



Automotive NA1150

Audio Switching Driver with Load Diagnostics

FEATURES

- Monaural BTL Output
- PWM input Single-ended/Differential
- Supply Voltage: $V^+ = 2.6\text{ V to } 5.5\text{ V}$
- Operating Temperature Range: $-40^\circ\text{C to } 125^\circ\text{C}$
- Quiescent Current: $2.0\text{ mA typ. (No input signal)}$
- Output Power
 $P_o = 1.5\text{ W typ. (@} V^+ = 5\text{ V, } R_L = 8\Omega, \text{ THD+N} = 10\%)$
- Load Diagnostics Function
- Over Temperature Detecting Function
- Over Current Detecting Function
- UVLO
- CMOS Process
- Package Outline DFN2323-8-GS / VSP-8-AF
- AEC-Q100 grade 1

GENERAL DESCRIPTION

The NA1150 is a CMOS process PWM input - mono BTL output audio Switching driver, ideal for use in microcontroller-based sound systems such as automotive instrument cluster, and infotainment applications. The device provides up to 1.5 W into 8Ω at less than 10% THD+N from a 5 Vdc supply.

The integrated load diagnostic function notifies the MCU of any speaker connection anomalies through an open-drain output port. Fewer external components with a smaller package provide a reliable, space-saving solution for voice speech and sound reproduction designs.

APPLICATIONS

- Instrument Cluster Systems
- Infotainment Audio
- ADAS

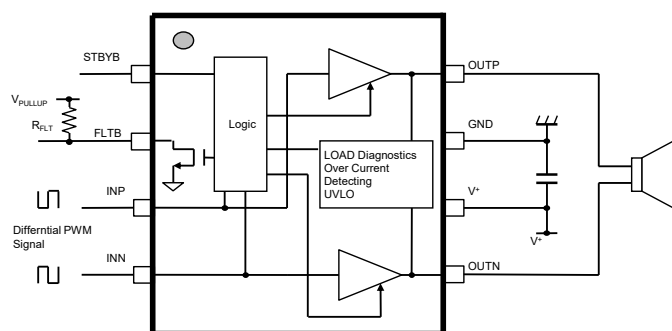
Under
Development



DFN2323-8-GS
 $2.3 \times 2.3 \times 0.427(\text{mm})$
Pitch: 0.5 mm



VSP-8-AF
 $4.0 \times 2.9 \times 1.1(\text{mm})$
Pitch: 0.65 mm



Application Circuits

NA1150 supports only BTL (differential) output format.
The input signal can be set to support both single-ended and differential input formats.

■ PRODUCT NAME INFORMATION

NA1150 aa c dd e

Description of configuration

Composition	Item	Description
aa	Package code	Indicates the package. GS: DFN2323-8-GS, AF: VSP-8-AF
c	Version	Fixed with A
dd	Packing	Taping direction. Refer to the packing specifications.
e	Grade	Indicates the quality grade.

Grade

e	Applications	Operating Temperature Range	Test Temperature
P	Chassis, Body control and In-vehicle	-40°C to 125°C	25°C, -40°C, 125°C

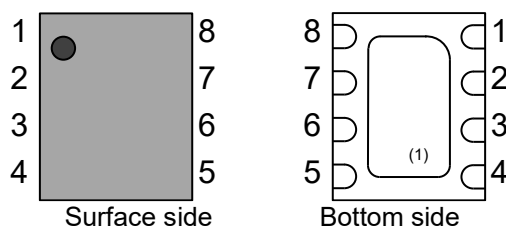
■ ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	PLATING COMPOSITION	WEIGHT (mg)	Quantity (pcs/reel)
NA1150GSAE4P	DFN2323-8-GS	✓	✓	Sn2Bi	7	3,000
NA1150AFAE2P	VSP-8-AF	✓	✓	Sn2Bi	21	2,000

The AF package of this product is only available in E2 format, and the GS package is only available in E4 format.
The VSP-8-AF package version is under development.

■ PIN DESCRIPTIONS

DFN2323-8-GS



NA1150 Pin Configuration

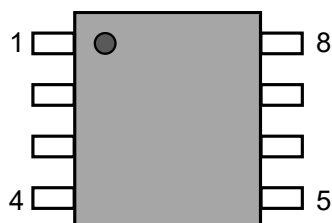
(1) Connect exposed pad to the GND. Exposed pad is electronically connected to the backside of the die, but cannot be function as GND.

Pin No.	Pin Name	I/O	Description
1	STBYB	I	Standby pin (Active low).
2	FLTb	O	Fault notification pin (Open drain active low).
3	INP	I	Positive input pin. Please refer to the Input signal waveform section for recommended input requirements.
4	INN	I	Negative input pin. Please refer to the Input signal waveform section for recommended input requirements.
5	OUTN	O	Negative output pin. For details on the output signal, please refer to the output signal waveform section.
6	V ⁺	Power	Power Supply Input Pin.
7	GND	-	Ground Pin.
8	OUTP	O	Positive output pin. For details on the output signal, please refer to the output signal waveform section.

Please refer to "[TYPICAL APPLICATION CIRCUIT](#)" or "[OPERATING MODE](#)" or "[INPUT/OUTPUT SIGNALS](#)" for details.

■ PIN DESCRIPTIONS

VSP-8-AF



NA1150 Pin Configuration

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6	V ⁺	Power	Power Supply Input Pin.
7	GND	-	Ground Pin.
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Please refer to "[TYPICAL APPLICATION CIRCUIT](#)" or "[OPERATING MODE](#)" or "[INPUT/OUTPUT SIGNALS](#)" for details.

The VSP-8-AF package version is under development.

■ ABSOLUTE MAXIMUM RATINGS

	Symbol	Ratings	Unit
Supply Voltage	V ⁺	7	V
Input Voltage	V _{IN}	-0.3 to 5.5 or V ⁺ (1)	V
Load Resistance(Ta=25°C)	R _L	≥ 3.2	Ω
Storage Temperature Range	T _{stg}	-40 to 150	°C
Junction Temperature Range(2)	T _j	150	°C

(1) For supply voltage less than 5.5V, the absolute maximum input voltage is equal to supply voltage.

This specification applies to INP, INN, STBYB, FLTB pins.

(2) Calculate the power consumption of the IC from the operating conditions and calculate the junction temperature with the thermal resistance.

Please refer to "[Thermal characteristics](#)" for the thermal resistance under our measurement board conditions.

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

■ THERMAL CHARACTERISTICS

Package	Parameter	Measurement Result	Unit
DFN2323-8-GS	Thermal Resistance (θ _{ja})	2-Layer ⁽¹⁾ / 4-Layer ⁽²⁾ 223 / 78	°C/W
	Thermal Characterization Parameter (ψ _{jt})	2-Layer ⁽¹⁾ / 4-Layer ⁽²⁾ 23 / 15	
VSP-8-AF (Under Development)	Thermal Resistance (θ _{ja})	2-Layer ⁽³⁾ / 4-Layer ⁽⁴⁾ 228 / 170	°C/W
	Thermal Characterization Parameter (ψ _{jt})	2-Layer ⁽³⁾ / 4-Layer ⁽⁴⁾ 46 / 38	

θ_{ja} : Junction-to-Ambient Thermal Resistance

ψ_{jt} : Junction-to-Top Thermal Characterization Parameter

(1) 2-Layer: Mounted on glass epoxy board (101.5 mm × 114.5 mm × 1.6 mm: based on EIA/JEDEC standard, 2-layer FR-4) with exposed pad.

(2) 4-Layer: Mounted on glass epoxy board (101.5 mm × 114.5 mm × 1.6 mm: based on EIA/JEDEC standard, 4-layer FR-4) with exposed pad.

(For 4-layer: Applying 99.5 mm × 99.5 mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5.)

(3) Mounted on glass epoxy board (76.2mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 2-layer FR-4).

(4) Mounted on glass epoxy board (76.2mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 4-layer FR-4).

■ ELECTROSTATIC DISCHARGE RATINGS

	Conditions	Protection Voltage
HBM	C = 100 pF, R = 1.5 kΩ	±2000 V
CDM		±1000 V

ELECTROSTATIC DISCHARGE RATINGS

The electrostatic discharge test is done based on JEDEC JS-001, JS-002.

■ RECOMMENDED OPERATING CONDITIONS

	Symbol	Ratings	Unit
Supply Voltage	V ⁺	2.6 to 5.5	V
Operating Temperature Range	T _a	-40 to 125	°C

RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

■ ELECTRICAL CHARACTERISTICS

$V^+ = 5.0V$, $V_{PULLUP} = 5.0V$ unless otherwise specified.

For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of $-40\text{ }^{\circ}\text{C} \leq T_a \leq 125\text{ }^{\circ}\text{C}$ is described.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
DC CHARACTERISTICS						
Standby Current	I _{ST}	Ta=25°C	-	-	1	μA
			-	-	5	
Quiescent Current	I _Q	INP=INN=0V, R _L =Open, Ta=25°C	-	2	2.5	mA
		INP=INN=0V, R _L =Open	-	2	3.0	
On Resistance	R _{ON}	V _{DS} =10mV, Ta=25°C	-	0.5	-	Ω
		V _{DS} =10mV	-	0.5	-	
High Level Input Voltage ⁽¹⁾	V _{IH}	High Level, Ta=25°C	2.0	-	V ⁺	V
		High Level	2.0	-	V ⁺	
Low Level Input Voltage ⁽¹⁾	V _{IL}	Low Level, Ta=25°C	-0.3	-	0.8	V
		Low Level	-0.3	-	0.8	
FLTB High Level Output Voltage	V _{OHFLT}	R _{FLT} =47 kΩ, Ta=25°C	V _{PULLUP} -0.2	-	-	V
		R _{FLT} =47 kΩ	V _{PULLUP} -0.2	-	-	
FLTB Low Level Output Voltage	V _{OLFLT}	R _{FLT} =47 kΩ, Ta=25°C	-	-	0.5	V
		R _{FLT} =47 kΩ	-	-	0.5	
Pull Down Resistance	R _{DWN}	STBYB pin, Ta=25°C	-	300	-	kΩ
Input Pull Down Resistance	R _{IN}	INP, INN pin, Ta=25°C	-	1000	-	kΩ
TRANSIENT CHARACTERISTICS (R _L = 8Ω, f _{PWM} = 100kHz unless otherwise specified.)						
Turn On Time 0	T _{ON0}	Normal mode, Ta=25°C	2.5	5	10	ms
		Normal mode	2.5	5	10	
Turn On Time 1	T _{ON1}	Load diagnostics mode, Ta=25°C	-	225	-	ms
		Load diagnostics mode	-	225	-	
AC CHARACTERISTICS (f=1kHz, R _L = 8Ω+33μH, f _{PWM} = 100kHz, BW=20Hz to 20kHz, unless otherwise specified.)						
Output Power	P _o	THD+N = 10%, Ta=25°C	-	1.5	-	W
		THD+N = 10%	-	1.5	-	
Efficiency	η	THD+N = 10%, Ta=25°C	-	85	-	%
		THD+N = 10%	-	85	-	

⁽¹⁾STBYB pin, INP pin and INN pin

All electrical characteristic parameters that specify the minimum and maximum specifications are tested.

■ ELECTRICAL CHARACTERISTICS (continued)

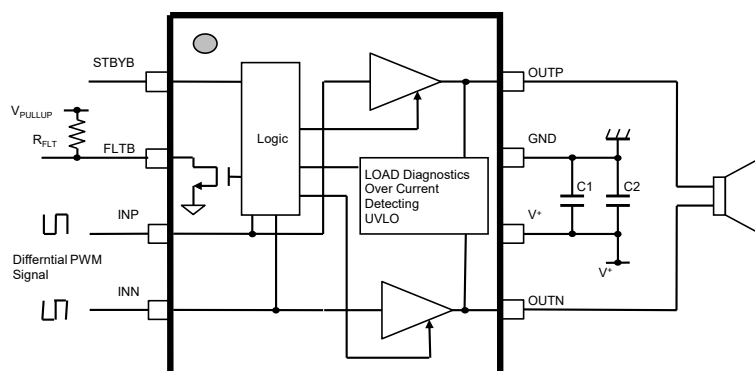
$V^+ = 5.0V$, $V_{PULLUP} = 5.0V$ unless otherwise specified.

For parameter that do not describe the temperature condition, the MIN / MAX value under the condition of $-40^\circ C \leq T_a \leq 125^\circ C$ is described.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Detection circuit characteristics (R_L = Open unless otherwise specified.)						
UVLO Detect Voltage	V_{UVLO}	Ta=25°C	1.85	-	2.55	V
			1.85	-	2.55	
UVLO Release Voltage	V_{UVLOR}	Ta=25°C	1.90	-	2.59	V
			1.90	-	2.59	
Over Temperature detect level	T_{OT}		-	180	-	°C
Over Temperature Release level	T_{OTR}		-	155	-	°C
Over Current Detect Current	I_{OC}	Ta=25°C	-	2.2	-	A
			-	2.2	-	
Open Load Detection Threshold	R_{LO}	Including speaker wires, Ta=25°C	100	-	300	Ω
		Including speaker wires	100	-	300	
Short Load Detection Threshold	R_{LSH}	Including speaker wires, Ta=25°C	-	-	2.5	Ω
		Including speaker wires, Ta= 125°C	-	-	2.5	
		Including speaker wires, Ta= -40°C	-	-	2.5	
Short to V ⁺ Detection Threshold	R_{SH}	Including speaker wires, Ta=25°C	200	-	800	Ω
		Including speaker wires	200	-	800	
Short to GND Detection Threshold	R_{SL}	Including speaker wires, Ta=25°C	200	-	800	Ω
		Including speaker wires	200	-	800	

All electrical characteristic parameters that specify the minimum and maximum specifications are tested.

■ TYPICAL APPLICATION CIRCUIT



NA1150 Typical Application Circuit

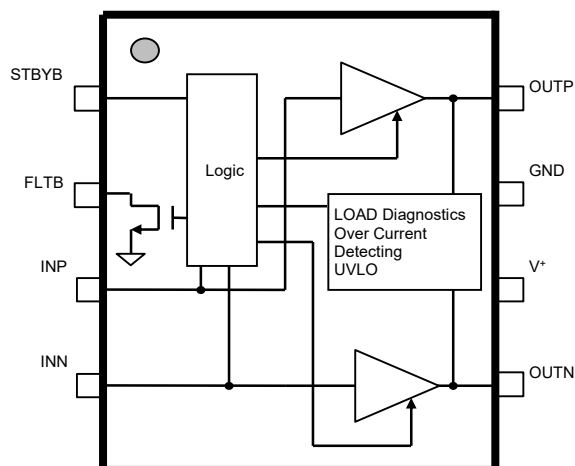
The voltage value of V_{PULLUP} be equal to V^+ or Set according to the absolute maximum rating of the input voltage.

Notes on External Components

Table 1 Component list

SYMBOL	VALUE	NOTE
C1	0.1 μ F	The power supply decoupling capacitor. This capacitor is intended to lower and stabilize the impedance of the power supply line in the high frequency band caused by class D switching. The recommended characteristics for this capacitor are a ceramic capacitor with temperature characteristics of X7R, DC bias characteristics of less than -1% (at 5V), and a self-resonant frequency of 2MHz or more.
C2	10 μ F	The power supply decoupling capacitor. This capacitor is primarily intended to lower and stabilize the impedance of the power supply line in the low frequency band of the audio signal. Use a capacitor with temperature characteristics of X7R, DC bias characteristics of less than -1% (at 5V), and ESR of 100m Ω or less.
R _{FLT}	47k Ω	The pull-up resistor for the open-drain output pin. The recommended value is 47k Ω , with a maximum upper limit of 750k Ω . Select a resistance value that allows for margin for variations and temperature characteristics and perform an evaluation on the actual device before use.

■ BLOCK DIAGRAM



NA1150 Block Diagram

INP to OUTP and INN to OUTN are output in phase.

■ DETAILED DESCRIPTION

The NA1150 is a PWM input PWM output speaker driver that drives a dynamic speaker by inputting a differential PWM signal from a microcontroller.

Figure 1 shows a typical application using the NA1150. The input pins of the NA1150 are directly connected to the GPIO of the MCU, and a PWM signal is input to drive the speaker. The NA1150 also has a load diagnostic circuit that executes a diagnostic sequence when the IC starts operation to detect output short to GND, short to V⁺, open load, or shorted load.

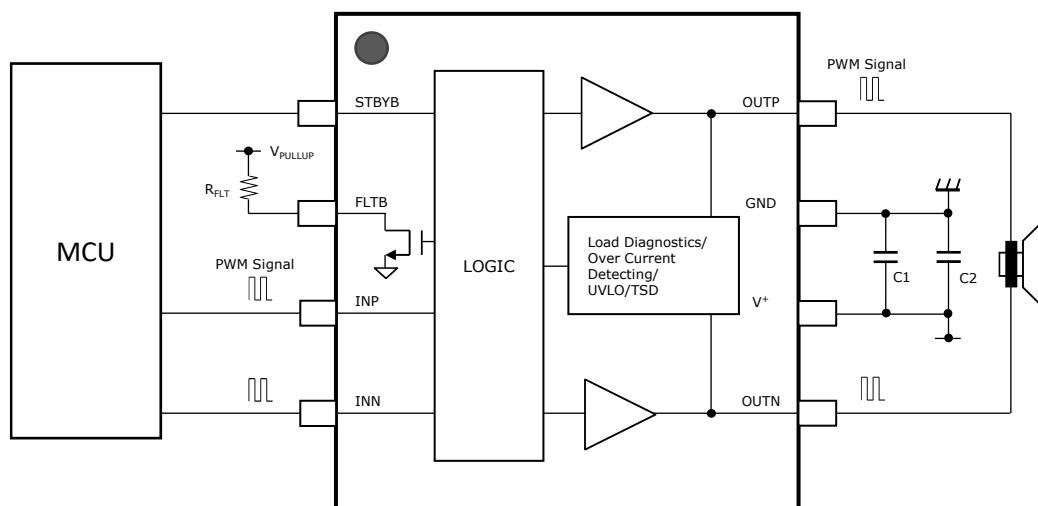


Figure 1 Application Circuit

● OPERATING MODE

The NA1150 has the following four operating modes.

Standby mode

Asserting the active-low STBYB pin completely shuts down the device into a low power standby mode.

Active mode

Negating the active LOW STBYB pin, the NA1150 is in active mode and outputs a signal voltage according to the input signal. Depending on the voltage state of the input pin, it is possible to shift to load diagnosis mode before entering active mode. For details, please refer to "STARTUP SEQUENCE AND INPUT MODE" section.

Load Diagnostics sequence

The NA1150 can be operated in the load diagnostic sequence mode immediately after transitioning from standby mode to active mode. If no failure is detected in the load diagnosis result, it shifts to active mode. For details, please refer to "STARTUP SEQUENCE AND INPUT MODE" section.

Fault modes

Detecting Short, Short to V⁺ or GND and OPEN in Load Diagnostics sequence

In case NA1150 detects a shorted load in the load diagnosis mode, it sets the FLTB pin to low level and repeats load diagnosis sequence until the cause of the fault is removed. If OPEN of the output pin is detected, the FLTB is set to low level, and it shifts to the active mode.

In case the Output pin is short to V⁺, or a short to the GND, the NA1150 stops operating; to operate the NA1150, remove the cause of the short and set the STBY pin to a "L" level once and then to a "H" level.

Over Temperature Detect

The NA1150 shuts down the output when the die junction temperature reaches the over temperature detecting threshold. Then the device asserts the FALT pin.

Recovery is automatic when the temperature returns to Over Temperature release level.

UVLO

The power supply voltage falls below the UVLO Detect Voltage, the IC goes into Fault mode and sets the FLTB pin to L level. Then the power supply voltage exceeds the UVLO release voltage, the IC transitions to Active Mode via Load diagnostic Mode and sets the FLTB terminal to H level.

For details, see the "Detecting Functions" section.

Over Current Detect

In Active Mode, when the output current exceeds the Over Current Detect Current, the IC enters the Fault mode, stops output, and sets the FLTB pin to L level. After about 5msec, the NA1150 will start working again.

Fault mode with FLTB pin.

During the fault mode, the FLTB pin (open drain active low) is asserted and outputs an L level voltage.

If the cause of the Fault is UV or Over Temp, the FLTB pin becomes high impedance and outputs a high level, and the NA1150 becomes Active mode if the cause is removed.

Otherwise, the FLTB pin is latched low. Once the cause of the Fault has been removed, the NA1150 can be set to Standby mode to release the latched state.

Table 2: Faults and Actions with operating mode.

Operating Mode		STBYB	FLTB	INP	INN	OUTP	OUTN	Clearing to Active Condition	Clearing FLTB=L to H
Standby		L	H	*	*	Hi-Z	Hi-Z	STBYB=H	-
Active		H	H	L/H	L/H	L/H	L/H	-	-
Load diagnostic sequence		H	H or L	*	*	DC Bias	DC Bias	-	-
Fault modes	Speaker-Short	H	L	*	*	Hi-Z	Hi-Z	Self-Clearing by removing the cause of the fault	STBYB=L
	Output Short to V ⁺ or GND	H	L	*	*	Hi-Z	Hi-Z	Removing the cause of the fault and STBYB=L to H	STBYB=L
	Speaker-Open	H	L	L/H	L/H	L/H	L/H	-	STBYB=L
	Over Current	H	L	*	*	Hi-Z	Hi-Z	Self-Clearing by removing the cause of the fault	STBYB=L
	UVLO	H	L	*	*	Hi-Z	Hi-Z	Self-Clearing	Self-Clearing
	Over Temp	H	L	*	*	Hi-Z	Hi-Z	Self-Clearing	Self-Clearing

*:Don't Care

● STARTUP SEQUENCE AND INPUT MODE

The device can be used in three different startup sequence and input modes selected by the input check. In the input check, these operating modes are selected by the voltages of INP and INN during the 5ms input check after the STBYB turns High.

Table 3 Startup sequence and input mode

Startup sequence	Applied voltage during input check period.		note
	INP	INN	
Normal	L	L	Start up without Load diagnostics and differential PWM signal input.
Load diagnostic	H or PWM	H or PWM	Start up with Load diagnostics and differential PWM signal input.
Single-ended input mode	H or PWM	L	Start up with Load diagnostics and single-ended PWM signal input.

• Normal mode

In this mode, the device turns on without load diagnostics. And inputs differential PWM signal.

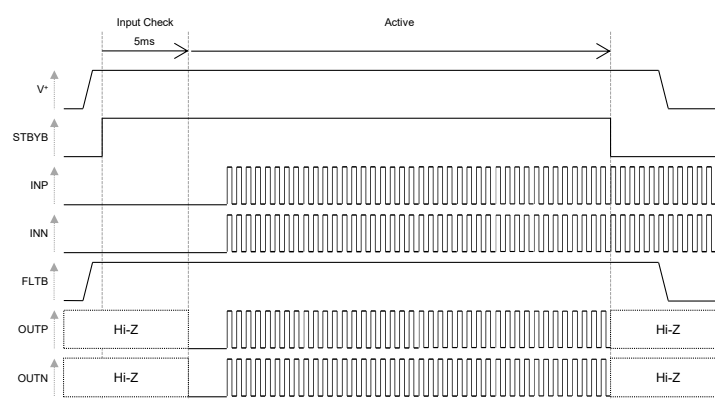


Figure 2 Normal mode

• Load diagnostics startup mode

In this mode, the device turns on with Load diagnostics. And inputs differential PWM signal.

In load diagnostics, the device diagnoses the status of the OUTP and OUTN pins. Details of load diagnostics can be viewed in the "Load Diagnostics Function" section.

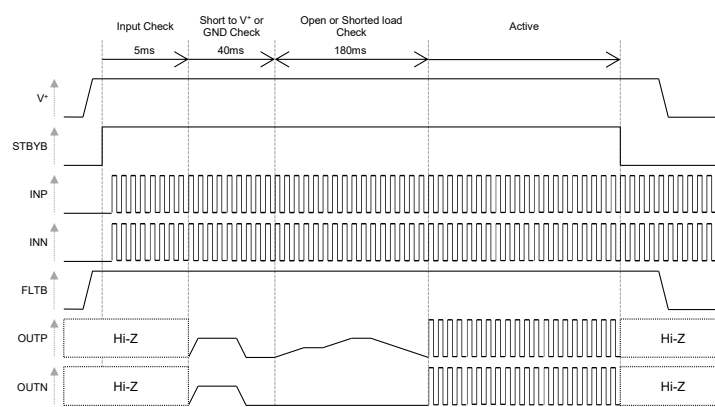


Figure 3 Load diagnostics mode

• Single-ended PWM mode

In this mode, the device turns on with Load diagnostics. And inputs single-ended PWM signal.

The speaker is driven by an inverted output PWM signal with $OUTP = INP$ and $OUTN = -INP$.

Single-ended PWM mode is not recommended for new consideration because it is inferior to differential PWM (see "Input/Output signals" section).

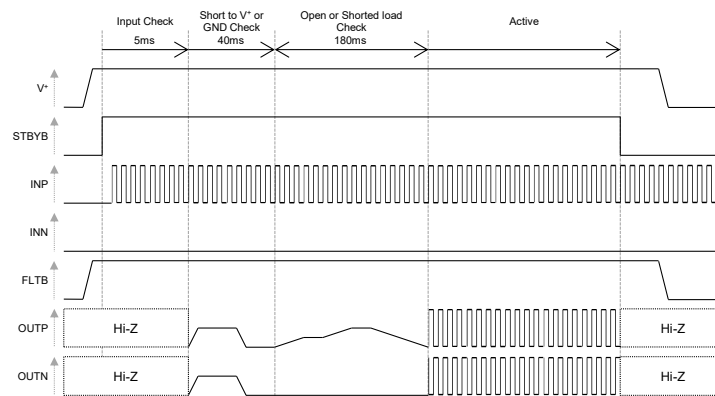


Figure 4 Single-ended PWM mode

The Full Data Sheet

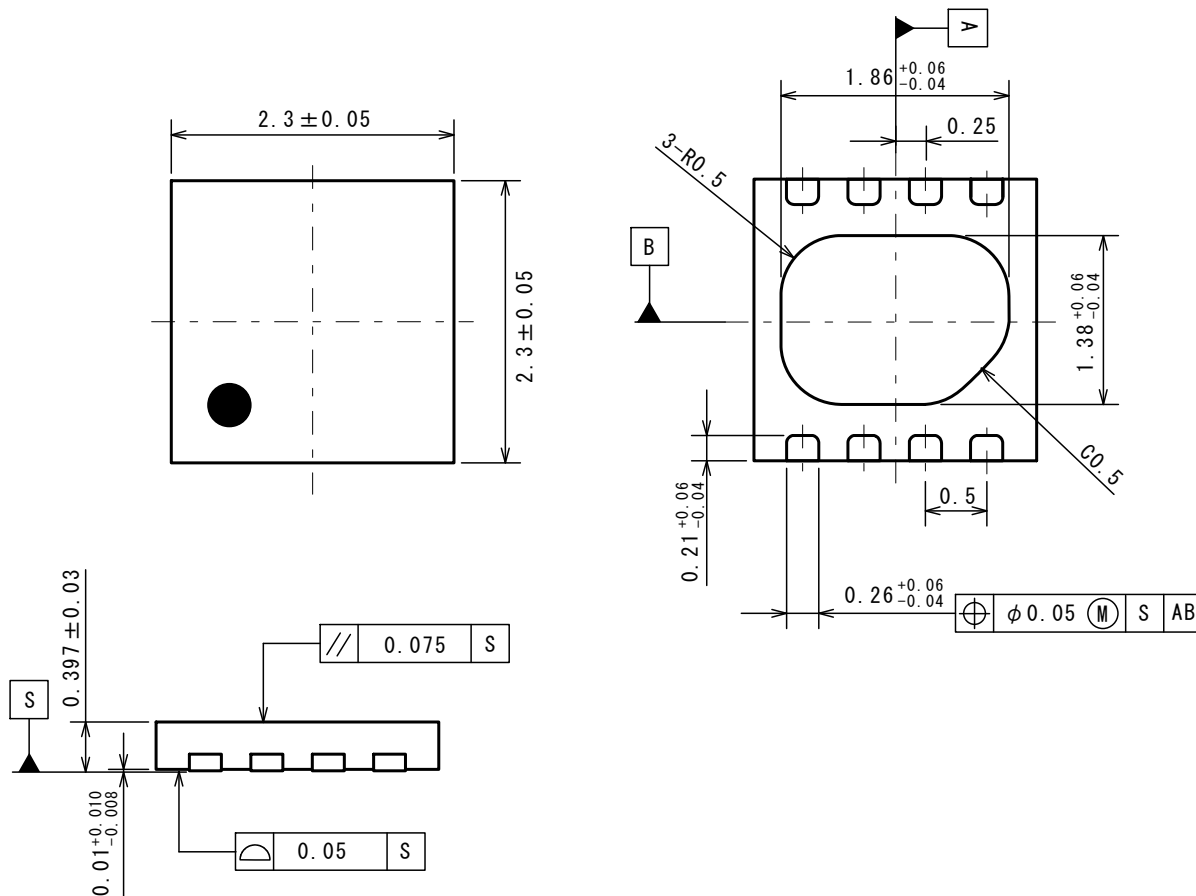
This datasheet is a short version. Please refer to the latest full datasheet for your design.
The full datasheet can be downloaded from the description section of the [NA1150 Web page](#) or contact your nearest distributor.

■ REVISION HISTORY

Date	Revision	Contents of Changes
August 1, 2024	Ver. 1.0	Initial release
October 1, 2024	Ver. 1.1	Add Min & Max value to Output Pulse Propagation Delay Time in Table.7. Correct the output power value in GENERAL DESCRIPTION. Add "V _{PULLUP} =5.0V" to ELECTRICAL CHARACTERISTICS (continued).
January 6, 2025	Ver. 1.2	Correct the item name in "FEATURES". Change the package height 0.397mm(typ) to 0.427mm(max) at DFN2323-8-GS in "GENERAL DESCRIPTION". Change minimum value of FLT B High Level Output Voltage from V ⁺ -0.2V to V _{PULLUP} -0.2V.

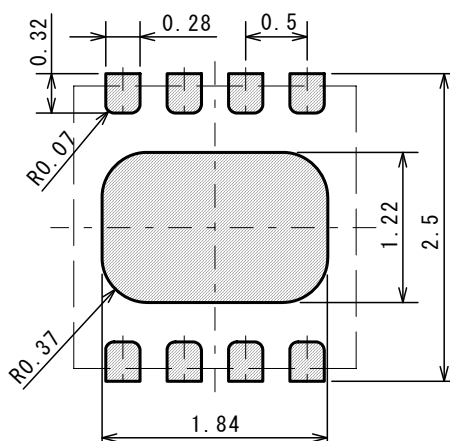
■ PACKAGE DIMENSIONS

UNIT: mm



■ EXAMPLE OF SOLDER PADS DIMENSIONS

UNIT: mm



Nisshinbo Micro Devices Inc.

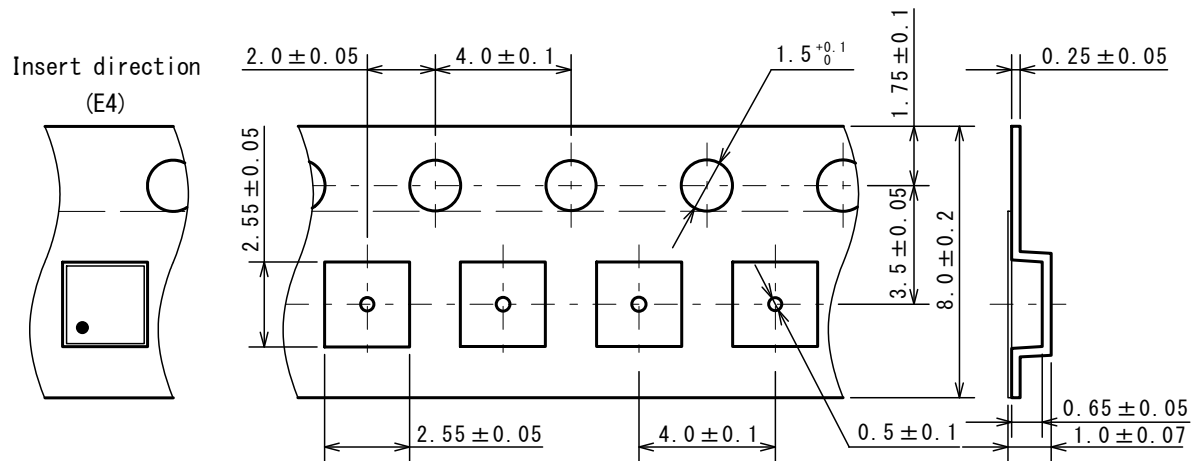
DFN2323-8-GS

PI-DFN2323-8-GS-E-A

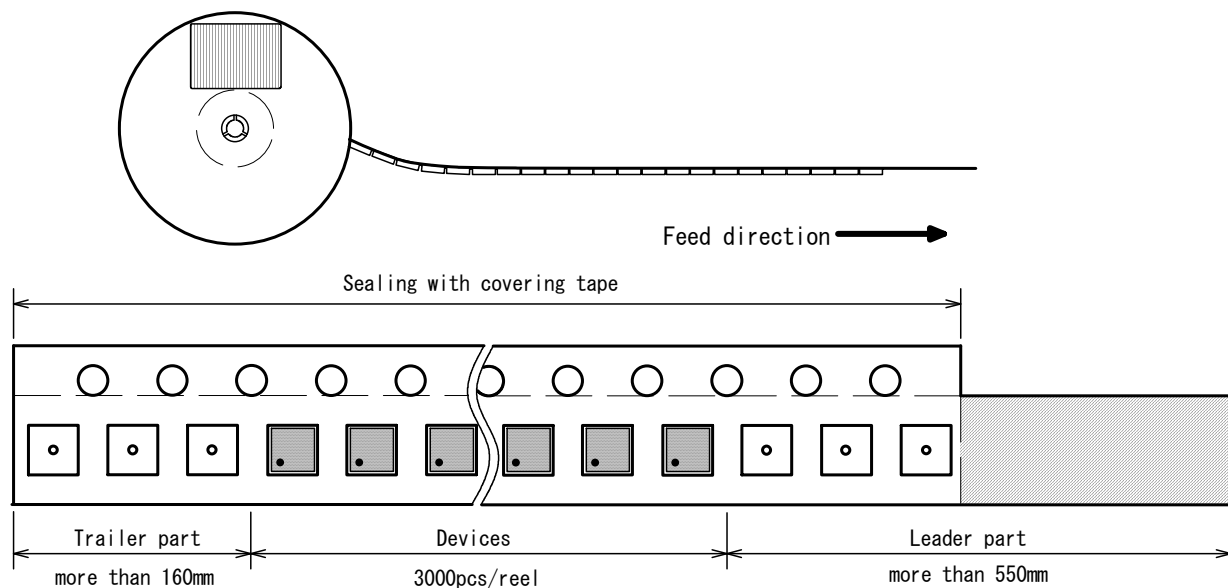
■ PACKING SPEC

UNIT: mm

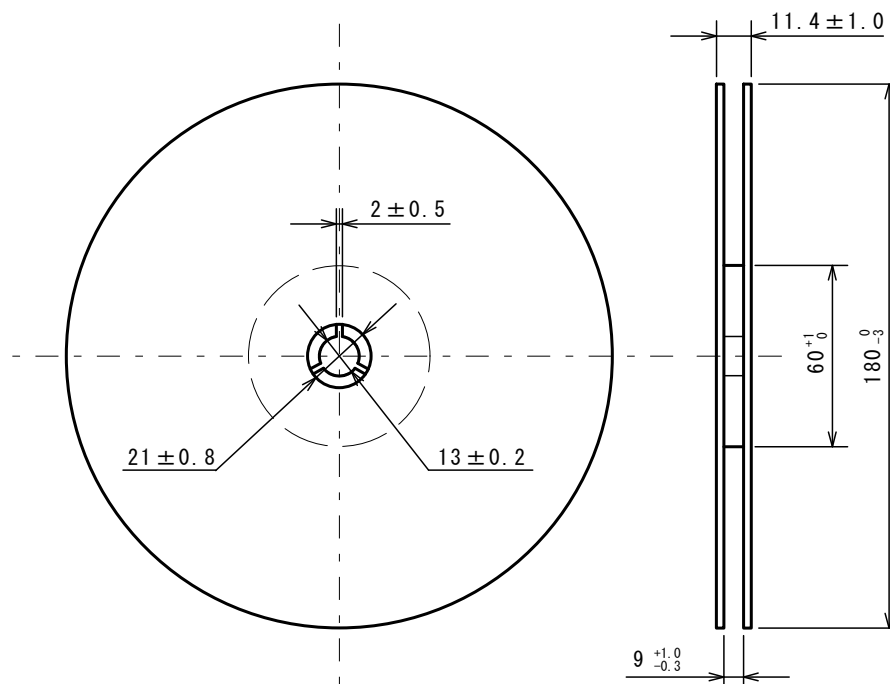
(1) Taping dimensions / Insert direction



(2) Taping state



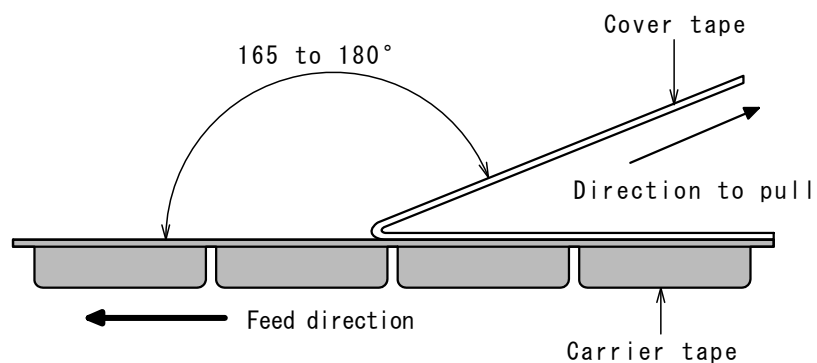
(3) Reel dimensions



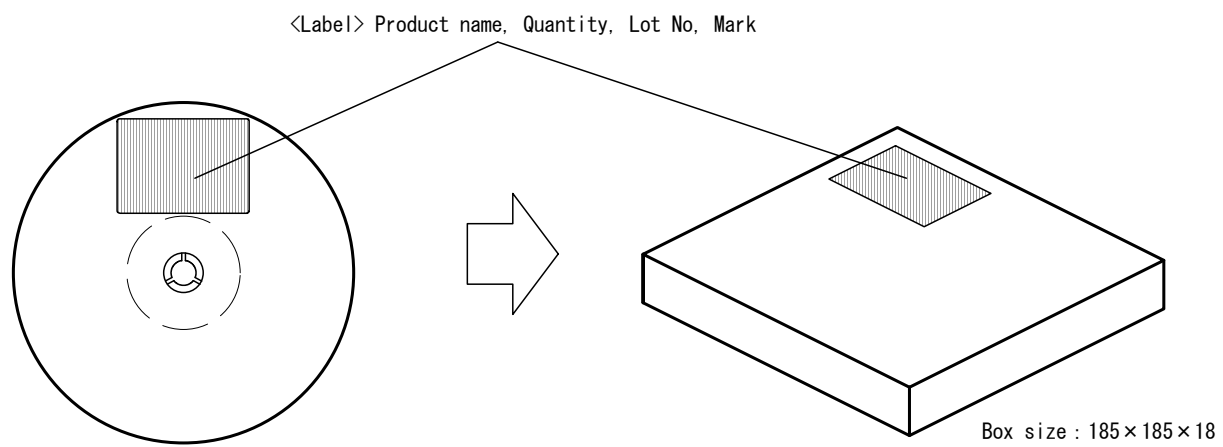
(4) Peeling strength

Peeling strength of cover tape

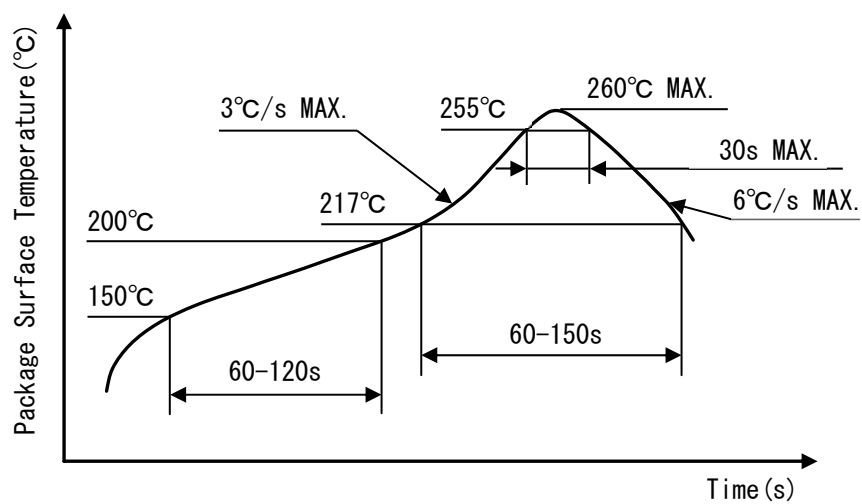
- Peeling angle: 165 to 180° degrees to the taped surface.
- Peeling speed: 300mm/min
- Peeling strength: 0.1 to 1.0N



(5) Packing state



■ HEAT-RESISTANCE PROFILES



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 - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
 - Life Maintenance Medical Equipment
 - Fire Alarms / Intruder Detectors
 - Vehicle Control Equipment (airplane, railroad, ship, etc.)
 - Various Safety Devices
 - Traffic control system
 - Combustion equipment

In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.

6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. **Quality Warranty**
 - 8-1. **Quality Warranty Period**
In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
 - 8-2. **Quality Warranty Remedies**
When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.
Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
 - 8-3. **Remedies after Quality Warranty Period**
With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.



Nisshinbo Micro Devices Inc.

Official website

<https://www.nisshinbo-microdevices.co.jp/en/>

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