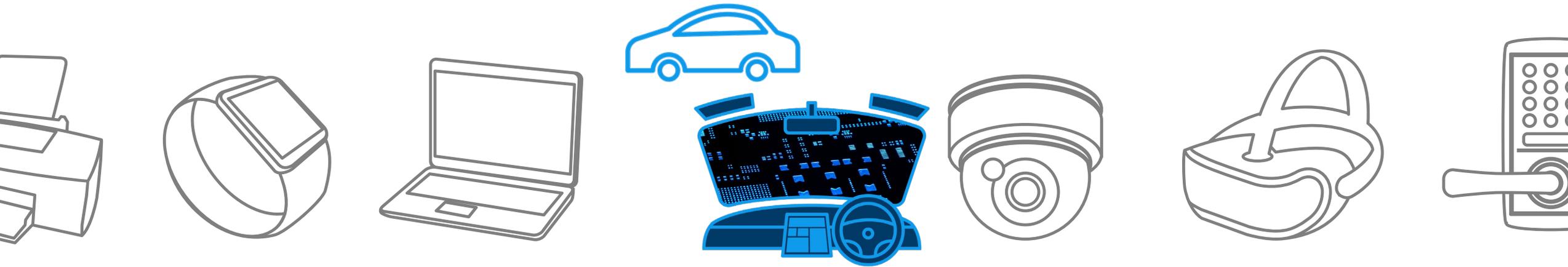**TOSHIBA**

R21

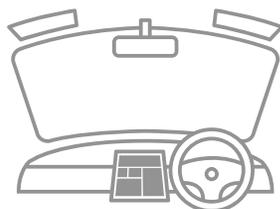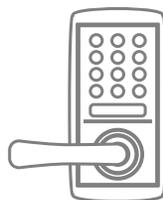# IVI
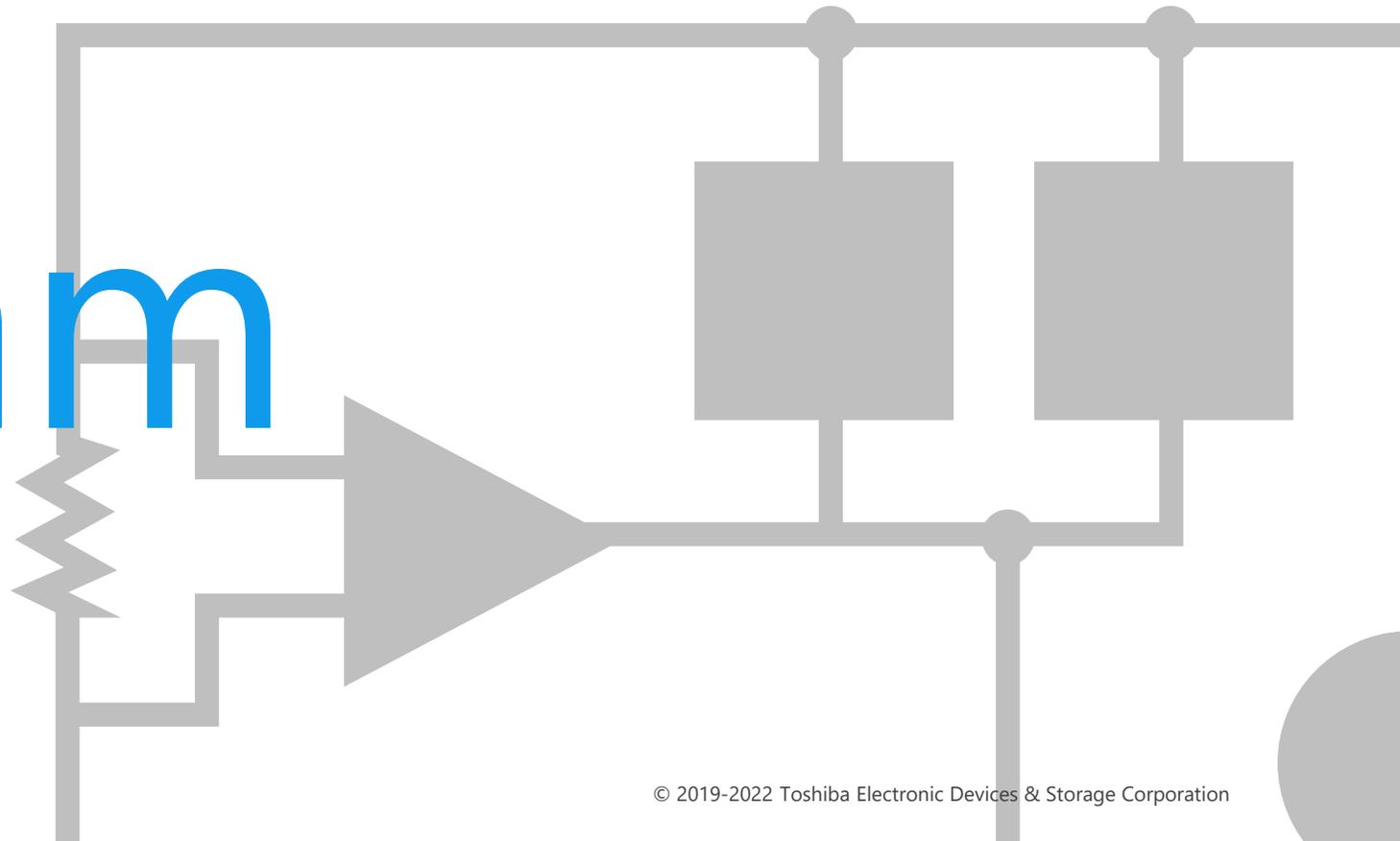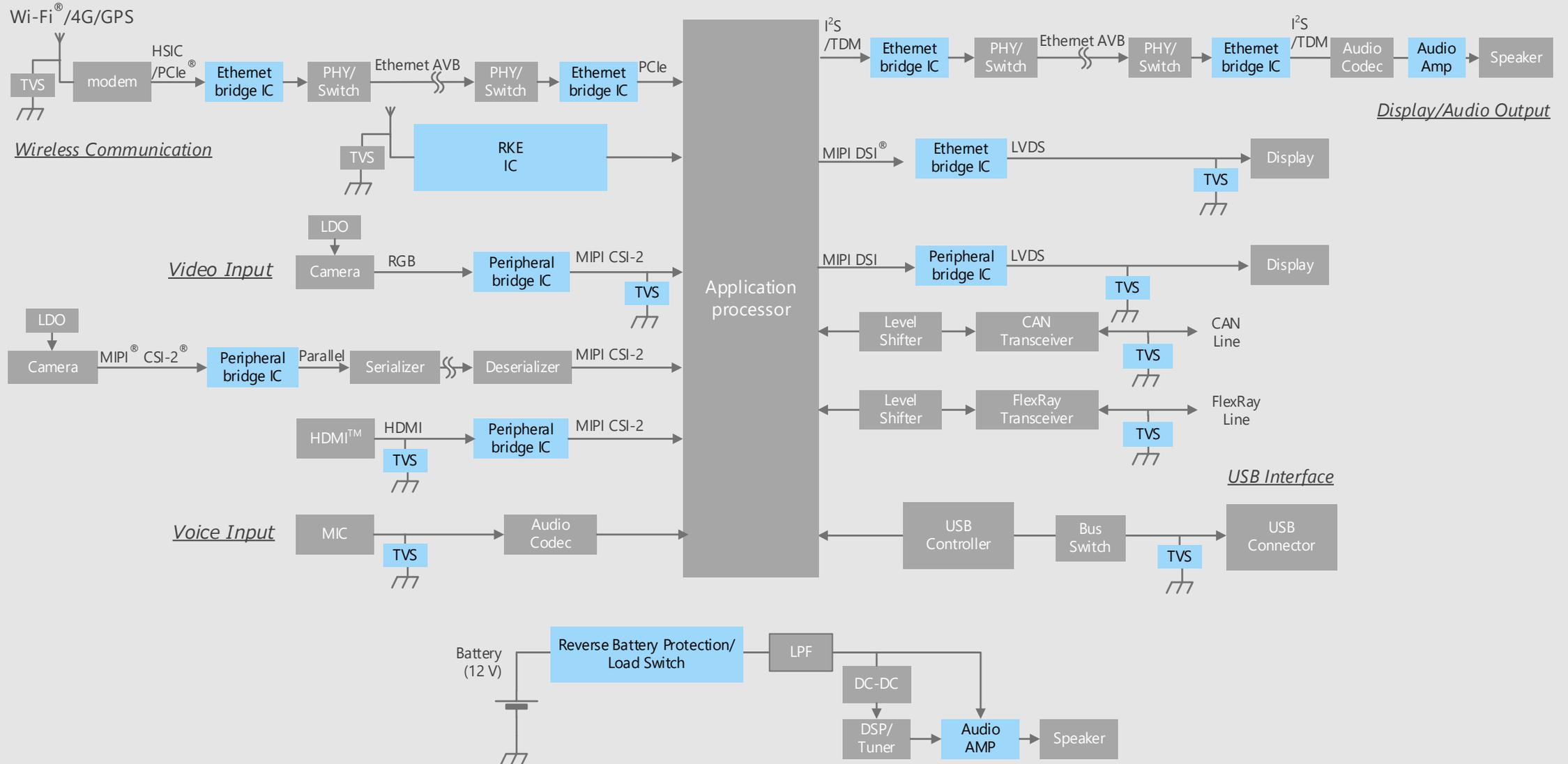# (In-vehicle Infotainment)

Solution Proposal by Toshiba

Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.
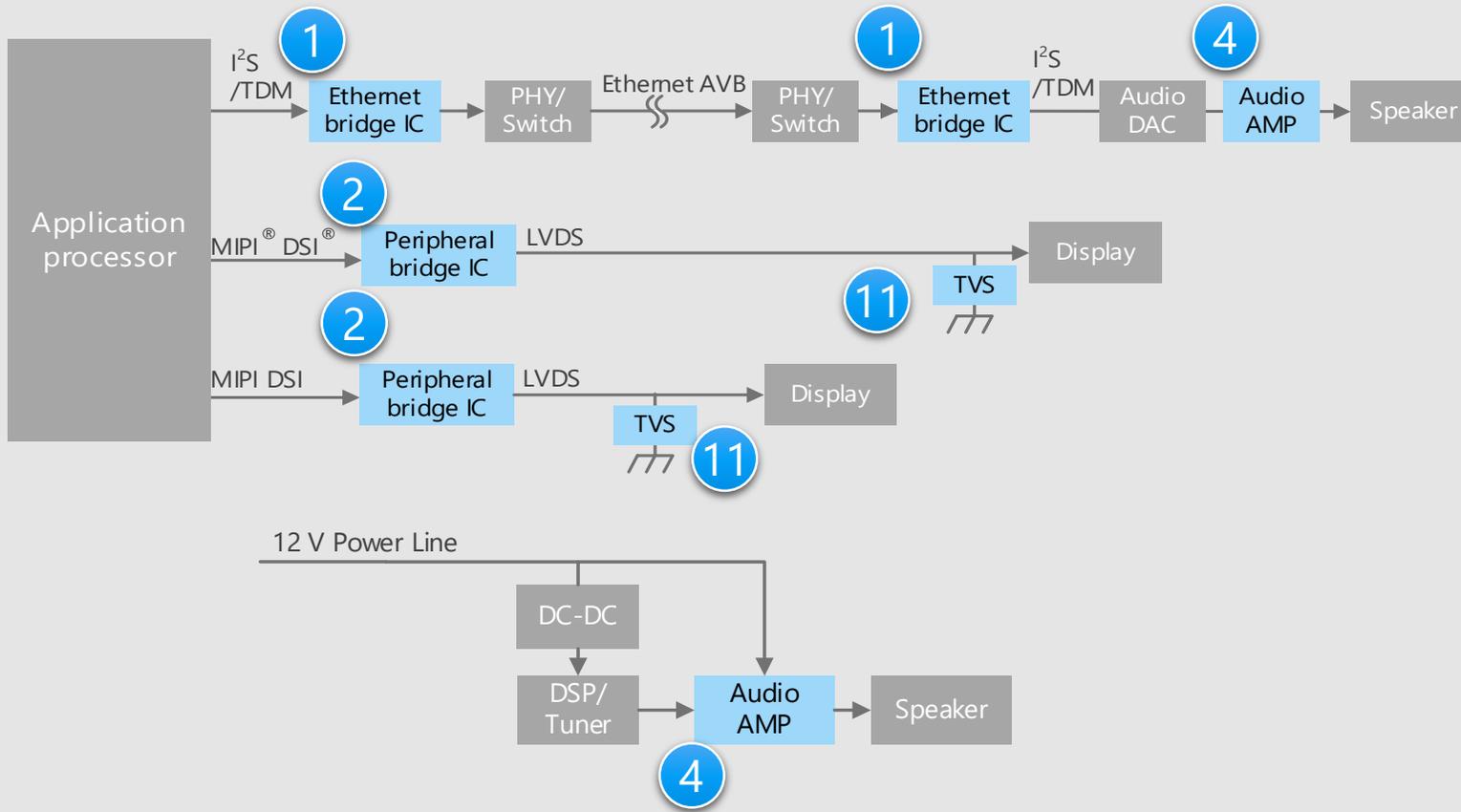
Block Diagram

Display and audio output section

Application processor

① I²S/TDM → **Ethernet bridge IC** → PHY/Switch → Ethernet AVB → PHY/Switch → ① **Ethernet bridge IC** → I²S/TDM → Audio DAC → ④ **Audio AMP** → Speaker

② MIPI® DSI® → **Peripheral bridge IC** → LVDS → ⑪ TVS → Display

② MIPI DSI → **Peripheral bridge IC** → LVDS → TVS ⑪ → Display

12 V Power Line → DC-DC → DSP/Tuner → Audio AMP ④ → Speaker

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

Criteria for device selection
- The adoption of Ethernet AVB/TSN is expanding as the next generation car networks.
- SoCs used in smartphones and tablets are also being designed into automotive systems. These require interface conversion of their peripheral devices.

Proposals from Toshiba
- **It realizes easy connection to the next generation in-vehicle network**
Ethernet bridge IC ①
- **Resolve differences between interfaces**
Peripheral bridge IC ②
- **High output power with low heat generation is realized**
Audio power amplifier IC ④
- **Suitable for ESD protection**
TVS diode (for high speed communication) ⑪

Video and voice input section

Video Input

LDO

②

Camera ——RGB——► Peripheral bridge IC ——MIPI CSI-2——►

TVS

LDO

②

Camera ——MIPI®CSI-2®——► Peripheral bridge IC ——Parallel——► Serializer ⟿ Deserializer ——MIPI CSI-2——► Application processor

②

HDMI™ ——HDMI——► Peripheral bridge IC ——MIPI CSI-2——►

TVS

⑪

Voice Input

MIC ——► Audio Codec ——►

TVS

⑪

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

Criteria for device selection

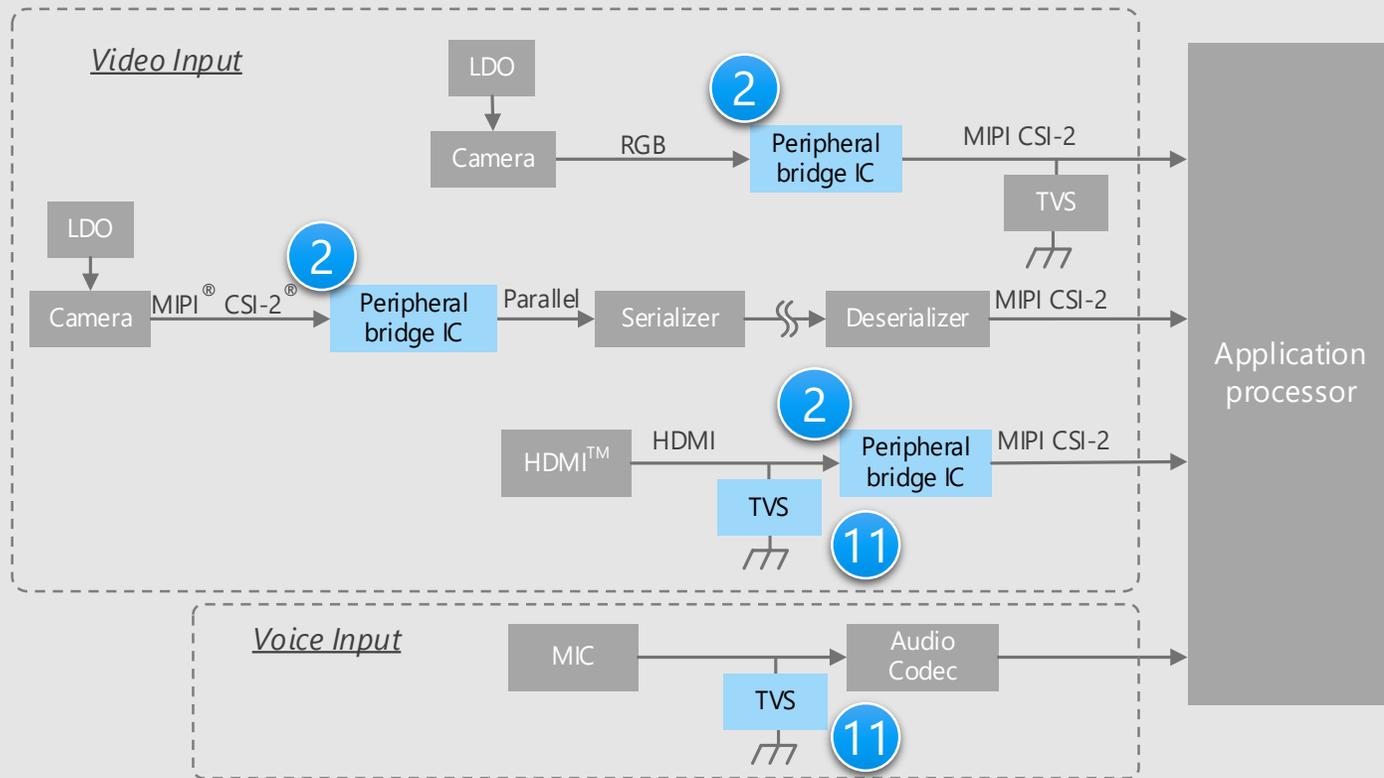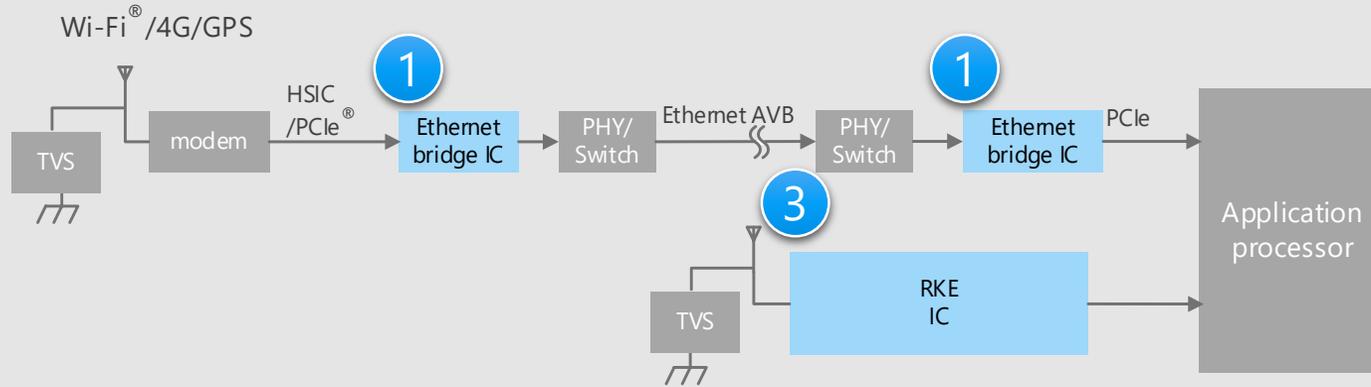- SoCs used in smartphones and tablets are also being designed into automotive systems. These require interface conversion of their peripheral devices.

Proposals from Toshiba

- **Resolve differences between interfaces**
  Peripheral bridge IC ②

- **Suitable for ESD protection**
  TVS diode (for high speed communication) ⑪

Wireless communications section

Wi-Fi®/4G/GPS

TVS

modem

HSIC /PCIe®

1 Ethernet bridge IC

PHY/ Switch

Ethernet AVB

PHY/ Switch

1 Ethernet bridge IC

PCIe

Application processor

3

TVS

RKE IC

Criteria for device selection

- The adoption of Ethernet AVB/TSN is expanding as the next generation car networks.
- Functions such as keyless entry is realized by using communication ICs.

Proposals from Toshiba

- **It realizes easy connection to the next generation in-vehicle network**
  Ethernet bridge IC **1**
- **It realizes various information sharing**
  Wireless communication IC **3**

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

DC-DC converter circuit (non-isolated buck type)
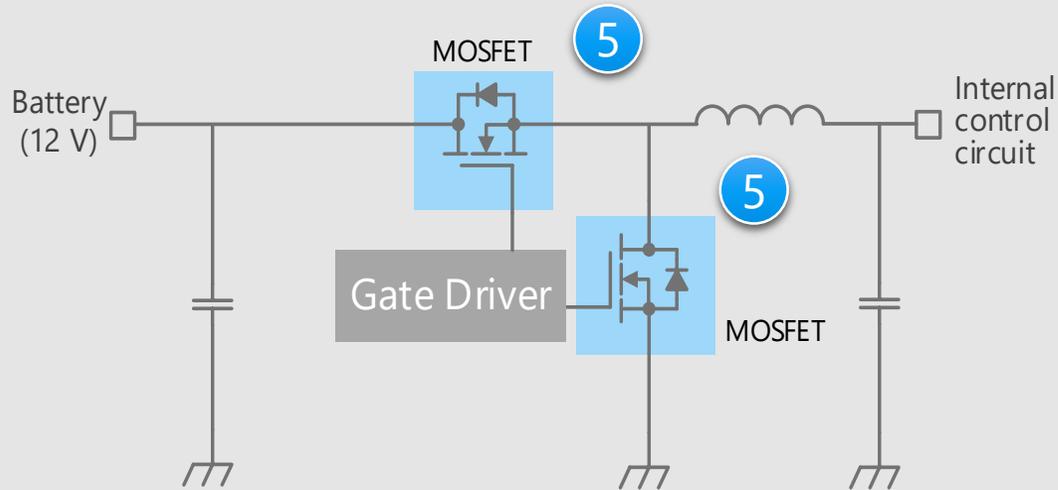
Criteria for device selection

- It is necessary to select the product with the suitable voltage and current ratings for each application.
- A small surface mount package is suitable for realizing miniaturization of the ECU.
- It is necessary to select high speed MOSFETs to prevent short through current.
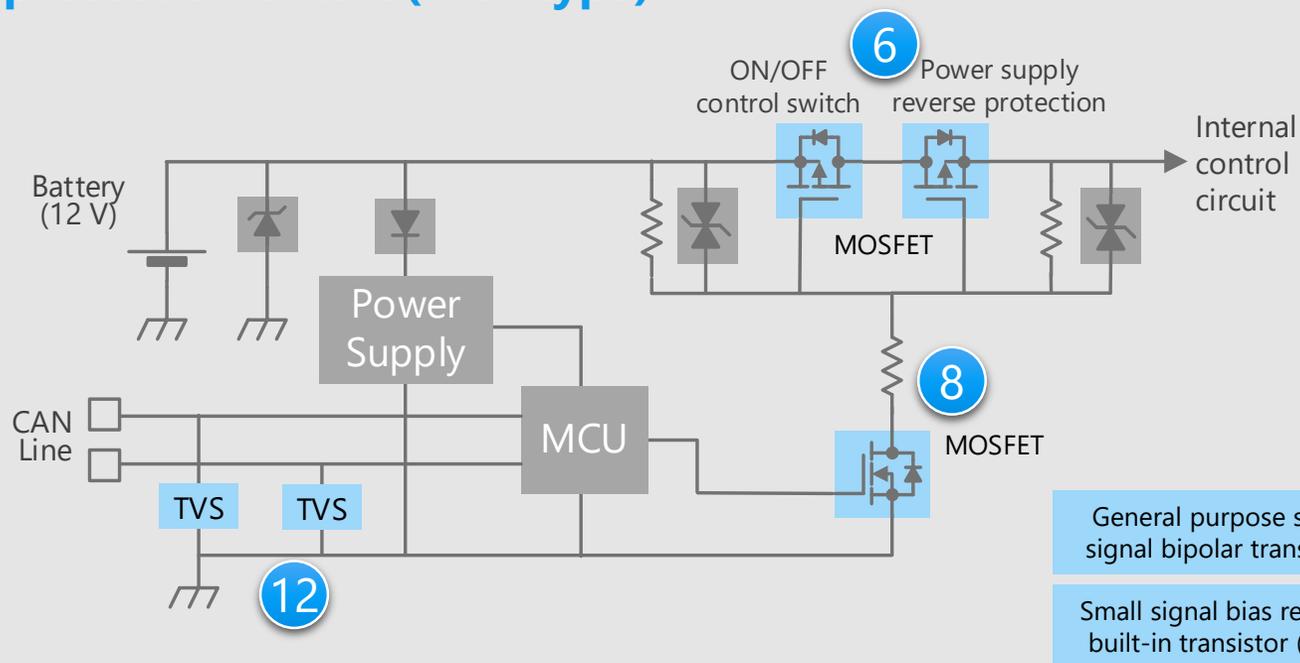
Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET

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

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

Battery (12 V)

ON/OFF control switch — ⑥ — Power supply reverse protection

MOSFET

Internal control circuit

Power Supply

MCU

⑧ MOSFET

CAN Line

TVS   TVS

⑫

General purpose small signal bipolar transistor	⑨
Small signal bias resistor built-in transistor (BRT)	⑩

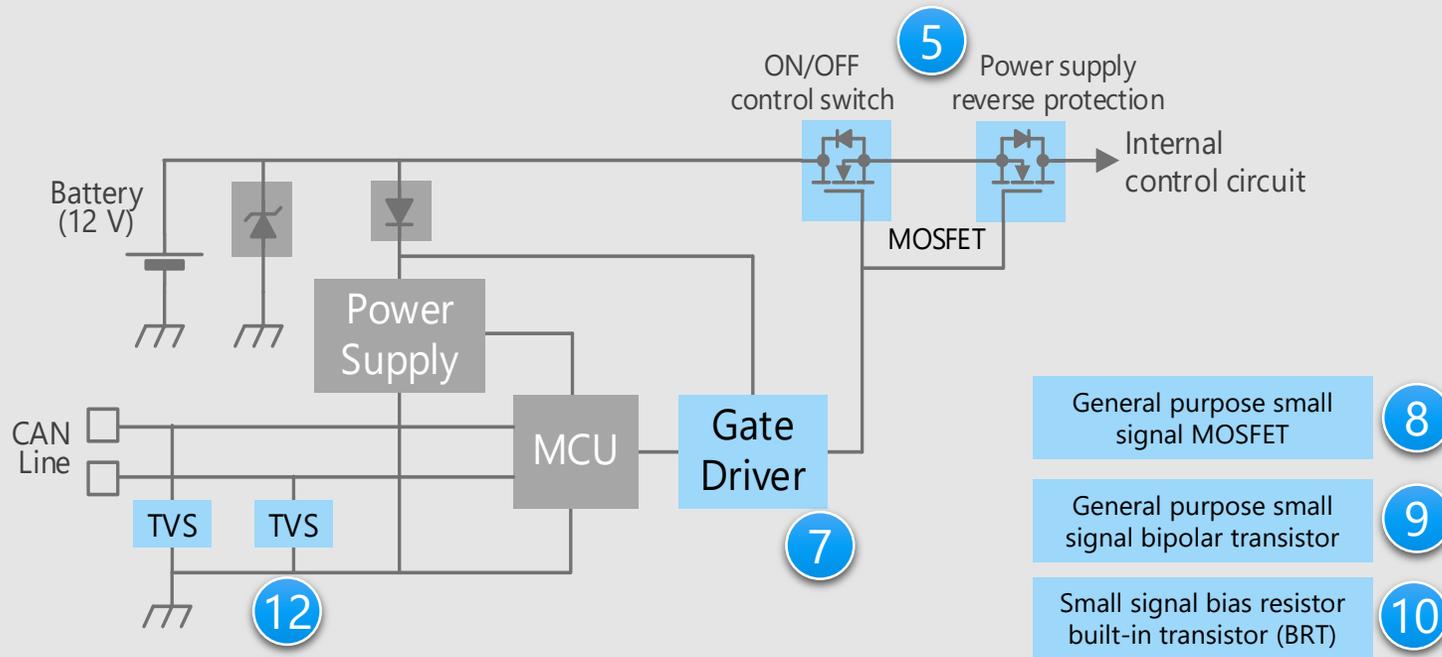* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Criteria for device selection
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposals from Toshiba
- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series -40 V / -60 V P-ch MOSFET ⑥
- **Extensive product lineup**
  General purpose small signal MOSFET ⑧
  General purpose small signal bipolar transistor ⑨
  Small signal bias resistor built-in transistor (BRT) ⑩
- **Suitable for ESD protection**
  TVS diode (for CAN communication) ⑫

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

⑤ ON/OFF control switch — Power supply reverse protection — Internal control circuit

MOSFET

Battery (12 V)

Power Supply

CAN Line

MCU

Gate Driver ⑦

TVS TVS ⑫

General purpose small signal MOSFET ⑧

General purpose small signal bipolar transistor ⑨

Small signal bias resistor built-in transistor (BRT) ⑩

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

Criteria for device selection

- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET ⑤
- **Gate driver with protection and diagnosis functions**
  Gate driver (for switch) ⑦
- **Extensive product lineup**
  General purpose small signal MOSFET ⑧
  General purpose small signal bipolar transistor ⑨
  Small signal bias resistor built-in transistor (BRT) ⑩
- **Suitable for ESD protection**
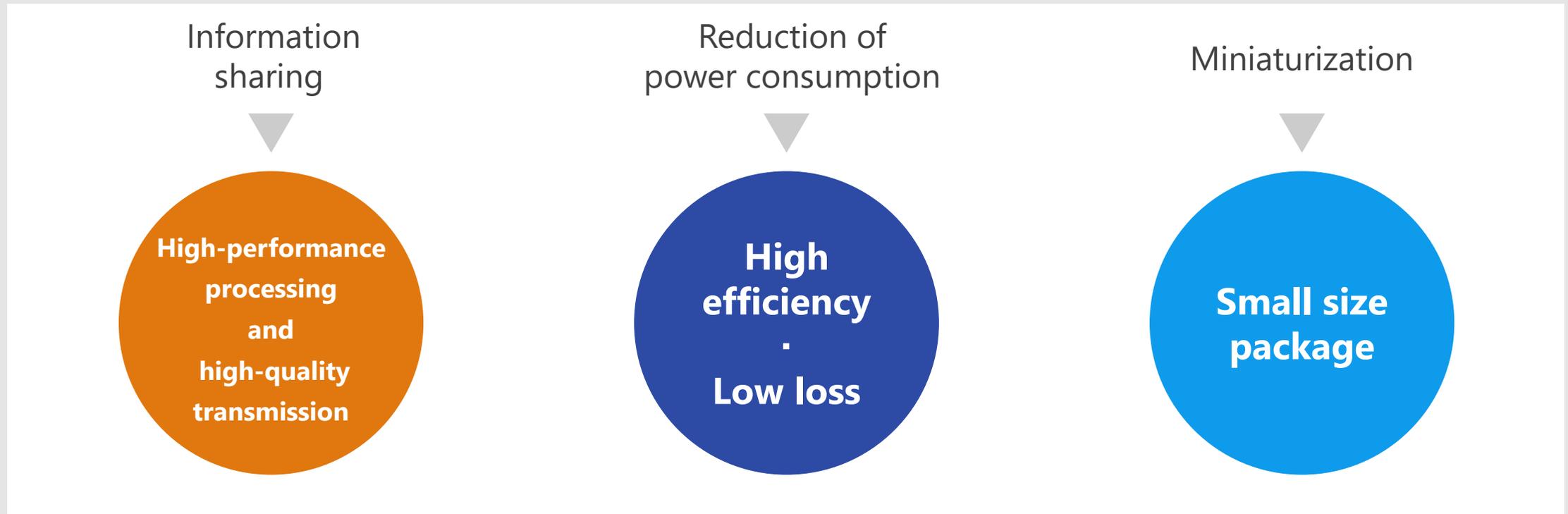 TVS diode (for CAN communication) ⑫

Recommended Devices
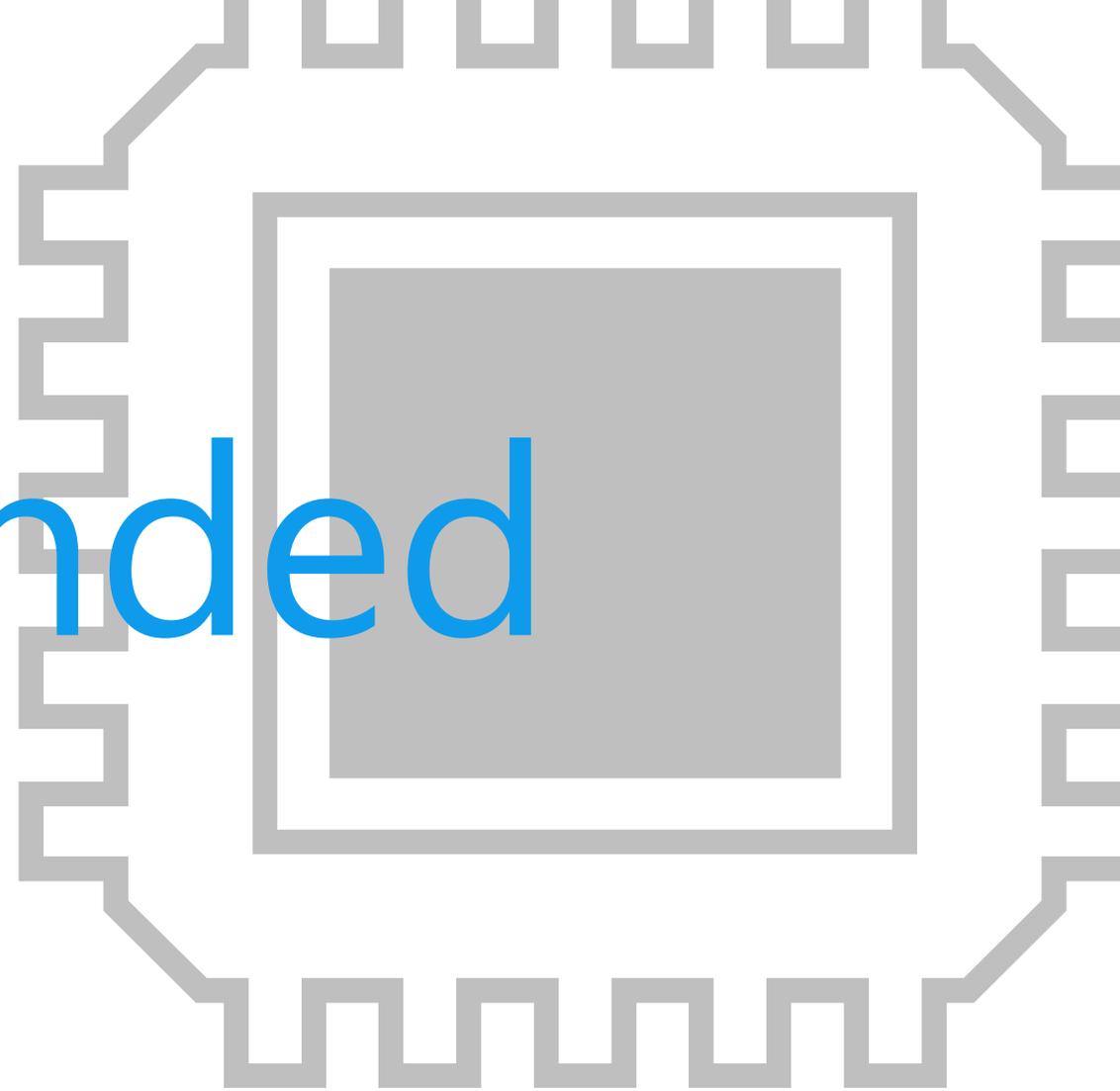
Device solutions to address customer needs

As described above, in the design of IVI, **"Information sharing"**, **"Reduction of power consumption"** and **"Miniaturization"** are important factors. Toshiba's proposals are based on these three solution perspectives.
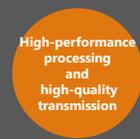
Information sharing ▽

Reduction of power consumption ▽

Miniaturization ▽

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Device solutions to address customer needs

		High-performance processing and high-quality transmission	High efficiency · Low loss	Small size package
①	**Ethernet bridge IC**	●	●	●
②	**Peripheral bridge IC**	●	●	●
③	**Wireless communication IC**	●	●	●
④	**Audio power amplifier IC**		●	●
⑤	**U-MOS Series 40 V N-ch MOSFET**		●	●
⑥	**U-MOS Series -40 V / -60 V P-ch MOSFET**		●	●
⑦	**Gate driver (for switch)**	●		●
⑧	**General purpose small signal MOSFET**		●	●
⑨	**General purpose small signal bipolar transistor**			●
⑩	**Small signal bias resistor built-in transistor (BRT)**			●
⑪	**TVS diode (for high speed communication)**	●		●
⑫	**TVS diode (for CAN communication)**	●		●

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

It realizes easy connection to the next generation in-vehicle network.

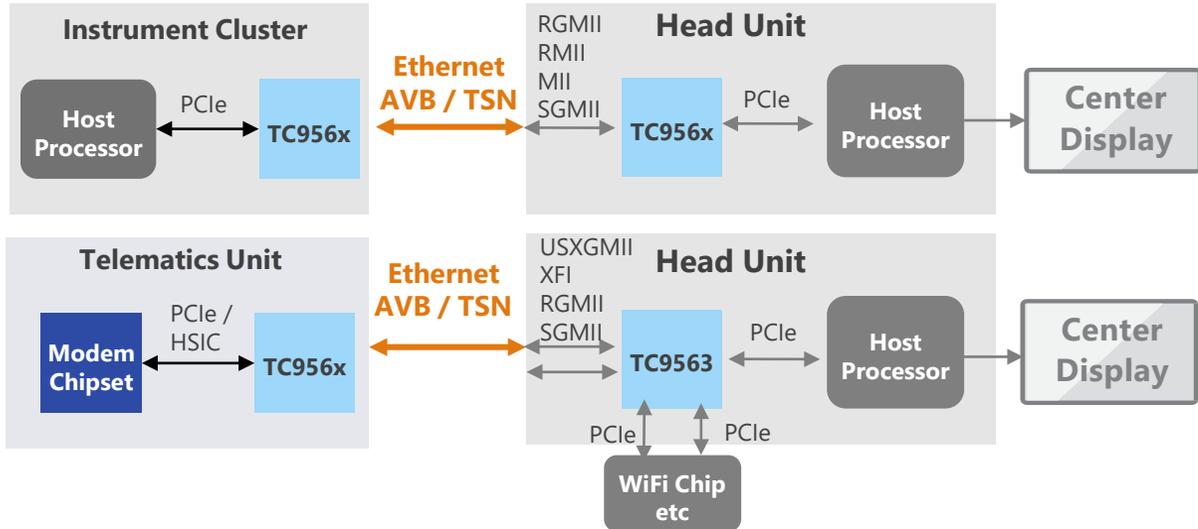**1** **Compliant with Ethernet AVB / TSN**

It complies with Ethernet AVB/TSN specified by IEEE 802.1 Qav/Qbv each other etc.
Low delay transmission is possible.

2 **Built-in various interfaces**

PCIe®, HSIC, I²S and TDM (Time Division Multiplex) interfaces are built in. It can be easily connected with modem SoCs or application processors etc..

3 **AEC Q-100 Grade 3 qualified**

AEC Q-100 Grade 3 qualified.

Instrument Cluster

Host Processor — PCIe — TC956x

Head Unit

RGMII RMII MII SGMII

Ethernet AVB / TSN

TC956x — PCIe — Host Processor — Center Display

Telematics Unit

Modem Chipset — PCIe / HSIC — TC956x

Head Unit

USXGMII XFI RGMII SGMII

Ethernet AVB / TSN

TC9563 — PCIe — Host Processor — Center Display

PCIe — WiFi Chip etc — PCIe

Lineup

Part number	TC9560 BXBG	TC9560 XBG	TC9562 XBG	TC9562 AXBG	TC9562 BXBG	TC9563XBG
Package	P-LFBGA170-1010-0.65		P-LFBGA120-0909-0.65			P-FBGA220-1010-0.65
Host I/F	HSIC	PCIe I/F [Gen2, Gen1 Endpoint] Upstream Port: 1lane x 1port				PCIe I/F [Gen3, Gen2, Gen1Endpoint] Upstream Port: 4lanes x 1port Downstream Port: 1lane x 2ports
I/F	Ethernet AVB					Ethernet AVB, Ethernet TSN
	RGMII / RMII / MII			RGMII / RMII / MII / SGMII		Port A: USXGMII / XFI / SGMII Port B: USXGMII / XFI / SGMII / RGMII

◆Return to Block Diagram TOP

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

Resolve gaps of interface standard between host and peripheral devices.

1 Increase the choice of parts

By using a peripheral bridge IC, it is possible to connect to various types of peripheral devices.
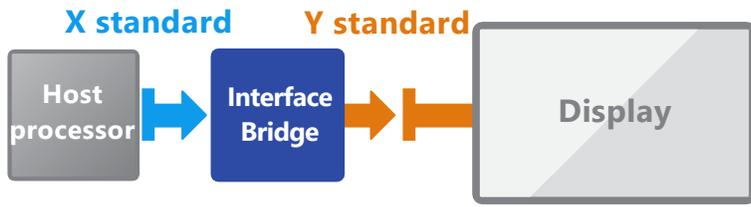
2 Reduce noise

Converting parallel bus line to serial improves noise immunity. That also suppresses the generation of own noise.
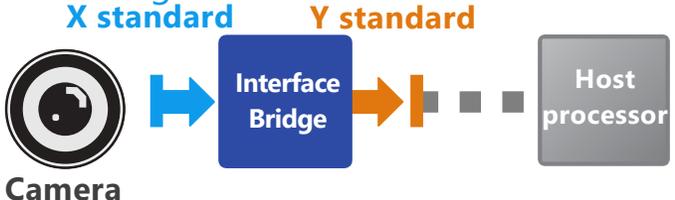
3 Reduce disconnection risk

Converting parallel bus line to serial reduces the number of wires on a board, and so reduce the risk of disconnection.

■ **Display interface**

X standard → Y standard

Host processor → **Interface Bridge** → Display

■ **Camera interface bridge**

X standard → Y standard

Camera → **Interface Bridge** → Host processor

Lineup

Part number	Camera I/F Bridge		Display I/F Bridge			
	TC9590XBG	TC9591XBG	TC9592XBG	TC9593XBG	TC9594XBG	TC9595XBG
Package	P-LFBGA64-0707-0.80-002	P-VFBGA80-0707-0.65-001	P-VFBGA49-0505-0.65-001	P-VFBGA64-0606-0.65-001	P-VFBGA80-0707-0.65-001	P-VFBGA80-0707-0.65-001
Input	HDMI™1.4a	(1) MIPI® CSI-2® (2) Parallel 24bit @166 MHz	MIPI DSI® 4lanes x 1ch		Parallel input 24bit @166 MHz	MIPI DSI 4lanes x 1ch / MIPI DPI™ (24bit)
Output	MIPI CSI-2 4lanes x 1ch	(1) Parallel 24bit @100 MHz (2) MIPI CSI-2	LVDS Single Link		MIPI DSI 4lanes x 1ch	DisplayPort™ 1.1a x 2ports / MIPI DPI (24bit)

◆Return to Block Diagram TOP

High-performance processing and high-quality transmission | High efficiency · Low loss | Small size package

Value provided

Contribute to realize comfortable driving environment by connectivity among next information.

1 TC32306FTG for RKE [Note1] and TPMS [Note2]

It is suitable for receivers of RKE and TPMS.
It can also be used for the bidirectional low rate data communications using transmitting function.

[Note1] Remote keyless entry system
[Note2] Tire pressure monitoring system

In-vehicle ETC

In-vehicle RKE
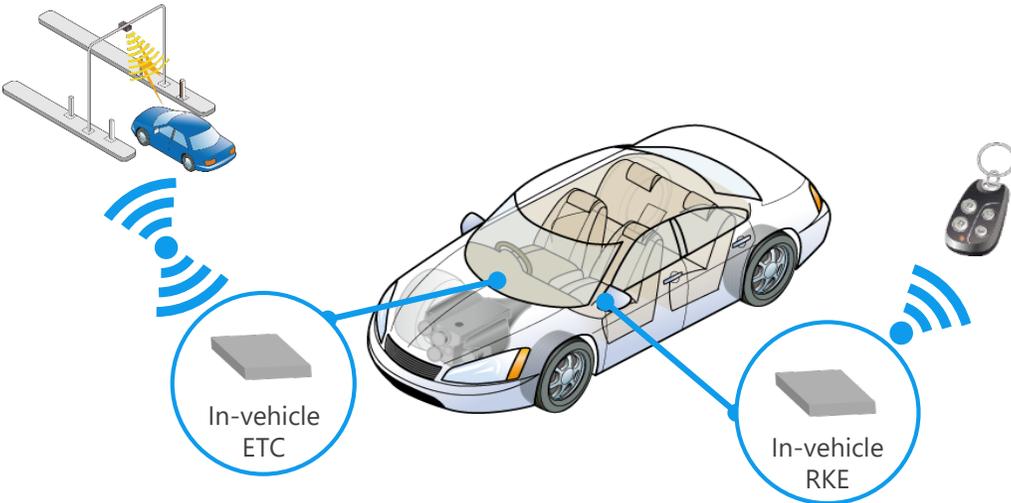
2 TC32163FG for ETC [Note3]

It complies with ETC standards of Japan, China and South Korea.
It is possible to use also for RSU. [Note4]

[Note3] Electronic Toll Collection System
[Note4] Road side Units

Lineup

	RKE	ETC
Part number	TC32306FTG	TC32163FG
Package	QFN36-P-0606-0.50	LQFP48-P-0707-0.50
RF frequency	315 to 915 MHz	5.8 GHz band
I/F frequency	230 kHz (wide band), 280 kHz (middle band)	40 MHz (1st), 7.232 MHz (2nd)
Supply voltage	2.0 to 5.5 V	2.7 to 3.6 V

Value provided

These linear amplifier ICs realize same level of power loss and heat generation the class D amplifier.

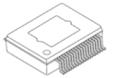| **1** Proprietary high efficiency amplifier (patent registered)	**2** Reduction of external components	**3** Built-in fulltime output offset detection (patent registered)
Realizes equivalent efficiency to the class D amplifiers [Note1] at output of 4 W or less. Power consumption of these ICs are about 1/5 of our class AB amplifiers and about 1/2 of our high efficiency linear class KB amplifiers. [Note2] [Note1] Based on Toshiba research (April 2020) . [Note2] Class KB = Toshiba original linear amplifier	Since these ICs operate without switching such as the class D amplifier, the external parts such as low pass filter or components for EMI suppression can be reduced.	Includes a proprietary speaker burnout prevention system that continuously checks for any abnormal output DC offset regardless of input signal presence and informs the microcomputer.

■ Power consumption (for 0.8 W x 4 channels)

(Toshiba internal comparison)

▲1/5

▲1/2

equivalent

Power consumption (W)

| 20 | 8 | 4 | 4 |
| Conventional linear amp (Class AB) | Conventional high eff. Amp (Class KB) | New high eff. Amp (Class TB) | Digital amp (Class D) |

Lineup

Part number	TCB701FNG	TCB702FNG
Package	P-HSSOP36-1116-0.65-001 (36 pin)	
Maximum output power	49 W x 4ch (V_{CC} = 15.2 V, R_L = 4 Ω)	45 W x 4ch (V_{CC} = 15.2 V, R_L = 4 Ω)
Total harmonic distortion (THD)	0.01 % (at P_{OUT} = 4 W)	
Supply voltage	6 to 18 V	
Output noise voltage	60 μVrms (Filter = DIN AUDIO)	

◆Return to Block Diagram TOP

U-MOS Series 40 V N-ch MOSFET
XPN3R804NC / TK1R4S04PB / XPHR7904PS / TPWR7904PB / XPJR6604PB* / XPQR3004PB

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

The latest processes enables low on-resistance and low noise, thereby reducing power consumption.

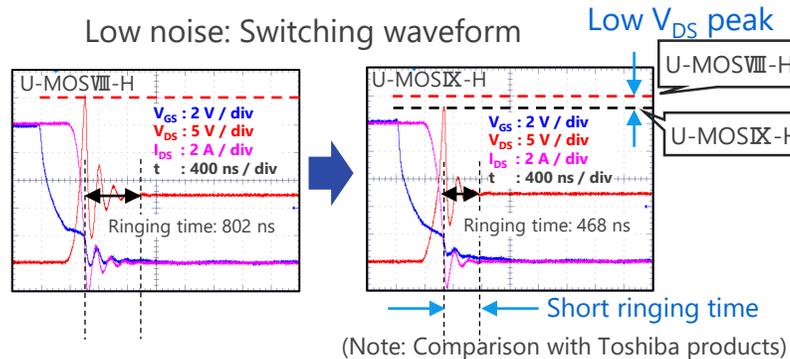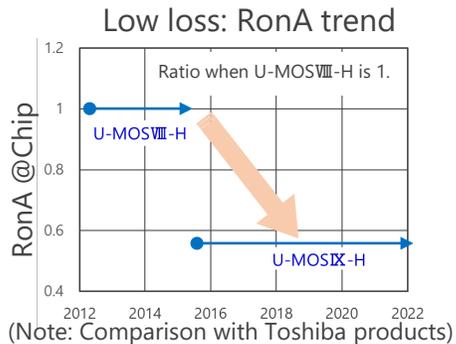**1 Low loss (reduced on-resistance)**

Using low on-resistance technology to contribute to reduced power consumption systems.
On-resistance of 44 % reduction per unit area.
(compared to Toshiba's U-MOSVIII-H products)

2 Small and low loss package

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

3 Low noise (low EMI)

Improved chip process reduces surge voltage and ringing time.

Low loss: RonA trend

Ratio when U-MOSVIII-H is 1.

U-MOSVIII-H

U-MOSIX-H

RonA @Chip

(Note: Comparison with Toshiba products)

Low noise: Switching waveform

Low V_{DS} peak

U-MOSVIII-H

V_{GS} : 2 V / div
V_{DS} : 5 V / div
I_{DS} : 2 A / div
t : 400 ns / div

Ringing time: 802 ns

U-MOSIX-H

V_{GS} : 2 V / div
V_{DS} : 5 V / div
I_{DS} : 2 A / div
t : 400 ns / div

Ringing time: 468 ns

U-MOSVIII-H
U-MOSIX-H

Short ringing time

(Note: Comparison with Toshiba products)

DSOP Advance(WF)L double-sided cooling package

Thermal resistance is reduced by 76 % @t = 3 s, mounted on board
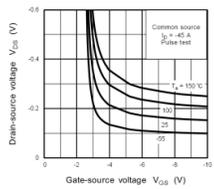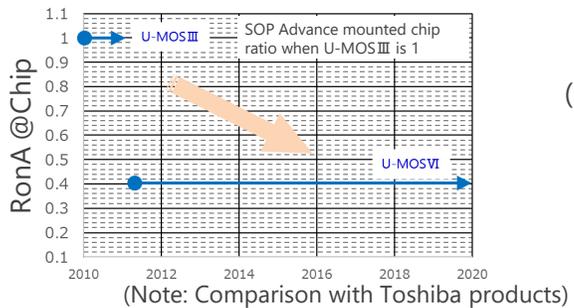Compared to Toshiba's SOP Advance(WF)

S-TOGL™ & L-TOGL™ Cu clip structure

High Current & Low resistance

Cu connector

Cu clip

Post (solder connection)

Postless

Lineup

Part number	Rated drain current [A]	On-resistance (Max) [mΩ] @V_{GS} = 10 V	Package
XPN3R804NC	40	3.8	TSON Advance(WF)
TK1R4S04PB	120	1.35	DPAK+
XPHR7904PS	150	0.79	SOP Advance(WF)
TPWR7904PB	150	0.79	DSOP Advance(WF)L
XPJR6604PB*	(200)	(0.66)	S-TOGL™
XPQR3004PB	400	0.30	L-TOGL™

*: Under development (Values enclosed in parentheses are tentative specifications. Specifications are subject to change without notice.)

◆Return to Block Diagram TOP

U-MOS Series -40 V / -60 V P-ch MOSFET
XPN9R614MC / XPH3R114MC / XPH8R316MC* / TJ90S04M3L

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

Low on-resistance contributes to reduce system power consumption.

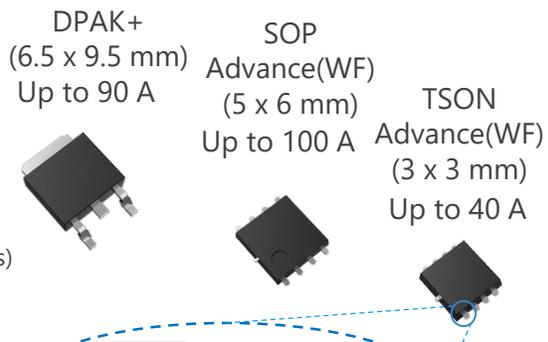### 1 Low loss (reduced on-resistance) and logic level drive

Using a low on-resistance technology contributes to reduce system power consumption.
A lineup of logic level drive type is supported.
The on-resistance per area is reduced by 60 %.
(compared to Toshiba's U-MOSⅢ products)

2 Small and low loss packages

By adopting a Cu connector structure, a low loss and high power dissipation package is realized.
Wettable Flank (WF) package contributes to good mountability.

Low loss: RonA reduction trend

SOP Advance mounted chip ratio when U-MOSⅢ is 1

U-MOSⅢ

U-MOSⅥ

(Note: Comparison with Toshiba products)

Logic level drive
TJ90S04M3L
$V_{DS(ON)}$ - V_{GS}

Large current, small size, high power dissipation package

DPAK+
(6.5 x 9.5 mm)
Up to 90 A

SOP Advance(WF)
(5 x 6 mm)
Up to 100 A

TSON Advance(WF)
(3 x 3 mm)
Up to 40 A

Mold

Plating

Wettable Flank (WF) structure

Lineup

Part Number	Rated drain-source voltage [V]	Rated drain current [A]	On-resistance (Max) [mΩ] @V_{GS} = -10 V	Package
XPN9R614MC	-40	-40	9.6	TSON Advance(WF)
XPH3R114MC	-40	-100	3.1	SOP Advance(WF)
XPH8R316MC*	-60	(-90)	(8.3)	
TJ90S04M3L	-40	-90	4.3	DPAK+

*: Under development (Values enclosed in parentheses are tentative specifications. Specifications are subject to change without notice.)

◆Return to Block Diagram TOP

Value provided

A charge pump circuit for the N-ch MOSFET gate drive is built in, allowing for easy semiconductor relay configuration.

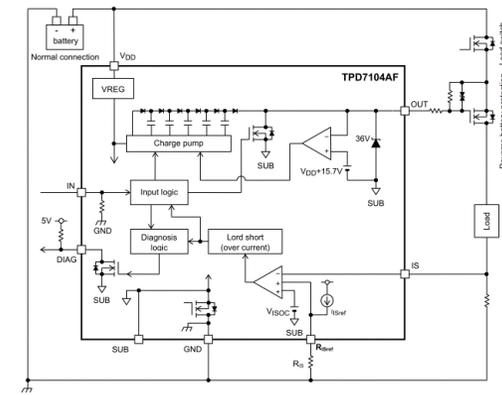| **1** Built-in charge pump circuit	**2** Can be controlled by logic level voltage	**3** Small package
Built-in charge pump circuit enables N-ch MOSFET as high side switch. Easy to configure a semiconductor relay.	It is possible to be controlled directly by output signal of MCUs or CMOS logic ICs.	The small surface mount packages such as PS-8, SSOP16 and WSON10A contribute to the miniaturization of equipment.

Semiconductor relay (switch) application (TPD7104AF)
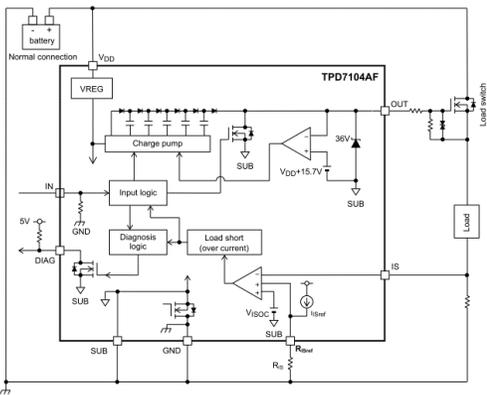
Power supply reverse connection protection MOSFET control (TPD7104AF)

Back to back configuration

Lineup

Part number	TPD7104AF	TPD7106F	TPD7107F
Package	PS-8 (2.8 x 2.9 mm)	SSOP16 (5.5 x 6.4 mm)	WSON10A (3 x 3 mm)
Function	High side gate driver	High side gate driver	High side gate driver
Output	1	1	1
Features	・Operating power supply voltage range: 5 to 18 V ・Built-in power supply reverse connection protection function (Protective MOSFET control with back-to-back circuitry)	・Operating power supply voltage range: 4.5 to 27 V ・Built-in power supply reverse connection protection function (Protective MOSFET control with back-to-back circuitry)	・Operating power supply voltage range: 5.75 to 26 V ・Current sense output ・Protective functions; overcurrent, overtemperature, GND disconnect, etc. reverse battery connection ・Diagnosis output; overcurrent, load open, overtemperature, etc.

◆Return to Block Diagram TOP

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

Wide lineup of small packages contribute to reduce the size and power consumption of system.

1 Small package

A lineup of various small packages such as SOT-723 (VESM 1.2 x 1.2 mm package) is available, contributing to reduce mounting area.
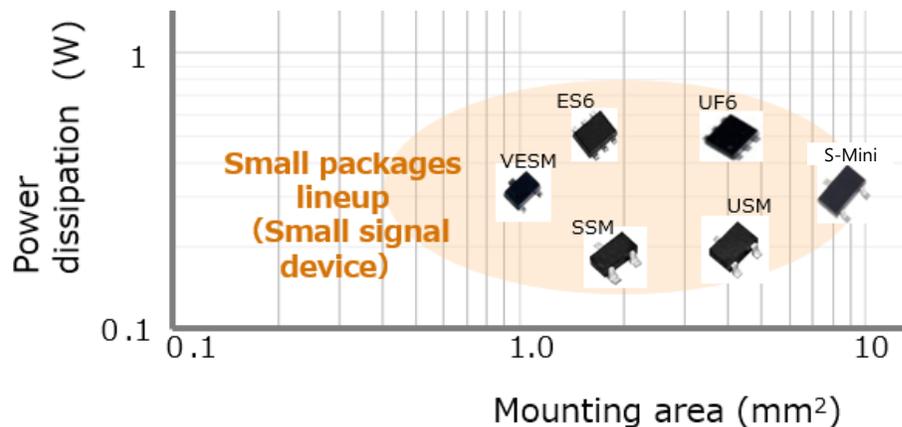
2 Low voltage drive

SSM3J66MFV can be driven at low gate-source voltage of 1.2 V.

3 AEC-Q101 qualified

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

Small signal package lineup

Power dissipation (W) vs Mounting area (mm²)

Lineup

Part number		SSM3K7002KF	SSM3J168F	SSM3J66MFV
Package		S-Mini (SOT-346)	S-Mini (SOT-346)	VESM (SOT-723)
V_{DSS} [V]		60	-60	-20
I_D [A]		0.4	-0.4	-0.8
$R_{DS(ON)}$ @$|V_{GS}|$ = 4.5 V [Ω]	Typ.	1.2	1.4	0.31
	Max	1.75	1.9	0.39
Drive voltage [V]		4.5	-4.0	-1.2
Polarity		N-ch	P-ch	P-ch

9 **General purpose small signal bipolar transistor**
2SC2712 / 2SA1162 / 2SC4116 / 2SA1586 / TTA501 / TTC501 and others

High-performance processing and high-quality transmission | High efficiency・Low loss | Small size package

Value provided

Extensive product lineup to meet customers' needs.

1 Extensive lineup of packages

Various packages such as 1-in-1, 2-in-1 are provided and suitable products for circuit board design are selectable.
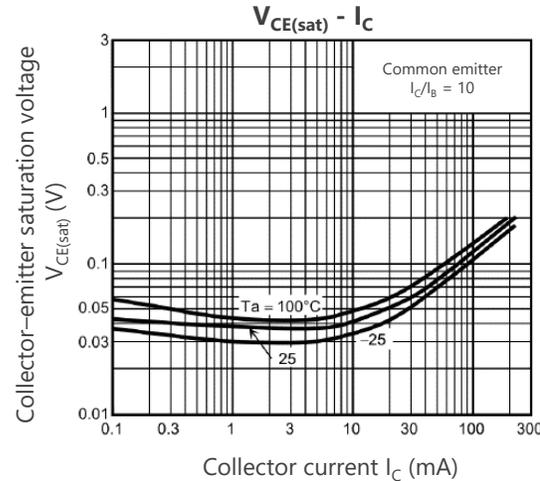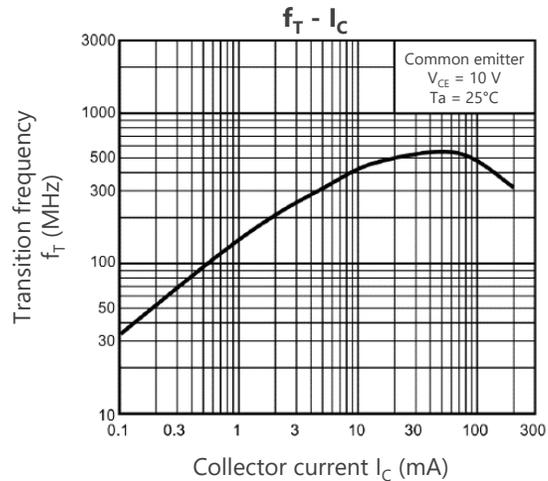
2 Extensive product lineup

Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance with the application.

3 AEC-Q101 qualified

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

Characteristic examples of 2SC2712

f_T - I_C

Common emitter
V_{CE} = 10 V
Ta = 25°C

Transition frequency f_T (MHz)

Collector current I_C (mA)

$V_{CE(sat)}$ - I_C

Common emitter
I_C/I_B = 10

Collector–emitter saturation voltage $V_{CE(sat)}$ (V)

Ta = 100°C
25
25

Collector current I_C (mA)

Lineup

Package			SOT-23F		USM (SOT-323) UFM (SOT-323F)*		S-Mini (SOT-346)	
Classification	| V_{CEO} | [V]	| I_C | [mA]	NPN	PNP	NPN	PNP	NPN	PNP
General purpose	50	150			2SC4116	2SA1586	2SC2712	2SA1162
	50	500					2SC3325	2SA1313
Low noise	120	100			2SC4117	2SA1587	2SC2713	2SA1163
High current	50	1700					2SA2195*	
	50	2000		TTA501				
	50	2500	TTC501					

* indicates UFM package

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

Extensive product lineup to meet customers' needs.

1 Built-in bias resistor type
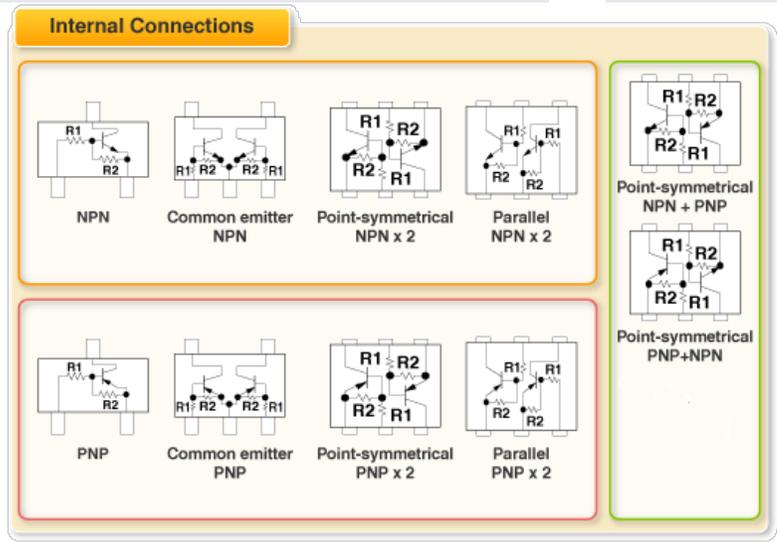(BRT : Bias Resistor built-in Transistor)

The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

2 Extensive lineup of package and pin assignment

Various package lineups, such as 1-in-1, 2-in-1 and various pin assignment type are provided and suitable products for circuit board design are selectable.

3 AEC-Q101 qualified

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

Internal Connections

Lineup			NPN (BRT)	PNP (BRT)
Package	ES6 (SOT-563)		RN1907FE	RN2907FE
	US6 (SOT-363)		RN1901	RN2901
V_{CEO} [V]			50	-50
I_C [mA]			100	-100

◆Return to Block Diagram TOP

TVS diode (for high speed communication)
DF2S5M4FS / DF2S6M4FS

High-performance processing and high-quality transmission

High efficiency・Low loss

Small size package

Value provided

TVS diodes prevent system damage and malfunction caused by electrostatic discharge (ESD).

1 Improve ESD pulse absorbability

Toshiba proprietary snapback technology (4th-Gen. process) improves ESD pulse absorption compared to Toshiba previous products.
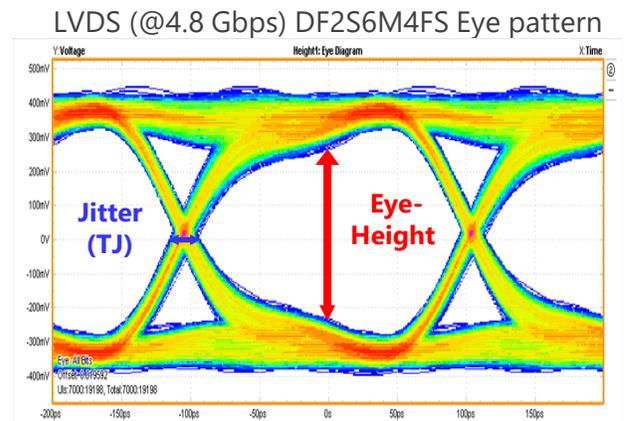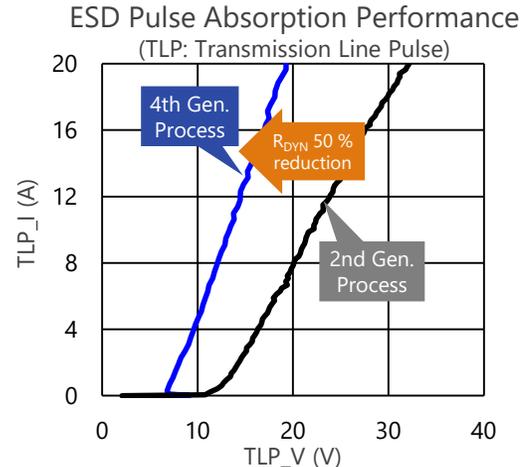(50 % reduction in R_{DYN})

2 Supports Ethernet and LVDS [Note]

These are products applicable to high speed communications (Gbps orders) such as Ethernet and LVDS.

[Note] Low voltage differential signaling

3 High ESD immunity

$V_{ESD} > \pm 30$ kV @ISO 10605
$V_{ESD} > \pm 20$ kV @IEC 61000-4-2 (Level 4)

ESD Pulse Absorption Performance
(TLP: Transmission Line Pulse)

4th Gen. Process

R_{DYN} 50 % reduction

2nd Gen. Process

TLP_I (A) vs TLP_V (V)

LVDS (@4.8 Gbps) DF2S6M4FS Eye pattern

Jitter (TJ)

Eye-Height

Lineup

Part number	DF2S5M4FS	DF2S6M4FS
Package	SOD-923	
V_{ESD} [kV] @ISO 10605	±30	±30
V_{RWM} (Max) [V]	3.6	5.5
C_t (Typ. / Max) [pF]	0.45 / 0.55	
R_{DYN} (Typ.) [Ω]	0.35	

(Note: Toshiba internal comparison)
(Note) This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

◆Return to Block Diagram TOP

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

Value provided

TVS diodes prevent system damage and malfunction caused by electrostatic discharge (ESD).

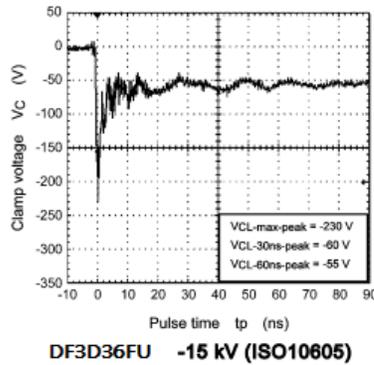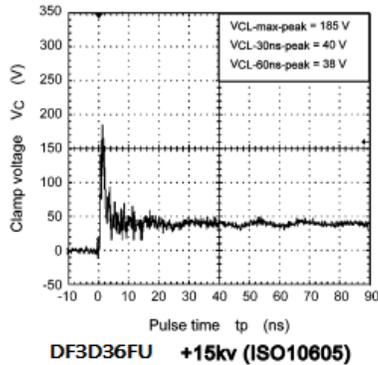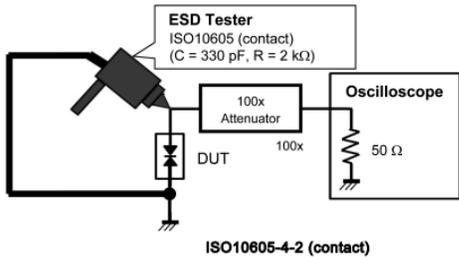### 1 Improve ESD pulse absorbability

Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes. (Achieving both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3 High ESD immunity

$V_{ESD} > \pm30$ kV @ISO 10605
$V_{ESD} > \pm20$ kV @IEC 61000-4-2 (Level 4)

ESD Tester ISO10605 (contact) (C = 330 pF, R = 2 kΩ)
Oscilloscope
100x Attenuator
DUT 100x 50 Ω
ISO10605-4-2 (contact)

DF3D36FU +15kv (ISO10605)
VCL-max-peak = 185 V
VCL-30ns-peak = 40 V
VCL-60ns-peak = 38 V

DF3D36FU -15 kV (ISO10605)
VCL-max-peak = -230 V
VCL-30ns-peak = -60 V
VCL-60ns-peak = -55 V

Lineup

Part number	DF3D18FU	DF3D29FU	DF3D36FU
Package		USM (SOT-323)	
V_{ESD} [kV] @ISO 10605	±30	±30	±20
V_{RWM} (Max) [V]	12	24	28
C_t (Typ. / Max) [pF]		9 / 10	6.5 / 8
R_{DYN} (Typ.) [Ω]	0.8	1.1	1.5

(Note) The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted. This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

Contact address: https://toshiba.semicon-storage.com/ap-en/contact.html

Terms of use

This terms of use is made between Toshiba Electronic Devices and Storage Corporation ("We") and customers who use documents and data that are consulted to design electronics applications on which our semiconductor devices are mounted ("this Reference Design"). Customers shall comply with this terms of use. Please note that it is assumed that customers agree to any and all this terms of use if customers download this Reference Design. We may, at its sole and exclusive discretion, change, alter, modify, add, and/or remove any part of this terms of use at any time without any prior notice. We may terminate this terms of use at any time and for any reason. Upon termination of this terms of use, customers shall destroy this Reference Design. In the event of any breach thereof by customers, customers shall destroy this Reference Design, and furnish us a written confirmation to prove such destruction.

1. Restrictions on usage
   1. This Reference Design is provided solely as reference data for designing electronics applications. Customers shall not use this Reference Design for any other purpose, including without limitation, verification of reliability.
   2. This Reference Design is for customer's own use and not for sale, lease or other transfer.
   3. Customers shall not use this Reference Design for evaluation in high or low temperature, high humidity, or high electromagnetic environments.
   4. This Reference Design shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

2. Limitations
   1. We reserve the right to make changes to this Reference Design without notice.
   2. This Reference Design should be treated as a reference only. We are not responsible for any incorrect or incomplete data and information.
   3. Semiconductor devices can malfunction or fail. When designing electronics applications by referring to this Reference Design, customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of semiconductor devices could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Customers must also refer to and comply with the latest versions of all relevant our information, including without limitation, specifications, data sheets and application notes for semiconductor devices, as well as the precautions and conditions set forth in the "Semiconductor Reliability Handbook".
   4. When designing electronics applications by referring to this Reference Design, customers must evaluate the whole system adequately. Customers are solely responsible for all aspects of their own product design or applications. WE ASSUME NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.
   5. No responsibility is assumed by us for any infringement of patents or any other intellectual property rights of third parties that may result from the use of this Reference Design. No license to any intellectual property right is granted by this terms of use, whether express or implied, by estoppel or otherwise.
   6. THIS REFERENCE DESIGN IS PROVIDED "AS IS". WE (a) ASSUME NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (b) DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO THIS REFERENCE DESIGN, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

3. Export Control
   Customers shall not use or otherwise make available this Reference Design for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). This Reference Design may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of this Reference Design are strictly prohibited except in compliance with all applicable export laws and regulations.

4. Governing Laws
   This terms of use shall be governed and construed by laws of Japan.

Restrictions on product use

- Toshiba Electronic Devices & Storage Corporation, and its subsidiaries and affiliates (collectively "TOSHIBA"), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively "Product") without notice.

- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.

- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**

- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE").** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative or contact us via our website.

- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.

- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.

- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**

- Product may include products using GaAs (Gallium Arsenide). GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.

- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.

- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**

TOSHIBA