



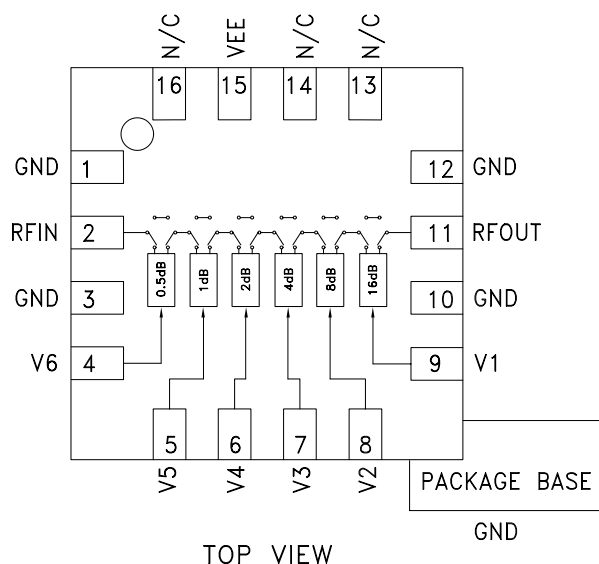
## 0.5dB LSB GaAs MMIC 6-BIT DIGITAL ATTENUATOR, DC - 13 GHz

### Typical Applications

The HMC424ALP3E is ideal for:

- Basestation Infrastructure
- Fiber Optics & Broadband Telecom
- Microwave & VSAT Radios
- Military & Space
- Test Instrumentation

### Functional Diagram



### Features

- 0.5 dB LSB Steps to 31.5 dB
- Single Control Line Per Bit
- ± 0.5 dB Typical Bit Error
- 9mm<sup>2</sup> Leadless SMT Plastic Package

### General Description

The HMC424ALP3E is a broadband 6-bit GaAs IC digital attenuator in low cost leadless surface mount package. Covering DC to 13 GHz, the insertion loss is less than 4 dB typical. The attenuator bit values are 0.5 (LSB), 1, 2, 4, 8, and 16 dB for a total attenuation of 31.5 dB. Attenuation accuracy is excellent at ± 0.5 dB typical step error with an IIP3 of +38 dBm. Six control voltage inputs, toggled between 0 and -5V, are used to select each attenuation state. A single Vee bias of -5V allows operation at frequencies down to DC.

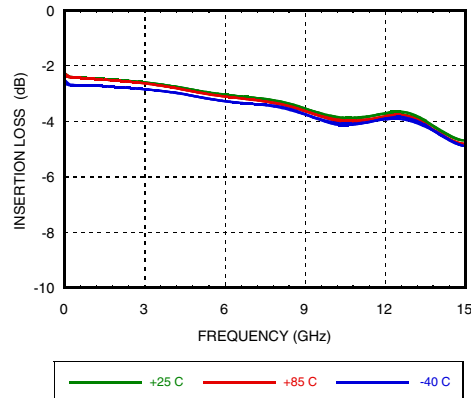
### Electrical Specifications, $T_A = +25^\circ\text{C}$ , With Vee = -5V & VCTL = 0/-5V

| Parameter                                                                       | Frequency (GHz) | Min.                               | Typ. | Max. | Units |
|---------------------------------------------------------------------------------|-----------------|------------------------------------|------|------|-------|
| Insertion Loss                                                                  | DC - 4 GHz      |                                    | 2.8  | 3.3  | dB    |
|                                                                                 | 4.0 - 8.0 GHz   |                                    | 3.3  | 3.8  | dB    |
|                                                                                 | 8.0 - 13.0 GHz  |                                    | 3.9  | 4.4  | dB    |
| Attenuation Range                                                               | DC - 13.0 GHz   |                                    | 31.5 |      | dB    |
| Return Loss (RF1 & RF2, All Atten. States)                                      | DC - 13.0 GHz   |                                    | 13   |      | dB    |
| Attenuation Accuracy: (Referenced to Insertion Loss)<br>0.5 - 31.5 dB States    | DC - 13.0 GHz   | ± (0.3 + 5% of Atten. Setting) Max |      |      | dB    |
| Input Power for 0.1 dB Compression                                              | 1.0 - 13.0 GHz  |                                    | 23   |      | dBm   |
| Input Third Order Intercept Point<br>(Two-Tone Input Power = +10 dBm Each Tone) | 1.0 - 13.0 GHz  | REF State                          | 45   |      | dBm   |
|                                                                                 |                 | All Other States                   | 42   |      | dBm   |
| Switching Characteristics                                                       | DC - 13.0 GHz   |                                    |      |      |       |
| tRISE, tFALL (10/90% RF)                                                        |                 |                                    | 30   |      | ns    |
| tON/tOFF (50% CTL to 10/90% RF)                                                 |                 |                                    | 50   |      | ns    |

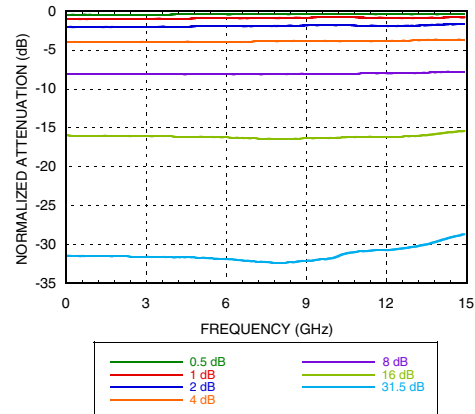


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**Insertion Loss**

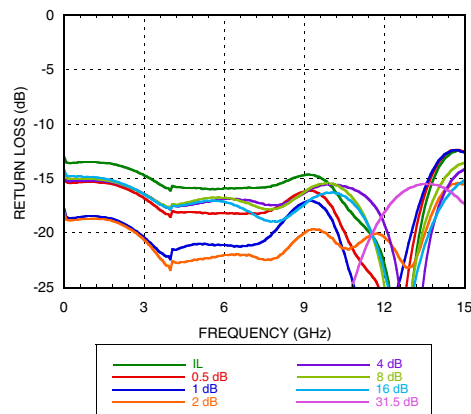


**Normalized Attenuation**  
(Only Major States are Shown)



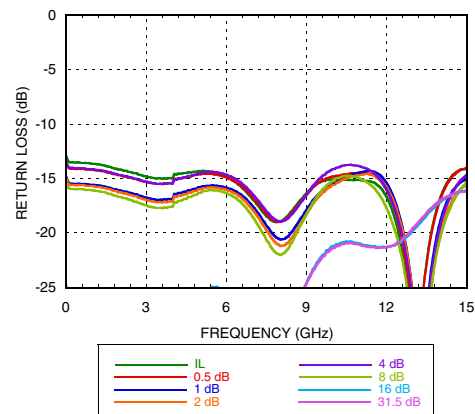
**Input Return Loss**

(Only Major States are Shown)



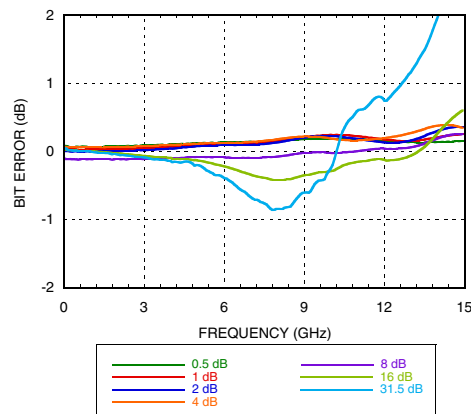
**Output Return Loss**

(Only Major States are Shown)

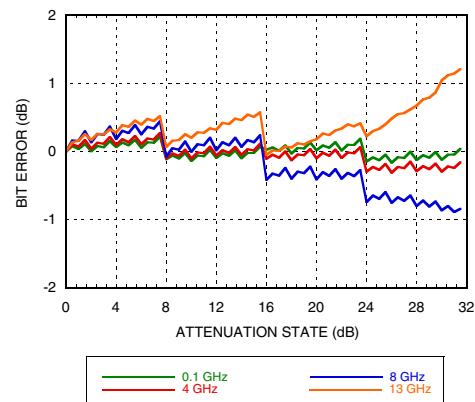


**Bit Error vs. Frequency**

(Only Major States are Shown)



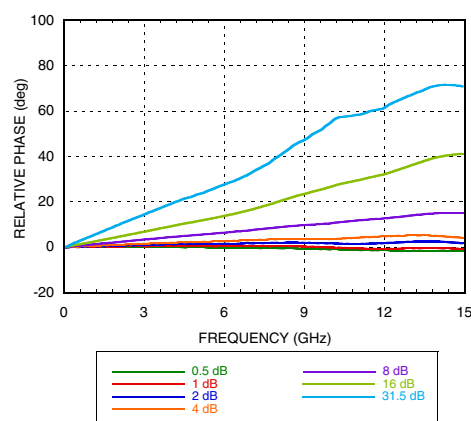
**Bit Error vs. Attenuation State**



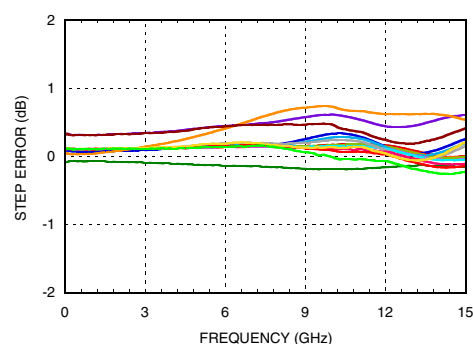


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### Relative Phase vs. Frequency (Only Major States are Shown)



### Worst Case Step Error Between Successive Attenuation States



### Truth Table

| Control Voltage Input |            |            |            |            |              | Attenuation<br>State<br>RF1 - RF2 |
|-----------------------|------------|------------|------------|------------|--------------|-----------------------------------|
| V1<br>16 dB           | V2<br>8 dB | V3<br>4 dB | V4<br>2 dB | V5<br>1 dB | V6<br>0.5 dB |                                   |
| Low                   | Low        | Low        | Low        | Low        | Low          | Reference<br>I.L.                 |
| Low                   | Low        | Low        | Low        | Low        | High         | 0.5 dB                            |
| Low                   | Low        | Low        | Low        | High       | Low          | 1 dB                              |
| Low                   | Low        | Low        | High       | Low        | Low          | 2 dB                              |
| Low                   | Low        | High       | Low        | Low        | Low          | 4 dB                              |
| Low                   | High       | Low        | Low        | Low        | Low          | 8 dB                              |
| High                  | Low        | Low        | Low        | Low        | Low          | 16 dB                             |
| High                  | High       | High       | High       | High       | High         | 31.5 dB                           |

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

### Bias Voltage & Current

| Vee Range= -5 Vdc ± 10% |                    |                    |
|-------------------------|--------------------|--------------------|
| Vee<br>(VDC)            | Iee (Typ.)<br>(mA) | Iee (Max.)<br>(mA) |
| -5                      | 2                  | 5                  |

### Control Voltage

| State | Bias Condition                |
|-------|-------------------------------|
| Low   | 0 to -3V @ 35 µA Typ.         |
| High  | Vee to Vee +0.8V @ <1 µA Typ. |



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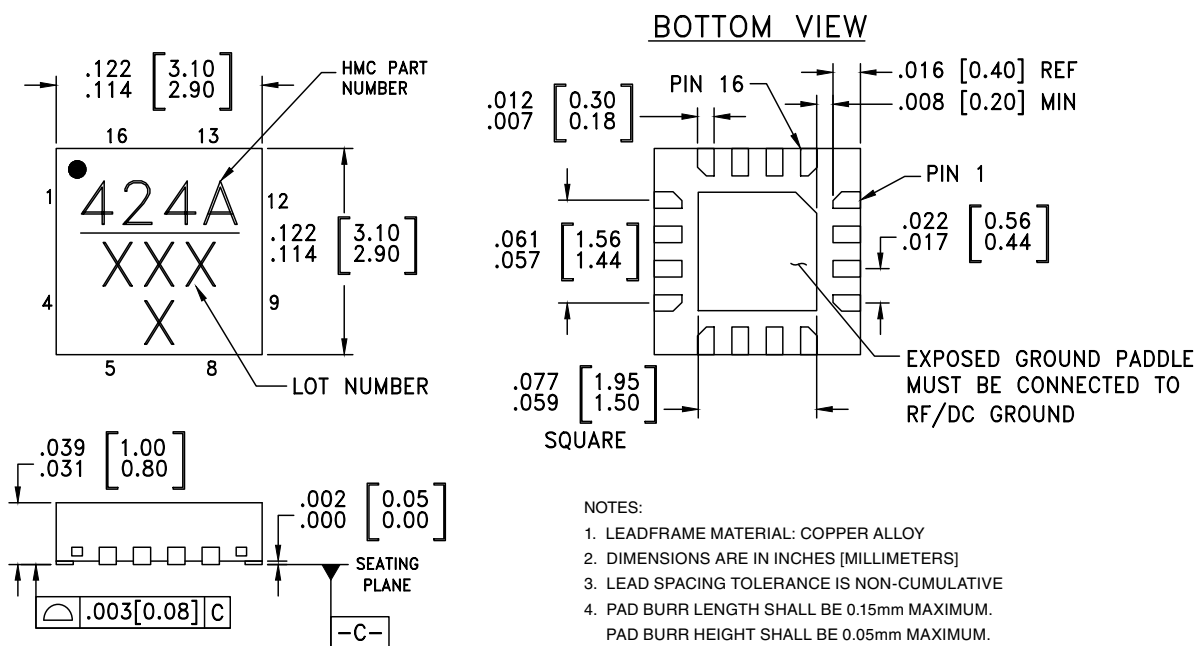
### Absolute Maximum Ratings

|                               |                 |
|-------------------------------|-----------------|
| Control Voltage (V1 to V6)    | Vee - 0.5 Vdc   |
| Bias Voltage (Vee)            | -7 Vdc          |
| Channel Temperature           | 150 °C          |
| Thermal Resistance            | 330 °C/W        |
| Storage Temperature           | -65 to + 150 °C |
| Operating Temperature         | -55 to +85 °C   |
| RF Input Power (0.5 - 13 GHz) | +25 dBm         |
| ESD Sensitivity (HBM)         | Class 1A        |



ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS

### Outline Drawing



#### NOTES:

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

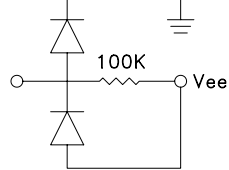
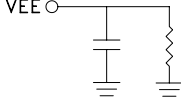
### Package Information

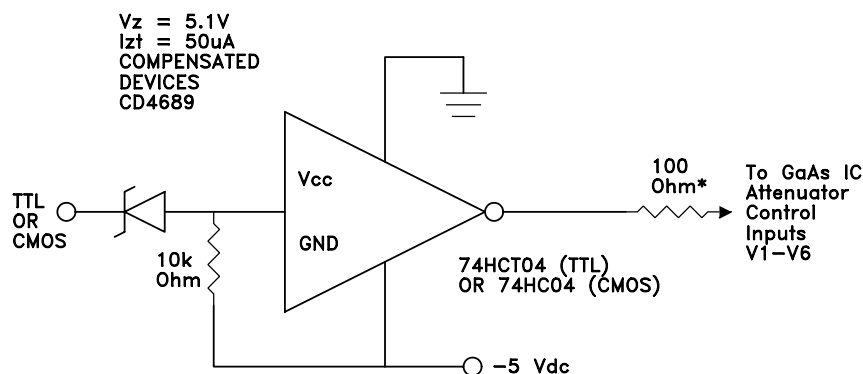
| Part Number | Package Body Material                              | Lead Finish   | MSL Rating          | Package Marking <sup>[2]</sup> |
|-------------|----------------------------------------------------|---------------|---------------------|--------------------------------|
| HMC424ALP3E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 <sup>[1]</sup> | 424A<br>XXXX                   |

[1] Max peak reflow temperature of 260 °C

[2] 4-Digit lot number XXXX

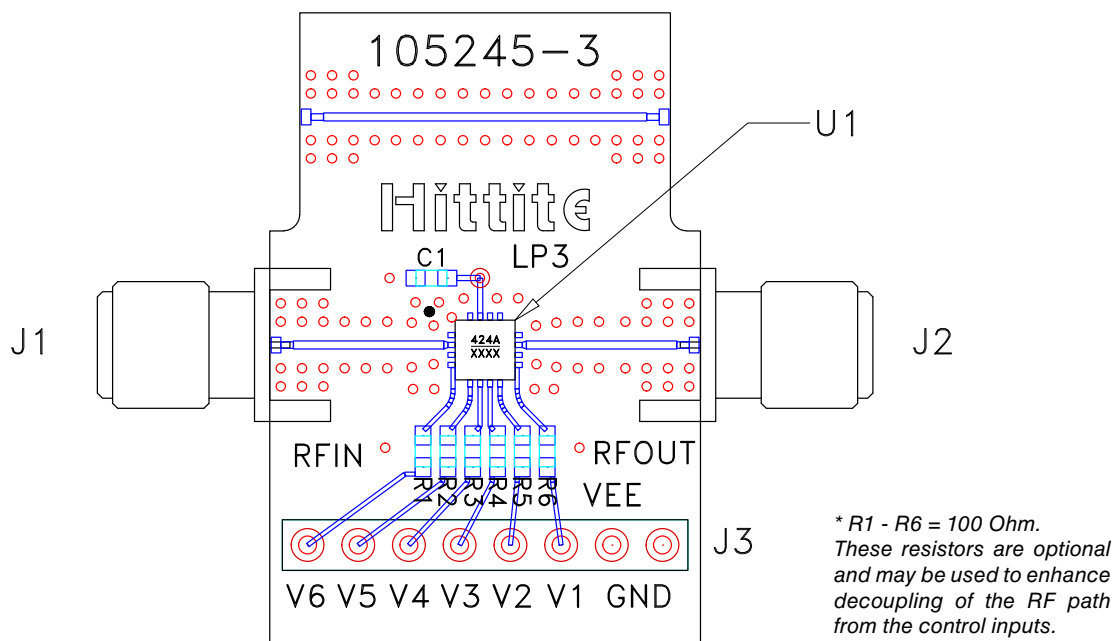
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**Pin Description**

| Pad Number       | Function    | Description                                                                                                             | Interface Schematic                                                                 |
|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1, 3, 10, 12     | GND         | Package bottom has an exposed metal paddle that must also be connected to RF ground                                     |  |
| 2, 11            | RFIN, RFOUT | This pin is DC coupled and matched to 50 Ohm. Blocking capacitors are required if RF line potential is not equal to 0V. |                                                                                     |
| 4, 5, 6, 7, 8, 9 | V6 - V1     | See truth table and control voltage table.                                                                              |  |
| 13, 14, 16       | N/C         | This pin should be connected to PCB RF ground to maximize performance                                                   |  |
| 15               | VEE         | Supply Voltage -5V $\pm$ 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 - V6 control lines.

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**Evaluation PCB**

**List of Materials for Evaluation PCB EV1HMC424ALP3 <sup>[1]</sup>**

| Item               | Description                       |
|--------------------|-----------------------------------|
| J1 - J2            | PCB Mount SMA Connector           |
| J3                 | 8 Pin DC Connector                |
| C1                 | 0.01 $\mu$ F Capacitor, 0603 Pkg. |
| R1 - R6            | 100 Ohm Resistor, 0603 Pkg.       |
| U1                 | HMC424ALP3E Digital Attenuator    |
| PCB <sup>[2]</sup> | 105245 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 Hittite upon request.