Automotive Battery management system

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
Battery Management System for Automotive

HIGH SID(+)  
- Pre-charge Switch  
- Sticking Detection  
- High-side Switch  
- DC-DC  
- Battery Management IC  
- Isolation  
- MCU  
- CAN Line

LOW SID(−)  
- Sticking Detection  
- Low-side Switch  
- DC-DC  
- Battery Management IC  
- ADC  
- High Speed Logic Coupler

© 2019 Toshiba Electronic Devices & Storage Corporation
Power line circuit (1)

**Device selection points**
- Changing from mechanical relays to semiconductor relays reduces the risk of switch failure.
- It is necessary to select the product with the optimum blocking voltage/output current for each application.
- It is necessary to select small surface mount packages suitable for miniaturization of the set.

**Proposals from Toshiba**
- **MOSFET drive couplers that do not require external power supply**
  Photovoltaic coupler
- **Photovoltaic coupler and MOSFET are in one package**
  Photorelay

**Charge circuit**
Prevention of sticking

**Charge circuit**
Detection of mechanical relay sticking

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page.
Power supply line circuit diagram (2)

**Charge circuit**
Ground fault sensing circuit

- Changing from mechanical relays to semiconductor relays reduces the risk of switch failure.
- It is necessary to select the product with the optimum blocking voltage/output current for each application.
- It is necessary to select small surface mount packages suitable for miniaturization of the set.

**Device selection points**

**Proposals from Toshiba**
- **Photovoltaic coupler and MOSFET are in one package**

*Click on the numbers in the circuit diagram to jump to the detailed descriptions page*
Passive cell voltage regulation (Use of Battery Management IC)

- Changing from mechanical relays to semiconductor relays reduces the risk of switch failure.
- It is necessary to select the product with the optimum blocking voltage/output current for each application.
- It is necessary to select small surface mount packages suitable for miniaturization of the set.

Proposals from Toshiba
- MOSFET drive couplers that do not require external power supply
  Photovoltaic coupler
- Various product lineups and small packages
  General-purpose small-signal MOSFET

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

Battery monitoring circuit

Adding redundancy to communications

Device selection points
- Using isolation devices capable of holding the total voltage of the battery is desirable.
- Current feedback circuit to the MCU should be low power consumption.
- A redundant signal communication is required for the safety of the set.

Proposals from Toshiba
- Device capable of holding total battery voltage
  Photorelay
- Contributing to high-speed switching or low consumption
  IC output photocoupler
- Contributing to redundant communications
  Transistor output photocoupler

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

Device selection points
- It is necessary to select a device with a protection function against surge voltage generated from inductance of inductive load.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

Proposals from Toshiba
- **Built-in active clamp circuit and pull-down resistor for relay drive**
  U-MOSIV series active clamp MOSFET
- **Driver with protection function**
  Low-side switch / High-side switch (~1A)
  Low-side switch / High-side switch (1 ~ 5A)
- **Various product lineups and small packages**
  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)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page
Recommended Devices
As described above, in the design of Automotive Battery Management System, “Improvement of 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>Photovoltaic coupler</th>
<th>Photo relay</th>
<th>General-purpose small-signal MOSFET</th>
<th>IC output photocoupler</th>
<th>Transistor output photocoupler</th>
<th>U-MOSIV series active clamp MOSFET</th>
<th>Low-side switch / High-side switch (~1A)</th>
<th>Low-side switch / High-side switch (1 ~ 5A)</th>
<th>General-purpose small-signal bipolar transistor</th>
<th>Small-signal bias resistor built-in transistor (BRT)</th>
<th>One-gate logic (L-MOS)</th>
<th>TVS diode (for CAN communication)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Robustness**
- **High efficiency - Low loss**
- **Small size package**
Photovoltaic coupler that consists of an infrared light-emitting diode and a photodiode array.

1 External power supply for driving the light-receiving chip not required.

The photodiode array (PDA) receives the light from the LED and generates electricity. External power source for driving the light-receiving chip is not needed due to the electricity generated by itself, and contributes to miniaturization of the circuit board.

2 Semiconductor relays can be realized by combinations with MOSFET.

The output current and voltage are the highest in the industry. The semiconductor relays of any voltage/output current can be realized combined with MOSFET.

---

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLX9905</th>
<th>TLX9906</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation Voltage [Vrms]</td>
<td>3750</td>
<td>3750</td>
</tr>
<tr>
<td>Open circuit voltage [V] @I_{s}=10mA</td>
<td>Typ. 9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Min 7</td>
<td>7</td>
</tr>
<tr>
<td>Short-circuit current [μA] @I_{s}=10mA</td>
<td>Typ. 30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Min 12</td>
<td>12</td>
</tr>
<tr>
<td>Discharge circuit</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>AEC-Q101</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

---

The ECU board can be miniaturized.

The photodiode array (PDA) receives the light from the LED and generates electricity. The photovoltaic coupler itself is the power supply.

Return to Block Diagram TOP
Solid-state relay (non-contact relay) that consists of an infrared LED and a MOSFET.

1. Safety switching
   No mechanical contact due to use of semiconductor relay. Thus, the risk of mechanical sticking and welding can be avoided, and contributes to safety switching.

2. High blocking voltage
   High breakdown-voltage MOSFETs with $V_{\text{OFF}}=600\text{V}$ are used. It is suitable for the control application of high-voltage battery devices.

3. To reduce the board area
   Photodiodes and MOSFET infused in one package. This contributes to the reduction of the board area compared to the mechanical relay.

TLX 9175J Internal circuit

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLX9175J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation Voltage [Vrms]</td>
<td>3750</td>
</tr>
<tr>
<td>Blocking voltage [V]</td>
<td>600</td>
</tr>
<tr>
<td>Trigger LED current [mA] @$I_{\text{ON}}=15\text{mA}, Ta=25^\circ\text{C}$</td>
<td>3</td>
</tr>
<tr>
<td>On-resistance @$I_{\text{ON}}=15\text{mA}, I_F=10\text{mA}, Ta=25^\circ\text{C}$</td>
<td>Max 335, Min 185</td>
</tr>
<tr>
<td>AEC-Q101</td>
<td>○</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
General-purpose small-signal MOSFET
SSM3K7002KF / SSM3J168F / SSM3J66MFV

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

<table>
<thead>
<tr>
<th>Voltage</th>
<th>ID</th>
<th>RDS(ON)</th>
<th>Drive Voltage</th>
<th>MOS Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(DS(DC)) [V]</td>
<td>I_D [A]</td>
<td>R_DSON(@VGS=4.5V) [Ω]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0.4</td>
<td>1.2</td>
<td>N-channel</td>
<td></td>
</tr>
<tr>
<td>-60</td>
<td>-0.4</td>
<td>1.4</td>
<td>P-channel</td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td>-0.8</td>
<td>0.31</td>
<td>P-channel</td>
<td></td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
IC output photocoupler
TLX9304 / TLX9309 / TLX9310 / TLX9378 / TLX9376

1. High insulation and noise cutoff
   - Isolation voltage 3750V
   - Common mode transient immunity 15kV/µs

2. Low power consumption and high-speed
   - The combination of a LED chip and light receiving chip contributes to power savings. Product lineup of 1~20Mbps available.

3. Assurance of maximum operating temperature of 125°C
   - Heat resistance package allows an operating temperature range of -40 to 125°C as well as a longer life.

Photocoupler that consists of an infrared light-emitting diode and an integrated photodetector.

Non-electrical communication provides excellent insulation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

TLX9304
- Topr=125°C
- 1M logic

TLX9309
- Topr=125°C
- 1M analog

TLX9310
- Topr=105°C
- 5M logic
- Low power-consumption

TLX9376
- Topr=125°C
- 20M logic

TLX9378
- Topr=125°C
- 10M logic

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLX9304</th>
<th>TLX9309</th>
<th>TLX9310</th>
<th>TLX9378</th>
<th>TLX9376</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation Voltage [Vrms]</td>
<td>3750</td>
<td>3750</td>
<td>3750</td>
<td>3750</td>
<td>3750</td>
</tr>
<tr>
<td>Output type</td>
<td>Open collector (INV)</td>
<td>Open collector (INV)</td>
<td>Totem pole (BUF)</td>
<td>Open collector (INV)</td>
<td>Totem pole (INV)</td>
</tr>
<tr>
<td>Power supply voltage [V]</td>
<td>30</td>
<td>30</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Threshold input current (Max) [mA]</td>
<td>5</td>
<td>Analog</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Power supply current (Max) [mA]</td>
<td>1.3</td>
<td>Analog</td>
<td>0.3</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Data rate (Typ.)</td>
<td>1Mbps</td>
<td>1Mbps</td>
<td>5Mbps</td>
<td>10Mbps</td>
<td>20Mbps</td>
</tr>
<tr>
<td>AEC-Q101</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

(Comparison with our previous products)

© 2019 Toshiba Electronic Devices & Storage Corporation
Transistor output photocoupler
TLX9291A / TLX9185A / TLX9000 / TLX9300

Contributes to safe improvement and design miniaturization.

1 High insulation
Non-electrical communication provides excellent insulation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

2 Small package
A lineup of the SO4 package, reduced mounting area by 30% compared with conventional SO6 package. It contributes to reduce mounting area of the board.

3 Assurance of maximum operating temperature of 125℃
High heat resistance package allows an operating temperature range of -40 to 125℃ as well as a longer life. The TLX9000/9300 has built-in base-emitter resistor to reduce dark currents at high temperatures.

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLX9291A / TLX9185A</th>
<th>TLX9000 / TLX9300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation Voltage [Vrms]</td>
<td>3750</td>
<td>3750</td>
</tr>
<tr>
<td>Collector-emitter voltage [V]</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Dark current [nA] @Ta=125℃</td>
<td>&lt; 100 @ VCE=48V</td>
<td>&lt; 10 @ VCE=24V</td>
</tr>
<tr>
<td>Conversion efficiency (%) @ Ii=5mA, VCE=5V, Ta=25℃</td>
<td>50 ~ 600</td>
<td>100 ~ 900</td>
</tr>
<tr>
<td>Conversion efficiency (saturation) (%) @ Ii=1mA, VCE=0.4V, Ta=25℃</td>
<td>&gt; 30</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

AEC-Q101

© 2019 Toshiba Electronic Devices & Storage Corporation
These devices have a built-in active clamp circuit to reduce the number of components and to save mounting space.

1. **Built-in active clamp circuit**
   An active clamp circuit MOSFET with a zener between the drain-gate terminals prevents damage due to voltage surges during inductive loads driving.

2. **Built-in pull-down resistor**
   A 47kΩ pull-down resistor is built in between the gate-source terminals, which reduces required components and mounting space. (SSM3K347R)

3. **Low voltage drive**
   The gate-source voltage can be driven at a low voltage of 4.0 V

---

### Internal circuit

<table>
<thead>
<tr>
<th>Pin Assignment</th>
<th>1. Gate</th>
<th>2. Source</th>
<th>3. Drained</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSM3K347R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSM3K337R</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM3K347R</th>
<th>SSM3K337R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SOT-23F</td>
<td>SOT-23F</td>
</tr>
<tr>
<td>$V_{DPS,DC}$ [V]</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>$I_D$ [A]</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>$R_{ON, typ.}$ @$V_{GS}=4.0V$ [mΩ]</td>
<td>350</td>
<td>161</td>
</tr>
<tr>
<td>Max</td>
<td>480</td>
<td>200</td>
</tr>
<tr>
<td>MOS Type</td>
<td>N-channel</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
Protection and diagnostic output functions are built-in and can be directly controlled at the logic level, contributing to improved reliability and miniaturization of the equipment.

1. **Built-in protection and diagnostic output function**

   Overcurrent and overheat protection in the event of a load error (short circuit, etc.) and feedback (diagnostic output) to the microcomputer are built-in. This contributes to the reliability of the equipment.

   Example of Low-side switch application (Block diagram of TPD1054F)

   Suitable for applications with small current load below 1A, such as mechanical relay.

2. **Logic level drive**

   Direct control is possible using a microcomputer and CMOS logic chip.

3. **Small package**

   Product line-up includes small surface mount package PS8 and dual-output type. This contributes to equipment miniaturization.

### Line up

<table>
<thead>
<tr>
<th>Function</th>
<th>Low-side switch</th>
<th>High-side switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of output</td>
<td>1 output</td>
<td>2 outputs</td>
</tr>
<tr>
<td>Part number</td>
<td>TPD1044F</td>
<td>TPD1054F</td>
</tr>
<tr>
<td></td>
<td>TPD1030F</td>
<td>TPD1052F</td>
</tr>
<tr>
<td>Package</td>
<td>PS8 (2.8 x 2.9 mm)</td>
<td>PS8 (2.8 x 2.9 mm)</td>
</tr>
<tr>
<td></td>
<td>SOP8 (5 x 6 mm)</td>
<td>PS8 (2.8 x 2.9 mm)</td>
</tr>
<tr>
<td>Features</td>
<td>Overcurrent/overheat protection, Active clamp, on-resistance: 0.6 Ω</td>
<td>Overcurrent/overheat protection, Active clamp, on-resistance: 0.8 Ω</td>
</tr>
<tr>
<td></td>
<td>Overcurrent/overheat protection, Active clamp, Diagnostic output function, on-resistance: 0.6 Ω</td>
<td>Overcurrent/overheat protection, Diagnostic output function, on-resistance: 0.8 Ω</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
Protection and diagnostic output functions are built-in and can be directly controlled at the logic level, contributing to improved reliability and miniaturization of the equipment.

1 Built-in protection and diagnostic output function

Overcurrent and overheat protection in the event of a load error (short circuit, etc.) and feedback (diagnostic output) to the microcomputer are built-in. This contributes to the reliability of the equipment.

Example of Low-side switch application
(Blocking diagram of TPD1058A)

Suitable for valve timing and solenoid drive of transmission.

2 Logic level drive

Direct control is possible using a microcomputer and CMOS logic chip.

3 Small package

Product lineup includes small and high heat dissipation package WSON10 and dual-output type. This contributes to equipment miniaturization.
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 $V_{CE\text{(sat)}}$ 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>$V_{CEO}$ [V]</th>
<th>$I_C$ [mA]</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>General purpose</td>
<td>50</td>
<td>150</td>
<td>2SC4738</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>500</td>
<td>2SA1832</td>
</tr>
<tr>
<td>Low noise</td>
<td>120</td>
<td>100</td>
<td>2SC4117</td>
</tr>
<tr>
<td>High-current</td>
<td>50</td>
<td>1700</td>
<td>2SA1587</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2SC2713</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2SA1586</td>
</tr>
</tbody>
</table>

Line up

<table>
<thead>
<tr>
<th>Classification</th>
<th>$V_{CEO}$ [V]</th>
<th>$I_C$ [mA]</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>General purpose</td>
<td>50</td>
<td>150</td>
<td>2SC4738</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>500</td>
<td>2SA1832</td>
</tr>
<tr>
<td>Low noise</td>
<td>120</td>
<td>100</td>
<td>2SC4117</td>
</tr>
<tr>
<td>High-current</td>
<td>50</td>
<td>1700</td>
<td>2SA1587</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2SC2713</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2SA1586</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation
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>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
</tr>
<tr>
<td>Package</td>
</tr>
<tr>
<td>SSM (SOT-416)</td>
</tr>
<tr>
<td>S-Mini (SOT-346)</td>
</tr>
<tr>
<td>$V_{CEO}$ (Max) [V]</td>
</tr>
<tr>
<td>$I_C$ [mA]</td>
</tr>
</tbody>
</table>

© 2019 Toshiba Electronic Devices & Storage Corporation

Return to Block Diagram TOP
One-gate logic (L-MOS)
TC7SH / TC7WH / TC7SZ / TC7WZ series

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.

<table>
<thead>
<tr>
<th>Package</th>
<th>VHS series</th>
<th>SHS series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</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>
<tr>
<td>$V_{CC}$ [V]</td>
<td>2.0 ~ 5.5</td>
<td>1.65/1.8 ~ 5.5</td>
</tr>
<tr>
<td>$I_{O}(mA)$</td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

* Compliant products with AEC-Q100’s reliability test only

© 2019 Toshiba Electronic Devices & Storage Corporation 23
TVS diode (for CAN communication)
DF3D18FU / DF3D29FU / DF3D36FU

Value provided

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></td>
<td></td>
</tr>
<tr>
<td>$V_{\text{ESD}}$ (kV) @ISO10605</td>
<td>±30</td>
<td>±30</td>
<td>±20</td>
</tr>
<tr>
<td>$V_{\text{RMA}}$ (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>1.1</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

© 2019 Toshiba Electronic Devices & Storage Corporation
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. WE ASSUME NO LIABILITY FOR CUSTOMERS' 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 OR CONDITIONS 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 the 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, Unauthorized 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 AGREED SIGNATURE, 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.