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DATA SHEET

LB11681H — Monolithic Digital IC
PWM Three-phase Brushless Motor Driver

Overview

The LB11681H is a three-phase brushless fan motor driver IC. This IC uses a PWM soft switching drive-method (for low-noise drive). Since this IC includes a motor constraint protection circuit necessary for a fan motor system, highly reliable products including this IC can be designed. Also, this IC can be operated with 12V single power supply.

Functions

- Direct PWM drive
- Three-phase full-wave driving method
- Soft switching driving
- Built-in lock (constraint) protection circuit
- Built-in lock (constraint) detection circuit
- FG output (provides one Hall effect sensor equivalent FG outputs)
- Built-in Forward / Reverse switching circuit
- Built-in thermal shut down circuit
- Built-in current limitation circuit

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage	VM max		15.0	V
Output current	I_O max		1.3	A
Allowable Power dissipation 1	Pd max1	Independence IC	0.8	W
Allowable Power dissipation 2	Pd max2	Mounted on a circuit board*	2.0	W
Operating temperature	Topr		-20 to 85	°C
Storage temperature	Tstg		-55 to 150	°C

* Mounted on a specified board: 114.3mm×76.1mm×1.6mm, glass epoxy.

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Recommended Operating Ranges at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage range	VM		10 to 14	V
FG pin output current	VFG		0 to 3.0	mA
LD pin output current	VLD		0 to 1.0	mA

Electrical Characteristics at Ta = 25°C, VM = 12.0V

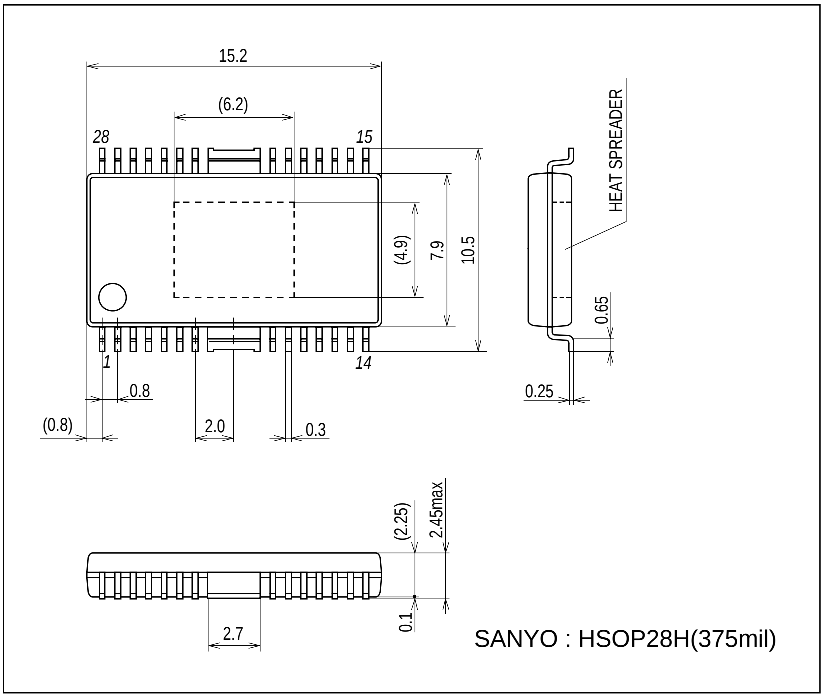
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Current drain1	IM1	VCTL=1.75V and VREF=1.75V		(10.0)		mA
VR pin						
VR pin voltage	VR			5.0		V
Output block						
Saturated voltage	VSAT	SOURCE + SINK, I_O=0.6A		1.4	2.1	V
Diode forward voltage	VD	I_O=0.6A		1.2	1.6	V
PWM frequency	fPWM	OSC=220pF	60	75	90	kHz
Hall amplifier						
Common-mode input range	VCM		1.0		4.0	V
Input off set voltage	VHOF		-5		5	mV
Input current	IHIN		-3		3	μA
Hall minimum input level	VHIN	Differential input	50			mVp-p
Hysteresis	VHYS	Sum of upper and lower hysteresis	6	15	35	mVp-p
Current control circuit						
VCTL input voltage range	VCTL		0		VR-1	V
VREF input voltage range	VCREF	Linear region 1.5 to 2.0V	0	1.75	3.5	V
Driving gain	GDF+L		0.18	0.21	0.24	V/V
Control start voltage	VDS		VREF		VREF+40	mV
Limiter voltage	VRf		0.17	0.21	0.25	V
LCK pin						
Charge current	IIC		3.8	4.1	4.4	μA
Discharge current 1	IDC1	When the lock protection function is running	2.1	2.4	2.7	μA
Discharge current 2	IDC2	When a Hall FG is input, VCLK=4	3.5	3.9	4.3	mA
Lock detection operation voltage	VLDON		0.70VR		0.85VR	V
Lock detection release voltage	VLDOFF		0.22VR		0.28VR	V
F/R pin						
High level input voltage range	VFRH		2.5		VR	V
Low level input voltage range	VFRL		0		0.6	V
High level input current	IFRH	VFR=VR		120	300	μA
LD pin						
Low level voltage	VLDL	ILOAD=1mA		0.15	0.4	V
FG output pin						
Low level voltage	VFGL	ILOAD=3mA		0.15	0.4	V
Hall bias						
Minus- side pin voltage	VH-	IH=5mA	1.1	1.5	1.8	V
Thermal shut down circuit						
Thermal shut down operation temperature	TSD	Design target*	150	180		°C
Temperature hysteresis	ΔTSD	Design target*		40		°C

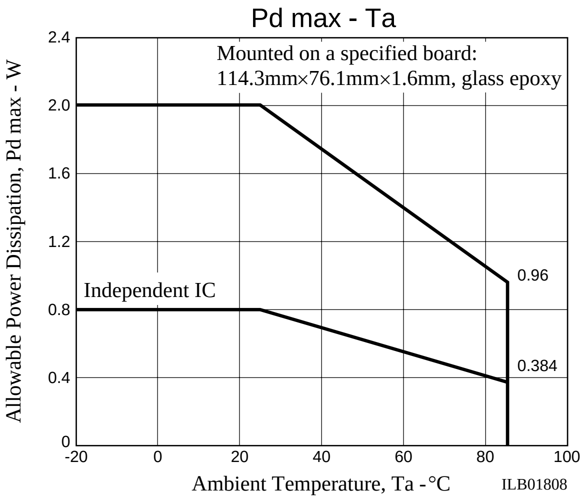
*: Design target value and no measurement was made.

Package Dimensions

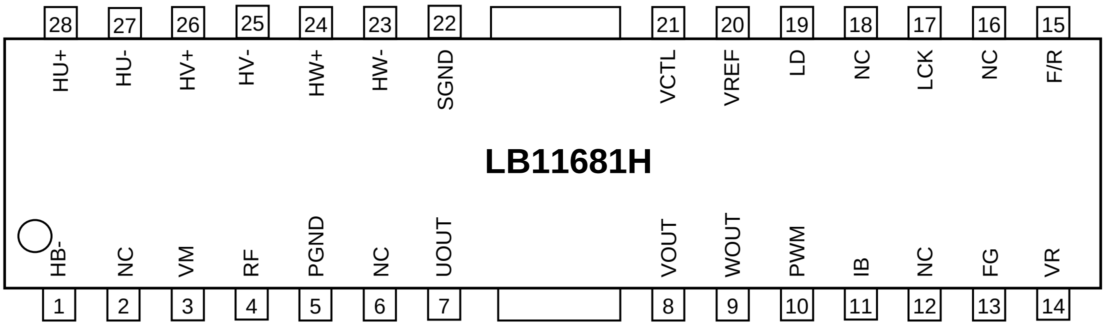
unit : mm (typ)

3233B



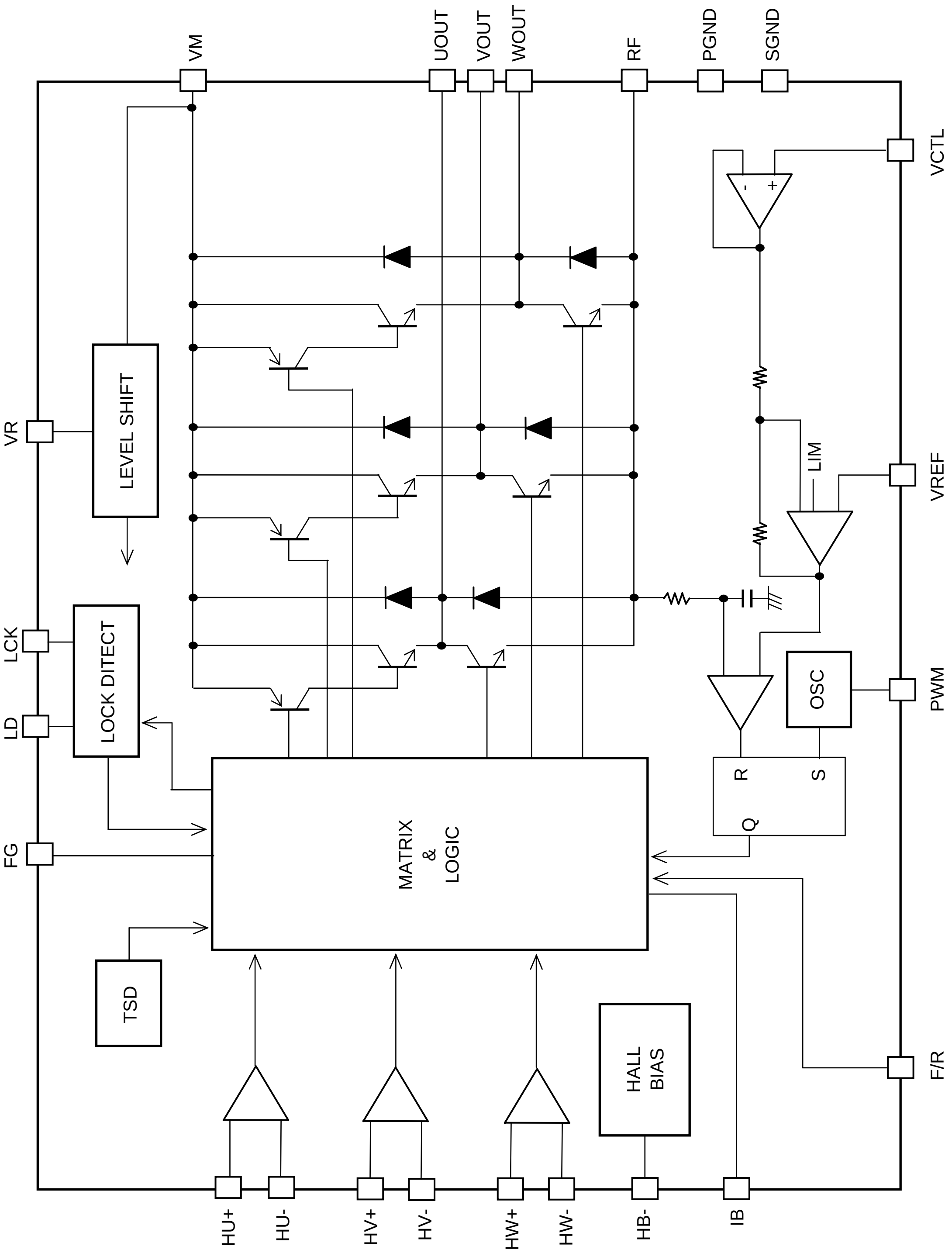


Pin Assignment



Top view

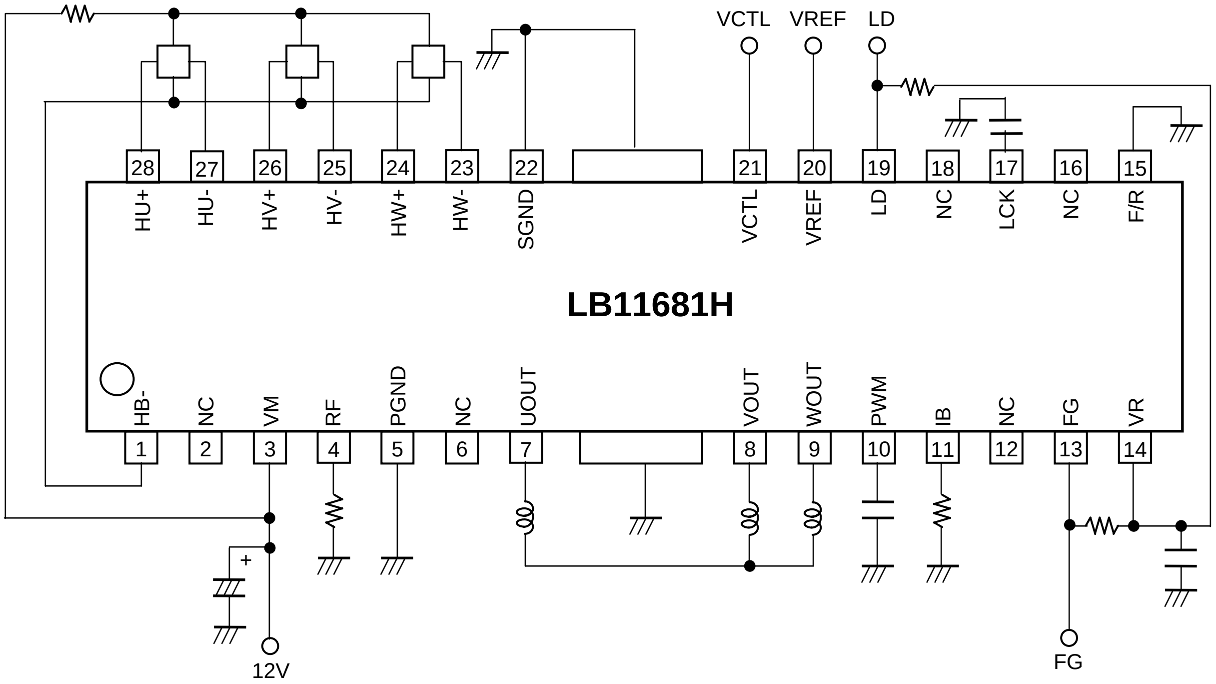
Block Diagram



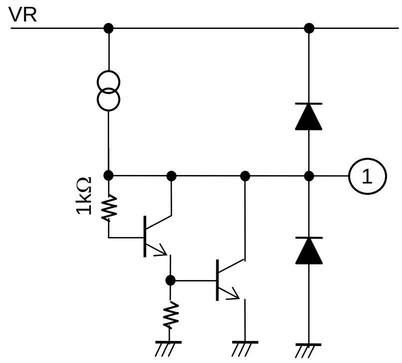
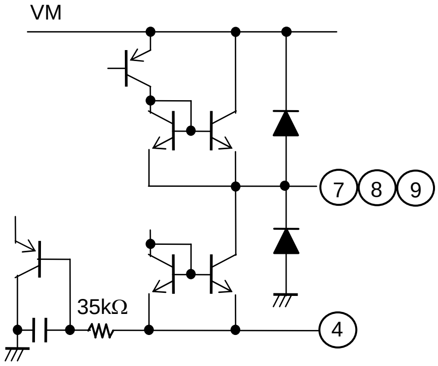
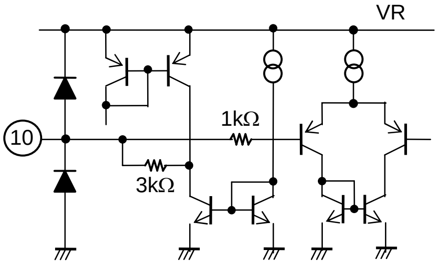
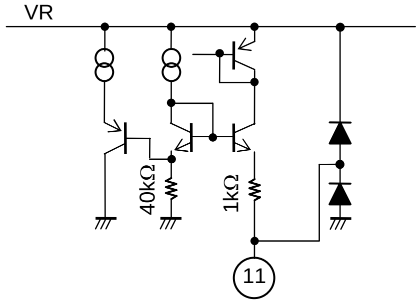
Truth Table

	Source Sink	F/R "L"			F/R "H"		
		HU+	HV+	HW+	HU+	HV+	HW+
1	WOUT→VOUT	H	H	L	L	L	H
2	WOUT→UOUT	H	L	L	L	H	H
3	VOUT→UOUT	H	L	H	L	H	L
4	VOUT→WOUT	L	L	H	H	H	L
5	UOUT→WOUT	L	H	H	H	L	L
6	UOUT→VOUT	L	H	L	H	L	H

Sample Application Circuit



Pin Functions

Pin No.	Symbol	Pin Description	Equivalent Circuit
1	HB-	Hall bias minus-side bias pin. Minus-side bias pin of Hall element is connected with this pin. In addition, connect a bias resistance between Hall element plus-side bias and power supply.	
3	VM	Power supply pin. Connect a capacitor between this pin and GND.	
4	RF	Pin to detect the output current. The drive current is detected by connecting a low-resistance between this pin and GND.	
7 8 9	UOUT VOUT WOUT	Output pin. The motor coils are connected with these pins.	
5	PGND	Output system ground	
10	PWM	PWM oscillation pin. Connect a capacitor between this pin and GND.	
11	IB	Output drive current adjustment pin. Connect a resistor between this pin and GND.	

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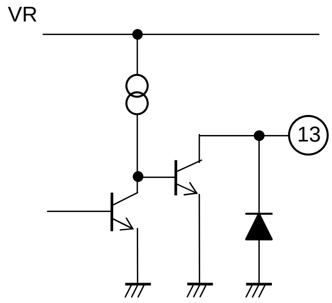
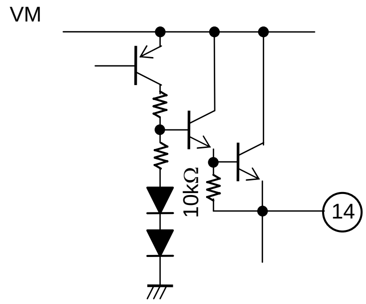
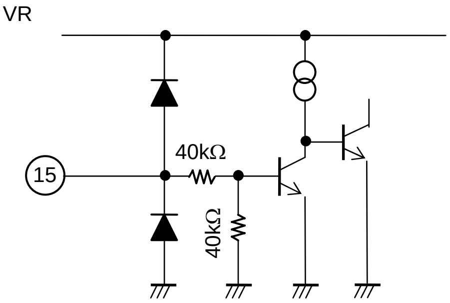
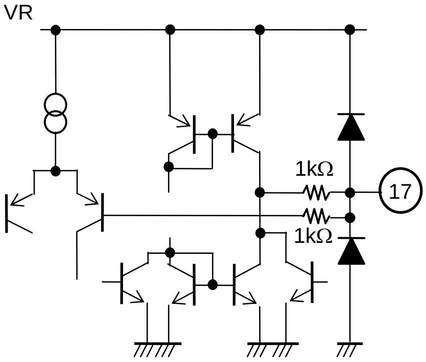
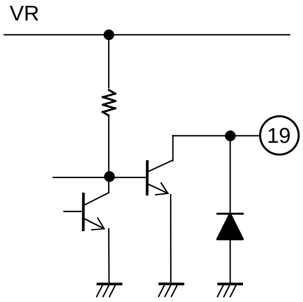
Pin No.	Symbol	Pin Description	Equivalent Circuit
13	FG	FG pulse output pin (Open collector output) Provides one Hall effect sensor equivalent FG output) When the FG output is necessary, connect a pull-up resistance with this pin.	
14	VR	Simplified power supply output pin. Connect a capacitor between this pin and GND. This pin is connected with power supply of the small signal system circuit in IC.	
15	F/R	Pin to switch the rotating mode in spindle motor block. Do not apply a voltage above the voltage of the VR pin. Switch F / R when the motor has stopped.	
17	LCK	Lock protection circuit timing setting pin. Connect a capacitor between this pin and GND. As the capacity increase, the time of lock detection / release setting can be lengthened	
19	LD	Lock detection output pin (Open collector output) The LD output goes to the high level during lock protection When LD output is necessary, connect a pull-up resistance with this pin	

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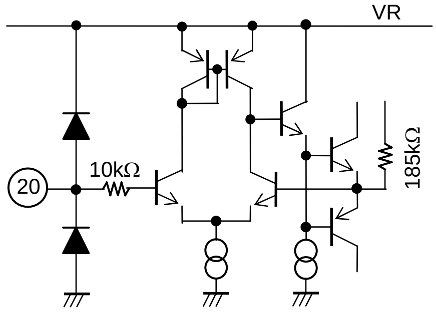
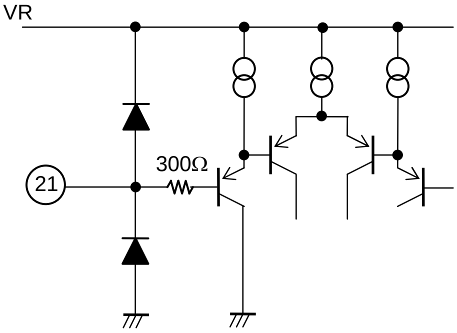
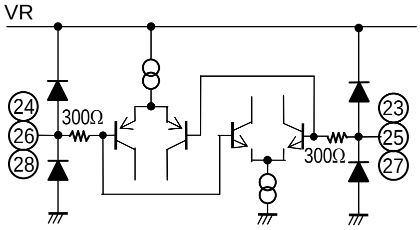
Pin No.	Symbol	Pin Description	Equivalent Circuit
20	VREF	The pin as reference voltage of control amplifier	
21	VCTL	Control amplifier input pin	
22	SGND	Small signal system ground pin	
23,24 25,26 27,28	HW± HV± HU±	Hall input pin	

Explanation of LB11681H and External Parts

The LB11681H is three-phase brush less fan motor driver IC that can be operated with 12V signal power supply. Since this IC is PWM soft switching drive, it is perfect to operate as high-efficiency motor for a low-noise drive. Also, since this IC incorporates a motor constraint protection function necessary for a fan motor, highly reliable products can be designed.
To design the system by using the LB11681H, please develop the system that is obtained sufficient characteristics after reading the following details.

1. Output Drive Circuit

The LB11681H is three-phase brush less type fan motor driver.
A high-efficiency direct PWM drive method is adopted in this drive.
Also, for low-noise drive of motor, 180degrees current-carrying soft switching method is adopted.

2. Hall Amplifier and Bias circuit

Since motor driving current depends on the Hall input waveform, the Hall input amplitude should be set to appropriate value. To obtain good driving current, please adjust the bias resistance so that the Hall input amplitude is 100-200mVp-p. When the Hall input amplifier is large, a current-carrying OFF band is made.
Connect a Hall bias resistance between the Hall power supply and plus-side of Hall bias.
Also, connect the minus-side of the Hall bias with the HB-pin (pin 1) directly. (No bias resistance on the minus-Side).

3. Current Limitation Circuit

The LB11681H incorporates the current limitation circuit. The value of control current of the current limitation circuit is determined by I = VRF / Rf. (VRF = 0.21V typical)
The current limitation operation, when the voltage of the RF pin (pin 4) exceeds the limiting value,
The transistor on the sink-side is turned off.

4. PWM oscillation circuit

The PWM frequency of this IC is adjustable by connecting the capacitor between the PWM pin (pin 10) and GND. We recommend the PWM frequency of 50kHz to 100kHz. When the PWM oscillation frequency is too low, the ripple amplitude of the coil current becomes large. Also, when the PWM oscillation frequency is too high, the driving efficiency is reduced.

5. Adjust of the driving current

In order to ensure the soft switching, it is necessary to set the driving current value by the best value with inputting a proper the Hall input amplitude.
The driving current is set by the IB pin (pin 11).
When the value of the IB resistance becomes small, large amounts of the driving current will flow.
The constants of reference for the IB resistance and the RF resistance are shown below.

RF limited current	RF resistance	IB constant	Controlled gain
0.64(A)	1Ω 3parallel	8.2(kΩ)	0.66(A/V)
0.84(A)	1Ω 4parallel	6.8(kΩ)	0.88(A/V)
1.05(A)	1Ω 5parallel	4.7(kΩ)	1.10(A/V)
1.26(A)	1Ω 6parallel	3.3(kΩ)	1.32(A/V)

6. FG output

The FG pin (pin 13) of this IC is the Hall input U-phase comparator output.
Also, since the FG pin is a open collector output, please connect a pull-up resistance with this pin.
(When the FG output is not used, no a pull-up resistance necessary.)

7. F / R pin (Forward / Reverse)

The F/R pin (pin 15) is a pin for the motor rotation direction switching.
By switching the input level, the direction of rotation of the motor is switchable.
In the high input level, Please do not apply beyond the limits of the voltage of the VR pin (pin 14).
Also, carry out switching of forward / reverse when the motor has stopped.

8. Motor Lock Detection Protection Circuit

The LB11681H incorporates the lock protection circuit to protect the IC and the system from the motor restrained condition. If the rotor of the brush less motor is not rotated by any reason a certain period of time, the voltage of the LCK pin is rising. And, when the voltage reaches the lock detection operation voltage the motor is judged as a restrained condition. Then, the LD pin output (Lock detection output, pin 19) is changed from low to high.
The output transistor becomes a intermittent driving mode at a time.
Therefore, the system is protected by suppressing the heat generation of IC. The setting of the lock detection time can be adjusted by connecting the capacitance value between the LCK pin (pin 17) and GND.
When the rotor have started, the motor is released from restriction. And, when the motor becomes a normal drive from a intermitted drive, the LD output goes to low.
When the motor is rotating, the current (discharged current 2) of one-PWM period is discharged every one-pulse of a Hall FG. In addition, since the LD pin is a open-collector output, please connect a pull-up resistance with the LD pin (When the LD pin is not used, no a pull-up resistance).
The relationship between the average time from the lock protection condition to release of the lock protection condition and the capacity of a LCK capacitor (C_{LCK}) are as follows.

The average time from the lock condition (Stopped of the motor) to the operation of the lock protection function
$= (3.8 - {}^*V_{LCK}) \times C_{LCK}F / 4.1\mu A$
The average time from the operation of the lock protection function to release of the lock protection condition
$= 2.6 \times C_{LCK}F / 2.4\mu A$
Note : $^*V_{LCK}$ is the voltage of the LCK pin.
The voltage of the LCK pin changes depending on a rotating speed or the lock protection circuit is nonfunctional.

When C_{LCK} is 2.2μF,
The average time from the lock condition (Stopped of the motor) to the operation of the lock protection function
= 2.0s
The average time from the operation of the lock protection function to release of the lock protection condition
= 2.4s

9. Control Amplifier

The driving current of the LB11681H can be controlled by the difference in voltage (the difference in voltage is shown as “ΔCTL” from here.) between the VCTL pin (pin 21) and the VREF pin (pin 20).
When ΔCTL increases, the driving current becomes large.
Dynamic range of ΔCTL is about 1V, when the voltage of the CTL pin becomes 1V or more, the IC becomes a full-driving state. Also, when “ΔCTL is a positive relationship, the output is turned off.

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10. Usage Note :

As for the GND

The frames of center of IC are the power system ground.

The power GND and the system GND are set to the lowest potential.

As for the bypath capacitor

The bypath capacitor between the VM pin and GND must connect as close as possible to the GND pin of IC.

As for VM, GND and short-circuit between the outputs.

Please avoid the following matters. :

- Short between the output pin and the VM pin.
- Short between the output pin and GND
- Short between the outputs.

Also, the IC should be oriented on the board because the IC may be destroyed and may be emitted smoke possibly.

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