

DESCRIPTION

PT2515 is a three-phase sine wave current BLDC motor driver IC with integrated control and driver, which can operate without Hall sensor or feedback from a single Hall IC. This chip has multiple protection functions, including over-current protection, over-temperature protection, locked protection and lack-of-phase protection. PT2515 supports VSP, PWM, Clock input methods to control the effective output voltage or speed of the motor. The motor parameters can be adjusted by external the capacitance or resistance, without software or program recording. PT2515 uses HTSSOP20/28 or QFN24 (4x4mm) small package, with few peripheral components, can achieve compact PCB layout. The typical operating voltage of PT2515 is 24V, and it can provide a maximum driving current of about 1A, which is suitable for use in 10W~24W motor applications.

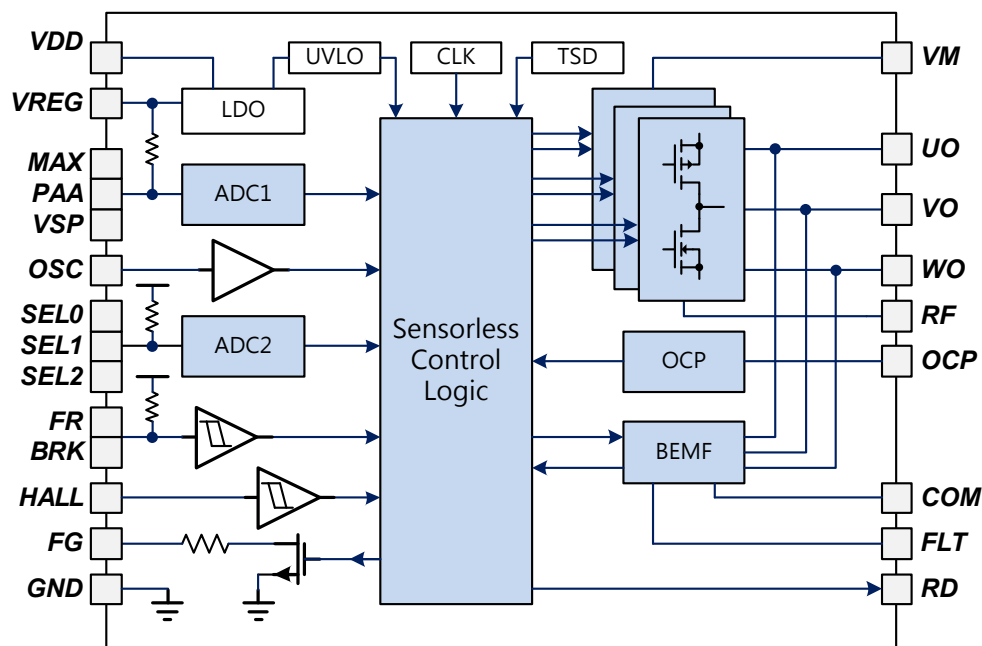
FEATURES

- 24V three-phase sensorless driver
- One Hall sensor control (option)
- 180-degree sinusoidal current operation
- VSP, PWM input open loop control
- VSP, PWM & CLK input closed loop control
- Maximum speed, advance angle compensation settings
- Current limit, over current, lock protection & over temperature protection
- Open Drain FG, 1/2FG & 3FG output
- Forward and reverse FR, brake BRK input

APPLICATIONS

- Three-phase sensorless BLDC motor driver
- Appliance fans, circulating fans
- Water pump

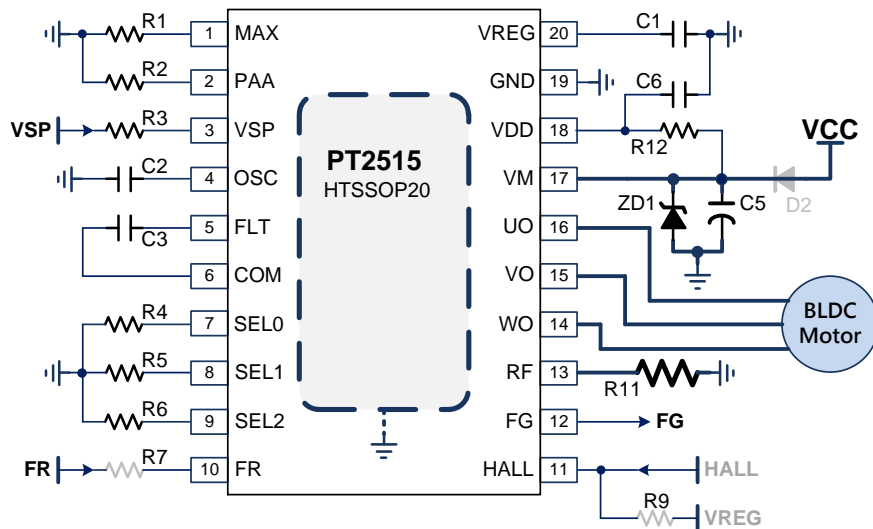
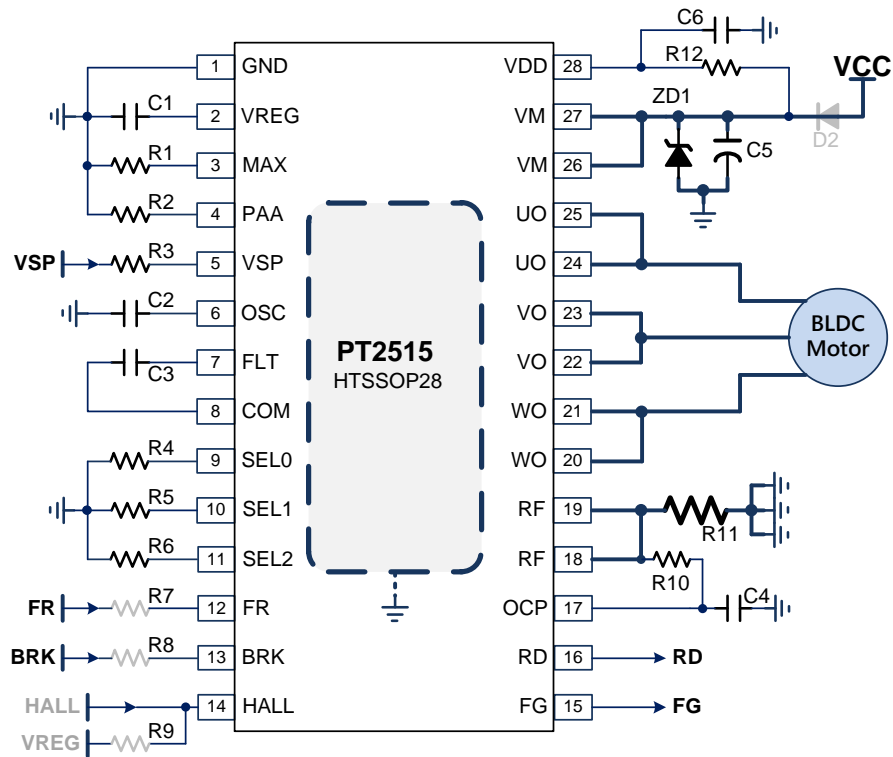
FUNCTION BLOCK

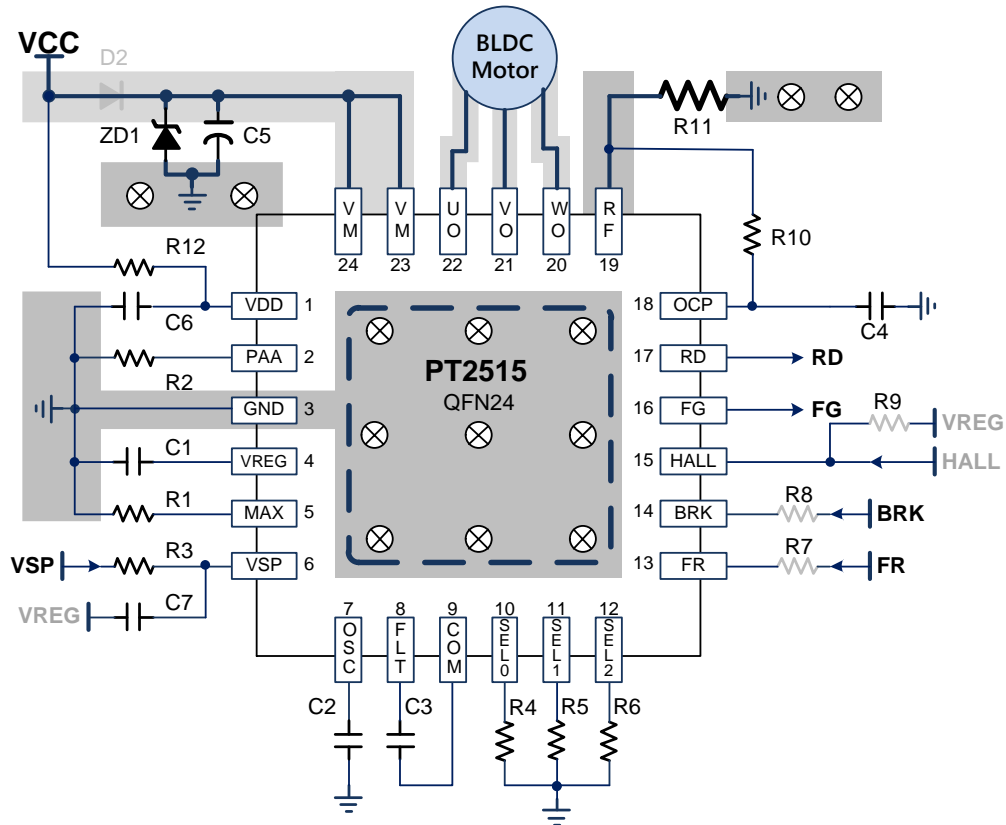


ORDER INFORMATION

Part Number	Package	Top Logo
PT2515-HT	28-PIN, HTSSOP	PT2515-HT
PT2515	20-PIN, HTSSOP	PT2515
PT2515	24-PIN, QFN	PT2515

APPLICATION CIRCUIT & BOM





Part	Value	Unit	Description
C1	1u	F	VREG output regulator capacitor
C2	10p ~ 3.9n	F	Start setting capacitor
C3	10p ~ 10n	F	ZZC signal processing low-pass filter capacitor
C4	10p ~ 10n	F	OCP signal processing low pass filter capacitor
C5	10u ~47u/50V	F	Motor power terminal filter capacitor
C6	1u/25V	F	VREG input filter capacitor
R1/R2	5K ~ 150K	Ω	MAX/PAA parameter setting resistance
R3/R7/R8	1K ~10K	Ω	VSP / FR/ BRK Input Protection Resistor
R4/R5/R6	1K ~ 500K	Ω	SEL0/1/2 parameter setting resistance
R9	3.3K ~ 10K	Ω	Hall IC output pull high resistor
R10	1K ~ 100K	Ω	OCP signal processing low pass filter resistor
R11	0.1 ~ 1.0	Ω	OCP protection detection resistor, use power resistor. Pay attention to avoid over-temperature burn
R12	10 ~ 100	Ω	VREG input filter resistor
ZD1	5W/27V	V	Voltage surge protection Zener diode

Part	Value	Unit	Description
D2	1N5819	V	Anti-reverse polarity protection diode. Pay attention to avoid over-temperature burn
U1	PT2515	IC	3-phase BLDC control IC

PIN NAME & DESCRIPTION

Pin Name	I/O	Description	Pin No.		
			HTSSOP28	HTSSOP20	QFN24
GND	P	System ground	1	19	3
VREG	IO	Built-in 5V voltage regulator, external voltage regulator capacitor	2	20	4
MAX	I	Maximum speed setting, internal 100KΩ pull-up resistor	3	1	5
PAA	I	Phase angle adjustment setting, internal 100KΩ pull-up resistor	4	2	2
VSP	I	Control command input, accept VSP (DC) or PWM and Clock signal	5	3	6
OSC	I	Start pace and acceleration and deceleration settings	6	4	7
FLT	I	Back EMF signal filter input	7	5	8
COM	I	Motor virtual common contact, BEMF comparison reference	8	6	9
SELO	I	Senorless & One hall control parameter setting	9	7	10
SEL1	I	FG/RD output and speed closed loop parameter setting	10	8	11
SEL2	I	PWM frequency, IPD and stop brake parameter setting	11	9	12
FR	I	Forward and reverse setting, internal 500KΩ pull-up resistor Open or high potential for UVW CW; ground or low potential for CCW direction	12	10	13
BRK	I	Brake, internal 500KΩ pull-up resistor Emergency braking when grounding or low potential, the three phase MOS low sides are shorted to ground at the same time	13	-	14
HALL	I	Hall sensor signal input	14	11	15
FG	O	FG output, open drain structure	15	12	16

Pin Name	I/O	Description	Pin No.		
			HTSSOP28	HTSSOP20	QFN24
RD	O	RD signal output; motor status indication, 5V logic, low potential during normal operation, high potential output during overcurrent, lock or over temperature protection	16	-	17
OCP	I	Current limiting and overcurrent protection inputs	17	-	18
RF	I	U, V, W Three-phase MOS low sides source parallel output, Connect an external resistor to ground as a reference potential for current limiting or overcurrent detection	18,19	13	19
WO	O	W phase output	20,21	14	20
VO	O	V phase output	22,23	15	21
UO	O	U phase output	24,25	16	22
VM	P	Motor driver power supply input	26,27	17	23,24
VDD	P	VREG input	28	18	1
Heat sink	P	Bottom heat sink plate	back-side		

PIN EQUIVALENT CIRCUIT

FR/BRK	VSP	SEL0/1/2	MAX/PAA
COM/FLT	OSC	FG	RD
VM/UO/VO/WO/RF	VDD/VREG	OCP	

FUNCTION DESCRIPTION

Power supply

The PT2515 supports operation with supply voltages ranging from 9V to 26V. VM is the output stage MOS power supply, and VDD is the input voltage of the internal voltage regulator VREG. VREG provides 5V for analog and digital circuits. Since the loading of application is an inductive motor coil, when the motor starts to rotate, a large current and voltage surge may be induced. Use an appropriate bypass capacitor as close to the VM pin as possible. In addition, the use of external Zener diodes will help suppress excessive BEMF voltages when the motor decelerates.

SELx parameters settings

For different application requirements, PT2515 can use SEL0, SEL1 and SEL2 to make different corresponding requirements. SELx internal 100KΩ pull-up resistor, use different external grounding resistor R as parameter setting. Each SELx can set 8 modes, the parameters under the same SELx are bound together, and different SELx can be set independently. The contents are as follows :

SELx external Resistor	SEL0			SEL1			SEL2			
	Sensorless or One Hall	Hi-Z Number	Hi-Z Angle	VSP Close loop	FG output	RD output	PWM Freq.	PWM off	Startup IPD	Lock Protect
R=NC	Sensorless sine	One	9 deg	No	FG	Fault	20KHz	decelerate	No	Yes
R=270KΩ	Sensorless sine	One	15 deg	Yes	FG	Fault	40KHz	decelerate	No	Yes
R=150KΩ	Sensorless sine	Six	9 deg	No	3FG	Fault	40KHz	decelerate	Yes	Yes
R=82KΩ	Sensorless sine	Six	15 deg	No	1/2FG	Fault & OCL	20KHz	decelerate	Yes	Yes
R=51KΩ	Sensorless Trapezoid	Six	15 deg	No	1/2FG	PWM on	20KHz	decelerate	No	waiting time OSC related
R=33KΩ	Sensorless square	Six	30 deg	No	3FG	PWM on	20KHz	floating	No	Yes
R=18 KΩ	One Hall trapezoid	Six	0 deg	Yes	FG	PWM on	20KHz	brake	No	Yes
R=0Ω	One Hall sine	NA	0 deg	No	FG	PWM on	20KHz	decelerate	No	No

MAX input settings

PT2515 uses the MAX pin to set the maximum speed of the motor, which can not only be used as the maximum speed reference point for closed-loop speed control, but also the reference speed of the maximum speed during lock protection. Therefore, no matter using open-loop or closed-loop control, MAX must be set. There are 3 ways to set MAX :

The first way is to set by the external direct input voltage MAXV. The valid range of MAXV is 0.3V ~ 3V. When using voltage setting, it must be within the range. Below 0.3V will be considered as minimum, no effect (the motor cannot turn successfully); more than 3V will be considered as maximum MAXFG = 1024Hz.

The second way is to directly input the PWM duty (MAXD) from the outside. When MAXD is set, the high potential needs to be greater than 3.3V, and the low potential needs to be less than 0.3V. The recommended PWM input frequency is between 5K and 50KHz.

The third way is to obtain MAXV from the external (grounding) resistor Rmax and the internal 100KΩ pull-up resistor to 5V. MAXV is calculated as follows:

$$MAXV = 5V * (Rmax) / (100 + Rmax) (V)$$

or $R_{max} = 100 * MAXV / (5V - MAXV) (K\Omega)$; $MAXV$: unit is V , R_{max} unit is $K\Omega$

The valid range of $MAXV$ is 0.3V ~ 3V. When using voltage setting, it must be within the range. Below 0.3V will be considered inactive (the motor will not turn successfully); more than 3V will be considered as maximum $MAXFG = 1024Hz$. The corresponding relationship between the $MAXV$ input voltage and the maximum speed $MAXFG$ is as follows:

$$MAXFG = (MAXV - 0.3)^2 * 140 (Hz)$$

or $MAXV = (MAXFG / 140)^{1/2} + 0.3 (V)$; $MAXFG$: unit Hz · the maximum control frequency

The relation between R_{max} and $MAXFG$ is as follows:

$$R_{max} = [100 * (MAXFG/140)^{1/2} + 0.3] / [5V - ((MAXFG/140)^{1/2} + 0.3)]$$

Using voltage to set the speed range and target speed, the error of speed control will be larger than that of using CLK. In addition, the actual speed of the motor will be different due to the number of stages. The table below shows the maximum speed (RPM) of the motor with different pole numbers when the MAX is set. A more suitable range can be set according to the needs.

MAXV	Rmax	MAXD	MAXFG	Motor Poles						
				2P	4P	6P	8P	10P	12P	14P
(V)	(K Ω)	Duty	(Hz)	(rpm)	(rpm)	(rpm)	(rpm)	(rpm)	(rpm)	(rpm)
3	>151	100%	1024	61,440	30,720	20,480	15,360	12,288	10,240	8,777
2.9	138.7	96%	950	56,973	28,487	18,991	14,243	11,395	9,496	8,139
2.8	127.7	93%	878	52,675	26,337	17,558	13,169	10,535	8,779	7,525
2.5	100.3	81%	680	40,791	20,396	13,597	10,198	8,158	6,799	5,827
2	66.8	63%	406	24,357	12,178	8,119	6,089	4,871	4,059	3,480
1.5	42.9	44%	202	12,136	6,068	4,045	3,034	2,427	2,023	1,734
1	25.1	26%	69	4,130	2,065	1,377	1,032	826	688	590
0.5	11.3	7%	6	337	169	112	84	67	56	48
0.4	8.3	4%	1	84	42	28	21	17	14	12
0.3	0	0%	0	-	-	-	-	-	-	-

PAA input settings

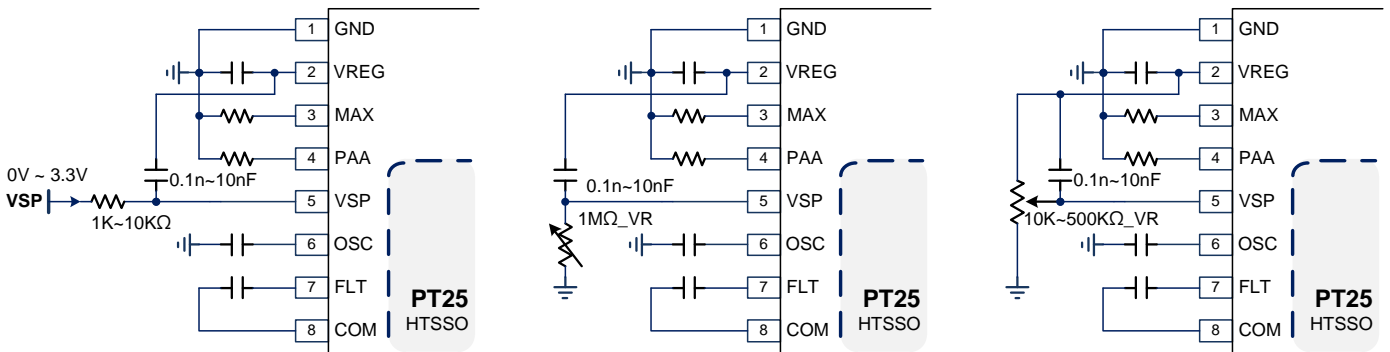
The PT2515 provides PAA as a timing compensation adjustment, which can adjust the best efficiency point for the target speed. There is a 100K Ω pull-up to 5V inside the PAA, and the PAAV can be divided by adjusting the external grounding resistance of the PAA. The effective integral range of PAAV is 0.3V ~ 3.0V. The higher the PAA voltage, the longer the commutation time in advance. It is calculated as follows:

$$PAA = 300 * (PAAV - 0.3) + 20 (us) ; PAA \text{ unit is } \mu\text{sec}$$

VSP input control

PT2515 can accept VSP pin to adjust motor speed by external input DC voltage or PWM signal. When using PWM input, the high level needs to be greater than 3.3V, and the low level needs to be less than 0.3V. The recommended PWM input frequency is between 5K and 50KHz. When using an analog DC voltage input, the voltage control range should be between 0.3V and 3.3V. When the VSP pin is unconnected, it is internally pulled high and the motor runs at full speed with 100% PWM duty cycle.

When using VSP (DC voltage) input control, there are three ways: The first way is to directly input the external voltage of 0V ~ 3.3V to VSP. The second way is to use an external adjustable resistor to divide the voltage between the internal 500KΩ pull-high to VREG resistor on the VSP pin. The third way is to use an external adjustable resistor to divide the voltage between VREG and GND to generate a voltage input VSP of 0V ~ 3.3V. When using VSP (DC voltage) input, please connect the filter capacitor to VREG to avoid jumping to PWM or CLK mode during startup. Below is the suggested circuit.



(1) External voltage input (2) Shunt adjustable resistor (3) Adjustable resistor to VREG/GND

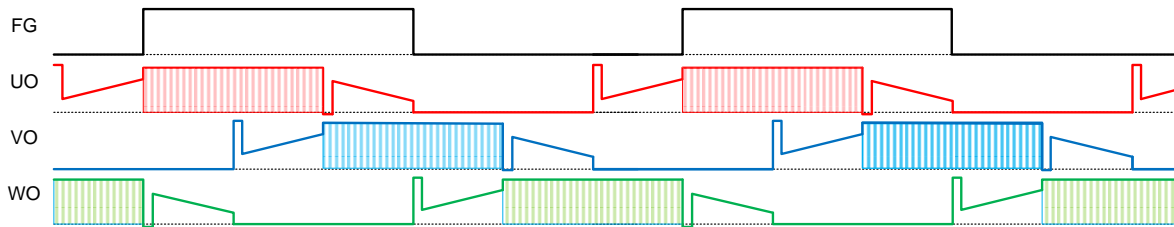
In addition to using VSP or PWM for open-loop control, PT2515 can also perform speed closed-loop control, in the following two ways.

The first is to use the CLK input. When the VSP input frequency is between 10Hz and 3KHz, the PT2515 will automatically perform speed closed-loop control. The U-phase commutation frequency is the same as the input CLK frequency, and the controllable range is 10Hz to 1KHz. This method can achieve more precise speed control.

The second method is to set SEL1 as closed-loop control, and use the MAX pin resistor to divide the voltage to set the maximum speed. At this time, VSP or PWM can be used to set the maximum speed in the range (0.3V~3V, or PWM 5% ~ 100%) for speed closed-loop control.

Startup

For sensorless control or a single Hall sensor, the starting method of the PT2515 is initial alignment and a gradual increase in control voltage (or increase in PWM duty cycle) to achieve motor excitation and rotation. The initial alignment may cause the rotor to randomly rotate forward or backward one electrical cycle at start-up. If the ZC signal is unclear, it will cause the motor to fail to start. If the motor does not start successfully within a certain period of time, the PT2515 will enter the lock protection mode and restart after a period of time. The PT2515 uses square wave PWM control during the startup process. At this time, there is a large BEMF detection interval, which reduces the probability of startup failure, as shown in the figure below.



The startup process adopts 120° square wave PWM control mode

In order to adapt to the load requirements of different motors, the starting capacitor of the OSC pin can be adjusted to make the motor start smoothly. The range of OSC capacitance values is about 10pF~3.9nF. Lighter and faster motors generally require smaller capacitance values, and heavier and slower motors generally require larger capacitance values.

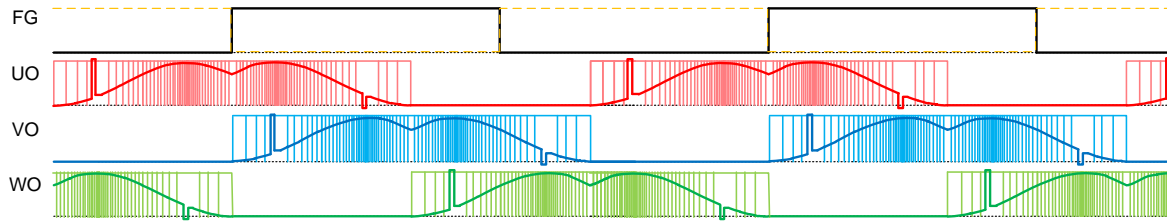
When using single Hall control, PT2515 only supports Hall IC. The placement position of the Hall IC is corresponding to the commutation point of the U-phase, and the Hall phase can be fine-tuned by using PAA parameter.

Sensorless control

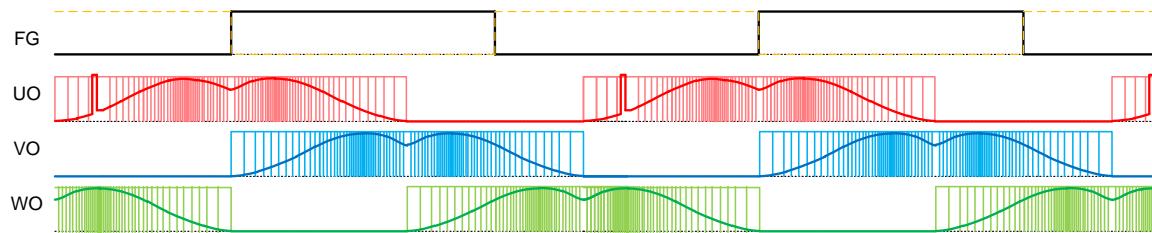
The PT2515 control scheme is based on a sensorless sinusoidal current waveform. Feedback for sensorless control is primarily achieved by measuring the induced electromotive force (BEMF) of the motor leads as the motor rotates. Sensorless control is achieved by utilizing the U-phase to open a narrow window at the beginning of the commutation interval to detect the zero-crossing signal.

The PT2515 performs commutation detection by reducing the UVW phase voltage to below 5V using an internal voltage divider resistor, processing it through an emulation circuit and generating a ZC signal. Since factors such as different motors, operating voltages, or loads will affect the ZC signal, it is necessary to adjust the external ZC filter capacitors to achieve optimal operation. The capacitance value between "COM" and "FLT" ranges from about 10pF to 10nF.

The PT2515 uses 180° commutation and sinusoidal PWM control to help reduce audible current noise. Generally, during operation, PT2515 uses U-phase to open a (Hi-Z) window to detect BEMF, and the noise of operation is minimal at this time. When PWM is less than 20% or in the acceleration and deceleration range, because the BEMF is small or changes drastically, the PWM control method with six Hi-Z windows will be forced to be used at this time.



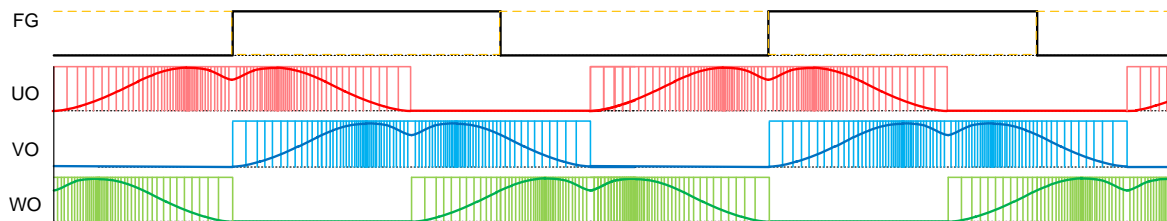
During the sensorless sine wave acceleration and deceleration process, six Hi-Z windows are used to detect BEMF



Sensorless sine wave operation uses a U-phase Hi-Z window to detect BEMF

One Hall feedback sine wave current control

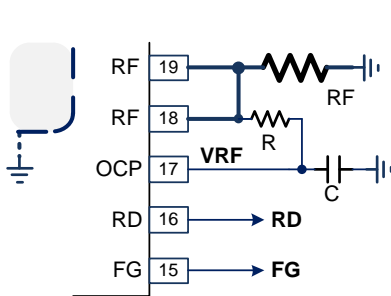
PT2515 can be set to use one Hall control mode, and use Hall sensor IC signal for commutation control. At this time, there is no need for a Hi-Z window, the current is a complete sine wave, and the noise can be minimized. When using one Hall control, the position of the Hall IC is relative to the U-phase position and needs to be placed correctly. The PT2515 provides PAA as the timing compensation adjustment to adjust the best efficiency point for the target speed. Or the change is drastic, at this time, the PWM control method of six Hi-Z windows will be forced.



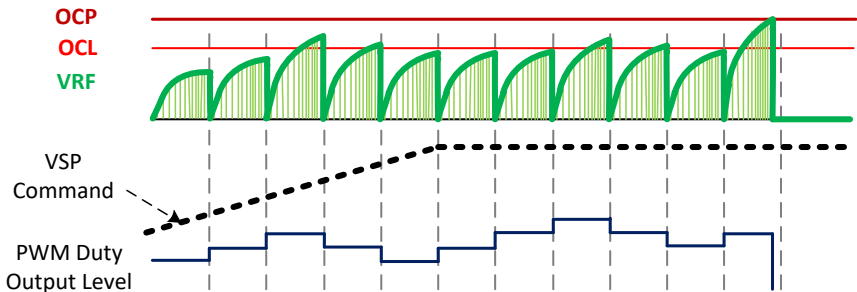
With one Hall control, no Hi-Z window is required to detect BEMF

Current limit (OCL) and overcurrent protection (OCP)

The PT2515 implements Over Current Limit (OCL) and Over Current Protection (OCP) functions by using an external resistor to sense the current flowing through the motor coil. When measuring the voltage signal VRF on the RF pin, when the VRF voltage exceeds 0.3V, the PT2515 will reduce the PWM duty cycle to prevent overcurrent (OCL); when the VRF voltage exceeds 0.5V, it is determined as an abnormality causing overcurrent (OCP), the system will enter the lock protection mode.



OCL/OCP external circuit



The process of PWM duty output when OCL/OCP occurs

By measuring the VRF voltage, the current $IRF = VRF / RF$ can be calculated. When VRF passes through the external RC filter circuit, different values will affect the way of OCL/OCP judgment. The effects of larger and smaller RC filter values are:

When the RC value is large (for example, $R=10K\Omega/C=1\mu F$), the IRF is relatively close to the average current flowing into the VM, and it is also relatively close to the average current of the power supply. At this time, the OCL/OCP response is slow, and a relatively large RF resistor is also required to be used as the trigger reference for the OCL/OCP. When the OCL is triggered, the behavior is closer to a fixed current. At this time, the voltage increases and the power consumption increases proportionally.

When the RC value is small (such as $R=100\Omega/C=1nF$) or using HTSSOP20 package IC, the IRF is relatively close to the peak current of the motor coil. At this time, the OCL/OCP response is faster, and the smaller RF resistance can trigger the OCL/OCP. When the OCL is triggered, it is closer to the fixed power consumption. At this time, the voltage increases, the supply current will decrease, and the power consumption change is small. In different motor applications, the coil current is related to the coil impedance, back-electric type and load, so the selection of RF resistance must be adjusted according to the actual application. In the selection of RF resistance, $RF = 0.3V / IRF$ can be used as the initial value, and then adjust the RC circuit and RF resistance according to the actual measurement.

There are two situations in which the current limit protection (OCL) does not work. The first is to prevent the current limit from affecting the startup when the startup PWM duty cycle has not yet reached 14%. The second is the deceleration stage. When the inertia of the motor load is heavy and the deceleration time is short, although the PWM duty cycle will gradually decrease, it may cause the BEMF voltage to rise due to the inertia, thereby causing the current to exceed the predetermined limit value.

Lock Protection

The PT2515 has four conditions that cause the control algorithm to enter lock protection mode. First, the controller cannot determine any correct commutation signals when the motor is in the start-up stage. Second, when the motor starts successfully and is in run mode, but the ZC or Hall signal suddenly changes too much. Third, when the motor current is too large to trigger the OCP potential. Fourth, when the speed is too high, higher than 1.5 times of the MAXFG setting. At this moment the motor will immediately stop and the output driver will be switched off. After a few seconds, the control algorithm will try to restart the motor. If the motor starts successfully, it will continue to operate normally. However, if the motor still fails to start, the control algorithm will return to lock protection mode and try to restart again after a few seconds.

Over temperature protection (OTP)

PT2515 has built-in temperature detection circuit. When the internal temperature exceeds 150°C, the PT2515 will shut down the output driver stage. When the internal temperature drops below 120°C, the PT2515 will restart again and operate normally.

FG output setting

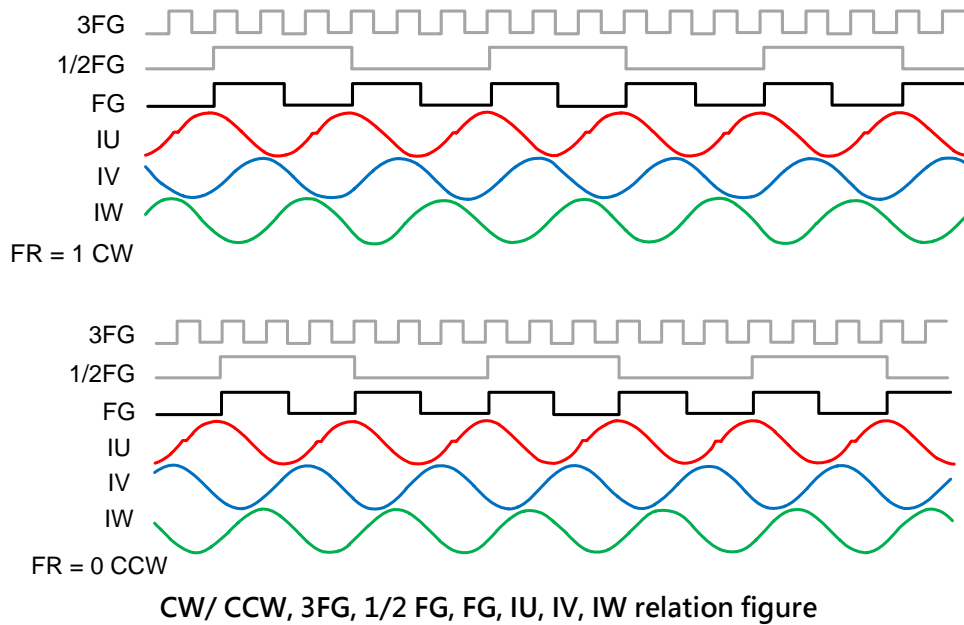
PT2515 provides FG output to monitor motor speed. When the rotor runs for one (electrical) cycle, the FG pin will output a high and a low. The number of rotor poles needs to be known when calculating the rotational speed. For example, if the rotor has 8 poles (four pairs of NS), one cycle of the motor will produce 4 FG outputs. Generally, the motor speed is in RPM (revolutions per minute), and the conversion formula between the speed (RPM) and the FG frequency (Hz) is as follows:

$$\text{RPM} = \text{FG} \times 120 / \text{POLE},$$

Where FG is the frequency in Hz; POLE is the number of pole of the motor rotor (N and S are one pole each).

When PT2515 starts to output PWM, it detects BEMF signal and starts to output FG. After PWM stops output, FG will stop output regardless of whether the motor is rotating or not. The position of the FG trigger is about 90 degrees behind the U-phase commutation point, and the starting point may be the rising edge or the falling edge. The FG output pin is an open drain structure, and the highest pull-up power supply can be up to VDD. In

In addition, PT2515 also provides 1/2FG or 3FG frequency output when SEL1 has been set in the corresponding position.



RD output

PT2515 HTSSOP28 package IC provides RD output to monitor motor operation or abnormal conditions. The RD pin is a general 5V logic output, which can be set through SEL1 in three cases:

The first is a general false alarm, namely stall, over temperature and OCP. The second is to add OCL alarm output. The third is the PWM on output indication, there will be RD output if there is PWM output.

Forward and reverse setting

The PT2515 can be set to forward or reverse mode through the FR pin. UVW CW when FR=5V or High, CCW operation when FR=0V or Low. The FR mode can be changed directly during operation. There is a pull-up resistor inside the FR pin, which can be kept empty when forward and reverse switching is not required. When the PT2515 is in the sensorless control mode, the forward and reverse settings can also be changed by changing the motor wiring. When using the one Hall function, the current/speed difference between forward and reverse rotation may be caused by the difference in the placement of the Hall sensor, or the reverse operation may not be possible.

Brake (BRK) input

The PT2515 HTSSOP28 package IC can perform braking action through the BRK pin. When the BRK input is Low, the 3 upper side MOSs will be immediately turned off to become an open circuit, and the 3 lower side MOSs will be immediately turned on into a short circuit to perform braking action. When BRK returns to High, it will enter

lock protection mode regardless of whether the braking is done or the motor has stopped. If VSP/PWM off occurs during the braking process, the BRK will brake until the internal PWM duty is reduced to 0%, and the lower side MOSs will be off. When BRK is Low, VSP/PWM/CLK will not work.

Capacitor value selection between COM and FLT pins

The PT2515 detects the motor position by comparing the back EMF generated by the motor rotation with the virtual midpoint voltage to generate the ZC signal. However, noise caused by motor startup or rotation may interfere with the accuracy of the zero-crossing signal, which may cause failure at startup or affect rotational stability. A capacitor between the COM and FLT pins helps mitigate noise interference. The recommended capacitance range is 0.1nF to 10nF. In addition, when a filter circuit is used, a delay will be caused to the commutation signal ZC. Therefore, in general, the higher the speed of the motor, the smaller the capacitance value, so that the efficiency will not be affected by excessive delay. Because when FLT_C= 1nF, it is suitable for applications where the highest motor rotation FG is about 100Hz. For other applications with different maximum speeds, this value can be used as a preliminary setting, and then fine-tuned to achieve a more stable and efficient effect. Usually higher speed motors have higher frequencies, and smaller FLT capacitors can be selected, and vice versa.

Capacitor value selection for OSC pin

OSC is the relative benchmark of all variable adjustment steps or time of PT2515, including starting steps, acceleration and deceleration time. When OSC_C= 1nF, OSC~1KHz, it is also suitable for applications where FG is about 100Hz when the motor rotates at its highest. Other applications with different maximum speeds can be equivalent to OSC_C=1nF, FG=100Hz as the initial setting value, and then fine-tune it to achieve a smoother startup effect. Usually higher speed or faster startup applications choose a smaller OSC capacitor, and vice versa.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Value	Unit
VM supply voltage	VMmax	PT2515 No break down	28	V
VDD supply voltage	VDDmax	PT2515	28	V
Output pin current ⁽¹⁾	Iout,max	PT2515 UO, VO, WO pins	1.5	A
Input pin withstand voltage	Vin,max	MAX, PAA, VSP, SELx, FR, BRK	6	V
Power dissipation 1 IC only	Pd,max1	HTSSOP28	0.5	W
		HTSSOP20	0.3	W
Power dissipation 2 IC assembled on the test board ⁽²⁾	Pd,max2	HTSSOP28	1.5	W
		HTSSOP20	1.2	W
External ambient temperature	Ta	TSD is not triggered	-40 to +105	°C

Parameter	Symbol	Condition	Value	Unit
Core operating temperature	Tj	TSD is not triggered	-40 to +150	°C
Storage temperature	Ts	-	-40 to +150	°C

Notes: 1. 500ms of test time and installed in designated areas with heat sinks
 2. Mounted on a board with a heat sink.

ELECTRICAL CHARACTERISTICS

(Standard conditions : VDD = 24V, T = 25°C)

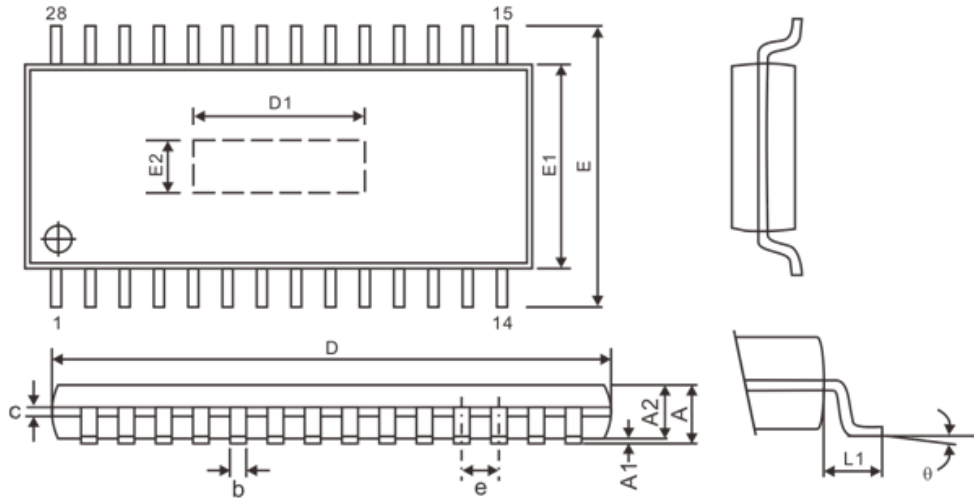
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
VDD supply voltage	VDD	PT2515	9.0	24	26	V
VDD consumption current	IDD	PWM pin = VREG, without load	-	6.0	7.5	mA
MOS stage resistance	Rdson	Io = 500mA, (H+L)	-	0.4	-	Ω
MOS output switching frequency	Fmos	U, V, W output, SEL2 set 20KHz	-	20K	-	Hz
OSC pin charge and discharge current	Iosc	OSCx pins	-	5.6	-	μA
VREG pin voltage	Vreg	No load	4.5	5	5.5	V
VSP DC control range ^(Note)	DCvsp	VSP input	0.4	-	3.2	V
VSP PWM input frequency	Fpwm	VSP input	5K	-	25K	Hz
VSP CLK input frequency	Fclk	VSP input	10	-	3K	Hz
VSP PWM/CLK input high	Vpwmh	VSP input , PWM/CLK voltage rising	3.3	-	5	V
VSP PWM/CLK input low	Vpwml	VSP input PWM/CLK voltage falling	0	-	0.3	V
FG output low	Vfgl	IFG=1mA	-	0.25	-	V
FG output leakage current	Ifgl	VFG=24V	-	-	10	μA
Logic input pin pull-up current	Isource	FR, BRK pins	-	10	-	μA
MAX, PAA pull-up resistance	Rmax Rpaa	MAX, PAA pins	90K	100K	110K	Ω
SELx pull-up resistance	Rselx	SELx pins	90K	100K	110K	Ω
Current limit reference voltage OCL	Vocl	RF pin	0.25	0.3	0.35	V
Over current protection reference voltage OCP	Vocp	RF pin	-	0.5	-	V
Lock protection release time	Tlock	SEL2≠51KΩ setting	-	5.0	-	S

Thermal shunt down	Tshdn	Temperature increasing, design target	-	150	-	°C
TSD release	Trel	Temperature decreasing, design target	-	120	-	°C

Note : When PWM input, the minimum start-able PWM duty = 3%, when VSP(DC) input, the minimum start-able voltage is about 0.5V. If the PWM/VSP is too small, it may fail to start

PACKAGE INFORMATION

28 Pins, HTSSOP (Shrink Small Outline Package with Heat Sink)

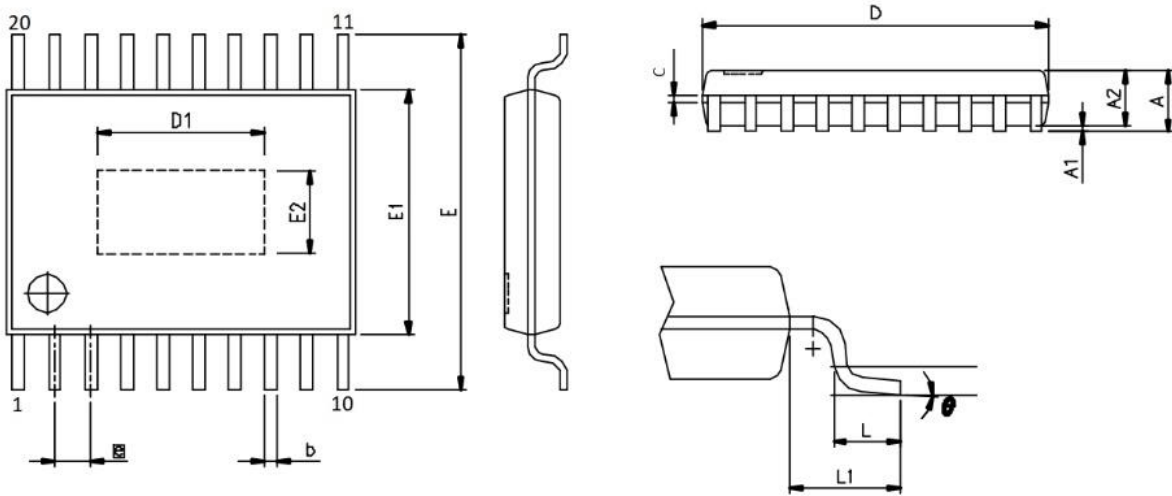


Symbol	Size (mm)		
	Min.	Typ.	Max.
A	-	-	1.20
A1	0.05	-	0.15
b	0.19	-	0.30
c	0.09	-	0.20
D	9.60	9.70	9.80
E1	4.30	4.40	4.50
E	6.4 BSC		
e	0.65 BSC		
D1	4.98 BSC		
E2	2.70 BSC		
L1	1.00 BSC		
θ	0°	-	8°

Notes:

1. Refer to JEDEC MO-153 AET
2. Unit : mm

20 PINS, HTSSOP

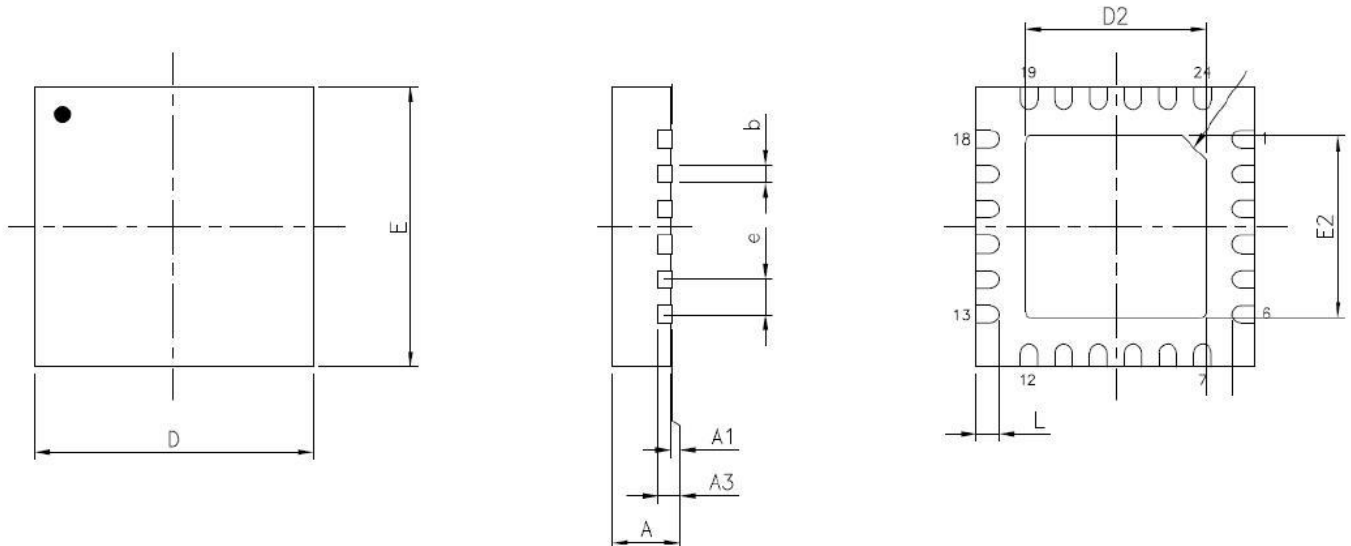


Symbol	Dimension (mm)		
	Min.	Typ.	Min.
A	-	-	1.20
A1	0.05	-	0.15
A2	0.80	1.00	1.05
b	0.19	-	0.30
c	0.09	-	0.20
e	0.65 BSC		
D	6.40	6.50	6.60
D1	3.79	3.99	4.35
E	6.4BSC		
E1	4.30	4.40	4.50
E2	2.60	2.80	3.15
L	0.45	0.60	0.75
L1	1.00REF		
θ	0°	-	8°

Notes:

1. Refer to JEDEC MO-153 ACT (Thermally Enhanced Variations only)
2. Unit : mm

24 Pins, QFN



Symbol	Dimension (mm)		
	Min.	Typ.	Min.
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	4.00BSC		
E	4.00BSC		
D2	2.55	2.60	2.65
E2	2.55	2.60	2.65
e	0.50 BSC		
L	0.275	0.325	0.375

Notes:

1. Refer to JEDEC MO-220 WGGD-8
2. Unit : mm

IMPORTANT NOTICE

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