IVI
(In-vehicle Infotainment)

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
IVI (In-vehicle Infotainment) Overall block diagram

Wireless Communication
- Wi-Fi®/4G/GPS
- Ethernet AVB
- Ethernet bridge IC
- HSIC/PCIe®

Video Input
- Camera
- HDMI
- MIPI® CSI-2®
- Parallel Serializer/Deserializer
- MIPI CSI-2

Voice Input
- MIC
- Audio Codec

Application processor
- RKE IC
- Ethernet bridge IC
- PCIe

Display/Audio Output
- Display
- LVDS
- Audio Codec
- Audio Amp
- Speaker

USB Interface
- USB Controller
- Bus Switch
- USB Connector

Battery (12 V)
- Reverse Battery Protection/Load Switch
- DC-DC
- Audio AMP
- Speaker

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Criteria for device selection
- The adoption of Ethernet AVB/TSN is expanding as the next generation car networks.
- SoCs used in smartphones and tablets are also being designed into automotive systems. These require interface conversion of their peripheral devices.

Proposals from Toshiba
- **It realizes easy connection to the next generation in-vehicle network**
  Ethernet bridge IC
- **Resolve differences between interfaces**
  Peripheral bridge IC
- **High output power with low heat generation is realized**
  Audio power amplifier IC
- **Suitable for ESD protection**
  TVS diode (for high speed communication)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page
Video and voice input section

Criteria for device selection
- SoCs used in smartphones and tablets are also being designed into automotive systems. These require interface conversion of their peripheral devices.

Proposals from Toshiba
- **Resolve differences between interfaces**
  Peripheral bridge IC
- **Suitable for ESD protection**
  TVS diode (for high speed communication)

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

Criteria for device selection
- The adoption of Ethernet AVB/TSN is expanding as the next generation car networks.
- Functions such as keyless entry is realized by using communication ICs.

Proposals from Toshiba
- It realizes easy connection to the next generation in-vehicle network
  Ethernet bridge IC
- It realizes various information sharing
  Wireless communication IC

* 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.
- A small surface mount package is suitable for realizing miniaturization of the ECU.
- It is necessary to select high speed MOSFETs to prevent short through current.

Proposals from Toshiba
- Low on-resistance contributes to low power consumption of the system
  U-MOS Series 40 V N-ch MOSFET

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

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

CAN Line → CAN Line → TVS → TVS → MCU → Power Supply

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)

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

- **Battery (12 V)**
- **Power Supply ON/OFF control switch**
- **MOSFET (Power supply reverse protection)**
- **Internal control circuit**
- **Gate Driver**
- **MCU**
- **ON/OFF control switch**
- **Power supply reverse protection**
- **Gate driver with protection and diagnosis functions**
- **General purpose small signal MOSFET**
- **General purpose small signal bipolar transistor**
- **Small signal bias resistor built-in transistor (BRT)**
- **Gate 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 to low power consumption of the system
  - U-MOS Series 40 V N-ch MOSFET
- Gate driver with protection and diagnosis functions
  - 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)

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page.
Recommended
Devices
As described above, in the design of IVI, “Information sharing”, “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>Device Type</th>
<th>High-performance processing and high-quality transmission</th>
<th>High efficiency • Low loss</th>
<th>Small size package</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ethernet bridge IC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Peripheral bridge IC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Wireless communication IC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Audio power amplifier IC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>U-MOS Series 40 V N-ch MOSFET</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>Gate driver (for switch)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>General purpose small signal MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>General purpose small signal bipolar transistor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Small signal bias resistor built-in transistor (BRT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>TVS diode (for high speed communication)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>TVS diode (for CAN communication)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
It realizes easy connection to the next generation in-vehicle network.

1 Compliant with Ethernet AVB / TSN

It complies with Ethernet AVB/TSN specified by IEEE 802.1 Qav/Qbv each other etc. Low delay transmission is possible.

2 Built-in various interfaces

PCIe®, HSIC, I²S and TDM (Time Division Multiplex) interfaces are built in. It can be easily connected with modem SoCs or application processors etc..

3 AEC Q-100 Grade 3 qualified

AEC Q-100 Grade 3 qualified.
Value provided

Resolve gaps of interface standard between host and peripheral devices.

1. Increase the choice of parts
   By using a peripheral bridge IC, it is possible to connect to various types of peripheral devices.

2. Reduce noise
   Converting parallel bus line to serial improves noise immunity. That also suppresses the generation of own noise.

3. Reduce disconnection risk
   Converting parallel bus line to serial reduces the number of wires on a board, and so reduce the risk of disconnection.

### Display interface

- **X standard**: Parallel input 24bit @ 166 MHz
- **Y standard**: HDMI™ 1.4a

### Camera interface bridge

- **X standard**: MIPI® CSI-2®, Parallel 24bit @ 166 MHz
- **Y standard**: MIPI® DSI®, 4lanes x 1ch

### Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>Camera I/F Bridge</th>
<th>Display I/F Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC9590XBG</td>
<td>P-LFBGA64-0707-0.80-002</td>
<td>P-VFBGA64-0707-0.65-001</td>
</tr>
<tr>
<td>TC9591XBG</td>
<td>P-VFBGA64-0505-0.65-001</td>
<td>P-VFBGA64-0606-0.65-001</td>
</tr>
<tr>
<td>TC9592XBG</td>
<td>P-VFBGA64-0707-0.65-001</td>
<td>P-VFBGA80-0707-0.65-001</td>
</tr>
<tr>
<td>TC9593XBG</td>
<td>P-VFBGA64-0707-0.65-001</td>
<td>P-VFBGA80-0707-0.65-001</td>
</tr>
<tr>
<td>TC9594XBG</td>
<td>P-VFBGA64-0707-0.65-001</td>
<td>P-VFBGA80-0707-0.65-001</td>
</tr>
<tr>
<td>TC9595XBG</td>
<td>P-VFBGA64-0707-0.65-001</td>
<td>P-VFBGA80-0707-0.65-001</td>
</tr>
</tbody>
</table>

- **Input**: MIPI® CSI-2®, (1) Parallel 24bit @ 166 MHz
- **Output**: MIPI® DSI®, 4lanes x 1ch
- **DisplayPort™ 1.1a x 2ports / MIPI DPI (24bit)
Value provided

Contribute to realize comfortable driving environment by connectivity among next information.

1. **TC32306FTG for RKE [Note1] and TPMS [Note2]**
   
   It is suitable for receivers of RKE and TPMS. It can also be used for the bidirectional low rate data communications using transmitting function.

   [Note1] Remote keyless entry system  
   [Note2] Tire pressure monitoring system

2. **TC32163FG for ETC [Note3]**
   
   It complies with ETC standards of Japan, China and South Korea. It is possible to use also for RSU [Note4].

   [Note3] Electronic Toll Collection System  
   [Note4] Road side Units

### Lineup

<table>
<thead>
<tr>
<th></th>
<th>RKE</th>
<th>ETC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
<td>TC32306FTG</td>
<td>TC32163FG</td>
</tr>
<tr>
<td>Package</td>
<td>QFN36-P-0606-0.50</td>
<td>LQFP48-P-0707-0.50</td>
</tr>
<tr>
<td>RF frequency</td>
<td>315 to 915 MHz</td>
<td>5.8 GHz band</td>
</tr>
<tr>
<td>I/F frequency</td>
<td>230 kHz (wide band), 280 kHz (middle band)</td>
<td>40 MHz (1st), 7.232 MHz (2nd)</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>2.0 to 5.5 V</td>
<td>2.7 to 3.6 V</td>
</tr>
</tbody>
</table>
These linear amplifier ICs realize same level of power loss and heat generation the class D amplifier.

1. Proprietary high efficiency amplifier (patent registered)
   Realizes equivalent efficiency to the class D amplifiers \([\text{Note1}]\), at output of 4 W or less. Power consumption of these ICs are about 1/5 of our class AB amplifiers and about 1/2 of our high efficiency linear class KB amplifiers. \([\text{Note2}]\)
   \([\text{Note1}]\) Based on Toshiba research (April 2020).
   \([\text{Note2}]\) Class KB = Toshiba original linear amplifier

2. Reduction of external components
   Since these ICs operate without switching such as the class D amplifier, the external parts such as low pass filter or components for EMI suppression can be reduced.

3. Built-in fulltime output offset detection (patent registered)
   Includes a proprietary speaker burnout prevention system that continuously checks for any abnormal output DC offset regardless of input signal presence and informs the microcomputer.

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**Lineup**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCB701FNG</th>
<th>TCB702FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>P-HSSOP36-1116-0.65-001 (36 pin)</td>
<td></td>
</tr>
<tr>
<td>Maximum output power</td>
<td>49 W x 4ch ((V_{CC} = 15.2 V, R_{L} = 4 \Omega))</td>
<td>45 W x 4ch ((V_{CC} = 15.2 V, R_{L} = 4 \Omega))</td>
</tr>
<tr>
<td>Total harmonic distortion (THD)</td>
<td>0.01 % (at (P_{OUT} = 4 W))</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>6 to 18 V</td>
<td></td>
</tr>
<tr>
<td>Output noise voltage</td>
<td>60 (\mu)Vrms (Filter = DIN AUDIO)</td>
<td></td>
</tr>
</tbody>
</table>

\[\text{Note1}\] Based on Toshiba research (April 2020).
\[\text{Note2}\] Class KB = Toshiba original linear amplifier

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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)

- Low loss: RonA trend
- Low noise: Switching waveform

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.

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**U-MOS Series 40 V N-ch MOSFET**

XPN3R804NC / TK1R4S04PB / XPHR7904PS / TPWR7904PB / XPJ6604PB* / XPQR3004PB

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

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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)

![Low loss: RonA reduction trend](image1)

<table>
<thead>
<tr>
<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>XPN9R614MC</td>
<td>-40</td>
<td>-40</td>
<td>9.6</td>
<td>TSON Advance(WF)</td>
</tr>
<tr>
<td>XPH3R114MC</td>
<td>-40</td>
<td>-100</td>
<td>3.1</td>
<td>SOP Advance(WF)</td>
</tr>
<tr>
<td>XPH8R316MC*</td>
<td>-60 (-90)</td>
<td>(8.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<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.)

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.

![Large current, small size, high power dissipation package](image2)
A charge pump circuit for the N-ch MOSFET gate drive is built in, allowing for easy semiconductor relay configuration.

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

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

### 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>

- 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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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.

---

**Small signal package lineup**

<table>
<thead>
<tr>
<th>Power dissipation (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0.1</td>
</tr>
</tbody>
</table>

**Mounting area (mm²)**

| 10 | 1 | 0.1 |

**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>$R_{ON} \text{ Typ.}$ @$V_{GSS} = 4.5 \text{ V } [Ω]$</td>
<td>1.2</td>
<td>1.4</td>
<td>0.31</td>
</tr>
<tr>
<td>$R_{ON} \text{ Max}$</td>
<td>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>Polarity</td>
<td>N-ch</td>
<td>P-ch</td>
<td>P-ch</td>
</tr>
</tbody>
</table>

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**General purpose small signal bipolar transistor**
2SC2712 / 2SA1162 / 2SC4116 / 2SA1586 / TTA501 / TTC501 and others

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**Value provided**

**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.

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**Characteristic examples of 2SC2712**

- **$f_T - I_C$**
- **$V_{CE(sat)} - I_C$**

---

**Lineup**

<table>
<thead>
<tr>
<th>Classification</th>
<th>$V_{CEO}$ [V]</th>
<th>$I_C$ [mA]</th>
<th>NPN</th>
<th>PNP</th>
<th>NPN</th>
<th>PNP</th>
<th>NPN</th>
<th>PNP</th>
</tr>
</thead>
<tbody>
<tr>
<td>General purpose</td>
<td>50</td>
<td>150</td>
<td>2SC4116</td>
<td>2SA1586</td>
<td>2SC2712</td>
<td>2SA1162</td>
<td>2SC3325</td>
<td>2SA1313</td>
</tr>
<tr>
<td>Low noise</td>
<td>120</td>
<td>100</td>
<td>2SC4117</td>
<td>2SA1587</td>
<td>2SC2713</td>
<td>2SA1163</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High current</td>
<td>50</td>
<td>1700</td>
<td>2SA2195*</td>
<td>2SA2195*</td>
<td>2SA2195*</td>
<td>2SA2195*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2000</td>
<td>TTA501</td>
<td>TTA501</td>
<td>TTA501</td>
<td>TTA501</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2500</td>
<td>TTC501</td>
<td>TTC501</td>
<td>TTC501</td>
<td>TTC501</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates UFM package

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Return to Block Diagram TOP
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>
<tr>
<td>V_{CEO} [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>

*Return to Block Diagram TOP*
TVS diodes prevent system damage and malfunction caused by electrostatic discharge (ESD).

1. **Improve ESD pulse absorbability**
   Toshiba proprietary snapback technology (4th-Gen. process) improves ESD pulse absorption compared to Toshiba previous products. (50 % reduction in $R_{DYN}$)

2. **Supports Ethernet and LVDS**
   These are products applicable to high speed communications (Gbps orders) such as Ethernet and LVDS.

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

**Lineup**

<table>
<thead>
<tr>
<th>Part number</th>
<th>DF2S5M4FS</th>
<th>DF2S6M4FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SOD-923</td>
<td></td>
</tr>
<tr>
<td>$V_{ESD} \text{ [kV] @ISO 10605}$</td>
<td>$\pm 30$</td>
<td>$\pm 30$</td>
</tr>
<tr>
<td>$V_{RWM} \text{ (Max) [V]}$</td>
<td>3.6</td>
<td>5.5</td>
</tr>
<tr>
<td>$C_{t} \text{ (Typ. / Max) [pF]}$</td>
<td>0.45 / 0.55</td>
<td></td>
</tr>
<tr>
<td>$R_{DYN} \text{ (Typ.) [\Omega]}$</td>
<td>0.35</td>
<td></td>
</tr>
</tbody>
</table>

(Note) This product is an ESD protection diode and cannot be used for purposes other than ESD protection.
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 \(R_{\text{DYN}}\) 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**

- \(V_{\text{ESD}} > \pm 30 \text{ kV} \) @ISO 10605
- \(V_{\text{ESD}} > \pm 20 \text{ kV} \) @IEC 61000-4-2 (Level 4)

**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></td>
<td></td>
</tr>
<tr>
<td>(V_{\text{ESD}}) [kV] @ISO 10605</td>
<td>±30</td>
<td>±30</td>
<td>±20</td>
</tr>
<tr>
<td>(V_{\text{RVM}}) (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></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) 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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