

## 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, 2.4 - 8.0 GHz

### Typical Applications

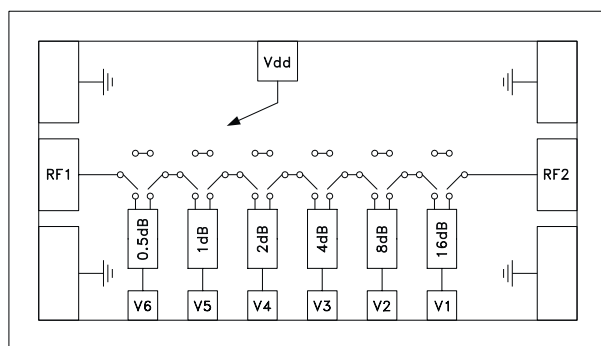
The HMC425 is ideal for:

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

### Features

- 0.5 dB LSB Steps to 31.5 dB
- Single Control Line Per Bit
- ±0.5 dB Typical Bit Error
- Die Size: 1.5 x 0.85 x 0.1 mm

### Functional Diagram



### General Description

The HMC425 die is a broadband 6-bit GaAs IC digital attenuator MMIC chip. Covering 2.4 to 8 GHz, the insertion loss is less than 3.5 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 +40 dBm. Six control voltage inputs, toggled between 0 and +3 to +5V, are used to select each attenuation state. A single Vdd bias of +3 to +5V is required.

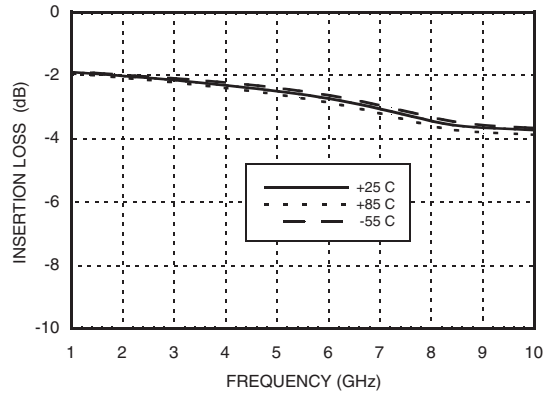
### Electrical Specifications,

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

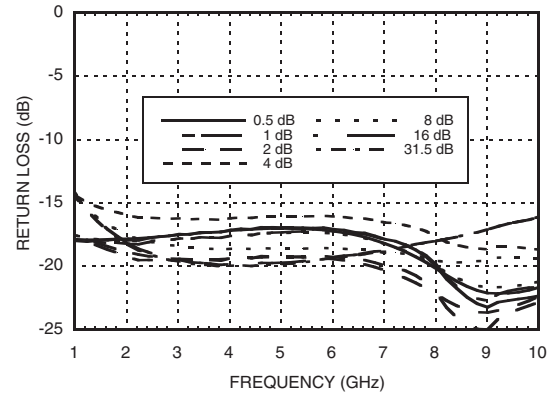
Parameter	Frequency (GHz)	Min.	Typ.	Max.	Units
Insertion Loss	2.4 - 6.0 GHz		2.7	3.2	dB
	6.0 - 8.0 GHz		3.5	4.0	dB
Attenuation Range	2.4 - 8.0 GHz		31.5		dB
Return Loss (RF1 & RF2, All Atten. States)	2.4 - 8.0 GHz	12	15		dB
Attenuation Accuracy: (Referenced to Insertion Loss)	All States	± 0.4 + 4% of Atten. Setting Max			dB
Input Power for 0.1 dB Compression	2.4 - 8.0 GHz		Vdd= 5V		dBm
			Vdd= 3V		dBm
Input Third Order Intercept Point (Two-Tone Input Power= 0 dBm Each Tone)	2.4 - 8.0 GHz		REF - 16.0 dB States		dBm
			16.5 - 31.5 dB States		dBm
Switching Characteristics	2.4 - 8.0 GHz		tRISE, tFALL (10/90% RF)	160	ns
			tON/tOFF (50% CTL to 10/90% RF)	180	ns

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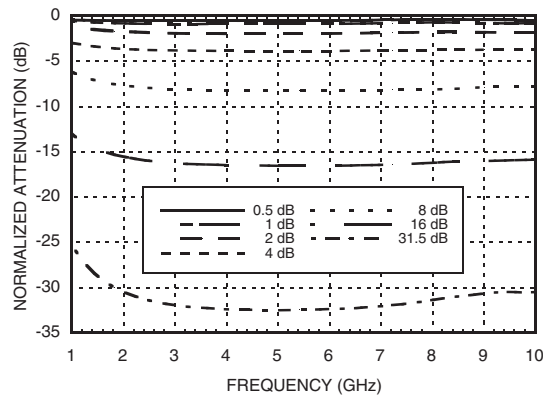
**Insertion Loss**



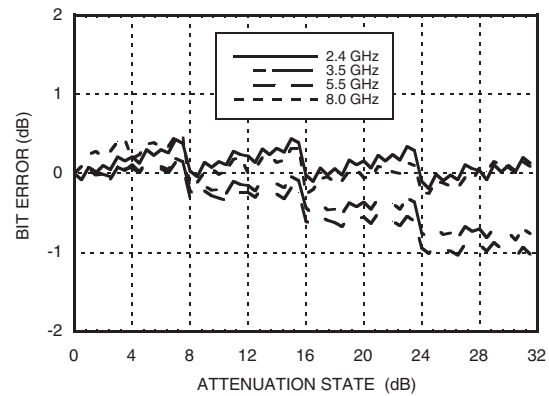
**Return Loss RF1, RF2**  
(Only Major States are Shown)



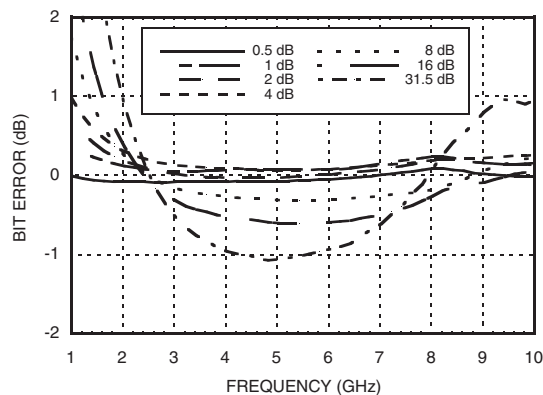
**Normalized Attenuation**  
(Only Major States are Shown)



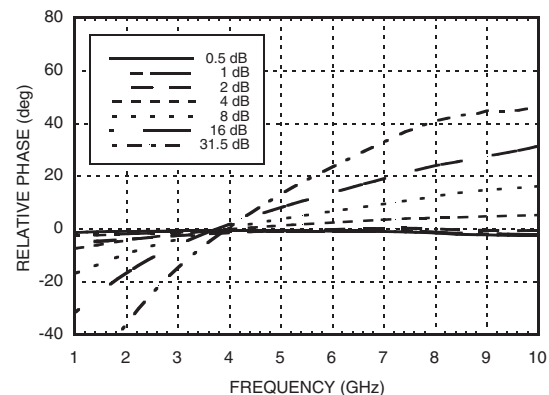
**Bit Error vs. Attenuation State**



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



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



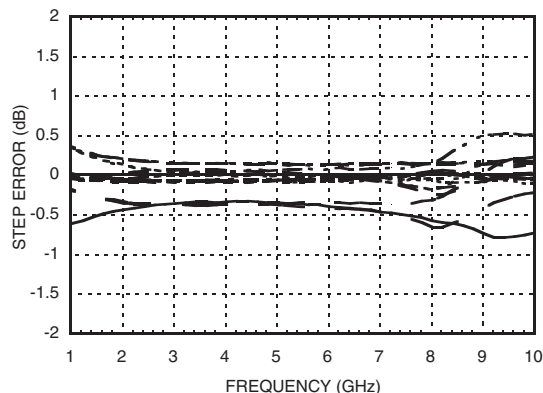
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ATTENUATORS - DIGITAL - CHIP

**Worst Case Step Error**

**Between Successive Attenuation States**



**Bias Voltage & Current**

Vdd Range= +3 to +5 Vdc	
Vdd (Vdc)	Idd (Typ.) (μA)
+3.0	10
+5.0	30

**Control Voltage**

State	Bias Condition
Low	0 to 0.2V @ 10 μA Typ.
High	Vdd ± 0.2V @ 5 μA Typ.
Note: Vdd= +3V to +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.						

**Absolute Maximum Ratings**

Control Voltage (V1 to V6)	Vdd +0.5 Vdc
Bias Voltage (Vdd)	+7.0 Vdc
Storage Temperature	-65 to + 150 °C
Operating Temperature	-55 to +85 °C
RF Input Power (2.4 - 8.0 GHz)	+30 dBm
ESD Sensitivity (HBM)	Class 1A



**ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS**

**Die Packaging Information <sup>[1]</sup>**

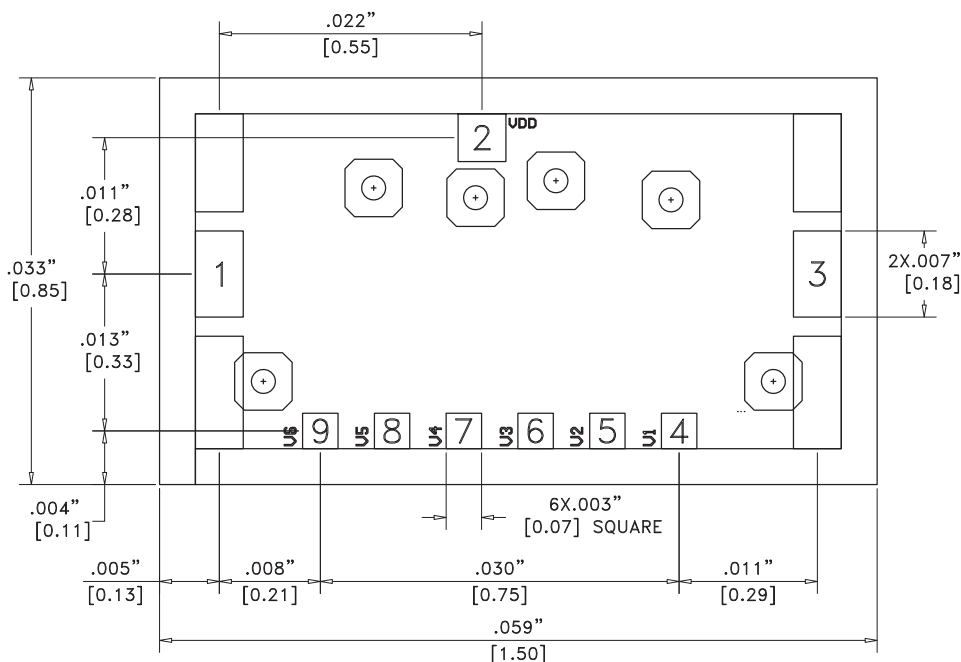
Standard	Alternate
WP-8 (Waffle Pack)	[2]

[1] Refer to the "Packaging Information" section for die packaging dimensions.

[2] For alternate packaging information contact Hittite Microwave Corporation.


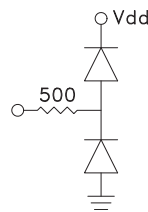
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**Outline Drawing**



1. ALL DIMENSIONS ARE IN INCHES (MILLIMETERS).
2. TYPICAL BOND PAD IS .004" SQUARE.
3. TYPICAL BOND PAD SPACING IS .006" CENTER TO CENTER EXCEPT AS NOTED.
4. BACKSIDE METALIZATION: GOLD
5. BACKSIDE METAL IS GROUND
6. BOND PAD METALIZATION: GOLD

**Pad Descriptions**

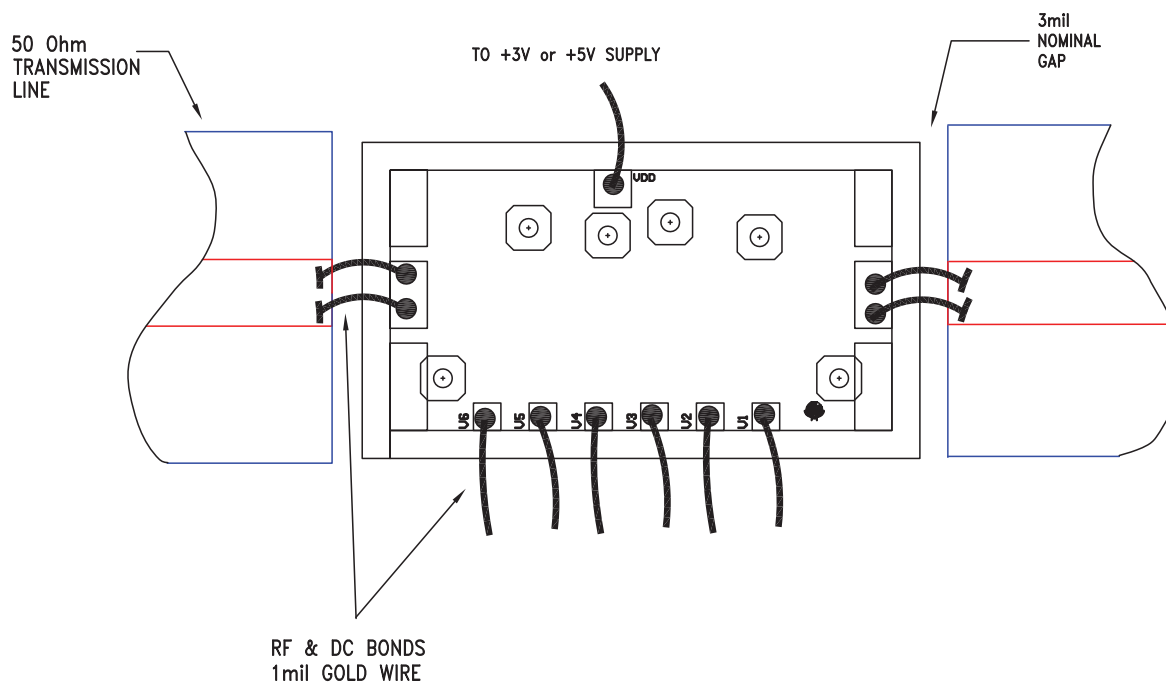
Pad Number	Function	Description	Interface Schematic
	GND	Die bottom must be connected to RF ground.	
1, 3	RF1, RF2	This pad is DC coupled and matched to 50 Ohm. Blocking capacitors are required.	
2	Vdd	Supply Voltage	
4, 5, 6, 7, 8, 9	V1 - V6	See truth table and control voltage table.	

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**Assembly Diagram**



## **0.5 dB LSB GaAs MMIC 6-BIT DIGITAL POSITIVE CONTROL ATTENUATOR, 2.4 - 8.0 GHz**

### **Mounting & Bonding Techniques for Millimeterwave GaAs MMICs**

The die should be attached directly to the ground plane eutectically or with conductive epoxy (see HMC general Handling, Mounting, Bonding Note).

50 Ohm Microstrip transmission lines on 0.127mm (5 mil) thick alumina thin film substrates are recommended for bringing RF to and from the chip (Figure 1). If 0.254mm (10 mil) thick alumina thin film substrates must be used, the die should be raised 0.150mm (6 mils) so that the surface of the die is coplanar with the surface of the substrate. One way to accomplish this is to attach the 0.102mm (4 mil) thick die to a 0.150mm (6 mil) thick molybdenum heat spreader (moly-tab) which is then attached to the ground plane (Figure 2).

Microstrip substrates should be brought as close to the die as possible in order to minimize bond wire length. Typical die-to-substrate spacing is 0.076mm to 0.152 mm (3 to 6 mils).

### **Handling Precautions**

Follow these precautions to avoid permanent damage.

**Storage:** All bare die are placed in either Waffle or Gel based ESD protective containers, and then sealed in an ESD protective bag for shipment. Once the sealed ESD protective bag has been opened, all die should be stored in a dry nitrogen environment.

**Cleanliness:** Handle the chips in a clean environment. DO NOT attempt to clean the chip using liquid cleaning systems.

**Static Sensitivity:** Follow ESD precautions to protect against ESD strikes.

**Transients:** Suppress instrument and bias supply transients while bias is applied. Use shielded signal and bias cables to minimize inductive pick-up.

**General Handling:** Handle the chip along the edges with a vacuum collet or with a sharp pair of bent tweezers. The surface of the chip has fragile air bridges and should not be touched with vacuum collet, tweezers, or fingers.

### **Mounting**

The chip is back-metallized and can be die mounted with AuSn eutectic preforms or with electrically conductive epoxy. The mounting surface should be clean and flat.

**Eutectic Die Attach:** A 80/20 gold tin preform is recommended with a work surface temperature of 255 °C and a tool temperature of 265 °C. When hot 90/10 nitrogen/hydrogen gas is applied, tool tip temperature should be 290 °C. DO NOT expose the chip to a temperature greater than 320 °C for more than 20 seconds. No more than 3 seconds of scrubbing should be required for attachment.

**Epoxy Die Attach:** Apply a minimum amount of epoxy to the mounting surface so that a thin epoxy fillet is observed around the perimeter of the chip once it is placed into position. Cure epoxy per the manufacturer's schedule.

### **Wire Bonding**

Ball or wedge bond with 0.025mm (1 mil) diameter pure gold wire. Thermosonic wirebonding with a nominal stage temperature of 150 °C and a ball bonding force of 40 to 50 grams or wedge bonding force of 18 to 22 grams is recommended. Use the minimum level of ultrasonic energy to achieve reliable wirebonds. Wirebonds should be started on the chip and terminated on the package or substrate. All bonds should be as short as possible <0.31mm (12 mils).

