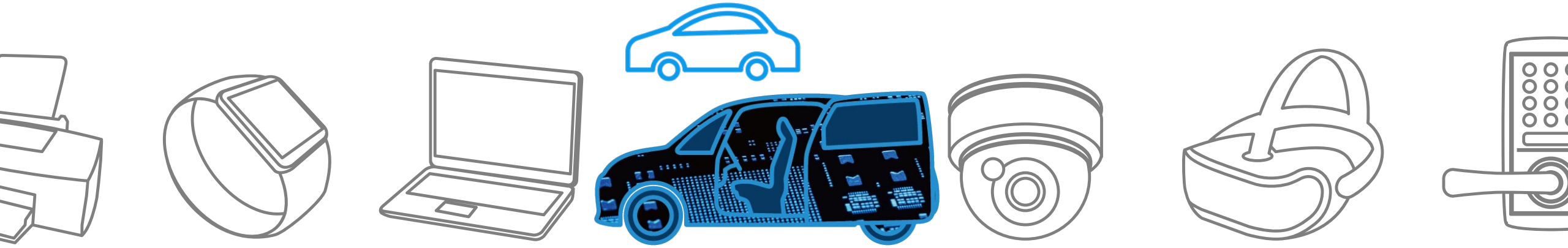
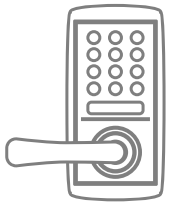
TOSHIBA

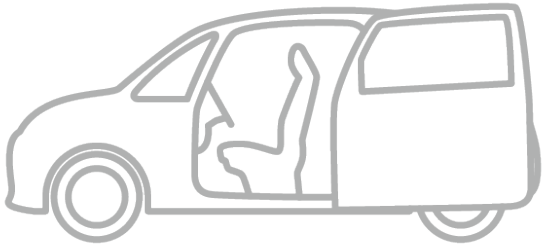
R20

Automotive Power Sliding Door

Solution Proposal by Toshiba

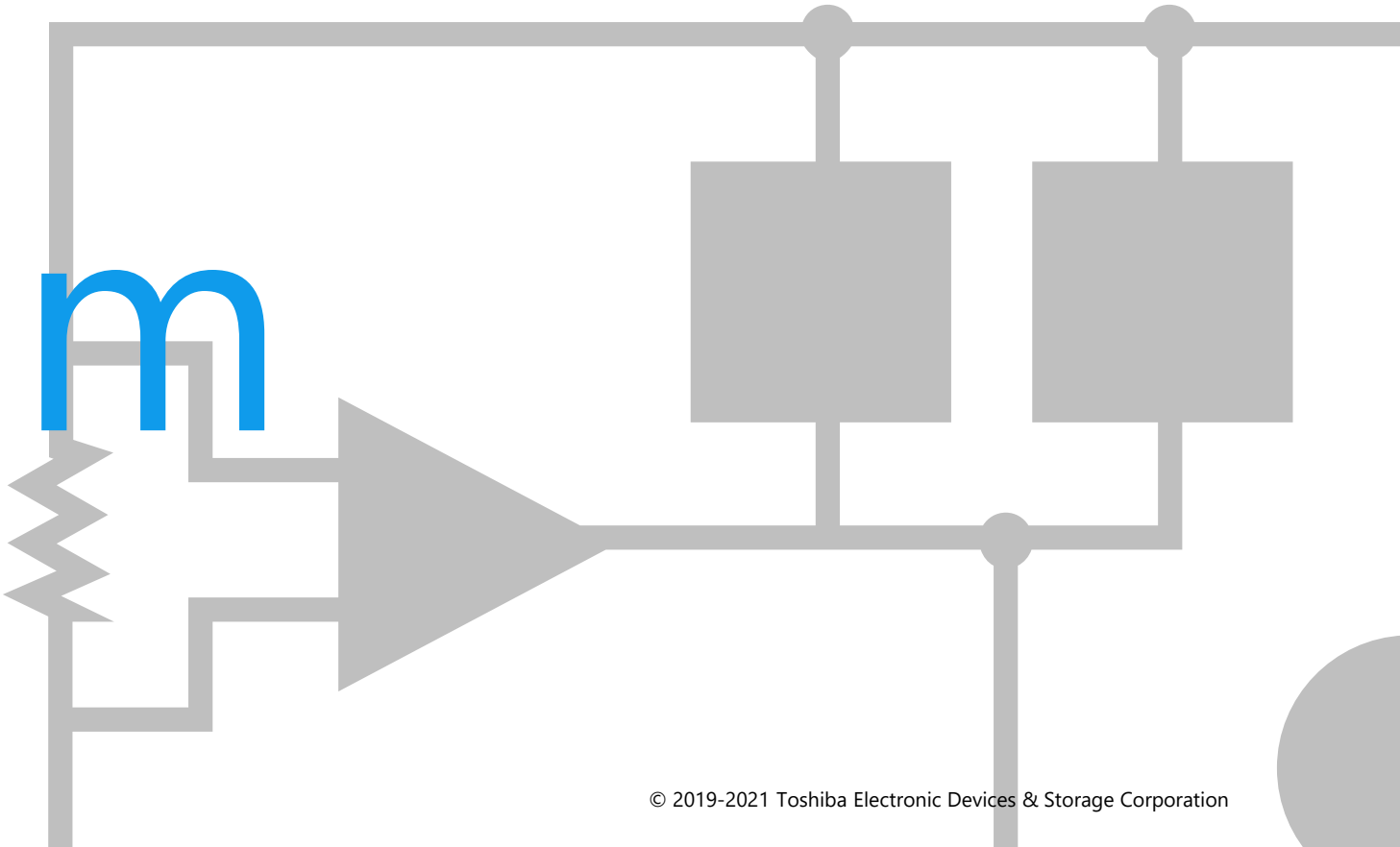




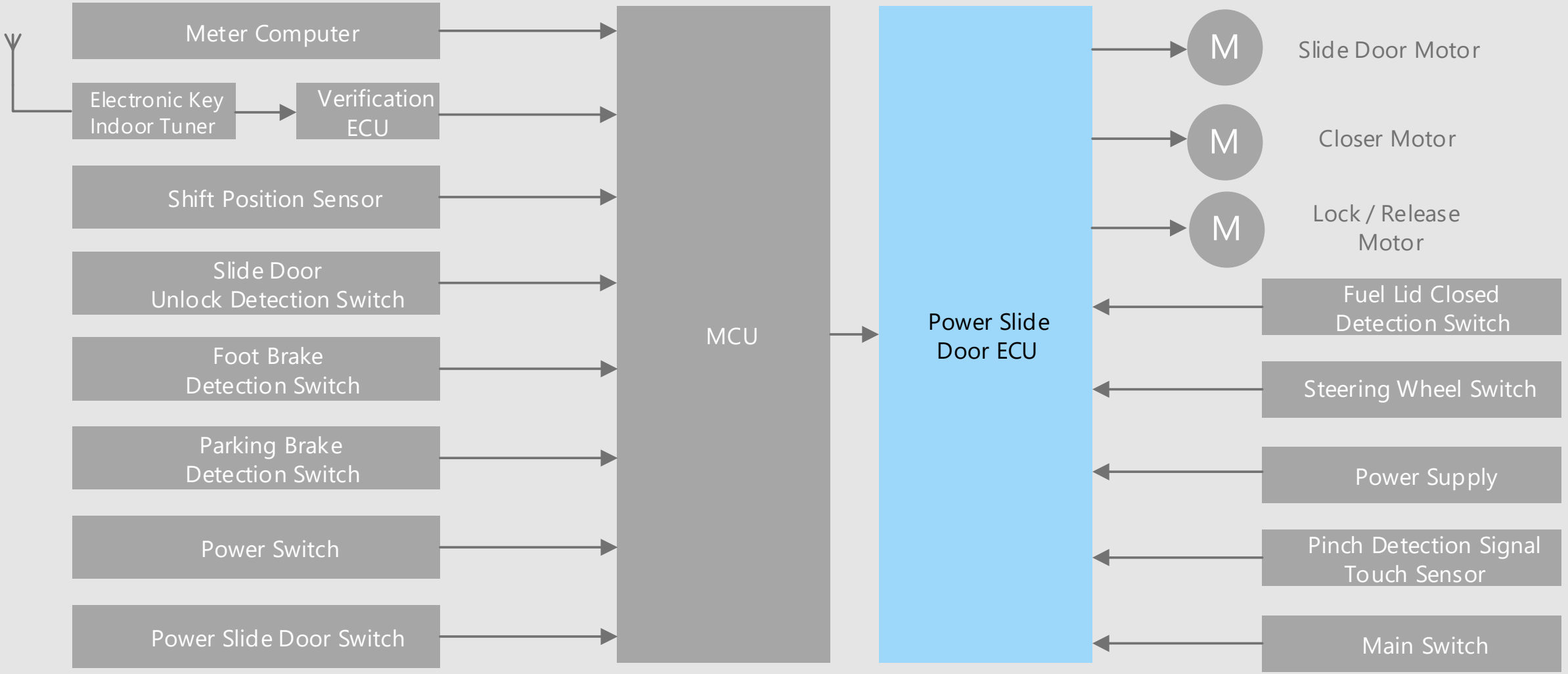


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

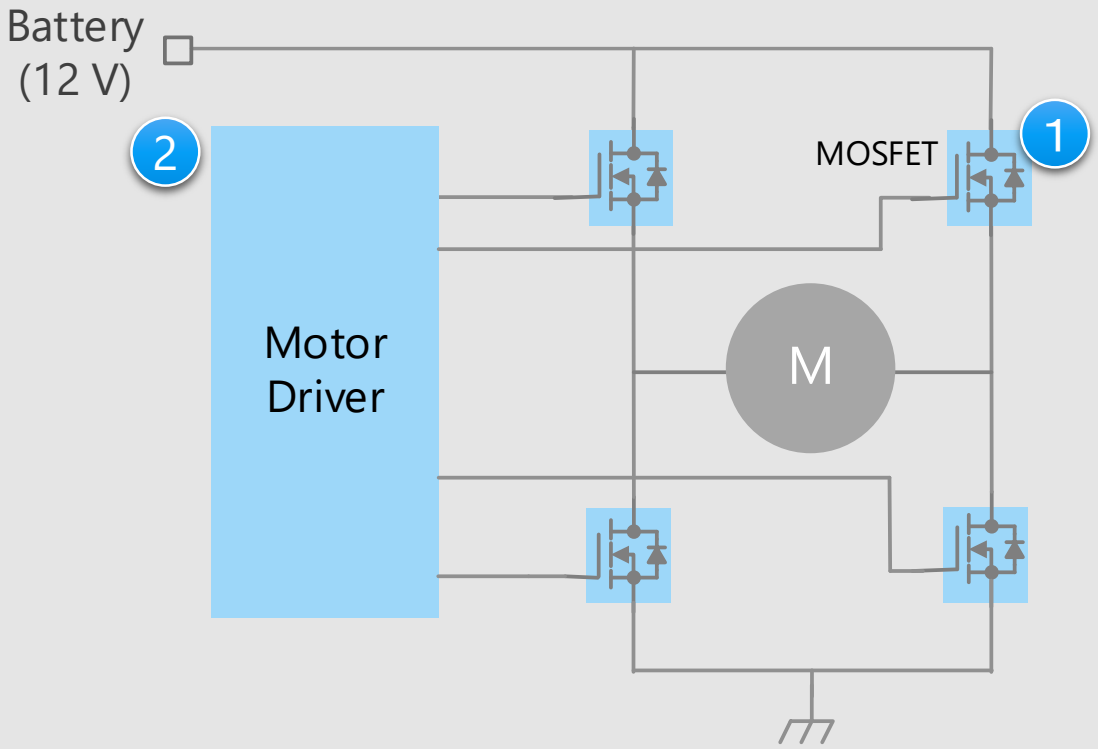


Power Sliding Door　Overall block diagram



Power Sliding Door　Detail of brushed DC motor drive (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

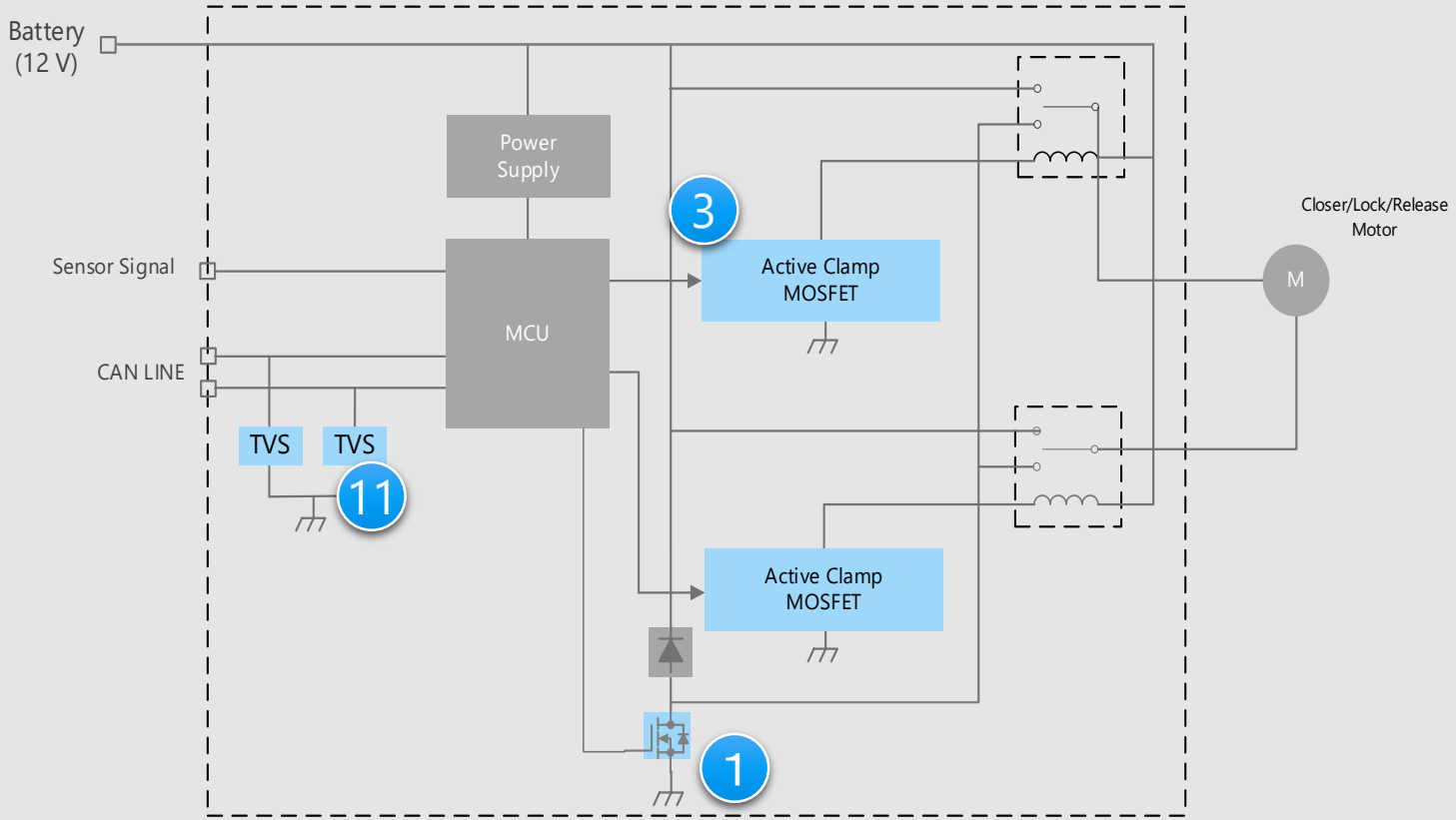
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

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

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

Drive circuit for brushed DC motor (2)



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Criteria for device selection

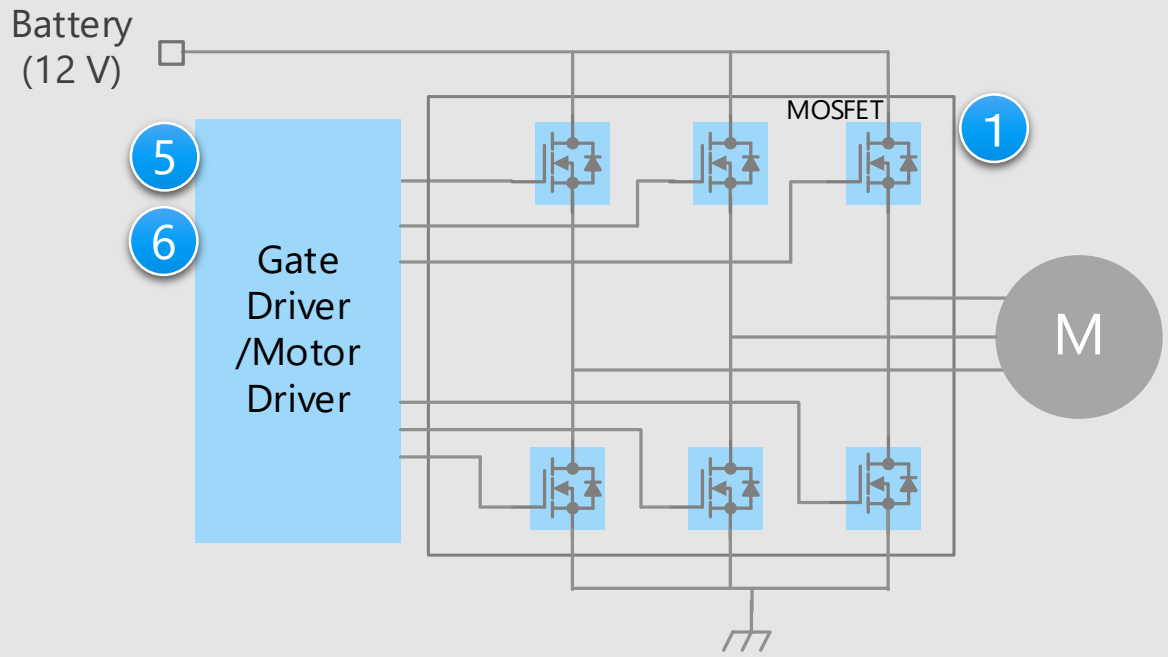
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET 1
- **Built-in active clamp circuit and pull-down resistor for relay drive**
  MOSFET with a built-in active clamp circuit 3
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 11

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.

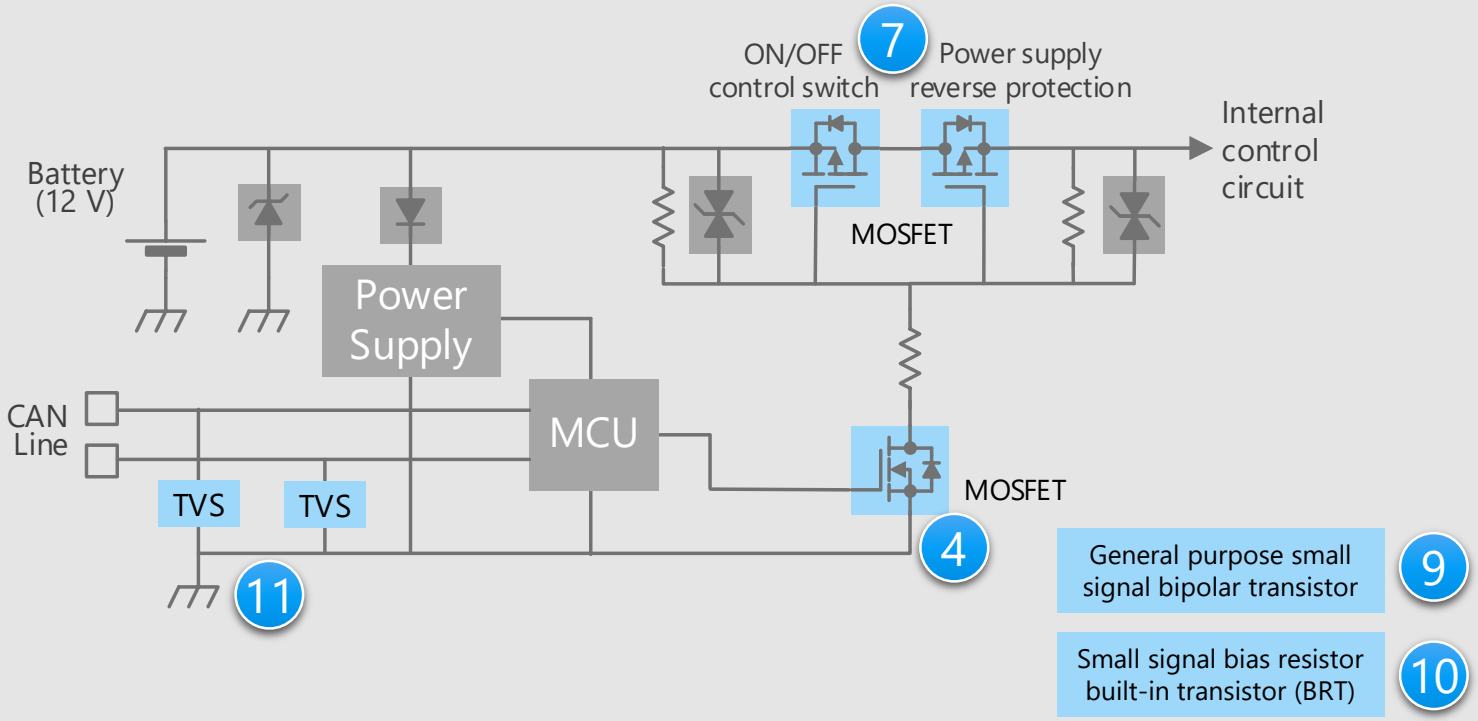
Proposals from Toshiba

- **Low on-resistance contributes 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 motor)　5
- **Pre driver with built-in safety relay drivers**
  Brushless DC motor pre driver　6

Power Sliding Door

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.
- 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.

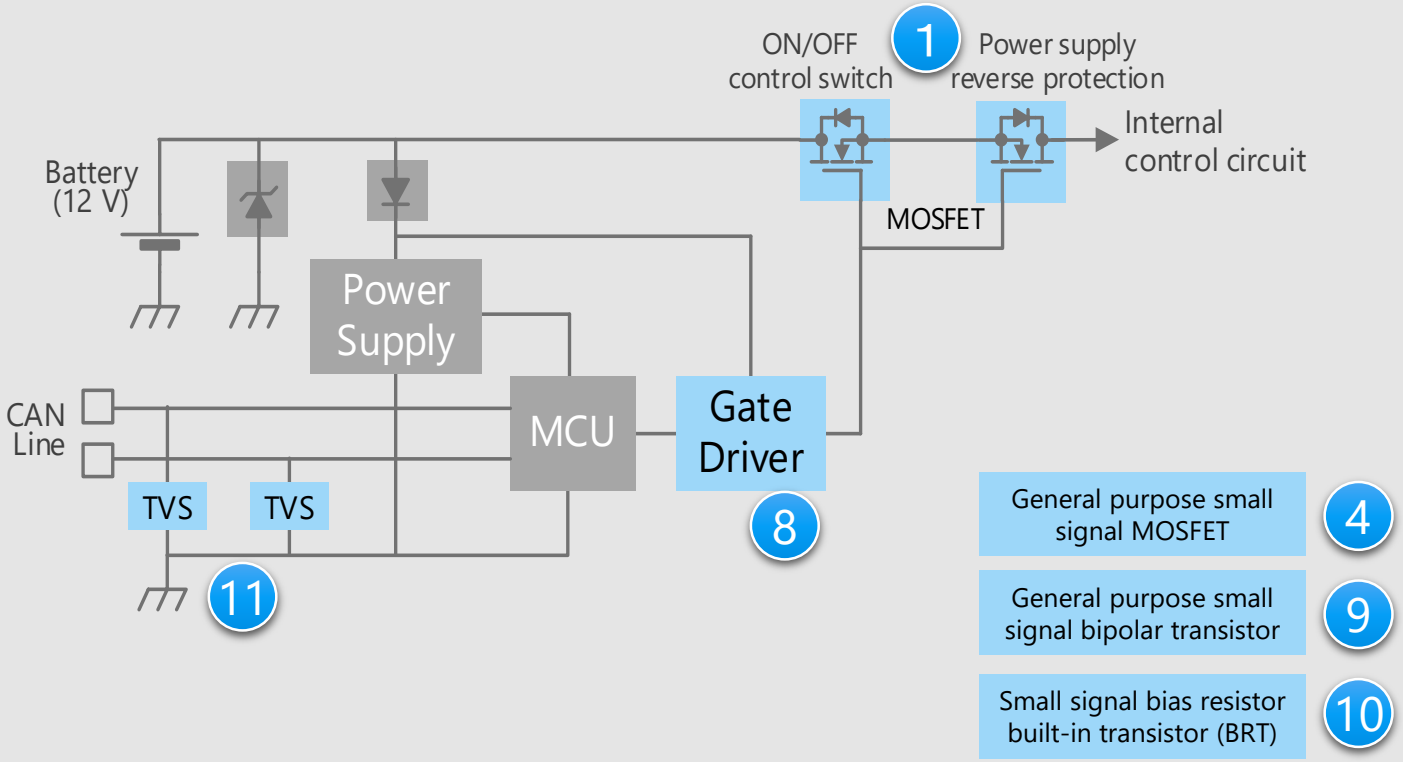
Proposals from Toshiba

- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series -40 V / -60 V P-ch MOSFET 7
- **Extensive product lineup**
  General purpose small signal MOSFET 4
  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

Power Sliding Door

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

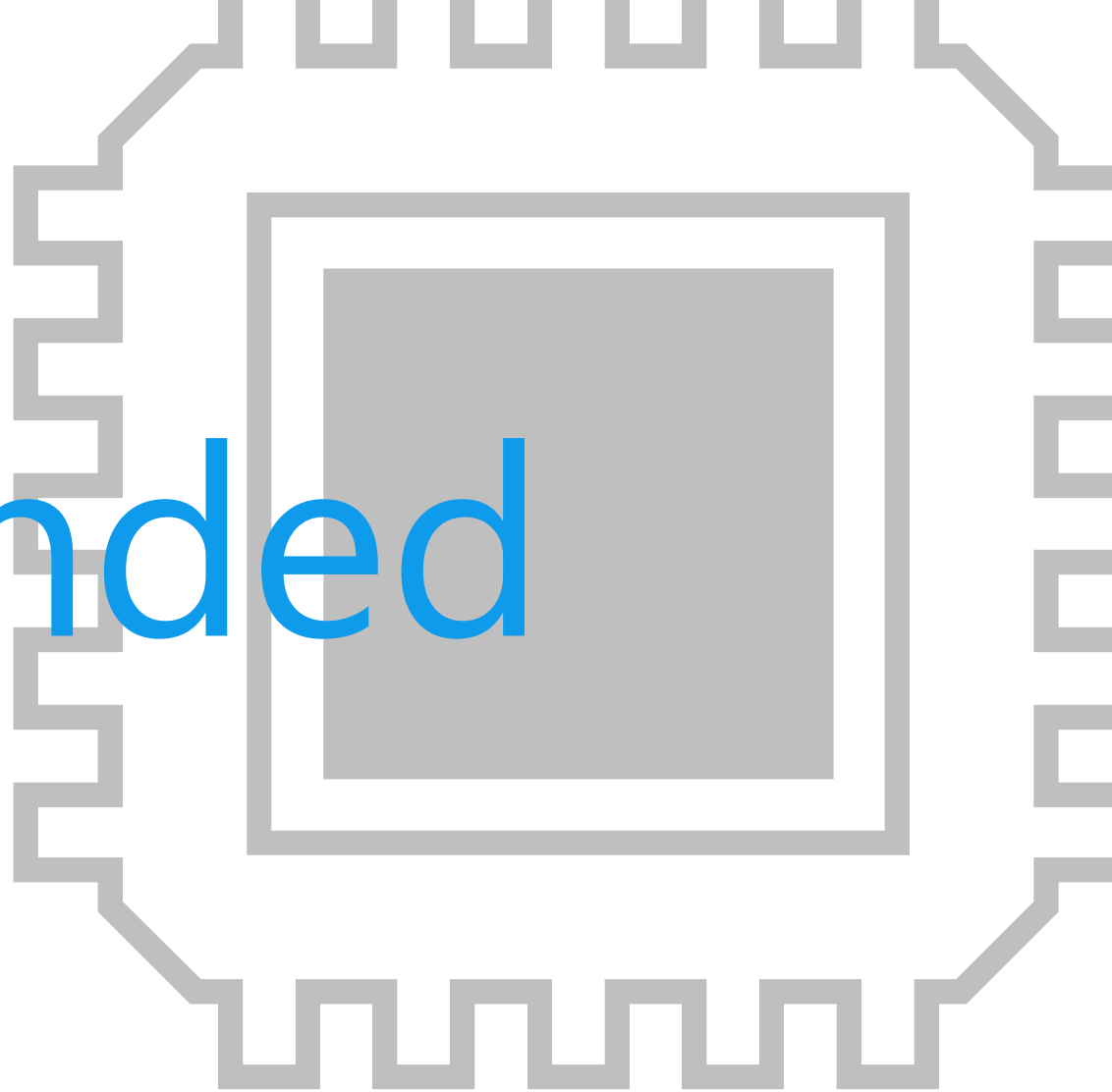
Criteria for device selection

- 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

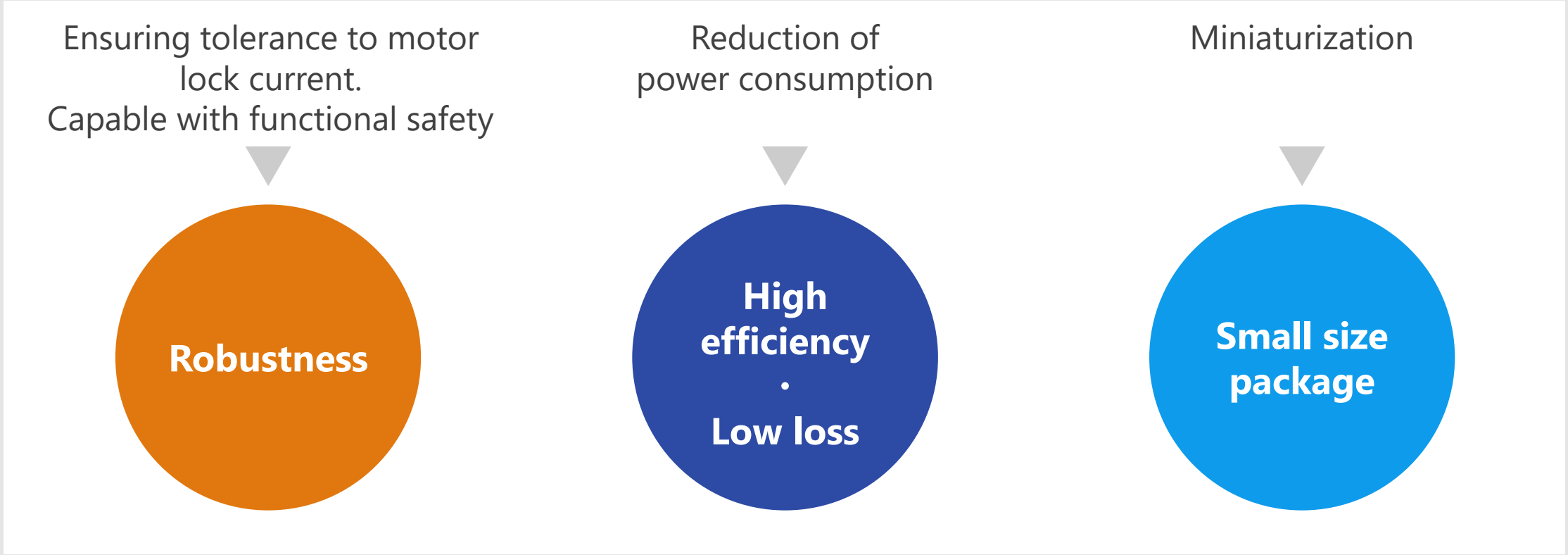
- **Low on-resistance contributes low power consumption of the system**
  U-MOS Series 40 V N-ch MOSFET 1
- **Gate driver with built-in protection and diagnosis functions**
  Gate driver (for switch) 8
- **Extensive product lineup**
  General purpose small signal MOSFET 4
  General purpose small signal bipolar transistor 9
  Small signal bias resistor built-in transistor (BRT) 10
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 11

Recommended Devices

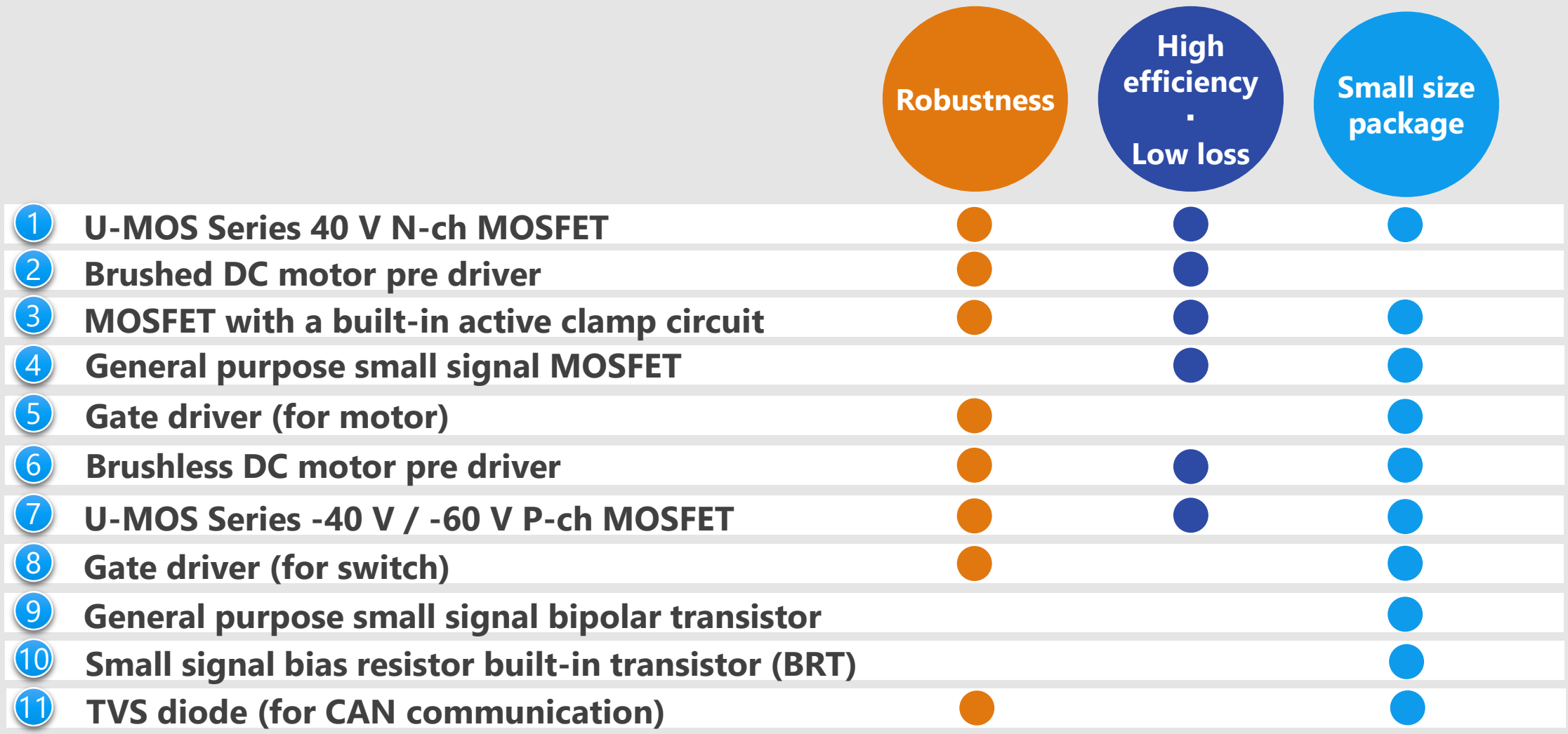


Device solutions to address customer needs

As described above, in the design of 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



1 U-MOS Series 40 V N-ch MOSFET

XPN3R804NC / TK1R4S04PB / TPHR7904PB / TPWR7904PB / TKR74F04PB / TK1R5R04PB

Robustness | High efficiency · Low loss | Small size package

Value provided

The advanced U-MOSⅨ-H 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 61 % reduction per unit area.
(compared to U-MOSⅣ)

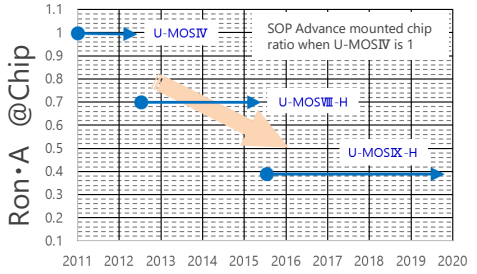
2 Compact and low loss package

By adopting a Cu connector structure and a double-sided heat dissipation structure, low loss and high heat dissipation are realized.
Wettable Frank (WF) package contributes good mountability.

3 Low noise (low EMI)

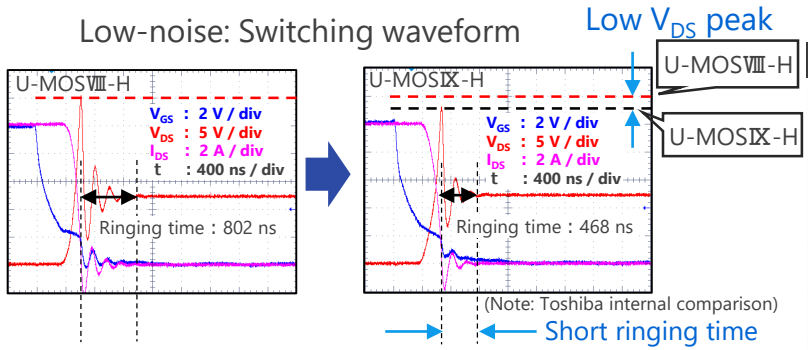
Improved chip process reduces surge voltage and ringing time.

Low Loss: RonA Trend



(Note: Toshiba internal comparison)

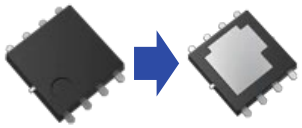
Low-noise: Switching waveform



TO-220SM(W) Cu connector design

Package resistance is reduced by 64 %, compared to D2PAK+.

DSOP Advance(WF)L double-sided cooling package



Thermal resistance is reduced by 76 % @t = 3 s, mounted on board compared to SOP Advance(WF).

Line up

Part number	Drain current	On-resistance (Max) @V_{GS} = 10 V	Package
XPN3R804NC	40 A	3.8 mΩ	TSON Advance(WF)
TK1R4S04PB	120 A	1.35 mΩ	DPAK+
TPHR7904PB	150 A	0.79 mΩ	SOP Advance(WF)
TPWR7904PB	150 A	0.79 mΩ	DSOP Advance(WF)L
TKR74F04PB	250 A	0.74 mΩ	TO-220SM(W)
TK1R5R04PB	160 A	1.5 mΩ	D2PAK+

◆Return to Block Diagram TOP

2 Brushed DC motor pre driver

TB9057FG

Robustness | High efficiency · Low loss | Small size package

Value provided

Compliant with automotive functional safety standard (ISO26262 : ASIL-D) and motor current detecting function is built in.

1 Compliant with automotive functional safety standard

Compliant with ISO26262 ASIL-D. [Note1] FMEDA [NOTE2] and safety manuals can be provided.

[Note1] Automotive Safety Integrity Level
[Note2] Failure Modes Effects and Diagnostics Analysis

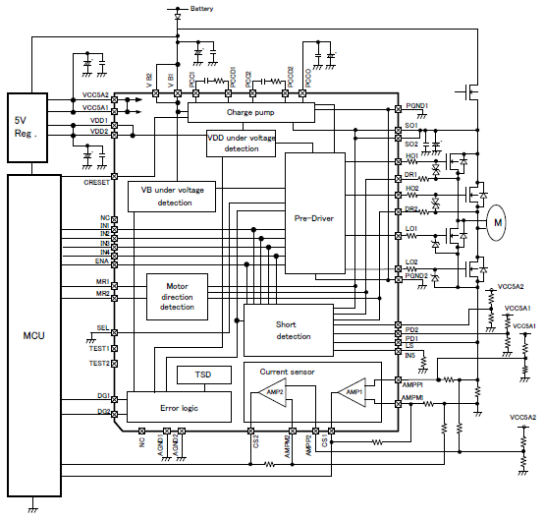
2 Built-in motor current detection amplifier

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 Typical Connection Diagram



Line up

Part number		TB9057FG
Package		LQFP48
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

3 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.

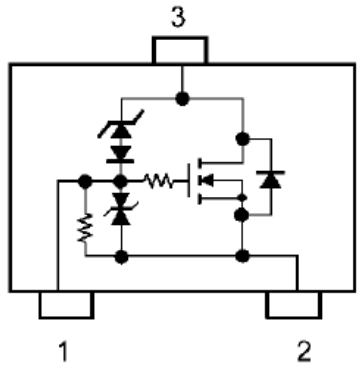
2 Built-in pull-down resistor

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.

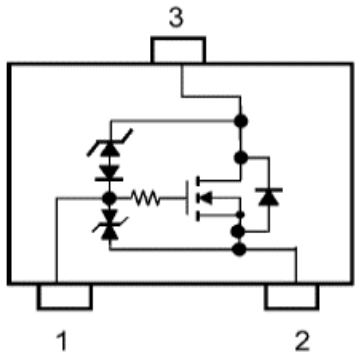
3 Low voltage drive

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

Internal circuit



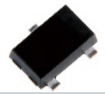
SSM3K347R



SSM3K337R

Pin Assignment
1. Gate
2. Source
3. Drain

Line up

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

◆Return to Block Diagram TOP

4 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.

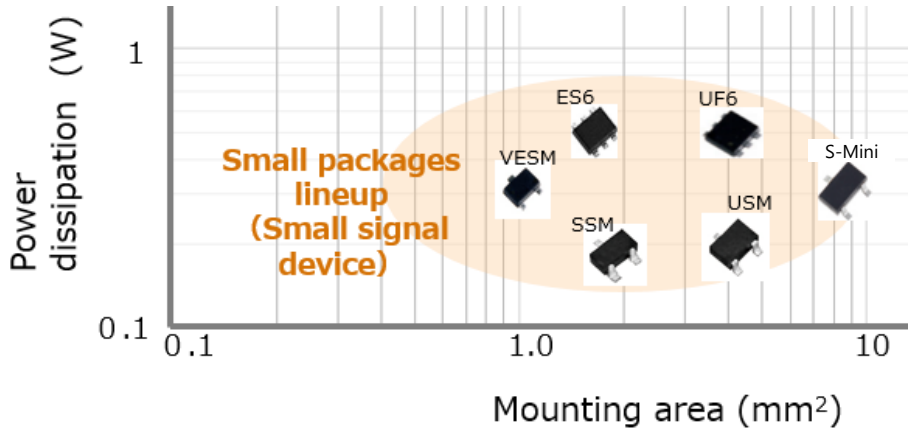
2 Low voltage drive

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



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	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

5 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

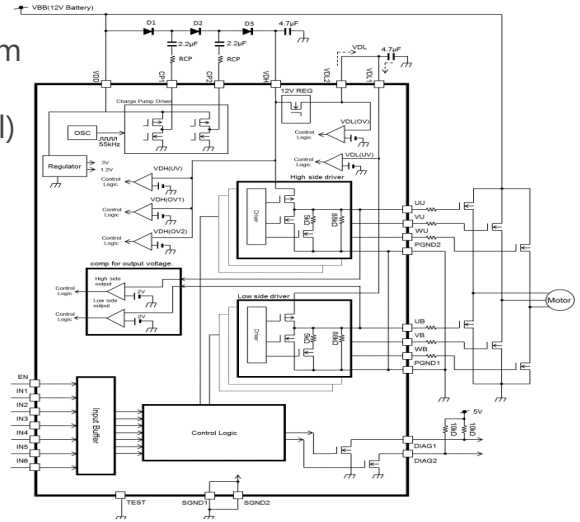
2 Built-in protection / diagnostic output function

- 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.

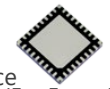
3 Small surface mount package

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

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



Line up

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  WQFN32 (5 x 5 mm) TPD7212FN  SSOP30 (7.6 x 10.2 mm)
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

6 Brushless DC motor pre 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.

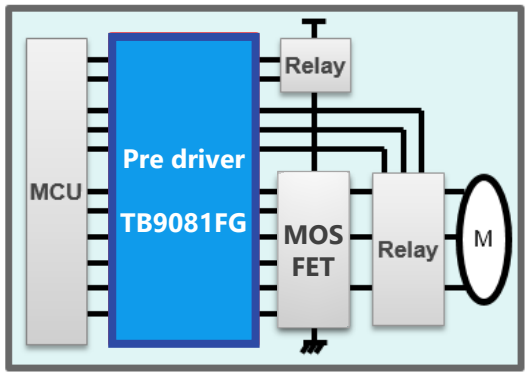
3 AEC-Q100 qualified

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

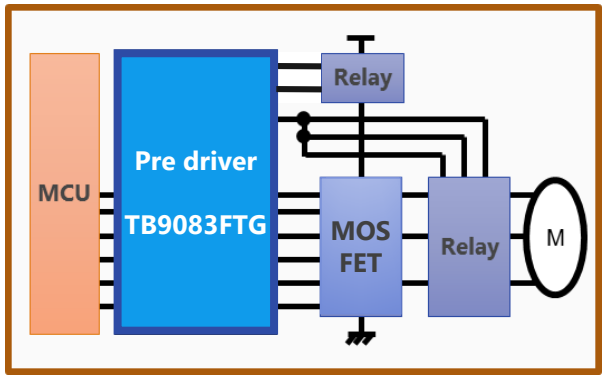
*: Under development (The specification is subject to change without notice.)

Built-in safety relay drivers

TB9081FG : 5 channels



TB9083FTG : 3 channels



Line up

Part number		TB9081FG	TB9083FTG*
Package		LQFP64	WQFN48
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])	✓ (BIST)

* TB9083FTG: Under development (The specification is subject to change without notice.)
**[Note] Built-in Self Test

◆Return to Block Diagram TOP

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

TJ90S04M3L / TJ60S06M3L / XPH3R114MC / TJ200F04M3L

Robustness | High efficiency · Low loss | Small size package

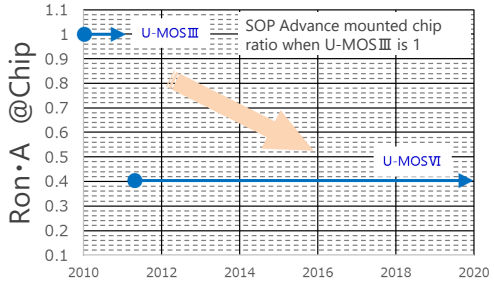
Value provided

Low on-resistance contributes to reduce system power consumption.

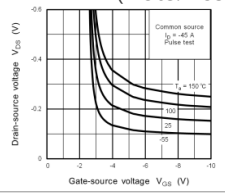
1 Low loss (reduced on-resistance) and logic level drive

Using low on-resistance technology contributes to reduce system power consumption.
Lineups of logic level drive type are supported.

Low Loss: RonA Reduction Trend



(Note: Toshiba internal comparison)



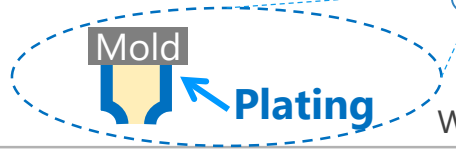
Logic level drive
TJ90S04M3L
$V_{DS(ON)}$ - V_{GS}

Large current, small size, high heat dissipation package

TO-220SM(W)
(10 x 13 mm)
Up to 200 A

DPAK+
(6.5 x 9.5 mm)
Up to 90 A

SOP Advance(WF)
(5 x 6 mm)
Up to 100 A



Wettable Flank (WF) structure

2 Small surface mount package developed

By adopting a Cu connector structure and a double-sided heat dissipation structure, low loss and high heat dissipation are realized.
Wettable Frank (WF) package contributes good mountability.

Line up

Part number	Drain-source Voltage	Drain current	On-resistance (Max) @V_{GS} = -10 V	Package
TJ90S04M3L	-40 V	-90 A	4.3 mΩ	DPAK+ 
TJ60S06M3L	-60 V	-60 A	11.2 mΩ	
XPH3R114MC	-40 V	-100 A	3.1 mΩ	SOP Advance(WF) 
TJ200F04M3L	-40 V	-200 A	1.8 mΩ	TO-220SM(W) 

◆Return to Block Diagram TOP

8 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.

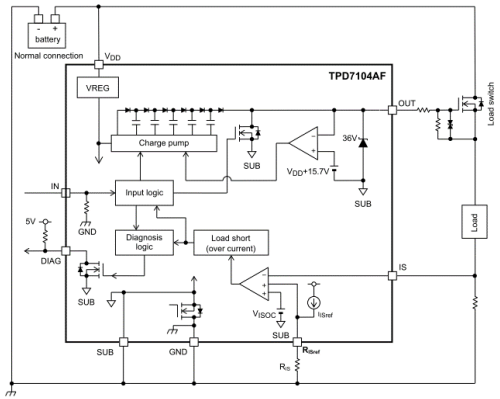
2 Can be controlled by logic level voltage

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

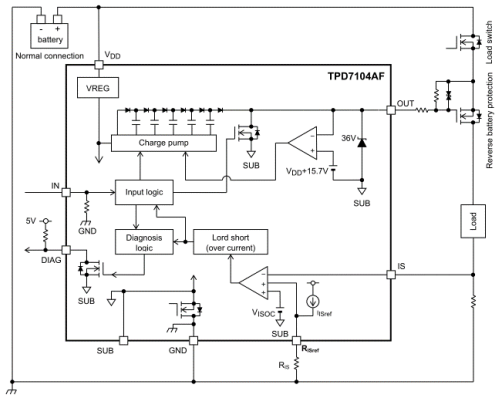
3 Small package

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	・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)	・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)	・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

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.

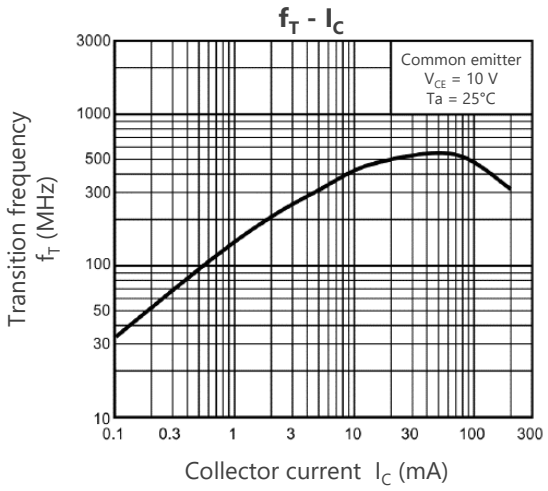
2 Extensive product lineup

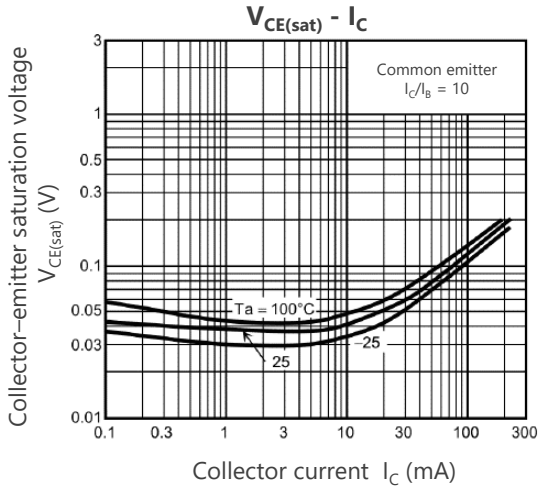
Various product lineups, such as general purpose, low noise, low $V_{CE(sat)}$ and high current types are provided. Products can be selected in accordance to the application.

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	$\|V_{CEO}\|$ [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					

◆Return to Block Diagram TOP

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)

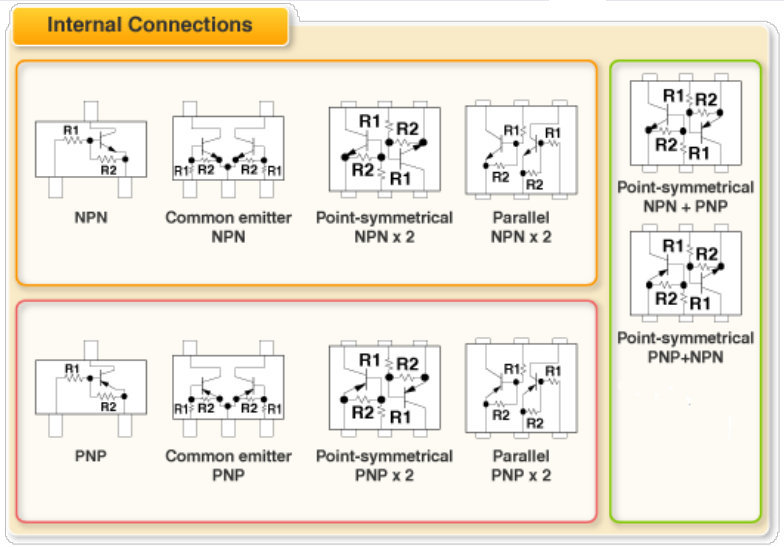
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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.



Line up

Part number		NPN (BRT)	PNP (BRT)
Package	ES6 (SOT-563)	RN1907FE	RN2907FE
	US6 (SOT-363)	RN1901	RN2901
V_{CEO} (Max) [V]		50	-50
I_C [mA]		100	-100

◆Return to Block Diagram TOP

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

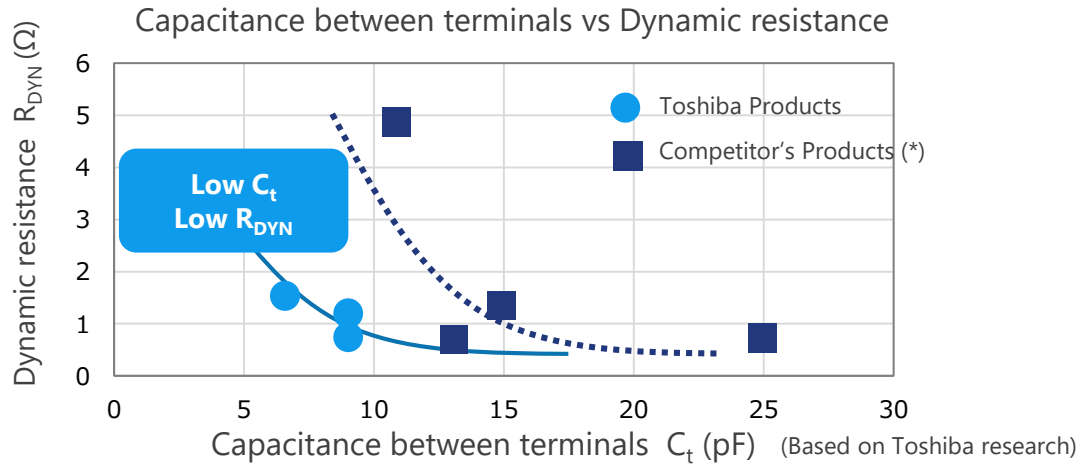
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

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 (L4) @ IEC61000-4-2



(Based on Toshiba research)

(NOTE) : This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

(*): Measurements of the commercial product

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

◆Return to Block Diagram TOP

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