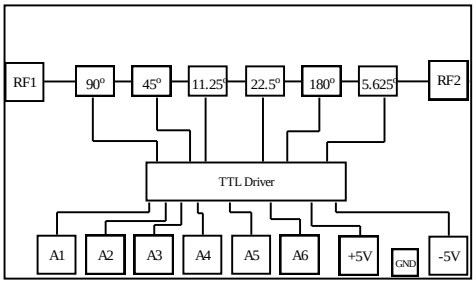
# 8.5 – 11.0 GHz 6-Bit Digital Phase Shifter

## Features

- **Frequency Range: 8.5-11 GHz**
- **Low RMS Error < 2 deg.**
- **6.5 dB midband Insertion Loss**
- **TTL Control Inputs**
- **0.5-um InGaAs pHEMT Technology**
- **Chip Size : 4.5mm x 2.2 mm x 0.1 mm**

**Functional Diagram**




## Typical Applications

- **Military & Space**
- **RADAR**
- **Instrumentation**

## Description

The ASL2013 is a 6-bit digital phase shifter MMIC designed to operate over a frequency band of 8.5-11.0 GHz. The phase shifter features a low RMS phase error of less than 2 deg over the entire operating band. The chip features a typical insertion loss of 7 ± 1dB over the band and the 64 phase states. The input /output ports are well matched to 50 Ohms. The integrated TTL compatible drivers provide a convenient digital interface for 6-bit control. The chip operates on +5V /-5V DC supply voltages with a low current. The MMIC die is fabricated using a robust 0.5µm InGaAs pHEMT technology.

## Absolute Maximum Ratings (1)

| Parameter | Absolute Maximum | Units |
|---|---|---|
| RF Input Power | 20 | dBm |
| Positive Supply Voltage | +6 | V |
| Negative Supply Voltage | -6 | V |
| Control Voltage | -0.5 to +5.5 | V |
| Operating Temperature | -55 to +85 | ºC |
| Storage Temperature | -65 to +150 | ºC |

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

## Electrical Specifications (1) @ $T_A$ = 25 ºC, $Z_o$ =50 Ω

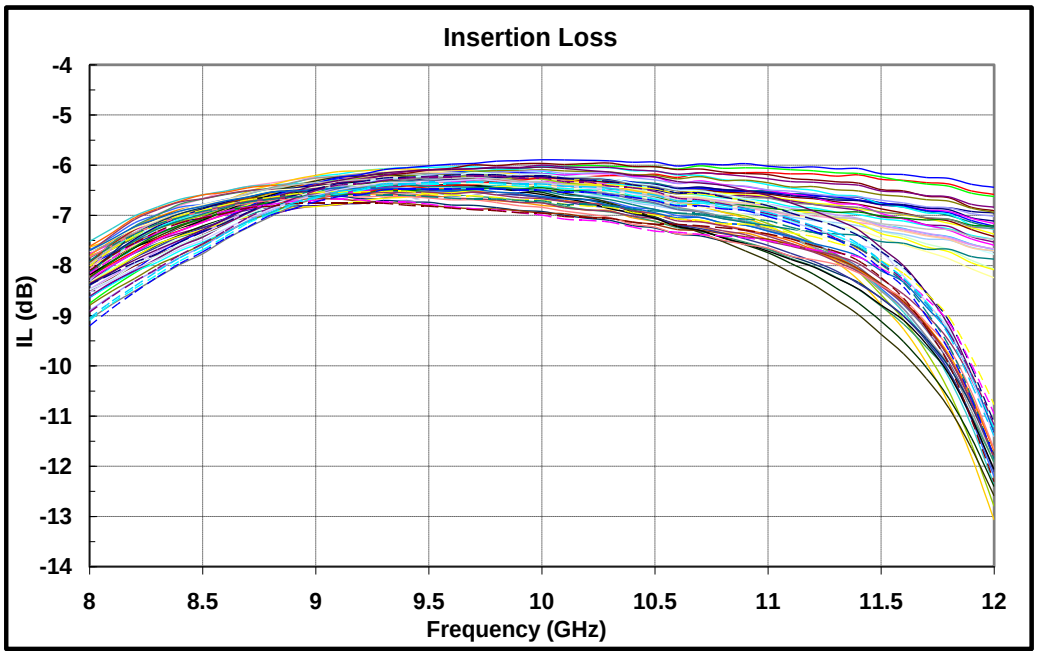
| Parameter | Typical Values | | | Units |
|---|---|---|---|---|
| Bandwidth | 8.5 to 9 | 9 to 10 | 10 to 11 | GHz |
| Phase Shift | 0 to 360 in 64 steps | | | deg |
| Insertion Loss | 7 | 6.5 | 7 | dB |
| Peak Amplitude Error | ± 0.75 | ± 0.6 | ± 1 | dB |
| Peak Phase Shift Error | 6.2 to -1.5 | 3.2 to -5.6 | 1.3 to -6.2 | deg |
| RMS Phase Shift Error (max.) | 2 | 2 | 2 | deg |
| Port1 Return loss | 11 | 11 | 11 | dB |
| Port2 Return Loss | 11 | 11 | 9 | dB |
| P1 dB @ Input | 14 | 14 | 14 | dBm |
| DC Supply | +5/6 , -5/3 | | | V/mA |
| Control Voltage | TTL compatible | | | |
| ON | +3 to +5 V | | | V |
| OFF | 0 to +0.5 V | | | V |

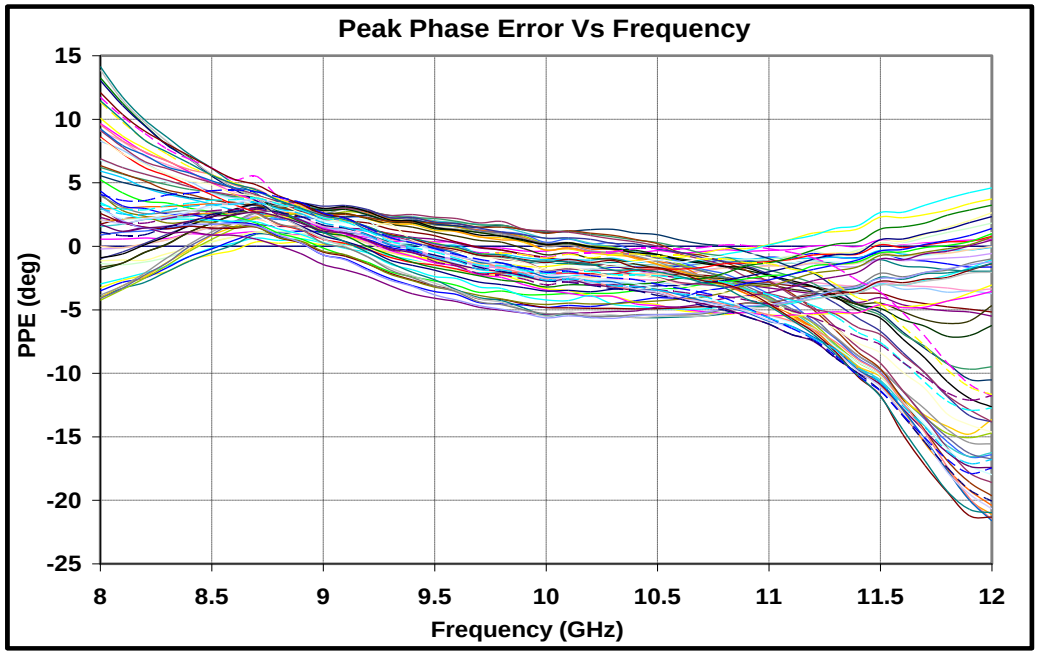
***Note:***

1. The above mentioned electrical specifications are measured On-Wafer.

## On Wafer data

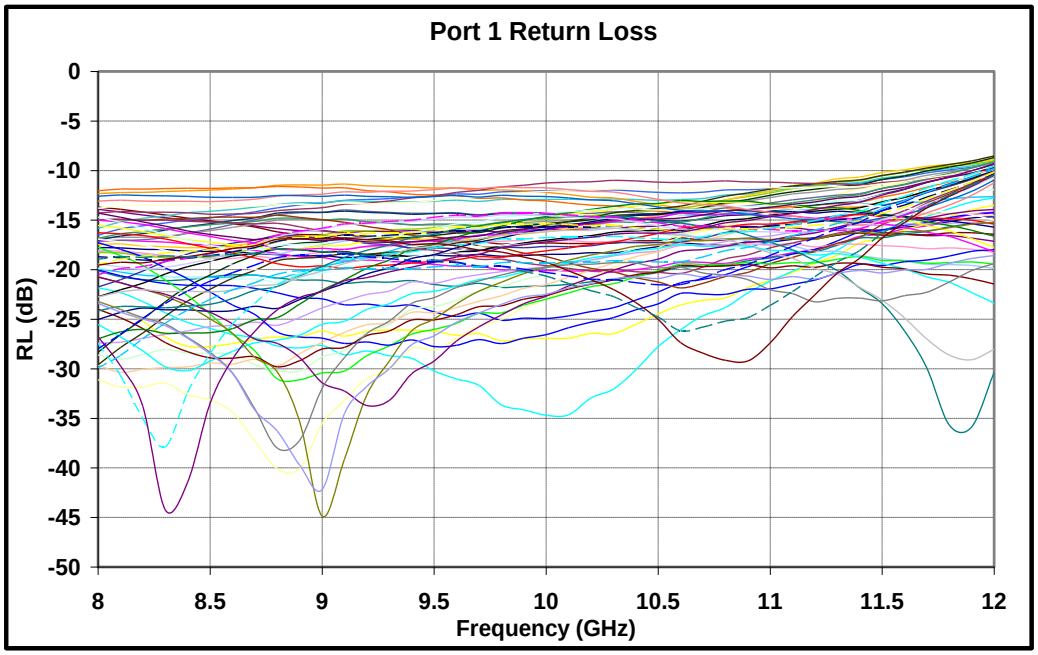
$T_A$ = 25 °C

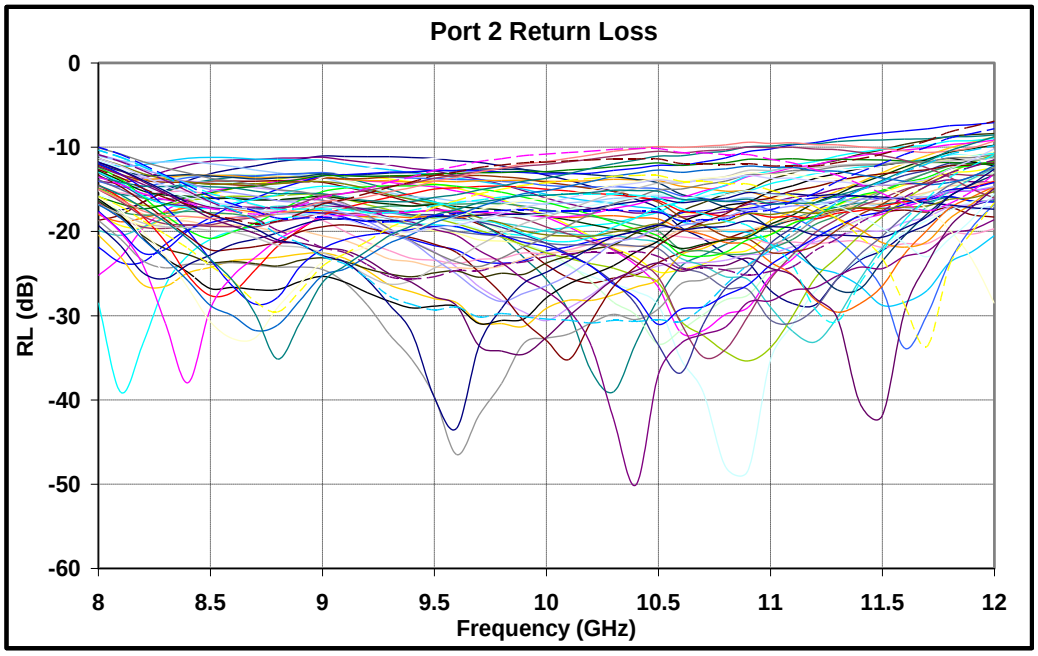


## On Wafer data

$T_A$ = 25 °C



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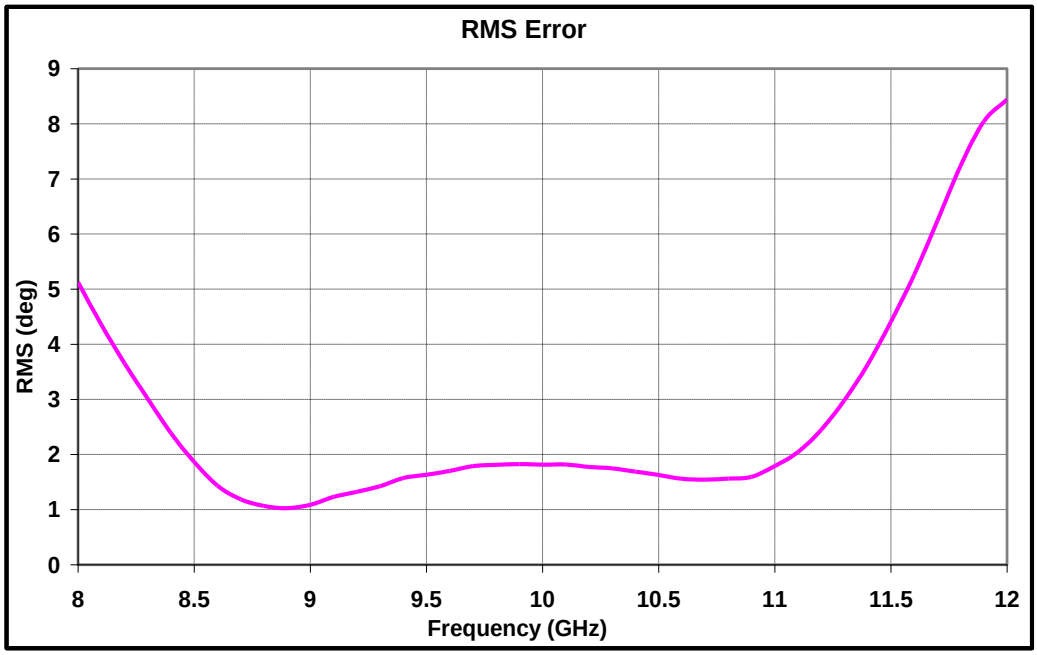
$T_A$ = 25 °C



## Truth Table

| State | Phase Shift (deg.) | TTL Control ( 1 = 3 to 5 V, 0 = 0 to 0.5 V ) | | | | | |
|---|---|---|---|---|---|---|---|
| | | A1 (180) | A2 (90) | A3 (45) | A4 (22.5) | A5 (11.25) | A6 (5.625) |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 5.625 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2 | 11.25 | 0 | 0 | 0 | 0 | 1 | 0 |
| 3 | 16.875 | 0 | 0 | 0 | 0 | 1 | 1 |
| 4 | 22.5 | 0 | 0 | 0 | 1 | 0 | 0 |
| 5 | 28.125 | 0 | 0 | 0 | 1 | 0 | 1 |
| 6 | 33.75 | 0 | 0 | 0 | 1 | 1 | 0 |
| 7 | 39.375 | 0 | 0 | 0 | 1 | 1 | 1 |
| 8 | 45 | 0 | 0 | 1 | 0 | 0 | 0 |
| 9 | 50.625 | 0 | 0 | 1 | 0 | 0 | 1 |
| 10 | 56.25 | 0 | 0 | 1 | 0 | 1 | 0 |
| 11 | 61.875 | 0 | 0 | 1 | 0 | 1 | 1 |
| 12 | 67.5 | 0 | 0 | 1 | 1 | 0 | 0 |
| 13 | 73.125 | 0 | 0 | 1 | 1 | 0 | 1 |
| 14 | 78.75 | 0 | 0 | 1 | 1 | 1 | 0 |
| 15 | 84.375 | 0 | 0 | 1 | 1 | 1 | 1 |
| 16 | 90 | 0 | 1 | 0 | 0 | 0 | 0 |
| 17 | 95.625 | 0 | 1 | 0 | 0 | 0 | 1 |
| 18 | 101.25 | 0 | 1 | 0 | 0 | 1 | 0 |
| 19 | 106.875 | 0 | 1 | 0 | 0 | 1 | 1 |
| 20 | 112.5 | 0 | 1 | 0 | 1 | 0 | 0 |
| 21 | 118.125 | 0 | 1 | 0 | 1 | 0 | 1 |
| 22 | 123.75 | 0 | 1 | 0 | 1 | 1 | 0 |
| 23 | 129.375 | 0 | 1 | 0 | 1 | 1 | 1 |
| 24 | 135 | 0 | 1 | 1 | 0 | 0 | 0 |
| 25 | 140.625 | 0 | 1 | 1 | 0 | 0 | 1 |
| 26 | 146.25 | 0 | 1 | 1 | 0 | 1 | 0 |
| 27 | 151.875 | 0 | 1 | 1 | 0 | 1 | 1 |
| 28 | 157.5 | 0 | 1 | 1 | 1 | 0 | 0 |
| 29 | 163.125 | 0 | 1 | 1 | 1 | 0 | 1 |
| 30 | 168.75 | 0 | 1 | 1 | 1 | 1 | 0 |
| 31 | 174.375 | 0 | 1 | 1 | 1 | 1 | 1 |
| 32 | 180 | 1 | 0 | 0 | 0 | 0 | 0 |
| 33 | 185.625 | 1 | 0 | 0 | 0 | 0 | 1 |
| 34 | 191.25 | 1 | 0 | 0 | 0 | 1 | 0 |
| 35 | 196.875 | 1 | 0 | 0 | 0 | 1 | 1 |

## Truth Table

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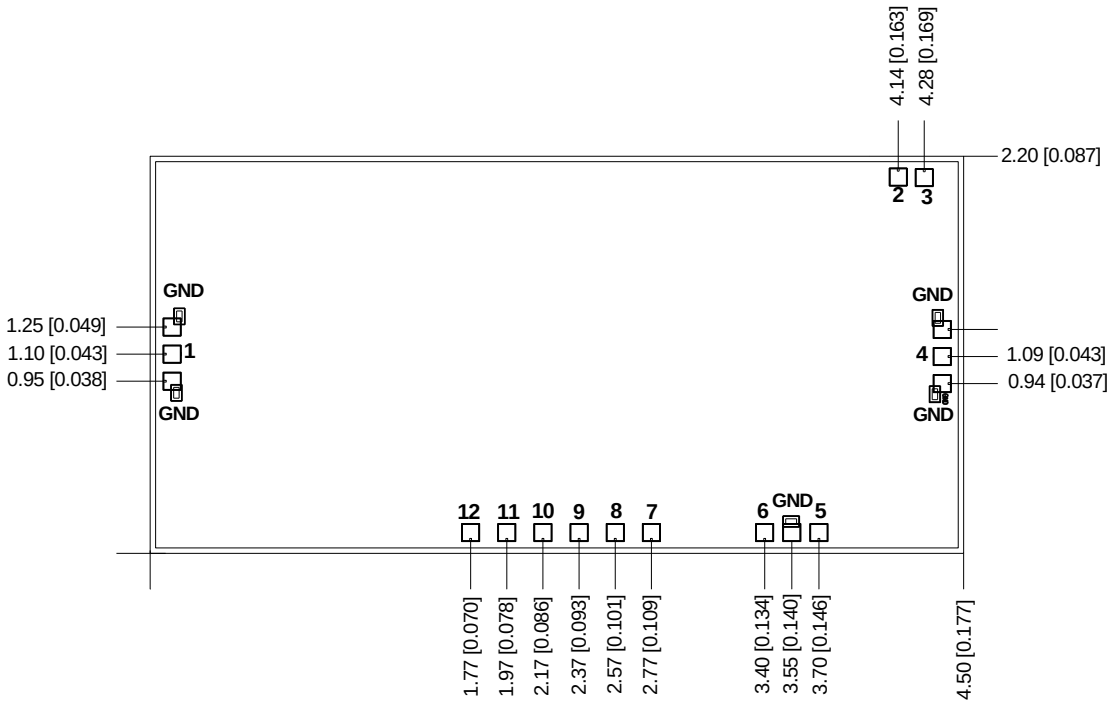
|---|---|---|---|---|---|---|---|
| | | A1 (180) | A2 (90) | A3 (45) | A4 (22.5) | A5 (11.25) | A6 (5.625) |
| 36 | 202.5 | 1 | 0 | 0 | 1 | 0 | 0 |
| 37 | 208.125 | 1 | 0 | 0 | 1 | 0 | 1 |
| 38 | 213.75 | 1 | 0 | 0 | 1 | 1 | 0 |
| 39 | 219.375 | 1 | 0 | 0 | 1 | 1 | 1 |
| 40 | 225 | 1 | 0 | 1 | 0 | 0 | 0 |
| 41 | 230.625 | 1 | 0 | 1 | 0 | 0 | 1 |
| 42 | 236.25 | 1 | 0 | 1 | 0 | 1 | 0 |
| 43 | 241.875 | 1 | 0 | 1 | 0 | 1 | 1 |
| 44 | 247.5 | 1 | 0 | 1 | 1 | 0 | 0 |
| 45 | 253.125 | 1 | 0 | 1 | 1 | 0 | 1 |
| 46 | 258.75 | 1 | 0 | 1 | 1 | 1 | 0 |
| 47 | 264.375 | 1 | 0 | 1 | 1 | 1 | 1 |
| 48 | 270 | 1 | 1 | 0 | 0 | 0 | 0 |
| 49 | 275.625 | 1 | 1 | 0 | 0 | 0 | 1 |
| 50 | 281.25 | 1 | 1 | 0 | 0 | 1 | 0 |
| 51 | 286.875 | 1 | 1 | 0 | 0 | 1 | 1 |
| 52 | 292.5 | 1 | 1 | 0 | 1 | 0 | 0 |
| 53 | 298.125 | 1 | 1 | 0 | 1 | 0 | 1 |
| 54 | 303.75 | 1 | 1 | 0 | 1 | 1 | 0 |
| 55 | 309.375 | 1 | 1 | 0 | 1 | 1 | 1 |
| 56 | 315 | 1 | 1 | 1 | 0 | 0 | 0 |
| 57 | 320.625 | 1 | 1 | 1 | 0 | 0 | 1 |
| 58 | 326.25 | 1 | 1 | 1 | 0 | 1 | 0 |
| 59 | 331.875 | 1 | 1 | 1 | 0 | 1 | 1 |
| 60 | 337.5 | 1 | 1 | 1 | 1 | 0 | 0 |
| 61 | 343.125 | 1 | 1 | 1 | 1 | 0 | 1 |
| 62 | 348.75 | 1 | 1 | 1 | 1 | 1 | 0 |
| 63 | 354.375 | 1 | 1 | 1 | 1 | 1 | 1 |

## Mechanical Characteristics



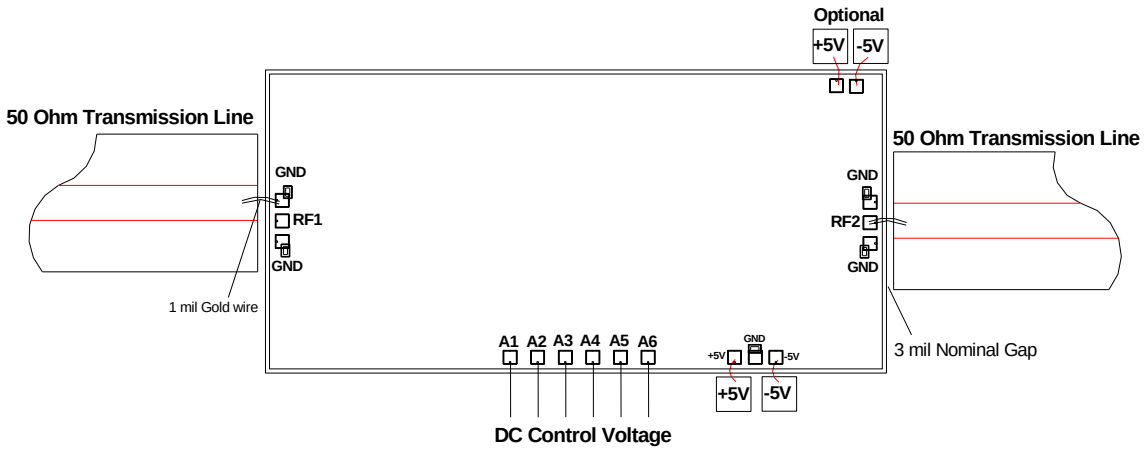

**Units:** millimeters (inches)

**Note:**

1. All RF and DC bond pads are 100µm x 100µm
2. Pad no. 1 : RF In
3. Pad no. 2, 6* : +5 V
4. Pad no. 3, 5* : -5 V
5. Pad no. 4 : RF Out
6. Pad no. 7 to 12 : A6 to A1 (Control bits from LSB to MSB)

* Only one of the set of pads 2 and 3 or the set of pads 5 and 6 should be used for DC supply, and not both the sets simultaneously

## Recommended Assembly Diagram




**Note :**

1. Two 1 mil (0.0254mm) bond wires of minimum length should be used for RF input and output.
2. The RF input & output 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***

All information and Specifications are subject to change without prior notice