

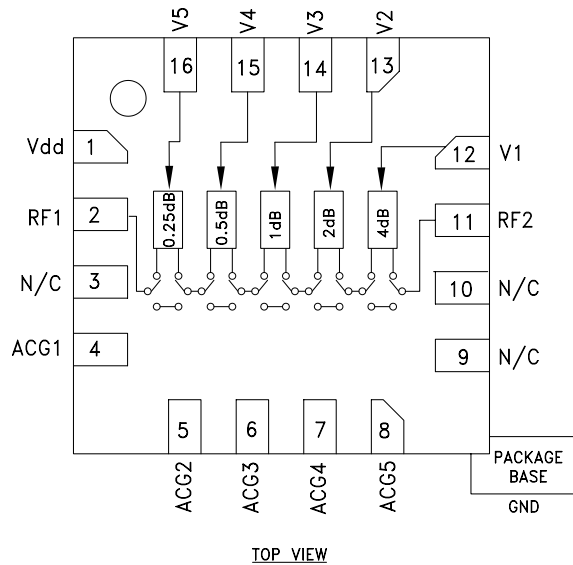
0.25 dB LSB GaAs MMIC 5-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, DC - 4 GHz

Typical Applications

The HMC539ALP3/539ALP3E is ideal for both RF and IF applications:

- Cellular Infrastructure
- ISM, MMDS, WLAN, WiMAX, WiBro
- Microwave Radio & VSAT
- Test Equipment and Sensors

Functional Diagram



Features

- 0.25 dB LSB Steps to 7.75 dB
- ± 0.05 dB Typical Step Error
- Low Insertion Loss: 0.7 dB
- High IP3: +62 dBm
- Single Control Line Per Bit
- TTL/CMOS Compatible Control
- Single +3V to +5V Supply
- 3x3 mm SMT Package

General Description

The HMC539ALP3/539ALP3E is a broadband 5-bit GaAs IC digital attenuator in a low cost leadless surface mount package. This single positive control line per bit digital attenuator utilizes an off chip AC ground capacitor for near DC operation, making it suitable for a wide variety of RF and IF applications. Covering DC to 4 GHz, the insertion loss is less than 0.7 dB typical. The attenuator bit values are 0.25 (LSB), 0.5, 1, 2, and 4 dB for a total attenuation of 7.75 dB. Attenuation accuracy is excellent at ± 0.05 dB typical step error. The attenuator also features a high IIP3 of +62 dBm. Five TTL/CMOS control inputs are used to select each attenuation state. A single Vdd bias of +3V to +5V is required.

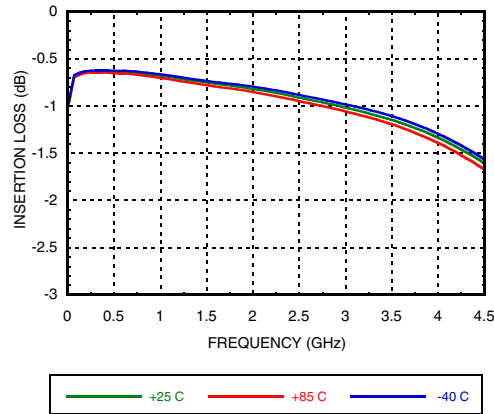
Electrical Specifications,

$T_A = +25^\circ \text{C}$, With $V_{dd} = +5V$ & $V_{ctl} = 0/+5V$ (Unless Otherwise Noted)

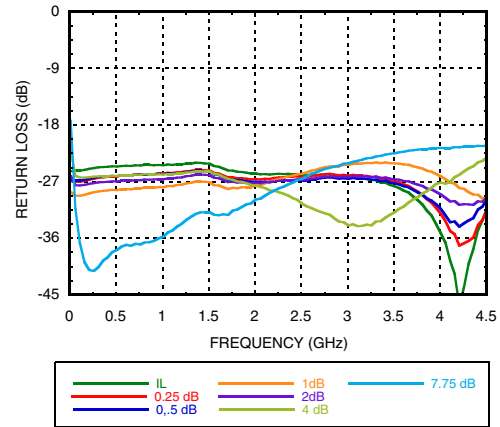
| Parameter | Frequency (GHz) | Min. | Typ. | Max. | Units |
|---|---|-------------------------------------|------|------|-------|
| Insertion Loss | DC - 1.5 GHz | | 0.7 | 1.0 | dB |
| | 1.5 - 3.0 GHz | | 1.0 | 1.3 | dB |
| | 3.0 - 4.0 GHz | | 1.3 | 1.7 | dB |
| Attenuation Range | DC - 4 GHz | | 7.75 | | dB |
| Return Loss (RF1 & RF2, All Atten. States) | DC - 3 GHz | | 27 | | dB |
| | 3.0 - 4.0 GHz | | 25 | | dB |
| Attenuation Accuracy: (Referenced to Insertion Loss) | All States DC - 3 GHz 3.0 - 4.0 GHz | ± (0.2 + 2% of Atten. Setting) Max. | | | dB |
| | | ± (0.2 + 4% of Atten. Setting) Max. | | | dB |
| Input Power for 0.1 dB Compression | 0.1 - 4.0 GHz | | 32 | | dBm |
| Input Third Order Intercept Point (Two-Tone Input Power= 15 dBm Each Tone) | 0.1 - 4.0 GHz | | 62 | | dBm |
| Switching Characteristics | DC - 4 GHz | | | | |
| | | tRISE, tFALL (10/90% RF) | | 45 | ns |
| | | tON, tOFF (50% CTL to 10/90% RF) | | 52 | ns |

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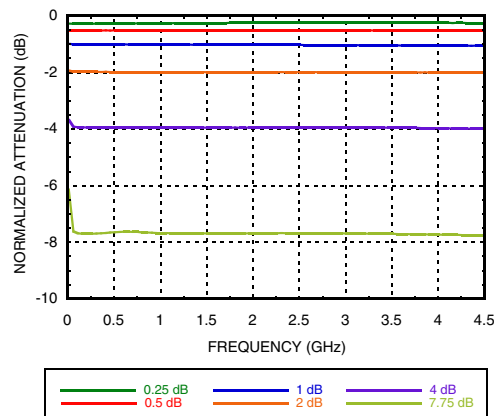
Insertion Loss



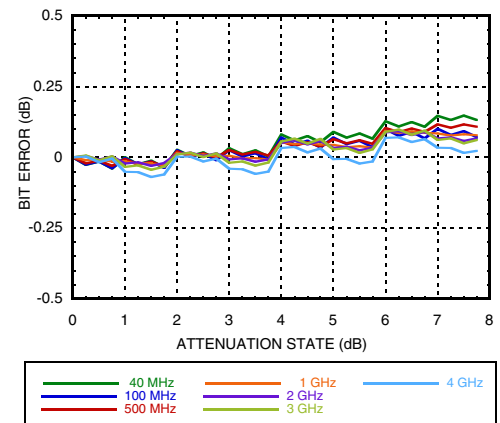
Return Loss RF1, RF2
(Only Major States are Shown)



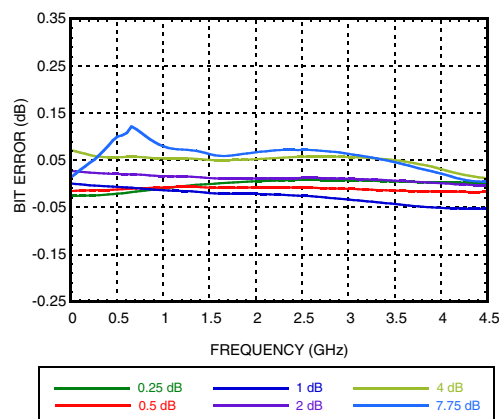
Normalized Attenuation
(Only Major States are Shown)



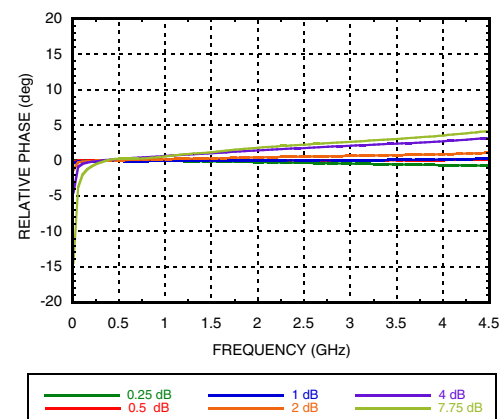
Bit Error vs. Attenuation State



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

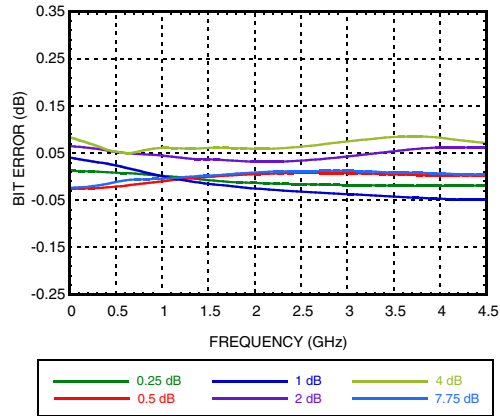


Relative Phase vs. Frequency
(Only Major States are Shown)

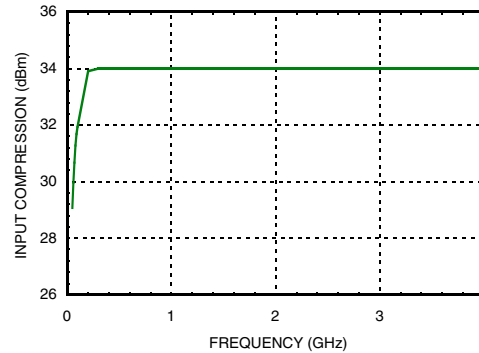


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Step Error vs. Frequency (Only Major States are Shown)



1dB Input Compression Point



Bias Voltage & Current

| Vdd = +5.0 Vdc ± 10% | |
|----------------------|-----------------|
| Vdd (VDC) | Idd (Typ.) (mA) |
| +3.0 | 1.6 |
| +5.0 | 1.7 |

Truth Table

| Control Voltage Input | | | | | Attenuation State RF1 - RF2 |
|-----------------------|------------|------------|--------------|---------------|--------------------------------|
| V1 4 dB | V2 2 dB | V3 1 dB | V4 0.5 dB | V5 0.25 dB | |
| High | High | High | High | High | Reference I.L. |
| High | High | High | High | Low | 0.25 dB |
| High | High | High | Low | High | 0.5 dB |
| High | High | Low | High | High | 1 dB |
| High | Low | High | High | High | 2 dB |
| Low | High | High | High | High | 4 dB |
| Low | Low | Low | Low | Low | 7.75 dB |

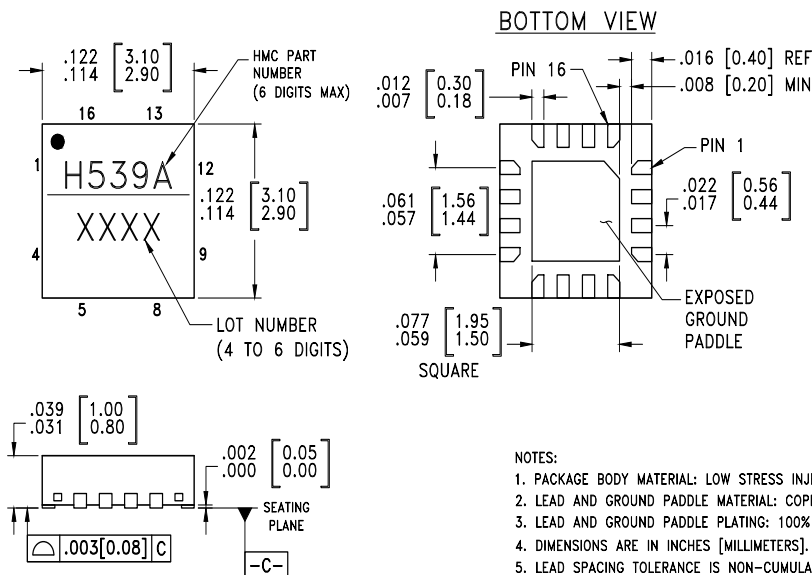
Any combination of the above states will provide an attenuation approximately equal to the sum of the bits selected.

Control Voltage

| State | Vdd = +3V | Vdd = +5V |
|-------|---------------------|---------------------------|
| Low | 0 to 0.8V @ <1 uA | 0 to +1.1V @ 33uA Typ. |
| High | 1.2 to 3.3V @ <1 uA | 1.8V to +5.0V @ 33uA Typ. |

**0.25 dB LSB GaAs MMIC 5-BIT DIGITAL
POSITIVE CONTROL ATTENUATOR, DC - 4 GHz**
Absolute Maximum Ratings

| | |
|---|----------------------|
| RF Input Power (DC - 4 GHz) | +29 dBm (T = +85 °C) |
| Control Voltage Range (V1 to V5) | -1V to Vdd +1V |
| Bias Voltage (Vdd) | +7.0 Vdc |
| Channel Temperature | 150 °C |
| Continuous Pdiss (T = 85 °C) (derate 12.0 mW/°C above 85 °C) | 0.551 W |
| Thermal Resistance | 118 °C/W |
| Storage Temperature | -65 to +150 °C |
| Operating Temperature | -40 to +85 °C |


**ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS**
Outline Drawing

Package Information

| Part Number | Package Body Material | Lead Finish | MSL Rating | Package Marking ^[3] |
|-------------|--|---------------|---------------------|--------------------------------|
| HMC539ALP3 | Low Stress Injection Molded Plastic | Sn/Pb solder | MSL3 ^[1] | H539A XXXX |
| HMC539ALP3E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL3 ^[2] | H539A XXXX |

[1] Max peak reflow temperature of 235 °C

[2] Max peak reflow temperature of 260 °C

[3] 4-Digit lot number XXXX

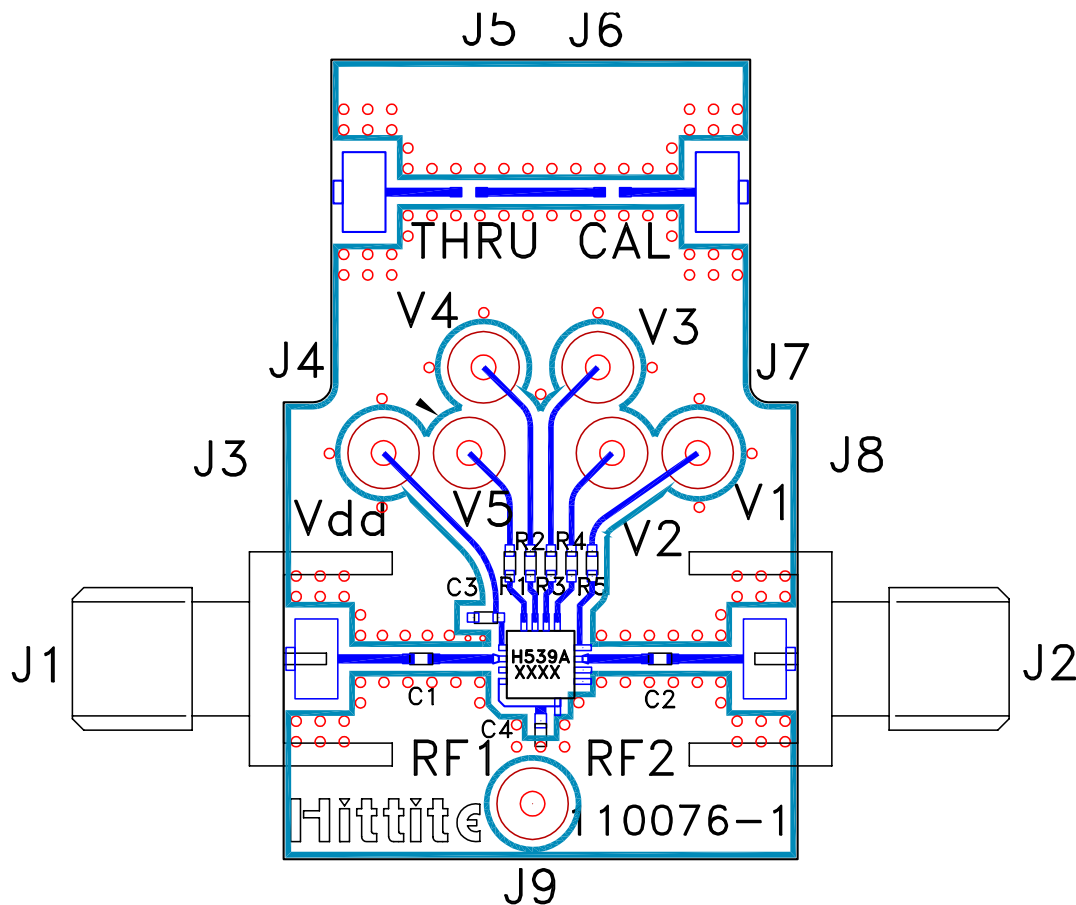
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Pin Descriptions

| Pin Number | Function | Description | Interface Schematic |
|------------|-------------|---|---------------------|
| 1 | Vdd | Supply Voltage. | |
| 2, 11 | RF1, RF2 | This pin is DC coupled and matched to 50 Ohm. Blocking capacitors are required. Select value based on lowest frequency of operation. | |
| 3, 9, 10 | N/C | These pins should be connected to PCB RF ground to maximize performance. | |
| 4 - 8 | ACG1 - ACG5 | External capacitor to ground is required. Select value for lowest frequency of operation. Place capacitor as close to pins as possible. | |
| 12 - 16 | V1 - V5 | See truth table and control voltage table. | |
| | GND | Package bottom has an exposed metal paddle that must be connected to RF Ground. | |

Application Circuit



**0.25 dB LSB GaAs MMIC 5-BIT DIGITAL
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Evaluation PCB

List of Materials for Evaluation PCB EV1HC539ALP3 [1]

| Item | Description |
|---------|--|
| J1, J2 | PCB Mount SMA Connector |
| J3 - J9 | DC Pin |
| C1, C2 | 100 pF Capacitor, 0402 Pkg. |
| C3 | 1000 pF Capacitor, 0402 Pkg. |
| C4 | 330 pF Capacitor, 0402 Pkg. |
| R1 - R5 | 100 Ohm Resistor 0402 |
| U1 | HMC539ALP3/539ALP3E Digital Attenuator |
| PCB [2] | 110076 Evaluation PCB |

[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 and exposed paddle 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 Analog Devices Inc upon request.

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