

# TQP4M9072

High Linearity 6-Bit, 31.5dB Digital Step Attenuator

**TriQuint**   
SEMICONDUCTOR

## Applications

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



24-pin 4x4mm leadless QFN package

## Product Features

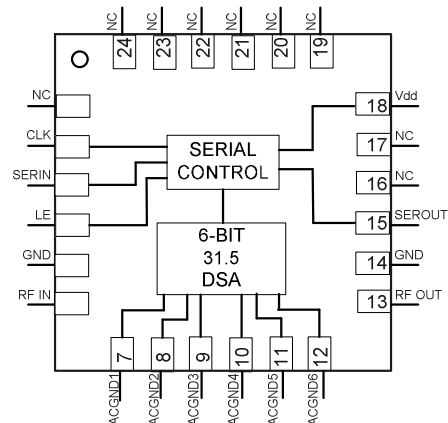
- DC - 4 GHz
- 0.5 dB LSB Steps to 31.5 dB
- +57 dBm Input IP3
- 1.7 dB Insertion Loss @ 2.2 GHz
- TTL/CMOS compatible Serial Control Interface
- No requirement for external bypass capacitors for operation above 700 MHz
- 50  $\Omega$  Impedance
- +5V Supply Voltage

## General Description

The TQP4M9072 is a high linearity, low insertion loss, 6-bit, 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™) 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.

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

## Functional Block Diagram



## Pin Configuration

Pin #	Symbol
2	CLK
3	SERIN
4	LE
6	RF_Input
13	RF_Output
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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High Linearity 6-Bit, 31.5dB Digital Step Attenuator



## Specifications

### Absolute Maximum Ratings

Parameter	Rating
Storage Temperature	-55 to 150 °C
Junction Temperature	150 °C
RF Input Power, 50Ω, T = 85°C	+28 dBm
V <sub>dd</sub> , Power Supply Voltage	+6.0 V
Digital Input Voltage	V <sub>dd</sub> + 0.5V

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

### Recommended Operating Conditions

Parameter	Min	Typ	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<sub>dd</sub> = +5V, 50Ω 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
Insertion Loss	1.0 GHz		1.3		dB
	2.0 GHz		1.6		dB
	2.2 GHz		1.7	2.2	dB
	3.5 GHz		2.1		dB
Return Loss	All States		17		dB
Accuracy Error	0.04-2.7 GHz, All States, Mode 2	± (0.3 + 3% of Atten. Setting) Max			dB
	0.7-2.7 GHz, All States, Mode 1 or Mode 2	± (0.3 + 3% of Atten. Setting) Max			dB
	2.7-3.5 GHz, All States, Mode 1 or Mode 2	± (0.4 + 4% of Atten. Setting) Max			dB
Attenuation Step	To be monotonic (Step Attenuation ≥ 0)	0	0.5		dB
Input IP3	Input = +15dBm / tone, All States		+57		dBm
Input P0.1dB	All States, DC-4 GHz		+30		dBm
Time <sub>rise / fall</sub>	10% / 90% RF		90		ns
Time <sub>On</sub> , Time <sub>Off</sub>	50% CTL to 10% / 90% RF		100		ns
Supply Voltage, V <sub>dd</sub>			+5		V
Supply Current, I <sub>dd</sub>			2.0		mA

Notes:

1. In Mode 1 no external bypass capacitors are used and operating frequency is 0.7-4GHz. See page 5 for details.
2. In Mode 2 external bypass capacitors are used and operating frequency may be extended to 0.04-4GHz. See page 6 for details.

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### Serial Control Interface

The TQP4M9072 has a CMOS SPI™ 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™ 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

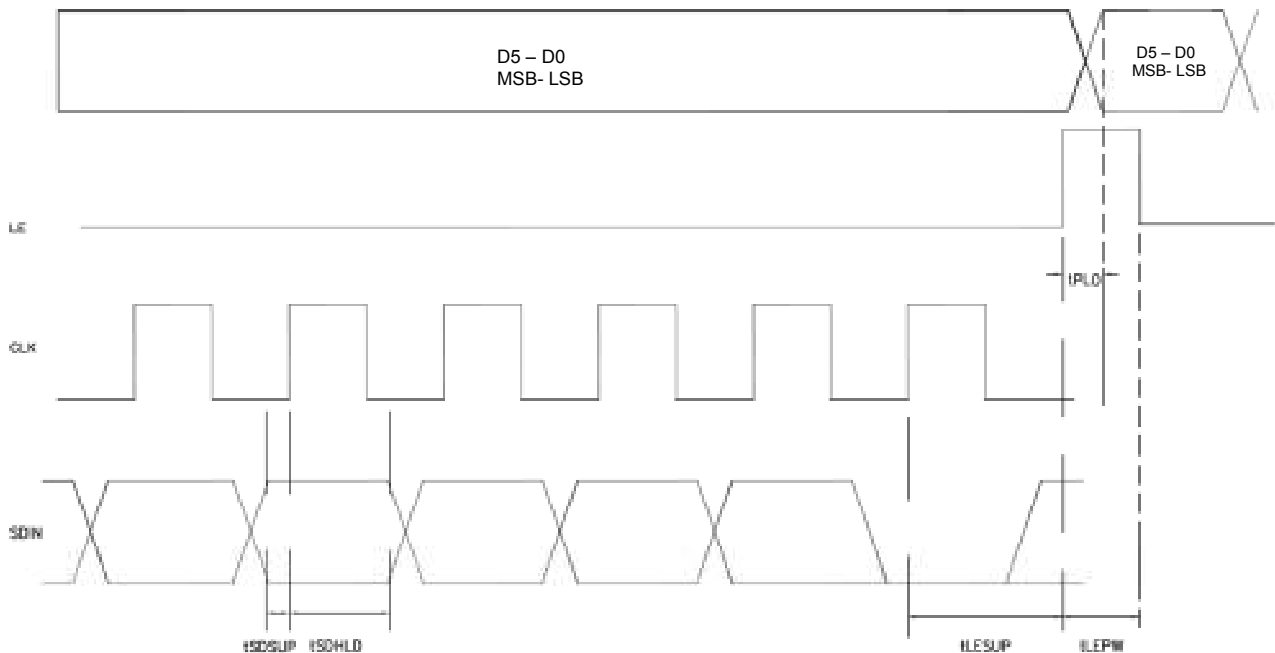
Test conditions: 25°C,  $V_{dd} = +5V$

6-Bit Control Word to DSA						Attenuation State	
LSB	D5	D4	D3	D2	D1		MSB
	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

Any combination of the possible 64 states will provide an attenuation of approximately the sum of bits selected

### 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	Typical	Units
Maximum Clock Frequency	50% Duty Cycle	10	MHz
Minimum LE Setup Time, $t_{LESUP}$	after last CLK rising edge	10	ns
LE Minimum Pulse Width, $t_{LEPW}$		30	ns
Minimum SERIN set-up time, $t_{SDSUP}$	before CLK rising edge	10	ns
Minimum SERIN hold-time, $t_{SDHLD}$	after CLK rising edge	10	ns
Minimum LE Pulse Spacing $T_{LE}$	LE to LE pulse spacing	630	ns

### Serial Control DC Logic Characteristics

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

Parameter	Condition	Typical	Units
Maximum Input Low Voltage, $V_{ILmax}$		0.8	V
Minimum Input High Voltage, $V_{IHmin}$		2.4	V
Minimum Output High Voltage, $V_{OHmin}$	On SEROUT	2.0	V
Maximum Output Low Voltage, $V_{OLmax}$	On SEROUT	0.8	V
Input Current, $I_{IH} / I_{IL}$	On SERIN, LE and CLK	$\pm 10$	$\mu A$

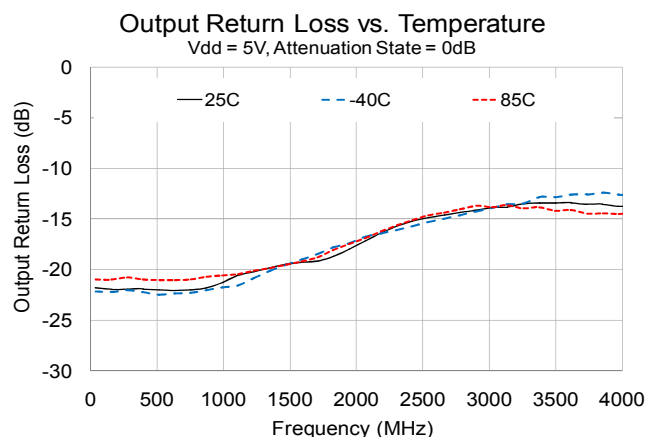
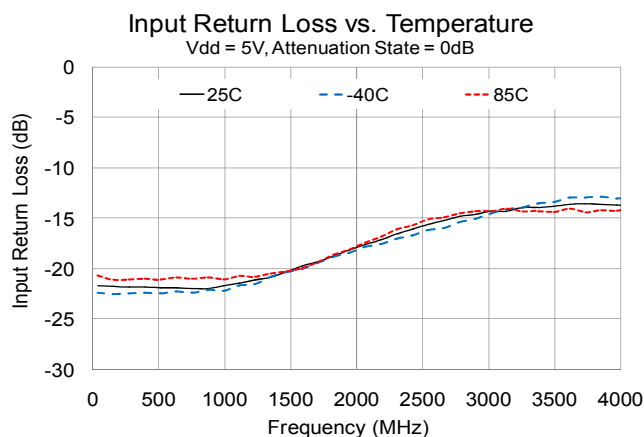
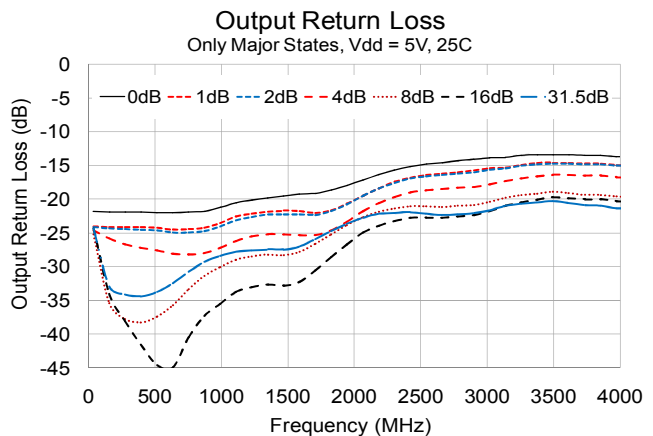
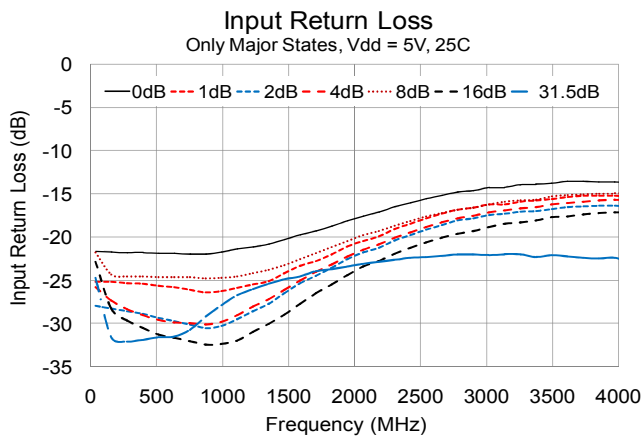
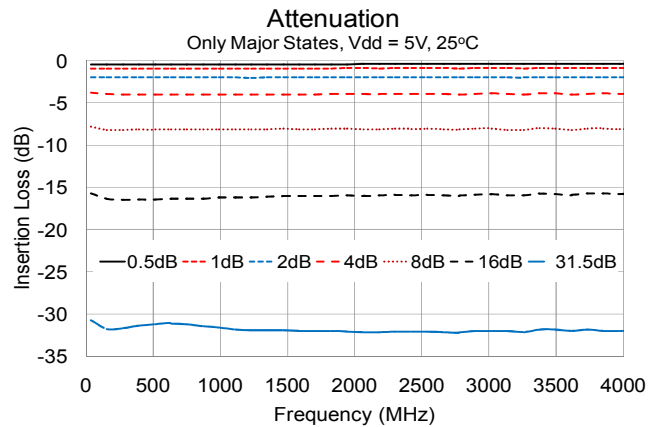
# TQP4M9072

## High Linearity 6-Bit, 31.5dB Digital Step Attenuator



### 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.

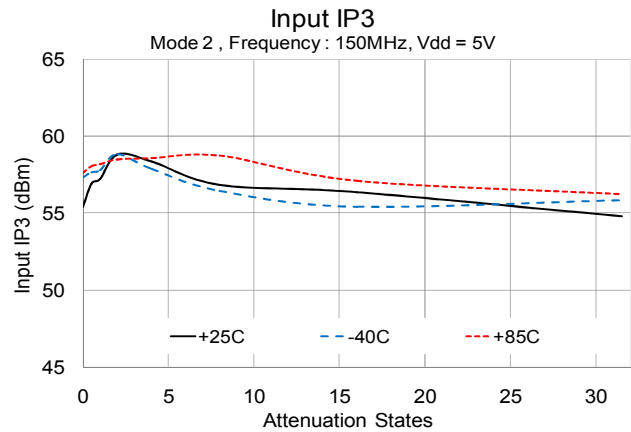
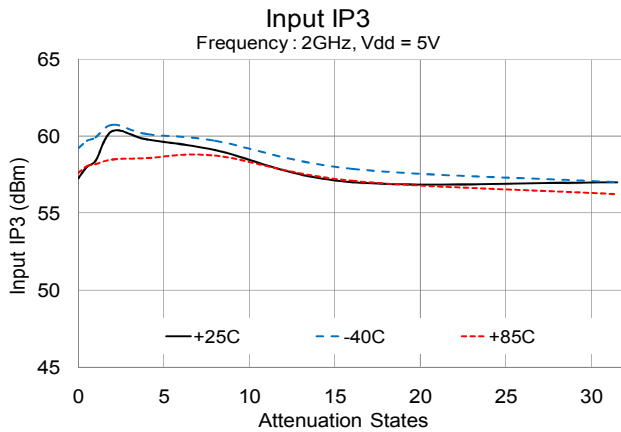


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## Typical Performance Data

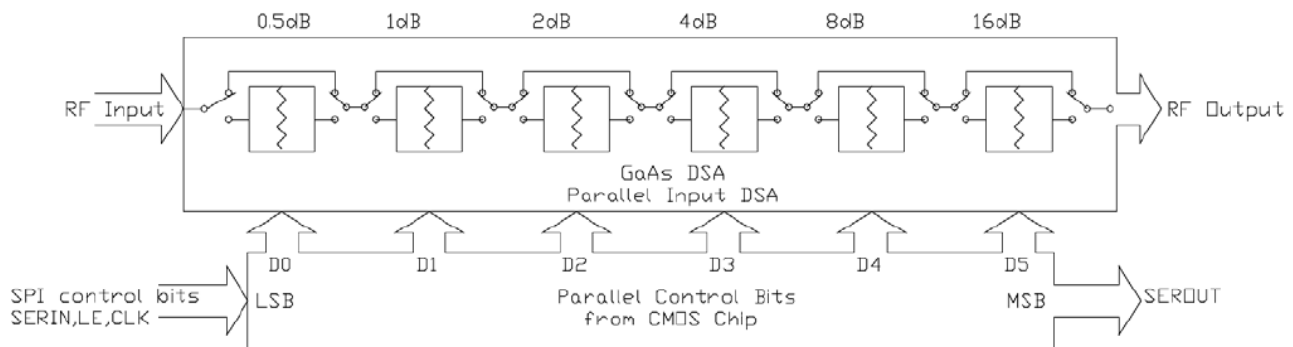


## Detailed Device Description

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™ 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, [sjapplications.engineering@tqs.com](mailto:sjapplications.engineering@tqs.com).

## Functional Schematic Diagram



# TQP4M9072

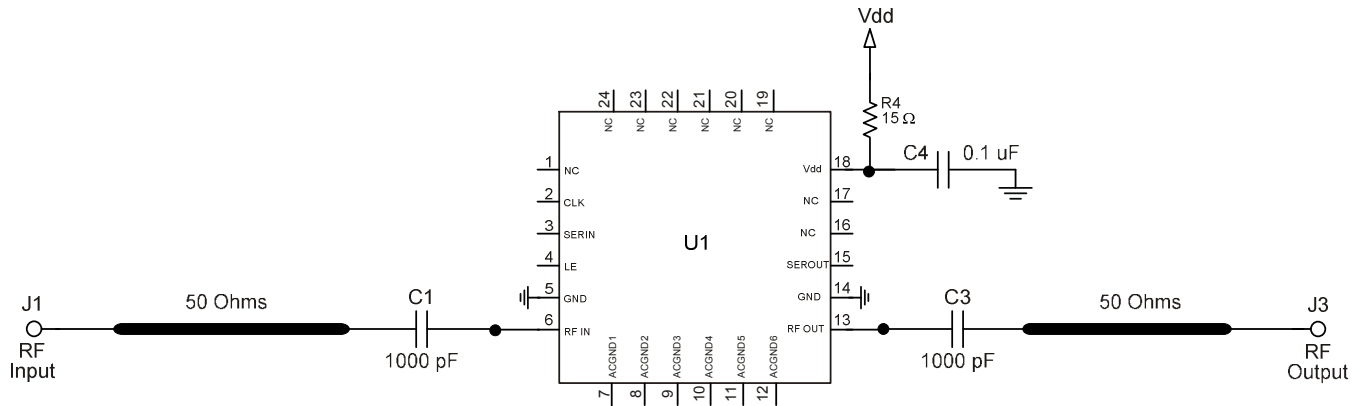
High Linearity 6-Bit, 31.5dB Digital Step Attenuator



## Detailed Device Description

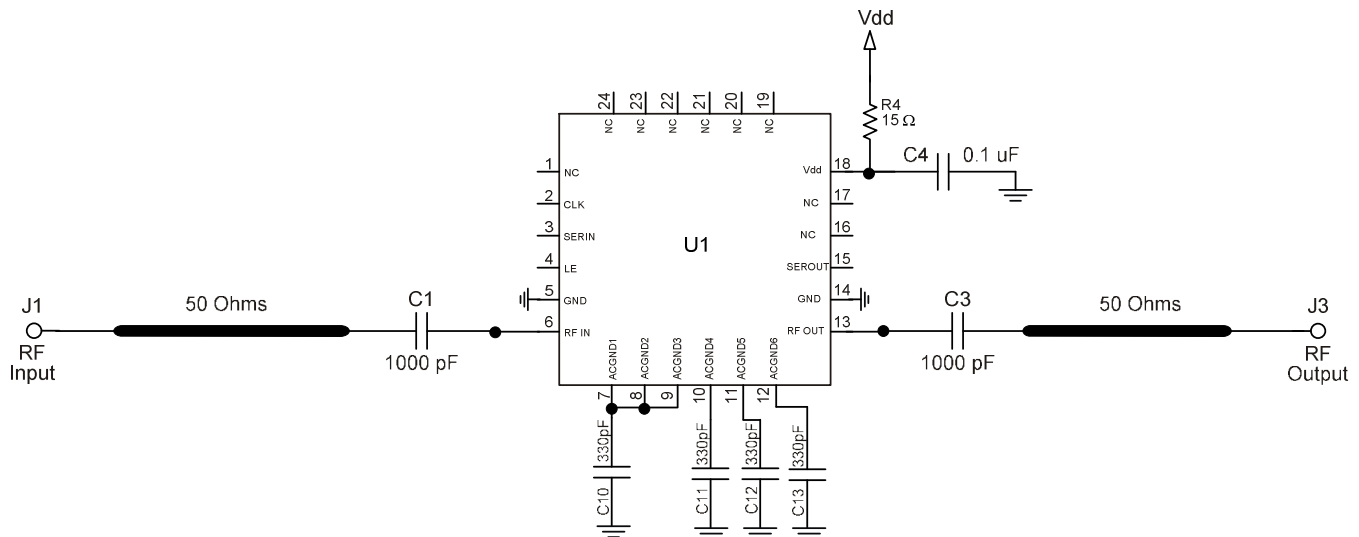
### Mode 1: 0.7 - 4.0 GHz Operation (TQP4M9072-PCB\_RF)

No external bypass capacitors required.



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

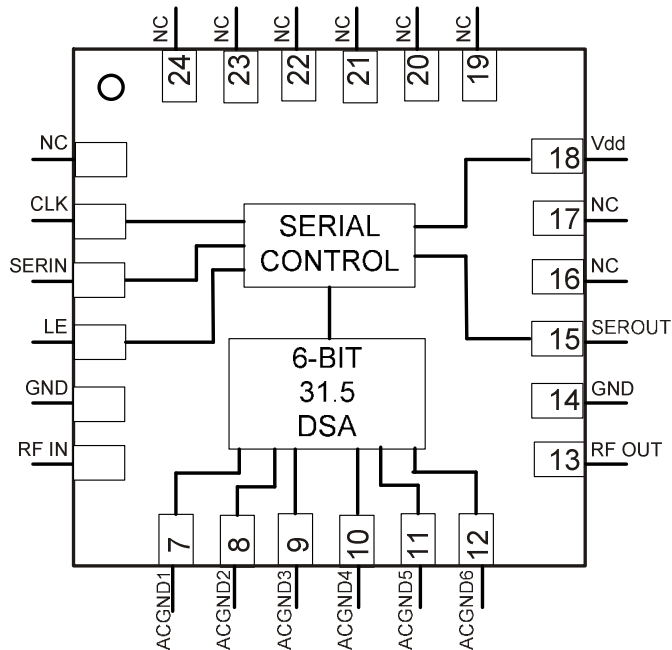
External bypass capacitors required on ACGND0 - ACGND5 pins. For improved operation below 0.1 GHz, blocking and bypass capacitors values can be increased to 10 nF. This circuit configuration can also be used for operation up to 4 GHz. The DSA performance remains unchanged for frequency range 0.7 - 4 GHz in either Mode 1 or Mode 2.



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## 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
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
15	SEROUT	Serial Output Data
18	V <sub>dd</sub>	Supply Voltage. Bypass capacitor required close to the pin. Dropping resistor highly recommended to ensure 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



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## 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".

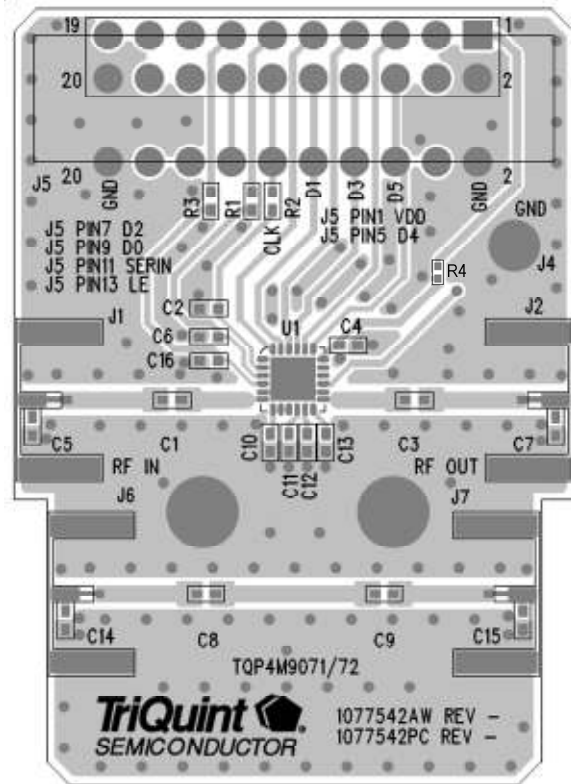
External DC blocking capacitors are required on RFin and RFout pins of the device. The supply voltage for the DSA is supplied externally through pin Vdd. Frequency bypassing for this pin is supplied by surface mount capacitor 0.1 uF (C4). This capacitor is placed close to the device pin in the board 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 de-embedded 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.



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**High Linearity 6-Bit, 31.5dB Digital Step Attenuator**



## 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	
C4	0.1 uF	Cap, Chip, 0402, 50V, X7R, 10%	various	
R1, R2, R3	33 $\Omega$	Res, Chip, 0402, 1/16W, 1%	various	
R4	15 $\Omega$	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	
C4	0.1 uF	Cap, Chip, 0402, 50V, X7R, 10%	various	
R1, R2, R3	33 $\Omega$	Res, Chip, 0402, 1/16W, 1%	various	
R4	15 $\Omega$	Res, Chip, 0402, 1/16W, 5%	various	
C10, C11, C12, C13	330 pF	Cap, Chip, 0402, 50V, X7R, 10%	various	

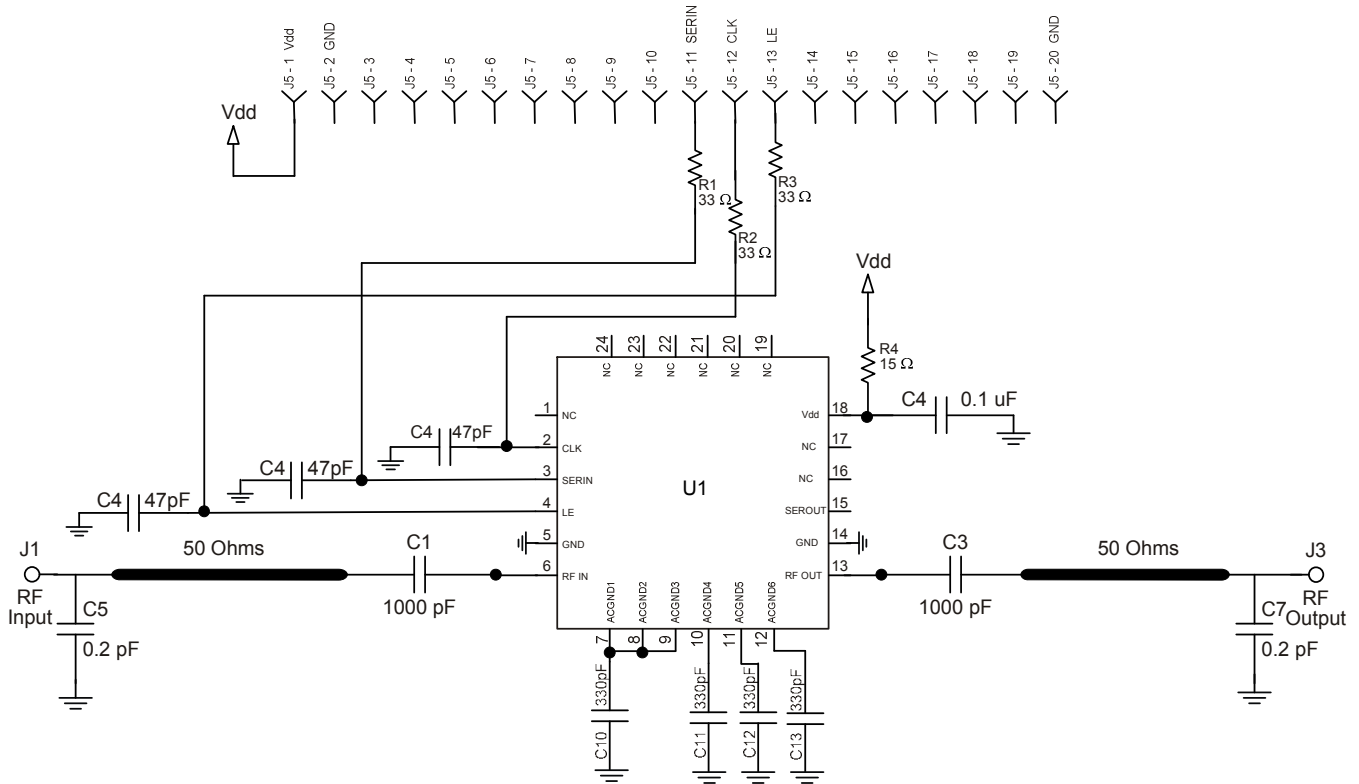
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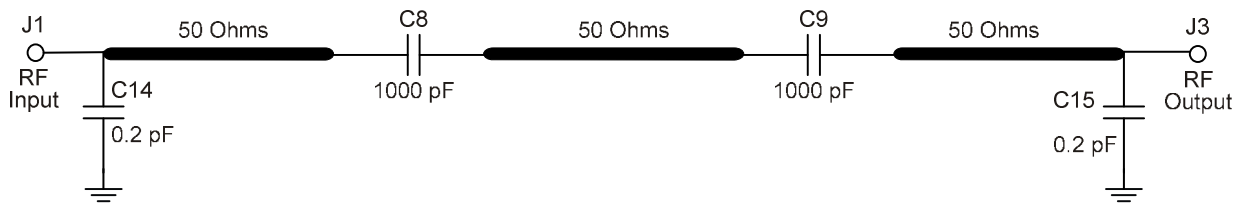


## Applications Information

### PC Board Schematic



### Thru Calibration Line



# TQP4M9072

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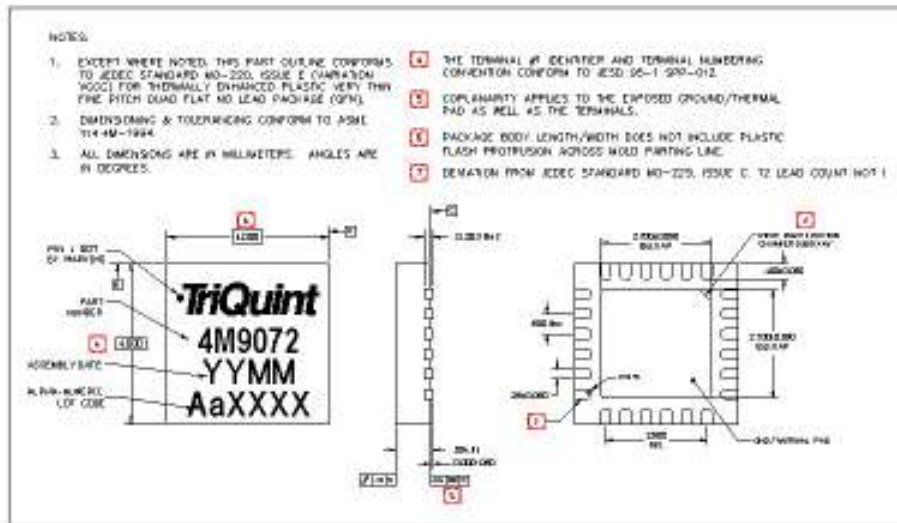


## Mechanical Information

### Package Information and Dimensions

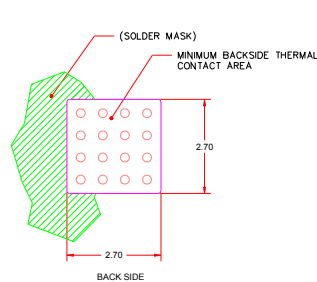
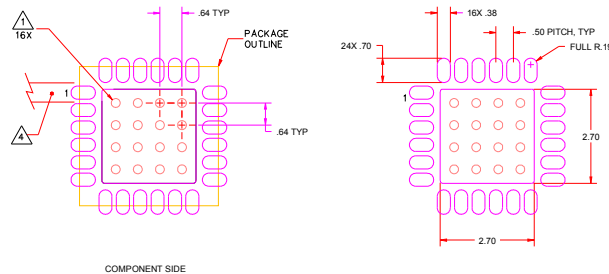
This package is lead-free, RoHS-compliant, and green. The plating material on the pins is annealed matte tin over copper. It is compatible with both lead-free (maximum 260 °C reflow temperature) and leaded (maximum 245 °C reflow temperature) soldering processes.

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.



- NOTES:
- GROUND/THERMAL VIAS ARE CRITICAL FOR THE PROPER PERFORMANCE OF THIS DEVICE. VIAS SHOULD USE A .35mm (#80 / .0135") DIAMETER DRILL AND HAVE A FINAL PLATED THRU DIAMETER OF .25mm (.010").
  - ADD AS MUCH COPPER AS POSSIBLE TO INNER AND OUTER LAYERS NEAR THE PART TO ENSURE OPTIMAL THERMAL PERFORMANCE.
  - TO ENSURE RELIABLE OPERATION, DEVICE GROUND PADDLE-TO-GROUND PAD SOLDER JOINT IS CRITICAL.
  - RF TRACE WIDTH DEPENDS UPON THE PCB BOARD MATERIAL AND CONSTRUCTION.
  - USE 1 OZ. COPPER MINIMUM.
  - ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.

Notes:

- 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").
- Add as much copper as possible to inner and outer layers near the part to ensure optimal thermal performance.

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## Product Compliance Information

### ESD Information



**Caution! ESD-Sensitive Device**

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

ESD Rating: Class IV  
Value: Passes  $\geq 1000$  V  
Test: 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 the latest version of J-STD-020, Lead free solder, 260°

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<sub>15</sub>H<sub>12</sub>Br<sub>4</sub>O<sub>2</sub>) Free
- PFOS Free
- SVHC Free

## Contact Information

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

Web: [www.triquint.com](http://www.triquint.com)  
Email: [info-sales@tqs.com](mailto:info-sales@tqs.com)

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For technical questions and application information:

Email: [sjapplications.engineering@tqs.com](mailto:sjapplications.engineering@tqs.com)

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