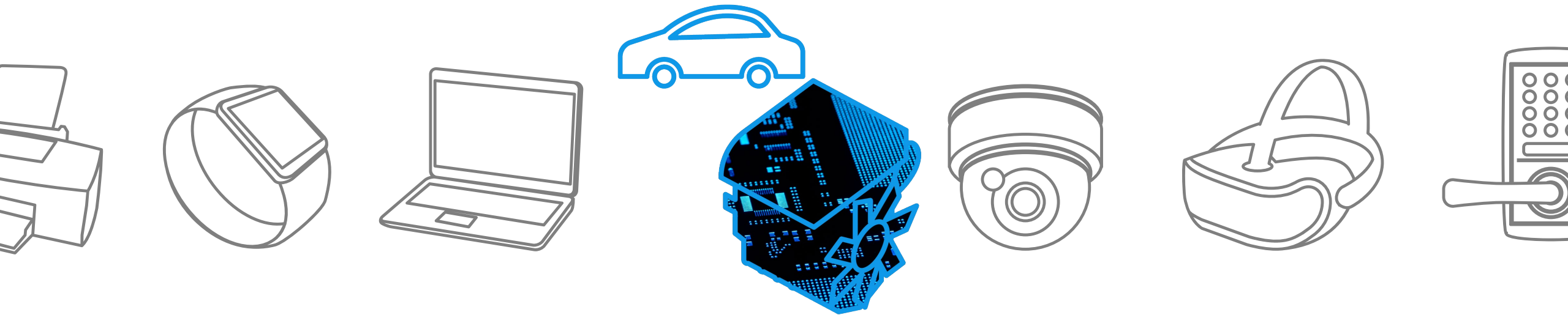


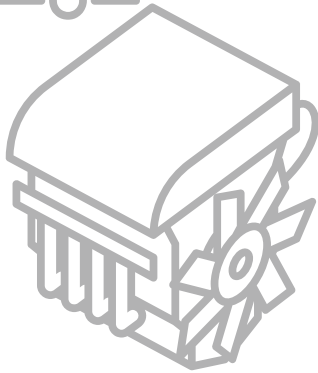
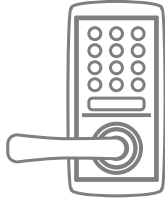
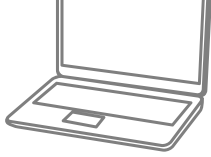
TOSHIBA

Automotive Engine Control

R20

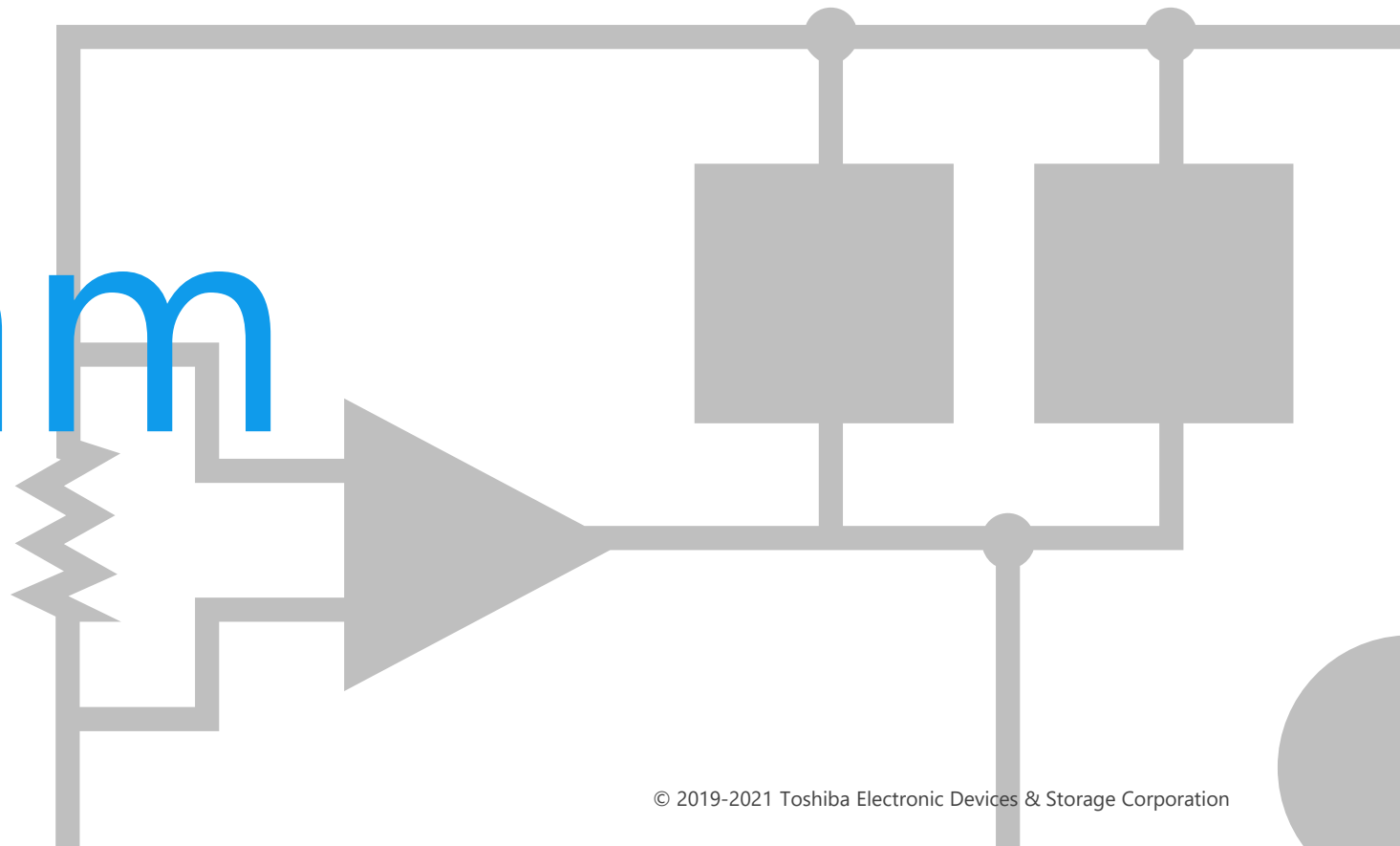
Solution Proposal by Toshiba



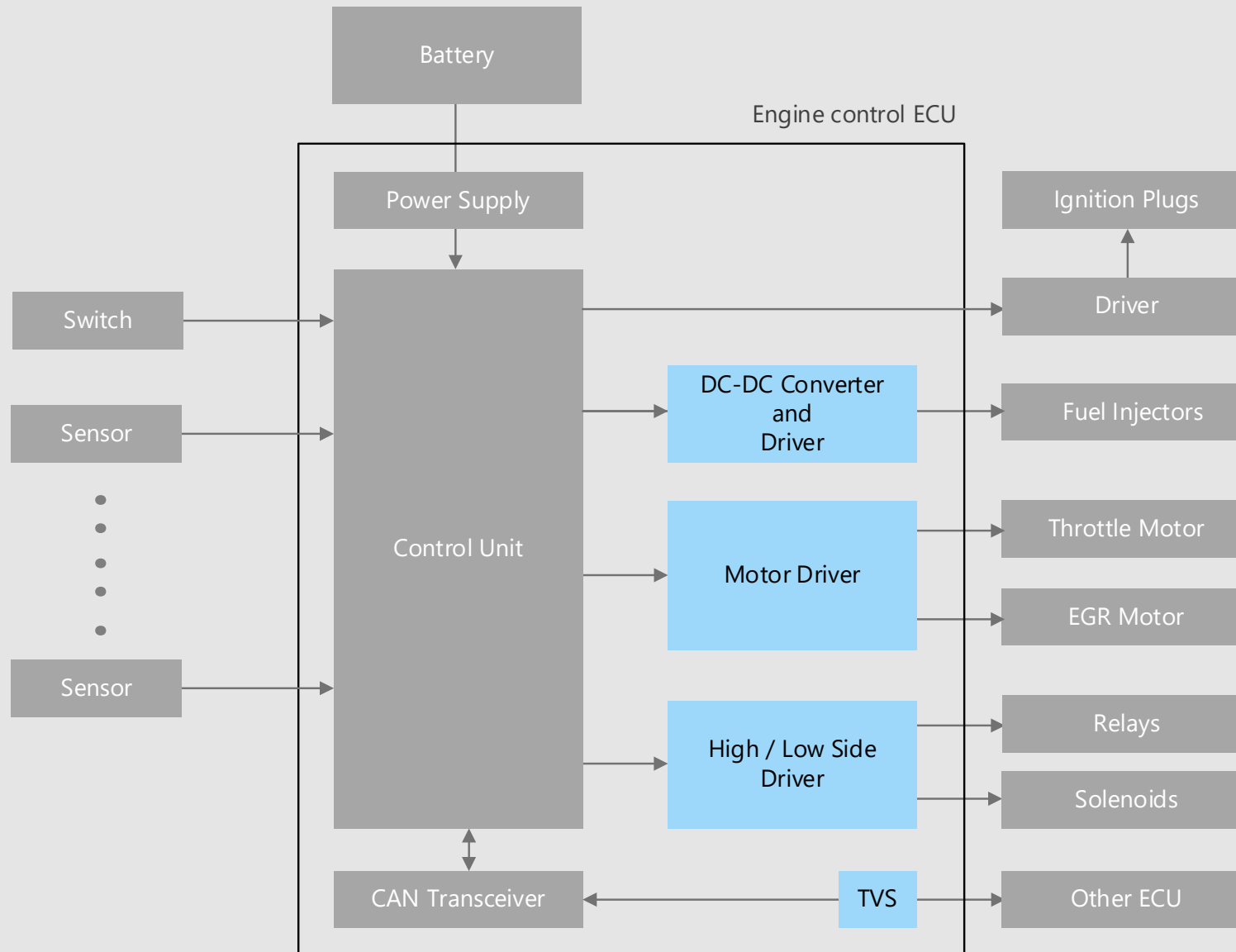


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

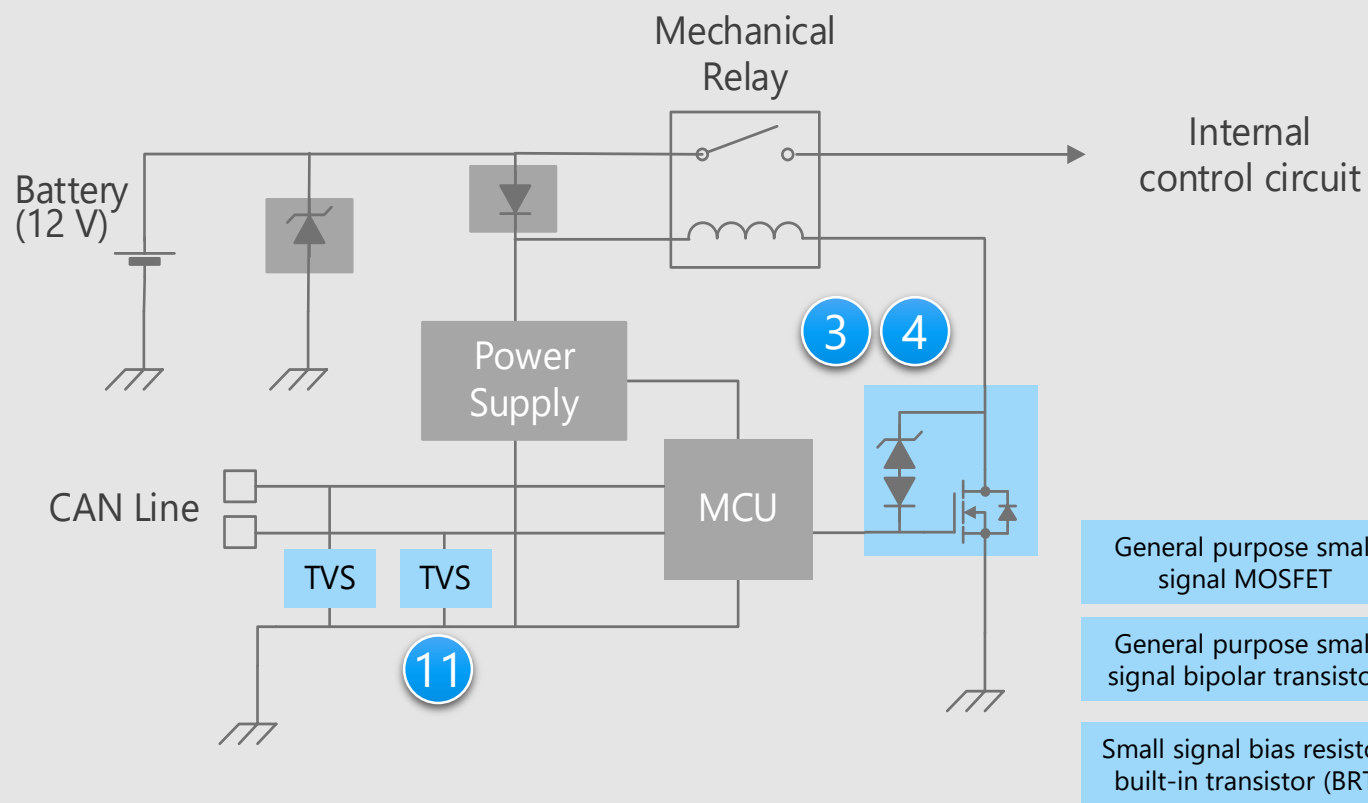


Engine Control Overall block diagram



Engine Control Detail of power management circuit

Mechanical relay type



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

- **Driver with protection function**

Low side switch / high side switch (up to 1 A)

- **Extensive product lineup**

General purpose small signal MOSFET

General purpose small signal bipolar transistor

Small signal bias resistor built-in transistor (BRT)

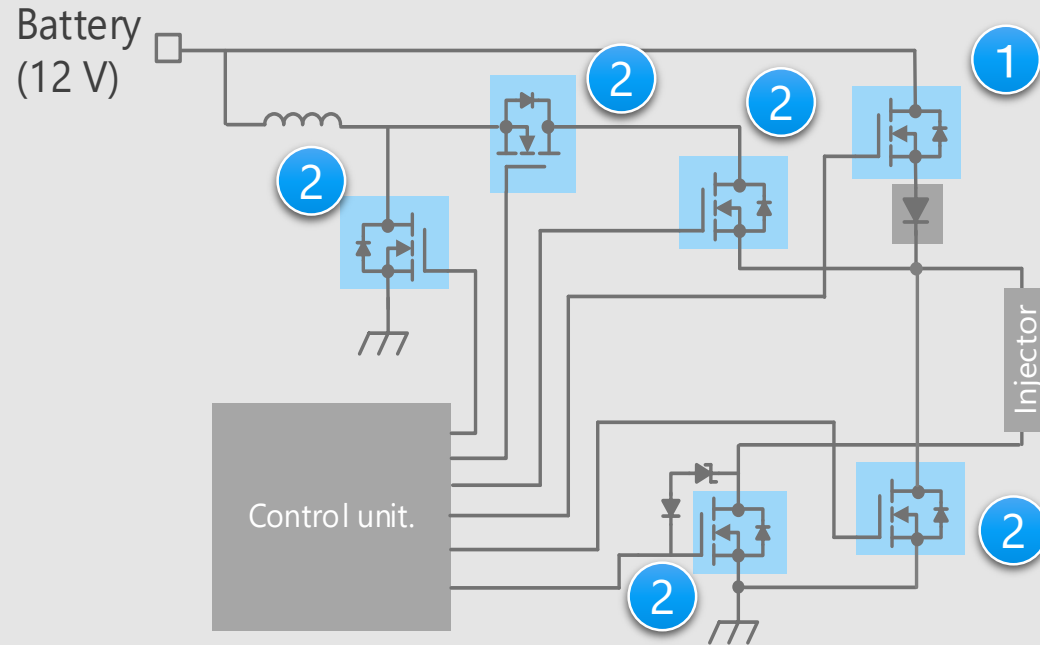
- **Suitable for ESD protection**

TVS diode (for CAN communication)

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

Engine Control Detail of injector drive circuit

Fuel injection system



Criteria for device selection

- 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.
- Products with higher breakdown-voltage must be selected according to the power supply voltages.

Proposals from Toshiba

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

U-MOS Series 40 V N-ch MOSFET

U-MOS Series 100 V N-ch MOSFET

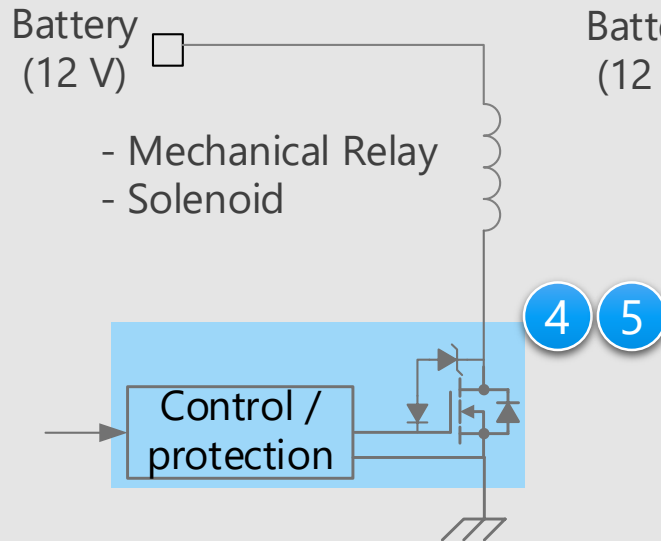
1

2

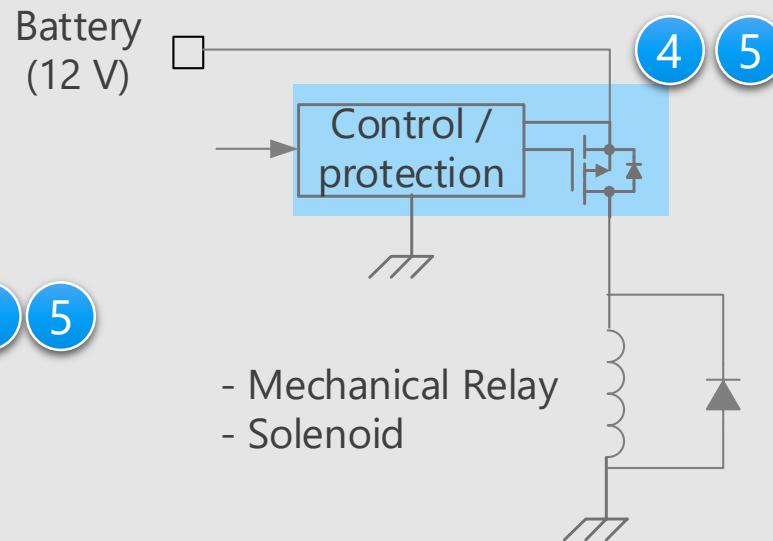
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Engine Control Detail of actuator drive circuit

Low side switch drive circuit



High side switch drive circuit



Criteria for device selection

- 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

- Driver with protection function

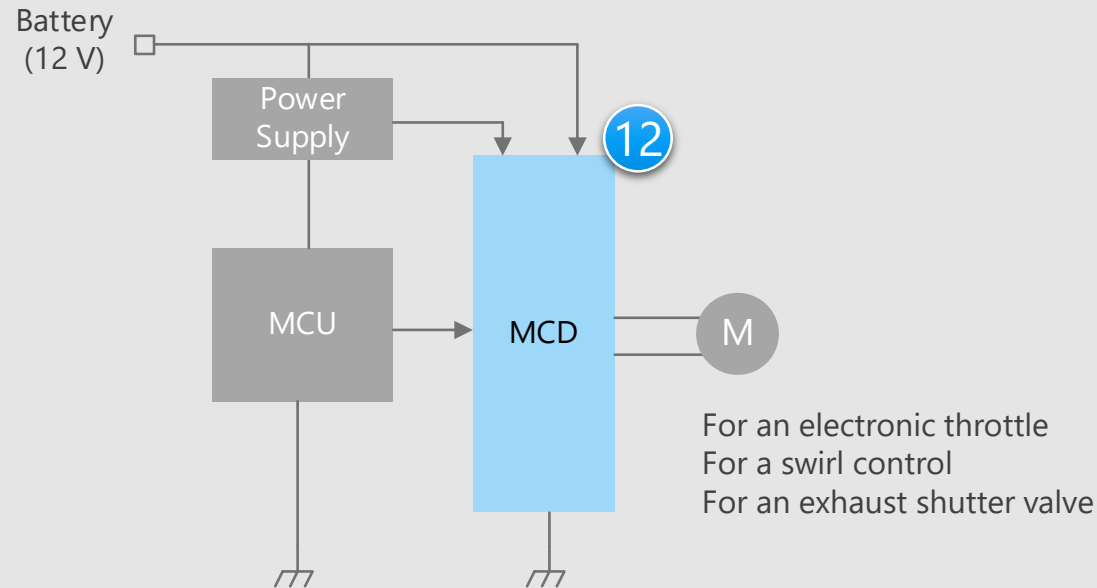
Low side switch / high side switch (up to 1 A)

Low side switch / high side switch (1 to 5 A)

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

Engine Control Detail of motor drive circuit

Motor drive for engine control valves



The number of loading=1 to 3ch

Criteria for device selection

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

Proposals from Toshiba

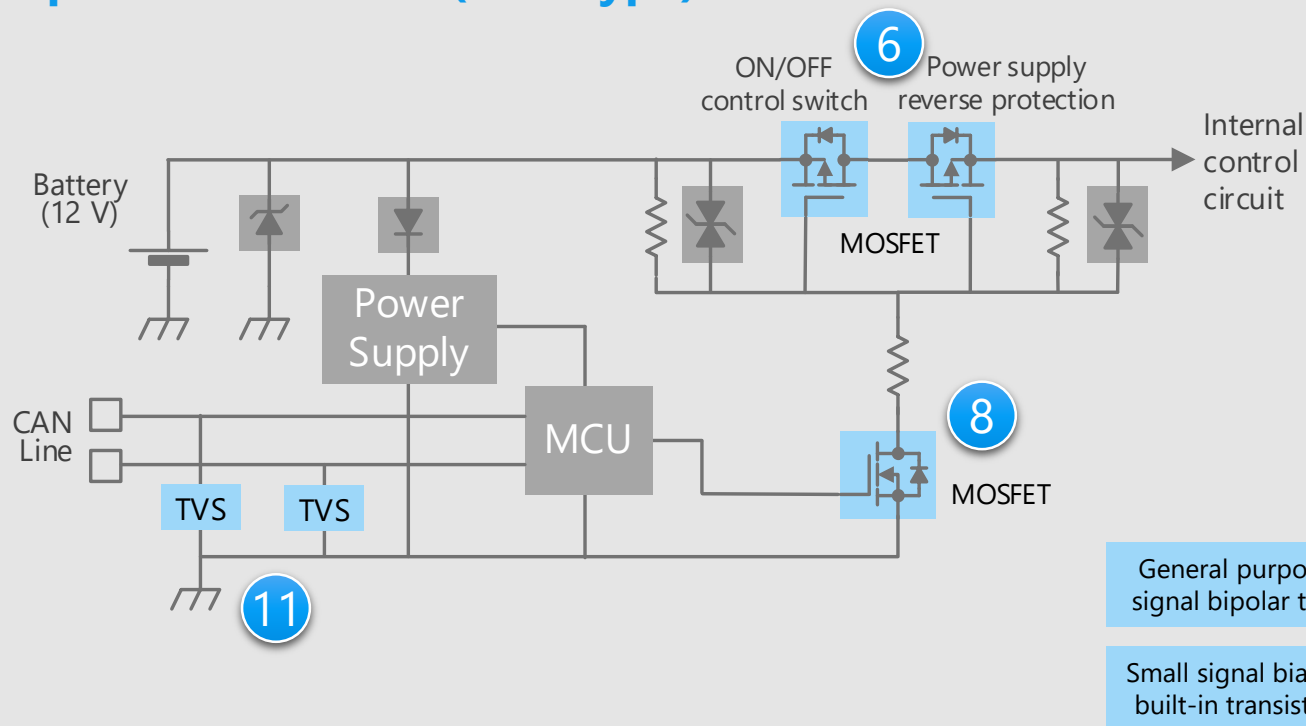
- **H-bridge driver using PWM**
Brushed DC motor driver

12

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

Engine Control 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)



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

- **Extensive product lineup**

General purpose small signal MOSFET

General purpose small signal bipolar transistor

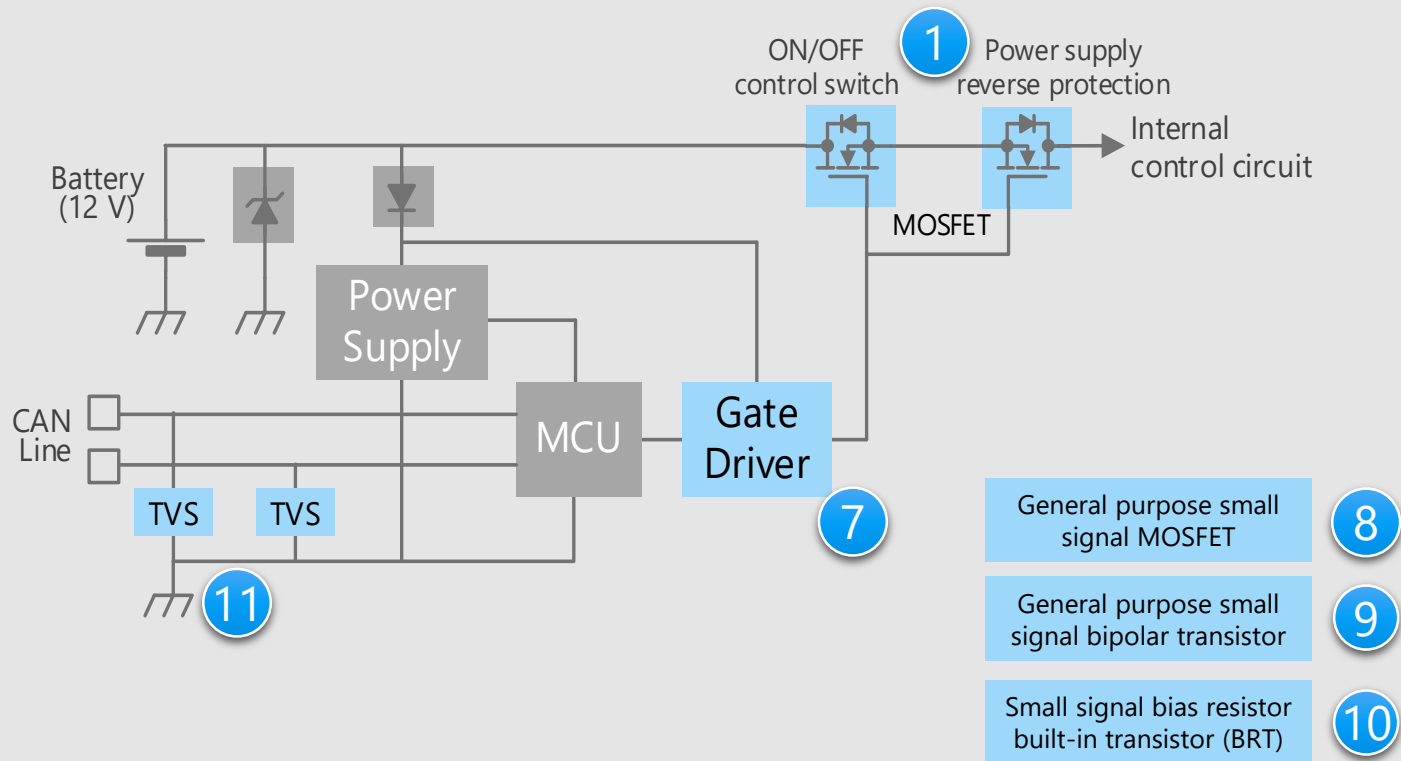
Small signal bias resistor built-in transistor (BRT)

- **Suitable for ESD protection**

TVS diode (for CAN communication)

* 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

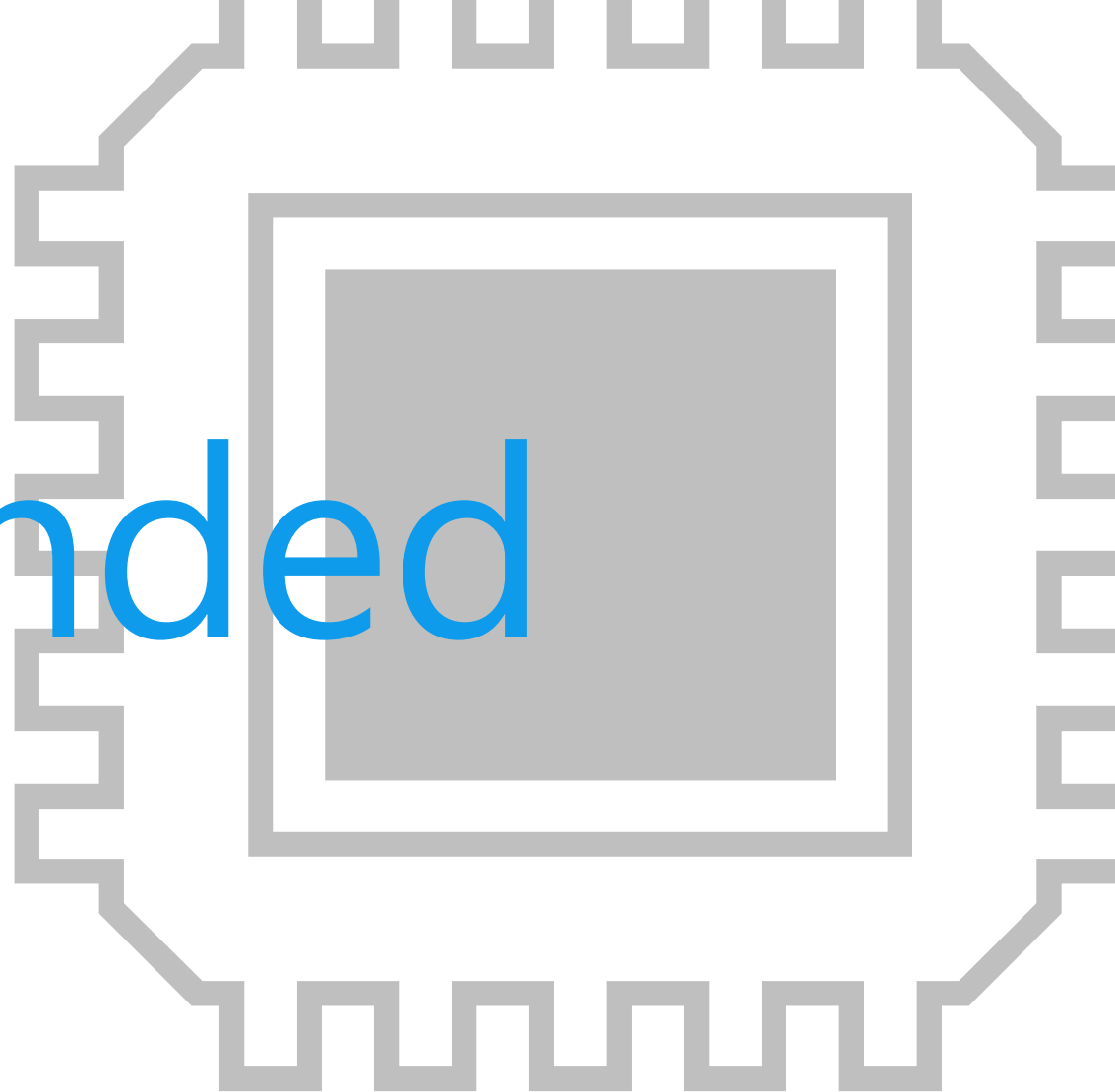
Criteria for device selection

- 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

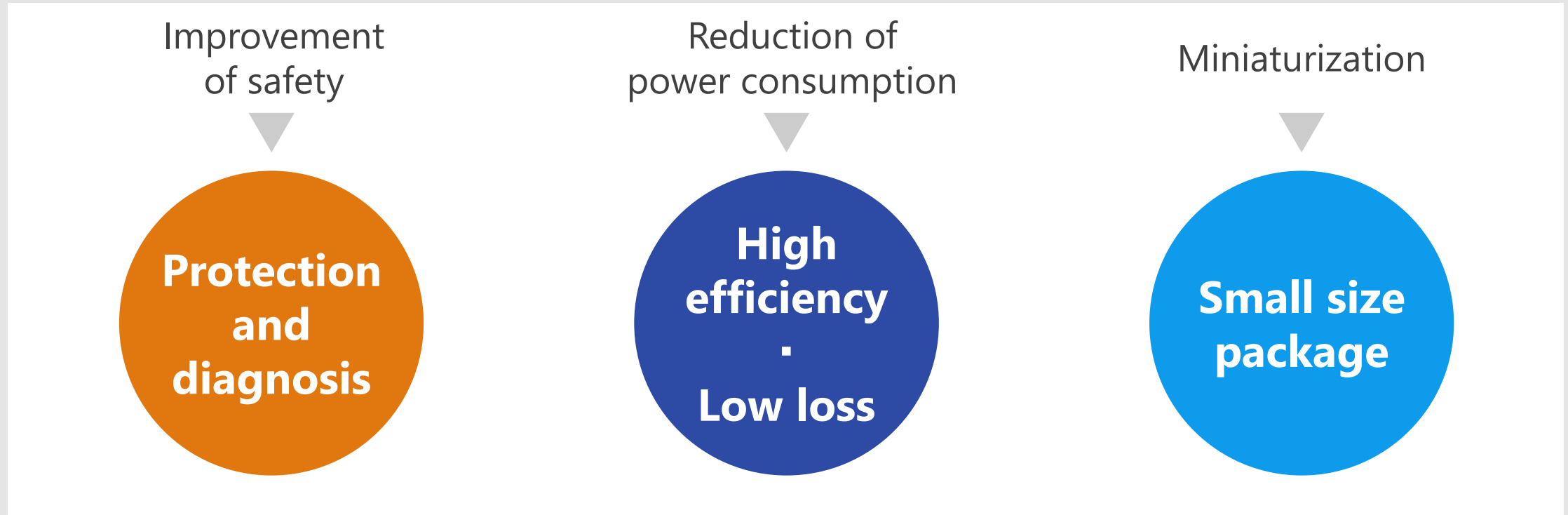
- **Low on-resistance contributes low power consumption of the system**
U-MOS Series 40 V N-ch MOSFET
- **Gate driver with built-in protection and diagnosis functions**
Gate driver (for switch)
- **Extensive product lineup**
General purpose small signal MOSFET
General purpose small signal bipolar transistor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

Recommended Devices



Device solutions to address customer needs

As described above, in the design of Engine Control, **“Improvement of 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

	Protection and diagnosis	High efficiency · Low loss	Small size package
① U-MOS Series 40 V N-ch MOSFET		●	●
② U-MOS Series 100 V N-ch MOSFET		●	●
③ MOSFET with a built-in active clamp circuit	●	●	●
④ Low side switch / High side switch (up to 1 A)	●		●
⑤ Low side switch / High side switch (1 to 5 A)	●		●
⑥ U-MOS Series -40 V / -60 V P-ch MOSFET		●	●
⑦ Gate driver (for switch)	●		●
⑧ General purpose small signal MOSFET		●	●
⑨ General purpose small signal bipolar transistor			●
⑩ Small signal bias resistor built-in transistor (BRT)			●
⑪ TVS diode (for CAN communication)	●		●
⑫ Brushed DC motor driver	●	●	●

Value provided

The advanced U-MOS^{IX}-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-MOS^{IV})

2 Compact and low loss package

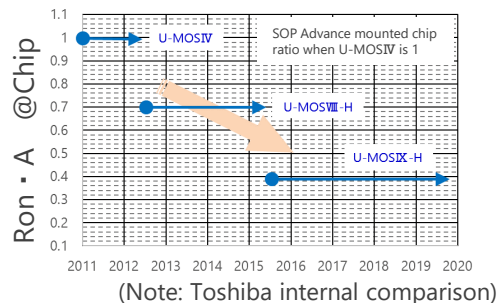
By adopting a Cu connector structure and a double-sided heat dissipation structure, low loss and high heat dissipation are realized.

Wettable Frank (WF) package contributes good mountability.

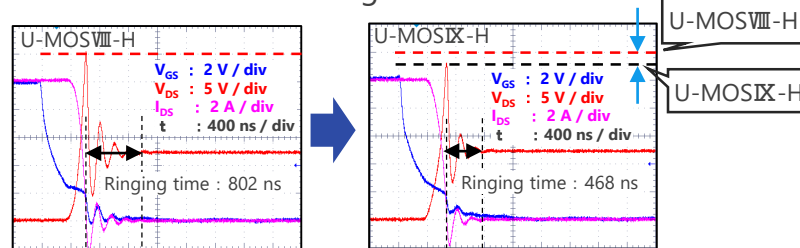
3 Low noise (low EMI)

Improved chip process reduces surge voltage and ringing time.

Low Loss: RonA Trend



Low-noise: Switching waveform

Low V_{DS} peak

Line up

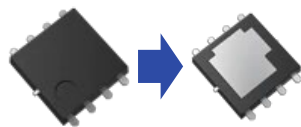
Part number	Drain current	On-resistance (Max) @ $V_{GS} = 10\text{ V}$	Package
XPN3R804NC	40 A	3.8 mΩ	TSOP Advance(WF)
TK1R4S04PB	120 A	1.35 mΩ	DPAK+
TPHR7904PB	150 A	0.79 mΩ	SOP Advance(WF)
TPWR7904PB	150 A	0.79 mΩ	DSOP Advance(WF)L
TKR74F04PB	250 A	0.74 mΩ	TO-220SM(W)
TK1R5R04PB	160 A	1.5 mΩ	D2PAK+

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 % @ $t = 3\text{ s}$, mounted on board compared to SOP Advance(WF).

[Return to Block Diagram TOP](#)

Value provided

Low on-resistance contributes to reduced system power consumption.

1 Low loss (reduced on-resistance)

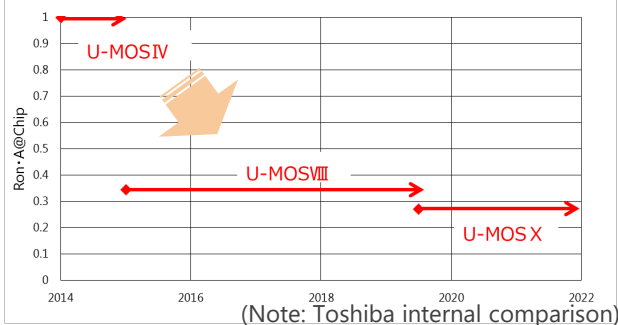
Using low resistance wafer process technology to contribute to reduced power consumption systems.

2 Small and high heat dissipation package

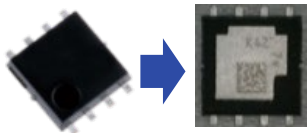
Development of small and high heat dissipation packages by adopting a Cu connector structure.

Ensuring mountability by using the Wettable Flank (WF) structure.

Low Loss: RonA Reduction Trend



DSOP Advance(WF) double-sided cooling packages



Decrease of thermal resistance
76 % reduction @ $t=3$ s,
mounted on board
Compared to SOP Advance (WF)

Small and high heat dissipation package

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








DDPAK+
(6.5 x 10 mm)
Up to 90 A



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



Line up

Part number	Drain current	ON-resistance (Max) @ $V_{GS} = 10$ V	Package
XPN2400ANC *	20 A	23.5 m Ω	TSOP Advance(WF) 
TK60S10N1L	60 A	6.11 m Ω	DDPAK+ 
XPH4R10ANB	70 A	4.1 m Ω	SOP Advance(WF) 
XPW4R10ANB	70 A	4.1 m Ω	DSOP Advance(WF) 
TK160F10N1L	160 A	2.4 m Ω	TO-220SM(W) 
XK1R9F10QB	160 A	1.92 m Ω	
XK4R0F10QB *	(60 A)	(4.0 m Ω)	

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

[Return to Block Diagram TOP](#)

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.

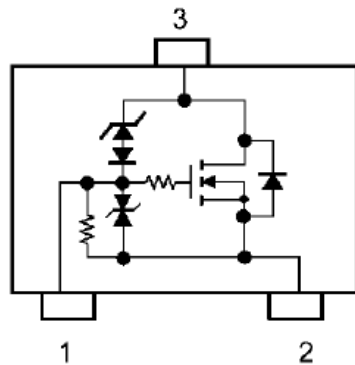
2 Built-in pull-down resistor

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.

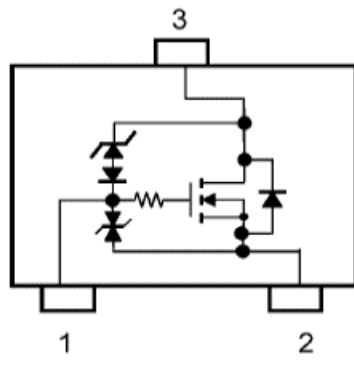
3 Low voltage drive

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

Internal circuit



SSM3K347R


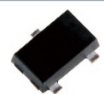


SSM3K337R

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
	Max	480
Polarity	N-ch	N-ch

[◆Return to Block Diagram TOP](#)

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.

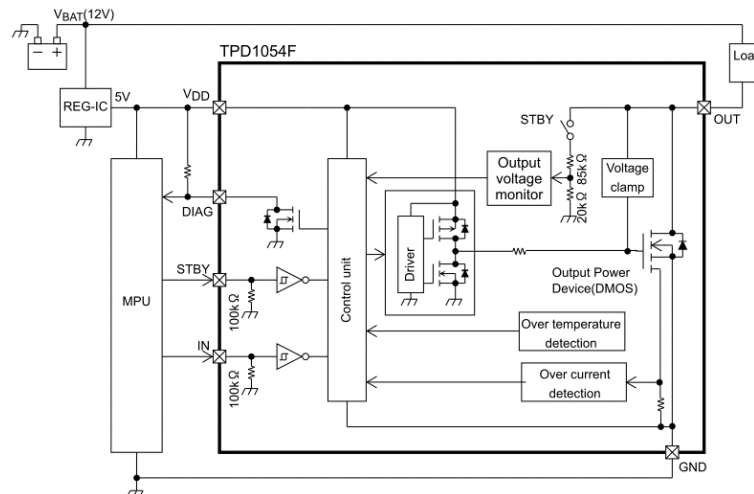
2 Can be controlled by logic level voltage

It is possible that Direct control 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

Line up

Function	Low side switch		High side switch
Part number	TPD1044F	TPD1054F	TPD1052F
Package	 PS-8 (2.8 x 2.9 mm)		
Features	<ul style="list-style-type: none"> Overcurrent / over-temperature protection Active clamp On-resistance: 0.6 Ω 	<ul style="list-style-type: none"> Overcurrent / over-temperature protection Active clamp Diagnostic output function On-resistance: 0.8 Ω 	<ul style="list-style-type: none"> Overcurrent / over-temperature protection Diagnostic output function On-resistance: 0.8 Ω

[Return to Block Diagram TOP](#)

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.

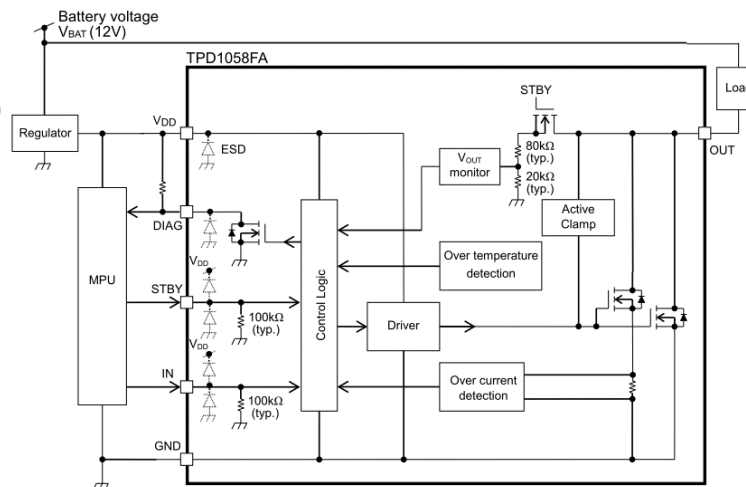
2 Can be controlled by logic level voltage

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

3 Small package


WSO10 is small surface mount package. It contributes to the miniaturization of system.

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



Suitable for valve timing and solenoid drive of transmission.

Line up

Function	Low side switch	High side switch
Part number	TPD1058FA	TPD1055FA
Package	Back surface  WSON10 (3 x 3 mm)	
Features	<ul style="list-style-type: none"> Overcurrent / Overtemperature protection Active clamp Diagnostic output function ON-resistance: 0.1 Ω 	<ul style="list-style-type: none"> Overcurrent / Overtemperature protection Diagnostic output function ON-resistance: 0.12 Ω

[Return to Block Diagram TOP](#)

Value provided

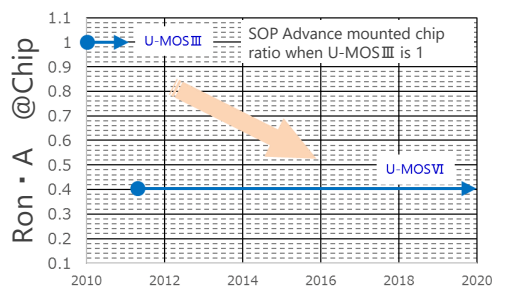
Low on-resistance contributes to reduce system power consumption.

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

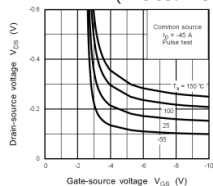
Using low on-resistance technology contributes to reduce system power consumption.

Lineups of logic level drive type are supported.

Low Loss: RonA Reduction Trend



(Note: Toshiba internal comparison)



Logic level drive

TJ90S04M3L

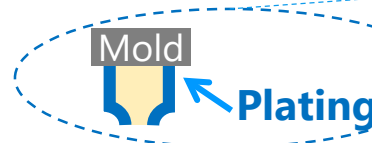
$V_{DS(ON)} - V_{GS}$

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 Flank (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 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

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.

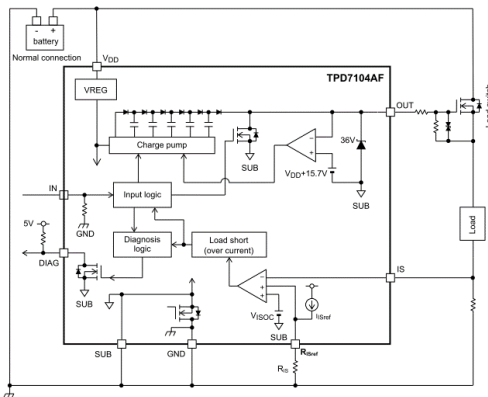
2 Can be controlled by logic level voltage

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

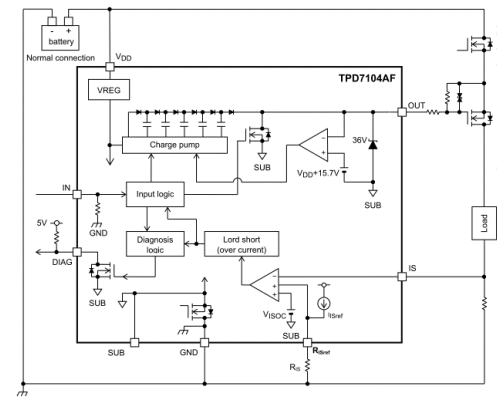
3 Small package

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. reverse battery connection Diagnosis output; overcurrent, load open, overtemperature, etc.

[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.

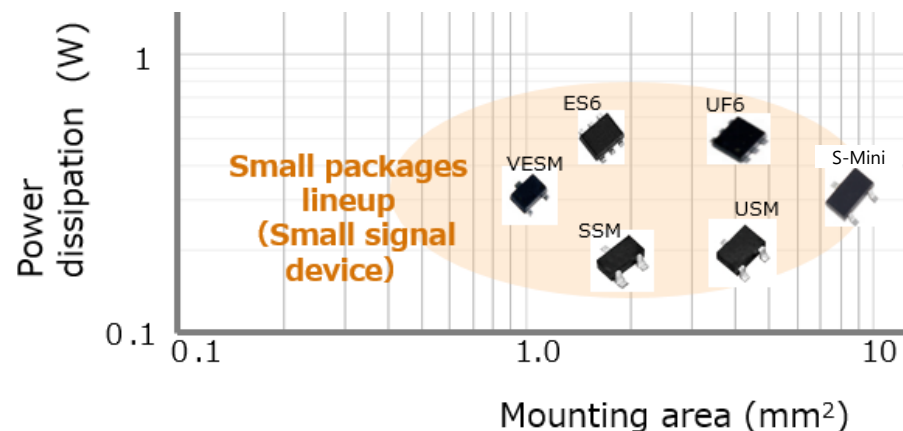
2 Low voltage drive

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



Line up

Part number	SSM3K7002KF	SSM3J168F	SSM3J66MFV
Package	S-Mini (SOT-346) 	S-Mini (SOT-346) 	VESM (SOT-723) 
V_{DS} [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

[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.

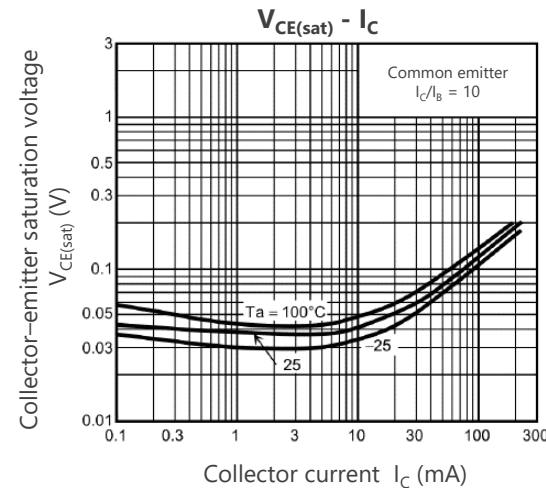
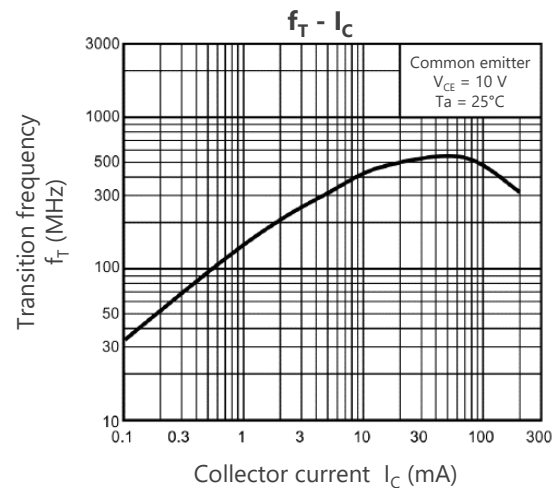
2 Extensive product lineup

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 to the application.


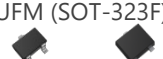

3 AEC-Q101 qualified

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)

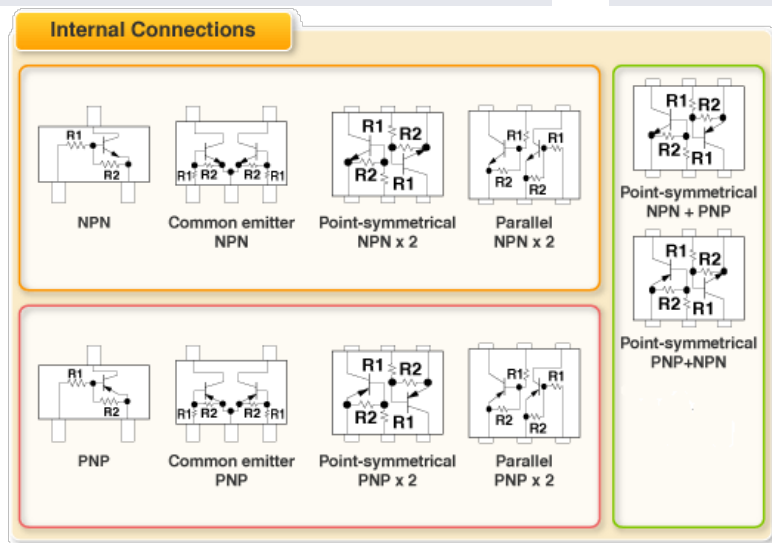
The BRTs contribute to reduction of the number of components, assembly workload and mounting area of circuit boards.

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_{CEO} (Max) [V]		50	-50
I_C [mA]		100	-100

[◆Return to Block Diagram TOP](#)

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)

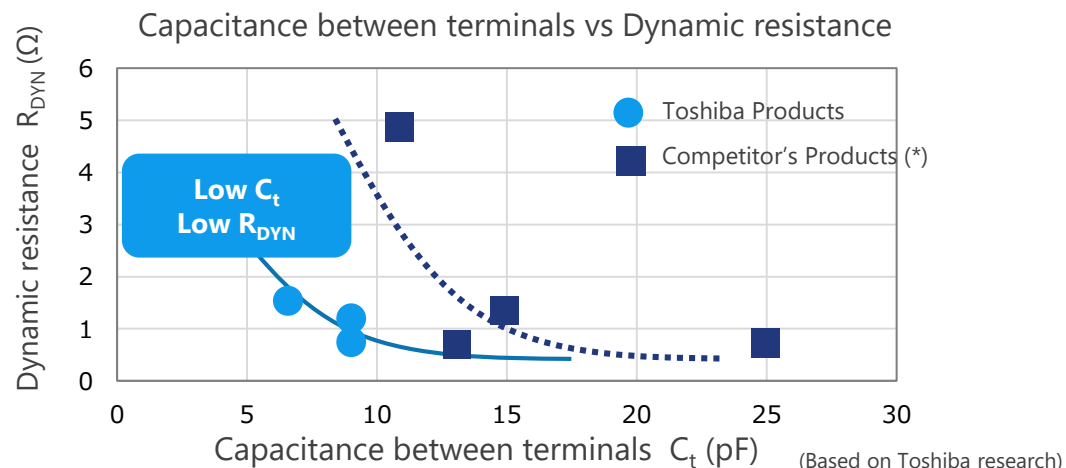
2 Supports CAN, CAN FD and FlexRay

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



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

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

(*): Measurements of the commercial product

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Value provided

This is a brushed DC motor driver IC packaged in a compact package to control the engine throttle valve and other engine valves.

1 PWM type 1ch H-bridge driver

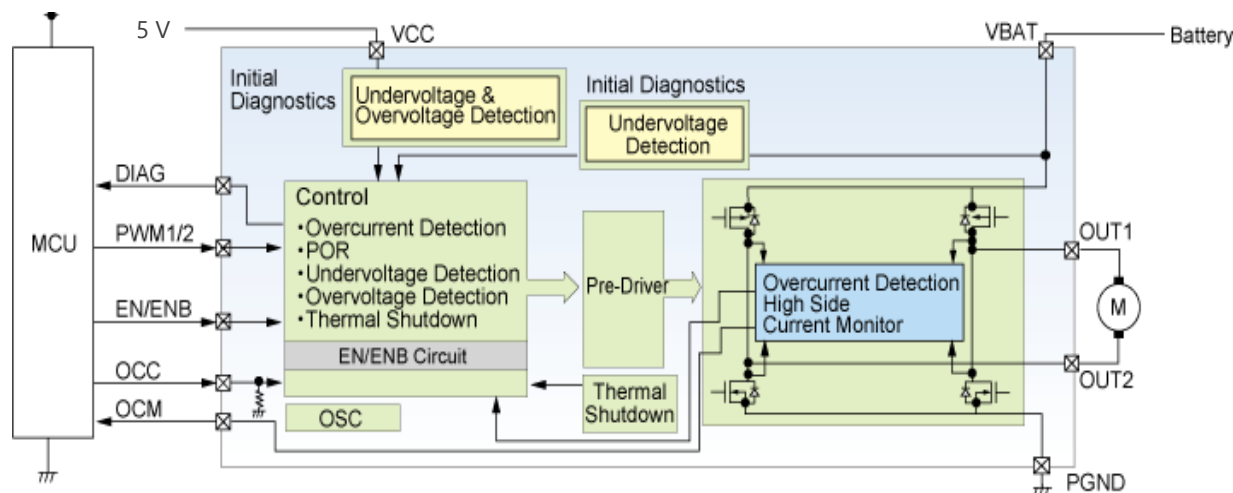
High efficiency drive is realized by PWM controlling of H-bridge consist of P-ch and N-ch DMOS with low on-resistance.

2 Various built-in fault detection functions

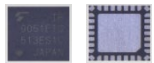
Over current detection, over temperature detection, VCC high voltage detection and VCC low voltage detection function are built in. In addition, through current protection circuit is also built in.

3 Small package

PQFN28 (6 x 6 mm) package contributes to miniaturization of ECU.



Line up

Part number	TB9051FTG	
Package	PQFN28	
Operating voltage range [V]	4.5 to 28	
Over current / Over temperature detection	✓	
Diagnostics	✓	
$R_{ON(Pch+Nch)}$ @ $V_{BAT} = 8V$, $T_j = 150^\circ C$ [Ω]	Max	0.45
Output current [A]	Max	5

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Value provided

These 2ch H-bridge driver ICs packaged in the compact packages can drive and control brushed DC motor through the SPI (Serial Peripheral Interface) registers.

1 5 A rating [Note1], PWM type 2ch H-bridge driver

2 channels of H-bridge driver with 5 A rating [Note 1] composed of low on-resistance DMOS FETs are built in. 10 A rating [Note 1] 1 channel drive with 2 channel parallel connection is also possible.

[Note1] The value will be limited smaller by the condition such as environment temperature or battery voltage

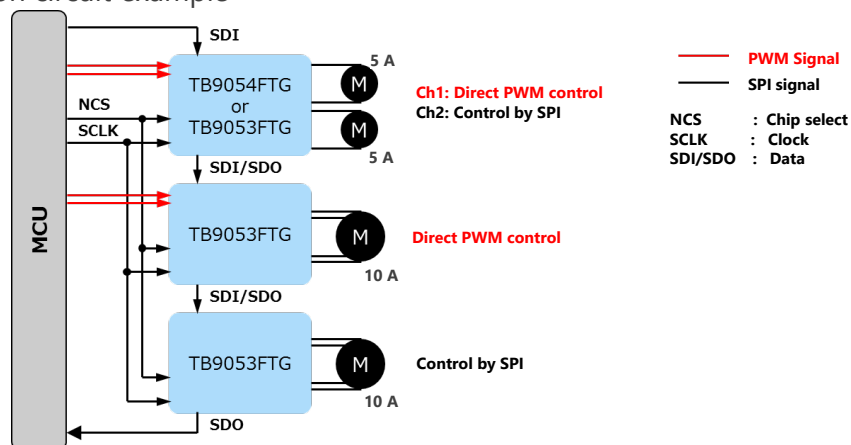
2 Motor speed control by using SPI communication

Daisy chain connection and SPI communication contribute to reduction of MCU port number or increasing flexibility of system design.



3 Small package

TB9053FTG is packaged in P-QFN40 package with high heat dissipation, and TB9054FTG is packaged in P-VQFN40 package with wettable frank structure. These contribute to the miniaturization of ECUs.

Application circuit example



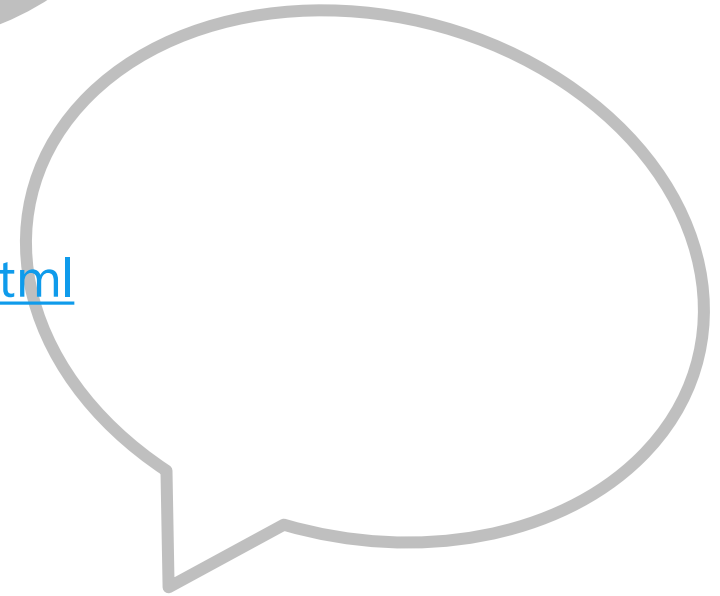
Line up

Part number	TB9053FTG	TB9054FTG
Package	P-QFN40 (6 x 6 mm) 	P-VQFN40 (6 x 6 mm) 
Operating voltage range [V]	4.5 to 28	
Over current / Over temperature detection	✓	
Diagnostics	✓	
$R_{ON(Nch+Nch)}$ @ $V_{BAT} = 8\text{ V}$, $T_j = 150\text{ °C}$ [Ω]	Max	0.35
Output current [A]	Max	5 (x 2ch)

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