RESTRICTIONS ON PRODUCT USE

In addition to the above, the following are applicable only to development tools.

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".

Do not incorporate Product into your products or system. Products are for your own use and not for sale, lease or other transfer.

Purpose, including without limitation, evaluation in high or low temperature or humidity, and verification of reliability.

This document, the instruction manual, the specifications, the data sheets for Product. For using the Product, customers must also refer to and comply with the latest versions of all relevant TOSHIBA information, including without limitation, risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss.

Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Use the Product in a way which minimizes risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss. TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.

Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in a way which minimizes risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss. TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT.
Reasons why Toshiba’s motor drivers are chosen

The Interplay of Heritage and Practice
System proposals based on 40 years of experience
Experience in collaborative development with system manufacturers in Japan and abroad
Deployment of power electronics technology cultivated with R&D and SBUs of Toshiba

Development and Growth
Contributions to efficiency improvement and energy saving
Increase in the flexibility of system design
Reduction in the amount of heat generated by semiconductor devices
Increase in motor drive performance
Reduction in package size
Serving as the "Heart and Soul" of Motors

<table>
<thead>
<tr>
<th>Component</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brushed DC Motor Driver (H-Bridge Driver) ICs</td>
<td>6</td>
</tr>
<tr>
<td>Stepping Motor Driver ICs</td>
<td>8</td>
</tr>
<tr>
<td>Small Low-Voltage BLDC Motor Driver ICs</td>
<td>12</td>
</tr>
<tr>
<td>High-Voltage Brushless DC Motor Driver ICs</td>
<td>14</td>
</tr>
<tr>
<td>Discrete Semiconductor Devices</td>
<td></td>
</tr>
<tr>
<td>- Photocouplers (IGBT/MOSFET Drivers, Isolation Amplifiers)</td>
<td>18</td>
</tr>
<tr>
<td>- Mid- to High-$V_{DS}$ MOSFETs</td>
<td>20</td>
</tr>
<tr>
<td>- Low-$V_{DS}$ MOSFETs</td>
<td>22</td>
</tr>
<tr>
<td>MCUs: Microcontrollers for Camera Control Applications</td>
<td>24</td>
</tr>
<tr>
<td>* Support tools (for MCUs, ICs, and Discrete Transistors)</td>
<td>25</td>
</tr>
</tbody>
</table>

- Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.
- All other company names, product names, and service names may be trademarks of their respective companies.
Types of Toshiba's Motor Drivers and Their Applications

**Brushed DC Motor Driver (H-Bridge Driver) ICs p.6**

Applications
- Consumer electronics
- Industrial equipment
  - Factory automation systems, multi-function printers, office equipment
  - Vending machines, home appliances, housing equipment
  - Others

**Stepping Motor Driver ICs p.8**

Applications
- Factory automation systems
- Office equipment
  - Multi-function printers
  - Camera lenses, security cameras
  - Vending machines, sewing machines
  - Amusement equipment
  - Automatic teller machines (ATMs)
  - Others

**Small Low-Voltage BLDC Motor Driver ICs p.12**

Applications
- PC fans
- Server fans
- Pumps
- Home appliances, housing equipment

*See the Automotive Solutions catalog for automotive motor drivers.*
High-Voltage Brushless DC Motor Driver ICs  p.14

- Three-phase brushless DC motor drivers (with integrated power devices)

- Microcontrollers with Vector Engines (VE)

Discrete Semiconductor Devices

- Photocouplers (IGBT/MOSFET drivers, isolation amplifiers)  p.18

- Mid- to high-V_{DS} MOSFETs  p.20
- Mid- to high-voltage SiC SBDs and discrete IGBTs  p.21
- Low-V_{DS} MOSFETs  p.22

MCUs: Microcontrollers for Camera and Other Small Applications  p.24

- MCUs in small packages suitable for high-precision analog-controlled equipment

* See the Automotive Solutions catalog for automotive motor drivers.
## Brushed DC Motor Drivers (H-Bridge Drivers)

Fabricated using a leading-edge BiCD process with low power consumption and low output on-resistance, sealing in thermally enhanced small packages, Toshiba’s brushed DC motor drivers help improve the efficiency and reduce the size of motor applications. Toshiba provides brushed DC motor drivers with different supply voltage and output current levels and with different numbers of channels. Therefore, you can select motor driver ICs that best suit your target motors.

### Applications
- Consumer electronics and industrial equipment
- Factory automation systems, multi-function printers, office equipment, robotic vacuum cleaners, fan motors, vending machines, home appliances, housing equipment, etc.

### Technical discussion
- Latest BiCD and CD silicon technologies:
  - The sophisticated high-voltage 0.13 μm silicon technology helps increase the current and reduce the on-resistance of driving transistors, making it possible to drive a motor with high efficiency and reduce the power consumption of the IC.
  - Toshiba’s product portfolio includes brushed DC motor drivers fabricated using a 0.13-μm high-voltage silicon technology.
- Incorporating a standby power consumption reduction circuit: TB67H450FNG
  - The TB67H450FNG, a high-voltage motor driver, provides a maximum standby current of only 1 μA, making it possible to reduce system standby power consumption. The TB67H450FNG is particularly suitable for reducing the standby discharge current of battery-powered devices.

### 50 V 3.5 A Brushed DC Motor Driver (TB67H450FNG)
- **Typical pinout**
  - Wide supply voltage range: 4.5 to 44 V
  - Low output on-resistance: 0.6 Ω typical (high side + low side)
  - Low standby supply current: 1 μA maximum at VM = 24 V and Ta = 25°C
  - Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
  - Small package: HSOP8 with E-pad

### 8 V 2.0/4.0 A Dual Brushed DC Motor Driver (TC78H653FTG)
- **Ideal for battery (e.g., dry cell) operations because of low supply voltage (1.8 V or higher)**
  - Supply voltage range: 1.8 to 7.5 V (suitable for low supply voltage drive)
  - Low output on-resistance: 0.22 Ω typical per channel (high side + low side)
  - Low standby supply current: 0.22 μA maximum at VM = 3 V and Ta = 25°C
  - Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
  - Small package: QFN16 with E-pad

### 40 V 3.5/5.0 A Four-Channel Brushed DC Motor Driver (TB67H452FTG)
- **Capable of driving up to four brushed DC motors**
  - Wide supply voltage range: 6.3 to 38 V
  - Low output on-resistance: 0.6 Ω typical per channel (high side + low side)
  - Low standby supply current: 0.3 μA maximum at VM = 24 V and Ta = 25°C
  - Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
  - Small package: QFN48 with E-pad
Brushed DC Motor Drivers

**50 V 4.5/9.0 A Dual Brushed DC Motor Driver (TB67H420FTG)**
- High-current drive (9 A)
- Advanced Current Detection System (ACDS)
- Wide supply voltage range: 10 to 47 V
- Low output on-resistance: 0.33 Ω typical per channel (high side + low side)
  * In Large mode: 0.165 Ω typical
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- Small package: QFN48 with E-pad

**50 V 3.0/6.0 A Dual Brushed DC Motor Driver (TB67H401FTG)**
- Current limiter and flag (for motor lock detection)
- Wide supply voltage range: 10 to 47 V
- Low output on-resistance: 0.25 Ω typical (high side + low side)
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- Small package: QFN48 with E-pad

---

**Major Brushed DC Motor Driver products**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Large</th>
<th>Absolute Maximum Ratings</th>
<th>Temperature Range</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB67H402FTG</td>
<td></td>
<td>40</td>
<td>3.0</td>
<td>1.00</td>
</tr>
<tr>
<td>TB67H402SGG</td>
<td>50</td>
<td>5.0</td>
<td>0.40</td>
<td>2</td>
</tr>
<tr>
<td>TB67H402HSG</td>
<td>50</td>
<td>10</td>
<td>0.20</td>
<td>1</td>
</tr>
<tr>
<td>TB67H450AFTG</td>
<td>50</td>
<td>4.0 / 6(4)</td>
<td>0.49 / 0.25(4)</td>
<td>2 / 1(4)</td>
</tr>
<tr>
<td>TB67H450FTG</td>
<td>*</td>
<td>50</td>
<td>1.0 / 6(4)</td>
<td>0.49 / 0.25(4)</td>
</tr>
<tr>
<td>TB67H450FTNG</td>
<td>50</td>
<td>4.5 / 3(4)</td>
<td>0.53 / 0.17(4)</td>
<td>2 / 1(4)</td>
</tr>
<tr>
<td>TB67H450FNG</td>
<td>*</td>
<td>50 2.0</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>TB67H450FTG</td>
<td>•</td>
<td>40</td>
<td>1.5 / 5(4)</td>
<td>0.60 / 0.30(4)</td>
</tr>
<tr>
<td>TC78H300FTGLF</td>
<td>18</td>
<td>1.0</td>
<td>1.20</td>
<td>2</td>
</tr>
<tr>
<td>TC78H301FNLG</td>
<td>18</td>
<td>1.5</td>
<td>0.80</td>
<td>2</td>
</tr>
<tr>
<td>TC78H3121FNLG</td>
<td>18</td>
<td>2.1</td>
<td>0.80</td>
<td>2</td>
</tr>
<tr>
<td>TC78H3123FNLG</td>
<td>18</td>
<td>2.1</td>
<td>0.40</td>
<td>1</td>
</tr>
<tr>
<td>TC78H3124FNLG</td>
<td>*</td>
<td>8</td>
<td>2.0</td>
<td>0.22</td>
</tr>
<tr>
<td>TC78H3125FNLG</td>
<td>*</td>
<td>8</td>
<td>2.0 / 4(4)</td>
<td>0.22 / 0.11(4)</td>
</tr>
<tr>
<td>TC78H3126FNLG</td>
<td>*</td>
<td>40</td>
<td>3.5 / 5(4)</td>
<td>0.60 / 0.30(4)</td>
</tr>
<tr>
<td>TC78H3127FNLG</td>
<td>*</td>
<td>40</td>
<td>3.5 / 5(4)</td>
<td>0.60 / 0.30(4)</td>
</tr>
</tbody>
</table>

Note: (1) Under voltage lockout (2) Overcurrent detection (3) Thermal shutdown (4) Large Mode

* : New product

---

**Technical discussion**

Incorporating a standby power consumption reduction circuit: TB67H450FNG

Latest BiCD and CD silicon technologies: Toshiba’s product portfolio includes brushed DC motor drivers fabricated using a 0.13-μm high-voltage silicon technology. This technology allows for improved efficiency and reduced power consumption. The TB67H450FNG is particularly suitable for reducing the standby discharge current of systems, making it possible to drive a motor with high efficiency and reduce the power consumption of the IC.

Ideal for battery (e.g., dry cell) operations because of low supply voltage (1.8 V or higher)
Stepping Motor Drivers

Fabricated using a leading-edge BiCD process with low power consumption and low output on-resistance, Toshiba’s stepping motor drivers in thermally enhanced small packages help improve the efficiency and reduce the size of motor applications. These stepping motor drivers incorporate a high-speed, high-precision control technology required for factory automation systems and office equipment, and help reduce the number of external parts required, simplifying system design. Toshiba provides stepping motor drivers with different supply voltage and output current levels and with different numbers of channels. Therefore, you can select motor driver ICs that best suit your target motors.

Applications
Factory automation systems, office equipment, vending machines, sewing machines, security cameras, amusement equipment, automatic teller machines (ATMs), etc.

Technical discussion

- **Advanced Dynamic Mixed Decay (ADMD):**
  Toshiba’s original ADMD technology controls decay current more adequately than the conventional mixed-decay mode, making highly efficient motor control possible at high rpm.

- **Active Gain Control (AGC):**
  AGC is Toshiba’s unique stepping motor technology to automatically optimize the drive current in real time according to load torque. It helps reduce unnecessary current, drastically cut power consumption and heat generation.

- **Advanced Current Detection System (ACDS):**
  Toshiba’s original ACDS technology enables motor drive with highly accurate constant current without requiring external current-sensing resistors, which contribute to reduce part count, to save board area as well.

- **Microstepping:**
  The 128-microstep decoder enables high-precision microstepping control only with a clock pulse input. Stair-stepped approximation of a sine wave helps reduce excessive current, heating, and motor vibration, leading to smooth and quiet motor rotation.

- **Error detection**
  • Thermal Shutdown
  • Overcurrent detection
  • Power-On Reset
  • Motor load open detection
Bipolar Stepping Motor Drivers

50 V 5.0 A PWM Chopper-Type Bipolar Stepping Motor Driver (TB67S128FTG)
- Allows microstepping (1/128th step)
- Low output on-resistance: 0.25 Ω typical (high side + low side)
- Advanced Dynamic Mixed Decay (ADMD)
- Active Gain Control (AGC)
- Advanced Current Detection System (ACDS)
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), VM power-on reset (POR), motor load open detection (OPD)
- Small package: QFN64 with E-pad

50 V 4.0 A Two-Phase Bipolar Stepping Motor Drivers (TB67S101AFTG/AFNG/ANG, TB67S102AFTG/AFNG, TB67S103AFTG, TB67S109AFTG/AFNG, TB67S105FTG)
- Advanced Dynamic Mixed Decay (ADMD)
- Allows 1/32nd-step operation (TB67S103A, TB67S109A)
- Low output on-resistance: 0.49 Ω typical (high side + low side)
  * TB67S105: 0.6 Ω typical (high side + low side)
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), VM power-on reset (POR)
- Interfaces: Clock input, serial input, phase input
- Packages: QFN48, HTSSOP48, HZIP25, SDIP24

40 V 2.0 A PWM Chopper-Type Dual Stepping Motor Drivers (TC78S121FNG/FTG, TC78S122FNG/FTG)
- Capable of controlling two bipolar stepping motors
- Low output on-resistance: 0.6 Ω typical per channel (high side + low side)
  * In Large mode: 0.3 Ω typical
- Single power supply
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), VM power-on reset (POR)
- Interfaces: Clock input, phase input
- Small packages: HTSSOP48, QFN48

50 V 2.0 A Bipolar Stepping Motor Driver (TB67S261FTG, TB67S265FTG, TB67S269FTG)
- Stepping modes: TB67S265FTG: Full-step, half-step
  TB67S261FTG: Up to 1/4th step
  TB67S269FTG: Up to 1/8th step, 1/16th step, 1/32nd step
- Low output on-resistance: 0.8 Ω typical (high side + low side)
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), VM power-on reset (POR)
- Interfaces: Clock input, serial input, phase input
- Packages: QFN48 (7 mm x 7 mm)
Stepping Motor Drivers

50 V 4.5/3.0/2.0 A Single-Channel Bipolar Stepping Motor Drivers (TB67S249FTG/289FTG/279FTG)

- Active Gain Control (AGC)
- Advanced Current Detection System (ACDS)
- Low output on-resistance: S249: 0.33 Ω typ., S279: 0.6 Ω typ., S289: 0.4 Ω typ. (high-side + low-side)
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO), motor load open detection (OPD)
- Small package: QFN48

---

**Major Stepping Motor Driver products for Bipolar Motor Applications**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Interface</th>
<th>Absolute/Maximum Ratings</th>
<th>Stepping Mode</th>
<th>Protection</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Code</td>
<td>Phase</td>
<td>Serial</td>
<td>Voltage (V)</td>
<td>Current (A)</td>
</tr>
<tr>
<td>TB62269FTG/FTAG</td>
<td>●</td>
<td>40</td>
<td>1.8 (FTG)/1.5 (FTAG)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB62269FTG/FTAG</td>
<td>●</td>
<td>40</td>
<td>1.8 (FTG)/1.5 (FTAG)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB66089FTG/FTAG</td>
<td>●</td>
<td>40</td>
<td>2.8 (FTG)/2.0 (FTAG)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S1181FTG/AFMG/ANG</td>
<td>●</td>
<td>50</td>
<td>4.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S1181FTG/AFMG</td>
<td>●</td>
<td>50</td>
<td>4.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S1181FTG</td>
<td>●</td>
<td>40</td>
<td>2.5</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S1181FTG</td>
<td>●</td>
<td>40</td>
<td>2.5</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TC816000FTG/FTMG</td>
<td>●</td>
<td>38</td>
<td>1.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB6113FTG</td>
<td>●</td>
<td>6</td>
<td>0.8</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S261FTG</td>
<td>●</td>
<td>50</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S261FTG</td>
<td>●</td>
<td>50</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S261FTG</td>
<td>●</td>
<td>50</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TC816121FTG/FTMG</td>
<td>●</td>
<td>40</td>
<td>2.0 x 2 ch</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TC816121FTG/FTMG</td>
<td>●</td>
<td>40</td>
<td>2.0 x 2 ch</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S299FTG</td>
<td>●</td>
<td>50</td>
<td>4.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S299FTG</td>
<td>●</td>
<td>50</td>
<td>4.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S588FTG</td>
<td>●</td>
<td>40</td>
<td>3.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S512FTAG</td>
<td>●</td>
<td>40</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S512FTAG</td>
<td>●</td>
<td>40</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S512FTAG</td>
<td>●</td>
<td>40</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TB67S512FTAG</td>
<td>●</td>
<td>40</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TC716000FTG</td>
<td>●</td>
<td>50</td>
<td>5.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TC716000FTG</td>
<td>●</td>
<td>50</td>
<td>5.0</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>TC716000FTG</td>
<td>●</td>
<td>20</td>
<td>2.0</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

* New Product
** Under development
* Only major motor drivers are listed above. For the complete list, visit our website.
Stepping Motor Drivers

84 V 3.0 A Unipolar Stepping Motor Drivers (TB67S141FTG/NG, TB67S142FTG/NG, TB67S145FTG, TB67S149FTG/FG/HG)
- Constant-current drive and Advanced Current Detection System (ACDS)
- Full-, half-, 1/4th-, 1/8th-, 1/16th-, and 1/32nd-step commutation
- Low output on-resistance: 0.25 Ω typical
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- Interfaces: Phase input, clock input, serial input
- Package: QFN48, HZIP24, SDIP24

80 V 1.5 A Unipolar Stepping Motor Driver (TB67S158FTG/NG)
- Constant-voltage drive
- Capable of controlling two unipolar stepping motors
- Stepping modes: Full-step, half-step
- Low output on-resistance: 0.5 Ω typical
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- Interfaces: Phase input, clock input, serial input, full parallel input
- Package: QFN48, SDIP24

80 V 1.5 A Unipolar Stepping Motor Driver (TB67S111PG)
- Constant-voltage drive
- Stepping modes: Full-step, half-step
- Low output on-resistance: 0.35 Ω typical
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- Interfaces: full parallel input
- Package: DIP16

Major Stepping Motor Driver products for Unipolar Motor Applications

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Interface</th>
<th>Absolute Maximum Ratings</th>
<th>Stepping Mode</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clock</td>
<td>Phase</td>
<td>Voltage (V)</td>
<td>Output Current (A)</td>
</tr>
<tr>
<td>TB67S111FG</td>
<td></td>
<td></td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>TB67S141FTG/NG</td>
<td></td>
<td></td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>TB67S142FTG/NG</td>
<td></td>
<td></td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>TB67S145FTG</td>
<td></td>
<td></td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>TB67S149FTG/FG/HG</td>
<td></td>
<td></td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>TB67S158FTG/NG</td>
<td></td>
<td></td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

50 V 1.5 A DMOS Transistor Arrays (TBD62064A/TBD62308A)
- Clamp diodes
- Package: DIP16, HSOP16, SSOP24
- Pin-compatible with the previous equivalents (TD62064A/308A)

Major Transistor Array products

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Output Form</th>
<th># Outputs</th>
<th>Output Current (A)</th>
<th>Output Voltage (V)</th>
<th>Clamp Diode</th>
<th>Active Input Level</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD62064A/4FG/AFG/AFAG</td>
<td>Sink</td>
<td>4</td>
<td>1.5</td>
<td>50</td>
<td>H</td>
<td></td>
<td>DIP16/HSOP16/SSOP24</td>
</tr>
<tr>
<td>TBD62308A/4FG/AFG/AFAG</td>
<td>Sink</td>
<td>4</td>
<td>1.5</td>
<td>50</td>
<td>H</td>
<td></td>
<td>DIP16/HSOP16/SSOP24</td>
</tr>
</tbody>
</table>
Small Low-Voltage BLDC Motor Driver ICs

Toshiba provides motor driver ICs suitable for small BLDC motor applications. Housed in a small package, Toshiba’s high-efficiency BLDC motor driver ICs incorporate a unique control technology that automatically minimizes the current-voltage phase difference of a motor, reducing its acoustic noise and power consumption.

Applications
- PC and server fans, small fans

Technical discussion – Reducing power consumption and acoustic noise

- **Intelligent Phase Control**
  
  Intelligent Phase Control (InPAC) is the state-of-the-art motor control technology developed by Toshiba. InPAC minimizes the current-voltage phase difference of a motor over the entire rpm range to improve its power efficiency. Because phase control is automated, InPAC provides an efficiency improvement regardless of the rpm, load torque, and supply voltage of the motor and therefore helps reduce the development workload required for setup and phase adjustment. (See the boxed explanation on Page 16.)

- **Closed-loop speed control**
  
  Toshiba provides BLDC motor driver ICs that incorporate a closed-loop speed control circuit, which maintains a constant motor speed by reducing variations in rpm due to supply voltage and load variations.

- **Sensorless and sine-wave drive technologies**
  
  Toshiba provides an extensive lineup of BLDC motor driver ICs that incorporate sensorless and sine-wave drive technologies, which make it possible to reduce the number of parts required for and therefore the size of motor applications, improve their power efficiency, and reduce a motor’s acoustic noise. You can select BLDC motor drivers that best suit your application needs.

18 V 3.5 A Three-Phase BLDC Motor Driver (TC78B025FTG)

- **Intelligent Phase Control**
- **Closed-loop speed control**
- Operating supply voltage range: 4.5 to 16 V
- Single-sensor-based sine-wave and 150-degree commutation
- Low output on-resistance: 0.24 Ω typical (high side + low side)
- RPM control input: PWM or analog voltage input
- Support for Hall effect sensor elements and Hall ICs
- Motor lock protection and automatic recovery functions
- Protection features: Thermal shutdown (TSD), overcurrent limit protection (OCP), undervoltage lockout (UVLO)
- Small package: QFN24

18 V Three-Phase BLDC Motor Predriver (TC78B027FTG)

- **Intelligent Phase Control**
- **Closed-loop speed control**
- Operating supply voltage range: 5.0 to 16 V
- Single-sensor-based sine-wave and 150-degree commutation
- Drives external N-channel + N-channel half-bridges
- RPM control input: PWM or analog voltage input
- Support for Hall effect sensor elements and Hall ICs
- Motor lock protection and automatic recovery functions
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), overcurrent limit protection (OCP), undervoltage lockout (UVLO)
- Small package: QFN24

See Page 22 for external MOSFETs.
Small Low-Voltage BLDC Motor Drivers

**18 V 1.5 A Single-Phase Full-Wave Driver (TC78B002FTG/FNG)**
- Operating supply voltage range: 3.5 to 16 V
- Soft switching (capable of sine-wave commutation)
- Integrated boot sequence
- Motor lock protection and automatic recovery functions
- Quick start function
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- On-chip voltage regulator: 5 V typical, 10 mA maximum
- Small packages: QFN16, SSOP16

**40 V Single-Phase Full-Wave Predriver (TC78B006シリーズ)**
- Operating supply voltage range: 3.5 to 30 V
- Soft switching (capable of sine-wave commutation)
- Drives a pair of external P-channel and N-channel half-bridges
- Motor lock protection and automatic recovery functions
- Quick start function
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
- On-chip voltage regulator: 5 V typical, 10 mA maximum
- Small packages: QFN16, SSOP16

**40 V 3.0 A Three-Phase BLDC Motor Driver (TC78B016FTG)**
- **Intelligent Phase Control**
  - Operating supply voltage range: 6 to 30 V
  - Three-sensor-based sine-wave commutation
  - Low output on-resistance: 0.24 Ω typical (high side + low side)
  - RPM control input: PWM or analog voltage input
  - Support for Hall effect sensor elements and Hall ICs
  - Motor lock detection
  - Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), overcurrent limit protection (OCP), undervoltage lockout (UVLO)
- Small packages: QFN36

**Major Low-Voltage small BLDC Motor Driver products**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>1-Phase</th>
<th>3-Phase</th>
<th>Predriver</th>
<th>Driver</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Sensors</th>
<th>Position Sensing</th>
<th>Commutation Strategies</th>
<th>Lead Angle Control</th>
<th>Closed Loop</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB6102FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>0.02</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TB6102FTG/GFTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TB610200FNG/FPNG/CFNG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SSOP14</td>
</tr>
<tr>
<td>TB61000FTG/1AFTG/BOFG/CF RNG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN24</td>
</tr>
<tr>
<td>TB61000FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TC78B002FTG/FNG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>1.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN16, SSOP16</td>
</tr>
<tr>
<td>TC78B004FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31</td>
<td>0.1</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN40</td>
</tr>
<tr>
<td>TC78B006 Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>0.02</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN16, SSOP16</td>
</tr>
<tr>
<td>TC78B002FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TC78B015FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>3.0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TC78B015FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td>3.0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TC78B016FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>3.0</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TC78B0150FTG/CFNG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td>3.0</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN36</td>
</tr>
<tr>
<td>TC78B025FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>4.0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN24</td>
</tr>
<tr>
<td>TC78B027FTG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>0.2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QFN24</td>
</tr>
</tbody>
</table>

* : New product  
**: Under development
High-Voltage BLDC Motor Driver ICs

To reduce a motor’s power consumption and acoustic noise, BLDC motors are increasingly used for home appliances. Toshiba provides monolithic ICs incorporating IGBTs fabricated with the latest silicon-on-insulator (SOI) process and multi-chip modules combining well-proven MOSFETs and a driver IC. These BLDC motor driver ICs are available with a rated supply voltage ranging from 250 to 600 V and a rated output current ranging from 0.7 to 5 A, making them suitable for high-efficiency motor applications with an input voltage of 100 to 220 V-AC. Housed in a small package, they also help reduce the board area.

Applications
Home appliances
– Air conditioner fans, refrigerator fans, refrigerator compressors, washing machine fans, air purifiers, ceiling fans, etc.

600 V 2.0 A High-Voltage Three-Phase BLDC Motor Driver (TB67B000AHG/AFG)

• SiP (PWM controller and 600-V IPD combination)
• Three-sensor-based sine-wave PWM and trapezoidal commutation
• Support for Hall effect sensor elements and Hall ICs
• External lead angle control
• On-chip oscillator (external resistor required)
• Motor lock detection
• Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)
• Package: HDIP30/HSSOP34

Major High-Voltage BLDC Motor Driver products Incorporating a Controller (for Sine-Wave Commutation)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>Commutation/Waveform</th>
<th>Position Sensing</th>
<th>Lead Angle Control</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB67B000AHG/FG</td>
<td>500</td>
<td>2</td>
<td>●</td>
<td>●</td>
<td>3</td>
</tr>
<tr>
<td>TB67B000AHG/AFG</td>
<td>600</td>
<td>2</td>
<td>●</td>
<td>●</td>
<td>3</td>
</tr>
</tbody>
</table>
Three-Phase BLDC Motor Driver Incorporating Power Devices (for Square-Wave Commutation)

- High-voltage IC fabricated with an SOI process
- Available with a rated voltage ranging from 250 to 600 V and a rated current ranging from 0.7 to 5.0 A
- Incorporates a bootstrap circuit, for high-side gate-drivers
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)

Package
- HSSOP31

Three-Phase BLDC Motor Driver Incorporating Power Devices (for Sine-Wave Commutation)

- High-voltage IC fabricated with an SOI process
- Available with a rated voltage ranging from 500 to 600 V and a rated current ranging from 2.0 to 5.0 A
- Incorporates a bootstrap circuit, for a high-side gate-drivers
- Protection features: Thermal shutdown (TSD), overcurrent protection (ISD), undervoltage lockout (UVLO)

Package
- HSSOP31, SSOP30, HDIP30

Major High-Voltage BLDC Motor Driver products (for Square-Wave and Sine-Wave Commutation)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>Package</th>
<th>Three-Phase Distribution PWM Circuit</th>
<th>Commutation Waveform</th>
<th>Position Sensing</th>
<th>Hall Sensor Inputs (4 Sensors)</th>
<th>Output Stage</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD4115F **</td>
<td>250V / 1A</td>
<td>HSSOP31</td>
<td>●</td>
<td>Square-Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td>IGBT</td>
<td>Monolithic IC</td>
</tr>
<tr>
<td>TPD4116F **</td>
<td>600V / 0.7A</td>
<td>HSSOP31</td>
<td>●</td>
<td>Square-Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td>IGBT</td>
<td>Monolithic IC</td>
</tr>
<tr>
<td>TPD4116F **</td>
<td>600V / 1A</td>
<td>HSSOP31</td>
<td>●</td>
<td>Square-Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td>IGBT</td>
<td>Monolithic IC</td>
</tr>
<tr>
<td>TPD4204F **</td>
<td>600V / 2.5A</td>
<td>SSOP30</td>
<td>–</td>
<td>('1)</td>
<td>('1)</td>
<td>IGBT</td>
<td>MOSFET</td>
<td>Multi-chip module</td>
</tr>
<tr>
<td>TPD4206F **</td>
<td>600V / 5A</td>
<td>SSOP30</td>
<td>–</td>
<td>('1)</td>
<td>('1)</td>
<td>IGBT</td>
<td>MOSFET</td>
<td>Multi-chip module</td>
</tr>
<tr>
<td>TPD4207F **</td>
<td>400V / 6A</td>
<td>SSOP30</td>
<td>–</td>
<td>('1)</td>
<td>('1)</td>
<td>IGBT</td>
<td>MOSFET</td>
<td>Multi-chip module</td>
</tr>
<tr>
<td>TPD4164F **</td>
<td>600V / 2A</td>
<td>HSSOP31</td>
<td>–</td>
<td>('1)</td>
<td>('1)</td>
<td>IGBT</td>
<td>MOSFET</td>
<td>Multi-chip module</td>
</tr>
<tr>
<td>TPD4164K **</td>
<td>600V / 2A</td>
<td>HDIP30</td>
<td>–</td>
<td>('1)</td>
<td>('1)</td>
<td>IGBT</td>
<td>IGBT</td>
<td>Monolithic IC</td>
</tr>
</tbody>
</table>

* Under development

(*) 1: Depends on the preceding controller
**Controller Logic**

**Sine-Wave PWM Three-Phase BLDC Motor Controllers (TC78B041FNG/TC78B042FTG)**

- **Intelligent Phase Control**
  - Operating supply voltage range: 6 to 16.5 V
  - Three-sensor-based sine-wave commutation
  - Support for Hall effect sensor elements and Hall ICs
  - Forward and reverse rotation
  - Motor lock detection
  - Selectable output pulse count per rotation
  - On-chip voltage regulator: 5 V typical, 35 mA maximum
  - Output current limiting
  - Small packages: SSOP30, VQFN32

**Major High-Voltage BLDC Motor Driver and Controller products**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>Commutation Waveform</th>
<th>Position Sensing</th>
<th>Number of Hall Sensor Inputs</th>
<th>External Input</th>
<th>Lead Angle Control</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB6931FAG</td>
<td>Voltage [V]: 12</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP34</td>
</tr>
<tr>
<td>TB6936FQG</td>
<td>Voltage [V]: 12</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP30</td>
</tr>
<tr>
<td>TB6919FNG</td>
<td>Voltage [V]: 12</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP34</td>
</tr>
<tr>
<td>TB6993FNG</td>
<td>Voltage [V]: 12</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP30</td>
</tr>
<tr>
<td>TB6939FNG</td>
<td>Voltage [V]: 12</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP34</td>
</tr>
<tr>
<td>TB6950FNG</td>
<td>Voltage [V]: 12</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP30</td>
</tr>
<tr>
<td>TC78B041FNG</td>
<td>Voltage [V]: 18</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP30</td>
</tr>
<tr>
<td>TC78B042FNG</td>
<td>Voltage [V]: 18</td>
<td>Square, Sine</td>
<td>Sensor-less</td>
<td>3</td>
<td></td>
<td></td>
<td>SSOP30</td>
</tr>
</tbody>
</table>

* New Product

---

**Intelligent Phase Control for automatic lead angle control**

- Toshiba’s unique motor drive technology provides high-efficiency and quiet motor operation.
- **Automatic lead angle control eliminates the need for complicated adjustment.**

To drive a BLDC motor efficiently, it is necessary to control the phase of the motor drive voltage so that the phase of the motor’s induced voltage matches that of the motor current. This is called lead angle adjustment. Since the lead angle varies with a motor’s rpm and load torque, lead angle adjustment is a complicated task. Unless the lead angle is properly adjusted, the polarities of the motor voltage and current reverse at zero-crossing points, producing braking torque. This causes acoustic noise and vibration and reduces motor efficiency. Although vector control is employed for high-capacity motors, it has not been widely applied to small motors because of the need for intensive computing and parameter tuning.

Intelligent Phase Control (InPAC) is a technique for automatic lead angle control to achieve high-efficiency motor drive with a simple circuit. InPAC monitors only the polarities of a motor’s current and induced voltage, and accordingly adjusts the phase of the motor drive voltage so that they change simultaneously. Because this process is automated, InPAC eliminates the need for complicated lead angle adjustment and requires no external parts. InPAC is effective regardless of a motor’s rpm, load torque, and supply voltage and enables a high-efficiency motor operation. Toshiba provides an extensive portfolio of BLDC motor drivers incorporating InPAC. InPAC is Toshiba’s unique motor drive technology.
## High-Voltage Brushless DC Motor Drivers

### Microcontrollers with Vector Engine (VE)

Toshiba’s original coprocessor offloads the CPU considerably.

- Various motor control functions: On-chip peripherals suitable for controlling high-performance BLDC motors, including Vector Engines (VEs), programmable motor drivers (PMDs), encoders (ENCs), AD converters (ADCs), and allows 5 V single-supply operation
- Reliable basic performance: Arm® Cortex®-M3 and Cortex®-M4 cores with a maximum clock rate of 120 MHz
- Extensive lineup: MCUs with 32 to 100 pins, 64 to 512 KB memory options, extensive package lineup
- Extended maximum operating temperature range: -40 to +105°C
- Efficient evaluation environment: Extensive debugging functions and evaluation boards

### Applications

- Air conditioner compressors and fans, refrigerator fans, washing machine fans, ceiling fans, and other home appliance motors

### Technical discussion – Microcontrollers for motor applications –

**Vector engine (VE)**

Vector control is a technique for efficiently turning a BLDC motor over low- to high-rpm regions. To simplify mathematical computations, vector control converts the three-phase AC components (i.e., coil currents) into two-phase orthogonal components, which define the magnetic flux and torque of a motor respectively. This conversion involves three-phase to orthogonal transformation, coordinate system rotation, reverse transformation, and other computations. The Vector Engine performs these mathematical computations in dedicated hardware, considerably offloading the CPU and simplifying software design. Additionally, Toshiba’s vector control MCUs contain programmable motor drivers (PMDs), high-speed AD converter interfaces and other peripheral hardware units necessary for motor control in order to perform a sequence of motor control tasks efficiently.

The Vector Engine provides high-speed PWM drive and high-resolution vector control, making it possible to drive motors with high efficiency and low acoustic noise.

### MCUs with Vector Engine (VE) for Inverter Home Appliance Applications (TMPM475xxxx)

- Arm Cortex-M4 with FPU
- Operating frequency: 120 MHz, operating voltage: 4.5 to 5.5 V
- 256 to 512 KB code flash memory
- 100-pin
- Capable of controlling up to two motors simultaneously
- CAN (1 ch)
- Hardware peripherals for motor control (A-VE, PMD, A-ENC, ADC)

### Major MCU products with Vector Engine (VE)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Maximum Operating Frequency (MHz)</th>
<th>ROM (Flash) (Kbyte)</th>
<th>Motor Controllers (ch)</th>
<th>12-Bit AD Converter (ch) (Conversion Time)</th>
<th>Encoder Input Circuits (ch)</th>
<th>CAN (ch)</th>
<th>I/O Port (ch)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPM37FSOUG/PFG</td>
<td>80</td>
<td>256</td>
<td>1</td>
<td>22 (2μs)</td>
<td>2</td>
<td>76</td>
<td>QFP100/QFP100</td>
<td></td>
</tr>
<tr>
<td>TMPM37FVUG</td>
<td>80</td>
<td>128</td>
<td>2</td>
<td>22 (2μs)</td>
<td>2</td>
<td>53</td>
<td>LQFP64</td>
<td></td>
</tr>
<tr>
<td>TMPM37FVUG</td>
<td>80</td>
<td>128</td>
<td>1</td>
<td>7 (μs)</td>
<td>1</td>
<td>37</td>
<td>LQFP48</td>
<td></td>
</tr>
<tr>
<td>TMPM37FVUG</td>
<td>80</td>
<td>128</td>
<td>1</td>
<td>6 (μs)</td>
<td>1</td>
<td>33</td>
<td>LQFP44</td>
<td></td>
</tr>
<tr>
<td>TMPM37FVUG</td>
<td>80</td>
<td>128</td>
<td>1</td>
<td>22 (2μs)</td>
<td>2</td>
<td>82</td>
<td>QFP100/QFP100</td>
<td></td>
</tr>
<tr>
<td>TMPM37FSOUG</td>
<td>40</td>
<td>64</td>
<td>1</td>
<td>4 (μs)</td>
<td>1</td>
<td>21</td>
<td>SSOP30</td>
<td></td>
</tr>
<tr>
<td>TMPM37FSQG</td>
<td>40</td>
<td>64</td>
<td>1</td>
<td>5 (μs)</td>
<td>1</td>
<td>13</td>
<td>QFP32</td>
<td></td>
</tr>
<tr>
<td>TMPM475FSOUG/PFG</td>
<td>256/384/512</td>
<td>2</td>
<td>23 (μs)</td>
<td>2</td>
<td>2</td>
<td>79</td>
<td>LQFP100</td>
<td></td>
</tr>
<tr>
<td>TMPM475FSOUG/PFG</td>
<td>256/384/512</td>
<td>2</td>
<td>23 (μs)</td>
<td>2</td>
<td>2</td>
<td>79</td>
<td>LQFP100</td>
<td></td>
</tr>
</tbody>
</table>
Photocouplers

Toshiba’s extensive portfolio of high-performance IC-output and other types of photocouplers provides total solutions for inverter systems. Toshiba provides smart IGBT gate drivers with protection features fabricated using the latest 0.13-μm BiCD process and high-luminance optically isolated isolation amplifiers.

IGBT/MOSFET-Drive Photocoupler with Overcurrent Protection (TLP5214A)

The TLP5214A is an isolated IGBT/MOSFET gate driver. It provides a protection feature called DESAT, which monitors the saturation voltage, \( V_{\text{CE(sat)}} \), of an IGBT and performs a soft shutdown of its output when \( V_{\text{CE(sat)}} \) exceeds 6.5 V typical in the event of an overcurrent condition. Additionally, the TLP5214A is housed in the thin SO16L package and provides active Miller clamping, rail-to-rail output, and other features, reducing the number of external components. This helps reduce bill-of-material (BOM) costs and board size. The TLP5214A provides a clearance distance of 8 mm and guarantees an isolation voltage of up to 5 kVrms, making it suitable for applications requiring high insulation performance.

- \( V_{\text{CE(sat)}} \) detection and shutdown protect an IGBT/MOSFET in the event of overcurrent.
- The FAULT signal is fed back to the controller at high speed.
- Active Miller clamping prevents IGBT/MOSFET failures due to Miller current.
- A rail-to-rail output reduces power loss.
- Maximum output peak current: 4.0 A
- Propagation delay (\( t_{\text{PLH}} / t_{\text{PHL}} \)): 150 ns max

High-Precision Isolation Amplifier with a High-Performance \( \Delta \Sigma \)AD Converter (TLP7820)

Typical AC servo inverters for industrial applications require feedback of the motor current. Therefore, the signal lines of a CPU or an MPU that control inverter circuitry at low voltage must be isolated from the current lines of a three-phase motor that operated at high voltage. Toshiba’s optically isolated isolation amplifier, the TLP7820, provides a solution for this requirement. The TLP7820 has an analog-output delta-sigma AD converter.

- Exhibits primary-side current consumption of only 9 mA typical and thus helps to reduce the size of power supplies
- Unique test mode that makes it possible to monitor internal characteristics
- Housed in the thin SO8L package and thus can be soldered on the backside of a PCB
## Recommended Photocouplers for Motor Applications

### IC Output IPM Drive

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Toshiba’s Package Name</th>
<th>Features</th>
<th>Propagation delay time</th>
<th>Output</th>
<th>Isolation voltage (Vrms)</th>
<th>Safety Standards*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLP2719</td>
<td>SO8L(SO6L,F4)</td>
<td>Reinforced insulation VCC = 4.5 to 20 V Topv (max) 100°C</td>
<td>2 µs (max)</td>
<td>Open-collector (Inverter logic output)</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) CQC (6)</td>
<td></td>
</tr>
<tr>
<td>TLP2704</td>
<td>SO8L(SO6L,F4)</td>
<td>Reinforced insulation VCC = 4.5 to 20 V Topv (max) 125°C Threshold Input Current (max) 5 mA</td>
<td>550 ns (max)</td>
<td>Open-collector (Inverter logic output)</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) VQ (3)</td>
<td></td>
</tr>
<tr>
<td>TLP2745</td>
<td>SO8L(SO6L,F4)</td>
<td>Reinforced insulation Topv (max) 110°C Threshold Input Current (max) 1.6 mA</td>
<td>120 ns (max)</td>
<td>Totem pole (Buffer logic output)</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) CQC (6)</td>
<td></td>
</tr>
</tbody>
</table>

### IC Output IGBT/MOSFET Gate Drive

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Toshiba’s Package Name</th>
<th>Features</th>
<th>Propagation delay time</th>
<th>Threshold Input Current (mA)</th>
<th>Isolation voltage (Vrms)</th>
<th>Safety Standards*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLP5214A</td>
<td>SO16L</td>
<td>Smart gate drive photocoupler Direct drive of a medium-power IGBT/MOSFET Overvoltage protection, Self-shutdown Active miller clamp Rail to Rail output</td>
<td>0.15 µs (max)</td>
<td>±4.0 A</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) CQC (6)</td>
<td></td>
</tr>
<tr>
<td>TLP5754 (LF4)</td>
<td>SO6L</td>
<td>Direct drive of a medium-power IGBT/MOSFET Rail to Rail output Topv (max) 110°C</td>
<td>0.15 µs (max)</td>
<td>±4.0 A</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) VQ (3)</td>
<td></td>
</tr>
<tr>
<td>TLP7374 (LF4)</td>
<td>SO6L</td>
<td>Direct drive of a medium-power IGBT/MOSFET Topv = 100 V Topv (max) 110°C</td>
<td>0.15 µs (max)</td>
<td>±4.0 A</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) CQC (6)</td>
<td></td>
</tr>
</tbody>
</table>

### Isolation Amplifier Analog output

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Toshiba’s Package Name</th>
<th>Features</th>
<th>Specifications</th>
<th>Input side supply current (IIP)</th>
<th>Output side supply current (IOP)</th>
<th>Isolation voltage (Vrms)</th>
<th>Safety Standards*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLP7120</td>
<td>SO8L (F4)</td>
<td>Analog output Isolation amplifier Gain = 8.2 (typ.) Topv (max) 125°C</td>
<td>Gain accuracy (Ta=25°C) Rank (max)</td>
<td>Output nonlinearity</td>
<td>±0.5%</td>
<td>±1%</td>
<td>±3%</td>
<td>±0.02%</td>
</tr>
<tr>
<td>TLP7830</td>
<td>SO8L (F4)</td>
<td>1 bit Digital &amp; CL output isolation amplifier Topv (max) 100°C</td>
<td>ENDR Ta=25°C (typ.) SKR Ta=25°C (typ.)</td>
<td>INL (L5B) (typ.)</td>
<td>12/8.0</td>
<td>120 ns</td>
<td>80 dB</td>
<td>4</td>
</tr>
</tbody>
</table>

### High Speed Communications

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Toshiba’s Package Name</th>
<th>Features</th>
<th>Data Rate (Gbps)</th>
<th>Output</th>
<th>@IF (mA)</th>
<th>Isolation voltage (Vrms)</th>
<th>Safety Standards*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLP7168A</td>
<td>SO8L (SO6L,F4)</td>
<td>Reinforced insulation Topv (max) 125°C</td>
<td>20Mbit/s</td>
<td>Open-collector (Inverter logic output)</td>
<td>I&lt;sub&gt;f&lt;/sub&gt; = 15 (max)</td>
<td>5000</td>
<td>UL 1577 (2) VDE (4) CQC (6)</td>
<td></td>
</tr>
</tbody>
</table>

### Transistor Output DC Input

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Toshiba’s Package Name</th>
<th>Features</th>
<th>CTR</th>
<th>V&lt;sub&gt;ISO&lt;/sub&gt; (V)</th>
<th>Isolation voltage (Vrms)</th>
<th>Safety Standards*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLP183</td>
<td>4pin SO</td>
<td>Reinforced insulation Low input drive current Topv (max) 125°C</td>
<td>–</td>
<td>50</td>
<td>600</td>
<td>0.5, 5, 80</td>
<td>3750</td>
</tr>
<tr>
<td>TLP185 (SE)</td>
<td>4pin SD</td>
<td>Reinforced insulation General-purpose</td>
<td>Y</td>
<td>75</td>
<td>150</td>
<td>0.5, 5, 80</td>
<td>3750</td>
</tr>
<tr>
<td>TLP291 (SE)</td>
<td>SO4</td>
<td>Reinforced insulation Load pitch : 1.27 mm</td>
<td>GB</td>
<td>100</td>
<td>600</td>
<td>0.5, 5, 80</td>
<td>3750</td>
</tr>
<tr>
<td>TLP293</td>
<td>SO4</td>
<td>Reinforced insulation Low input drive current Topv (max) 125°C</td>
<td>BL</td>
<td>200</td>
<td>600</td>
<td>0.5, 5, 80</td>
<td>3750</td>
</tr>
</tbody>
</table>

---

*Note: (1): Certified to safety standards. For details on certification status, contact your Toshiba sales representative.  
(2): UL 1577 Standard for Optical Isolators  
(3): UL 1577 Optical Isolators Certified for Canada  
(4): EN 60747-5-5  
(5): EN 60605, EN 60950-1 or EN 62368-1  
(6): GB4943.1, GB4998
High-Voltage MOSFETs (Super-Junction MOSFET)

Fabricated with a single-epitaxial process, Toshiba’s super-junction MOSFET DTMOS-IV series provides RonA 30% lower than that of the previous DTMOS-III series and therefore helps reduce system size and power consumption.

Technical discussion

- High efficiency and low heat generation because of low Ron and short recovery time –
- The three DTMOSIV series satisfy various requirements for MOSFETs.
  - DTMOSIV: Standard series
    Part number suffix: W
    e.g. TK31N60W
  - DTMOSIV HSD: High-speed diode series
    Part number suffix: W5
    e.g. TK31N60W5
  - DTMOSIV-H: High-speed-switching series
    Part number suffix: X
    e.g. TK31N60X

- DTMOS IV (HSD) Series
  The DTMOS HSD series provides a recovery time approximately 70% shorter than the standard DTMOS series and thus helps reduce recovery loss due to the parasitic diode. It is the ideal choice for half- and full-bridge AC-DC power supplies as well as for motor drive applications.

- 30% lower RonA than the previous series
  Due to reduced RonA, the DTMOS IV series helps improve power efficiency.
  This makes it possible to house more chips in a single package, contributing to reducing the size of motor applications.

- Coss loss: Eoss reduction
  The reduced Eoss helps improve efficiency at light load.

- The use of a single-epitaxial process helps reduce on-resistance and therefore temperature increase.
  The reduction in temperature increase in the high-temperature region contributes to improving efficiency.

DMOSIV HSD Series (with 600-V Voss and High-Speed Recovery Diode)

<table>
<thead>
<tr>
<th>Ic (A)</th>
<th>R(ON) MAX (Ω)</th>
<th>DPAK (TO-252)</th>
<th>DPAK (TO-263)</th>
<th>DFN8B8</th>
<th>TO-220</th>
<th>TO-220S15</th>
<th>TO-3P (N)</th>
<th>TO-247</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.65 / 0.67</td>
<td>TK7P60W5 (0.67Ω)</td>
<td>TK7P60W5 (0.67Ω)</td>
<td>TK7A60W5</td>
<td>16</td>
<td>400</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.54 / 0.56</td>
<td>TK8A60W5 (0.56Ω)</td>
<td>TK8A60W5 (0.56Ω)</td>
<td>TK8A60W5</td>
<td>22</td>
<td>590</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>9.7</td>
<td>0.46</td>
<td>TK10A60W5 (0.46Ω)</td>
<td>TK10A60W5 (0.46Ω)</td>
<td>TK10A60W5</td>
<td>23</td>
<td>720</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>18.8</td>
<td>0.29 / 0.24</td>
<td>TK25J65W5 (0.24Ω)</td>
<td>TK25J65W5 (0.24Ω)</td>
<td>TK25J65W5</td>
<td>43</td>
<td>1200</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.175 / 0.13</td>
<td>TK20J60W5 (0.13Ω)</td>
<td>TK20J60W5 (0.13Ω)</td>
<td>TK20J60W5</td>
<td>55</td>
<td>1800</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0.14 / 0.10</td>
<td>TK25J65W5 (0.10Ω)</td>
<td>TK25J65W5 (0.10Ω)</td>
<td>TK25J65W5</td>
<td>60</td>
<td>2400</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>30.8</td>
<td>0.099 / 0.109</td>
<td>TK31J60W5 (0.10Ω)</td>
<td>TK31J60W5 (0.10Ω)</td>
<td>TK31J60W5</td>
<td>105</td>
<td>3000</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>38.8</td>
<td>0.074</td>
<td>TK39J60W5</td>
<td>TK39J60W5</td>
<td>TK39J60W5</td>
<td>135</td>
<td>4100</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>68.8</td>
<td>0.045</td>
<td>TK62J65W5</td>
<td>TK62J65W5</td>
<td>TK62J65W5</td>
<td>205</td>
<td>7200</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>

* I : High speed switching/recovery type, suffixed by "X5"

DTSIV HSD Series (with 600-V Voss and High-Speed Recovery Diode)

<table>
<thead>
<tr>
<th>Ic (A)</th>
<th>R(ON) MAX (Ω)</th>
<th>DPAK (TO-252)</th>
<th>DPAK (TO-263)</th>
<th>DFN8B8</th>
<th>TO-220</th>
<th>TO-220S15</th>
<th>TO-3P (N)</th>
<th>TO-247</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.7</td>
<td>0.3</td>
<td>TK14J65W5</td>
<td>TK14J65W5</td>
<td>TK14J65W5</td>
<td>40</td>
<td>1300</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>17.3</td>
<td>0.23</td>
<td>TK17J65W5</td>
<td>TK17J65W5</td>
<td>TK17J65W5</td>
<td>50</td>
<td>1800</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0.16 / 0.17</td>
<td>TK22J65W5</td>
<td>TK22J65W5</td>
<td>TK22J65W5</td>
<td>50</td>
<td>2400</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>27.6</td>
<td>0.13 / 0.14</td>
<td>TK28J65W5 (0.14Ω)</td>
<td>TK28J65W5 (0.14Ω)</td>
<td>TK28J65W5</td>
<td>90</td>
<td>3000</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>0.095</td>
<td>TK35J65W5</td>
<td>TK35J65W5</td>
<td>TK35J65W5</td>
<td>115</td>
<td>4500</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>49.2</td>
<td>0.057</td>
<td>TK49J65W5</td>
<td>TK49J65W5</td>
<td>TK49J65W5</td>
<td>185</td>
<td>6500</td>
<td>145</td>
<td></td>
</tr>
</tbody>
</table>
Discrete IGBTs

The current sixth-generation discrete IGBTs are fabricated with small field-stop and gate geometries to reduce power loss. Toshiba will employ a field-stop structure and a new gate structure for the seventh-generation IGBTs to further optimize the trade-off between high-speed switching speed and low power loss.

Major 600-V D-IGBTs

<table>
<thead>
<tr>
<th>Vce (V)</th>
<th>kA Rating</th>
<th>Part Number</th>
<th>Voltage @Rated kA</th>
<th>Power Dissipation</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>15</td>
<td>GT15J641</td>
<td>1.5V</td>
<td>35W</td>
<td>D2PAK</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>GT20J641</td>
<td>2.0V</td>
<td>45W</td>
<td>D2PAK</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>GT30J641</td>
<td>3.0V</td>
<td>60W</td>
<td>D2PAK</td>
</tr>
</tbody>
</table>

SiC Schottky Barrier Diodes

Toshiba offers an extensive portfolio of small, high-efficiency diodes, including SiC Schottky barrier diodes (SBDs) featuring high-speed operation and low forward loss.

The use of the Junction Barrier Schottky (JBS) structure reduces leakage current compared to the typical SBD structure, making it possible to realize stable operation even at high voltage and high current.

Features of the Second-Generation Products (Compared to the First-Generation Products)

- **70% higher allowable peak forward surge current (Ifsm)**
- **30% lower switching loss (examples of 650-V and 10-A diodes)**
Discrete Semiconductor Devices

**Low-Voltage MOSFETs**

Toshiba has endeavored to reduce the power losses of MOSFET by optimizing cell structure with fine integration technologies.

**Features**
- Low on-resistance due to the use of a small-geometry process
- Low power losses due to an improved trade-off between on-resistance and charge characteristics
- MOSFETs with a wide range of V_DSS and extensive packaging options suitable for various applications
- High avalanche ruggedness and ESD tolerance
- Optimized device structure for ease of application design with switching noise reduced

**Technical discussion** — Reducing system size and increasing power density —

- **DSOP Advance (double-sided-cooling package)**
  1. The DSOP Advance package efficiently dissipates heat from the metal plates on the top and bottom surfaces.
  2. The DSOP Advance package is footprint-compatible with the SOP Advance package.
  3. The DSOP Advance package has lower resistance.

**U-MOSIX-H／U-MOSIX-H series**

**Major 30-V, 40-V, and 60-V MOSFET products in the SOP Advance and SOP Advance (N) Packages**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Series</th>
<th>Absolute Maximum Ratings</th>
<th>R_DS(ON) (mΩ)</th>
<th>Ciss (Typ.) (nC)</th>
<th>Qg (Typ.) (pF)</th>
<th>Vth (Typ.) (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-MOSIX-H</td>
<td>30</td>
<td>Vs = 10V</td>
<td>Vs = 4.5V</td>
<td>Vs = 100</td>
<td>Vs = 4.5V</td>
<td></td>
</tr>
<tr>
<td>TPH1R403NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 120mΩ</td>
<td>0.77</td>
<td>0.89</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH1R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 133mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 167mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
<tr>
<td>TPH2R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 246mΩ</td>
<td>0.77</td>
<td>0.92</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH2R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 340mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH2R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 393mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
<tr>
<td>TPH1R204NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 120mΩ</td>
<td>0.77</td>
<td>0.89</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 133mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH1R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 167mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 246mΩ</td>
<td>0.77</td>
<td>0.92</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH1R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 340mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 393mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
</tbody>
</table>

**Conduction and Output Charge Losses**

- Comparison with a MOSFET from another manufacturer (as surveyed by Toshiba in August 2019)
- Rs(ON) × Qoss (Normalized) at Vgs = 10V

**U-MOSIX-H／U-MOSIX-H series**

**Major 30-V, 40-V, and 60-V MOSFET products in the DSOP Advance Package**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Series</th>
<th>Absolute Maximum Ratings</th>
<th>R_DS(ON) (mΩ)</th>
<th>Ciss (Typ.) (nC)</th>
<th>Qg (Typ.) (pF)</th>
<th>Vth (Typ.) (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-MOSIX-H</td>
<td>30</td>
<td>Vs = 10V</td>
<td>Vs = 4.5V</td>
<td>Vs = 100</td>
<td>Vs = 4.5V</td>
<td></td>
</tr>
<tr>
<td>TPH1R403NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 120mΩ</td>
<td>0.77</td>
<td>0.89</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH1R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 133mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 167mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
<tr>
<td>TPH2R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 246mΩ</td>
<td>0.77</td>
<td>0.92</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH2R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 340mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH2R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 393mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
<tr>
<td>TPH1R204NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 120mΩ</td>
<td>0.77</td>
<td>0.89</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 133mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH1R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 167mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 246mΩ</td>
<td>0.77</td>
<td>0.92</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>TPH1R506PL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 340mΩ</td>
<td>0.41</td>
<td>0.66</td>
<td>0.6</td>
<td>0.89</td>
</tr>
<tr>
<td>TPH1R506NL</td>
<td>U-MOSIX-H</td>
<td>30 +/-20 393mΩ</td>
<td>0.39</td>
<td>0.59</td>
<td>0.5</td>
<td>0.98</td>
</tr>
</tbody>
</table>

**Double sided cooling**

Top  Bottom
Low-voltage MOSFET Applications (Power Tools)

Low-voltage MOSFET is applied to wider voltage range because of the variety of battery voltage such as 12 and 48V. Toshiba provides wide variety of voltage and package lineup.

<Requirement for MOSFETs for main switch applications>
- Low on-resistance

<Requirements for MOSFETs for motor drive applications>
- Low on-resistance
- Lower switching loss
- Good reverse recovery performance

Electric Speed Controller (ESC) Module for Industrial Drone Applications (TPMD0001A)

The TPMD0001A is an ESC module containing the TMPM475FYFG vector control MCU and the TPH1R204PL MOSFETs with low heat dissipation in a small package. It handles two-way communication via Control Area Network (CAN). Two-way CAN communication allows the ESC to transmit information about voltage, current, temperature, etc. to the main controller, greatly improving a drone’s safety performance, i.e., the ability not to crash or become uncontrollable. The use of vector control helps reduce the power consumption, vibration, and acoustic noise of a motor as well as its rpm variations due to load variations. The TPMD0001A helps reduce the size and weight of 24-V/50-A-class ESCs.
Microcontrollers for Camera and Other Small Applications

Toshiba provides MCUs in small packages incorporating a high-resolution programmable pulse generator (PPG) suitable for high-precision analog-controlled equipment. These MCUs allow parallel processing, making it possible to reduce the operating frequency.

Features

- Up to four programmable servo/sequence controller (PSC) units (suitable for servo computation, motor control, and communication sequencing for camera shake compensation)
- High-resolution PPG for ultrasound control
- Various timer serial interfaces

Applications

- Security cameras, camera lenses, digital video cameras

MCUs with a Programmable Servo/Sequence Controller (PSC) suitable for high-precision motor control applications (TMPM343FDXBG/10XBG)

The TMPM343FDXBG and TMPM310XBG incorporate a programmable serve/sequence controller (PSC) required for camera shake compensation, auto-focus tracking for video, lens control and overall system control, as well as motor controller/drivers and analog circuitry. The high-performance ARM Cortex-M3 core provides high-speed computation. Additionally, a micro-step driver and a high-resolution programmable phase generator (PPG) enable smooth and quiet motor operation.

- ARM Cortex-M3 core
- Supply voltage: 2.7 to 3.6 V (regulated on-chip)
- Maximum operating frequency: 50 MHz
- On-chip memory: Flash ROM 512 KB/1 MB
- SRAM FD: 48 KB + 32 KB (PSC)
- F10: 64 KB + 32 KB (PSC)
- Motor driver
- Operating voltage: 2.5 V to 5.5 V (with the driver on)
- 2.7 V to 3.6 V (peripheral analog blocks)
- On-chip peripherals
  - PSC: 4 units
  - 12-bit AD converters (for MR sensors):
    - 3 unit (8 channels + 4 channels x 2)
  - 16-bit HS PPM (high-resolution PPG output):
    - 8 channels (4 channels x 4 channels)
  - 16-bit timer:
    - 16 channels (free-running, compare output, PPG output)
  - Two-phase input pulse counter:
    - 3 channels (MR sensors)
  - Serial interfaces:
    - 32-bit TSP: 4 channels, UART: 1 channel, i2C: 1 channel
- Package: VFBGA162 (7 x 7 mm, 0.5 mm pitch)

Sample programs for motor control are available among those for the M370 Group of the TX03 Series.

Our website provides sample programs that customers can use as references to evaluate the functionality of our microcontroller products.

For details of evaluation kits, visit our website at:
https://toshiba.semicon-storage.com/ap-en/design-support/referencedesign.html

For more information on development tools, visit our website at:

<table>
<thead>
<tr>
<th>Microcontrollers for Camera and Other Small Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number</td>
</tr>
<tr>
<td>TMPM343FXXBG</td>
</tr>
<tr>
<td>TMPM343FDXBG</td>
</tr>
<tr>
<td>TMPM343F10XBG</td>
</tr>
</tbody>
</table>

* The TMPM343 contains four PSC units. The TMPM342 contains one PSC unit.
### MCU Development Support Tools

Various development tools are available for Arm-core-based MCUs. Visit Toshiba's website to choose the best development tools and partners that suit your needs.

#### Development Environment

- Genuine MDK-Arm development environment
- IAR Systems’ EWARM development environment

#### Sample Programs

Our website provides sample programs that customers can use as references to evaluate the functionality of our microcontrollers and develop applications. Sample programs for motor control are available among those for the M370 Group of the TX03 Series.

<table>
<thead>
<tr>
<th>Sample Program/Function</th>
<th>Description</th>
<th>TMPM370</th>
<th>TMPM372</th>
<th>TMPM373</th>
<th>TMPM374</th>
<th>TMPM375</th>
<th>TMPM376</th>
<th>TMPM37A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Control Circuit</td>
<td>PMD: This example demonstrates the phase outputs.</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
</tbody>
</table>

https://toshiba.semicon-storage.com/ap-en/design-support/referencedesign.html

#### Evaluation Kits

In order to evaluate whether to use Toshiba's microcontroller, it is advisable to use entry-level or other evaluation kits to start software development. Evaluation kits are available from development environment and evaluation kit vendors.

For details of evaluation kits, visit our website at:
Reference Design Center

- The Reference Design Center is an open environment that provides reference designs for motor control and other applications to help you save the time and effort required for circuit design and consideration.

https://toshiba.semicon-storage.com/ap-en/design-support/referencedesign.html

- In addition to technical documents, the Reference Design Center provides data for electronic design automation (EDA) tools, which can be modified, processed, and partially used to suit your design according to its specifications.

Design Documents

- Circuit Schematics
- BOM
- Reference Guides

Design Files

- Circuit schematics
- PCB files
- PCB fabrication data
- etc.

Circuit Data (OrCAD®)
Development Support Tools

• More than 100 types of MCD evaluation boards are available for different types of motors.

![Brushed DC Motor Driver](image1)
![BLDC Motor Driver](image2)
![Stepping Motor Driver](image3)

• You can purchase evaluation boards from one of the following online sites.

![Digi-Key Electronics](image4)
https://www.digikey.jp/

![Marutsuelec Co., Ltd.](image5)
http://sv.marutsu.co.jp/toshiba/

• Development documents and simulation models (datasheets, reference guides, BOM lists, PCB files, and PSpice models) are available for download from Toshiba’s website.
RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”. Hardware, software and systems described in this document are collectively referred to as “Product”.

- TOSHIBA reserves the right to make changes to the information in this document and related Product without notice.
- 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.
- Though TOSHIBA works continually to improve Product’s quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the “TOSHIBA Semiconductor Reliability Handbook” and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS’ PRODUCT DESIGN OR APPLICATIONS.

- PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT (“UNINTENDED USE”). Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT. For details, please contact your TOSHIBA sales representative or contact us via our website.

- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporate into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.

- ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

- Product may include products using GaAs (Gallium Arsenide). GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.

- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.

- Product may include products subject to foreign exchange and foreign trade control laws.

- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.

In addition to the above, the following are applicable only to development tools.

- Though TOSHIBA works continually to improve Product’s quality and reliability, Product can malfunction or fail. Use the Product in a way which minimizes risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. For using the Product, customers must also refer to and comply with the latest versions of all relevant TOSHIBA information, including without limitation, this document, the instruction manual, the specifications, the data sheets for Product.

- Product is provided solely for the purpose of performing the functional evaluation of a semiconductor product. Please do not use Product for any other purpose, including without limitation, evaluation in high or low temperature or humidity, and verification of reliability.

- Do not incorporate Product into your products or system. Products are for your own use and not for sale, lease or other transfer.