



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

### Typical Applications

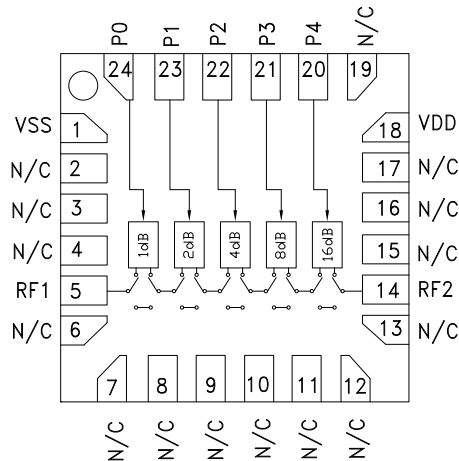
The HMC939LP4 / HMC939LP4E is ideal for:

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

### Features

- 1.0 dB LSB Steps to 31 dB
- Single Positive Control Line Per Bit
- ±1.0 dB Typical Bit Error
- High Input IP3: +43 dBm
- 16mm<sup>2</sup> Leadless SMT Plastic Package

### Functional Diagram

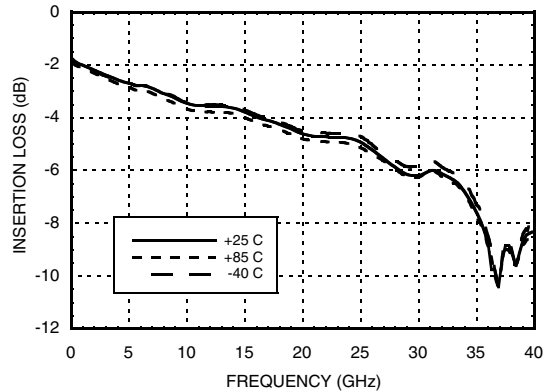


### General Description

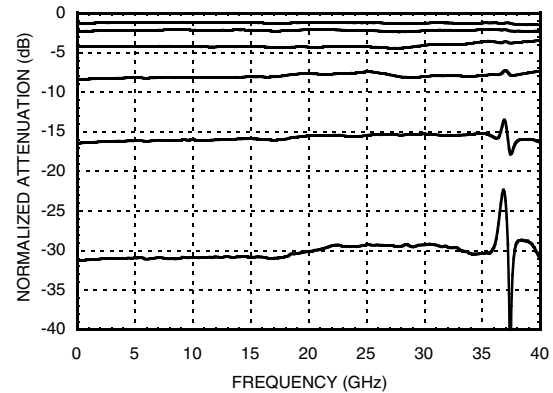
The HMC939LP4 & HMC939LP4E are broadband 5-bit GaAs IC digital attenuators in low cost leadless surface mount packages. Covering 0.1 to 33.0 GHz, the insertion loss is less than 5 dB typical. The attenuator bit values are 1.0 (LSB), 2, 4, 8, 16 for a total attenuation of 31 dB. Attenuation accuracy is excellent at ±0.4 dB typical step error with an IIP3 of +43 dBm. Five control voltage inputs, toggled between +5V and 0V, are used to select each attenuation state.

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

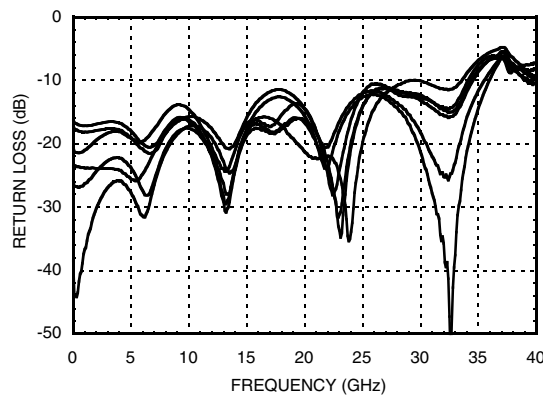
| Parameter                                                                    | Frequency (GHz)    | Min.                               | Typ. | Max. | Units |
|------------------------------------------------------------------------------|--------------------|------------------------------------|------|------|-------|
| Insertion Loss                                                               | 0.1 - 18.0 GHz     |                                    | 4.0  | 5.5  | dB    |
|                                                                              | 18.0 - 26.5 GHz    |                                    | 5.5  | 7.0  | dB    |
|                                                                              | 26.5 - 33.0 GHz    |                                    | 6.5  | 8.5  | dB    |
| Attenuation Range                                                            | 0.1 - 33.0 GHz     |                                    | 31   |      | dB    |
| Return Loss (RF1 & RF2, All Atten. States)                                   | 0.1 - 33.0 GHz     |                                    | 12   |      | dB    |
| Attenuation Accuracy: (Referenced to Insertion Loss)                         | 1.0 - 15 dB States | ± (0.5 + 5%) of Atten. Setting Max |      |      | dB    |
|                                                                              | 16 - 31 dB States  | ± (0.5 + 5%) of Atten. Setting Max |      |      | dB    |
|                                                                              | 16 - 31 dB States  | ± (0.6 + 8%) of Atten. Setting Max |      |      | dB    |
| Input Power for 0.1 dB Compression                                           | 0.1 - 0.5 GHz      |                                    | 20   |      | dBm   |
|                                                                              | 0.5 - 33.0 GHz     |                                    | 25   |      | dBm   |
| Input Third Order Intercept Point<br>(Two-Tone Input Power= 0 dBm Each Tone) | 0.1 - 0.5 GHz      |                                    | 40   |      | dBm   |
|                                                                              | 0.5 - 33.0 GHz     |                                    | 43   |      | 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 <sub>dd</sub>                                                              | 0.1 - 33.0 GHz     | 2.5                                | 4.5  | 6.5  | mA    |
| I <sub>ss</sub>                                                              | 0.1 - 33.0 GHz     | -7.0                               | -5.0 | -3.0 | mA    |


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**Insertion Loss vs. Temperature**

**Normalized Attenuation**

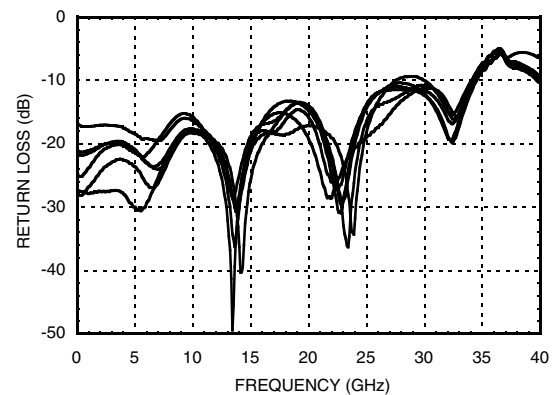
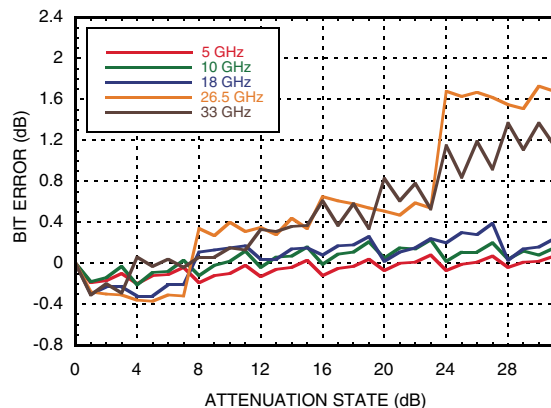
(Only Major States are Shown)


**Input Return Loss**

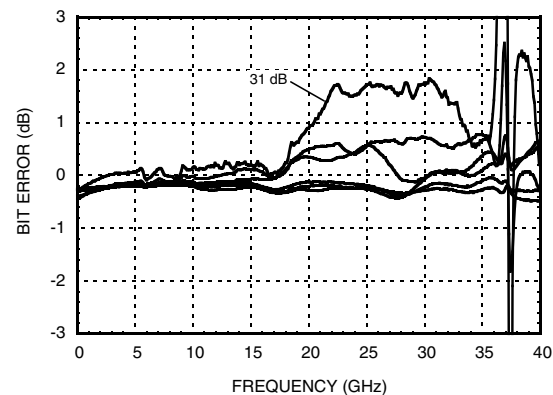
(Only Major States are Shown)

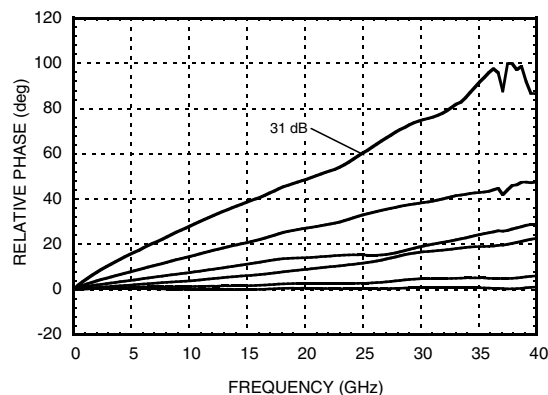
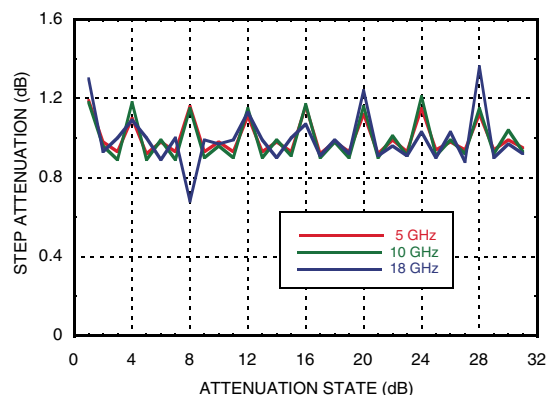
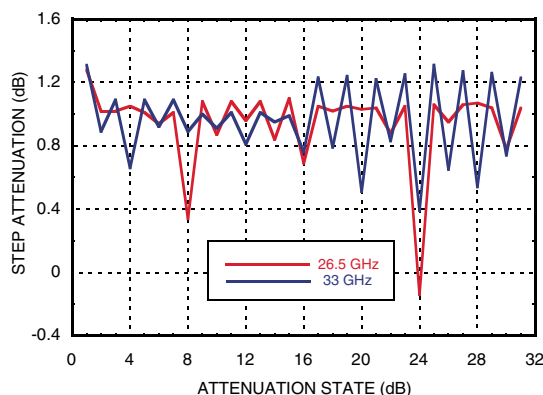
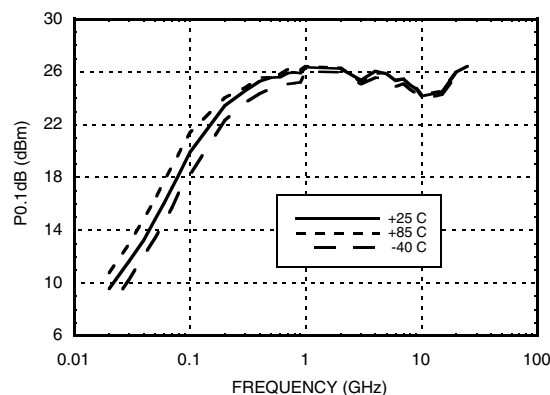
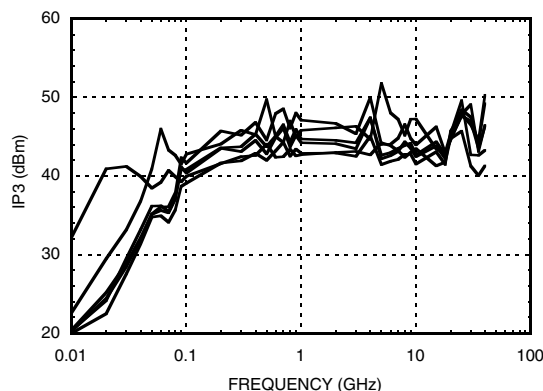
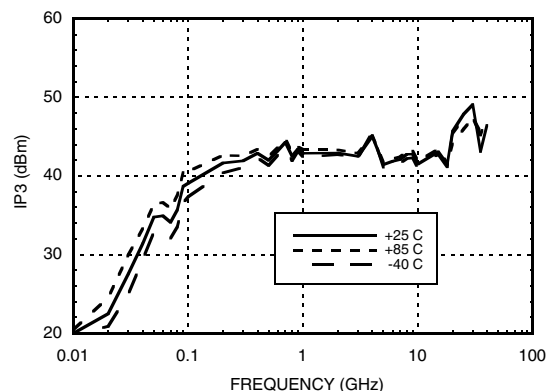

**Output Return Loss**

(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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ATTENUATOR, 0.1 - 33 GHz**
**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)




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

### Absolute Maximum Ratings

|                                                                |                 |
|----------------------------------------------------------------|-----------------|
| RF Input Power (0.1 to 33.0 GHz)                               | +25 dBm         |
| Control Voltage (P0 to P4)                                     | Vdd + 0.5V      |
| Vdd                                                            | +7 Vdc          |
| Vss                                                            | -7 Vdc          |
| Channel Temperature                                            | 150 °C          |
| Continuous Pdiss (T = 85 °C)<br>(derate 6.8 mW/°C above 85 °C) | 0.451 W         |
| Thermal Resistance                                             | 144 °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   |

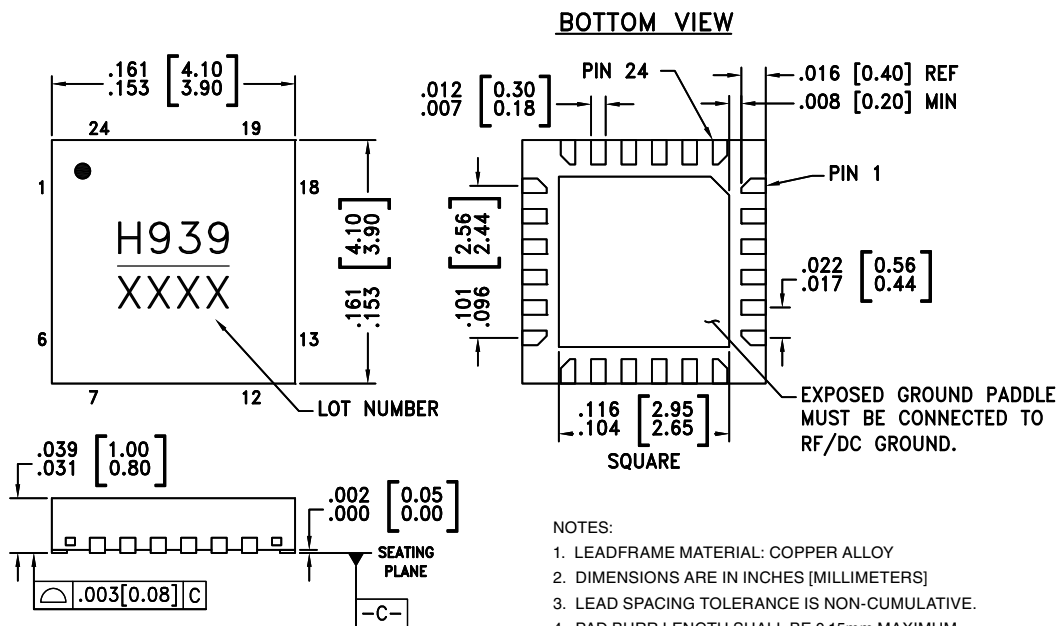
### Control Voltage

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



ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS

### Outline Drawing



### Package Information

| Part Number | Package Body Material                              | Lead Finish   | MSL Rating          | Package Marking <sup>[3]</sup> |
|-------------|----------------------------------------------------|---------------|---------------------|--------------------------------|
| HMC939LP4   | Low Stress Injection Molded Plastic                | Sn/Pb Solder  | MSL1 <sup>[1]</sup> | H939<br>XXXX                   |
| HMC939LP4E  | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 <sup>[2]</sup> | H939<br>XXXX                   |

[1] Max peak reflow temperature of 235 °C

[2] Max peak reflow temperature of 260 °C

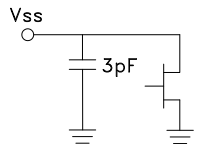
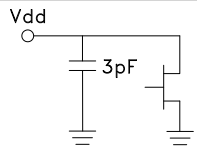
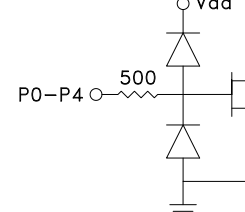
[3] 4-Digit lot number XXXX


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**Truth Table**

| Control Voltage Input |            |            |            |            | Attenuation<br>State<br>RF1 - RF2 |
|-----------------------|------------|------------|------------|------------|-----------------------------------|
| P4<br>16 dB           | P3<br>8 dB | P2<br>4 dB | P1<br>2 dB | P0<br>1 dB |                                   |
| High                  | High       | High       | High       | High       | Reference I.L.                    |
| High                  | High       | High       | High       | Low        | 1 dB                              |
| High                  | High       | High       | Low        | High       | 2 dB                              |
| High                  | High       | Low        | High       | High       | 4 dB                              |
| High                  | Low        | High       | High       | High       | 8 dB                              |
| Low                   | High       | High       | High       | High       | 16 dB                             |
| Low                   | Low        | Low        | Low        | Low        | 31 dB                             |

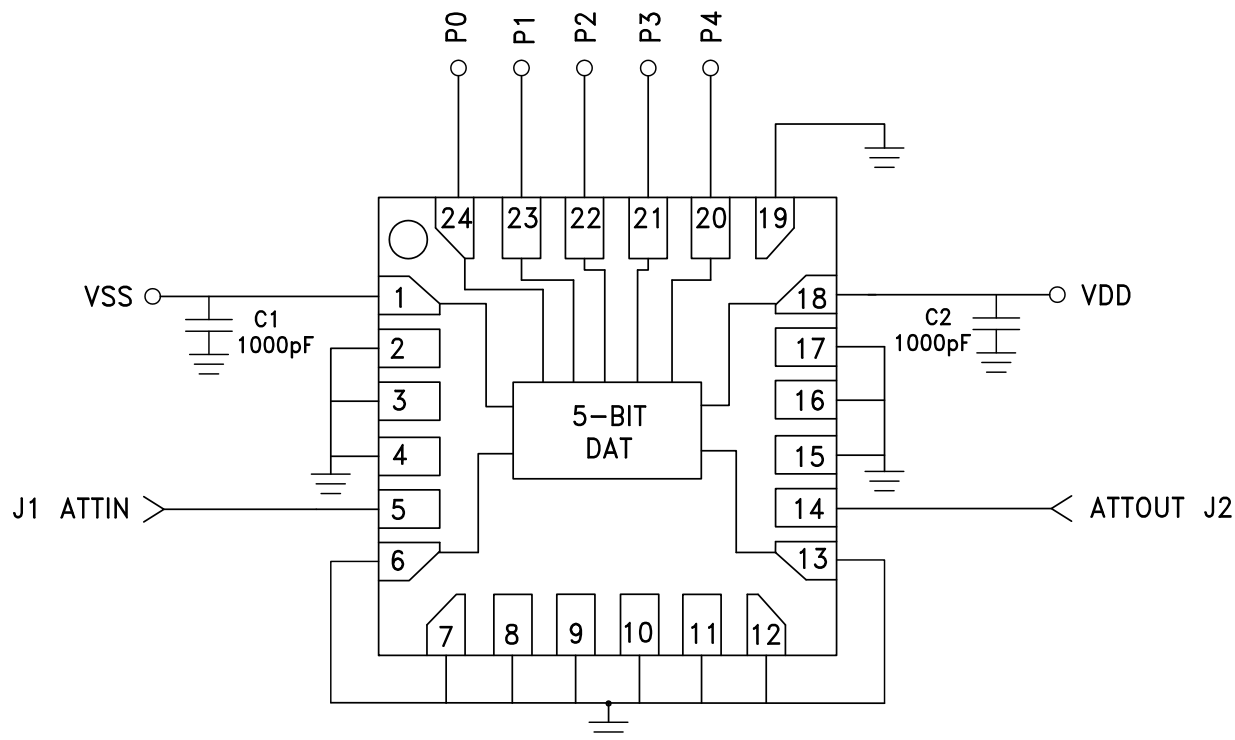
Any Combination of the above states will provide an attenuation approximately equal to the sum of the bits selected.

**Pin Descriptions**

| Pad Number              | Function | Description                                                                                                                              | Interface Schematic                                                                   |
|-------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1                       | Vss      | Negative Bias -5V                                                                                                                        |  |
| 2-4, 6-13,<br>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.                                                                                        |  |

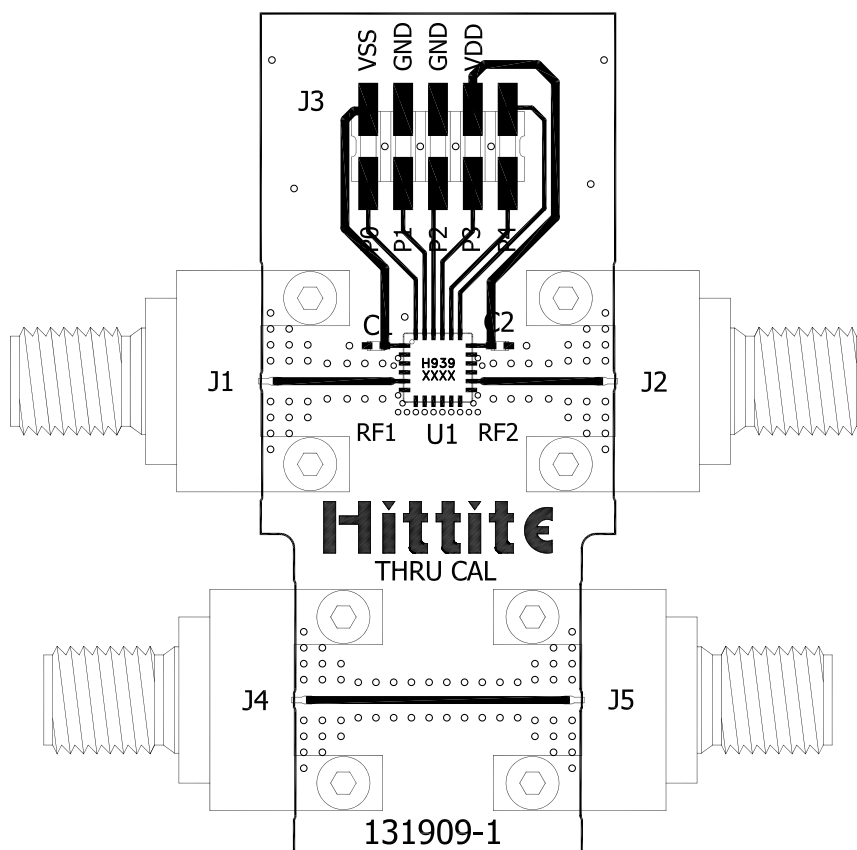
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**Application Circuit**



**Evaluation PCB**

v01.1211

**HMC939LP4 / 939LP4E**
**1.0 dB LSB GaAs MMIC 5-BIT DIGITAL  
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**List of Materials for Evaluation PCB 130450 <sup>[1]</sup>**

| Item               | Description                  |
|--------------------|------------------------------|
| J1, J2, J4, J5     | 2.9 mm PC Mount RF Connector |
| J3                 | DC Connector                 |
| C1, C2             | 1000 pF Capacitor, 0402 Pkg. |
| U1                 | HMC939LP4 Digital Attenuator |
| PCB <sup>[2]</sup> | 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:**

## HMC939LP4 / 939LP4E

v01.1211

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