DESCRIPTION

The PT2501 is a three-phase, hall sensor sinusoidal brushless DC motor control chip. The three-phase control is based on sine wave driving scheme and it is designed to reduce electrical audible noise in motor phase commutation. On-chip +5V LDO provide voltage for logic and analog circuits operation. Combined with an external high voltage gate driver and six n-channel MOSFETs, PT2501 can operate with high voltage motor to 400V. For 12V to 24V operation, the built-in 60mA gate driving can connect to external high side PMOS and low side NMOS easily. The PT2501 offers external and internal OTP parameters setting to optimize with different motors and applications. The package of PT2501 is SSOP28.

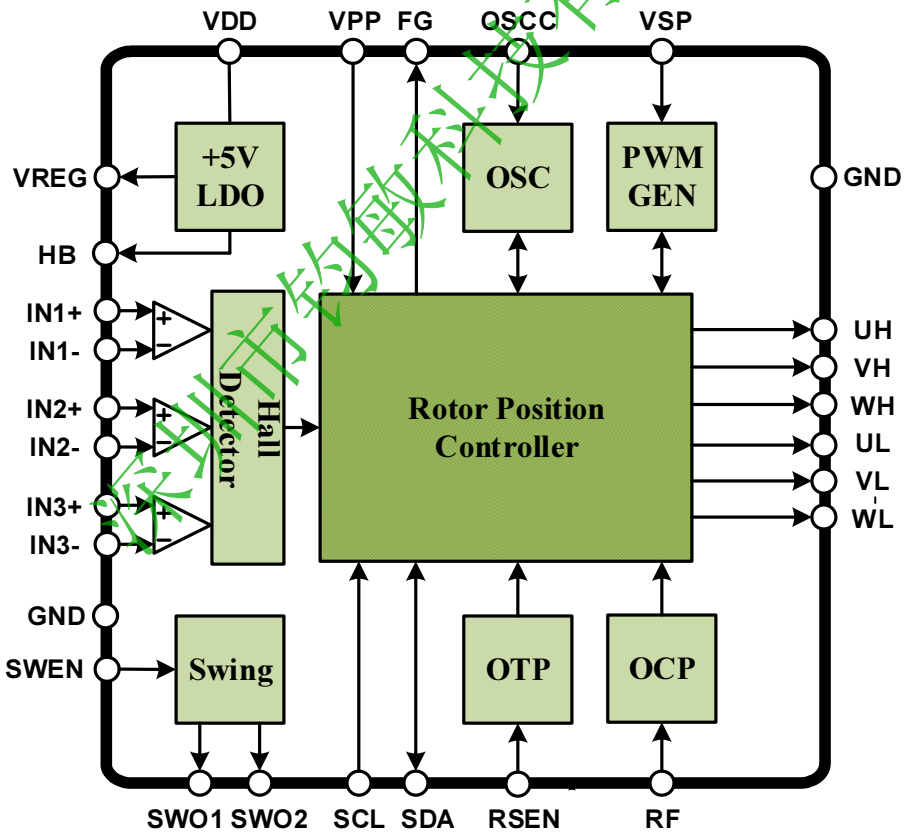
FEATURES

- Hall sensor sinusoidal control for 3-phase BLDC
- Current limit function
- Over temperature protection from external NTC
- Motor lock protection
- Reverse function.
- PWM or DC input for speed control
- FG output for rotation speed
- Pre-driver for 12V to 24V high side PMOS and low side NMOS.
- Support Hall element and Hall sensor
- I2C interface for parameter setting and write to interal OTP.

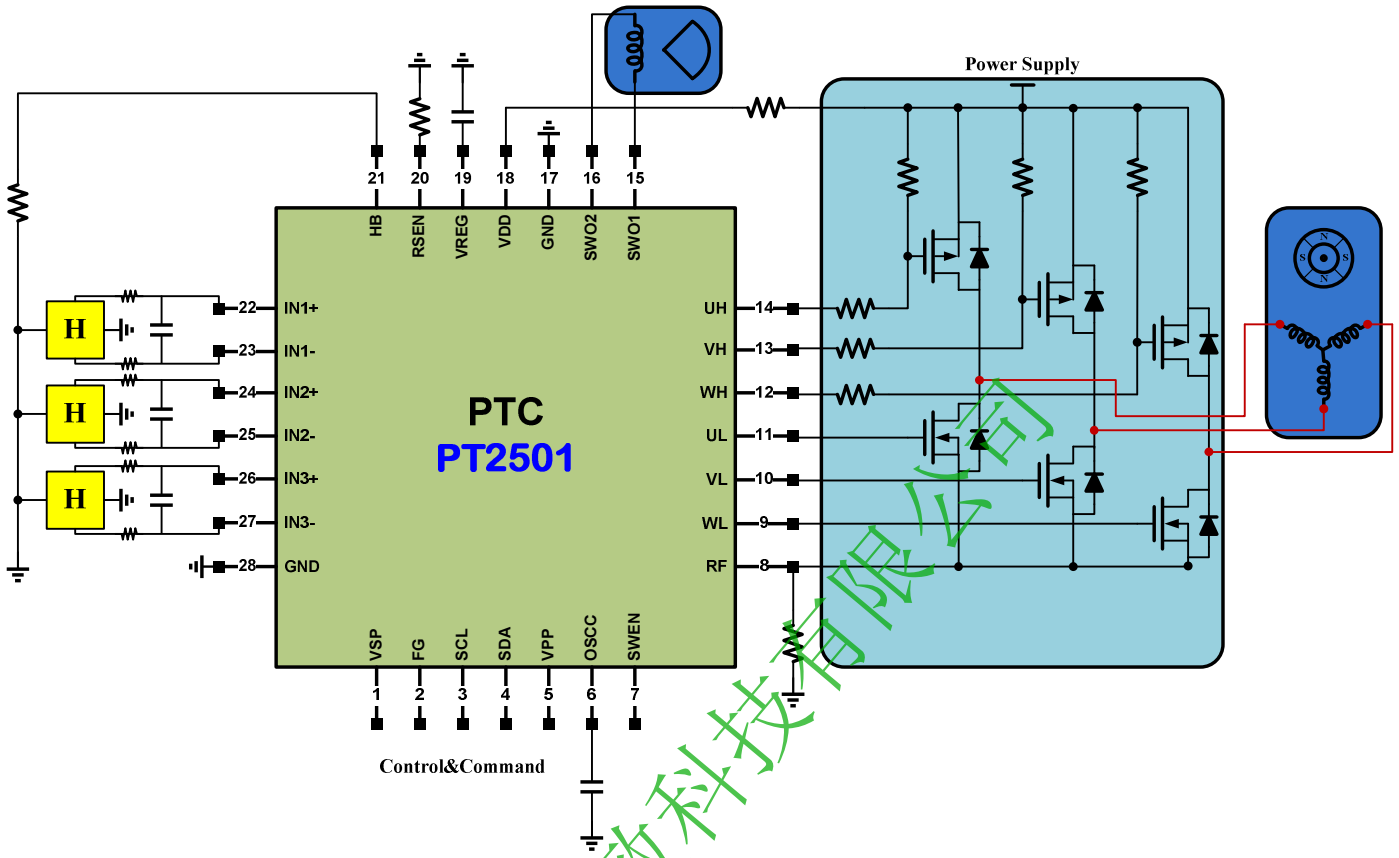
APPLICATIONS

- Three-phase BLDC motor
- Fan application

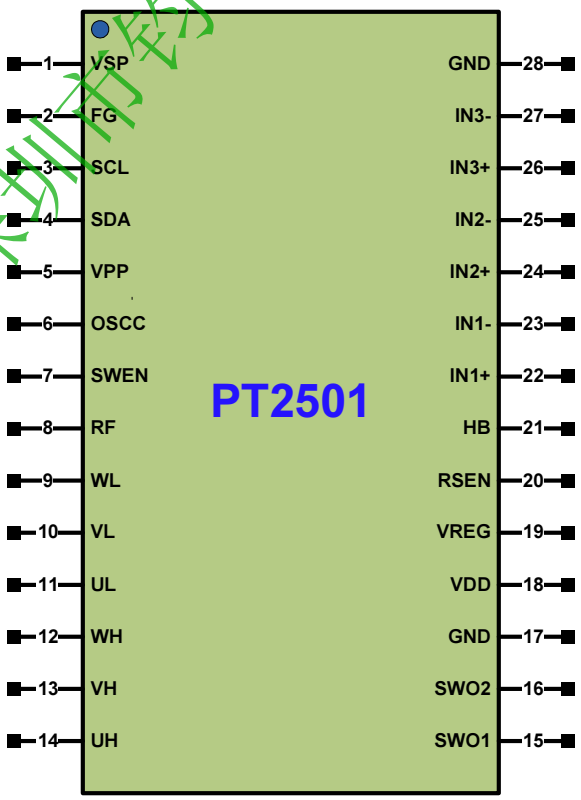
BLOCK DIAGRAM



APPLICATION BLOCK DIAGRAM



PIN ASSIGNMENT



PIN DESCRIPTION

Pin Name	I/O/P	Description	Pin No.
VSP	I	DC or PWM input for speed control	1
FG	O	Motor rotation speed indicator, logic level output	2
SCL	I	Serial clock input - I2C control interface	3
SDA	I/O	Serial data input/output – I2C control interface	4
VPP	P	a. Apply +7.5v for OTP programming b. Apply +5v for OTP reading	5
OSCC	I	Connect to external capacitor for startup step setting	6
SWEN	I	Swing head enable control; “1” = start motor	7
RF	I	Current limit voltage sensing	8
WL	O	W phase low side signal output	9
VL	O	V phase low side signal output	10
UL	O	U phase low side signal output	11
WH	O	W phase high side signal output(open drain)	12
VH	O	V phase high side signal output(open drain)	13
UH	O	U phase high side signal output(open drain)	14
SWO1	I/O	Swing motor control – full-bridge output 1	15
SWO2	I/O	Swing motor control – full-bridge output 2	16
GND	P	Signal ground	17
VDD	P	VDD supply input	18
VREG	O	+5V LDO output	19
RSEN	O	Connect to external NTC resistors for over temperature sensing	20
HB	O	Controlled +5V output for Hall sensor bias	21
IN1+	I	Hall element 1 input+	22
IN1-	I	Hall element 1 input-	23
IN2+	I	Hall element 2 input+	24
IN2-	I	Hall element 2 input-	25
IN3+	I	Hall element 3 input+	26
IN3-	I	Hall element 3 input-	27
GND	P	Signal ground	28

FUNCTION DESCRIPTION

POWER SUPPLY

PT2501 consumes very low current (<5mA) and build-in a 5V LDO for logic and analog circuits. For high voltage (24V<VM<400V) motor application, a 15V supply voltage is used for PT2501's VDD. For 12V to 24V motor application, PT2501 can adapt the supply voltage through a simple resistor-voltage-divider, or an external 12V regulator, without adding an external 5V regulator.

PT2501 will detect VREG to reach 3V internally for avoiding instability on external power. A power good signal will send to logic circuit to start operation within 10ms.

Adding proper bypass capacitor(s) close to the sensible IC pins will reduce interference from motor systems or wires and improve chip performance.

PWM OR DC INPUT FOR SPEED CONTROL

The PT2501 has an external DC or PWM control input to change the motor speed. For PWM input, the HIGH voltage level needs to be greater than 3.3V(recommended to 3.5V) and the LOW voltage level need to be less than 0.5V(recommended to 0.3V). The PWM carrier frequency is recommended between 15 KHz to 25 KHz. For DC input, the DC control voltage should range from 0.5V to 3.3V.

PT2501 has no speed control loop and it is suggested to get speed information from FG signal.

HALL SENSOR CONTROL SCHEME

The PT2501 control scheme is based on hall sensor information and produce sinusoidal excitation waveform. It benefits to provide accurate and silent (without electrical noise) driving control. Unlike the sensorless control scheme, hall sensor control provides smooth start-up without reverse rotation.

As shown in **Figure 1** and **Figure 2**, three hall sensors can be configured as 60° or 120° spacing through internal parameter.

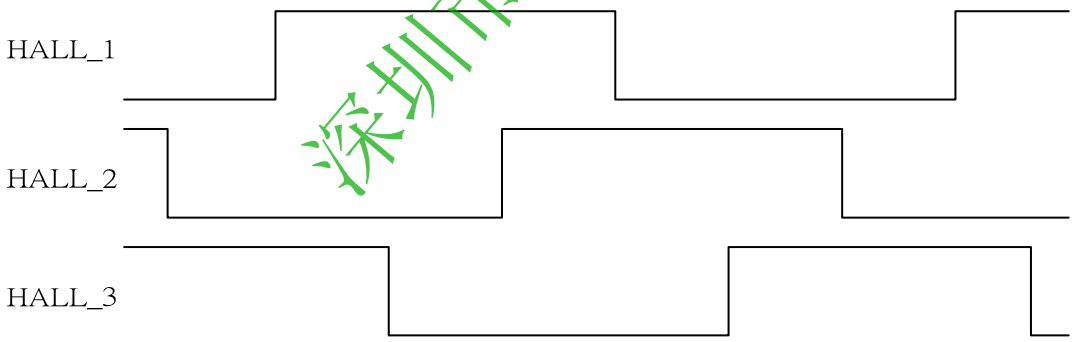


Figure 1. 120 degree spacing of the hall signals

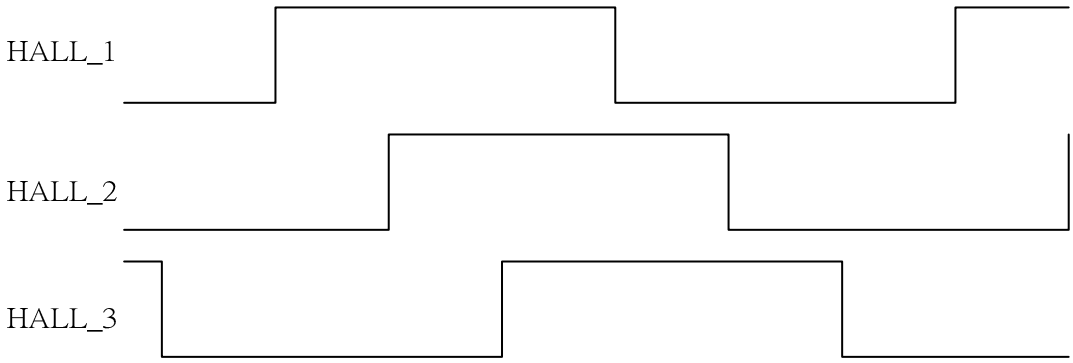


Figure 2. 60 degree spacing of the hall signals

The hall sensor has different sensitivity and layout distance from the rotor to cause phase offset. As shown in **Figure 3**, PT2501 can compensate the phase offset range from -60 degree to 60 degree through internal parameter.

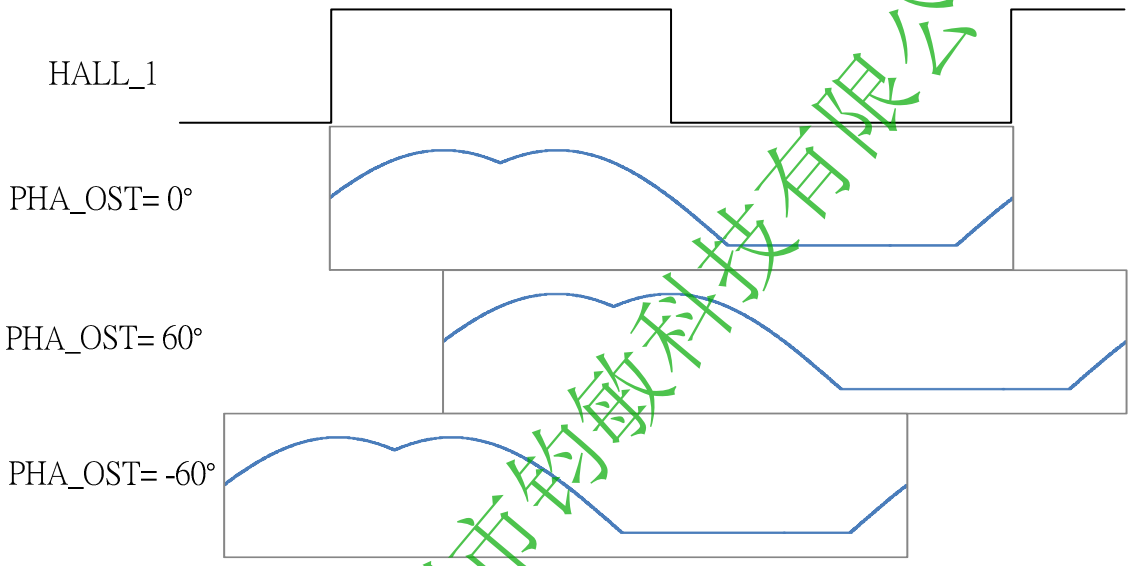


Figure 3, phase offset setting of the hall sensor signal

CURRENT PROTECTION

The PT2501 has a current limit function by using a sense resistor over RF pin and the sensed signal (V_{RF}) are related to phase-to-phase current. When the V_{RF} exceeds 0.4V, PWM duty will reduce to keep V_{RF} under 0.4V threshold. And if the V_{RF} exceed suddenly and abnormally, the PWM turnoff, system go in lock mode.

START UP & LOCK PROTECTION

The initial position information is provided by hall sensor. According to hall signal, PT2501 commutates motor and startup. To increase/ decrease PWM duty, the motor speed can be accelerated/ decelerated. And the profit can be set from parameters.

If the controller did not detect the expected hall sensor signal, the state machine would go to the lock protection mode. PT2501 will wait a period and re-start again (the period and re-start times are set by internal parameter). If the motor remained to be locked, it would cause system fall into the dead lock status. System no longer start at this state, and the only way to restart the system is turning off then turning on the supply voltage.

OVER TEMPERATURE PROTECTION

PT2501 supports the use of external negative temperature coefficient resistor (NTC) as the sources of temperature sensor. For pin RSEN, there is a pull-up resistor 47K inside the chip. The NTC resistor can tie to ground thru pin RSEN and place near a heat source, such as a MOSFET. If the temperature rises, the NTC resistance will decrease and RSEN voltage level will be reduced. When RSEN voltage is less than 0.6V, the system will enter protection mode and shut down. After the system is cooling, RSEN voltage rise, when it is higher than 1.2V, the system will start again.

FG OUTPUT FOR SPEED INFORMATION

PT2501 has FG output to observe motor speed. When the rotor is running an electric cycle, the FG output toggles High to Low. So when calculating the rotation speed, it needs to take into account the pole numbers of the rotor. For example, if rotor is 8 poles (four pairs of NS), the motor run a lap will have 4 FG output. Motor speed is usually present in RPM (Revolutions per Minute), so the rotation speed of the simple formula is calculated as

RPM = FG x 120 / POLE, FG is frequency in Hz, “POLE” is numbers of rotor.

FG pin is a 5V logic output.

FORWARD AND REVERSE SETTING

PT2501 can be set to forward or reverse rotation with internal parameter. If the rotation is switched, the motor will stop automatically and rotate with opposite direction. It is also suggested to control the motor speed by monitoring FG signal to optimize the reverse behavior, such as slow down profile or reverse waiting time.

PARAMETERS SETTING

In PT2501, the over temperature and over current protection is set by external resistor. The other parameters are adjustable and wrote to internal OTP(One Time Programming) memory. PT2501 can be programmed two times through the I2C interface. VPP pin need apply +7.5V during the OTP programming.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min.	Max.	Unit
Supply voltage rage	V_{DD}	5	28	V
I/O voltage	–	-0.3	5	V
Operating temperature range	T_A	-40	+85	°C
Storagetemperature range	T_{STG}	-55	+125	°C

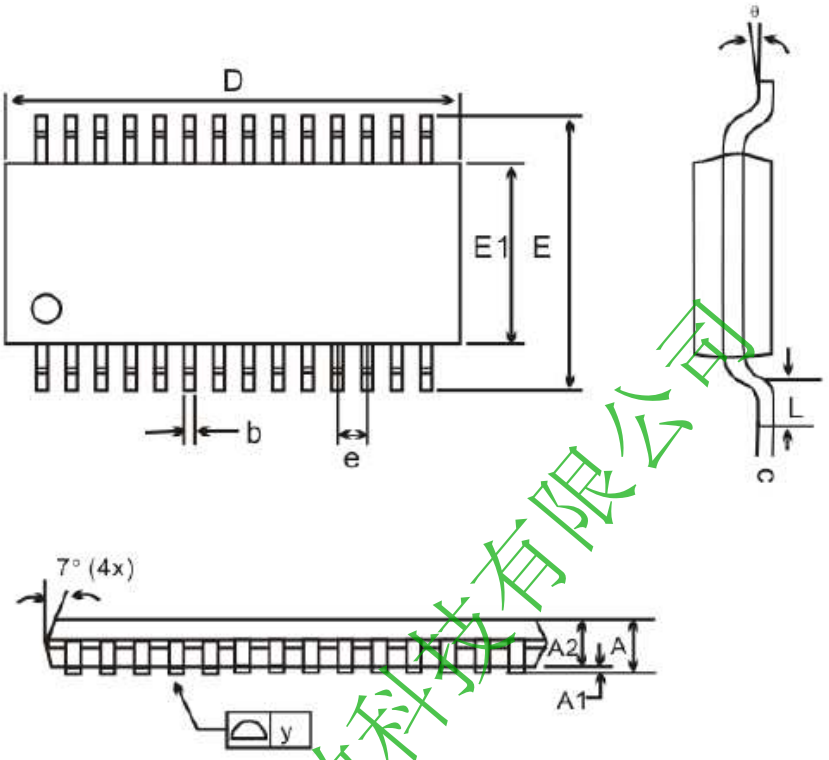
ELECTRICAL CHARACTERISTICS

Nominal conditions: V_{DD} =24.0V, SGND=V_{SS}, T_A = +27°C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
General Characteristics						
Supply voltage	V_{DD}		5	24	28	V
Current consumption	I_{DD}	V_{DD}=15V		5	7	mA
Regulator output voltage	V_{REG}		4.75	5	5.25	V
Regulator output current	I_{REG}			20		mA
Parameters Setting						
Over temperature protection	VT_{OVER}	RSEN pin		0.6		V
Over temperature protection release	VT_{RE}	RSEN pin		1.2		V
Over current protection voltage level low (OCPL, current limit)	V_{OCPL}	RF pin		0.4		V
Over current protection voltage level high (OCPH, lock protection)	V_{OCPH}	RF pin		0.5		V
External oscillator	F_{OSC_1K}	OSCC= 470pF		1		KHz
External oscillator range	F_{OSC_C}	OSCC pin	0.1	-	10	KHz
Pre-driver Characteristics						
High side output voltage	V_{OLH}	UH,VH,WH, I_{SINK}= 60mA		0.5	1	V
Low side output HIGH voltage	V_{OHL}	UL,VL,WL, I_{SOURCE}= 30mA	7	9		V
Low side output LOW voltage	V_{OLL}	UL,VL,WL, I_{SINK}= 30mA		0.5	1	V
Swing-head driver Characteristics						
Voltage drop in full bridge driver		SW1O, SW2O, V_{DD}=15V, I=200mA		1	2	V
Hall element amplifier						
Common-mode input range	V_{CM}	Using hall element	-0.3		V_{REG} -0.3	V
Hall input sensitivity	V_{HIN}			80		mV
Hysteresis voltage range	V_{hyst}		10	30	50	mV
Operation Characteristics						
PWM switching frequency	Fsw			20		KHz
I/O Interface						
Logic output high level	V_{OH}	UVWL, UVWH	4.0	4.5	5.5	V
Logic output low level	V_{OL}	UVWL, UVWH		0	0.3	V
RSEN internal pull high resistance	R_{SEN}	RSEN pin, connect to V_{REG}		47		KΩ
VSP internal pull high resistance	R_{VSP}	VSP pin, connect to V_{REG}		150		KΩ
DC for speed control input level	V_{DC}	DC input (VSP pin)	0.5		3.3	V
PWM input high level	V_{PWMH}	PWM input (VSP pin)	3.5			V
PWM input low level	V_{PWML}	PWM input (VSP pin)			0.3	V
PWM input clock	F_{PWM_IN}	PWM input (VSP pin)	15		25	KHz

PACKAGE INFORMATION

28 Pins, SSOP 150MIL



Symbol	Min.	Nom.	Max.
A	1.34	1.6	1.75
A1	0.10	-	0.25
A2	1.24	-	1.52
b	0.20	0.25	0.30
c	0.10	-	0.25
D	9.80	-	10.00
E	5.79	5.99	6.19
E1	3.81	3.91	3.98
e	-	0.63	-
L	0.38	-	1.27
θ	0°	-	8°
y	-	-	0.1

Notes :
1. Refer to JEDEC MO-137
2. Unit : mm

IMPORTANT NOTICE

Princeton Technology Corporation (PTC) reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and to discontinue any product without notice at any time.

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