TOSHIBA

System Catalog May 2019

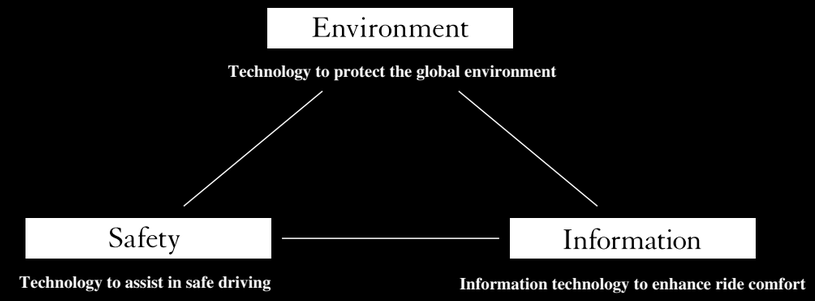
Automotive Solutions

SEMICONDUCTOR & STORAGE PRODUCTS

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.

Semiconductor devices fulfill a major role in the evolution of automobiles. Toshiba's Three Core Technologies



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

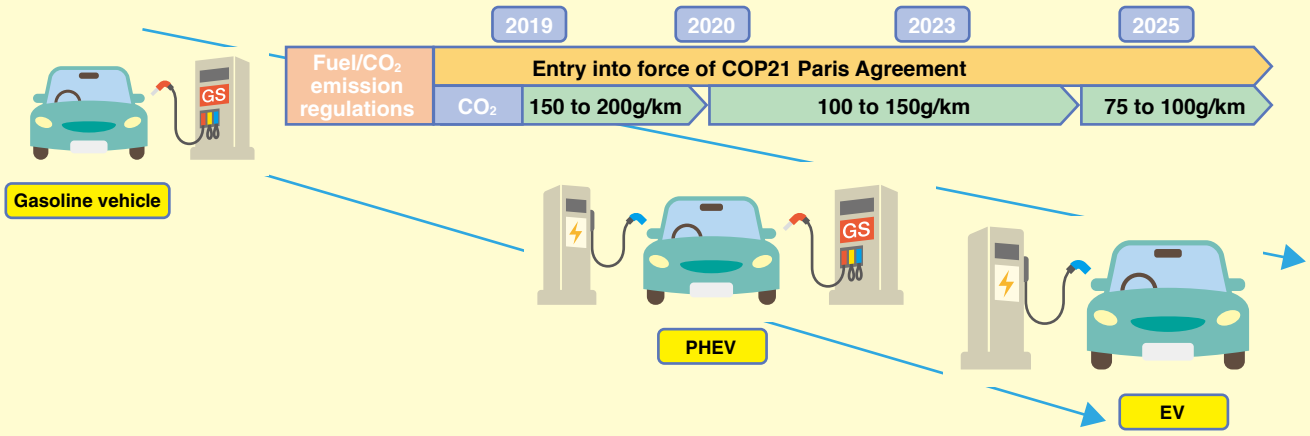
https://toshiba.semicon-storage.com/

CONTENTS

Environment

Carbon dioxide (CO_2) 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.

Changes in the environment surrounding the automobile

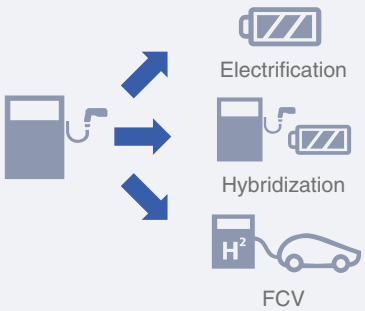


Promote reduced CO_2 emissions and drive system electrification/diversification by conforming with fuel economy/emission regulations.

Improved fuel economy

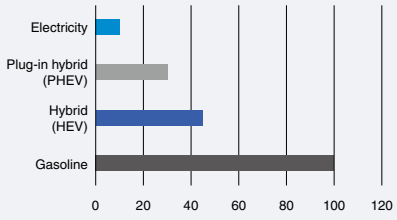
(1) Weight reduction/efficient use of resources

(2) Diversification of drive system



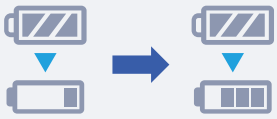
Transition to EV

CO_2 emissions by drive system
(Gasoline vehicle taken as 100)

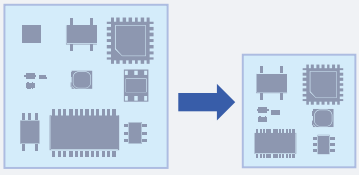


Extension of driving range

High performance/high efficiency



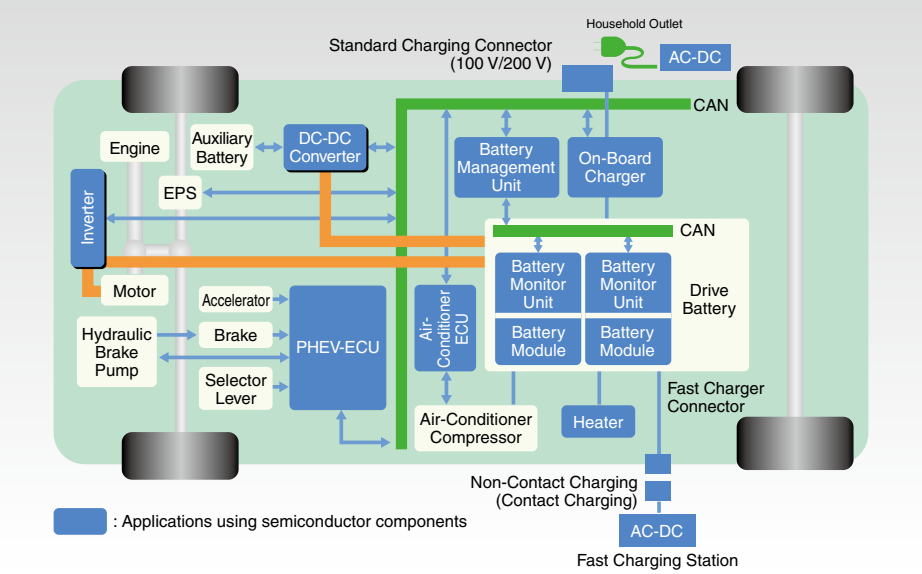
Downsizing



Applications: HEVs, PHEVs, EVs and Inverters

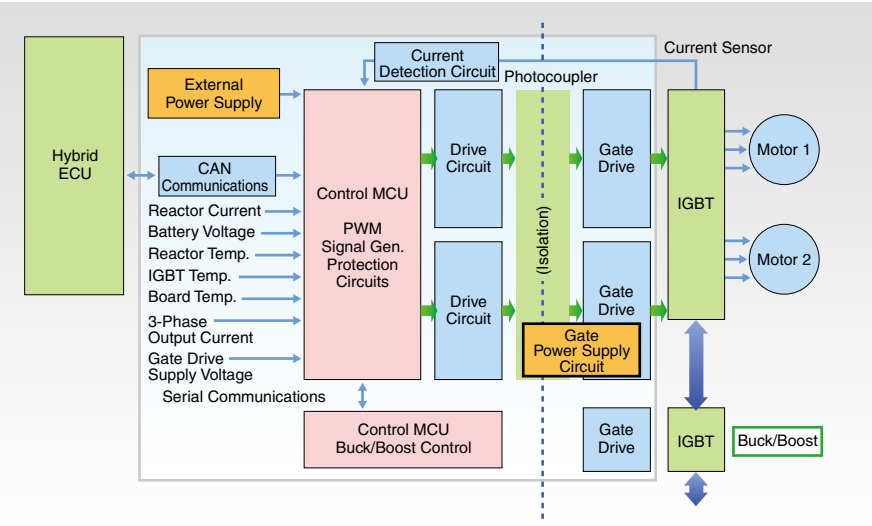
System Diagram of an Electric Vehicle (HEV/PHEV/EV)

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.



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

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Power Supply	MOSFET	DPAK+	**TK25S06N1L**	Nch U-MOS VIII-H	60 V, 25 A, 18.5 mΩ, T_{ch} = 175˚C	○
		DPAK+	**TJ30S06M3L**	Pch U-MOS VI	−60 V, −30 A, 21.8 mΩ, T_{ch} = 175˚C	○
	Voltage Regulators	HQFN52	**TB9042FTG**	BiCD process	Switching Reg., 5 V Reg., Watchdog timer, Topr: −40 to 125˚C	○
MCU	Motor control MCU	HLQFP144	**TMPR454F10TFG**	Arm-Cortex-R4F (160 MHz)	Vector Engine, RDC, PMD, ADC, CAN, Topr: −40 to 125˚C	○
Isolation	Photocouplers	5pin SO6	**TLX9304**	–	Open collector output,1 M LOGIC, Topr = 125˚C (max)	○
		5pin SO6	**TLX9378**	–	Open collector output, 10 M LOGIC, Topr = 125˚C (max)	
		5pin SO6	**TLX9376**	–	Totempole output, 20 M LOGIC, Top r= 125˚C (max)	

Applications: DC-DC Converters for HEVs, PHEVs and EVs, Battery Monitoring Systems (BMS), Start-Stop Systems

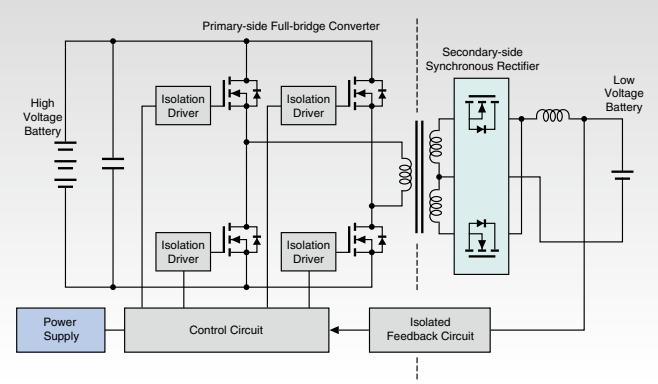
DC-DC Converters for HEVs, PHEVs and EVs

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

Functional Block	Product Category	Package	Part Number
Synchronous Rectifier Circuit	MOSFET	DPAK+	See pages 26-27.
Power Supply	MOSFET	DPAK+	
		DSOP Advance (WF)	

Application Block Diagram



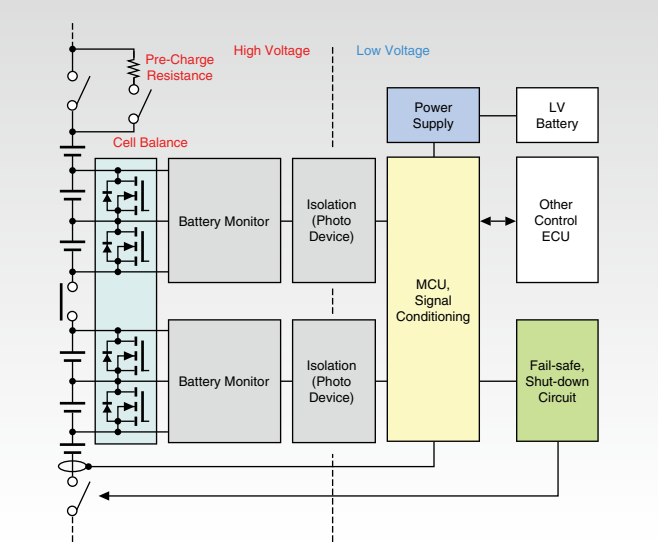
Battery Monitoring System (BMS)

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

Functional Block	Product Category	Package	Part Number
Power Supply	Bipolar transistor	New PW-Mold	TTB002
	System power supply IC	HTSSOP16	TB9021FNG
		SSOP20	TB9005FNG
Fail-safe, Shut Down	IPD (High-side switch)	WSON-10	TPD1055FA
	IPD (Low-side switch)	PS-8	TPD1044F
Cell Balance	MOSFET	UF6	See pages 26-27.
		SOT-23F	
	Photocoupler	SO4, SO6	See pages 24.
Main Control	Battery monitoring MCUs	LQFP100	TMPM358FDTFG

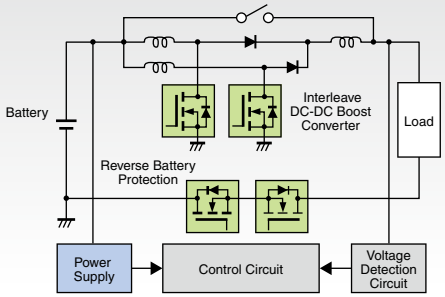
Application Block Diagram



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

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Semicon.Relay	IPD	PS-8	**TPD7104AF**	BiCD process	1ch high side Nch MOSFET Gate drive.	○
Motor drive or reverse-battery protection	MOSFET	DPAK+	**TK100S04N1L**	Nch/VIII	40 V/100 A/2.3 mΩ max	○
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TK55S10N1	Nch/VIII	100 V/55 A/6.5 mΩ max	
Semicon.Relay	IPD	VSOP16	**TPD7106F****		1ch high side Nch MOSFET gate drive.	○
		WSON10	**TPD7107F****		1ch high side Nch MOSFET gate drive.	○

**: Under development

Applications: Brake Control (ABS/ESC), Electronic Suspension Control, Electric parking brake (EPB), precrash seat belt tensioners

Brake Control (ABS/ESC)

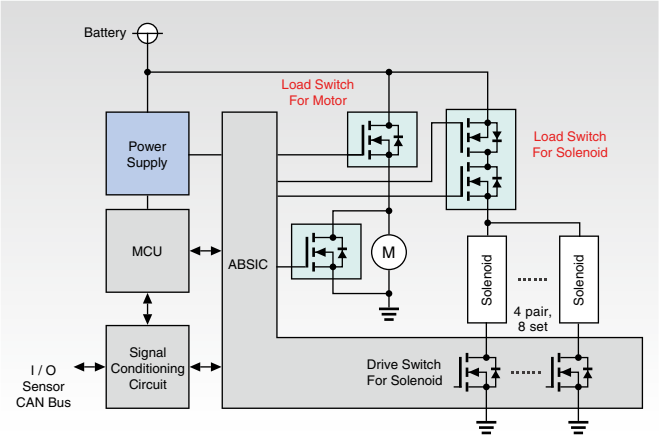
Many electromagnetic solenoids and mechanical relays are used to control hydraulic valves, and MOSFETs and intelligent power devices (IPDs) are widely used for the switching of solenoids and relays. Since these applications are exposed to large instantaneous changes in voltage, high-voltage MOSFETs and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

Recommended Products

Functional Block	Product Category	Package	Part Number
Switch for Motor, Solenoid	MOSFET	DPAK+	See pages 26-27.
Power Supply	MOSFET	DPAK+	
	System power supply IC	HQFN52	TB9042FTG**

**: Under development

Application Block Diagram



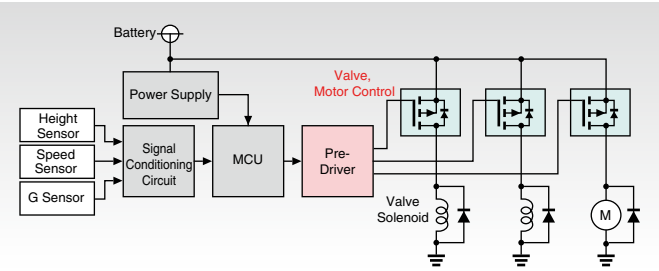
Electronic Suspension Control

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.

Recommended Products

Functional Block	Product Category	Package	Part Number	Polarity/ Generation	Feature	AEC
Solenoid, Motor Control	MOSFET	PS-8	See pages 26-27.			
		SOT-23				
	Diode	S-FLAT	CRG07			○

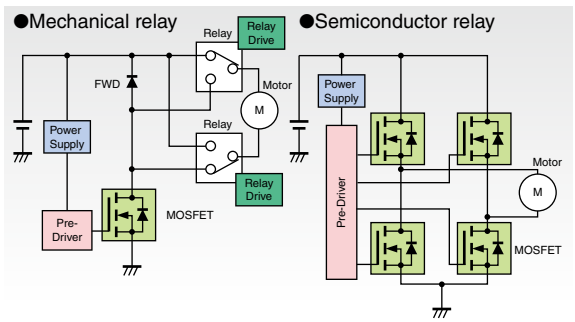
Application Block Diagram



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.

System Block Diagram



Recommended Products

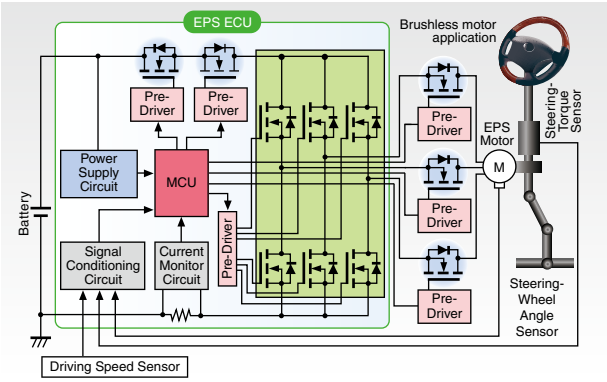
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor drive Relay drive	MOSFET	DPAK+	**TK65S04N1L**	Nch/VIII	40 V/65 A/4.3 mΩ max	○
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TK90S06N1L	Nch/VIII	60 V/90 A/3.3 mΩ max	
			TJ60S04M3L	Pch/VI	−40 V/−60 A/6.3 mΩ max	
			TJ80S04M3L		−40 V/−80 A/5.2 mΩ max	
			TJ60S06M3L		−60 V/−60 A/11.2 mΩ max	
		SOP Advance (WF)	**TPHR7904PB**	Nch/IX	40 V/150 A/0.79 mΩ max	
			TPH1R104PB		40 V/120 A/1.14 mΩ max	
Relay Driver	MOSFET	SOT23F	**SSM3K337R**	Active Clamp Nch	38 V/2 A, 0.2Ω@4 V	○
		UFM	**SSM3H137TU**	Nch + ZD	34 V/2 A, 0.28Ω@4.5 V	○
Pre-driver	IPD	PS8	**TPD7211F**	BiCD process	Half bridge MOSFET Gate drive.	–
		WQFN-32	**TPD7212F**		3 Phase Full Bridge Nch MOSFET Gate drive.	○
	MCD	HTSSOP48	**TB9052FNG**		1-channel H-bridge pre-driver (external N-channel FET) Built-in motor current detection circuit	○
		LQFP48	**TB9057FG**		1-channel H-bridge pre-driver (external N-channel FET) Built-in motor current detection circuit Built-in motor rotational direction detection circuit	○
Power Supply	Voltage Regulators	SSOP20	**TB9005FNG**		Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: −40 to 125˚C	–
		HTSSOP16	**TB9021FNG**		Single output (with integrated output transistors) LDO (5 V, 200 mA) Window-Watchdog timer, Topr: −40 to 125˚C	○
	Bip-Tr	New PW-Mold	**TTA005**	PNP	−50 V/−5 A/hFE200 min	–
			TTB002		−60 V/−6 A/hFE100 min	–

Applications: Electronic Power Steering (EPS) System

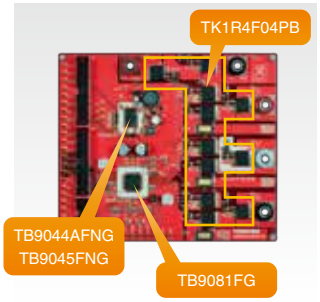
Electronic Power Steering (EPS) System

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.

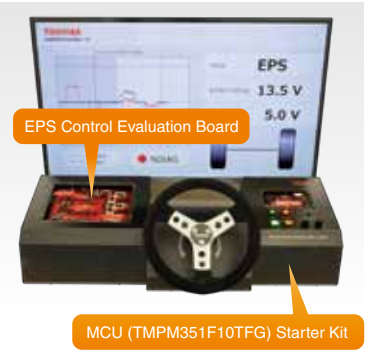
■ System Block Diagram



■ EPS Control Evaluation Board



■ Reference Model for EPS



■ Recommended Products

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor control Reverse battery protection	IPD	PS8	**TPD7104AF**	BiCD process	1ch high side Nch MOSFET Gate drive.	○
	MOSFET	DPAK+	**TK65S04N1L**	Nch/VIII	40 V/65 A/4.3 mΩ max	○
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TJ40S04M3L	Pch/VI	−40 V/−40 A/9.1 mΩ max	
			TJ60S04M3L		−40 V/−60 A/6.3 mΩ max	
			TJ80S04M3L		−40 V/−80 A/5.2 mΩ max	
		SOP Advance (WF)	**TPHR7904PB**	Nch/IX	40 V/150 A/0.79 mΩ max	
			TPH1R104PB		40 V/120 A/1.14 mΩ max	
		DSOP Advance(WF)	**TPWR7904PB**	Nch/IX	40 V/150 A/0.79 mΩ/175˚C	
			TPW1R104PB		40 V/120 A/1.14 mΩ/175˚C	
MCU	Motor control MCU	LQFP100	**TMPM351F10TFG**	Arm Cortex-M3 (144 MHz)	PMD, CAN, ADC, Topr = −40 to 105˚C	○

Block	Type	Package	Part Number	Polarity/ Generation	Feature	AEC
Pre-driver	MCD	LQFP64	**TB9081FG**	BiCD process	5-channel safety relays Selectable operation on fault detection Initial diagnosis of monitoring circuitry	○
		HTSSOP48	**TB9052FNG**		1-channel H-bridge pre-driver (external N-channel FET) Built-in motor current detection circuit	○
		LQFP48	**TB9057FG**		1-channel H-bridge pre-driver (external N-channel FET) Built-in motor current detection circuit Built-in motor rotational direction detection circuit	○
Power Supply	Voltage Regulators	HQFN52	**TB9042FTG**		Multiple outputs (with integrated output transistors) DCDC1 (1.2/1.5 V), LDO1 to 2 (5 V), LDO3 (5/3.3 V) Window-Watchdog timer, Topr: −40 to 125˚C	○
		HTSSOP48	**TB9044AFNG****		Multiple outputs (with integrated output transistors) LDO1(5V), three tracker channels, Window-Watchdog timer, Topr = −40 to 150˚C	Planning
		HTSSOP48	**TB9045FNG****		Multiple outputs (with integrated output transistors), three tracker channels, DCDC1(1.1/1.2/1.25/1.5V), LDO1(5V) Window-Watchdog timer, Topr = −40 to 150˚C	Planning

**: Under development

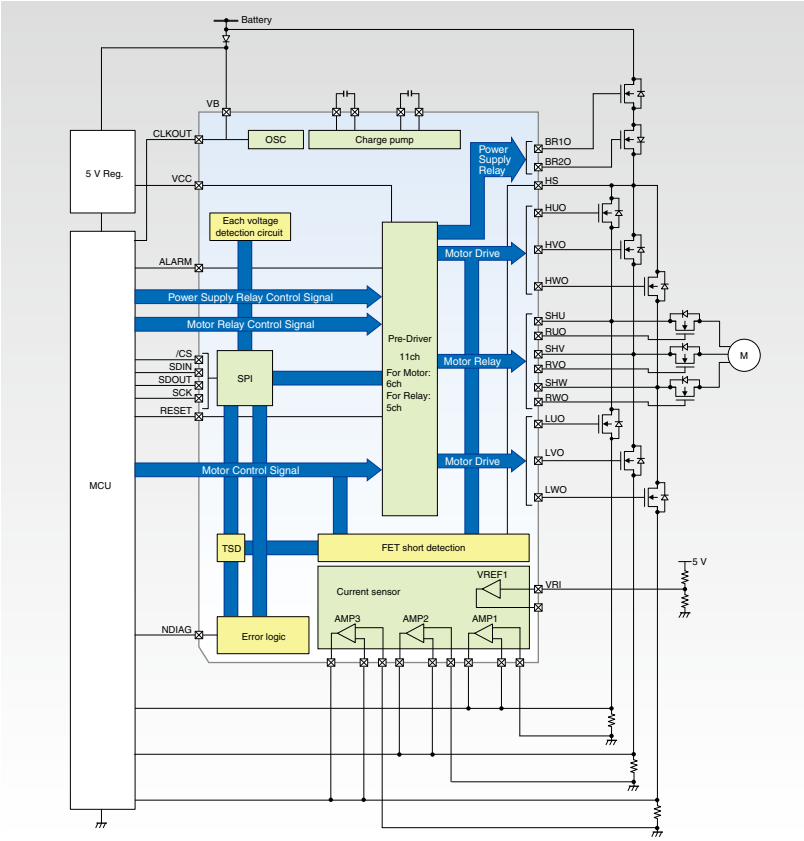
▼ Three-Phase Brushless Motor Pre-driver IC for EPS Applications: TB9081FG

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
- PWM operating frequency: 20 kHz
- Operating temperature range: Ta = −40 to 125°C
- Package: LQFP64

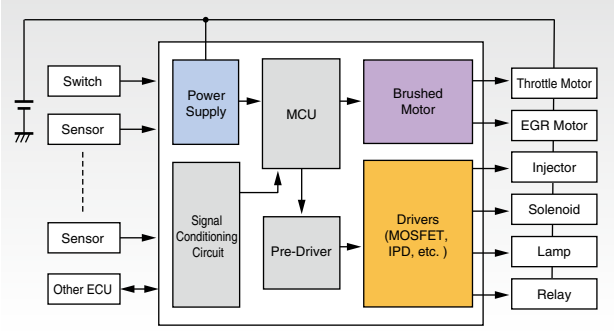


Applications: Gasoline Engine System, Direct Injection, Transmission Control

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.

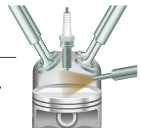
System Block Diagram



Recommended Products

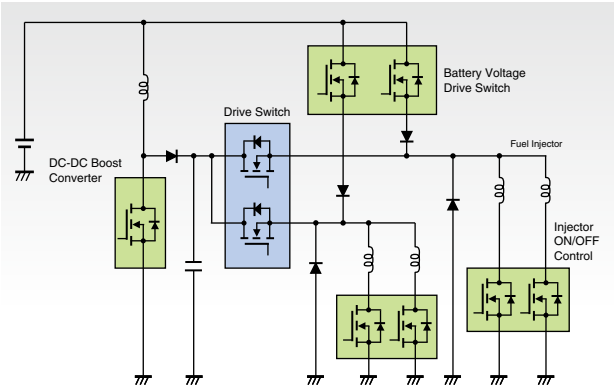
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Relays	IPD	PS-8	**TPD1044F**	Logic Nch + DMOS	1 ch Low side switch (1 A)	○
		SOP-8	**TPD1046F**		2 ch Low side switch (2 A)	–
Solenoids	IPD	PS-8	**TPD1054F**	BiCD process	1 ch Low side switch (1 A)	–
		WSON-10	**TPD1058FA**		1 ch Low side switch (6 A)	–
Driver	MCD	P-QFN28	**TB9051FTG**		1 ch H-Bridge driver (Pch + Nch), Iout±5 A Topr: −40 to 125˚C	○
	MOSFET	DPAK+	**TK25S06N1L**	Nch/VIII	60 V/25 A/18.5 mΩ max	○
			TK40S06N1L		60 V/40 A/10.5 mΩ max	
			TK90S06N1L		60 V/90 A/3.3 mΩ max	
			TJ30S06M3L	Pch/VI	−60 V/−30 A/21.8 mΩ max	
			TJ60S06M3L		−60 V/−60 A/11.2 mΩ max	
	MOSFET	DPAK+	**TJ8S06M3L**		−60 V/−8 A/104 mΩ max	
Power Supply	Voltage Regulators	HQFN52	**TB9042FTG**	BiCD process	Multiple outputs (with integrated output transistors) DCDC1 (1.2/1.5 V), LDO1 to 2 (5 V), LDO3 (5/3.3 V) Window-Watchdog timer, Topr: −40 to 125˚C	○

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



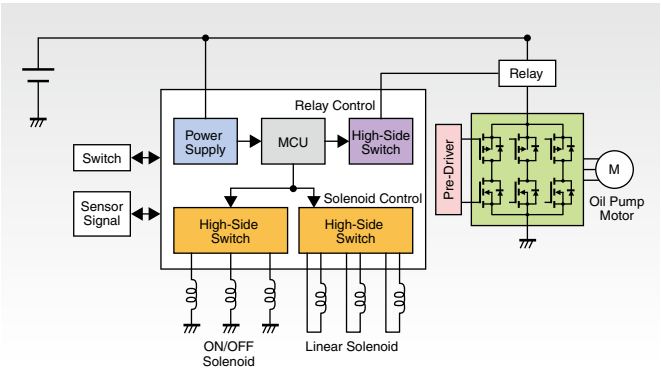
Recommended Products

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Boost Converter	MOSFET	DPAK+	**TK40S06N1L**	Nch/VIII	60 V/40 A/10.5 mΩ max	○
			TK90S06N1L		60 V/90 A/3.3 mΩ max	
			TK33S10N1L		100 V/33 A/9.7 mΩ max	
			TK55S10N1		100 V/55 A/6.5 mΩ max	
Drive Switch		DPAK+	**TJ50S06N3L**	Pch/IV	−60 V/−50 A/13.8 mΩ max	
			TJ60S06N3L		−60 V/−60 A/11.2 mΩ max	

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



Recommended Products

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Relays & solenoids	IPD	PS-8	**TPD1044F**	Logic Nch + DMOS	1 ch High side switch (1 A)	○
		PS-8	**TPD1054F**	BiCD process	1 ch Low side switch (1 A)	–
		WSON-10	**TPD1055FA**		1 ch High side switch (3 A)	○
		SOP-8	**TPD1060F**		1 ch Low side switch (3 A)	○
Oil pump drive	MOSFET	DPAK+	**TK65S04N1L**	Nch/VIII	40 V/65 A/4.3 mΩ max	○
			TK100S04N1L		40 V/100 A/2.3 mΩ max	
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TK90S06N1L	Nch/VIII	60 V/90 A/3.3 mΩ max	
			TJ60S04M3L	Pch/VI	−40 V/−60 A/6.3 mΩ max	
			TJ80S04M3L		−40 V/−80 A/5.2 mΩ max	
			TJ60S06M3L		−60 V/−60 A/11.2 mΩ max	
Pre-driver	MCD	SSOP24	**TB9061AFNG**	BiCD process	3 Phase Brushless Sensor-less Pre-Driver Topr: −40 to 125˚C	○
			TB9062FNG**		3 Phase Brushless Sensor-less Pre-Driver,High Start-up Performance, Topr: −40 to 125˚C	–
	IPD	WQFN-32	**TPD7212F**		3 Phase Full Bridge Nch MOSFET Gate drive.	○
		PS-8	**TPD7211F**		Half bridge MOSFET Gate drive.	–

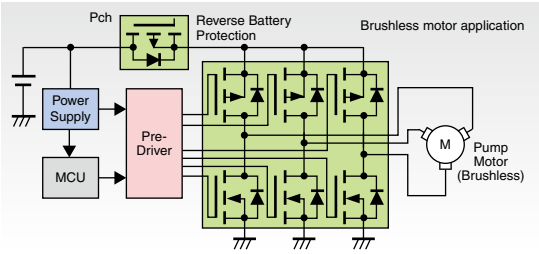
**: Under development

Applications: Pump Control (for Water, Oil and Fuel) , Cooling Fan

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



Pump Control Evaluation Board

Reference Model for Water Pump Control

Recommended Products

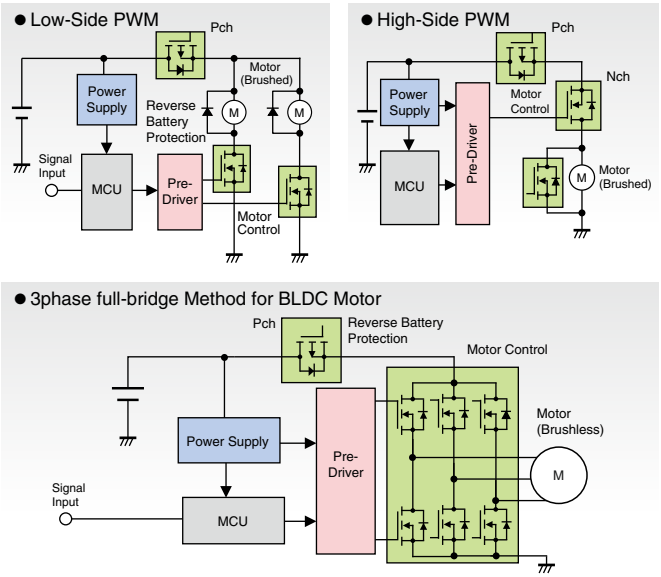
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Pre-driver	IPD	WQFN-32	**TPD7212F**	BiCD process	3 Phase Full Bridge Nch MOSFET Gate drive.	○
		PS-8	**TPD7211F**		Half bridge MOSFET Gate drive.	–
			TPD7104AF		1 ch high side Nch MOSFET Gate drive.	○
	MCD	SSOP24	**TB9061AFNG**		3 Phase Brushless Sensor-less Pre-Driver, −40 to 125˚C	○
			TB9062FNG**		3 Phase Brushless Sensor-less Pre-Driver, High Start-up Performance, −40 to 125˚C	–
Driver	MCD	HTSSOP24	**TB9064FNG****		3 Phase Brushless Sensor-less Driver, −40 to 125˚C	○
Motor control Reverse battery protection	MOSFET	DPAK+	**TJ20S04M3L**	Pch/VI	−40 V/−20 A/22.2 mΩ max	○
			TJ40S04M3L		−40 V/−40 A/9.1 mΩ max	
			TJ60S04M3L		−40 V/−60 A/6.3 mΩ max	
		SOP Advance (WF)	**TK1R4S04PB**	Nch/IX	40 V, 120 A, 1.35 mΩ, Tch = 175˚C	
			TPHR7904PB		40 V, 150 A, 0.79 mΩ, Tch = 175˚C	
			TPH1R104PB		40 V, 120 A, 1.14 mΩ, Tch = 175˚C	
		DSOP Advance (WF)	**TPWR7904PB**		40 V, 150 A, 0.79 mΩ, Tch = 175˚C	○
			TPW1R104PB		40 V, 120 A, 1.14 mΩ, Tch = 175˚C	
Power Supply	Voltage Regulators	SSOP20	**TB9005FNG**	BiCD process	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: −40 to 125˚C	–
		HTSSOP16	**TB9021FNG**		Single output (with integrated output transistors) LDO (5 V, 200 mA) Window-Watchdog timer, Topr: −40 to 125˚C	○
	BipTr	New PW-Mold	**TTA005**	PNP	−50 V/−5 A/hFE200 min	–
			TTB002		−60 V/−6 A/hFE100 min	–

**: Under development

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



Recommended Products

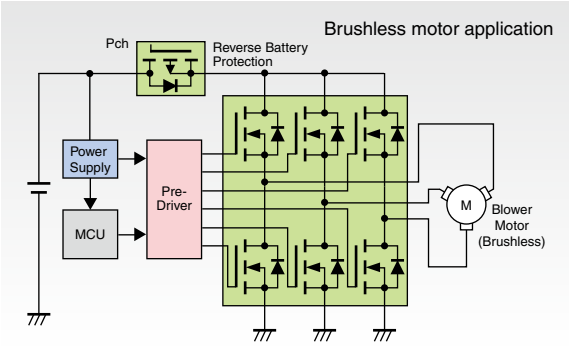
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor drive	Pre-driver	LQFP64	**TB9080FG**	BiCD process	Quiet motor operation due to sine-wave current, High-efficiency motor drive due to auto lead angle control	○
		SSOP24	**TB9110FNG**		1-channel pre-driver (external N-ch FET), Built-in charge pump circuit, Topr: −40 to 105˚C	–
	MOSFET	DPAK+	**TK100S04N1L**	Nch/VIII	40 V/100 A/2.3 mΩ max	○
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TK55S10N1	Nch/VIII	100 V/55 A/6.5 mΩ max	
Power Supply	Voltage Regulators	SSOP20	**TB9005FNG**	BiCD process	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: −40 to 125˚C	–
		HTSSOP16	**TB9021FNG**		Single output (with integrated output transistors) LDO (5 V, 200 mA) Window-Watchdog timer, Topr: −40 to 125˚C	○
	Bip-Tr	New PW-Mold	**TTA005**	PNP	−50 V/−5 A/hFE200 min	–
			TTB002		−60 V/−6 A/hFE100 min	–
Pre-driver	IPD	PS-8	**TPD7211F**	BiCD process	Half bridge MOSFET Gate drive.	–
		WQFN-32	**TPD7212F**		3 Phase Full Bridge Nch MOSFET Gate drive.	○

Applications: Air-Conditioning (HVAC), LED Headlights, Airbags

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



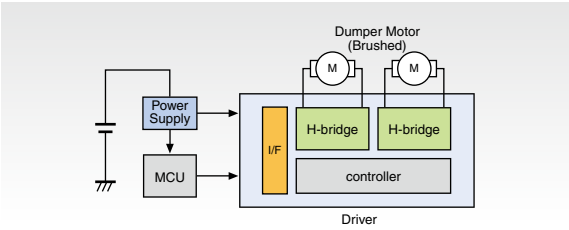
Recommended Products

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor control Reverse battery protection	IPD	PS8	**TPD7104AF**	BiCD process	1ch high side Nch MOSFET Gate drive.	○
	MOSFET	DPAK+	**TK100S04N1L**	Nch/VIII	40 V/100 A/2.3 mΩ max	○
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TK55S10N1	Nch/VIII	100 V/55 A/6.5 mΩ max	
			TJ60S04M3L	Pch/VI	−40 V/−60 A/6.3 mΩ max	
			TJ80S04M3L		−40 V/−80 A/5.2 mΩ max	
Pre-driver	IPD	WQFN-32	**TPD7212F**	BiCD process	3 Phase Full Bridge Nch MOSFET Gate drive.	○
	MCD	LQFP64	**TB9080FG**		Quiet motor operation due to sine-wave current High-efficiency motor drive due to auto lead angle control	○
		SSOP24	**TB9110FNG**		1-channel pre-driver (external N-ch FET), Built-in charge pump circuit, Topr: −40 to 105°C	−
Power Supply	Voltage Regulators	SSOP20	**TB9005FNG**		Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: −40 to 125°C	−
		HTSSOP16	**TB9021FNG**		Single output (with integrated output transistors) LDO (5 V, 200 mA) Window-Watchdog timer, Topr: −40 to 125°C	○
	Bip-Tr	New PW-Mold	**TTA005**	PNP	−50 V/−5 A/hFE200 min	−
			TTB002		−60 V/−6 A/hFE100 min	−

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



Recommended Products

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor drive	Motor driver	SSOP24	**TB9101FNG**	BiCD process	2 ch H-Bridge, 1.2 Ω (±0.5 A), Topr: −40 to 125°C	○
			TB9102FNG		6 ch Half-bridge, 1.0 Ω (±0.5 A), Topr: −40 to 125°C	○
			TB9056FNG		LIN-Slave 1 ch H-Bridge, 1.0 Ω (±0.5 A), Topr: −40 to 125°C (Classic Checksum)	−
			TB9058FNG		LIN-Slave 1 ch H-Bridge, 1.0 Ω (±0.5 A), Topr: −40 to 125°C (Enhanced Checksum)	○

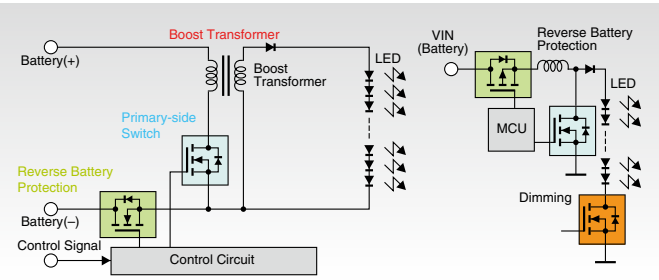
LED Headlights

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

Functional Block	Product Category	Package	Part Number
Booster Circuit	MOSFET	DPAK+	See pages 26-27.
		SOP Advance	
Reverse Battery Protection	MOSFET	DPAK+	
		SOP Advance	
		SOT-23F	
		TSOP6F	
Dimming	MOSFET	SOT-23F	
		TSOP6F	

Application Block Diagram



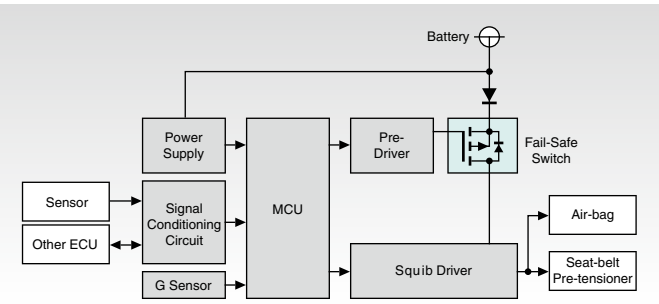
Airbags

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

Recommended Products

Functional Block	Product Category	Package	Part Number
Fail-Safe Switch	MOSFET	SOP Advance (WF)	See pages 26-27.
		DSOP Advance (WF)	

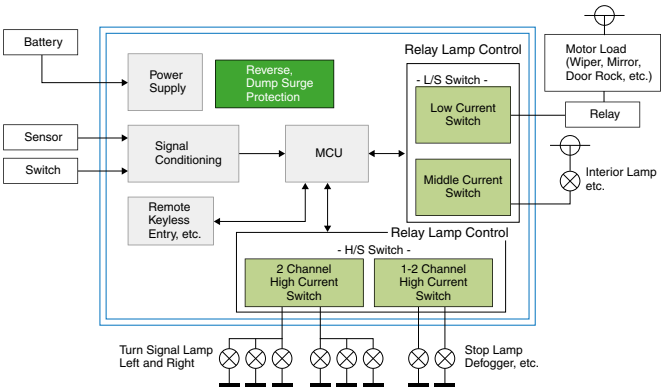
Application Block Diagram



Applications: Body Control Module (BCM), In-Vehicle Networks

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 SSM3K337R, 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

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Mechanical Relay	MOSFET	SOT23F	**SSM3K337R**	Active Clamp Nch	38 V/2 A, 0.20 Ω@4.0 V(equivalent to 2SK3408 from R Corp.)	○
			SSM3K347R*		38 V/2 A, 0.48 Ω@4.0 V, with pulldown resistor	○
	MOSFET+ZD	UFM	**SSM3H137TU**	Nch+ZD	34 V/2 A, 0.28 Ω@4.5 V	○
		PS-8	**TPCP8R01**		60 V/2 A, 0.44 Ω@4.0 V, Vz = 43 V	○
	IPD (HSS)	PS-8	**TPD1052F**	BiCD process	High side 1ch, VDD (opr) = 5 to 18 V, IC = 0.8 A, 0.8 Ω, Topr = –40 to 125°C	–
	IPD (LSS)	SOP-8	**TPD1030F**	Logic Nch +DMOS	Low side 2ch, VDS = 40 V, IC = 1 A, 0. 6Ω, Topr = –40 to 110°C	–
			TPD1032F		Low side 2ch, VDS = 20 V, IC = 3 A, 0.4 Ω, Topr = –40 to 110°C	–
		PS-8	**TPD1044F**		High side 1ch, VDS = 41 V, IC = 1 A, 0.6 Ω, Topr = –40 to 125°C	○
		SOP-8	**TPD1046F**		Low side 2ch, VDS = 40 V, IC = 3 A, 0.2 Ω, Topr = –40 to 125°C	–
Semicon. Relay	IPD (Pre-Driver)	PS-8	**TPD7104AF**	BiCD process	1ch high side Nch MOSFET gate drive	○
		WSON10	**TPD7107F****		1ch high side Nch MOSFET gate drive	○
Power Supply	Voltage Regulators	SSOP20	**TB9005FNG**	BiCD process	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr. –40 to 125°C	–
		HTSSOP16	**TB9021FNG**		Single output (external transistors required) LDO (5 V, 200 mA) Watchdog timer, Topr. –40 to 125°C	○
	Bip-Tr	New PW-Mold	**TTA005**	PNP	–50 V/–5 A/hFE 200 Min	–
			TTB002		–60 V/–6 A/hFE 100 Min	–

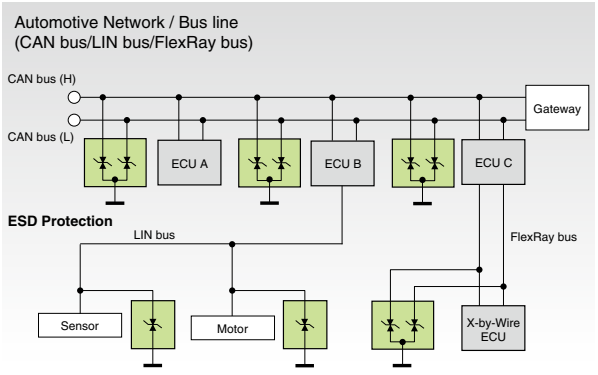
■ MOSFET

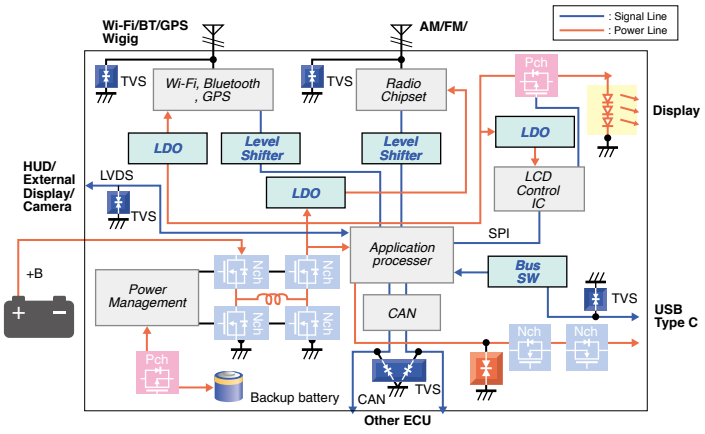
Block	Type	Package	Part Number	Feature	AEC
Relay Lamp Control	MOSFET	PS8	**TPCP8207**	Nch Dual, 40 V/5 A, 36.3 mΩ, Tch = 175°C	○
			TPCP8407	Nch+Pch, 40/–40 V, 5/–4 A, 36.3 mΩ, Tch = 175°C	○
		SOT-23F	**SSM3K2615R**	Nch, 60 V/2 A, 0.44 Ω@4.0 V	○
		TSOP6F	**SSM6N357R***	Nch, 60 V/0.65 A, 2.4 ΩMax@3.0 V (equivalent to NUD3160L from O)	○
		DPAK+	**TK1R404PB**	Nch, 40 V/120 A, 1.35 mΩMax	○
Reverse Dump Surge Protection			**TK55S10N1**	Nch, 100 V/55 A, 6.5 mΩ, Tch = 175°C	○
			TJ30S06M3L	Pch, –60 V/–30 A, 21.8 mΩ, Tch = 175°C	○

*: New Product **: Under development

In-Vehicle Networks

Transient-voltage-suppression (TVS) diodes protect CAN, LIN, FlexRay bus, Ethernet AVB, 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)

Package Unit (mm)	Part Number	Pin Assignment	Absolute Maximum Ratings			Electrical Characteristics				
			T_j (°C)	V_{ESD} (kV) IEC 61000-4-2	V_{ESD} (kV) ISO 10605 @330 pF/2 kΩ	V_{BR} (V) (min)	I_R (μA) (max)	@V_{RWM} (V)	R_{RDYN} (Ω) (typ.)	C_t (pF) (typ.)
USC (SOD-323) 1.25 x 2.5 t = 1.1	**DF2B18FU**		150	±30 kV	±30 kV	16.2	0.1	12	0.8	9
	DF2B29FU		150	±25 kV	±30 kV	26	0.1	24	1.1	9
	DF2B36FU		150	±20 kV	±20 kV	32	0.1	28	1.5	6.5
USM (SOT-323) 2.0 x 2.1 t = 1.1	**DF3D18FU**		150	±30 kV	±30 kV	16.2	0.1	12	0.8	9
	DF3D29FU		150	±25 kV	±30 kV	26	0.1	24	1.1	9
	DF3D36FU		150	±20 kV	±20 kV	32	0.1	28	1.5	6.5

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

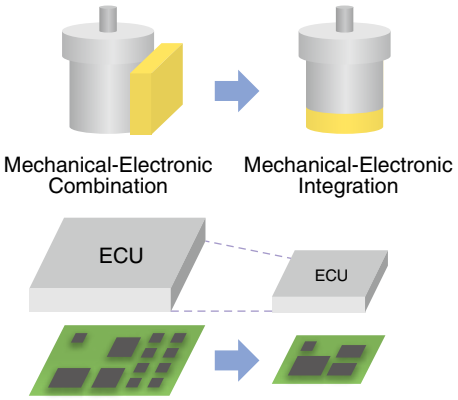
Package Unit (mm)	Part Number	Pin Assignment	Absolute Maximum Ratings		Electrical Characteristics				
			T_j (°C)	V_{ESD} (kV) IEC 61000-4-2	V_{BR} (V) (min)	I_R (μA) (max)	@V_{RWM} (V)	R_{RDYN} (Ω) (typ.)	C_t (pF) (typ.)
SOD-923 1.0 x 0.6 t = 0.45	**DF2S5M4FS***		150	±20 kV	3.7	0.1	3.6	0.35	0.45
	DF2S6M4FS*		150	±20 kV	5.5	0.1	5.5	0.35	0.45
	DF2S20M4FS**		150	±15 kV	18	0.1	18	0.3	0.45

*: New Product **: Under development

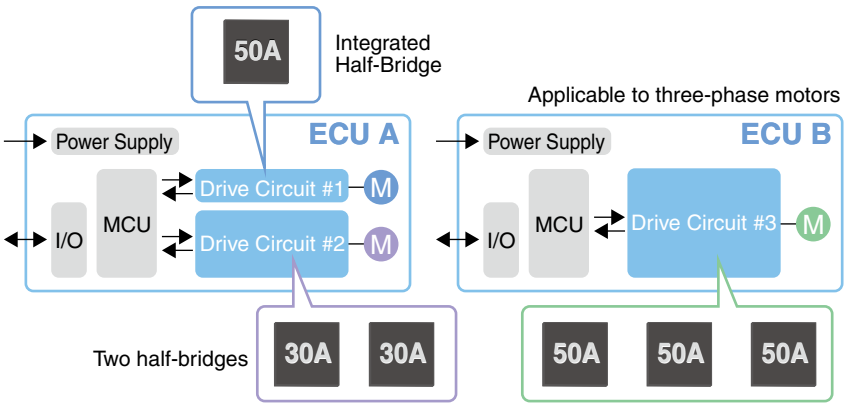
Automotive Analog Power Device
Product: TB9111FTG Half-Bridge MCP

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.

Accelerating ECU size reduction, modularization, and mechanical-electronic integration



Use of Common Devices: Half-Bridge Configuration



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.)


Power sliding doors

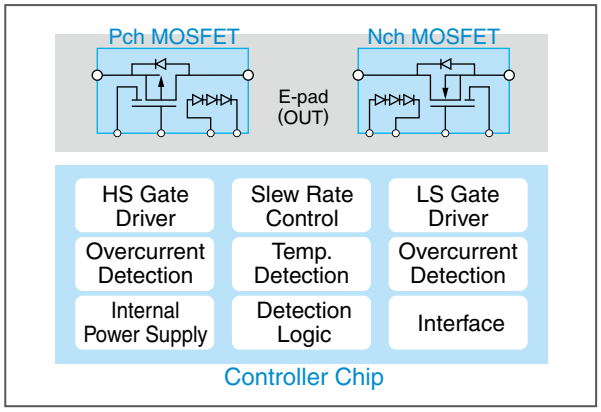

power rear door

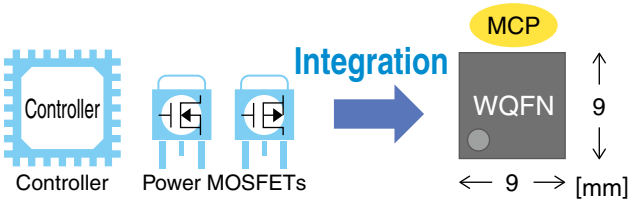

power seats

▼ TB9111FTG Half-Bridge MCP

Under development

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

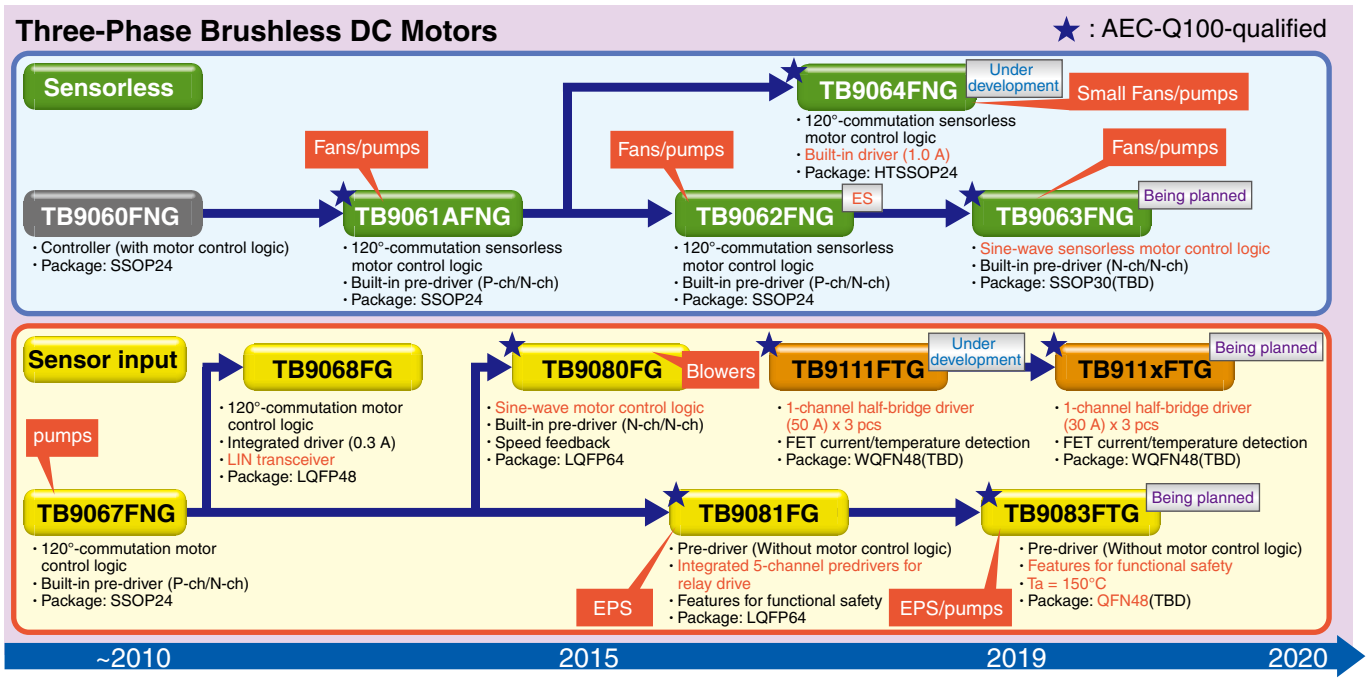
Controller chip

- 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 Sensorless Pre-driver IC TB9062FNG

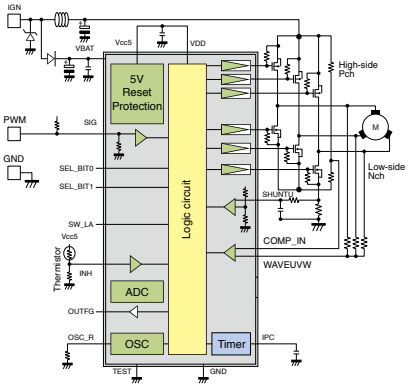
Under development

Sensorless control pre-driver with startup stability and out-of-step prevention function improved from TB9061AFNG

- PWM input
- Improved startability by logic control
- Out-of-step prevention function by inhibiting sudden change of output duty
- 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/low voltage detection, thermal shutdown

<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



▼ Three-Phase Brushless Sensorless Driver IC TB9064FNG

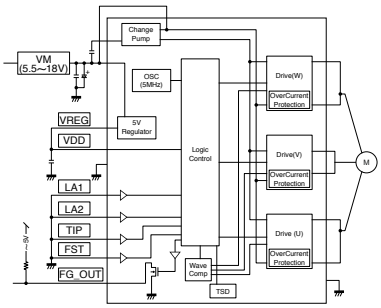
Under development

Three-phase sensorless driver with built-in output FET

- 1 A output
- Built-in 5-V power supply & reset function
- Various built-in detection circuits
  Overcurrent detection, overvoltage/low voltage detection, thermal shutdown

<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

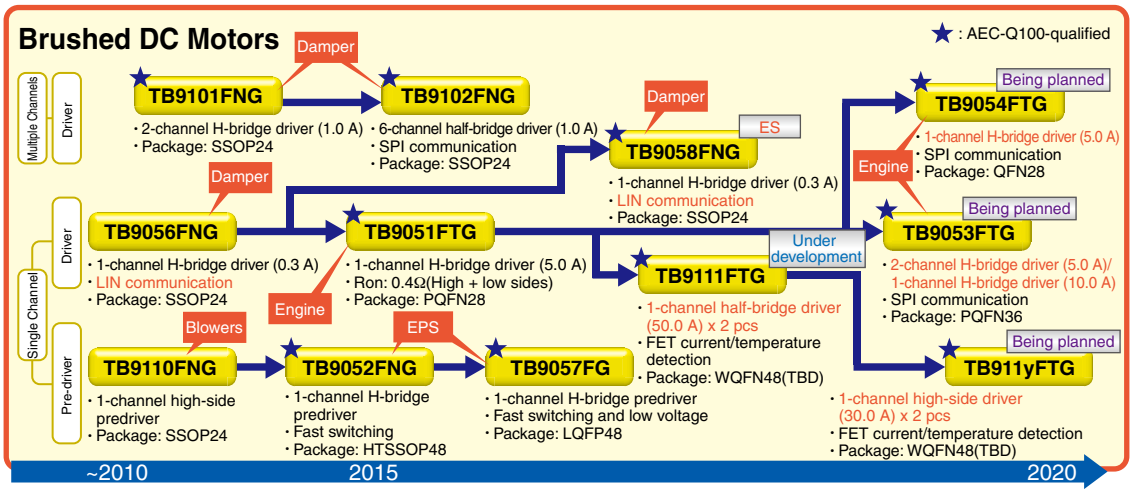


▼ Lineup

Part Number	Package	Input	Commutation	Output	Features & Functions	Supply Voltage (V)	AEC
TB9061AFNG	SSOP24-P-300-0.65A	PWM, DC voltage	120 degree (Sensorless)	Pre-drivers P-ch/N-ch	Simple application circuit due to external part count reduction Sensorless control, Overcurrent detection, Wide PWM dynamic range for output	5.5 to 18	○
TB9062FNG**	SSOP24-P300-0.65A	PWM	120 degree (Sensorless)	Pre-drivers P-ch/N-ch	Simple application circuit due to external part count reduction Sensorless control, Overcurrent detection, improved startup	6.5 to 16.6	–
TB9064FNG**	P-HTSSOP24-0508-0.65	Interlocked with power ON	120 degree (Sensorless)	Direct	Simple sensorless control due to part count reduction,Built-in detection circuits against motor overcurrent and power supply overvoltage, etc.	5.5 to 18.0	○
TB9067FNG	SSOP24-P-300-0.65A	PWM, DC voltage	120 degree	Pre-drivers P-ch/N-ch	Only a few external parts required, Support for both PWM and DC inputs 120-degree commutation, 5-V sensor comparator	6 to 18	–
TB9068FG	LQFP48-P-0707-0.50	PWM, phase signals	120 degree External control	Direct	Allows direct drive of a motor with built-in 0.3-A drivers LIN 1.3 transceiver, 5-V system power supply	7 to 18	–
TB9080FG	LQFP48-P-0707-0.50	PWM, DC voltage	180 degree Sine wave	Pre-drivers N-ch/N-ch	Quiet motor operation due to the use of sine wave current High drive efficiency thanks to auto lead angle control	7 to 18	○
TB9081FG	LQFP64-P-0707-0.50	Phase signal	External control	Pre-drivers N-ch/N-ch	5-channel safety relays, Selectable operation on fault detection Initial diagnosis of detection circuits	4.5 to 28	○

**: Under development

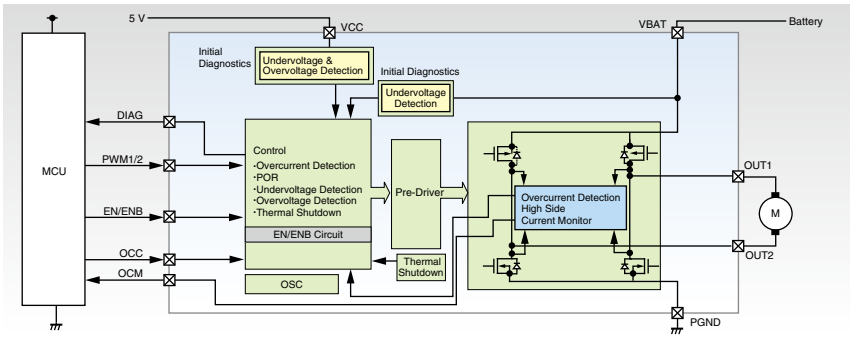
Products: Automotive Brushed DC Motor Driver ICs



▼ 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

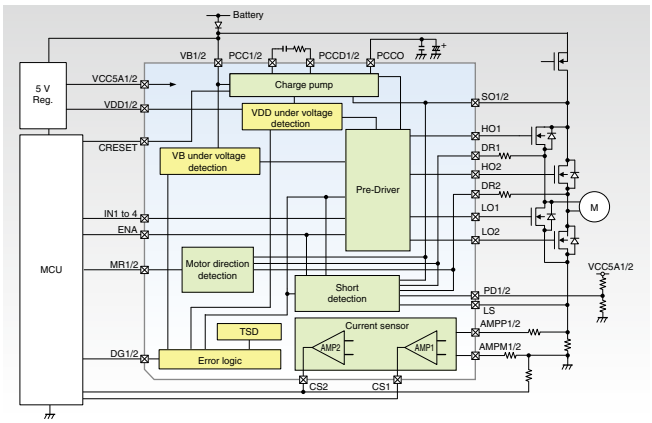
The TB9051FTG is housed in a small QFN package (measuring 6 mm × 6 mm) and contributes to reducing the size of electronic control units (ECUs). The output stage has a low-on-resistance H-bridge that consists of P-channel and N-channel DMOS transistors. This eliminates the need for a charge pump and thus 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
- Output 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

<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

▼ Lineup

Part Number	Package	Recommended Applications	Features	Output Current (A)	Output Voltage (V)	AEC
TB9051FTG	P-QFN28-0606-0.65-001	Open/close control for engine throttle and other valves	1-channel PWM H-bridge driver Small package, various fault detection functions	±5	4.5 to 28	○
TB9052FNG	HTSSOP48-P-200-0.50	EPS, electric power brake, seat belt pretensioners, auto sunroof, electric sliding doors, power windows, electric power seats, etc.	1-channel PWM H-bridge driver (external N-channel FET) Motor current sense circuit	±1	6 to 18	○
TB9056FNG	SSOP-24-P-300-0.65A	HVAC damper control	1-channel H-bridge, LIN Version 1.3 slave	±0.3	7 to 18	–
TB9057FG	LQFP48-P-0707-0.50C	EPS, electric power brake, seat belt pretensioners, auto sunroof, electric sliding doors, power windows, electric power seats, etc.	1-channel H-bridge pre-driver (external N-channel FET) Built-in motor current detection circuit, Built-in circuit for motor rotation direction detection	±1	5 to 21	○
TB9058FNG**	SSOP-24-P-300-0.65A	HVAC damper control	1-channel H-bridge, LIN Version 1.3 slave (for enhanced checksum)	±0.3	7 to 18	○
TB9101FNG	SSOP24-P-300-0.65A	HVAC damper control, door mirror angle control, etc.	2-channel H-bridge driver, DMOS power transistor version of the TA8083FG	±1	7 to 18	○
TB9102FNG	SSOP24-P-300-0.65A	HVAC damper control, door mirror angle control, etc.	6-channel half-bridge driver, SPI interface	±1	7 to 18	○
TB9110FNG	SSOP24-P-300-0.65A	Automotive fan motors (HVAC, seat ventilation, radiator, etc.)	1-channel pre-driver, Built-in charge pump (external N-channel FET)	0.02	7 to 18	–

**: Under development

Products: Automotive Stepping Motor Driver ICs Evaluation Boards (for Motor Control)

▼ Automotive Stepping Motor Driver IC: TB9120FTG

Under development

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.

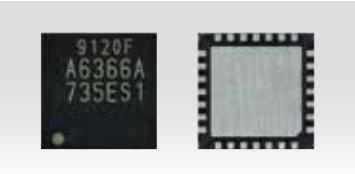
<Features>

- Drive method: PWM constant-current control of a two-phase bipolar motor
  The Mixed Decay mode tracks input current closely.
- Stepping 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

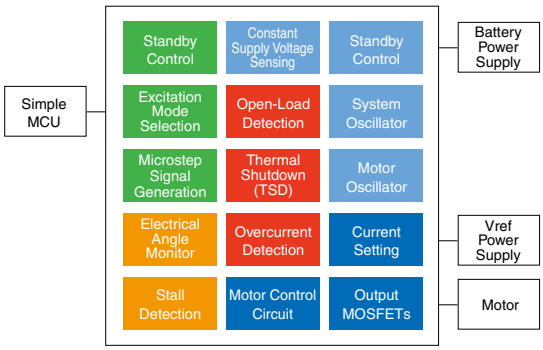
■ TB9120FTG



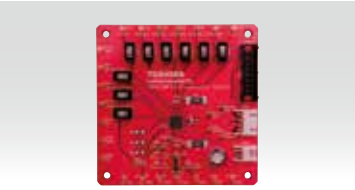
TB9120FTG

■ System Configuration Example

TB9120FTG



■ Evaluation Board



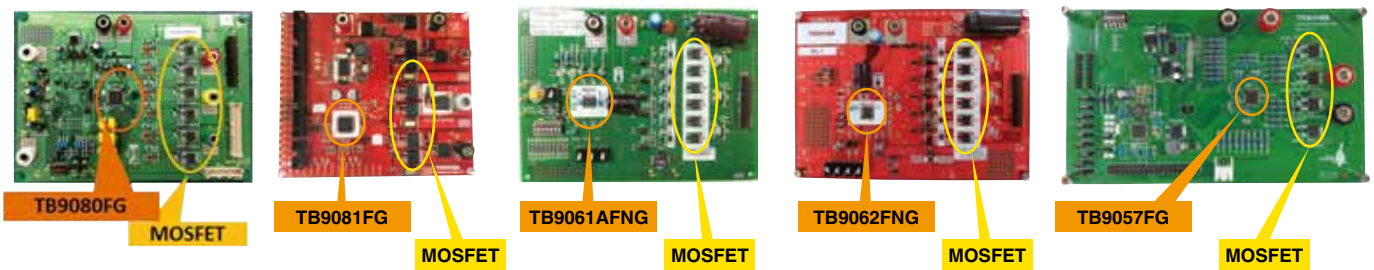
▼ Stepping Motor Driver IC Lineup

Part Number	Package	Functions & Applications	Features	Supply Voltage (A)	Supply Current (V)	AEC
TB9120FTG**	P-VQFN28-0606-0.65-002	Automotive stepping motor driver	Up to 1/32 microstepping PWM constant-current control Mixed decay mode Out-of-step detection Thermal shutdown, overcurrent detection, and open-load detection Wettable flanks with excellent solder wettability QFN package	1.0	7.0 to 18	○

**: Under development

▼ Evaluation Boards (for Motor Control)

Board No.	Motor	Driver	Control	MOS No.	MOSFET (Small power)		MOSFET (Middle power)		Application		
1 TB9080	3-phase BLDC	TB9080FG	Sinusoidal waveform drive (Silent drive)	Nch x3/ Nch x3	TK20S04K3L		TK100S04N1L		100~200 W	HVAC blower motor	Cooling fan
2 TB9081	3-phase BLDC Sensorless	TB9081FG	External MCU Control	Nch x11	–		–	TK1R4F04PB	EPS	Brake	4WS
3 TB9061	3-phase BLDC Sensorless	TB9061AFNG	Low-side PWM	Pch x3/ Nch x3	TJ20S04M3L	TK20S04K3L	TJ80S04M3L	TK100S04N1L	Oil pump	Water pump	Fuel pump
4 TB9062	3-phase BLDC Sensorless	TB9062FNG	High-side PWM	Pch x3/ Nch x3	TJ20S04M3L	TK15S04N1L	TJ80S04M3L	TK100S04N1L	Oil pump	Water pump	Fuel pump
5 TB9057	Brushed DC	TB9057FG	H-bridge driver	Nch x4	TK80A04K3L		TK100S04N1L		200 W~	EPS	Body motors



Products compatible to product evaluation boards

<Three-Phase Motor Driver ICs> TB9061AFNG / TB9062FNG / TB9067FNG / TB9080FG / TB9081FG
<Brushed DC Motor Driver ICs> TB9101FNG / TB9102FNG / TB9110FNG / TB9051FTG / TB9052FNG / TB9057FG
<Stepper Motor Drivers> TB9120FTG

For details, contact your local Toshiba sales representative.

Products: System Power Supply ICs for Automotive

System Power Supply ICs with an Integrated DC/DC Convertor

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 TB9045FNG, 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 TB9045FNG

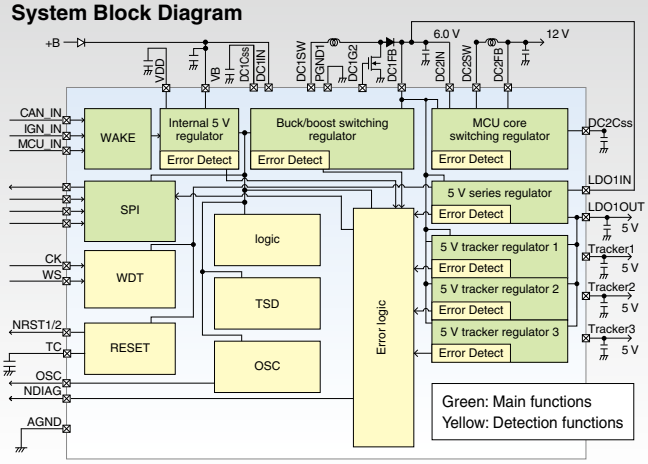
Low-voltage drive (2.7 V or above) and three sensor supply voltage channels
Functional Safety with Automotive Safety Integrity Level D (ASIL D)

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
- LDO1: 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

System Block Diagram



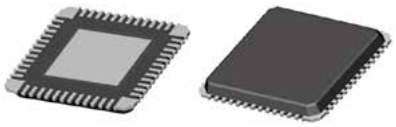
▼ High-efficiency DC/DC converter + LDO multi power IC TB9042FTG Under development

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
- LDO1: 5 V output (400 mA)
- LDO2: 5 V output (100 mA)

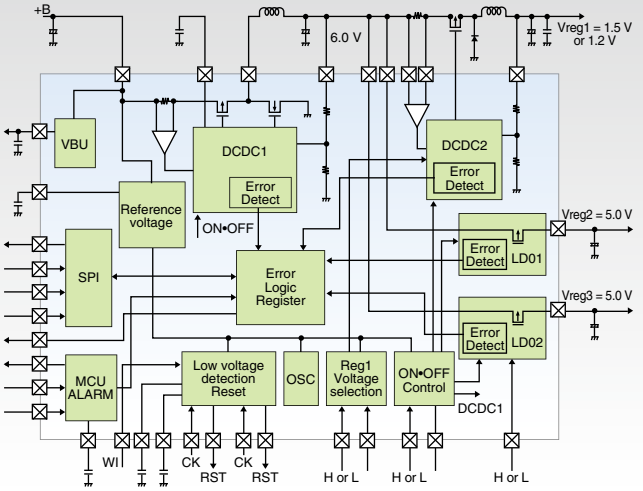
Power Supply for Backup
- VBU: 5 V/3.3 V (10 mA) (selectable)

SPI Communication
- Failure notification
- MCU diagnosis



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

System Block Diagram



▼ System Power Supply ICs (Series Power Supplies)

Part Number	Package	Functions	Characteristics				Remarks	Supply Voltage (V)	AEC
			Output Voltage Typ. (V)	Output Current (mA)	Input Voltage Max (V)	Power Dissipation Max (W)			
TB9005FNG	SSOP20-P-225-0.65A	CPU voltage regulator, watchdog timer	5	Depends on ext. Tr.	45 (1 sec.)	0.68	•Low current consumption: 90 μA (typ.) •Reset detection: 4.7 V/4.2 V (selectable) •Watchdog timer enable/disable •External transistor required	6 to 18	–
TB9021FNG	P-HTSSOP16-0505-0.65-001	CPU voltage regulator, watchdog timer	5	200	50	2.8	•Low current consumption: 30 μA (typ.) •Reset detection: 4.7 V/4.2 V (selectable) •Watchdog timer enable/disable •Integrated output transistors	6 to 18	○

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

Part Number	Package	Functions	Characteristics				Remarks	Supply Voltage (V)	AEC
			Output Voltage Typ. (V)	Output Current (mA)	Input Voltage Max (V)	Power Dissipation Max (W)			
TB9042FTG**	HQFN52-P-0808-0.50	CPU voltage regulator DC-DC converter & LDO Watchdog timer On-chip SPI	1.5/1.2 5 5 5/3.3	1000 400 100 10	40 (1 sec.)	5.5	•DC/DC converter: 6 V & Vreg1 outputs SW frequency: 370 kHz •3 LDO regulators •Low voltage detection, POR, WDT •SPI interface (error information output, for MCU diagnosis)	7 to 20	○
TB9044AFNG**	HTSSOP48-P-300-0.50	CPU voltage regulator DC-DC converter & LDO Watchdog timer On-chip SPI	5 5 5 5	400 100 100 100	40 (1 sec.)	3.84	•DC-DC converter •Voltage monitor, POR, WDT •Four low-dropout (LDO) regulators •SPI (error information output) •5-V series power supply (with a 400-mA driver) •5-V tracking power supply (with three 100-mA driver channels)	2.7 to 18	○
TB9045FNG**	HTSSOP48-P-300-0.50	CPU voltage regulator DC-DC converter & LDO Watchdog timer On-chip SPI	1.1/1.2/ 1.25/1.5 5 5 5 5	800 400 100 100 100	40 (1 sec.)	3.84	•DC-DC converter •Voltage monitor, POR, WDT •Four low-dropout (LDO) regulators •SPI (error information output) •5-V series power supply (with a 400-mA driver) •5-V tracking power supply (with three 100-mA driver channels)	2.7 to 18	○

**: Under development

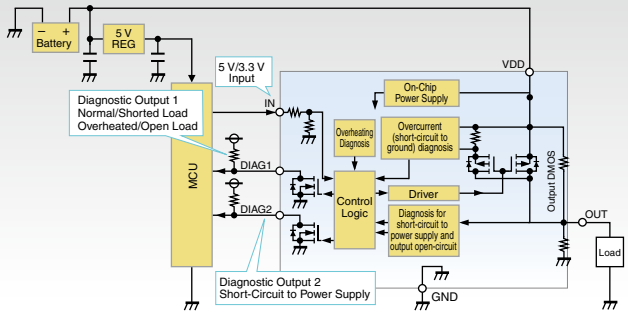
Products: Automotive Intelligent Power Devices (IPDs)

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.

Application Example of a High-Side Power Switch (TPD1055FA)



▼ IPDs for High-Side Switch Lineup

Part Number	Output	Supply voltage	Output Current	Operating temperature range	Package	Feature	AEC
TPD1052F	1	5 to 18 V	< 0.8 A	−40 to 125˚C	PS-8	•Thermal shutdown, overcurrent protection, diagnosis output	–
TPD1053F	1	5 to 18 V	< 3 A	−40 to 125˚C	SOP-8	•Thermal shutdown, overcurrent protection, diagnosis output •Detection of load open-circuit •Overvoltage protection (active clamp)	–
TPD1055FA	1	5 to 18 V	< 3 A	−40 to 125˚C	WSON-10	•Thermal shutdown, overcurrent protection, diagnosis output •Detection of load short-circuit and open-circuit	○
TPD1060F	1	4 to 18 V	< 3 A	−40 to 125˚C	SOP-8	•Thermal shutdown, overcurrent protection, diagnosis output •Detection of load open-circuit	○

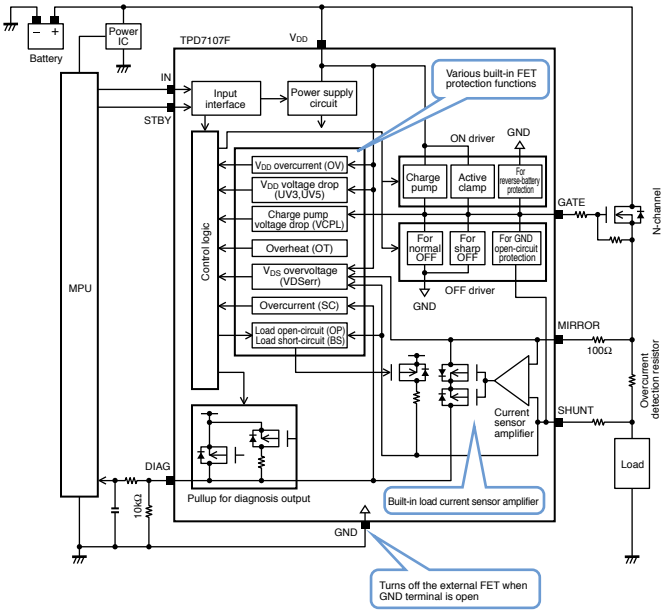
▼ IPDs for Low-Side Switch Lineup

Part Number	Output	Supply voltage	Output Current	Operating temperature range	Package	Feature	AEC
TPD1030F	2	to 40 V	< 1 A	−40 to 110˚C	SOP-8	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection	–
TPD1032F	2	to 20 V	< 3 A	−40 to 110˚C	SOP-8	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection	–
TPD1036F	2	to 30 V	< 1.5 A	−40 to 110˚C	SOP-8	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection	–
TPD1044F	1	to 41 V	< 1 A	−40 to 125˚C	PS-8	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection	○
TPD1046F	2	to 20 V	< 3 A	−40 to 125˚C	SOP-8	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection	–
TPD1054F	1	V_{OUT}: Up to 40 V V_{DD}: Up to 5.5 V	< 1 A	−40 to 125˚C	PS-8	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection •Thermal shutdown, overcurrent protection, load open-circuit, diagnosis output	–
TPD1058FA	1	V_{OUT}: Up to 40 V V_{DD}: Up to 5.5 V	< 6 A	−40 to 125˚C	WSON-10	•Overvoltage protection (active clamp) •Thermal shutdown, overcurrent protection •Thermal shutdown, overcurrent protection, load open-circuit, diagnosis output	–

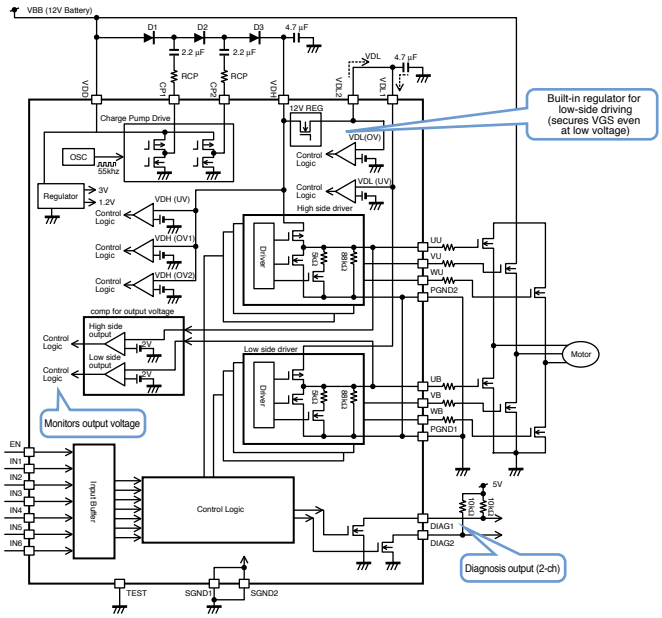
* The up-to-date and more detailed information on automotive MOSFETs and IPDs is available on our website. https://toshiba.semicon-storage.com/

■ Gate Drivers

Application Example of Gate Drivers (TPD7107F**)



Application Example of Gate Drivers (TPD7212F)



Target applications
- Semiconductor relay
- Junction box

Target applications
- Automotive three-phase brushless DC motor

* 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

▼ IPDs for Power MOSFET Gate Driver Lineup

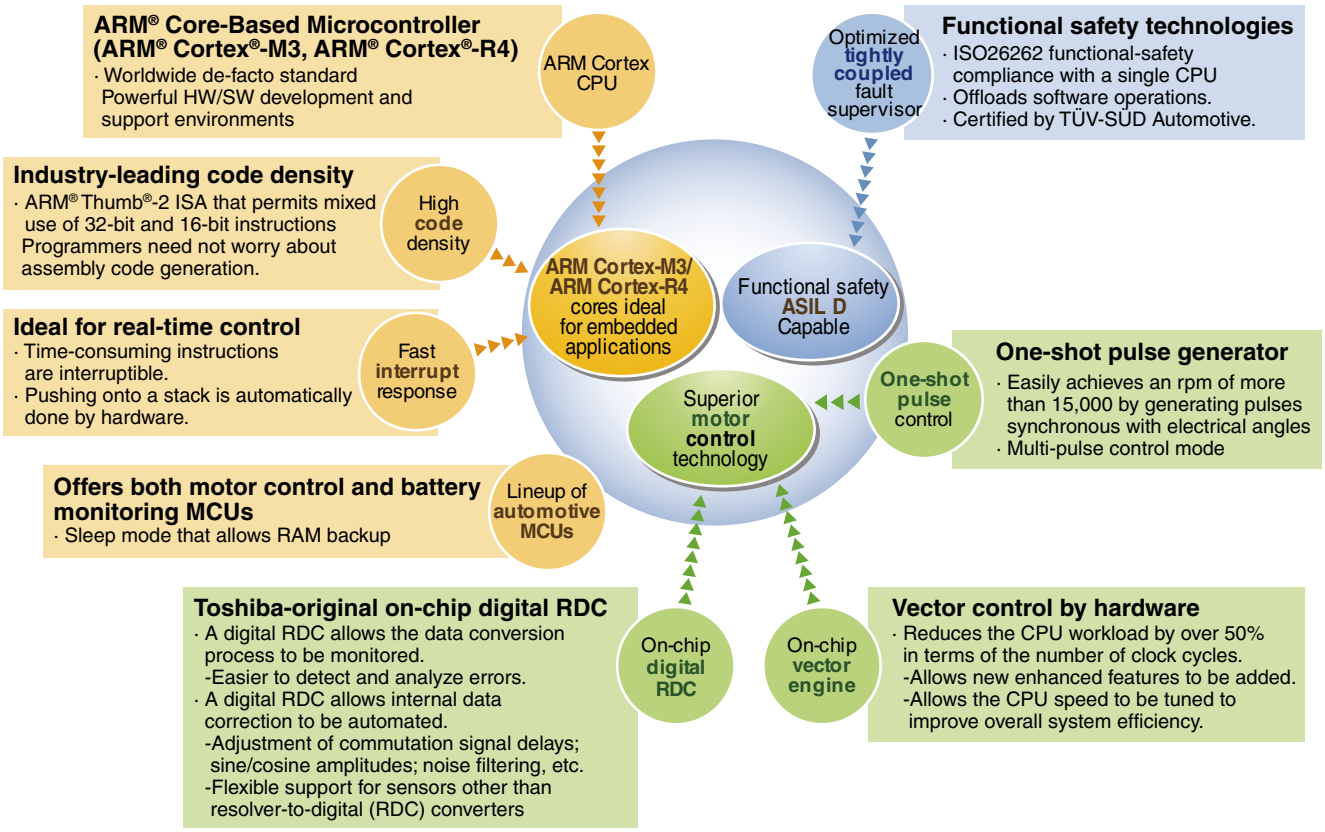
Part Number	Function	Supply voltage	Output Current	Operating temperature range	Package	Characteristic	AEC
TPD7104AF	1ch High Side Nch Pw-MOSFET Gate Driver	5 to 18 V	Depends on internal drive	–40 to 125˚C	PS-8	•Built-in charge pump circuit •Overcurrent detection/protection, diagnosis output •Reverse-battery protection	○
TPD7106F**	1ch High Side Nch Pw-MOSFET Gate Driver	4.5 to 27 V	–10 mA/ +10 mA	–40 to 150˚C	VSOP-16	•Built-in charge pump circuit (with external capacitor) •Charge pump voltage drop detection/protection •Reverse-battery protection •Externally controlled sharp OFF (+400 mA)	○
TPD7107F**	1ch High Side Nch Pw-MOSFET Gate Driver	5.75 to 26 V	Depends on internal drive	–40 to 125˚C	WSON-10	•Built-in charge pump circuit •Protection from abnormal supply voltage, diagnosis 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	○
TPD7211F	Half-bridge Pw-MOSFET Gate Driver	5 to 18 V	±0.5 A (max)	–40 to 125˚C	PS-8	•Driving of high-side P-ch MOFET and low-side N-ch MOSFET	–
TPD7212F	3 Phase Full bridge Pw-MOSFET Gate Driver	4.5 to 18 V	–1.0 A/ +1.5 A	–40 to 125˚C	WQFN-32	•Built-in charge pump circuit •Protection from driver abnormal supply voltage, diagnosis output (low voltage, overvoltage) •Output voltage monitoring (protection, diagnosis output)	○

**: Under development

Products: Automotive Microcontrollers

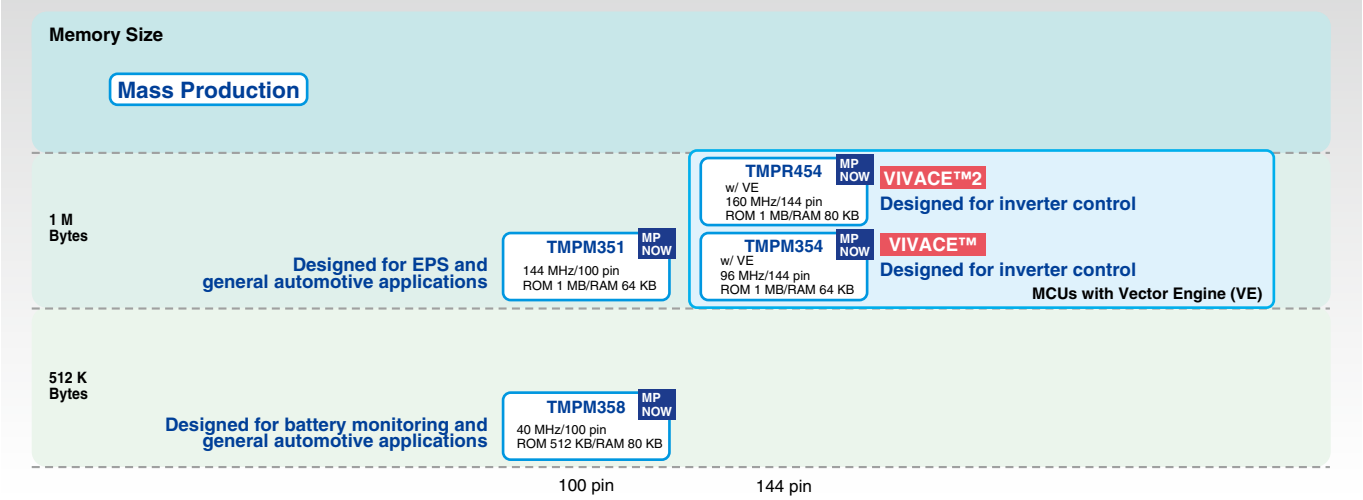
Features of Toshiba's Automotive Microcontrollers

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.



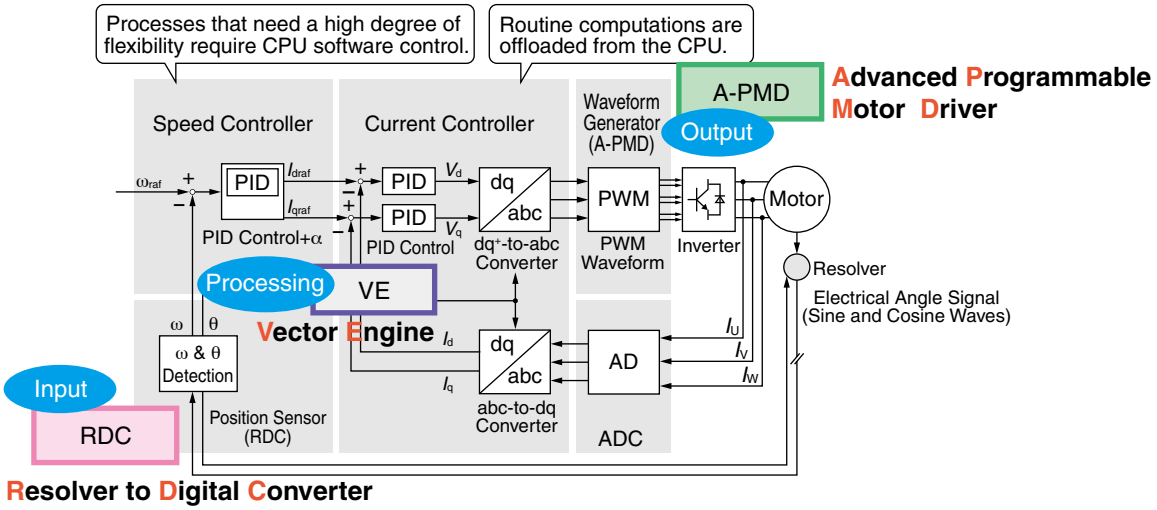
Roadmap for Automotive Microcontrollers

Toshiba is expanding its portfolio of automotive microcontrollers, based on the Arm Cortex-based CPU cores.



Vector Control Technology

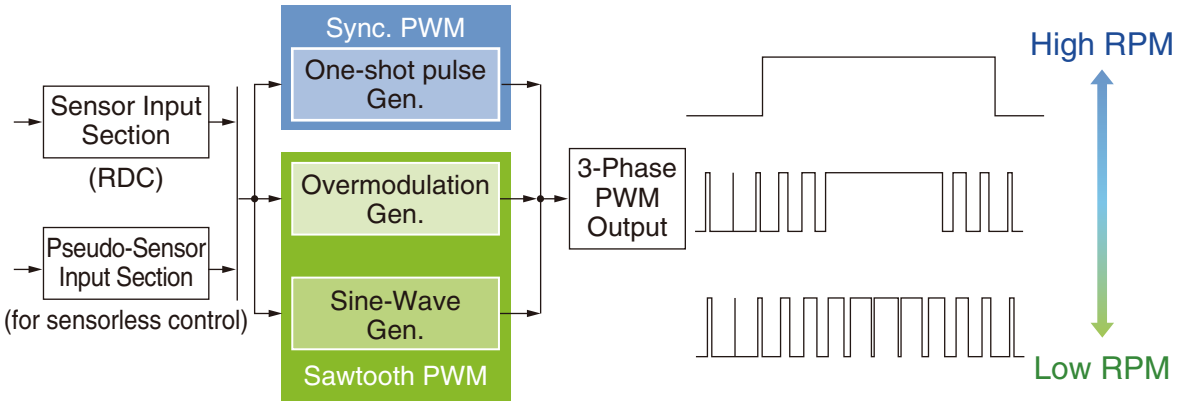
The integrated RDC, Vector Engine (VE), and Advanced Programmable Motor Driver (A-PMD), which run in parallel with the CPU, handle computation unique to motor control and therefore reduce the CPU workload.



▼ 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



Development Tools and Partners

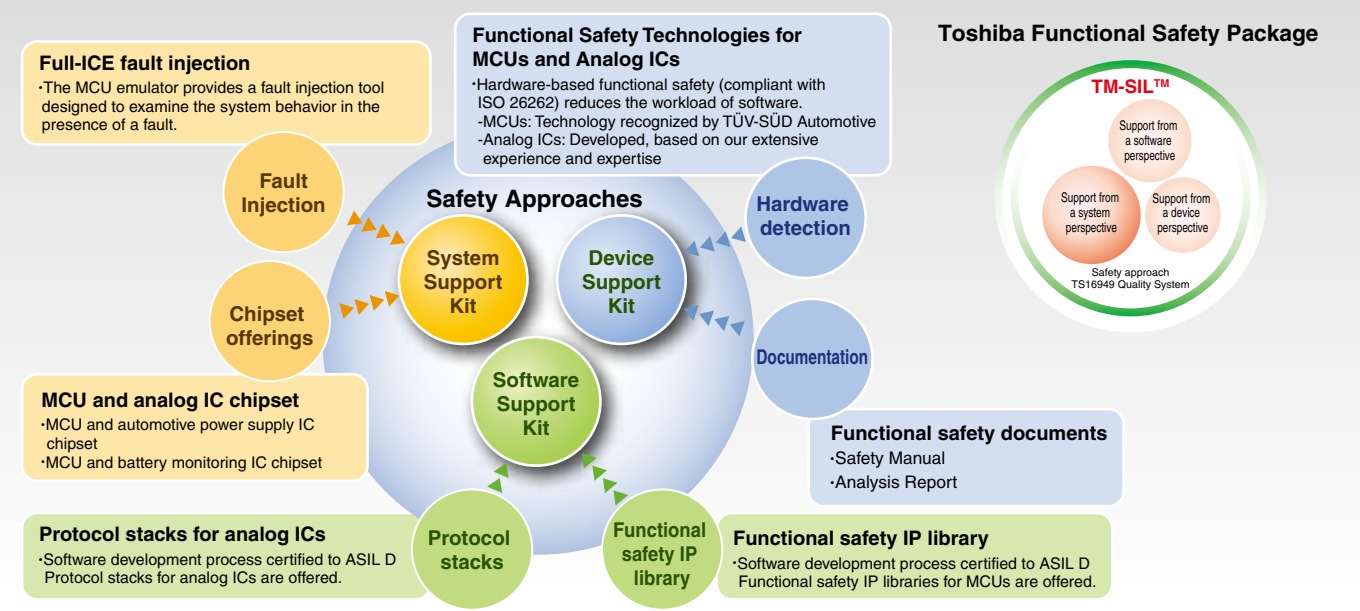
A wide range of development tools are available from many partners for automotive ARM Cortex-based microcontrollers. Choose the best development tools and partners that best suit your needs.

	IDE/Compiler	Debugger	Simulator	OS	Software development /SI	Board/ Evaluation kit	FLASH Programmer /Writer	Teaching Materials /Seminar
ARM Ltd. (Yokogawa Digital Computer Corporation)	●	●	●	●				
IAR Systems AB	●	●	●	●		●		●
Green Hills Software / Advanced Data Controls Corp.	●	●	●	●				
ATI Japan		●						
Elektrobit Corporation				●				
GAIO TECHNOLOGY CO.,LTD.			●		●			●
iFORCOM Kyoei Co., Ltd.							ON board	
KPIT Technologies Ltd.				●				
Computex Co.,Ltd.							ON board	
Sohwa & Sophia Technologies Co.,Ltd.							ON board	
dSPACE GmbH		●						
DTS INSIGHT Corporation		●					ON board	●
SEGGER Microcontroller GmbH							ON board	

Functional Safety

Toshiba Functional Safety Package

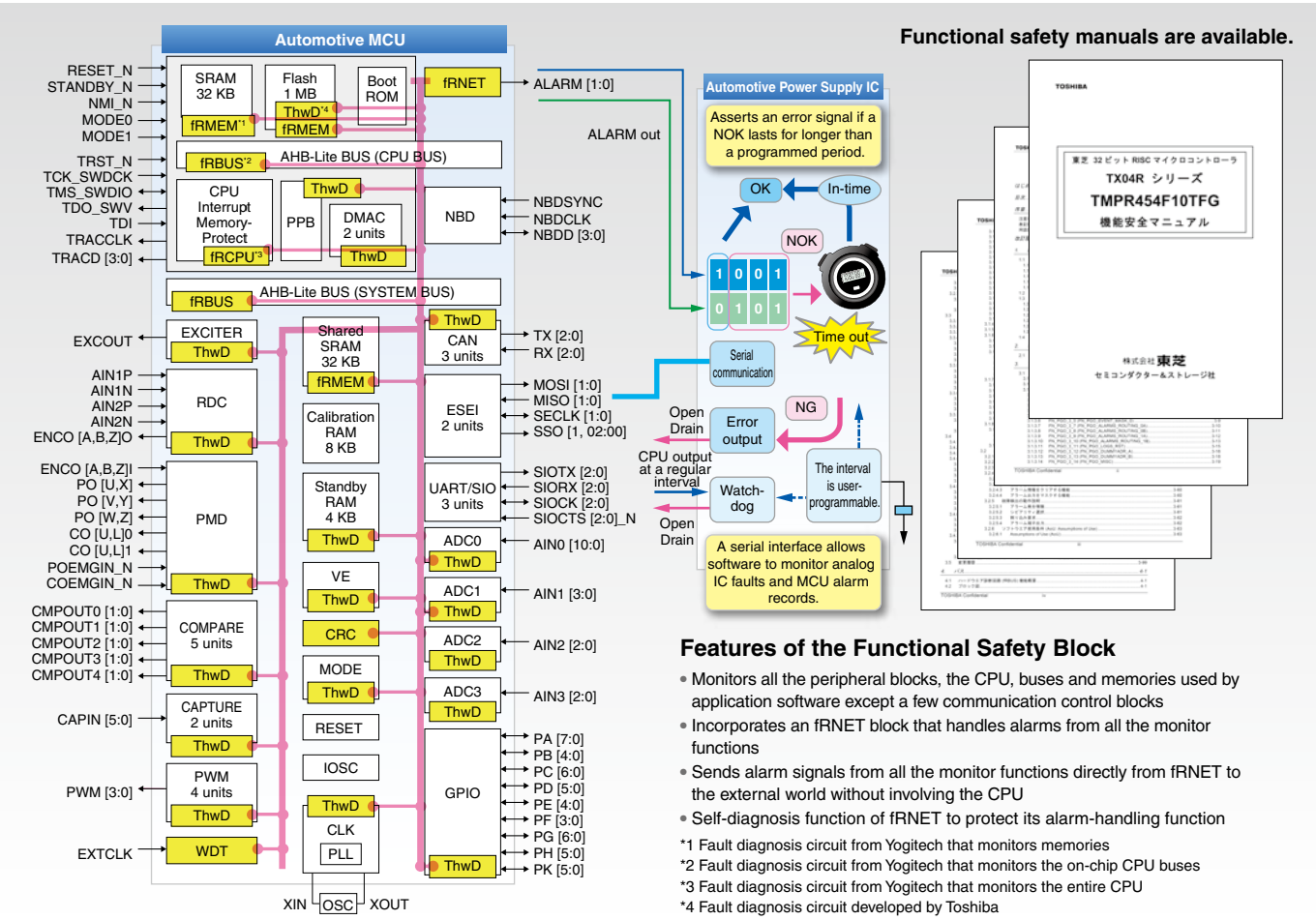
Toshiba offers a support environment not only from a system perspective but also from a customer perspective.



▼ 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)



Features of the Functional Safety Block

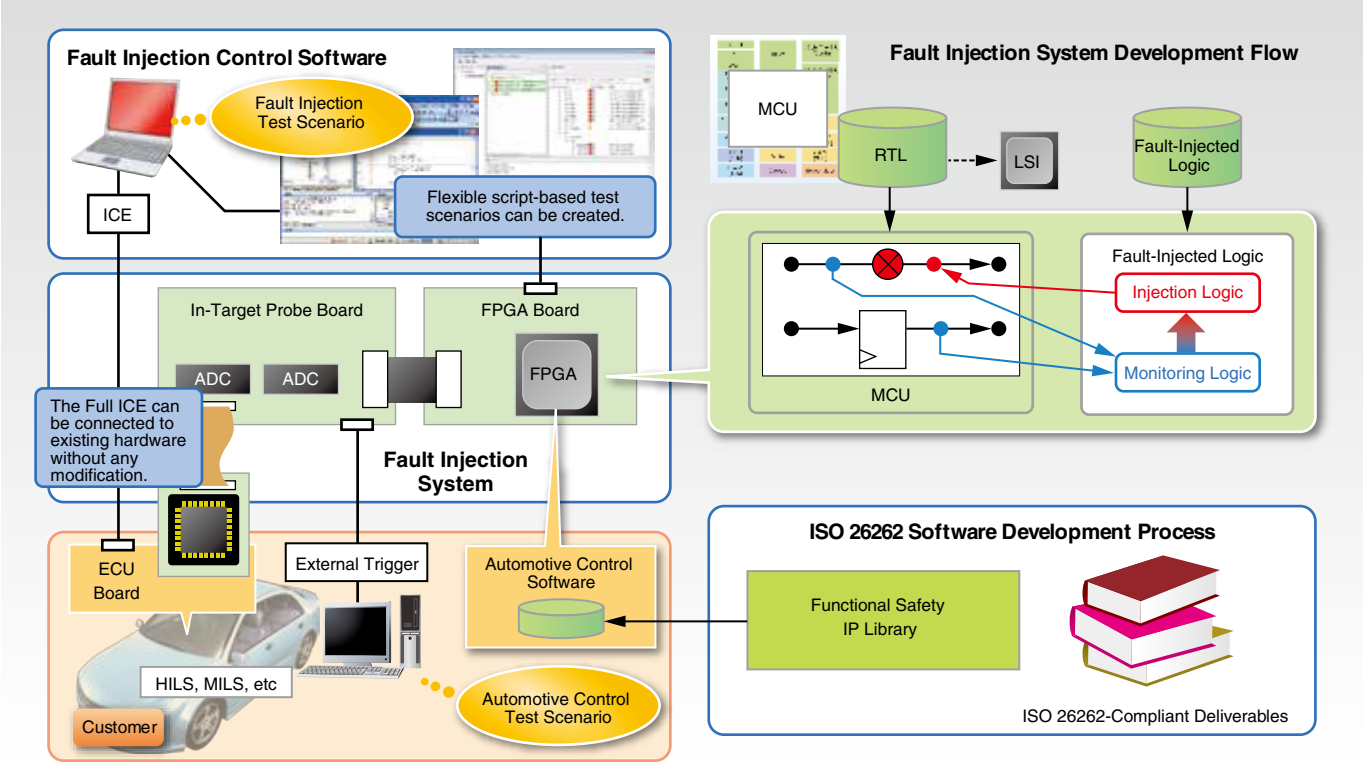
- Monitors all the peripheral blocks, the CPU, buses and memories used by application software except a few communication control blocks
- Incorporates an fRNET block that handles alarms from all the monitor functions
- Sends alarm signals from all the monitor functions directly from fRNET to the external world without involving the CPU
- Self-diagnosis function of fRNET to protect its alarm-handling function

*1 Fault diagnosis circuit from Yogitech that monitors memories
*2 Fault diagnosis circuit from Yogitech that monitors the on-chip CPU buses
*3 Fault diagnosis circuit from Yogitech that monitors the entire CPU
*4 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.



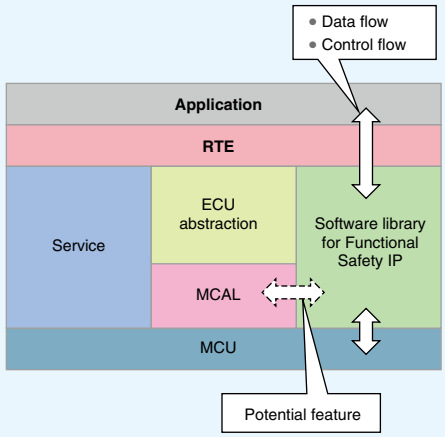
▼ Feature 3: Functional Safety IP Library

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.

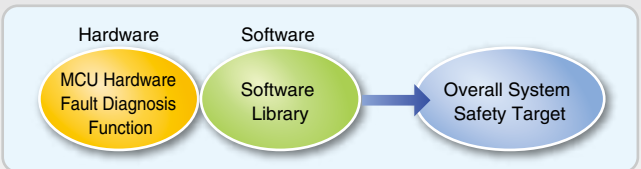
▼ The Functional Safety IP Library helps its users reduce development time.

Software library offerings



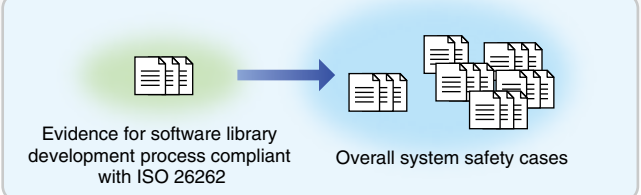
Reduction in the time required to create a safety mechanism

- 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



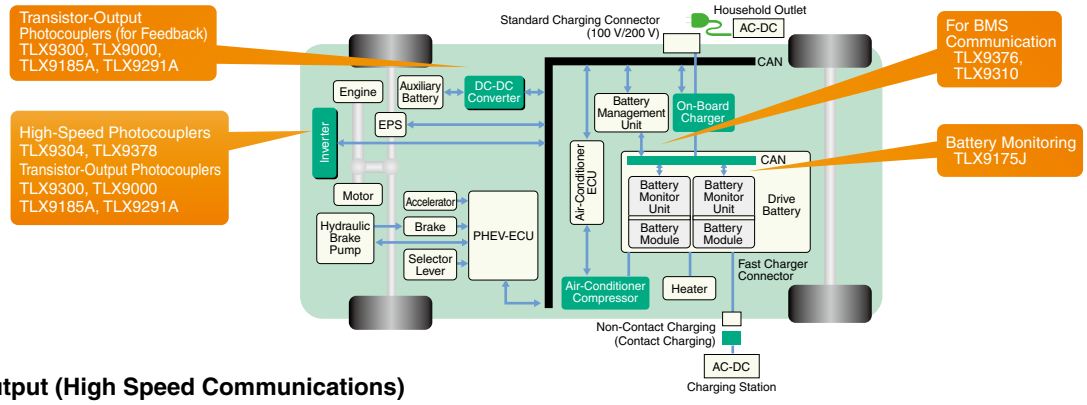
Reduction in the time required to meet accountability requirements

- A set of documents necessary to achieve accountability is pre-packaged.



Products: Photocoupler for Automotive Applications

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)

Part Number	Pin Configuration	Characteristics					Isolation Voltage BV_S(Vrms)	Clearance/ Creepage Distance	Package	AEC
		Output Type	Data Rate (Standard)	I_{FHL} (max) (mA)	Tstg (˚C) (min) to (max)	Topr (˚C) (min) to (max)				
TLX9304		Open collector	1 Mbps	5	−55 to 150	−40 to 125	3750	5 mm	5pin SO6	○
TLX9309		Open collector (Analog output)	1 Mbps	15~300 @7/4.5*	−55 to 150	−40 to 125	3750	5 mm	5pin SO6	
TLX9310		Totempole	5 Mbps	1	−55 to 125	−40 to 105	3750	5 mm	5pin SO6	
TLX9378		Open collector	10 Mbps	5	−55 to 150	−40 to 125	3750	5 mm	5pin SO6	
TLX9376		Totempole	20 Mbps	4	−55 to 150	−40 to 125	3750	5 mm	5pin SO6	

*Note: The values in the table refer to I_O/I_F (%) (min) to (max). @ refers to a value under the measuring condition I_O (mA)/V_{cc}.

▼ Transistor Output (DC Input)

Part Number	Pin Configuration	Characteristics					Isolation Voltage BV_S(Vrms)	Clearance/ Creepage Distance	Package	AEC
		I_C / I_F (%) (min) to (max) @I_F (mA)/V_{CE} (V)	$V_{CE\ (sat)}$ (V) (MAX) @I_C (mA)/I_F (mA)	V_{CEO} (MIN) (V)	Tstg (˚C) (min) to (max)	Topr (˚C) (min) to (max)				
TLX9000		100 to 900 @5/5	0.4 @2.4/8	40	−55 to 150	−40 to 125	3750	5 mm	SO4	○
TLX9300		100 to 900 @5/5	0.4 @2.4/8	40	−55 to 150	−40 to 125	3750	5 mm	4pin SO6	
TLX9291A		50 to 600 @5/5	0.4 @2.4/8	80	−55 to 150	−40 to 125	3750	5 mm	SO4	
TLX9185A		50 to 600 @5/5	0.4 @2.4/8	80	−55 to 150	−40 to 125	3750	5 mm	4pin SO6	

▼ Photovoltaic Output

A photovoltaic-output photocoupler is an element that receives LED light with the photodiode array on the photodetecting side and extracts output voltage. This device enables a gate drive circuit to be configured without a secondary external power source when driving loads such as MOSFET.

Part Number	Pin Configuration	Short-Circuit Current (uA) (min) @I_F (mA)	Open Voltage VOC (V) (min) @I_F (mA)	Tstg (˚C) (min) to (max)	Topr (˚C) (min) to (max)	Isolation Voltage BV_S(Vrms)	Clearance/ Creepage Distance	Package	AEC
TLX9905		12 @10	7 @10	−55 to 150	−40 to 125	3750	5 mm	4pin SO6	○
TLX9906		12 @10	7 @10	−55 to 150	−40 to 125	3750	5 mm	4pin SO6	

▼ Photorelays (1-Form-A)

A photorelay is a semiconductor relay composed of a luminous element (LED) and photodetecting element (MOSFET). It is mainly used as a substitute for a signal relay. It is contactless and is said to have a long service life compared to mechanical relays.

Part Number	Pin Configuration	OFF-State Output Terminal Voltage V_{OFF} (Max) (V)	ON-State Current I_{ON} (MAX) (mA)	ON-state Resistance		Trigger LED I_{FT} (Max) (mA)	Isolation Voltage BV_S(Vrms)	Clearance/ Creepage Distance	Package	AEC
				R_{ON} (Max) (Ω)	@I_{ON} (mA)/I_F (mA)					
TLX9175J		600	15	335	15/10	3	3750	5 mm	4pin SO6	○

Products: Automotive Discrete Devices

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.

Small Signal Device	**2 Pins**	**USC SOD-323** ★	**ESC SOD-523** ★	**SOD-923** ★			
	3 Pins	**S-MINI SOT-346** ★	**SOT-23F** ★	**USM SOT-323** ★	**UFM** ★	**SSM SOT-416** ★	**VESM SOT-723** ★
	5 Pins	**SMV SOT-25** ★	**USV SOT-353** ★	**UFV**	**ESV SOT-553** ★		
	6 Pins	**TSOP6F** ★	**US6 SOT-363** ★	**UF6** ★	**ES6 SOT-563** ★	**UDFN6 SOT-1220** ★	
	8 Pins	**US8 SOT-765** ★					
	14 Pins	**TSSOP14** ★	**16 Pins**	**TSSOP16** ★	**20 Pins**	**TSSOP20** ★	

★ AEC qualified

▼ AEC-Q101-Qualified Devices(*)

- MOSFETs
- Bipolar transistor
- Switching Diodes
- Transient-voltage-suppression (TVS) diodes
- Schottky Barrier Diodes

▼ AEC-Q100(*)

- CMOS Logic ICs
- One-Gate Logic (L-MOS)

* Contact your Toshiba sales representative for details
* This device is compliant with the reliability requirements of AEC-Q100.

Major TVS Diodes Compliant with the AEC Standards

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

Package Unit (mm)	Part Number	Pin Assignment	Absolute Maximum Ratings			Electrical Characteristics				
			T_j (°C)	V_{ESD} (kV) IEC 61000-4-2	V_{ESD} (kV) ISO 10605 @330 pF/2 kΩ	V_{BR} (V) (min)	I_R (μA) (max)	@V_{RWM} (V)	R_{RDYN} (Ω) (typ.)	C_t (pF) (typ.)
USC (SOD-323) 1.25 x 2.5 t = 1.1	**DF2B18FU**		150	±30 kV	±30 kV	16.2	0.1	12	0.8	9
	DF2B29FU		150	±25 kV	±30 kV	26	0.1	24	1.1	9
	DF2B36FU		150	±20 kV	±20 kV	32	0.1	28	1.5	6.5
USM (SOT-323) 2.0 x 2.1 t = 1.1	**DF3D18FU**		150	±30 kV	±30 kV	16.2	0.1	12	0.8	9
	DF3D29FU		150	±25 kV	±30 kV	26	0.1	24	1.1	9
	DF3D36FU		150	±20 kV	±20 kV	32	0.1	28	1.5	6.5

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

Package Unit (mm)	Part Number	Pin Assignment	Absolute Maximum Ratings		Electrical Characteristics				
			T_j (°C)	V_{ESD} (kV) IEC 61000-4-2	V_{BR} (V) (min)	I_R (μA) (max)	@V_{RWM} (V)	R_{RDYN} (Ω) (typ.)	C_t (pF) (typ.)
SOD-923 1.0 x 0.6 t = 0.45	**DF2S5M4FS***		150	±20 kV	3.7	0.1	3.6	0.35	0.45
	DF2S6M4FS*		150	±20 kV	5.5	0.1	5.5	0.35	0.45
	DF2S20M4FS**		150	±15 kV	18	0.1	18	0.3	0.45

*: New product **: Under development

Products: AEC-Qualified Automotive Discrete Devices

Major Small-Signal Devices Compliant with the AEC Standards

▼ MOSFETs

Package Unit (mm)	Polarity	Part Number	Absolute Maximum Ratings			RDS (ON) max (mΩ)			Ciss (pF)	Qg (nC)	Tch (°C)
			V_{DSS} (V)	V_{GSS} (V)	I_D (A)	$\|V_{GS}\|$ = 1.5 V	$\|V_{GS}\|$ = 2.5 V	$\|V_{GS}\|$ = 4.5 V			
UFM 2.0 x 2.1 t = 0.75	Nch + Zener	**SSM3H137TU**	34	±20	2	–	–	280	119	3	150
UF6 2.0 x 2.1 t = 0.75	Nch x 2	**SSM6N62TU***	20	±8	0.8	121 (typ.) @1.2 V	74 (typ.)	67 (typ.)	177	2	150
SOT-23F 2.9 x 2.4 t = 0.88	Nch	**SSM3K337R**	38	±20	2	–	–	176	120	3	150
		SSM3K341R*	60	±20	6	–	–	51	550	9.3	175
		SSM3K318R	60	±20	2.5	–	–	145	235	7	150
		SSM3K2615R	60	±20	2	–	580@3.3 V	440@4 V	150	6	150
		SSM3K361R*	100	±20	3.5	–	–	92	430	3.2	175
	Pch	**SSM3J356R***	−60	−20/+10	−2	–	–	400@4 V	330	8.3	150
		SSM3J351R*	−60	−20/+10	−3.5	–	–	184@4 V	660	15.1	150
TSOP6F 2.9 x 2.8	Nch Dual	**SSM6N357R***	60	±12	0.65	–	2400 (@3 V)	1800@5 V	43	1.5	150
		SSM6N813R*	100	±20	3.5	–	–	154	242	3.6	175
SOT-323F 2.0 x 2.1 t = 0.75	Nch	**SSM3K62TU***	20	±8	0.8	139	68	57	177	2.0	150
		SSM3K341TU*	60	±20	6	–	–	51	550	9.3	175
		SSM3K361TU*	100	±20	3.5	–	–	92	430	3.2	175
TSOP6F 2.9 x 2.8 t = 0.88	Nch Single	**SSM6K809R***	60	±20	6	–	–	51	550	9.3	175
		SSM6K810R*	100	±20	3.5	–	–	92	430	3.2	175
		SSM6K818R*	30	±20	15	–	–	12	1130	7.5	150
		SSM6K819R*	100	±20	10	–	–	36.4	840	3.1	175
SOT-23F 2.9 x 2.4 t = 0.88	Nch	**SSM3K376R***	30	12/−8	4	–	72	56	200	2.2	150
	Pch	**SSM3J377R***	−20	−8/+6	−3.9	240	123	93	290	4.6	150
		SSM3J378R*	−20	−8/+6	−6	88.4	39.7	29.8	840	12.8	150

*: New product

▼ Bipolar Transistors

Package Unit (mm)	Polarity	Part Number	Absolute Maximum Ratings				hFE			$V_{CE\ (sat)}$ (V)	
			V_{CEO} (V)	I_C (A)	P_C (W)	T_j (°C)	MIN	MAX	Test Condition	MAX	Test Condition
USM (SOT-323) 2.0 x 2.1 t = 1.1	NPN	**2SC4116**	50	0.15	0.1	125	70	700	V_{CE} = 6 V, I_C = 2 mA	0.25	I_C = 0.1 A, I_B = 10 mA
	PNP	**2SA1586**	−50	−0.15	0.1	125	70	400	V_{CE} = −6 V, I_C = −2 mA	−0.3	I_C = −0.1 A, I_B = −10 mA
S-Mini (SOT-346) 2.9 x 2.5 t = 1.4	NPN	**2SC2712**	50	0.15	0.15	125	70	700	V_{CE} = 6 V, I_C = 2 mA	0.25	I_C = 0.1 A, I_B = 10 mA
	PNP	**2SA1162**	−50	−0.15	0.15	125	70	400	V_{CE} = −6 V, I_C = −2 mA	−0.3	I_C = −0.1 A, I_B = −10 mA

▼ Switching Diodes

Package Unit (mm)	Part Number	Pin Assignment	Absolute Maximum Ratings				Electrical Characteristics (max)			
			V_R (V)	I_{FSM} (A)	I_O (A)	T_j (°C)	V_F (V) @IF = 0.1 (A)	I_R (μA)	@V_R (V)	t_{rr} (ns)
ESC (SOD-523) 0.8 x 1.6 t = 0.7	**1SS307E**		80	1	0.1	150	1.3	0.01	80	–
USC (SOD-323) 1.25 x 2.5 t = 1.1	**1SS352**		80	1	0.1	125	1.2	0.1	30	4
	1SS403		200	2	0.1	125	1.2	0.1	50	60
USM (SOT-323) 2.0 x 2.1 t = 1.1	**1SS302A**		80	2	0.1	150	1.2	0.1	30	4

▼ Standard Logic ICs (Topr: −40°C to 125°C)

Package Unit (mm)	Series	Part Number	Key Electrical Characteristics
TSSOP14B (5.0 x 6.4 t = 1.2) TSSOP16B (5.0 x 6.4 t = 1.2) TSSOP20B (6.5 x 6.4 t = 1.2)	VHC Series	**74VHCxxFT**	V_{CC} = 2.0 V to 5.5 V tpd = 8.5 ns@4.5 V
		74VHCTxxFT	V_{CC} = 4.5 V to 5.5 V, TTL input
		74VHCVxxFT	V_{CC} = 1.8 V to 5.5 V tpd = 8.5 ns@4.5 V

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.

▼ One-Gate Logic ICs (Topr: −40°C to 125°C)

Package Unit (mm)	Series	Part Number	Key Electrical Characteristics
USV (SOT-353) 2.0 x 2.1 t = 1.1	VHS Series	**TC7SHxxFU**	V_{CC} = 2.0 V to 5.5 V tpd = 9 ns@4.5 V
		TC7SETxxFU	V_{CC} = 4.5 V to 5.5 V TTL input
	SHS Series	**TC7SZxxFU**	V_{CC} = 1.65 V to 5.5 V tpd = 5.5 ns@3.0 V

Major Power Devices Compliant with the AEC Standards

▼ MOSFETs

Package Unit (mm)	Polarity	Part Number	Absolute Maximum Ratings		$R_{DS\ (ON)}$ Max (mΩ)	Series	AEC
			V_{DSS} (V)	I_D (A)	$\|V_{GS}\|$ = 10 V		
DPAK+ 	N-ch	**TK1R4S04PB**	40	120	1.35	U-MOSIX-H	○
		TK65S04N1L	40	65	4.3	U-MOSVIII-H	
		TK40S06N1L	60	40	10.5		
		TK25S06N1L	60	25	18.5		
		TK60S10N1L	100	60	6.1		
		TK33S10N1L	100	33	9.7		
	P-ch	**TJ90S04M3L**	−40	−90	4.3	U-MOSVI	
		TJ40S04M3L	−40	−40	9.1		
		TJ20S04M3L	−40	−20	22.2		
SOP Adv (WF) 	N-ch	**TPHR7904PB**	40	150	0.79	U-MOSIX-H	
		TPH1R104PB	40	120	1.14		
DSOP Adv (WF) 	N-ch	**TPWR7904PB**	40	150	0.79		
		TPW1R104PB	40	120	1.14		
PS-8 	N-ch	**TPCP8009**	40	10	11.8	U-MOSIV	
		TPCP8010	40	6	23.8		
		TPCP8011	40	5	31.8		
		TPCP8012	60	8	20.2		
		TPCP8013	60	4	51.8		
	P-ch	**TPCP8107**	−40	−8	18	U-MOSVI	
		TPCP8109	−40	−4.5	52.3		
		TPCP8110	−60	−5	39.5		
		TPCP8111	−60	−3	117		
	N-chx2	**TPCP8207**	40 V/40 V	5/5	36.3/36.3	U-MOSIV	
	N-ch+N-ch	**TPCP8407**	40 V/−40 V	5/−4	36.3/56.8	U-MOSIV+VI	

▼ Bipolar Transistors

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

Package Unit (mm)	Polarity	Part Number	Absolute Maximum Ratings		h_{FE}			$V_{CE\ (sat)}$ (V)			AEC
			V_{CEO} (V)	I_C (A)	min	V_{CE} (V)	I_C (A)	max	I_C (A)	I_B (mA)	
New PW-Mold 6.5 x 9.5 t = 2.3 	NPN	**TTC016**	50	5	400	2	0.5	0.22	1.6	32	Planning
		2SC3303	80	5	70	1	1	0.4	3	150	
		TTC012	375	2	100	5	0.3	0.5	0.5	62.5	
		TTC014	800	1	100	5	0.1	1.0	0.5	50	
		2SD1223	80	4	2000	2	1	1.5	3	6	
	PNP	**TTA005**	−50	−5	200	−2	−0.5	−0.27	−1.6	−53	
		TTA009	−80	−3	100	−2	−0.5	−0.5	−1	−100	
		2SA2142	−600	−0.5	100	−5	−0.05	−1.0	−0.1	−10	

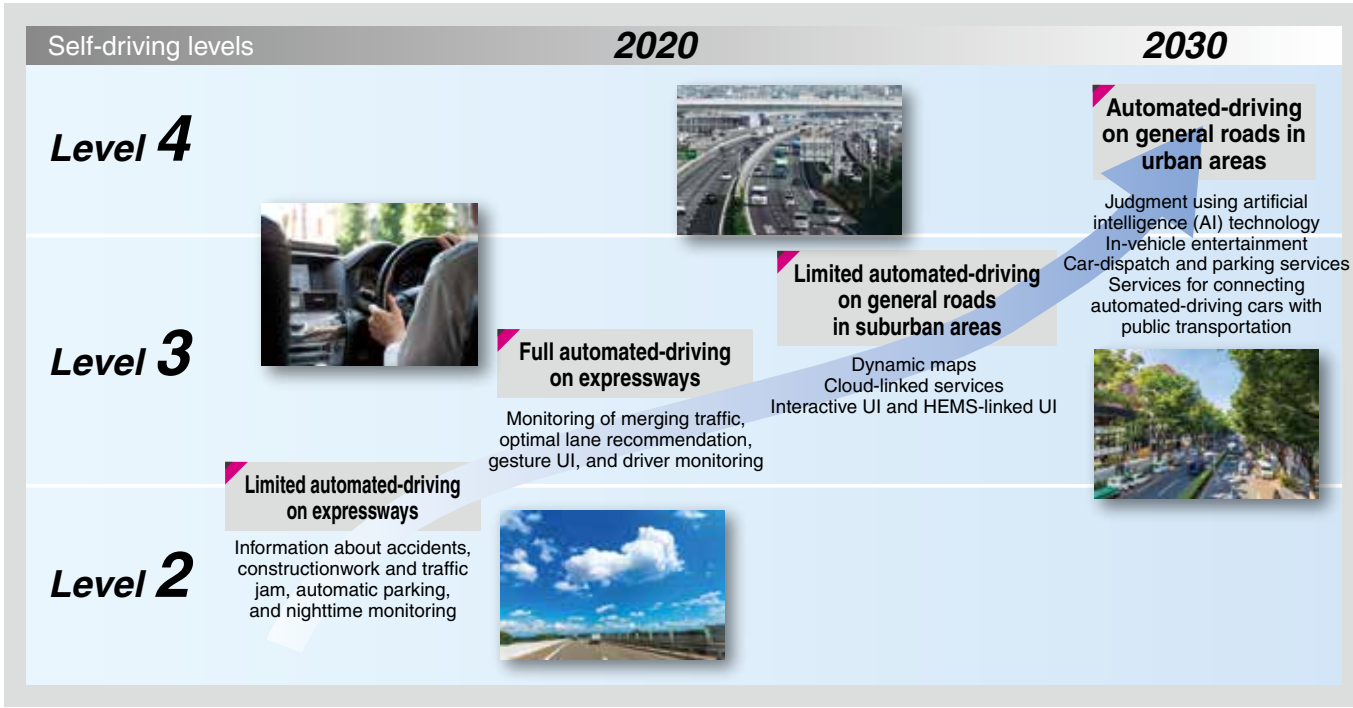
▼ Diodes

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

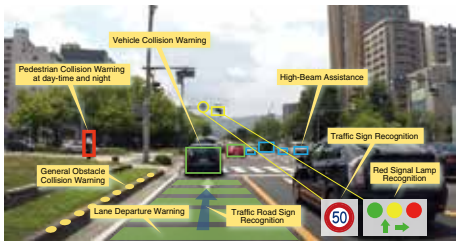
Package Unit (mm)	Part Number	Absolute Maximum Ratings		Electrical Characteristics (max)	AEC
		V_{RRM} (V)	$I_{F\ (AV)}$ (A)	V_{FM} (V)	
S-FLAT 1.6 x 2.6 t = 0.98 	**CRG09A**	400	1.0	1.1 (@0.7A)	○
	CRG10A	600	0.7	1.1	
	CRG05	800	1.0	1.2	
M-FLAT 2.4 x 4.7 t = 0.98 	**CMG02**	400	2.0	1.1	
	CMG03	600	2.0	1.1	

Safety: Automated-Driving

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.

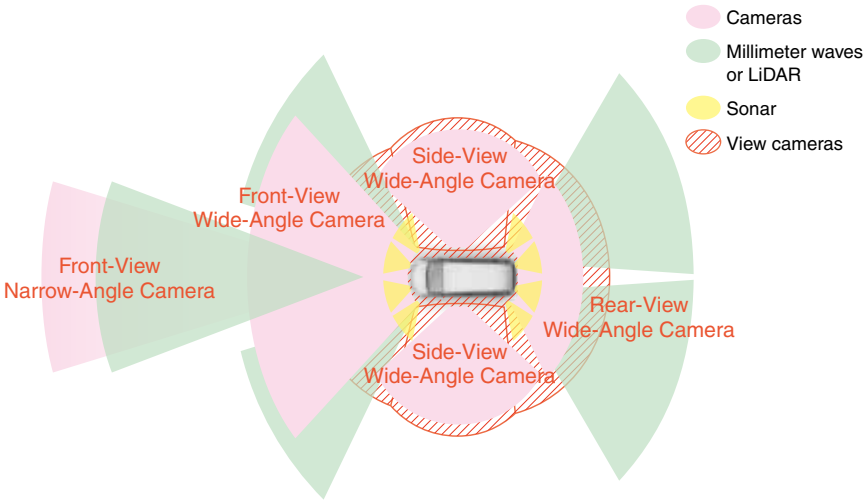


ADAS → P.30



Parking Assist → P.32

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.

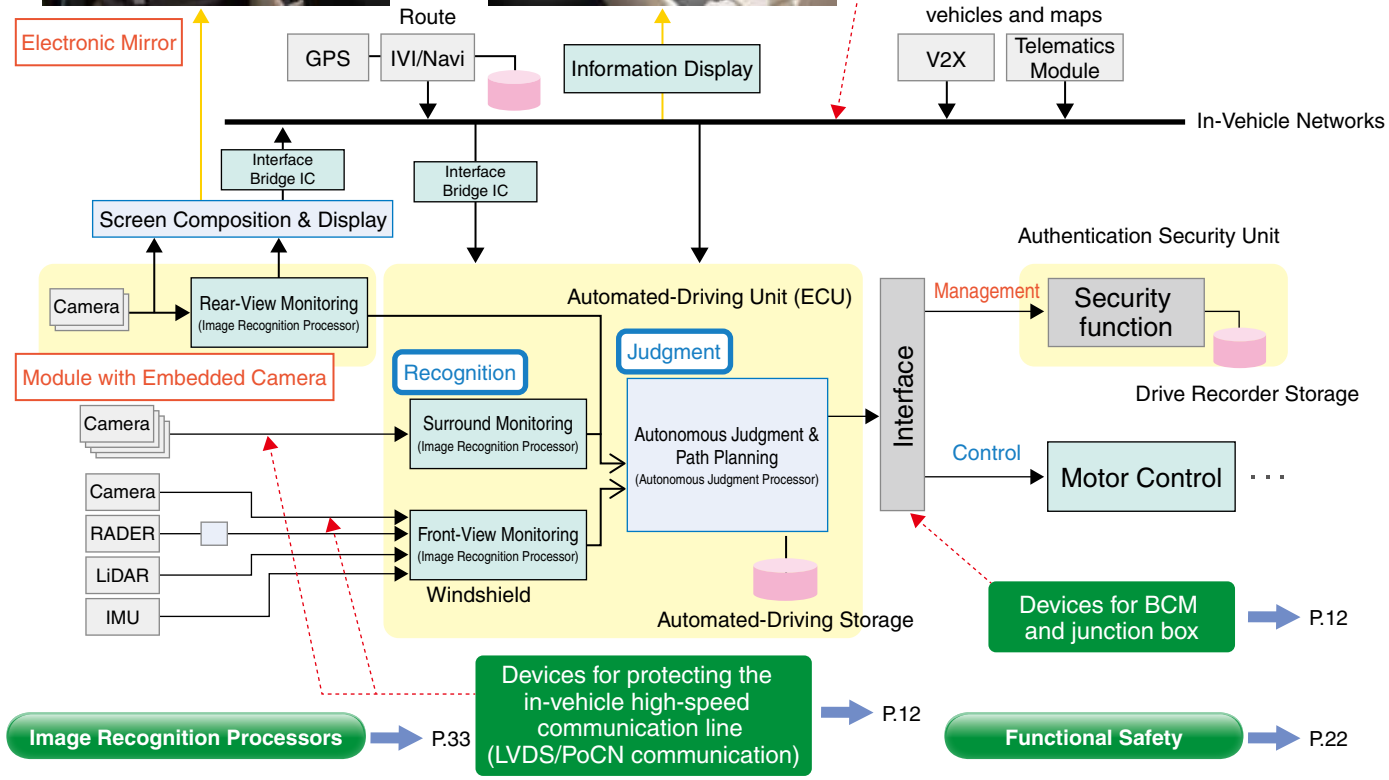


Automotive Video Processors → P.38, 39

Center console

Devices for protecting the in-vehicle LAN (CAN/LIN communication) from outside noise and surge → P.12

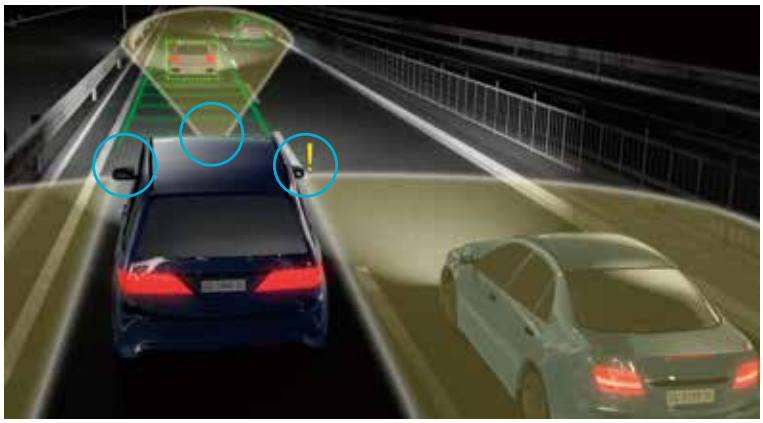
Information about invisible vehicles and maps



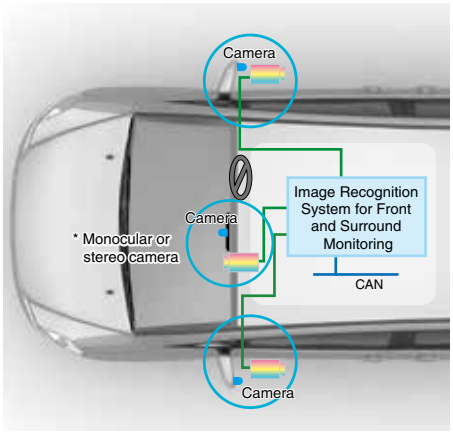
ADAS (Advanced Driver Assistance Systems)

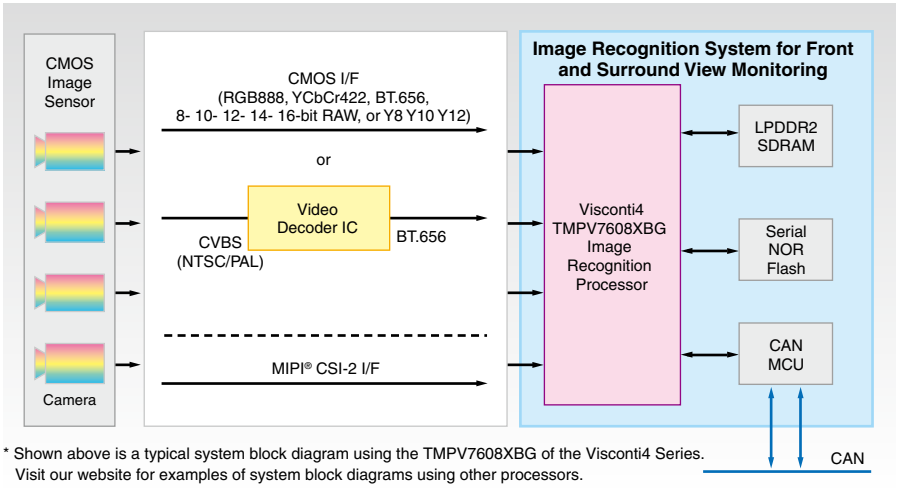
Toshiba offers the Visconti™ Family of image recognition processors that provide extensive support for image feature extraction and recognition using automotive cameras while offering an excellent combination of high performance and low power consumption. Our image recognition processors can run multiple 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.





* Shown above is a typical system block diagram using the TMPV7608XBG of the Visconti4 Series. Visit our website for examples of system block diagrams using other processors.

▼ Image Recognition Processors P.33

Part Number	Series	CPU	MPE	Image Processing Accelerator	Video Input	Main Features	Package
TMPV7608XBG	Visconti4 Series	Two Toshiba-original 32-bit RISC MePs	8	Affine Transformation, Filter, Histogram, HOG, Enhanced CoHOG, Matching, Pyramid, SfM	Up to 8 ch.*	On-chip Memory, Memory Controller, CAN, I²C, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.	PFBGA796
TMPV7528XBG	Visconti3 Series	Toshiba-original 32-bit RISC MeP and Arm®Cortex®-A9 MPCore	4	Affine Transformation, Filter, Histogram, HOG, Matching	Up to 4 ch.	On-chip Memory, Memory Controller, PCI Express®, CAN, I²C, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.	PBGA516
TMPV7506XBG	Visconti2 Series	Toshiba-original 32-bit RISC MeP					
TMPV7504XBG				Affine Transformation, Filter, Histogram, Matching	Up to 2 ch.	On-chip Memory, Memory Controller, CAN, I²C, UART, SPI, PCM, Timer/Counter, External MCU Interface, etc.	
TMPV7502XBG			2	Affine Transformation, Filter, Histogram, HOG, Matching	1 ch	On-chip Memory, Memory Controller, CAN, I²C, UART, SPI, PCM, Timer/Counter, etc.	PLFBGA324

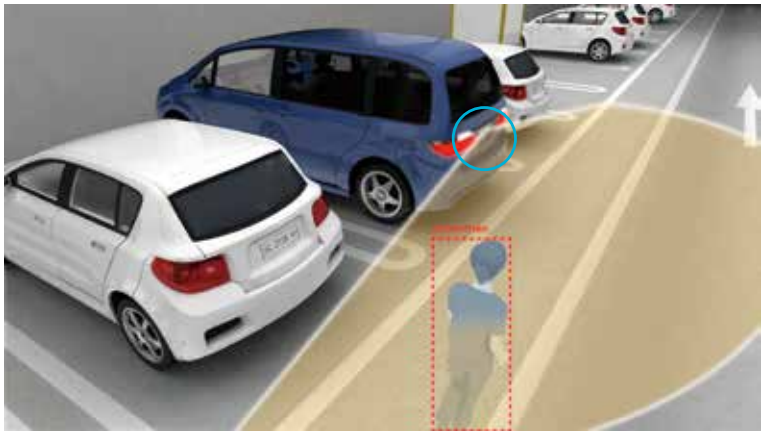
* The video input interface of the TMPV7608XBG has a 4-of-8 video switch.

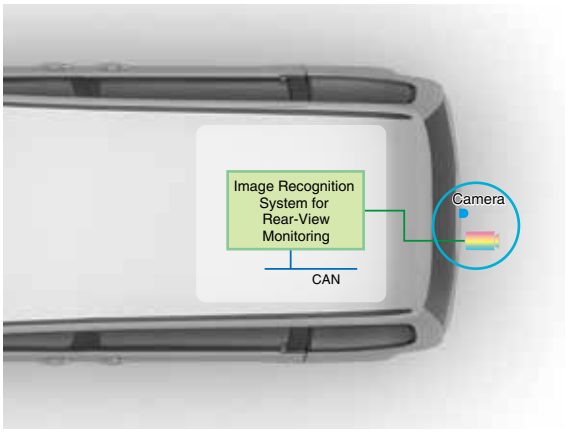
▼ Video Decoder ICs P.39

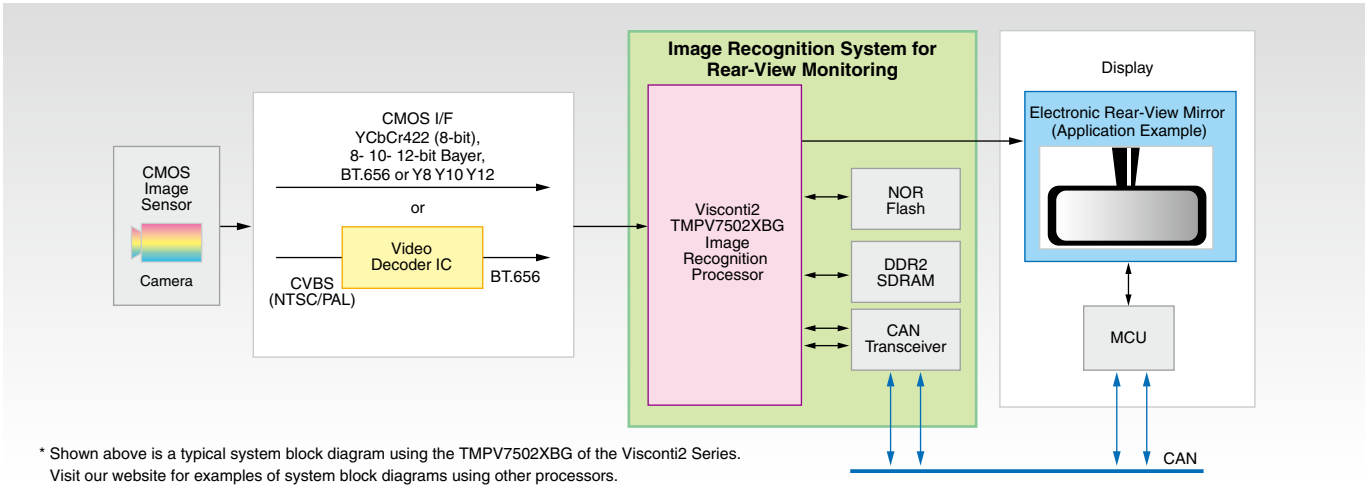
Part Number	Features & Functions	Operating Temperature	Supply Voltage (V)	Package
TC90105FG	Two video decoder channels, 2.5-V voltage regulator, newly developed picture adjustment function, horizontal aberration correction, ITU-R BT.656 output	−40 to +85°C	1.4 to 1.6 2.3 to 2.7 3.0 to 3.6	LQFP 80pin 12 x 12 mm
TC90107FG	One video decoder channel, 2.5-V voltage regulator, newly developed picture adjustment function, horizontal aberration correction, ITU-R BT.656 output			LQFP 64pin 10 x 10 mm

▼ 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.

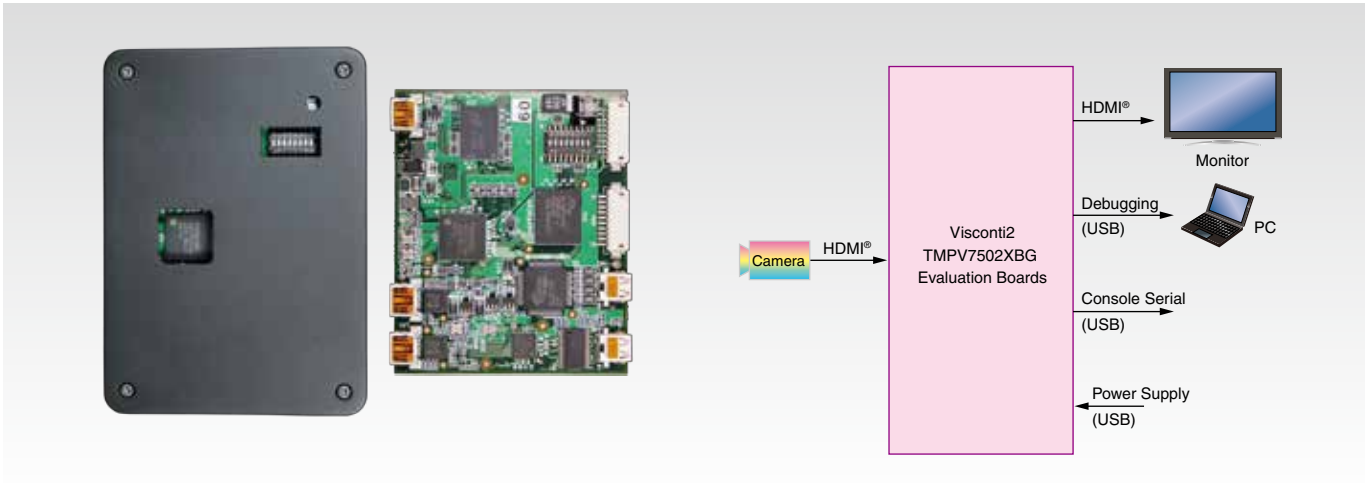






* Shown above is a typical system block diagram using the TMPV7502XBG of the Visconti2 Series.
Visit our website for examples of system block diagrams using other processors.

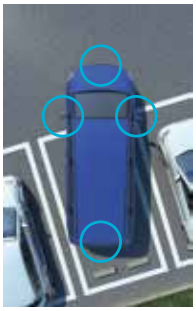
▼ Visconti2 TMPV7502XBG Evaluation Board

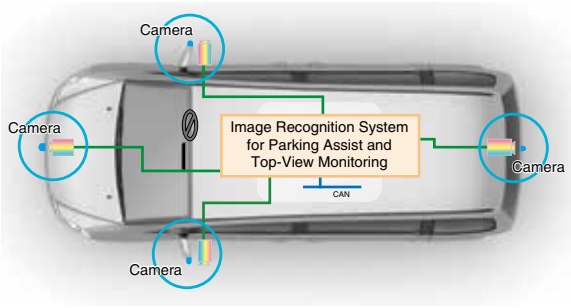


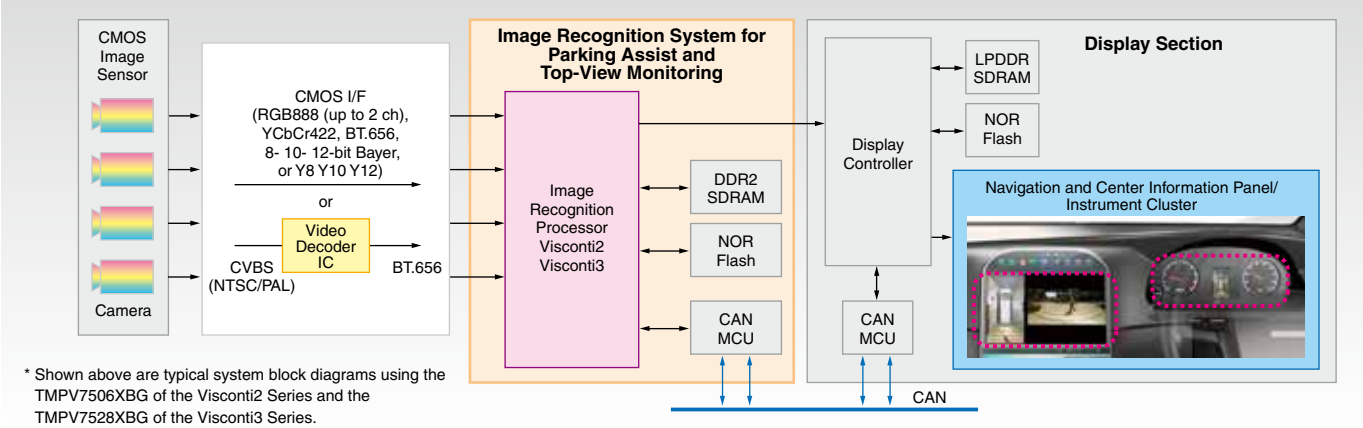
* MIPI is a registered trademark owned by the MIPI Alliance.
* HDMI is a trademark or registered trademark of HDMI Licensing, LLC in the United States and/or other countries.
* Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.
* PCI Express and PCIe are trademarks or registered trademarks of PCI-SIG.

Parking Assist Systems

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.

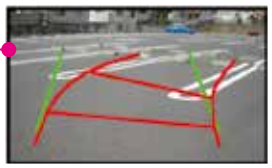






* Shown above are typical system block diagrams using the TMPV7506XBG of the Visconti2 Series and the TMPV7528XBG of the Visconti3 Series.
Visit our website for examples of system block diagrams using other processors.

▼ **Image Recognition from Top and Rear Views**



▼ **Parking Assist by Line Rendering**

▼ Lineup

	Series	Part Number	Page
Image recognition processors	Visconti4	**TMPV7608XBG**	33,34,35,36
	Visconti3	**TMPV7528XBG**	
	Visconti2	**TMPV7506XBG**	
		TMPV7504XBG	
		TMPV7502XBG	

	Series	Part Number	Page
Video processors	Dual/single-picture video processors	**TC90195AXBG**	38
		TC90175XBG	
	Video Decoder ICs	**TC90105FG**	39
		TC90107FG	

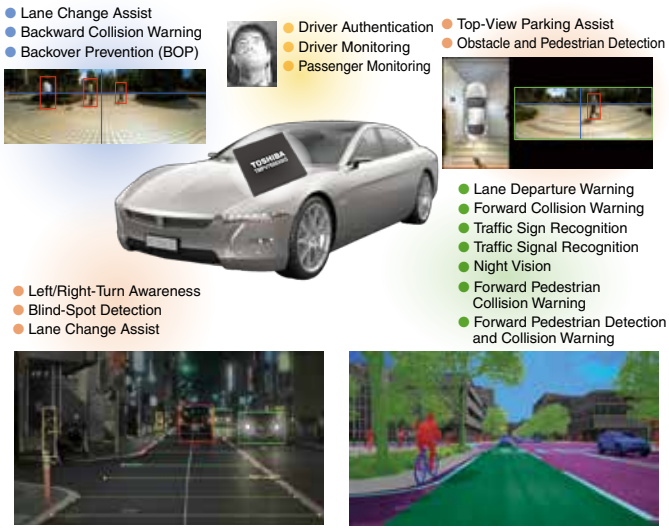
Visconti™ Image Recognition Processors

Running image recognition algorithms necessary for an ADAS at high speed and low power consumption

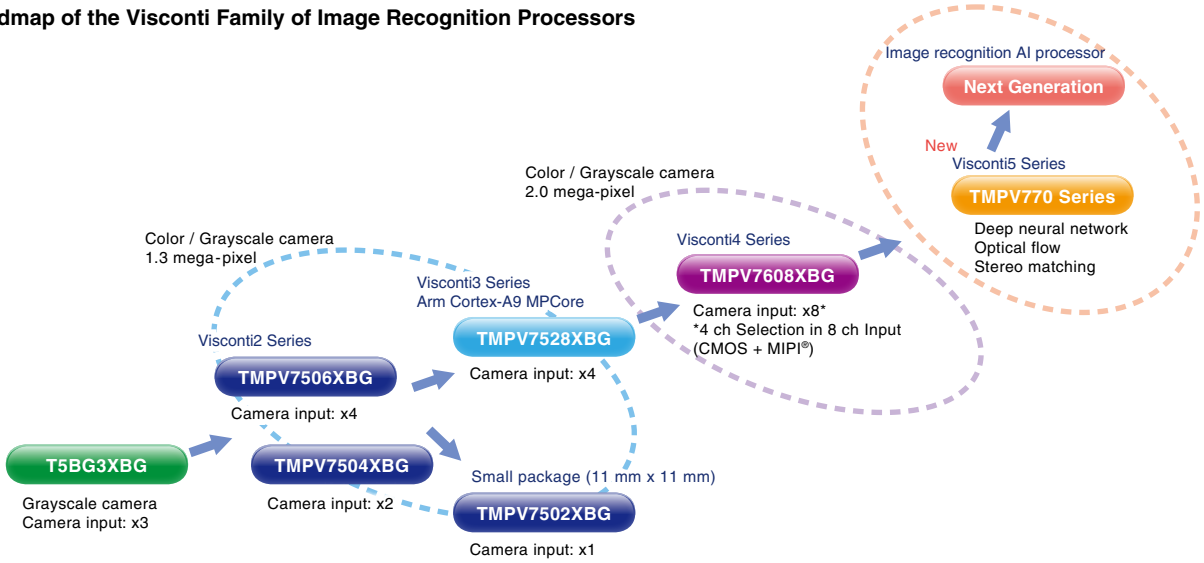
▼ Features

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 and 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.

▼ Driving Assistance Applications



▼ Roadmap of the Visconti Family of Image Recognition Processors



▼ Lineup

Series	Part Number	Maximum Operating Frequency (MHz) (MeP, MPE)	Media Processing Engine [MPE]	Image Processing Accelerator: Affine Transformation	Pyramid	Filter	Histogram	Histogram of Oriented Gradients [HOG]	Enhanced CoHOG	Matching	SfM	Video Input Interface (ch)	Video Output Interface (ch)	PCI Express®	UART	SPI	I²C	CAN	PCM	Memory Controller	CPU Core: Toshiba's Proprietary 32-bit RISC CPU MeP	CPU Core: Arm 32-bit RISC Arm® Cortex®-A9 MPCore	Package
Visconti2	**TMPV7502XBG**	266.7	○	○	–	○	○	○	–	○	–	1	1	–	5	1	4	2	2	DDR2-SDRAM, SRAM, ROM, NOR Flash	○	–	PLFBGA324
	TMPV7504XBG	266.7	○	○	–	○	○	–	–	○	–	2	1	–	5	4	4	3	2	DDR2-SDRAM, SRAM, ROM, NOR Flash	○	–	PBGA516
	TMPV7506XBG	266.7	○	○	–	○	○	○	–	○	–	4	1	1	5	4	4	3	2	DDR2-SDRAM, SRAM, ROM, NOR Flash	○	–	PBGA516
Visconti3	**TMPV7528XBG**	266.7 (300)	○	○	–	○	○	○	–	○	–	4	1	1	5	4	4	3	2	DDR2-SDRAM, SRAM, ROM, NOR Flash	○	○	PBGA516
Visconti4	**TMPV7608XBG**	266.7	○	○	○	○	○	○	○	○	○	8	1	–	5	4	8	3	2	LPDDR2-SDRAM, SRAM, ROM, NOR Flash	○	–	PFBGA796

* 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.
* Contact the Toshiba sales representative for information about RoHS compliance before you purchase any components.

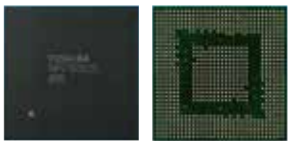
* MIPI is a registered trademark owned by the MIPI Alliance.
* MediaLB is a registered trademark of Microchip Technology Inc. in the US and other countries.
* PCI Express and PCIe are trademarks or registered trademarks of PCI-SIG.
* Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

Visconti™ Image Recognition Processors

Visconti4 Series

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

▼ Package

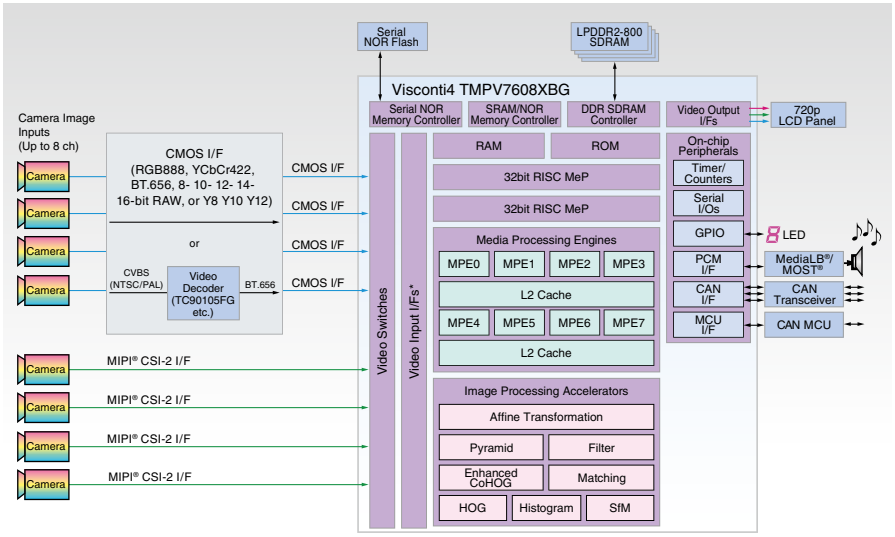


Package size
27 mm x 27 mm

P-FBGA 796 Ball
0.8 mm Ball pitch

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



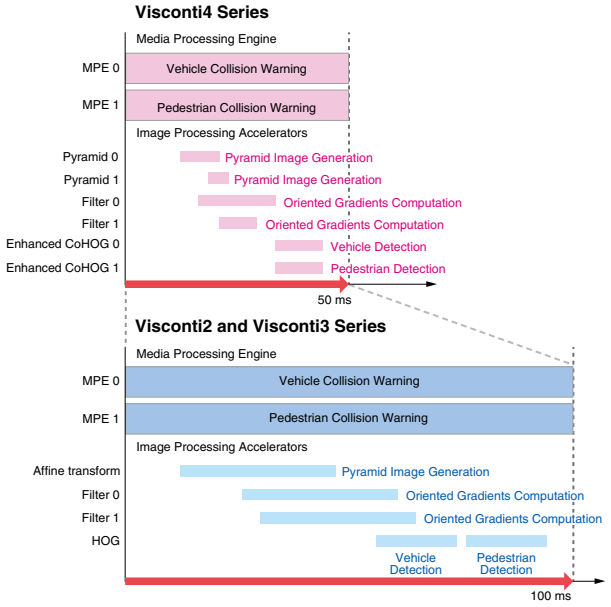
* The video input interface of the TMPV7608XBG has a 4-of-8 video switch.

Features of Visconti

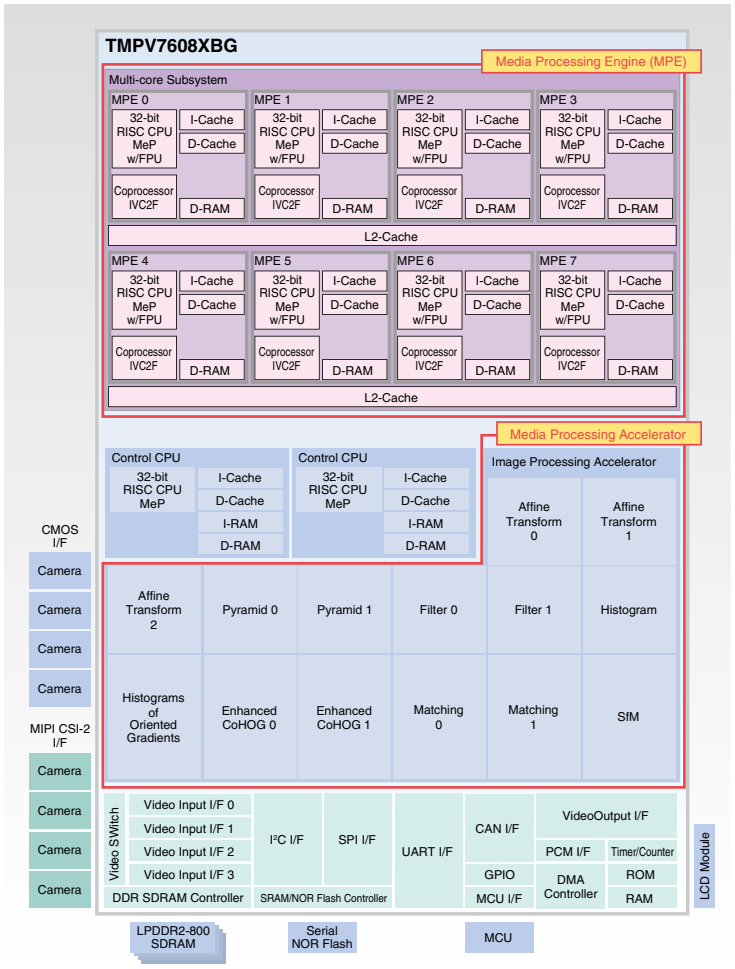
▼ Feature 1: 10 times the image processing performance of the conventional product (Visconti4)

The Visconti4 Series incorporates eight new image processing engines called Media Processing Engines (MPEs) with a double-precision floating-point unit, and various image processing accelerators*1, numbering 14 in all, to achieve 10 times*2 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



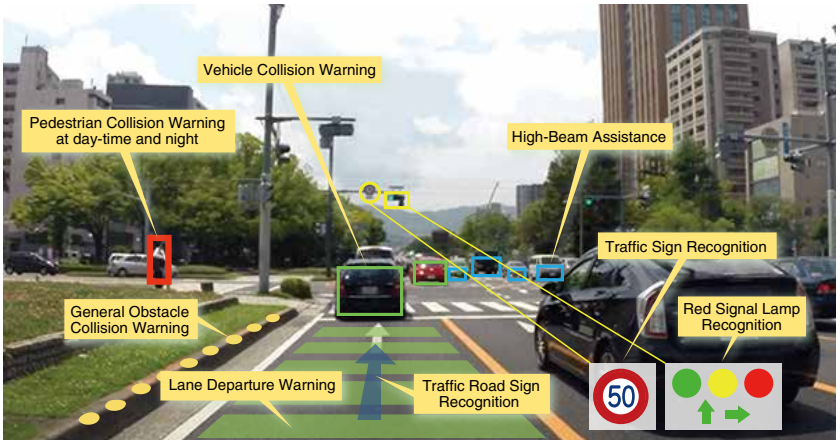
▼ Visconti4 Block Diagram



▼ 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 2 (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.

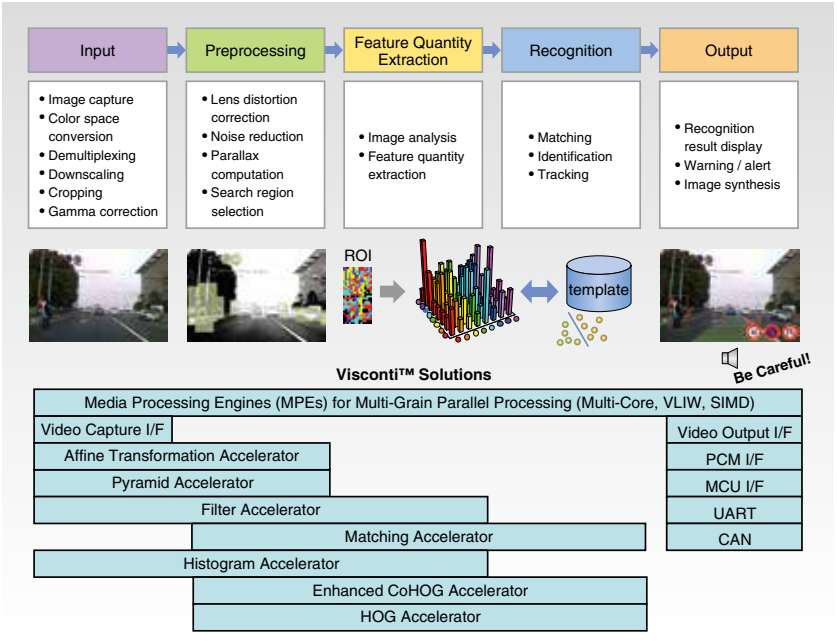


▼ Feature 3: Toshiba's original pattern recognition using color features (Visconti4)

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 TMPV7504XBG) 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.



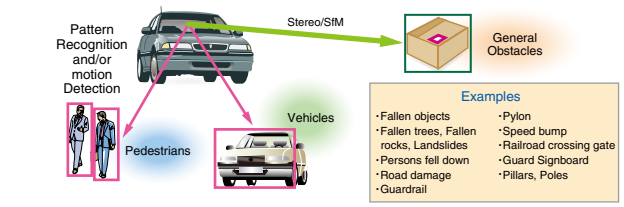
Visconti™ Image Recognition Processors

▼ Feature 5: General obstacle detection using 3D reconstruction technology (TMPV7608XBG of the Visconti4 Series)

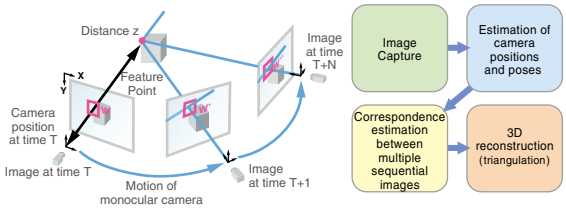
The Structure from Motion (SfM) accelerator allows detection of general stationary obstacles such as fallen objects, fallen rocks and landslides.

Detection of Road Obstacles Using 3D Reconstruction Technique

Not only pedestrians, vehicles and moving objects but also static obstacles are detectable.

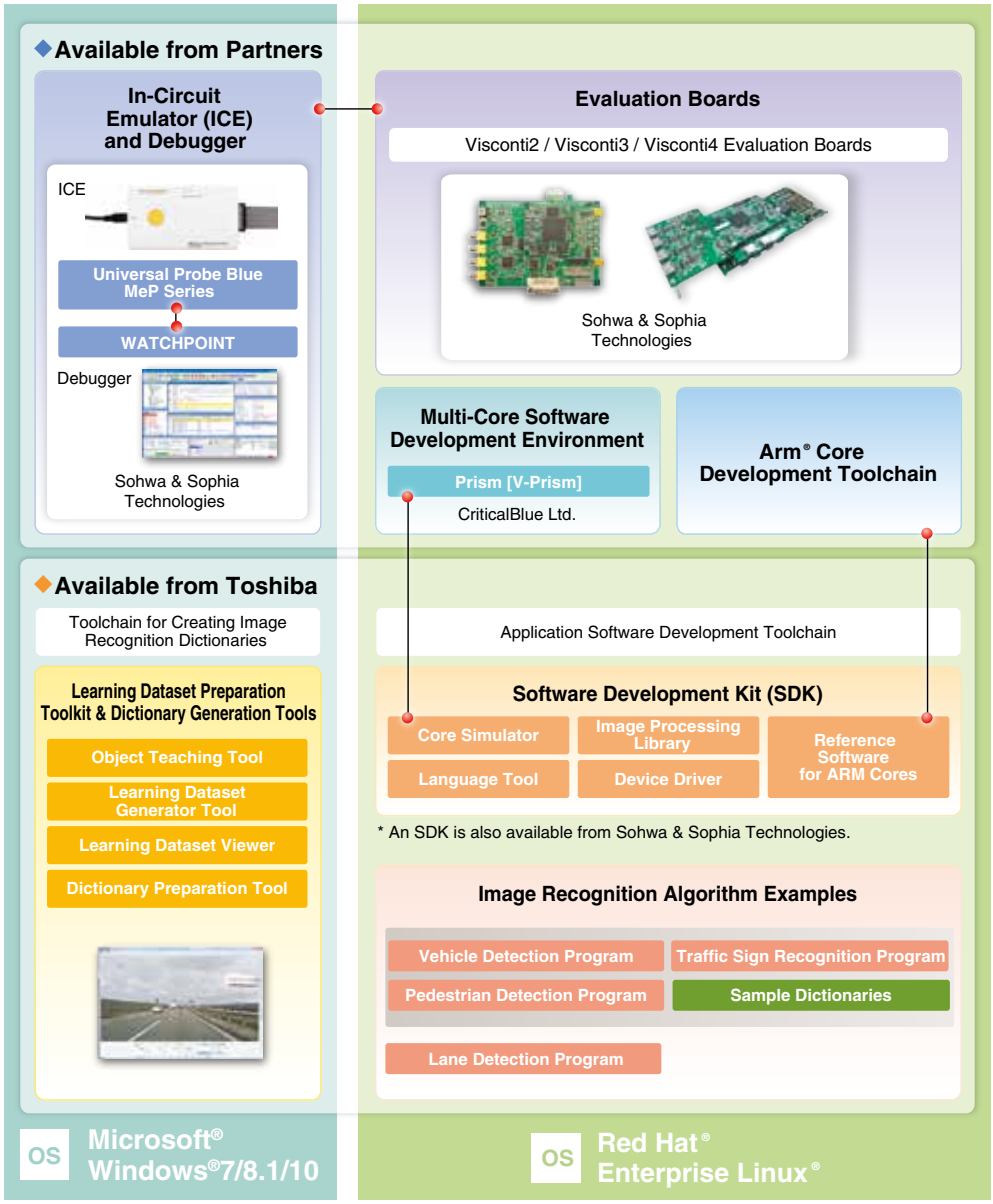


3D reconstruction technology



Software Development Environments

For details of software development environments for the Visconti2 / Visconti3 / Visconti4 series, see the following table.



*Microsoft and Windows are registered trademarks or trademarks of Microsoft Corporation in the U.S. and other countries.
*Red Hat and Enterprise Linux are registered trademarks of Red Hat, Inc. in the U.S. and other countries.

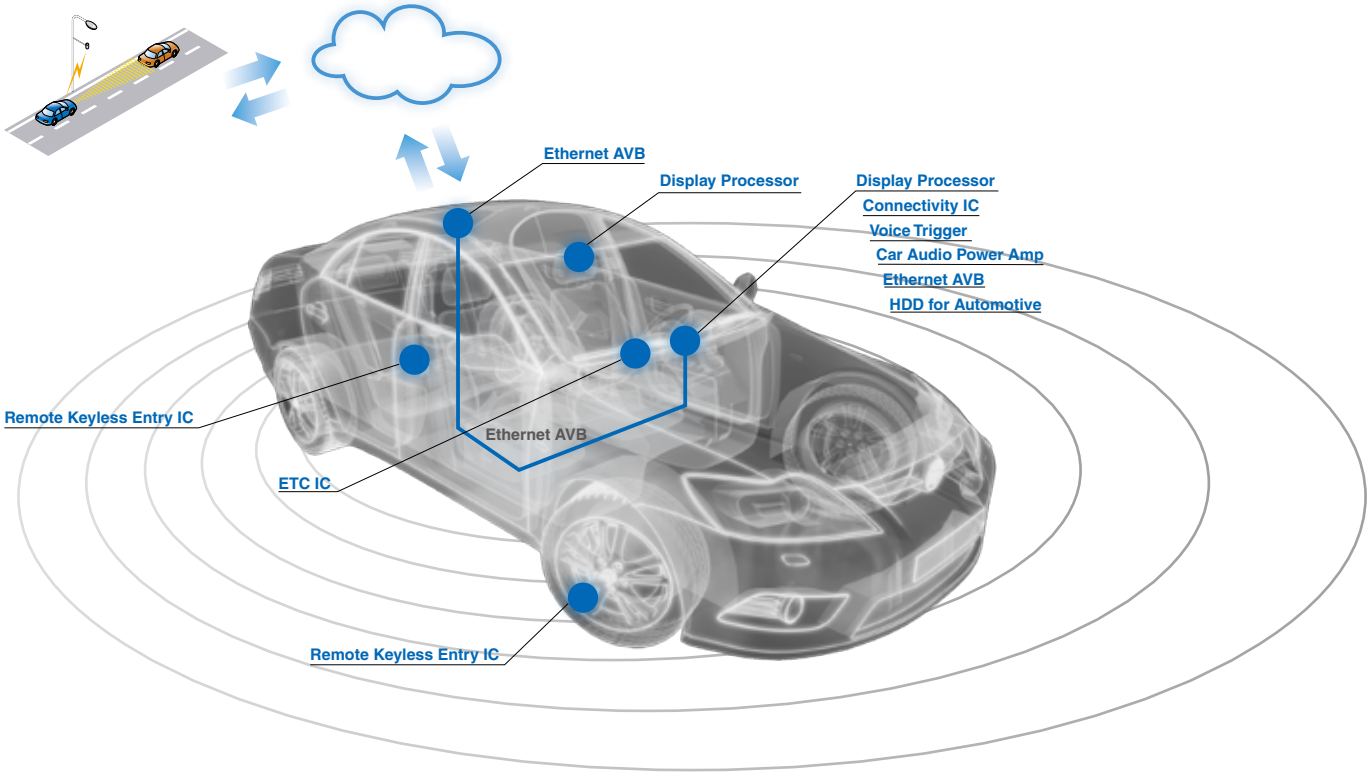
Information and Entertainment Applications

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	Connection between occupants and cars	Connection between outside and cars
Personal devices such as portable audio are easily connected to cars.	Occupants can naturally and directly communicate with cars without any media such as mobile phone.	As IoE is increasingly adopted, cars become capable of directly collecting and utilizing various information.

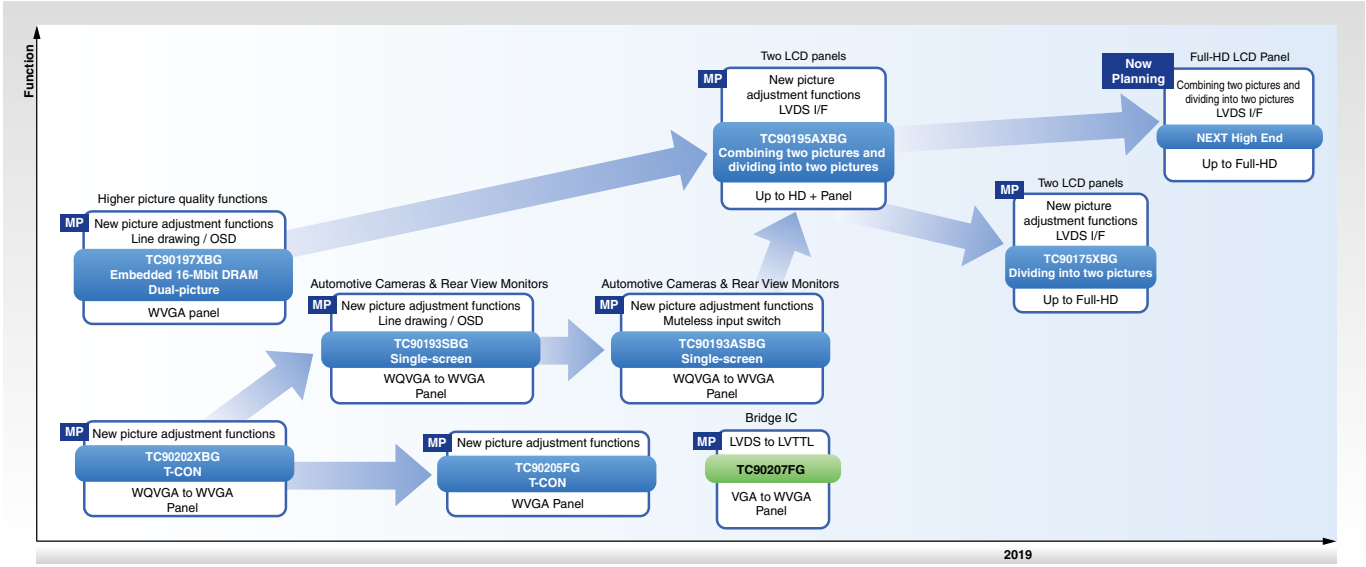
Key products for realizing connected cars



Dual/Single-Picture Video Processors

Dual/Single-Picture Video Processors

▼ Roadmap

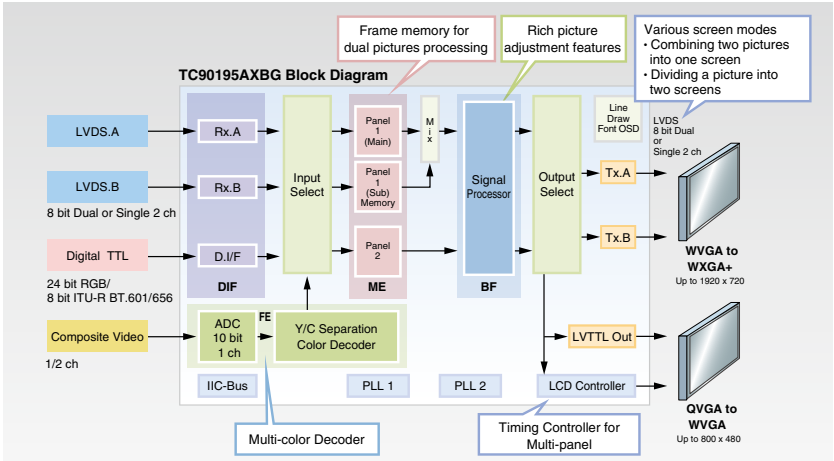


▼ Highlights

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.

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.

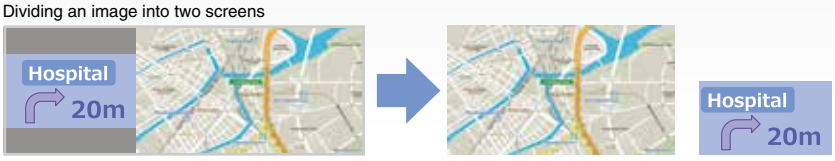


▼ TC90195AXBG

- 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)

Various Display Features

Dividing an image into two screens



Input picture (2080 x 720) | Output picture 1 (1280 x 720) | Output picture 2 (800 x 480)

▼ Lineup

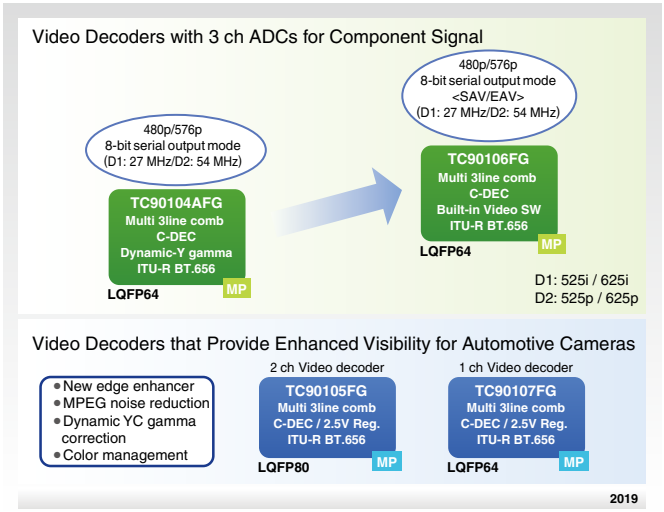
Part Number	Package	Status	Function	ADC	Color Decoder	Dual pictures Overlay	Muteless Input Switch	New Picture Adjustment	LVDS Input	Supported LCD Size	Operating Temperature	Supply Voltage (V)
TC90195AXBG	LFBGA 293pin 17 x 17 mm	MP	Dual pictures	1	1	○	○	○	○	WXGA+	−40 to +85˚C	1.1 to 1.3 3.0 to 3.6
TC90175XBG			Single picture (It can divide into two pictures)	1	1	–	○	○	○	Full-HD		
TC90197XBG	LBGA 256pin 17 x 17 mm		Dual pictures	4	2	○	–	○	–	WVGA		1.4 to 1.6 2.3 to 2.7 3.0 to 3.6
TC90193SBG	FBGA 228pin 15 x 15 mm		Single picture (Rear-view monitor)	1	1	–	–	○	–	WVGA		
TC90193ASBG							○					
TC90202XBG	FBGA 121pin 10 x 10 mm		Picture quality adjustment	–	–	–	–	○	–	WVGA		1.4 to 1.6 3.0 to 3.6
TC90205FG	LQFP 80pin 12 x 12 mm		Picture quality adjustment	–	–	–	–	○	–	WVGA		
TC90207FG	LQFP 64pin 10 x 10 mm		LVDS-to-LVTTL bridge IC	–	–	–	–	–	○	WVGA		1.4 to 1.6 3.0 to 3.6

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.

Video Decoder ICs

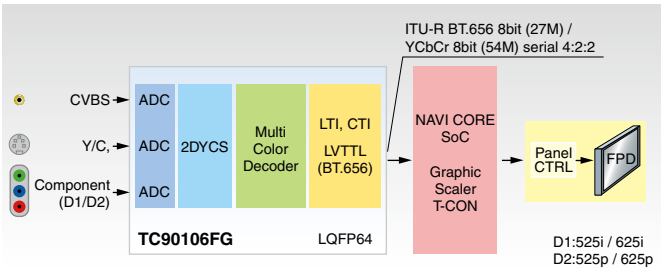
Video Decoder ICs

▼ Roadmap



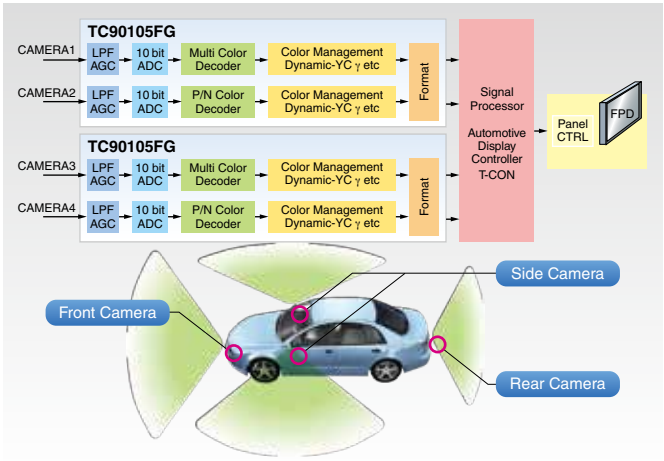
▼ Full, Multi-Standard Video Decoder IC: TC90106FG

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 ITUR-656 output interface, an 8-bit serial (SAV/EAV insertion) output is selectable for a D2 video input, with the clock rate converted from 27 MHz to 54 MHz.



▼ 2-Channel Multi-Standard Video Decoders IC: TC90105FG

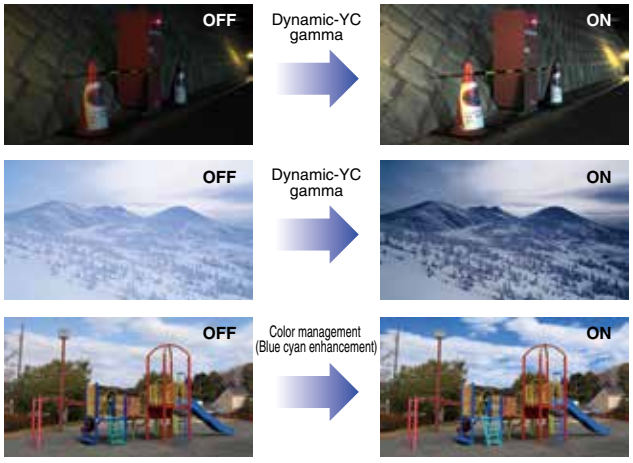
The TC90105FG contains is two channels of video decoders, featuring various picture adjustment functions, such as an HV & diagonal (HVD) enhancer, color management and dynamic YC gamma correction. It allows image rendering, according to the videos from automotive cameras.



▼ 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

Part Number	Package	Status	Function	ADC	Component Video Input (D2 Signal)	Color Decoder(s)	New Picture Adjustment	ITU-R BT.601 Output	ITU-R BT.656 Output	8-Bit Serial Output (D2 Signal)	Operating Temperature	Supply Voltage (V)
TC90104AFG	LQFP 64pin 10 x 10 mm	MP	Video decoder	3	○	1	–	○	○	○	−40 to +85˚C	1.4 to 1.6 2.3 to 2.7 3.0 to 3.6
TC90106FG	LQFP 64pin 10 x 10 mm		Video decoder	3	○	1	–	–	○	○ Embedded SAV/EAV		
TC90105FG	LQFP 80pin 12 x 12 mm		Video decoder with 2.5 V regulator	2	–	2	○	○	○	–		
TC90107FG	LQFP 64pin 10 x 10 mm		Video decoder with 2.5 V regulator	1	–	1	○	–	○	–		

Automotive Peripheral Bridge ICs

The Peripheral Bridge IC supports the transmission of various image signals between the main processor and peripheral devices.

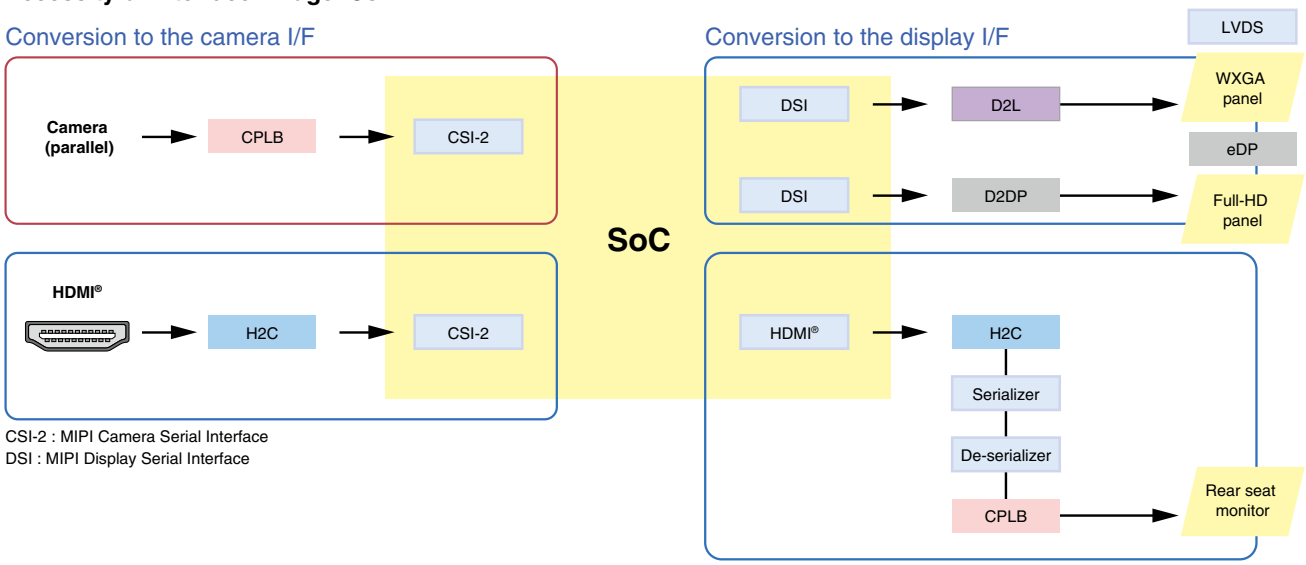
1. Support of various high-speed serial transmission systems

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

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

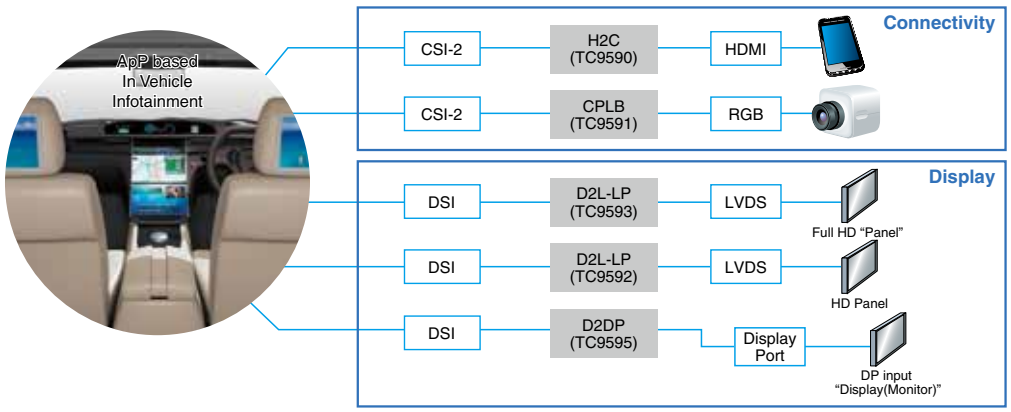
The interface bridge IC solves the connectivity issue that prohibits the as-is connection among peripheral devices, such as between the IVI SoC and display, due to interface difference.

▼ Necessity of Interface Bridge ICs



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

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



▼ Lineup

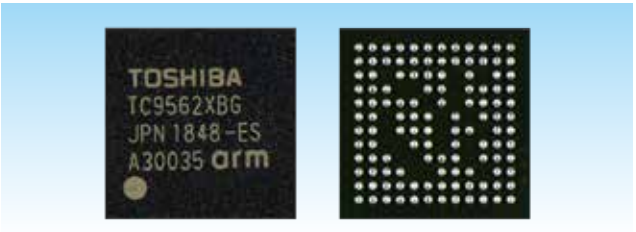
Symbol	Part Number	Input	Output	Resolution	Ta	Package
H2C	**TC9590XBG**	HDMI 1.4a	MIPI CSI-2 4 lane x 1ch	–	–40 to 85˚C	P-LFBGA64 7 mm x 7 mm 0.8 mm pitch
CPLB	**TC9591XBG**	MIPI CSI-2 4 lane x 1ch Parallel input 24bit@166Mhz	Parallel output 24bit@100MHz MIPI CSI-2 4 lane x 1ch	–	–40 to 105˚C	P-VFBGA80 7 mm x 7 mm 0.65 mm pitch
D2L-LP	**TC9592XBG**	MIPI DSI 4 lane x 1ch	LVDS Single Link (5pairs/link)	UXGA 1600x1200 24bit	–40 to 85˚C	P-VFBGA49 5 mm x 5 mm 0.65 mm pitch
	TC9593XBG	MIPI DSI 4 lane x 1ch	LVDS Dual Link (5pairs/link)	WUXGA 1920x1200 24bit	–40 to 85˚C	P-VFBGA64 6 mm x 6 mm 0.65 mm pitch
D2DP	**TC9595XBG**	MPI DSI 4 lane x 1ch Parallel input 24bit@154Mhz	DisplayPort 1.1a	WUXGA 1920x1200 24bit	–40 to 85˚C	P-VFBGA80 7 mm x 7 mm 0.65 mm pitch

Automotive Ethernet Bridge ICs

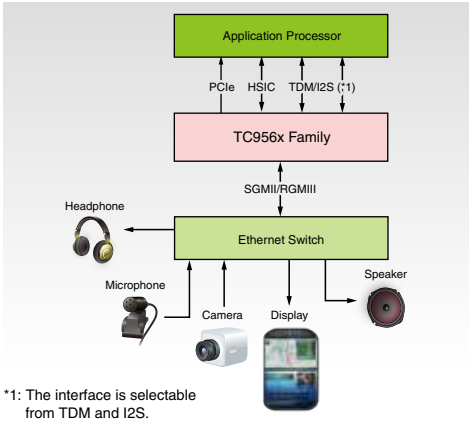
The TC9560 and TC9562 families provide the Ethernet AVB and Ethernet TSN (for TC9562BXBG only) interfaces as well as various audio, video and data interfaces, making each family suitable as a bridge IC for in-vehicle IP networks for telematics and next-generation IVI applications.

▼ Bridge ICs for Next-Generation In-Vehicle Infotainment (IVI) Systems: TC9560 and TC9562 families

The TC9560 and TC9562 families are bridge ICs compliant with IEEE 802.1AS and IEEE 802.1Qav, part of the set of Ethernet AVB standards that support Gigabit Ethernet (10/100/1000 Mbps).
The TC9562BXBG is compliant with the Ethernet TSN standards as well. These devices provide reliable and low-latency data communication through timing synchronization and packet prioritization. In addition, the TSN standards are expected to be applied to industrial equipment.

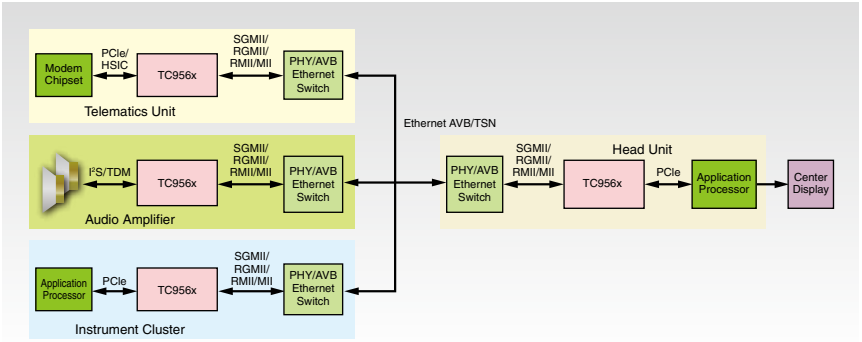


■ System Block Diagram



*1: The interface is selectable from TDM and I2S.

■ Interfacing Example



■ Features

1. The TC9560 and TC9562 families incorporates 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 TC9562BXBG is compliant with the Ethernet TSN standards [compliant with IEEE802.1 Qbv, IEEE802.1 Qbu and IEEE802.3 br] as well.
2. Provides an Ethernet PHY interface selectable from SGMII, RGMII, RMII and MII depending on model.
3. The TC9560 and TC9562 families provides PCIe Gen2.0 (5 GT/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 has 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.

■ Demonstration Board

Part Number	Package	Host (External application) I/F:	Automotive I/F				Audio I/F:	Peripheral I/F:	CPU Core:	Supply Voltage(V)
			Ethernet AVB [IEEE802.1AS, IEEE802.1Qav]	Ethernet TSN [IEEE802.1 Qbv, IEEE802.1 Qbu, IEEE802.3 br]	MAC-PHY I/F	CAN-FD				
TC9560XBG	PLFBGA170 (0.65)	PCIe I/F Gen2.0 (5 GT/s), Endpoint, Single lane	✓		RGMII /RMII /MII		I2S/TDM	• I2C/SPI • Quad-SPI • UART • GPIO • INTC	Arm® Cortex® M3	1.8/3.3 for IO 1.8/2.5/3.3 for RGMII/RMII/MII, 1.8 for PCIe, 1.1 for Core
TC9560AXBG **			✓			2ch				1.8/3.3 for IO 1.8/2.5/3.3 for RGMII/RMII/MII, 1.8 for PCIe, 1.1 for Core
TC9560BXBG **		HSIC I/F (480 Mbps)	✓							1.8/3.3 for IO 1.2 for HSIC 1.8/2.5/3.3 for RGMII/RMII/MII, 1.1 for Core
TC9562XBG**	PLFBGA120 (0.65)	PCIe I/F Gen2.0 (5 GT/s), Endpoint, Single lane	✓							1.8/3.3 for IO 1.8/2.5/3.3 for RGMII/RMII/MII, 1.8 for PCIe, 1.1 for Core
TC9562AXBG**			✓		RGMII /RMII /MII /SGMII					1.8/3.3 for IO 1.8/2.5/3.3 for RGMII/RMII/MII, 1.8 for SGMII, 1.8 for PCIe 1.1 for Core
TC9562BXBG**			✓	✓						1.8/3.3 for IO 1.8/2.5/3.3 for RGMII/ RMII/MII, 1.8 for SGMII, 1.8 for PCIe, 1.1 for Core

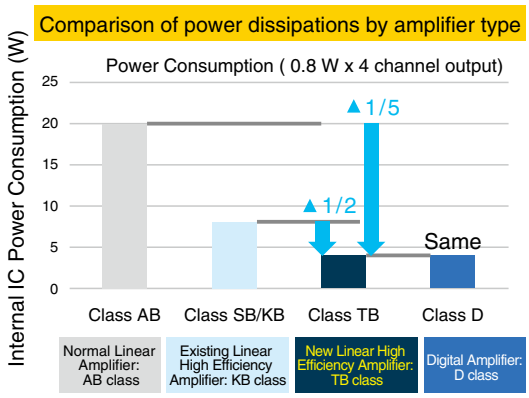
**: Under development

In-Vehicle Audio Power Amplifier ICs

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

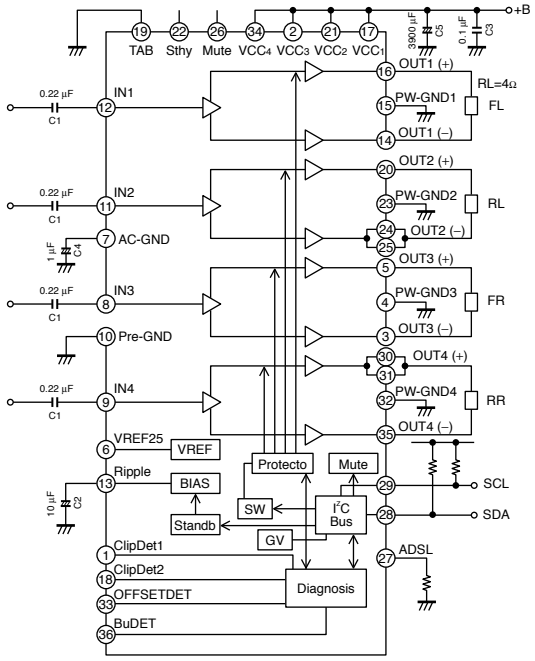
A function is installed that performs constant (full-time) monitoring for abnormal output DC offset and informs the microcontroller if it detects any.
→ **Realizes the speaker burning prevention system**

■ +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) ☑ Full-time offset detection function (Toshiba patent)

Process	Part Number	Max Output VCC = 15.2 V	Max Output VCC = 14.4 V	Class	Voltage Gain	I²C Bus	Offset Detection	Clip Detection	Short-Circuit Detection	High-Side Switch	Half Short Det.	Speaker Burning Prevention	2-Ω Load	GSM Support	6-V Operation	Package	Availability
BiCD 0.13 um	**TB2952AHQ**	49 W	45 W	AB	26 dB/12 dB	✓	✓	✓	✓		✓		✓	✓	✓	HZIP25	MP
	TB2975HQ	49 W	45 W	KB	26 dB/16 dB	✓	✓	✓	✓		✓		✓	✓	✓	HZIP25	
CD 0.13 um	**TCB001HQ TCB001FNG**	45 W	40 W	AB	26 dB		✓		✓			✓		✓	✓	HZIP25 HSOP36	
	TCB501HQ	49 W	44 W	AB	26 dB		✓		✓	✓	✓		✓	✓	✓	HZIP25	
	TCB502HQ	49 W	44 W	AB	26 dB		✓		✓		✓		✓	✓	✓	HZIP25	
	TCB503HQ	49 W	44 W	AB	26 dB		✓	✓	✓		✓		✓	✓	✓	HZIP25	ES:OK
	TCB701FNG*	49 W	45 W	TB	26 dB/16 dB	✓	✓	✓	✓		✓		✓	✓	✓	HSOP36	MP 2019/1Q
	TCB702FNG	45 W	40 W	TB	26 dB/16 dB	✓	✓	✓	✓		✓			✓	✓	HSOP36	

*: New product

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

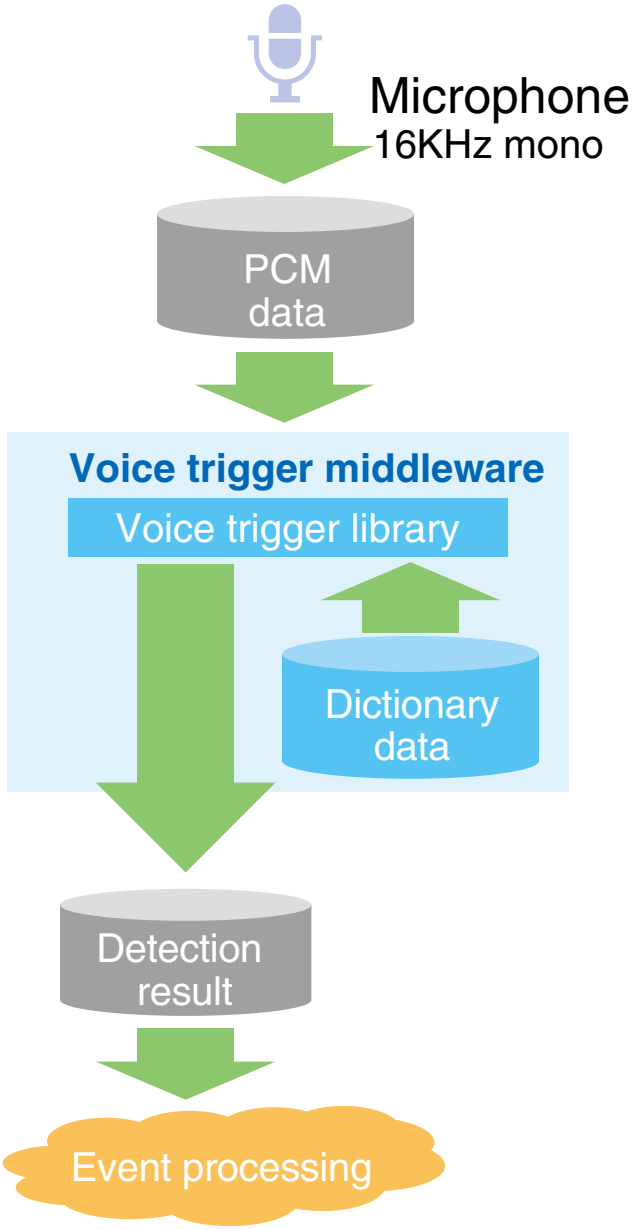
Process	Part Number	Max Output VCC = 16 V	Max Output VCC = 12 V	Class	Voltage Gain	Thermal Detection	Speaker Open-Circuit Detection	Output Short-Circuit Detection	Overvoltage Detection	Applications	Package	Availability
BiCD0.13um	**TB2909FNG**	5 W	3 W	AB	26 dB (variable)	✓	✓	✓	✓	AVAS, etc.	TSSOP16	MP

Speech Middleware (Voice Trigger)

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

1. High-speed response	2. High detection rate	3. Small resource requirement
A response to a trigger word is given in approx. 0.1 sec. The system responds before voice input ends.	Deep learning technology secures high detection rate even in noisy environment.	Since required CPU power/memory is small, it can be used for embedding.

Voice-triggered, switchless operation



Specifications	
CPU	75MIPS
ROM	200KB
RAM	230KB(Note1)
Detection rate	97.5% at SNR 0dB(Note1)
Compatible platform	• Windows® • Linux® • Android™/iOS® • Non OS

(Note 1) Values measured by Toshiba. Values are subject to change according to measurement conditions.

Sources
• Dictionary data • Voice trigger library • Header file • Sample program • Manual

Target Applications of Automotive Communication ICs

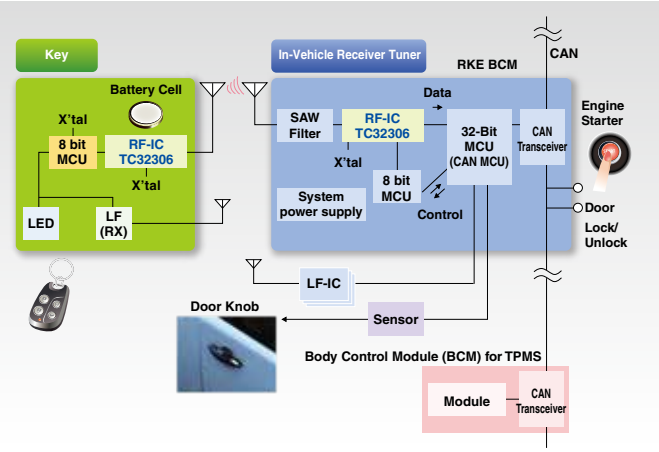
Toshiba's portfolio of automotive communication ICs includes ICs for remote keyless entry (RKE), electronic toll collection (ETC), and Bluetooth. RF devices not only allow remote operations but also can be used to receive information from a tire pressure monitoring system (TPMS) for display on the instrument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

Block	Product name	Page
RF-IC	**TC32306FTG**	P.45
8 bit MCU	**TMP89FM82TUDG**	–
32 bit MCU	**TMPM358FDTFG**	P.20
System power supply	**TB9005FNG** **TB9021FNG** **TB9042FTG** **TB9044AFNG**	P.17

Block Diagram of a Remote Keyless Entry System

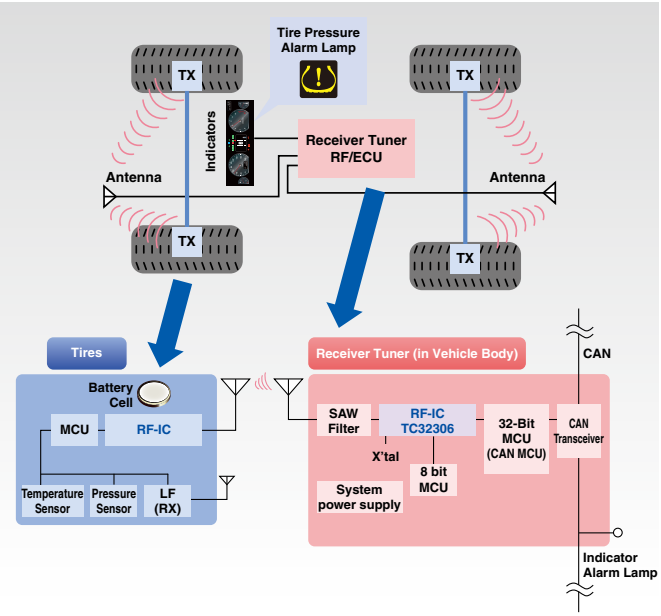


Tire Pressure Monitoring System (TPMS)

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.

Block	Product name	Page
RF-IC (in-vehicle)	**TC32306FTG**	P.45
8 bit MCU	**TMP89FM82TUDG**	–
32 bit MCU	**TMPM358FDTFG**	P.20
System power supply	**TB9005FNG** **TB9021FNG** **TB9042FTG** **TB9044AFNG**	P.17

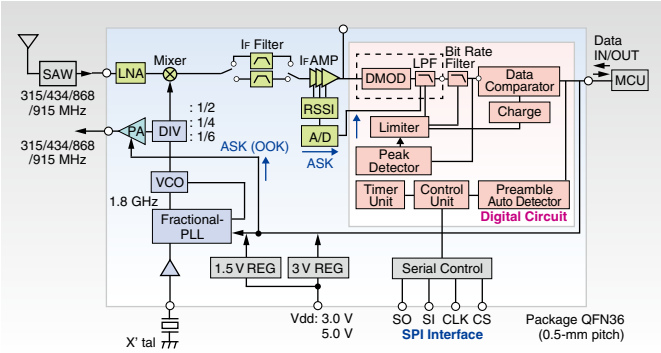
Block Diagram of a Tire Pressure Monitoring System



RF Devices for Automotive

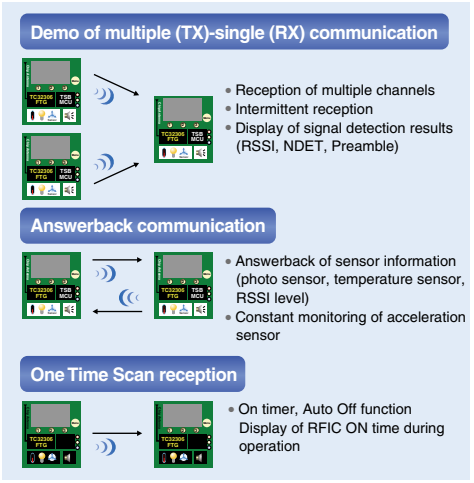
▼ Transceiver IC (TC32306FTG)

- 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)/RSSI 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.



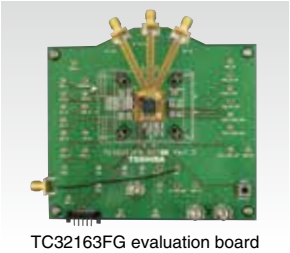
▼ Transceiver IC (TC32306FTG) Demo Board

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.



RF IC Series for ETC2.0/DSRC

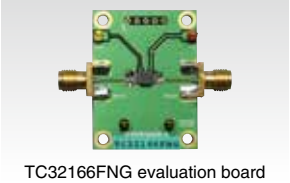
Road-to-vehicle communications provide toll collection and traffic information to enhance automobile convenience.
The collected probe data helps reduce traffic congestion.


TC32163FG evaluation board

▼ RF 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


TC32166FNG evaluation board

▼ 5.8 GHz Automotive Power Amplifier

TC32166FNG

- Operating voltage: 3.0 to 3.6 V
- Operating frequency: 5.8 GHz band
- Operating temperature: −40 to +85˚C


TC32168FG evaluation board

▼ RF Combo IC for Chinese ETC Applications

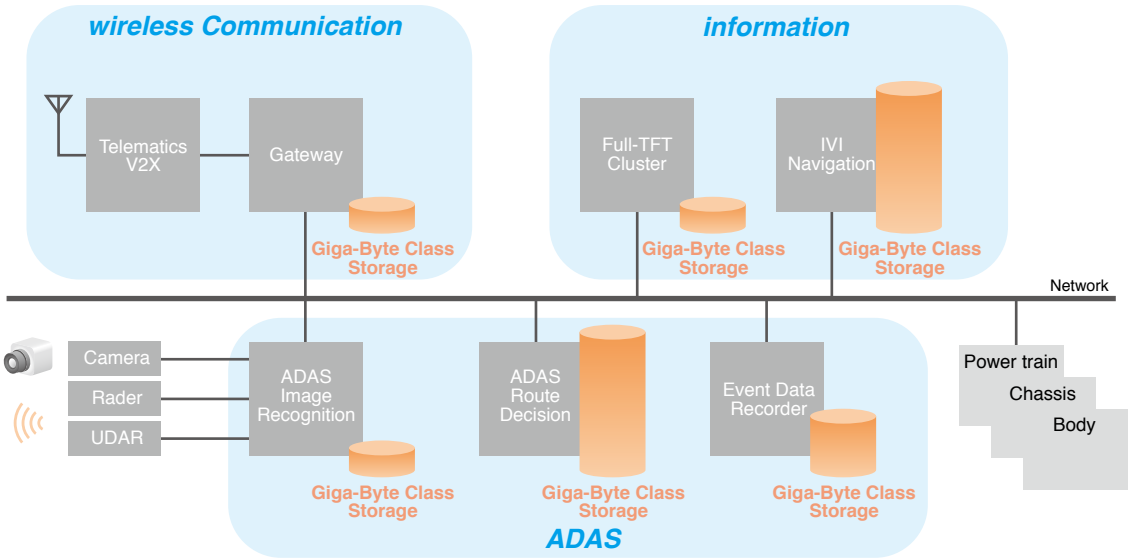
TC32168FTG

- 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 Hard Disk Drives

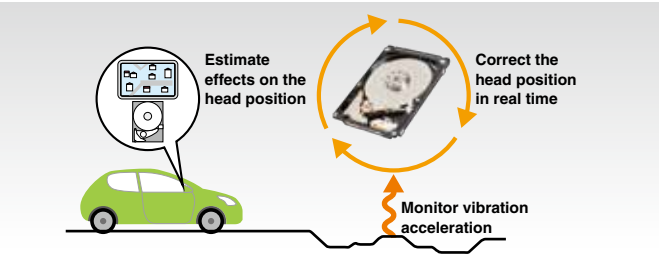
Automotive Hard Disk Drives

Automated-driving cars require large-capacity storage in addition to the current storage for navigation maps, music and other personal data. Toshiba offers hard disk drives (HDDs) designed for automotive applications.



▼ Features

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.



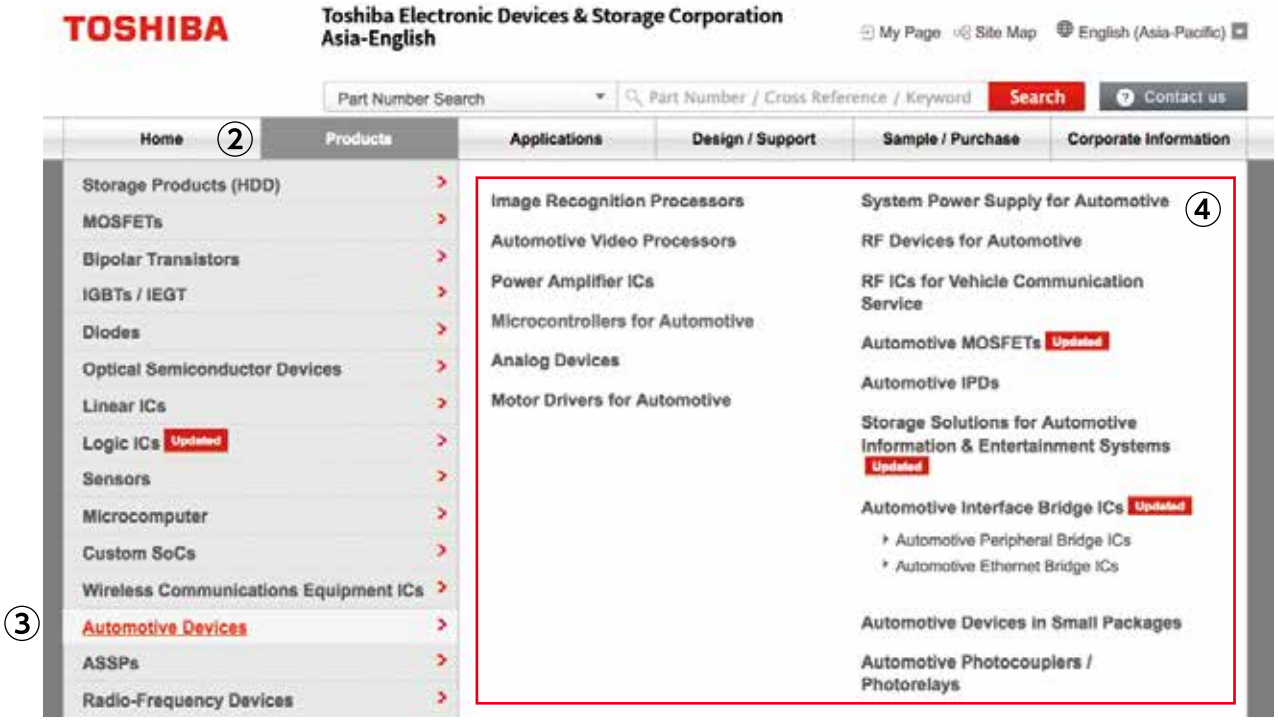
▼ Lineup

Capacity	Part Number	Rotation Speed (rpm)	Interface	Interface Speed	Operating Temperature (°C)
320 GB	**MQ01AAD032C**	4,200	Serial ATA 2.6/ATA8	3.0 Gbit/s, 1.5 Gbit/s	–30 to +85
200 GB	**MQ01AAD020C**				
100 GB	**MQ01AAD010C**				

• 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.

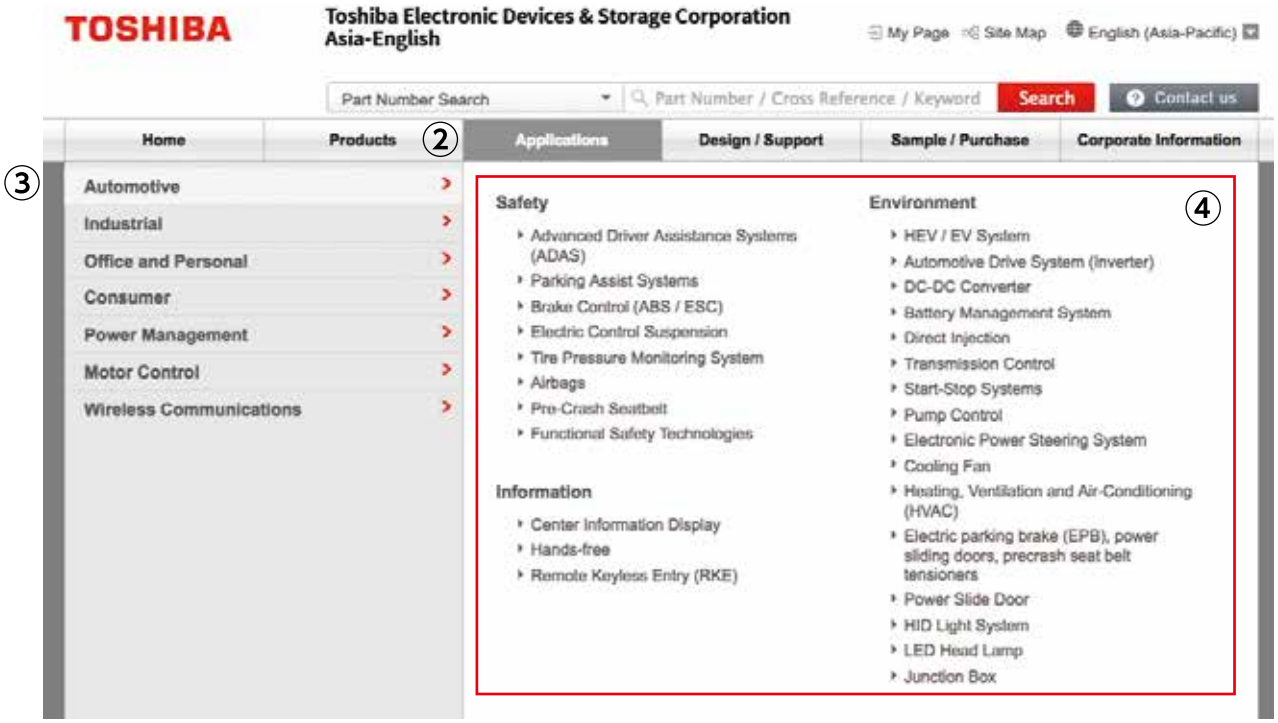
Webpages

① Webpages on Automotive Devices



1. Go to the Toshiba website at https://toshiba.semicon-storage.com/ap-en/top.html.
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.

① Webpages on Automotive Applications



1. Go to the Toshiba website at https://toshiba.semicon-storage.com/ap-en/top.html.
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.

Automotive Solutions

RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”.
Hardware, software and systems described in this document are collectively referred to as “Product”.

- TOSHIBA reserves the right to make changes to the information in this document and related Product without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**
- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE").** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative or contact us via our website.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Product may include products using GaAs (Gallium Arsenide). GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Product may include products subject to foreign exchange and foreign trade control laws.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**

In addition to the above, the following are applicable only to development tools.

- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Use the Product in a way which minimizes risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. For using the Product, customers must also refer to and comply with the latest versions of all relevant TOSHIBA information, including without limitation, this document, the instruction manual, the specifications, the data sheets for Product.
- Product is provided solely for the purpose of performing the functional evaluation of a semiconductor product. Please do not use Product for any other purpose, including without limitation, evaluation in high or low temperature or humidity, and verification of reliability.
- Do not incorporate Product into your products or system. Products are for your own use and not for sale, lease or other transfer.

TOSHIBA

Toshiba Electronic Devices & Storage Corporation

Website: https://toshiba.semicon-storage.com/

2019-5