Automotive Electric Pump (Water/Oil)

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 Pump (Water/Oil)  Overall block diagram

Battery (12 V) → Power supply → MCU → Gate driver/Pre driver/Motor controller → Inverter → Motor (M) → TVS → Sensor Signal → CAN Line → Reverse battery protection and load switch
Proposals from Toshiba

- Low on-resistance contributes to low power consumption of the system
  U-MOS Series 40 V N-ch MOSFET
  U-MOS Series 60 V N-ch MOSFET
- H-bridge pre driver compliant with automotive functional safety standard
  Brushed DC motor pre driver
- Voltage regulator with low current consumption
  Power supply IC (for MCU)

Criteria for device selection

- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Driving circuit for brushed DC motor

(N-ch type)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page
Electric Pump (Water/Oil)  Detail of driving circuit for brushless DC motor (1)

Driving circuit for brushless DC motor (N-ch type)

- **Battery (12 V)**
- **Power supply**
- **MCU**
- **Gate driver/Pre driver/Motor controller**
- **MOSFET**

Criteria for device selection
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposals from Toshiba
- **Low on-resistance contributes to low power consumption of the system**
  - U-MOS Series 40 V N-ch MOSFET
  - U-MOS Series 60 V N-ch MOSFET
- **Gate driver with protection diagnostic function**
  - Gate driver (for motor)
- **Full bridge pre driver compliant with automotive functional safety standard**
  - Brushless DC motor pre driver
- **Voltage regulator with low current consumption**
  - Power supply IC (for MCU)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page.
Electric Pump (Water/Oil)  Detail of driving circuit for brushless DC motor (2)

Driving circuit for brushless DC motor (N-ch/P-ch type)

Battery (12 V)

Power supply

Gate driver/ Pre driver / Motor controller

MOSFET

MCU

M

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

Criteria for device selection

- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposals from Toshiba

- Low on-resistance contributes to low power consumption of the system
  U-MOS Series 40 V N-ch MOSFET
  U-MOS Series 60 V N-ch MOSFET
  U-MOS Series -40 V / -60 V P-ch MOSFET
- Gate driver with protection diagnostic function
  Gate driver (for motor)
- Full bridge pre driver compliant with automotive functional safety standard
  Brushless DC motor pre driver
- Voltage regulator with low current consumption
  Power supply IC (for MCU)

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Power supply ON/OFF control and reverse connection protecting circuit (P-ch type)

criteria for device selection
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

proposals from toshiba
- Low on-resistance contributes to low power consumption of the system
  U-MOS Series -40 V / -60 V P-ch MOSFET
- Extensive product lineup
  General purpose small signal MOSFET
  General purpose small signal bipolar transistor
  Small signal bias resistor built-in transistor (BRT)
- Suitable for ESD protection
  TVS diode (for CAN communication)
- Voltage regulator with low current consumption
  Power supply IC (for MCU)

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

Battery (12 V)
ON/OFF control switch
Power supply
reverse protection
Internal control circuit
Power supply
MCU
CAN Line
TVS
TVS
MOSFET
MOSFET
General purpose small signal bipolar transistor
Small signal bias resistor built-in transistor (BRT)
Power supply ON/OFF control and reverse connection protection circuit (N-ch type)

- **Criteria for device selection**
  - It is necessary to select the product with the suitable voltage and current ratings for each application.
  - It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
  - A small surface mount package is suitable for realizing miniaturization of the ECU.

- **Proposals from Toshiba**
  - Low on-resistance contributes low power consumption of the system
    U-MOS Series 40 V N-ch MOSFET
  - Gate driver with protection diagnostic function
    Gate driver (for switch)
  - Extensive product lineup
    General purpose small signal MOSFET
    General purpose small signal bipolar transistor
    Small signal bias resistor built-in transistor (BRT)
  - Suitable for ESD protection
    TVS diode (for CAN communication)
  - Voltage regulator with low current consumption
    Power supply IC (for MCU)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page.
Recommended Devices
Device solutions to address customer needs

As described above, in the design of Electric Pump (Water/Oil), “Ensuring tolerance to motor lock current. 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>Description</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 40 V N-ch MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>U-MOS Series 60 V N-ch MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Brushed DC motor pre driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Gate driver (for motor)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Brushless DC motor pre driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>U-MOS Series -40 V / -60 V P-ch MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>General purpose small signal MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>TVS diode (for CAN communication)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Gate driver (for switch)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>General purpose small signal bipolar transistor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Small signal bias resistor built-in transistor (BRT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Power supply IC (for MCU)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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The latest processes enables low on-resistance and low noise, thereby reducing power consumption.

1 **Low loss (reduced on-resistance)**

Using low on-resistance technology to contribute to reduced power consumption systems.

On-resistance of 44 % reduction per unit area.

(compared to Toshiba’s U-MOSⅧ-H products)

2 **Small and low loss package**

By adopting a Cu clip structure and a double-sided heat dissipation structure, low loss and high heat dissipation are realized.

Wettable Flank (WF) package contributes to good mountability.

3 **Low noise (low EMI)**

Improved chip process reduces surge voltage and ringing time.

---

### Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>Rated drain current [A]</th>
<th>On-resistance (Max) [mΩ] @VGS = 10 V</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>XPN3R804NC</td>
<td>40</td>
<td>3.8</td>
<td>TSON Advance(WF)</td>
</tr>
<tr>
<td>TK1R4S04PB</td>
<td>120</td>
<td>1.35</td>
<td>DPAK+</td>
</tr>
<tr>
<td>XPHR7904PS</td>
<td>150</td>
<td>0.79</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td>TPWR7904PB</td>
<td>150</td>
<td>0.79</td>
<td>DSOP Advance(WF)L</td>
</tr>
<tr>
<td>XPRR6604PB*</td>
<td>(200)</td>
<td>(0.66)</td>
<td>S-TOGL™</td>
</tr>
<tr>
<td>XPRR3004PB</td>
<td>400</td>
<td>0.30</td>
<td>L-TOGL™</td>
</tr>
</tbody>
</table>

* : Under development (Values enclosed in parentheses are tentative specifications. Specifications are subject to change without notice.)

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**1 Low loss (reduced on-resistance)**

Using a low on-resistance technology contributes to reduce system power consumption. The on-resistance per area is reduced by 40%. (compared to Toshiba’s U-MOS IV products)

**2 Small and high power dissipation package**

By adopting a Cu connector structure, a high power dissipation package is realized. Wettable Flank (WF) package contributes to good mountability.

---

**Lineup**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Rated drain current (A)</th>
<th>On-resistance (Max) (mΩ) @VGS = 10 V</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>XPN12006NC</td>
<td>20</td>
<td>12.0</td>
<td>TSON Advance(WF)</td>
</tr>
<tr>
<td>XPN6R706NC</td>
<td>40</td>
<td>6.7</td>
<td>TSON Advance(WF)</td>
</tr>
<tr>
<td>XPH3R206NC</td>
<td>70</td>
<td>3.2</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td>XPH2R106NC</td>
<td>110</td>
<td>2.1</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td>TK90S06N1L</td>
<td>90</td>
<td>3.3</td>
<td>DPAK+</td>
</tr>
</tbody>
</table>
Compliant with automotive functional safety standard (ISO 26262 : ASIL-D) and motor current detecting function is built in.

1. Compliant with automotive functional safety standard
   - Compliant with ISO 26262 ASIL-D. [Note1]
   - FMEDA [NOTE2] and safety manuals can be provided.
   - [Note1] Automotive Safety Integrity Level
   - [Note2] Failure Modes Effects and Diagnostics Analysis

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

3. AEC-Q100 qualified
   - It is AEC-Q100 qualified and it can be used for various automotive applications.

**Lineup**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9057FG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>LQFP48-P-0707-0.50C</td>
</tr>
<tr>
<td>Package body size</td>
<td>7.0 x 7.0 mm</td>
</tr>
</tbody>
</table>

- Control method: Direct
- External MOSFET (High side / Low side): N-ch / N-ch
- Detection of overheating, low voltage and short circuit: ✔
- Output of detection function diagnosis result: ✔
Gate driver (for motor)
TPD7211F / TPD7212F / TPD7212FN

Value provided

The high gate drive current capability reduces MOSFET losses and improves the efficiency of system.

1 High gate drive current

High drive current capability and high speed switching contribute to reduce the loss.
- TPD7211F: ±0.5 A
- TPD7212F, TPD7212FN: -1 / +1.5 A

Example of application and block diagram of TPD7212F, TPD7212FN (Three phase brushless DC motor control)

2 Built-in protection / diagnostic output function

MOSFET is turn off when a signal is input that causes arm short circuit. Functions to monitor abnormalities of the power supply voltage and output voltage are built-in.

3 Small surface mount package

PS-8, WQFN32 and SSOP30 are small surface mount packages. They contribute to the miniaturization of system.

Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>Function</th>
<th>Number of output</th>
<th>Package</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD7211F</td>
<td>Half bridge output gate driver</td>
<td>2 outputs</td>
<td>PS-8 (2.8 x 2.9 mm)</td>
<td>- For high side P-ch MOSFET drive</td>
</tr>
<tr>
<td>TPD7212F</td>
<td>Gate driver for three-phase brushless motor</td>
<td>6 outputs</td>
<td>WQFN32-0505-0.50-002 P-WQFN32-0505-0.50-002 SSOP30-P-300-0.65</td>
<td>- For driving high side N-ch MOSFET (with built-in charge pumps) - Built-in voltage monitoring function (power supply, output)</td>
</tr>
</tbody>
</table>

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Compliant with automotive functional safety standard (ISO 26262 : ASIL-D) and safety relay drivers are built in.

1. Compliant with automotive functional safety standard
Compliant with ISO 26262 ASIL-D, [NOTE 1] FMEDA [NOTE 2] and safety manuals can be provided.

[NOTE 1] Automotive Safety Integrity Level
[NOTE 2] Failure Modes Effects and Diagnostics Analysis

2. Built-in safety relay drivers and motor current detection amplifiers
The safety relay drivers are built in for the power supply side MOSFETs and the motor phase cut MOSFETs. In addition, a 3 channels of motor current detection amplifiers are built in to support 3 shunts.

3. AEC-Q100 qualified
It is AEC-Q100 qualified and it can be used for various automotive applications.

Built-in safety relay drivers
TB9081FG : 5 channels
TB9083FTG : 3 channels

Lineup

<table>
<thead>
<tr>
<th>Function</th>
<th>Part number</th>
<th>TB9081FG</th>
<th>TB9083FTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control method</td>
<td>Package</td>
<td>LQFP64</td>
<td>VQFN48</td>
</tr>
<tr>
<td>Operating ambient temperature</td>
<td>Ta = -40 to 125 °C</td>
<td>Ta = -40 to 150 °C</td>
<td></td>
</tr>
<tr>
<td>Detection of overheating, low voltage and short circuit</td>
<td>External MOSFET (High side / Low side)</td>
<td>N-ch / N-ch</td>
<td>N-ch / N-ch</td>
</tr>
<tr>
<td>Output of detection function diagnosis result</td>
<td>✔</td>
<td>✔ (BIST [Note 3])</td>
<td>✔ (BIST)</td>
</tr>
</tbody>
</table>

[Note 3] Built-in Self Test
It is built in a sensorless control circuit and can drive a brushless DC motor without using Hall elements.

1. Three-phase sensorless drive
   It can drive a brushless DC motor by change of detecting the back electromotive force of each motor phase without using Hall elements.

2. Built-in external MOSFET drive circuits
   It is built in three-phase circuit for driving external P-ch and N-ch MOSFETs.

3. AEC-Q100 qualified
   AEC-Q100 qualified and can be used for various automotive applications.

Application circuit example

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9061AFNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SSOP24-P-300-0.65A (7.8 x 7.6 mm)</td>
</tr>
<tr>
<td>Power supply voltage $V_B$ (Max) [V]</td>
<td>40</td>
</tr>
<tr>
<td>Output voltage $V_{OH}$ (Min) / $V_O$ (Max) [V]</td>
<td>$V_B-0.5$ @ $I_OH = -20$ mA / 0.5 @ $I_{OL} = 20$ mA</td>
</tr>
<tr>
<td>PWM frequency $f_{pint}$ (Typ.) [kHz]</td>
<td>20</td>
</tr>
<tr>
<td>Oscillation frequency $f_{osc}$ (Typ.) [MHz]</td>
<td>5.12</td>
</tr>
</tbody>
</table>

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It is built in a sensorless control circuit and can drive a brushless DC motor without using Hall elements.

1 Three-phase sensorless drive

It can drive a brushless DC motor by change of detecting the back electromotive force of each motor phase without using Hall elements.

2 Built-in external MOSFET drive circuits

It is built in three-phase circuit for driving external P-ch and N-ch MOSFETs.

3 Stable start-up and step-out prevention function

Stable start-up is realized because the start duty is automatically selected according to the battery voltage fluctuation. It also has a function to suppress the sudden change in output duty in response to a sudden change in input duty to prevent step-out.

Application circuit example

<table>
<thead>
<tr>
<th>Lineup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
</tr>
<tr>
<td>Package</td>
</tr>
<tr>
<td>Power supply voltage VBAT [V] (Max)</td>
</tr>
<tr>
<td>Output voltage VOH (Min) / VOL (Max) [V]</td>
</tr>
<tr>
<td>PWM frequency f_{pin} [kHz] (Typ.)</td>
</tr>
<tr>
<td>Oscillation frequency f_{osc} [MHz] (Typ.)</td>
</tr>
</tbody>
</table>

Return to Block Diagram TOP
Brushless DC motor pre driver
TB9067FNG

Value provided
It is suitable for sensor type brushless DC motor control.

1 Compatible with both internal PWM drive and external direct drive
The PWM signals can be input are as follows.
PWM frequency
・ Internal PWM drive : 4 kHz (Max)
・ External direct drive : 23 kHz (Max)

2 Built-in external MOSFET drive circuits
It is built in three-phase circuit for driving external P-ch and N-ch MOSFETs.

3 Built-in various abnormality detection functions
This IC has a variety of built-in abnormality detection functions.
・ External overcurrent/thermal detection for the motor driver
・ BIAS voltage rise / fall detection
・ 100 % drive detection

Application circuit example

Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9067FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SSOP24-P-300-0.65A (7.8 x 7.6 mm)</td>
</tr>
<tr>
<td>Power supply voltage VB [V] (Max)</td>
<td>40</td>
</tr>
<tr>
<td>Output voltage VoH (Min) / Vol (Max) [V]</td>
<td>BIAS-0.3 / 0.3 @ IOUT = ±10 mA</td>
</tr>
<tr>
<td>PWM frequency fPWM [kHz] (Typ.)</td>
<td>20</td>
</tr>
<tr>
<td>Oscillation frequency fosc [MHz] (Typ.)</td>
<td>5.12</td>
</tr>
</tbody>
</table>

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Low on-resistance contributes to reduce system power consumption.

1. **Low loss (reduced on-resistance) and logic level drive**

Using a low on-resistance technology contributes to reduce system power consumption. A lineup of logic level drive type is supported. The on-resistance per area is reduced by 60% (compared to Toshiba’s U-MOS III products).

2. **Small and low loss packages**

By adopting a Cu connector structure, a low loss and high power dissipation package is realized. Wettable Flank (WF) package contributes to good mountability.

<table>
<thead>
<tr>
<th>Lineup</th>
<th>Part number</th>
<th>Rated drain-source voltage [V]</th>
<th>Rated drain current [A]</th>
<th>On-resistance (Max) [mΩ] @VGS = -10 V</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>XPN9R614MC</td>
<td>-40</td>
<td>-40</td>
<td>9.6</td>
<td>TSON Advance(WF)</td>
</tr>
<tr>
<td></td>
<td>XPH3R114MC</td>
<td>-40</td>
<td>-100</td>
<td>3.1</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td></td>
<td>XPH8R316MC*</td>
<td>-60</td>
<td>(-90)</td>
<td>(8.3)</td>
<td>DPAK+</td>
</tr>
<tr>
<td></td>
<td>TJ90S04M3L</td>
<td>-40</td>
<td>-90</td>
<td>4.3</td>
<td>DPAK+</td>
</tr>
</tbody>
</table>

* Under development (Values enclosed in parentheses are tentative specifications. Specifications are subject to change without notice.)

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Wide lineup of small packages contribute to reduce the size and power consumption of system.

1. **Small package**

A lineup of various small packages such as SOT-723 (VESM 1.2 x 1.2 mm package) is available, contributing to reduce mounting area.

2. **Low voltage drive**

SSM3J66MFV can be driven at low gate-source voltage of 1.2 V.

3. **AEC-Q101 qualified**

AEC-Q101 qualified and can be used for various automotive applications.

### Lineup

<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>$V_{DSS}$ [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>$R_{DS(on)}$ @$V_{GS}=4.5$ [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>N-ch</td>
<td>P-ch</td>
<td>N-ch</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-ch</td>
<td>P-ch</td>
<td>P-ch</td>
</tr>
</tbody>
</table>

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TVS diodes prevent system damage and malfunction caused by electrostatic discharge (ESD).

1. **Improve ESD pulse absorbability**
   Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes. (Achieving both low dynamic resistance $R_{DYN}$ and low capacitance between terminals $C_t$)

2. **Supports CAN, CAN FD and FlexRay**
   These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3. **High ESD immunity**
   $V_{ESD} > \pm 30 \, \text{kV} @ \text{ISO 10605}$
   $V_{ESD} > \pm 20 \, \text{kV} @ \text{IEC 61000-4-2 (Level4)}$

**Lineup**

<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] @ISO 10605</td>
<td>$\pm 30$</td>
<td>$\pm 30$</td>
<td>$\pm 20$</td>
</tr>
<tr>
<td>$V_{RWM}$ (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>6.5 / 8</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) The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted. This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

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A charge pump circuit for the N-ch MOSFET gate drive is built in, allowing for easy semiconductor relay configuration.

1. Built-in charge pump circuit
   
   Built-in charge pump circuit enables N-ch MOSFET as high side switch. Easy to configure a semiconductor relay.

2. Can be controlled by logic level voltage
   
   It is possible to be controlled directly by output signal of MCUs or CMOS logic ICs.

3. Small package
   
   The small surface mount packages such as PS-8, SSOP16 and WSON10A contribute to the miniaturization of equipment.

### Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>TPD7104AF</th>
<th>TPD7106F</th>
<th>TPD7107F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>PS-8 (2.8 x 2.9 mm)</td>
<td>SSOP16 (5.5 x 6.4 mm)</td>
<td>WSON10A (3 x 3 mm)</td>
</tr>
<tr>
<td>Function</td>
<td>High side gate driver</td>
<td>High side gate driver</td>
<td>High side gate driver</td>
</tr>
<tr>
<td>Output</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
| Features      | Operating power supply voltage range: 5 to 18 V  
Built-in power supply reverse connection protection function (Protective MOSFET control with back-to-back circuitry) | Operating power supply voltage range: 4.5 to 27 V  
Built-in power supply reverse connection protection function (Protective MOSFET control with back-to-back circuitry) | Operating power supply voltage range: 5.75 to 26 V  
Current sense output  
Protective functions; overcurrent, overtemperature, GND disconnect, etc.  
Reverse battery connection  
Diagnosis output; overcurrent, load open, overtemperature, etc. |

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Extensive product lineup to meet customers’ needs.

1 Extensive lineup of packages
Various packages such as 1-in-1, 2-in-1 are provided and suitable products for circuit board design are selectable.

2 Extensive 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 in accordance with the application.

3 AEC-Q101 qualified
AEC-Q101 qualified and can be used for various automotive applications.

Characteristic examples of 2SC2712

| Classification | $|V_{CEO}|$ | $|I_C| (mA)$ |
|----------------|--------|-------------|
| General purpose | 50 | 150 |
| | 50 | 500 |
| Low noise | 120 | 100 |
| | 50 | 1700 |
| High current | 50 | 2000 |
| | 50 | 2500 |

* indicates UFM package

Lineup

<table>
<thead>
<tr>
<th>Package</th>
<th>SOT-23F</th>
<th>UFM (SOT-323)</th>
<th>S-Mini (SOT-346)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General purpose</td>
<td>2SC4116</td>
<td>2SC1586</td>
<td>2SC2712</td>
</tr>
<tr>
<td></td>
<td>2SC3325</td>
<td>2SA1313</td>
<td></td>
</tr>
<tr>
<td>Low noise</td>
<td>2SC4117</td>
<td>2SA1587</td>
<td>2SC2713</td>
</tr>
<tr>
<td></td>
<td>2SA2195*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High current</td>
<td>TTA501</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TTC501</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Extensive product lineup to meet customers’ needs.

1. **Built-in bias resistor type (BRT: Bias Resistor built-in Transistor)**
   The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

2. **Extensive lineup of package and pin assignment**
   Various package lineups, such as 1-in-1, 2-in-1 and various pin assignment type are provided and suitable products for circuit board design are selectable.

3. **AEC-Q101 qualified**
   AEC-Q101 qualified and can be used for various automotive applications.

---

**Lineup**

<table>
<thead>
<tr>
<th>Package</th>
<th>Part number</th>
<th>NPN (BRT)</th>
<th>PNP (BRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES6 (SOT-563)</td>
<td>RN1907FE</td>
<td>RN2907FE</td>
<td></td>
</tr>
<tr>
<td>US6 (SOT-363)</td>
<td>RN1901</td>
<td>RN2901</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CEO}$ [V]</td>
<td>50</td>
<td>-50</td>
</tr>
<tr>
<td>$I_C$ [mA]</td>
<td>100</td>
<td>-100</td>
</tr>
</tbody>
</table>

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This is voltage regulator with low current consumption, and various monitoring functions such as WDT [Note] contribute to improving system stability.

1. Low current consumption

External transistor type voltage regulator with low current consumption.
Load stability is 1% (Max) (@ILOAD = 1 to 300 mA).

2. Built-in WDT and various monitoring functions

The WDT monitors the operation of the MCU.
In addition, current detection functions contribute to improving system stability.

3. AEC-Q100 qualified

It is AEC-Q100 qualified and can be used for various automotive applications.

[Note] Watchdog Timer

Application circuit example (The current limiter can be adjusted by an external resistor.)

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9005FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SSOP20 (6.4 x 7.0 mm)</td>
</tr>
<tr>
<td>Current consumption $I_{CC}$ (Typ.) ($\mu$A)</td>
<td>90 (@$V_{IN}$ = 12 V, $T_a$ = 25 °C)</td>
</tr>
<tr>
<td>Load stability $V_{LOAD}$ (Max) [%]</td>
<td>1 (@$I_{LOAD}$ = 1 to 300 mA)</td>
</tr>
<tr>
<td>Number of outputs</td>
<td>1ch (5 V)</td>
</tr>
<tr>
<td>Circuit type</td>
<td>External transistor type</td>
</tr>
<tr>
<td>WDT, Overcurrent limitation</td>
<td>✔</td>
</tr>
</tbody>
</table>

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