

CA-IS23050W Precision 120kHz Hall-Effect Current Sensor with 5kV_{RMS} Reinforced Isolation Voltage and Zero Current Output Voltage Reference

1. Features

- Differential hall sensing rejects common-mode fields and nearly zero magnetic hysteresis
- Integrated digital temperature compensation circuitry allows for near closed loop accuracy
- High immunity to external magnetic fields
- Precision zero-current reference output
- Primary conductor resistance: 0.61mΩ
- High current sense range capability: ±50A_{PK}
- High accuracy
 - Total output error: ±3% Max@25°C to +125°C
 - Total output error lifetime drift: ±5% Max
 - Sensitivity error: ±2.5% Max@25°C to +125°C
 - Non-linearity: ±1% Max
 - Symmetry: ±1% Max
- Fast response
 - Signal bandwidth: 120kHz
 - Propagation delay: 2μs
 - Response time: 3.7μs
- Operating supply voltage: 4.5V to 5.5V
- Bidirectional and unidirectional current sensing
- -40°C to +125°C Working Ambient Temperature Range
- Robust Galvanic Isolation
 - 5000V_{RMS} withstand isolation voltage
 - 1097V_{RMS} maximum working isolation voltage
 - 10kV maximum surge isolation withstand voltage
- 16-pin wide-body SOIC16 (W) Package
- Safety regulatory approvals
 - 5kV_{RMS} isolation for 1 minute according to UL1577

2. Applications

- Solar Energy
- Motor Control
- EC Charging
- Power supplies

- Industrial AC/DC and DC/DC

3. General Description

The CA-IS23050W is a highly accurate and cost-effective current sensor IC suitable for AC/DC current sensing in a variety of industrial, commercial, and communications systems. It features a low-offset, linear Hall sensor circuit and a copper conduction path that generates a magnetic field when current flows through it. The integrated Hall IC senses this magnetic field and converts it into a proportional voltage output, which has a positive slope proportional to the current flowing through the primary copper conduction path. The device senses current differentially, rejecting common-mode fields and improving accuracy in magnetically noisy environments. With its 0.61mΩ internal resistance, the primary copper conduction path offers low power loss and high inrush current withstand capability. The CA-IS23050W is available in a 16-pin wide-body SOIC packages. The CA-IS23050W is rated for operation at working ambient temperatures of -40°C to +125°C.

Device Information

| Part Number | Package | Package Size(NOM) |
|-------------|-----------|-------------------|
| CA-IS23050W | SOIC16-WB | 10 mm x 7.5 mm |

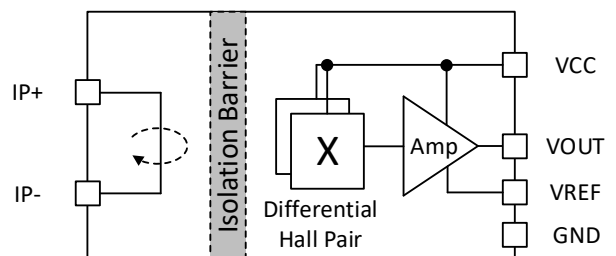


Figure 3-1. Simplified Schematic

4. Ordering Information

Table 4-1. Ordering Information

| Part # | Primary Current(A) | Power Supply(V) | Sensitivity(mV/A) | Zero Current Output Voltage(V) | Package |
|-------------|--------------------|-----------------|-------------------|--------------------------------|-----------|
| CA-IS23050W | ±50 | 5 | 40 | 2.5 | SOIC16-WB |

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5. Revision History

| Revision Number | Description | Page Changed |
|-----------------|-----------------|--------------|
| Version 1.0 | Initial publish | NA |

6. Pin Configuration and Description

6.1. CA-IS23050W Pin Configuration and Description

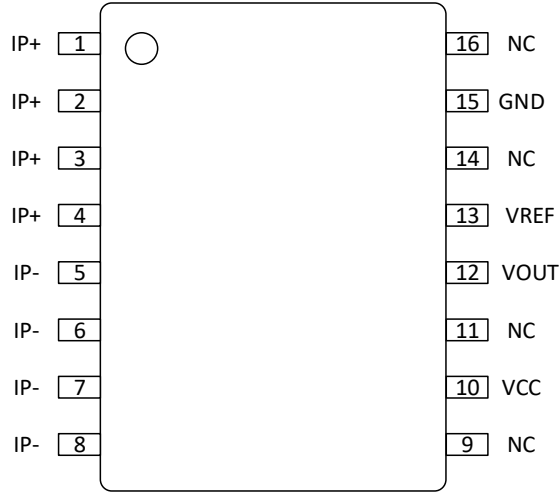


Figure 6-1. The CA-IS23050W Pin Configuration

Table 6-1. The CA-IS23050W Pin Description

| Pin Name | Pin Number | Type | Description |
|----------|------------|--------------|---|
| IP+ | 1-4 | Input | Input current positive pin |
| IP- | 5-8 | Input | Input current negative pin |
| NC | 9,11,14,16 | --- | Reserved. Pin can be connected to GND or left floating |
| VCC | 10 | Power Supply | Power supply |
| VOUT | 12 | Output | Output voltage |
| VREF | 13 | Output | Zero current output voltage reference. Leave pin floating if not used |
| GND | 15 | Ground | Ground |

7. Specifications

7.1. Absolute Maximum Ratings¹

over operating free-air temperature range unless otherwise specified. ¹

| Parameters | | Minimum | Maximum | Unit |
|-----------------------------|-------------------------------|---------|---------|------|
| V _{CC} | Supply voltage | 0 | 6 | V |
| V _{RCC} | Reverse supply voltage | -0.5 | 0 | V |
| V _{OUT} | Output voltage | 0 | 6 | V |
| V _{ROUT} | Reverse output voltage | -0.5 | 0 | V |
| T _A | Operating ambient temperature | -40 | 125 | °C |
| T _J ² | Junction temperature | -55 | 165 | °C |
| T _{stg} | Storage temperature | -65 | 165 | °C |

Notes:

- The stresses listed under “Absolute Maximum Ratings” are stress ratings only, not for functional operation condition. Exposure to absolute maximum rating conditions for extended periods may cause permanent damage to the device.
- To maintain the recommended operating junction temperature conditions, see Thermal Information.

7.2. ESD Ratings

| | | | Value | Unit |
|------------------|-------------------------|--|-------|------|
| V _{ESD} | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001. | ±2000 | V |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101. | ±500 | |

7.3. Recommended Operating Conditions

Over operating free-air temperature range unless otherwise specified.

| Parameters | | Minimum | Typical | Maximum | Unit |
|-----------------|--------------------------|---------|---------|---------|------|
| V _{CC} | Operating supply voltage | 4.5 | 5 | 5.5 | V |
| T _A | Ambient temperature | -40 | | 125 | °C |

7.4. Thermal Information

| Thermal Metric | | SOIC16-WB | Unit |
|------------------|--|-----------|------|
| | | (W) | |
| R _{θJA} | Junction-to-ambient thermal resistance | 25 | °C/W |

7.5. Insulation Specifications

| Parameters | | Test Conditions | Specifications | Unit |
|--------------------|-------------------------------------|--|----------------|------------------------|
| | | | W | |
| V _{surge} | Surge voltage | Tested ±5 pulses at 2/minute in compliance to IEC 61000-4-5 1.2 μs (rise) / 50 μs (width) | 10 | kV |
| V _{ISO} | Dielectric Strength Test Voltage | Agency type-tested for 60 seconds per UL standard 60950-1 (edition 2); production- tested at VISO for 1 second, in accordance with UL 60950-1 (edition 2). | 5000 | V _{RMS} |
| V _{WVBI} | Working Voltage for Basic Isolation | Maximum approved working voltage for basic (single) isolation according to UL 60950-1 (edition 2) | 1550 | V _{pk} or VDC |
| | | | 1097 | V _{RMS} |
| D _{cl} | External Clearance | Minimum distance through air from IP leads to signal leads. | 8.2 | mm |
| D _{cr} | External Creepage | Minimum distance along package body from IP leads to signal leads. | 8.2 | mm |
| DTI | Distance Through Insulation | Minimum internal distance through insulation | 90 | μm |
| CTI | Comparative Tracking Index | Material Group II | 400 to 599 | V |

7.6. Safety-Related Certifications

| UL(Pending) | TUV(Pending) |
|--|--|
| Certified according to UL 1577 Component Recognition Program | Certified according to GB 4943.1-2011 and GB 8898-2011 |
| | |

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7.7. Common Electrical Characteristics¹

 All minimum/maximum specs are at $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, $V_{CC} = 5\text{V}$, unless otherwise noted.

| Parameters | Test Conditions | Minimum | Typical | Maximum | Unit | | |
|--|---|---|---------|-----------|---------|-------------------|----|
| POWER | | | | | | | |
| V_{CC} | Supply Voltage | 4.5 | 5.0 | 5.5 | V | | |
| I_{CC} | Supply Current | VCC=5V, output open | | 11.5 | 14.0 | 16.0 | mA |
| t_{po} | Power-on Time | $T_A = 25^{\circ}\text{C}$ | | 78.0 | | μs | |
| V_{UVLOH} | UVLO voltage threshold | VCC rising | | 3.8 | 4.1 | V | |
| V_{UVLOL} | UVLO voltage threshold | VCC falling | | 2.9 | 3.2 | V | |
| Output Satge | | | | | | | |
| C_L | Output Capacitance Load | VOUT to GND | | 1.0 | 10.0 | nF | |
| R_L | Output Resistive Load | VOUT to GND and VOUT to VCC | | 4.7 | | k Ω | |
| R_{REF} | VREF Resistive Load | VREF to GND and VREF to VCC | | 100 | | k Ω | |
| t_r | Rise Time | $T_A = 25^{\circ}\text{C}$, $C_L = 1\text{ nF}$ | | 3.6 | | μs | |
| t_{pd} | Propagation Time | $T_A = 25^{\circ}\text{C}$, $C_L = 1\text{ nF}$ | | 2.0 | | μs | |
| $t_{response}$ | Response Time | $T_A = 25^{\circ}\text{C}$, $C_L = 1\text{ nF}$ | | 3.0 | 3.7 | μs | |
| SR | Output Slew Rate | $T_A = 25^{\circ}\text{C}$, $C_L = 1\text{ nF}$ | | 0.4 | | V/ μs | |
| V_{REF_INI} | Reference Output Voltage | 2.48 | 2.5 | 2.52 | V | | |
| $V_{SAT(H)}$ | High Output Saturation Soltage ² | $R_{L(DOWN)} = 10\text{k}\Omega$ to GND | | 4.7 | | V | |
| $V_{SAT(L)}$ | Low Output Saturation Voltage ² | $R_{L(UP)} = 10\text{k}\Omega$ to VCC | | | 0.3 | V | |
| Input Stage | | | | | | | |
| R_{IP} | Primary Conductor Resistance | $T_A = 25^{\circ}\text{C}$ | | 0.61 | | m Ω | |
| L_{IP} | Primary Conductor Inductance | $T_A = 25^{\circ}\text{C}$ | | 2 | | nH | |
| CMFRR | Common Mode Field Rejection Ratio | Uniform external magnetic field | | 70 | | dB | |
| Accuracy and Frequency | | | | | | | |
| BW | Frequency Bandwidth | Small signal -3 dB; $C_L = 1\text{ nF}$ | | 120 | | kHz | |
| I_N | Noise | Input-referenced noise: $C_F = 4.7\text{ nF}$, $C_L = 1\text{ nF}$, BW = 18 kHz, $T_A = 25^{\circ}\text{C}$ | | 100 | | mA _{RMS} | |
| E_{LIN} | Nonlinearity | Over full range of I_P | | ± 0.2 | ± 1 | % | |
| E_{SYM} | Symmetry | Over full range of I_P | | ± 0.2 | ± 1 | % | |
| Notes: | | | | | | | |
| 1. Device may be operated at higher primary current levels, I_P , ambient temperatures, T_A , and internal leadframe temperatures, provided the Maximum Junction Temperature, $T_J(\text{max})$, is not exceeded. | | | | | | | |
| 2. The sensor IC will continue to respond to current beyond the range of I_P until the high or low output saturation voltage; however, the nonlinearity in this region will be worse than through the rest of the measurement range. | | | | | | | |

7.8. Performance Characteristics

 All minimum/maximum specs are at $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, $V_{CC} = 5\text{V}$, unless otherwise noted.

| Parameters | Test Conditions | Minimum | Typical ¹ | Maximum | Unit | | |
|---|---------------------------------|--|----------------------|---------|------|------|---|
| Nominal Performance | | | | | | | |
| I_{PR} | Current-sensing Range | -50 | | 50 | A | | |
| Sens | Sensitivity | Over full range of I_P , $T_A = 25^{\circ}\text{C}$ | | 40 | mV/A | | |
| $V_{OUT(Q)}$ | Zero Current Output Voltage | Bidirectional; $I_P = 0\text{ A}$, $T_A = 25^{\circ}\text{C}$ | | 2.49 | 2.5 | 2.51 | V |
| Accuracy Performance | | | | | | | |
| E_{TOT} | Total Output Error ² | $I_P = I_{PR(\text{max})}$, $T_A = 25^{\circ}\text{C}$ to 125°C | | -3 | 3 | % | |
| | | $I_P = I_{PR(\text{max})}$, $T_A = -40^{\circ}\text{C}$ to 25°C | | -1 | 4.5 | % | |
| Total Output Error Components³ $E_{TOT} = E_{SENS} + 100 \times V_{OE} / (\text{Sens} \times I_P)$ | | | | | | | |
| E_{sens} | Sensitivity Error | $I_P = I_{PR(\text{max})}$, $T_A = 25^{\circ}\text{C}$ to 125°C | | -2.5 | 2.5 | % | |
| | | $I_P = I_{PR(\text{max})}$, $T_A = -40^{\circ}\text{C}$ to 25°C | | -0.5 | 4.0 | % | |
| V_{OE} | Voltage Offset Error | $I_P = 0\text{ A}$, $T_A = 25^{\circ}\text{C}$ to 125°C | | -10 | 20 | mV | |
| | | $I_P = 0\text{ A}$, $T_A = -40^{\circ}\text{C}$ to 25°C | | -10 | 10 | mV | |

| Life Time Drift Characteristics | | | |
|---------------------------------|-----------------------------------|--|-----------|
| E_{sens_drift} | Sensitivity Error Lifetime Drift | | ± 1 % |
| E_{tot_drift} | Total Output Error Lifetime Drift | | ± 1 % |

Notes:

1. Typical values with \pm are 3 sigma values.
2. Percentage of I_P , with $I_P = I_{PR(max)}$.
3. A single part will not have both the maximum/minimum sensitivity error and maximum/minimum offset voltage, as that would violate the maximum/minimum total output error specification. Also, 3 sigma distribution values are combined by taking the square root of the sum of the squares.

7.9. Typical Operating Characteristics

All values are at $V_{CC} = 5V$, $C_L = 1nF$, unless otherwise noted.

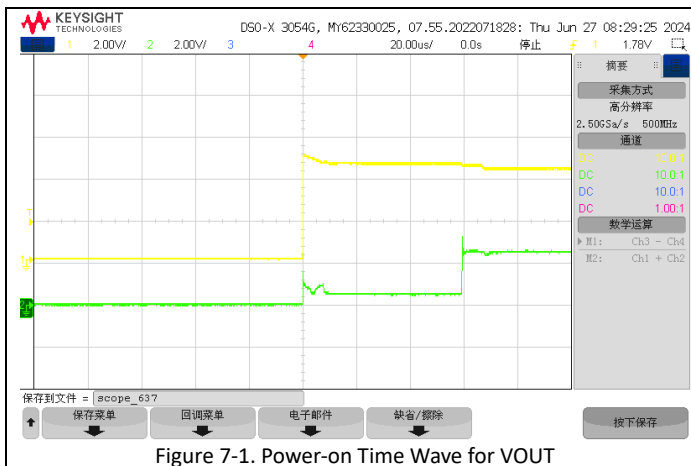


Figure 7-1. Power-on Time Wave for VOUT

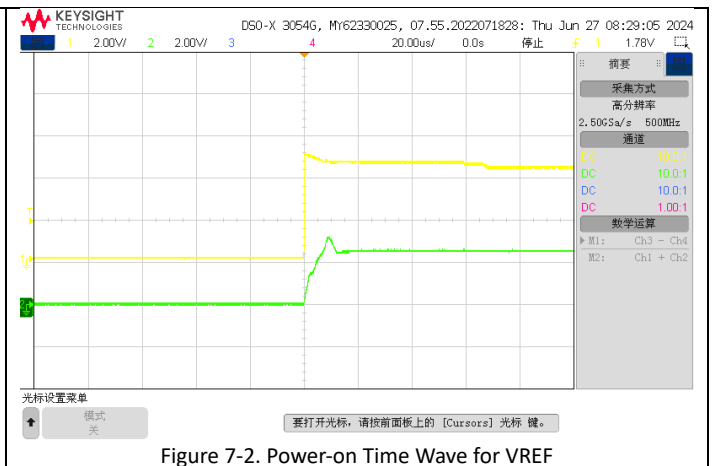


Figure 7-2. Power-on Time Wave for VREF

8. Detailed Description

8.1. Overview

The CA-IS23050W current sensor are based on the Hall principle and can accurately measure AC/DC current while minimizing measurement costs. This sensor finds extensive use in various current monitoring applications, including consumer, industrial, and automotive scenarios. Compared to current transformers, the CA-IS23050W offers a compact size, which can significantly reduce PCB size. In comparison to shunt resistor + isolated amplifier solutions, the CA-IS23050W only requires low-side power supply, eliminating the complexity of high-side power supply design.

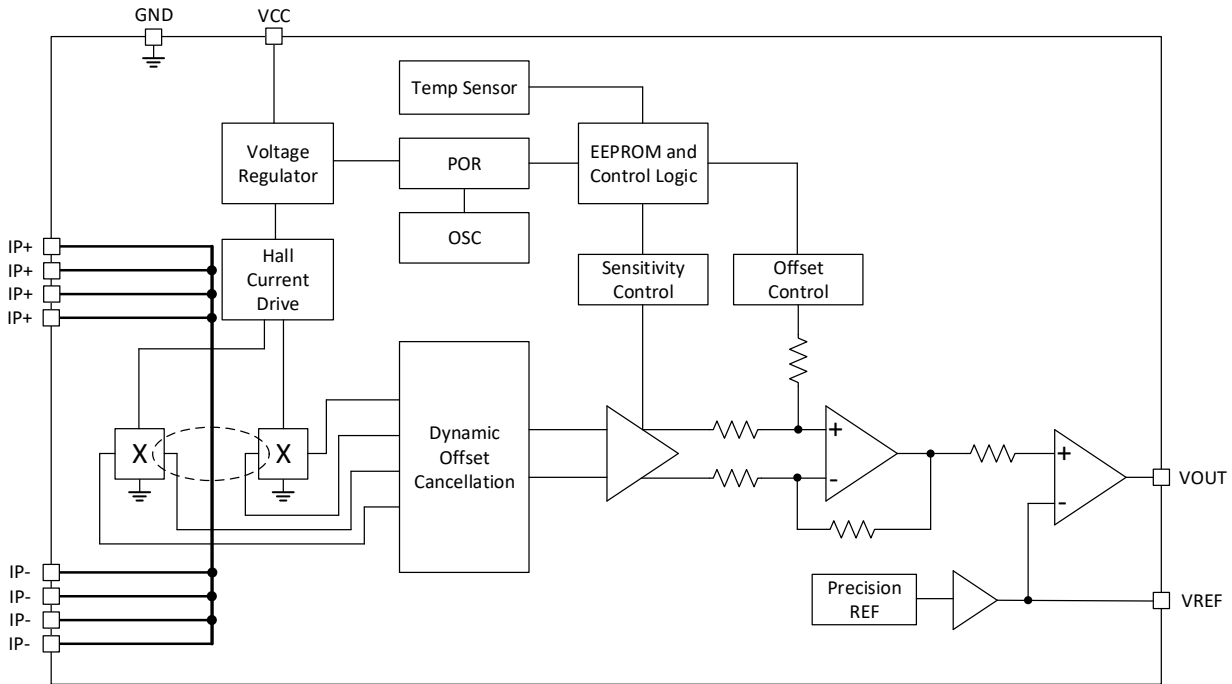


Figure 8-1. Functional block diagram

The internal conductor of the CA-IS23050W generates a magnetic field proportional to the current value, according to Maxwell's equations. The sensor converts this magnetic field value into a voltage output, ensuring a high level of accuracy. Moreover, the sensor has an ultra-small resistor value, ensuring little influence on thermal power consumption.

8.2. Quiescent Output Voltage ($V_{OUT(Q)}$)

The quiescent output voltage $V_{OUT(Q)}$ of the CA-IS23050W indicates the output voltage of the IC when there is no magnetic field. Although the theoretical output voltage of the CA-IS23050W is 2.5V, factors such as offset voltage, sensitivity, packaging stress, and temperature coefficient may cause the actual quiescent output voltage to deviate from the theoretical figure. During factory testing, the actual quiescent voltage is modified to be within $\pm 10\text{mV}$ of the theoretical value. The quiescent output voltage is also influenced by the temperature coefficient, which means that as the temperature changes, the quiescent output voltage will also change (this effect is more noticeable when sensitivity is higher). The CA-IS23050W is equipped with temperature sensors that can modify the temperature coefficient of the quiescent output voltage.

8.3. Response Time ($t_{RESPONSE}$)

Response Time is a term used to define the time difference between the moment when the magnetic field reaches 80% of its target value and the moment when the output voltage of the IC reaches 80% of its target value. This difference is measured and expressed in microseconds. The Response Time is related to the sensitivity of the IC and the size of the output load capacitance. It is an important parameter to consider when using magnetic sensors, especially in applications where a quick response is

required. The accuracy of the Response Time measurement is crucial to ensure reliable and precise operation of the sensor in various conditions.

8.4. Power-On Time (t_{PO})

Power-On Time is a term used to define the time required for the output voltage of a sensor to reach 90% of its target value after the supply voltage reaches 4.5V, at a specific magnetic field strength. This time difference is measured and expressed in micro seconds. The Power-On Time is an important parameter to consider when using magnetic sensors, especially in applications where a quick response is required. The accuracy of the Power-On Time measurement is crucial to ensure reliable and precise operation of the sensor in various conditions.

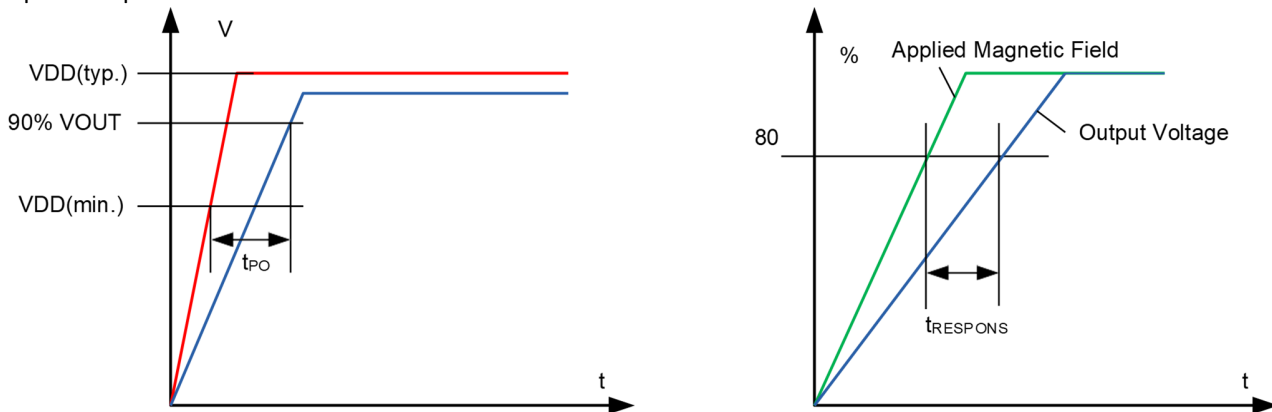


Figure 8-2. Power-On Time and Response Time

8.5. Transfer Function

The ideal first-order transfer function of the CA-IS23050W is given by Equation 1, where the output voltage V_{OUT} is a linear function of input current I_P . The accuracy of the device is quantified both by the error terms in the transfer function parameters, as well as by nonidealities that introduce additional error terms not in the simplified linear model.

$$V_{OUT} = (I_P \times Sens) + V_{REF}$$

Where

- V_{OUT} is the output voltage.
- I_P is the isolated input current.
- Sens is the sensitivity of the CA-IS23050W.
- V_{REF} is the zero current reference output voltage.

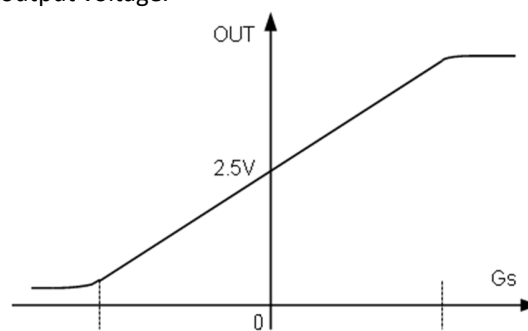


Figure 8-3. Transfer Function

9. Application and Implementation

9.1. Typical Application Circuit

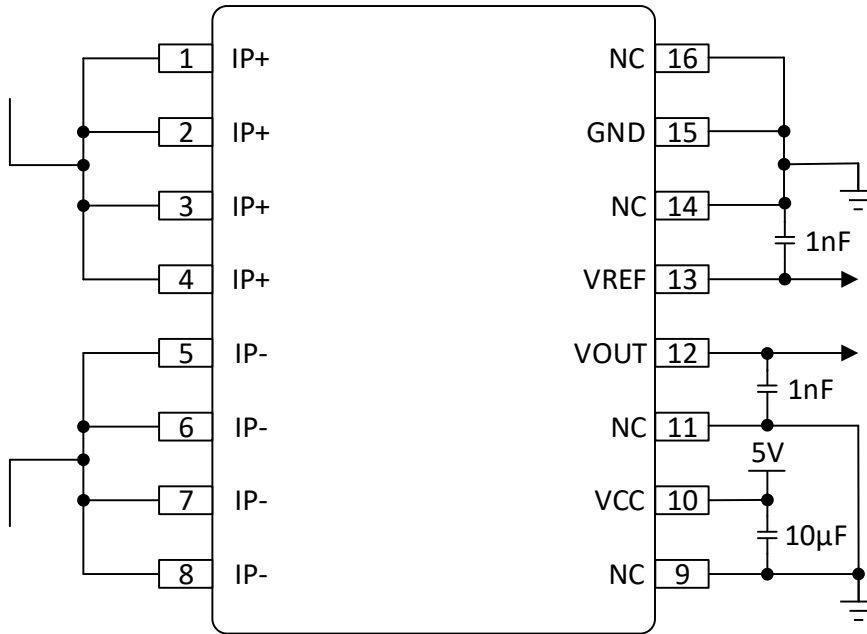


Figure 9-1. Single-end output application

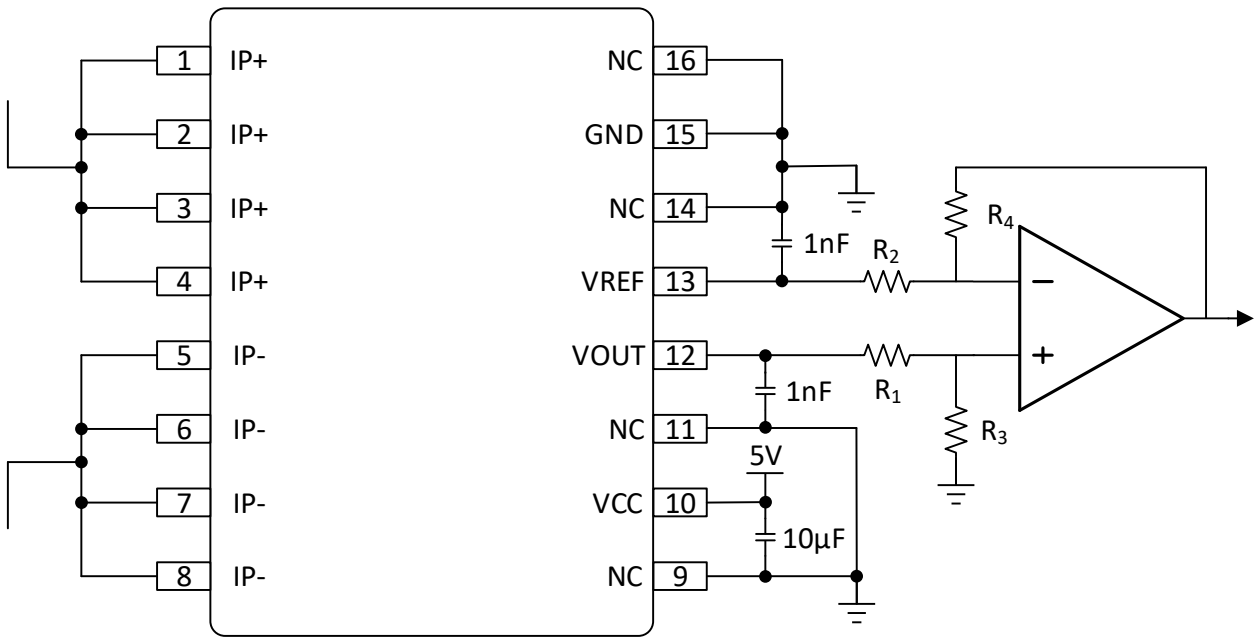


Figure 9-2. Differential output application

9.2. PCB Layout

9.2.1. Layout Guidelines

The CA-IS23050W is specified for a continuous current handling capability on the EVM which uses 4oz copper planes. This current capability is fundamentally limited by the maximum device junction temperature and the thermal environment, primarily the PCB layout and design. To maximize current-handling capability and thermal stability of the device, take care with PCB layout and construction to optimize the thermal capability. Efforts to improve the thermal performance beyond the design and construction of the EVM can result in increased continuous-current capability due to higher heat transfer to the ambient environment. Keys to improving thermal performance of the PCB include:

- Use large copper planes for both input current path and isolated power planes and signals.
- Use heavier copper PCB construction.
- Place thermal via farms around the isolated current input.
- Provide airflow across the surface of the PCB.

9.2.2. Layout example

An example layout, shown in Figure 9-3, is from the EVM User's Guide. Device performance is targeted for thermal and magnetic characteristics of this layout, which provides optimal current flow from the terminal connectors to the device input pins while large copper planes enhance thermal performance.

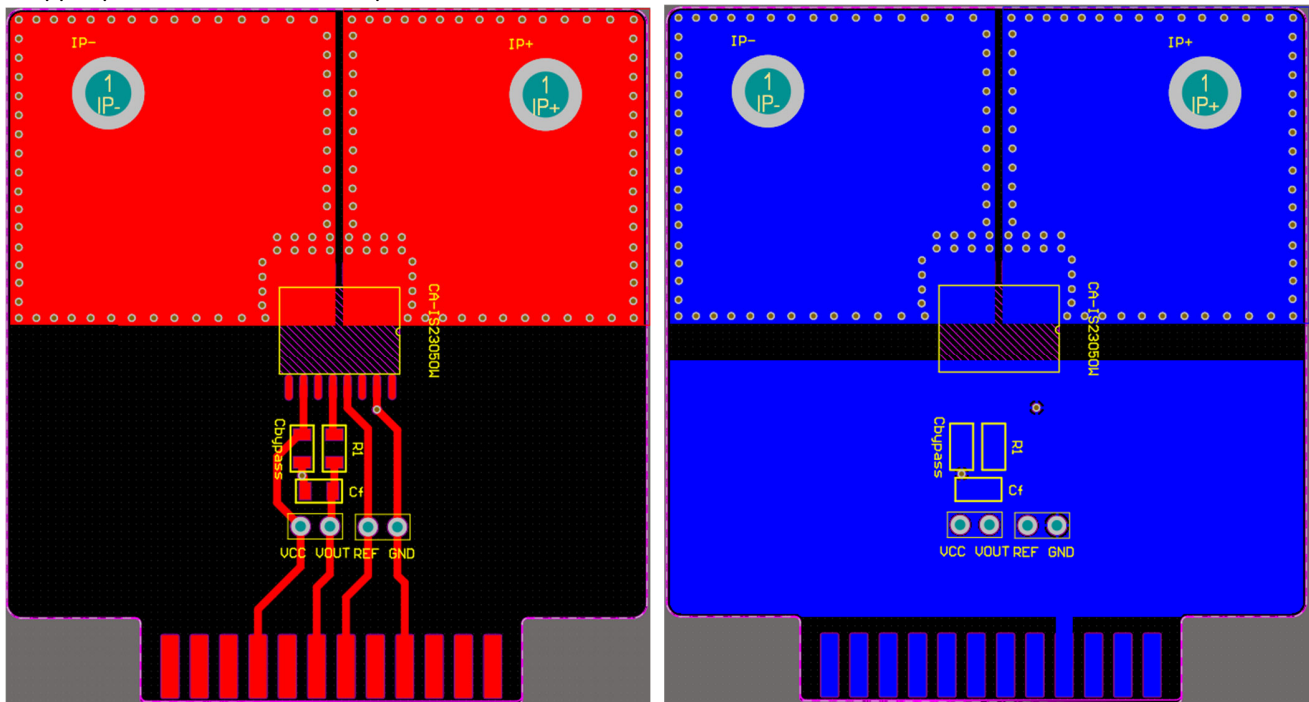
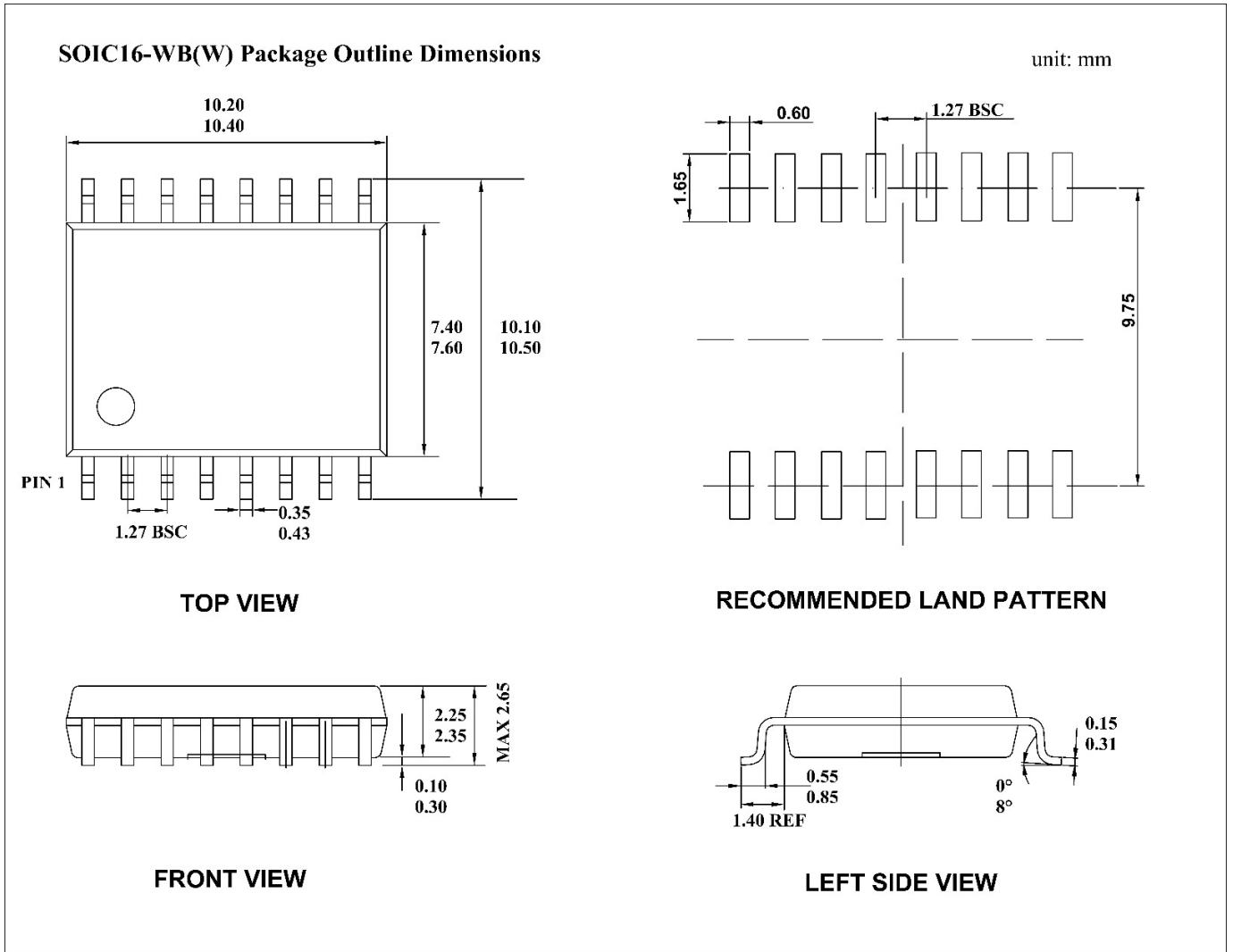


Figure 9-3. Recommended Board Layout

10. Package Information

10.1. 16-Pin Wide Body SOIC Package Outline



Note:

1. All dimensions are in millimeters, angles are in degrees.

11. Soldering Temperature (reflow) Profile

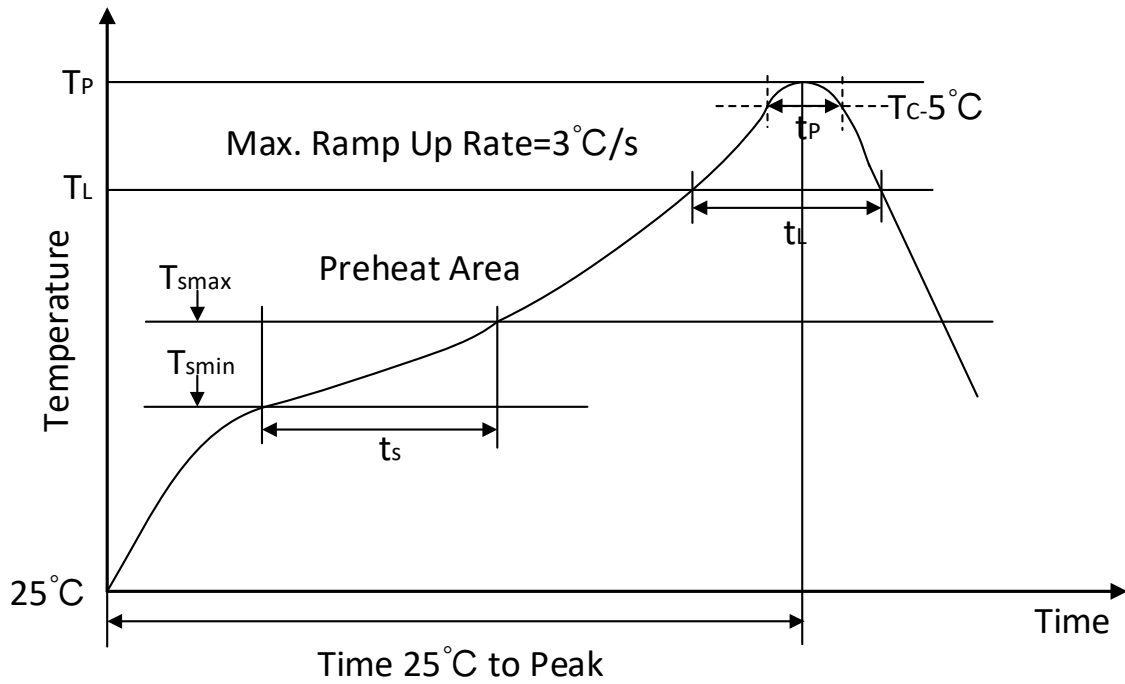


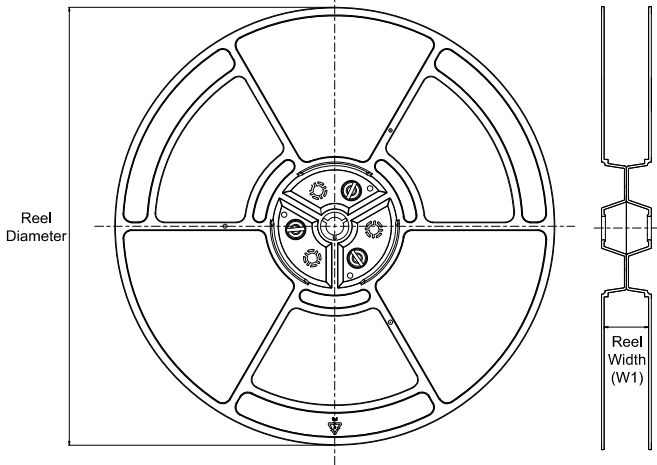
Figure 12-1. Soldering Temperature (reflow) Profile

Table 12-1. Soldering Temperature Parameter

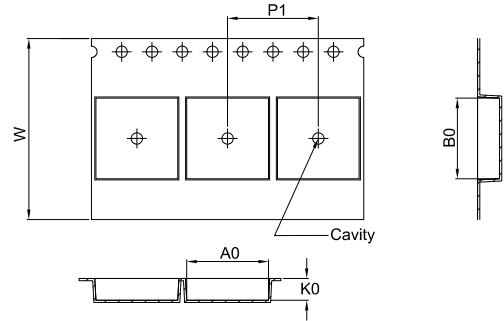
| Profile Feature | Pb-Free Assembly |
|---|------------------|
| Average ramp-up rate(217 ℃ to Peak) | 3 ℃/second max |
| Time of Preheat temp(from 150 ℃ to 200 ℃) | 60-120 second |
| Time to be maintained above 217 ℃ | 60-150 second |
| Peak temperature | 260 +5/-0 ℃ |
| Time within 5 ℃ of actual peak temp | 30 second |
| Ramp-down rate | 6 ℃/second max. |
| Time from 25 ℃ to peak temp | 8 minutes max |

12. Tape and Reel Information

REEL DIMENSIONS

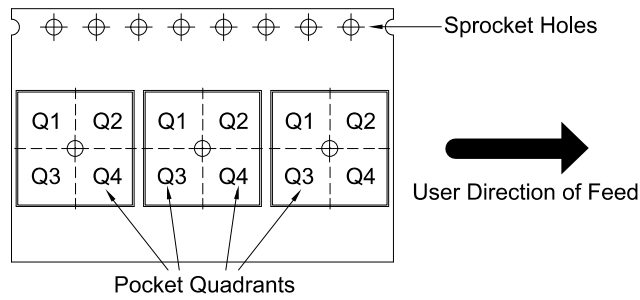


TAPE DIMENSIONS



| | |
|----|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

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 |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| CA-IS23050W | SOIC | W | 16 | 1000 | 330 | 16.40 | 10.90 | 10.70 | 3.2 | 12.00 | 16.00 | Q1 |

13. Important statement

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