# 0.1 GHz to 30 GHz Digital Attenuator Die

# ADH941S

## 1.0 SCOPE

This specification documents the detail requirements for space qualified die per MIL-PRF-38534 class K except as modified herein.

The manufacturing flow described in the SPACE DIE BROCHURE is to be considered a part of this specification.

This datasheet specifically details the space grade version of this product. A more detailed operational description and a complete datasheet for commercial product grades can be found at **https://www.analog.com/hmc941.**

## 2.0 Part Number: The complete part number(s) of this specification follows:

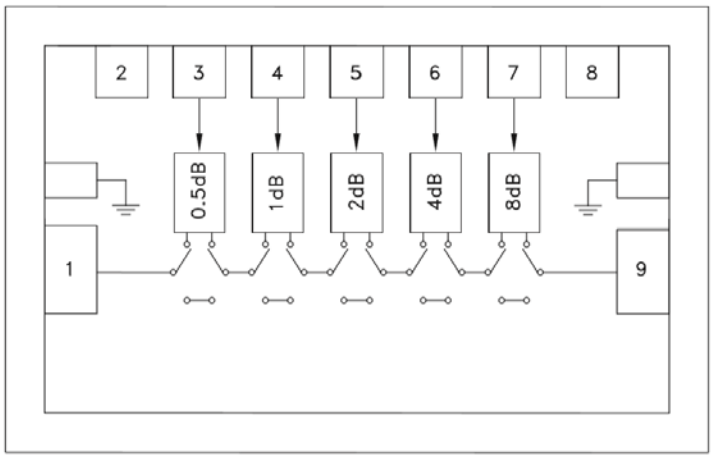
| Specific Part Number | Description |
|---|---|
| ADH941-000C | 0.1 GHz to 30 GHz, GaAs, MMIC, 5-Bit 0.5 dB LSB, Digital Attenuator Die |

## 3.0 Die Information

### 3.1. Die Dimensions

| Die Size | Die Thickness | Bond Pad and Backside Metallization |
|---|---|---|
| 90.2 mils x 37.4 mils | 4 mils | Au |

### 3.2. Die Picture




1. RF1
2. Vss
3. P0
4. P1
5. P2
6. P3
7. P4
8. Vdd
9. RF2

Die bottom is GND

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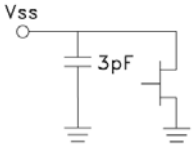
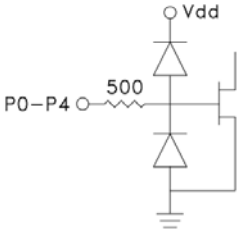
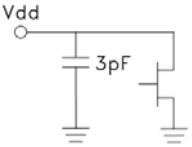
3.3. Pad Descriptions

| Pad Number | Function | Description | Interface Schematic |
|---|---|---|---|
| Die Bottom | GND | Die bottom must be connected to RF ground. |   |
| 1, 9 | RF1, RF2 | These pads are DC coupled and matched to 50 Ohm. Blocking capacitors are required if RF line potential is not equal to 0 V. | |
| 2 | Vss | Negative Bias -5 V. |   |
| 3 - 7 | P0 - P4 | See Truth Table (Table IV) and Control Voltage Table (Table V). |   |
| 8 | Vdd | Positive Bias +5 V. |   |

## 4.0 Specifications

4.1. Absolute Maximum Ratings 1/

| | |
|---|---|
| RF Input Power (0.1 GHz to 30 GHz) | +27 dBm |
| Control Voltage (P0 to P4) | Vdd + 0.5 V |
| Vdd | +7 V dc |
| Vss | -7 V dc |
| Channel Temperature | 150 °C |
| Thermal Resistance (Junction to die bottom) | 146 °C/W |
| Storage Temperature Range | -65 °C to +150 °C |
| Operating Temperature Range | -55 °C to +85 °C |
| ESD Sensitivity (HBM) | Class 1A passed 250 V |

4.2 Nominal Operating Performance Characteristics 2/

Insertion Loss (30 GHz) ..... 4.4 dB
Attenuation Accuracy: 0.5-7.5 dB States (30 GHz) 3/ ..... ± (0.3 + 4 % of Atten. Setting) Max dB
Attenuation Accuracy: 8-15.5 dB States (30 GHz) 3/ ..... ± (0.3 + 5 % of Atten. Setting) Max dB
Return Loss RF1 & RF2 (30 GHz) 4/ ..... 15 dB

1/ Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions outside of those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.
2/ All specifications apply with $T_A$ = 25 °C, Vdd = 5 V, Vss = -5 V and P0 – P4 Low = 0 V, High = 5 V unless otherwise noted.
3/ Referenced to insertion loss.
4/ Applies across all attenuator states.

## 5.0 Die Qualification

In accordance with class-K version of MIL-PRF-38534, Appendix C, Table C-II, except as modified herein.
(a) Pre-screen test post assembly required prior to die qualification, to remove all assembly related rejects.
(b) Mechanical Shock or Constant Acceleration not performed.
(c) Interim and post burn-in electrical tests will include tests screened at +25 °C only.

## 6.0 Dice Electrical Characteristics

**TABLE I – DIE ELECTRICAL CHARACTERISTICS**

| Parameter | Symbol | Conditions 1/2/3/4/ Unless otherwise specified | Limits | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| Insertion Loss | IL | 2 GHz & 8 GHz | | 3.5 | dB |
| | | 26 GHz | | 4.8 | |
| Attenuation Accuracy 0.5-7.5 dB States 5/ 6/ | AA | | ± (0.3 + 4 % of Atten. Setting) Max | | dB |
| Attenuation Accuracy 8-15.5 dB States 5/ 6/ | AA | | ± (0.3 + 5 % of Atten. Setting) Max | | dB |
| Return Loss RF1 & RF2 5/ | S11, S22 | | 10 | | dB |
| Vdd Supply Current | Idd | No signal on RF1 | 2 | 6 | mA |
| Vss Supply Current | Iss | No signal on RF1 | -7 | -3 | mA |

TABLE I Notes:
1/ Limits apply at $T_A$ = +25 ºC only.
2/ RF1 = 0 dBm, Vdd = 5 V and Vss = -5 V.
3/ P0 – P4 Low = 0 V, High = 5 V.
4/ Parameters measured at 2 GHz, 8 GHz & 26 GHz unless otherwise specified.
5/ Measured at major attenuation states only as shown in Table IV.
6/ Referenced to insertion loss.

| TABLE II – ELECTRICAL CHARACTERISTICS FOR QUALIFICATION SAMPLES | | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Symbol** | **Conditions 1/2/3/4/ Unless otherwise specified** | **Sub-Group** | **Limits** | | **Unit** |
| | | | | **Min** | **Max** | |
| Insertion Loss | IL | 2 GHz & 8 GHz | 4 | | 3.5 | dB |
| | | | 5, 6 | | 3.8 | |
| | | 26 GHz | 4 | | 4.8 | |
| | | | 5, 6 | | 5.2 | |
| Attenuation Accuracy: 0.5-7.5 dB Sates 5/ 6/ | AA | | 4, 5, 6 | ± (0.3 + 4 % of Atten. Setting) Max | | dB |
| Attenuation Accuracy: 8-15.5 dB States 5/ 6/ | AA | | 4, 5, 6 | ± (0.3 + 5 % of Atten. Setting) Max | | dB |
| Return Loss RF1 & RF2 5/ | S11, S22 | | 4 | 10 | | dB |
| | | | 5,6 | 8 | | |
| Vdd Supply Current | Idd | | 1 | 3 | 7 | mA |
| | | | 2, 3 | 2 | 9 | |
| Vss Supply Current | Iss | | 1 | -8 | -4 | mA |
| | | | 2, 3 | -10 | -3 | |

TABLE II Notes:

1/ $T_A$ Nom = +25 ºC, $T_A$ Max = +85 ºC, $T_A$ Min = -40 ºC.

2/ RF1 = -25 dBm, Vdd = 5 V and Vss = -5 V.

3/ P0 – P4: Low = 0.8 V, High = 2.0 V.

4/ Parameters measured at 2 GHz, 8 GHz & 26 GHz unless otherwise specified.

5/ Measured at major attenuation states only as shown in Table IV.

6/ Referenced to insertion loss.

| TABLE III – BURN-IN/LIFE TEST DELTA LIMITS 1/ 2/ 3/ 4/ | | | |
|---|---|---|---|
| **Parameter** | **Symbol** | **Delta** | **Units** |
| Insertion Loss | IL | ± 1 | dB |
| Vdd Supply Current | Idd | ± 10 | % |
| Vss Supply Current | Iss | ± 10 | % |

TABLE III Notes:

1/ 240 hour burn-in and 1000 hour life test end point electrical parameters.

2/ Deltas are performed at $T_A$ = +25 °C only.

3/ Product is tested in accordance with conditions in Table II.

4/ Table II limits will not be exceeded.

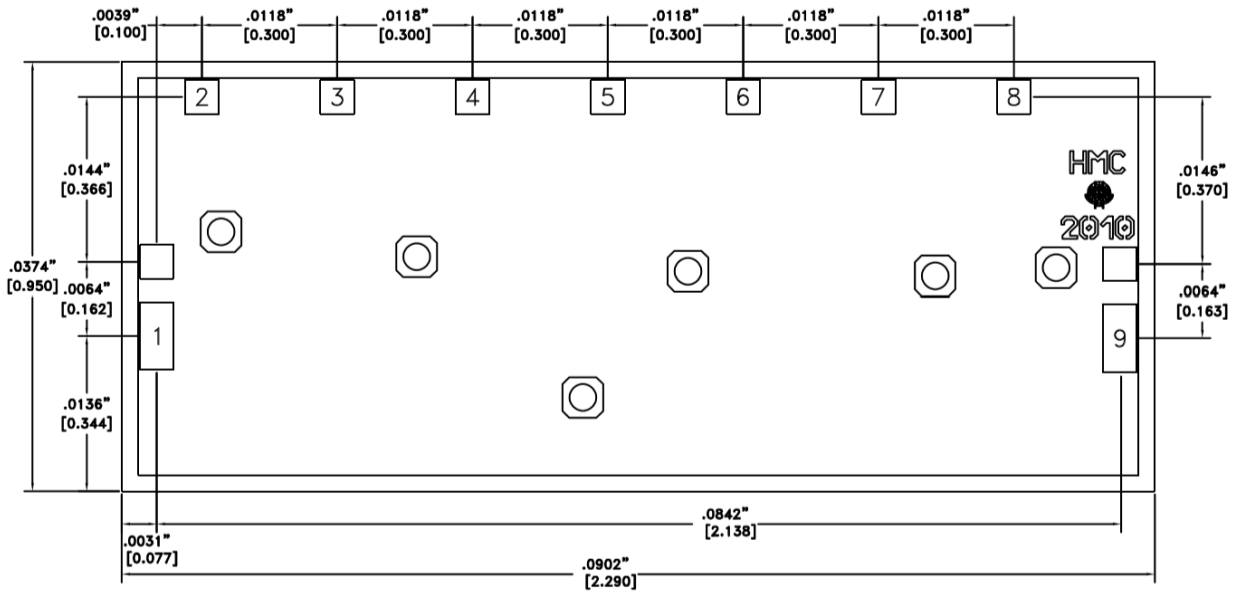
| TABLE IV – TRUTH TABLE 1/ | | | | | Attenuation State RF1 – RF2 |
|---|---|---|---|---|---|
| P4 (8 dB) | P3 (4 dB) | P2 (2 dB) | P1 (1 dB) | P0 (0.5 dB) | |
| High | High | High | High | High | Reference I.L. |
| High | High | High | High | Low | 0.5 dB |
| High | High | High | Low | High | 1 dB |
| High | High | Low | High | High | 2 dB |
| High | Low | High | High | High | 4 dB |
| Low | High | High | High | High | 8 dB |
| Low | Low | Low | Low | Low | 15.5 dB |

TABLE IV Note:

1/ Any combination of the above states will provide an attenuation approximately equal to the sum of the bits selected.

| TABLE V – CONTROL VOLTAGE | |
|---|---|
| State | Bias Condition |
| Low | 0 V to 0.8 V at 1 µA |
| High | 2 V to 5 V at 1 µA |

## 7.0 Die Outline




| PAD | DESCRIPTION | PAD SIZE |
|---|---|---|
| 1 | RF1 | .0059[.150] X .0030[.075] |
| 2 | Vss | .0030[.075] X .0030[.075] |
| 3 | P0 | .0030[.075] X .0030[.075] |
| 4 | P1 | .0030[.075] X .0030[.075] |
| 5 | P2 | .0030[.075] X .0030[.075] |
| 6 | P3 | .0030[.075] X .0030[.075] |
| 7 | P4 | .0030[.075] X .0030[.075] |
| 8 | Vdd | .0030[.075] X .0030[.075] |
| 9 | RF2 | .0059[.150] X .0030[.075] |

NOTES:

1. ALL DIMENSIONS ARE IN INCHES [MM]
2. DIE THICKNESS IS .004"
3. TYPICAL BOND PAD IS .003" SQUARE
4. BOND PAD METALIZATION: GOLD
5. BACKSIDE METALIZATION: GOLD
6. BACKSIDE METAL IS GROUND
7. OVERALL DIE SIZE ±.002"
8. THERE ARE NO AIR BRIDGES ON THIS DIE

## 8.0 Application Notes

Figure 1 shows the assembly diagram. The die should be attached directly to the ground plane eutectically or with conductive epoxy. 50 Ω microstrip transmission lines on 0.127 mm (5 mil) thick alumina thin film substrates are recommended for bringing RF to and from the chip (Figure 2). If 0.254 mm (10 mil) thick alumina thin film substrates must be used, the die should be raised 0.15 mm (6 mil) so that the surface of the die is coplanar with the surface of the substrate. One way to accomplish this is to attach the 0.102 mm (4 mil) thick die to a 0.150 mm (6 mil) thick molybdenum heat spreader (moly-tab) which is then attached to the ground plane (Figure 3). Microstrip substrates should be brought as close to the die as possible in order to minimize wire bond length. Typical die-to-substrate spacing is 0.076 mm to 0.152 mm (3 to 6 mils).

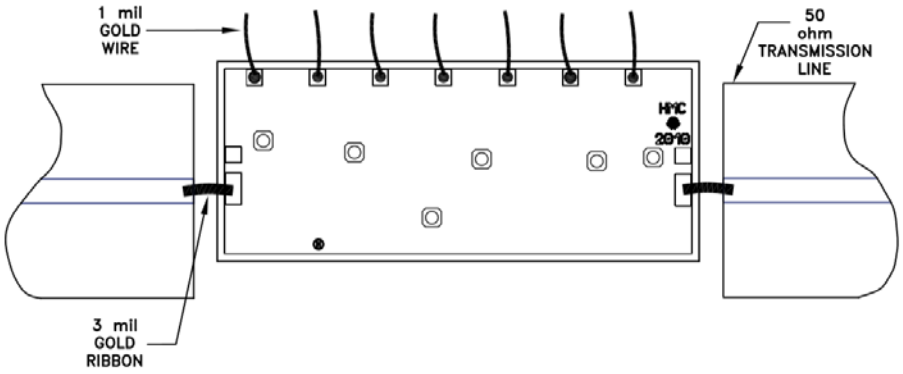



Figure 1. Assembly Diagram

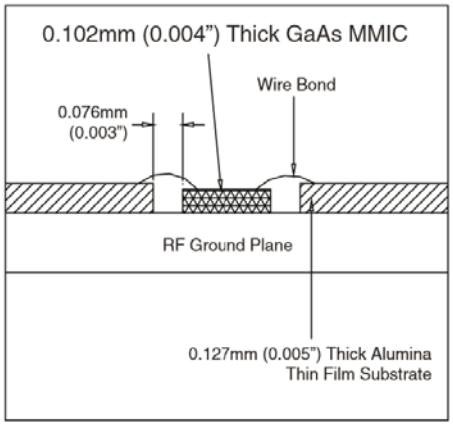



Figure 2. Die without Moly Tab

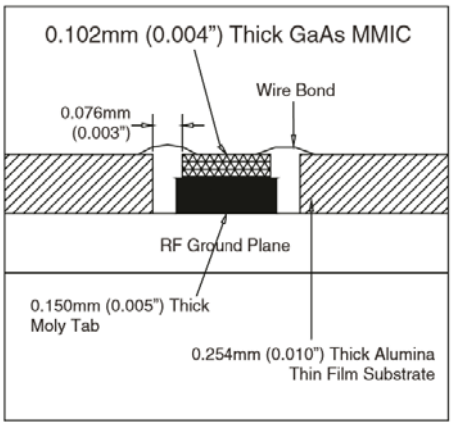



Figure 3. Die with Moly Tab

**Die Packaging Information**

| Standard | Alternate |
|---|---|
| GP-2 (Gel Pack) | 1/ |

Note:

1/ For alternate packaging information, contact Analog Devices Inc.

| Rev | Description of Change | Date |
|---|---|---|
| A | Production release. | 20-March-2020 |
| B | Add Return Losses to Table I and correct Vss polarity typo in section 4.1. | 11-January-2021 |
| C | Corrected AMR RF Input Frequency Range | 4-October-2021 |
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