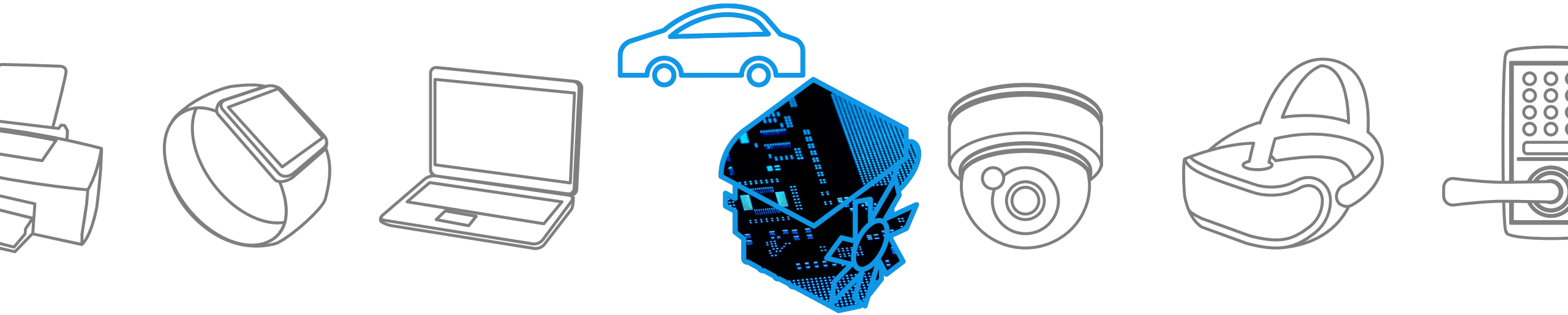
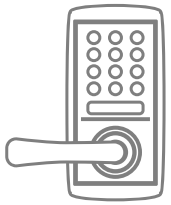
TOSHIBA

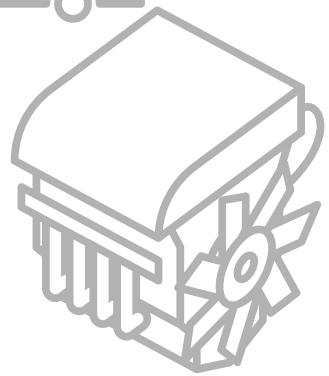
R17

Automotive Engine Control

Solution Proposal by Toshiba

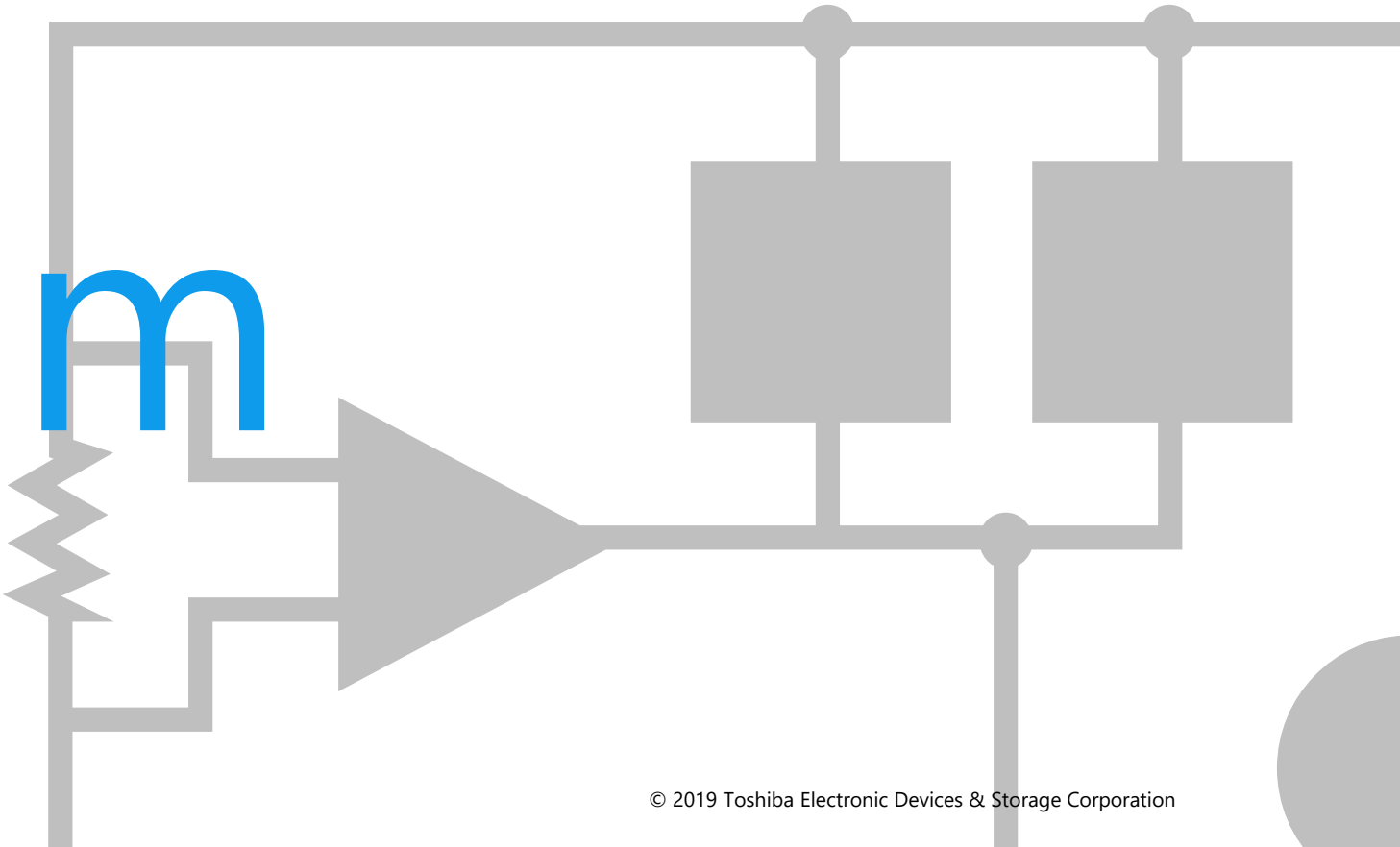




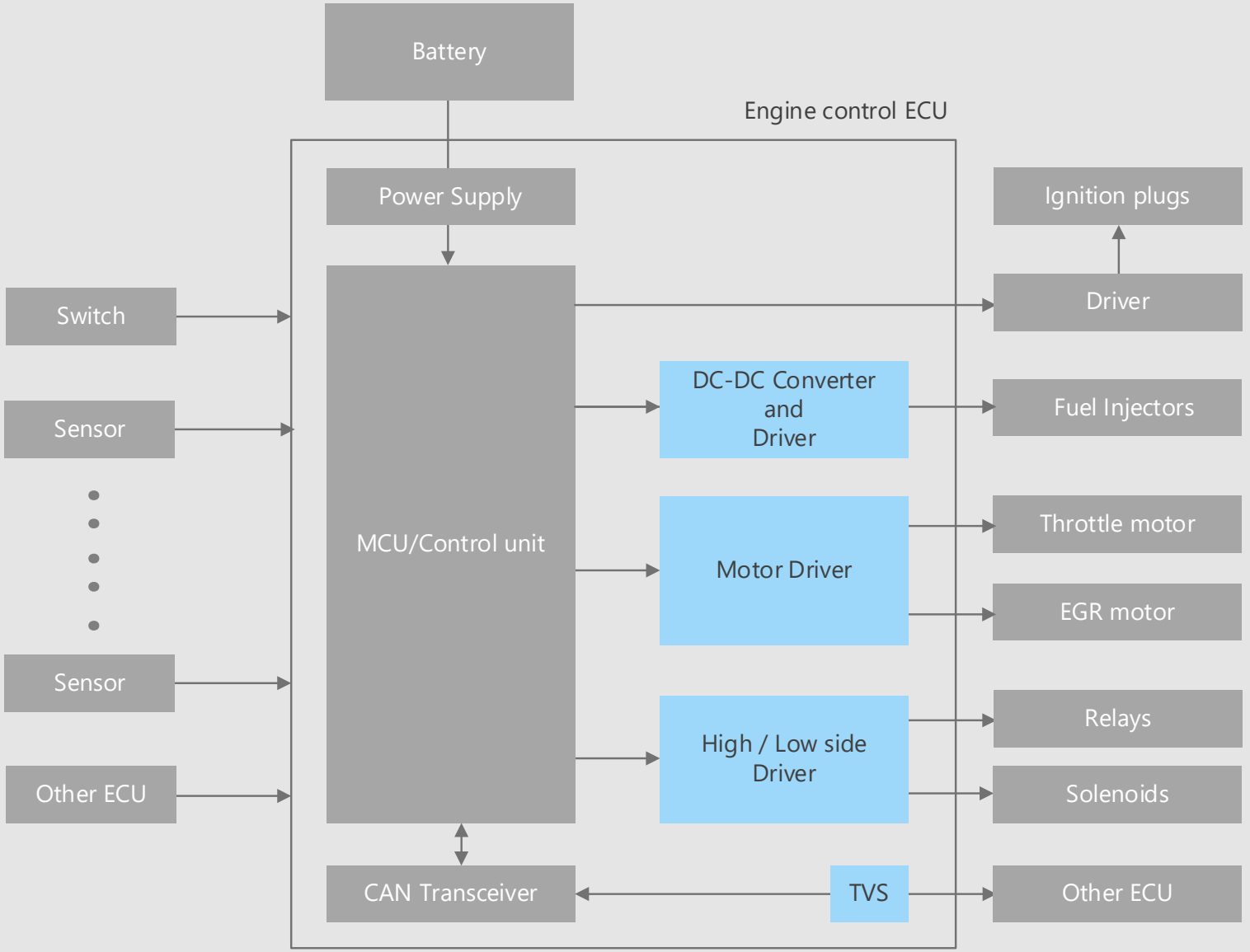


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

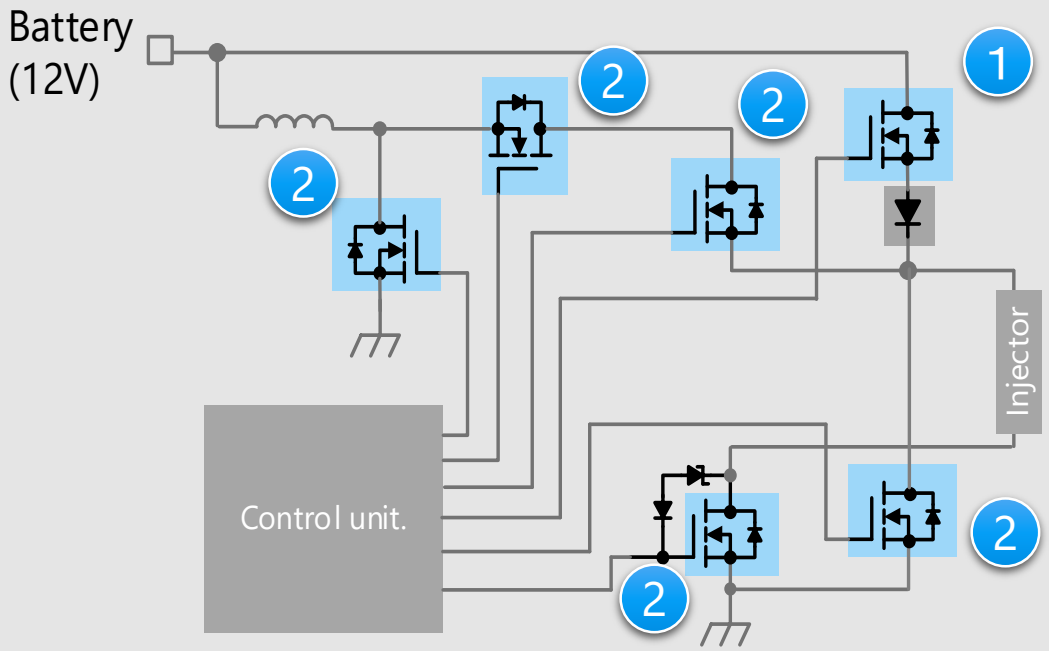


Direct injection engine control



Direct injection engine control　Output drive circuit (1)

Fuel injection system



Device selection points

- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.
- Products with higher breakdown-voltage must be selected according to the power supply voltages.

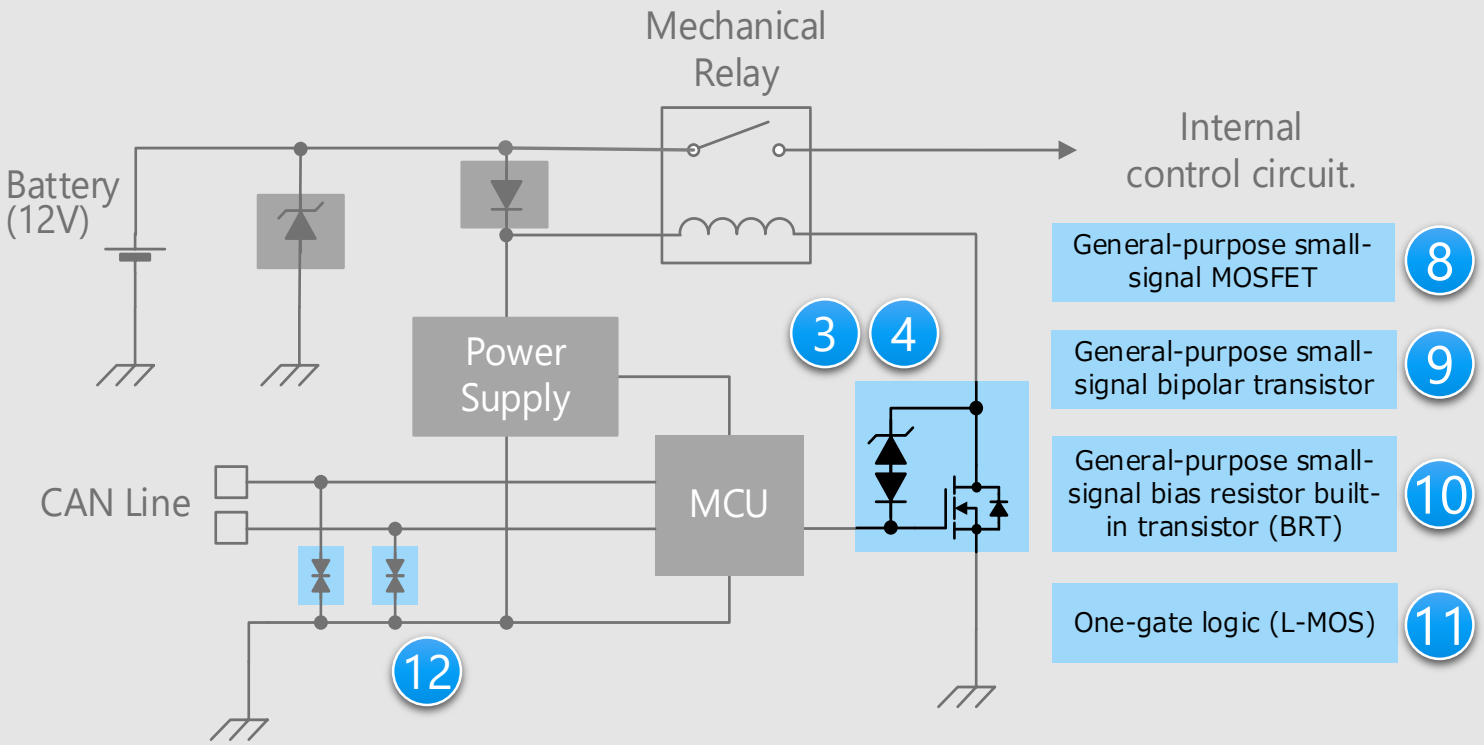
Proposals from Toshiba

- **Low power consumption of the system is realized by low on-resistance**
  U-MOS series 40V N-ch power MOSFET 1
  U-MOS series 100V N-ch power MOSFET 2

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

Direct injection engine control　Output drive circuit (2)

Mechanical relay system



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

Device selection points

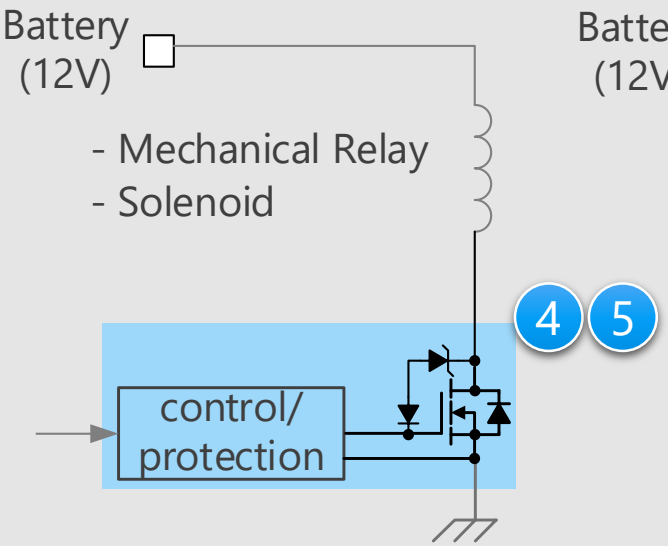
- It is necessary to select a device with a protection function against surge voltage generated from inductance of inductive load.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

Proposals from Toshiba

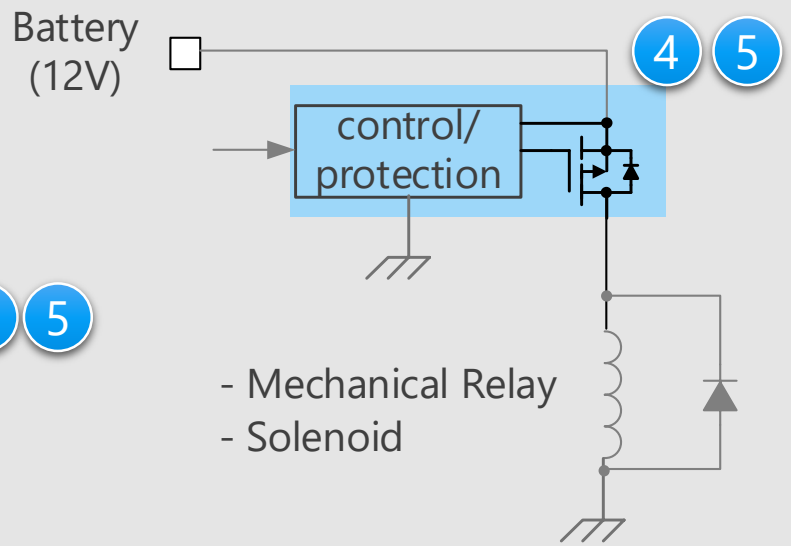
- **Built-in active clamp circuit and pull-down resistor for relay drive** 3
  U-MOSIV series active clamp MOSFET
- **Driver with protection function** 4
  Low-side switch / High-side switch (~1A)
- **Various product lineups and small packages** 8 9 10 11
  General-purpose small-signal MOSFET
  General-purpose small-signal bipolar transistor
  General-purpose small-signal bias resistor built-in transistor (BRT)
  One-gate logic (L-MOS)
- **Both device protection and signal quality is realized** 12
  TVS diode (for CAN communication)

Direct injection engine control　Output drive circuit (3)

Low-side switch drive circuit



High-side switch drive circuit



Device selection points

- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

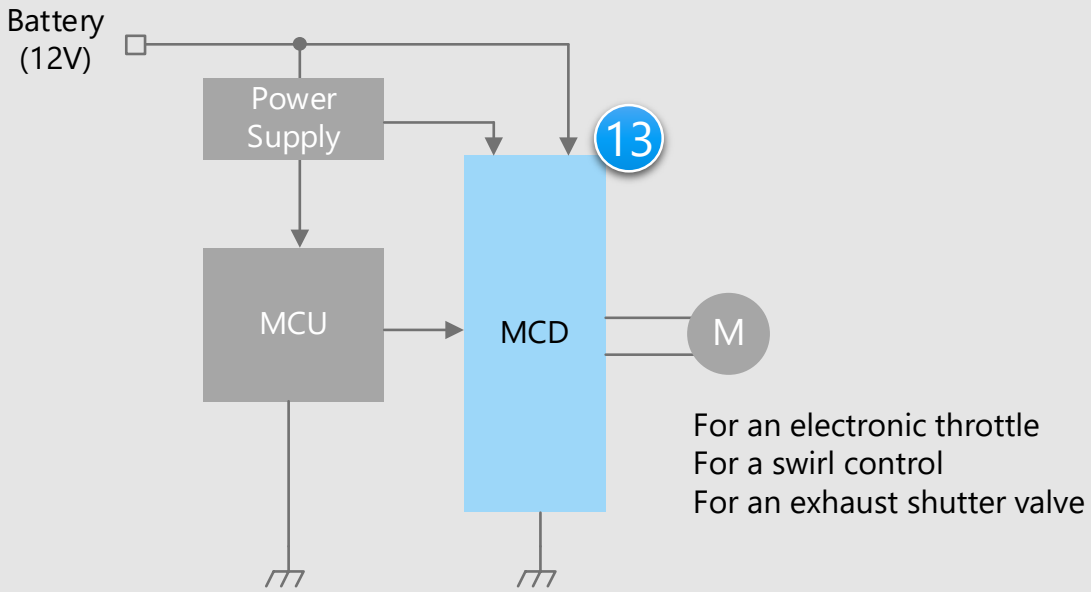
Proposals from Toshiba

- **Driver with protection function**
  Low-side switch / High-side switch (~1A) 4
  Low-side switch / High-side switch (1 ~ 5A) 5

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

Direct injection engine control　Output drive circuit (4)

Motor Valve for engine



The number of loading＝1～3 ch

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

Device selection points

- With the use of small packages, it is necessary to design heat dissipation in consideration of reliability.

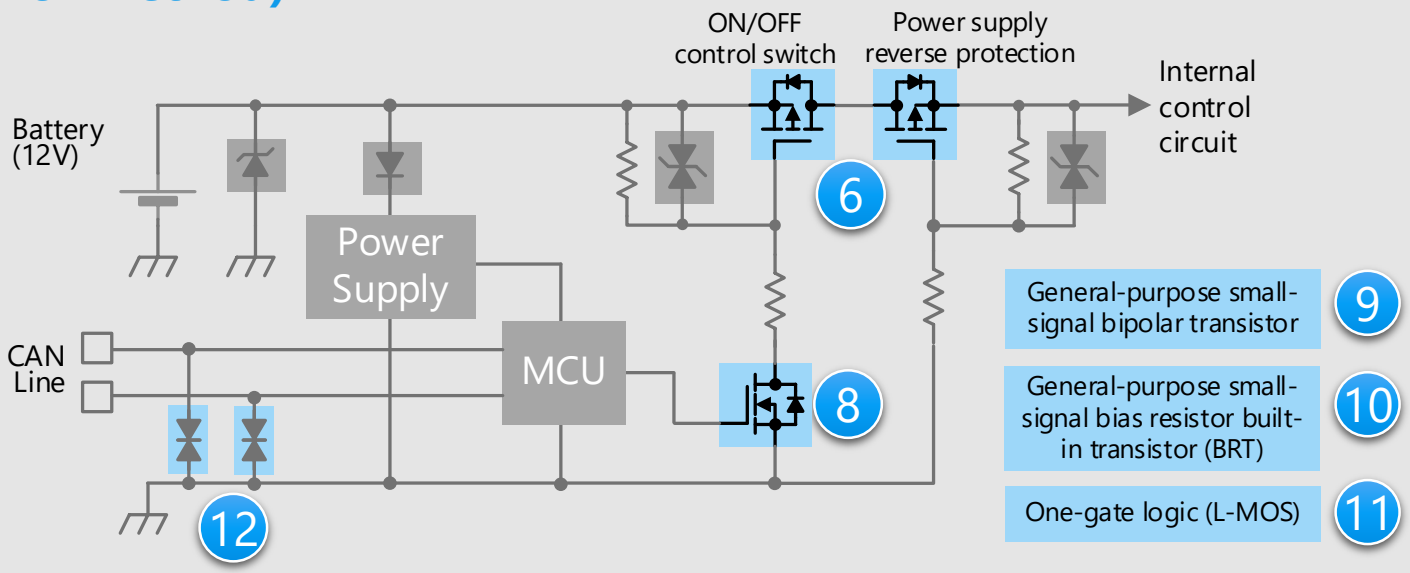
Proposals from Toshiba

- **H-Bridge Driver using PWM**
  Motor controller (for brush motor)

13

SW for power supply ON/OFF control and reverse connection protection (1)

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



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

Device selection points

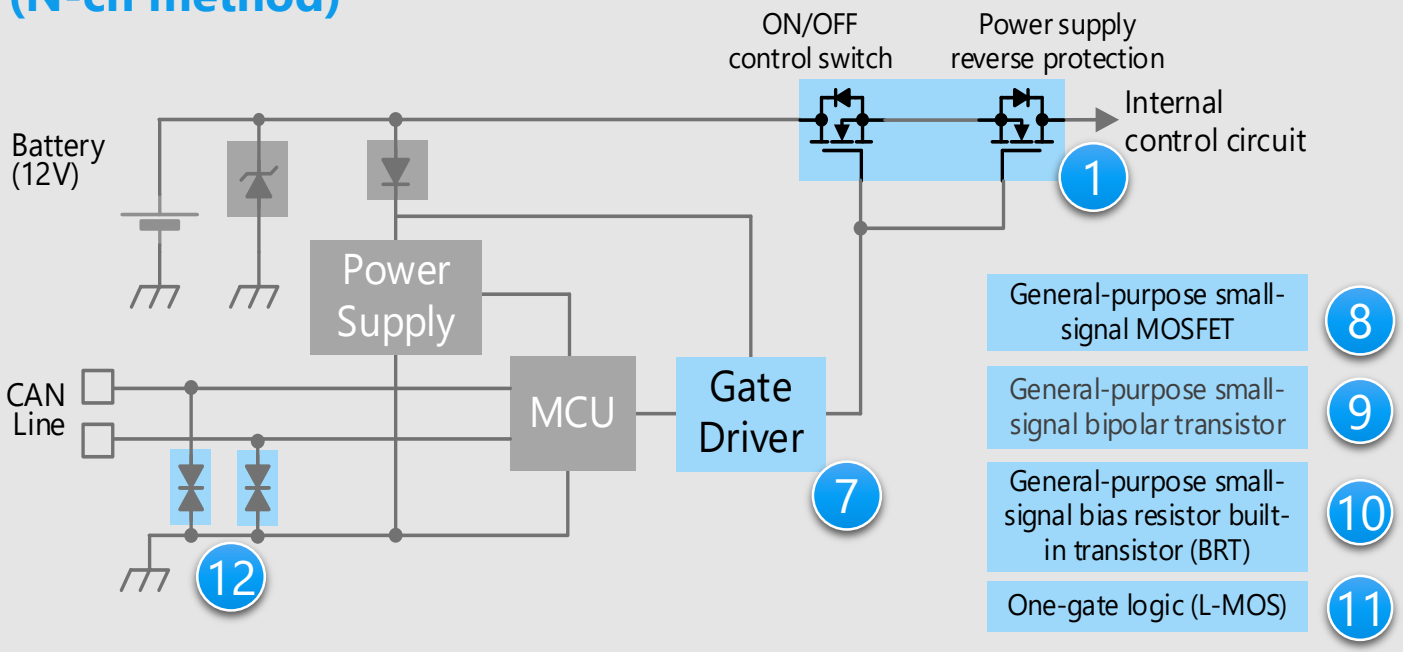
- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a gate driver according to the performance of the switching device to be driven.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

Proposals from Toshiba

- **Low power consumption of the system is realized by low on-resistance** 6
  U-MOS series -40V / -60V P-ch power MOSFET
- **Various product lineups and small packages** 8
  General-purpose small-signal MOSFET
  General-purpose small-signal bipolar transistor 9
  General-purpose small-signal bias resistor built-in transistor (BRT) 10
  One-gate logic (L-MOS) 11
- **Both device protection and signal quality is realized**
  TVS diode (for CAN communication) 12

SW for power supply ON/OFF control and reverse connection protection (2)

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



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

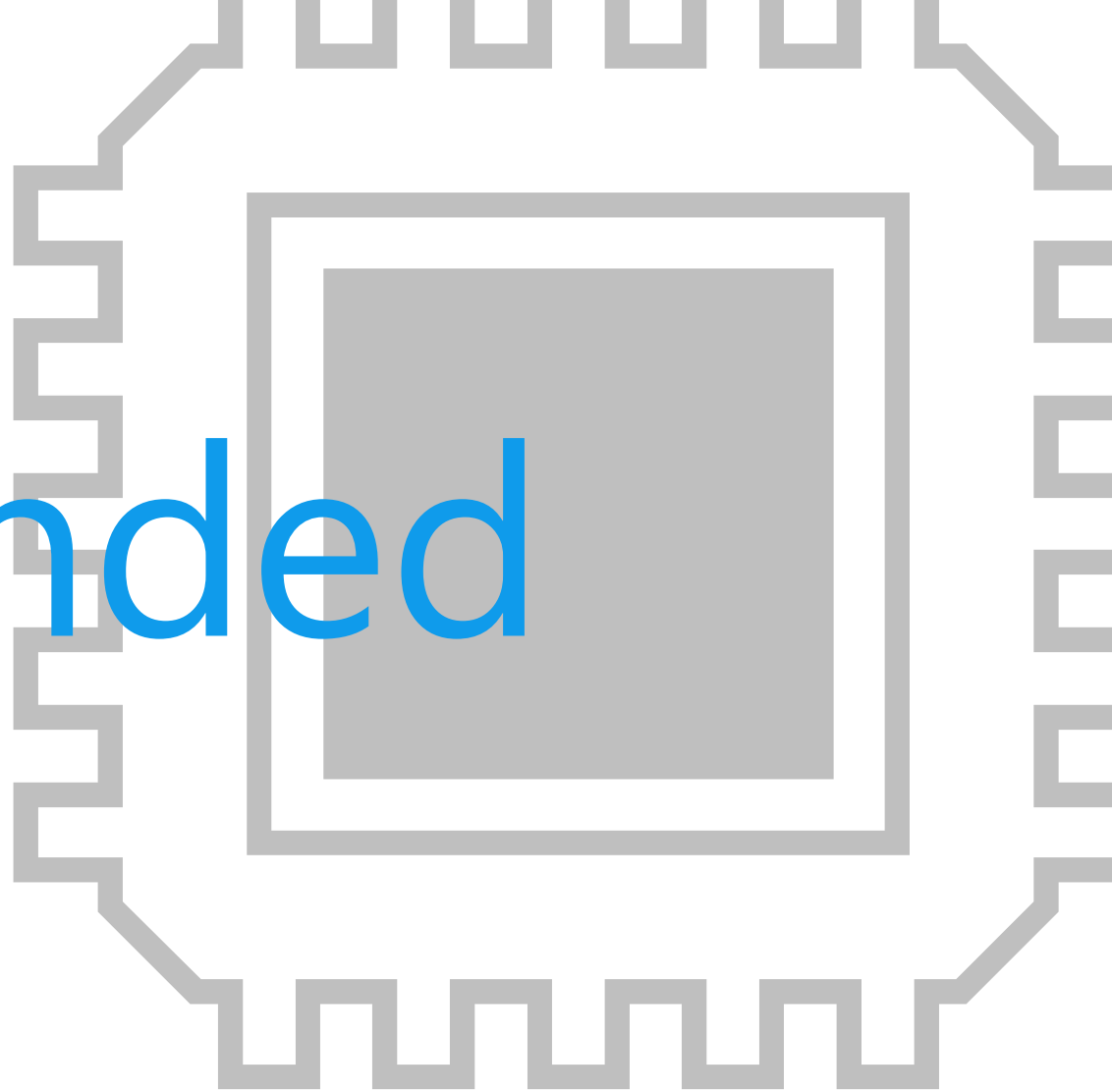
Device selection points

- It is necessary to select the product with the optimum current rating for each application.
- It is necessary to select a gate driver according to the performance of the switching device to be driven.
- It is necessary to select a small surface mount package suitable for miniaturization of the ECU.

Proposals from Toshiba

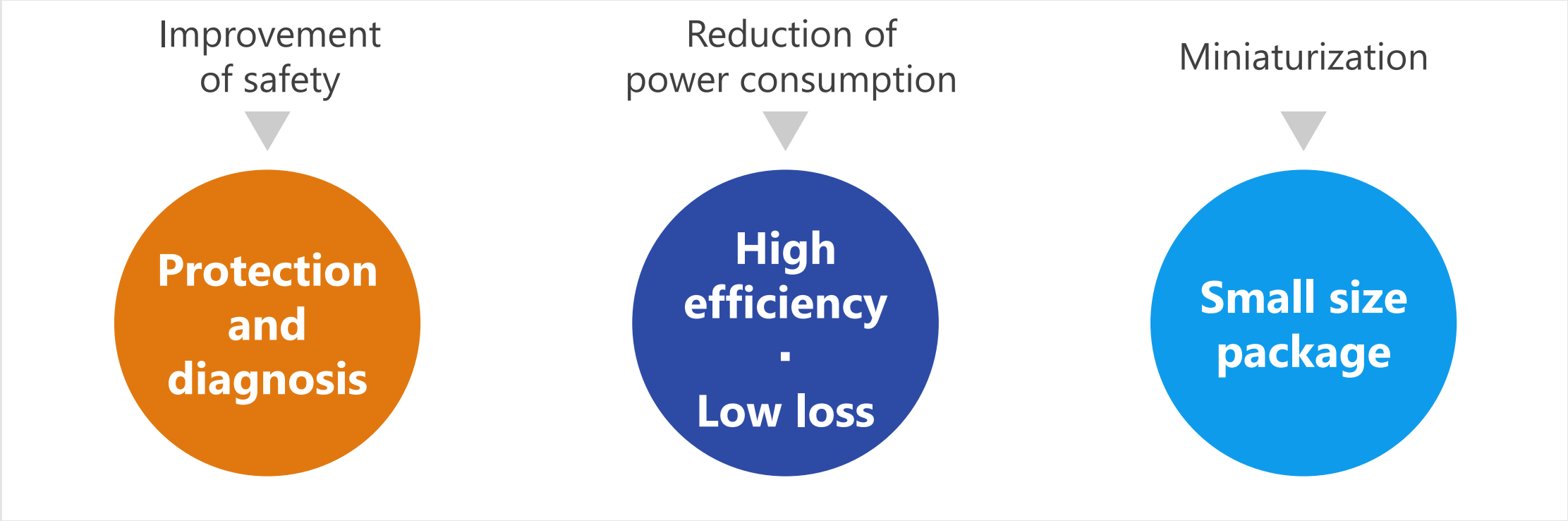
- **Low power consumption of the system is realized by low on-resistance** (1)
  U-MOS series 40V N-ch power MOSFET
- **Gate driver with protection diagnostic function** (7)
  Gate driver (for switch)
- **Various product lineups and small packages**
  General-purpose small-signal MOSFET (8)
  General-purpose small-signal bipolar transistor (9)
  General-purpose small-signal bias resistor built-in transistor (BRT) (10)
  One-gate logic (L-MOS) (11)
- **Both device protection and signal quality is realized**
  TVS diode (for CAN communication) (12)

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 High efficiency · Low loss	Small size package
1 U-MOS series 40V N-ch power MOSFET		●	●
2 U-MOS series 100V N-ch power MOSFET		●	●
3 U-MOSIV series active clamp MOSFET	●	●	●
4 Low-side switch / High-side switch (~1A)	●		●
5 Low-side switch / High-side switch (1 ~ 5A)	●		●
6 U-MOS series -40V / -60V P-ch power 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 One-gate logic (LMOS)			●
12 TVS diode (for CAN communication)	●		●
13 Motor controller (for brush motor)	●	●	●

1 U-MOS series 40V N-ch power MOSFET

XPN3R804NC / TK1R4S04PB / TPHR7904PB / TPWR7904PB / TKR74F04PB / TK1R5R04PB

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

Value provided

The advanced U-MOS IX-H processes enables low on-resistance and low noise, thereby reducing power consumption.

1 Low loss (reduced chip resistance)

Using low chip resistance technology to contribute to reduced power consumption systems.
Chip resistance of 61% reduction per unit area (compared to UMOSIV)

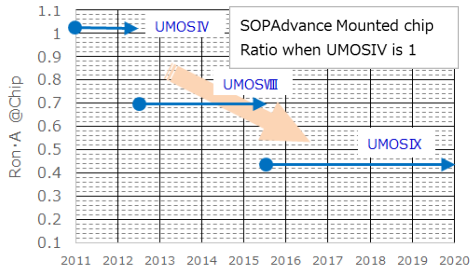
2 Compact, low-loss package

By adopting a Cu connector structure and a double-sided heat dissipation structure, Development of low-loss, high-heat-dissipation packages

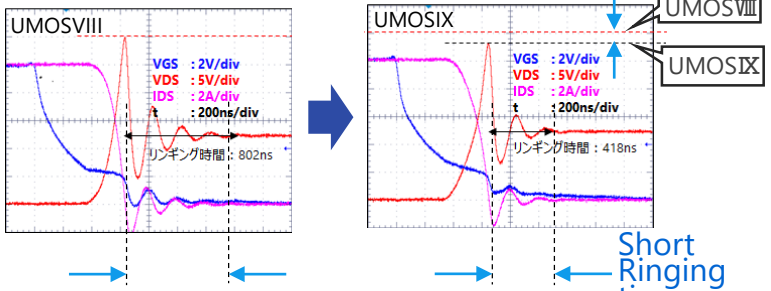
3 Low noise (low EMI)

Optimized chip process, reduce surge voltage and ringing time.

Low Loss: RonA Trend



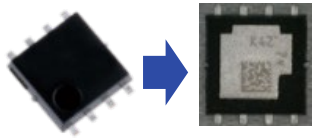
Low-noise: Switching Waveform



TO-220SM(W) Cu connector design

Package resistance reduction 64%, Compared to D2PAK

DSOP Advance(WF) double-sided cooling packages



Decrease of thermal resistance 76% reduction @t=3s, mounted on board Compared to SOP-8

Line up

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

◆Return to Block Diagram TOP

2 U-MOS series 100V N-ch power MOSFET

TK60S10N1L / XPH4R10ANB / XPW4R10ANB / TK160F10N1L / TK60R10N1L

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

Value provided

Low on-resistance contributes to reduced system power consumption.

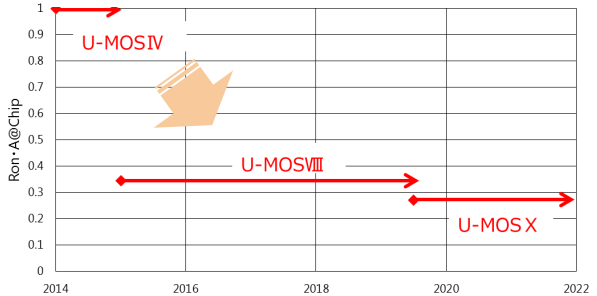
1 Low loss (reduced chip resistance)

Using low chip resistance technology to contribute to reduced power consumption systems

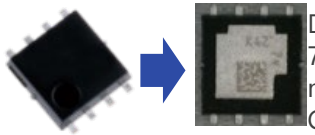
2 Small, high-heat-dissipation package

Development of low-loss, 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=3s,
mounted on board
Compared to SOP-8

Small, high-heat-dissipation package

TO-220SM(W)
(10x13mm)
~200A

DPAK+
(6.5x10mm)
~90A

SOP
Advance(WF)
(5x6mm)
~100A

Wettable
Flank structure

Line up

Part number	Drain current	On-resistance (Max) @V_{GS}=10V	Package
TK60S10N1L	60A	6.11mΩ	DPAK+
XPH4R10ANB	70A	4.1mΩ	SOP Advance(WF)
XPW4R10ANB	70A	4.1mΩ	DSOP Advance(WF)
TK160F10N1L	160A	2.4mΩ	TO-220SM(W)
TK60R10N1L	60A	6.31mΩ	D2PAK+

◆Return to Block Diagram TOP

3 U-MOSIV series active clamp MOSFET

SSM3K347R / SSM3K337R

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

Value provided

These devices has a built-in active clamp circuit to reduce the number of components and to save mounting space.

1 Built-in active clamp circuit

An active clamp circuit MOSFET with a zener between the drain-gate terminals prevents damage due to voltage surges during inductive loads driving.

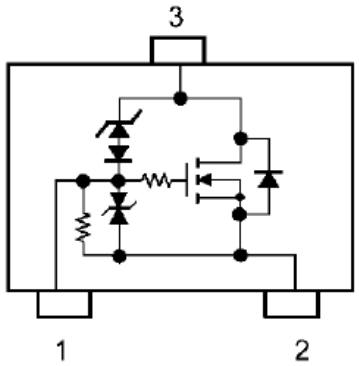
2 Built-in pull-down resistor

A 47kΩ pull-down resistor is built in between the gate-source terminals, which reduces required components and mounting space. (SSM3K347R)

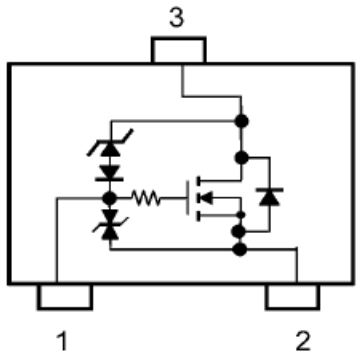
3 Low voltage drive

The gate-source voltage can be driven at a low voltage of 4.0 V

Internal circuit



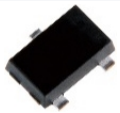
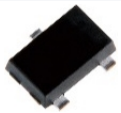
SSM3K347R



SSM3K337R

Pin Assignment
1. Gate
2. Source
3. Drained

Line up

Part number		SSM3K347R	SSM3K337R
Package		SOT-23F 	SOT-23F 
$V_{DS(DC)}$ [V]		38	38
I_D [A]		2	2
$R_{DS(ON)}$ @V_{GS}=4.0V [mΩ]	Typ.	350	161
	Max	480	200
MOS Type		N-channel	N-channel

◆Return to Block Diagram TOP

4 Low-side switch / High-side switch (~1A)

TPD1044F / TPD1054F / TPD1030F / TPD1052F

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

Value provided

Protection and diagnostic output functions are built-in and can be directly controlled at the logic level, contributing to improved reliability and miniaturization of the equipment.

1 Built-in protection and diagnostic output function

Overcurrent and overheat protection in the event of a load error (short circuit, etc.) and feedback (diagnostic output) to the microcomputer are built-in. This contributes to the reliability of the equipment.

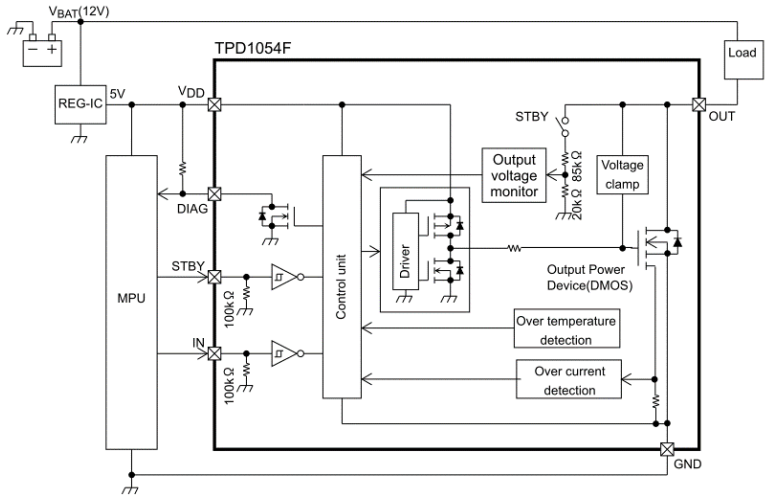
2 Logic level drive

Direct control is possible using a microcomputer and CMOS logic chip.

3 Small package

Product line-up includes small surface mount package PS8 and dual-output type. This contributes to equipment miniaturization.

Example of Low-side switch application
(Block diagram of TPD1054F)



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

Line up

Function	Low-side switch			High-side switch
Number of output	1 output		2 outputs	1 output
Part number	TPD1044F	TPD1054F	TPD1030F	TPD1052F
Package	PS8 (2.8 x 2.9 mm)	PS8 (2.8 x 2.9 mm)	SOP8 (5 x 6 mm)	PS8 (2.8 x 2.9 mm)
Features	・Overcurrent/overheat protection ・Active clamp ・on-resistance: 0.6 Ω	・Overcurrent/overheat protection ・Active clamp ・Diagnostic output function ・on-resistance: 0.8 Ω	・Overcurrent/overheat protection ・Active clamp ・on-resistance: 0.6 Ω	・Overcurrent/overheat protection ・Diagnostic output function ・on-resistance: 0.8 Ω

◆Return to Block Diagram TOP

5 Low-side switch / High-side switch (1 ~ 5A)

TPD1058FA / TPD1046F / TPD1055FA / TPD1060F

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

Value provided

Protection and diagnostic output functions are built-in and can be directly controlled at the logic level, contributing to improved reliability and miniaturization of the equipment.

1 Built-in protection and diagnostic output function

Overcurrent and overheat protection in the event of a load error (short circuit, etc.) and feedback (diagnostic output) to the microcomputer are built-in. This contributes to the reliability of the equipment.

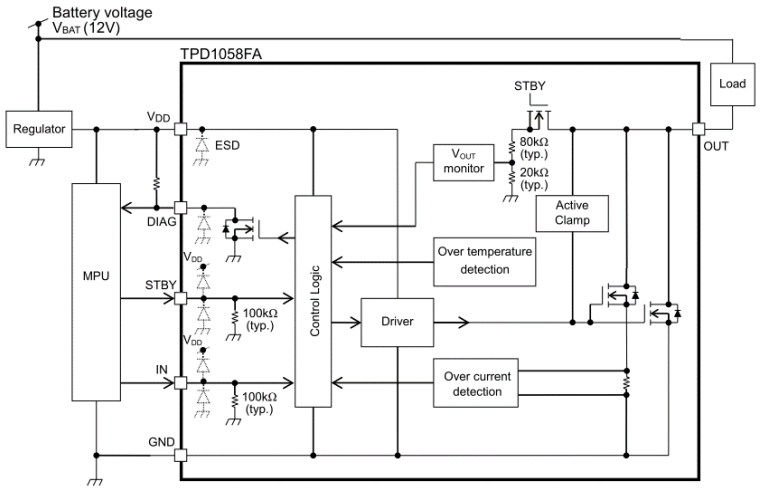
2 Logic level drive

Direct control is possible using a microcomputer and CMOS logic chip.

3 Small package

Product lineup includes small and high heat dissipation package WSON10 and dual-output type. This contributes to equipment miniaturization.

Example of Low-side switch application
(Block diagram of TPD1058A)



Suitable for valve timing and solenoid drive of transmission.

Line up

Function	Low-side switch		High-side switch	
Number of output	1 output	2 outputs	1 output	
Part number	TPD1058FA	TPD1046F	TPD1055FA	TPD1060F
Package	Back surface WSON10 (3 x 3 mm)	SOP8 (5 x 6 mm)	Back surface WSON10 (3 x 3 mm)	SOP8 (5 x 6 mm)
Feature	・Overcurrent/overheat protection ・Active clamp ・Diagnostic output function ・on-resistance: 0.1 Ω	・Overcurrent/overheat protection ・Active clamp ・on-resistance: 0.2 Ω	・Overcurrent/overheat protection ・Diagnostic output function ・on-resistance: 0.12 Ω	・Overcurrent/overheat protection ・Diagnostic output function ・on-resistance: 0.12 Ω

◆Return to Block Diagram TOP

6 U-MOS series -40V, -60V P-ch power MOSFET

TJ90S04M3L / TJ60S06M3L / XPH3R114MC / TJ200F04M3L / TJ150F06M3L

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

Value provided

Low on-resistance contributes to reduced system power consumption.

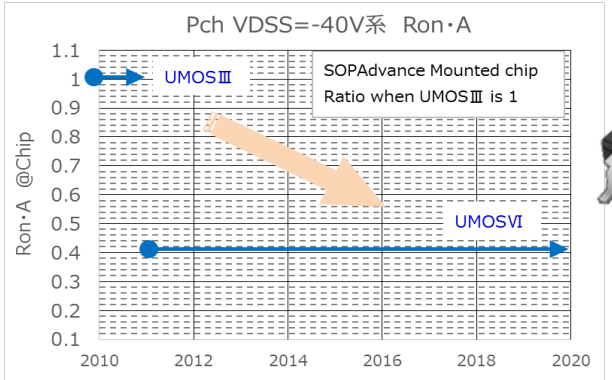
1 Low-loss (reduced chip resistance), logic-level response

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

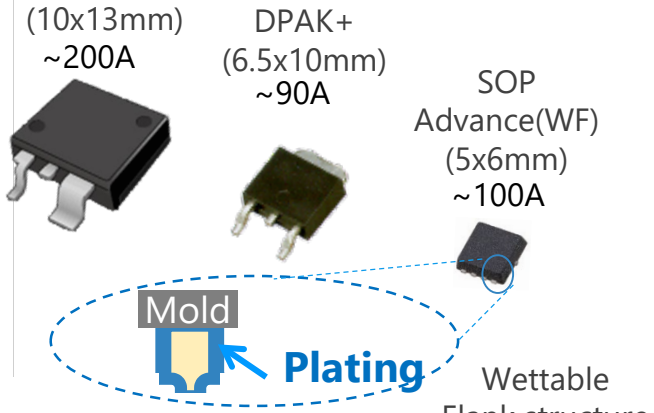
2 Small surface mount package developed

Development of low-loss, high-heat-dissipation packages by adopting a Cu connector structure
Ensuring mountability by using the Wettable Flank (WF) structure

Low Loss: RonA Reduction Trend



Large current, small size, high heat dissipation package



Line up

Part number	Drain-source Voltage	Drain current	On-resistance (Max) @V_{GS}=10V	Package
TJ90S04M3L	-40V	-90A	4.3mΩ	DPAK+
TJ60S06M3L	-60V	-60A	11.2mΩ	
XPH3R114MC	-40V	-100A	3.1mΩ	SOP Advance(WF)
TJ200F04M3L	-40V	-200A	1.8mΩ	TO-220SM(W)
TJ150F06M3L	-60V	-150A	5.6mΩ	

◆Return to Block Diagram TOP

7 Gate driver (for switch)

TPD7104AF

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

Value provided

A charge pump for the FET gate drive is built-in, allowing for easy semiconductor relay configuration.

1 Built-in charge pump

No external add-ons required for driving the N-channel on the high side, making it easy to configure a semiconductor relay.

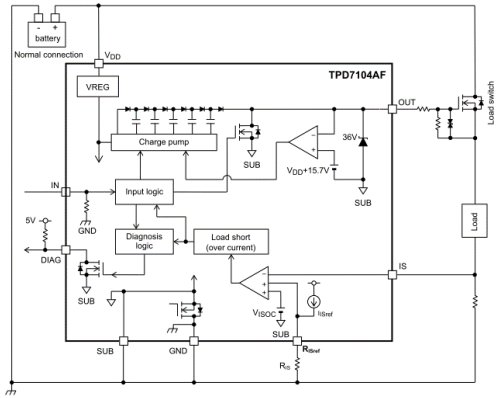
2 Logic level drive

Direct control is possible from microcomputer and CMOS logic.

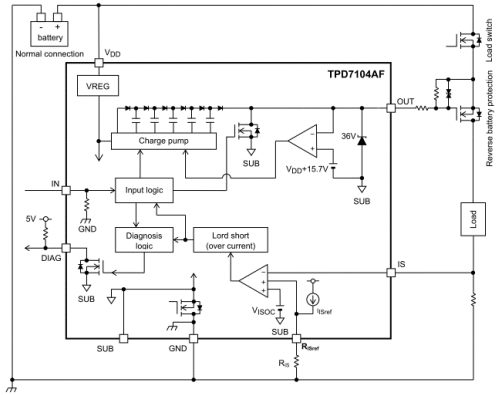
3 Small package

The small surface mount PS8 contributes to the miniaturization of equipment.

Semiconductor relay (switch) application



Power supply reverse connection protection FET control



Back to back configuration

Line up

Part number	TPD7104AF
Function	High-side gate driver
Number of output	1 output
Features	・Operating power supply voltage range: 5 to 18 V ・Built-in charge pump ・Built-in power supply reverse connection protection function (Supported for power supply reverse connection protection FET applications)

Package

PS8 (2.8 x 2.9 mm)

◆Return to Block Diagram TOP

8 General-purpose small-signal MOSFET

SSM3K7002KF / SSM3J168F / SSM3J66MFV

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

Value provided

Choose from a wide array of small packages which contribute to the miniaturization and reduction of power consumption of equipment.

1 Small package

Starting with the SOT-723 (VESM 1.2mm^2 package), a lineup of various small packages is available, contributing to space savings during mounting.

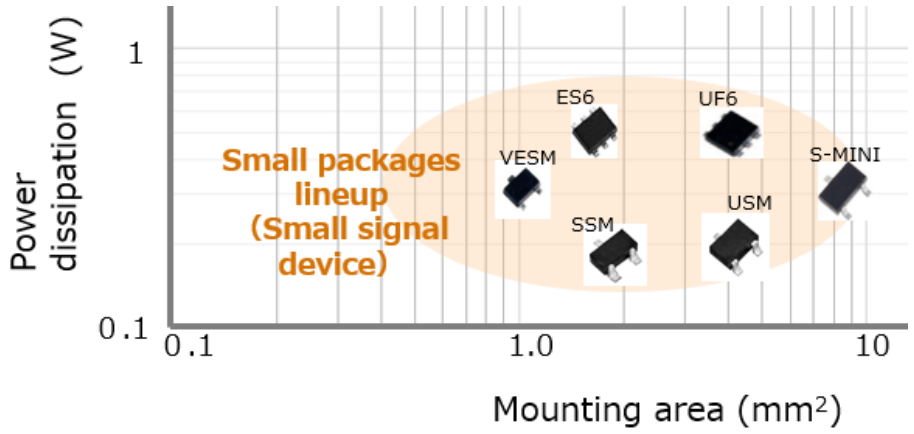
2 Low voltage drive

The gate-source voltage can be driven at a low voltage of 1.2 V(SSM3J66MFV).

3 AEC-Q101 qualified

AEC-Q101 qualified and can be used for a wide range of 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)
$V_{DS(DC)}$ [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
MOS Type		N-channel	P-channel	P-channel

◆Return to Block Diagram TOP

9 General-purpose small-signal bipolar transistor

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

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

Value provided

Extensive product lineup to meet all your needs.

1 Extensive lineup of packages

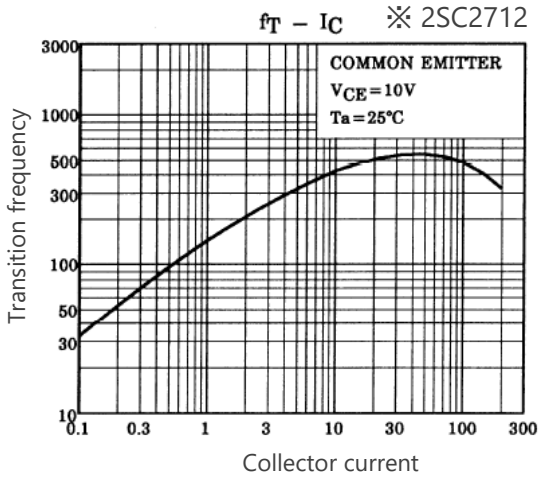
Various package lineups, such as 1in1, 2in1 are provided and suitable product for circuit board design can be selected.

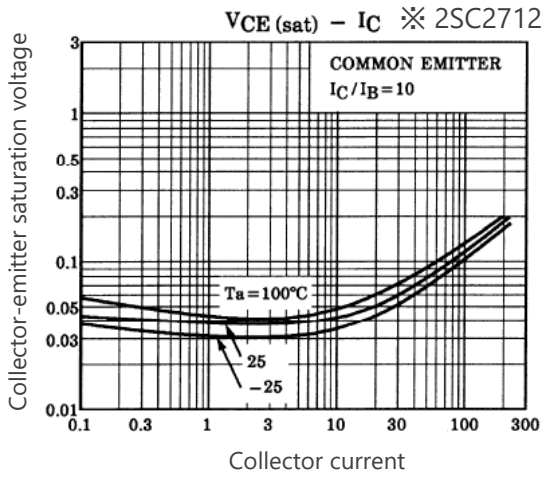
2 Various product lineup

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

3 AEC-Q101 qualified

AEC-Q101 qualified and can be used for a wide range of automotive applications.





Line up

Package			SSM (SOT-416)		USM (SOT-323) UFM (SOT-323F)*		S-Mini (SOT-346)	
Classification	$\|V_{CEO}\|$ [V]	$\|I_C\|$ [mA]	NPN	PNP	NPN	PNP	NPN	PNP
General purpose	50	150	2SC4738	2SA1832	2SC4116	2SA1586	2SC2712	2SA1162
	50	500					2SC3325	2SA1313
Low noise	120	100			2SC4117	2SA1587	2SC2713	2SA1163
High-current	50	1700				2SA2195*		

◆Return to Block Diagram TOP

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

RN1114 / RN2114 / RN1414 / RN2414 series

Value provided

Extensive product lineup to meet all your needs.

1 Built-in bias resistor type (BRT)

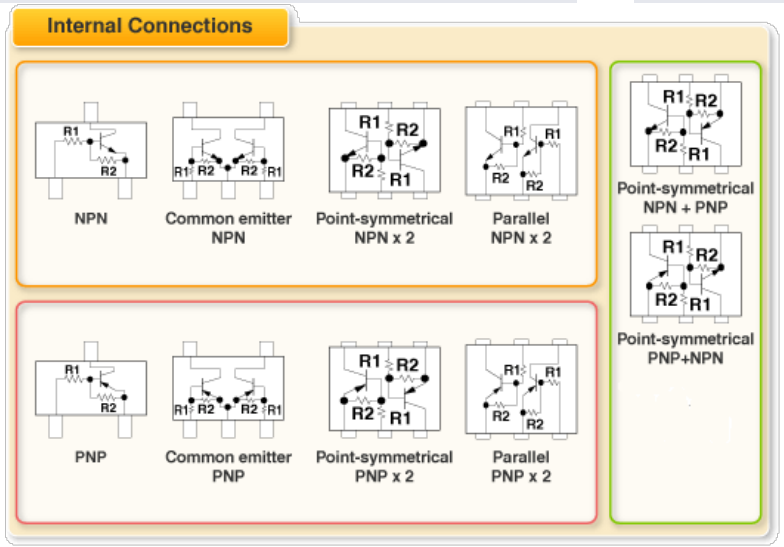
The BRT reduces the number of parts contributing to miniaturization and shorter production times.

2 Extensive lineup of package and pin assignment

Various package lineups, such as 1in1, 2in1 are provided and suitable product for circuit board design can be selected.

3 AEC-Q101 qualified

AEC-Q101 qualified and can be used for a wide range of automotive applications.



Line up

Part number		NPN (BRT)	PNP (BRT)
Package	SSM (SOT-416) 	RN1114	RN2114
	S-Mini (SOT-346) 	RN1414	RN2414
V_{CEO} (Max) [V]		50	-50
I_C [mA]		100	-100

◆Return to Block Diagram TOP

11 One-gate logic (L-MOS)

TC7SH / TC7WH / TC7SZ / TC7WZ series

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

Value provided

Extensive product lineup to meet all your needs.

1 Small package

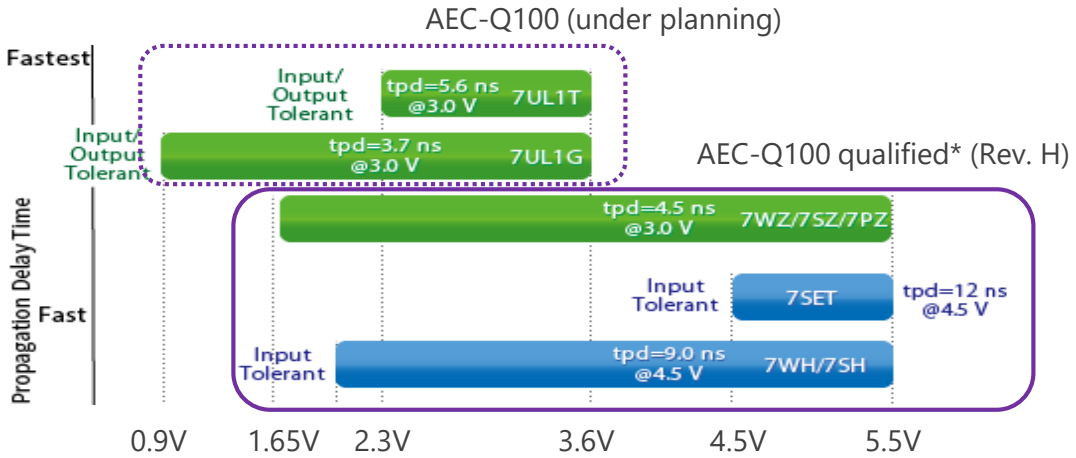
A standard multi gate CMOS is separated into individual or dual gates and embedded in a small package. This can be suited for simpler designs and contributes to miniaturization.

2 Extensive lineup

The VHS/SHS series, which is widely used in Automotive, offers a wide range of functions, including a total of 230 products.

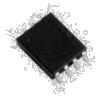
3 AEC-Q100 qualified (reliability levels)

AEC-Q100 qualified and can be used for a wide range of automotive applications.



* Compliant products with AEC-Q100's reliability test only

Line up

		VHS series	SHS series
Package	USV (SOT-353) 	TC7SH series	TC7SZ series
	US8 (SOT-765) 	TC7WH Series	TC7WZ series
V_{CC} [V]		2.0 ~ 5.5	1.65/1.8 ~ 5.5
Io[mA]		8	24

◆Return to Block Diagram TOP

12 TVS diode (for CAN communication)

DF3D18FU / DF3D29FU / DF3D36FU

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

Value provided

TVS diode absorbs static electricity (ESD) from external terminals, prevents circuit malfunction and protects devices.

1 Improve ESD absorbability

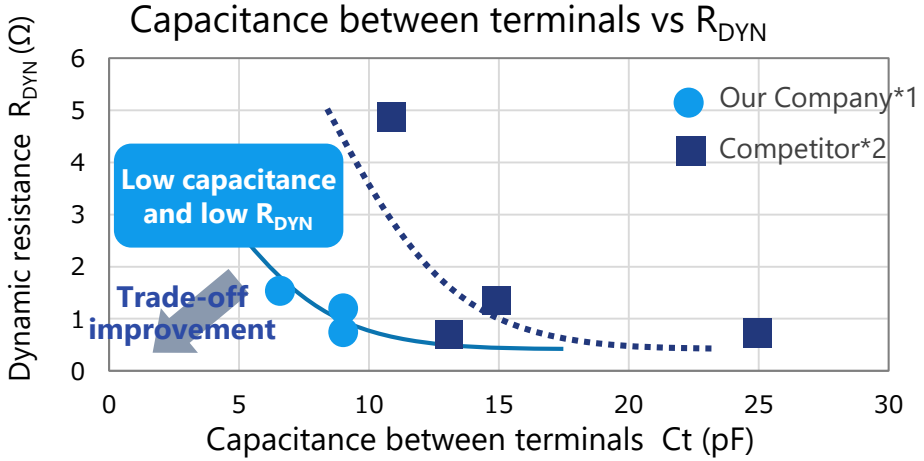
Improved absorption of ESD through our proprietary Zener process.
(Both low operating resistance R_{DYN} and low capacitance C_t)

2 Ensuring high signal integrity

Supports in-vehicle LAN communication such as CAN, CAN-FD, FlexRay. Lower capacitance ensures higher signal integrity.

3 High ESD immunity

Compliant products with
ISO10605 Standard > ±20 kV
IEC61000-4-2 Standard > ±20 kV (L4)



Line up

Part number	DF3D18FU	DF3D29FU	DF3D36FU
Package	USM (SOT-323) 		
V_{ESD} [kV] @ISO10605	±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 (including but not limited to constant voltage diode applications).

*1:TOSHIBA Electronic Device & Strage Corporation
*2:Measurements of the commercial product

◆Return to Block Diagram TOP

13 Motor controller (for brush motor)

TB9051FTG

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

Value provided

The motor drivers for DC brush motor packaged in small packages optimized for controlling valves such as an engine throttle valve.

1 1ch H-Bridge Driver using PWM

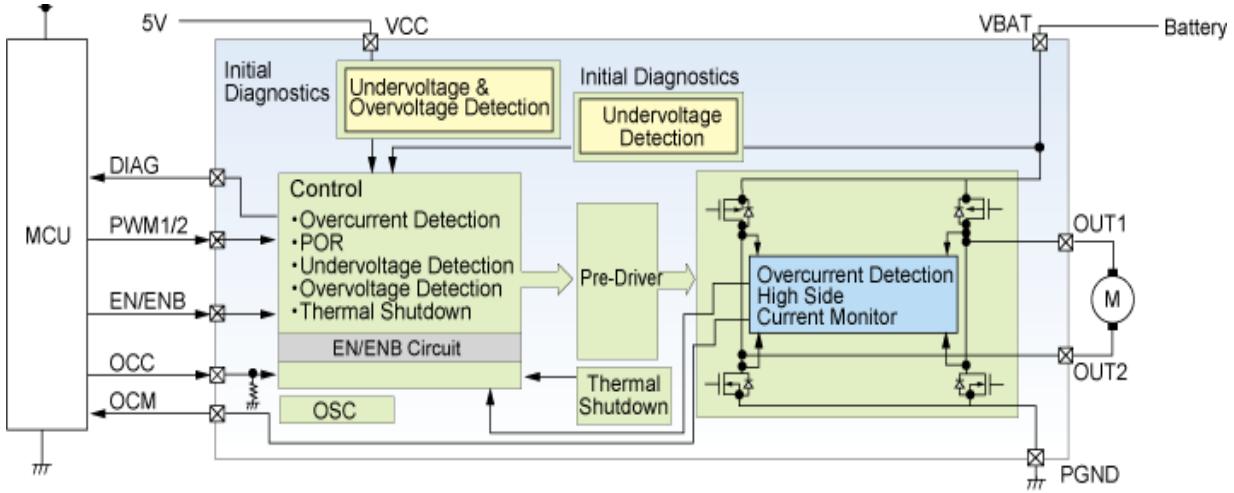
Low Ron Pch + Nch DMOS configured as H-Bridge and PWM operation for efficient drive

2 Various of abnormal status detection features

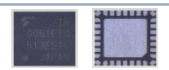
Integrated overcurrent detection, over-temperature detection, VCC overvoltage / undervoltage detection and shoot-through current protection

3 Small package

PQFN28(6mmx6mm) allows an ECU to downsize.



Line up

Part number		TB9051FTG
Package		PQFN28 
Operating range [V]		4.5~28
Over-current・Over-temperature detection		○
DIAG Output		○
R_{ON} (Pch+Nch) @V_{BAT}=8V、Tj=150℃ [Ω]	MAX	0.45
Output current (A)	MAX	5

◆Return to Block Diagram TOP

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