

## 22.5° MMIC 4-BIT DIGITAL PHASE SHIFTER, 8 - 12 GHz

### Typical Applications

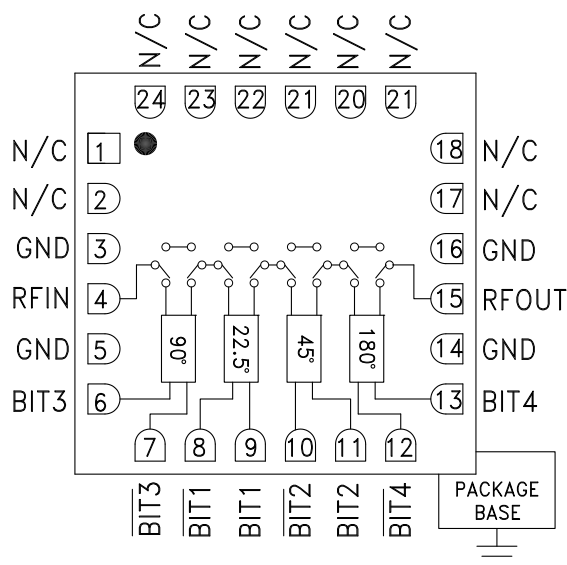
The HMC543ALC4B is ideal for:

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

### Features

- Low RMS Phase Error: 4°
- Low Insertion Loss: 6.5 dB
- Excellent Flatness
- 360° Coverage, LSB = 22.5°
- 24 Lead Ceramic SMT Package: 16mm<sup>2</sup>

### Functional Diagram



### General Description

The HMC543ALC4B is a 4-bit digital phase shifter which is rated from 8 to 12 GHz, providing 0 to 360 degrees of phase coverage, with a LSB of 22.5 degrees. The HMC543ALC4B features very low RMS phase error of 4 degrees and extremely low insertion loss variation of  $\pm 0.8$  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 HMC543ALC4B is housed in a compact 4x4 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.

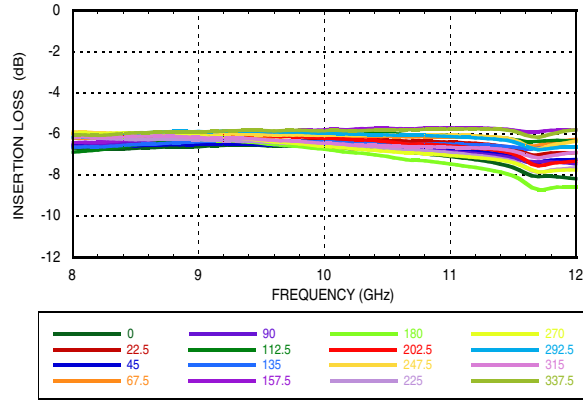
### Electrical Specifications, $T_A = +25^\circ\text{C}$ , 50 Ohm System, Control Voltage = 0/-3V

| Parameter                        | Min.            | Typ.      | Max.     | Units         |
|----------------------------------|-----------------|-----------|----------|---------------|
| Frequency Range                  | 8               |           | 12       | GHz           |
| Insertion Loss*                  | 8.0 - 11.0 GHz  | 6.5       | 8        | dB            |
|                                  | 11.0 - 12.0 GHz | 7.5       | 9.5      | dB            |
| Input Return Loss*               | 8.0 - 12.0 GHz  | 10        |          | dB            |
| Output Return Loss*              | 8.0 - 12.0 GHz  | 10        |          | dB            |
| Phase Error*                     | 8.0 - 12.0 GHz  | +5/-10    | $\pm 15$ | deg           |
| RMS Phase Error                  | 8.0 - 12.0 GHz  | 4         |          | deg           |
| Gain Variation*                  | 8.0 - 11.0 GHz  | $\pm 0.8$ |          | dB            |
|                                  | 11.0 - 12.0 GHz | $\pm 1.5$ |          | dB            |
| Input Power for 1 dB Compression | 8.0 - 12.0 GHz  | 21        | 24.5     | dBm           |
| Input Third Order Intercept      | 8.0 - 12.0 GHz  |           | 40       | dBm           |
| Control Voltage Current          | 8.0 - 12.0 GHz  | 0.4       |          | $\mu\text{A}$ |

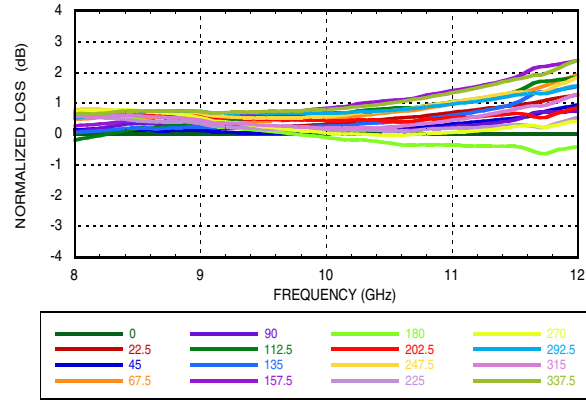
\*Note: All States Shown

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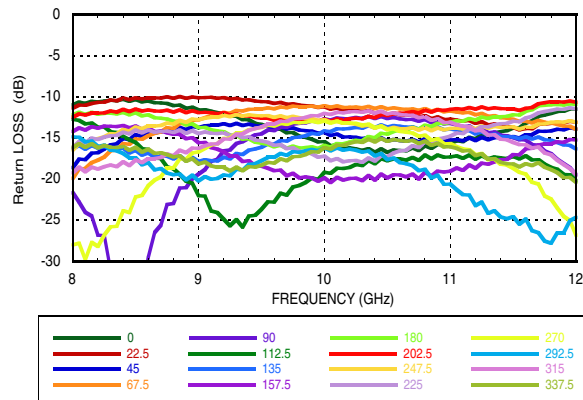
**Insertion Loss, All States**



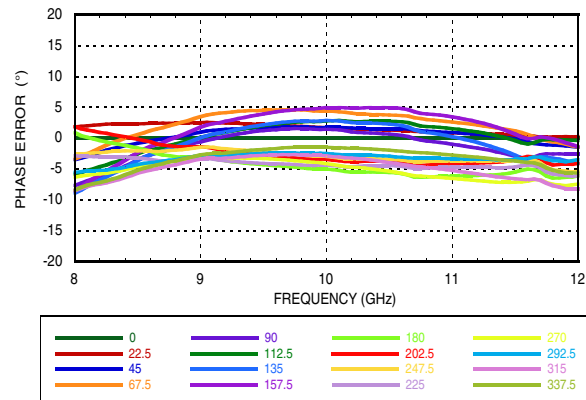
**Normalized Loss, All States**



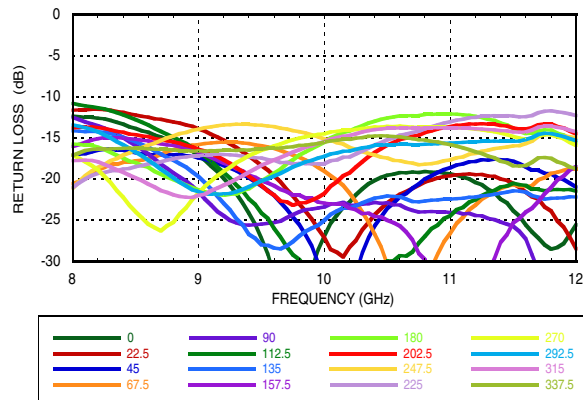
**Input Return Loss, All States**



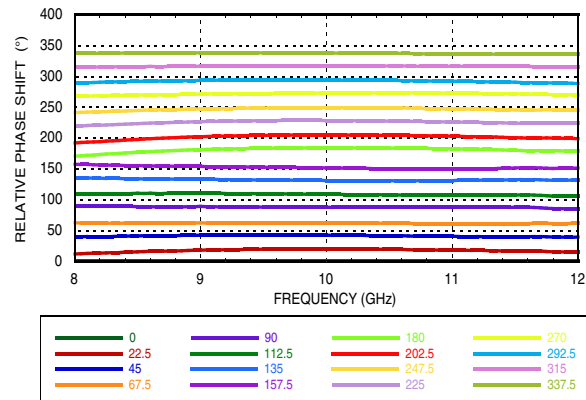
**Phase Error, All States**



**Output Return Loss, All States**

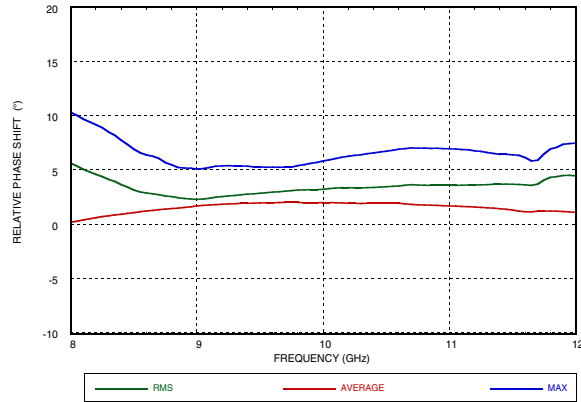


**Relative Phase Shift, All States**

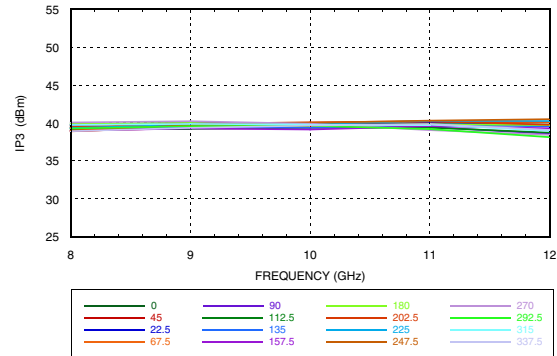


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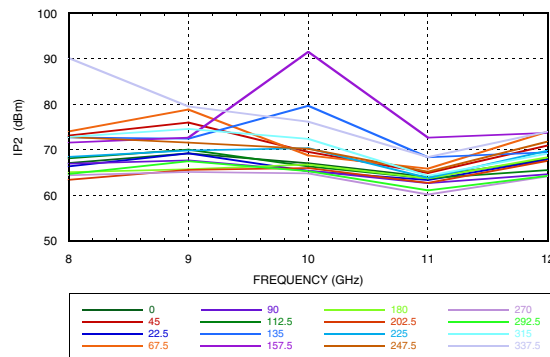
**Relative Phase Shift,  
RMS, Average, Max, All States**



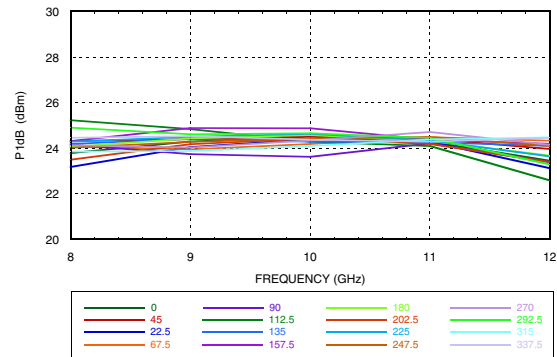
**Input IP3, All States**



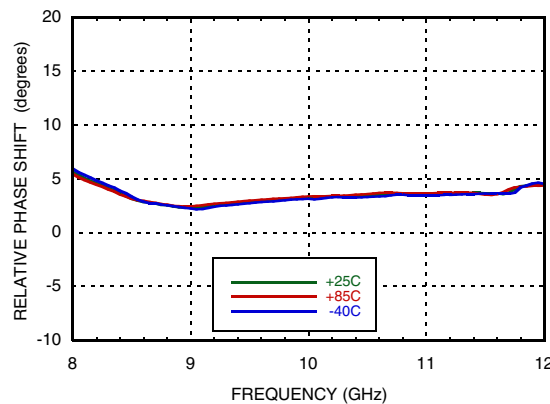
**Input IP2, All States**



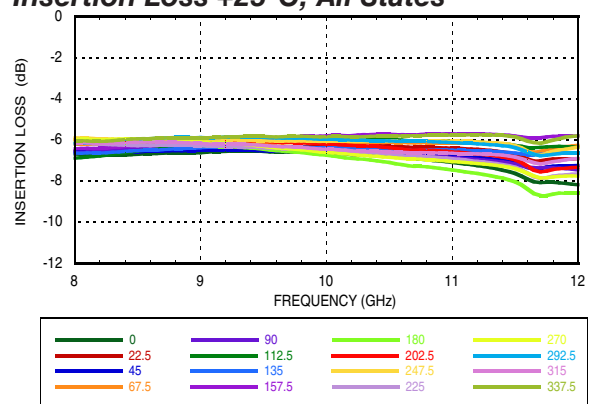
**Input P1dB, All States**



**RMS Phase Error vs. Temperature**

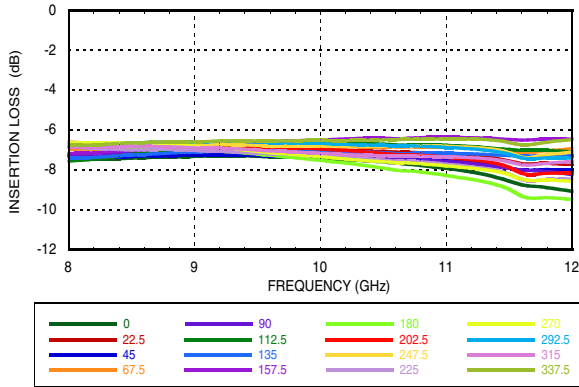


**Insertion Loss +25°C, All States**

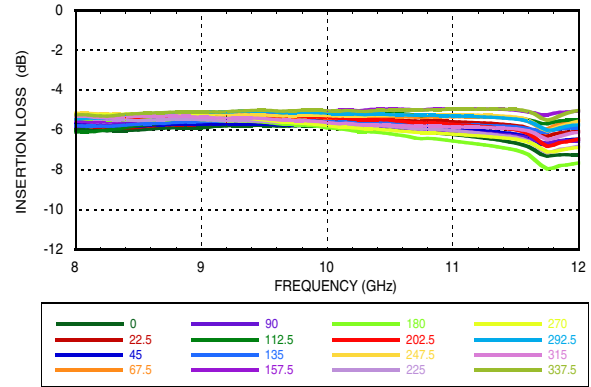


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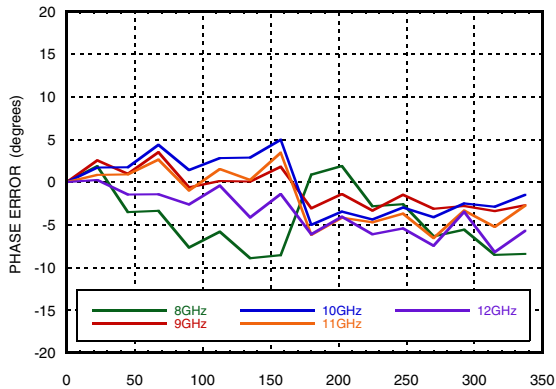
**Insertion Loss +85°C, All States**



**Insertion Loss -40°C, All States**



**Phase Error vs. State**



**Absolute Maximum Ratings**

|   |                     |
|---|---------------------|
| Input Power (RFin) (8-11 GHz)                 | +27 dBm (T= +85 °C) |
| Channel Temperature (Tc)                      | 150 °C              |
| Thermal Resistance (channel to ground paddle) | 130 °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

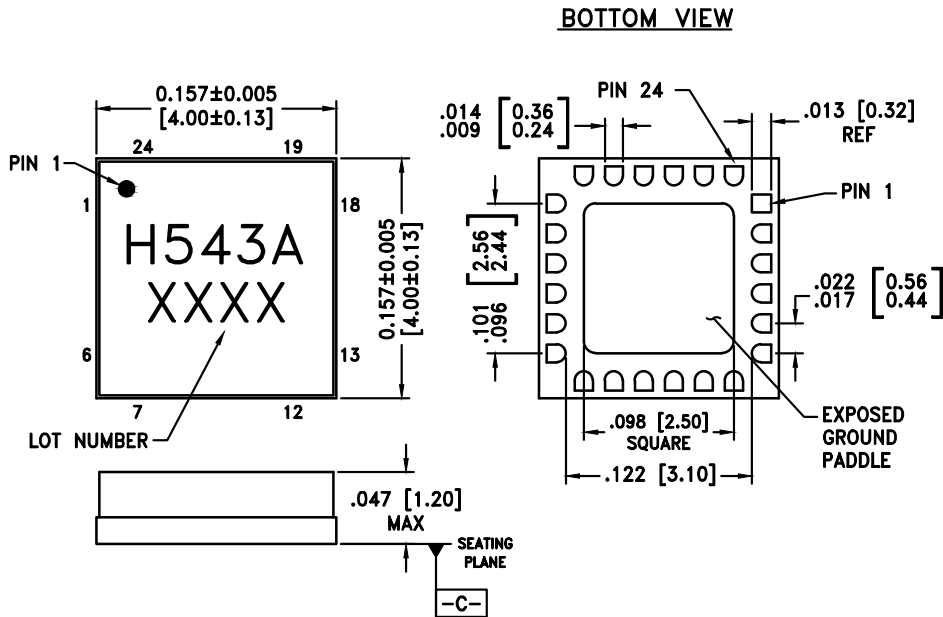
**Truth Table**

| Control Voltage Input |       |       |       |       |       |       |       | Phase Shift (Degree)<br>RFIN - RFOUT |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|--------------------------------------|
| Bit 1                 | Bit 1 | Bit 2 | Bit 2 | Bit 3 | Bit 3 | Bit 4 | Bit 4 |                                      |
| 0                     | 1     | 0     | 1     | 0     | 1     | 0     | 1     | Reference                            |
| 1                     | 0     | 0     | 1     | 0     | 1     | 0     | 1     | 22.5                                 |
| 0                     | 1     | 1     | 0     | 0     | 1     | 0     | 1     | 45.0                                 |
| 0                     | 1     | 0     | 1     | 1     | 0     | 0     | 1     | 90.0                                 |
| 0                     | 1     | 0     | 1     | 0     | 1     | 1     | 0     | 180.0                                |
| 1                     | 0     | 1     | 0     | 1     | 0     | 1     | 0     | 337.5                                |

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

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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**


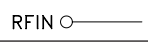

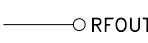
| Part Number | Package Body Material | Lead Finish      | MSL Rating          | Package Marking <sup>[2]</sup> |
|-------------|-----------------------|------------------|---------------------|--------------------------------|
| HMC543ALC4B | Alumina, White        | Gold over Nickel | MSL3 <sup>[1]</sup> | H543A<br>XXXX                  |

[1] Max peak reflow temperature of 260 °C

[2] 4-Digit lot number XXXX

## 22.5° MMIC 4-BIT DIGITAL PHASE SHIFTER, 8 - 12 GHz

### Pin Descriptions

| Pin Number    | Function   | Description  | Interface Schematic   |
|---------------|--|--|---|
| 1, 2, 17 - 24 | N/C  | No connection required. These pins may be connected to RF/DC ground without affecting performance. |   |
| 3, 5, 14, 16  | GND  | These pins and exposed ground paddle must be connected to RF/DC ground.                            |  |
| 4             | RFIN   | This port is matched to 50 Ohms.   |  |
| 6, 9, 11, 13  | BIT3, BIT1, BIT2, BIT4   | Non-Inverted Control Input. See truth table and control voltage tables.                            |  |
| 7, 8, 10, 12  | $\overline{\text{BIT3}}, \overline{\text{BIT1}}$<br>$\overline{\text{BIT2}}, \overline{\text{BIT4}}$ | Inverted Control Input. See truth table and control voltage tables.                                |   |
| 15            | RFOUT  | This port is matched to 50 Ohms.   |  |

### Application Circuit

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

