DC Brushless Motor Driver IC

PL392F
12V Single coil Motor Driver IC with PWM control

Applications

- Single coil DC brushless motor

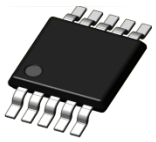
Features

- Built-in hall sensor
- Single phase full wave driver
- Soft switching output driver
- Motor locked protection and automatic restart
- Speed controllable by DC/PWM
- FG output
- Current limit
- Quick start
- Built-in hysteresis comparator
- Built-in zener diode
- High balance and low thermal drift magnetic sensing
- Low power consumption and high driving efficiency
- Jump start protection
- AEC Q100 qualified
- RoHS 2.0 compliance
- MSOP10/DFN10 with heat sink for better thermal performance .

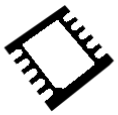
Package:

MSOP-10

SOP-10



DFN-10 (3x3)



Specifications

Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol	Conditions	Rating	Units
Maximum supply voltage	VDDmax		18	V
Allowable power dissipation	Pd	MSOP10	1786*1	mW
		SOP10	833	
		DFN10	1860	
Operating temperature	Ta		-40~+105	℃
Storage temperature	Ts		-50~+150	℃
Max. output current	Iomax	0.5sec	1200*2	mA
Max. FG output voltage	V_{FGMAX}		18	V
Max. FG output current	I_{FGMAX}		10	mA
VREF driving capability	I_{VREF}		5	mA
Junction Temperature	Tj		150	℃

*1: Reduced by 14.3mW for each increase in Ta of 1°C over 25°C When mounted on 50mm x 50mm x 1.6mm glass epoxy board
*2: Should not exceed Pd

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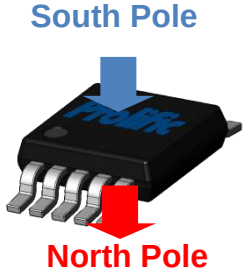
Electrical Characteristics (T_A=+25°C, V_{DD}=12V)

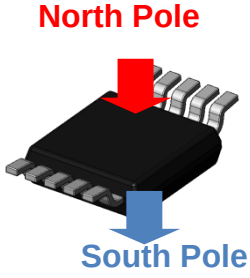
Characteristic	Symbol	Test Condition	Min.	Typ.	Max.	Units
Supply Voltage	V_{DD}		3.8		16	V
Output High Voltage	$V_{OH(ON)}$	@ I_{OUT} =300mA	V_{DD}-0.4	V_{DD}-0.2		V
Output Low Voltage	$V_{OL(ON)}$	@ I_{OUT} =300mA		0.2	0.4	V
Output Voltage Clamp	V_{BV}		18			V
Supply Current	I_{DD}	Output open		7	10	mA
FG output voltage	V_{FG}				18	V
FG sink voltage	V_{DSFG}	R_{FG}=4.7K		0.2	0.3	V
PWM input voltage	V_{PWM}		0		VREF	V
PWM input current	I_{PWM}				10	uA
Built-in PWM frequency	F_{PWM}		20	25	30	KHz
PWM ON Duty 1	D1	V_{PWM}=1V	75	80	85	%
PWM ON Duty 2	D2	V_{PWM}=2.5V	15	20	25	%
VREF Voltage	V_{REF}		3.6	3.8	4.0	V
VL input Voltage	VL		GND		VREF	V
VL input current	I_{VL}				-10	uA
Current limit Voltage	V_{CL}		220	250	280	mV
Shutdown Time	T_{SD}		2.8	4.2	5.6	S
Restart Time	T_{RS}		0.2	0.3	0.4	S
Magnetic Characteristics (T_A=+25°C, V_{DD}=12V)						
Operate Point	B_{OP}		-	15	35	G
Release Point	B_{RP}		-35	-15	-	G
Hysteresis	B_{HYS}		10	30	60	G

Truth Table

Parameter	Test Condition	O1	O2	FG	Mode
South Pole to Marking side	B>Bop	L	H	L	During rotation
North Pole to Marking side	B<Brp	H	L	H	



O1 Output = Low



O1 Output = Low

General Specifications

The PL392F 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 PL392F will benefit EMI performance. PL392F is also featuring with jump start protection according to ISO16750-2. This IC is an optimal solution with speed controllable by direct PWM input signal for Automotive DC brushless fan application specifically.

Lock Protection

In order to protect the motor, the driver IC will be shutdown to drive the coil when the motor is locked over 0.3 second. Then, it restarts to drive the motor after 4.2 seconds. Figure 1 shows the timing diagram between the hall input signal and driver's output state.

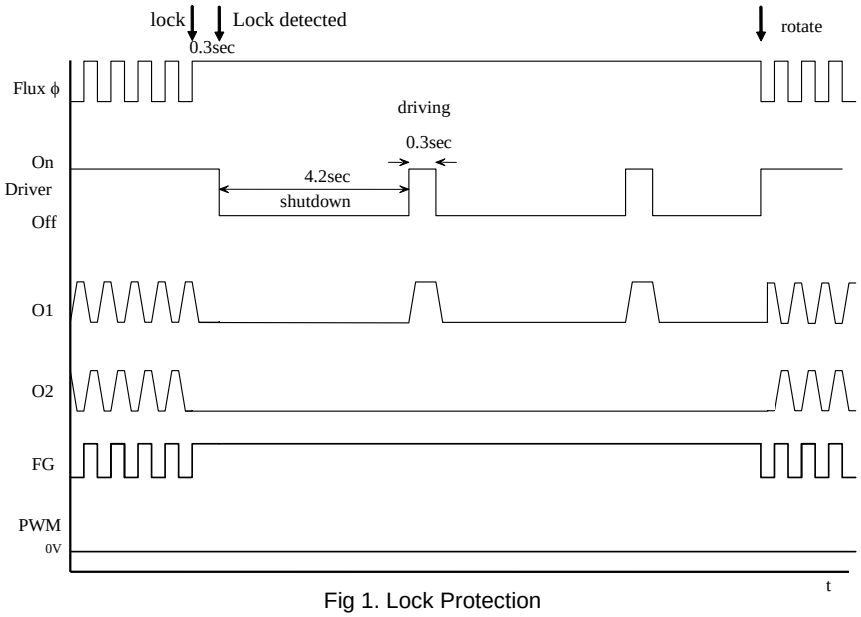


Fig 1. Lock Protection

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 PWM duty cycle and control the speed of fan motor as Fig 2. The V_{PWM} Voltage is compared with an internal 0.5V-3V saw waveform V_{SAW} and output PWM duty control signal. The output PWM ON duty cycle is controlled by 0.5V~3V DC V_{PWM} voltage from 100% to 0%. The formula of ON duty is Duty=-40(V_{PWM}-3)%. The digital PWM input signal also can be converted to DC voltage level via an external RC low pass filter.

Lowest speed setting

The VL is used to set the lowest duty cycle of PWM output as Fig3. The VL voltage determines the lowest speed of Fan motor. Example, the minimum ON duty will be 20% when VL=2.5V. However, this driver IC starts motor with full duty of PWM in beginning.

Quick Start

Motor's speed is controlled by PWM input signal. When PWM pin is open or tied to GND, the motor will be full speed rotation. This PWM speed control make the lock protection off and stop the motor when the PWM input keeps high level (>3V) for more than 25mS(typ.). The motor will be started directly without the lock protection time delay when the PWM signal set to (0V~VO) as Fig4.

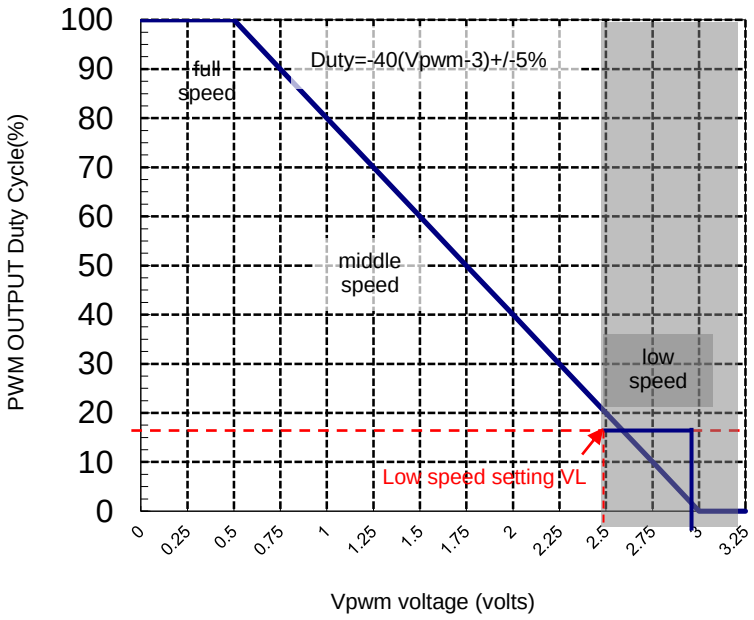


Fig. 2 Output duty cycle vs. V_{PWM} voltage

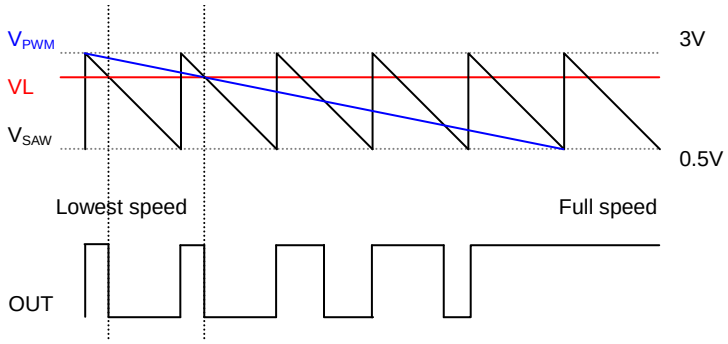


Fig. 3 Output duty cycle vs. VL voltage

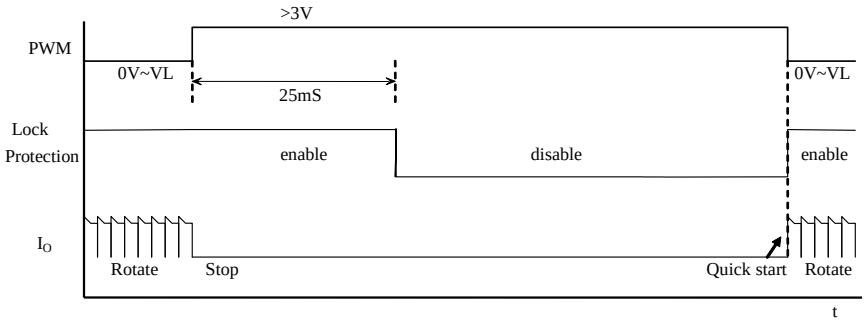


Fig 4. PWM input and Lock Protection

Current limit

This diver IC has built-in current limit function to protect Fan motor. The output current limit is activated when the current sensing voltage CS detected from RNF resistor exceeds 250mV (typical). The value of current limit is got by the formula 250mV/RNF. Example, the maximum output current is limited at 1A when the current detecting resistor RNF is 0.25ohm. The value of current limit is adjustable to meet different need by RNF changing. If the RNF=1ohm, the value of current limit is 250mA.

Current Limit (A) = 0.25(V) / RNF(Ω)

Low-pass filter constituted by R1,C1 could smooth RNF signal but also increase limit error due to sensing delay. R1,C1 value shall be decided first and match with coils. Then, adjust RNF resistor value to obtain ideal current limit value.

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. 5 and the threshold of the magnetic flux density is +-15 Gauss.

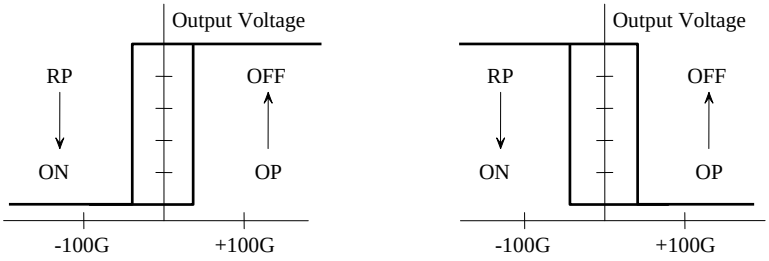


Fig 5. Magnetic Hysteresis Characteristics

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

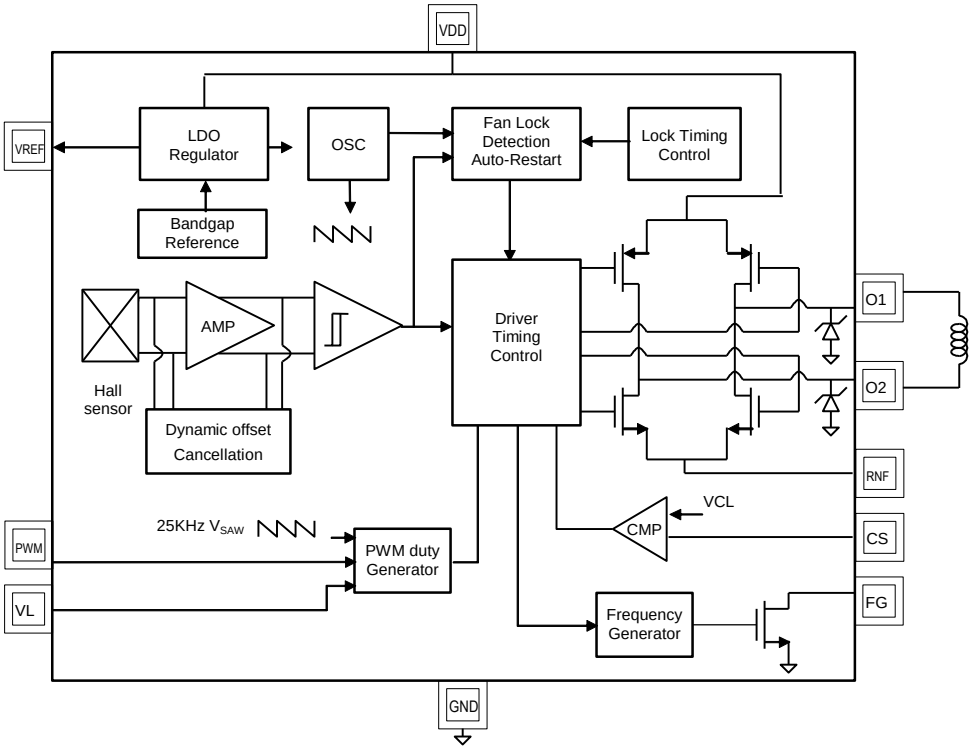
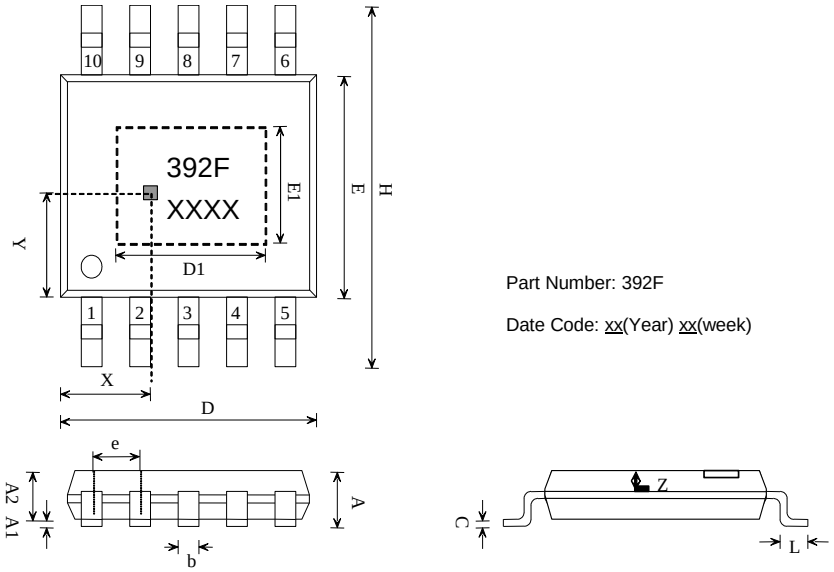


Fig6. PWM Driver IC Architecture

Pin Description

MSOP-10

NAME	Pin	Description	Type	HBM (V)	MM (V)	Sustained Voltage (V)
PWM	1	Direct PWM speed control input	I	±8000	±450	16
VREF	2	Reference voltage output	O	±6000	±450	18
VDD	3	DC power supply	P	±8000	±450	18
O2	4	Second output pin	O	±8000	±1000	18
RNF	5	Current sensing resistor	O	±6000	±450	18
GND	6	DC ground	P	±8000	±450	18
O1	7	First output pin	O	±8000	±1000	18
CS	8	Current sensing input	I	±6000	±400	16
VL	9	Low speed setting	I	±6000	±450	16
FG	10	Frequency Generation	O	±4000	±400	16



Part Number: 392F

Date Code: xx(Year) xx(week)

SYMBOLS	DIMENSIONS IN MILLIMETERS(mm)		
	MIN	NOM	MAX
A	0.90	1.00	1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
b	0.15	-	0.30
C	0.13	-	0.23
D	2.90	3.00	3.10
D1	1.42		1.78
E	2.90	3.00	3.10
E1	1.52		1.91
H	4.65	4.90	5.15
e	-	0.50	-
L	0.40	0.60	0.80
SENSOR LOCATION			
X	-	1.10	-
Y	-	1.50	-

Pin Description

SOP-10

NAME	Pin	Description	Type	HBM (V)	MM (V)	Sustained Voltage (V)
PWM	1	Direct PWM speed control input	I	±8000	±450	16
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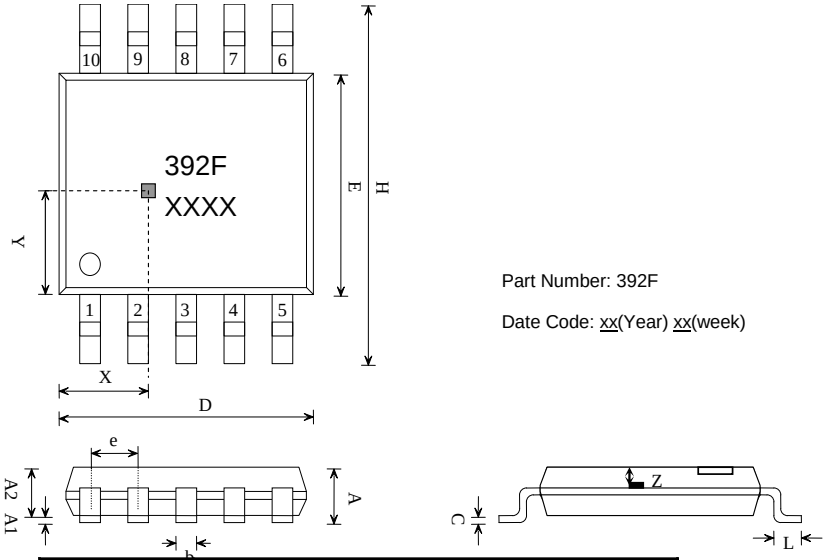

Part Number: 392F

Date Code: xx(Year) xx(week)

SYMBOLS	DIMENSIONS IN MILLIMETERS(mm)		
	MIN	NOM	MAX
A	1.47	1.60	1.73
A1	0.10	-	0.30
A2	-	1.45	-
b	0.33	0.41	0.51
C	0.19	0.20	0.25
D	4.80	4.85	4.95
E	3.81	3.91	3.99
H	5.79	5.99	6.20
e	-	1.00	-
L	0.8	-	1.27
SENSOR LOCATION			
X	-	2.00	-
Y	-	1.85	-
Z	-	0.35	-

Pin Description

DFN-10

NAME	Pin	Description	Type	HBM (V)	MM (V)	Sustained Voltage (V)
PWM	1	Direct PWM speed control input	I	±8000	±450	16
VREF	2	Reference voltage output	O	±6000	±450	18
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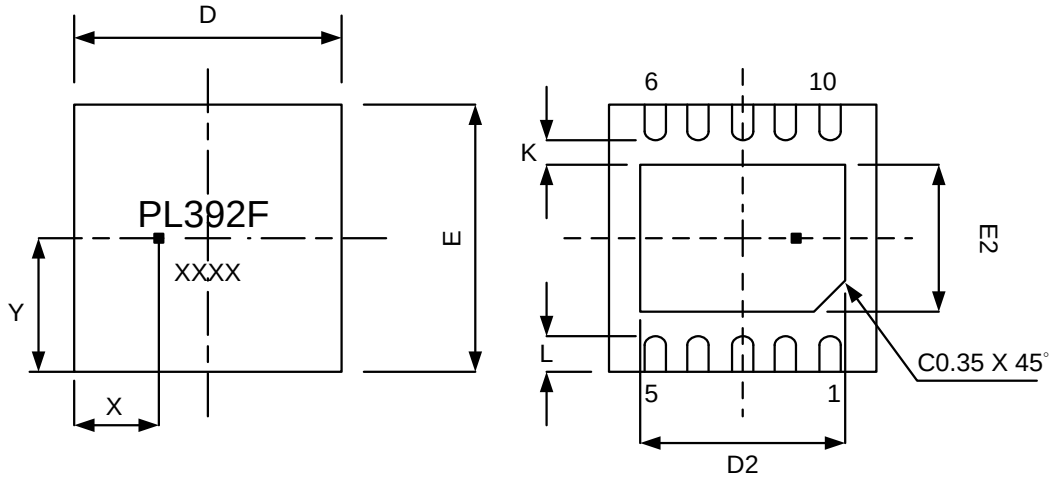
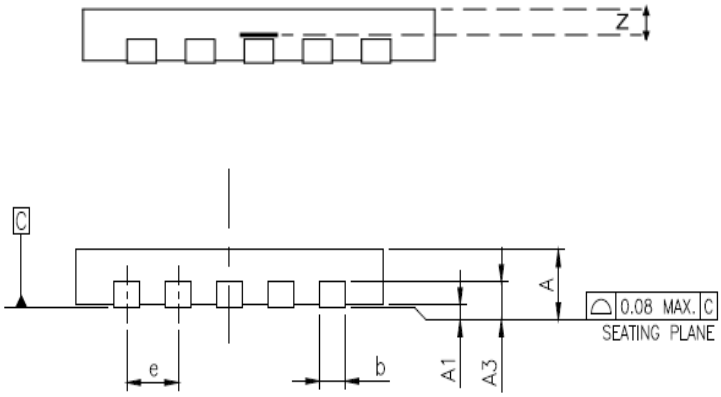
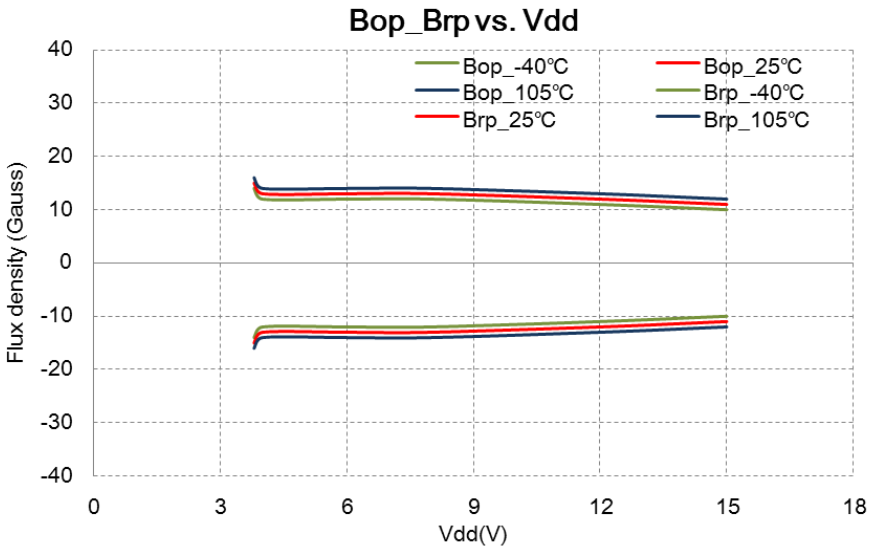
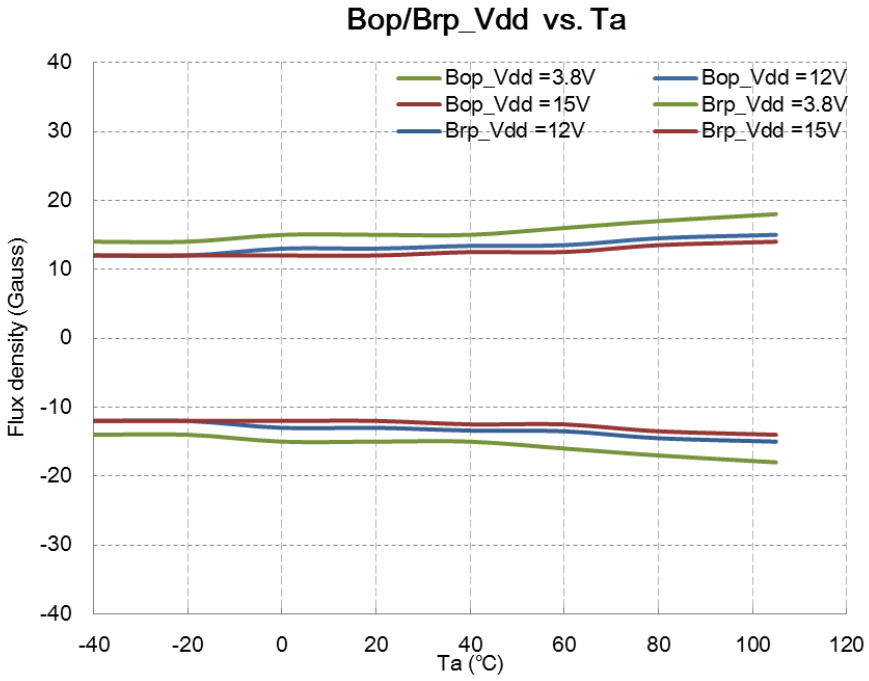
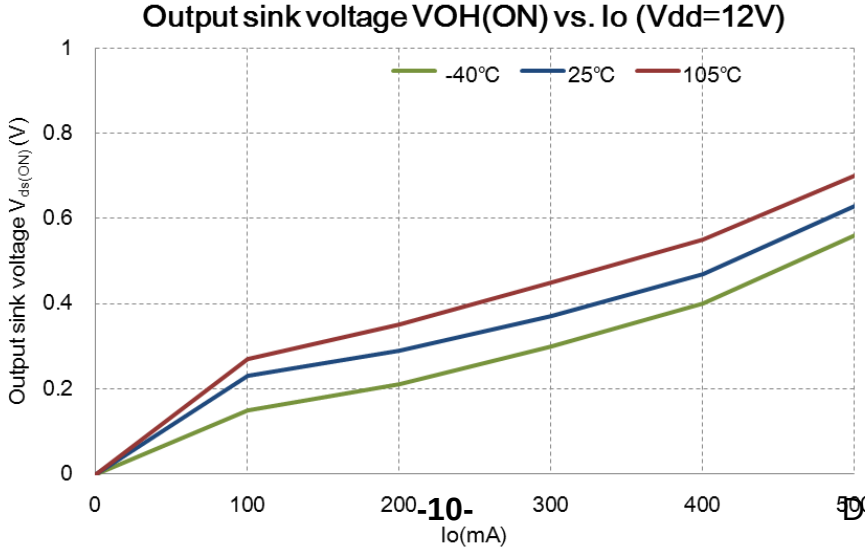


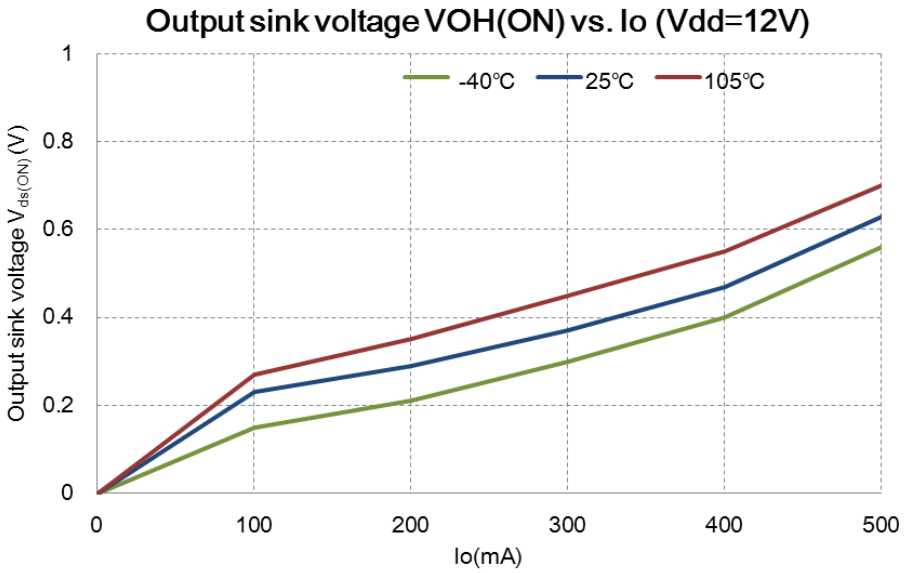
SYMBOLS	MIN.	NOM.	MAX.
A	0.7	0.75	0.8
A1	0.00	0.02	0.05
A3		0.203 REF	
b	0.18	0.25	0.3
D		3.00 BSC	
E		3.00 BSC	
e		0.50 BSC	
K	0.20	-	-
Pad Size			
D2	2.20	2.30	2.35
E2	1.55	1.65	1.70
L	0.30	0.40	0.50
Sensor Location			
X	0.85	0.95	1.05
Y	1.40	1.50	1.60
Z	0.07	0.08	0.09

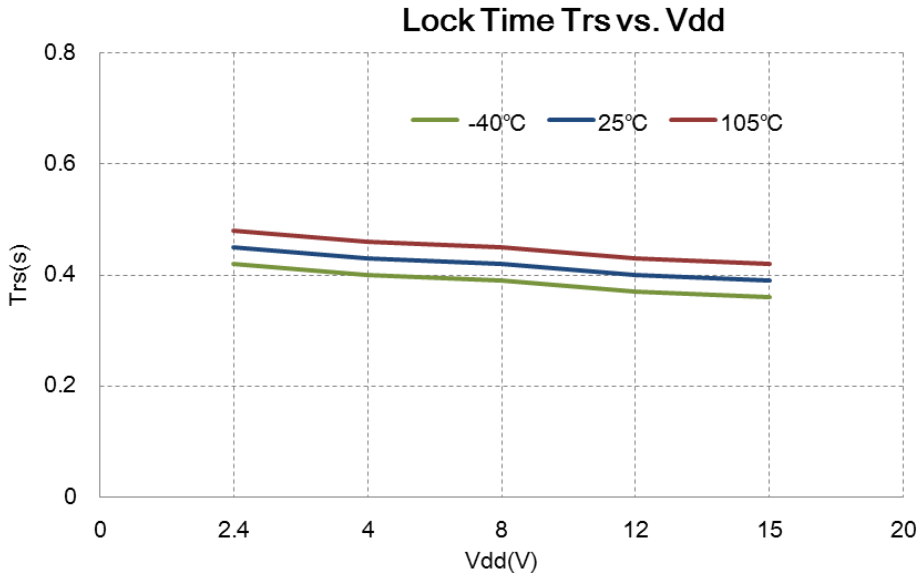



Bop_Brp vs. Vdd
Bop_-40℃
Bop_25℃
Bop_105℃
Brp_-40℃
Brp_25℃
Brp_105℃
Flux density (Gauss)
40
30
20
10
0
-10
-20
-30
-40
0
3
6
9
12
15
18
Vdd(V)


Bop/Brp_Vdd vs. Ta
Bop_Vdd =3.8V
Bop_Vdd =12V
Bop_Vdd =15V
Brp_Vdd =3.8V
Brp_Vdd =12V
Brp_Vdd =15V
Flux density (Gauss)
40
30
20
10
0
-10
-20
-30
-40
-40
-20
0
20
40
60
80
100
120
Ta (℃)

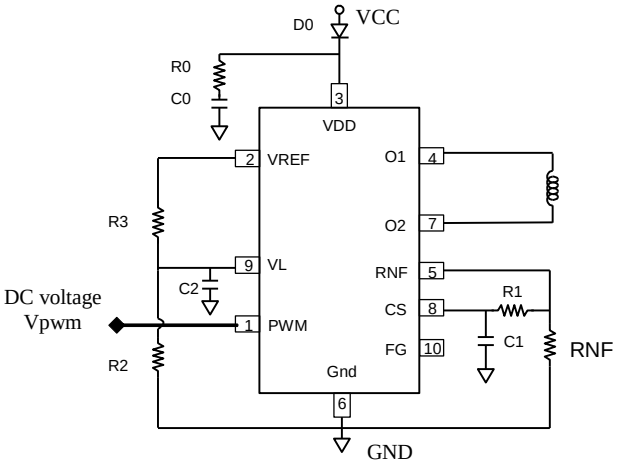

Output sink voltage VOH(ON) vs. Io (Vdd=12V)
-40℃
25℃
105℃
Output sink voltage Vds(ON) (V)
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
Io(mA)


Output sink voltage VOH(ON) vs. Io (Vdd=12V)
-40℃
25℃
105℃
Output sink voltage $V_{ds(ON)}$ (V)
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
Io(mA)


Lock Time Trs vs. Vdd
-40℃
25℃
105℃
Trs(s)
0.8
0.6
0.4
0.2
0
0
2.4
4
8
12
15
20
Vdd(V)

Application circuits

DC voltage PWM input

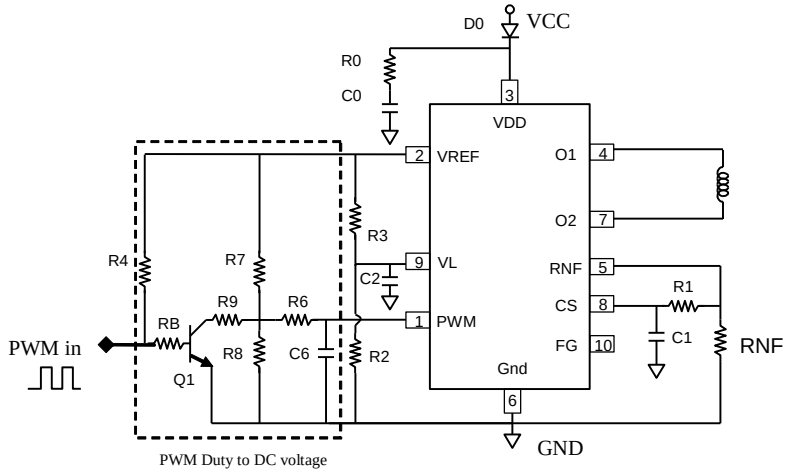


C0: decoupling capacitor 0.1uF ~ 1uF
R0: Snubber circuit resistor 4.7ohm~10ohm
RNF: Current sensing resistor (ex. 0.25ohm for 1A current limit)
C1, R1: Low pass filter (ex. C1=1n~0.01uF, R1=1K~10K; need to match with coil)
R2, R3: Low speed setting resistor (ex. R2=10K, R3=5.2K, VO=VREF*R2/(R2+R3)=2.5V)
C2 : filter capacitor 1nF

Duty=-40(Vpwm-3)%

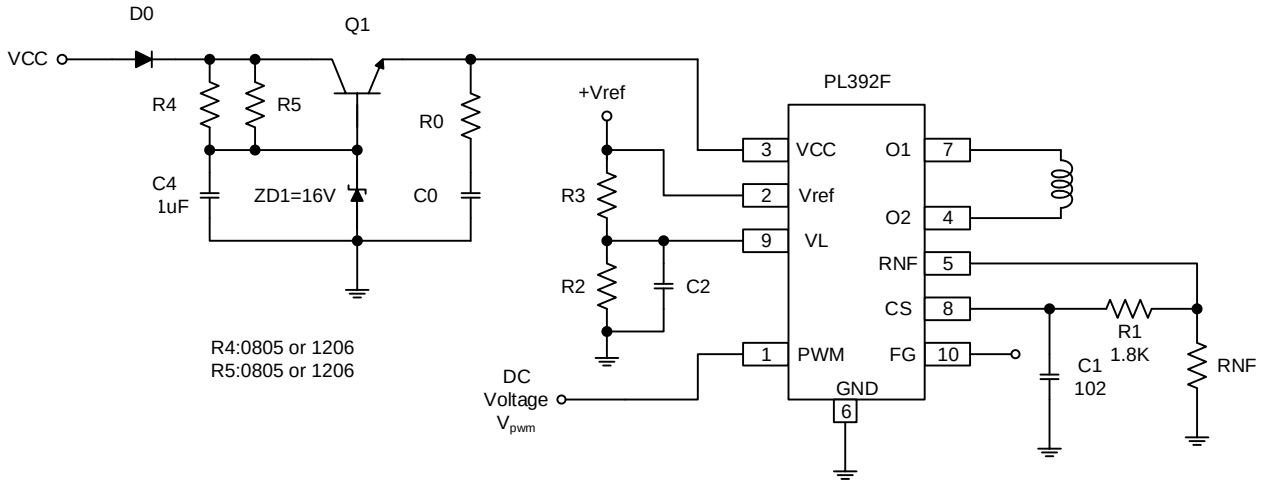
PWM Voltage(Vpwm)	Output Duty(on/off)%	FAN Speed
0V~0.5V	100/0	Full speed
1.0V	80/20	
1.5V	60/40	
2.0V	40/60	
2.5V	20/80	Low speed
3.0V~	0/100	STOP

Digital PWM input



R4: pull up resistor (option)
RB: Bias resistor 1K~10K for Q1
C6, R6: Low pass filter (ex. R6=100K~470K, C6=0.01uF~1uF)
R7, R8, R9: Vpwm level setting resistor (ex. R7=1.8K, R8=10K, R9=0~330)
Q1: NPN Transistor (ex 2222A)

Jump Start Protection Circuit



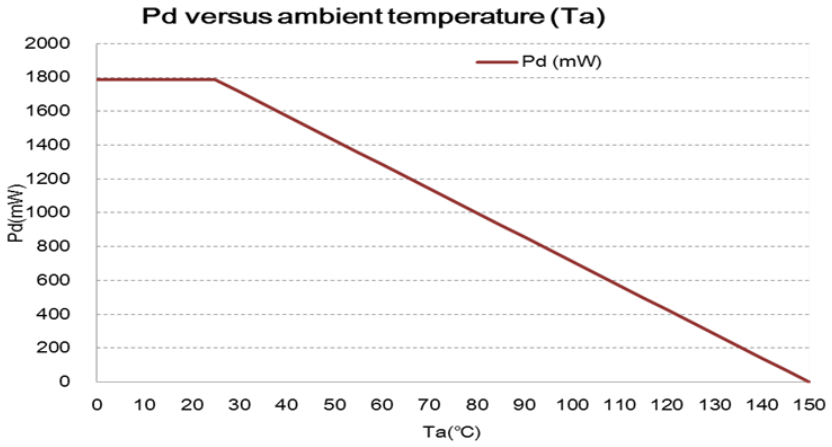
C0: decoupling capacitor 0.1uF ~ 1uF
R0: Snubber circuit resistor 4.7ohm~10ohm
RNF: Current sensing resistor (ex. 0.25ohm for 1A current limit)
C1, R1: Low pass filter ,C1=1nF, R1=1.8K
R2, R3: Low speed setting resistor (ex. R2=10K, R3=5.2K, VL=VREF*R2/(R2+R3)=2.5V)
C2 : filter capacitor 1nF
ZD1 : 16V
R4 : 0805 or 1206
R5 : 0805 or 1206
C4 : 1uF

MSOP10

Thermal resistance

Parameter	Symbol	Conditions	Rating	Units
Allowable power dissipation	P_d		1786*1	mW
Junction to ambient thermal resistance	θ_{JA}		70	℃/W
Junction to case thermal resistance	θ_{JC}		12	℃/W
Maximum junction temperature	T_J		150	℃

*1: Reduced by 14.3mW for each increase in Ta of 1°C over 25°C When mounted on 50mm x 50mm x 1.6mm glass epoxy board

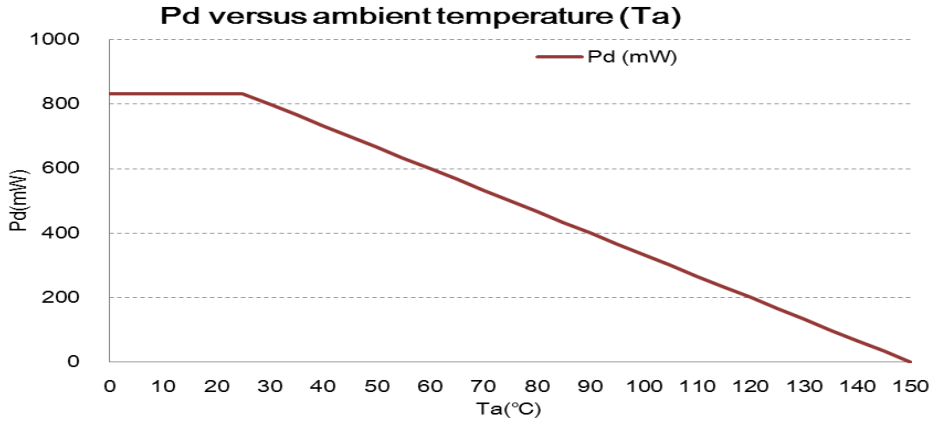


SOP10

Thermal resistance

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_J		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

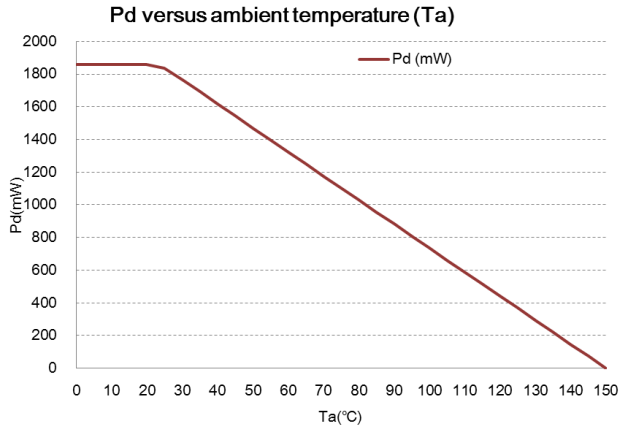


DFN10

Thermal resistance

Parameter	Symbol	Conditions	Rating	Units
Allowable power dissipation	P_d		1860	mW
Junction to ambient thermal resistance	θ_{JA}		78	℃/W
Junction to case thermal resistance	θ_{JC}		10	℃/W
Maximum junction temperature	T_J		150	℃

*1: Reduced by 14.3mW for each increase in Ta of 1°C over 25°C When mounted on 50mm x 50mm x 1.6mm glass epoxy board



Power dissipation calculation

Power Dissipation Total = Static power dissipation (Pd_static) + Driving power dissipation (Pd_drv) + Switching loss (Pd_sw)

Static power dissipation (Pd_static) : Vdd * Idd

Driving power dissipation (Pd_drv) : Io * Vsat

Switching loss (Pd_sw) : duration of switching * period of per rotation * Io * Vdd

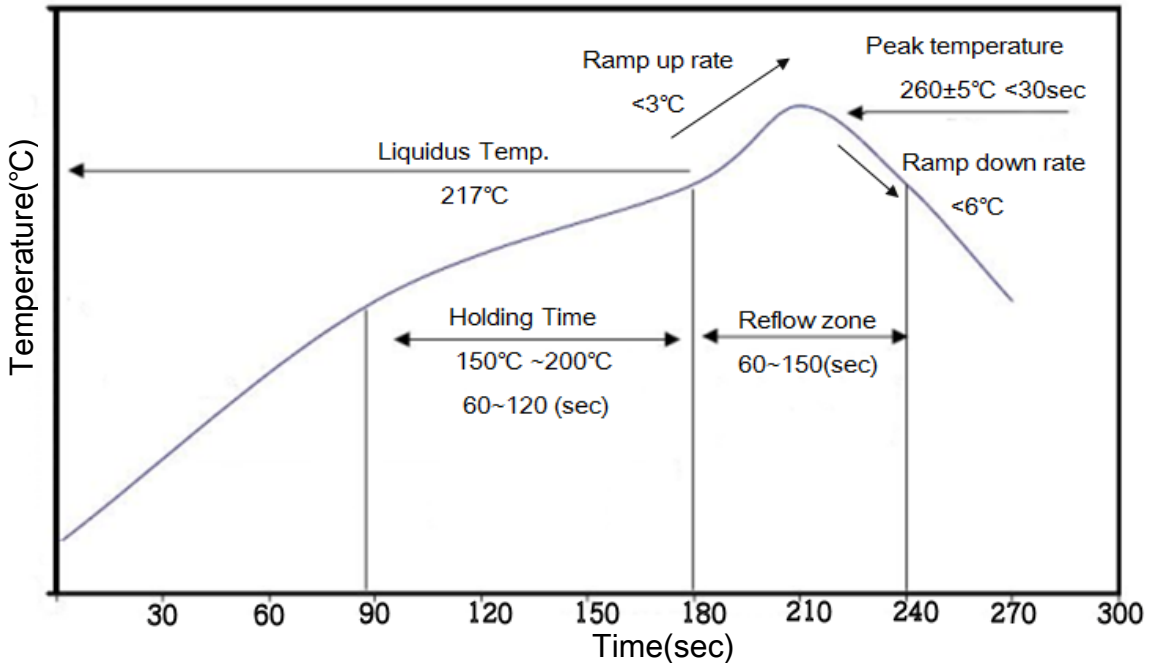
Soldering recommendations

1. JEDEC J-STD-20
2. Iron Soldering

Temperature and Time: 350°C, 3S

3. Reflow

Temperature profile should conform to described in JEDEC-020 standard

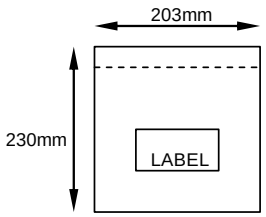


ESD Sensitivity level

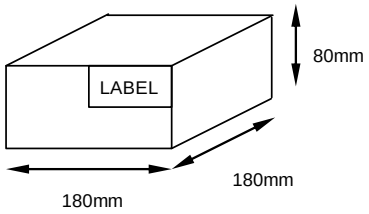
Immunity test	Standard	Class	Sensitivity Range
HBM	MIL-STD-883H / Method 3015.8	3A	4000V
MM	ANSI/ESD S5.2-2009	M4	450V

Packing specification

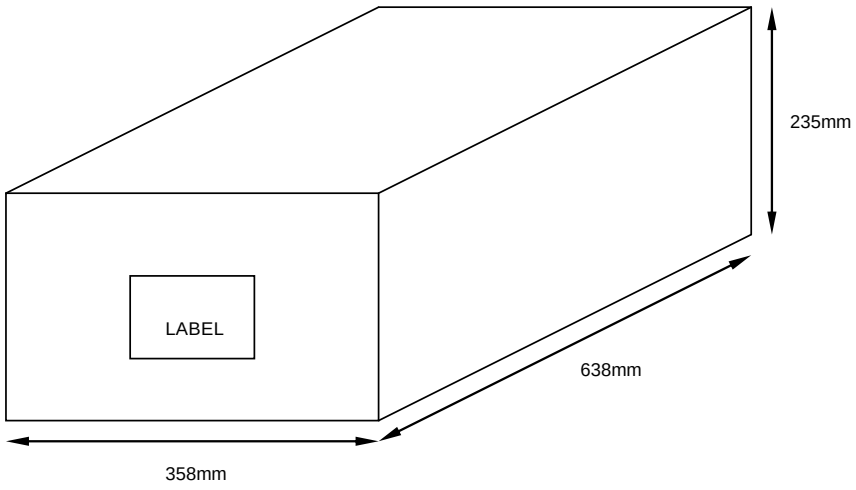
1. Reference document: PD-3-75-010
2. Dimension:



BAG



BOX



CARTON

3. Quantity:

Type	Package	Amount Per Reel (EA)	Amount Carton (EA)
SOP10	Reel	2500	12500
SOP10	Reel	2500	12500
DFN10	Reel	2500	12500

Order information

Part Number	Temperature Range	Package Type	Delivery	MOQ
PL392FI1MFG8P1	-40°C~+105°C	MSOP-10	Reel	12.5K EA/BOX
PL392FI1PFG8P1	-40°C~+105°C	SOP-10	Reel	12.5K EA/BOX
PL392FI1HGG8P1	-40°C~+105°C	DFN-10	Reel	12.5K EA/BOX