

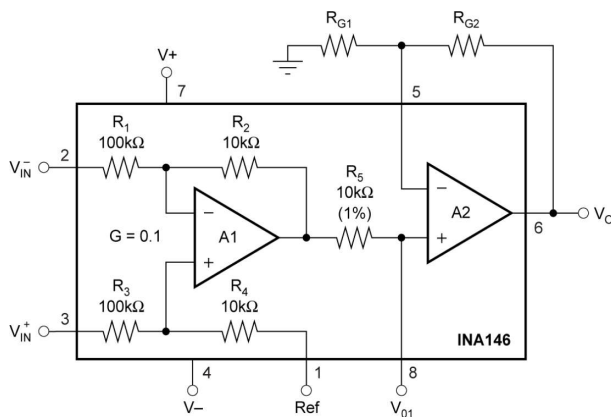
INA146 高電圧、プログラマブルゲイン差動アンプ

1 特長

- 高い同相電圧:
 - 40V ($V_S = 5V$ 時)
 - $\pm 100V$ ($V_S = \pm 15V$ 時)
- 差動ゲイン = 0.1V/V ~ 100V/V:
 - 外付け抵抗により設定
- 低い静止電流: 570 μ A
- 幅広い電源電圧範囲:
 - 単電源: 4.5V ~ 36V
 - 両電源: $\pm 2.25V$ ~ $\pm 18V$
- 低ゲイン誤差: 0.025%
- 大きい同相除去: 80dB

2 アプリケーション

- バッテリ・セル形成とテスト機器
- ACドライブ制御モジュール
- HVACコントローラ
- 業務用オーディオ・アンプ (ラック・マウント)
- プログラマブル DC 電源
- データ・アキュイジション (DAQ)



INA146 の概略ブロック図

3 概要

INA146 は高精度の差動アンプで、高い差動電圧を正確に減衰させ、高い同相電圧を除去して、一般的な信号処理電圧レベルとの互換性を確保できます。また、高電圧機能により、継承的に入力保護機能も備えていることとなります。入力同相範囲が両方の電源レールを超えているため、INA146 は単電源と両電源の両方のアプリケーションに最適です。

レーザトリミングされたオンチップの高精度抵抗により、高いゲイン精度と高い同相除去比を実現します。これらの抵抗の優れた TCR トラッキングにより、温度範囲全体にわたって高精度が維持されます。

出力アンプがユニティゲインバッファとして使用されている場合、10:1 の差動アンプにより 0.1V/V のゲインが得られます。この構成では、最大 $\pm 100V$ までの入力電圧を測定できます。0.1V/V を超えるゲインは、同相入力範囲に影響を与えることなく、外付けの抵抗ペアを使用して設定できます。

INA146 は、拡張工業用温度範囲 (-40°C ~ 85°C) で動作が規定されている、SO-8 表面実装パッケージで供給されます。

パッケージ情報

| 部品番号 | パッケージ (1) | 規定温度範囲 | パッケージ・サイズ (2) |
|--------|-----------|--------------|-----------------|
| INA146 | SOIC (8) | -40°C ~ 85°C | 4.90mm × 6.00mm |

- (1) 利用可能なすべてのパッケージについては、データシートの末尾にある注文情報を参照してください。
- (2) パッケージ・サイズ (長さ×幅) は公称値であり、該当する場合はピンも含まれます。



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4 Pin Configuration and Functions

Top View

SO-8

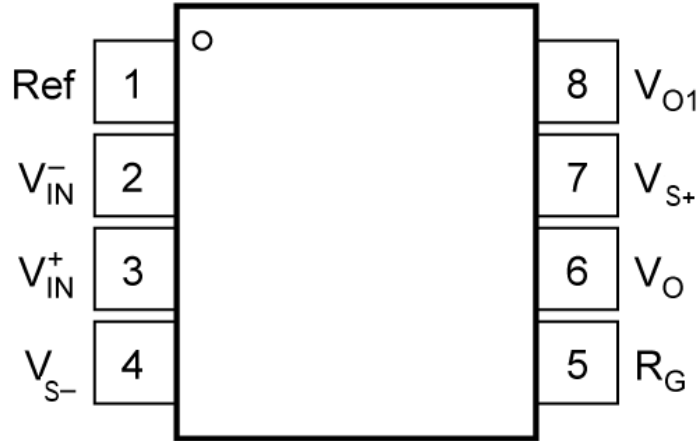


図 4-1. INA146 D Package, 8-Pin SOIC (Top View)

表 4-1. Pin Functions

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|-----------|-----|---------------------|---|
| NAME | NO. | | |
| Ref | 1 | I | Reference input. This pin must be driven by a low impedance source. |
| V_{IN-} | 2 | I | Negative (inverting) input |
| V_{IN+} | 3 | I | Positive (non-inverting) input |
| V_{S-} | 4 | - | Negative supply |
| R_G | 5 | I | Gain setting input. Place a resistor network between pin 1 and pin 5. |
| V_O | 6 | O | Output of amplifier A2 |
| V_{S+} | 7 | - | Positive supply |
| V_{O1} | 8 | O | Output of amplifier A1 |

(1) Signal Types: I = Input, O = Output, I/O = Input or Output.

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

| | | | MIN | MAX | UNIT |
|-------------------------------------|-------------------------------------|---|------------|------|------|
| V _S | Supply voltage | Dual supply, V _S = (V _{S+}) – (V _{S-}) | | ±18 | V |
| | | Single supply, V _S = (V _{S+}) – 0 V | | 36 | |
| V _{IN+} , V _{IN-} | Signal input voltage | | | ±100 | V |
| | Signal input current | | | ±1 | mA |
| | Output short-circuit ⁽²⁾ | | Continuous | | |
| T _A | Operating temperature | | –55 | 125 | °C |
| T _{stg} | Storage temperature | | –55 | 125 | °C |
| T _J | Junction temperature | | | 150 | °C |
| | Lead temperature (soldering, 10 s) | | | 240 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Short-circuit to V_S / 2.

5.2 ESD Ratings

| | | | VALUE | UNIT |
|--------------------|-------------------------|--|-------|------|
| V _(ESD) | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±1000 | V |
| | | Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±1000 | |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | | MIN | TYP | MAX | UNIT |
|----------------|-----------------------|---------------|-------|-----|-----|------|
| V _S | Supply voltage | Single-supply | 4.5 | 30 | 36 | V |
| | | Dual-supply | ±2.25 | ±15 | ±18 | |
| T _A | Specified temperature | | –40 | | 85 | °C |

5.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | INA146 | UNIT |
|-------------------------------|--|--------|------|
| | | SO-8 | |
| | | 8 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 110.3 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 43.6 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 55.5 | °C/W |
| Ψ _{JT} | Junction-to-top characterization parameter | 6.2 | °C/W |
| Ψ _{JB} | Junction-to-board characterization parameter | 54.3 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

5.5 Electrical Characteristics $V_S = \pm 2.25\text{ V to } \pm 18\text{ V}$

 at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.25\text{ V to } \pm 18\text{ V}$, $R_L = 10\text{ k}\Omega$, $V_{REF} = 0\text{ V}$, $V_{CM} = V_S / 2$, and $G = 0.1$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------------|------------------------------------|--|--|----------------|-------------|----------------|------------------------------|
| INPUT | | | | | | | |
| V_{OS} | Offset voltage, V_O | RTI, $V_S = \pm 15\text{ V}$, $V_{CM} = 0\text{ V}$ | | | ± 1 | ± 5 | mV |
| | Offset voltage, V_{O1} | RTI | | | ± 1 | | mV |
| | Offset voltage drift | RTI, $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | | ± 10 | | $\mu\text{V}/^\circ\text{C}$ |
| PSRR | Power-supply rejection ratio | RTI, $V_S = \pm 1.35\text{ V to } \pm 18\text{ V}$ | | | ± 100 | ± 600 | $\mu\text{V}/\text{V}$ |
| V_{CM} | Common-mode voltage ⁽¹⁾ | $V_S = \pm 15\text{ V}$, $V_{IN} = 0\text{ V}$ | | -100 | | 100 | V |
| CMRR | Common-mode voltage rejection | RTI, $11(-V_S) < V_{CM} < 11(V_S - 1)$, $R_S = 0\ \Omega$ | | 70 | 80 | | dB |
| | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | 64 | 74 | | |
| | Differential input impedance | Non-inverting input | | | 110 | | k Ω |
| | | Inverting input | | | 91.7 | | |
| | Common-mode input impedance | | | | 55 | | k Ω |
| BIAS CURRENT | | | | | | | |
| I_B | Bias Current | $V_{CM} = V_S / 2$ | | | ± 50 | | nA |
| I_{OS} | Offset Current | | | | ± 5 | | nA |
| NOISE | | | | | | | |
| e_N | Voltage noise | RTI, $f_B = 0.1\text{ Hz to } 10\text{ Hz}$ | | | 12 | | μV_{PP} |
| | | RTI, $f = 1\text{ kHz}$ | | | 550 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| GAIN | | | | | | | |
| | Gain | | | 0.1 | | 100 | V/V |
| GE | Gain error | $V_O = (V_-) + 0.15\text{ V to } (V_+) - 1\text{ V}$, $R_L = 100\text{ k}\Omega$, $G = 1$ | | | ± 0.025 | ± 0.1 | % |
| | | $V_O = (V_-) + 0.3\text{ V to } (V_+) - 1.25\text{ V}$, $R_L = 10\text{ k}\Omega$, $G = 1$ | | | ± 0.025 | ± 0.1 | |
| | Gain error drift ⁽²⁾ | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | $V_O = (V_-) + 0.25\text{ V to } (V_+) - 1\text{ V}$, $R_L = 100\text{ k}\Omega$, $G = 1$ | | ± 1 | ± 10 | ppm/ $^\circ\text{C}$ |
| | | | $V_O = (V_-) + 0.5\text{ V to } (V_+) - 1.25\text{ V}$, $R_L = 10\text{ k}\Omega$, $G = 1$ | | ± 1 | ± 10 | |
| | Gain nonlinearity | $V_O = (V_-) + 0.3\text{ V to } (V_+) - 1.25\text{ V}$, $G = 1$ | | | ± 0.001 | ± 0.01 | % of FSR |
| OUTPUT | | | | | | | |
| | Output voltage | $R_L = 100\text{ k}\Omega$, $G = 1$ | | $(V_-) + 0.15$ | | $(V_+) - 1$ | V |
| | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | $(V_-) + 0.25$ | | $(V_+) - 1$ | |
| | | $R_L = 10\text{ k}\Omega$, $G = 1$ | | $(V_-) + 0.3$ | | $(V_+) - 1.25$ | |
| | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | $(V_-) + 0.5$ | | $(V_+) - 1.25$ | |
| C_L | Load capacitance | Stable operation | | | 1 | | nF |
| I_{SC} | Short-circuit current | Continuous to $V_S / 2$ | | | ± 15 | | mA |
| FREQUENCY RESPONSE | | | | | | | |
| BW | Bandwidth, -3 dB | $G = 0.1$ | | | 550 | | kHz |
| | | $G = 1$ | | | 50 | | |
| SR | Slew rate | | | | 0.3 | | V/ μs |
| t_s | Settling time | To 0.1%, | $V_O = 10\text{ V-step}$ | | 40 | | μs |
| | | To 0.01% | $V_O = 10\text{ V-step}$ | | 80 | | |
| | Overload recovery | 50% input overload | | | 40 | | μs |
| POWER SUPPLY | | | | | | | |
| I_Q | Quiescent current | $V_{IN} = 0\text{ V}$ | | | ± 570 | ± 700 | μA |
| | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | | | ± 750 | |

 (1) Input common-mode voltage varies with output voltage; see *Typical Characteristics*.

(2) Specified by wafer test.

5.6 Electrical Characteristics $V_S = 5\text{ V}$ Single Supply

at $T_A = 25^\circ\text{C}$, $V_S = 5\text{ V}$, $R_L = 10\text{ k}\Omega$, $V_{REF} = 0\text{ V}$, $V_{CM} = V_S / 2$, and $G = 0.1$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------------|------------------------------------|---|---|------|-------------|------------|------------------------------|
| INPUT | | | | | | | |
| V_{OS} | Offset voltage, V_O | RTI, $V_{CM} = 0\text{ V}$ | | | ± 3 | ± 10 | mV |
| | Offset voltage, V_{O1} | RTI, $V_{CM} = 0\text{ V}$ | | | ± 1 | | mV |
| | Offset voltage drift | RTI, $T_A = -40^\circ\text{C}$ to 85°C | | | ± 10 | | $\mu\text{V}/^\circ\text{C}$ |
| PSRR | Power-supply rejection ratio | RTI, $V_S = \pm 1.35\text{ V}$ to $\pm 18\text{ V}$ | | | ± 100 | ± 600 | $\mu\text{V}/\text{V}$ |
| V_{CM} | Common-mode voltage ⁽¹⁾ | $V_{IN} = 0\text{ V}$ | | -25 | | 19 | V |
| CMRR | Common-mode voltage rejection | $V_{CM} = -25\text{ V}$ to 19 V , $R_S = 0\ \Omega$ | | 70 | 80 | | dB |
| | | $T_A = -40^\circ\text{C}$ to 85°C | | 64 | 74 | | |
| | Differential input impedance | Non-inverting input | | | 110 | | k Ω |
| | | Inverting input | | | 91.7 | | |
| | Common-mode input impedance | | | | 55 | | k Ω |
| BIAS CURRENT | | | | | | | |
| I_B | Bias Current | $V_{CM} = V_S / 2$ | | | ± 50 | | nA |
| I_{OS} | Offset Current | $V_{CM} = V_S / 2$ | | | ± 5 | | nA |
| NOISE | | | | | | | |
| e_N | Voltage noise | RTO, $f_B = 0.1\text{ Hz}$ to 10 Hz | | | 12 | | μV_{PP} |
| | | RTO, $f = 1\text{ kHz}$ | | | 550 | | nV/ $\sqrt{\text{Hz}}$ |
| GAIN | | | | | | | |
| | Gain | | | 0.1 | | 100 | V/V |
| GE | Gain error | $V_O = 0.15\text{ V}$ to 4 V , $R_L = 100\text{ k}\Omega$ | | | ± 0.025 | ± 0.1 | % |
| | | $V_O = 0.3\text{ V}$ to 3.75 V , $R_L = 10\text{ k}\Omega$ | | | ± 0.025 | ± 0.1 | |
| | Gain error drift ⁽²⁾ | $T_A = -40^\circ\text{C}$ to 85°C | $V_O = 0.25\text{ V}$ to 4 V , $R_L = 100\text{ k}\Omega$ | | ± 1 | ± 10 | ppm/ $^\circ\text{C}$ |
| | | | $V_O = 0.5\text{ V}$ to 3.75 V , $R_L = 10\text{ k}\Omega$ | | ± 1 | ± 10 | |
| | Gain nonlinearity | $V_O = 0.3\text{ V}$ to 3.75 V | | | ± 0.001 | ± 0.01 | % of FSR |
| OUTPUT | | | | | | | |
| | Output voltage | $R_L = 100\text{ k}\Omega$ | | 0.15 | | 4 | V |
| | | | $T_A = -40^\circ\text{C}$ to 85°C | 0.25 | | 4 | |
| | | $R_L = 10\text{ k}\Omega$ | | 0.3 | | 3.75 | |
| | | | $T_A = -40^\circ\text{C}$ to 85°C | 0.5 | | 3.75 | |
| C_L | Load capacitance | Stable operation | | | 1 | | nF |
| I_{SC} | Short-circuit current | Continuous to $V_S / 2$ | | | ± 15 | | mA |
| FREQUENCY RESPONSE | | | | | | | |
| BW | Bandwidth, -3 dB | $G = 0.1$ | | | 550 | | kHz |
| | | $G = 1$ | | | 50 | | |
| SR | Slew rate | | | | 0.3 | | V/ μs |
| t_s | Settling time | To 0.1%, | $V_O = 10\text{ V-step}$ | | 40 | | μs |
| | | To 0.01% | $V_O = 10\text{ V-step}$ | | 80 | | |
| | Overload recovery | 50% input overload | | | 40 | | μs |
| POWER SUPPLY | | | | | | | |
| I_Q | Quiescent current | $V_{IN} = 0\text{ V}$ | | | ± 570 | ± 700 | μA |
| | | $T_A = -40^\circ\text{C}$ to 85°C | | | | ± 750 | |

(1) Input common-mode voltage varies with output voltage; see *Typical Characteristics*.

(2) Specified by wafer test.

5.7 Amplifier A1, A2 Performance

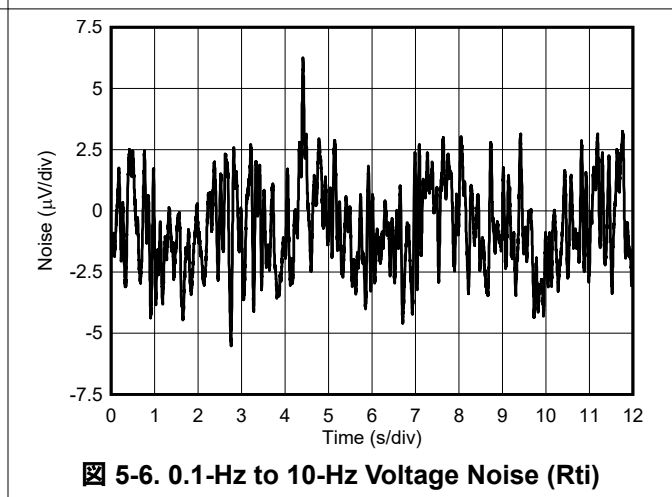
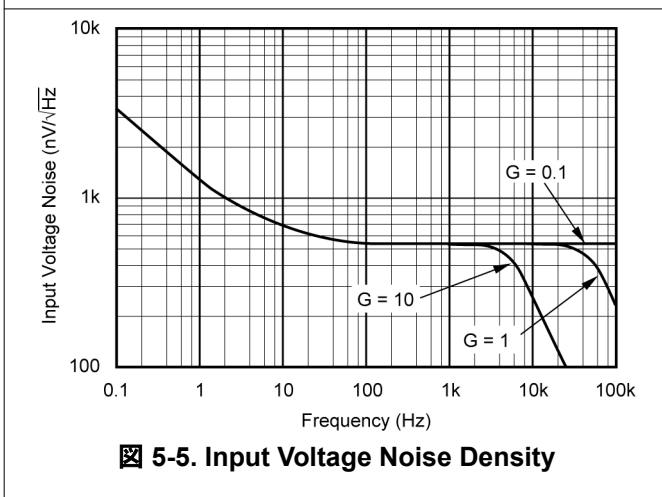
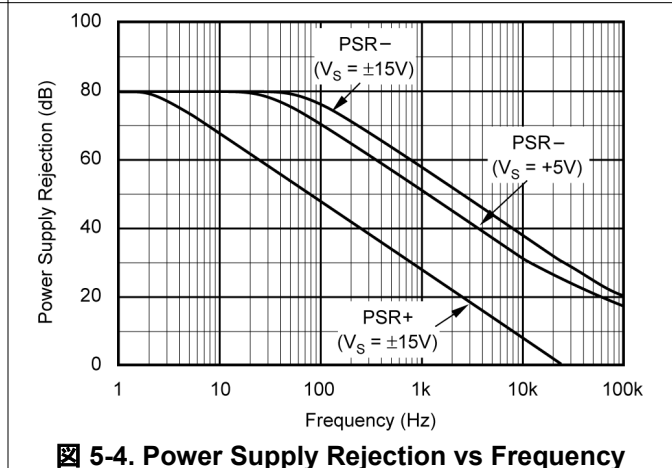
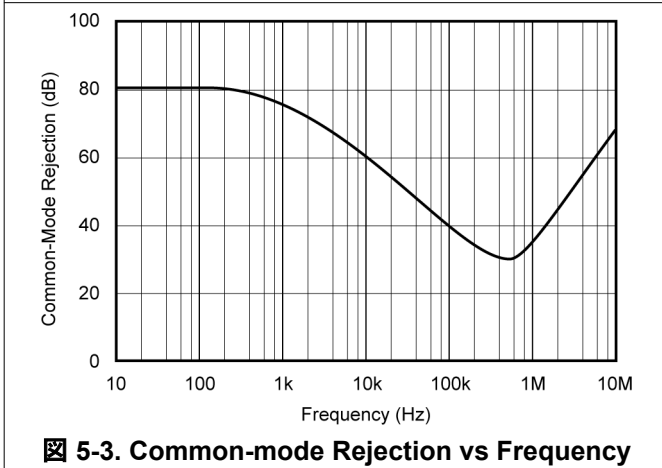
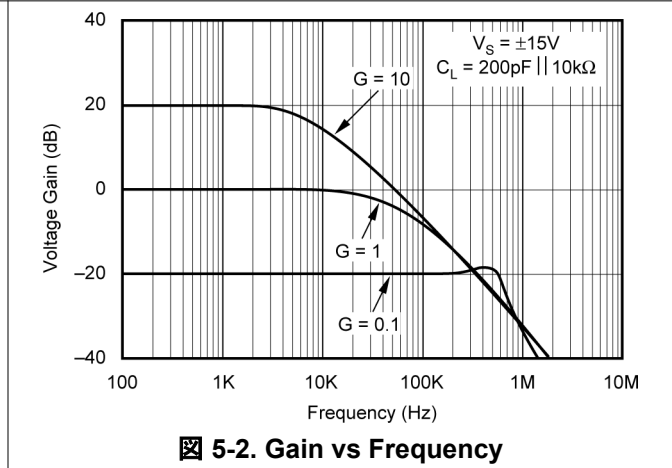
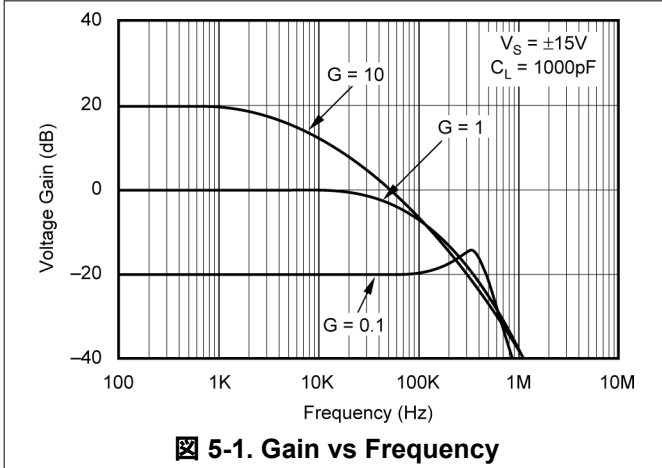
at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$, $V_{REF} = 0\text{ V}$, $V_{CM} = V_S / 2$, and $G = 0.1$ (unless otherwise noted)

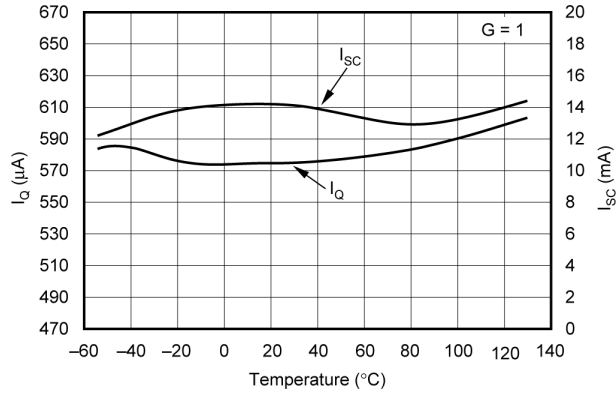
| PARAMETER | TEST CONDITIONS | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------|------------------------------------|--|-----|----------------------------|-----|------------------------------|
| INPUT | | | | | | |
| V_{OS} | Offset voltage, V_O | RTI, $V_S = \pm 15\text{ V}$, $V_{CM} = V_O = 0\text{ V}$ | | ± 0.5 | | mV |
| | Offset voltage drift | RTI, $T_A = -40^\circ\text{C}$ to 85°C | | ± 1 | | $\mu\text{V}/^\circ\text{C}$ |
| V_{CM} | Common-mode voltage ⁽¹⁾ | $V_{IN} = V_O = 0\text{ V}$ | | V_{S-} to $(V_{S+}) - 1$ | | V |
| CMRR | Common-mode voltage rejection | $V_{CM} = V_{S-}$ to $(V_{S+}) - 1$ | | 90 | | dB |
| GAIN | | | | | | |
| A_{OL} | Open Loop Gain | | | 110 | | dB |
| BIAS CURRENT | | | | | | |
| I_B | Bias Current | | | ± 50 | | nA |
| I_{OS} | Offset Current | | | ± 5 | | nA |
| OUTPUT | | | | | | |
| | Resistor at V_{O1} | Initial | | 10 | | k Ω |
| | Error at V_{O1} | | | ± 1 | | % |
| | Error drift at V_{O1} | | | ± 100 | | ppm/ $^\circ\text{C}$ |

(1) Input common-mode voltage varies with output voltage; see *Typical Characteristics*.

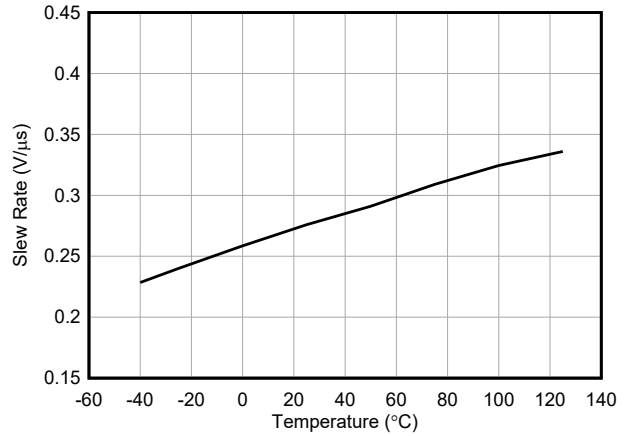
5.8 Typical Performance Curves

At $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{ V}$, $G = 0.1$, $R_L = 10\text{ k}\Omega$ connected to ground and Ref pin connected to ground, unless otherwise noted.

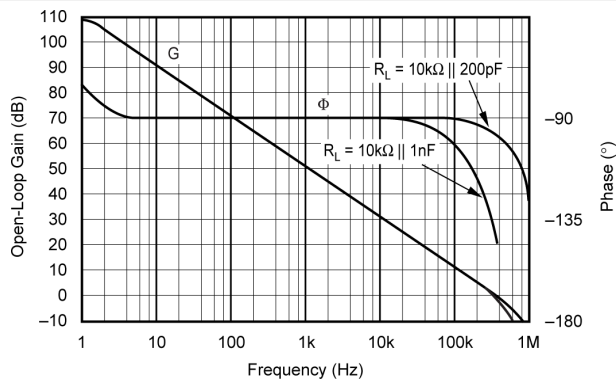




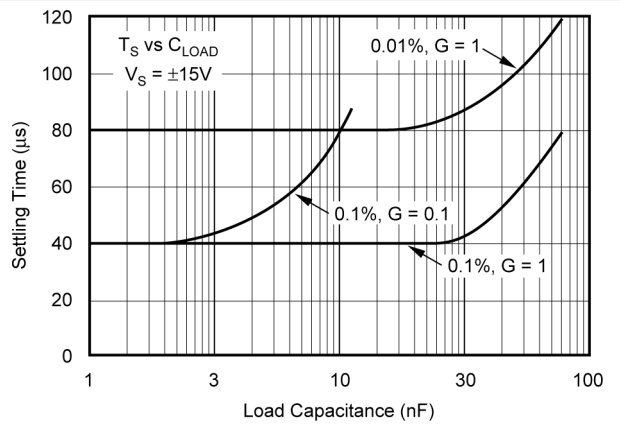
5-7. Quiescent Current and Short-circuit Current vs Temperature



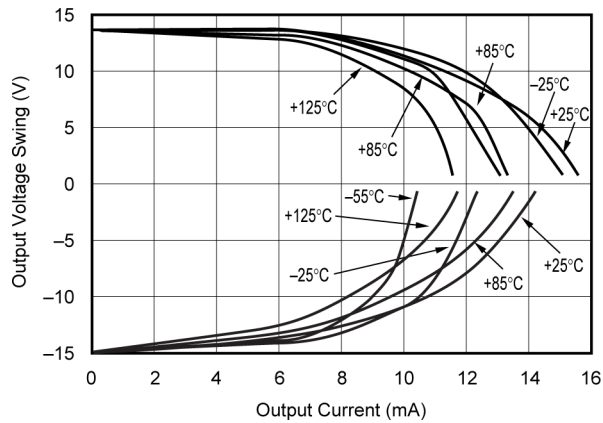
5-8. Slew Rate vs Temperature



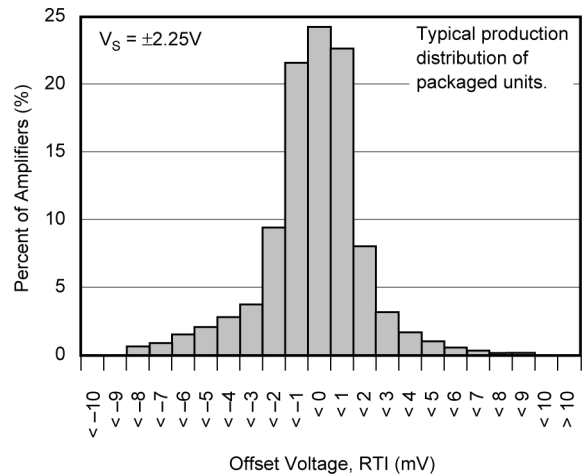
5-9. Gain and Phase vs Frequency Op Amp A1 and A2



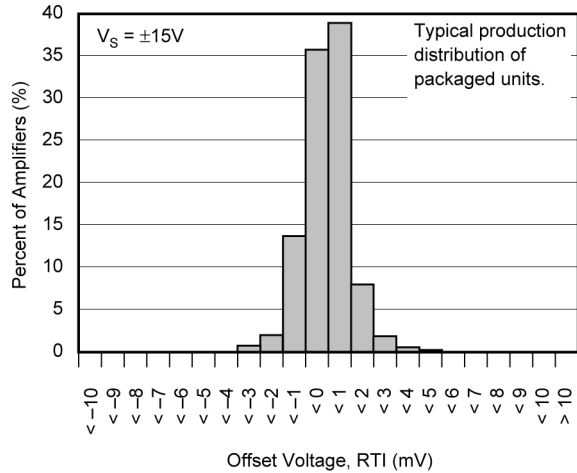
5-10. Settling Time vs Load Capacitance



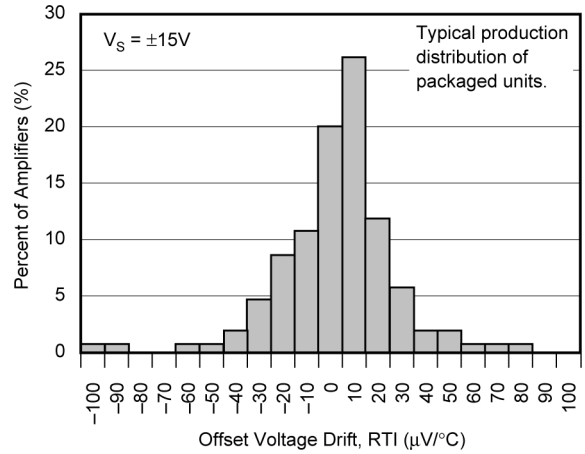
5-11. Maximum Output Voltage Swing vs Output Current



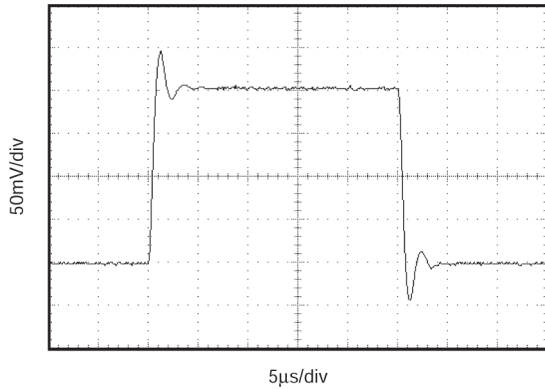
5-12. Offset Voltage Production Distribution



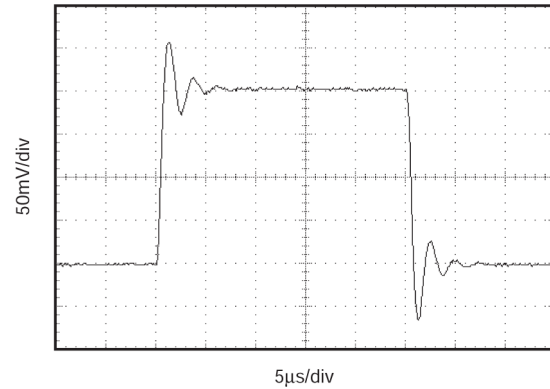
5-13. Offset Voltage Production Distribution



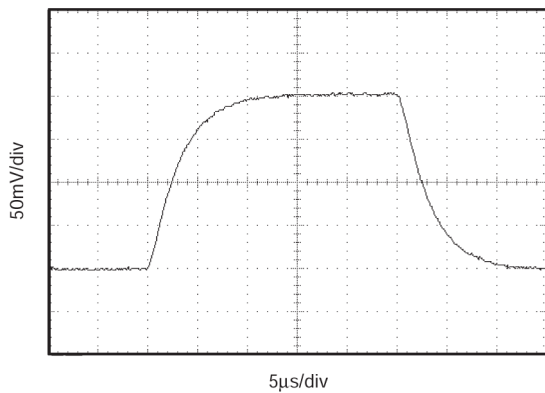
5-14. Offset Voltage Drift Production Distribution



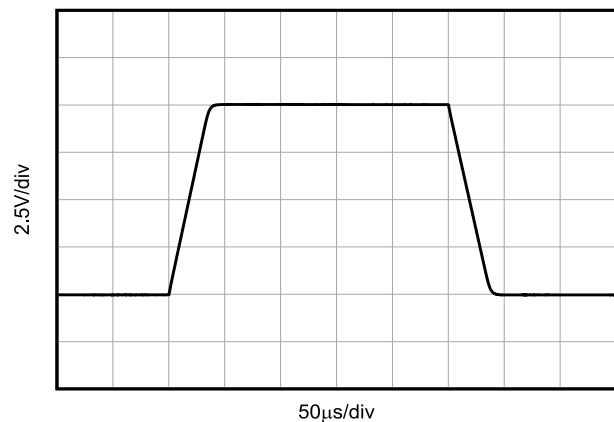
5-15. Small-signal Step Response ($G = 0.1$, $R_L = 10\text{ k}\Omega$, $C_L = 200\text{ pF}$)



5-16. Small-signal Step Response ($G = 0.1$, $C_L = 1000\text{ pF}$)



5-17. Small-signal Step Response ($G = 1$, $C_L = 1000\text{ pF}$)



5-18. Large-signal Step Response ($G = 1$, $R_L = 10\text{ k}\Omega$, $C_L = 200\text{ pF}$)

6 Application and Implementation

注

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6.1 Application Information

The INA146 is a programmable gain difference amplifier consisting of a gain of 0.1 difference amplifier and a programmable-gain output buffer stage. Basic circuit connections are shown in [図 6-1](#). Power supply bypass capacitors must be connected close to pins 4 and 7, as shown. The amplifier is programmable in the range of $G = 0.1$ to $G = 50$ with two external resistors.

The output of A1 is connected to the noninverting input of A2 through a 10-k Ω resistor which is trimmed to $\pm 1\%$ absolute accuracy. The A2 input is available for applications such as a filter or a precision current source. See application figures for examples.

6.1.1 Operating Voltage

The INA146 is fully specified for supply voltages from ± 2.25 V to ± 18 V with key parameters specified over the temperature range -40°C to 85°C . The INA146 can be operated with single or dual supplies with excellent performance. Parameters that vary significantly with operating voltage, load conditions or temperature are shown in the typical performance curves.

6.1.2 Setting the Gain

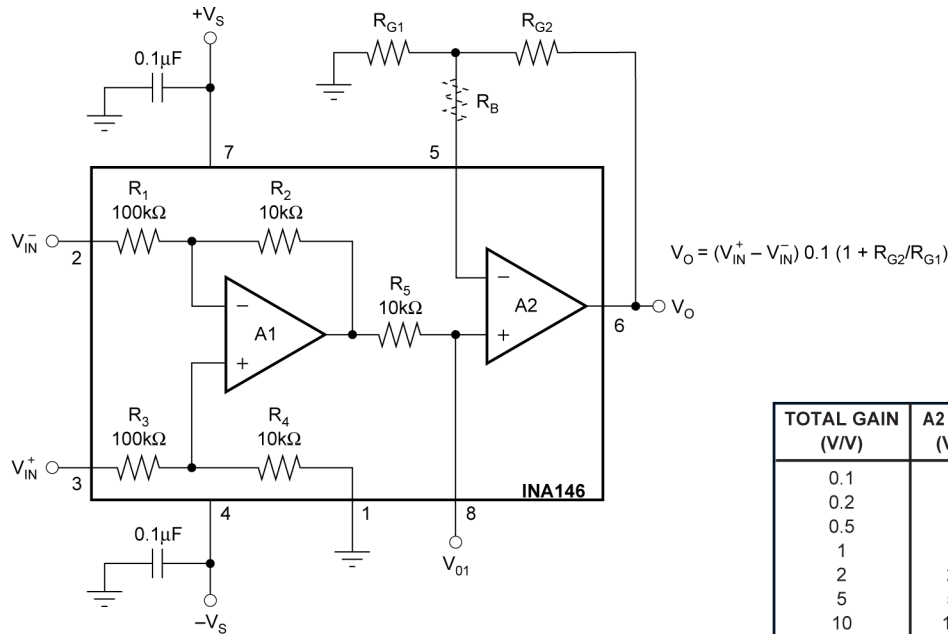
The gain of the INA146 is set by using two external resistors, R_{G1} and R_{G2} , according to the equation:

$$G = 0.1 \times (1 + R_{G2}/R_{G1})$$

For a total gain of 0.1, A2 is connected as a buffer amplifier with no R_{G1} . A feedback resistor, $R_{G2} = 10$ k Ω , must be used in the buffer connection. This provides bias current cancellation (in combination with internal R_5) to assure specified offset voltage performance. Commonly used values are shown in the table of [図 6-1](#). Resistor values for other gains must be chosen to provide a 10-k Ω parallel resistance.

6.1.3 Common-mode Range

The 10:1 input resistor ratio of the INA146 provides an input common-mode range that can extend well beyond the power supply rails. Exact range depends on the power supply voltage and the voltage applied to the Ref terminal (pin 1). For proper operation, the voltage at the non-inverting input of A1 (an internal node) must be within the linear operating range. The voltage is determined by the simple 10:1 voltage divider between pin 3 and pin 1. This voltage must be between V_- and $(V_+) - 1$ V.



| TOTAL GAIN (V/V) | A2 GAIN (V/V) | STANDARD 1% RESISTORS | | |
|---------------------|------------------|-----------------------|------------|-----------|
| | | RG1 (Ω) | RG2 (Ω) | RB (Ω) |
| 0.1 | 1 | (None) | 10k | — |
| 0.2 | 2 | 20k | 20k | — |
| 0.5 | 5 | 12.4k | 49.9k | — |
| 1 | 10 | 11.0k | 100k | — |
| 2 | 20 | 10.5k | 200k | — |
| 5 | 50 | 10.2k | 499k | — |
| 10 | 100 | 10.2k | 1M | — |
| 20 | 200 | 499 | 100k | 9.53k |
| 50 | 500 | 100 | 49.9k | 10k |
| 100 | 1000 | 100 | 100k | 10k |

6-1. Basic Circuit Connections

6.1.4 Offset Trim

The INA146 is laser-trimmed for low offset voltage and drift. Most applications require no external offset adjustment. [6-2](#) shows an optional circuit for trimming the offset voltage. A voltage applied to the Ref terminal is summed with the output signal. This feature can be used to null offset voltage. To maintain good common-mode rejection, the source impedance of a signal applied to the Ref terminal must be less than 10 Ω and a resistor added to the positive input terminal must be 10 times that, or 100 Ω. Alternatively, the trim voltage can be buffered with an operational amplifier such as the OPA277.

6.1.5 Input Impedance

The input impedance of the INA146 is determined by the input resistor network and is approximately 100 kΩ. The source impedance at the two input terminals must be nearly equal to maintain good common-mode rejection. A 12-Ω mismatch in impedance between the two inputs causes the typical common-mode rejection to be degraded to approximately 72 dB. [6-7](#) shows a common application measuring power supply current through a shunt resistor. The source impedance of the shunt resistor, RS, is balanced by an equal compensation resistor, RC.

Source impedances greater than 800 Ω are not recommended, even if the source impedances are perfectly matched. Internal resistors are laser trimmed for accurate ratios, not to absolute values. Adding equal resistors greater than 800 Ω can cause a mismatch in the total resistor ratios, degrading CMR.

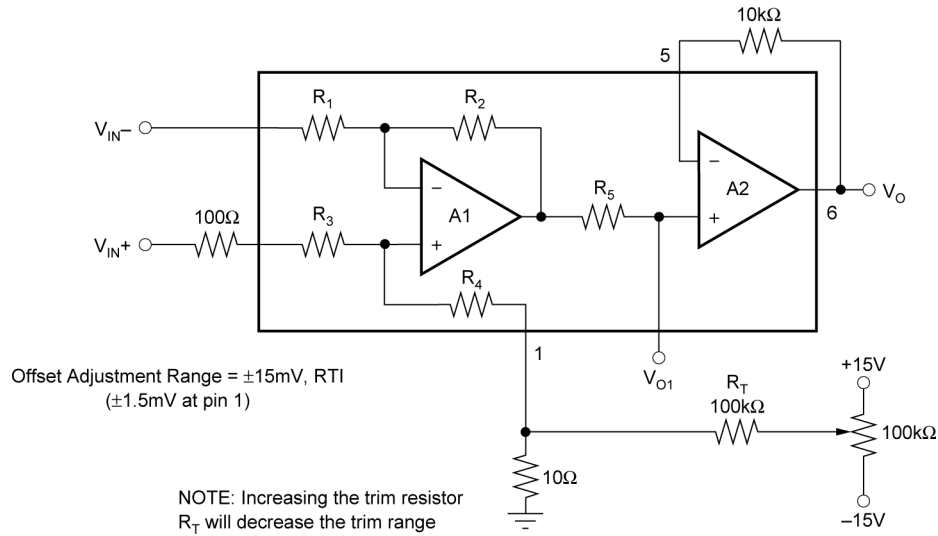


图 6-2. Optional Offset Trim Circuit

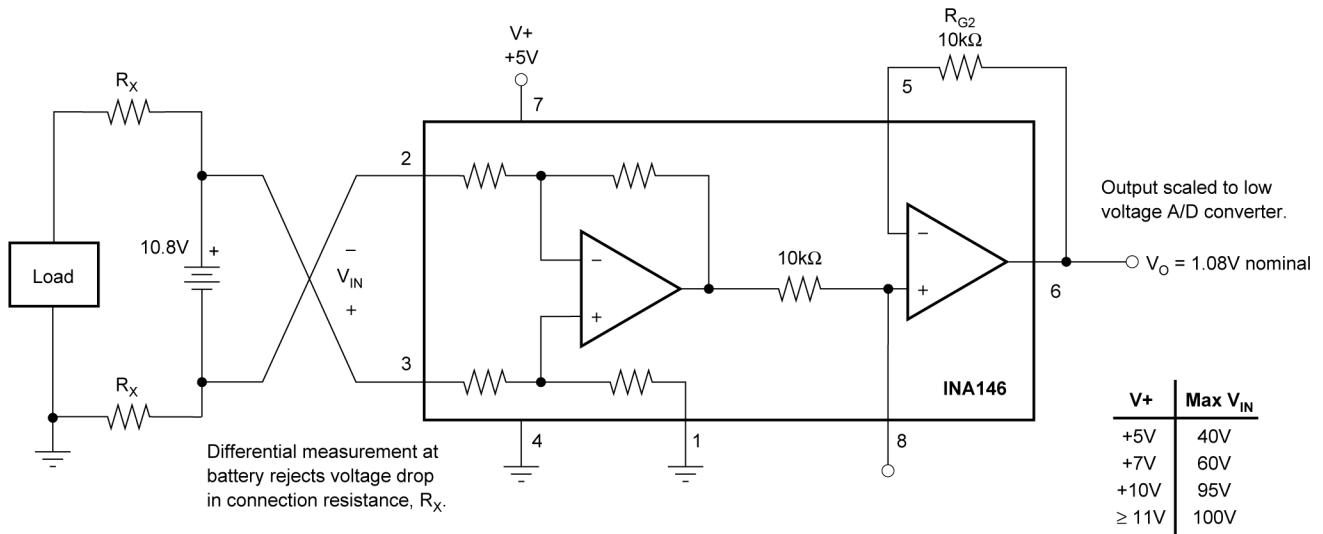


图 6-3. Measuring Voltages Greater Than Supply Voltage

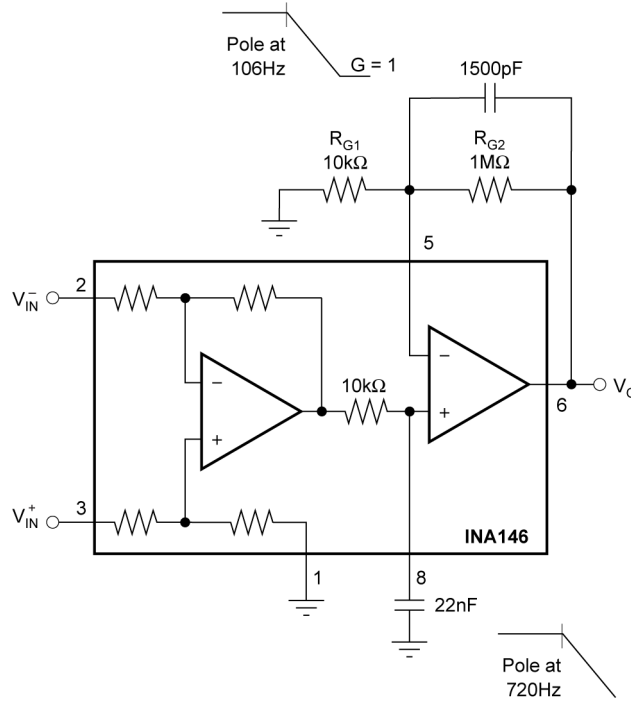


图 6-4. Noise Filtering

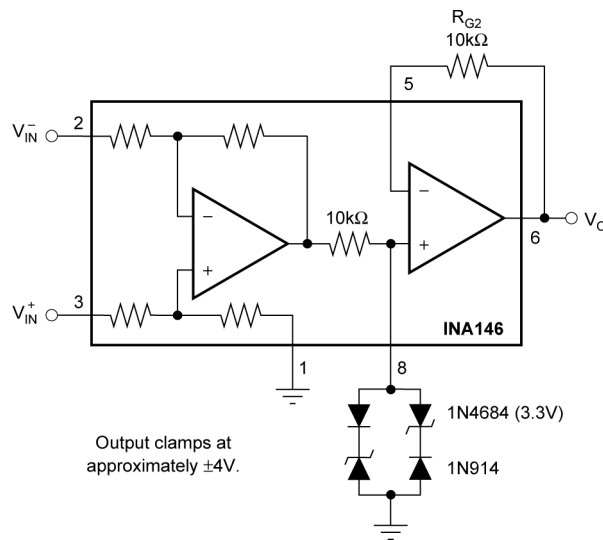
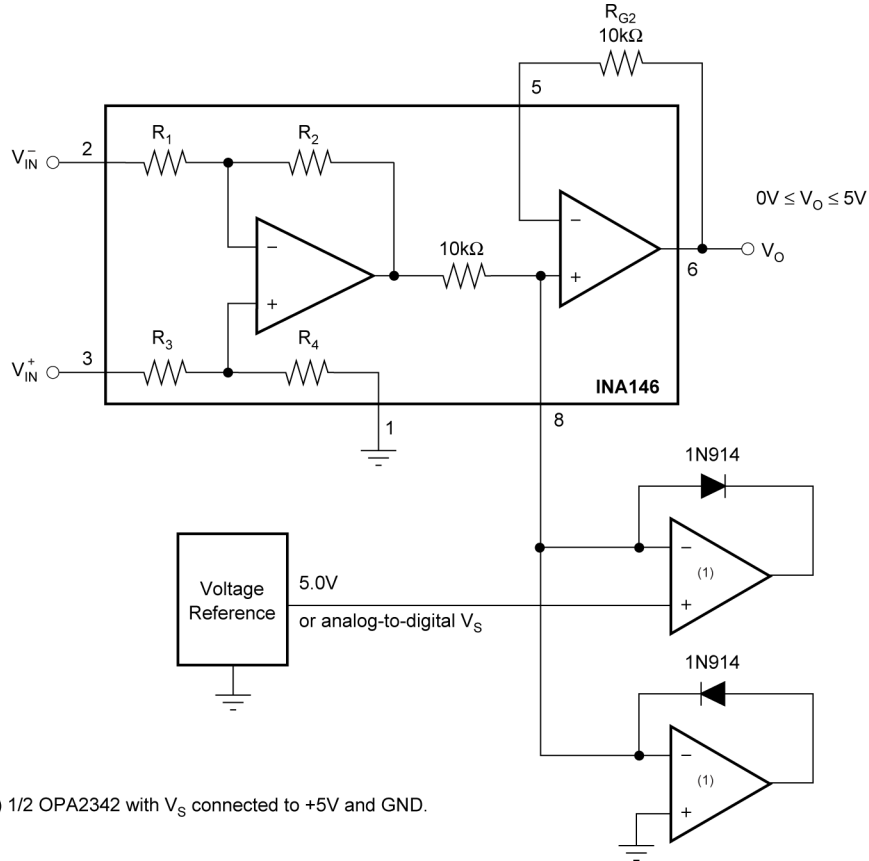


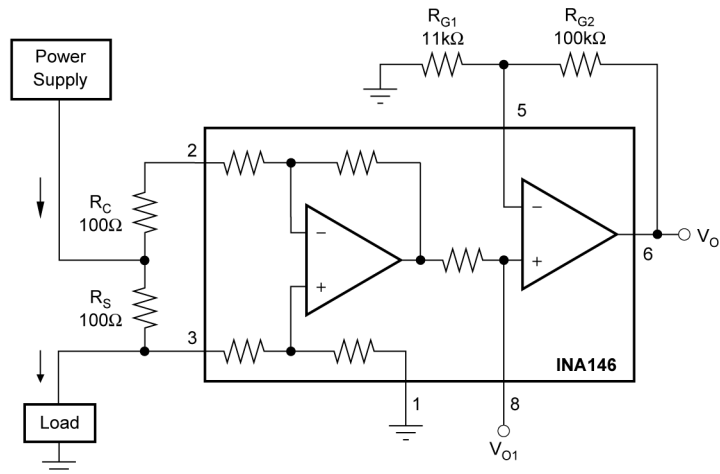
图 6-5. Output Clamp



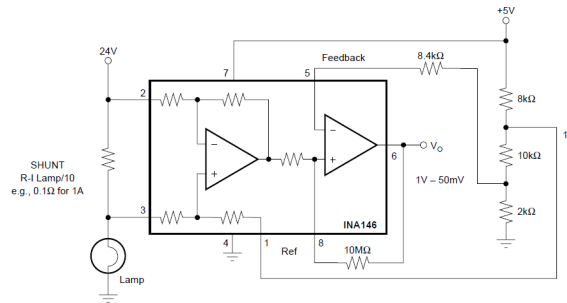
NOTE: (1) 1/2 OPA2342 with V_S connected to +5V and GND.

6-6. Precision Clamp

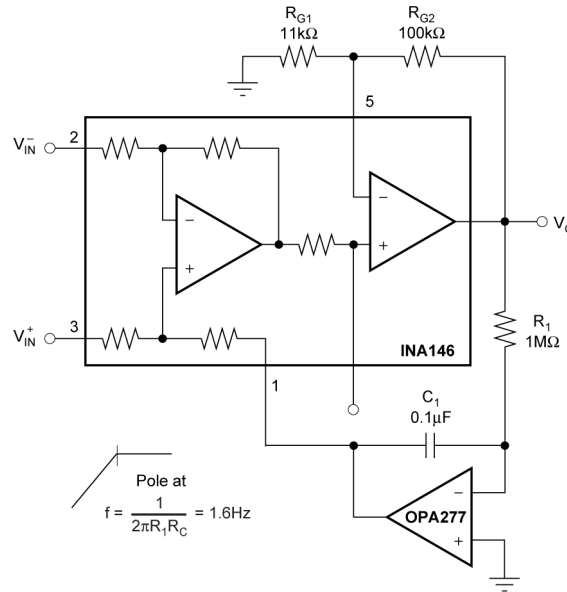
For sense resistors (R_S) greater than 10Ω , use series compensation resistor (R_C) for good common-mode rejection. Sense resistors greater than 500Ω are not recommended.



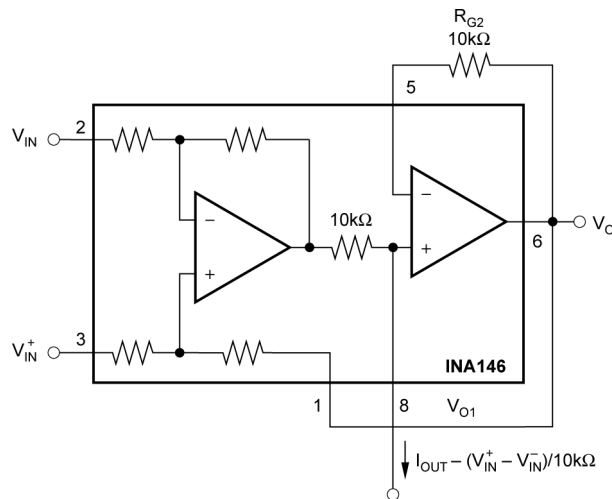
6-7. Current Monitor, $G = 1$



☒ 6-8. Comparator Output With Optional Hysteresis Application to Sense Lamp Burn-Out



☒ 6-9. AC Coupling (DC Restoration)



☒ 6-10. Precision Current Source

7 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

7.1 サード・パーティ製品に関する免責事項

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7.2 Documentation Support

7.2.1 Related Documentation

For related documentation see the following:

- Texas Instruments, [Comprehensive Error Calculation for Instrumentation Amplifiers](#), application note
- Texas Instruments, [High-Voltage Signal Conditioning for Low Voltage ADCs](#), application note
- Texas Instruments, [Analog Engineer's Calculator](#), application

7.3 ドキュメントの更新通知を受け取る方法

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7.7 用語集

テキサス・インスツルメンツ用語集

この用語集には、用語や略語の一覧および定義が記載されています。

8 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

| Changes from Revision * (September 1999) to Revision A (October 2023) | Page |
|---|------|
| • ドキュメント全体にわたって表、図、相互参照の採番方法を更新。..... | 1 |
| • Changed pin 7 from V+ to V _{S+} and pin 4 from V- to V _{S-} | 3 |
| • Added V _{REF} = 0 V, V _{CM} = V _S / 2 "unless otherwise noted" conditions in <i>Electrical Characteristics</i> and <i>Typical Characteristics</i> for clarity..... | 5 |
| • Changed from Offset Voltage vs Power Supply to Power-supply rejection ratio for more clarity..... | 5 |
| • Change test condition V _{CM} formula for more clarity..... | 5 |
| • Added test condition "TA = -40°C to 85°C" for "Gain error vs temperature" in <i>Electrical Characteristics</i> and renamed to "Gain drift" for clarity..... | 5 |
| • Added test condition "TA = -40°C to 85°C" for Output over Temperature in <i>Electrical Characteristics</i> | 5 |
| • Added test condition "Continuous to V _S / 2" short-circuit current specification in <i>Electrical Characteristics</i> for clarity..... | 5 |
| • Deleted redundant voltage range, operating temperature range, and specification temperature range specifications from <i>Electrical Characteristics</i> | 5 |
| • Added V _{REF} = 0 V, V _{CM} = V _S / 2, to "unless otherwise noted" conditions in <i>Electrical Characteristics</i> and <i>Typical Characteristics</i> for clarity..... | 6 |
| • Changed from Offset Voltage vs Power Supply to Power-supply rejection ratio for more clarity..... | 6 |
| • Added test condition "TA = -40°C to 85°C" for "Gain error vs temperature" in <i>Electrical Characteristics</i> and renamed to "Gain drift" for clarity..... | 6 |
| • Added test condition "TA = -40°C to 85°C" to "Output voltage" in <i>Electrical Characteristics</i> | 6 |
| • Added test condition "Continuous to V _S / 2" short-circuit current specification in <i>Electrical Characteristics</i> for clarity..... | 6 |
| • Deleted redundant voltage range, operating temperature range, and specification temperature range specifications from <i>Electrical Characteristics</i> | 6 |
| • Added V _{REF} = 0 V, V _{CM} = V _S / 2 to "unless otherwise noted" conditions in <i>Electrical Characteristics</i> and <i>Typical Characteristics</i> for clarity..... | 7 |

9 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|---------|
| INA146UA | OBSOLETE | SOIC | D | 8 | | TBD | Call TI | Call TI | -40 to 85 | INA 146UA | |
| INA146UA/2K5 | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | -40 to 85 | INA 146UA | Samples |
| INA146UAE4 | NRND | SOIC | D | 8 | 75 | TBD | Call TI | Call TI | -40 to 85 | | |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| INA146UA/2K5 | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| INA146UA/2K5 | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| INA146UA/2K5 | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| INA146UA/2K5 | SOIC | D | 8 | 2500 | 353.0 | 353.0 | 32.0 |

TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|----------|--------------|--------------|------|-----|--------|--------|--------|--------|
| INA146UA | D | SOIC | 8 | 75 | 506.6 | 8 | 3940 | 4.32 |

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