TOSHIBA

R23

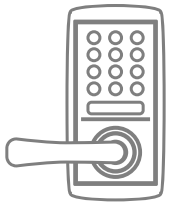
Cordless Cleaner

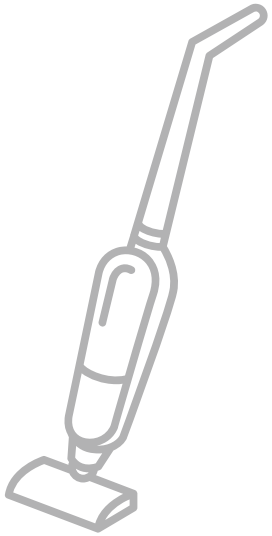
Solution Proposal by Toshiba



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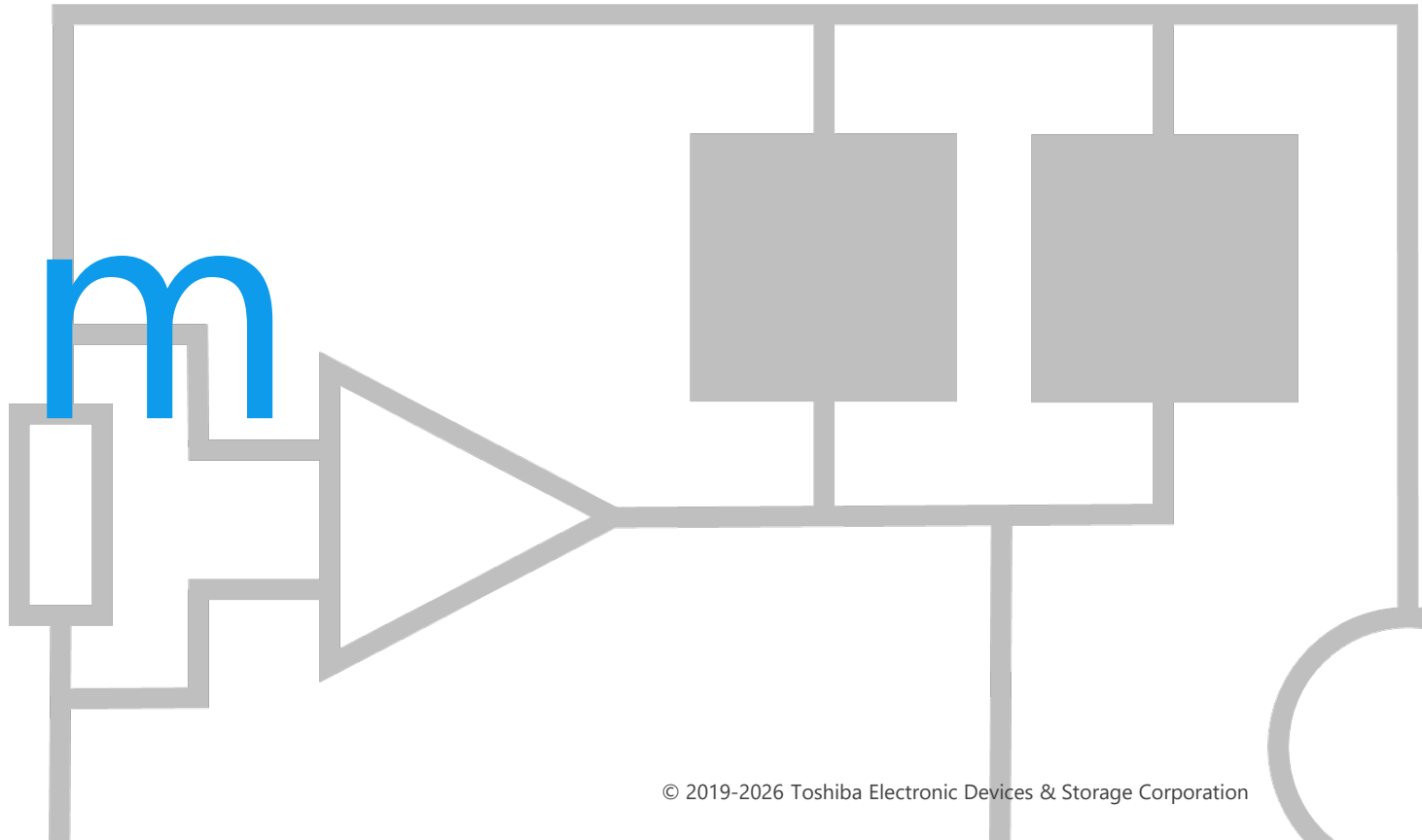




Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

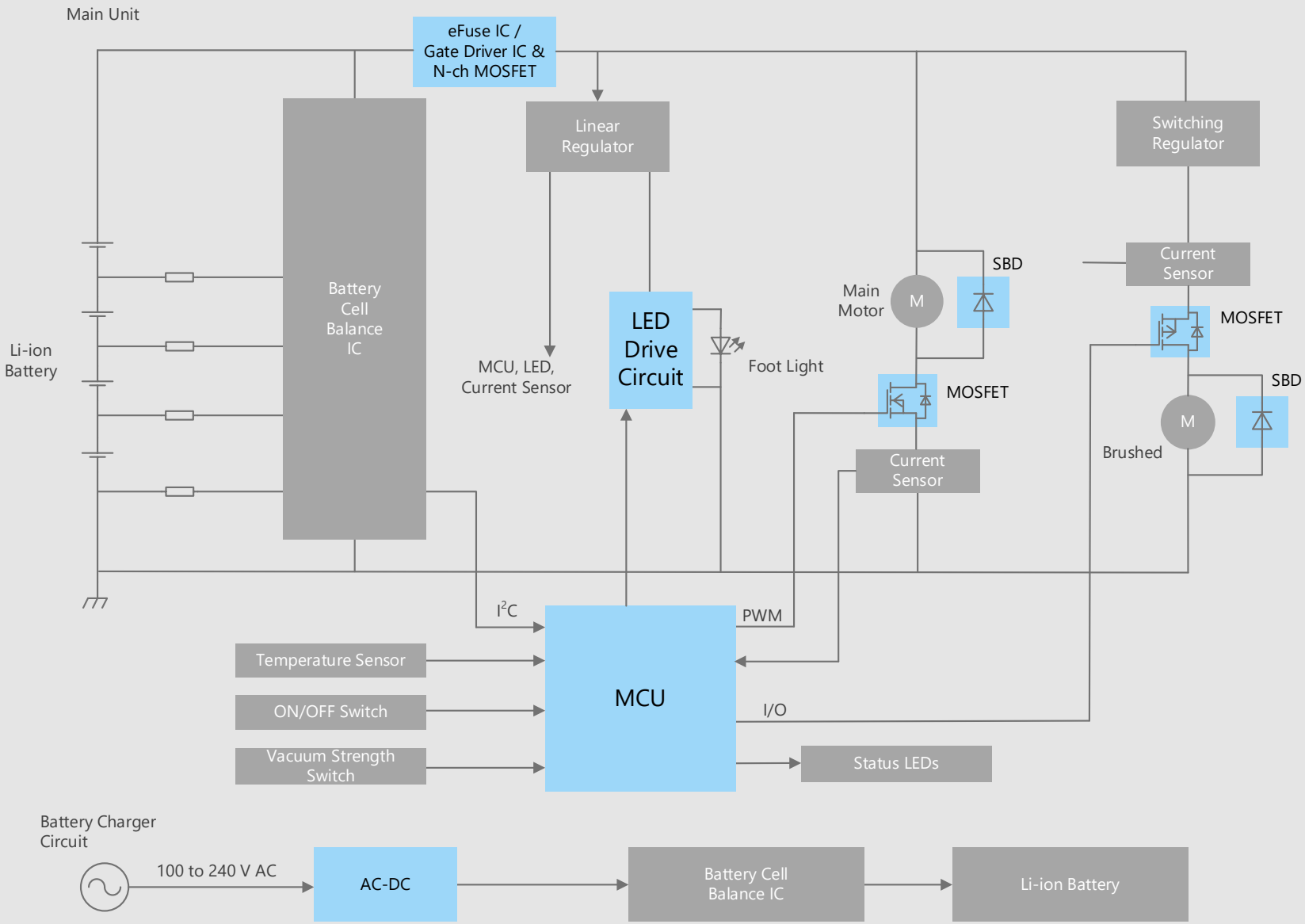
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Block Diagram



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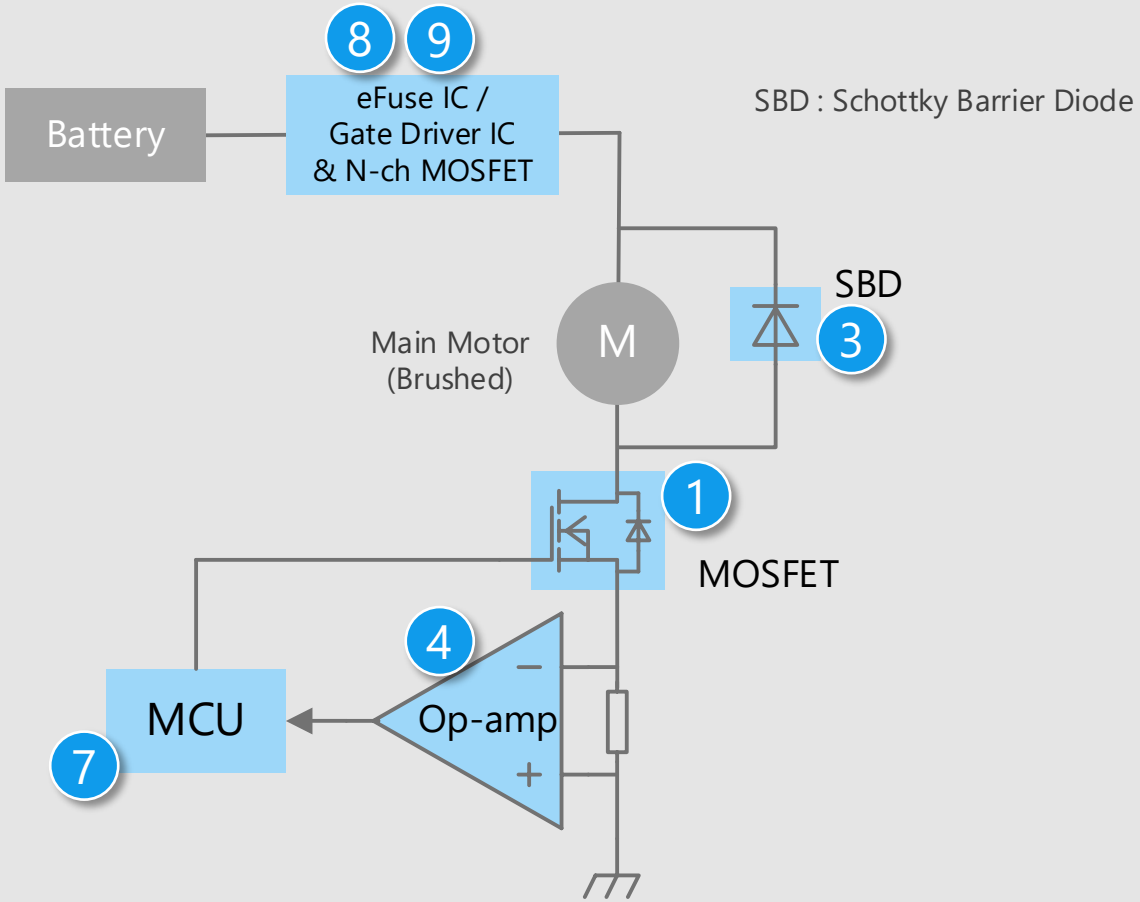
Cordless Cleaner　Overall block diagram



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Cordless Cleaner　Detail of motor drive circuit (1)

Main motor drive circuit



<u>* Click on the number in the circuit diagram to jump to the detailed description page</u>

Criteria for device selection

- Products with packages that have good heat dissipation and high speed switching characteristic contribute to reducing motor losses.
- High precision current detection is possible by an operational amplifier with small input offset voltage.

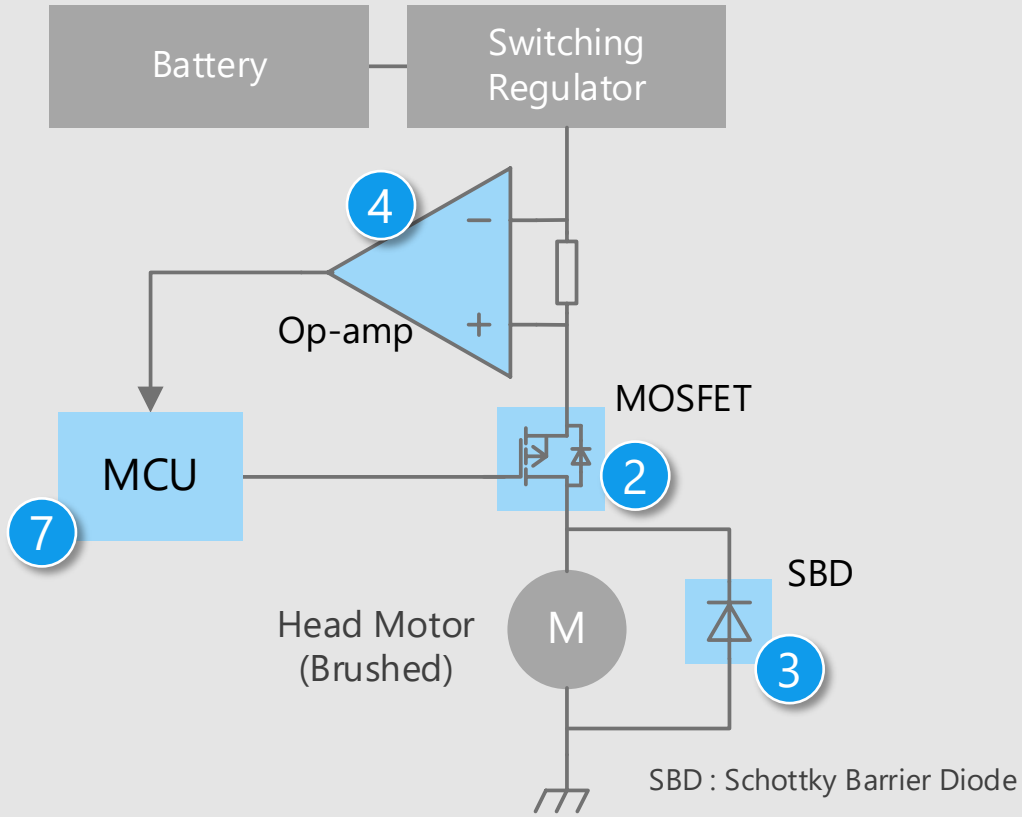
Proposals from Toshiba

- **Realize the set with low power consumption by low on-resistance**
  U-MOS Series N-ch MOSFET　1
- **Strong against surge current**
  Schottky barrier diode　3
- **Realize low voltage drive and low current consumption. And built-in phase compensation circuit**
  CMOS operational amplifier　4
- **Built-in ADCs, timers, and three-phase PWM output. Execute system control with low power consumption**
  MCU M4K / M470 / M370 Group　7
- **Built-in protection function against short circuit, over current, over voltage, etc.**
  Electronic fuse (eFuse IC)　8
- **Small size package and built-in over voltage protection function**
  N-ch MOSFET gate driver IC　9

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Cordless Cleaner　Detail of motor drive circuit (2)

Head motor drive circuit



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

Criteria for device selection

- Products with packages that have good heat dissipation and high speed switching characteristic contribute to reducing motor losses.
- High precision current detection is possible by an operational amplifier with small input offset voltage.

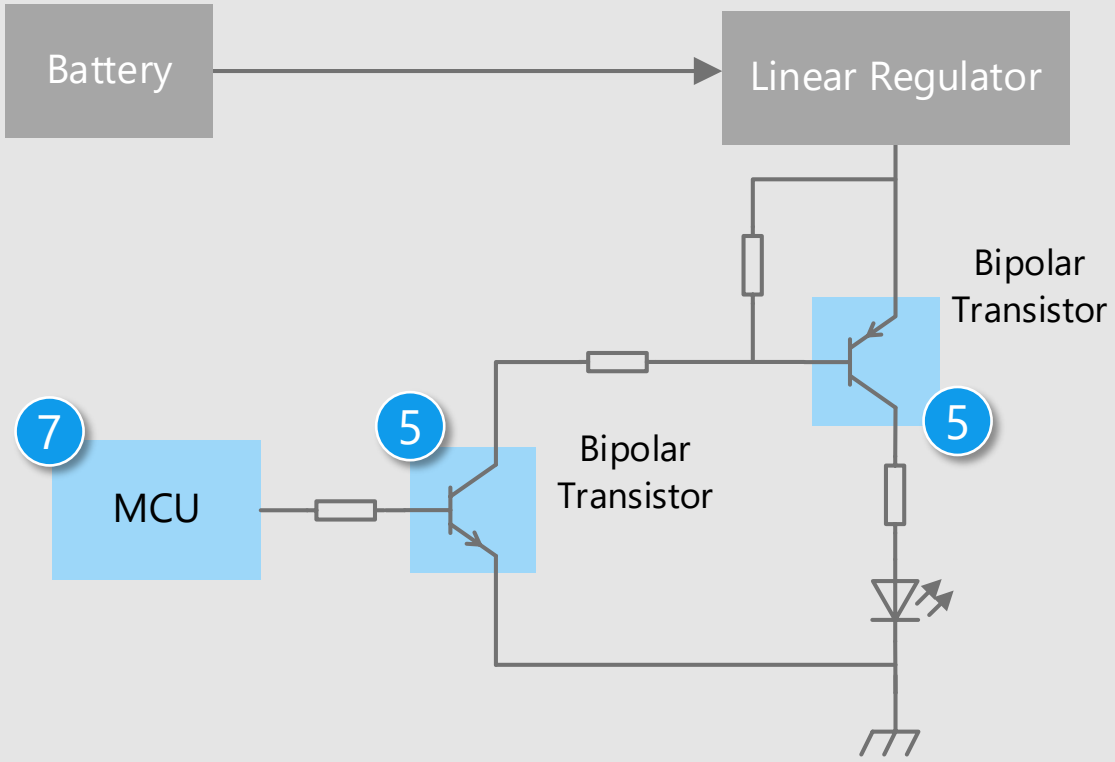
Proposals from Toshiba

- **Realize the set with low power consumption by low on-resistance**
  U-MOS Series P-ch MOSFET　2
- **Strong against surge current**
  Schottky barrier diode　3
- **Realize low voltage drive and low current consumption. And built-in phase compensation circuit**
  CMOS operational amplifier　4
- **Built-in ADCs, timers, and three-phase PWM output. Execute system control with low power consumption**
  MCU M4K / M470 / M370 Group　7

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Cordless Cleaner　Detail of LED drive circuit

LED drive circuit for lighting



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

Criteria for device selection

- Transistors with small package and low collector-emitter saturation voltage are required.

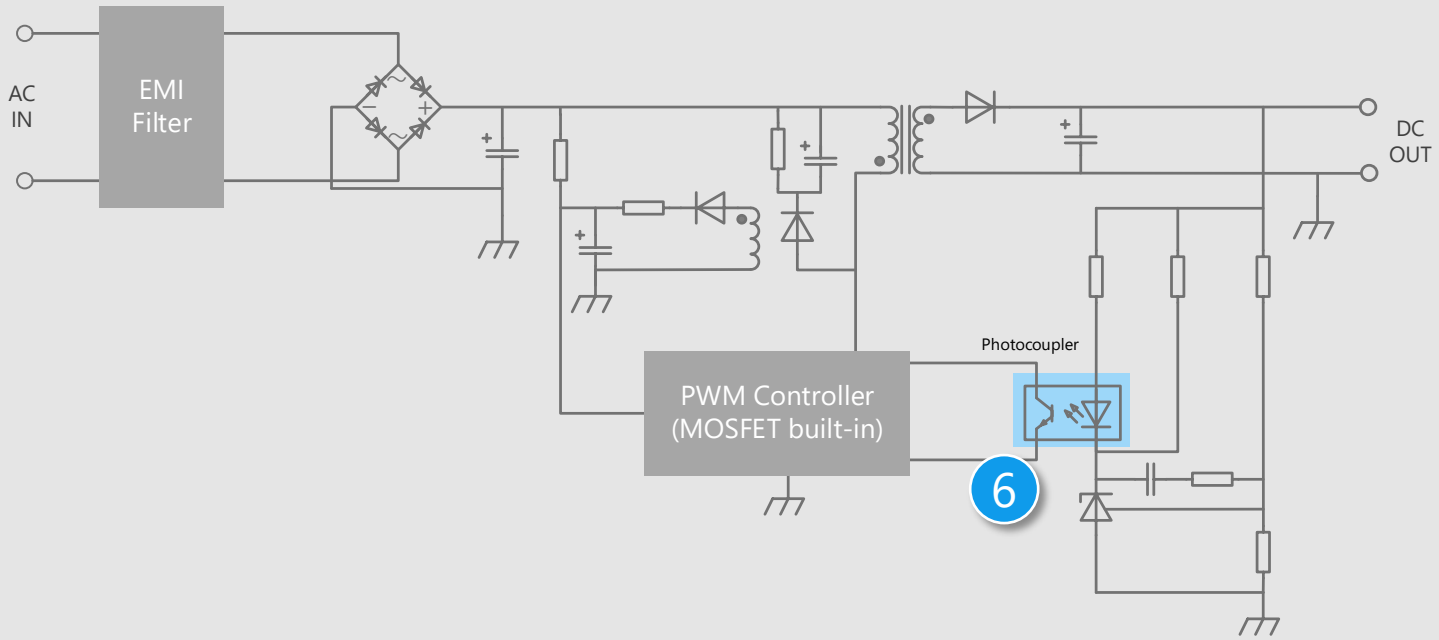
Proposals from Toshiba

- **High voltage and high h_{FE}**
  Small surface mount bipolar transistor 5
- **Built-in ADCs, timers, and three-phase PWM output. Execute system control with low power consumption**
  MCU M4K / M470 / M370 Group 7

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Cordless Cleaner　Detail of power supply section

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 using photocouplers with high current transfer ratio even in the low input current range.

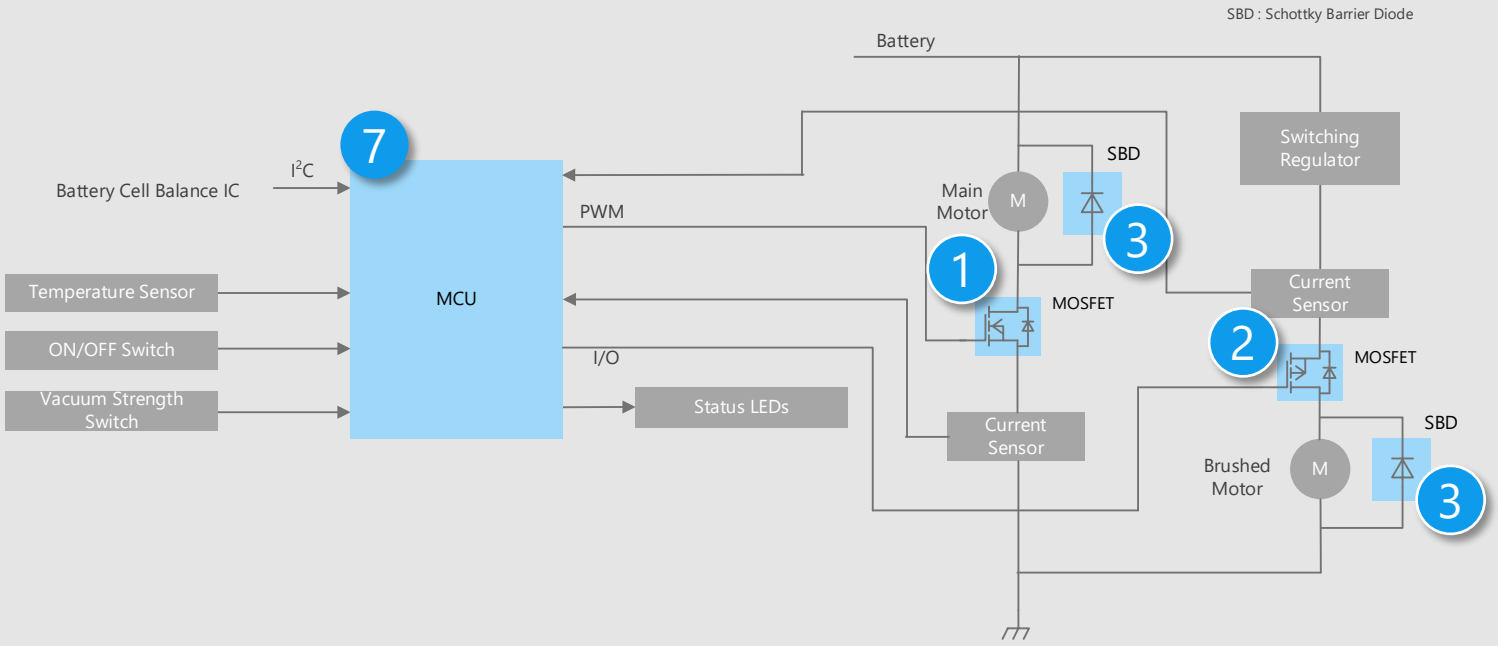
Proposal from Toshiba

- **Photocoupler with excellent environmental resistance**
  Transistor output photocoupler　6

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Cordless Cleaner　Detail of main control section

Main control circuit



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

Criteria for device selection

- Products with packages that have good heat dissipation and high speed switching characteristic contribute to reducing motor losses.
- An MCU is required to control motors in main and brush parts at the same time.
- For system control, an MCU with monitoring various sensors such as current, temperature and light is required.

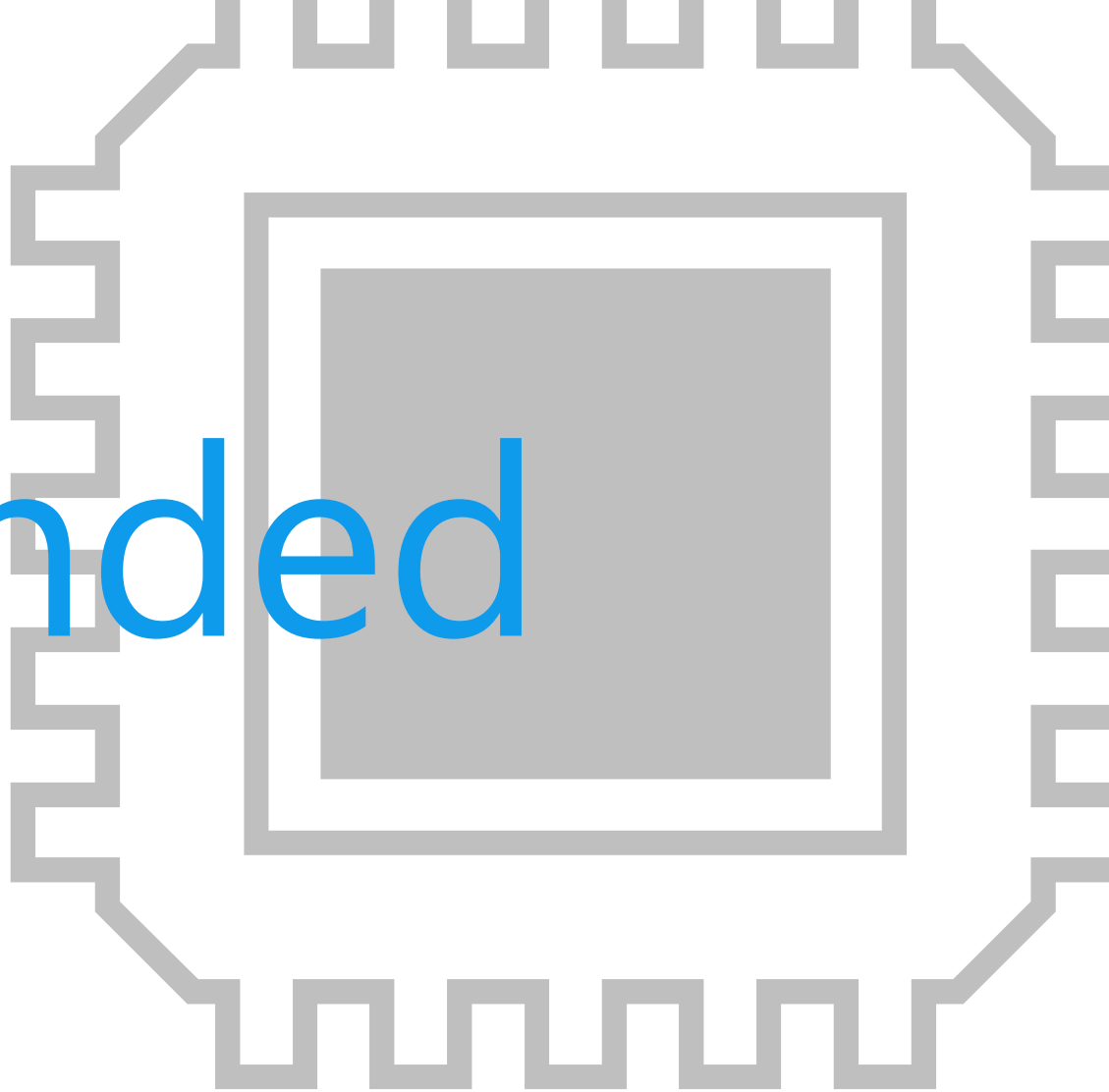
Proposals from Toshiba

- **Realize low power consumption by low on-resistance**
  U-MOS Series N-ch MOSFET
  U-MOS Series P-ch MOSFET
- **Strong against surge current**
  Schottky barrier diode
- **Built-in ADCs, timers, and three-phase PWM output. Execute system control with low power consumption**
  MCU M4K / M470 / M370 Group

1
2
3
7

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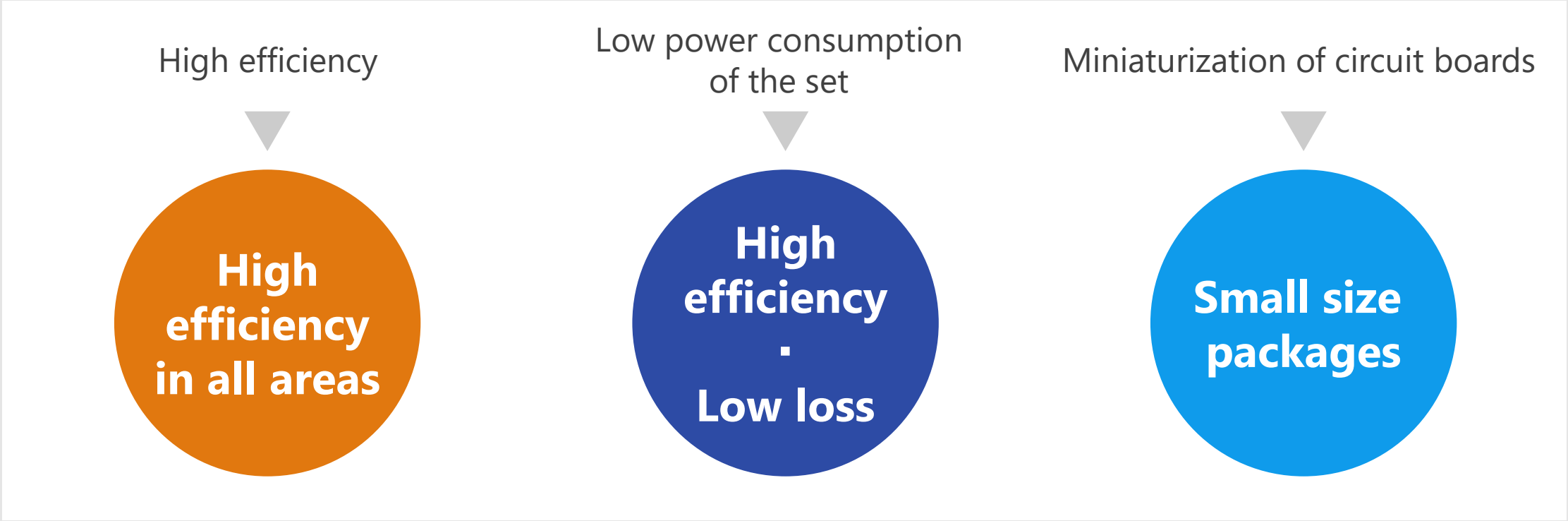
Recommended Devices



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Device solutions to address customer needs

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



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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 U-MOS Series P-ch MOSFET	●	●	●
3 Schottky barrier diode	●		●
4 CMOS operational amplifier	●	●	●
5 Small surface mount bipolar transistor			●
6 Transistor output photocoupler	●		●
7 MCU M4K / M470 / M370 Group	●		●
8 Electronic fuse (eFuse IC)	●	●	●
9 N-ch MOSFET gate driver IC		●	●

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1 U-MOS Series N-ch MOSFET

TPH7R006PL / TPH4R008QM / TPH2R408QM / TPN7R006PL / TPN8R408QM / TK5R1P08QM / TK6R9P08QM

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

Value provided

Low on-resistance products are available in the lineup. Improvement of trade-off characteristics between on-resistance and capacitance contributes to energy saving.

1 Low on-resistance

Low on-resistance between drain and source contributes to reducing heat generation and power consumption.

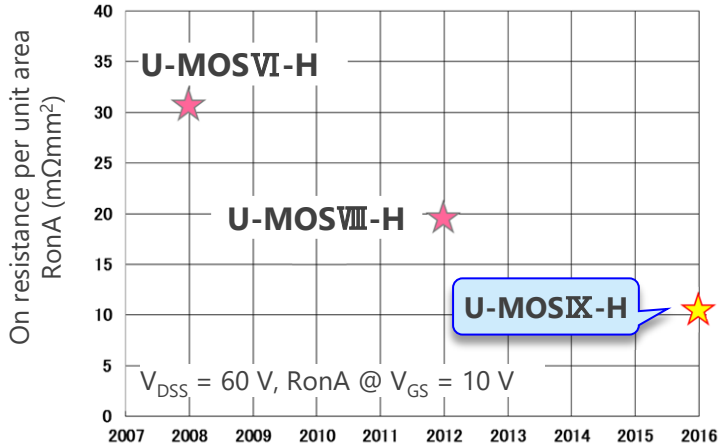
2 Small total gate charge

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

Lineup

Part number		TPH7R006PL	TPH4R008QM	TPH2R408QM	TPN7R006PL	TPN8R408QM	TK5R1P08QM	TK6R9P08QM
Package		SOP Advance	SOP Advance(N)		TSON Advance		DPAK	
V_{DSS} [V]		60	80	80	60	80	80	80
I_D [A]		60 (79*)	86 (140*)	120 (200*)	54 (76*)	32 (77*)	84 (105*)	62 (83*)
$R_{DS(ON)}$ [mΩ] @V_{GS} = 10 V	Typ.	5.4	3.1	1.9	5.4	6.5	4.2	5.5
	Max	7.0	4.0	2.43	7.0	8.4	5.1	6.9
Generation		U-MOSⅨ-H	U-MOSⅧ-H	U-MOSⅧ-H	U-MOSⅨ-H	U-MOSⅧ-H	U-MOSⅧ-H	U-MOSⅧ-H

* : Silicon limit

◆Return to Block Diagram TOP

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2 U-MOS Series P-ch MOSFET

TPCA8120

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

Value provided

Low on-resistance products are available in the lineup. Improvement of trade-off characteristics between on-resistance and capacitance contributes to energy saving.

1 Low on-resistance

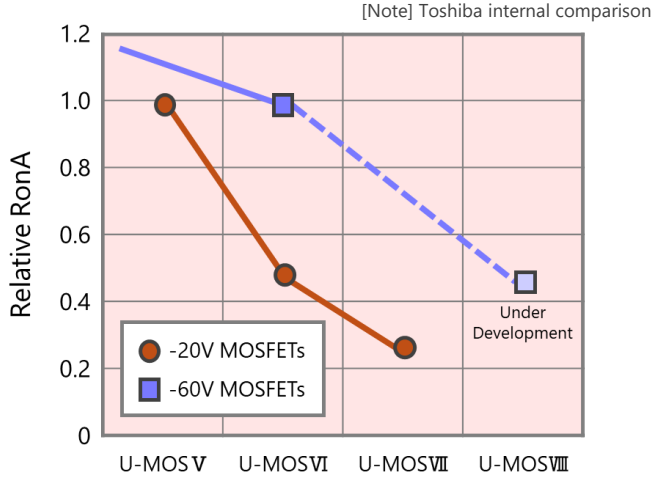
Low on-resistance between drain and source contributes to reducing heat generation and power consumption.

2 Small total gate charge

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

RonA reduction of P-ch MOSFET

[Note] Toshiba internal comparison



Lineup

Part number		TPCA8120
Package		SOP Advance  Top view  Bottom view
V_{DSS} [V]		-30
I_D [A]		-45
$R_{DS(ON)}$ [mΩ] @V_{GS} = -10 V	Typ.	2.4
	Max	3.0
Generation		U-MOSⅥ

◆Return to Block Diagram TOP

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3 Schottky barrier diode
CMS05 / CMS15

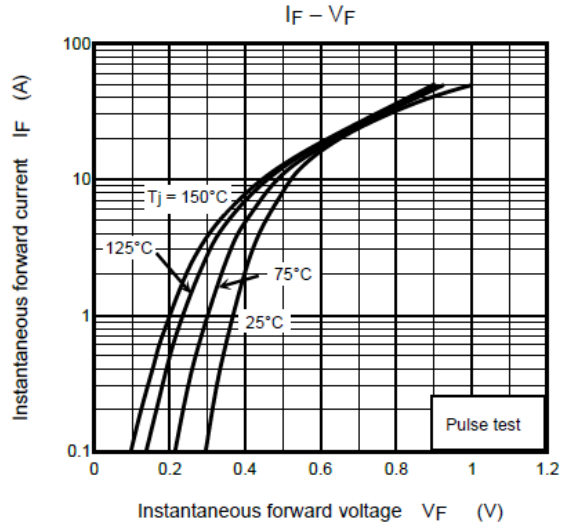
High efficiency in all areas | High efficiency · Low loss | Small size packages

Value provided

We offer a wide lineup of products, featuring small size surface mount type packages suitable for high density mounting.

1 Small size surface mount package

Adopting M-FLAT™ package, contribute space saving of equipment.



CMS05
Forward characteristic

2 Extensive product lineup

Reverse voltage: up to 60 V
Average forward current: up to 5 A
It is possible to choose suitable product according to specification of set.

Lineup

Part number	CMS05	CMS15
Package	M-FLAT™  Top view  Bottom view	
$I_{F(AV)}$ [A]	5	3
V_{RRM} [V]	30	60
V_{FM} (Typ.) [V]	0.43	0.55

◆Return to Block Diagram TOP

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4 CMOS operational amplifier

TC75S55F / TC75S55FU

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

Value provided

Compared to bipolar types, it features lower operating voltage and lower current consumption, contributing to flexibility in equipment design and reduced power loss.

1 Low operating voltage

CMOS processes enable low voltage operation compared to Toshiba's bipolar type operational amplifiers.

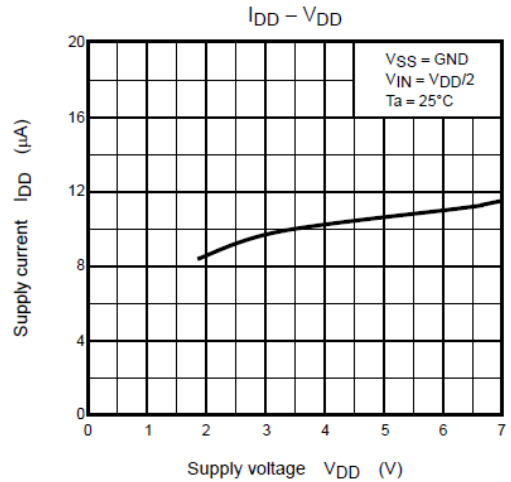
2 Low current consumption

Low current consumption characteristics of CMOS processes contribute to extending the battery life of equipment.

[Note] Comparison with Toshiba's bipolar process operational amplifiers

3 Built-in phase compensation circuit

Eliminating the need for external components, CMOS operational amplifier contributes to reduction in the number of parts and size of equipment.



TC75S55F
I_{DD} = 10 μA (Typ.)
@ V_{DD} = 3 V

Low current consumption design compared with bipolar type operational amplifier
(Supply current of Toshiba's bipolar process products: I_{CC} = 400 [μA] (Typ.))

Lineup

Part number	TC75S55F	TC75S55FU
Package	SMV 	USV 
V_{DD} [V]	1.8 to 7 or ±0.9 to ±3.5	
I_{DD} (Typ.) [μA]	10	
f_T (Typ.) [MHz]	0.16	

◆Return to Block Diagram TOP

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5 Small surface mount 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 product that suit customer's circuit board.

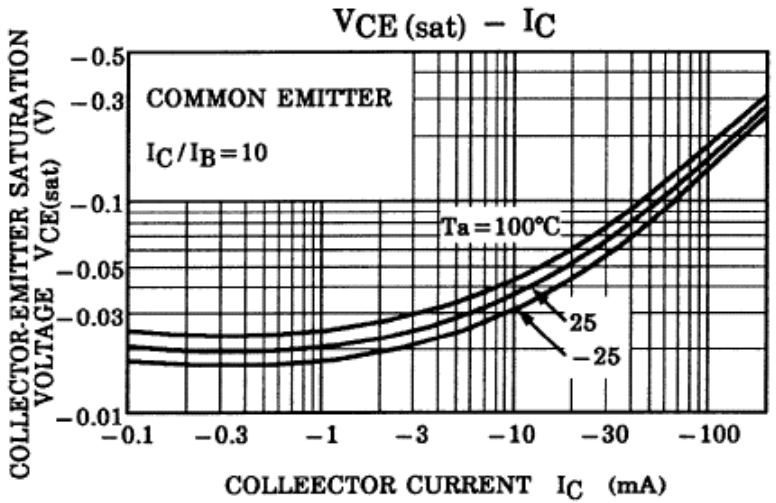
2 Low collector-emitter saturation voltage

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

3 High ESD resistance

In applications where static electricity is easily generated, such as in vacuum cleaners, bipolar transistors with higher ESD resistance than MOSFET[Note] are helpful.

[Note] Compared to Toshiba's products



2SA1162

Lineup

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

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6 Transistor output photocoupler
TLP383

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

Value provided

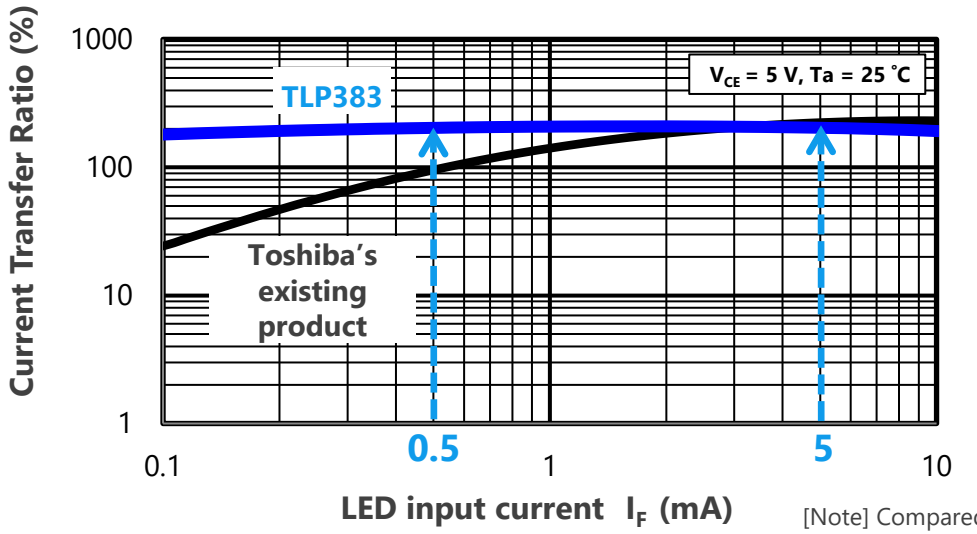
High current transfer ratio (CTR) is realized even in the low input current range (I_F=0.5 mA).

1 High current transfer ratio

Phototransistor and InGaAs infrared light emitting diode are optically coupled. Highly isolated photocouplers realize higher CTR than Toshiba's existing product (TLP385) 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.



[Note] Compared to Toshiba's products

Lineup

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 [Vrms]	5000
T_{opr} [°C]	-55 to 125

◆Return to Block Diagram TOP

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Value provided

System cost 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. [Note 1]

2 Equipped with motor control circuit

A variety of three-phase PWM [Note 2] waveforms and AD converters enable highly efficient, low noise control. The Advanced Encoder (A-ENC) reduces the load of CPU process in detecting the position performed for each PWM.

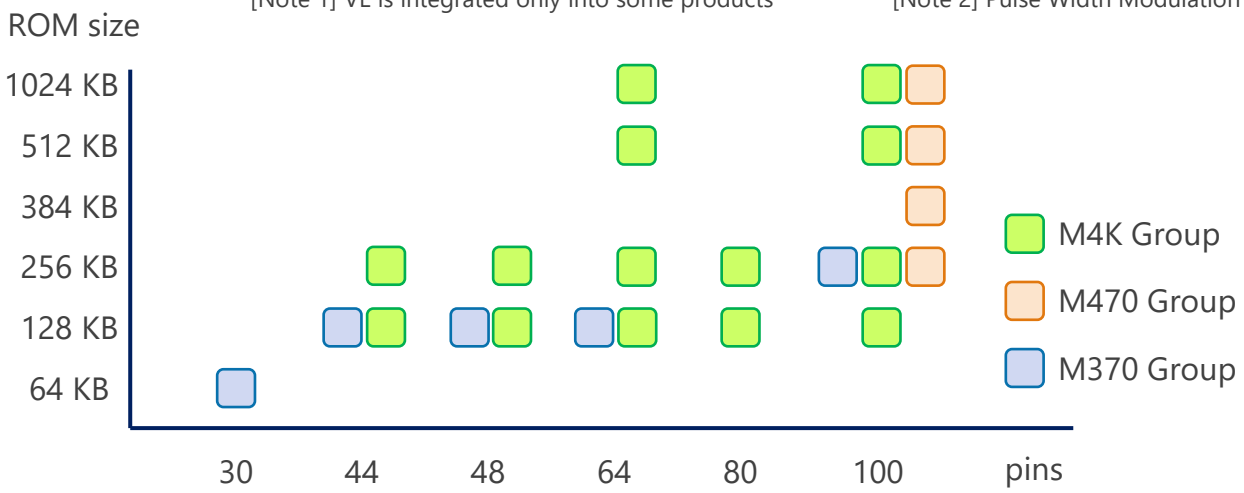
3 Provide development support tools

Third party evaluation boards and sample programs that can be used to shorten the development time are provided. Toshiba has also offered simple and versatile motor control software development kits (MCU Motor Studio). [Note 3]

[Note 1] VE is integrated only into some products

[Note 2] Pulse Width Modulation

[Note 3] MCU Motor Studio supports only some products and will expand in TXZ+™ family.



Lineup

Series	Group	Function
TXZ+™ 4A Series	M4K Group	Arm® Cortex®-M4, Max. 160 MHz operation 4.5 to 5.5 V, 3motor control (Max), Data Flash
TX04 Series	M470 Group	Arm® Cortex®-M4, Max. 160 MHz operation 4.5 to 5.5 V, 2motor control (Max)
TX03 Series	M370 Group	Arm® Cortex®-M3, 80 MHz operation 4.5 to 5.5 V, 2motor control (Max)

◆Return to Block Diagram TOP

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8a 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 over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 IEC 62368-1 certified

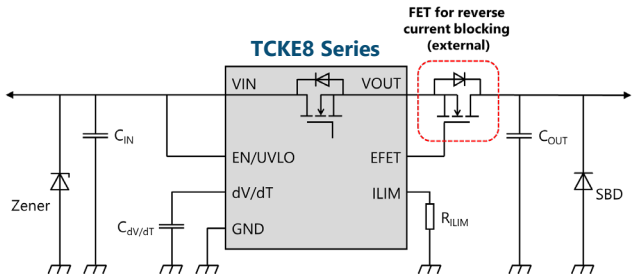
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

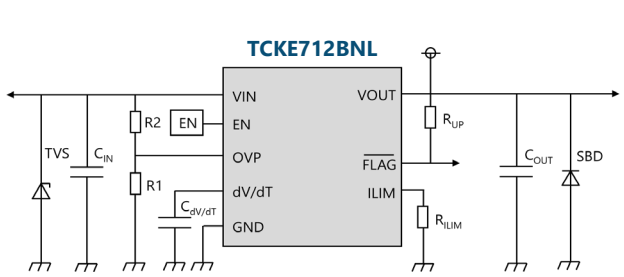
TCKE8 Series: short circuit protection, over current protection, over current clamp function, over voltage clamp function, thermal shutdown, inrush current suppression, backflow prevention (optional), etc.

TCKE7 Series: short circuit protection, over current protection, over voltage protection, thermal shutdown, FLAG signal output, backflow prevention (built-in), etc.

Example of peripheral circuit for TCKE8 Series



Example of peripheral circuit for TCKE7 Series



Lineup

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSON10B 3.0 x 3.0 x 0.75 mm  Top view  Bottom view			WSON10 3.0 x 3.0 x 0.75 mm 
V_{IN} [V]	4.4 to 18.0			4.4 to 13.2
R_{ON} (Typ.) [mΩ]	28			53
Fault response	NA: Auto-retry NL: Latched (external signal control)			Latched (external signal control)
V_{OVC} (Typ.) [V]	-	6.04	15.1	Adjustable

◆Return to Block Diagram TOP

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Electronic fuse (eFuse IC)

TCKE9 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 over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 Product selection is possible according to usage

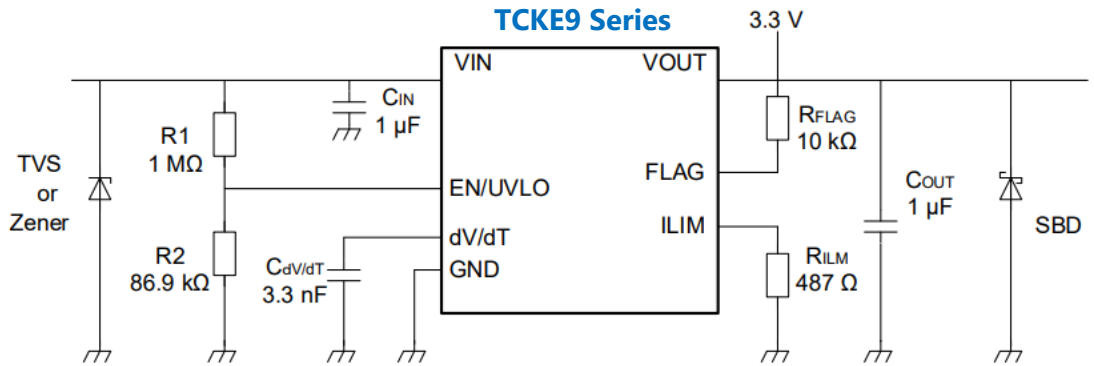
Suitable product with suitable failure response can be selected according to usage.

NA: Auto-retry type
QNA: Auto-retry with quick output discharge type
NL: Latched type

3 Rich protection functions

TCKE9 Series feature many protection functions such as adjustable over current limit, short circuit protection, over voltage clamp, adjustable under voltage protection and thermal shutdown.

Example of peripheral circuit for TCKE9 Series



Lineup

Part number	TCKE903NA/NL/QNA	TCKE905ANA/NL/QNA	TCKE912NA/NL	TCKE920NA/NL
Package	WSON8 2.0 x 2.0 x 0.75 mm	 Top view	 Bottom view	
V_{IN} [V]	2.7 to 23			
R_{ON} (Typ.) [mΩ]	34			
Fault response	NA: Auto-retry (QNA: with quick output discharge), NL: Latched			
V_{OVC} (Typ.) [V]	3.87	5.7	13.7	22.2

◆Return to Block Diagram TOP

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Electronic fuse (eFuse IC)

TCKE6 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 over current and over voltage.

1 Can be used repeatedly

When over current flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. Unlike conventional fuses, eFuse IC can be used repeatedly.

2 Product selection is possible according to usage

Suitable product can be selected according to usage.

FLAG function: TCKE601RA/RL

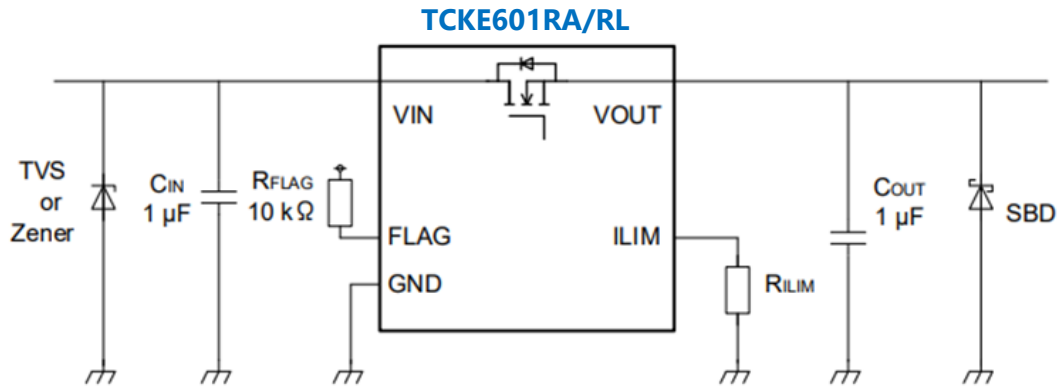
MODE function (selectable recovery mode): TCKE602RM

EN (enable) function: TCKE603RA/RL

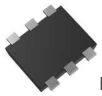
3 Rich protection functions

TCKE6 Series feature many protection functions such as adjustable over current limit, short circuit protection, under voltage protection, and thermal shutdown.

Example of peripheral circuit for TCKE601RA/RL



Lineup

Part number	TCKE601RA	TCKE601RL	TCKE602RM	TCKE603RA	TCKE603RL
Package	TSOP6F  Top view  Bottom view				
V_{IN} [V]	4.4 to 30				
R_{ON} (Typ.) [mΩ]	52				
Function	FLAG		MODE	EN	
Fault response	Auto-retry	Latched	Selectable type	Auto-retry	Latched

◆Return to Block Diagram TOP

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9 N-ch MOSFET gate driver IC

TCK4xx Series

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

Value provided

It is N-ch MOSFET gate driver IC with OVP [Note 1] function. It contributes to miniaturization and reduction of power loss of load switch circuit.

[Note 1] OVP: Over Voltage Protection

1 Three types of N-ch MOSFET can be driven

The following types of MOSFET can be driven:
TCK40xG: Single high side connection
Common source connection
TCK42xG: Single high side connection
Common drain connection

2 Wide operating voltage range and various OVLO [Note 2] threshold voltage

Operating voltage V_{opr}: 2.7 to 28 V
Maximum input voltage: 40 V
V_{IN_OVLO} [Note 3] lineups suitable for 5 to 24 V power supply line.

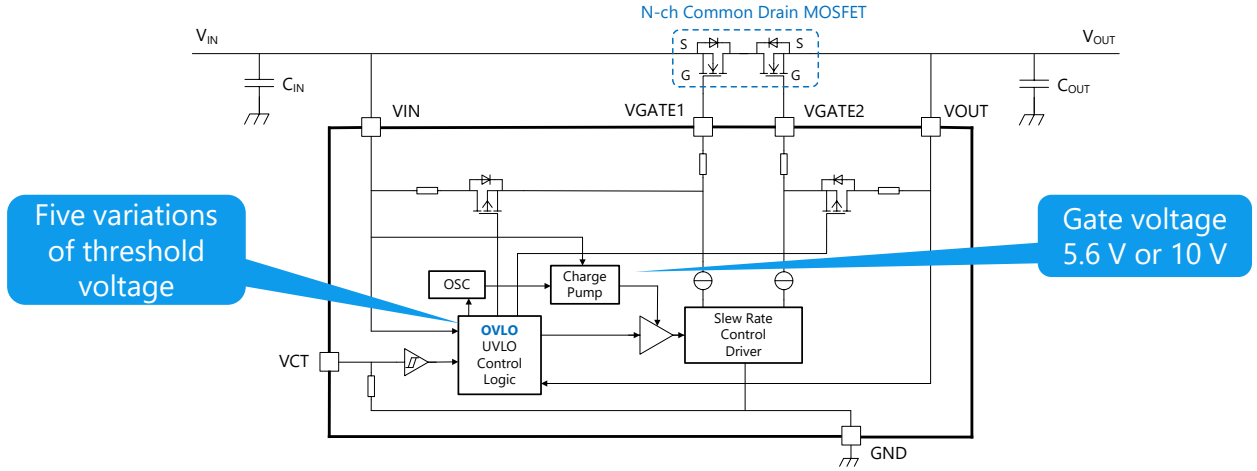
[Note 2] OVLO: Over Voltage Lock Out
[Note 3] V_{IN_OVLO}: V_{IN} OVLO threshold

3 Small packages

It contributes to reduction of the mounting area and miniaturization of the circuit board:

WCSP6E: 1.2 x 0.8 mm, t: 0.55 mm
WCSP6G: 1.2 x 0.8 mm, t: 0.35 mm

Circuit example of TCK42xG with N-ch common drain connection MOSFET



Lineup

Part number	V_{IN_OVLO} Min / Max [V]	V_{GS} Typ. / Max [V]	N-ch MOSFET type can be driven	Package
TCK401G	Over 28	Max 10 (V_{IN} ≥12 V)	Single high side Common Source	WCSP6E
TCK402G				
TCK420G	26.50 / 28.50	10 / 11 (V_{IN} ≥ 5 V)	Single high side Common Drain	WCSP6G
TCK421G	22.34 / 24.05			
TCK422G	13.61 / 14.91			
TCK423G	13.61 / 14.91	5.6 / 6.3		
TCK424G	10.35 / 11.47			
TCK425G	5.76 / 6.87			

◆Return to Block Diagram TOP

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