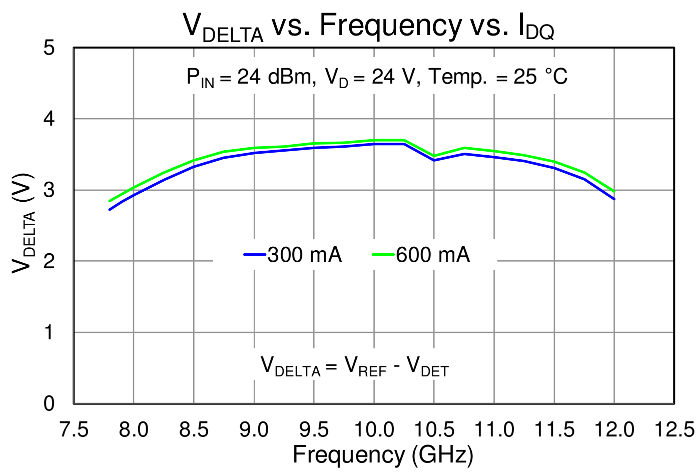

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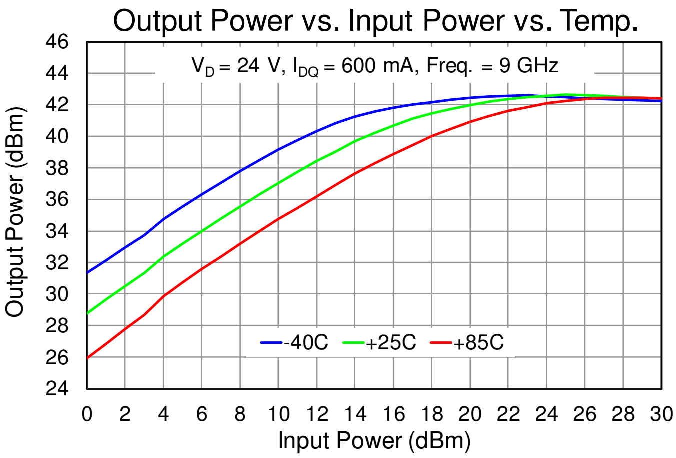

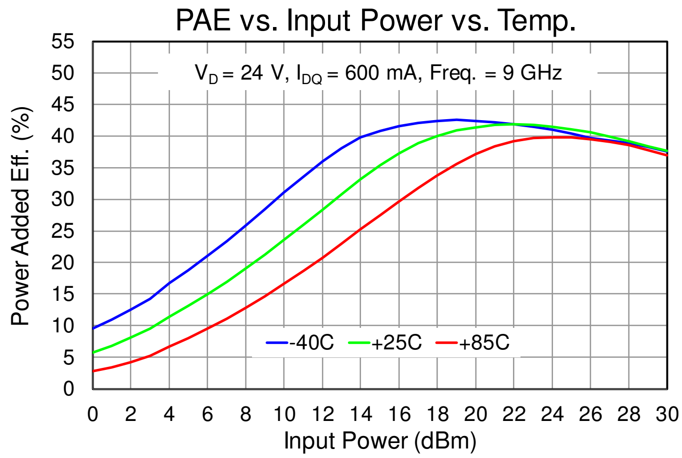

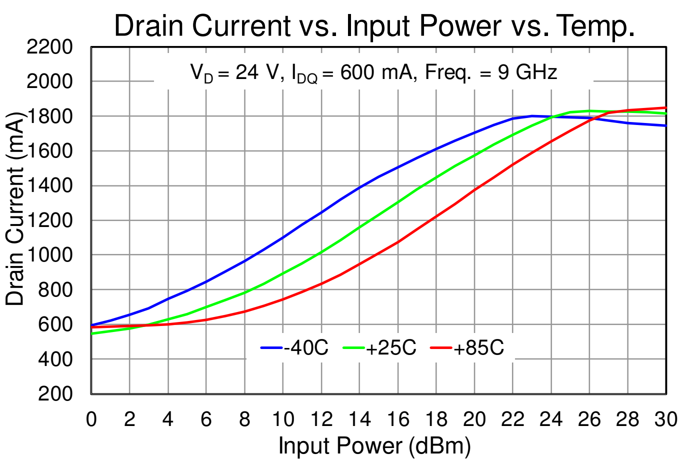

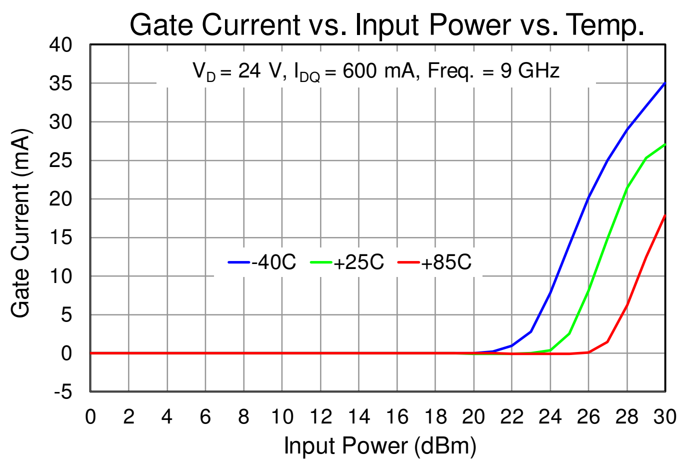

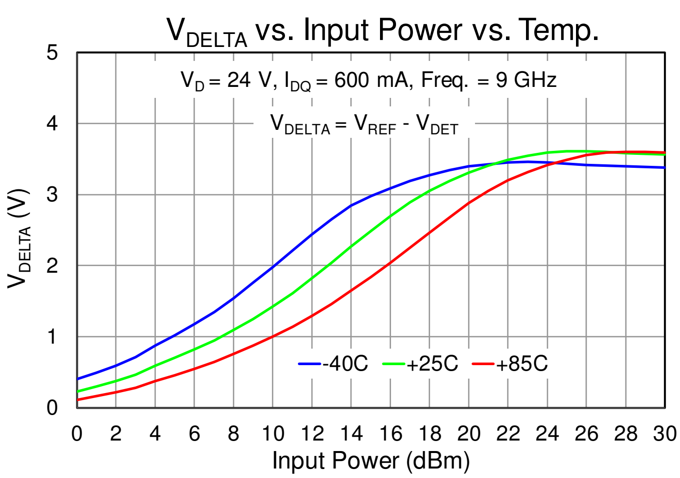

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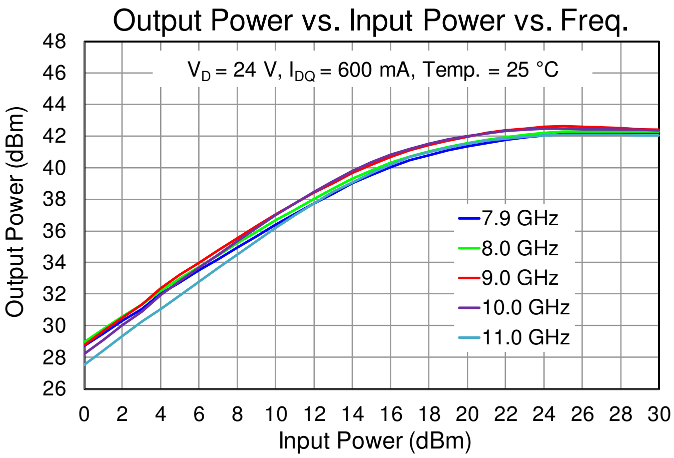

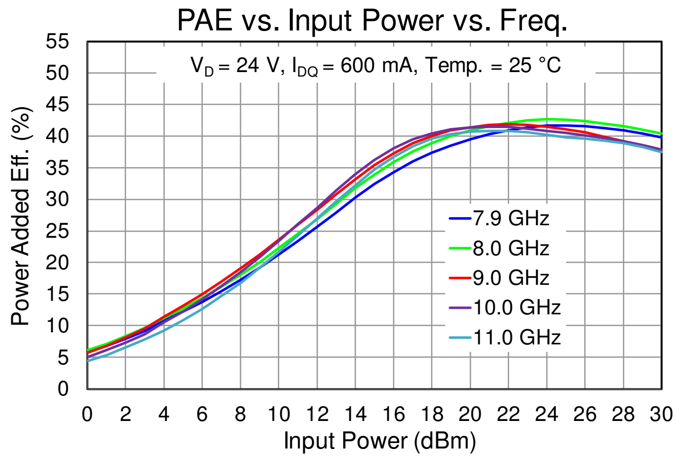

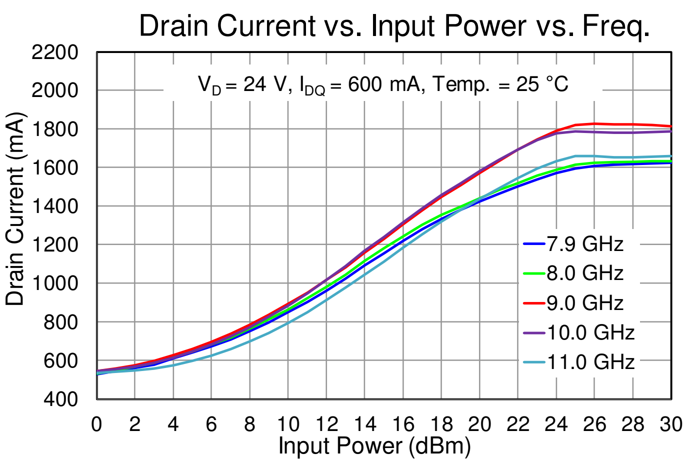

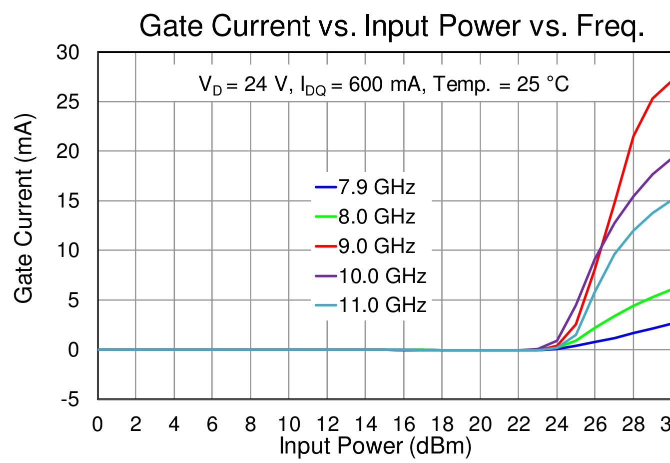

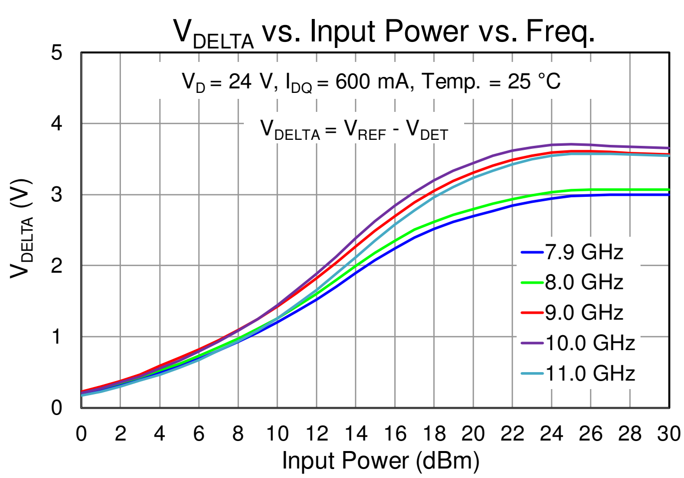

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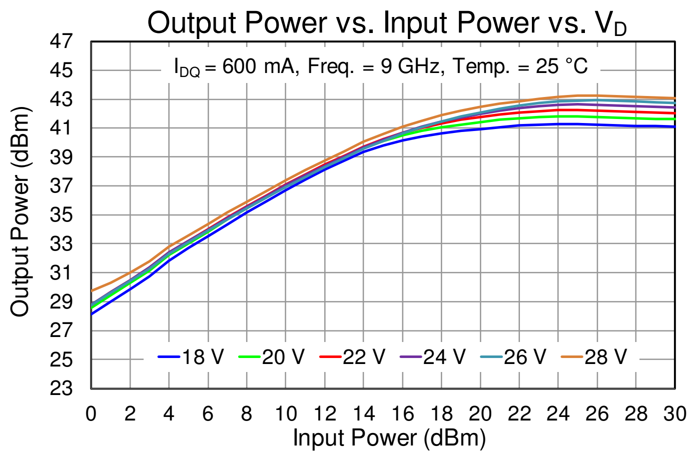
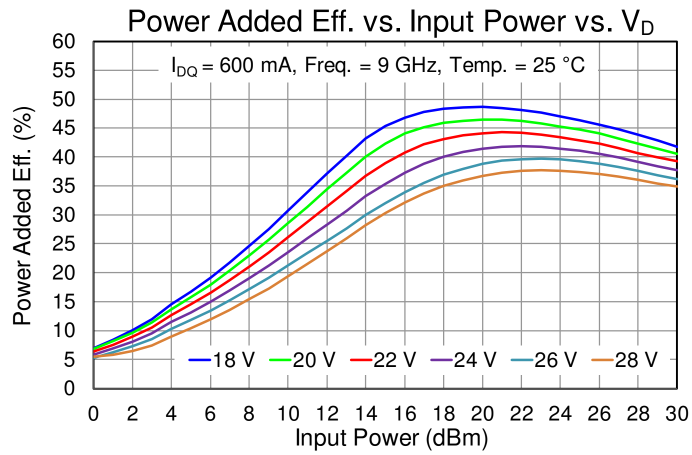
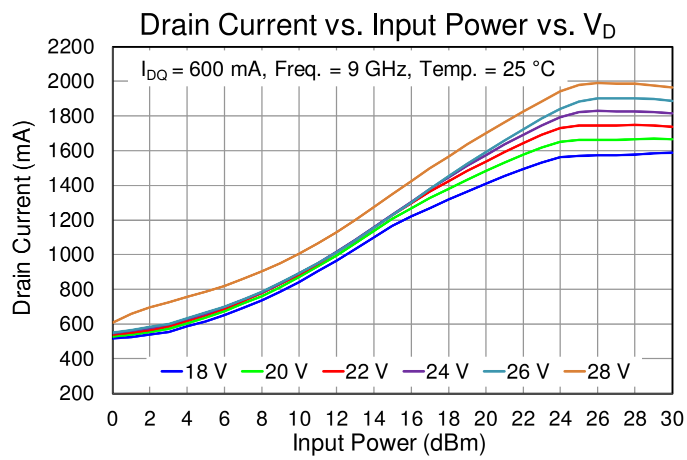
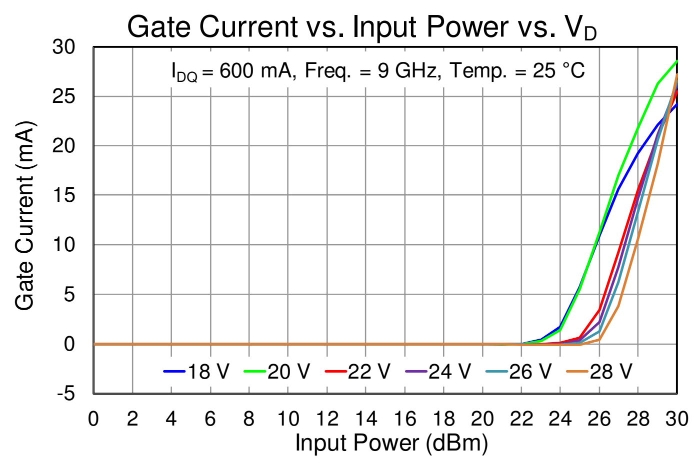
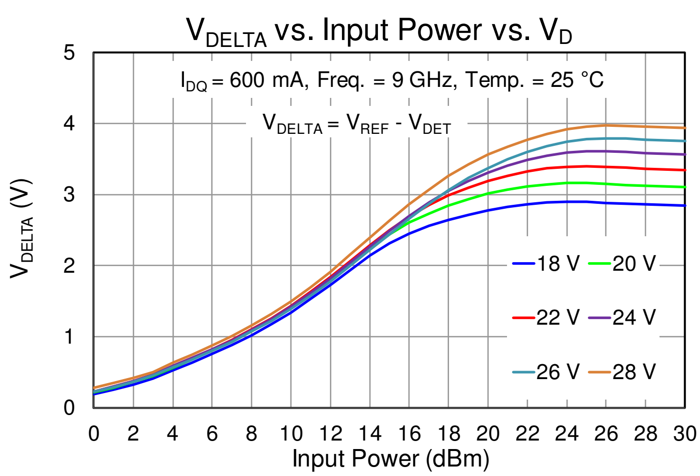


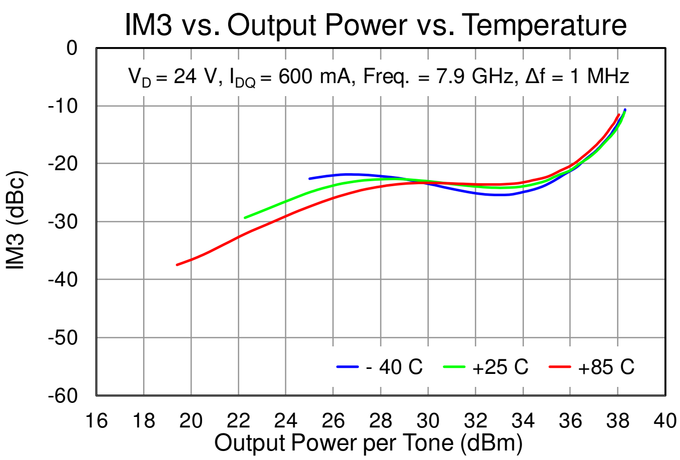


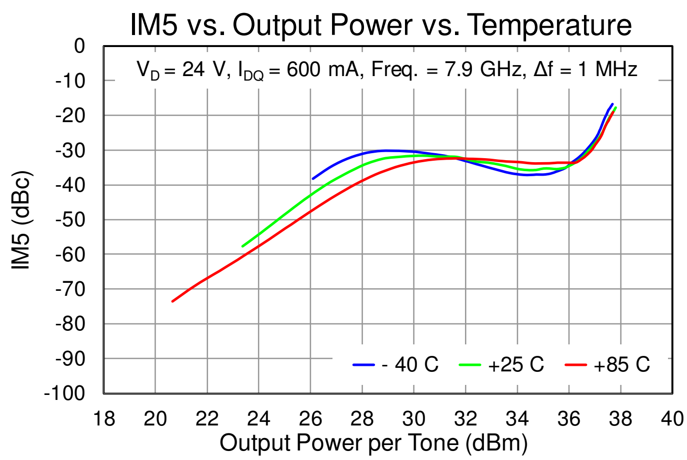


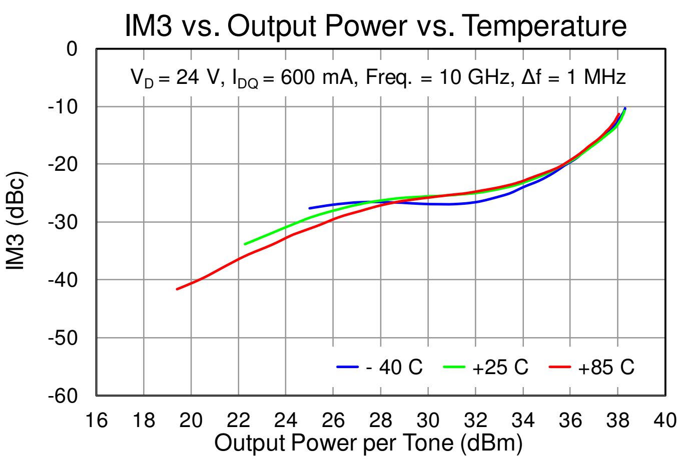


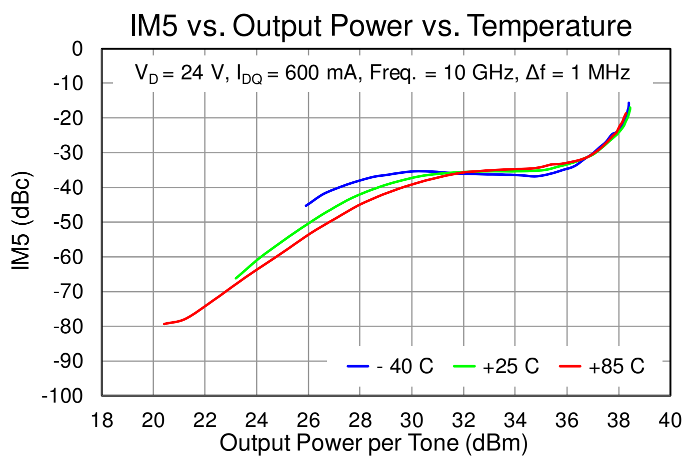


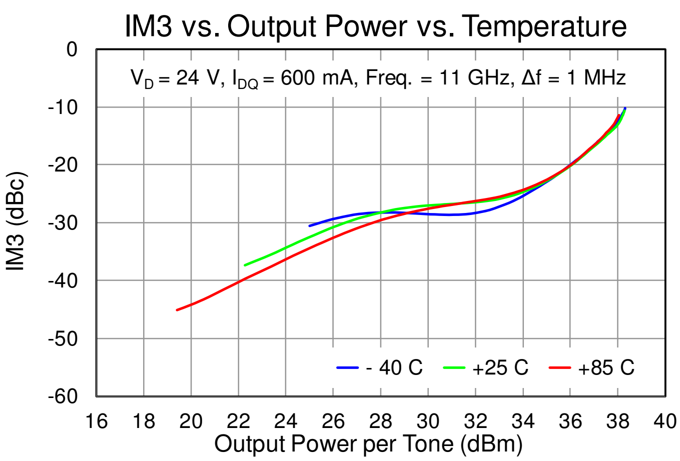
Performance Plots – Linearity

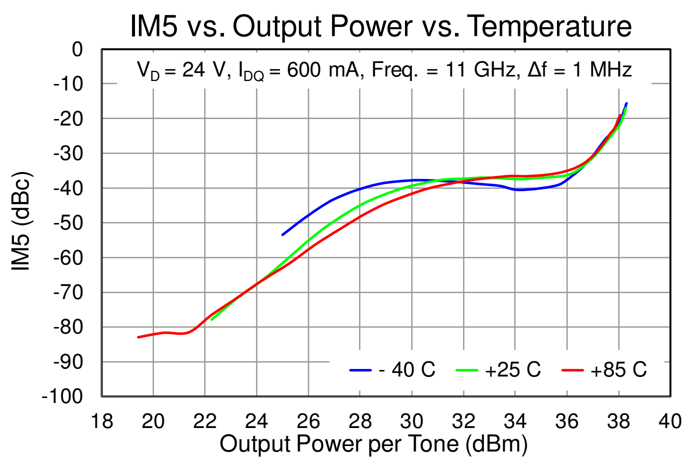












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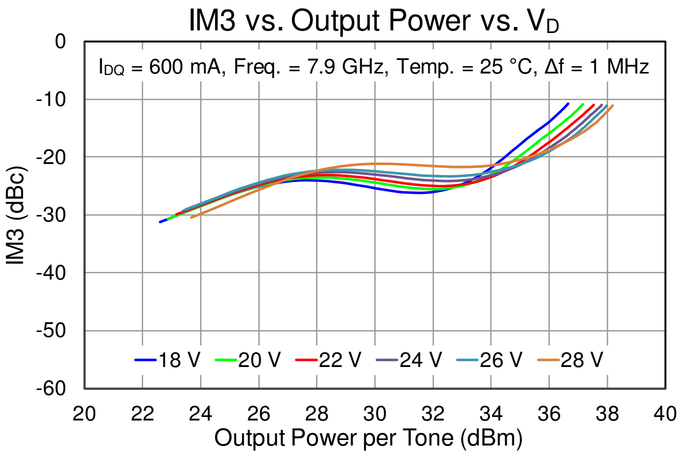
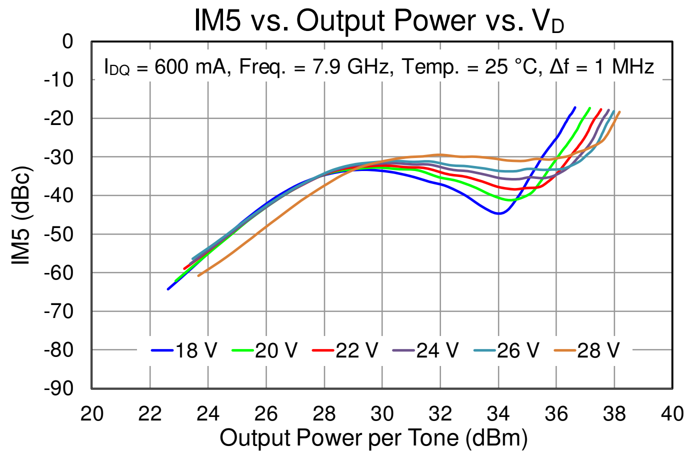
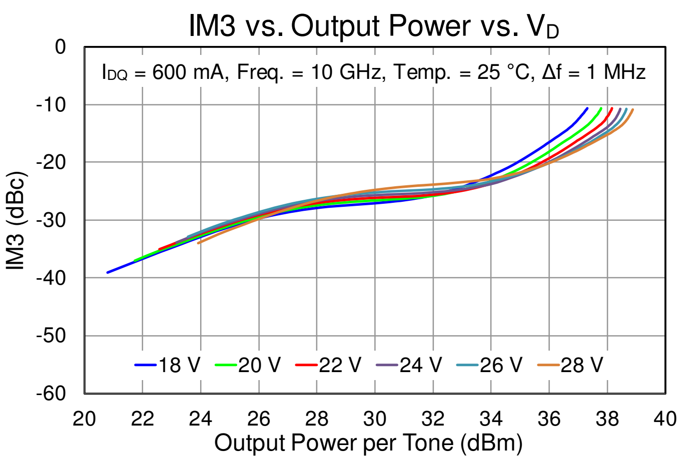
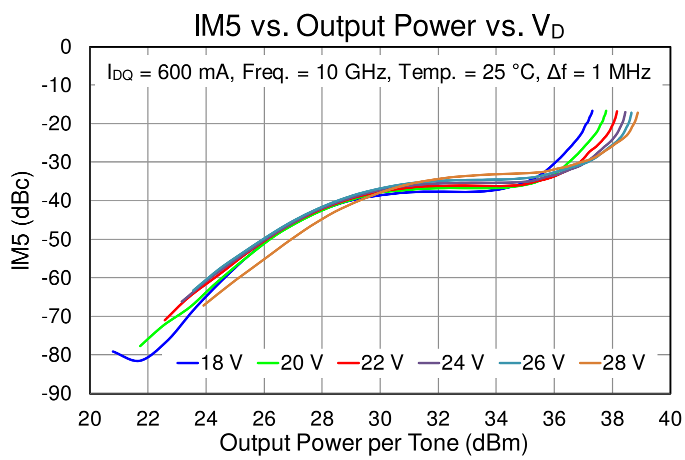
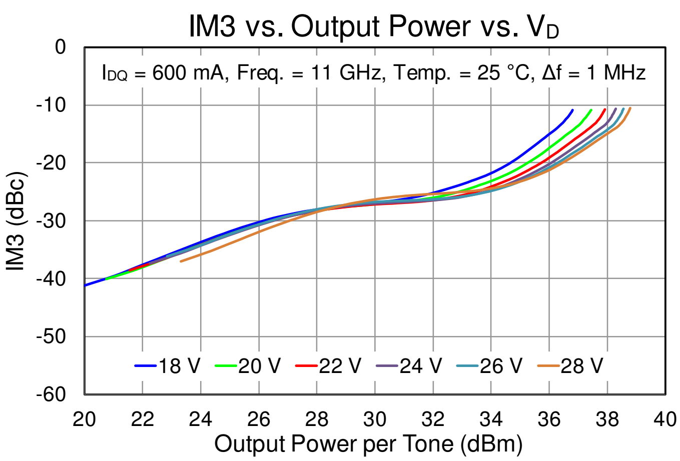
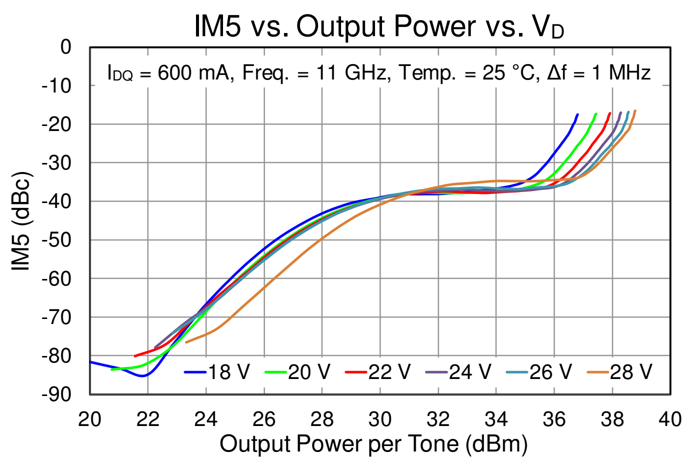




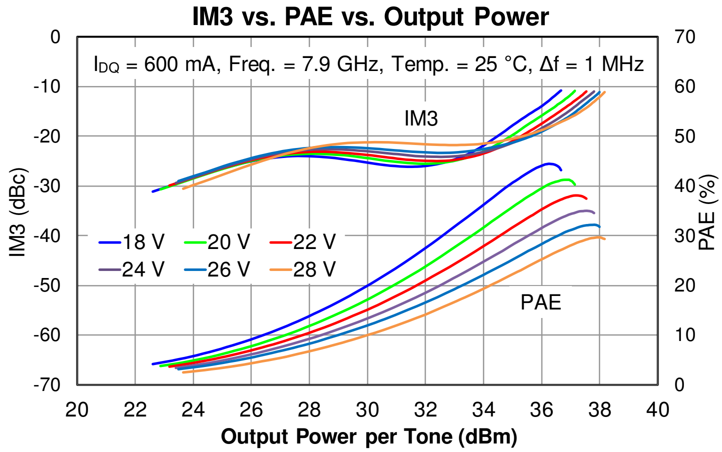




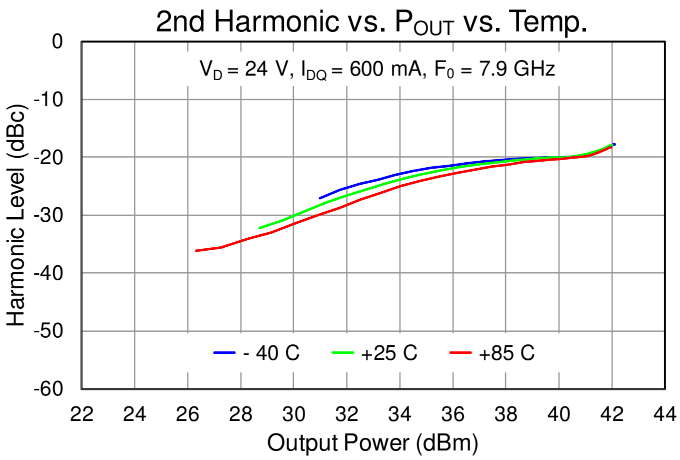


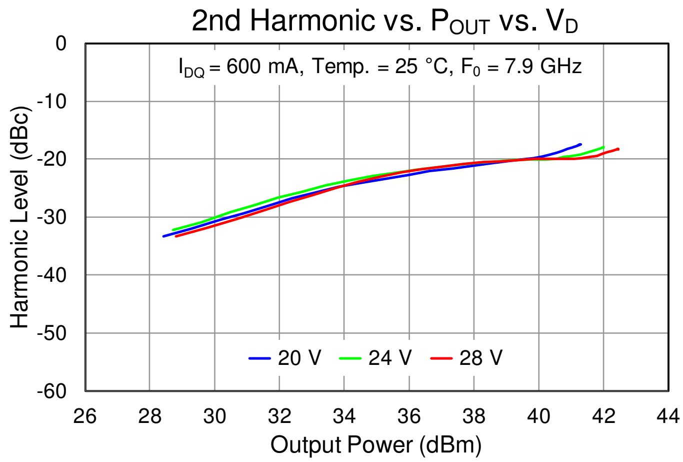


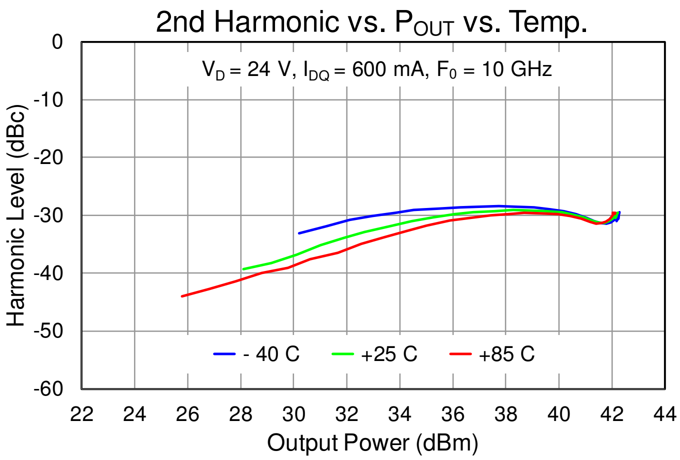
Performance Plots – Linearity

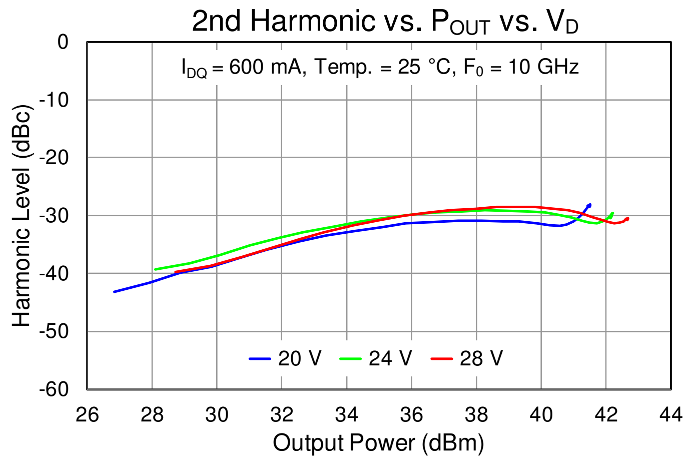


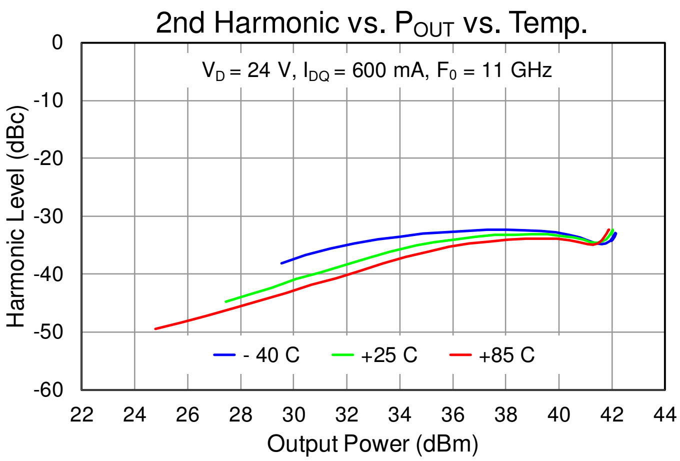
Performance Plots – Harmonics

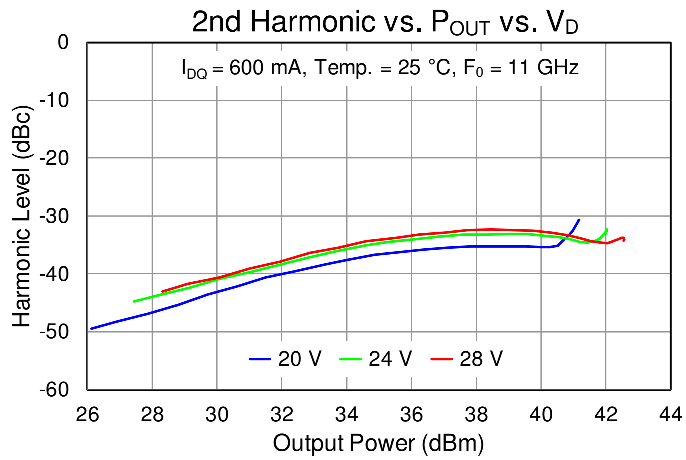




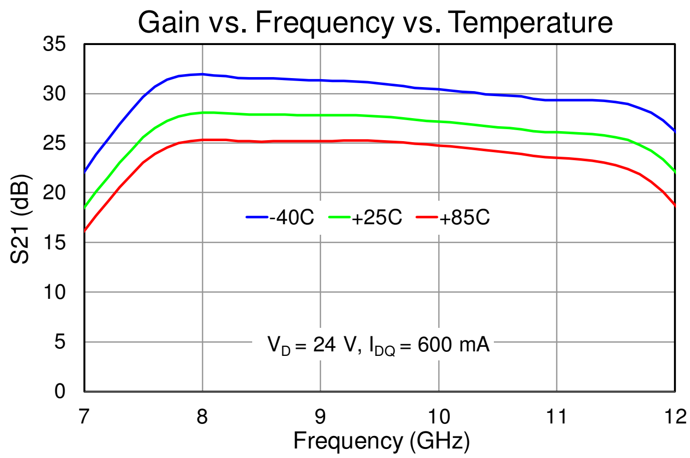


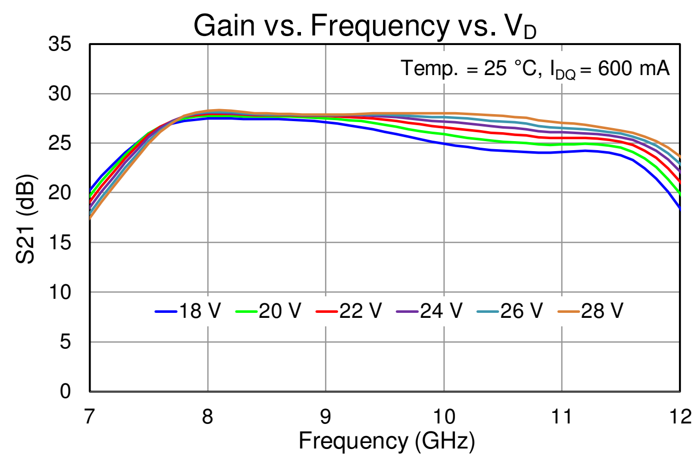


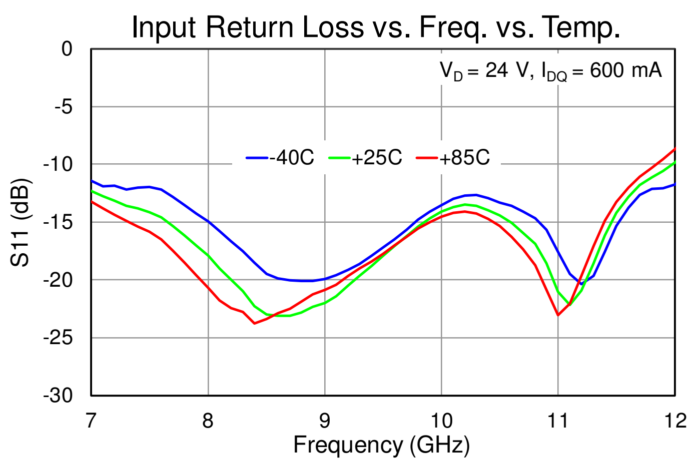


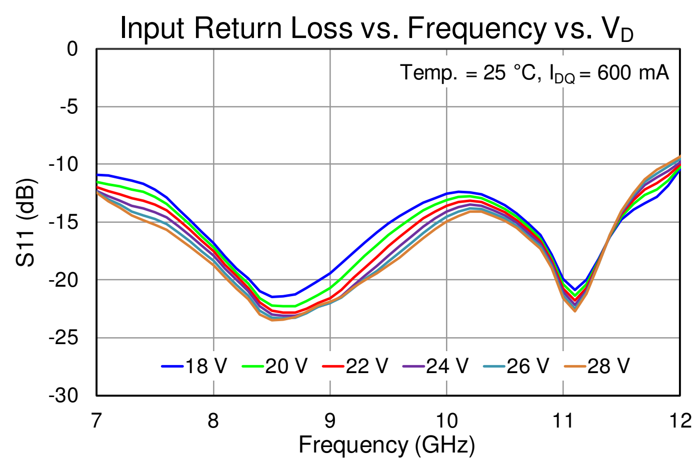


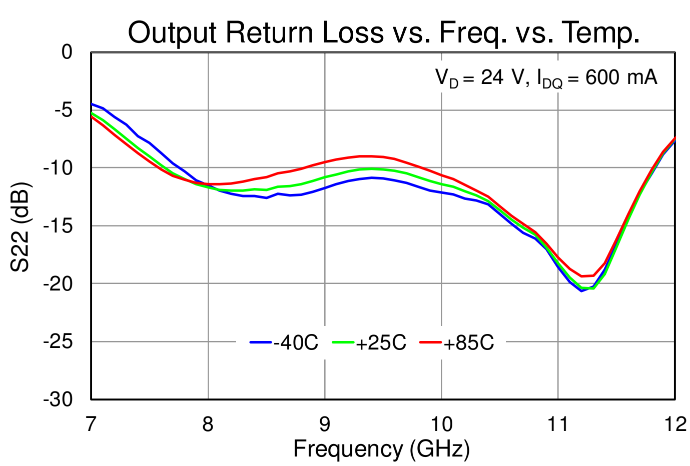
Performance Plots – Small Signal

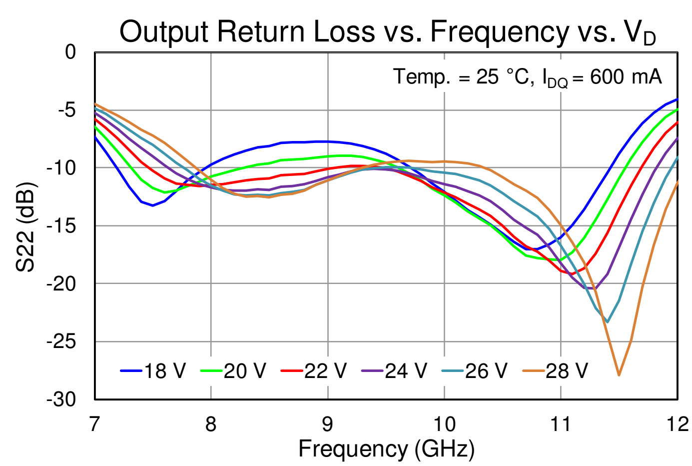




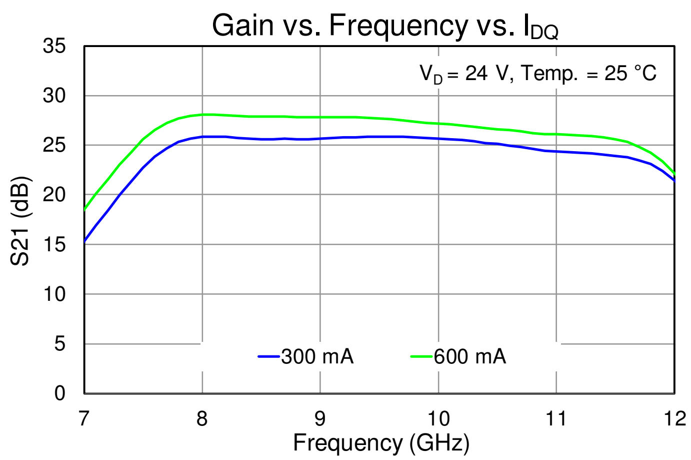


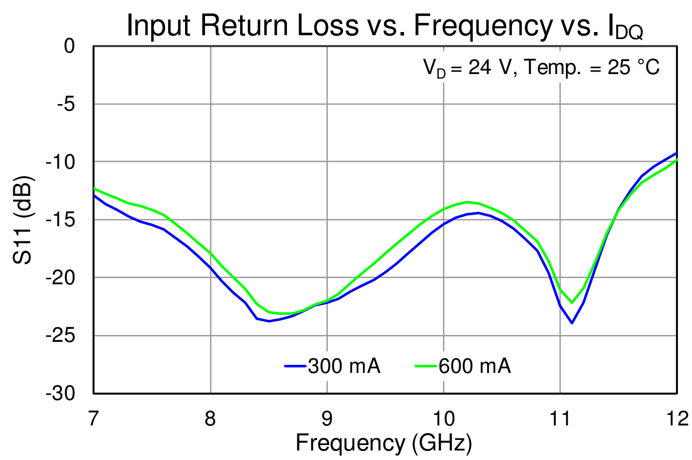


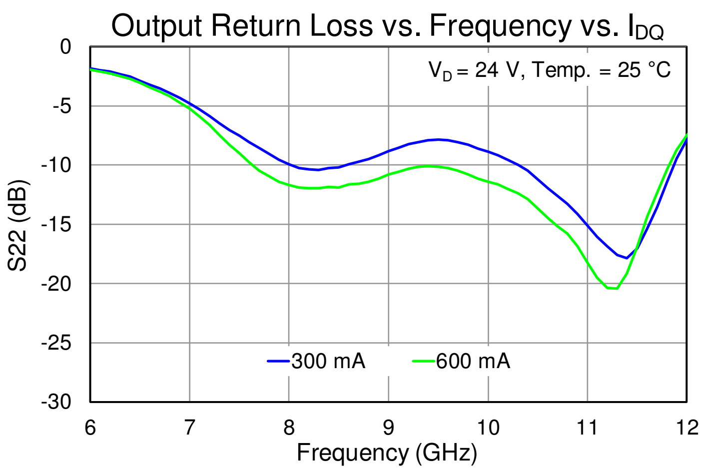




Performance Plots – Small Signal







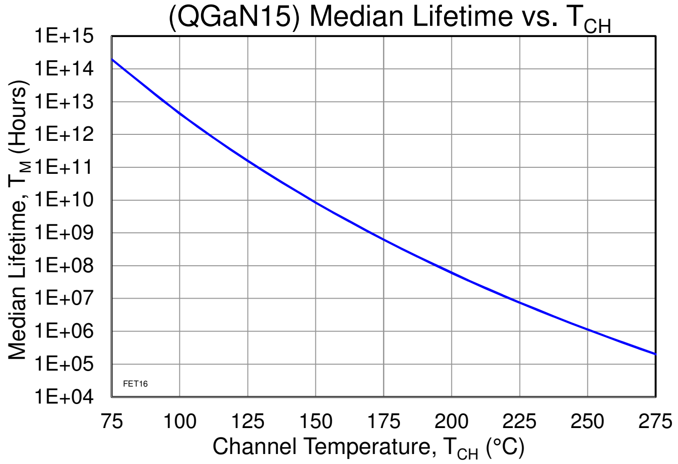
Thermal and Reliability Information

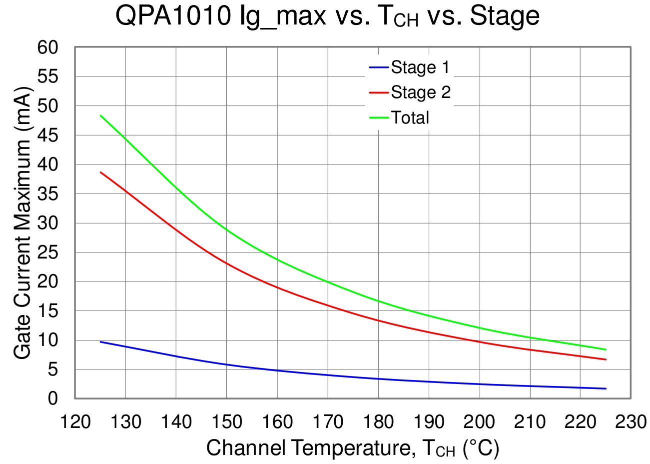
Parameter	Test Conditions	Value	Units
Thermal Resistance (θ_{JC}) (1)	T_{BASE} = 85 °C, V_D = +24 V, I_{DQ} = 600 mA, Pulsed V_D: PW = 100 us; DC = 10%, Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.7 A, P_{OUT} = 42 dBm, P_{DISS} = 25.9 W	2.97	°C/W
Channel Temperature (T_{CH}) (Under RF drive)		162	°C
Median Lifetime (T_M)		2.3E +09	Hrs
Thermal Resistance (θ_{JC}) (1)	T_{BASE} = 85 °C, V_D = +24V, I_{DQ} = 600 mA, CW, P_{DISS} = 14.4 W	4.17	°C/W
Channel Temperature (T_{CH}) (Quiescent, No RF)		145	°C
Median Lifetime (T_M)		1.5E +10	Hrs
Thermal Resistance (θ_{JC}) (1)	T_{BASE} = 85 °C, V_D = +24 V, I_{DQ} = 600 mA, CW, Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.7 A, P_{OUT} = 42 dBm, P_{DISS} = 24.2 W	4.05	°C/W
Channel Temperature (T_{CH}) (Under RF drive)		183	°C
Median Lifetime (T_M)		2.9E +08	Hrs
Thermal Resistance (θ_{JC}) (1)	T_{BASE} = 85 °C, V_D = +20 V, I_{DQ} = 600 mA, Pulsed V_D: PW = 100 us; DC = 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	2.75	°C/W
Channel Temperature (T_{CH}) (Under RF drive)		136	°C
Median Lifetime (T_M)		4.2 +10	Hrs
Thermal Resistance (θ_{JC}) (1)	T_{BASE} = 85 °C, V_D = +20V, I_{DQ} = 600 mA, CW, P_{DISS} = 12 W	4.08	°C/W
Channel Temperature (T_{CH}) (Quiescent, No RF)		134	°C
Median Lifetime (T_M)		5.3E +10	Hrs
Thermal Resistance (θ_{JC}) (1)	T_{BASE} = 85 °C, V_D = +20 V, I_{DQ} = 600 mA, CW, Freq = 9.25 GHz, P_{IN} = 24 dBm, I_{D_Drive} = 1.56 A, P_{OUT} = 41.4 dBm, P_{DISS} = 17.7 W	3.73	°C/W
Channel Temperature (T_{CH}) (Under RF drive)		151	°C
Median Lifetime (T_M)		7.6E +09	Hrs

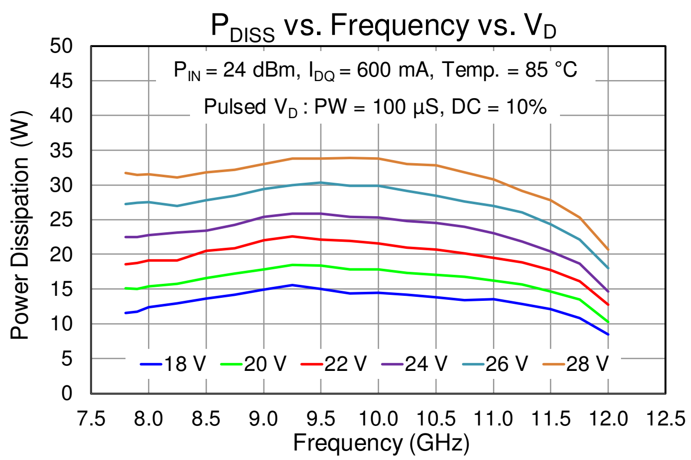
Notes:
1. Thermal resistance is measured to the package backside.

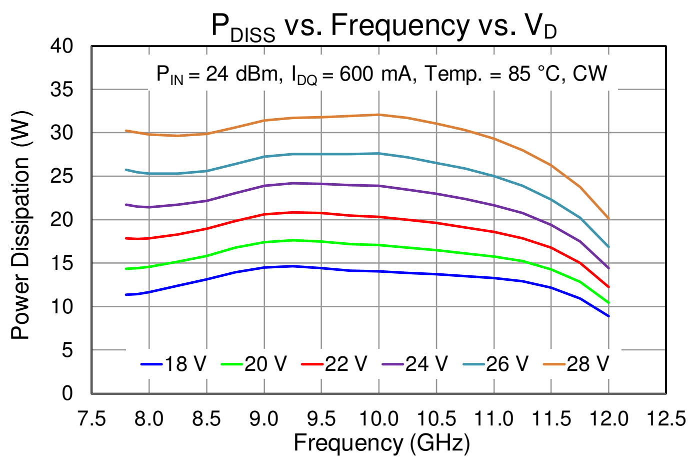
Median Lifetime

Median Life Test Conditions: V_D = +28 V; Failure Criteria = 10 % reduction in I_{D_MAX} during DC Life Testing

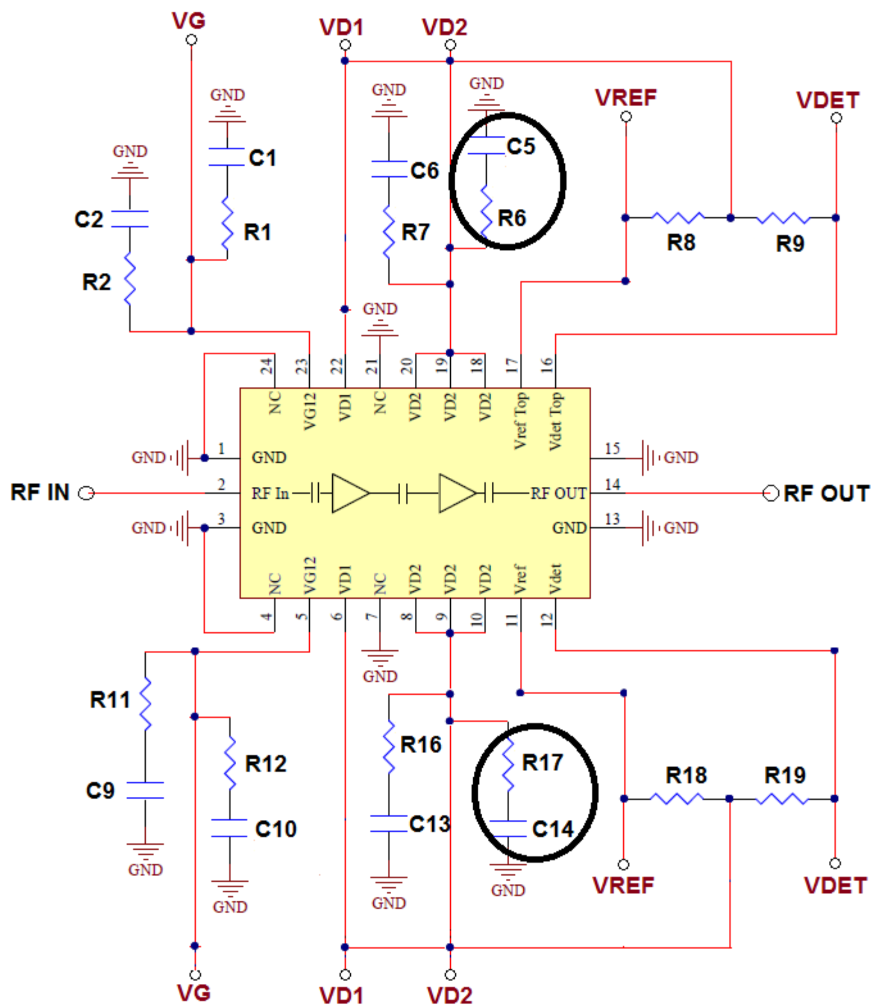








Applications Circuit for Linear and Pulsed Operations



Note: $V_{DELTA} = V_{REF} - V_{DET}$

- QPA1010 can be biased from either the top side or bottom side.
- V_{D1} and V_{D2} need to be tied together.
- V_{D1} / V_{D2} and V_{REF} / V_{DET} have to be on the same side for V_{DELTA} to work.
- Bypassing components required for the side(s) being biased.
- The extra bias components (R6, R17, C5 and C14) are required for optimum linearity.

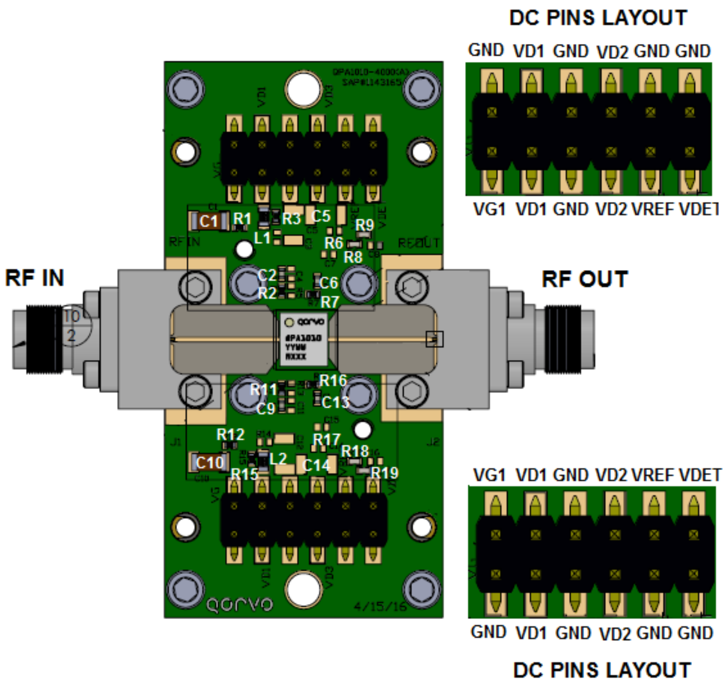
Bias Up Procedure

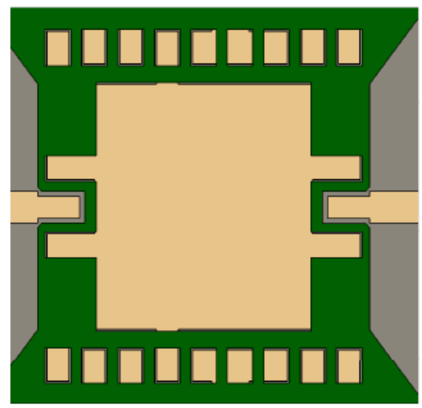
1. Set I_D limit to 2000 mA, I_G limit to 20 mA
2. Apply –5 V to V_G
3. Apply +24 V to V_D; ensure I_{DQ} is approx. 0 mA
4. Adjust V_G until I_{DQ} = 600 mA (V_G ~ –1.8 V Typ.).
5. Turn on RF supply

Bias Down Procedure

1. Turn off RF supply
2. Reduce V_G to –5 V; ensure I_{DQ} is approx. 0 mA
3. Set V_D to 0 V
4. Turn off V_D supply
5. Turn off V_G supply

Evaluation Board (EVB) Layout Assembly for Pulsed Operation





Note: PCB is a multilayer

1. All 4 metal thicknesses are 0.5 oz
2. Upper core 1 is Rogers 4003C, 8 mil thick
3. Lower core 2 is 370HR, 6 mil thick
4. Pre-Preg is an epoxy coated glass fabric
5. Total finished PCB thickness is 25 ±3 mil
6. This EVB uses a copper-coined PCB for optimum thermal management under high dissipation long pulse and/or CW conditions

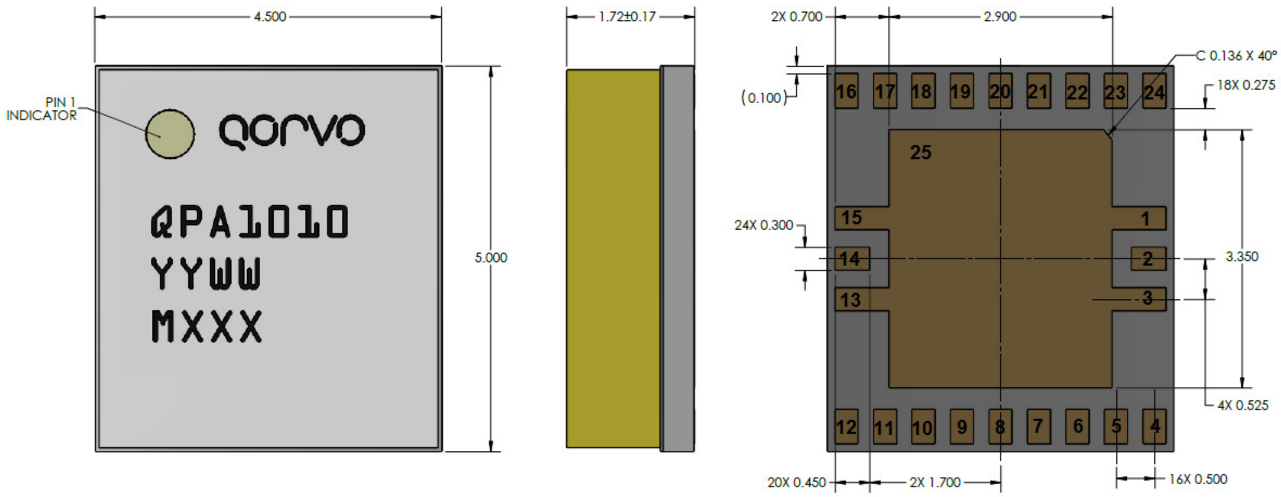
Bill of Materials for EVB

Reference Des.	Value	Description	Manuf.	Part Number
C1, C5, C10, C14	10 uF	CAP, 1206, 50 V, 20 %, X5R	Various	–
C2, C6, C9, C13	0.01 uF	CAP, 0402, 50 V, 10 %, X7R	Various	–
R1, R12	5.1 Ohm	RES, 0402, 50V, 5 %, SMT	Various	–
R2, R3, R6, R7, R11, R15, R16, R17 (1)	0 Ohm	RES, 0402, 5 %, SMD	Various	–
R8, R9, R18, R19	25.5 K Ohm	RES, 0402, 1/16W, 1%, 0402	Various	–
L1, L2 (1)	0 Ohm	RES, 0603, 1/10 W	Various	–

Note:

1. These components are acting as the jumpers for this EVB.

Mechanical Information



Units: millimeters
Tolerances: unless specified
x.xx = ± 0.25
x.xxx = ± 0.100
Materials:
Base: Laminate
Lid: FR4
All metalized features are gold plated
Part is epoxy sealed
Marking:
QPA1010: Part number
YY: Part Assembly year
WW: Part Assembly week
MXXX: Batch ID

Pin Description

Pad No.	Symbol	Description
1, 3, 13, 15, Center	GND	Ground. Must be grounded on the PCB. Conductive filled vias recommended for least inductance and improved thermal performance
2	RF_{IN}	RF Input; matched to 50 Ω; DC blocked
4, 7, 21, 24	N/C	Not connected internally. Recommended to be grounded
5, 23	V_{G1-2}	Stage 1-2 Gate Voltage. Bias network is required; see recommended Application Information above on page 21
6, 22	V_{D1}	Stage 1 Drain Voltage. Bias network is required; see recommended Application Information above on page 21
8 – 10, 18 - 20	V_{D2}	Stage 2 Drain voltage; Bias network is required; see recommended Application Information above on page 21
11, 17	V_{REF}	Reference voltage
12, 16	V_{DET}	Detector voltage
14	RF_{OUT}	RF Output; matched to 50 Ω; DC blocked

Handling Precautions

Parameter	Rating	Standard
ESD – Human Body Model (HBM)	TBD	ESDA / JEDEC JS-001
ESD – Charged Device Model (CDM)	TBD	ESDA / JEDEC JS-002
MSL – Convection Reflow 260 °C	TBD	JEDEC standard IPC/JEDEC J-STD-020

Caution!
ESD-Sensitive Device

Solderability

Compatible with the latest version of J-STD-020, Lead-free solder, 260 °C

RoHS Compliance

This product is compliant with the 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
- SVHC Free
- Qorvo Green

Contact Information

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

Tel: **1-844-890-8163**

Web: **www.qorvo.com**

Email: **customer.support@qorvo.com**

For technical questions and application information: **Email:** **sjcapplications.engineering@qorvo.com**

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