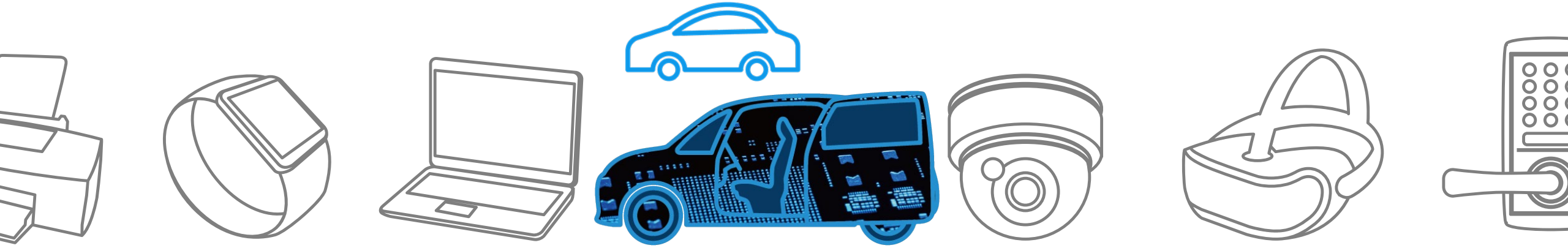
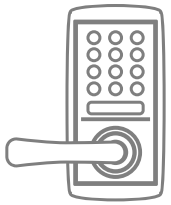
TOSHIBA

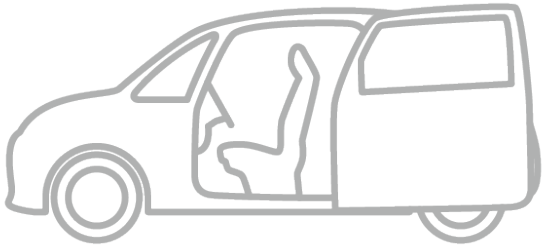
R22

Automotive Power Sliding Door

Solution Proposal by Toshiba

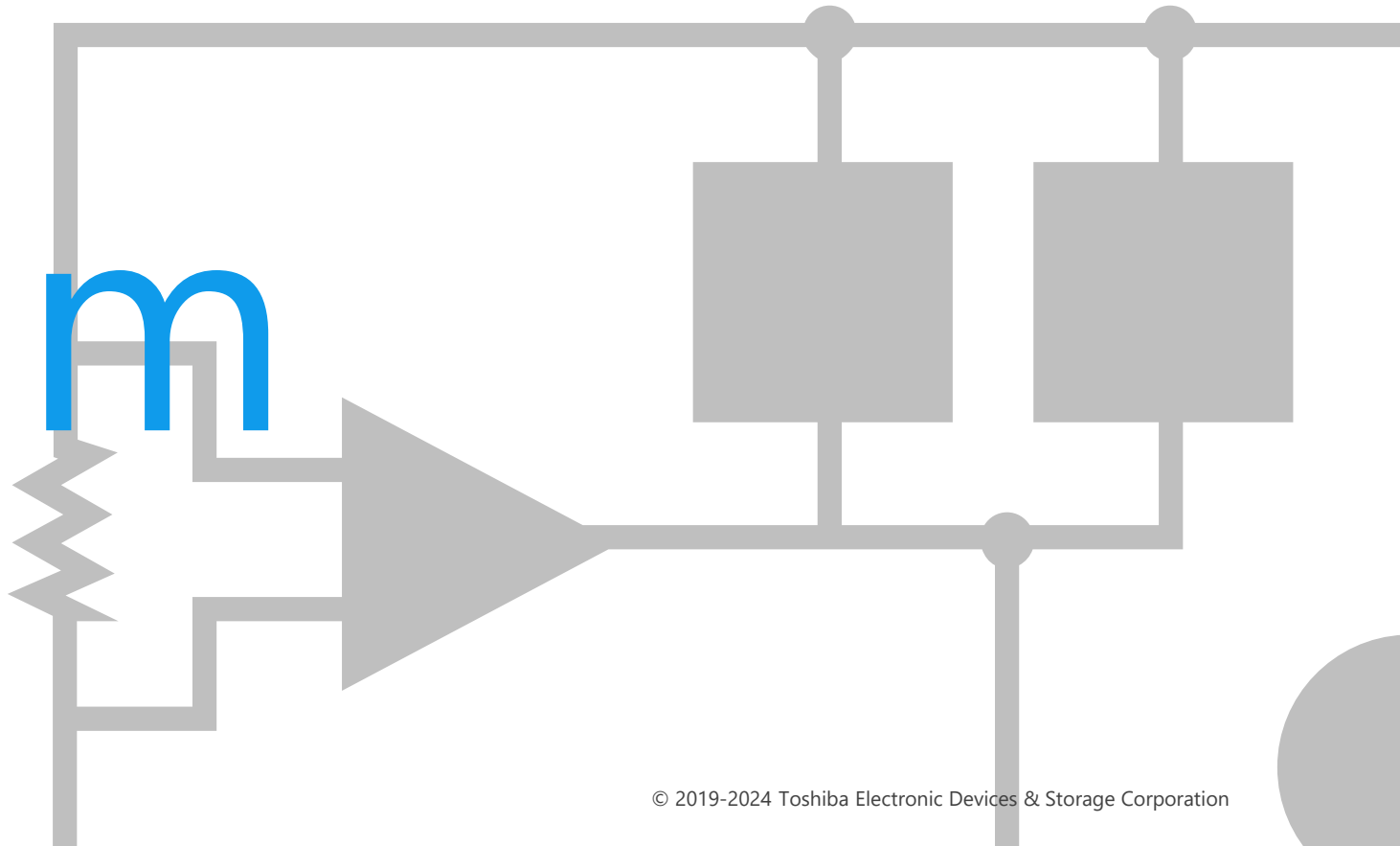




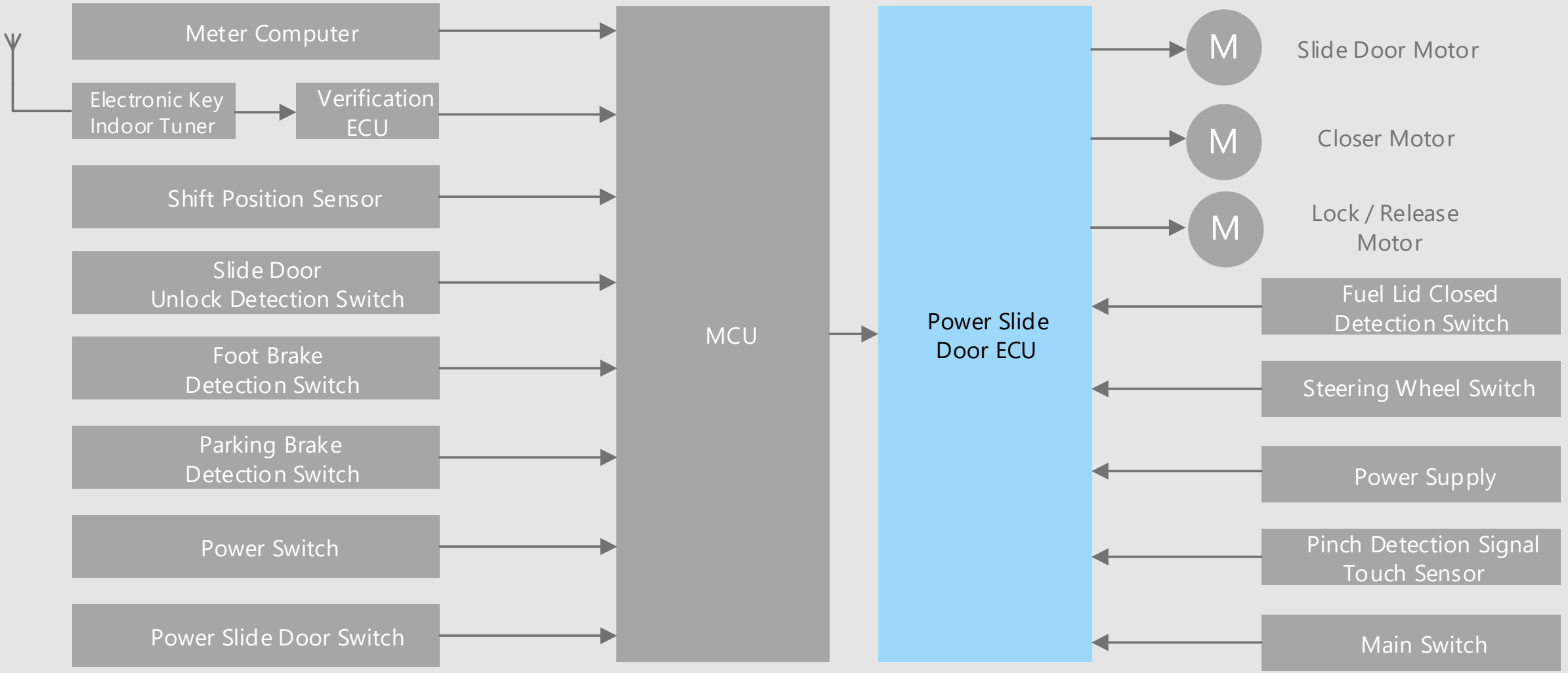


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

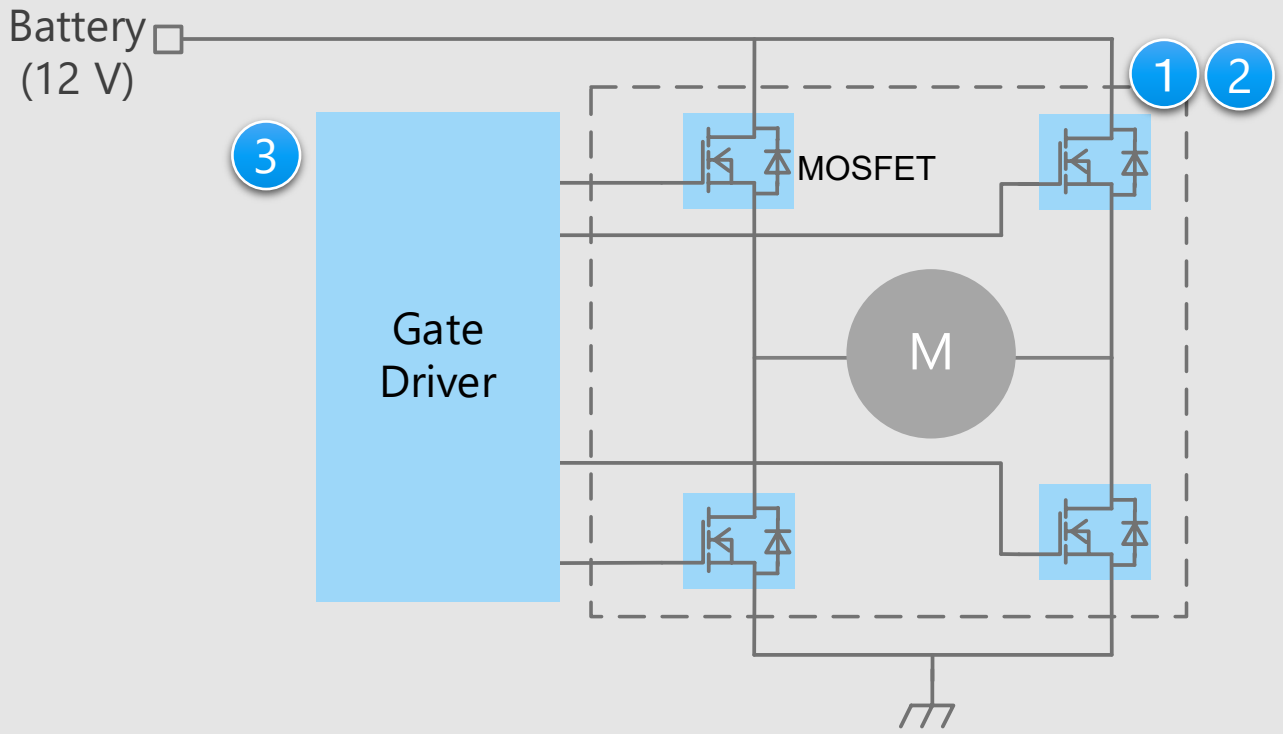


Power Sliding Door　Overall block diagram



Power Sliding Door　Detail of brushed DC motor drive circuit (1)

Drive circuit for brushed DC motor (1)



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

Criteria for device selection

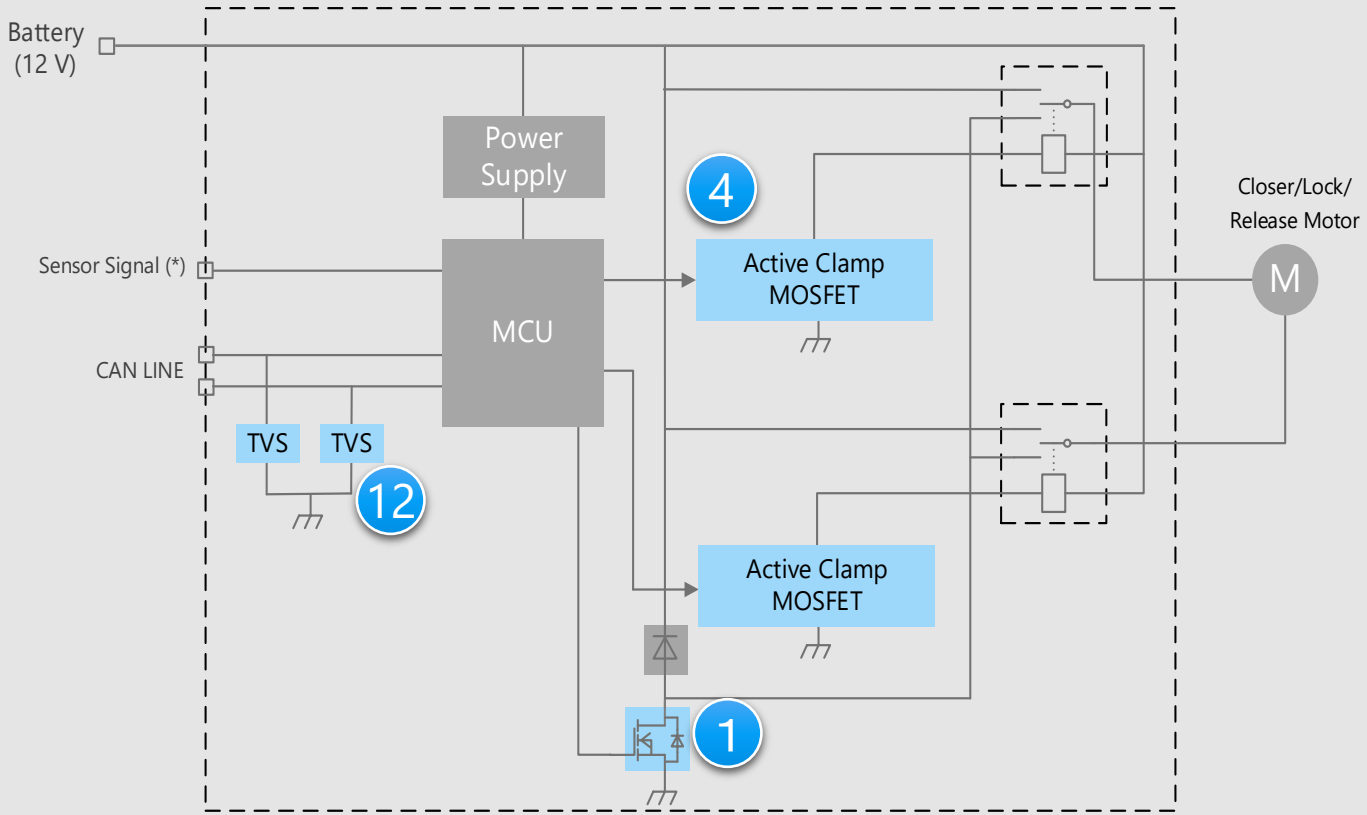
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET　1
  U-MOS Series 60 V N-ch MOSFET　2
- **H-bridge pre driver compliant with automotive functional safety standard**
  Brushed DC motor gate driver　3

Power Sliding Door　Detail of brushed DC motor drive circuit (2)

Drive circuit for brushed DC motor (2)



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

Criteria for device selection

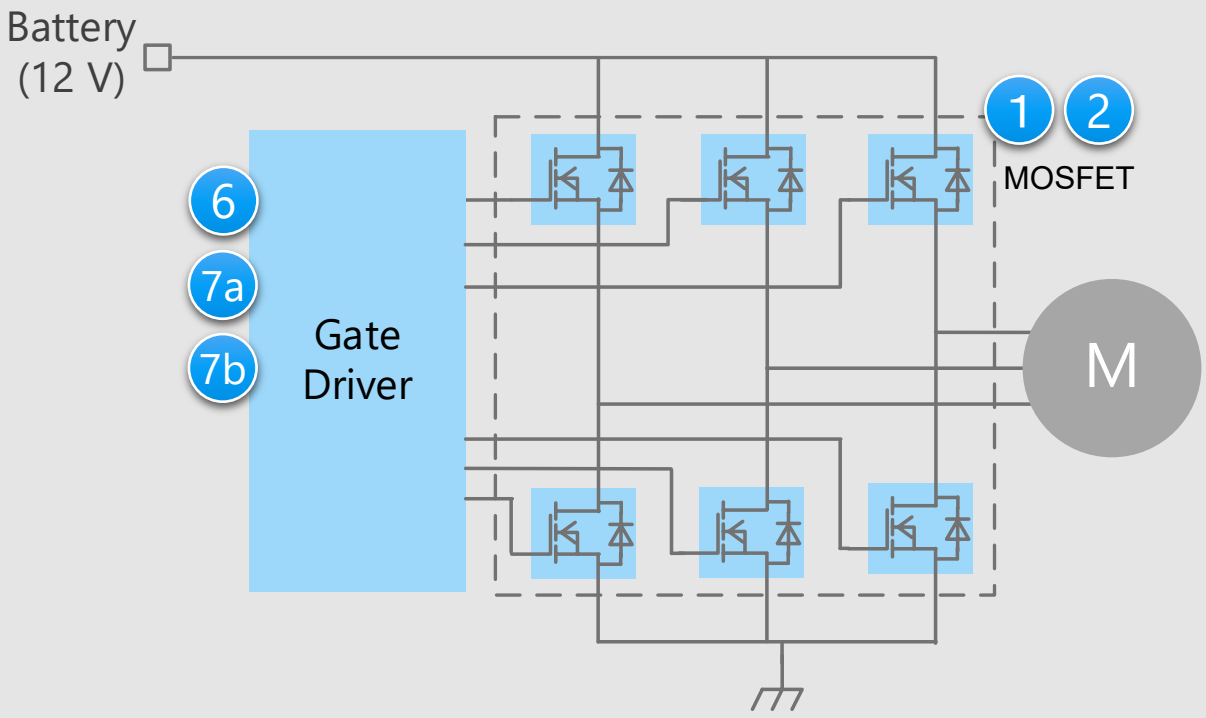
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET 1
- **Built-in active clamp circuit and pull-down resistor for relay drive**
  MOSFET with a built-in active clamp circuit 4
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 12

Power Sliding Door　Detail of brushless DC motor drive circuit

Drive circuit for brushless DC motor



* 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.

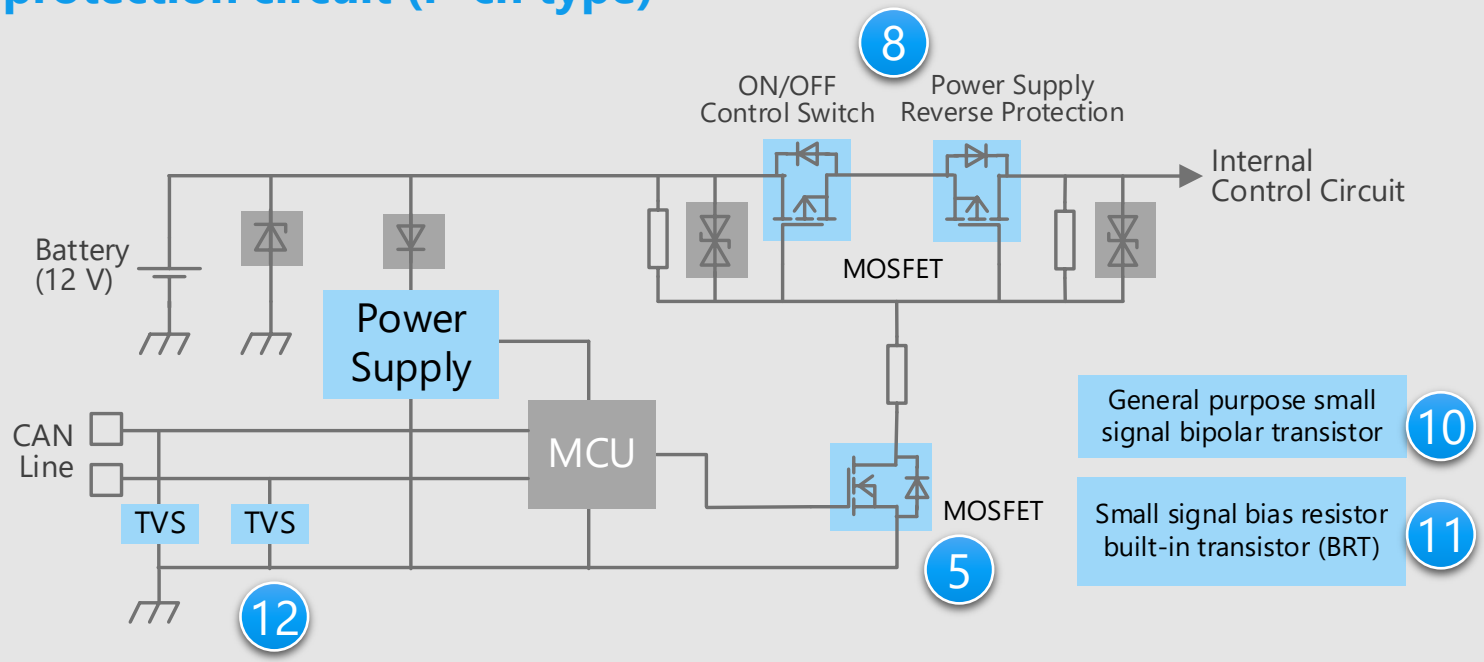
Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET
  U-MOS Series 60 V N-ch MOSFET
- **Gate driver with built-in protection and diagnosis functions**
  Gate driver (for motor)
- **Full bridge gate driver with a lineup according to the safety requirements of the system**
  Brushless DC motor gate driver

1 2 6 7a 7b

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

Power supply ON/OFF control and reverse connection protection circuit (P-ch type)



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

Criteria for device selection

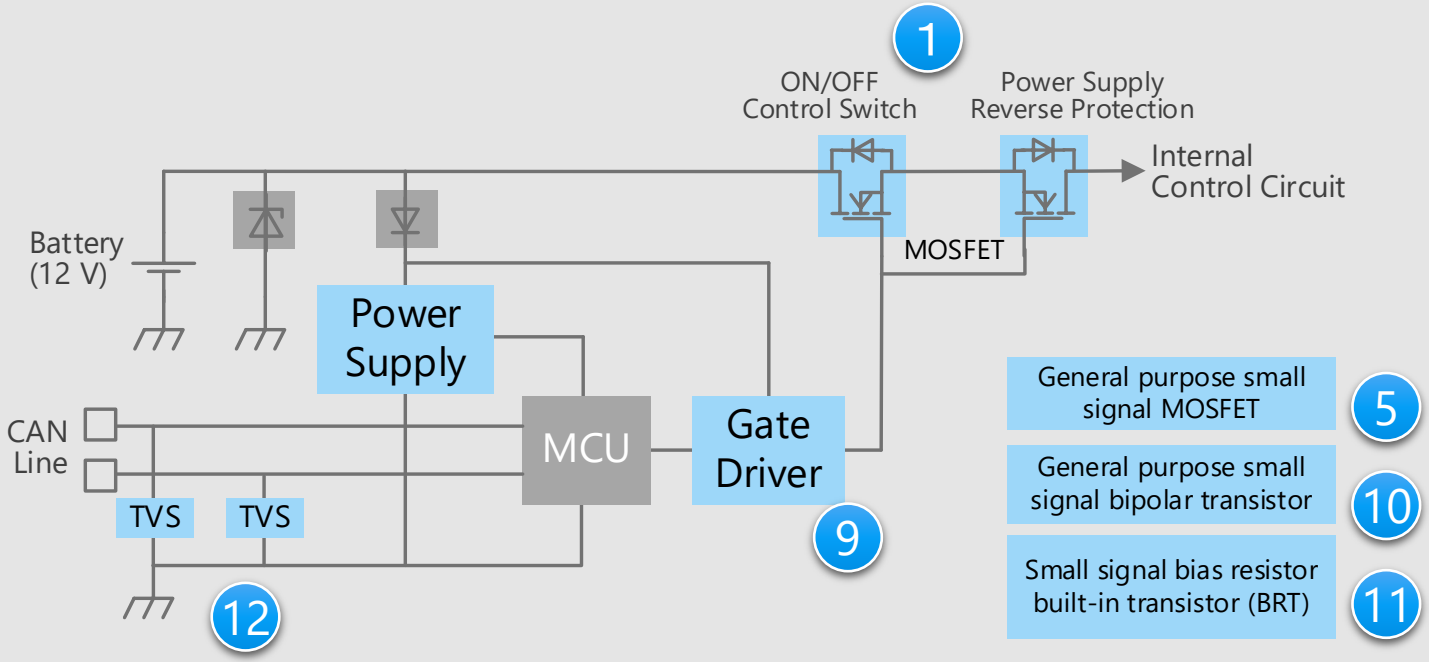
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series -40 V / -60 V P-ch MOSFET 8
- **Extensive product lineup**
  General purpose small signal MOSFET 5
  General purpose small signal bipolar transistor 10
  Small signal bias resistor built-in transistor (BRT) 11
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 12

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

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



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

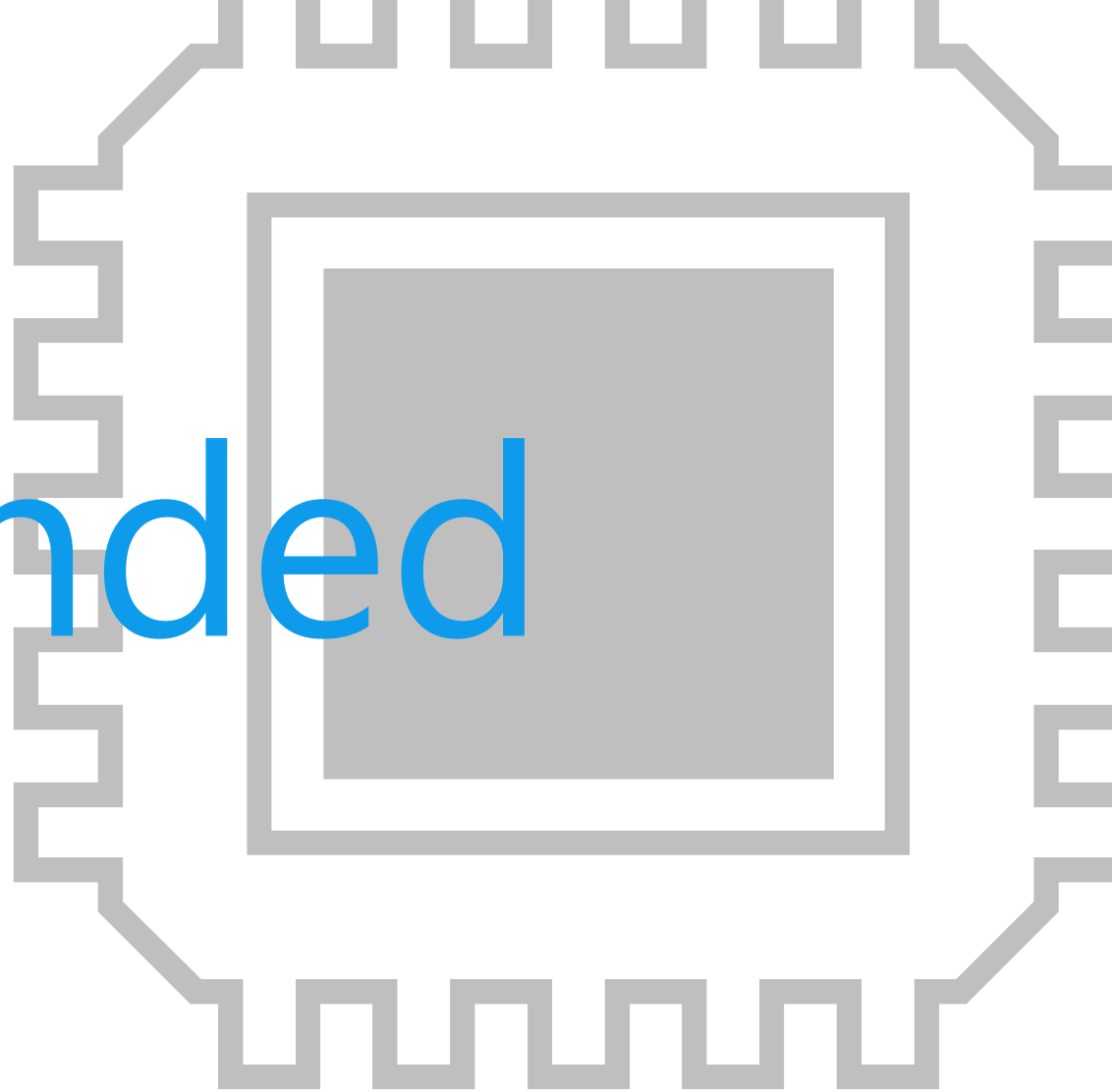
Criteria for device selection

- 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

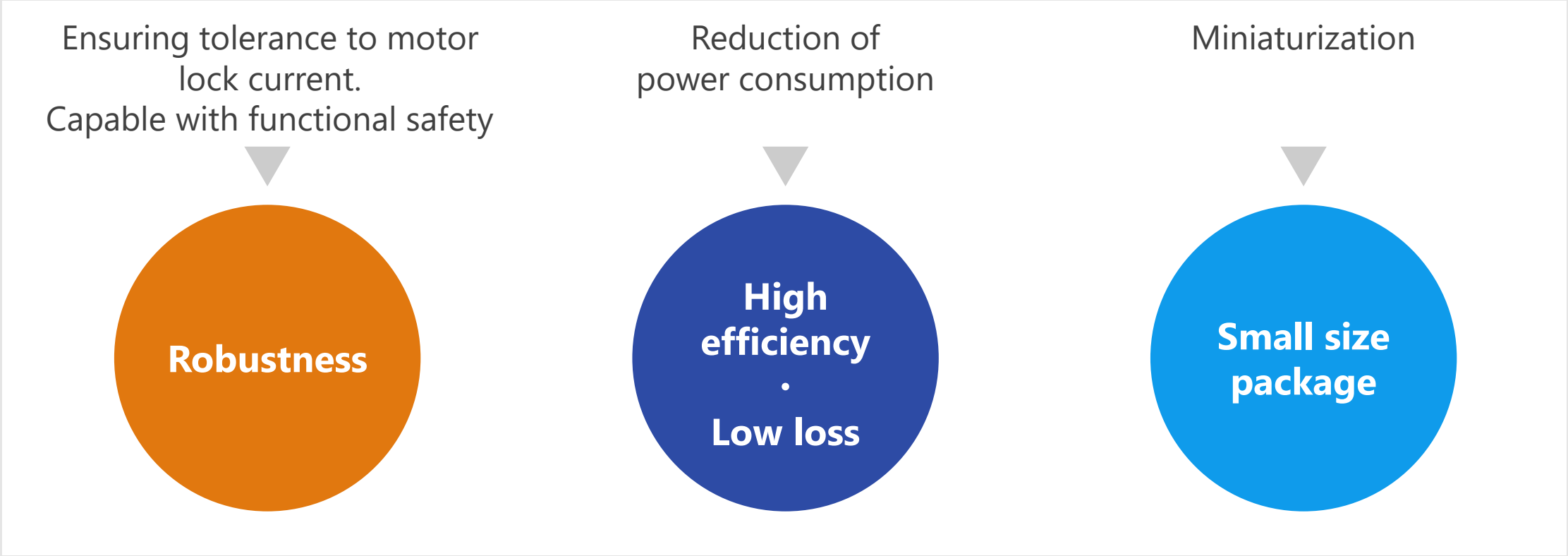
- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET 1
- **Gate driver with built-in protection and diagnosis functions**
  Gate driver (for switch) 9
- **Extensive product lineup** 5
  General purpose small signal MOSFET
  General purpose small signal bipolar transistor 10
  Small signal bias resistor built-in transistor (BRT) 11
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 12

Recommended Devices



Device solutions to address customer needs

As described above, in the design of Power Sliding Door, **“Ensuring tolerance to motor lock current. Capable with functional 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	U-MOS Series 40 V N-ch MOSFET	●	●	●
2	U-MOS Series 60 V N-ch MOSFET	●	●	●
3	Brushed DC motor gate driver	●	●	
4	MOSFET with a built-in active clamp circuit	●	●	●
5	General purpose small signal MOSFET		●	●
6	Gate driver (for motor)	●		●
7	Brushless DC motor gate driver	●	●	
8	U-MOS Series -40 V / -60 V P-ch MOSFET	●	●	●
9	Gate driver (for switch)	●		●
10	General purpose small signal bipolar transistor			●
11	Small signal bias resistor built-in transistor (BRT)			●
12	TVS diode (for CAN communication)	●		●

1 U-MOS Series 40 V N-ch MOSFET

XPN3R804NC / TK1R4S04PB / XPHR7904PS / TPWR7904PB / XPJR6604PB / XPQR3004PB

Robustness | 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)

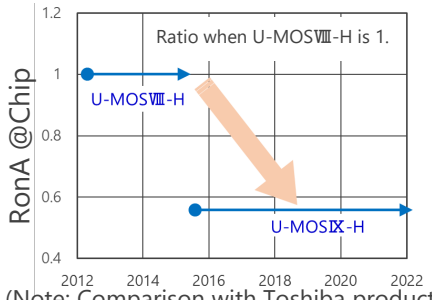
2 Small and low loss package

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)

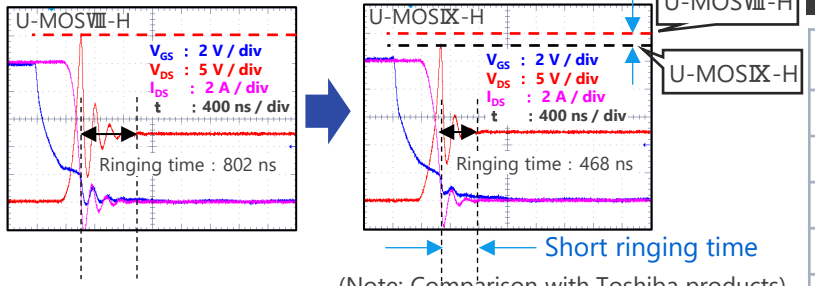
Improved chip process reduces surge voltage and ringing time.

Low loss: RonA trend



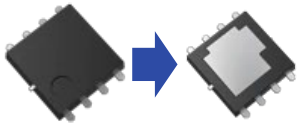
(Note: Comparison with Toshiba products)

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

High Current & Low resistance

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™

◆Return to Block Diagram TOP

2 U-MOS Series 60 V N-ch MOSFET

XPN12006NC / XPN6R706NC / XPH3R206NC / XPH2R106NC / TK90S06N1L

Robustness | High efficiency · Low loss | Small size package

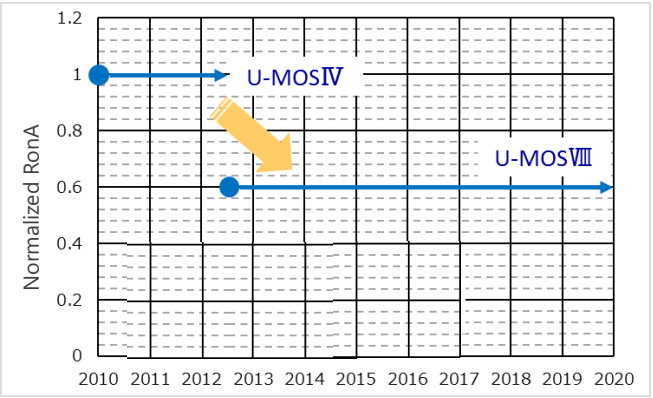
Value provided

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

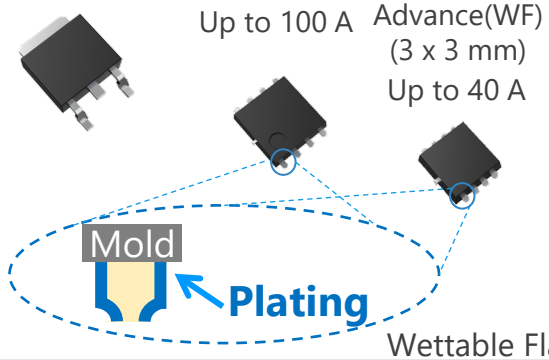
By adopting a Cu connector structure, a high power dissipation package is realized.
Wettable Flank (WF) package contributes to good mountability.

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 Brushed DC motor gate driver

TB9057FG

Robustness | High efficiency · Low loss | Small size package

Value provided

Compliant with automotive functional safety standard (ISO 26262 : ASIL-D) and motor current detecting function is built in.

1 Compliant with automotive functional safety standard

Compliant with ISO 26262 ASIL-D. [Note1] FMEDA [Note2] and safety manuals can be provided.

[Note1] Automotive Safety Integrity Level

[Note2] Failure Modes Effects and Diagnostics Analysis

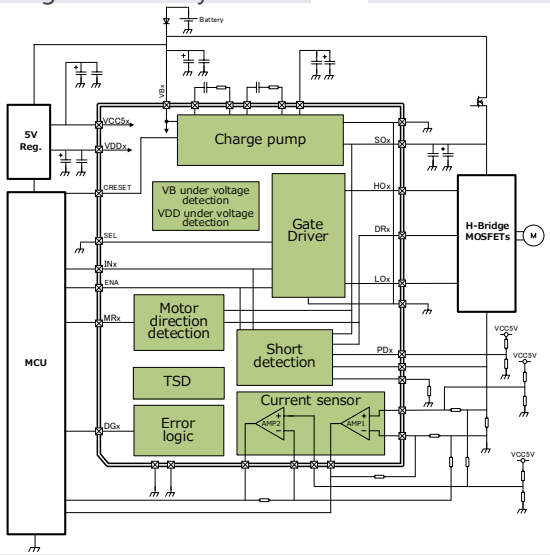
2 Built-in motor current detection amplifier

Two channels of motor current detection amplifiers are built in to make them redundant.

3 AEC-Q100 qualified

It is AEC-Q100 qualified and it can be used for various automotive applications.

TB9057FG
Reference Circuit Diagram



Lineup

Part number		TB9057FG
Package		LQFP48-P-0707-0.50C
Package body size		7.0 x 7.0 mm
Function	Control method	Direct
	External MOSFET (High side / Low side)	N-ch / N-ch
	Detection of overheating, low voltage and short circuit	✓
	Output of detection function diagnosis result	✓

◆Return to Block Diagram TOP

4 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.

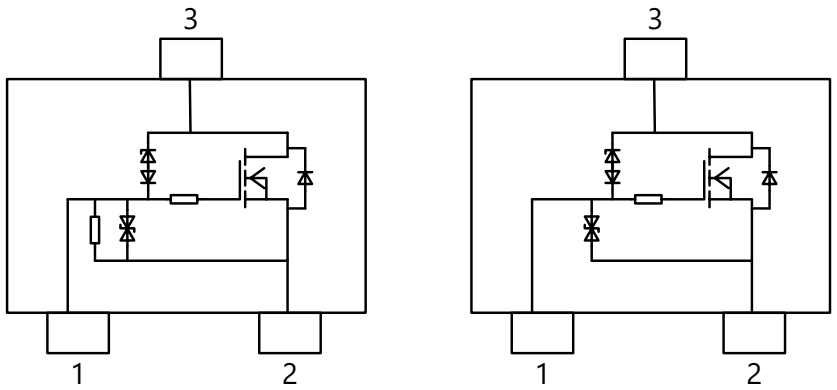
2 Built-in pull-down resistor

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



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 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.

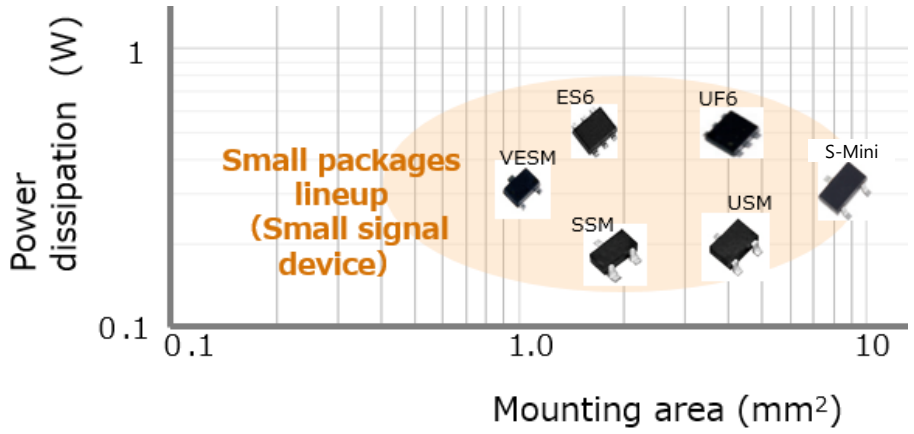
2 Low voltage drive

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

6 Gate driver (for motor)

TPD7211F / TPD7212F / TPD7212FN

Robustness | High efficiency · Low loss | Small size package

Value provided

The high gate drive current capability reduces MOSFET losses and improves the efficiency of system.

1 High gate drive current

High drive current capability and high speed switching contribute to reduce the loss.

TPD7211F: ±0.5 A

TPD7212F, TPD7212FN: -1 / +1.5 A

2 Built-in protection / diagnostic output function

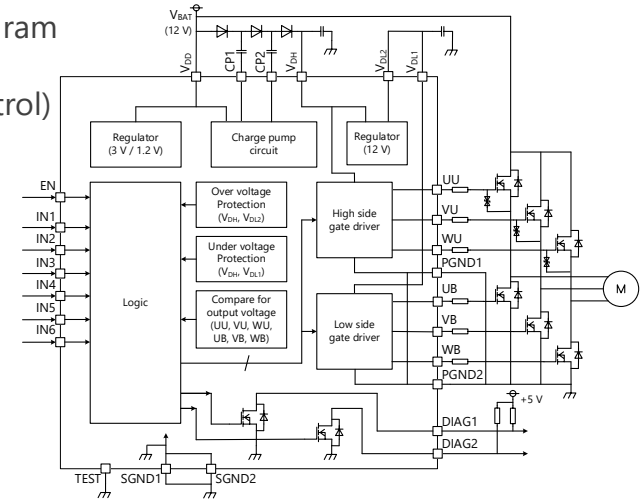
MOSFET is turn off when a signal is input that causes arm short circuit.

Functions to monitor abnormalities of the power supply voltage and output voltage are built-in.

3 Small surface mount package

PS-8, WQFN32 and SSOP30 are small surface mount packages. They contribute to the miniaturization of system.

Example of application and block diagram of TPD7212F, TPD7212FN
(Three phase brushless DC motor control)



Lineup

Part number	TPD7211F	TPD7212F / TPD7212FN
Function	Half bridge output gate driver	Gate driver for three-phase brushless motor
Number of output	2 outputs	6 outputs
Package	 PS-8 (2.8 x 2.9 mm)	TPD7212F Back surface P-WQFN32-0505-0.50-002  TPD7212FN SSOP30-P-300-0.65 
Features	・For high-side P-ch MOSFET drive	・For driving high-side N-ch MOSFET (with built-in charge pumps) ・Built-in voltage monitoring function (power supply, output)

◆Return to Block Diagram TOP

7a Brushless DC motor gate driver

TB9081FG / TB9083FTG

Robustness | High efficiency · Low loss | Small size package

Value provided

Compliant with automotive functional safety standard (ISO 26262 : ASIL-D) and safety relay drivers are built in.

1 Compliant with automotive functional safety standard

Compliant with ISO 26262 ASIL-D. [NOTE 1] FMEDA [NOTE 2] and safety manuals can be provided.

[NOTE 1] Automotive Safety Integrity Level
[NOTE 2] Failure Modes Effects and Diagnostics Analysis

2 Built-in safety relay drivers and motor current detection amplifiers

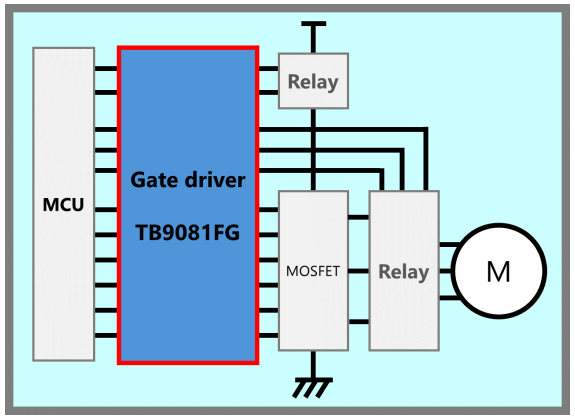
The safety relay drivers are built in for the power supply side MOSFETs and the motor phase cut MOSFETs. In addition, a 3 channels of motor current detection amplifiers are built in to support 3 shunts.

3 AEC-Q100 qualified

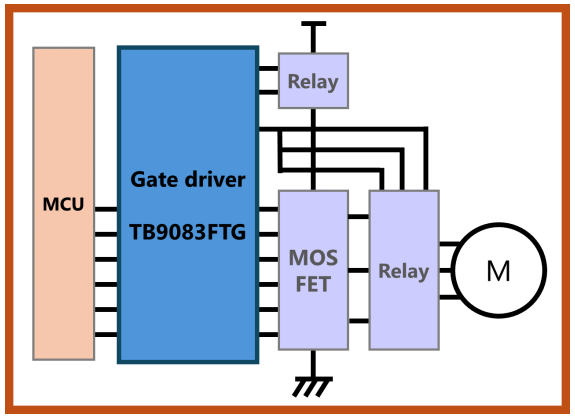
It is AEC-Q100 qualified and it can be used for various automotive applications.

Built-in safety relay drivers

TB9081FG : 5 channels



TB9083FTG : 3 channels



Lineup

Part number		TB9081FG	TB9083FTG
Package		LQFP64	VQFN48
Package body size		10.0 x 10.0 mm	7.0 x 7.0 mm
Operating ambient temperature		Ta = -40 to 125 °C	Ta = -40 to 150 °C
Function	Control method	Direct	Direct
	External MOSFET (High side / Low side)	N-ch / N-ch	N-ch / N-ch
	Detection of overheating, low voltage and short circuit	✓	✓
	Output of detection function diagnosis result	✓ (BIST [Note 3])	✓ (BIST)

[Note 3] Built-in Self Test

◆Return to Block Diagram TOP

7b Brushless DC motor gate driver

TB9084FTG *

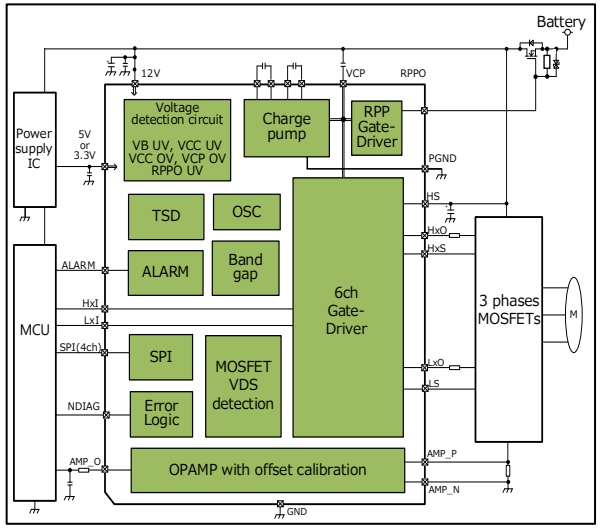
Robustness | High efficiency · Low loss | Small size package

Value provided

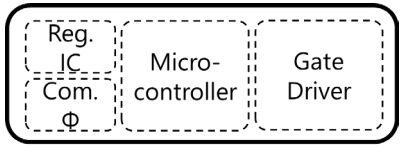
For various in-vehicle applications, it incorporates the minimum required functions as a gate driver IC.

1 Flexibility of system design

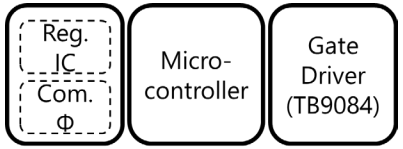
Compared to microcontroller-integrated products, this product has a separate configuration, so when system requirements are changed, replacing the corresponding external components enables flexible system design changes compared to built-in microcontroller products.



【Built-in microcontroller】



【Independent components】



2 Miniaturization of system size

The package size is the world's smallest class in the field of gate drivers for in-vehicle three-phase brushless DC motors. [Note1]

[Note1] Toshiba survey, as of September 2024.

Lineup

Part number		TB9084FTG *
Package		VQFN36
Package body size		6.0 x 6.0 mm
Operating ambient temperature(Ta)		-40 to 150 °C
Function	Control method	Direct
	External MOSFET (High side / Low side)	N-ch / N-ch
	Gate driver for external relays	1ch
	Current sense amplifier	1ch
	Detection of overheating low voltage and short circuit	○
	Output of detection function diagnosis result [Note2]	-

* : Under development [Note2] Built-in Self Test

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8 U-MOS Series -40 V / -60 V P-ch MOSFET

XPN9R614MC / XPH3R114MC / XPH8R316MC / TJ90S04M3L

Robustness | High efficiency · Low loss | Small size package

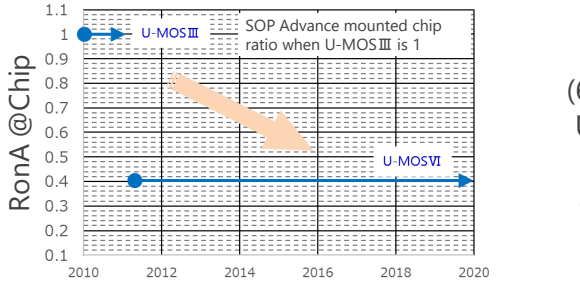
Value provided

Low on-resistance contributes to reduce system power consumption.

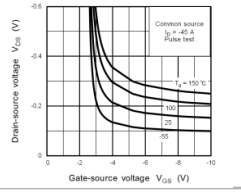
1 Low loss (reduced on-resistance) and logic level drive

Using a low on-resistance technology contributes to reduce system power consumption.
A lineup of logic level drive type is supported.
The on-resistance per area is reduced by 60 %.
(compared to Toshiba's U-MOSⅢ products)

Low loss: RonA reduction trend



(Note: Comparison with Toshiba products)



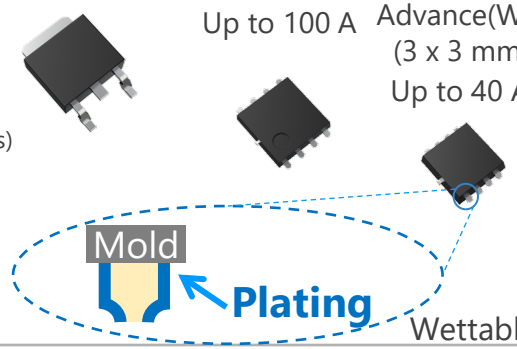
Logic level drive
TJ90S04M3L
$V_{DS(ON)}$ - V_{GS}

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

2 Small and low loss packages

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

Lineup

Part number	Rated drain-source voltage [V]	Rated drain current [A]	On-resistance (Max) [mΩ] @V_{GS} = -10 V	Package
XPN9R614MC	-40	-40	9.6	TSON Advance(WF)
XPH3R114MC	-40	-100	3.1	SOP Advance(WF)
XPH8R316MC	-60	-90	8.3	
TJ90S04M3L	-40	-90	4.3	DPAK+

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9 Gate driver (for switch)

TPD7104AF / TPD7106F / TPD7107F

Robustness | 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.

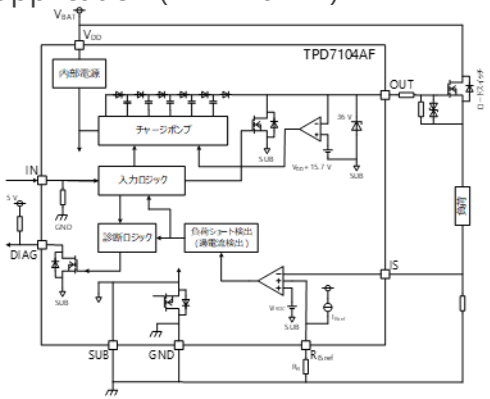
2 Can be controlled by logic level voltage

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

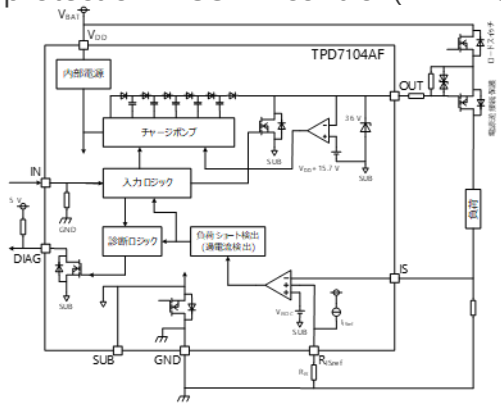
3 Small package

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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10 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.

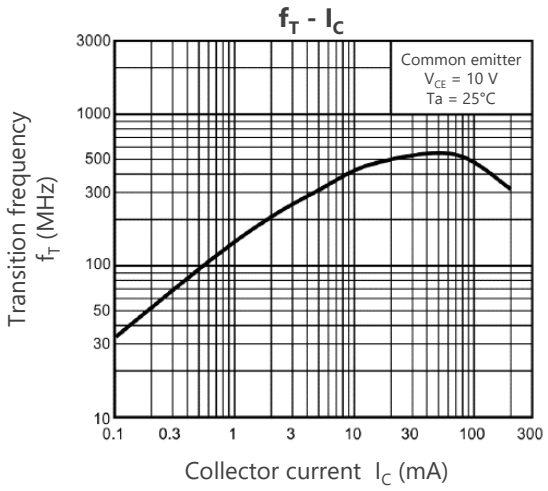
2 Extensive product lineup

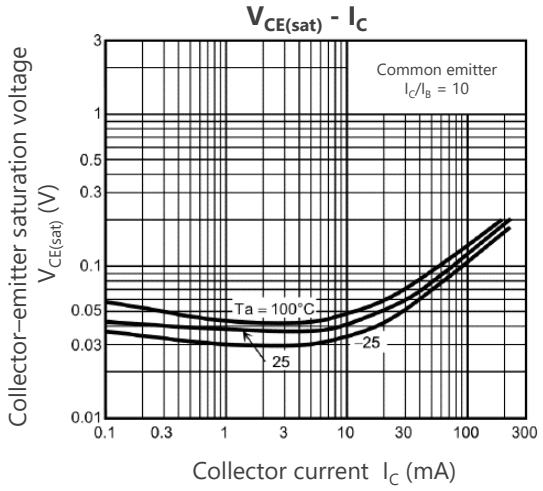
Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance with the application.

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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11 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)

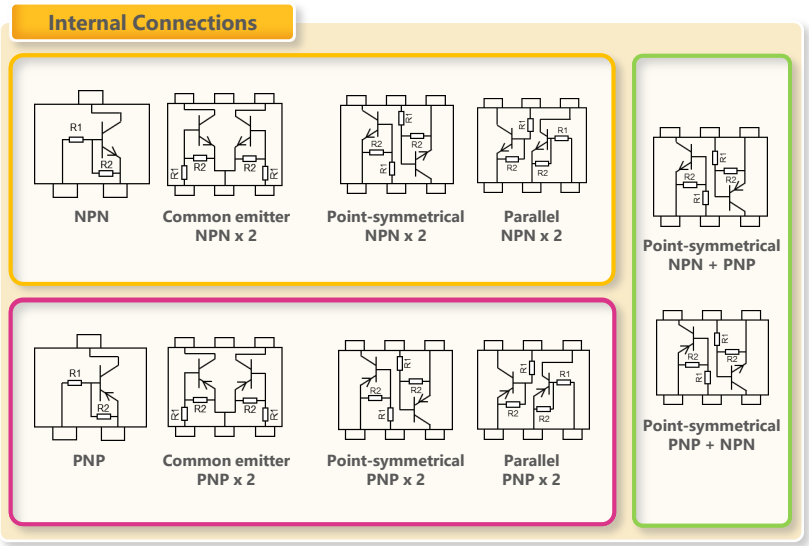
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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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12 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

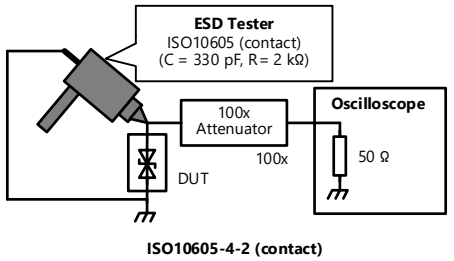
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Achieving both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

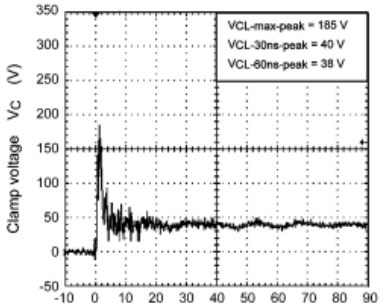
These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3 High ESD immunity

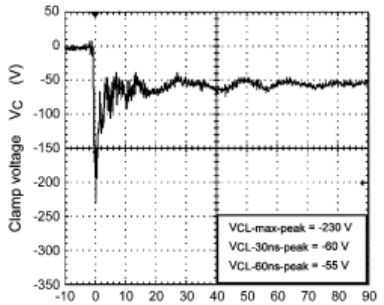
V_{ESD} > ±30 kV @ ISO 10605
V_{ESD} > ±20 kV @ IEC 61000-4-2 (Level 4)



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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