

## GaAs MMIC 5-BIT DIGITAL PHASE SHIFTER, 15 - 18.5 GHz

### Typical Applications

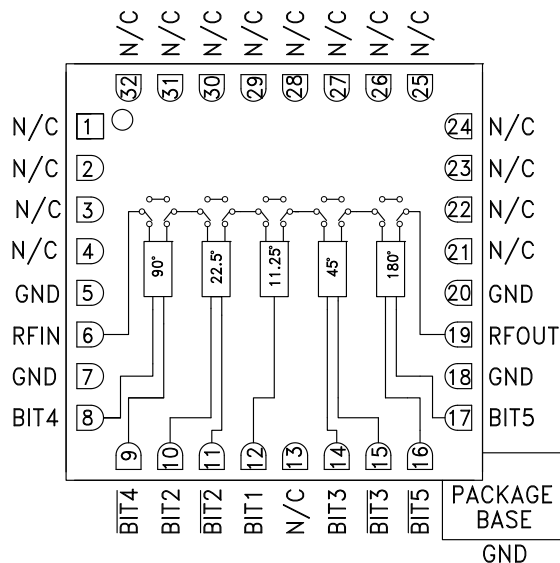
The HMC644ALC5 is ideal for:

- EW Receivers
- Weather & Military Radar
- Satellite Communications
- Beamforming Modules
- Phase Cancellation

### Features

- Low RMS Phase Error: 3.5°
- Low Insertion Loss: 7.5 dB
- High Linearity: +40 dBm
- 360° Coverage, LSB = 11.25°
- 32 Lead Ceramic SMT Package: 25mm<sup>2</sup>

### Functional Diagram



### General Description

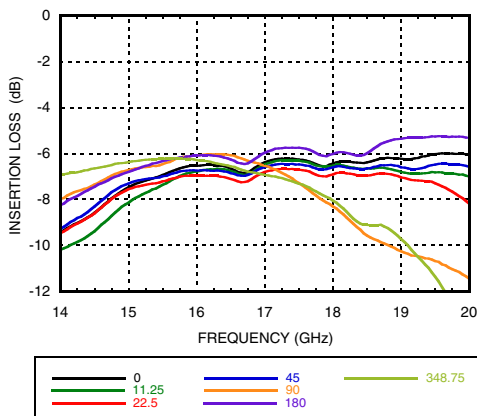
The HMC644ALC5 is a 5-bit digital phase shifter which is rated from 15 to 18.5 GHz, providing 360 degrees of phase coverage, with a LSB of 11.25 degrees. The HMC644ALC5 features very low RMS phase error of 3.5 degrees and extremely low insertion loss variation of  $\pm 0.5$  dB across all phase states. This high accuracy phase shifter is controlled with complementary logic of 0/-3V, and requires no fixed bias voltage. The HMC644ALC5 is housed in a compact 5x5 mm ceramic leadless SMT package and is internally matched to 50 Ohms with no external components. Simple external level shifting circuitry can be used to convert a positive CMOS control voltage into complementary negative control signals.

### Electrical Specifications, $T_A = +25^\circ\text{C}$ , 50 Ohm System, Control Voltage = 0/-3V

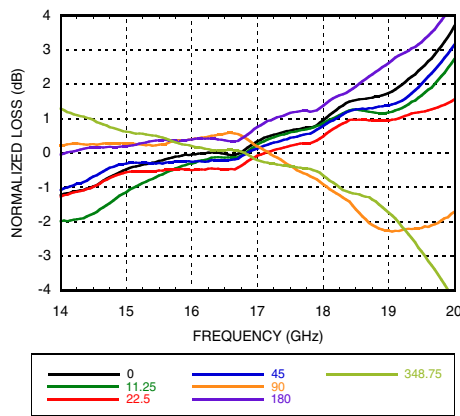
Parameter	Min.	Typ.	Max.	Units
Frequency Range	15		18.5	GHz
Insertion Loss		7.5	10	dB
Input Return Loss		10		dB
Output Return Loss		12		dB
Phase Error		$\pm 5$	+20 / -10	deg
RMS Phase Error		3.5		deg
Insertion Loss Variation		$\pm 0.5$		dB
Input Power for 1 dB Compression		23		dBm
Input Third Order Intercept		40		dBm
Control Voltage Current		<1		mA

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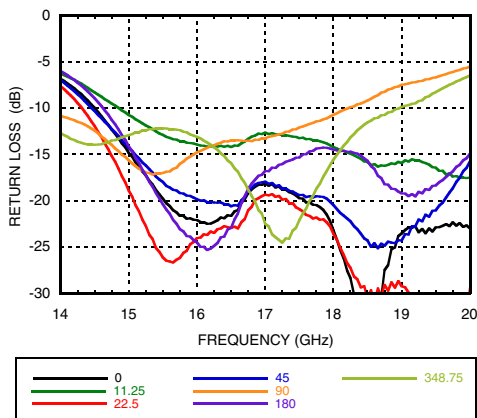
**Insertion Loss, Major States Only**



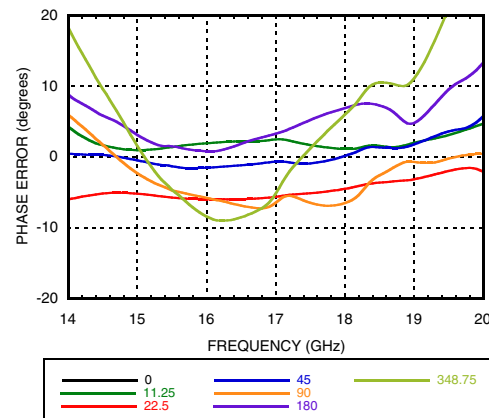
**Normalized Loss, Major States Only**



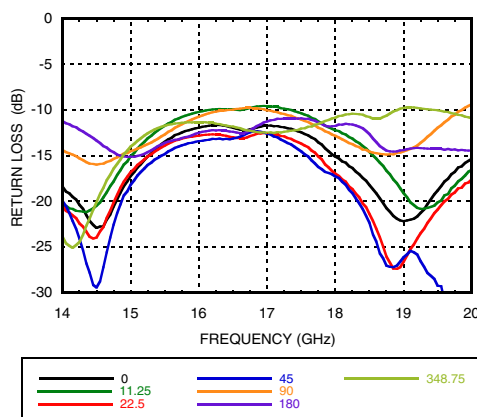
**Input Return Loss, Major States Only**



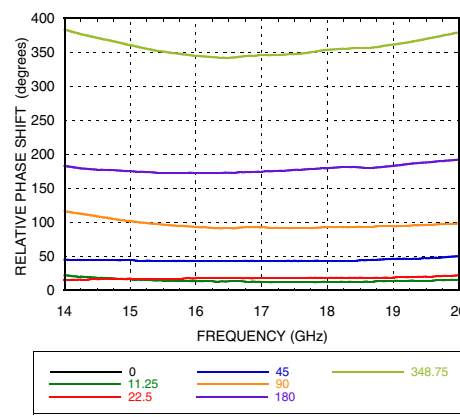
**Phase Error, Major States Only**



**Output Return Loss, Major States Only**

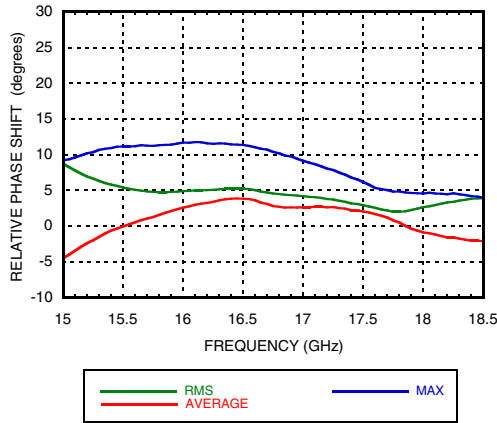


**Relative Phase Shift  
Major States Including All Bits**

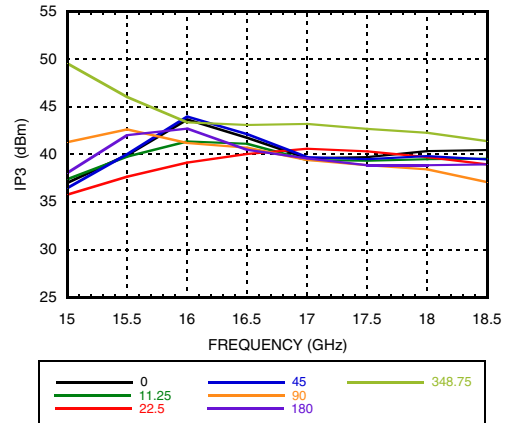


**GaAs MMIC 5-BIT DIGITAL  
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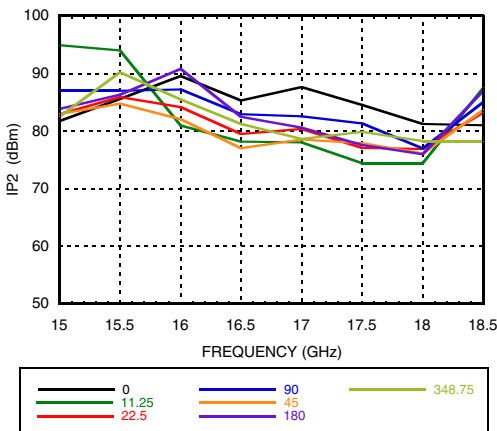
**Relative Phase Shift,  
RMS, Average, Max, All States**



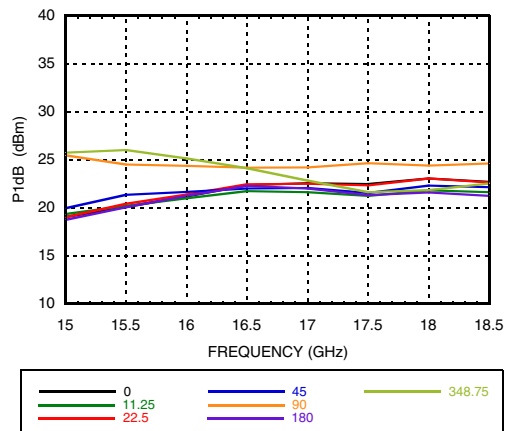
**Input IP3, Major States Only**



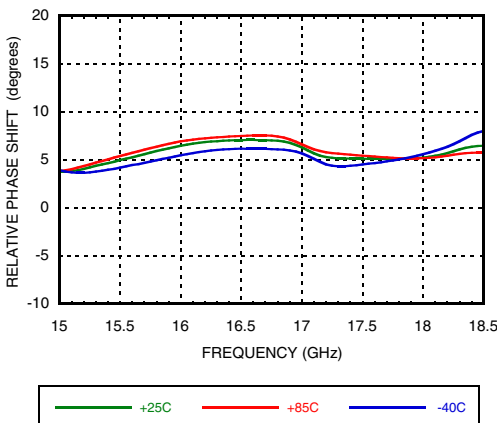
**Input IP2, Major States Only**



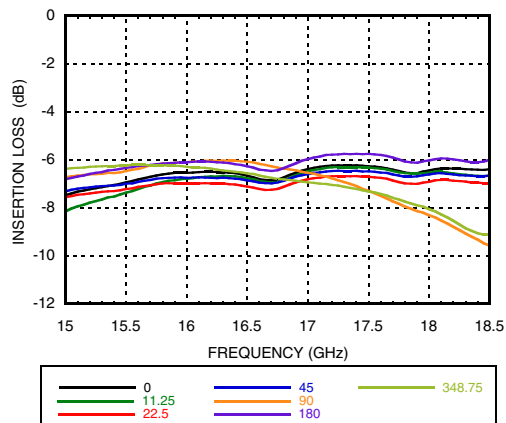
**Input P1dB, Major States Only**



**RMS Phase Error vs. Temperature**

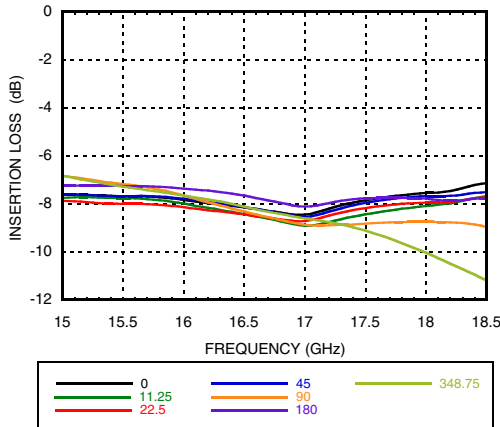


**Insertion Loss +25C, Major States Only**

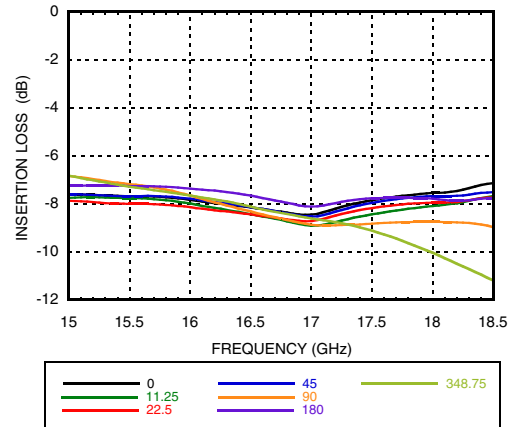


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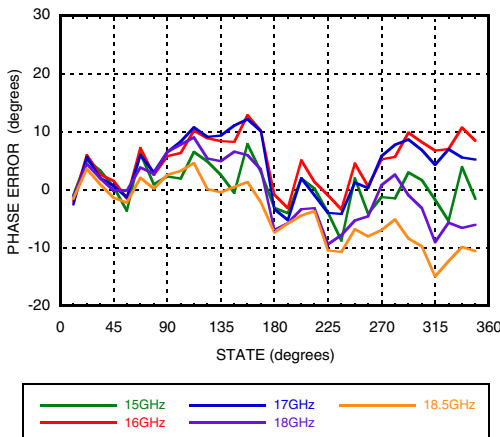
**Insertion Loss +85C, Major States Only**



**Insertion Loss -40C, Major States Only**



**Phase Error vs. State, Major States Only**



**Absolute Maximum Ratings**

Input Power (RFIN)	26 dBm (T= +85 °C)
Channel Temperature (Tc)	150 °C
Thermal Resistance (channel to ground paddle)	150 °C/W
Storage Temperature	-65 to +150 °C
Operating Temperature	-40 to +85 °C
ESD sensitivity(HBM)	Class 0 Passed 100V

**Control Voltage**

State	Bias Condition
Low (0)	-2.5 to -3.5V @ 0.4 μA Typ.
High (1)	0 to +0.3V @ 0.4 μA Typ.



**ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS**

**Truth Table**

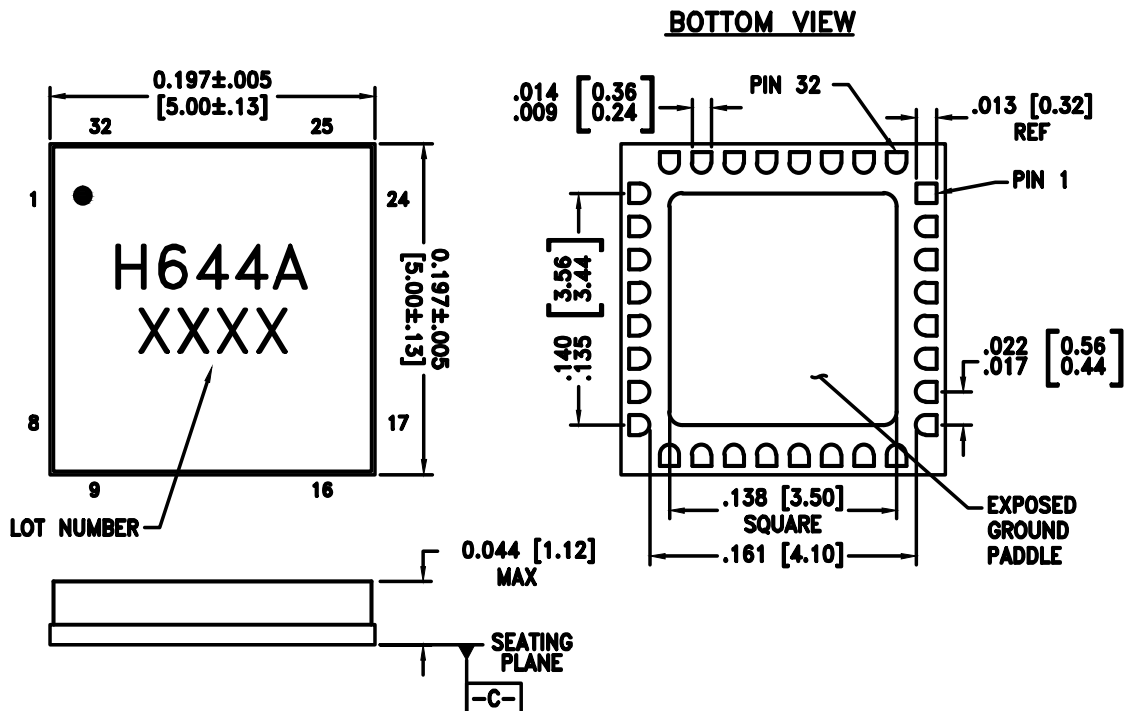
Control Voltage Input									Phase Shift (Degrees) RFIN - RFOUT
Bit 1	Bit 2	Bit 2	Bit 3	Bit 3	Bit 4	Bit 4	Bit 5	Bit 5	
0	0	1	0	1	0	1	0	1	Reference*
1	0	1	0	1	0	1	0	1	11.25
0	1	0	0	1	0	1	0	1	22.5
0	0	1	1	0	0	1	0	1	45.0
0	0	1	0	1	1	0	0	1	90.0
0	0	1	0	1	0	1	1	0	180.0
1	1	0	1	0	1	0	1	0	348.75

**Any combination of the above states will provide a phase shift approximately equal to the sum of the bits selected.**

**\*Reference corresponds to monotonic setting**

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**Outline Drawing**



**NOTES:**

1. PACKAGE BODY MATERIAL: ALUMINA
2. LEAD AND GROUND PADDLE PLATING: 30-80 MICROINCHES GOLD OVER  
50 MICROINCHES MINIMUM NICKEL.
3. DIMENSIONS ARE IN INCHES [MILLIMETERS].
4. LEAD SPACING TOLERANCE IS NON-CUMULATIVE
5. PACKAGE WARP SHALL NOT EXCEED 0.05mm DATUM -C-
6. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.


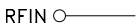

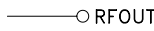
**Package Information**

Part Number	Package Body Material	Lead Finish	MSL Rating	Package Marking [2]
HMC644ALC5	Alumina, White	Gold over Nickel	MSL3 [1]	H644A 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 - 4, 13 21 - 32	N/C	No connection required. These pins may be connected to RF/DC ground without affecting performance.	
5, 7, 18, 20	GND	These pins and exposed ground paddle must be connected to RF/DC ground.	
6	RFIN	This port is DC coupled and matched to 50 Ohms.	
8, 10, 12, 14, 17	BIT4, BIT2, BIT1, BIT3, BIT5	Non-Inverted Control Input. See truth table and control voltage tables.	
9, 11, 15, 16	$\overline{\text{BIT4}}$ , $\overline{\text{BIT2}}$ $\overline{\text{BIT3}}$ , $\overline{\text{BIT5}}$	Inverted Control Input. See truth table and control voltage tables.	
19	RFOUT	This port is DC coupled and matched to 50 Ohms.	

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**Application Circuit**

This circuit converts a single line positive (0/+5V) control signal to complementary negative (0/-3V) control signals.

