

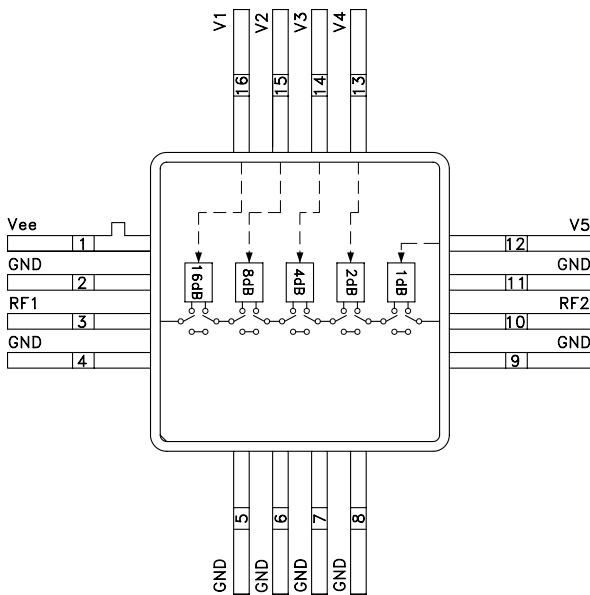
## 1dB LSB GaAs MMIC 5-BIT DIGITAL ATTENUATOR, DC - 3 GHz

### Typical Applications

The HMC335G16 is ideal for:

- Telecom Infrastructure
- Military Radios, Radar & ECM
- Space Applications
- Test Instrumentation

### Functional Diagram



### Features

- 1 dB LSB Steps to 31 dB
- Single Control Line Per Bit
- +/- 0.5 dB Typical Bit Error
- 16 Lead Hermetic SMT Package

### General Description

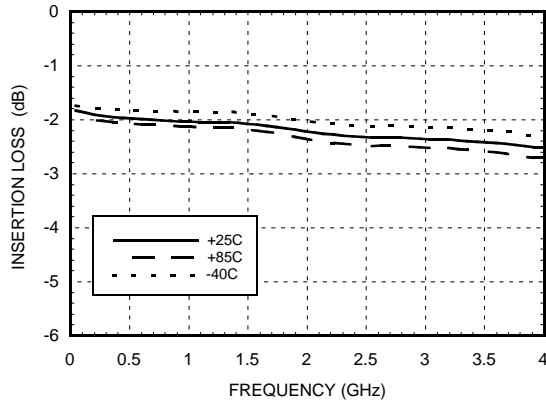
The HMC335G16 is a broadband 5-bit GaAs IC digital attenuator in a 16 lead glass/metal (hermetic) surface mount package. Covering DC to 3 GHz, the insertion loss is less than 2.3 dB typical. The attenuator bit values are 1 (LSB), 2, 4, 8, and 16 dB for a total attenuation of 31 dB. Attenuation accuracy is excellent at  $\pm 0.5$  dB typical with an IIP3 of up to +44 dBm. Five bit control voltage inputs, toggled between 0 and -5V, are used to select each attenuation state at less than 70  $\mu$ A each. A single Vee bias of -5V allows operation down to DC.

### Electrical Specifications, $T_A = +25^\circ\text{C}$ , $V_{ee} = -5\text{V}$ & $V_{ctl} = 0/V_{ee}$

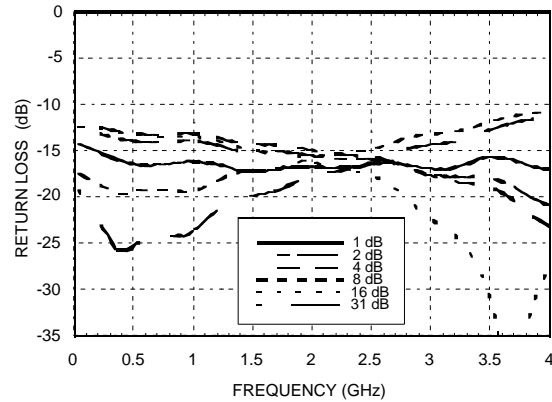
| Parameter   | Frequency     | Min.                                   | Typical | Max. | Units |
|---|---------------|--|---------|------|-------|
| Insertion Loss  | DC - 1.5 GHz  |  | 2.0     | 2.5  | dB    |
|   | 1.5 - 3.0 GHz |  | 2.3     | 2.8  | dB    |
| Attenuation Range   | DC - 3.0 GHz  |  | 31      |      | dB    |
| Return Loss (RF1 & RF2, All Atten. States)                                    | DC - 3.0 GHz  |  | 13      |      | dB    |
| Attenuation Accuracy: (Referenced to Insertion Loss)                          |               |  |         |      |       |
| 1 - 31 dB States  | DC - 1.0 GHz  | $\pm 0.3 + 5\%$ of Atten. Setting Max  |         |      | dB    |
| 1 - 27 dB States  | 1.0 - 2.0 GHz | $\pm 0.3 + 5\%$ of Atten. Setting Max  |         |      | dB    |
| 28 - 31 dB States   | 1.0 - 2.0 GHz | $\pm 0.3 + 8\%$ of Atten. Setting Max  |         |      | dB    |
| 1 - 23 dB States  | 2.0 - 3.0 GHz | $\pm 0.3 + 5\%$ of Atten. Setting Max  |         |      | dB    |
| 24 - 27 dB States   | 2.0 - 3.0 GHz | $\pm 0.3 + 8\%$ of Atten. Setting Max  |         |      | dB    |
| 28 - 31 dB States   | 2.0 - 3.0 GHz | $\pm 0.5 + 10\%$ of Atten. Setting Max |         |      | dB    |
| Input Power for 0.1 dB Compression  | 0.5 - 3.0 GHz |  | 24      |      | dBm   |
| Input Third Order Intercept Point<br>(Two-tone Input Power = 0 dBm Each Tone) | 0.5 - 3.0 GHz |  | 44      |      | dBm   |
| Switching Characteristics   | DC - 3.0 GHz  |  |         |      |       |
| tRISE, tFALL (10/90% RF)  |               |  | 140     |      | ns    |
| tON, tOFF (50% CTL to 10/90% RF)  |               |  | 160     |      | ns    |

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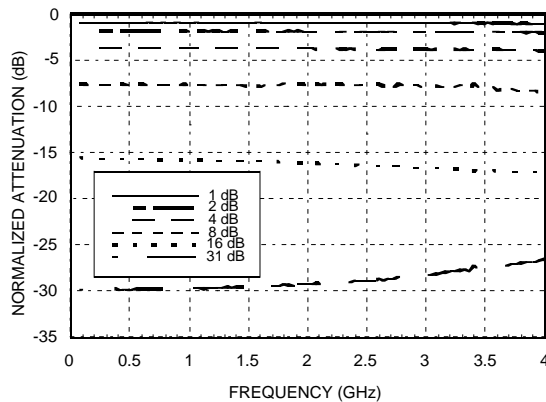
**Insertion Loss**



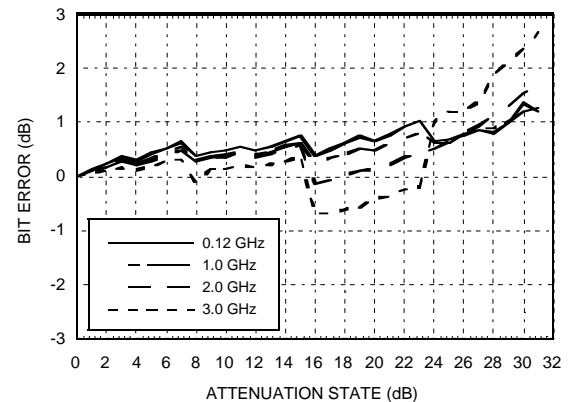
**Return Loss RF1, RF2**  
(Only Major States are Shown)



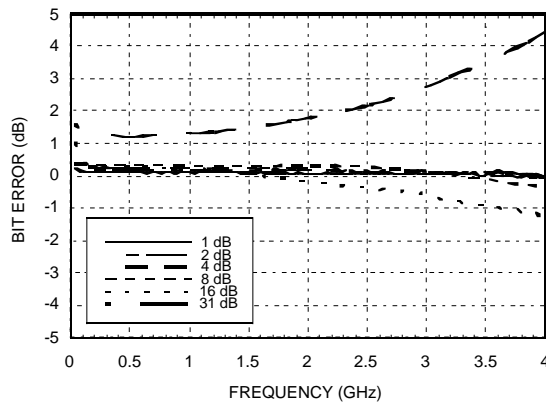
**Normalized Attenuation**  
(Only Major States are Shown)



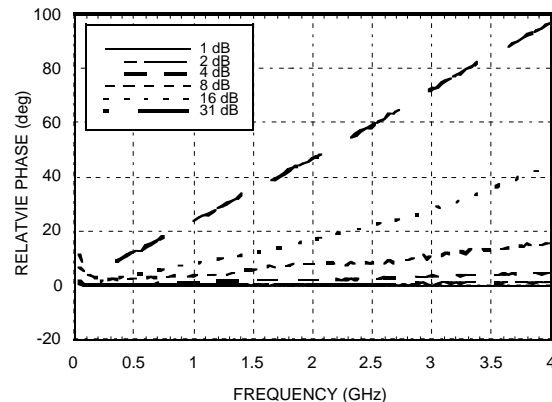
**Bit Error vs. Attenuation State**



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

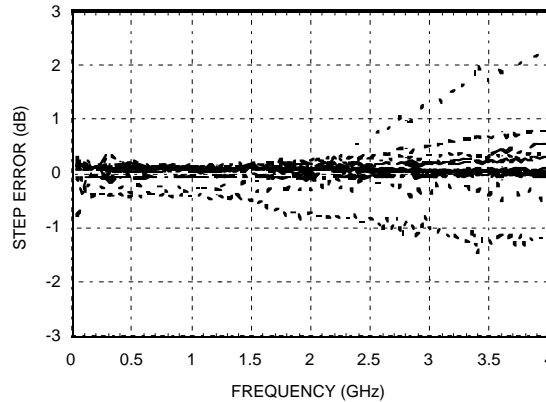


**Relative Phase vs. Frequency**  
(Only Major States are Shown)



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**Worst Case Step Error  
Between Successive Attenuation States**



### Bias Voltage & Current

| Vee Range = -5.0 Vdc ± 10% |                 |                 |
|----------------------------|-----------------|-----------------|
| Vee (VDC)                  | Iee (Typ.) (mA) | Iee (Max.) (mA) |
| -5.0                       | 3               | 6               |

### Control Voltage

| State | Bias Condition                |
|-------|-------------------------------|
| Low   | 0 to -2V @ 70 µA Typ.         |
| High  | Vee to Vee + 0.8V @ 5 µA Typ. |

Note: Vee = -5V ± 10%

### Absolute Maximum Ratings

|                              |                |
|------------------------------|----------------|
| Control Voltage (V1 - V5)    | Vee - 0.5 Vdc  |
| Bias Voltage (Vee)           | -7.0 Vdc       |
| Storage Temperature          | -65 to +150 °C |
| Operating Temperature        | -40 to +85 °C  |
| RF Input Power (0.5 - 3 GHz) | +26 dBm        |

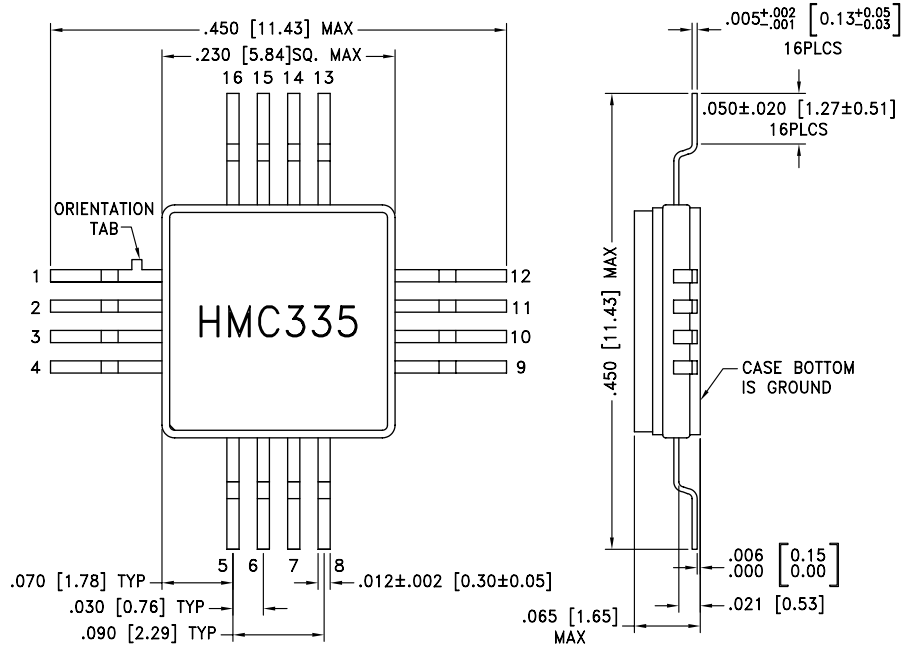
### Truth Table

| Control Voltage Input |            |            |            |            | Attenuation State<br>RF1 - RF2 |
|-----------------------|------------|------------|------------|------------|--------------------------------|
| V1<br>16 dB           | V2<br>8 dB | V3<br>4 dB | V4<br>2 dB | V5<br>1 dB |                                |
| Low                   | Low        | Low        | Low        | Low        | Reference I.L.                 |
| Low                   | Low        | Low        | Low        | High       | 1 dB                           |
| Low                   | Low        | Low        | High       | Low        | 2 dB                           |
| Low                   | Low        | High       | Low        | Low        | 4 dB                           |
| Low                   | High       | Low        | Low        | Low        | 8 dB                           |
| High                  | Low        | Low        | Low        | Low        | 16 dB                          |
| High                  | High       | High       | High       | High       | 31 dB<br>Max. Atten.           |

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

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### Outline Drawing



**NOTES:**

1. PACKAGE MATERIAL: ALUMINA LOADED BOROSILICATE GLASS.
2. LEADS, BASE, COVER MATEIRAL: KOVARTM (#7052 CORNING).
3. PLATING: ELECTROLYTIC GOLD 50 MICROINCHES MIN., OVER ELECTROLYTIC NICKEL 75 MICROINCHES MIN.
4. ALL DIMENSIONS ARE IN INCHES [MILLIMETERS].
5. TOLERANCES: 0.005 [0.13] UNLESS OTHERWISE SPECIFIED.
6. CHARACTERS TO BE HELVETICA MEDIUM .030 HIGH, BLACK INK, LOCATED APPROX. AS SHOWN.
7. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.

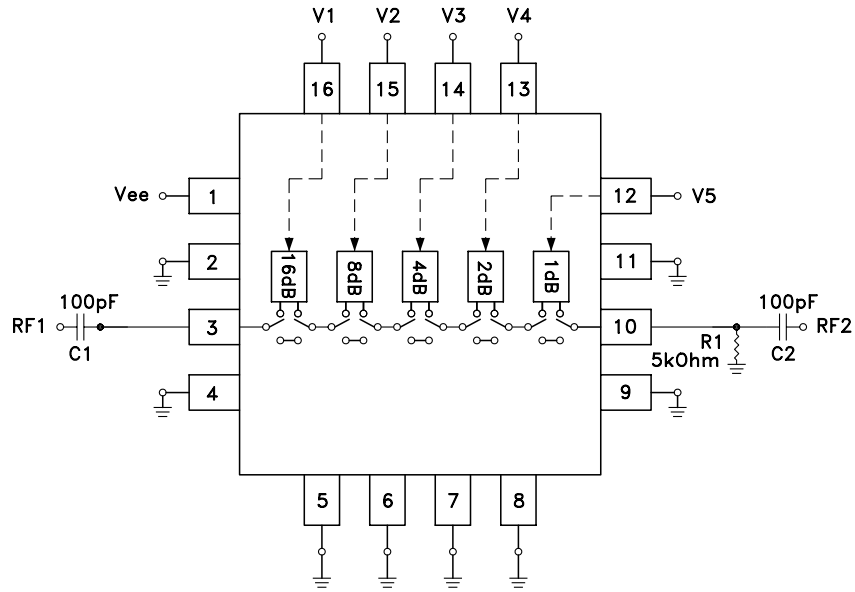
### Pin Descriptions

| Pin Number | Function | Description  | Interface Schematic |
|------------|----------|--|---------------------|
| 1          | Vee      | Supply Voltage -5V ±10%  |                     |
| 2, 4-9, 11 | GND      | Package bottom must also be connected to RF ground.                                |                     |
| 3, 10      | RF1, RF2 | These pins are DC coupled and matched to 50 Ohm. Blocking capacitors are required. |                     |
| 12-16      | V1-V5    | See truth table and control voltage table.   |                     |

For price, delivery, and to place orders, please contact Hittite Microwave Corporation:  
12 Elizabeth Drive, Chelmsford, MA 01824 Phone: 978-250-3343 Fax: 978-250-3373  
Order Online at [www.hittite.com](http://www.hittite.com)

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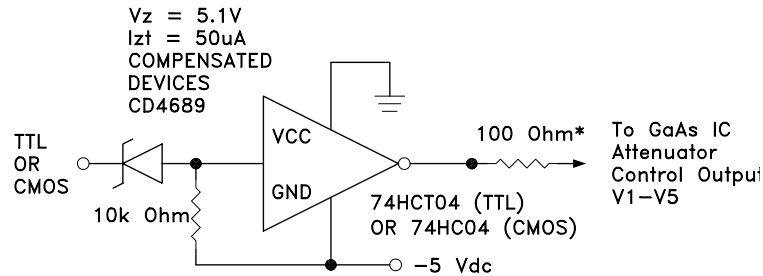
### Application Circuit



DC Blocking Capacitors C1 & C2 are required on RF1 & RF2. Choose  $C1 = C2 = 100 \text{ pF} \sim 0.1 \text{ uF}$  to allow lowest customer specific frequency to pass with minimal loss. R1= 5K Ohm is required to supply voltage to the circuit through either Pin 3 or Pin 10.

### Suggested Driver Circuit

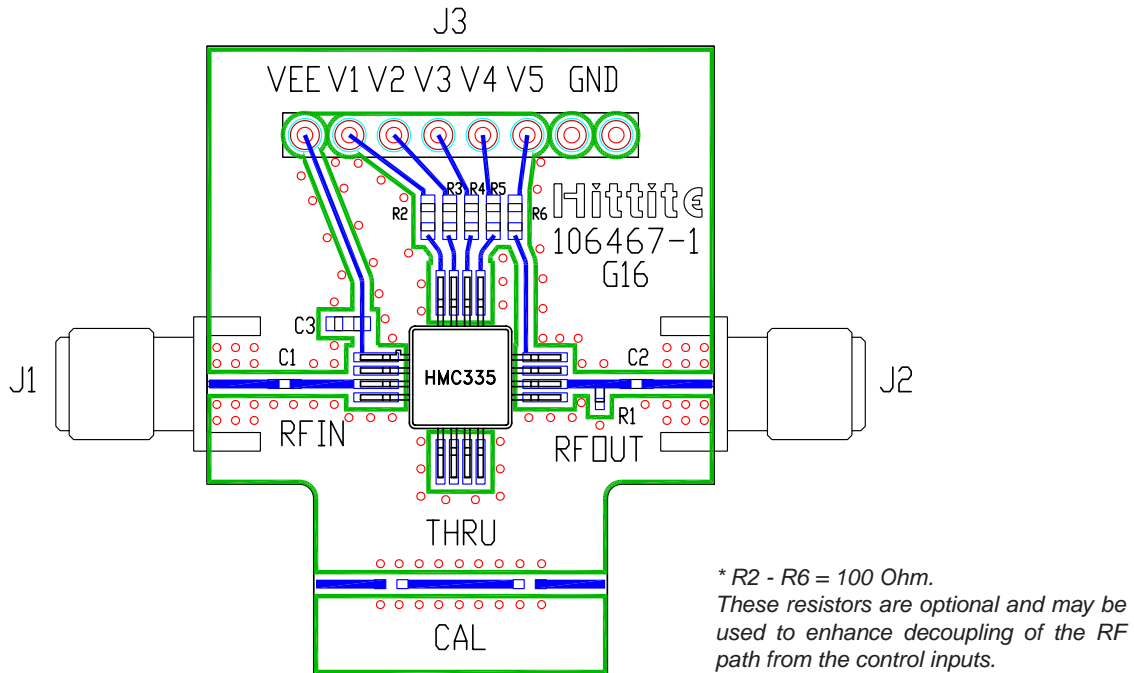
(One Circuit Required Per Bit Control Input)



Simple driver using inexpensive standard logic ICs provides fast switching using minimum DC current. \* Recommended value to suppress unwanted RF signals at V1 - V5 control lines.

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### Evaluation PCB



### List of Material

| Item                                 | Description   |
|--------------------------------------|---|
| J1 - J2                              | PC Mount SMA Connector  |
| J3                                   | DC Connector  |
| R1                                   | 5k Ohm Resistor 0402 Pkg.   |
| R2 - R6                              | 100 Ohm Resistor, 0402 Pkg.   |
| C1, C2                               | 0402 Chip Capacitor, Select Value for Lowest Frequency of Operation |
| C3                                   | 1000pF Capacitor, 0603 Pkg.   |
| U1                                   | HMC335G16 Digital Attenuator  |
| PCB*                                 | 106467 Evaluation PCB   |
| *Circuit Board Material: Rogers 4350 |   |

The circuit board used in the final application should use RF circuit design techniques. Signal lines should have 50 ohm impedance while the package ground leads and package bottom 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.