



0.5 dB LSB GaAs MMIC 5-BIT DIGITAL ATTENUATOR, 0.1 - 33 GHz

Typical Applications

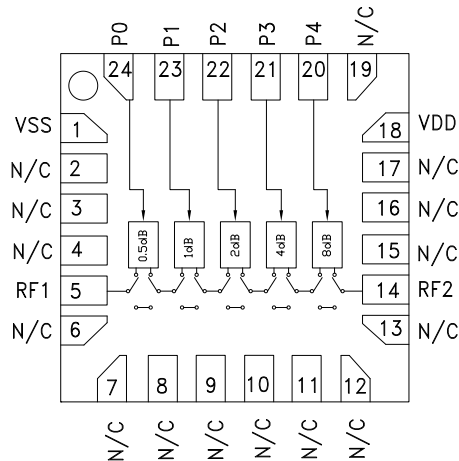
The HMC941LP4 / HMC941LP4E is ideal for:

- Fiber Optics & Broadband Telecom
- Microwave Radio & VSAT
- Military Radios, Radar & ECM
- Space Applications
- Sensors
- Test & Measurement Equipment

Features

- 0.5 dB LSB Steps to 15.5 dB
- Single Positive Control Line Per Bit
- ±0.5 dB Typical Bit Error
- High Input IP3: +45 dBm
- 16mm² Leadless SMT Plastic Package

Functional Diagram



General Description

The HMC941LP4 & HMC941LP4E are broadband 5-bit GaAs IC digital attenuators in low cost leadless surface mount packages. Covering 0.1 to 33.0 GHz, the insertion loss is less than 4 dB typical. The attenuator bit values are 0.5 (LSB), 1, 2, 4, 8, for a total attenuation of 15.5 dB. Attenuation accuracy is excellent at ±0.3 dB typical step error with an IIP3 of +45 dBm. Five control voltage inputs, toggled between +5V and 0V, are used to select each attenuation state.

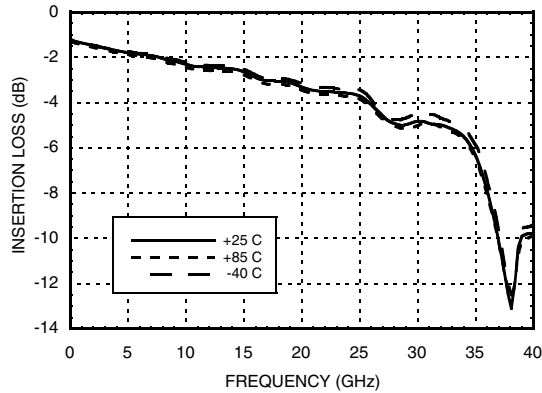
Electrical Specifications, $T_A = +25^\circ C$, With $V_{dd} = +5V$, $V_{ss} = -5V$, $P_0 - P_4 = 0 / +5V$

| Parameter | Frequency (GHz) | Min. | Typ. | Max. | Units |
|---|---------------------|---------------------------------|------------------------------------|------|-------|
| Insertion Loss | 0.1 - 18.0 GHz | | 3.0 | 4.5 | dB |
| | 18.0 - 26.5 GHz | | 4.0 | 6.0 | dB |
| | 26.5 - 33.0 GHz | | 5.0 | 6.5 | dB |
| Attenuation Range | 0.1 - 33.0 GHz | | 15.5 | | dB |
| Return Loss (RF1 & RF2, All Atten. States) | 0.1 - 33.0 GHz | | 12 | | dB |
| Attenuation Accuracy: (Referenced to Insertion Loss) | 0.5 - 7.5 dB States | 0.1 - 33.0 GHz | ± (0.3 + 4%) of Atten. Setting Max | | dB |
| | 8 - 15.5 dB States | 0.1 - 33.0 GHz | ± (0.3 + 8%) of Atten. Setting Max | | dB |
| Input Power for 0.1 dB Compression | 0.1 - 0.5 GHz | | 22 | | dBm |
| | 0.5 - 33.0 GHz | | 27 | | dBm |
| Input Third Order Intercept Point (Two-Tone Input Power= 0 dBm Each Tone) | 0.1 - 0.5 GHz | | 42 | | dBm |
| | 0.5 - 33.0 GHz | | 45 | | dBm |
| Switching Characteristics | 0.1 - 33.0 GHz | tRISE, tFALL (10/90% RF) | 60 | | ns |
| | | tON/tOFF (50% CTL to 10/90% RF) | 90 | | ns |
| I _{dd} | 0.1 - 33.0 GHz | 2.5 | 4.5 | 6.5 | mA |
| I _{ss} | 0.1 - 33.0 GHz | -7.0 | -5.0 | -3.0 | mA |

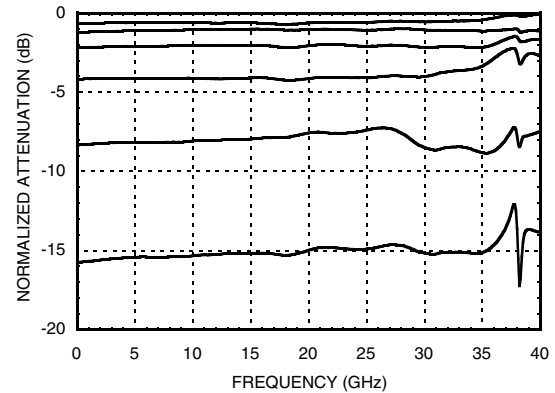


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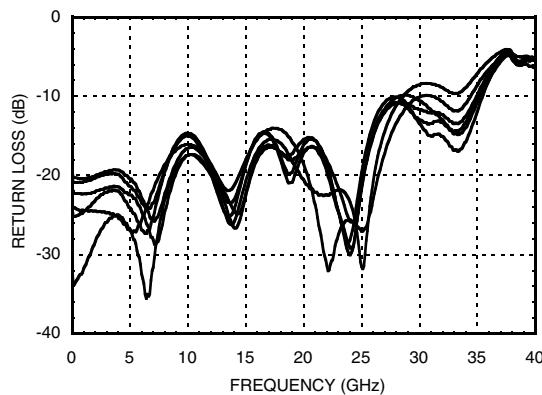
Insertion Loss vs. Temperature



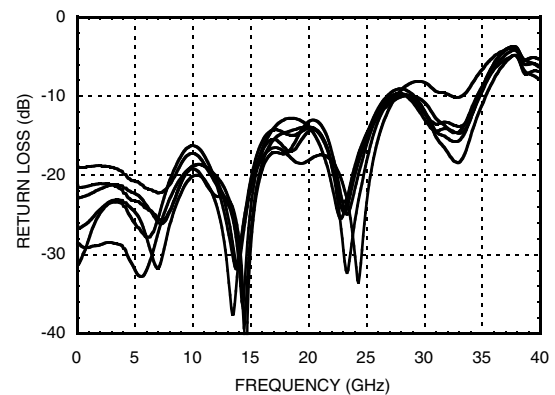
Normalized Attenuation
(Only Major States are Shown)



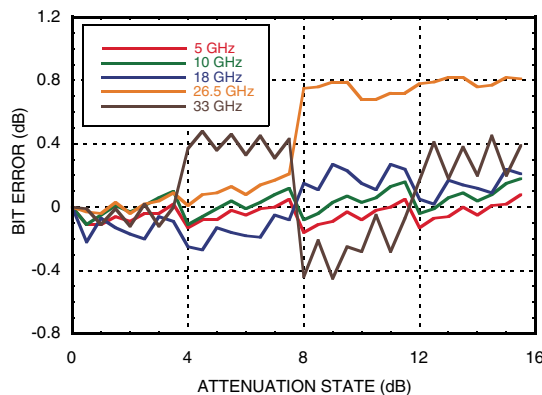
Input Return Loss
(Only Major States are Shown)



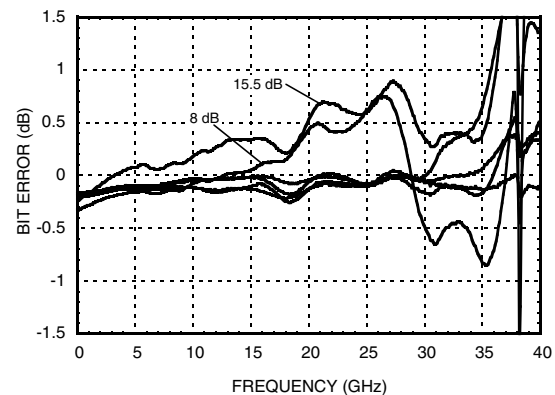
Output Return Loss
(Only Major States are Shown)



Bit Error vs. Attenuation State

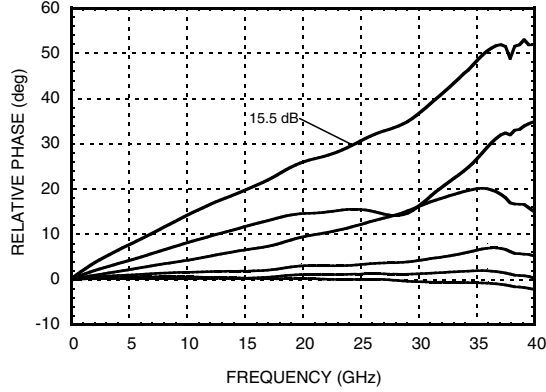


Bit Error vs. Frequency
(Only Major States are Shown)



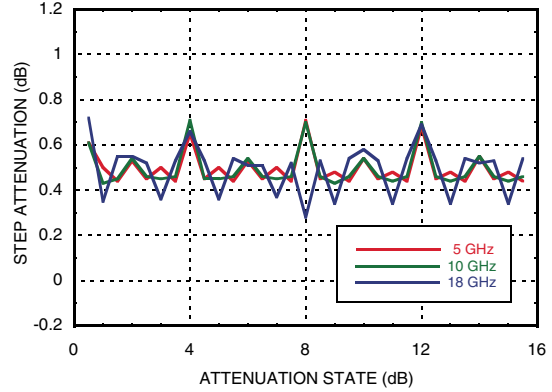


Relative Phase vs. Frequency
(Only Major States are Shown)

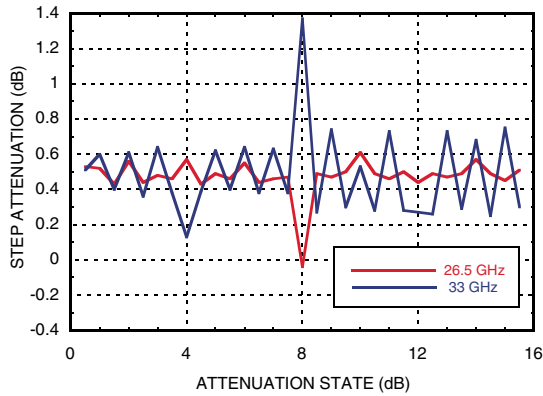


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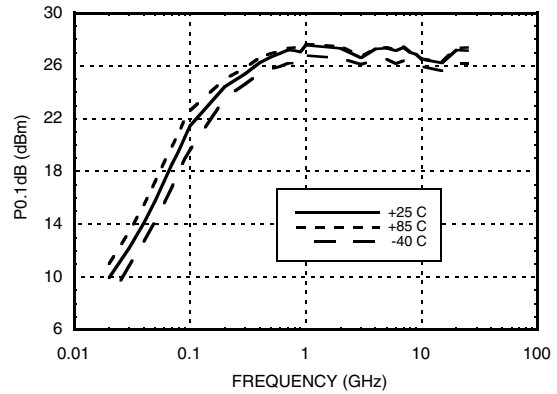
Step Attenuation vs. Attenuation State
0.1 - 18 GHz



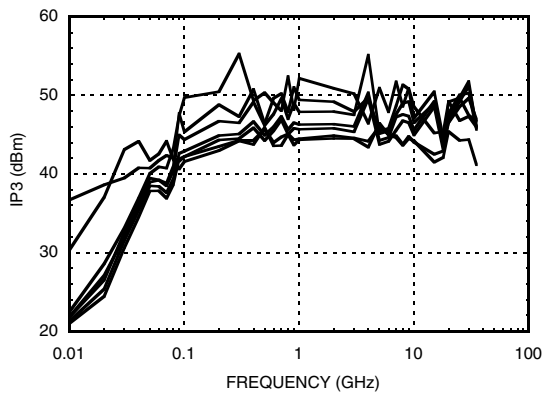
Step Attenuation vs. Attenuation State
18 - 33 GHz



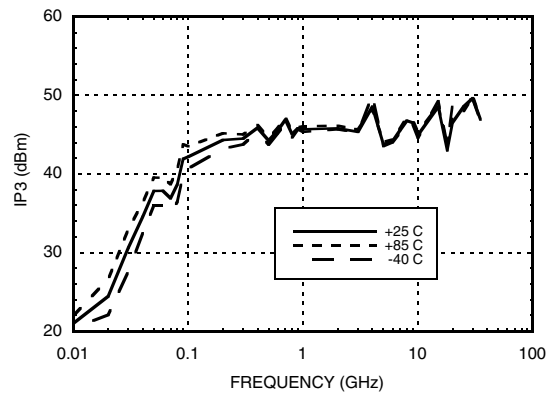
Input Power for 0.1 dB Compression



Input IP3 Over Major Attenuation States



Input IP3 vs. Temperature
(Minimum Attenuation State)



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Absolute Maximum Ratings

| | |
|--|-----------------|
| RF Input Power (0.1 to 33.0 GHz) | +27 dBm |
| Control Voltage (P0 to P4) | Vdd + 0.5V |
| Vdd | +7 Vdc |
| Vss | -7 Vdc |
| Channel Temperature | 150 °C |
| Continuous Pdiss (T = 85 °C) (derate 6.8 mW/°C above 85 °C) | 0.445 W |
| Thermal Resistance | 146 °C/W |
| Storage Temperature | -65 to + 150 °C |
| Operating Temperature | -40 to +85 °C |
| ESD Sensitivity (HBM) | Class 1A |

Bias Voltages & Currents

| | |
|-----|--------------|
| Vdd | +5V @ 4.5 mA |
| Vss | -5V @ 5 mA |

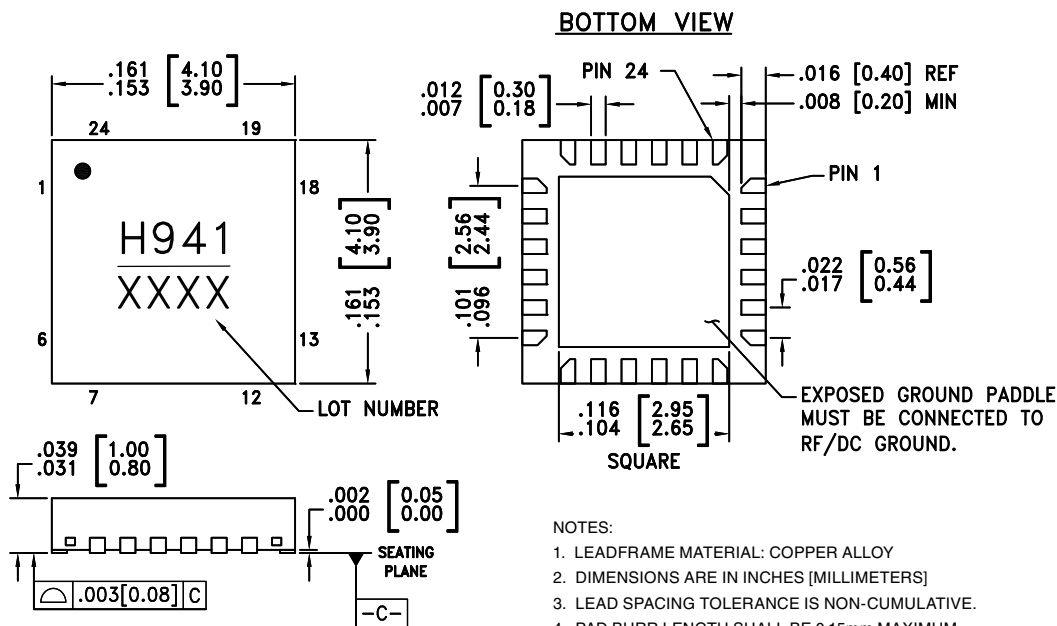
Control Voltage

| State | Bias Condition |
|-------|------------------|
| Low | 0 to 0.8V @ 1 μA |
| High | 2 to 5V @ 1 μA |



ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

Outline Drawing



NOTES:

- LEADFRAME MATERIAL: COPPER ALLOY
- DIMENSIONS ARE IN INCHES [MILLIMETERS]
- LEAD SPACING TOLERANCE IS NON-CUMULATIVE.
- PAD BURR LENGTH SHALL BE 0.15mm MAXIMUM.
PAD BURR HEIGHT SHALL BE 0.05mm MAXIMUM.
- PACKAGE WARP SHALL NOT EXCEED 0.05mm.
- ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.
- REFER TO HITTITE APPLICATION NOTE FOR SUGGESTED LAND PATTERN.

Package Information

| Part Number | Package Body Material | Lead Finish | MSL Rating | Package Marking ^[3] |
|-------------|--|---------------|---------------------|--------------------------------|
| HMC941LP4 | Low Stress Injection Molded Plastic | Sn/Pb Solder | MSL1 ^[1] | H941 XXXX |
| HMC941LP4E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 ^[2] | H941 XXXX |

[1] Max peak reflow temperature of 235 °C

[2] Max peak reflow temperature of 260 °C

[3] 4-Digit lot number XXXX



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Truth Table

| Control Voltage Input | | | | | Attenuation State RF1 - RF2 |
|-----------------------|------------|------------|------------|--------------|--------------------------------|
| P4 8 dB | P3 4 dB | P2 2 dB | P1 1 dB | P0 0.5 dB | |
| High | High | High | High | High | Reference I.L. |
| High | High | High | High | Low | 0.5 dB |
| High | High | High | Low | High | 1 dB |
| High | High | Low | High | High | 2 dB |
| High | Low | High | High | High | 4 dB |
| Low | High | High | High | High | 8 dB |
| Low | Low | Low | Low | Low | 15.5 dB |

Any Combination of the above states will provide an attenuation approximately equal to the sum of the bits selected.

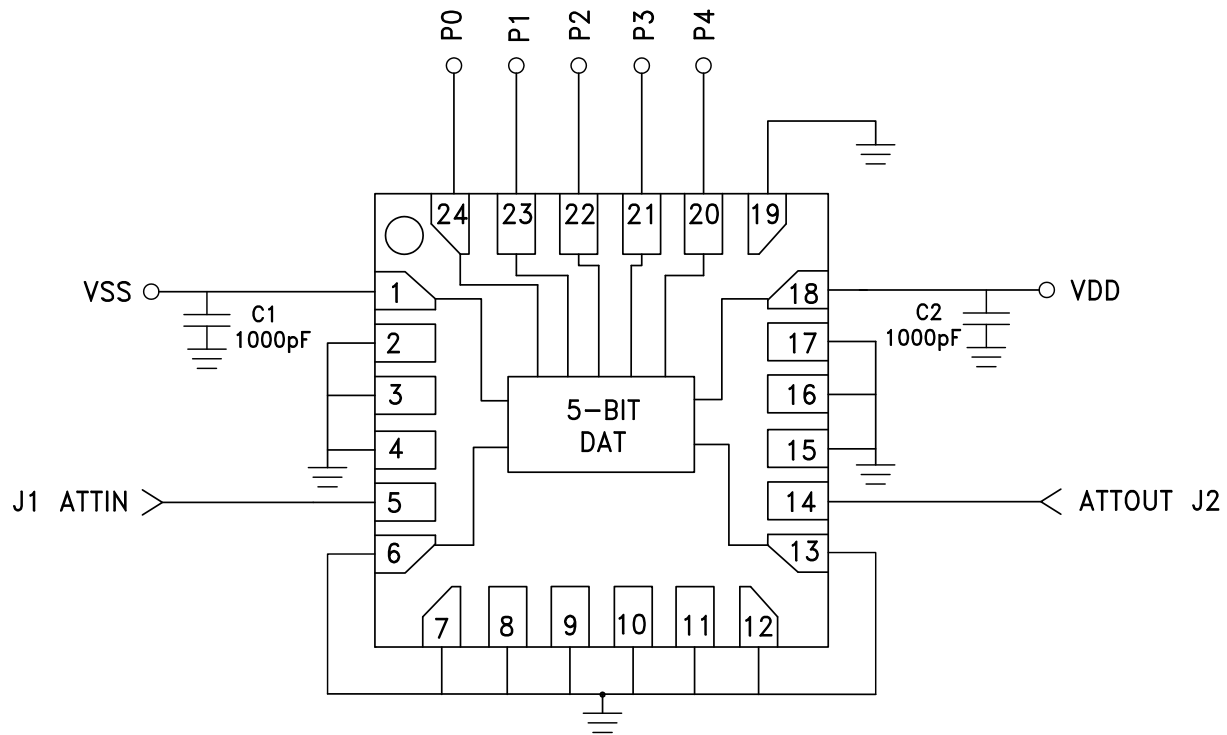
Pin Descriptions

| Pad Number | Function | Description | Interface Schematic |
|----------------------|----------|--|---------------------|
| 1 | Vss | Negative Bias -5V | |
| 2-4, 6-13, 15-17, 19 | N/C | The pins are not connected internally; however, all data shown herein was measured with these pins connected to RF/DC ground externally. | |
| 5, 14 | RF1, RF2 | These pins are DC coupled and matched to 50 Ohm. Blocking capacitors are required if RF line potential is not equal to 0V. | |
| 18 | Vdd | Positive Bias +5V | |
| 20 - 24 | P0 - P4 | See truth table and control voltage table. | |
| | GND | Package bottom must be connected to RF/DC ground. | |



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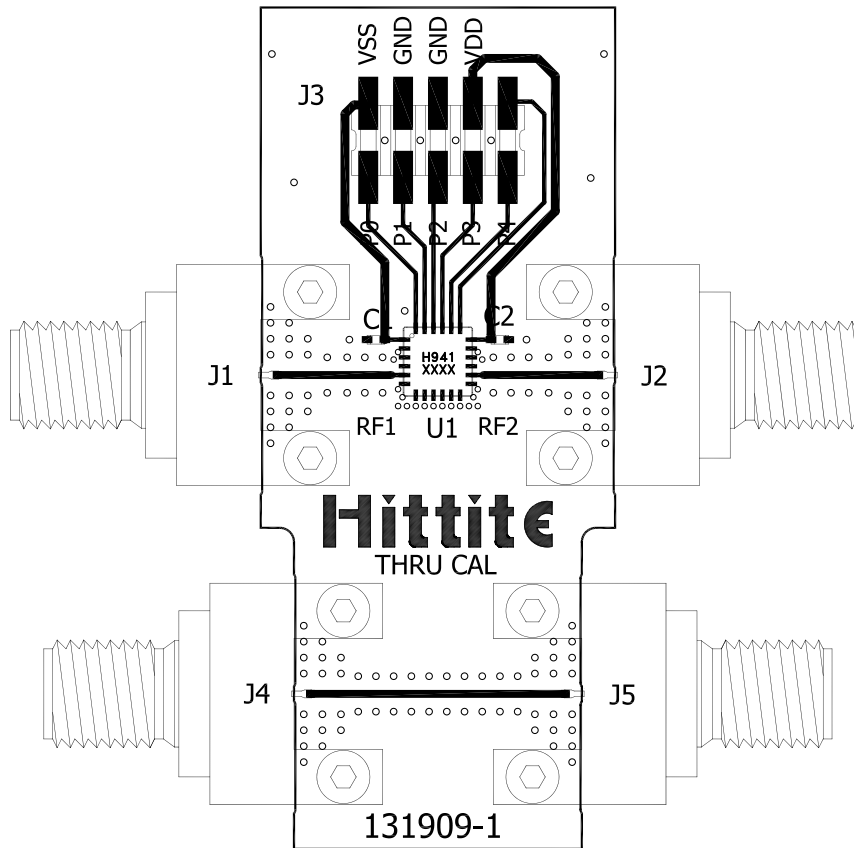
Application Circuit





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Evaluation PCB



List of Materials for Evaluation PCB 130450 [1]

| Item | Description |
|----------------|------------------------------|
| J1, J2, J4, J5 | 2.9 mm PC Mount RF Connector |
| J3 | DC Connector |
| C1, C2 | 1000 pF Capacitor, 0402 Pkg. |
| U1 | HMC941LP4 Digital Attenuator |
| PCB [2] | 131909 Evaluation Board |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350

The circuit board used in the application should use RF circuit design techniques. Signal lines should have 50 Ohm impedance while the package ground leads should be connected directly to the ground plane similar to that shown. A sufficient number of via holes should be used to connect the top and bottom ground planes. The evaluation circuit board shown is available from Hittite upon request.

**Notes:**

v00.0910

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