

TOSHIBA

System Catalog May 2021

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.

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.

Toshiba offers automotive semiconductor devices for connected, autonomous, shared, and electric (CASE) vehicles to support the safety of motorized mobility for society in the new era.



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

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

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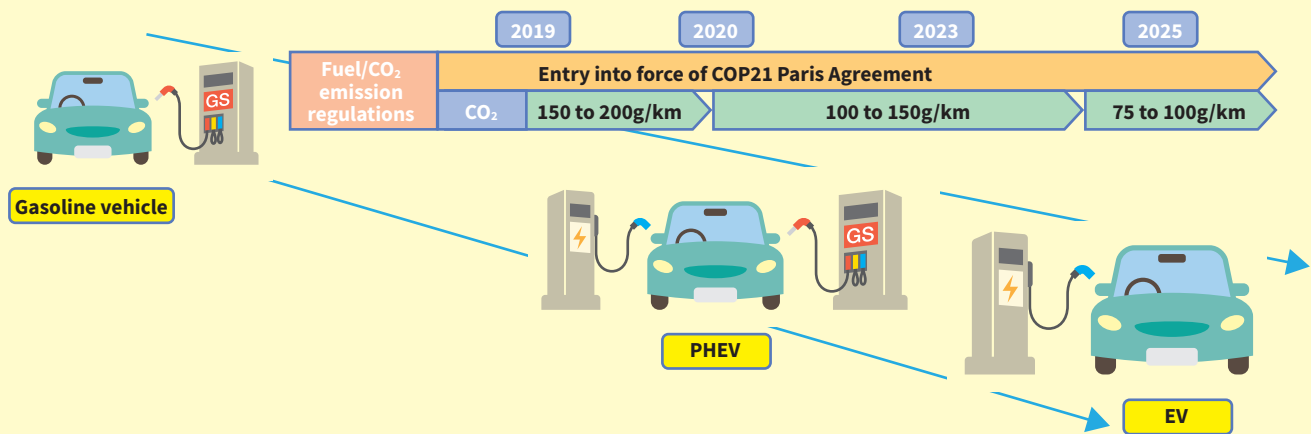
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Carbon dioxide (CO₂) emission regulations are being increasingly tightened around the world. Automobile manufacturers are under pressure to shift to electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs), and now the challenge for electric vehicles is mileage. Taking advantage of its technology that enables efficient use of electric power, Toshiba Electronic Devices & Storage Corporation contributes to increasing mileage for the purpose of handling environmental issues.

Changes in the environment surrounding the automobile



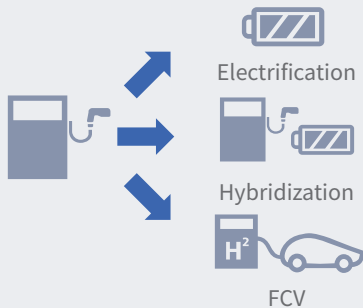
Promote reduced CO₂ emissions and drive system electrification/diversification by conforming with fuel economy/emission regulations.

Improved fuel economy

(1) Weight reduction/efficient use of resources



(2) Diversification of drive system

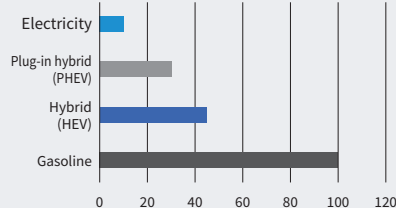


Transition to EV

CO₂ emissions by drive system

(Gasoline vehicle taken as 100)

Note: As surveyed by Toshiba

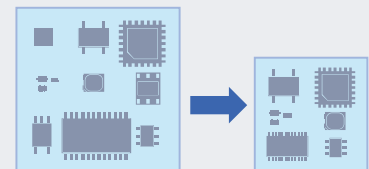


Extension of driving range

High performance/high efficiency



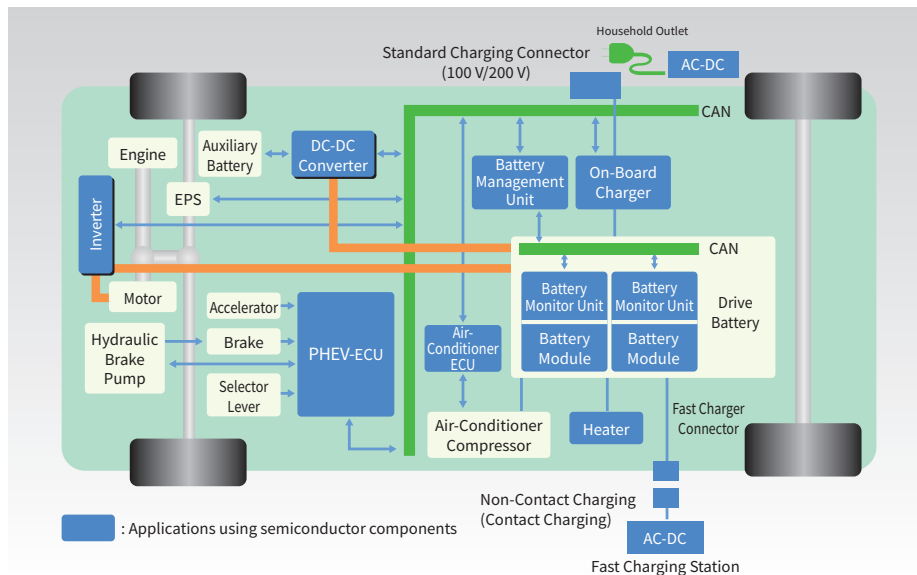
Downsizing



Applications: HEVs, PHEVs, EVs and Inverters

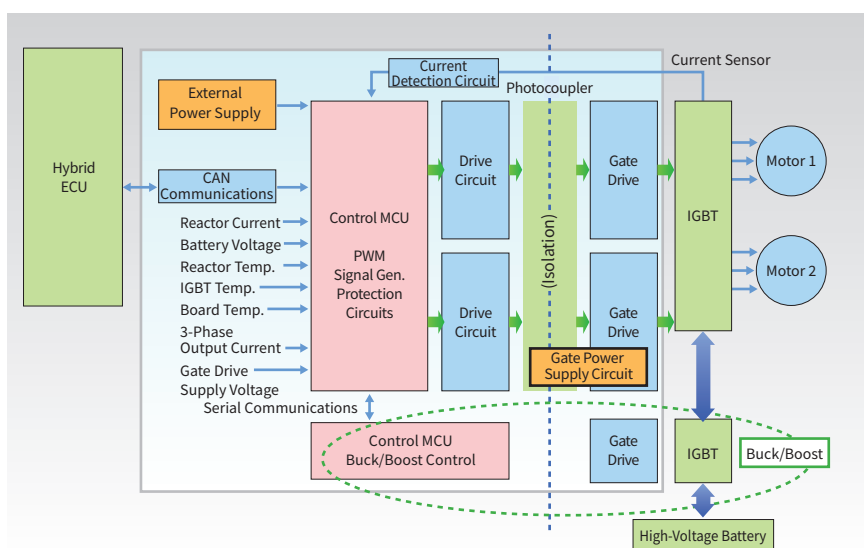
System Diagram of an Electric Vehicle (HEV/PHEV/EV)

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-MOSVIII-H	60 V, 25 A, 18.5 mΩ max, T _{on} = 175°C	○
		DPAK+	TJ30S06M3L	Pch U-MOSVI	-60 V, -30 A, 21.8 mΩ max, T _{on} = 175°C	○
MCU	Motor control MCU	HLQFP144	TMPR454F10TFG	Arm®Cortex®-R4F (160 MHz)	Vector Engine, RDC, PMD, ADC, CAN, Topr: -40 to 125°C	○
Isolation	Photocoupler	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	—	Totem-pole output, 20 M LOGIC, Topr = 125°C (max)	

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

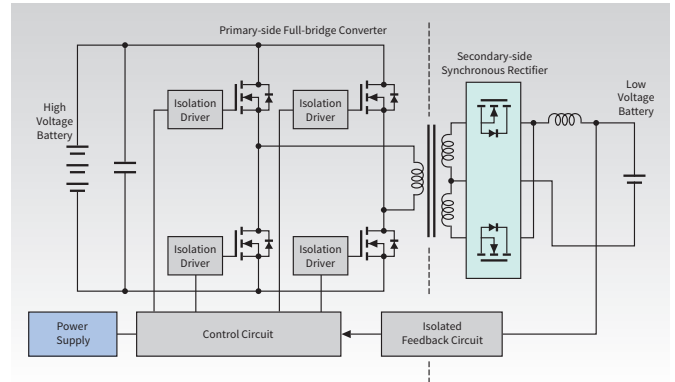
DC-DC Converters for HEVs, PHEVs and EVs

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 21.
Power Supply	MOSFET	DPAK+	
		DSOP Advance(WF)	

Application Block Diagram



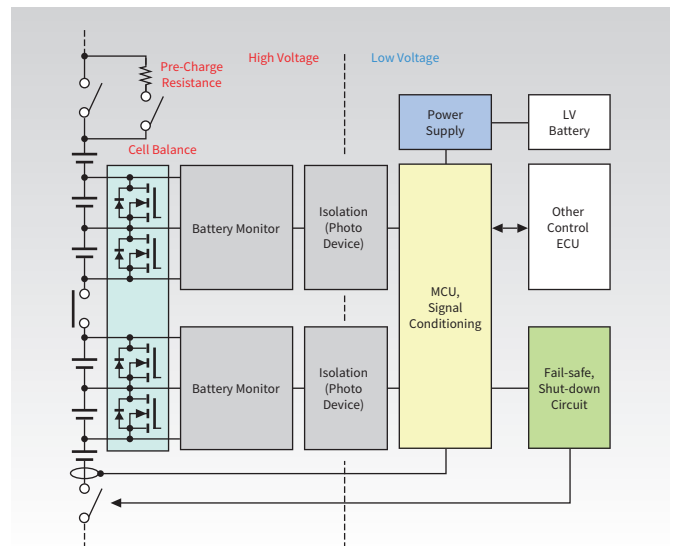
Battery Monitoring System (BMS)

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 TTA005
	System power supply IC	SSOP20	TB9005FNG
Fail-safe, Shut Down	IPD (High-side switch)	WSN-10	TPD1055FA
	IPD (Low-side switch)	PS-8	TPD1044F
Cell Balance	MOSFET	UF6	See pages 19.
	Photocoupler	SO4, SO6	
Main Control	Battery monitoring MCUs	LQFP100	TMPM358FDTFG

Application Block Diagram

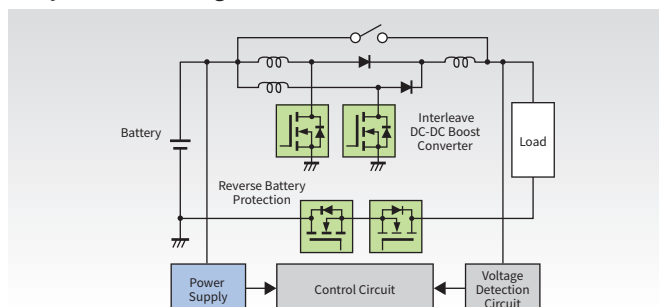


Start-Stop Systems

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.	○
Synchronous rectification 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	
			TK5S510N1	Nch/VIII	100 V/55 A/6.5 mΩ max	
Semicon.Relay	IPD	VSOP16	TPD7106F**	BiCD process	1ch high side Nch MOSFET gate drive.	○
		WSN10	TPD7107F**	BiCD process	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

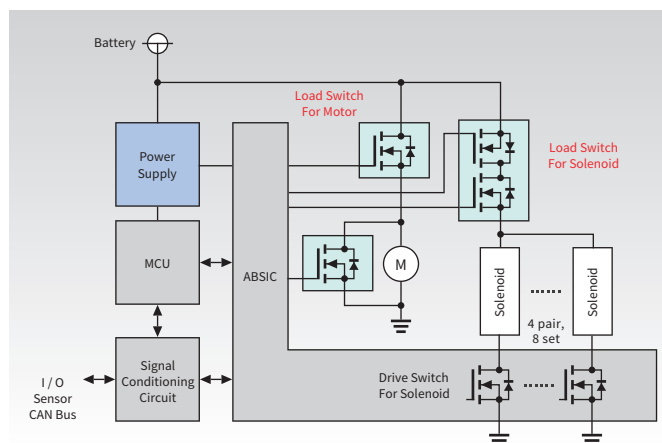
Brake Control (ABS/ESC)

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 21.
Power Supply	MOSFET	DPAK+	

Application Block Diagram



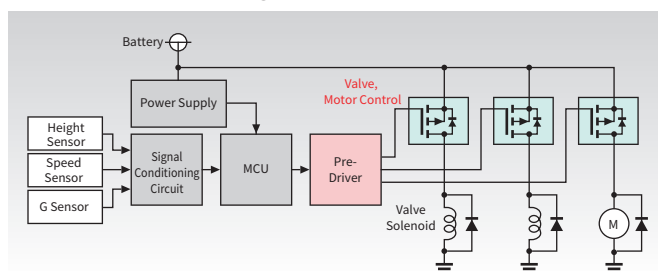
Electronic Suspension Control

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 SOT-23	See pages 20-21.			
	Diode	S-FLAT™	CRG07	General-purpose	400V, 0.7A, VF=1.1V (max), TJ=175°C	○

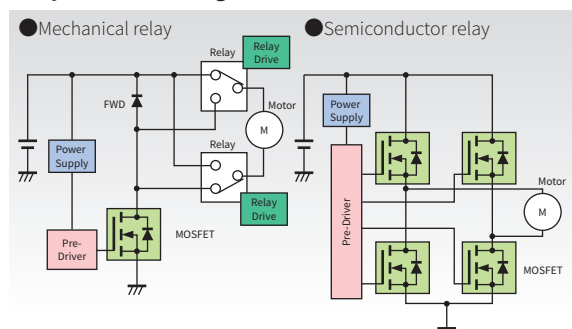
Application Block Diagram



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	
Relay Driver	MOSFET	SOT-23F	TPHR7904PB	Nch/IX	40 V/150 A/0.79 mΩ max	○
		UFM	TPH1R104PB		40 V/120 A/1.14 mΩ max	
		SSM3K337R			Active Clamp Nch	
Pre-driver	IPD	WQFN-32	SSM3H137TU	Nch + ZD	38 V/2 A, 0.2 Ω max @ 4 V	○
		PS8	TPD7211F		34 V/2 A, 0.28 Ω max @ 4.5 V	○
		HTSSOP48	TPD7212F		Half bridge MOSFET Gate drive.	-
	MCD	LQFP48	TB9052FNG	BiCD process	3 Phase Full Bridge Nch MOSFET Gate drive.	○
			TB9057FG		1-channel H-bridge pre-driver (external N-channel FET) Built-in motor current detection circuit	○
					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	PNP	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: -40 to 125°C	○
	Bip-Tr	New PW-Mold	TTA005		-50 V/-5 A/h FE200 min	-
			TTB002		-60 V/-6 A/h FE100 min	-

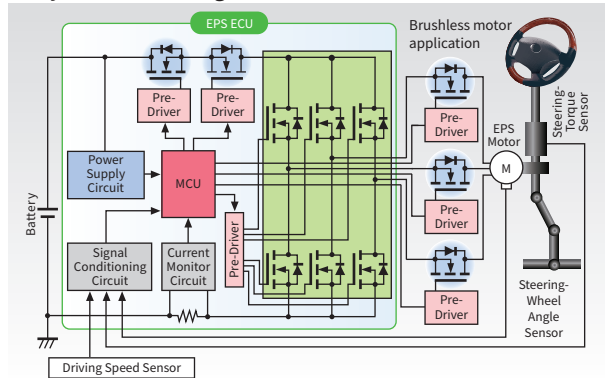
Applications: Electronic Power Steering (EPS) System

Electronic Power Steering (EPS) System

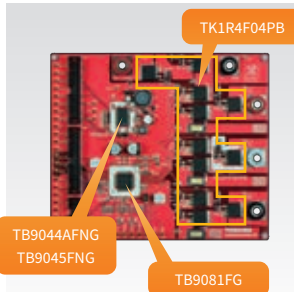
EPS systems are finding widespread use in automobiles to improve mileage. Here are block diagrams of EPS systems that use power MOSFETs for motor drivers, power supply and motor relay applications in EPS systems.



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	Nch/IX	-40 V/-80 A/5.2 mΩ max	
		SOP Advance (WF)	TPHR7904PB		40 V/150 A/0.79 mΩ max	
		DSOP Advance(WF)	TPH1R104PB	Nch/IX	40 V/120 A/1.14 mΩ max	○
			TPWR7904PB		40 V/150 A/0.79 mΩ/175°C	
			TPW1R104PB		40 V/120 A/1.14 mΩ/175°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	HTSSOP48	TB9044AFNG		Multiple outputs (with integrated output transistors) LDO1(5V), three tracker channels, Window-Watchdog timer, T _{opr} = -40 to 150°C	○
		HTSSOP48	TB9045FNG-110 TB9045FNG-120 TB9045FNG-125 TB9045FNG-150		Multiple outputs (with integrated output transistors), three tracker channels, DDCI(1.1/1.2/1.25/1.5V), LDO1(5V) Window-Watchdog timer, T _{opr} = -40 to 150°C	○
	Schottky Barrier Diodes	M-FLAT™	CMS30I40A	-	40 V, 3 A, V _F = 0.55V(max), T _J = 150°C	○
	MOSFET	SOT-23F	SSM3K333R	Nch-U-MOS VII	30 V, 6 A, 42 mΩ max, T _{ch} = 150°C	○

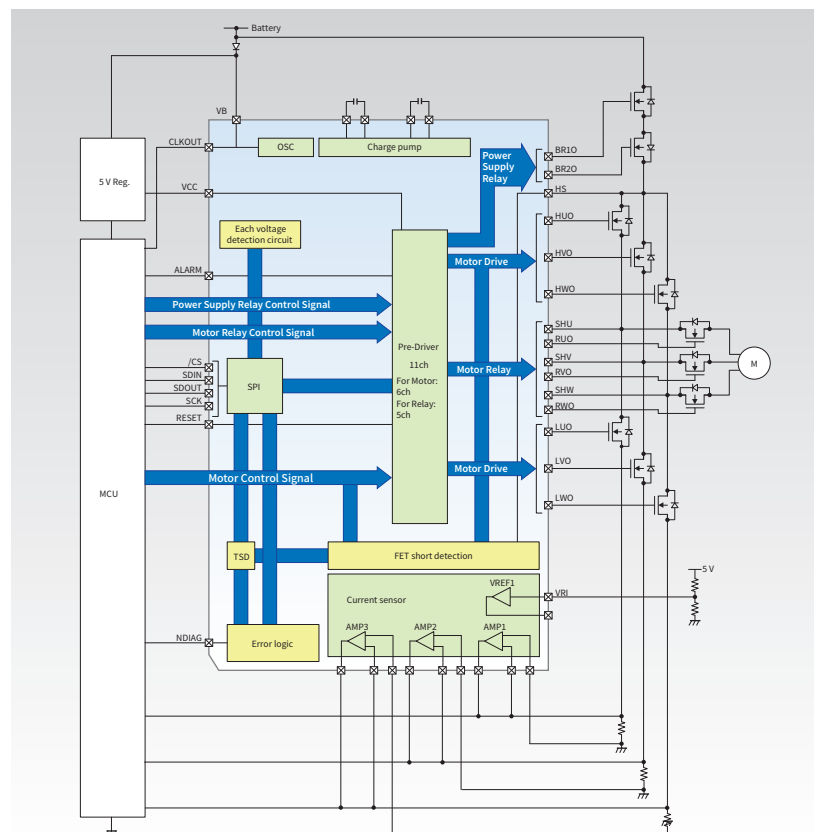
Three-Phase Brushless Motor Pre-driver IC for EPS Applications: TB9081FG

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>

- Maximum voltage: 40 V peak (load dump)
- Operating voltage range: 4.5 to 28 V
- PWM operating frequency: 20 kHz
- Operating temperature range: T_a = -40 to 125°C
- Package: LQFP64



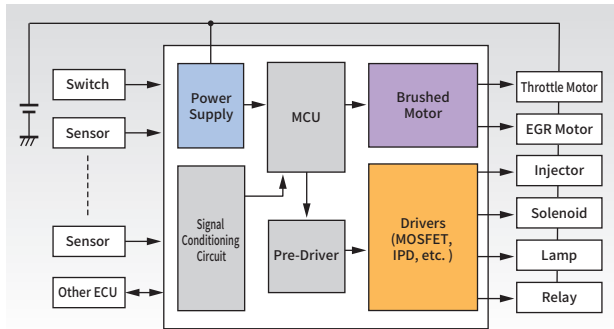
Applications: Gasoline Engine System, Direct Injection, Transmission Control



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)	○
Solenoids	IPD	PS-8	TPD1054F	BiCD process	1 ch Low side switch (1 A)	—
		WSO-10	TPD1058FA		1 ch Low side switch (6 A)	—
	MCD	P-QFN28	TB9051FTG		1 ch H-Bridge driver (Pch + Nch), Iout5 A ToPr: -40 to 125°C	○
		P-QFN40	TB9053FTG**		2 ch (5A) / 1 ch (10A) H-Bridge driver (Nch + Nch) ToPr: -40 to 125°C	○
		V-QFN40	TB9054FTG**		2 ch (5A) H-Bridge driver (Nch + Nch) ToPr: -40 to 125°C	○
Driver	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		-60 V/-30 A/21.8 mΩ max	
	MOSFET	DPAK+	TJ60S06M3L	Pch/VI	-60 V/-60 A/11.2 mΩ max	○
			TJ80S06M3L		-60 V/-8 A/104 mΩ max	
			TB9045FNG-110		Multiple outputs (integrated output power MOSFETs), three channel voltage trackers, DDC1 (1.1/1.2/1.25/1.5 V), LDO1 (5 V)	
			TB9045FNG-125		Window-Watchdog timer, ToPr = -40 to 150°C	
Power Supply	Voltage Regulators	HTSSOP48	TB9045FNG-150	BiCD process		○
	Schottky Barrier Diodes	M-FLAT™	CMS30I40A	—	40 V, 3 A, VF=0.55V(max), Tj=150°C	○
	MOSFET	SOT-23F	SSM3K333R	Nch-U-MOS VII	30 V, 6 A, 42 mΩ max, Tch=150°C	○

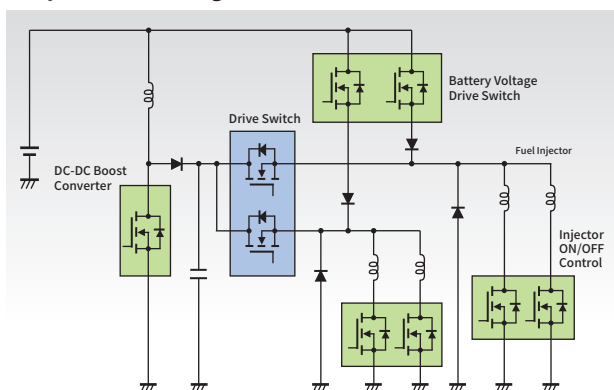
** : Under development

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

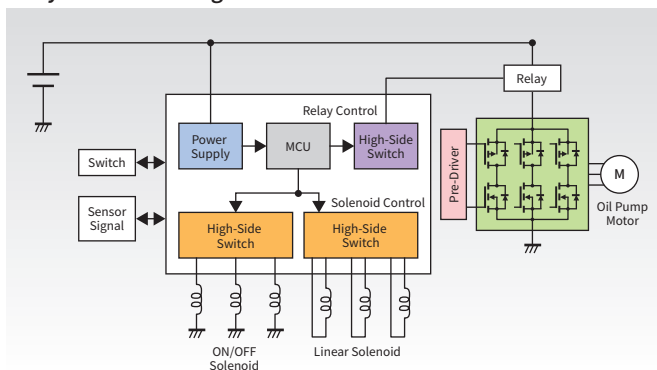
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Boost Converter	MOSFET	DPAK+	TK40S06N1L	Nch/VIII	60 V/40 A/10.5 mΩ max	○
			TK90S06N1L		60 V/90 A/3.3 mΩ max	
			TK33S10N1L		100 V/33 A/9.7 mΩ max	
			TK55S10N1L		100 V/55 A/6.5 mΩ max	
Drive Switch	MOSFET	DPAK+	TJ50S06M3L	Pch/VI	-60 V/-50 A/13.8 mΩ max	○
			TJ60S06M3L		-60 V/-60 A/11.2 mΩ max	
Relays	IPD	PS-8	TPD1044F	Logic Nch + DMOS	1 ch Low side switch (1 A)	○
Solenoids	IPD	PS-8	TPD1054F	BiCD process	1 ch Low side switch (1 A)	—
		WSO-10	TPD1058FA		1 ch Low side switch (6 A)	—

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)	—
		WSO-10	TPD1055FA		1 ch High 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	
Pre-driver	MCD	SSOP24	TB9061AFNG	BiCD process	-60 V/-60 A/11.2 mΩ max	○
			TB9062FNG		3 Phase Brushless Sensor-less Pre-Driver ToPr: -40 to 125°C	—
	IPD	WQFN-32	TPD7212F		3 Phase Brushless Sensor-less Pre-Driver, High Start-up Performance, ToPr: -40 to 125°C	○
		PS-8	TPD7211F		3 Phase Full Bridge Nch MOSFET Gate drive.	—

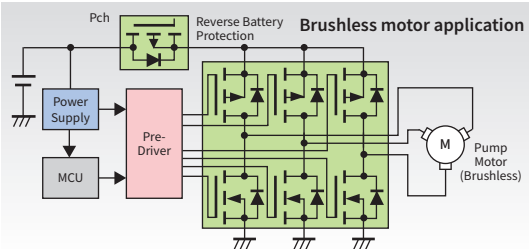
Applications: Pump Control (for Water, Oil and Fuel), Cooling Fan

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

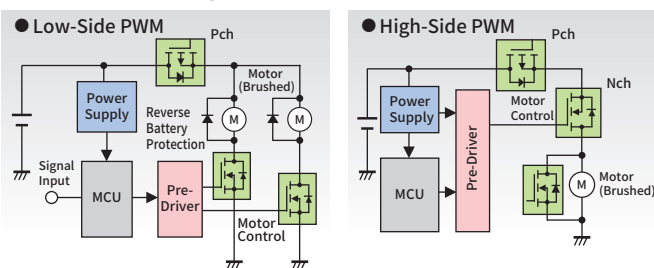
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Pre-driver	IPD	WQFN-32	TPD7212F	BiCD process	3 Phase Full Bridge Nch MOSFET Gate drive.	○
		PS-8	TPD7211F		Half bridge MOSFET Gate drive.	-
			TPD7104AF		1 ch high side Nch MOSFET Gate drive.	○
	MCD	SSOP24	TB9061AFNG		3 Phase Brushless Sensor-less Pre-Driver, -40 to 125°C	○
			TB9062FNG		3 Phase Brushless Sensor-less Pre-Driver, High Start-up Performance, -40 to 125°C	-
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	
			TK1R4S04PB		40 V, 120 A, 1.35 mΩ max, T _{ch} = 175°C	
		SOP Advance (WF)	TPHR7904PB	Nch/IX	40 V, 150 A, 0.79 mΩ max, T _{ch} = 175°C	○
			TPH1R104PB		40 V, 120 A, 1.14 mΩ max, T _{ch} = 175°C	
		DSOP Advance (WF)	TPWR7904PB		40 V, 150 A, 0.79 mΩ max, T _{ch} = 175°C	
			TPW1R104PB		40 V, 120 A, 1.14 mΩ max, T _{ch} = 175°C	
			TB9005FNG	BiCD process	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: -40 to 125°C	○
Power Supply	Voltage Regulators	SSOP20	TTA005	PNP	-50 V/-5 A/hFE200 min	-
	Bip-Tr	New PW-Mold	TTB002		-60 V/-6 A/hFE100 min	-

Cooling Fan

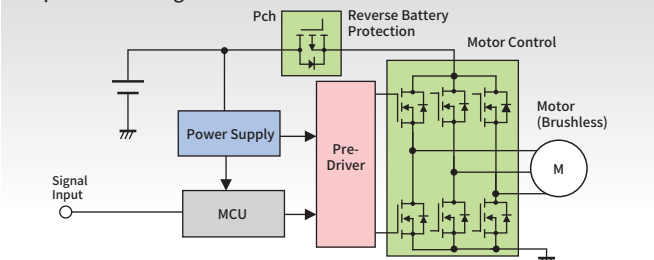


Automobiles have electric cooling fans of various sizes for the engine, battery pack and LED headlights. With the increasing uptake of electric vehicles (EVs), the market demand for quieter fan motors is growing. Toshiba's sine-wave motor controller ICs help realize quiet motor operation.

System Block Diagram



3phase full-bridge Method for BLDC Motor



Recommended Products

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor drive	Pre-driver	LQFP64	TB9080FG	BiCD process	Low noise motor drive using sinusoidal current wave, high-efficiency motor drive using auto lead angle control	○
	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	○
	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.	○

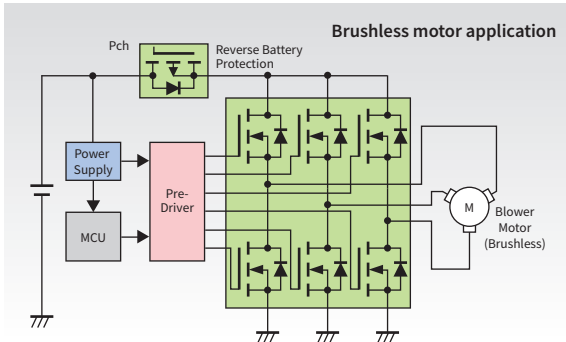
Applications: Air-Conditioning (HVAC), LED Headlights, Airbags

Air-Conditioning (HVAC) – Blowers



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

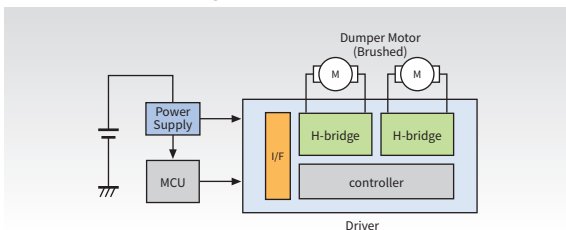
Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Motor control Reverse battery protection	IPD	PS8	TPD7104AF	BiCD process	1ch high side Nch MOSFET Gate drive.	○
	MOSFET	DPAK+	TK100S04N1L	Nch/VIII	40 V/100 A/2.3 mΩ max	○
			TK1R4S04PB	Nch/IX	40 V/120 A/1.35 mΩ max	
			TK55S10N1	Nch/VIII	100 V/55 A/6.5 mΩ max	
			TJ60S04M3L	Pch/VI	-40 V/-60 A/6.3 mΩ max	
Pre-driver	IPD	WQFN-32	TPD7212F	BiCD process	3 Phase Full Bridge Nch MOSFET Gate drive.	○
	MCD	LQFP64	TB9080FG		Low noise motor drive using sinusoidal current wave, high-efficiency motor drive using auto lead angle control	○
Power Supply	Voltage Regulators	SSOP20	TB9005FNG	PNP	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: -40 to 125°C	○
	Bip-Tr	New PW-Mold	TTA005 TTB002		-50 V/-5 A/hFE200 min -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)	○

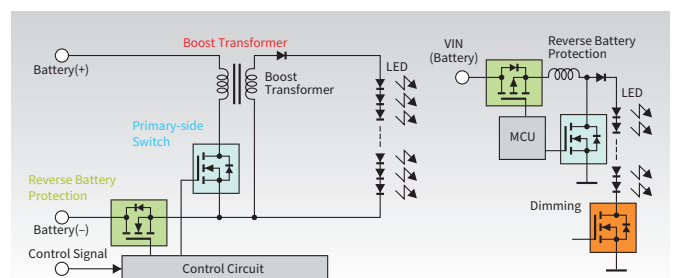
LED Headlights

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+ SOP Advance	See pages 20-21.
Reverse Battery Protection	MOSFET	DPAK+ SOP Advance	
		SOT-23F	
Dimming	MOSFET	TSOP6F	
		SOT-23F	
		TSOP6F	

Application Block Diagram



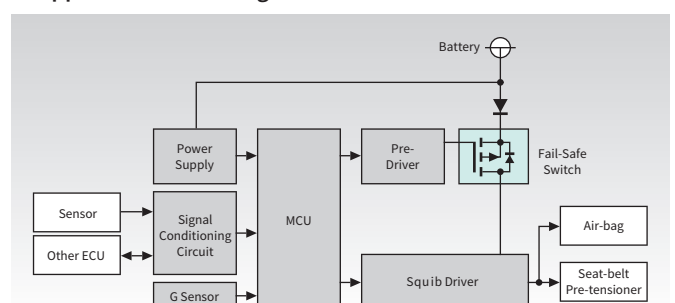
Airbags

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 21.
		DSOP Advance (WF)	

Application Block Diagram

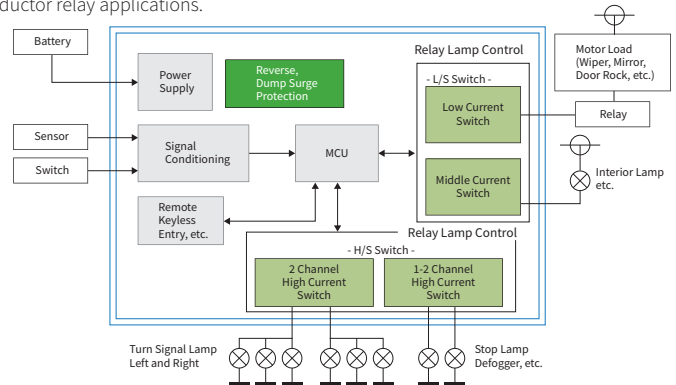


Applications: Body Control Module (BCM), In-Vehicle Networks

Body Control Module (BCM)

Body control modules (BCMs) come in two types: those using mechanical relays and those using MOSFETs as semiconductor relays. To meet the needs of mechanical-relay drive applications, Toshiba has developed the SSM3K337R, a MOSFET in a small package (with 85% of the mounting area of the predecessor) that has active clamping circuitry for inductive loads.

Toshiba also offers power MOSFETs in DPAK+ and other packages suitable for semiconductor relay applications.



IPD, Active Clamp, Complex Device

Block	Type	Package	Part Number	Polarity/Generation	Feature	AEC
Mechanical Relay	MOSFET	SOT-23F	SSM3K337R	Active Clamp Nch	38 V/2 A, 0.20 Ω max @ 4.0 V	○
	MOSFET	SOT-23F	SSM3K347R*		38 V/2 A, 0.48 Ω max @ 4.0 V, Built-in pull-down resistor	○
	MOSFET+ZD	UFM	SSM3H137TU	Nch+ZD	34 V/2 A, 0.28 Ω max @ 4.5 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	-
Semicon. Relay	IPD (LSS)	PS-8	TPD1044F	Logic Nch +DMOS	High side 1ch, VDS = 41 V, IC = 1 A, 0.6 Ω , Topr = -40 to 125°C	○
	IPD (Pre-Driver)	WS0N10	TPD7104AF	BiCD process	1ch high side Nch MOSFET gate drive	○
Power Supply	Voltage Regulators	SSOP20	TPD7107F**	BiCD process	1ch high side Nch MOSFET gate drive	○
	Voltage Regulators	SSOP20	TPB9005FNG	BiCD process	Single output (external transistors required) LDO (5 V) Watchdog timer, Topr: -40 to 125°C	○
	Bip-Tr	New PW-Mold	TTA005	PNP	-50 V/-5 A/hFE 200 Min	-
	Bip-Tr	New PW-Mold	TTB002		-60 V/-6 A/hFE 100 Min	-

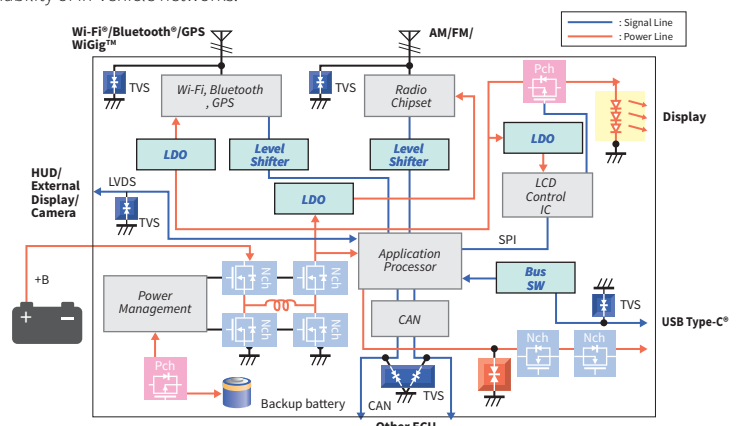
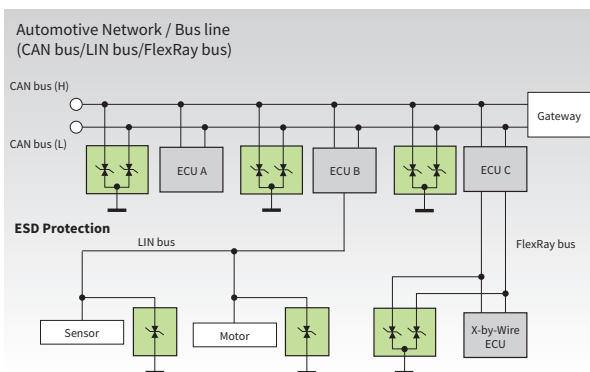
MOSFET

Block	Type	Package	Part Number	Feature	AEC
Relay Lamp Control	MOSFET	PS8	TPCP8207	Nch Dual, 40 V/5 A, 36.3 m Ω max, Tch = 175°C	○
		PS8	TPCP8407	Nch+Pch, 40/-40 V, 5/-4 A, 36.3 m Ω max, Tch = 175°C	○
		SOT-23F	SSM3K2615R	Nch, 60 V/2 A, 0.44 Ω max @ 4.0 V	○
		TSOP6F	SSM6N357R*	N-ch, 60 V/0.65 A, 2.4 Ω max @ 3.0 V	○
Reverse Dump Surge Protection	MOSFET	DPAK+	TK1R404PB	Nch, 40 V/120 A, 1.35 m Ω max	○
		DPAK+	TK5S510N1	Nch, 100 V/55 A, 6.5 m Ω max, Tch = 175°C	○
		DPAK+	TJ30S06M3L	Pch, -60 V/-30 A, 21.8 m Ω max, 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.

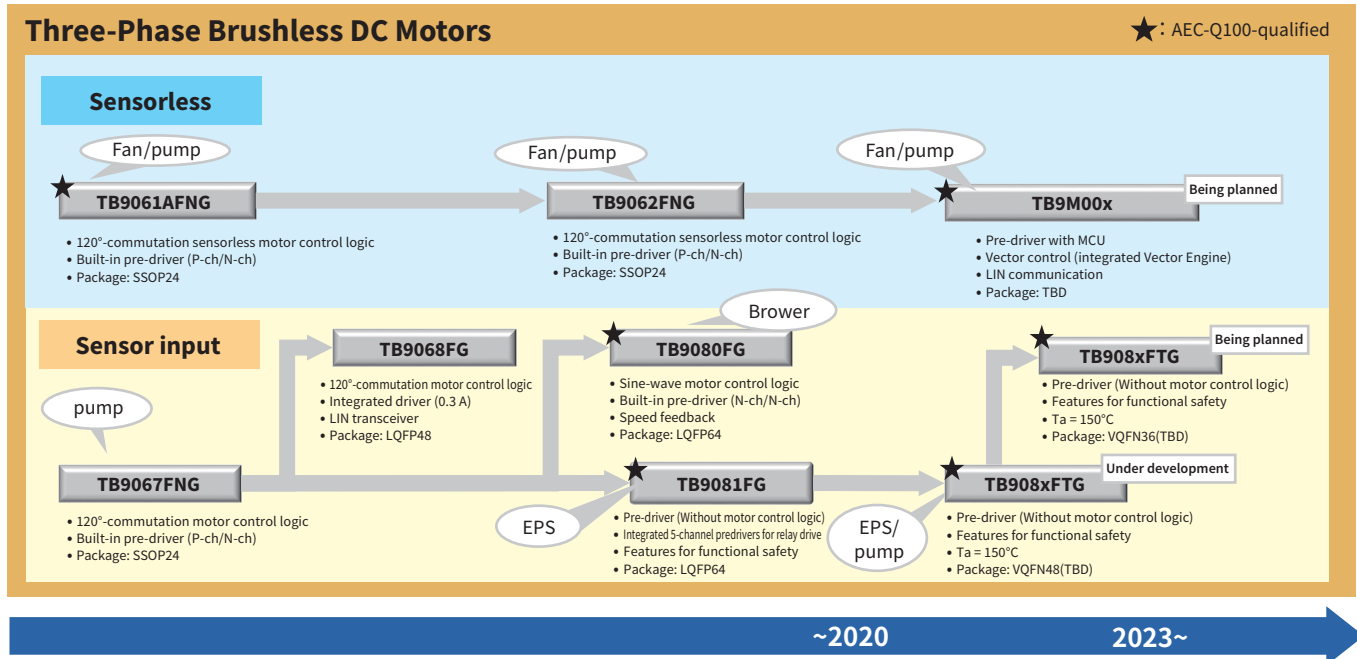


TVS Diodes

Block	Package	Part Number
CAN/LIN bus protection	USC	See pages 19.
	USM	
LVDS bus protection	SOD-923	

Products: Automotive Three-Phase Brushless DC Motor Driver ICs

▼ Roadmap



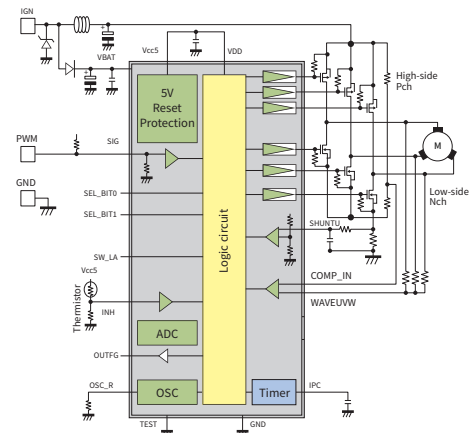
▼ Three-Phase Brushless Sensorless Pre-driver IC TB9062FNG

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>

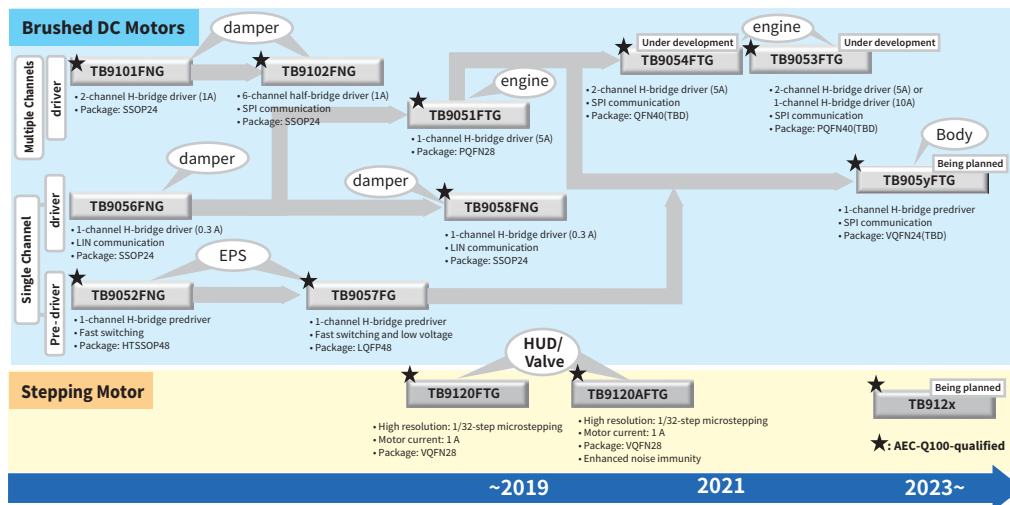
- Operating voltage range: 6.5 to 16.6 V
- Max. voltage: 40 V peak (load dump)
- Operating temperature range: Ta = -40 to 125°C
- Package: SSOP24



▼ Lineup

Part Number	Package	Input	Commutation	Output	Features & Functions	Operating Voltage	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-P-300-0.65A	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	-
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	LQFP64-P-1010-0.50E	PWM, DC voltage	180 degree Sine wave	Pre-drivers N-ch/N-ch	Low noise motor drive using sinusoidal current wave, high-efficiency motor drive using 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	○

Products: Automotive Brushed DC Motor Driver ICs

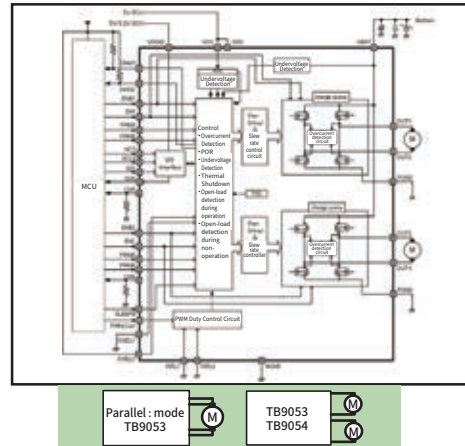


▼ Brushed DC Motor Driver ICs: TB9053FTG and TB9054FTG

Under development

Housed in a small QFN package, the TB9053FTG and TB9054FTG contribute 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. The TB9053FTG and TB9054FTG incorporate capacitors, eliminating the need for the outer leads that would otherwise be required for slew rate control and charge pumping and thereby reducing noise. During initial diagnosis, these motor driver ICs check the threshold of the internal comparator for various fault detection circuits. Applications of the TB9053FTG and TB9054FTG include electronic engine throttle control; opening and closing of various engine valves; and body electronics such as electric door mirror retractors.

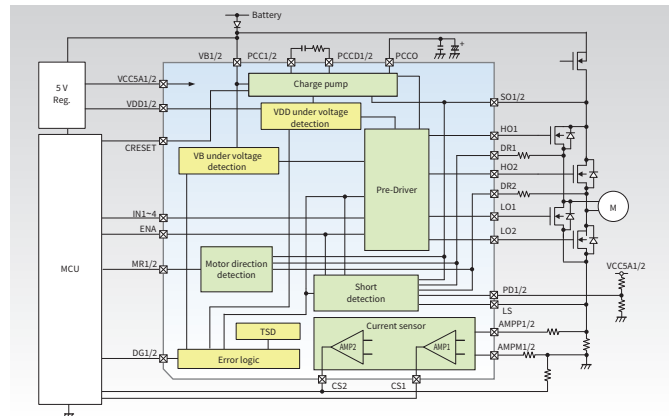
- Dual-channel 5-A/single-channel 10-A H-bridge drivers
- High-side and low-side drivers (N-ch/N-ch configuration)
- Output current: 5.0 A (TB9054FTG) / 10.0 A (TB9053FTG)
- Various detection circuits, (Overcurrent detection, over-temperature detection, open-load detection, current monitor), SPI communication, etc.
- SPI communication and SR control
- Operating supply voltage: 4.5 to 28 V
- Operating temperature: -40 to 125°C
- Package: PQFN40 (TB9053FTG)/VQFN40 (TB9054FTG)
- AEC-Q100-qualified



▼ 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>**
- Maximum voltage: 40 Vpeak (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)	Operating 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 parking brake, seat belt pretensioners, electric 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	○
TB9053FTG**	P-QFN40-0606-0.5	Open/close control for engine throttle and other valves	PWM drive dual H-bridge driver, small package with high power dissipation, various fault detection functions	±5/±10	4.5 to 28	○
TB9054FTG**	P-VQFN40-0606-0.5	Open/close control for engine throttle and other valves	2-channel PWM H-bridge driver Small package, various fault detection functions	±5	4.5 to 28	○
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 parking brake, seat belt pretensioners, electric 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 TB8083FG	±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	○

** Under development

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

▼ Stepping Motor Driver IC: TB9120AFTG

New Product

The TB9120AFTG 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.

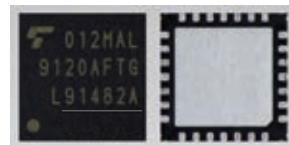
<Features>

- 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 TB9120AFTG 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 TB9120AFTG 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>

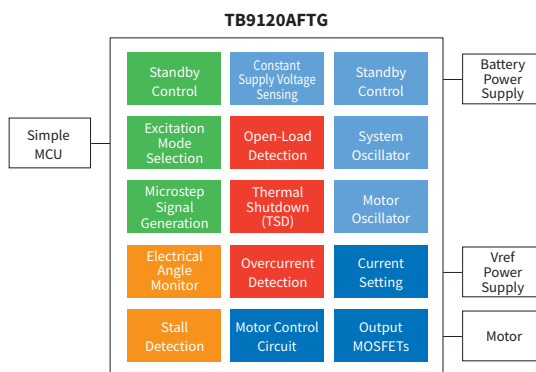
- Suitable for various automotive stepping motor applications because of versatile product specifications
Valve opening/closing (e.g., expansion valve in a cooling system for heat pumps), adjustment of an image-reflecting mirror for head-up displays, damper control for HVAC, adjustment of a headlamp's optical axis, etc.

■ TB9120AFTG



TB9120AFTG

■ System Configuration Example

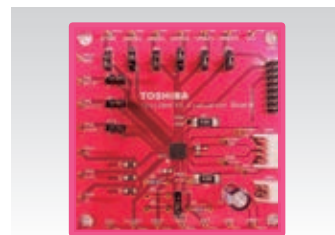


▼ Stepping Motor Driver IC Lineup

Part Number	Package	Functions & Applications	Features	Output Current (A)	Operating Voltage (V)	AEC
TB9120AFTG*	P-VQFN28-0606-0.65-002	Automotive stepping motor driver	Up to 1/32 microstepping PWM constant-current control Mixed decay mode Stall detection Thermal shutdown, overcurrent detection, and open-load detection Wettable flanks with excellent solder wettability QFN package	1.0	7.0 to 18	○

*: New Product

■ Evaluation Board



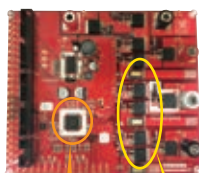
▼ Evaluation Boards (for Motor Control)

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



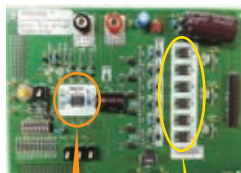
TB9080FG

MOSFET



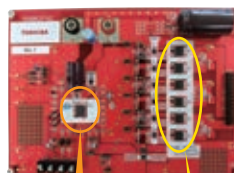
TB9081FG

MOSFET



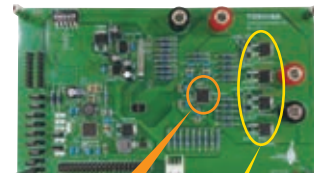
TB9061AFNG

MOSFET



TB9062FNG

MOSFET



TB9057FG

MOSFET

Products compatible to product evaluation boards

<Three-Phase Motor Driver ICs> TB9061AFNG/TB9062FNG/TB9067FNG/TB9080FG/TB9081FG

<Brushed DC Motor Driver ICs> TB9101FNG/TB9102FNG/TB9051FTG/TB9052FNG/TB9057FG/TB9056FNG/TB9058FNG

<Stepper Motor Drivers> TB9120AFTG

For details, contact your local Toshiba sales representative.

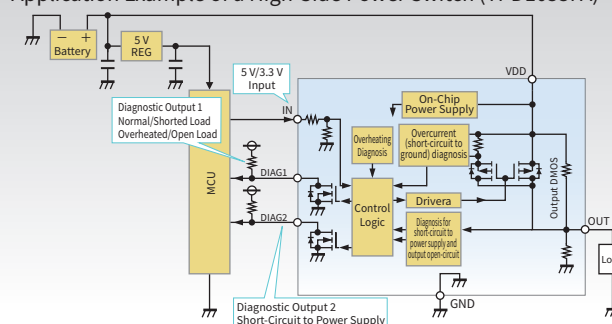
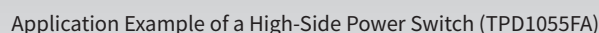
Products: Automotive Intelligent Power Devices (IPDs) : Part1

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.



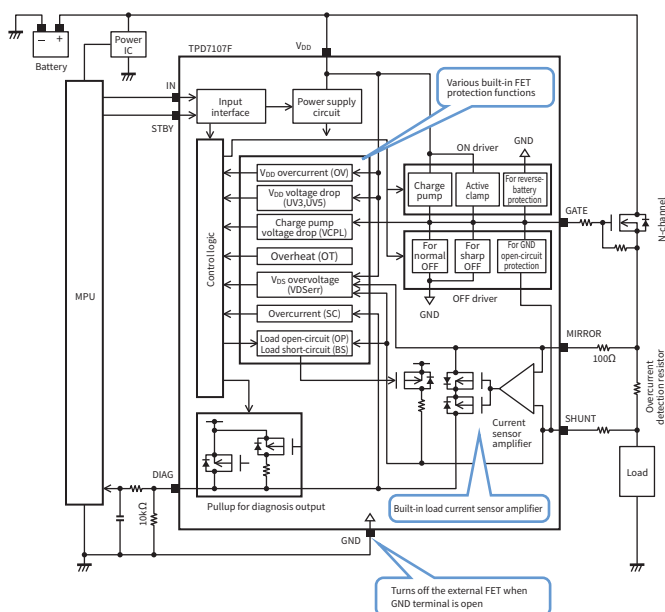
Part Number	Package	Function					Operating temperature		Protection and Diagnostic Functions														AEC-Q100		
		Low-side switch	High-side switch	High-side gate drive	Three-phase motor gate drive	Half-bridge gate drive	Channels	-40 to 125°C	-40 to 150°C	Reverse battery protection	Short-to-VDD detection	Broken ground	Short-to-ground protection	Overvoltage Detection	Undervoltage Detection	Overcurrent	Overheating	Active clamp of external FET	Monitoring of drain-source voltage of external FET	Short-circuit protection	Current sense	Undervoltage detection (for supply voltage booster)		Rapid off-driver	Broken wire detection
TPD7104AF	PS-8			✓			1	✓		✓									✓						-
TPD7107F*	WSON10A			✓			1	✓		✓	✓	✓		✓	✓	✓	✓	✓		✓				✓	Planning
TPD7106F*	SSOP16			✓			1		✓	✓											✓	✓			Planning
TPD7212F	WQFN32				✓		6		✓		✓		✓	✓	✓										-
TPD7212FN**	SSOP30				✓		6		✓		✓		✓	✓	✓				✓	✓					Planning
TPD7211F	PS-8					✓	2	✓																	-
TPD7213FN**	SSOP16					✓	2		✓						✓				✓	✓		✓			Planning
TPD1052F	PS-8		✓				1	✓								✓	✓								-
TPD1055FA	WSON10		✓				1	✓								✓	✓							✓	✓
TPD1044F	PS-8	✓					1	✓						✓		✓	✓								-
TPD1054F	PS-8	✓					1	✓						✓		✓	✓								-
TPD1058FA	WSON10	✓					1	✓						✓		✓	✓							✓	-

* : New Product
 **: Under development

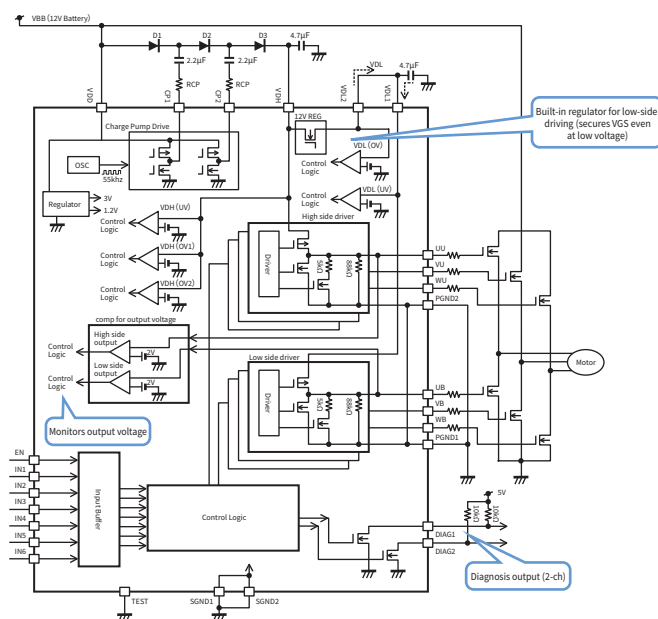
Products: Automotive Intelligent Power Devices (IPDs) : Part2

■ Gate Drivers

Application Example of Gate Drivers (TPD7107F**)

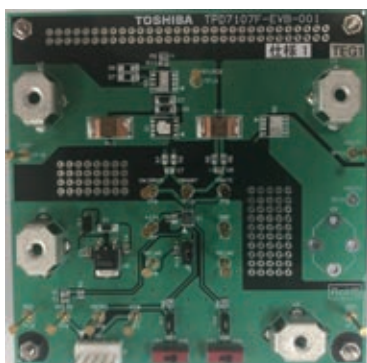


Application Example of Gate Drivers (TPD7212F)



Target applications

- Semiconductor relay
- Junction box



Target applications

- Automotive three-phase brushless DC motor

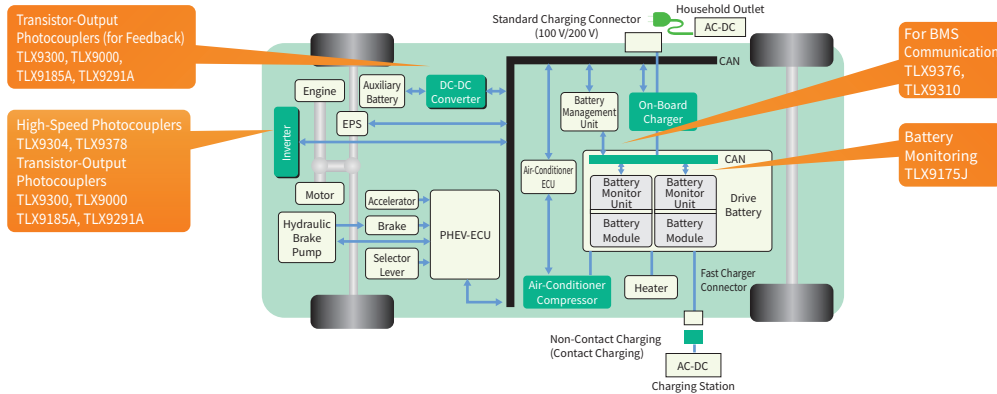


* The up-to-date and more detailed information on automotive MOSFETs and IPDs is available on our website. <https://toshiba.semicon-storage.com/>

** : Under development

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)	To _{pr} (°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		Totem-pole	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		Totem-pole	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 _{CE0} (MIN) (V)	Tstg (°C) (min) to (max)	To _{pr} (°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 I _{sc} (μA) (min) @I _f (mA)	Open Voltage V _{OC} (V) (min) @I _f (mA)	Tstg (°C) (min) to (max)	To _{pr} (°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-Q101-Qualified Devices(*)

- MOSFETs
- Bias resistor built-in transistors
- Schottky Barrier Diodes
- Bipolar transistor
- Transient-voltage-suppression (TVS) diodes
- Switching Diodes

▼ AEC-Q100(*)

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

* Contact your Toshiba sales representative for details
Note: This device is compliant with the reliability requirements of AEC-Q100.
Note: Visit our website for a line-up of our automotive discrete devices.

★ AEC qualified

Major Small-Signal Devices 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 _{SDM} (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)

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 _{SDM} (Ω) (typ.)	C _T (pF) (typ.)
SOD-923 1.0 x 0.6 t = 0.45	DF2S5M4FS*		150	±20 kV	±30 kV	3.7	0.1	3.6	0.35	0.45
	DF2S6M4FS*		150	±20 kV	±30 kV	5.6	0.1	5.5	0.35	0.45

*: New product

▼ Bipolar Transistors

Package Unit (mm)	Polarity	Part Number	Absolute Maximum Ratings				hFE			V _{CE(BAT)} (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

Products: AEC-Qualified Automotive Discrete Devices : Part1

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 _{GS} (V)	I _O (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
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	1110	8.5	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

** : Under development

▼ Switching Diodes

Package	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 _r (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	TC74VHCxxFT	V _{CC} = 2.0 V to 5.5 V tpd = ~8.5 ns
		TC74VHCTxxFT	V _{CC} = 4.5 V to 5.5 V, TTL input
		TC74VHCVxxFT	V _{CC} = 1.8 V to 5.5 V tpd = ~5.5 ns
		TC74VHC936xFT	V _{CC} = 2.0 V to 5.5 V Outputs with built-in pull-up or pull-down resistors (for IGBT gate drive)

*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 (2.0 x 2.1 t = 0.9)	VHS Series	TC7SHxxFU TC7WHxxFK	V _{CC} = 2.0 V to 5.5 V tpd = ~5.5 ns
		TC7SETxxFU	V _{CC} = 4.5 V to 5.5 V TTL input
US8 (SOT-765) (2.0 x 3.1 t = 0.7)	SHS Series	TC7SZxxFU TC7WZxxFK	V _{CC} = 1.65 V to 5.5 V tpd = ~5.0 ns

*For details of AEC compliance, contact your Toshiba sales representative.

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▼ CMOS Level Shifters and Bus Switches (Topr: –40 to 125°C)

Package Unit (mm)	Function	Part Number	Key Electrical Characteristics
TSSOP16(5.0 x 6.4 t = 1.2)	Dual-supply bidirectional level shifters	TC7MP3125FT TC7MPN3125FT	V _{CC} (A) = 1.1V to 2.7V V _{CC} (B) = 1.65V to 3.6V
TSSOP14(5.0 x 6.4 t = 1.2)	Single-supply unidirectional level shifters	74LV4T125FT 74LV4T126FT	V _{CC} ~1.65V to 5.5V
US8(2.0 x 3.1 t = 0.7)	Dual-supply level-shift bus switches	TC7WPB Series	V _{CC} (A) = 1.65V to 5.0V V _{CC} (B) = 2.3V to 5.5V
TSSOP14(5.0 x 6.4 t = 1.2)		TC7QPB Series	
TSSOP14(5.0 x 6.4 t = 1.2)		TC7MPB Series	

*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.

▼ Low-Voltage One-Gate Logic ICs (Topr: –40 to 125°C)

Package Unit (mm)	Series	Key Electrical Characteristics
USV (2.0 x 2.1 t = 0.9)	7UL1G Series	V _{CC} = 0.9 V to 3.6 V
	7UL1T Series	V _{CC} = 2.3 V to 3.6 V * With level-shifting function
US8 (SOT-765) (2.0 x 3.1 t = 0.7)	7UL2G Series	V _{CC} = 0.9 V to 3.6 V
	7UL2T Series	V _{CC} = 2.3 V to 3.6 V * With level-shifting function

*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.

Products: AEC-Qualified Automotive Discrete Devices : Part2

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	○
		2SC3303	80	5	70	1	1	0.4	3	150	
		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 	CMG03A	600	2.0	1.1	

Products: System Power Supply ICs for Automotive

System Power Supply ICs with an Integrated DC/DC Converter

As vehicle electronics become more sophisticated, it is becoming essential to increase the output current capability and the number of outputs of power supply ICs. Toshiba provides power supply ICs with a DC-DC converter. The TB9045FNG and TB9044AFNG are ideal for electronic power steering applications. In addition to a switching regulator for an MCU core, these power supply ICs have three tracker regulators for sensors.

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

TB9045FNG Series

Switching regulator for the MCU core (5 V, 1.1 to 1.5 V) and three tracker regulators for sensors

Low-voltage operation and functional safety mechanism compliant with Automotive Safety Integrity Level D (ASIL-D)

DC-DC Converter Power Supplies

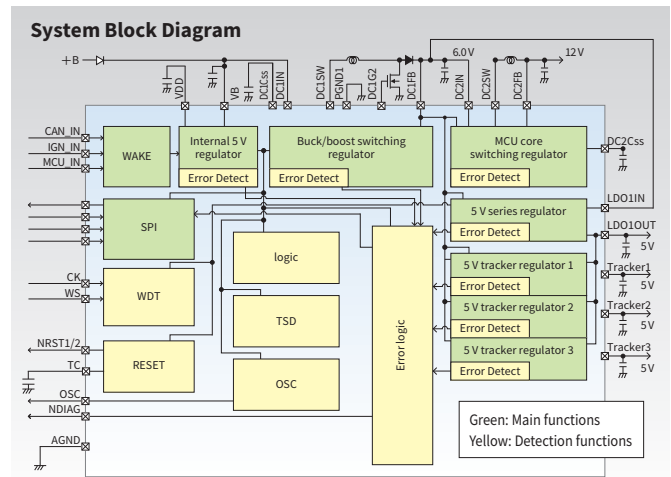
- DCDC1 (step-up/down)
6 V output, 2.7 V drive, built-in step-down driver, external step-up driver, built-in phase compensation
- DCDC2 (step-down)
Integrated step-down driver and phase compensation filter; 0.8-A current capability
Available with an output voltage of 1.1, 1.2, 1.25 and 1.5

Series Power Supplies

- LDO1: 5 V output (400 mA)
- Tracker regulators 1 to 3: 5 V outputs (100 mA)

Various detection circuits

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



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

TB9044AFNG

Series regulator for the MCU core (5 V) and three tracker regulators for sensors

Low-voltage operation and functional safety mechanism compliant with Automotive Safety Integrity Level D (ASIL-D)

DC-DC Converter Power Supplies

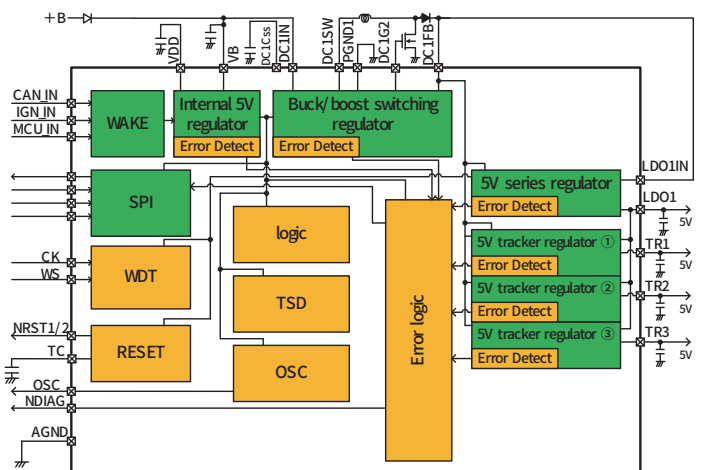
- DCDC1 (step-up/down)
6 V output, 2.7 V drive, built-in step-down driver, external step-up driver, built-in phase compensation capacitor

Series Power Supplies

- LDO1: 5 V output (400 mA)
- Tracker regulators 1 to 3: 5 V outputs (100 mA)

Various detection circuits

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



System Power Supply ICs (Series Power Supplies)

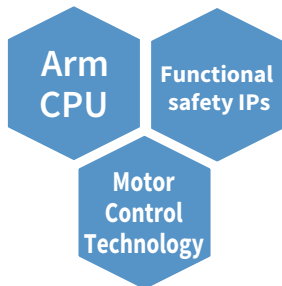
Part Number	Package	Functions	Characteristics				Remarks	Supply Voltage (V)	AEC
			Output Voltage Typ. (V)	Output Current (mA)	Input Voltage Max (V)	Power Dissipation Max (W)			
TB9005FNG	SSOP20-P-225-0.65A	CPU voltage regulator, watchdog timer	5	Depends on ext. Tr.	45 (1 sec.)	0.68	• Low current consumption: 90 μA (typ.) • Watchdog timer enable/disable • Reset detection: 4.7 V/4.2 V (selectable) • SPI (error information output) • External transistor required	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)			
TB9044AFNG	HTSSOP48-P-300-0.50	CPU voltage regulator DC-DC converter & LDO Watchdog timer On-chip SPI	5	400	40 (1 sec.)	3.84	• DC-DC converter • Four low-dropout (LDO) regulators • 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-110 TB9045FNG-120 TB9045FNG-125 TB9045FNG-150	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	800	40 (1 sec.)	3.84	• DC-DC converter • Four low-dropout (LDO) regulators • 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	○

Products: Automotive Microcontrollers

Features of Toshiba's Automotive Microcontrollers



Motor control technologies:

Toshiba's automotive microcontrollers incorporate hardware inverter system solutions (VE¹, RDC², A-PMD³) that integrate Toshiba Group's expertise in motor control, which help increase the torque power, reduce the size, and improve the efficiency, for motor systems.

Functional safety IPs:

Each peripheral IP is provided a hardware fault detection mechanism, eliminating the need for software of continuously monitoring to random faults. This enables real-time fault detection with reduces the workload required for software development, and helps achieve ASIL-level functional safety.

Arm® CPU:

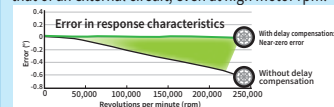
Toshiba's automotive microcontrollers incorporate an arm core processor that is regarded as a global de facto standard, securing customers' software assets for many years ahead and providing access to extensive technical resources.

VE^{*1}: Vector Engine
RDC^{*2}: Resolver to Digital Convertor
A-PMD^{*3}: Advanced Programmable Motor Driver

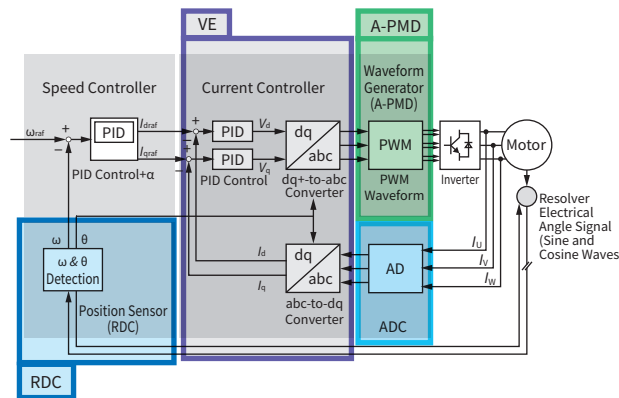
Field Oriented Control Technology for Automotive Motor Control MCUs

VE: Toshiba's Vector Engine (VE) provides an efficient and high-speed field oriented control capability because it implements all the field oriented control tasks in hardware and communicates with PMD, RDC, and ADC automatically. Any field oriented control tasks can also be implemented as software; the VE is therefore highly compatible with existing motor systems.

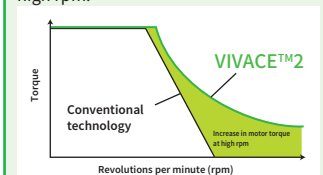
RDC: The resolver-to-digital converter (RDC) incorporates a delay compensation mechanism, which minimizes an error caused by a signal delay, including that of an external circuit, even at high motor rpm.



Note: In comparison on delay compensation on/off evaluation to Toshiba device

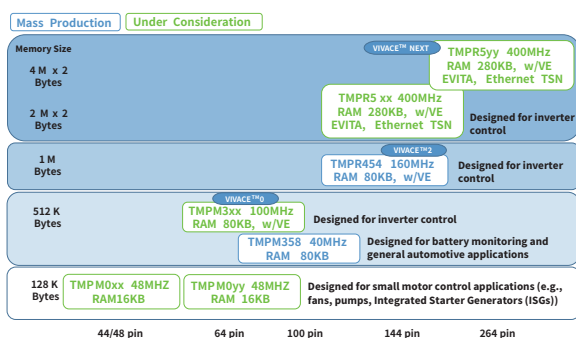


A-PMD: With a one-shot pulse generator, the Advanced Programmable Motor Driver (A-PMD) helps increase motor torque at high rpm.



Note: As surveyed by Toshiba

Roadmap for Automotive Microcontrollers



Drawing on all the power electronics technologies of Toshiba Group, we will strive for plan and develop automotive microcontrollers that will contribute to the dramatic transformation of the automotive industry. In addition, in order to contribute to the achievement of the SDGs, Toshiba aspires to realize a product development and development support environment in cyberspace, departing from the traditional paradigm of physical prototyping with substantial environmental impact. In pursuing this initiative, we will form partnerships or collaborate with customers who share the same values.

Development Tools and Partners

A wide range of development tools are available from many partners for automotive ARM Cortex-based microcontrollers.

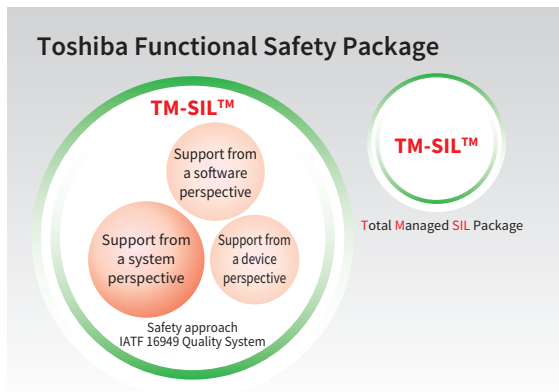
Choose the best development tools and partners that best suit your needs.

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. (DTS INSIGHT 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	●
SEGGR Microcontroller GmbH							ON board	

Functional Safety

Toshiba Functional Safety Package TM-SIL™

Toshiba offers a support environment not only from the device perspective but also from the customer's perspective, one step more.

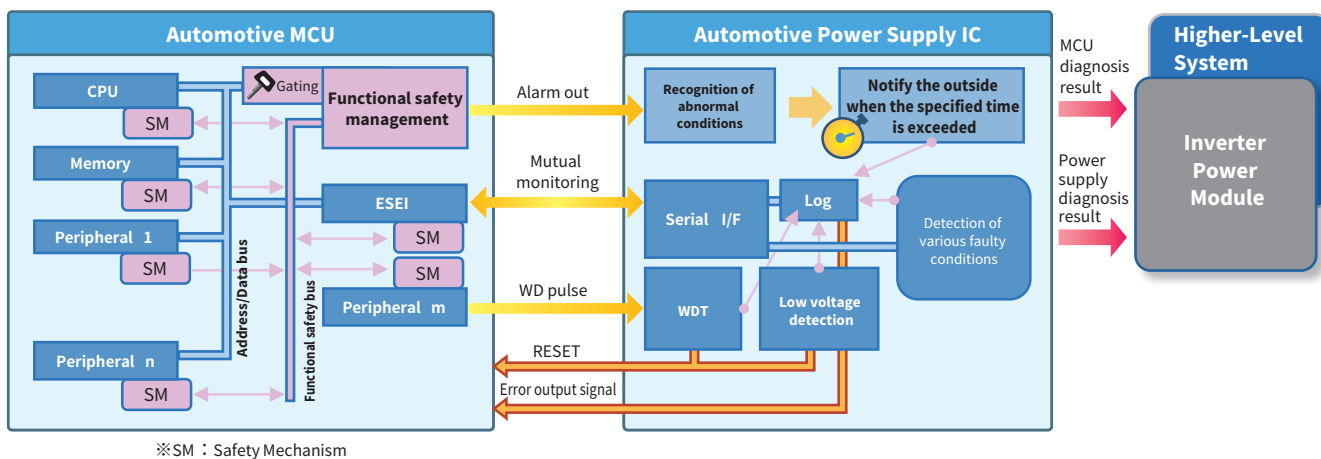


TM-SIL™ is Toshiba's packaged service designed to help create a functional safety system. Our specialist team provides support for various services from device, software, and system perspectives.

To develop a functional safety system, you need to address many issues, including device metrics reporting, FMEDA, ASIL-compliant software development, and an analysis of the functional safety of application circuits. Therefore, Toshiba considers that a chipset and a packaged service are extremely useful.

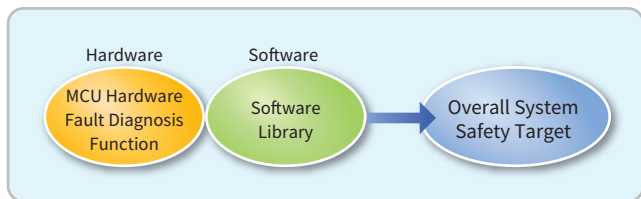
Note: Some products provide support only for ISO 26262:2011. If necessary, ensure that the product you are interested in supports ISO 26262:2018.

Support from a device perspective: Toshiba's microcontrollers for functional safety have been provided a hardware monitoring mechanism for detecting faulty conditions in each internal functional block, contributing to meeting the system safety requirements of ASIL.

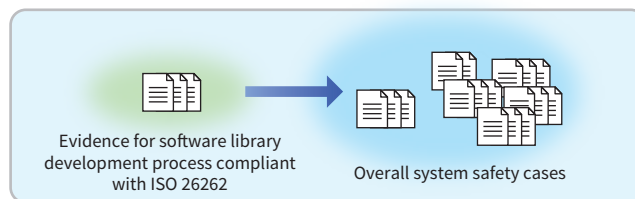


Support from a software perspective: Toshiba provides a software IP library for functional safety: Software library for operation diagnosis to failure monitoring mechanism (by hardware) installed in MCU and initial diagnosis for other portions. Developed based on a process certified by TÜV SÜD, this software IP library comes with development evidence required for the ISO 26262 ASIL D. It therefore helps reduce system development time.

Reduction in the time required to create a safety mechanism



Reduction in the time required to meet accountability requirements

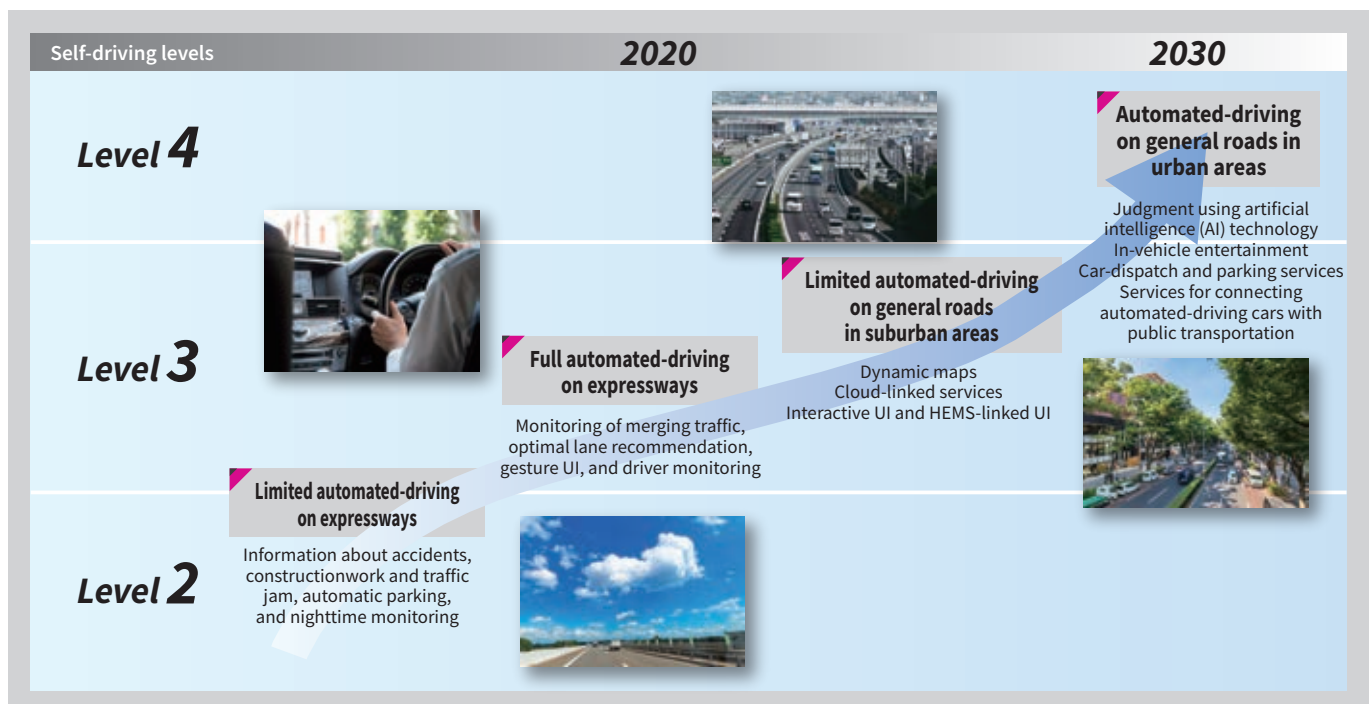


Support from a system perspective: A team of specialists in automotive MCUs, system power supply ICs, and the functional safety IP library provide support to help facilitate your development of a functional safety system.



Autonomous (ADAS and Automated-Driving): Part 1

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.



Autonomous (ADAS and Automated-Driving): Part 2

ADAS

P.27



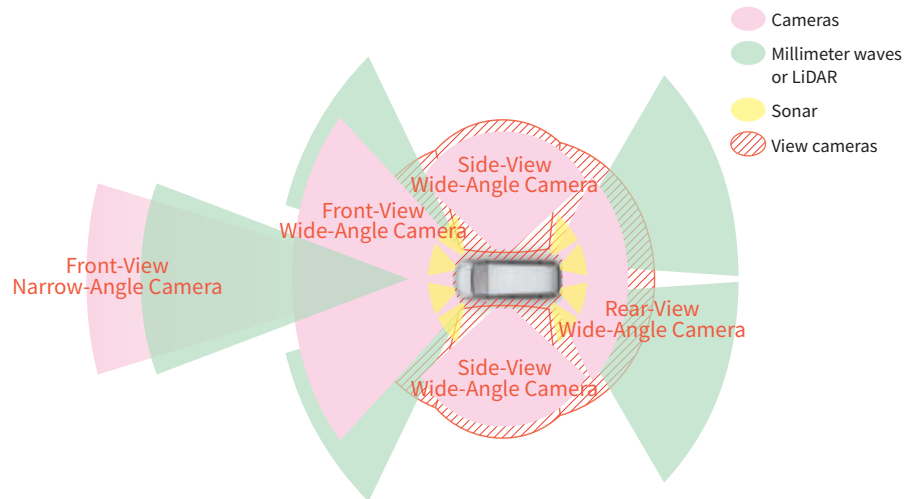
Parking Assist



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.30,31,32



Electronic Mirror

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

V2X Telematics Module

In-Vehicle Networks

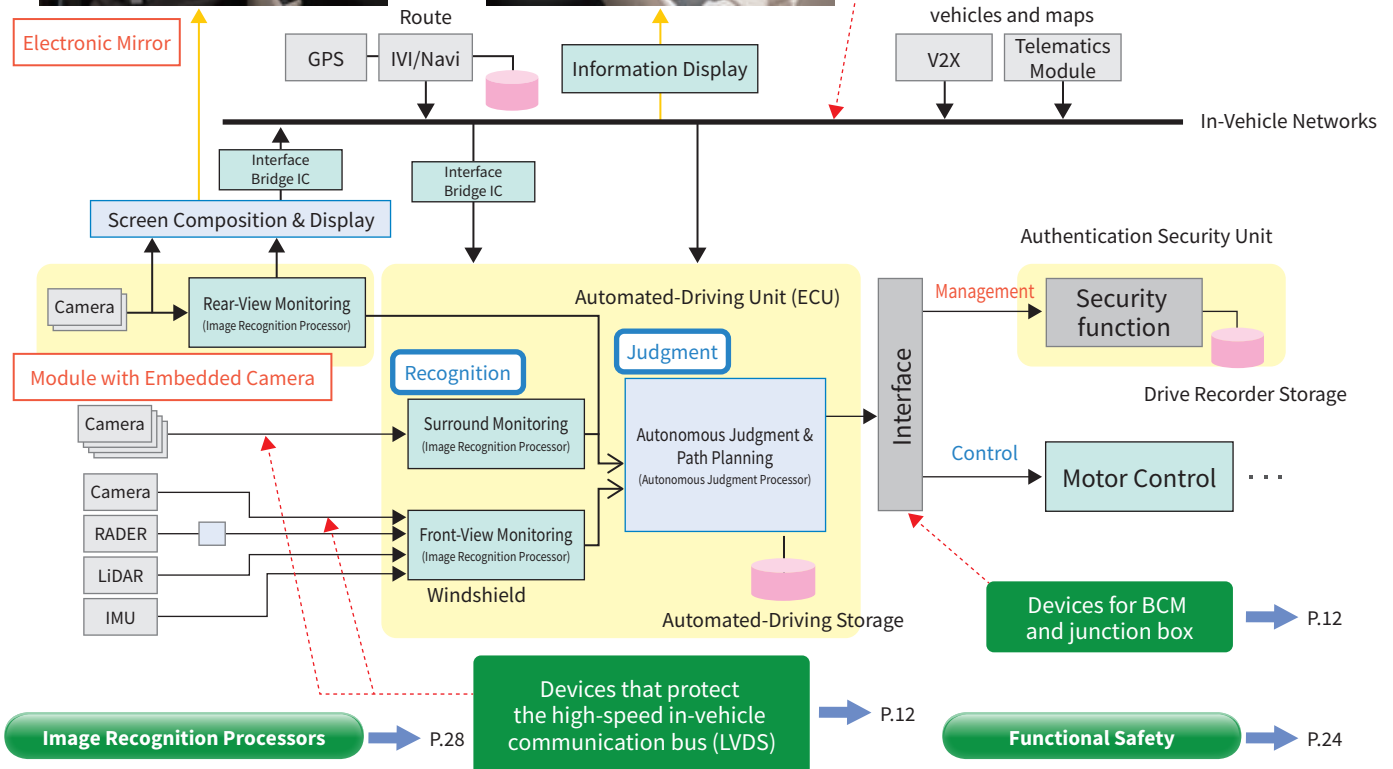


Image Recognition Processors

P.28

Devices that protect the high-speed in-vehicle communication bus (LVDS)

P.12

Functional Safety

P.24

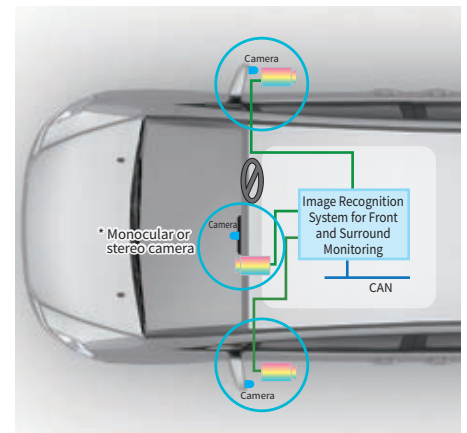
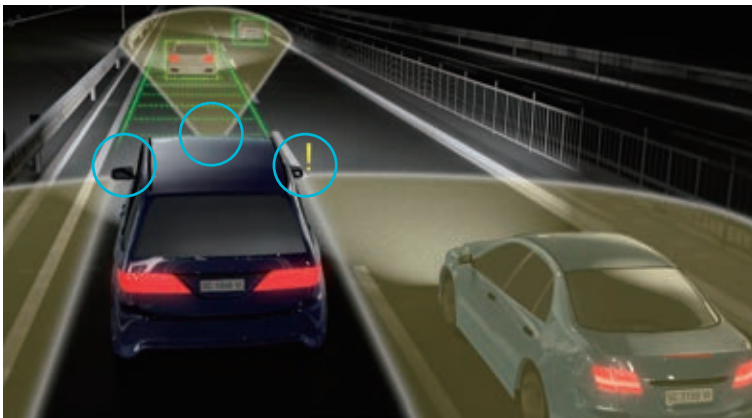
ADAS (Advanced Driver Assistance Systems)

The Visconti™ family of image recognition processors combine low power consumption with the high computing performance required to run various image recognition algorithms for an advanced driver assistance system (ADAS) at high speed.

▼ ADAS: Front and Surround View Monitoring Solution

The Visconti™ image recognition processor is capable of processing input images from multiple cameras in real time to recognize vehicles, pedestrians, traffic lines, traffic signs and the like around the vehicle on which it is mounted. Visconti™ can run multiple ADAS applications in parallel, including those for 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.

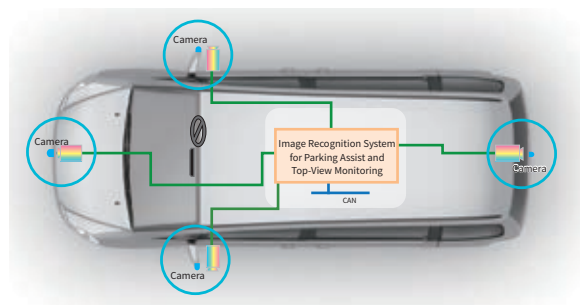
Visconti™ 5 incorporates deep-neural-network (DNN) hardware IP, which uses the results of deep learning to recognize various objects at higher accuracy than conventional pattern recognition and machine learning.



▼ 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.



Visconti™ Image Recognition Processors

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

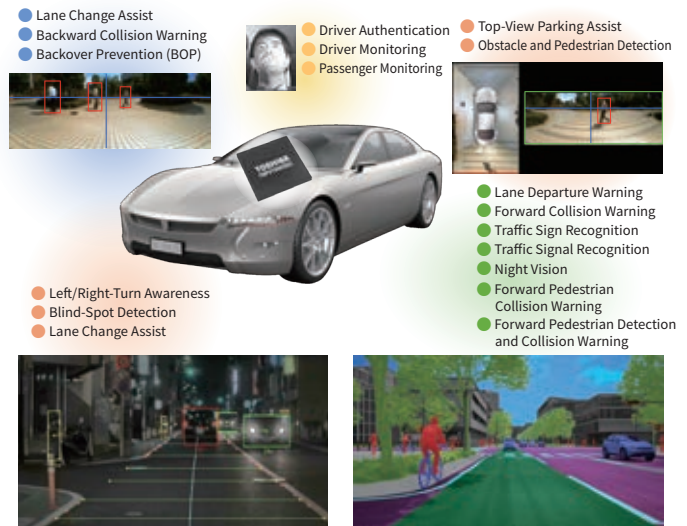
▼ Features

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.

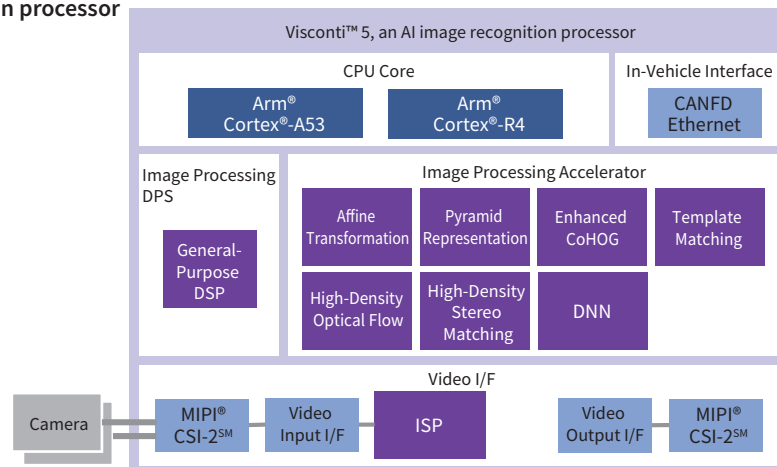
The Visconti™ family recognizes, in real time, traffic lines, vehicles, pedestrians, traffic signs, etc. around the vehicle on which it is mounted, thus enabling various advanced driver assistance applications. Possible applications include lane departure warning, forward/backward collision warning, forward/backward pedestrian collision warning, traffic sign recognition, and top-view parking assistance.

Visconti™ 5, an automotive AI image recognition processor, incorporates deep-neural-network (DNN) hardware IP suitable for ADAS and Automated-Driving applications.

▼ Driving Assistance Applications



▼ Visconti™ 5, an AI image recognition processor



▼ Lineup

Series	Part Number	Maximum Operating Frequency (MHz)	Arm®Cortex®-A53	General-Purpose DSP	Image Processing Accelerator							Video Input Interface (ch)	Video Output Interface (ch)	Gigabit Ethernet	UART	SPI	I²C	CAN FD	Memory Controller	CPU Core	Package
					Affine Transformation	Pyramid Representation	Enhanced CoHOG	Template Matching	High-Density Optical Flow	High-Density Stereo Matching	DNN										
Visconti™ 5	TMPV7706XBG	CA53:840 CR4:900 DSP:500 DNN:500	○	○	○	○	○	○	○	○	○	2	1	○	○	○	○	○	LPDDR4-SDRAM, Serial NOR Flash	○	PFBGA621

Series	Part Number	Maximum Operating Frequency (MHz) (MeP, MPE)	Media Processing Engine [MPE]	Image Processing Accelerator								Video Input Interface (ch)	Video Output Interface (ch)	UART	SPI	I²C	CAN	PCM	Memory Controller	CPU Core	Package
				Affine Transformation	Pyramid	Filter	Histogram	Histogram of Oriented Gradients [HOG]	Enhanced CoHOG	Matching	SfM									Toshiba's Proprietary 32-bit RISC CPU MeP	
Visconti™ 4	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.

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

Connected and Shared (IVI and communication)

Realization of automated-driving cars requires cars to be connected to social infrastructures such as traffic information and signal information and be capable of judging environmental changes through communication with other cars in front and behind. Connected cars must be provided with advanced infotainment systems that allow communication between cars and drivers. Toshiba Electronic Devices & Storage contributes to “connection” and “communication” through its technology.

Proliferation of connected cars

Connection between everyday life (products) and cars

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

Connection between occupants and cars

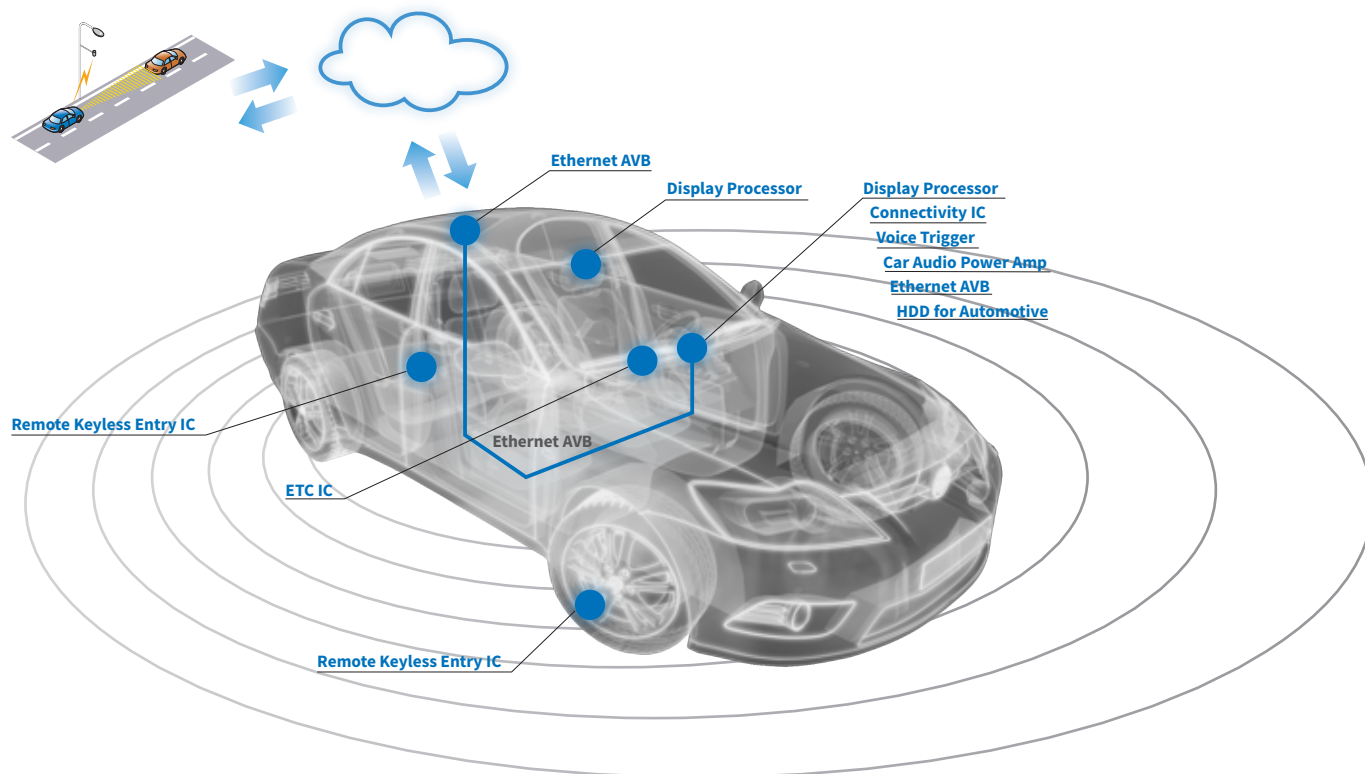
Occupants can naturally and directly communicate with cars without any media such as mobile phone.

Connection between outside and cars

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



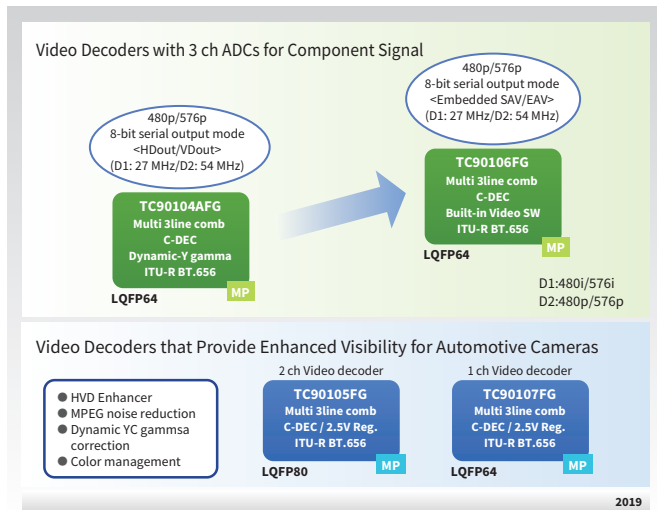
Key products for realizing connected cars



Video Decoder ICs

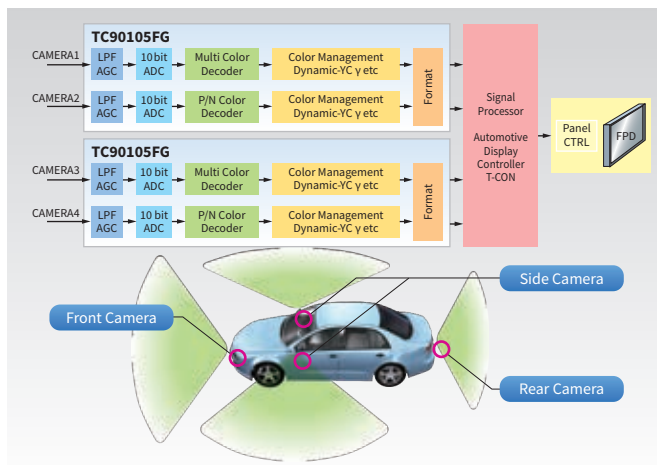
Video Decoder ICs

Roadmap



2-Channel Multi-Standard Video Decoders IC: TC90105FG

The TC90105FG contains 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.



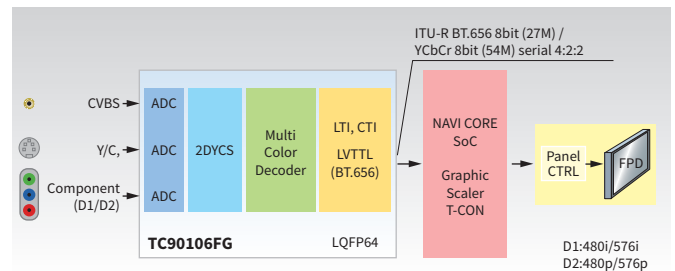
Lineup

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	○	—	○	—		

Full, Multi-Standard Video Decoder IC: TC90106FG

TC90106FG is a video decoder which supports full multi-color standards. This decoder converts CVBS input into ITU-R Bt.656 format. It also supports D1 and D2 component signal.

In case of D2 signal input, output format is 8bit serial data of 54MHz clock rate, with embedded SAV and EAV codes.

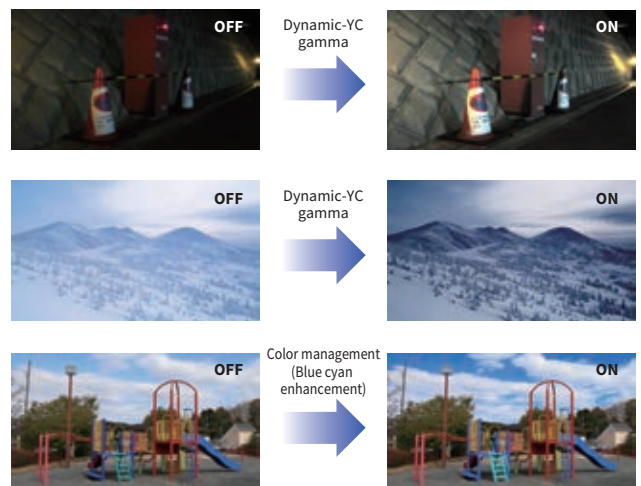


New Picture Adjustment Functions and Effects

HVD enhancement: This function allows diagonal image enhancement in addition to conventional horizontal and vertical enhancement. It provides increased edge enhancement of image while keeping natural images.

Color management: This function enhances the saturation of the selected colors. It is designed to increase the image visibility by enhancing specific colors such as red. The TC90105FG allows up to three colors and their enhancement levels to be selected separately.

Dynamic YC gamma correction: This function suppresses images of areas that are too dark and images of areas that are too bright to improve image visibility by optimally adjusting the gamma correction curve for luma according to images. In addition, it maintains the balance between the luma and chroma levels by adjusting the chroma gain according to the luma gamma correction curve.



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

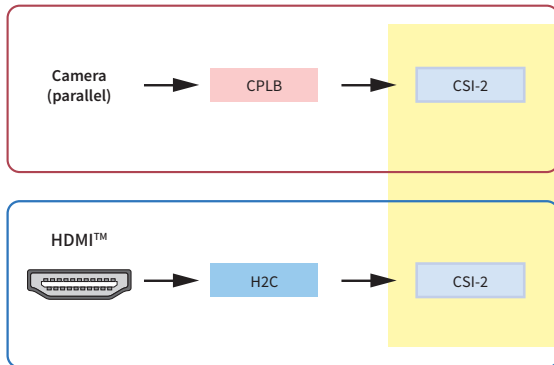
MIPI® DSISM, CSI-2SM, LVDS, DisplayPortTM and HDMITM are supported.

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

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

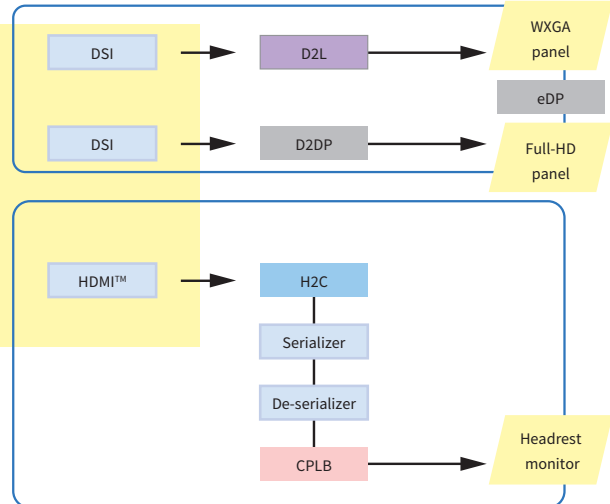
▼ Necessity of Interface Bridge ICs

Conversion to the camera I/F

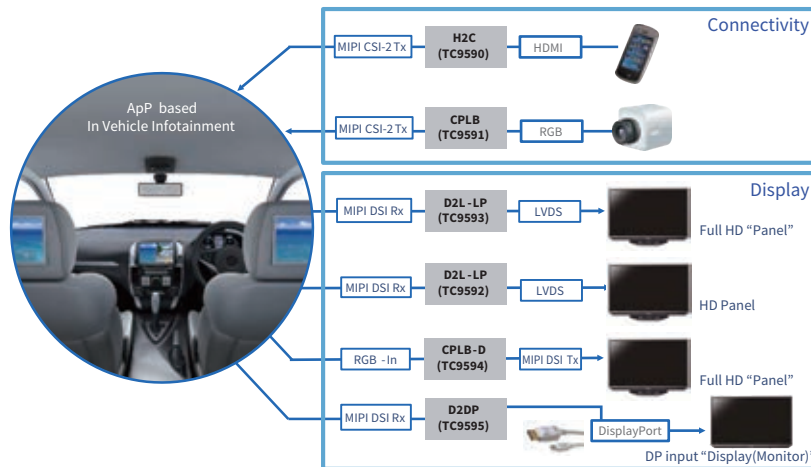


CSI-2: MIPI Camera Serial Interface
DSI: MIPI Display Serial Interface

Conversion to the display I/F



▼ 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	Full-HD 1920x1080 @60fps	-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
CPLB-D	TC9594XBG	Parallel input 24bit@166MHz	MIPI DSI 4 lane x 1ch	WUXGA 1920x1200 24bit	-40 to 105°C	P-VFBGA80 7 mm x 7 mm 0.65 mm pitch
D2DP	TC9595XBG	MIPI 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

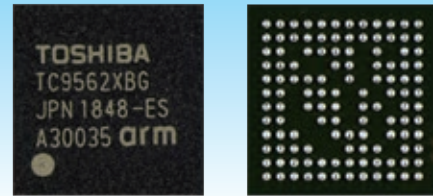
Automotive Ethernet Bridge ICs

The TC9560 and TC9562 families provide the Ethernet AVB and Ethernet TSN (for TC9562BXXBG 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.

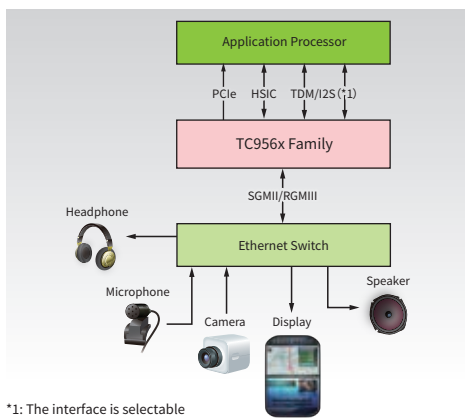
▼ Bridge ICs for Next-Generation In-Vehicle Infotainment (IVI) Systems: TC9560 and TC9562 families

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 TC9562BXXBG 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.

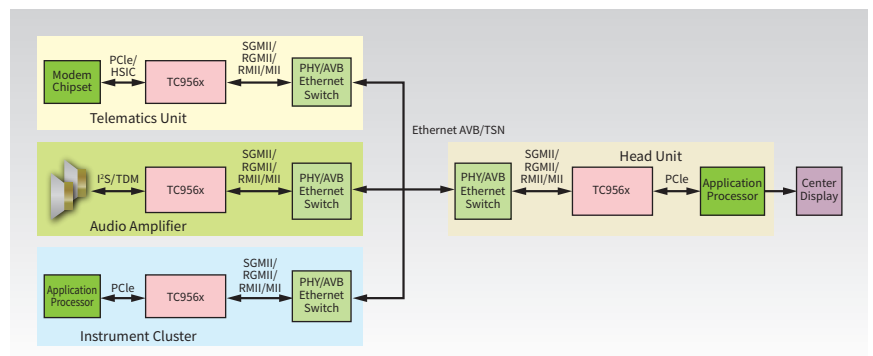


■ System Block Diagram



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

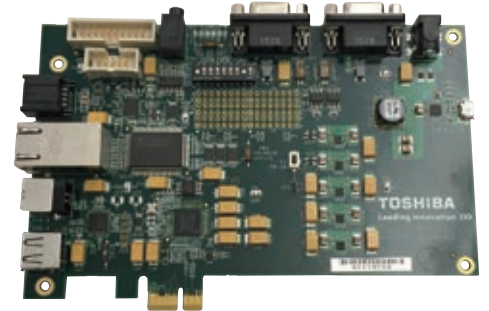
■ Interfacing Example



■ 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 TC9562BXXBG 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:	Communication 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				
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
TC9560BXXBG		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	✓						RGMII /RMII /MII /SGMII
TC9562AXBG			✓		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				
TC9562BXXBG			✓	✓	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				

In-Vehicle Audio Power Amplifier ICs

Toshiba's power amplifier ICs for car audio applications incorporate the functions necessary to realize audio systems with high efficiency and reliability.

■ **High efficiency:** Toshiba's proprietary Class-TB amplifiers make it possible to achieve as low loss as digital amplifiers under actual usage conditions.

■ **High reliability:** A full-time offset detector simplifies speaker burnout prevention.

▼ Toshiba's Unique High-Efficiency Class-TB Amplifiers (Tied BTL): TCB701FNG and 702FNG

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.

▼ Speaker burnout prevention with a full-time offset 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.

Benefits of a full-time offset detector

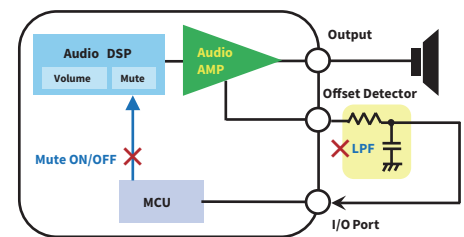
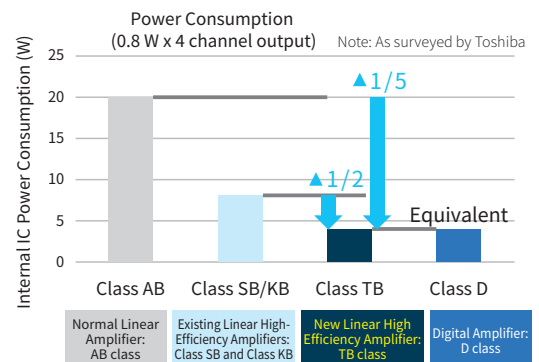
The DC offset at the speaker terminals due to water droplets or capacitor leakage currents might damage the speaker coil.

In the event of the burnout of the voice coil, a speaker might produce distorted sound, strange noise, or no sound at all, or even cause smoke or fire. It is therefore crucial to prevent an output DC offset.

All of Toshiba's four-channel power amplifiers incorporate a speaker burnout prevention function.

In particular, the power amplifiers with the patented full-time offset detector allow full-time detection of an output DC offset, making it possible to create a speaker system free of burning hazards. These power amplifiers also simplify the development of MCU software.

Comparison of power dissipations by amplifier type



✗ Not required by power amplifier ICs with a full-time offset detector

Power amplifier ICs with a full-time offset detector:

TCB501/502HQ: Mass production

TCB701/702FNG: Mass production

Mode	Output Signal Level	Conventional Technology	Full-Time Offset Detector
1	When no sound signal is present (when sound is muted)	Available	Available
2	When an output sound signal with a small amplitude is present (when the output is NOT clipped)	An LPF is required to adjust time constants.	Available (No LPF is required.)
3	When an output sound signal with a large amplitude is present (when the output is clipped)	N/A (DC offset detector malfunctions or is unable to detect an output DC offset.)	Available

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

TB New proprietary Class-TB high-efficiency amplifiers

✓ Full-time offset detection function (Toshiba patent)

Process	Part Number	Max Output		Class	Voltage Gain	I ² C Bus	Offset Detection	Clip Detection	Short-Circuit Detection	High-Side Switch	Half Short Det.	Speaker Burning Prevention	2- Load	GSM Support	6-V Operation	Package	Availability
		V _{CC} = 15.2 V	V _{CC} = 14.4 V														
BiCD 0.13 μm	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 μm	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	
	TCB701FNG*	49 W	45 W	TB	26 dB/16 dB	✓	✓	✓	✓		✓		✓	✓	✓	HSOP36	
	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		Class	Voltage Gain	Thermal Detection	Speaker Open-Circuit Detection	Output Short-Circuit Detection	Overvoltage Detection	Applications	Package	Availability
		V _{CC} = 16 V	V _{CC} = 12 V									
BiCD0.13 μm	TB2909FNG	5 W	3 W	AB	26 dB (variable)	✓	✓	✓	✓	AVAS, etc.	TSSOP16	MP

Target Applications of Automotive Communication ICs

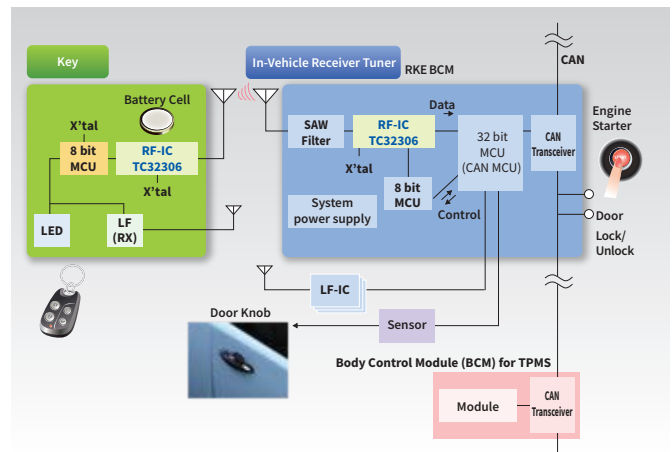
Toshiba's portfolio of automotive communication ICs includes ICs for remote keyless entry (RKE), electronic toll collection (ETC), and Bluetooth. RF devices not only allow remote operations but also can be used to receive information from a tire pressure monitoring system (TPMS) for display on the instrument 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.35
32 bit MCU	TMPM358FDTFG	P.23
System power supply	TB9005FNG TB9044AFNG	P.22

Block Diagram of a Remote Keyless Entry System

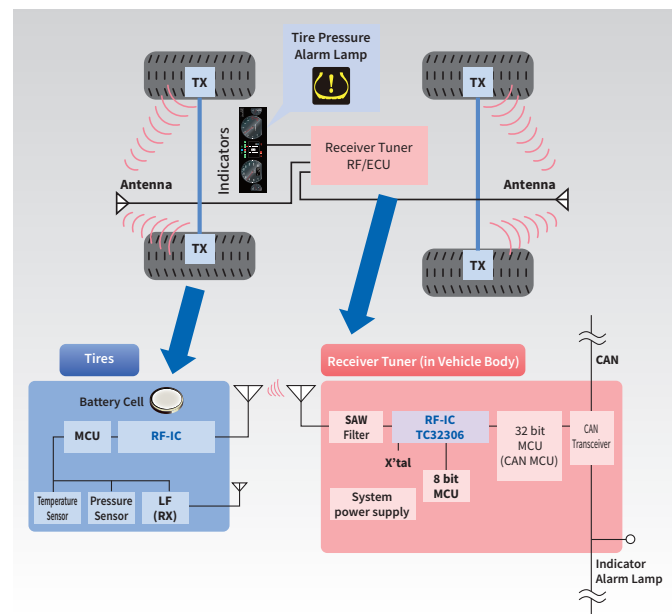


Tire Pressure Monitoring System (TPMS)

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.35
32 bit MCU	TMPM358FDTFG	P.23
System power supply	TB9005FNG TB9044AFNG	P.22

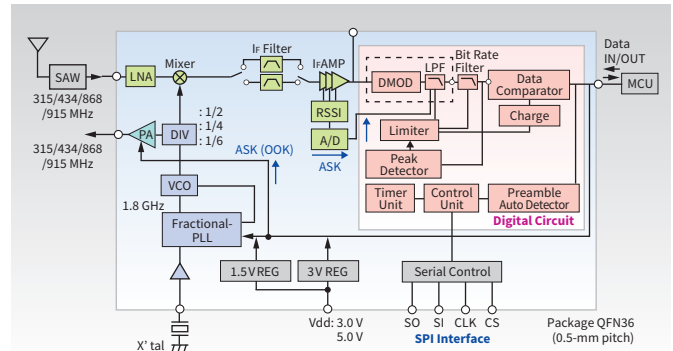
Block Diagram of a Tire Pressure Monitoring System



RF Devices for Automotive

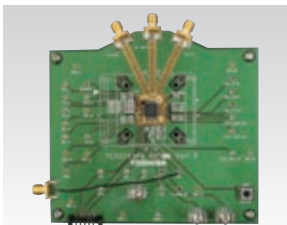
▼ Transceiver IC (TC32306FTG)

- 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 μ A (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 = $\pm$ 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.



Wireless Communication IC Series for ETC Applications

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

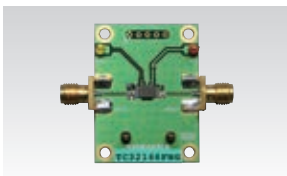


TC32163FG evaluation board

▼ 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

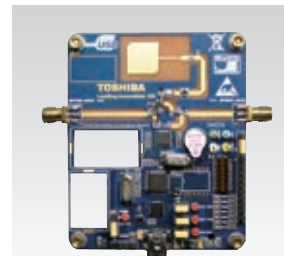


TC32166FNG evaluation board

▼ 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/TC32169FTG

- 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 μ A typ.)
- FM0 modem (addition of CRC checksum words, postambles and preambles)
- Small package: VQFN32 (5 x 5 mm, 0.5 mm pitch)

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