Digital Phase Shifter, 6 Bit, 8 - 12 GHz

MAPS-010166-DIE
Rev. V1

Features

- 6 Bit Digital Phase Shifter
- 360° Coverage with LSB = 5.6°
- Parallel Control
- Low DC Power Consumption
- Minimal Attenuation Variation over Phase Shift Range
- Bidirectional RF Input/Output
- EAR99
- Bare Die
- RoHS* Compliant

Applications

- Cellular Infrastructure
- Phase Array Radars
- Frequency Upconverters
- Test Instruments
- General Purpose

Description

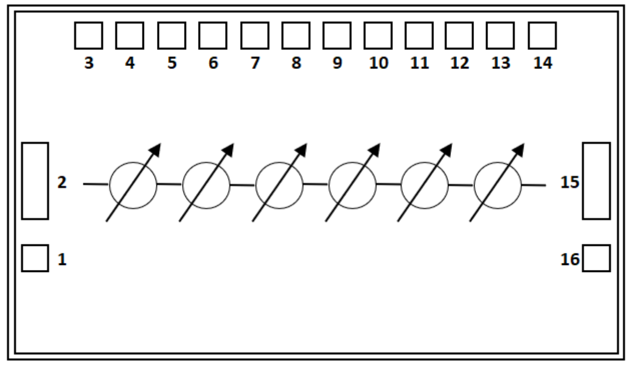
The MAPS-010166-DIE is a GaAs pHEMT 6-bit X-band digital phase shifter. Step size is 5.6° providing phase shift from 0° to 360° in 5.6° steps. This design has been optimized to minimize variation in attenuation over the phase shift range.

The MAPS-010166-DIE is ideally suited for use where high phase accuracy with minimum loss variation over the phase shift range are required. Typical applications include communications antennas and phased array radars. The die size is 2.44 x 1.34 x 0.1 mm.

Ordering Information

Part Number	Package
MAPS-010166-DIE	Bare Die

Functional Schematic



Pad Configuration[1]

Pad #	Name	Function
1, 16	GND	Ground
2	RF_{IN}	RF Input
3	A1	5.6° Control
4, 6	N/C	No Connect
5	A2	11.2° Control
7	A3	22.5° Control
8	B3	22.5° Control
9	A4	45° Control
10	B4	45° Control
11	A5	90° Control
12	B5	90° Control
13	A6	180° Control
14	B6	180° Control
15	RF_{OUT}	RF Output

1. The backside of the die must be connected to RF, DC, and thermal ground.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

Electrical Specifications:
Freq. = 8 - 12 GHz, T_A = 25°C, Z_0 = 50 Ω, P_{IN} = 0 dBm, V_L = -5 V & V_H = 0 V

Parameter	Test Conditions	Units	Min. 8 GHz / 12 GHz	Typ.	Max. 8 GHz / 12 GHz
Insertion Loss (Any Phase State)	Any Phase State	dB	—	5.0	7.0 / 8.75
Attenuation Variation	Across All Phase States	dB	—	± 1.4	1.9 / 3.2
RMS Attenuation Error	All Values Relative to Insertion Loss at Reference Phase	dB	—	0.7	—
RMS Phase Error [2]	All Values Relative to Reference Phase	Deg.	—	3.0	—
Phase Accuracy Relative to Reference Loss State	5.6 Degree Bit 11.2 Degree Bit 22.5 Degree Bit 45 Degree Bit 90 Degree Bit 180 Degree Bit Sum of All Bits	Deg.	4.5 / 4.25 8.5 / 6.5 22 / 23 44 / 39.5 89.5 / 90.5 176 / 179 -4.5 / -0.5	— — — — — — —	6.5 / 7.25 10.5 / 9.5 26 / 27 49 / 44.5 95 / 96 183 / 186 3.5 / 7.5
VSWR	RF IN / RF OUT	Ratio	—	1.8:1	—
1 dB Compression	Reference State	dBm	—	27	—
Input IP3	Two-tone inputs up to +5 dBm	dBm	—	45	—
T_{RISE}, T_{FALL}	10% to 90% RF, 90% to 10% RF	ns	—	50	—

2. RMS is calculated across all 64 amplitude or phase states relative to the amplitude or phase in the 0° phase state at a given frequency.

$$\delta phase\_RMS = \sqrt{\frac{1}{n}\sum_{m=1}^{n}\delta^2 phase - \left(\frac{1}{n}\sum_{m=1}^{n}\delta phase\right)^2}$$

Truth Table[3] (Major BITs)

A1	B2	A2	B3	A3	B3	A4	B4	A5	B5	A6	B6	Phase Shift
V_L	X	V_L	X	V_L	V_H	V_L	V_H	V_L	V_H	V_L	V_H	Reference Phase
V_H	**X**	V_L	X	V_L	V_H	V_L	V_H	V_L	V_H	V_L	V_H	5.6°
V_L	X	**V_H**	**X**	V_L	V_H	V_L	V_H	V_L	V_H	V_L	V_H	11.2°
V_L	X	V_L	X	**V_H**	**V_L**	V_L	V_H	V_L	V_H	V_L	V_H	22.5°
V_L	X	V_L	X	V_L	V_H	**V_H**	**V_L**	V_L	V_H	V_L	V_H	45°
V_L	X	V_L	X	V_L	V_H	V_L	V_H	**V_H**	**V_L**	V_L	V_H	90°
V_L	X	V_L	X	V_L	V_H	V_L	V_H	V_L	V_H	**V_H**	**V_L**	180°
V_H	**X**	**V_H**	**X**	**V_H**	**V_L**	**V_H**	**V_L**	**V_H**	**V_L**	**V_H**	**V_L**	354.4°

3. V_L = -5 V, V_H = 0 V.

Maximum Operating Conditions

Parameter	Maximum
Input Power	27 dBm
Input Voltage	0 to -5 V
Operating Temperature	-40ºC to +85ºC

Absolute Maximum Ratings[4,5]

Parameter	Absolute Maximum
Input Power	29 dBm
Operating Temperature	-40ºC to +85ºC
Storage Temperature	-65ºC to +150ºC

4. Exceeding any one or combination of these limits may cause permanent damage to this device.
5. MACOM does not recommend sustained operation near these survivability limits.

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these 200 V HBM, Class 0B devices.

Mounting and Bonding Information

The DIE should be directly attached to the RF/DC ground plane; either with solder (AuSn) or a thin application of conductive epoxy. Avoid overflows.

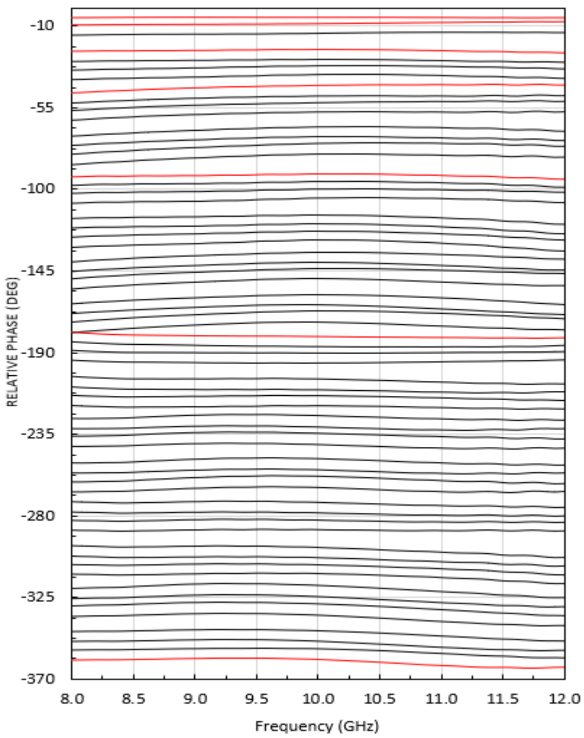
Any connecting microstrip (50 Ω Transmission Line) substrate should be brought as close as possible to the die in order to minimize bond wire inductance. A typical spacing between die and microstrip substrate should be kept between 75 - 125 µm for best RF behavior.

Two Bond-Wires are recommended on pad 2, and 15 (1mil diameter each). All bonds should be kept as short as possible.

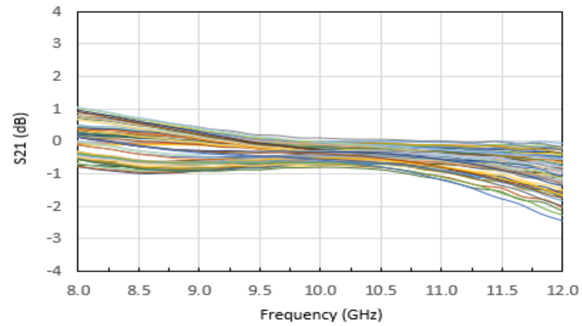
Use minimum ultrasonic energy for reliable wire bonds.

Typical Performance Curves

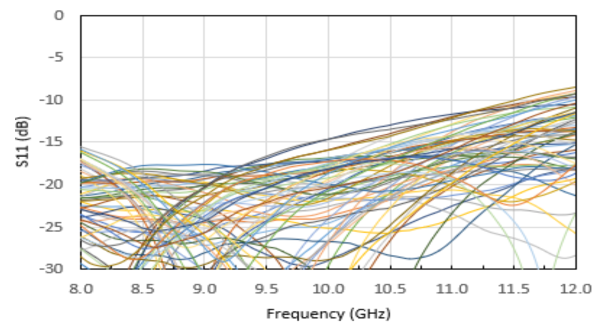
Normalized Phase Shift vs. Frequency



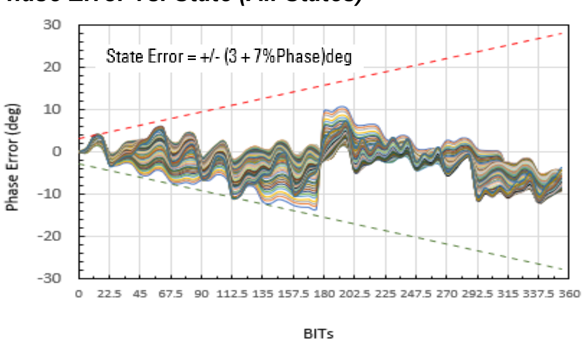
Normalized Attenuation Variation



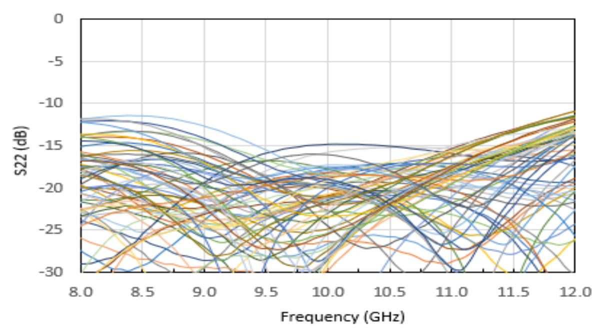
Input Return Loss (All States)



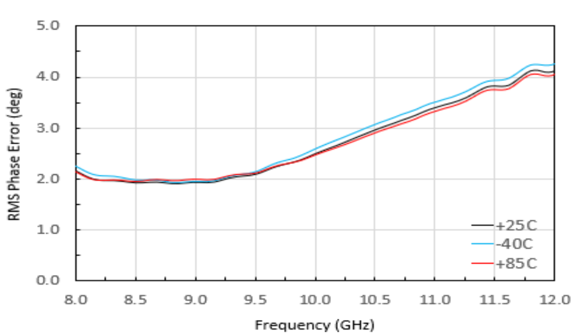
Phase Error vs. State (All States)



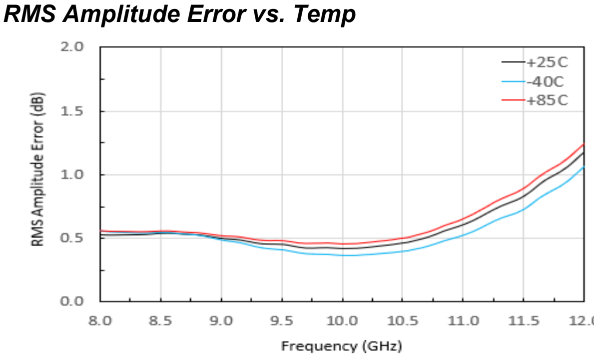
Output Return Loss (All States)



RMS Phase Error vs. Temp

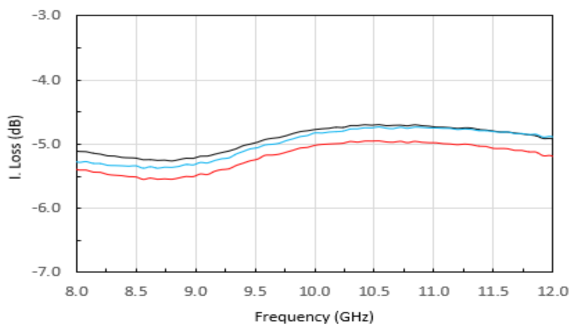


RMS Amplitude Error vs. Temp

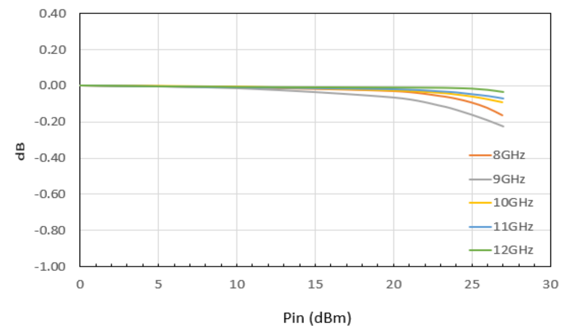


Typical Performance Curves

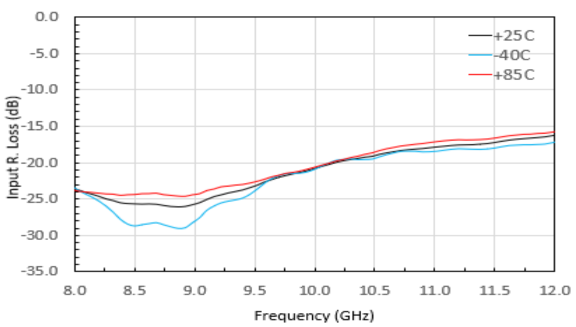
Insertion Loss vs. Temp



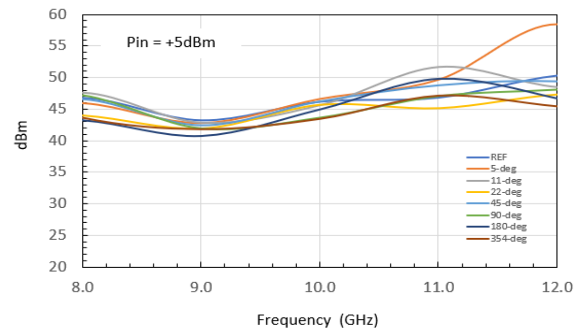
P1dB vs. P_{IN} and Frequency



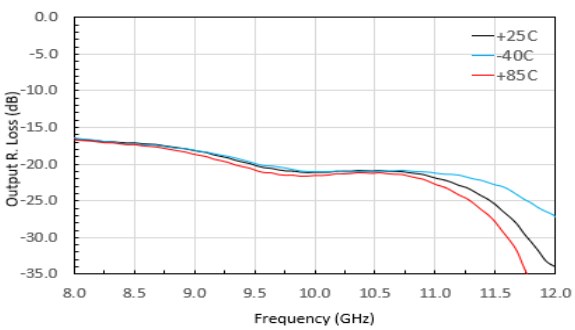
Input Return Loss vs. Temp



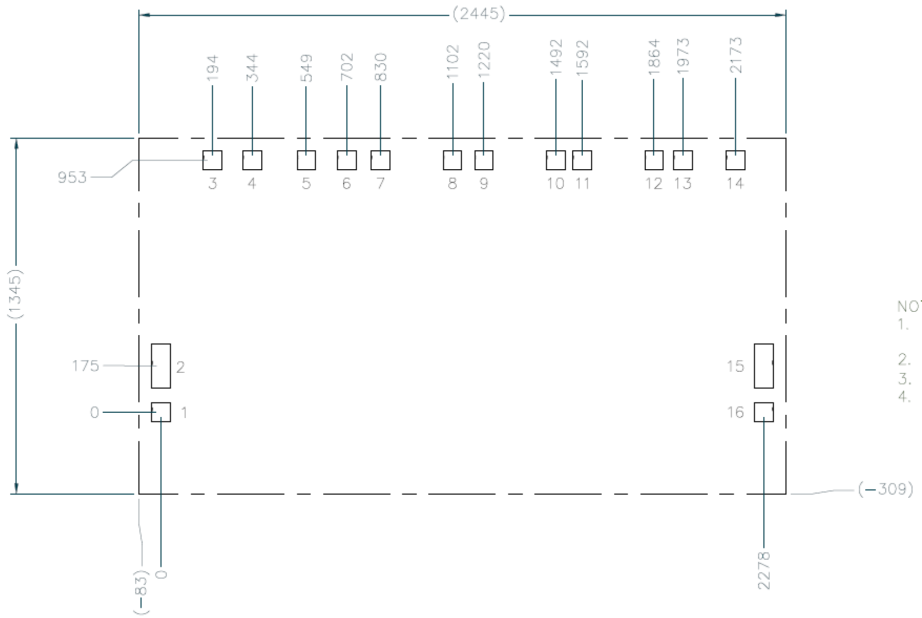
I_IP3 vs. BITs and Frequency



Output Return Loss vs. Temp



Die Outline



BOND PAD DIM (μm)		
PAD	X	Y
1,3,4,5,6,7, 8,9,10,11, 12,13,14,16	70	70
2,15	70	167

NOTES:
1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS SHOWN ARE μm WITH A TOLERANCE OF ±5μm.
2. DIE THICKNESS IS 100 ±10μm
3. BOND PAD/BACKSIDE METALLIZATION: GOLD.
4. DIE SIZE REFLECTS FINAL CUT DIMENSIONS.