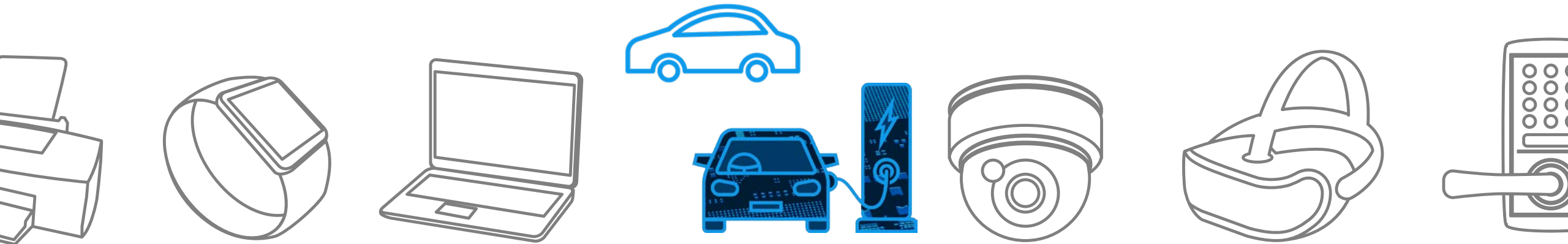


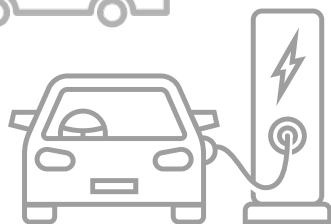
TOSHIBA

Automotive On-board Charger

Solution Proposal by Toshiba

R20

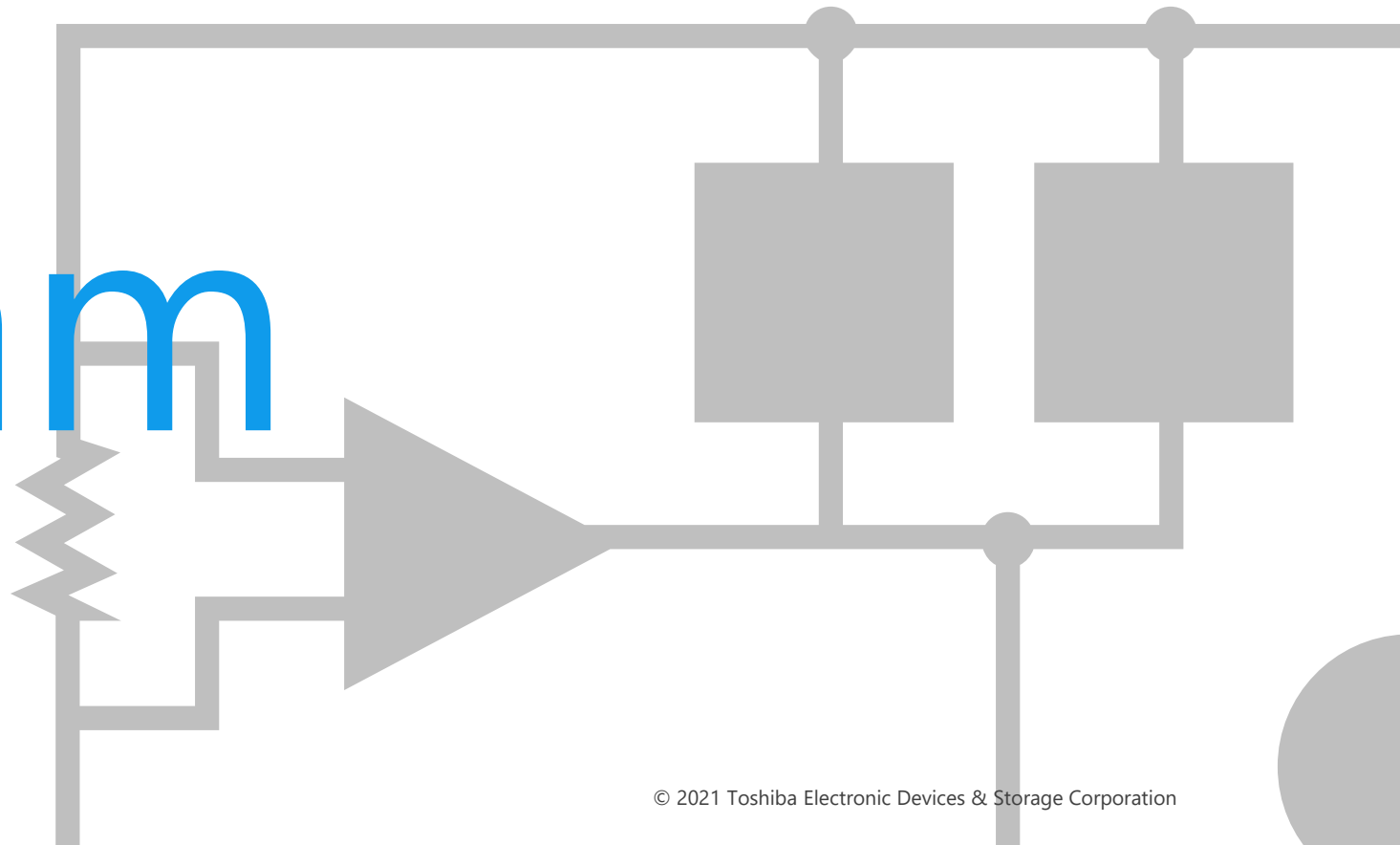




Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

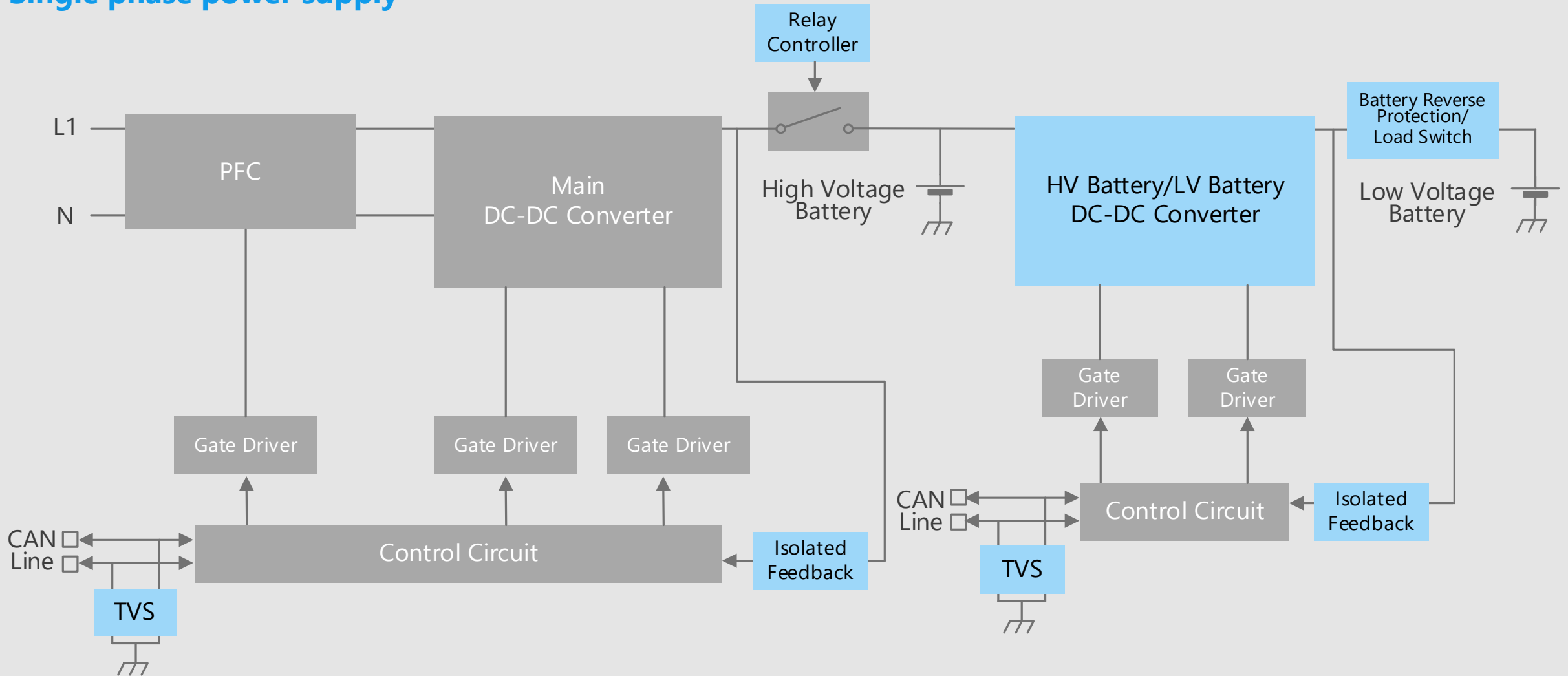


Block Diagram



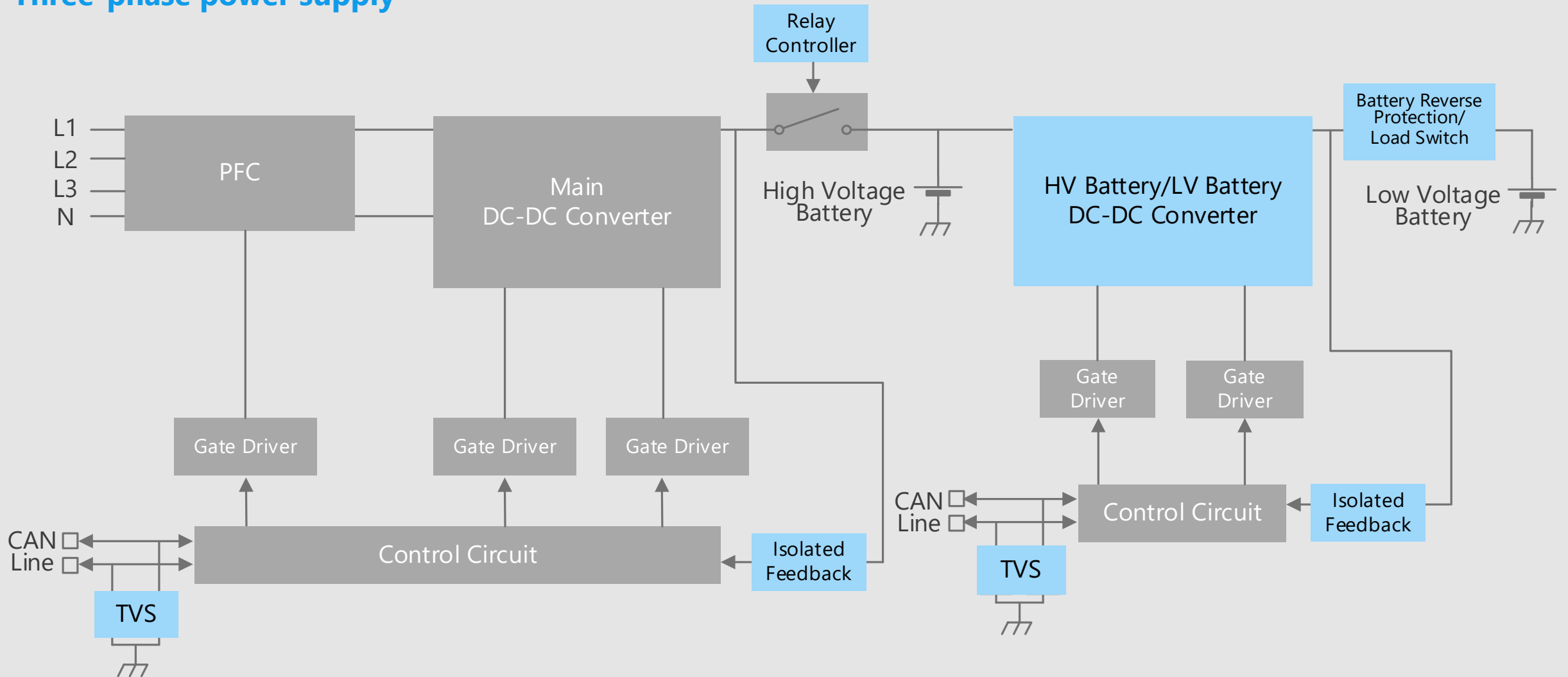
On-board Charger Overall block diagram (1)

Single phase power supply



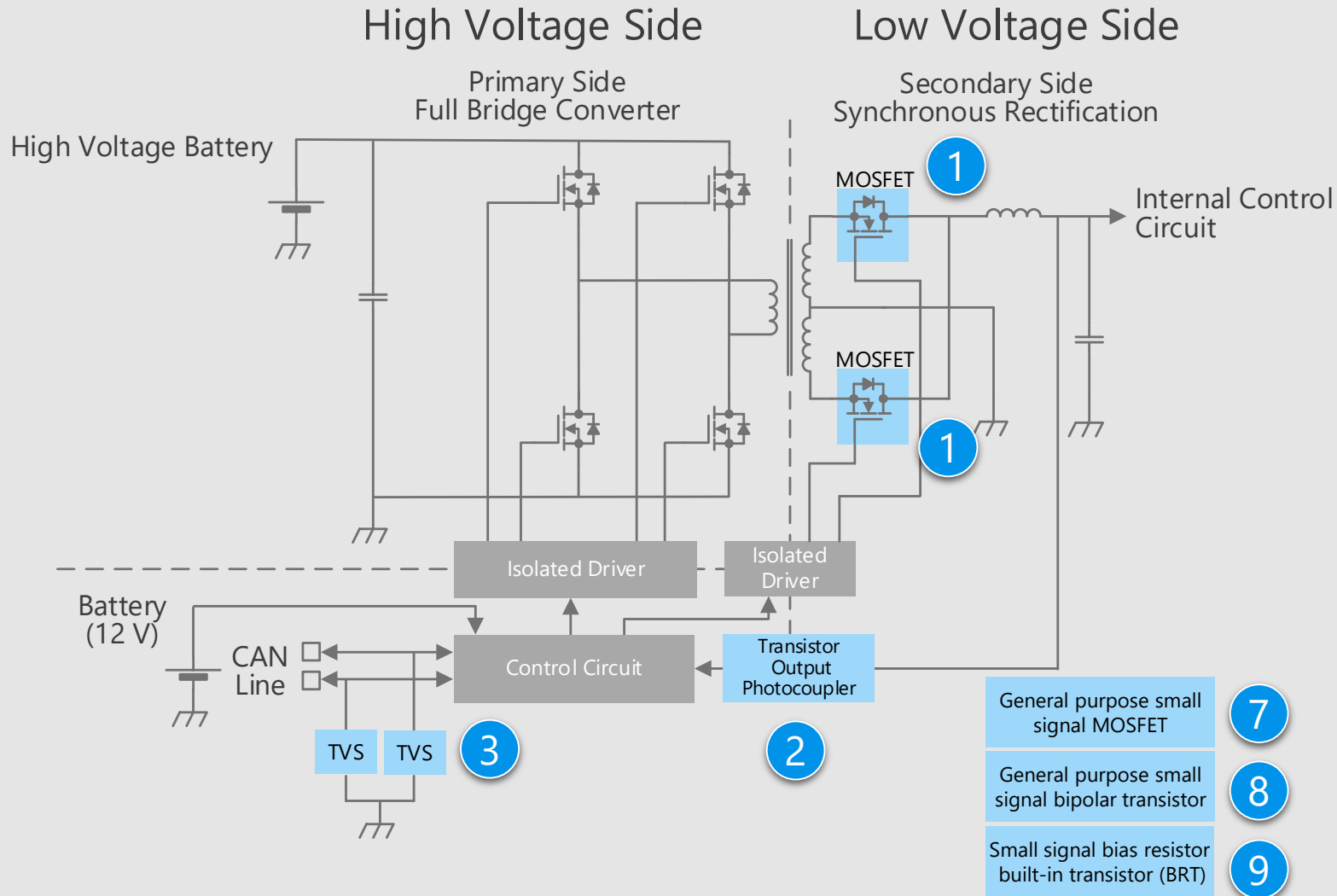
On-board Charger Overall block diagram (2)

Three-phase power supply



On-board Charger Detail of power supply circuit

12 V DC-DC converter (Isolated type)



Criteria for device selection

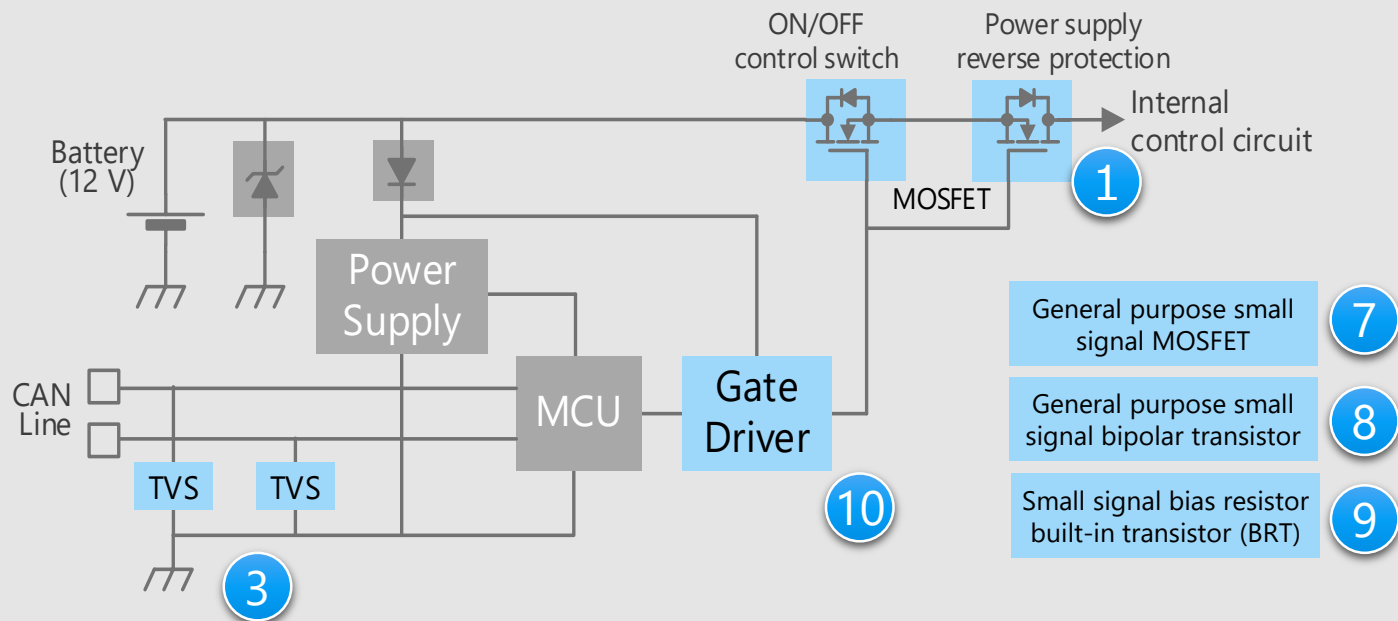
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- A small surface mount package is suitable for realizing miniaturization of the ECU.
- Isolation voltage should be noted to design voltage feedback to MCU.

Proposal from Toshiba

- **Low on-resistance contributes low power consumption of the system**
U-MOS Series 40 V / 80 V / 100 V N-ch MOSFET
- **Photocouplers with environmental resistance**
Transistor output photocoupler
- **Suitable for ESD protection**
TVS diode (for CAN communication)
- **Extensive product lineup**
General purpose small signal MOSFET
General purpose small signal bipolar transistor
Small signal bias resistor built-in transistor (BRT)

* 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 (N-ch type)



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.

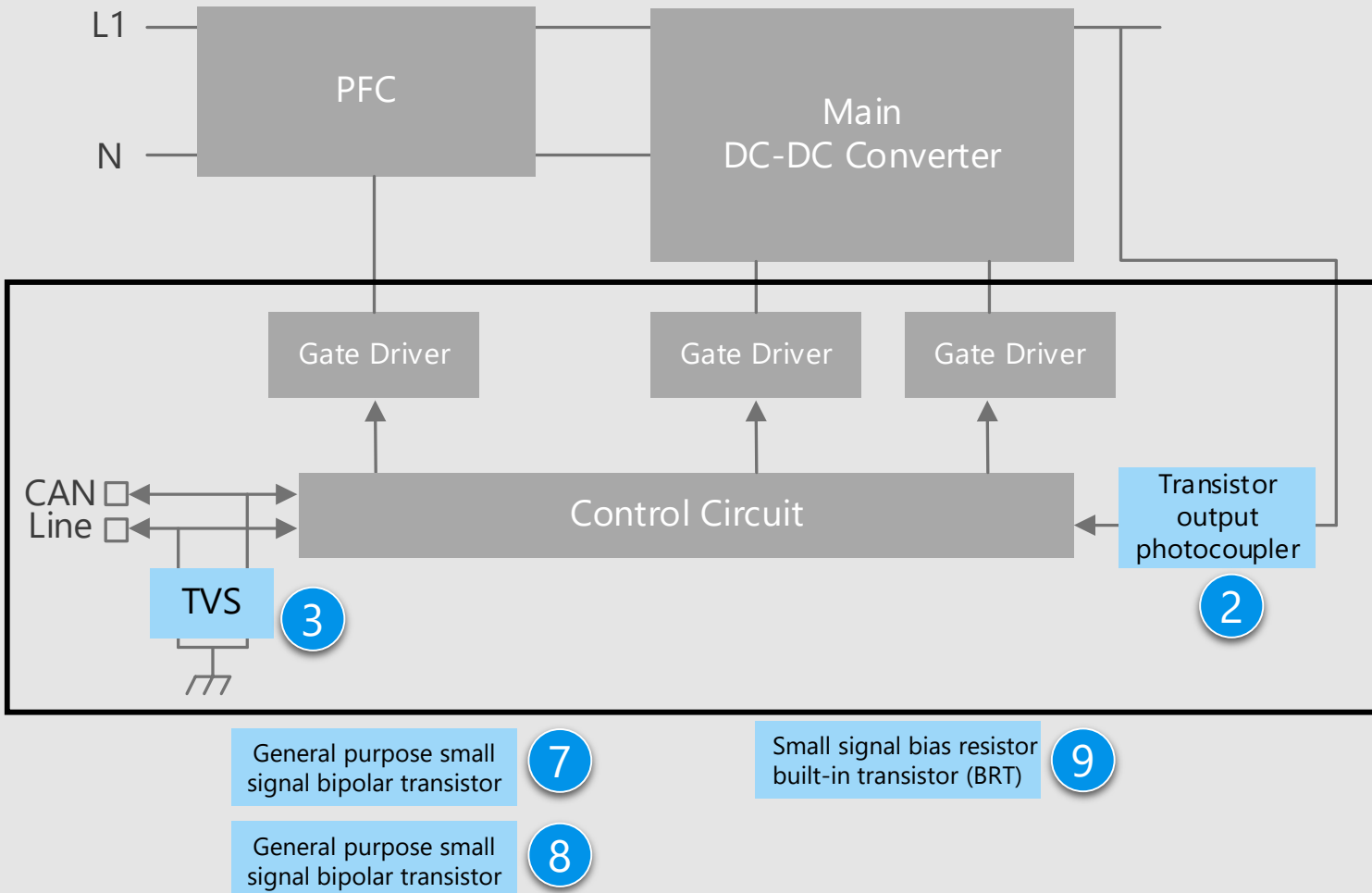
Proposal from Toshiba

- **Low on-resistance contributes low power consumption of the system**
U-MOS Series 40 V / 80 V / 100 V N-ch MOSFET
- **Suitable for ESD protection**
TVS diode (for CAN communication)
- **Extensive product lineup**
General purpose small signal MOSFET
General purpose small signal bipolar transistor
Small signal bias resistor built-in transistor (BRT)
- **Gate driver with built-in protection and diagnosis functions**
Gate driver (for switch)

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

On-board Charger Detail of control circuit

Control circuit



Criteria for device selection

- A small surface mount package is suitable for realizing miniaturization of the ECU.
- Isolation voltage should be noted to design voltage feedback to MCU.

Proposal from Toshiba

- **Photocouplers with environmental resistance**

Transistor output photocopler

- **Suitable for ESD protection**

TVS diode (for CAN communication)

- **Extensive product lineup**

General purpose small signal MOSFET

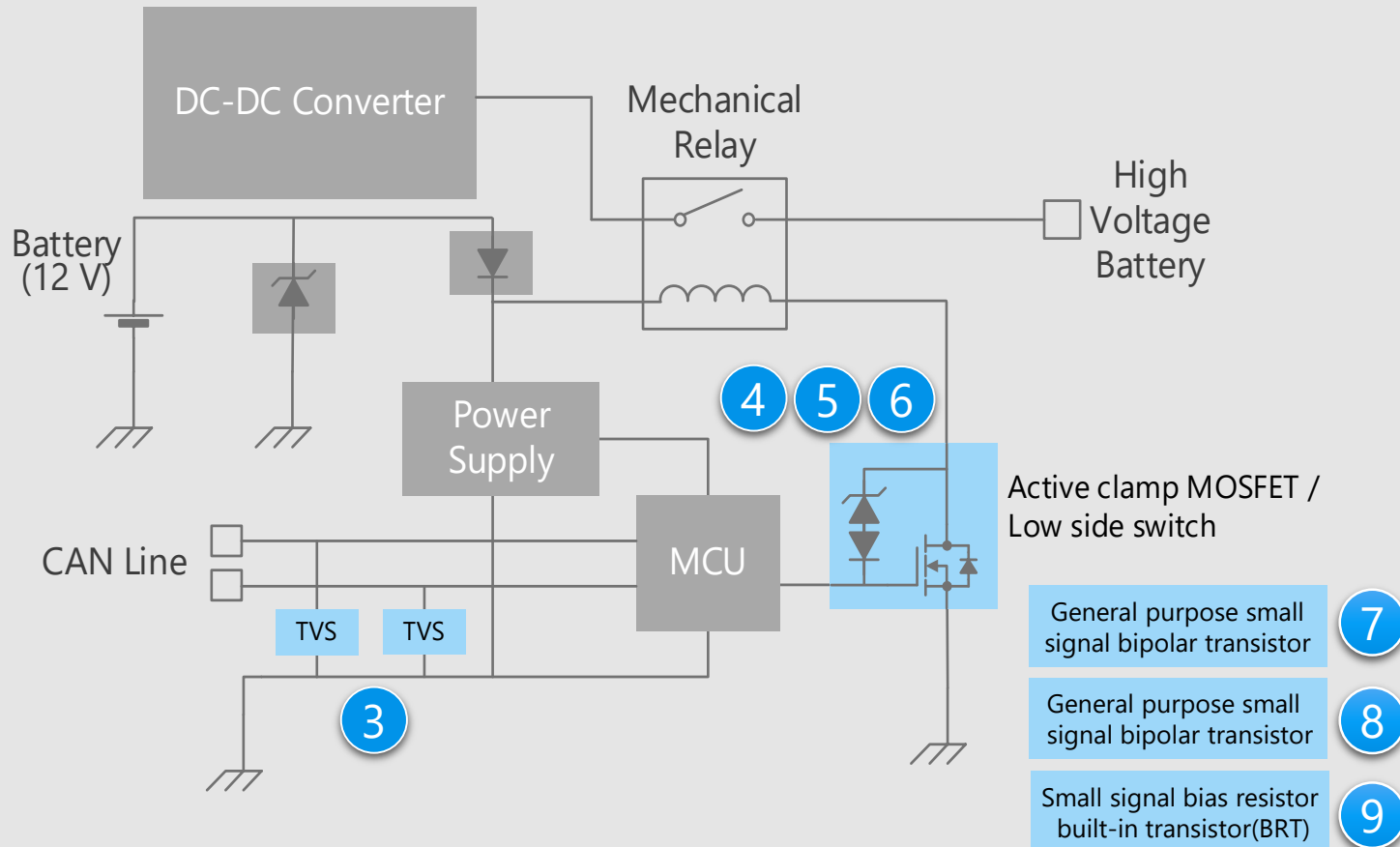
General purpose small signal bipolar transistor

Small signal bias resistor built-in transistor (BRT)

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

On-board Charger Detail of relay control

Mechanical relay control circuit



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

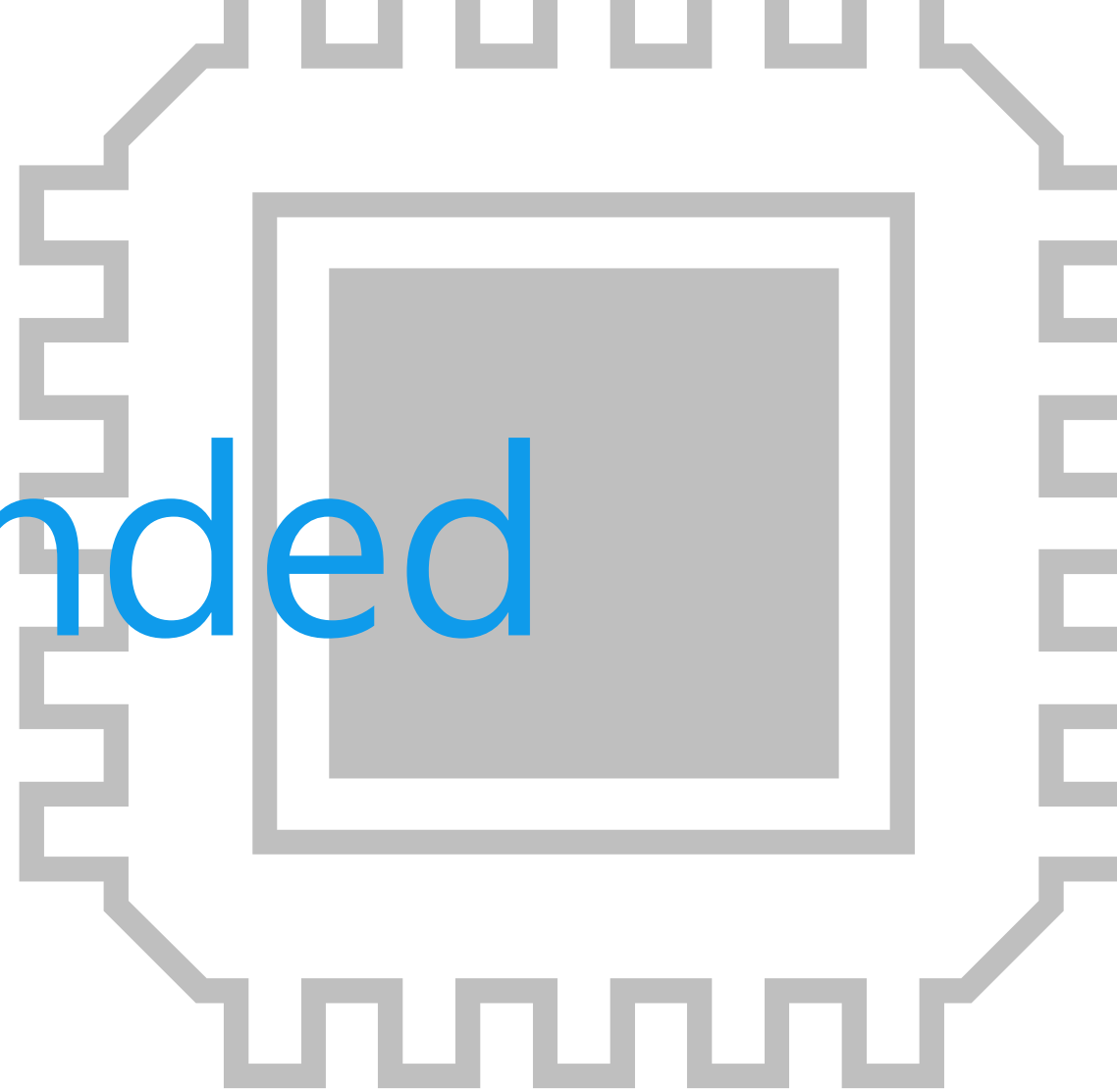
Criteria for device selection

- It is necessary to select a device that can protect the system from the voltage generated by the back electromotive force (EMF) of inductive loads.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposal from Toshiba

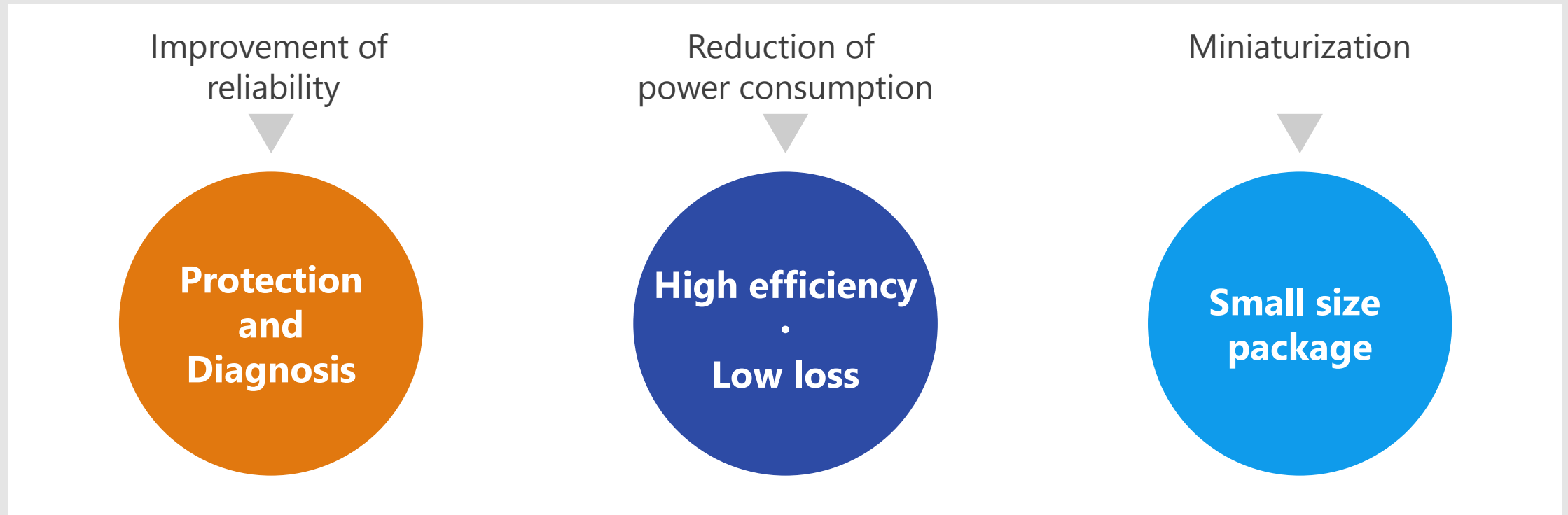
- **Suitable for ESD protection** (3)
TVS diode (for CAN communication)
- **Built-in active clamp circuit and pull-down resistor for relay drive** (4)
MOSFET with a built-in active clamp circuit
- **Driver with built-in protection function** (5)
Low side switch / High side switch (up to 1 A)
- **Extensive product lineup** (6)
Low side switch / High side switch (1 to 5 A)
- **General purpose small signal MOSFET** (7)
- **General purpose small signal bipolar transistor** (8)
- **Small signal bias resistor built-in transistor (BRT)** (9)

Recommended Devices



Device solutions to address customer needs

As described above, in the design of On-board Chargers, “**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 40 V / 80 V / 100 V N-ch MOSFET	●	●	●
2 Transistor output photocoupler	●		●
3 TVS diode (for CAN communication)	●		●
4 MOSFET with a built-in active clamp circuit	●	●	●
5 Low side switch / High side switch (up to 1 A)	●		●
6 Low side switch / High side switch (1 to 5 A)	●		●
7 General purpose small signal MOSFET		●	●
8 General purpose small signal bipolar transistor			●
9 Small signal bias resistor built-in transistor (BRT)			●
10 Gate driver (for switch)	●		●

Value provided

The combination of low on-resistance and low noise by the latest U-MOS series process and a small package contributes to system performance improvement.

1 Low loss (reduced on-resistance)

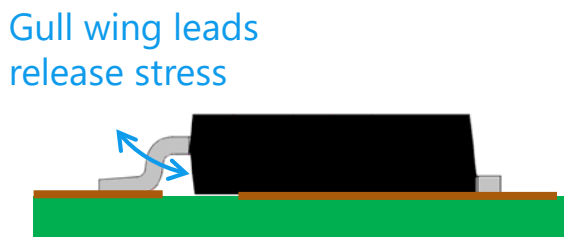
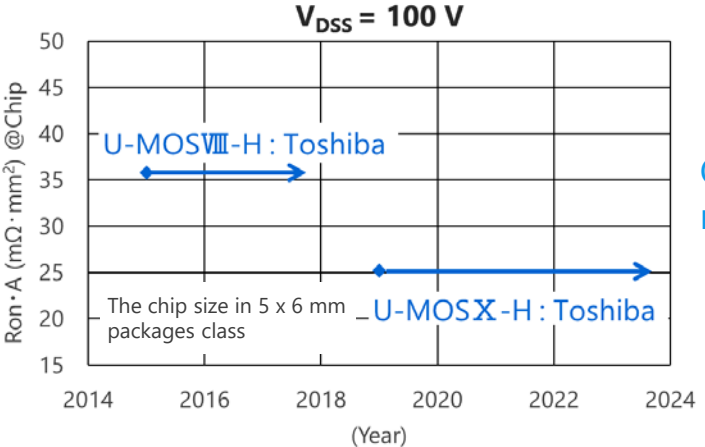
Using low on-resistance technology to contribute to reduced power consumption systems.

2 Low noise (low EMI)

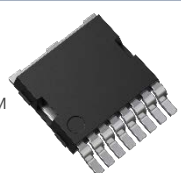
Improved chip process reduces surge voltage and ringing time.

3 Compact gull wing package

Package size reduced by 23 % compared to D2PAK (10 x 5 mm). Gull wing shaped leads to reduce mounting solder stress in high environments with ambient temperature and mechanical stress.



Line up

Part number	Drain-source voltage	Drain current	On-resistance (Max) @ $V_{GS}=10\text{ V}$	Package
XPQ1R004PB*	40 V	200 A	1.0 mΩ	 L-TOGL™
XPQR3004PB*	40 V	400 A	0.3 mΩ	
XPQR8308QB*	80 V	400 A	0.83 mΩ	
XPQ1R00AQB*	100 V	400 A	1.0 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

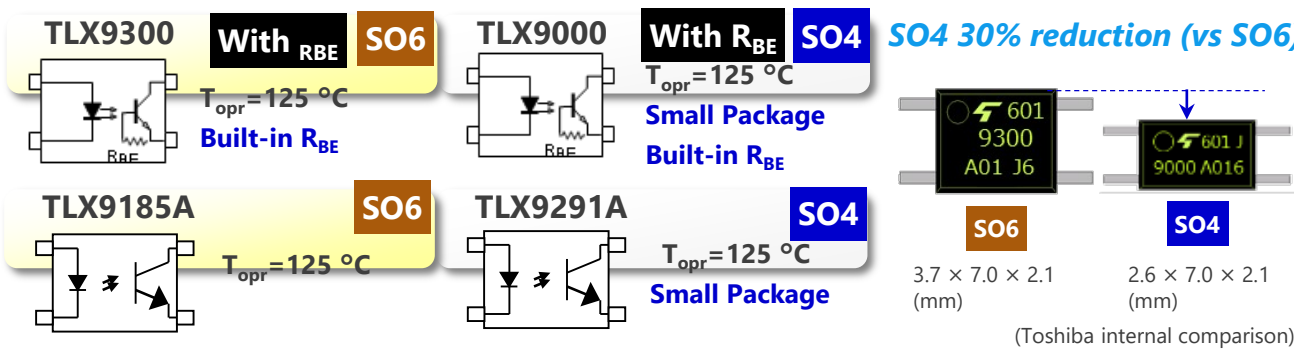
Non-electrical communication provides excellent isolation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

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.



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	✓	✓

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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

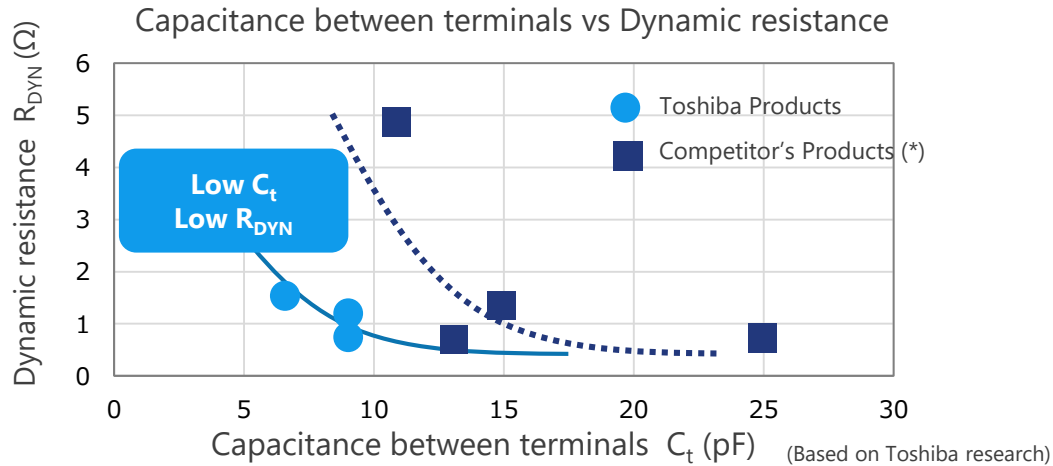
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes. (Both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

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

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



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

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Value provided

These devices have a built-in active clamp circuit to reduce the number of components and to save mounting area.

1 Built-in active clamp circuit

MOSFET with a built-in active clamp circuit which connected a zener diode between the drain and gate terminals prevents damage caused by voltage surges generated by inductive loads such as a mechanical relay.

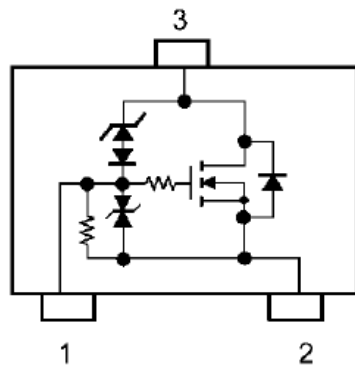
2 Built-in pull-down resistor

SSM3K347R has built-in 47 k Ω pull-down resistor between the gate and source terminals, thus contributes to reduction of number of components and mounting area.

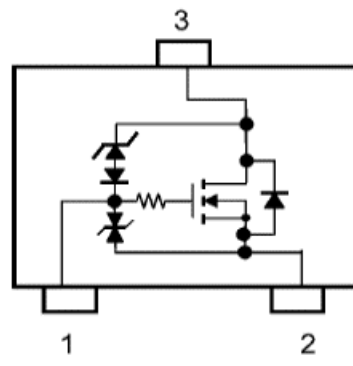
3 Low voltage drive

These devices can be driven at low gate-source voltage of 4.0 V.

Internal circuit



SSM3K347R

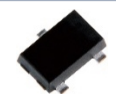



SSM3K337R

Pin Assignment

1. Gate
2. Source
3. Drain

Line up

Part number	SSM3K347R	SSM3K337R
Package	SOT-23F 	SOT-23F 
$V_{DS(DC)}$ [V]	38	38
I_D [A]	2	2
$R_{DS(ON)}$ [m Ω] @ $V_{GS}=4.0$ V	Typ.	350
	Max	480
Polarity	N-ch	N-ch

[◆Return to Block Diagram TOP](#)

5 Low side switch / High side switch (up to 1 A)

TPD1044F / TPD1054F / TPD1052F



Value provided

Various protection and diagnostic output functions are built in, contributing to improve reliability and to miniaturize the system.

1 Built-in various protection and diagnostic output functions

Overcurrent and overheat protection and diagnostic output (except TPD1044F) to the MCUs or the control circuits are built in. These functions contribute to improve reliability of the system.

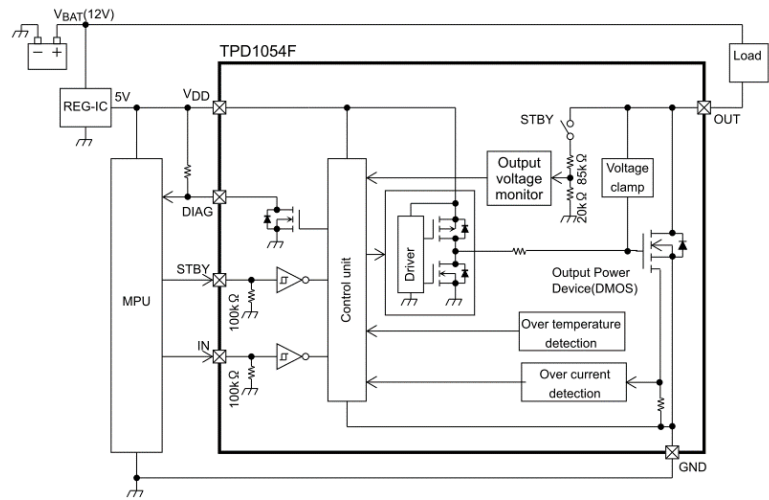
2 Can be controlled by logic level voltage

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


3 Small package

PS-8 is small surface mount package. It contributes to the miniaturization of system.

Example of low side switch application
(Block diagram of TPD1054F)



Suitable for applications with small current load below 1 A, such as mechanical relay

Line up			
Function	Low side switch		High side switch
Part number	TPD1044F	TPD1054F	TPD1052F
Package	 PS-8 (2.8 x 2.9 mm)		
Features	<ul style="list-style-type: none"> Overcurrent / over-temperature protection Active clamp On-resistance: 0.6 Ω 	<ul style="list-style-type: none"> Overcurrent / over-temperature protection Active clamp Diagnostic output function On-resistance: 0.8 Ω 	<ul style="list-style-type: none"> Overcurrent / over-temperature protection Diagnostic output function On-resistance: 0.8 Ω

[Return to Block Diagram TOP](#)

Value provided

Various protection and diagnostic output functions are built in, contributing to improve reliability and to miniaturize the system.

1 Built-in various protection and diagnostic output functions

Overcurrent and overheat protection and diagnostic output to the MCUs or the control circuits are built in. These functions contribute to improve reliability of the system.

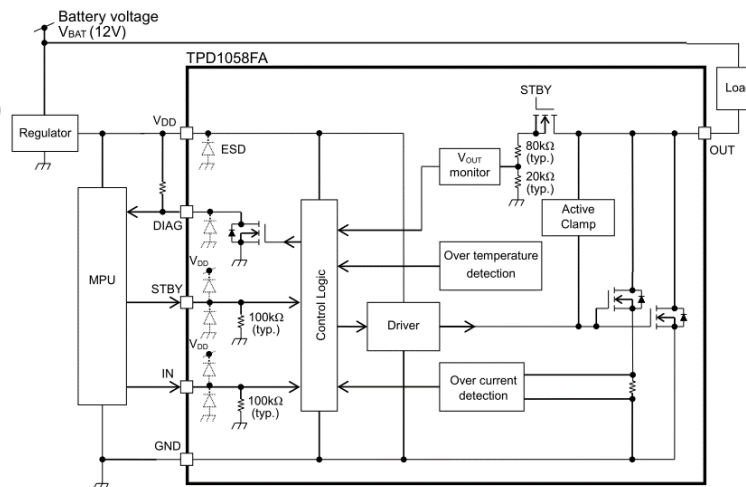
2 Can be controlled by logic level voltage

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

3 Small package

WSO10 is small surface mount package. It contributes to the miniaturization of system.

Example of low side switch application
(Block diagram of TPD1058FA)



Suitable for valve timing and solenoid drive of transmission.

Line up

Function	Low side switch	High side switch
Part number	TPD1058FA	TPD1055FA
Package	Back surface WSO10 (3 x 3 mm)	
Features	<ul style="list-style-type: none"> Overcurrent / Overheat protection Active clamp Diagnostic output function ON-resistance: 0.1 Ω 	<ul style="list-style-type: none"> Overcurrent / Overheat protection Diagnostic output function ON-resistance: 0.12 Ω

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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.

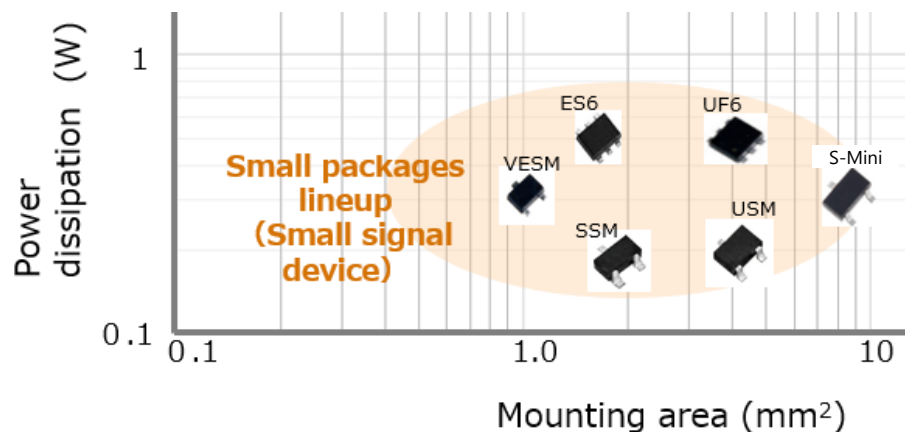
2 Low voltage drive

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	0.31
	Max	1.75	0.39
Drive voltage [V]	4.5	-4.0	-1.2
Polarity	N-ch	P-ch	P-ch

[◆Return to Block Diagram TOP](#)

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.

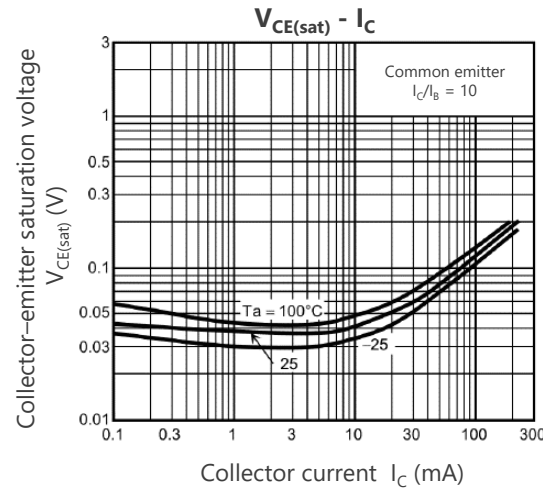
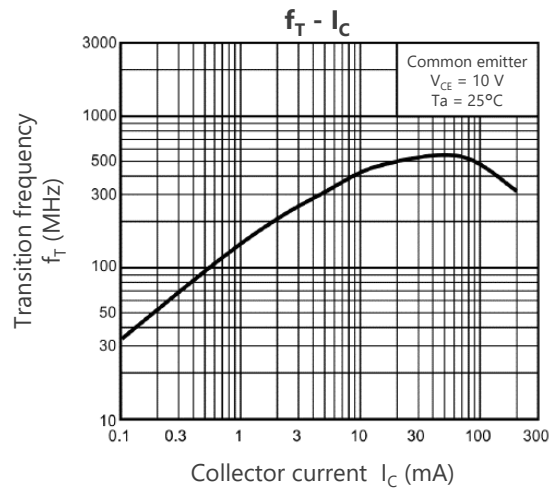
2 Extensive product lineup

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_{CE0} $ [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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Value provided

Extensive product lineup to meet customers' needs.

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

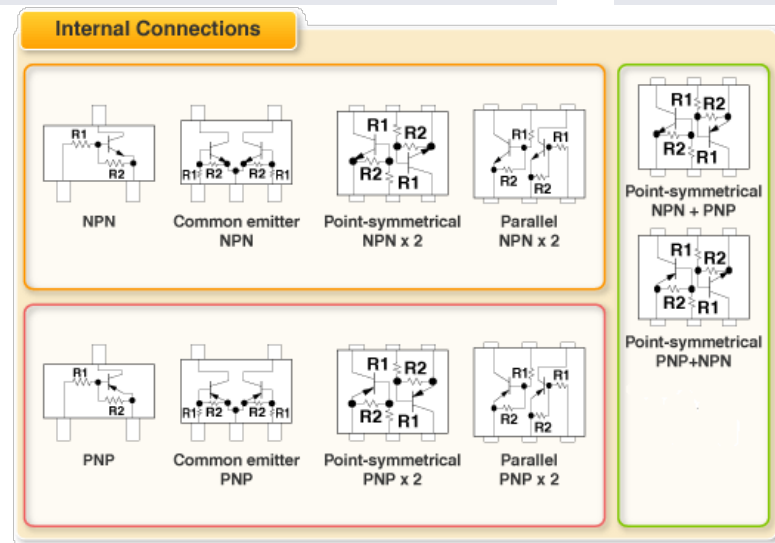
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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_{CE0} (Max) [V]		50	-50
I_C [mA]		100	-100

[◆Return to Block Diagram TOP](#)

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.

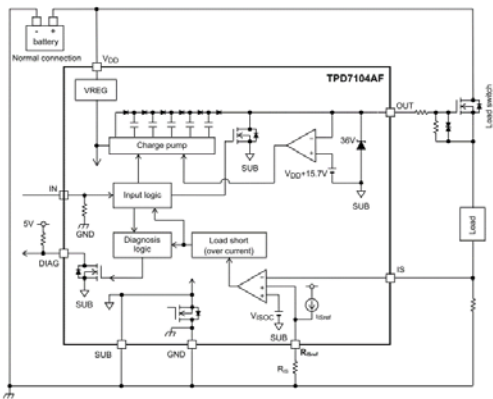
2 Can be controlled by logic level voltage

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

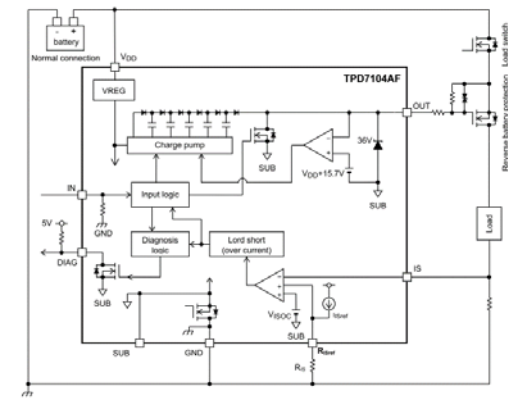
3 Small package

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	<ul style="list-style-type: none"> 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) 	<ul style="list-style-type: none"> 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) 	<ul style="list-style-type: none"> Operating power supply voltage range: 5.75 to 26 V Current sense output Protective functions; overcurrent, overtemperature, GND disconnect etc. Diagnosis output; overcurrent, load open, overtemperature etc.

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