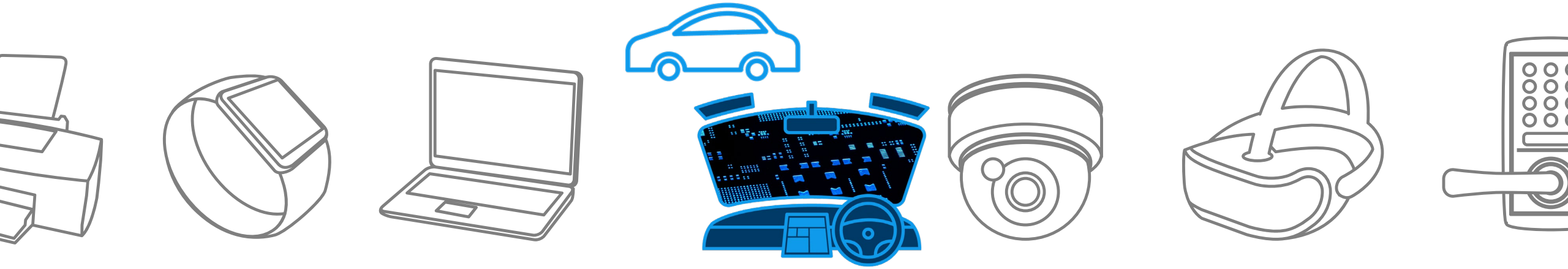
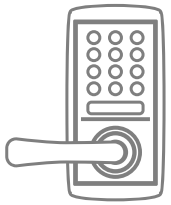
TOSHIBA

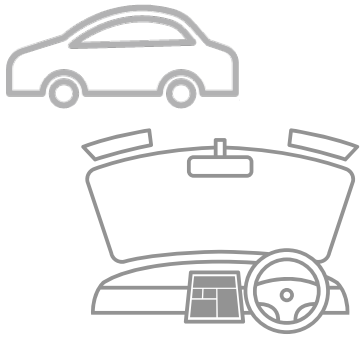
R20

IVI (In-vehicle Infotainment)

Solution Proposal by Toshiba

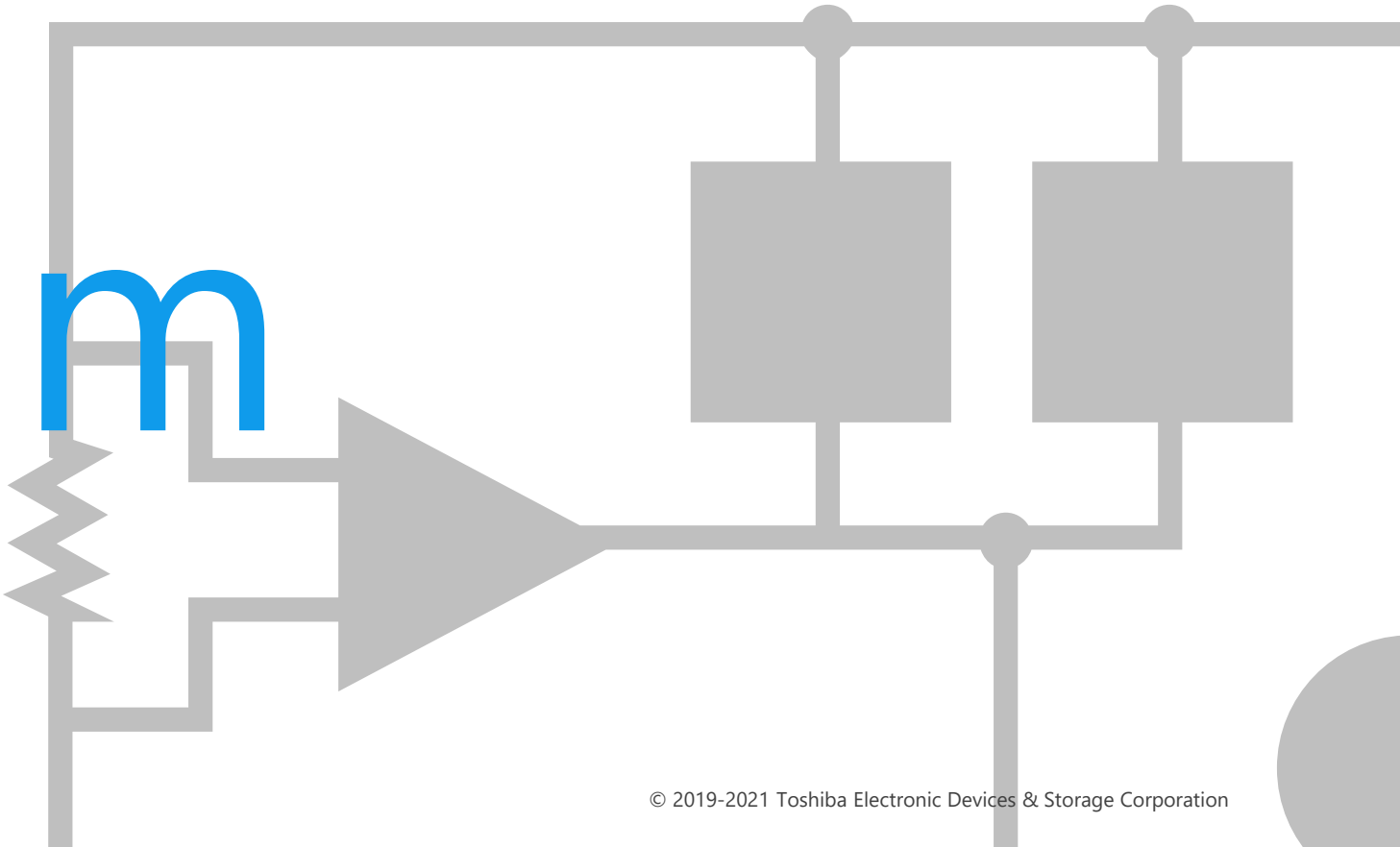




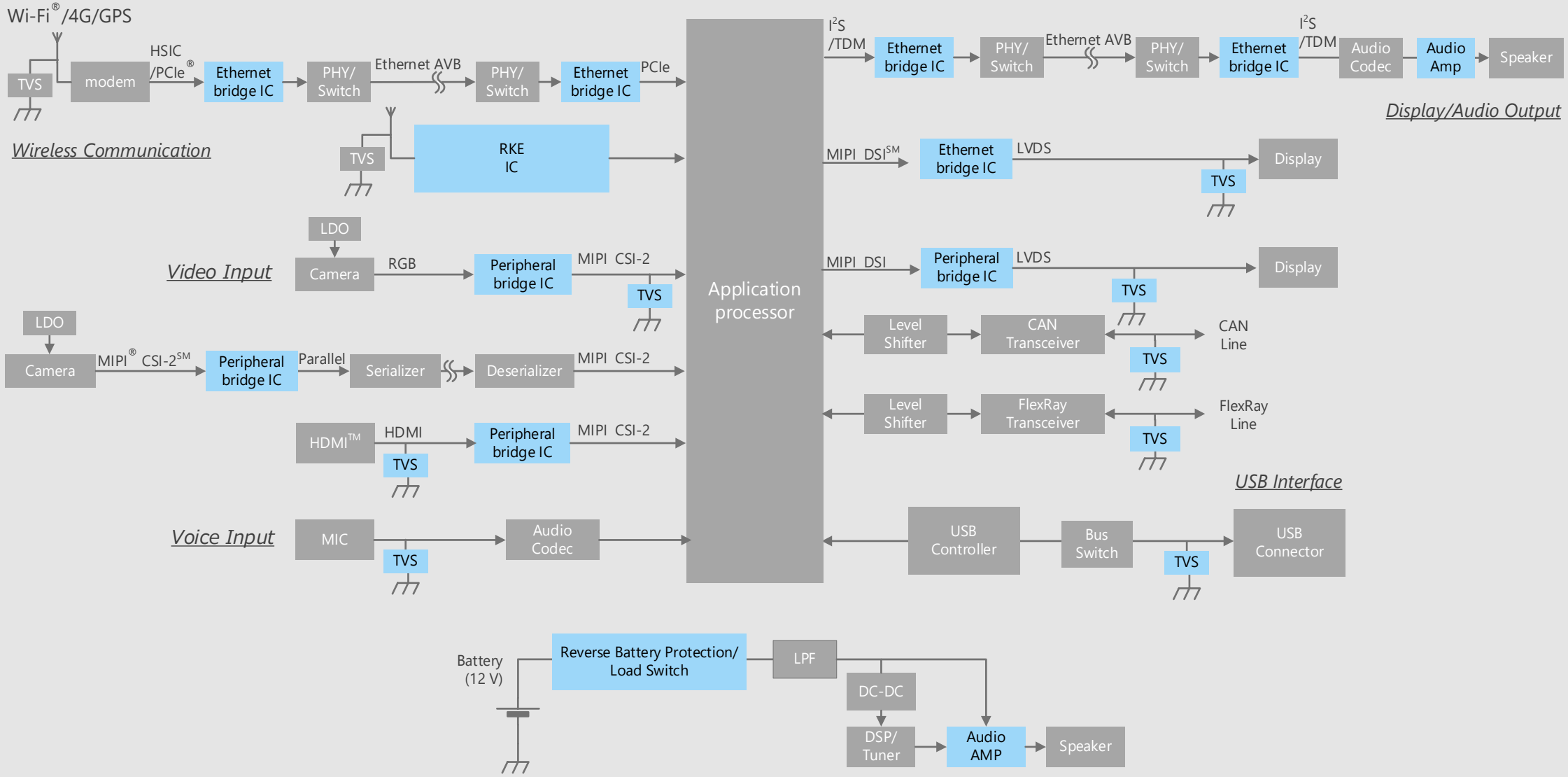


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

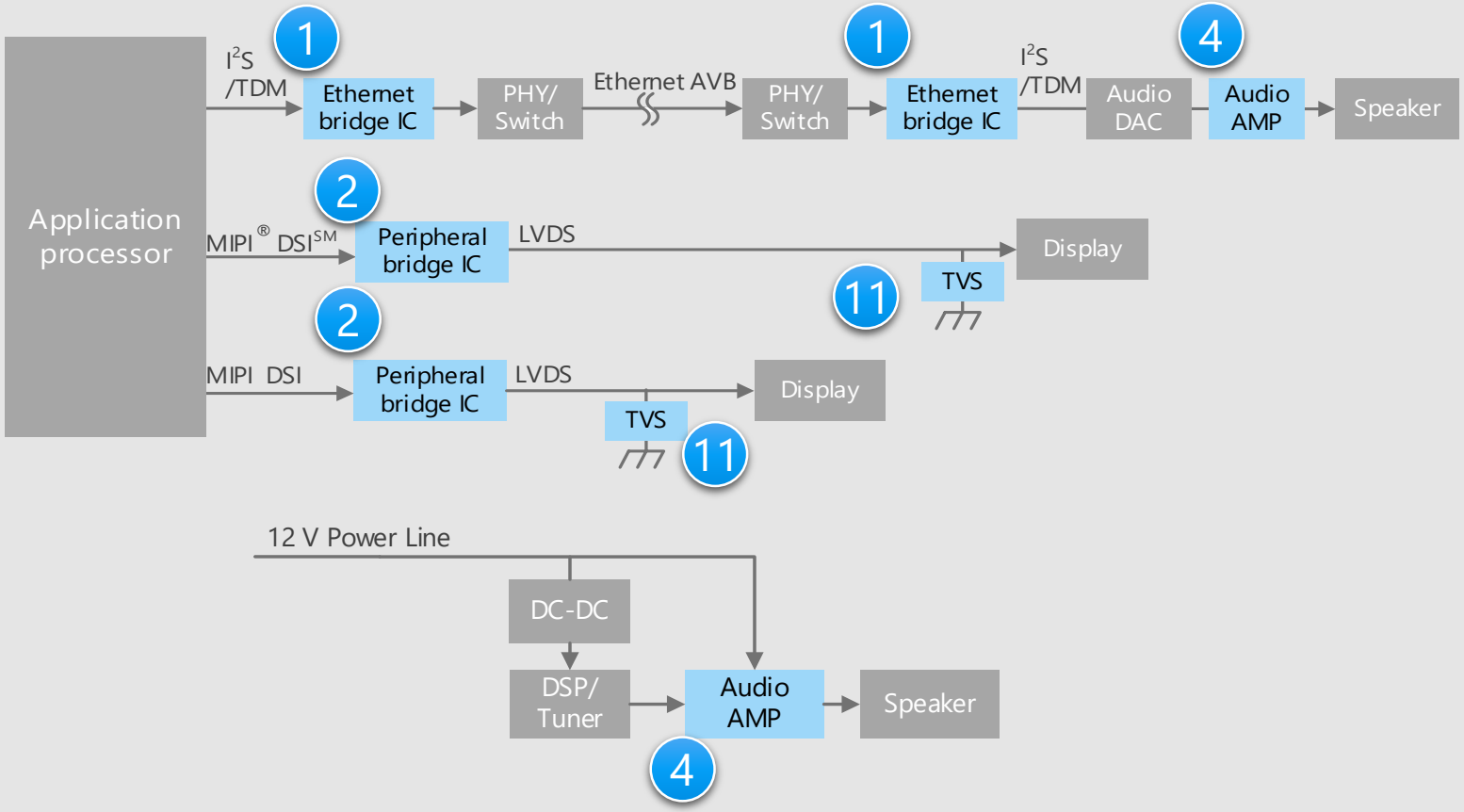


IVI (In-vehicle Infotainment)　Overall block diagram



IVI (In-vehicle Infotainment)　Detail of output section

Display output unit and audio output unit



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

Criteria for device selection

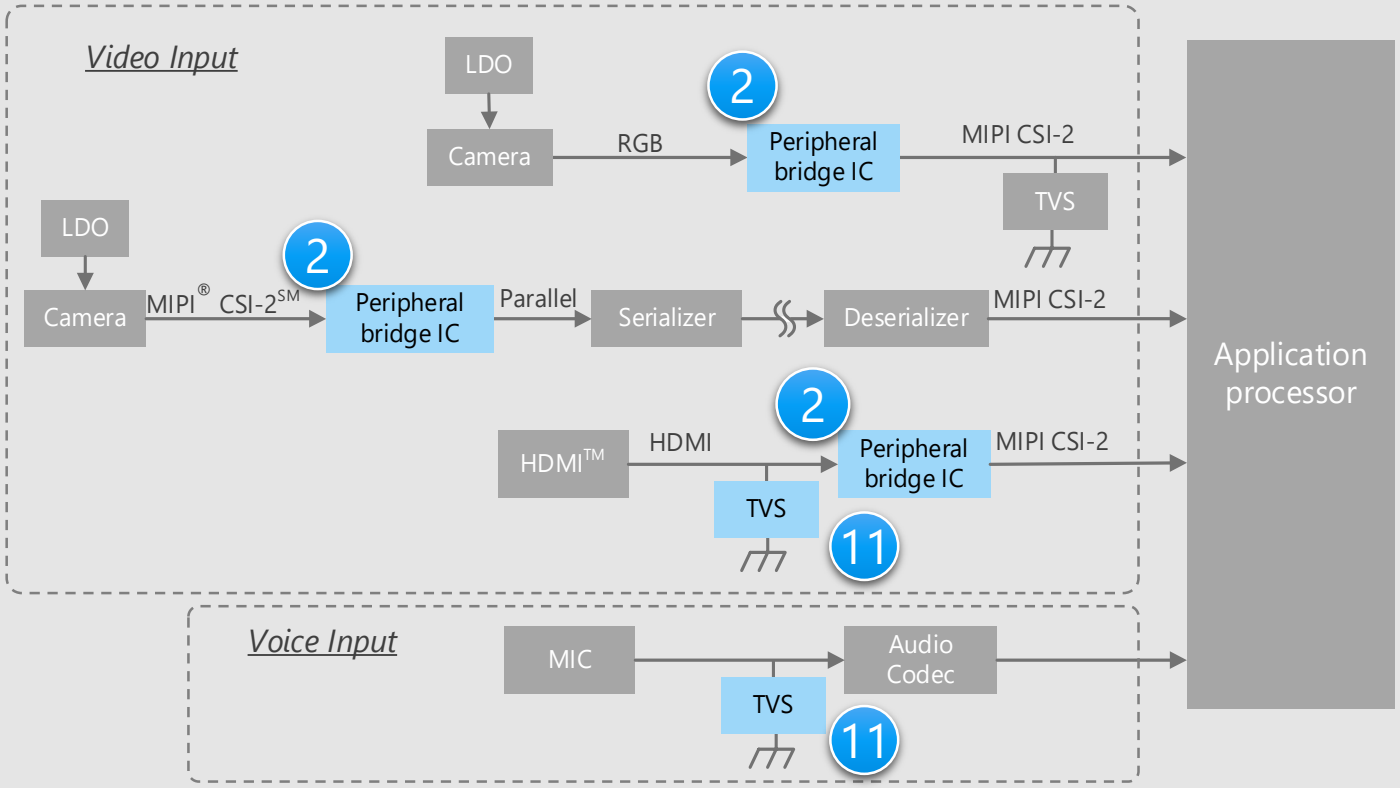
- The adoption of Ethernet AVB/TSN is expanding as the next generation car networks.
- SoCs used in smartphones and tablets are also being designed into automotive systems. These require interface conversion of their peripheral devices.

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

IVI (In-vehicle Infotainment)　Detail of input section

Video input section, Audio input section



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

Criteria for device selection

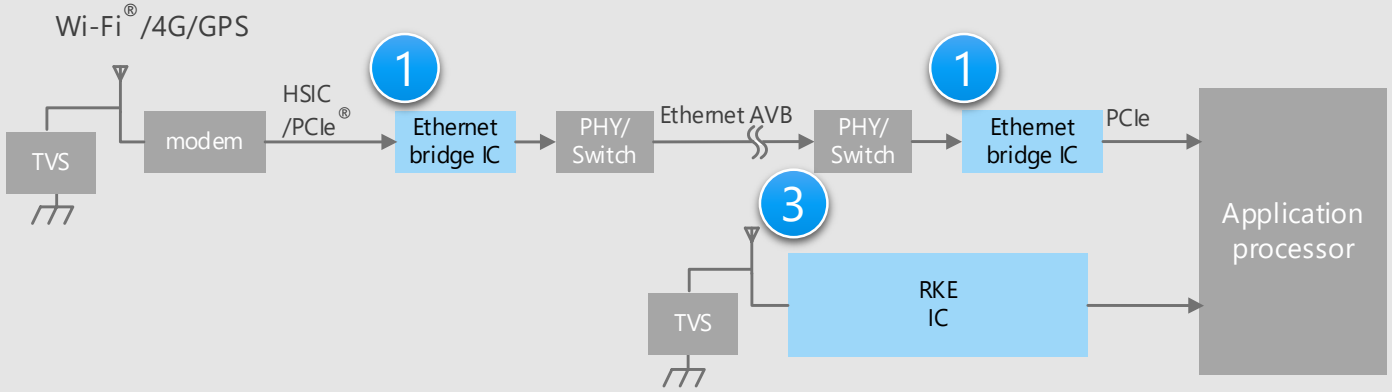
- SoCs used in smartphones and tablets are also being designed into automotive systems. These require interface conversion of their peripheral devices.

Proposals from Toshiba

- **Resolve differences between interfaces**
  Peripheral bridge IC 2
- **Suitable for ESD protection**
  TVS diode (for high speed communication) 11

IVI (In-vehicle Infotainment)　Detail of information transmission section

Wireless communications section



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.

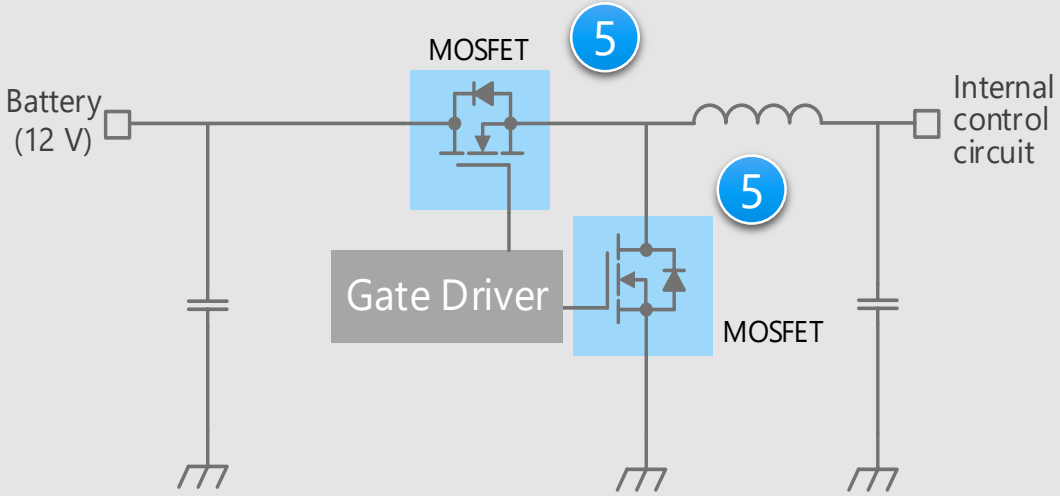
Proposals from Toshiba

- **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

IVI (In-vehicle Infotainment)　Detail of power supply circuit

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 low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET

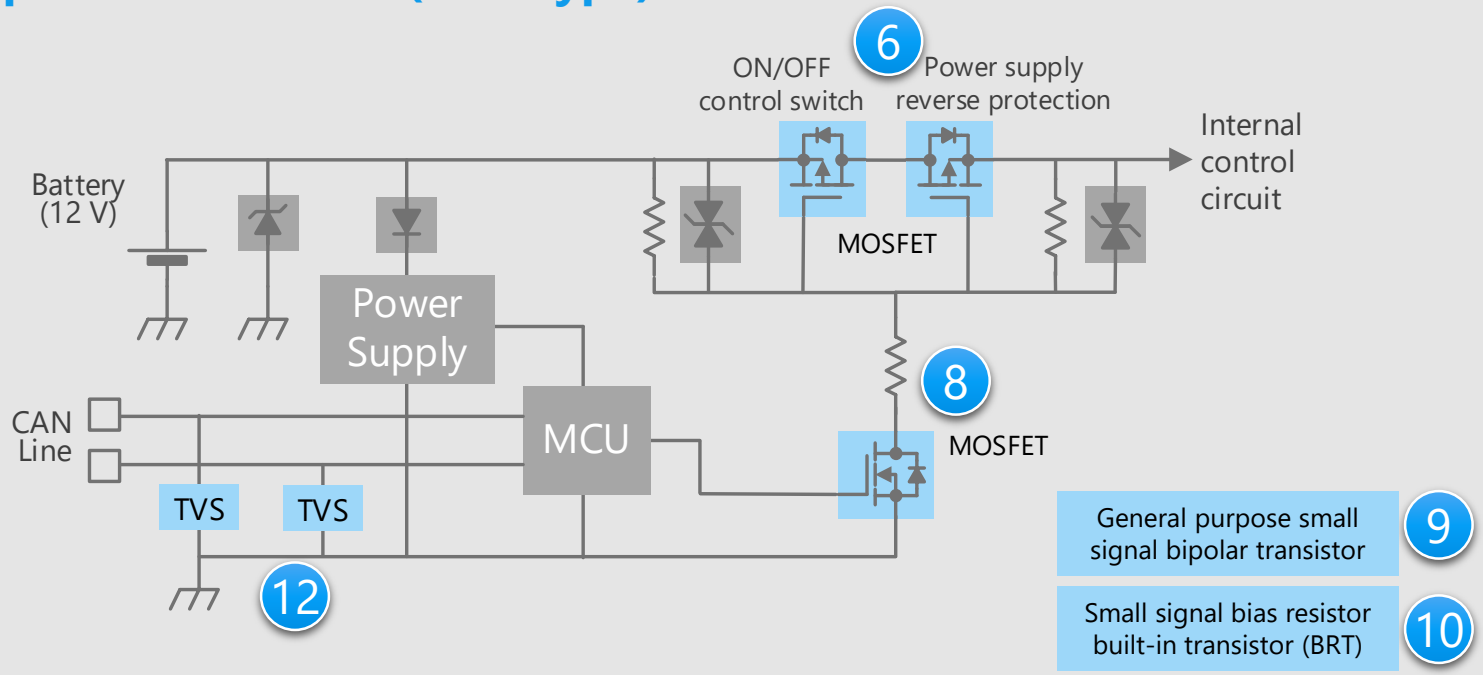
5

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

IVI (In-vehicle Infotainment)

Detail of Switch for power supply ON/OFF control and reverse connection protection (1)

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



* 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.

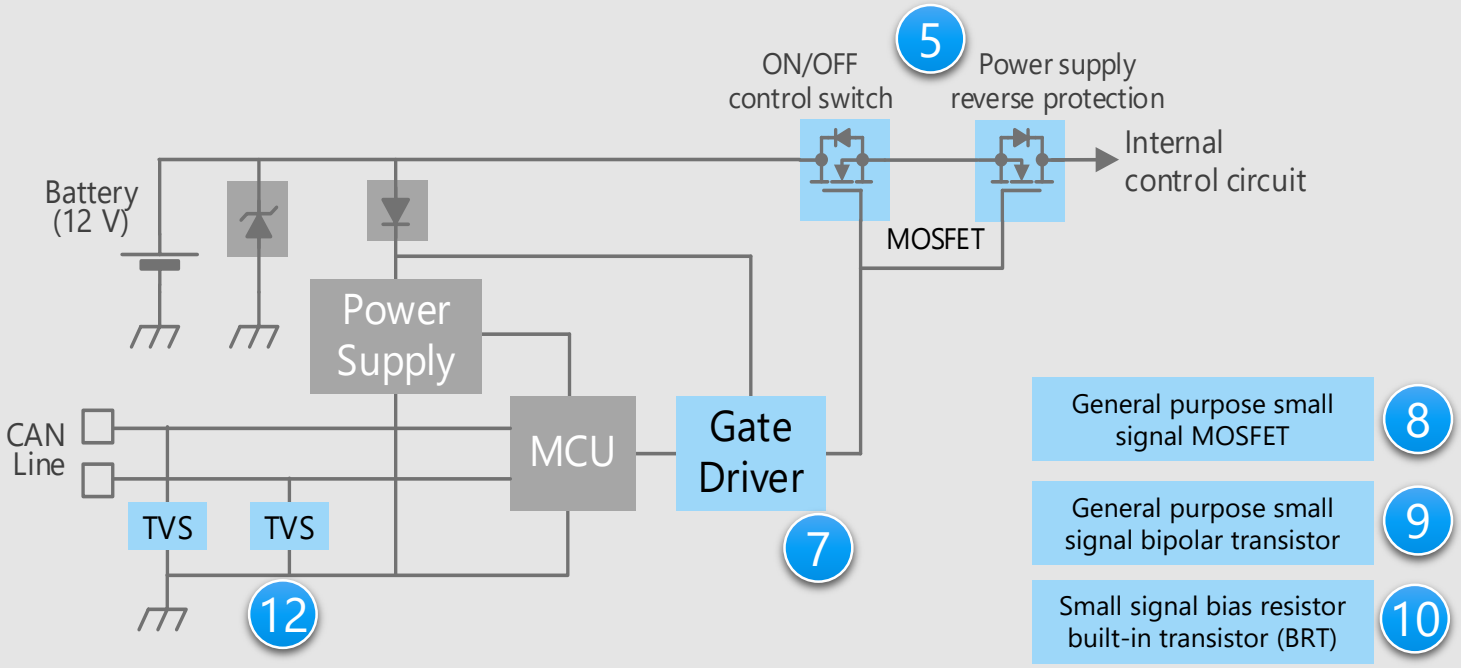
Proposals from Toshiba

- **Low on-resistance contributes 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

IVI (In-vehicle Infotainment)

Detail of Switch for power supply ON/OFF control and reverse connection protection (2)

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



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

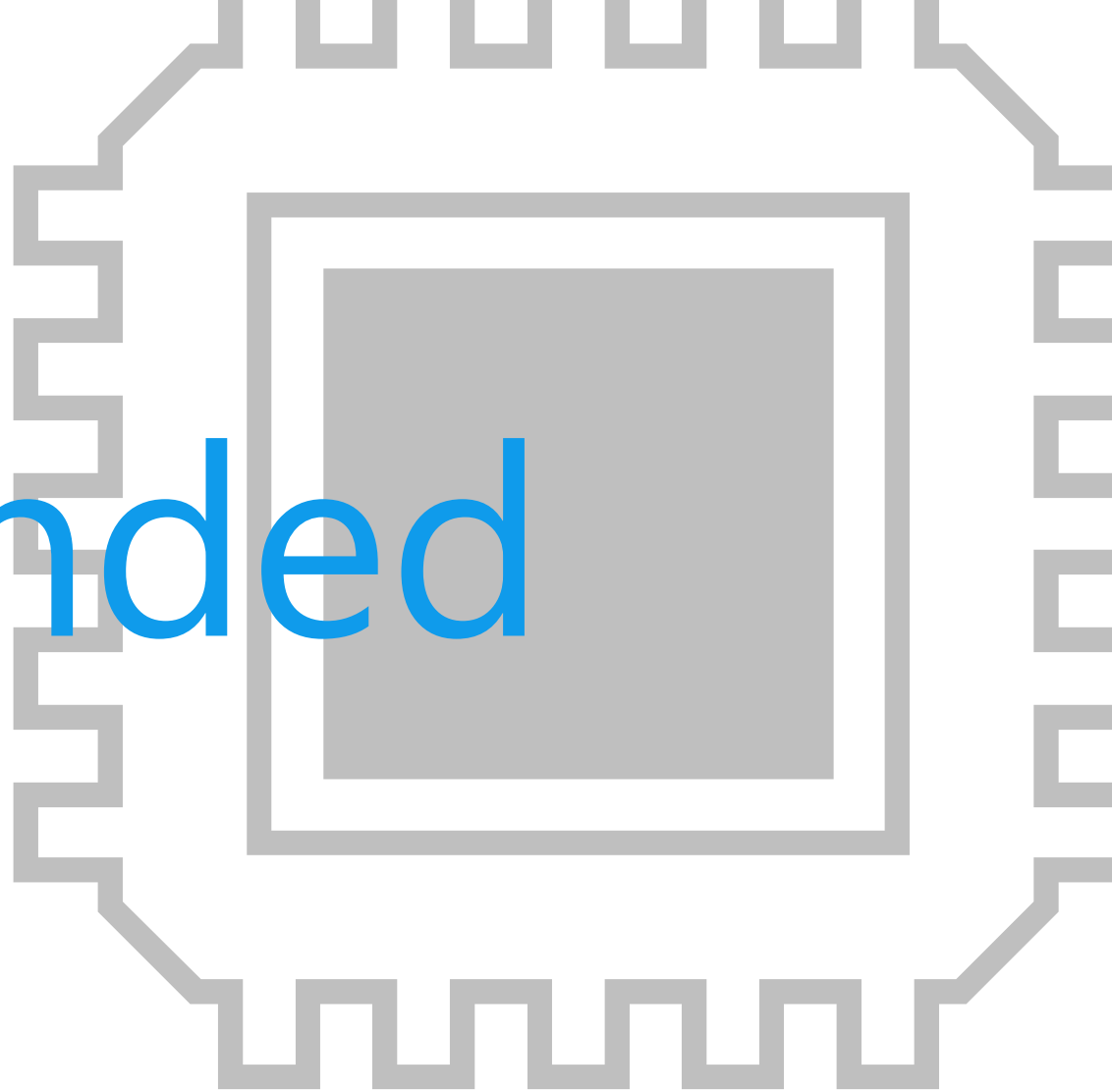
Criteria for device selection

- 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

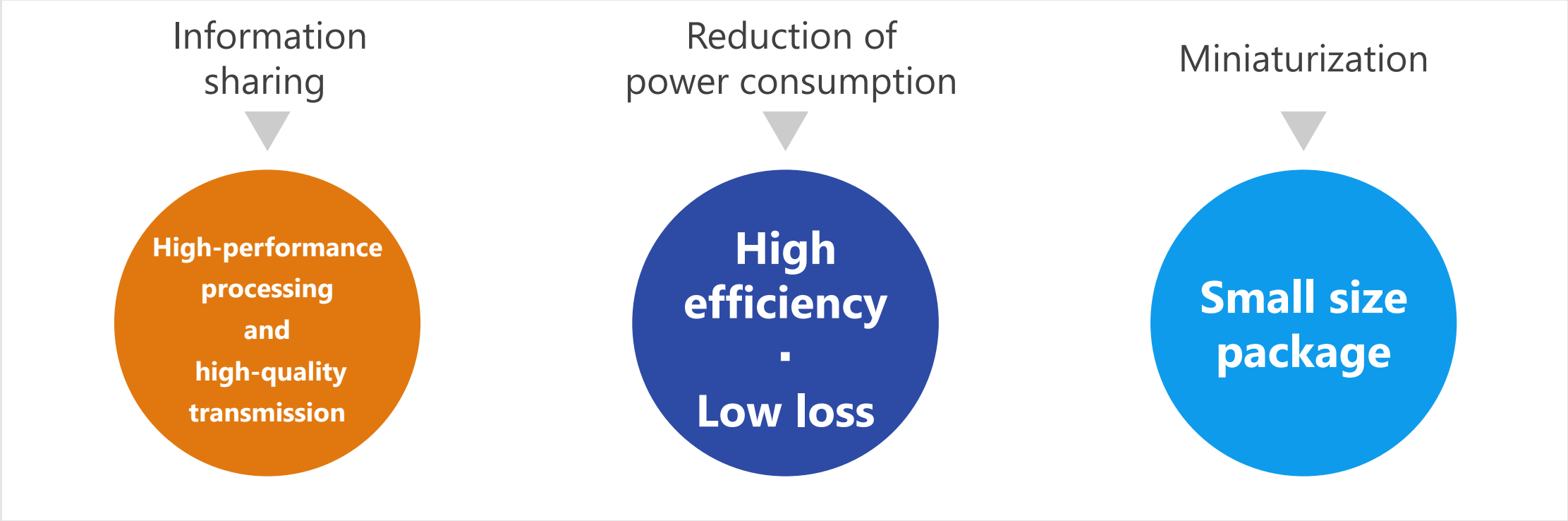
- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET (5)
- **Gate driver with protection and diagnosis functions**
  Gate driver (for switch) (7)
- **Extensive product lineup**
  General purpose small signal MOSFET (8)
  General purpose small signal 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.



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)	●		●

1 Ethernet bridge IC
TC956x Series

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

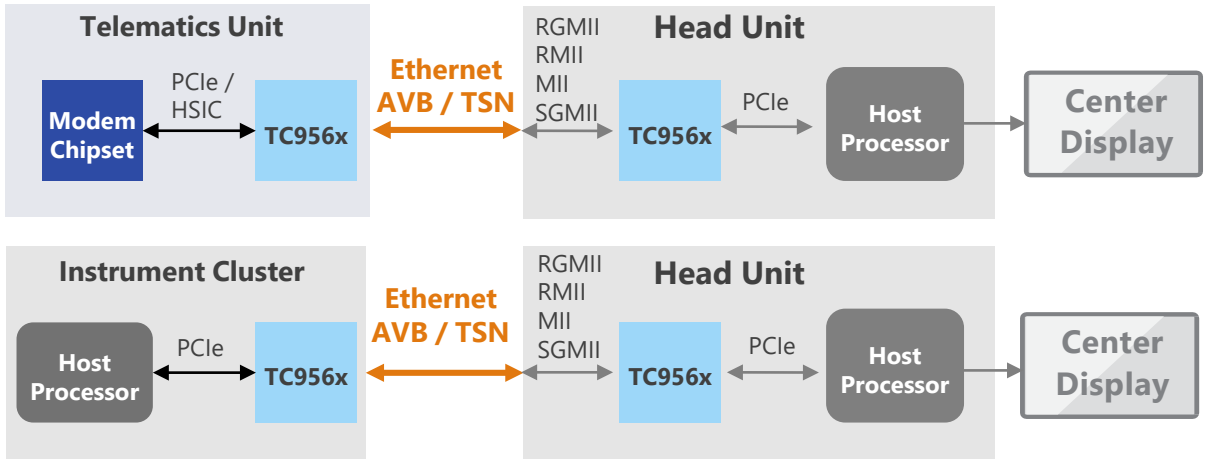
It complies with Ethernet AVB/TSN specified by IEEE 802.1 Qav/Qbv each other etc.
Low delay transmission is possible.

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.



Line up

Part number	TC9560 BXBG	TC9560 XBG	TC9562 XBG	TC9562 AXBG	TC9562 BXBG
Package	P-LFBGA170-1010-0.65		P-LFBGA120-0909-0.65		
Host I/F	HSIC	PCIe I/F [GEn2.0 (5 GT/s), Gen1.0 (2.5 GT/s), Endpoint, Single lane]			
Automotive I/F	Ethernet AVB				Ethernet AVB and Ethernet TSN
	Select from RGMII / RMII / MII			Select from RGMII / RMII / MII /SGMII	

◆Return to Block Diagram TOP

2 Peripheral bridge IC

TC9590 / TC9591 / TC9592 / TC9593 / TC9594 / TC9595

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.

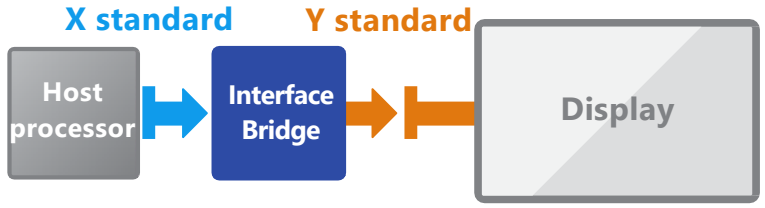
2 Reduce noise

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

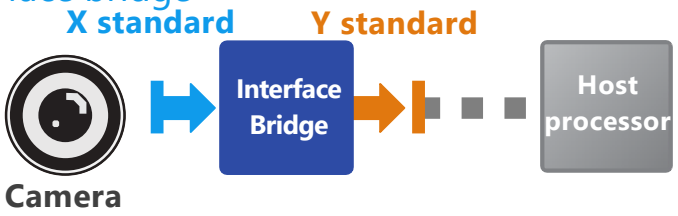
3 Reduce disconnection risk

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

■ Display interface



■ Camera interface bridge



Line up

	Camera I/F Bridge		Display I/F Bridge			
Part number	TC9590	TC9591	TC9592	TC9593	TC9594	TC9595
Package	VFBGA80	VFBGA80	VFBGA49	VFBGA64	VFBGA80	VFBGA80
Input	HDMI™1.4a	(1) MIPI® CSI-2SM (2) Parallel 24bit@166 MHz	MIPI DSISM 4 Lanes x 1ch		Parallel input 24bit@166 MHz	MIPI DSI 4 Lanes x 1ch. / MIPI DPI (24bit)
Output	MIPI CSI-2 4 Lanes x 1ch	(1) Parallel 24bit@100 MHz (2) MIPI CSI-2	LVDS Single Link		MIPI DSI 4 Lanes x 1ch	DisplayPort™ 1.1a x 2 Ports / MIPI DPI (24bit)

◆Return to Block Diagram TOP

3 Wireless communication IC

TC32306FTG / TC32163FG

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

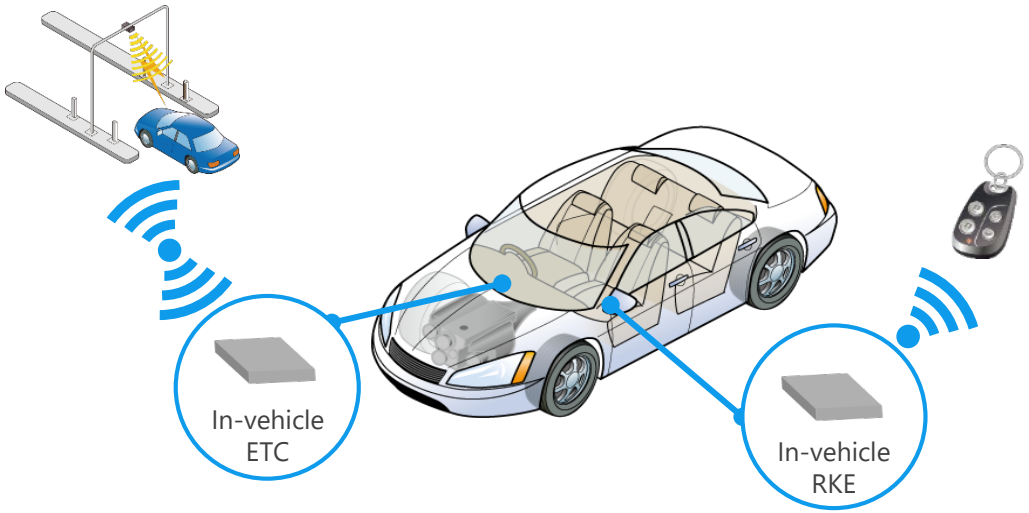
Value provided

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



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

Line up

	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

◆Return to Block Diagram TOP

4 Audio power amplifier IC

TCB701FNG / TCB702FNG

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

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)

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

2 Reduction of external components

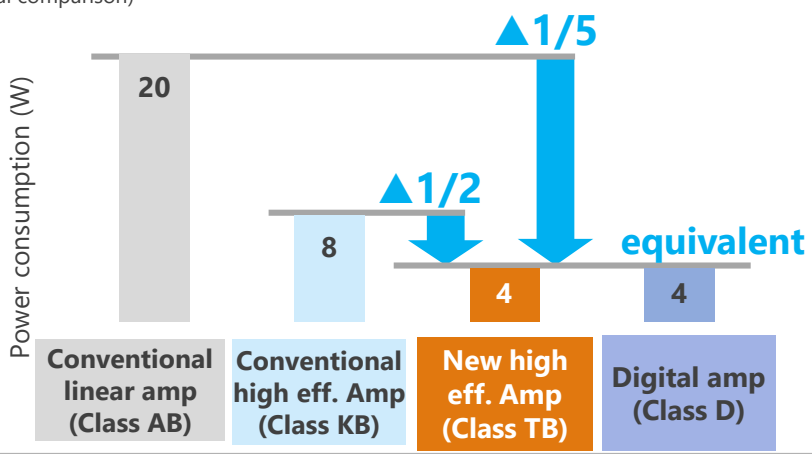
Since these ICs operate without switching such as the class D amplifier, the external parts such as low pass filter or components for EMI suppression can be reduced.

3 Built-in fulltime output offset detection (patent registered)

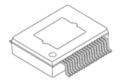
Includes a proprietary speaker burnout prevention system that continuously checks for any abnormal output DC offset regardless of input signal presence and informs the microcomputer.

■ Power consumption (for 0.8 W x 4 channels)

(Toshiba internal comparison)



Line up

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

5 U-MOS Series 40 V N-ch MOSFET

XPN3R804NC / TK1R4S04PB / TPHR7904PB / TPWR7904PB / TKR74F04PB / TK1R5R04PB

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

Value provided

The advanced U-MOSⅨ-H 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 61 % reduction per unit area.
(compared to U-MOSⅣ)

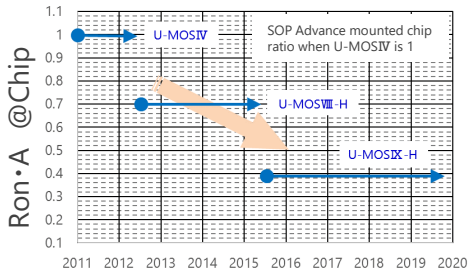
2 Compact and low loss package

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

3 Low noise (low EMI)

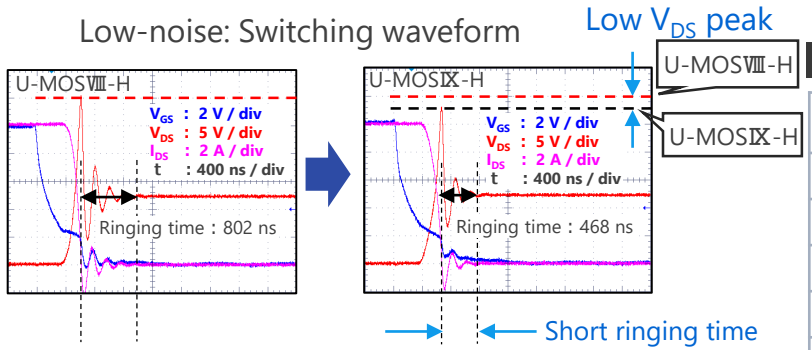
Improved chip process reduces surge voltage and ringing time.

Low Loss: RonA Trend



(Note: Toshiba internal comparison)

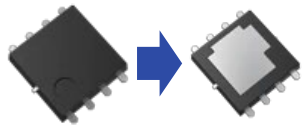
Low-noise: Switching waveform



TO-220SM(W) Cu connector design

Package resistance is reduced by 64 %, compared to D2PAK+.

DSOP Advance(WF)L double-sided cooling package



Thermal resistance is reduced by 76 % @t = 3 s, mounted on board compared to SOP Advance(WF).

Line up

Part number	Drain current	On-resistance (Max) @V_{GS} = 10 V	Package
XPN3R804NC	40 A	3.8 mΩ	TSON Advance(WF)
TK1R4S04PB	120 A	1.35 mΩ	DPAK+
TPHR7904PB	150 A	0.79 mΩ	SOP Advance(WF)
TPWR7904PB	150 A	0.79 mΩ	DSOP Advance(WF)L
TKR74F04PB	250 A	0.74 mΩ	TO-220SM(W)
TK1R5R04PB	160 A	1.5 mΩ	D2PAK+

◆Return to Block Diagram TOP

6 U-MOS Series -40 V / -60 V P-ch MOSFET

TJ90S04M3L / TJ60S06M3L / XPH3R114MC / TJ200F04M3L

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

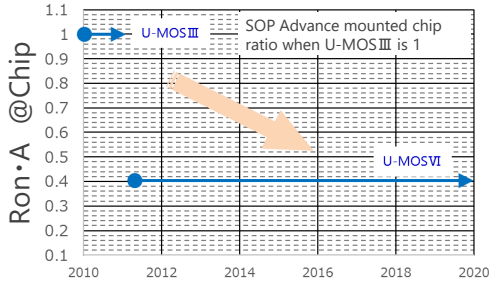
Value provided

Low on-resistance contributes to reduce system power consumption.

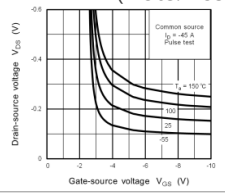
1 Low loss (reduced on-resistance) and logic level drive

Using low on-resistance technology contributes to reduce system power consumption.
Lineups of logic level drive type are supported.

Low Loss: RonA Reduction Trend



(Note: Toshiba internal comparison)



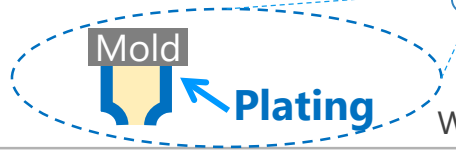
Logic level drive
TJ90S04M3L
$V_{DS(ON)}$ - V_{GS}

Large current, small size, high heat dissipation package

TO-220SM(W)
(10 x 13 mm)
Up to 200 A

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

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



Wettable Flank (WF) structure

2 Small surface mount package developed

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

Line up

Part number	Drain-source Voltage	Drain current	On-resistance (Max) @V_{GS} = -10 V	Package
TJ90S04M3L	-40 V	-90 A	4.3 mΩ	DPAK+ 
TJ60S06M3L	-60 V	-60 A	11.2 mΩ	
XPH3R114MC	-40 V	-100 A	3.1 mΩ	SOP Advance(WF) 
TJ200F04M3L	-40 V	-200 A	1.8 mΩ	TO-220SM(W) 

◆Return to Block Diagram TOP

7 Gate driver (for switch)

TPD7104AF / TPD7106F / TPD7107F

High-performance processing and high-quality transmission

High efficiency · Low loss

Small size package

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

Built-in charge pump circuit enables N-ch MOSFET as high side switch.
Easy to configure a semiconductor relay.

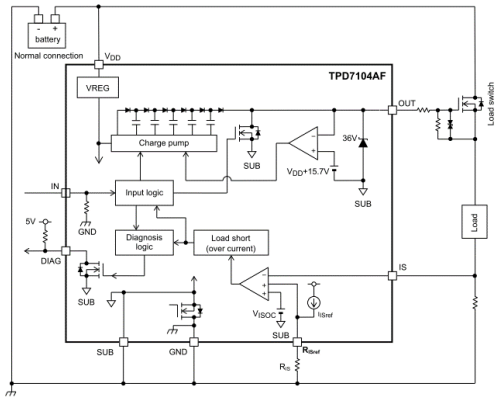
2 Can be controlled by logic level voltage

It is possible that Direct control by output signal of MCUs or CMOS logic ICs.

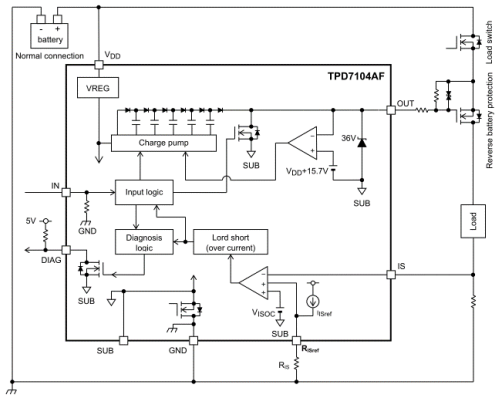
3 Small package

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

Line up

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)
Features	・Operating power supply voltage range: 5 to 18 V ・Built-in power supply reverse connection protection function (Supported for power supply reverse connection protection MOSFET applications)	・Operating power supply voltage range: 4.5 to 27 V ・Built-in power supply reverse connection protection function (Supported for power supply reverse connection protection MOSFET applications)	・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

8 General purpose small signal MOSFET

SSM3K7002KF / SSM3J168F / SSM3J66MFV

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.

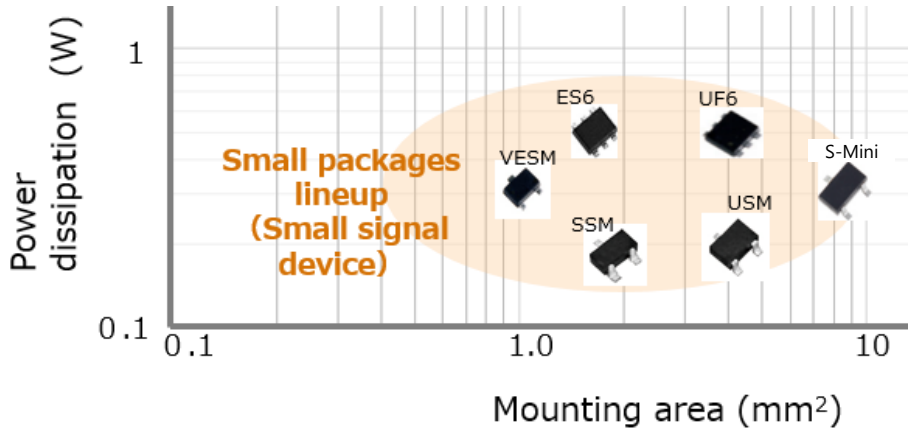
2 Low voltage drive

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



Line up

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

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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.

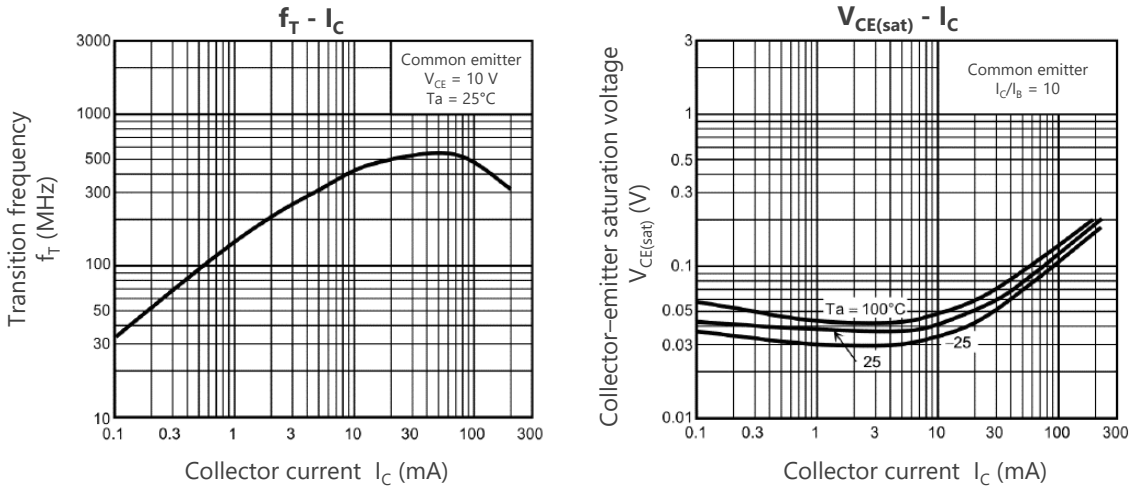
2 Extensive product lineup

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 to the application.

3 AEC-Q101 qualified

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

Characteristic examples of 2SC2712



Line up

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				
	100	2500	TTC501					

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

RN1907FE / RN2907FE / RN1901 / RN2901 Series

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)

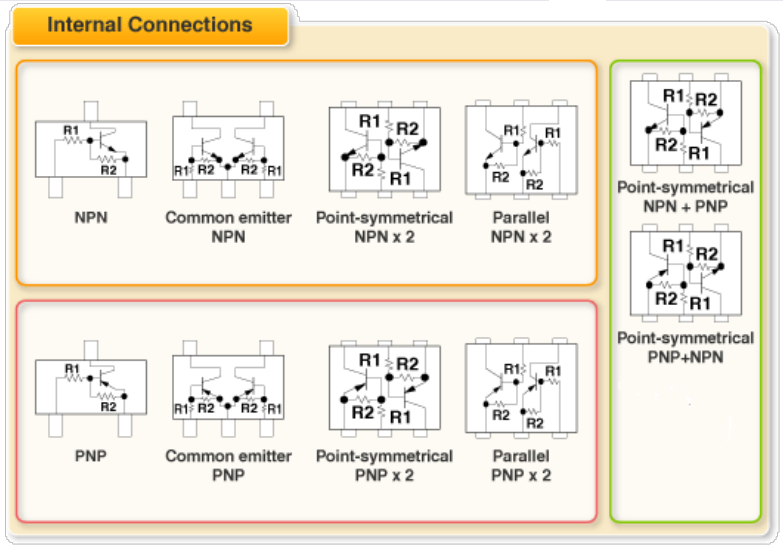
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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.



Line up

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

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11 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(*)

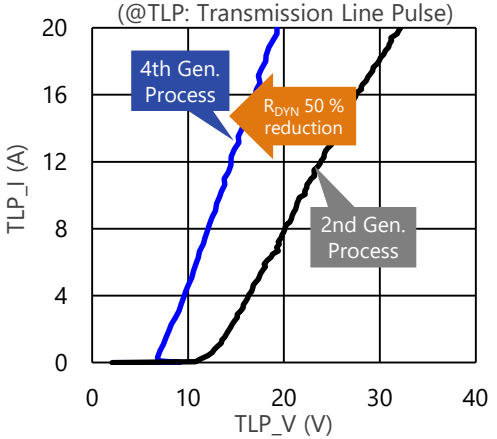
These are products applicable to high speed communications (Gbps orders) such as Ethernet and LVDS.

(*): Low voltage differential signaling

3 High ESD immunity

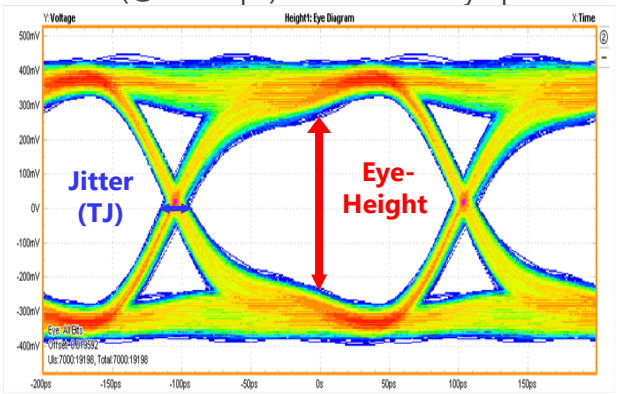
V_{ESD} > ±30 kV @ ISO 10605
V_{ESD} > ±20 kV (L4) @ IEC61000-4-2

ESD Pulse Absorption Performance
(@TLP: Transmission Line Pulse)



(Note: Toshiba internal comparison)

LVDS (@4.8 Gbps) DF2S6M4FS Eye pattern



Line up

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) : This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

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12 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU

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

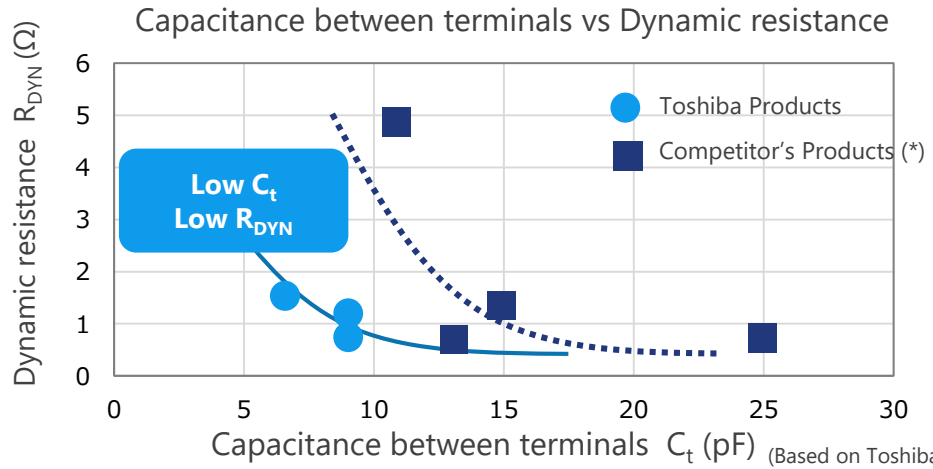
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

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} > ±30 kV @ ISO 10605
V_{ESD} > ±20 kV (L4) @ IEC61000-4-2



(Based on Toshiba research)

(NOTE) : This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

(*): Measurements of the commercial product

Line up

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

◆Return to Block Diagram TOP

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