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Automotive Solutions

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With Vision and Intellect, You Can Make It!

Automobiles have been making tremendous progress in terms of safety, environmental performance, and the utilization of information technology. Now, a suite of driver-assist technologies that enhance both vehicle and driver safety are attracting much attention, such as collision avoidance, parking assist and self-driving.

Toshiba offers various automotive semiconductor devices designed to improve driving safety, including advanced driver assistance systems (ADAS) using an image recognition processor. Toshiba provides leading-edge semiconductor technologies from a future perspective to deliver comprehensive driver assistance solutions such as self-driving that emulate human eyes and other intricate human senses.

For the latest information about Toshiba’s semiconductor devices, including automotive devices, please visit the following URL:

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For the latest information about Toshiba’s semiconductor devices, including automotive devices, please visit the following URL:
Carbon dioxide (CO₂) emission regulations are being increasingly tightened around the world. Automobile manufacturers are under pressure to shift to electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs), and now the challenge for electric vehicles is mileage. Taking advantage of its technology that enables efficient use of electric power, Toshiba Electronic Devices & Storage Corporation contributes to increasing mileage for the purpose of handling environmental issues.

In order to address the requirements for environmental regulations worldwide, it is necessary to increase the proportion of electric vehicles manufactured. Increasing the use of electric energy to reduce fossil fuel consumption helps protect the environment. Vehicles using electric energy include hybrid electric vehicles (HEVs) that combine the advantages of both electric motors and internal combustion engines, electric vehicles (EVs) that use electric motors for propulsion instead of an internal combustion engine, and plug-in hybrid vehicles (PHEVs) that share the characteristics of EVs and HEVs.

Promote reduced CO₂ emissions and drive system electrification/diversification by conforming with fuel economy/emission regulations.

**Changes in the environment surrounding the automobile**

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ Emission Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>150 to 200g/km</td>
</tr>
<tr>
<td>2020</td>
<td>100 to 150g/km</td>
</tr>
<tr>
<td>2023</td>
<td>75 to 100g/km</td>
</tr>
</tbody>
</table>

**Improved fuel economy**

1. Weight reduction/efficient use of resources
2. Diversification of drive system

**Transition to EV**

**CO₂ emissions by drive system**

- Electricity
- Plug-in hybrid
- Hybrid
- Gasoline

**Extension of driving range**

High performance/high efficiency

Downsizing
Improved fuel economy

Changes in the environment surrounding the automobile

Transition to EV Extension of driving range

(1) Weight reduction/efficient use of resources CO2 emissions by drive system

(2) Diversification of drive system

Hybridization

Downsizing

High performance/high efficiency

Electrification

Electricity (Gasoline vehicle taken as 100)

Gasoline

Plug-in hybrid (PHEV)

Hybrid (HEV)

Fuel/CO2 emission regulations

Autobahn

PHEV

EV

Entry into force of COP21 Paris Agreement

75 to 100g/km

100 to 150g/km

150 to 200g/km

2025

2023

2020

2019

Applications using semiconductor components

Fast Charger Connector

Non-Contact Charging (Contact Charging)

Fast Charging Station

System Diagram of an Electric Vehicle (HEV/PHEV/EV)

In order to address the requirements for environmental regulations worldwide, it is necessary to increase the proportion of electric vehicles manufactured. Increasing the use of electric energy to reduce fossil fuel consumption helps protect the environment. Vehicles using electric energy include hybrid electric vehicles (HEVs) that combine the advantages of both electric motors and internal combustion engines, electric vehicles (EVs) that use electric motors for propulsion instead of an internal combustion engine, and plug-in hybrid vehicles (PHEVs) that share the characteristics of EVs and HEVs.

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Automotive Drive System Block Diagram (Inverter)

Generally, HEVs, PHEVs and EVs use three-phase brushless motors for electric propulsion. Because the vehicle drive battery supplies a dc current, it needs to be converted to a three-phase ac current using an inverter. A three-phase inverter, which is composed of power devices, converts dc to ac during acceleration (powering) and converts ac to dc during braking (regeneration), to recharge the battery.

Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Power/Generation</th>
<th>Feature</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TK25S06N1L</td>
<td>60 V, 25 A, 18.5 mΩ, Tch = 175˚C</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DPAK+</td>
<td>TJ30S06M3L</td>
<td>–60 V, –30 A, 21.8 mΩ, Tch = 175˚C</td>
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<tr>
<td>Voltage Regulators</td>
<td></td>
<td>HQFP52</td>
<td>TB9042FTG</td>
<td>Switching Reg., 5 V Reg., Watchdog timer, Topr: –40 to 125˚C</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>MCU</td>
<td>Motor control MCU</td>
<td>HLQFP144</td>
<td>TMP9454F10TFG</td>
<td>Arm-Cortex-R4F (160 MHz)</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Isolation</td>
<td>Photocouplers</td>
<td>Spin SO8</td>
<td>TLX9394</td>
<td>Open collector output, 1 M LOGIC, Topr = 125˚C</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spin SO8</td>
<td>TLX9378</td>
<td>Open collector output, 10 M LOGIC, Topr = 125˚C (max)</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spin SO8</td>
<td>TLX9376</td>
<td>Totempole output, 20 M LOGIC, Topr = 125˚C (max)</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>
Applications: DC-DC Converters for HEVs, PHEVs and EVs, Battery Monitoring Systems (BMS), Start-Stop Systems

DC-DC Converters for HEVs, PHEVs and EVs

In HEVs, PHEVs and EVs, DC-DC converters are used to step down the high-voltage DC from the main battery to the low-voltage DC necessary for electronic loads. Toshiba’s product portfolio includes 80- to 100-V MOSFETs with high current capability that are suitable for use on the secondary side of DC-DC converters.

Recommended Products

<table>
<thead>
<tr>
<th>Functional Block</th>
<th>Product Category</th>
<th>Package</th>
<th>Part Number</th>
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</thead>
<tbody>
<tr>
<td>Synchronous Rectifier Circuit</td>
<td>MOSFET</td>
<td>DPAK++</td>
<td>See pages 26-27.</td>
</tr>
<tr>
<td>Power Supply</td>
<td>MOSFET</td>
<td>DSOP Advance (WF)</td>
<td></td>
</tr>
</tbody>
</table>

Battery Monitoring System (BMS)

The high-voltage battery for HEVs is comprised of many cells connected in series. MOSFETs are used to optimally balance the voltage among the cells. Photocouplers with low power consumption help reduce the power loss incurred by continuous battery monitoring.

Recommended Products

<table>
<thead>
<tr>
<th>Functional Block</th>
<th>Product Category</th>
<th>Package</th>
<th>Part Number</th>
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</thead>
<tbody>
<tr>
<td>Power Supply</td>
<td>Bipolar transistor</td>
<td>New PW Mold</td>
<td>T89020</td>
</tr>
<tr>
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<td>System power supply IC</td>
<td>HTSS016</td>
<td>TB9021FNM3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSOP20</td>
<td>TB9005FNM3</td>
</tr>
<tr>
<td>Fail-safe, Shut Down</td>
<td>IPD (High-side switch)</td>
<td>WSON-10</td>
<td>TPD1655FA</td>
</tr>
<tr>
<td></td>
<td>IPD (Low-side switch)</td>
<td>PS-8</td>
<td>TPD1644F</td>
</tr>
<tr>
<td>Cell Balance</td>
<td>MOSFET</td>
<td>SOF-23F</td>
<td>See pages 26-27.</td>
</tr>
<tr>
<td></td>
<td>Photocoupler</td>
<td>SO1, SO6</td>
<td>See pages 24.</td>
</tr>
<tr>
<td>Main Control</td>
<td>Battery monitoring MCUs</td>
<td>LQFP100</td>
<td>TMPM058FDFTFG</td>
</tr>
</tbody>
</table>

Start-Stop Systems

Toshiba’s power devices and driver ICs can be combined to build efficient circuits for the charging/discharging control of lead-acid batteries, lithium-ion batteries and generators in start-stop systems.

System Block Diagram

Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor/Relay</td>
<td>IPD</td>
<td>PS-8</td>
<td>TPD1604A</td>
<td>1ch high side hih MOSFET data drive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TPD1604A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TPD1604A</td>
<td></td>
</tr>
<tr>
<td>Motor drive or ceramics protection</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TK05S06N1M</td>
<td>Nch/VIII</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TK05S06N1M</td>
<td>Nch/VIII</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TK05S06N1M</td>
<td>Nch/VIII</td>
</tr>
<tr>
<td>Sensor/Relay</td>
<td>IPD</td>
<td>WSON10</td>
<td>TPD1607Y*</td>
<td>1ch high side hih MOSFET data drive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TPD1607Y*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TPD1607Y*</td>
<td></td>
</tr>
</tbody>
</table>
Brake Control (ABS/ESC)

Many electromagnetic solenoids and mechanical relays are used to control hydraulic valves, and MOSFETs and intelligent power devices (IPDs) are widely used for the switching of solenoids and relays. Since these applications are exposed to large instantaneous changes in voltage, high-voltage MOSFETs and IPDs are required.

<table>
<thead>
<tr>
<th>Recommended Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Block</td>
</tr>
<tr>
<td>Motor, Solenoid</td>
</tr>
<tr>
<td>Power Supply</td>
</tr>
</tbody>
</table>

Electronic Suspension Control

Many electromagnetic solenoids and mechanical relays are used to control hydraulic valves, and MOSFETs and intelligent power devices (IPDs) are widely used for the switching of solenoids and relays.

<table>
<thead>
<tr>
<th>Recommended Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Block</td>
</tr>
<tr>
<td>Solenoid, Motor Control</td>
</tr>
<tr>
<td>Diode</td>
</tr>
</tbody>
</table>

Electric parking brake (EPB), precrash seat belt tensioners

Nowadays, more and more automotive applications rely on electronic control, including electric parking brakes (EPB) and precrash seat belt tensioners. The H-bridge circuit configuration is most commonly used to drive motors for these applications. Fabricated using the latest silicon process, the DPAK+ MOSFET Series for motor drive applications delivers low on-resistance, as well as low wiring resistance by the use of a Cu connector. These characteristics combine to help reduce the system power consumption. Toshiba also offers pre-drivers that integrate various detection circuits (for undervoltage detection, FET short-circuit detection, thermal shutdown), a charge pump and a high-speed pre-driver circuit.

<table>
<thead>
<tr>
<th>System Block Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical relay</td>
</tr>
</tbody>
</table>

Application Block Diagram

- Battery
- Power Supply
- MCU
- Signal Conditioning Circuit
- I/O Sensor
- CAN Bus
- Load Switch
- Motor Control
- ABSIC
- Solenoid
- Drive Switch
- For Solenoid
- Valve
- Pre-driver
- Valve Solenoid
Electronic Power Steering (EPS) System

EPS systems are finding widespread use in automobiles to improve mileage. Here are block diagrams of EPS systems that use power MOSFETs for motor drivers, power supply and motor relay applications in EPS systems.

### System Block Diagram

- **Motor Control:** Reverse battery protection
- **MOSFET:** Pre-driver
- **Motor control:** LQFP100
- **Microcontroller:** T9081FG

### EPS Control Evaluation Board

- **Microcontroller:** T9081FG
- **MOSFET:** TPD7104AF

### Reference Model for EPS

- **Microcontroller:** T9081FG Starter Kit
- **MOSFET:** TPD7104AF

---

### Three-Phase Brushless Motor Pre-driver IC for EPS Applications: TB9081FG

Three-phase brushless motor pre-driver IC designed for high-current applications such as electric power-assisted steering (EPS)

- Three-phase pre-driver (that requires an external FET)
- High-side and low-side charge pumps
- High-speed pre-driver
- 5-channel safety relays
- High-speed motor current sense circuit
- Various detection circuits
  - Undervoltage detection for each power supply, thermal shutdown, external FET short-circuit detection
  - Initial diagnosis of the detection circuits
  - The operation of pre-drivers in the event of a fault is pre-configurable via SPI communication.
  - Abnormal status readable via the SPI interface

**Overview**

- Supply voltage: 40 V peak (load dump)
- Operating voltage range: 4.5 to 28 V
- PIW operating frequency: 20 kHz
- Operating temperature range: Ta = –40 to 125°C
- Package: LQFP64

---

### Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor control</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TP07104AF</td>
<td>Pch/IX</td>
<td>40 V/65 A/4.5 mΩ max</td>
<td>○</td>
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<tr>
<td>Motor control</td>
<td>Reverser</td>
<td>LQFP64</td>
<td>T9081FG</td>
<td>Nch/IX</td>
<td>40 V/120 A/1.14 mΩ max</td>
<td>○</td>
</tr>
<tr>
<td>Motor control</td>
<td>Signal Conditioning</td>
<td>DPAK+</td>
<td>TP05104AF</td>
<td>Pch/IX</td>
<td>40 V/60 A/8.3 mΩ max</td>
<td>○</td>
</tr>
<tr>
<td>Motor control</td>
<td>MCU</td>
<td>LQFP100</td>
<td>L9025F107FG</td>
<td>Arm Cortex-M0 (144 MHz)</td>
<td>PMD, CAN, ADC, Topr = –40 to 105°C</td>
<td>○</td>
</tr>
</tbody>
</table>

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Applications: Electronic Power Steering (EPS) System

More and more gasoline cars are equipped with a direct-injection engine to improve fuel efficiency. Toshiba provides switches for suitable for the control of throttle and exhaust gas recirculation. Accompanying the tightening of environmental regulations, devices with a current drive capability and various protection features suitable for on-off and linear solenoids in transmissions.

The hydraulic control in the transmission is mainly driven by a valve using an electromagnetic solenoid. Toshiba offers semiconductor drivers suitable for the control of throttle and exhaust gas recirculation.
Gasoline Engine System

Accompanying the tightening of environmental regulations, automotive engines are required to meet the standards for higher efficiency and lower emissions. Toshiba's motor ICs suitable for the control of throttle and exhaust gas recirculation (EGR) valves help optimize engine efficiency.

**System Block Diagram**

- **Switch**
- **Power Supply**
- **MCU**
- **Brushed Motor**
- **Throttle Motor**
- **EGR Motor**
- **Injection**
- **Sensor**
- **Pre-Driver**
- **Drivers (MOSFET, IPD, etc.)**

Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
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<td>Relays</td>
<td>IPD</td>
<td>PS-8</td>
<td>TPD1004F</td>
<td>Logic Nch + DMOS</td>
<td>1 ch Low side switch (1 A)</td>
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<td></td>
<td>IPD</td>
<td>SOP-8</td>
<td>TPD1064F</td>
<td>2 ch Low side switch (2 A)</td>
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<td>–</td>
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<tr>
<td>Solenoids</td>
<td>IPD</td>
<td>PS-8</td>
<td>TPD1054F</td>
<td>1 ch Low side switch (1 A)</td>
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<td>–</td>
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<tr>
<td></td>
<td>IPD</td>
<td>WSON-10</td>
<td>TPD1059FA</td>
<td>1 ch Low side switch (6 A)</td>
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<tr>
<td>Driver</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TK2550N1L</td>
<td>Nch/VIII</td>
<td>60 V/10 A/18.5 mΩ max</td>
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<td>TK4550N1L</td>
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<tr>
<td>Power Supply</td>
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<td>TB9062F7G</td>
<td>BCD process</td>
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</table>

Direct Injection

More and more gasoline cars are equipped with a direct-injection engine to improve fuel efficiency. Toshiba provides switches for high-pressure injector control applications as well as MOSFETs suitable for DC/DC converter applications.

**System Block Diagram**

- **DC-DC Boost Converter**
- **Booster Supply**
- **Engine**
- **Sensor**
- **Fuel Injector**
- **Switch**
- **Fuel Pump**
- **MOSFET**
- **Pre-Driver**
- **Pre-Driver**

Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
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<td>TPD1044F</td>
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<td>WSON-10</td>
<td>TPD1059FA</td>
<td>1 ch Low side switch (6 A)</td>
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<td>–</td>
</tr>
<tr>
<td>Driver</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TK6550N1L</td>
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<td>60 V/10 A/18.5 mΩ max</td>
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<td>TK1050N1L</td>
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<td>60 V/10 A/18.5 mΩ max</td>
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<tr>
<td>Oil pump drive</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TK1050G4FB</td>
<td>Nch/IX</td>
<td>40 V/100 A/2.3 mΩ max</td>
<td>○</td>
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<tr>
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<td></td>
<td></td>
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<td>40 V/100 A/2.3 mΩ max</td>
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<tr>
<td>Pre-driver</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TB9061APNG</td>
<td>BCD process</td>
<td>3 Phase Brushless Sensor-less Pre-driver</td>
<td>○</td>
</tr>
<tr>
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<td></td>
<td>TB9061APNG</td>
<td>3 Phase Brushless Sensor-less Pre-driver</td>
<td>Topr.: –40 to 125˚C</td>
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<td>TB9062PHG+</td>
<td>Pre-driver</td>
<td>High Start-up Performance, Topr.: –40 to 125˚C</td>
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</tr>
<tr>
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<td>WSON-10</td>
<td>TPD7212F</td>
<td>3 Phase Brushless Sensor-less Pre-driver</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TPD7211F</td>
<td>Half bridge MOSFET Gate drive</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Under development**

Transmission Control

The hydraulic control in the transmission is mainly driven by a valve using an electromagnetic solenoid. Toshiba offers semiconductor devices with a current drive capability and various protection features suitable for on-off and linear solenoids in transmissions.

**System Block Diagram**

- **Switch**
- **Power Supply**
- **MCU**
- **Relay Control**
- **High-Side Switch**
- **Pre-Driver**
- **Sensor Signal**
- **Solenoide Control**
- **Oil Pump Motor**
- **Linear Solenoid**

Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relays &amp; solenoids</td>
<td>IPD</td>
<td>PS-8</td>
<td>TPD1054F</td>
<td>Logic Nch + DMOS</td>
<td>1 ch High side switch (1 A)</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>IPD</td>
<td>PS-8</td>
<td>TPD1054F</td>
<td>Logic Nch + DMOS</td>
<td>1 ch High side switch (1 A)</td>
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<tr>
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<td>IPD</td>
<td>WSON-10</td>
<td>TPD1059FA</td>
<td>1 ch High side switch (6 A)</td>
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<td>–</td>
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<tr>
<td>Oil pump drive</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TK1050G4FB</td>
<td>Nch/IX</td>
<td>40 V/100 A/2.3 mΩ max</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>–</td>
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<td>TK1050G4FB</td>
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<td></td>
<td>TK1050G4FB</td>
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<td>–</td>
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</tr>
<tr>
<td>Pre-driver</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TB9061APNG</td>
<td>BCD process</td>
<td>3 Phase Brushless Sensor-less Pre-driver</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TB9061APNG</td>
<td>3 Phase Brushless Sensor-less Pre-driver</td>
<td>Topr.: –40 to 125˚C</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TB9062PHG+</td>
<td>Pre-driver, High Start-up Performance, Topr.: –40 to 125˚C</td>
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<td>–</td>
</tr>
<tr>
<td>IPD</td>
<td>WSON-10</td>
<td>TPD7212F</td>
<td>3 Phase Brushless Sensor-less Pre-driver</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TPD7211F</td>
<td>Half bridge MOSFET Gate drive</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Under development**
Pump Control (for Water, Oil and Fuel)

The TB9061AFNG can control a pump control unit without using a microcontroller and Hall sensors. This eliminates the need for the development of software for electronic control units (ECUs) or reduces the workload for the development. Moreover, the reduction in the number of components due to the elimination of Hall elements etc. helps reduce the size of ECU boards. Toshiba’s semiconductor devices designed for pump control units tolerate a high-temperature environment of up to 125°C in an engine compartment.

### System Block Diagram

#### Pch

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **MOSFET**
- **Pre-driver**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Motor Control**
- **Motor (Brushless)**

#### System Block Diagram

#### Low-Side PWM

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Control**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Signal Input**

#### High-Side PWM

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Control**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Signal Input**

#### 3-phase full-bridge Method for BLDC Motor

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Motor Control**

### Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-driver</td>
<td>IPD</td>
<td>WQFN-32</td>
<td>TPD7121F</td>
<td></td>
<td>3 Phase Full Bridge Nch MOSFET Gate drive,</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PS-8</td>
<td>TPD7211F</td>
<td></td>
<td>Half bridge MOSFET Gate drive,</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>MCD</td>
<td>SSOP24</td>
<td>TB9061AFNG</td>
<td></td>
<td>3 Phase Brushless Sensor-less Pre-Driver, –40 to 125°C</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TB9062FNG</td>
<td></td>
<td>3 Phase Brushless Sensor-less Pre-Driver, High Start-up Performance, –40 to 125°C</td>
<td>–</td>
</tr>
<tr>
<td>Driver</td>
<td>MCD</td>
<td>HTSSOP24</td>
<td>TB9064FNG**</td>
<td></td>
<td>3 Phase Brushless Sensor-less Pre-Driver, –40 to 125°C</td>
<td>O</td>
</tr>
</tbody>
</table>

### Motor control

- **MOSFET**
- **DPAK+**
- **SOOP Advance (WF)**
- **D SOP Advance (WF)**

### Voltage Regulators

- **SSOP20**
- **THSO20**
- **BipTr**

### Power Supply

- **ICP**
- **New PW-Mold**
- **TTA005**
- **TTB002**

### Cooling Fan

Automobiles have electric cooling fans of various sizes for the engine, battery pack and LED headlights. With the increasing uptake of electric vehicles (EVs), the market demand for quieter fan motors is growing. Toshiba’s sine-wave motor controller ICs help realize quiet motor operation.

### System Block Diagram

#### Pch

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Motor Control**
- **Motor (Brushless)**

#### System Block Diagram

#### Low-Side PWM

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Control**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Signal Input**

#### High-Side PWM

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Control**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Signal Input**

#### 3-phase full-bridge Method for BLDC Motor

- **Power Supply**
- **MCU**
- **Pre-Driver**
- **Motor Brushless**
- **Reverse Battery Protection**
- **Motor Control**

### Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
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<tr>
<td>Pre-driver</td>
<td>IPD</td>
<td>WQFN-32</td>
<td>TPD7121F</td>
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<td>Quiet motor operation due to sine-wave current, High-efficiency motor drive due to auto lead angle control</td>
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<tr>
<td></td>
<td></td>
<td>PS-8</td>
<td>TPD7211F</td>
<td></td>
<td></td>
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<tr>
<td>Motordrive</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TB91050F</td>
<td>Nch/VIII</td>
<td>High output with integrated output transistors input, LDO (5 V) Watchdog timer, Topr: –40 to 125°C</td>
<td>O</td>
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<tr>
<td></td>
<td></td>
<td>SSOP20</td>
<td>TB9005F</td>
<td>Nch/VIII</td>
<td>Single output with integrated output transistors input, LDO (5 V) Watchdog timer, Topr: –40 to 125°C</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TB9012F</td>
<td>Nch/VIII</td>
<td>Simple output with integrated output transistors input, LDO (5 V) Watchdog timer, Topr: –40 to 125°C</td>
<td>O</td>
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</tbody>
</table>
**Air-Conditioning (HVAC) - Compressors**

In order to improve fuel efficiency, various motors are being replaced by brushless motors. Accompanying this trend, MOSFETs with lower power losses are required for motor drive and reverse-battery protection applications. Toshiba offers MOSFETs that use a copper (Cu) connector with lower resistance than aluminum in order to reduce conduction loss.

**System Block Diagram**

![System Block Diagram](image)

**Recommended Products**

<table>
<thead>
<tr>
<th>Block Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
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<tbody>
<tr>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TPD710AF</td>
<td>Nch/VIII</td>
<td>1-ch high side Nch MOSFET Gate drive.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>SOP</td>
<td>TPD7212F</td>
<td></td>
<td>3 Phase Full Bridge Nch MOSFET Gate drive.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>SSOP24</td>
<td>TB9110FNG</td>
<td></td>
<td>1-ch channel pre-driver (external N-ch FET), 1.0-500Ω, 1-500mA, Topr: –40 to 125°C</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>TSOP9F</td>
<td>TB9021FNG</td>
<td></td>
<td>Single output (with integrated output transistors), LDO (5 V), Winner/Badger timer, Topr: –40 to 125°C</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>TSOP9F</td>
<td>TB9005FNG</td>
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<td>Single output (external transistors required), LDO (5 V), Winner/Badger timer, Topr: –40 to 125°C</td>
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<tr>
<td></td>
<td>TSOP9F</td>
<td>TB9058FNG</td>
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<td>Single output (external transistors required), LDO (5 V), Winner/Badger timer, Topr: –40 to 125°C</td>
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</tr>
</tbody>
</table>

**Air-Conditioning (HVAC) - Dampers**

Toshiba offers motor drivers for HVAC applications incorporating multiple dampers. Our product lineup includes ICs that integrate a low-on-resistance driver capable of controlling multiple channels and those that integrate a driver that provides fine temperature regulation and other features through LIN communications with system electronics.

**System Block Diagram**

![System Block Diagram](image)

**Recommended Products**

<table>
<thead>
<tr>
<th>Block Type</th>
<th>Package</th>
<th>Part Number</th>
<th>Polarity/Generation</th>
<th>Feature</th>
<th>AEC</th>
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<td>Motor drive</td>
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<td>TB9102FNG</td>
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<tr>
<td></td>
<td>TSOP9F</td>
<td>TB9006FNG</td>
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<td>LNI-Slave 1ch, 1.0 Ω (±0.5 A), Topr: –40 to 125°C (Classic Checkerboard)</td>
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<tr>
<td></td>
<td>TSOP9F</td>
<td>TB9058FNG</td>
<td></td>
<td>LNI-Slave 1ch, 1.0 Ω (±0.5 A), Topr: –40 to 125°C (Enhanced Checkerboard)</td>
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</tr>
</tbody>
</table>

**LED Headlights**

Electric bulbs for direction indicators and other automotive lamps are being replaced by LEDs. LEDs are driven by DC-DC converters in which many MOSFETs with a VDSS of 60 V or higher are utilized.

**Recommended Products**

<table>
<thead>
<tr>
<th>Functional Block</th>
<th>Product Category</th>
<th>Package</th>
<th>Part Number</th>
<th>See pages 26-27.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booster Circuit</td>
<td>MOSFET</td>
<td>DPAK+</td>
<td>TPD710AF</td>
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<tr>
<td>Reverse Battery Protection</td>
<td>MOSFET</td>
<td>SOP Advance</td>
<td>TPD7212F</td>
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<tr>
<td>Dimming</td>
<td>MOSFET</td>
<td>TSOP9F</td>
<td>TB9021FNG</td>
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</tbody>
</table>

**Airbags**

MOSFETs or other types of switches are used as failsafe switches in the power supply section of electronic control units (ECUs).

**Recommended Products**

<table>
<thead>
<tr>
<th>Functional Block</th>
<th>Product Category</th>
<th>Package</th>
<th>Part Number</th>
<th>See pages 26-27.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail-Safe Switch</td>
<td>MOSFET</td>
<td>SOP Advance (WF)</td>
<td>TPD710AF</td>
<td></td>
</tr>
</tbody>
</table>

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**Application Block Diagram**

![Application Block Diagram](image)
Body Control Module (BCM)

Body control modules (BCM) consist of two types: those that use mechanical relays and those that use MOSFETs as semiconductor relays instead of mechanical relays. To meet the needs of mechanical-relay drive applications, Toshiba developed the SSM9337R, a MOSFET in a small package (with 85% of the mounting area of the predecessor) with active clamping circuitry for inductive loads. Toshiba also offers power MOSFETs such as those in the DPAK+ package suitable for semiconductor relay applications.

See the following for details of TVS products. IPD, Active Clamp, Complex Device

In-Vehicle Networks

Transient-voltage-suppression (TVS) diodes protect CAN, LIN, FlexRay bus, Ethernet A/B, and other in-vehicle networks from permanent damage due to surge voltages. The high protection performance of Toshiba’s TVS diodes helps improve the reliability of in-vehicle networks.

TVS Diodes (ESD Protection Diodes for CAN/LIN)

TVS Diodes (ESD Protection Diodes for LVDS/PoC)

* New Product  ** Under development
As integration of mechanical and electronic subsystems progresses, reduction in the size of electronic control units (ECUs) is required. Size reduction and integration of semiconductor devices are essential to meet this requirement.

In response, Toshiba is developing multichip package (MCP) products consisting of FETs and predrivers.

Toshiba is planning to release 30- to 50-A half-bridge MCPs for automotive body electronics applications. (Power sliding doors, power rear door, door closers, power seats, power windows, sunroofs, wipers, etc.)

The number of external parts can be reduced thanks to various on-chip fault detection circuits.

**<Key specifications>**
- Three-chip integration
- Package: WFQFN48-0909-0.65 (E-pad on back)
- On-resistance: Approx. 10 mΩ (sum of the P and N channels)
- Drive current: 35 A (current limiter ON), 54 A (current limiter OFF)

**<Functional blocks>**
- FET chips:
  - High-side P-channel FETs (without charge pump), low-side N-channel FETs
  - Equipped with temperature sensor diode and current sensor terminal
- Controller chip:
  - FET control pre-driver
  - Slew rate control (for EMI reduction)
  - Current limiters (for P-channel and N-channel FETs), IC pin for ON/OFF
  - Current monitoring terminal (only for P-channel FETs)
  - On-chip 5-V regulator
  - Fault detection

Undervoltage and overcurrent (for P-channel and N-channel FETs)
Overheating (for P-channel and N-channel FETs and controller)
Forecast (for P-channel and N-channel FETs)
Products: Automotive Three-Phase Brushless DC Motor Driver ICs

**Roadmap**

### Three-Phase Brushless DC Motors

#### Sensorless

- **TB9060FNG**
  - Controller (with motor control logic)
  - Package: SSOP24

- **TB9061AFNC**
  - 120°-commutation sensorless motor control logic
  - Built-in pre-driver (P-ch/N-ch)
  - Package: SSOP24

- **TB9062FNG**
  - 120°-commutation sensorless motor control logic
  - Built-in pre-driver (P-ch/N-ch)
  - Package: SSOP24

- **TB9063FNG**
  - 120°-commutation sensorless motor control logic
  - Built-in pre-driver (P-ch/N-ch)
  - Package: SSOP24

#### Various built-in detection circuits
- Undervoltage detection, Low-side pre-driver for low-voltage drive
- Output stage has a low-on-resistance H-bridge that consists of P-channel and N-channel DMOS transistors

#### PWM input
- Improved startability by logic control

#### Various detection circuits
- Undervoltage detection, Current limit control, Overvoltage Detection

### Three-Phase Brushless Sensorless Pre-driver IC TB9062FNG

#### Overview
- Operating voltage range: 6.5 to 16.6 V
- Max. voltage: 40 V peak (load dump)
- Operating temperature range: Ta = –40 to 125°C
- Package: SSOP24

#### Features & Functions
- Built-in position detection circuit
- Built-in 5-V power supply & reset function
- Built-in 8-bit AD converter
- Various built-in detection circuits
- Overcurrent detection, overvoltage/lown voltage detection, thermal shutdown

### Three-Phase Brushless Sensorless Driver IC TB9064FNG

#### Overview
- Operating voltage range: 5.5 to 18 V
- Max. voltage: 40 V peak (load dump)
- Operating temperature range: Ta = –40 to 125°C
- Package: HTSSOP24
- AEC-Q100: Compliant

#### Features & Functions
- Built-in motor current detection circuit,
- Built-in motor rotation direction detection
- Built-in circuit for motor rotation direction detection

### Lineup

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Input</th>
<th>Commutation</th>
<th>Output</th>
<th>Features &amp; Functions</th>
<th>Supply Voltage (V)</th>
<th>AEC-Q100</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB9060FNG</td>
<td>SSOP24</td>
<td>120°</td>
<td>Pre-drivers</td>
<td>Simple application circuit due to external part count reduction Sensorless control, Overcurrent detection, Wide PWM dynamic range for output</td>
<td>5.5 to 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB9061AFNC</td>
<td>SSOP24</td>
<td>120°</td>
<td>Pre-drivers</td>
<td>Simple application circuit due to external part count reduction Sensorless control, Overcurrent detection, Improved startup</td>
<td>6.5 to 16.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB9062FNG**</td>
<td>SSOP24</td>
<td>120°</td>
<td>Pre-drivers</td>
<td>Simple application circuit due to external part count reduction Sensorless control, Overcurrent detection, Improved startup</td>
<td>6.5 to 18.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB9063FNG</td>
<td>SSOP24</td>
<td>120°</td>
<td>Pre-drivers</td>
<td>Only a few external parts required, Support for both PWM and DC inputs</td>
<td>6 to 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB9064FNG**</td>
<td>SSOP24</td>
<td>120°</td>
<td>Direct</td>
<td>Simple motor control due to external part count reduction, Built-in detection circuits against motor overcurrent and power supply (overvoltage), etc.</td>
<td>7 to 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB9066FNG</td>
<td>SSOP24</td>
<td>120°</td>
<td>Direct</td>
<td>Allows direct drive of a motor with built-in 0.3-A drivers LIN 1.3 transceiver, 5-V system power supply</td>
<td>7 to 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB9067FNG</td>
<td>SSOP24</td>
<td>120°</td>
<td>Direct</td>
<td>5-channel safety relays, Selectable operation on fault detection initial diagnosis of detection circuits</td>
<td>4.5 to 28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ENVIRONMENT-FRIENDLY

Products: Automotive Brushed DC Motor Driver ICs

**Brushed DC Motors**

TB9101FNG
- 2-channel H-bridge driver (1.3 A)
- Package: SSOP24

TB9102FNG
- 6-channel half-bridge driver (1.0 A)
- SPI communication
- Package: SSOP24

TB9056FNG
- 1-channel H-bridge driver (0.3 A)
- LIN communication
- Package: SSOP24

TB9057FNG
- 1-channel H-bridge driver (0.3 A)
- Ron: 0.4Ω
- Package: SSOP24

TB9058FNG
- 1-channel H-bridge driver (5.0 A)
- Ron: 0.4Ω High + low sides
- Package: PQFN28

TB9059FNG
- 2-channel H-bridge driver (5.0 A)
- 1-channel H-bridge driver (10.0 A)
- SPI communication
- Package: PQFN36

TB9110FNG
- 1-channel high-side driver (30.0 A x 2 pcs)
- FET current/temperature detection
- Package: WQFN48(TBD)

TB9111FNG
- 1-channel half-bridge driver (50.0 A) x 2 pcs
- FET current/temperature detection
- Package: WQFN48(TBD)

TB9112FNG
- 1-channel high-side driver (30.0 A)
- Package: PQFN28

TB9113FNG
- 1-channel H-bridge driver (5.0 A)
- LIN communication
- Package: SSOP24

TB9114FNG
- 2-channel H-bridge driver (5.0 A)
- LIN communication
- Package: SSOP24

**1-Channel Brushed DC Motor Driver IC: TB9051FTG**

DC motor driver IC in a small package that is capable of controlling the throttle and other valves of a vehicle engine.

The TB9051FTG is housed in a small QFN package (measuring 6 mm x 6 mm) and contributes to reducing the size of electronic control units (ECUs). The output stage has a low-on-resistance H-bridge that consists of P-channel and N-channel MOS transistors. This eliminates the need for a charge pump and thus helps reduce noise and power consumption. To ensure functional safety, the supply voltage monitoring circuit performs initial diagnosis of each on-chip comparator. Applications of the TB9051FTG include opening and closing engine throttle and other valves; retracting electric door mirrors; and seat, rear door open/close and other applications that conduct current exceeding 3 A.

- 1-channel PWM H-bridge driver
- Operating current: 5 A
- Low Ron DMOS: ≈ 0.45 Ω (P channel + N channel)
- Forward, reverse, brake, current limit control, high-side current monitor, diagnostic output, initial diagnosis
- Through-current protection
- Operating voltage range: 4.5 to 28 V
- Operating temperature range: –40 to 125°C
- Package: PQFN28 (6 mm x 6 mm)

**H-Bridge Pre-driver: TB9057FG**

H-bridge pre-driver IC designed for high-current applications such as electric power steering (EPS)

- H-bridge pre-driver (that requires an external FET)
- Built-in charge pump (with a VB of +7 V or greater)
- Low-side pre-driver for low-voltage drive
- A charge pump is used to boost a supply voltage.
- Built-in circuit for motor rotation direction detection
- High-speed pre-driver
- Built-in high-speed and high-accuracy motor current sense circuit
- Duplicate power and ground terminals as a provision for functional safety
- Various detection circuits: Undervoltage detection, FET short-circuit detection, thermal shutdown

**Lineup**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Recommended Applications</th>
<th>Features</th>
<th>Maximum Current (A)</th>
<th>Output Voltage (V)</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB9051FTG</td>
<td>PQFN28-0656-0.65-001</td>
<td>Overdrive control for engine throttle and other valves</td>
<td>1-channel PWM H-bridge driver</td>
<td>±5</td>
<td>4.5 to 28</td>
<td>🟩</td>
</tr>
<tr>
<td>TB9052FNG</td>
<td>HTSSOP48-4-P-200-0.50</td>
<td>EPS, electric power brake, seat belt pretensionen, auto sunroof</td>
<td>1-channel PWM H-bridge driver (external N-channel FET) Motor current series circuit</td>
<td>±1</td>
<td>6 to 18</td>
<td>🟩</td>
</tr>
<tr>
<td>TB9056FNG</td>
<td>SSOP24-P-300-0.65A</td>
<td>HVAC damper control</td>
<td>1-channel H-bridge, LIN Version 1.3 slave</td>
<td>±0.3</td>
<td>7 to 18</td>
<td>⬤</td>
</tr>
<tr>
<td>TB9057FNG</td>
<td>LQFP48-P-0707-0.50C</td>
<td>EPS, electric power brake, seat belt pretensionen, auto sunroof</td>
<td>1-channel H-bridge (external N-channel FET) Built-in motor current detection circuit</td>
<td>±1</td>
<td>7 to 21</td>
<td>🟩</td>
</tr>
<tr>
<td>TB9058FNG</td>
<td>SSOP24-P-300-0.65A</td>
<td>HVAC damper control</td>
<td>1-channel H-bridge, LIN Version 1.3 slave (for enhanced checksum)</td>
<td>±0.3</td>
<td>7 to 18</td>
<td>⬤</td>
</tr>
<tr>
<td>TB9101FNG</td>
<td>SSOP24-P-300-0.65A</td>
<td>HVAC damper control, door mirror angle control, etc.</td>
<td>2-channel H-bridge, DMOS power transistor version of the TA8035FG</td>
<td>±1</td>
<td>7 to 18</td>
<td>🟩</td>
</tr>
<tr>
<td>TB9102FNG</td>
<td>SSOP24-P-300-0.65A</td>
<td>HVAC damper control, door mirror angle control, etc.</td>
<td>5-channel half-bridge driver, SPI interface</td>
<td>±1</td>
<td>7 to 18</td>
<td>🟩</td>
</tr>
<tr>
<td>TB9110FNG</td>
<td>SSOP24-P-300-0.65A</td>
<td>Automotive fan motors, (HVC, seat ventilation, radiator, etc.)</td>
<td>1-channel pre-driver, Built-in charge pump (external N-channel FET)</td>
<td>0.02</td>
<td>7 to 18</td>
<td>⬤</td>
</tr>
</tbody>
</table>

**Under development**

- TB9083FG
- TB9095FG
- TB9111FG

**Features**

- AEC-Q100: Compliant
- Operating voltage range: 5.5 to 18 V
- Operating temperature range: Ta = –40 to 125°C
- Max. voltage: 40 V peak (load dump)
- Features for functional safety
- Various detection circuits: Undervoltage detection, FET short-circuit detection, thermal shutdown
- Built-in charge pump (with a VB of +7 V or greater)
- Built-in pre-driver (N-ch/N-ch)
- High-speed pre-driver
- Built-in high-speed and high-accuracy motor current sense circuit
- Duplicate power and ground terminals as a provision for functional safety
- AEC-Q100-qualified
- PWM operating frequency: 20 KHz
- Operating temperature range: Ta = –40 to 125°C
- Package: SSOP24

**Applications**

- Electric power steering (EPS)
- Electric sliding doors, power windows, electric power seats, etc.

**Roadmap**

- 2010
- 2015
- 2020

**Overview**

- Supply voltage: 40 V peak (load dump)
- Operating voltage range: 5 to 21 V
- PWM operating frequency: 20 KHz
- Operating temperature range: Ta = –40 to 125°C
- Package: LQFP48

**Pre-Driver**

- Motor current sense circuit
- Forward, reverse, brake, current limit control, high-side current monitor, diagnostic output, initial diagnosis
- Through-current protection
- Operating voltage range: 4.5 to 28 V
- Operating temperature range: –40 to 125°C
- Package: PQFN28 (6 mm x 6 mm)

**Product Category**

- 1-Channel Brushed DC Motor Driver ICs

**Other Products**

- 2-channel H-bridge driver (5.0 A)
- LIN communication
- Package: SSOP24

**Note**

- Using the driver in new applications?
- Using the driver in any new applications that have been qualified for AEC-Q100?
- Using the driver in any new applications that are not AEC-Q100 qualified?
Automotive Stepping Motor Driver IC: TB9120FTG

The TB9120FTG is a constant-current stepping motor driver IC capable of generating microstepped sine waves only from an input clock signal, eliminating the need for a high-performance MCU and software.

<Features>
- Drive method: PWM constant-current control of a two-phase bipolar motor
- Mixed Decay mode tracks input current currently.
- <Stepper Motor Input: Clock>
  Since the TB9120FTG does not use Serial Peripheral Interface (SPI), it does not need a high-performance MCU and software to generate microstepped sine waves.
- Number of microsteps per full step: Selectable from 1, 2, 4, 8, 16, and 32
- Microstepping helps reduce the vibration of a motor, enabling smooth and fine control of the motor.
- Fault detection circuits with flag outputs: Thermal shutdown, overcurrent detection, open-load detection, and stall detection

The TB9120FTG provides a dedicated flag output pin for stall detection, making it possible to detect a motor stall separately.

- Small package: 6 x 6-mm QFN with reduced footprint

<Target applications>
- Simple clock input
- Adjustment of the angle of a reflecting mirror for a head-up display (HUD), opening and closing of automotive valves, damper control for HVAC

Stepping Motor Driver IC Lineup

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Functions &amp; Applications</th>
<th>Features</th>
<th>Supply Voltage (V)</th>
<th>Supply Current (A)</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB9120FTG**</td>
<td>P-VQFN28-0606-0.65-05</td>
<td>Automotive stepping motor driver</td>
<td>Up to 1/32 microstepping, PWM constant-current control, Mixed decay mode, Out-of-step detection, Thermal shutdown, overcurrent detection, and open-load detection, Writable fans with excellent solder wettability, QFN package</td>
<td>1.0</td>
<td>7.0 to 18</td>
<td>○</td>
</tr>
</tbody>
</table>

**: Under development

System Configuration Example

TB9120FTG

Evaluation Board

Evaluation Boards (for Motor Control)

<table>
<thead>
<tr>
<th>Board No.</th>
<th>Motor</th>
<th>Driver</th>
<th>Control</th>
<th>MOS No.</th>
<th>MOSFET (Small power)</th>
<th>MOSFET (Middle power)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 TB9080</td>
<td>3-phase BLDC</td>
<td>Sinusoidal waveform drive (Silent drive)</td>
<td>Nch x3 / Nch x3</td>
<td>TK20S04K3L</td>
<td>TK100S04N1L</td>
<td>100~200 W</td>
<td>HVAC blower motor, Cooling fan</td>
</tr>
<tr>
<td>2 TB9081</td>
<td>3-phase BLDC</td>
<td>External MCU</td>
<td>Nch x11</td>
<td>—</td>
<td>—</td>
<td>TK1R4F04PB</td>
<td>EPS, Brake, 4WS</td>
</tr>
<tr>
<td>3 TB9061</td>
<td>3-phase BLDC</td>
<td>Low-side PWM</td>
<td>Pch x3 / Nch x3</td>
<td>TK20S04M3L</td>
<td>TK20S04K3L</td>
<td>TK100S04N1L</td>
<td>Oil pump, Water pump, Fuel pump</td>
</tr>
<tr>
<td>4 TB9062</td>
<td>3-phase BLDC</td>
<td>High-side PWM</td>
<td>Pch x3 / Nch x3</td>
<td>TK1S04M3L</td>
<td>TK1S04N1L</td>
<td>TK100S04N1L</td>
<td>Oil pump, Water pump, Fuel pump</td>
</tr>
<tr>
<td>5 TB9057</td>
<td>Brushed DC</td>
<td>H-bridge driver</td>
<td>Nch x4</td>
<td>TK80A04K3L</td>
<td>TK100S04N1L</td>
<td>200 W</td>
<td>EPS, Body motors</td>
</tr>
</tbody>
</table>

Products compatible to product evaluation boards

<Three-Phase Motor Driver ICs> TB9061FNG / TB9062FNG / TB9067FNG / TB9080F / TB9081F

<Brushed DC Motor Driver ICs> TB9101FNG / TB9102FNG / TB9110FNG / TB9051FG / TB9052FG / TB9057FG

<Slepper Motor Drivers> TB9120FTG

For details, contact your local Toshiba sales representative.
**System Power Supply ICs with an Integrated DC/DC Converter**

With the increasing performance of automotive electronic devices, it is becoming essential to increase the current capability and the number of outputs of power supply ICs. To address these needs, Toshiba offers system power supply ICs with an integrated DC/DC converter. The latest addition to our portfolio of system power supply ICs, the TB9045FG, is ideal for power supply applications for electronic power steering systems that require an extremely high level of safety.

**High-efficiency DC/DC converter + LDO multi power IC TB9045FG**

- Low-voltage drive (2.7 V or above) and three sensor supply voltage channels
- Functional Safety with Automotive Safety Integrity Level D (ASIL D)

**DC-DC Converter Power Supplies**
- DCDC1 (step-up/down)
- 6-V output, 2.7-V drive, built-in step-down driver, external step-up driver, built-in phase compensation
- DCDC2 (step-down)
  - Integrated step-down driver and phase compensation filter; 0.8-A current capability
  - Available with an output voltage of 1.1, 1.2, 1.25 and 1.5

**Series Power Supplies**
- LD01: 5 V output (400 mA)
- Tracker1: 5 V output (100 mA)
- Tracker2: 5 V output (100 mA)
- Tracker3: 5 V output (100 mA)

**Various detection circuits**
- Output undervoltage detection
- Output overvoltage detection
- Overcurrent Detection
- Thermal Shutdown
- Watch-dog timer (WDT)
- Self-diagnosis of the detection circuits

**High-efficiency DC/DC converter + LDO multi power IC TB9042FTG**

**DC-DC Converter Power Supply**
- DC/DC Converter (SW frequency: 370 kHz)
- DCDC1: 6 V (1.0 A), Efficiency over 80%
- DCDC2: 1.5 V/1.2 V (1.0 A) output (selectable)

**Series Power Supplies**
- LD01: 5 V output (400 mA)
- LD02: 5 V output (100 mA)

**Power Supply for Backup**
- VBU: 5 V/3.3 V (10 mA) (selectable)

**SPI Communication**
- Failure notification
- MCU diagnosis

**Reset Timer**
- Power-on-reset (POR)
- Watch-dog timer (WDT)
- Output undervoltage detection
- Output overvoltage detection

---

**System Power Supply ICs (Series Power Supplies)**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Functions</th>
<th>Output Voltage Type (V)</th>
<th>Output Current (mA)</th>
<th>Input Voltage Max (V)</th>
<th>Power Dissipation Max (W)</th>
<th>Remarks</th>
<th>AEC</th>
<th>Supply Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB9005FNG</td>
<td>SSOP20-P-2SS-0.65A</td>
<td>CPU voltage regulator, watchdog timer</td>
<td>5</td>
<td>Depends on ext. Tr.</td>
<td>45 (1 sec.)</td>
<td>0.66</td>
<td>Low current consumption: 90 µA (typ).</td>
<td>-</td>
<td>6 to 18</td>
</tr>
<tr>
<td>TB9021FNG</td>
<td>P-HTSSOP16-3SS-0.65-01</td>
<td>CPU voltage regulator, watchdog timer</td>
<td>5</td>
<td>200</td>
<td>50</td>
<td>2.8</td>
<td>Watch-dog timer enable/disable.</td>
<td>-</td>
<td>6 to 18</td>
</tr>
</tbody>
</table>

**System Power Supply ICs (DC-Converter Power Supply)**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Functions</th>
<th>Output Voltage Type (V)</th>
<th>Output Current (mA)</th>
<th>Input Voltage Max (V)</th>
<th>Power Dissipation Max (W)</th>
<th>Remarks</th>
<th>AEC</th>
<th>Supply Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB9042FTG**</td>
<td>HQFNS2-P-2Q08-0.50</td>
<td>CPU voltage regulator, DC-DC converter &amp; LDO, watchdog timer, On-chip SPI</td>
<td>1.1/1.2</td>
<td>1000</td>
<td>40 (1 sec.)</td>
<td>5.5</td>
<td>DC-DC converter: - Voltage monitor, POR, WDT - Four-lower-drop (LDO) regulators - SPI (error information output) - 5 V series power supply (with 400 mA driver) - 5 V tracking power supply (with three 100 mA driver channels)</td>
<td>2.7 to 18</td>
<td></td>
</tr>
<tr>
<td>TB9044AFNG**</td>
<td>HTSSOP48-P-3Q00-0.50</td>
<td>CPU voltage regulator, DC-DC converter &amp; LDO, watchdog timer, On-chip SPI</td>
<td>5</td>
<td>400</td>
<td>40 (1 sec.)</td>
<td>3.84</td>
<td>DC-DC converter: - Voltage monitor, POR, WDT - Four-lower-drop (LDO) regulators - SPI (error information output) - 5 V series power supply (with 400 mA driver) - 5 V tracking power supply (with three 100 mA driver channels)</td>
<td>7 to 18</td>
<td></td>
</tr>
<tr>
<td>TB9045FG**</td>
<td>HTSSOP43-P-3Q08-0.50</td>
<td>CPU voltage regulator, DC-DC converter &amp; LDO, watchdog timer, On-chip SPI</td>
<td>1.1/1.2</td>
<td>1000</td>
<td>40 (1 sec.)</td>
<td>3.84</td>
<td>DC-DC converter: - Voltage monitor, POR, WDT - Four-lower-drop (LDO) regulators - SPI (error information output) - 5 V series power supply (with 400 mA driver) - 5 V tracking power supply (with three 100 mA driver channels)</td>
<td>2.7 to 18</td>
<td></td>
</tr>
</tbody>
</table>

**Under development**
Toshiba’s automotive IPDs can be directly controlled by a microcontroller. In the event of a shorted load, overcurrent protection or thermal shutdown is tripped to protect an ECU in which IPDs are used. Toshiba’s automotive IPDs also have a diagnostic output that feeds back the states of their output and an ECU to a microcontroller for easy monitoring.

### High-Side and Low-Side Power Switches

Toshiba’s high-side and low-side power switches contain protection circuits for a shorted load, open load and an output short-circuit to the power supply as well as an abnormal ECU condition (overheating). These power switches also have diagnostic outputs that provide feedback to a microcontroller. Thus, they help to reduce the number of components and improve the reliability of an ECU. Toshiba’s power switches are available in small packages such as SOP8, PS8 and WSON-10, which contribute to reducing the ECU size.

#### IPDs for High-Side Switch Lineup

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Output Supply voltage</th>
<th>Output Current</th>
<th>Operating temperature range</th>
<th>Package</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD1052F</td>
<td>5 to 18 V</td>
<td>&lt; 0.8 A</td>
<td>–40 to 125°C</td>
<td>PS-8</td>
<td>Thermal shutdown, overcurrent protection, diagnosis output</td>
</tr>
<tr>
<td>TPD1053F</td>
<td>5 to 18 V</td>
<td>&lt; 3 A</td>
<td>–40 to 125°C</td>
<td>SOP-8</td>
<td>Thermal shutdown, overcurrent protection, diagnosis output</td>
</tr>
<tr>
<td>TPD1055FA</td>
<td>5 to 18 V</td>
<td>&lt; 3 A</td>
<td>–40 to 125°C</td>
<td>WSON-10</td>
<td>Thermal shutdown, overcurrent protection, diagnosis output</td>
</tr>
<tr>
<td>TPD1060F</td>
<td>4 to 18 V</td>
<td>&lt; 3 A</td>
<td>–40 to 125°C</td>
<td>SOP-8</td>
<td>Thermal shutdown, overcurrent protection, diagnosis output</td>
</tr>
</tbody>
</table>

#### IPDs for Low-Side Switch Lineup

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Output Supply voltage</th>
<th>Output Current</th>
<th>Operating temperature range</th>
<th>Package</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD1030F</td>
<td>2 to 40 V</td>
<td>&lt; 1 A</td>
<td>–40 to 110°C</td>
<td>SOP-8</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
<tr>
<td>TPD1032F</td>
<td>2 to 20 V</td>
<td>&lt; 3 A</td>
<td>–40 to 110°C</td>
<td>SOP-8</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
<tr>
<td>TPD1036F</td>
<td>2 to 30 V</td>
<td>&lt; 1.5 A</td>
<td>–40 to 110°C</td>
<td>SOP-8</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
<tr>
<td>TPD1044F</td>
<td>1</td>
<td>&lt; 1 A</td>
<td>–40 to 125°C</td>
<td>PS-8</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
<tr>
<td>TPD1046F</td>
<td>2 to 20 V</td>
<td>&lt; 3 A</td>
<td>–40 to 125°C</td>
<td>SOP-8</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
<tr>
<td>TPD1054F</td>
<td>1</td>
<td>&lt; 1 A</td>
<td>–40 to 125°C</td>
<td>PS-8</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
<tr>
<td>TPD1058FA</td>
<td>1</td>
<td>&lt; 6 A</td>
<td>–40 to 125°C</td>
<td>WSON-10</td>
<td>Overvoltage protection (active clamp)</td>
</tr>
</tbody>
</table>

*The up-to-date and more detailed information on automotive MOSFETs and IPDs is available on our website. [https://toshiba.semicon-storage.com/](https://toshiba.semicon-storage.com/)
Gate Drivers

Application Example of Gate Drivers (TPD7107F**)

- Semiconductor relay
- Junction box

IPDs for Power MOSFET Gate Driver Lineup

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Function</th>
<th>Supply voltage</th>
<th>Output Current</th>
<th>Operating temperature</th>
<th>Package</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD7104AF</td>
<td>1ch High Side Nch</td>
<td>5 to 18 V</td>
<td>Depends on internal drive</td>
<td>–40 to 125°C</td>
<td>PS-8</td>
<td>• Built-in charge pump circuit • Overcurrent detection/protection/protection output • Reverse-battery protection</td>
</tr>
<tr>
<td>TPD7106F**</td>
<td>1ch High Side Nch</td>
<td>4.5 to 27 V</td>
<td>–10 mA to +10 mA</td>
<td>–40 to 150°C</td>
<td>VSOP-16</td>
<td>• Built-in charge pump circuit (with external capacitor) • Charge pump voltage drop detection/protection • Reverse-battery protection • Externally controlled sharp OFF (+400 mA)</td>
</tr>
<tr>
<td>TPD7107F**</td>
<td>1ch High Side Nch</td>
<td>5.75 to 26 V</td>
<td>Depends on internal drive</td>
<td>–40 to 125°C</td>
<td>WSON-10</td>
<td>• Built-in charge pump circuit • Protection from abnormal supply voltage &amp; detection output (power supply drop, overvoltage, reverse battery) • Load current sensor • Overcurrent detection/protection, diagnosis output • Thermal shutdown, diagnosis output • Monitoring of voltage between drain-sources of external FET, active clamp • GND terminal open-circuit protection • Load short-circuit and open-circuit diagnosis output</td>
</tr>
<tr>
<td>TPD7211F</td>
<td>Half-bridge Pw-MOSFET</td>
<td>5 to 18 V</td>
<td>±0.5 A (max)</td>
<td>–40 to 125°C</td>
<td>PS-8</td>
<td>• Driving of high-side P-ch MOSFET and low-side N-ch MOSFET</td>
</tr>
<tr>
<td>TPD7212F</td>
<td>3 Phase Full bridge</td>
<td>4.5 to 18 V</td>
<td>–1.0 A to +1.5 A</td>
<td>–40 to 125°C</td>
<td>WQFN-32</td>
<td>• Built-in charge pump circuit • Protection from driver abnormal supply voltage, diagnosis output (low voltage, overvoltage, reverse battery) • Output voltage monitoring (protection, diagnosis output)</td>
</tr>
</tbody>
</table>

* The up-to-date and more detailed information on automotive MOSFETs and IPDs is available on our website. https://toshiba.semicon-storage.com/

**: Under development
Toshiba’s IP cores incorporate dedicated hardware for motor control and functional safety to provide the optimal control and functionality. Offloading complicated computations to the dedicated hardware reduces the workload of the CPU and helps reduce the overall power consumption.

**Features of Toshiba’s Automotive Microcontrollers**

- Toshiba’s IP cores incorporate dedicated hardware for motor control and functional safety to provide the optimal control and functionality.
- Offloading complicated computations to the dedicated hardware reduces the workload of the CPU and helps reduce the overall power consumption.
- Toshiba’s Automotive Microcontrollers are ideal for real-time control and offer a high degree of control.
- They are designed for battery monitoring and general automotive applications, including EPS and inverter control.
- They are equipped with advanced programmable motor driver (A-PMD) technology, allowing for flexible and efficient control.
- They are equipped with resolver-to-digital (RDC) converters, which correct for sensorless control, and vector engine (VE) technology, which allows for optimized control.
- They are equipped with optimized tightly coupled fault supervisor and one-shot pulse generator, enabling precise and efficient control.
- They are designed for high rpm control and can achieve speeds greater than 15,000 by generating pulses.

**Roadmap for Automotive Microcontrollers**

Toshiba is expanding its portfolio of automotive microcontrollers, based on the Arm Cortex-based CPU cores. The roadmap includes various models with different memory sizes, pin counts, and features, designed for different applications such as EPS and inverter control.

**Features of Toshiba’s Automotive Microcontrollers**

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Vector Control Technology

The integrated RDC, Vector Engine (VE), and Advanced Programmable Motor Driver (A-PMD), which run in parallel with the CPU, handle computations unique to motor control and therefore reduce the CPU workload.

**One-shot pulse generator**
At high RPMs, the one-shot pulse generator allows the A-PMD to control motors with one pulse per revolution, thereby making it possible to spin them at 15,000 RPM or faster. At mid to high RPMs, the one-shot pulse generator results in an approximately 10% increase in the motor output power, compared to asynchronous PWM control. This provides greater flexibility in the use of smaller batteries or motors.

**Autonomous Control in Three Different Modes**

A wide range of development tools are available from many partners for automotive ARM Cortex-based microcontrollers. Choose the best development tools and partners that best suit your needs.

<table>
<thead>
<tr>
<th>Development Tools and Partners</th>
<th>IDE/Compiler</th>
<th>Debugger</th>
<th>Simulator</th>
<th>OS</th>
<th>Software Development Kit</th>
<th>Board Evaluation Kit</th>
<th>Programmer/Writer</th>
<th>Teaching Materials/Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARM Ltd. (Yokogawa Digital Computer Corporation)</td>
<td>★★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAR Systems AB</td>
<td>★</td>
<td>★</td>
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<tr>
<td>Green Hills Software / Advanced Data Controls Corp.</td>
<td>★</td>
<td>★</td>
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<tr>
<td>ATI Japan</td>
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<td></td>
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<tr>
<td>Elektrobit Corporation</td>
<td></td>
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<tr>
<td>GAIO TECHNOLOGY CO., LTD.</td>
<td></td>
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<tr>
<td>iFORCOM Kyoei Co., Ltd.</td>
<td></td>
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<td>KPIT Technologies Ltd.</td>
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<td>Computex Co., Ltd.</td>
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<td>Schwa &amp; Sophia Technologies Co., Ltd.</td>
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<tr>
<td>dSPACE GmbH</td>
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<tr>
<td>DTS INSIGHT Corporation</td>
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<td></td>
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<tr>
<td>SEGGER Microcontroller GmbH</td>
<td></td>
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</tr>
</tbody>
</table>
Toshiba Functional Safety Package

Toshiba offers a support environment not only from a system perspective but also from a customer perspective.

**Feature 1: Support from a device perspective**

Toshiba’s functional safety technology is based on an optimized tightly coupled fault supervisor, which observes and directs the operation of not only the CPU but also its peripherals. The functional safety alarm output at the interface between an MCU and a power supply IC can be monitored to enhance automotive functional safety from a system perspective.

**Example of Functional Safety Block for an Automotive MCU (including the interface between the MCU and the power supply IC)**

**Functional Safety Technologies for MCUs and Analog ICs**

- Hardware-based functional safety (compliant with ISO 26262)
- MCUs: Technology recognized by TÜV-SÜD Automotive
- Analog ICs: Developed based on our extensive experience and expertise

**Full-ICE fault injection**

- The MCU emulator provides a fault injection tool designed to examine the system behavior in the presence of a fault.

**MCU and analog IC chipsets**

- MCU and automotive power supply IC chipsets
- MCU and battery monitoring IC chipsets

**Protocol stacks for analog ICs**

- Software development process certified to ASIL D

**Functional Safety IP Library**

- Software development process certified to ASIL D
- Functional safety IP libraries for MCUs are offered.

**Features of the Functional Safety Block**

- Monitors all the peripheral blocks, the CPU, buses and memories used by application software except a few communication control blocks
- Incorporates an RNET block that handles alarms from all the monitor functions
- Sends alarm signals from all the monitor functions directly from RNET to the external world without involving the CPU
- Self-diagnosis function of RNET to protect its alarm-handling function
- Fault diagnosis circuit from Yogitech that monitors the CPU
- Fault diagnosis circuit from Yogitech that monitors the entire CPU
- Fault diagnosis circuit developed by Toshiba
**Feature 2: Fault Injection (Under Development)**

The Full-ICE MCU emulator provides a fault injection test environment that can directly be connected to a customer’s hardware evaluation environment. It is easy to learn and yet allows flexible fault injection testing.

Note: Contact your Toshiba sales representative for the availability of functional-safety IP libraries.

**Feature 3: Functional Safety IP Library**

The Functional Safety IP Library is a software library designed to detect faults in an automotive MCU. It has been created using a software development process certified by TÜV-SÜD.

Note: Contact your Toshiba sales representative for the availability of functional-safety IP libraries.

**The Functional Safety IP Library helps its users reduce development time.**

**Software library offerings**

- Application
  - RTE
  - Service
    - ECU abstraction
    - MCAL
  - MCU

- Potential feature

**Reduction in the time required to create a safety mechanism**

- Performs requirements analysis and verification on the fault diagnosis section of an MCU
- Identifies application-specific interfaces (APIs) to enable quick feedback to a system design
- Guarantees that the fault coverage required by ASIL D is met

**Reduction in the time required to meet accountability requirements**

- A set of documents necessary to achieve accountability is pre-packaged.
Toshiba offers photocouplers that consist of a high-power infrared LED coupled with a photodetector fabricated using the latest process. These photocouplers provide high isolation voltage and low power consumption, making them ideal for applications that require enhanced safety and environmental friendliness.

**IC Output (High Speed Communications)**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Characteristics</th>
<th>Output Type</th>
<th>I_{OC} (mA)</th>
<th>Data Rate (Mbps)</th>
<th>T_{stg} (°C)</th>
<th>T_{opr} (°C)</th>
<th>Isolation Voltage BV_{(1Vrms)}</th>
<th>Clearance/Creepage Distance (mm)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLX9304</td>
<td></td>
<td></td>
<td>Open collector</td>
<td>5</td>
<td>1</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>5pin SO6</td>
</tr>
<tr>
<td>TLX9309</td>
<td></td>
<td></td>
<td>Open collector (Analog output)</td>
<td>5–300 @7/4.5°</td>
<td>1</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>5pin SO6</td>
</tr>
<tr>
<td>TLX9310</td>
<td></td>
<td></td>
<td>Totem-pole</td>
<td>1</td>
<td>5</td>
<td>5–55 to 125</td>
<td>105</td>
<td>3750</td>
<td>5 mm</td>
<td>5pin SO6</td>
</tr>
<tr>
<td>TLX9378</td>
<td></td>
<td></td>
<td>Open collector</td>
<td>5</td>
<td>10</td>
<td>5–55 to 125</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>5pin SO6</td>
</tr>
<tr>
<td>TLX9376</td>
<td></td>
<td></td>
<td>Totem-pole</td>
<td>4</td>
<td>20</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>5pin SO6</td>
</tr>
</tbody>
</table>

*Note: The values in the table refer to L/Ω (%)(min) to (max). @ refers to a value under the measuring condition I_{OC}(mA)/V_{CC}.

**Transistor Output (DC Input)**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Characteristics</th>
<th>L/Ω (%) (min) to (max)</th>
<th>V_{OC} (V) (MAX)</th>
<th>V_{CC} (V) (MAX)</th>
<th>T_{stg} (°C)</th>
<th>T_{opr} (°C)</th>
<th>Isolation Voltage BV_{(1Vrms)}</th>
<th>Clearance/Creepage Distance (mm)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLX9000</td>
<td></td>
<td></td>
<td>100 to 900 @5/5</td>
<td>0.4</td>
<td>40</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>SO4</td>
</tr>
<tr>
<td>TLX9300</td>
<td></td>
<td></td>
<td>100 to 900 @5/5</td>
<td>0.4</td>
<td>40</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>4pin SO6</td>
<td></td>
</tr>
<tr>
<td>TLX9291A</td>
<td></td>
<td></td>
<td>50 to 600 @5/5</td>
<td>0.4</td>
<td>80</td>
<td>5–55 to 125</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>SO4</td>
</tr>
<tr>
<td>TLX9185A</td>
<td></td>
<td></td>
<td>50 to 600 @5/5</td>
<td>0.4</td>
<td>80</td>
<td>5–55 to 125</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>4pin SO6</td>
</tr>
</tbody>
</table>

**Photovoltaic Output**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>Short-Circuit Current (A) (min)</th>
<th>Open Voltage VOC(V) (MAX)</th>
<th>T_{stg} (°C)</th>
<th>T_{opr} (°C)</th>
<th>Isolation Voltage BV_{(1Vrms)}</th>
<th>Clearance/Creepage Distance (mm)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLX9905</td>
<td></td>
<td>12</td>
<td>7 @10</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>4pin SO6</td>
</tr>
<tr>
<td>TLX9906</td>
<td></td>
<td>12</td>
<td>7 @10</td>
<td>5–55 to 150</td>
<td>40–125</td>
<td>3750</td>
<td>5 mm</td>
<td>4pin SO6</td>
</tr>
</tbody>
</table>

**Photorelays (1-Form-A)**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Pin Configuration</th>
<th>OFF-State Output Terminal Voltage VO_{off} (MAX) (V)</th>
<th>ON-State Current I_{ON} (MAX) (A)</th>
<th>ON-state Resistance R_{ON} (Max) (Ω)</th>
<th>@I_{ON} (mA)</th>
<th>@I_{off} (mA)</th>
<th>Trigger LED BVS (Vrms)</th>
<th>Isolation Voltage BV_{(1Vrms)}</th>
<th>Clearance/Creepage Distance (mm)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLX9175J</td>
<td></td>
<td>600</td>
<td>15</td>
<td>335</td>
<td>15/10</td>
<td>3</td>
<td>3750</td>
<td>5 mm</td>
<td>4pin SO6</td>
<td></td>
</tr>
</tbody>
</table>

*This device is compliant with the reliability requirements of AEC-Q100.

For details, contact your Toshiba sales representative.
**Automotive Devices in Small Packages**

As electronic control of automobiles becomes increasingly pervasive, demand for semiconductor devices in small packages is increasing. Toshiba offers various types of semiconductor devices for automotive applications, including mechanical relay drive, LED control, battery cell balancing, and protection of the CAN and LIN buses. Toshiba’s product portfolio includes an extensive array of devices certified for AEC-Q100 and AEC-Q101, reliability specifications for automotive electronics.

### Major TVS Diodes Compliant with the AEC Standards

#### TVS Diodes (ESD Protection Diodes for CAN/LIN)

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Part Number</th>
<th>Pin Assignment</th>
<th>Absolute Maximum Ratings</th>
<th>Electrical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOD-323 1.25 x 2.5</td>
<td>DF2B18FU</td>
<td>2 Pins</td>
<td>V_{ESD} (V)</td>
<td>V_{MOS} (V)</td>
</tr>
<tr>
<td></td>
<td>DF2B22FU</td>
<td></td>
<td>±30 kV</td>
<td>±30 kV</td>
</tr>
<tr>
<td></td>
<td>DF2B26FU</td>
<td></td>
<td>±20 kV</td>
<td>±20 kV</td>
</tr>
<tr>
<td>SOD-323 2.0 x 2.1</td>
<td>DF3D18FU</td>
<td>3 Pins</td>
<td></td>
<td>±30 kV</td>
</tr>
<tr>
<td></td>
<td>DF3D22FU</td>
<td></td>
<td>±25 kV</td>
<td>±30 kV</td>
</tr>
<tr>
<td></td>
<td>DF3D26FU</td>
<td></td>
<td>±20 kV</td>
<td>±20 kV</td>
</tr>
</tbody>
</table>

#### TVS Diodes (ESD Protection Diodes for LVDS/PoC)

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Part Number</th>
<th>Pin Assignment</th>
<th>Absolute Maximum Ratings</th>
<th>Electrical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOD-923 1.0 x 0.6</td>
<td>DF25S5M4FS</td>
<td>2 Pins</td>
<td>T_j (˚C)</td>
<td>V_{ESD} (V)</td>
</tr>
<tr>
<td></td>
<td>DF25S6M4FS</td>
<td></td>
<td>±20 kV</td>
<td>±30 kV</td>
</tr>
<tr>
<td></td>
<td>DF25S20M4FS</td>
<td></td>
<td>±15 kV</td>
<td>±20 kV</td>
</tr>
</tbody>
</table>

* Contact your Toshiba sales representative for details

* This device is compliant with the reliability requirements of AEC-Q100.
Products: AEC-Qualified Automotive Discrete Devices

**Major Small-Signal Devices Compliant with the AEC Standards**

### MOSFETs

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Polarity</th>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>RDS (ON) max (mΩ)</th>
<th>Ciss (pF)</th>
<th>Qg (nC)</th>
<th>Toh (˚C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UFM 2.0 x 2.1</td>
<td>Nch + Zener</td>
<td>SSM3H137TU</td>
<td>34</td>
<td>±0.2</td>
<td>2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>UFE 2.0 x 2.1</td>
<td>Nch x 2</td>
<td>SSM6N62TU*</td>
<td>20</td>
<td>±0.8</td>
<td>0.8</td>
<td>121 (typ.)</td>
<td>74 (typ.)</td>
</tr>
<tr>
<td>SOT-23F 2.9 x 2.4</td>
<td>Nch</td>
<td>SSM3K337R</td>
<td>38</td>
<td>±0.2</td>
<td>2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM3K341R*</td>
<td>60</td>
<td>±0.2</td>
<td>6</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM3K318R</td>
<td>60</td>
<td>±0.2</td>
<td>2.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM3K2615R</td>
<td>60</td>
<td>±0.2</td>
<td>2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM3K361R*</td>
<td>100</td>
<td>±0.2</td>
<td>3.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>TSOIPU 2.9 x 2.8</td>
<td>Nch Dual</td>
<td>SSM6N357TU*</td>
<td>60</td>
<td>±0.12</td>
<td>0.65</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>SOT-333F 2.0 x 2.1</td>
<td>Nch</td>
<td>SSM6K62TU*</td>
<td>100</td>
<td>±0.2</td>
<td>3.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>TSOIPF 2.9 x 2.8</td>
<td>Nch Single</td>
<td>SSM6K809R*</td>
<td>60</td>
<td>±0.2</td>
<td>6</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM6K810R*</td>
<td>100</td>
<td>±0.2</td>
<td>3.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM6K819R*</td>
<td>30</td>
<td>±0.2</td>
<td>15</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSM6K818R*</td>
<td>100</td>
<td>±0.2</td>
<td>10</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### Bipolar Transistors

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Polarity</th>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>NFE</th>
<th>VCEO (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USM (SOT-323) 2.0 x 2.1</td>
<td>NPN</td>
<td>2SC4116</td>
<td>50</td>
<td>0.15</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>PNP</td>
<td>2SA1586</td>
<td>–50</td>
<td>–0.15</td>
<td>0.1</td>
</tr>
<tr>
<td>S-Mini (SOT-346) 2.9 x 2.5</td>
<td>NPN</td>
<td>2SC2712</td>
<td>50</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>PNP</td>
<td>2SA1162</td>
<td>–50</td>
<td>–0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### Switching Diodes

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Part Number</th>
<th>Pin Assignment</th>
<th>Absolute Maximum Ratings</th>
<th>Electrical Characteristics (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC (SOD-523) 0.8 x 1.6</td>
<td>1SS307E</td>
<td></td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>USC (SOD-323) 1.25 x 2.5</td>
<td>1SS352</td>
<td></td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>1SS403</td>
<td></td>
<td></td>
<td>200</td>
<td>2</td>
</tr>
<tr>
<td>USM (SOT-323) 2.0 x 2.1</td>
<td>1SS302A</td>
<td></td>
<td>80</td>
<td>2</td>
</tr>
</tbody>
</table>

### Standard Logic ICs (Topr: –40°C to 125°C)

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Series</th>
<th>Part Number</th>
<th>Key Electrical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSSOP14B (5.0 x 6.4 x 1.2)</td>
<td>VHCC Series</td>
<td>74VHCxxFT</td>
<td>Vcc = 2.0 V to 5.5 V</td>
</tr>
<tr>
<td>TSSOP16B (5.0 x 6.4 x 1.2)</td>
<td></td>
<td>74VHCxxFT</td>
<td>Vcc = 4.5 V to 5.5 V, TTL input</td>
</tr>
<tr>
<td>TSSOP20B (6.5 x 6.4 x 1.2)</td>
<td></td>
<td>74VHCxxFT</td>
<td>Vcc = 1.8 V to 5.5 V</td>
</tr>
</tbody>
</table>

### One-Gate Logic ICs (Topr: –40°C to 125°C)

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Series</th>
<th>Part Number</th>
<th>Key Electrical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>USV (SOT-353) 2.0 x 2.1</td>
<td>VHS Series</td>
<td>TC7SHxxFU</td>
<td>Vcc = 2.0 V to 5.5 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC7SETxxFU</td>
<td>Vcc = 4.5 V to 5.5 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC7SZxxFU</td>
<td>Vcc = 1.65 V to 5.5 V</td>
</tr>
</tbody>
</table>

For details of AEC compliance, contact your Toshiba sales representative. Toshiba is expanding its portfolio of AEC-qualified devices. For the latest information, visit Toshiba’s website.
Major Power Devices Compliant with the AEC Standards

MOSFETs

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Polarity</th>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>$R_{DS(ON)}$ Max (mΩ)</th>
<th>Series</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPak+ N-ch</td>
<td>TK1R4S04PB</td>
<td>40 120</td>
<td>1.35</td>
<td>U-MOSIX-H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TK6S04N1L</td>
<td>40 65</td>
<td>4.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TK40S06N1L</td>
<td>60 40</td>
<td>10.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TK25S06N1L</td>
<td>60 25</td>
<td>18.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TK6S10N1L</td>
<td>100 60</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TK35S10N1L</td>
<td>100 33</td>
<td>9.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-ch</td>
<td>TJ90S04M3L</td>
<td>–40 –90</td>
<td>4.3</td>
<td>U-MOSV1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TJ40S04M3L</td>
<td>–40 –40</td>
<td>9.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TJ20S04M3L</td>
<td>–40 –20</td>
<td>22.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOP Adv (WF) N-ch</td>
<td>TPHR7904PB</td>
<td>40 150</td>
<td>0.79</td>
<td>U-MOSIX-H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPH1R104PB</td>
<td>40 120</td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSOP Adv (WF) N-ch</td>
<td>TPWR7904PB</td>
<td>40 150</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPW1R104PB</td>
<td>40 120</td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS-8</td>
<td>TPC8009</td>
<td>40 10</td>
<td>11.8</td>
<td>U-MOSIV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8010</td>
<td>40 6</td>
<td>23.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8011</td>
<td>40 5</td>
<td>31.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8012</td>
<td>60 8</td>
<td>20.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8013</td>
<td>60 4</td>
<td>51.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-ch</td>
<td>TPC8107</td>
<td>–40 –8</td>
<td>18</td>
<td>U-MOSV1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8109</td>
<td>–40 –4.5</td>
<td>52.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8110</td>
<td>–60 –5</td>
<td>39.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TPC8111</td>
<td>–60 –3</td>
<td>117</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N-chx2</td>
<td>TPC8207</td>
<td>40 V/–40 V</td>
<td>5/150</td>
<td>U-MOSIV-V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N-ch+N-ch</td>
<td>TPC8407</td>
<td>40 V/–10 V</td>
<td>5/–4</td>
<td>36.3/56.8</td>
<td>U-MOSIV-VI</td>
<td></td>
</tr>
</tbody>
</table>

Bipolar Transistors

Toshiba is expanding its portfolio of bipolar transistors in the PW-Mini package.

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Polarity</th>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>$h_{FE}$</th>
<th>$V_{CEO}$ (V)</th>
<th>$I_{C}$ (A)</th>
<th>$I_{B}$ (mA)</th>
<th>Series</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>New PW-Mold 6.5 x 9.5</td>
<td>NPN</td>
<td>TTC016</td>
<td>50 5 400 2 0.5 0.22 1.6 32</td>
<td>Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2SC3303</td>
<td>80 5 70 1 1 0.4 3 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTC012</td>
<td>375 2 100 5 0.3 0.5 0.5 62.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTC014</td>
<td>800 1 100 5 0.1 1.0 0.5 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2SD1233</td>
<td>80 4 2000 2 1 1.5 3 6</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PNP</td>
<td>TTA005</td>
<td>–50 –5 200 –2 –0.5 –0.27 –1.6 –53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTA009</td>
<td>–80 –3 100 –2 –0.5 –0.5 –1 –100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2SA2142</td>
<td>–600 –0.5 100 –5 –0.05 –1.0 –0.1 –10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Diodes

In addition to standard rectifier diodes, Toshiba is expanding its portfolio of high-speed rectifier and Schottky barrier diodes.

<table>
<thead>
<tr>
<th>Package Unit (mm)</th>
<th>Part Number</th>
<th>Absolute Maximum Ratings</th>
<th>Electrical Characteristics (max)</th>
<th>AEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-FLAT 1.6 x 2.6 I = 0.98</td>
<td>CRG09A</td>
<td>400 1.0</td>
<td>$1.1 \times (0.7A)$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRG10A</td>
<td>600 0.7</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRG05</td>
<td>800 1.0</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>M-FLAT 2.4 x 4.7 I = 0.98</td>
<td>CMG02</td>
<td>400 2.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CMG03</td>
<td>600 2.0</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>
Technological enablers for Automated-Driving cars include sophisticated sensing and image recognition, high-bandwidth communication with traffic infrastructure, and an efficient human-machine interface to provide drivers with necessary information. Automated-Driving cars also require enhancements to security and functional safety technologies.

<table>
<thead>
<tr>
<th>Self-driving levels</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited automated-driving on expressways</td>
<td>Full automated-driving on expressways</td>
<td>Limited automated-driving on general roads in urban areas</td>
</tr>
<tr>
<td>Information about accidents, construction work and traffic jam, automatic parking, and nighttime monitoring</td>
<td>Monitoring of merging traffic, optimal lane recommendation, gesture UI, and driver monitoring</td>
<td>Judgment using artificial intelligence (AI) technology</td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited automated-driving on expressways</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited automated-driving on expressways</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Automated-driving on general roads in suburban areas: Dynamic maps, Cloud-linked services, Interactive UI and HEMS-linked UI
Car-dispatch and parking services
Services for connecting automated-driving cars with public transportation

Automated-driving on general roads in urban areas: Judgment using artificial intelligence (AI) technology
In-vehicle entertainment

To help pave the way for the advent of automated-driving cars, Toshiba offers various solutions for advanced driver assistance systems.
Upcoming automated-driving cars incorporate a wide range of driver assistance applications using various sensors. Automated-driving cars also need capabilities for driver-to-vehicle communication and collecting information from traffic infrastructure. To help pave the way for the advent of automated-driving cars, Toshiba offers various solutions for advanced driver assistance systems.

Technological enablers for Automated-Driving cars include sophisticated sensing and image recognition, high-bandwidth communication with traffic infrastructure, and an efficient human-machine interface to provide drivers with necessary information. Automated-Driving cars also require enhancements to security and functional safety technologies.
Toshiba offers the Visconti™ Family of image recognition processors that provide extensive support for image feature extraction and recognition using automotive cameras while offering an excellent combination of high performance and low power consumption. Our image recognition processors can run multiple image recognition applications in parallel and support system solutions for reliable nighttime pedestrian recognition.

**ADAS: Front and Surround View Monitoring Solution**

The Visconti™ image recognition processors are capable of processing input images from one to four cameras in real time (and allow connection of up to eight cameras). Visconti™ can run multiple ADAS applications in parallel to recognize vehicles, pedestrians, traffic lines, traffic signs and the like around the vehicle on which it is mounted. Possible applications include vehicle detection and collision warning; pedestrian detection and collision warning; lane detection and departure warning; traffic sign recognition; and red-signal detection. Visconti™ combines high performance and low power consumption.

In order to achieve high visibility of pedestrians in dark places where neither headlights nor street lamps reach, the Visconti4 Series combines CoHOG (Co-occurrence Histograms of Oriented Gradients) with Color-COHOG and three other types of color-based feature descriptors.

**Image Recognition Processors**

The Visconti™ image recognition processors are capable of processing input images from one to four cameras in real time (and allow connection of up to eight cameras). Visconti™ can run multiple ADAS applications in parallel to recognize vehicles, pedestrians, traffic lines, traffic signs and the like around the vehicle on which it is mounted. Possible applications include vehicle detection and collision warning; pedestrian detection and collision warning; lane detection and departure warning; traffic sign recognition; and red-signal detection. Visconti™ combines high performance and low power consumption.

In order to achieve high visibility of pedestrians in dark places where neither headlights nor street lamps reach, the Visconti4 Series combines CoHOG (Co-occurrence Histograms of Oriented Gradients) with Color-COHOG and three other types of color-based feature descriptors.

**Video Decoder ICs**

The video input interface of the TMPV7608XBG has a 4-of-8 video switch.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Series</th>
<th>CPU</th>
<th>MPE</th>
<th>Image Processing Accelerator</th>
<th>Video Input</th>
<th>Main Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPV7608XBG</td>
<td>Visconti4 Series</td>
<td>Two Toshiba-original 32-bit RISC MePs</td>
<td>8</td>
<td>Affine Transformation, Filter, Histogram, HOG, Enhanced CoHOG, Matching, Pyramid, SIMD</td>
<td>Up to 8 ch.*</td>
<td>On-chip Memory, Memory Controller, CAN, FC, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.</td>
<td>PFBGA796</td>
</tr>
<tr>
<td>TMPV7528XBG</td>
<td>Visconti3 Series</td>
<td>Toshiba-original 32-bit RISC MeP and Arm® Cortex®-A9 MPCore</td>
<td>4</td>
<td>Affine Transformation, Filter, Histogram, HOG, Matching</td>
<td>Up to 4 ch.</td>
<td>On-chip Memory, Memory Controller, PCI Express, CAN, FC, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.</td>
<td>PBGA516</td>
</tr>
<tr>
<td>TMPV7506XBG</td>
<td>Visconti2 Series</td>
<td>Two Toshiba-original 32-bit RISC MeP</td>
<td>2</td>
<td>Affine Transformation, Filter, Histogram, HOG, Matching</td>
<td>Up to 2 ch.</td>
<td>On-chip Memory, Memory Controller, CAN, FC, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.</td>
<td>PLFBGA324</td>
</tr>
<tr>
<td>TMPV7502XBG</td>
<td></td>
<td></td>
<td></td>
<td>Affine Transformation, Filter, Histogram, HOG, Matching</td>
<td>1 ch</td>
<td>On-chip Memory, Memory Controller, CAN, FC, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.</td>
<td></td>
</tr>
</tbody>
</table>

* The video input interface of the TMPV7608XBG has a 4-of-8 video switch.

**Part Number | Features & Functions | Operating Temperature | Supply Voltage (V) | Package**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Features &amp; Functions</th>
<th>Operating Temperature</th>
<th>Supply Voltage (V)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC90105FG</td>
<td>Two video decoder channels, 2.5-V voltage regulator, newly developed picture adjustment function, horizontal aberration correction, ITU-R BT.656 output</td>
<td>–40 to +85°C</td>
<td>1.4 to 1.6, 2.3 to 2.7, 3.0 to 3.6</td>
<td>LQFP 80pin 12 x 12 mm</td>
</tr>
<tr>
<td>TC90107FG</td>
<td>One video decoder channel, 2.5-V voltage regulator, newly developed picture adjustment function, horizontal aberration correction, ITU-R BT.656 output</td>
<td>–40 to +85°C</td>
<td>1.4 to 1.6, 2.3 to 2.7, 3.0 to 3.6</td>
<td>LQFP 64pin 10 x 10 mm</td>
</tr>
</tbody>
</table>
ADAS Monocular-Camera Rear-View Monitoring Solution
(Rear-View Monitor, Electronic Rear-View Mirror, Electronic Door Mirrors)

The TMPV7502XBG of the Visconti2 Series combines high image recognition performance with low power consumption (0.6 W typical, as measured by Toshiba) due to the use of only a single video input interface channel for a monocular camera. Consequently, the TMPV7502XBG is available in a small package. It is suitable for rear-view monitor applications that provide vehicle and pedestrian recognition and moving-object detection capabilities, as well as for electronic room mirror and door mirror applications.

![Image Recognition System for Rear-View Monitoring](image1)

- CMOS Image Sensor
- Camera
- Video Decoder IC
- CVBS (NTSC/PAL)
- BT.656
- 8-10-12-bit Bayer, BT.656 or Y8 Y10 Y12
- Image Recognition Processor
- Visconti2 TMPV7502XBG
- NOR Flash
- DDR2 SDRAM
- CAN Transceiver
- Display
- Electronic Rear-View Mirror (Application Example)
- MCU
- CAN

* Shown above is a typical system block diagram using the TMPV7502XBG of the Visconti2 Series. Visit our website for examples of system block diagrams using other processors.

Visconti2 TMPV7502XBG Evaluation Board

![Evaluation Boards](image2)

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* PCI Express and PCIe are trademarks or registered trademarks of PCI-SIG.
Toshiba’s Visconti™ image recognition processors are suitable for parking assist applications that help drivers safely park their vehicles. From camera images, these image recognition processors recognize parking stripes and detect pedestrians, vehicles and moving obstacles around a vehicle. The image recognition processor can be combined with an in-vehicle display controller and a video processor to display a top-view image and parking stripes on the instrument cluster or center information display.

Image recognition processors

<table>
<thead>
<tr>
<th>Series</th>
<th>Part Number</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visconti4</td>
<td>TMPV7608XBG</td>
<td></td>
</tr>
<tr>
<td>Visconti3</td>
<td>TMPV7528XBG</td>
<td></td>
</tr>
<tr>
<td>Visconti2</td>
<td>TMPV7506XBG</td>
<td>33,34,35,36</td>
</tr>
<tr>
<td></td>
<td>TMPV7504XBG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMPV7502XBG</td>
<td></td>
</tr>
</tbody>
</table>

Video processors

<table>
<thead>
<tr>
<th>Series</th>
<th>Part Number</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual single-picture video processors</td>
<td>TC90195AXBG</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>TC90175XBG</td>
<td></td>
</tr>
<tr>
<td>Video Decoder ICs</td>
<td>TC90105FG</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>TC90107FG</td>
<td></td>
</tr>
</tbody>
</table>
Running image recognition algorithms necessary for an ADAS at high speed and low power consumption

**Features**
The Visconti™ family of image recognition processor LSIs process input images from in-vehicle cameras and detect the motion of target objects such as human beings, heads, hands, vehicles and output detection results. The Visconti family can provide recognition results in various ways, such as marking the recognized objects over a camera image on an LCD panel, alerting the driver with a voice message or beep, or notifying other electronic units via a communication interface. The Visconti family recognizes, in real time, traffic lines, vehicles, pedestrians, traffic signs, etc. around the vehicle on which it is mounted, thus enabling various advanced driver assistance applications. Possible applications include lane departure warning, forward/backward collision warning, forward/backward pedestrian collision warning, traffic sign recognition, and top-view parking assistance.

The image recognition AI processor Visconti 5 Series under development are provided with Deep Neural Network (DNN) hardware IP suitable for advanced driver assistance applications and autonomous driving functions.

**Roadmap of the Visconti Family of Image Recognition Processors**

**Lineup**

<table>
<thead>
<tr>
<th>Series</th>
<th>Part Number</th>
<th>Maximum Operating Frequency (MHz)</th>
<th>Media Processing Core</th>
<th>Motion Estimation</th>
<th>3D Video Processing</th>
<th>Image Recognition Accelerator</th>
<th>Memory Controller</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visconti2</td>
<td>TMPV7502XBG</td>
<td>266.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PLBG1A304</td>
</tr>
<tr>
<td></td>
<td>TMPV7504XBG</td>
<td>266.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PBGA516</td>
</tr>
<tr>
<td></td>
<td>TMPV7506XBG</td>
<td>266.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PBGA516</td>
</tr>
<tr>
<td>Visconti3</td>
<td>TMPV7528XBG</td>
<td>266.7 (300)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PBGA516</td>
</tr>
<tr>
<td></td>
<td>TMPV7608XBG</td>
<td>266.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PBGA516</td>
</tr>
</tbody>
</table>

* The video input interface of the TMPV7608XBG has a 4-of-8 video switch.
* The value in parentheses below the maximum operating frequency of the TMPV7528XBG indicates the clock rate of the embedded Arm core.

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Visconti™ Image Recognition Processors

Visconti4 Series

TMPV7608XBG: Improved recognition of nighttime pedestrians and parallel execution of up to eight image recognition applications

► Package

The TMPV7608XBG allows an ADAS to realize nighttime pedestrian recognition as reliable as daytime pedestrian recognition available with conventional vision systems. Toshiba’s original Enhanced CoHOG (Co-occurrence Histograms of Oriented Gradients) accelerators combine the conventional luminance-based CoHOG feature descriptors with four types of color-based feature descriptors. This enhancement leads to a remarkable improvement in the recognition accuracy, especially at nighttime and at scenes with less luminance differences between objects and the background. Additionally, the Enhanced CoHOG accelerators deliver outstanding computational performance, reducing the time taken for recognition.

► System Block Diagram

Features of Visconti

► Feature 1: 10 times the image processing performance of the conventional product (Visconti4)

The Visconti Series incorporates eight new image processing engines called Media Processing Engines (MPEs) with a double-precision floating-point unit, and various image processing accelerators¹, numbering 14 in all, to achieve 10 times² the image processing performance of the conventional product. All the image processing engines and accelerators can recognize pedestrians and vehicles simultaneously in 50 milliseconds, running at a clock frequency of up to 266.7 MHz.

¹ See the product specifications for details. ² Comparison with the previous Toshiba model

Visconti4 Block Diagram

Visconti2 and Visconti3 Series

Camera Image Inputs (Up to 8-in)

Camera Image Outputs

Camera Image Outputs

Visconti™ Solutions Be Careful!

* The video input interface of the TMPV7608XBG has a 4-of-8 video switch.
Feature 2: Parallel execution of up to eight image recognition applications

The Media Processing Engine (MPE) is suitable for image recognition and other multimedia processing. It is a very long instruction word (VLIW) machine that can issue multiple instructions simultaneously. It consists of Toshiba’s proprietary low-power 32-bit RISC core called a Media Embedded Processor (MeP) and either a coprocessor suitable for multimedia processing called Image Recognition VLIW Coprocessor (IVC2) or its successor, IVC2 with FPU (IVC2F). IVC2 and IVC2F can execute one or two SIMD (single instruction stream, multiple data stream) instructions, which perform one or two operations on multiple data in parallel. The second-generation IVC2F can efficiently perform double-precision floating-point operations.

The Visconti Family can execute multiple applications simultaneously because of its multi-core configuration containing multiple MPEs.

* See the product specifications for details.

Feature 3: Toshiba’s original pattern recognition using color features (Visconti4)

In addition to the Toshiba-original luminance-based CoHOG, the image recognition accelerator contained in the Visconti4 processes four kinds of feature quantities: color-based CoHOG, Co-occurrence Histograms of Pairs of Edge Orientations and Color Differences (CoHED), Co-occurrence Histograms of Color Differences (CoHD), and Color Histograms. This accelerator provides high recognition performance even at nighttime and at scenes with less luminance differences between objects and the background.

Feature 4: Image processing solutions

The Visconti Family contains image processing accelerators that perform the image processing required frequently in each step of image recognition at very high speed with low power consumption. The Visconti Family contains an affine transformation accelerator, which corrects any distortion of a fish-eye or wide-angle lens and performs point-of-view transformation. In addition, the Visconti Family contains filter accelerators, which perform noise reduction, edge detection, color space conversion and other image processing. The Visconti Family also includes a histogram accelerator that creates histograms, and a matching accelerator that performs disparity calculation for a stereo camera system and motion detection. Furthermore, the Visconti2 Series (except the TMPV7504XBQ) and the Visconti3 Series contain a HOG accelerator, which handles Histogram of Oriented Gradients (HOG) and/or Toshiba Co-occurrence Histograms of Oriented Gradients (CoHOG) features that are suitable for robust human recognition. These processors can detect both moving and stationary pedestrians in real time. The Visconti4 Series incorporates an Enhanced CoHOG accelerator that combines luminance-based CoHOG feature descriptors with color-based feature descriptors obtained using a newly developed technique. It delivers a significant improvement in nighttime image recognition.
Feature 5: General obstacle detection using 3D reconstruction technology
(TMPV7608XBG of the Visconti4 Series)
The Structure from Motion (SfM) accelerator allows detection of general stationary obstacles such as fallen objects, fallen rocks and landslides.

Software Development Environments
For details of software development environments for the Visconti2 / Visconti3 / Visconti4 series, see the following table.
Realization of automated-driving cars requires cars to be connected to social infrastructures such as traffic information and signal information and be capable of judging environmental changes through communication with other cars in front and behind. Connected cars must be provided with advanced infotainment systems that allow communication between cars and drivers. Toshiba Electronic Devices & Storage contributes to “connection” and “communication” through its technology.

Proliferation of connected cars

Connection between everyday life (products) and cars

Personal devices such as portable audio are easily connected to cars.

Connection between occupants and cars

Occupants can naturally and directly communicate with cars without any media such as mobile phone.

Connection between outside and cars

As IoE is increasingly adopted, cars become capable of directly collecting and utilizing various information.

Key products for realizing connected cars

- Ethernet AVB
- Display Processor
- Connectivity IC
- Voice Trigger
- Car Audio Power-Amp
- Ethernet AVB
- HDD for Automotive
- Remote Keyless Entry IC
- ETC IC
- Ethernet AVB
- Display Processor
In addition, Idea system corporation (Partner company) plans to sell the reference board of TC90195AXBG and TC90175XBG in April 2019.

The TC90175XBG is a single-video processor without a frame memory. Both the TC90195AXBG and the TC90175XBG incorporate a color decoder, support various analog and digital video input formats, and allow optimal picture adjustment according to the specific LCD panel. The output stage has a T-Con, which adapts to LCD panels from multiple manufacturers.

**TC90195AXBG**
- Pin-compatible with the family product TC90175XBG
- Dual video output channels: LVDS (for WVGA to WXGA+) and LVTTL (for QVGA to WVGA)
- Combining two pictures such as PIP and Overlay
- Dividing into two pictures
- Dual LCD display (WXGA dual LCD display using LVDS.A and LVDS.B)

**Highlights**
The TC90195AXBG incorporates a frame memory to display two independent pictures. It can display two asynchronous video signals simultaneously and overlay graphics signals from a system-on-a-chip (SoC) on video signals.

**Dual/Single-Picture Video Processors**

### Roadmap

#### Dual/Single-Picture Video Processors

- ● New picture adjustment functions
- ● New picture adjustment functions in line drawing/OSD
- ● Dual-picture T-CON
- ● LCVD to LVTTL bridge IC
- ● Dual/Single-Picture Video Processors

### Part Number | Package | Status | Function | ADC | Color Decoder | Dual picture | Mutless Switch | New Picture Adjustment | LVDS Input | Supported LCD Size | Operating Temperature | Supply Voltage (V) |
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TC90195AXBG</td>
<td>LFBGA 293pin 17 x 17 mm</td>
<td>MP</td>
<td>Dual pictures</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>WXGA+</td>
<td>1.1 to 1.3</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
<tr>
<td>TC90175XBG</td>
<td>LFBGA 293pin 17 x 17 mm</td>
<td>MP</td>
<td>Single picture (it can divide into two pictures)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Full-HD</td>
<td>1.4 to 1.6</td>
<td>2.3 to 2.7</td>
<td>3.0 to 3.6</td>
</tr>
<tr>
<td>TC90197XBG</td>
<td>LBGA 256pin 17 x 17 mm</td>
<td>MP</td>
<td>Dual pictures</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>WVGA</td>
<td>1.4 to 1.6</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
<tr>
<td>TC90193SBG</td>
<td>FBGA 228pin 15 x 15 mm</td>
<td>MP</td>
<td>Single picture (rear-view monitor)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>WVGA</td>
<td>1.4 to 1.6</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
<tr>
<td>TC90193ASBG</td>
<td>FBGA 228pin 15 x 15 mm</td>
<td>MP</td>
<td>Picture quality adjustment</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>WVGA</td>
<td>1.4 to 1.6</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
<tr>
<td>TC90202XBG</td>
<td>FBGA 121pin 10 x 10 mm</td>
<td>MP</td>
<td>Picture quality adjustment</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>WVGA</td>
<td>1.4 to 1.6</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
<tr>
<td>TC90205FG</td>
<td>LQFP 80pin 12 x 12 mm</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC90207FG</td>
<td>LQFP 64pin 10 x 10 mm</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>

In order to evaluate whether to use Toshiba’s Video processor, Toshiba offers the board to evaluate the functionality of Video processor. In addition, Idea system corporation (Partner company) plans to sell the reference board of TC90195AXBG and TC90175XBG in April 2019. Please inquire of our sales department for details of the boards.
Please inquire of our sales department for details of the boards.

In order to evaluate whether to use Toshiba’s Video processor, Toshiba offers the board to evaluate the functionality of Video processor (SoC) on video signals. The output stage has a T-Con, which incorporates a color decoder, supports various picture adjustment functions without a frame memory.

- **Roadmap**
  - Video Decoders with 3 ch ADCs for Component Signal
  - Video Decoders that Provide Enhanced Visibility for Automotive Cameras
  - 2-Channel Multi-Standard Video Decoders IC: TC90105FG
  - Full, Multi-Standard Video Decoder IC: TC90106FG
  - New Picture Adjustment Functions and Effects

### Full, Multi-Standard Video Decoder IC: TC90106FG

The TC90106FG is a full, multi-standard video decoder, which supports not only a CVBS input, but also D1 and D2 component inputs. For picture-quality enhancement, the TC90106FG provides a baseband tint function that allows tint adjustment for all video formats up to D2 resolution. In addition to the ITU-R 656 output interface, an 8-bit serial (SAV/EAV) output is selectable for a D2 video input, with the clock rate converted from 27 MHz to 54 MHz.

### New Picture Adjustment Functions and Effects

HVD enhancer: Provides diagonal edge enhancement in addition to the traditional edge enhancement in the horizontal and vertical directions. The HVD enhancer in the TC90105FG features the ability to apply a greater amount of edge enhancement while minimizing an artificial look.

- **Color management:** Provides a capability to increase the saturation of selected colors. Its objective is to improve visibility by making particular colors such as red more prominent. The TC90105FG allows you to select three colors and program their saturation levels. Dynamic YC gamma correction: Suppresses black and white collapsing to improve visibility by optimally adjusting the gamma correction curve for luma according to images. The TC90105FG maintains the balance between the luma and chroma levels by adjusting the chroma gain based on the luma gamma correction.

### Lineup

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Status</th>
<th>Function</th>
<th>ADC</th>
<th>Component Video Input (D2 Signal)</th>
<th>Color Encoder(s)</th>
<th>New Picture Adjustment</th>
<th>ITU-R BT.601 Output</th>
<th>ITU-R BT.656 Output</th>
<th>8-Bit Serial Output (D2 Signal)</th>
<th>Operating Temperature</th>
<th>Supply Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC90104FG</td>
<td>LQFP 64pin 10 x 10 mm</td>
<td>MP</td>
<td>Video decoder</td>
<td>3</td>
<td>○ 1 - - ○ ○ ○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>-40 to +85°C</td>
<td>1.4 to 1.6</td>
<td></td>
</tr>
<tr>
<td>TC90106FG</td>
<td>LQFP 64pin 10 x 10 mm</td>
<td>MP</td>
<td>Video decoder</td>
<td>3</td>
<td>○ 1 - - ○ ○ ○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>-40 to +85°C</td>
<td>2.3 to 2.7</td>
<td></td>
</tr>
<tr>
<td>TC90105FG</td>
<td>LQFP 80pin 12 x 12 mm</td>
<td>MP</td>
<td>Video decoder with 2.5 V regulator</td>
<td>2</td>
<td>- 2 ○ ○ ○ ○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>-40 to +85°C</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
<tr>
<td>TC90107FG</td>
<td>LQFP 64pin 10 x 10 mm</td>
<td>MP</td>
<td>Video decoder with 2.5 V regulator</td>
<td>1</td>
<td>- 1 ○ ○ ○ ○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>-40 to +85°C</td>
<td>3.0 to 3.6</td>
<td></td>
</tr>
</tbody>
</table>
The Peripheral Bridge IC supports the transmission of various image signals between the main processor and peripheral devices.

### 1. Support of various high-speed serial transmission systems

- MIPI® DSI™, CSI-2™, LVDS, DisplayPort™ and HDMI® are supported.

### 2. Solution of the interface issue of IVI (In-Vehicle Infotainment) systems

The interface bridge IC solves the connectivity issue that prohibits the as-is connection among peripheral devices, such as between the IVI SoC and display, due to interface difference.

#### Necessity of Interface Bridge ICs

**Conversion to the camera I/F**

- Camera (parallel) ➔ CPLB ➔ CSI-2

**Conversion to the display I/F**

- SoC ➔ DSI ➔ D2L ➔ D2DP

#### Lineup for Diversified Peripheral Devices and High-Speed Data Transmission

- **CSI-2**: MIPI Camera Serial Interface
- **DSI**: MIPI Display Serial Interface

#### Lineup

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Part Number</th>
<th>Input</th>
<th>Output</th>
<th>Resolution</th>
<th>Ta</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2C</td>
<td>TC9590XBG</td>
<td>HDMI 1.4a</td>
<td>MIPI CSI-2 4 lane x 1ch</td>
<td>–</td>
<td>–40 to 85°C</td>
<td>P-LFBGA64 7 mm x 7 mm 0.8 mm pitch</td>
</tr>
<tr>
<td>CPLB</td>
<td>TC9591XBG</td>
<td>MIPI CSI-2 4 lane x 1ch</td>
<td>Parallel output 24bit @ 166MHz</td>
<td>–</td>
<td>–40 to 105°C</td>
<td>P-VFBGA80 7 mm x 7 mm 0.65 mm pitch</td>
</tr>
<tr>
<td>D2L-LP</td>
<td>TC9592XBG</td>
<td>MIPI CSI-2 4 lane x 1ch</td>
<td>LVDS Single Link (5pairs/link)</td>
<td>UXGA 1600x1200 24bit</td>
<td>–40 to 85°C</td>
<td>P-VFBGA49 5 mm x 5 mm 0.65 mm pitch</td>
</tr>
<tr>
<td>D2L</td>
<td>TC9593XBG</td>
<td>MIPI CSI-2 4 lane x 1ch</td>
<td>LVDS Dual Link (8pairs/link)</td>
<td>WUXGA 1920x1200 24bit</td>
<td>–40 to 85°C</td>
<td>P-VFBGA64 6 mm x 6 mm 0.65 mm pitch</td>
</tr>
<tr>
<td>D2DP</td>
<td>TC9595XBG</td>
<td>MIPI CSI-2 4 lane x 1ch</td>
<td>DisplayPort 1.1a</td>
<td>WUXGA 1920x1200 24bit</td>
<td>–40 to 85°C</td>
<td>P-VFBGA80 7 mm x 7 mm 0.65 mm pitch</td>
</tr>
</tbody>
</table>

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The TC9560 and TC9562 families provide the Ethernet AVB and Ethernet TSN (for TC9562XBG only) interfaces as well as various audio, video and data interfaces, making each family suitable as a bridge IC for in-vehicle IP networks for telematics and next-generation IVI applications.

**Features**

1. The TC9560 and TC9562 families incorporate the Gigabit Ethernet MAC layer, allowing audio, video, and data communication with a host SoC (application processor) in accordance with the Ethernet AVB standard (which is compliant with IEEE 802.1AS and IEEE 802.1Qav). The TC9562XBG is compliant with the Ethernet TSN standards (compliant with IEEE802.1 Qav, IEEE802.1 Qbe and IEEE802.3 br) as well.
2. Provides an Ethernet PHY interface selectable from SGMII, RGMII, RMII and MI as well.
3. The TC9560 and TC9562 families provide PCIe Gen2.0 (5GT/s), PCIe Gen1.0 (2.5 GT/s), and HSIC (480 Mbps) interfaces with the host SoC (application processor). In addition, the TC9560 and TC9562 families have an I2S/TDM (Time Division Multiplex) audio interface.
4. The design target is to achieve a low-power mode that typically consumes 1 mW [TC9560 Series] or 0.5 mW [TC9562 Series] at room temperature (measured by Toshiba). The families typically take only 100 ms to return to normal operation (measured by Toshiba) in order to meet market needs.
5. Furthermore, the TC9560 and TC9562 families is compliant with Grade 3 of AEC-Q100, a qualification standard for automotive ICs.

**Interfacing Example**

**Demonstration Board**

**System Block Diagram**

**Table:**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Host (External application) I/F:</th>
<th>Automotive I/F:</th>
<th>Audio I/F:</th>
<th>Peripheral I/F:</th>
<th>CPU Core:</th>
<th>Supply Voltage(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC9560XBG</td>
<td>PLFBGA170 (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td>1.8/3.3 for IO, 1.8/2.5/3.3 for RGMII/RMI/MII, 1.8 for PCIe, 1.1 for Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC9560AXBG **</td>
<td>PLFBGA170 ** (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td>2ch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC9560XBG **</td>
<td>PLFBGA120 (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC9562AXBG **</td>
<td>PLFBGA120 (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC9562XB **</td>
<td>PLFBGA120 (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC9562AXBG **</td>
<td>PLFBGA120 (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC9562XB **</td>
<td>PLFBGA120 (0.65)</td>
<td>PCIe I/F, Gen2.0 (5 GT/s), Endpoint, Single lane</td>
<td>Ethernet AVB [IEEE802.1AS, IEEE8021.1Qav] Ethernet TSN [IEEE802.1 Qav, IEEE802.1 Obu, IEEE802.3 br] MAC-PHY I/F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

- **TC9562XBG** and **TC9562AXBG** are under development.
Toshiba’s in-vehicle audio power amplifier ICs fabricated using a 0.13-µm process with low on-resistance and provided with various built-in circuits for in-vehicle protection provide high reliability. Toshiba is expanding its portfolio of unique high-efficiency Class-TB linear amplifiers to fulfill the market needs for low power consumption and environmental friendliness.

**Toshiba’s Unique High-Efficiency Class-TB Amplifiers (Tied BTL)**

**Power dissipation comparison**
- vs Conventional Class-AB AMP >>> -80% reduction
- vs Digital Class-D AMP >>> Closer under Pout <4 W

**Low BOM Cost**
- Unlike digital amplifiers (Class-D), these amplifiers do not require switching and thus do not require external LPF or anti-EMI parts, which halves BOM cost.

**Proposal of “speaker burning prevention system” with full-time fault detector**
- The amplifiers constantly (full-time) detect abnormal output DC offset regardless of presence/absence of signal and equipped with unique system that informs the microcontroller of any abnormalities.

**TCB701/702FNG High-Efficiency Linear Amplifier (Class-TB)**

- High-efficiency linear amplifier
  Toshiba’s unique high-efficiency linear amplifier: Class-TB (Tied BTL)
  Heat generation and temperature increase are suppressed.
- Improved RF noise immunity
  High RF noise immunity protects GSM and +B/Output, which reduces the number of external parts necessary for noise suppression.
- Full-time DC offset detection
  A function is installed that performs constant (full-time) monitoring for abnormal output DC offset and informs the microcontroller if it detects any.
  → Realizes the speaker burning prevention system
- +B voltage detection
  +B voltage detection circuit is provided.
  The I2C bus allows the setting of 6 V to 8.5 V (0.5 V steps).
- 6-V cruising design
  For vehicles with idling reduction systems, a pop sound eliminator is provided to eliminate the sound that occurs when supply voltage fluctuates.

**4-Channel Audio Power Amplifier ICs (Recommended Products)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BCD 0.13 µm</td>
<td>TB2952AHQ</td>
<td>40 W</td>
<td>45 W</td>
<td>AB</td>
<td>26 dB/12 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HZIP25</td>
</tr>
<tr>
<td></td>
<td>TB2975HQ</td>
<td>40 W</td>
<td>45 W</td>
<td>KB</td>
<td>26 dB/16 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HZIP25</td>
</tr>
<tr>
<td>CD 0.13 µm</td>
<td>TCB001HQ</td>
<td>45 W</td>
<td>40 W</td>
<td>AB</td>
<td>26 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HZIP25</td>
</tr>
<tr>
<td></td>
<td>TCB501HQ</td>
<td>40 W</td>
<td>44 W</td>
<td>AB</td>
<td>26 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HZIP25</td>
</tr>
<tr>
<td></td>
<td>TCB502HQ</td>
<td>40 W</td>
<td>44 W</td>
<td>AB</td>
<td>26 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HZIP25</td>
</tr>
<tr>
<td></td>
<td>TCB505HQ</td>
<td>40 W</td>
<td>44 W</td>
<td>AB</td>
<td>26 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HZIP25</td>
</tr>
<tr>
<td></td>
<td>TCB701FNG</td>
<td>40 W</td>
<td>45 W</td>
<td>TB</td>
<td>26 dB/16 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HOSP36</td>
</tr>
<tr>
<td></td>
<td>TCB702FNG</td>
<td>45 W</td>
<td>40 W</td>
<td>TB</td>
<td>26 dB/16 dB</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>HOSP36</td>
</tr>
</tbody>
</table>

**1-Channel Audio Power Amplifier ICs (Recommended Products)**

<table>
<thead>
<tr>
<th>Process</th>
<th>Part Number</th>
<th>Max Output</th>
<th>Voltage Gain</th>
<th>Thermal Detection</th>
<th>Speaker Open-Circuit Detection</th>
<th>Output Short-Circuit Detection</th>
<th>Overvoltage Detection</th>
<th>Applications</th>
<th>Package</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCD0.13 µm</td>
<td>TB2909FNG</td>
<td>5 W</td>
<td>3 W</td>
<td>AB</td>
<td>26 dB (variable)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>AVAS, etc.</td>
</tr>
</tbody>
</table>

**42**
Toshiba offers a technology that constantly monitors for spoken trigger words (approx. 10 words) and returns a result.

1. High-speed response
A response to a trigger word is given in approx. 0.1 sec. The system responds before voice input ends.

2. High detection rate
Deep learning technology secures high detection rate even in noisy environment.

3. Small resource requirement
Since required CPU power/memory is small, it can be used for embedding.

---

**Voice-triggered, switchless operation**

---

**Specifications**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>75MIPS</td>
</tr>
<tr>
<td>ROM</td>
<td>200KB</td>
</tr>
<tr>
<td>RAM</td>
<td>230KB[Note1]</td>
</tr>
<tr>
<td>Detection rate</td>
<td>97.5% at SNR 0dB[Note1]</td>
</tr>
</tbody>
</table>
| Compatible platform | • Windows®  
|                  | • Linux®  
|                  | • Android™/iOS®  
|                  | • Non OS |

**Notes:**

[Note1]: Values measured by Toshiba. Values are subject to change according to measurement conditions.

---

**Sources**

- Dictionary data
- Voice trigger library
- Header file
- Sample program
- Manual

---

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Toshiba’s portfolio of automotive communication ICs includes ICs for remote keyless entry (RKE), electronic toll collection (ETC), and Bluetooth. RF devices not only allow remote operations but also can be used to receive information from a tire pressure monitoring system (TPMS) for display on the instrument cluster so as to help increase the driving safety.

Nowadays, a Remote Keyless Entry (RKE) unit, which is already available with most vehicles, is being integrated into the TPMS receiver.

**Remote Keyless Entry (RKE)**

A remote keyless entry (RKE) system is used to lock and unlock the vehicle doors. Further adding to the convenience, a smart key can also start the engine remotely. Generally, on the push of a button on a key fob, an RF signal is transmitted to a receiver in the vehicle body, which decodes the signal and sends the decoded information to an in-vehicle system.

<table>
<thead>
<tr>
<th>Block</th>
<th>Product name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF-IC</td>
<td>TC32306FTG</td>
<td>P.45</td>
</tr>
<tr>
<td>8 bit MCU</td>
<td>TMP89FM82TUDG</td>
<td>–</td>
</tr>
<tr>
<td>32 bit MCU</td>
<td>TMPM358FDTFG</td>
<td>P.20</td>
</tr>
<tr>
<td>System power supply</td>
<td>TB9005FNG</td>
<td>P.17</td>
</tr>
</tbody>
</table>

**Tire Pressure Monitoring System (TPMS)**

A tire pressure monitoring system (TPMS) is an electronic system designed to monitor the air pressure in vehicle tires. TPMS consists of sensor modules (transmitters) in the wheels and receivers in the vehicle body. TPMS is now legally required in North America, Europe, and Korea. The Chinese and Japanese governments are also deliberating on legislation that mandates the installation of TPMS on all vehicles.

<table>
<thead>
<tr>
<th>Block</th>
<th>Product name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF-IC (in-vehicle)</td>
<td>TC32306FTG</td>
<td>P.45</td>
</tr>
<tr>
<td>8 bit MCU</td>
<td>TMP89FM82TUDG</td>
<td>–</td>
</tr>
<tr>
<td>32 bit MCU</td>
<td>TMPM358FDTFG</td>
<td>P.20</td>
</tr>
<tr>
<td>System power supply</td>
<td>TB9005FNG</td>
<td>P.17</td>
</tr>
</tbody>
</table>
Toshiba’s portfolio of automotive communication ICs includes ICs for remote keyless entry (RKE), electronic toll collection (ETC), and delibering on legislation that mandates the installation of TPMS on vehicle body. TPMS is now legally required in North America, Europe, and Korea. The Chinese and Japanese governments are also start the engine remotely. Generally, on the push of a button on a vehicle doors. Further adding to the convenience, a smart key can also start the engine remotely. Generally, on the push of a button on a vehicle doors. Further adding to the convenience, a smart key can

1. Tire Pressure Monitoring System (TPMS)

![Block Diagram of a Tire Pressure Monitoring System](image)

- LED LF
- Key
- MCU
- X’tal
- 8 bit

- Tire Receiver Tuner (in Vehicle Body)
- Battery
- Antenna Antenna
- Cell
- Battery Cell
- TC32306
- RF-IC
- X’tal
- (RX)

- Door Knob
- Indicators
- Alarm Lamp
- System
- Receiver Tuner
- LF-IC
- System
- TC32306
- 32-Bit
- MCU
- 8 bit

- Power supply
- Filter
- SAW
- RF/ECU
- X’tal
- TC32306
- RF-IC
- X’tal
- MCU
- TC32306
- 32-Bit
- MCU

2. Transceiver IC (TC32306FTG)

This remote controller demonstrates functions such as sending, receiving and answerback. Operation can be determined by confirming on register of this IC embedded on this board. Operation can be determined by confirming on register of this IC embedded on this board. Operation can be determined by confirming on register of this IC embedded on this board. Operation can be determined by confirming on register of this IC embedded on this board.

- Operating voltage range: 2.0 to 5.5 V
- Current consumption: At Vdd = 3.0 V (FSK modulation)
  - RX: 9.7 mA
  - TX: 12 mA (at +10 dBm output)
  - Battery-save mode: 0 μA (Typ.)
- TX output: 0 dBm, +5 dBm, +8 dBm, +10 dBm
  (Fine-tunable in increments of approx. 0.5 dB.)
- High receiver sensitivity (12 dB SINAD) -117 dBm@IFBW = 270 kHz
  [FSK, Data Rate = 600 Hz, fdev = +40 kHz]
- Multiband (315/434/868/915 MHz)
- Data rate (TX/RX): 300 Hz to 10 kHz, on-chip digital bit rate filter
- Multi-channel (Fractional-N PLL, 5-kHz frequency step width)
- Supported modulation: FSK/OOK (ASK)
- Two IF Filter bandwidths: Wide range 320 kHz at IF = 230 kHz/
  Middle range 270 kHz at IF = 280 kHz, switching
- Signal detection: Preamble detection/noise detection (only for FSK/RSIS detection
- Fast response (on-chip digital high-speed comparator)
- Serial control: Read/Write mode, 4-wire serial interface (SPI)
  Control is also available after storing communication setting data in EEPROM.

3. Transceiver IC (TC32306FTG) Demo Board

This remote controller demonstrates functions such as sending, receiving and answerback. Operation can be determined by confirming on the OLED installed. The register of this IC embedded on this board can be set. Considering possible applications, a photo sensor, temperature sensor and acceleration sensor are installed.

4. RF IC Series for ETC2.0/DSRC

Road-to-vehicle communications provide toll collection and traffic information to enhance automobile convenience. The collected probe data helps reduce traffic congestion.

- **Transceiver IC for ETC, ETC 2.0 and DSRC Applications**
  - TC32163FG
    - Operating voltage: 2.7 to 3.6 V
    - Operating frequency: 5.8 GHz band
    - Operating temperature: -40 to +85°C

- **5.8 GHz Automotive Power Amplifier**
  - TC32166FG
    - Operating voltage: 3.0 to 3.6 V
    - Operating frequency: 5.8 GHz band
    - Operating temperature: -40 to +85°C

- **RF Combo IC for Chinese ETC Applications**
  - TC32168FTG
    - Operating voltage: 1.8 to 3.6 V
    - Operating frequency: 5.8 GHz band
    - Operating temperature: -40 to +85°C
    - Data rate: ASK 256/512 kbps
    - Wake-up function (4.5 μA typ.)
    - FM0 modem (addition of CRC checksum words, postambles and preambles)
    - Small package: VQFN32 (5 x 5 mm, 0.5 mm pitch)
Automotive HDDs are designed to withstand harsh environments because they are exposed to shock and vibration when automobiles run on bumpy and rough roads. Toshiba’s automotive HDDs provide high vibration resistance through the use of lightweight moving parts, a high-strength casing, and a control technology. This control technology estimates the degree of impact on the read/write head position from the acceleration applied to the HDD and automatically adjusts the head position in real time. Toshiba’s automotive HDDs are also designed to operate over a temperature range of −30°C to +85°C, which is wider than the operating temperature range of typical HDDs.

### Capacity

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Part Number</th>
<th>Rotation Speed (rpm)</th>
<th>Interface</th>
<th>Interface Speed</th>
<th>Operating Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>320 GB</td>
<td>MQ01AAD032C</td>
<td>4,000</td>
<td>Serial ATA 2.6/ATA8</td>
<td>3.0 Gb/s, 1.5 Gb/s</td>
<td>−30 to +85</td>
</tr>
<tr>
<td>200 GB</td>
<td>MQ01AAD020C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 GB</td>
<td>MQ01AAD010C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Definition of capacity: Toshiba defines a megabyte (MB) as 1,000,000 bytes, a gigabyte (GB) as 1,000,000,000 bytes and a terabyte (TB) as 1,000,000,000,000 bytes. A computer operating system, however, reports storage capacity using powers of 2 for the definition of 1GB = 2^30 = 1,073,741,824 bytes and therefore shows less storage capacity. Available storage capacity (including examples of various media files) will vary based on file size, formatting, settings, software and operating system, such as Microsoft Operating System and/or pre-installed software applications, or media content. Actual formatted capacity may vary.
Automotive HDDs are designed to withstand harsh environments because they are exposed to shock and vibration when automobiles run on bumpy and rough roads. Toshiba's automotive HDDs provide high vibration resistance through the use of lightweight moving parts, a high-strength casing, and a control technology. This control technology estimates the degree of impact on the read/write head position from the acceleration applied to the HDD and automatically adjusts the head position in real time. Toshiba's automotive HDDs are also designed to operate over a temperature range of −30°C to +85°C, which is wider than the operating temperature range of typical HDDs.

Automotive Hard Disk Drives

2. Place the cursor over the Products tab.
3. A drop-down menu appears. Move the cursor to “Automotive Devices”.
4. An underlying submenu appears to the right. Click on the desired item.

2. Place the cursor over the Applications tab.
3. A drop-down menu appears. Move the cursor to “Automotive”.
4. An underlying submenu appears to the right. Click on the desired item.
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