# HMC472ALP4E

## 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, DC - 3.8 GHz

### Typical Applications

The HMC472ALP4E is ideal for:

- 3G Infrastructure & access points
- Cellular/3G, LTE & UMB
- WiMAX, WiBN & Fixed Wireless
- Test Equipment and Sensors
- GSM, WCDMA & TD-SCDMA

### Features

0.5 dB LSB Steps to 31.5 dB

Single Control Line Per Bit

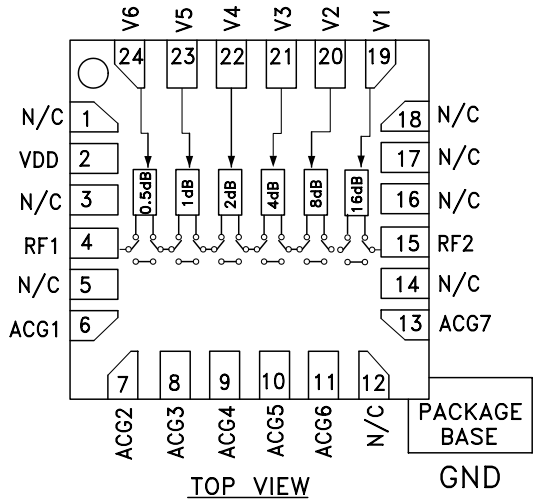
TTL/CMOS Compatible Control

± 0.25 dB Typical Step Error

Single +5V Supply

24 Lead Ceramic 4x4mm SMT Package: $16mm^2$

### Functional Diagram




### General Description

The HMC472ALP4E are broadband 6-bit GaAs IC digital attenuators in low cost leadless surface mount packages. This single positive control line per bit digital attenuator incorporates off chip AC ground capacitors for near DC operation, making it suitable for a wide variety of RF and IF applications. Covering DC to 3.8 GHz, the insertion loss is less than 2.0 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 ± 0.25 dB typical step error with an IIP3 of +54 dBm. Six TTL/CMOS control inputs are used to select each attenuation state. A single Vdd bias of +5V is required.

### Electrical Specifications, $T_A$ = +25° C, With Vdd = +5V & Vctl = 0/+5V (Unless Otherwise Noted)

| Parameter | | Frequency (GHz) | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Insertion Loss | | DC - 1.5 GHz<br>1.5 - 3.0 GHz<br>3.0 - 3.8 GHz | | 1.4<br>1.7<br>1.9 | 1.8<br>2.3<br>3 | dB<br>dB<br>dB |
| Attenuation Range | | DC - 3.8 GHz | | 31.5 | | dB |
| Return Loss (RF1 & RF2, All Atten. States) | | DC - 3.8 GHz | | 20 | | dB |
| Attenuation Accuracy: (Referenced to Insertion Loss)<br>All Attenuation States<br>0.5 - 3.5 dB States<br>4.0 - 31.5 dB States<br>All Attenuation States<br>All Attenuation States | | DC - 1.0 GHz<br>1.0 - 2.2 GHz<br>1.0 - 2.2 GHz<br>2.2 - 3.0 GHz<br>3.0 - 3.8 GHz | ± (0..20 + 3% of Atten. Setting) Max.<br>± (0.25 + 3% of Atten. Setting) Max.<br>± (0.15 + 4% of Atten. Setting) Max.<br>± (0.30 + 3% of Atten. Setting) Max<br>± (0.35 + 5% of Atten. Setting) Max. | | | dB<br>dB<br>dB<br>dB<br>dB |
| Input Power for 0.1 dB Compression | | 0.1 - 3.8 GHz | | 30 | | dBm |
| Input Third Order Intercept Point<br>(Two-Tone Input Power= 0 dBm Each Tone) | REF - 15.5 dB States<br>16.0 - 31.5 dB States | 0.1 - 3.8 GHz | | 54<br>49 | | dBm<br>dBm |
| Switching Characteristics<br>tRISE, tFALL (10/90% RF)<br>tON, tOFF (50% CTL to 10/90% RF) | | DC - 3.8 GHz | | 40<br>60 | | ns<br>ns |

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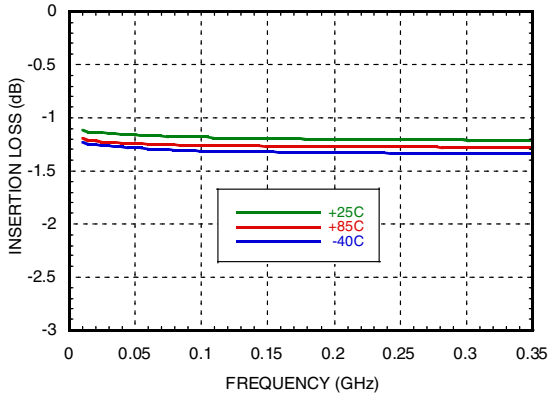
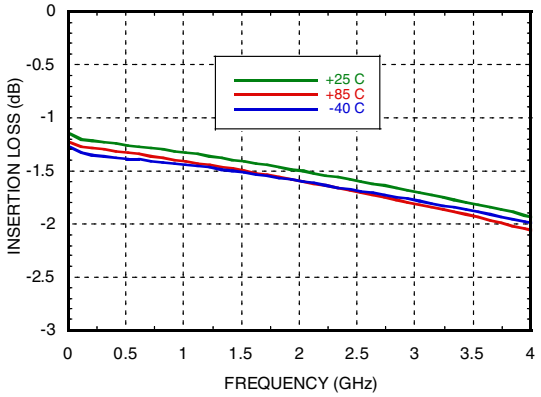
### Insertion Loss

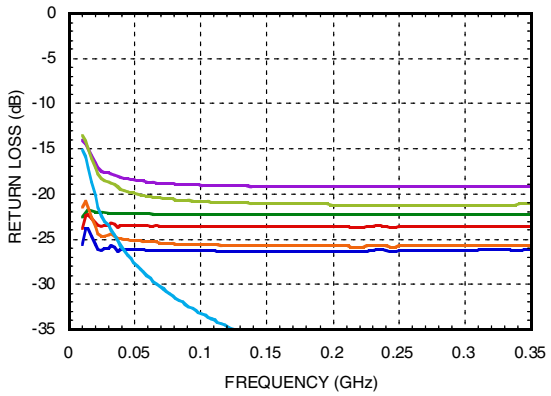



### Insertion Loss



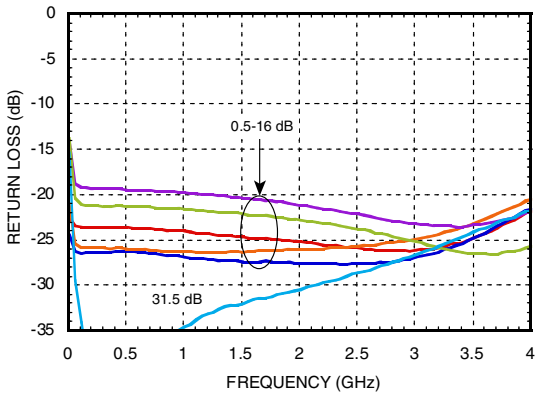

### Return Loss RF1, RF2

*(Only Major States are Shown)*



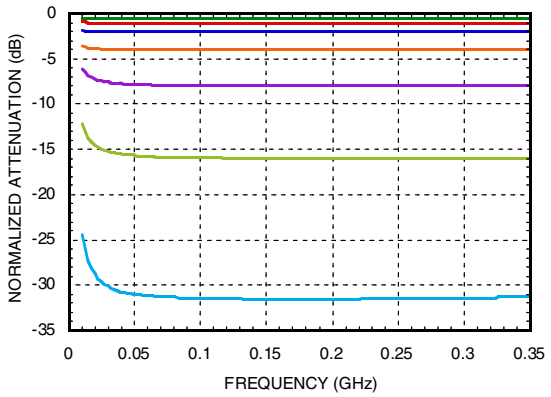

### Return Loss RF1, RF2

*(Only Major States are Shown)*



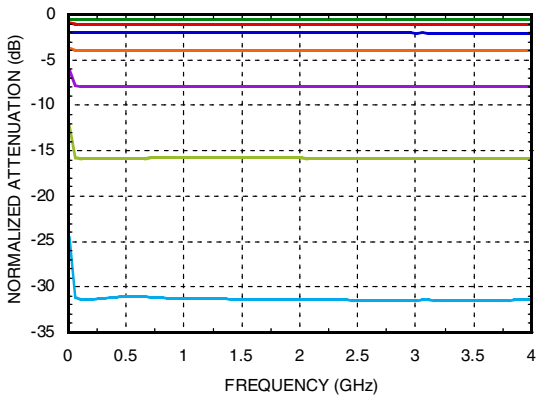

### Normalized Attenuation

*(Only Major States are Shown)*




### Normalized Attenuation

*(Only Major States are Shown)*



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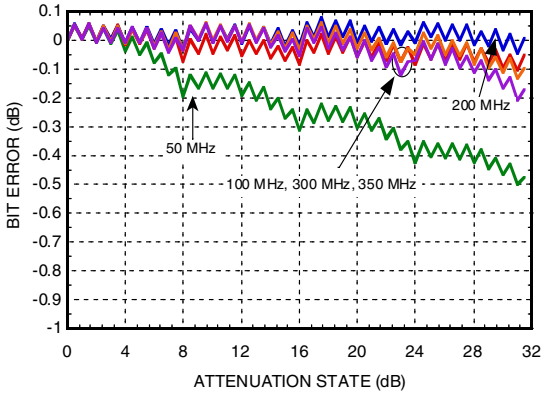
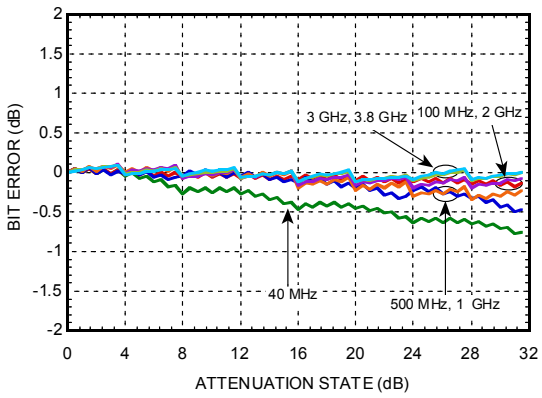
### Bit Error vs. Attenuation State

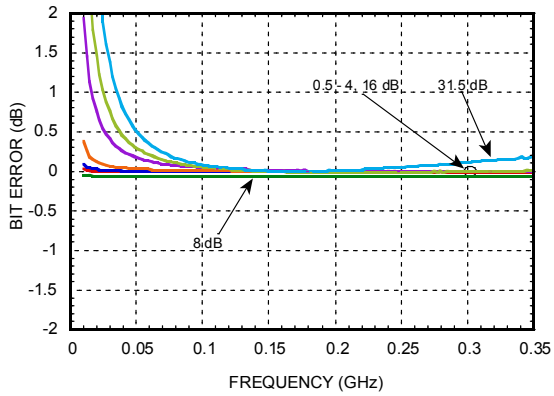



### Bit Error vs. Attenuation State



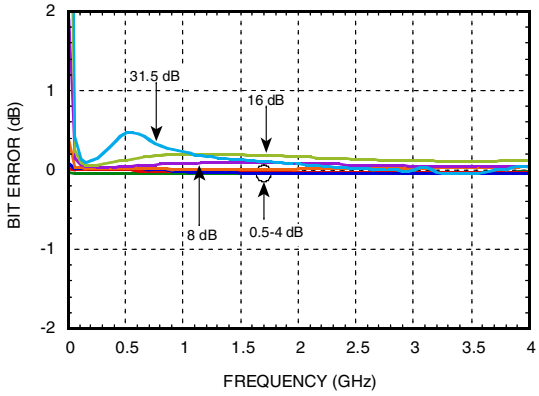

### Bit Error vs. Frequency

*(Only Major States are Shown)*



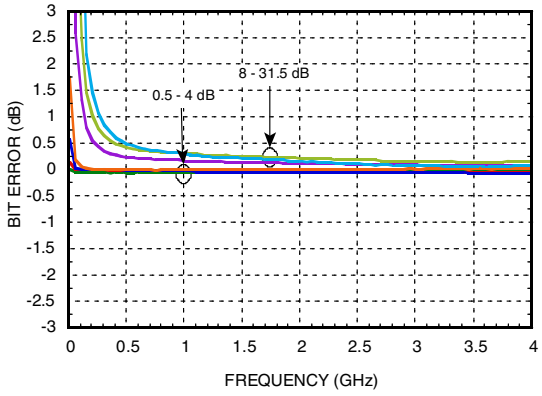

### Bit Error vs. Frequency

*(Only Major States are Shown)*



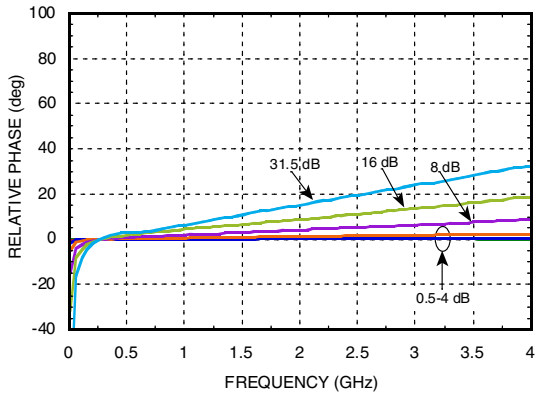

### Bit Error vs. Frequency without AC Ground Caps

*(Only Major States are Shown)*

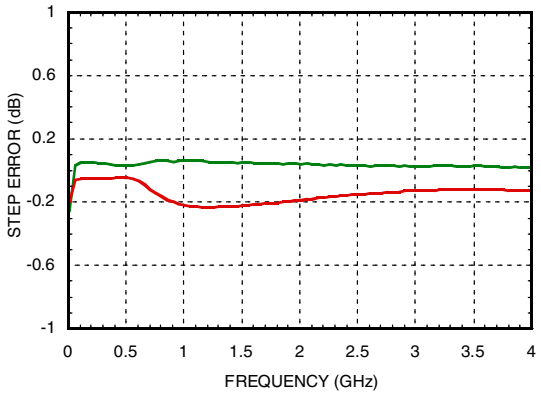


# 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, DC - 3.8 GHz

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




### Worst Case Step Error Between Successive Attenuation States




### Bias Voltage & Current

| Vdd = +5V ± 10% | |
|---|---|
| Vdd (V) | Idd (Typ.) (mA) |
| +4.5 | 2.4 |
| +5.0 | 2.5 |
| +5.5 | 2.6 |

### Control Voltage

| State | Bias Condition |
|---|---|
| Low | 0 to +0.8 Vdc @ -5 uA Typ. |
| High | + 2.0 to + 5.0 Vdc @ 40 uA Typ. |
| Note: Vdd = +5V | |

### Truth Table

| Control Voltage Input | | | | | | Attenuation State RF1 - RF2 |
|---|---|---|---|---|---|---|
| V1 16 dB | V2 8 dB | V3 4 dB | V4 2 dB | V5 1 dB | V6 0.5 dB | |
| High | High | High | High | High | High | Reference I.L. |
| High | High | High | High | High | Low | 0.5 dB |
| High | High | High | High | Low | High | 1 dB |
| High | High | High | Low | High | High | 2 dB |
| High | High | Low | High | High | High | 4 dB |
| High | Low | High | High | High | High | 8 dB |
| Low | High | High | High | High | High | 16 dB |
| Low | Low | Low | Low | Low | Low | 31.5 dB |
| Any combination of the above states will provide an attenuation approximately equal to the sum of the bits selected. | | | | | | |

# HMC472ALP4E

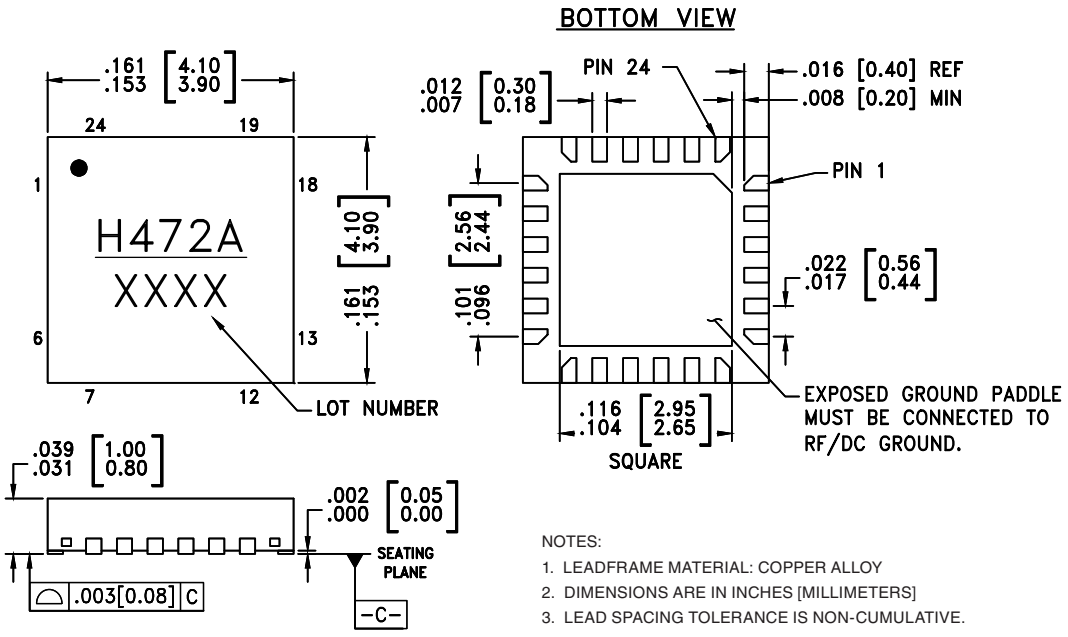
## 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, DC - 3.8 GHz

### Absolute Maximum Ratings

| | |
|---|---|
| RF Input Power (DC - 3 GHz) | +28 dBm (T = +85 °C) |
| Control Voltage Range (V1 to V6) | -1V to Vdd +1V |
| Bias Voltage (Vdd) | +7V |
| Channel Temperature | 150 °C |
| Continuous Pdiss (T = 85 °C) (derate 8.6 mW/°C above 85 °C) | 0.56 W |
| Thermal Resistance | 116 °C/W |
| Storage Temperature | -65 to +150 °C |
| Operating Temperature | -40 to +85 °C |
| 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 [2] |
|---|---|---|---|---|
| HMC472ALP4E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 [1] | H472A<br>XXXX |

[1] Max peak reflow temperature of 260 °C
[2] 4-Digit lot number XXXX

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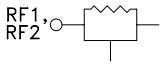
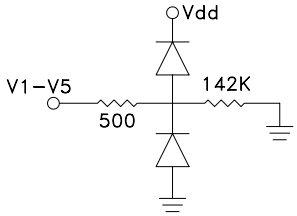
### Pin Descriptions

| Pin Number | Function | Description | Interface Schematic |
|---|---|---|---|
| 1, 3, 5, 12, 14, 16, 17, 18 | N/C | These pins should be connected to PCB RF ground to maximize performance. | |
| 2 | Vdd | Supply Voltage. | |
| 4, 15 | RF1, RF2 | This pin is DC coupled and matched to 50 Ohm. Blocking capacitors are required. Select value based on lowest frequency of operation. |  |
| 6 - 11, 13 | ACG1 - ACG7 | External capacitors to ground are recommended for low and high frequency operation. Select value for lowest frequency of operation. Place capacitor as close to pins as possible. For operation from 700 to 2700 MHz, these pins may be left unconnected. | |
| 19 - 24 | V1 - V6 | See truth table and control voltage table. |  |
| | GND | Package bottom has an exposed metal paddle that must also be connected to RF/DC Ground. |  |

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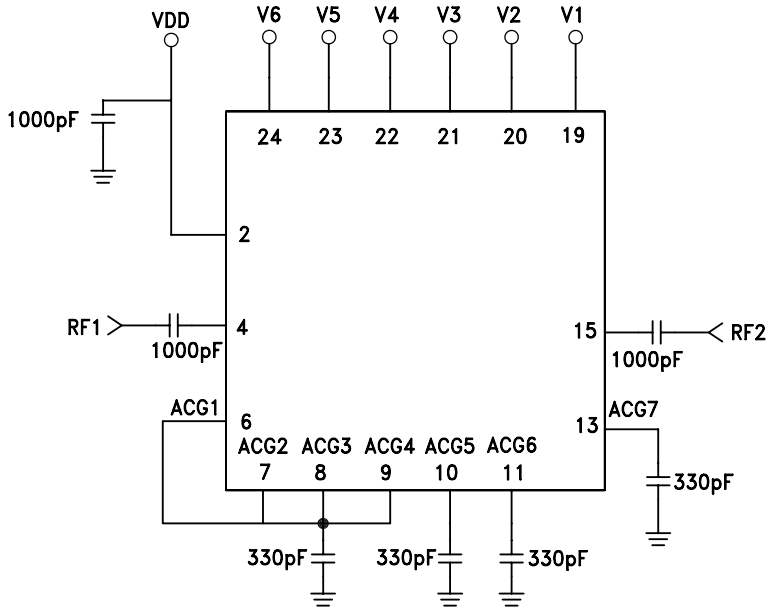
### Application Circuit

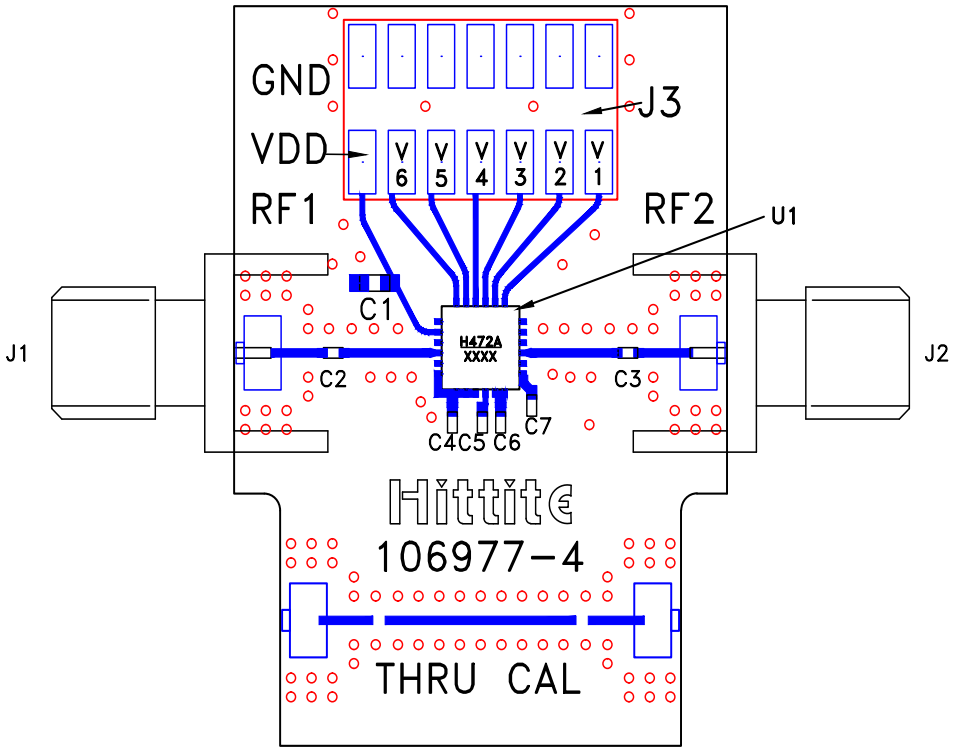



*Note: For operations from 700 to 2700 MHz, pins 6 through 13 may be left unconnected.*

## 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, DC - 3.8 GHz



### Evaluation PCB




### List of Materials for Evaluation PCB 107010 - HMC472ALP4 [1]

| Item | Description |
|---|---|
| J1 - J2 | PCB Mount SMA Connector |
| J3 | 14 Pin DC Connector |
| C1 | 1000 pF Capacitor, 0603 Pkg. |
| C2, C3 | 1000 pF Capacitor, 0402 Pkg. |
| C4 - C7 | 330 pF Capacitor, 0402 Pkg. |
| U1 | HMC472ALP4E Digital Attenuator |
| PCB [2] | 106977 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.