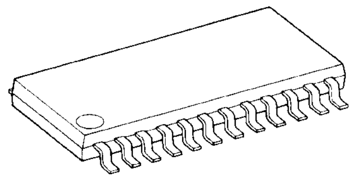
TOSHIBA CMOS Integrated Circuit Silicon Monolithic

TB6548F

3-Phase Full-Wave PWM Sensorless Controller for Brushless DC Motors

TB6548F is a 3-phase full-wave sensorless controller for brushless DC motors. It is capable of controlling voltage by PWM signal input. It is capable of PWM type sensorless driving when used conjunction with TA84005F



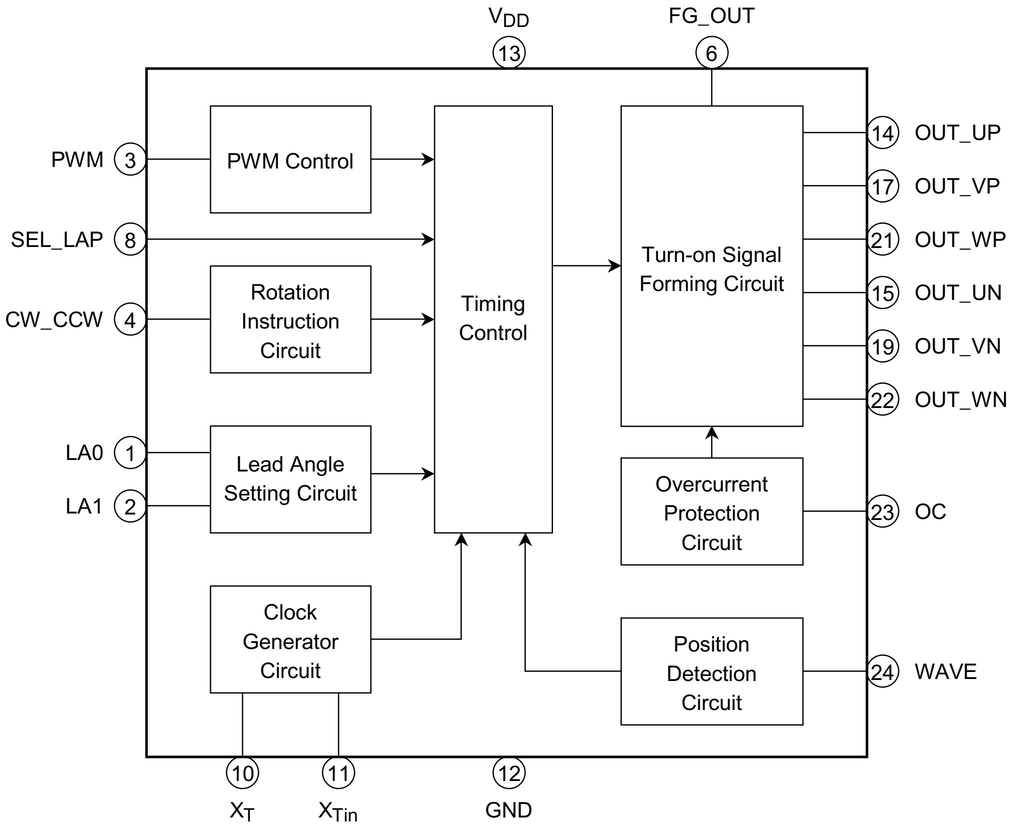
SSOP24-P-300-1.00

Weight: 0.32 g (typ.)

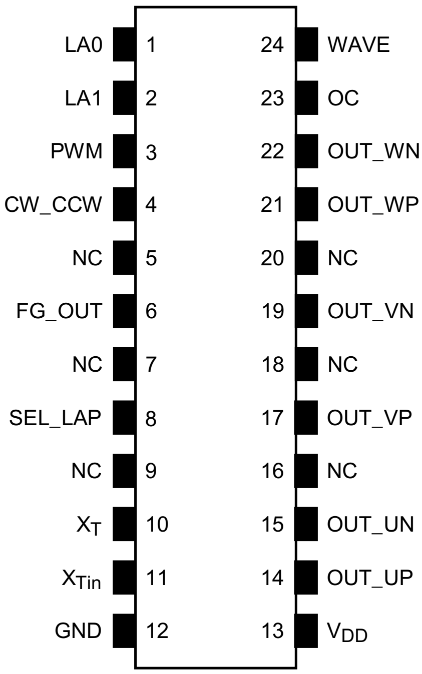
Features

- 3-phase full-wave sensorless drive
- PWM control (PWM signal is supplied from external sources.)
- Turn-on signal output current: 20 mA
- Built-in protection against overcurrent
- Forward/reverse modes
- Built-in lead angle control function (0, 7.5, 15 and 30 degrees)
- Built-in lap turn-on function

Block Diagram



Pin Assignment



Pin Description

Pin No.	Symbol	I/O	Description
1	LA0	I	Lead angle setting signal input pin • LA0 = Low, LA1 = Low: Lead angle 0 degree • LA0 = High, LA1 = Low: Lead angle 7.5 degree • LA0 = Low, LA1 = High: Lead angle 15 degree • LA0 = High, LA1 = High: Lead angle 30 degree • Built-in pull-down resistor
2	LA1	I	
3	PWM	I	PWM signal input pin • Inputs Low-active PWM signal • Built-in pull-up resistor • Disables input of duty-100% (Low) signal High for 250 ns or longer is required.
4	CW_CCW	I	Rotation direction signal input pin • High: Reverse (U → W → V) • Low, Open: Forward (U → V → W) • Built-in pull-down resistor
5	NC	—	Not connected
6	FG_OUT	O	Number of ratation detection signal output pin • Equiralent to U-phase signal (except PWM)
7	NC	—	Not connected
8	SEL_LAP	I	Lap turn-on select pin • Low: Lap turn-on • High: 120 degrees turn-on • Built-in pull-up resistor
9	NC	—	Not connected
10	X_T	—	Resonator connecting pin • Selects starting commutation frequency. Starting commutation frequency f_{st} = Resonator frequency $f_{xt}/(6 \times 2^{17})$
11	X_{Tin}	—	
12	GND	—	Connected to GND.
13	V_{DD}	—	Connected to 5-V power supply.
14	OUT_UP	O	U-phase upper turn-on signal output pin • U-phase winding wire positive ON/OFF switching pin • ON: Low, OFF: High
15	OUT_UN	O	U-phase lower turn-on signal output pin • U-phase winding wire negative ON/OFF switching pin • ON: High, OFF: Low
16	NC	—	Not connected
17	OUT_VP	O	V-phase upper turn-on signal output pin • V-phase winding wire positive ON/OFF switching pin • ON: Low, OFF: High
18	NC	—	Not connected
19	OUT_VN	O	V-phase lower turn-on signal output pin • V-phase winding wire negative ON/OFF switching pin • ON: High, OFF: Low
20	NC	—	Not connected

Pin No.	Symbol	I/O	Description
21	OUT_WP	O	W-phase upper turn-on signal output pin • W-phase winding wire positive ON/OFF switching pin • ON: Low, OFF: High
22	OUT_WN	O	W-phase lower turn-on signal output pin • W-phase winding wire negative ON/OFF switching pin • ON: High, OFF: Low
23	OC	I	Overcurrent signal input pin • High on this pin can put constraints on the turn-on signal which is performing PWM control. • Built-in pull-up resistor
24	WAVE	I	Positional signal input pin • Inputs majority logic synthesis signal of three-phase pin voltage. • Built-in pull-up resistor

Functional Description

1. Sensorless Drive

On receipt of PWM signal start instruction turn-in signal for forcible commutation (commutation irrespective of the motor's rotor position) is output and the motor starts to rotate. The motor's rotation causes induced voltage on winding wire pin for each phase.

When signals indicating positive or negative for pin voltage (including induced voltage) for each phase are input on respective positional signal input pin, the turn-on signal for forcible commutation is automatically switched to turn-on signal for positional signal (induced voltage).

Thereafter turn-on signal is formed according to the induced voltage contained in the pin voltage so as to drive the brushless DC motor.

2. Starting commutation frequency (resonator pin and counter bit select pin)

The forcible commutation frequency at the time of start is determined by the resonator's frequency and the number of counter bit (within the IC).

Starting commutation frequency f_{st} = Resonator frequency $f_{xt}/(6 \times 2^{(bit + 3)})$ bit = 14

The forcible commutation frequency at the time of start can be adjusted using inertia of the motor and load.

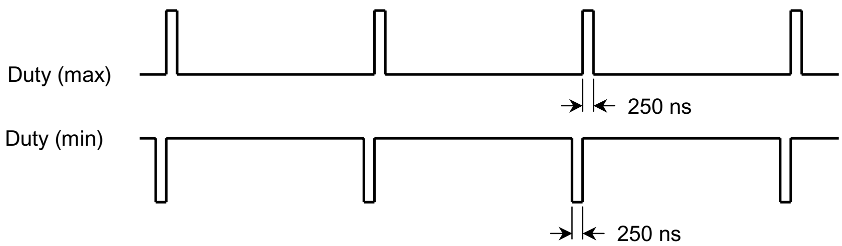
- The forcible commutation frequency should be set higher as the number of magnetic poles increases.
- The forcible commutation frequency should be set lower as the inertia of the load increases.

3. PWM Control

PWM signal can be reflected in turn-on signal by supplying PWM signal from external sources.

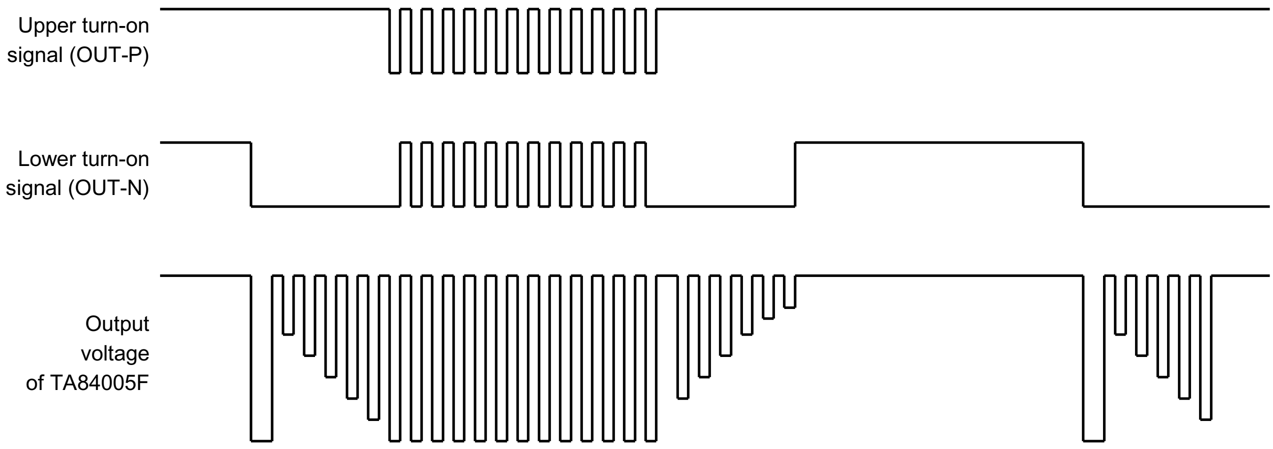
The frequency of the PWM signal shoud be set adequately high with regard to the electrical frequency of the motor and in accordance to the switching characteristics of the drive circuit.

Because positional detection is performed in synchronization with the falling edges of PWM signal, positional detection cannot be performed with 0% duty or 100% duty.



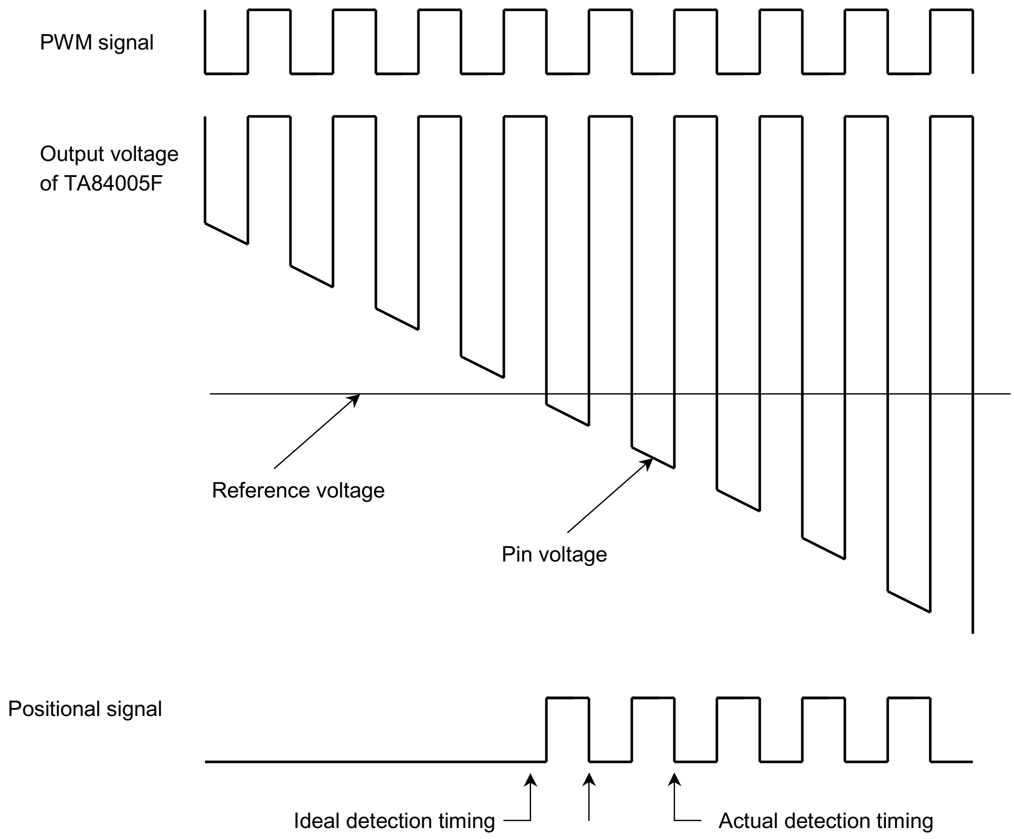
The voltage applied to the motor is duty 100% because of the storage time of the drive circuit even if the duty is 99%.

4. PWM Control



5. Positional Variation

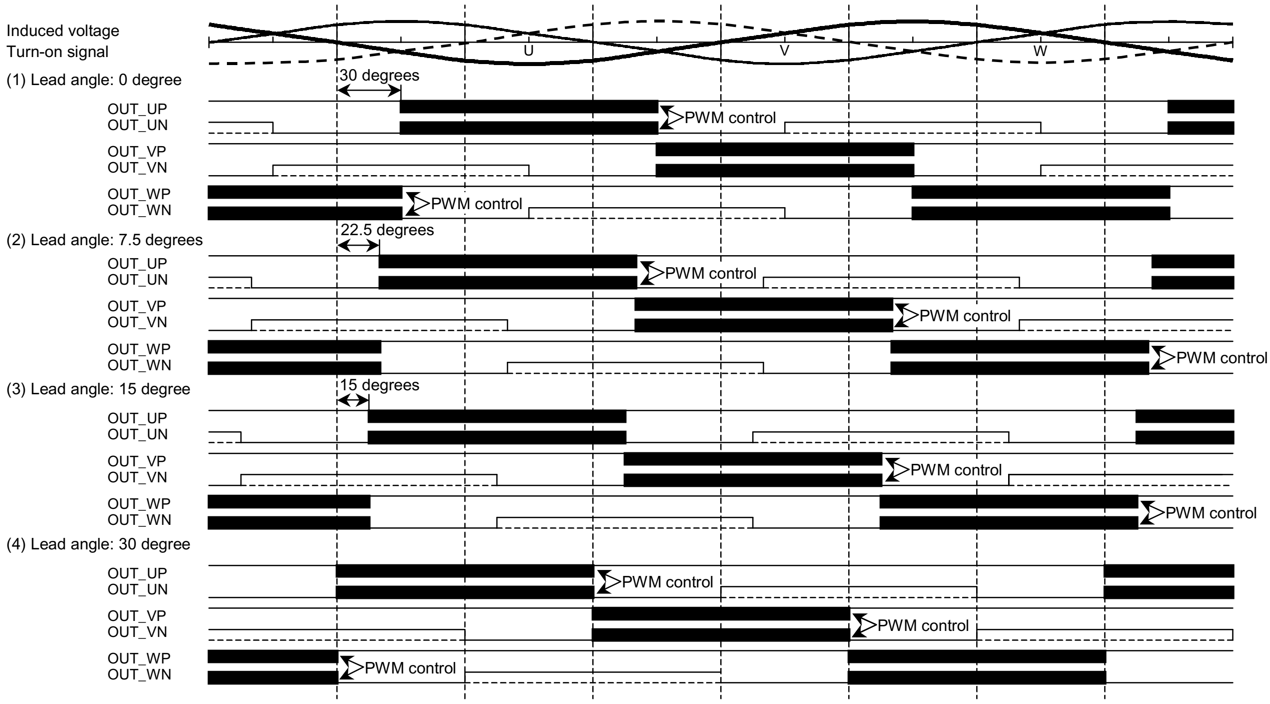
Since positional detection is performed in synchronization with PWM signal, positional variation occurs in connection with the frequency of PWM signal. Be especially careful when the IC is used for high-speed motors.



Variation is calculated by detecting at two consecutive rising edges of PWM signal.
$1/f_p$ < Detection time variation < $2/f_p$ f_p: PWM frequency

6. Lead Angle Control

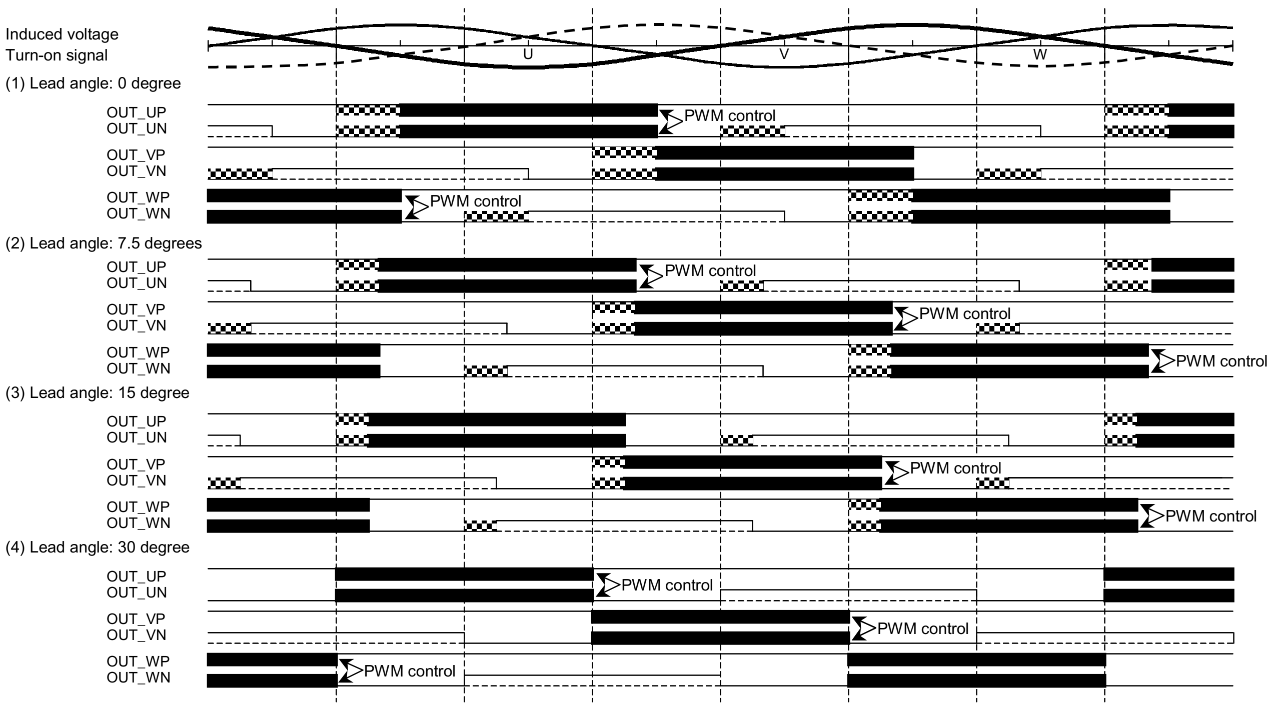
The lead angle is 0 degree during the starting forcible commutation and when normal commutation is started, automatically changes to the lead angle which has been set using LA0 and LA1. However, if both LA0 and LA1 are set for High, the lead angle is 30 degrees in the starting forcible commutation as well as in normal commutation.



7. Lap Turn-on Control

When SEL_LAP = High, the turn-on degree is 120 degrees. When SEL_LAP = Low, Lap Turn-on Mode starts.

In Lap Turn-on Mode, the time between zero-cross point and the 120 degrees turn-on timing becomes longer (shaded area in the below chart) so as to create some overlap when switching turn on signals. The lap time differs depending ong the lead angle setting.

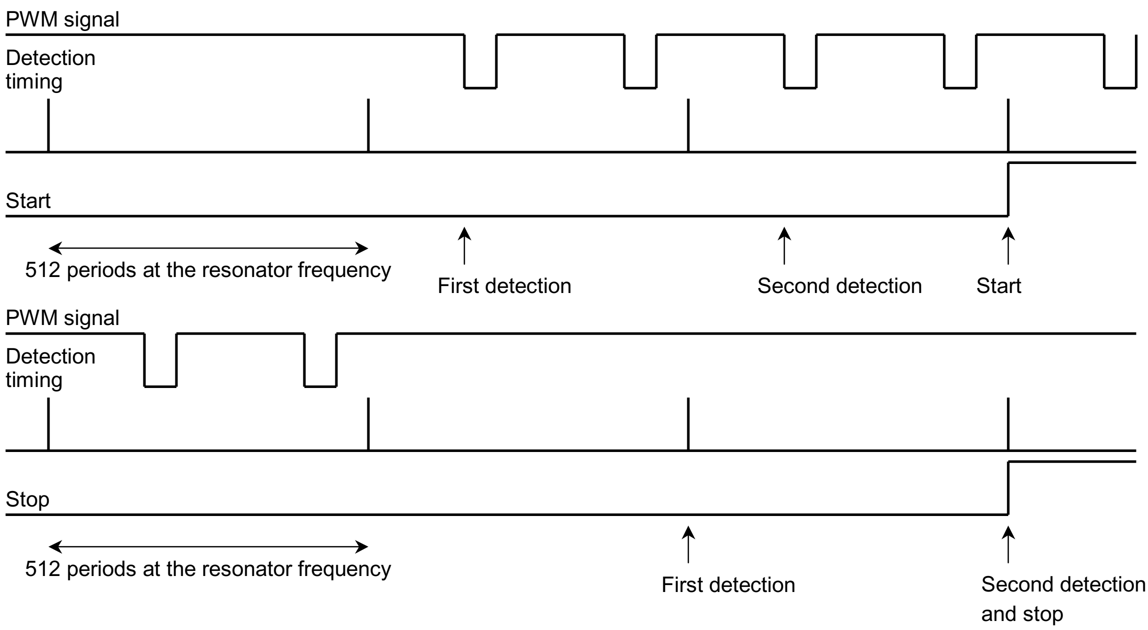


8. Start/Stop Control

Start/Stop is controlled using PWM signal input pin.

A stop is acknowledged when PWM signal duty is 0, and a start is acknowledged when ON-signal of a frequency 4 times higher than the resonator frequency or even higher is input continuously.

Timing chart



Note: Take sufficient care for noise on PWM signal input pin.

Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{DD}	5.5	V
Input voltage	V_{in}	-0.3 to V_{DD} + 0.3	V
Turn-on signal output current	I_{OUT}	20	mA
Power dissipation	P_D	590	mW
Operating temperature	T_{opr}	–30 to 85	°C
Storage temperature	T_{stg}	–55 to 150	°C

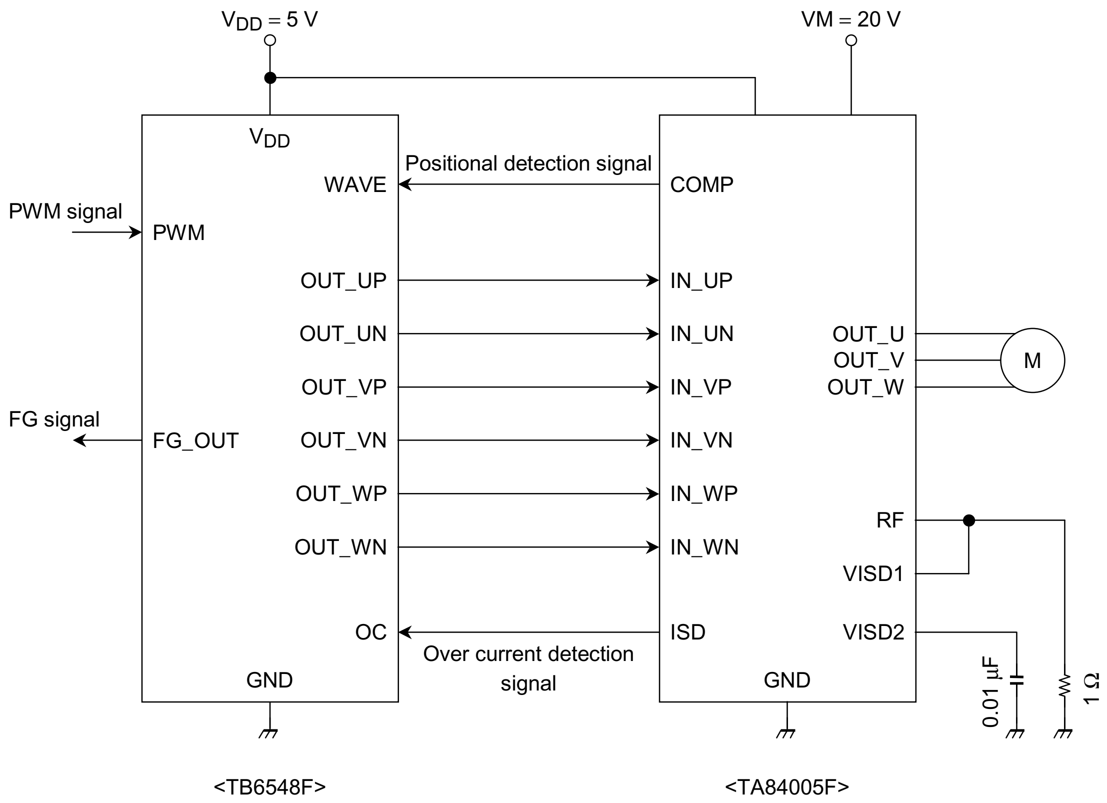
Recommended Operating Conditions (Ta = –30 to 85°C)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Power supply voltage	V_{DD}	—	4.5	5.0	5.5	V
Input voltage	V_{in}	—	–0.3	—	V_{DD} + 0.3	V
PWM frequency	f_{PWM}	—	—	16	—	kHz
Oscillation frequency	f_{osc}	—	1.0	—	10	MHz

Electrical Characteristics (Ta = 25°C, V_{DD} = 5 V)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Static power supply current	I_{DD}	—	PWM = H, X_{Tin} = H	—	0.1	0.3	mA
Dynamic power supply current	$I_{DD\ (opr)}$	—	PWM = 50% Duty, X_{Tin} = 4 MHz	—	1	3	mA
Input current	$I_{IN\text{-}1}$ (H)	—	V_{IN} = 5 V, PWM, OC, WAVE_U, SEL_LAP	—	0	1	μA
	$I_{IN\text{-}1}$ (L)	—	V_{IN} = 0 V, PWM, OC, WAVE_U, SEL_LAP	–75	–50	—	
	$I_{IN\text{-}2}$ (H)	—	V_{IN} = 5 V, CW_CCW, LA0, LA1	—	50	75	
	$I_{IN\text{-}2}$ (L)	—	V_{IN} = 0 V, CW_CCW, LA0, LA1	–1	0	—	
Input voltage	V_{IN} (H)	—	PWM, OC, SEL_LAP, CW_CCW WAVE_U, LA0, LA1	3.5	—	5	V
	V_{IN} (L)	—	PWM, OC, SEL_LAP, CW_CCW WAVE_U, LA0, LA1	GND	—	1.5	
Input hysteresis voltage	V_H	—	PWM, OC, SEL_LAP, CW_CCW WAVE_U, LA0, LA1	—	0.6	—	V
Output voltage	$V_{O\text{-}1}$ (H)	—	I_{OH} = –1 mA OUT_UP, OUT_VP, OUT_WP	4.3	—	V_{DD}	V
	$V_{O\text{-}1}$ (L)	—	I_{OL} = 20 mA OUT_UP, OUT_VP, OUT_WP	GND	—	0.5	
	$V_{O\text{-}2}$ (H)	—	I_{OH} = –20 mA OUT_UN, OUT_VN, OUT_WN	4.0	—	V_{DD}	
	$V_{O\text{-}2}$ (L)	—	I_{OL} = 1 mA OUT_UN, OUT_VN, OUT_WN	GND	—	0.5	
	$V_{O\text{-}3}$ (H)	—	I_{OH} = –0.5 mA FG_OUT	4.0	—	V_{DD}	
	$V_{O\text{-}3}$ (L)	—	I_{OL} = 0.5 mA FG_OUT	GND	—	0.5	
Output leak current	I_L (H)	—	V_{DD} = 5.5 V, V_{OUT} = 0 V OUT_UP, OUT_VP, OUT_WP OUT_UN, OUT_VN, OUT_WN FG_OUT	—	0	10	μA
	I_L (L)	—	V_{DD} = 5.5 V, V_{OUT} = 5.5 V OUT_UP, OUT_VP, OUT_WP OUT_UN, OUT_VN, OUT_WN FG_OUT	—	0	10	
Output delay time	t_{pLH}	—	PWM-Output	—	0.5	1	μs
	t_{pHL}			—	0.5	1	

Application Circuit Example

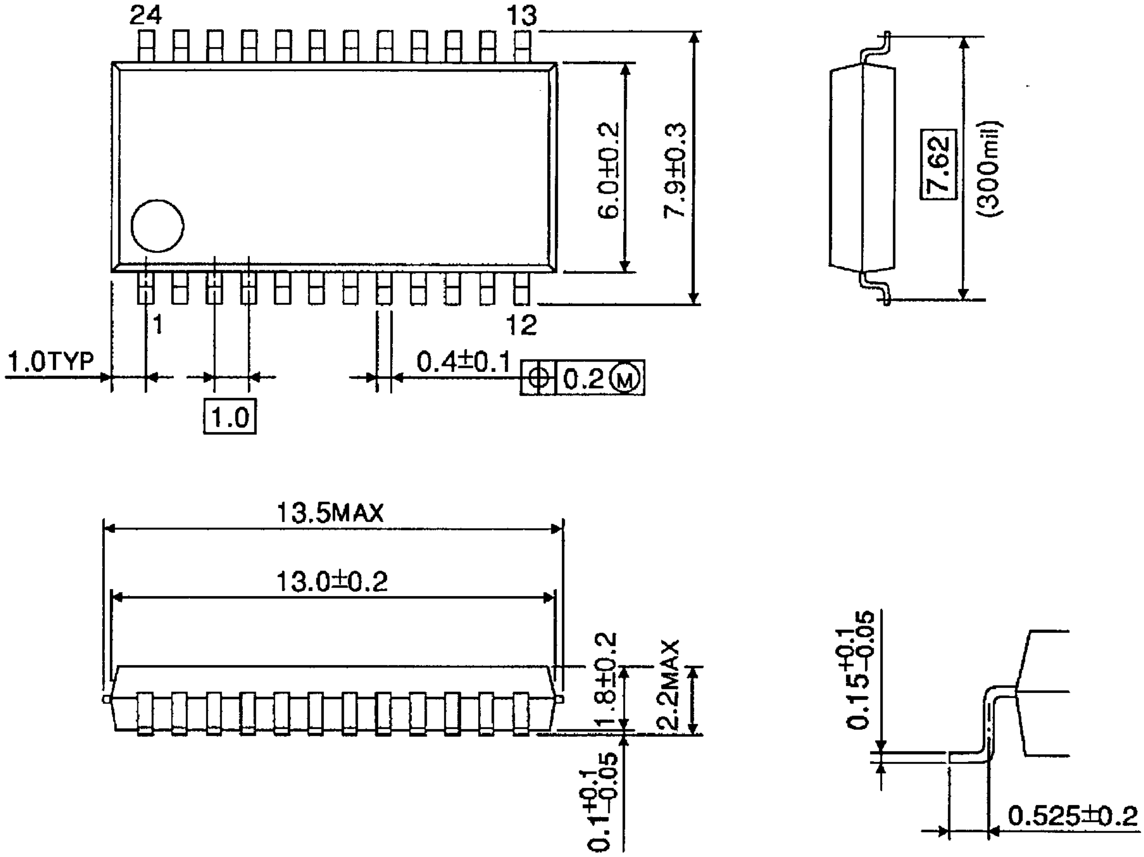


Note 1: Take enough care in designing output V_{DD} line and GND line to avoid short circuit between outputs, V_{DD} fault or GND fault which may cause the IC to break down.

Note 2: The above application circuit and values mentioned are just an example for reference. Since the values may vary depending on the motor to be used, appropriate values must be determined through experiments before using the device.

Package Dimensions

SSOP24-P-300-1.00 Unit : mm



Weight: 0.32 g (typ.)