Automotive Electric Power Steering

Solution Proposal by Toshiba
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.
Block Diagram
Electric Power Steering (Brush motor)

- Driving Speed Sensor
- Reverse Battery Protection/Load Switch
- Power Supply
- MCU
- Signal Conditioning Circuit
- TVS
- Motor Controller
- Current Monitor Circuit
- Inverter (Brush)
- CAN Line
- Battery (12V)
- CAN Line
- Wheel Angle Sensor
- Torque Sensor
- M
- Reverse Battery Protection/Load Switch
- Current Monitor Circuit
- Inverter (Brush)
Electric Power Steering (Brushless motor)
Electric Power Steering (Brushless motor, Partially redundant)

- **Motor Current Monitor Circuit**
- **Power Supply**
- **MCU (Dual Core)**
- **Gate Driver/Motor Controller**
- **Inverter (Brushless)**
- **Semiconductor Relay**
- **Gate Driver/Motor Controller**
- **Inverter (Brushless)**
- **Semiconductor Relay**
- **Current Monitor Circuit**
- **Reverse Battery Protection/Load Switch**
- **Driving Speed Sensor**
- **Battely (12V)**
- **CAN Line**
- **TVS**
- **Signal Conditioning Circuit**
- **Inverter (Brushless)***
- **Gate Driver/Motor Controller***
- **Inverter (Brushless)***
- **Gate Driver/Motor Controller***
- **Inverter (Brushless)***
- **Semiconductor Relay**
- **Wheel Angle Sensor**
- **Torque Sensor**
- **Position Detection Sensor**

---

© 2019 Toshiba Electronic Devices & Storage Corporation
Electric Power Steering (Brushless motor, Fully redundant)
Brush motor drive circuit

Device selection points
- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a motor controller according to the performance of the switching device to be driven.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU

Proposals from Toshiba
- Low power consumption of the system is realized by low on-resistance
  U-MOS series 40V N-ch power MOSFET
- H-bridge drive circuit is realized
  Motor controller (for brush motor)
- 5V regulator with low current consumption
  Power supply IC (for MCU) (TB9021 is Diode Built-in)
- Power supply with a Built-in tracker
  Power supply IC (for MCU+tracker)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page
Brushless motor drive circuit

Device selection points
- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a gate driver controller according to the performance of the switching device to be driven.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU

Proposals from Toshiba
- Low power consumption of the system is realized by low on-resistance
  U-MOS series 40V N-ch power MOSFET
- Gate driver with protection diagnostic function
  Gate driver (for motor)
- Full-bridge drive circuit is realized
  Motor controller (for brushless motor)
- 5V regulator with low current consumption
  Power supply IC (for MCU) (TB9021 is Diode Built-in)
- Power supply with a Built-in tracker
  Power supply IC (for MCU+tracker)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page.
Power supply ON/OFF control and reverse connection protecting circuit (P-ch method)

- **Battery (12V)**
- **Power Supply**
- **MCU**
- **ON/OFF control switch**
- **Power supply reverse protection**
- **Internal control circuit**

**Device selection points**
- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a gate driver according to the performance of the switching device to be driven.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

**Proposals from Toshiba**
- Low power consumption of the system is realized by low on-resistance
  - U-MOS series -40V / -60V P-ch power MOSFET
- Various product lineups and small packages
  - General-purpose small-signal MOSFET
  - General-purpose small-signal bipolar transistor
  - Small-signal bias resistor built-in transistor (BRT)
  - One-gate logic (L-MOS)
- Both device protection and signal quality is realized
  - TVS diode (for CAN communication)
- 5V regulator with low current consumption
  - Power supply IC (for MCU) (TB9021 is Diode Built-in)
- Power supply with a Built-in tracker
  - Power supply IC (for MCU+tracker)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page.
SW for power supply ON/OFF control and reverse connection protection (2)

Power supply ON/OFF control and reverse connection protecting circuit (N-ch method)

Battery (12V) → Power Supply → Gate Driver → MCU → Internal control circuit → Power supply reverse protection → ON/OFF control switch

Device selection points
- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a gate driver according to the performance of the switching device to be driven.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

Proposals from Toshiba
- Low power consumption of the system is realized by low on-resistance
  U-MOS series 40V N-ch power MOSFET
- Gate driver with protection diagnostic function
  Gate driver (for switch)
- Various product lineups and small packages
  General-purpose small-signal MOSFET
  General-purpose small-signal bipolar transistor
  General-purpose small-signal bias resistor built-in transistor (BRT)
  One-gate logic (L-MOS)
- Both device protection and signal quality is realized
  TVS diode (for CAN communication)
- 5V regulator with low current consumption
  Power supply IC (for MCU) (TB9021 is Diode Built-in)
- Power supply with a Built-in tracker
  Power supply IC (for MCU+tracker)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page
Recommended Devices
As described above, in the design of Power Sliding Door, “Ensuring tolerance to motor lock current and immunity. Capable with functional safety”, “Reduction of power consumption” and “Miniaturization” are important factors. Toshiba’s proposals are based on these three solution perspectives.
## Device solutions to address customer needs

<table>
<thead>
<tr>
<th></th>
<th>Robustness</th>
<th>High efficiency - Low loss</th>
<th>Small size package</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U-MOS series 40V N-ch power MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Motor controller (for brush motor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gate driver (for motor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Motor controller (for brushless motor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>U-MOS series -40V / -60V P-ch power MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>General-purpose small-signal MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>TVS diode (for CAN communication)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Gate driver (for switch)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>General-purpose small-signal bipolar transistor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Small-signal bias resistor built-in transistor (BRT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>One-gate logic (L-MOS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Power supply IC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The advanced U-MOS IX-H processes enables low on-resistance and low noise, thereby reducing power consumption.

1. **Low loss (reduced chip resistance)**
   - Using low chip resistance technology to contribute to reduced power consumption systems.
   - Chip resistance of 61% reduction per unit area (compared to UMOSIV)

2. **Compact, low-loss package**
   - By adopting a Cu connector structure and a double-sided heat dissipation structure.
   - Development of low-loss, high-heat-dissipation packages

3. **Low noise (low EMI)**
   - Optimized chip process, reduce surge voltage and ringing time.

---

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>Drain current</th>
<th>On-resistance (Max)  @VGS=10V</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>XPN3R804NC</td>
<td>40A</td>
<td>3.8mΩ</td>
<td>TSON Advance(WF)</td>
</tr>
<tr>
<td>TK1R4S04PB</td>
<td>120A</td>
<td>1.35mΩ</td>
<td>DPAK+</td>
</tr>
<tr>
<td>TPHR7904PB</td>
<td>150A</td>
<td>0.79mΩ</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td>TPWR7904PB</td>
<td>150A</td>
<td>0.79mΩ</td>
<td>DSOP Advance(WF)</td>
</tr>
<tr>
<td>TKR74F04PB</td>
<td>250A</td>
<td>0.74mΩ</td>
<td>TO-220SM(W)</td>
</tr>
<tr>
<td>TK1R5R04PB</td>
<td>160A</td>
<td>1.5mΩ</td>
<td>D2PAK+</td>
</tr>
</tbody>
</table>

---

© 2019 Toshiba Electronic Devices & Storage Corporation
Motor controller (for brush motor)
TB9057FG

Value provided

**Functional safety** (ASIL-D capable) and **built-in motor-current detecting function**

1. **Functional safety**
   - ISO26262 compliant.
   - FMEDA and safety manuals can be provided.

2. **Built-in current detection amplifier**
   - Two channels of current detection amplifiers are built in to make them redundant.

3. **AEC-Q100 qualified**
   - It is compatible with the AEC-Q100 and can be used for a wide range of Automotive applications.

---

**TB9057FG Typical Connection Diagram**

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9057FG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>LQFP48</td>
</tr>
<tr>
<td>Package body size</td>
<td>7.0 x 7.0 mm</td>
</tr>
</tbody>
</table>

**Function**

- Control method: Direct
- External MOSFET: N-ch / N-ch
- Detection of overheating, low voltage and short circuit: ✔
- Output of detection function diagnosis result: ✔

---

© 2019 Toshiba Electronic Devices & Storage Corporation
The large gate drive-current capability reduces power MOSFET losses and improves the efficiency of equipment.

1. **Large gate drive current**
   - Improves efficiency of high-speed FET switching.
   - TPD7211F: ±0.5 A
   - TPD7212F: -1 / +1.5 A

2. **Built-in protection / diagnostic output function**
   - Hi-Lo side short is prevented and FET is switched off.
   - Functions to monitor abnormalities of the power supply voltage and output voltage are built-in.

3. **Small package**
   - Small surface mount package PS8 and WQFN32

---

**Example of application and block diagram of TPD7212F (Three-phase brushless motor control)**

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TPD7211F</th>
<th>TPD7212F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Half bridge output gate driver</td>
<td>Gate driver for three-phase brushless motor</td>
</tr>
<tr>
<td>Number of output</td>
<td>2 outputs</td>
<td>6 outputs</td>
</tr>
<tr>
<td>Package</td>
<td>PS8 (±0.6 x ±2.9 mm)</td>
<td>WQFN32 (&gt; ±5 mm)</td>
</tr>
<tr>
<td>Features</td>
<td>• For high-side P-channel MOSFET drive</td>
<td>• For driving high-side N-channel MOSFET (with built-in charge pumps) • Built-in voltage monitoring function (power supply, output)</td>
</tr>
</tbody>
</table>
Motor controller (for brushless motor)
TB9081FG / TB9083FTG*

Value provided

Functional safety (ASIL-D capable), built-in safety relay driver

1. Functional safety
   ISO26262 compliant. FMEDA and safety manuals can be provided.

2. Built-in safety relay driver and current detection amplifier
   The safety relay driver is built in for the power supply side FET and the motor phase cut FET. In addition, a 3-channel current detection amplifier is built in to support 3 shunts.

3. AEC-Q100 qualified
   It is compatible with the AEC-Q100 and can be used for a wide range of Automotive applications.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9081FG</th>
<th>TB9083FG*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>LQFP64</td>
<td>WQFN48</td>
</tr>
<tr>
<td>Package body size</td>
<td>10.0 x 10.0 mm</td>
<td>7.0 x 7.0 mm</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>Tj=-40~150°C</td>
<td>Tj=-40~175°C</td>
</tr>
<tr>
<td>Control method</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>External MOSFET</td>
<td>N-ch / N-ch</td>
<td>N-ch / N-ch</td>
</tr>
<tr>
<td>Detection of overheating, low voltage and short circuit</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Output of detection function diagnosis result</td>
<td>✓ (Built-in BIST)</td>
<td>✓ (Built-in BIST)</td>
</tr>
</tbody>
</table>

* TB9083FTG: Under development

Robustness
High efficiency + Low loss
Small size package

High efficiency + Low loss

18 © 2019 Toshiba Electronic Devices & Storage Corporation
Low on-resistance contributes to reduced system power consumption.

1. **Low-loss (reduced chip resistance), logic-level response**

Using low chip resistance technology to contribute to reduced power consumption systems

Lineup of Logic-level-drive types

<table>
<thead>
<tr>
<th>Part number</th>
<th>Drain-source Voltage</th>
<th>Drain current</th>
<th>On-resistance (Max) @VGS=10V</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TJ90S04M3L</td>
<td>-40V</td>
<td>~90A</td>
<td>4.3mΩ</td>
<td>DPAK+</td>
</tr>
<tr>
<td>TJ60S06M3L</td>
<td>-60V</td>
<td>~60A</td>
<td>11.2mΩ</td>
<td>DPAK+</td>
</tr>
<tr>
<td>XPH3R114MC</td>
<td>-40V</td>
<td>~100A</td>
<td>3.1mΩ</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td>TJ200F04M3L</td>
<td>-40V</td>
<td>~200A</td>
<td>1.8mΩ</td>
<td>TO-220SM(W)</td>
</tr>
<tr>
<td>TJ150F06M3L</td>
<td>-60V</td>
<td>~150A</td>
<td>5.6mΩ</td>
<td>TO-220SM(W)</td>
</tr>
</tbody>
</table>

2. **Small surface mount package developed**

Development of low-loss, high-heat-dissipation packages by adopting a Cu connector structure

Ensuring mountability by using the Wettable Flank (WF) structure

Line up

---

© 2019 Toshiba Electronic Devices & Storage Corporation
Choose from a wide array of small packages which contribute to the miniaturization and reduction of power consumption of equipment.

1. **Small package**

Starting with the SOT-723 (VESM 1.2mm² package), a lineup of various small packages is available, contributing to space savings during mounting.

2. **Low voltage drive**

The gate-source voltage can be driven at a low voltage of 1.2 V (SSM3J66MFV).

3. **AEC-Q101 qualified**

AEC-Q101 qualified and can be used for a wide range of automotive applications.

### Small signal package lineup

![Small signal package lineup diagram](image)

#### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM3K7002KF</th>
<th>SSM3J168F</th>
<th>SSM3J66MFV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>S-Mini (SOT-346)</td>
<td>S-Mini (SOT-346)</td>
<td>VESM (SOT-723)</td>
</tr>
<tr>
<td>VDS(DC) [V]</td>
<td>60</td>
<td>-60</td>
<td>-20</td>
</tr>
<tr>
<td>I_D [A]</td>
<td>0.4</td>
<td>-0.4</td>
<td>-0.8</td>
</tr>
<tr>
<td>R_DON@VGS=4.5V [Ω]</td>
<td>Typ. 1.2</td>
<td>1.4</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Max 1.75</td>
<td>1.9</td>
<td>0.39</td>
</tr>
<tr>
<td>Drive voltage [V]</td>
<td>4.5</td>
<td>-4.0</td>
<td>-1.2</td>
</tr>
<tr>
<td>MOS Type</td>
<td>N-channel</td>
<td>P-channel</td>
<td>P-channel</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
TVS diode (for CAN communication)
DF3D18FU / DF3D29FU / DF3D36FU

TVS diode absorbs static electricity (ESD) from external terminals, prevents circuit malfunction and protects devices.

1. **Improve ESD absorbability**
   Improved absorption of ESD through our proprietary Zener process. (Both low operating resistance $R_{DYN}$ and low capacitance $C_t$)

2. **Ensuring high signal integrity**
   Supports in-vehicle LAN communication such as CAN, CAN-FD, FlexRay. Lower capacitance ensures higher signal integrity.

3. **High ESD immunity**
   Compliant products with ISO10605 Standard > ±20 kV
   IEC61000-4-2 Standard > ±20 kV (L4)

![Capacitance between terminals vs $R_{DYN}$](chart.png)

**Dynamic resistance $R_{DYN}$ (Ω)**

- Our Company*1
- Competitor*2

- Low capacitance and low $R_{DYN}$
- Trade-off improvement

- Capacitance between terminals $C_t$ (pF)

<table>
<thead>
<tr>
<th>Part number</th>
<th>DF3D18FU</th>
<th>DF3D29FU</th>
<th>DF3D36FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>USM (SOT-323)</td>
<td>USM (SOT-323)</td>
<td>USM (SOT-323)</td>
</tr>
<tr>
<td>$V_{ESD}$ (kV) @ISO10605</td>
<td>±30</td>
<td>±30</td>
<td>±20</td>
</tr>
<tr>
<td>$V_{RMS}$ (Max) [V]</td>
<td>12</td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td>$C_t$ (Typ./Max) [pF]</td>
<td>9 / 10</td>
<td>6.5 / 8</td>
<td>1.5</td>
</tr>
<tr>
<td>$R_{DYN}$ (Typ.) [Ω]</td>
<td>0.8</td>
<td>1.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**NOTE**: This product is an ESD protection diode and cannot be used for purposes other than ESD protection (including but not limited to constant voltage diode applications).

*1: TOSHIBA Electronic Device & Storage Corporation
*2: Measurements of the commercial product

© 2019 Toshiba Electronic Devices & Storage Corporation
A charge pump for the FET gate drive is built-in, allowing for easy semiconductor relay configuration.

1. Built-in charge pump

No external add-ons required for driving the N-channel on the high side, making it easy to configure a semiconductor relay.

2. Logic level drive

Direct control is possible from microcomputer and CMOS logic.

3. Small package

The small surface mount PS8 contributes to the miniaturization of equipment.

### Value provided

**Gate driver (for switch)**

**TPD7104AF**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TPD7104AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>High-side gate driver</td>
</tr>
<tr>
<td>Number of output</td>
<td>1 output</td>
</tr>
</tbody>
</table>
| Features | • Operating power supply voltage range: 5 to 18 V  
• Built-in charge pump  
• Built-in power supply reverse connection protection function (Supported for power supply reverse connection protection FET applications) |
General-purpose small-signal bipolar transistor
2SC2712 / 2SA1162 / 2SC4116 / 2SA1586 and others

Value provided

Extensive product lineup to meet all your needs.

1. Extensive lineup of packages
Various package lineups, such as 1in1, 2in1 are provided and suitable product for circuit board design can be selected.

2. Various product lineup
Various product lineups, such as general-purpose, low-noise, low V_{CE(sat)} and high-current types, are provided. Products can be selected depending on the application.

3. AEC-Q101 qualified
AEC-Q101 qualified and can be used for a wide range of automotive applications.

- Return to Block Diagram TOP
Small-signal bias resistor built-in transistor (BRT)
RN1114 / RN2114 / RN1414 / RN2414 series

Value provided

Extensive product lineup to meet all your needs.

1. **Built-in bias resistor type (BRT)**

   The BRT reduces the number of parts contributing to miniaturization and shorter production times.

2. **Extensive lineup of package and pin assignment**

   Various package lineups, such as 1in1, 2in1 are provided and suitable product for circuit board design can be selected.

3. **AEC-Q101 qualified**

   AEC-Q101 qualified and can be used for a wide range of automotive applications.

### Line up

<table>
<thead>
<tr>
<th>Package</th>
<th>Part number</th>
<th>NPN (BRT)</th>
<th>PNP (BRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSM (SOT-416)</td>
<td>RN1114</td>
<td>RN2114</td>
<td></td>
</tr>
<tr>
<td>S-Mini (SOT-346)</td>
<td>RN1414</td>
<td>RN2414</td>
<td></td>
</tr>
<tr>
<td>$V_{CEO}$ (Max) [V]</td>
<td>50</td>
<td>-50</td>
<td></td>
</tr>
<tr>
<td>$I_c$ [mA]</td>
<td>100</td>
<td>-100</td>
<td></td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
One-gate logic (L-MOS)
TC7SH / TC7WH / TC7SZ / TC7WZ series

Value provided

Extensive product lineup to meet all your needs.

1 Small package

A standard multi gate CMOS is separated into individual or dual gates and embedded in a small package. This can be suited for simpler designs and contributes to miniaturization.

2 Extensive lineup

The VHS/SHS series, which is widely used in Automotive, offers a wide range of functions, including a total of 230 products.

3 AEC-Q100 qualified (reliability levels)

AEC-Q100 qualified and can be used for a wide range of automotive applications.

Line up

<table>
<thead>
<tr>
<th>Package</th>
<th>VHS series</th>
<th>SHS series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>USV (SOT-353)</td>
<td>TC7SH series</td>
</tr>
<tr>
<td>US8 (SOT-765)</td>
<td>TC7WH Series</td>
<td>TC7WZ series</td>
</tr>
<tr>
<td>VCC [V]</td>
<td>2.0 ~ 5.5</td>
<td>1.65/1.8 ~ 5.5</td>
</tr>
<tr>
<td>Io[mA]</td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

* Compliant products with AEC-Q100’s reliability test only
5V Regulator with low current consumption for automotive MCU. Built-in WDT and various abnormality detection circuits.

1 5V Regulator with low current consumption

5V Regulator with low current consumption used external Tr. for automotive MCU. Output voltage accuracy is +/- 2%.

2 Current limitation value is adjustable

Load current is monitored by the external resistor, so current limitation value is adjustable by changing the resistor value.

3 Built-in WDT and various error detections.

MCU condition is monitored by using WDT. Implemented various abnormality detection circuits (UV detection, Current limitation etc.) contribute a system safety.

TB9005FNG Series Block Diagram

<table>
<thead>
<tr>
<th>Function</th>
<th>Part number</th>
<th>TB9005FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of outputs</td>
<td>Package</td>
<td>SSOP20</td>
</tr>
<tr>
<td>Output Current $I_{OUT}(MAX)$</td>
<td>Package body size</td>
<td>6.4 x 7.0mm</td>
</tr>
<tr>
<td>WDT, Overheat detection, Overcurrent limitation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5V Regulator with low current consumption for automotive MCU. Built-in WDT and various abnormality detection circuits

1. 5V Regulator with low current consumption

   5V Regulator with low current consumption used Built-in Tr. for automotive MCU. Output voltage accuracy is +/- 2%.

2. Built-in WDT and various error detections.

   MCU condition is monitored by using WDT. Implemented various abnormality detection circuits (UV detection, Current limitation etc.) contribute a system safety.

3. AEC-Q100 qualified

   It is compatible with the AEC-Q100 and can be used for a wide range of automotive applications.

---

**TB9021FNG Series Block Diagram**

<table>
<thead>
<tr>
<th>Function</th>
<th>Part number</th>
<th>TB9021FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TSSOP16</td>
<td></td>
</tr>
<tr>
<td>Package body size</td>
<td>5.0 x 6.4mm</td>
<td></td>
</tr>
<tr>
<td>Number of outputs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Output Current IOUT(MAX)</td>
<td>200mA</td>
<td></td>
</tr>
<tr>
<td>WDT, Overheat detection, Overcurrent limitation</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
Value provided

**Built-in high precision power supply for MCU, and various monitoring functions applies to functional safety.**

1. **Built-in high precision power supply for MCU**
   - Built-in 5V LDO for MCU and 3ch Trackers for Sensors

2. **Functional safety (ASIL-D capable)**
   - Built-in safety mechanism applies to functional safety, and abnormality detection functions and diagnostic functions for detection functions.

3. **AEC-Q100 qualified**
   - AEC-Q100 qualified and can be used for a wide range of automotive applications. We provide high-quality, highly reliable products.

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9044AFNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>HTSSOP48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Package body size</th>
<th>8.1 x 12.5mm</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Function</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of outputs</td>
<td>4</td>
</tr>
<tr>
<td>Output Current $I_{OUT}(MAX)$</td>
<td>400mA/100mA×3</td>
</tr>
<tr>
<td>WDT, Overheat detection</td>
<td>○</td>
</tr>
<tr>
<td>Overcurrent detection</td>
<td>○</td>
</tr>
<tr>
<td>Output Internal status</td>
<td>○</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
Built-in high precision power supply for MCU, and various monitoring functions applies to functional safety.

**1 Built-in high precision power supply for MCU**

Built-in 5V LDO for MCU and 3ch Trackers for Sensors. In addition, four types (1.1 / 1.2 / 1.25 / 1.5V) are available as MCU core power supplies.

**2 Functional safety (ASIL-D capable)**

Built-in safety mechanism applies to functional safety, and abnormality detection functions and diagnostic functions for detection functions.

**3 AEC-Q100 qualified**

AEC-Q100 qualified and can be used for a wide range of automotive applications. We provide high-quality, highly reliable products.

**Line up**

<table>
<thead>
<tr>
<th>Function</th>
<th>Number of outputs</th>
<th>Output Current I_{OUT}(MAX)</th>
<th>Package body size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.1 x 12.5mm</td>
</tr>
<tr>
<td>WDT, Overheat detection, Overcurrent detection</td>
<td>5</td>
<td>400mA/800mA/100mA x3</td>
<td></td>
</tr>
</tbody>
</table>

**Part number**

TB9045FNG Series

**Package**

HTSSOP48

**Part number TB9045FNG Series**

Package

**Package body size**

8.1 x 12.5mm

**Function**

- WDT, Overheat detection, Overcurrent detection
If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

Contact address: https://toshiba.semicon-storage.com/ap-en/contact.html
Terms of use

This terms of use is made between Toshiba Electronic Devices and Storage Corporation ("We") and customers who use documents and data that are consulted to design electronics applications on which our semiconductor devices are mounted ("this Reference Design"). Customers shall comply with this terms of use. Please note that it is assumed that customers agree to any and all this terms of use if customers download this Reference Design. We may, at its sole and exclusive discretion, change, alter, modify, add, and/or remove any part of this terms of use at any time without any prior notice. We may terminate this terms of use at any time and for any reason. Upon termination of this terms of use, customers shall destroy this Reference Design. In the event of any breach thereof by customers, customers shall destroy this Reference Design, and furnish us a written confirmation to prove such destruction.

1. Restrictions on usage
   1. This Reference Design is provided solely as reference data for designing electronics applications. Customers shall not use this Reference Design for any other purpose, including without limitation, verification of reliability.
   2. This Reference Design is for customer's own use and not for sale, lease or other transfer.
   3. Customers shall not use this Reference Design for evaluation in high or low temperature, high humidity, or high electromagnetic environments.
   4. This Reference Design shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

2. Limitations
   1. We reserve the right to make changes to this Reference Design without notice.
   2. This Reference Design should be treated as a reference only. We are not responsible for any incorrect or incomplete data and information.
   3. Semiconductor devices can malfunction or fail. When designing electronics applications by referring to this Reference Design, 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 semiconductor devices could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Customers must also refer to and comply with the latest versions of all relevant our information, including without limitation, specifications, data sheets and application notes for semiconductor devices, as well as the precautions and conditions set forth in the "Semiconductor Reliability Handbook".
   4. When designing electronics applications by referring to this Reference Design, customers must evaluate the whole system adequately. Customers are solely responsible for all aspects of their own product design or applications.
   5. No responsibility is assumed by us for any infringement of patents or any other intellectual property rights of third parties that may result from the use of this Reference Design. No license to any intellectual property right is granted by this terms of use, whether express or implied, by estoppel or otherwise.
   6. THIS REFERENCE DESIGN IS PROVIDED "AS IS". WE (a) ASSUME 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 (b) DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO THIS REFERENCE DESIGN, INCLUDING WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

3. Export Control
   Customers shall not use or otherwise make available this Reference Design 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). This Reference Design 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 this Reference Design are strictly prohibited except in compliance with all applicable export laws and regulations.

4. Governing Laws
   This terms of use shall be governed and construed by laws of Japan.
RESTRICTIONS ON PRODUCT USE

- Toshiba Electronic Devices & Storage Corporation, and its subsidiaries and affiliates (collectively “TOSHIBA”), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively “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, 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, devices related to electric power, and equipment used in finance-related fields. IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT. For details, please contact your TOSHIBA sales representative.

- 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 incorporated 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.

- GaAs (Gallium Arsenide) is used in Product. 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.

- 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.