Global Mixed-mode Technology

M8360

Three-Phase DC Fan Driver

Features

- **Speed Controllable by CMD (DC / PWM) Input**
- **Adjustable Speed curve (XP1 / YP1 / YMD / XP2)**
- **PWM Soft Switching**
- **Adjustable Leading Angle and Auto Leading Angle Function**
- **Adjustable current limit level**
- **Adjustable Soft-start time**
- **SO Speed Output (4pole / 6pole / 8pole / 10pole / 12pole / 14pole / 16pole / RD)**
- **Lock Protection and Automatic Restart**
- **Over Current Protection**
- **Low I_Q Function**
- **TQFN4X4-24 Package**

Applications

- **Cooling fan**

General Description

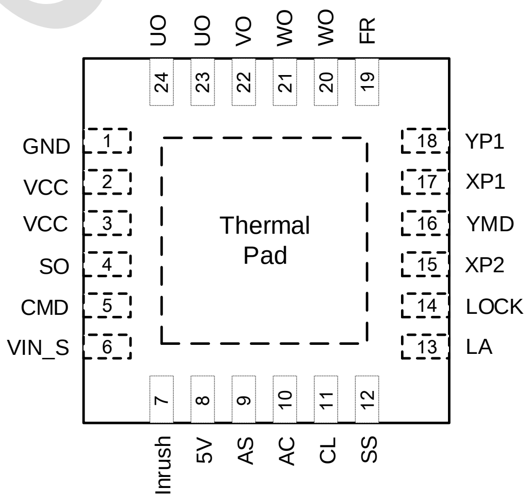
M8360 is designed for three phase motor driver that is composed of power MOS. It's driven by sensor-less sinusoidal method to achieves silent operation and low vibration. It has auto floating time function to minimize floating time for low acoustic noise.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
M8360R51U	8360	-40°C to +105°C	TQFN4X4-24

Note: R5: TQFN4X4-24
1: Bonding Code
U: Tape & Reel
Green : Lead Free / Halogen Free

Pin Configuration



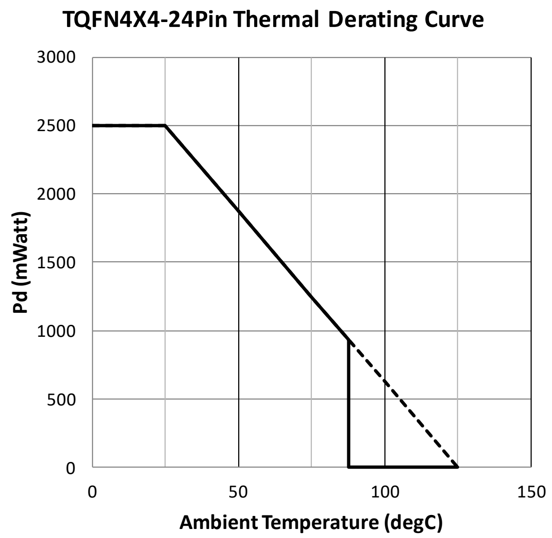
TQFN4X4-24

Note: Recommend connecting the Thermal Pad to the Ground for excellent power dissipation.

Absolute Maximum Ratings

VCC to GND . . . . -0.3V to 18V
VCC to GND Peak Voltage under 100nS 25V
5VREG to GND . . . . -0.3V to 7V
5VREG Output Source Current. 30mA
UO, VO, WO Output Peak current 3.5A
UO, VO, WO Output Voltage . . . . -0.3V to VCC
SO Output Voltage . . . . -0.3V to 18V
SO Output Current 10mA
CMD to GND . . . .-0.3V to 18V
FR to GND . . . .-0.3V to 18V
INRUSH to GND . . . . -0.3V to 7V
XP1, YP1, YMD, XP2, LA, CL, SS, LOCK , AS, AC, VIN_S Pin to GND . . . . -0.3V to 7V

Thermal Resistance Junction to Case, (θ_{Jc})
TQFN4X4-24. . . . . 20°C/W
Continuous Power Dissipation (T_A=25°C)
TQFN4X4-24 . . . . .2.5W
Operating Temperature Range . . . . . -40°C to +105°C
Junction Temperature . . . . +150°C
Storage Temperature Range . . . . -65°C to +150°C
Reflow Temperature (soldering, 10sec) . . . . 260°C
ESD (HBM) 4KV
ESD (MM) 200V



Note : When glass epoxy board (double layer) of 35mmx35mmX1.2mm is mounted.

Recommended Operating Conditions

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Power Supply Voltage	V_{CC}	3	12	18	V
CMD PIN Input Voltage	V_{CMD}	0	---	V_{5VREG}	V
FR PIN Input Voltage	V_{FR}	0	---	V_{5VREG}	V
XP1 PIN Input Voltage	V_{XP1}	0	---	V_{5VREG}	V
YP1 PIN Input Voltage	V_{YP1}	0	---	V_{5VREG}	V
YMD PIN Input Voltage	V_{YMD}	0	---	V_{5VREG}	V
XP2 PIN Input Voltage	V_{XP2}	0	---	V_{5VREG}	V
LA PIN Input Voltage	V_{LA}	0	---	V_{5VREG}	V
CL PIN Input Voltage	V_{CL}	0	---	V_{5VREG}	V
SS PIN Input Voltage	V_{SS}	0	---	V_{5VREG}	V
LOCK PIN Input Voltage	V_{LOCK}	0	---	V_{5VREG}	V
AS PIN Input Voltage	V_{YMD}	0	---	V_{5VREG}	V
AC PIN Input Voltage	V_{YP2}	0	---	V_{5VREG}	V
VIN_S PIN Input Voltage	V_{VIN_S}	0	---	V_{5VREG}	V
Operating Temperature	T_{OPR}	-40	---	100	°C

Electrical Characteristics

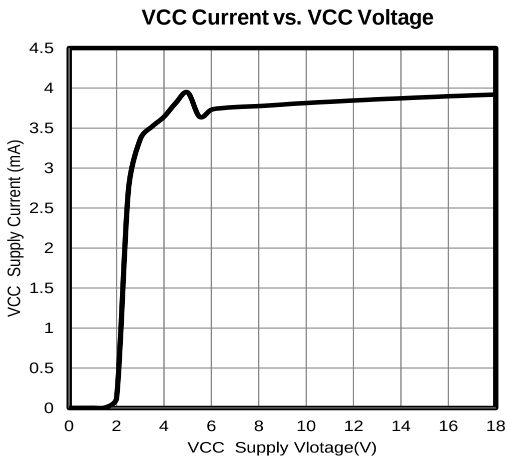
V_{CC}=12V; T_A = T_J =25°C.

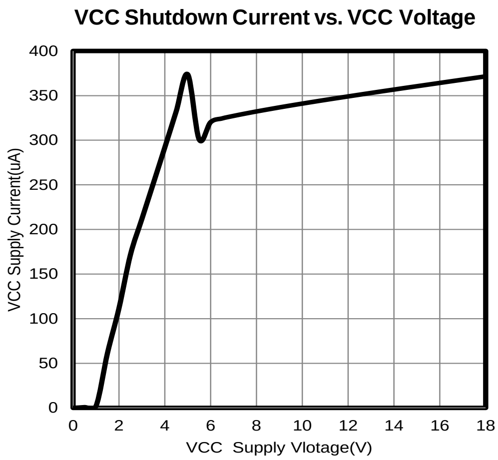
The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

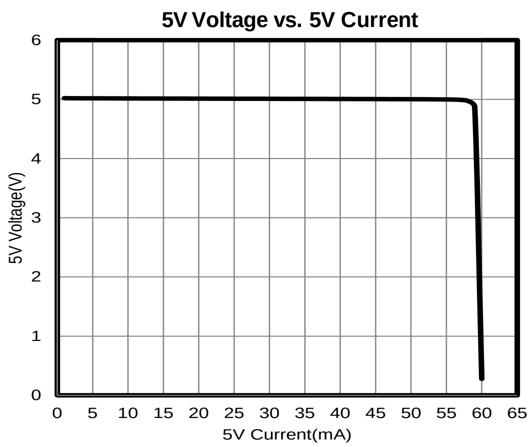
PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Power Supply						
Operating Current	I_{VCC}		2	3	4	mA
Shutdown Current	I_Q	CMD = GND & XP1<2.5V	300	400	500	µA
Power on Delay						
Power ON delay Time	Ttd	VCC = 0V to 12V XP1 > 2.5V & AS = 5V	56	80	104	ms
Power ON delay Time	Ttd	VCC = 0V to 12V XP1< 2.5V & AS = 5V	112	160	208	ms
Power Voltage Protection						
VIN Sense Voltage	Vin_s		0.5	0.6	0.7	V
PWM Mode						
CMD Input Low Voltage	V_{CMDL}		0	---	0.8	V
CMD Input High Voltage	V_{CMDH}		2	---	VCC	V
CMD Pull High Current	I_{CMD}	YMD < 2.5V	15	20	30	µA
CMD Pull High Current	I_{CMD}	YMD > 2.5V	150	200	250	µA
CMD Input Frequency	F_{CMD}		0.1	---	50	kHz
Output Switch Frequency	F_{OUT}		40	50	60	kHz
FR						
FR Input Low Voltage	V_{FRL}		0	---	0.8	V
FR Input High Voltage	V_{FRH}		2	---	VCC	V
FR Pull Low Resistor	R_{FR}		---	100	---	kΩ
Internal Regulator						
5V Regulator Output Voltage	V_{5VREG}	I_{5VREG} = -10 mA	4.9	5	5.1	V
5V Regulator Current Limit	I_{5VOC}	V_{5VREG} = 0V	20	25	35	mA
Output Drivers						
High-side Output Rdson	R_{OH}	VCC =12V, I_{OUT} = 500mA	---	0.15	0.18	Ω
Low-side Output Rdson	R_{OL}	VCC =12V, I_{OUT} = 500mA	---	0.1	0.12	Ω
SO Low Voltage	V_{SOL}	I_{SO} = 5mA	---	0.2	0.3	V
SO Off Leakage Current	I_{SOL}	V_{SO} = 12V	---	2	4	µA
INRUSH High Voltage	V_{INRH}	I_{INR} = -1mA	4.1	4.5	---	V
INRUSH Low Voltage	V_{INRL}	I_{INR} = 5mA	---	0.2	0.3	V
Current Protection						
Current Limit level	I_{LIM}	CL = 5V	2.5	3	3.5	A
Over current protection level	I_{OC}		3.36	4.2	5.04	A
Lock Protection						
Re-start Time	T_{on}	AS = 5V, SS = 5V	---	2	---	Sec
Lock Mode Time	T_{off}	Lock = 5V	3.5	5	6.5	Sec
Thermal Protection						
Thermal Protection Temp.	T_{TSD}		---	165	---	°C
Thermal Protection Hysteresis	T_{HYS}		---	30	---	°C
RPM						
Maximum RPM	R_{limit}	2 pair pole (4P)	48000	60000	72000	RPM

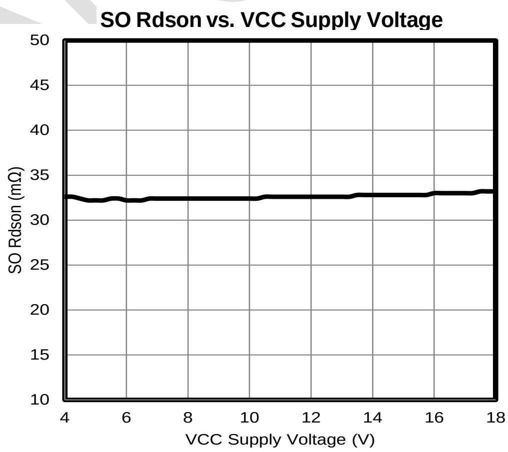
Typical Performance Characteristics

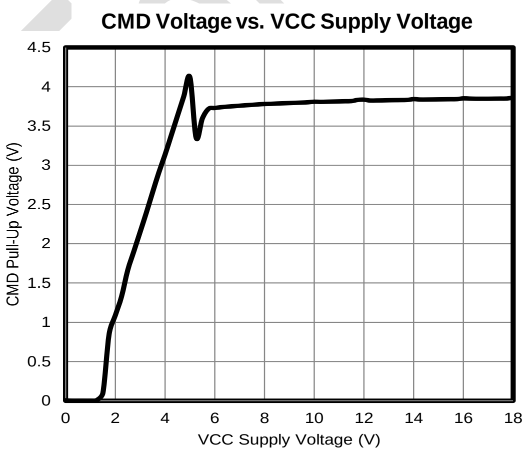
(TA =25°C)

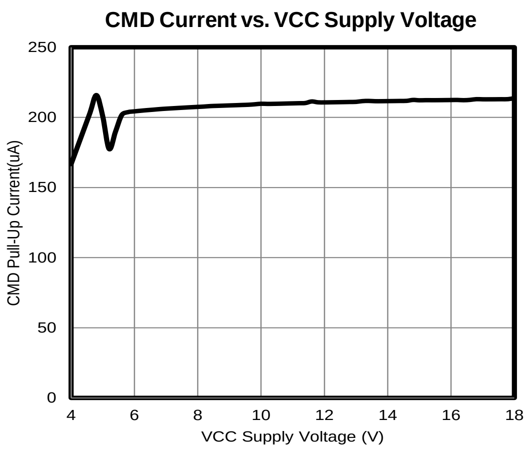




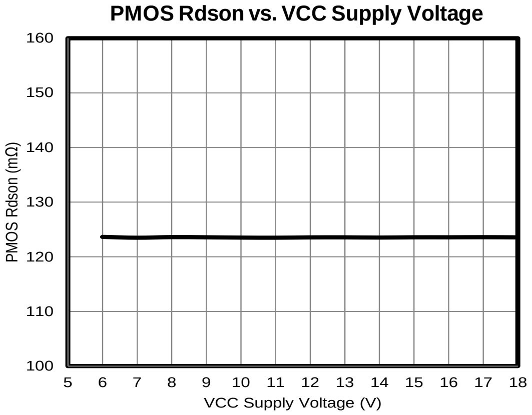


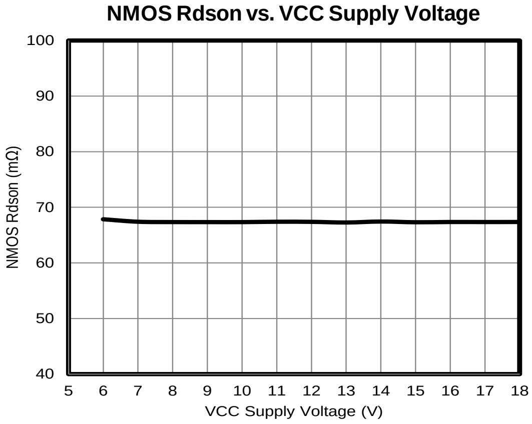






Typical Performance Characteristics (Continued)

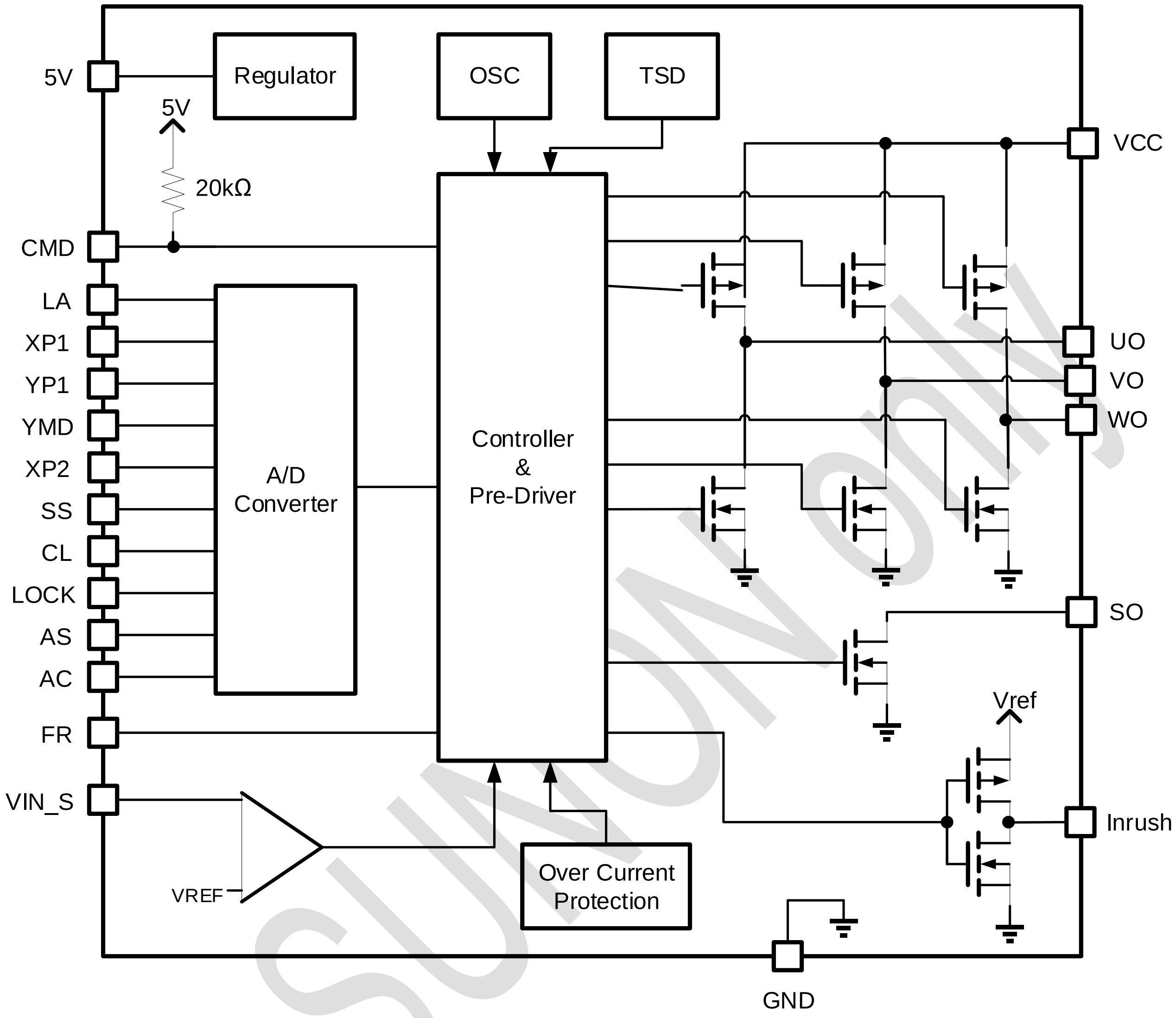




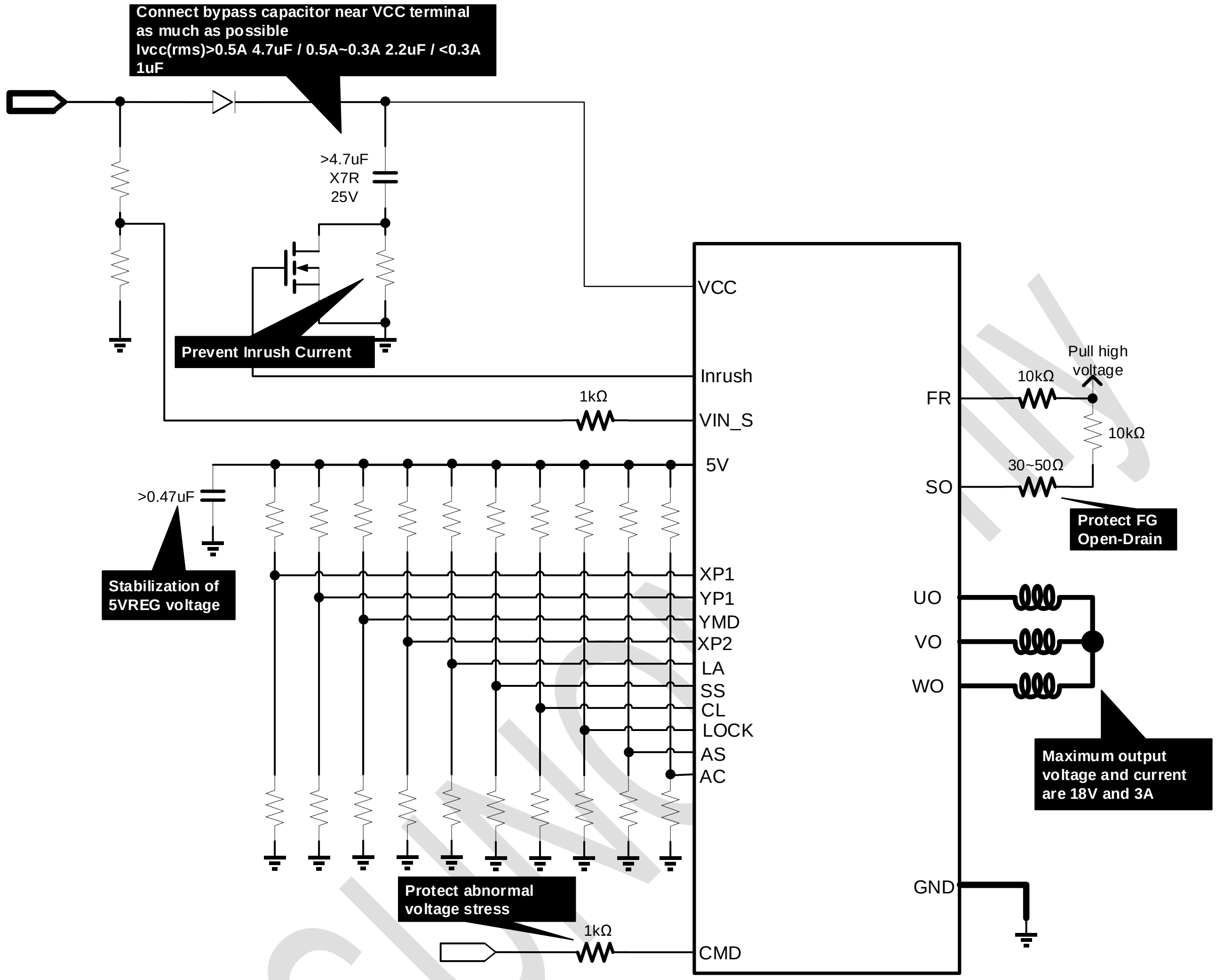
Pin Description

PIN NO.	SYMBOL	DESCRIPTION
1	GND	Ground
2	VCC	Power Supply
3	VCC	Power Supply
4	SO	Rotation Speed/Detection Output
5	CMD	Speed Control
6	VIN_S	Detect Power Supply before Input Diode
7	Inrush	Reduce Inrush Current
8	5V	5V Regulator Output
9	AS	Alignment Final Speed
10	AC	Alignment Initial Current
11	CL	Current Limit level
12	SS	Duty soft start
13	LA	Leading Angle Setting
14	LOCK	Lock Off Time
15	XP2	Maximum Input PWM Duty Setting
16	YMD	Mid Output PWM Duty Setting at PWM duty=75%
17	XP1	Minimum Input PWM Duty Setting
18	YP1	Minimum Output PWM Duty Setting
19	FR	Rotation Forward or Reverse
20	WO	Motor output terminal W
21	WO	Motor output terminal W
22	VO	Motor output terminal V
23	UO	Motor output terminal U
24	UO	Motor output terminal U

Block Diagram



Application Circuit Examples



Function Descriptions

Speed Control Setting

The XP1 / YP1 / YMD / XP2 is detected by ADC which has 256 steps, and the resolution is 15.625mV/step. As a result, the ADC can detect voltage from 0.5V(ADC=0) to 4.5V(ADC=255).

(A) The XP1 pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the turning point of input low duty at speed curve. The second function is to set speed curve with standby or minimum speed.

Equation :

$$D_{XP1}=\left(\frac{V_{IN}}{15.625mV}X\frac{5}{8}+12\right)X\frac{50\%}{128}$$

$$V_{XP1}>2.5V,\ V_{IN}=4.5V-V_{XP1}$$

$$V_{XP1}<2.5V,\ V_{IN}=V_{XP1}-0.5V$$

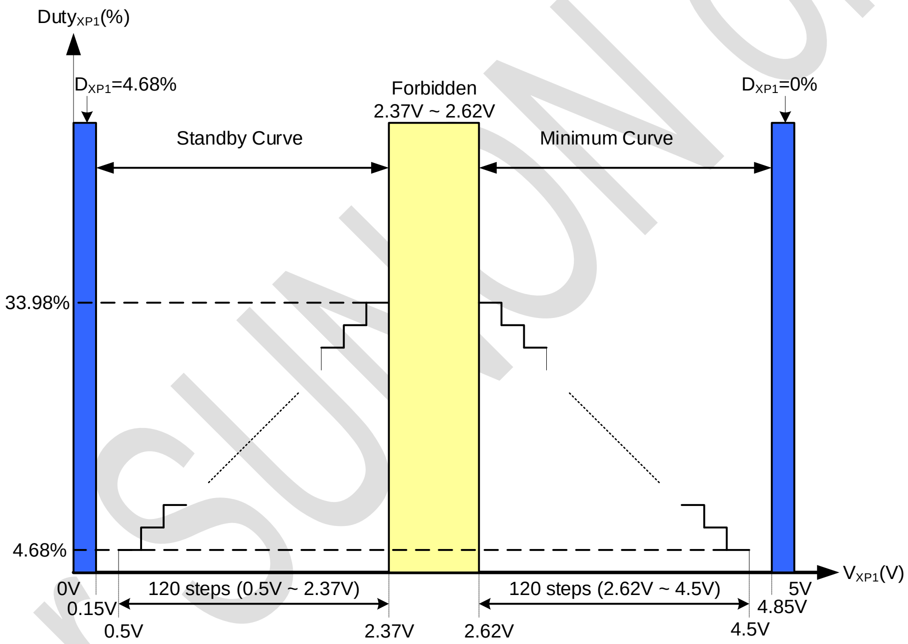


Figure : XP1 Voltage Setting Range

Table : XP1 Voltage Setting Table

Step	VXP1 (V)	Duty Input (%)	Sec. Function
	>4.85	0	Minimum
255	4.5	4.68	
136	2.62	33.98	
Forbidden			
120	2.37	33.98	Standby
0	0.5	4.68	
	<0.15	4.68	

(B) The YP1 pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the turning point of output low duty at speed curve.

Equation :

$$D_{YP1}=\left(\frac{V_{IN}}{15.625mV}\times\frac{5}{8}+12\right)\times\frac{50\%}{128}$$

$V_{YP1}>2.5V$, $V_{IN}=4.5V-V_{YP1}$

$V_{YP1}<2.5V$, $V_{IN}=V_{YP1}-0.5V$

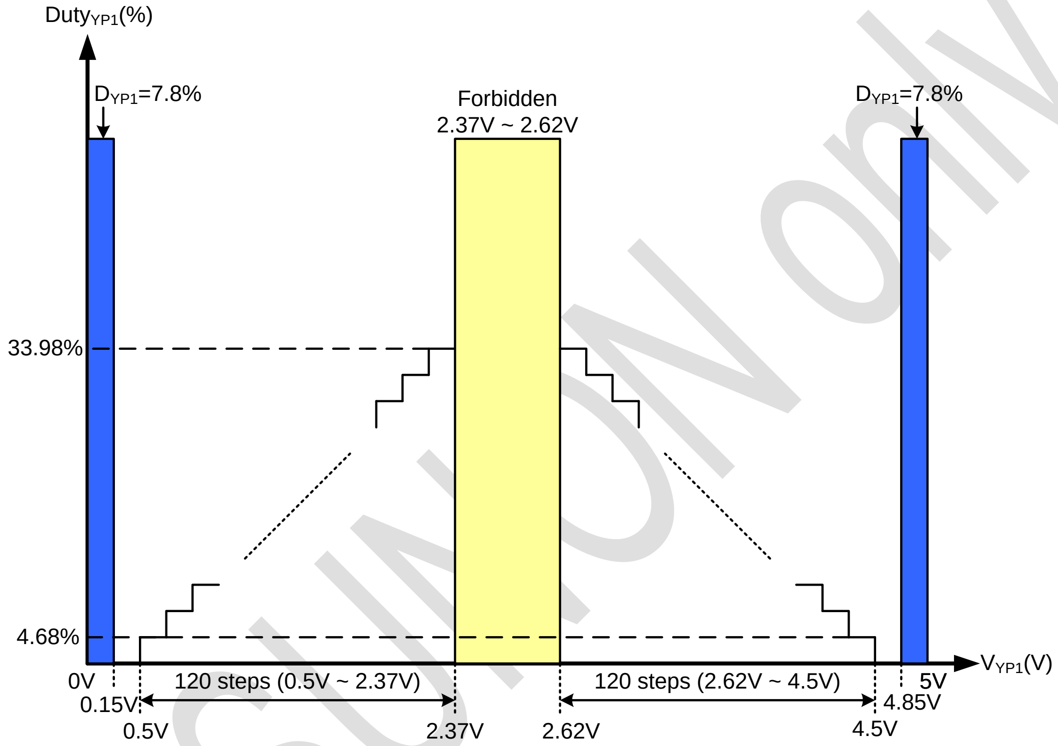


Figure : YP1 Voltage Setting Range

Table : YP1 Voltage Setting Table

Step	VYP1 (V)	Duty output (%)	Sec. Function
	>4.85	7.8	SO select
255	4.5	4.68	
136	2.62	33.98	
Forbidden			
120	2.37	33.98	SO select
0	0.5	4.68	
	<0.15	7.8	

(C) The YMD pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the turning point of output mid duty (CMD = 75%) at speed curve. The second function is to set CMD PIN pull high current.

Equation :

$$D_{YMD} = \left(\frac{V_{IN}}{15.625mV} X \frac{13}{16} \right) X \frac{50\%}{128} + 50\%$$

V_{YMD}>2.5V, V_{IN}=V_{YMD}-2.5V

V_{YMD}<2.5V, V_{IN}=2.5V-V_{YMD}

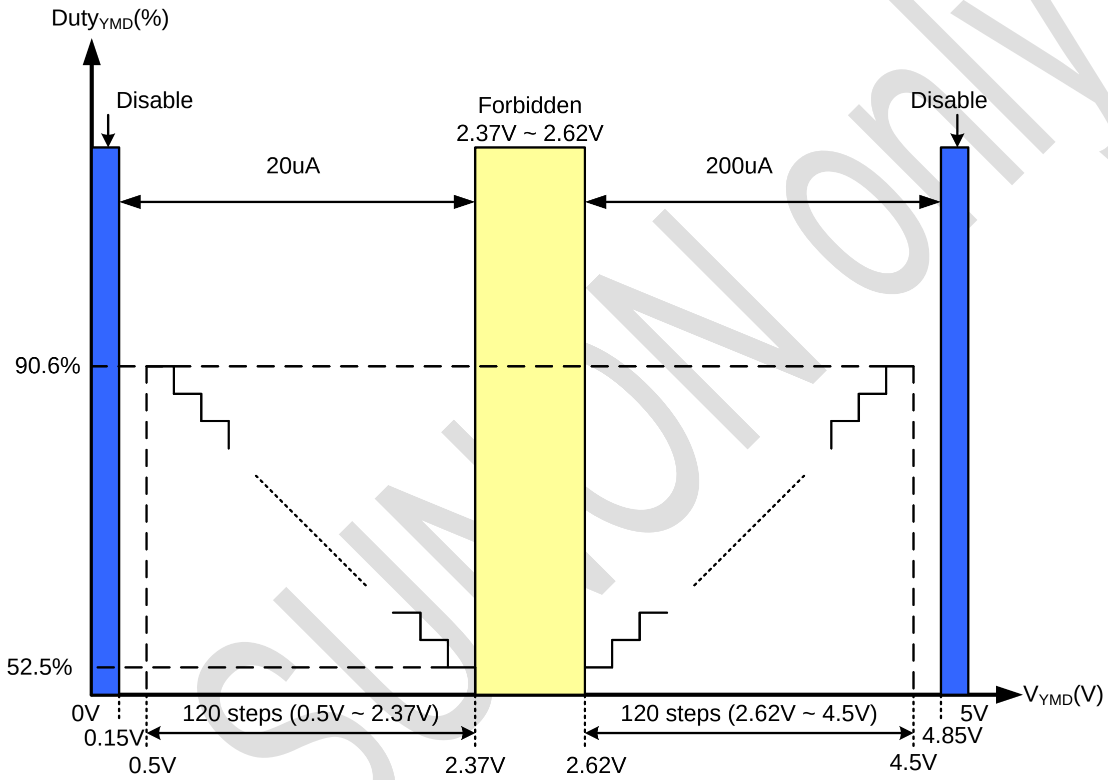


Figure : YMD Voltage Setting Range

Table : YMD Voltage Setting Table

Step	VYMD (V)	Duty output (%)	Sec. Function
	>4.85	Disable	CMD Current 200uA
255	4.5	90.6	
136	2.62	52.5	
Forbidden			
120	2.37	52.5	CMD Current 20uA
0	0.5	90.6	
	<0.15	Disable	

(D) The XP2 pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the turning point of input high duty at speed curve. The second function is to set brake mode after IC power off.

Equation :

$$D_{XP2} = \frac{V_{IN}}{15.625mV} \times \frac{50\%}{128} + 50\%$$

$$V_{XP2} > 2.5V,\ V_{IN} = V_{XP2} - 2.5V$$

$$V_{XP2} < 2.5V,\ V_{IN} = 2.5V - V_{XP2}$$

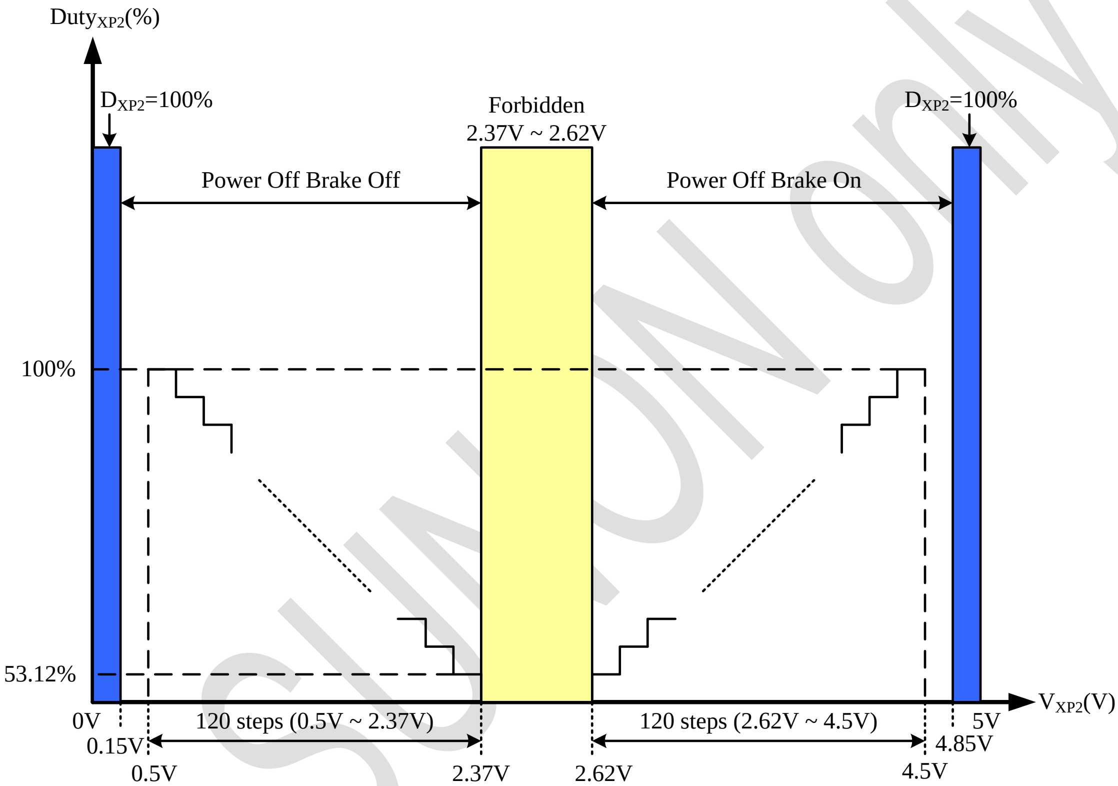


Figure : XP2 Voltage Setting Range

Table : XP2 Voltage Setting Table

Step	VXP2 (V)	Duty Input (%)	Sec. Function
	>4.85	100	Power off Brake Off
255	4.5	100	
136	2.62	53.12	
Forbidden			
120	2.37	53.12	Power off Brake On
0	0.5	100	
	<0.15	100	

Phase Control Setting

The LA pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the leading angle based on BEMF voltage zero crossing point..

Equation :

$$P_{LA} = \left(\frac{V_{IN}}{15.625mV} \right) X \frac{32^\circ}{128}$$

$V_{LA}>2.5V$, $V_{IN}=4.5V-V_{LA}$

$V_{LA}<2.5V$, $V_{IN}=V_{LA}-0.5V$

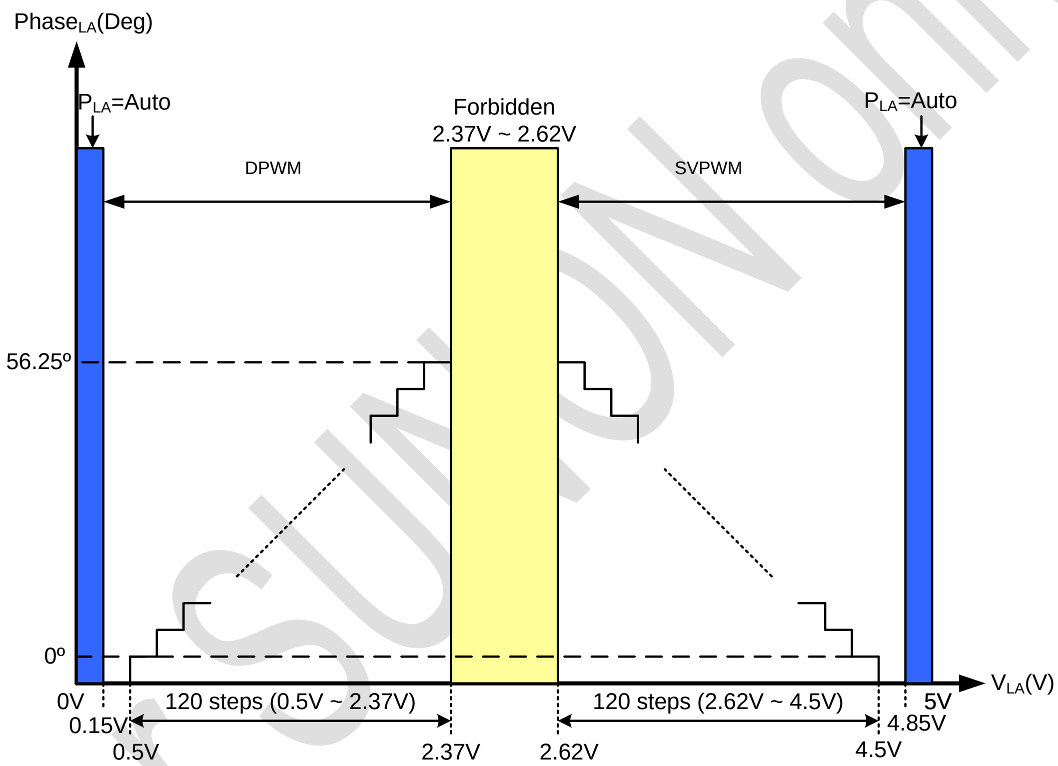


Figure : LA Voltage Setting Range

Table : LA Voltage Setting Table

Step	VLA (V)	LA (Deg)	Sec. Function
	>4.85	AUTO	SVPWM
255	4.5	0	
136	2.62	56.25	
Forbidden			
120	2.37	56.25	DPWM
0	0.5	0	
	<0.15	AUTO	

Soft Start Setting

The SS pin is a multi function pin setting by voltage from 0V ~ 5V. The main function can use two type soft start mode :

(a) Adjustable duty soft start time + fix current limit soft start time.

(b) Fix duty soft start time + adjustable current limit soft start time.

Equation :

$$Tduty\_SS = \left(\left(\frac{V_{IN}}{15.625mV}\right)\times\frac{3}{8}+4\right)X\frac{256}{2000}$$

V_{SS}>2.5V, V_{IN}=4.5V-V_{SS}

$$T_{CL}\_SS = \left(\left(\frac{V_{IN}}{15.625mV}\right)\times\frac{5}{8}+12\right)X\frac{64}{512}$$

V_{SS}<2.5V, V_{IN}=V_{SS}-0.5V

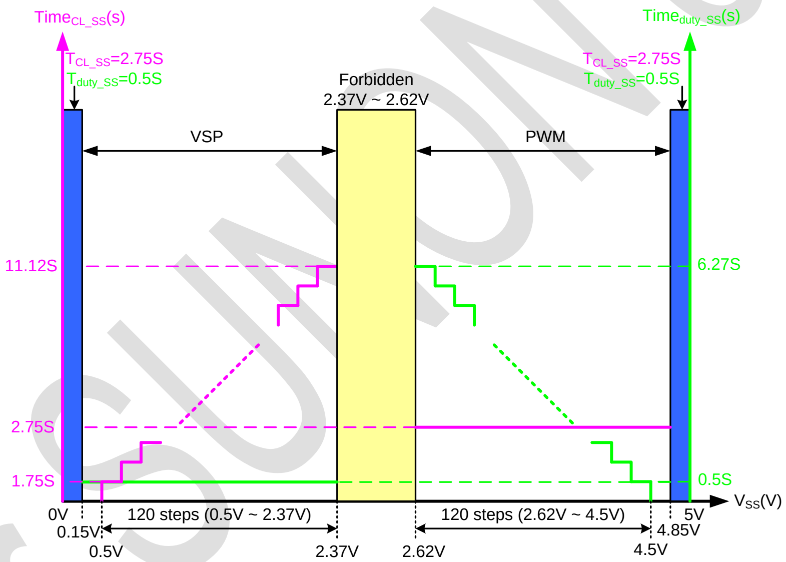


Figure : SS Voltage Setting Range

Table : SS Voltage Setting Table

Step	VSS (V)	Lock > 2.5V		Lock < 2.5V		Sec. Function
		Duty SS	CL SS	Duty SS	CL SS	
	>4.85	0.512	0.25+10.87	0.512	0.25+2.5	PWM
255	4.5		0.25+1.5	0.512		
136	2.62		0.25+2.5	6.27		
Forbidden						
120	2.37	0.512	0.25+10.87	0.512	0.25+2.5	VSP
0	0.5		0.25+1.5	0.512		
	<0.15		0.25+2.5	6.27		

Current Limit Setting

The CL pin is a multi function pin setting by voltage from 0V ~ 5V. The main function has third features :

(a) The current limit level is adjustable by command pin.
(b) The chip can detect overall coil current to adjust output duty.
(c) The chip also has CMD clock mode.

Equation :

$$I_{CL} = \left(\left(\frac{V_{IN}}{15.625mV} \right) \times \frac{3}{4} + 10 \right) X \frac{(3-0.3)}{128} + 0.3$$

V_{CL}>2.5V, V_{IN}=V_{CL}-2.5V

V_{CL}<2.5V, V_{IN}=2.5V-V_{CL}

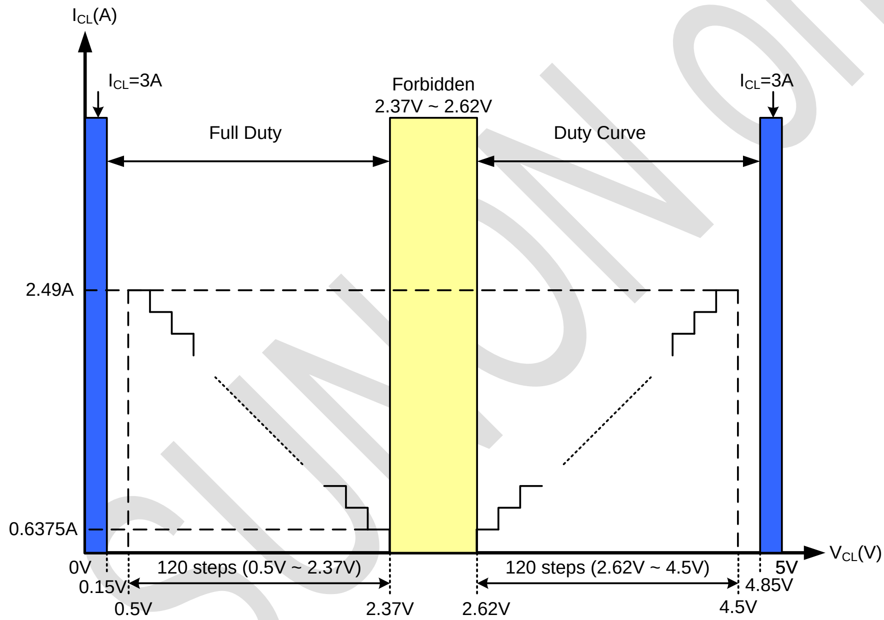


Figure : CL Voltage Setting Range

Table : CL Voltage Setting Table

Step	VCL (V)	CL (A)	Sec. Function	Third Function
	>4.85	3	CCL Off CL Curve	
255	4.5	2.49	CCL On CL Curve	
136	2.62	0.6375		
Forbidden				
120	2.37	0.6375	CCL On Full Duty (CMD > 50%)	
0	0.5	2.49		
	<0.15	3	CCL Off CL Curve	CMD Clock Mode

※CCL : Current Close Loop

Lock Off Time

The LOCK pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the lock off time when the fan enter lock mode. The second function is to set output soft start type.

Equation :

$$T_{OFF} = \left(\frac{V_{IN}}{15.625mV}\right) X \frac{3}{8} X0.25$$

V_{LOCK}>2.5V, V_{IN}=V_{LOCK}-2.5V

V_{LOCK}<2.5V, V_{IN}=2.5V-V_{LOCK}

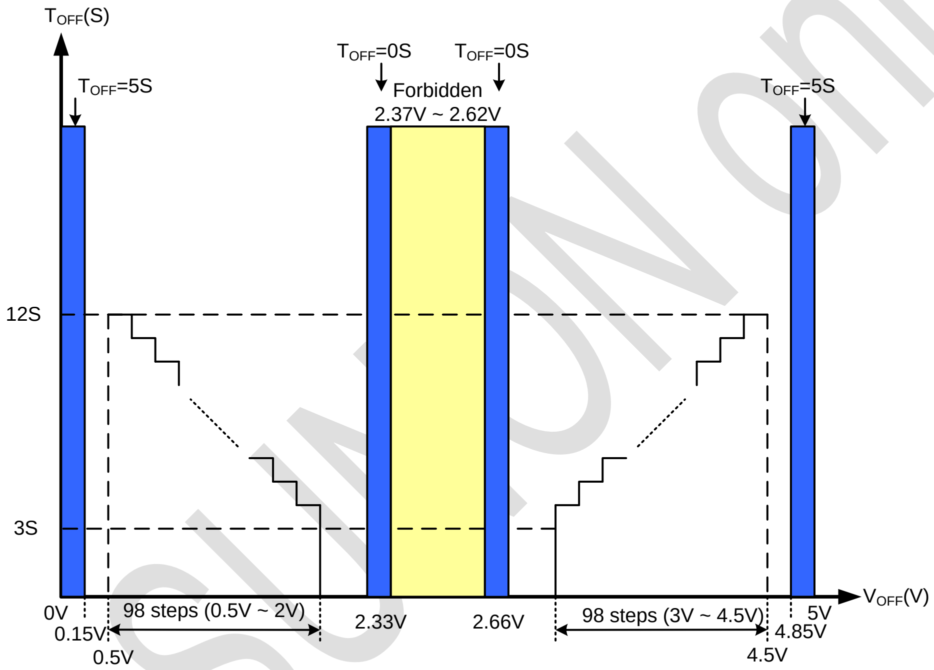


Figure : Lock Off Time Setting Range

Table : Lock Off Time Setting Table

Step	VLOCK (V)	Off Time (S)	Sec. Function
	>4.85	5	
255	4.5	12	CL SS
158	3	3	
138	2.66	0	Lock Off
Forbidden			
117	2.33	0	Lock Off
98	2	3	
0	0.5	12	Duty SS
	<0.15	5	

Alignment Setting

The AS / AC is detected by ADC which has 256 steps, and the resolution is 15.625mV/step. As a result, the ADC can detect voltage from 0.5V(ADC=0) to 4.5V(ADC=255).

(A)The AS(align speed) pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the final alignment RPM.

Equation :

$$RPM_{AS} = \left(\frac{V_{IN}}{15.625mV}\right) X16 + 200$$

$V_{AS}>2.5V$, $V_{IN}=4.5V-V_{AS}$

$V_{AS}<2.5V$, $V_{IN}=V_{AS}-0.5V$

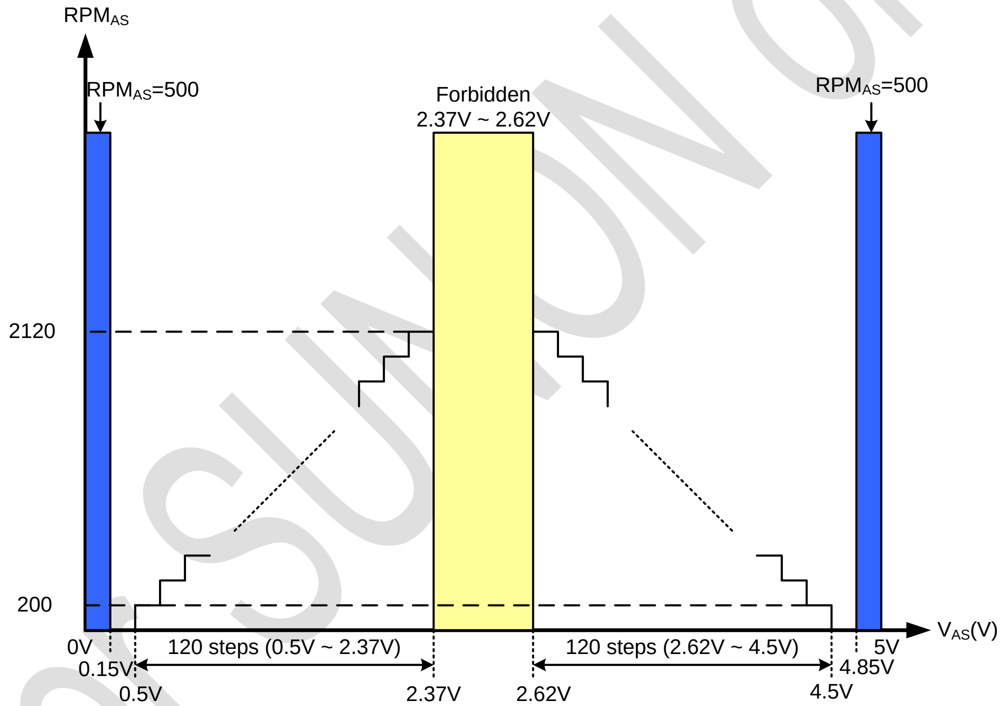


Figure : AS Voltage Setting Range

Table : AS Voltage Setting Table

Step	VAS (V)	AS(RPM)	Sec. Function
	>4.85	500	SO select
255	4.5	200	
136	2.62	2120	
Forbidden			
120	2.37	2120	SO select
0	0.5	200	
	<0.15	500	

(B)The AC(align current) pin is a multi function pin setting by voltage from 0V ~ 5V. The main function controls the alignment process current level.

Equation :

$$I_{AC}=\left(\frac{V_{IN}}{15.625mV}\right)X\frac{3}{8}X\frac{(3-0.3)}{128}+0.3$$

$V_{AC}>2.5V$, $V_{IN}=V_{AC}-2.5V$

$V_{AC}<2.5V$, $V_{IN}=2.5V-V_{AC}$

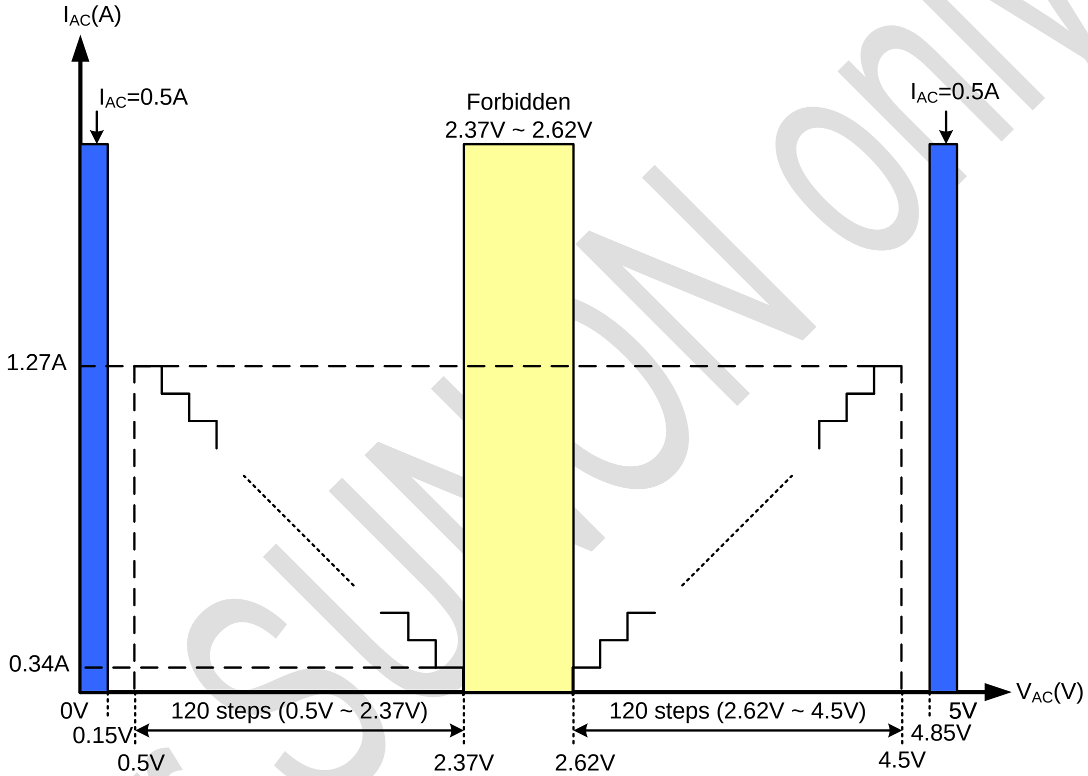


Figure : AC Voltage Setting Range

Table : AC Voltage Setting Table

Step	VAC (V)	AC(A)	Sec. Function
	>4.85	0.5	SO select
255	4.5	1.27	
136	2.62	0.34	
Forbidden			
120	2.37	0.34	SO select
0	0.5	1.27	
	<0.15	0.5	

Truth Table

(A) Mode select

Mode	SO = RD	VSP	Normal	YMD<2.5V
CMD Pull high	200µA	NA	200µA	20µA
5V OFF (shutdown mode)	NA	NA	Yes	Yes

(B) SO Type

	FG	$\frac{4}{8}$FG	$\frac{4}{6}$FG	$\frac{4}{10}$FG	RD	$\frac{4}{12}$FG	$\frac{4}{14}$FG	$\frac{4}{16}$FG
YP1	1	1	1	1	0	0	0	0
AC	1	1	0	0	1	1	0	0
AS	1	0	1	0	1	0	1	0

※PIN voltage > 2.5V means 1, and PIN voltage < 2.5V means 0.

(C) Clock Mode

Pole	4	6	8	10	12	14	16
Clock cycle(Hz) / RPM	6	9	12	15	18	21	24
150	15	22.5	30	37.5	45	52.5	60
300	30	45	60	75	90	105	120
600	60	90	120	150	180	210	240
1200	120	180	240	300	360	420	480
2400	240	360	480	600	720	840	960
4800	480	720	960	1200	1440	1680	1920
9600	960	1440	1920	2400	2880	3360	---
19200	1920	2880	3840	4800	5760	---	---
38400	3840	5760	7680	9600	---	---	---
76800	7680	---	---	---	---	---	---

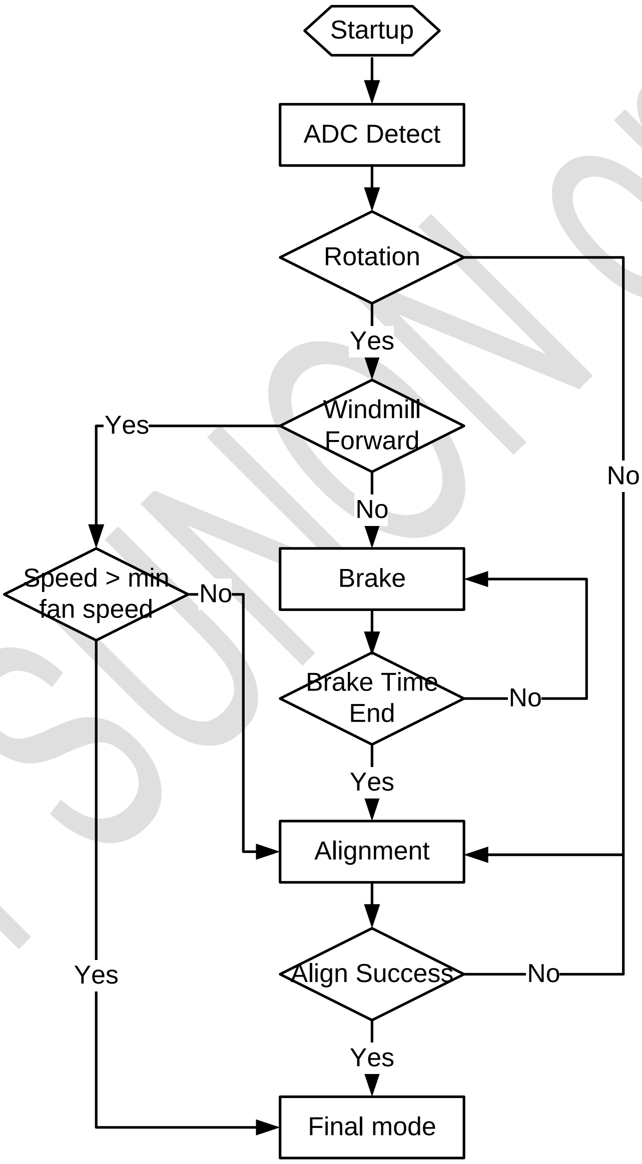
※ $\text{Clock Cycle} = \frac{2}{3} \times \text{Pole}$

※ $\text{RPM} = \frac{\text{FrequencyIN}}{\text{Clock Cycle}} \times 60$

Function Descriptions

[1]Startup Procedure

The M8360 is to detect every multi function pin by ADC when power on. After calculating speed curve by multi function pin setup, the M8360 will enters startup procedure. When the IC's driver MOS is still under floating state, it must enable windmill function to detect the motor rotation is forward or not. If the motor is forward rotation, the IC will enter driving mode directly. If the motor is reverse rotation, the IC will enable brake function. If the motor is under static state, the IC will enable alignment startup procedure. It must make sure that the Back Electromotive Force (BEMF) voltage is big enough after alignment. If the M8360 can successfully to detect BEMF voltage, IC will enter sensorless mode, or the IC will enter alignment procedure again. If the IC alignment procedure fail again, it will enter lock off mode for preventing IC from over heat.



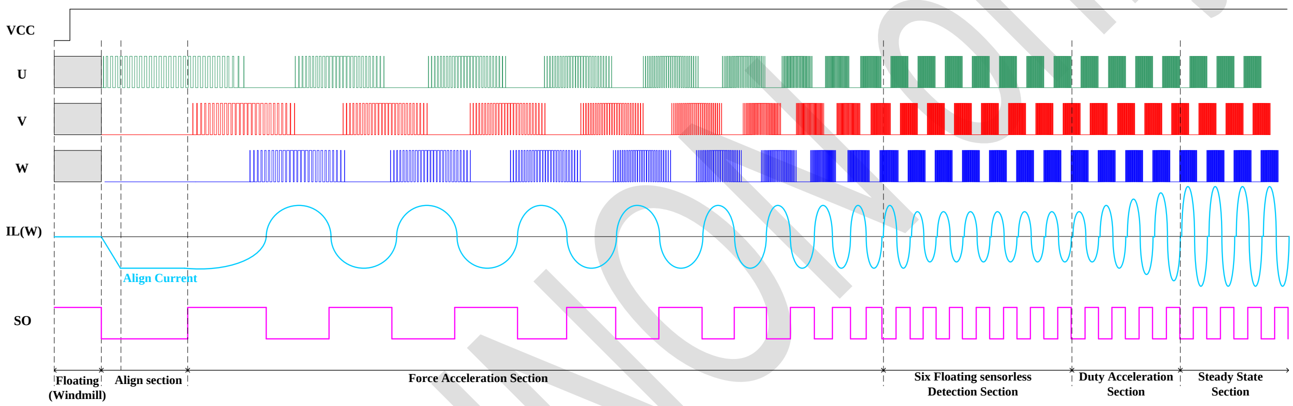
[2]Windmill Procedure

The first key condition is to make sure that the BEMF comparator can successfully detect BEMF voltage which is producing by motor rotation speed. So we can check the BEMF voltage is bigger than noise voltage when motor rotation speed is at minimum fan speed. This condition let BEMF comparator can detect phase zero point correctly without interference by noise. We can setup the minimum detecting speed of windmill function by AS(align speed) PIN. The windmill function will be trigger when the motor rotation speed is bigger than the minimum detecting speed.

There are four condition under windmill function detection :

(1) Rotation speed ≧ minimum fan speed & forward rotation => IC enter driving mode.
(2) Rotation speed < minimum fan speed & forward rotation => IC enter alignment mode.
(3) Rotation speed ≧ minimum fan speed & reverse rotation => IC enter brake mode.
(4) Rotation speed < minimum fan speed & reverse rotation => IC enter alignment mode.

[3]Alignment Startup Procedure



3.1 Align Section

Align section means giving motor an initial position. Therefore we can obtain an initial align time by converting align speed (AS) PIN for stopping motor at initial position stably. The IC force output drive an fix state, and let motor rotate to the initial position at a given time, then enter force acceleration section. As a result, this method can reduce rocking of motor and increase the probability of startup success.

In the early stage, the IC driver MOS must give motor a safe and reliable power that ensuring the moving of motor follow the IC's electrical change signal. Further the power can not destroy any electrical device and fan mechanism. As a result, for increasing the probability of startup success, we use current limit alignment technique for alignment startup.

3.2 Force Acceleration Section

The purpose of force acceleration section is to speed up motor for stably detecting BEMF voltage. Therefore the final speed of motor produces BEMF voltage for comparator detecting, and it must make sure that the comparator can detect BEMF zero point stably. The BEMF peak voltage is ten times bigger than noise voltage as much as possible, and it can reduce detecting phase angle error from noise interference.

The essential point is to produce enough BEMF voltage. It can easily accomplish this requirement by setting align speed (AS) pin, and the consequence of adjusting AS can result in three way :

(1) Align speed (AS) too slow : the motor rotation speed is not enough, and result in BEMF voltage too small, and it make comparator detect phase error. Finally the motor will stop.
(2) Align speed (AS) Moderate : the BEMF voltage is large enough for comparator detecting, and it can enter sensorless mode easily.
(3) Align speed (AS) too fast : the rotor of motor can not follow the velocity of electrical change signal, and it will cause motor not to reach align speed exactly, and severely it make rotor stop or reverse rotating.

It must be careful to decide align speed (AS) pin setup, and one way to confirm this setup :
Taking a reference of minimum fan speed, we can setup the same speed by the align speed (AS) PIN. It can ensure the BEMF voltage of alignment before entering sensorless mode, and the BEMF voltage of alignment is the same with the BEMF voltage of sensorless mode under minimum fan speed.

3.3 Six floating sensorless Detection Section

There are two items for entering sensorless mode :

(1) When the motor go from alignment to sensorless mode, the M8360 adopt six floating time for detecting zero crossing point of BEMF voltage. This method can shrink the updating time of fan speed data, and enhance the stability of fan speed.
(2) Furthermore it needs different time for the stability of fan speed at different motor. So the M8360 provide adjusting motor rotation times under six floating sensorless detection section by SS pin setup.

3.4 Duty Acceleration Section

When the motor can stably detect zero crossing of BEMF voltage under six floating sensorless detection senction, the motor can proceed to the next step :

(1) Allow increase or decrease the output duty.
(2) For reducing the rock and noise, the IC must reduce floating time and degree. Therefore the M8360 go from six floating time to single floating time after stably detecting BEMF voltage.

3.5 Steady State Section

As the output duty reach the target duty, the motor finally archive steady state.

[4]Brake Procedure

By turning on low side NMOS of three phase, the coil will produce brake current, and this brake current will stop the motor. The length of brake time will affect the speed of motor, so we can decide the length of brake time by SS PIN setup. There are three condition to enter brake procedure :

(1) Initial reverse rotation, the IC must brake the motor speed under align speed (AS), for it can make sure the opportunity of alignment success.
(2) The control system change FR pin H/L level to change the motor rotation direction.
(3) When the power system is turn off, the voltage (vin_s) before diode is going to low voltage immediately. The IC will turn on all low side NMOS, let fan stop immediately.

[5]Current Protection

The M8360 includes internal current limit. It will turn off high side PMOS when output driver current is over 3A. The high side PMOS will turn on at next PWM cycle, and reduce the output duty. The M8360 also includes over current protection (OCP). If the output driver current is over 4.2A, all output MOS will turn off and enable lock protection. Chip will restart when lock off time is count down.

[6]Lock Protection and Automatic Restart

Motor rotation is detected by detecting BEMF zero crossing point signal. When the fan encounters an external force, result in detection fail. This chip internal clock detect an on time (T_{ON} 0.5s), then all driver MOSFETs are turned off and auto restart after the recovery time (T_{OFF} 5s). It also can change the recovery time by the lock pin table setup.

[7]Standby and Shutdown

When driver off logic is setup by the control signal (CMD pin) over a fixed time (70ms), the lock protection signal will be disable. Chip all circuit still work except driver MOSFETs turned off, and wait for quick start by the control signal. This chip also has shutdown function detected by the control signal under low level (0%). In the shutdown mode, it will turn off all driver MOSFETs, internal clock and SO function, and the quiescent current is under 400uA.

[8]Over Voltage Protect (OVP)、Under Voltage Lockout (UVLO)、Input Voltage Sense (VIN_S)、Hot Plug Protect (Inrush)

8.1 Over Voltage Protect (OVP)

Under the motor operating process, it may result in over voltage phenomenon because of the coil current charging input capacitor at variation condition. In order to protect IC from burning out, the M8360 can detect OVP voltage which is divider from vm voltage by resistor. If IC find over voltage, it will turn on all low side driver MOS for the coil current flow through low side NMOS. Until there are no any OVP and waiting for appropriate time, IC will return to normal driving mode. Besides over voltage phenomenon may cause by input voltage , similarly the IC will turn off high side driver PMOS and turn on all low side driver NMOS. It can also prevent the motor power from being too high.

8.2 Under Voltage Lockout (UVLO)

There are still some current storage in capacitor after disconnect input power, and it can keep the motor running for a while. At this time, in order to ensure that the IC can work correctly and not disturb by voltage, the IC can detect UVLO voltage which is divider from VCC voltage by resistor. When the VCC voltage is lower than UVLO voltage, the IC will turn off all driver MOS. Therefore it can prevent capacitor charge from decreasing too fast, and the IC still work correctly to appropriately deal with the residual current of coil. If the VCC voltage is higher than UVLO voltage again, the IC can directly enter normal driving mode because of the IC still under working state.

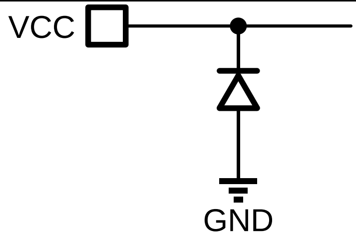
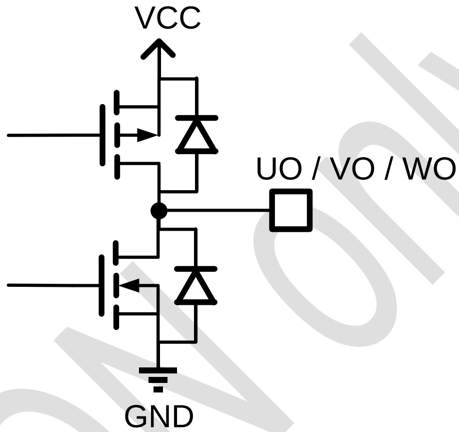
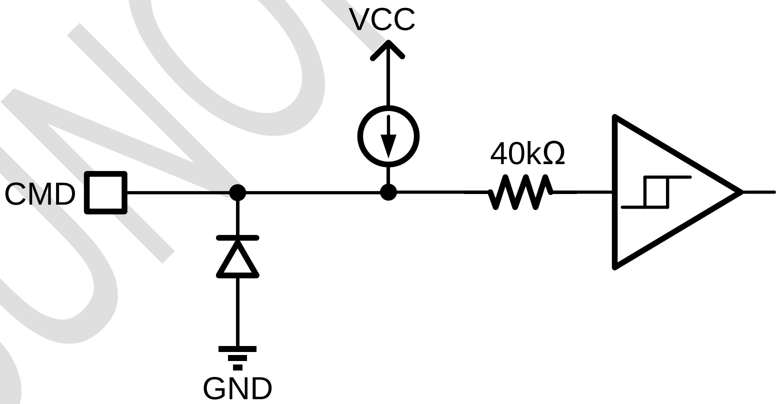
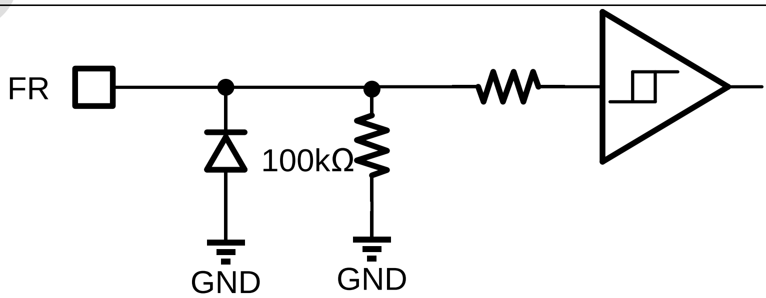
8.3 Input Voltage Sense (VIN_S)

Input diode is common using in motor driving circuit to prevent input power from reverse current of motor. The IC provide an input voltage sense circuit which is divided from input voltage (input side of diode) by resistor. The IC can turn off driving MOS by detecting input voltage, and it can work more perfectly than detecting UVLO voltage.

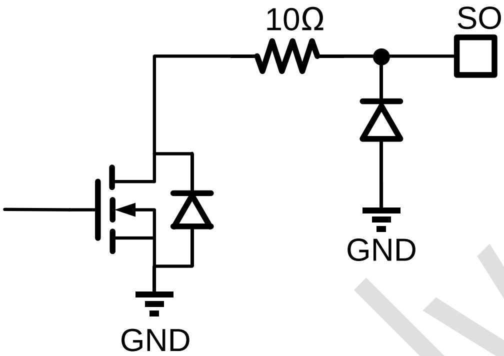
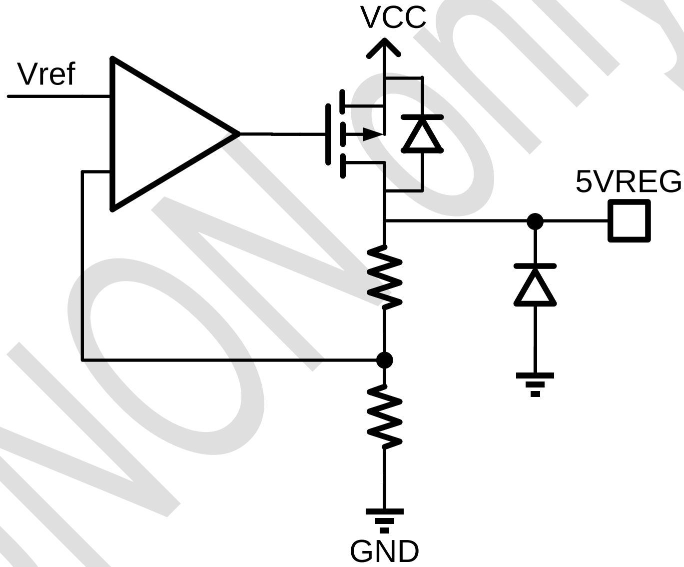
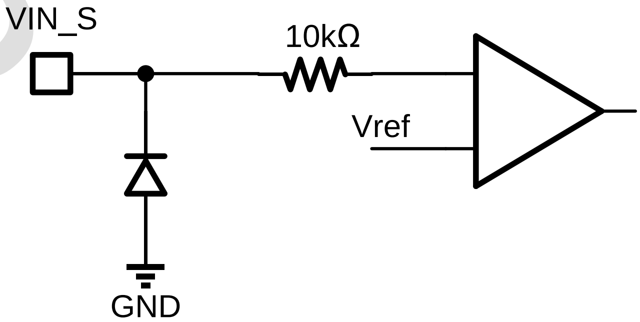
8.4 Hot Plug Protect (Inrush)

Hot Plug is very usually application condition. Due to there are input diode and input capacitor on application circuit. Input power provide current for input capacitor through power line and input diode. Because of inductance characteristic of power line, it will result in over voltage in VCC point (output side of diode). The IC uses INRUSH pin to reduce inrush current which is setup like application circuit. In the hot plug process, the inrush current is as small as possible, it will cause less over voltage phenomenon. The IC will wait for a given time before the input capacitor is really turned on.

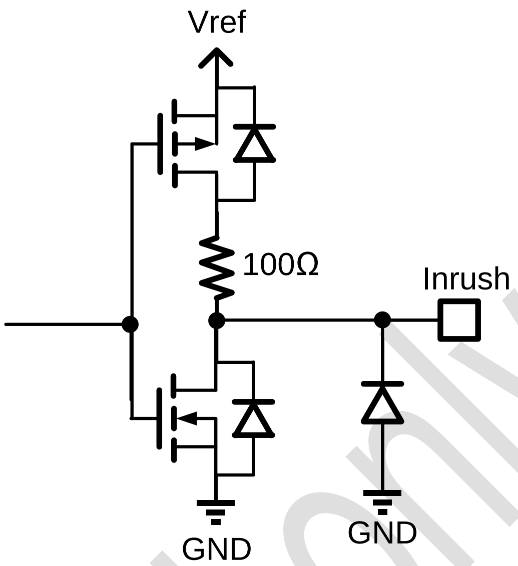
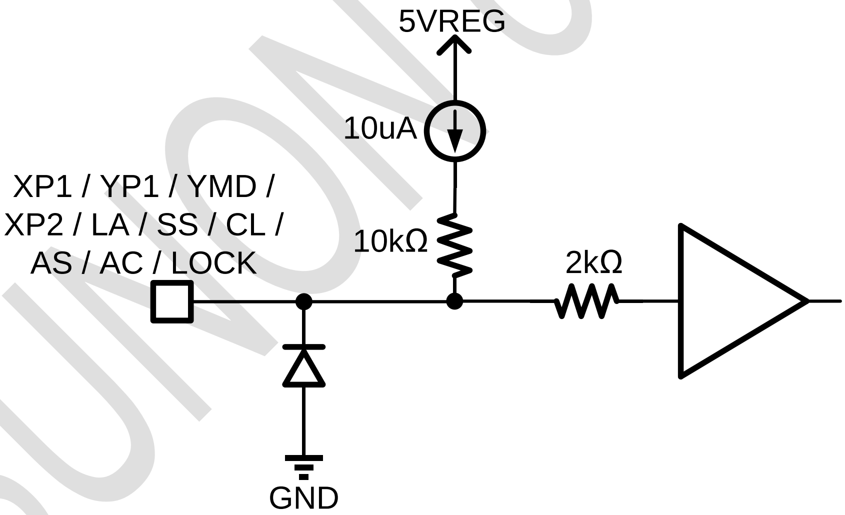
I/O Equivalence Circuit

PIN	I/O	Equivalence Circuit
Power supply (VCC / GND)	Input	
UO / VO / WO	Output	
CMD	Input	
FR	Input	

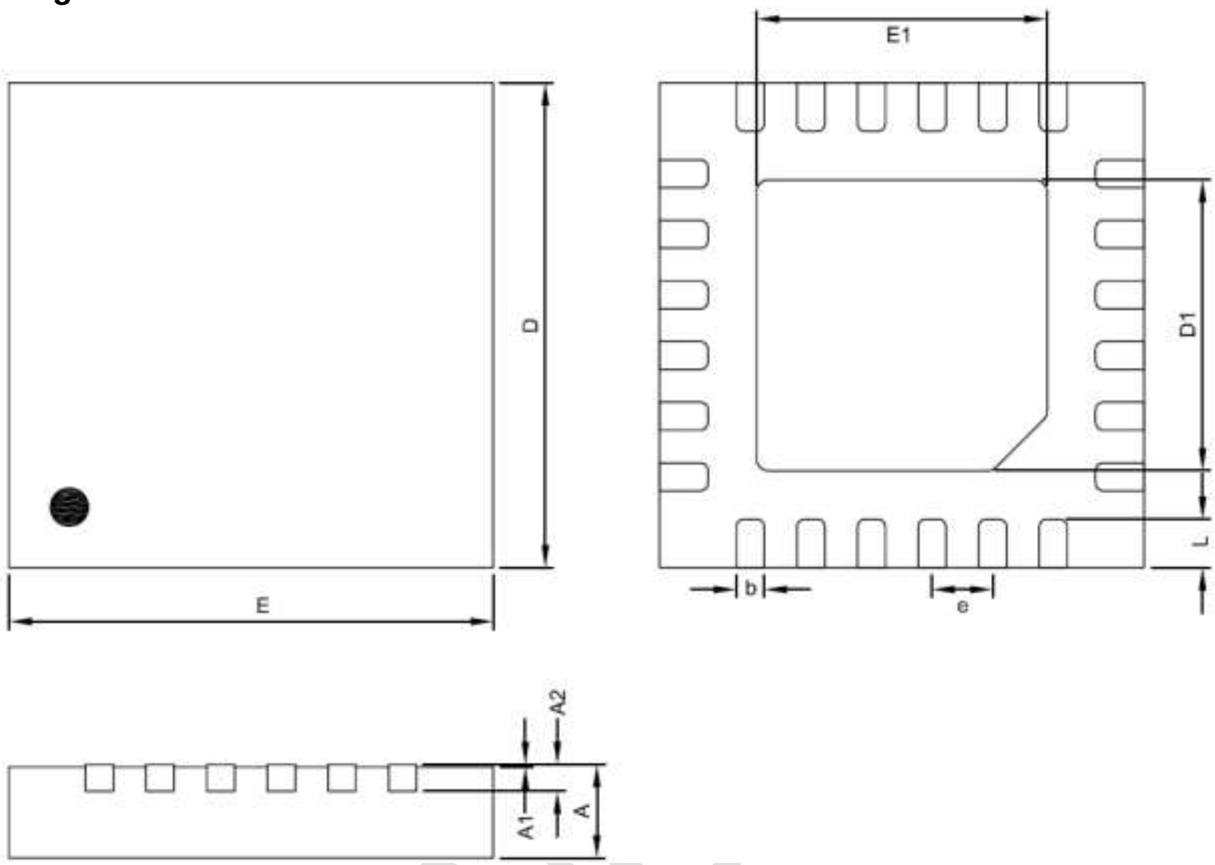
I/O Equivalence Circuit

PIN	I/O	Equivalence Circuit
SO	Output	
Reference volt-age 5VREG	Output	
VIN_S	Input	

I/O Equivalence Circuit

Inrush	Output	
XP1 / YP1 / YMD / XP2 / LA / SS / CL / AS / AC / LOCK	Input	

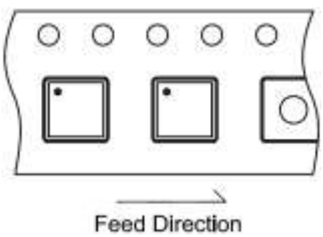
Package Information



TQFN4X4-24 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.20 REF			0.0079 REF		
D	3.95	4.00	4.05	0.1555	0.1575	0.1594
E	3.95	4.00	4.05	0.1555	0.1575	0.1594
D1	2.50	2.70	2.85	0.0984	0.1063	0.1122
E1	2.50	2.70	2.85	0.0984	0.1063	0.1122
b	0.18	0.23	0.30	0.0071	0.0091	0.0118
e	0.50 BSC			0.0197 BSC		
L	0.35	0.40	0.45	0.0118	0.0138	0.0177

Taping Specification



PACKAGE	Q'TY/BY REEL
TQFN4X4-24	3,000 ea