LB1668M

2-phase Unipolar Brushless Motor Driver
Monolithic Digital IC

Overview
The LB1668M is 2-phase unipolar drive brushless motor driver that features a wide usable voltage range and a minimal number of required external components. It also supports the formation of motor lock protection and automatic recovery circuits.

Features
• Output protection Zener Diodes with Variable Breakdown Voltages
  ♦ When the Z1 and Z2 Pins are Open: \( V_{OM} = 57 \text{ V} \)
  ♦ When the Z1 and Z2 Pins are Shorted: \( V_{OM} = 32 \text{ V} \)
  ♦ An External Zener Diode can be Connected between Z1 and VCC
• Can Support Both 12 V and 24 V Power Supplies by Changing an External Resistor
• Hall Elements can be Connected Directly
• 1.5 A Output Current Output Transistors Built in
• Built-in Rotation Detection Function that Outputs Low when Driven and High when Stopped
• Motor Lock Protection and Automatic Recovery Functions Built in
• Thermal Shutdown Function

MARKING DIAGRAM

XXXXXXX = Specific Device Code
Y = Year
M = Month
DDD = Additional Traceability Data

PIN ASSIGNMENT

OUT1
OUT2
GND
NC
NC
NC
Z1
Z2
C
IN−
IN+
VIN
RD
14
1
8
7
(Top View)

ORDERING INFORMATION
See detailed ordering and shipping information on page 7 of this data sheet.
# SPECIFICATIONS

## ABSOLUTE MAXIMUM RATINGS \((T_A = 25^\circ C)\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I_{CC \ max})</td>
<td>Maximum Input Current</td>
<td>(t \leq 20) ms</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>(V_{OUT})</td>
<td>Output Supply Voltage</td>
<td>Internal</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>(I_{OUT})</td>
<td>Output Current</td>
<td></td>
<td>1.5</td>
<td>A</td>
</tr>
<tr>
<td>(I_{RD}/I_{FG})</td>
<td>RD/FG Flow-in Current</td>
<td></td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>(V_{RD}/V_{FG})</td>
<td>RD/FG Supply Voltage</td>
<td></td>
<td>30</td>
<td>V</td>
</tr>
<tr>
<td>(P_d \ max)</td>
<td>Allowable Power Dissipation</td>
<td>With specified board (Note 1)</td>
<td>0.8</td>
<td>W</td>
</tr>
<tr>
<td>(T_{opr})</td>
<td>Operating Temperature</td>
<td>−30 to +80 °C</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>(T_{stg})</td>
<td>Storage Temperature</td>
<td>−55 to +150 °C</td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Specified board: 20 mm × 15 mm × 1.5 mm, glass epoxy.

## ALLOWABLE OPERATING RANGES \((T_A = 25^\circ C)\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I_{CC})</td>
<td>Input Current Range</td>
<td></td>
<td>6.0 to 50</td>
<td>mA</td>
</tr>
<tr>
<td>(V_{CM})</td>
<td>Common-mode Input Voltage Range</td>
<td></td>
<td>0 to (V_{IN})−1.5</td>
<td>V</td>
</tr>
</tbody>
</table>

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

## ELECTRICAL CHARACTERISTICS \((T_A = 25^\circ C, I_{CC} = 10\ mA)\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{OLM1})</td>
<td>Output Limit Voltage</td>
<td>(Z_1, Z_2) open</td>
<td>54</td>
<td>57</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>(V_{OLM2})</td>
<td>Output Limit Voltage</td>
<td>(Z_1, Z_2) short</td>
<td>31</td>
<td>33</td>
<td>35</td>
<td>V</td>
</tr>
<tr>
<td>(V_{O(sat)1})</td>
<td>Output Saturation Voltage</td>
<td>(I_O = 0.5) A</td>
<td>−</td>
<td>0.95</td>
<td>1.2</td>
<td>V</td>
</tr>
<tr>
<td>(V_{O(sat)2})</td>
<td>Output Saturation Voltage</td>
<td>(I_O = 1.0) A</td>
<td>−</td>
<td>1.15</td>
<td>1.5</td>
<td>V</td>
</tr>
<tr>
<td>(V_{O(sat)3})</td>
<td>Output Saturation Voltage</td>
<td>(I_O = 1.5) A</td>
<td>−</td>
<td>1.4</td>
<td>2.0</td>
<td>V</td>
</tr>
<tr>
<td>(V_{IN})</td>
<td>(V_{IN}) Input Voltage</td>
<td>(I_{CC} = 7.0) mA</td>
<td>6.4</td>
<td>6.7</td>
<td>7.0</td>
<td>V</td>
</tr>
<tr>
<td>(V_{OFF})</td>
<td>Amp Input Offset Voltage</td>
<td>−7.0</td>
<td>0</td>
<td>+7.0</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>(I_{BA})</td>
<td>Amp Input Bias Current</td>
<td>−250</td>
<td>−</td>
<td>−</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>(V_{RD(sat)})</td>
<td>RD Output Saturation Voltage</td>
<td>(I_{RD} = 5) mA</td>
<td>−</td>
<td>0.1</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td>(I_C1)</td>
<td>C Flow-out Current</td>
<td>2.1</td>
<td>3.0</td>
<td>3.9</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>(I_C2)</td>
<td>C Discharge Current</td>
<td>0.31</td>
<td>0.44</td>
<td>0.59</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>(V_{TH1})</td>
<td>Comparator Input Threshold Voltage</td>
<td>0.77</td>
<td>0.8 (V_{IN})</td>
<td>0.83</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>(V_{TH2})</td>
<td>Comparator Input Threshold Voltage</td>
<td>0.42</td>
<td>0.45 (V_{IN})</td>
<td>0.48</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>(TSD)</td>
<td>Thermal Shutdown Current Operating Temperature</td>
<td>Design target value (Note 2)</td>
<td>−</td>
<td>180</td>
<td>−</td>
<td>°C</td>
</tr>
<tr>
<td>(\Delta TSD)</td>
<td>Thermal Shutdown Circuit Hysteresis</td>
<td>Design target value (Note 2)</td>
<td>−</td>
<td>40</td>
<td>−</td>
<td>°C</td>
</tr>
</tbody>
</table>

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

2. Design target value and si not measured.
Figure 1. $P_d \max - T_A$

TRUTH TABLE

<table>
<thead>
<tr>
<th>IN+</th>
<th>IN−</th>
<th>C</th>
<th>OUT1</th>
<th>OUT2</th>
<th>RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
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<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

BLOCK DIAGRAM

Figure 2. Block Diagram
1. 12 V Power Supply Type

![12 V Power Supply Type Diagram]

2. 24 V Power Supply Type

![24 V Power Supply Type Diagram]

3. Circuit for use when large output currents are required and heat dissipation is high.

![Circuit for Use when Large Output Currents are Required and Heat Dissipation is High Diagram]
1. Power Supply Voltage (VIN pin):
The resistor R1 (when VCC = 12 V, R1 = 330 Ω, and when VCC = 24, R1 = about 1.2 kΩ) is inserted between VIN and the power supply VCC pin. When the ICC current is set in the range 6 to 50 mA, the VIN pin will be regulated to be 6.7 V. Not only does this provide stability with respect to power supply voltage variations and motor kickback, but it also provides adequate strength to withstand surges.

2. Output Transistors (OUT1 and OUT2 Pins)
A Zener diodes with the following characteristics is inserted between the collector and base of each output transistor to absorb kickback voltages at 57 V (typical) and provide output protection.
- Sustained output voltage: \( V_O = 65 \, \text{V minimum} \) (design guarantee)
- Output current: \( I_O = 1.5 \, \text{A maximum} \)
- Output saturation voltage: \( V_{O \, \text{sat}} = 1.25 \, \text{V/1.0 A (typical)} \)
- Safe operating range: \( I_O = 1.0 \, \text{A, V_{OLM} = 57 \, V, t = 200 \, \mu s} \)

3. Output Circuit Kickback Voltage Protection (Z1 and Z2 pins):
These ICs support output protection that minimizes kickback noise by changing the kickback absorption voltage and absorption method according to the output current and power supply voltage used.
1) When the Z1 and Z2 pins are shorted:
The output protection voltage will be 32 V (typical) using a VCC = 12 V power supply.
2) When the Z1 and Z2 pins are open:
The output protection voltage will be 57 V (typical) using a VCC = 24 V power supply.
3) With a Zener diode inserted between Z1 and VCC or between Z1 and ground:
This technique handles 120mm square H speed applications which require large output currents and involve large amounts of heat generated in the IC by dissipating the motor coil switching loss in external Zener diodes.

4. Output Protection when the Motor is Lock (C and FG pins):
This circuit detects motor stopping due to, for example, overloading, and cuts the coil current. It also automatically recovers drive and motor turning from the output stopped state when the load returns to an appropriate level. The lock detection time is set with the value of an external capacitor.
When \( C = 0.47 \, \mu F \)
- Lock detection time: about 1 s
- Lock protection time:
  - about 0.5 s (output on)
  - about 3 s (output off)
The RD pin is an open collector output and outputs a low level during drive and a high level when stopped.

5. Thermal Shutdown:
This circuit turns the output off in response to coil shorting or IC overheating.

6. In applications that use an external transistor to turn the cooling fan power on and off, connect a capacitor of about 0.47 to 10 \( \mu F \) between the fan power supply VCC and ground to provide a regenerative route for the fan motor coil current.
1. While the blades are turning, the capacitor is charged with a current of about 3 μA (typical), and C is discharged by pulses that correspond to the motor speed.
2. When the blades lock, the capacitor is no longer discharged, and the voltage across the capacitor increases. The output is turned off when that voltage reaches $0.8 \times V_{IN}$.
3. When the output is turned off, the capacitor is discharged at about 0.44 μA (typical). When the capacitor voltage falls under $V_{TH2}$, if the lock state is not yet cleared the capacitor continues discharging until $V_{TH1}$. (Note that the output is turned on at this time.)
4. If the lock is cleared at the point the capacitor voltage reaches $V_{TH2}$, motor rotation is started by turning the output on.

Figure 7. Automatic Return Circuit C-pin Voltage

Figure 8. $V_{O(sat)} - I_O$

Figure 9. ASO
### Figure 10. $V_{IN} - I_{CC}$

![Graph showing $V_{IN} - I_{CC}$ relationship](image)

### ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Wire Bond</th>
<th>Shipping† (Qty / Packing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB1668M–TLM–E</td>
<td>MFP14S (225mil) (Pb–Free)</td>
<td>Au–wire</td>
<td>1,000 / Tape &amp; Reel</td>
</tr>
<tr>
<td>LB1668M–TLM–H</td>
<td>MFP14S (225mil) (Pb–Free / Halogen Free)</td>
<td>Au–wire</td>
<td>1,000 / Tape &amp; Reel</td>
</tr>
<tr>
<td>LB1668M–W–AH</td>
<td>MFP14S (225mil) (Pb–Free / Halogen Free)</td>
<td>Cu–wire</td>
<td>1,000 / Tape &amp; Reel</td>
</tr>
</tbody>
</table>

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
SOIC14 W / MFP14S (225 mil)
CASE 751CB
ISSUE A
DATE 25 OCT 2013

NOTE: The measurements are not to guarantee but for reference only.

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

XXXXX = Specific Device Code
Y = Year
M = Month
DDD = Additional Traceability Data

*This information is generic. Please refer to device data sheet for actual part marking.
Pb-Free indicator, “G” or microdot “/C0071”, may or may not be present.