说明

PT2505 是一个三相，使用霍尔传感器的正弦波驱动无刷直流马达控制芯片，并具有不同的保护机制。三相控制是基于正弦波驱动，以减少电机换相电磁噪音。芯片内建+5V 稳压器，结合外部的高压栅级驱动器以及六个 N 通道 MOSFETs，让 PT2505 能工作于高压马达的应用，PT2505 提供以刻录方式来改变内部参数设置以优化不同的电机和应用。PT2505 的包装为 SSOP24 及 SSOP28，其中 SSOP24 的包装，它的接脚安排相容于 ROHM BD62017AFS。

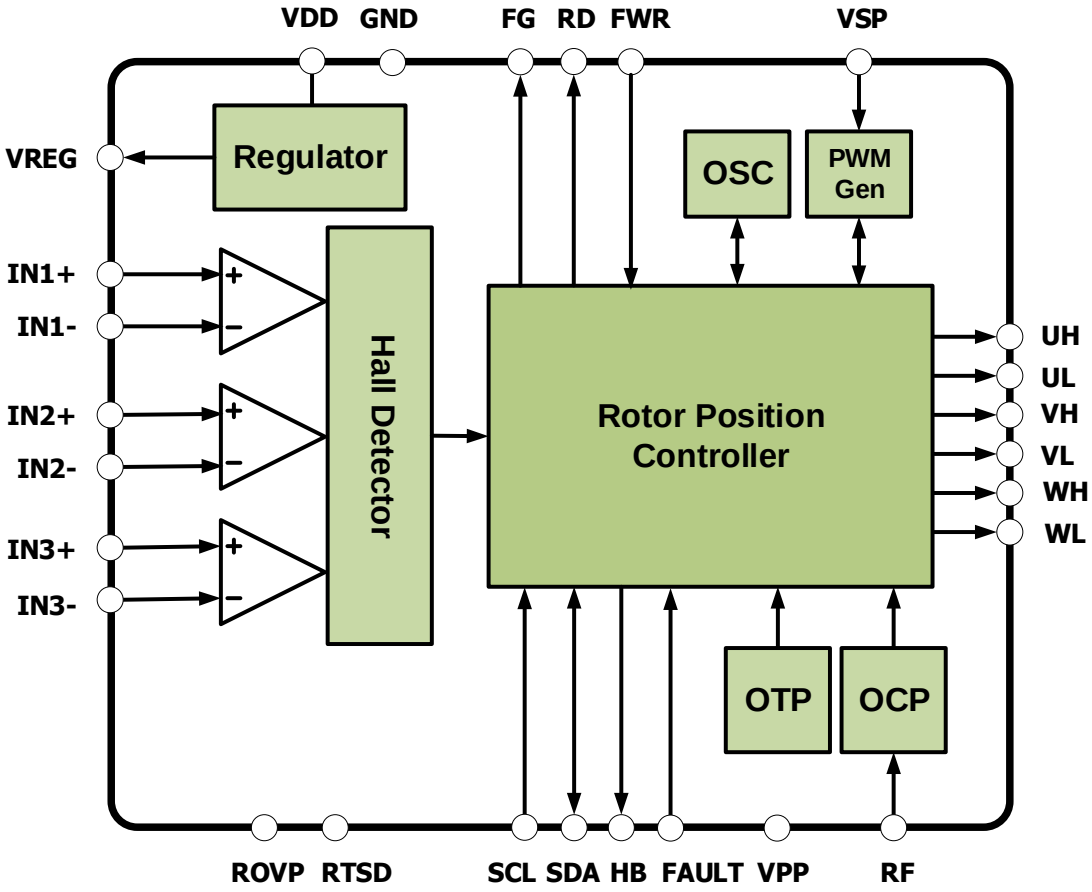
产品特性

- 霍尔传感器三相正弦控制无刷直流马达
- 过电流保护及过温度保护
- 欠电压保护及过电压保护
- 堵转保护及故障输入保护
- 正反转控制
- 直流, PWM, I2C 或频率输入速度控制
- FG 转速输出
- +5V 逻辑输出推动外部栅级驱动器
- 支持霍尔组件和霍尔传感器
- 利用 I2C 界面来做内部参数调整及 OTP 的读写

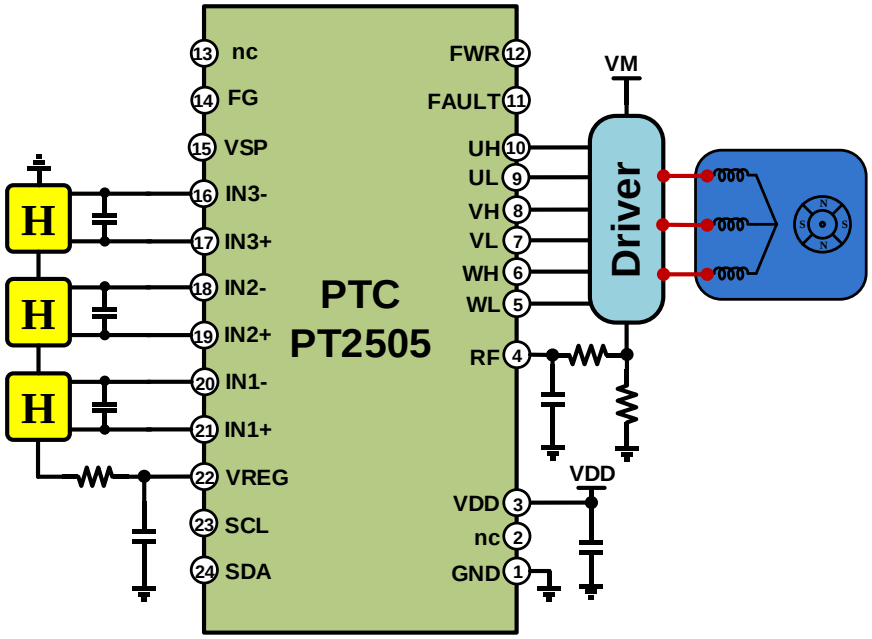
应用

- 三相控制无刷直流马达
- 风扇

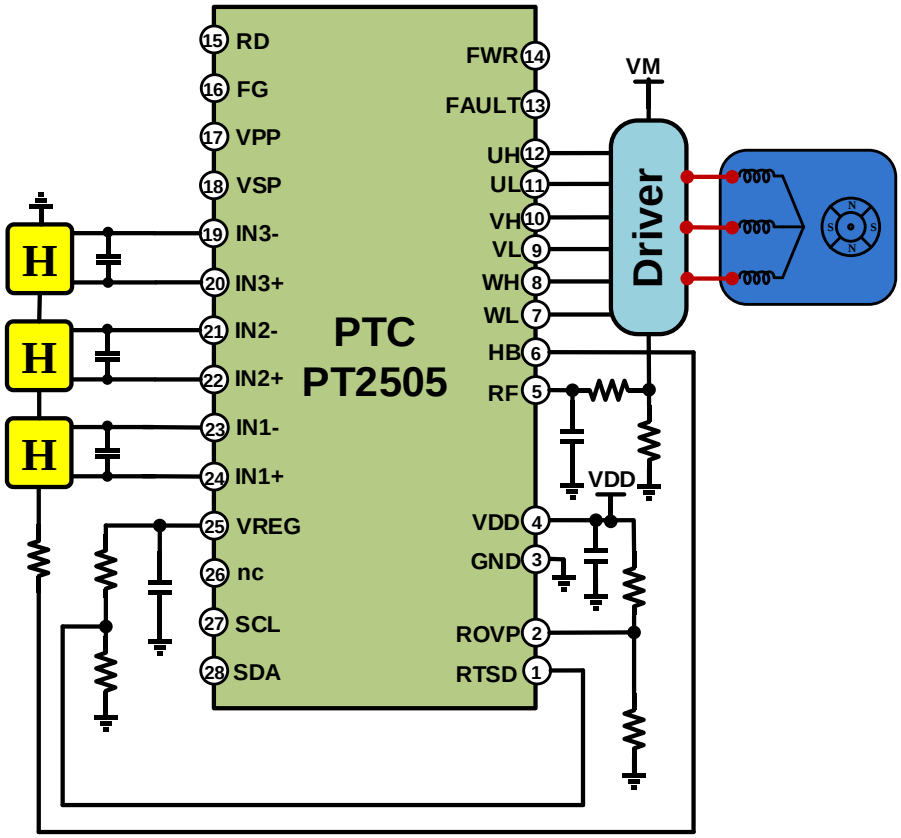
内部方块图



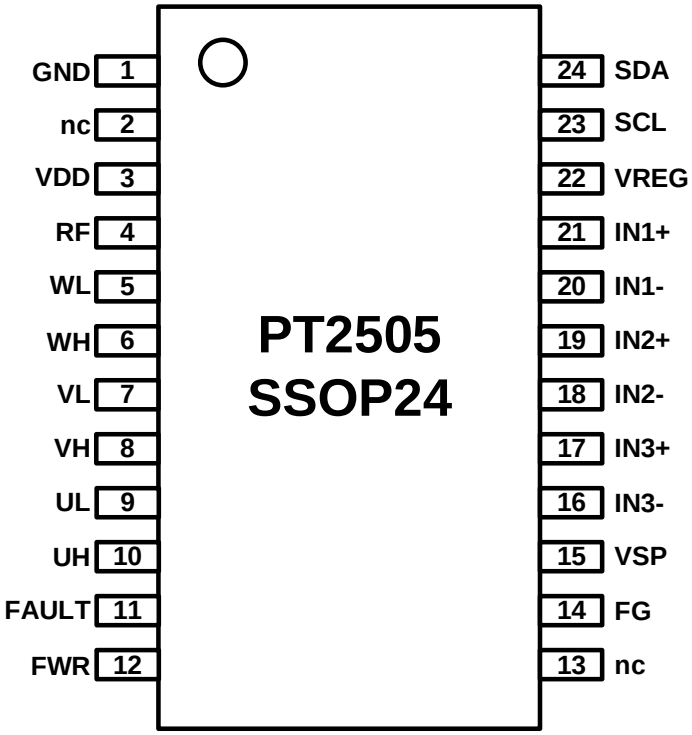
应用电路 – **SSOP24**

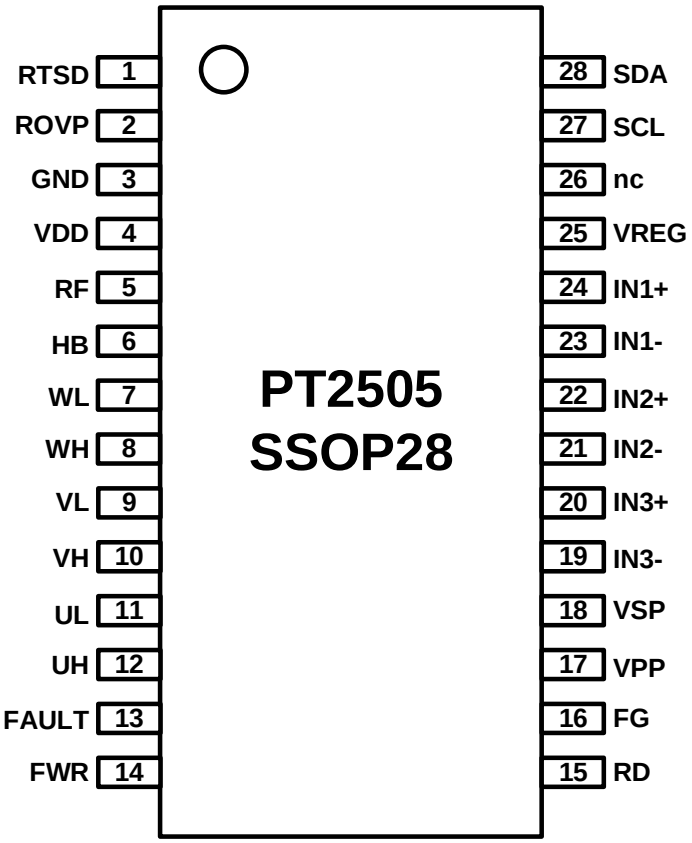


应用电路 – **SSOP28**



接脚安排


GND 1
nc 2
VDD 3
RF 4
WL 5
WH 6
VL 7
VH 8
UL 9
UH 10
FAULT 11
FWR 12
24 SDA
23 SCL
22 VREG
21 IN1+
20 IN1-
19 IN2+
18 IN2-
17 IN3+
16 IN3-
15 VSP
14 FG
13 nc
PT2505
SSOP24


RTSD 1
ROVP 2
GND 3
VDD 4
RF 5
HB 6
WL 7
WH 8
VL 9
VH 10
UL 11
UH 12
FAULT 13
FWR 14
28 SDA
27 SCL
26 nc
25 VREG
24 IN1+
23 IN1-
22 IN2+
21 IN2-
20 IN3+
19 IN3-
18 VSP
17 VPP
16 FG
15 RD
PT2505
SSOP28

接脚描述

接脚名称	I/O/P	描述	24 Pin Pin No.	28 Pin Pin No.
GND	P	信号接地	1	3
VDD	P	电源输入	3	4
RF	I	限流电压感测	4	5
HB	O	受控的+5V 电源用以供给霍尔传感器	nc	6
WL	O	W 相低端信号输出	5	7
WH	O	W 相高端信号输出	6	8
VL	O	V 相低端信号输出	7	9
VH	O	V 相高端信号输出	8	10
UL	O	U 相低端信号输出	9	11
UH	O	U 相高端信号输出	10	12
FAULT	I	外部故障信号输入 (低电位触发)	11	13
FWR	I	正反转控制(平常内部有电位拉升成反转状态)	12	14
RD	O	马达堵转指示(电位为高时表示异常状况).	nc	15
FG	O	电机转速指示	14	16
VPP	O	+7.5V 作为 OTP 刻录时使用,可由内部或外部提供	nc	17
VSP	I	DC 或 PWM 输入速度控制	15	18
IN3-	I	霍尔组件 3- 输入	16	19
IN3+	I	霍尔组件 3+或霍尔传感器 3 输入	17	20
IN2-	I	霍尔组件 2- 输入	18	21
IN2+	I	霍尔组件 2+或霍尔传感器 2 输入	19	22
IN1-	I	霍尔组件 1- 输入	20	23
IN1+	I	霍尔组件 1+或霍尔传感器 1 输入	21	24
VREG	O	+5V 稳压器输出	22	25
SCL	I	Serial clock input - I^2C control interface	23	27
SDA	I/O	Serial data input/output – I^2C control interface	24	28
RTSD	I	过温保护感测电阻输入	DB	1
ROVP	I	过压保护感测电阻输入	DB	2

功能描述

电源供给

PT2505 消耗电流小于 5mA，且内建+5V 稳压器用以供给内部的逻辑及模拟电路使用。 输出信号为 5V 的逻辑位准用以推动外部的栅级驱动器。

为了避免电源干扰或不稳定，PT2505 内部会检测 LDO 电压。当 LDO 电压超过 3V 时，会在 10ms 内告知逻辑电路开始运作。在电机系统，芯片很容易受到感应噪声的影响，建议放置适当数量的旁路电容器，而且离 IC 电源引脚越近越好。

速度控制界面

PT2505 可藉由输入 I²C命令，直流电压以及PWM信号来控制马达转速。当输入为PWM信号时，其高及低电压位准为5V的逻辑系统。输入PWM的载波频率建议介于15KHz到25KHz之间。当输入直流电压时,其上下限电压由V_{SPMIN}和V_{SPMAX}来决定。在使用外部分压电阻调整VSP时，要加以注意VSP 脚位在内部透过200kΩ 电阻连接至GND。

为了工作于不同的 VSP 范围，可以设定不同的 V_{SPMAX} 及 V_{SPMIN} 于缓存器中。V_{SPMAX} 的设定范围介于 3.0V 到 5.4V 而 V_{SPMIN} 的设定范围介于 0.3V 到 2.1V。其运作方式如**图 1.**

a. VspSel 选择 VSP 信号直接进入比较器或经过一个 2/3 的衰减电路再进入比较器
b. OschSel 及 OsclSel 可设定锯齿波波峰及波谷的数值
c. OschSel 的选择可得到波峰为 (3V, 3.6V). OsclSel 的选择可得到波谷为 (0.3V, 0.5V, 0.7V, 1.4V)
d. 结合以上的设定可得到以下 V_{SPMAX} 和 V_{SPMIN} 的组合
   组合一: V_{SPMAX} = (3V, 3.6V) / V_{SPMIN} = (0.3V, 0.5V, 0.7V, 1.4V)
   组合二: V_{SPMAX} = (4.5V, 5.4V) / V_{SPMIN} = (0.45V, 0.75V, 1.05V, 2.1V)
e. 控制缓存器地址是 0x54

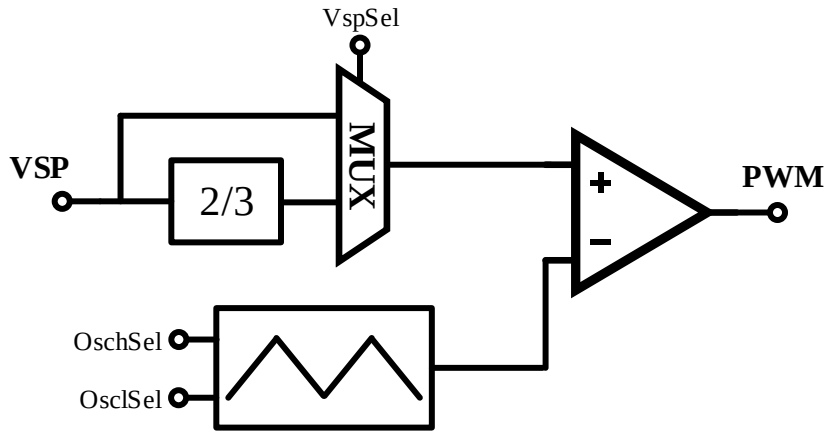


图 1 VSP 输入范围的解释

除了一般的电压输入，藉由缓存器 0x39 SpdEN 的设定，PT2505 还提供了闭回路的速度控制。配合 RiseStep, FallStep1 及 FallStep2 等参数，PT2505 能得到稳定的转速控制

转速的计算可表示成 Input Duty * Hz/Duty。当 VSP 输入频率命令做转速控制时，FG 的输出会追随输入频率命令。相关的参数为缓存器 0x39 的 IfDiv, SpdEn 及 FreqEn。

霍尔传感器控制方式

PT2505控制方式是基于霍尔传感器的信息，并产生正弦电压波形。它有利于提供准确无声（无电噪声）驱动控制。不同于无传感器控制方案，霍尔传感器控制提供了顺利启动没有反转。

如**图 2** 和**图 3** 中，三个霍尔传感器位置可以被配置为 60°或 120°的间隔方式，PT2505 可以通过内部参数来应对不同的配置方式。

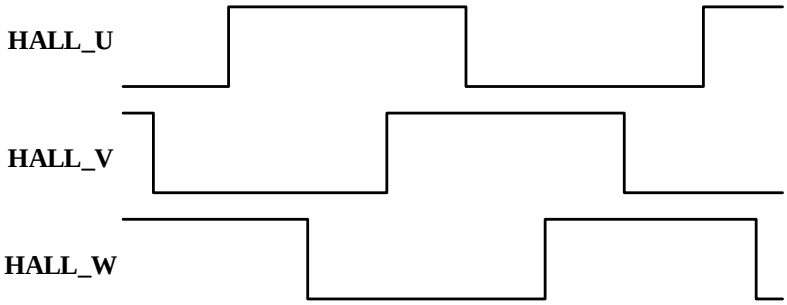


图 2 120 度间距的霍尔传感器信号

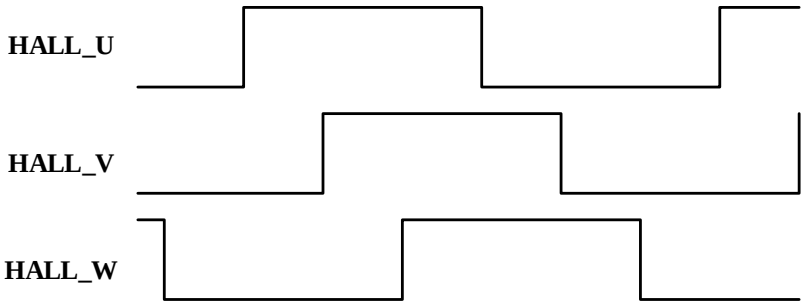


图 3 60 度间距的霍尔传感器信号

不同的霍尔传感器会因感度不同，摆放位置偏差等问题造成转子讯号产生相角差，如**图 4** 所示。PT2505 可以经由设定内部参数来补偿偏移，可补偿的范围从-60 度到+60 度，并就正转或反转的情形来分别调整。PT2505 可支持霍尔组件和霍尔传感器。

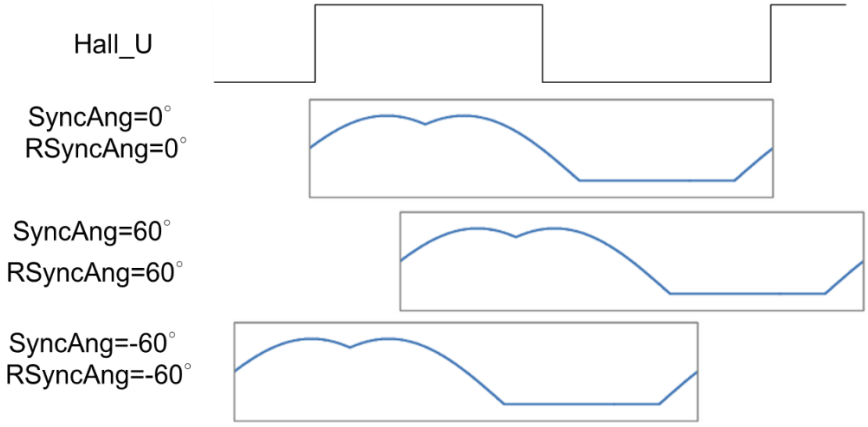


图 4 正反转时同步角度的调整

领先角设定

由于马达定子线圈的电感加载特性，线圈电流的相角差会随着转子速度增加而偏移。PT2505 提供了自动或手动方式来修正偏移以得到最佳的效率，其对应的参数是缓存器 0x30 的 PAAuto。在自动调整时 PT2505 提供了 16 条曲线 PASlope 以及最大领先角参数 MaxPA 来调整，**图 5** 是其示意图。

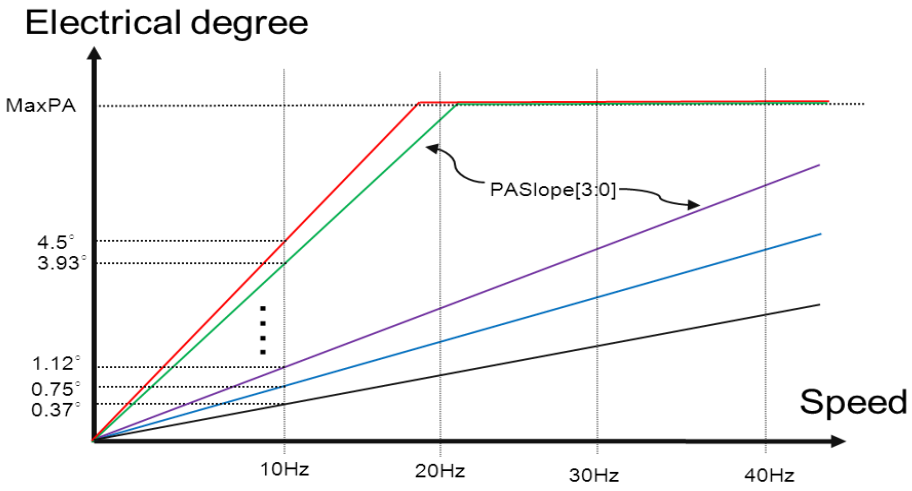


图 5 自动领先角调整曲线

此外最佳的效率点和 BEMF 强度，线圈电流，转子速度及线圈电感的大小有关。由于其非线性的相关特性，在手动调整方面 PT2505 提供了 PAM10HZ 到 PAM150HZ 的分区调整方式. 这里最大的对应转速是 150Hz，最大的领先角是由 MaxPA 所设定及限制，**图 6** 是其示意图。

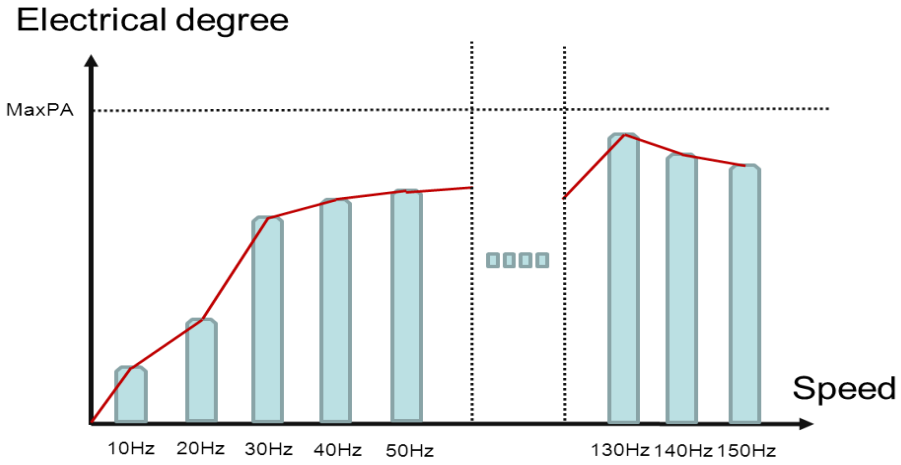


图 6 手动领先角的调整和转速的对应

输入速度命令对应曲线

PT2505 提供了平滑的加速及减速曲线可面对不同的负载特性. **图 7** 是示意图，藉由 StopDuty 的设定，使用者可以决定何时放开线圈的激磁以免产生噪音。

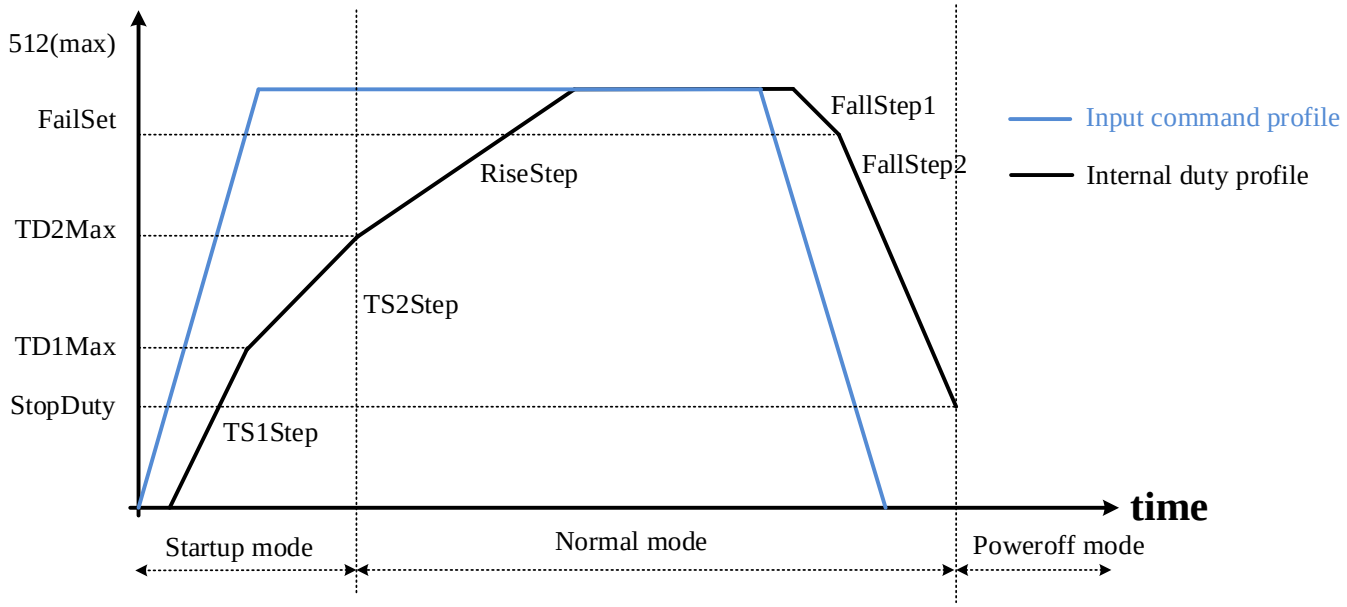


图 7 平滑的加速及减速参数调整

过电流保护

PT2505 具有两阶段的过电流保护，藉由放置于 RF 接脚的感测电阻及低通滤波器，能得知马达电流 I_{MOTOR}。当感测电阻上的电压 V_{RF} 大于 V_{OCPL} 时，OCPL 的条件会被触发，此时 PT2505 会降低 PWM 的周期直到 V_{RF} 小于 V_{OCPL}，当 V_{RF} 大于 V_{OCPH} 时，OCPH 的条件会被触发，PT2505 会立刻关掉 PWM 的控制信号进入锁住模式，**图 8** 是示意图。

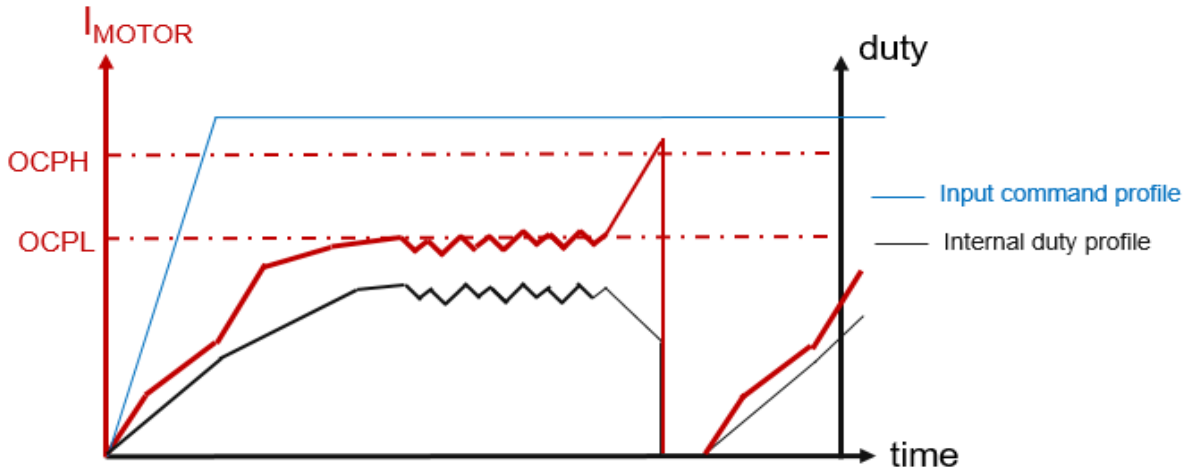


图 8 两阶段过电流保护

参数 OCPHFilter 及 OCPLFilter 可用来减少控制上的扰动，其范围介于 0.4us 到 0.4ms 之间。V_{OCPL}/ V_{OCPH} 可藉由参数 OCPLsel/OCPHsel 设成不同的位准。PT2505 还提供 OCPLL 的设定来限制马达最大启动电流。

启动及堵转保护

根据霍尔传感器提供的初始位置讯息，PT2505 可判断启动及换向程序，启动时最大 PWM 周期由参数 TD2Max 控制，针对不同马达的应用这个参数决定了启动时最大的推力，并表现在马达加速及减速的特性曲线上。

在运转中，当 PT2505 未侦测到预期的霍尔传感器信号，就会进入锁住保护模式，在等待一段时间后会尝试再次启动运转(等待时间及启转时间由参数 CTRise 及 CTFall 决定)，且将参数 ExptNum 加一,此时如马达仍未能正常启转,而且 ExptNum 的数值大于 MaxExptNum 的设定，系统会进入死锁状态，不会再尝试去启动马达，死锁状态只能藉由开关电源来解除。

外部过电压及欠电压保护

外部过电压及欠电压的保护可藉由 OVPSEL bit 为 1 的设定来达成，在芯片内 V_{PRTH} 固定为 3.5V， V_{PRTL} 的触发位准藉由缓存器来调整，当 VDD 的电压大于 V_{PRTH} 或小于 V_{PRTL} 时，PT2505 会停止工作，用户可观察缓存器 SYS_CTRL2 中 OVP 位来得知触发状况，**图 9** 是示意图。

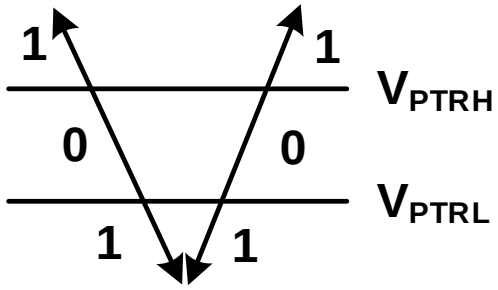


图 9 外部过电压及欠电压的触发位准

内部欠电压保护

内部欠电压的保护可藉由 OVPSEL bit 为 0 的设定来达成，当 VDD 低于 8V 时 PT2505 会停止工作，当电压上升至 9V 时欠压保护就会解除，系统缓存器 SYS_CTRL2 OVP bit 可得知目前工作状态。

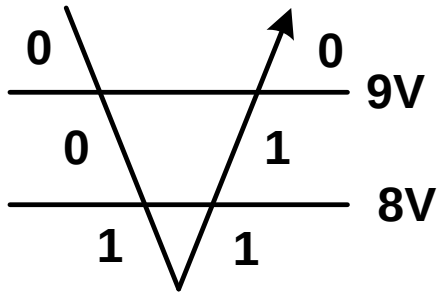


图 10 内部欠电压保护位准

过温保护及紧急煞车

PT2505 提供内部和外部的过温保护方式。
OTPSEL 设定为 1 时，PT2505 工作于内部过温保护模式，在芯片的温度超过 150℃时，PT2505 会进入过温保护停止工作，在芯片温度降到 95℃时过温保护会解除并继续工作，藉由系统缓存器 SYS_CTRL2 TSD bit 可得知目前工作状态。

OTPSEL 设定为 0 时，PT2505 工作于外部过温保护模式，外部的 NTC 温度感测电阻连接方式如**图 11**，在温度升高时 RTSD 的电压下降，当其小于 V_{REFL} 时过温保护启动，PT2505 停止工作，在芯片温度下降时 RTSD 的电压会上升，当其大于 V_{REFH} 时，过温保护会解除。
接脚 FAULT 输入为低电位时，PT2505 会立刻送出信号，将外部功率晶体的上臂开路下臂接地，做紧急煞车的动作。

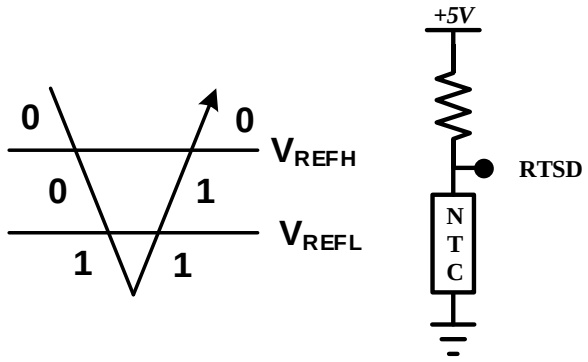


图 11 过温保护触发位准及 NTC 电阻的连接方法

FG 输出速度讯息

PT2505 输出 FG 作为电机转速指示，当转子运行一个电气周期时，FG 输出一对高和低信号，所以转速计算需要考虑到转子的极数，举例来说，如果转子是 8 极（四对极），电机跑一圈将有 4 个 FG 输出。电机转速通常以 RPM（每分钟转数）来表达，因此电机的旋转速度计算为：

RPM = FG×120 /极，FG 是频率（Hz），「极」是转子极数

FG 引脚为 5V 逻辑输出。
PT2505 提供了不同的 FG 输出配置，便于配合外界的程序计算，如**图 12** 所示, HU/HV/HW XOR 后会得到 3 倍的输出频率，，再配合 1/2/4/8 的除法器可得到下列的输出组合
(1, 1/2, 1/4, 1/8) 及(3, 3/2, 3/4, 3/8)

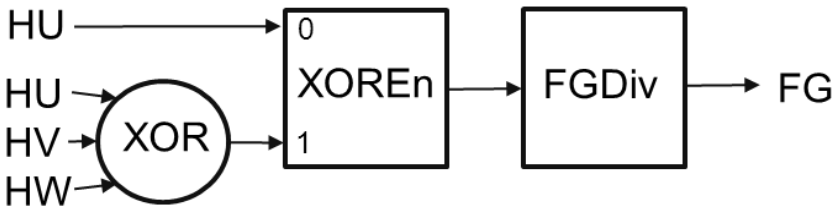


图 12 FG 输出配置

正反转设定

PT2505 可藉由控制接脚或缓存器的参数来设定马达正反转，在改变马达的转动方向时，马达会先停下来再往另一个方向转动. 这里建议进行正反转控制时，可藉由观察 FG 的信号以得到最好的降速曲线及反转等待时间。

顺风启动以及逆风启动设定

PT2505 能自动侦测马达是处于顺风或逆风的情形，在顺风启动时 PT2505 会先将马达刹车，直到速度降到可接受的范围，在逆风启动时 PT2505 会去调整启动的 PWM 周期并确保 BEMF 不会损伤高压组件，而启动 PWM 周期是由转子速度，比例因子及偏差量来计算，其公式如下

StartDuty=(RotorSpeed>>DNWScale*4) + DNWInit，这里 “>>” 表示数值右移

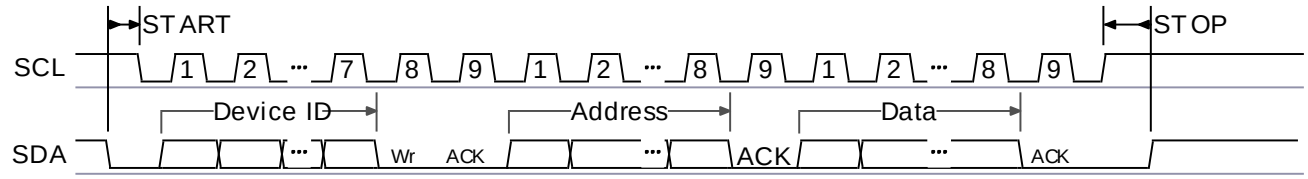
参数设定

PT2505 的外部过温及过流保藉由外部电阻来设定动作范围，其他可调整的参数都可纪录在 OTP(One Time Programming)的内存中，PT2505 可藉由 I²C 控制界面两次刻录到 OTP 中。

I²C 控制界面

PT2505 可以透过 I²C 的界面来存取内部缓存器的数值，并完成 OTP 的刻录，每笔 I²C 的命令由 **START** bit 开始，其中 **Device ID 是** 7-bit 用以表示芯片的地址，PT2505 的地址固定为 0110100b， **Wr/Rd** 用来表示读或写的动作，**ACK** 是接收端用来做确认的动作，告知发射端数据已收到或停止传送. **Address** 是 PT2505 的缓存器编号，接下来的数据就是用于缓存器的写入或读出，**STOP 表示** I²C 命令的结束，The I²C 在读写时都以一个 Byte 来运作，**图 13** 是其时序图，目前 I²C 界面最快可工作于 50 KHz。

I²C Byte Write



I²C Byte Read

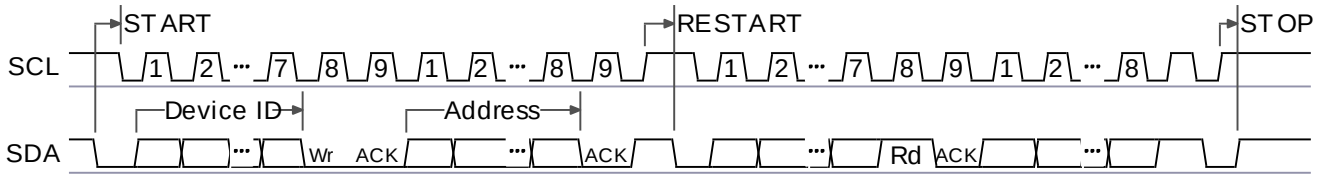


图 13 I²C byte 写入及读出时序

SpdSel[1:0]用以提供不同的马达应用，配合 RiseStep，FallStep1 和 FallStep2 等参数，PT2505 可得到稳定的转速输出。

控制缓存器数据表

缓存器地址 0x00 到 0x10

Bit								Address
7	6	5	4	3	2	1	0	Hex
PWM_I2C[9:8]		Reserved			PWMS	FWRS[1:0]		0
PWM_I2C[7:0]								1
FGCnt[7:0]								2
Mstate[2:0]			RDL	TSD	FGCnt[10:8]			3
OVP		FLD	SumErr	BlankErr[1:0]		OCPL	OCPH	4
OCPLL	PS	Reserved	VppAlarm	STestA_En	Stesth	SFwr	Sswinh	5
HVID								6
ExpNum[7:0]								7
Reserved							ExpNum[8]	8
ActDuty[7:0]								9
Reserved						ActDuty[9:8]		0A
NumID								0B
PTM				PCTL				10

缓存器地址 0x21 到 0x5E

								20
TS1Step[7:0]								21
TD2Max[7:0]								22
TS1Step[8]	DnWScale[1:0]		TD1Max[5:0]					23
TS2Step[7:0]								24
RiseStep[7:0]								25
DnWInit[5:0]						TS2Step[8]	RiseStep[8]	26
FallStep1[7:0]								27
FallStep2[7:0]								28
HallP[2:0]			DeadTime[2:0]			FallStep1[8]	FallStep2[8]	29
FallSet[7:0]								2A
StopDuty[7:0]								2B
OCPHDis	FLT	HallSel		ZcTarget[3:0]				2C
ZCCntMn[7:0]								2D
FilterMax[9:8]		ZCCntMn[13:8]						2E
FilterMax[7:0]								2F
HallPwrEn	OCPLSlope[1:0]		PAAuto	PASlope[3:0]				30
RSyncAng[7:0]								31
SyncAng[7:0]								32
CTRise[3:0]				CTFall[3:0]				33
Deadlock[7:0]								34
TimeUp1[7:0]								35
HsfEn	Deadlock[8]	TimeUp1[13:8]						36
TimeUp2[7:0]								37
ShortNum[1:0]		TimeUp2[13:8]						38
HsMos	HallCode	PllEn	IfDiv	SpdEn	FreqEn	SpdHyst[1:0]		39
CID[7:0]								3A
MaxPA[7:0]								3B
Pam10Hz[7:0]								3C
Pam20Hz[7:0]								3D

Pam30Hz[7:0]							3E
Pam40Hz[7:0]							3F
Pam50Hz[7:0]							40
Pam60Hz[7:0]							41
Pam70Hz[7:0]							42
Pam80Hz[7:0]							43
Pam90Hz[7:0]							44
Pam100Hz[7:0]							45
Pam110Hz[7:0]							46
Pam120Hz[7:0]							47
Pam130Hz[7:0]							48
Pam140Hz[7:0]							49
Pam150Hz[7:0]							4A
TrimClk[7:0]							4B
OVPSel[3:0]							4C
OCPHFltr[7:0]							4D
OCPLFltr[5:0]						OCPHFltr[9:8]	4E
UpWSel[1:0]		TSOVDis	DutyDcrs[1:0]		HallUP	HallVP	HallWP	4F
UpWNum[7:0]							50
MinDuty[7:0]							51
	VPPToleranceOe	VPP7p5En	ENDG				52
ADutyEn					FGDiv[1:0]		HXorEn	53
VspSel	OschSel	OsclSel[1:0]		LdoTrim[3:0]				54
OCPLLSel[3:0]						OvphSel	OtpSel	55
MaxDuty[7:0]							56
PFrEn	PFr	PSDis	OCPLLEn	OCPLLFltr	PWMSmp	MaxDuty[9:8]		57
Reserved		PllPiKi[1:0]		Reserved		PllPiKp[1:0]		58
HSmthEn	HSmthT	QSDEn	XNor3Ha	OneHall	UVWP[2:0]			59
OCPLSel[3:0]				OCPHSel[3:0]				5A
StartFrq[1:0]		Reserved				VspOffBk	MSpdSel	5B
SDutyCtl[3:0]				Reserved	AlignTime[2:0]			5C
Reserved	IRSpd[2:0]			Reserved	Racc[2:0]			5D
HzPDuty[7:0]								5E

控制缓存器功能描述

地址 0x0~0x11 是系统控制缓存器，提供如工作模式 PWM 周期 正反转等讯息

Address	Register Name	Description		Default	Unit	R/W
0x00	**SYS_CTL1**	Bit[7:6]	PWM_I2C[9:8]			R/W
		Bit [5:4]	Reserved			
		Bit[2]	**PWMS,** PWM Selection 1 : select internal PWM duty control 0 : external VSP control	0		
		Bit[1:0]	**FWRS**, FWR is controlled by 0x : external FWR pin 10_b : FWR is 0 11_b : FWR is 1	0		
0x01	**PWM_I2C**	**PWM_I2C**[7:0]: When PWMS set 1, PWM duty is controlled by PWM_I2C[9:0]		0	duty	R/W
0x02	**FGCnt[7:0]**	Combine FGCnt[10:8] to get a 11 bit frequency counter value for every second		0	count	R
0x03	**SYS_CTL2**	Bit[7:5]	**MState**, Motor status 3'b000 : Startup 3'b001 : Normal 3'b010 : PWMOff 3'b011 : AlignStartUp 3'b100 : LockOn 3'b101: DeadLock 3'b110: PowerSavingAck 3'b111: PowerSaving			R
		Bit[4]	**RDL**, normal operation status 0 : motor is in the normal state 1 : motor is not in the normal state			
		Bit[3]	**TSD**, TSD signal from the RSEN pin 0 : Comparator result is correct 1 : Comparator result is not correct			
		Bit[2:0]	FGCnt[10:8]			
0x04	**SYS_CTL3**	Bit[7]	**OVP**, Overvoltage Protection: 0: Normal 1: Overvoltage happening			R
		Bit[5]	**FLD**, Frequency lock up detection 1: Frequency locked up 0: Frequency not locked up			
		Bit[4]	**SumErr**, OTP checksum error indicator. If the first byte is 0x5A, the checksum is generated automatically. 1 : OTP checksum is error 0 : OTP checksum is correct.			
		Bit[3:2]	**BlankErr**, OTP blanking check. 00 : Bank 0 and 1 is blank. 01 : Bank 0 is blank, bank 1 is not blank. 10 : Bank 0 is not blank, bank 1 is blank. 11 : Bank 0 and 1 is not blank.			

Address	Register Name	Description		Default	Unit	R/W
		Bit[1]	**OCPL**, 1 : RF pin voltage exceed low level threshold. 0 : RF pin voltage is under low level threshold.			
		Bit[0]	**OCPH** 1 : RF pin voltage exceed high level threshold. 0 : RF pin voltage is under high level threshold.			
0x05	**OCPLL**	Bit[7]	**OCPLL** 1: Maximum Start-up current Alarm 0: Normal			R
	PS	Bit[6]	**PS**, Power Saving Signal 1: Power Saving happening 0: Normal			
		Bit[5]	Reserved			
	VppAlarm	Bit[4]	**VppAlarm**, VppAlarm Signal 0: VPP OK 1: VPP not normal			
		Bit[3:0]	Reserved for system test			
0x06	**HVID**	**HVID**, Hardware version control ID				R
0x07	**ExpNum[8:0]**	**ExpNum**, Combine with ExpNum[8] to get a ExpNum[8:0] register. The EXPTNUM will add one automatically when exception happens, for example, OCPH or LockOn state happens.			count	R
0x08		Bit[7:1]	Reserved			R
		Bit[0]	ExpNum[8]			
0x09	**ActDuty[9:0]**	**ActDuty**, Combine with ActDuty[9:8] to get a ActDuty[9:0] register array. The register array means real work duty in motor system.			duty	R
0x0a		Bit[7:2]	Reserved			R
		Bit[1:0]	ActDuty[9:8]			

地址 0x21~0x5F 是纪录于 OTP 中对应的缓存器，提供各类马达控制参数

Address	Register Name	Description		Default	Unit	R/W
0x21	**TS1Step**	Combine with bit 7 of sub-address 0x23 to form 9-bit of TS1Step[8:0] TS1Step is the first stage slope before reaching TD1MAX in the startup mode. Please refer to **Figure** 7. Unit is ms		10	0.25ms	R/W
0x22	**TD2Max**	TD2Max is the maximum duty of the second stage startup. Please refer to **Figure** 7		50	4 duty	R/W
0x23	**TS1Step[8]**	Bit [7]	TS1Step[8]			R/W
	DnWScale [1:0]	Bit[6:5]	**DnWScale**[1:0], a scale of current speed in Hz, for example, the current speed is 48Hz, DnwScale set to 3, then the initial duty is startup from (48>> 3)x4 + DnwInit.	0	scale	
	TD1Max[4:0]	Bit[4:0]	**TD1Max** is the maximum duty of the first stage startup. Please refer to **Figure** 7.	3	4 duty	
0x24	**TS2Step[7:0]**	**TS2Step**, Combine with bit 1 of sub-address 0x26 to form 9-bit of TS2Step[8:0] TS2Step is the second stage slope before reaching TD2MAX in the startup mode. Please refer to **Figure** 7.		47	0.25 ms	R/W
0x25	**RiseStep[7:0]**	**RiseStep**, Combine with bit 0 of sub-address 0x26 to form 9-bit of RiseStep[8:0] RiseStep is the update slope before reaching the OCPL or desire speed setting. Please refer to **Figure** 7.		47	0.25 ms	R/W
0x26	**DnWInit[5:0]**	Bit [7:2]	**DnWInit**[5:0], Combine with DnWScale[1:0], a suitable initial force to startup the motor when motor in a forward running situation.	0	4 duty	R/W
	TS2Step[8]	Bit [1]	**TS2Step**[8]			
	RiseStep[8]	Bit [0]	**RiseStep**[8]			
0x27	**FallStep1[7:0]**	**FallStep1**, The first stage slope of slow down before the actual duty down to Fallset.		47	0.25 ms	R/W
0x28	**FallStep2[7:0]**	**FallStep2**, The second stage slope of slow down before the actual duty down to StopDuty		47	0.25 ms	R/W
0x29	**HallP[2:0]**	Bit[7:5]	**HallP,** Hall Input Permutation 3'b000: [U, V, W] 3'b001: [U, W, V] 3'b010: [V, U, W] 3'b011: [V, W, U] 3'b100: [W, U, V] 3'b101: [W, V, U] Others: [U, V, W]	0	clock	R/W
	DeadTime [2:0]	Bit[4:2]	**DeadTime**, Dead time setting, range from 0.4us to 2.4us, suit for wide voltage operation. 0: 0.4us, 1: 0.8us, 2: 1.2us, 3: 1.6us, 4: 2.0us, 5~7: 2.4us			
	FallStep1[8]	bit [1]	**FallStep1**[8]			

Address	Register Name	Description		Default	Unit	R/W
	FallStep2[8]	bit [0]	**FallStep2**[8]			
0x2A	**FallSet[7:0]**	**FallSet**, the first stage duty for the actual duty decrease to.		40	4 duty	R/W
0x2B	**StopDuty[7:0]**	**StopDuty**, the second stage duty for the actual duty decrease to.		64	4 duty	R/W
0x2C	**ZCTarget**	Bit[7]	**OCPHDis**, OCPH diablbe 1: OCPH function disable 0: OCPH function normal	6	count	R/W
		Bit[6]	**FLT**, Frequency lock threshold 1, 0: 1/32 difference compared with the desired frequency.			
		Bit[5]	**HallSel**, Hall selection 0: Hall Sensor 1: Hall element			
		Bit[3:0]	**ZcTarget**, Six-step startup count before entering normal state			
0x2D	**ZCCntMn[7:0]**	Bit[7:0]	**ZCCntMn**, combine ZCCntMn[13:8] to get a ZCCntMn[13:0]. The register array means the minimum pulse width of zero crossing signal.	200	4 clock	
0x2E	**FilterMax[9:8]**	Bit[7:6]	**FilterMax**[9:8]	0		R/W
	ZCCntMn[13:8]	Bit[5:0]	ZCCntMn[13:8]			
0x2F	**FilterMax[7:0]**	**FilterMax**, combine with bit[7:6] of sub-address 0x2E, to form 10-bit of FilterMax[9:0]. FilterMax is the deglitch time period both for the hall sensor/hall element signal.		100	4 clock	R/W
0x30	**HallPwrEn**	Bit[7]	**HallPwrEn**, HB power output control 0: Turn off HB output during power-off mode, 1: HB output is always enable.	0		R/W
	OCPLSlope [1:0]	Bit[6:5]	**OCPLSlope**, OCPL update rate selection when the OCPL event happens. 0: 1.5ms, 1: 3ms, 2:5.75ms, 4:11.75ms	2		
	PAAuto	Bit[4]	**PAAuto**, Phase leading adjustment selection, 0: manually, 1: auto	1		
	PASlope[3:0]	Bit[3:0]	**PASlope**, when PAAuto set to 1, there are 16 slope curves selection according to the rotation speed. Please check **Figure 5** and **6** for further explanation. The sixteen slope of phase advance per 10Hz is 4.5, 3.93, 3.56, 3.18, 3.0 ,2.8, 2.6, 2.43, 2.25, 2.06, 1.87, 1.68, 1.5, 1.12, 0.75, 0.37 degree.	7		
0x31	**RSyncAng [7:0]**	**RSyncAng**, Hall sensor synchronization angle for the reversion rotation.		0		R/W
				45	0.75 deg	
0x32	**SyncAng [7:0]**	**SyncAng**, Hall sensor synchronization angle for the forward rotation		45	0.75 deg	R/W
0x33	**CTRisel[3:0]**	Bit[7:4]	**CTRise**, Maximum time period before entering normal mode. If startup period exceed this period, lock-on number plus one and restart again.	2	0.5 sec.	R/W

Address	Register Name	Description		Default	Unit	R/W
	CTFal[3:0]	Bit[3:0]	**CTFall**, Rest time period between each startup.	1	0.5 sec.	
0x34	**DeadLock [7:0]**	**DeadLock**, Combine DeadLock[8] to get a DeadLock[8:0]. The register array means the maximum exception number before entering dead-lock state. The exception includes OCPH and lock-on. When entering dead-lock state, PT2505 release it only by system power on again.		20	times	R/W
0x35	**TimeUp1[7:0]**	**TimeUp**, Combine TimeUp1[13:8] to a TimUp1[13:0]. The register array means that the minimum time when zero crossing signals must toggle without toggling once before. With the condition, system will restart the motor.		8'hE8	1ms	R/W
0x36	**HsfEn**	Bit[7]	**HsfEn**, Hall U signal falling edge sampling Enable 0: Disable, 1: Enable	8'h03		R/W
	DeadLock	Bit[6]	**DeadLock**[8]			
	TimeUp1 [13:8]	Bit[5:0]	**TimeUp1**[13:8]			
0x37	**TimeUp2[7:0]**	**TimeUp2**, Combine TimeUp2[13:8] to get a TimeUp2[13:0] . The register array means that the minimum time when zero crossing signals must toggle with toggling at least once before. With this condition, system will restart the motor.		232	1ms	R/W
0x38	**ShortNum[1:0]**	Bit[7:6]	**ShortNum**, The number of short pulses of zero crossing signals	8'hC3		R/W
	TimeUp2[13:8]	Bit[5:0]	**TimeUp2**[13:8]			
0x39	**SPDCtrl**	Bit[7]	**HsMos**, high side MOS type selection 1:NMOS, 0:PMOS	0		R/W
		Bit[6]	**HallCode**, Hall effect sensor position 0: 60 degree spacing, 1: 120 degree spacing	0		
		Bit[5]	**PllEn**, PLL enable: 0: disable, 1: enable	0		
		Bit[4]	**IfDiv**; Input frequency divider for VSP speed command 0: divide by 1, 1: divide by 4	0		
		Bit[3]	**SpdEn**; Speed input enable in VSP pin 0: PWM Pulse Control, 1: Speed Control	0		
		Bit[2]	**FreqEn**; Frequency input enable in VSP pin. 1: Speed controlled by VSP frequency 0: Speed controlled by VSP duty	0		

Address	Register Name	Description		Default	Unit	R/W
		Bit[1:0]	**SpdHyst**; Speed Control Hysteresis setting 00: Disable speed hysteresis control. 01: The difference between current hall sensor U speed and the desired speed is less than 1/16 of the desired speed, the function works. 10: The difference between current hall sensor U speed and the desired speed is less than 1/64 of the desired speed, the function works. 11: The difference between current hall sensor U speed and the desired speed is less than 1/128 of the desired speed, the function works.	0		
0x3B	**MaxPA[7:0]**	**MaxPA**, Maximum phase advance limitation		60	0.75 deg.	R/W
0x3C~ 0x4A	**Pam10HZ~ Pam150HZ**	Phase advance adjusted manually from 10Hz to 150Hz according the rotation speed.		2,4,6,8,10 ,12,13,15, 17,18,20, 21,23,24, 25	0.75 deg	R/W
0x4B	**TrimClk[7:0]**	**TrimClk**[7:0] provide 8 bits for precise basic clock output.		164	level	R/W
0x4C	**OVPSel[3:0]**	Bit[7:4]	**OVPSel**, over voltage protection level(VPRTL), selection, range from 0.8V~3.2V(0x0~0xE), 16 level settings.	8	level	R/W
		Bit[3:0]	Reserved			
0x4D	**OCPHFltr [7:0]**	**OCPHFltr**, combine with bit[1:0] of sub-address 0x4E, to form 10-bit of deglitch time period for the OCPH signal, range from 0.4us to 0.4ms.		256	4 clock	R/W
0x4E	**OCPLFltr [5:0]**	Bit[7:2]	**OCPLFltr**, deglitch time period for the OCPL signal, range from 0.4us to 25.6us.	8	4 clock	R/W
	OCPHFltr [9:8]	Bit[1:0]	**OCPHFltr**[9:8]			
0x4F	**UpWSel[1:0]**	Bit[7:6]	**UpWSel**, upwind startup setting, the motor brake until the speed reach: 0:4Hz, 1:6Hz, 2:8Hz, 3:12Hz, then start up with six-step till the motor in the forward direction.	0		R/W
	TSOVDis	Bit[5]	**TSOVDis**, thermal Shut down/Over Voltage Protection Disable 0: Enable 1: Disable			

Address	Register Name	Description		Default	Unit	R/W
	DutyDcrs[1:0]	Bit[4:3]	**DutyDcrs**, duty decrease when OCPL happens : 1. Duty control: 00: 25% specified duty decrease 01: 50% specified duty decrease 10: 100% specified duty decrease 11: decreased by 1 2. Speed control 00: 50% specified speed decrease 01: 80% specified speed decrease 10: 100% specified speed decrease 11: decreased by 1			
	HallUP	Bit[2]	**HallUP**, Hall U polarity 0: inverse Hall U 1: not inverse Hall U			
	HallVP	Bit[1]	**HallVP**, Hall V polarity: 0: inverse Hall V 1: not inverse Hall V			
	HallWP	Bit[0]	**HallWP**, Hall W polarity: 0: inverse Hall W 1: not inverse Hall W			
0x50	**UpWNum[7:0]**	**UpWNum**, ExpNum add 1 if the low-side braking time exceed UpWNum*0.5 second		20	number	R/W
0x51	**MinDuty[7:0]**	**MinDuty**, The motor is activated until the duty setting exceed MinDuty		0	2 duty	R/W
0x52	**VPPToleranceOe**	Bit[6]	**VPPToleranceOe**, the bit is to control the power MOSFET switch. 0: the power MOSFET is turned off 1: the power MOSFET is turned on and connected to internal VREG.	1		R/W
	VPP7p5En	Bit[5]	**Vpp7p5En**, The bit is to enable the internal 7.5 V regulator. 0: the internal 7.5 V regulator is disabled. 1: the internal 7.5 V regulator is enabled to provide the OTP programing power.	0		
	ENDG	Bit[4]	**ENDG**, The bit is enable analog deglitch function of hall element. 0: The deglitch function is ignored. 1: The deglitch function is enable.	1		
0x53	**ADutyEn**	Bit[7]	**ADutyEn**, Average PWM duty 1: Average PWM duty 0: Disable the function	0		R/W
	FGDiv[1:0]	Bit[2:1]	**FGDiv**: FG divide setting, 00:1, 01:2, 10:4, 11:8			
	HXorEn	Bit[0]	**HXorEn**: FG XOR enable setting, 0:disable, 1:enable			
0x54	**VspSel**	Bit[7]	**VspSel** is used to select the VSP input attenuation 0: no attenuation, 1: attenuate to 2/3*VSP	0		R/W
	OschSel	Bit[6]	OschSel is used to set the PWM input high level. 0: PWM input high level is set to 3V. 1: PWM input high level is set to 3.6V.	0		

Address	Register Name	Description		Default	Unit	R/W
	OsclSel[1:0]	Bit[5:4]	**OsclSel**[1:0] is used to set the PWM input low level. 00: PWM input low level is set to 0.3V. 01: PWM input low level is set to 0.5V. 10: PWM input low level is set to 0.7V. 11: PWM input low level is set to 1.4V.	0		
	LdoTrim[3:0]	Bit[3:0]	**LdoTrim**[3:0] provide 4 bit for precise 5V output (VREG).	8		
0x55	**OCPLLSel [3:0]**	Bit[7:4]	**OCPLLSel**, Over current protection level(OCPLL) selection, range from 0.04V to 0.2V, 16 level settings.	8		R/W
		Bit[3:2]	Reserved			
	OvphSel	Bit[1]	**OvphSel** is used to set internal (default) or external over voltage protection.	0		
	OtpSel	Bit[0]	**OtpSel** is used to set internal (default) or external over temperature protection.	1		
0x56	**MaxDuty[7:0]**	**MaxDuty**, combine MaxDuty[9:8] to get a MaxDuty[9:0]. The register array means maximum duty option			duty	R/W
0x57	**PFrEn**	Bit[7]	**PFrEn**; Parameter Forward/Reverse rotation Enable 0: disable 1: enable	8'h23		R/W
	PFr	Bit[6]	**PFr**; Parameter Forward/Reverse rotation control On the condition PfrEn = 1'b1, the bit's function as 1: Forward Rotation 0: Reverse Rotation			
	PSDis	Bit[5]	**PSDis**; Power Saving Disable 0: Power Saving Normal 1: Power Saving Disable			
	OCPLLEn	Bit[4]	**OCPLLEn,** Maximum start-up current limitation Enable 0: disable 1: enable			
	OCPLLFltr	Bit[3]	**OCPLLFltr,** the setting of the minimum width of OCPLL for validity 0: 32 system clock 1: 128 system clock			
	PWMSmp	Bit[2]	**PWMSmp,** PWM sampling rate setting 0: 20K 1: 40K			
	MaxDuty[9:8]	Bit[1:0]	MaxDuty[9:8]			
0x58		Bit[7:6]	Reserved	8'h12		R/W
	PllPiKi[1:0]	Bit[5:4]	**PllPiKi**, Ki value of PI for DPLL 00: 1/16 01: 1/32 10: 1/64 11: 1/128			
		Bit[3:2]	Reserved			
	PllPiKp[1:0]	Bit[1:0]	**PllPiKp**, Kp value of PI for DPLL 00: 0.5 01: 1 10: 2 11: 4			
0x59	**HSmthEn**	Bit[7]	**HSmthEn**, Hall U Sensor Signal Smooth Enable 1: Enable 0: disable			

Address	Register Name	Description		Default	Unit	R/W
	HSmthEn	Bit[6]	**HSmthT**, Hall U Sensor Signal Smooth Threshold on the condition HSmthEn = 1. 1: The difference between current hall U sensor signal and average hall U sensor one is less than 1/16 cycles of the average hall U sensor signal, the cycles of the average hall U signal will be adopted as the real cycles of the current hall U signal for now. 0: The difference between current hall U sensor signal and average hall U sensor one is less than 1/8 cycles of the average hall u sensor signal, the cycles of the average hall U signal will be adopted as the real cycles of the current hall U signal for now.	8'h20		R/W
	OSDEn	Bit[5]	**OSDEn**, Half second Detection Enable 1: Enable 0: Disable			
	Xor3Ha	Bit[4]	**Xor3Ha**, The setting of the function ,XOR Hall U, Hall V, and Hall W as the tracked signal in frequency speed mode 1: enable 0: disable			
	OneHall	Bit[3]	**OneHall**, One Hall input: 0: three Hall 1: one Hall			
	UVWP	Bit[2:0]	**UVWP**, U/V/W drive signal permutation: 3'b000: {UH, VH, WH} {UL, VL, WL} 3'b001: {UH, WH, VH} {UL, WL, VL} 3'b010: {VH, UH, WH} {VL, UL, WL} 3'b011: {VH, WH, UH} {VL, WL, UL} 3'b100: {WH, UH, VH} {WL, UL, VL} 3'b101: {WH, VH, UH} {WL, VL, UL} Others: {UH, VH, WH} {UL, VL, WL}			
0x5A	**OCPLSel[3:0]**	Bit[7:4]	**OCPLSel**, Over current protection level selection, range from 0.08V to 0.4V, 16 level settings.	8		R/W
	OCPHSel [3:0]	Bit[3:0]	**OCPHSel**, Over current protection level selection, range from 0.14V to 0.7V, 16 level settings.	8		R/W
0x5B	**StartFrq**	Bit[7:6]	**StartFrq**, It means the smallest frequency where the motor can run from Start-Up to Normal state. During the start-up period, the motor can't reach the speed, then it will enter lock-on state. The setting as 00: 3HZ 01: 4HZ 10: 5HZ 11: 6HZ The two bits are only written.	8'h00		R/W
		Bit[5:2]	Reserved			
	VspOffBk	Bit[1]	**VspOffBk**, When PWM is off, braking enables or disables. 0: disable 1: braking until FG<= 4HZ			
	MSpdSel	Bit[0]	**MSpdSel**, Max Speed Selection for Duty control: 0: Maxspeed is HzPDuty * 64 1: Maxspeed is HzPDuty * 512			

Address	Register Name	Description		Default	Unit	R/W
0x5C	**SDutyCtl [3:0]**	Bit[7:4]	**SDutyCt**l, Section Duty setting for speed control: 4'b0000: Disable 4'b0001: 1 section 4'b0010: 2 sections 4'b0011: 3 sections 4'b0100: 4 sections 4'b0101: 5 sections 4'b0110: 6 sections 4'b0111 : 7 sections 4'b1000: 8 sections 4'b1001: 9 sections 4'b1010: 10 sections 4b'1011: 11 sections 4'b1100: 12 sections 4'b1101: 13 sections 4'b1101: 14 sections 4'b1111 : 15 sections	8'h75		R/W
		Bit[3]	Reserved			
	AlignTime [2:0]	Bit[2:0]	**AlignTime**, Align Time 3'b000: 0.04s 3'b001: 0.08s 3'b010: 0.16s 3'b011: 0.32s 3'b100: 0.64s 3'b101: 1.28s 3'b110: 2.56s 3'b111: 5.12s			
0x5D		Bit[7]	Reserved			
	IRSpd[2:0]	Bit[6:4]	**IRSpd**, Initial rotating speed setting 3'b000: 1 HZ 3'b001: 2 HZ 3'b010: 3 HZ 3'b011: 4 HZ 3'b100: 5 HZ 3'b101: 6 HZ 3'b110: 8 HZ 3'b111: 16 HZ	8'h00		R/W
		Bit[3]	Reserved			
	Racc[2:0]	B[2:0]	**Racc**, Rotating acceleration 3'b000: 0.1 HZ/s 3'b001: 0.3 HZ/s 3'b010: 0.6 HZ/s 3'b011: 1.2 HZ/s 3'b100: 2.4 HZ/s 3'b101: 4.8 HZ/s 3'b110: 9.6 HZ/s 3'b111: 19.2 HZ/s			
0x5E	**HzPDuty[7:0]**	**HzPDuty**, The number of Hz per Duty for speed control by duties. Bit 7-6 : Integral part Bit 5-0 : Fractional part		8'h40		R/W

绝对最大额定值

Parameter	Symbol	Min.	Max.	Unit
供电电压	V_{DD}	5	30	V
输入/输出接脚电压	–	-0.3	5	V
工作温度范围	T_A	-40	+85	°C
储存温度范围	T_{STG}	-55	+125	°C

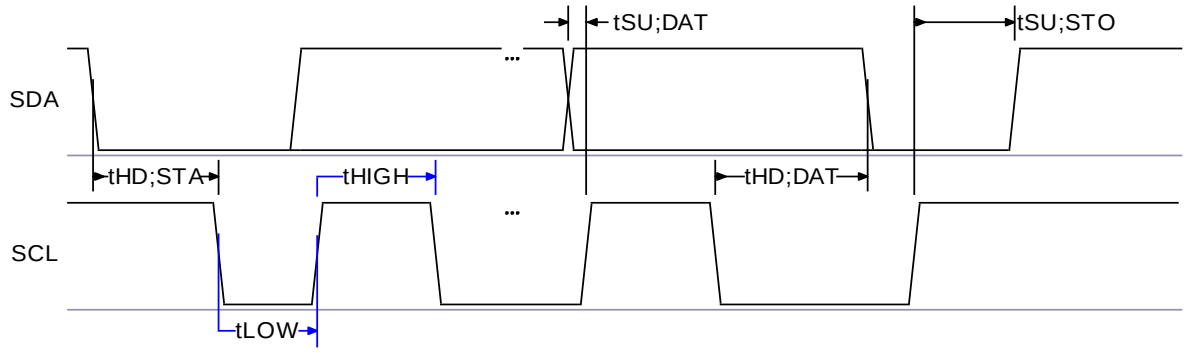
电气特性

一般工作条件: V_{DD} =24.0V, GND=0V, T_A = +27°C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
一般特性						
供电电压	V_{DD}		9*	24	28	V
消耗电流	I_{DD}			5**	7	mA
稳压器输出电压	V_{REG}		4.75	5	5.25	V
稳压器输出电流	I_{REG}	$(V\_{NOLOAD} - V\_{LOAD20mA})/V\_{NOLOAD} < 5\%$		20		mA
外部过温保护 (OtpSel=0)						
下限电压	V_{REFL}	RTSD 接脚 低于下限电压时触发		1.2		V
上限电压	V_{REFH}	RTSD 接脚 高低于上限电压时释放		2.6		V
外部欠电压及过电压保护(OvphSel=1)						
下限电压***	V_{PRTL}	ROVP 接脚 低于下限电压时触发	0.8		3.2	V
上限电压	V_{PRTH}	ROVP 接脚 高于上限电压时触发		3.5		V
内部欠电压保护 (OvphSel=0)						
释放电压	V_{UVH}		8.5	9.0	9.5	V
触发电压	V_{UVL}		7.5	8.0	8.5	V
磁滞区间电压	V_{UVHY}		0.5	1.0	1.5	V
过电流保护						
下限电压***	V_{OCPL}	RF pin	0.08		0.4	V
上限电压	V_{OCPH}	RF pin	0.14		0.7	V
驱动级输出						
低电位输出	V_{DOL}	UH,VH,WH,UL,VL,WL	0	0.14	0.60	V
高电位输出	V_{DOH}	UH,VH,WH,UL,VL,WL	V_{REG} - 0.6	V_{REG} - 0.2	V_{REG}	V
霍尔传感器放大器特性						
共模电压范围	V_{HCM}	使用霍尔组件	+0.5		V_{REG} - 0.5	V
霍尔传感器放大器灵敏度	V_{HSEN}			80		mV
HB 输出电压	V_{HB}	I_{HB}= 10mA	4.5			V
输入/输出界面						
低电位输出	V_{OL}	FG, FAULT, RD		0	0.3	V
高电位输出	V_{OH}	FG, FAULT, RD	4.0	4.5	5.5	V
PWM 周期控制						
最小周期电压	V_{SPMIN}		0.3		2.1	V
最大周期电压	V_{SPMAX}		3.0		5.4	V
PWM 输入频率****	F_{PWM_IN}	PWM input (VSP pin)		20		KHz

* 针对 VPP 由内部产生的情形，如须于较低电压工作，可将 VDD 和 VREG 连在一起，并由外部供给 VPP
**霍尔传感器会消耗额外的电流，这里只计算芯片所消耗的电流
***上下限电压可利用 I²C 界面来设定
****输入 PWM 信号时采用 5V 的逻辑位准

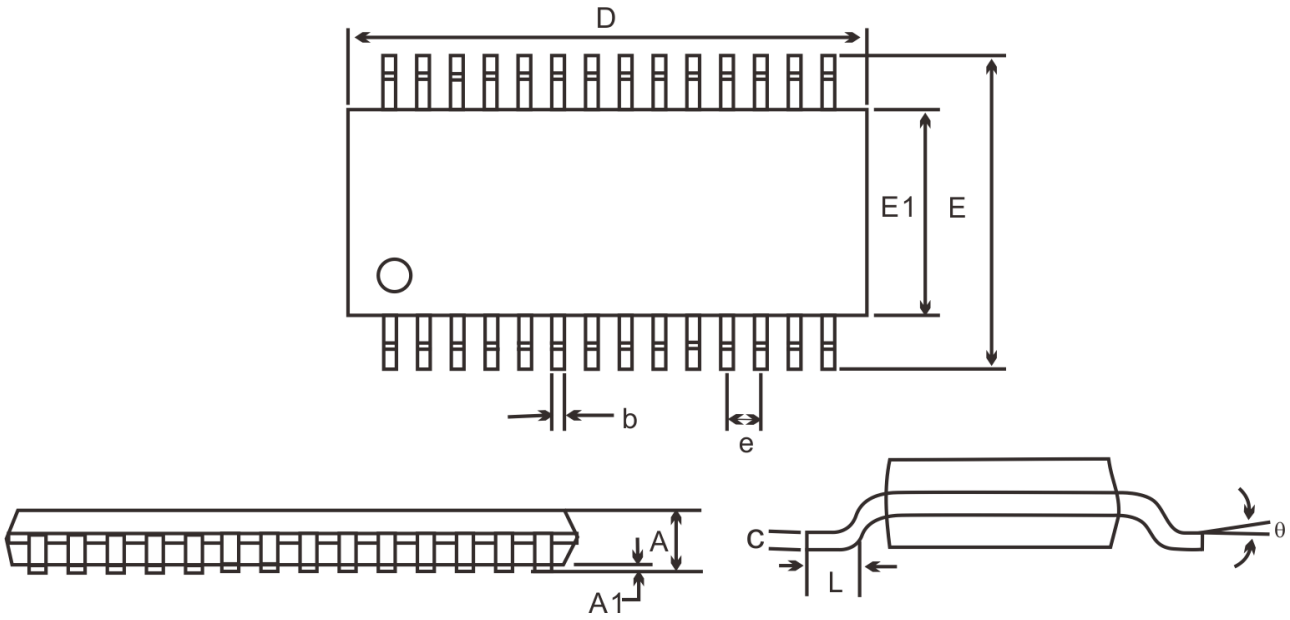
I²C 时序图:



Parameter	Symbol	Min	Max	Unit
SCL 频率	f_{SCL}	0	50	KHz
START 信号的保持时间	$t_{HD;STA}$	4		µS
SCL 为低电位的时间	t_{LOW}	4.7		µS
SCL 为高电位的时间	t_{HIGH}	4.0		µS
Data 的建立时间	$t_{SU;DAT}$	250		nS
Data 的保持时间	$t_{HD;DAT}$	5.0		µS
STOP 信号的建立时间	$t_{SU;STO}$	4.0		µS

包装讯息

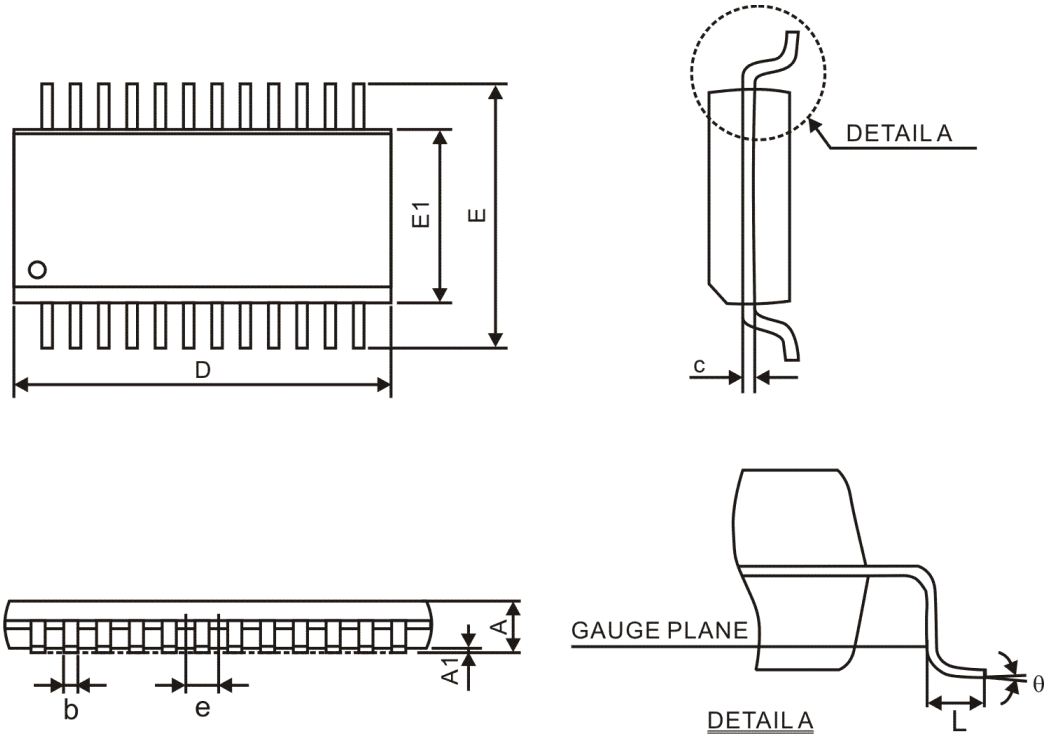
28 Pins, SSOP 150MIL



Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	-	-	1.750
A1	0.100	-	0.250
b	0.200	-	0.300
c	0.100	-	0.250
e	0.635 BSC		
D	9.9 BSC		
E	5.99 BSC		
E1	3.91 BSC		
L	0.410	-	1.270
θ	0°	-	8°

Notes : Refer to JEDEC MO-137 AF

24 Pins, SSOP 150MIL



Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	-	-	1.750
A1	0.100		0.250
b	0.200	-	0.300
c	0.100	-	0.250
e	0.635 BSC		
D	8.66 BSC		
E	5.99 BSC		
E1	3.91 BSC		
L	0.410	-	1.270
θ	0°	-	8°

Notes :Refer to JEDEC MO-137 AE

IMPORTANT NOTICE

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