

# Applications

- Mobile Infrastructure
- LTE / WCDMA / CDMA / EDGE
- Test Equipments and Sensors
- IF and RF Applications

Product Features

+57 dBm Input IP3

50  $\Omega$  Impedance

+5V Supply Voltage

Serial Control Interface

operation above 700 MHz

0.5 dB LSB Steps to 31.5 dB

1.7 dB Insertion Loss @ 2.2 GHz

DC - 4 GHz

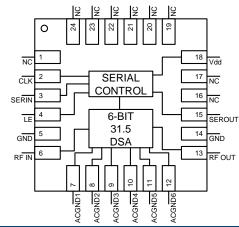
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General Purpose Wireless

# тораннот2

24-pin 4x4mm leadless QFN package

#### **Functional Block Diagram**



#### **Pin Configuration**

Pin #	Symbol
2	CLK
3	SERIN
4	LE
6	RF IN
13	RF OUT
15	SEROUT
18	Vdd
5, 14	GND
7, 8, 9, 10, 11, 12	ACGND1-ACGND6
Backside Paddle	Ground
All other pins are N/C	

# **Ordering Information**

Part No.	Description			
TQP4M9072	6-Bit, 31.5 dB DSA			
TQP4M9072-PCB_IF	40-500MHz Evaluation Board			
TQP4M9072-PCB_RF	0.7-3.5GHz Evaluation Board			
PCB includes USB control interface board, EVH.				

Standard T/R size = 2500 pieces on a 13" reel.

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# **General Description**

The TQP4M9072 is a high linearity, low insertion loss, 6bit, 31.5 dB Digital Step Attenuator (DSA) operating over the DC-4 GHz frequency range. The digital step attenuator uses a single positive 5V supply and has a serial periphery interface (SPI<sup>TM</sup>) for changing attenuation states. This product maintains high attenuation accuracy over frequency and temperature. No external matching components are needed for the DSA. The product has an added feature of not requiring external AC ground capacitors for operation above 700 MHz.

No requirement for external bypass capacitors for

The TQP4M9072 is available in a standard lead-free /green/RoHS-compliant 24-pin 4x4mm QFN package. The TQP4M9071 is also available from TriQuint as a footprint and pin compatible DSA equivalent with a parallel control interface



# **Specifications**

# Absolute Maximum Ratings

Parameter	Rating
Storage Temperature	-55 to 150 °C
Junction Temperature	150 °C
RF Input Power, $50\Omega$ , T = $85^{\circ}$ C	+28 dBm
V <sub>dd</sub> , Power Supply Voltage	+6.0 V
Digital Input Voltage	$V_{dd} + 0.5V$

Operation of this device outside the parameter ranges given above may cause permanent damage.

# **Recommended Operating Conditions**

Parameter	Min	Тур	Max	Units
V <sub>dd</sub>	4.75	5	5.25	V
T (case)	-40		85	°C

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

# **Electrical Specifications**

Test conditions: 25°C,  $V_{dd}$  = +5V, 50 $\Omega$  system, Mode 1, No external bypass capacitors used on pins 7-12.

Parameter	Conditions	Min	Typical	Max	Units
Operational Frequency Range	See Note 1 and 2.	DC		4000	MHz
	1.0 GHz		1.3		dB
Insertion Loss	2.0 GHz		1.6		dB
Insertion Loss	2.2 GHz		1.7	2.2	dB
	3.5 GHz		2.1		dB
Return Loss	All States		17		dB
	0.04-2.7 GHz, All States, Mode 2	$\pm$ (0.3 + 3% of Atten. Setting) Max			dB
Accuracy Error	0.7-2.7 GHz, All States, Mode 1 or Mode 2	$\pm$ (0.3 + 3% of Atten. Setting) Max			dB
	2.7-3.5 GHz, All States, Mode 1 or Mode 2	$\pm$ (0.4 + 4% of Atten. Setting) Max		dB	
Attenuation Step	To be monotonic (Step Attenuation $\geq 0$ ) 0 0.5		dB		
Input IP3	Input = $+15$ dBm / tone, All States		+57		dBm
Input P0.1dB	All States, DC-4 GHz		+30		dBm
Time rise / fall	10% / 90% RF		90		ns
Time <sub>On</sub> , Time <sub>Off</sub>	50% CTL to 10% / 90% RF		100		ns
Supply Voltage, Vdd			+5		V
Supply Current, Idd			2.0		mA

Notes:

1. In Mode 1 no external bypass capacitors are used and operating frequency is 0.7-4GHz. See page 8 for details.

2. In Mode 2 external bypass capacitors are used and operating frequency may be extended to 0.04-4GHz. See page 8 for details.



# **Serial Control Interface**

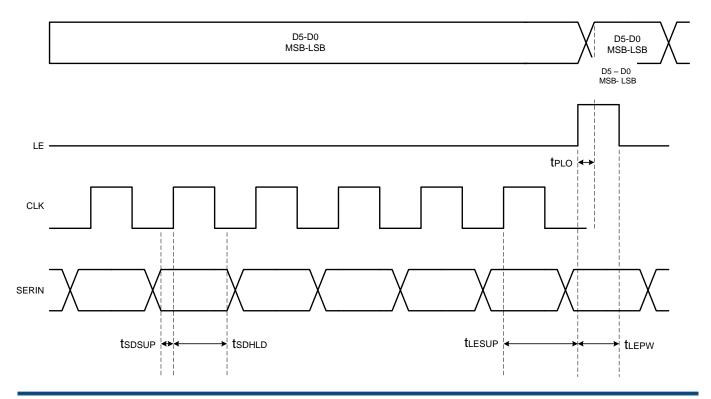
The TQP4M9072 has a CMOS SPI<sup>TM</sup> input compatible serial interface. This serial control interface converts the serial data input stream to parallel output word. The input is 3-wire (CLK, LE and SERIN) SPI<sup>TM</sup> input compatible. At power up, the serial control interface resets device attenuation state to 31.5dB. The 6-bit SERIN word is loaded into the register on rising edge of the CLK, MSB first. When LE is high, CLK is disabled.

# SERIN (MSB in First 6-Bit Word) Control Logic Truth Table

Test cond	ditions: 25°C	$V_{dd} = +5V$				
	6-Bit	Contro	Word t	o DSA		Attenuation
LSB					MSB	State
D5	D4	D3	D2	D1	D0	
1	1	1	1	1	1	Reference : IL
1	1	1	1	1	0	0.5 dB
1	1	1	1	0	1	1 dB
1	1	1	0	1	1	2 dB
1	1	0	1	1	1	4 dB
1	0	1	1	1	1	8 dB
0	1	1	1	1	1	16 dB
0	0	0	0	0	0	31.5 dB
-	nbination of bits sele	•	ble 64 states	s will provid	de an atten	uation of approximately

# Serial Control Interface Timing Diagram

CLK is disabled when LE is high



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# **Serial Control Timing Characteristics**

Test conditions: 25°C, $V_{dd} = +5V$				
Parameter	Condition	Min	Max	Units
Clock Frequency	50% Duty Cycle		10	MHz
LE Setup Time, t <sub>LESUP</sub>	after last CLK rising edge	10		ns
LE Pulse Width, t <sub>LEPW</sub>		30		ns
SERIN set-up time, t <sub>SDSUP</sub>	before CLK rising edge	10		ns
SERIN hold-time, t <sub>SDHLD</sub>	after CLK rising edge	10		ns
LE Pulse Spacing t <sub>LE</sub>	LE to LE pulse spacing	630		ns
Propagation Delay t <sub>PLO</sub>	LE to Parallel output valid		30	ns

# **Serial Control DC Logic Characteristics**

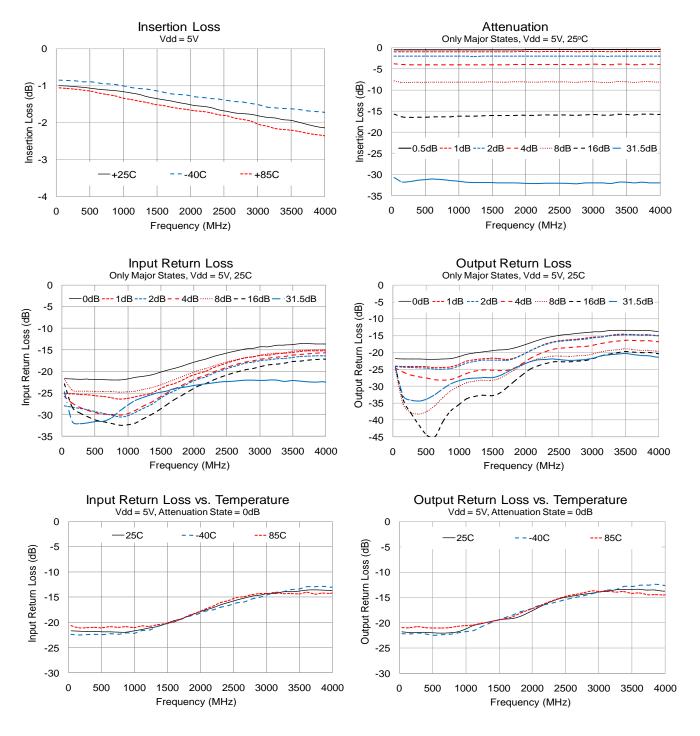
Test conditions: 25°C,  $V_{dd} = +5V$ 

Parameter	Condition	Min	Max	Units
Input Low Voltage, V <sub>IL</sub>		0	0.8	V
Input High Voltage, V <sub>IH</sub>		2.4	Vdd	V
Output High Voltage, V <sub>OH</sub>	On SEROUT	2.0	Vdd	V
Output Low Voltage, V <sub>OL</sub>	On SEROUT	0	0.8	V
Input Current, I <sub>IH</sub> / I <sub>IL</sub>	On SERIN, LE and CLK	-10	+10	μA



#### **Typical Performance Data**

Performance plots data is measured using Bias Tee on RF ports in Mode 2 configuration. Mode 2 operation is required to obtain performance at frequencies lower than 0.7 GHz. For frequency range 0.7 - 4.0 GHz, data is identical in Mode 1 and Mode 2.

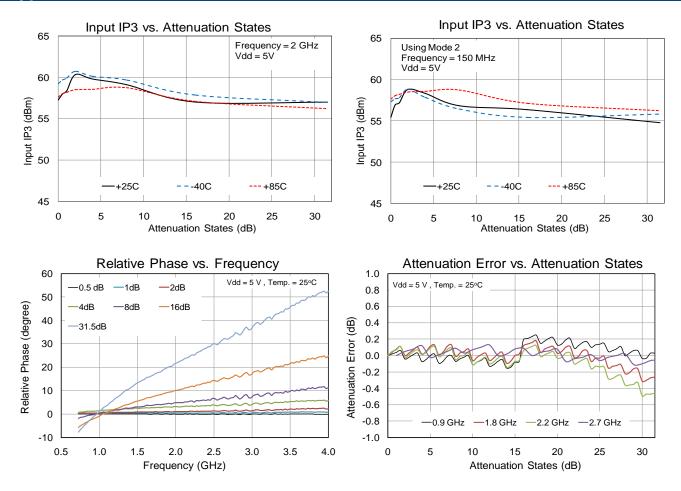


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#### **Typical Performance Data**

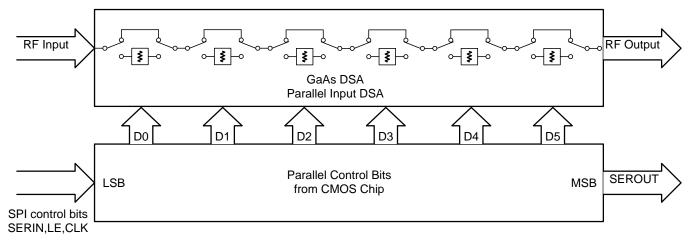




#### **Detailed Device Description**

The TQP4M9072 is a high linearity, low insertion loss, wideband, 6-bit, 31.5 dB digital step attenuator. The digital step attenuator uses a single 5V supply and has a CMOS SPI<sup>TM</sup> controller. This product maintains high attenuation accuracy over frequency and temperature. The product does not require any external bypass capacitors on AC ground pins for operation above 700 MHz. The DSA performance remains unchanged for frequency range 0.7 - 4 GHz in either Mode 1 or Mode 2. The operating frequency may be extended to low frequency range (0.04 - 0.7 GHz) with external bypass capacitors on AC ground pins (ACGND1-ACGND6).

Further assistance may be requested from TriQuint Applications Engineering, sjcapplications.engineering@tqs.com.



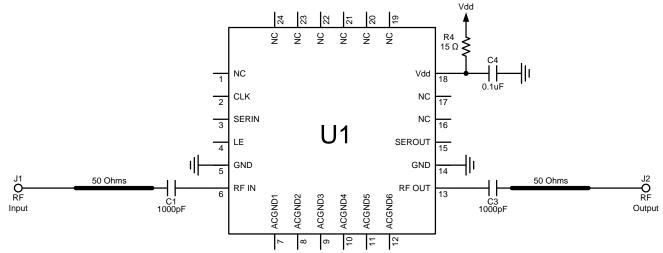
# **Functional Schematic Diagram**



#### **Detailed Device Description**

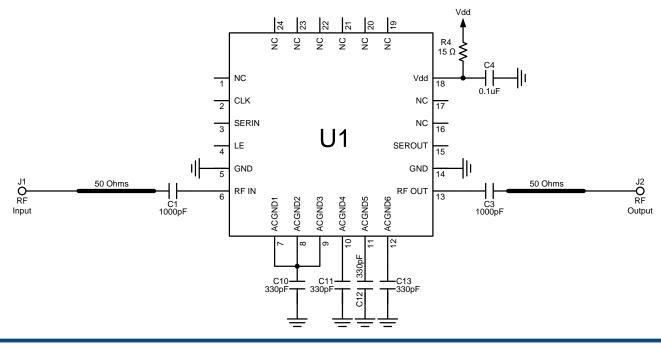
#### Mode 1: 0.7 - 4.0 GHz Operation (TQP4M9072-PCB\_RF)

No external bypass capacitors required. There are 0.2 pF shunt capacitors (C5 and C7) next to RF connectors, on the application board, to resonate out the RF connector parasitic. These shunt capacitors are not required in the final application circuit.



#### Mode 2: 0.04 - 4.0 GHz Operation (TQP4M9072-PCB\_IF)

External bypass capacitors required on ACGND0 - ACGND5 pins. For improved operation below 0.1 GHz, blocking and bypass capacitors values can be increased to 10 nF. This circuit configuration can also be used for operation up to 4 GHz. The DSA performance remains unchanged for frequency range 0.7 - 4 GHz in either Mode 1 or Mode 2. There are 0.2 pF shunt capacitors (C5 and C7) next to RF connectors, on the application board, to resonate out the RF connector parasitic. These shunt capacitors are not required in the final application circuit.



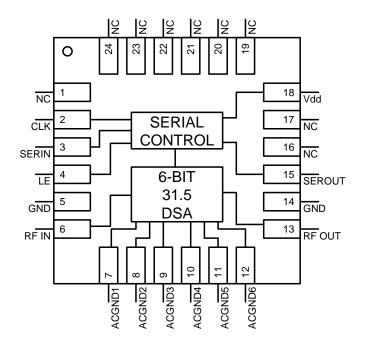
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# TQP4M9072

High Linearity 6-Bit, 31.5dB Digital Step Attenuator



# **Pin Description**



Pin	Symbol	Description
2	CLK	Clock. This serial clock is used to clock in the serial data to the registers. The data is latched on the CLK rising edge. This input is a high impedance CMOS input.
3	SERIN	Serial Input Data. The 6-bit serial data is loaded MSB first. This input is a high impedance CMOS input.
4	LE	Latch Enable, When LE goes high, 6-bit data in the serial input register is transferred to the attenuator. When LE is high, CLK is disabled
6	RF IN	RF Input, DC voltage present, blocking capacitor required. Can be used for Input or Output.
7	ACGND1	AC ground for extended low frequency operation option
8	ACGND2	AC ground for extended low frequency operation option
9	ACGND3	AC ground for extended low frequency operation option
10	ACGND4	AC ground for extended low frequency operation option
11	ACGND5	AC ground for extended low frequency operation option
12	ACGND6	AC ground for extended low frequency operation option
13	RF OUT	RF Output, DC voltage present, blocking capacitor required. Can be used for Input or Output.
15	SEROUT	Serial Output Data
18	V <sub>dd</sub>	Supply Voltage. Bypass capacitor required close to the pin. Dropping resistor highly recommended ensuring compatibility with different power supplies.
5, 14	GND	These pins must be connected to RF/DC ground
1, 16, 17, 19, 20, 21, 22, 23, 24	N/C	These pins are not connected internally but can be grounded on the PCB
Backside Paddle	GND	Multiple vias should be employed for proper performance; see page 10 for suggested footprint



#### **Applications Information**

#### PC Board Layout

Top RF layer is .020" Rogers-4003,  $\epsilon_r = 3.45$ , 4 total layers (0.062" thick) for mechanical rigidity. Metal layers are 1-oz copper. Microstrip line details: width = .040", spacing = .020".

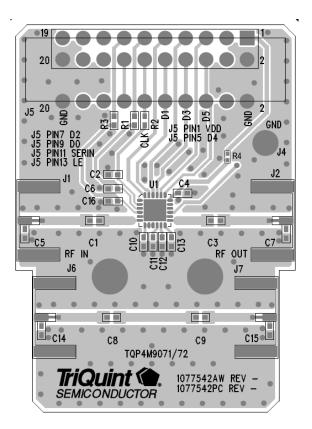
External DC blocking capacitors are required on RFin and RFout pins of the device. The supply voltage for the DSA is supplied externally through pin Vdd. Frequency bypassing for this pin is supplied by surface mount capacitor 0.1 uF (C4). This capacitor is placed close to the device pin in the board layout. To ensure application circuit is compatible with different standard power supplies, 15  $\Omega$  (R4) dropping resistor is highly recommended on Vdd supply line.

R1, R2 and R3 are used as termination for digital noise or any noise reflection on Serial Input, CLK and LE pins.

RF layout is critical for getting the best performance. RF trace impedance needs to be 50 ohm. For measuring the actual device performance on connectorized PC board, input losses due to RF traces need to be subtracted from the data measured through SMA connectors. The calibration microstrip line J6-J7 estimates the PCB insertion loss for removal from the evaluation board measured data. All data shown on the datasheet are deembedded up to the device input/output pins.

The PC board is designed to test using USB control interface board, Evaluation Board Host (EVH). Each TQP4M9072 evaluation board is supplied with the EVH board, USB cable and EVH graphical user interface (EVH GUI) to change attenuation states. Manual for using EVH and Application note describing the EVH are also available. Refer to TriQuint's website for more information

The pad pattern shown has been developed and tested for optimized assembly at TriQuint Semiconductor. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company, careful process development is recommended.





# Bill of Material: 0.7 - 4.0 GHz Operation (Mode 1)

Reference Desg.	Value	Description	Manufacturer	Part Number
U1		High Linearity 6-Bit, 31.5dB, DSA	TriQuint	TQP4M9072
C2, C6, C16	47 pF	Cap, Chip, 0402, 50V, NPO, 5%	various	
C1,C3	1000 pF	Cap, Chip, 0402, 50V, X7R, 10%	various	
<u>C4</u>	0.1 uF	Cap, Chip, 0402, 50V, X7R, 10%	various	
R1, R2, R3	33 Ω	Res, Chip, 0402, 1/16W, 1%	various	
R4	15 Ω	Res, Chip, 0402, 1/16W, 5%	various	
C10, C11, C12, C13	DNP	Do Not Place	various	

# Bill of Material: 0.04 - 4.0 GHz Operation (Mode 2)

Reference Desg.	Value	Description	Manufacturer	Part Number
U1		High Linearity 6-Bit, 31.5dB, DSA	TriQuint	TQP4M9072
C2, C6, C16	47 pF	Cap, Chip, 0402, 50V, NPO, 5%	various	
C1,C3	1000 pF	Cap, Chip, 0402, 50V, X7R, 10%	various	
<u>C4</u>	0.1 uF	Cap, Chip, 0402, 50V, X7R, 10%	various	
R1, R2, R3	33 Ω	Res, Chip, 0402, 1/16W, 1%	various	
R4	15 Ω	Res, Chip, 0402, 1/16W, 5%	various	
C10, C11, C12, C13	330 pF	Cap, Chip, 0402, 50V, X7R, 10%	various	

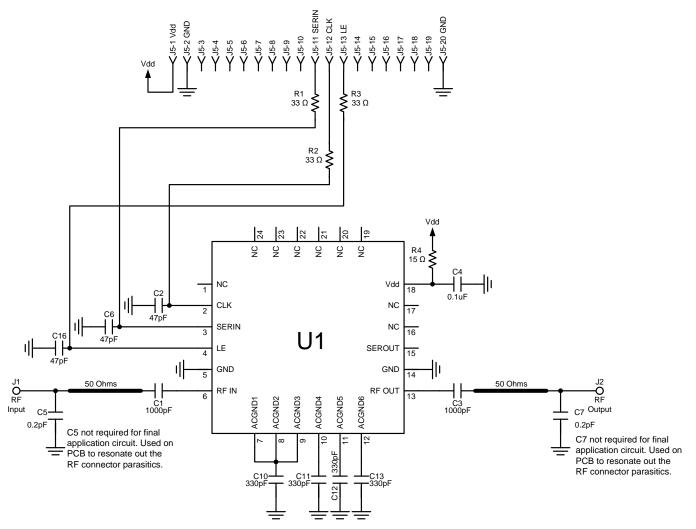
# TQP4M9072

High Linearity 6-Bit, 31.5dB Digital Step Attenuator

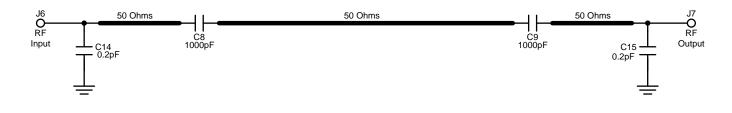


#### Applications Information

## **PC Board Schematic**



Thru Calibration Line



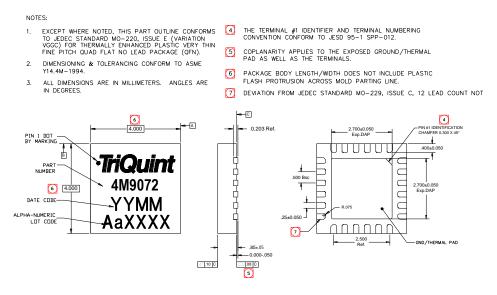


#### **Mechanical Information**

#### **Package Information and Dimensions**

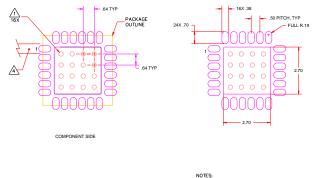
This package is lead-free, RoHS-compliant, and green. The plating material on the pins is annealed matte tin over copper. It is compatible with both lead-free (maximum 260 °C reflow temperature) and leaded (maximum 245 °C reflow temperature) soldering processes.

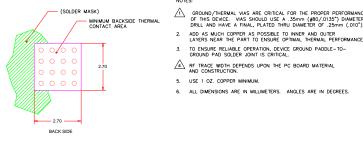
The component will be laser marked with "4M9072" product label with an alphanumeric lot code on the top surface of the package.



# **Mounting Configuration**

All dimensions are in millimeters (inches). Angles are in degrees.





All dimensions are in millimeters (inches). Angles are in degrees.

Notes:

- 1. Ground vias are critical for the proper RF performance of this device. Vias should use a .35mm (#80 / .0135") diameter drill and have a final plated thru diameter of .25 mm (.010").
- 2. Add as much copper as possible to inner and outer layers near the part to ensure optimal thermal performance.



#### **Product Compliance Information**

#### **ESD** Information



ESD Rating:	Class 1C
Value:	Passes $\geq 1000 \text{ V}$ to $< 2000 \text{ V}$
Test:	Human Body Model (HBM)
Standard:	JEDEC Standard JESD22-A114
ECD Datimat	Class IV

ESD Rating:Class IVValue:Passes  $\geq 1000$  VTest:Charged Device Model (CDM)Standard:JEDEC Standard JESD22-C101

# **MSL** Rating

MSL 1 at +260 °C convection reflow The part is rated Moisture Sensitivity Level 1 at 260°C per JEDEC standard IPC/JEDEC J-STD-020.

# Solderability

Compatible with both lead-free (maximum 260 °C reflow temperature) and tin/lead (maximum 245 °C reflow temperature) soldering processes.

This part is compliant with EU 2002/95/EC RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment).

This product also has the following attributes:

- Lead Free
- Halogen Free (Chlorine, Bromine)
- Antimony Free
- TBBP-A ( $C_{15}H_{12}Br_40_2$ ) Free
- PFOS Free
- SVHC Free

#### **Contact Information**

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

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