DC Brushless Motor Driver IC

PL393W-A
Single-phase Motor Driver with PWM speed control

Applications

- Automotive cooling fan

Features

- Built-in high sensitivity hall sensor
- Single phase full wave driver
- Linear Soft switching output driver
- Speed controllable by Digital PWM or DC voltage two modes identified automatically
- Quick start
- FG/RD open drain output
- Protections
  - Motor locked protection and automatic restart
  - Over thermal protection
  - Current limit protection
  - Jump start overvoltage protection
- Built-in zener diode
- High balance and low thermal drift magnetic sensing
- AEC Q100 qualified
- RoHS 2.0 compliance

Package:

SOP-10F (4.9x3.9x1.4mm)

Straight pin

DFN-10 (3x3x0.75mm)

Specifications

Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol	Conditions	Rating	Units
Maximum supply voltage	VDDmax		32	V
Allowable power dissipation	Pd	SOP-10F	833	mW
		DFN-10	1860	mW
Operating temperature range	Tj		-40~+150	℃
Storage temperature	Ts		-50~+150	℃
Max. O1/O2 output voltage	V_{OMAX}		32	V
Max. output current	I_{OMAX}	0.5sec	1200*1	mA
Max. FG/RD output voltage	$V_{FG/RDMAX}$		32	V
Max. FG/RD output current	$I_{FG/RDMAX}$		10	mA
Max. input voltage (PWM,VSEN)	V_{INMAX}		6	V
VREF driving capability	I_{VREF}		5	mA

*1: Should not exceed Pd

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Electrical Characteristics (T_J=-40°C ~150°C, V_{DD}=24V)

Characteristic	Symbol	Test Condition	Min.	Typ.	Max.	Units
Supply Voltage	V_{DD}		4.5		30	V
Output High Voltage	$V_{OH(ON)}$	@I_{OUT} =200mA	V_{DD}-0.4	V_{DD}-0.3		V
Output Low Voltage	$V_{OL(ON)}$	@I_{OUT} =200mA		0.15	0.2	V
Output On Resistance	$R_{DS(ON)}$	@T_J=25°C,V_{DD}=24V		2.25		ohm
		@T_J=25°C,V_{DD}=12V		2.75		ohm
		@T_J=150°C,V_{DD}=24V		3		ohm
Supply Current	I_{DD}	Output open		6	10	mA
FG/RD output voltage	$V_{FG/RD}$				30	V
FG/RD sink voltage	$V_{DSFG/RD}$	I_{FG}=3mA		0.2	0.3	V
PWM input H level	$V_{PWM(H)}$		2.5		V_{REF}	V
PWM input L level	$V_{PWM(L)}$		GND		0.8	V
PWM input frequency	f_{PWMI}		0.1		100	KHz
PWM input current	I_{PWM}	V_{PWM}=0V	-20			uA
Built-in PWM frequency	f_{PWM}		20	25	30	KHz
PWM ON Duty 1	D1	V_{PWM}=1V	20	25	30	%
PWM ON Duty 2	D2	V_{PWM}=2V	70	75	80	%
VREF Voltage	V_{REF}	I_{REF}=2mA	4.8	5	5.2	V
VSEN input Voltage	V_{SEN}		GND		V_{REF}	V
Current limit Voltage	V_{CL}		130	160	190	mV
Shutdown Time	T_{SD}		4.2	5.6	7.0	S
Restart Time	T_{RS}		0.3	0.4	0.5	S
Thermal Protection Temp.	T_{JTSD}	T_J		165		°C
Shutdown hysteresis	ΔT			25		°C
Magnetic Characteristics (T_J=-40°C ~150°C , V_{DD}=24V)						
Operate Point	B_{OP}		5	10	25	G
Release Point	B_{RP}		-25	-10	-5	G
Hysteresis	B_{HYS}		10	20	50	G

Truth Table

Parameter	Test Condition	O1	O2	Rotation Mode		Lock Mode	
				FG	RD	FG	RD
North Pole	B<Brp	H	L	H	L	H	H
South Pole	B>Bop	L	H	L	L	H	H

General Specifications

The PL393W-A is a variable speed DC fan motor driver IC with built-in Hall sensor. The built-in dynamic offset cancellation of pre-amplifier stage achieves optimal symmetrical magnetic sensing. The output driver provides a linear drive to eliminate switching noise. Furth, the linear driving of PL393W-A will benefit EMI performance. PL393W-A is also featuring with jump start protection according to ISO16750-2. This IC is an optimal solution with PWM speed control for Automotive DC brushless fan motor application.

Lock Protection

In order to protect the motor, the driver IC will be shutdown to drive the coil when the motor is locked for over 0.4 seconds and the RD output signal will turn high level, It then restarts to drive the motor after 5.6 seconds, If the Hall signal exchange is detected in lock protection cycle, the lock protection will be released after the end of protection cycle and RD output signal turns low level again. Figure 1 shows the timing diagram between the hall input signal and the driver's output state.

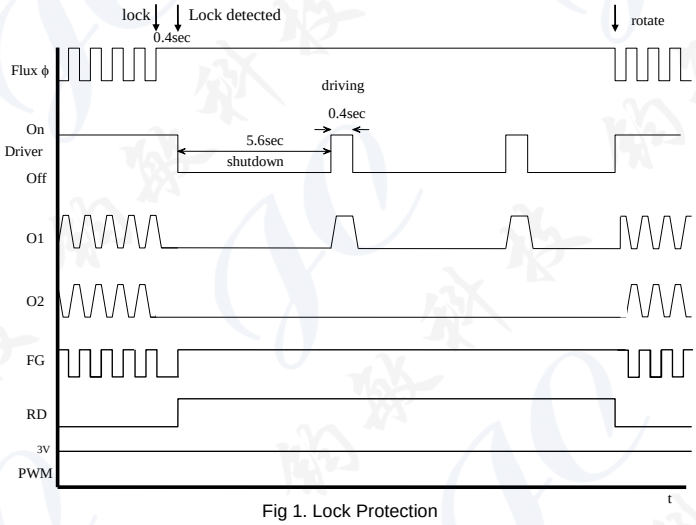

Fig 1. Lock Protection

PWM Speed Control

This Driver IC has built-in pulse width modulation to control motor speed. The output duty cycle of PWM is controlled by the direct voltage level of V_{PWM}. The V_{PWM} input voltage determines the output PWM duty cycle and control the speed of fan motor as Fig 2a. The V_{PWM} Voltage is compared with an internal 0.8V-2.5V saw waveform V_{SAW} and output PWM duty control signal. The output PWM ON duty cycle is controlled by 0.8V~2.5V DC V_{PWM} voltage from 15% to 100%. The formula of ON duty is Duty=50(V_{PWM}-0.5)%. The digital PWM input signal also can be converted to DC voltage level via an internal integrator to do variable speed control. The transfer function of PWM IN and OUT duty cycle is shown in Fig 2b.

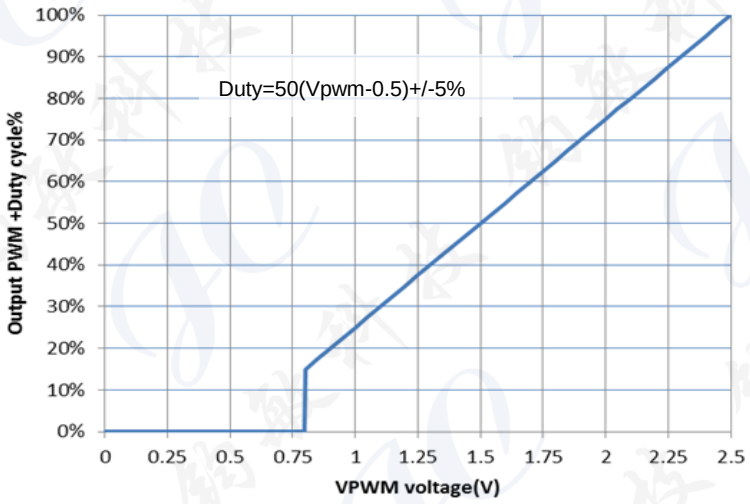

Fig. 2a Output PWM duty cycle vs. V_{PWM} voltage

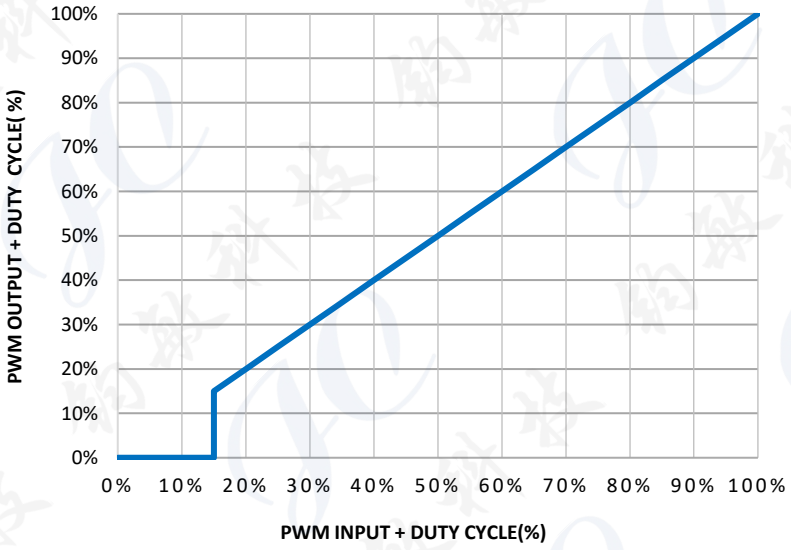

Fig. 2b PWM Output duty cycle vs. PWM IN duty cycle

Quick Start

Motor's speed is controlled by PWM input signal. When PWM pin is open or tied to High voltage (> 2.5V) , the motor will be full speed rotation. This PWM speed control make the lock protection off and stop the motor when the PWM input voltage keeps low level (<0.8V) for more than 25mS(typ.). The motor will be started directly without the lock protection time delay when the PWM voltage is above 0.8V as Fig3.

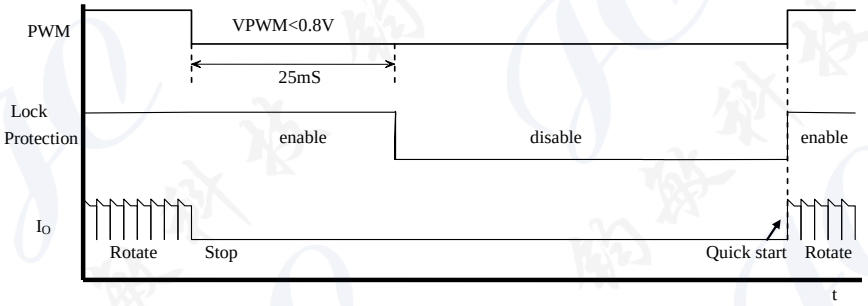

Fig 3. PWM input and Lock Protection

Current limit

This diver IC has built-in current limit function to protect Fan motor. The current limit is detected by internal comparator to limit output current. The output current limit is activated when the current sensing voltage detected from RNF resistor exceeds 160mV (typical). The value of current limit is got by the formula 160mV/RNF. Example, the maximum output current is limited at 0.8A when the current detecting resistor RNF is 0.2ohm. The value of current limit is adjustable to meet different need by RNF changing. If the RNF=0.5ohm, the value of current limit is 320mA.

$$\text{Current Limit (A)} = 0.16\text{(V)} / \text{RNF}(\Omega)$$

Hall Sensor

This Hall effect sensor IC integrates the sensor, pre-amplifier with dynamic offset cancellation and the hysteresis comparator in single chip. The hysteresis characteristic is illustrated in Fig. 4 and the threshold of the magnetic flux density is +/-10 Gauss.

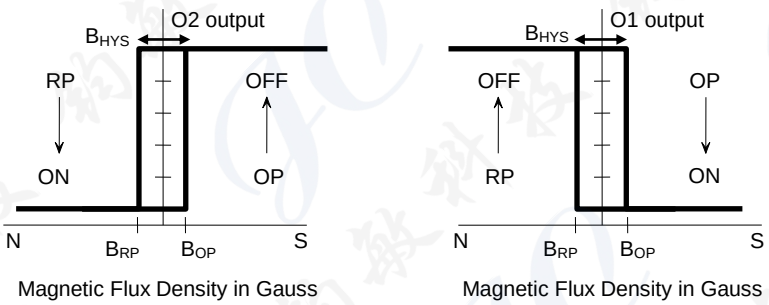

Fig 4. Magnetic Hysteresis Characteristics

Jump start protection

During the jump-start overvoltage test (ISO16750-2), an overvoltage will be applied to supply voltage of fan motor for 60 seconds. In that case, output current will be increased substantially and generate extra heat. PL393W-A will activate jump-start protection to shut down the output to avoid such kind of circumstance. The trigger voltage of jump-start protection could be adjusted by external resistor connected to VSEN pin as below formula.

$$V_{JS}=\frac{1.28x(R_U+R_D)}{R_D}$$

V_{JS} : V_{DD} voltage value when jump-start protection is activated

If the external resistor R_D=2.7K ohm and R_U=33K ohm, jump-start protection will be activated while V_{JS} = 16.9V.

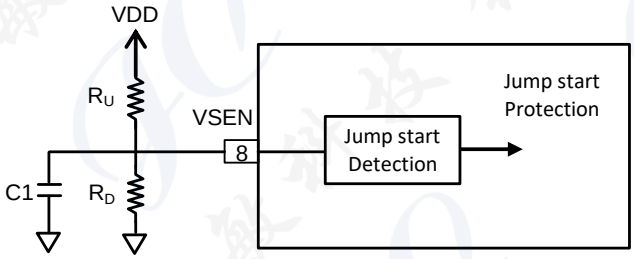

Fig 5. VSEN setting for Jump start protection

The Driver IC architecture block diagram is shown in Fig. 6.

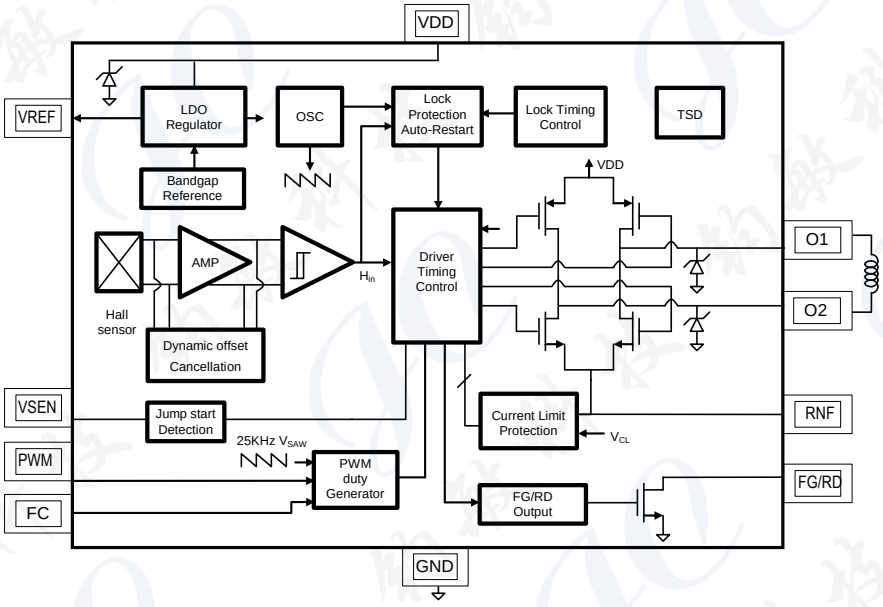

Fig.6. Fan Motor Driver IC Architecture

Pin Description

SOP-10F (straight pin)

NAME	Pin	Description
PWM	1	DC voltage/Digital PWM input pin
VREF	2	Reference Voltage Output
VDD	3	DC power supply
O2	4	Second output pin
RNF	5	Current Sensing resistor
GND	6	DC ground
O1	7	First output pin
VSEN	8	JS Voltage setting input pin
FC	9	Filter capacitor
FG/RD	10	Frequency Generation/Rotation Detection

DFN-10 (Exposed pad)

NAME	Pin	Description
PWM	1	DC voltage/Digital PWM input pin
VREF	2	Reference Voltage Output
VDD	3	DC power supply
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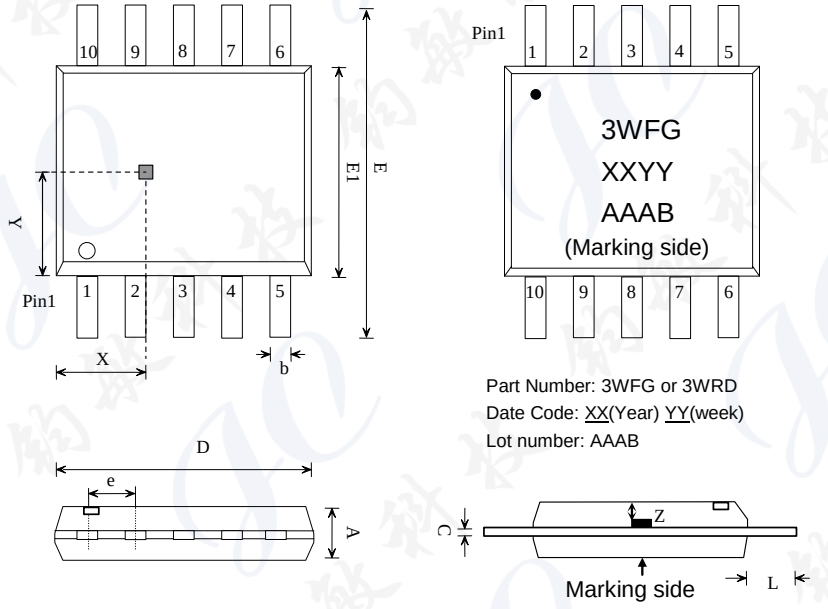
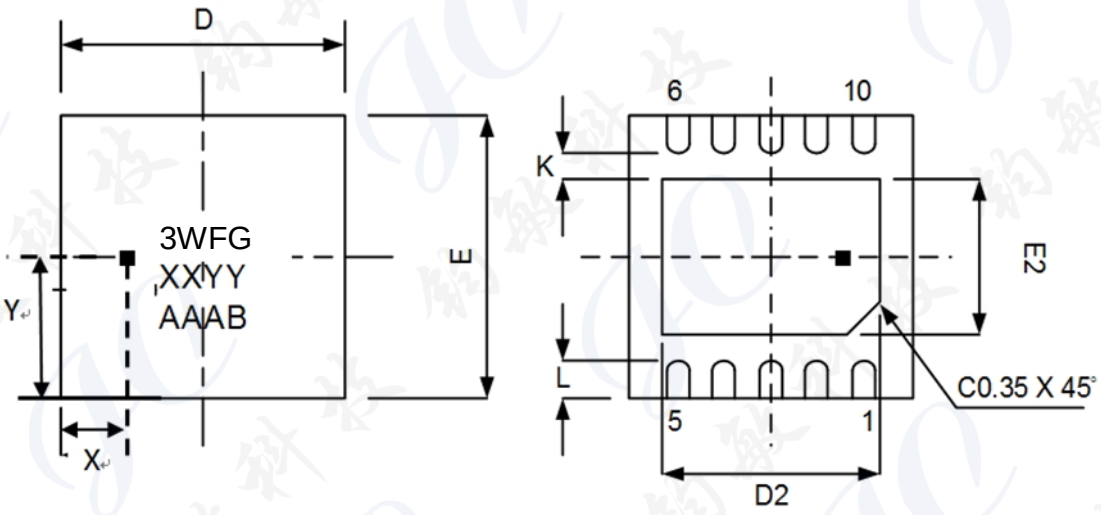
Package Information

SOP-10F (straight pin)

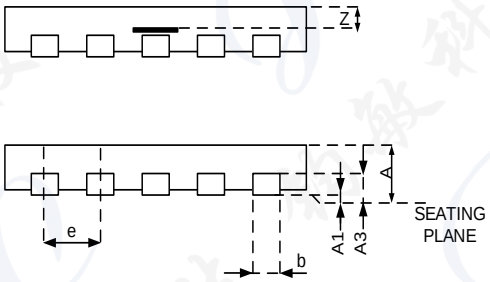


SYMBOLS	DIMENSIONS IN MILLIMETERS(mm)		
	MIN	NOM	MAX
A	1.25		1.50
b	0.30		0.45
C	0.10		0.25
D		4.90	
E	5.95		6.05
E1		3.90	
e	-	1.00	-
L	1.00	-	1.10
SENSOR LOCATION			
X	1.80	2.00	2.20
Y	1.65	1.85	2.05
Z	0.31	0.35	0.39

DFN-10 (Exposed pad)



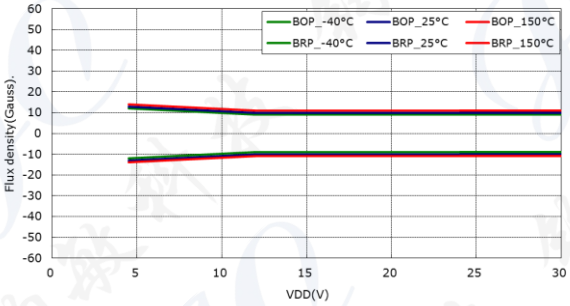
Part Number : 3WFG or 3WRD
Date Code : XX(Year) YY (Week)
Lot Number : AAAB



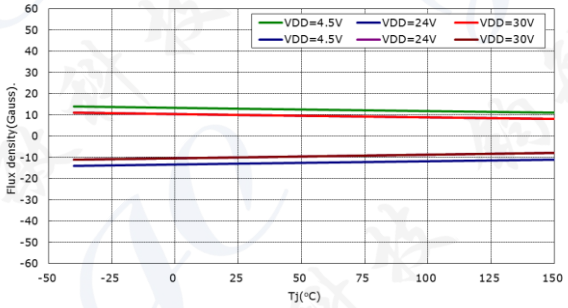
SYMBOLS	MILLIMETERS(mm)		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.203 REF	
b	0.18	0.25	0.30
D		3.00 BSC	
E		3.00 BSC	
e		0.50 BSC	
K	0.20	-	-
EXPOSED PAD			
D2	2.20	2.30	2.35
E2	1.55	1.65	1.70
L	0.30	0.40	0.50
SENSOR LOCATION			
X	0.55	0.65	0.75
Y	1.40	1.50	1.60
Z	0.35	0.38	0.41

Performance curve

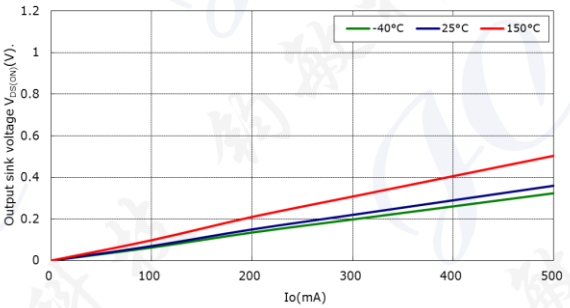
BOP_BRP vs. VDD



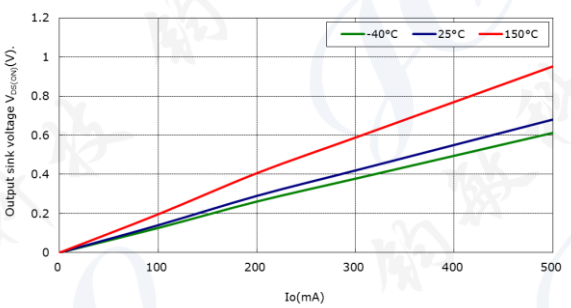
BOP_BRP vs. Tj



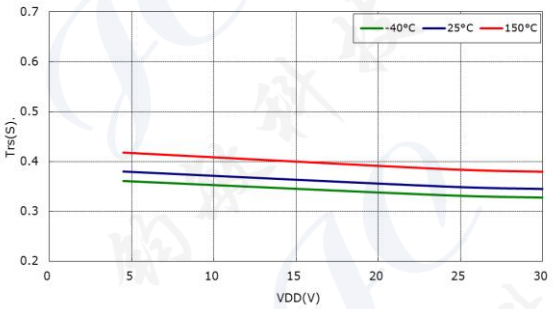
Output sink voltage VOL(ON) vs. Io (VDD=24V)



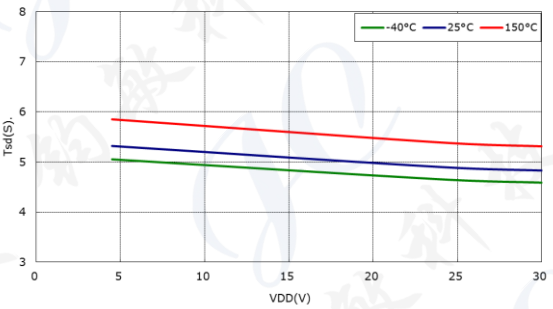
Output sink voltage VOH(ON) vs. Io (VDD=24V)



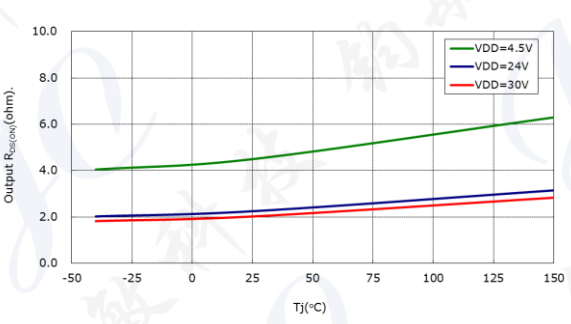
Lock Trs vs. VDD



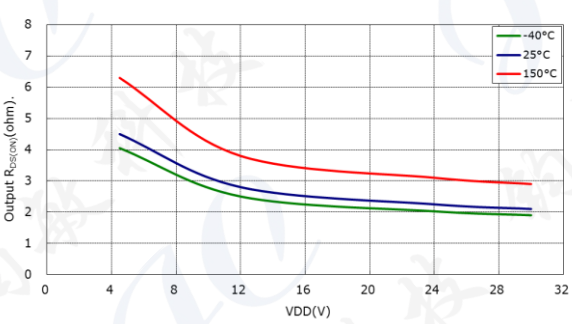
Lock Tsd vs. VDD

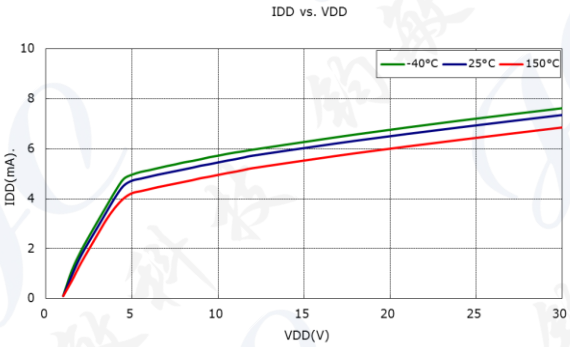


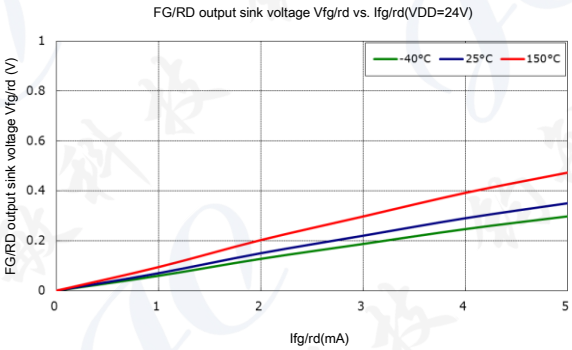
RDS(ON) vs.Tj



RDS(ON) vs. VDD

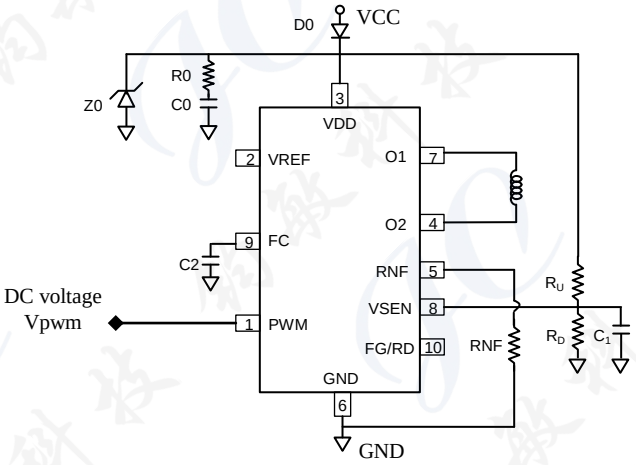



IDD vs. VDD
-40°C
25°C
150°C
IDD(mA).
VDD(V)
0
2
4
6
8
10
0
5
10
15
20
25
30


FG/RD output sink voltage Vfg/rd vs. Ifg/rd(VDD=24V)
-40°C
25°C
150°C
FG/RD output sink voltage Vfg/rd (V)
Ifg/rd(mA)
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5

Application circuits

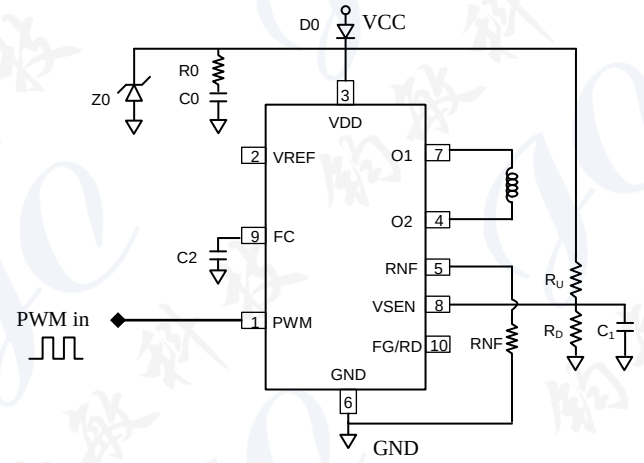
DC Voltage speed control



D0: Polarity protection diode
Z0: Transient-voltage-suppression diode (TVS), 30V V_{BR}
C0: decoupling capacitor 1uF ~ 2.2uF
R0: Snubber circuit resistor 2.2ohm~4.7ohm
RNF: Current sensing resistor (ex. 0.2ohm for 0.8A current limit)
C1 : filter capacitor 0.1uF
C2 : filter capacitor 0.1uF
R_U, R_D: VSEN setting resistor

Note: A Transient-voltage-suppression diode (TVS) with 30V breakdown voltage V_{BR} from VDD to GND is recommended for ISO7637-2 transient immunity test.

Digital PWM speed control



D0: Polarity protection diode
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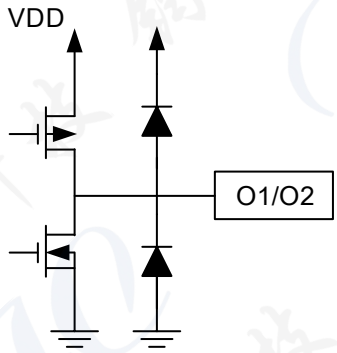
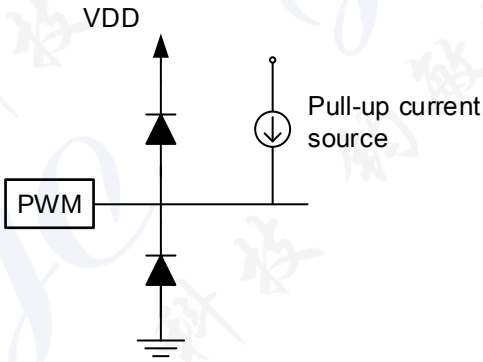
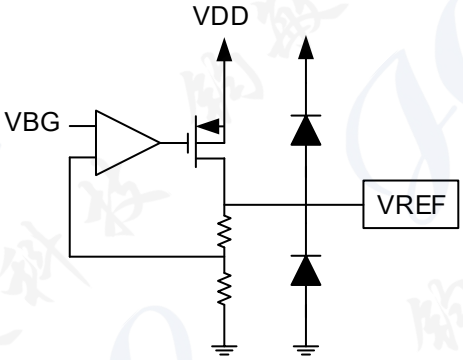
I/O Equivalent circuits



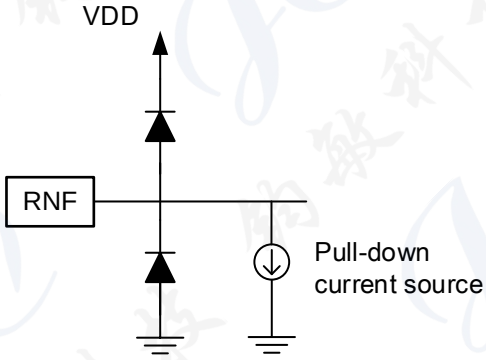
O1/O2 Output



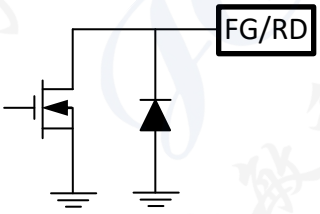
PWM input



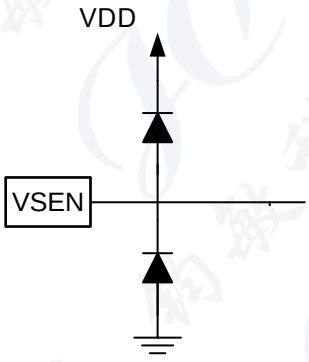
VREF Output



RNF Input



FG/RD Output



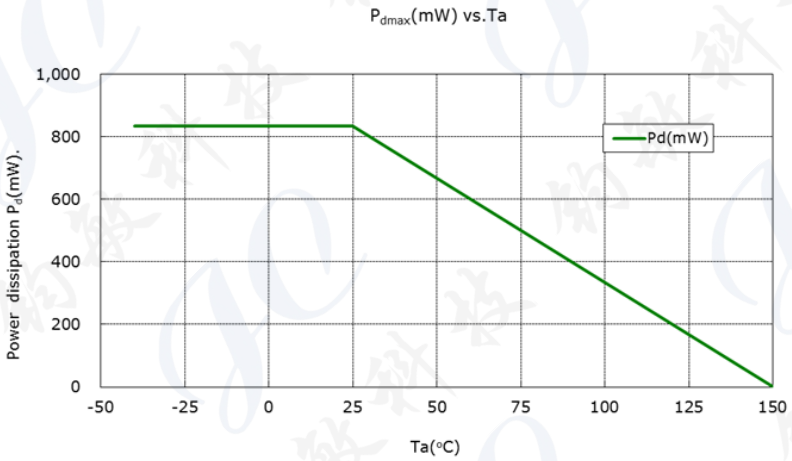
VSEN Input

Thermal resistance

SOP-10F

Parameter	Symbol	Conditions	Rating	Units
Allowable power dissipation	P_d		833*1	mW
Junction to ambient thermal resistance	θ_{JA}		150	℃/W
Junction to case thermal resistance	θ_{JC}		50	℃/W
Maximum junction temperature	T_{Jmax}		150	℃

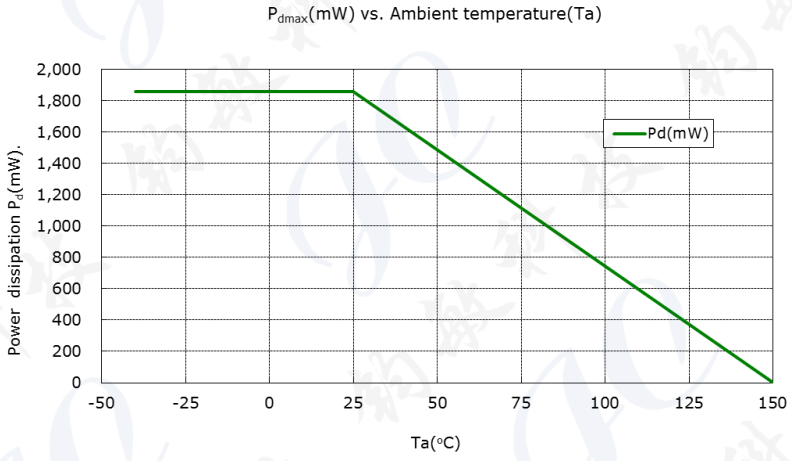
*1: Reduced by 6.67mW for each increase in Ta of 1°C over 25°C When mounted on 50mm x 50mm x 1.6mm glass epoxy board



DFN-10

Parameter	Symbol	Conditions	Rating	Units
Allowable power dissipation	P_d		1860	mW
Junction to ambient thermal resistance	θ_{JA}	2s0p PCB, still-air	67	℃/W
Junction to case thermal resistance	θ_{JC}		10	℃/W
Maximum junction temperature	T_{Jmax}		150	℃

*1: Reduced by 14.88mW for each increase in Ta of 1°C over 25°C When mounted on 50mm x 50mm x 1.6mm glass epoxy board

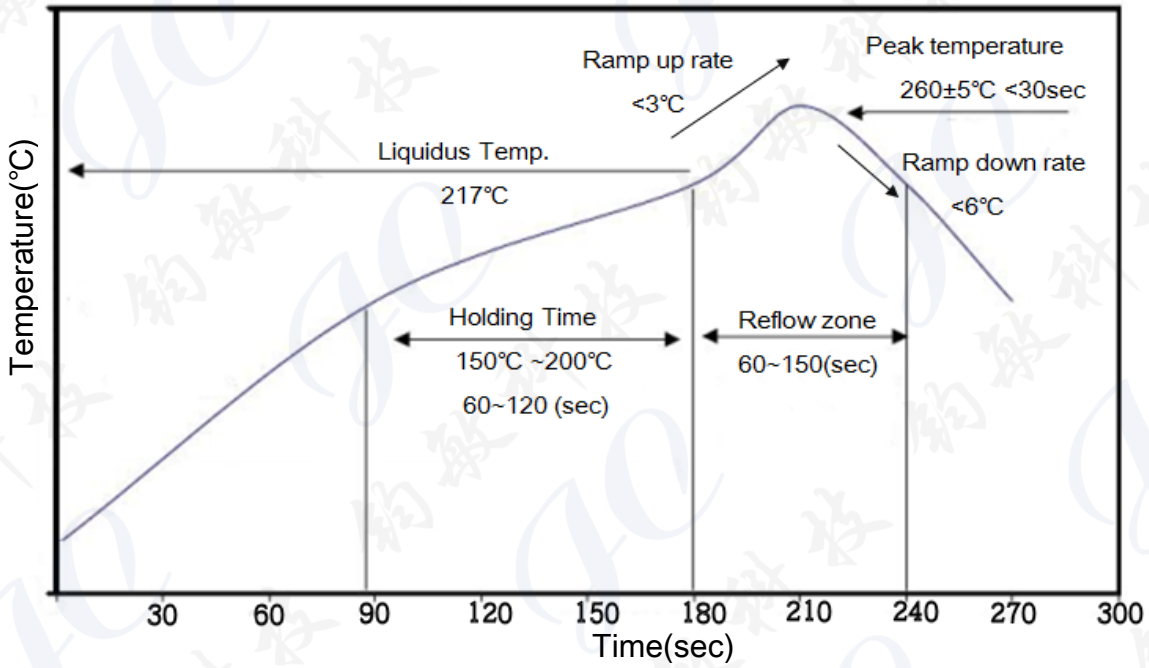


Soldering recommendations

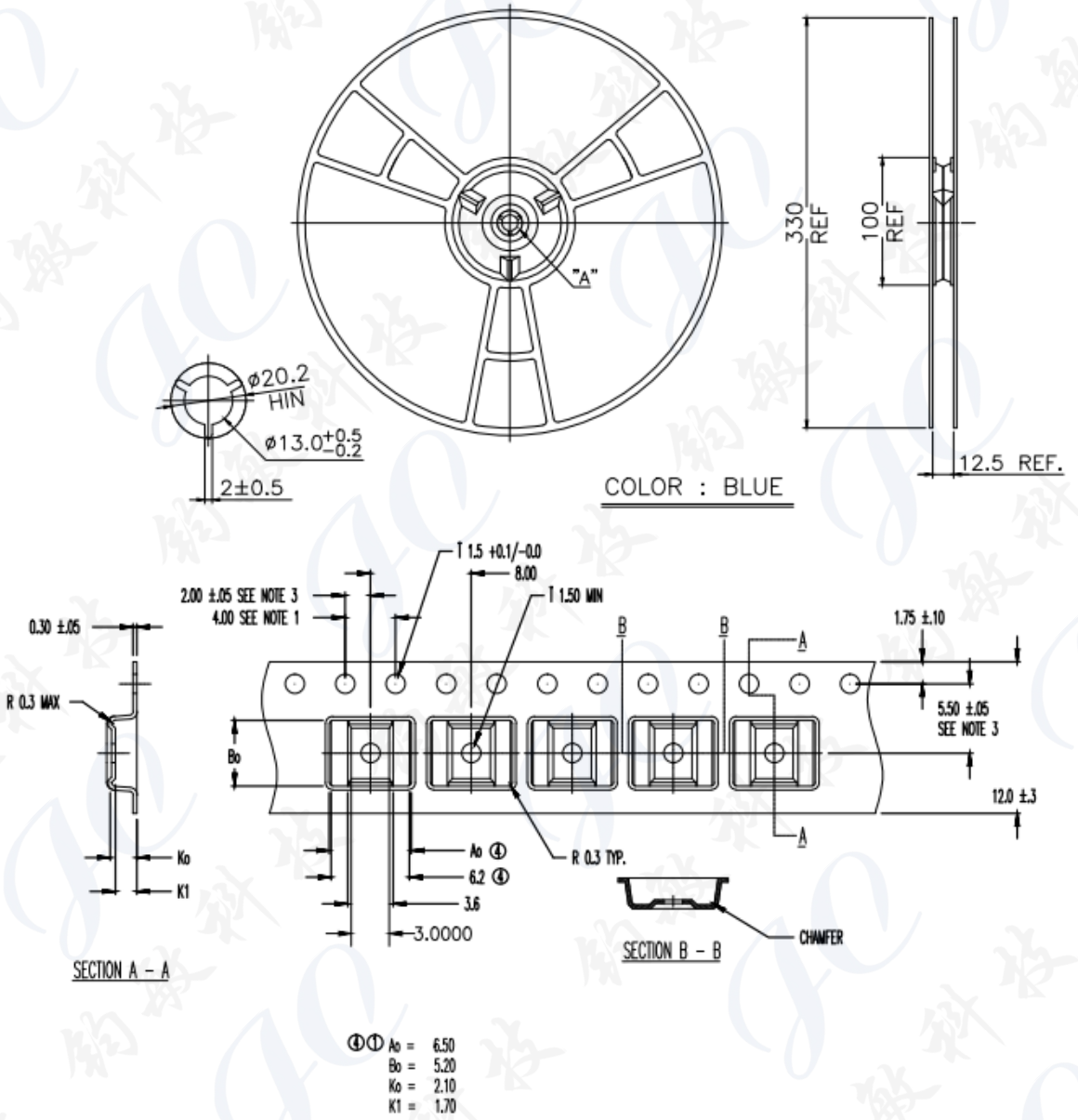
1. JEDEC J-STD-020
2. Iron Soldering

   Temperature and Time: 350°C, 3S
3. Reflow

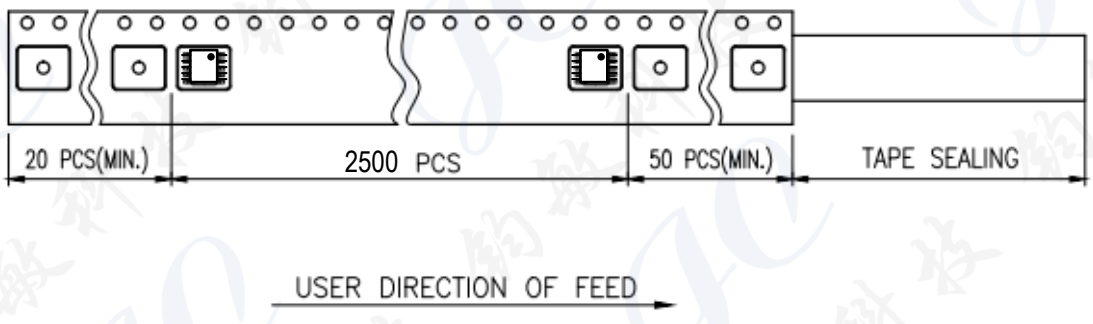
   Temperature profile should conform to described in JEDEC-020 standard



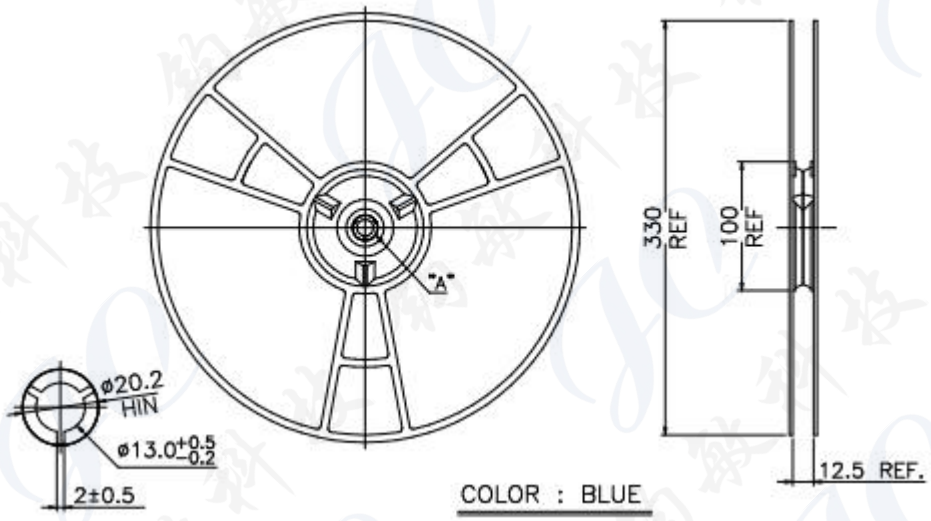
Carrier Tape & Reel specifications
SOP-10F (Reverse)

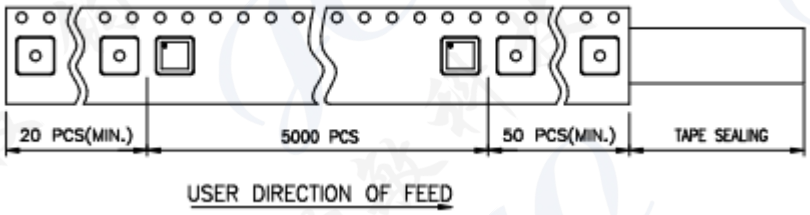


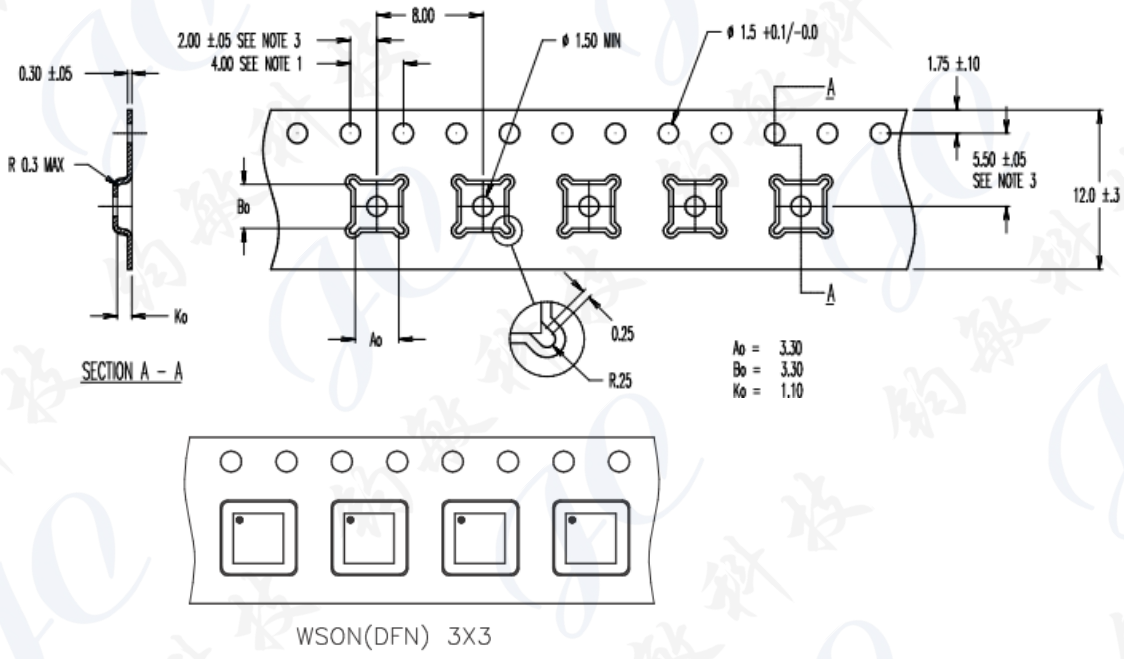
Quantity: 2500 EA/PER REEL, 5 REEL/BOX



DFN-10







QUANTITY: 5000 EA/PER REEL, 5 REEL/BOX

Ordering information

Product	Function Code	Temp. Code(Tj)	Package Code	MOQ
PL393W-A	FG	A(-40°C~+150°C)	PR(SOP-10F,Reverse)	12.5K EA/BOX
PL393W-A	RD	A(-40°C~+150°C)	PR(SOP-10F,Reverse)	12.5K EA/BOX
PL393W-A	FG	A(-40°C~+150°C)	HF(DFN-10)	25K EA/BOX
PL393W-A	RD	A(-40°C~+150°C)	HF(DFN-10)	25K EA/BOX

Please issue order P/N code. like : PL393W-AFGAPR

Revision history table

Revision Date	Description of Revision
2019/11/05	● Add RD output function.
2019/01/25	● Add Thermal protection description. ● Add Output On Resistance description(R_{DSON}).
2020/08/04	● Add revision history table list. ● Truth table add SOP-10F icon. ● Add RD function description. ● Adjust Hall sensor and truth table relevance description.
2021/09/29	● Jump start protection: The example calculation formula Ru is corrected to 33KΩ.