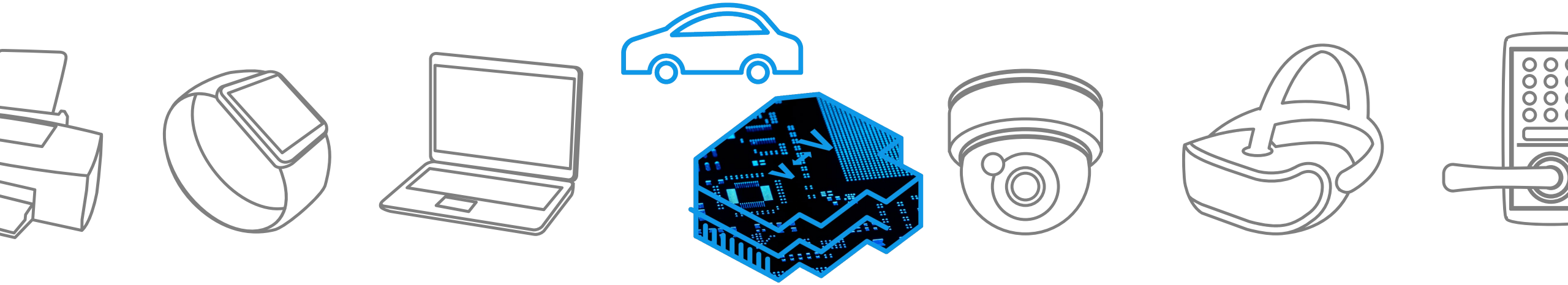
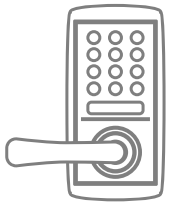
TOSHIBA

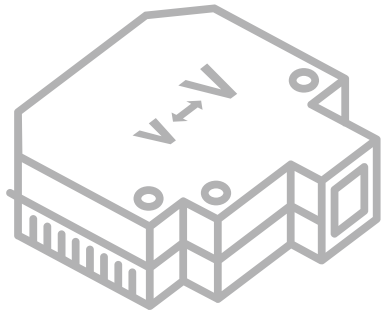
R21

Automotive DC-DC Converter

Solution Proposal by Toshiba

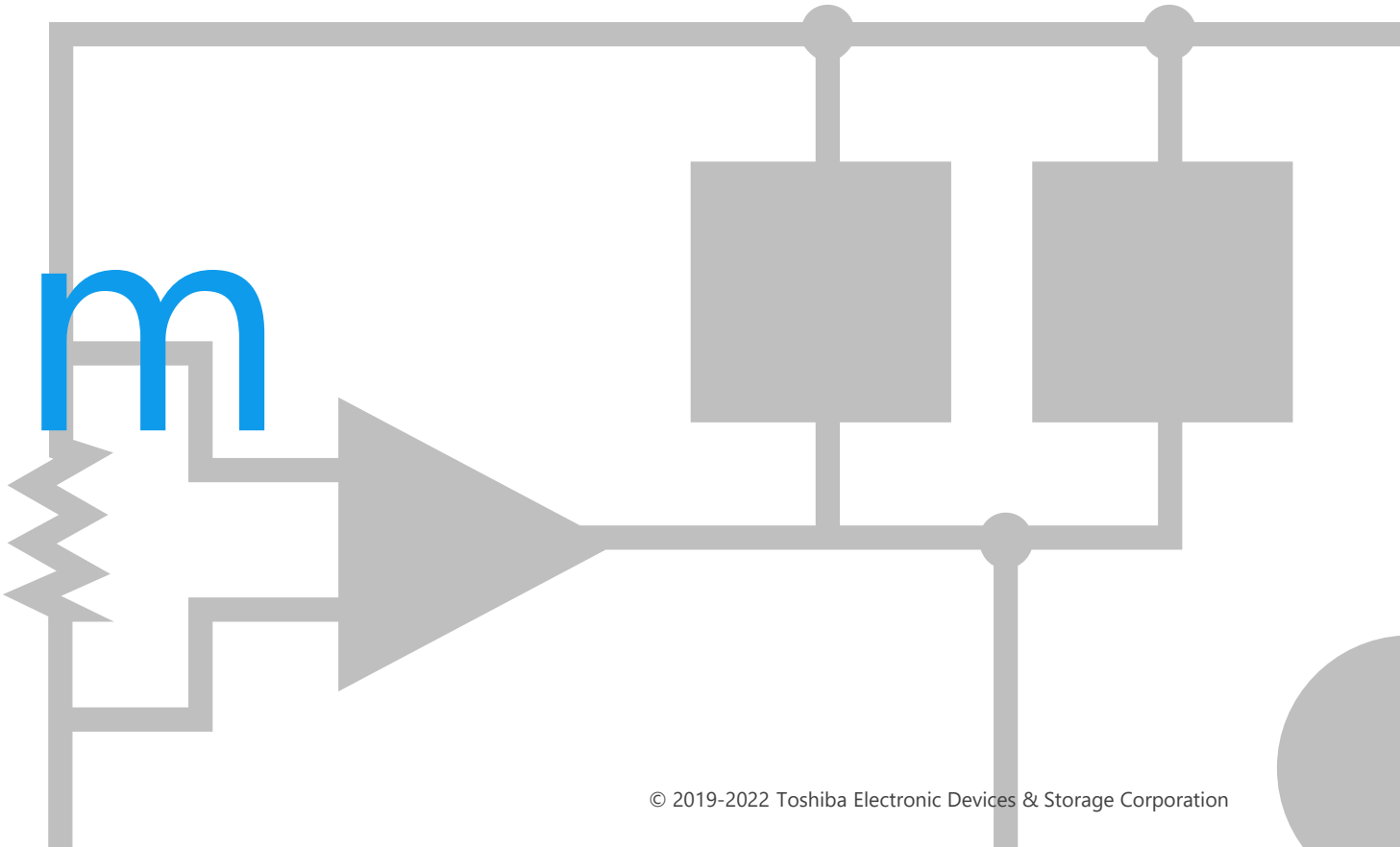




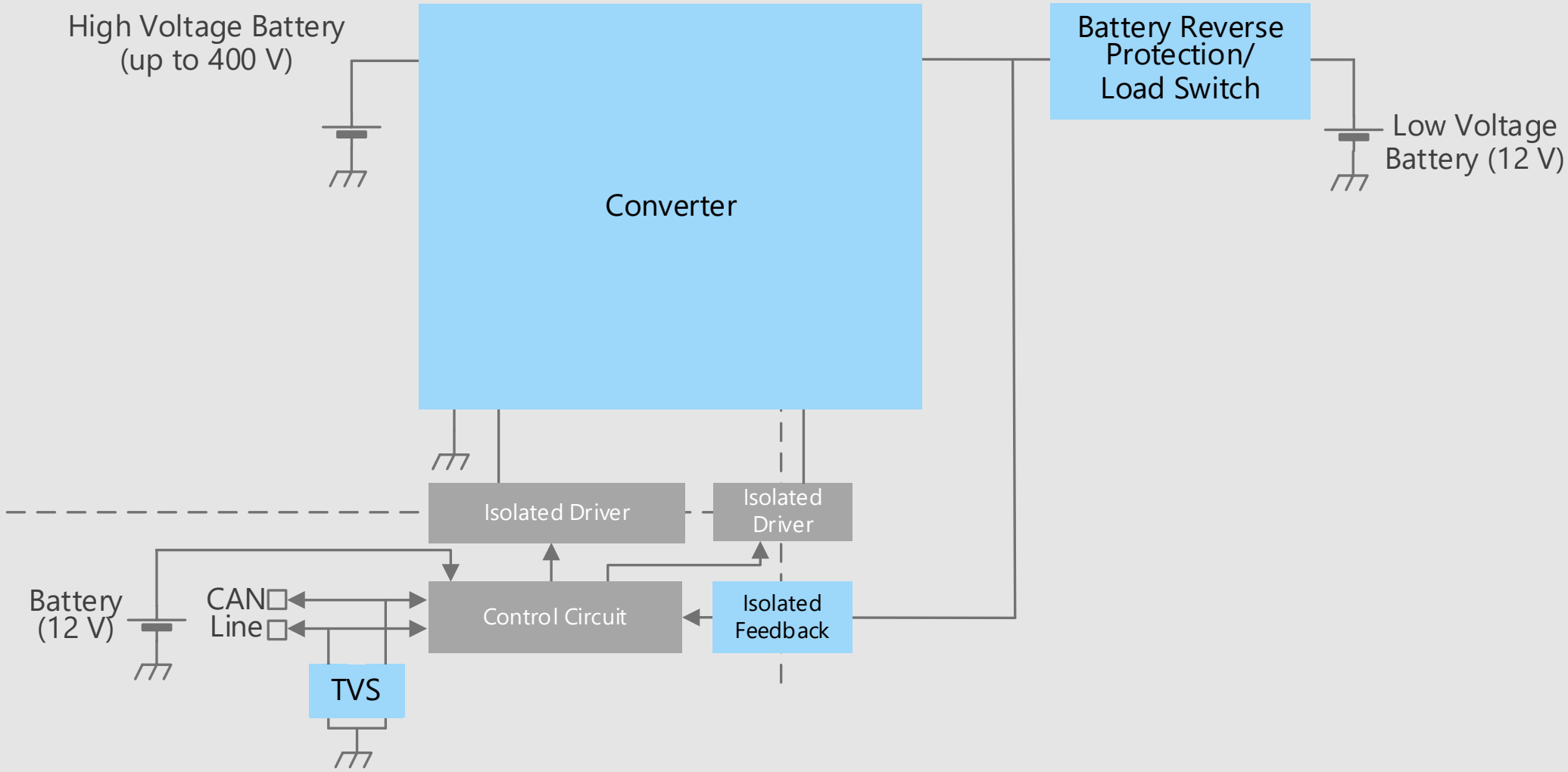


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

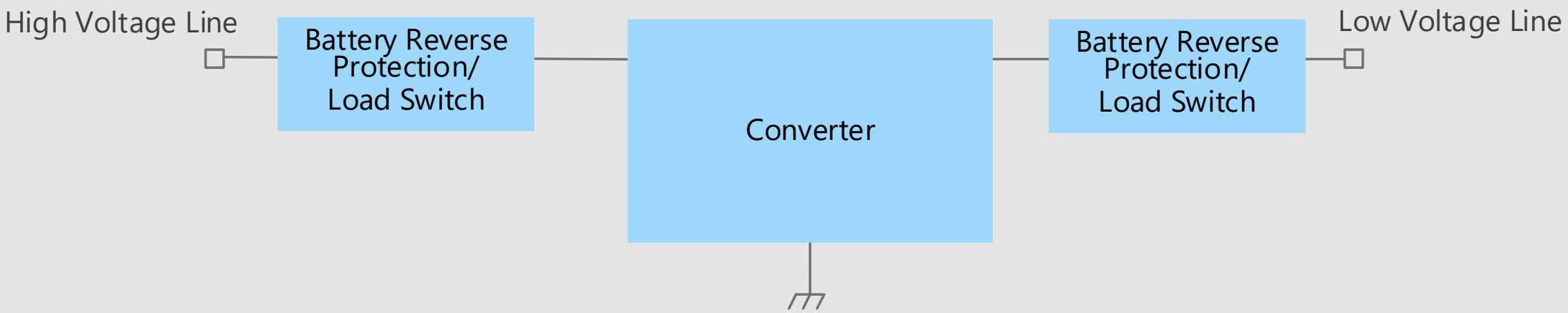
Block Diagram



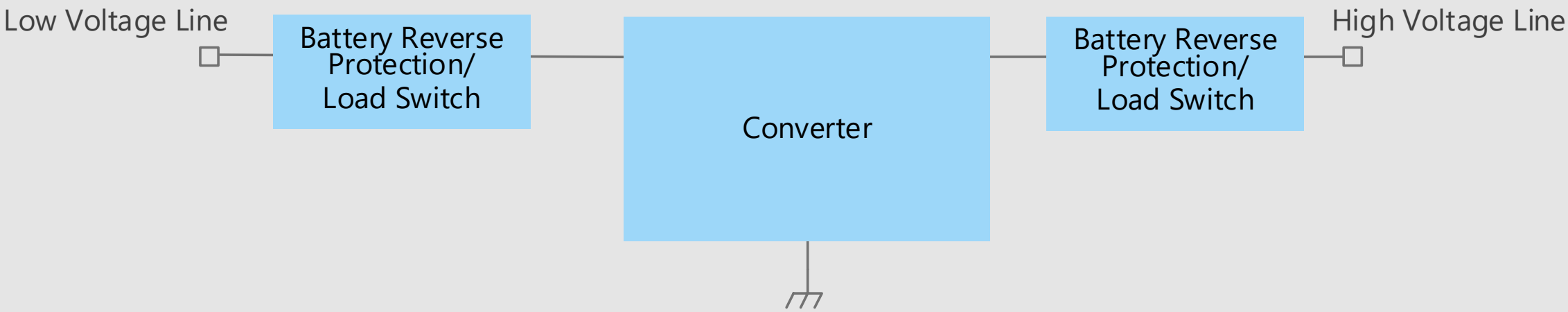
DC-DC Converter (isolated type)　Overall block diagram



DC-DC Converter (non-isolated buck type)　Overall block diagram

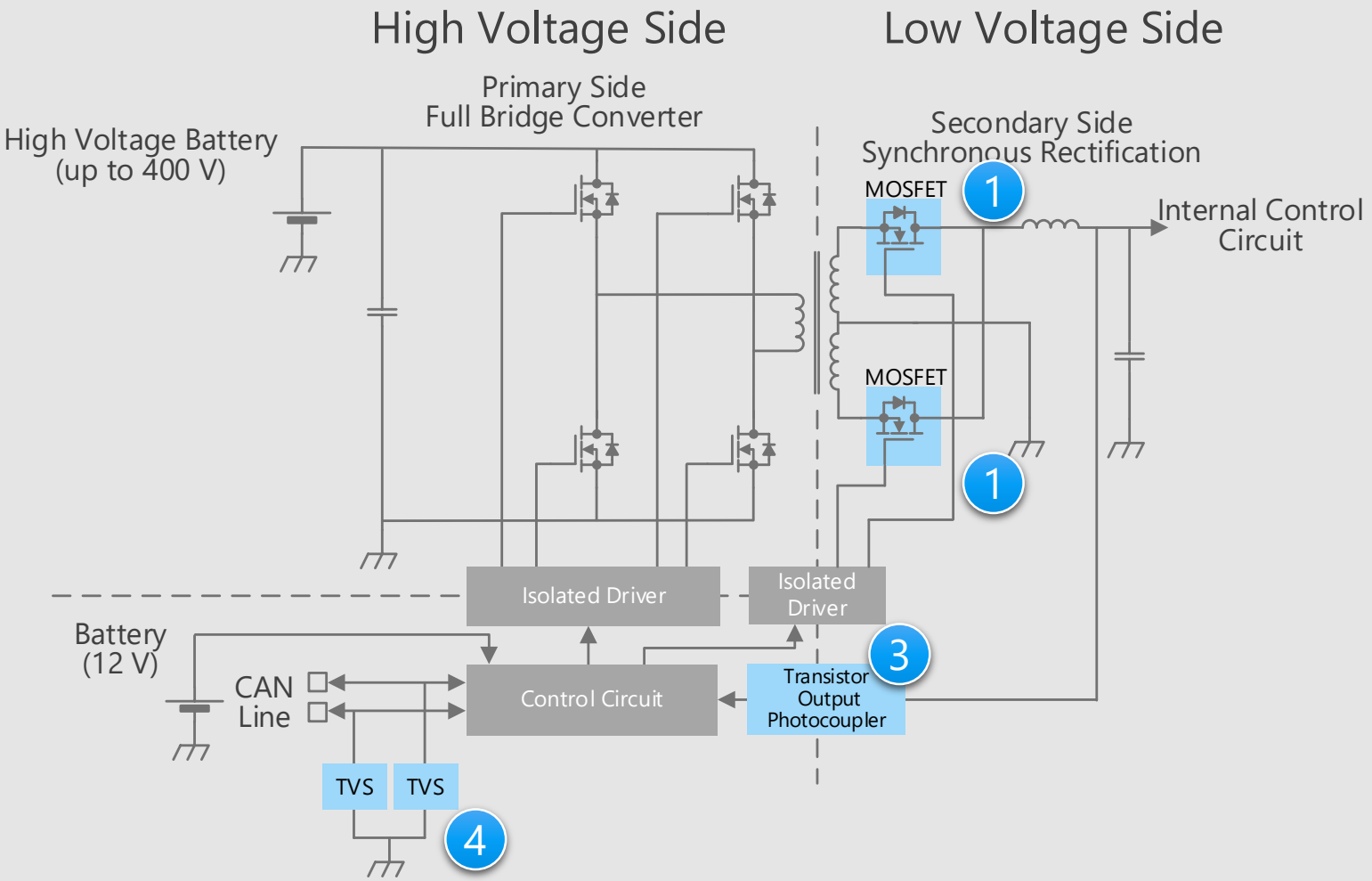


DC-DC Converter (non-isolated boost type)　Overall block diagram



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

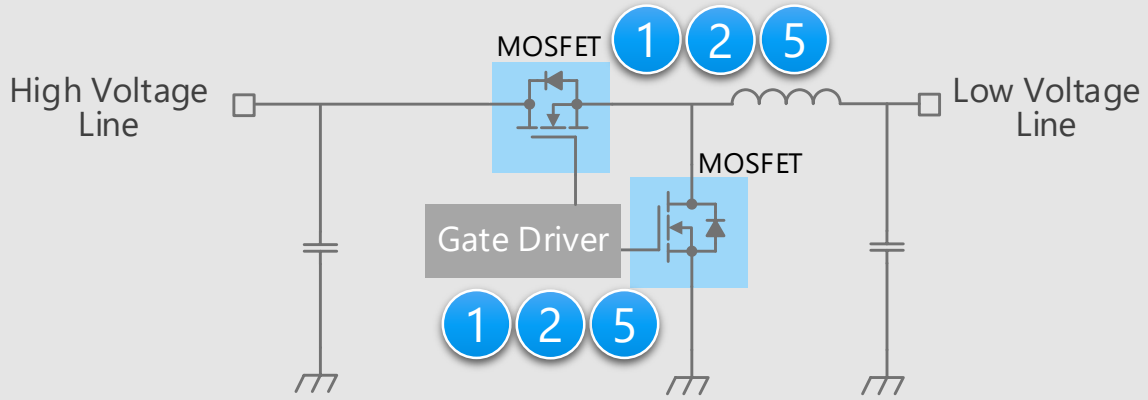
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- A small surface mount package is suitable for realizing miniaturization of the ECU.
- Isolation voltage should be noted to design voltage feedback to MCU.

Proposals from Toshiba

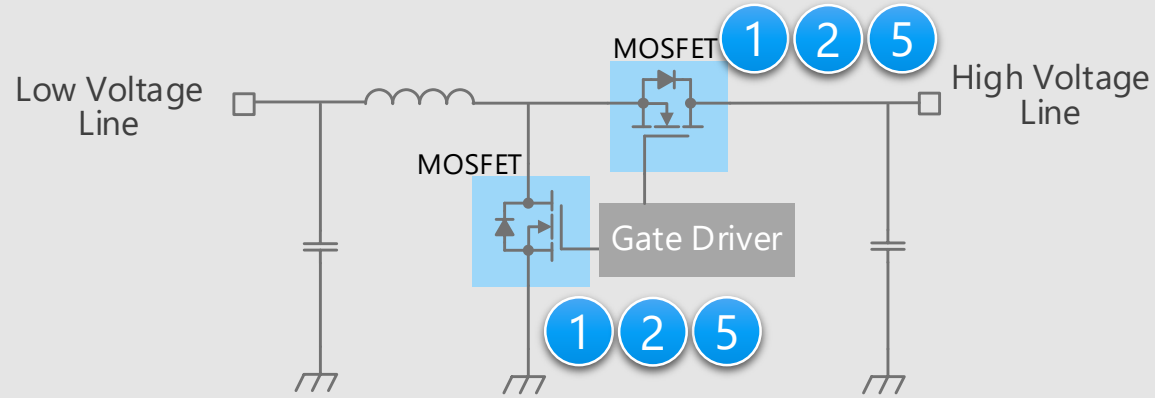
- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 100 V N-ch MOSFET　1
- **Photocouplers with environmental resistance**
  Transistor output photocoupler　3
- **Suitable for ESD protection**
  TVS diode (for CAN communication)　4

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

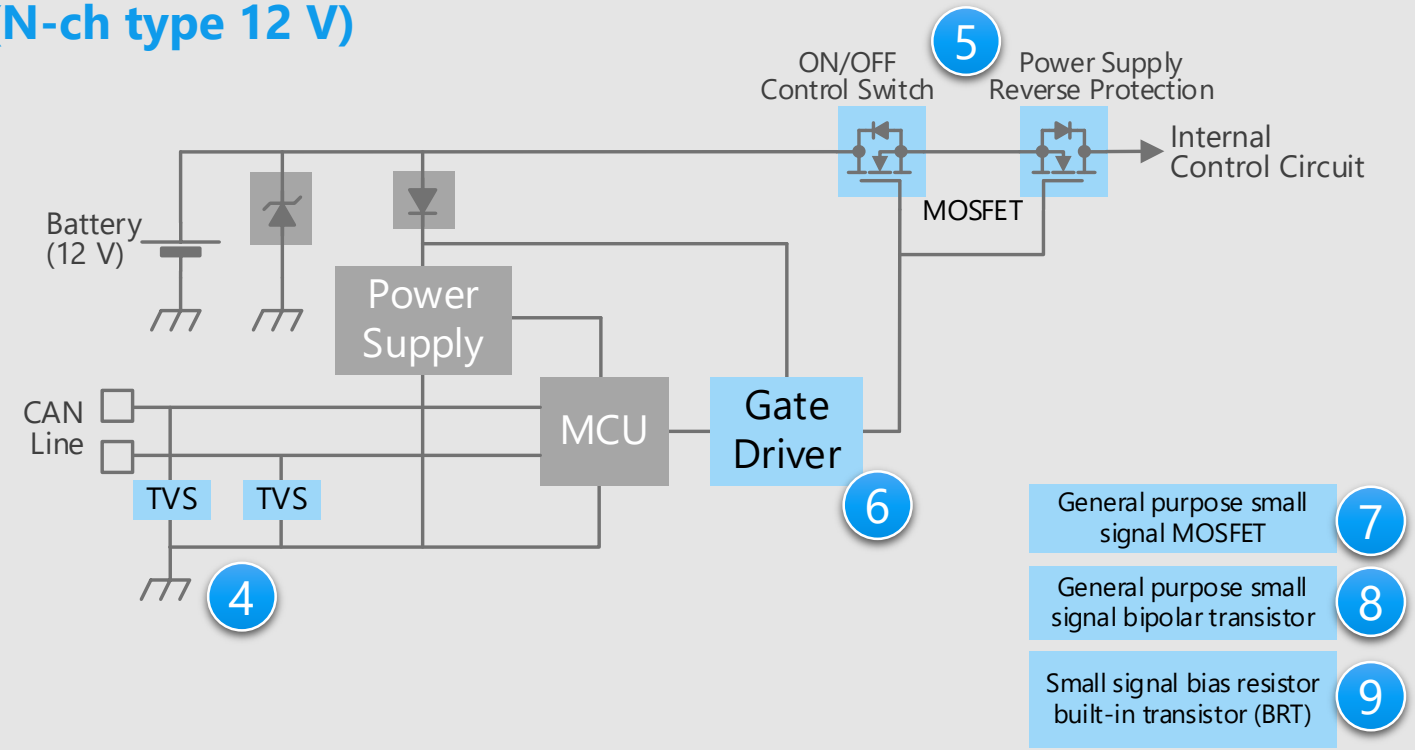
- **Low on-resistance contributes to low power consumption of the system**

  U-MOS Series 100 V N-ch MOSFET
  U-MOS Series 60 V N-ch MOSFET
  U-MOS Series 40 V N-ch MOSFET

1
2
5

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

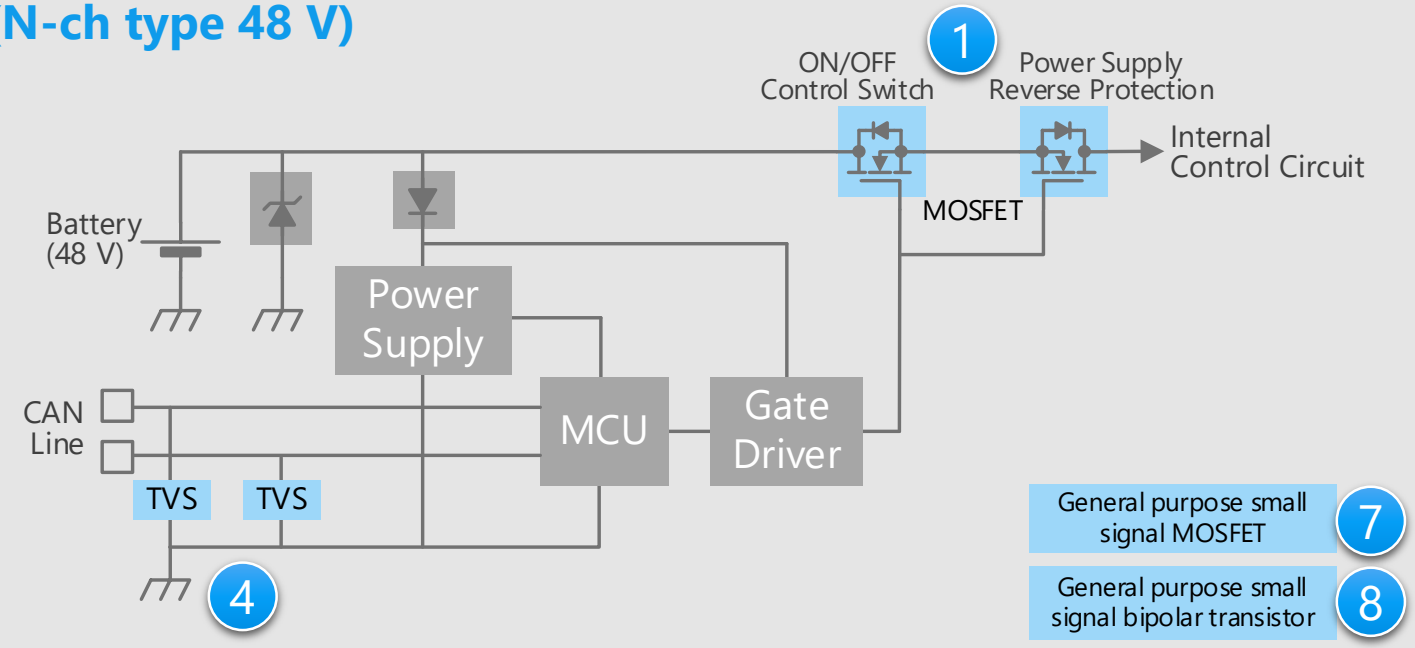
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system** 5
  U-MOS Series 40 V N-ch MOSFET
- **Gate driver with built-in protection and diagnostic function** 6
  Gate driver (for switch)
- **Extensive product lineup** 7 8 9
  General purpose small signal MOSFET
  General purpose small signal bipolar transistor
  Small signal bias resistor built-in transistor (BRT)
- **Suitable for ESD protection** 4
  TVS diode (for CAN communication)

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)



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

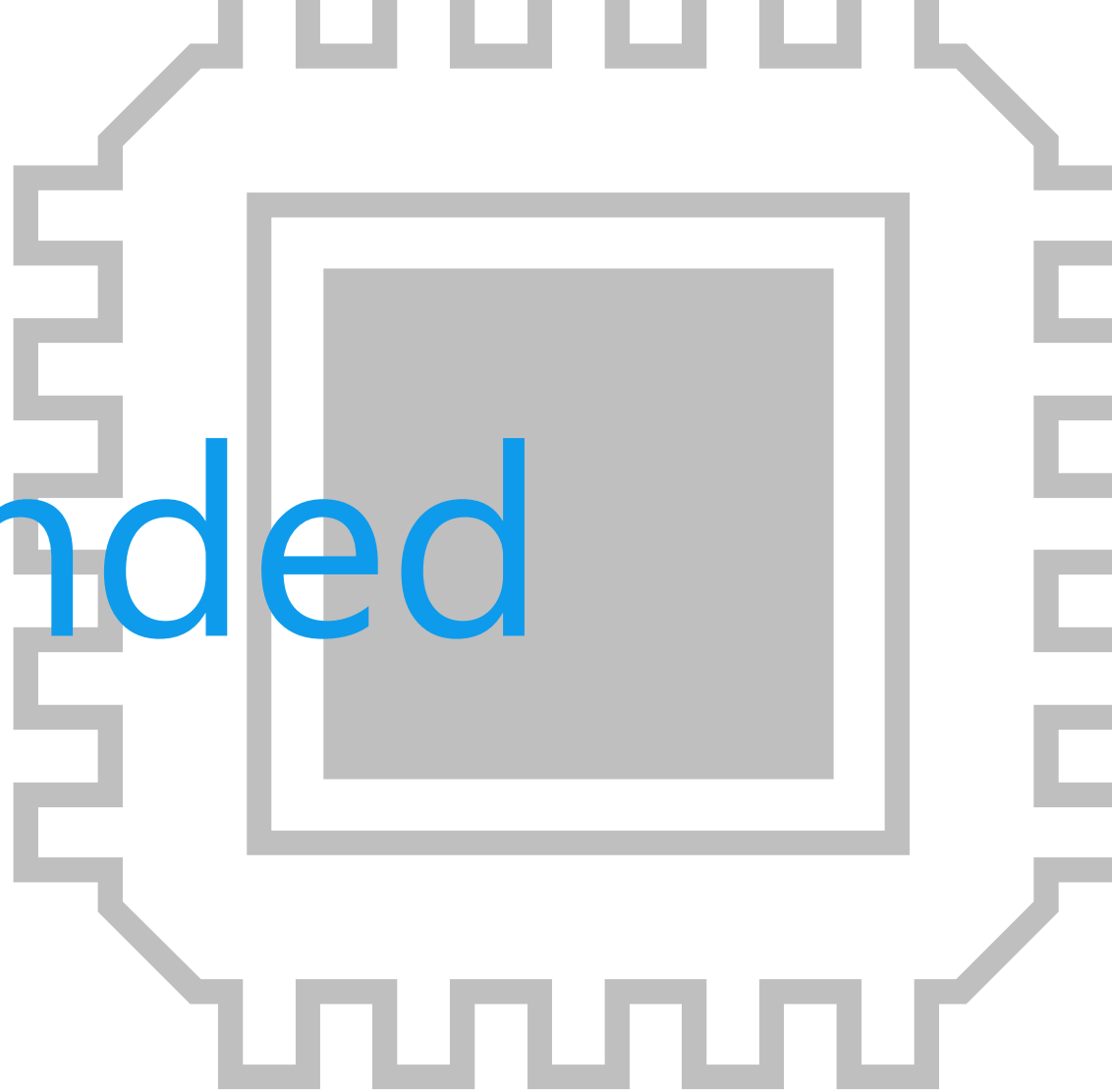
Criteria for device selection

- 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

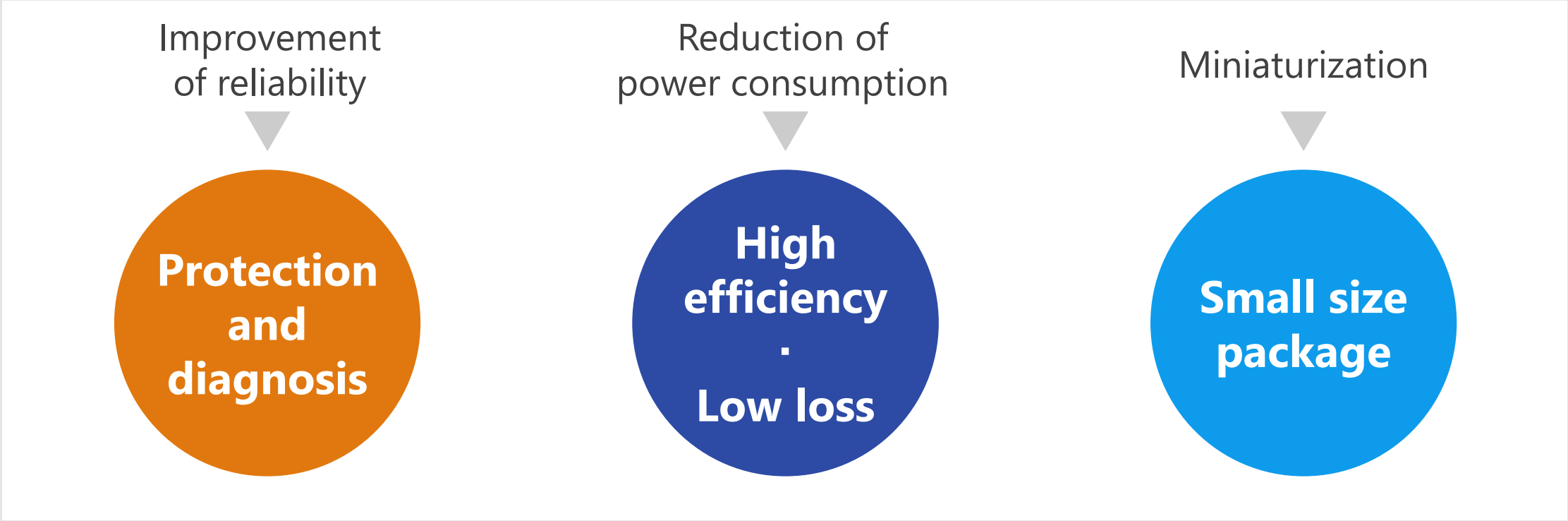
- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 100V N-ch MOSFET
- **Extensive product lineup**
  General purpose small signal MOSFET
  General purpose small signal bipolar transistor
  Small signal bias resistor built-in transistor (BRT)
- **Suitable for ESD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

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 U-MOS Series 60 V N-ch MOSFET		●	●
3 Transistor output photocoupler	●		●
4 TVS diode (for CAN communication)	●		●
5 U-MOS Series 40 V N-ch MOSFET		●	●
6 Gate driver (for switch)	●		●
7 General purpose small signal MOSFET		●	●
8 General purpose small signal bipolar transistor			●
9 Small signal bias resistor built-in transistor (BRT)			●

Value provided

Low on-resistance contributes to reduced system power consumption.

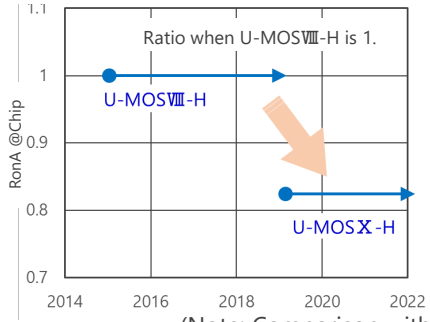
1 Low loss (reduced on-resistance)

Using low on-resistance technology to contribute to reduced power consumption systems.
On-resistance per unit area has been reduced by 18 %.
(compared to Toshiba's U-MOSⅧ-H products)

2 Small and high power dissipation package

The small and high power dissipation packages are developed by adopting Cu clip or Cu connector structure.
Wettable Flank (WF) package contributes to good mountability.

Low loss: RonA reduction trend



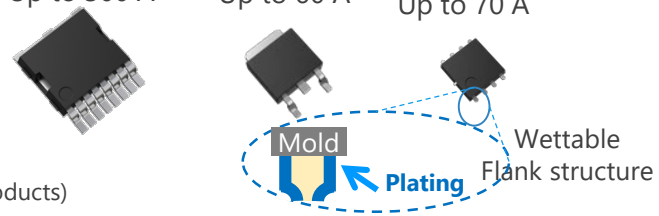
(Note: Comparison with Toshiba products)

Small and high power dissipation package

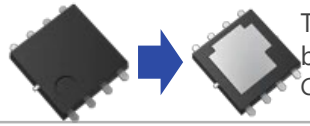
L-TOGL™ (9.9 x 11.8 mm) Up to 300 A

DPAK+ (6.5 x 10 mm) Up to 60 A

SOP Advance(WF) (5 x 6 mm) Up to 70 A



DSOP Advance(WF)L double-sided cooling packages



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

L-TOGL™ Cu clip structure

Lineup

Part number	Rated drain current [A]	On-resistance (Max) [mΩ] @V_{GS} = 10 V	Package
XPN1300ANC	30	13.3	TSON Advance(WF)
XPN2400ANC *	20	23.5	
TK60S10N1L	60	6.11	DPAK+
XPH4R10ANB	70	4.1	SOP Advance(WF)
XPH6R30ANB	45	6.3	
XPW4R10ANB	70	4.1	DSOP Advance(WF)L
XPW6R30ANB	45	6.3	DSOP Advance(WF)M
XPQ1R00AQB *	300	1.03	L-TOGL™

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

◆Return to Block Diagram TOP

2 U-MOS Series 60 V N-ch MOSFET

XPN12006NC / XPN6R706NC / XPH3R206NC / XPH2R106NC / TK90S06N1L

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

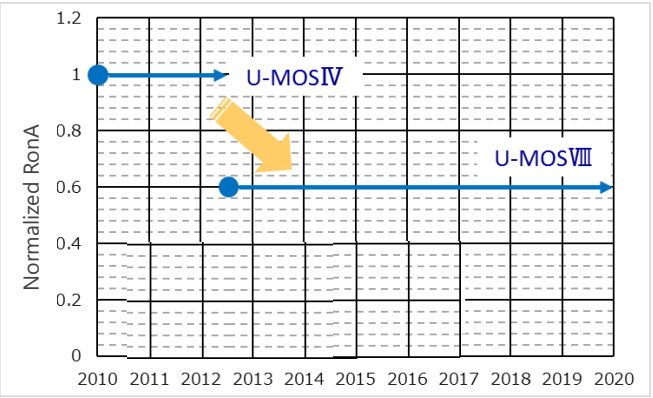
Value provided

Low on-resistance contributes to reduce system power consumption.

1 Low loss (reduced on-resistance)

Using a low on-resistance technology contributes to reduce system power consumption.
The on-resistance per area is reduced by 40 %.
(compared to Toshiba's U-MOSⅣ products)

Low loss: RonA reduction trend



(Note: Comparison with Toshiba products)

2 Small and high power dissipation package

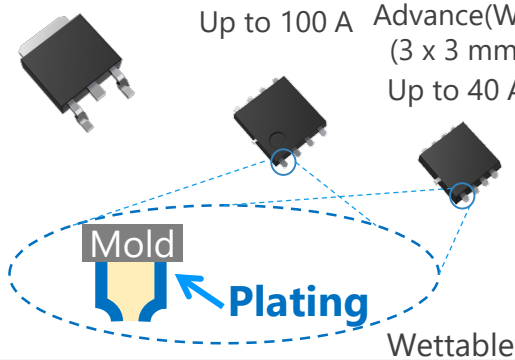
By adopting a Cu connector structure, a high power dissipation package is realized.
Wettable Flank (WF) package contributes to good mountability.

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



Wettable Flank (WF) structure

Lineup

Part number	Rated drain current [A]	On-resistance (Max) [mΩ] @V_{GS} = 10 V	Package
XPN12006NC	20	12.0	TSON Advance(WF)
XPN6R706NC	40	6.7	TSON Advance(WF)
XPH3R206NC	70	3.2	SOP Advance(WF)
XPH2R106NC	110	2.1	SOP Advance(WF)
TK90S06N1L	90	3.3	DPAK+

◆Return to Block Diagram TOP

3 Transistor output photocoupler

TLX9291A / TLX9185A / TLX9000 / TLX9300 / TLX9188

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

Value provided

Photocoupler consists of an infrared light emitting diode and a photodetector transistor.

1 High isolation

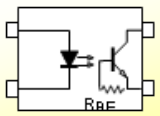
Non-electrical communication provides excellent isolation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

2 Small package

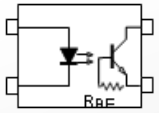
SO4 package that reduced mounting area by about 30 % compared with our conventional SO6 package is aligned in the package lineup. It contributes to reduce occupied area on the board.

3 Maximum operating temperature is extended to 125 °C

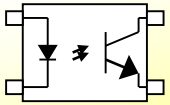
High heat resistance package has realized operating temperature range of -40 to 125 °C. The dark current of TLX9000 / TLX9300 has reduced at high temperature range by pulling out the collector cutoff current I_{CBO} by the built-in base-emitter resistance. And TLX9188 has realized a collector-emitter voltage rating of 200 V by increasing the withstand voltage of the chip.

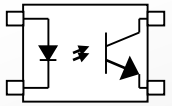
TLX9300 — With R_{BE} — SO6


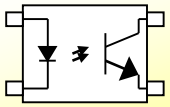
T_{opr} = 125 °C
Built-in R_{BE}

TLX9000 — With R_{BE} — SO4


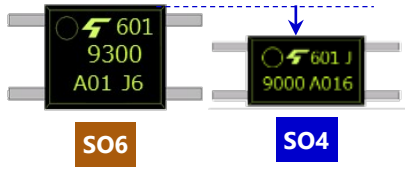
T_{opr} = 125 °C
Small Package
Built-in R_{BE}

TLX9185A — SO6

T_{opr} = 125 °C

TLX9291A — SO4

T_{opr} = 125 °C
Small Package

TLX9188 — SO6

T_{opr} = 125 °C
V_{CE} = 200 V

SO4 about 30 % reduction (vs SO6)



SO6 — 3.7 x 7.0 x 2.1 (mm)

SO4 — 2.6 x 7.0 x 2.1 (mm)

(Note: Comparison with Toshiba products)

Lineup

Part number	TLX9291A / TLX9185A	TLX9000 / TLX9300	TLX9188
Isolation voltage [Vrms]	3750	3750	3750
Collector-emitter voltage [V]	80	40	200
Dark current [μA] @Ta = 125 °C	< 100 @V_{CE} = 48 V	< 10 @V_{CE} = 24 V	< 50 @V_{CE} = 200 V, Ta = 105 °C
Conversion efficiency [%] @I_F = 5 mA, V_{CE} = 5 V, Ta = 25 °C	50 to 600 100 to 600 (GB rank)	100 to 900	50 to 600 100 to 600 (GB rank)
Conversion efficiency (saturation) [%] @I_F = 1 mA, V_{CE} = 0.4 V, Ta = 25 °C	> 30	> 30	> 30
AEC-Q101	✓	✓	✓

◆Return to Block Diagram TOP

4 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

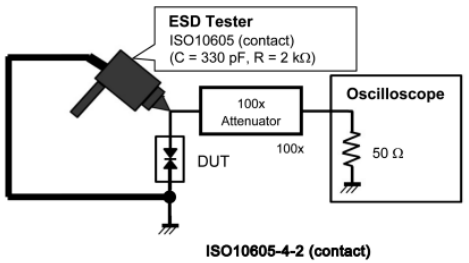
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Achieving both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

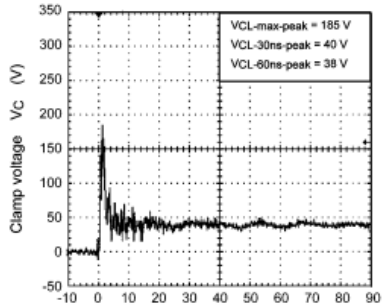
These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3 High ESD immunity

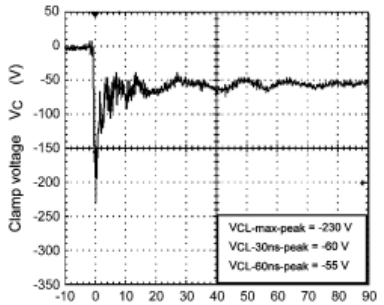
V_{ESD} > ±30 kV @ ISO 10605
V_{ESD} > ±20 kV @ IEC 61000-4-2 (Level 4)



ISO10605-4-2 (contact)



DF3D36FU +15kv (ISO10605)



DF3D36FU -15 kV (ISO10605)

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.

◆Return to Block Diagram TOP

5 U-MOS Series 40 V N-ch MOSFET

XPN3R804NC / TK1R4S04PB / XPHR7904PS / TPWR7904PB / XPJR6604PB* / XPQR3004PB

Protection and diagnosis | 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)

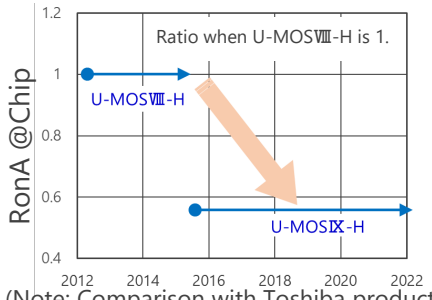
2 Small and low loss package

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)

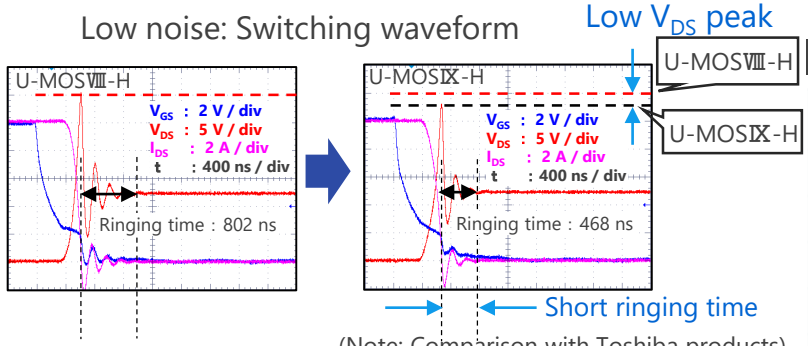
Improved chip process reduces surge voltage and ringing time.

Low loss: RonA trend



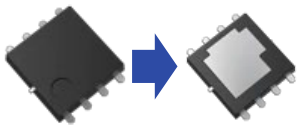
(Note: Comparison with Toshiba products)

Low noise: Switching waveform



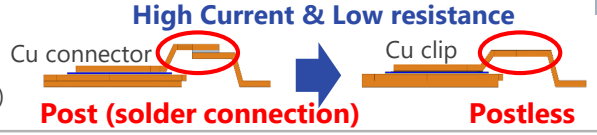
(Note: Comparison with Toshiba products)

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



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

6 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-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.

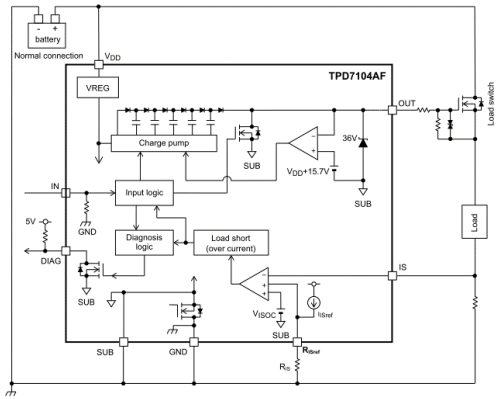
2 Can be controlled by logic level voltage

It is possible to be controlled directly by output signal of MCUs or CMOS logic ICs.

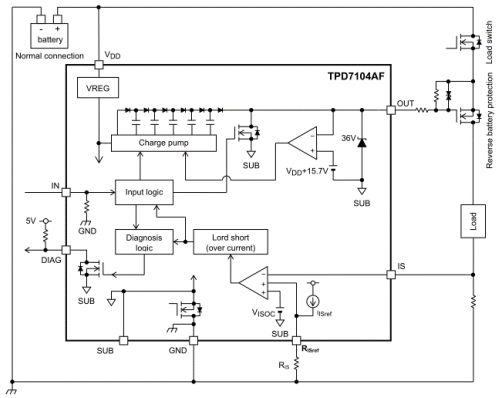
3 Small package

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

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.

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7 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.

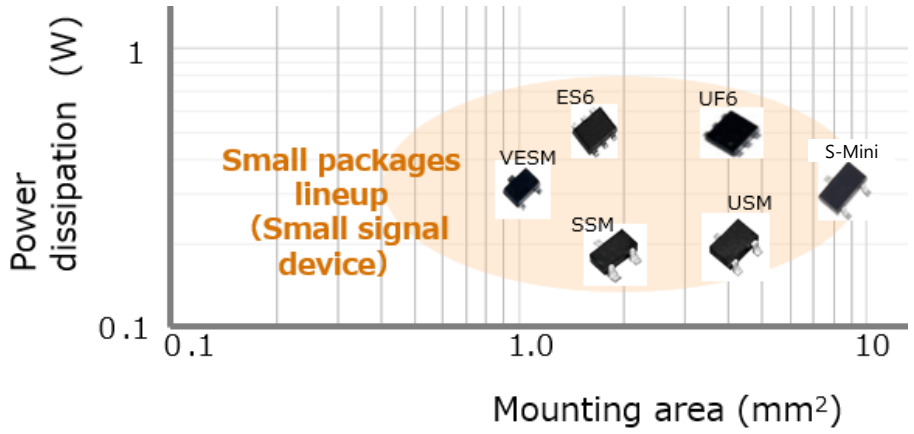
2 Low voltage drive

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



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

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8 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.

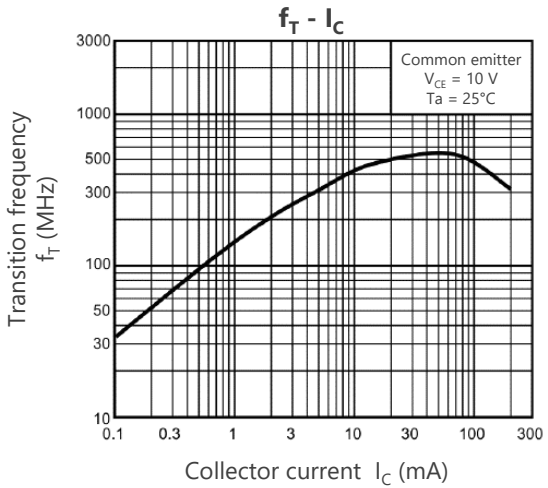
2 Extensive product lineup

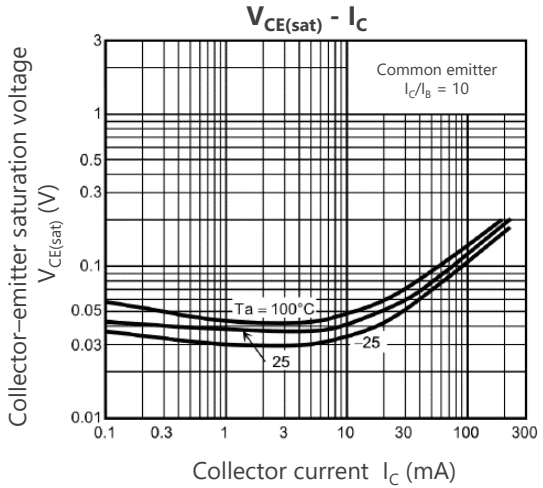
Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance with the application.

3 AEC-Q101 qualified

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

Characteristic examples of 2SC2712





Lineup

Package			SOT-23F		USM (SOT-323) UFM (SOT-323F)*		S-Mini (SOT-346)	
Classification	$\lvert V_{CEO} \rvert$ [V]	$\lvert I_C \rvert$ [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

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9 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)

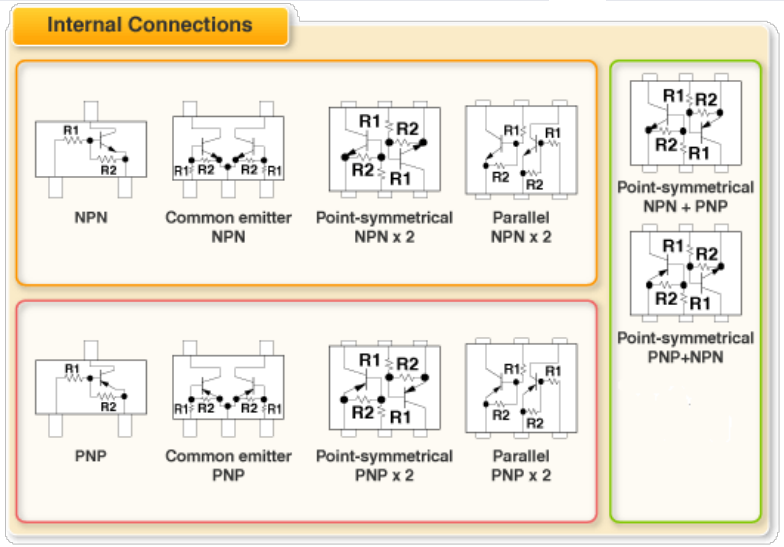
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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.



Lineup

Part number		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

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