DESCRIPTION

PT2432 is an integrated 3-phase sensorless brushless DC motor driver. Including soft start circuit, over temperature protection, lock on protection and current limit protection. PT2432 is very suitable for sensorless motor applications and ideal for fan motor control requiring high efficiency. The speed control interface (VSP) can support PWM and DC commands, allowing for smooth low-speed to high-speed motor control. The PT2432 requires only a few peripheral components and can achieve a compact PCB layout.
PT2432 utilizes a multi-power BCD process, only requires a single power supply, and uses HTSSOP16, HTSOP20 packages to achieve excellent power efficiency, making it a perfect solution for for a highly integrated, low-cost, sensorless brushless DC motor system.

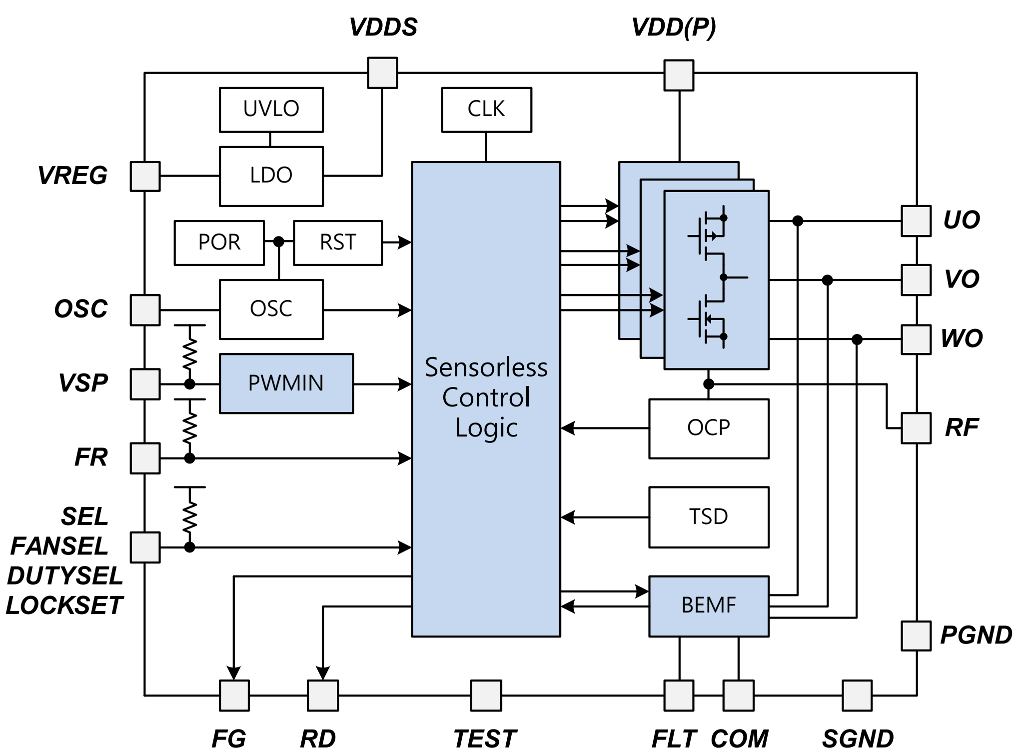
FEATURES

- 3-phase sensorless control
- 150° trapezoidal wave or 120° square wave drive control
- 12V or 24V interval voltage operation
- Support PWM or DC motor speed control commands
- FR forward and reverse input
- FG/RD output
- Rated maximum output current of 1.5A
- Soft-start control function
- Lock on protect function
- Thermal protection function with 30°C hysteresis window
- Supports both PWM or DC command for motor speed control
- Over-current limit set by an external precision resistor
- Built-in fast startup function (option)

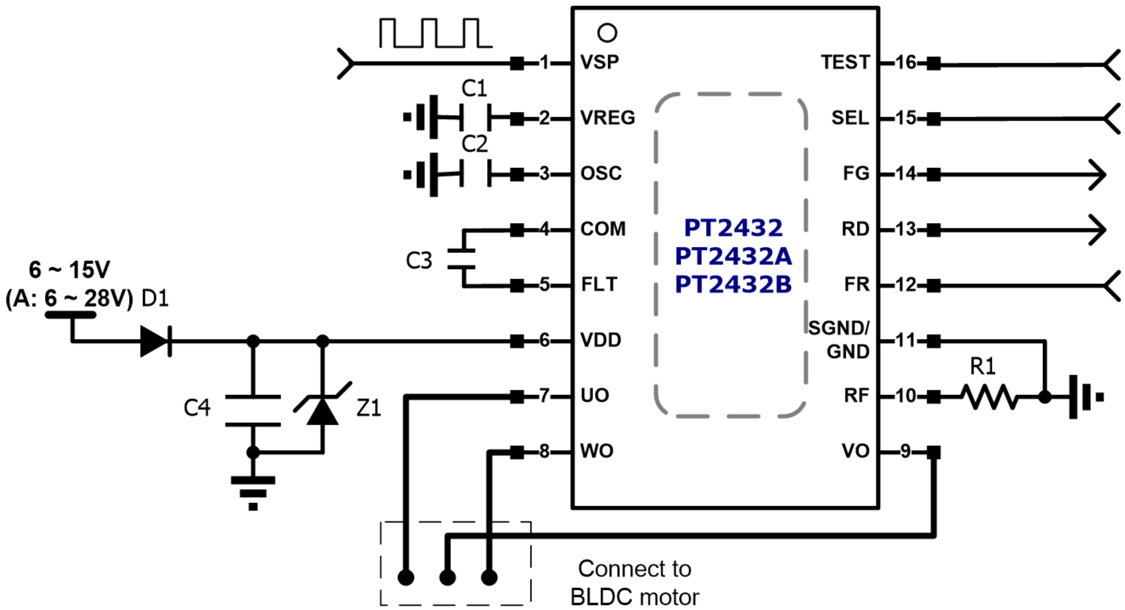
APPLICATIONS

- 3-phase sensor-less BLDC motor driver
- Fans for CPU, GPU, or server
- Pump

BLOCK DIAGRAM



APPLICATION CIRCUIT FOR HTSSOP16

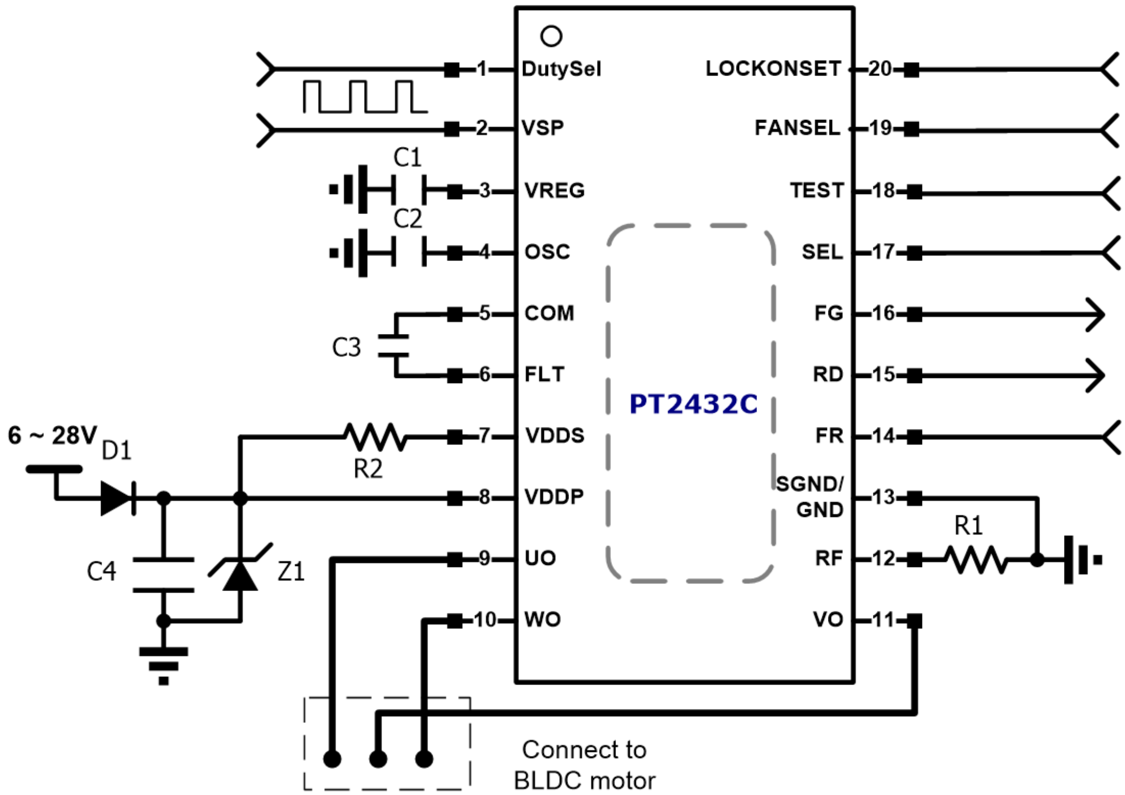


BOM FOR APPLICATION CIRCUIT

Part	Value	Unit	Description
C1	1u	F	Regulator stability capacitor
*C2	1n	F	Oscillator start-up capacitor, 100pF - 3.9nF
*C3	1n	F	ZC signal low pass filter capacitor, 100pF - 10nF
C4	10u	F	Power supply de-coupling capacitor
*R1	0.15	Ω	Reference voltage current limit resistor
D1	1N5819	V	Prevent BEMF feedback to power supply
Z1	15 (A: 28)	V	Large voltage spike Zener protection diode
U1	PT2432	IC	3-phase sensor-less driver IC

Notes : 1. C2 & C3 are depend on motor type.
2. R1 is depend on motor application.

APPLICATION CIRCUIT FOR HTSSOP20



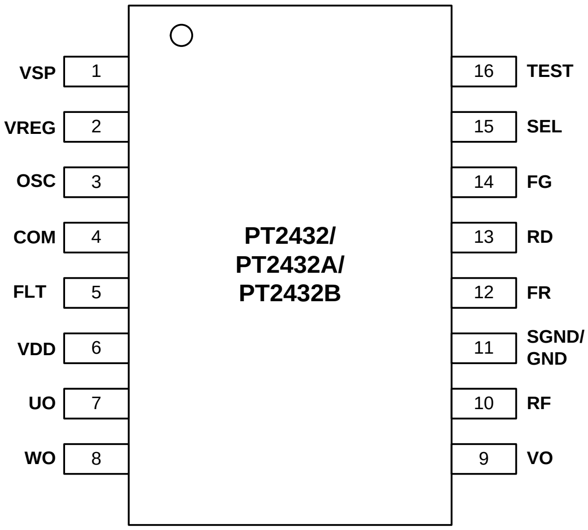
BOM FOR APPLICATION CIRCUIT

Part	Value	Unit	Description
C1	1u	F	Regulator stability capacitor
*C2	1n	F	Oscillator start-up capacitor, 100pF - 3.9nF
*C3	1n	F	ZC signal low pass filter capacitor, 100pF - 10nF
C4	10u	F	Power supply de-coupling capacitor
*R1	0.15	Ω	Reference voltage current limit resistor
R2	47	Ω	Voltage current limit resistor
D1	1N5819	V	Prevent BEMF feedback to power supply
Z1	28	V	Large voltage spike Zener protection diode
U1	PT2432C	IC	3-phase sensor-less driver IC

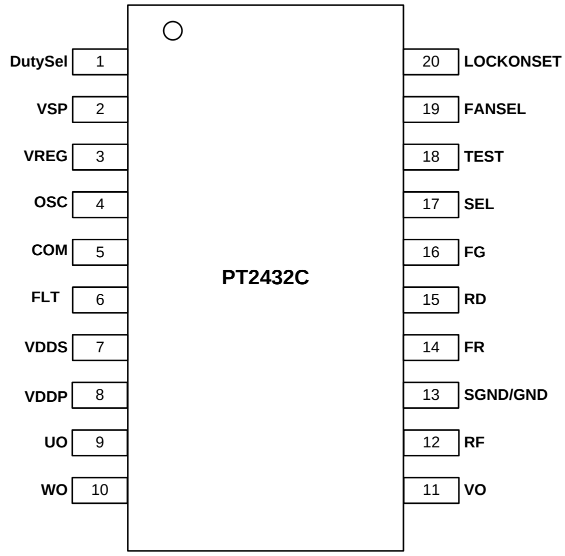
Notes : 1. C2 & C3 are depend on motor type.
2. R1 is depend on motor application.

PIN CONFIGURATION

HTSSOP16



HTSSOP20



ORDER INFORMATION

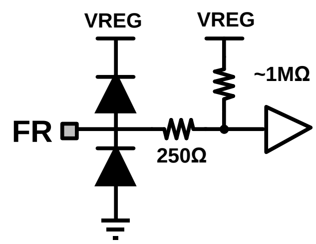
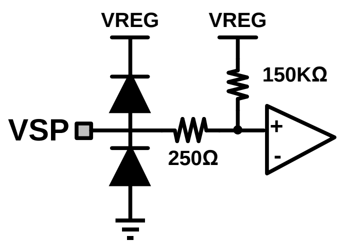
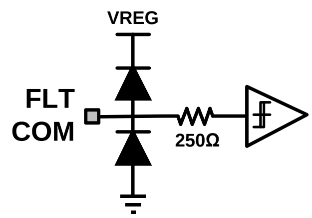
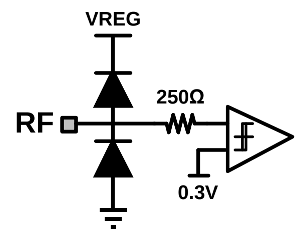
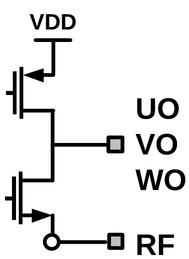
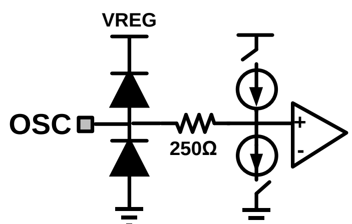
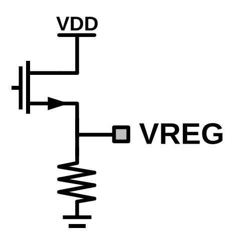
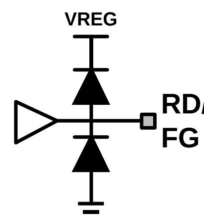
Valid Part No.	Package Type	Top Code
PT2432	16 Pins, HTSSOP	PT2432-HT
PT2432A	16 Pins, HTSSOP	PT2432A-HT
PT2432B	16 Pins, HTSSOP	PT2432B-HT
PT2432C	20 Pins, HTSSOP	PT2432C-HT

PIN DESCRIPTION

Pin Name	I/O	Description	Pin number	
			PT2432/A/B HTSSOP16	PT2432C HTSSOP20
DUTYSEL	I	1: PWM duty output will be processed by the internal controller, rising and falling slowly, and output gradually. 0: PWM duty output will not be processed by the internal controller and will be output directly.	–	1
VSP	I	Speed command input pin (accepts DC or PWM signal), internal pull high, it runs at full speed when pin floating.	1	2
VREG	IO	Internal 5V regulator pin. Connect an external bypass capacitor to ground.	2	3
OSC	IO	The base frequency pin for starting step and acceleration /deceleration settings. The external capacitor determines the frequency.	3	4
COM	I	Motor coil UVW virtual common contact, filter input pin.	4	5
FLT	I	UVW back-EMF signal, filter input pin.	5	6
VDDS	P	High voltage power supply pin, LDO terminal input	–	7
VDD	P	High voltage power supply pin, MOS terminal (HTSSOP 16 VDD & VDDS same pin)	6	8
UO	O	Motor driver pin U (connected to U phase of the motor coil).	7	9
WO	O	Motor driver pin W (connected to W phase of the motor coil).	8	10
VO	O	Motor driver pin V (connected to V phase of the motor coil).	9	11
RF	O	MOS lower side current output pin Connect a 0.3Ω resistor to ground as a 1A output current limit	10	12
GND/SGND	P	High voltage and low voltage ground signal pins.	11	13
FR	I	Forward or reverse select input pin. The power must be turned off when changing the status.	12	14
RD	O	Lock mode signal output terminal (5V CMOS logic)	13	15
FG	O	Fan speed signal output terminal (5V CMOS logic)	14	16
SEL	I	1: default, with soft-switching (enable noise reduction). 0: without soft-switching	15	17
TEST	I	Input pin for test, keep floating	16	18
FANSEL	I	The allowable times of continuous lock on protection to enter deadlock mode. Unplug & plug power supply to release. 1: 20 ; 0: 255	–	19
LOCKONSET	I	Setting of stall time when entering lock on protection 1: The lock on is fixed at 5 seconds. 0: The lock on time is proportional to OSC's capacitance,	–	20

Pin Name	I/O	Description	Pin number	
			PT2432/A/B HTSSOP16	PT2432C HTSSOP20
		OSC=1nF, about 6 seconds.		
Heatsink	P	Back side heat sink	back-side	back-side

PIN EQUIVALENT CIRCUIT

FR/SEL/FANSEL DUTYSEL LOCKONSET	VSP	FLT/COM	RF
			
UO/VO/WO	**OSC**	**VREG**	**RD/FG**
			

PT2432 APPLICATIONS SUMMARY

Part	BEMF RATIO	SEL	FAN SEL	LOCKON SET	DUTY SEL
	Voltage interval **H : 12V** **L : 24V**	Soft switching H : Yes L : No	Lock on time limit H : 20 L : 255	Lock on time H : 5 sec L : OSC_C	PWM processing H : smoothly L : directly
PT2432 HTSSOP16	12V	H/L	20	5 sec.	H : smoothly
PT2432A HTSSOP16	24V	H/L	20	5 sec.	H : smoothly
PT2432B HTSSOP16	12V	H/L	20	5 sec.	L : directly
PT2432C HTSSOP20	24V	H/L	H/L	H/L	H/L

Notes : 1. H or L means that the options are fixed.
2. H/L means that the options can be adjusted thru the pins selection.

FUNCTION DESCRIPTION

Power supply

PT2432 provides a built-in 5V voltage regulator to supply the analog and digital circuit blocks. A diode can be connected in series with the power input terminal as needed to prevent circuit damage caused by reverse connection of the power supply. Since the load of the driver stage is a motor coil, which exhibits inductive characteristics, when the motor starts to rotate, a larger current and peak voltage will be generated. A proper bypass capacitor is required and placed as close as possible to the VDD or VDDS pin to reduce these spikes. In addition, it is recommended to add a Zener diode with a landing point slightly higher than the operating voltage to help withstand the back electromotive force (BEMF) voltage generated when the motor decelerates.

PWM or DC input for speed control

The PT2432 offers an external DC or PWM control input to the VSP pin to adjust the motor speed. With PWM input, the high voltage potential needs to be greater than 3.0V and the low potential to be less than 0.3V. The recommended PWM input frequency is between 5 KHz – 25 KHz. With an analog DC input, the voltage control ranges should be between 0.3V to 3.0V. When the VSP pin is floating, internal pull-HIGH logic will set the motor to run with full speed at 100% duty cycle.

PT2432 has no speed control loop. Speed information may be determined from the FG signal.

Start-up

The most difficult part of sensorless control is during startup process, because the rotor position is unknown, and the BEMF signal is weak or undetectable. The PT2432 startup method is to align the rotor to an initial position and gradually increase the control voltage (or increase the PWM duty cycle) to achieve motor excitation and rotation. The initial position alignment may cause the rotor to rotate forward or reverse randomly for a cycle start time. PT2432 uses a smaller force (1.6% PWM duty cycle) and a shorter time to align to minimize the reverse jitter. Immediately after the alignment, it sends out six-step commutation and gradually increases the PWM duty cycle to 20% to accelerate. This stage is called start-up. The speed of acceleration and the start-up time are proportional to the OSC capacitance. When OSC_C = 1nF, the allowable time for the start-up process is about 3.2 seconds. During the startup process, the program will detect the correct commutation zero-crossing signal (ZC). If there is not enough ZC signal detected within 3.2 seconds, it will be judged as a startup failure, and the PT2432 will enter the lock on protection mode. .

In order to adapt to the load requirements of different motors, adjusting the proper OSC pin capacitance value will help the motor to start more smoothly. The range of OSC capacitance is about 100pF to 3.9nF. Generally lighter or faster-running motors generally require smaller capacitance values, while heavier or slower-running motors require larger capacitance values.

Acceleration and deceleration

PT2432 will determine the acceleration and deceleration mode according to the status of the "DUTYSEL" pin. When PT2432B or PT2432C ”DUTYSEL” is set to Low, the value of the external VSP or PWM input will be directly output, and there will be no slow rise and slow fall processing. Choose this method when the application needs to be accelerated faster.

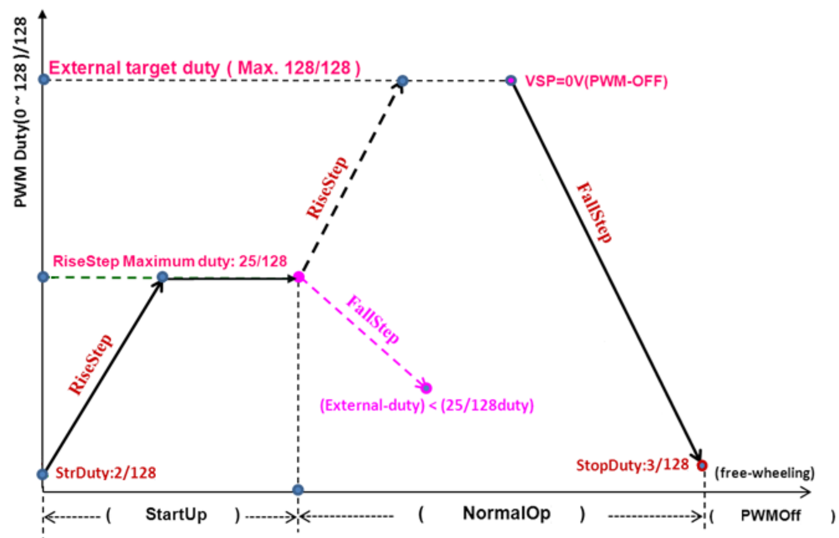
When PT2432/A or PT2432C “DUTYSEL” is set to High or the pin is left unconnected, in order to make the acceleration and deceleration behave more slowly, the external VSP or PWM command will be processed by the internal program for slow rise and slow fall. When the startup is completed, it will be accelerated according to a fixed PWM increase, and the acceleration time is related to the value of the OSC external capacitor. Usually when OSC_C=1nF, it takes about 4.7 seconds from start-up to 100% PWM duty cycle. The deceleration situation is similar, it takes about 3.8 seconds to decrease from 100% PWM duty cycle to 0% (not including the coasting time of the motor due to inertia). The following figure shows how the internal program handles the PWM ramp-up and ramp-down during startup and acceleration

/deceleration.

Sensorless control

The PT2432 control scheme is based on a sensorless trapezoidal wave control method. The main advantage is that there is no need for a Hall sensor, thereby reducing the cost of the module and the problem of Hall sensor alignment and temperature changes. Sensorless control is mainly achieved by measuring the BEMF induced by the motor coil and its zero-crossing signal (ZC) when the motor is rotating to produce a commutation basis to achieve sensorless control.

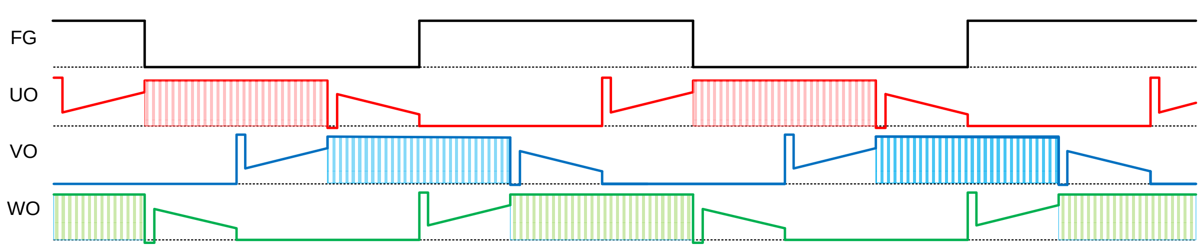
Using the internal resistor divider to reduce the UVW amplitude to less than 5V, a virtual "COM" signal can be synthesized. The signal after UVW step-down (FLT pin) is compared with COM in turn to generate ZC commutation signal



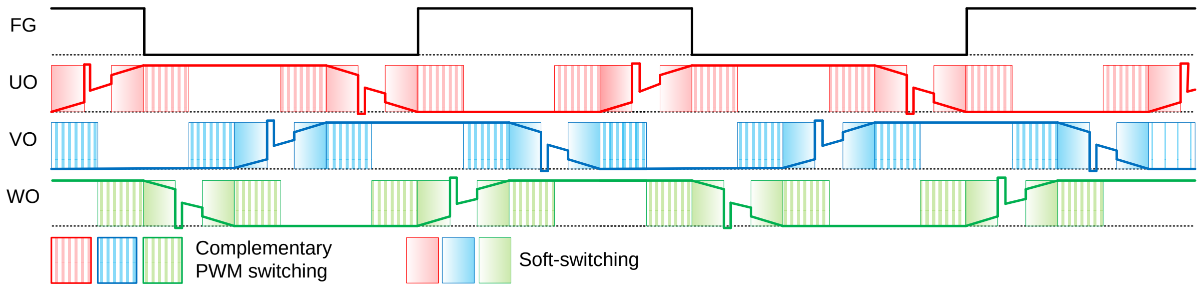
DUTYSEL=high，VSP input and PWM output processing

Driver Stage PWM switching

PT2432 provides PWM soft switching function to reduce the large noise caused by square wave switching. This can be selected through the "SEL" pin. When "SEL" is set to high or open, PWM has a soft switching function, which is called 150° commutation control. When "SEL" is set to low, there is no soft switching function, or it is called 120° commutation control. Before starting to enter the sensorless operation, the PWM has no soft switching to improve the probability of ZC detection success. Generally, the PWM switching frequency is 20KHz, and the soft switching interval uses a higher 80KHz switching frequency.



Startup or SEL=low, PWM without soft-switching，FG & motor phase voltage schematic diagram



SEL=high and motor into sensorless operation, PWM with soft-switching，FG & motor phase voltage diagram

Lock on protection

During the start-up process, when the controller cannot determine any valid ZC signal, it will make the motor enter the lock on protection mode. If external force intervenes or interferes during the operation of the motor, resulting in excessive ZC variation, it will also force the motor to enter the lock on protection mode. After about 5 seconds, the program will try to restart the motor. After the motor restarts successfully, normal operation will continue. However, if the motor still fails to start, the control algorithm will continue to return to the lock on protection mode and try to restart the motor again. After 20 consecutive startup failures, it will enter the deadlock protection mode, which can be released after power-on again. PT2432C can use OSC to adjust the shutdown time of lock on protection (LOCKONSET = L). The upper limit of the number of consecutive stalls can also be set to 255 through (FANSEL = L). When entering the lock on protection mode, the RD pin will output a high level.

Over temperature protection

PT2432 has a built-in thermal sensing circuit. When the internal temperature of the chip exceeds 150°C, PT2432 will turn off the output driver stage. Once the internal temperature of the chip drops below 120°C, the PT2432 will operate normally again. When over-temperature protection occurs, the RD pin will output a high level.

Current limit

PT2432 uses the phase current of the motor coil to pass through the external resistor R to obtain a voltage drop (RF), and detect this voltage to achieve the current limit function. When the detected RF voltage exceeds 0.3V, PT2432 will reduce the PWM duty cycle to prevent the current from exceeding. After the RF voltage signal becomes lower than 0.3V, the PWM operation restarts. The calculation method of the current limit is I = 0.3V/R.

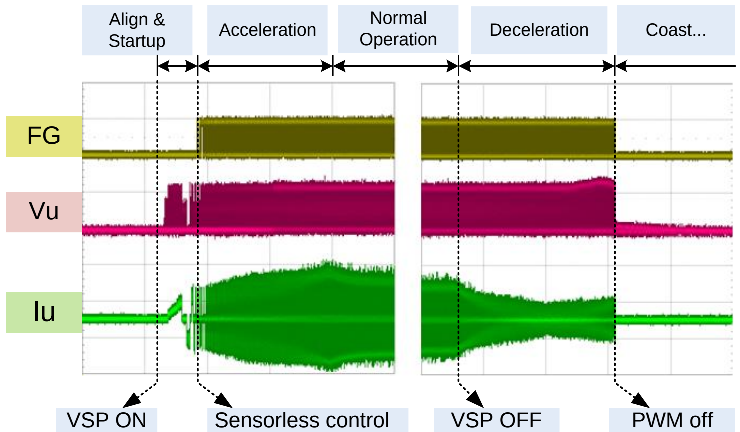
There are two situations in which the current limit remains inactive. The first is when starting, in order to prevent the current limit from affecting the start, so the current limit protection will be activated only after the start is successful. The second is the deceleration stage. When the load is heavy and the deceleration time is short, although the PWM duty cycle will gradually decrease, it is possible that the motor voltage will rise due to inertia, and the current will exceed the predetermined limit value.

FG output for speed information

FG will not output during startup, and will output only when it enters non-inductive operation after successful startup, as shown in the figure below. When the rotor runs for more than one (electrical) cycle, the FG pin will output a high and one low signal. When calculating the rotation speed, it is necessary to know the number of rotor poles. For example, if the rotor has 8 poles (four pairs of NS), one cycle of the motor will produce 4 FG outputs. The rotation speed of the motor is mostly expressed in RPM (revolutions per minute), and the rotation speed can be converted by the following simple formula

$$RPM = FG \times 120 / POLE,$$

Where FG is the frequency in Hz, and POLE is the number of rotor poles.



FG, U-phase voltage, U-phase current from the start to the end of the operation relationship diagram

Forward and reverse setting

PT2432 can be set to forward or reverse rotation via the FR pin. If the FR mode is changed, the motor will automatically stop and then rotate in the opposite direction. There is a pull-up resistor of about 22KΩ inside the FR.

External capacitance selection between COM and FLT pins

PT2432 detects the motor position by comparing the back-EMF generated by the motor rotation and the virtual midpoint voltage to generate a ZC signal. However, noise caused by the motor when it starts or rotates may interfere with the accuracy of the zero-crossing signal, which may cause failure at startup or affect rotation stability. The capacitor between the COM and FLT pins helps to reduce noise interference. The recommended capacitance range is 0.1nF to 10nF. In addition, when a filter circuit is used, the commutation signal ZC will cause a delay. Therefore, the higher the speed of the motor, the smaller the capacitance value, so that too much delay will not affect the efficiency.

External capacitance selection of OSC pin

OSC is the relative benchmark for all variable adjustment steps or time of PT2432, including start step, 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 the highest speed. For other applications with different maximum speeds, OSC_C=1nF, FG=100Hz can be used as the initial setting value, and then fine-tuned to achieve a smoother start effect. Usually higher speed or faster start-up applications choose a smaller OSC capacitor, and vice versa. The initial selection of FLT capacitor can be the same as that of OSC capacitor, and then fine-tune it according to the desired effect.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Max.	Unit
VDD supply voltage	VDDmax	PT2432/B No break down	20	V
		PT2432A/C No break down	30	V
Output pin current(1)	Iout,max	PT2432/B UO, VO, WO pins	1.5	A
		PT2432A/C UO, VO, WO pins	1.0	A
Input pin withstand voltage	Vin,max	PWM, OSC, FR, SEL,TEST	6	V
Power dissipation 1	Pd,max1	Independent IC	0.3	W
Power dissipation 2	Pd,max2	Mounted on evaluation board(2)	1.2	W
Operating temperature	Topr	–	–40 to +125	°C
Storage temperature	Tstg	–	–40 to +150	°C

Notes: 1. 500ms test time and mounted on the designated board with heat-sink area.
2. Mounted on the designated board with heat-sink area.

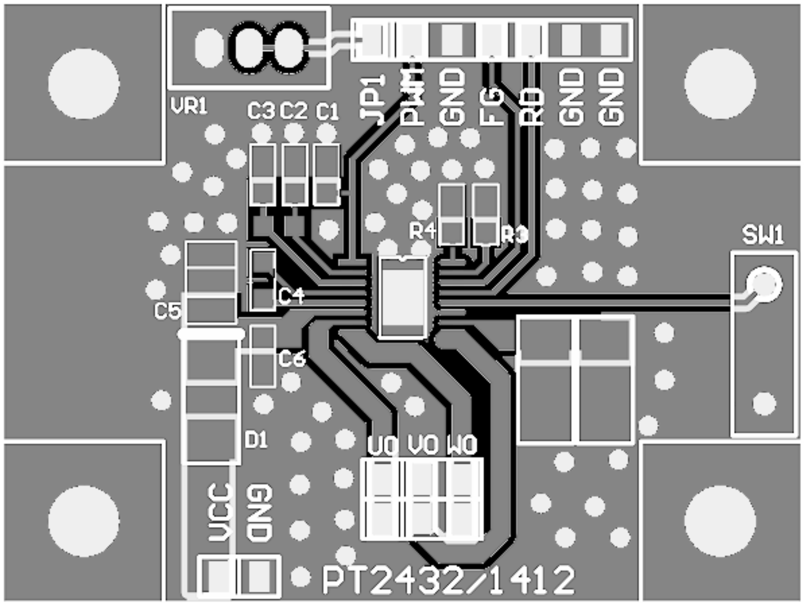
ELECTRIC CHARACTERISTIC

(VDD = 12V, T = 25°C unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
VDD supply voltage	VDD	PT2432/B	6.0	–	15	V
		PT2432A/C	6.0	–	28	V
Power supply current 1	IDD 1	PWM pin = VREG, without load	–	3.0	5.0	mA
Power PMOS Rdson	RPdson	Io = 500mA	–	0.3	0.4	Ω
Power NMOS Rdson	RNdson	Io = 500mA	–	0.3	0.4	Ω
OSC pin charge current	Iosc 1	OSC pin	–	–5.6	–	μA
OSC pin discharge current	Iosc 2	OSC pin	–	5.6	–	μA
VREG pin voltage	Vreg	No load	4.5	5	5.5	V
VSP pull-up resistance	Rvsp	Pull-up to VREG internally	–	150	–	KΩ
DC for VSP control range	DCvsp	VSP input	0.3	–	3.0	V
PWM frequency for VSP control	Fpwm	VSP input	5	–	25	KHz
PWM high input voltage for VSP control	Vpwmh	VSP input , PWM voltage rising	3.3	–	5	V
PWM low input voltage for VSP control	Vpwml	VSP input PWM voltage falling	0	–	0.3	V
Logic input pull high current	Isource	FR, SEL, TEST pins	–	–	10	μA
Logic output high level	Voh	RD, FG pins	4.5	–	–	V
Logic output low level	Vol	RD, FG pins	–	–	0.5	V
Current limiter voltage	Vrf	–	0.25	0.3	0.35	V
Thermal shutdown	Tshdn	Temperature increasing, design target	–	150	–	°C
Thermal release	Trel	Temperature decreasing, design target	–	120	–	°C

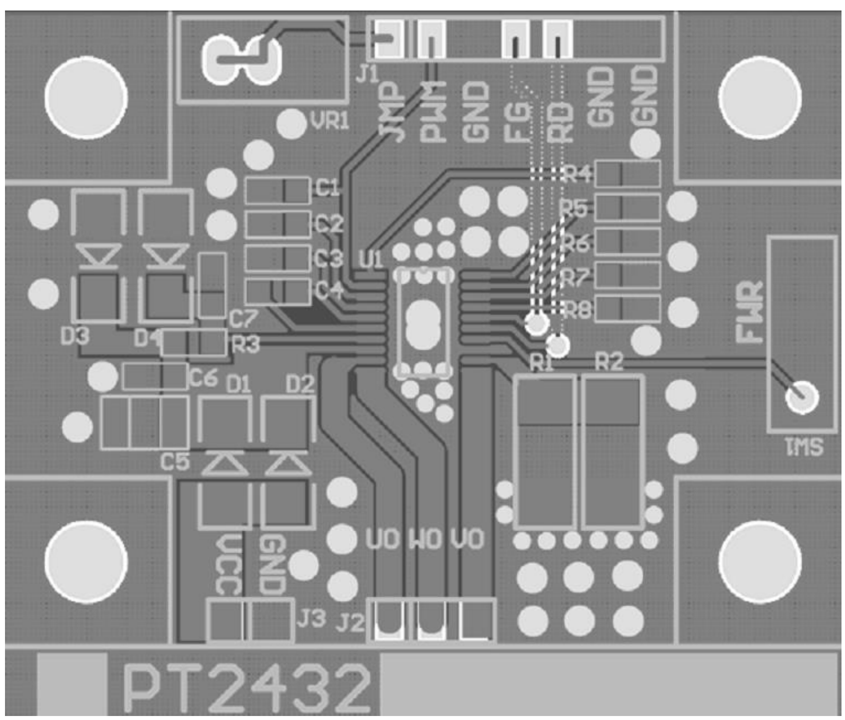
EVALUATION PCB

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



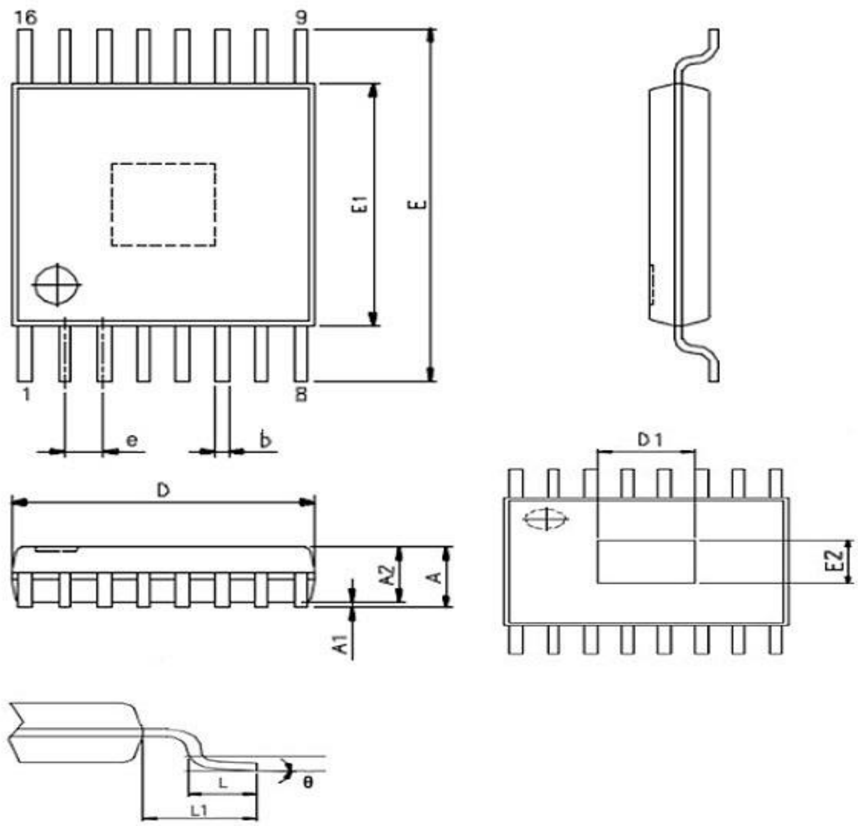
EVALUATION PCB

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



PACKAGE INFORMATION

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

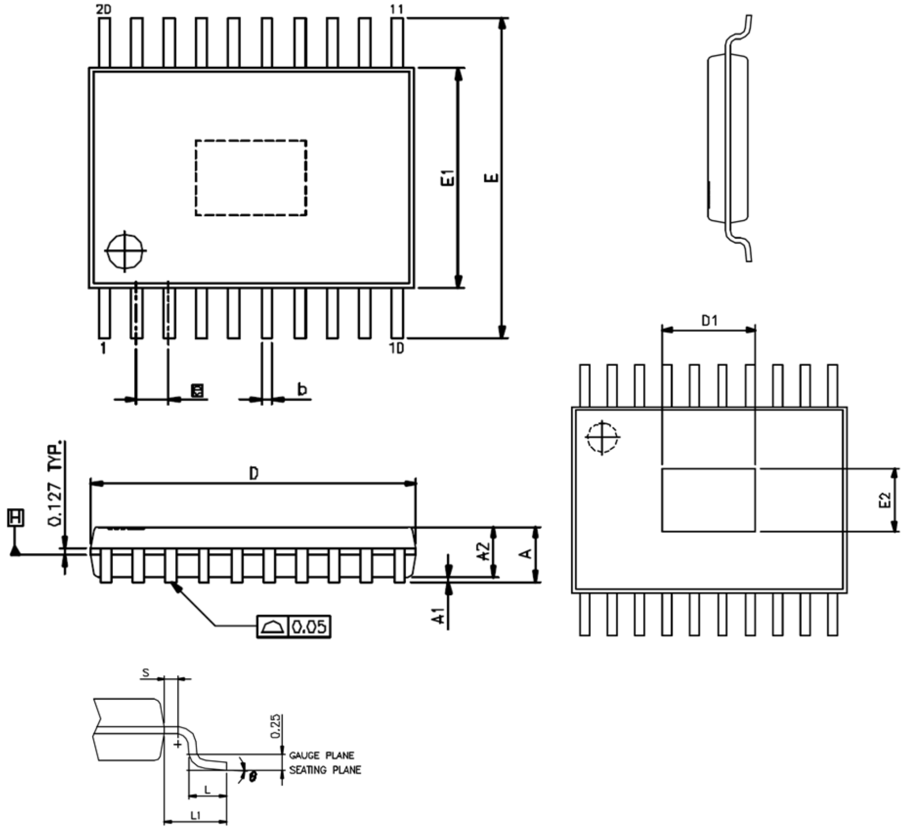


Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	-	-	1.20
A1	0.00	-	0.15
A2	0.80	1.00	1.05
b	0.19	-	0.30
D	4.90	5.00	5.10
D1	1.98	-	-
E	6.4 BSC		
E1	4.30	4.40	4.50
E2	1.98	-	3.00
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
θ	0º	-	8º

Notes:

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

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



Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	-	-	1.20
A1	0.00	-	0.15
A2	0.80	1.00	1.05
b	0.19	-	0.30
D	6.40	6.50	6.60
D1	2.20	-	-
E	6.4 BSC		
E1	4.30	4.40	4.50
E2	1.50	-	3.00
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
θ	0º	-	8º

Notes:

1. Refer to JEDEC MO-153 AB/ABT (Thermally Enhanced Variations only)
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.
PTC cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a PTC product. No circuit patent licenses are implied.

Princeton Technology Corp.
2F, 233-1, Baociao Road,
Sindian Dist., New Taipei City 23145, Taiwan
Tel: 886-2-66296288
Fax: 886-2-29174598
http://www.princeton.com.tw