NSI1200: Isolated Amplifier

Datasheet (EN) 0.1

Product Overview

The NSI1200 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 ±250mV (±320mV 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 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_{RMS} Insulation Voltage
- ±250mV Linear Input Voltage Range
- Fixed Gain: 8
- Low Offset Error and Drift:
  ±0.2mV (Max), ±3µV/°C (Max)
- Low Gain Error and Drift:
  ±0.3% (Max), ±50ppm/°C (Max)
- Low Nonlinearity and Drift:
  ±0.03% (Max), ±1ppm/°C (Typ)
- SNR: 85dB (Typ, BW=10kHz), 72dB (Typ, BW=100kHz)
- Bandwidth: 100kHz (Typ)
- High CMTI: 100kV/μs (Typ)
- System-Level Diagnostic Features:
  VDD1 monitoring
  Input common-mode overvoltage detection
- Operation Temperature: -40℃~125℃
- RoHS-Compliant Packages:
  DUB-8
  SOP-8(300mil)

Safety Regulatory Approvals (pending)

- UL recognition: up to 5kV_{RMS} for 1 minute per UL1577
- CQC certification per GB4943.1-2011
- CSA component notice 5A approval
- DIN VDE V 0884-11 (VDE V 0884-11): 2017-01

Applications

- Shunt current monitoring
- AC motor controls
- Power and solar inverters
- Uninterruptible Power Suppliers
- Automotive onboard chargers

Functional Block Diagram

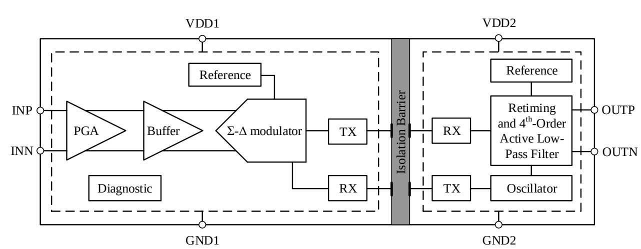

Figure 1. NSI1200 Block Diagram

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1.0 ABSOLUTE MAXIMUM RATINGS

Parameters	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	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
Output current per Output Pin	Io	-10		10	mA
Operating Temperature	T_{OPR}	-40		125	℃
Storage Temperature	T_{STG}	-40		150	℃
Electrostatic discharge	HBM			±2000	V
	CDM			±1000	V

2.0 RECOMMENDED OPERATING CONDITIONS

Parameters		Symbol	Min	Typ	Max	Unit
Side1 Power Supply		VDD1	3.0	5.0	5.5	V
Side2 Power Supply		VDD2	3.0	3.3	5.5	V
NSI1200	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		0.8	V
Operating Ambient Temperature		T_A	-40		125	℃

3.0 SPECIFICATIONS

3.1. ELECTRICAL CHARACTERISTICS: NSI1200

(VDD1 = 3.0V~5.5V, VDD2 = 3.0V~5.5V, INP = -250mV to +250mV, and INN = GND1 = 0V, T_A = -40℃ to 125℃. Unless otherwise noted, Typical values are at VDD1 = 5V, VDD2 = 3.3V, T_A = 25℃)

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		11.4	15.1	mA	
Side2 supply current	IDD2		6.3	8.4	mA	
VDD1 undervoltage detection threshold voltage	$VDD1_{UV}$	1.8	2.5	2.7	V	VDD1 falling

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Analog Input						
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		0.8	V	(INP + INN) / 2 to GND1
Common-mode overvoltage detection level	V_{CMov}	0.9			V	Detection level has a typical hysteresis of 96 mV
Input offset voltage	V_{OS}	-0.2	±0.01	0.2	mV	INP = INN = GND1
Input offset drift	TCV_{OS}	-3	±1	3	µV/°C	
Input bandwidth	BW		100		kHz	
Common-mode rejection ratio	CMRR		-100		dB	INP = INN, f_{IN} = 0 Hz, $V_{CM\ min} \le V_{IN} \le V_{CM\ max}$
			-100		dB	INP = INN, f_{IN} = 10 kHz, $V_{CM\ min} \le V_{IN} \le V_{CM\ max}$
Single-ended input resistance	R_{IN}				kΩ	INN = GND1
Differential input resistance	R_{IND}				kΩ	
Input bias current	I_{IB}				µA	INP = INN = GND1, $I_{IB} = (I_{IBP} + I_{IBN}) / 2$
Input bias current drift	TCI_{IB}				nA/°C	
Analog Output						
Nominal Gain			8		V/V	
Gain error	E_G	-0.3%	±0.05%	0.3%		
Gain error thermal drift	TCE_G	-50	±15	50	ppm/°C	
Nonlinearity		-0.03%	±0.01%	0.03%		
Nonlinearity drift			±1		ppm/°C	
Total harmonic distortion	THD		-85		dB	V_{IN} = 0.5V, f_{IN} = 10kHz, BW = 100kHz
Output noise			230		μV_{RMS}	INP = INN = GND1, BW = 100kHz
Signal to noise ratio	SNR	80	85		dB	V_{IN} = 0.5V, f_{IN} = 1kHz, BW = 10kHz
			72		dB	V_{IN} = 0.5V, f_{IN} = 10kHz, BW = 100kHz
Common-mode output voltage	V_{CMout}	1.39	1.44	1.49	V	

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Failsafe differential output voltage	$V_{FAILSAFE}$		-2.6	-2.5	V	V_{CM}>V_{CMov}, or VDD1 missing
Power supply rejection ratio	PSRR		-100		dB	PSRR vs VDD1, at DC
			-90		dB	PSRR vs VDD1, 100mV and 10kHz ripple
			-100		dB	PSRR vs VDD2, at DC
			-90		dB	PSRR vs VDD2, 100mV and 10kHz ripple
Output resistance	R_{OUT}		<0.2		Ω	
Common-mode transient immunity	CMTI	50	100		kV/µs	Common-mode transient immunity
Timing						
Rising time of OUTP, OUTN	t_r		1.3		µs	
Falling time of OUTP, OUTN	t_f		1.3		µs	
INP, INN to OUTP, OUTN signal delay (50% - 50%)	t_{PD}		1.6	2.1	µs	
Analog setting time	t_{AS}		0.5		ms	VDD1 step to 3.0 V with VDD2 ≥ 3.0 V, to OUTP, OUTN valid, 0.1% settling

3.2. TYPICAL PERFORMANCE CHARACTERISTICS

3.3. PARAMETER MEASUREMENT INFORMATION

4.0 HIGH VOLTAGE FEATURE DESCRIPTION

4.1. INSULATION AND SAFETY RELATED SPECIFICATIONS

Parameters	*Symbol*	*Value*	*Unit*	*Comments*
Minimum External Air Gap (Clearance)	L(I01)	≥ 8	mm	Shortest terminal-to-terminal distance through air
Minimum External Tracking (Creepage)	L(I02)	≥ 8	mm	Shortest terminal-to-terminal distance across the package surface
Minimum internal gap	DTI	32	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

4.2. DIN VDE V 0884-11 (VDE V 0884-11) INSULATION CHARATERISTICS

Description	*Test Condition*	*Symbol*	*Value*		*Unit*
			DUB8	*SOP8(300mil)*	
Installation Classification per DIN VDE 0110					
For Rated Mains Voltage ≤ 150Vrms			I to IV	I to IV	
For Rated Mains Voltage ≤ 300Vrms			I to III	I to III	
For Rated Mains Voltage ≤ 400Vrms			I to III	I to III	
Climatic Classification			10/105/21	10/105/21	
Pollution Degree per DIN VDE 0110, Table 1			2	2	
Maximum repetitive isolation voltage		V_{IORM}	1200	1414	V_{PEAK}
Maximum working isolation voltage	AC Voltage	V_{IOWM}	848	1000	V_{RMS}
	DC Voltage		1200	1414	V_{PEAK}
Input to Output Test Voltage, Method B1	$V_{IORM} \times 1.875 = V_{pd (m)}$ (Reinforced), $V_{IORM} \times 1.5 = V_{pd (m)}$ (Basic), 100% production test, $t_{ini} = t_m = 1$ sec, partial discharge < 5 pC	$V_{pd (m)}$	1800	2652	V_{PEAK}
Input to Output Test Voltage, Method A					
After Environmental Tests Subgroup 1	$V_{IORM} \times 1.5 = V_{pd (m)}$ (Reinforced),	$V_{pd (m)}$	1440	2121	V_{PEAK}

Description	*Test Condition*	*Symbol*	*Value*		*Unit*
			DUB8	*SOP8(300mil)*	
	$V_{IORM} \times 1.2 = V_{pd\ (m)}$ (Basic), t_{ini} = 60 sec, t_m = 10 sec, partial discharge < 5 pC				
After Input and /or Safety Test Subgroup 2 and Subgroup 3	$V_{IORM} \times 1.2 = V_{pd\ (m)}$, t_{ini} = 60 sec, t_m = 10 sec, partial discharge < 5 pC	$V_{pd\ (m)}$	1440	1697	V_{PEAK}
Maximum transient isolation voltage	t = 60 sec	V_{IOTM}	4000	7000	V_{PEAK}
Maximum Surge Isolation Voltage	Test method per IEC60065,1.2/50us waveform, $V_{TEST}=V_{IOSM}/1.6$	V_{IOSM}	6000	6250	V_{PEAK}
Isolation resistance	VIO =500V	R_{IO}	$>10^9$	$>10^9$	Ω
Isolation capacitance	f = 1MHz	C_{IO}	0.8	0.8	pF
Input capacitance		C_I	2	2	pF
Total Power Dissipation at 25℃		Ps			mW
Safety input, output, or supply current	θ_{JA} = 75 °C/W, V_I = 5.5V, T_J = 150 °C, T_A = 25 °C	Is	300		mA
Safety input, output, or supply current	θ_{JA} = 86 °C/W, V_I = 5.5V, T_J = 150 °C, T_A = 25 °C	Is		260	mA
Case Temperature		Ts	150	150	℃

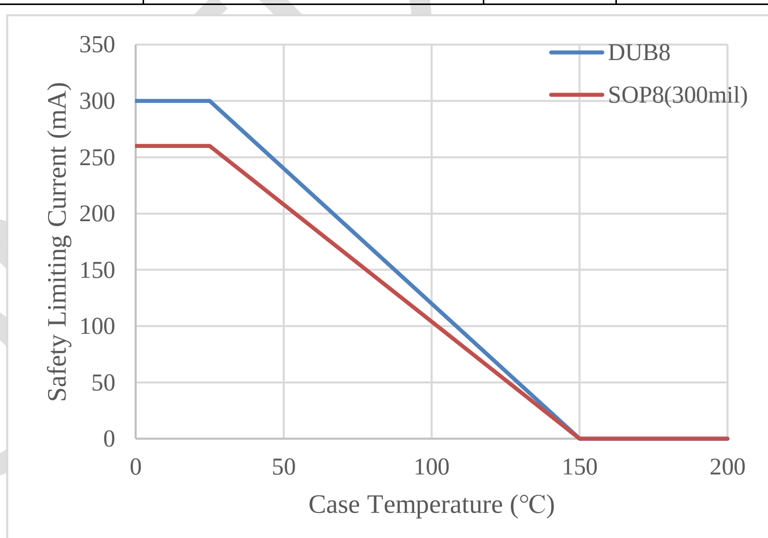


Figure 4.1 NSI1200 Thermal Derating Curve, Dependence of Safety Limiting Values with Case Temperature per DIN V VDE V 0884-10

4.3. REGULATORY INFORMATION

The NSI1200 is approved or pending approval by the organizations listed in table.

UL	*CSA*	*VDE*

UL 1577 Component Recognition Program[1]	Approved under CSA Component Acceptance Notice 5A IEC60950-1	DIN V VDE V0884-11 (VDE V 0884-11):2017-01[2]
Single Protection, 5000Vrms Isolation voltage	1000V_{RMS} basic insulation working voltage	Basic Insulation 1414Vpeak, V_{IOSM}=6250Vpeak
File (pending)	File (pending)	File (pending)

[1] In accordance with UL 1577, each NSI1200 is proof tested by applying an insulation test voltage ≥ 6000 V rms for 1 sec.

[2] In accordance with DIN V VDE V 0884-10, each NSI1200 is proof tested by applying an insulation test voltage ≥ 2652V peak for 1 sec (partial discharge detection limit = 5 pC). The * marking branded on the component designates DIN V VDE V 0884-11 approval.

5.0 FUNCTION DESCRIPTION

5.1. OVERVIEW

The NSI1200 is a fully-differential, precision, isolated amplifier. The input stage of the device consists of a fully-differential amplifier that drives a second-order, sigma-delta (ΣΔ) modulator. The modulator uses the internal voltage reference and clock generator to convert the analog input signal to a digital bitstream. The drivers (called TX in the Functional Block Diagram) transfer the output of the modulator across the isolation barrier that separates the side1 and side2 voltage domains. The received bitstream and clock are synchronized and processed, as shown in the Functional Block Diagram, by a fourth-order analog filter on the side2 and presented as a differential output of the device.

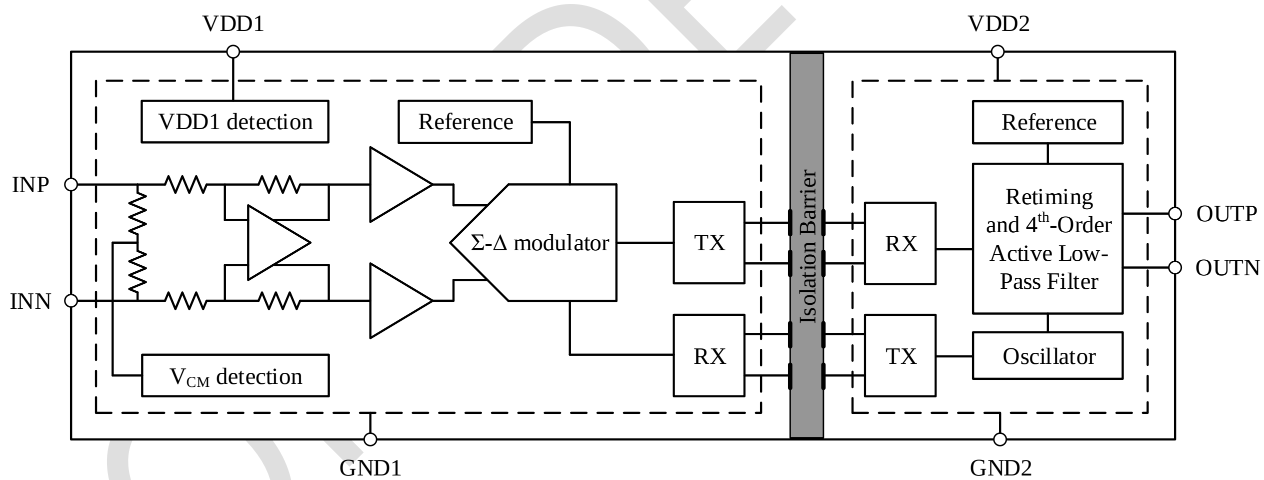


Figure 5.1 Function Block Diagram

5.2. ANALOG INPUT

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

- If the input voltage exceeds the range GND1 – 6 V to VDD1 + 0.5 V, 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.

5.3. ANALOG OUTPUT

For linear input range, the analog output of NSI1200 has a fixed gain of 8. If a full-scale input signal is applied to the NSI1200 ($V_{IN} \geq V_{Clipping}$), the analog output will be clipped.

In addition, NSI1200 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 ($V_{CM} > V_{CMov}$).

6.0 APPLICATION NOTE

6.1. APPLICATION CIRCUIT

NSI1200 is ideally suited to shunt resistor-based current sensing in high voltage applications such as frequency inverters. The typical application circuit is shown in Figure 6.1.

The voltage across the shunt resistor R_{sense} is applied to the differential input of NSI1200 through a RC filter. The differential output of the isolated amplifier is converted to a single-ended analog output with an operational-amplifier-based circuit. An analog-to-digital converter usually receives the analog output and converts to digital signal for controller processing.

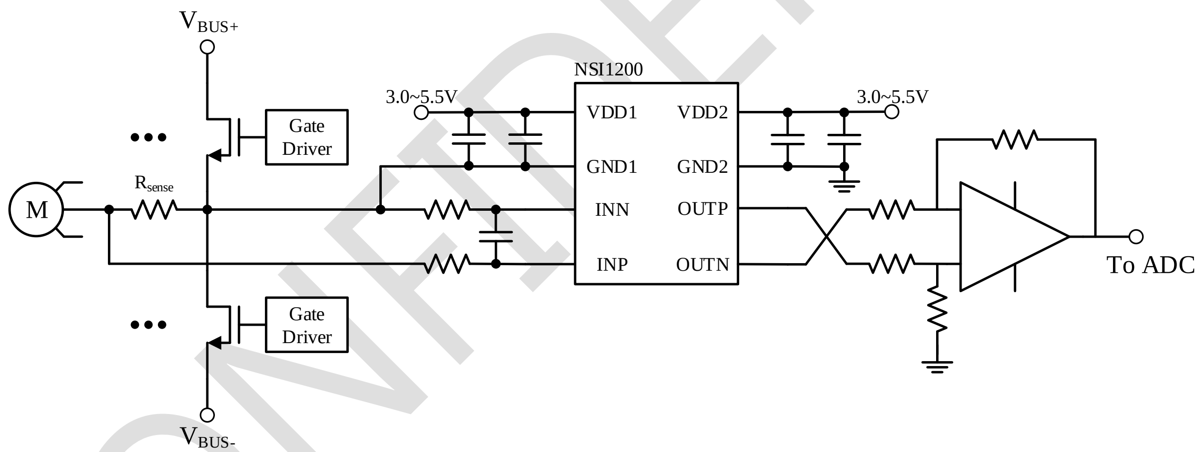


Figure 6.1 Typical application circuit in phase current sensing

6.2. 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: $V_{SHUNT} \leq V_{Clipping}$.

6.3. PCB LAYOUT CONSIDERATIONS

- NSI1200 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 NSI1200. 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 NSI1200. This minimizes the loop area of the connection and reduces the possibility of stray magnetic fields from interfering with the measured signal.

7.0 PIN DESCRIPTION

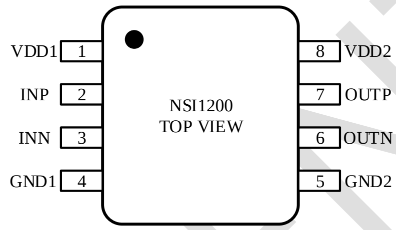
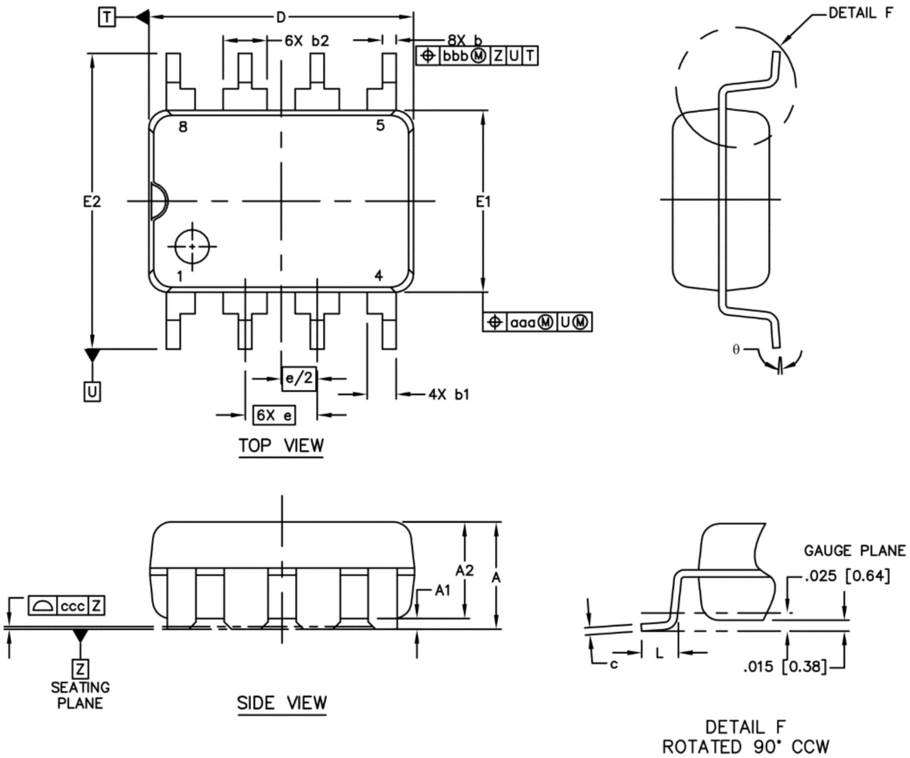


Table7.1 NSI1200 Pin Configuration and Description

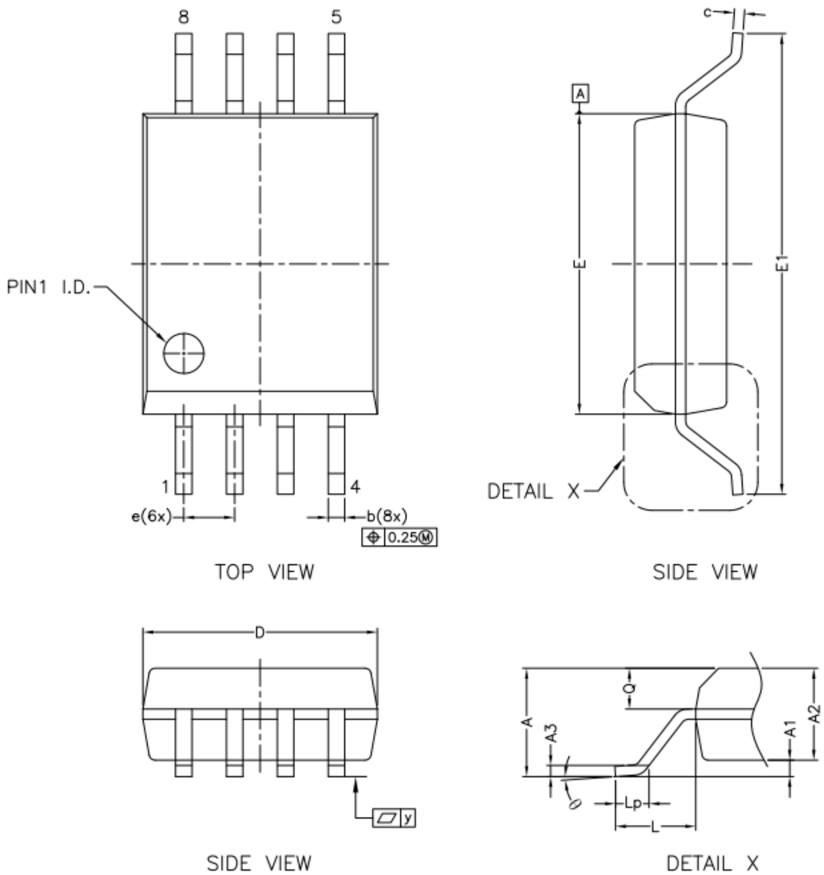
NSI1200 PIN NO.	***SYMBOL***	***FUNCTION***
1	VDD1	Power supply for isolator side 1(3.0V to 5.5V)
2	INP	Positive analog input (±250mV recommended for NSI1200)
3	INN	Negative analog input
4	GND1	Ground 1, the ground reference for Isolator Side 1
5	GND2	Ground 2, the ground reference for Isolator Side 2
6	OUTN	Negative output
7	OUTP	Positive output
8	VDD2	Power supply for isolator side 2 (3.0V to 5.5V)

8.0 PACKAGE INFORMATION



	SYMBOL	MIN	NOM	MAX	MIN	NOM	MAX
TOTAL THICKNESS	A	---	---	.191	---	---	4.85
STAND OFF	A1	.015	---	---	0.38	---	---
MOLD THICKNESS	A2	.126	---	.142	3.20	---	3.61
LEAD WIDTH	b	.014	---	.022	0.36	---	0.56
	b1	---	0.039 REF	---	---	0.99 REF	---
	b2	---	0.06 REF	---	---	1.524 REF	--
L/F THICKNESS	c	.008	---	.014	0.20	---	0.36
BODY SIZE	D	.365	---	.369	9.27	---	9.37
	E1	.244	---	.260	6.20	---	6.60
	E2	.398	---	.421	10.11	---	10.69
LEAD PITCH	e	.100 BSC			2.54 BSC		
LEAD LENGTH	L	.0453	---	.0571	1.15	---	1.45
	θ	0°	---	8°	0°	---	8°
LEAD OFFSET	aaa	.010			0.254		

Figure 8.1 DUB8 package shape and dimension in millimeters



* 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 8.2 SOW8 package shape and dimension in millimeters

9.0 ORDER INFORMATION

Part No.	Isolation Rating(kV)	Linear Input Range(mV)	Input Type	Output Type	Temperature	Automotive	Package Type	Package Drawing
NSI1200-DDBR	5	-250~250	Differential	Differential	-40 to 125°C	NO	DUB8	DUB8
NSI1200-DSWVR	5	-250~250	Differential	Differential	-40 to 125°C	NO	SOP8(300mil)	SOW8

10.0 REVISION HISTORY

Revision	Description	Date
0.1	Original	2020/2/4