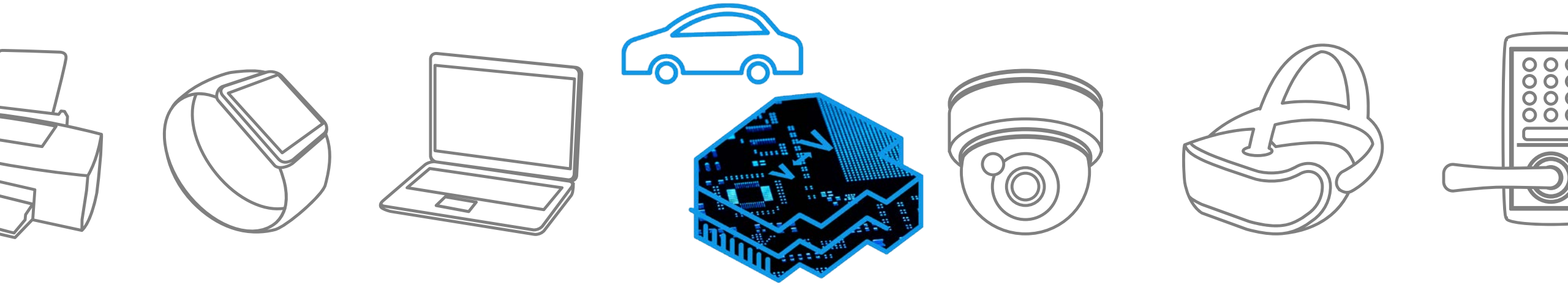
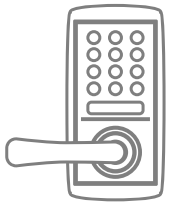
TOSHIBA

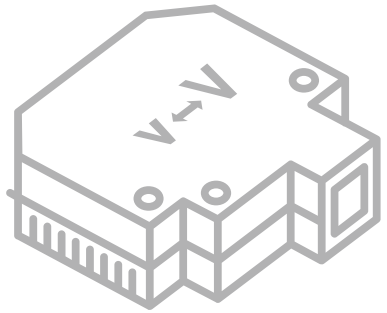
R20

Automotive DC-DC Converter

Solution Proposal by Toshiba

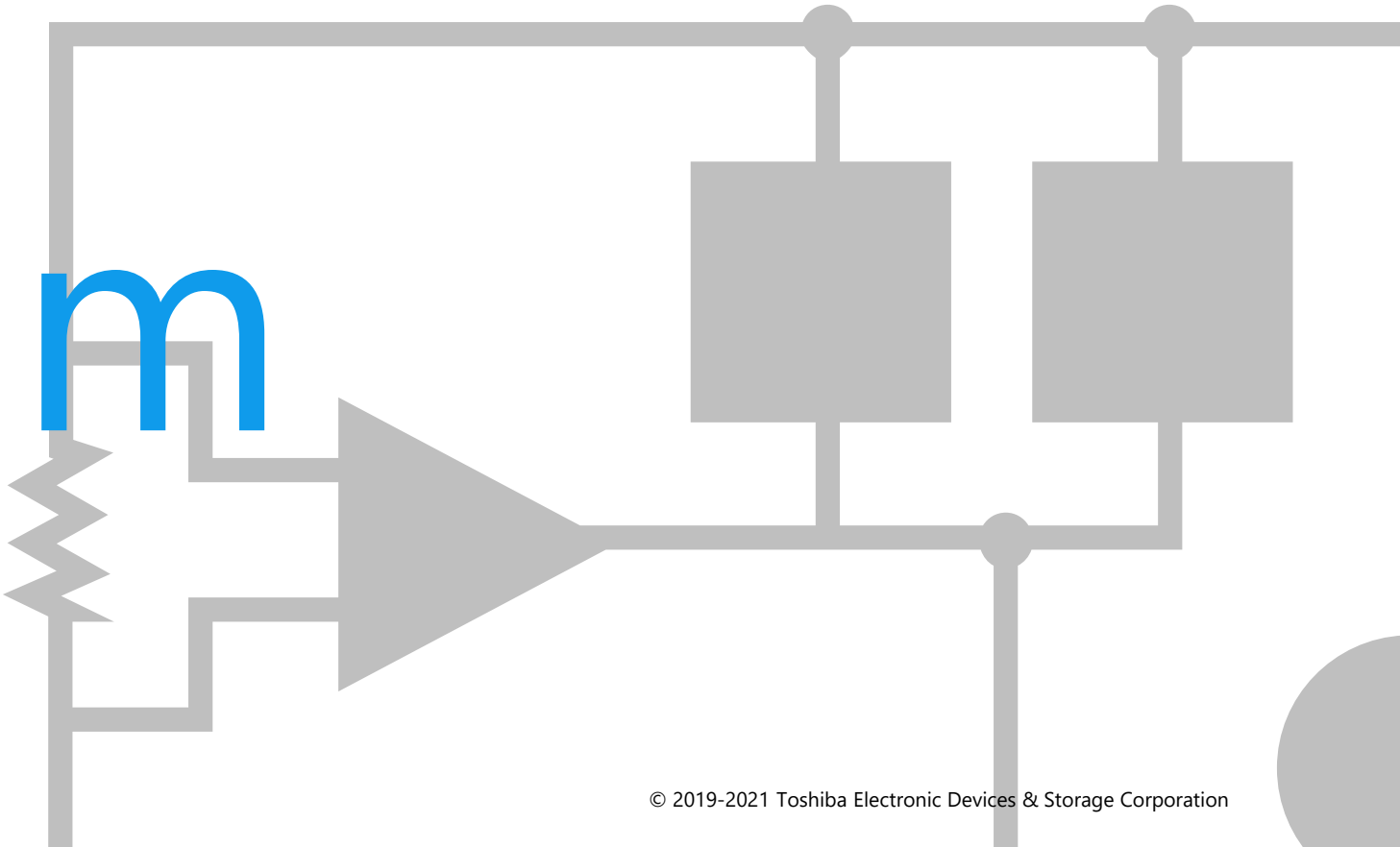




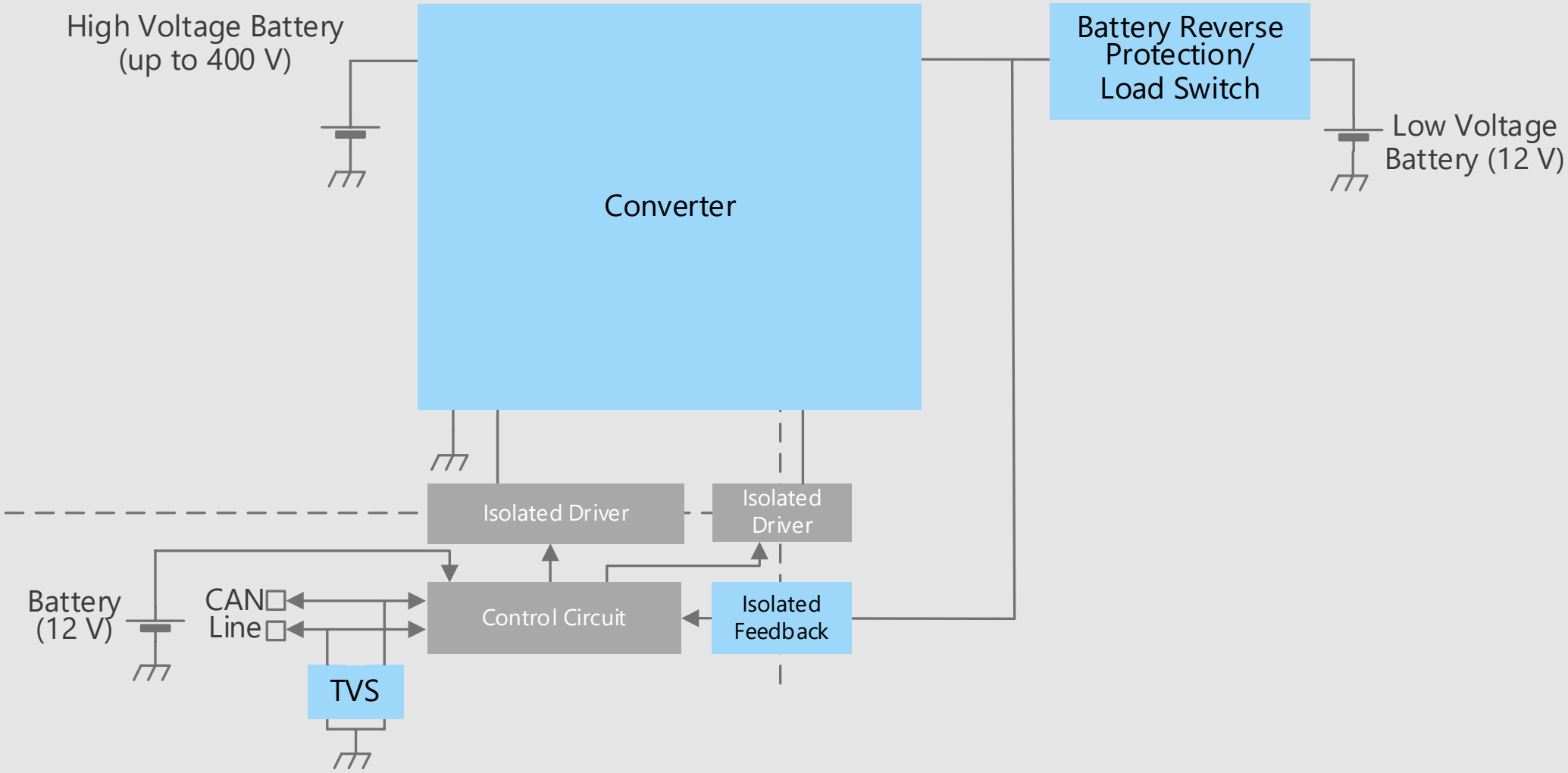


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

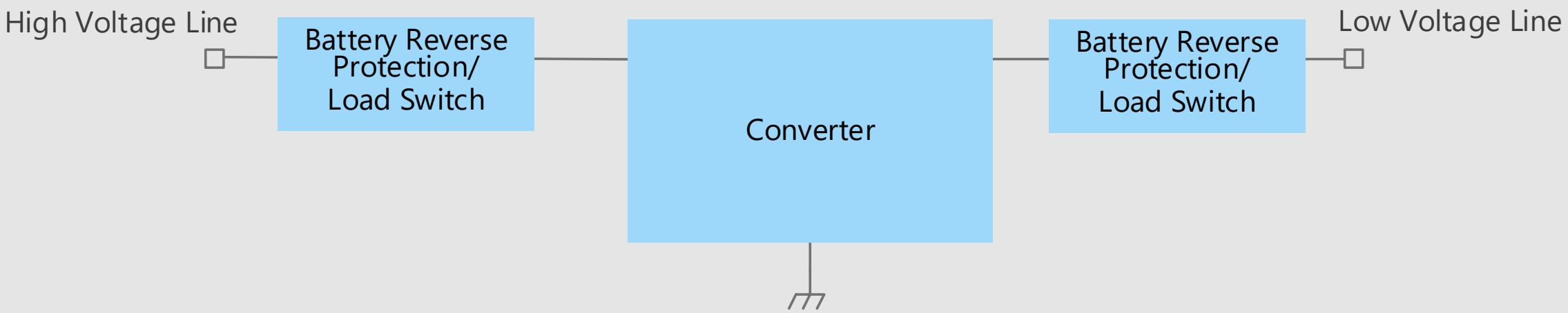
Block Diagram



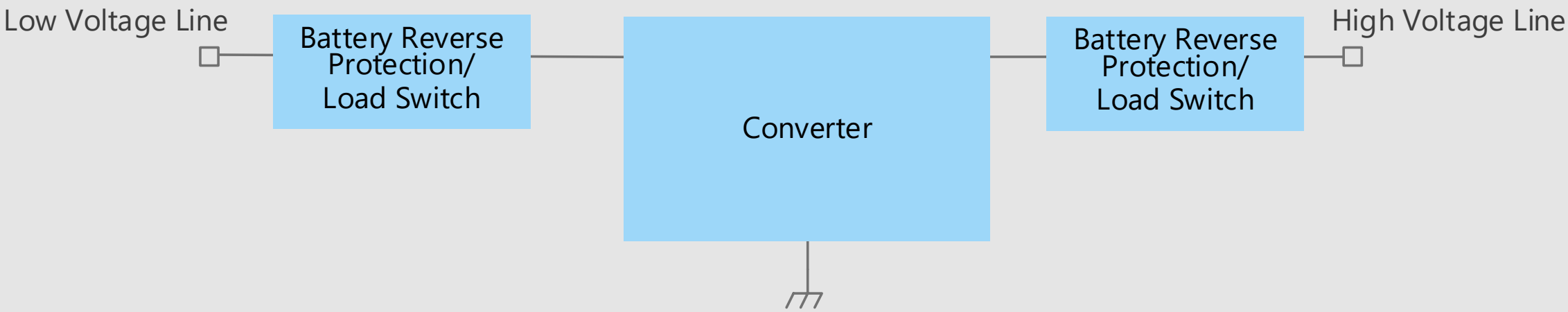
DC-DC Converter (Isolated)　Overall block diagram



DC-DC Converter (Non-Isolated buck type)　Overall block diagram

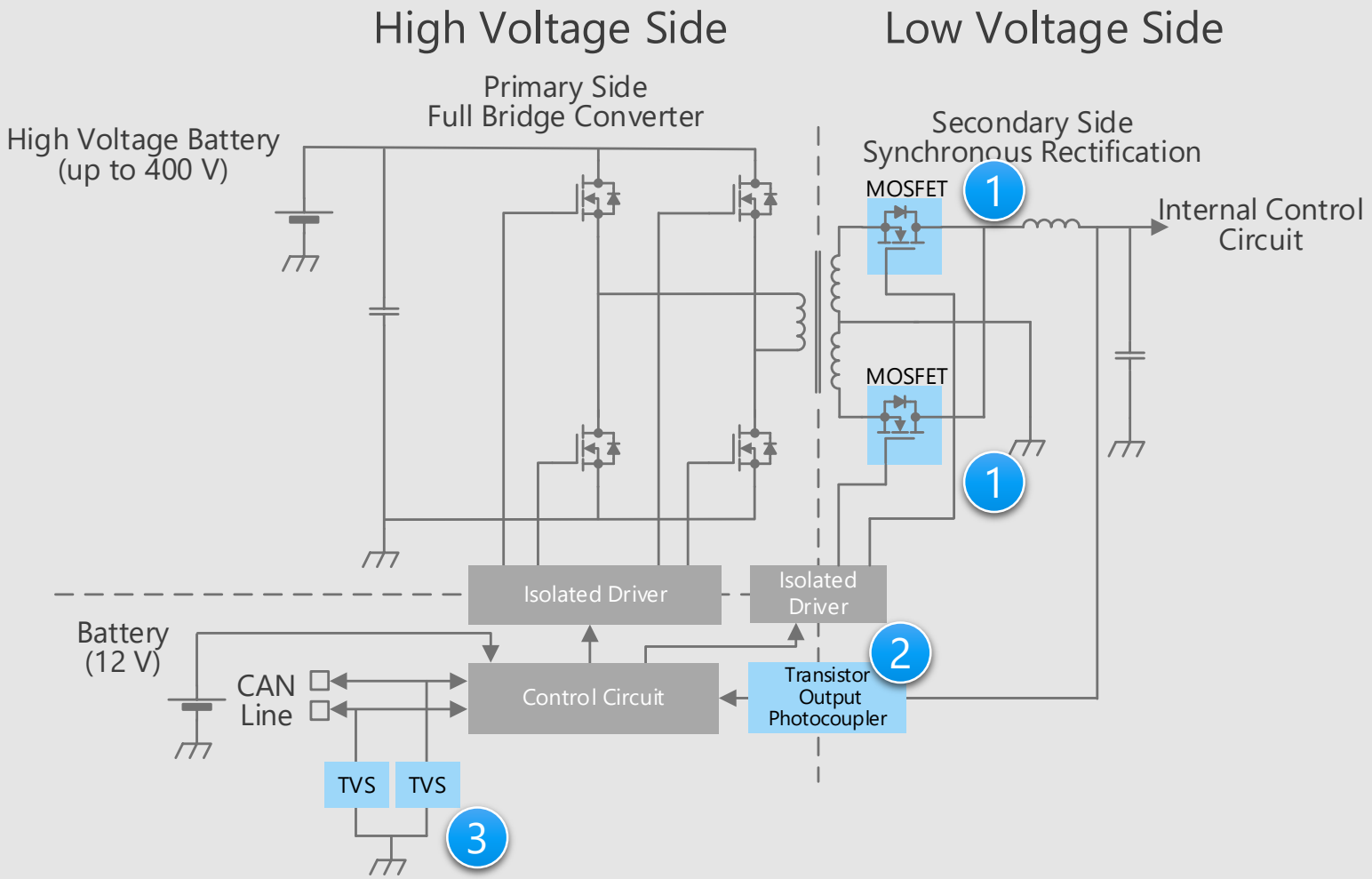


DC-DC Converter (Non-Isolated boost type)　Overall block diagram



DC-DC Converter　Detail of isolated type

DC-DC converter circuit (isolated type)



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

Criteria for device selection

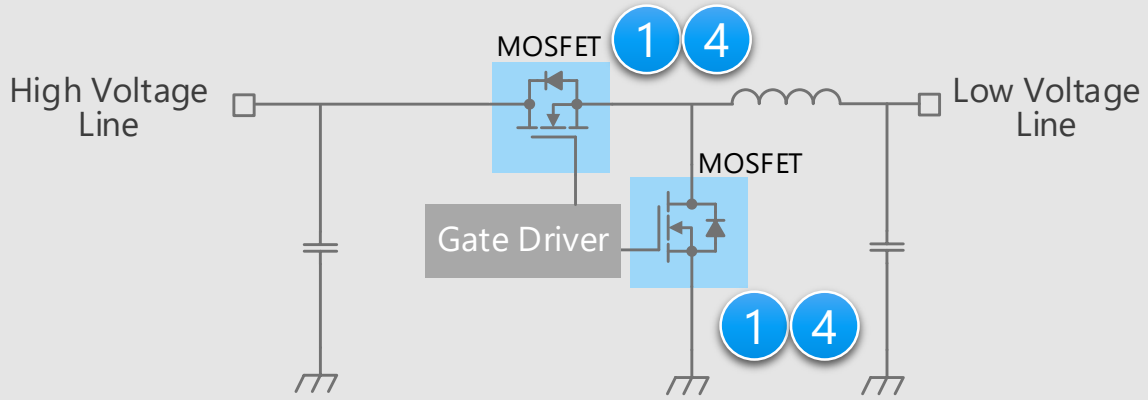
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- A small surface mount package is suitable for realizing miniaturization of the ECU.
- Isolation voltage should be noted to design voltage feedback to MCU.

Proposals from Toshiba

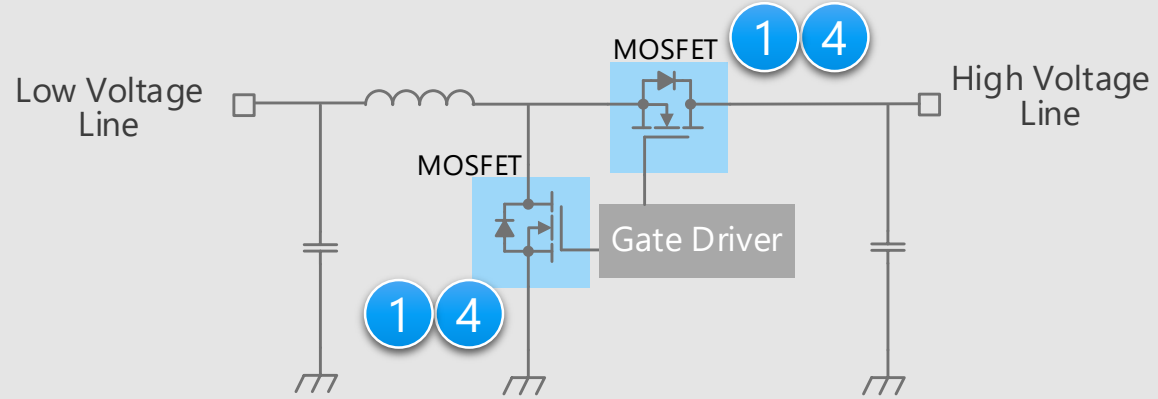
- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 100 V N-ch MOSFET　1
- **Photocouplers with environmental resistance**
  Transistor output photocoupler　2
- **Suitable for ESD protection**
  TVS diode (for CAN communication)　3

DC-DC Converter　Detail of non-isolated boost / buck types

DC-DC converter circuit (non-isolated buck type)



DC-DC converter circuit (non-isolated boost 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**

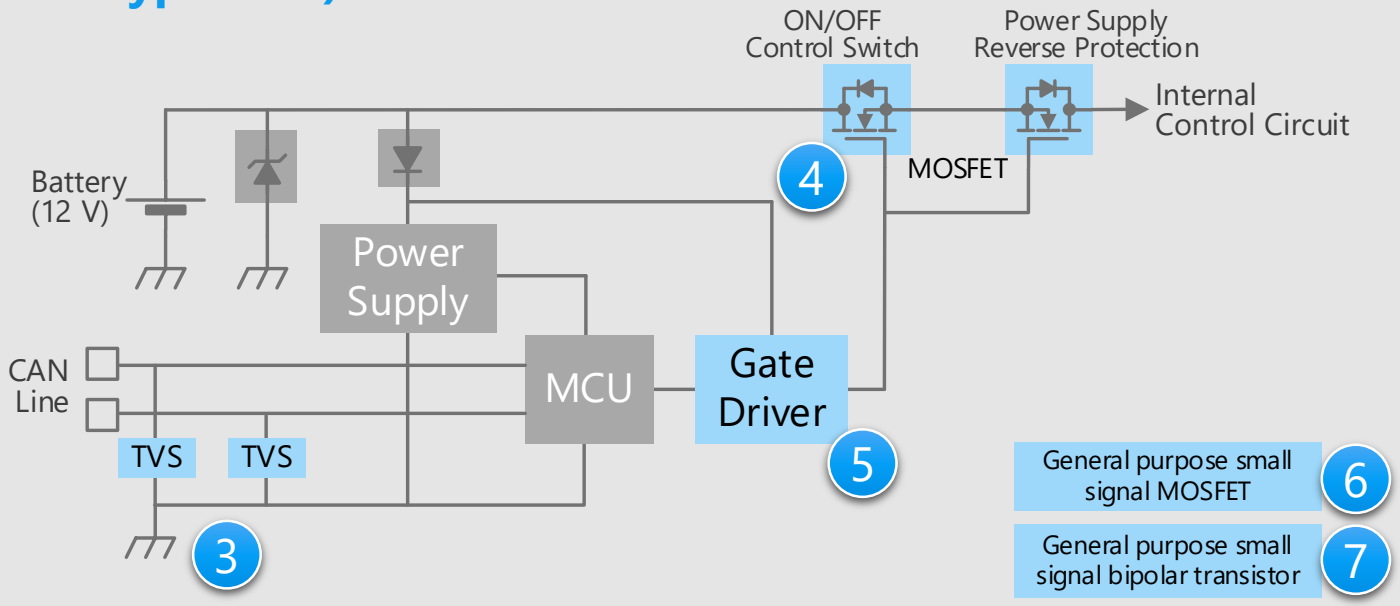
  U-MOS Series 100 V N-ch MOSFET　1

  U-MOS Series 40 V N-ch MOSFET　4

DC-DC Converter

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

Power supply ON/OFF control and reverse connection protecting circuit (N-ch type 12 V)



* 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

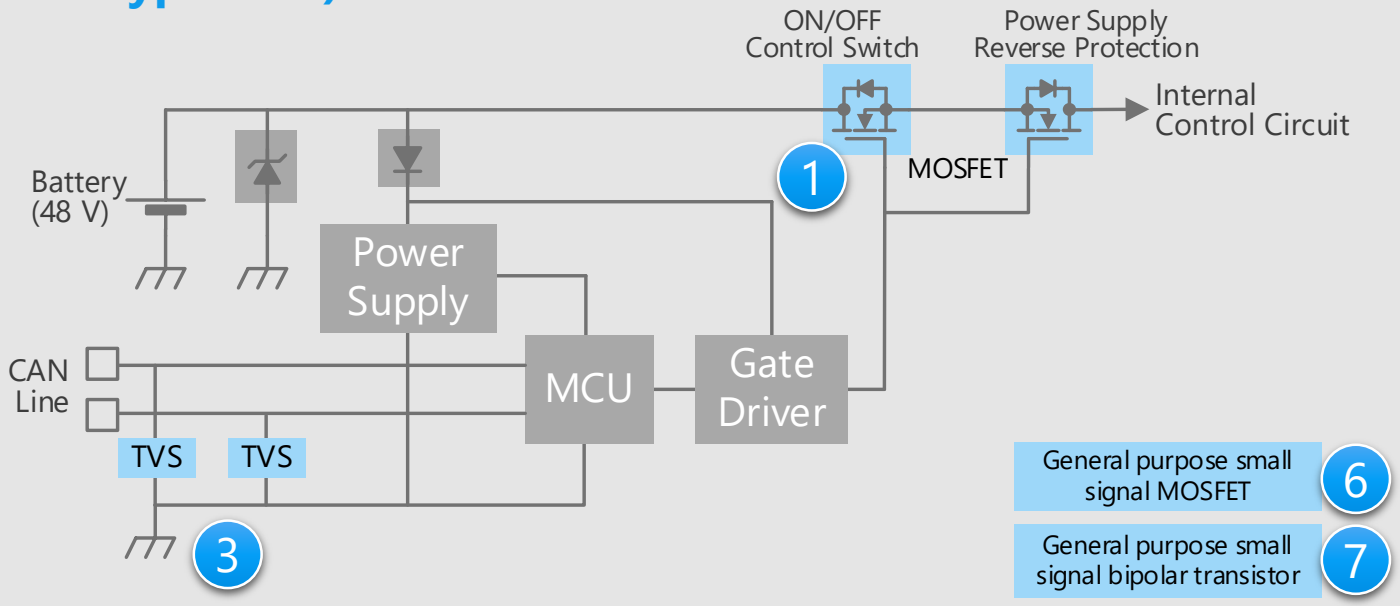
- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET
- **Gate driver with built-in protection and diagnostic function**
  Gate driver (for switch)
- **Extensive product lineup**
  General purpose small signal MOSFET
  General purpose small signal bipolar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

4
5
6
7
8
3

DC-DC Converter

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

Power supply ON/OFF control and reverse connection protecting circuit (N-ch type 48 V)



General purpose small signal MOSFET	6
General purpose small signal bipolar transistor	7
Small signal bias resistor built-in transistor (BRT)	8

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

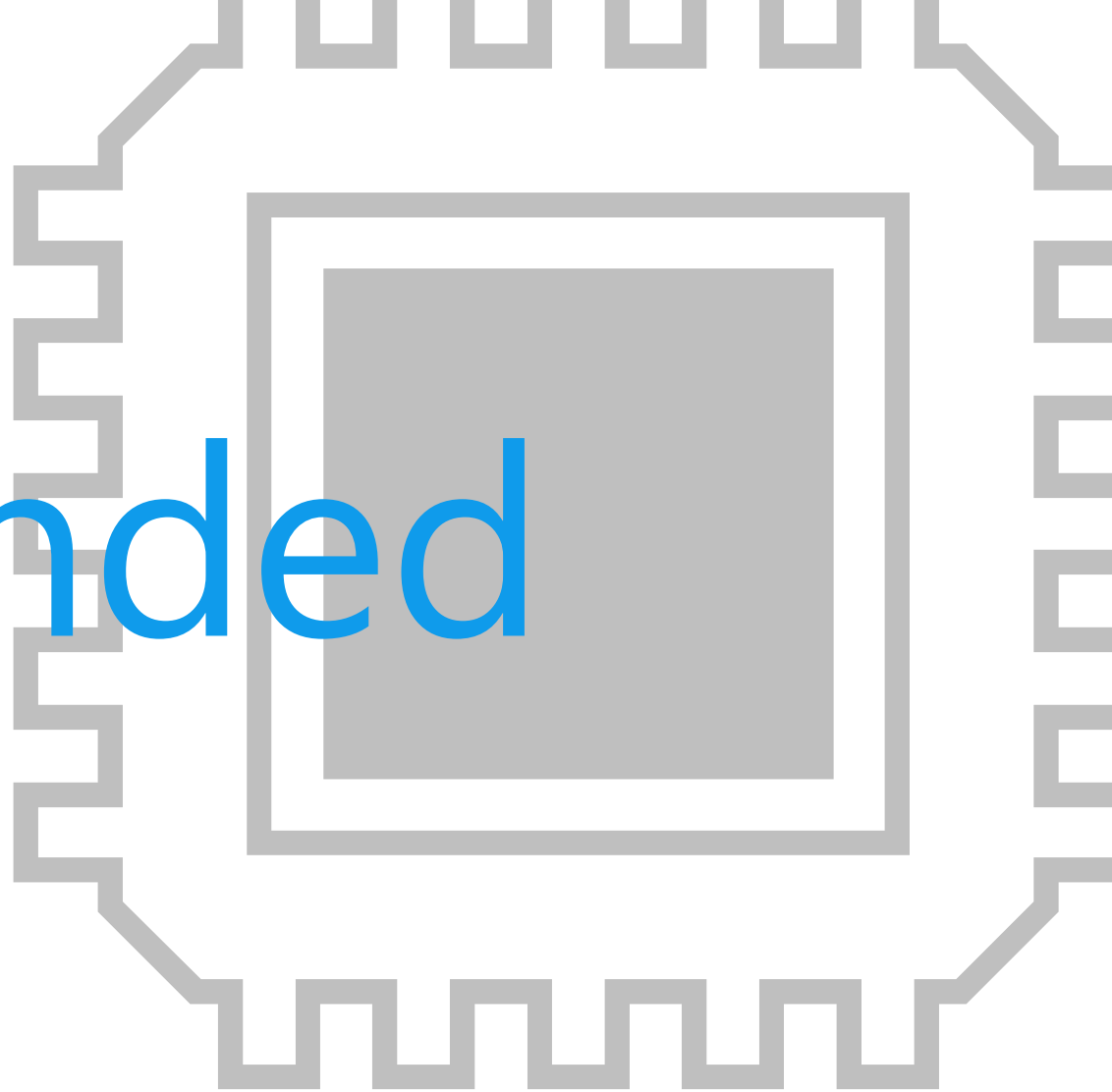
Criteria for device selection

- 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

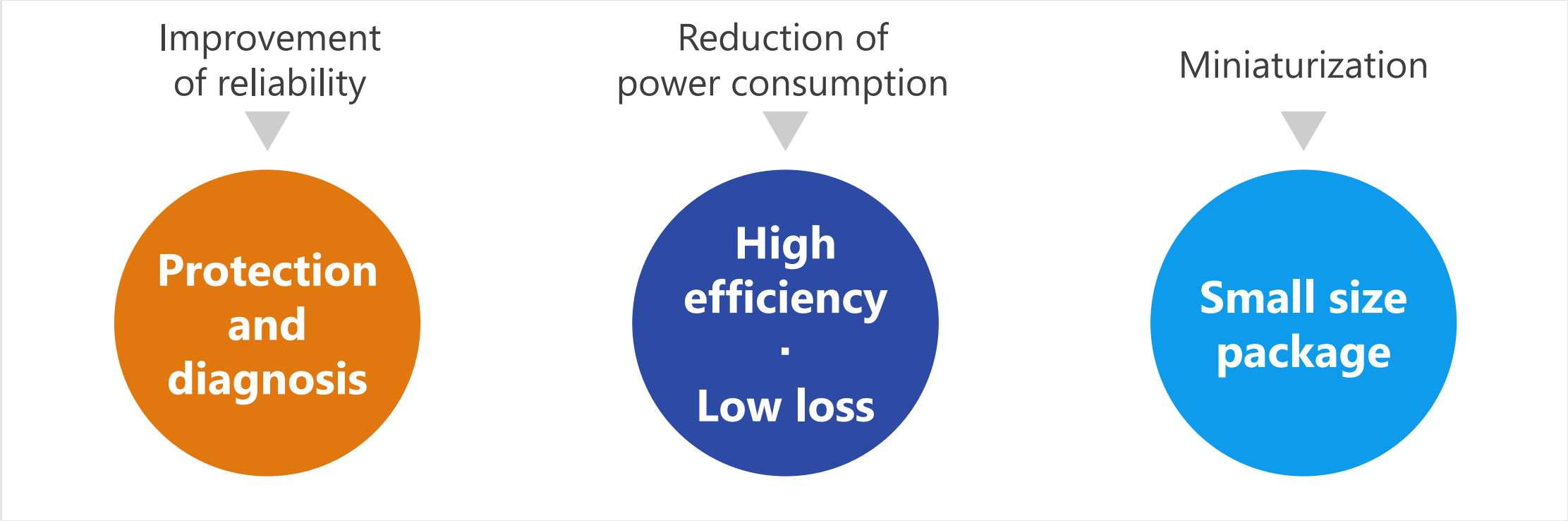
- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 100V N-ch MOSFET 1
- **Extensive product lineup**
  General purpose small signal MOSFET 6
  General purpose small signal bipolar transistor 7
  Small signal bias resistor built-in transistor (BRT) 8
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 3

Recommended Devices



Device solutions to address customer needs

As described above, in the design of DC-DC Converters, **“Improvement of reliability”**, **“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

	Protection and diagnosis	High efficiency · Low loss	Small size package
1 U-MOS Series 100 V N-ch MOSFET		●	●
2 Transistor output photocoupler	●		●
3 TVS diode (for CAN communication)	●		●
4 U-MOS Series 40 V N-ch MOSFET		●	●
5 Gate driver (for switch)	●		●
6 General purpose small signal MOSFET		●	●
7 General purpose small signal bipolar transistor			●
8 Small signal bias resistor built-in transistor (BRT)			●

1 U-MOS Series 100 V N-ch MOSFET

XPN2400ANC / TK60S10N1L / XPH4R10ANB / XPW4R10ANB / TK160F10N1L / XK1R9F10QB / XK4R0F10QB

Protection and diagnosis | High efficiency · Low loss | Small size package

Value provided

Low on-resistance contributes to reduced system power consumption.

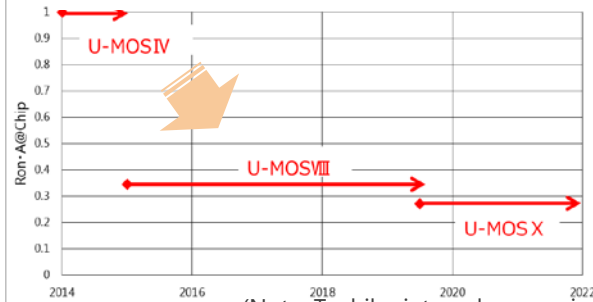
1 Low loss (reduced on-resistance)

Using low resistance wafer process technology to contribute to reduced power consumption systems.

2 Small and high heat dissipation package

Small and high heat dissipation packages are realized by adopting a Cu connector structure.
Ensuring mountability by using the Wettable Flank (WF) structure.

Low Loss: RonA Reduction Trend



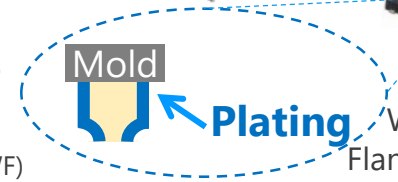
(Note: Toshiba internal comparison)

Small and high heat dissipation package

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

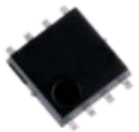
DPAK+
(6.5 x 10 mm)
Up to 90 A

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



Wettable Flank structure

DSOP Advance(WF) double-sided cooling packages



Decrease of thermal resistance
76 % reduction @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
XPN2400ANC *	20 A	23.5 mΩ	TSON Advance(WF)
TK60S10N1L	60 A	6.11 mΩ	DPAK+
XPH4R10ANB	70 A	4.1 mΩ	SOP Advance(WF)
XPW4R10ANB	70 A	4.1 mΩ	DSOP Advance(WF)
TK160F10N1L	160 A	2.4 mΩ	TO-220SM(W)
XK1R9F10QB	160 A	1.92 mΩ	
XK4R0F10QB *	(60 A)	(4.0 mΩ)	

* : Under Development (The specification is subject to change without notice.)

◆Return to Block Diagram TOP

2 Transistor output photocoupler

TLX9291A / TLX9185A / TLX9000 / TLX9300

Protection and diagnosis | High efficiency · Low loss | Small size package

Value provided

Contributes to safe improvement and design miniaturization.

1 High isolation

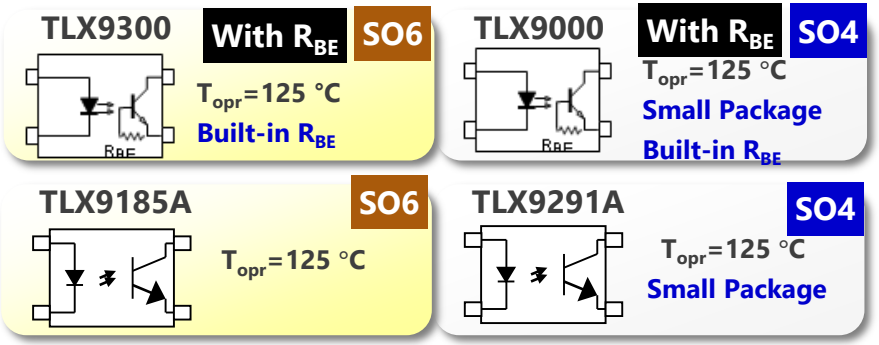
Non-electrical communication provides excellent isolation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

2 Small package

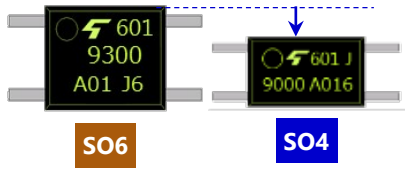
SO4 package that reduced mounting area by 30 % compared with our conventional SO6 package is aligned in the package lineup. It contributes to reduce occupied area on the board.

3 Maximum operating temperature of 125 °C

High heat resistance package has realized operating temperature range of -40 to 125 °C, and extension of lifespan. The TLX9000/9300 has built-in base-emitter resistor to reduce dark currents at high temperatures.



SO4 30% reduction (vs SO6)



(Toshiba internal comparison)

Line up

Part number	TLX9291A / TLX9185A	TLX9000 / TLX9300
Isolation Voltage [Vrms]	3750	3750
Collector-emitter voltage [V]	80	40
Dark current [nA] @Ta=125 °C	< 100 @ V_{CE}=48 V	< 10 @ V_{CE}=24 V
Conversion efficiency [%] @ I_F=5 mA, V_{CE}=5 V, Ta=25 °C	50 to 600 100 to 600 (GB rank)	100 to 900
Conversion efficiency (saturation) [%] @ I_F=1 mA, V_{CE}=0.4 V, Ta=25 °C	> 30	> 30
AEC-Q101	✓	✓

◆Return to Block Diagram TOP

3 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU

Protection and diagnosis | 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

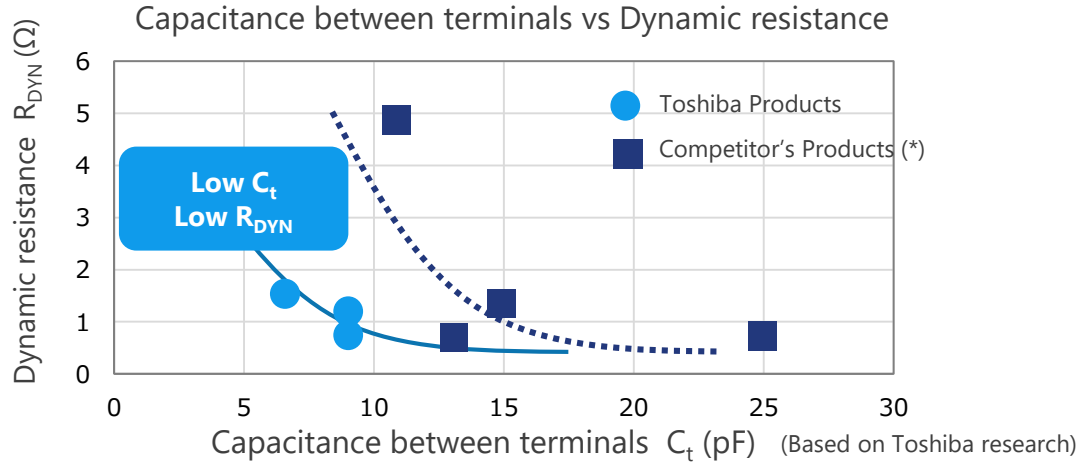
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

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)

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

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

(*): Measurements of the commercial product

◆Return to Block Diagram TOP

4 U-MOS Series 40 V N-ch MOSFET

XPN3R804NC / TK1R4S04PB / TPHR7904PB / TPWR7904PB / TKR74F04PB / TK1R5R04PB

Protection and diagnosis | 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)

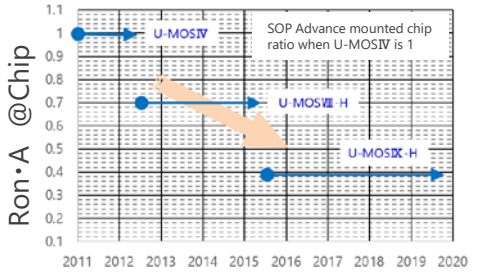
2 Compact and low loss package

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)

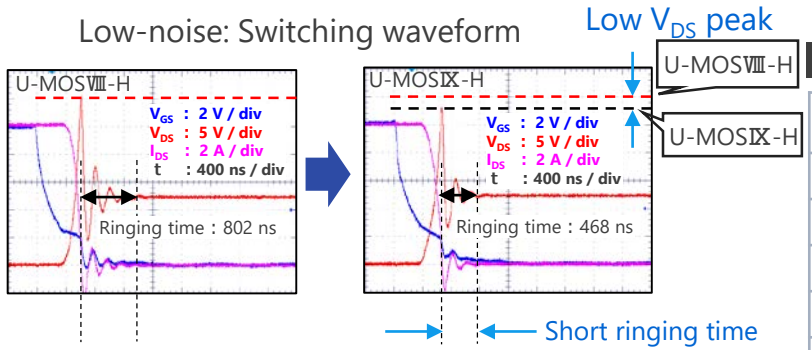
Improved chip process reduces surge voltage and ringing time.

Low Loss: RonA Trend



(Note: Toshiba internal comparison)

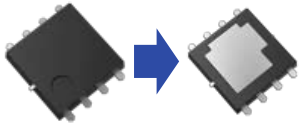
Low-noise: Switching waveform



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

5 Gate driver (for switch)

TPD7104AF / TPD7106F / TPD7107F

Protection and diagnosis | High efficiency · Low loss | Small size package

Value provided

A charge pump circuit for the N-channel 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-channel MOSFET as high side switch.
Easy to configure a semiconductor relay.

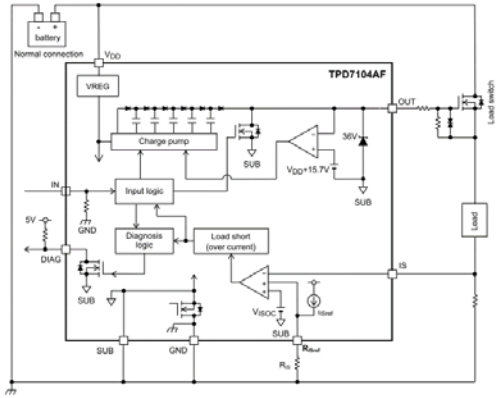
2 Can be controlled by logic level voltage

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

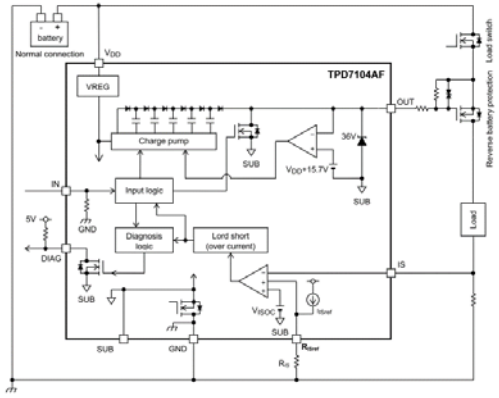
3 Small package

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

6 General purpose small signal MOSFET

SSM3K7002KF / SSM3J168F / SSM3J66MFV

Protection and diagnosis | 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.

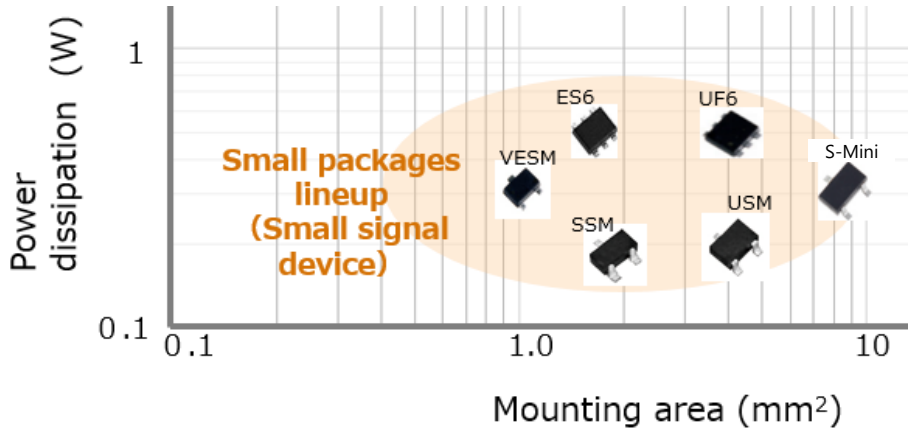
2 Low voltage drive

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

◆Return to Block Diagram TOP

7 General purpose small signal bipolar transistor

2SC2712 / 2SA1162 / 2SC4116 / 2SA1586 / TTA501 / TTC501 and others

Protection and diagnosis | 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.

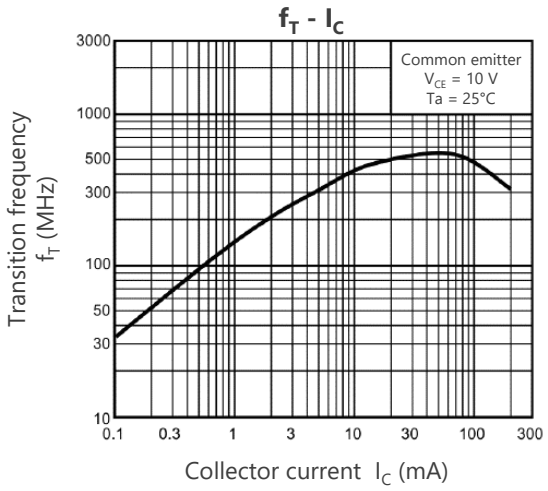
2 Extensive product lineup

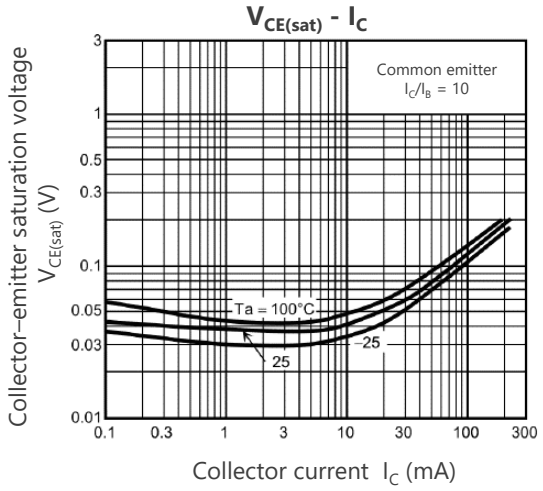
Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance to the application.

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					

◆Return to Block Diagram TOP

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

RN1907FE / RN2907FE / RN1901 / RN2901 Series

Protection and diagnosis | 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)

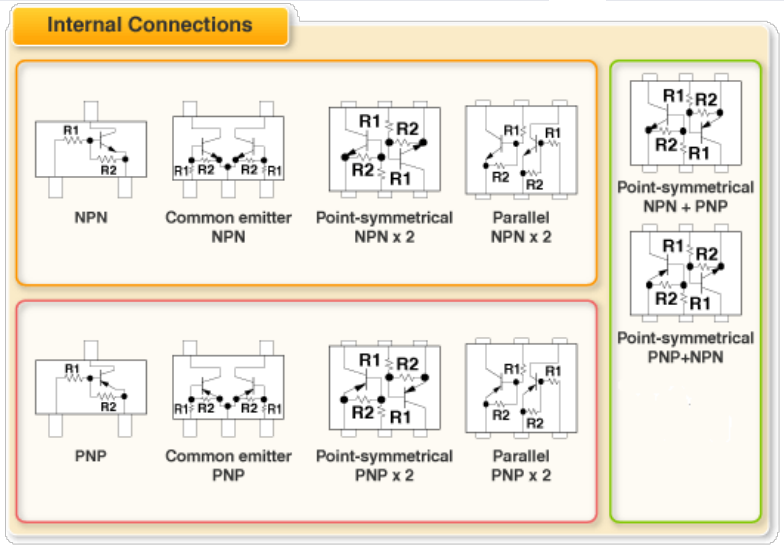
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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

◆Return to Block Diagram TOP

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

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