Automotive
V2X
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
V2X Overall block diagram

GNSS: Global Navigation Satellite System
[Global positioning satellite system: generic term for satellite positioning systems such as GPSs, GLONASS, Galileo, quasi-top satellites (QZSS)]
### V2X Detail of RF block

**Antenna peripheral circuit**

- **V2V / V2I / V2P**
- **V2N**
- **Switch**
- **LNA**
- **TVS**
- **V2X Transceiver / Processor**

**Criteria for device selection**
- It is necessary to select low noise and high gain device suitable for improve receiver sensitivity.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

**Proposals from Toshiba**
- **Low noise and high gain are realized**
  High frequency bipolar SiGe transistor

[Note1] GNSS: Global Navigation Satellite System

[Global positioning satellite system: generic term for satellite positioning systems such as GPSs, GLONASS, Galileo, quasi-top satellites (QZSS)]

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

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**V2X  Detail of power supply circuit**

**12 V DC-DC converter (non-isolated buck type)**

![Diagram of 12 V DC-DC converter](image)

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

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**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.

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**Proposals from Toshiba**
- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET
Power supply ON/OFF control and reverse connection protection 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.

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

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

**Proposals from Toshiba**

- **Low on-resistance contributes 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
V2X  Detail of switch for power supply ON/OFF control and reverse connection protection (2)

Power supply ON/OFF control and reverse connection protection circuit (N-ch type)

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

1. General purpose small signal MOSFET
2. General purpose small signal bipolar transistor
3. Small signal bias resistor built-in transistor (BRT)
4. TVS diode (for CAN communication)
5. Suitable for ESD protection
6. TVS diode
7. Gate driver with protection and diagnosis functions

**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 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 V2X, “Reduction of power supply and signal noise”, “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>No.</th>
<th>Component Description</th>
<th>Low noise</th>
<th>High efficiency &amp; 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 -40 V / -60 V P-ch MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gate driver (for switch)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>General purpose small signal MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>General purpose small signal bipolar transistor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Small signal bias resistor built-in transistor (BRT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>TVS diode (for CAN communication)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>High frequency bipolar SiGe transistor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. **Low loss (reduced on-resistance)**

Using low on-resistance technology to contribute to reduced power consumption systems.
On-resistance of 61% reduction per unit area. (compared to U-MOS IV)

2. **Compact and low loss package**

By adopting a Cu connector structure and a double-sided heat dissipation structure, low loss and high heat dissipation are realized. Wettable Frank (WF) package contributes good mountability.

3. **Low noise (low EMI)**

Improved chip process reduces surge voltage and ringing time.

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**Line up**

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

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**Ringing time**

- U-MOS IX-H: 802 ns
- U-MOS IX-II: 468 ns

**Switching waveform**

- VGS: 2 V / div
- VDS: 5 V / div
- IDS: 2 A / div
- t: 400 ns / div

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**Value provided**

The advanced U-MOS IX-H processes enables low on-resistance and low noise, thereby reducing power consumption.
Value provided

Low on-resistance contributes to reduce system power consumption.

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

Using low on-resistance technology contributes to reduce system power consumption. Lineups of logic level drive type are supported.

2 Small surface mount package developed

By adopting a Cu connector structure and a double-sided heat dissipation structure, low loss and high heat dissipation are realized. Wettable Frank (WF) package contributes good mountability.

Line up

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

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A charge pump circuit for the N-channel 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-channel MOSFET as high side switch. Easy to configure a semiconductor relay.

2. **Can be controlled by logic level voltage**

   It is possible that Direct control 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.

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**Value provided**

**Gate driver (for switch)**

**TPD7104AF / TPD7106F / TPD7107F**

**Features**
- Operating power supply voltage range: 5 to 18 V
- Built-in power supply reverse connection protection function
  (Supported for power supply reverse connection protection MOSFET applications)
- Operating power supply voltage range: 4.5 to 27 V
- Built-in power supply reverse connection protection function
  (Supported for power supply reverse connection protection MOSFET applications)
- 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.

**Line up**

<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>
</tbody>
</table>

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Value provided

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>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>$R_{DSS}$ @$</td>
<td>V_{GS}</td>
<td>=4.5$ [Ω]</td>
<td>1.2</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>
<tr>
<td>Polarity</td>
<td>N-ch</td>
<td>P-ch</td>
<td>P-ch</td>
</tr>
</tbody>
</table>

Return to Block Diagram TOP
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 to the application.

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

Characteristic examples of 2SC2712

| Classification | $|V_{CEO}|$ [V] | $|I_C|$, [mA] | NPN | PNP | NPN | PNP | NPN | PNP |
|----------------|-------------|-------------|------|-----|------|-----|------|-----|
| General purpose| 50 | 150 | 2SC4116 | 2SA1586 | 2SC2712 | 2SA1162 |
|                | 50 | 500 | 2SC4117 | 2SA1587 | 2SC2713 | 2SA1163 |
| Low noise      | 120 | 100 | 2SC4116 | 2SA1587 | 2SC2713 | 2SA1163 |
|                | 50 | 1700 | 2SC4117 | 2SA1587 | 2SC2713 | 2SA1163 |
| High current   | 50 | 2000 | TTA051 | 2SA195* | 2SA1163 |
|                | 100 | 2500 | TTCS01 | 2SA195* | 2SA1163 |

◆Return to Block Diagram TOP
Value provided

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.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>NPN (BRT)</th>
<th>PNP (BRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES6 (SOT-563)</td>
<td>RN1907FE</td>
<td>RN2907FE</td>
</tr>
<tr>
<td>US6 (SOT-363)</td>
<td>RN1901</td>
<td>RN2901</td>
</tr>
<tr>
<td>( V_{CEO} ) (Max) [V]</td>
<td>50</td>
<td>-50</td>
</tr>
<tr>
<td>( I_C ) [mA]</td>
<td>100</td>
<td>-100</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 Zener process improves the ESD pulse absorption of TVS diodes. (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**

   - $V_{ESD} > \pm 30 \text{ kV} \ @ \ ISO \ 10605$
   - $V_{ESD} > \pm 20 \text{ kV} (L4) \ @ \ IEC61000-4-2$

**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>$V_{ESD} [kV] @ ISO 10605$</td>
<td>$\pm 30$</td>
<td>$\pm 30$</td>
<td>$\pm 20$</td>
</tr>
<tr>
<td>$V_{RVM} [\text{Max}] [V]$</td>
<td>12</td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td>$C_t [\text{Typ. / Max}] [\text{pF}]$</td>
<td>9 / 10</td>
<td>6.5 / 8</td>
<td></td>
</tr>
<tr>
<td>$R_{DYN} [\text{Typ.}] [\Omega]$</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.
- Measurements of the commercial product

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Radio frequency SiGe bipolar transistor
MT4S300U / MT4S301U

Value provided

Low noise and high gain are realized. That contributes to improve receiver sensitivity.

1 Low noise and high gain

Low noise and high gain are realized by using SiGe.
Noise figure (@f = 2 GHz) : 0.57 dB (Typ.)
Insertion gain (@f = 2 GHz) : 18.1 dB (Typ.)
Electrostatic breakdown resistance : 2 kV or more (HBM method)
(in the case of MT4S301U)

Characteristic of MT4S301U

2 Small surface mount package

The small package contributes to reduce the mounting area.

Insertion gain $|S_{21e}|^2$ (Typ.) [dB] : 16.9 @f = 2 GHz
Noise figure NF (Typ.) [dB] : 0.55 @f = 2 GHz

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>MT4S300U</th>
<th>MT4S301U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>USQ (SOT-343) (2.0 x 2.1 mm)</td>
<td></td>
</tr>
<tr>
<td>$V_{CEO}$ (Max) [V]</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>$I_C$ (Max) [mA]</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>Transition frequency $f_T$ (Typ.) [GHz]</td>
<td>26.5</td>
<td>27.5</td>
</tr>
<tr>
<td>Noise figure NF (Typ.) [dB]</td>
<td>0.55 @f = 2 GHz</td>
<td>0.57 @f = 2 GHz</td>
</tr>
<tr>
<td>Insertion gain $</td>
<td>S_{21e}</td>
<td>^2$ (Typ.) [dB]</td>
</tr>
</tbody>
</table>

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