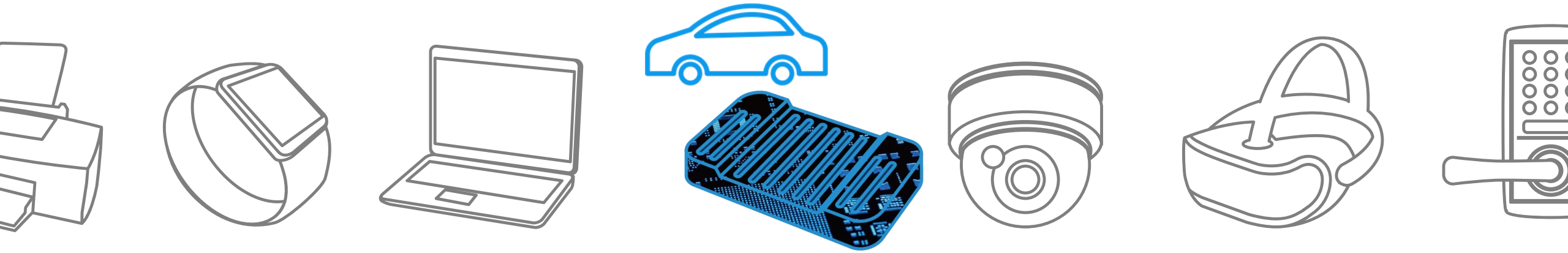
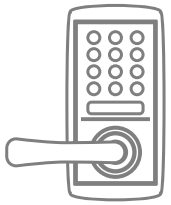
TOSHIBA

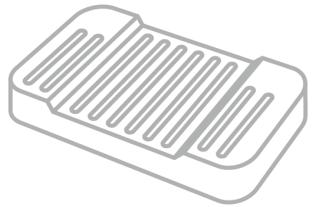
R21

Automotive Battery Management System

Solution Proposal by Toshiba

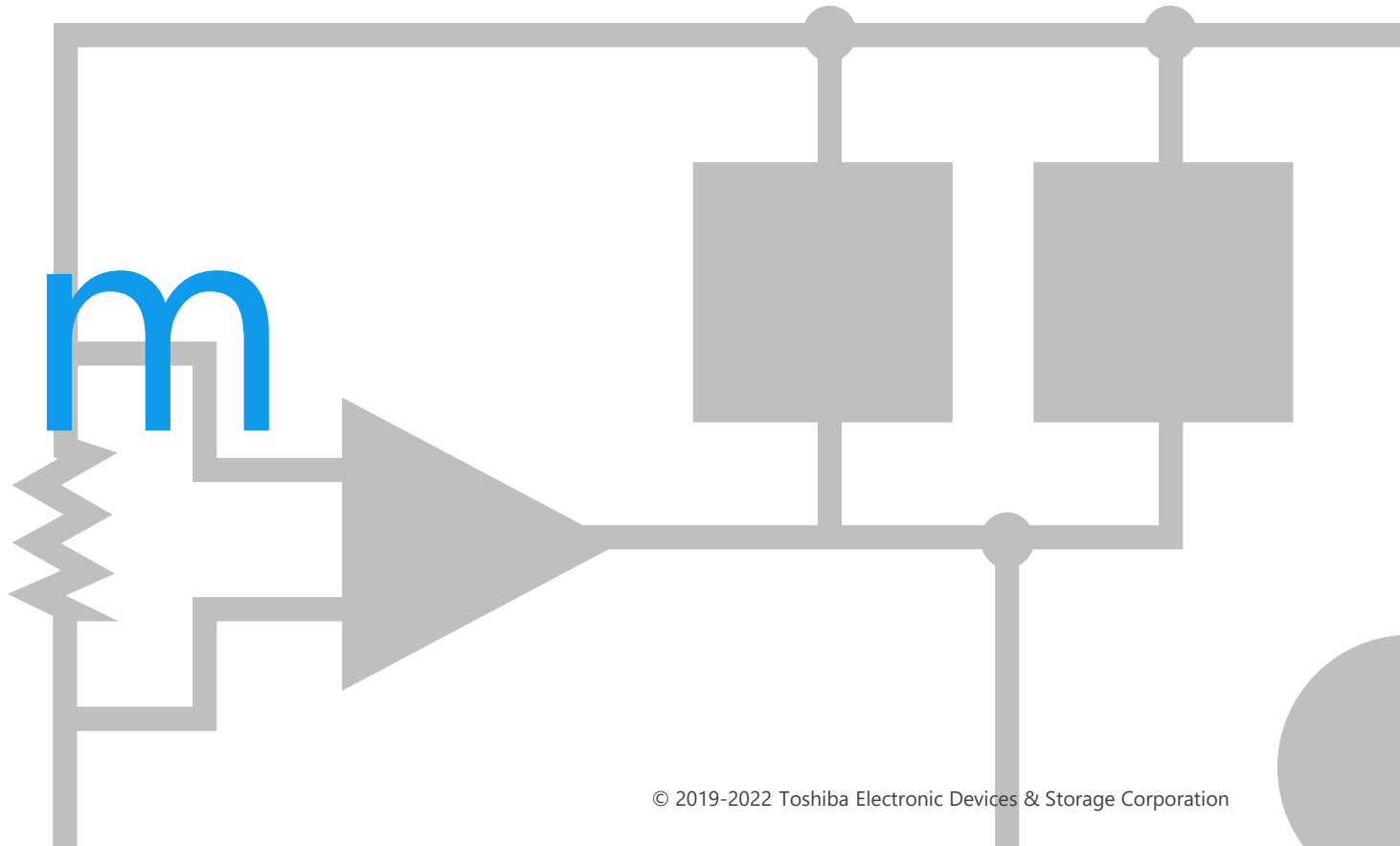




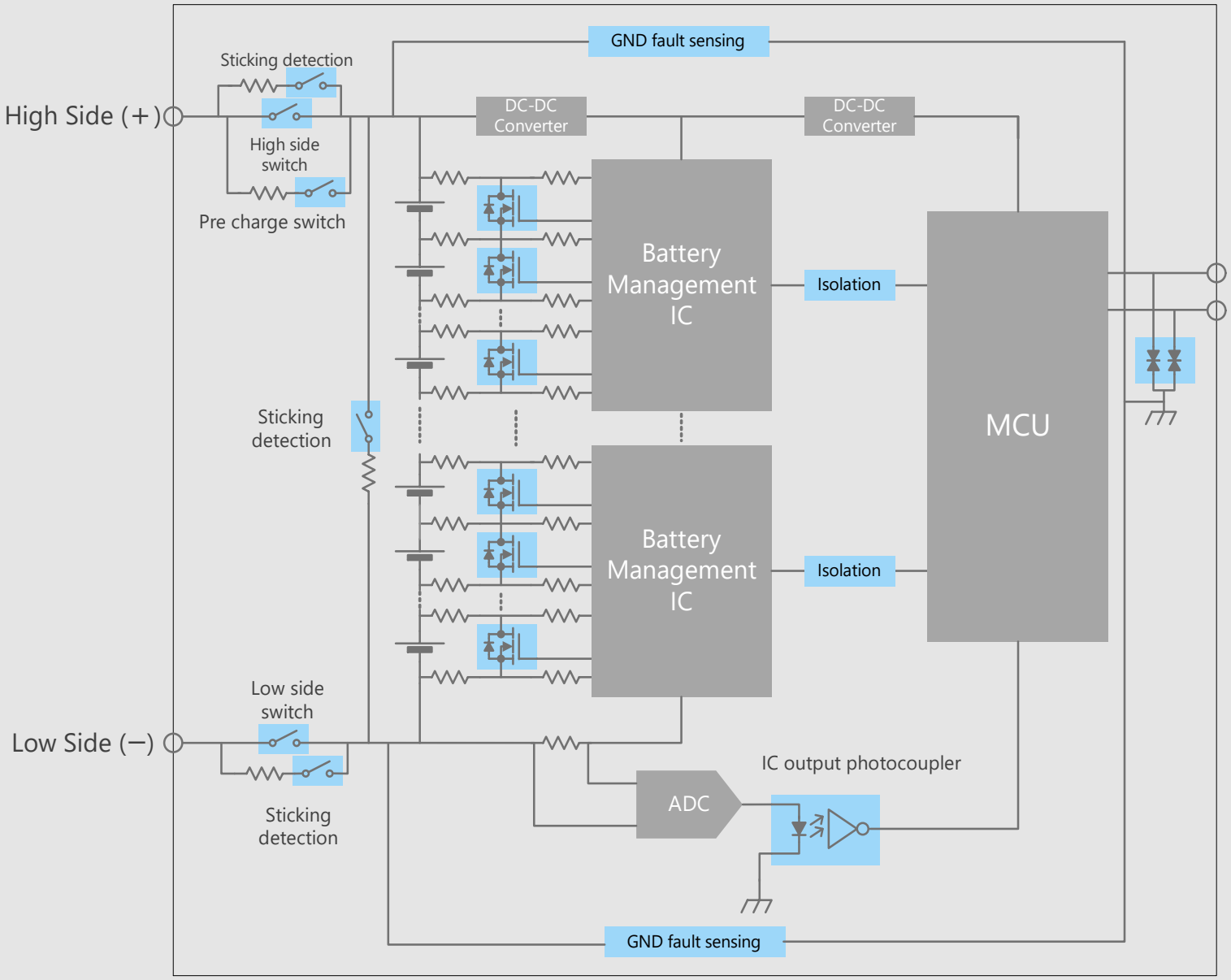


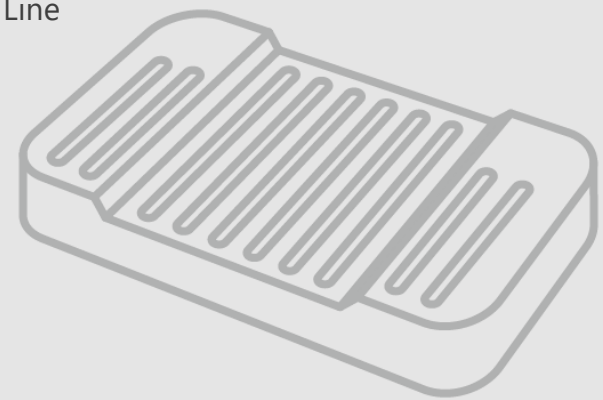
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



Battery Management System　Overall block diagram

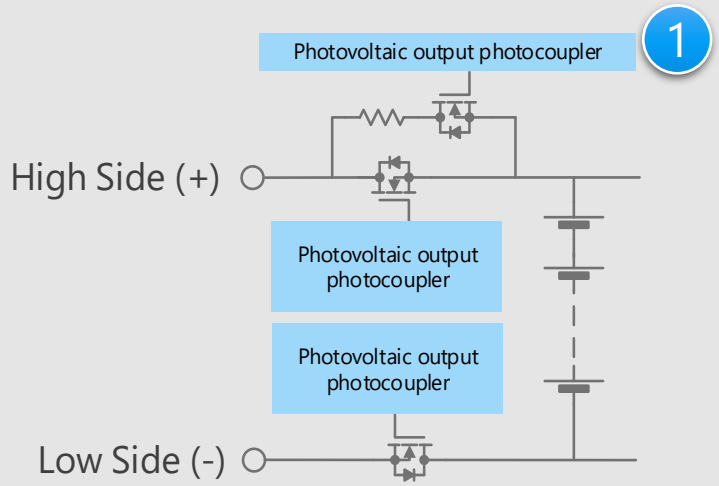




Battery Management System　Detail of charging circuit (1)

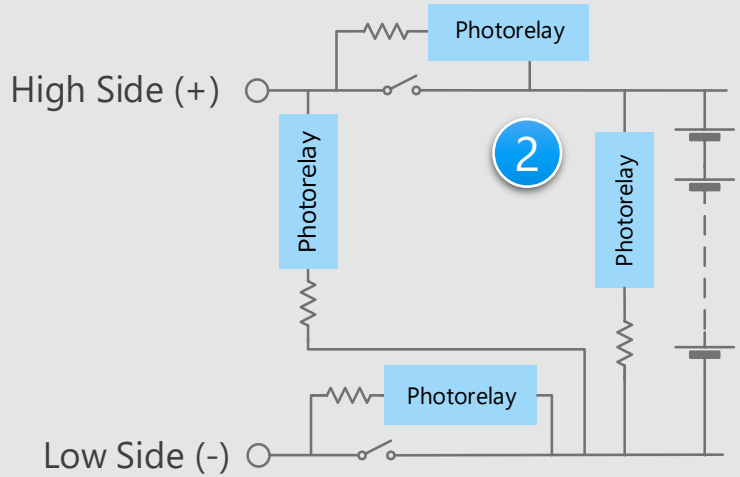
Charging circuit

Prevention of sticking



Charging circuit

Detection of mechanical relay sticking



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

Criteria for device selection

- Changing from mechanical relays to semiconductor relays reduces the risk of switch failure.
- It is necessary to select the product with the optimum blocking voltage / output current for each application.
- It is necessary to select small surface mount packages suitable for miniaturization of the set.

Proposals from Toshiba

- **Photocoupler for external MOSFET gate drive**

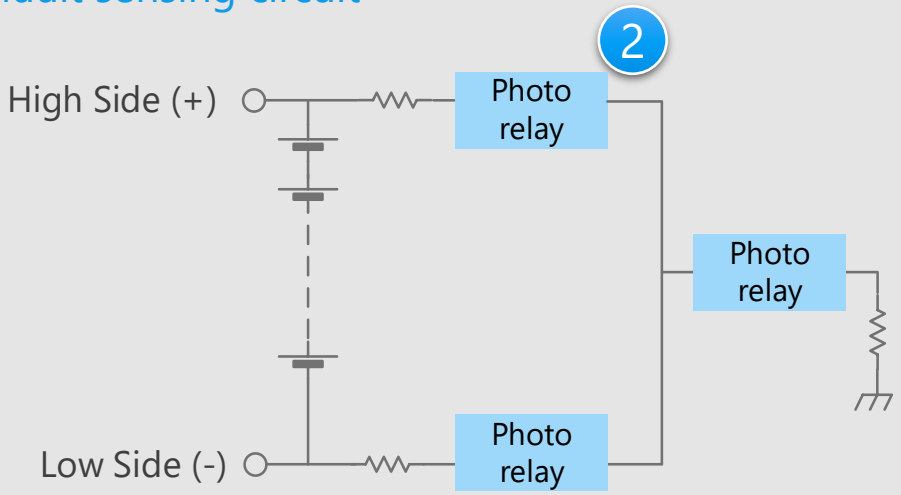
  Photovoltaic output photocoupler　1
- **Photovoltaic output photocoupler and MOSFET are in one package**

  Photorelay　2

Battery Management System　Detail of charging circuit (2)

Charging circuit

Ground fault sensing circuit



Criteria for device selection

- Changing from mechanical relays to semiconductor relays reduces the risk of switch failure.
- It is necessary to select the product with the optimum blocking voltage / output current for each application.
- It is necessary to select small surface mount packages suitable for miniaturization of the set.

Proposals from Toshiba

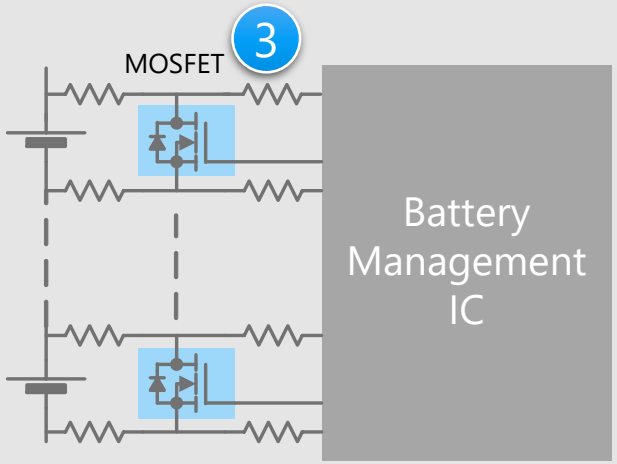
- **Photovoltaic output photocoupler and MOSFET are in one package**
  Photorelay

2

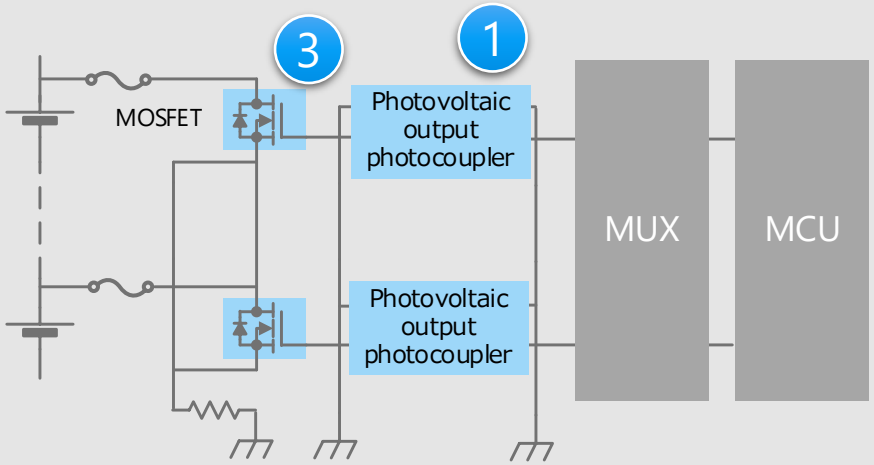
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Battery Management System　Detail of charging / discharging circuit

Passive cell voltage regulation (Use of PMIC)



Passive cell voltage regulation (Not use of PMIC)



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

Criteria for device selection

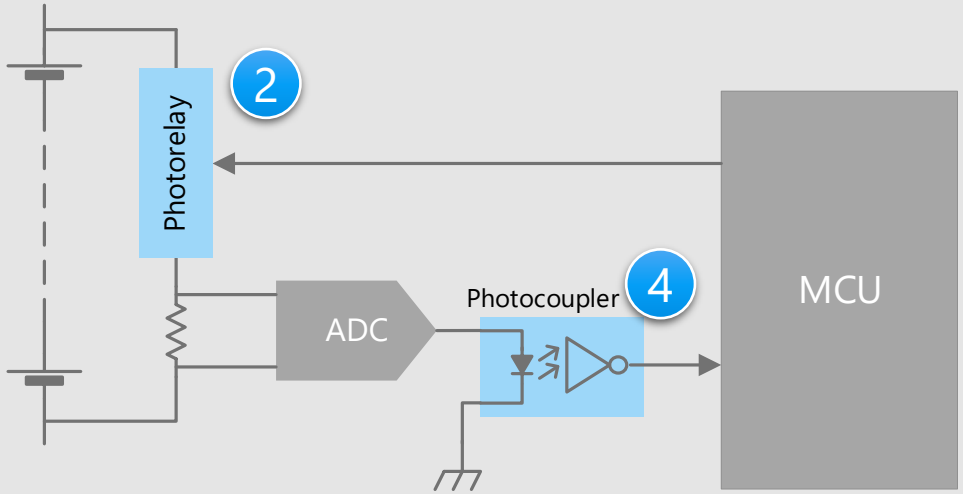
- It is necessary to select the product with the optimum blocking voltage / output current for each application.
- It is necessary to select small surface mount packages suitable for miniaturization of the set.

Proposals from Toshiba

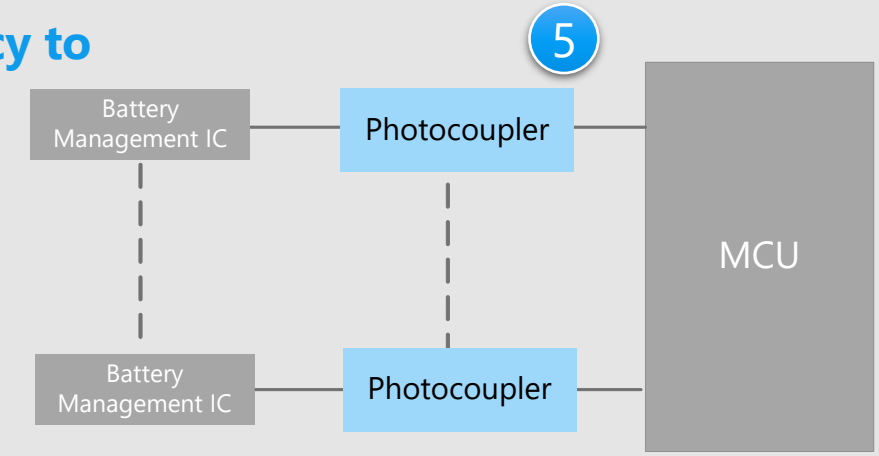
- **Photocoupler for external MOSFET gate drive**
  Photovoltaic output photocoupler 1
- **Extensive product lineup**
  General purpose small signal MOSFET 3

Battery Management System　Detail of control circuit

Battery monitoring circuit



Adding redundancy to communications



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

Criteria for device selection

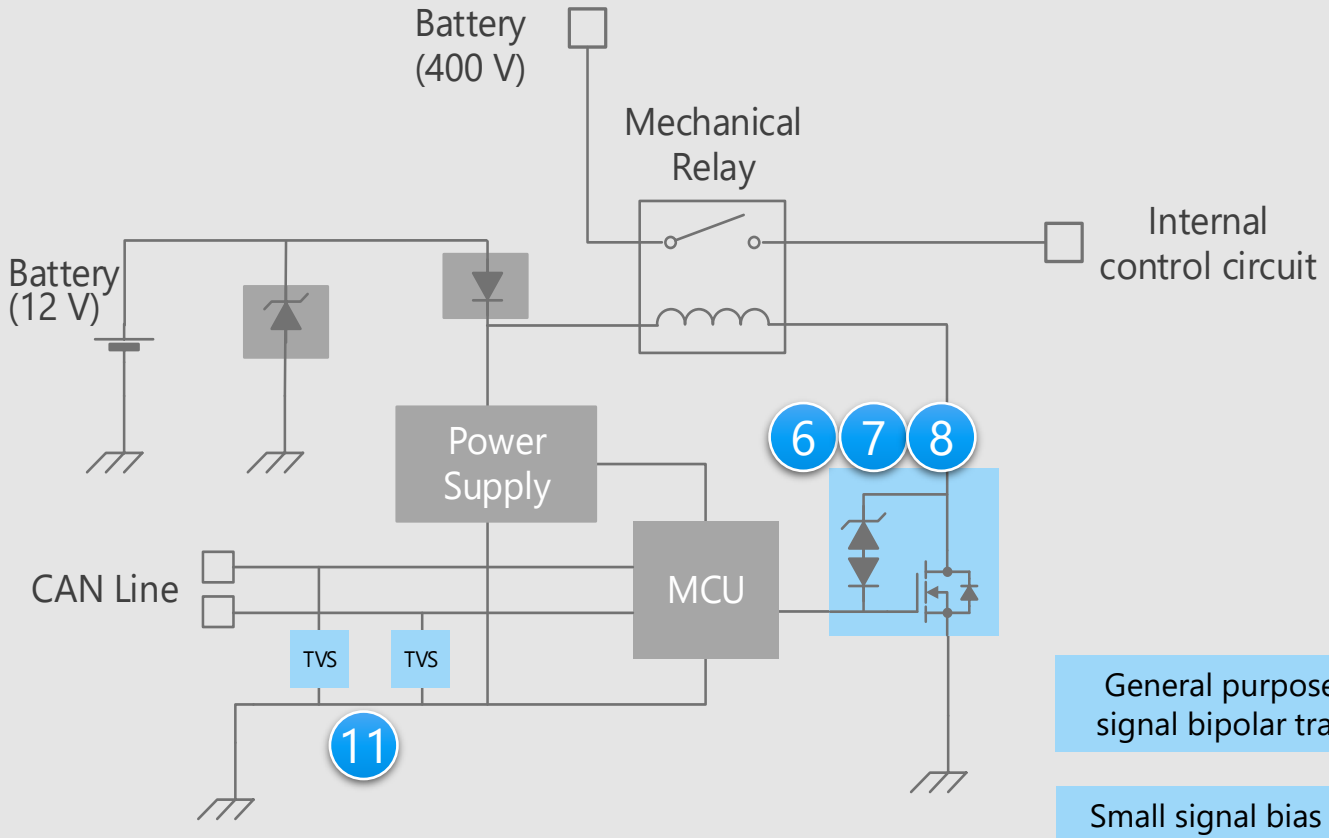
- It is necessary to apply isolation devices with low leakage current for holding total battery voltage.
- Isolation voltage should be noted to design voltage feedback to MCU.
- A redundant signal communication is necessary for the functional safety of the systems.

Proposals from Toshiba

- **Semiconductor relay with low leakage current**
  Photorelay 2
- **Both high speed switching and high isolation voltage are realized**
  IC output photocoupler 4
- **Contributes to redundant communications**
  Transistor output photocoupler 5

Battery Management System　Detail of battery shutdown circuit

Battery shutdown circuit



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

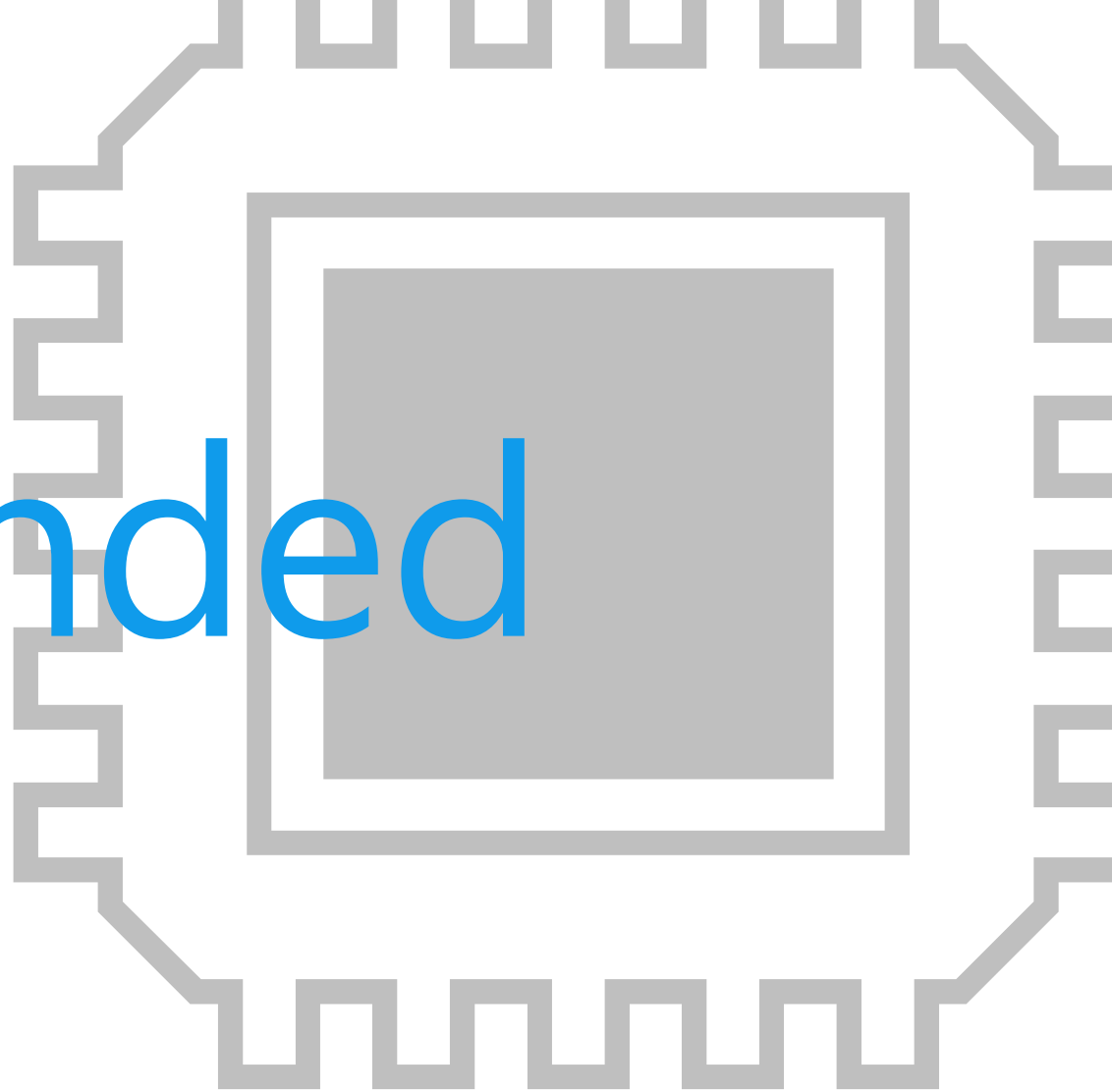
Criteria for device selection

- 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

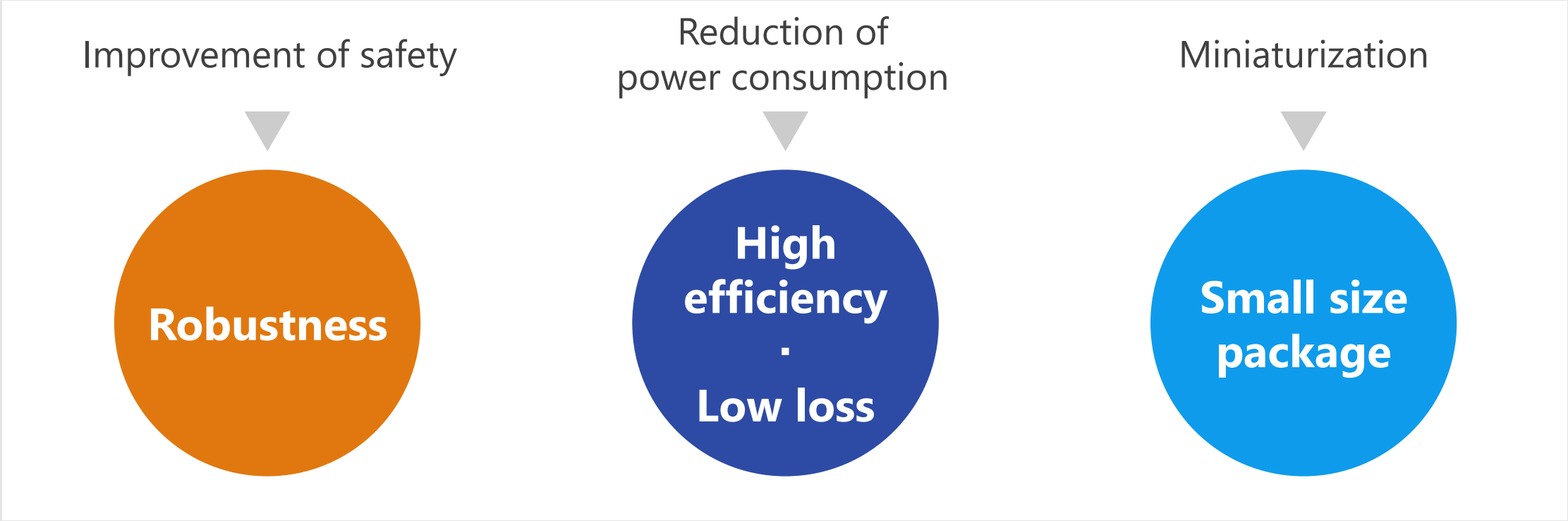
- **Built-in active clamp circuit and pull down resistor for relay drive** 6
  MOSFET with a built-in active clamp circuit
- **Driver with protection function**
  Low side switch / high side switch (up to 1 A) 7
  Low side switch / high side switch (1 to 5 A) 8
- **Extensive product lineup**
  General purpose small signal bipolar transistor 9
  Small signal bias resistor built-in transistor (BRT) 10
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 11

Recommended Devices



Device solutions to address customer needs

As described above, in the design of Automotive Battery Management System, **“Improvement of safety”**, **“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

		Robustness	High efficiency · Low loss	Small size package
1	Photovoltaic output photocoupler	●	●	●
2	Photorelay	●	●	●
3	General purpose small signal MOSFET		●	●
4	IC output photocoupler	●	●	●
5	Transistor output photocoupler	●		●
6	MOSFET with a built-in active clamp circuit	●	●	●
7	Low side switch / High side switch (up to 1 A)	●		●
8	Low side switch / High side switch (1 to 5 A)	●		●
9	General purpose small signal bipolar transistor			●
10	Small signal bias resistor built-in transistor (BRT)			●
11	TVS diode (for CAN communication)	●		●

1 Photovoltaic output photocoupler

TLX9905 / TLX9906

Robustness | High efficiency · Low loss | Small size package

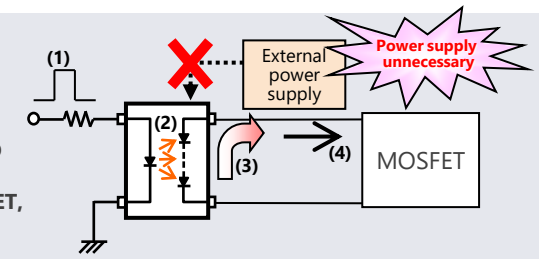
Value provided

Photovoltaic output photocoupler that consists of an infrared light-emitting diode and a photodiode array.

1 External power supply for driving the light-receiving chip not required.

The photodiode array (PDA) receives the light from the LED and generates electricity. External power source for driving the light-receiving chip is not needed due to the electricity generated by itself, and contributes to miniaturization of the circuit board.

(1)Apply voltage to input side
↓
(2)the LED of input side lights
↓
(3)PDA generate electricity, receiving light emitted LED
↓
(4)electricity generated by PDA input to Gate of MOSFET, then MOSFET can be driven



➡ The ECU board can be miniaturized.

The photodiode array (PDA) receives the light from the LED and generates electricity.
The photovoltaic coupler itself is the power supply. ➡ **No external power supply**

2 Semiconductor relays can be realized by combinations with MOSFET.

The output current and voltage are the highest class in the industry [Note]. The semiconductor relays of any voltage / output current can be realized combined with MOSFET.

[Note] Based on automotive photovoltaic output photocoupler as of March, 2021 by Toshiba research.

Lineup

Part number		TLX9905	TLX9906
Isolation voltage [Vrms]		3750	3750
Open circuit voltage [V] @I_F = 10 mA	Typ.	9	9
	Min	7	7
Short-circuit current [μA] @I_F = 10 mA	Typ.	30	30
	Min	12	12
Discharging circuit		No	Yes
AEC-Q101		✓	✓

◆Return to Block Diagram TOP

2 Photorelay
TLX9175J / TLX9160T

Robustness | High efficiency · Low loss | Small size package

Value provided

Solid state relay (non-contact relay) that consists of an infrared LED and MOSFETs.

1 Stable switching

No mechanical contact due to use of solid state relay. Thus, the risk of mechanical sticking and welding can be avoided, and realize stable switching.

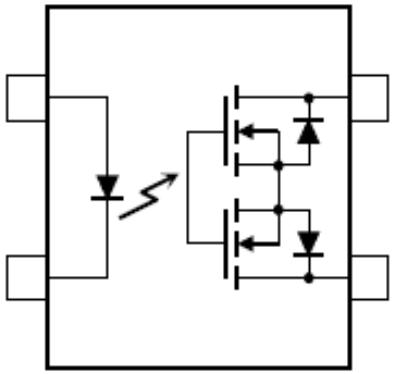
2 High blocking voltage

This photorelay uses MOSFETs with a breakdown voltage of 600 or 1500 V.
It is suitable for the control application of main battery used in eco-friendly cars.

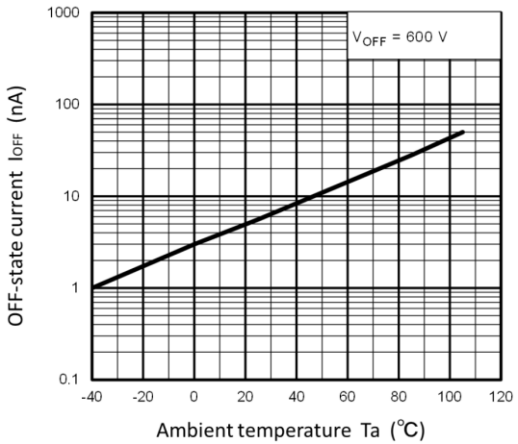
3 To reduce the board area

This photorelay contributes to the reduction of the board area compared to the mechanical relay.

TLX 9175J Internal circuit



I_{OFF} - Ta characteristic (TLX9175J)



Lineup

Part number		TLX9175J	TLX9160T
Isolation voltage [Vrms]		3750	5000
Blocking voltage [V]		600	1500
Trigger LED current [mA] @Ta = 25 °C		3 (@I_{ON} = 15 mA)	3 (@I_{ON} = 50 mA)
On-resistance [Ω] @I_F = 10mA, Ta = 25 °C	Max	335 (@I_{ON} = 15 mA)	250 (@I_{ON} = 50 mA)
	Min	185 (@I_{ON} = 15 mA)	-
AEC-Q101		✓	✓

◆Return to Block Diagram TOP

3 General purpose small signal MOSFET

SSM3K7002KF / SSM3J168F / SSM3J66MFV

Robustness | 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.

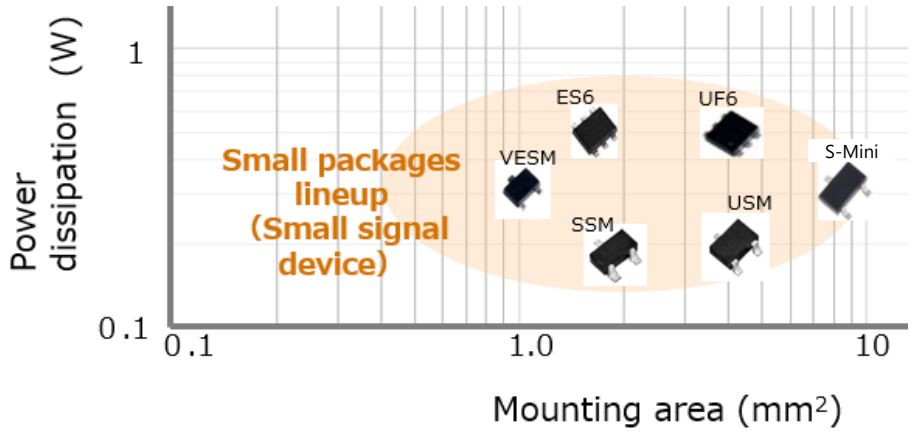
2 Low voltage drive

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

4 IC output photocoupler

TLX9304 / TLX9309 / TLX9310 / TLX9378 / TLX9376

Robustness | High efficiency · Low loss | Small size package

Value provided

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

1 High isolation voltage and noise cutoff

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

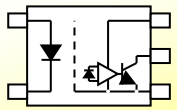
2 Low power consumption and high speed transmission

The combination of a LED and light receiving IC contributes to power consumption saving of this device. Product lineup of 1 to 20 Mbps transmission speed is available.

3 Maximum operating temperature is extended to 125 °C

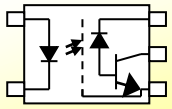
In the case of TLX9304, TLX9309, TLX9378 and TLX9376, the operating temperature range of -40 to 125 °C and long lifetime are realized by adopting heat resistant package.

TLX9304



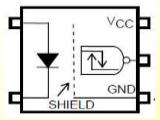
T_{opr} = 125°C
1 Mbps
Logic output

TLX9309



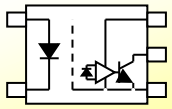
T_{opr} = 125°C
1 Mbps
Analog output

TLX9310



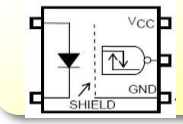
T_{opr} = 105°C
5 Mbps
Logic output
Low power-consumption

TLX9378



T_{opr} = 125°C
10 Mbps
Logic output

TLX9376



T_{opr} = 125°C
20 Mbps
Logic output

Power consumption 1/4

(Comparison with Toshiba previous products)

Lineup

Part number	TLX9304	TLX9309	TLX9310	TLX9378	TLX9376
Isolation voltage [Vrms]	3750	3750	3750	3750	3750
Output type	Open collector (INV)	Open collector (INV)	Totem pole (BUF)	Open collector (INV)	Totem pole (INV)
Power supply voltage [V]	30	30	6	6	6
Threshold input current (Max) [mA]	5	Analog	1	5	4
Power supply current (Max) [mA]	1.3	-	0.3	1.3	1.7
Data rate (Typ.)	1 Mbps	1 Mbps	5 Mbps	10 Mbps	20 Mbps
AEC-Q101	✓	✓	✓	✓	✓

◆Return to Block Diagram TOP

5 Transistor output photocoupler

TLX9291A / TLX9185A / TLX9000 / TLX9300 / TLX9188

Robustness | High efficiency · Low loss | Small size package

Value provided

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

1 High isolation

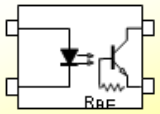
Non-electrical communication provides excellent isolation. Moreover, the light receiving chip is Faraday shielded and provides excellent noise resistance.

2 Small package

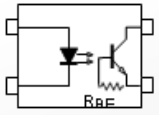
SO4 package that reduced mounting area by about 30 % compared with our conventional SO6 package is aligned in the package lineup. It contributes to reduce occupied area on the board.

3 Maximum operating temperature is extended to 125 °C

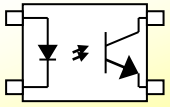
High heat resistance package has realized operating temperature range of -40 to 125 °C. The dark current of TLX9000 / TLX9300 has reduced at high temperature range by pulling out the collector cutoff current I_{CBO} by the built-in base-emitter resistance. And TLX9188 has realized a collector-emitter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

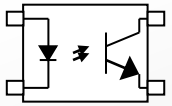
TLX9300 — With R_{BE} — SO6


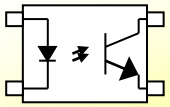
T_{opr} = 125 °C
Built-in R_{BE}

TLX9000 — With R_{BE} — SO4


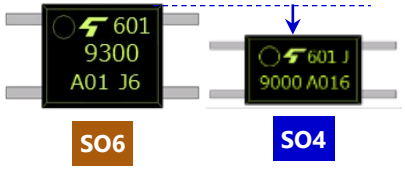
T_{opr} = 125 °C
Small Package
Built-in R_{BE}

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 × 7.0 × 2.1 (mm)

SO4 — 2.6 × 7.0 × 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

6 MOSFET with a built-in active clamp circuit

SSM3K347R / SSM3K337R

Robustness | 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.

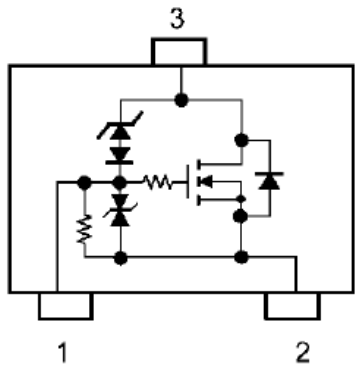
2 Built-in pull-down resistor

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.

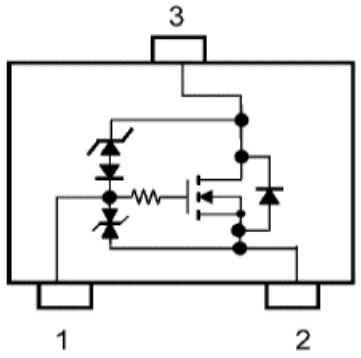
3 Low voltage drive

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

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

TPD1044F / TPD1054F / TPD1052F

Robustness | 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.

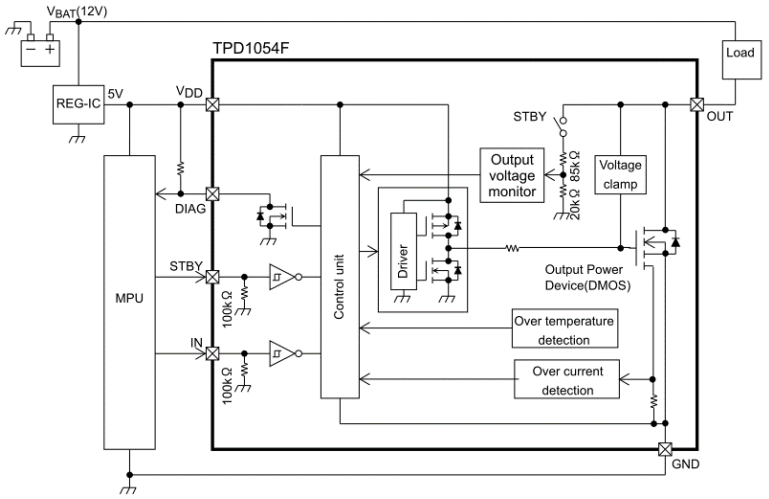
2 Can be controlled by logic level voltage

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 / over-temperature protection ・Active clamp ・On-resistance: 0.6 Ω	・Overcurrent / over-temperature protection ・Active clamp ・Diagnostic output function ・On-resistance: 0.8 Ω	・Overcurrent / over-temperature protection ・Diagnostic output function ・On-resistance: 0.8 Ω

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

TPD1058FA / TPD1055FA

Robustness | 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.

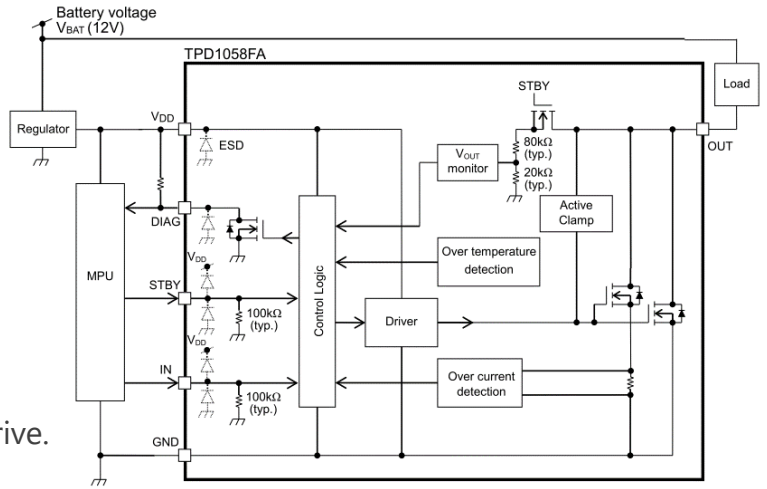
2 Can be controlled by logic level voltage

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

3 Small package

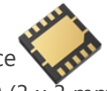
WSON10 is small surface mount package. It contributes to the miniaturization of system.

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 / Overtemperature protection ・Active clamp ・Diagnostic output function ・ON-resistance: 0.1 Ω	・Overcurrent / Overtemperature protection ・Diagnostic output function ・ON-resistance: 0.12 Ω

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9 General purpose small signal bipolar transistor

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

Robustness | 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.

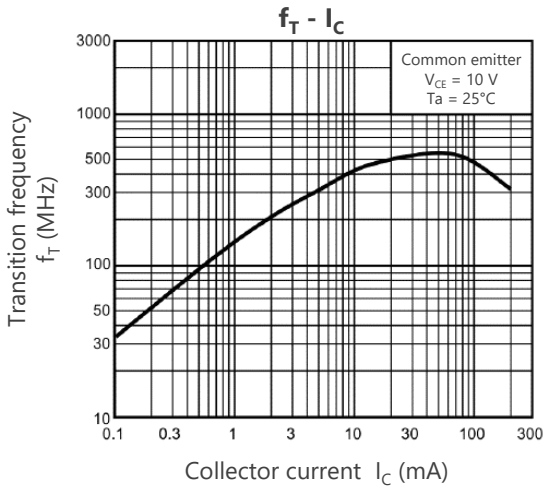
2 Extensive product lineup

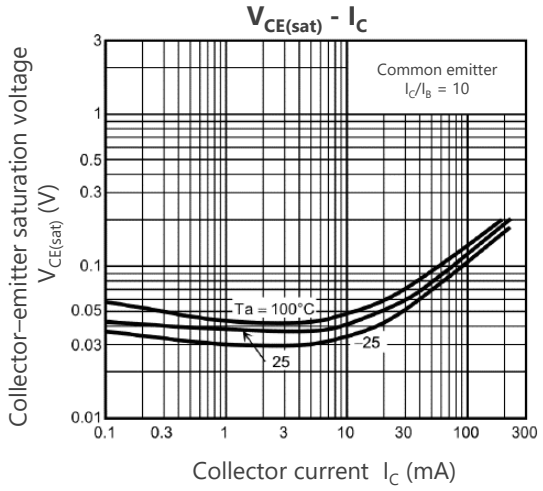
Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance with the application.

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

RN1907FE / RN2907FE / RN1901 / RN2901 Series

Robustness | 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)

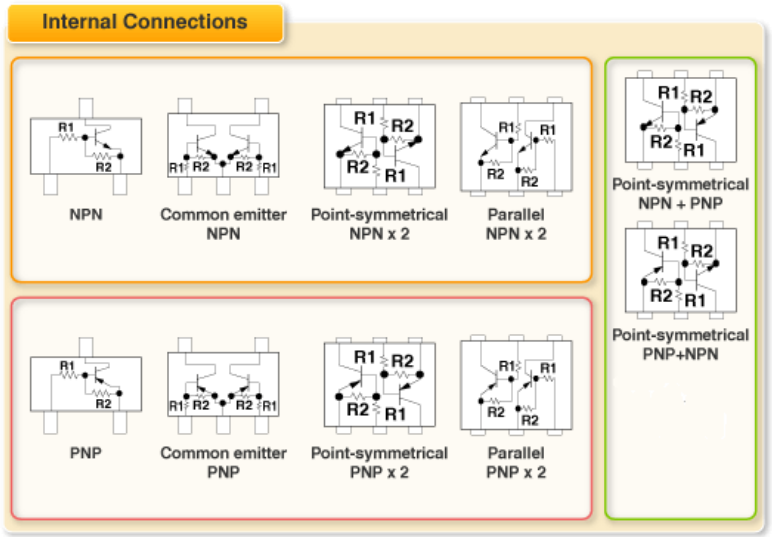
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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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11 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU

Robustness | 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

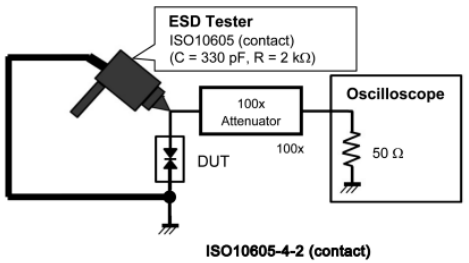
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Achieving both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

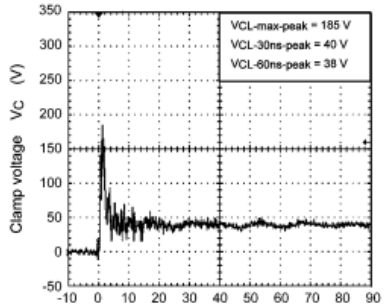
These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3 High ESD immunity

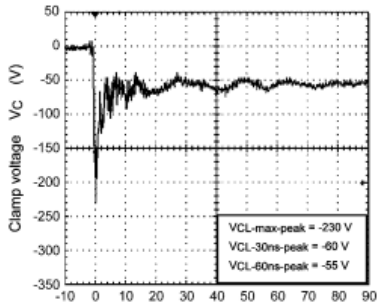
V_{ESD} > ±30 kV @ISO 10605
V_{ESD} > ±20 kV @IEC 61000-4-2 (Level 4)



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.

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