Stepping Motor Drivers for Automotive Applications

The annual average growth rate of the Head-Up Display (HUD) market is rapidly growing to 20%. In 2020, it is estimated to reach 10,000,000 units in the world, and becoming more and more popular. Stepping motors are used for 70% or more of HUDs.

We have developed an automotive stepping motor driver (TB9120FTG) and entered the market for the first time.

The following describes the features of the TB9120FTG compared to competitors.

- **Input signal interface**: Clock signal
  - It can output sine-wave current without using high-function microcontrollers or software. (Competitors use SPI interface control.)
  - Low ON resistance: 0.7 Ω (typ.)
- **Not required charge pump circuits**: Use the combination of upper P-channel FET and lower N-channel FET. (Competitors' products use the combination of upper and lower N-channel FETs.)
- **Micro steps**: 1/32 step resolution
  - The finest in automotive stepping motor drivers.
- **Package**: QFN package (6 mm × 6 mm)
  - The smallest in automotive stepping motor drivers.

Though TB9120FTG has the optimal specifications for automotive adjustment of the projection position of heads-up displays, it is highly versatile and can be used for various stepping motor applications such as valves.

### FEATURES
- Microstep driving by clock input
- Stall detection function
- Low ON resistance

### ADVANTAGES
- Whereas the mainstream of competitors is SPI interface control, the TB9120FTG uses clock signal input only. Full step to 1/32 step resolution can be supported.
- When the rotation is abnormal, the detection signal is output by judging to be stalled. Method of detecting an induced voltage, whose temperature and voltage dependence is low, is adopted.
- It incorporates DMOSFET with ON resistance of 0.7 Ω. (upper + lower: typ.)

### BENEFITS
- It supports 1/32 step resolution. (contributing to noise and vibration reductions)
- Neither high-function microcontrollers nor software are required.
- Neither high-function microcontrollers nor software are required.
- The external simple microcontroller can receive the detection signal and feed it back to the control system.
- It is easy to be incorporated to the system design because of its lower dependence of temperature and voltage.
- Self-heating is low and thermal design is easy. Maximum current rating is 1.5 A.

### PRODUCT LINEUP

<table>
<thead>
<tr>
<th>Product number</th>
<th>Voltage (Absolute maximum rating) (V)</th>
<th>Voltage (Operating range) (V)</th>
<th>Current (Absolute maximum rating) (A)</th>
<th>Current (Recommended upper limit) (A)</th>
<th>Step resolution</th>
<th>ON resistance (upper + lower) (Ω)</th>
<th>Operating temperature (℃)</th>
<th>Package</th>
<th>Other functions and features</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB9120FTG</td>
<td>4.5 to 7.0</td>
<td>7.0 to 18.0</td>
<td>1.5</td>
<td>1.0 (Note 2)</td>
<td>Supporting full, half, quarter, 1/8, 1/16, and 1/32 steps</td>
<td>0.7</td>
<td>-40 to 125</td>
<td>QFN28</td>
<td>6.0 mm × 6.0 mm Wettable pins with excellent solderability Standby function (dedicated pin)</td>
</tr>
</tbody>
</table>

Note 1: In the range of 4.5 to 7.0V, some values of the electrical characteristics are not guaranteed.

Note 2: The upper output current is limited according to the ambient temperature and the heat dissipation of the board.

---

**Restrictions on Product Use**

- Toshiba Corporation and its subsidiaries and affiliates collectively referred to as “TOSHI BA”.
- Hardware, software and systems described in this document are collectively referred to as “Product”.
- Toshiba reserves the right to make changes in the information in this document and related Product without notice.

**Applications**

- Concave mirror angle adjustment for head-up displays
- Motorcycle valves
- HVAC valves and dampers

---

**Motor drivers for Automotive applications**

- Driver for a 2-phase Bipolar Stepping Motor
- Excitation mode up to 1/32

---

**Restrictions on Product Use**

- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Hardware, software and systems described in this document are collectively referred to as “Product”.
- Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”.
- Toshiba works continually to improve Product’s quality and reliability, but Product can malfunction or fail.
- Toshiba assumes no liability whatsoever, including but not limited to (a) the determinability of the use of the Product in such design or applications, (b) the instructions for the application with which the Product will be used with or for, (c) Customers are solely responsible for all aspects of their own product design or applications, including but not limited to the determinability of the use of the Product, whether in whole or in part.
- Toshiba assumes no liability for damages or losses occurring as a result of non-compliance with applicable laws and regulations.
ADVANTAGE: Micro step drive

The above figure shows an example of output current waveforms of the 2-phase stepping motor. Waveforms of half step, 1/8 step, and 1/32 step resolution are shown in order from the top.

It can support up to 1/32 step resolution (micro steps), which is the finest in automotive stepping motor drivers, contributing to noise and vibration reductions.

ADVANTAGE: Stall detection

(1) Without stall detection: Normal motor rotation with induced voltage → SD pin is in HIZ state (5 V)

When the rotation is abnormal, the detection signal is output by judging to be stalled. The external simple microcontroller can receive the detection signal and feed it back to the control system. As an example, it can determine the original position of the motor at the initial startup of the system, contributing to cost reduction by eliminating the mechanical switches for detection and their routing wires. For stall detection method, some competitors' products monitor PWM frequency changes. However, this method has a significant dependence of temperature and voltage because the PWM chopping current changes easily due to them. On the other hand, the TB9120FTG has a method of detecting motor's induced voltage, resulting in lower dependence of temperature and voltage and easier system design.

(2) With stall detection: Induced voltage is not detected → SD pin outputs low level