Ordering number : EN5975

Monolithic Digital IC

LB1999M

Three-Phase Brushless Motor Driver for VCR Capstan Motors

Overview

The LB1999M is a 3-phase brushless motor driver that is particularly appropriate for VCR capstan motor drivers.

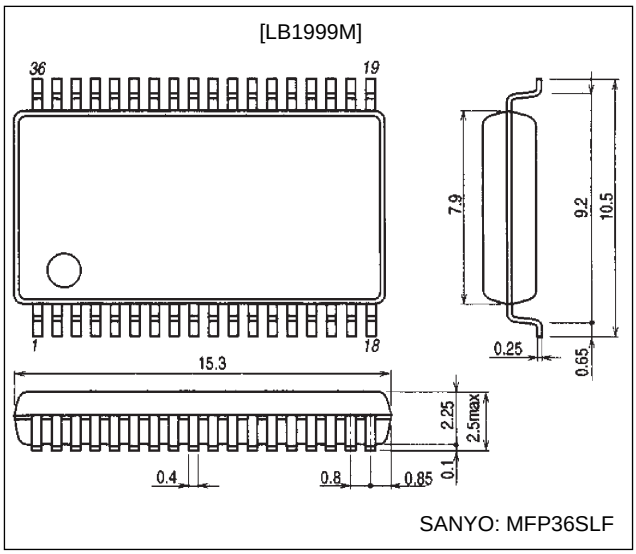
Functions

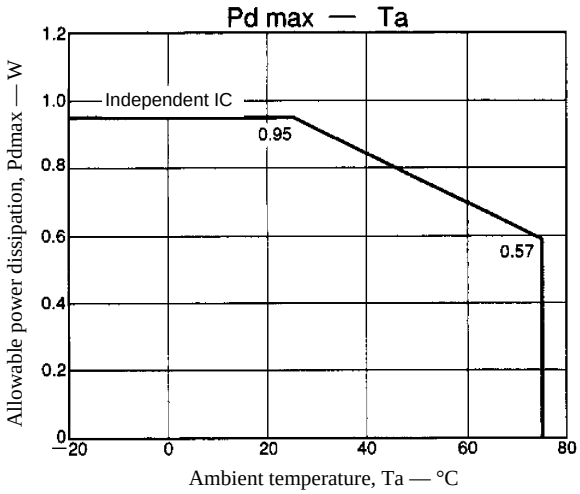
- 3-phase full-wave drive
- Built-in torque ripple correction circuit (fixed correction ratio)
- Built-in current limiter circuit and control characteristics that include gain switching
- Upper and lower side output stage over-saturation prevention circuit that does not require external capacitors.
- FG amplifier with built-in Schmitt comparator
- Thermal shutdown circuit

Package Dimensions

unit: mm

3129-MFP36SLF





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Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max		7	V
	V_S max		24	V
Maximum output current	I_O max		1.3	A
Allowable power dissipation	Pd max	Independent device	0.95	W
Operating temperature	Topr		–20 to + 75	°C
Storage temperature	Tstg		–55 to + 150	°C

Allowable Operating Ranges at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_S		5 to 22	V
	V_{CC}		4.5 to 5.5	V
Hall input amplitude	V_{HALL}	Between the Hall inputs	±30 to ±80	mVo-p
GSENSE pin input range	V_{GSENSE}	With respect to the control system ground	–0.20 to + 0.20	V

Electrical Characteristics at Ta = 25°C, V_{CC} = 5 V, V_S = 15 V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
VCC supply current	I_{CC}	RL = ∞, V_{CTL} = 0 V (Quiescent)		12	18	mA
[Outputs]						
Output saturation voltage	$V_O$sat1	I_O = 500 mA, Rf = 0.5 Ω, Sink + Source V_{CTL} = V_{LIM} = 5 V (With saturation prevention)		2.1	2.6	V
	$V_O$sat2	I_O = 1.0 A, Rf = 0.5 Ω, Sink + Source V_{CTL} = V_{LIM} = 5 V (With saturation prevention)		2.6	3.5	V
Output leakage current	$I_O$leak				1.0	mA
[FR]						
FR pin input threshold voltage	V_{FSR}		2.25	2.50	2.75	V
FR pin input bias current	I_B (FSR)		–5.0			µA
[Control]						
CTLREF pin voltage	V_{CREF}		2.37	2.50	2.63	V
CTLREF pin input range	V_{CREFIN}		1.7		3.50	V
CTL pin input bias current	I_B (CTL)	With V_{CTL} = 5 V and the CTLREF pin open			8.0	µA
CTL pin control start voltage	V_{CTL} (ST)	With Rf = 0.5 Ω, V_{LIM} = 5 V, I_O ≥ 10 mA, Hall input logic fixed (U, V, W = H, H, L)	2.20	2.35	2.50	V
CTL pin control switching voltage	V_{CTL} (ST2)	With Rf = 0.5 Ω, V_{LIM} = 5 V	3.00	3.15	3.30	V
CTL pin control Gm1	Gm (CTL)	With Rf = 0.5 Ω, ΔI$_O$ = 200 mA, Hall input logic fixed (U, V, W = H, H, L)	0.52	0.65	0.78	A/V
CTL pin control Gm2	Gm2 (CTL)	With Rf = 0.5 Ω, ΔV_{CTL} = 200 mV, Hall input logic fixed (U, V, W = H, H, L)	1.20	1.50	1.80	A/V
[Current Limiter]						
LIM current limit offset voltage	Voff (LIM)	With Rf = 0.5 Ω, V_{CTL} = 5 V, I_O ≥ 10 mA, Hall input logic fixed (U, V, W = H, H, L)	140	200	260	mV
LIM pin input bias current	I_B (LIM)	With V_{CTL} = 5 V and the V_{CREF} pin open, V_{LIM} = 0 V	–2.5			µA
LIM pin current control level	I_{LIM}	With Rf = 0.5 Ω, V_{CTL} = 5 V, V_{LIM} = 2.06 V, Hall input logic fixed (U, V, W = H, H, L)	830	900	970	mA
[Hall Amplifier]						
Hall amplifier input offset voltage	Voff (HALL)		–6		+6	mV
Hall amplifier input bias current	I_B (HALL)			1.0	3.0	µA
Hall amplifier common-mode input voltage range	V_{CM} (HALL)		1.3		3.3	V
Torque ripple correction ratio	TRC	For the high and low peaks in the Rf waveform when I_O = 200 mA. (Rf = 0.5 Ω)*1		9		%
[FG Amplifier]						
FG amplifier input offset voltage	Voff (FG)		–8		+8	mV
FG amplifier input bias current	I_B (FG)		–100			nA
FG amplifier output saturation voltage	$V_O$sat (FG)	Sink side, for the load provided by the internal pull-up resistor		0.5	0.6	V
FG bias voltage	V_{FGBI}		2.4	2.5	2.6	V
FG amplifier common-mode input voltage	V_{GM} (FG)		0.5		4.0	V

Notes : 1. The torque ripple correction ratio is determined as follows from the Rf voltage waveform.
2. Parameters that are indicated as design target values in the conditions column are not tested.

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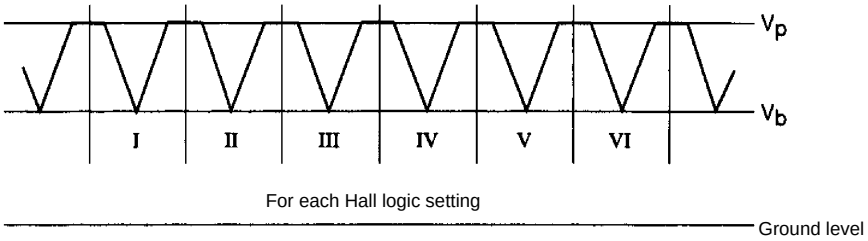
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
[Saturation]						
Saturation prevention circuit lower side voltage setting	$V_O$sat (DET)	The voltages between each OUT and Rf pair when I_O = 10 mA, Rf = 0.5 Ω, and V_{CTL} = V_{LIM} = 5 V	0.175	0.25	0.325	V
[Schmitt Amplifier]						
Duty ratio	DUTY	Under the specified conditions (R_F = 39 kΩ)	48.7	50	51.3	%
Upper side output saturation voltage	Vsatu (SH)	I_O = –20 μA	4.8			V
Lower side output saturation voltage	Vsatd (SH)	I_O = 100 μA			0.2	V
Hysteresis width	Vhys		32	46	60	mV
TSD operating temperature	T-TSD	Design target value*2		170		°C

Notes : 1. The torque ripple correction ratio is determined as follows from the Rf voltage waveform.
2. Parameters that are indicated as design target values in the conditions column are not tested.



$$\text{Correction ratio} = \frac{2 \times (V_p - V_b)}{V_p - V_b} 100 \times (\%)$$

Truth Table and Control Functions

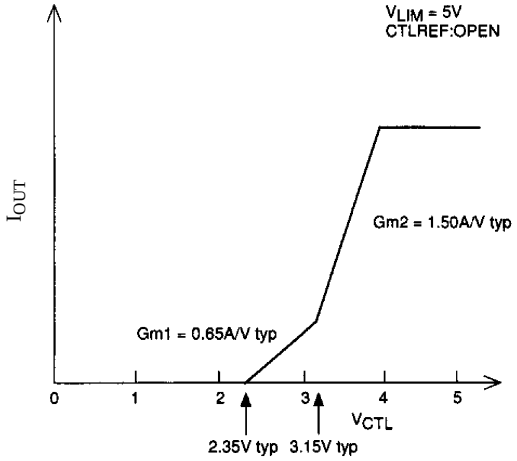
	Source → Sink	Hall input			FR
		U	V	W	
1	Phase V → Phase W	H	H	L	H
	Phase W → Phase V				L
2	Phase U → Phase W	H	L	L	H
	Phase W → Phase U				L
3	Phase U → Phase V	H	L	H	H
	Phase V → Phase U				L
4	Phase W → Phase V	L	L	H	H
	Phase V → Phase W				L
5	Phase W → Phase U	L	H	H	H
	Phase U → Phase W				L
6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

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

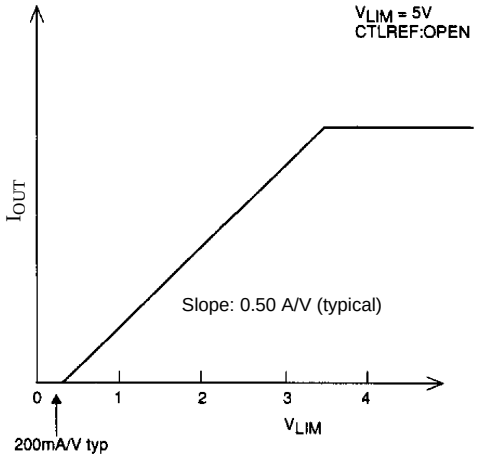
Note: In the FR column, “H” refers to a voltage of 2.75 V or higher, and “L” refers to 2.25 V or lower (when V_{CC} = 5 V.)

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

Control Function and Current Limiter Function

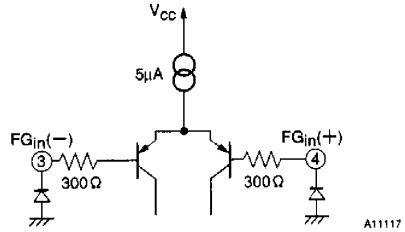
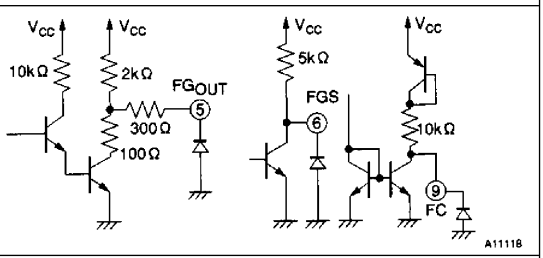
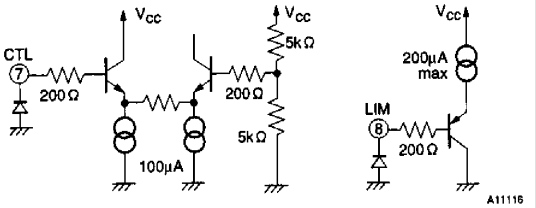
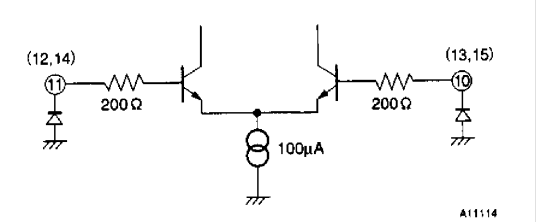


Control Characteristics



Control Limiter Characteristics

Pin Descriptions

Pin No.	Pin	Function	Equivalent circuit
3	FG_{IN}^{+}	Input used when the FG amplifier is used as an inverting input. A feedback resistor must be connected between FG_{OUT} and this pin.	
4	FG_{IN}^{-}	Noninverting input used when the FG amplifier is used as a differential input amplifier. No bias is applied internally.	
5	FG_{OUT}	FG amplifier output. There is an internal resistive load.	
6	FGS	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 4.3 kΩ).	
9	FC	Speed control loop frequency characteristics correction.	
7	CTL	Speed control input. The control implemented is fixed current drive controlled by current feedback from Rf. Gm = 0.58/V (typical) when Rf = 0.5 Ω.	
8	LIM	Current limiter function control. The output current can be varied linearly by applying a voltage to this pin. The slope is 0.5 A/V (typical) when Rf = 0.5 Ω.	
10 11	U_{IN}^{+} U_{IN}^{-}	U phase Hall element inputs. Logic high is defined as states where $IN^{+} > IN^{-}$.	
12 13	V_{IN}^{+} V_{IN}^{-}	V phase Hall element inputs. Logic high is defined as states where $IN^{+} > IN^{-}$.	
14 15	W_{IN}^{+} W_{IN}^{-}	W phase Hall element inputs. Logic high is defined as states where $IN^{+} > IN^{-}$.	
16	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.	

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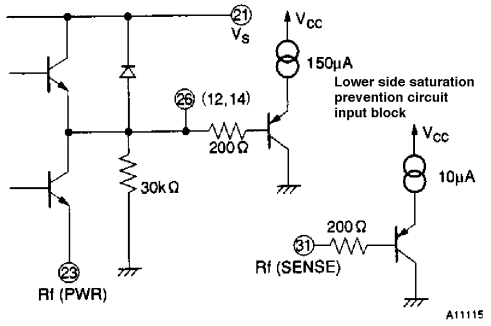
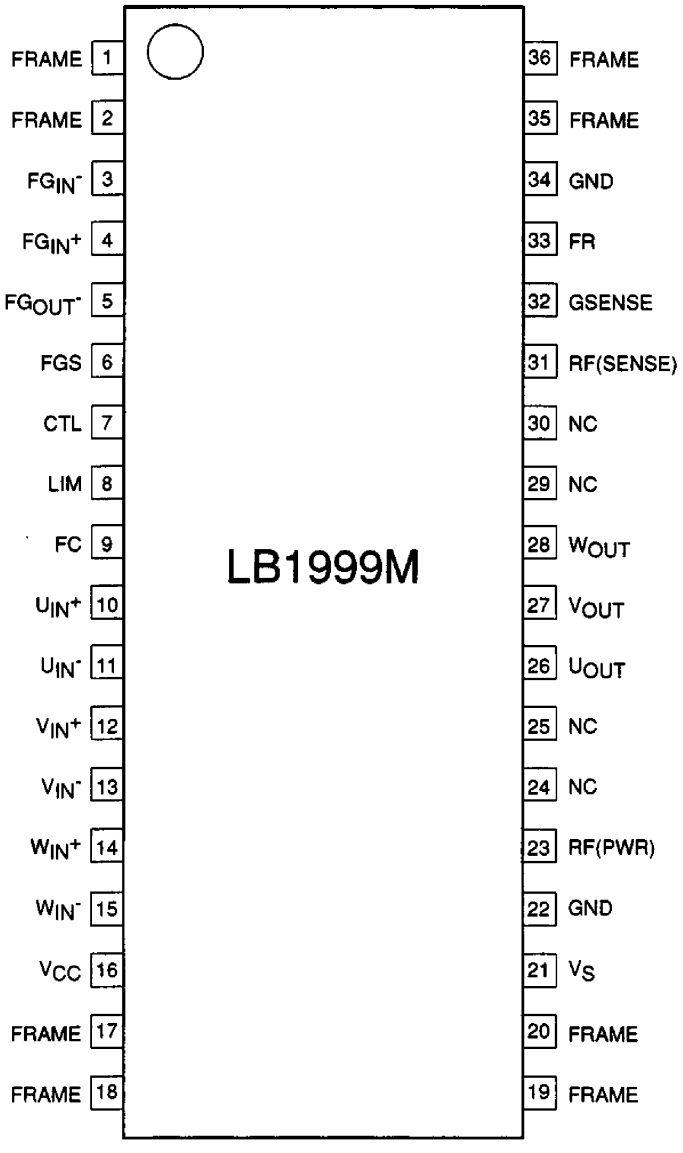
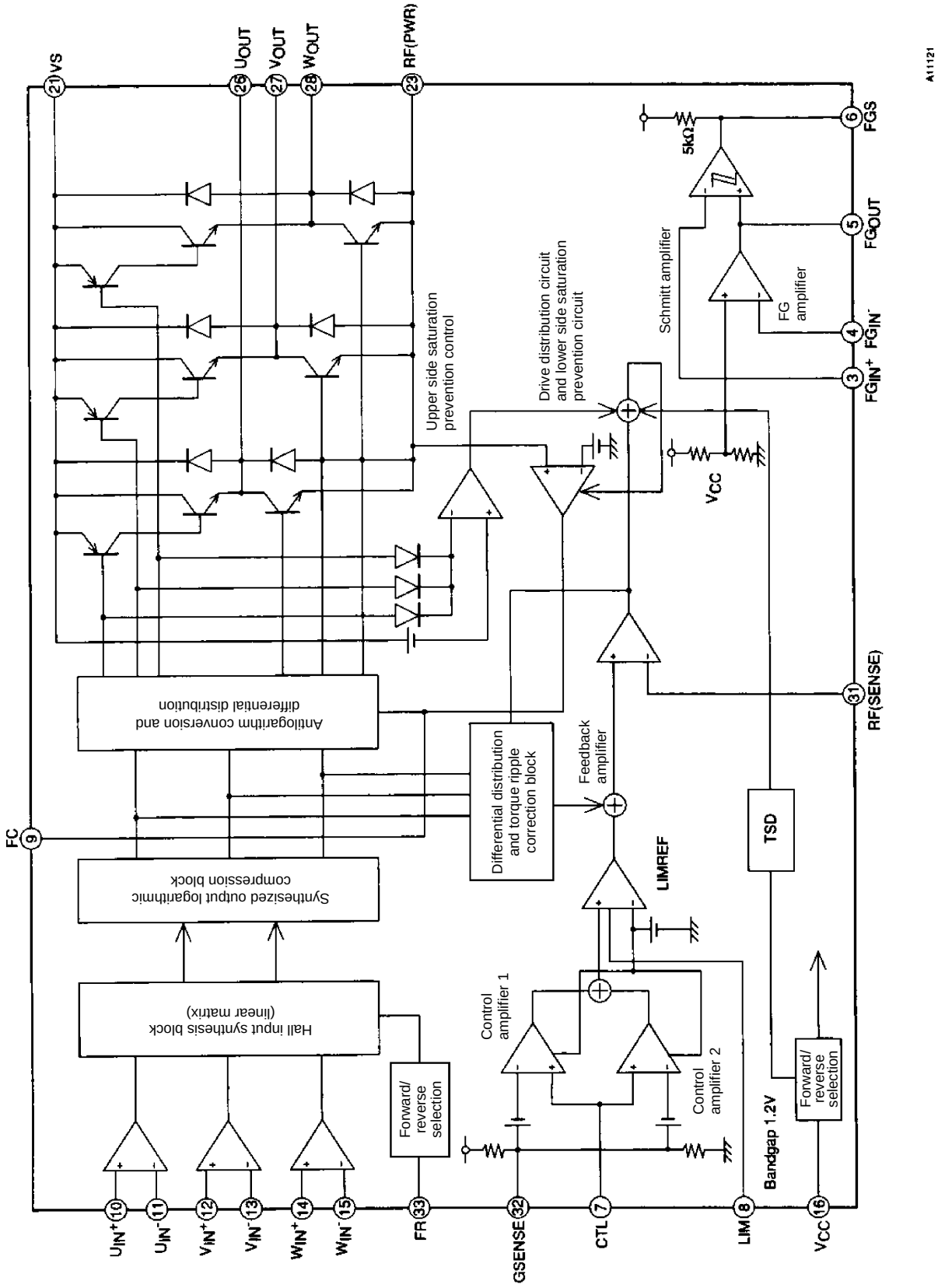
Pin No.	Pin	Function	Equivalent circuit
21	V_S	Output block power supply	
23 31	Rf (PWR) Rf (SNS)	Output current detection. The control block current limiter operates using the resistor Rf connected between these pins and ground. Also, the lower side saturation prevention circuit and the torque ripple correction circuit operate based on the voltages to this pin. It is especially important to note that, since the saturation prevention level is set using this voltage, the lower side saturation prevention circuit will become less effective in the large current region if the value of Rf is lowered excessively. Also, the PWR and SENSE pins must be connected together.	
26 27 28	U_{OUT} V_{OUT} W_{OUT}	U phase output V phase output W phase output (Spark killer diodes are built-in.)	
32	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.)	
33	FR	Forward/reverse selection. The voltage applied to this pin selects the motor direction (forward or reverse). (Vth = 2.5 V at V_{CC} = 5 V (typical))	

Pin Assignment



Note: Although the FRAME pins and the GND pins are not connected internally, the potentials of the GND pins and the FRAME pins externally be identical to assure ground potential stability.

Block Diagram



Sample Application Circuit