

GENERAL DESCRIPTION

The AP302 is a high-performance GaAs MMIC 6-bit digital phase shifter which covers the frequency range 8 to 12 GHz and can be used in Radar and Telecommunication applications. It has no on-chip digital control logic and is controlled only by 0/-3.3 voltages. This chip is manufactured using 0.5 μm gate length pHEMT process (pHEMT05 from Svetlana-Rost, JSC). The MMIC uses gold bond pads and backside metallization and is fully protected with Silicon Nitride and BCB passivation to obtain the highest level of reliability.

CHIP LAYOUT



MAIN FEATURES

- Operating range 8 to 12 GHz
- Insertion loss 6.5 dB at 10 GHz
- Phase shift range 355° (6 bit, 64 states, 5.625° step)
- Parallel Data Input (0/-3.3V control signals)
- 100% On-Wafer DC and RF Tested
- 100% Visual Inspection to MIL-STD-883 Method 2010
- Chip size 3150×2100 μm^2 , thickness 100 μm

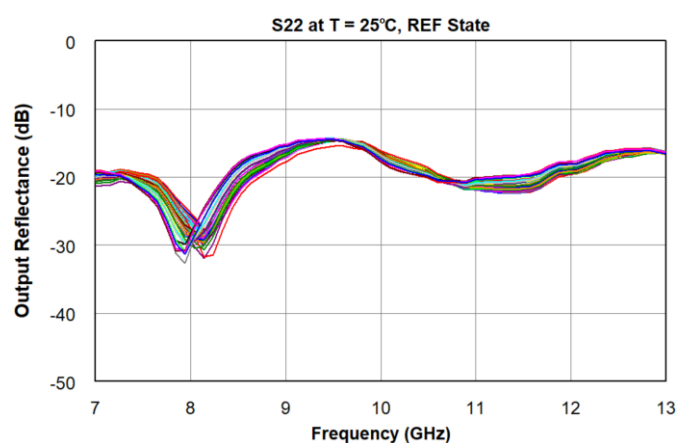
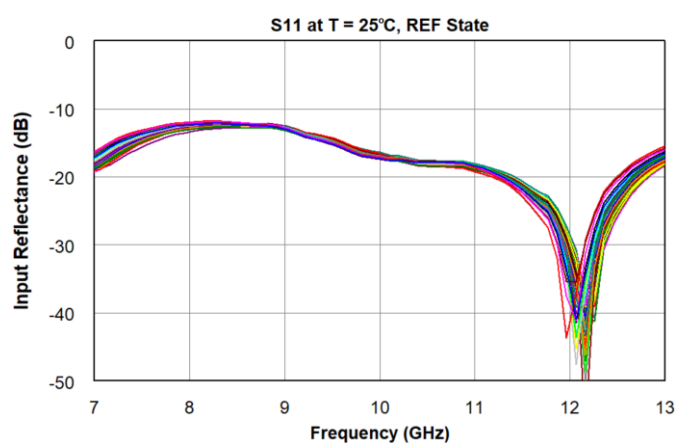
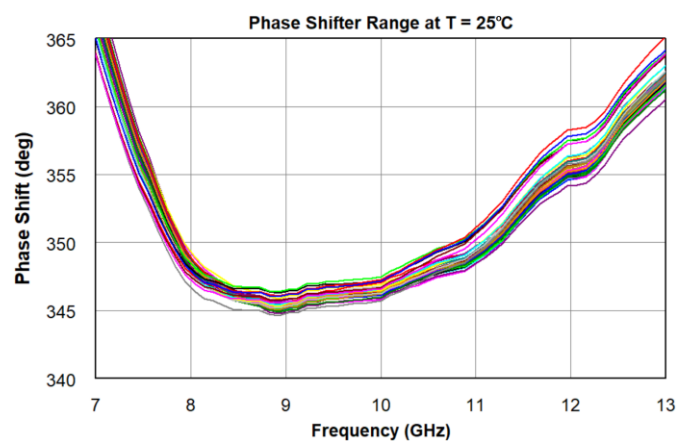
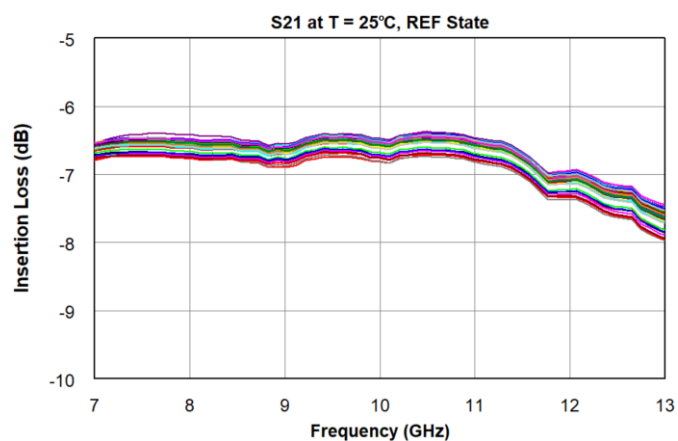
ABSOLUTE MAXIMUM RATINGS

Parameter	Value
Control Voltages	0/-3.3 V
RF Input Power	TBD
Operating Temperature	-40° to +85°C
Storage Temperature	-55° to +125°C

ELECTRICAL CHARACTERISTICS (Ambient Temperature T = 25°C)

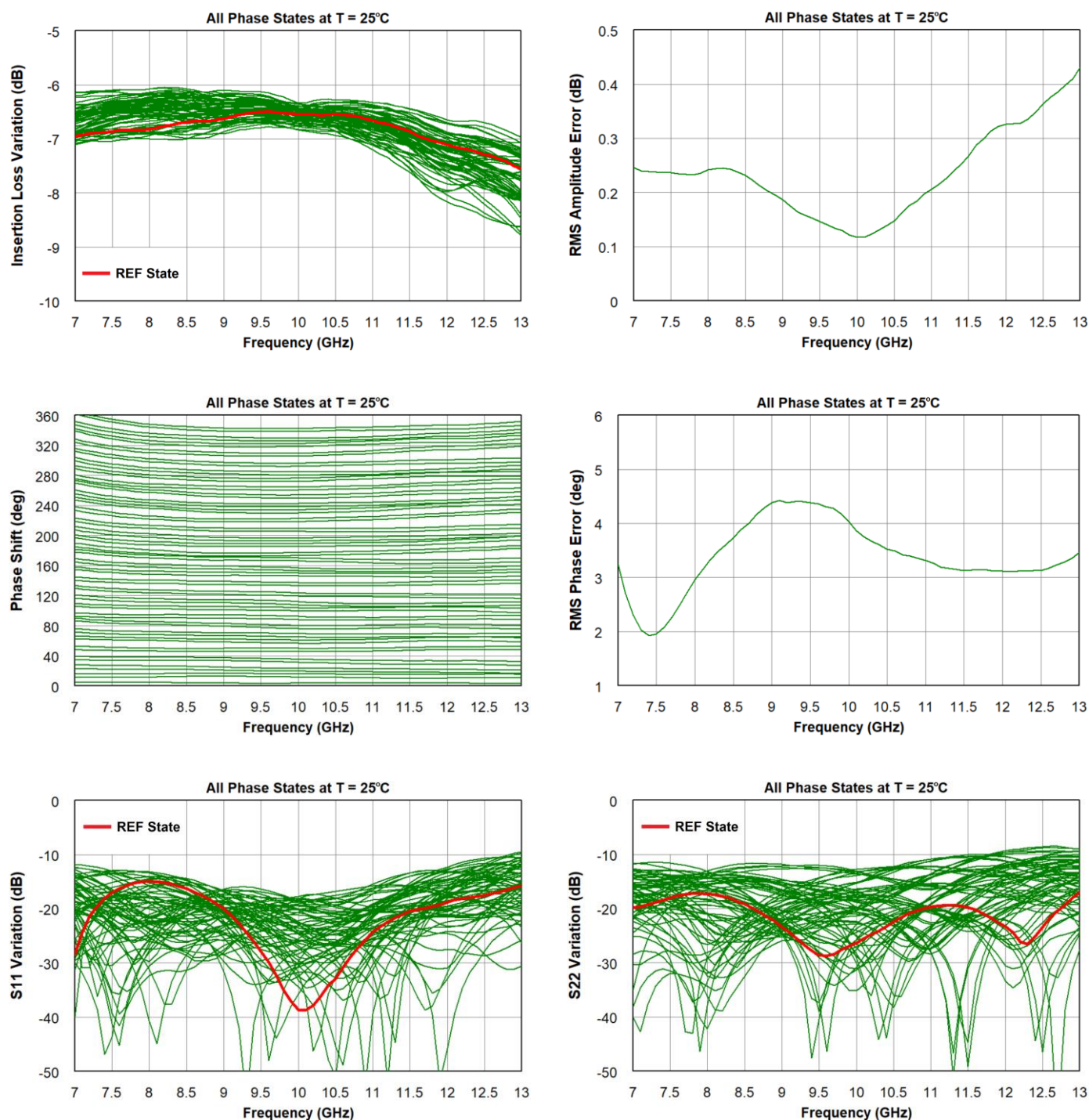
Symbol	Parameter	Min.	Typ.	Max.	Unit
ΔF	Frequency Range		8-12		GHz
IL	Insertion Loss		6.5	8.1	dB
IL_Var	Insertion Loss Variation			1.6	dB
S11	Input Return Loss	12			dB
S22	Output Return Loss	9			dB
P1dB	Input Power at 1 dB Compression Point		21		dBm
ΔPhS	Phase Shifter Range (6 bit, 64 states, 5.625° step)		355		deg
RMS_PhS	RMS Phase Error			4.5	deg
RMS_S21	RMS Amplitude Error			0.4	dB
VLH	Control Voltage High		-3.3		VDC
VLL	Control Voltage Low		0		VDC

ON-WAFER MEASUREMENTS at T = 25°C (Multiple Devices)



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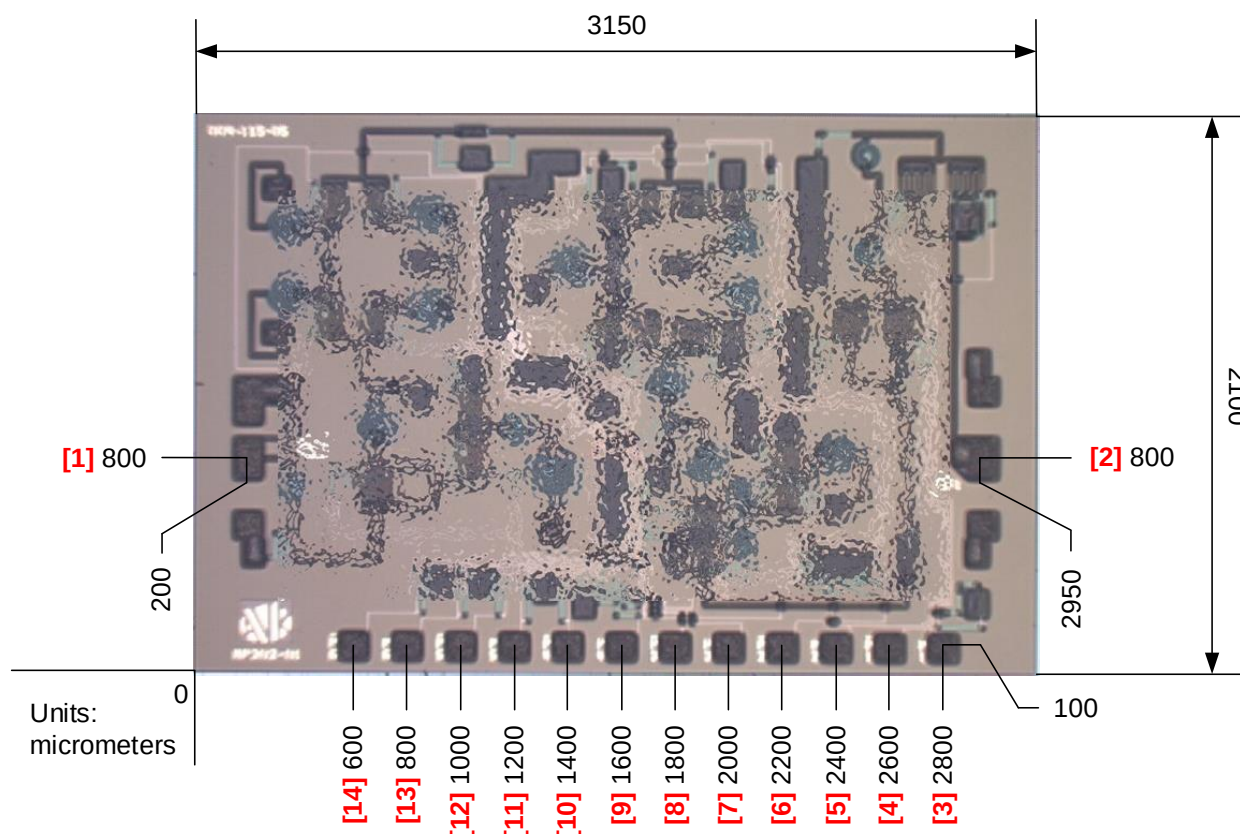
ON-WAFER MEASUREMENTS at T = 25°C (Typical)



NOTE #1 – All parameters consider two wires (diameter 25 μm , length 500 μm) at each RF pad.

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MECHANICAL DATA



- Chip size = $2100 \times 3150 \mu\text{m}^2$ (before wafer dicing), thickness = $100 \mu\text{m}$;
- Bond pad dimensions are shown to a centre of a bond pad. Bond pad / Backside metallization: Gold;
- RF pads (1 and 2) are $100 \times 150 \mu\text{m}^2$;
- Control pads (3 to 14) are $100 \times 100 \mu\text{m}^2$.

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BOND PAD DESIGNATIONS

Pad number	Pad ID	DC Voltage (V)	Description
1	RF2	–	RF port #2
2	RF1	–	RF port #1
3	P1	0 / -3.3	Control of 5.625° phase shifter bit – Direct input
4	$\overline{P1}$	-3.3 / 0	Control of 5.625° phase shifter bit – Complemented input
5	P2	0 / -3.3	Control of 11.25° phase shifter bit – Direct input
6	$\overline{P2}$	-3.3 / 0	Control of 11.25° phase shifter bit – Complemented input
7	P3	0 / -3.3	Control of 22.5° phase shifter bit – Direct input
8	$\overline{P3}$	-3.3 / 0	Control of 22.5° phase shifter bit – Complemented input
9	P4	0 / -3.3	Control of 45° phase shifter bit – Direct input
10	$\overline{P4}$	-3.3 / 0	Control of 45° phase shifter bit – Complemented input
11	P5	0 / -3.3	Control of 90° phase shifter bit – Direct input
12	$\overline{P5}$	-3.3 / 0	Control of 90° phase shifter bit – Complemented input
13	P6	0 / -3.3	Control of 180° phase shifter bit – Direct input
14	$\overline{P6}$	-3.3 / 0	Control of 180° phase shifter bit – Complemented input

APPLICATION NOTES

[1] Wire Bonding. A recommendation for RF pads (1 and 2) is two wires: diameter 25 μm , length 500 μm . A recommendation for control pads (3 to 14) is one wire: diameter 25 μm , length 700-1000 μm .

[2] Phase Shifter Control Bias. The phase shifter has no on-chip digital control logic and necessary internal switching voltages should be applied to corresponding control pads. The reference state is enabled with logic low (0V) on all direct input pads (3, 5, 7, 9, 11 and 13) and logic high (-3.3V) on all complemented input pads (4, 6, 8, 10, 12 and 14). A full control table is presented below.

[3] Recommended ESD Management.



This device is susceptible to electrostatic and mechanical damage. Dice are supplied in antistatic containers, which should be opened in cleanroom conditions at an appropriately grounded antistatic workstation. Devices need careful handling using correctly designed collets, vacuum pickups or, with care, sharp tweezers.

PHASE SHIFTER CONTROL TABLE

State number	Phase Shift (degree)	Voltage to apply on the control pads											
		P6	$\overline{P6}$	P5	$\overline{P5}$	P4	$\overline{P4}$	P3	$\overline{P3}$	P2	$\overline{P2}$	P1	$\overline{P1}$
0 (REF)	0.000	0	1	0	1	0	1	0	1	0	1	0	1
1	5.625	0	1	0	1	0	1	0	1	0	1	1	0
2	11.250	0	1	0	1	0	1	0	1	1	0	0	1
3	16.875	0	1	0	1	0	1	0	1	1	0	1	0
4	22.500	0	1	0	1	0	1	1	0	0	1	0	1
5	28.125	0	1	0	1	0	1	1	0	0	1	1	0
6	33.750	0	1	0	1	0	1	1	0	1	0	0	1
7	39.375	0	1	0	1	0	1	1	0	1	0	1	0
8	45.000	0	1	0	1	1	0	0	1	0	1	0	1
9	50.625	0	1	0	1	1	0	0	1	0	1	1	0
10	56.250	0	1	0	1	1	0	0	1	1	0	0	1
11	61.875	0	1	0	1	1	0	0	1	1	0	1	0
12	67.500	0	1	0	1	1	0	1	0	0	1	0	1
13	73.125	0	1	0	1	1	0	1	0	0	1	1	0
14	78.750	0	1	0	1	1	0	1	0	1	0	0	1
15	84.375	0	1	0	1	1	0	1	0	1	0	1	0
16	90.000	0	1	1	0	0	1	0	1	0	1	0	1
17	95.625	0	1	1	0	0	1	0	1	0	1	1	0
18	101.250	0	1	1	0	0	1	0	1	1	0	0	1
19	106.875	0	1	1	0	0	1	0	1	1	0	1	0
20	112.500	0	1	1	0	0	1	1	0	0	1	0	1
21	118.125	0	1	1	0	0	1	1	0	0	1	1	0
22	123.750	0	1	1	0	0	1	1	0	1	0	0	1
23	129.375	0	1	1	0	0	1	1	0	1	0	1	0
24	135.000	0	1	1	0	1	0	0	1	0	1	0	1
25	140.625	0	1	1	0	1	0	0	1	0	1	1	0
26	146.250	0	1	1	0	1	0	0	1	1	0	0	1
27	151.875	0	1	1	0	1	0	0	1	1	0	1	0
28	157.500	0	1	1	0	1	0	1	0	0	1	0	1
29	163.125	0	1	1	0	1	0	1	0	0	1	1	0
30	168.750	0	1	1	0	1	0	1	0	1	0	0	1
31	174.375	0	1	1	0	1	0	1	0	1	0	1	0
32	180.000	1	0	0	1	0	1	0	1	0	1	0	1
33	185.625	1	0	0	1	0	1	0	1	0	1	1	0
34	191.250	1	0	0	1	0	1	0	1	1	0	0	1
35	196.875	1	0	0	1	0	1	0	1	1	0	1	0
36	202.500	1	0	0	1	0	1	1	0	0	1	0	1
37	208.125	1	0	0	1	0	1	1	0	0	1	1	0
38	213.750	1	0	0	1	0	1	1	0	1	0	0	1
39	219.375	1	0	0	1	0	1	1	0	1	0	1	0
40	225.000	1	0	0	1	1	0	0	1	0	1	0	1

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PHASE SHIFTER CONTROL TABLE (continuation)

State number	Phase Shift (degree)	Voltage to apply on the control pads											
		P6	$\overline{P6}$	P5	$\overline{P5}$	P4	$\overline{P4}$	P3	$\overline{P3}$	P2	$\overline{P2}$	P1	$\overline{P1}$
41	230.625	1	0	0	1	1	0	0	1	0	1	1	0
42	236.250	1	0	0	1	1	0	0	1	1	0	0	1
43	241.875	1	0	0	1	1	0	0	1	1	0	1	0
44	247.500	1	0	0	1	1	0	1	0	0	1	0	1
45	253.125	1	0	0	1	1	0	1	0	0	1	1	0
46	258.750	1	0	0	1	1	0	1	0	1	0	0	1
47	264.375	1	0	0	1	1	0	1	0	1	0	1	0
48	270.000	1	0	1	0	0	1	0	1	0	1	0	1
49	275.625	1	0	1	0	0	1	0	1	0	1	1	0
50	281.250	1	0	1	0	0	1	0	1	1	0	0	1
51	286.875	1	0	1	0	0	1	0	1	1	0	1	0
52	292.500	1	0	1	0	0	1	1	0	0	1	0	1
53	298.125	1	0	1	0	0	1	1	0	0	1	1	0
54	303.750	1	0	1	0	0	1	1	0	1	0	0	1
55	309.375	1	0	1	0	0	1	1	0	1	0	1	0
56	315.000	1	0	1	0	1	0	0	1	0	1	0	1
57	320.625	1	0	1	0	1	0	0	1	0	1	1	0
58	326.250	1	0	1	0	1	0	0	1	1	0	0	1
59	331.875	1	0	1	0	1	0	0	1	1	0	1	0
60	337.500	1	0	1	0	1	0	1	0	0	1	0	1
61	343.125	1	0	1	0	1	0	1	0	0	1	1	0
62	348.750	1	0	1	0	1	0	1	0	1	0	0	1
63	354.375	1	0	1	0	1	0	1	0	1	0	1	0

NOTE #2 – «0» is control voltage low (VLL) and «1» is control voltage high (VLH).

ORDERING INFORMATION

Part Number	Package Type	Version	Description
AP302	Bare Die	01	X-band Phase Shifter