Automotive Electric Pump

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 for Automotive

- Battery (12V)
- Sensor Signal
- CAN Line
- Power Supply
- Reverse Battery Protection and Load Switch
- MCU
- TVS
- Gate Driver/Motor Controller
- Inverter
- M
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)

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

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

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page
Brushless motor drive circuit (2)

Proposals from Toshiba

- **Low power consumption of the system is realized by low on-resistance**
  - U-MOS series 40V N-ch power MOSFET
  - U-MOS series -40V/-60V P-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)

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

*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 (1)

**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**
- **General-purpose small-signal bipolar transistor**
- **General-purpose small-signal bias resistor built-in transistor (BRT)**
- **One-gate logic (L-MOS)**

---

**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)

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* 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 (N-ch method)

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 bipolar transistor (BRT)
  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)

* 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 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.

- **Ensuring tolerance to motor lock current and immunity. Capable with functional safety**
- **Reduction of power consumption**
- **Miniaturization**

- **Robustness**
- **High efficiency**
- **Small size package**
- **Low loss**
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(for MCU)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**U-MOS series 40V N-ch power MOSFET**

XPN3R804NC / TK1R4S04PB / TPHR7904PB / TPWR7904PB / TKR74F04PB / TK1R5R04PB

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**Value provided**

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>

---

**TO-220SM(W) Cu connector design**
- Package resistance reduction 64%, Compared to D2PAK

**DSOP Advance(WF) double-sided cooling packages**
- Decrease of thermal resistance 76% reduction @t=3s, mounted on board Compared to SOP-8
Motor controller (for brush motor)
TB9057FG

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.

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>
<tr>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>Control method</td>
<td>Direct</td>
</tr>
<tr>
<td>External MOSFET</td>
<td>N-ch / N-ch</td>
</tr>
<tr>
<td>Detection of overheating, low voltage and short circuit</td>
<td>✗</td>
</tr>
<tr>
<td>Output of detection function diagnosis result</td>
<td>✗</td>
</tr>
</tbody>
</table>

TB9057FG Typical Connection Diagram

◆Return to Block Diagram TOP
Gate driver (for motor)
TPD7211F / TPD7212F

Value provided

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)

<table>
<thead>
<tr>
<th>Line up</th>
<th>TPD7211F</th>
<th>TPD7212F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
<td>TPD7211F</td>
<td>TPD7212F</td>
</tr>
<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 (2.8 x 2.9 mm)</td>
<td>WQFN32 (5 x 3 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>

Return to Block Diagram TOP
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.

Built-in safety relay driver (TB9081FG:5ch, TB9083FTG:3ch)

<table>
<thead>
<tr>
<th>Line up</th>
<th>Part number</th>
<th>TB9081FG</th>
<th>TB9083FTG*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>LQFP64</td>
<td>WQFN48</td>
<td></td>
</tr>
<tr>
<td>Package body size</td>
<td>10.0 x 10.0 mm</td>
<td>7.0 x 7.0 mm</td>
<td></td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>Tj=-40~150°C</td>
<td>Tj=-40~175°C</td>
<td></td>
</tr>
<tr>
<td>Control method</td>
<td>Direct</td>
<td>Direct</td>
<td></td>
</tr>
<tr>
<td>External MOSFET</td>
<td>N-ch / N-ch</td>
<td>N-ch / N-ch</td>
<td></td>
</tr>
<tr>
<td>Detection of overheating, low voltage and short circuit</td>
<td>✔</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>
<td></td>
</tr>
</tbody>
</table>

* TB9083FTG: Under development

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Motor controller (for brushless motor)
TB9061AFNG

Value provided

Auto Servo control system for stable motor operation

1 3-phase full-wave sensorless drive system
By detecting changes in the induced voltage of each phase of the motor, it is possible to drive a brushless DC motor without a Hall element.

2 Built-in external MOSFET drive output for 3 phases 6 outputs
The drive outputs for P-ch/N-ch external MOSFET are built-in 3-phase 6 outputs.

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

Application circuit example

| Line up |
|-------------------|-----------------|
| Part number       | TB9061AFNG      |
| Package           | SSOP24 7.8X7.6mm |
| Power-supply voltage VB [V] (Max) | 40 |
| Output voltage VOH/VOL [V] (Max) | VB-0.5/0.5 @ IOUT=20mA |
| PWM frequency fPWM [kHz] (Typ.) | 20 |
| Oscillation frequency fosc [MHz] (Typ.) | 6.14 |

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Motor controller (for brushless motor)
TB9062FNG

Value provided

Auto Servo control system for stable motor operation

1 3-phase full-wave sensorless drive system
By detecting changes in the induced voltage of each phase of the motor, it is possible to drive a brushless DC motor without a Hall element.

2 Built-in external MOSFET drive output for 3 phases 6 outputs
The drive outputs for P-ch/N-ch external MOSFET are built-in 3-phase 6 outputs.

3 Start-up stability control is superior
TB9062FNG has an automatically compensating function and has a stall preventing function.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSOP24 7.8X7.6mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TB9062FNG</td>
</tr>
<tr>
<td>Power-supply voltage VB [V] (Max)</td>
<td>40</td>
</tr>
<tr>
<td>Output voltage VOH/VOL [V] (Max)</td>
<td>VB-0.5/0.5 @ IOUT=1mA</td>
</tr>
<tr>
<td>PWM frequency f_{pwm} [kHz] (Typ.)</td>
<td>17.0 @ Rext=39kΩ</td>
</tr>
<tr>
<td>Oscillation frequency f_{osc} [MHz] (Typ.)</td>
<td>4.00 @ Rext=39kΩ</td>
</tr>
</tbody>
</table>

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Suitable for sensor type BLDC motor control

1. Either internal PWM drive or external direct drive Available

The PWM signals can be input are as follows.
- Internal PWM frequency drive: ~4kHz
- External direct drive: ~23kHz

2. Built-in external MOSFET drive output for 3 phases 6 outputs

The drive outputs for P-ch/N-ch external MOSFET are built-in 3-phase 6 outputs.

3. Built-in various abnormality detection functions

- External motor driver overcurrent / overheat detection
- BIAS voltage rise / fall detection
- 100% drive detection

Application circuit example

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9067FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SSOP24</td>
</tr>
<tr>
<td></td>
<td>7.8x7.6mm</td>
</tr>
<tr>
<td>Power-supply voltage VB [V] (Max)</td>
<td>40</td>
</tr>
<tr>
<td>Output current [mA] (Max)</td>
<td>$I_{OUT} = \pm 250$</td>
</tr>
<tr>
<td>PWM frequency $f_{PWM}$ [kHz] (Typ.)</td>
<td>20</td>
</tr>
<tr>
<td>Oscillation frequency $f_{osc}$ [MHz] (Typ.)</td>
<td>5.12</td>
</tr>
</tbody>
</table>

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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

Low Loss: RonA Reduction Trend

Large current, small size, high heat dissipation package

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

<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>
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.

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**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>V_{DS(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_{DSS} [Ω] @V_{GS}=4.5 V</td>
<td>1.2</td>
<td>1.4</td>
<td>0.31</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>

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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 $R_{\text{DYN}}$ 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)

Line up

<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>$V_{\text{ESD}}$ [kV] @ISO10605</td>
<td>±30</td>
<td>±30</td>
<td>±20</td>
</tr>
<tr>
<td>$V_{\text{RMS}}$ (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>6.5 / 8</td>
</tr>
<tr>
<td>$R_{\text{DYN}}$ (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

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Return to Block Diagram TOP
A charge pump for the FET gate drive is built-in, allowing for easy semiconductor relay configuration.

### 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.

### Logic level drive

Direct control is possible from microcomputer and CMOS logic.

### Small package

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

---

**Line up**

<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.

### Line up

<table>
<thead>
<tr>
<th>Classification</th>
<th>Package</th>
<th>SSM (SOT-416)</th>
<th>USM (SOT-323)</th>
<th>UFM (SOT-323F)*</th>
<th>S-Mini (SOT-346)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General purpose</td>
<td>NPN</td>
<td>50</td>
<td>150</td>
<td>2SC4738</td>
<td>2SA1162</td>
</tr>
<tr>
<td>Low noise</td>
<td>PNP</td>
<td>50</td>
<td>500</td>
<td>2SC4116</td>
<td>2SA1586</td>
</tr>
<tr>
<td>High-current</td>
<td>NPN</td>
<td>120</td>
<td>100</td>
<td>2SC4117</td>
<td>2SA1587</td>
</tr>
<tr>
<td></td>
<td>PNP</td>
<td>1700</td>
<td></td>
<td></td>
<td>2SA2195*</td>
</tr>
</tbody>
</table>

※2SC2712

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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.

---

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

◆ Return to Block Diagram TOP
### 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>USV (SOT-353)</td>
<td>TC7SH series</td>
<td>TC7SZ series</td>
</tr>
<tr>
<td>US8 (SOT-765)</td>
<td>TC7WH Series</td>
<td>TC7WZ series</td>
</tr>
</tbody>
</table>

| $V_{CC}$ [V] | 2.0 ~ 5.5 | 1.65/1.8 ~ 5.5 |
| Io [mA] | 8 | 24 |

* 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.

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB9005FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SSOP20</td>
</tr>
<tr>
<td>Package body size</td>
<td>6.4 x 7.0mm</td>
</tr>
<tr>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>Number of outputs</td>
<td>1</td>
</tr>
<tr>
<td>Output Current $I_{OUT}(MAX)$</td>
<td>Depends on External Tr.</td>
</tr>
<tr>
<td>WDT, Overheat detection, Overcurrent limitation</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**

- **Part number**: TB9021FNG
- **Package**: TSSOP16
- **Package body size**: 5.0 x 6.4mm
- **Function**
  - Number of outputs: 1
  - Output Current $I_{OUT}(MAX)$: 200mA
  - WDT, Overheat detection, Overcurrent limitation

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