



LB1971V

Three-Phase Full-Wave Sensorless CD and MD Players Spindle Motor Driver

Overview

The LB1971V is a bipolar sensorless motor driver that provides a reverse torque braking function and is appropriate for use as the spindle motor driver in CD and MD players. Since the LB1971V can drive motors without the use of Hall elements, this device can contribute to miniaturization, thinner form factors, and lower power dissipation in end products.

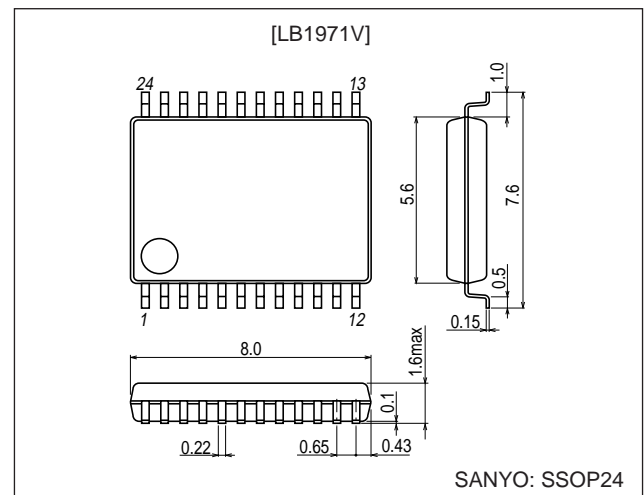
Functions and Features

- Three-phase bipolar sensorless drive
- Soft switching drive technique
- Reverse torque braking
- Standby mode power saving function
- FG outputs
- Can be operated from a 3-V supply.
- Thermal protection circuit

Package Dimensions

unit: mm

3175A-SSOP24



Specifications

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

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage 1	V_{CC1max}		7.0	V
Maximum supply voltage 2	V_{CC2max}		7.0	V
Maximum output circuit supply voltage	$V_S max$		7.0	V
Maximum output current	$I_O max$		700	mA
Allowable power dissipation	P_{dmax}		0.4	W
Operating temperature	T_{opr}		-20 to +75	$^\circ\text{C}$
Storage temperature	T_{stg}		-55 to +150	$^\circ\text{C}$

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Allowable Operating Ranges at $T_a = 25^\circ\text{C}$

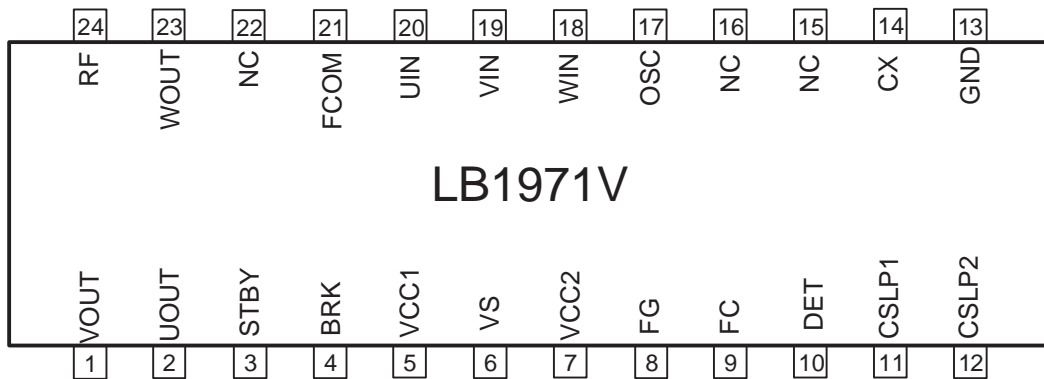
Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage 1	V_{CC1}		2.0 to 6.0	V
Supply voltage 2	V_{CC2}		2.0 to 6.0	V
Output circuit supply voltage	V_S		0 to V_{CC2}	V
FG pin applied voltage	V_{FG}		0 to 6.0	V
FG pin output current	I_{FG}		2.0	mA

Electrical Characteristics at $V_{CC} = 3.0\text{ V}$, $V_S = 1.5\text{ V}$, $T_a = 25^\circ\text{C}$

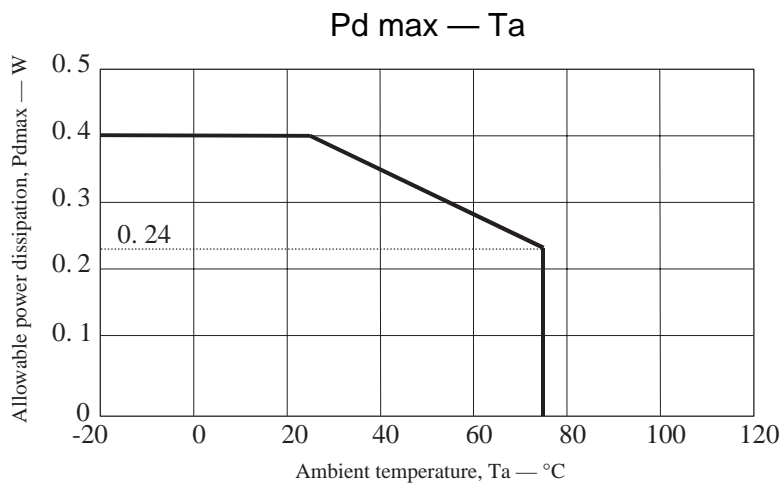
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
[Current Drain]						
Power save mode current drain	I_{CC1-1}	STBY mode			5	μA
Operating current drain	I_{CC1-2}	$I_O = 20\text{ mA}$		3.6	4.6	mA
Pre-drive current	I_{CC2}	$I_O = 20\text{ mA}$		0.4	1.0	mA
Current drain + pre-drive current	I_{CC1+2}	$I_O = 20\text{ mA}$		4.0	5.5	mA
[Output Saturation Voltage]						
Source 1-1	V_{sat1-1}	$I_O = 0.4\text{ A}$, $V_{CC1} = V_{CC2} = V_S$		0.90	1.00	V
Source 1-2	V_{sat1-2}	$I_O = 0.2\text{ A}$, $V_{CC1} = V_{CC2} = V_S$		0.85	0.95	V
Source 2-1	V_{sat2-1}	$I_O = 0.4\text{ A}$, $V_{CC1} = V_{CC2} = 3\text{V}$, $V_S = 1.5\text{ V}$		0.25	0.35	V
Source 2-2	V_{sat2-2}	$I_O = 0.2\text{ A}$, $V_{CC1} = V_{CC2} = 3\text{V}$, $V_S = 1.5\text{ V}$		0.15	0.25	V
Sink 1	V_{sat3-1}	$I_O = 0.4\text{ A}$		0.20	0.35	V
Sink 2	V_{sat3-2}	$I_O = 0.2\text{ A}$		0.13	0.25	V
[STBY Pin]						
High-level input voltage	V_{SSH}		1.4		V_{CC1}	V
Low-level input voltage	V_{SSL}		-0.1		0.3	V
High-level input current	I_{SSH}	$V_{STBY} = 3.0\text{ V}$		75		μA
Low-level input current	I_{SSL}	$V_{STBY} = 0\text{ V}$	-10			μA
[BRAKE Pin]						
High-level input voltage	V_{BRKH}		1.4		V_{CC1}	V
Low-level input voltage	V_{BRKL}		-0.1		0.3	V
High-level input current	I_{BRKH}	$V_{BRK} = 3\text{ V}$		60		μA
Low-level input current	I_{BRKL}	$V_{BRK} = 0\text{ V}$	-10			μA
[Startup Oscillator]						
High-level output voltage	V_{OSCH}		1.35	1.50	1.65	V
Low-level output voltage	V_{OSCL}		0.50	0.65	0.80	V
[Position Detection Circuit]						
Offset voltage	V_{OFS}	Design target value	-10		+10	mV
Common-mode input voltage range	V_{ICM}		0		$V_{CC2} - 1.5$	V
[FG Output Pin]						
Output saturation voltage	V_{FGSAT}	$I_{FG} = 0.4\text{ mA}$		0.1	0.25	V
[Thermal Protection Circuit]						
Operating temperature	TSD	Design target value	150	180		$^\circ\text{C}$
Hysteresis	ΔTSD	Design target value		40		$^\circ\text{C}$
[CX Oscillator]						
High-level output voltage	V_{CXH}		0.8	1.0	1.2	V
Low-level output voltage	V_{CXL}		0.3	0.5	0.7	V
Oscillator frequency	f_{CX}	$C = 470\text{ pF}$		40		Hz
[SLOPE Circuit]						
Charge current	I_{CHG1}		-6.0	-4.5	-3.0	μA
Discharge current	I_{CHG2}		3.0	4.5	6.0	μA

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Pin Assignment

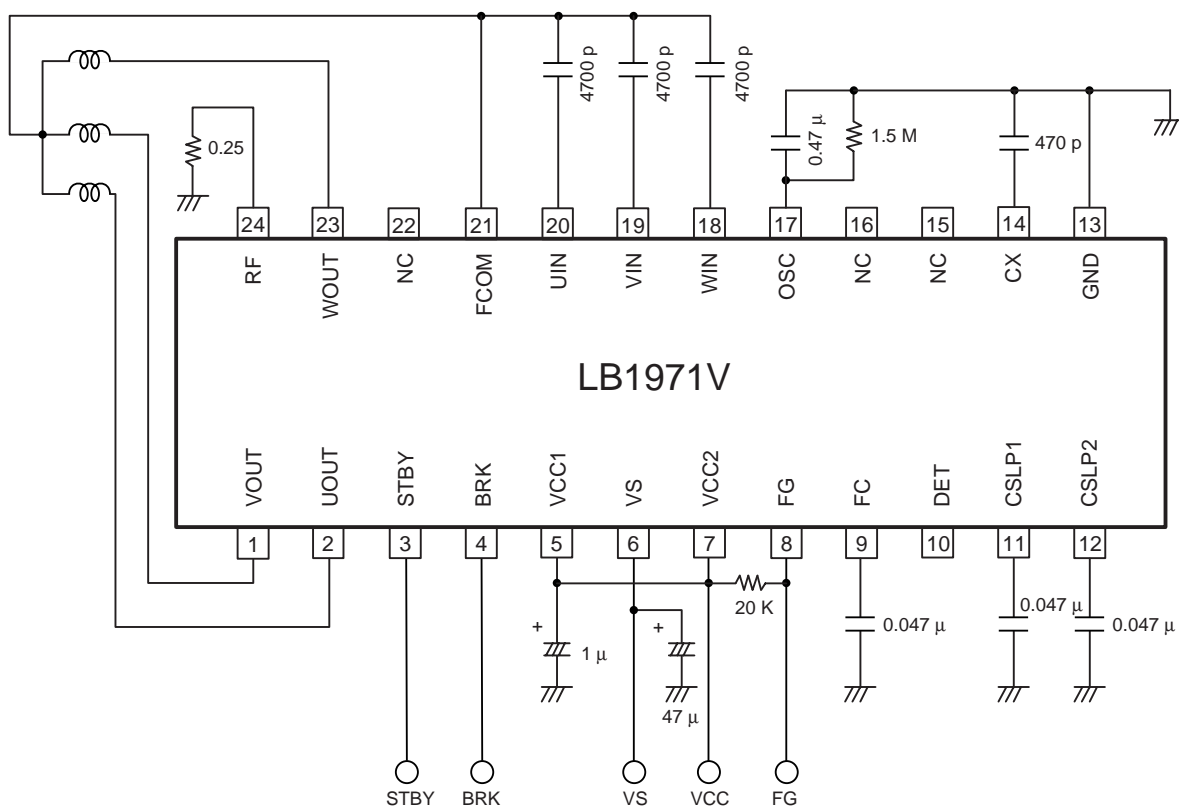


Top view



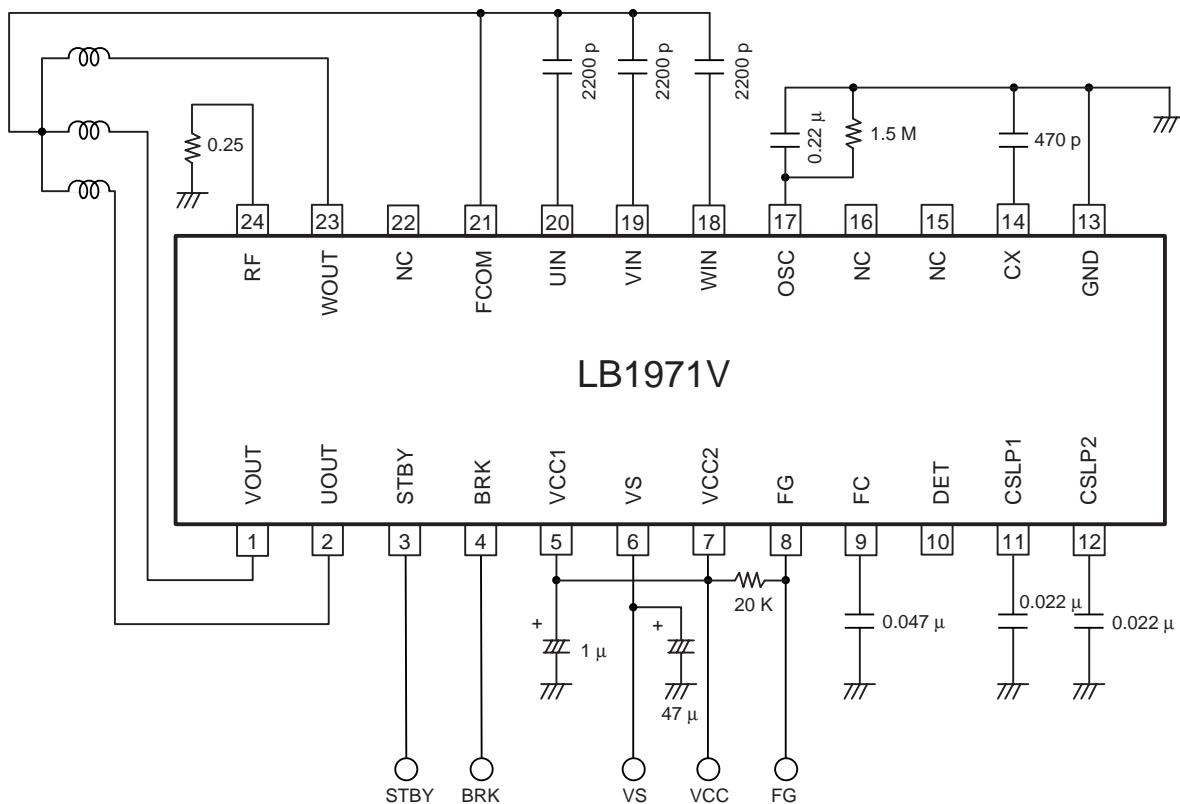
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Application Circuit Example 1: Portable CD Player (maximum speed: about 1000 rpm)



Unit (resistance: Ω, capacitance: F)

Application Circuit Example 2: Portable MD Player (maximum speed: about 2000 rpm)



Unit (resistance: Ω, capacitance: F)

Notes on the LB1971V and External Components

1. Three-phase full-wave sensorless drive

The LB1971V is a 3-phase full-wave sensorless motor driver that provides a reverse torque braking function and is appropriate for CD and MD players spindle motor drive. Furthermore, since this driver does not require the use of Hall-effect devices, it can contribute to miniaturization, thinner form factors, and lower power in the motor system.

2. Power supply

This IC uses 3 power supply systems: V_S , V_{CC1} , and V_{CC2} . V_S is connected to the motor drive transistors, and allows motor speed control to be implemented by connecting a power supply that varies according to the speed control. Since V_{CC2} is connected to the pre-drive circuit and the position detection comparator circuit, the SOURCE pin output can be made to have a low saturation voltage and a highly efficient motor operation can be achieved by maintaining the condition that $V_S \leq V_{CC2} - 1$ V. Also note that while this IC can be operated from voltages as low as $V_{CC1} = V_{CC2} = 2$ V, the common-mode input voltage range of the position detector becomes quite narrow at this low voltage, and care is required with respect to the applied V_S voltage.

Capacitors with an adequate capacitance for stability must be inserted between each of the power supplies and ground.

3. Soft switching drive

This IC adopts a soft switching drive technique to minimize motor noise. When the output transistors switch between phases, a two-phase excitation state is created, and the output current is switched gradually to suppress motor noise. The two-phase excitation state is determined by the amplitude of the CSLP pin waveform, and that waveform amplitude is determined by the value of the capacitor connected at the CSLP pin and the motor speed. Note that while the soft switching operation increases as the amplitude of the CSLP pin voltage decreases, drive efficiency is reduced and timing problems may occur if this amplitude becomes too small. Therefore, the CSLP pin amplitude should be at least 200 mVp-p at the maximum motor speed.

4. Position detection comparator circuit

The position detection comparator circuit uses the back EMF generated during motor rotation to detect the position of the rotor. The position information acquired by this circuit is used to determine to which sections of the output block power will be applied. Problems that occur during startup due to noise in the VS line can be prevented by inserting capacitors between the FCOM pin and the UIN, VIN, and WIN pins. However, the timing with which power is applied during high-speed motor operation may be delayed and efficiency reduced if these capacitors are too large.

5. Startup oscillator circuit (OSC pin)

This oscillator circuit creates the commutation logic timing required to start a sensorless motor.

A capacitor and a resistor are connected in parallel to ground. Use a high resistance of about 1.5 M Ω for this resistor. The value of the capacitor depends on the characteristics of the motor: select a value such that the time required to reach the target speed is minimum and the variation in the startup time is as small as possible. If the capacitance is too large, the variations in startup time will increase, and if it is too small the motor may be prevented from starting up normally.

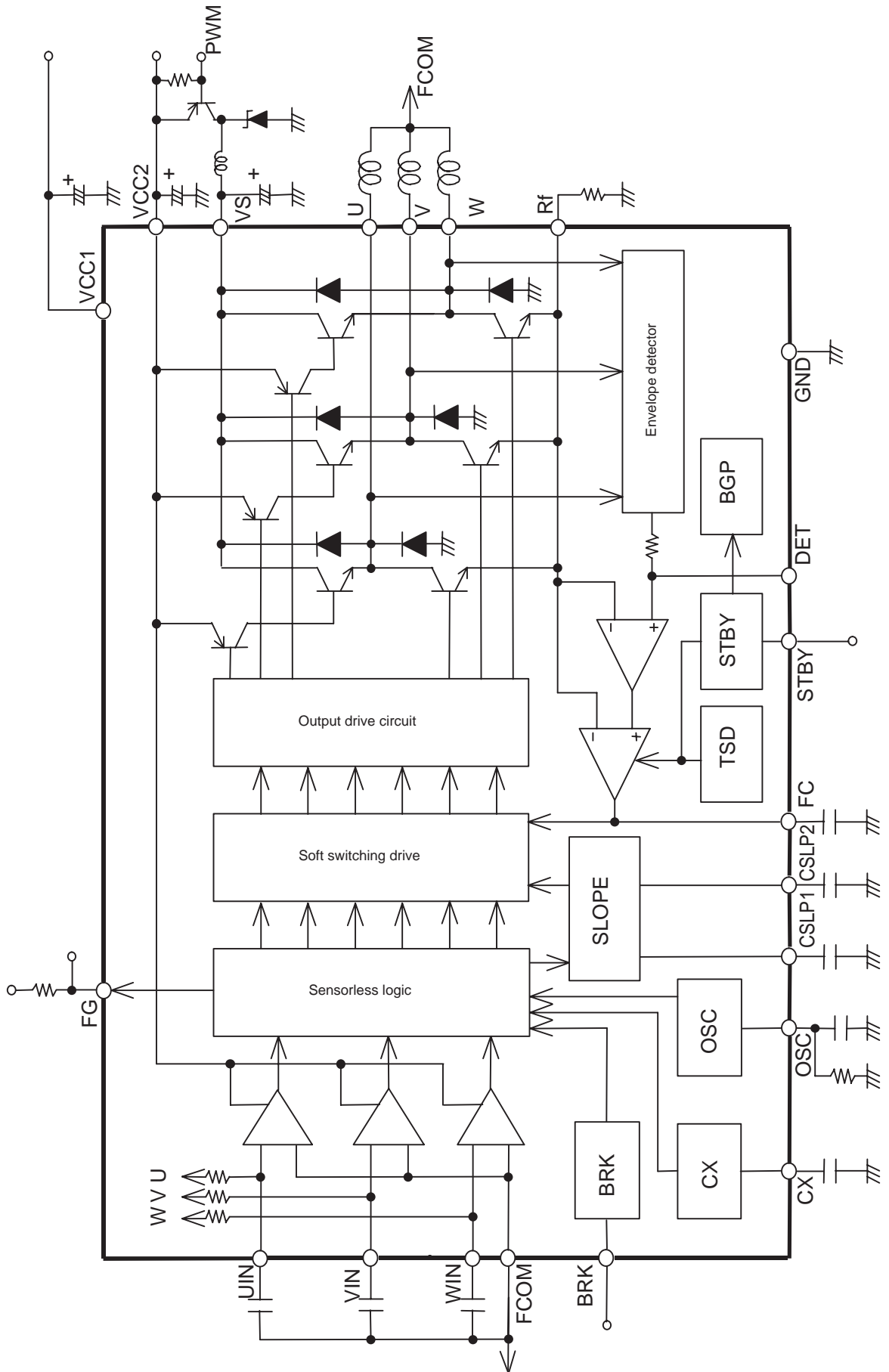
6. CX oscillator circuit

This oscillator circuit creates the reference clock used for the sensorless motor logic system. Insert a capacitor to ground. The oscillator frequency increases as the capacitance decreases. The oscillator frequency must be less than 60 Hz. (The recommended capacitance is 470 pF.)

7. FG output circuit

The FG output is created from the position detection information acquired from the back EMF waveform. This output has a frequency three times that of the switching frequency. The output circuit is an open collector circuit. The output is pulled up with a resistor.

Block Diagram



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Pin Functions

Pin No.	Symbol	Pin voltage	Function	Equivalent circuit
2 1 23	U_{OUT} V_{OUT} W_{OUT}		<ul style="list-style-type: none"> U, V, and W phases coil outputs 	
24	RF		<ul style="list-style-type: none"> Rf connection The LB1971V implements current control using a resistor (Rf) connected between this pin and ground to detect the drive current. 	
3	STBY	0 to V_{CC1}	<ul style="list-style-type: none"> Standby control Normal operation: High Standby: Low or open 	
4	BRK	0 to V_{CC1}	<ul style="list-style-type: none"> Forward/reverse torque switching Forward torque: Low or open Reverse torque: High 	
5	V_{CC1}	2.0 V to 6.0 V	<ul style="list-style-type: none"> Power supply connection 	
6	V_S	0 V to V_{CC2}	<ul style="list-style-type: none"> Motor drive and speed control blocks power supply The voltage applied to this pin must be strictly lower than V_{CC2}. 	
7	V_{CC2}	2.0 V to 6.0 V	<ul style="list-style-type: none"> Power supply connection for the pre-drive circuit and the motor back EMF detection comparator circuit 	
8	FG		<ul style="list-style-type: none"> FG output These are open collector output. 	

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Pin No.	Symbol	Pin voltage	Function	Equivalent circuit
9	FC		<ul style="list-style-type: none"> Frequency characteristics determination Closed loop oscillation of the current control system can be stopped by connecting a capacitor between this pin and ground. 	
10	DET		<ul style="list-style-type: none"> Drive waveform sink side envelope detection Nothing connected to this pin in normal operation. 	
11 12	CSLP1 CSLP2		<ul style="list-style-type: none"> Connection for the capacitor used for triangular wave generation The soft switching operation of the coil output waveform is created using this triangular waveform. 	
13	GND		<ul style="list-style-type: none"> Ground 	
14	CX		<ul style="list-style-type: none"> Clock oscillator used by the sensorless logic Connect a capacitor between the CX pin and ground. Oscillator frequency must be set up to 60 kHz. 	
15 16 22	NC		<ul style="list-style-type: none"> Unused 	

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Pin No.	Symbol	Pin voltage	Function	Equivalent circuit
17	OSC		<ul style="list-style-type: none"> Connection for the triangular waveform oscillator capacitor. This waveform is used to generate the forcible motor startup waveform during motor startup. Connect a capacitor and a resistor between this pin and ground. Capacitance required depends on the characteristics of motor. Use a capacitor so that the time interval until when the motor rotation reaches the desired speed becomes the shortest. 	
18 20 19	W_{IN} U_{IN} V_{IN}		<ul style="list-style-type: none"> Inputs to the motor back EMF detection comparator. These pins are connected to the output pins via a resistor internally in the IC. Connect capacitors between these IN pins and their corresponding -FCOM. 	
21	FCOM		<ul style="list-style-type: none"> Motor coil midpoint input. The back EMF output is detected by referring to these voltages. 	

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