

### Typical Applications

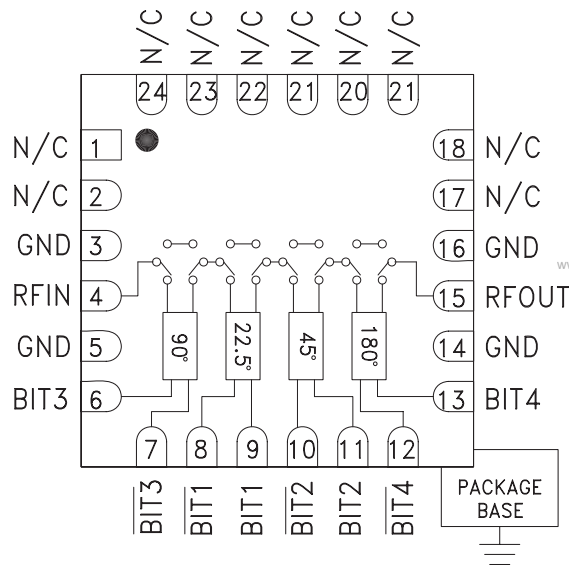
The HMC543LC4B is ideal for:

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

### Features

- Low RMS Phase Error: 5°
- 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 HMC543LC4B 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 HMC543LC4B features very low RMS phase error of 5 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 HMC543LC4B 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

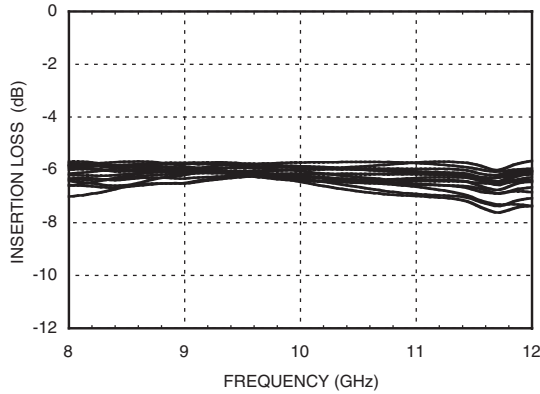
Parameter	Min.	Typ.	Max.	Units
Frequency Range	8		12	GHz
Insertion Loss*		6.5	8	dB
Input Return Loss*		10		dB
Output Return Loss*		10		dB
Phase Error*		$\pm 10$	$\pm 15$	deg
RMS Phase Error		5		deg
Gain Variation*		$\pm 0.8$		dB
Input Power for 1 dB Compression	21	24.5		dBm
Input Third Order Intercept		40		dBm
Control Voltage Current		7		mA

\*Note: All States Shown

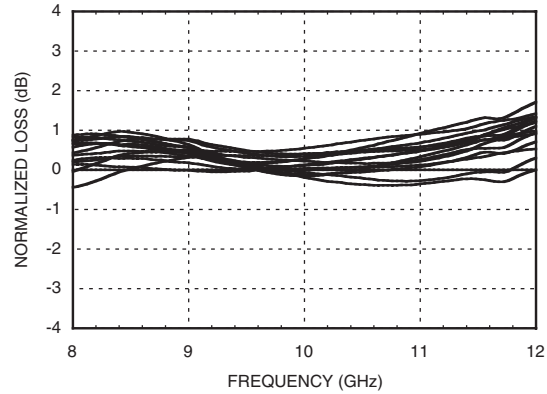


**22.5° MMIC 4-BIT DIGITAL  
PHASE SHIFTER, 8 - 12 GHz**

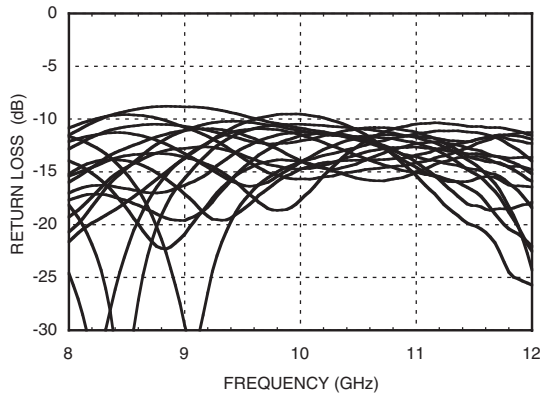
**Insertion Loss, All States**



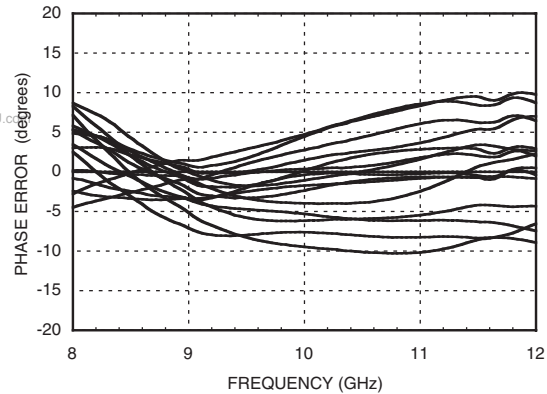
**Normalized Loss, All States**



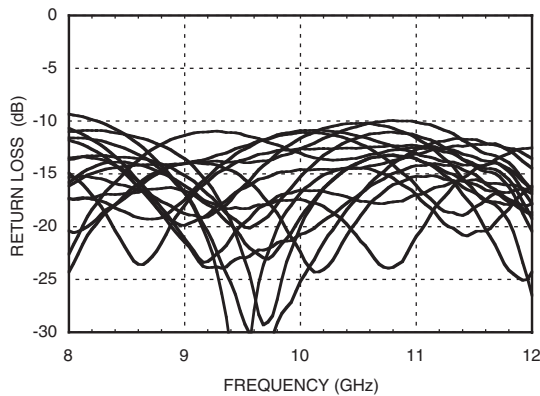
**Input Return Loss, All States**



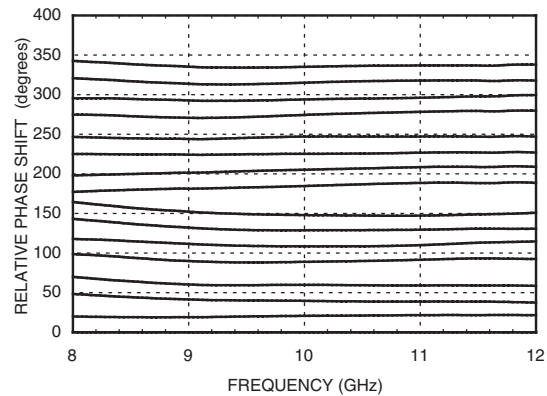
**Phase Error, All States**



**Output Return Loss, All States**



**Relative Phase Shift, All States**



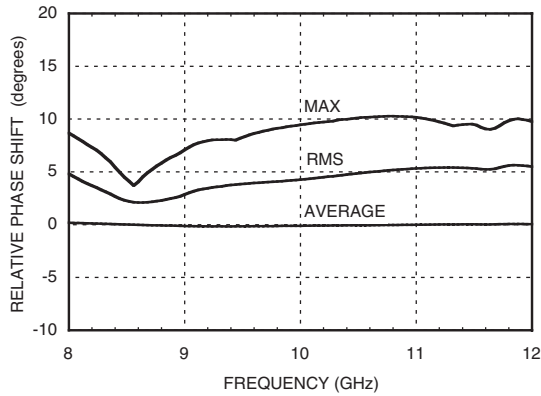


## 22.5° MMIC 4-BIT DIGITAL PHASE SHIFTER, 8 - 12 GHz

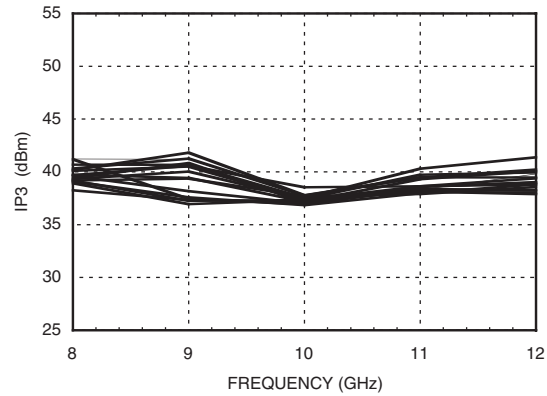
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PHASE SHIFTERS - SMT

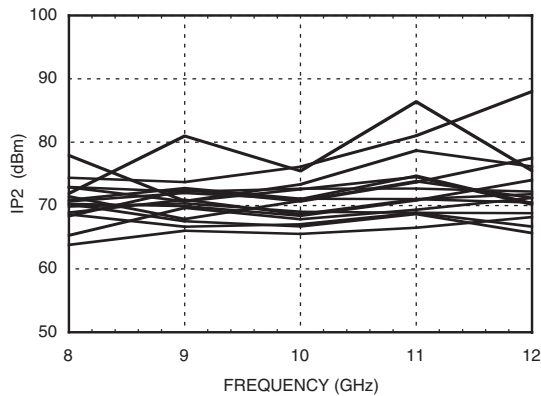
**Relative Phase Shift, RMS, Average, Max, All States**



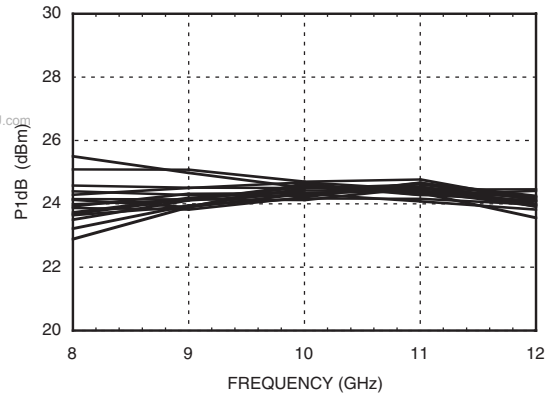
**Input IP3, All States**



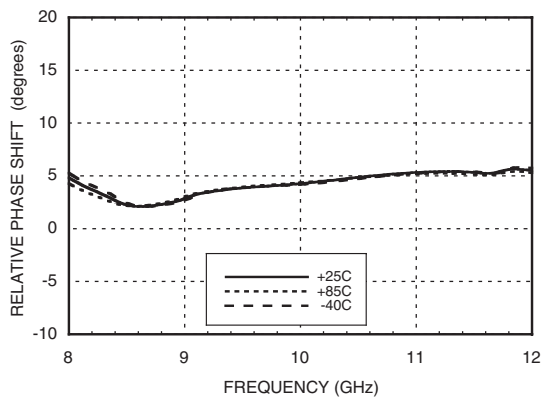
**Input IP2, All States**



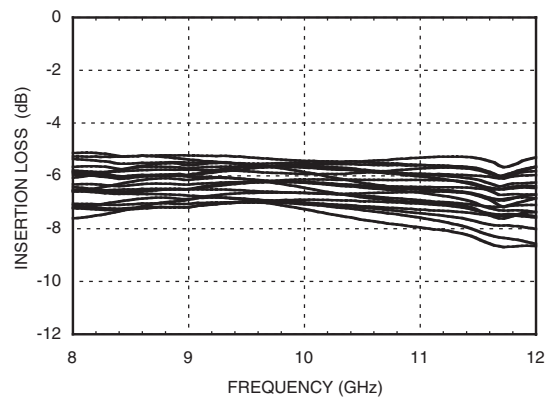
**Input P1dB, All States**



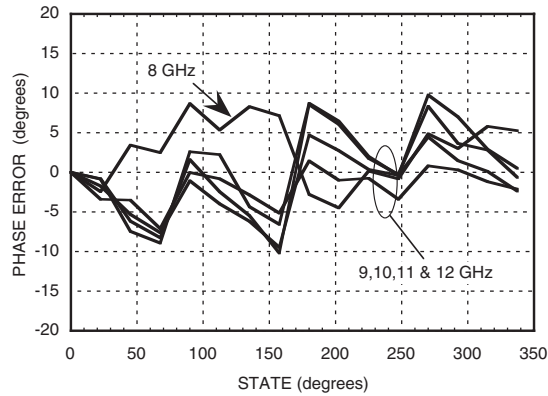
**RMS Phase Error vs. Temperature**



**Insertion Temperature All States**



### Phase Error vs. State



### Absolute Maximum Ratings

Input Power (RFin) (8-12 GHz)	+27 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 1B

### Control Voltage

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



**ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS**

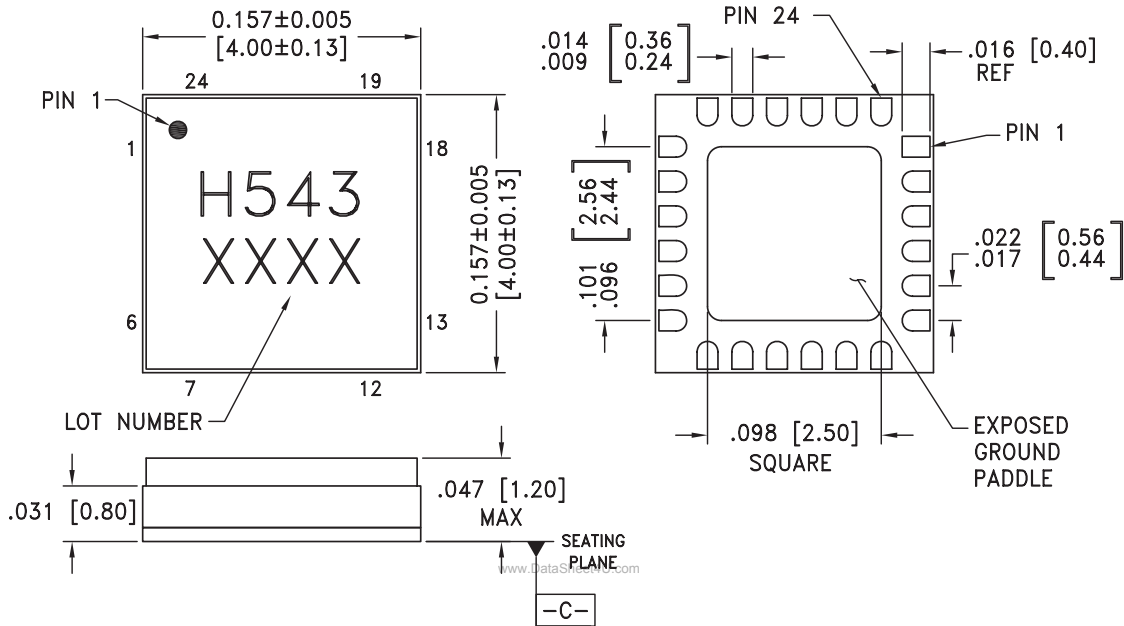
### Truth Table

Control Voltage Input								Phase Shift (Degree) RFIN - RFOUT
Bit 1	$\overline{\text{Bit 1}}$	Bit 2	$\overline{\text{Bit 2}}$	Bit 3	$\overline{\text{Bit 3}}$	Bit 4	$\overline{\text{Bit 4}}$	
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.

**Outline Drawing**

**BOTTOM VIEW**


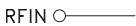


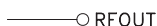


**NOTES:**

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.
7. CLASSIFIED AS MOISTURE SENSITIVITY LEVEL (MSL) 1.



**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	BIT1, BIT2, BIT3, BIT4	Non-Inverted Control Input. See truth table and control voltage tables.	
7, 8, 10, 12	$\overline{\text{BIT1}}, \overline{\text{BIT2}}$ $\overline{\text{BIT3}}, \overline{\text{BIT4}}$	Inverted Control Input. See truth table and control voltage tables.	
15	RFOUT	This port is matched to 50 Ohms.	

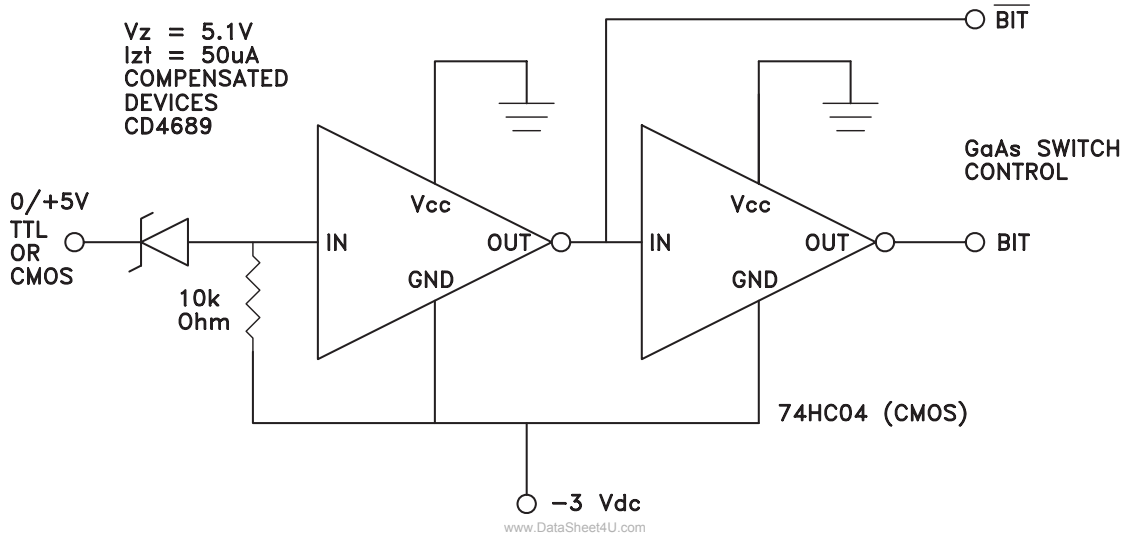
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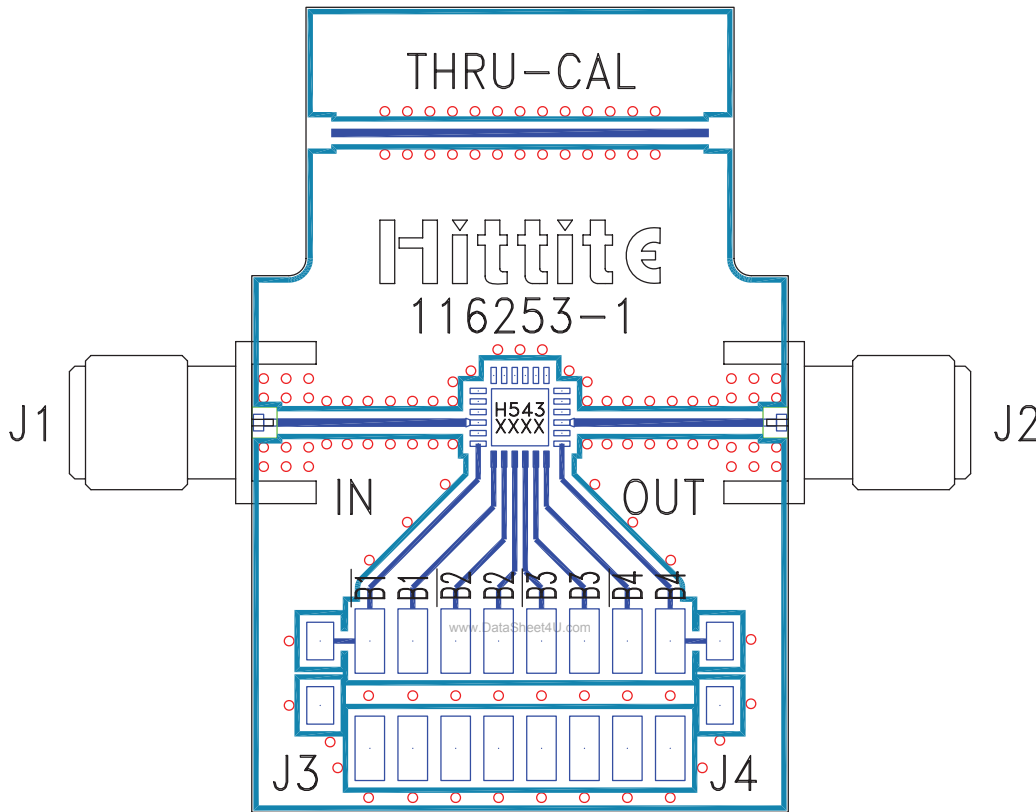
### 22.5° MMIC 4-BIT DIGITAL PHASE SHIFTER, 8 - 12 GHz

#### Application Circuit

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



### Evaluation PCB



### List of Materials for Evaluation PCB 108812 [1]

Item	Description
J1 - J2	PCB Mount SMA RF Connector
J3 - J4	Molex Header 2mm
U1	HMC543LC4B 4-Bit Digital Phase Shifter
PCB [2]	116253 Eval Board

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350

The circuit board used in the final 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 board should be mounted to an appropriate heat sink. The evaluation circuit board shown is available from Hittite upon request.