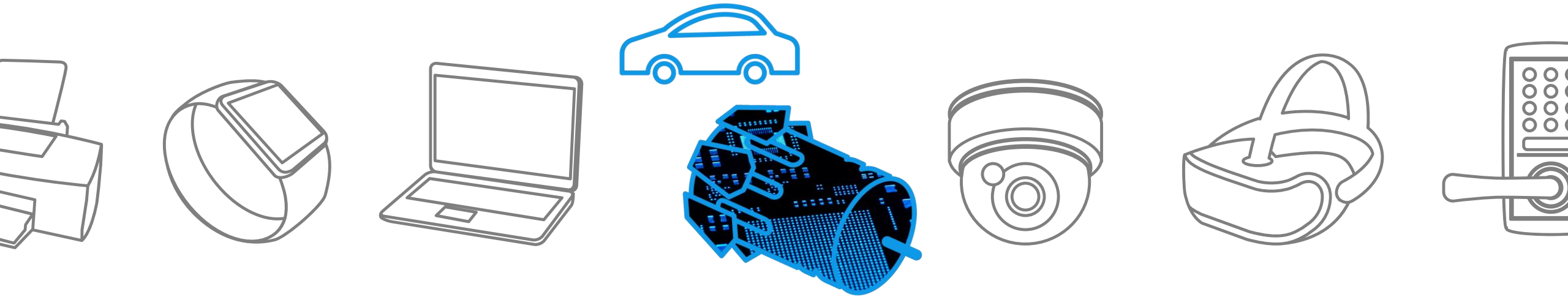


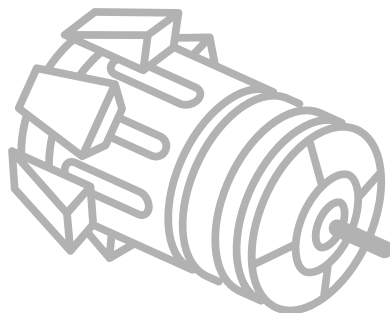
**TOSHIBA**

# Automotive Inverter for xEV

R21.1

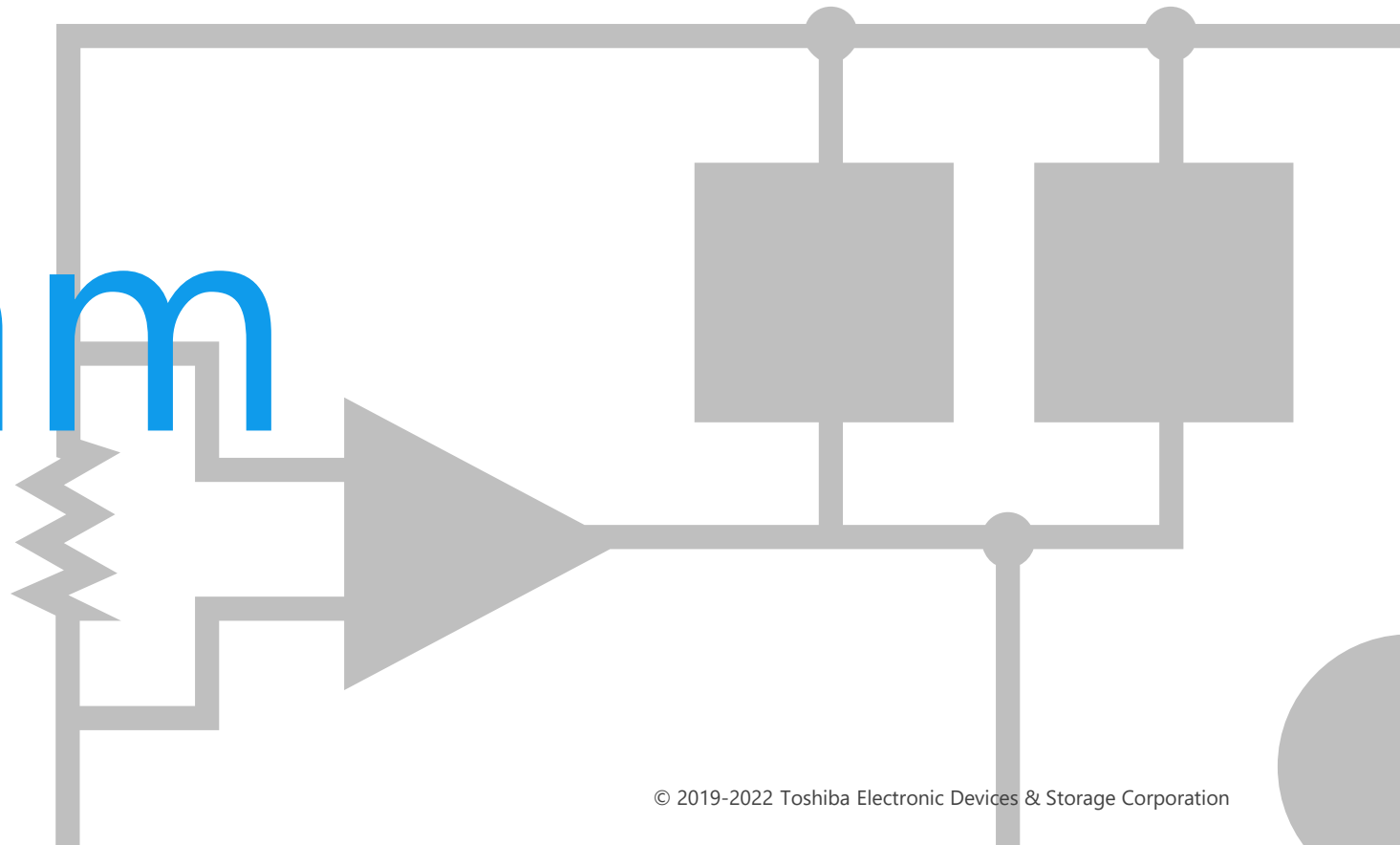
Solution Proposal by Toshiba



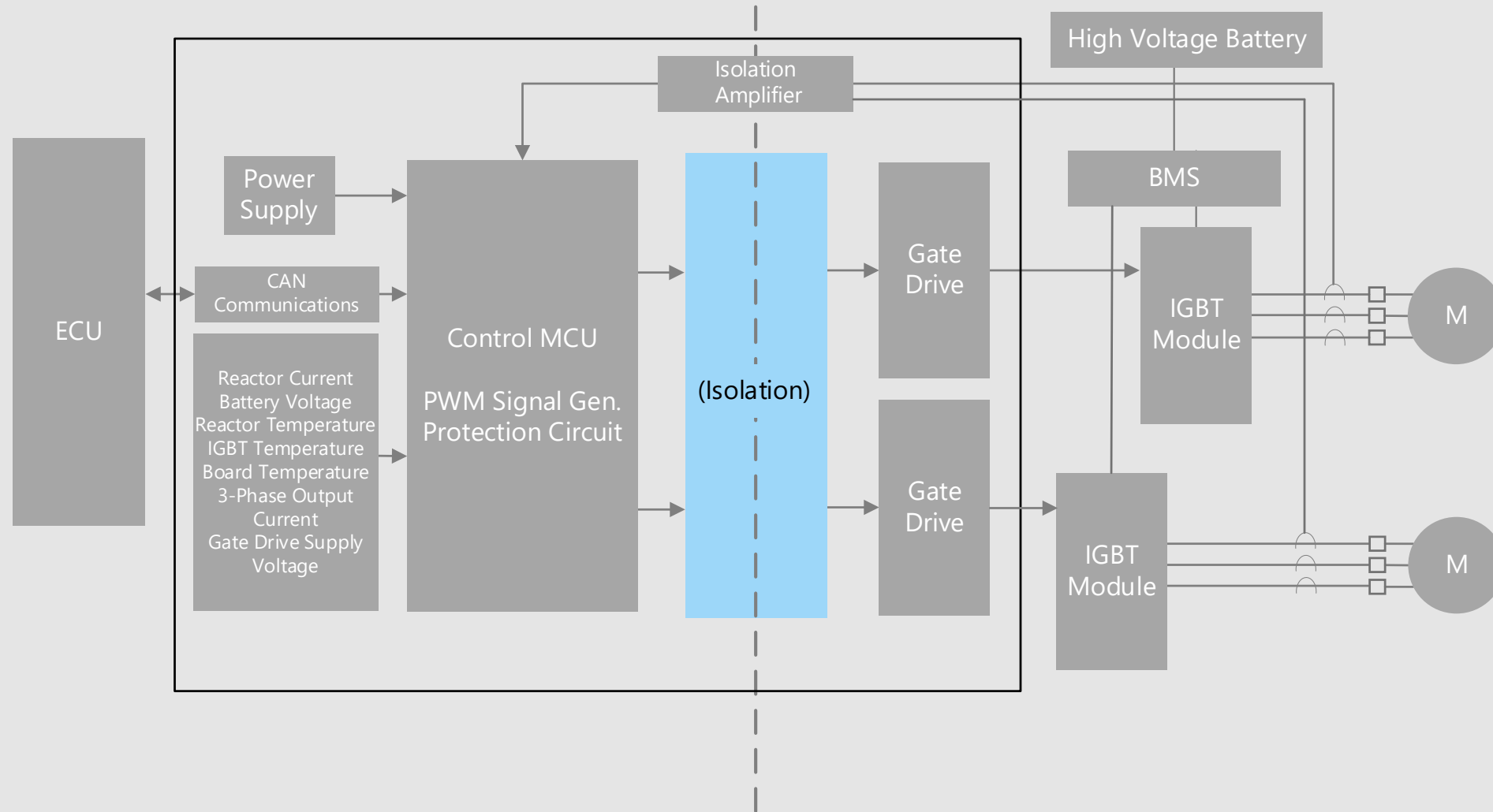


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

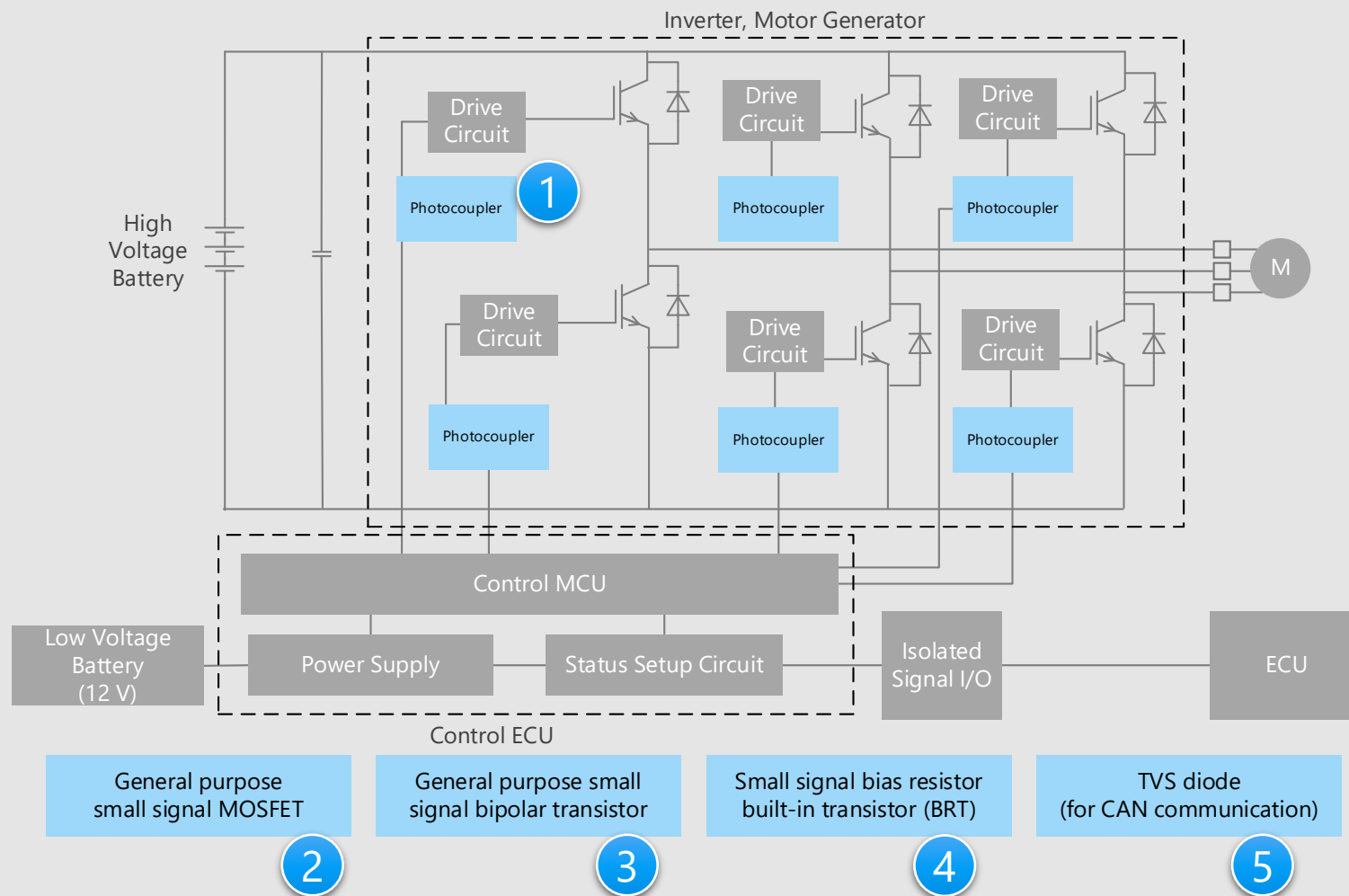
# Block Diagram



# xEV Overall block diagram



## 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 isolate high voltage system from control system.
- 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

- **Suitable for isolation between high voltage system and control system**

IC output photocoupler

- **Various product lineups and small packages**

General purpose small signal MOSFET

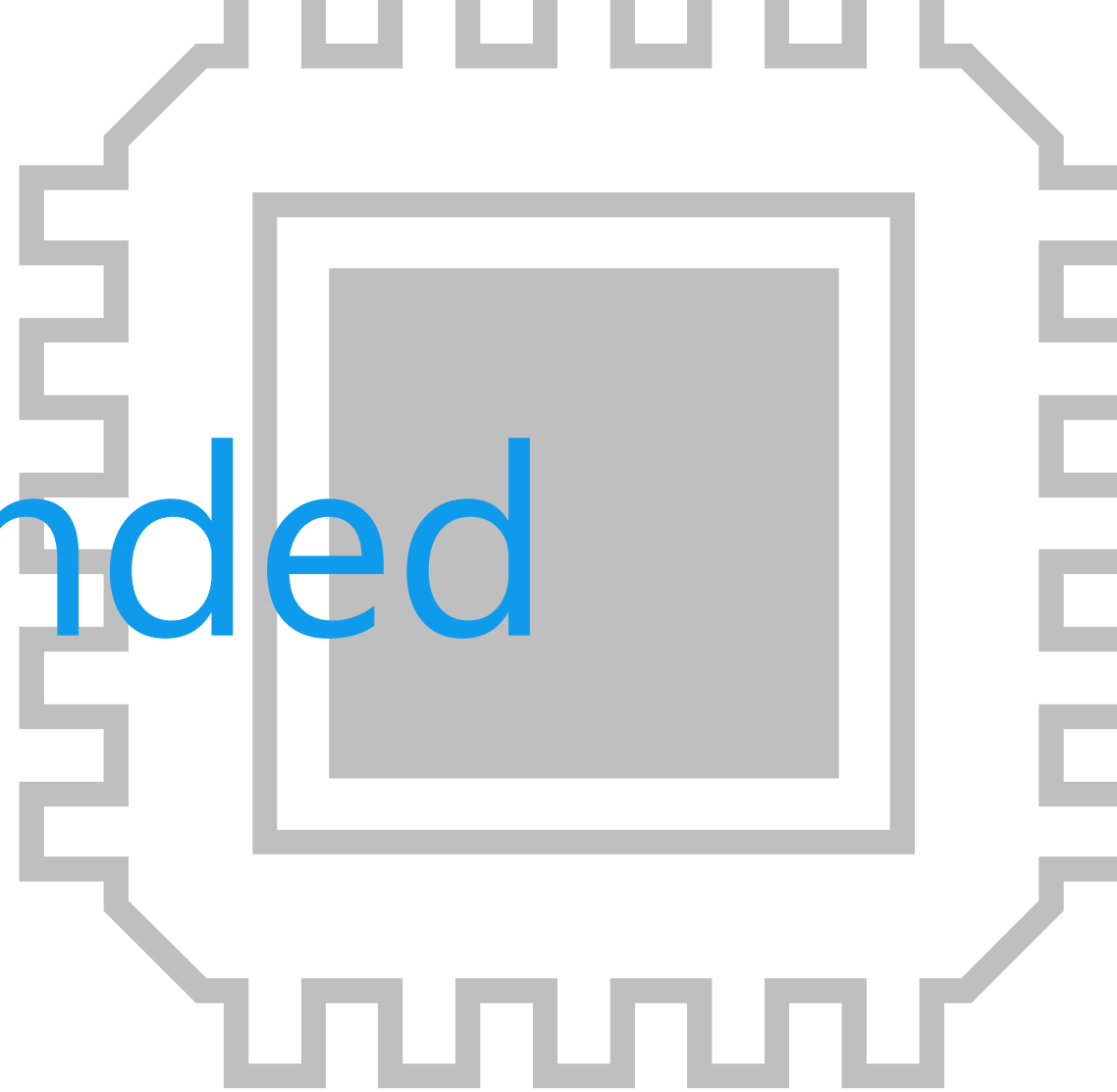
General purpose small signal bipolar transistor

Small signal bias resistor built-in transistor (BRT)

- **Suitable for ESD protection**

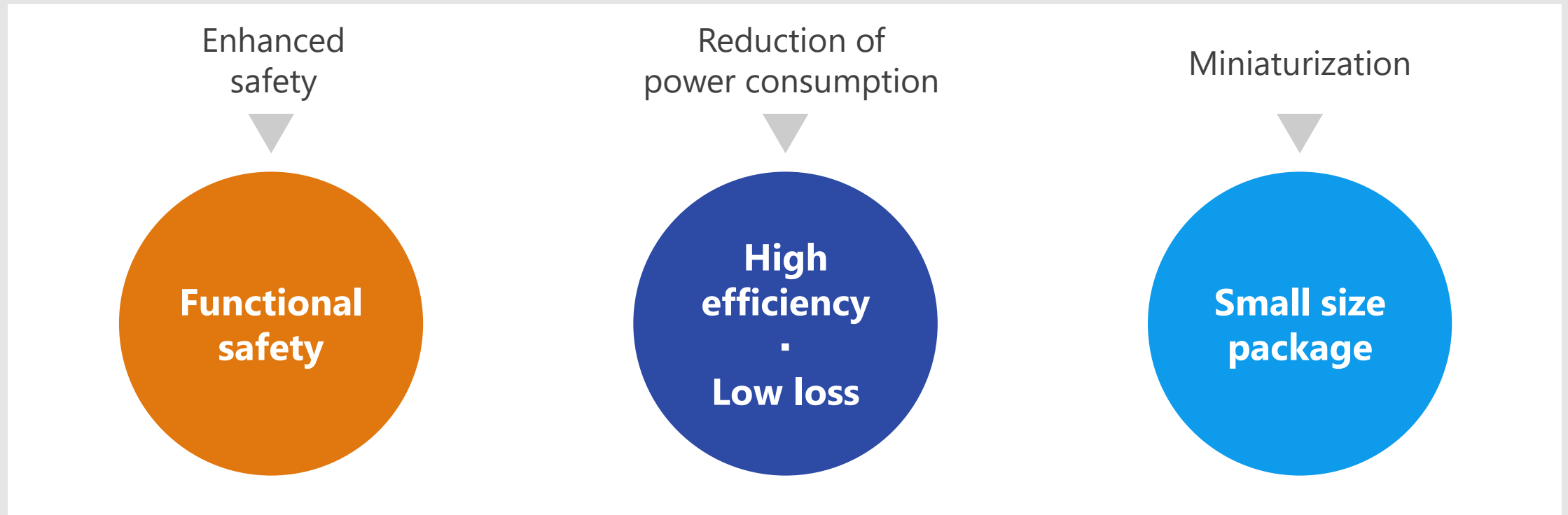
TVS diode (for CAN communication)

# Recommended Devices



# Device solutions to address customer needs

As described above, in the design of inverters for xEV, “**Enhanced 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

Functional  
safety

High  
efficiency  
·  
Low loss

Small size  
package

① IC output photocoupler



② General purpose small signal MOSFET



③ General purpose small signal bipolar transistor



④ Small signal bias resistor built-in transistor (BRT)



⑤ TVS diode (for CAN communication)





Value provided

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

**1 High isolation voltage and noise cutoff**

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

**2 Low power consumption and high speed transmission**

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

**3 Maximum operating temperature is extended to 125°C**

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

**TLX9304**  $T_{opr} = 125\text{ }^{\circ}\text{C}$   
**1 Mbps Logic output**

**TLX9309**  $T_{opr} = 125\text{ }^{\circ}\text{C}$   
**1 Mbps Analog output**

**TLX9310**  $T_{opr} = 105\text{ }^{\circ}\text{C}$   
**5 Mbps Logic output Low power-consumption**

**TLX9378**  $T_{opr} = 125\text{ }^{\circ}\text{C}$   
**10 Mbps Logic output**

**TLX9376**  $T_{opr} = 125\text{ }^{\circ}\text{C}$   
**20 Mbps Logic output**

**Power consumption 1/4**

(Comparison with Toshiba previous products)

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

[Return to Block Diagram TOP](#)

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.

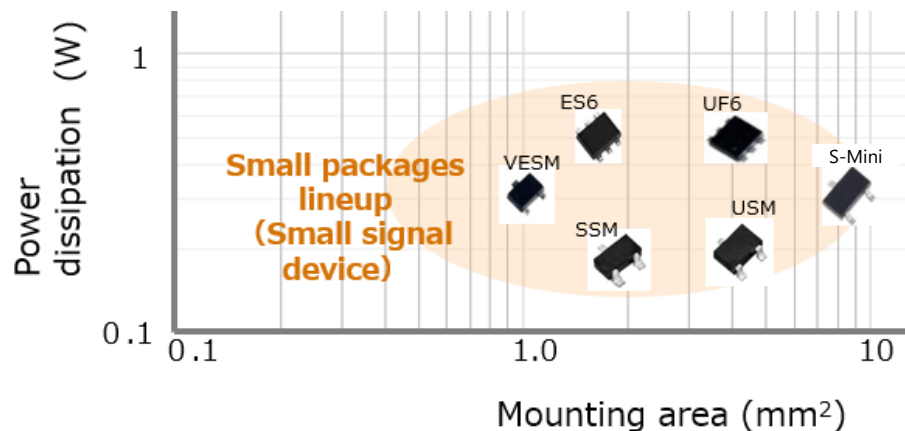
## 2 Low voltage drive

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 [ $\Omega$ ]	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

[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.

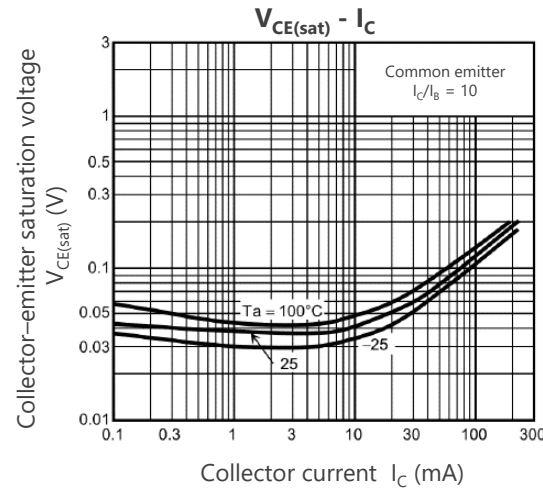
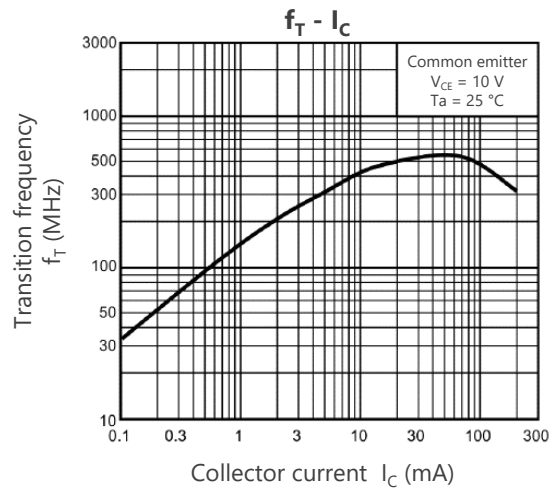
### 2 Extensive product lineup

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	$V_{CE0}$ [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				
	50	2500	TTC501					

\* indicates UFM package

[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)

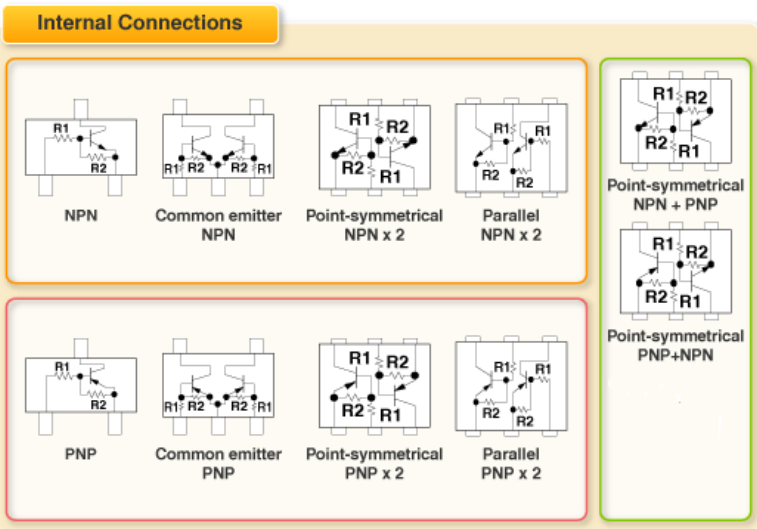
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

### 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.



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

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# 5 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU

Functional safety

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

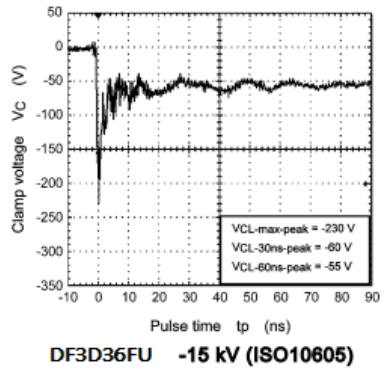
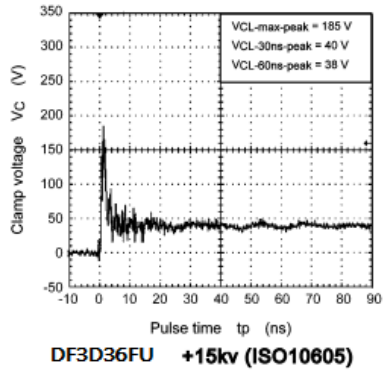
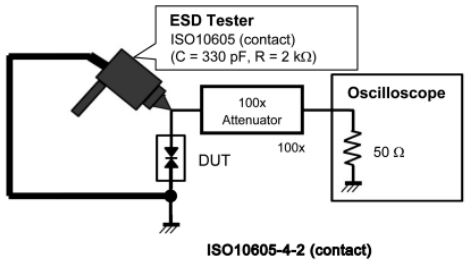
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.  
(Achieving both low dynamic resistance  $R_{DYN}$  and low capacitance between terminals  $C_t$ )

## 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

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



Lineup			
Part number	DF3D18FU	DF3D29FU	DF3D36FU
Package	USM (SOT-323)		
$V_{ESD}$ [kV] @ISO 10605	$\pm 30$	$\pm 30$	$\pm 20$
$V_{RWM}$ (Max) [V]	12	24	28
$C_t$ (Typ. / Max) [pF]	9 / 10		6.5 / 8
$R_{DYN}$ (Typ.) [ $\Omega$ ]	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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