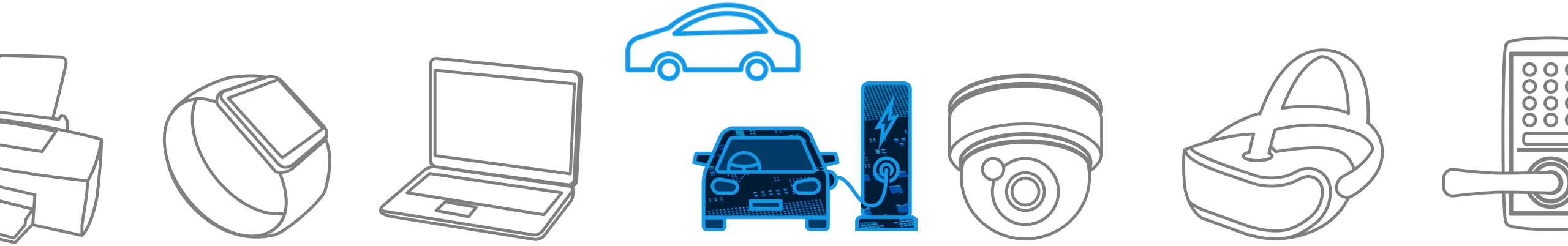
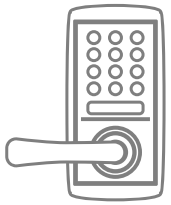
TOSHIBA

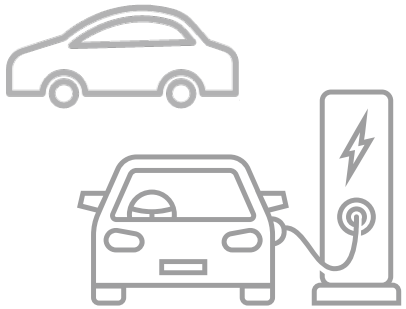
R21

Automotive On-board Charger

Solution Proposal by Toshiba

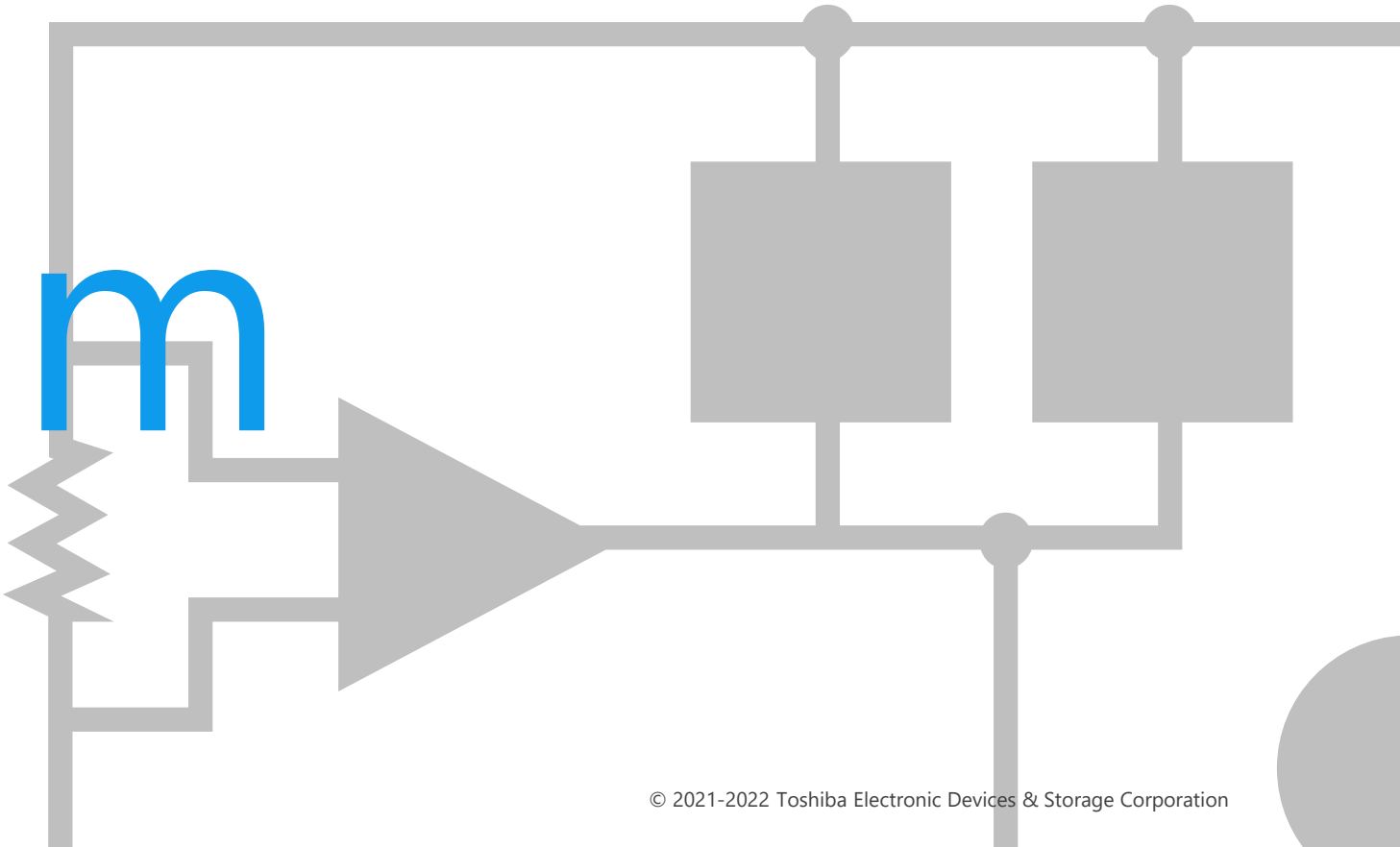






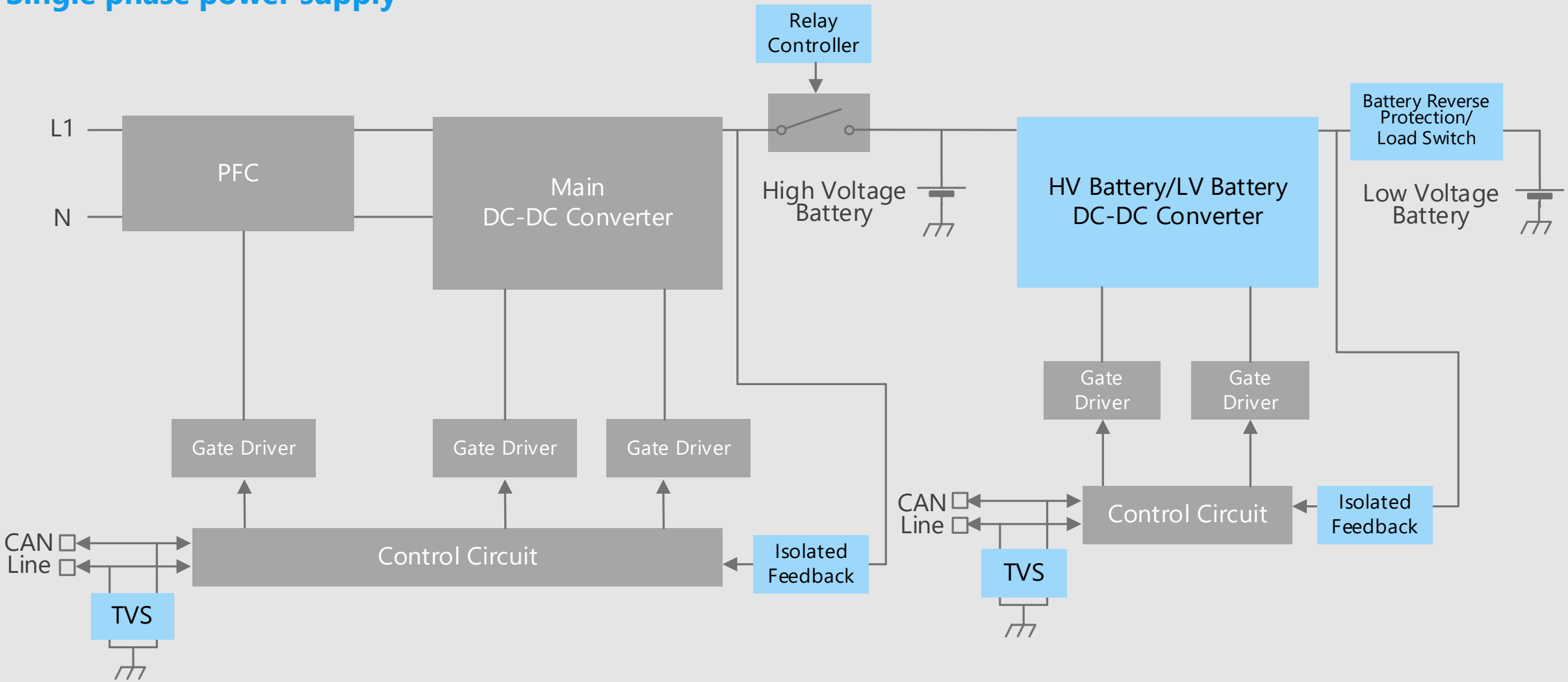
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



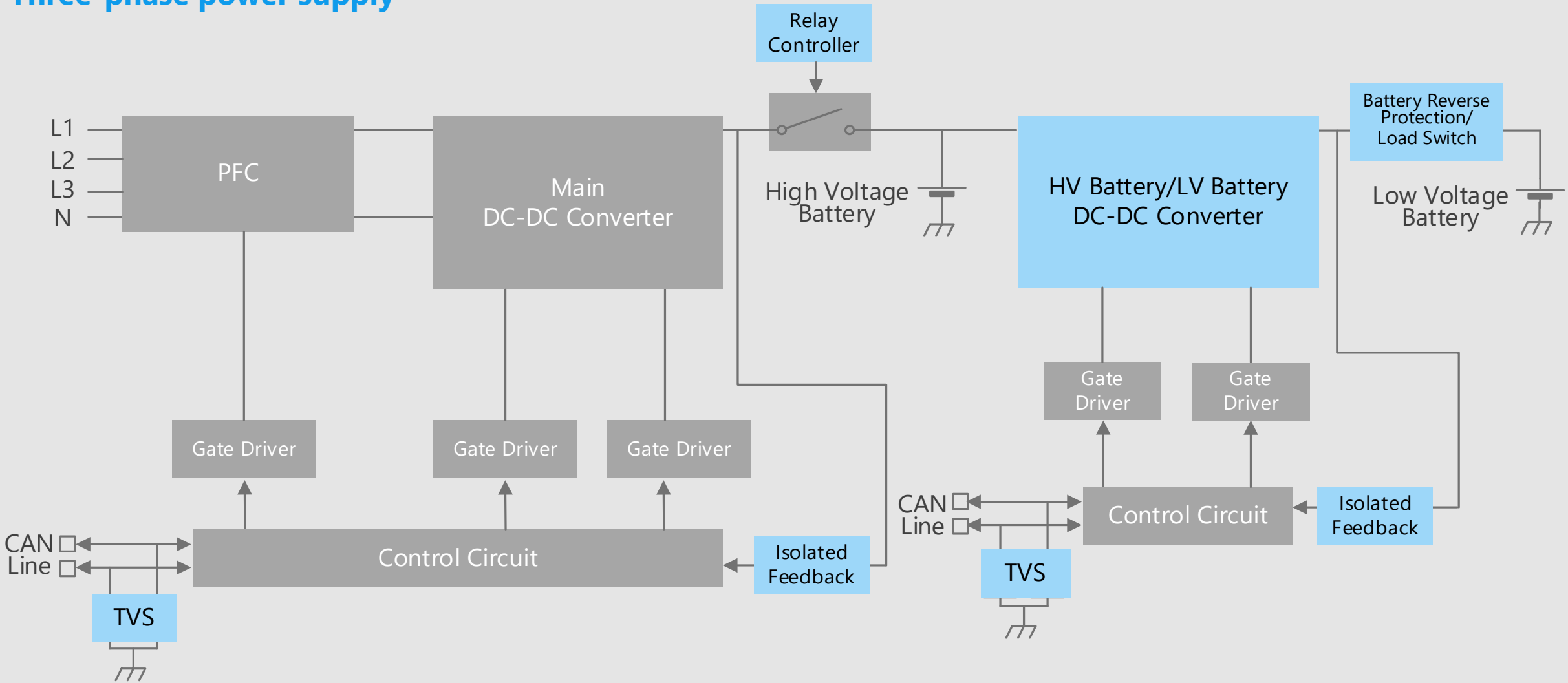
On-board Charger　Overall block diagram (1)

Single phase power supply



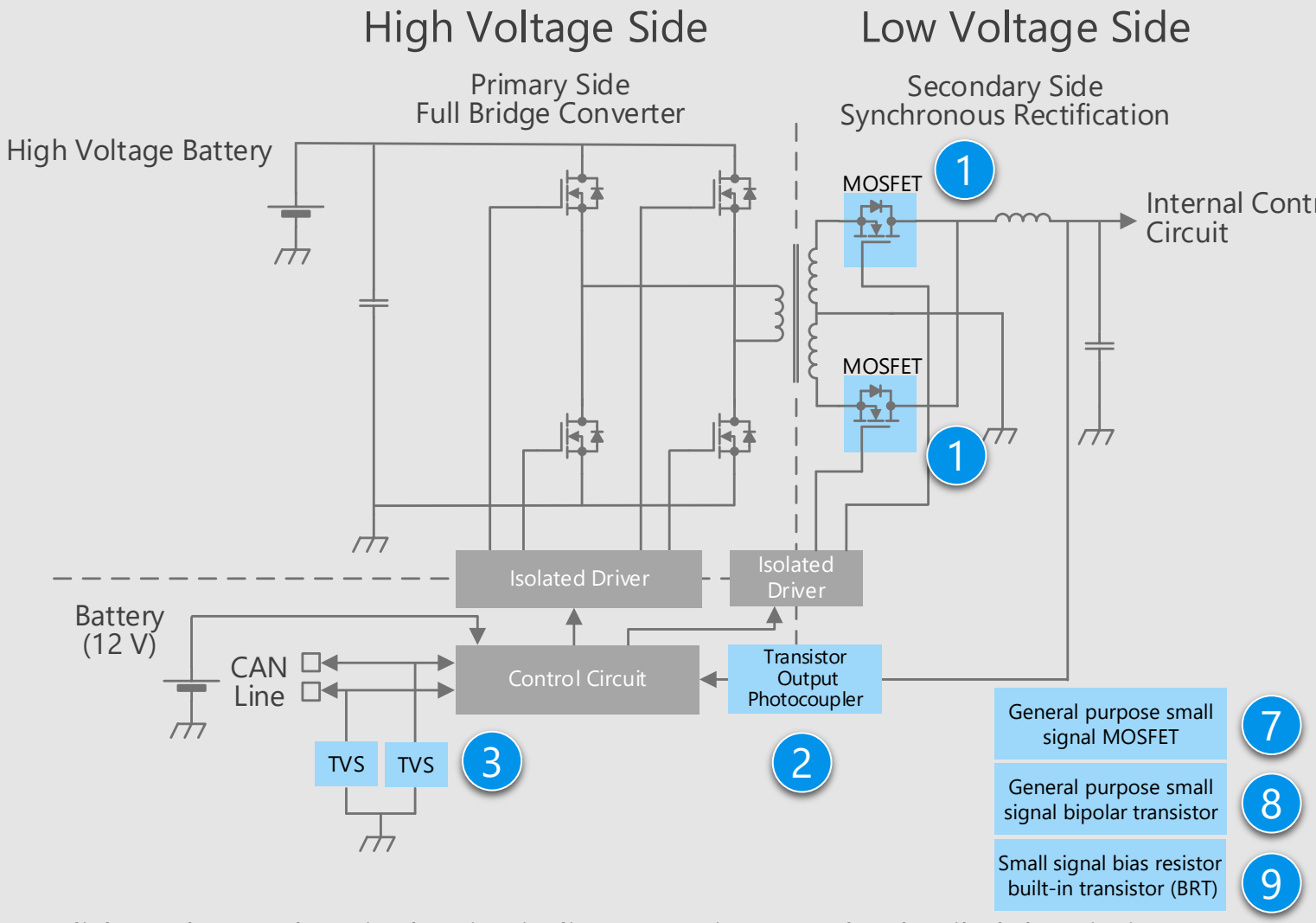
On-board Charger　Overall block diagram (2)

Three-phase power supply



On-board Charger　Detail of power supply circuit

12 V DC-DC converter (Isolated type)



* 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.

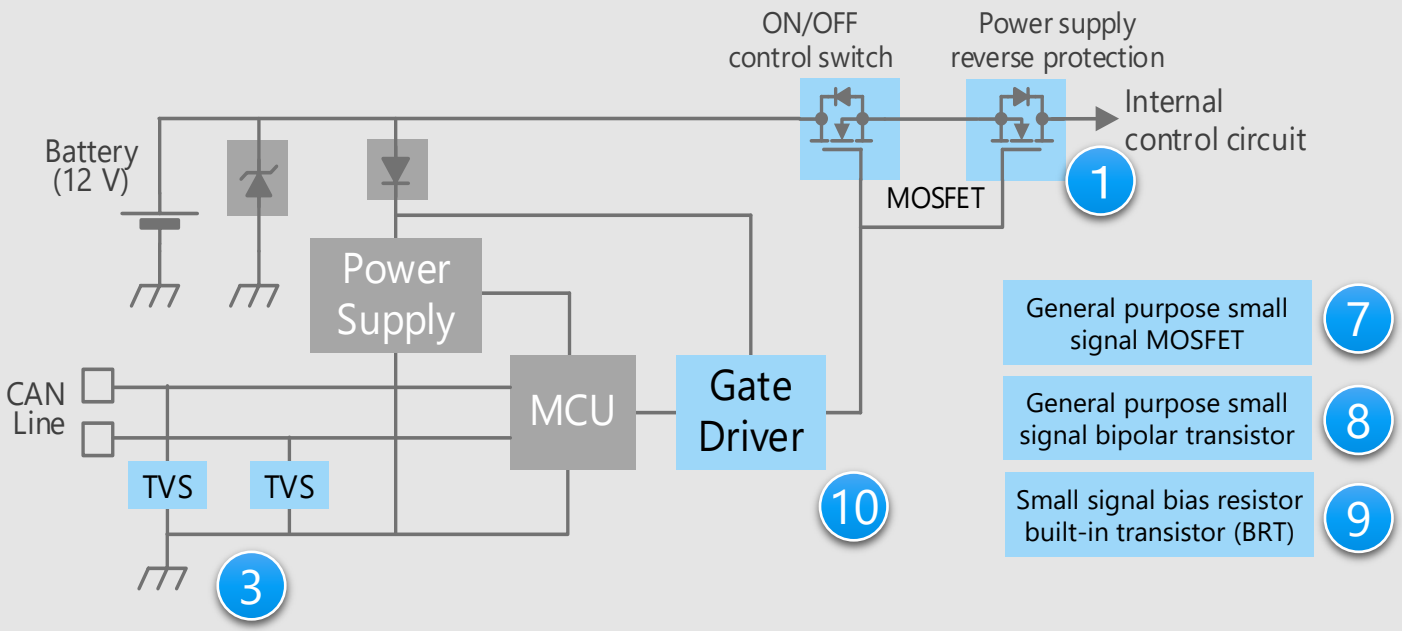
Proposals from Toshiba

- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 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)

On-board Charger

Detail of power supply ON/OFF control and reverse connection protection

Power supply ON/OFF control and reverse connection protection circuit



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

Criteria for device selection

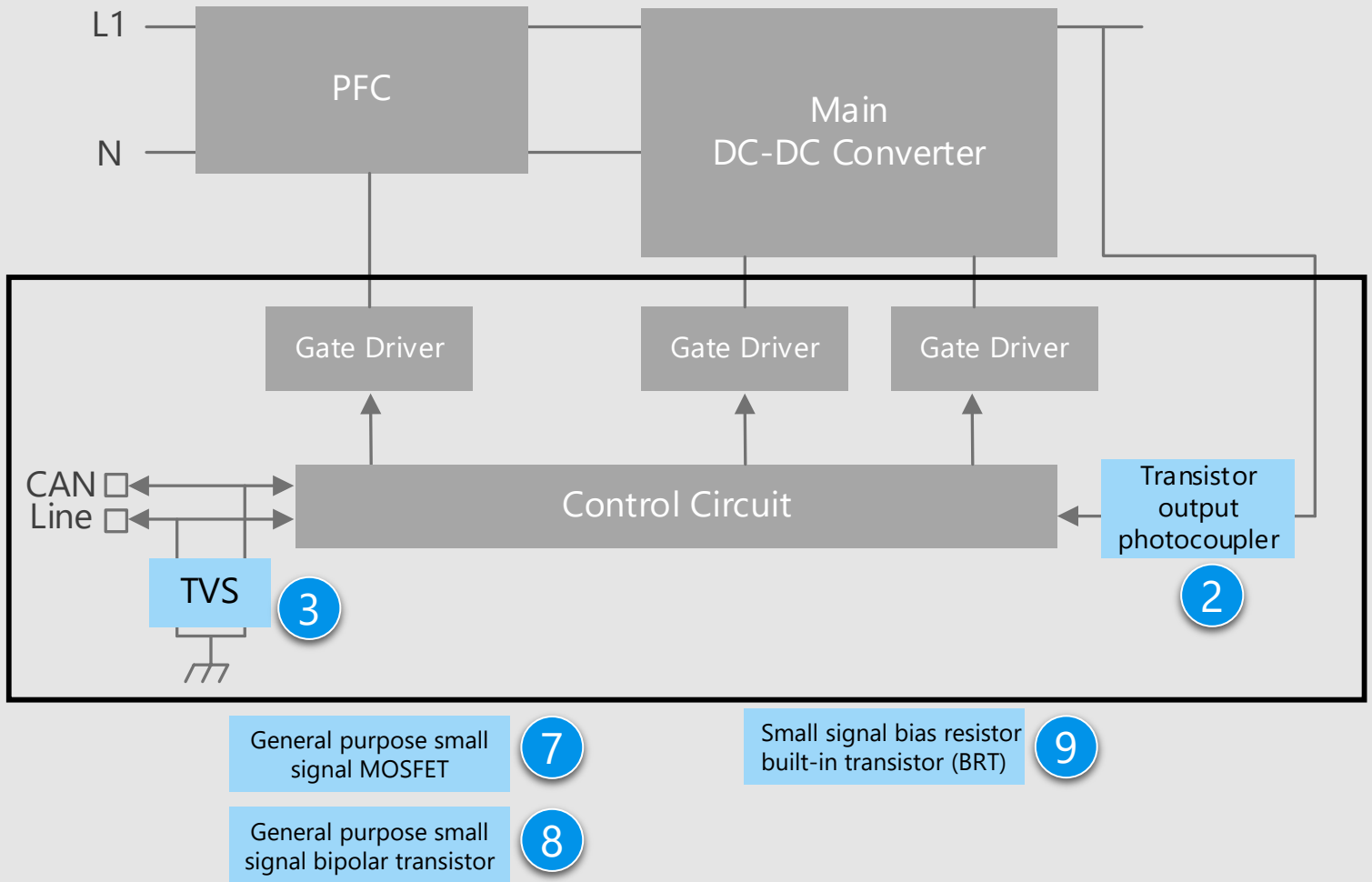
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 40 V / 80 V / 100 V N-ch MOSFET 1
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 3
- **Extensive product lineup**
  General purpose small signal MOSFET 7
  General purpose small signal bipolar transistor 8
  Small signal bias resistor built-in transistor (BRT) 9
- **Gate driver with built-in protection and diagnosis functions**
  Gate driver (for switch) 10

On-board Charger　Detail of control circuit

Control circuit



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

Criteria for device selection

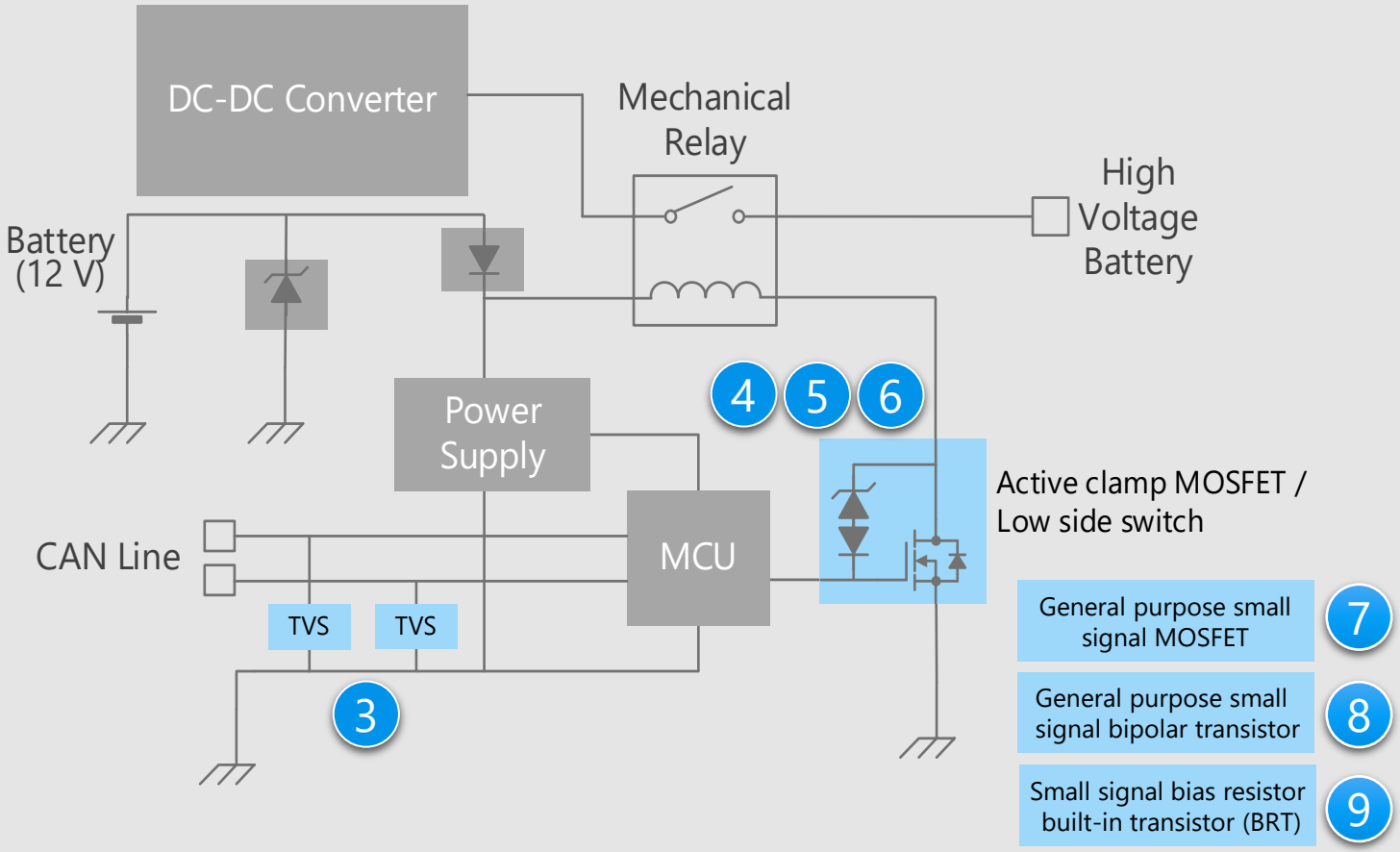
- A small surface mount package is suitable for realizing miniaturization of the ECU.
- Isolation voltage should be noted to design voltage feedback to MCU.

Proposals from Toshiba

- **Photocouplers with environmental resistance**
  Transistor output photocoupler 2
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 3
- **Extensive product lineup**
  General purpose small signal MOSFET 7
  General purpose small signal bipolar transistor 8
  Small signal bias resistor built-in transistor (BRT) 9

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

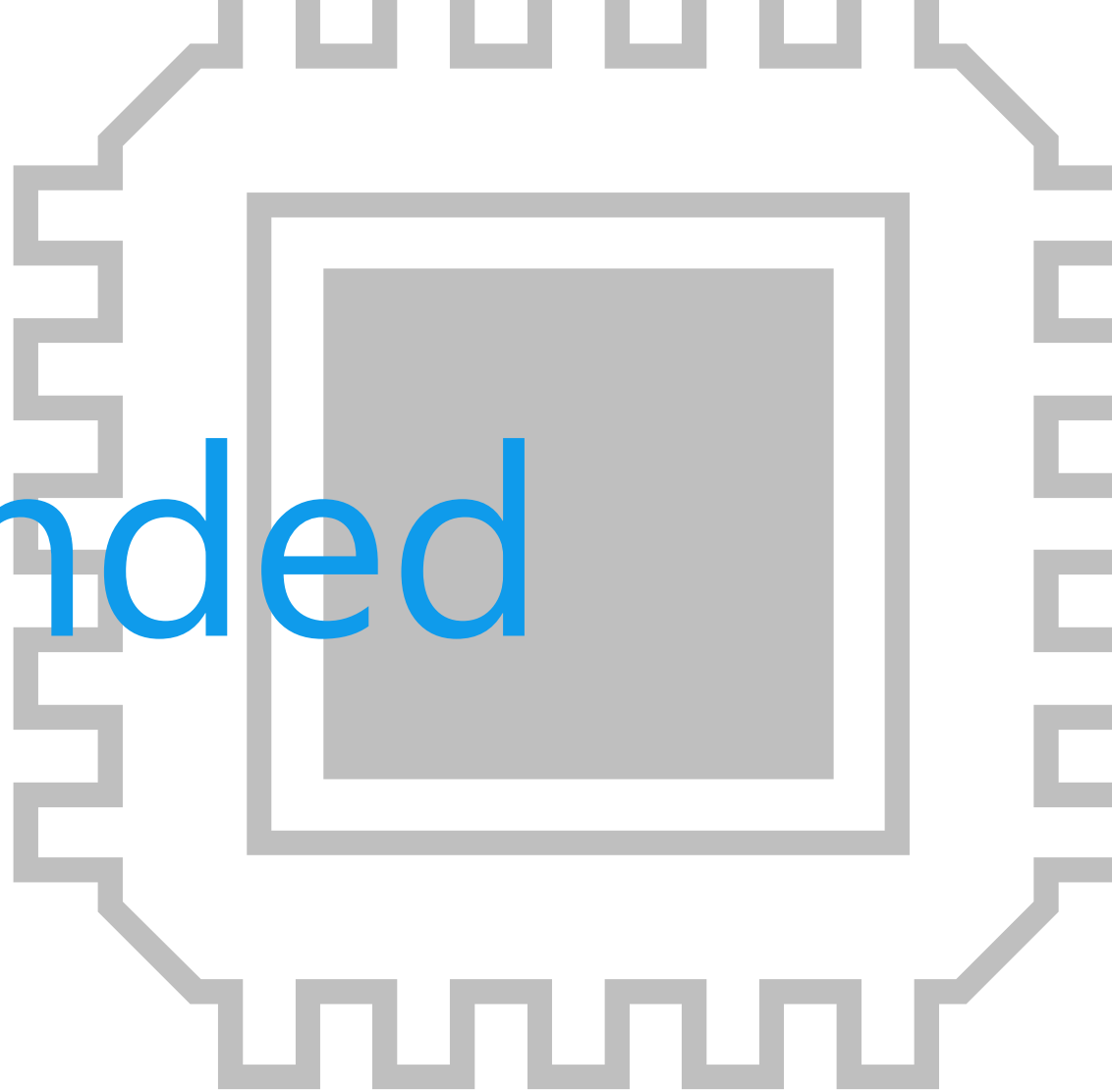
Criteria for device selection

- 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.

Proposals from Toshiba

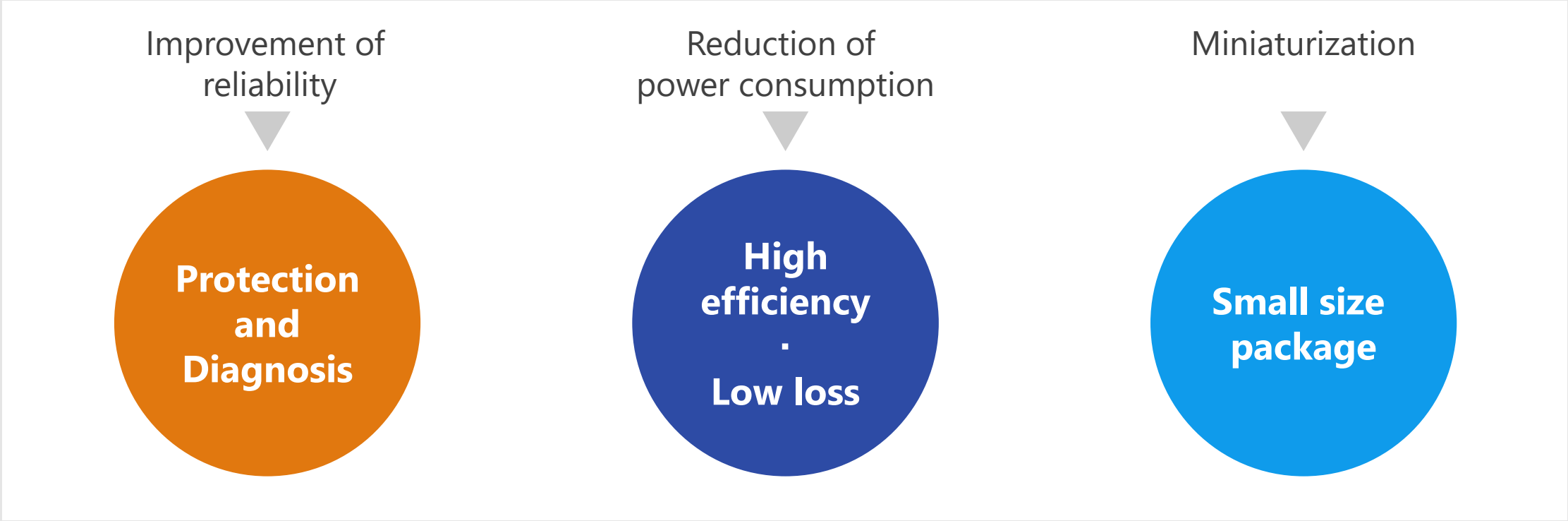
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 3
- **Built-in active clamp circuit and pull-down resistor for relay drive**
  MOSFET with a built-in active clamp circuit 4
- **Driver with built-in protection function**
  Low side switch / High side switch (up to 1 A) 5
  Low side switch / High side switch (1 to 5 A) 6
- **Extensive product lineup**
  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)	●		●

1 U-MOS Series 40 V / 80 V / 100 V N-ch MOSFET

XPQ1R004PB / XPQR3004PB / XPQR8308QB* / XPQ1R00AQB*

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

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)

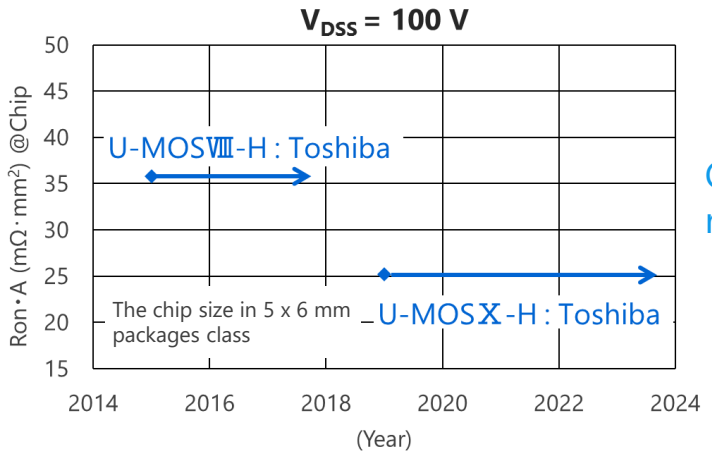
Using low on-resistance technology to contribute to reduced power consumption systems.

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 environments with high ambient temperature and high mechanical stress.



Lineup

Part number	Drain-source voltage [V]	Rated drain current [A]	On-resistance (Max) [mΩ] @V_{GS} = 10 V	Package
XPQ1R004PB	40	200	1.0	L-TOGL™
XPQR3004PB	40	400	0.30	
XPQR8308QB*	80	350	0.83	
XPQ1R00AQB*	100	300	1.03	

*: Under development (The specifications are subject to change without notice.)

◆Return to Block Diagram TOP

2 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

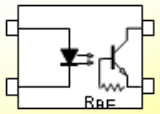
Non-electrical communication provides excellent isolation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

2 Small package

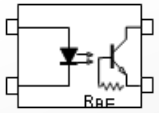
SO4 package that reduced mounting area by about 30 % compared with our conventional SO6 package is aligned in the package lineup. It contributes to reduce occupied area on the board.

3 Maximum operating temperature is extended to 125 °C

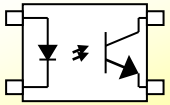
High heat resistance package has realized operating temperature range of -40 to 125 °C. The dark current of TLX9000 / TLX9300 has reduced at high temperature range by pulling out the collector cutoff current I_{CBO} by the built-in base-emitter resistance. And TLX9188 has realized a collector-emitter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

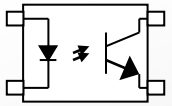
TLX9300 — With R_{BE} — SO6


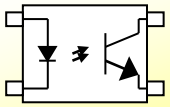
T_{opr} = 125 °C
Built-in R_{BE}

TLX9000 — With R_{BE} — SO4


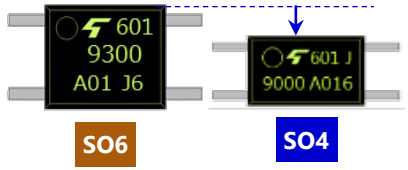
T_{opr} = 125 °C
Small Package
Built-in R_{BE}

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

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

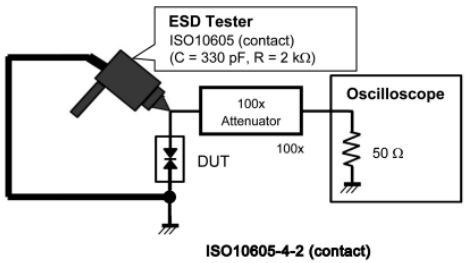
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Achieving both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

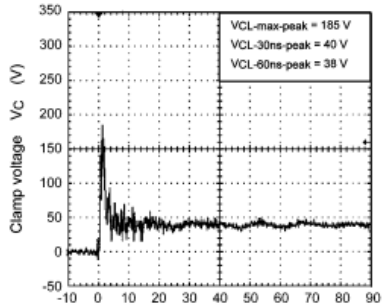
These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3 High ESD immunity

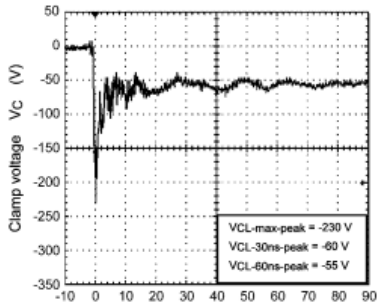
V_{ESD} > ±30 kV @ISO 10605
V_{ESD} > ±20 kV @IEC 61000-4-2 (Level 4)



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

4 MOSFET with a built-in active clamp circuit

SSM3K347R / SSM3K337R

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

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.

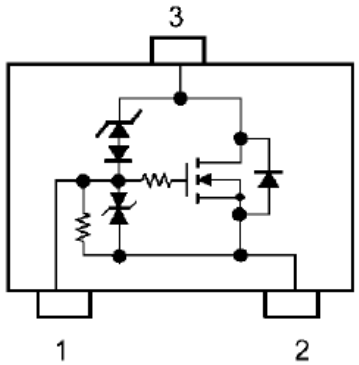
2 Built-in pull-down resistor

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

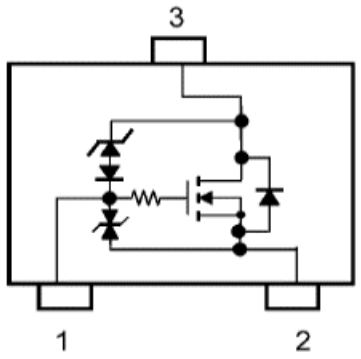
3 Low voltage drive

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

Lineup

Part number		SSM3K347R	SSM3K337R
Package		SOT-23F 	SOT-23F 
$V_{DS(DC)}$ [V]		38	38
I_D [A]		2	2
$R_{DS(ON)}$ [mΩ] @V_{GS} = 4.0 V	Typ.	350	161
	Max	480	200
Polarity		N-ch	N-ch

◆Return to Block Diagram TOP

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

TPD1044F / TPD1054F / TPD1052F

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

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.

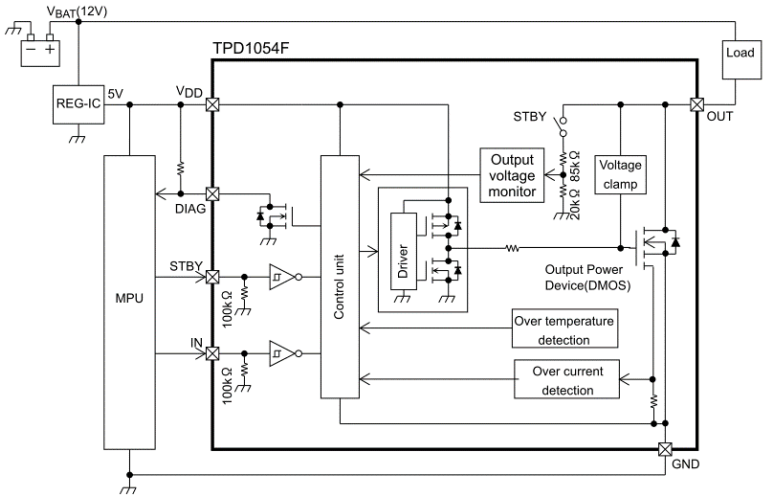
2 Can be controlled by logic level voltage

It is possible to be controlled directly 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

Lineup

Function	Low side switch		High side switch
Part number	TPD1044F	TPD1054F	TPD1052F
Package	 PS-8 (2.8 x 2.9 mm)		
Features	・Overcurrent / overtemperature protection ・Active clamp ・On-resistance: 0.6 Ω	・Overcurrent / overtemperature protection ・Active clamp ・Diagnostic output function ・On-resistance: 0.8 Ω	・Overcurrent / overtemperature protection ・Diagnostic output function ・On-resistance: 0.8 Ω

◆Return to Block Diagram TOP

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

TPD1058FA / TPD1055FA

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

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.

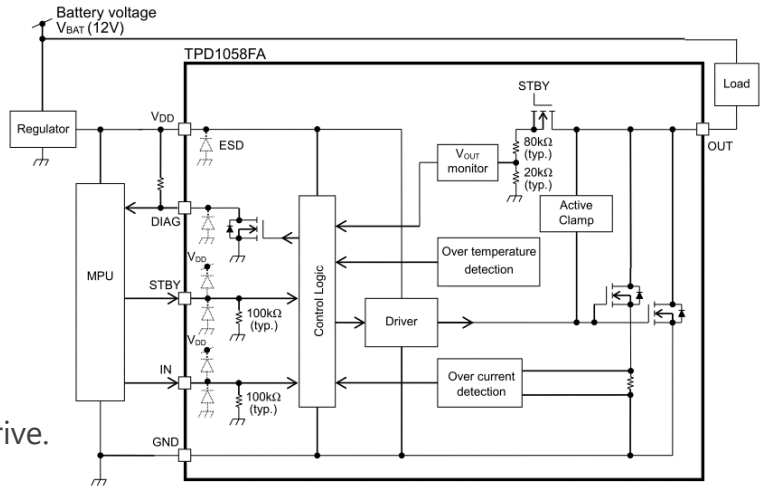
2 Can be controlled by logic level voltage

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

3 Small package

WSON10 is small surface mount package. It contributes to the miniaturization of system.

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



Suitable for various solenoid drive.

Lineup

Function	Low side switch	High side switch
Part number	TPD1058FA	TPD1055FA
Package	Back surface  WSON10 (3 x 3 mm)	
Features	・Overcurrent / Overheat protection ・Active clamp ・Diagnostic output function ・ON-resistance: 0.1 Ω	・Overcurrent / Overheat protection ・Diagnostic output function ・ON-resistance: 0.12 Ω

◆Return to Block Diagram TOP

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.

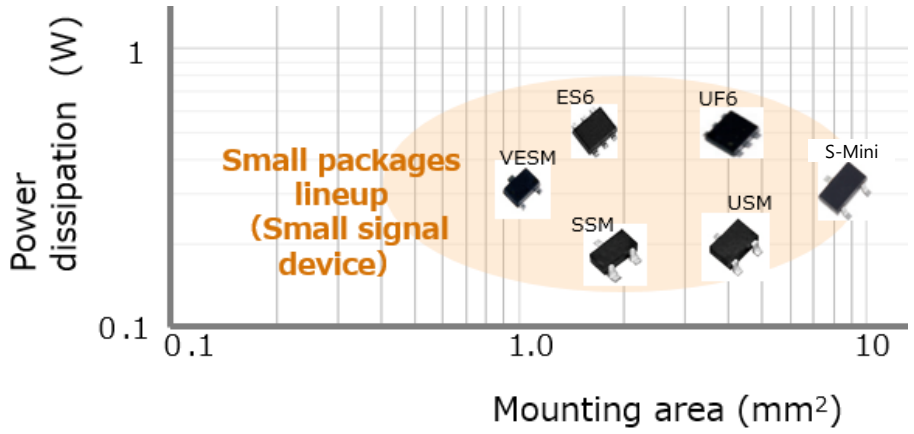
2 Low voltage drive

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

◆Return to Block Diagram TOP

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.

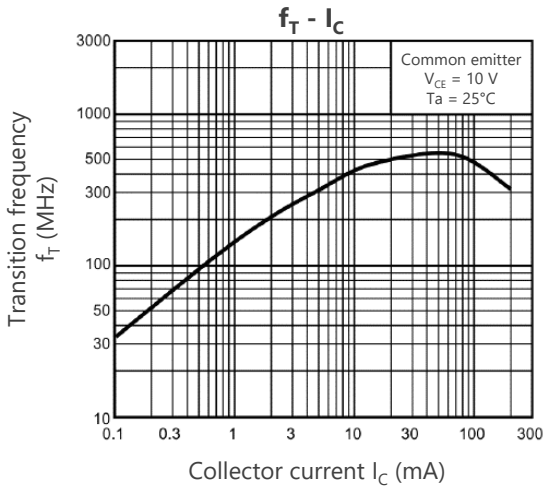
2 Extensive product lineup

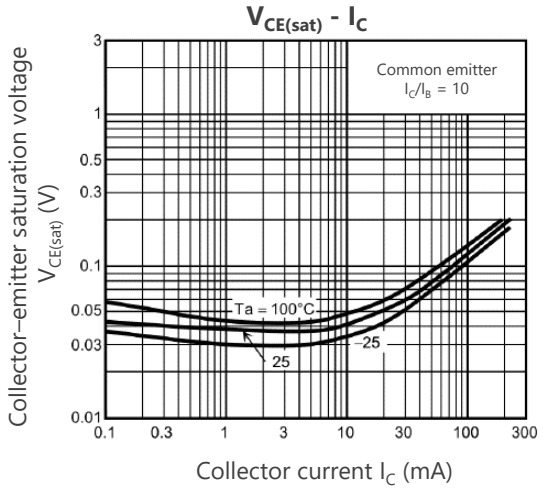
Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance with the application.

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

◆Return to Block Diagram TOP

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)

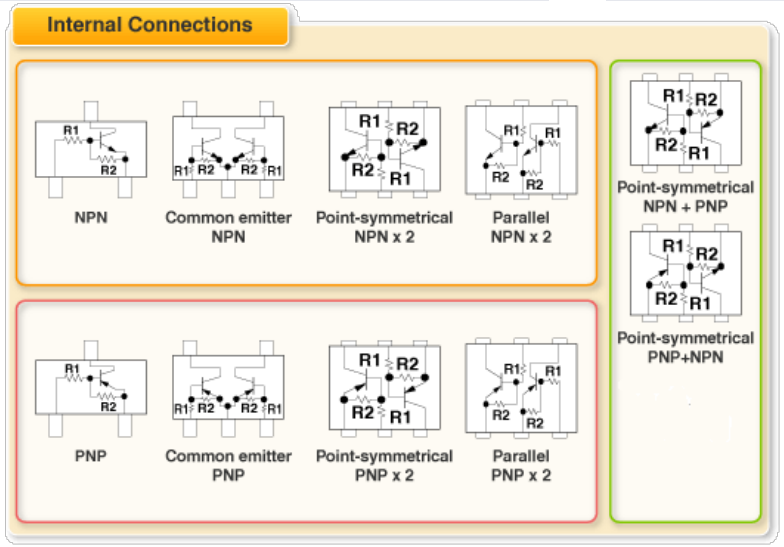
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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

◆Return to Block Diagram TOP

10 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.

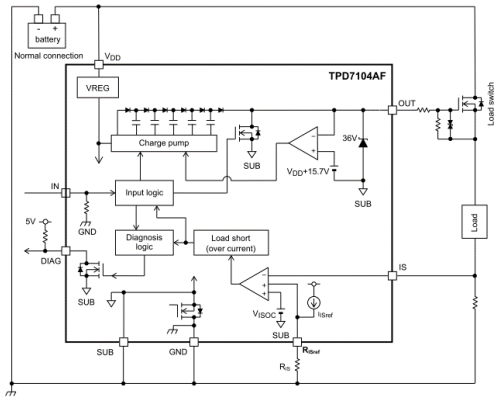
2 Can be controlled by logic level voltage

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

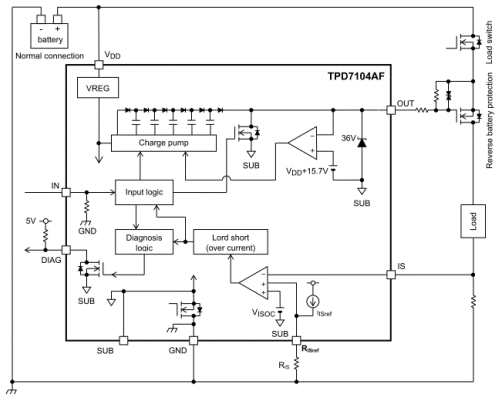
3 Small package

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.

◆Return to Block Diagram TOP

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