AiP6133
2 CH DC Motor H Bridge Driver

Product Specification

Specification Revision History：

Version	Date	Description
2023-08-T1	2023-08	New
2024-01-A1	2024-01	Modify the content
2024-04-A2	2024-04	Modify the content

Contents

1、General Description

The AiP6133 is a dual H-bridge motor driver with current control. The device has two H-bridges and can drive two DC brushed motors, a bipolar stepper motor, solenoids, or other inductive loads. Each H-bridge output consists of N-channel MOSFETs, with circuitry that regulates or limits the winding current. The device provides an integrated dual-bridge motor driver solution for toys, printers, and other mechatronic applications.

Features:

- dual H-bridge motor driver with current control
- low on resistance: HS+ LS 420mΩ
- output current (@VM=5V, 25℃) per H-bridge: I_{RMS}=1.5A, I_{PP}=2A (ETSSOP/QFN package)
- two H-bridges can be connected in parallel
- wide power supply voltage range: 2.7V～10.8V
- PWM winding current regulation/current limitation
- protection features: overcurrent protection (OCP), short circuit protection (SCP), under-voltage lockout (UVLO), over-temperature protection (OTP)
- provide fault output pin
- provide low-power sleep mode
- packaging information: ETSSOP16/TSSOP16/QFN16(4*4)

Ordering Information:

Tube packing specifications:

Part number	Packaging form	Marking code	Tube quantity	Boxed tube quantity	Boxed quantity	Notes
AiP6133TE16.TB	ETSSOP16	AiP6133	96 PCS/tube	200 tube/box	19200 PCS/box	Dimensions of plastic enclosure: 5.0mm×4.4mm Pin spacing: 0.65mm
AiP6133TA16.TB	TSSOP16	AiP6133	96 PCS/tube	200 tube/box	19200 PCS/box	Dimensions of plastic enclosure: 5.0mm×4.4mm Pin spacing: 0.65mm
AiP6133QB16.TB	QFN16	AiP6133	490 PCS/plate	10 tube/box	4900 PCS/box	Dimensions of plastic enclosure: 4.0mm×4.0mm Pin spacing: 0.65mm

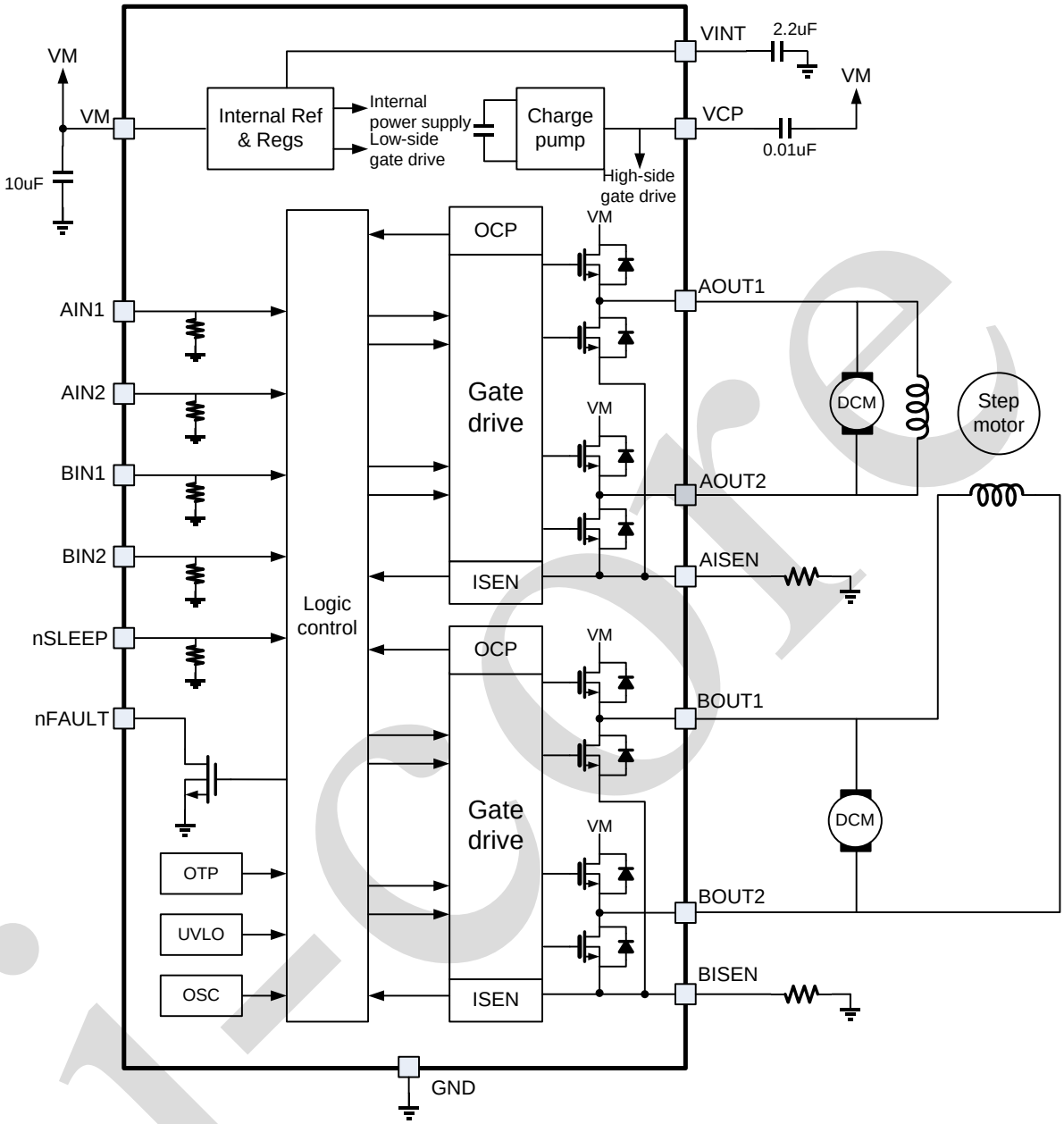
Reel packing specifications:

Part number	Packaging form	Marking code	Reel quantity	Boxed reel quantity	Notes
AiP6133TE16.TR	ETSSOP16	AiP6133	5000PCS/reel	10000PCS/box	Dimensions of plastic enclosure: 5.0mm×4.4mm Pin spacing: 0.65mm
AiP6133TA16.TR	TSSOP16	AiP6133	5000PCS/reel	10000PCS/box	Dimensions of plastic enclosure: 5.0mm×4.4mm Pin spacing: 0.65mm
AiP6133QB16.TR	QFN16	AiP6133	4000PCS/reel	8000PCS/box	Dimensions of plastic enclosure: 4.0mm×4.0mm Pin spacing: 0.65mm

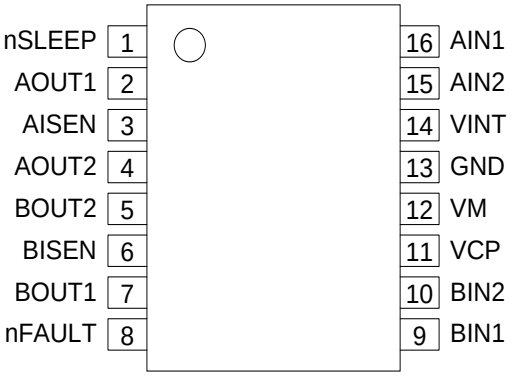
Note: If the physical information is inconsistent with the ordering information, please refer to the actual product.

2、Block Diagram And Pin Description

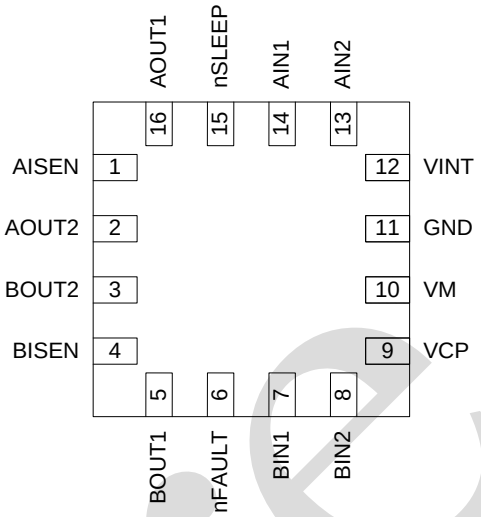
2.1、Block Diagram



2.2、Pin Configurations



ETSSOP16/TSSOP16



QFN16

2.3、Pin Description

Pin No.		Pin Name	IO	Description	External Components or Connections
ETSSOP/ TSSOP	QFN				
Power and Ground					
13	11	GND	-	ground	Both the GND pin and device PPAD must be connected to ground (QFN and ETSSOP: PowerPAD)
-	-	PPAD			
14	12	VINT	-	internal supply bypass	Bypass to GND with 2.2-μF, 6.3-V capacitor
12	10	VM	-	power supply	Motor supply, a 10-μF (minimum) ceramic bypass capacitor to GND is recommended
11	9	VCP	IO	High-side gate drive power supply	Connect a 0.01-μF, 16-V (minimum) X7R ceramic capacitor to VM
Control					
16	14	AIN1	I	bridge A input 1	Logic input controls state of AOUT1. Internal pull-down.
15	13	AIN2	I	bridge A input 2	Logic input controls state of AOUT2. Internal pull-down.
9	7	BIN1	I	bridge B input 1	Logic input controls state of BOUT1. Internal pull-down.
10	8	BIN2	I	bridge B input 2	Logic input controls state of BOUT2. Internal pull-down.
1	15	nSLEEP	I	sleep mode input	Logic high to enable device, logic low to enter low-power sleep mode and reset all internal logic. Internal pull-down.
Status					
8	6	nFAULT	OD	fault output	Logic low when in fault condition (over-temperature, over-current), open drain output, and external pull-up is required for use

Ouput					
3	1	AISEN	IO	bridge A ground /ISENSE	Connect to current sense resistor for bridge A, or GND if current control not needed.
6	4	BISEN	IO	bridge B ground /ISENSE	Connect to current sense resistor for bridge B, or GND if current control not needed.
2	16	AOUT1	O	bridge A output 1	Connect to motor winding A
4	2	AOUT2	O	bridge A output 2	
7	5	BOUT1	O	bridge B output 1	Connect to motor winding B
5	3	BOUT2	O	bridge B output 2	

Note: I =input; O=output; OD=open-drain output; IO=input/output

3、Electrical Parameter

3.1、Absolute Maximum Ratings

(T_{amb}=25℃, unless otherwise specified)

Characteristic	Symbol	Conditions	Value	Unit
power supply voltage	VM	-	-0.3 to 13	V
logic input voltage	V_{IN}	-	-0.5 to 5.5	V
xISEN pin voltage	V_{SENSE}	-	-0.3 to 0.5	V
maximum output current	I_{OUT}	-	±1.5	A
peak motor drive output current	I_{PEAK}	Internally limited	>2	A
operating temperature	T_{amb}	-	-40 to 85	℃
maximum junction temperature	T_J	-	150	℃
storage temperature	T_{stg}	-	-60 to 150	℃
soldering temperature	T_L	10s	260	℃

3.2、Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
power supply voltage	VM	2.7	-	10.8	V
logic input voltage	V_{IN}	-0.3	-	5.5	V
RMS output current per bridge	I_{OUT}	-	-	1.5	A

3.3、Thermal Characteristics

Characteristic	Symbol	Conditions	Value	Unit
junction-to-ambient thermal resistance	$R_{\theta JA}$	ETSSOP16	40.5	℃/W
		TSSOP16	103.1	℃/W
		QFN16	37.2	℃/W
junction-to-case (top) thermal resistance	$R_{\theta JC(top)}$	ETSSOP16	32.9	℃/W
		TSSOP16	38	℃/W
		QFN16	34.3	℃/W
junction-to-board thermal resistance	$R_{\theta JB}$	ETSSOP16	28.2	℃/W
		TSSOP16	48.1	℃/W
		QFN16	15.3	℃/W
junction-to-top characterization parameter	ψ_{JT}	ETSSOP16	0.6	℃/W
		TSSOP16	3	℃/W
		QFN16	0.3	℃/W
junction-to-board characterization parameter	ψ_{JB}	ETSSOP16	11.5	℃/W
		TSSOP16	47.5	℃/W
		QFN16	15.4	℃/W
junction-to-case (bottom) characterization parameter	$R_{\theta JC(bot)}$	ETSSOP16	4.8	℃/W
		TSSOP16	N/A	℃/W
		QFN16	3.5	℃/W

3.4、Electrical Characteristics

(T_{amb}=25℃, VM=5V, unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power Supply						
power supply voltage	V_M	-	2.7	-	10.8	V
logic input voltage	V_{IN}	-	-0.3	-	5.5	V
RMS output current per bridge	I_{OUT}	-	-	-	1.5	A
VM supply current	I_{VM}	VM=5V, xIN1=0V, xIN2=0V	-	1.6	2.5	mA
VM sleep mode supply current	I_{VMQ}	VM=5V	-	0.8	2	μA
VM under-voltage lockout voltage	V_{UVLO}	VM falling	-	2.5	2.6	V
VM under-voltage lockout hysteresis	V_{HYS}	-	-	90	-	mV
Logic Level Inputs						
input low voltage	V_{IL}	nSLEFP	-	-	0.5	V
		all other pins	-	-	0.7	
input high voltage	V_{IH}	nSLEFP	2.5	-	-	V
		all other pins	2	-	-	
input hysteresis	V_{HYS}	nSLEFP	-	0.4	-	V
		all other pins	-	0.4	-	
input pull-down resistance	R_{PD}	nSLEFP	-	540	-	kΩ
		all except nSLEEP	-	265	-	

input low current	I_{IL}	VIN=0	-	-	1	μA
input high current	I_{IH}	VIN=3.3V, nSLEFP	-	6.1	-	μA
		VIN=3.3V, all except nSLEEP	-	12.5	-	
input deglitch time	t_{DEG}	-	-	450	-	ns
nFAULT Output (Open-Drain Output)						
output low voltage	V_{OL}	IO=5mA	-	-	0.5	V
output high leakage current	I_{OH}	VO=3.3V	-	-	1	μA
H-Bridge Fets						
HS FET on resistance	R_{DS}（ON）	VM=5.0V, IO=500mA, TJ=25℃	-	240	-	mΩ
		VM=5.0V, IO=500mA, TJ=85℃	-	-	360	
		VM=2.7V, IO=500mA, TJ=25℃	-	310	—	
		VM=2.7V, IO=500mA, TJ=85℃	-	-	410	
LS FET on resistance	R_{DS}（ON）	VM=5.0V, IO=500mA, TJ=25℃	-	180	-	
		VM=5.0V, IO=500mA, TJ=85℃	-	-	300	
		VM=2.7V, IO=500mA, TJ=25℃	-	240	-	
		VM=2.7V, IO=500mA, TJ=85℃	-	-	340	
OFF-state leakage current	I_{OFF}	VM=5V, VOUT=0, TJ=25℃	-1	-	1	μA
Motor Drive						
current control PWM frequency	f_{PWM}	internal PWM frequency	-	50	-	kHz
rise time	t_R	VM=5V, 16Ω to GND, 10% to 90%VM	-	270	-	ns
fall time	t_F	VM=5V, 16Ω to GND, 10% to 90%VM	-	230	-	ns
propagation delay INx to OUTx	t_{PROP}	VM=5V	-	1	-	μs
dead time	t_{DEAD}	VM=5V	-	450	-	ns
Protection Circuits						
overcurrent protection trip level	I_{OCP}	-	-	2.4	-	A
OCP Deglitch time	t_{DEG}	-	4	-	-	μs
overcurrent protection period	t_{OCP}	-	-	1.35	-	ms
thermal shutdown temperature	t_{TSD}	Die temperature	-	180	-	℃
Current Control						
xISEN trip voltage	V_{TRIP}	-	160	200	240	mV
current sense blanking time	t_{BLANK}	-	-	3.75	-	μs
Sleep Mode						
startup time	t_{WAKE}	nSLEEP inactive high to H-bridge on	-	-	1	ms

4、Function Description

The AiP6133 is an integrated motor driver solution for brushed DC or bipolar stepper motors. It can be powered with a supply voltage from 2.7V to 10.8V and can provide an output current up to 1.5A RMS.

The device integrates two identical NMOS H-bridges, current regulation circuitry and various protection circuits, including under-voltage lockout (UVLO), overcurrent protection (OCP) and thermal shutdown (TSD). The fault condition is indicated by the nFAULT pin.

A simple PWM interface allows easy interfacing to the external controller circuit, and requires minimal resources.

At the same time, AiP6133 also provides a low-power sleep mode, in which the H-bridges are disabled, the gate drive charge pump is stopped, all internal logic is reset, and all internal clocks are stopped. All inputs are ignored until nSLEEP is brought logic high.

4.1、H-Bridge Control

The xIN1 and xIN2 input pins control the state of the xOUT1 and xOUT2 outputs, Table 1 shows the logic.

Table 1 H-bridge Logic Control

xIN1	xIN2	xOUT1	xOUT2	Function
0	0	Z	Z	Coast/fast decay
0	1	L	H	Reverse
1	0	H	L	Forward
1	1	L	L	Brake/slow decay

4.2、Drive and Decay Modes

The motor speed can be controlled by the PWM signal. When the drive current is interrupted, the inductive nature of the motor requires that the current must continue to flow. This called recirculation current. To handle this recirculation current, the H-bridge can operate in two different states: fast decay or slow decay. In fast decay mode, the H-bridge is disabled and recirculation current flows through the body diodes, as shown in ② in the following figure; in slow decay mode, the motor winding is shorted, as shown in ③ in the following figure.

To PWM using fast decay, the PWM signal is applied to one xIN pin while the other is held low; to use slow decay, one xIN pin is held high.

Table 2 PWM Control of Motor Speed

xIN1	xIN2	Function
PWM	0	Forward PWM, fast decay
1	PWM	Forward PWM, slow decay
0	PWM	Reverse PWM, fast decay
PWM	1	Reverse PWM, slow decay

Figure 6 shows the current paths in different drive and decay modes.

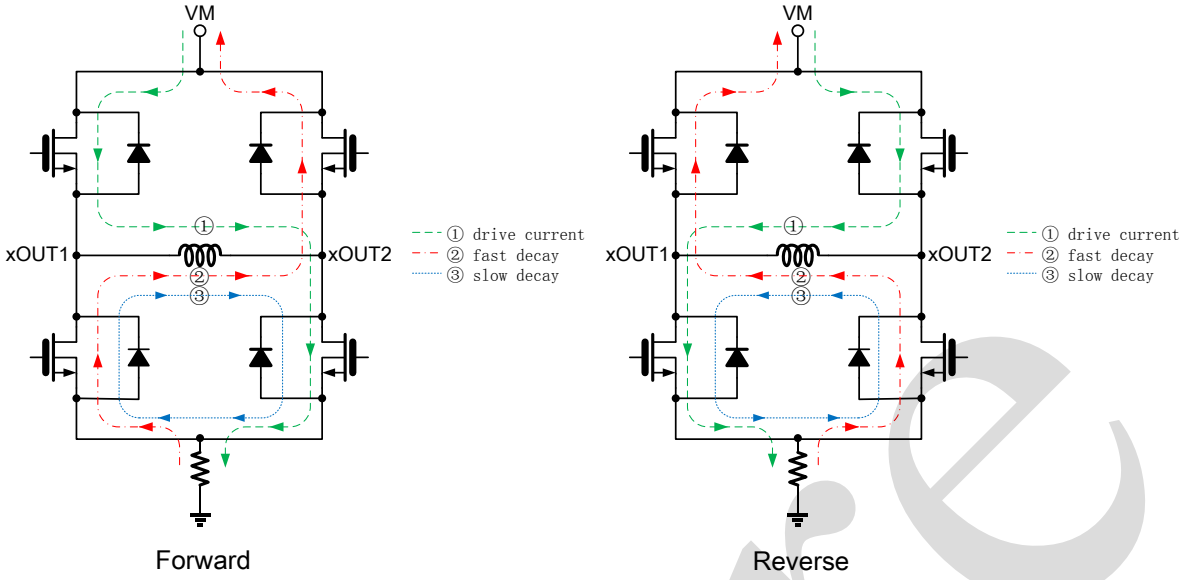


Figure 6. Drive and Decay Modes

4.3、Current Control

Current control can be achieved by connecting an external sense resistor to the xISEN pin. The current through the motor windings may be limited or controlled by a fixed-frequency PWM current regulation or current chopping.

If the current reaches the current chopping threshold, the H-bridge switches to slow decay mode, and disables the current until the beginning of the next PWM cycle. The PWM chopping current is calculated in the following formula:

$$I_{chop} = \frac{200mV}{R_{ISENSE}}$$

Example: If a 1Ω resistor is used, the chopping current will be 200mA.

Note that if current control is not needed, the xISEN pins should be connected directly to ground.

4.4、Blanking Time (t_{BLANK})

Immediately after the H-bridge is enabled, the voltage on the xISEN pin is ignored for a fixed period of time before enabling the current sense circuitry. This blanking time is generally fixed at 3.75us. This blanking time also sets the minimum on time of the PWM when operating in current chopping mode.

4.5、Protection Circuits

The AiP6133 is protected against under-voltage, over-current and over-temperature events.

4.5.1、Under-voltage Lockout (UVLO)

When the voltage on the VM pin falls below the under-voltage lockout threshold voltage, all circuitry in the device will be disabled, and all internal logic will be reset. Operation will resume when VM voltage rises above the UVLO threshold. nFAULT is driven low in the event of an under-voltage condition.

4.5.2、Over-current Protection (OCP)

If the current through the H-bridge exceeds the over-current threshold and persists for longer than the OCP deglitch time, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. The driver will be re-enabled after the OCP retry period (t_{OCP}) has passed. nFAULT becomes high again at this time. If the fault condition is still present, the cycle repeats. If the fault is no longer present, normal operation resumes and nFAULT remains deasserted.

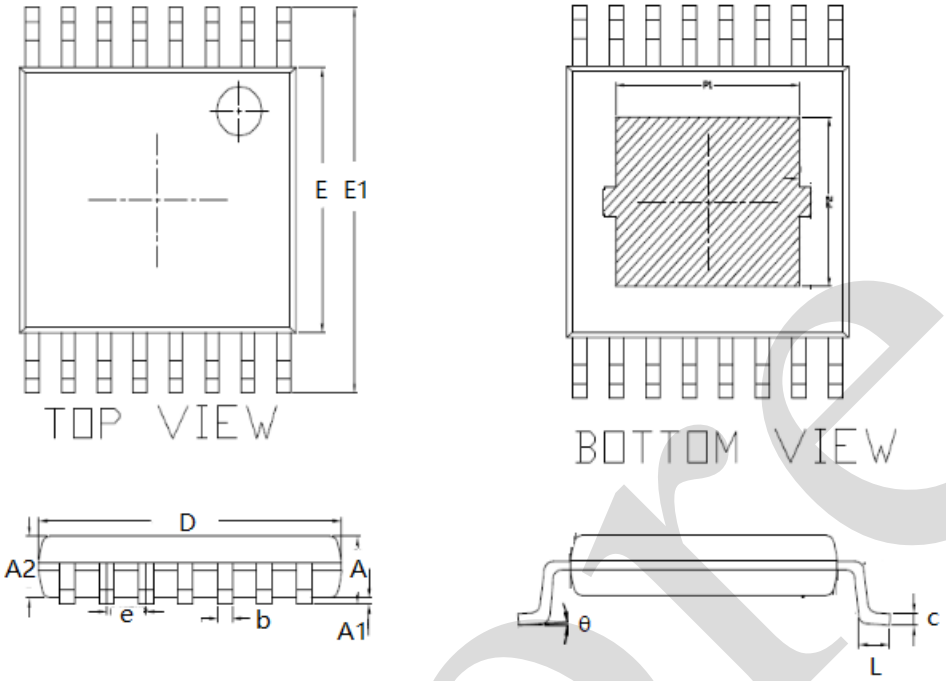
Overcurrent conditions are detected independently on both high and low side devices, and only the H-bridge in which the OCP is detected will be disabled while the other bridge will function normally. Note that overcurrent protection does not use the current sense circuitry used for PWM current control, so functions even without presence of the xISEN resistors.

4.5.3、Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. Once the die temperature has fallen to a safe level, operation will automatically resume.

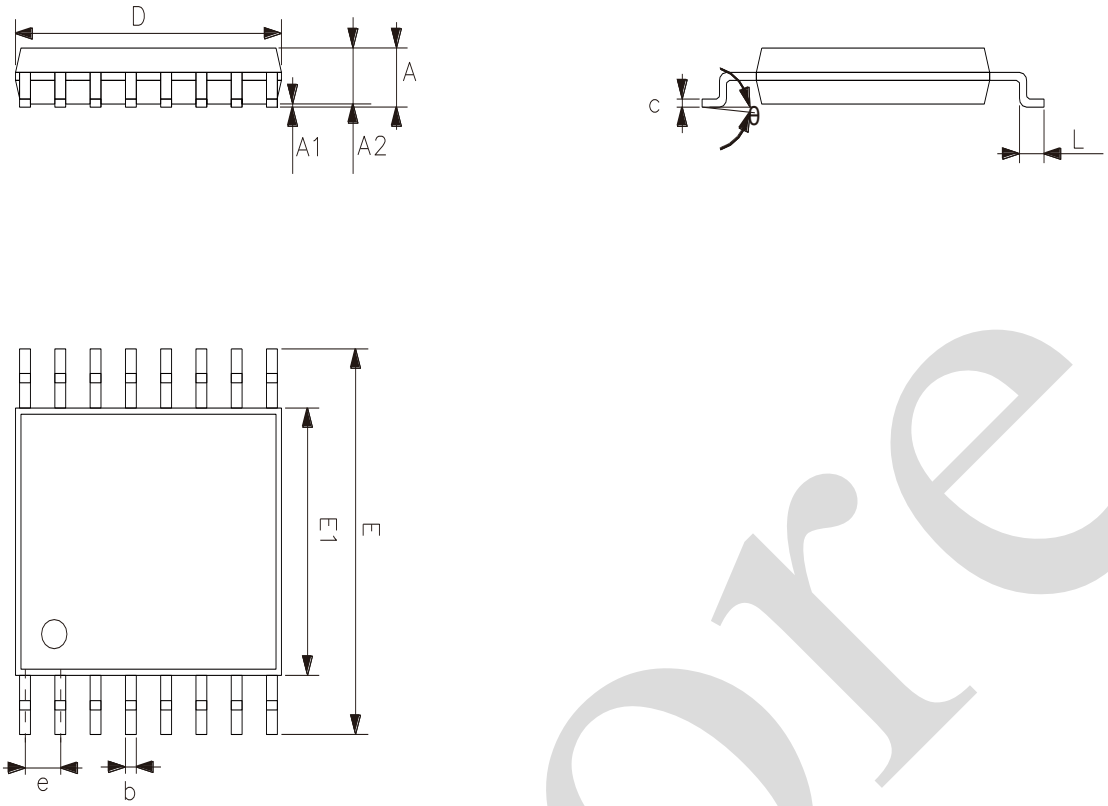
5、Package Information

5.1、ETSSOP16



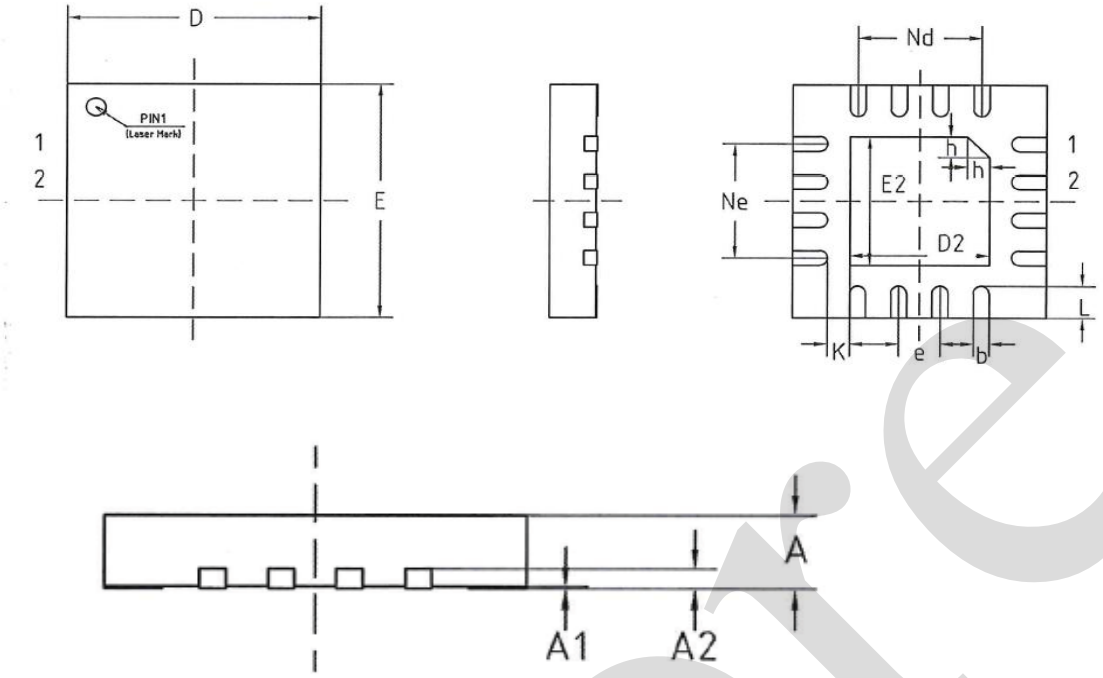
2023/12/A	Dimensions In Millimeters	
Symbol	**Min**	**Max**
A	—	1.20
A1	0.05	0.13
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	4.90	5.10
E	4.30	4.50
E1	6.25	6.55
P1	3.15	3.35
P2	2.65	2.85
e	0.65	
L	0.45	0.75
θ	0°	8°

5.2、TSSOP16



2023/12/A	Dimensions In Millimeters	
Symbol	**Min**	**Max**
A	—	1.20
A1	0.05	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	4.90	5.10
E1	4.30	4.50
E	6.20	6.60
e	0.65	
L	0.45	0.75
θ	0°	8°

5.3、QFN16



2023/12/A	Dimensions In Millimeters	
Symbol	**Min**	**Max**
A	0.70	0.80
A1	0	0.05
A2	0.20	
b	0.25	0.35
D	3.90	4.10
D2	2.10	2.30
E	3.90	4.10
E2	2.10	2.30
e	0.65	
Ne	1.95	
Nd	1.95	
K	0.25	0.45
L	0.45	0.65
h	0.30	0.40

7、Statements And Notes

7.1、The name and content of Hazardous substances or Elements in the product

Part name	Hazardous substances or Elements									
	Lead and lead compounds	Mercury and mercury compounds	Cadmium and cadmium compounds	Hexavalent chromium compounds	Polybrominated biphenyls	Polybrominated biphenyl ethers	Dibutyl phthalate	Butylbenzyl phthalate	Di-2-ethylhexyl phthalate	Diisobutyl phthalate
Lead frame	○	○	○	○	○	○	○	○	○	○
Plastic resin	○	○	○	○	○	○	○	○	○	○
Chip	○	○	○	○	○	○	○	○	○	○
The lead	○	○	○	○	○	○	○	○	○	○
Plastic sheet installed	○	○	○	○	○	○	○	○	○	○
explanation	○：Indicates that the content of hazardous substances or elements in the detection limit of the following the SJ/T11363-2006 standard. ×：Indicates that the content of hazardous substances or elements exceeding the SJ/T11363-2006 Standard limit requirements.									

7.2、Notes

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