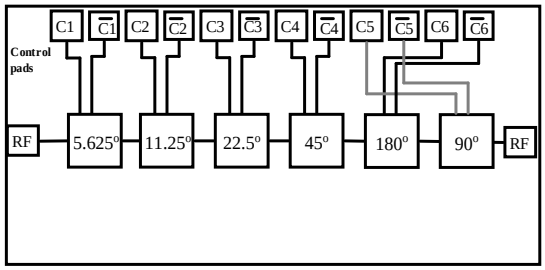
5.4 – 5.9 GHz 6-Bit digital Phase Shifter

Features

- **Frequency Range: 5.4 to 5.9 GHz**
- **Low RMS Phase Error ~ 3°**
- **8.5 dB Maximum Insertion Loss**
- **23dBm Input P_{1dB}**
- **Chip Size: 4.5 × 1.8 × 0.1 mm**

Functional diagram



Typical Applications

- **RADAR**
- **Instrumentation**

Description

The AMT2231021 is a 6-bit digital phase shifter MMIC designed to work from 5.4 to 5.9 GHz. The phase shifter has an RMS phase error within 3 deg. The insertion loss is 8 dB maximum and varies within ±0.5 dB over the band and the 64 states. The chip has an input P1dB of 23 dBm. The chip is well matched to 50Ω in the operating band over all phase states. The die is fabricated using a robust 0.5µm InGaAs pHEMT technology. The phase shifter requires external TTL drivers to provide the necessary digital interface for a 6-bit control.

Absolute Maximum Ratings (1)

Parameter	Absolute Maximum	Units
RF Input Power	30	dBm
Positive Supply Voltage	+6	V
Negative Supply Voltage	-6	V
Control Voltage ON OFF	 +5 to +5.5 -0.5 to 0	 V V
Operating Temperature	-40 to +85	ºC
Storage Temperature	-65 to +150	ºC

1. Operation beyond these limits may cause permanent damage to the component

Electrical Specifications @ 0/-5V Control, 50 Ohm System, T_A = +25℃

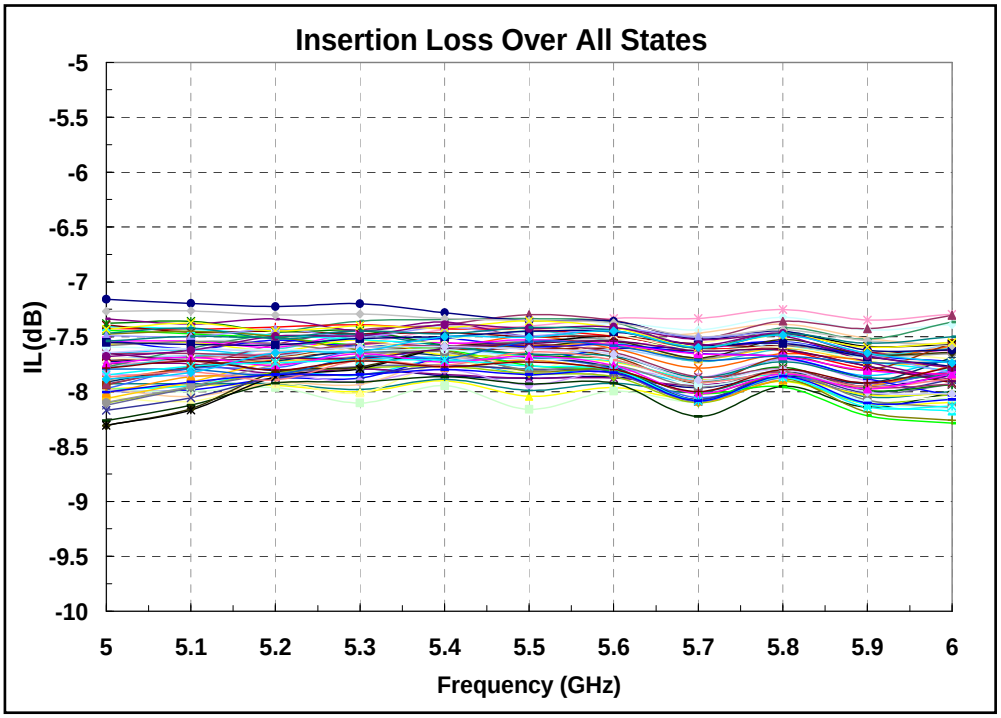
Parameter	Value	Units
Frequency Range	5.4 – 5.9	GHz
Phase Shift	0 – 360 in 64 steps	deg
Insertion Loss (typ)	8	dB
Peak Amplitude Error	±0.5	dB
Peak Phase Shift Error	- 6 to +7	deg
RMS Phase Shift Error	3	deg
Input Return loss, all states (max)	-10	dB
Output Return Loss, all states (max)	-10	dB
Input Power for 1 dB gain compression (2)	+ 23	dBm

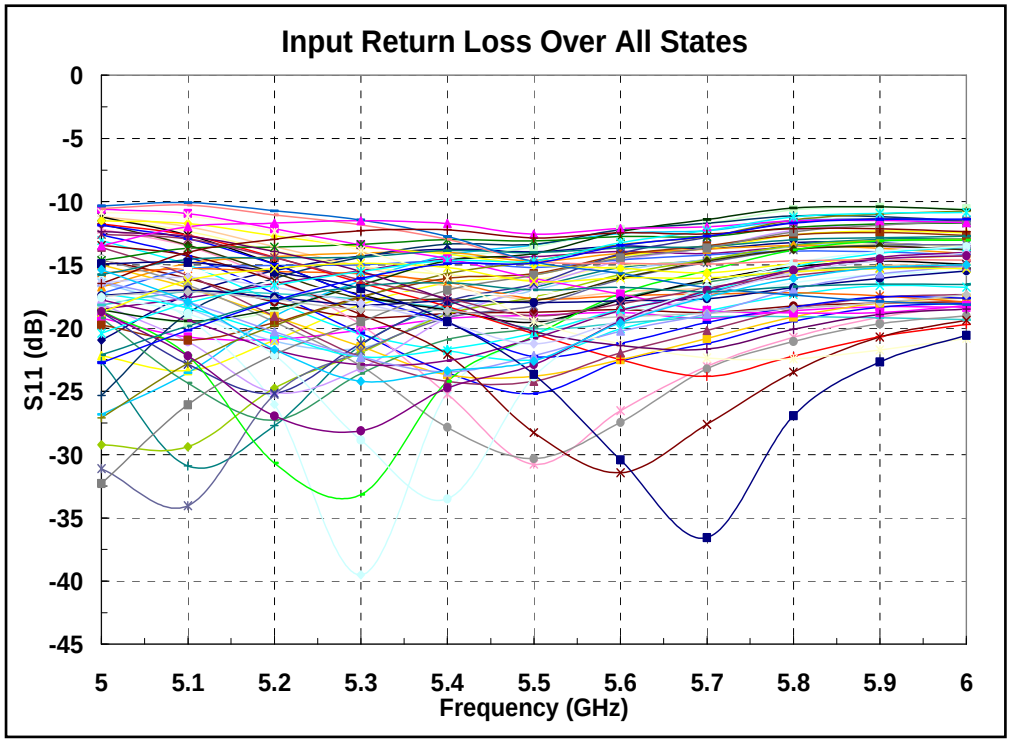
Note:

1. Electrical specifications as measured in a text fixture.
2. Measured for major states only.

Test fixture data

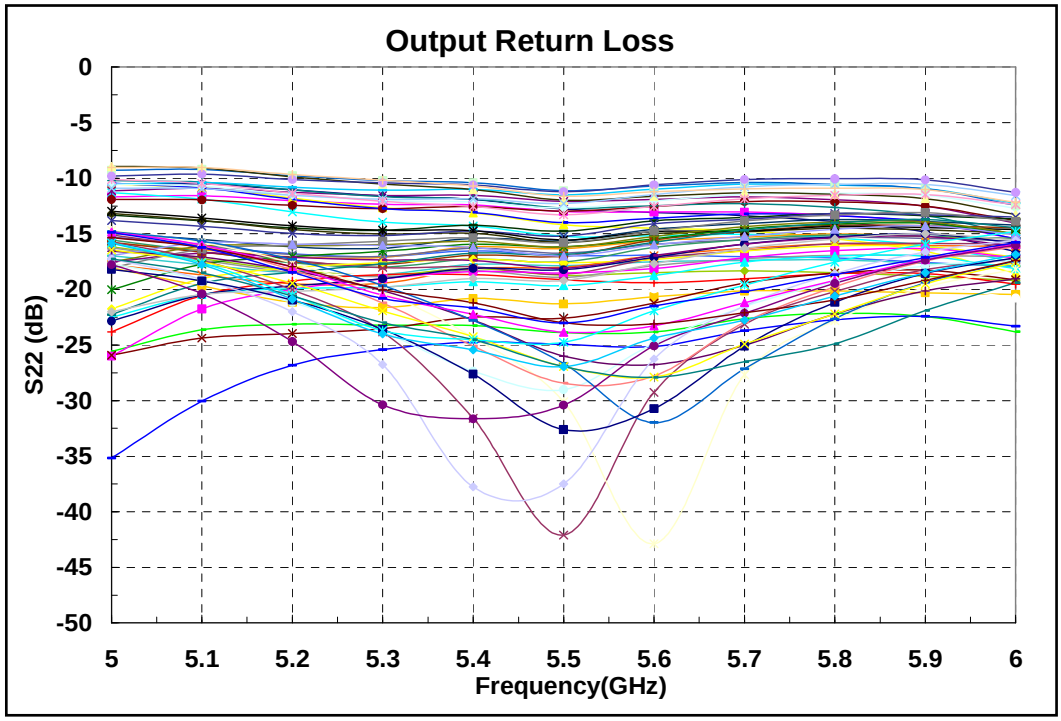
TTL Control, 50 Ohm System, T_A = +25℃

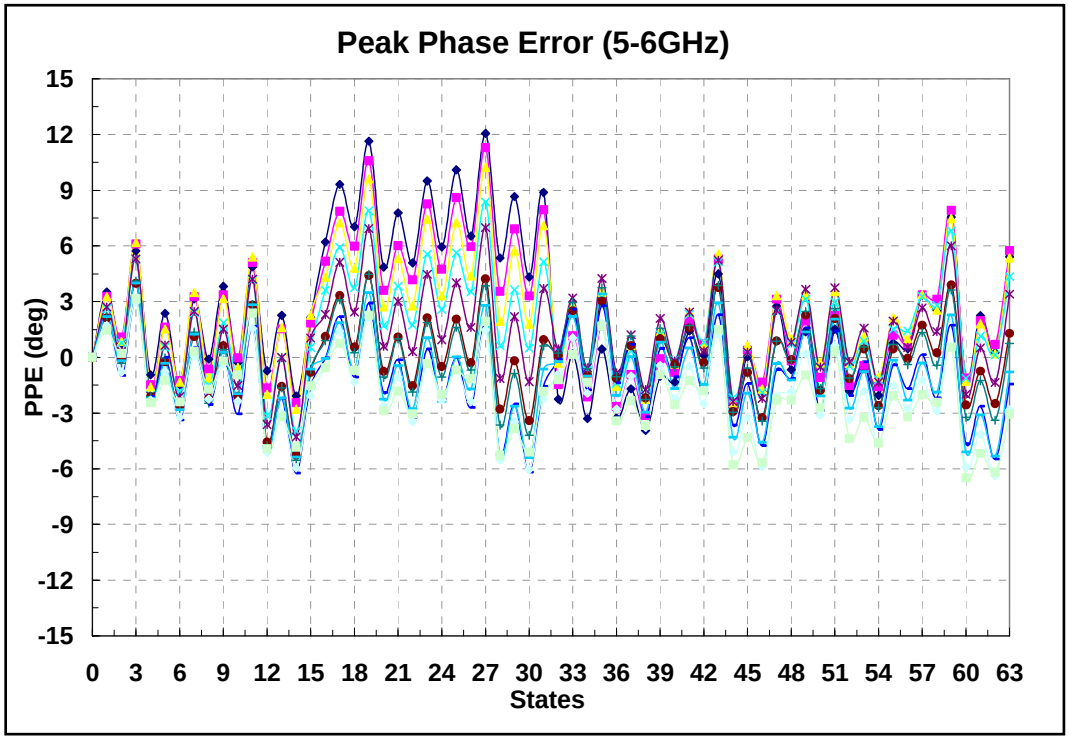




Test fixture data

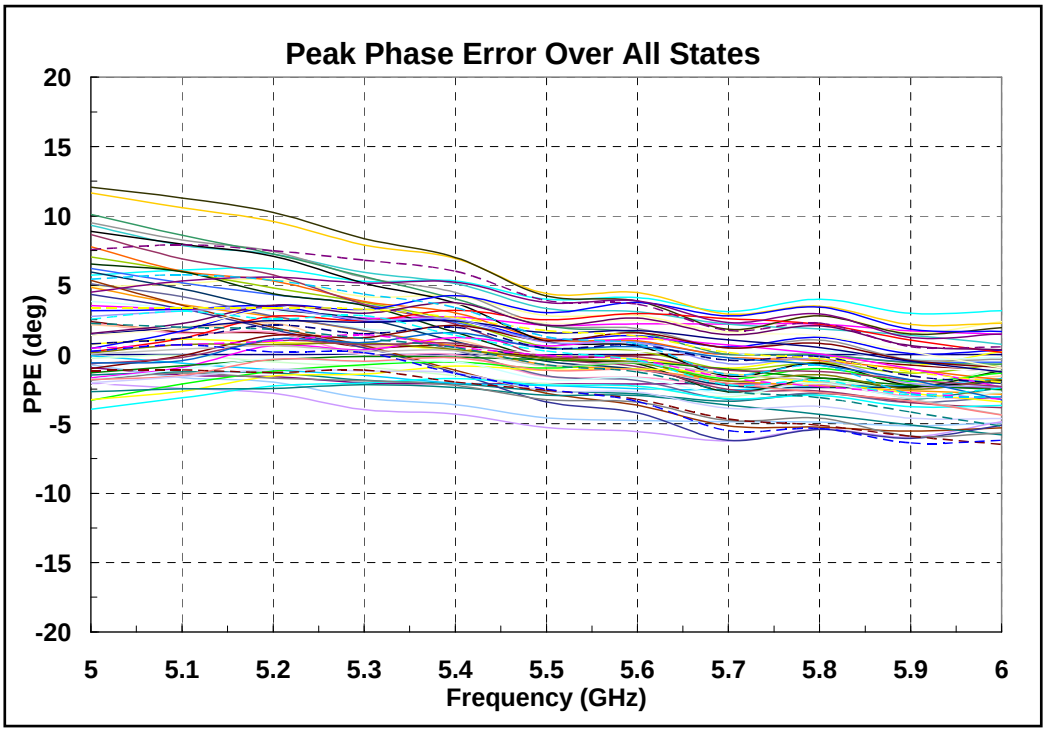
TTL Control, 50 Ohm System, T_A = +25℃

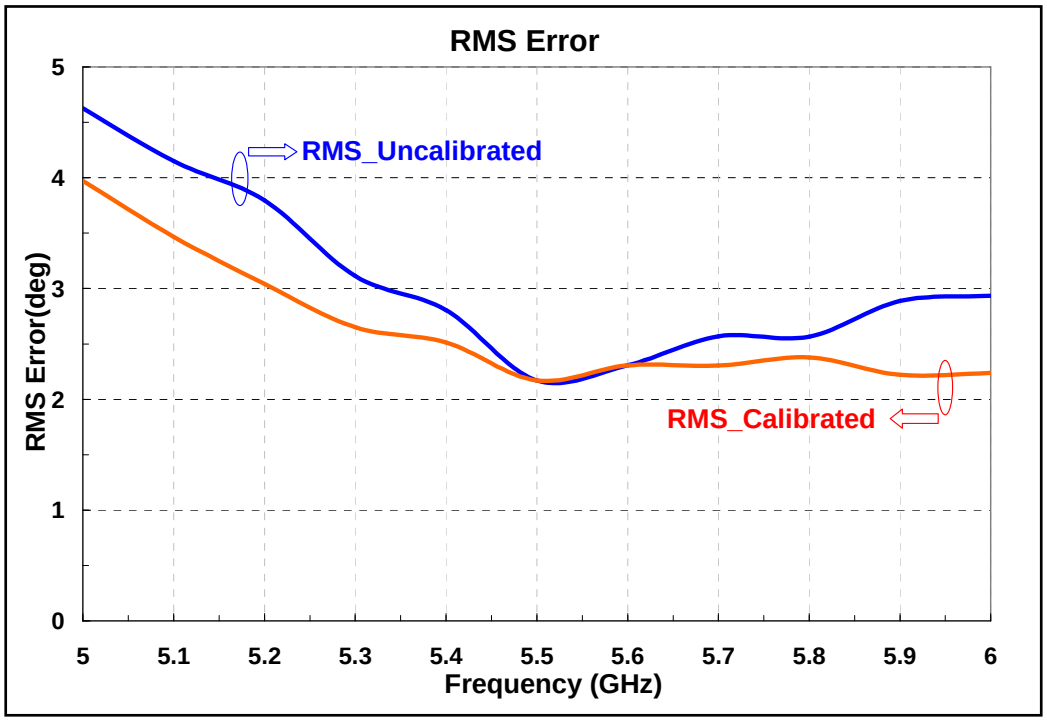




Test fixture data

TTL Control, 50 Ohm System, T_A = +25℃





Truth Table

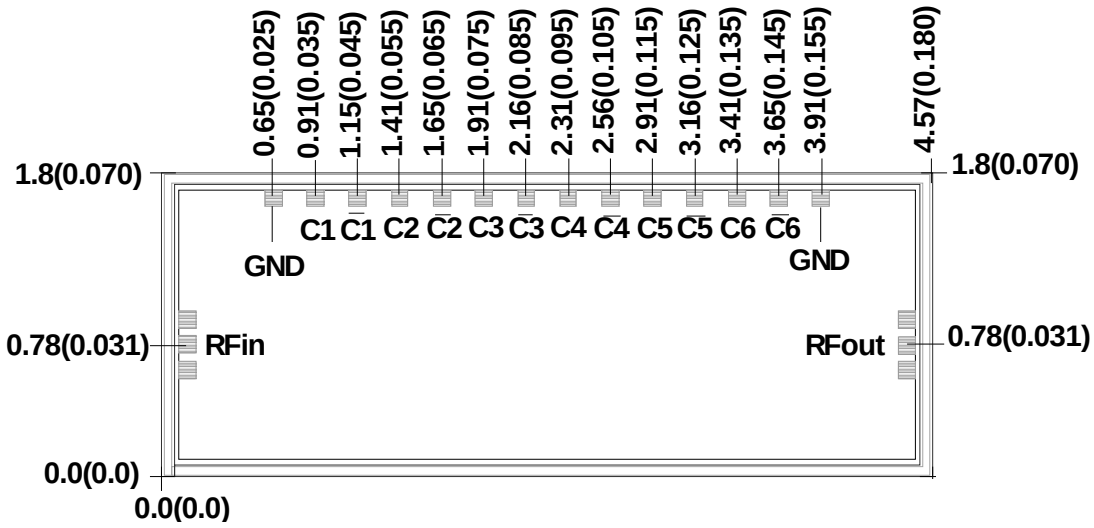
Control Voltage levels : High = 0 V ; Low = -5V

Bit State	Ideal Phase shift (deg.)	Control Voltage (V)											
		C1	$\overline{C1}$	C2	$\overline{C2}$	C3	$\overline{C3}$	C4	$\overline{C4}$	C5	$\overline{C5}$	C6	$\overline{C6}$
		5.625°		11.25°		22.5°		45°		90°		180°	
0	0	0	-5	0	-5	0	-5	0	-5	0	-5	0	-5
1	5.625	-5	0	0	-5	0	-5	0	-5	0	-5	0	-5
2	11.25	0	-5	-5	0	0	-5	0	-5	0	-5	0	-5
3	16.875	-5	0	-5	0	0	-5	0	-5	0	-5	0	-5
4	22.5	0	-5	0	-5	-5	0	0	-5	0	-5	0	-5
5	28.125	-5	0	0	-5	-5	0	0	-5	0	-5	0	-5
6	33.75	0	-5	-5	0	-5	0	0	-5	0	-5	0	-5
7	39.375	-5	0	-5	0	-5	0	0	-5	0	-5	0	-5
8	45	0	-5	0	-5	0	-5	-5	0	0	-5	0	-5
9	50.625	-5	0	0	-5	0	-5	-5	0	0	-5	0	-5
10	56.25	0	-5	-5	0	0	-5	-5	0	0	-5	0	-5
11	61.875	-5	0	-5	0	0	-5	-5	0	0	-5	0	-5
12	67.5	0	-5	0	-5	-5	0	-5	0	0	-5	0	-5
13	73.125	-5	0	0	-5	-5	0	-5	0	0	-5	0	-5
14	78.75	0	-5	-5	0	-5	0	-5	0	0	-5	0	-5
15	84.375	-5	0	-5	0	-5	0	-5	0	0	-5	0	-5
16	90	0	-5	0	-5	0	-5	0	-5	-5	0	0	-5
17	95.625	-5	0	0	-5	0	-5	0	-5	-5	0	0	-5
18	101.25	0	-5	-5	0	0	-5	0	-5	-5	0	0	-5
19	106.875	-5	0	-5	0	0	-5	0	-5	-5	0	0	-5
20	112.5	0	-5	0	-5	-5	0	0	-5	-5	0	0	-5
21	118.125	-5	0	0	-5	-5	0	0	-5	-5	0	0	-5
22	123.75	0	-5	-5	0	-5	0	0	-5	-5	0	0	-5
23	129.375	-5	0	-5	0	-5	0	0	-5	-5	0	0	-5
24	135	0	-5	0	-5	0	-5	-5	0	-5	0	0	-5
25	140.625	-5	0	0	-5	0	-5	-5	0	-5	0	0	-5
26	146.25	0	-5	-5	0	0	-5	-5	0	-5	0	0	-5
27	151.875	-5	0	-5	0	0	-5	-5	0	-5	0	0	-5
28	157.5	0	-5	0	-5	-5	0	-5	0	-5	0	0	-5
29	163.125	-5	0	0	-5	-5	0	-5	0	-5	0	0	-5
30	168.75	0	-5	-5	0	-5	0	-5	0	-5	0	0	-5
31	174.375	-5	0	-5	0	-5	0	-5	0	-5	0	0	-5
32	180	0	-5	0	-5	0	-5	0	-5	0	-5	-5	0

Truth Table

Bit State	Ideal Phase shift (deg.)	Control Voltage (V)											
		C1	$\overline{C1}$	C2	$\overline{C2}$	C3	$\overline{C3}$	C4	$\overline{C4}$	C5	$\overline{C5}$	C6	$\overline{C6}$
		5.625°		11.25°		22.5°		45°		90°		180°	
33	185.625	-5	0	0	-5	0	-5	0	-5	0	-5	-5	0
34	191.25	0	-5	-5	0	0	-5	0	-5	0	-5	-5	0
35	196.875	-5	0	-5	0	0	-5	0	-5	0	-5	-5	0
36	202.5	0	-5	0	-5	-5	0	0	-5	0	-5	-5	0
37	208.125	-5	0	0	-5	-5	0	0	-5	0	-5	-5	0
38	213.75	0	-5	-5	0	-5	0	0	-5	0	-5	-5	0
39	219.375	-5	0	-5	0	-5	0	0	-5	0	-5	-5	0
40	225	0	-5	0	-5	0	-5	-5	0	0	-5	-5	0
41	230.625	-5	0	0	-5	0	-5	-5	0	0	-5	-5	0
42	236.25	0	-5	-5	0	0	-5	-5	0	0	-5	-5	0
43	241.875	-5	0	-5	0	0	-5	-5	0	0	-5	-5	0
44	247.5	0	-5	0	-5	-5	0	-5	0	0	-5	-5	0
45	253.125	-5	0	0	-5	-5	0	-5	0	0	-5	-5	0
46	258.75	0	-5	-5	0	-5	0	-5	0	0	-5	-5	0
47	264.375	-5	0	-5	0	-5	0	-5	0	0	-5	-5	0
48	270	0	-5	0	-5	0	-5	0	-5	-5	0	-5	0
49	275.625	-5	0	0	-5	0	-5	0	-5	-5	0	-5	0
50	281.25	0	-5	-5	0	0	-5	0	-5	-5	0	-5	0
51	286.875	-5	0	-5	0	0	-5	0	-5	-5	0	-5	0
52	292.5	0	-5	0	-5	-5	0	0	-5	-5	0	-5	0
53	298.125	-5	0	0	-5	-5	0	0	-5	-5	0	-5	0
54	303.75	0	-5	-5	0	-5	0	0	-5	-5	0	-5	0
55	309.375	-5	0	-5	0	-5	0	0	-5	-5	0	-5	0
56	315	0	-5	0	-5	0	-5	-5	0	-5	0	-5	0
57	320.625	-5	0	0	-5	0	-5	-5	0	-5	0	-5	0
58	326.25	0	-5	-5	0	0	-5	-5	0	-5	0	-5	0
59	331.875	-5	0	-5	0	0	-5	-5	0	-5	0	-5	0
60	337.5	0	-5	0	-5	-5	0	-5	0	-5	0	-5	0
61	343.125	-5	0	0	-5	-5	0	-5	0	-5	0	-5	0
62	348.75	0	-5	-5	0	-5	0	-5	0	-5	0	-5	0
63	354.375	-5	0	-5	0	-5	0	-5	0	-5	0	-5	0

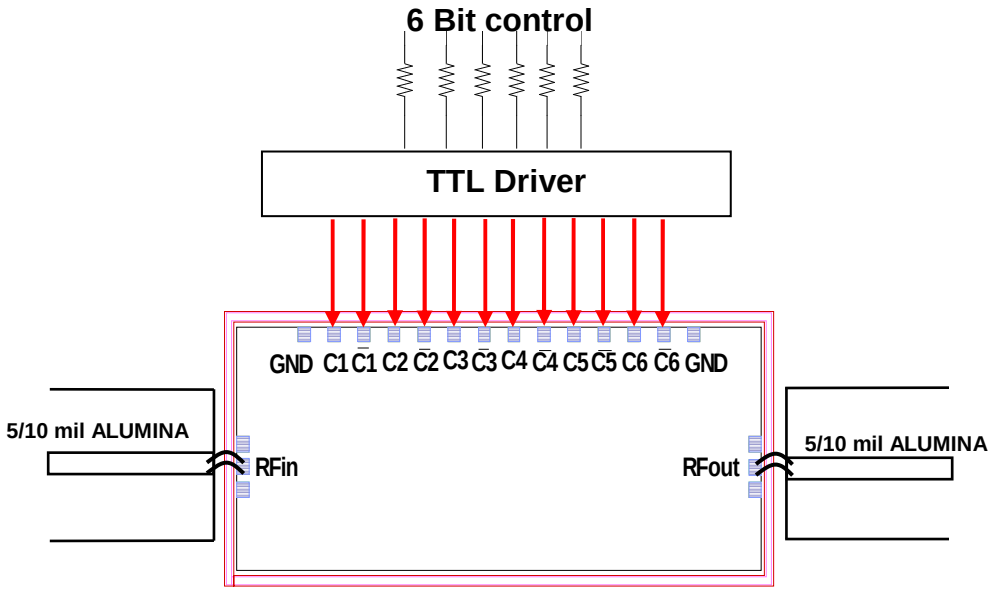
Mechanical Characteristics



Units: millimetres (inches)

All RF and DC bond pads are 100µm x 100µm

Recommended Assembly Diagram



Control	C1/C1	C2/C2	C3/C3	C4/C4	C5/C5	C6/C6
Phase Bit (deg.)	5.625	11.25	22.5	45	90	180

Note:

1. All control inputs were given through ~100-200Ω series resistors
2. Input and output 50 ohm lines are on 5/10 mil substrate.
3. Both the RF ports are DC coupled.

Die attach: For Epoxy attachment, use of a two-component conductive epoxy is recommended. An epoxy fillet should be visible around the total die periphery. If Eutectic attachment is preferred, use of fluxless AuSn (80/20) 1-2 mil thick preform solder is recommended. Use of AuGe preform should be strictly avoided.

Wire bonding: For DC pad connections use either ball or wedge bonds. For best RF performance, use of 150 - 200µm length of wedge bonds is advised. Single Ball bonds of 250-300µm though acceptable, may cause a deviation in RF performance.

GaAs MMIC devices are susceptible to Electrostatic discharge. Proper precautions should be observed during handling, assembly & testing