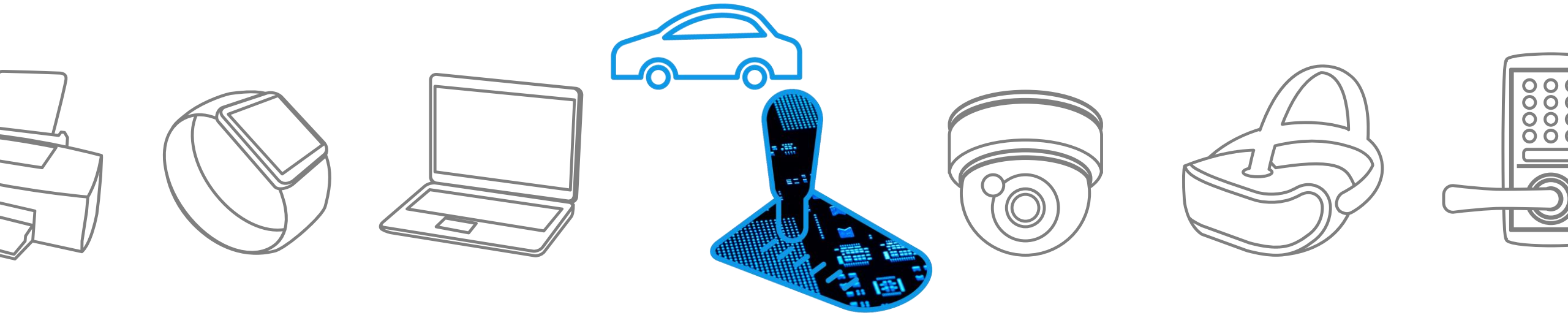
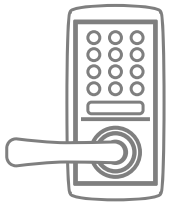
TOSHIBA

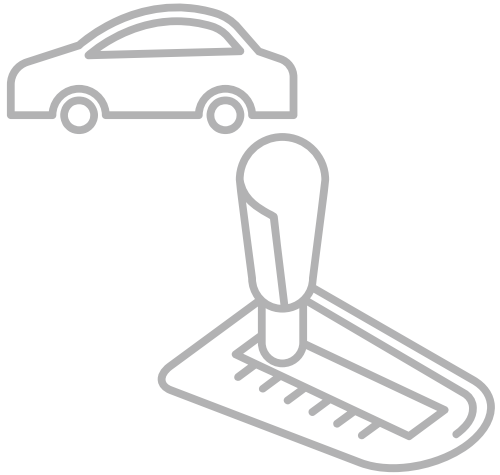
R21

Automotive Transmission Management

Solution Proposal by Toshiba

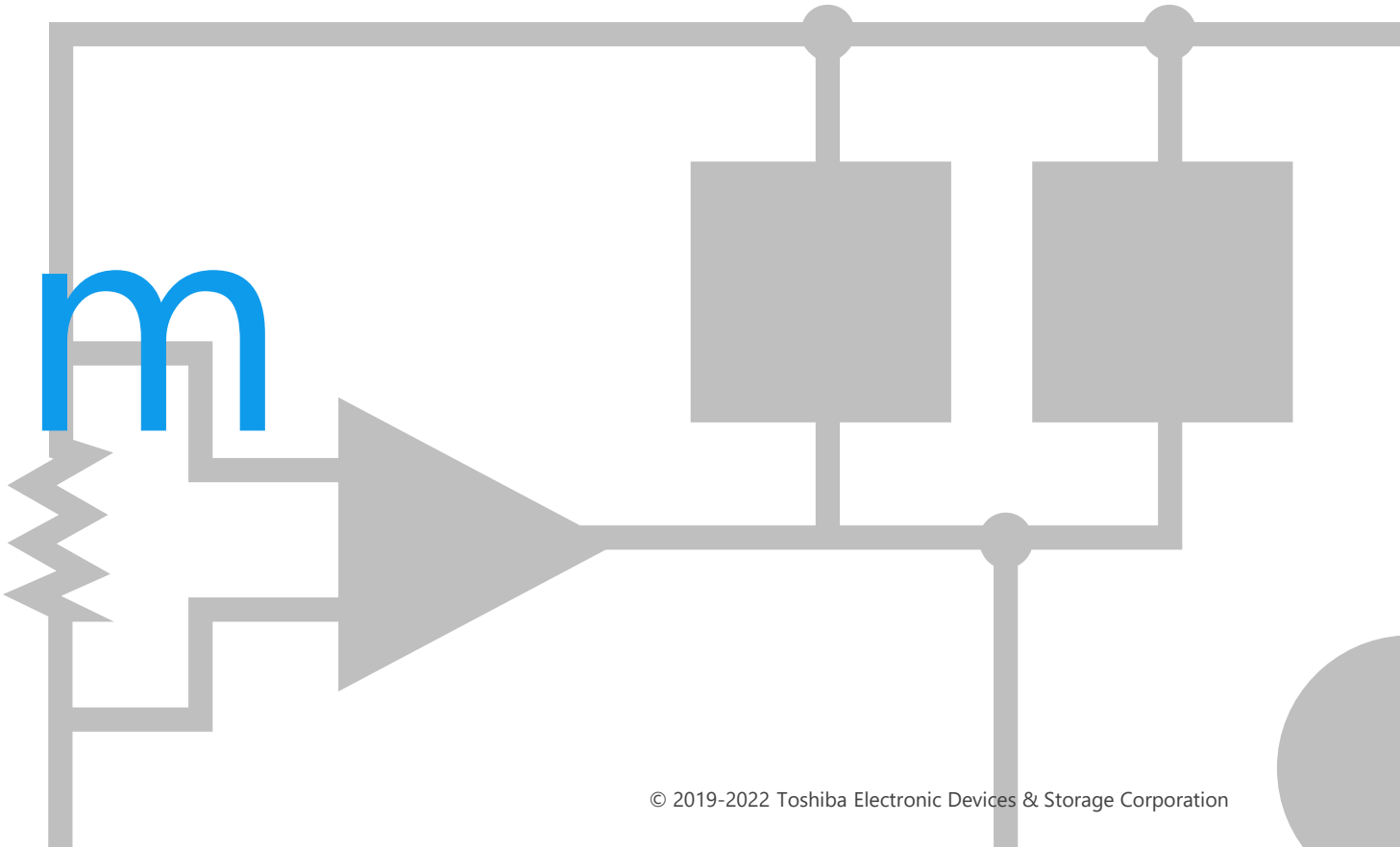






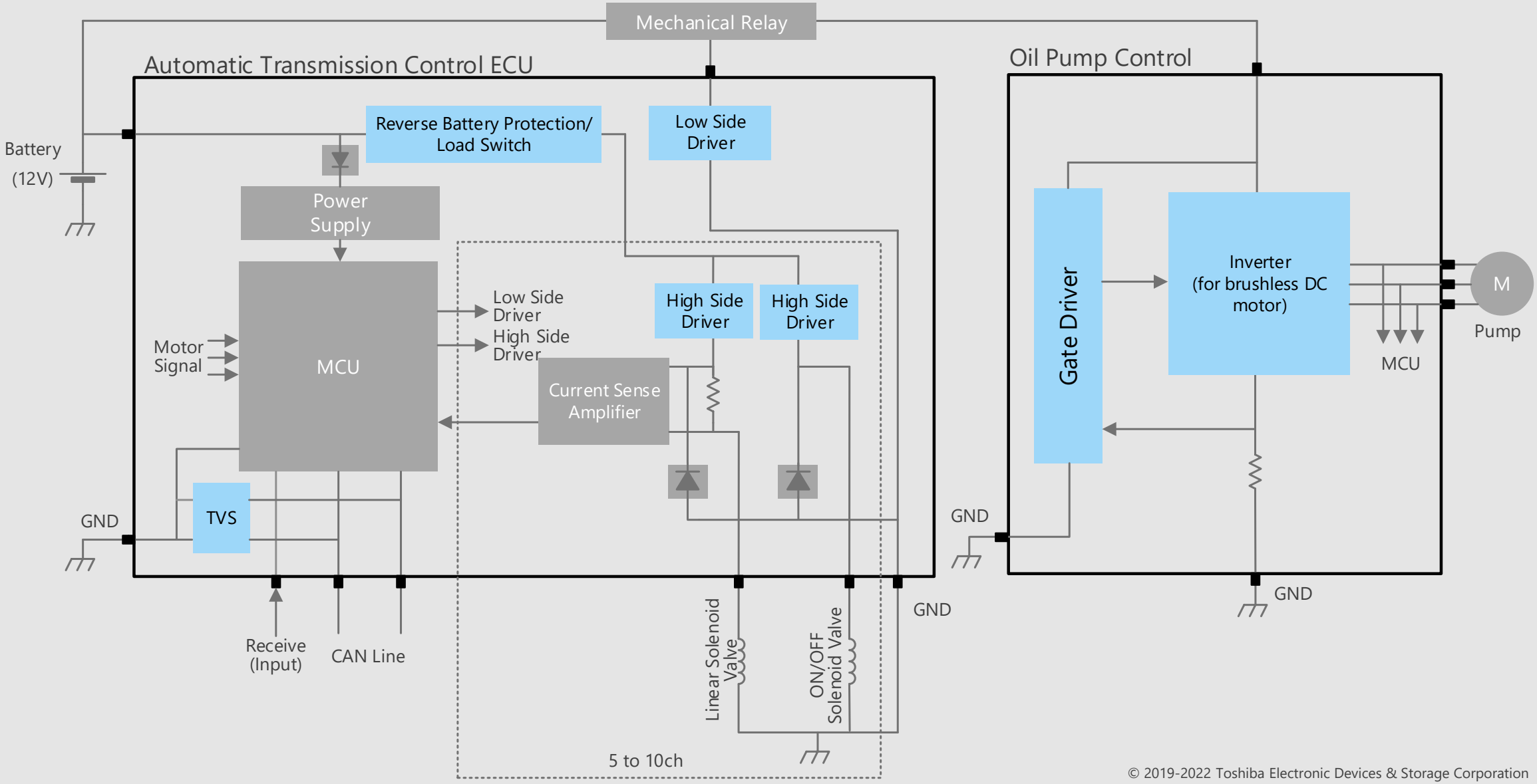
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



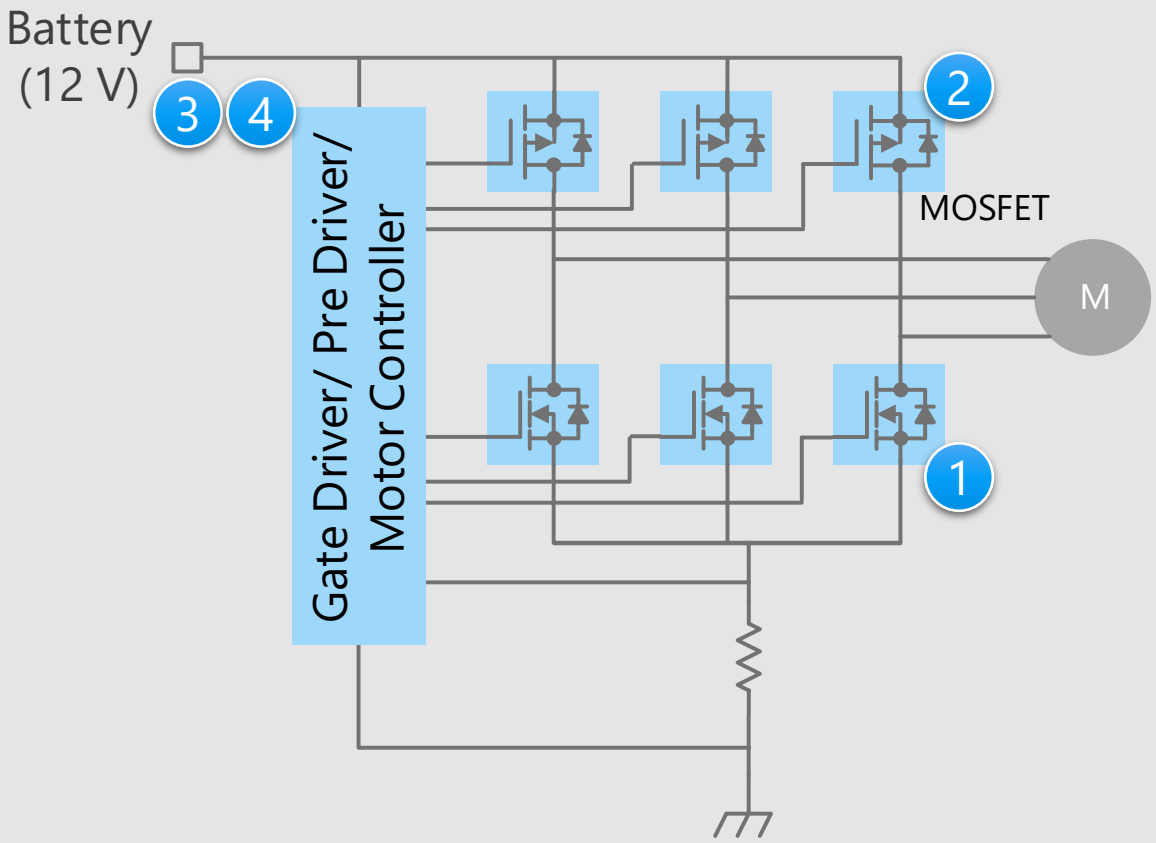
Transmission Management　Overall block diagram

Automatic Transmission (AT) / Continuously Variable Transmission (CVT) management System (Hydraulic control)



Detail of brushless DC motor drive circuit

Brushless DC motor drive circuit (N-ch / P-ch type)



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

Criteria for device selection

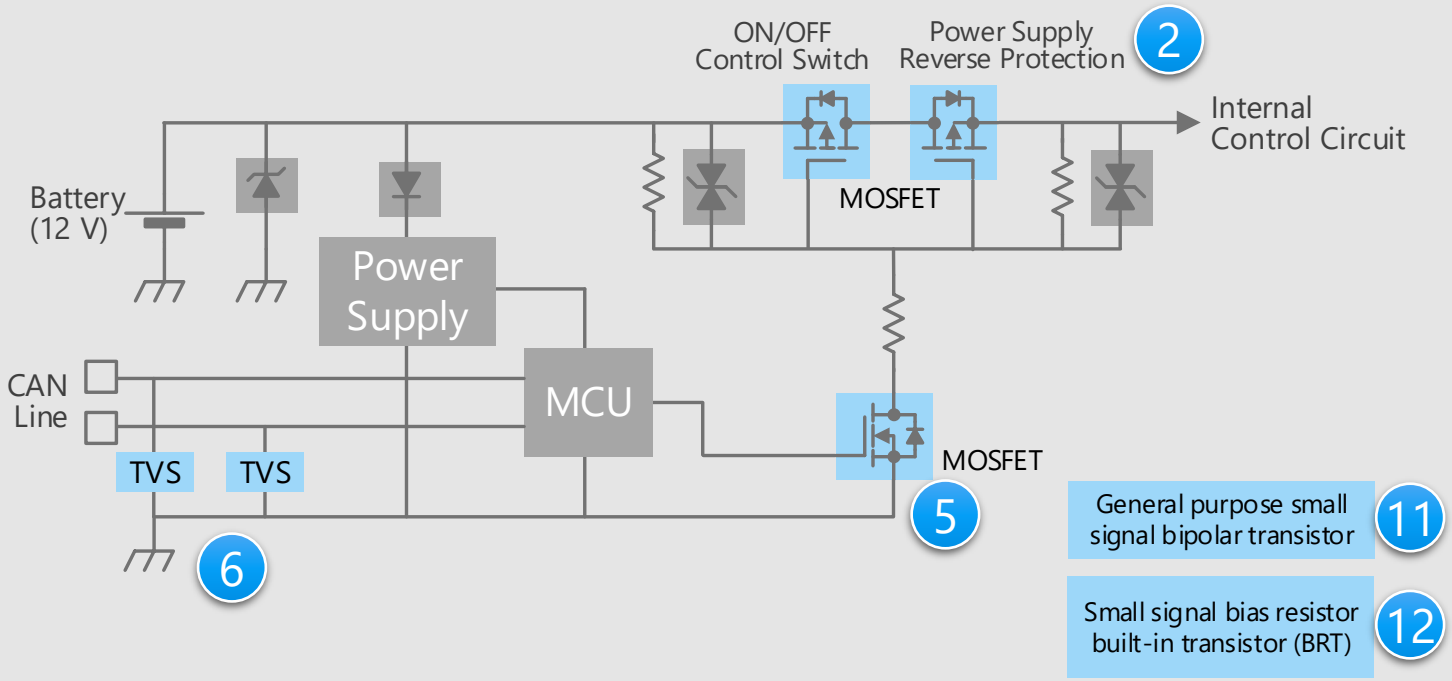
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system** 1
  U-MOS Series 40 V N-ch MOSFET
  U-MOS Series -40 V / -60 V P-ch MOSFET 2
- **Gate driver with built-in protection and diagnosis functions**
  Gate driver (for motor) 3
- **Full bridge pre driver**
  Brushless DC motor pre driver 4

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

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



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

Criteria for device selection

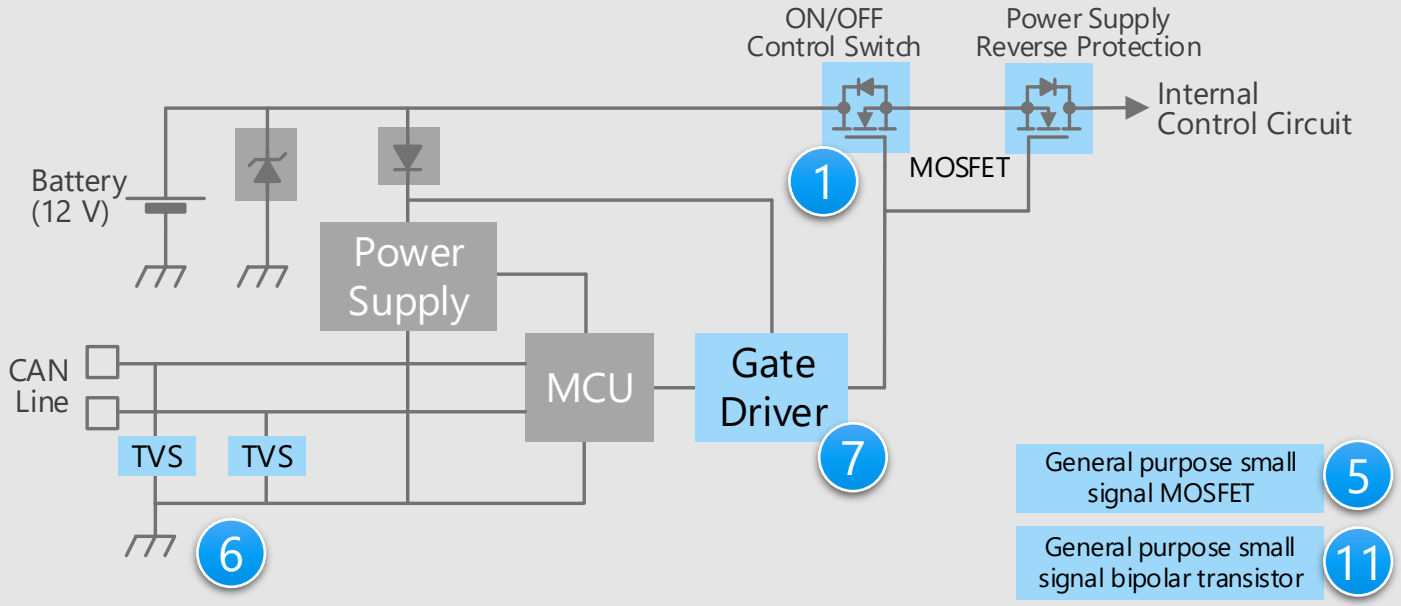
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the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

Proposals from Toshiba

- **Low on-resistance contributes to low power consumption of the system**
  U-MOS Series -40 V / -60 V P-ch MOSFET 2
- **Extensive product lineup**
  General purpose small signal MOSFET 5
  General purpose small signal bipolar transistor 11
  Small signal bias resistor built-in transistor (BRT) 12
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 6

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

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



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

Criteria for device selection

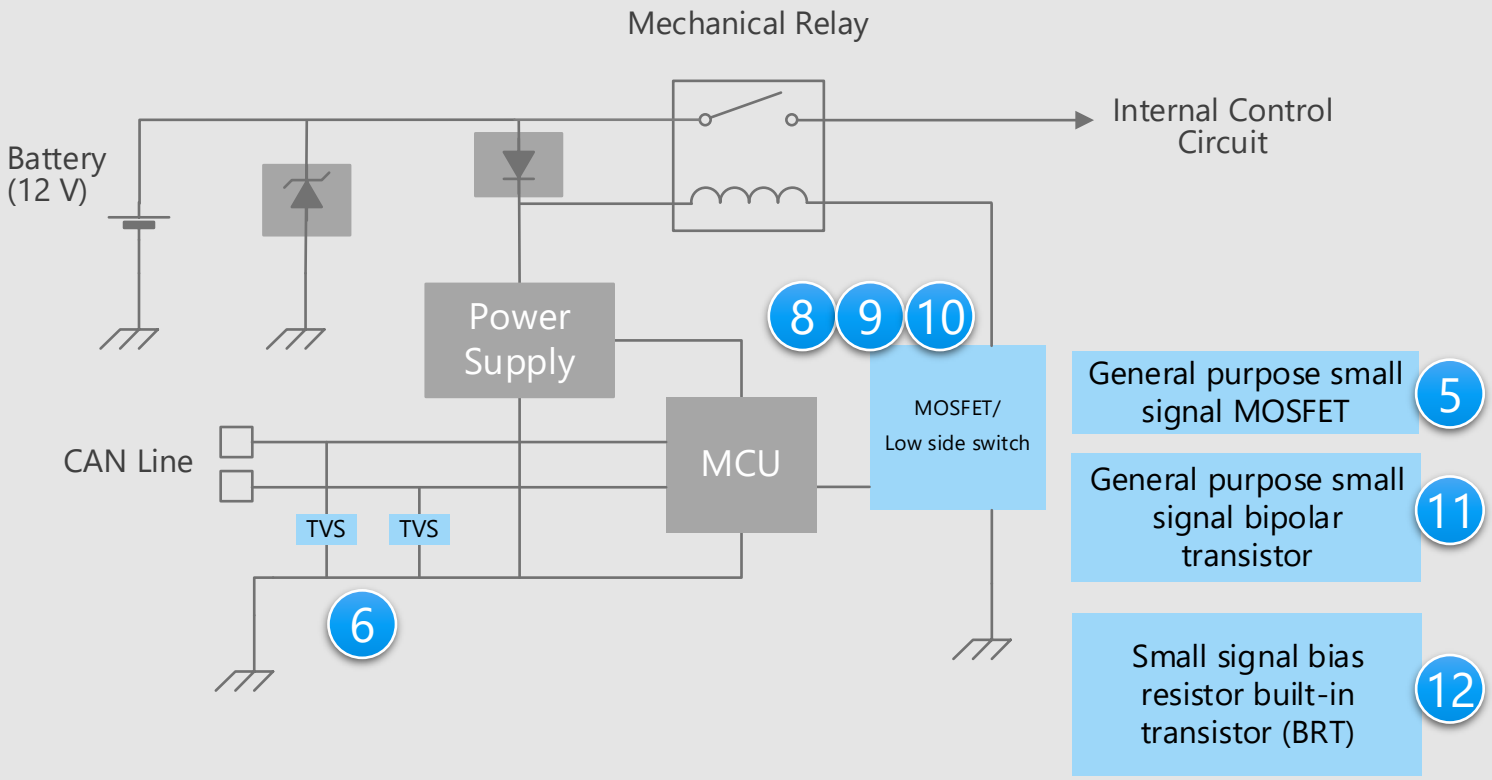
- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- A small surface mount package is suitable for realizing miniaturization of the 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) 7
- **Extensive product lineup**
  General purpose small signal MOSFET 5
  General purpose small signal bipolar transistor 11
  Small signal bias resistor built-in transistor (BRT) 12
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 6

Detail of mechanical relay drive circuit

Mechanical relay drive circuit



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

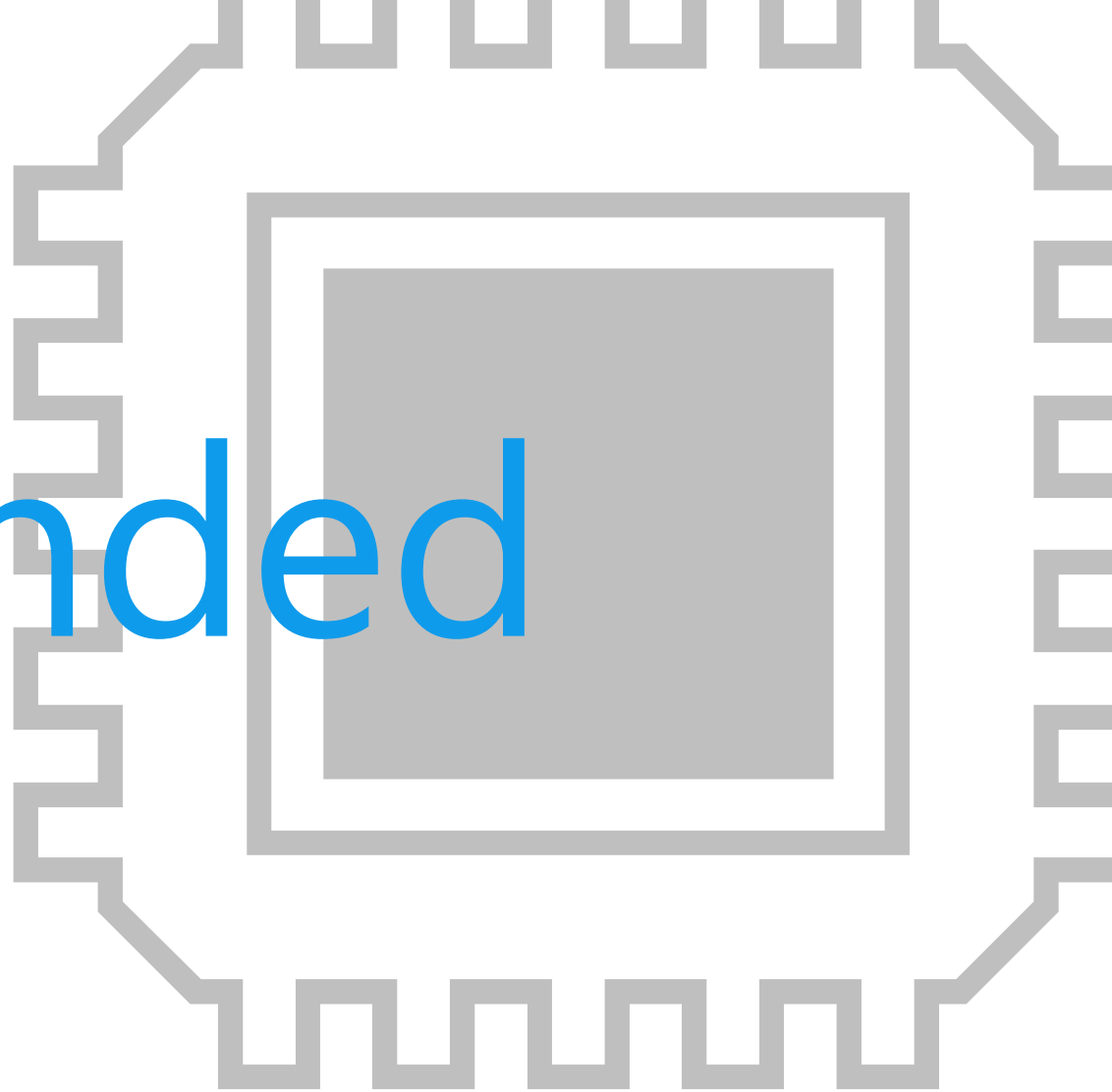
Criteria for device selection

- It is necessary to select a device that can protect the system from the voltage generated by the back electromotive force (EMF) of inductive loads.
- A small surface mount package is suitable for realizing miniaturization of the ECU.

Proposals from Toshiba

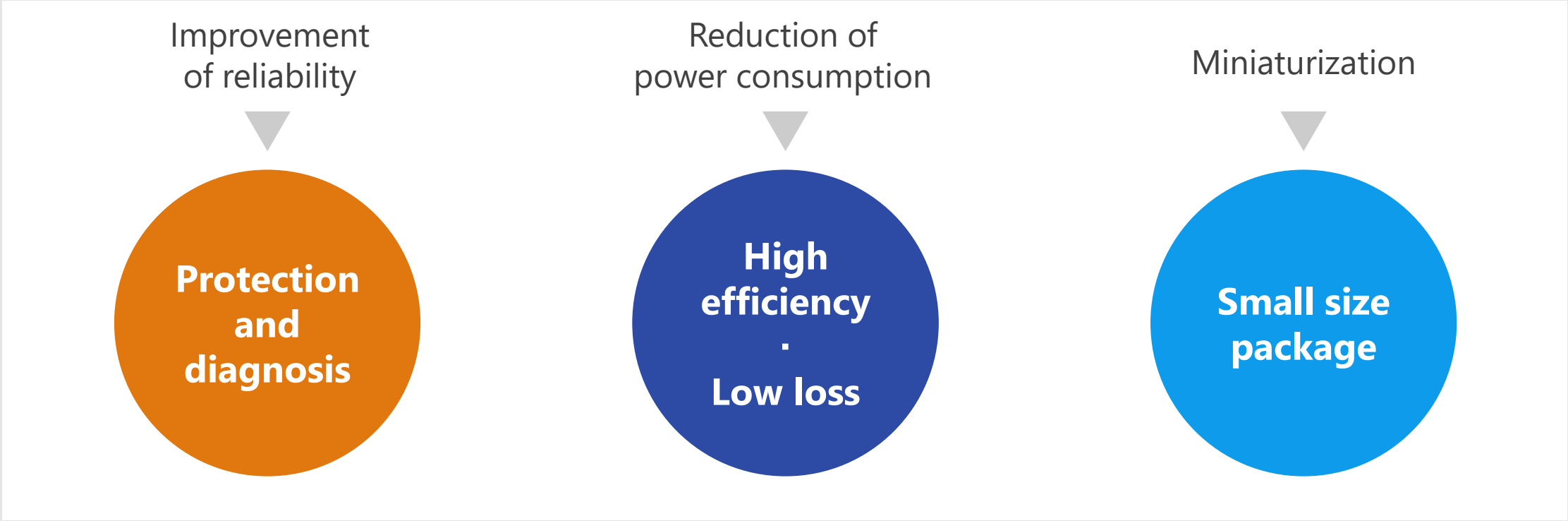
- **Built-in active clamp circuit and pull-down resistor for relay drive**
  MOSFET with a built-in active clamp circuit 8
- **Driver with protection function**
  Low side switch / High side switch (up to 1 A) 9
  Low side switch / High side switch (1 to 5 A) 10
- **Extensive product lineup**
  General purpose small signal MOSFET 5
  General purpose small signal bipolar transistor 11
  Small signal bias resistor built-in transistor (BRT) 12
- **Suitable for ESD protection**
  TVS diode (for CAN communication) 6

Recommended Devices



Device solutions to address customer needs

As described above, in the design of Transmission Management, **“Improvement of reliability”**, **“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

		Protection and diagnosis	High efficiency · Low loss	Small size package
1	U-MOS Series 40 V N-ch MOSFET		●	●
2	U-MOS Series -40 V / -60 V P-ch MOSFET		●	●
3	Gate driver (for motor)	●		●
4	Brushless DC motor pre driver	●	●	
5	General purpose small signal MOSFET		●	●
6	TVS diode (for CAN communication)	●		●
7	Gate driver (for switch)	●		●
8	MOSFET with a built-in active clamp circuit	●	●	●
9	Low side switch / High side switch (up to 1 A)	●		●
10	Low side switch / High side switch (1 to 5 A)	●		●
11	General purpose small signal bipolar transistor			●
12	Small signal bias resistor built-in transistor (BRT)			●

1 U-MOS Series 40 V N-ch MOSFET

XPN3R804NC / TK1R4S04PB / XPHR7904PS / TPWR7904PB / XPJR6604PB* / XPQR3004PB

Protection and diagnosis | 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)

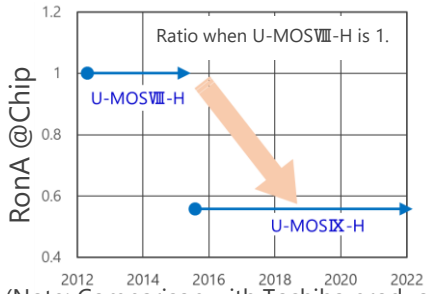
2 Small and low loss package

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)

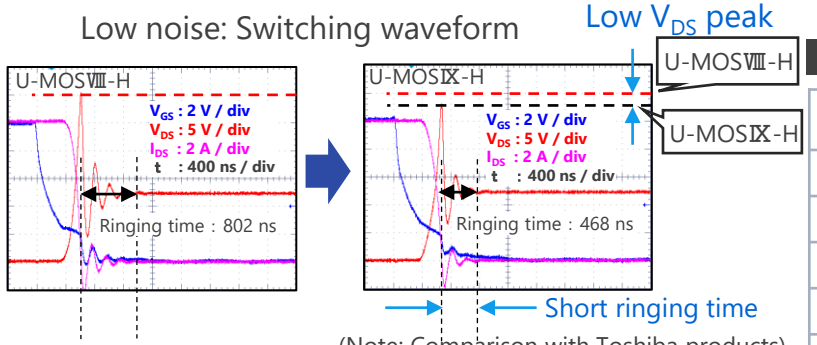
Improved chip process reduces surge voltage and ringing time.

Low loss: RonA trend



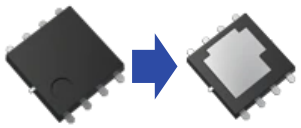
(Note: Comparison with Toshiba products)

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

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+
XPHR7904PB	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™

* : Under development (Values enclosed in parentheses are tentative specifications. Specifications are subject to change without notice.)

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

XPN9R614MC / XPH3R114MC / XPH8R316MC* / TJ90S04M3L

Protection and diagnosis | High efficiency · Low loss | Small size package

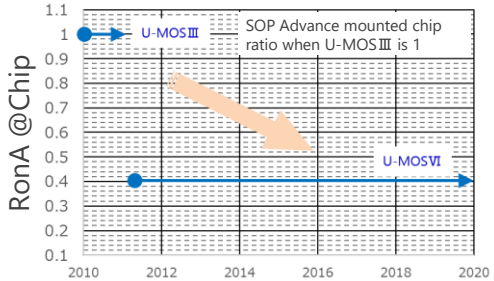
Value provided

Low on-resistance contributes to reduce system power consumption.

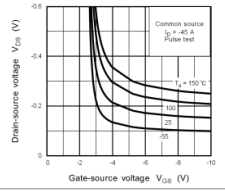
1 Low loss (reduced on-resistance) and logic level drive

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)



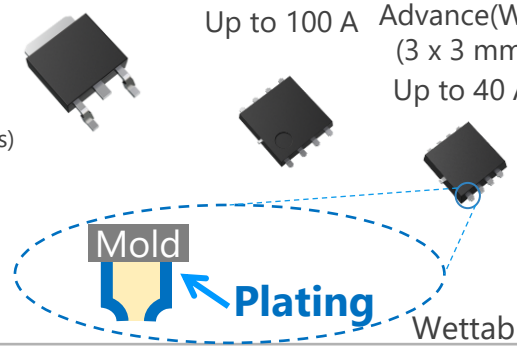
Logic level drive
TJ90S04M3L
$V_{DS(ON)}$ - V_{GS}

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+

* Under development (Values enclosed in parentheses are tentative specifications. Specifications are subject to change without notice.)

◆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

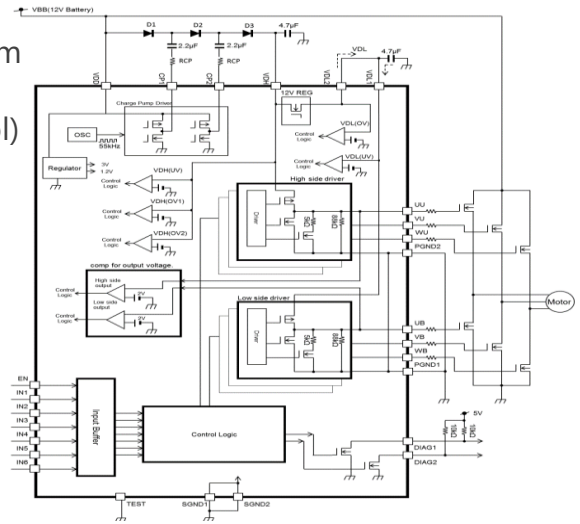
2 Built-in protection / diagnostic output function

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 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

4 Brushless DC motor pre driver

TB9061AFNG

Protection and diagnosis | High efficiency · Low loss | Small size package

Value provided

It is built in a sensorless control circuit and can drive a brushless DC motor without using Hall elements.

1 Three-phase sensorless drive

It can drive a brushless DC motor by change of detecting the back electromotive force of each motor phase without using Hall elements.

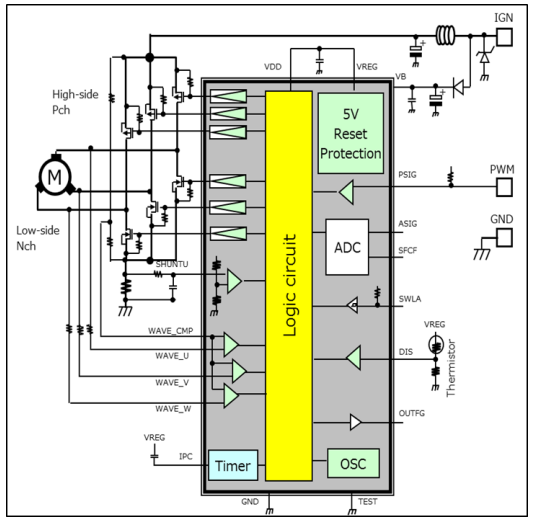
2 Built-in external MOSFET drive circuits

It is built in three-phase circuit for driving external P-ch and N-ch MOSFETs.

3 AEC-Q100 qualified

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

TB9061AFNG
Application circuit example



Lineup

Part number	TB9061AFNG
Package	SSOP24-P-300-0.65A (7.8 x 7.6 mm)
Power supply voltage VB [V]	40
Output voltage VOH (Min) / VOL (Max) [V]	VB-0.5 @IOH = -20 mA / 0.5 @IOL = 20 mA
PWM frequency fpint (Typ.) [kHz]	20
Oscillation frequency fosc (Typ.) [MHz]	5.12

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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.

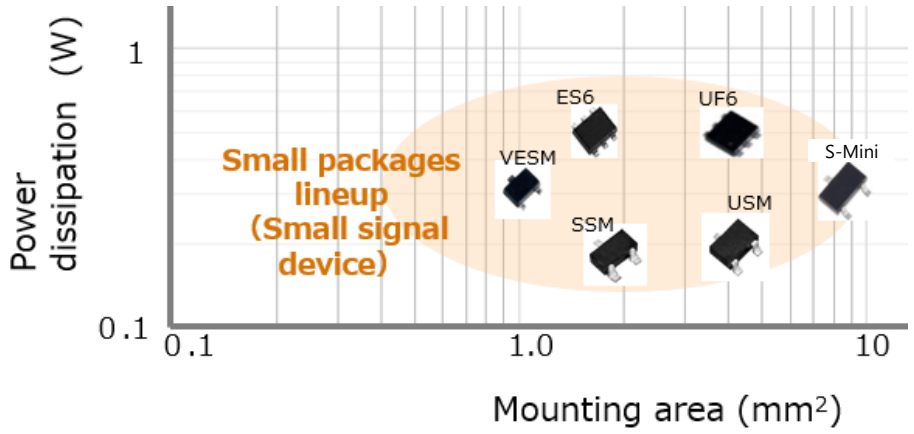
2 Low voltage drive

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



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 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

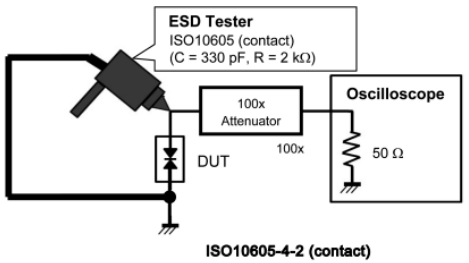
Toshiba proprietary Zener process improves the ESD pulse absorption of TVS diodes.
(Achieving both low dynamic resistance R_{DYN} and low capacitance between terminals C_t)

2 Supports CAN, CAN FD and FlexRay

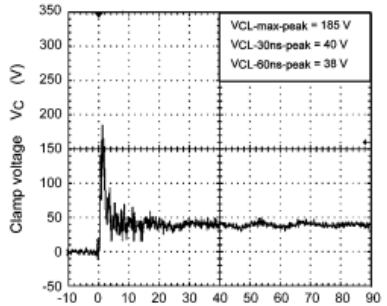
These are products applicable to in-vehicle LAN communication such as CAN, CAN FD and FlexRay.

3 High ESD immunity

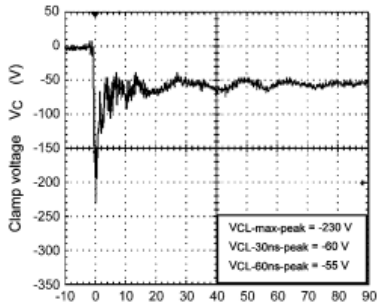
V_{ESD} > ±30 kV @ISO 10605
V_{ESD} > ±20 kV @IEC 61000-4-2 (Level 4)



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.

◆Return to Block Diagram TOP

7 Gate driver (for switch)

TPD7104AF / TPD7106F / TPD7107F

Protection and diagnosis | 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.

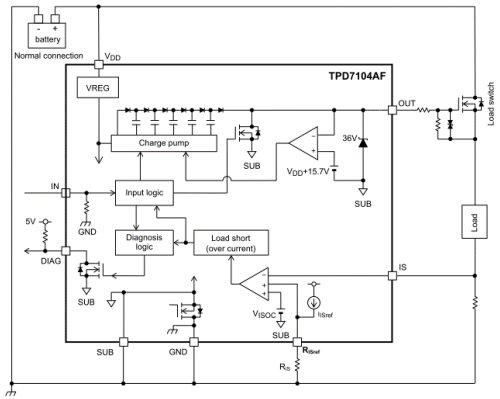
2 Can be controlled by logic level voltage

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

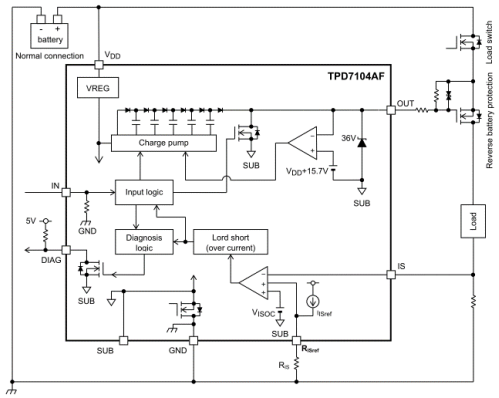
3 Small package

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.

◆Return to Block Diagram TOP

8 MOSFET with a built-in active clamp circuit

SSM3K347R / SSM3K337R

Protection and diagnosis | 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.

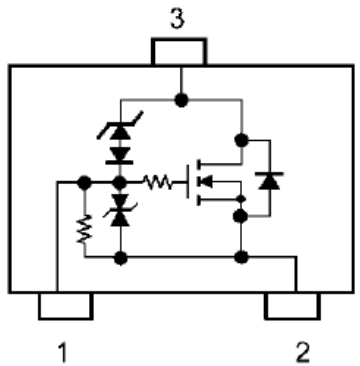
2 Built-in pull-down resistor

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.

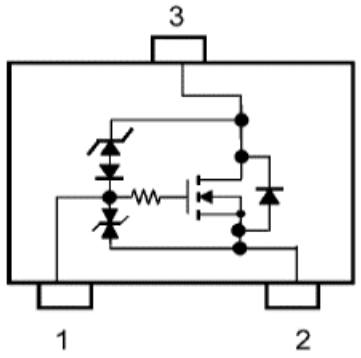
3 Low voltage drive

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

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

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9 Low side switch / High side switch (up to 1 A)

TPD1044F / TPD1054F / TPD1052F

Protection and diagnosis | High efficiency · Low loss | Small size package

Value provided

Various protection and diagnostic output functions are built in, contributing to improve reliability and to miniaturize the system.

1 Built-in various protection and diagnostic output functions

Overcurrent and overheat protection and diagnostic output (except TPD1044F) to the MCUs or the control circuits are built in. These functions contribute to improve reliability of the system.

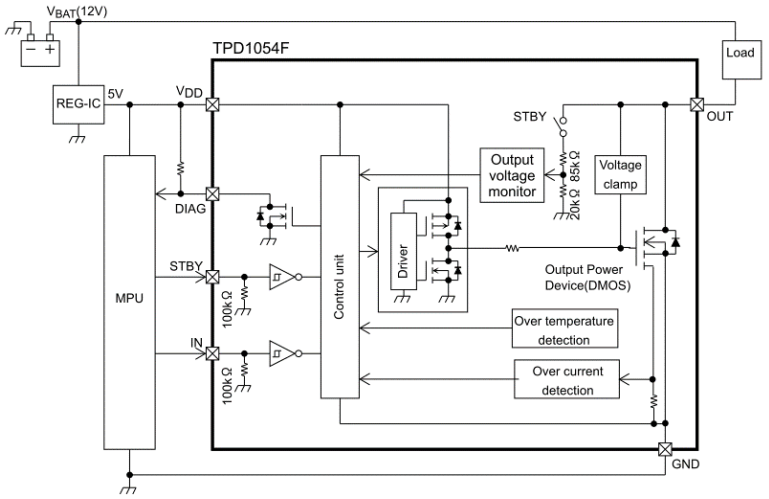
2 Can be controlled by logic level voltage

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

3 Small package

PS-8 is small surface mount package. It contributes to the miniaturization of system.

Example of low side switch application
(Block diagram of TPD1054F)



Suitable for applications with small current load below 1 A, such as mechanical relay

Lineup

Function	Low side switch		High side switch
Part number	TPD1044F	TPD1054F	TPD1052F
Package	 PS-8 (2.8 x 2.9 mm)		
Features	・Overcurrent / over-temperature protection ・Active clamp ・On-resistance: 0.6 Ω	・Overcurrent / over-temperature protection ・Active clamp ・Diagnostic output function ・On-resistance: 0.8 Ω	・Overcurrent / over-temperature protection ・Diagnostic output function ・On-resistance: 0.8 Ω

◆Return to Block Diagram TOP

10 Low side switch / High side switch (1 to 5 A)

TPD1058FA / TPD1055FA

Protection and diagnosis | High efficiency · Low loss | Small size package

Value provided

Various protection and diagnostic output functions are built in, contributing to improve reliability and to miniaturize the system.

1 Built-in various protection and diagnostic output functions

Overcurrent and overheat protection and diagnostic output to the MCUs or the control circuits are built in. These functions contribute to improve reliability of the system.

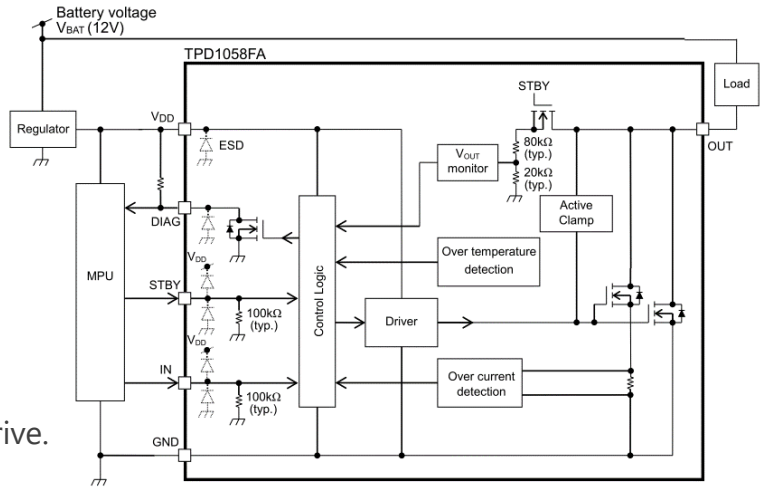
2 Can be controlled by logic level voltage

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

3 Small package

WSON10 is small surface mount package. It contributes to the miniaturization of system.

Example of low side switch application
(Block diagram of TPD1058FA)



Suitable for various solenoid drive.

Lineup

Function	Low side switch	High side switch
Part number	TPD1058FA	TPD1055FA
Package	Back surface  WSON10 (3 x 3 mm)	
Features	・Overcurrent / Overheat protection ・Active clamp ・Diagnostic output function ・ON-resistance: 0.1 Ω	・Overcurrent / Overheat protection ・Diagnostic output function ・ON-resistance: 0.12 Ω

◆Return to Block Diagram TOP

11 General purpose small signal bipolar transistor

2SC2712 / 2SA1162 / 2SC4116 / 2SA1586 / TTA501 / TTC501 and others

Protection and diagnosis | 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.

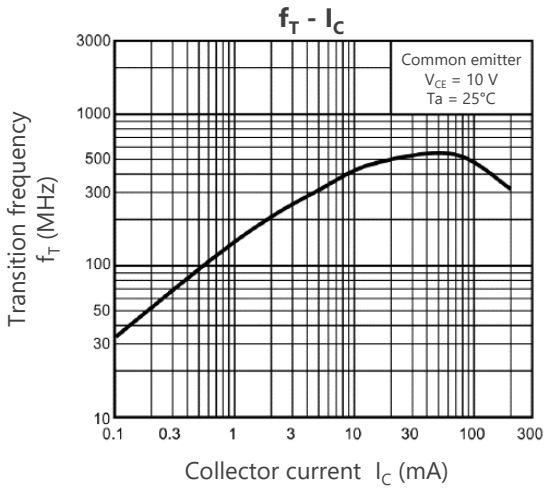
2 Extensive product lineup

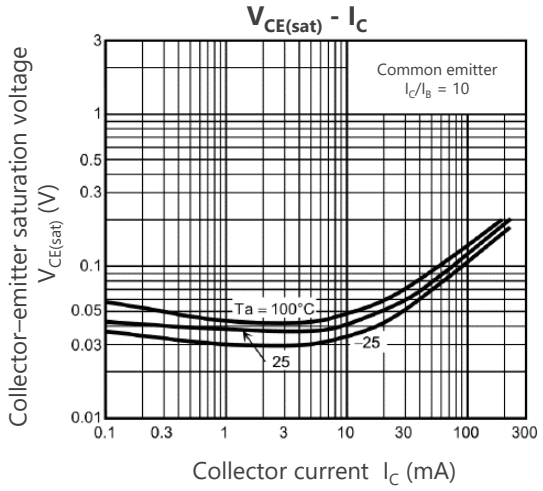
Various product lineups, such as general purpose, low noise, low VCE(sat) and high current types are provided. Products can be selected in accordance with the application.

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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Small signal bias resistor built-in transistor (BRT)

RN1907FE / RN2907FE / RN1901 / RN2901 Series

Protection and diagnosis | 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)

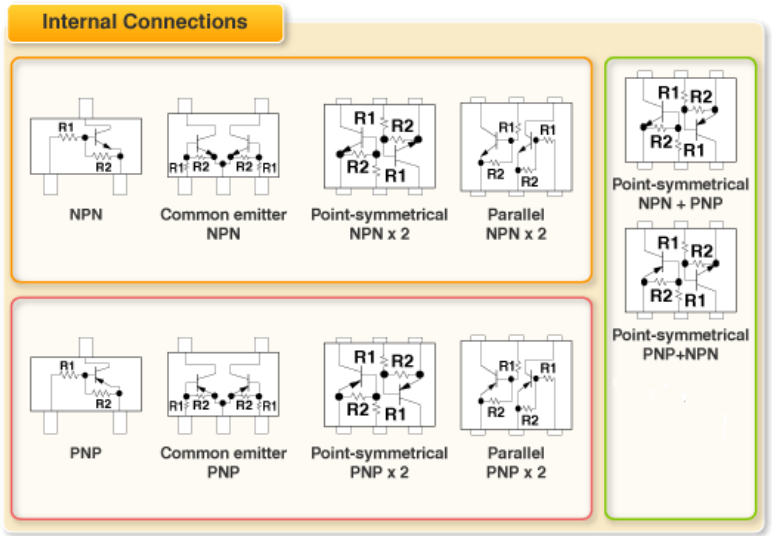
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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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