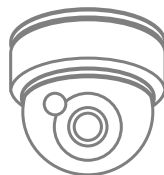
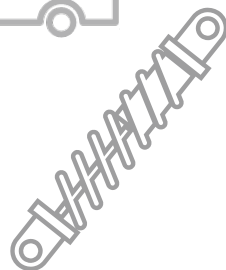
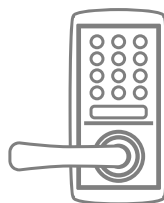


Automotive Electro Active Suspension

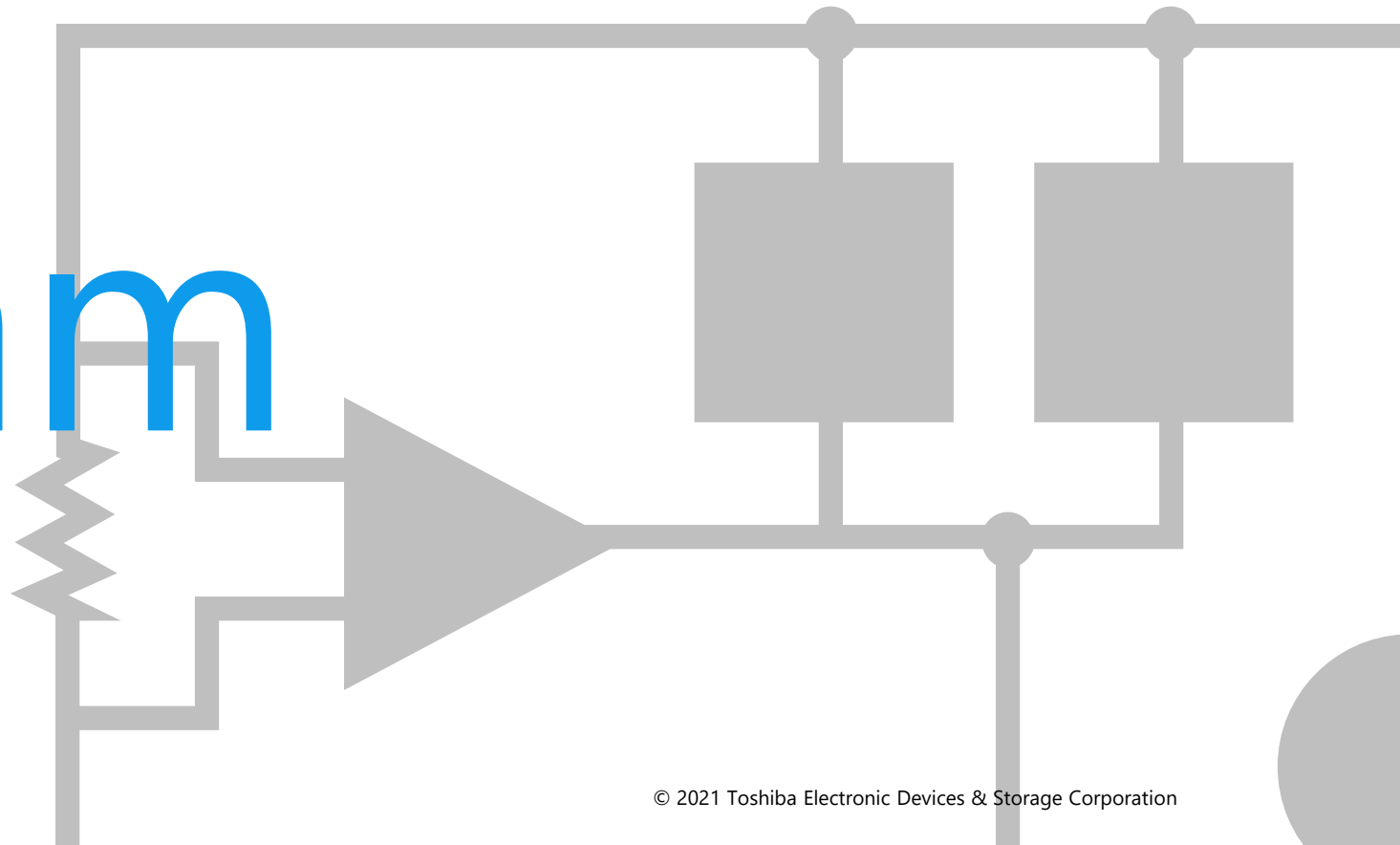
Solution Proposal by Toshiba



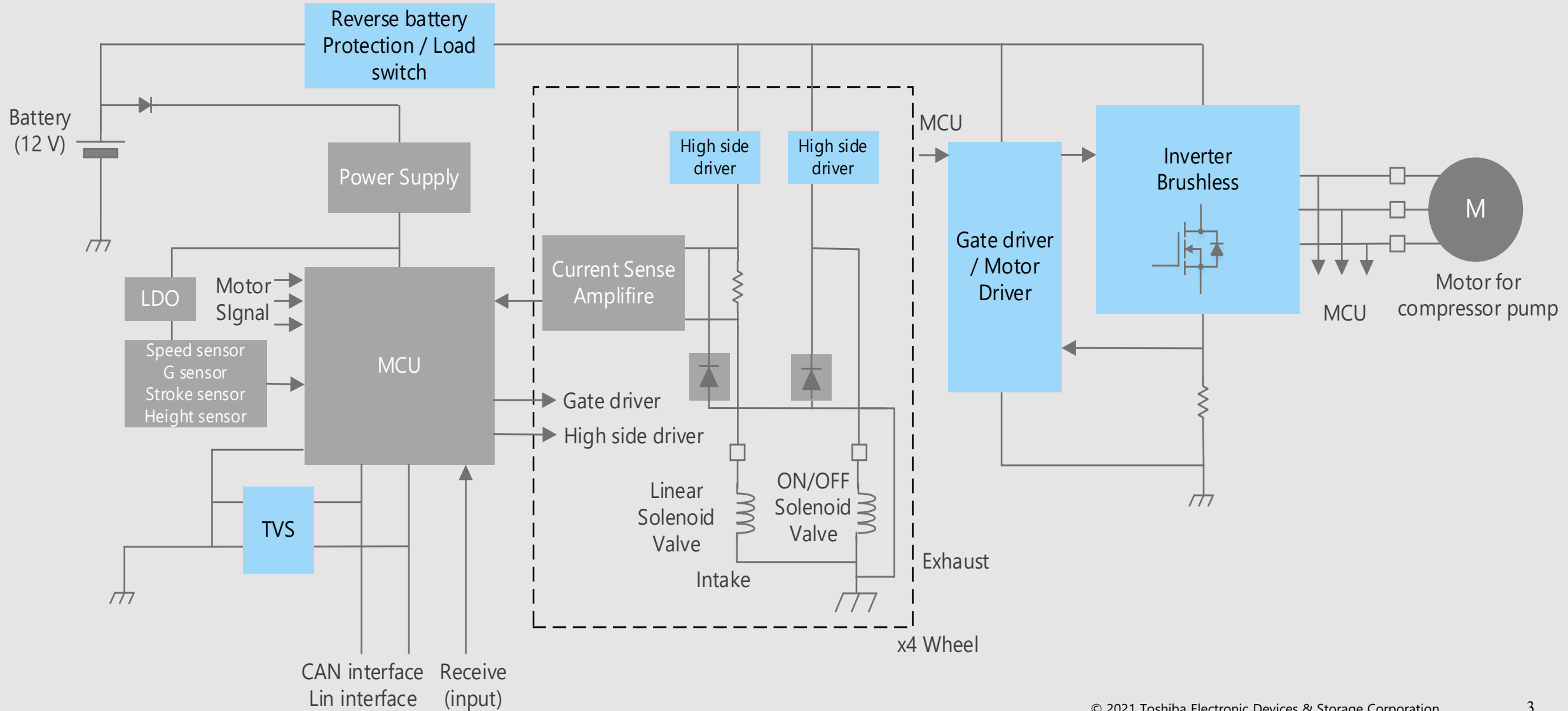


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

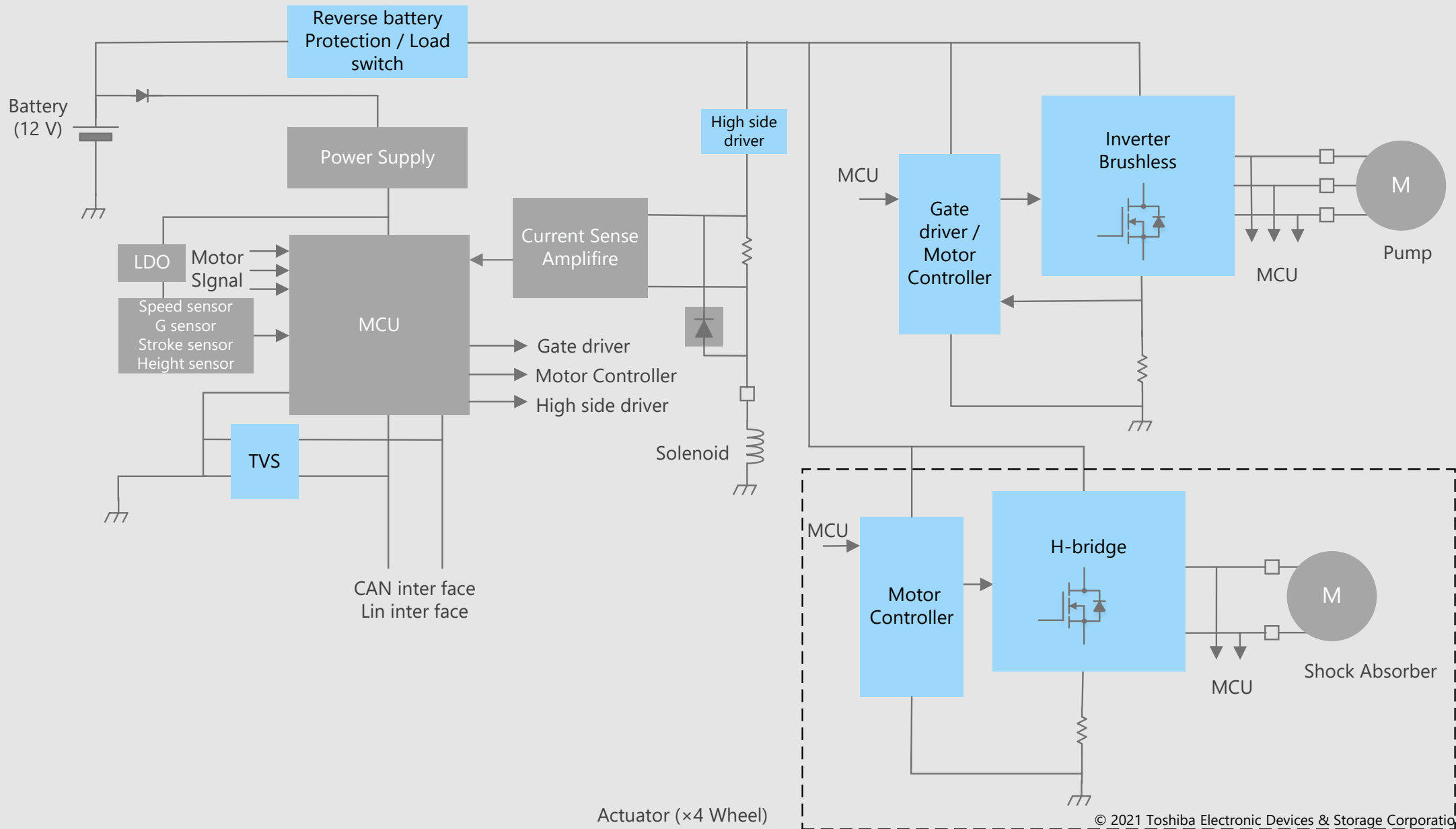
Block Diagram



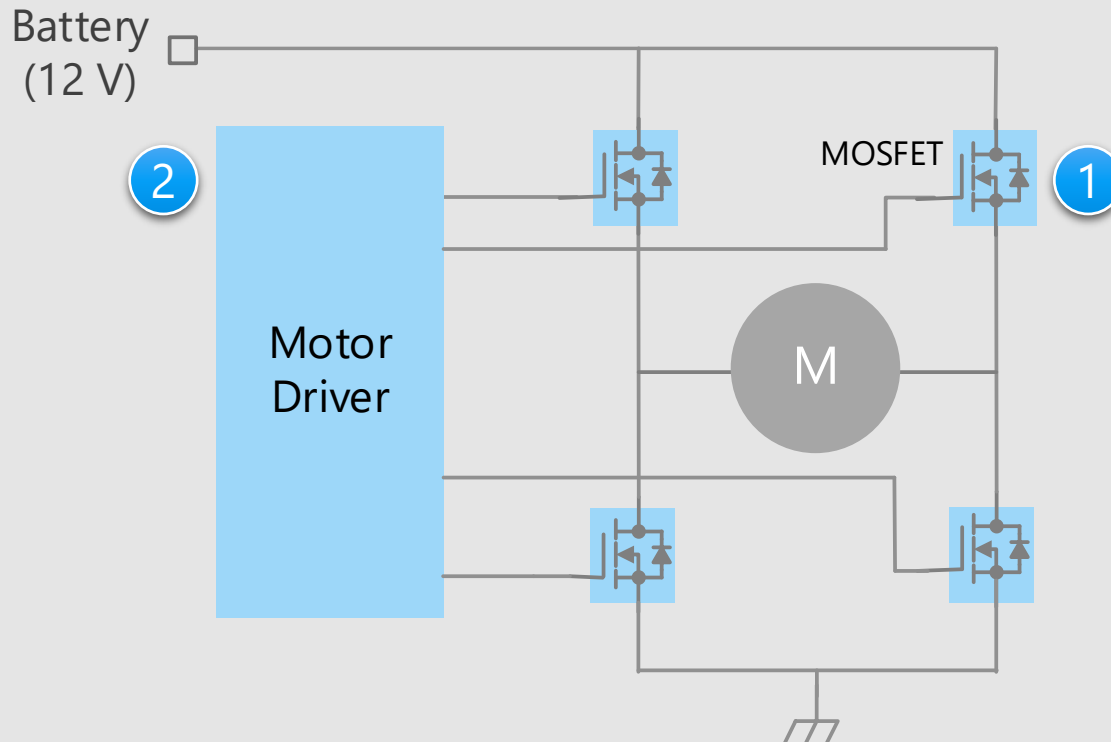
Active Suspension Overall block diagram of air suspension



Active Suspension Overall block diagram of hydraulic actuator type suspension



Drive circuit for brushed DC motor



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.

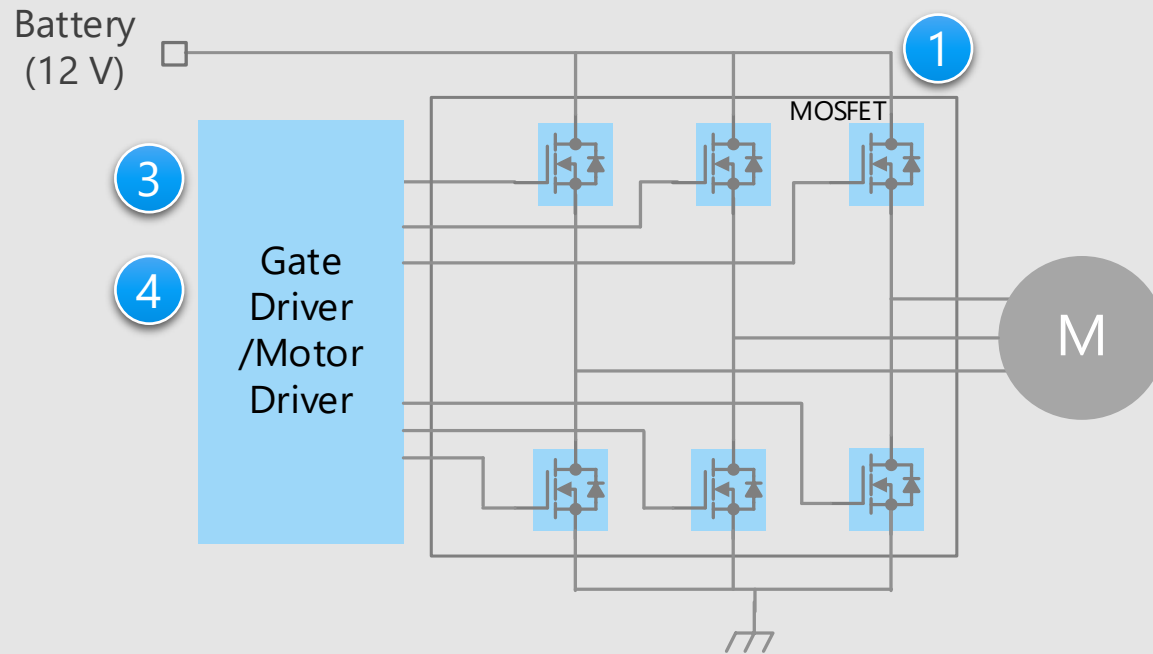
Proposals from Toshiba

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

※ Click the number in the circuit diagram to jump to the detailed explanation page.

Active Suspension Detail of Brushless DC motor drive circuit

Drive circuit for brushless DC motor



Criteria for device selection

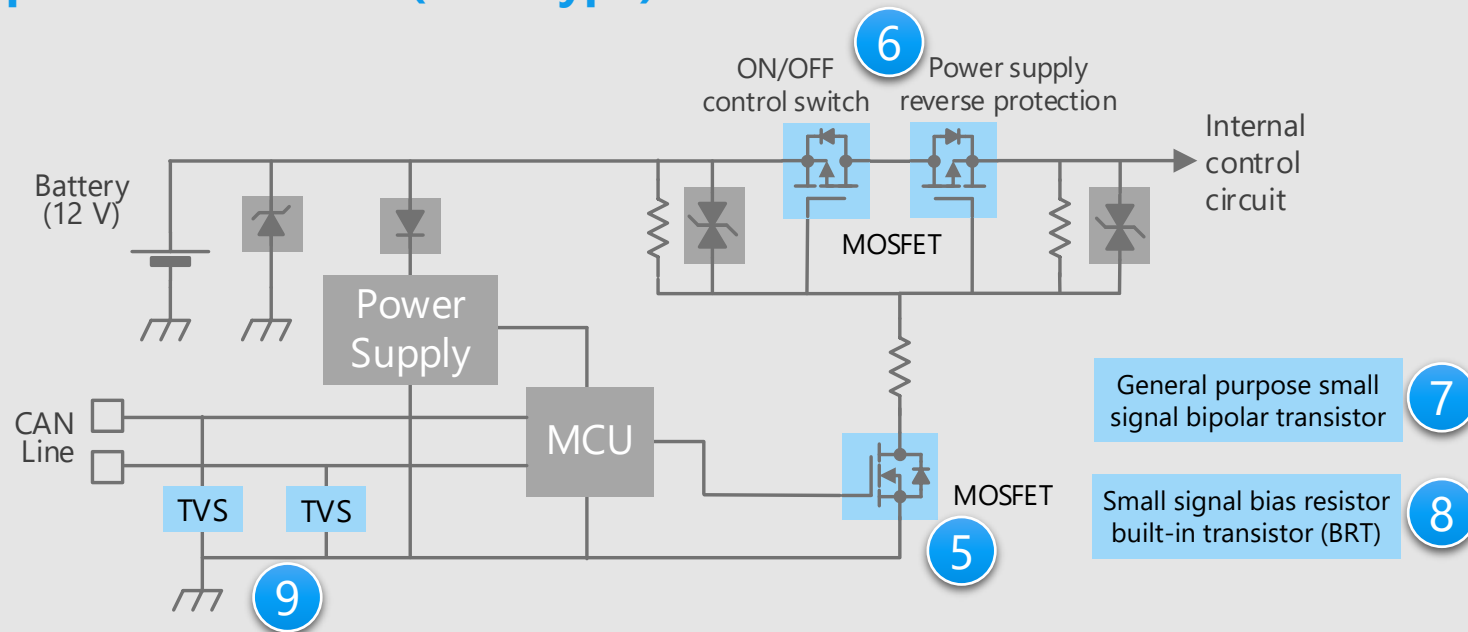
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes low power consumption of the system**
U-MOS Series 40 V N-ch MOSFET
- **Gate driver with built-in protection and diagnosis functions**
Gate driver (for motor)
- **Pre driver with built-in safety relay drivers**
Brushless DC motor pre driver

※ Click the number in the circuit diagram to jump to the detailed explanation page.

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



Criteria for device selection

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

Proposals from Toshiba

- **Low on-resistance contributes low power consumption of the system**

U-MOS Series -40 V / -60 V P-ch MOSFET (6)

- **Extensive product lineup**

General purpose small signal MOSFET (5)

General purpose small signal bipolar transistor (7)

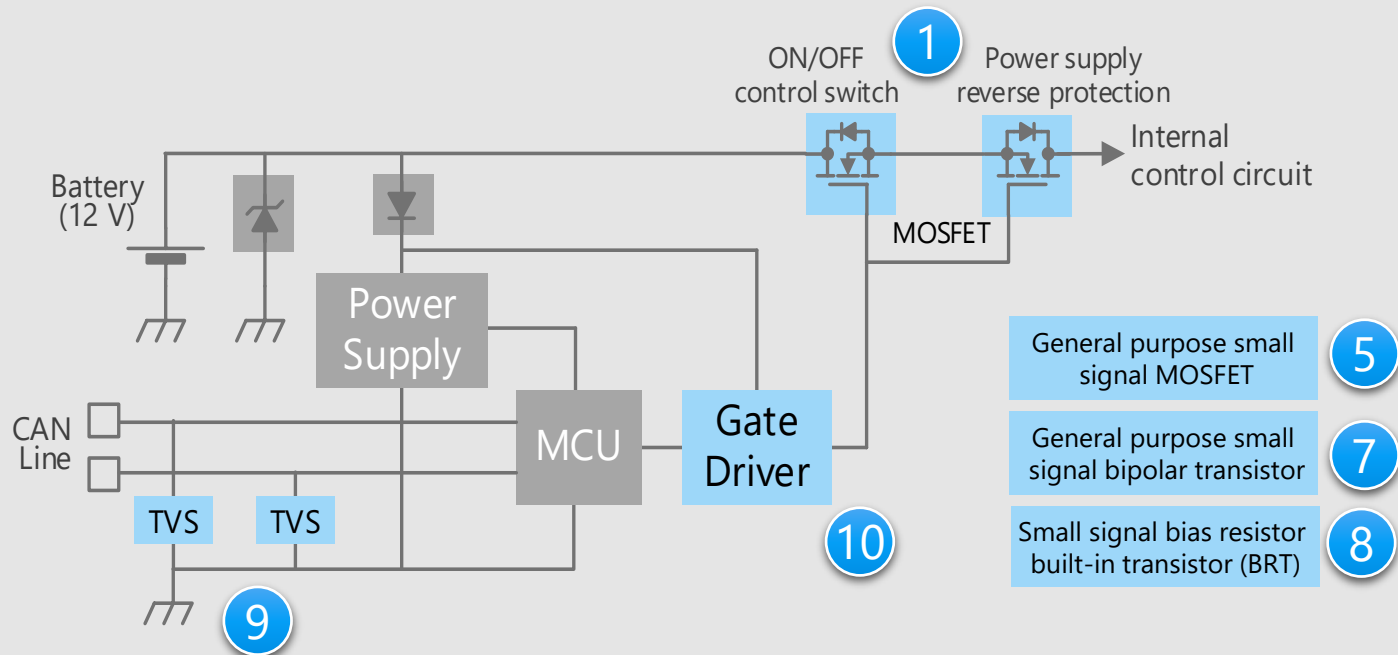
Small signal bias resistor built-in transistor (BRT) (8)

- **Suitable for ESD protection**

TVS diode (for CAN communication) (9)

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

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



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

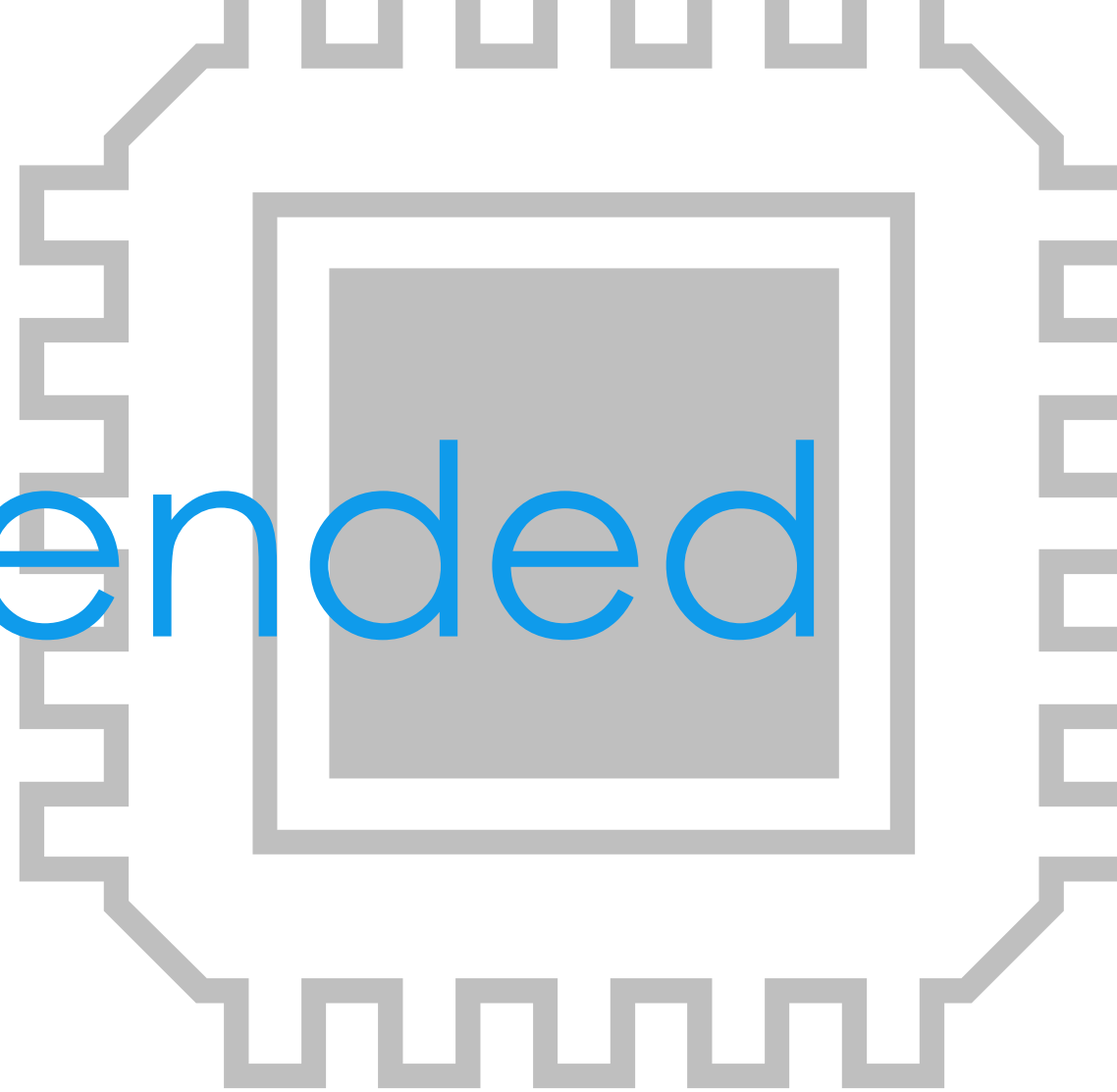
Criteria for device selection

- 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

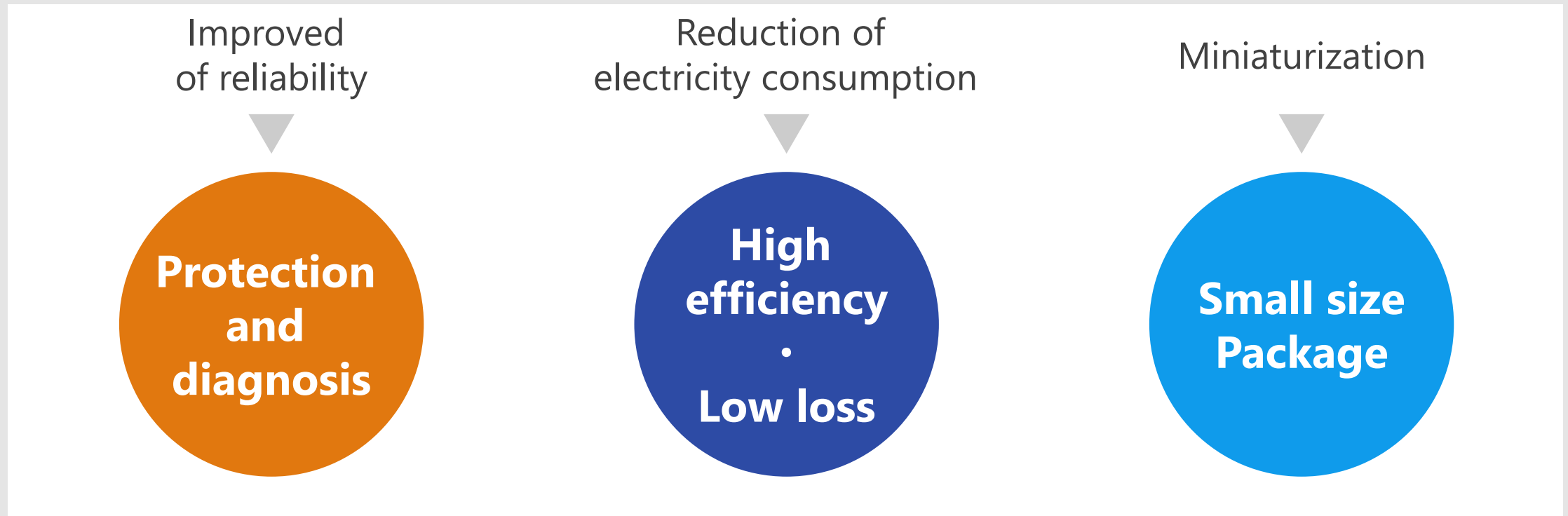
- **Low on-resistance contributes low power consumption of the system**
U-MOS Series 40 V N-ch MOSFET
- **Gate driver with built-in protection and diagnosis functions**
Gate driver (for switch)
- **Extensive product lineup**
General purpose small signal MOSFET
General purpose small signal bipolar transistor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

Recommended Devices



Device Solutions Solving Customer Issues

As described above, in the design of Electoro Active Suspension Control, “**Improvement of reliability**”, “**Reduction of power consumption**” and “**Miniaturization**” are important factors. Toshiba’s proposals are based on these three solution perspectives.



Device Solutions Solving Customer Issues

Protection
and
diagnosis

High
efficiency
·
Low loss

Small size
Package

	Protection and diagnosis	High efficiency · Low loss	Small size Package
① U-MOS Series 40V N-ch MOSFET		●	●
② Brushed DC motor pre driver	●		
③ Gate driver (for motor)	●		●
④ Brushless DC motor pre driver	●		
⑤ General purpose small signal MOSFET		●	●
⑥ U-MOS Series -40 V / -60 V P-ch MOSFET	●	●	●
⑦ General purpose small signal bipolar transistor			●
⑧ Small signal resistor built-in transistor (BRT)			●
⑨ TVS diode (for CAN communication)	●		●
⑩ Gate driver (for switch)	●		●

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)

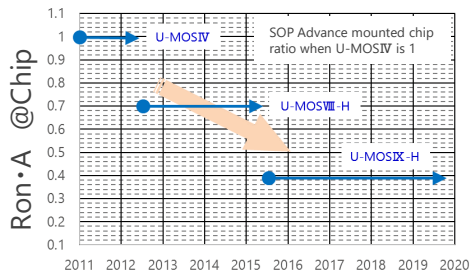
2 Compact and low loss package

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)

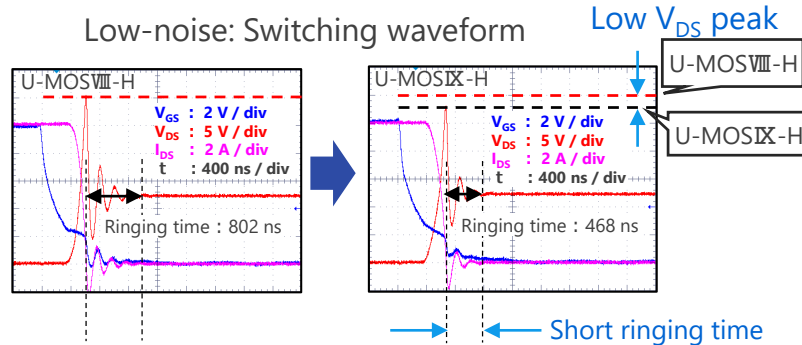
Improved chip process reduces surge voltage and ringing time.

Low Loss: RonA Trend



(Note: Toshiba internal comparison)

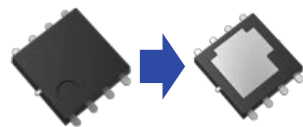
Low-noise: Switching waveform



TO-220SM(W) Cu connector design









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



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

Protection and diagnosis

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

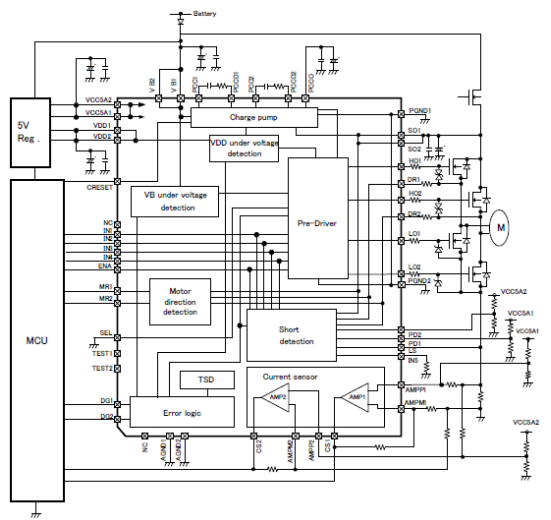
2 Built-in motor current detection amplifier

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 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 Gate driver (for motor)

TPD7211F / TPD7212F / TPD7212FN

Protection and diagnosis

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

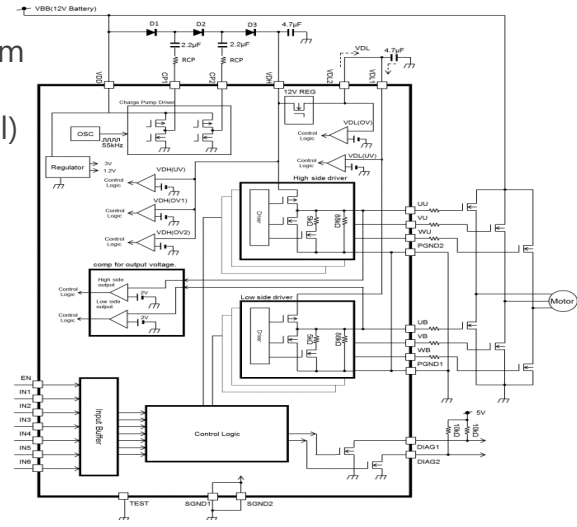
MOSFET is turn off when a signal is input that causes arm short circuit.


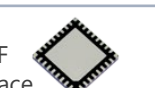

Functions to monitor abnormalities of the power supply voltage and output voltage are built-in.

3 Small surface mount package

PS-8, WQFN32, SSOP30

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  TPD7212FN Back surface WQFN32 (5 x 5 mm) SSOP30 (7.6 x 10.2 mm)
Features	<ul style="list-style-type: none"> For high side P-ch MOSFET drive 	<ul style="list-style-type: none"> 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](#)

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

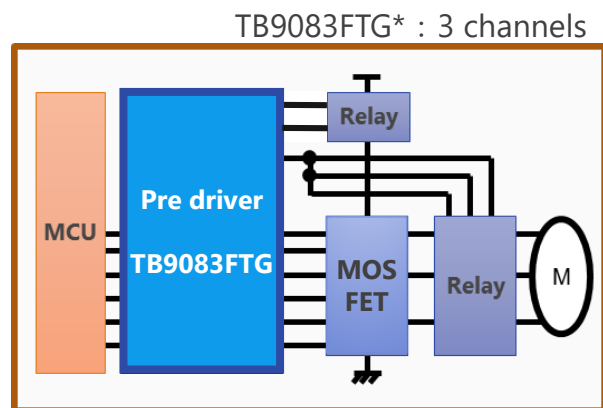
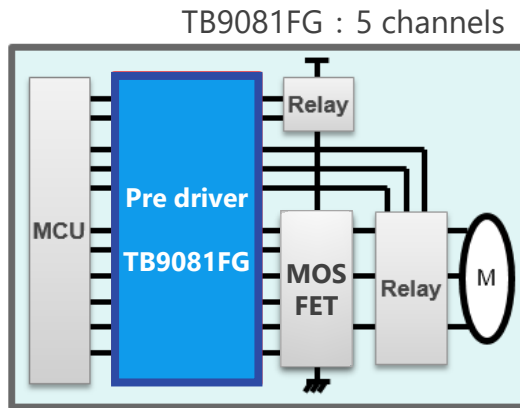
2 Built-in safety relay drivers and motor current detection amplifiers

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



* TB9083FTG: Under development (The specification is subject to change without notice.)

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 3])	✓ (BIST)

[Note 3] Built-in Self Test

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5 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.

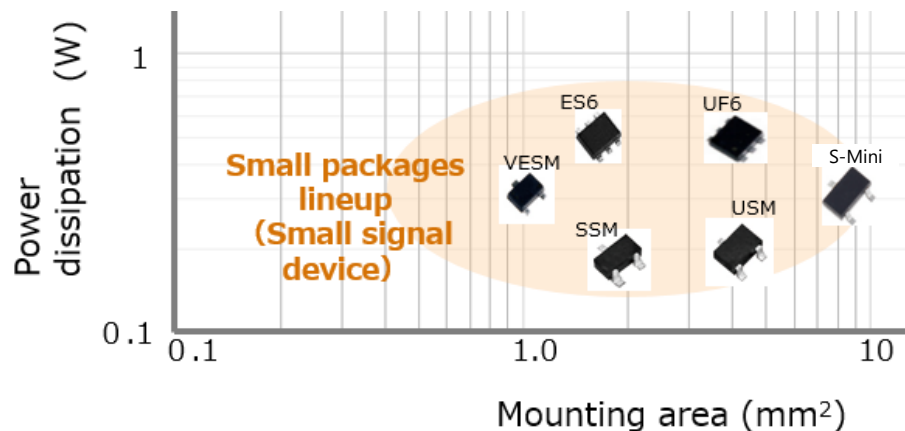
2 Low voltage drive

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



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
	Max	1.75	1.9
Drive voltage [V]	4.5	-4.0	-1.2
Polarity	N-ch	P-ch	P-ch

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Value provided

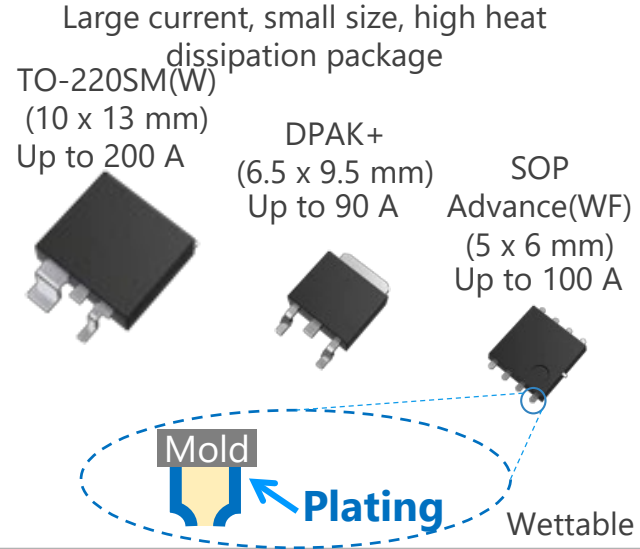
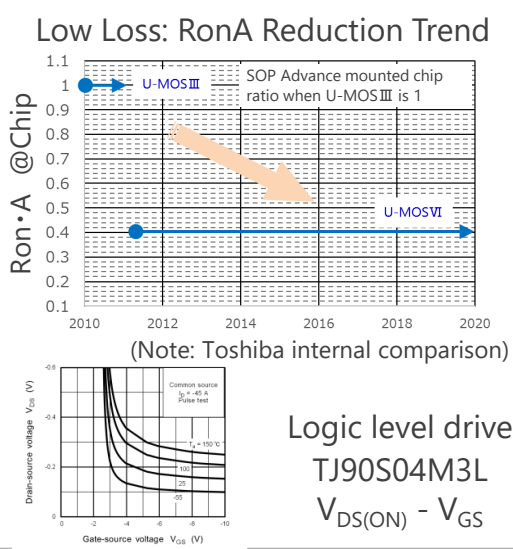
Low on-resistance contributes to reduce system power consumption.

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

Using low chip resistance technology to contribute to reduced power consumption systems
Lineup of Logic level drive types

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) @ $V_{GS} = -10\text{ V}$	Package
TJ90S04M3L	-40 V	-90 A	4.3 m Ω	DPAK+
TJ60S06M3L	-60 V	-60 A	11.2 m Ω	
XPH3R114MC	-40 V	-100 A	3.1 m Ω	SOP Advance(WF)
TJ200F04M3L	-40 V	-200 A	1.8 m Ω	TO-220SM(W)

[Return to Block Diagram TOP](#)

Value provided

Extensive product lineup to meet customers' needs.

1 Extensive lineup of packages

Various packages such as 1-in-1, 2-in-1 are provided and suitable products for circuit board design are selectable.

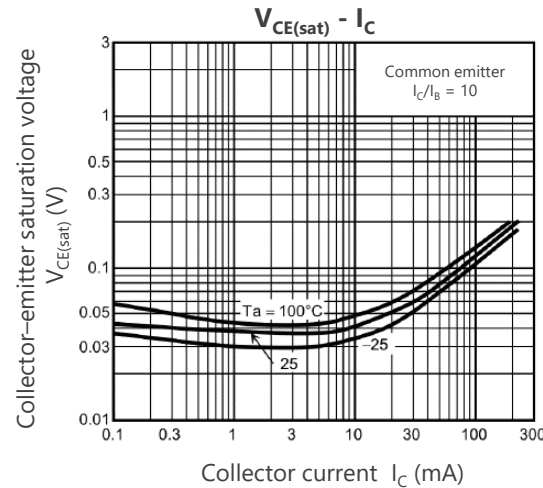
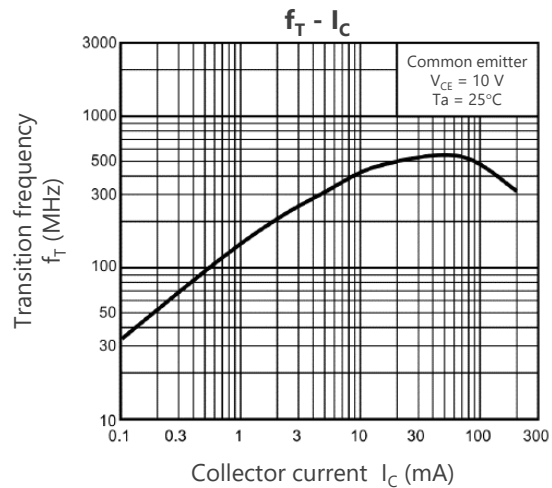
2 Various product lineup

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

3 AEC-Q101 qualified

AEC-Q101 qualified and can be used for various automotive applications.

Characteristic examples of 2SC2712



Line up

Package			SOT-23F		USM (SOT-323) UFM (SOT-323F)*		S-Mini (SOT-346)	
Classification	$ V_{CE0} $ [V]	$ I_C $ [mA]	NPN	PNP	NPN	PNP	NPN	PNP
General purpose	50	150			2SC4116	2SA1586	2SC2712	2SA1162
	50	500					2SC3325	2SA1313
Low noise	120	100			2SC4117	2SA1587	2SC2713	2SA1163
High current	50	1700				2SA2195*		
	50	2000		TTA501				
	100	2500	TTC501					

[Return to Block Diagram TOP](#)

Value provided

Extensive product lineup to meet customers' needs.

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

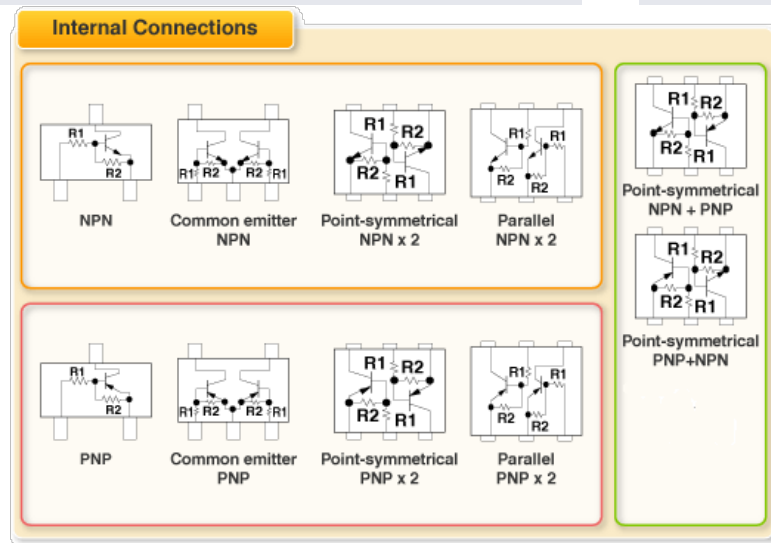
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

2 Extensive lineup of package and pin assignment



Various package lineups, such as 1-in-1, 2-in-1 and various pin assignment type are provided and suitable products for circuit board design are selectable.

3 AEC-Q101 qualified

AEC-Q101 qualified and can be used for various automotive applications.



Line up

Part number		NPN (BRT)	PNP (BRT)
Package	ES6 (SOT-563) 	RN1907FE	RN2907FE
	US6 (SOT-363) 	RN1901	RN2901
V_{CE0} (Max) [V]		50	-50
I_C [mA]		100	-100

[◆Return to Block Diagram TOP](#)

9 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU

Protection and diagnosis

High efficiency
Low loss

Small size Package

Value provided

TVS diodes prevent system damage and malfunction caused by electrostatic discharge (ESD).

1 Improve ESD pulse absorbability

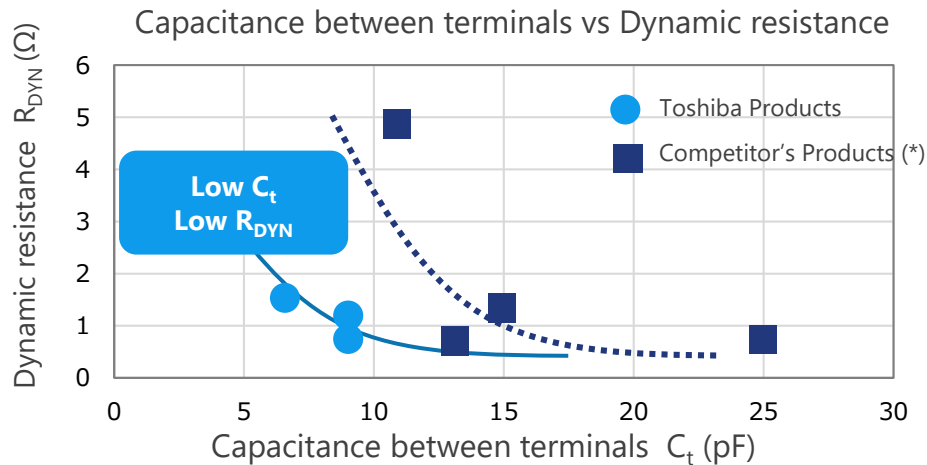
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

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

3 High ESD immunity


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



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

(Based on Toshiba's measurement data)
(*): 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](#)

Value provided

A charge pump circuit for the N-channel MOSFET gate drive is built in, allowing for easy semiconductor relay configuration.

1 Built-in charge pump circuit

Built-in charge pump circuit enables N-channel MOSFET as high side switch.
Easy to configure a semiconductor relay.

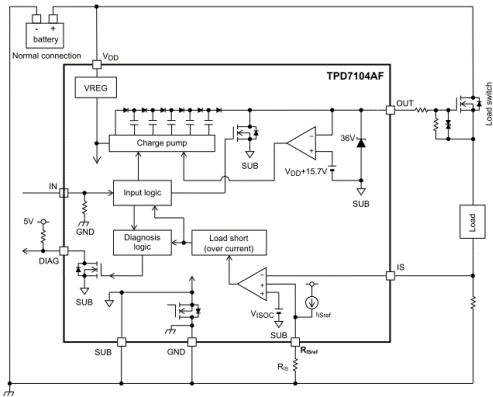
2 Can be controlled by logic level voltage

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

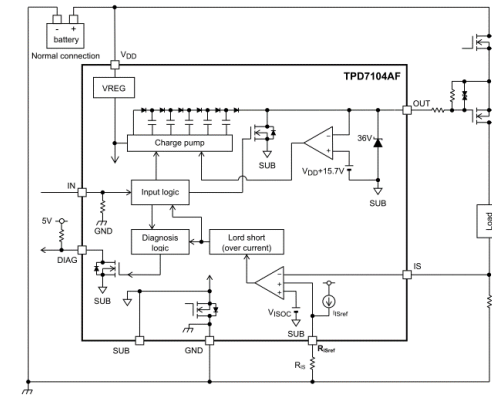
3 Small package

The small surface mount packages such as PS-8, SSOP16 and WSON10A contribute to the miniaturization of equipment.

Semiconductor relay (switch) application (TPD7104AF)






Power supply reverse connection protection MOSFET control (TPD7104AF)



Back to back configuration

Line up

Part number	TPD7104AF	TPD7106F	TPD7107F
Package	PS-8 (2.8 x 2.9 mm) 	SSOP16 (5.5 x 6.4 mm) 	WSON10A (3 x 3 mm) 
Features	<ul style="list-style-type: none"> Operating power supply voltage range: 5 to 18 V Built-in power supply reverse connection protection function (Supported for power supply reverse connection protection MOSFET applications)	<ul style="list-style-type: none"> Operating power supply voltage range: 4.5 to 27 V Built-in power supply reverse connection protection function (Supported for power supply reverse connection protection MOSFET applications)	<ul style="list-style-type: none"> Operating power supply voltage range: 5.75 to 26 V Current sense output Protective functions; overcurrent, overtemperature, GND disconnect etc. Diagnosis output; overcurrent, load open, overtemperature etc.

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If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

Contact address: <https://toshiba.semicon-storage.com/ap-en/contact.html>



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