AM4959S H-Bridge Brushed DC Motor Driver

Features

- Operating Voltage Range : 5 to 30V
- Low Rds(on): HS + LS = 170mΩ
- 2.2A Continuous Current, 4A Peak Current
- Low standby current < 2μA
- Current Limit Protection
- Overcurrent Protection
- Over Temperature Protection
- SOP8 Package for small PCB layout
- Halogen-Free Green Product & RoHS compliant Package

Application

- Robotics
- AI Home Appliances
- Robot Vacuum
- Printer
- Electric Curtains
- Industrial Equipment
- Other Mechatronic Applications

Description

AM4959S is a brushed DC motor driver IC, provides outside PWM pulse to control motor speed, and it drives current capability up to 2.2A continuous and 4A peak.

The device provides well protection for motor and device itself including internal functions for overcurrent, current limit, and over temperature protection.

Ordering Information

Orderable Part Number	Package	Marking
AM4959S	SOP-8	AM4959S

Absolute Maximum Ratings (T_A=25℃)

Parameter	Symbol	Limit	Unit
Power Supply Voltage	VCC	40	V
VREF Input Voltage	VREF	-0.3 to 6	V
Signal Input IN_A and IN_B Voltage	V_{IN_X}	-0.3 to 6	V
Sense Voltage (LSS pin)	V_S	-0.5 to 0.6	V
Output Voltage	V_{OUT}	-0.3 to 40	V
Peak Current	I_{OUT}	4	A
Operate Temperature Range	T_{OPR}	-40～+125	°C
Storage Temperature Range	T_{STG}	-40～+150	°C

ESD Rating

		Value	Unit
V_{ESD} Electrostatic discharge	Human-body model (HBM) (1)	±8000	V
	Machine model (MM) (1)	±400	V

(1) The test method refers to JEDEC EIA/JESD22-A114-B.

Recommended Operating Conditions (T_A =25℃)

(Set the power supply voltage taking allowable dissipation into considering)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power Supply Operating Voltage	VCC	5		30	V
Signal Input IN_A and IN_B Voltage	V_{IN_X}	-0.3		6(1)	V
VREF Input Voltage	VREF	0.3		5	V
H-Bridge Output Current	I_{OUT}	0		2.2(2)	A
Externally Applied PWM Frequency	f_{IN_X}			30	kHz

(1) Input signal voltage does not be higher than VCC voltage.

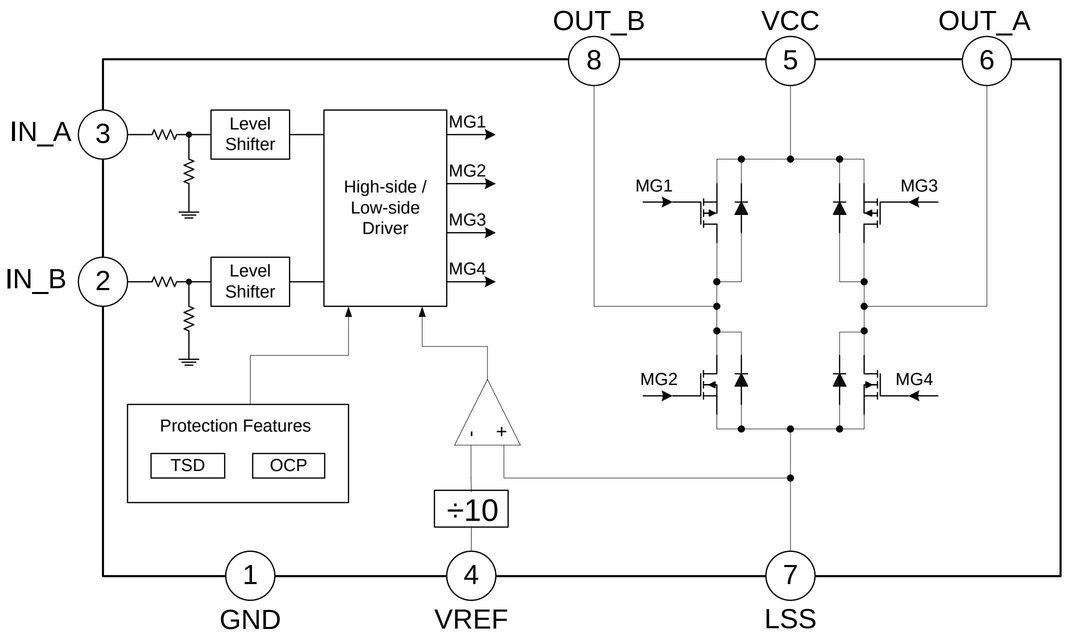
(2) Power dissipation and thermal limits must be observed

● Electrical Characteristics (Unless otherwise specified, T_A = 25℃,VCC=12V)

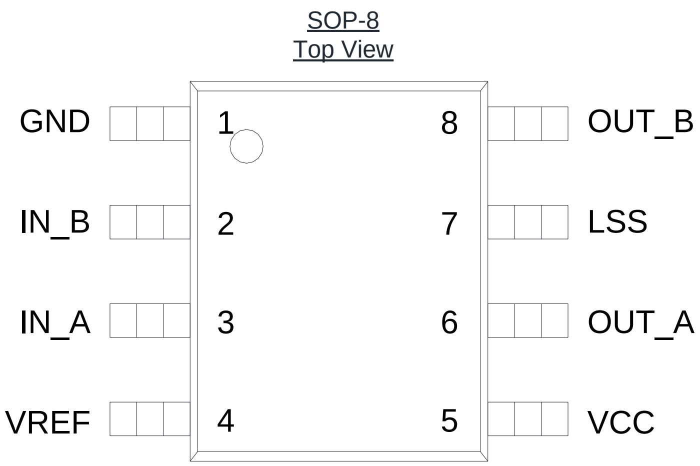
Parameter	Symbol	Limit			Unit	Conditions
		Min.	Typ.	Max.		
Power Supply						
Supply Current	I_{CC}		6		mA	Input signal IN_A/B = L/H or H/L or H/H, no load
Standby Current	I_{STB}			2	µA	Input signal IN_A/B = L/L
IN_X Inputs						
Input H level Voltage	V_{IN_XH}	2.0		6	V	
Input L level Voltage	V_{IN_XL}	-0.3		0.7	V	
Input H level Current	I_{IN_X}		100		µA	V_{IN} = 3V
Input Frequency	f_{IN_X}			30	kHz	
Input Pulldown Resistance	R_{IN_X}		30		kΩ	
H-Bridge FETs						
On-Resistance	$R_{DS(ON)}$		170		mΩ	I_{OUT} = 1A Upper and Lower total
On-Resistance	$R_{DS(ON)}$		225		mΩ	I_{OUT} = 2A Upper and Lower total
Current Limit Protection						
Current Gain	A_V	8	10	12	V/V	VREF = 2.5V
PWM Blank Time	T_{BLANK}		3		µs	
PWM Off-time	T_{OFF}		25		µs	R + L = 8ohm + 5.5mH
Overcurrent Protection						
Overcurrent Trip Level	I_{OCP}		4		A	
Thermal Shutdown Protection						
Thermal Shutdown Protection	TSD_P		160		°C	*1
Thermal Shutdown Release	TSD_R		110		°C	*1

*1: It is design target, not to be measured at production test.

Block Diagram



Pin configuration



Pin Descriptions

Pin No.	Pin Name	I/O	Description
1	GND	I	Ground Pin
2	IN_B	I	Logic Input B
3	IN_A	I	Logic Input A
4	VREF	I	Analog Input
5	VCC	I	Power Supply
6	OUT_A	O	Output Terminal A
7	LSS	-	Power Return – Sense Resistor Connection
8	OUT_B	O	Output Terminal B

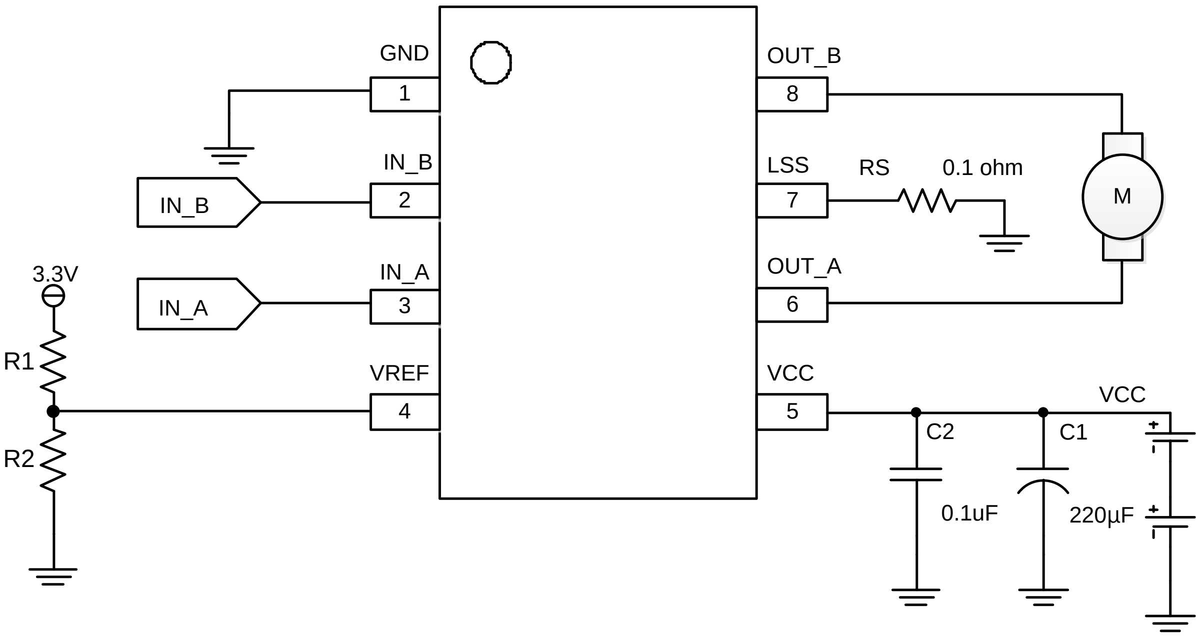
Input Logic Descriptions

Function Truth Table

IN_A	IN_B	OUT_A	OUT_B	Mode
L	L	High-Z*	High-Z	Stop
L	H	L	H	Reverse
H	L	H	L	Forward
H	H	L	L	Brake

Note*: “High-Z” is the status that High-side MOSFETs and Low-side MOSFETs of H-Bridge are switched to “OFF”.

- **Application:**



- **Circuit Descriptions**

The function descriptions of capacitors on the application circuit:

1. C1、C2: Power supply VCC pin capacitors:

   The capacitors can reduce the power spike when the motor is in motion, and prevent the IC from damaging by the VCC peak voltage. They can stabilize the power supply voltage and reduce its ripples.

   The C1 capacitor can compensate power supply when motor starts running.

   The capacitor value (µF) determines the stability of the VCC during motor is in motion. If the larger voltage power or a heavier loading motor is used, then a larger capacitor would be needed.

   On the PCB configuration, the C1、C2 must be placed as close as possible to the VCC pin.

2. It's not allowed INA, INB input remain floating status, because there is a minor leakage current between P-N junction when temperature rising, the leakage current will flow through internal pull- low resistor which causes INA or INB floating level abnormal pull high and output abnormal working.

3. Sense Pin (LSS):

   In order to use PWM current control, a low-value resistor is placed between the LSS pin and ground for current sensing purposes. The ground-trace should be as short as possible. For low-value sense resistors, the ground-trace voltage drops in the PCB could be significant, and should be taken into account.

   When selecting a value for the sense resistor, be sure not to exceed the maximum voltage on the LSS pin of ±500 mV at maximum load. During over-current events, this rating may be exceeded for short durations.

   The resistance of the sense resistor must be rated for high enough power.

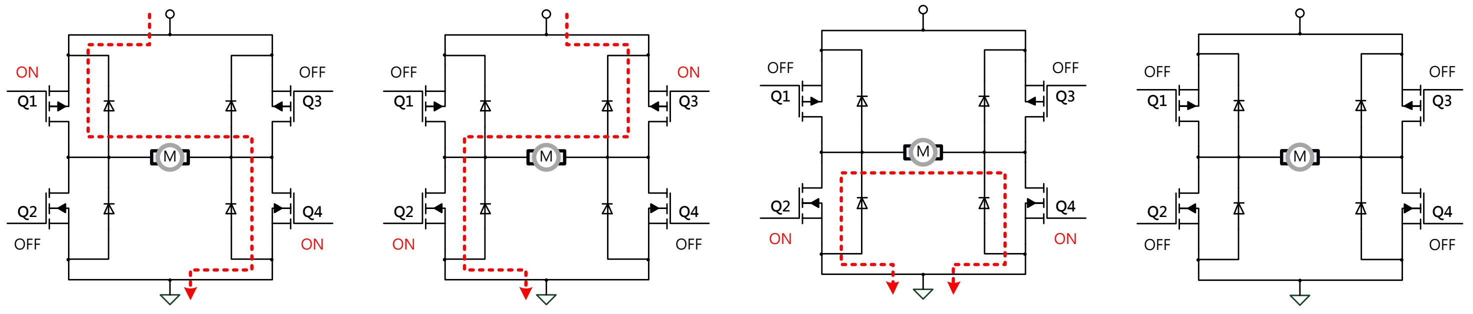
Operating Mode Descriptions

a) Forward mode: When IN_A=H, IN_B=L, then OUT_A=H, OUT_B=L

b) Reverse mode: When IN_A=L, IN_B=H, then OUT_A=L, OUT_B=H

c) Brake mode: When IN_A=IN_B= H, then OUT_A=OUT_B=L

d) Stop mode: When IN_A=IN_B= L, then OUT_A=OUT_B=Hi-Z



a) Forward mode b) Reverse mode c) Brake mode d) Stop mode

Protection Mechanisms Descriptions

(1) Overcurrent Protection:

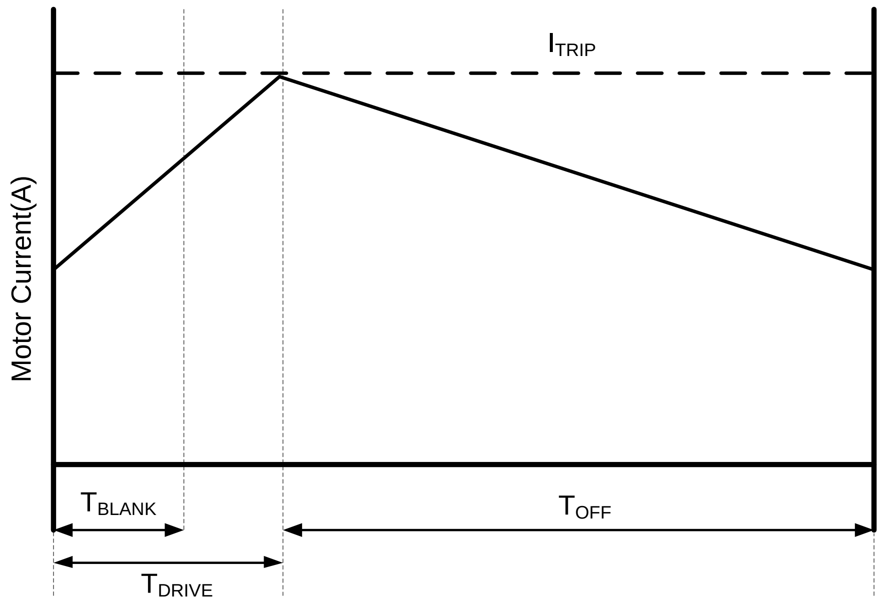
When the IC conducts a large current, 4A (Typ), the internal overcurrent protection will be triggered. The device enters protection mode and disables partial MOSFETs in the H-Bridge to avoid damaging IC and system. The device operation resumes when the current falls below safe range. If the overcurrent protection is still be triggered, the cycle repeats.

(2) Adjustable PWM Current Limit:

The AM4959S device limits the output current based on the analog input, VREF, and the resistance of an external sense resistor on the LSS pin according to the Equation:

$$\mathbf{I_{TRIP}} = \frac{\mathbf{VREF(V)}}{\mathbf{A_V \times R_S(\Omega)}} = \frac{\mathbf{VREF(V)}}{\mathbf{10 \times R_S(\Omega)}}$$

For example, if VREF=2V and a R_S=0.1Ω, the AM4959S device limits motor current to 2A no matter how much load torque is applied. When I_{TRIP} is reached, the device enforces slow current decay by enabling both low-side FETs, where the off time of R (8ohm) + L (5.5mH) is 25us.



Adjustable PWM Current Limit Time Periods

After T_{OFF} elapses, the output is re-enabled according to the two inputs, IN_A and IN_B. The drive time (T_{DRIVE}) and T_{OFF} until reaching another I_{TRIP} event heavily depends on the motor voltage, the back-EMF of the motor, and the inductance of the motor.

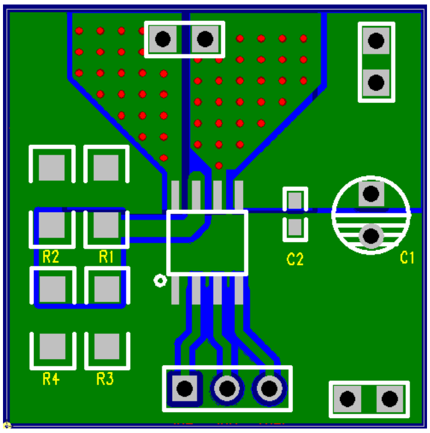
(3) Thermal Shutdown (TSD):

If the IC junction temperature exceeds 160°C (Typ.), the internal thermal shutdown protection will be triggered, and then partial FETs in the H-Bridge are disabled so that it will ensure the safety of customers' products. If the IC junction temperature falls to 110°C (Typ.), the IC resumes automatically.

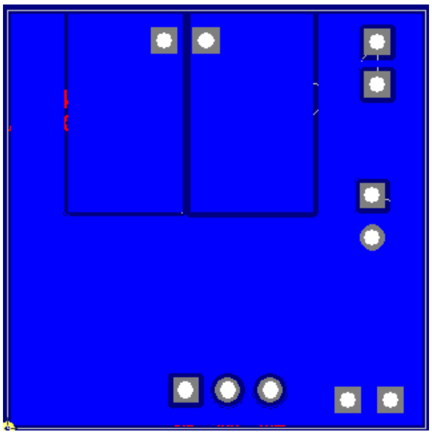
Layout Guidelines

1. Layout Example:

   PCB Size 25x25 mm^2、double-sided printed board.



Top Layer



Bottom Layer

2. Layout Consideration:

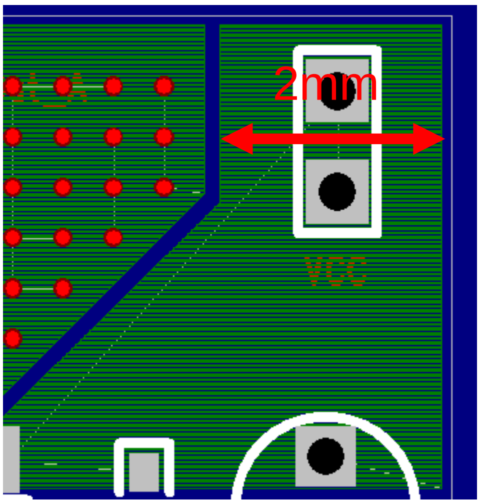
   The layout is very important when designing high current and high frequency switching converters. Layout will affect noise pickup. Correct layout can realize a good design with less background noise. Make all the connections for the power components in the top layer with wide copper filled areas or polygons. In general, it is desirable to make proper use of GND planes and polygons for power distribution and heat dissipation.

3. Power Trace:

   Power trace (VCC) should be as short as possible.

   On the PCB configuration, the C1 and C2 must be placed as close as possible to the VCC pin in order to reduce EMI noise.

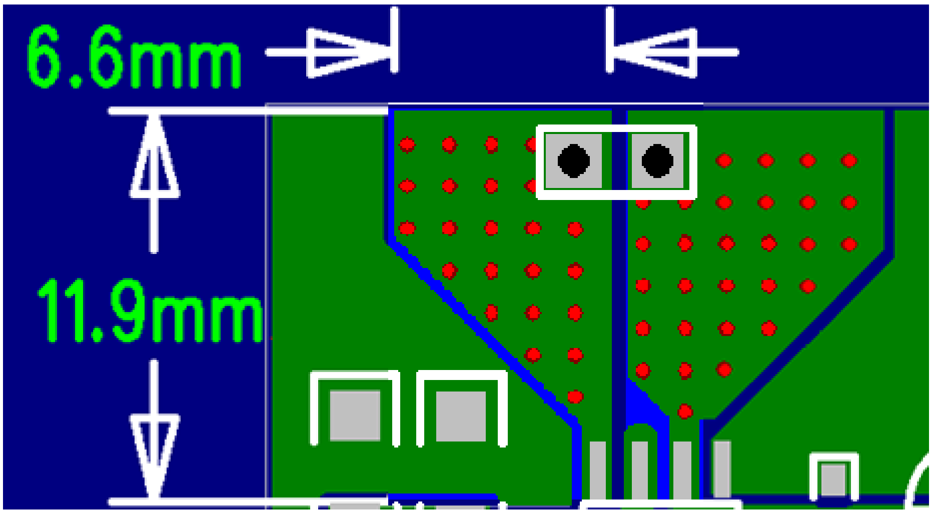
   To ensure that power trace can conduct high current, the width of power trace should be wider than 2 mm.



4. Output Trace:

   OUT_A and OUT_B trace width need at least 2mm for high current flowing through.

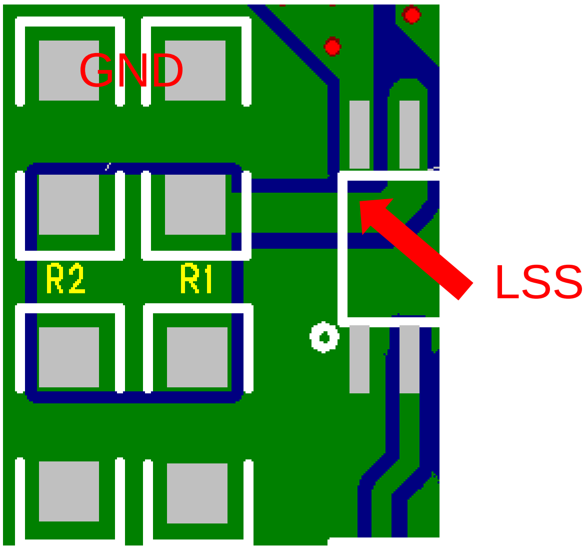
For OUT_A & OUT_B thermal design consideration, it should increase copper area widely (for example: 11.9mm x 6.6mm) without any gaps.



TOP Layer

5. LSS (Sense Pin):

LSS is high-current path through the motor driver. The width of connecting metal trace should be as wide as possible.



TOP Layer

Thermal Information

θja	junction-to-ambient thermal resistance	89.2℃/W
Ψjt	junction-to-top characterization parameter	10.6℃/W

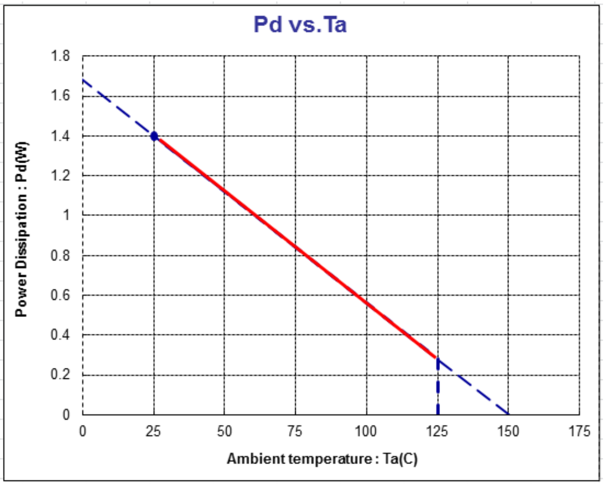
Condition :

a. FR4 PCB 25 x 25 mm^2

b. 1S1P-2 layers

c. with 1 oz copper

Power Dissipation



How to predict Tj in the environment of the actual PCB

Step 1: Used the simulated Ψjt value listed above.

Step 2: Measure Tt value by using ~40 gauge thermocouple or thermo gun.

Tt : Temp. at top center of the package

Step 3: calculating power dissipation

$$\mathbf{P} \cong \left(\mathbf{VCC} - \left|\mathbf{V_{O\_Hi}} - \mathbf{V_{O\_Li}}\right|\right) \times \mathbf{I_{OUT}} + \mathbf{VCC} \times \mathbf{Icc}$$

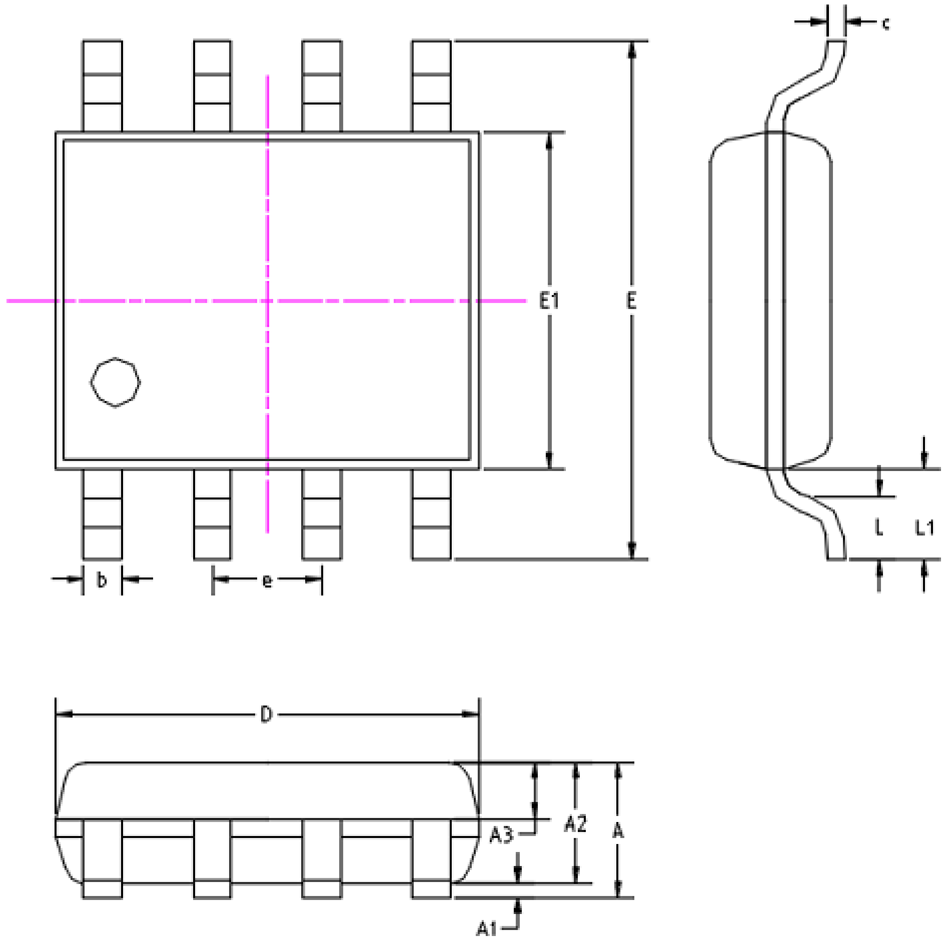
Step 4: Estimate Tj value

$$\mathbf{Tj} = \mathbf{Tt} + \mathbf{\Psi jt} \times \mathbf{P}$$

Step 5: Calculated Θja value of actual PCB

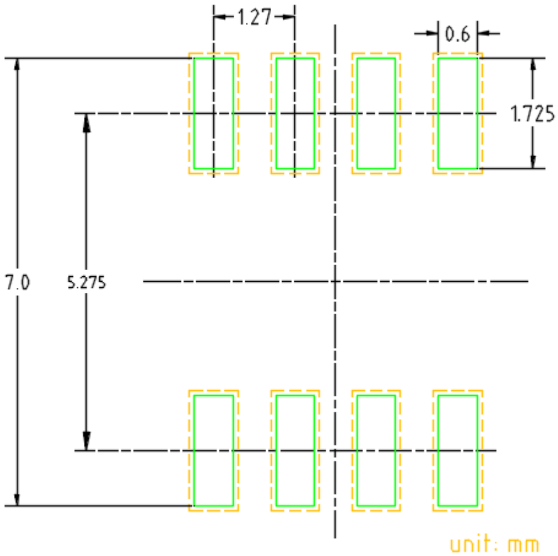
$$\mathbf{\theta ja} = \frac{(\mathbf{Tj} - \mathbf{Ta})}{\mathbf{P}} = \frac{\mathbf{Tt} + \mathbf{\Psi jt} \times \mathbf{P} - \mathbf{Ta}}{\mathbf{P}} = \frac{\mathbf{Tt} - \mathbf{Ta}}{\mathbf{P}} + \mathbf{\Psi jt}$$

- **Packaging outline --- SOP8** **Unit: mm**

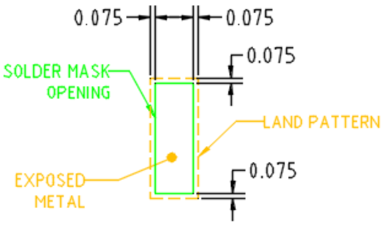


SYMBOL	MILLIMETERS		INCHES	
	Min.	Max.	Min.	Max.
A	--	1.75	--	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.50	0.70	0.020	0.028
b	0.39	0.49	0.015	0.190
c	0.10	0.25	0.004	0.010
D	4.70	5.10	0.185	0.201
E	5.90	6.10	0.232	0.240
E1	3.80	4.00	0.150	0.157
e	1.27 TYP.		0.05 TYP.	
L	0.45	1.00	0.018	0.039
L1	1.10 TYP		0.043 TYP.	

- **Land Pattern And Solder Mask**



SOP-8L LAND PATTERN



Solder Mask Define

Marking Identification

Package Type: SOP-8

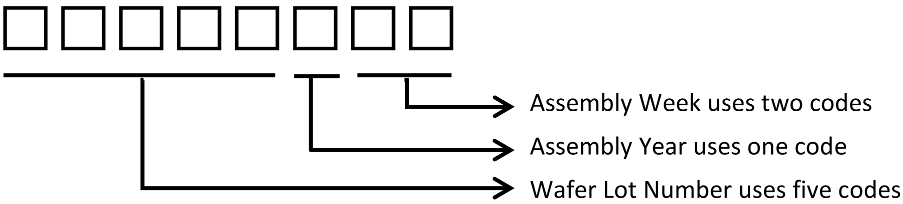
Device：AM4959S

NOTE:

Row1: Logo

Row2: Device Name

Row3: Wafer Lot Number + Assembly Year + Assembly Week



Example: Wafer lot number is G8668 + Year 2021 is B + Week 31 is 31, we type 〝G8668B31〞.

The last code of assembly year, explanation as below:

(Year: A=0, B=1, C=2, D=3, E=4, F=5, G=6, H=7, I=8, J=9. For example: year 2020=A)

- **Revision History**

Date	Revision	Changes
5.Jan.2022	V0.3	New release
20.Jul.2022	V0.4	P12. POD update P13. Add Land pattern and solder mask
14.Sep.2022	V0.5	P2. Operate Temperature Range up to 125℃ Add Storage Temperature Range condition. P11. Update power dissipation curve
27.Dec.2023	V1.0	P12. Packaging outline update