3-Phase DC Fan Driver

Features

- **Sinusoidal drive for low audible noise**
- **High efficiency control algorithm**
- **Sensorless/1-hall operation**
- **PWM speed control**
- **Adjustable Speed curve**
- **SO speed output**
- **Lock protection**
- **Over current protection**
- **Soft-start**
- **TQFN4X4-24 (R5) packages**

General Description

M8320 is designed for 3 phase motor control, driven by sensorless method or one hall. It includes 180° sinusoidal driving algorithm for low audible noise. M8320 is available in TQFN4X4-24 (R5) packages.

Applications

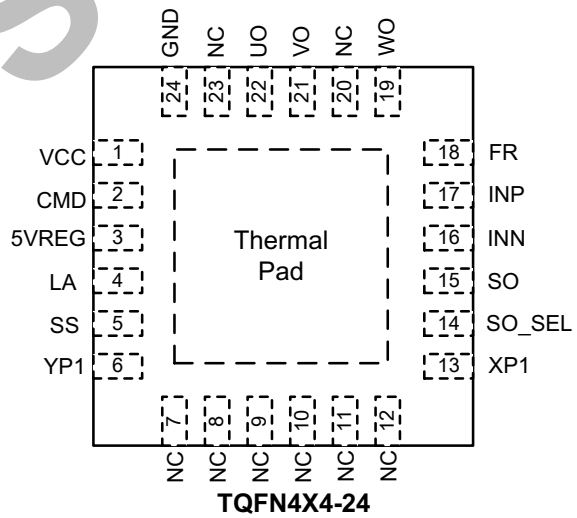
- **Notebook**

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
M8320R51U	8320	-40°C to +125°C	TQFN4X4-24

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

Pin Configuration



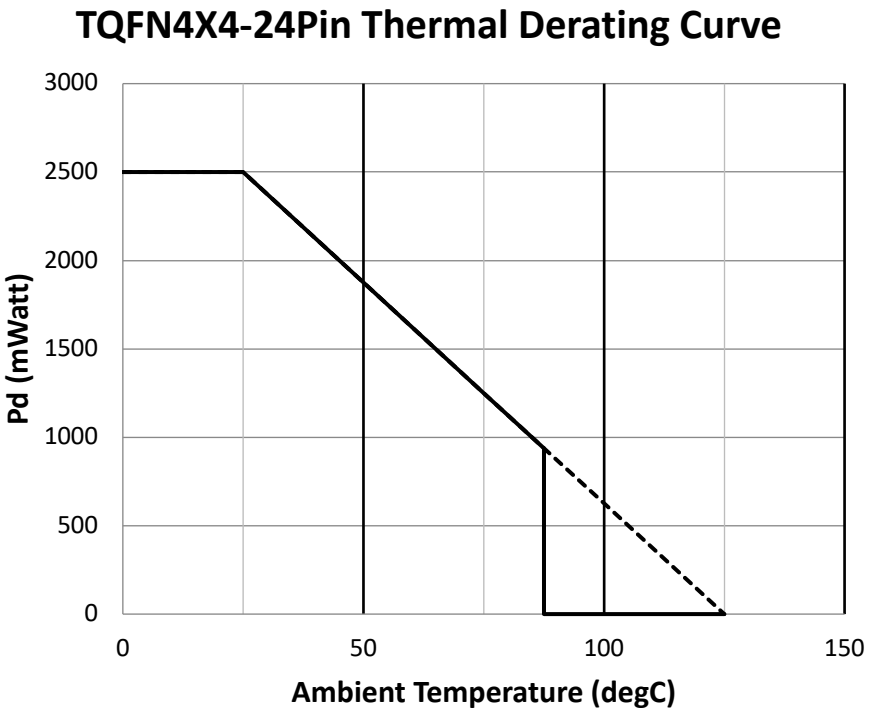
TQFN4X4-24

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

Absolute Maximum Ratings

VCC to GND Max Voltage. . . . . .-0.3V to 18V
VCC to GND Peak Voltage under 100nS 26V
5VREG to GND . . . . . .-0.3V to 7V
UO, VO, WO Output Peak current 2.16A
UO, VO, WO Output Voltage . . . . . .-0.3V to VCC
SO Output Voltage . . . . . -0.3V to VCC
SO Output Current 10mA
CMD to GND . . . . . .-0.3V to VCC
LA, SS, XP1, YP1, SO_SEL Pin to GND . . -0.3V to 7V
INP, INN to GND . . . . . .-0.3V to 7V
FR to GND . . . . . -0.3V to VCC

Thermal Resistance of Junction to Ambient (θ_{Jc})
TQFN4X4-24 . . . . . .20°C/W
Continuous Power Dissipation (T_A=25°C)
TQFN4X4-24 . . . . . .2.5W
Operating Temperature Range . . . . . -40°C to +125°C
Junction Temperature . . . . . +150°C
Storage Temperature Range . . . . . -65°C to +150°C
Reflow Temperature (soldering, 10sec) . . . . . 260°C
ESD (HBM) 4KV
ESD (MM) 400V



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

Electrical Characteristics

(V_{IN}=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
V_{IN}						
Input Voltage	V_{DD}		4.5	12	18	V
Operating Current	I_Q		2.5	3	3.5	mA
Standby Current	I_{SB}	V_{CMD} =0V	200	---	400	μA
Power ON delay Time	Ttd	Vcc = 0 V to 12V	153.6	192	230.4	mS
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}	V_{CMD} =0V	160	200	240	μA
PWM Input Frequency	F_{PWM}		0.1	---	50	kHz
Output Switch Frequency	F_{OUT}		50	62.5	75	kHz
Internal Regulator						
5V Regulator Output Voltage	V_{5VREG}	I_{5VREG} = -10mA	4.9	5	5.1	V
5V Regulator Current Limit	I_{5VOC}		15	60	70	mA
Output Drivers						
High-side Output Voltage	V_{OH}	VCC =12V, I_{OUT} = 400mA		0.22		V
Low-side Output Voltage	V_{OL}	VCC =12V, I_{OUT} = 400mA		0.14		V
SO Low Voltage	V_{SOL}	I_{SO} = 5mA	0.2		0.3	V
SO Off Leakage Current	I_{SOL}	V_{SO} = 12V	---	---	1	μA
Soft Start Oscillator						
SS High Voltage	V_{SSH}		1	1.2	1.4	V
SS Low Voltage	V_{SSL}		0.5	0.6	0.7	V
SS Charge Current	I_{SS1}	V_{SS} = 0V	8	10	12	μA
SS Discharge Current	I_{SS2}	V_{SS} = 2V	8	10	12	μA
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	120	140	kΩ
HALL						
INP Input Pull High Current	I_{INP}		5	8	15	μA
INN Input Pull High Current	I_{INN}		5	8	15	μA
HALL Input Hysteresis	V_{HALL}		5	12.5	20	mV
RPM						
Max RPM	R_limit	2 pair pole (4P)	25000	31250	---	rpm

Electrical Characteristics (Continued)

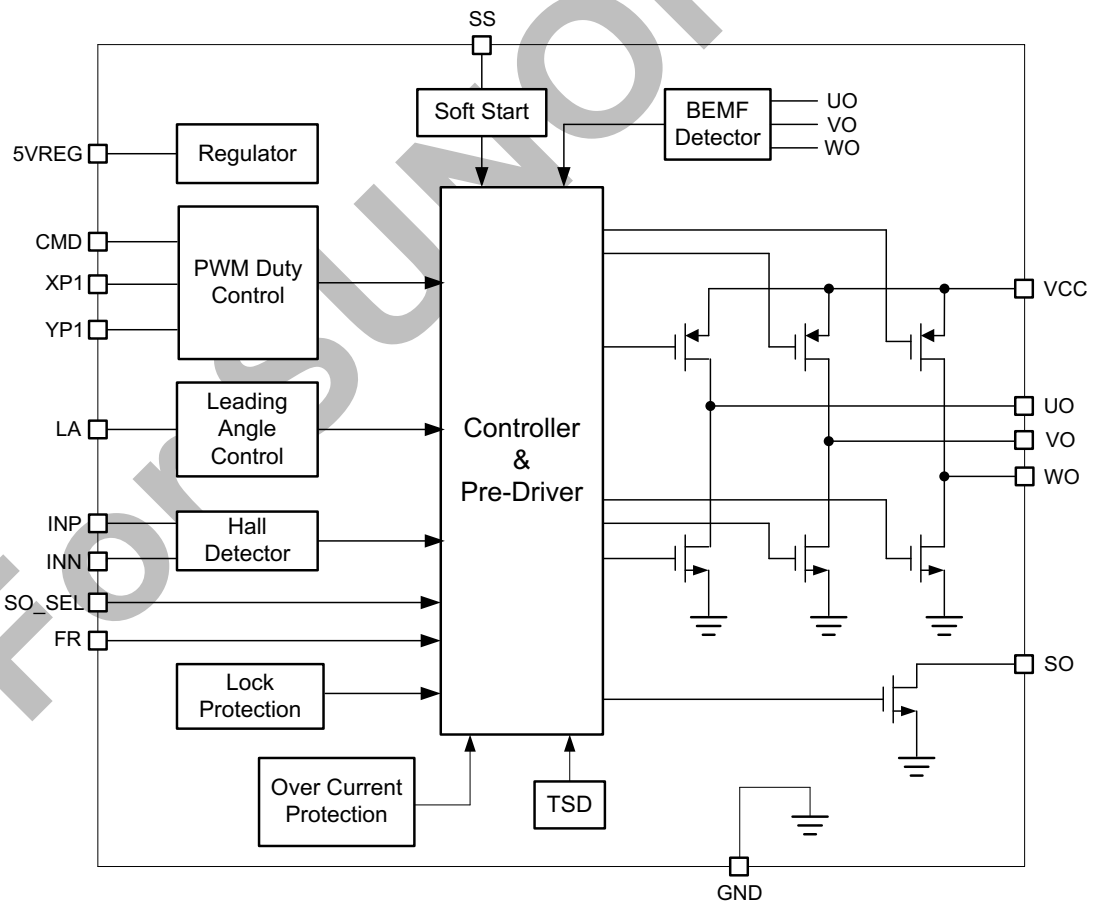
PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Current Protection						
Current Limit level	I_{LIM}	V_{SS} = 0V, Start-up	0.32	0.4	0.48	A
Current Limit level	I_{LIM}	Normal	0.96	1.2	1.44	A
Over current protection level	I_{OC}		1.44	1.8	2.16	A
Lock Protection						
Re-start Time *	T_{on_S}	Soft Start LA>2.5V	0.8	1	1.2	Sec
Re-start Time *	T_{on_F}	Full Duty LA<2.5V	1.2	1.25	1.5	Sec
Lock Mode Time	T_{off}		4	5	6	Sec
Lock Mode Time 1st	T_{off_1st}		0.8	1	1.2	Sec
On/Off Ratio			---	5	---	---
Thermal Protection						
Thermal Protection Temp.	T_{TSD}		155		175	°C
Thermal Protection Hysteresis	T_{HYS}		---	30	---	°C
Vzc Comparator						
Vzc Hysteresis Voltage Com to Output	Vzc_ST	Soft Start UP(Vcc>9V)	---	---	140	mV
Vzc Hysteresis Voltage Com to Output	Vzc	Soft Start UP(Vcc<7.5V) or Normal running or Full duty	---	---	50	mV

*Note : Lock ON Time = Duty 0% ~ 50% time + Ton_S / Detail see page 11 waveform

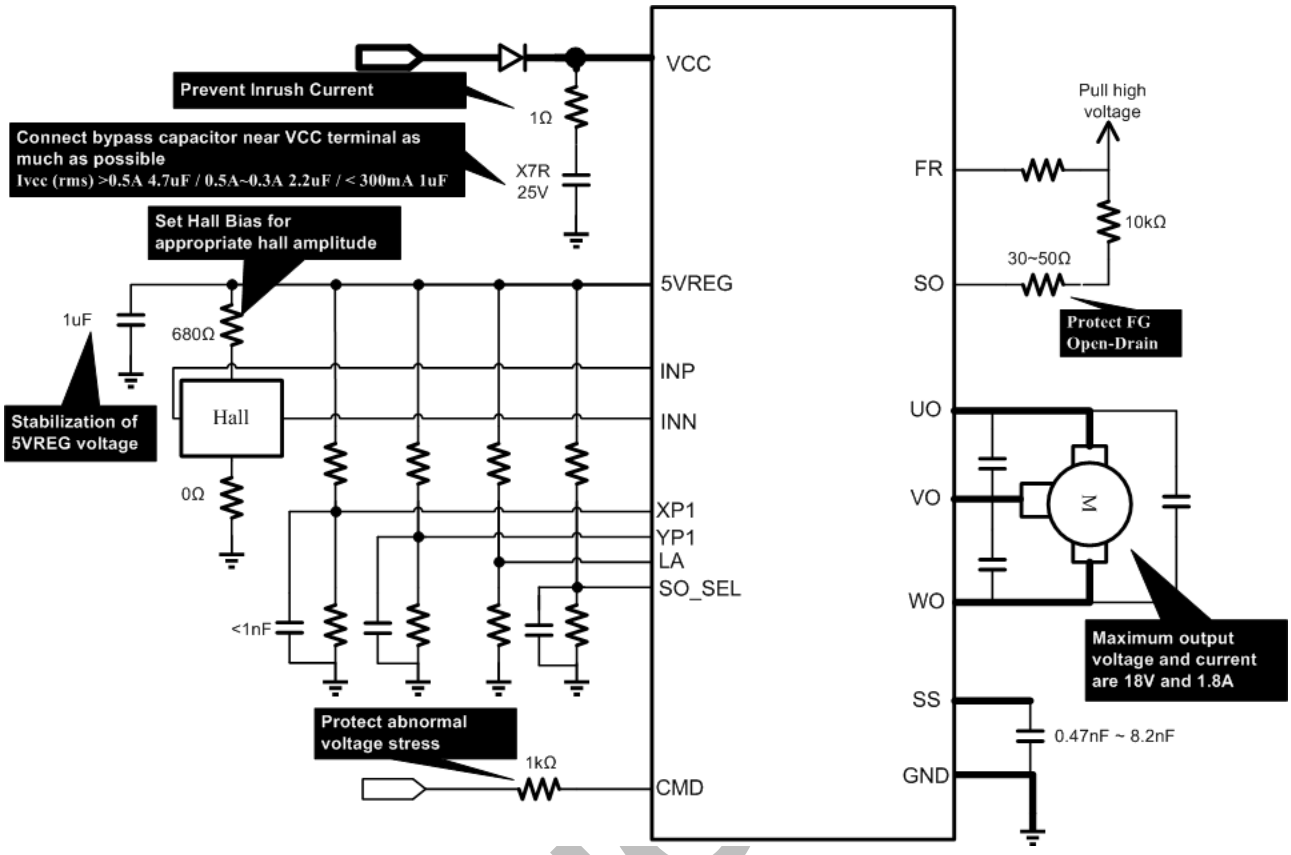
Pin Description

PIN NO.	SYMBOL	DESCRIPTION
1	VCC	Input Supply
2	CMD	Speed Control
3	5VREG	5V Regulator Output
4	LA	Leading Angle Setting
5	SS	Soft-Start Time Setting
6	YP1	Minimum Output PWM Duty Setting
7,8,9,10,11,12,20,23	NC	No Connection
13	XP1	Minimum Input PWM Duty Setting
14	SO_SEL	SO Mode Setting
15	SO	Rotation Speed/Detection Output
16	INN	Hall – input terminal
17	INP	Hall + input terminal
18	FR	Rotation Direction Control
19	WO	Motor Terminal W
21	VO	Motor Terminal V
22	UO	Motor Terminal U
24	GND	Ground

Block Diagram



Application Circuit Examples



Function Descriptions

Speed Control Setting

The XP1 / YP1 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 shutdown or minimum speed.

Equation :

$$D_{XP1} = \frac{V_{IN}}{15.625mV} \times \frac{100\%}{255}$$

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

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

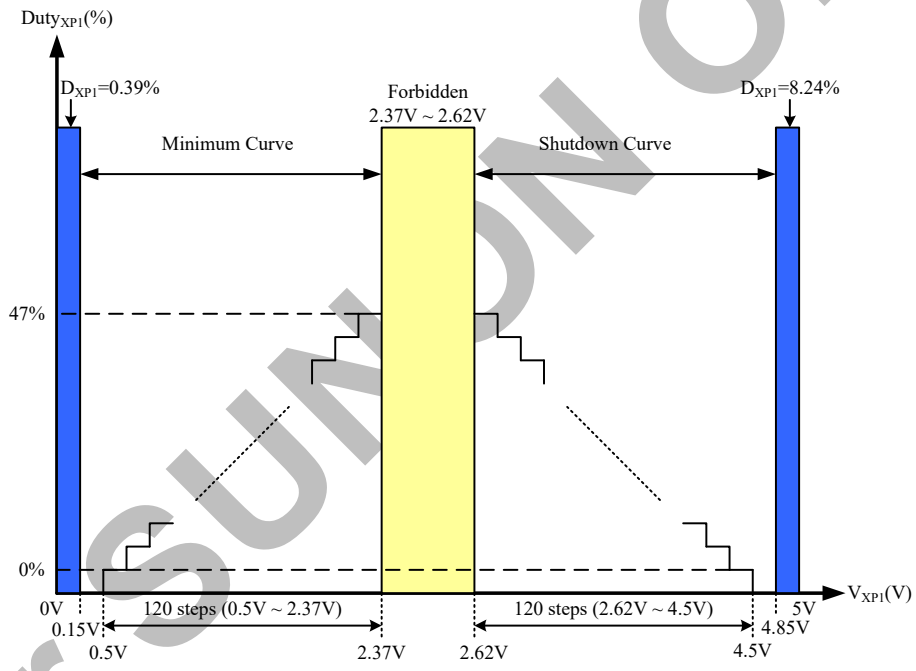


Figure 1. XP1 Voltage Setting Range

Step	VXP1 (V)	XP1 duty (%)	Sec. Function
	>4.85	8.24	Shutdown
255	4.5	0	
136	2.62	47	
Forbidden			
120	2.37	47	Minimum
0	0.5	0	
	<0.15	0.39	

(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. The second function is to set CMD pin with PWM or VSP speed control. When VSP control, CMD pin 0.5V ~ 4.5V means input PWM duty 0% ~ 100%.

Equation :

$$D_{YP1} = \frac{V_{IN}}{15.625mV} \times \frac{100\%}{255}$$

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

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

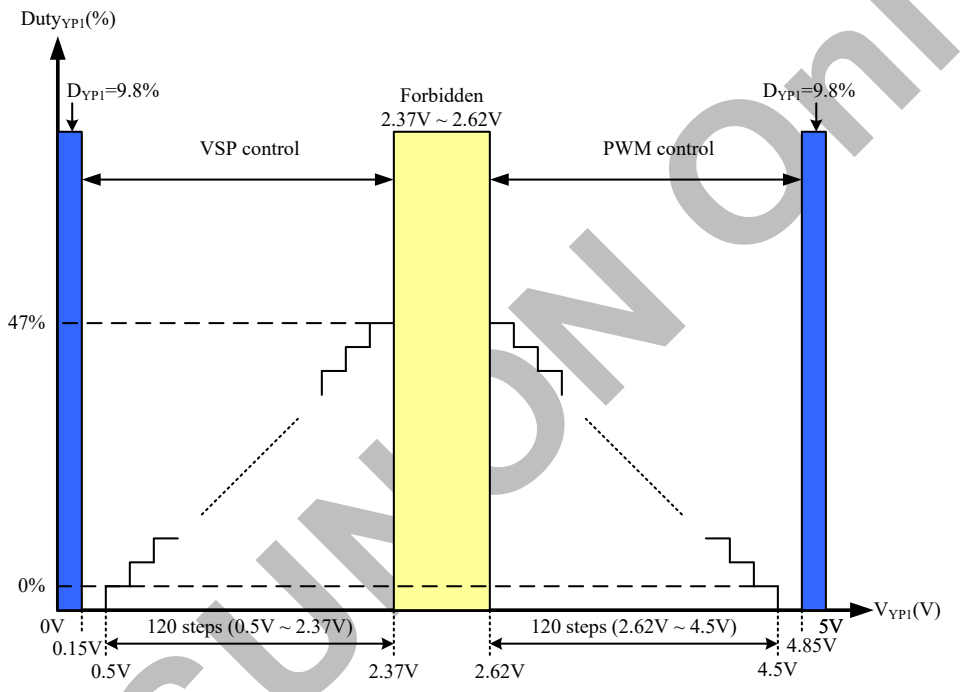


Figure 2. YP1 Voltage Setting Range

Step	VYP1 (V)	Duty output (%)	Sec. Function
	>4.85	9.8	PWM control
255	4.5	0	
136	2.62	47	
Forbidden			
120	2.37	47	VSP control
0	0.5	0	
	<0.15	9.8	

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 commutation signal. If LA pin is 0V or 5V, the leading angle is controlled automatically for high efficiency. The second function is to set soft-start or full duty start-up.

Equation :

$$P_{LA} = \left(\frac{V_{IN}}{62.5mV}\right) x \frac{29^\circ}{31} + 7.5^\circ$$

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

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

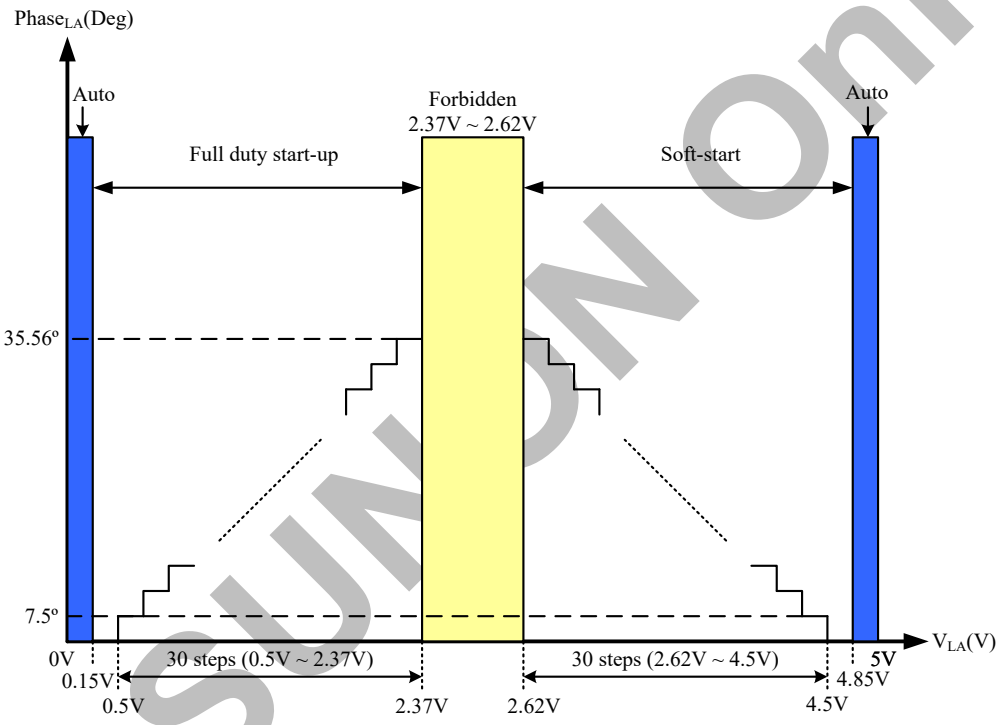


Figure 3. LA Voltage Setting Range

Step	VLA (V)	LA (Deg)	Sec. Function
	>4.85	Auto	Soft-start
255	4.5	7.5	
136	2.62	35.56	
Forbidden			
120	2.37	35.56	Full duty start-up
0	0.5	7.5	
	<0.15	Auto	

SO SEL Table

The M8320 supports FG、1/2FG、1/3FG、2FG and RD outputs.

SO_SEL Pin Input Voltage	SO Output
5V	FG
3.5V	1/2FG
2.5V	2FG
1.5V	1/3FG
0V	RD

Sensor less and 1-hall operation

The M8320 provides sensor less and 1-hall driving algorithm. At 1-hall mode, it supports both hall element and hall sensor applications. If the pins INP and INN keep floating or GND, the M8320 will switch to sensor less mode.

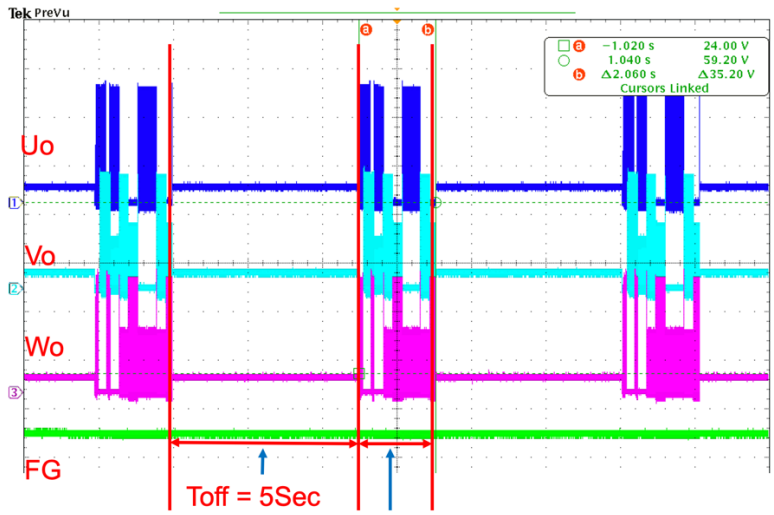
Current Limit

The M8320 includes internal current limit. It will turn off high side PMOS when output driver current is over 1.2A. The high side PMOS will turn on at next PWM cycle, and reduce the output duty. The M8320 also includes over current protection (OCP). If the output driver current is over 1.8A, all output MOS will turn off and enable lock protection. Chip will restart when lock off time is count down.

Lock Protection and Automatic Restart

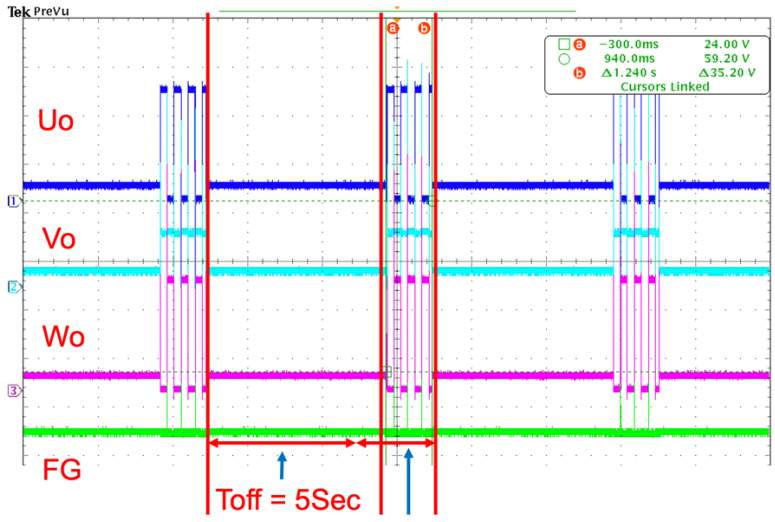
The M8320 provides the lockup protection and automatic restart function for preventing the motor coil burns out. If the motor cannot start-up successfully, this chip internal clock will count an on time 1s (T_{ON}). Then all driver MOSFETs are turned off and auto restart after the recovery time (T_{OFF}). The first recovery time is 1s and the others are 5s.

Vcc=12V Css=2.2nF LA=5V (Soft Start) Lock Restart



Ton = 1.1Sec (Tss 0% to 50%) + 1Sec (Ton_s) = 2.1Sec

Vcc=12V Css=2.2nF LA=0V (Full Duty) Lock Restart



Ton = Ton_F = 1.25Sec

Quick Start and Standby Mode

When the input PWM duty of CMD pin is below XP1 duty with shutdown function, 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. The M8320 also has standby mode enabled by the control signal under low duty (<0.5%) over a fixed time (16ms). In the standby mode, it will turn off all driver MOSFETs, internal clock and SO function, and the quiescent current is under 400μA.

SS Capacitor Setup

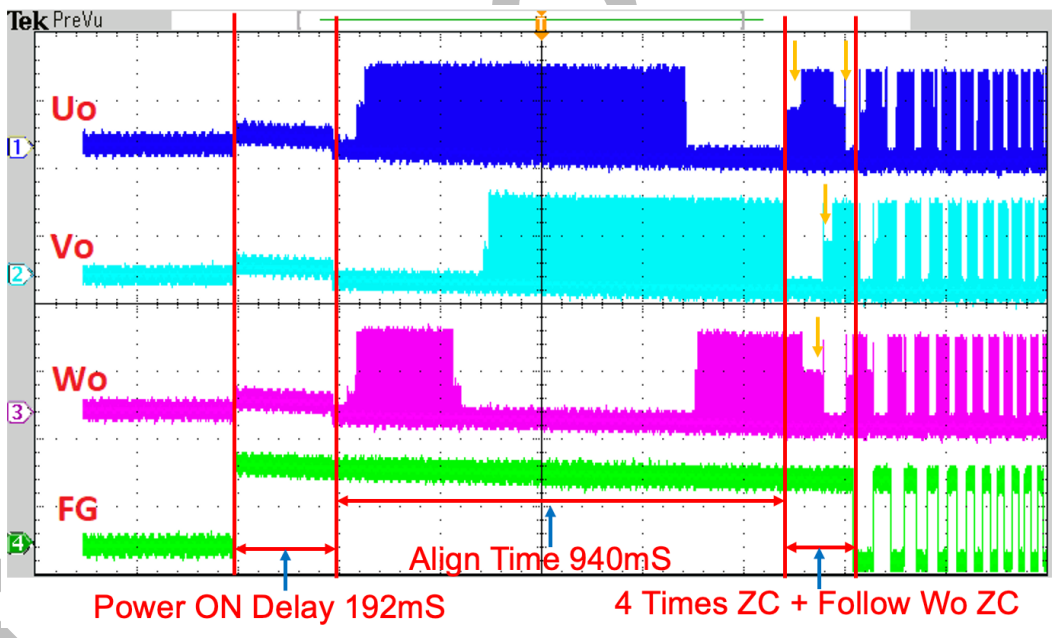
The SS capacitor is used to set output duty changing rate for soft-start and normal operation. The time of the output duty changing from 0% to 100% is 1s when the capacitor is 1nF. The proper capacitor value is obtained by experiments.

Css	SS time 0% to 100%	Align time _ Typical (Vcc > 8.5V)	Align time _ Typical (Vcc < 7.5V)	SC time _ Typical
1nF	1Sec	0.2Sec	0.3Sec	250mS
2.2nF	2.2Sec	0.44Sec	0.66Sec	250mS
3.3nF	3.3Sec	0.66Sec	0.99Sec	250mS
4.7nF	4.7Sec	0.96Sec	1.41Sec	250mS
5.6nF	5.6Sec	1.12Sec	1.68Sec	250mS
6.8nF	6.8Sec	1.36Sec	2.04Sec	250mS

Note : Align time & Soft Start time & SC time with +/- 20% tolerance

Soft Start UP

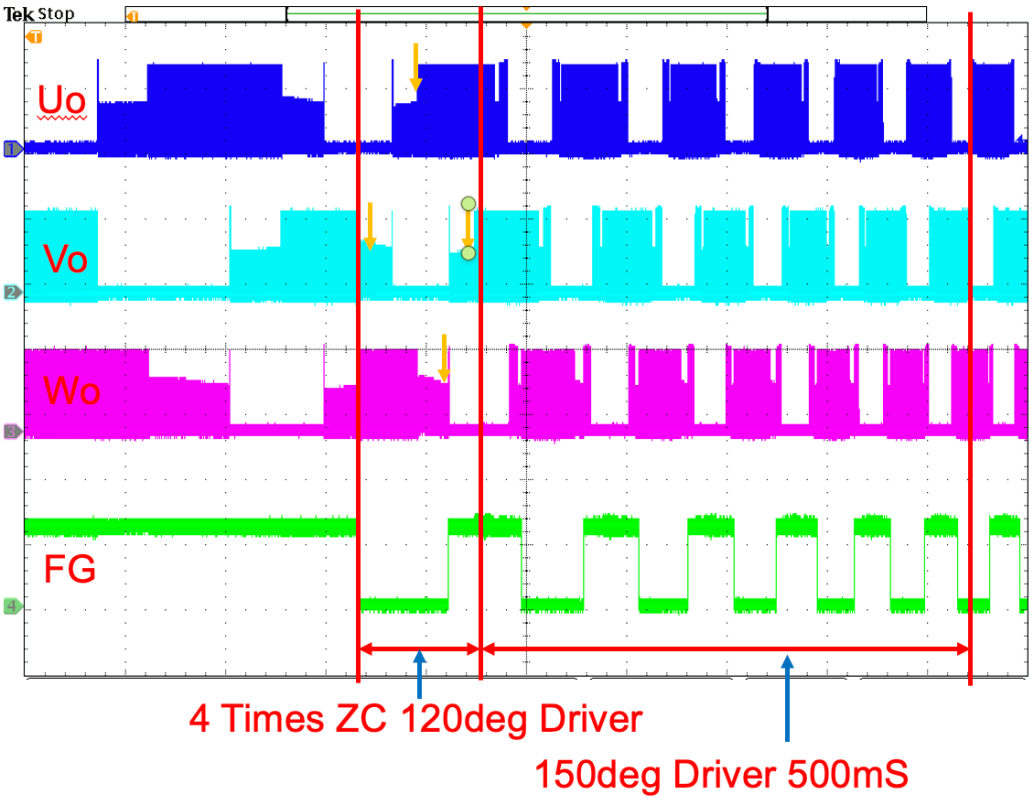
Start UP Waveform Vin = 12V Css = 4.7nF



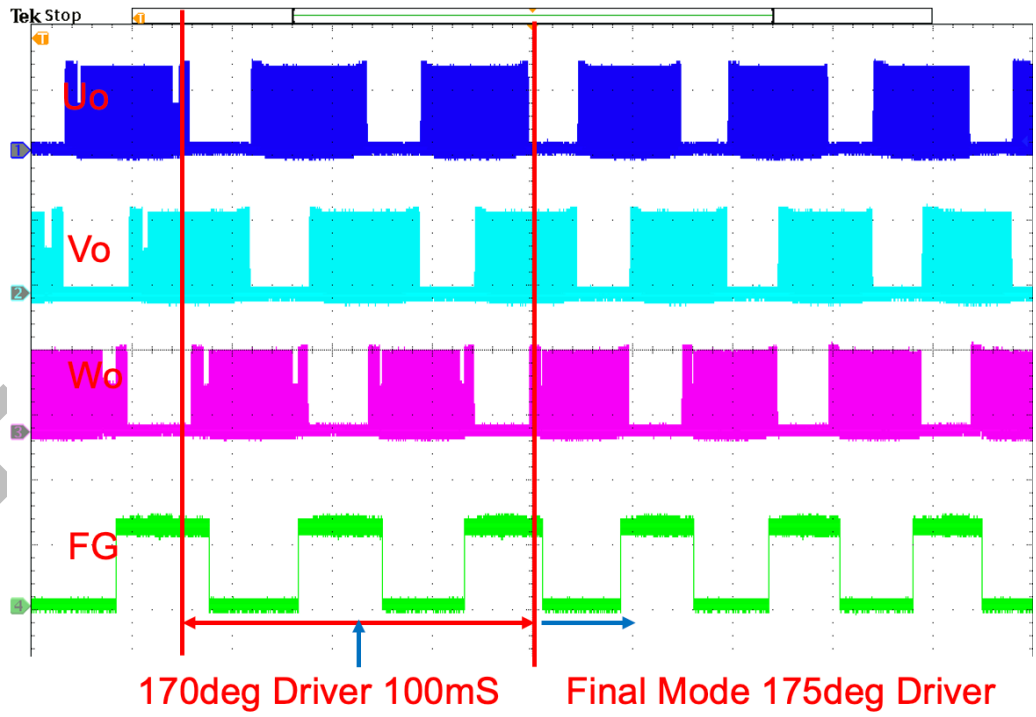
Note : FG out Time = Power ON Delay + Align Time + 4 Time ZC Follow Wo ZC

Start UP Transition Mode Driver :

Transition Mode 120deg Driver to 150deg Driver



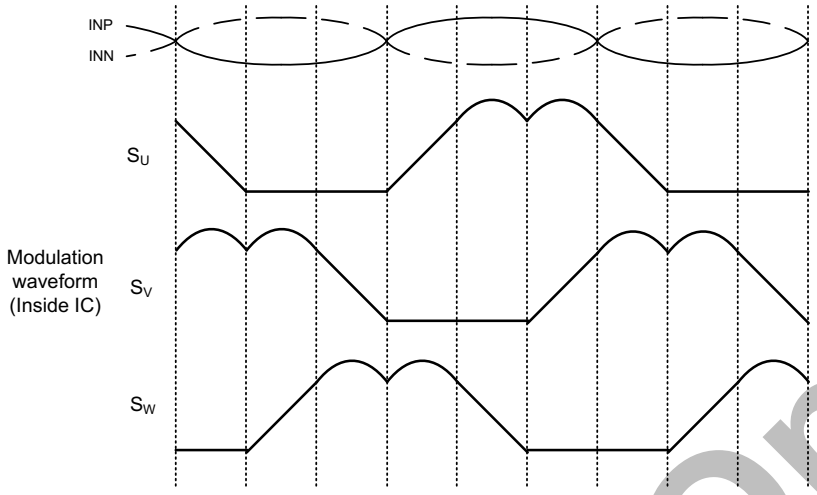
Transition Mode 170deg Driver to 175deg Driver



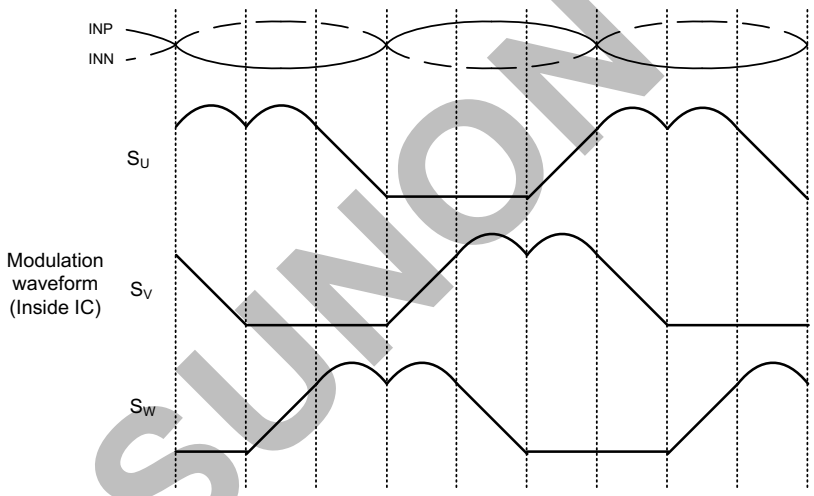
Note : FG out + 4ZC 120deg Driver + 150deg Driver 0.5sec + 170deg Driver 0.1Sec >> Final mode 175deg Driver

One Hall Driver

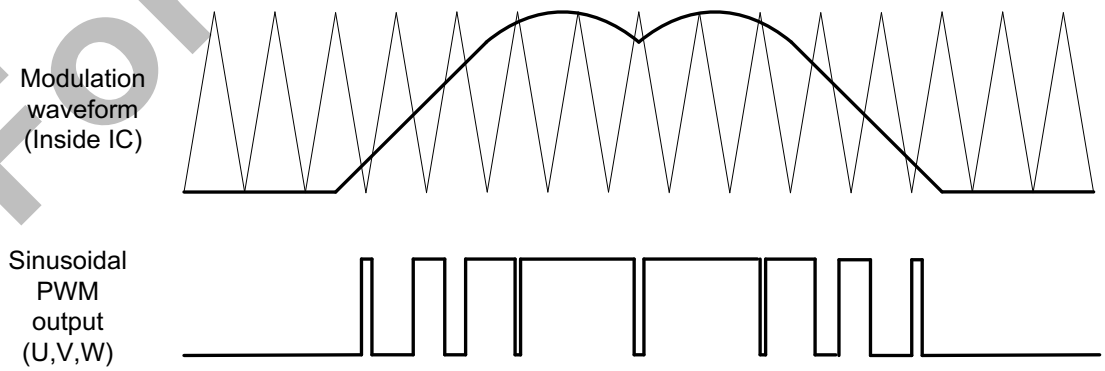
Forward Rotation Timing Chart (FR = 5VREG)



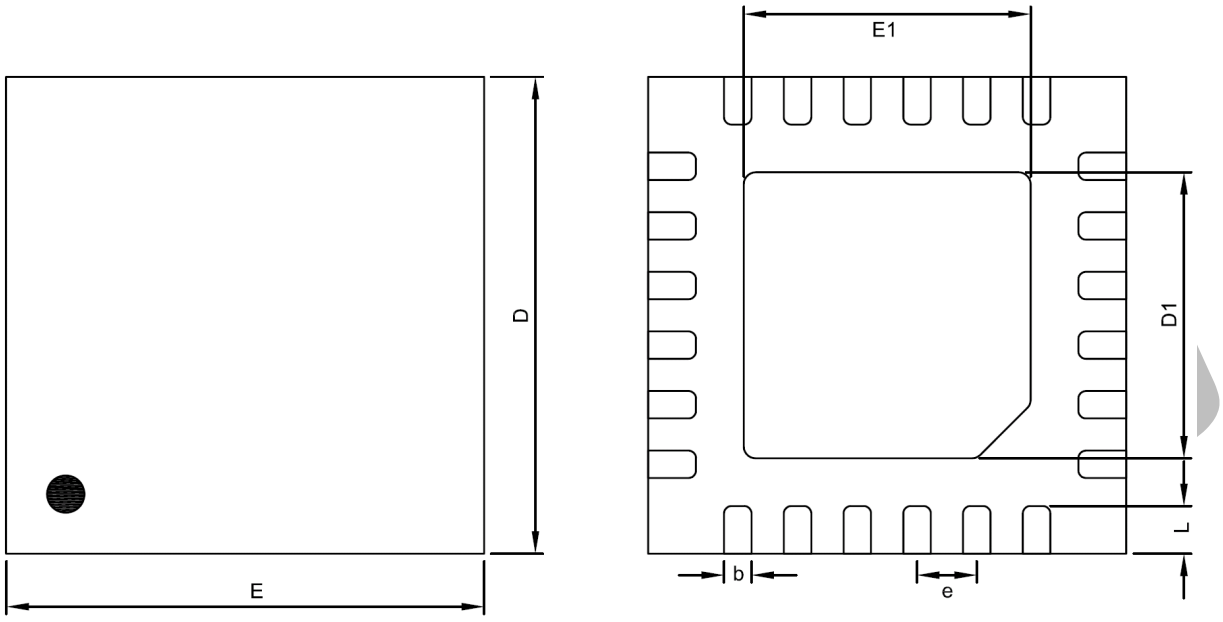
Reverse Rotation Timing Chart (FR = 0V)



Sine-Wave PWM Output



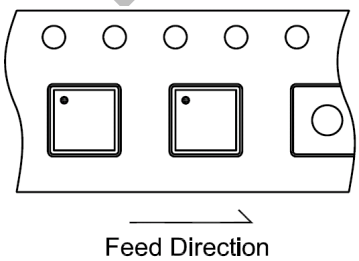
Package Information



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