Three Phase Sensorless BLDC Motor Controller

Description

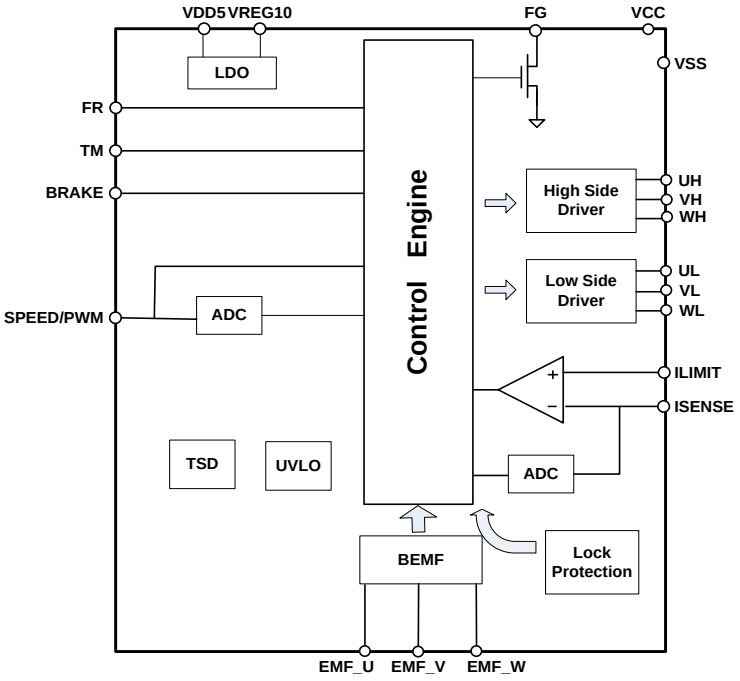
The FT3107T is a Three Phase sensorless BLDC Motor controller. It provides several drive modes (BLDC, Pseudo-BLDC, Pseudo-SINE, Narrow BLDC) with constant/variable lead angle intended for a wide range of motor characteristics. Open/Closed loop speed adjustment can be achieved through either direct-PWM or analog voltage or frequency control, initiated by soft-start. Speed indicator is provided through a Frequency Generator output, generating digital pulse with a configurable frequency proportional to the speed of the motor.

Protection functions of FT3107T are comprehensive including lock protection and automatic recovery, thermal shutdown and current limit protections. These prevent the control circuits and the motor from being damaged, particularly under stressed applications and demanding environments.

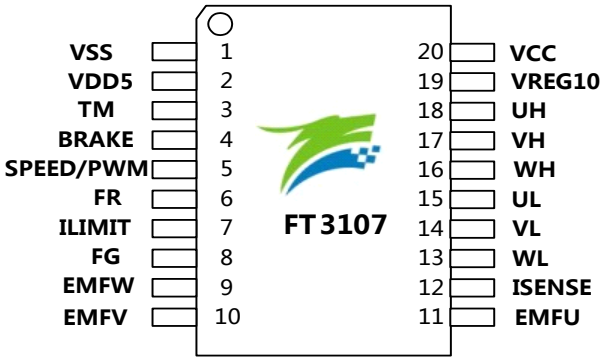
Feature

- Sensorless BLDC/Pseudo-BLDC /Pseudo-SINE/Narrow BLDC drives
- Two speed adjustment methods can be selected (direct-PWM and analog voltage control)
- Intelligent Soft-start
- Constant/Variable lead angle control
- Open/Closed loop speed adjustment can be selected (direct-PWM and analog voltage control).
- FG (Frequency Generator) output
- Current limit protection
- Built-in lock protection and automatic recovery circuit
- Built-in thermal shutdown protection (TSD)

Block Diagram



Pin Assignment



Pin Configuration

PIN NO.	PIN Name	Type	Description
1	VSS	GND	Signal and power ground.
2	VDD5	O	Digital power output, LDO DC5V output for digital signal.
3	TM	I	TEST PIN， Floating or connect to VDD5
4	BRAKE	I	Brake signal input, Low: Brake. Internal pull-up.
5	SPEED/PWM	I	Speed control input
6	FR	I	Motor rotation direction input
7	ILIMIT	I	Current limit analog input
8	FG	O	Open drain. Frequency Generator, speed signal output.
9	EMF_W	I	Phase W back EMF.
10	EMF_V	I	Phase V back EMF.
11	EMF_U	I	Phase U back EMF.
12	ISENSE	I	Current limit & Lead angle analog input
13	WL	O	Low side phase W NMOS driver
14	VL	O	Low side phase V NMOS driver
15	UL	O	Low side phase U NMOS driver
16	WH	O	High side phase W PMOS driver
17	VH	O	High side phase V PMOS driver
18	UH	O	High side phase U PMOS driver
19	VREG10	O	LDO output
20	VCC	POWER	Power supply

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may be damaged or may not function or be operational above these ratings and stressing the device to/above these levels is not recommended. Fortior does not recommend exceeding or designing about the Absolute Maximum Ratings.

Parameter	Symbol	Condition	Ratings	Unit
Power supply voltage	V_{cc}max		30.0	V
FG output current	I_{FG}max		10	mA
FG output pin withstand voltage	V_{FG} max		5.5	V
Operating temperature	Topr		-40~+125	℃
Storage temperature	Tstg		-65~+150	℃
Package Thermal Resistance，Junction to Ambient	Rθja	4-layer PCB based on JEDEC standard	100	℃/W

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.

Symbol	Parameter	Min.	Typ.	Max.	Unit
Power supply voltage	V_{cc}	3.7	12	28	V

Electrical Characteristics

Unless otherwise specified, Ta=25℃， VCC=12V

Parameter	Symbol	Condition	Ratings			Unit
			Min.	Typ.	Max.	
Power supply current	I_{cc}	Working		8	15	mA
VDD5 LDO						
Regulator voltage	VDD5		4.9	5	5.1	V
Regulator output current	Iv5out	VDD5=5V			10	mA
10V Regulator Block						
Regulator voltage	Vreg10		9.5	10.0	10.5	V
Regulator output current	Iv10out	Vreg10=10V			10	mA
Analog I/O Section*Note1						
Analog Input range			0		5.3	V
Digital Input Section*Note2						
High-level input voltage	Vdinh		2.5		5.3	V
Low-level input voltage	Vdinl		0		2	V
Internal pull up resistor	Rdio		50k	100k	150k	ohm
SPEED – PWM DIGITAL MODE						
PWM input frequency	Fpwm		1		60	kHz
HP(High Side PMOS Driver) *Note3						
Output high voltage	HVoh	Sink current = 20mA	11.2	11.5	12	V
Output low voltage	HVol	Source current = 20mA	-	3	5	V
Source Current	Io+		-	150	-	mA
Sink Current	Io-		-	90	-	mA
LN(Low Side NMOS Driver) *Note4						
Output high voltage	LVoh	Sink current = 20mA	8.5	10	11	V
Output low voltage	LVol	Source current = 20mA	-	0	0.3	V
Source Current	Io+		-	150	-	mA
Sink Current	Io-		-	180	-	mA
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		150		℃
Temperature hysteresis width	△TSD	Design target		30		℃

1. Note1: SPEED、ILIMIT、EMF_U、EMF_V、EMF_W、ISENSE.
2. Note2: BRAKE、PWM、FR.
3. Note3: UH、VH、WH
4. Note4: UL、VL、WL

Functional Description and Notes

Please read the following notes before designing driver circuits with FT3107T.

1. Drive Mode

FT3107T can be programmed to drive the motor with different drive modes, BLDC/Pseudo-BLDC/Pseudo-SINE/ Narrow BLDC. BLDC is driven at 120 degrees pulse width, Pseudo BLDC is driven at an increased pulse width with edges of the width superimposed with PWM. This mode is useful where acoustic noise is a concern over BLDC. Under some conditions, for acoustic noise reduction, Pseudo Sine can be used where the motor is driven sinusoidally except for a single window for back-EMF detection. In the event where the flyback current is large, narrow BLDC can be use where the pulse width is smaller and flyback current pulse can be accommodated for.

2. Speed Control Methods

FT3107T has two methods to control speed, through direct digital PWM input or analog voltage input. If digital PWM input is used, PWM input duty direct input to control speed. If analog voltage speed control is used, the voltage seen at SPEED will generate an internal PWM with its duty cycle determined by the following equation:

$$Duty\_cycle = \frac{V_{SPEED} - 0.5}{4}$$

The selection of digital PWM input control or analog voltage is done through efuse.

3. Closed loop speed control

Closed loop speed control can be is controlled through the duty cycle of the digital input PWM or the voltage level of the analog input PWM. Additional efuses (VLOW and VRANGE) together with SMIN_DUTY can be set in order to achieve the speed profiles. This is achieved using an internal PI loop with its proportional and integral gains configurable through efuses.

4. Frequency Generator Function

The Frequency Generator output generates a rotation pulse providing information about the speed of motor. It can be programmed using internal efuse to give 2 mechanical rotation for motor pole pairs ranging from 2-8, or 1-3 per electrical rotation. The default setting is 1 pulse per electrical degree. The FG pin is an open drain output, which is to be connected to a logical voltage level through an external pull-up resistor when used. This pin can be left open if unused.

5. EMF Feedback

EMF_U\ EMF_V\ EMF_W are motor back-EMF inputs and must be proportionately stepped down to less than VDD5 for protection of the IC.

6. Brake Function

FT3107T comes with brake function. Braking operates intelligently for protective purpose. When BRAKE pin is set low, if the motor is rotating above the brake threshold speed, output MOSFETs will be turned off to slow down the motor. However, if the motor is rotating below the brake threshold speed, and the lower legs of the output MOSFETs will be turned on to brake the motor. The reason for this distinction is to protect the MOSFETs from excessive braking currents due to large back-EMF.

7. Lead Angle Correction

The lead angle of generated motor driving signal related to the induced magnetic voltage can be shifted by an angle between 0 and 15 degrees. Lead angle control can be achieved by directly applying a voltage to the ISENSE pin.

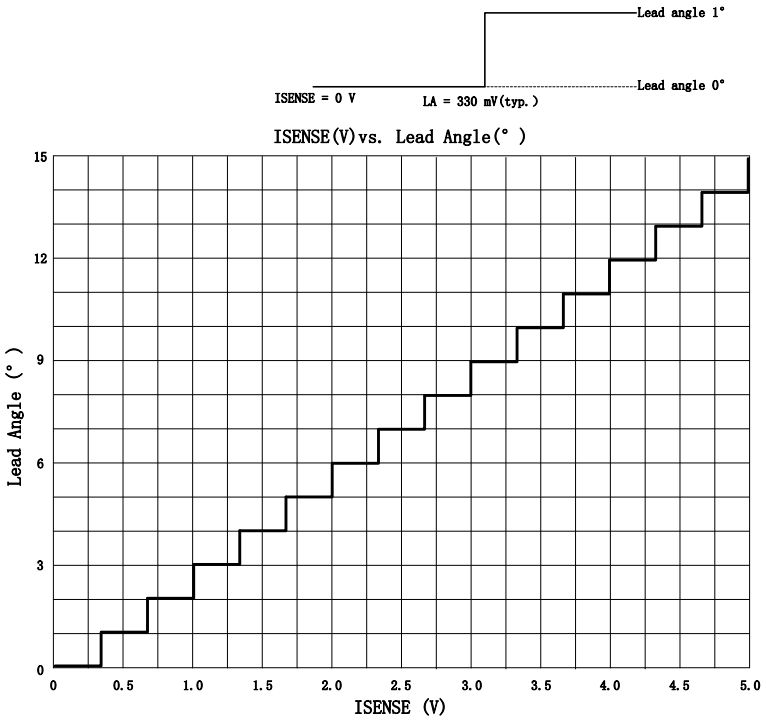


Figure 1 ISENSE vs Lead Angle

<Typical Characteristics of the ISENSE versus Lead Angle>

Step	ISENSE (V)	Lead angle(°)	Step	ISENSE(V)	Lead angle(°)	Step	ISENSE (V)	Lead angle(°)
0	0.00	0.00	6	2.00	6.00	12	4.00	12.00
1	0.33	1.00	7	2.33	7.00	13	4.33	13.00
2	0.66	2.00	8	2.66	8.00	14	4.66	14.00
3	1.00	3.00	9	3.00	9.00	15	5.00	15.00
4	1.33	4.00	10	3.33	10.00			
5	1.66	5.00	11	3.66	11.00			

8. Lockup Protection and Automatic Restart

If motor rotation is abnormal, the internal detection circuit starts self-locking detection for a given number of cycles (Trun). If the motor rotation is abnormal for Trun cycles, the lock-up protection circuit will disable the driver (by setting its outputs to high-impedance) in order to prevent the motor coil from burnout. After a “waiting time (Twait)”, the lock-up protection is released and normal operation resumes. Similarly if rotation is abnormal for another time period, Trun, lock-up protection will once again be triggered. Twait and Trun timings are configurable with internal efuse and can be modified by user.

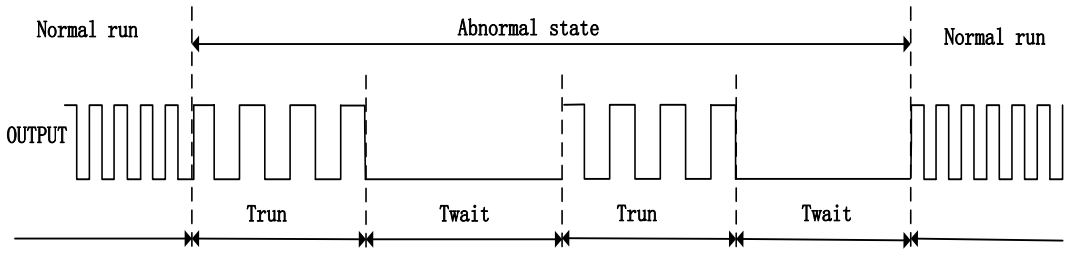


Figure2 Lockup Protection and Automatic Restart

9. Current Protection

There are two methods of current protection: overload current protection and cycle by cycle current protection. Cycle by cycle current protection is only available for BLDC. The overload current protection and cycle by cycle current protection of the motor is selected by setting internal efuse

The current limit circuit limits the output current peak value to a level determined by the equation:

$$I = Vref / R_{ISENSE}$$

For the overload current protection mode, the current limit circuit detects the peak current of the output transistors at the ISENSE pin and will reduce the duty cycle of PWM.

For the cycle by cycle current protection mode, when the voltage at the ISENSE input is higher than VREF, the current limit protection is generated and the output PWM will be turned off. Being cycle by cycle, it is reset every PWM cycle. The VREF voltage can be selected to internal voltage or ILIMIT pin input analog voltage using efuse.

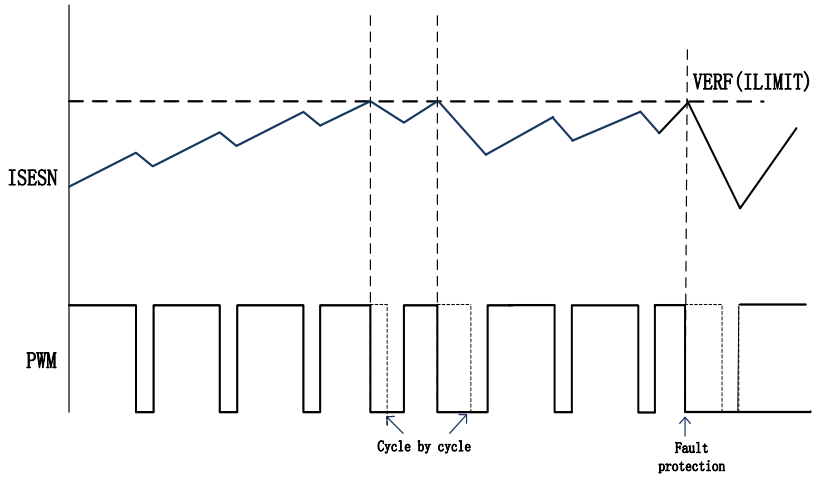
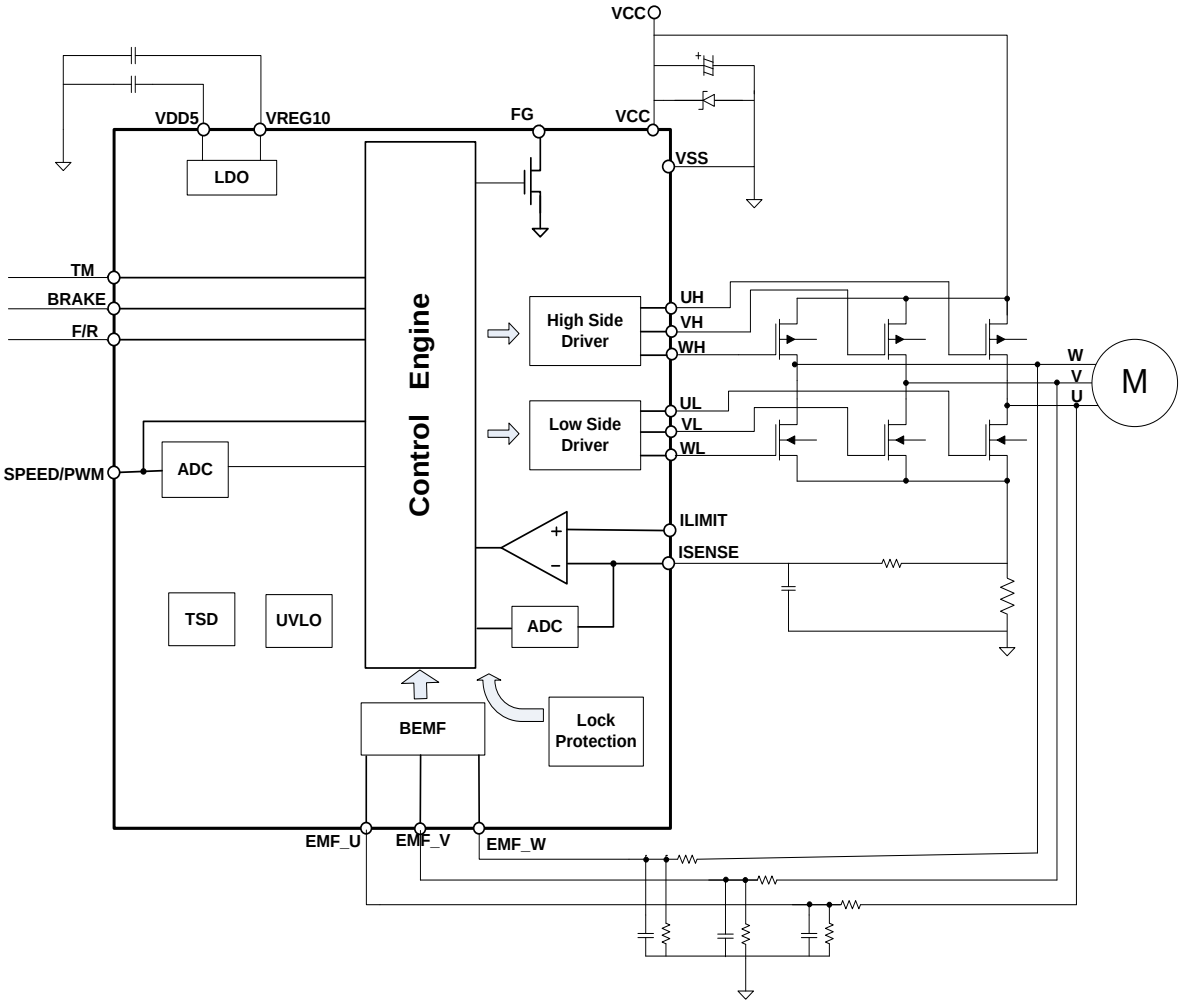


Figure 3 Cycle by cycle current protection mode

10. Thermal Protection.

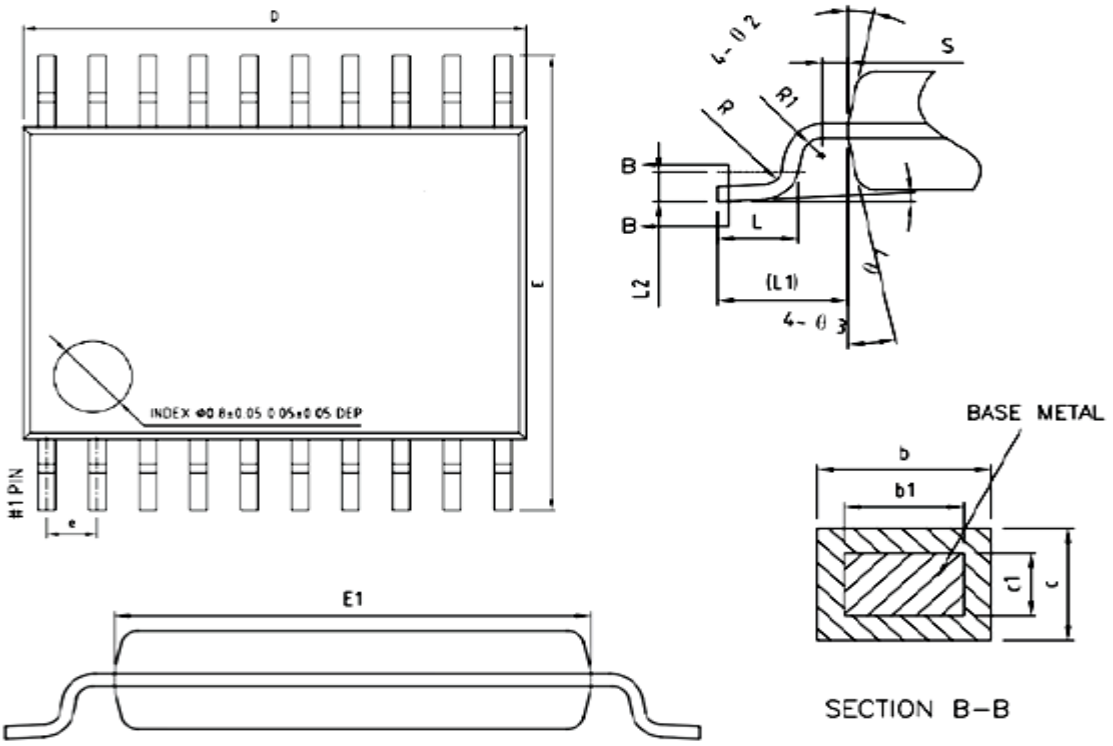
FT3107T has a built in thermal shunt down function, which will shut down the device when the junction temperature is over 150℃ and will resume operating when the junction temperature drops back to 120℃.

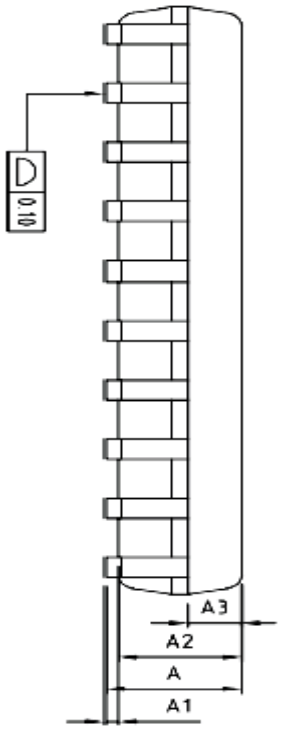
Application Circuit Example



Package Information

TSSOP-20





	MIN	NOM	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.80	1.00	1.05
b	0.19	-	0.30
b1	0.19	0.22	0.25
c	0.09	-	0.20
c1	0.09	-	0.16
D	6.40	6.50	6.60
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		

Part Number	Package Type	Marking ID	Package Method	Quantity
FT3107T	TSSOP20	FT3107T	TUBE	50

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