



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.

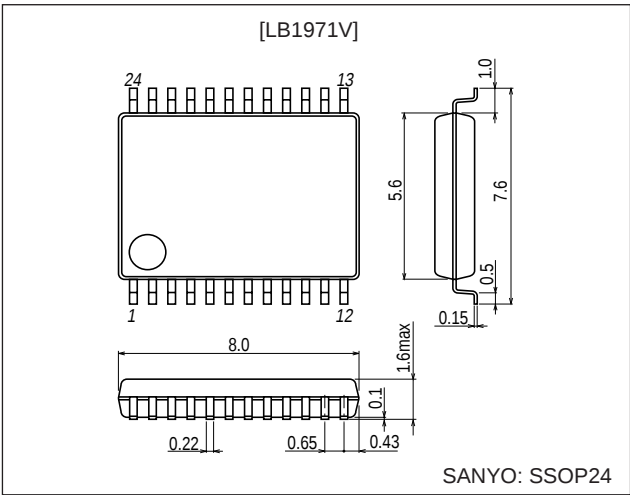
Functions and Features

- 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 Ta = 25°C

| Parameter                             | Symbol              | Conditions | Ratings     | Unit |
|---------------------------------------|---------------------|------------|-------------|------|
| Maximum supply voltage 1              | V <sub>CC1max</sub> |            | 7.0         | V    |
| Maximum supply voltage 2              | V <sub>CC2max</sub> |            | 7.0         | V    |
| Maximum output circuit supply voltage | V <sub>S max</sub>  |            | 7.0         | V    |
| Maximum output current                | I <sub>O max</sub>  |            | 700         | mA   |
| Allowable power dissipation           | P <sub>dmax</sub>   |            | 0.4         | W    |
| Operating temperature                 | T <sub>opr</sub>    |            | -20 to +75  | °C   |
| Storage temperature                   | T <sub>stg</sub>    |            | -55 to +150 | °C   |

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## LB1971V

### Allowable Operating Ranges at Ta = 25°C

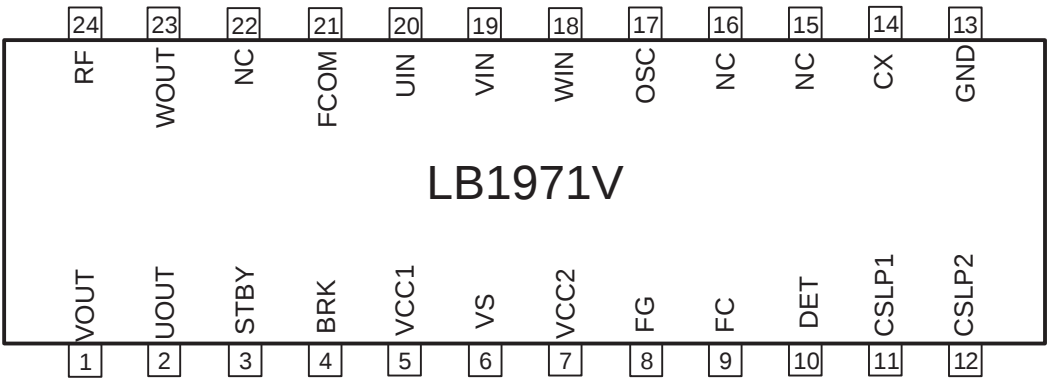
| Parameter                     | Symbol           | Conditions | Ratings               | Unit |
|-------------------------------|------------------|------------|-----------------------|------|
| Supply voltage 1              | V <sub>CC1</sub> |            | 2.0 to 6.0            | V    |
| Supply voltage 2              | V <sub>CC2</sub> |            | 2.0 to 6.0            | V    |
| Output circuit supply voltage | V <sub>S</sub>   |            | 0 to V <sub>CC2</sub> | V    |
| FG pin applied voltage        | V <sub>FG</sub>  |            | 0 to 6.0              | V    |
| FG pin output current         | I <sub>FG</sub>  |            | 2.0                   | mA   |

### Electrical Characteristics at V<sub>CC</sub> = 3.0 V, V<sub>S</sub> = 1.5 V, Ta = 25°C

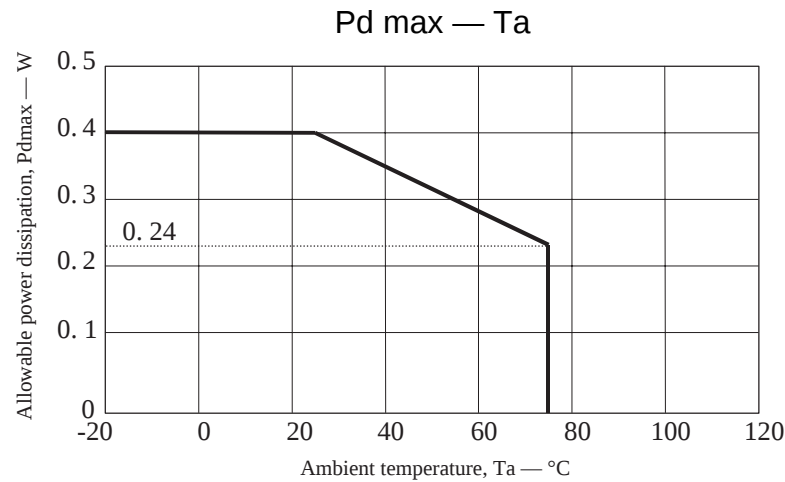
| Parameter                         | Symbol              | Conditions                                                                              | Ratings |      |                        | Unit |
|-----------------------------------|---------------------|-----------------------------------------------------------------------------------------|---------|------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

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Pin Assignment

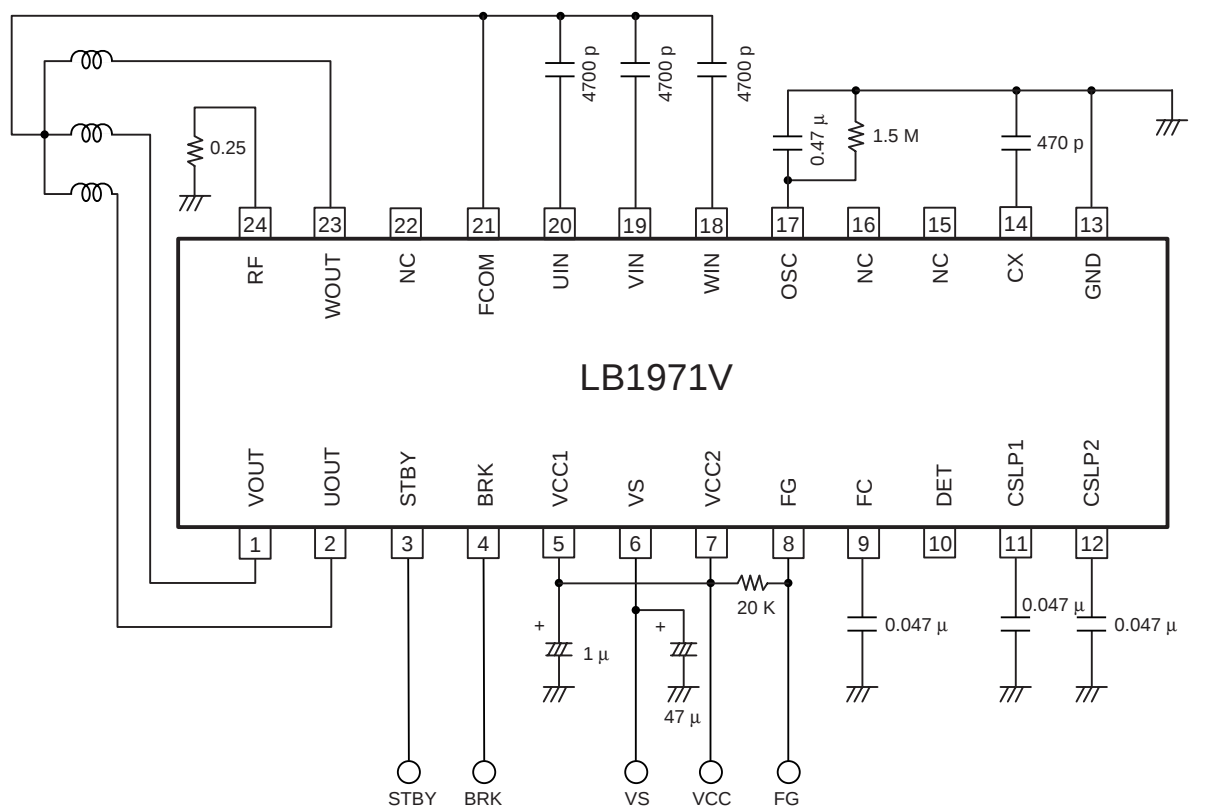


Top view

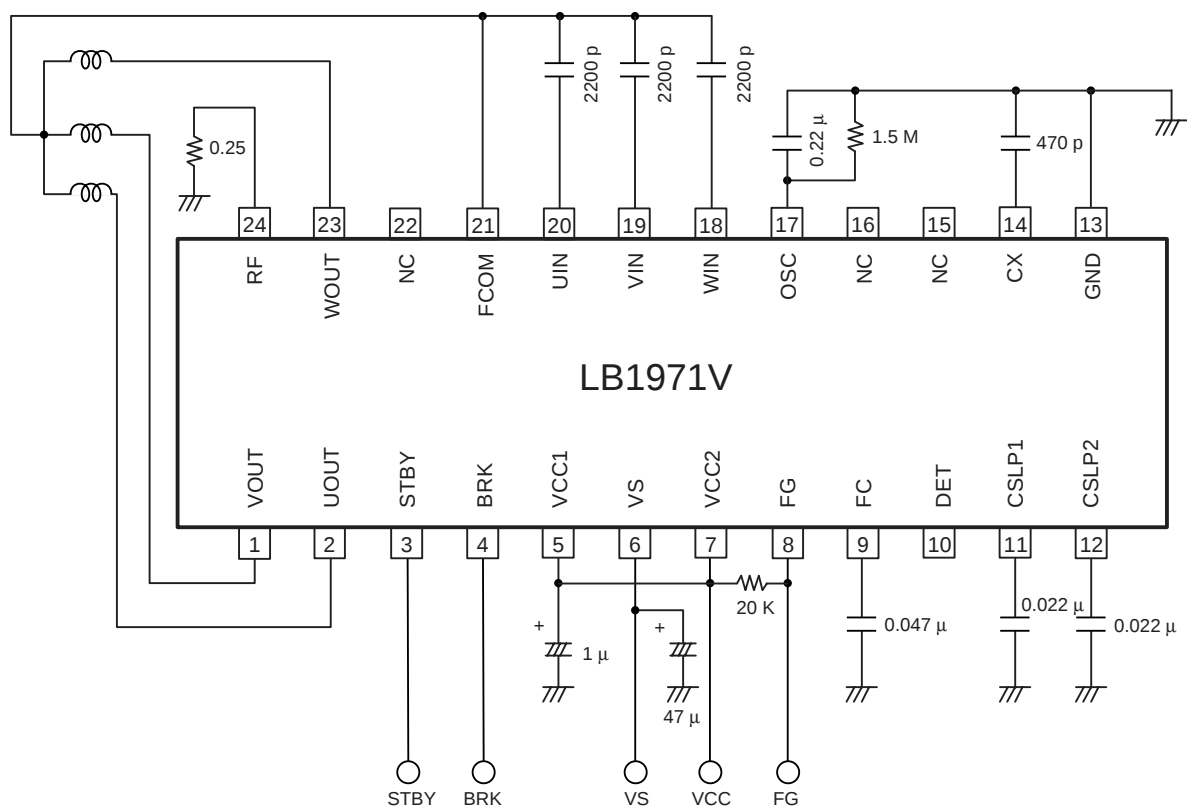


## LB1971V

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



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



## **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 $\Omega$  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.

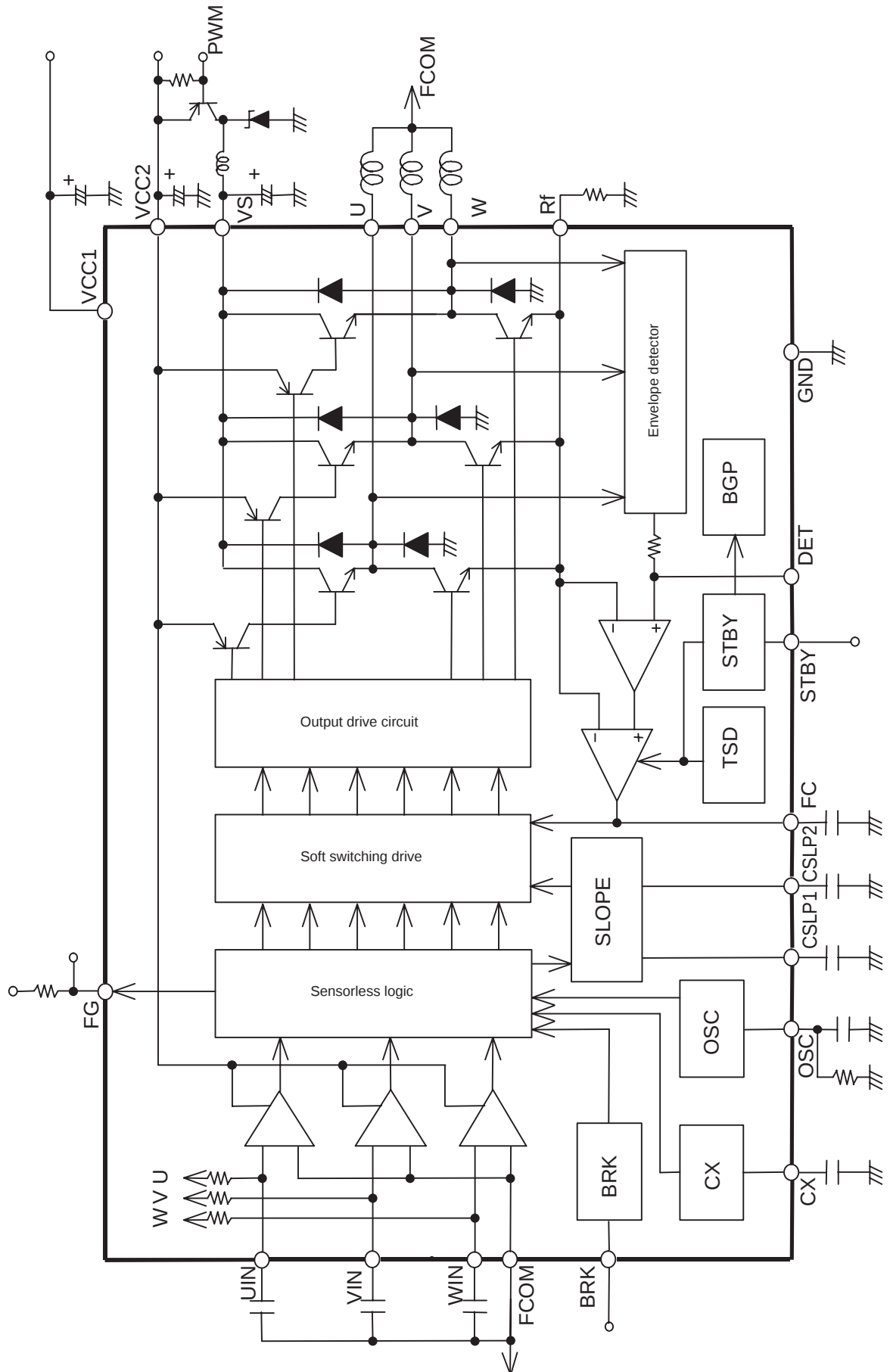
### **6. CX oscillator circuit**

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<br>1<br>23 | $U_{OUT}$<br>$V_{OUT}$<br>$W_{OUT}$ |                  | <ul style="list-style-type: none"> <li>U, V, and W phases coil outputs</li> </ul>                                                                                                                   |                    |
| 24           | RF                                  |                  | <ul style="list-style-type: none"> <li>Rf connection<br/>The LB1971V implements current control using a resistor (Rf) connected between this pin and ground to detect the drive current.</li> </ul> |                    |
| 3            | STBY                                | 0 to $V_{CC1}$   | <ul style="list-style-type: none"> <li>Standby control<br/>Normal operation: High<br/>Standby: Low or open</li> </ul>                                                                               |                    |
| 4            | BRK                                 | 0 to $V_{CC1}$   | <ul style="list-style-type: none"> <li>Forward/reverse torque switching<br/>Forward torque: Low or open<br/>Reverse torque: High</li> </ul>                                                         |                    |
| 5            | $V_{CC1}$                           | 2.0 V to 6.0 V   | <ul style="list-style-type: none"> <li>Power supply connection</li> </ul>                                                                                                                           |                    |
| 6            | $V_S$                               | 0 V to $V_{CC2}$ | <ul style="list-style-type: none"> <li>Motor drive and speed control blocks power supply<br/>The voltage applied to this pin must be strictly lower than <math>V_{CC2}</math>.</li> </ul>           |                    |
| 7            | $V_{CC2}$                           | 2.0 V to 6.0 V   | <ul style="list-style-type: none"> <li>Power supply connection for the pre-drive circuit and the motor back EMF detection comparator circuit</li> </ul>                                             |                    |
| 8            | FG                                  |                  | <ul style="list-style-type: none"> <li>FG output<br/>These are open collector output.</li> </ul>                                                                                                    |                    |

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

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| Pin No.        | Symbol                           | Pin voltage | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Equivalent circuit |
|----------------|----------------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| 17             | OSC                              |             | <ul style="list-style-type: none"> <li>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.</li> </ul> |                    |
| 18<br>20<br>19 | $W_{IN}$<br>$U_{IN}$<br>$V_{IN}$ |             | <ul style="list-style-type: none"> <li>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.</li> </ul>                                                                                                                                                                                                    |                    |
| 21             | FCOM                             |             | <ul style="list-style-type: none"> <li>Motor coil midpoint input. The back EMF output is detected by referring to these voltages.</li> </ul>                                                                                                                                                                                                                                                                                                                     |                    |

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