

Low Noise, Cascadable Silicon Bipolar MMIC Amplifier

Technical Data

INA-02184
INA-02186

Features

- **Cascadable 50 Ω Gain Block**
- **Low Noise Figure:**
2.0 dB Typical at 0.5 GHz
- **High Gain:**
31 dB Typical at 0.5 GHz
26 dB Typical at 1.5 GHz
- **3 dB Bandwidth:**
DC to 0.8 GHz
- **Unconditionally Stable**
($k > 1$)
- **Low Cost Plastic Package**

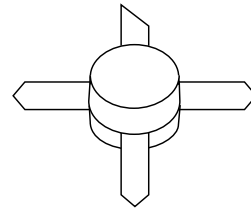
Description

The INA-02184 and INA-02186 are low-noise silicon bipolar Monolithic Microwave Integrated

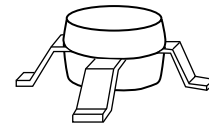
Circuit (MMIC) feedback amplifiers housed in low cost plastic packages. They are designed for narrow or wide bandwidth commercial applications that require high gain and low noise IF or RF amplification.

The INA series of MMICs is fabricated using HP's 10 GHz f_T , 25 GHz f_{MAX} , ISOSAT™-I silicon bipolar process which uses nitride self-alignment, submicrometer lithography, trench isolation, ion implantation, gold metallization and polyimide intermetal dielectric and scratch protection to achieve excellent performance, uniformity and reliability.

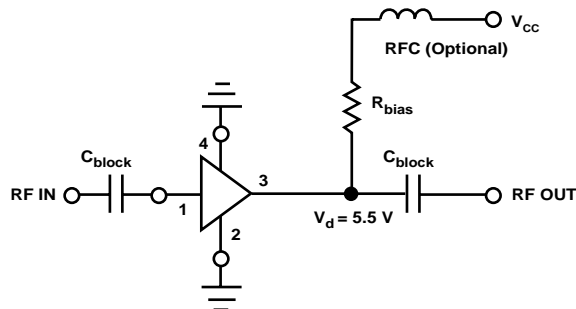
Package 84



Package 86



Typical Biasing Configuration



INA-02184, -02186 Absolute Maximum Ratings

| Parameter | Absolute Maximum ^[1] |
|--------------------------------------|---------------------------------|
| Device Current | 50 mA |
| Power Dissipation ^[2,3,4] | 400 mW |
| RF Input Power | +13 dBm |
| Junction Temperature | +150°C |
| Storage Temperature | -65 to 150°C |

Thermal Resistance^{[2]:}

$$\theta_{jc} = 90^{\circ}\text{C/W} \text{ — INA-02184}$$

$$\theta_{jc} = 100^{\circ}\text{C/W} \text{ — INA-02186}$$

Notes:

1. Permanent damage may occur if any of these limits are exceeded.
2. $T_{\text{CASE}} = 25^{\circ}\text{C}$.
3. Derate at 11.1 mW/°C for $T_{\text{C}} > 144^{\circ}\text{C}$ for INA-02184.
4. Derate at 10 mW/°C for $T_{\text{C}} > 110^{\circ}\text{C}$ for INA-02186.

INA-02184, -02186 Electrical Specifications^[1], $T_{\text{A}} = 25^{\circ}\text{C}$

| Symbol | Parameters and Test Conditions: $I_{\text{d}} = 35 \text{ mA}$, $Z_{\text{o}} = 50 \Omega$ | Units | INA-02184 | | | INA-02186 | | | |
|-----------------------|---|--|-----------|------|-----------|-----------|------|-----------|-----|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| G_{P} | Power Gain ($ S_{21} ^2$) | $f = 0.5 \text{ GHz}$ | dB | 29.0 | 31.0 | | 29.0 | 31.0 | |
| ΔG_{P} | Gain Flatness | $f = 0.01 \text{ to } 1.0 \text{ GHz}$ | dB | | ± 2.0 | | | ± 2.0 | |
| $f_3 \text{ dB}$ | 3 dB Bandwidth ^[2] | | GHz | | 0.8 | | | 0.8 | |
| ISO | Reverse Isolation ($ S_{12} ^2$) | $f = 0.01 \text{ to } 1.0 \text{ GHz}$ | dB | | 39 | | | 39 | |
| VSWR | Input VSWR (Max over Freq. Range) | $f = 0.01 \text{ to } 1.0 \text{ GHz}$ | | | 1.5 | | | 2.0 | |
| | Output VSWR (Max over Freq. Range) | $f = 0.01 \text{ to } 1.0 \text{ GHz}$ | | | 1.7 | | | 1.7 | |
| NF | 50 Ω Noise Figure | $f = 0.5 \text{ GHz}$ | dB | | 2.0 | | | 2.0 | |
| $P_{1 \text{ dB}}$ | Output Power at 1 dB Gain Compression | $f = 0.5 \text{ GHz}$ | dBm | | 11 | | | 11 | |
| IP_3 | Third Order Intercept Point | $f = 0.5 \text{ GHz}$ | dBm | | 23 | | | 23 | |
| t_{D} | Group Delay | $f = 0.5 \text{ GHz}$ | psec | | 330 | | | 350 | |
| V_{d} | Device Voltage | | V | 4.0 | 5.5 | 7.0 | 4.0 | 5.5 | 7.0 |
| dV/dT | Device Voltage Temperature Coefficient | | mV/°C | | +10 | | | +10 | |

Notes:

1. The recommended operating current range for this device is 30 to 40 mA. Typical performance as a function of current is on the following page.
2. Referenced from 10 MHz Gain (G_{P}).

INA-02184, -02186 Part Number Ordering Information

| Part Number | No. of Devices | Container |
|---------------|----------------|----------------|
| INA-02184-TR1 | 1000 | 7" Reel |
| INA-02184-BLK | 100 | Antistatic Bag |
| INA-02186-TR1 | 1000 | 7" Reel |
| INA-02186-BLK | 100 | Antistatic Bag |

For more information, see "Tape and Reel Packaging for Semiconductor Devices".

INA-02184, -02186 Typical Performance, $T_A = 25^\circ\text{C}$
(unless otherwise noted)

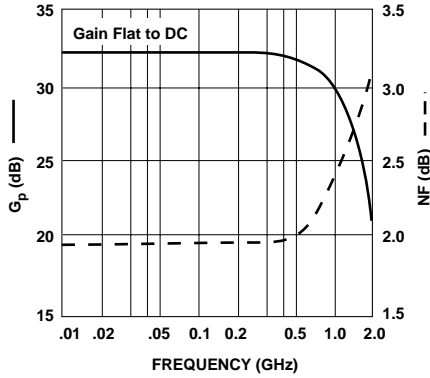


Figure 1. Typical Gain and Noise Figure vs. Frequency, $T_A = 25^\circ\text{C}$, $I_d = 35\text{ mA}$.

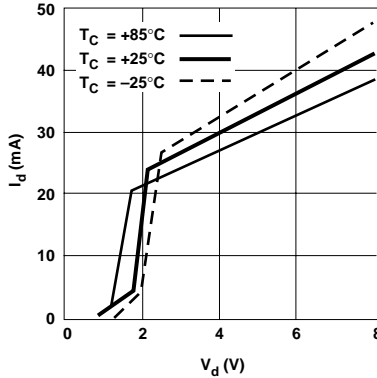


Figure 2. Device Current vs. Voltage.

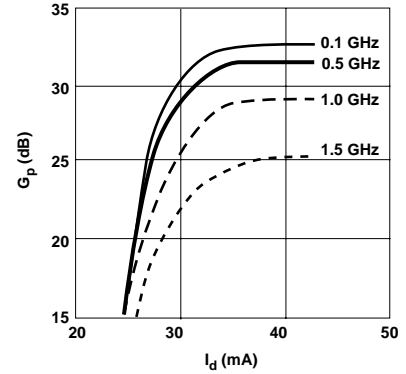


Figure 3. Power Gain vs. Current.

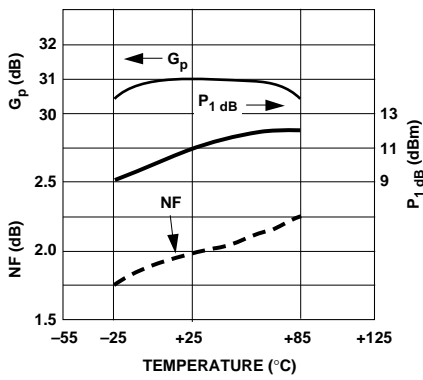


Figure 4. Output Power and 1 dB Gain Compression, NF and Power Gain vs. Case Temperature, $f = 0.5\text{ GHz}$, $I_d = 35\text{ mA}$.

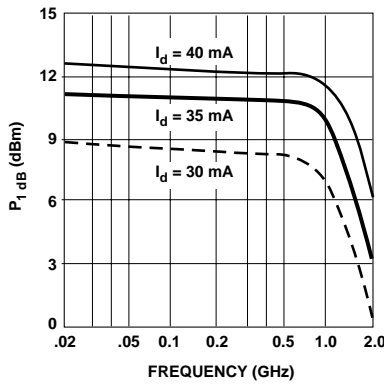


Figure 5. Output Power at 1 dB Gain Compression vs. Frequency.

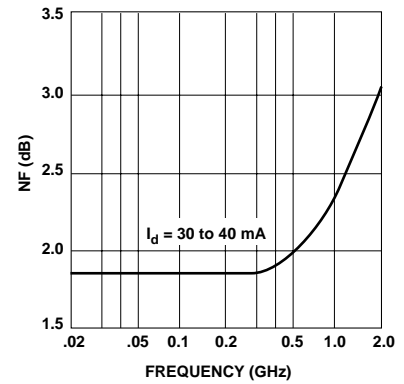


Figure 6. Noise Figure vs. Frequency.

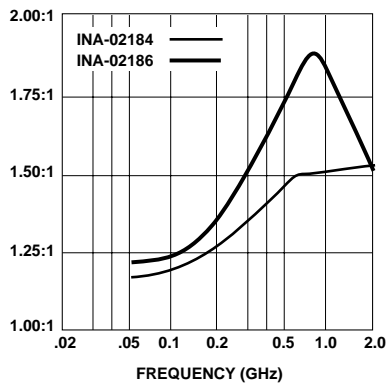


Figure 7. Input VSWR vs. Frequency, $I_d = 35\text{ mA}$.

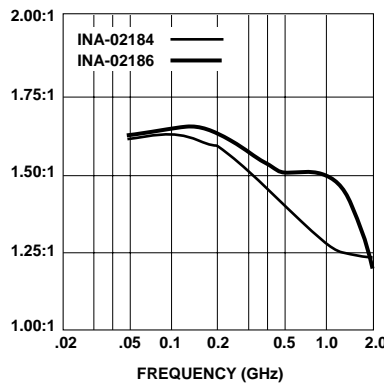


Figure 8. Output VSWR vs. Frequency, $I_d = 35\text{ mA}$.

Typical INA-02184 Scattering Parameters ($Z_o = 50 \Omega$, $T_A = 25^\circ\text{C}$, $I_d = 35 \text{ mA}$)

| Freq. GHz | S ₁₁ | | S ₂₁ | | | S ₁₂ | | | S ₂₂ | | k |
|--------------|-----------------|------|-----------------|-------|------|-----------------|------|-----|-----------------|------|------|
| | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang | |
| 0.01 | .09 | -176 | 31.9 | 39.33 | -1 | -40.0 | .010 | 1 | .25 | -1 | 1.40 |
| 0.05 | .09 | -171 | 31.9 | 39.24 | -6 | -41.9 | .008 | -12 | .25 | -4 | 1.66 |
| 0.10 | .10 | -163 | 31.8 | 39.07 | -13 | -40.9 | .009 | 1 | .25 | -8 | 1.52 |
| 0.20 | .13 | -159 | 31.7 | 38.30 | -26 | -40.0 | .010 | 15 | .23 | -13 | 1.44 |
| 0.30 | .15 | -161 | 31.4 | 37.30 | -39 | -38.4 | .012 | 16 | .22 | -17 | 1.29 |
| 0.40 | .18 | -168 | 31.2 | 36.42 | -51 | -39.2 | .011 | 32 | .21 | -15 | 1.39 |
| 0.50 | .19 | -175 | 31.0 | 35.40 | -63 | -40.0 | .010 | 34 | .21 | -16 | 1.52 |
| 0.60 | .20 | 179 | 30.7 | 34.20 | -75 | -37.1 | .014 | 35 | .21 | -17 | 1.24 |
| 0.80 | .19 | 166 | 29.9 | 31.21 | -101 | -38.4 | .012 | 38 | .24 | -26 | 1.44 |
| 1.00 | .17 | 159 | 28.4 | 26.36 | -126 | -36.5 | .015 | 53 | .24 | -41 | 1.40 |
| 1.20 | .15 | 159 | 26.8 | 21.89 | -149 | -34.0 | .020 | 56 | .22 | -60 | 1.31 |
| 1.40 | .15 | 163 | 24.8 | 17.36 | -169 | -33.2 | .022 | 62 | .18 | -78 | 1.50 |
| 1.60 | .16 | 168 | 22.6 | 13.59 | 175 | -31.4 | .027 | 67 | .14 | -93 | 1.50 |
| 1.80 | .18 | 168 | 20.7 | 10.86 | 161 | -31.1 | .028 | 61 | .11 | -108 | 1.74 |
| 2.00 | .19 | 165 | 18.8 | 8.71 | 149 | -30.2 | .031 | 64 | .08 | -125 | 1.92 |
| 2.50 | .23 | 159 | 14.9 | 5.56 | 127 | -29.1 | .035 | 56 | .05 | -167 | 2.54 |
| 3.00 | .27 | 150 | 11.5 | 3.76 | 106 | -27.1 | .044 | 65 | .04 | 156 | 2.89 |
| 3.50 | .30 | 143 | 8.8 | 2.74 | 89 | -26.0 | .050 | 57 | .04 | 137 | 3.39 |
| 4.00 | .33 | 133 | 6.6 | 2.14 | 73 | -25.0 | .056 | 62 | .05 | 137 | 3.78 |

Typical INA-02186 Scattering Parameters ($Z_o = 50 \Omega$, $T_A = 25^\circ\text{C}$, $I_d = 35 \text{ mA}$)

| Freq. GHz | S ₁₁ | | S ₂₁ | | | S ₁₂ | | | S ₂₂ | | k |
|--------------|-----------------|------|-----------------|-------|------|-----------------|------|-----|-----------------|-----|------|
| | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang | |
| 0.01 | .09 | -178 | 31.5 | 37.38 | -1 | -40.0 | .010 | 1 | .24 | -1 | 1.46 |
| 0.05 | .09 | -172 | 31.5 | 37.55 | -6 | -37.7 | .013 | 11 | .24 | -5 | 1.22 |
| 0.10 | .11 | -160 | 31.5 | 37.46 | -13 | -39.2 | .011 | 8 | .23 | -9 | 1.37 |
| 0.20 | .14 | -153 | 31.4 | 37.04 | -25 | -40.9 | .009 | 15 | .22 | -17 | 1.60 |
| 0.30 | .18 | -156 | 31.3 | 36.62 | -37 | -38.4 | .012 | 1 | .21 | -25 | 1.30 |
| 0.40 | .22 | -161 | 31.2 | 36.20 | -49 | -37.7 | .013 | 28 | .19 | -30 | 1.25 |
| 0.50 | .25 | -169 | 31.1 | 35.70 | -61 | -39.2 | .011 | 42 | .18 | -35 | 1.40 |
| 0.60 | .28 | -177 | 30.9 | 34.94 | -74 | -38.4 | .012 | 44 | .16 | -39 | 1.33 |
| 0.80 | .31 | 165 | 30.2 | 32.34 | -101 | -36.5 | .015 | 52 | .15 | -47 | 1.20 |
| 1.00 | .30 | 148 | 28.8 | 27.64 | -129 | -34.4 | .019 | 57 | .12 | -59 | 1.15 |
| 1.20 | .27 | 135 | 27.0 | 22.26 | -153 | -32.4 | .024 | 62 | .09 | -70 | 1.15 |
| 1.40 | .24 | 129 | 24.7 | 17.22 | -173 | -31.1 | .028 | 61 | .07 | -80 | 1.23 |
| 1.60 | .21 | 128 | 22.5 | 13.27 | 170 | -31.4 | .027 | 62 | .04 | -82 | 1.52 |
| 1.80 | .20 | 129 | 20.4 | 10.42 | 156 | -29.1 | .035 | 61 | .02 | -83 | 1.50 |
| 2.00 | .20 | 131 | 18.4 | 8.34 | 144 | -29.1 | .035 | 63 | .01 | -20 | 1.79 |
| 2.50 | .23 | 133 | 14.5 | 5.29 | 123 | -27.1 | .044 | 59 | .02 | 30 | 2.15 |
| 3.00 | .27 | 130 | 11.2 | 3.61 | 103 | -25.7 | .052 | 63 | .02 | 27 | 2.56 |
| 3.50 | .31 | 124 | 8.3 | 2.60 | 86 | -24.4 | .060 | 64 | .02 | 34 | 2.97 |
| 4.00 | .34 | 118 | 6.1 | 2.02 | 70 | -23.4 | .068 | 58 | .01 | 30 | 3.28 |

Emitter Inductance and Performance

As a direct result of their circuit topology, the performance of INA MMICs is extremely sensitive to groundpath (“emitter”) inductance. The two stage design creates the possibility of a feedback loop being formed through the ground returns of the stages. If the path to ground provided by the external circuit is “long” (high in impedance) compared to the path back through the ground return of the other stage, then instability can occur (see Fig. 1). This phenomena can show up as a “peaking” in the gain versus frequency response (perhaps creating a negative gain slope amplifier), an increase in input VSWR, or even as return gain (a

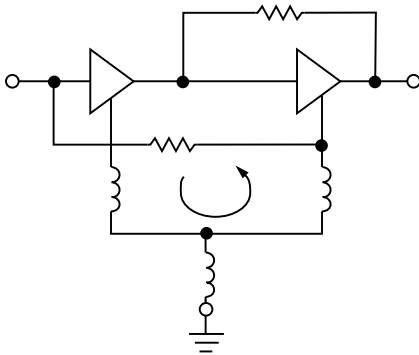


Figure 1. INA Potential Ground Loop.

reflection coefficient greater than unity) at the input of the MMIC.

The “bottomline” is that **excellent grounding is critical** when using INA MMICs. The use of plated through holes or equivalent minimal path ground returns **at the device** is essential. An appropriate layout is shown in Figure 2. A corollary is that designs should be done on the thinnest practical substrate. The parasitic inductance of a pair of via holes passing through 0.032" thick P.C. board is approximately 0.1 nH, while that of a pair of via holes passing through 0.062" thick board is close to 0.5 nH. HP does not recommend using INA family MMICs on boards thicker than 32 mils.

These stability effects are entirely predictable. A circuit simulation using the data sheet S-parameters and including a description of the ground return path (via model or equivalent “emitter” inductance) will give an accurate picture of the performance that can be expected. Device characterizations are made with the ground leads of the MMIC directly contacting a solid copper block (system ground) at a distance of 2 to 4 mils from the body of the package. Thus the information in the data sheet is a true description of the performance capability of the MMIC, and contains minimal contributions from fixturing.

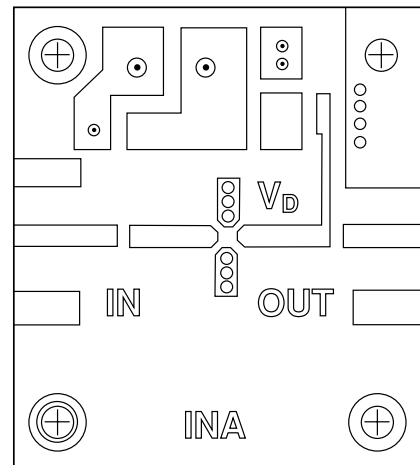
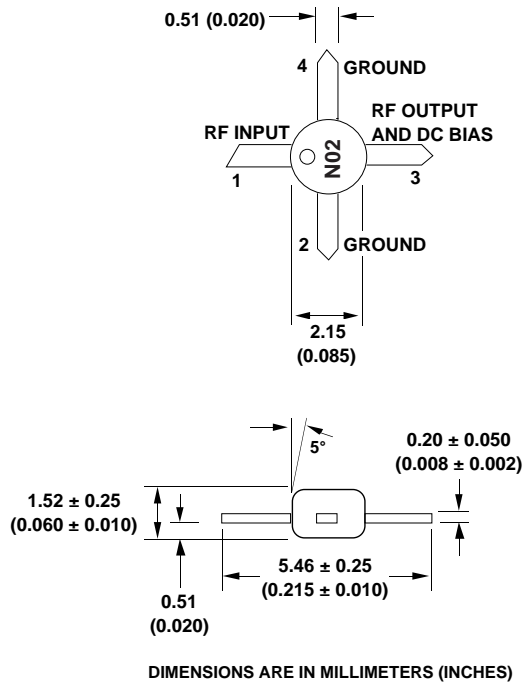


Figure 2. INA Circuit Board 2x Actual Size.

Package 84 Dimensions



Package 86 Dimensions

