Highly Efficient Single-Phase Full-wave FAN Motor Driver

Overview

The FA2200 is a highly efficient Single-Phase Brushless DC FAN motor driver with analog voltage speed control. Many safety features were incorporated to ensure the reliability of motor operation.

Unique current peak clipping (IClip) circuit is used to eliminate current overshoot when phase changes.

Patented hall insensitive (InSense) technique is also adopted to eliminate product yield loss caused by hall misalignment in fan motor, as production, assembly, testing and transportation may all cause reposition of hall sensor.

The FA2200 is designed with minimal external components to improve reliability.

Package

FA2200: HSSOP14
FA2200T: TSSOP16

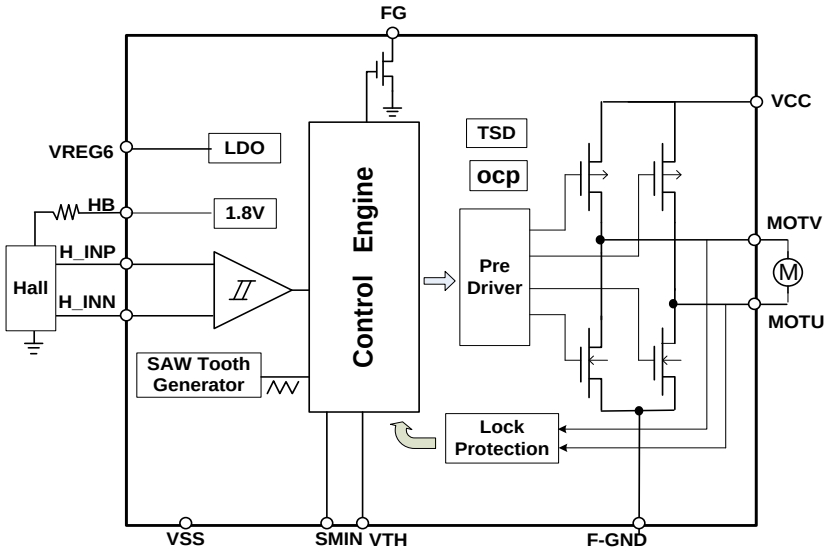
Feature

- Soft-Start circuit
- FG output signal
- Built-in Hall bias circuit
- Minimum speed setting
- IClip(Current Peak Clipping) circuit incorporated to damped current overshoot
- InSense technique to compensate hall misalignment
- Built-in lock protection and automatic recovery circuit
- Built-in thermal shutdown protection(TSD)
- Built-in over current protection(OCP)
- Built-in under voltage lock out (UVLO)

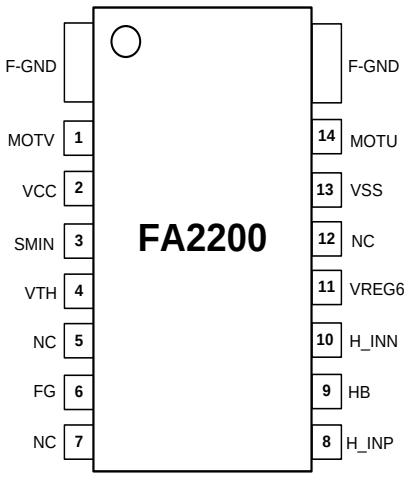
Applications

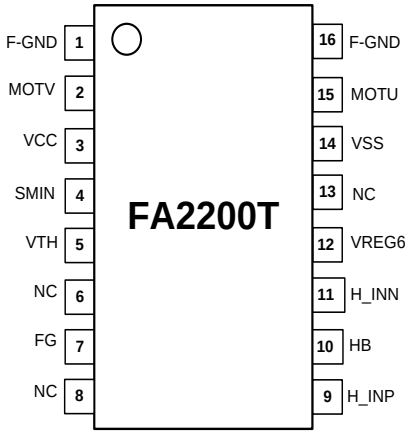
Variable speed BLDC fan for CPU/VGA cooler, power supplier, game console, etc.

Block Diagram



Pin Configuration





1. VSS: Control signal ground.
2. F-GND: Power ground and thermal dissipation pad, this pin must be connected together with VSS and ground on board.

PIN NO. FA2200	PIN NO. FA2200T	PIN Name	Type	Description
F-GND	1,16	F-GND	F-GND	Power ground
1	2	MOTV	O	Motor output
2	3	VCC	Power	Power supply
3	4	SMIN	I	Minimum speed setting
4	5	VTH	I	Voltage reference for thermal control
5	6	NC		Not connected
6	7	FG	O	Frequency generator
7	8	NC		Not connected
8	9	H_INP	I	Hall Sensor input, IN+
9	10	HB	O	Hall bias voltage
10	11	H_INN	I	Hall Sensor input, IN-
11	12	VREG6	O	LDO 6V output
12	13	NC		Not connected
13	14	VSS	GND	Control signal ground
14	15	MOTU	O	Motor output

Truth Table

VTH	H_INN	H_INP	MOTU	MOTV	FG	Mode
Low	H	L	H	L	OFF	Rotation-driver
	L	H	L	H	L	
High	H	L	OFF	L	OFF	Rotation-regeneration
	L	H	L	OFF	L	
-	H	L	L	L	OFF	Lock protection
-	L	H	L	L	L	

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress rating only.

Parameter	Symbol	Condition	Ratings	Unit
Power supply voltage	V_{CC} max		30	V
Output current	I_{OUT} max	Peak current	1.5	A
Logic input pin withstand voltage	V_{logic} max		6.5	V
FG output pin withstand voltage	V_{FG} max		30	V
FG output current	I_{FG} max		10	mA
Power dissipation	Pd max*		1.1	W
Operating temperature	Topr		-30~+90	℃
Storage temperature	Tstg		-55~+150	℃
ESD (Human Body Model)	ESD		2500	V

*Mounted circuit board: 70x70x1.6 mm^3glass epoxy board.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fortior does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{CC}	Power supply voltage	4.5		28	V
T_A	Operating Ambient Temperature	-30		90	℃

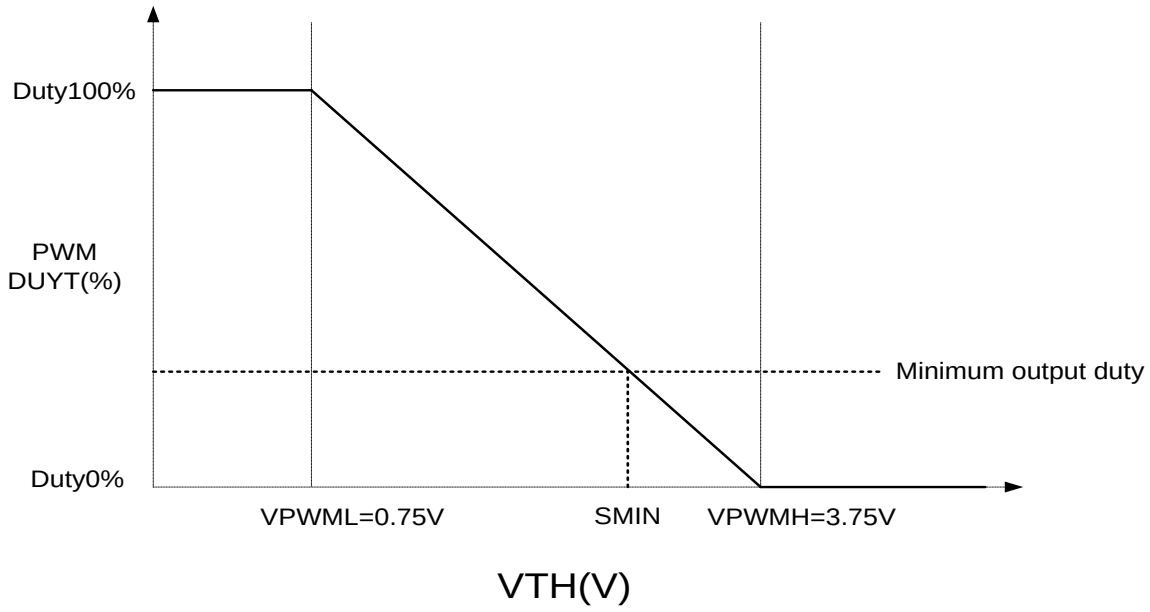
Electrical Characteristics (Unless otherwise specified, Ta = 25℃, VCC = 12 V)

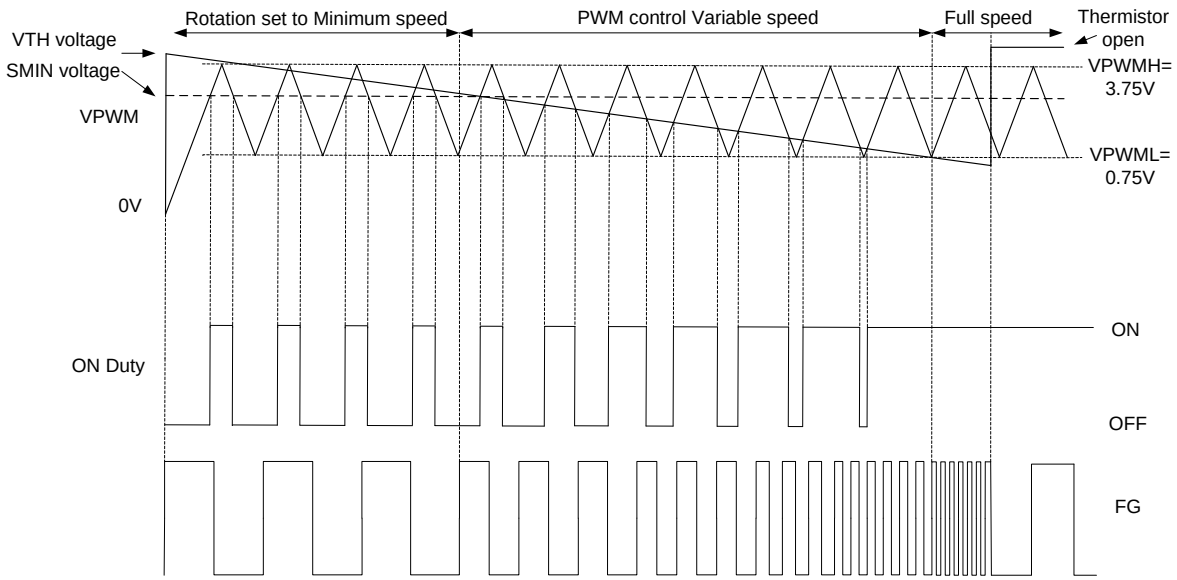
Parameter	Symbol	Condition	Ratings			Unit
			Min.	Typ.	Max.	
Power supply current	I_{CC}	Working	-	5	8	mA
Output Block						
Source	Ron (H)	I_O = 0.5A	-	0.7	1.2	Ω
Sink	Ron (L)	I_O = 0.5A	-	0.5	0.8	Ω
Source + sink	Ron (H+L)	I_O = 0.5A	-	1.2	2	Ω
6V Regulator Block						
Regulator voltage	VREG6		5.7	6	6.3	V
Regulator output current	Iv6out(1)	VREG6=6V			10	mA
HB Voltage						
HB voltage	HB		1.71	1.8	1.89	V
HB output current	Ihbout(2)	VHB=1.8V			10	mA
Hall input pin						
Hall sensor input sensitivity	VHN	Zero peak value (including offset and hysteresis)		10	20	mV
Analog I/O Section						
Analog Input range			0		6.3	V
PWM Block						
PWM Carrier Frequency	VPWM		20K	25K	30K	Hz
VPWM High Level Voltage	VPWMH		3.56	3.75	3.94	V
VPWM Low Level Voltage	VPWML		0.71	0.75	0.79	V
FG Output Pin						
FG output pin low-level voltage	VFG	When I_O = 5mA	-	0.1	0.2	V
Thermal Protection Circuit						
Thermal protection circuit operating temperature	TSD	Design target	-	170	-	℃
Temperature hysteresis width	ΔTSD	Design target	-	15	-	℃
Low-Voltage Detection						
Low voltage detection voltage	UVLO			3.5		V

1. This current is output of internal LDO. Please do not exceed the maximum value specified.
2. This current is output of internal LDO. Please do not exceed the maximum value specified.

Operating and Function description

1. Speed Control Mode





Note: VPWM is a reference voltage used for internal PWM generation.

When the system needs speed control, the FA2200 can work in full speed mode, variable speed mode or minimum speed mode.

a. Full Speed Mode

When ambient temperature is over expected value, VTH input voltage may be set to value lower than VPWM low side voltage using external thermistor (Fig.2), motor fan will then be driven at full speed.

b. Variable Speed Mode

In variable speed mode, the VTH voltage is set to value lower than SMIN input voltage. The output duty cycle increases when VTH voltage decreases and the motor fan speed increases consequently. When

VTH voltage increases, the motor fan speed decreases accordingly.

c. Minimum Speed Mode

The minimum speed mode is normally used in low ambient temperature environment, in this mode, the VTH voltage is set to value higher than SMIN voltage, the fan rotates at the lowest speed which is set be using SMIN (Fig.2).

2. Lock Protection and Automatic Recovery

When the rotor is blocked, the internal detection circuit will shut down output driver, and then the automatic recovery circuit will try to restart motor in soft-start mode until the blockage is removed. The typical timing diagram is shown as in figure1. Ton is lock detection ON time, Toff & Toff ' is lock detection OFF time. The automatic recovery processes has two stages, denoted as stage A & stage B. Once the rotor is blocked, the controller will restart the motor with 4 seconds interval for the first 20 trials in stage A. In stage B, the lock off interval Toff ' will change to 20 seconds to reduce coil loss and improve system reliability.

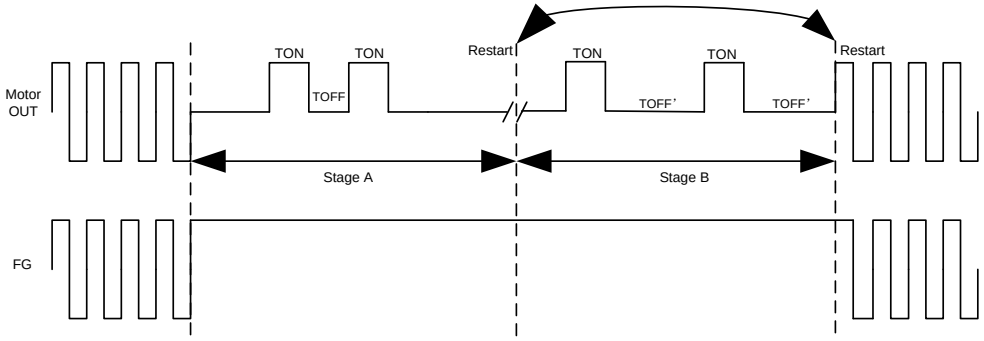


Figure1. Lock Protection and Automatic Recovery time Sequence diagram

3. Over Current Protection (OCP)

The over current protection circuit safeguards the internal FETs by monitoring the peak current. Once the current exceeds the over current protection limit, drive will be turned off until the next power on.

4. Input Under Voltage Lockout (UVLO)

If the voltage on the VREG6 pins falls below 3.5V, all internal circuitry will be disabled and logic will be reset.

5. Thermal Shutdown (TSD)

When the junction temperature of the device reaches the thermal shutdown limit(2) (the thermal shutdown value is shown in Electrical Characteristics Table), PWM drive output will be turned off. When the junction temperature cools to the required level, the PWM initiates normal start-up cycle. Thermal shutdown has a hysteresis of approximately 15°C.

12V Application Circuit

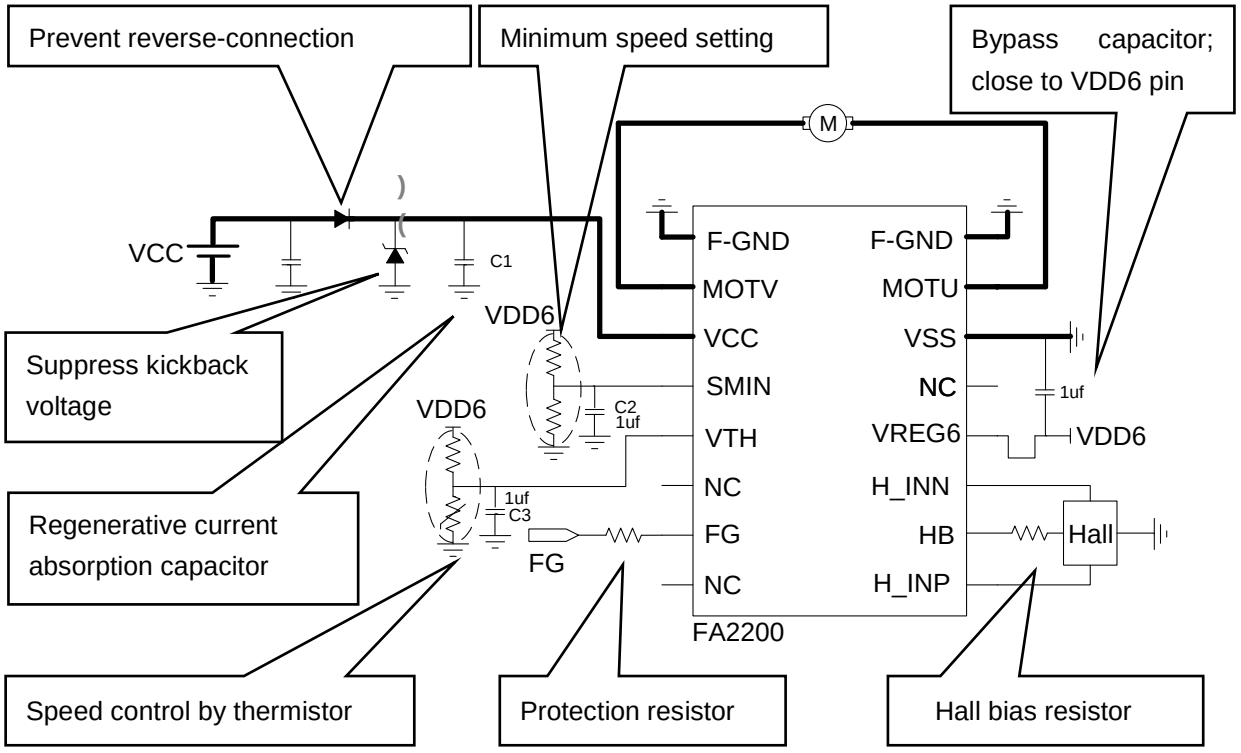


Figure2. 12V application circuit of FA2200 (with Thermal control)

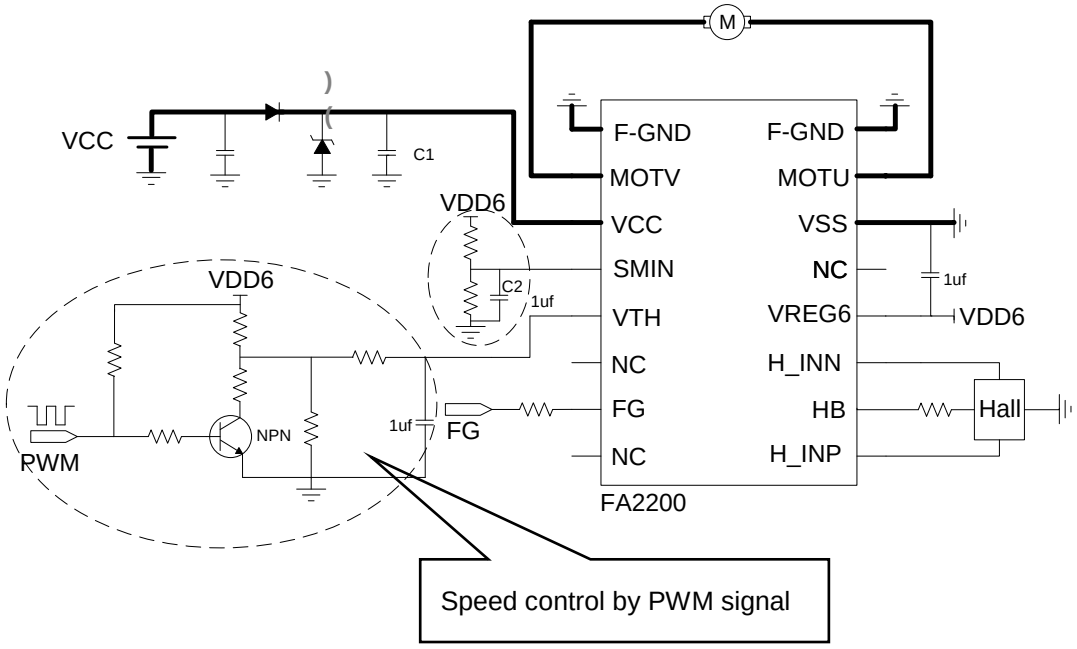


Figure3. 12V application circuit of FA2200 (with PWM control)

24V Application Circuit

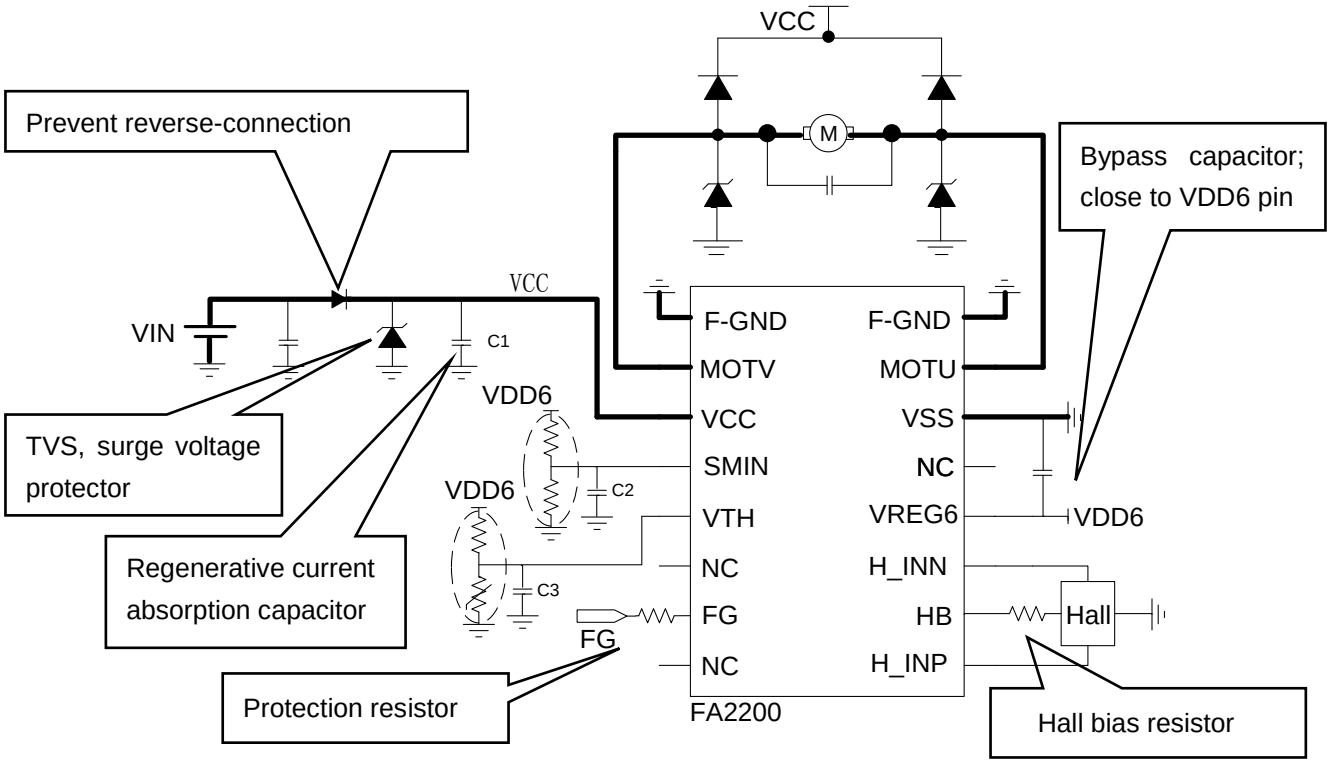


Figure4. 24V application circuit of FA2200 (with Thermal control)

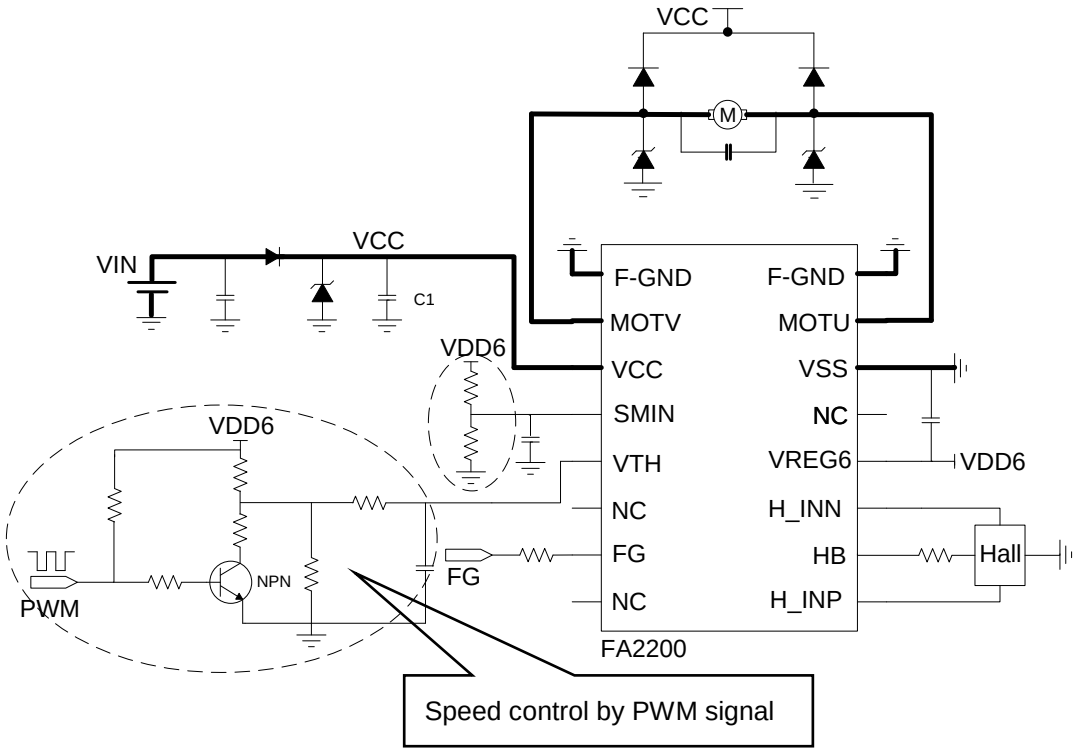


Figure5. 24V application circuit of FA2200 (with PWM control)

Application notes:

1. Power and ground lines

F-GND and VSS should be connected together on board.

2. Power supply bypass capacitor & TVS Zener Diodes

The capacitor C1on VCC provides power supply stabilization for both PWM drive and kickback absorption. When a diode is used to prevent destruction of controller IC from reverse connection, please make sure to add capacitor C1 for routing of regenerative current. In order to protect surge voltage damage, please insert a TVS zener diode between GND and VCC.

3. Hall input

The Hall sensor input circuit consists of a comparator with hysteresis of 20mV. Hall sensor input level with at least three times of this hysteresis, i.e. at least 60mVp-p is recommended.

4. FG output

This is an open collector output, the pin must be left open if unused. FG output is used to reflect rotation count, which corresponds to the phase switching.

5. HB pin

This pin provides constant-voltage output of 1.8V for hall effect sensor biasing. A serial resistor is required to prevent damaging of hall senor under extreme temperature conditions.

6. SMIN pin

This pin is used to set minimum speed by adjusting external resistors. Please insert a capacitor to VSS for more stability. Please pull-up to VREG6 if unused.

7. VTH pin

This pin is used to adjusting speed by adjusting VTH voltage. Please insert a capacitor to VSS for more stability. Please pull-up to VREG6 if unused.

8. Motor terminal schottky diode

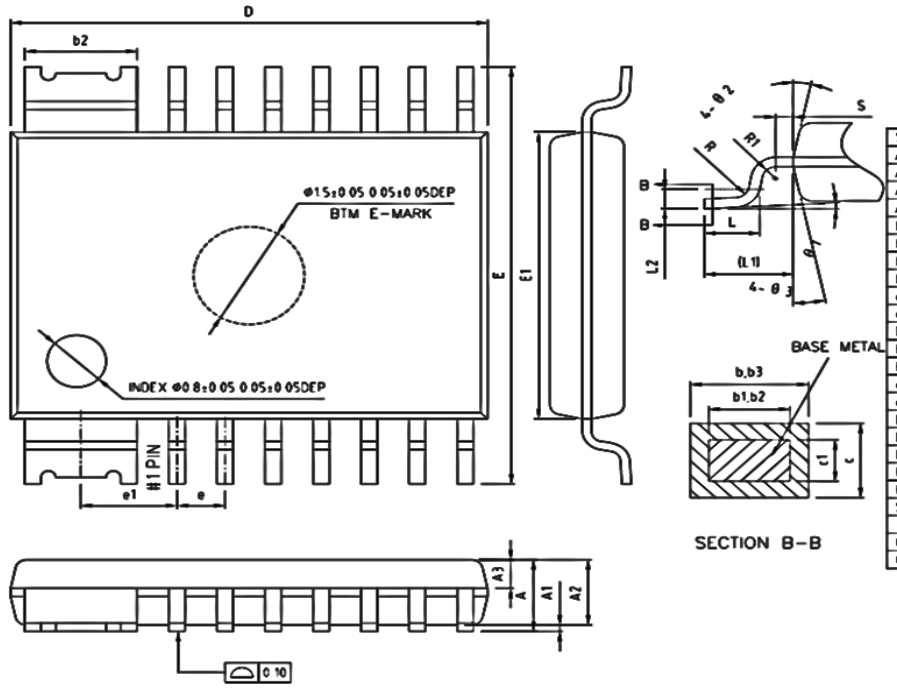
Please insert schottky diode between the motor terminal and VCC for bigger current.

9. Motor terminal zener diode

Insert zener diode between the motor terminal and VSS for routing of regenerative current

Package Information

HTSSOP14 (6.45X6.40mm)



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.20
A1	0.05	–	0.20
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	–	0.28
b1	0.20	0.22	0.24
b2	1.47	1.52	1.57
b3	1.48	–	1.61
c	0.10	–	0.19
c1	0.10	0.13	0.15
D	6.35	6.45	6.55
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
e1	1.30BSC		
L	0.45	0.60	0.75
L1	1.00REF		
L2	0.25BSC		
R	0.09	–	–
R1	0.09	–	–
S	0.20	–	–
θ1	0°	–	8°
θ2	10°	12°	14°
θ3	10°	12°	14°

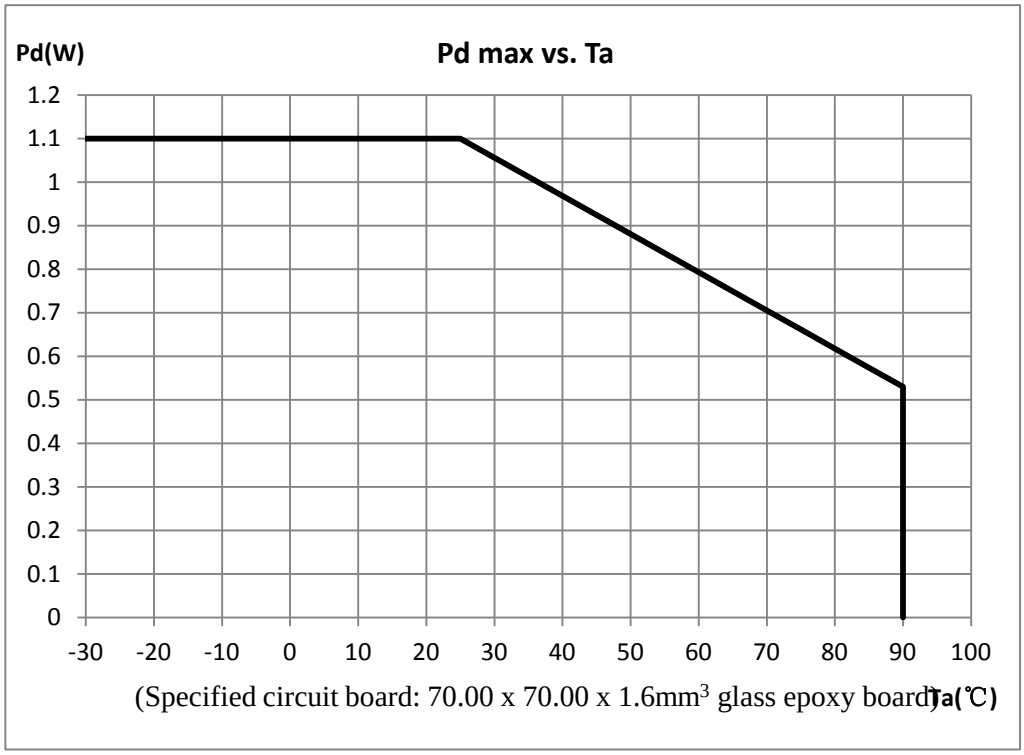
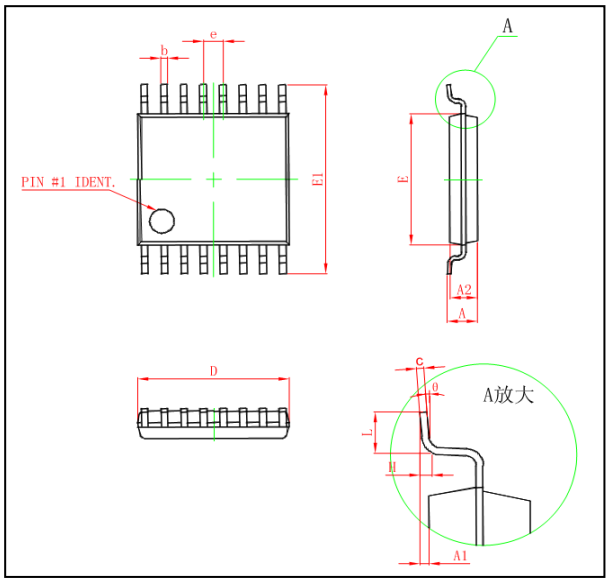
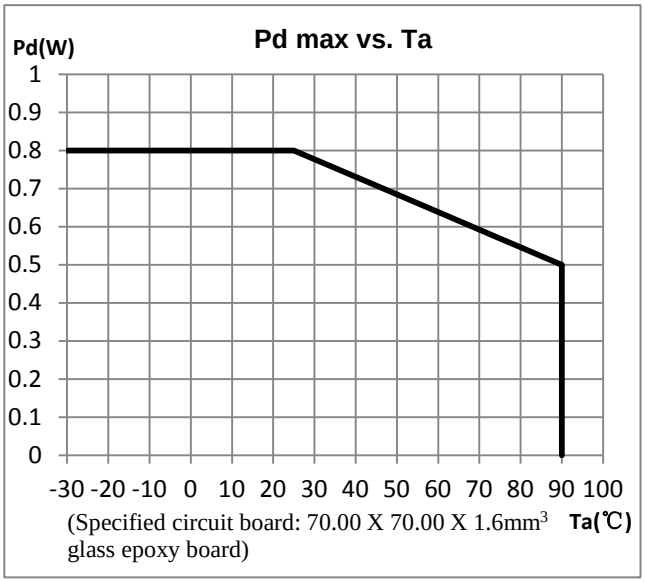


Figure6. Maximum Power Dissipation vs. Ambient Temperature

TSSOP16 (5.0X6.4mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.100		0.043
A2	0.800	1.000	0.031	0.039
A1	0.020	0.150	0.001	0.006
e	0.65(BSC)		0.026（BSC）	
L	05.00	0.700	0.020	0.028
H	0.25(TYP)		0.01（TYP）	
θ	1°	7°	1°	7°

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