PL393V-A
24V Single-phase Motor Driver with PWM speed control

Applications

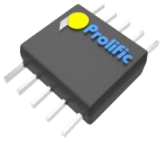
- Single coil DC brushless motor
- Automotive cooling fan driver

Features

- Built-in hall sensor
- Single phase full wave driver
- Linear Soft switching output driver
- Motor locked protection and automatic restart
- Speed controllable by DC/PWM
- FG output
- Current limit protection
- 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

Package:

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



DFN-10 (3x3x0.75mm)

Specifications

Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol	Conditions	Rating	Units
Maximum supply voltage	VDDmax	10u sec	42	V
Allowable power dissipation	Pd	SOP10F	833	mW
		DFN10	1860	mW
Operating temperature range	Tj		-40~+150	℃
Storage temperature	Ts		-50~+150	℃
Max. output current	I_{OMAX}	0.5sec	1200*1	mA
Max. FG output voltage	V_{FGMAX}		36	V
Max. FG output current	I_{FGMAX}		10	mA
Max. input voltage (PWM,VL,CS)	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 Breakdown Voltage	V_{BV}		32			V
Supply Current	I_{DD}	Output open		6	10	mA
FG output voltage	V_{FG}				30	V
FG sink voltage	V_{DSFG}	I_{FG}=3mA		0.2	0.3	V
PWM input voltage	V_{PWM}		GND		VREF	V
PWM input current	I_{PWM}	V_{PWM}=2.5V			10	uA
Built-in PWM frequency	f_{PWM}		20	25	30	KHz
PWM ON Duty 1	D1	V_{PWM}=1V	70	75	80	%
PWM ON Duty 2	D2	V_{PWM}=2V	20	25	30	%
VREF Voltage	V_{REF}	I_{REF}=2mA	4.8	5	5.2	V
VL input Voltage	V_L		GND		V_{REF}	V
VL input current	I_{VL}	V_L =V_{REF}	-1			uA
Current limit Voltage	V_{CL}		130	160	190	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_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	FG	Mode
North Pole	B<Brp	H	L	H	During rotation
South Pole	B>Bop	L	H	L	

South Pole

North Pole

O1 Output = Low

General Specifications

The PL393V-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 PL393V-A will benefit EMI performance. PL393V-A is also featuring with jump start protection according to ISO16750-2. This IC is an optimal solution with 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 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.

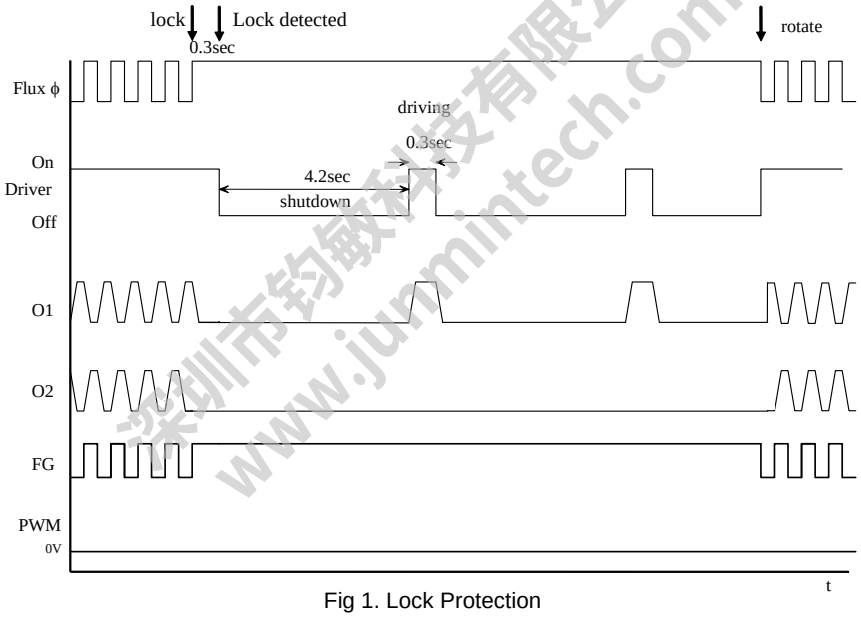


Fig 1. Lock Protection

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 output PWM duty cycle and control the speed of fan motor as Fig 2. The V_{PWM} Voltage is compared with an internal 0.5V-2.5V saw waveform V_{SAW} and output PWM duty control signal. The output PWM ON duty cycle is controlled by 0.5V~2.5V DC V_{PWM} voltage from 100% to 0%. The formula of ON duty is Duty=-50(V_{PWM}-2.5)%. 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 25% when VL=2.0V. 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 (>3.0V) for more than 25mS(typ.). The motor will be started directly without the lock protection time delay when the returned PWM voltage is lower than 2.5V as Fig4.

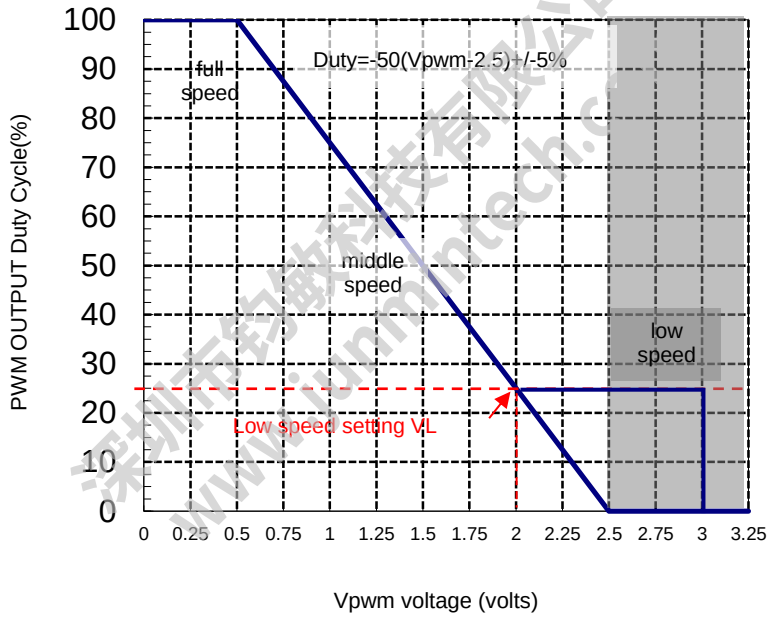


Fig. 2 Output duty cycle vs. V_{PWM} voltage

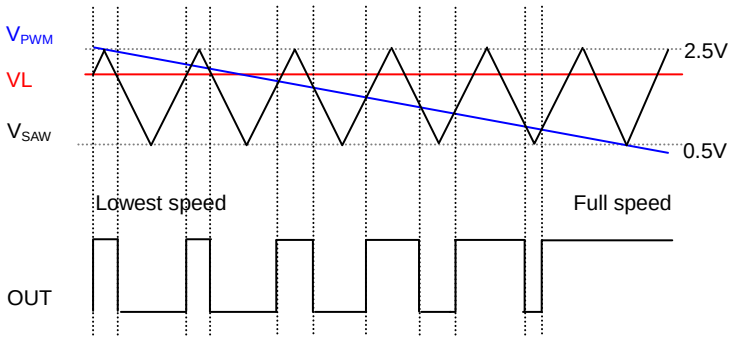


Fig. 3 Output duty cycle vs. VL voltage

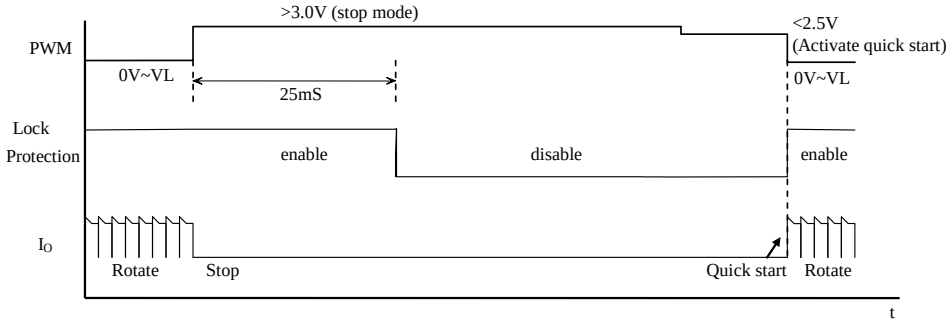


Fig 4 PWM input and Lock Protection

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 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.

Current Limit (A) = 0.16(V) / RNF(Ω)

Low-pass filter constituted by R,C could smooth RNF signal but also increase limit error due to sensing delay. R,C 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 +-10 Gauss.

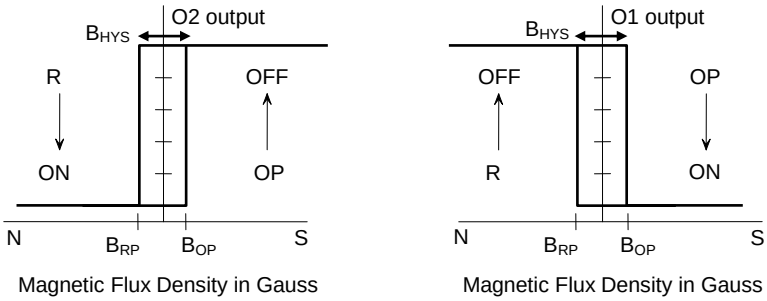


Fig 5. Magnetic Hysteresis Characteristics

Jump start protection

During the jump-start overvoltage test, an overvoltage will be applied to V_{DD}. In that case, output current will increase and extra heat generated. PL393V-A will activate jump-start protection to avoid such kind of circumstance.

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

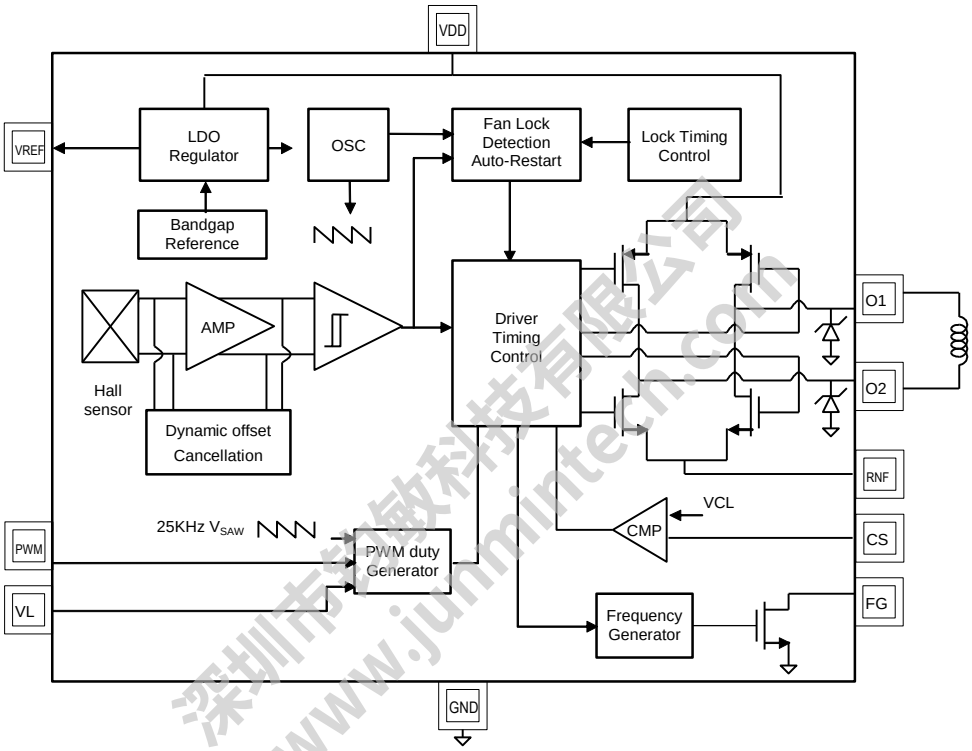
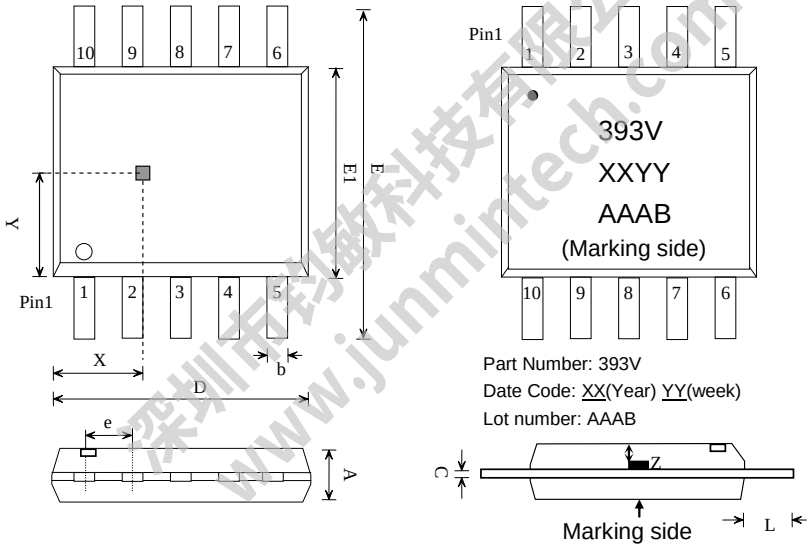


Fig6. PWM Driver IC Architecture

Pin Description

SOP-10F

NAME	Pin	Description
PWM	1	DC voltage/Direct PWM
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
CS	8	Current Sensing input pin
VL	9	Low Speed Setting input pin
FG	10	Frequency Generation output 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

NAME	Pin	Description
PWM	1	DC voltage/Direct PWM
VREF	2	Reference Voltage Output
VDD	3	DC power supply
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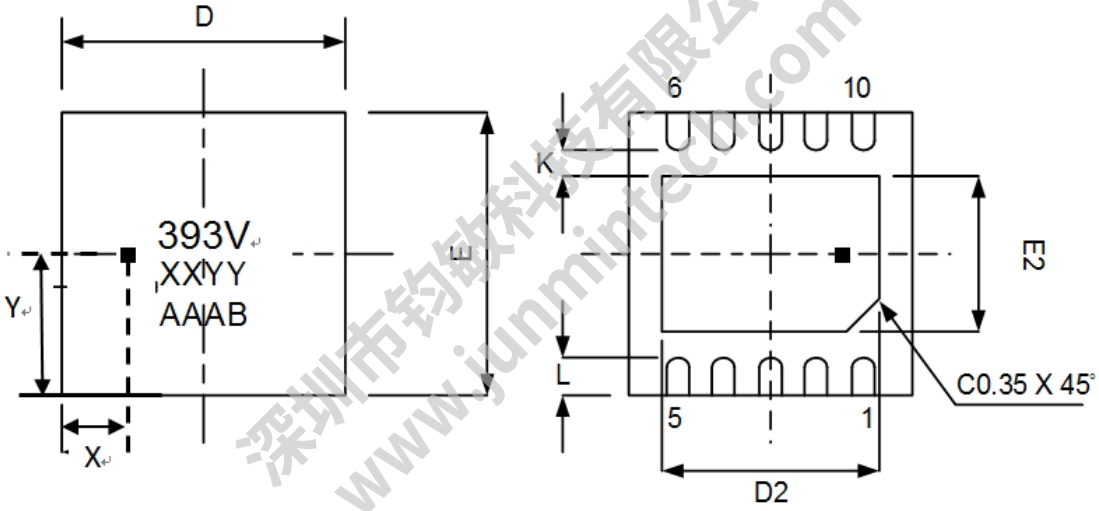
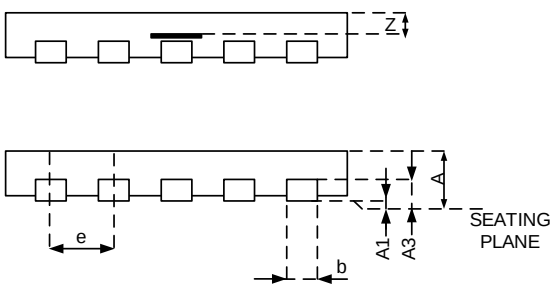


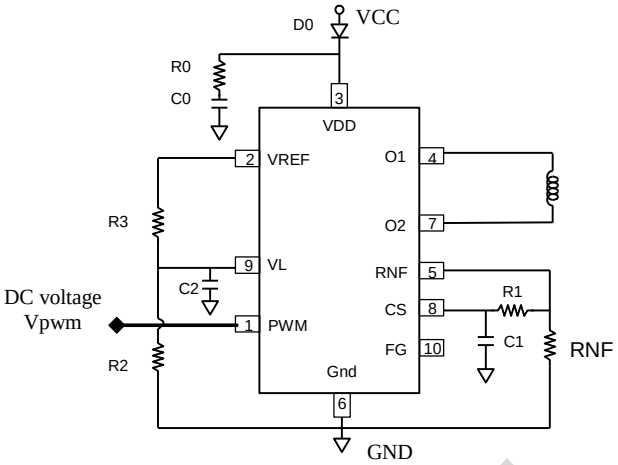
Part Number : 393V
Date Code : XX(Year) YY (Week)
Lot Number : AAAB



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		0.5 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

Application circuits

DC Voltage PWM input

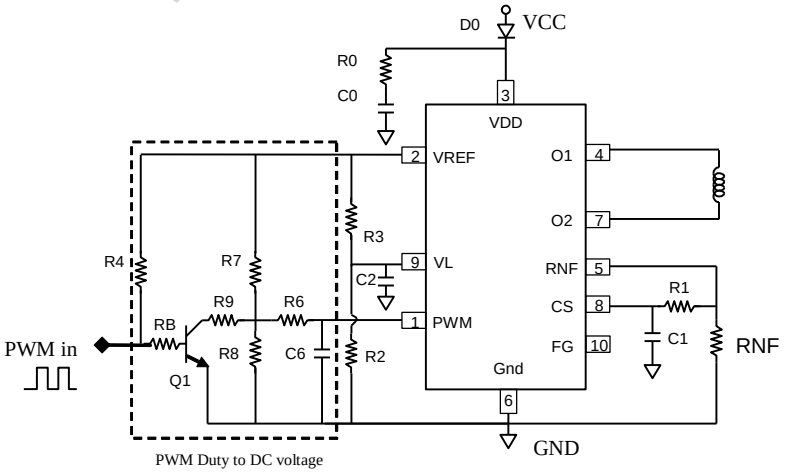


C0: decoupling capacitor 0.1uF ~ 1uF
R0: Snubber circuit resistor 4.7ohm~10ohm
RNF: Current sensing resistor (ex. 0.25ohm for 0.8A current limit)
C1, R1: Low pass filter (ex. C1=1n~0.01uF, R1=1K~10K; need to match with coil)
R2, R3: Low speed setting resistor (ex. R2=8K, R3=12K, VL=VREF*R2/(R2+R3)=2.0V; +Duty=25%)
C2 : filter capacitor 1nF

+ Duty=-50(Vpwm-2.5)%; VL=2.0V

PWM Voltage(Vpwm)	Output Duty(on/off)%	FAN Speed
0V~0.5V	100/0	Full speed
1.0V	75/25	
1.5V	50/50	
2.0V	25/75	
2.5V	25/75	Low speed by VL setting
3.0V	0	STOP mode

Digital PWM input



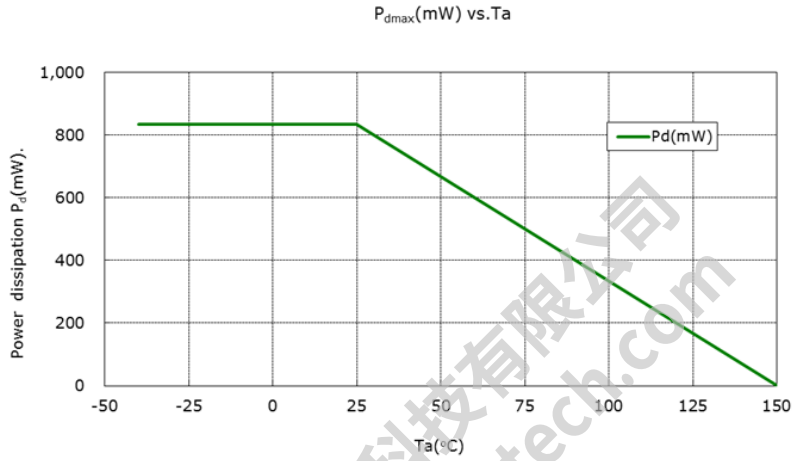
R4: pull up resistor (option)
RB: Bias resistor 1K~10K for Q1
C6, R6: Low pass filter (ex. R6=100K~470K, C6=0.01uF~1uF)
R7, R8, R9: Vpwm level setting resistor (ex. R7=1.8K, R8=10K, R9=0~330)
Q1: NPN Transistor (ex 2222A)

Thermal resistance

SOP-10

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



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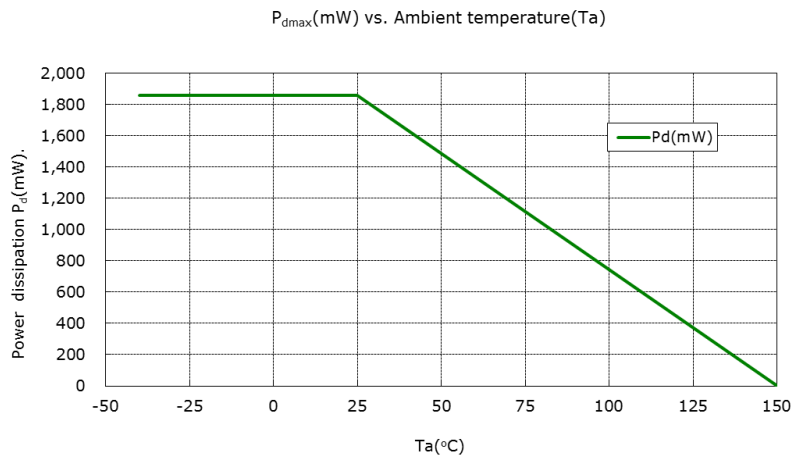
Parameter	Symbol	Conditions	Rating	Units
Allowable power dissipation	P_d		1860	mW
Junction to ambient thermal resistance	θ_{JA}	2s0p PCB, still-air	67	℃/W
Junction to case thermal resistance	θ_{JC}		10	℃/W
Maximum junction temperature	T_{Jmax}		150	℃

*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



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