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# LB1980JH

Monolithic Digital IC

## 3-Phase Brushless Motor Driver

### Overview

The LB1980JH is a 3-phase brushless motor driver that is particularly appropriate for automotive.

### Functions

- 3-phase full-wave drive
- Built-in torque ripple correction circuit (variable correction ratio)
- Current limiter circuit
- Upper and lower side output stage over-saturation prevention circuit that does not require external capacitors.
- FG amplifier
- Thermal shutdown circuit

### Specifications

**Absolute Maximum Ratings** at  $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{CC\text{ max}}$		7	V
	$V_S\text{ max}$		24	V
Maximum output current	$I_O\text{ max}$		1.3	A
Allowable power dissipation	$P_d\text{ max}$	Mounted on a board *	1.81	W
		Independent IC	0.77	W
Operating temperature	$T_{opr}$		-30 to 85	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-55 to +150	$^\circ\text{C}$

\* Mounted on a 76.1mm×114.3mm×1.6mm, glass epoxy printed circuit board.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

# LB1980JH

## Allowable Operating Ranges at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V <sub>S</sub>		5 to 22	V
	V <sub>CC</sub>		4.5 to 5.5	V
Hall input amplitude	V <sub>HALL</sub>	Between the hall inputs	±30 to ±80	mVo-p
GSENSE pin input range	V <sub>GSENSE</sub>	With respect to the control system ground	-0.20 to +0.20	V

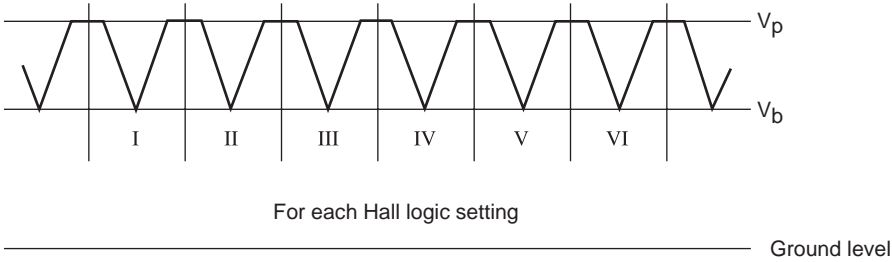
## Electrical Characteristics at Ta = 25°C, V<sub>CC</sub> = 5V, V<sub>S</sub> = 15V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
V <sub>CC</sub> supply current	I <sub>CC</sub>	R <sub>L</sub> =∞, V <sub>CTL</sub> =0V, V <sub>LIM</sub> =0V (Quiescent)		12	18	mA
<b>Outputs</b>						
Output saturation voltage	VO sat1	I <sub>O</sub> =500mA, R <sub>f</sub> =0.5Ω, Sink+Source V <sub>CTL</sub> =V <sub>LIM</sub> =5V(With saturation prevention)		2.1	2.6	V
	VO sat2	I <sub>O</sub> =1.0mA, R <sub>f</sub> =0.5Ω, Sink+Source V <sub>CTL</sub> =V <sub>LIM</sub> =5V(With saturation prevention)		2.6	3.5	V
Output leakage current	I <sub>O</sub> leak				1.0	mA
<b>FR</b>						
FR pin input threshold voltage	V <sub>FSR</sub>		2.25	2.50	2.75	V
FR pin input bias current	I <sub>B</sub> (FSR)		-5.0			mA
<b>Control</b>						
CTLREF pin voltage	V <sub>CREF</sub>		2.05	2.15	2.25	V
CTLREF pin input range	V <sub>CREFIN</sub>		1.50		3.50	V
CTL pin input bias current	I <sub>B</sub> (CTL)	With V <sub>CTL</sub> =5V and the CTLREF pin open			4.0	μA
CTL pin control start voltage	V <sub>CTL</sub> (ST)	With R <sub>f</sub> =0.5Ω, V <sub>LIM</sub> =5V, I <sub>O</sub> ≥10mA, Hall input logic fixed (U, V, W=H, H, L)	2.00	2.15	2.30	V
CTL pin control Gm	Gm(CTL)	With R <sub>f</sub> =0.5Ω, ΔI <sub>O</sub> =200mA, Hall input logic fixed (U, V, W=H, H, L)	0.46	0.58	0.70	A / V
<b>Current Limiter</b>						
LIM current limit offset voltage	V <sub>off</sub> (LIM)	With R <sub>f</sub> =0.5Ω, V <sub>CTL</sub> =5V, I <sub>O</sub> ≥10mA, Hall input logic fixed (U, V, W=H, H, L)	140	200	260	mV
LIM pin input bias current	I <sub>B</sub> (LIM)	With V <sub>CTL</sub> =5V and the V <sub>CREF</sub> pin open	-2.5			μA
LIM pin current control level	I <sub>LIM</sub>	With R <sub>f</sub> =0.5Ω, V <sub>CTL</sub> =5V, V <sub>LIM</sub> =2.06V Hall input logic fixed (U, V, W=H, H, L)	830	900	970	mA
<b>Hall Amplifier</b>						
Hall amplifier input offset voltage	V <sub>off</sub> (HALL)		-6		+6	mA
Hall amplifier input bias current	I <sub>B</sub> (HALL)			1.0	3.0	μA
Hall amplifier common-mode input voltage range	V <sub>CM</sub> (HALL)			1.3	3.3	V
<b>TRC</b>						
Torque ripple correction ratio	TRC	For the high and low peaks in the R <sub>f</sub> waveform when I <sub>O</sub> =200mA. (R <sub>f</sub> =0.5Ω, with the ADJ pin open) *1		9		%
ADJ pin voltage	V <sub>ADJ</sub>		2.37	2.50	2.63	V
<b>FG Amplifier</b>						
FG amplifier input offset voltage	V <sub>off</sub> (FG)		-8		+8	mV
FG amplifier input bias current	I <sub>B</sub> (FG)		-100			nA
FG amplifier output saturation voltage	V <sub>O</sub> sat (FG)	Sink side, for the load provided by the internal pull-up resistor			0.5	V
FG amplifier voltage gain	V <sub>G</sub> (FG)	For the open loop state with f=10kHz	41.5	44.5	47.5	dB
FG amplifier common-mode input voltage	V <sub>GM</sub> (FG)		0.5		4.0	V
<b>Saturation</b>						
Saturation prevention circuit lower side voltage setting	VO sat(DET)	The voltages between each OUT and R <sub>f</sub> pair when I <sub>O</sub> =10mA, R <sub>f</sub> =0.5Ω, and V <sub>CTL</sub> =V <sub>LIM</sub> =5V	0.175	0.25	0.325	V
<b>TSD</b>						
TSD operating temperature	TSD	Design target value *2		180		°C
Hysteresis width	ΔTSD	Design target value *2		20		°C

Notes : \*1. The torque ripple correction ratio is determined as follows from the R<sub>f</sub> voltage waveform.

\*2. Parameters that are indicated as design target values in the conditions column are not tested.

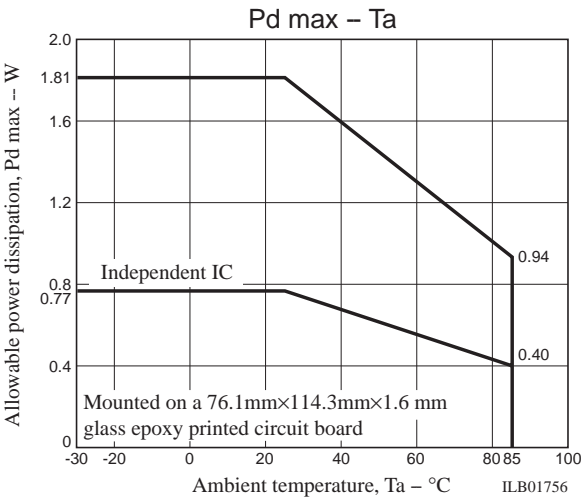
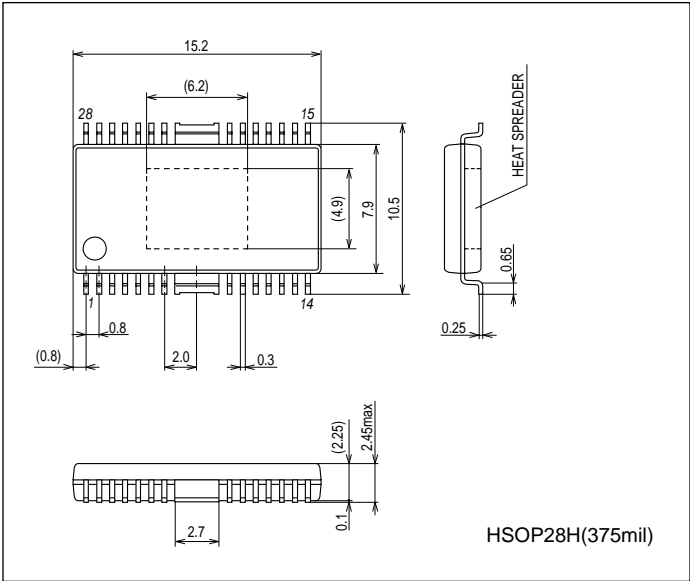
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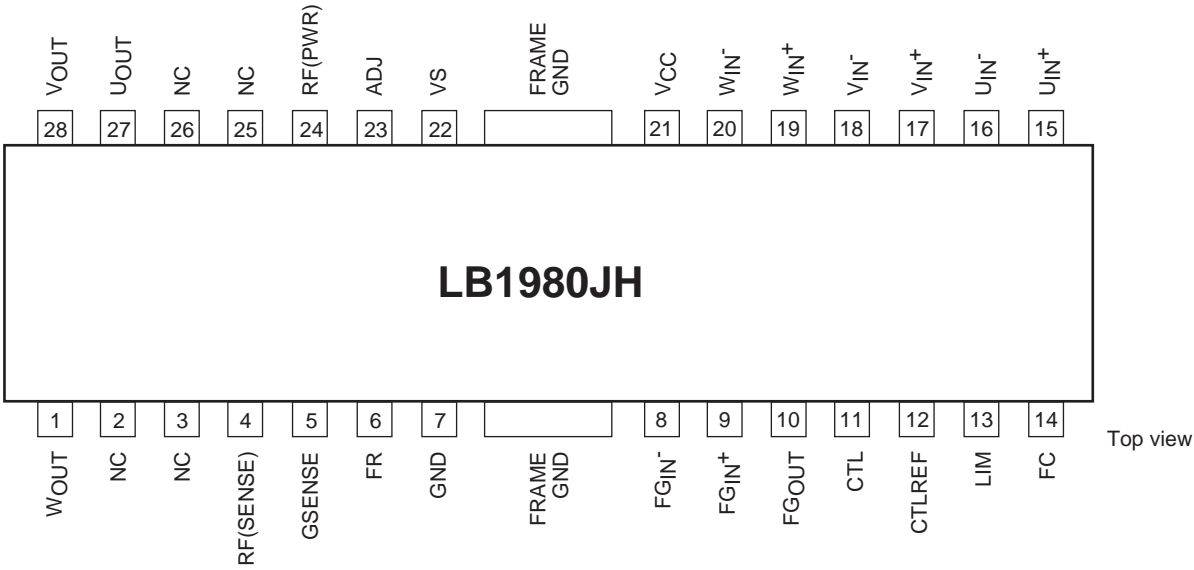
Correction ratio =  $\frac{25(V_p - V_b)}{V_p - V_b} \cdot 1005(\%)$

Package Dimensions

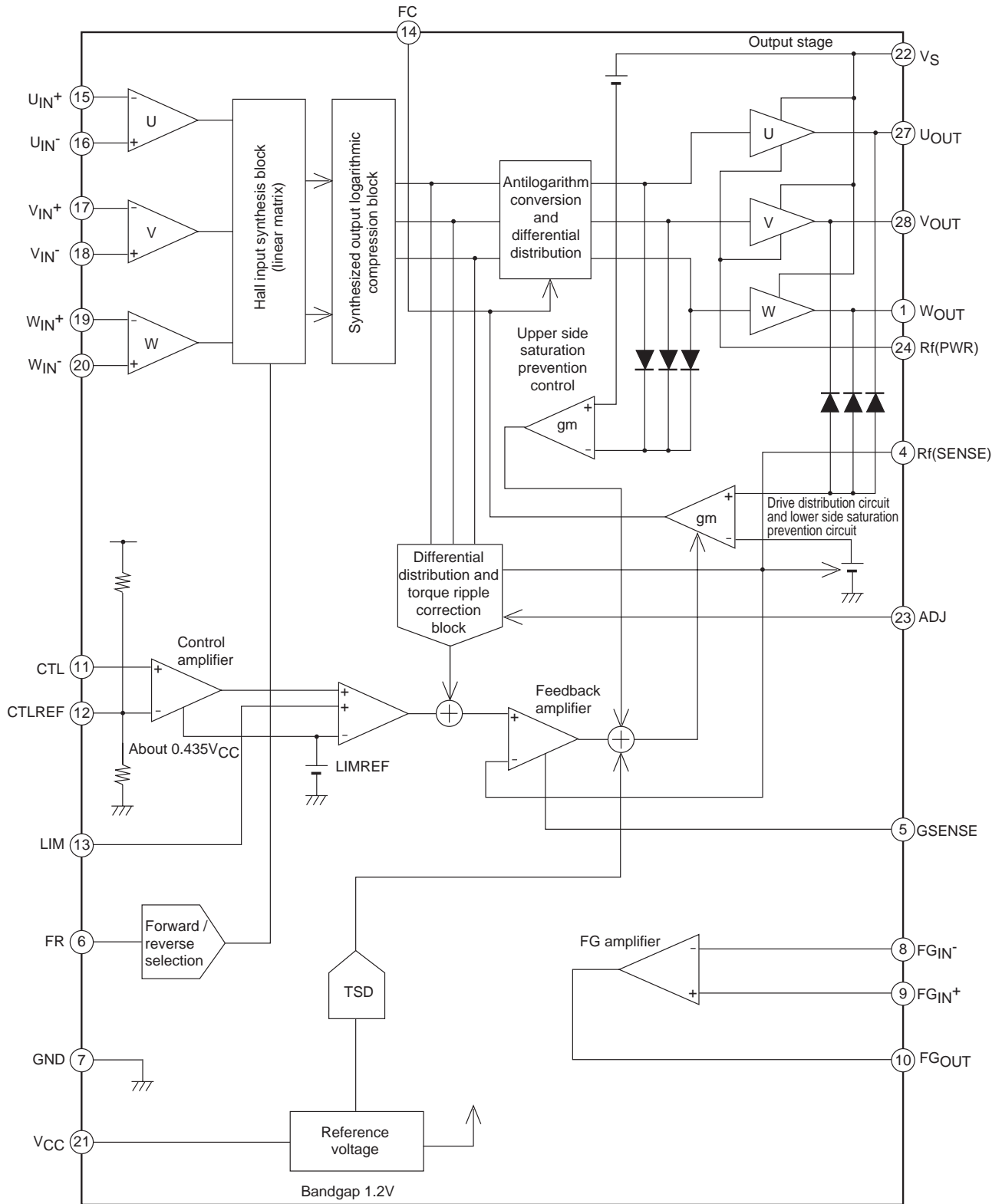
unit : mm (typ)  
3233B



Pin Assignment



# Block Diagram



**LB1980JH**

## Pin Function

Pin No.	Pin Name	Function	Equivalent circuit
27 28 1	U <sub>OUT</sub> V <sub>OUT</sub> W <sub>OUT</sub>	U phase output, Spark killer diodes are built-in. V phase output, Spark killer diodes are built-in. W phase output, Spark killer diodes are built-in.	<p>V<sub>CC</sub> 150μA Lower side saturation prevention circuit input block V<sub>CC</sub> 10μA 200Ω Rf (SENSE) ④</p>
22	V <sub>S</sub>	Output block power supply	
5	GSENSE	Ground sensing. The influence of the common ground impedance on Rf can be excluded by connecting this pin to nearest ground for the Rf resistor side of the motor ground wiring that includes Rf. (This pin must not be left open.)	
6	FR	Forward / reverse selection. The voltage applied to this pin selects the motor direction (forward or reverse). (V <sub>th</sub> =2.5V at V <sub>CC</sub> =5V (typical))	<p>V<sub>CC</sub> 200μA FR ⑥ 200Ω V<sub>CC</sub> ADJ ② 10kΩ 6kΩ 500Ω 6kΩ 10kΩ 20μA V<sub>CC</sub></p>
23	ADJ	Used for external adjustment of the torque ripple correction ratio. Apply a voltage externally with a low-impedance circuit to the ADJ pin to adjust the correction ratio. The correction ratio falls as the applied voltage is increased, and increases as the applied voltage decreases. The torque ripple correction ratio can be modified by factors in the range 0 to 2 times the ratio that applies when his pin is left open. (The pin voltage is set to about V <sub>CC</sub> /2 internally, and the input impedance is about 5kΩ.)	
7	GND	Ground for all circuits other than the output transistors. The lowest potential of the output transistors is that of the Rf pin.	
8	FG <sub>IN</sub> <sup>-</sup>	Input used when the FG amplifier is used as an inverting input. A feedback resistor must be connected between FG <sub>OUT</sub> and this pin.	<p>V<sub>CC</sub> 5μA FG<sub>IN</sub>(-) ⑨ 300Ω FG<sub>OUT</sub> ⑩ 300Ω FG<sub>IN</sub>(+) ⑧</p>
9	FG <sub>IN</sub> <sup>+</sup>	Non-inverting input used when the FG amplifier is used as a differential input amplifier. No bias is applied internally.	
10	FG <sub>OUT</sub>	FG amplifier output. There is an internal resistive load.	<p>V<sub>CC</sub> 2kΩ FG<sub>OUT</sub> ⑩ 300Ω FC ⑭ 10kΩ</p>
14	FC	Speed control loop frequency characteristics correction.	

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Pin No.	Pin Name	Function	Equivalent circuit
11	CTL	Speed control input. The control implemented is fixed current drive controlled by current feedback from Rf. $G_m=0.58 / V$ (typical) when $R_f=0.5\Omega$	
12	CTLREF	Control reference voltage. While this pin is set to about $0.43 \times V_{CC}$ internally, this voltage can be modified by applying a voltage from a low-impedance circuit. (The input impedance is about $4.3k\Omega$ ).	
13	LIM	Current limiter function control. The output current can be varied linearly by applying a voltage to this pin. The slope is $0.5A / V$ (typical) when $R_f=0.5\Omega$ .	
15	$U_{IN}^+$	U phase Hall element inputs.	
16	$U_{IN}^-$	Logic high is defined as states where $IN^+ > IN^-$ .	
17	$V_{IN}^+$	V phase Hall element inputs.	
18	$V_{IN}^-$	Logic high is defined as states where $IN^+ > IN^-$ .	
19	$W_{IN}^+$	W phase Hall element inputs.	
20	$W_{IN}^-$	Logic high is defined as states where $IN^+ > IN^-$ .	
21	$V_{CC}$	Power supply for all internal blocks other than the output block. This voltage must be stabilized so that noise and ripple do not enter the IC.	

### Truth Table and Control Functions

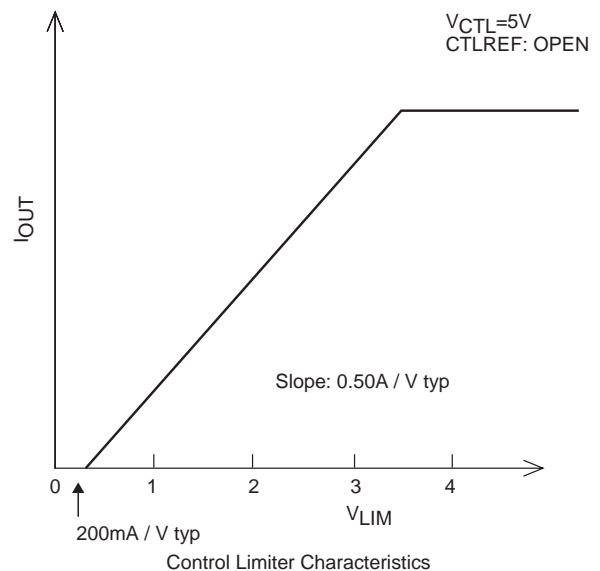
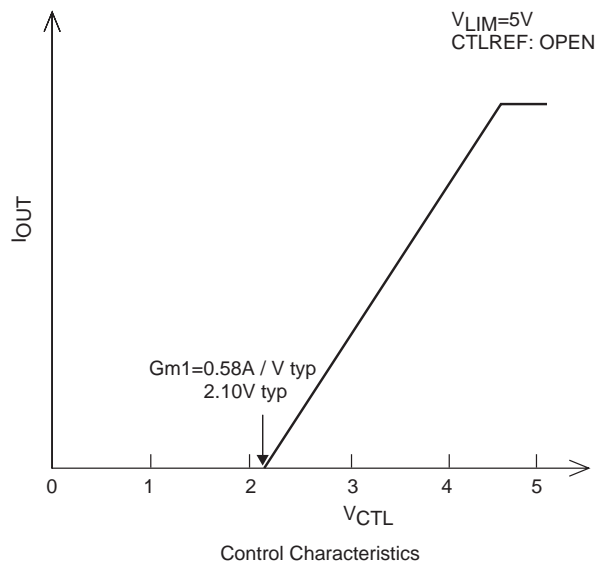
	Source → Sink	Hall input			FR
		U	V	W	
1	Phase V → Phase W	H	H	L	H
	Phase W → Phase V	H	H	L	L
2	Phase U → Phase W	H	L	L	H
	Phase W → Phase U	H	L	L	L
3	Phase U → Phase V	H	L	H	H
	Phase V → Phase U	H	L	H	L
4	Phase W → Phase V	L	L	H	H
	Phase V → Phase W	L	L	H	L
5	Phase W → Phase U	L	H	H	H
	Phase U → Phase W	L	H	H	L
6	Phase V → Phase U	L	H	L	H
	Phase U → Phase V	L	H	L	L

Note: In the FR column, “H” refers to a voltage of 2.75V or higher, and “L” refers to 2.25V or lower (when  $V_{CC}=5V$ ).

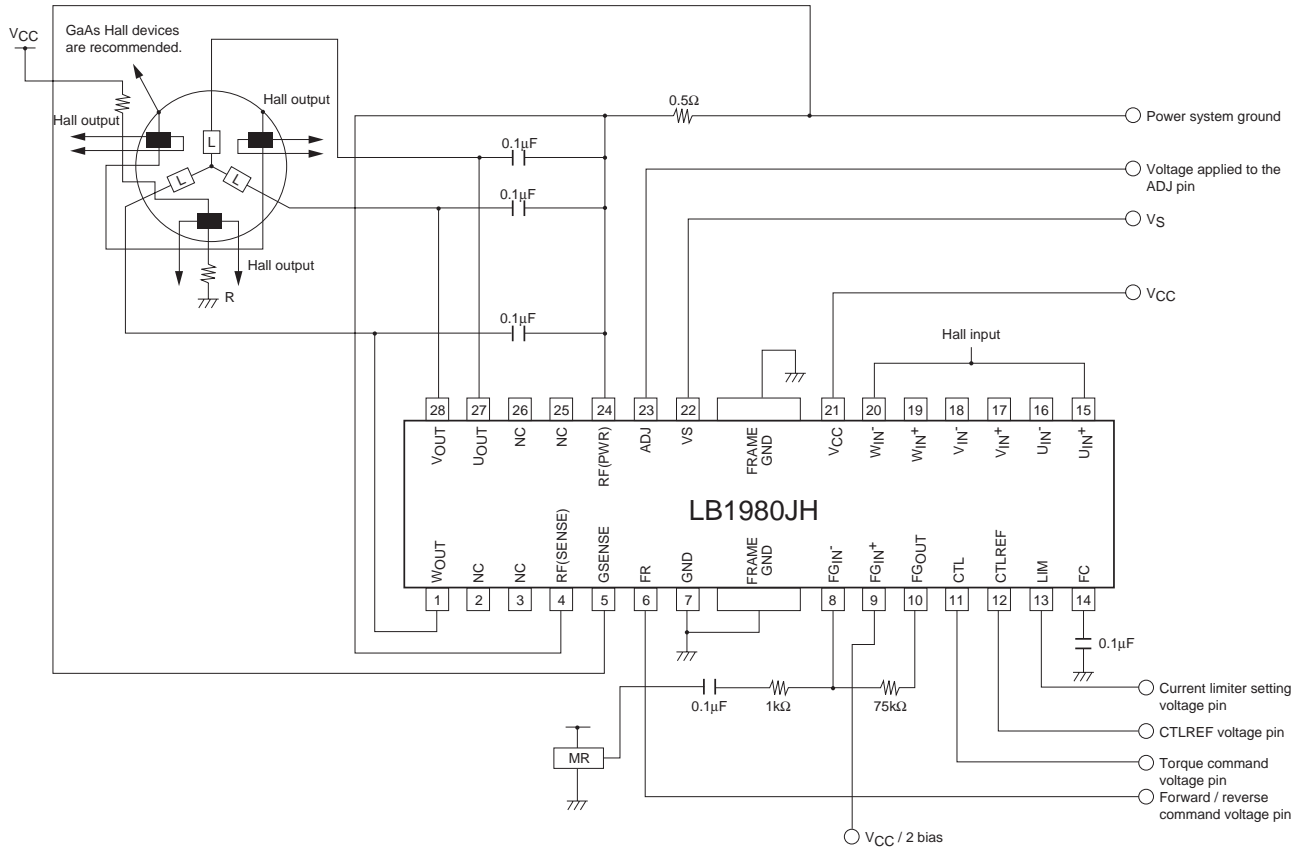
Note: In the Hall input column, “H” refers to the state in the corresponding phase where the +input is at a potential at least 0.01V higher than the -input, and “L” refers to the state where the -input is at a potential at least 0.01V higher than the +input.

Note: Since the drive technique adopted is a  $180^\circ$  technique, phases other than the sink and source phase do not turn off.

### Control Function and Current Limiter Function



# Application Circuit Example



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