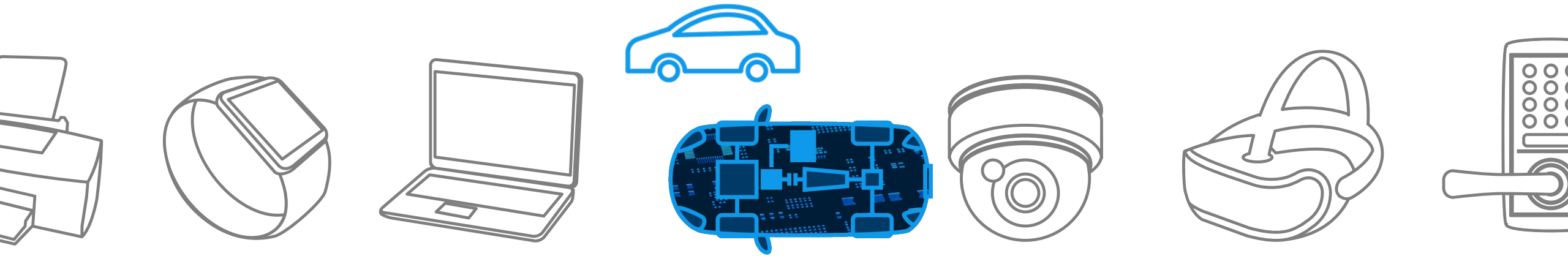


**TOSHIBA**

# Automotive Integrated Starter Generator

R20

**Solution Proposal by Toshiba**

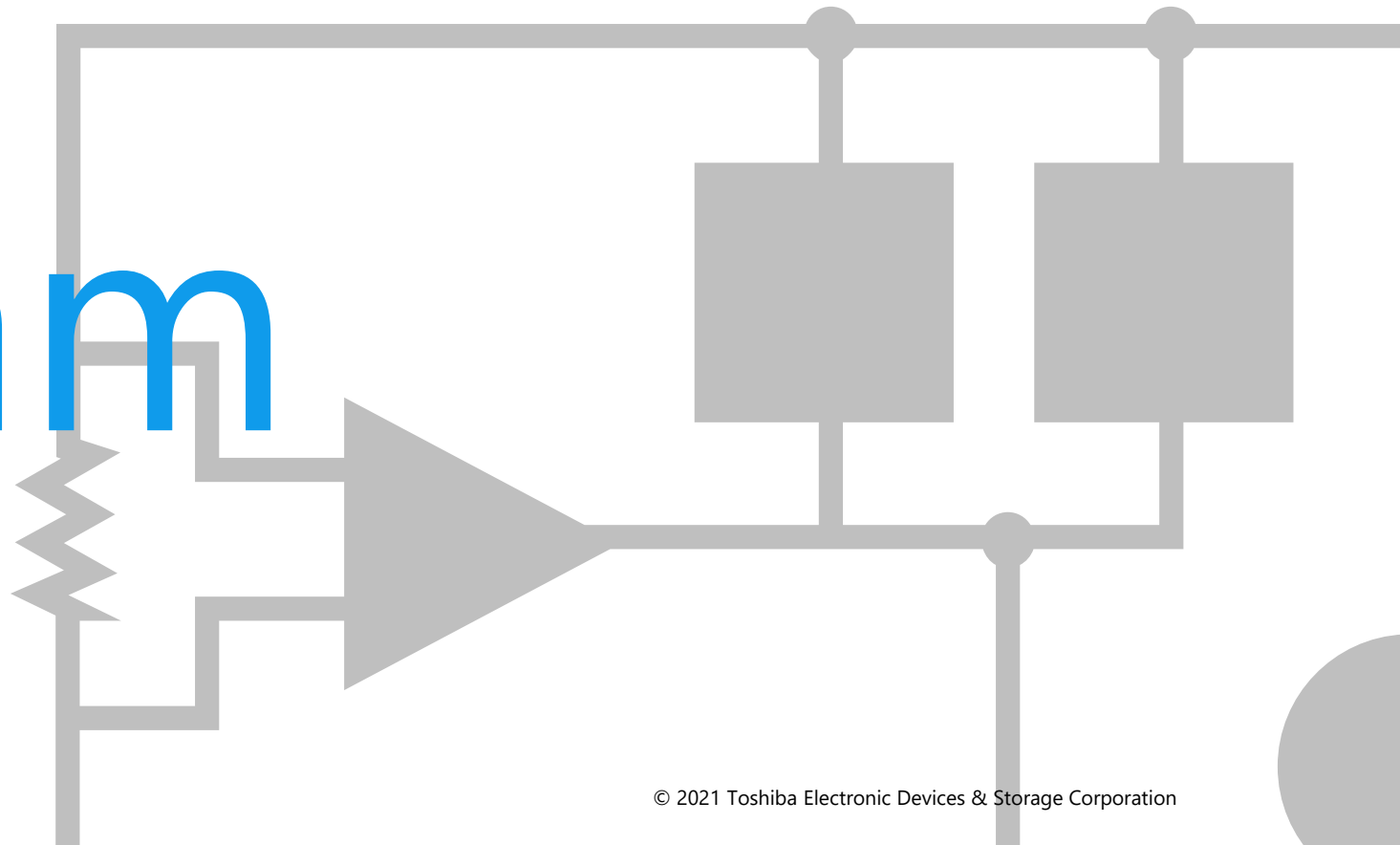




Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

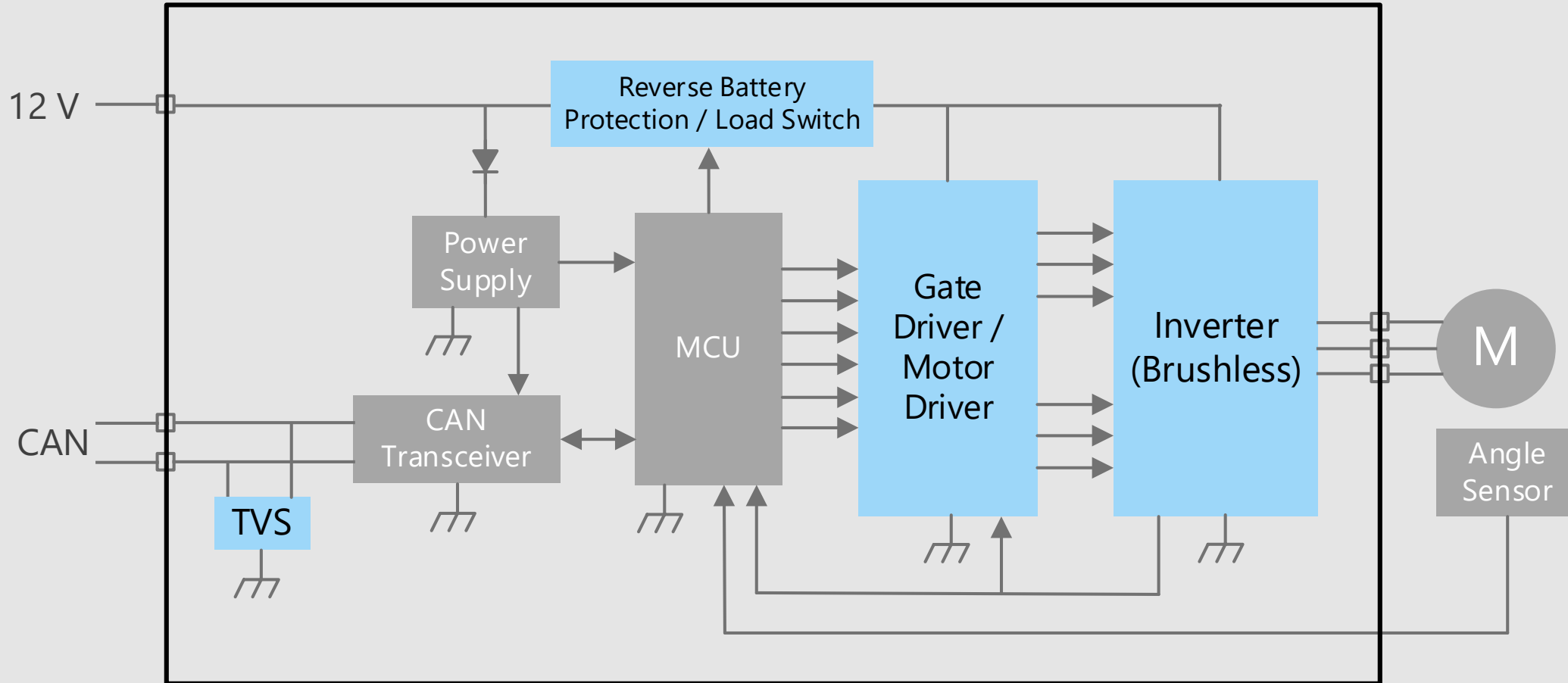


# Block Diagram



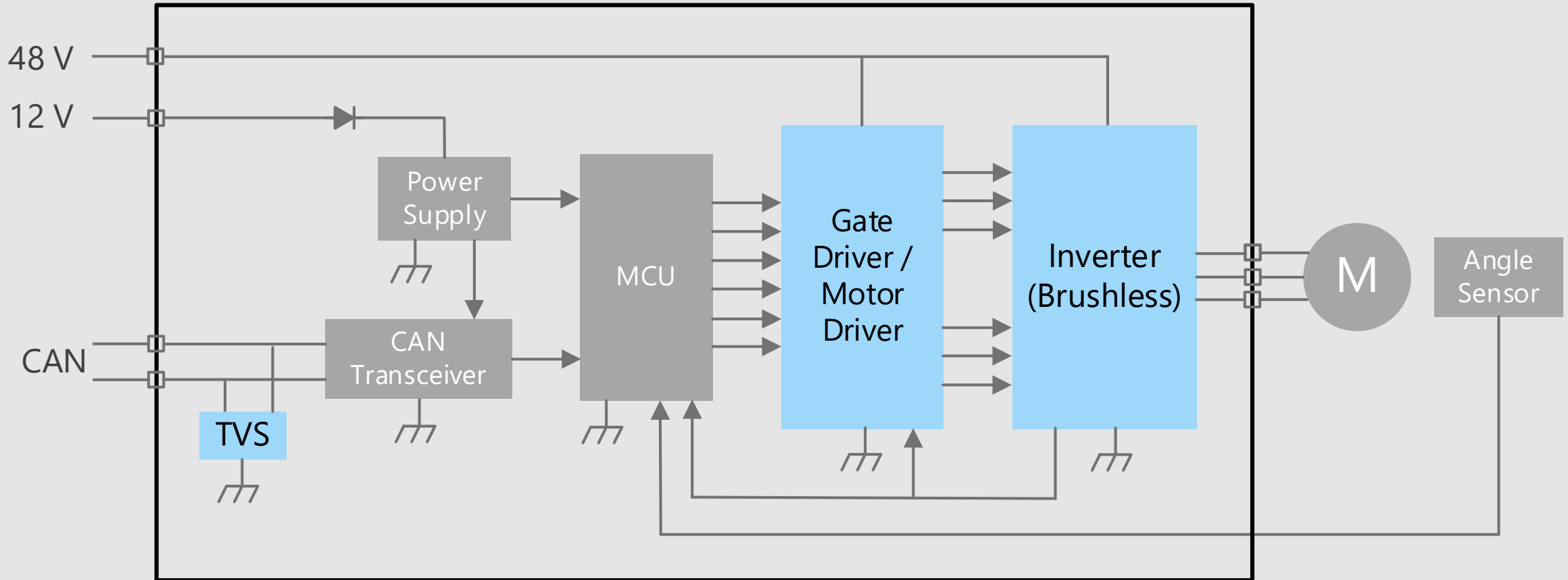
# ISG (Integrated Starter Generator) Overall Block Diagram (1)

## 12 V Integrated Starter Generator

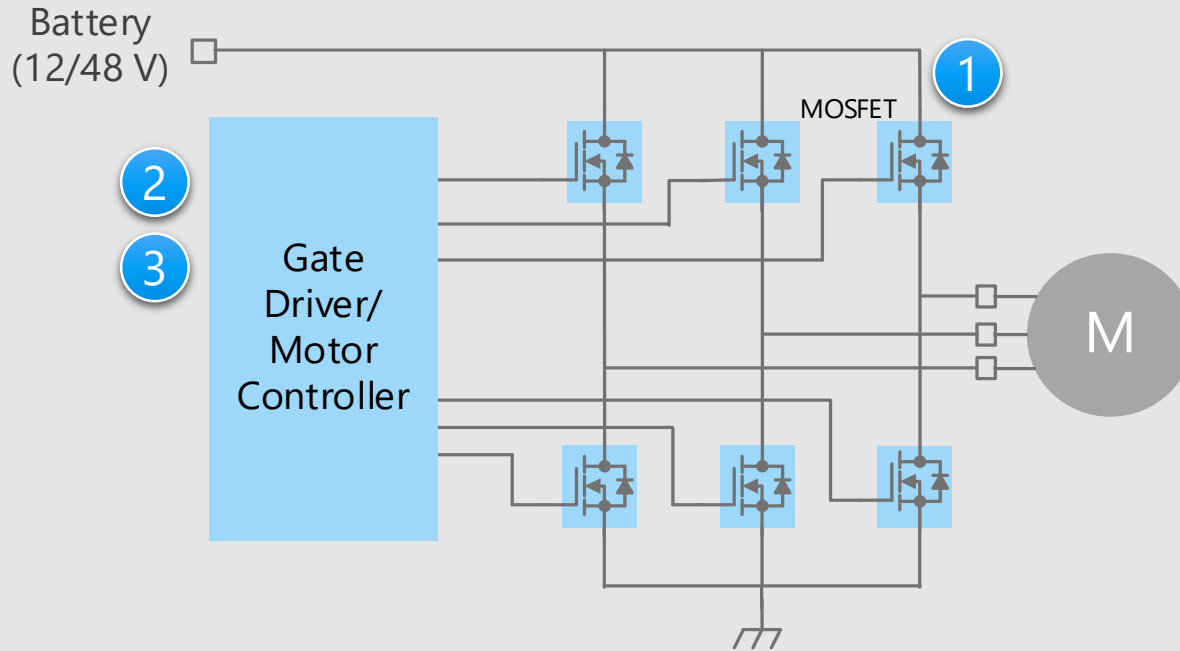


# ISG (Integrated Starter Generator) Overall Block Diagram (2)

## 48 V Integrated Starter Generator



## Brushless DC motor drive circuit



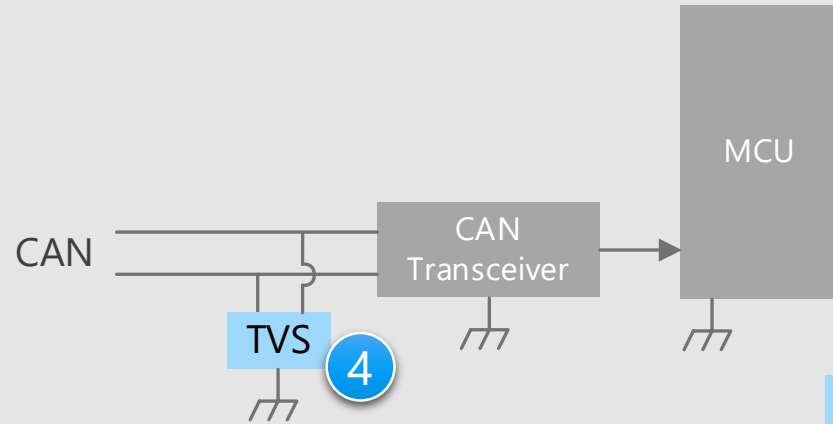
## Criteria for device selection

- 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.

## Proposal from Toshiba

- **Low on-resistance contributes low power consumption of the system**  
U-MOS Series 40 V 80 V / 100 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

## CAN transceiver protection circuit



General purpose small signal MOSFET

5

General purpose small signal bipolar transistor

6

Small signal bias resistor built-in transistor (BRT)

7

## Criteria for device selection

- A small surface mount package is suitable for realizing miniaturization of the ECU.

## Proposal from Toshiba

### - Suitable for ESD protection

TVS diode (for CAN communication)

4

### - Extensive product lineup

General purpose small signal MOSFET

5

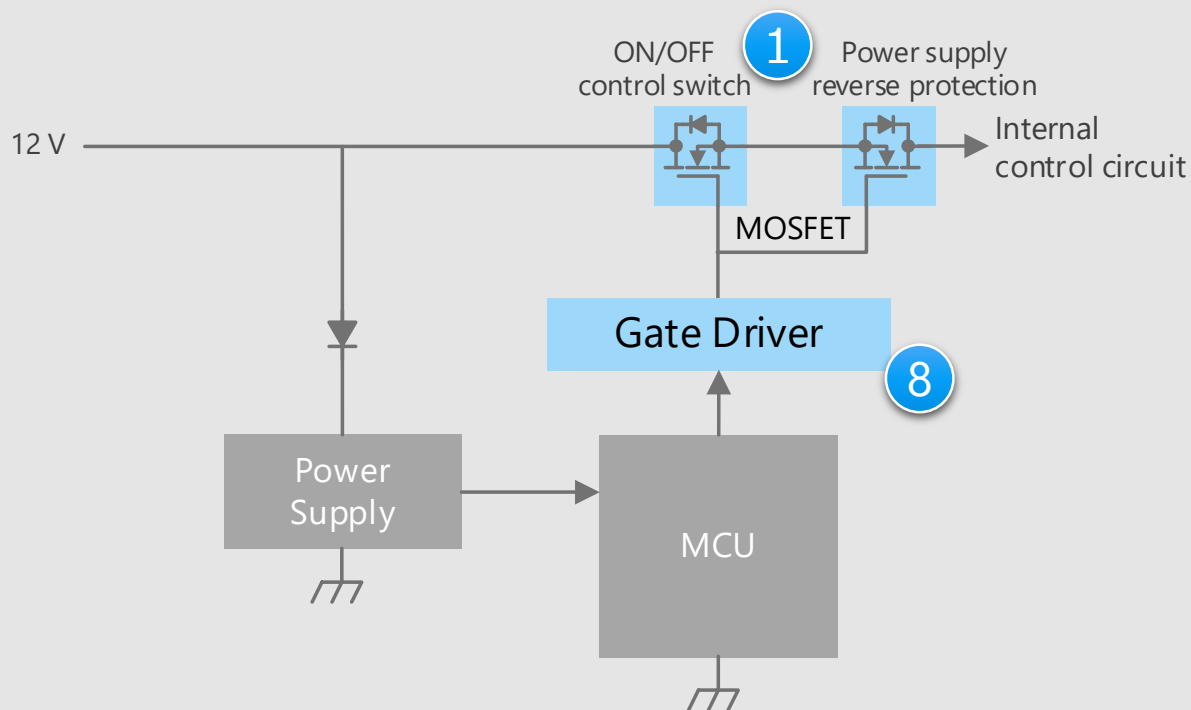
General purpose small signal bipolar transistor

6

Small signal bias resistor built-in transistor (BRT)

7

## Power supply ON/OFF control and reverse connection protection circuit



## Criteria for device selection

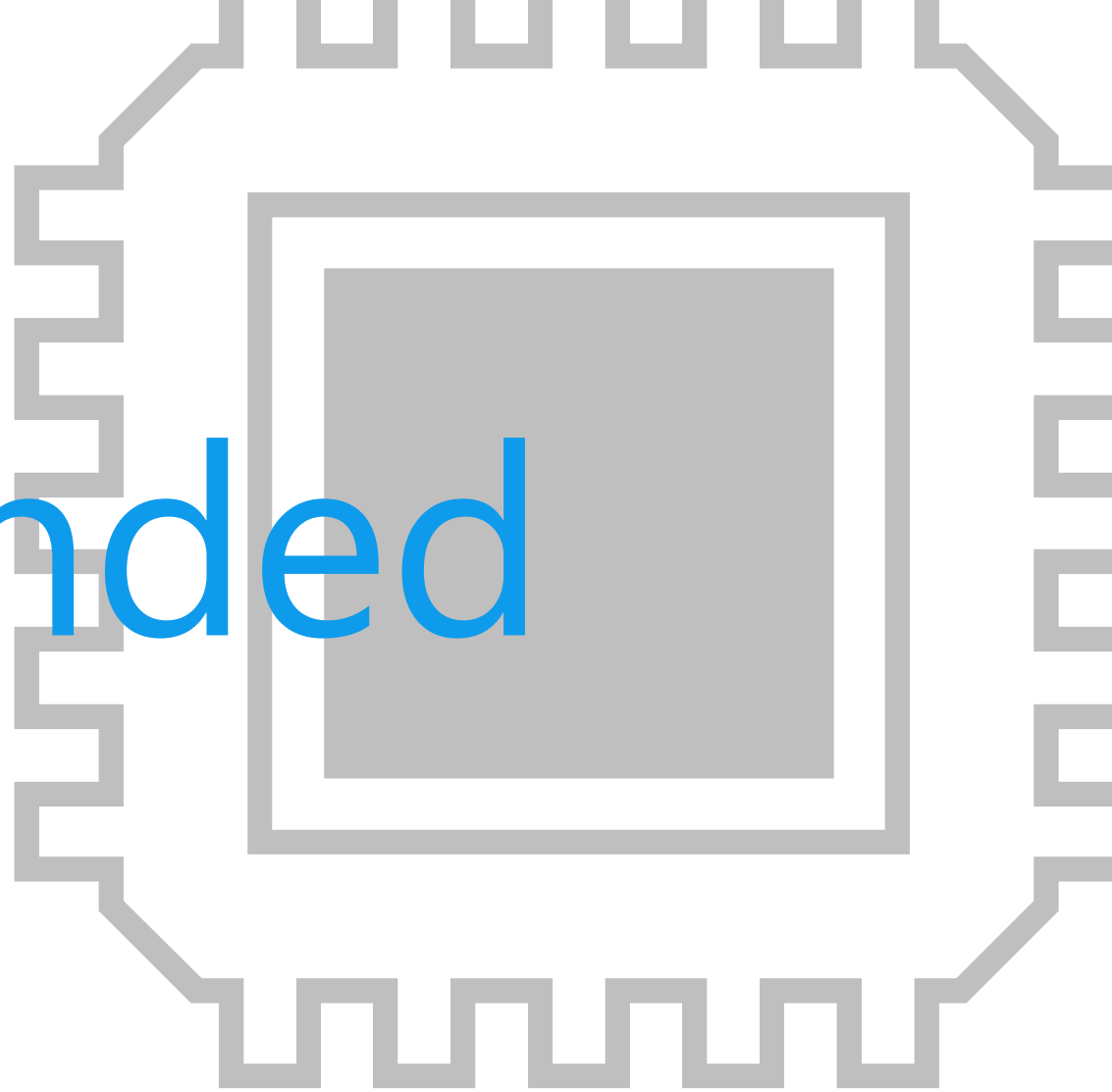
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
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## Proposal from Toshiba

- **Low on-resistance contributes low power consumption of the system**  
U-MOS Series 40 V / 80 V / 100 V  
N-ch MOSFET 1
- **Gate driver with built-in protection and diagnosis functions**  
Gate driver (for switch) 8



# Recommended Devices



# Device solutions to address customer needs

As described above, in the design of ISG, “**Ensuring tolerance to motor lock current and immunity. Capable with functional safety**”, “**Reduction of power consumption**” and “**Miniaturization**” are important factors. Toshiba’s proposals are based on these three solution perspectives.

Ensuring tolerance to motor lock current and immunity. Capable with functional safety



Reduction of power consumption



Miniaturization



# Device solutions to address customer needs



	Robustness	High efficiency · Low loss	Small size package
① U-MOS Series 40V / 80 V / 100 V N-ch MOSFET	●	●	●
② Gate driver (for motor)	●		●
③ Brushless DC motor pre driver	●	●	●
④ TVS diode (for CAN communication)	●		●
⑤ General purpose small signal MOSFET		●	●
⑥ General purpose small signal bipolar transistor			●
⑦ Small signal bias resistor built-in transistor (BRT)			●
⑧ Gate driver (for switch)	●		●

Value provided

The combination of low on-resistance and low noise by the latest U-MOS series process and a small package contributes to system performance improvement.

**1 Low loss (reduced on-resistance)**

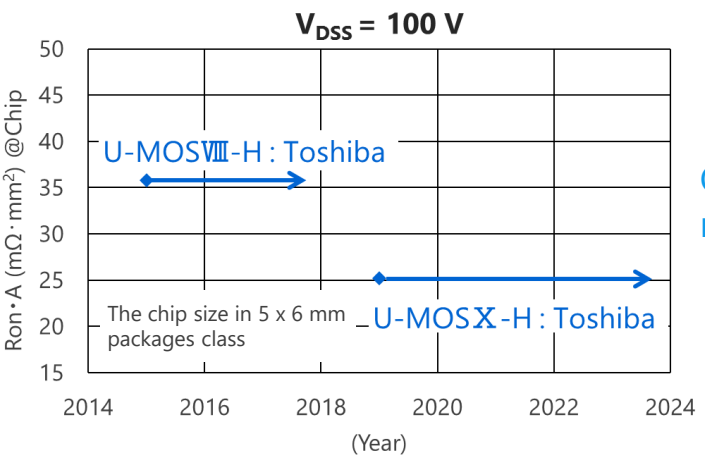
Using low on-resistance technology to contribute to reduced power consumption systems.

**2 Low noise (low EMI)**


Improved chip process reduces surge voltage and ringing time.

**3 Compact gull wing package**

Package size reduced by 23 % compared to D2PAK (10 x 5 mm). Gull wing shaped leads to reduce mounting solder stress in high environments with ambient temperature and mechanical stress.



Line up

Part number	Drain-source voltage	Drain current	On-resistance (Max) @V <sub>GS</sub> =10 V	Package
XPQ1R004PB*	40 V	200 A	1.0 mΩ	L-TOGL™ 
XPQR3004PB*	40 V	400 A	0.3 mΩ	
XPQR8308QB*	80 V	400 A	0.83 mΩ	
XPQ1R00AQB*	100 V	400 A	1.0 mΩ	

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

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# 2 Gate driver (for motor)

TPD7212F / TPD7212FN / TPD7213FN



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.

- TPD7213FN :  $\pm 2$  A
- TPD7212F, TPD7212FN : -1 A / +1.5 A

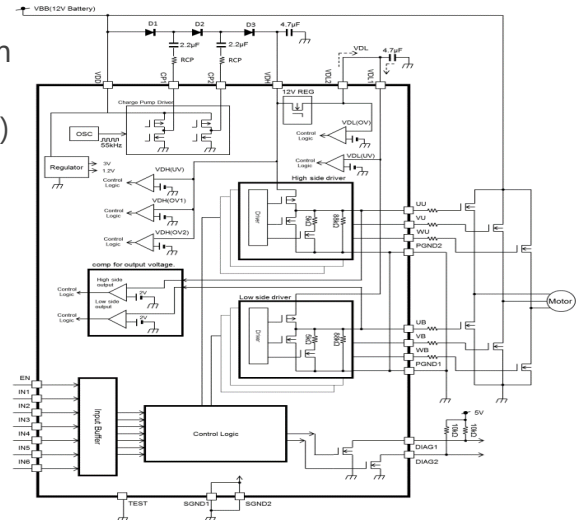
**2 Built-in protection / diagnostic output function**


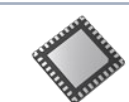

MOSFET is turn off when a signal is input that causes arm short circuit. Functions to monitor abnormalities of the power supply voltage and output voltage are built-in.

**3 Small surface mount package**

WQFN32, SSOP16, SSOP30

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



Line up		
Part number	TPD7213FN*	TPD7212F / TPD7212FN
Function	Half bridge gate driver	Gate driver for Three-phase brushless motor
Number of output	2 outputs	6 outputs
Package	 SSOP16 (5.5 x 6.4 mm)	  WQFN32 (5 x 5 mm) SSOP30 (10.2 x 7.6 mm)
Features	<ul style="list-style-type: none"> <li>• Suitable for 48V battery system</li> <li>• Can be used to drive a high side N-ch MOSFET</li> </ul>	<ul style="list-style-type: none"> <li>• For driving high-side N-ch MOSFET (with built-in charge pumps)</li> <li>• Built-in voltage monitoring function (power supply, output)</li> </ul>

\* : Under development (The specification is subject to change without notice.)  
[Return to Block Diagram TOP](#)

# 3 Brushless DC motor pre driver

TB9081FG / TB9083FTG\*



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

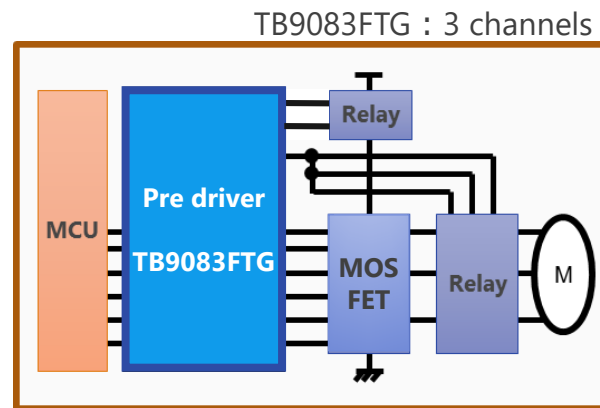
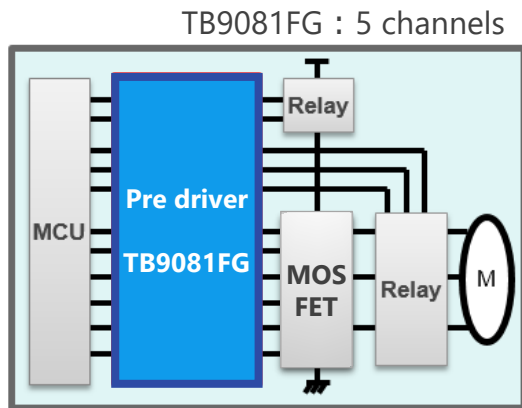
## 2 Built-in safety relay drivers and motor current detection amplifiers

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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# 4 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU



Value provided

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

## 1 Improve ESD pulse absorbability

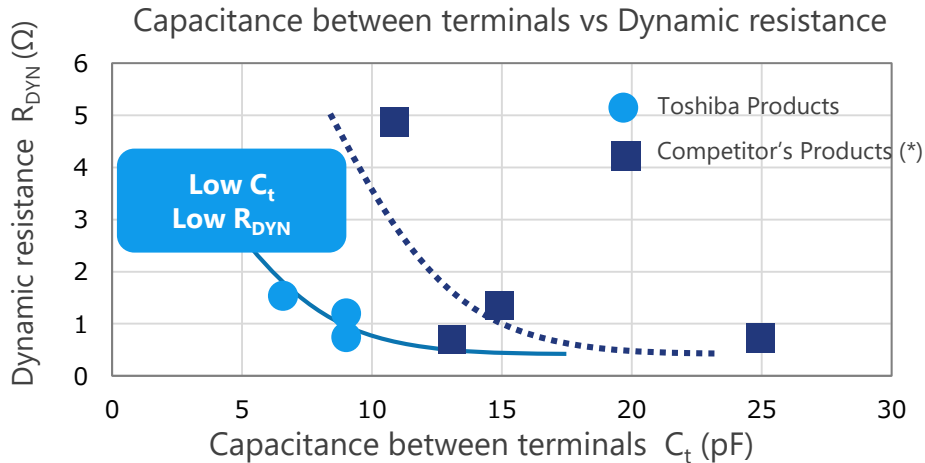
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.  
(Both low dynamic resistance  $R_{DYN}$  and low capacitance between terminals  $C_t$ )

## 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

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# 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.

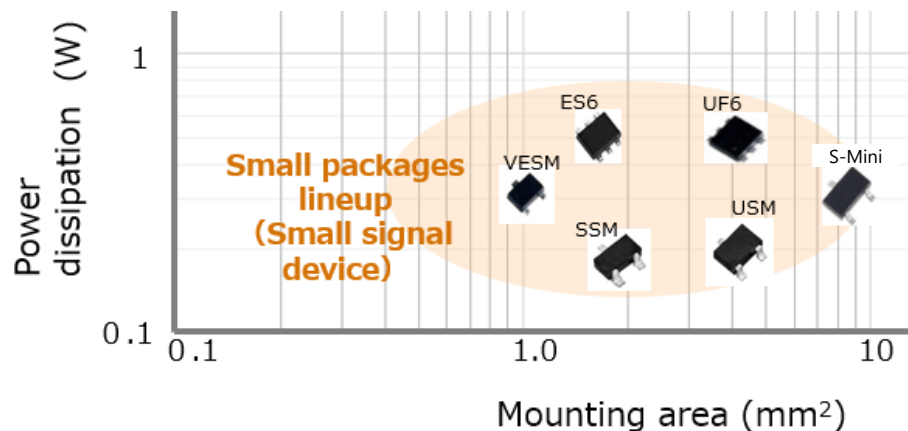
### 2 Low voltage drive

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



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 [ $\Omega$ ]	Typ.	1.2	0.31
	Max	1.75	0.39
Drive voltage [V]	4.5	-4.0	-1.2
Polarity	N-ch	P-ch	P-ch

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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.

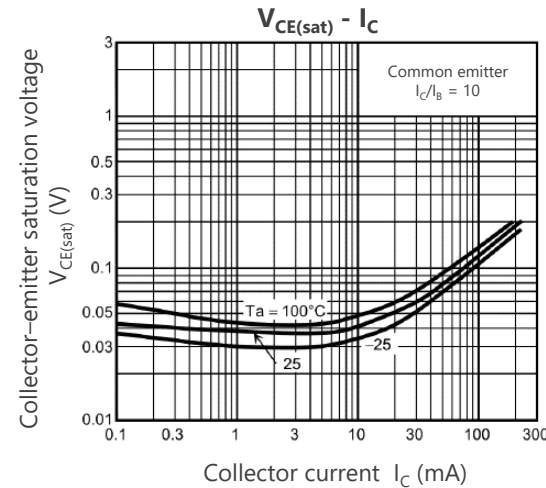
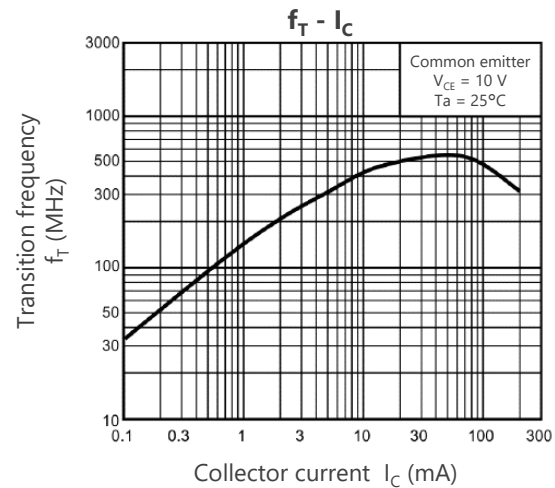
### 2 Extensive product lineup

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_{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					

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Value provided

## Extensive product lineup to meet customers' needs.

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

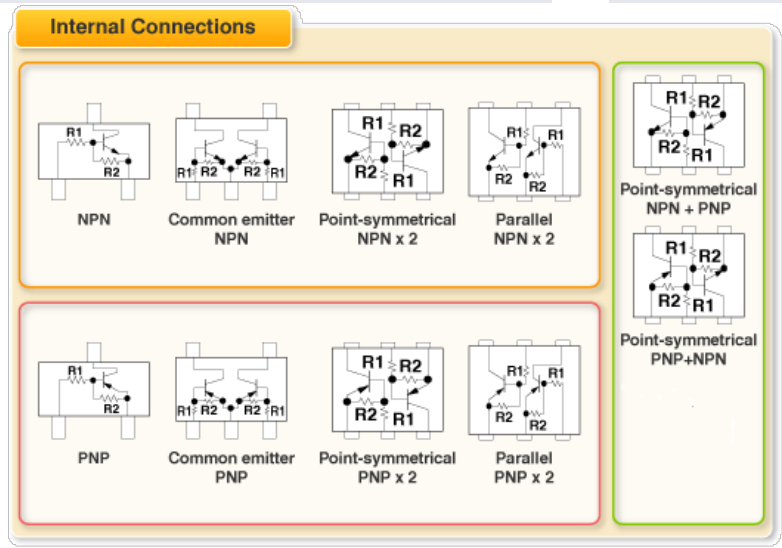
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

### 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

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# 8 Gate driver (for switch)

TPD7104AF / TPD7106F / TPD7107F



## 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.

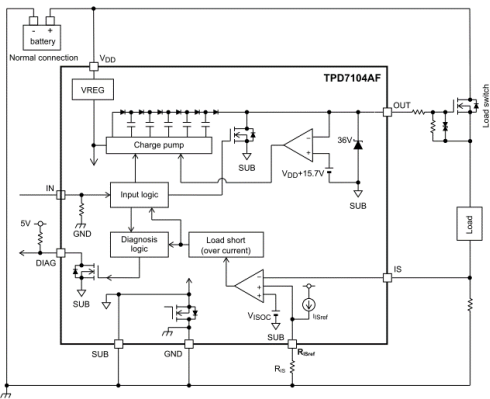
### 2 Can be controlled by logic level voltage

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

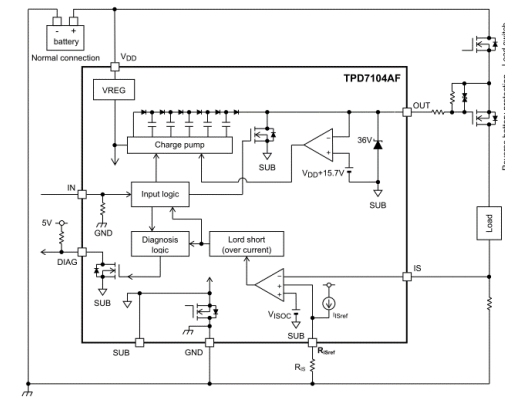
### 3 Small package

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"> <li>Operating power supply voltage range: 5 to 18 V</li> <li>Built-in power supply reverse connection protection function</li> </ul> (Supported for power supply reverse connection protection MOSFET applications)	<ul style="list-style-type: none"> <li>Operating power supply voltage range: 4.5 to 27 V</li> <li>Built-in power supply reverse connection protection function</li> </ul> (Supported for power supply reverse connection protection MOSFET applications)	<ul style="list-style-type: none"> <li>Operating power supply voltage range: 5.75 to 26 V</li> <li>Current sense output</li> <li>Protective functions; overcurrent, overtemperature, GND disconnect etc.</li> <li>Diagnosis output; overcurrent, load open, overtemperature etc.</li> </ul>

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