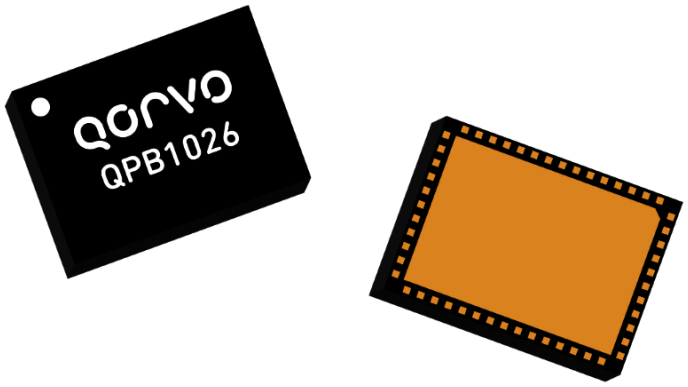
QPB1026

Switchable Dual Band Amplifier and Filter Module

Product Description

The QPB1026 is a dual-band switchable digital variable gain amplifier (DVGA) featuring high RF performance and integration of various functions. The DVGA integrates a preamp, an SPDT switch, digital step attenuators (DSA), band pass filters and high performance low noise amplifiers (LNA).

The switchable amplifiers have CMOS compatible control of channel switching, power up / down capability and bias adjustability for the LNAs controlled through external pins. The device has built-in filters for out of band signal suppression, gain control is implemented through DSAs with 31.5 dB of attenuation range in 0.5 dB steps. The QPB1026 is packaged with overmold compound in a RoHS-compliant, compact 52-pin 11 x 8 mm surface-mount leadless package.

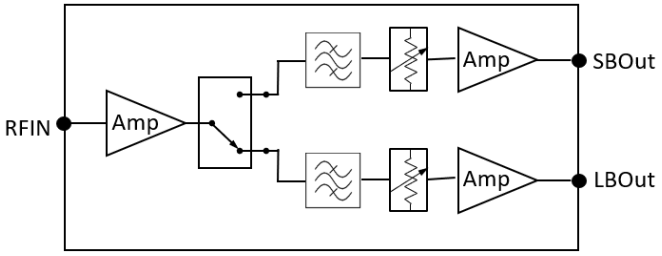


Product Features

- Low Band Frequency Range: 0.6 - 1.5 GHz
- Low Band Small Signal Gain: 35 dB
- Low Band Noise Figure: 0.8 dB
- Low Band P1dB : 20 dBm
- Low Band TOI: 37 dBm
- S - Band Frequency Range : 2.9 GHz - 3.5 GHz.
- S - Band Small Signal Gain: 37 dB
- S - Band Noise Figure: 1.0 dB
- S - Band P1dB : 24 dBm
- S - Band TOI: 38 dBm
- Channel Switching Time: 924 nS
- DSA Attenuation Range: 31.5 dB
- Attenuation LSB: 0.5 dB
- Direct Device Function Disable / Enable
- 3.3 V Logic Compatible Serial Inputs.
- Package Dimensions: 11 x 8 x 1.42 mm

Performance is typical at room temperature.
Please reference electrical specification table and data plots for more details.

Functional Block Diagram



Applications

- Electronics Warfare (EW)
- Commercial and Military Radar
- Communication Systems

Ordering Information

Part No.	Description
QPB1026	Dual Band Switchable Amplifier
QPB1026SR	Tape and Reel 7”, Qty 100
QPB1026TR13X	Tape and Reel 7”, Qty 1500
QPB1026EVB	QPB1026 Evaluation Board, Qty 1

Absolute Maximum Ratings

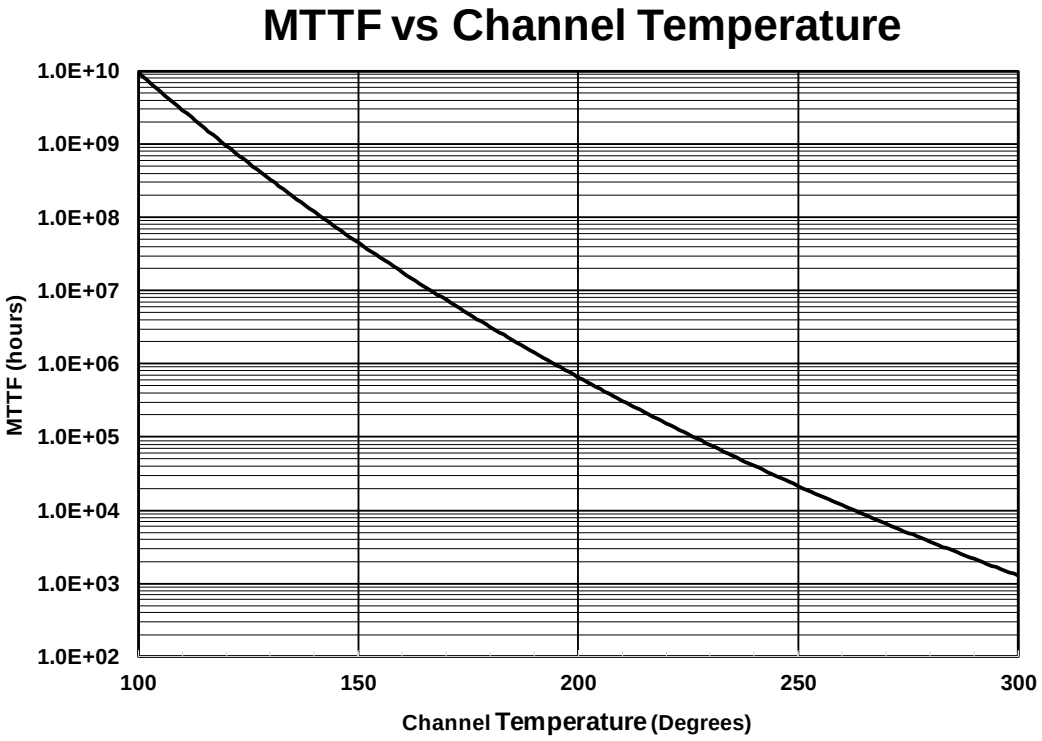
Parameter [1]	Min Value	Max Value	Units
Power Supply Voltage (VCC_AMP1, 2, 3, 4, AMP_CTRL) [2]	-	6.0	V
Switch Control Voltage (SW_CTRL_V1, SW_CTRL_V2) [2]	-	6.0	V
DSA Power Supply (VDD)	-	6.0	V
RF Input Power (25C, 50 Ohm)	-	23	dBm
Storage Temperature	−65	150	°C

1. 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. Extended application of Absolute Maximum Rating conditions may reduce device reliability.
2. Amplifiers bias currents are internally controlled, refer to Nominal Operating Conditions Table for these and other control bias value ranges.

Thermal and Reliability Information

Parameter	Values	Units	Conditions
Thermal Resistance (θ_{JC}) (1,2,3)	24.3	°C/W	T_{BASE} = + 85 °C, Nominal Operation Bias, Low Band Test, RF P_{IN} = 3 dBm, Pout = +24.4 dBm, P_{DISS} = 2.3 W
Channel Temperature (T_{CH})	141	°C	

Notes:
1. Thermal resistance is referenced to package backside, the base temperature is + 85 °C



Normal Operating Conditions

Parameter [1]	Min	Typ	Max	Units
Amplifier Power Supply Voltage: VCC_AMP1, VCCAMP2, VCC_AMP3, VCC_AMP4	3.3	5	5.25	V
Amplifier 3 and 4 Control Voltage (AMP_CTRL)	3.3	5	5.25	V
Switch Control Voltage High (SW_CTRL_V1, SW_CTRL_V2, Logic 1)	1.8	5	5.0	V
Switch Control Voltage Low (SW_CTRL_V1, SW_CTRL_V2, Logic 0)	0	0	0.45	V
Amplifier 1 Current (VCC_AMP1, ON State)	-	50	70	mA
Amplifier 1 Current (VCC_AMP1, OFF State)	-	3	6	mA
Amplifier 2 Current (VCC_AMP2, ON State)	40	68	90	mA
Amplifier 2 Current (VCC_AMP2, OFF State)	-	3	4	mA
Amplifier 3 and 4 Current (VCC_AMP3 and 4 Total, ON State)	-	284	350	mA
Amplifier 3 and 4 Current (VCC_AMP3 and 4 Total, OFF State)	-	7		mA
Amplifier 3 and 4 Control Current (AMP_CTRL Total)	-	3		mA
Amplifier 1 Control Voltage (VPD1, ON State, Logic 0)	0	0	0.63	V
Amplifier 1 Control Voltage (VPD1, OFF State, Logic 1)	1.17	5	VCC_AMP1	V
Amplifier 2 Control Voltage (VPD2, ON State, Logic 0)	0	0	0.4	V
Amplifier 2 Control Voltage (VPD2, OFF State, Logic 1)	2.5	5	VCC_AMP2	V
Amplifier 3 and 4 Control Voltage (VPD3, OFF State, Logic 0)	0	0	0.63	V
Amplifier 3 and 4 Control Voltage (VPD3, ON State, Logic 1)	1.17	1.8	3.6	V
DSA Power Supply	2.7	5	5.5	V
Operating Temperature Range	−40		85	°C
Junction Temperature for > 10^6 Hours MTTF			170	°C

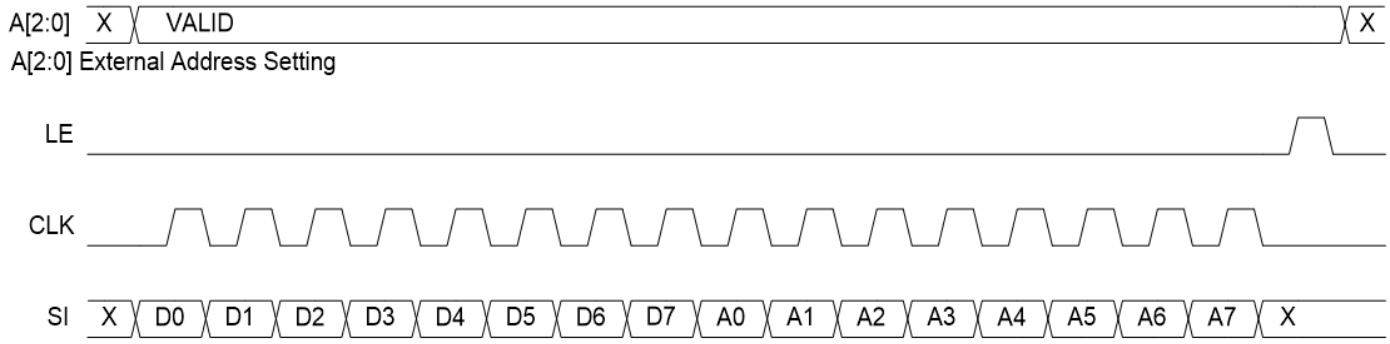
1 *Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.*

Switch Control Logic Truth Table

Logic “0” and Logic “1” levels refer to Nominal Operating Conditions Table

Operation Modes	SW_CTRL_V1	SW_CTRL_V2	VPD1	VPD2	VPD3	Comments
(N.A)	0	0	X	X	X	RFC – SW Floating Pin
LB	0	1	0	0	X	RFC to LB
SB	1	0	0	X	1	RFC to SB
Amps Off	x	X	1	1	0	Amplifiers Shutdown

DSA Serial Addressable Mode Control Data Diagram



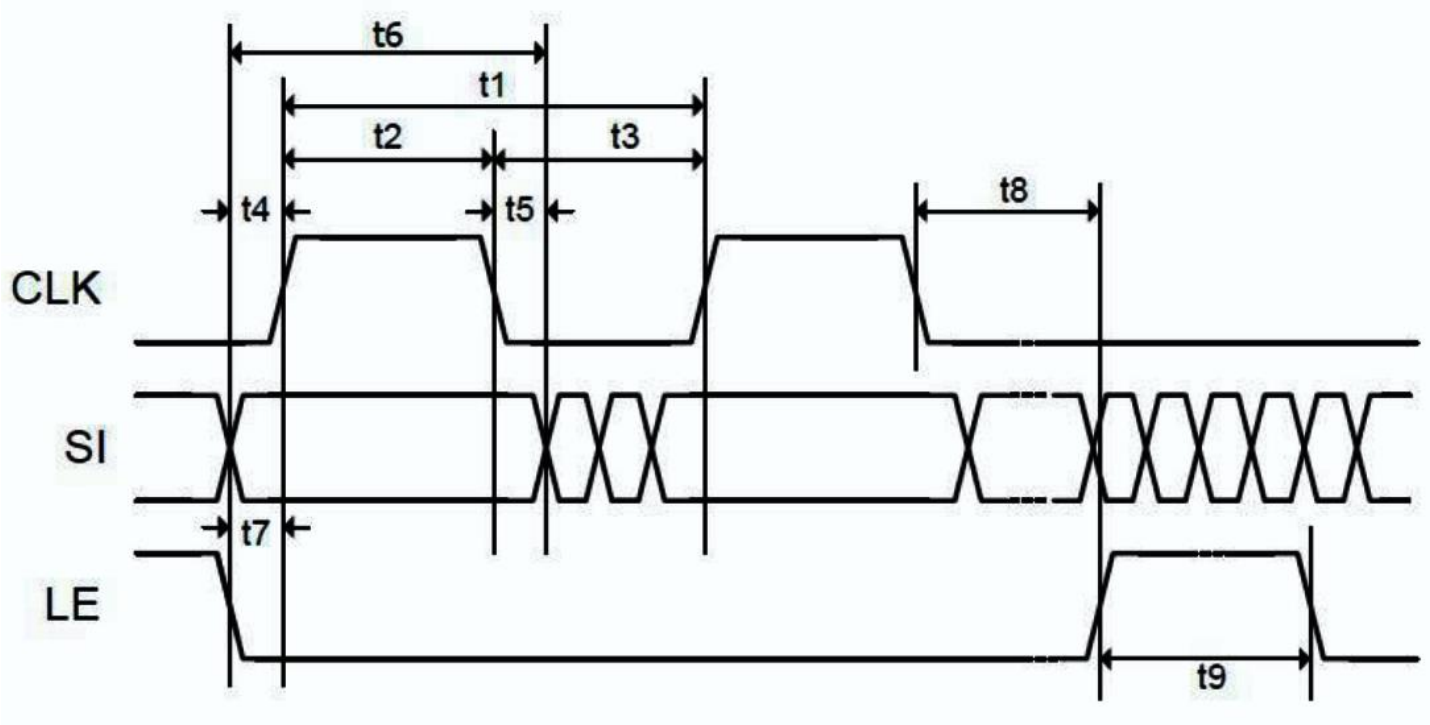
Note: Bts D0, D7, A3-A7 are not used and can be set to logic high or low

DSA Attenuation State Logic Truth Table

Attenuation States	D6	D5	D4	D3	D2	D1
0.0 dB / Reference State	0	0	0	0	0	0
0.5 dB	0	0	0	0	0	1
1 dB	0	0	0	0	1	0
2 dB	0	0	0	1	0	0
4 dB	0	0	1	0	0	0
8 dB	0	1	0	0	0	0
16 dB	1	0	0	0	0	0
31.5 dB	1	1	1	1	1	1

Note: Logic “0” and Logic “1” levels, refer to Nominal Operating Conditions Table

Serial Interface Timing Diagram



Serial Control Interface Timing Specifications

Parameters	Limits	Units	Comments
t1	20	MHz max	CLK Frequency
t2	20	ns min	CLK High
t3	20	ns min	CLK Low
t4	5	ns min	SI to CLK Setup Time
t5	5	ns min	SI to CLK Hold Time
t6	30	ns min	SI Valid
t7	5	ns min	LE to CLK Setup Time
t8	5	ns min	CLK to LE Setup Time
t9	10	ns min	LE Pulse Width

Electrical Specifications, Low Band

Test conditions unless otherwise noted: Nominal biases. Data for minimum attenuation. 25 °C. Data de-embedded fixture losses

Parameter	Min	Typical	Max	Units
Low Band Frequency	0.6		1.5	GHz
Small Signal Gain (@ 0.6 GHz)		43		dB
Small Signal Gain (@ 0.9 GHz)		39.5		dB
Small Signal Gain (@ 1.2 GHz)		38		dB
Small Signal Gain (@ 1.5 GHz)		34		dB
Out Band Rejection (@ 0.1 MHz to 0.3 GHz)	30			dB
Out Band Rejection (@ 1.92 GHz to 3.5 GHz)	30			dB
Noise Figure (@ 0.6 GHz)		1.2		dB
Noise Figure (@ 0.9 GHz to 1.5 GHz)		0.8		dB
P1dB		20		dB
Input Return Loss		10		dB
Output Return Loss		15		dB
Output Third Order Intermodulation 1		37		dB
DSA LSB Attenuation		0.5		dB
DSA Attenuation Range		31.5		dB
DSA Step Error 2		0.1		dB
DSA Attenuation Error [2]		0.5		dB
Switch On Time [3]		924		nS
Switch Off Time [3]		31		nS
Small Signal Gain Temperature Coefficient		−0.016		dB/°C

1. *At 5 dBm Pout / tone, 1 MHz tone spacing, minimum attenuation state.*
2. *Over the range of attenuation states.*
3. *From 50% trigger signal to 90% of signal On or 10 % signal Off.*

Electrical Specifications, S Band

Test conditions unless otherwise noted: Nominal biases. Data for minimum attenuation. 25 °C. Data de-embedded fixture losses

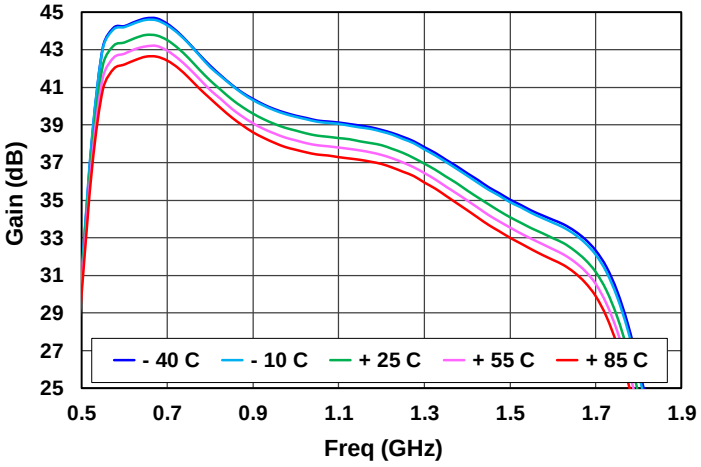
Parameter	Min	Typical	Max	Units
S Band Frequency	2.9		3.5	GHz
Small Signal Gain (@ 2.9 GHz)		36.4		dB
Small Signal Gain (@ 3.2 GHz)		38.5		dB
Small Signal Gain (@ 3.5 GHz)		37.2		dB
Out Band Rejection (@ 0.1 MHz to 1.5 GHz)	30			dB
Out Band Rejection (@ 5.8 MHz to 6.0 GHz)	40			dB
Noise Figure		1.0		dB
P1dB		24		dB
Input Return Loss		8		dB
Output Return Loss		20		dB
Output Third Order Intermodulation [2]		38		dB
DSA LSB Attenuation		0.5		dB
DSA Attenuation Range		31.5		dB
DSA Step Error [1]		0.4		dB
DSA Attenuation Error [1]		2.0		dB
Switch On Time		724		nS
Switch Off Time		28		nS
Small Signal Gain Temperature Coefficient		−0.03		dB/°C

1. *At 10 dBm Pout/tone, 1 MHz tone spacing, minimum attenuation state.*
2. *Over the range of attenuation states.*
3. *From 50% trigger signal to 90% of signal On or 10 % signal Off.*

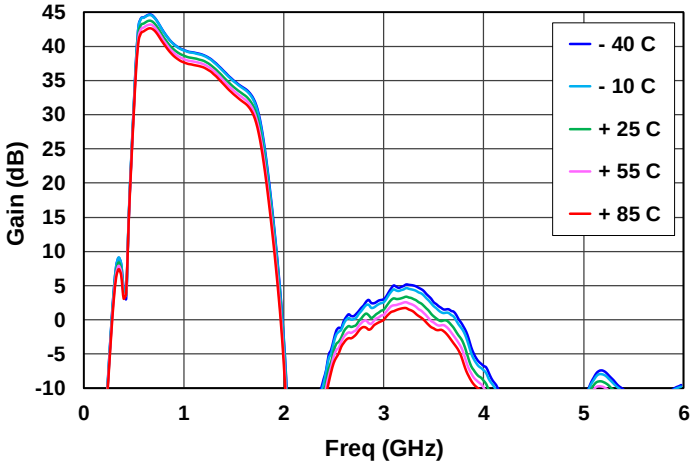
Performance Plots, Small Signal

Test Conditions unless otherwise stated: Low Band, Minimum Attenuation State, 25 °C

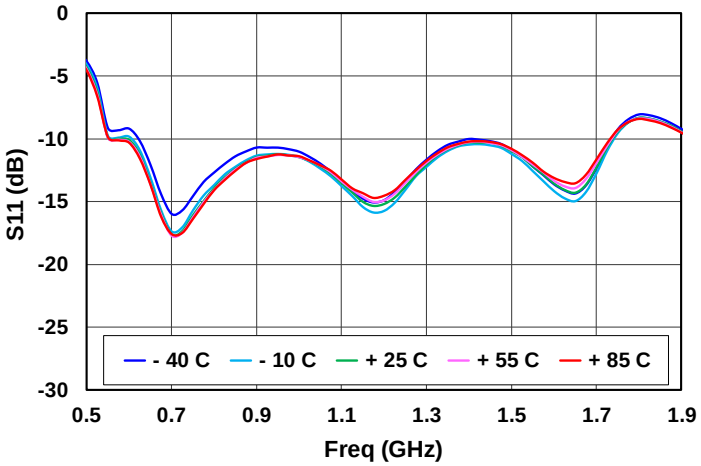
Gain vs Temperature



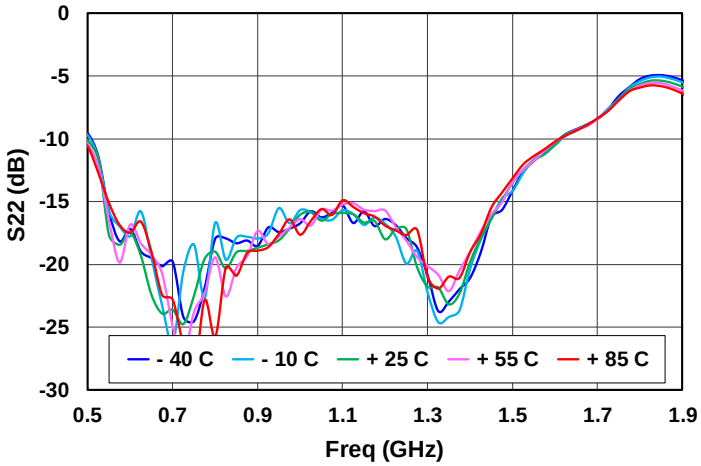
Gain vs Temperature



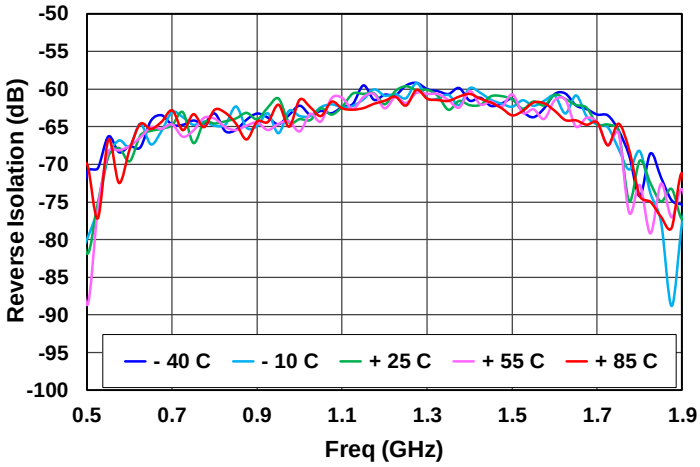
Input Return Loss vs Temperature



Output Return Loss vs Temperature



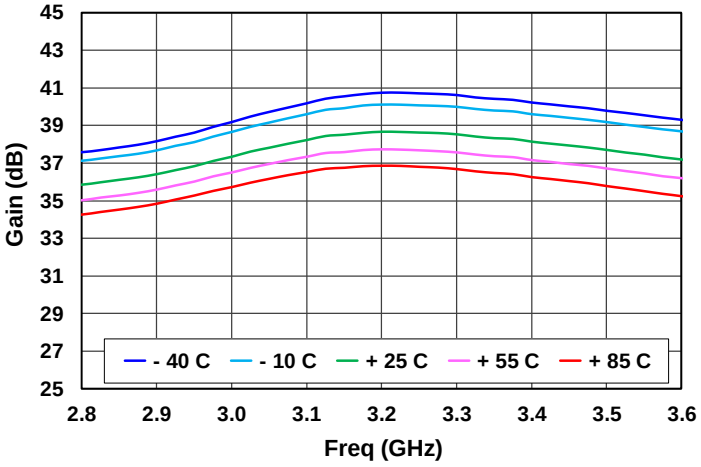
Reverse Isolation vs Temperature



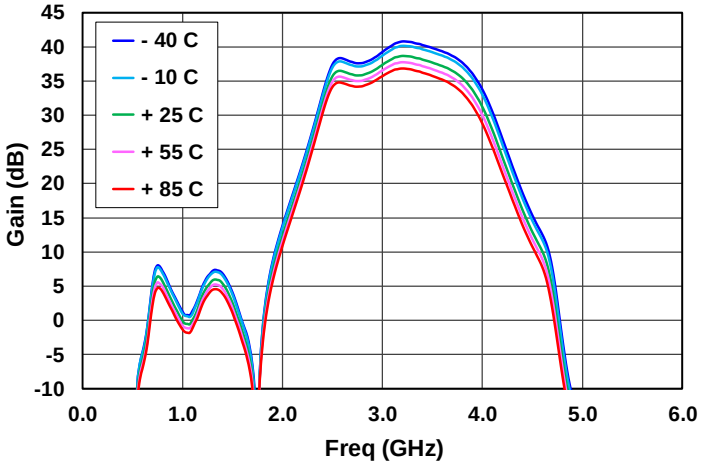
Performance Plots, Small Signal

Test Conditions unless otherwise stated: S Band, Minimum Attenuation State, 25 °C

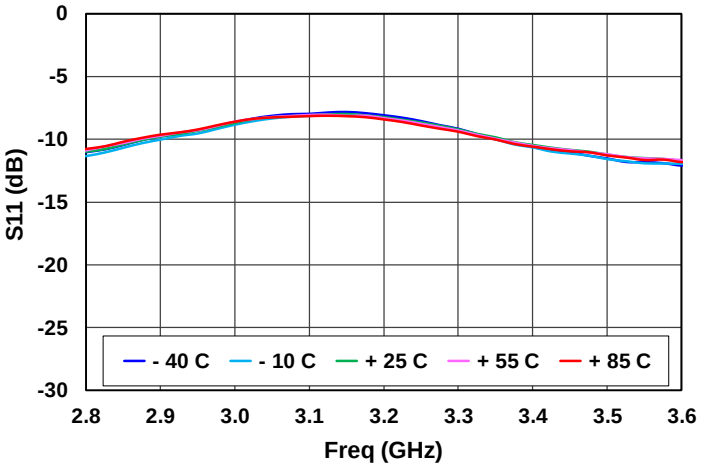
Gain vs Temperature



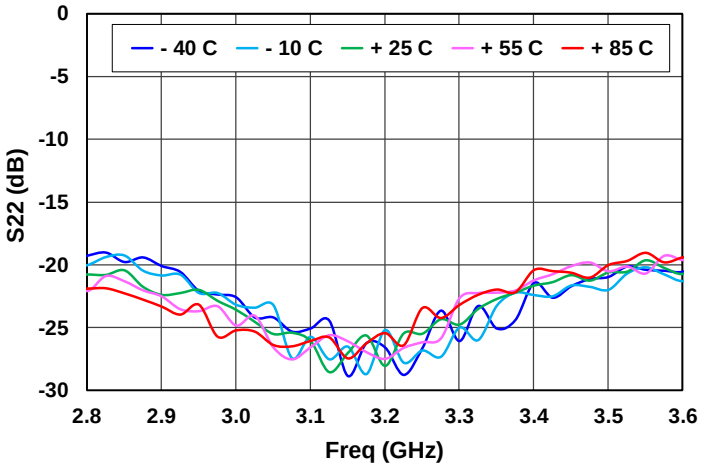
Gain vs Temperature



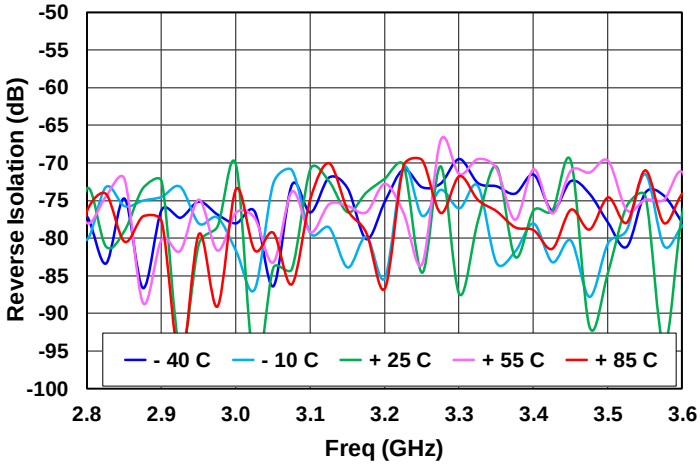
Input Return Loss vs Temperature



Output Return Loss vs Temperature



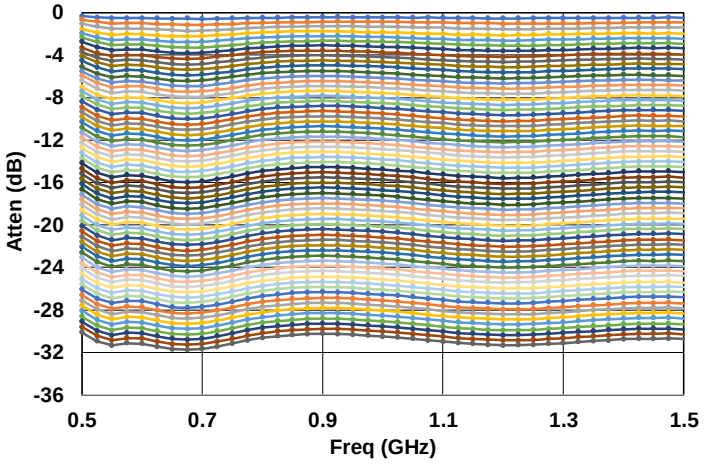
Reverse Isolation vs Temperature



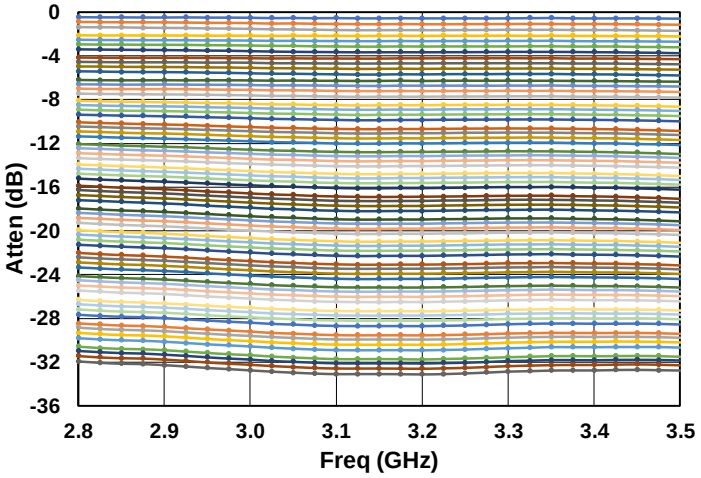
Performance Plots, Digital Attenuations

Test Conditions unless otherwise stated: 25 °C

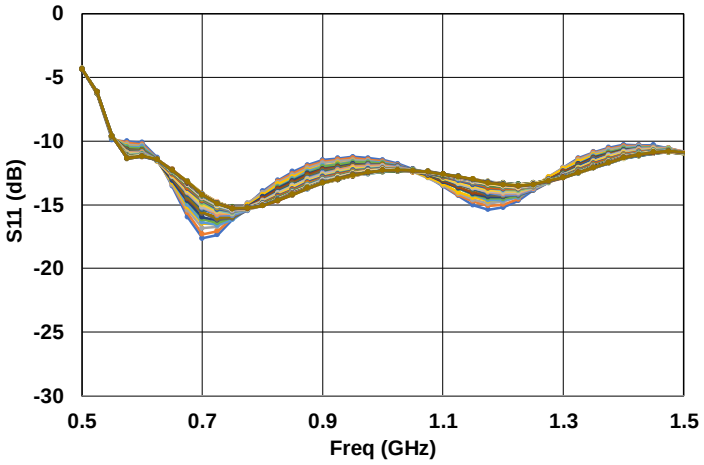
Low Band Attenuation vs States



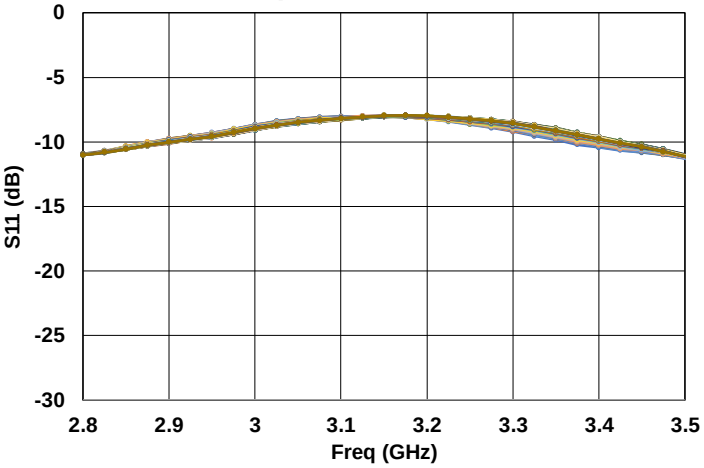
S Band Attenuation vs States



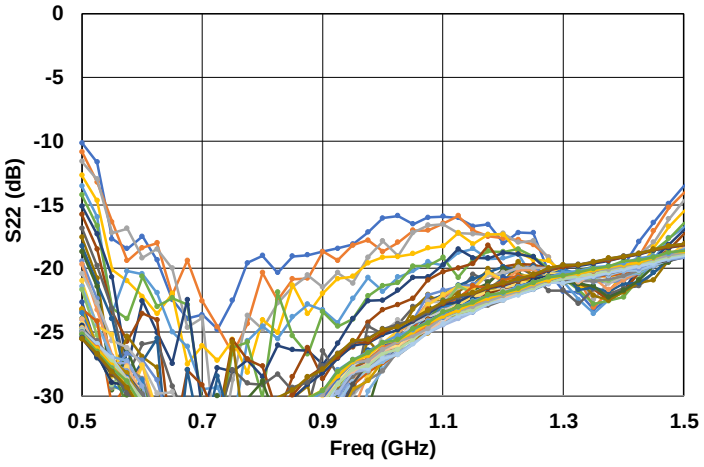
Low Band Input Return Loss vs States



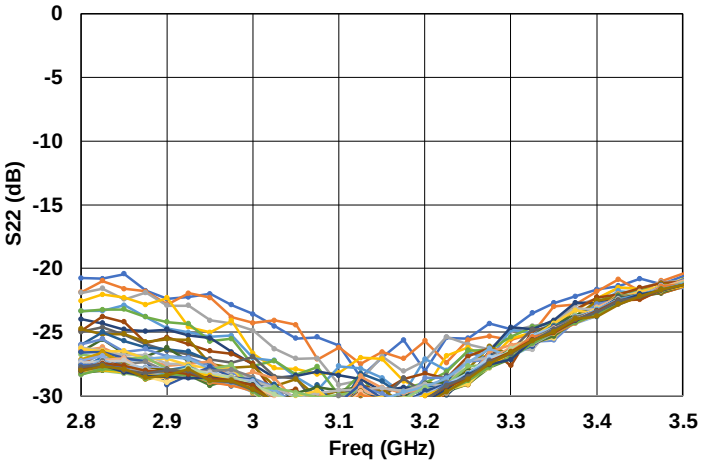
S Band Input Return Loss vs States



Low Band Output Return Loss vs States



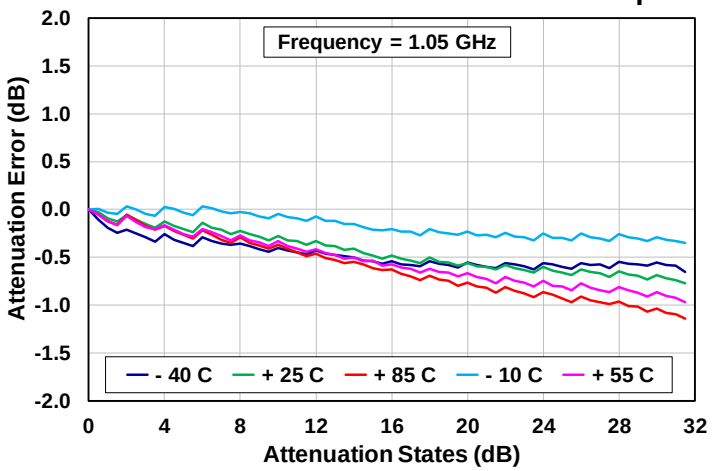
S Band Output Return Loss vs States



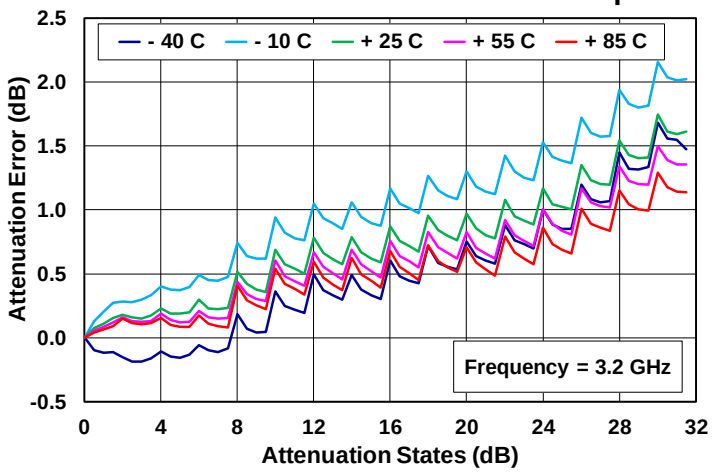
Performance Plots, Attenuations and Step Errors

Test Conditions unless otherwise stated: 25 °C

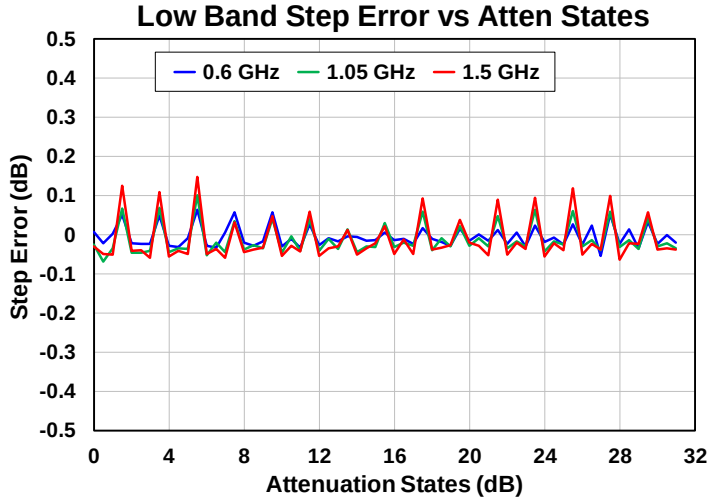
Low Band Attenuation Error vs Temp



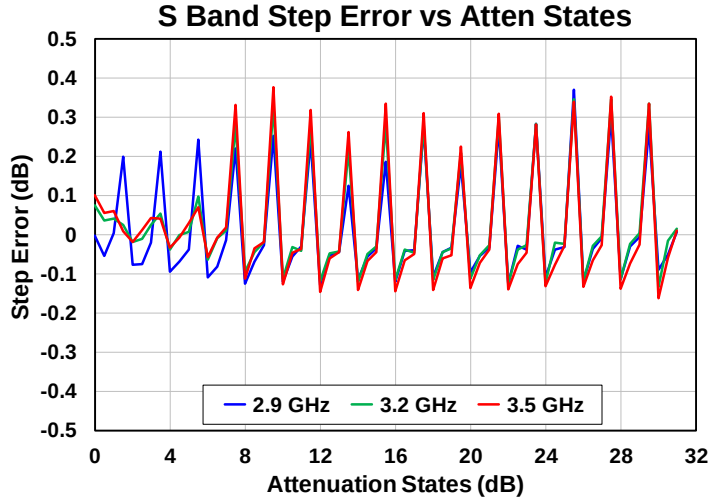
S Band Attenuation Error vs Temp



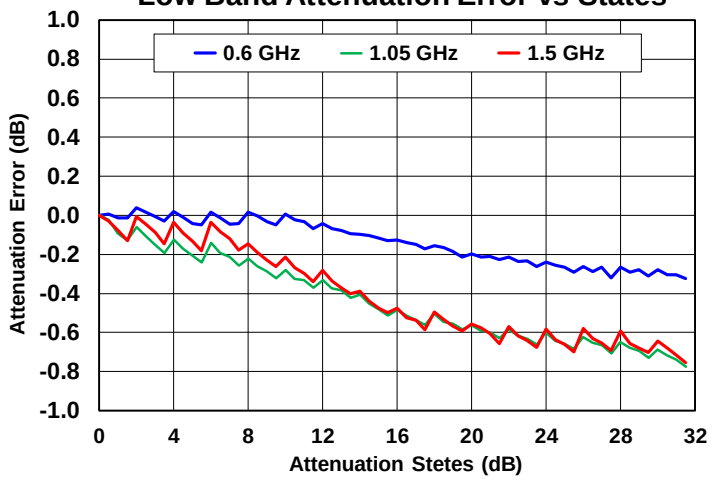
Low Band Step Error vs Atten States



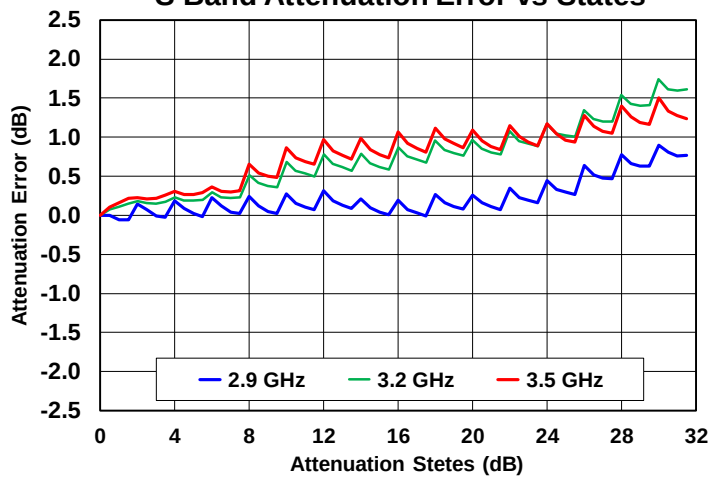
S Band Step Error vs Atten States



Low Band Attenuation Error vs States



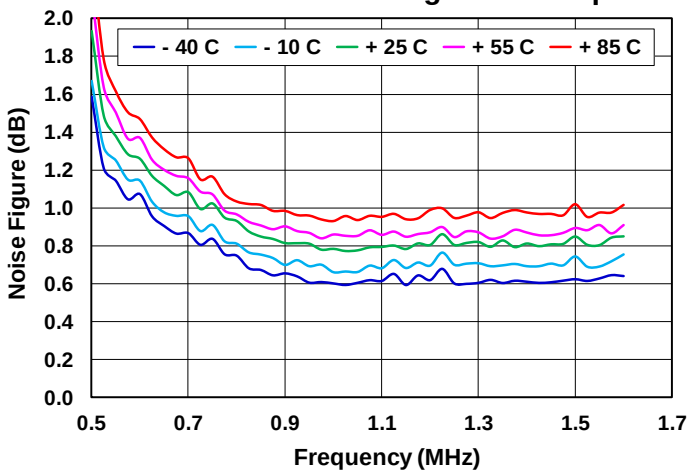
S Band Attenuation Error vs States



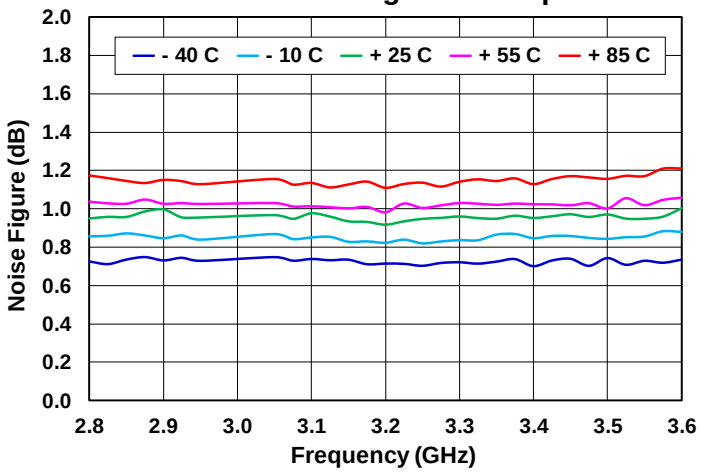
Performance Plots, Noise Figure and Linearity

Test Conditions unless otherwise stated: Minimum Attenuation State, 25 °C

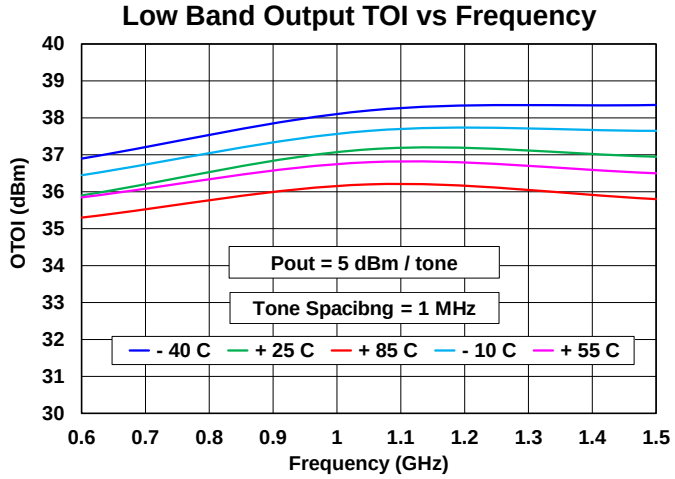
Low Band Noise Figure vs Freq



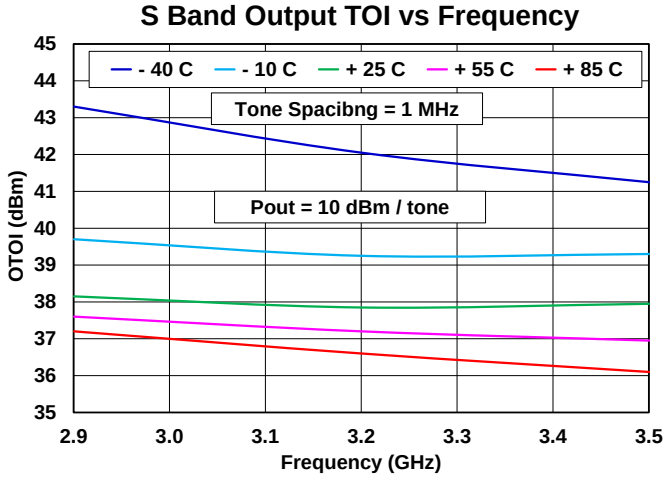
S Band Noise Fagire vs Freq



Low Band Output TOI vs Frequency

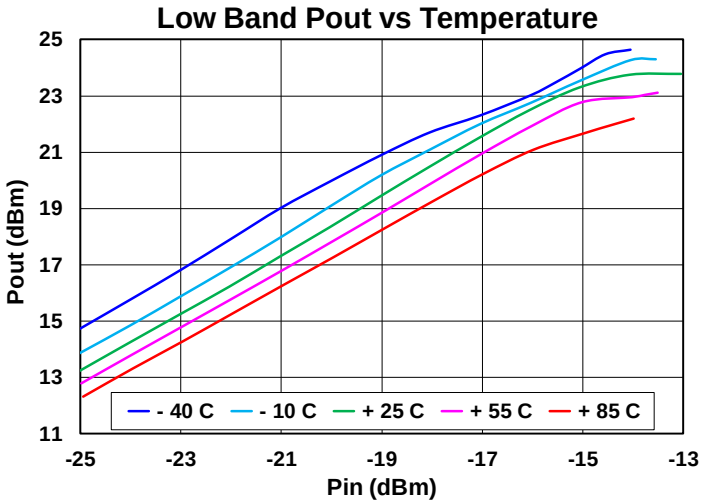


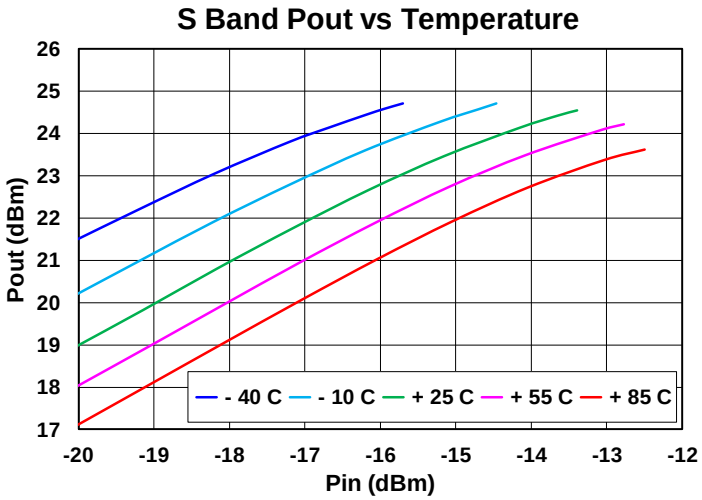
S Band Output TOI vs Frequency

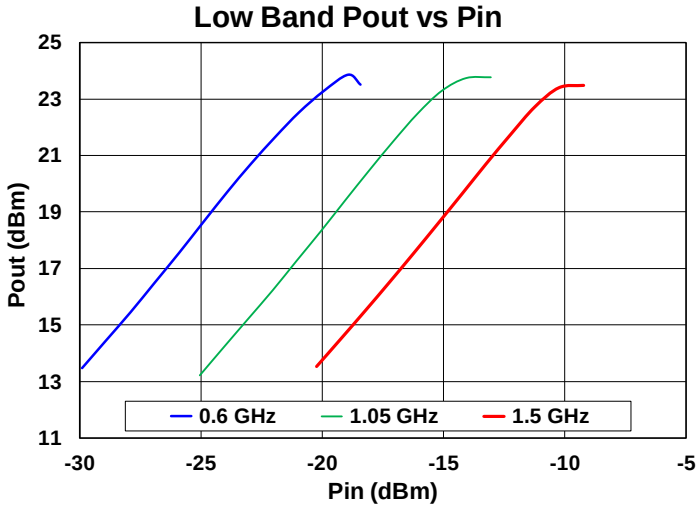


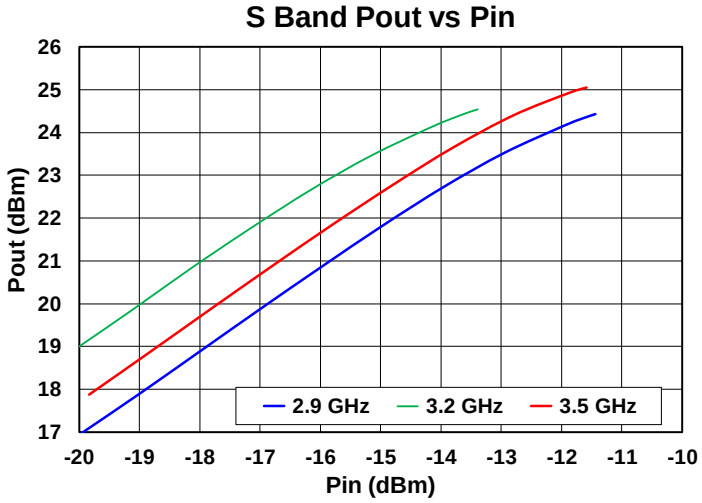
Performance Plots, Power Sweep

Test Conditions unless otherwise stated: Minimum Attenuation State, 25 °C

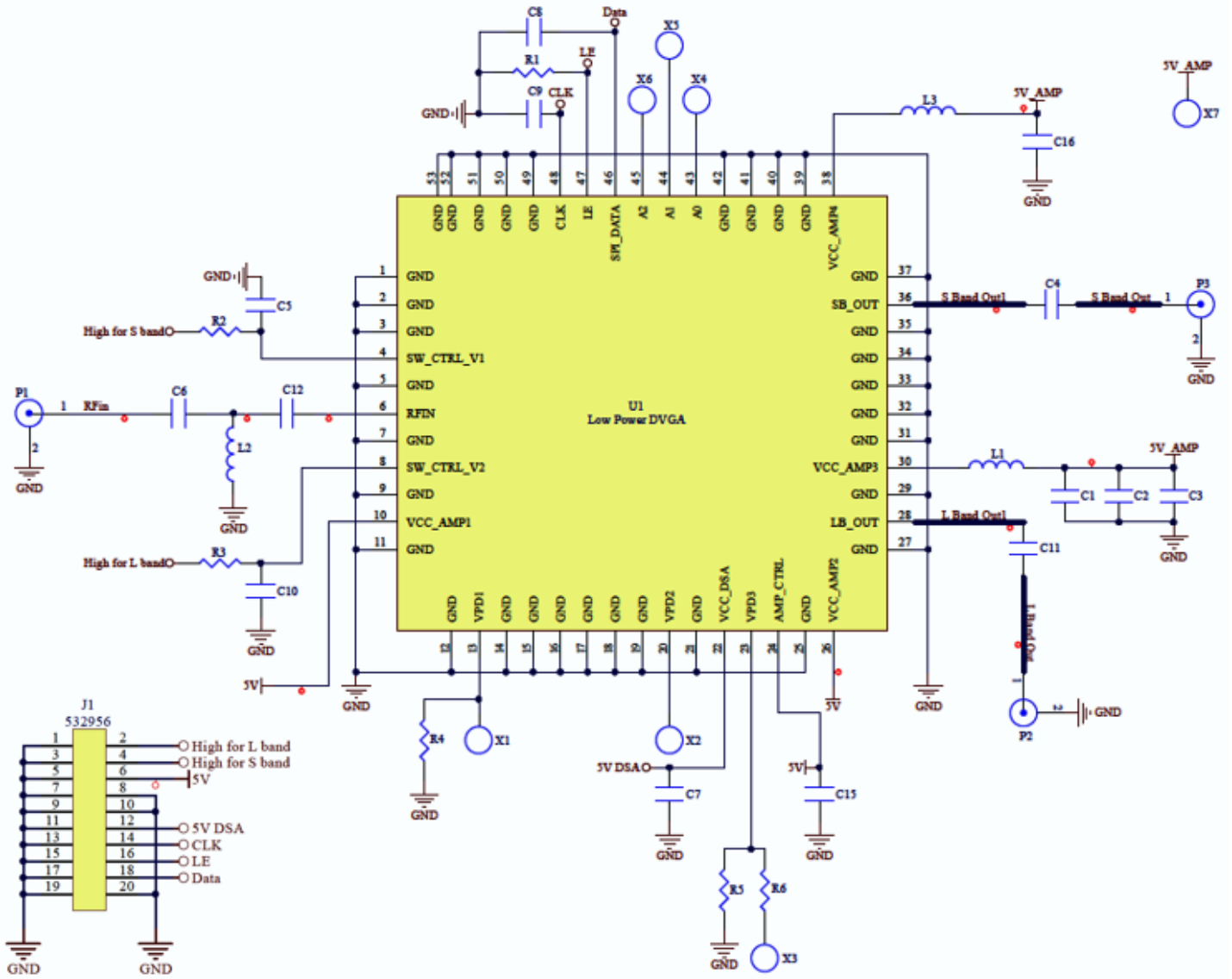








Application Circuit



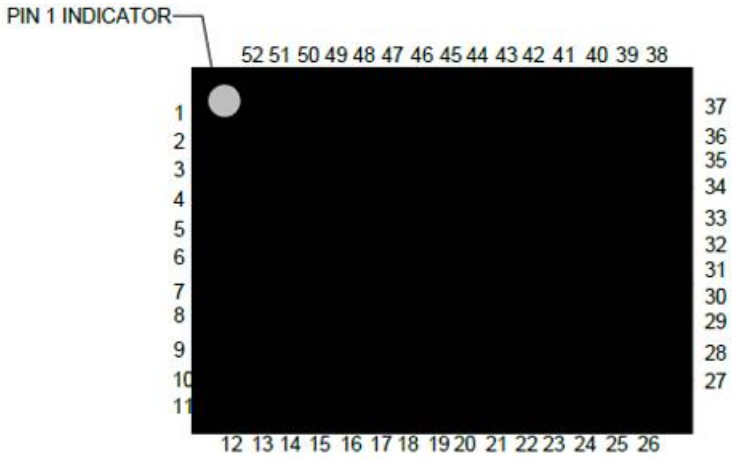
EVB Connections

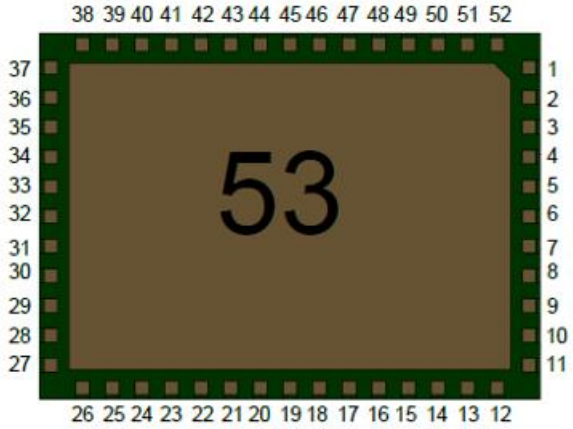
1. The configuration allows the user to control the attenuator through the J1 connector using an external harness. Note that the top row of J1 contains the serial bus signals and the bottom row is ground.
2. The VCC_Amp1, VCC_AMP2, VCC_CTRL are connected to 5V on EVB J1 connector.
3. BCC_AMP3 and VCC_AMP4 are connected to 5V_AMP on EVB connector.
4. A tuning CAP C17 and IND L2 are required at input for optimal RF performance.

DSA Serial Model Controls

The DSAs are controlled using serial mode. Both channel DSA's address pins are connected together, attenuation state will be the same for both. Refer to Qorvo's Control Bit Generator (CBG) Software Reference Manual for detailed instructions on how to setup the software for use. Select 'QPB1026' from the Qorvo parts list of the CBG user interface. Set the attenuation value using the CBG user interface and measurement can be taken. The default power on attenuation state is maximum (31.5dB).

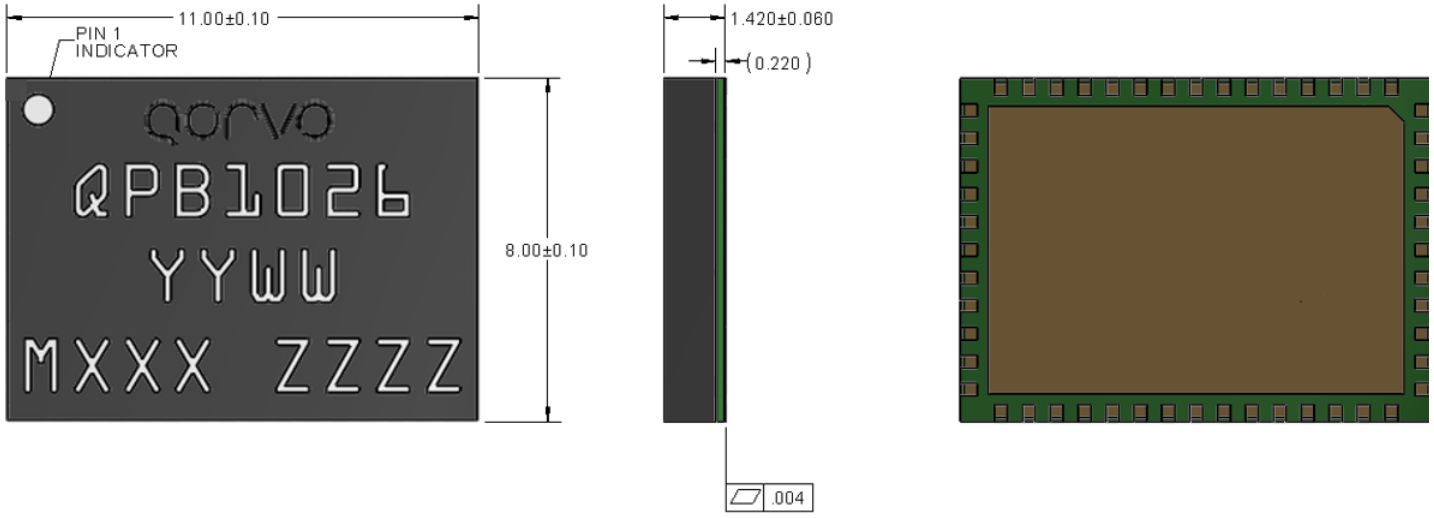
Pad Descriptions

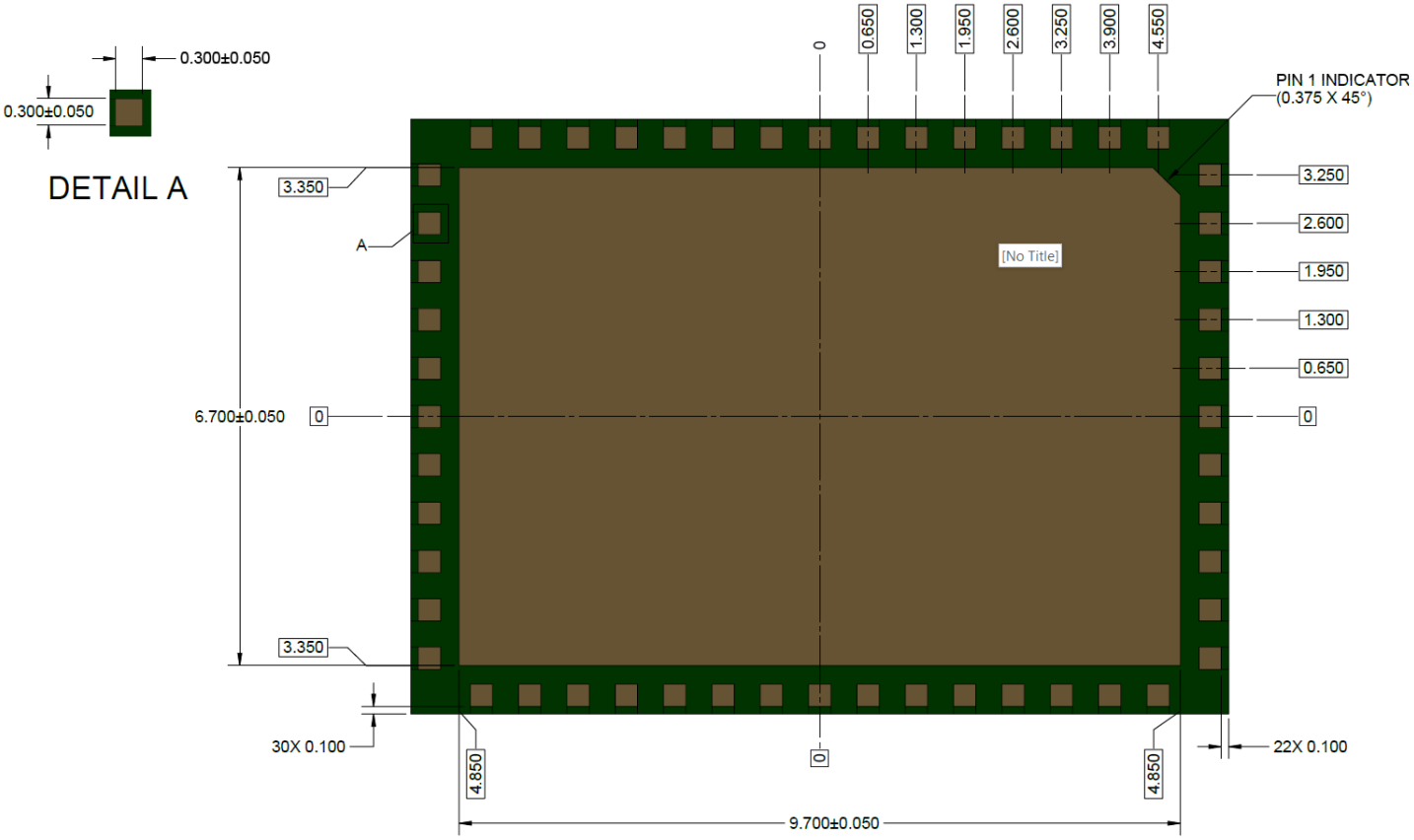




Pin Number	Label	Description
1-3, 5, 7, 9, 11, 12, 14-19, 25, 27, 29	GND	Ground
4	SW_CTRL_V1	Switch Control 1
6	RF IN	RF Input, DC Coupled
8	SW_CTRL_V2	Switch Control V2
10	VCC_AMP1	Power Supply for Amplifier 1
13	VPD1	Shut Down for Amplifier 1
20	VPD2	Shut Down for Amplifier 2
22	VCC_DSA	Power Supply for DSA
23	VPD3	Shut Down for Amplifier 3 and 4
24	AMP CTRL	Control for Amplifier 3
26	VCC_AMP2	Power Supply for Amplifier 2
28	LB Out	Low Band RF Output, DC Coupled
30	VCC_AMP3	Power Supply for Amplifier 3
36	SB Out	S Band RF Output, DC Coupled
38	VCC_AMP4	Power Supply for Amplifier 4
43	A0	External Address Input A0
44	A1	External Address Input A1
45	A2	External Address Input A2
46	SPI Data	SPI Data
47	LE	SPI Enable
48	CLK	SPI Clock
31, 35, 37, 39-42, 49-52	GND	Ground
53	GND	Ground Pedestal

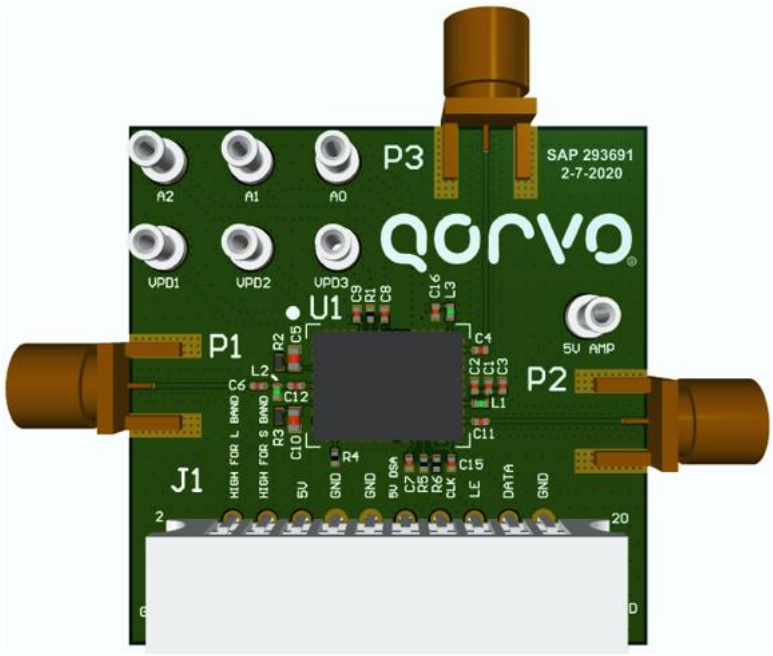
Mechanical Drawing and Dimensions

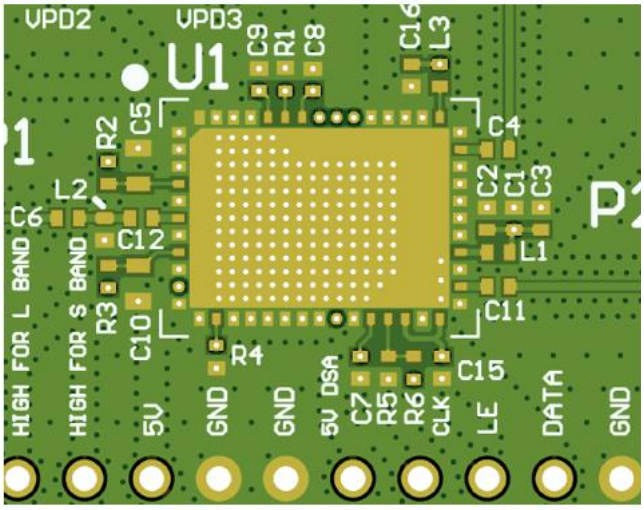




Dimensions in mm. Package is overmold QFN with gold plated lead finish, typical gold plating thickness: 0.095 um
Part Marking: QPB1026 = Part Number; YY = Part Assembly Year;
WW = Part Assembly Week; MXXX = Batch ID

Evaluation Board and Assembly





The evaluation board used multilayer dielectric configuration. The top RF Layers using 8 mils thick Rogers Corp. RO4003C (ε_r = 3.38), middle layer: 41 mils Isola 370HR (ε_r = 4.1), bottom layer: 8 mils FR4 (ε_r = 4.1). All metal layers used 0.5 oz. copper for plating. The RF feeding lines are impedance controlled.

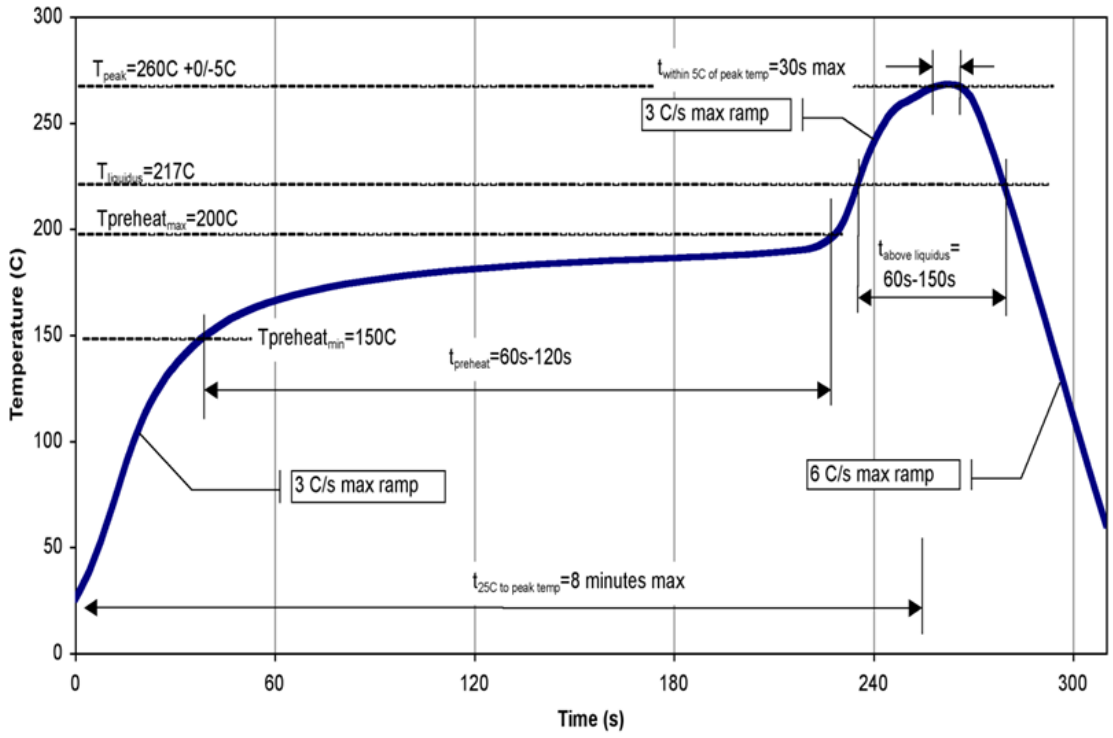
Bill of Materials

Ref. Des.	Component	Value	Manuf.	Part Number
C1, C4, C11-12, C15-16	SMT Cap.	CAP, 0402, 100 pF, +/-5%, 25 V, C0G	Various	
C2	SMT Cap.	CAP, 0402, 1 uF, +/-10%, 25 V, X5R	Various	
C6	SMT Cap.	CAP, 0402, 7.5 pF, +/-0.25pF, 25V, HI-Q	Various	
C5, C10	SMT Cap.	CAP, 0603, 100 pF, +/-5%, 25 V, X7R	Various	
C3	SMT Cap.	CAP, 0402, 0.01 uF, +/-5%, 25 V, C0G	Various	
C7, C8, C9	Not Populated			
R5	SMT Res.	RES, 0402, 10 K, 1%, 1/10W	Various	
R2, R3	SMT Res.	RES, 0402, 3.32 K, 1%, 1/10W	Various	
R6	SMT Res.	RES, 0402, 33 K, 5%, 1/10W	Various	
R4	SMT Res.	RES, 0402, 20 K, 1%, 1/10W	Various	
R1	SMT Res.	RES, 0402, 100 K, 1%, 1/10W	Various	
L1, L3	SMT Ind.	IND, 0402, 16 nH, 2%, 370mA	Various	
L2	SMT Ind.	IND, 0402, 11 nH, W/W, 2%	Various	
P1, P2, P3	RF connector	Jack Receptacle End Launch Connectors.	Radiall	9602-1111-018
J1	Connector	Receptacle 20 POS, 100 RT/A Dual.	TE Connectivity	5-532956-3

Assembly Notes

1. Compatible with both lead-free (260°C peak reflow temp.) and tin/lead (245°C peak reflow temp.) soldering processes.
2. This package is non-hermetic, and therefore cannot be subjected to aqueous washing.
   The use of no-clean solder to avoid washing is highly recommended.

Recommended Soldering Temperature Profile



Handling Precautions

Parameter	Rating	Standard
ESD – Human Body Model (HBM)	1B	ESDA / JEDEC JS-001-2017
ESD – Charged Device Model (CDM)	C3	ESDA / JEDEC JS-002-2014
MSL – Convection Reflow 260 °C	3	JEDEC standard IPC/JEDEC J-STD-020

Caution!
ESD-Sensitive Device

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:

- Halogen Free (Chlorine, Bromine)
- Antimony Free
- TBBP-A ($C_{15}H_{12}Br_4O_2$) Free
- SVHC Free

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

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