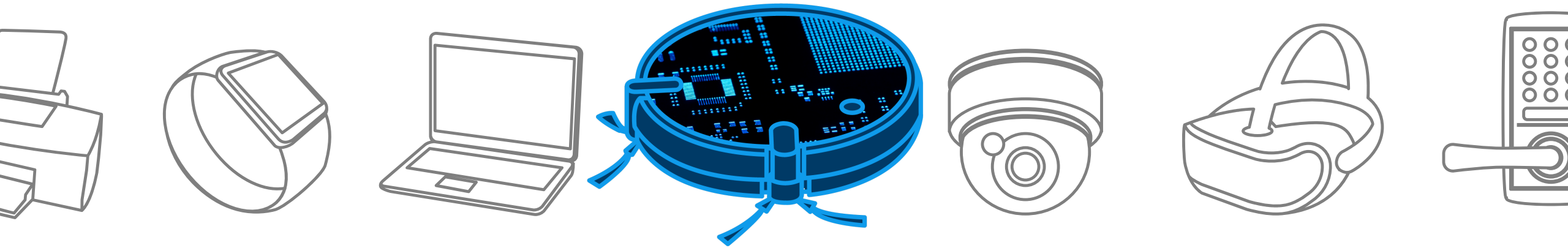
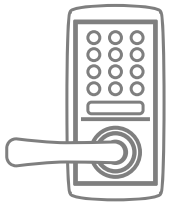
TOSHIBA

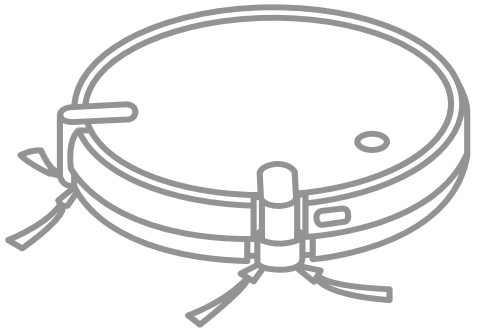
R20

Robot Cleaner

Solution Proposal by Toshiba

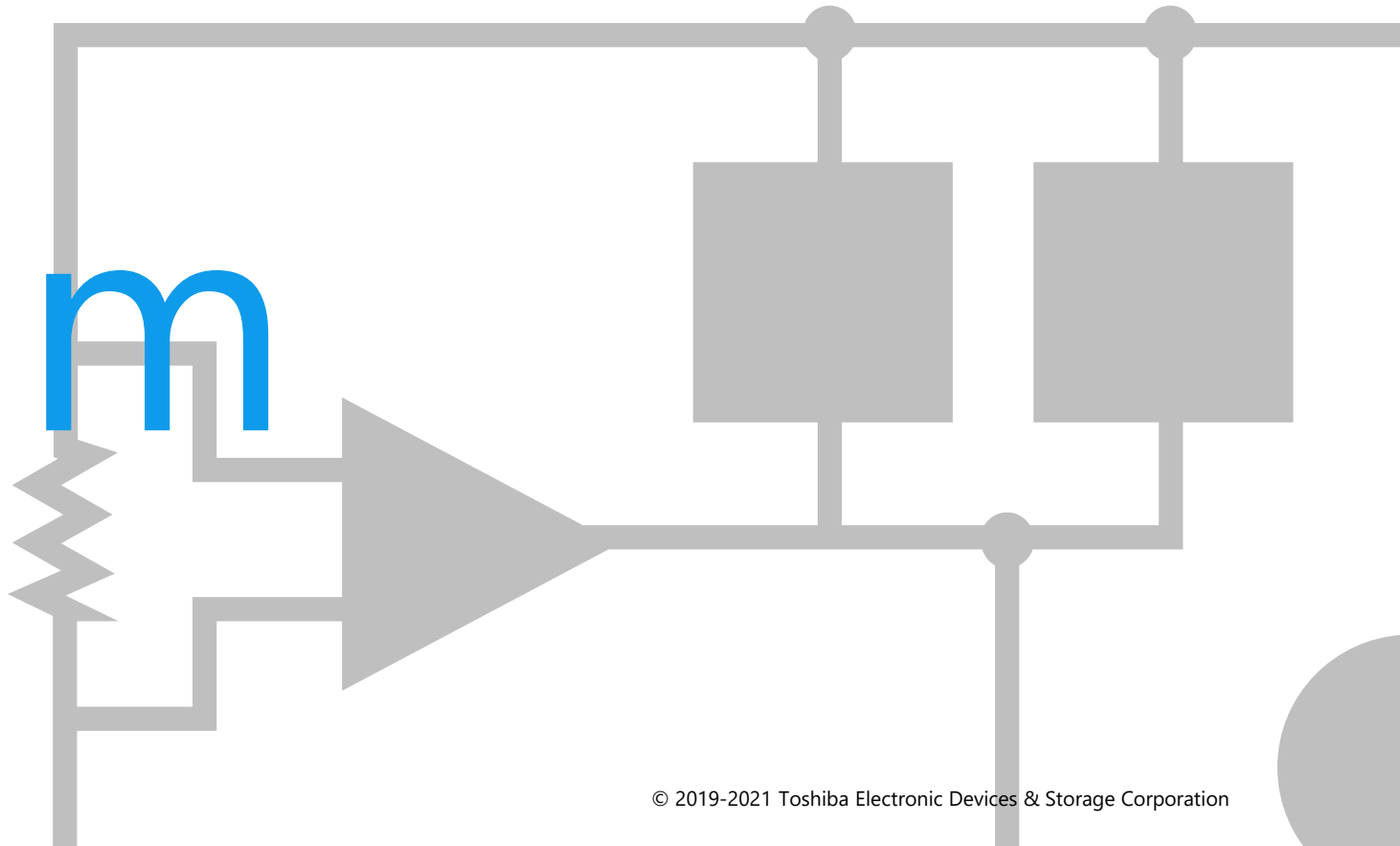




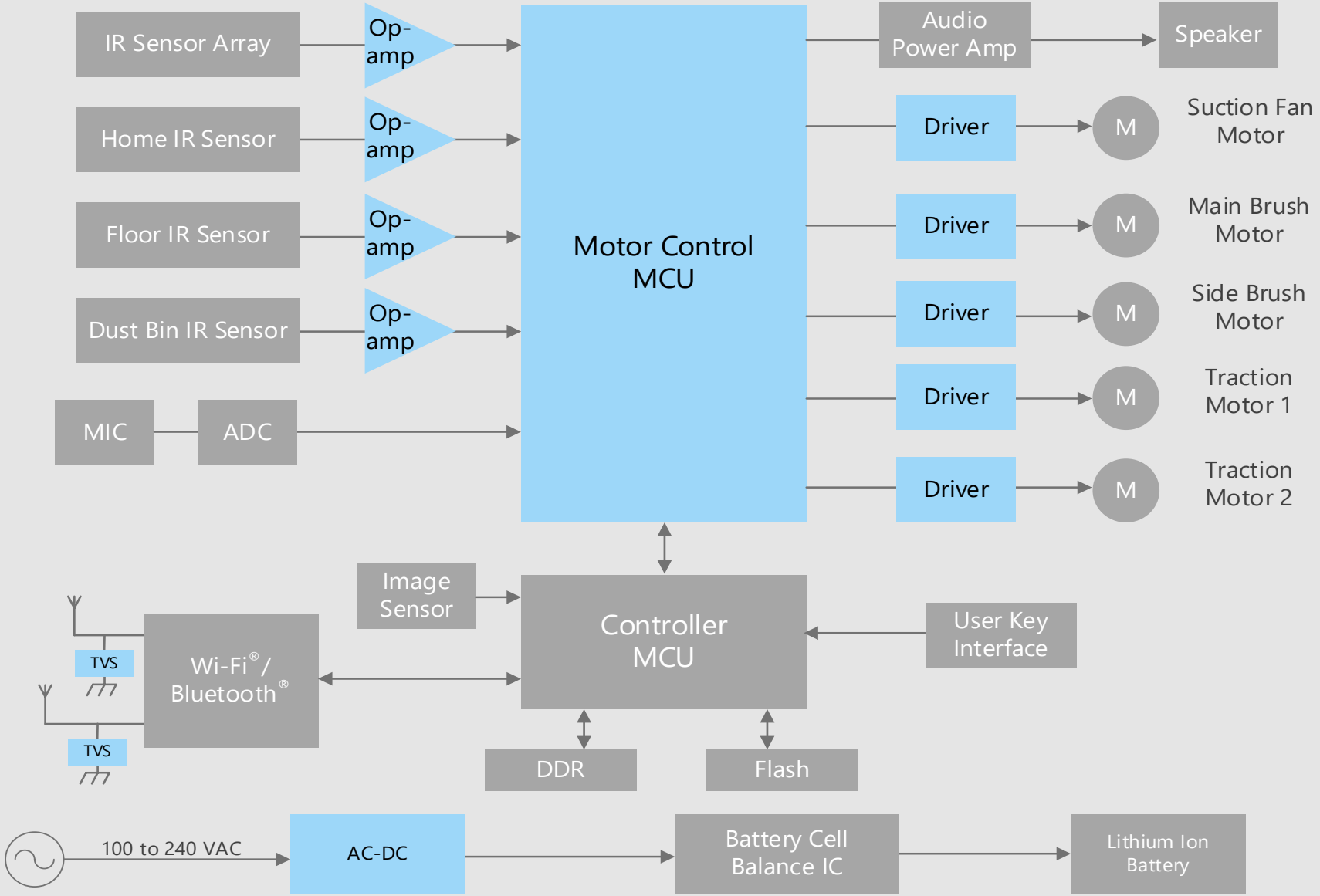


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



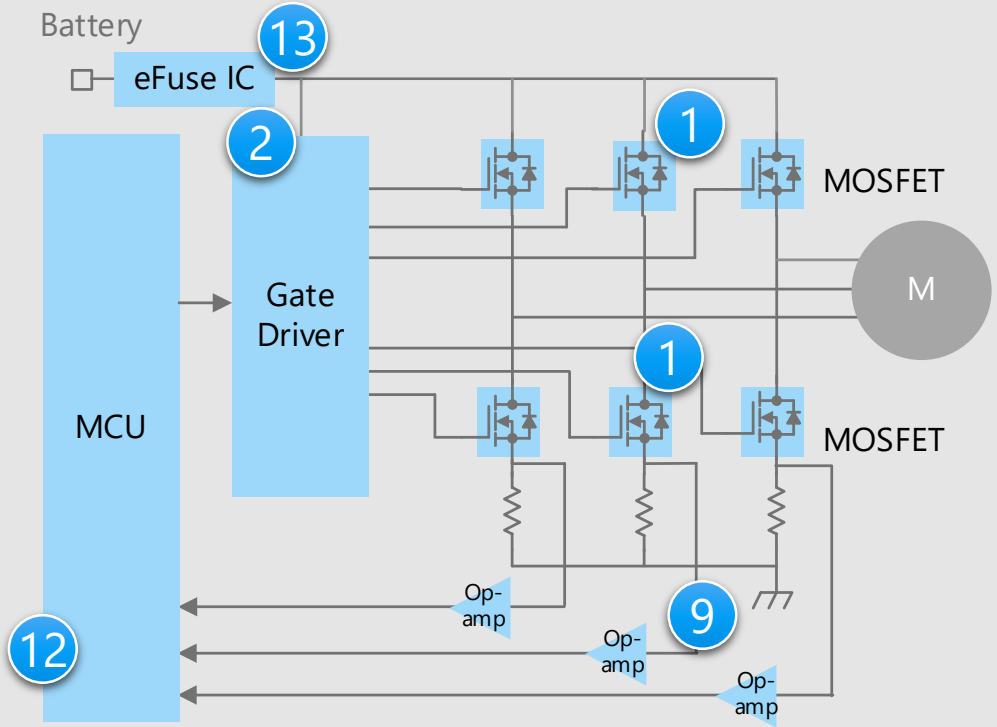
Robot Cleaner　Overall block diagram



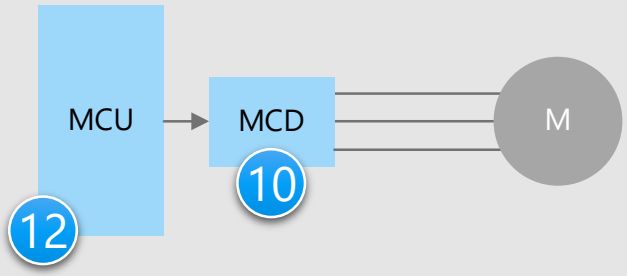
Robot Cleaner　Detail of motor drive unit (1)

Brushless DC motor drive circuit

IPD + MOSFET



Motor Driver



※ Click on the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- To select the product with a current rating that is suitable for the motor rating.
- To select suitable predriver for the rating of the switching device to be driven.
- A low noise operational amplifier is desirable for the sensor block.
- With the increasing current density of small surface mount components, it is necessary to design a heat dissipation that takes into account the reliability.

Proposals from Toshiba

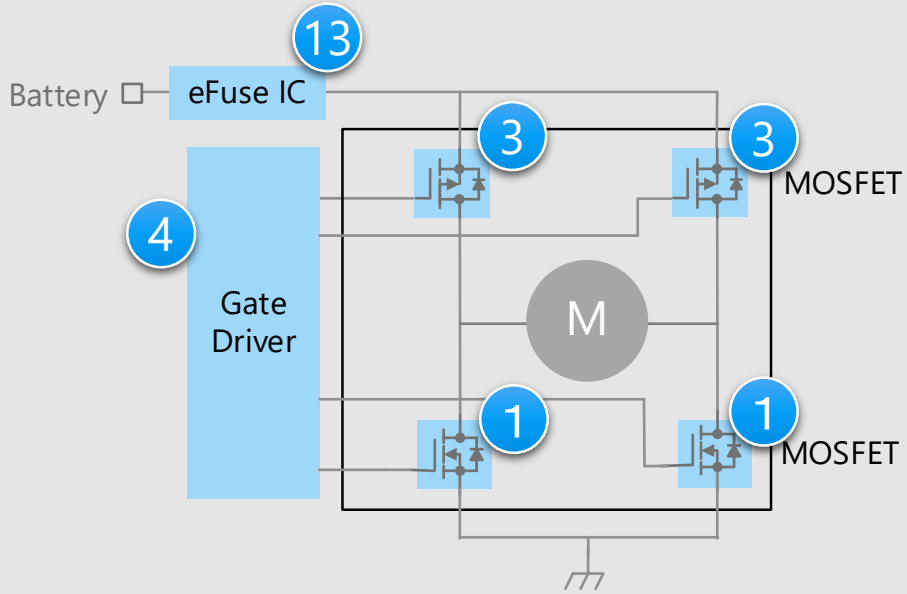
- **Realize low power consumption of the set with low on-resistance**
  U-MOS Series N-ch MOSFET
- **Realize full-bridge drive circuit**
  Intelligent power device (IPD)
- **Amplify the detected weak signal with low noise**
  Low noise operational amplifier
- **Easy control of motors**
  Brushless DC motor driver
- **Easy software development using general purpose CPU cores**
  MCU
- **Robust protection function**
  Electronic fuse (eFuse IC)

1 2 9 10 12 13

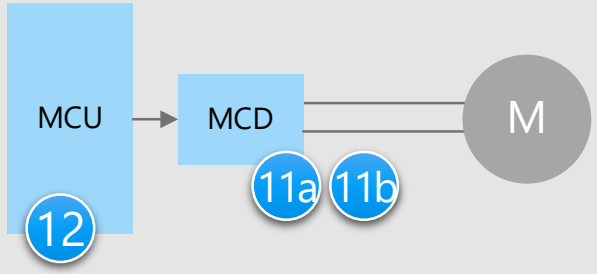
Robot Cleaner　Detail of motor drive unit (2)

Brushed DC motor drive circuit

IPD + MOSFET



Motor Driver



※ Click on the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

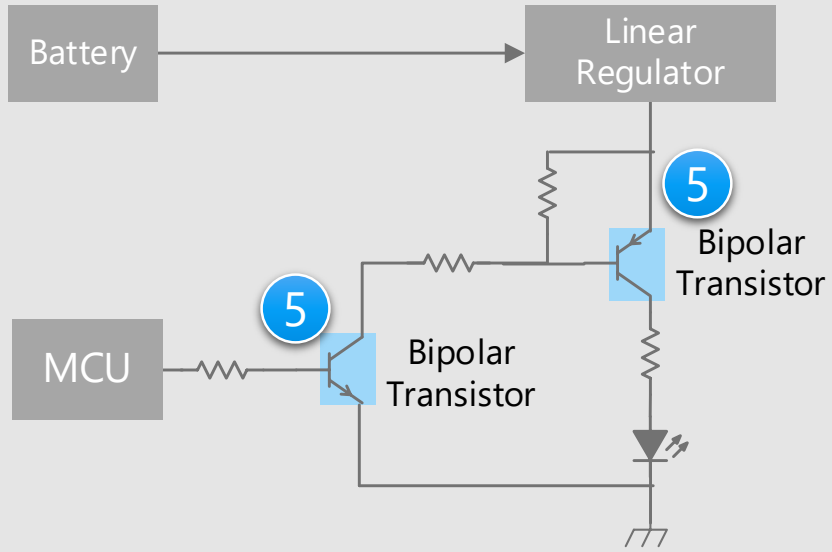
- To select the product with a current rating that is suitable for the motor rating.
- To select suitable predriver for the rating of the switching device to be driven.
- With the increasing current density of small surface mount components, it is necessary to design a heat dissipation that takes into account the reliability.

Proposal from Toshiba

- **Realize low power consumption of the set with low on-resistance** 1
  U-MOS Series N-ch MOSFET
- **Realize low power consumption of the set with low on-resistance** 3
  U-MOS Series P-ch MOSFET
- **Realize half-bridge drive circuit** 4
  Intelligent power device (IPD)
- **Easy control of motors** 11a 11b
  Brushed DC motor driver
- **Easy software development using general purpose CPU cores** 12
  MCU
- **Robust protection function** 13
  Electronic fuse (eFuse IC)

Robot Cleaner　Detail of LED drive unit

LED drive circuit for status display



※ Click on the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- Suppression of variations in LED brightness is possible by using constant current drive circuit.
- Use of a product with a low collector-emitter saturation voltage $V_{CE(sat)}$ has an advantage in power utilization efficiency.
- Circuit board area can be reduced by using small size package products.

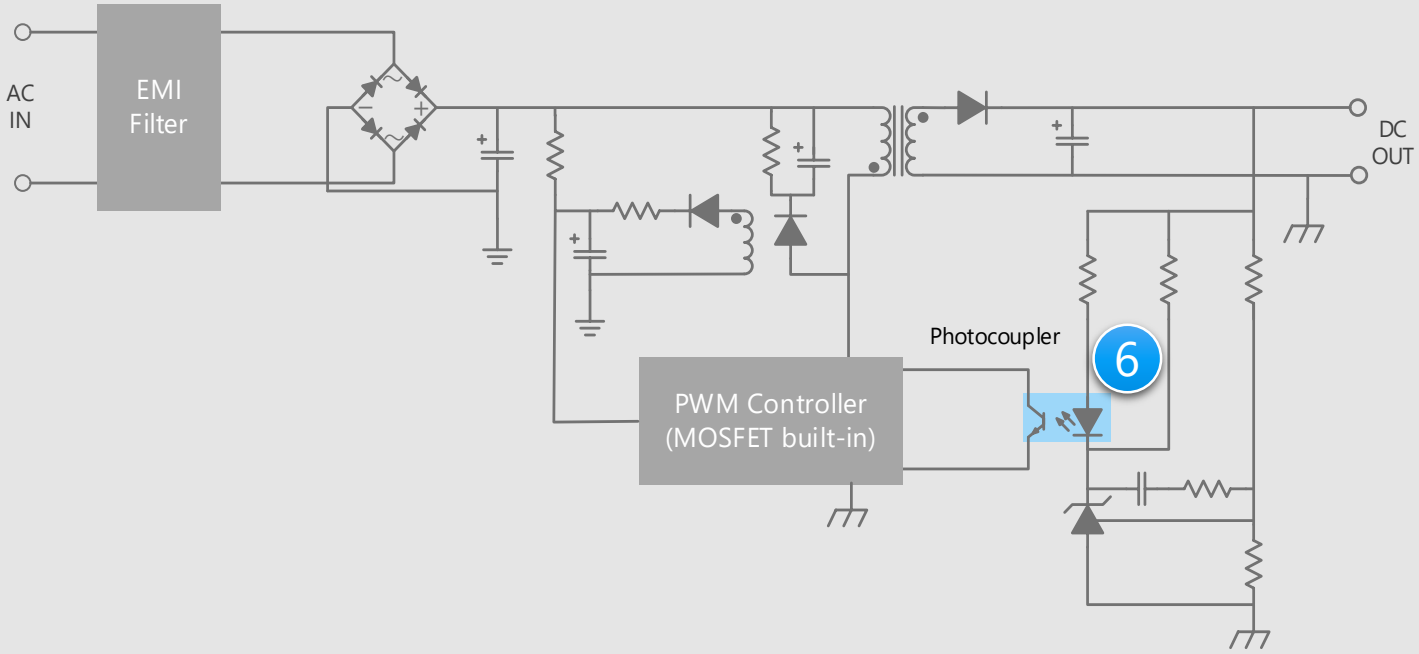
Proposal from Toshiba

- **High voltage and high h_{FE}**
  Bipolar transistor

5

Robot Cleaner　Detail of power supply unit

Flyback AC-DC circuit



※ Click on the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- Contribute to high power supply efficiency by realizing high conversion efficiency even in the low input current range.
- Circuit board area can be reduced by using small size package products.

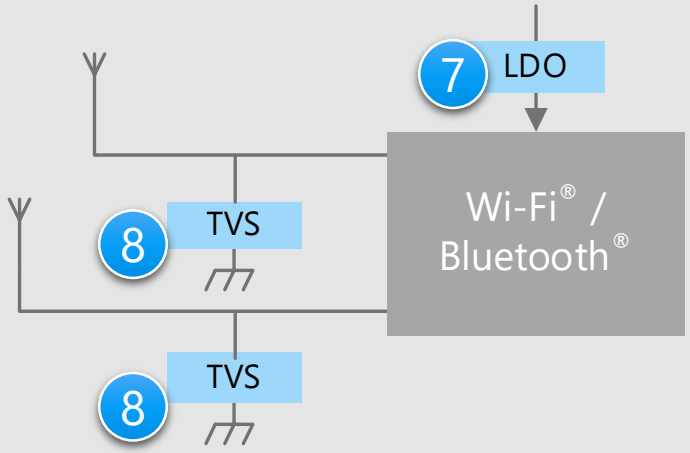
Proposal from Toshiba

- **Photocoupler with excellent environmental resistance**
  Transistor output photocoupler

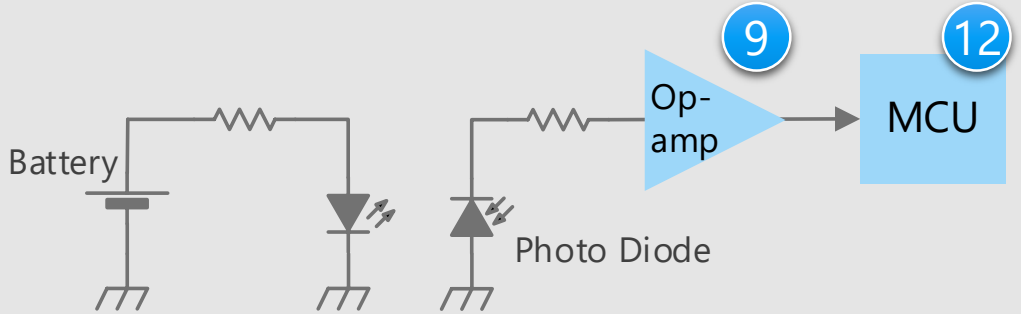
6

Robot Cleaner　Detail of RF and sensor unit

Wi-Fi®/Bluetooth® circuit



Infrared sensor circuit



※ Click on the number in the circuit diagram to jump to the detailed description page

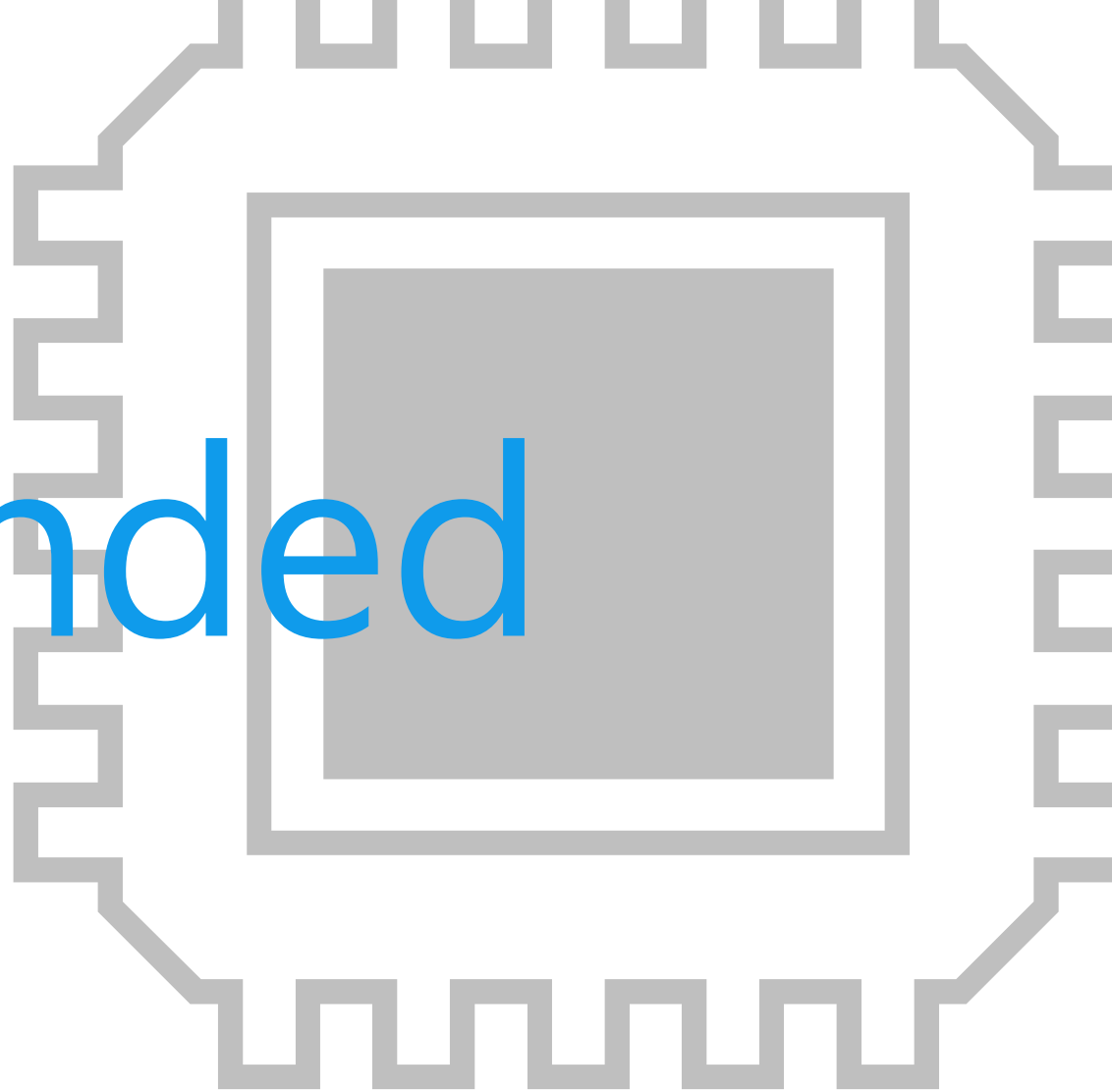
Criteria for device selection

- Power Supply Rejection Ratio (PSRR) is a key characteristic for wireless systems.
- Wi-Fi® system requires high current power supply.
- A small Transient Voltage Suppressor (TVS) with low C_t is suitable for ESD protection without attenuating the antenna signal.
- A low noise operational amplifier is desirable for the sensor block.

Proposal from Toshiba

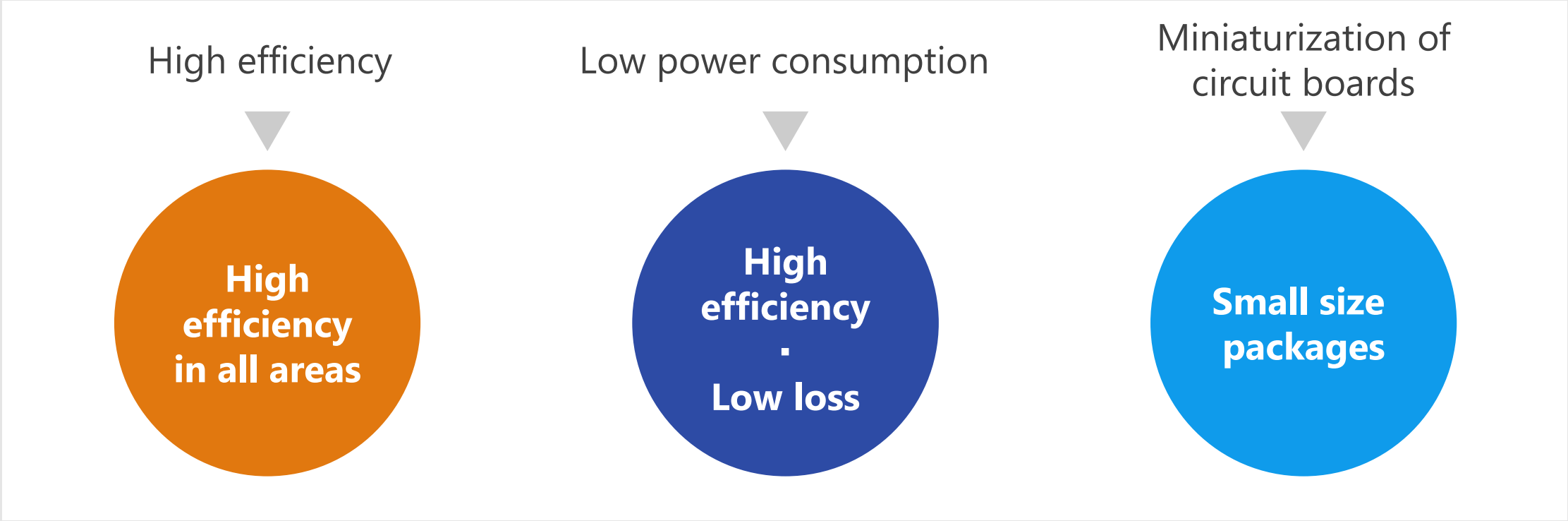
- **Realize noise-resistant power supply** 7
  Small surface mount LDO regulator
- **Absorb Electro Static Discharge (ESD) from antennas and prevent malfunction of the circuit** 8
  TVS diode
- **Amplify the detected weak signal with low noise** 9
  Low noise operational amplifier
- **Easy software development using general purpose CPU cores** 12
  MCU

Recommended Devices



Device solutions to address customer needs

As described above, in the design of robot cleaner, **“High efficiency “**, **“Low power consumption”** and **“Miniaturization of circuit boards”** are important factors. Toshiba’s proposals are based on these three solution perspectives.



Device solutions to address customer needs

	High efficiency in all areas	High efficiency · Low loss	Small size packages
① U-MOS Series N-ch MOSFET	●	●	●
② Intelligent power device (IPD)	●	●	●
③ U-MOS Series P-ch MOSFET	●	●	●
④ Intelligent power device (IPD)	●	●	●
⑤ Bipolar transistor			●
⑥ Transistor output photocoupler	●		●
⑦ Small surface mount LDO regulator	●	●	●
⑧ TVS diode		●	●
⑨ Low noise operational amplifier			●
⑩ Brushless DC motor driver	●	●	●
⑪ Brushed DC motor driver	●	●	●
⑫ MCU		●	●
⑬ Electronic fuse (eFuse IC)	●	●	●

1a U-MOS Series N-ch MOSFET

TPN5R203PL / TPN7R006PL / TPHR7404PU

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Contribute to energy saving and miniaturization by realizing lineup of low on-resistance type and trade-off characteristics of on-resistance between capacitance.

1 Low on-resistance

By reducing on-resistance, heat generation and power consumption can be kept low, and it contributes to miniaturization.

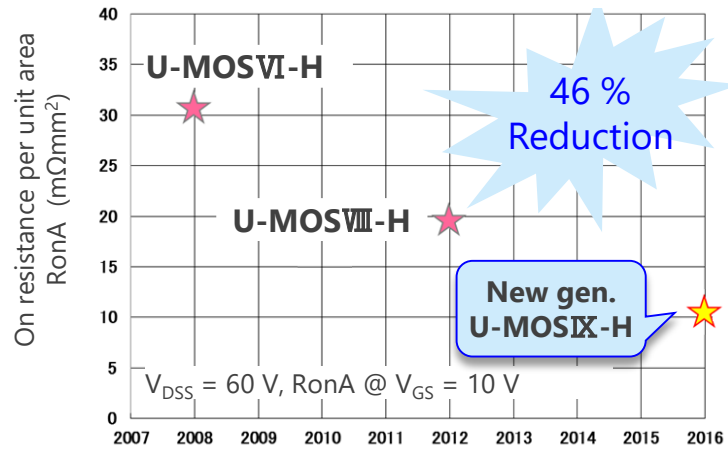
2 Small total gate charge

Reducing total gate charge reduces the performance required for driving the MOSFET, thereby improving the switching characteristics.

3 Fast switching speed

Reducing switching loss by high speed operation contributes to improving efficiency.

RonA reduction trend of N-ch MOSFET



Note: Toshiba internal comparison

Line up

Part number		TPN5R203PL	TPN7R006PL	TPHR7404PU
Package		TSON Advance 		SOP Advance 
V_{DSS} [V]		30	60	40
I_D [A]		36 (76*)	54 (76*)	150 (400*)
$R_{DS(ON)}$ [mΩ] @V_{GS} = 10 V	Typ.	3.9	5.4	0.51
	Max	5.2	7.0	0.74
Polarity		N-ch	N-ch	N-ch
Generation		U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H

* : Silicon limit

◆Return to Block Diagram TOP

1b U-MOS Series N-ch MOSFET (80 V)

TPH2R408QM / TPH4R008QM / TPN8R408QM / TPN12008QM / TPN19008QM / TK5R1P08QM / TK6R9P08QM

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Contributes to lower power consumption of system by low on-resistance and small Q_{OSS} characteristics.

1 Low on-resistance

By keeping the drain-source on-resistance low, heat generation and power consumption can be reduced. Products are provided from low on-resistance of 1.9 mΩ.

2 Small Q_{OSS}

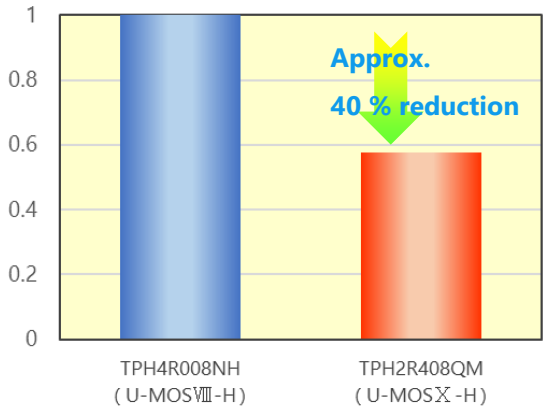
Contributes low output loss due to small Q_{OSS}. Performance index $R_{DS(ON)}$ x Q_{OSS} is reduced by approx. 30 % compared with Toshiba's previous generation product.

3 Variety of packages

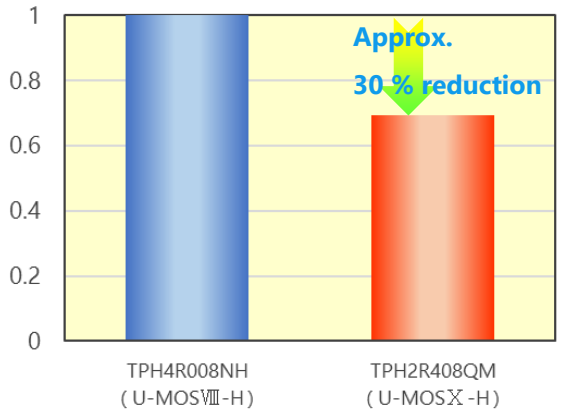
Adding SOP Advance of industries' standard package, smaller TSON Advance package had been provided.

Low on-resistance

$R_{DS(ON)}$(Typ.) @V_{GS}=10 V



$R_{DS(ON)}$ x Q_{OSS}



Note: Toshiba internal comparison

Line up

Part number		TPH2R408QM	TPH4R008QM	TPN8R408QM	TPN12008QM	TPN19008QM	TK5R1P08QM	TK6R9P08QM
Package		SOP Advance(N)		TSON Advance			DPAK	
V_{DSS} [V]		80	80	80	80	80	80	80
I_D [A]		120 (200*)	86 (140*)	32 (77*)	26 (60*)	34 (38*)	84 (105*)	62 (83*)
$R_{DS(ON)}$ [mΩ] @V_{GS} = 10 V	Typ.	1.9	3.1	6.5	9.6	14.7	4.2	5.5
	Max	2.43	4	8.4	12.3	19	5.1	6.9
Polarity		N-ch	N-ch	N-ch	N-ch	N-ch	N-ch	N-ch
Generation		U-MOSX-H	U-MOSX-H	U-MOSX-H	U-MOSX-H	U-MOSX-H	U-MOSX-H	U-MOSX-H

* : Silicon limit

◆Return to Block Diagram TOP

2 Intelligent power device (IPD)

TPD7212F / TPD7212FN

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

The built-in charge pump circuit for the high side drive makes it easy to configure a three-phase full bridge circuit.

1 Built-in power supply voltage diagnostic function

A short circuit protection and an output protection against a short circuit and ground fault circuit are built-in.

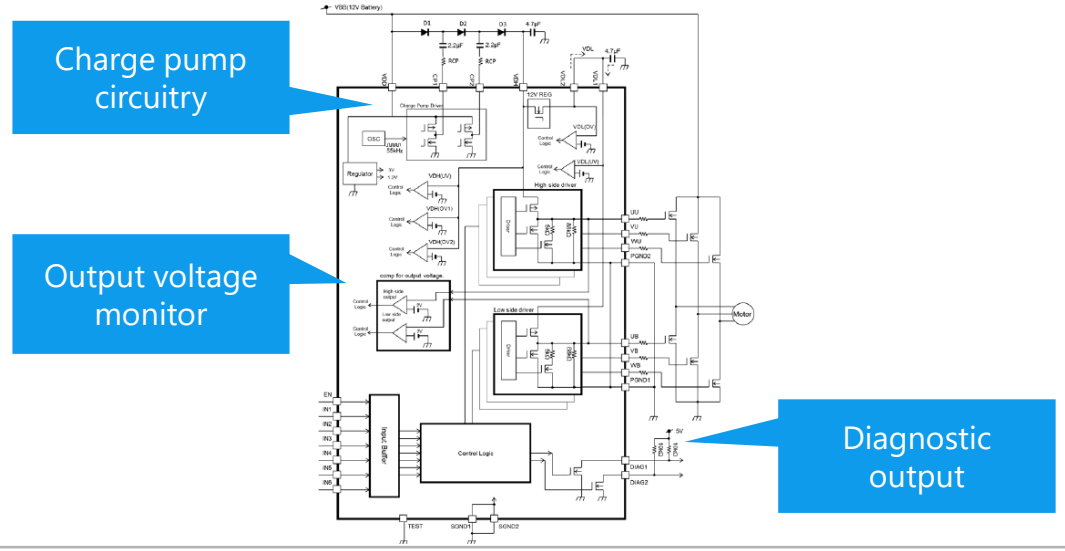
2 Built-in charge pump circuit

The built-in charge pump circuit makes easy to configure a three-phase full-bridge circuit.

3 Compact package

It is available in WQFN32 (5 x 5 mm) package. The mounting area of WQFN32 package is about one-fourth that of conventional products[Note].

[Note] Comparison with Toshiba products



Line up

Part number	TPD7212F	TPD7212FN
Package	WQFN32 	SSOP30 
$V_{DD(opr)}$ [V]	4.5 to 18	4.5 to 18
T_{opr} [°C]	-40 to 125	-40 to 125

◆Return to Block Diagram TOP

3 U-MOS Series P-ch MOSFET

TPCC8131 / TPCA8120

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Contribute to energy saving and miniaturization by realizing lineup of low on-resistance type and trade-off characteristics of on-resistance between capacitance.

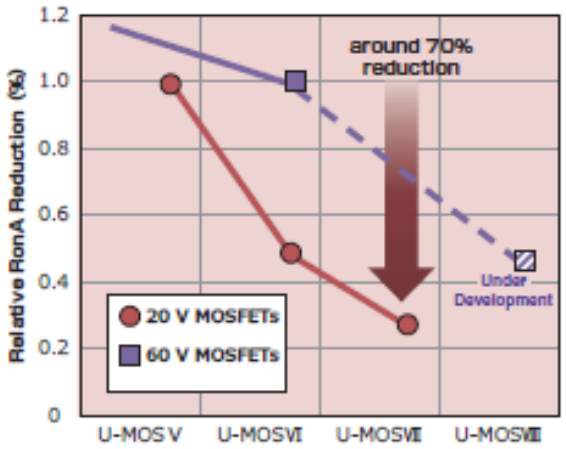
1 Low on-resistance

By reducing on-resistance between drain and source, heat generation and power consumption can be kept low, and it can contribute to miniaturization.

2 Small total gate charge

Reducing total gate charge reduces the performance required for driving the MOSFET, thereby improving the switching characteristics.

RonA reduction trend of P-ch MOSFET



Note: Toshiba internal comparison

Line up

Part number		TPCC8131	TPCA8120
Package		TSON Advance 	SOP Advance 
V_{DSS} [V]		-30	-30
I_D [A]		-30	-45
$R_{DS(ON)}$ [mΩ] @V_{GS} = -10 V	Typ.	13.5	2.4
	Max	17.6	3.0
Polarity		P-ch	P-ch
Generation		U-MOS Ⅵ	U-MOS Ⅵ

◆Return to Block Diagram TOP

4 Intelligent power device (IPD)

TPD7211F

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

A gate driver with half bridge output, which can be driven with a large current (±500 mA maximum).

1 Half bridge type

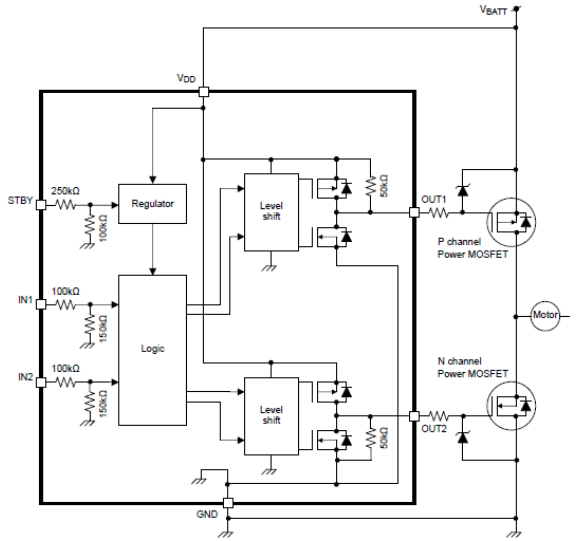
It is a half bridge type gate driver and is suited for high side P-ch type and low side N-ch type power MOSFET driving.

2 Can be driven with a large current

The output current rating of ±500 mA is secured, and high current driving is possible.

3 Compact package

It is packaged in the compact PS-8 package.
Dimensions of PS-8 : 2.8 x 2.9 x 0.8 mm



Line up

Part number	TPD7211F
Package	PS-8 
$V_{DD(opr)}$ [V]	5 to 18
I_{OUT} [mA]	±500
T_{opr} [°C]	-40 to 125

◆Return to Block Diagram TOP

5 Bipolar transistor

2SC2712 / 2SA1162 / TBC847 / TBC857 / HN1B01FU

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Through our extensive product lineup, we provide products that meet the needs of customers.

1 Various package lineups

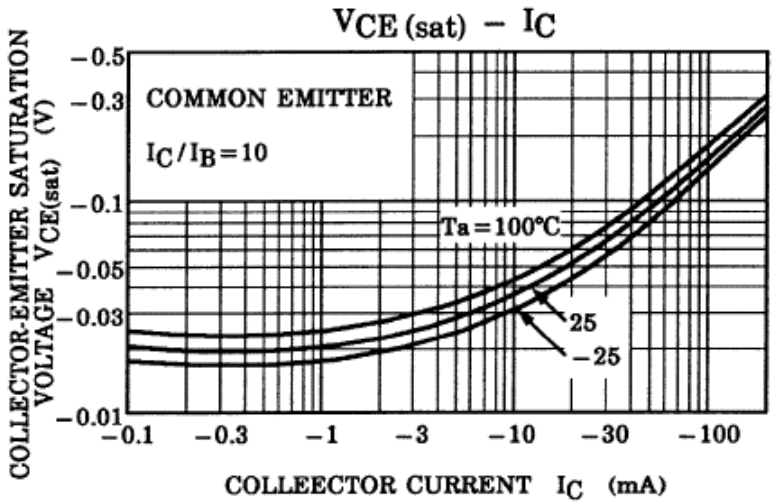
Many types of package, such as flat lead type and leadless type, are available. It is possible to choose the products.

2 Low collector-emitter saturation voltage

Low power consumption is realized by low collector-emitter saturation voltage.

3 High ESD resistance

In applications where static electricity is easily generated, bipolar transistors with higher ESD resistance are helpful.



2SA1162

Line up

Part number	NPN	2SC2712	TBC847	HN1B01FU (NPN+PNP)
	PNP	2SA1162	TBC857	
Package		S-Mini 	SOT23 	US6 
V_{CEO} (Max) [V]		50	50	50
I_C [mA]		150	150	150

◆Return to Block Diagram TOP

6 Transistor output photocoupler

TLP383

High efficiency in all areas | Low loss | Small size packages

Value provided

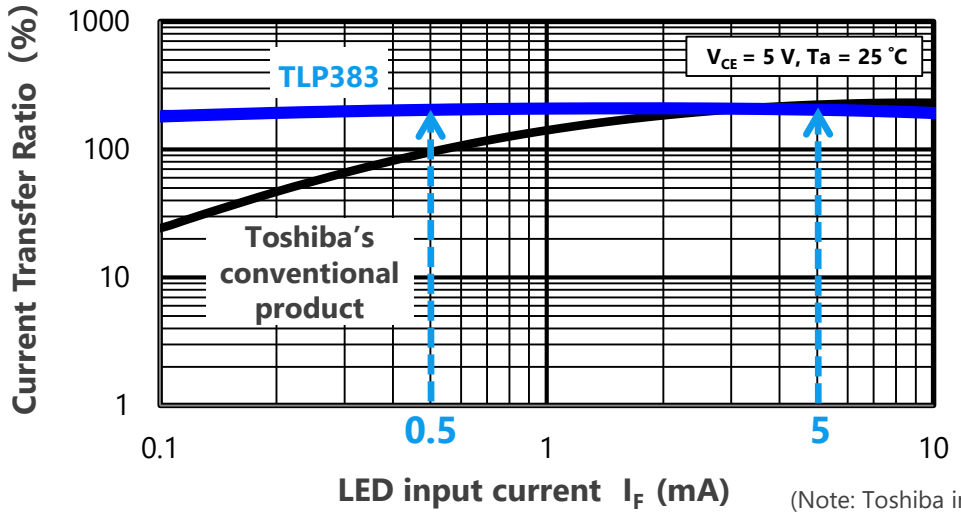
High current transfer ratio is realized even in the low input current range (I_F=0.5 mA).

1 High current transfer ratio

Phototransistor and InGaAs infrared light emitting diode are optically coupled. Highly isolated photocouplers realize higher CTR than Toshiba's conventional products in low input current range (@ I_F = 0.5 mA).

2 The operating temperature range is extended to 125 °C

It is designed to operate under severe conditions of ambient temperature environment, such as inverters, robots, machinery, and high output power supplies.



(Note: Toshiba internal comparison)

Line up

Part number	TLP383
Package	4pin SO6L 
I_C/I_F [%] @I_F = 0.5 mA, 5 mA	50 to 600
t_{off} (Typ.) [μs] @I_F = 1.6 mA	28
BV_S (Min) [Vrms]	5000
T_{opr} [°C]	-55 to 125

◆Return to Block Diagram TOP

7 Small surface mount LDO regulator

TCR15AG / TCR13AG / TCR8BM / TCR5BM / TCR5RG / TCR3RM / TCR3U / TCR2L / TAR5 Series

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Wide line up from general purpose type to small package type are provided. Contribute to realize a stable power supply not affected by fluctuation of battery.

1 Low dropout voltage

The newly developed new generation process significantly improved the dropout voltage characteristics.

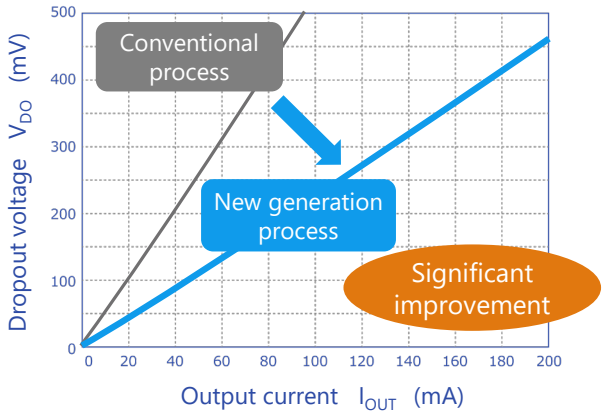
2 High PSRR Low output noise voltage

Many product series that realize both high PSRR (Power Supply Rejection Ratio) and low output noise voltage characteristics are provided. They are suitable for stable power supply for analog circuit.

3 Low current consumption

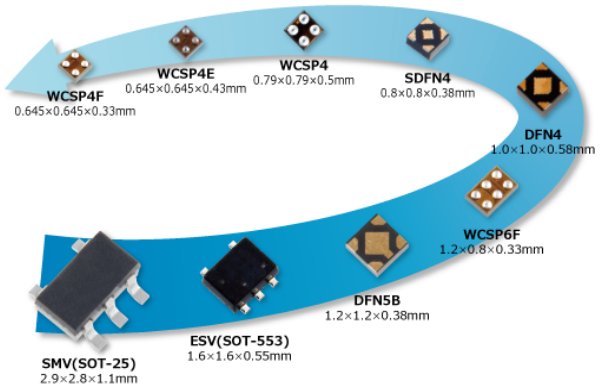
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.

Low dropout voltage



Note: Toshiba internal comparison

Rich package line up



Line up

Part number	TCR15AG Series	TCR13AG Series	TCR8BM Series	TCR5BM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR2L Series	TAR5 Series
Features	Low dropout voltage High PSRR				High PSRR Low noise Low current consumption		Low current consumption		15V Input voltage Bipolar type
I_{OUT} (Max) [A]	1.5	1.3	0.8	0.5		0.3		0.2	
PSRR (Typ.) [dB] @f=1 kHz	95	90	98	98	100	100	70	-	70
I_B (Typ.) [μA]	25	52	20	19	7	7	0.34	1	170

◆Return to Block Diagram TOP

8 TVS diode

DF2B6M4SL / DF2B6M4SL

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

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

1 High ESD pulse absorption performance

Improved ESD absorption compared to our conventio nal products. (50 % reduction in operating resistance) For some our products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

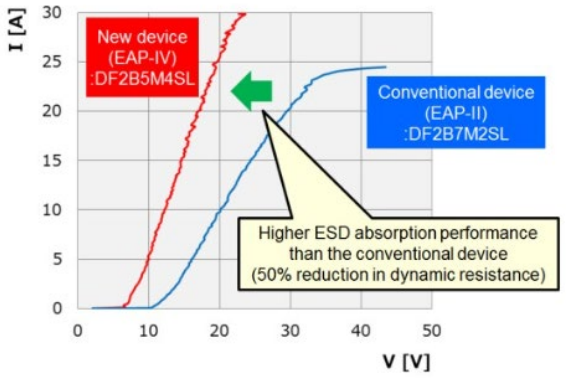
2 Suppress ESD energy by low clamp voltage

Steadily protect the connected circuits/devices using Toshiba original technology.

3 Suitable for high-density mounting

A variety of compact packages are available.

ESD Pulse Absorption Performance
(Toshiba internal comparison)



Unidirectional

Suitable for paths such as logic signals. There are lineups of 1in1, 2in1, 4in1, 5in1, 7in1.

Bidirectional

Suitable for paths with both polar signals such as audio signals

Line up

Part number	DF2B5M4SL	DF2B6M4SL
Package	SL2 	SL2 
V_{ESD} [kV]	±20	±20
V_{RWM} (Max) [V]	3.6	5.5
C_t (Typ.) [pF]	0.2	0.2
R_{DYN} (Typ.) [Ω]	0.5	0.5

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

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9 Low noise operational amplifier

TC75S67TU

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Very small signals detected by various sensors can be amplified with very low noise.

1 Low noise
V_{NI} = 6.0 [nV/√Hz] (Typ.)
@f = 1 kHz

Very small signals detected by various sensors [Note 1] can be amplify with low noise. We achieved one of the industry's lowest [Note 2] input equivalent noise.

2 Low current consumption
I_{DD} = 430 [µA] (Typ.)

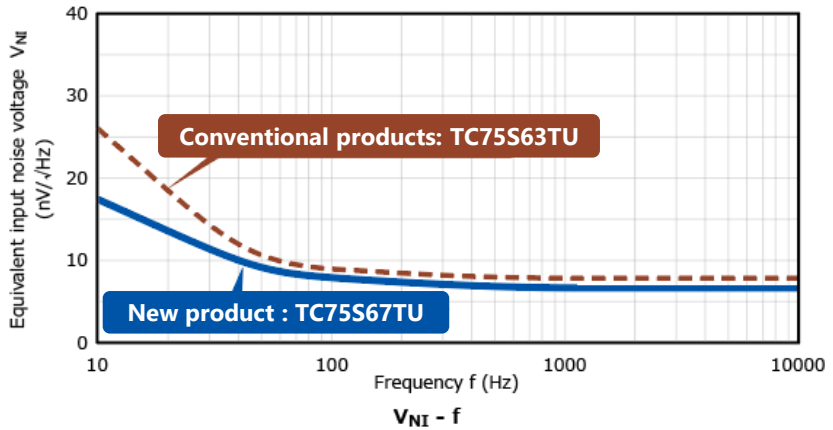
The low current consumption characteristics of CMOS processing contributes to the extension of battery life.

3 Enhancement type

It is easy to handle because it is an enhancement type in which no drain current flows when no gate voltage is applied.

Low-noise characteristic

(Toshiba internal comparison)



V_{NI} - f

Line up

Part number	TC75S67TU
Package	UFV 
$V_{DD,SS}$ (Max) [V]	±2.75
$V_{DD,SS}$ (Min) [V]	±1.1
I_{DD} (Typ. / Max) [µA]	430 / 700
V_{NI} (Typ.) [nV/√Hz] @f = 1 kHz	6

[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, and temperature sensor, etc.
[Note 2] Based on Toshiba data (as of Sep 2021)

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10 Brushless DC motor driver

TB67B001FTG / TC78B009FTG

High efficiency in all areas

High efficiency · Low loss

Small size packages

Value provided

Sensorless type three-phase brushless DC motor driver. It controls motor rotation speed by changing the PWM duty cycle.

1 Sensorless

Driving brushless DC motor without hall sensors by the commutation signal control based on the back-EMF voltage in each phase of the coil. It contributes to reduce system BOM cost.

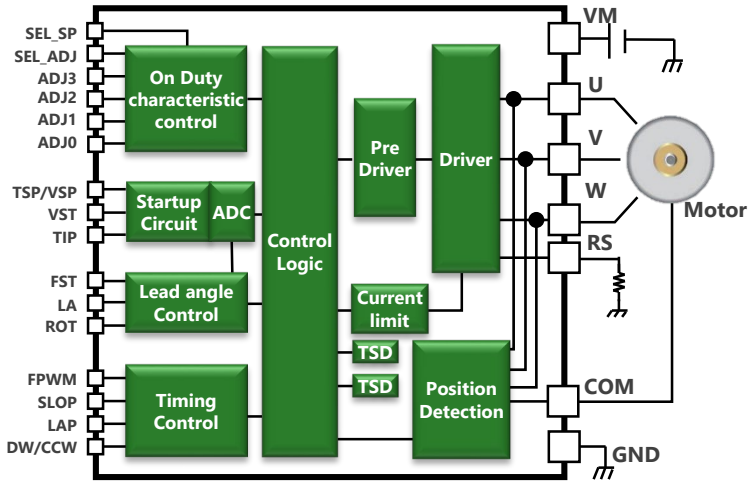
2 Low noise & low vibration

Smooth waveform by soft switching drive realizes low noise and low vibration.

3 Abnormality detection functions

Over current detection (ISD) , Over heat detection (TSD) & Low voltage detection (UVLO) are available for safe motor driving.

TB67B001FTG



Line up

Part number	TB67B001FTG	TC78B009FTG
Output voltage *	25 V	30 V
Drive type	Sensorless drive in three-phase full-wave mode, PWM chopper control	Sensorless PWM drive
Features & Others	Output Type : Square wave Output current * : 3A Output PWM duty adjustment Lead angle control Rotation pulse signal output Forced commutation frequency control Selectable PWM frequency	Output Type : Square wave N-ch MOSFETs drive Built-in closed loop speed control with adjustable speed curve Serial interface (I^2C) for various settings Standby mode CW/CCW control
Package	VQFN36	WQFN36

(* : Absolute maximum ratings)

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11a 1ch brushed DC motor driver

TB67H450AFNG / TB67H451AFNG

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

High voltage, high current & low power consumption by BiCD process. Simple single channel version.

1 High voltage (50 V) / High current

Maximum rating of the output voltage is improved from 40 to 50 V to allow margin for air discharge test etc.

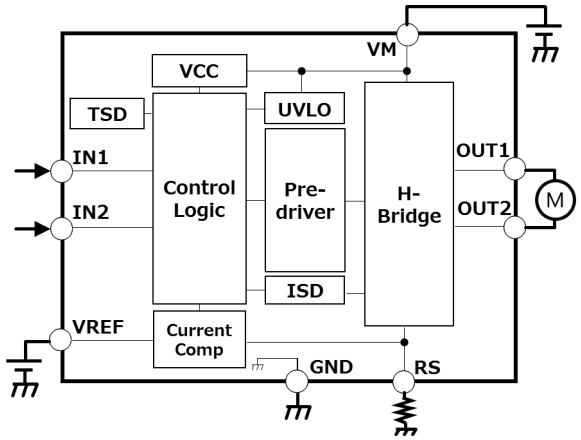
2 Wide operation voltage range

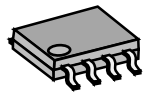
Wide power supply voltage range from 4.5 to 44 V supports battery drive applications.

3 Popular package

Adopting HTSSOP8 package compatible with competitor's products or conventional products.

■ Simple solution





HTSSOP8
(4.9 x 6.0 mm)

Line up

Part number	TB67H450AFNG	TB67H451AFNG
Motor type	Brushed DC motor	
Output voltage	50 V	
Output current	3.5 A	
Output ON resistance	0.6 Ω	
Output circuit	1 circuit	
Control interface	1 mode	
Phase mode	2-phase, 1-2 phase excitation	
Abnormality detection function	Over heat, over current, low voltage	
Package	HTSSOP8	

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11b 2ch brushed DC motor driver

TB67H401FTG / TB67H420FTG

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

High voltage, high current & low power consumption by BiCD process. 2ch version adopted Toshiba original current detection.

1 High voltage (50 V)/ High current

Maximum rating of the output voltage is improved from 40 to 50 V to allow margin for air discharge test etc.
TB67H420 can handle an absolute output maximum current of 9 A.

2 Toshiba original current detection

TB67H401FTG can feedback current detection signal to controller such as MCU by the current limiter output.
TB67H420FTG realizes the constant current PWM w/o detection resistors by ACDS function.

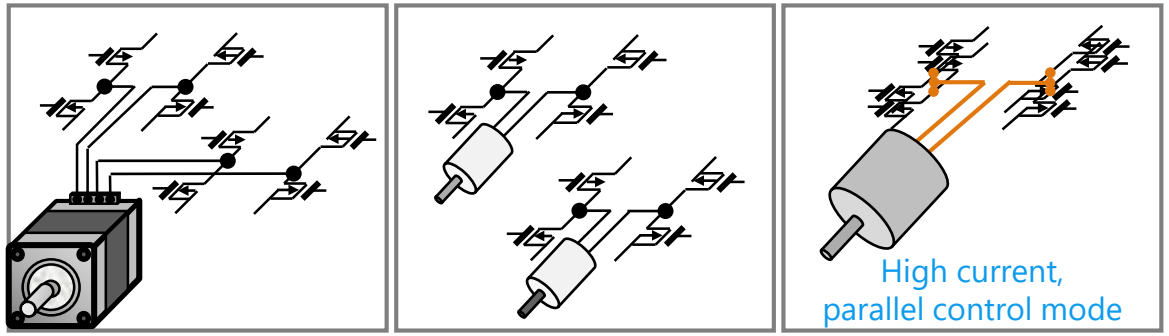
ACDS : Advanced Current Detection System

3 3 selectable drive modes

The H-bridge combination can be tailored according to the type of motor and the required current capacity as: (1) single stepper drive, (2) dual brush drive, and (3) high current, single-brush drive.

■3 selectable drive modes

① Single stepper ② Dual brush ③ High current, single brush



Line up

Part number	TB67H401FTG	TB67H420FTG
Motor type	Brushed DC motor	
Output withstand voltage	50 V	
Output current	6.0 A (Large mode)	9.0 A (Large mode)
Output On resistance	0.25 Ω	0.17 Ω
Output circuit	1 circuit (Large mode)	
Control impedance	4 modes	
Step resolution/excitation mode	1/1, 1/2 step (2-phase, 1-2 phase excitation)	
Error detection	Overheating, overcurrent, low voltage monitoring	
Package	QFN48	QFN48

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High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

System cost reduction, noise reduction, higher efficiency and less development work.

1 Equipped with motor control co-processor

Toshiba's original co-processor vector engine (VE) for motor control reduces CPU load and allows control of multiple motors and peripherals.

2 Equipped with motor control logic circuit

Versatile three-phase PWM output with high efficiency and low noise control made possible by sense timing.
The advanced encoder lightens CPU load of each PWM processing.

3 Equipped with analog circuit for motor control

Multiple high speed, high accuracy AD converter are integrated, allowing conversion timing and PWM output to be linked. External functions such as high performance operational amplifiers are on-chip.

TX Family

Line up

Series	Group	Function
TX03 Series	M370 Group	Arm® Cortex®-M3, includes 1st gen VE
TX04 Series	M470 Group	Arm® Cortex®-M4, includes 2nd gen VE

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13 Electronic fuse (eFuse IC)

TCKE8 Series / TCKE7 Series

High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as overcurrent and overvoltage.

1 Can be used repeatedly

When overcurrent flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. It is not destroyed by a single overcurrent and can be used repeatedly.

2 IEC62368-1 certified

Toshiba's eFuse ICs are certified to the international safety standard IEC62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

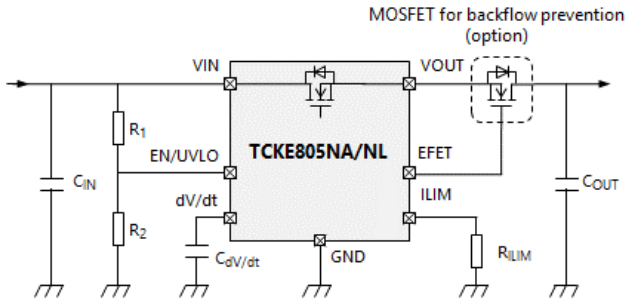
Note: TCKE712BNL is scheduled to be certified in Dec. 2021.

3 Rich protection functions

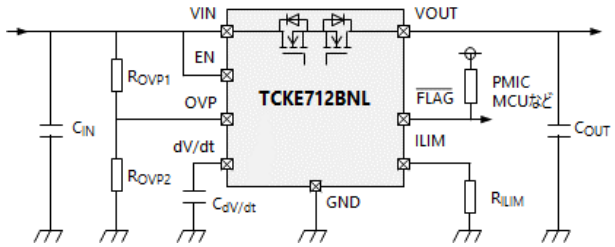
TCKE8 Series: short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

TCKE7 Series: short-circuit protection, overcurrent protection, overvoltage protection, thermal shut down, FLAG signal output, backflow prevention (built-in), etc.

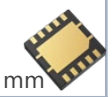
Reference circuit example of TCKE8 Series



Reference circuit example of TCKE7 Series



Line up

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSON10B 3.0 x 3.0 x 0.75 mm  			WSON10 3.0 x 3.0 x 0.75 mm 
V_{IN} [V]	4.4 to 18			4.4 to 13.2
R_{ON} (Typ.) [mΩ]	28			53
Return function	NA: Automatic return NL: Latch type (external signal control)			Latch type (external signal control)
V_{OVC} (Typ.) [V]	-	6.04	15.0	Adjustable

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