

Product Overview

NSI1400 is a high-performance isolated amplifier with output separated from input based on the NOVOSENSE capacitive isolation technology. The device has a linear differential input signal range of $\pm 250\text{mV}$ ($\pm 320\text{mV}$ full-scale). The differential input is ideally suited to shunt resistor-based current sensing in high voltage applications where isolation is required.

The device has a fixed gain of 8.2 and provides a differential analog output. The low offset and gain drift ensure the accuracy over the entire temperature range. High common-mode transient immunity ensures that the device is able to provide accurate and reliable measurements even in the presence of high-power switching such as in motor control applications.

The fail-safe functions including input common-mode overvoltage detection and missing VDD1 detection simplify system-level design and diagnostics.

Key Features

- Up to $5000V_{\text{rms}}$ Insulation voltage
- $\pm 250\text{mV}$ linear Input Voltage Range
- Fixed Gain of 8.2
- Excellent DC Performance:
 - Offset Error: $\pm 0.5\text{mV}$ (Max)
 - Offset Error Drift: $\pm 4\mu\text{V}/^\circ\text{C}$ (Max)
 - Gain Error: $\pm 0.3\%$ (Max)
 - Gain Error Drift: $\pm 30\text{ppm}/^\circ\text{C}$ (Max)
 - Nonlinearity: $\pm 0.05\%$ (Max)
 - Nonlinearity Drift: $\pm 1\text{ppm}/^\circ\text{C}$ (Typ)
- SNR: 72dB (Typ, BW=100kHz)
- Wide bandwidth: 220kHz (Typ)
- High CMTI: $125\text{kV}/\mu\text{s}$ (Typ)
- System-Level Diagnostic Features:
 - VDD1 monitoring

- Input common-mode overvoltage detection

- Operation Temperature: $-40^\circ\text{C} \sim 125^\circ\text{C}$
- RoHS-Compliant Packages:
 - SOP8(300mil), SOP8(150mil)

Safety Regulatory Approvals

- UL recognition:
 - SOW8: $5000V_{\text{rms}}$ for 1 minute per UL1577
 - SOP8: $3000V_{\text{rms}}$ for 1 minute per UL1577
- CQC certification per GB4943.1
- CSA component notice 5A
- DIN EN IEC 60747-17 (VDE 0884-17)

Applications

- Shunt current monitoring
- Motor Drives
- Uninterruptible Power Suppliers
- Solar Inverters

Device Information

| Part Number | Package | Body Size |
|----------------|--------------|-----------------|
| NSI1400D-DSWVR | SOP8(300mil) | 5.85mm × 7.50mm |
| NSI1400D-DSPR | SOP8(150mil) | 4.90mm × 3.90mm |

Functional Block Diagrams

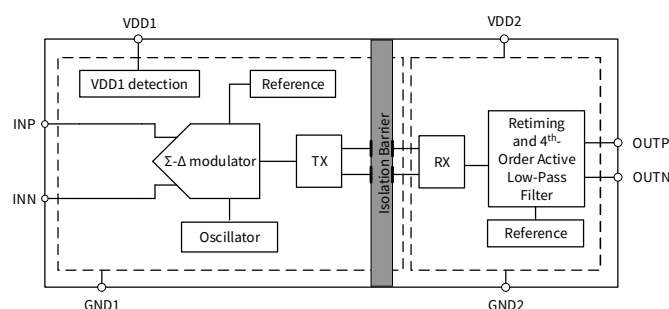


Figure 1. NSI1400D Block Diagram

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1. Pin Configuration and Functions

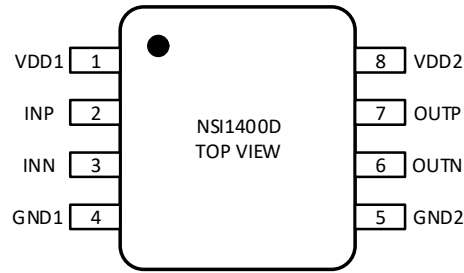


Figure 1.1 NSI1400D Package

Table 1.1 NSI1400 Pin Configuration and Description

| NSI1400D PIN NO. | SYMBOL | FUNCTION |
|------------------|--------|--|
| 1 | VDD1 | Power supply for input side (3.0V to 5.5V) |
| 2 | INP | Positive analog input (±250mV recommended for NSI1400D) |
| 3 | INN | Negative analog input |
| 4 | GND1 | Ground 1, the ground reference for input side |
| 5 | GND2 | Ground 2, the ground reference for output side |
| 6 | OUTN | Negative output |
| 7 | OUP | Positive output |
| 8 | VDD2 | Power supply for output side (3.0V to 5.5V) |

2. Absolute Maximum Ratings⁽¹⁾

| Parameters | Symbol | Min | Typ | Max | Unit |
|-------------------------------------|------------------|----------|-----|----------|------|
| Power Supply Voltage ⁽²⁾ | VDD1, VDD2 | -0.3 | | 6.5 | V |
| Input Voltage | INP, INN | GND1-6 | | VDD1+0.5 | V |
| Output Voltage | OUTP, OUTN | GND2-0.5 | | VDD2+0.5 | V |
| Input current per IO Pin | I _{in} | -10 | | 10 | mA |
| Junction Temperature | T _J | -40 | | 150 | °C |
| Storage Temperature | T _{STG} | -55 | | 150 | °C |

(1) The device cannot operate beyond the listed Absolute Maximum Ratings to prevent permanent device damage. The device is not fully functional if operating outside the Recommended Operating Conditions but within the Absolute Maximum Ratings. Long-time stress of the absolute maximum conditions may affect the device lifetime.

(2) VDD1 to GND1, VDD2 to GND2

3. ESD Ratings⁽¹⁾

| Parameters | Test condition | Value | Unit |
|-------------------------------|--|-------|------|
| Electrostatic discharge (ESD) | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽²⁾ | ±4000 | V |
| | Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽³⁾ | ±1000 | V |

(1) Though this device features proprietary protection circuitry, proper ESD precautions should be considered to avoid performance degradation of damage due to high energy ESD event. Charged devices and circuit boards may discharge without detection.

(2) Safe manufacturing requires 500-V HBM and standard ESD precautions, per JEDEC document JEP155.

(3) Safe manufacturing requires 250-V CDM and standard ESD precautions, per JEDEC document JEP157.

4. Recommended Operating Conditions

| Parameters | Symbol | Min | Typ | Max | Unit |
|---|-----------------------|-------|------|-----|------|
| Input side Power Supply | VDD1 | 3.0 | 5.0 | 5.5 | V |
| Output side Power Supply | VDD2 | 3.0 | 3.3 | 5.5 | V |
| Differential input voltage before clipping output | V _{clipping} | | ±320 | | mV |
| Linear differential input full scale voltage | V _{FSR} | -250 | | 250 | mV |
| Operating common-mode input voltage | V _{CM} | -0.16 | | 2.6 | V |
| Operating Ambient Temperature | T _A | -40 | | 125 | °C |

5. Thermal Information

| Parameters | Symbol | SOP8(150mil) | SOP8(300mil) | Unit |
|--|----------------------|--------------|--------------|------|
| Junction-to-ambient thermal resistance | $R_{\theta JA}$ | 137.7 | 86 | °C/W |
| Junction-to-case (top) thermal resistance | $R_{\theta JC(top)}$ | 54.9 | 28 | °C/W |
| Junction-to-board thermal resistance | $R_{\theta JB}$ | 71.7 | 42 | °C/W |
| Junction-to-top characterization parameter | Ψ_{JT} | 12 | 4 | °C/W |
| Junction-to-board characterization parameter | Ψ_{JB} | 46 | 42 | °C/W |

6. Specifications

6.1. Electrical Characteristics

(VDD1 = 3.0V ~ 5.5V, VDD2 = 3.0V ~ 5.5V, INP = -250mV to +250mV, and INN = GND1 = 0V, $T_A = -40^\circ\text{C}$ to 125°C . Unless otherwise noted, Typical values are at VDD1 = 5V, VDD2 = 3.3V, $T_A = 25^\circ\text{C}$)

| Parameters | Symbol | Min | Typ | Max | Unit | Comments |
|---|--------------------|------|------|-----|-------|--|
| Power Supply | | | | | | |
| Side1 Supply Voltage | VDD1 | 3.0 | 5.0 | 5.5 | V | |
| Side2 Supply Voltage | VDD2 | 3.0 | 3.3 | 5.5 | V | |
| Side1 Supply Current | IDD1 | 4.0 | 5.8 | 7.2 | mA | |
| Side2 Supply Current | IDD2 | 4.0 | 5.1 | 6.3 | mA | |
| VDD1 undervoltage detection threshold voltage | VDD1 _{UV} | 1.8 | 2.3 | 2.7 | V | VDD1 falling |
| Analog Input | | | | | | |
| Common-mode overvoltage detection level | V_{CMov} | | 2.8 | | V | Detection level has a typical hysteresis of 110mV |
| Input offset voltage ⁽¹⁾ | V_{OS} | -0.5 | ±0.1 | 0.5 | mV | INP = INN = GND1, at $T_A = 25^\circ\text{C}$ |
| Input offset drift ⁽²⁾ | TCV_{OS} | -4 | 1 | 4 | μV/°C | |
| Common-mode rejection ratio | $CMRR_{dc}$ | | -98 | | dB | INP = INN, $f_{IN} = 0\text{ Hz}$, $V_{CM\ min} \leq VIN \leq V_{CM\ max}$ |
| | $CMRR_{ac}$ | | -95 | | dB | INP = INN, $f_{IN} = 10\text{ kHz}$, $V_{CM\ min} \leq VIN \leq V_{CM\ max}$ |
| Single-ended input resistance | R_{IN} | | 29 | | kΩ | INN = GND1 |
| Differential input resistance | R_{IND} | | 29.5 | | kΩ | |
| Input capacitance | C_i | | 12 | | pF | |
| Input bias current | I_{IB} | | -0.1 | | μA | INP = INN = GND1, $I_{IB} = (I_{IBP} + I_{IBN}) / 2$, at $T_A = 25^\circ\text{C}$ |
| Input bias current drift ⁽²⁾ | TCI_{IB} | | ±1 | | nA/°C | |

| Parameters | Symbol | Min | Typ | Max | Unit | Comments |
|---|-----------------------|--------|--------|-------|-------------------|---|
| Analog Output | | | | | | |
| Nominal Gain | | | 8.2 | | V/V | |
| Gain error ⁽¹⁾ | E _G | -0.3% | ±0.05% | 0.3% | | at T _A =25°C |
| Gain error thermal drift ⁽¹⁾⁽²⁾ | TCE _G | -30 | ±5 | 30 | ppm/°C | |
| Nonlinearity ⁽¹⁾⁽³⁾ | | -0.05% | ±0.01% | 0.05% | | at T _A =25°C |
| Nonlinearity drift ⁽¹⁾⁽²⁾ | | | ±1 | | ppm/°C | |
| Total harmonic distortion ⁽⁴⁾ | THD | | -90 | -70 | dB | V _{IN} =500mVpp, f _{IN} = 1kHz, BW = 10kHz |
| | | | -75 | | dB | V _{IN} =500mVpp, f _{IN} = 10kHz, BW = 100kHz |
| Output noise | | | 360 | | μV _{RMS} | INP = INN = GND1, BW = 100kHz |
| Signal to noise ratio | SNR | 80 | 85 | | dB | V _{IN} = 500mVpp, f _{IN} = 1kHz, BW = 10kHz |
| | | | 72 | | dB | V _{IN} = 500mVpp, f _{IN} = 10kHz, BW = 100kHz |
| Common-mode output voltage | V _{CMout} | 1.38 | 1.45 | 1.49 | V | For NSI1400D |
| Failsafe differential output voltage | V _{FAILSAFE} | | -2.6 | -2.5 | V | V _{CM} >V _{CMov} , or VDD1 missing |
| Output bandwidth | BW | 175 | 220 | | kHz | |
| Power supply rejection ratio ⁽⁵⁾ | PSRR _{dc} | | -110 | | dB | PSRR vs VDD1, at DC |
| | PSRR _{ac} | | -100 | | dB | PSRR vs VDD1, 100mV and 10kHz ripple |
| | PSRR _{dc} | | -110 | | dB | PSRR vs VDD2, at DC |
| | PSRR _{ac} | | -90 | | dB | PSRR vs VDD2, 100mV and 10kHz ripple |
| Output resistance | R _{OUT} | | < 0.2 | | Ω | |
| Output current limit | I _{OUT} | | ±13 | | mA | |
| Load capacitance | C _{LOAD} | | 100 | | pF | |
| Common-mode transient immunity | CMTI | 100 | 125 | | kV/μs | Common-mode transient immunity |
| Timing | | | | | | |
| Rising time of OUTP, OUTN | t _r | | 1.7 | | μs | |
| Falling time of OUTP, OUTN | t _f | | 1.7 | | μs | |
| INP, INN to OUTP, OUTN signal delay (50% - 50%) | t _{PD} | | 1.6 | 2.0 | μs | C _{LOAD} =15pF |

| Parameters | Symbol | Min | Typ | Max | Unit | Comments |
|---------------------|----------|-----|-----|-----|------|---|
| Analog setting time | t_{AS} | | 0.5 | | ms | VDD1 step to 3.0 V with VDD2 \geq 3.0 V, to OUTP, OUTN valid, 0.1% settling |

- (1) The typical value includes one standard deviation (σ) range under typical operating conditions.
- (2) The temperature drift is calculated with the whole temperature range (-40°C to 125°C).
- (3) Nonlinearity is defined as half of the peak-peak value of the deviation between the measuring point and the fitting curve divided by the full-scale range of the output voltage.
- (4) THD is defined as the ratio of the sum of the rms value of first nine higher harmonics to the amplitude of the fundamental.
- (5) Input referred.

6.2. Typical Performance Characteristics

Unless otherwise noted, test at VDD1 = 5V, VDD2 = 3.3V, INN=GND1=0V, INP = -250mV to 250mV, f_{IN} = 1kHz, BW = 10kHz.

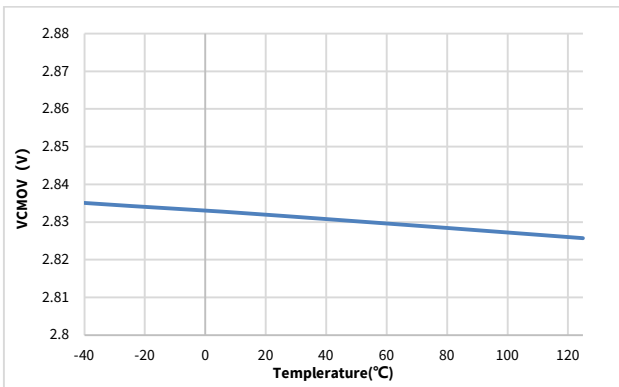


Figure 6.1 Common-Mode Overvoltage Detection Level vs Temperature

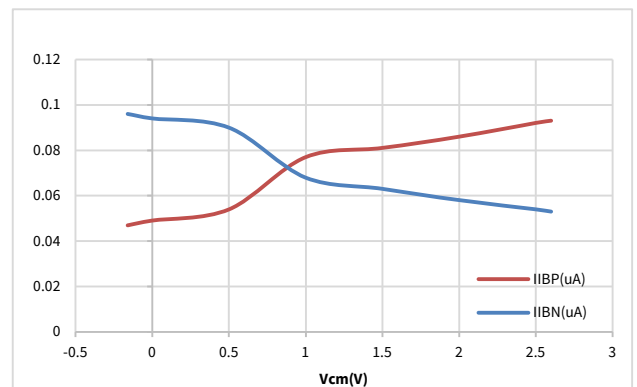


Figure 6.3 Input Bias Current vs Common-Mode Voltage

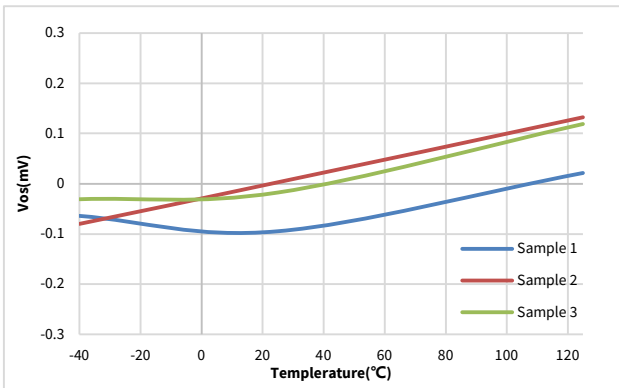


Figure 6.2 Input Offset Voltage vs Temperature

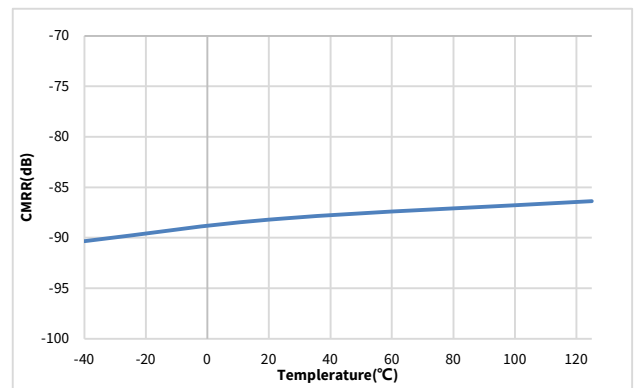


Figure 6.4 Common-Mode Rejection Ratio vs Temperature

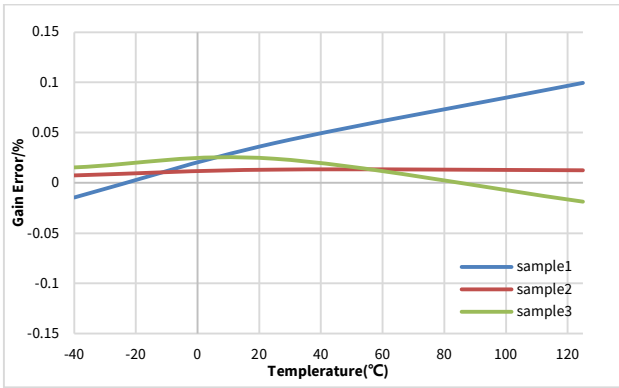


Figure 6.5 Gain Error vs Temperature

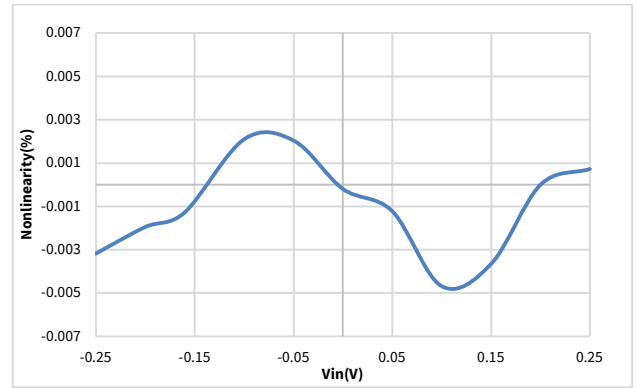


Figure 6.9 Nonlinearity vs Input Voltage

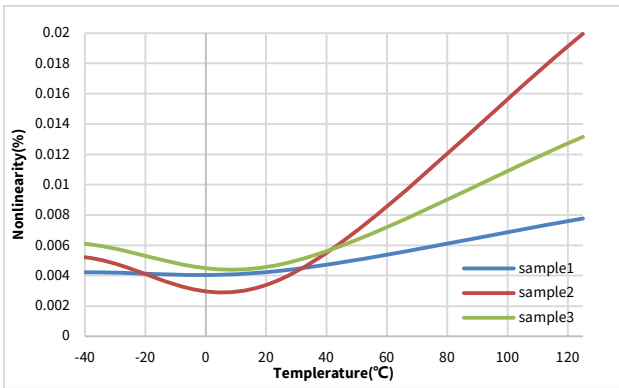


Figure 6.6 Nonlinearity vs Temperature

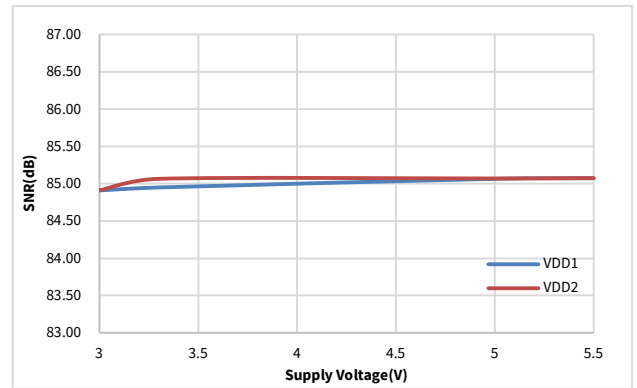


Figure 6.10 SNR vs Supply Voltage

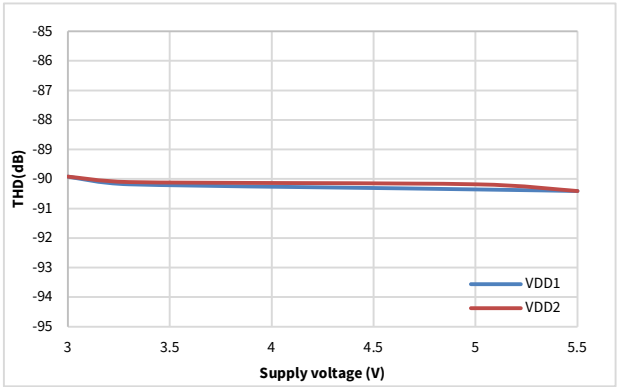


Figure 6.7 THD vs Supply Voltage

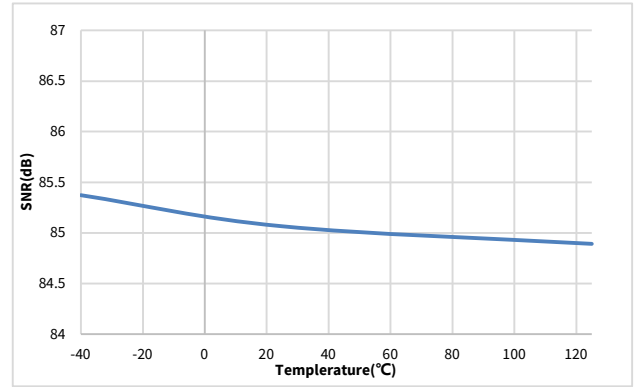


Figure 6.11 SNR vs Temperature

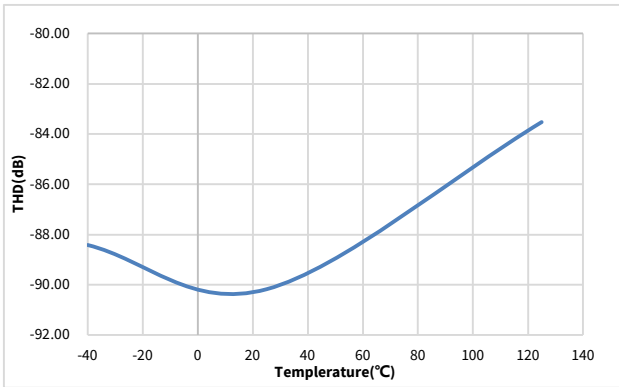


Figure 6.8 THD vs Temperature

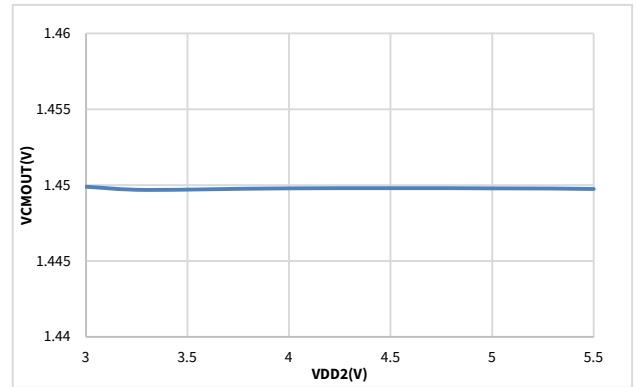


Figure 6.12 Output Common-Mode Voltage vs Side2 Supply Voltage

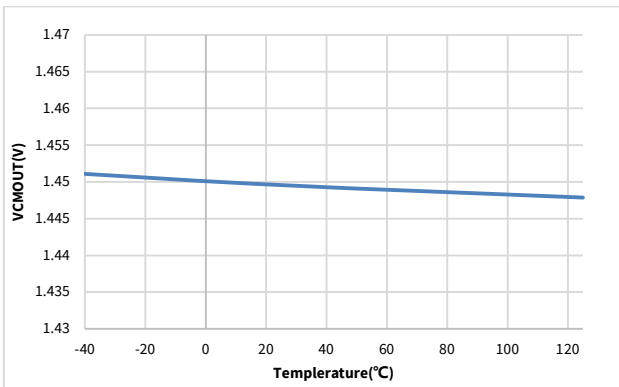


Figure 6.13 Output Common-Mode Voltage vs Temperature

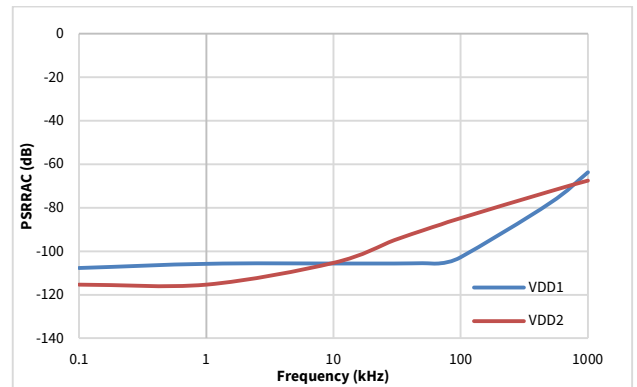


Figure 6.17 Power-Supply Rejection Ratio vs Ripple Frequency

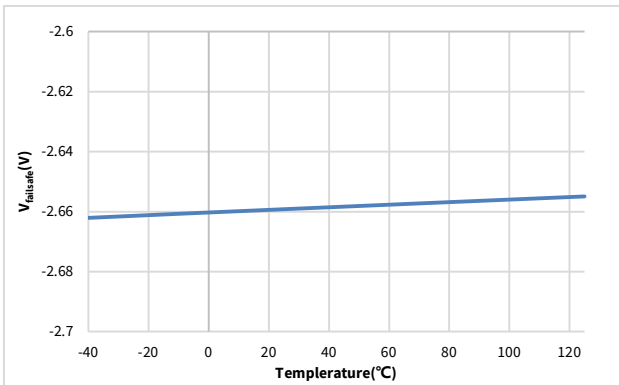


Figure 6.14 Fail-Safe Output Voltage vs Temperature

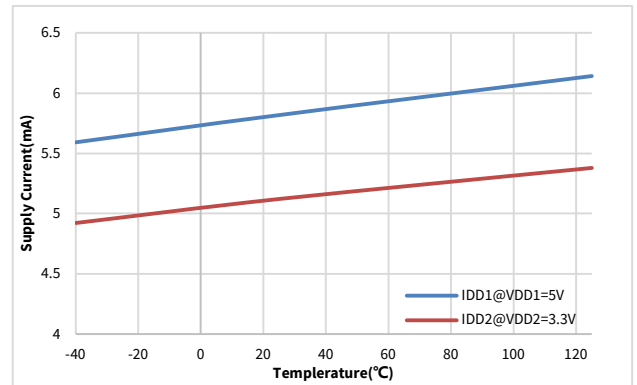


Figure 6.18 Supply Current vs Temperature

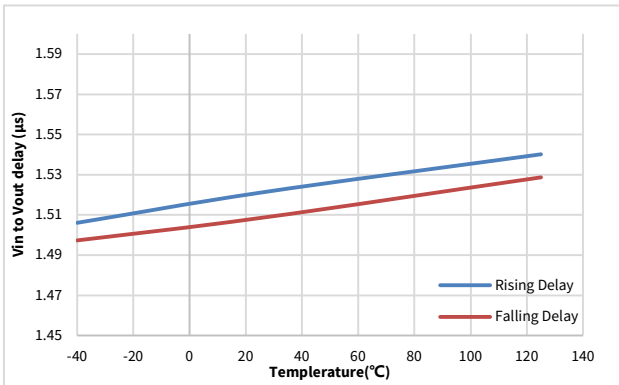


Figure 6.15 Vin to Vout Delay vs Temperature

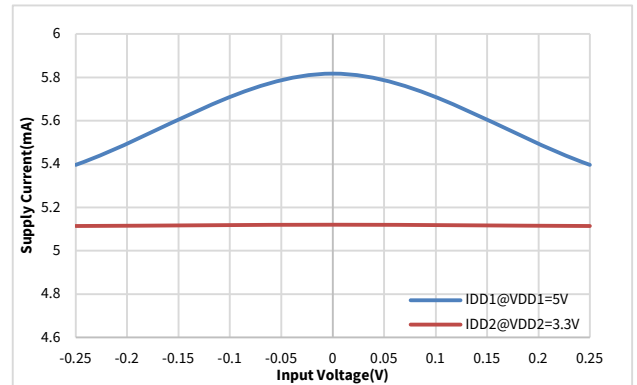


Figure 6.19 Supply Current vs Input Voltage

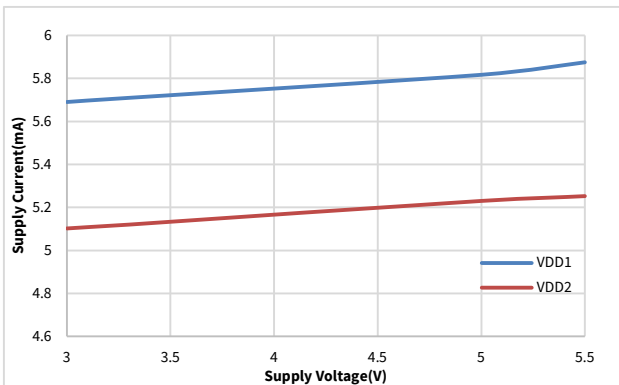


Figure 6.16 Supply Current vs Supply Voltage

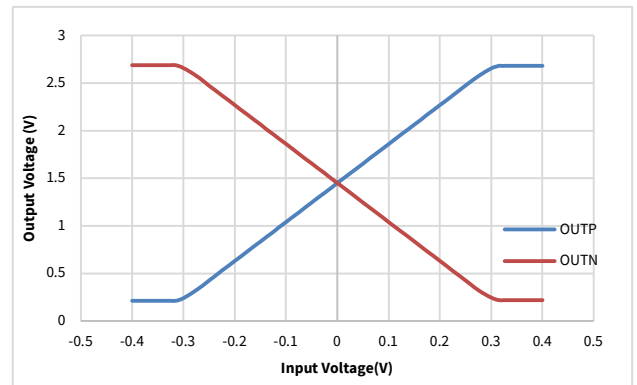


Figure 6.20 Output Voltage vs Input Voltage

6.3. Parameter Measurement Information

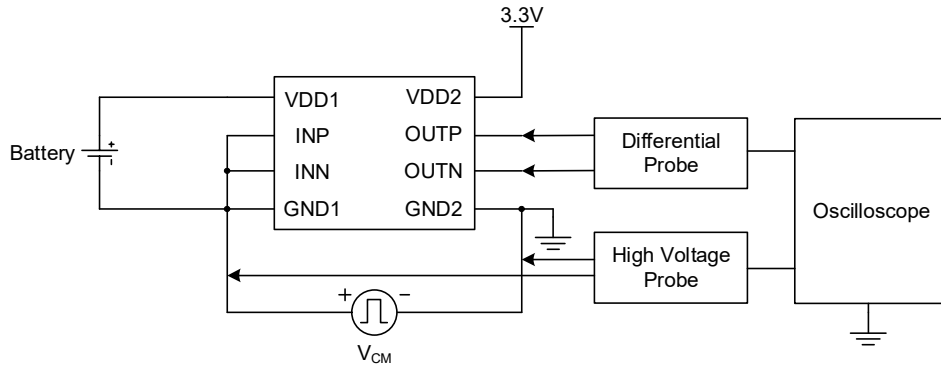


Figure 6.21 Common-Mode Transient Immunity Test Circuit

7. High Voltage Feature Description

7.1. Insulation and Safety Related Specifications

| Parameters | Symbol | Value | | Unit | Comments |
|--|--------|-------|------|------|---------------------------------------|
| | | SOP8 | SOW8 | | |
| Minimum External Clearance | CLR | 4 | 8 | mm | IEC 60664-1:2007 |
| Minimum External Creepage | CPG | 4 | 8 | mm | IEC 60664-1:2007 |
| Distance Through Insulation | DTI | 28 | | μm | Distance through insulation |
| Tracking Resistance (Comparative Tracking Index) | CTI | >600 | | V | DIN EN 60112 (VDE 0303-11); IEC 60112 |
| Material Group | | I | | | IEC 60664-1 |

| Description | Test Condition | Value | |
|-------------------------------------|------------------------------------|-----------|----------|
| | | SOP8 | SOW8 |
| Overvoltage Category per IEC60664-1 | For Rated Mains Voltage ≤ 150Vrms | I to IV | I to IV |
| | For Rated Mains Voltage ≤ 300Vrms | I to III | I to IV |
| | For Rated Mains Voltage ≤ 600Vrms | I to II | I to IV |
| | For Rated Mains Voltage ≤ 1000Vrms | I | I to III |
| Climatic Classification | | 40/125/21 | |
| Pollution Degree per DIN VDE 0110 | | 2 | |

7.2. Insulation Characteristics

| Description | Test Condition | Symbol | Value | | Unit |
|--|---|------------|------------|------------|------------|
| | | | SOP8 | SOW8 | |
| DIN EN IEC 60747-17 (VDE 0884-17) | | | | | |
| Maximum repetitive isolation voltage | | V_{IORM} | 990 | 2121 | V_{PEAK} |
| Maximum working isolation voltage | AC Voltage | V_{IOWM} | 700 | 1500 | V_{RMS} |
| | DC Voltage | | 990 | 2121 | V_{DC} |
| Apparent Charge | Method a, after Input/output safety test subgroup 2/3, $V_{ini}=V_{IOTM}$, $t_{ini}=60\text{ s}$, $V_{pd(m)}=1.2*V_{IORM}$, $t_m=10\text{ s}$. | q_{pd} | / | <5 | pC |
| | Method a, after environmental tests subgroup 1, $V_{ini}=V_{IOTM}$, $t_{ini}=60\text{ s}$, $V_{pd(m)}=1.6*V_{IORM}$, $t_m=10\text{ s}$ | | | | |
| | Method b, routine test (100% production) and preconditioning (type test); $V_{ini}=1.2*V_{IOTM}$, $t_{ini}=1\text{ s}$ $V_{pd(m)}=1.875*V_{IORM}$, $t_m=1\text{ s}$ (method b1) or $V_{pd(m)}=V_{ini}$, $t_m=t_{ini}$ (method b2) | | | | |
| Apparent Charge | Method a, after Input/output safety test subgroup 2/3, $V_{ini}=V_{IOTM}$, $t_{ini}=60\text{ s}$, $V_{pd(m)}=1.2*V_{IORM}$, $t_m=10\text{ s}$. | q_{pd} | <5 | / | pC |
| | Method a, after environmental tests subgroup 1, $V_{ini}=V_{IOTM}$, $t_{ini}=60\text{ s}$, $V_{pd(m)}=1.3*V_{IORM}$, $t_m=10\text{ s}$ | | | | |
| | Method b, routine test (100% production) and preconditioning (type test); $V_{ini}=1.2*V_{IOTM}$, $t_{ini}=1\text{ s}$ $V_{pd(m)}=1.5*V_{IORM}$, $t_m=1\text{ s}$ (method b1) or $V_{pd(m)}=V_{ini}$, $t_m=t_{ini}$ (method b2) | | | | |
| Maximum transient isolation voltage | $t=60\text{ sec}$ | V_{IOTM} | 4242 | 8000 | V_{PEAK} |
| Maximum impulse voltage | Tested in air, 1.2/50-us waveform per IEC62368-1 | V_{IMP} | 3000 | 6250 | V_{PEAK} |
| Maximum Surge Isolation Voltage | Test method per IEC62368-1, 1.2/50us waveform, $V_{IOSM} \geq V_{IMP} \times 1.3$ | V_{IOSM} | 6000 | 10000 | V_{PEAK} |
| Isolation resistance | $V_{IO}=500\text{ V}$, $T_{amb}=25^\circ\text{ C}$ | R_{IO} | $>10^{12}$ | $>10^{12}$ | Ω |
| | $V_{IO}=500\text{ V}$, $100^\circ\text{ C} \leq T_{amb} \leq 125^\circ\text{ C}$ | R_{IO} | $>10^{11}$ | $>10^{11}$ | Ω |
| | $V_{IO}=500\text{ V}$, $T_{amb}=T_s$ | R_{IO} | $>10^9$ | $>10^9$ | Ω |
| Isolation capacitance | $f=1\text{ MHz}$ | C_{IO} | 1.2 | 1.2 | pF |

| Description | Test Condition | Symbol | Value | | Unit |
|---|---|-----------|-------|------|------------------|
| | | | SOP8 | SOW8 | |
| Safety total power dissipation | $V_I = 5.5V, T_J = 150\text{ }^\circ\text{C}, T_A = 25\text{ }^\circ\text{C}$ | Ps | 907 | 1453 | mW |
| Safety input, output, or supply current | $\theta_{JA} = 137.7\text{ }^\circ\text{C/W}$ for SOP8, $V_I = 5.5V, T_J = 150\text{ }^\circ\text{C}, T_A = 25\text{ }^\circ\text{C}$ | Is | 165 | / | mA |
| | $\theta_{JA} = 86\text{ }^\circ\text{C/W}$ for SOW8, $V_I = 5.5V, T_J = 150\text{ }^\circ\text{C}, T_A = 25\text{ }^\circ\text{C}$ | | / | 264 | mA |
| Maximum safety temperature | | Ts | 150 | 150 | $^\circ\text{C}$ |
| UL1577 | | | | | |
| Insulation voltage per UL | $V_{TEST} = V_{ISO}, t = 60\text{ s}$ (qualification), $V_{TEST} = 1.2 \times V_{ISO}, t = 1\text{ s}$ (100% production test) | V_{ISO} | 3000 | 5000 | V_{RMS} |

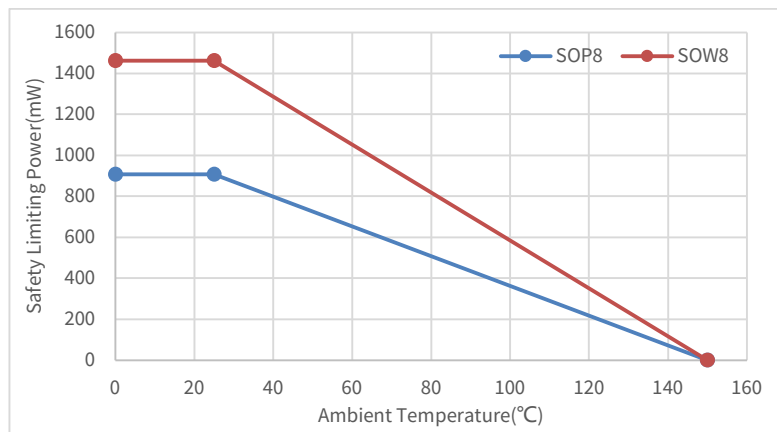


Figure 7.1 NSI1400 Thermal Derating Curve, Dependence of Safety Limiting Values with Case Temperature per DIN EN IEC 60747-17

7.3. Regulatory Information

The NSI1400D-DSWVR are approved or pending approval by the organizations listed in table.

| UL | | VDE | CQC |
|---|---|--|---|
| UL 1577 Component Recognition Program | Approved under CSA Component Acceptance Notice 5A | DIN EN IEC 60747-17 (VDE 0884-17) | Certified by CQC11-471543-2012 GB4943.1-2011 |
| Single Protection, 5000V _{rms} Isolation voltage | Single Protection, 5000V _{rms} Isolation voltage | Reinforce Insulation $V_{IORM}=2121V_{peak}$ $V_{IOTM}=8000V_{peak}$ $V_{IOSM}=10000V_{peak}$ | Reinforced insulation |
| Certificate No.E500602 | Certificate No.E500602 | File (pending) | File (pending) |

The NSi1400D-DSPR is approved or pending approval by the organizations listed in table.

| UL | | VDE | CQC |
|---|---|---|---|
| UL 1577 Component Recognition Program | Approved under CSA Component Acceptance Notice 5A | DIN EN IEC 60747-17 (VDE 0884-17) | Certified by CQC11-471543-2012 GB4943.1-2011 |
| Single Protection, 3000V _{rms} Isolation voltage | Single Protection, 3000V _{rms} Isolation voltage | Basic Insulation V _{IORM} =990Vpeak V _{IOTM} =4242Vpeak V _{IOSM} =6000Vpeak | Basic insulation |
| Certificate No.E500602 | Certificate No.E500602 | File (pending) | CQC20001264940 |

8. Function Description

8.1. Overview

The NSI1400 is a high-performance isolated amplifier that accepts fully-differential input. The fully-differential input is ideally suited to shunt current monitoring in high voltage applications where isolation is required. The analog input is continuously sampled by a second-order Σ - Δ modulator in the device. With the internal voltage reference and clock generator, the modulator converts the analog input signal to a digital bitstream. The output of the modulator is transferred by the drivers (called TX in the Functional Block Diagram) across the isolation barrier that separates the isolated input side and output side voltage. The received bitstream and clock are synchronized and processed, as shown in the Functional Block Diagram, by a fourth-order analog filter on the output side.

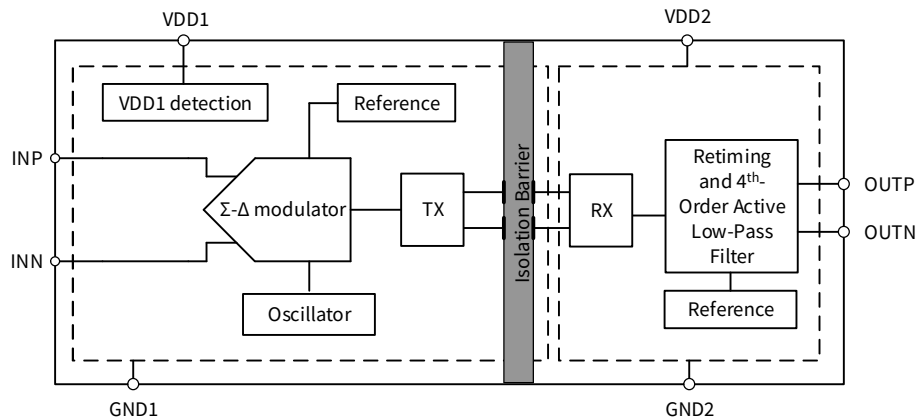


Figure 8.1 Function Block Diagram of NSI1400D

8.2. Analog Input

The analog input of the NSI1400 is a switched-capacitor circuit based on the second-order Σ - Δ modulator. The Equivalent circuit of analog input is shown in Figure 8.2. The internal capacitance C_{IND} is continuously charged and discharged through periodical switching action with the internal clock frequency f_{CLK} for input signal digitization. In the charging phase, the external input source must provide enough transient charge for the internal capacitance. To prevent transient voltage drop of C_{IND} , an external capacitor (C_{FLT} in Figure 8.1, also acting as filter capacitance) of more than 330pF should be placed as close as possible to the device as charge buffering, which ensures sensing accuracy.

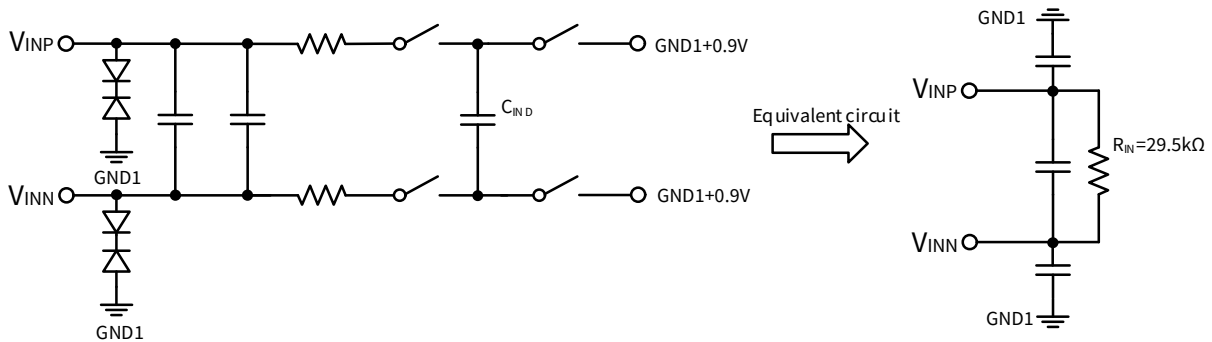


Figure 8.2 Equivalent Circuit of Analog Input

According to the equivalent circuit, the input resistance R_{IN} can be calculated as

$$R_{IND} = 1/(f_{CLK} * C_{IND})$$

There are two restrictions on the analog input signals (V_{INP} and V_{INN}).

- If the input voltage exceeds the range $GND1 - 6V$ to $VDD1 + 0.5V$, the input current must be limited to 10 mA because the device input electrostatic discharge (ESD) diodes turn on.
- The linearity and noise performance of the device are ensured only when the analog input voltage remains within the specified linear full-scale range (FSR) and within the specified common-mode input voltage range.

8.3. Analog Output

For linear input range, the analog output of NSI1400D has a fixed gain 8.2. If a full-scale input signal is applied to the NSI1400 ($V_{IN} \geq V_{Clipping}$), the differential analog output ($V_{OUTP} - V_{OUTN}$ for NSI1400D and $V_{OUT} - REF_{IN}$ for NSI1400S) will be clipped (typically, 2.45V for positive clipping and -2.45V for negative clipping).

For differential output version (NSI1400D), the differential output pins have a common-mode voltage of 1.45V (typ). The typical negative clipping output of NSI1400D is shown in Figure 8.3. The differential output V_{out} of the NSI1400D is expressed as:

$$V_{out} = Gain * (V_{INP} - V_{INN})$$

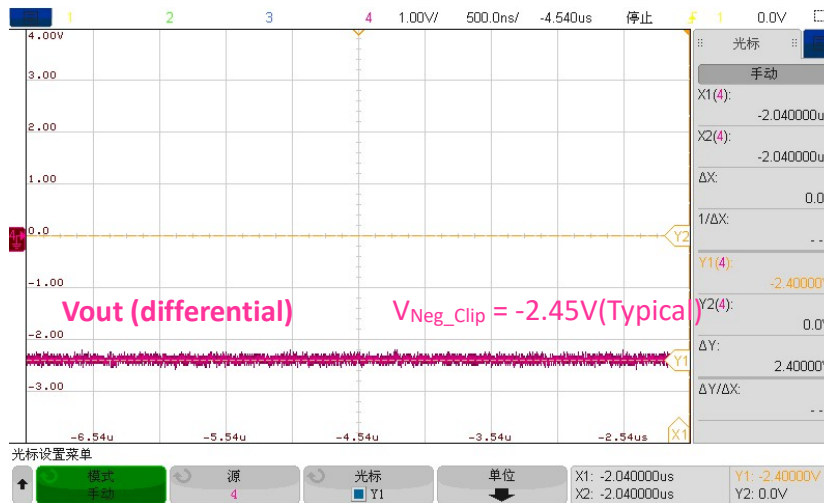


Figure 8.3 Typical negative clipping output of NSI1400D

In addition, NSI1400 integrates some diagnostic measures and offers a fail-safe output to simplify system-level design. The fail-safe output is a negative differential output voltage that does not occur under normal device operation, and it will only be activated in following conditions:

- When the undervoltage of $VDD1$ is detected ($VDD1 < VDD1_{UV}$).
- When the overvoltage of common-mode input voltage is detected ($V_{CM} > V_{CMOV}$).

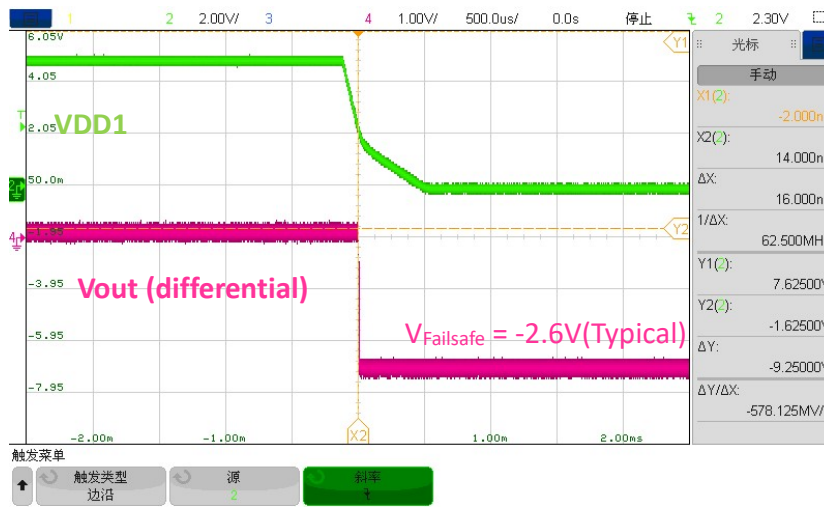


Figure 8.4 Typical Failsafe output when VDD1 undervoltage

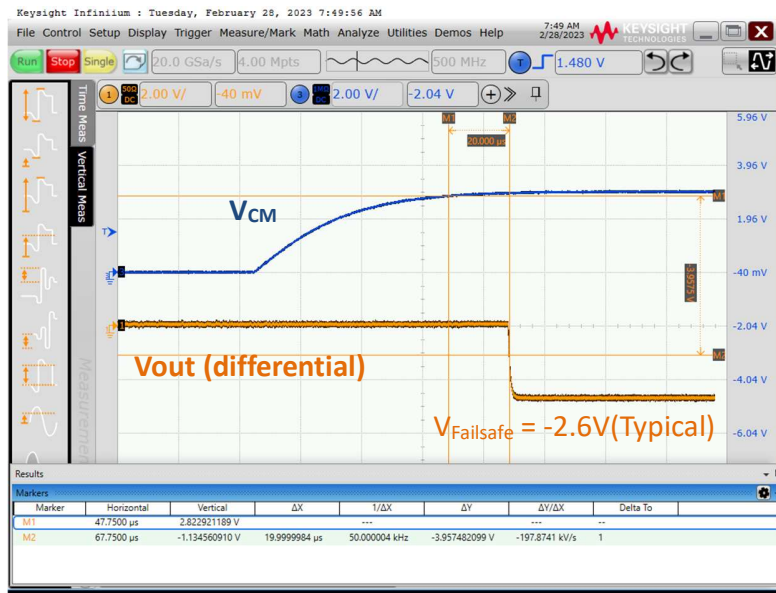


Figure 8.5 Typical Failsafe output when input common mode signal overvoltage

9. Application Note

9.1. Typical Application Circuit

NSI1400 is ideally suited to shunt resistor-based current sensing in high voltage applications such as motor drives. The typical application circuit is shown in Figure 9.1.

The voltage across the shunt resistor R_{sense} is applied to the differential input of NSI1400 through a RC filter (R_{FLT} and C_{FLT}). The filter capacitance of more than 330pF placing as close as possible to the device must be added for charge buffering of the input switched-capacitor circuit (further details in 8.2 Analog Input) and better performance in high-noise applications.

The differential output of the isolated amplifier is converted to a single-ended analog output with an operational-amplifier-based circuit. Suggest to add >1kΩ resistor on the OUPN and OUPP pin to prevent output over-current. An analog-to-digital converter usually receives the analog output and converts to digital signal for controller processing.

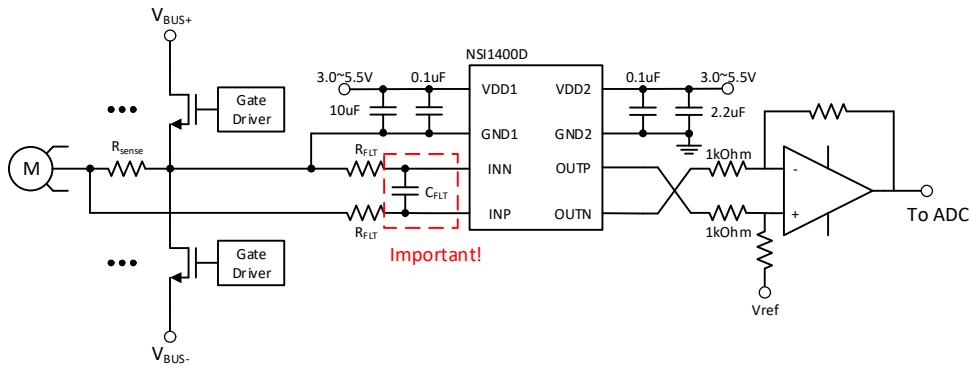


Figure 9.1 Typical application circuit in phase current sensing

9.2. Shunt Resistor Selection

Choosing a particular shunt resistor is usually a compromise between minimizing power dissipation and maximizing accuracy. Smaller sense resistor decreases power dissipation, while larger sense resistor can improve measure accuracy by utilizing the full input range of isolated amplifier.

There are two other factors should be considered when selecting the shunt resistor:

- The voltage-drop caused by the rated current range must not exceed the recommended linear input voltage range: $V_{SHUNT} \leq FSR$.
- The voltage-drop caused by the maximum allowed overcurrent must not exceed the input voltage that causes a clipping output: $V_{SHUNT} \leq V_{Clipping}$.

9.3. PCB Layout

There are some key guidelines or considerations for optimizing performance in PCB layout:

- Place the input filter capacitors as close as possible to the INP and INN pins for best performance.
- NSI1400 requires a 0.1µF bypass capacitor between VDD1 and GND1, VDD2 and GND2. The capacitor should be placed as close as possible to the VDD pin. If better filtering is required, an additional 1~10µF capacitor may be used.
- Kelvin rules is recommended for the connection between shunt resistor to NSI1400. Because of the Kelvin connection, any voltage drops across the trace and leads should have no impact on the measured voltage.
- Place the shunt resistor close to the INP and INN inputs and keep the layout of both connections symmetrical and run very close to each other to the input of the NSI1400. This minimizes the loop area of the connection and reduces the possibility of stray magnetic fields from interfering with the measured signal.

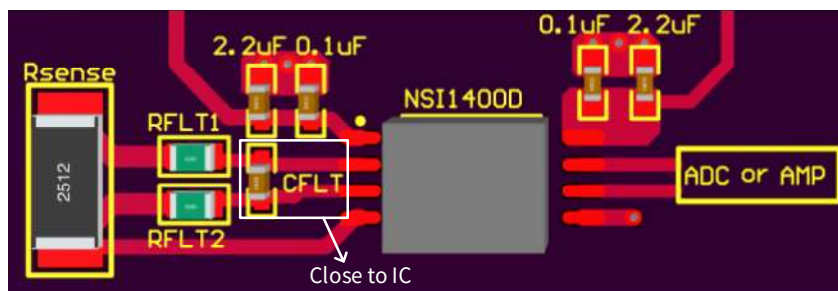
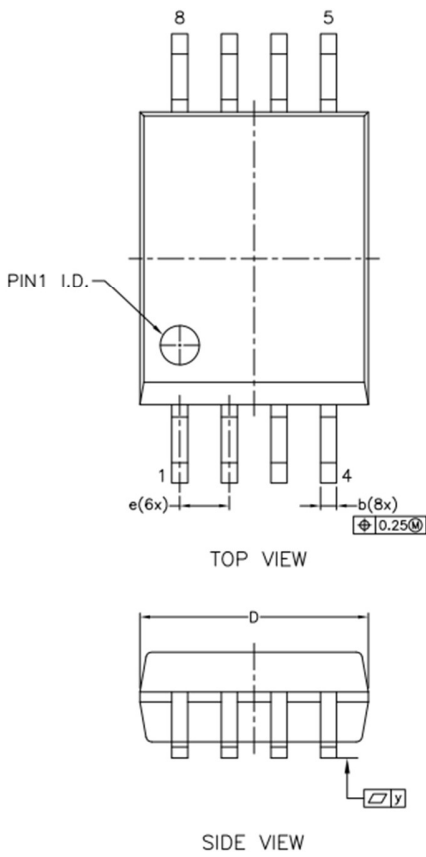


Figure 9.2 Typical application circuit in phase current sensing

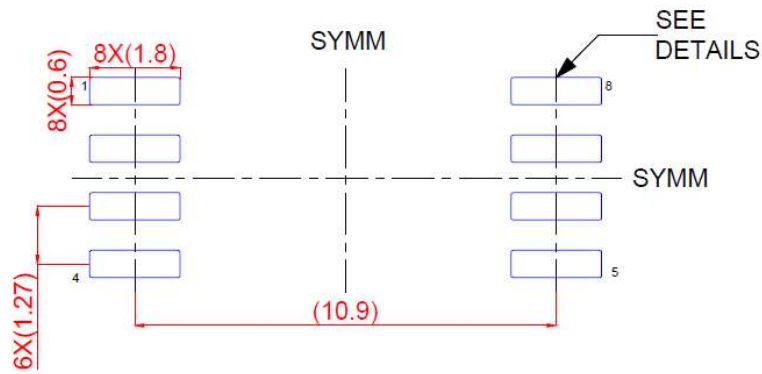
10. Package Information



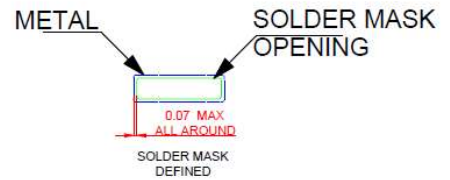
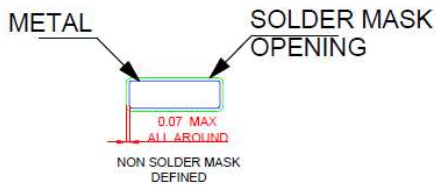
* CONTROLLING DIMENSION : MM

| SYMBOL | MM | | |
|----------|----------|-------|-------|
| | MIN. | NOM. | MAX. |
| A | --- | --- | 2.80 |
| A1 | 0.36 | --- | 0.46 |
| A2 | 2.20 | 2.30 | 2.40 |
| A3 | --- | 0.25 | --- |
| Q | 0.97 | 1.02 | 1.07 |
| b | 0.31 | 0.41 | 0.51 |
| c | 0.13 | --- | 0.33 |
| D | 5.75 | 5.85 | 5.95 |
| E | 7.40 | 7.50 | 7.60 |
| E1 | 11.25 | 11.50 | 11.75 |
| e | 1.27 bsc | | |
| L | 2.00 bsc | | |
| Lp | 0.50 | --- | 1.00 |
| y | --- | 0.10 | --- |
| θ | 0° | --- | 8° |

Figure 10.1 SOW8 Package Shape and Dimension in millimeters

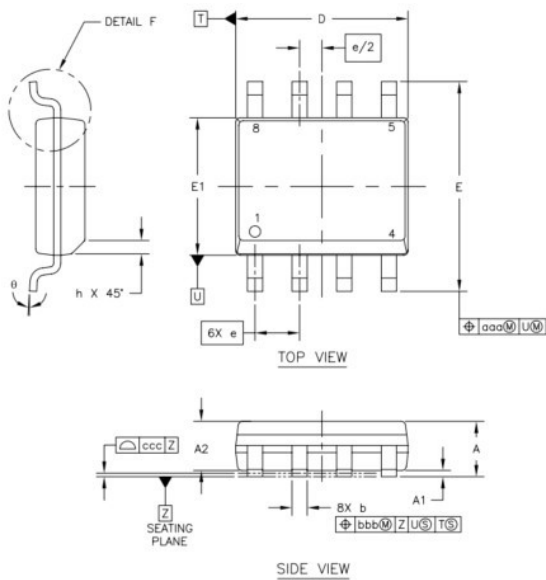


LAND PATTERN EXAMPLE(mm)
9.1 mm NOMINAL
CLEARANCE/CREEPAGE



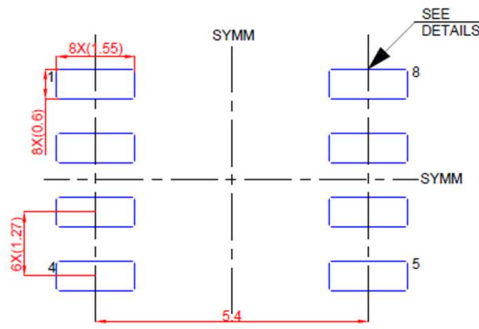
SOLDER MASK DETAILS

Figure 10.2 SOW8 Package Board Layout Example

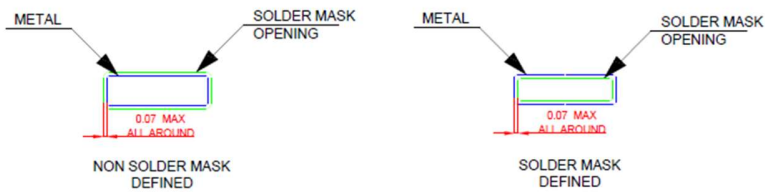


| DESCRIPTION | SYMBOL | INCH | | MILLIMETER | | | |
|------------------|--------|----------|------|------------|------|------|------|
| | | MIN | NOM | MAX | MIN | NOM | MAX |
| TOTAL THICKNESS | A | .053 | | .069 | 1.35 | | 1.75 |
| STAND OFF | A1 | .004 | | .010 | 0.10 | | 0.25 |
| MOLD THICKNESS | A2 | .049 | | --- | 1.25 | | --- |
| LEAD WIDTH | b | .014 | | .019 | 0.35 | | 0.49 |
| L/F THICKNESS | c | .007 | | .010 | 0.19 | | 0.25 |
| BODY SIZE | D | .189 | | .197 | 4.80 | | 5.00 |
| | E1 | .150 | | .157 | 3.80 | | 4.00 |
| | E | .228 | | .244 | 5.80 | | 6.20 |
| LEAD PITCH | e | .050 BSC | | 1.27 BSC | | | |
| | | L | .016 | | .049 | 0.40 | |
| | h | .010 | | .020 | 0.25 | | 0.50 |
| | theta | 0° | | 7° | 0° | | 7° |
| | theta1 | 5° | | 15° | 5° | | 15° |
| | theta2 | 2° | 7° | 12° | 2° | 7° | 12° |
| LEAD EDGE OFFSET | aaa | .010 | | 0.25 | | | |
| LEAD OFFSET | bbb | .010 | | 0.25 | | | |
| COPLANARITY | ccc | .004 | | 0.10 | | | |

Figure 10.3 SOP8 package shape and dimension in millimeters



LAND PATTERN EXAMPLE(mm)



SOLDER MASK DETAILS

Figure 10.4 SOP8 Package Board Layout Example

11. Ordering Information

| Part No. | Isolation Rating(kV) | Linear Input Range(mV) | Moisture Sensitivity Level | Temperature | Automotive | Package Type | Package Drawing | SPQ |
|----------------|----------------------|------------------------|----------------------------|--------------|------------|---------------|-----------------|------|
| NSI1400D-DSWVR | 5 | -250 ~ 250 | Level-3 | -40 to 125°C | NO | SOP8 (300mil) | SOW8 | 1000 |
| NSI1400D -DSPR | 3 | -250 ~ 250 | Level-3 | -40 to 125°C | NO | SOP8 (150mil) | SOP8 | 2500 |

12. Documentation Support

| Part Number | Product Folder | Datasheet | Technical Documents | Isolator selection guide |
|-------------|----------------------------|----------------------------|----------------------------|----------------------------|
| NSI1400 | Click here | Click here | Click here | Click here |

13. Tape and Reel Information

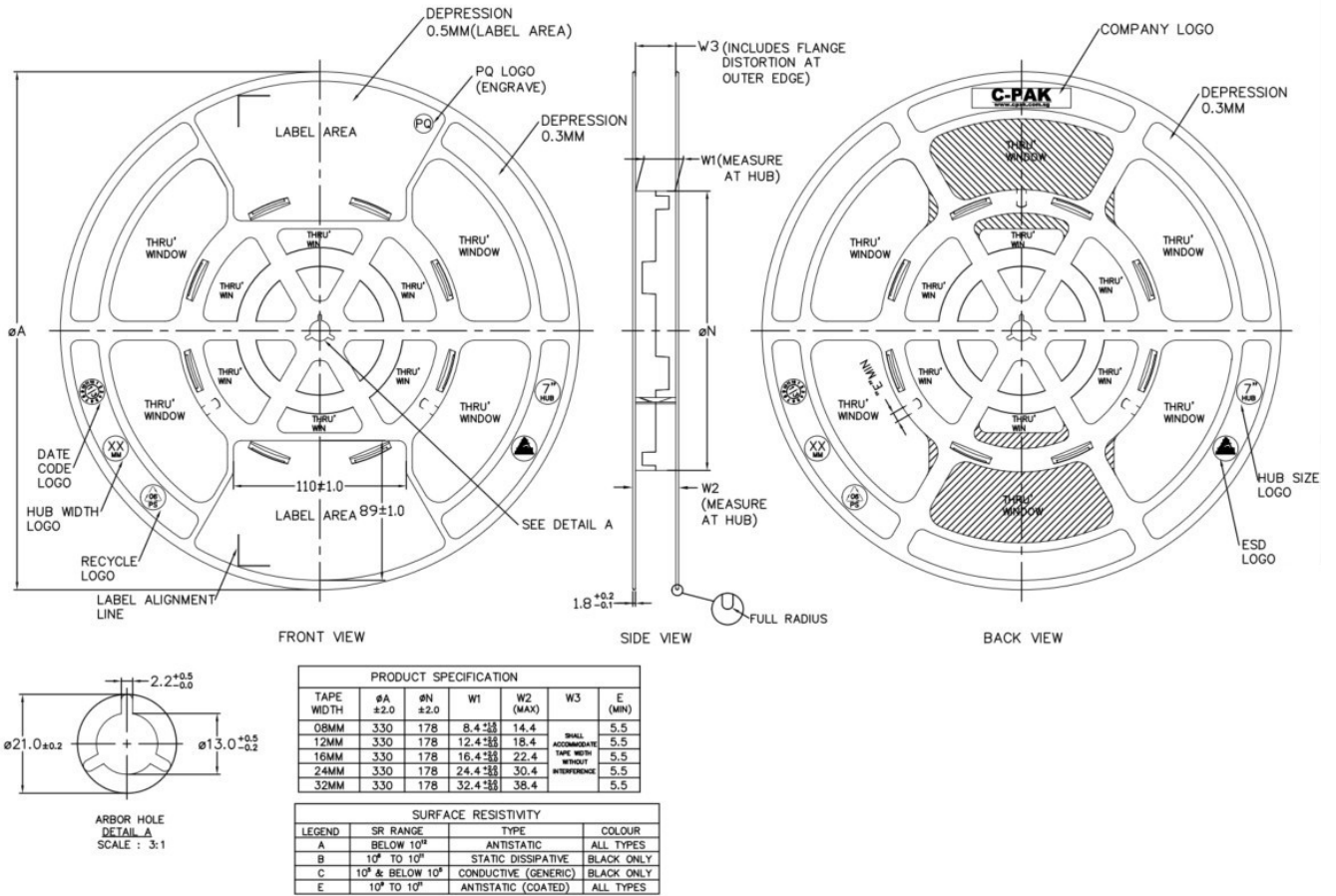


Figure 13.1 Tape Information

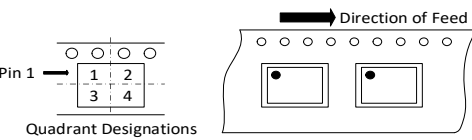
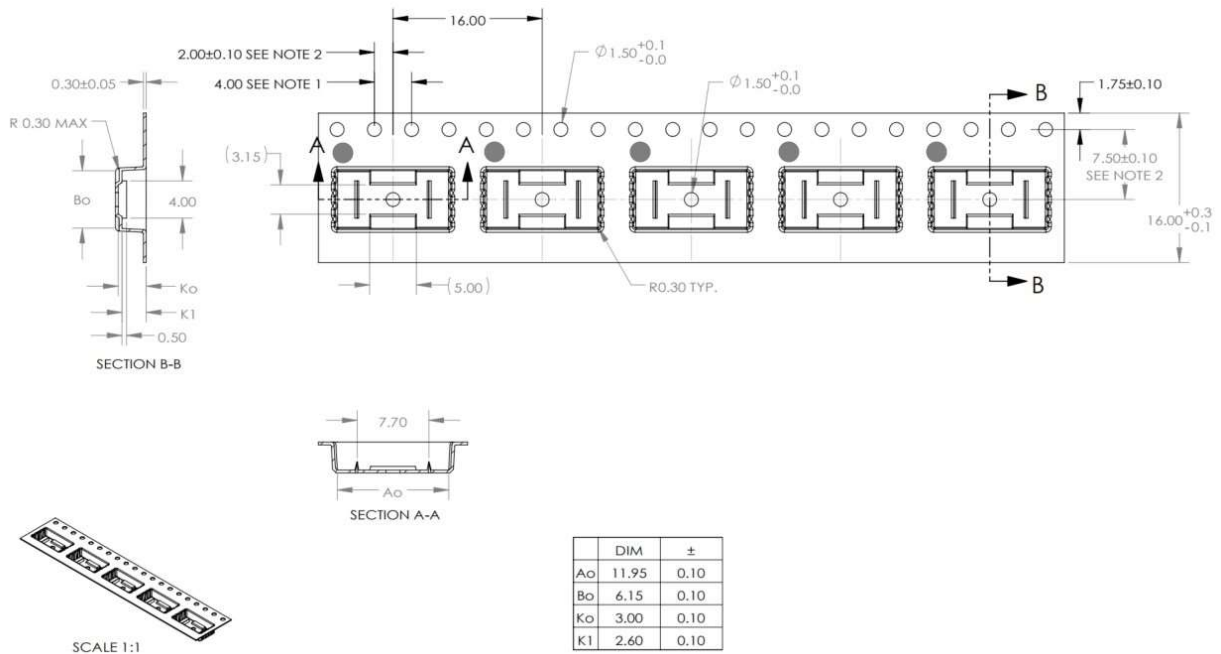


Figure 13.2 Reel Information of SOP8(300mil)

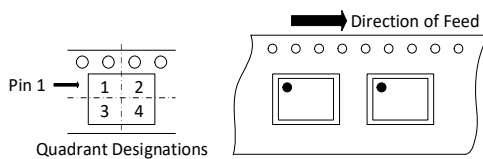
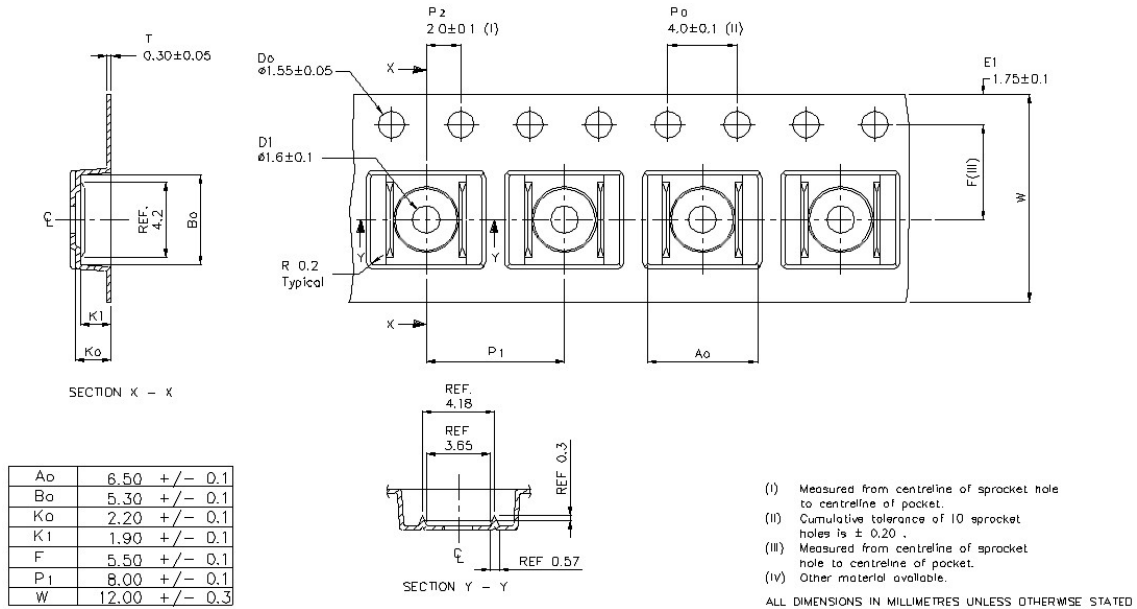


Figure 13.3 Reel Information of SOP8(150mil)

14. Revision History

| Revision | Description | Date |
|----------|-----------------|------------|
| 1.0 | Initial release | 2023/10/31 |

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