Automotive Inverter for xEV
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
Inverter for HEV/PHEV/EV
Inverter circuit

Device selection points
- The use of insulating device is effective for the control of high voltage systems.
- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

Proposals from Toshiba
- A monitoring function to support functional safety is built-in
  Automotive microcontroller
- Control of high voltage systems
  IC output photocoupler
- Various product lineups and small packages
  General-purpose small-signal MOSFET
  General-purpose small-signal bipolar transistor
  General-purpose 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 HEV/PHEV/EV Inverters, “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>Device Type</th>
<th>Functional Safety</th>
<th>High Efficiency - Low Loss</th>
<th>Small Size Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Automotive microcontroller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>IC output photocoupler</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>General-purpose small-signal MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>General-purpose small-signal bipolar transistor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Small-signal bias resistor built-in transistor (BRT)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td>One-gate logic (L-MOS)</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>
</tbody>
</table>
This Automotive control microcomputer has a single-pulse control function and a built-in RDC. This microcomputer can rotate at high speed with simple settings.

1 Adoption of Arm® Cortex®-R4 cores

Arm® Cortex®-R4 cores with floating-point units (FPUs) are used.

2 High-speed, high-efficiency motor control

The vector engine, resolver digital converter, and programmable motor driver, which are three hardware functions specializing in motor control, provide high-speed and high-efficiency motor control.

3 Functional safety technology

Systems are equipped with functional safety monitoring mechanisms that are useful for meeting ISO26262 ASIL D and IEC61508 SIL 3 safety standards requirements.

<table>
<thead>
<tr>
<th>Line up</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
<td>TMPR454F10TFG</td>
</tr>
<tr>
<td>Package</td>
<td>HQFP144</td>
</tr>
<tr>
<td>ROM</td>
<td>1MB</td>
</tr>
<tr>
<td>RAM</td>
<td>80KB</td>
</tr>
<tr>
<td>T_a [°C]</td>
<td>-40 ~ 125</td>
</tr>
</tbody>
</table>

* Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

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IC output photocoupler
TLX9304 / TLX9309 / TLX9310 / TLX9378 / TLX9376

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

1. High insulation and noise cutoff
   - Isolation voltage 3750V
   - Common mode transient immunity 15kV/μs
   Non-electrical communication provides excellent insulation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

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℃
   Heat resistance package allows an operating temperature range of -40 to 125℃ as well as a longer life.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLX9304</th>
<th>TLX9309</th>
<th>TLX9310</th>
<th>TLX9378</th>
<th>TLX9376</th>
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<tbody>
<tr>
<td>Isolation Voltage [Vrms]</td>
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<td>3750</td>
<td>3750</td>
<td>3750</td>
<td>3750</td>
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<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)
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.

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM3K7002KF</th>
<th>SSM3J168F</th>
<th>SSM3J66MFV</th>
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</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>$V_{DSS,DC}$ [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>$R_{DS,ON}$ @$V_{GS}=4.5$ [Ω]</td>
<td>1.2 Typ.</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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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>Package</th>
<th>SS (SOT-416)</th>
<th>USM (SOT-323)</th>
<th>UFM (SOT-325F)*</th>
<th>S-Mini (SOT-346)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>$V_{CE(sat)}$ [V]</td>
<td>$I_C$ [mA]</td>
<td>NPN</td>
<td>PNP</td>
</tr>
<tr>
<td>General purpose</td>
<td>50</td>
<td>150</td>
<td>2SC4738</td>
<td>2SA1832</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>500</td>
<td>2SC3325</td>
<td>2SC3325</td>
</tr>
<tr>
<td>Low noise</td>
<td>120</td>
<td>100</td>
<td>2SC4117</td>
<td>2SA1587*</td>
</tr>
<tr>
<td>High-current</td>
<td>50</td>
<td>1700</td>
<td>2SA2195*</td>
<td></td>
</tr>
</tbody>
</table>

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Small-signal bias resistor built-in transistor (BRT)
RN1114 / RN2114 / RN1414 / RN2414 series

Value provided

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.

---

### 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>SSM (SOT-416)</td>
<td>RN1114</td>
<td>RN2114</td>
</tr>
<tr>
<td>S-Mini (SOT-346)</td>
<td>RN1414</td>
<td>RN2414</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>

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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.

Extensive product lineup to meet all your needs.

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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.

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AEC-Q100 qualified and can be used for a wide range of automotive applications.

Functional safety
High efficiency
Small size package

AEC-Q100 qualified* (Rev. H)
AEC-Q100 qualified* (Rev. H)

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>
<tr>
<td>VCC [V]</td>
<td>2.0 – 5.5</td>
<td>1.65/1.8 – 5.5</td>
</tr>
<tr>
<td>Io[mA]</td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

* Compliant products with AEC-Q100’s reliability test only
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>$V_{\text{RWM}}$ (Max) [V]</td>
<td>12</td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td>$C_t$ (Typ./Max) [pF]</td>
<td>9 / 10</td>
<td>6.5 / 8</td>
<td>6.5 / 8</td>
</tr>
<tr>
<td>$R_{\text{DYN}}$ (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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