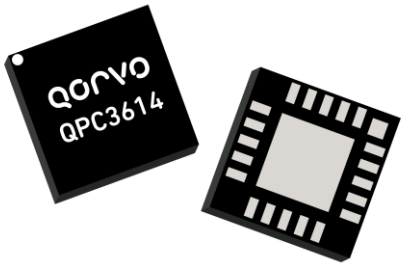
QPC3614

75Ω 5 –2000MHz Digital Step Attenuator

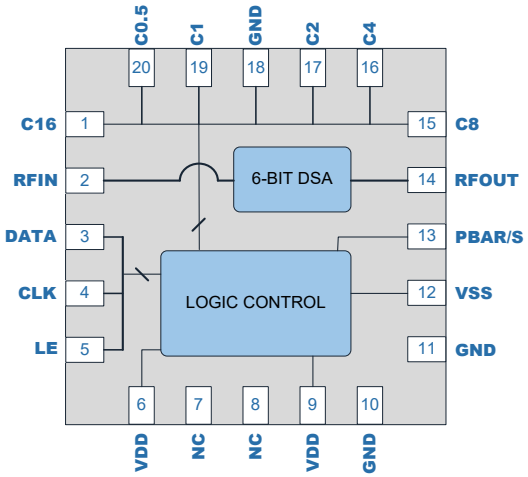
General Description

The QPC3614 is a 75Ω 6-bit digital step attenuator (DSA) that features high linearity over the entire 31.5 dB gain control range in 0.5 dB steps and has a low insertion loss of 1.2dB at 1 GHz. The QPC3614 features three modes of control: serial, latched parallel, and direct parallel programming. Patented circuit architecture provides overshoot-free transient switching performance. QPC3614 is available in a 20-pin 4.2mm x 4.2mm x 0.90mm QFN package.



20 Pin 4.2 x 4.2mm QFN Package

Functional Block Diagram



Top View

Key Features

- 6-Bit, 31.5dB Range, 0.5dB Step
- Patented Circuit Architecture
- Overshoot-free Transient Switching Performance
- Frequency Range 5MHz to 2000MHz
- High Linearity, IIP3 65dBm Typical at 1GHz
- Serial and Parallel Control Interface
- Fast Switching Speed, <500nsec Typical
- RF Pads Have No DC Voltage; Can be DC Grounded Externally
- Option to Turn Off Negative Voltage Generator and Supply V_{SS} Externally
- Power-up Default Setting Is Maximum Attenuation

Ordering Information

Part No.	Description
QPC3614SQ	Sample bag with 25 pieces
QPC3614SR	7" Reel with 100 pieces
QPC3614TR13	13" Reel with 2500 pieces
QPC3614PCK	5 - 2000 MHz PCBA with 5 pc. sample bag

Applications

- Optical Nodes
- Point-to-Point
- MDU Amplifiers
- Pre-amplifier Attenuation
- Inter-stage Attenuation
- Return Attenuation
- AGC
- Tilt Control

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Absolute Maximum Ratings

Parameter	Rating
Supply Voltage (V_{DD})	-0.5 to + 6.0V
Supply Voltage (V_{SS})	-6.0 to + 0.5V
All Other DC and Logic Pads (Supply Voltage Must Be Applied Prior to Any Other Pin Voltage)	-0.5 to VDD
Maximum Input Power at RFIN Pad at 85 °C Case Temperature	+30dBm
Maximum Input Power at RFOUT Pad at 85 °C Case Temperature	+27dBm
Storage Temperature Range	-40 to +150°C

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability.

Recommended Operating Conditions

Parameter	Min	Typ	Max	Units
Supply Voltage, V_{DD}	+2.7	+5.0	+5.5	V
Supply Voltage, V_{SS}	-5.5	-5.0	-4.5	V
Temperature Range	-40		+105 (2)	°C
Junction Temperature			+125	°C

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

(2) RF input power handling derates above 85 °C

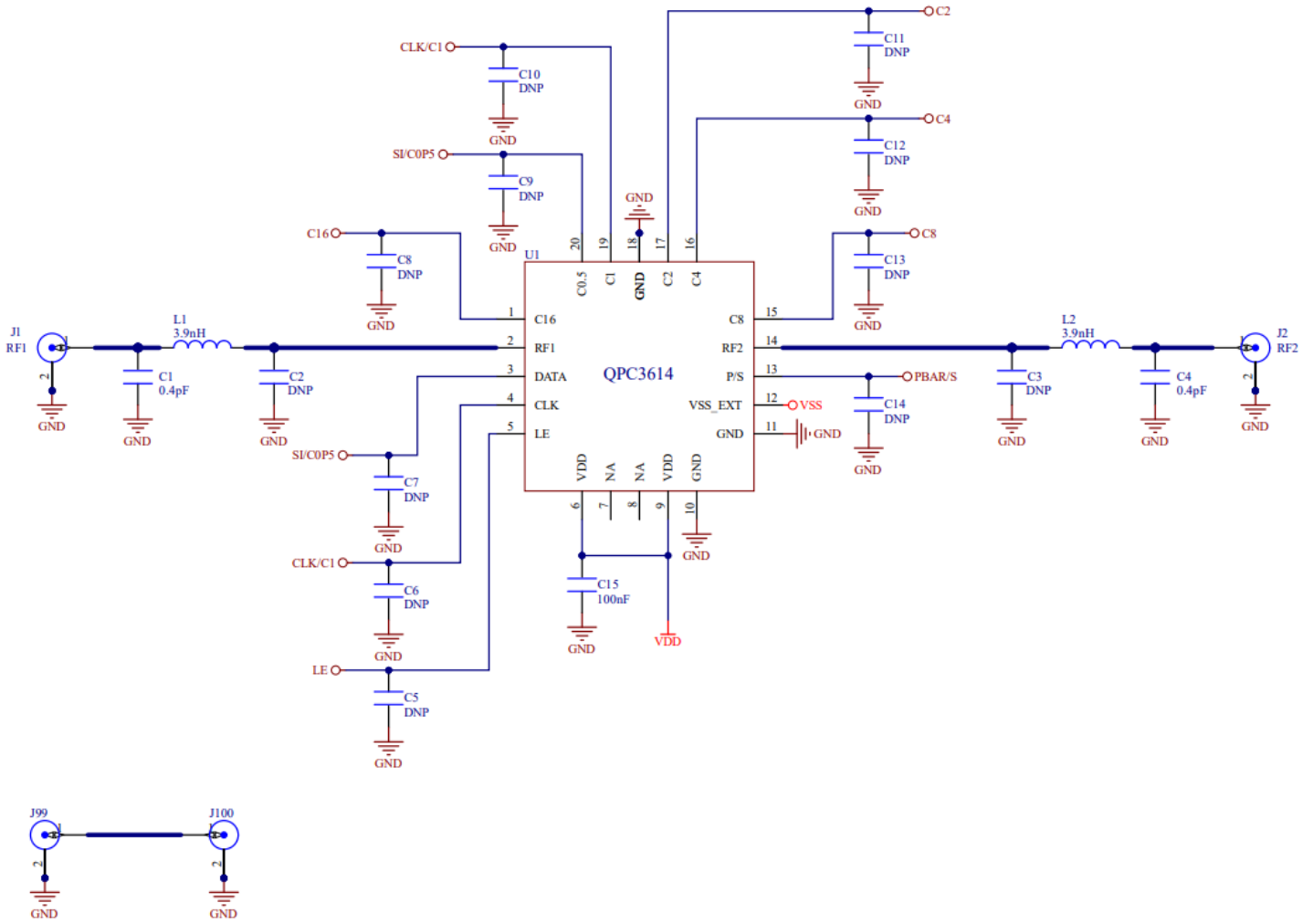
Electrical Specifications

Parameter	Condition (1)	Min	Typ	Max	Unit
Supply Current (I_{DD})	Steady state operation, current draw during attenuation state transitions is higher.		190		µA
Supply Current (I_{SS}) (optional use)	Steady state operation, current draw during attenuation state transitions is higher.		110		µA
Frequency Range		5		2000	MHz
Insertion Loss	5MHz – 684MHz		1.2		dB
	1.2GHz		1.35		
	1.8GHz		1.7		
Maximum Attenuation			31.5		dB
Absolute Attenuation Error			±(0.2 + 4%)		dB
Input IP3	1GHz, Two tones, 13dBm/tone		65		dBm
Input P0.1dB(2)			30		dBm
MER	75dBmV composite, 885MHz		40		dB
CCN	75dBmV composite, 885MHz		49		dB
Return Loss	5MHz – 1200MHz, all states		18		dB
	1800MHz, all states		17		
Nominal Impedance			75		Ω
Switching Speed	50% control to 10% / 90% RF		150		nsec
Digital Logic Low				0.63	V
Digital Logic High		1.17			V
Thermal Resistance, θjc	Junction to case		67		°C/W

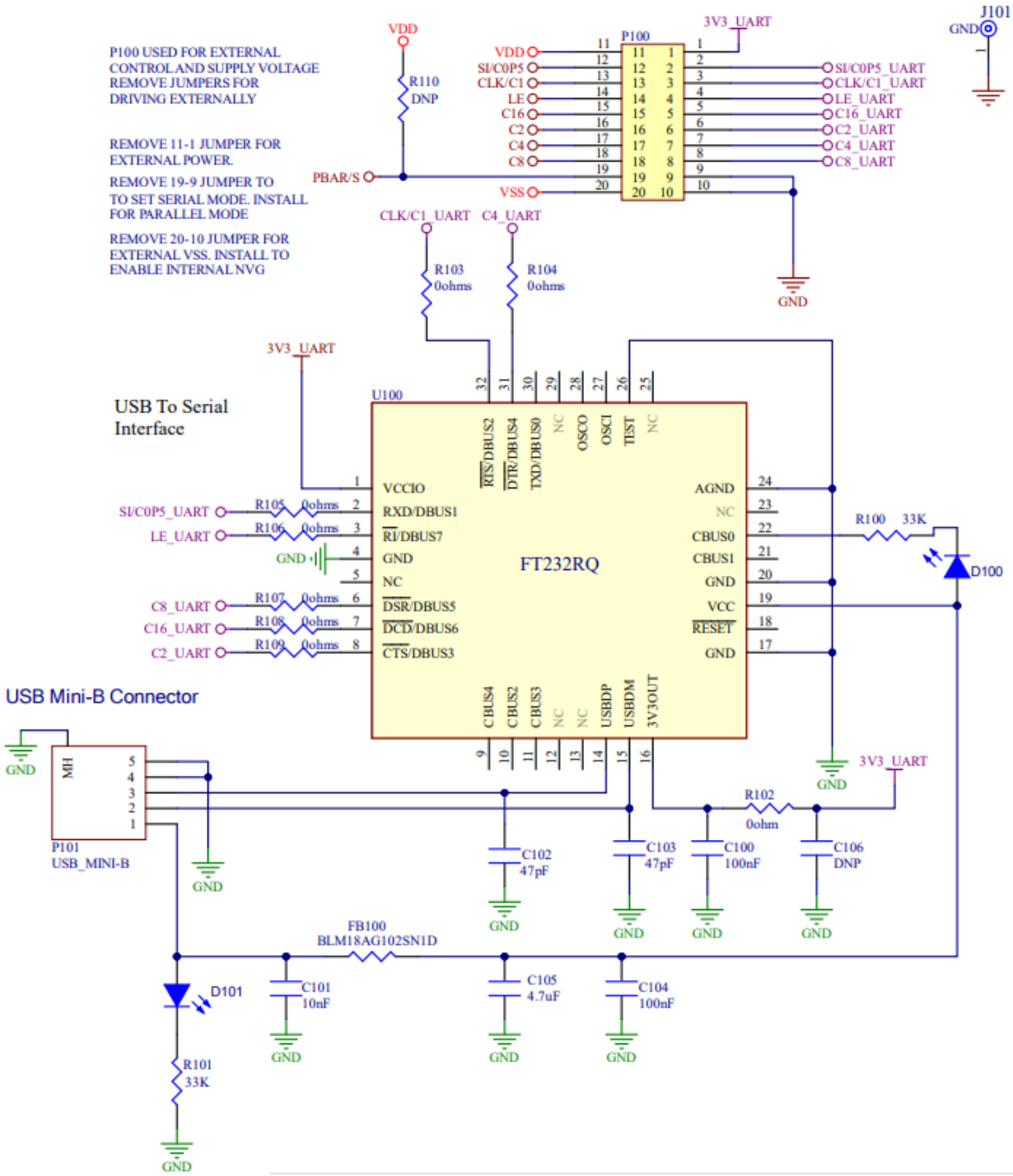
Notes:

1. Typical performance at these conditions: Temp = +25°C, 1000MHz, V_{DD} = +5V, V_{SS} = 0V, 75Ω system.
2. Figure of merit – exceeds maximum input power of device.
3. MER Test Conditions: 190 QAM256 Channels, 57-1215MHz, ITU-T J.83, Annex B
4. CCN test procedure according to ANSI/SCTE 17. System BW 5.36MHz.

Evaluation Board Schematic; 5-2000MHz



Evaluation Board Schematic; USB Interface



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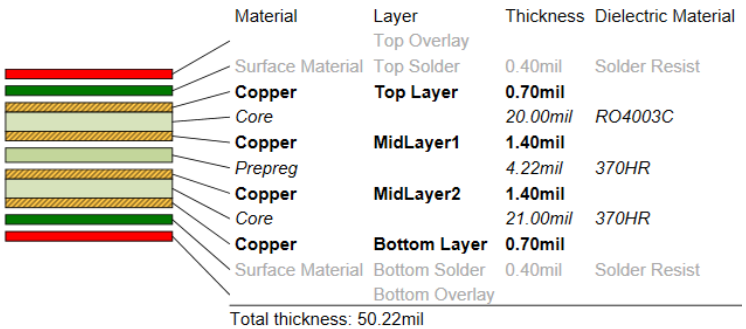
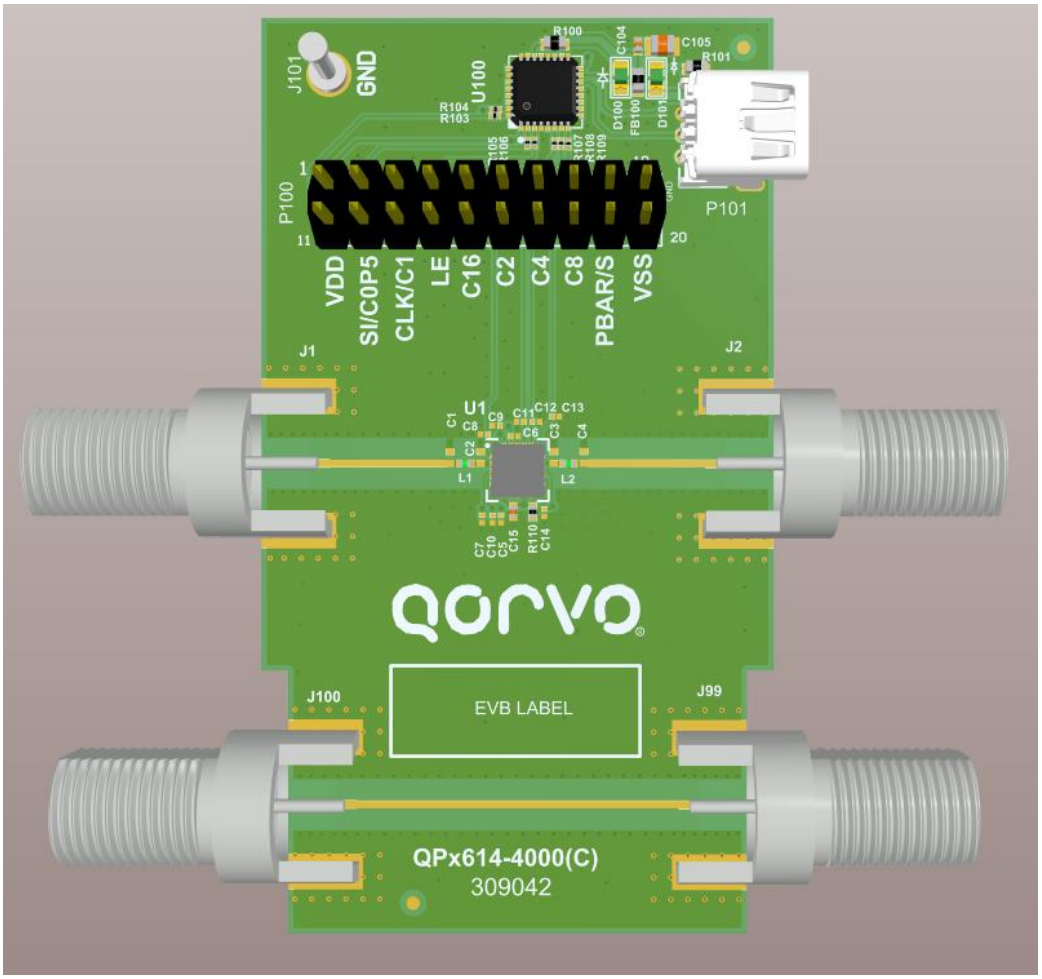
Evaluation Board Bill of Materials

Ref Designator	Qty	Description	Manufacturer	Manufacturer Part #
	1	PCB, QPC3614	TTM Technologies, Inc.	QPC3614-4000(C)
U1	1	5-2000MHz Digital Step Attenuator	Qorvo	QPC3614SR
C102, C103	2	CAP, 47pF, 5%, 50V, C0G, 0402	Kamaya, Inc	HH15N470J500CT
C101	1	CAP, 0.01uF, 10%, 50v, X7R, 0402	Murata Electronics	GCM155R71H103KA55D
C105	1	CAP, 4.7uF, 10%, 16V, X7R, 0805	AVX Asia Limited	0805YC475KAT2A
C15, C100, C104	3	CAP, 0.1uF, 10%, 50V, X7R, 0402	TDK Singapore PTE LT	C1005X7R1H104K050BE
L1, L2	2	IND, 3.9nH, +/-0.1nH, M/L, 0402	Murata Electronics	LQG15HS3N9B02D
R100, R101	2	RES, 33K, 5%, 1/10W, 0603	Kamaya, Inc	RMC1/16S-333JTH
R103, R104, R105, R106, R107, R108, R109	7	RES, 0 Ohm, JUMPER, 0201	Kamaya, Inc	RMC1/20JPPA15
R102	3	RES, 0 Ohm, 5%, 1/10W, 0402	Kamaya, Inc	RMC1/16SJPTH
D100, D101	2	LED, GRN, CLR, 3.2V, 30Ma, 0603	Wurth Elektronik	150060GS75000
FB100	1	FER, BEAD, 1K, 100mA, 0603	Murata Electronics	BLM18AG102SN1D
U100	1	IC, USB-ART, 3.3-5.25V, QFN-32	Future Technology Devices Int'l Ltd	FT232RQ-REEL
S1-11, S2-12, S3-13, S4-14, S5-15, S6-16, S7-17, S8-18, S9-19, S10-20	10	JUMPER, 2-Pin	3M Interconnect Solutions	929950-00
P100	1	CONN, HDR, ST, 2x10, 0.100"	Samtec, Inc.	TSW-110-07-G-D
P101	1	CONN, USB, MINI-B, RT, ANG, 5-PIN, T/H	Molex	054819-0519
J1, J2, J99, J100	4	CONN, F FEM EDGE MOUNT, 75 OHMS, 0.068"	Millimeter Wave Technologies	MW-846-C-DD-75
J101	1	862000-055 TERM, SOLDER TURRET, 0.062 PCB	Mouser Electronics, Inc	2533-0-00-44-00-00-07-0
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C106, R110	16	Do Not Populate		

Evaluation Board Stackup



Evaluation Board Assembly Drawing

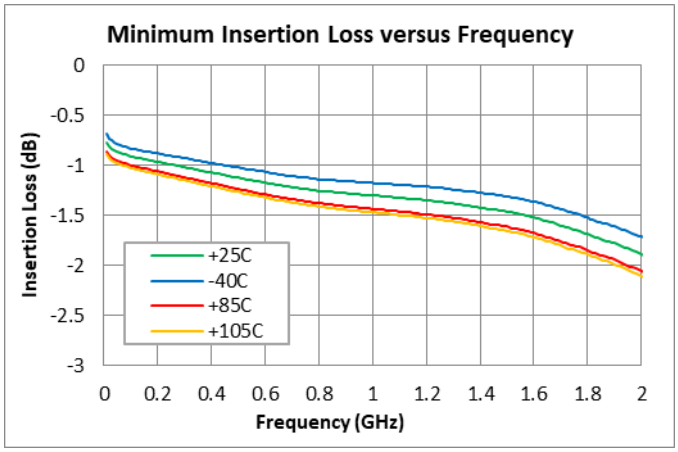


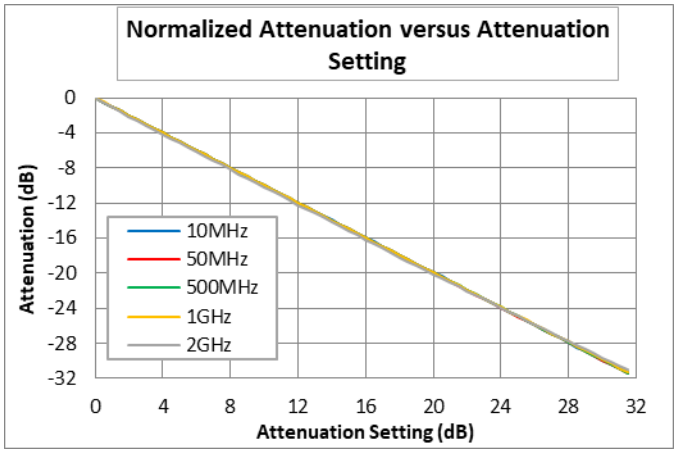
On Board Jumpers (P100)

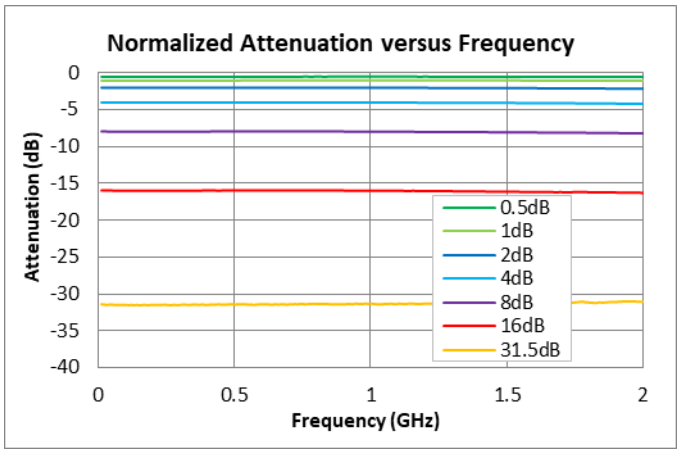
Jumper	Signal	Position	Comment
1-11	VDD	Jumper	Install to supply QPC32614 from USB 3.3V. Remove for external supply from P100-11.
2-12	CI/C0P5	Jumper	Serial Data / Parallel C0.5 Control Line
3-13	CLK/C1	Jumper	Serial Clock / Parallel C1 Control Line
4-14	LE	Jumper	Latch Enable Control Line
5-15	C16	Jumper	Parallel C16 Control Line
6-16	C2	Jumper	Parallel C2 Control Line
7-17	C4	Jumper	Parallel C4 Control Line
8-18	C8	Jumper	Parallel C8 Control Line
9-19	PBAR/SI	Open (Pin to Pull-up Resistor)	Serial Mode
		Jumper (Pin to GND)	Parallel Mode
10-20	VSS – Negative Source	Jumper	Use to tie VSS to GND to enable internal Negative Voltage Generator (NVG), or remove jumper to disable internal NVG and apply -5V.

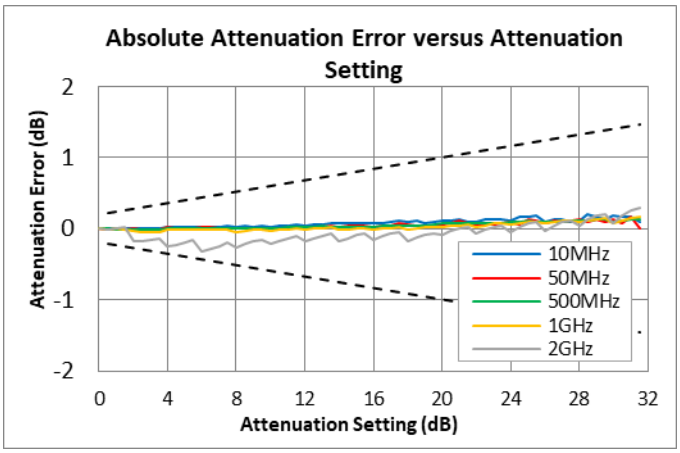
Note: Attenuator is internally controlled and powered, through the USB port, when all jumpers are applied (3.3V).

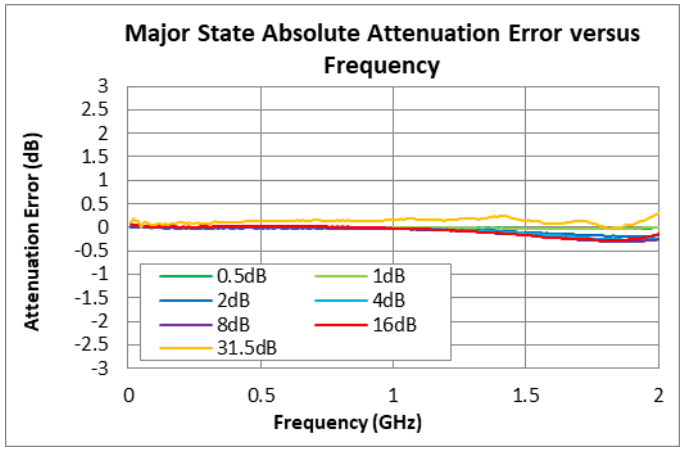
Performance Plots

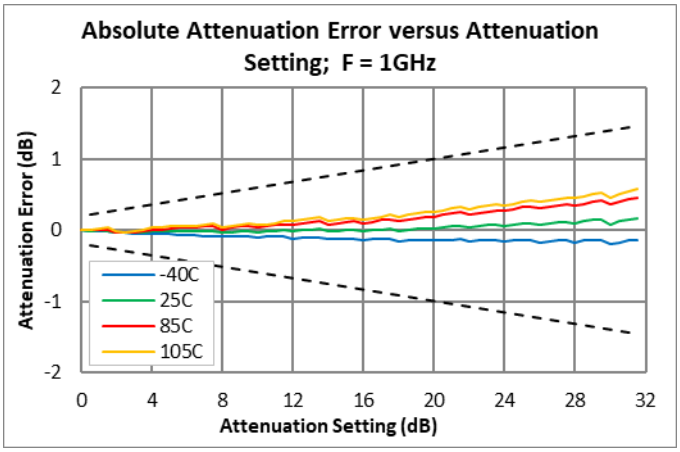








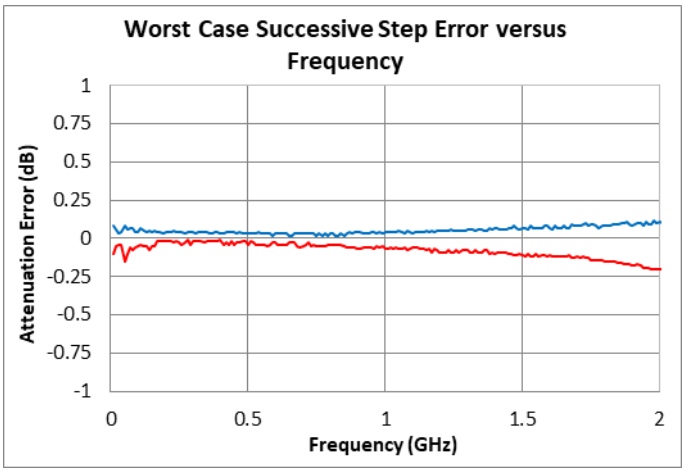


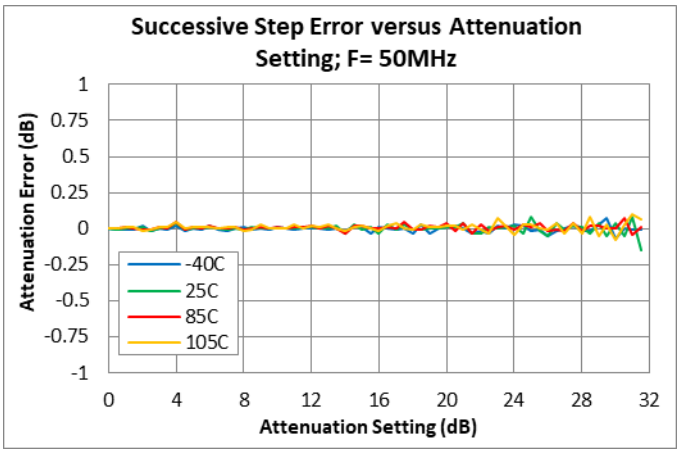


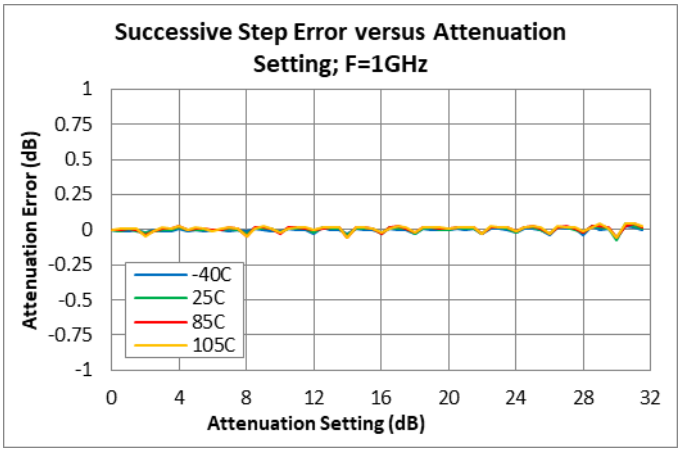
Notes:

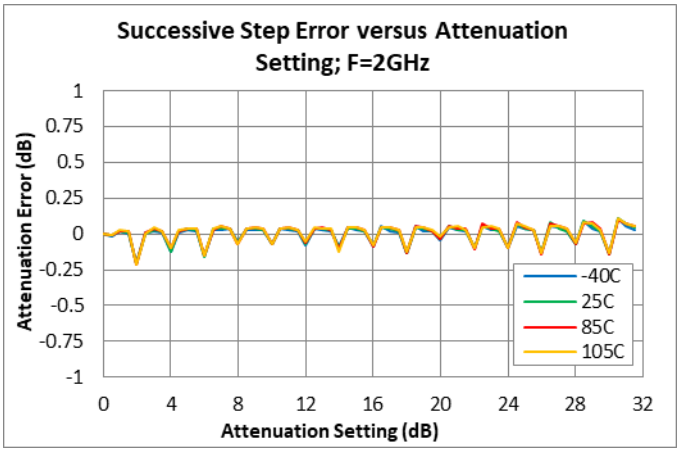
1. Test conditions unless otherwise noted: V_{DD} =+5V, V_{SS}= 0V Temp= +25°C, Z_o = 75Ω

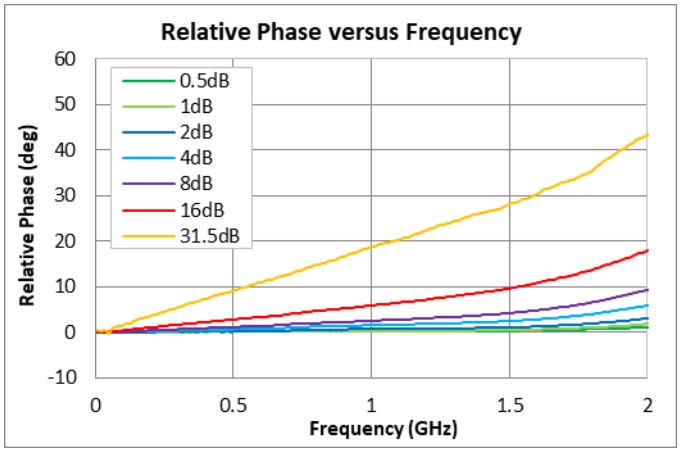
Performance Plots (cont'd.)

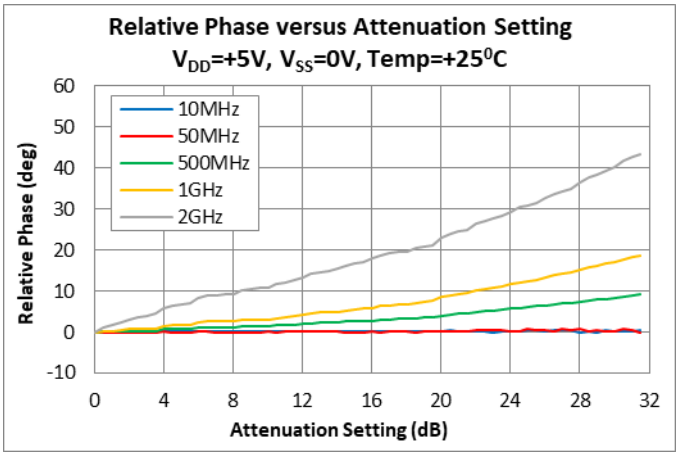












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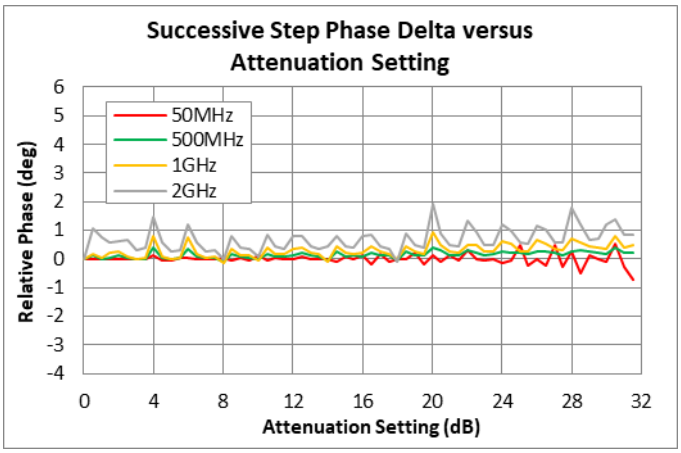
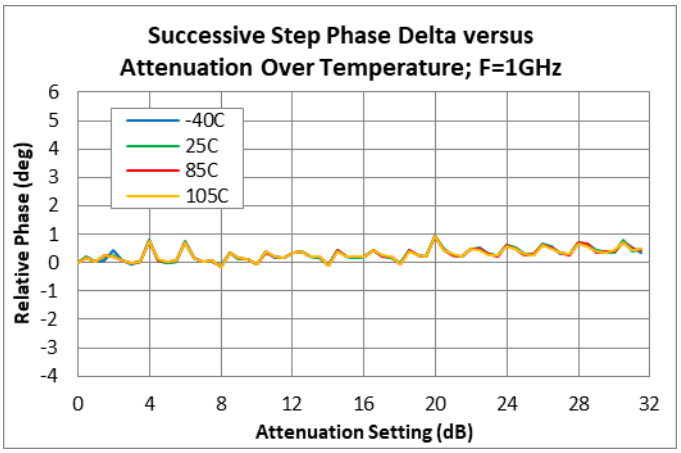
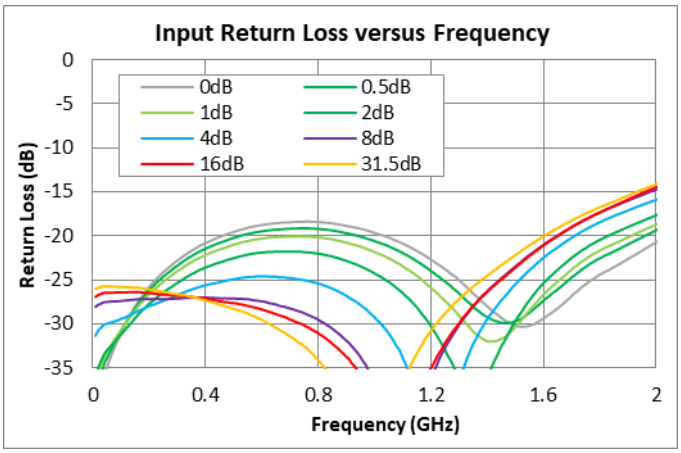
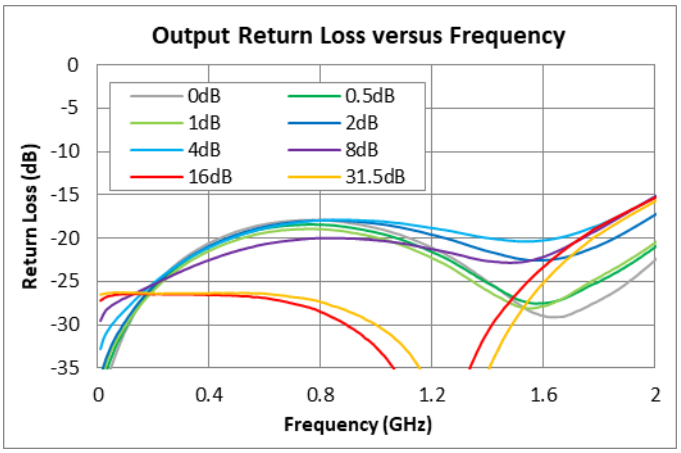
1. Test conditions unless otherwise noted: V_{DD} =+5V, V_{SS}= 0V Temp= +25°C, Z_o = 75Ω

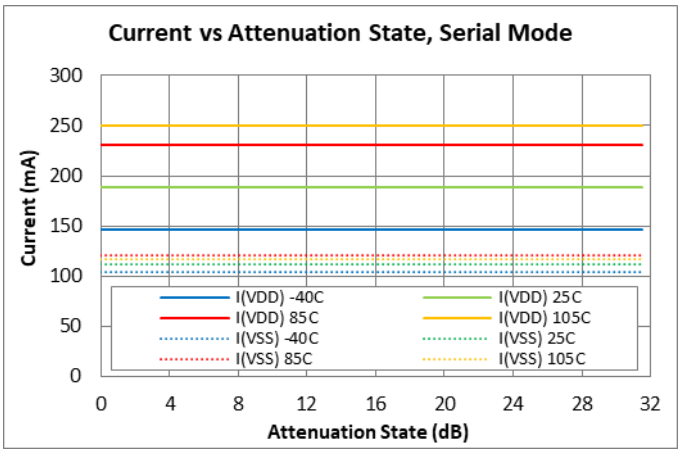
Performance Plots (cont'd.)

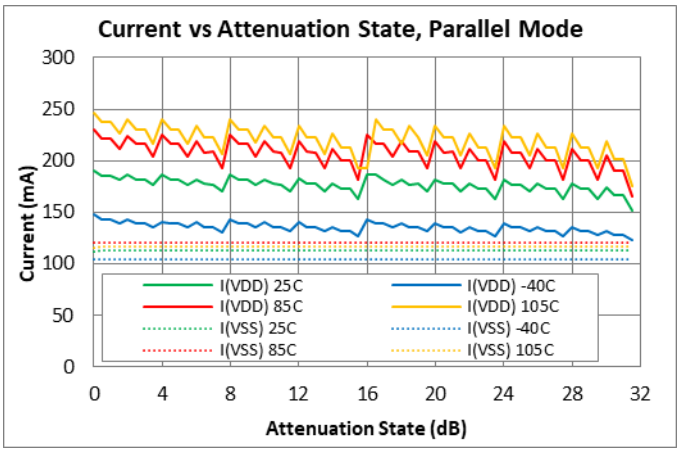








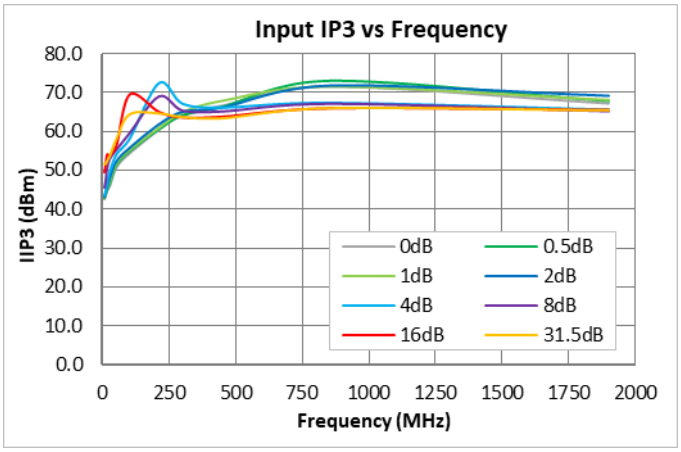


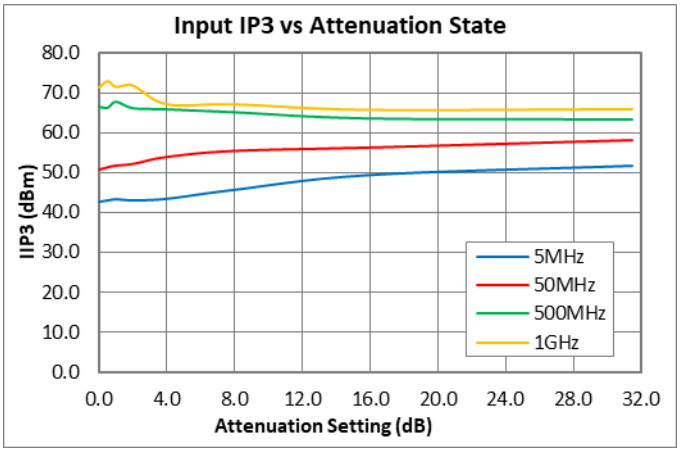


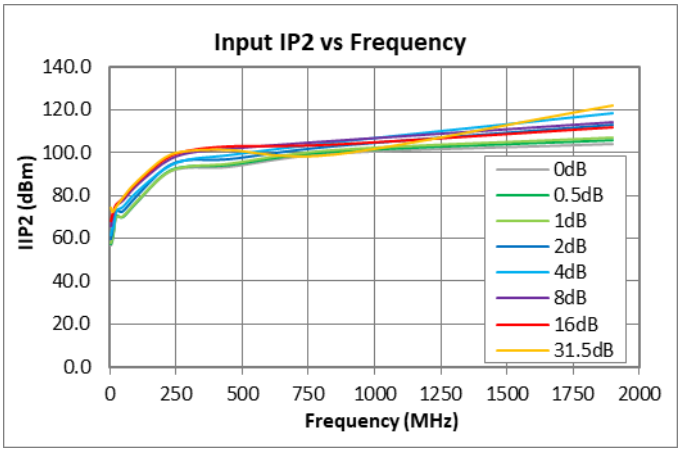
Notes:

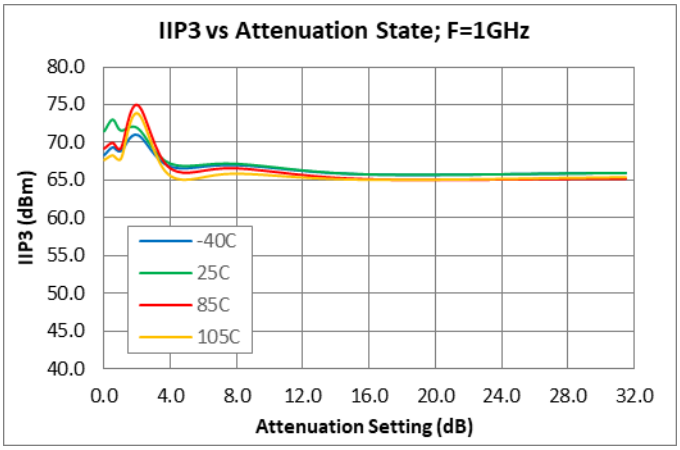
1. Test conditions unless otherwise noted: V_{DD} =+5V, V_{SS}= 0V Temp= +25°C, Z_o = 75Ω

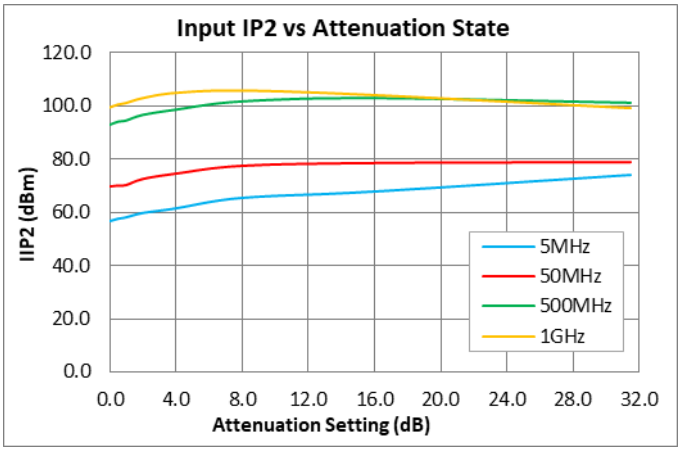
Performance Plots (cont'd.)

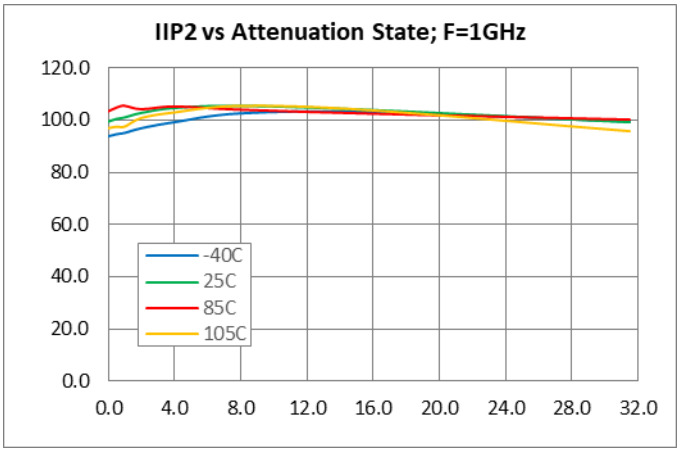








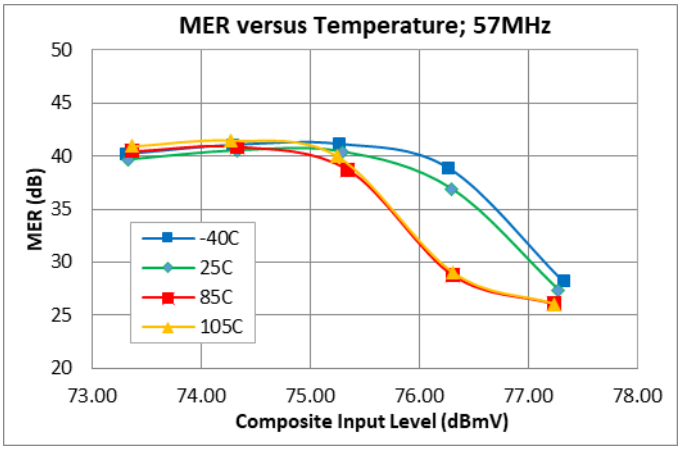


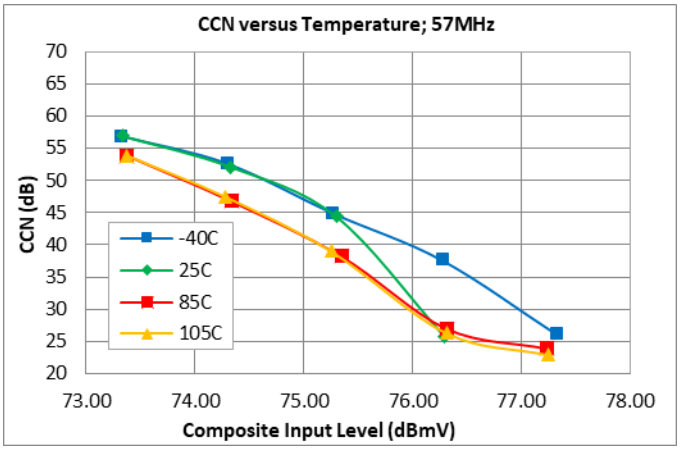


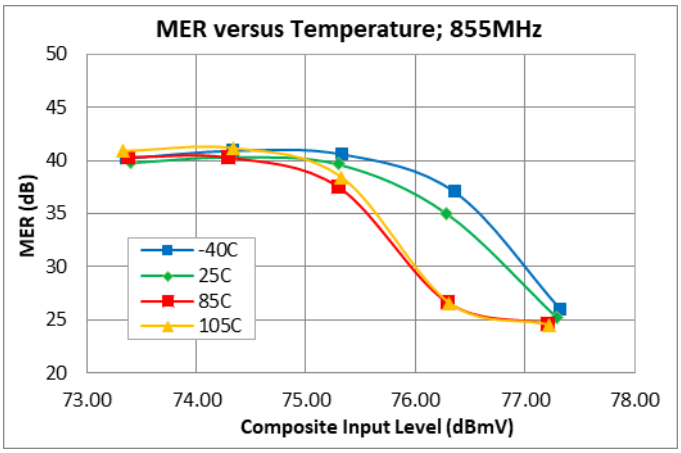
Notes:

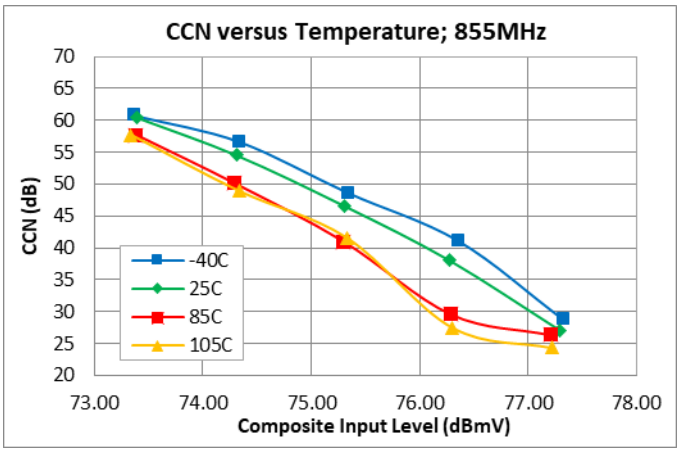
1. Test conditions unless otherwise noted: V_{DD} =+5V, V_{SS}= 0V Temp= +25°C, Z_o = 75Ω
2. IIP2/IIP3: +13dBm/tone.

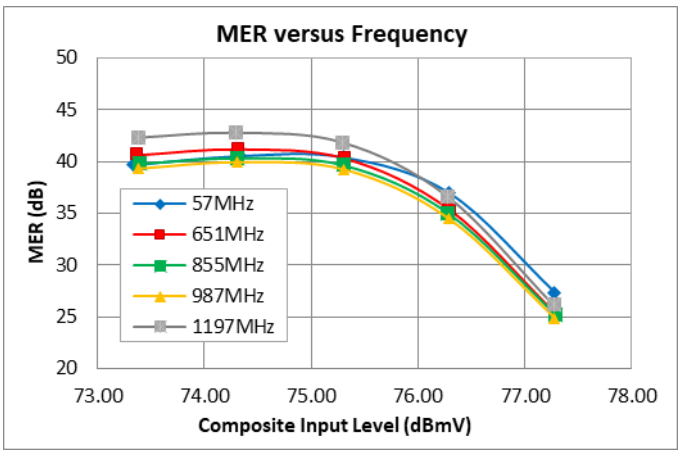
Performance Plots (cont'd.)

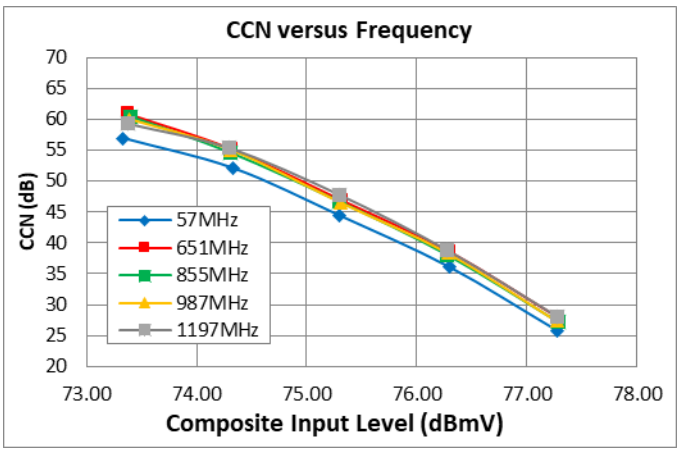












MER/CCN Test Conditions:

1. 190 QAM256 Channels, 57-1215MHz, ITU-T J.83, Annex B
2. CCN test procedure according to ANSI/SCTE 17. System BW 5.36MHz.
3. 0dB Attenuation Setting

Evaluation Board Programming Using USB Interface

Serial Mode
All programming jumpers on the evaluation board are installed as indicated in the table on page 6, except jumper 9-19,which is removed to set QPC3614 in serial mode. Power for QPC3614 is supplied from USB unless Jumper 1-11 is removed to apply an external VDD. Refer to the Control Bit Generator (CBG) Software Reference Manual for instructions on how to setup the software for use. Select 'QPC3614' for serial operation from the parts list of the CBG user interface. Set the attenuation value using the CBG user interface.

Direct Parallel Mode
All programming jumpers on the evaluation board are installed as indicated in the table on page 6. Jumper 19-9 is installed in this case to set QPC3614 in parallel mode. Power for QPC3614 is supplied from USB unless Jumper 1-11 is removed to apply an external VDD. Refer to the Control Bit Generator (CBG) Software Reference Manual for instructions on how to setup the software for use. Select 'QPC3614-P' from the parts list of the CBG user interface. Set the attenuation value using the CBG user interface.

Evaluation Board Programming Using External Bus

Serial Mode
For external control, remove all jumpers from P100 and connect a user-supplied harness on the QPC3614 side of P100 (pins 11-20). Apply the appropriate VDD, CLK, Data, LE, and GND signals to P100. Jumper 10-20 should be installed to enable the internal NVG unless an external -5V supply is applied to pin 20. Send the appropriate signals onto the serial bus lines in accordance with the Serial Mode Timing Diagram.

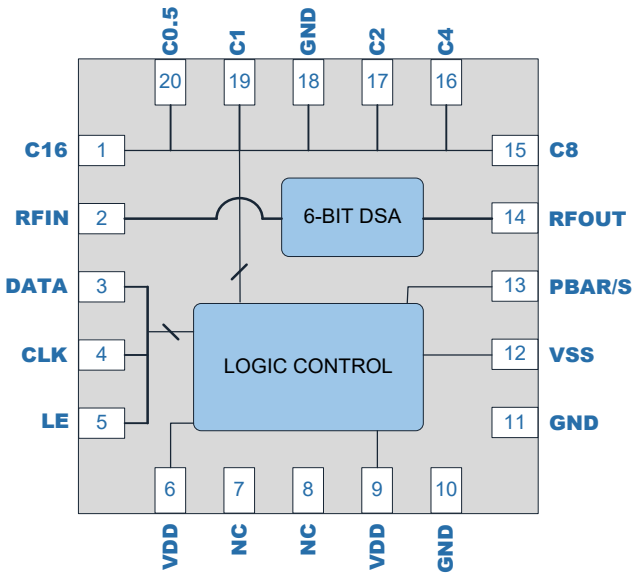
Latched Parallel Mode
Latched Parallel Mode holds the current attenuation state while the LE line remains low. Pulsing the LE control high will latch the internal registers to the state of the control line inputs and update the attenuation state. To operate in latched parallel mode with external controls, remove all jumpers except 9-19 (sets QPC3614 in parallel mode) and connect a user-supplied harness on the QPC3614 side of P100 (pins 11-20). Apply the appropriate VDD, C16 – C0.5, LE, and GND signals. Jumper 10-20 should be installed to enable the internal NVG unless an external -5V supply is applied to pin 20. Send the appropriate parallel control and LE signals in accordance with the Latched Parallel Mode Timing Diagram.

Direct Parallel Mode
In Direct Parallel Mode, the LE signal is held at logic high so that the attenuation will change state immediately when there is a change in logic state for any of the parallel bus signals, C16 – C0.5. Remove all jumpers except 9-19 (sets QPC3614 in parallel mode) and connect a user-supplied harness on the QPC3614 side of P100 (pins 11-20). Apply the appropriate VDD, C16 – C0.5 and GND signals. Jumper 10-20 should be installed to enable the internal NVG unless an external -5V supply is applied to pin 20.

Default Power-up State

The default attenuation state is maximum (31.5 dB) when supply voltage is applied to the attenuator in both serial and parallel modes. If a different attenuation state is desired during power-up, apply signals according to the Parallel Mode Truth Table to the C0.5 – C16 pins. The attenuator will power-up to the state applied to the parallel bus during turn on. The LE signal must be held to logic '0' during power-up.

Pad Configuration and Description



Top View

Pin	Label	Description
1	C16	16dB Parallel Control Bit
2	RFIN	RF Input Pin: Incident RF power must enter this pin for rated thermal performance and reliability. Do not apply DC power to this pin. Pin may be DC grounded externally and is grounded through resistors.
3	DATA	Serial Bus Data Input
4	CLK	Serial Bus Clock Input
5	LE	Latch Enable: The leading edge of signal on LE causes the attenuator to change state for serial and latched parallel modes. For direct parallel mode keep LE at logic high level.
6	VDD	Supply Voltage
7	NC	No Connection
8	NC	No Connection
9	VDD	Supply Voltage
10	GND	Ground Pin
11	GND	Ground Pin
12	VSS	External Negative Supply Voltage. Ground VSS pin to use internal negative voltage generator
13	PBAR/S	Mode Select Pin, Logic Low = Parallel, Logic High = Serial
14	RFOUT	RF Output Pin: Pin may be DC grounded externally and is grounded thru resistors internal to the part.
15	C8	8dB Parallel Control Bit
16	C4	4dB Parallel Control Bit
17	C2	2dB Parallel Control Bit
18	GND	Ground Pin
19	C1	1dB Parallel Control Bit
20	C0.5	0.5dB Parallel Control Bit
Backside Paddle	RF/DC GND	RF/DC ground. Use recommended via pattern to minimize inductance and thermal resistance. See PCB Mounting Pattern for suggested footprint.

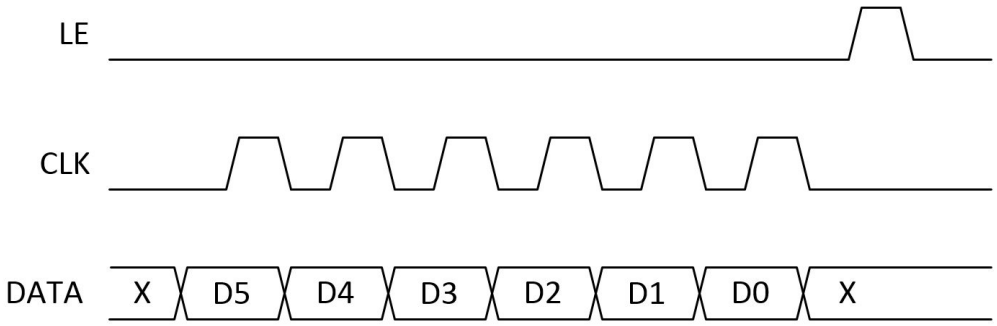
Serial Mode Attenuation Word Truth Table

Attenuation Word							Attenuation State
D5	D4	D3	D2	D1	D0 (LSB)		
L	L	L	L	L	L		0 dB / Reference Insertion Loss
L	L	L	L	L	H		0.5 dB
L	L	L	L	H	L		1 dB
L	L	L	H	L	L		2 dB
L	L	H	L	L	L		4 dB
L	H	L	L	L	L		8 dB
H	L	L	L	L	L		16 dB
H	H	H	H	H	H		31.5 dB

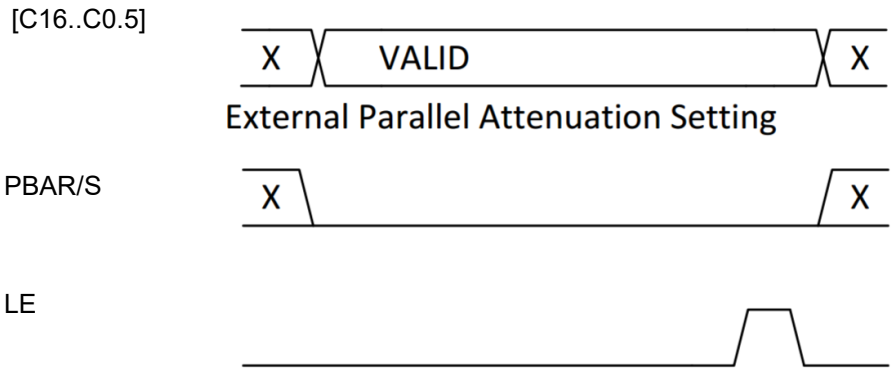
Parallel Mode Attenuation Word Truth Table

Attenuation Word							Attenuation State
C16	C8	C4	C2	C1	C0.5 (LSB)		
L	L	L	L	L	L		0 dB / Reference Insertion Loss
L	L	L	L	L	H		0.5 dB
L	L	L	L	H	L		1 dB
L	L	L	H	L	L		2 dB
L	L	H	L	L	L		4 dB
L	H	L	L	L	L		8 dB
H	L	L	L	L	L		16 dB
H	H	H	H	H	H		31.5dB

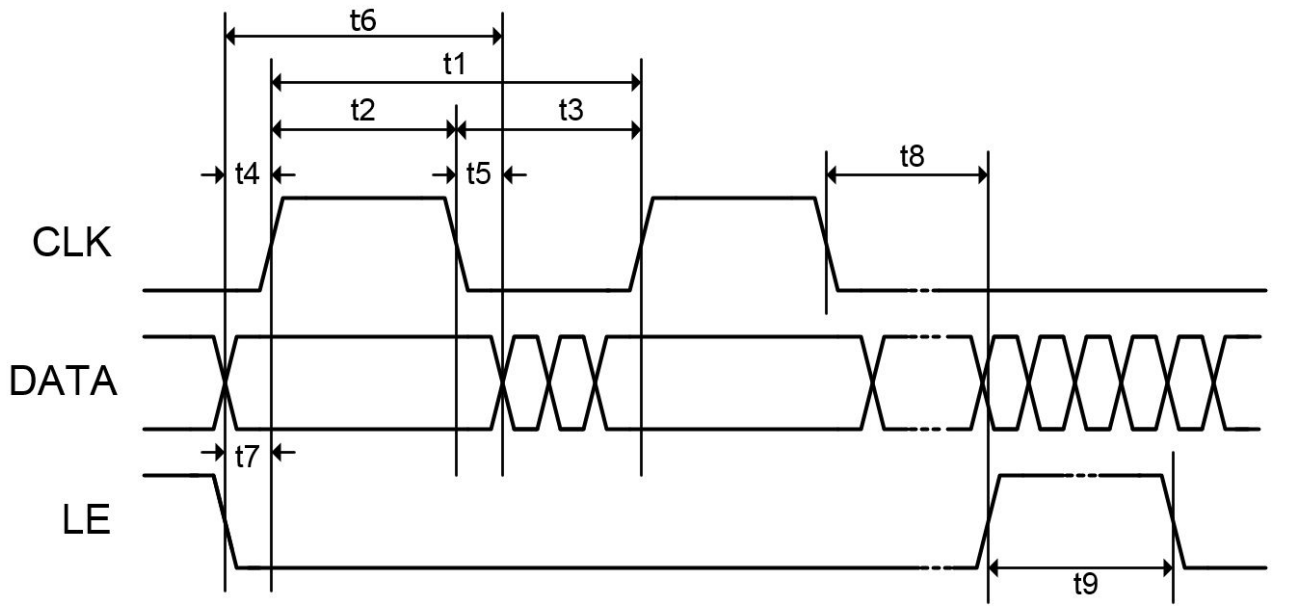
Serial Mode Timing Diagram



Latched Parallel Mode Timing Diagram

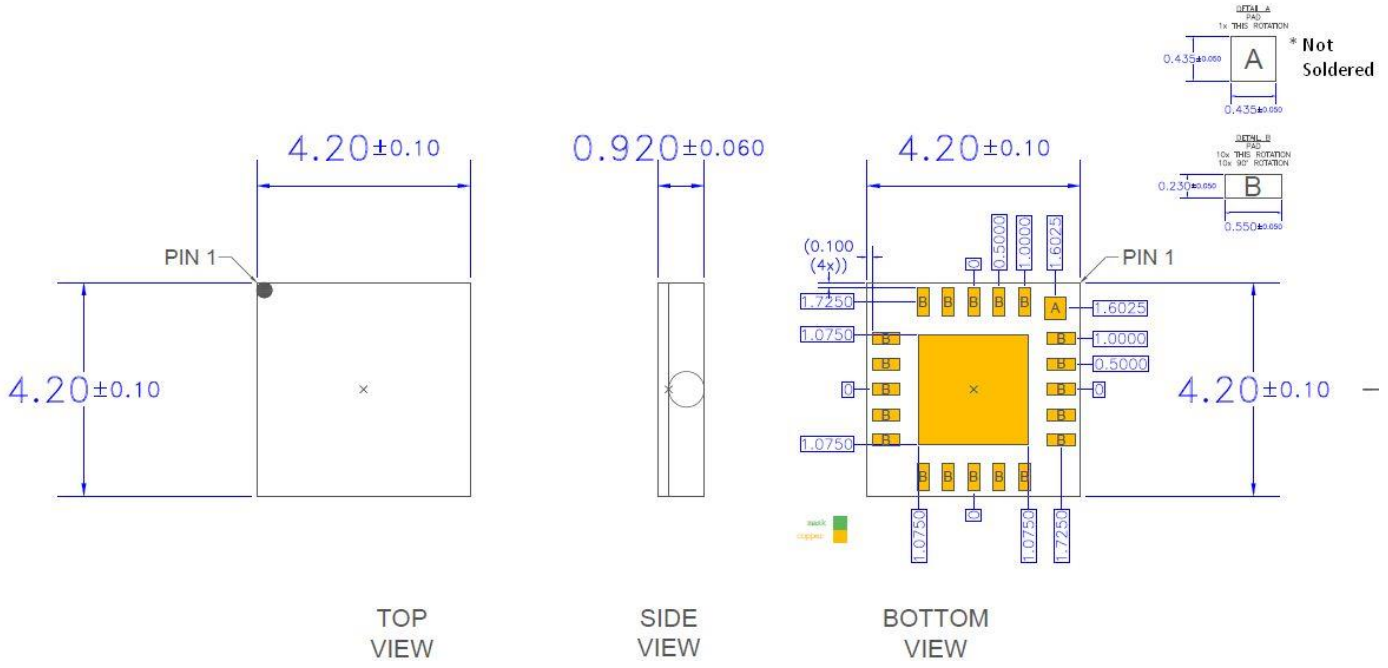


Serial Bus Timing Specifications



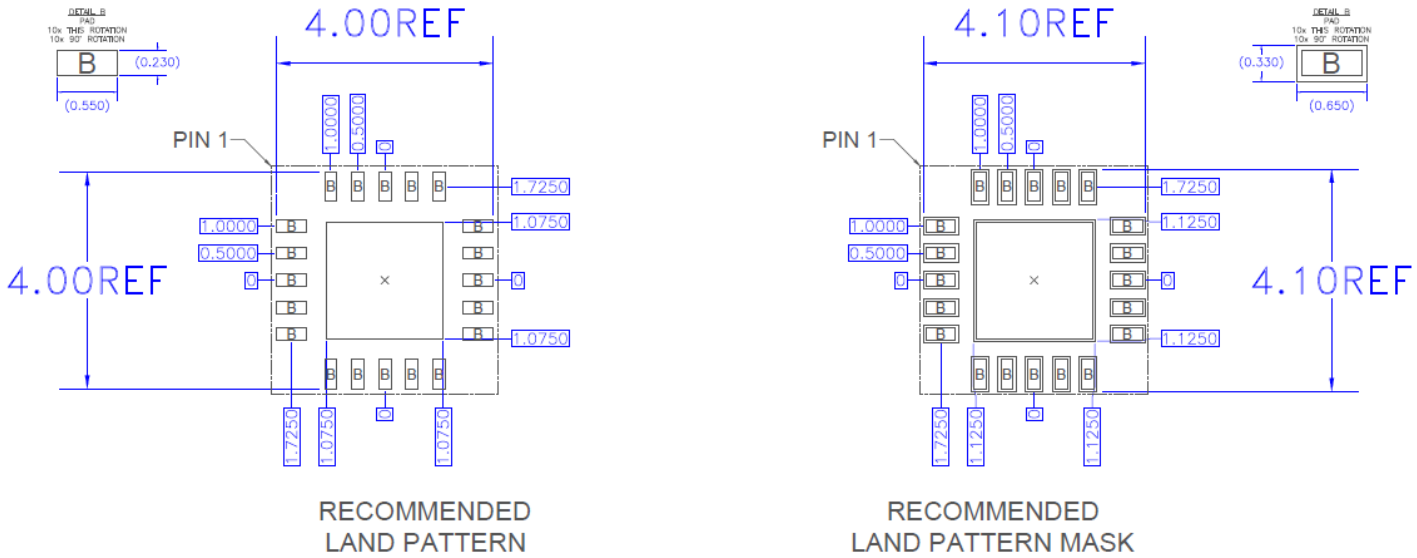
Parameter	Limit	Unit	Comment
t1	25	MHz max	CLK Frequency
t2	20	ns min	CLK High
t3	20	ns min	CLK Low
t4	5	ns min	Data to CLK Setup Time
t5	5	ns min	Data to CLK Hold Time
t6	30	ns min	Data Valid
t7	5	ns min	LE to CLK Setup Time
t8	5	ns min	CLK to LE Setup Time
t9	10	ns min	LE Pulse Width

Package Dimensions

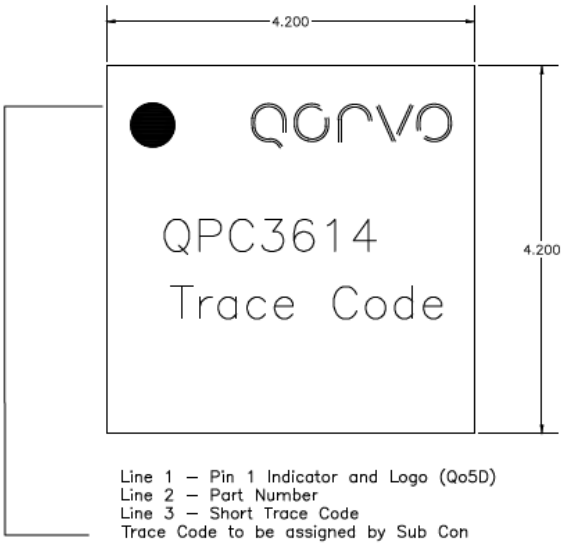


Notes:
1. All dimensions are in millimeters. Angles are in degrees.
2. Dimension and tolerance formats conform to ASME Y14.4M-1994.
3. The terminal #1 identifier and terminal numbering conform to JESD 95-1 SPP-012.
4. Contact plating: NiPdAu

Recommended Mounting Pattern

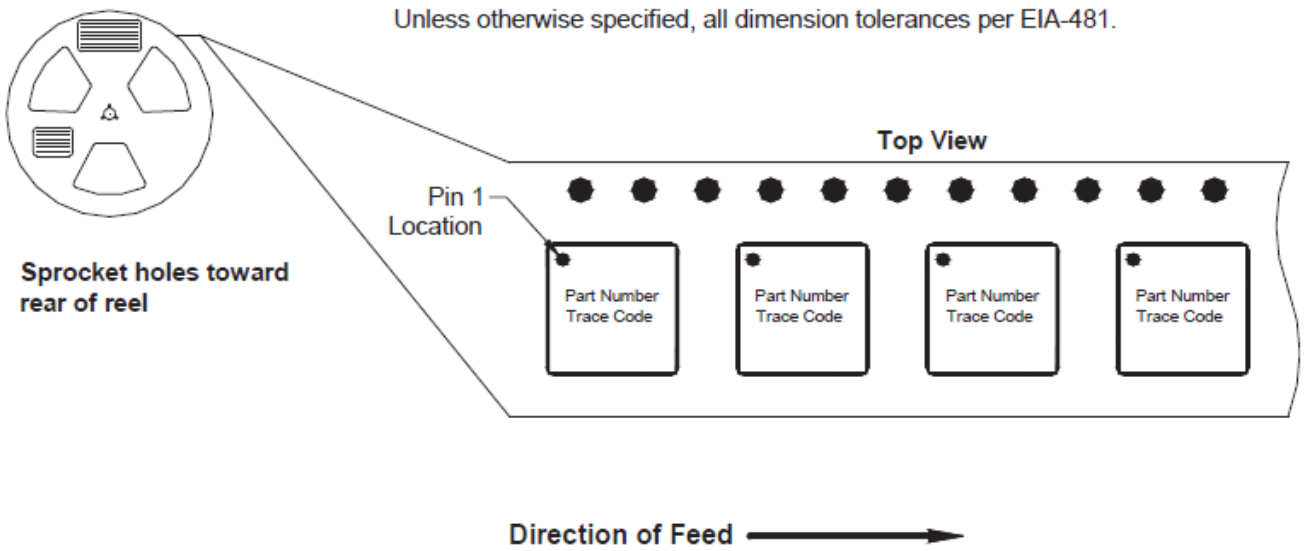


Package Marking



Tape and Reel Information

Qorvo Part Number	Reel Diameter Inch (mm)	Hub Diameter Inch (mm)	Width (mm)	Pocket Pitch (mm)	Feed	Units Per Reel
QPC3614TR13	13 (330)	4 (102)	12	8	Single	2500



4.2mm x 4.2mm Carrier Tape Drawing with Part Orientation

Handling Precautions

Parameter	Rating	Standard
ESD – Human Body Model (HBM)	1C (1000V)	ESDA / JEDEC JS-001-2012
ESD – Charged Device Model (CDM)	C3 (1000V)	JEDEC JESD22-C101F
MSL – Moisture Sensitivity Level	MSL3	IPC/JEDEC J-STD-020

Caution!
ESD-Sensitive Device

Solderability

Compatible with both lead-free (260°C max. reflow temp.) and tin/lead (245°C max. reflow temp.) soldering processes.
Solder profiles available upon request.

Contact plating: NiPdAu

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

Important Notices

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