DESCRIPTION

PT2502 is a 3 phase, sensor-less brushless DC motor control IC with square wave/trapezoidal wave control method based on detecting the zero-crossing of the motor back electromotive force (BEMF). It has a stable control effect and is not easily affected by motor differences. The IC's built-in +5V LDO provides operation for logic circuits and analog circuits. With an external high voltage gate driver and six N-channel MOSFETs, the PT2502 is capable of operating high voltage motors up to 400V. For 12V to 24V operation, external high side P-MOSFETs and low side N-MOSFETs can be driven motor through a simple circuit. PT2502 provides internal OTP to store parameter settings to optimize different motors and applications. The package of PT2502 is SSOP28.

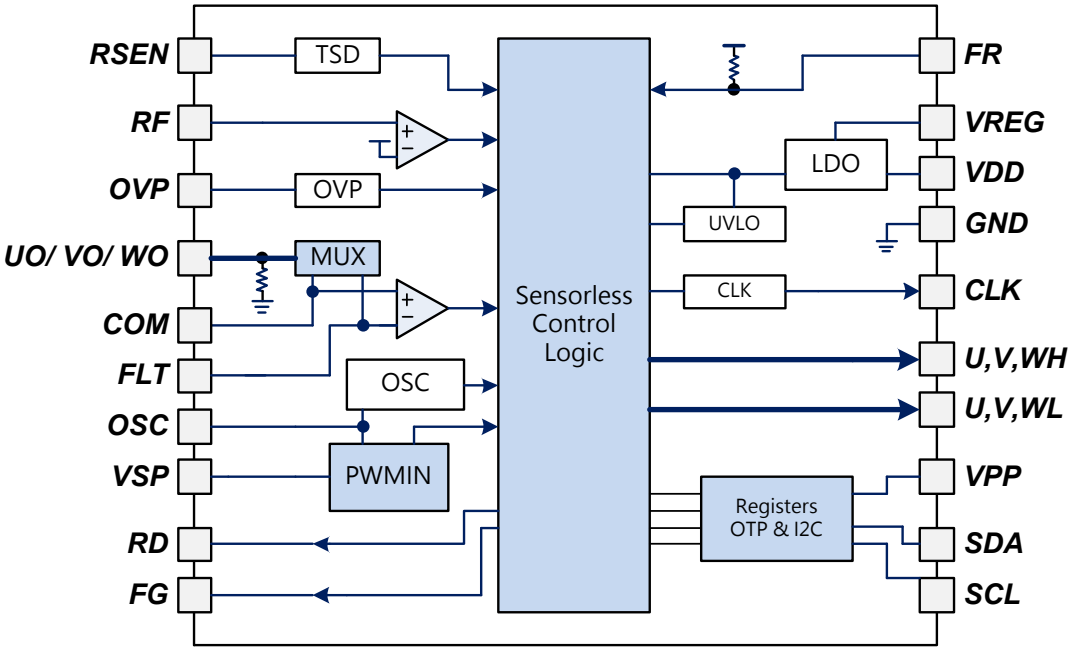
FEATURE

- 3-phase sensor-less BLDC control
- 5V – 24V power application with internal 5V LDO
- Internal OTP for parameters setting
- I2C interface for parameter setting
- Over-current protection and over-voltage protection
- Thermal shutdown protection function with an external NTC resistor
- Lock protect function
- PWM or DC control input support for motor speed control
- FG output function

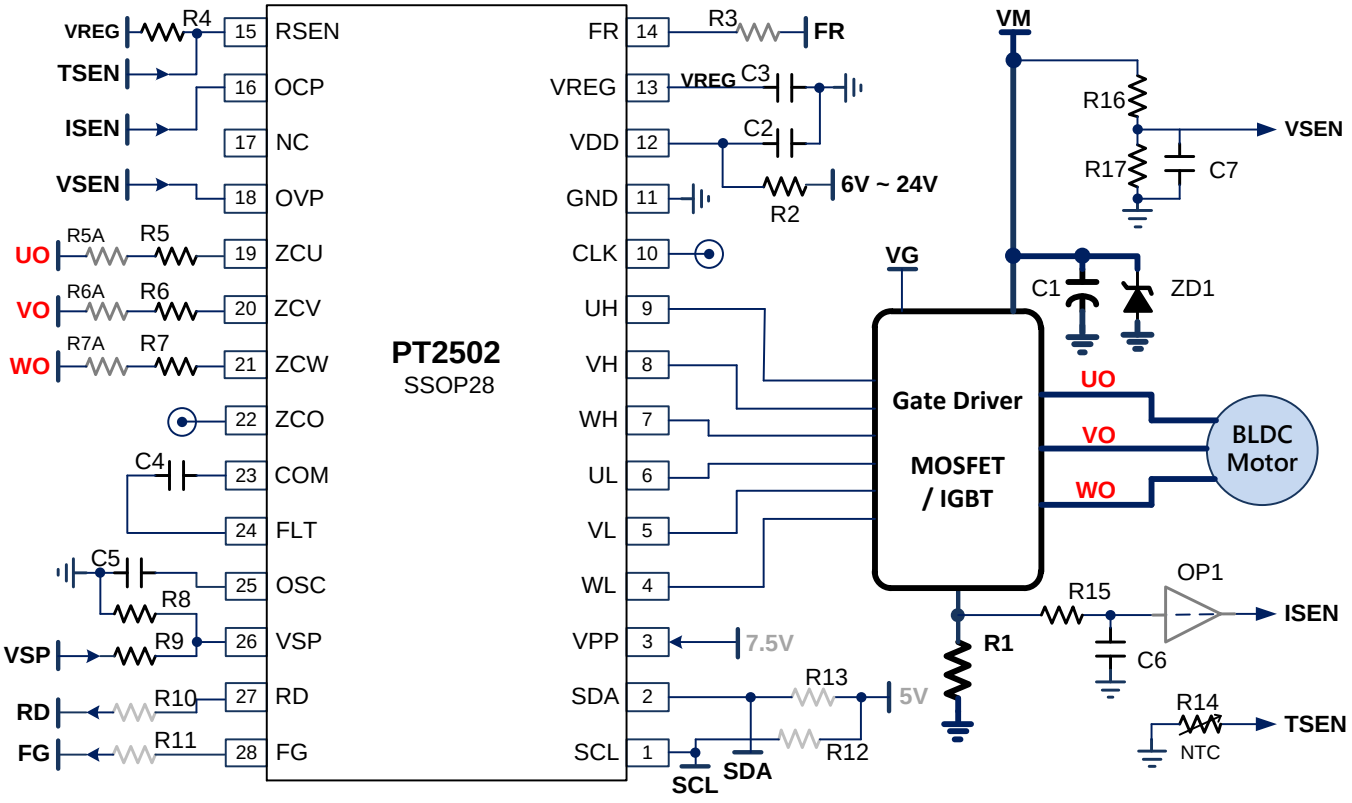
APPLICATION

- 3-phase sensor-less BLDC motor controller
- High speed fan
- Water pump

BLOCK DIAGRAM



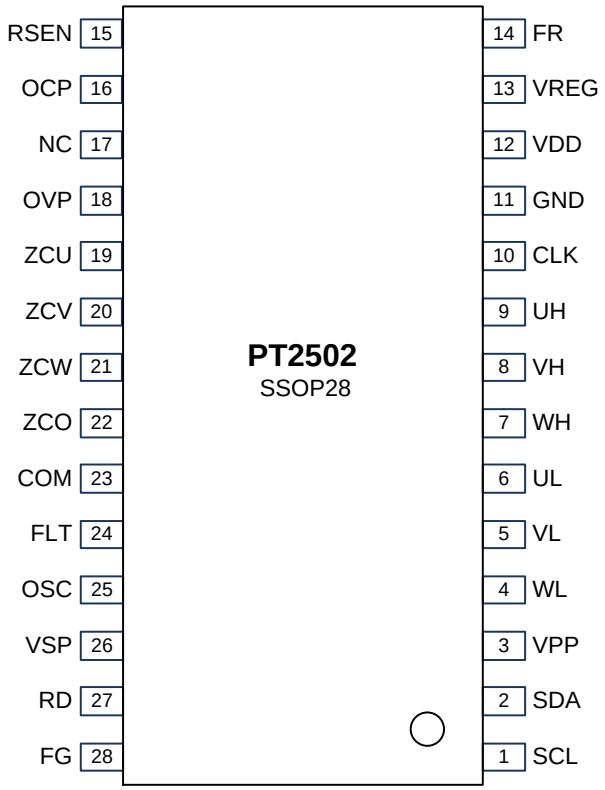
PT2502 APPLICATION CIRCUIT & BOM



Part	Value	Unit	Description
C1	10u ~ 1000u	F	Voltage stabilizing and filtering capacitor at the motor power supply, it is recommended to use electrolytic capacitors
C2	1u/25V	F	VREG input filter capacitor
C3	10u ~ 1000u	F	VREG output voltage stabilizing capacitor
C4	10p ~ 10n	F	ZC signal processing low pass filter capacitor
C5	1n	F	OSC external capacitor
C6	10p ~ 10n	F	OCP signal processing low pass filter capacitor
C7	10n	F	VSEN power supply voltage detection signal processing low-pass filter capacitor
R1	0.1 ~ 1.0	Ω	OCP protection detection resistor, use higher power resistor
R2	100 ~ 3.3K	Ω	VREG input filter resistor, when the input voltage is high, can share VREG heat
R3/R9/R10/R11	1K	Ω	VSP / FR/ RD/ FG input/output protection resistor
R4	1K ~ 100K	Ω	Over-temperature protection setting voltage dividing resistor

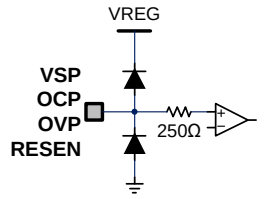
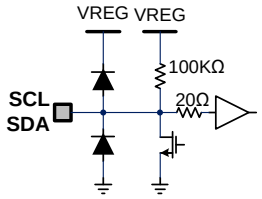
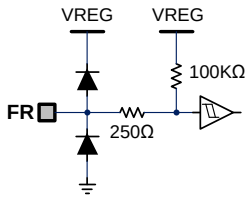
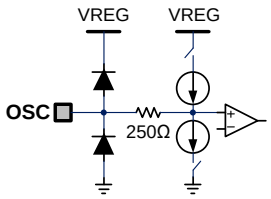
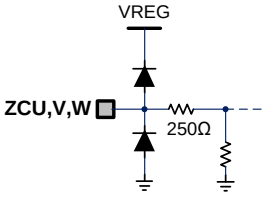
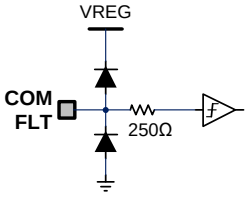
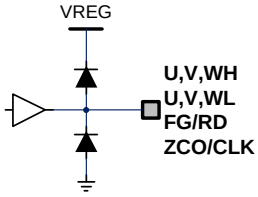
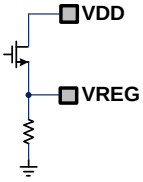
R5/R6/R7 R5A/R6A/R7A	10K ~ 1M	Ω	ZC detects the voltage dividing resistor. When the power supply voltage exceeds 100V, a series resistor is added to share the voltage drop and heat. When using a resistor, pay attention to the withstand voltage and power limitations.
R12/R13	10K	Ω	I2C pull high resistor, usually the UI Kit terminal has been placed, it does not need to be connected
R14	1K ~100K	Ω	Over-temperature protection detection resistor, use NTC type, placed close to the heat source
R16/R17	1K ~ 1M	Ω	Overvoltage/low voltage detection voltage dividing resistor, please pay attention to the withstand voltage and power limit
ZD1	> VM	V	Voltage rebound protection Zener diode, place as needed, or use a rebound circuit
OP1	X2 ~ X20		When the power is high, the resistance of R1 is low, and the OP can be used to amplify the signal and placed as needed.

PIN ASSIGNMENT & DESCRIPTION



Pin name	I / O / P	Description	Pin #
SCL	I	Serial clock input – I2C control interface	1
SDA	I / O	Serial data input/output – I2C control interface	2
VPP	P	High voltage power supply (7.5V) for programming OTP	3
WL	O	W phase low side signal output	4
VL	O	V phase low side signal output	5
UL	O	U phase low side signal output	6
WH	O	W phase high side signal output	7
VH	O	V phase high side signal output	8
UH	O	U phase high side signal output	9
CLK	O	Clock output pin	10
GND	P	High and low voltage ground	11
VDD	P	High voltage power supply	12
VREG	P	5V regulator output	13
FR	I	Forward or reverse select input	14
RSEN	I	External resistor connection for over temperature sensing	15
OCP	I	Current limit voltage sensor	16
NC	–		17
OVP	I	Over voltage protection	18
ZCU	I	U phase BEMF zero crossing input	19
ZCV	I	V phase BEMF zero crossing input	20
ZCW	I	W phase BEMF zero crossing input	21
ZCO	O	Six-step commutation signal output	22
COM	I	Motor pseudo middle point of the motor	23
FLT	I	Six-step commutation signal filter input	24
OSC	IO	External capacitor connection to generate PWM triangle waveform	25
VSP	I	Speed command control thru DC or PWM input	26
RD	O	Lock mode signal output (5V CMOS logic)	27
FG	O	Fan speed signal output (5V CMOS logic)	28

PIN EQUIVALENT CIRCUIT

VSP OCP/OVP/RSEN	SCL/SDA	FR	OSC
			
ZCU,V,W	**COM/FLT**	**U,V,WH/ U,V,WL FG/RD/ZCO/CLK**	**VDD/VREG**
			

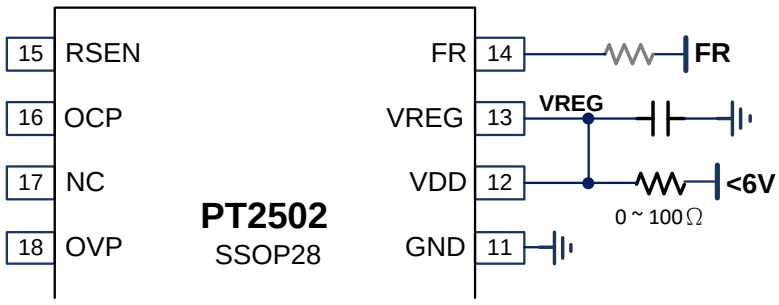
FUNCTION DESCRIPTION

POWER SUPPLY

Since the PT2502 consumes very low current (<5mA) and has a built-in 24V to 5V linear regulator (LDO) to provide operation of logic circuits and analog circuits, there is no need to add an external regulator device.

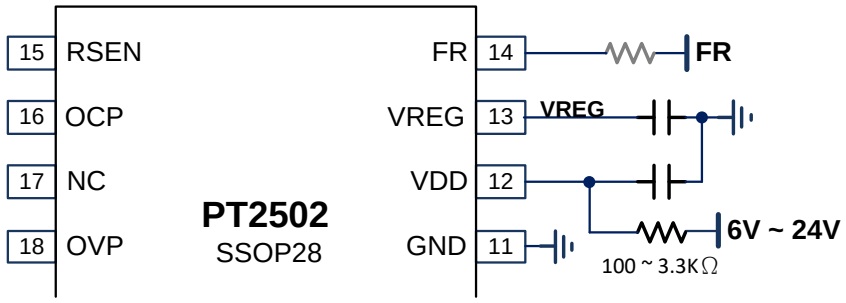
In order to avoid power interference or instability, PT2502 internally detects the LDO voltage. When the LDO voltage exceeds 3.5V, it will notify the logic circuit to start operation within 10ms. In motor systems, the chip is easily affected by induced noise. It is recommended that the bypass capacitor be placed as close to the IC power pin as possible.

When the power supply is less than 6V or the system provides a 5V power supply, please connect VDD and VREG in parallel, as shown below:



When the power supply is a high-voltage system with 6V~24V or VM>24V (usually with a 12V~15V power supply). At this time, in addition to being used as a filter circuit, the external series resistor can also be used

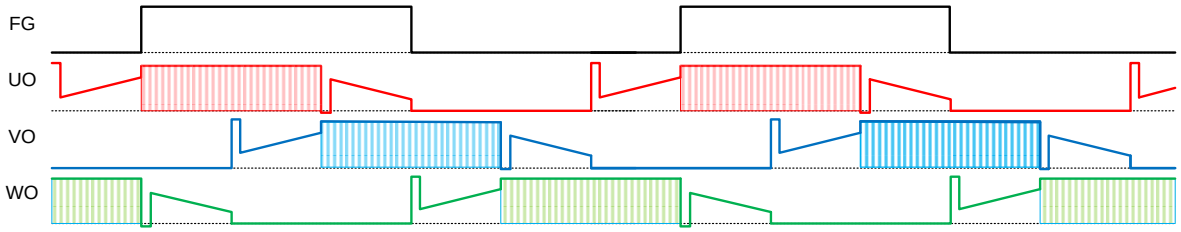
to share the heat generated by the voltage drop of the PT2502 internal linear regulator. The PT2502 power supply connection method is as follows:



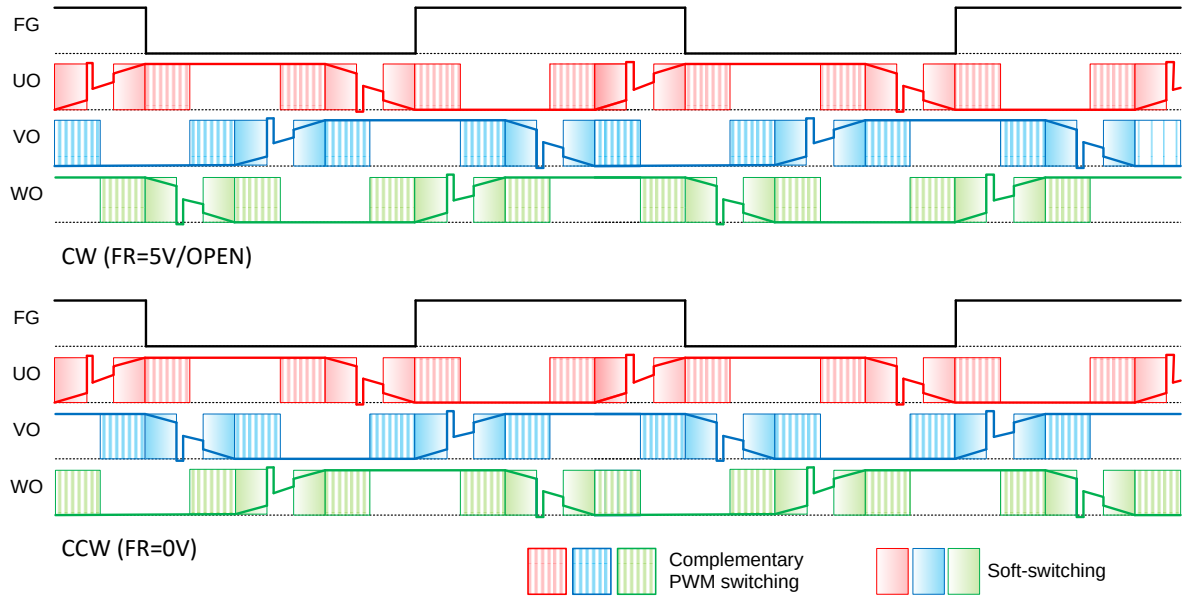
PT2502 can use the burning OTP to store motor control parameters. During the burning process, the VPP must be supplied with 7.5V external power.

Sensorless Control

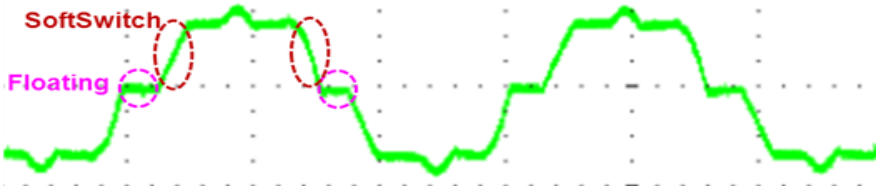
The PT2502 control scheme is based on sensorless trapezoidal wave control, which does not require Hall sensors, simplifying PCB manufacturing and adjustment, and reducing costs. The feedback of sensorless control is mainly achieved by measuring the BEMF induced by the motor coil during rotation. When the motor is controlled, the UVW coil endpoint voltage (phase voltage) mixes the control signal and BEMF, making it difficult to separate the back EMF from the phase voltage. Therefore, a floating time (a specific angle) is inserted during motor commutation without PWM output (Hi-Z) to obtain the BEMF zero-crossing position (ZC) and then control the motor operation. Under normal circumstances, the Hi-Z electrical appliance angle is 60° during pure square wave control, which is generally called 120° commutation control. During trapezoidal wave control, the Hi-Z electrical appliance angle is 30° to 60°. Generally, when using Hi-Z appliances at an angle of 30°, there is also a reversal control called 150°. PT2502 can use parameters to set the Hi-Z angle.



120° square wave PWM control method



150° Soft-switching PWM control method



Soft-switching current waveform

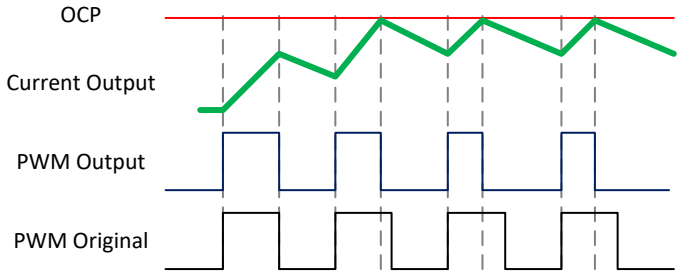
PT2502 uses a voltage dividing resistor to reduce the phase voltage below 5V (the ZCU, V, and W pins already have 10K ground resistors inside), allowing analog circuits to process signals.
And generate a zero-crossing (ZC) signal to detect UVW commutation. Because the system noise of the motor, operating voltage, speed and other factors is too large or the BEMF signal of the motor is too weak, it will affect the ZC signal accuracy, and this may cause control failure. This can be done by adjusting the analog filter (FLT&COM external capacitor) or digital filter (internal parameters) to improve. The PT2502's soft switching method can help reduce audible motor current noise.

When selecting an external voltage divider resistor, the withstand voltage and power limitations of the resistor itself need to be considered. Usually the VM voltage is above DC 100V. It is recommended to use two external resistors above 0805 in series to share the voltage drop and heat.

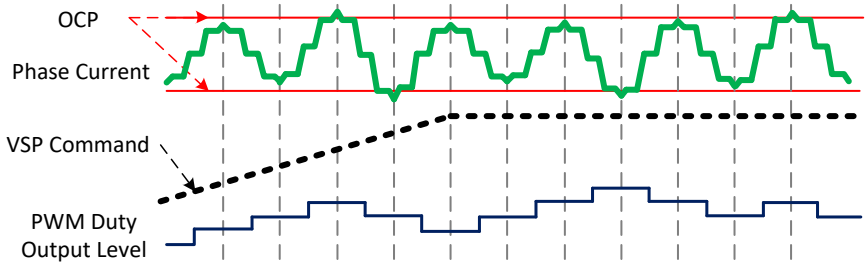
Current Limit

PT2502 achieves a current limit function (OCP) by detecting a single sampling resistor RF flowing through the power component and obtaining a voltage related to the current. When the detected OCP voltage exceeds 0.3V, parameters can be used to select the working mode of turning off PWM or reducing PWM Duty. When using the timely shutdown PWM method, the current is suppressed within the range in real time. The advantage is fast response speed, but the disadvantage is that electromagnetic noise may be generated due to incomplete current. If the PWM Duty reduction method is used, the PWM Duty will be reduced in the next

cycle when OCP is detected, so the response speed is slower, but electromagnetic noise due to incomplete current will not be generated. If it is necessary to achieve constant current control or constant power control, the option to reduce PWM Duty can be used in conjunction with the external ISEN RC low-pass filter circuit to achieve this. When the bandwidth of the low-pass filter circuit is large, the effect is close to constant power; when the bandwidth of the low-pass filter circuit is small, the effect is close to constant current.



OCP, timely shutdown PWM method



OCP, PWM Duty reduction method

RF resistors need to use high-power precision resistors to avoid burning due to overheating. When the RF resistor burns out, it will cause an open circuit, which may cause components such as the controller, gate driver, and MOSFET to instantly rise to high voltages, causing widespread damage. In high-current applications, an RF with a smaller resistance can be used, and an external OP can be used to amplify the voltage of ISEN to avoid RF consuming too much power and generating excessive heat.

Selection of Capacitor between COM & FLT

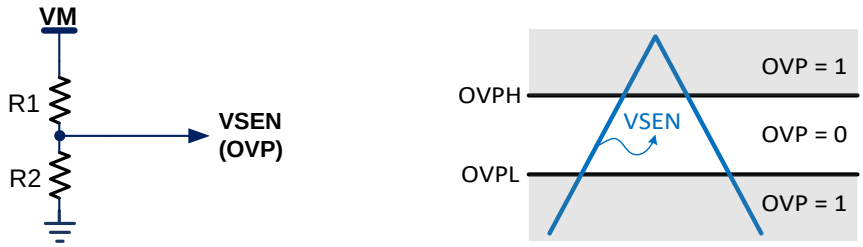
PT2502 detects the motor position by comparing the back electromotive force generated by the motor rotation with the three-phase virtual midpoint voltage (COM) to generate the ZC signal. However, noise from motor startup or rotation may interfere with the accuracy of the zero-crossing signal, which may result in failure at startup or reduced motor efficiency. A capacitor between the COM and FLT pins helps mitigate the effects of noise interference. The recommended range of capacitance value is 0.1nF to 10nF. Because the filter capacitor will also affect the judgment of commutation delay, usually the higher the speed, the smaller the capacitance value of the motor, so that excessive delay will not affect the efficiency. In addition, you can also use parameters to set digital filters. Whether it is a digital or analog filter, it will cause delays. PT2502 can compensate for various delays through parameters so that the motor can maintain efficient operation.

Thermal Shutdown Protection

The PT2502 uses an external negative temperature coefficient resistor (NTC) as the source of the over-temperature protection detector. In the RSEN pin, the normal resistor will be connected to 5V and the NTC resistor will be connected to ground. NTC resistors should be placed near protected targets such as MOSFETs. If the temperature increases, the NTC resistance value will decrease and the voltage level of the RSEN pin will also decrease. When the RSEN voltage is lower than 0.6V, PT2502 enters over-temperature protection (OTP) mode, pulls the RD pin to high level, and the system enters shutdown mode. After the protection source cools down, the voltage of the RSEN pin is higher than 1.2V, and the motor system will start again. In the shutdown mode of PT2502, the UH/UL/VH/VL/WH/WL output logic level is low level.

Over Voltage Protection

The overvoltage protection function of PT2502 is designed to stop the motor rotation to prevent the motor from burning out when the external voltage VM is too high, and the entire system from abnormal behavior when VM is too low. The overvoltage protection function diagram is as follows:



OVP application circuit and schematic diagram of protective effect

When the detection voltage of the OVP pin (VM is stepped down to VSEN through a resistor) is higher than OVPH or the detected voltage is lower than OVPL, a warning signal is issued. The system can only work properly when the detected signal is within a safe range. The overvoltage protection function is set to OFF by default, but its status can be read out through the UI program. In order to activate overvoltage protection, the register value can be set through the UI program. See the UI application manual for detailed instructions.

In PT2502, OVPH Code and OVPL Code can be set independently. The internal OVP comparator contains a hysteresis circuit to avoid abnormal shutdown when the detected OVP signal interferes.

OVPH Code	VSEN Voltage	Unit
0	2.125	V
1	2.225	V
2	2.375	V
3	2.5	V
4	2.625	V
5	2.75	V
6	2.875	V
7	3	V

OVPL Code	VSEN Voltage	Unit
0	1.125	V
1	1.25	V
2	1.375	V
3	1.5	V
4	1.625	V
5	1.75	V
6	1.875	V
7	2	V

OVPH / OVPL code and VSEN value setting table

The following are the steps to set the overvoltage protection function for PT2502.
1. Based on the upper and lower operating limits of the voltage requirement (if AC values are given, convert to DC values), add the upper (VMH) and lower (VML) values and divide by 4 to obtain the ratio value. Rate = (VML + VMH) / 4.
2. Divide the upper limit value and lower limit value by the ratio value to obtain the OVPH and OVPL detection thresholds respectively. Refer to the table above to determine the appropriate code for each required threshold.
3. As long as the relationship [R2 / (R1 + R2)] * [VMH+VML] / 2 = 2 is satisfied, calculate the resistor value according to customer requirements.
After selecting R2, we can get R1 = [Rate -1] * R2
4. When the DC voltage of VM is greater than 100V, it is recommended to use two 0805 resistors in series for R1 to share the voltage drop and heat.

For example, in one application, the required motor operating range is from AC 80V to AC 140V.
1. Change the AC value to the DC value by multiplying by 1.414. Add the upper and lower values and divide by 4 => (80 + 140) * 1.414 / 4 = 77.77.
2. Lower detection value, OVPL =(80 * 1.414) / 77.77 = 1.454. Upper limit detection value OVPH = (140 * 1.414) / 77.77 = 2.545.
From these two values, refer to the corresponding values in the table above to select the corresponding code. In this example, OVPH Code=3, OVPL Code=4.
3. Finally, the values of resistors R1 and R2 (shown in the application circuit above) can be selected. If R2 is 10kOhm, then
R1 = [77.77 -1] * 10KOhm. Calculated to be 768kOhm. R1 can choose two 390KOhm connected in series.

PWM、CLK or VSP(DC) Input for Speed Control

PT2502 can use external PWM Duty, Clock Frequency control or DC voltage input VSP pin to change the motor speed. When using PWM or CLK input, the highest voltage needs to be greater than 3.5V, and the lowest voltage needs to be less than 0.3V. The recommended PWM input frequency is 15KHz to 25KHz. The CLK input corresponds to the target FG frequency of the rotational speed (one electrical cycle generates a High/Low signal).

When using DC control, the adjustable speed range is between 0.6V and 3.3V. When using an external MCU to control the PT2502, the FG signal can be used to obtain speed information for speed control.

In addition, PT2502 can also accept I2C to input PWM duty command. In this case, please set VSP below 0.3V.

In addition to using CLK control to achieve speed closed loop, the closed loop control method of PWM Duty and DC voltage corresponding to the speed can also be set through parameters.

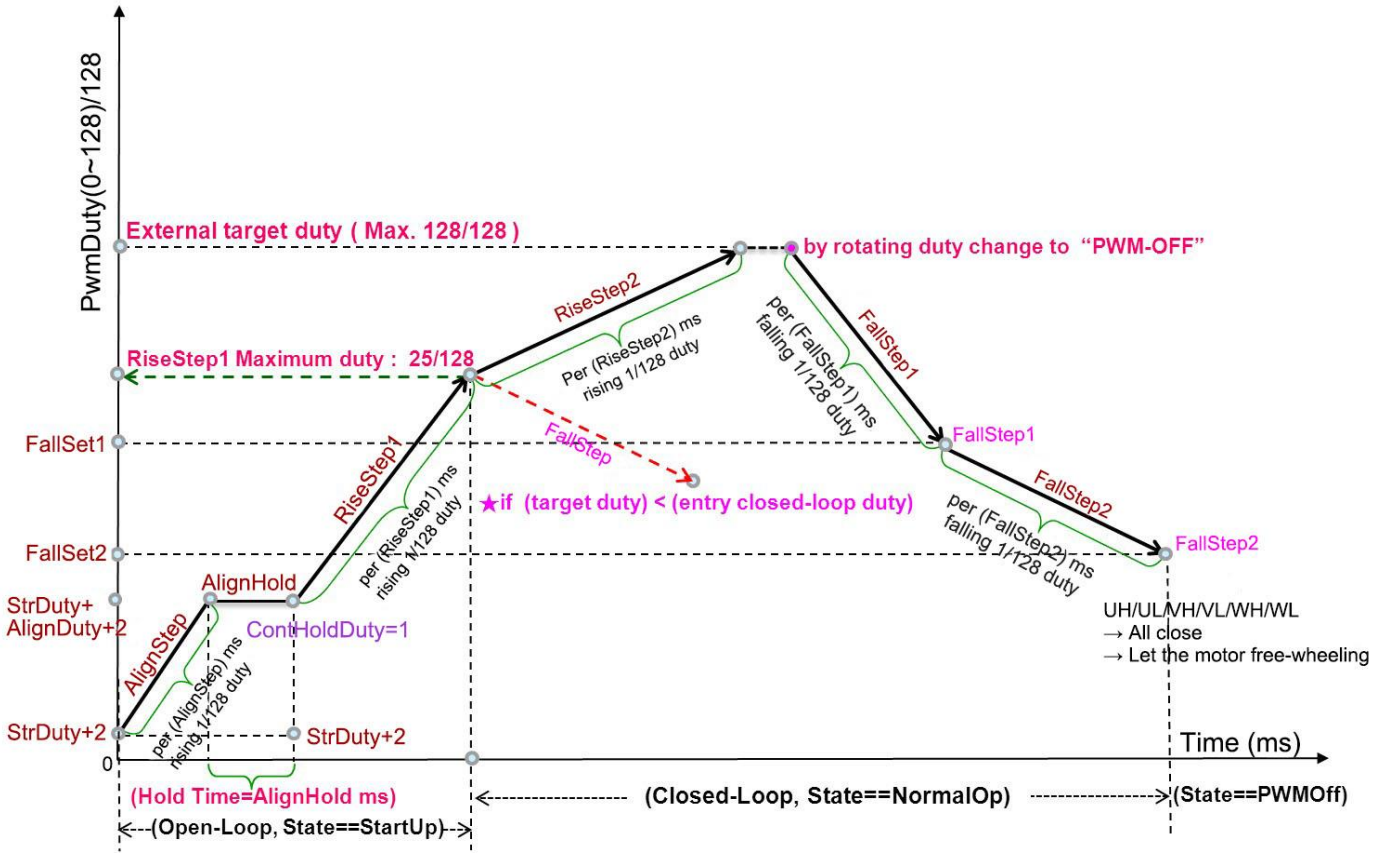
Forward and Reverse Setting

PT2502 can be set to forward or reverse mode via the FR pin, and can also be controlled via I2C. If the FR mode is changed, the motor will automatically stop and then rotate in the opposite direction. FR= 1 is U-V-W CW mode, FR=0 is U-W-V CCW mode.

Parameter Setting

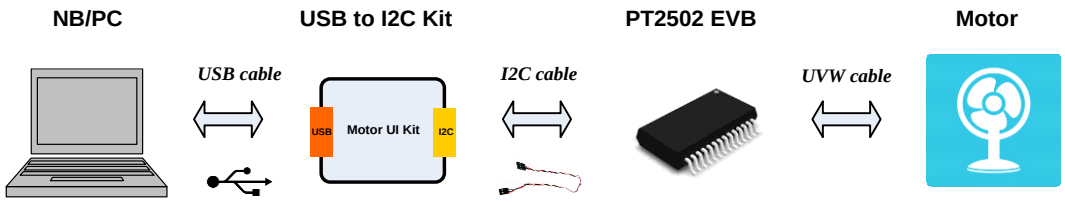
Except for the over-current, over-temperature protection and zero-crossing signal filter of PT2502, which need to be set by the resistance and capacitance of external pins, the other parameters need to be adjusted in real time through I2C or burned into the OTP memory, such as the startup process, acceleration and deceleration. Time and voltage lag compensation, etc. When using OTP recording, +7.5V must be provided to the VPP pin.

The figure below is a schematic diagram of some parameter descriptions of PT2502. For detailed parameter descriptions and adjustment methods, please refer to the PT2502_UI_Application_Note file.



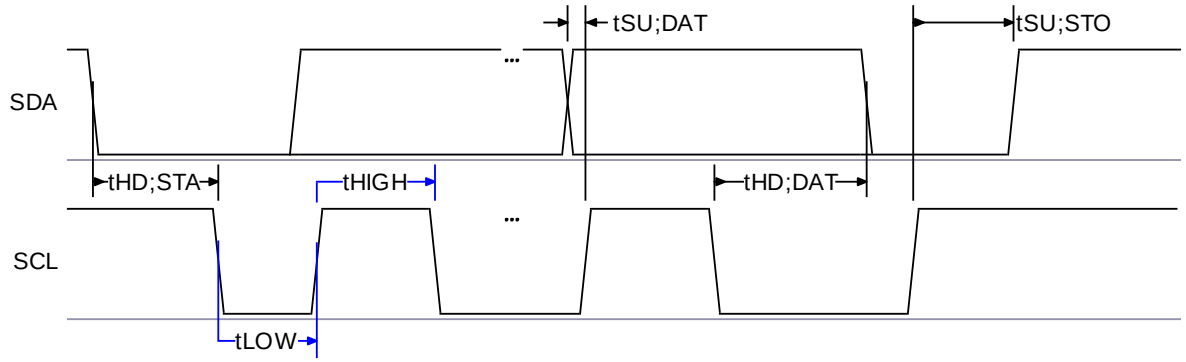
I²C Connection

PT2502 can control or transmit parameters or perform OTP parameter burning through I2C. When adjusting parameters, you can use the USB interface of NB/PC to convert to I2C to modify the internal registers of the IC. The connection method is as shown in the figure below:



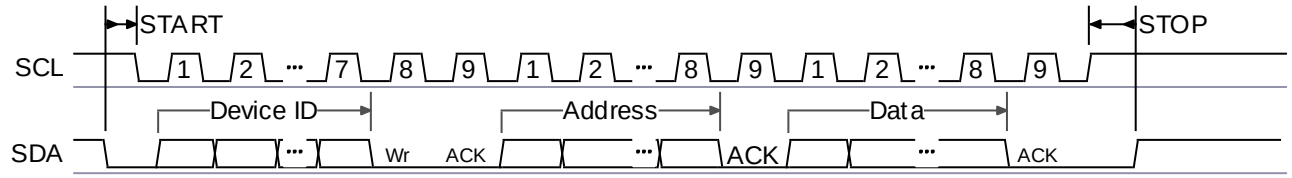
When adjusting the parameters of the IC register through I2C, it will not affect OTP burning, so you can adjust it arbitrarily until it meets your needs.
Adjusted parameters can be archived or burned. Please note that when the adjusted value is not burned into the OTP of the IC, the register value will not be the value on the NB/PC side after the IC is powered on again, but there will be three situations:
1. When OTP bank0 & bank1 are blank, the registers will be filled with default values.
2. When OTP bank0 has a value and bank1 is blank, the register will fill in the bank0 value.
3. When OTP bank0 & bank1 both have values, the register will fill in the bank1 value.

I2C frequency specification is below

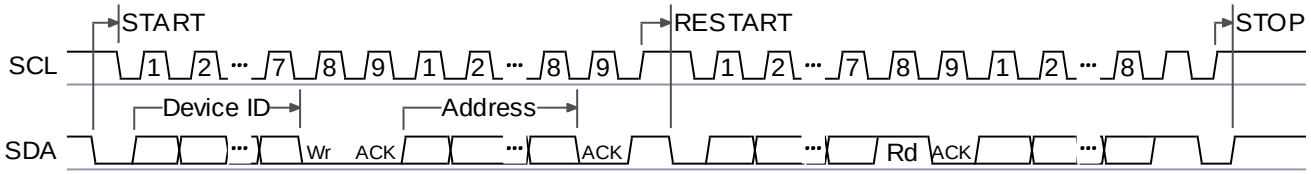


Parameter	Symbol	Condition	Min.	Typ.	Unit
SCL clock frequency	f_{SCL}		0	50	KHz
Hold time START condition	$t_{HD;STA}$		4	-	µS
LOW period of the SCL clock	t_{LOW}		4.7	-	µS
HIGH period of the SCL clock	t_{HIGH}		4.0	-	µS
Data setup time	$t_{SU;DAT}$		250	-	nS
Data hold time	$t_{HD;DAT}$		5.0	-	µS
Setup time for STOP condition	$t_{SU;STO}$		4.0	-	µS

I²C Timing of Parameters Write



I²C Timing of Parameter Read



I²C Read/Write Control

Commonly used I2C read and write command tables (READ / WRITE COMMAND TABLE) are as follows:
Register map (address h00 ~ h04):

Bit								Address	Default
7	6	5	4	3	2	1	0	Hex	Hex
					PWMS_EN	FWRS1_EN	FWRS0	0	0x00
PWM_I2C								1	0x00
FG_I2C[7:0]								2	0x00
				FG_I2C[11:8]				3	0x00
Mstate[2:0]			RD	TSD	OVP	OCP		4	0x40

Address (Hex)	Bytes	Register	Description	Default (Hex)	(R/W)
0x00	Bit[7:3]	Reserved		0x00	
	Bit[2]	PWMS_EN	1: select PWM duty cycle via I2C (PWM_I2C[7:0]) 0: select PWM duty cycle via external VSP input		W
	Bit[1]	FWRS1_EN	1: forward/reverse control by I2C 0: forward/reverse control via external FWR input pin		W
	Bit[0]	FWRS0	Forward/reverse control 1:forward (default) 0:reverse		W
0x01	Bit[7:0]	PWM_I2C[7:0]	PWM duty cycle select via I2C	0x00	W
0x02	Bit[7:0]	FG_I2C[7:0]	First byte of FG_I2C frequency count (read via I2C)	0x00	R
0x03	Bit[3:0]	FG_I2C[11:8]	4 MSBs of FG_I2Cfrequency count	0x00	R

0x04	Bit[7:5]	Mstate[2:0]	Motor statues: [000] : （Start-Up） [001] : （Normal） [010] : （PWM-Off） [011] : （TSD / OVP） [100] : （Lock-On） [101] : （Dead-Lock）	0x40	R
	Bit[4]	RD	1: Protection state 0 : Normal operation		R
	Bit[3]	TSD	1 : Thermal shutdown state 0 : Normal		R
	Bit[2]	OVP	1: OVP protection 0 : Normal		R
	Bit[1]	OCP	1: OCP protection 0 : Normal		R
	Bit[0]	Reserved	-		-

I2C control parameter

Figure 1: Register Map (Address h21 – h49)

Bit								Address	Default
7	6	5	4	3	2	1	0	Hex	Hex
AlignStep[7:0]								21	0x64
AlignHold[7:0]								22	0x00
RiseStep1[7:0]								23	0x64
RiseStep2[7:0]								24	0x64
DutySelect	SmoothSel[1:0]		RiseStep2[8]	RiseStep1[8]	AlignHold[9:8]		AlignStep[8]	25	0xC0
FallStep2[8]	FallStep1[8]	SSWDegree[2:0]			highSideMOS	ContHoldDuty	OCPSel	26	0x1E
FallStep1[7:0]								27	0x32
FallStep2[7:0]								28	0x64
EnOVP	BrakeEndSet[2:0]			DeadTime[3:0]				29	0x33
FallSet1[7:0]								2A	0x28
FallSet2[7:0]								2B	0x12
OCP_BlankWidth[2:0]			ZCTarget[4:0]					2C	0x8F
ZCCntMn[7:0]								2D	0xC8
DigitalFilter[9:8]		ZCCntMn[13:8]						2E	0x00
DigitalFilter[7:0]								2F	0xC0
TotalFilterDelay[7:0]								30	0xB8
TotalFilterDelay[15:8]								31	0x0B
MinDuty[7:0]								32	0x05
StartTimeLimit[3:0]				LockStopTime[3:0]				33	0x55
DeadLock[7:0]								34	0x14
StartStep1[7:0]								35	0xE8
EnSpdCtrl	DeadLock[8]	StartStep1[13:8]						36	0x03
StartStep2[7:0]								37	0x20
ShortNum[1:0]		StartStep2[13:8]						38	0xC3
LowFreqthd[1:0]		WaitTime[9:8]		FrFloating[3:0]				39	0x41
WaitTime[7:0]								3A	0x0D
EnFreqSpd	StrDuty[6:0]							3B	0x03
PreMUXTime[1:0]		AlignDuty[5:0]						3C	0x86
MaxDuty[7:0]								3D	0x80
Div4	BrakeCountSet[6:0]							3E	0x7F
PreCheckTime[7:0]								3F	0x7C
FGLSel[1:0]		PreCheckTime[13:8]						40	0x41
BrakeClkSel[1:0]		**RevBrakeTime[5:0]**						41	0x7C
TrimA[7:0]								42	0x88
TrimB[7:0]								43	0x88
TrimC[7:0]								44	0xF0
ZcTooLong[7:0]								45	0xC8
ZcTooLong[11:8]				EnPreCheck	SpdSel[2:0]			46	0x0B
ZCIgnoreTime[7:0]								47	0x80
HysterSel[1:0]		ZCIgnoreTime[13:8]						48	0x42
				ZCIgnoreSelect	ZCIgnorePhase[2:0]			49	0x01

Table 1: Parameter Table (Address h21 – h49)

Address Hex	Bit	Register	Description	Default (Hex)
0x21	Bit[7:0]	AlignStep [7:0]	During the alignment process, the force is gradually increased to avoid excessive swings. The incremental increase is 1/128 PWM duty at every time step (set by the AlignStep parameter).	0x64
0x22	Bit[7:0]	AlignHold [7:0]	Set the Align duration.	0x00
0x23	Bit[7:0]	RiseStep1 [7:0]	Set the accelerating slope before entering sensorless closed-loop control. Incremental step is 1/128 PWM duty for each RiseStep1 time step parameter. The maximum PWM duty is 25/128.	0x64
0x24	Bit[7:0]	RiseStep2 [7:0]	Set the accelerating slope after entering sensorless closed-loop control. Incremental step is 1/128 PWM duty for each RiseStep2 time step parameter. The maximum PWM duty is equal to the external setting speed or protected and clamped PWM duty by internal control.	0x64
0x25	Bit[7]	DutySelect	PWM duty processing selection 1 (default): The internal controller sets the PWM duty cycle change and the approximate rising and falling curves are achieved smoothly. 0: PWM duty cycle change is controlled via external command and is not adjusted by the internal controller.	0xC0
	Bit[6:5]	SmoothSel [1:0]	After the system has entered sensorless control mode, if the jitter of the ZC signal is too large, the system will consider this abnormal and will transition to the stall protection mode. SmoothSel[1:0] sets the ZC jitter range.	
	Bit[4]	RiseStep2 [8]	MSB of RiseStep2 (first byte is0x24 Bit[7:0])	
	Bit[3]	RiseStep1 [8]	MSB of RiseStep1 (first byte is 0x23 Bit[7:0])	
	Bit[2:1]	AlignHold [9:8]	2 MSBs of AlignHold. The units of AlignHold are milliseconds. The default value is 0.	
	Bit[0]	AlignStep [8]	MSB of AlignStep (first byte is0x21 Bit[7:0])	
0x26	Bit[7]	FallStep2 [8]	MSB of FallStep2 (first byte is0x28 Bit[7:0])	0x1E
	Bit[6]	FallStep1 [8]	MSB of Fallstep1 (first byte is0x27 Bit[7:0])	
	Bit[5:3]	SSWDegree [2:0]	Set the soft-switch angle parameter. The larger the SSWDegree value, the shorter the relative floating time angle will be.	
	Bit[2]	High-Side MOS	High side MOS polarity (default is 1). 1: positive logic 0: negative logic	

Address Hex	Bit	Register	Description	Default (Hex)
	Bit[1]	ContHoldDuty	Select whether to continue to use the old Align setting (strength setting) to start motor after the end of the AlignHold process. The default value is 1. 0: RiseStep1 duty begins from (StrDuty+2). 1: RiseStep1 duty begins from HoldTimeduty after the end of the HoldTime process.	
	Bit[0]	OCPselect	PT2502 detects the current thru motors and MOS drives by sensing the voltage across the RF pin resistor. When the voltage exceeds a set value, PT2502 PWM duty will be reduced to avoid over-current or current limit protection will occur. OCPselect selects the reaction time during the periods of reducing PWM duty. The default value is 0. 1: reaction time is 20KHz (0.5us). The fast response setting may generate electrical noise. 0: If the reaction time is one electrical cycle (or ZC period), the reaction becomes slow and there is no electronic noise generated by OCP.	
0x27	Bit[7:0]	FallStep1 [7:0]	Reduce by 1/128 PWM duty for every FallStep1 millisecond in the first speed reducing slope section.	0x32
0x28	Bit[7:0]	FallStep2 [7:0]	Reduce by 1/128 PWM duty for every FallStep2 millisecond in the second speed reducing slope section.	0x64
0x29	Bit[7]	EnOVP	Enable OVP function. The default value is 0. 1: Over voltage protection enabled. The system enters Lock-On stage when the detected voltage is over the setting value. 0: Disable the over-voltage protection function.	0x33
	Bit[6:4]	BrakeEndSet [2:0]	Set ZC stop duration according to the stop phenomena for the headwind brake condition. The default value is 3. 0: 7.8ms 1: 15.6ms 2: 23.4ms 3: 31.2ms 4: 39ms 5: 46.8ms 6: 54.6ms 7: 70.2ms Follows the Alignment procedure after the start up.	
	Bit[3:0]	DeadTime [3:0]	The dead time unit is one clock-cycle (0.39us) and the default value is 3.	
0x2A	Bit[7:0]	FallSet1 [7:0]	Use the second decreased slope from this segment set value connected to the two different slopes of the decreased PWM duty process.	0x28

Address Hex	Bit	Register	Description	Default (Hex)
0x2B	Bit[7:0]	FallSet2[7:0]	PWM duty will be changed to free wheeling duty setting (6 Power MOS off) if the PWMOFF or FWR reverse command is executed in the operation mode.	0x12
0x2C	Bit[7:5]	OCP_BlankWidth [2:0]	PWM switching may generate surge or jitter signals, and the use of the external low pass filter to filter those signals or internal control to avoid this switching time may be required to ensure the reading of the correct the OCP signal. The OCP_BlankWidth parameter specifies this switching signal avoidance time. The time period may be set from 0 to 4 clock-cycles (each clock-cycle is 0.39us). When the time period is set to 0, the OCP blanking function is disabled. The default value is 4.	0x8F
	Bit[4:0]	ZCTarget [4:0]	Set the number of the read ZC signals to allow the system enter closed loop mode in the startup process. The recommended value is 10–15 and the default value is 15.	
0x2D	Bit[7:0]	ZCCntMn [7:0]	After entering sensorless mode, if ZC signal time is too short, the system determines the ZC is abnormal and the system enters stall protection mode. ZCCntMn is the shortest ZC time period (unit: clock-cycle = 0.39us).	0xC8
0x2E	Bit[7:6]	DigitalFilter [9:8]	2 MSBs of DigitalFilter (first byte is0x2F BIT[7:0])	0x00
	Bit[5:0]	ZCCntMn [13:8]	6 MSBs of ZCCntMn (first byte is0x2D BIT[7:0])	
0x2F	Bit[7:0]	DigitalFilter [7:0]	Set the digital filter (de-glitch) duty width for ZC signal. The unit is one clock-cycle (0.39us) and the default is 192.	0xC0
0x30	Bit[7:0]	TotalFilterDelay [7:0]	This parameter is a corresponding delay time value caused by "external circuit filter capacitor" and "digital filter." Once the TotalFilterDelay value is optimized, the current waveform is symmetrical, ZC will be more stable, and the controller's efficiency will be the best. The unit is one clock-cycle (0.39us) and the default value is 3000.	0xB8
0x31	Bit[7:0]	TotalFilterDelay [15:8]		0x0B
0x32	Bit[7:0]	MinDuty [7:0]	The minimum PWM duty is limited to1/128 duty. The maximum setting value is 64/128. When the input PWM duty is less than minDuty, this is equivalent to asserting the PWMOFF command. The default value is 5.	0x05
0x33	Bit[7:4]	StartTimeLimit [3:0]	This parameter specifies the time limitation to allow the control system to enter the sensorless loop in the motor startup process. The unit is seconds and the default value is 5. The limitation time range is from 1 to 15 seconds. If the control system does not enter sensorless mode in the limit time set by the parameter, the system will enter the stall protection (lock-on state).	0x55
	Bit[3:0]	LockStopTime [3:0]	Set the waiting time when the system goes into the stall protection state. The unit is seconds and the default value is 5. The waiting time range is from 1 to 15 seconds.	

Address Hex	Bit	Register	Description	Default (Hex)
0x34	Bit[7:0]	DeadLock [7:0]	Set how many times the lock-on state happens before the system enters dead lock status. The unit is lock-on count. After lock-on stall happens the number of times specified by DeadLock[7:0],the system will lock the motor. The motor must be un-plugged and then re-plugged to the power supply to release the lock-on state.	0x14
0x35	Bit[7:0]	StartStep1 [7:0]	Set the step change time to force the motor to rotate before the correct ZC happens in the startup process.	0xE8
0x36	Bit[7]	EnSpdCtrl	Enable PWM-Duty Speed Control (default value is 0). This function is active when EnFreqSpdis set to 0 first. 1: The set speed command PWMIN is controlled by duty cycle. 0: When EnFreqSpdis set to 0 first, PWMIN uses the original command.	0x03
	Bit[6]	DeadLock [8]	MSB of DeadLock (first byte is0x34 Bit[7:0])	
	Bit[5:0]	StartStep1 [13:8]	6 MSBs of StartStep1 (first byte is0x35 Bit[7:0])	
0x37	Bit[7:0]	StartStep2 [7:0]	Set the step change time for the forcing motor to rotate when there are ZC signals but they do not meet the sensorless closed-loop condition in the startup process.	0x20
0x38	Bit[7:6]	ShortNum [1:0]	Set the number of consecutive ZC signals in a short time to determine whether the motor is in stall state. If the frequency of the ZC signal is too high in a short time, the motor may sometimes be disturbed. 0: disable and do not judge 1: detect ZC signal once 2: detect two consecutive ZC signals 3: detect three consecutive ZC signals	0xC3
	Bit[5:0]	StartStep2 [13:8]	6 MSBs of StartStep2 (first byte is0x37 Bit[7:0])	
0x39	Bit[7:6]	LowFreqthd	Low Frequency Threshold is the lowest frequency limit for the frequency speed control command input. When the input of control frequency is less than the LowFreqThd value, the Frequency is set to OFF. The default value is 1. 0: 1Hz 1: 5Hz 2: 10Hz 3: 20Hz	0x41
	Bit[5:4]	WaitTime [9:8]	2 MSBs of WaitTime (first byte is 0x3A Bit[7:0])	
	Bit[3:0]	FrFloating [3:0]	Set the buffer time for the system to be read to start the motor in the opposite direction when fans coast down to almost completely stopped and there is no ZC signal change in 0.3 sec after the FWR reverse command and Fallset2 are finished.	

Address Hex	Bit	Register	Description	Default (Hex)
0x3A	Bit[7:0]	WaitTime [7:0]	PT2502 uses square wave control (120 degree control) during start-up stage. This parameter is to set the delay time for the system control to enter the sensorless control of trapezoidal waveform and the purpose is to allow sensorless control to be more stable. The unit per step for WaitTime is 32ms and the default value is 13 (416ms).	0x0D
0x3B	Bit[7]	EnFreqSpd	Enable Frequency Speed Control and the default is 0. This is the highest priority control command. 1: Set input frequency for the speed control command 0: Set speed control or duty cycle command using original PWM Duty command	0x03
	Bit[6:0]	StrDuty [6:0]	Set the initial force in order to overcome the static friction of the motor. In the Alignment and Startup process this parameter will be used. The unit is 1/128 PWM duty and the default value is 3.	
0x3C	Bit[7:6]	PreMUXTime [1:0]	Set the period to check U, V, W-phase in turns and this parameter is used to determine the rotation direction of motor (clockwise or reverse). The default value is 2.	0x86
	Bit[5:0]	AlignDuty [5:0]	Set the maximum align force and the unit is 1/128 PWM duty. The maximum value is 31/128 PWM duty. The default is 6.	
0x3D	Bit[7:0]	MaxDuty [7:0]	Limit the maximum duty value of PWMIN and the unit is 1/128 PWM duty. The minimum setting is 64/128.When the input PWM duty is greater than the maxDuty, the output value is maxDuty. The default value is 128.	0x80
0x3E	Bit[7]	Div4	Input Frequency Divided by 4 and the default value is 0. 1: The input frequency is four times the FG output frequency 0: The input frequency is equal to the FG output frequency	0x7F
	Bit[6:0]	BrakeCountSet [6:0]	Set interval (floating state) between the motor brake points. The interval value is BrakeClkSel multiples (1 – 127) and the default value is 127.	
0x3F	Bit[7:0]	PreCheckTime [7:0]	Set maximum time for PreCheck program in the headwind and downwind.	0x7C
0x40	Bit[7:6]	FGLSel [1:0]	Set FG output frequency (units in Hz). The default value is 1. 0: FG output frequency is equal to FG divided by 1: The normal frequency output, i.e. if the motor has 8 poles, the rotational speed is (15 x FG frequency) RPM 2: FG output frequency is equal to 2 x FG 3: FG output frequency is equal to 3 x FG	0x41
	Bit[5:0]	PreCheckTime [13:8]	6 MSBs of PreCheckTime (first byte is 0x3F Bit[7:0])	

Address Hex	Bit	Register	Description	Default (Hex)
0x41	Bit[7:6]	BrakeClkSel [1:0]	When the system detects headwind condition, PT2502 will first brake and re-start. The braking method is by “pumping,” where each successive braking period is longer than the previous one, e.g. the first braking period is 1ms, the second is 2ms, the third time is 3ms, and so on until the motor stops. BrakeClKSel is set to the braking period unit time. The default value is 1 (500us). 0: 100us 1: 500us 2: 1ms 3: 2ms	0x7C
	Bit[5:0]	Reserved		
0x42	Bit[7:0]	Reserved	Trim Clock	0x88
0x43	Bit[7:0]	Reserved	Trim LDO	0x88
0x44	BIT[6:4]	OVPH[2:0]	Set OVPH Code，please refer to OVP function description	0xF0
	BIT[2:0]	OVPL[2:0]	Set OVPL Code，please refer to OVP function description	
0x45	Bit[7:0]	ZcTooLong [7:0]	The system enters the stall protection mode if the ZC signal is too long and system has determined that the motor is not operating normally after the system has entered sensorless control loop. Set the maximum waiting time for ZC signal.	0xC8
0x46	Bit[7:4]	ZcTooLong [11:8]	4 MSBs of ZcTooLong (first byte is 0x45 Bit[7:0])	0x0B
	Bit[3]	EnPreCheck	The default value is 1. 1: Enable headwind/downwind detect program 0: Disable headwind/downwind detect program	
	Bit[2:0]	SpdSel [2:0]	FG frequency selection range in PWM-Duty control speed command (default value is 3). 0: 16Hz 1: 32Hz 2: 64Hz 3: 128Hz 4: 256Hz 5: 512Hz 6: 1024Hz 7: 2048Hz	
0x47	Bit[7:0]	ZCIgnoreTime [7:0]	The parameter is a fixed time value in ST1 and ST2 equations and the unit is one clock-cycle (0.39us). The default value is 640.	0x80

Address Hex	Bit	Register	Description	Default (Hex)
0x48	Bit[7:6]	HysterSel [1:0]	PT2502 provides constant speed control (closed loop speed control) and command inputs may be frequency (also known as Clock), PWM duty, or VSP voltage. These inputs all need the delay hysteresis parameter. For frequency command or PWM-Duty command inputs while under constant speed control, the hysteresis angle selection options are below. The default value is 1. 0:No hysteresis 1: Hysteresis 0.23° 2: Hysteresis0.47° 3:Hysteresis0.94°	0x42
	Bit[5:0]	ZCIgnoreTime [13:8]	6 MSBs of the ZCIgnoreTime (first byte is 0x47 Bit[7:0])	
0x49	Bit[7:4]	Reserved		0x01
	Bit[3]	ZCIgnoreSelect	Reading the ZC signal in the interval (ST)when the motor commutation and ZC signal is unstable should be avoided. The time specified by the ST parameter should be changed for different fan speeds or different motors. If the ST time is set to be too short, the ZC judgment may be affected. If the ST time is too long, the ZC detection time may be shortened. PT2502 provides two options to set the ST time and the default value is 0.	
	Bit[2:0]	ZCIgnorePhase [2:0]	This parameter is the selection angle in ST2 equation. The default value is 1 (3.75°). 0: 1.875° 1: 3.75° 2: 7.5° 3: 11.25° 4: 15° 5: 18.75° 6: 20.625° 7: 22.5°	

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max.	Unit
VDD supply voltage	V_M	5	28	V
Input pin withstand voltage		–0.3	6	V
Operating temperature	T_A	–40	+105	°C
Storage temperature	T_{STG}	–40	+150	°C

ELECTRICAL CHARACTERISTIC

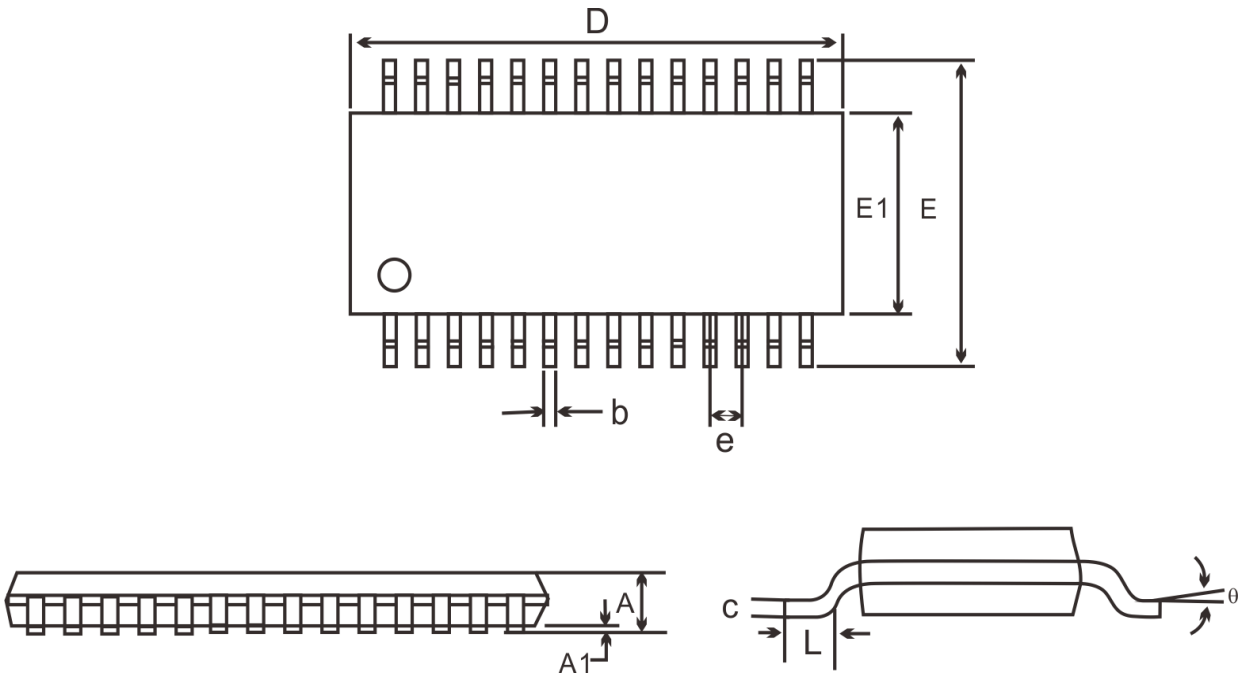
(V_{DD}=12.0 V, SGND = V_{SS}, T=27°C unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
General						
VDD supply voltage	V_{DD}	VDD input	6.0	12	24	V
Power supply current	I_{DD}	VDD = 12V	—	5	—	mA
Regulator output voltage	V_{REG}		4.75	5	5.25	V
Regulator output current	I_{REG}		—	20	—	mA
Pin Parameter Setting						
Over current protection voltage	V_{OCP}	RF pin	—	0.3	—	V
External oscillator	F_{OSC_1K}	OSC_C=470pF	—	1	—	KHz
External oscillator frequency range	F_{OSC_C}	OSC_C pin	0.1	—	10	KHz
Operation Characteristics						
PWM switching frequency	F_{SW}		—	20	—	KHz
I/O Interface						
Logic output high level	V_{OH}	UVWL, UVWH, RD, FG	4.0	4.5	5.5	V
Logic output low level	V_{OL}	UVWL, UVWH, RD, FG	—	0	0.3	V
Logic input pull high current	I_{SOURCE}	FR	—	—	10	uA
RSEN internal pull high resistance	R_{SEN}	RSEN pin, Connect to V_{REG}	—	47	—	K
VSP DC for control range	VSP_{DC}	DC input (VSPpin)	0.3		3.0	V
VSP input high level for PWM	VSP_H	PWM input (VSP pin)	3.3	—	—	V
VSP input low level for PWM	VSP_L	PWM input (VSP pin)	—	—	0.3	V
VSP input frequency range for PWM	VSP_F	PWM input (VSP pin)	15	—	25	KHz
Protection Parameters Setting						
Over temperature trigger voltage	V_{OTP}	RSEN pin	-	0.6	-	V
Over temperature recover voltage	V_{REL}	RSEN pin	-	1.2	-	V
Over voltage trigger voltage*	OVP_{VTH}	OVP pin	-	3.0	-	V
Under voltage trigger voltage*	OVP_{VTL}	OVP pin	-	1.125	-	V

* OVPVTH, OVPVTL can be set and adjusted by the I2C interface. Detailed parameter settings are as described in the overvoltage protection paragraph.

PACKAGE INFORMATION

28 pin，SSOP 150MIL



Symbol	Dimension（mm）		
	Min.	Typ.	Max.
A	1.35	-	1.75
A1	0.10	-	0.25
B	0.20	-	0.30
c	0.10	-	0.25
e	0.635 BSC		
D	9.80	9.90	10.00
E	5.80	6.20	6.20
E1	3.80	3.90	4.00
L	0.40	-	1.27
θ	0°	-	8°

Notes：

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

IMPORTANT NOTICE

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