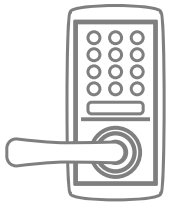
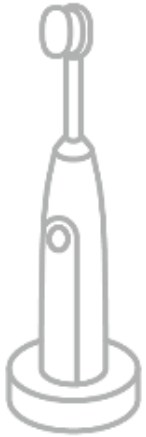
TOSHIBA

R21

Electric Toothbrush

Solution Proposal by Toshiba





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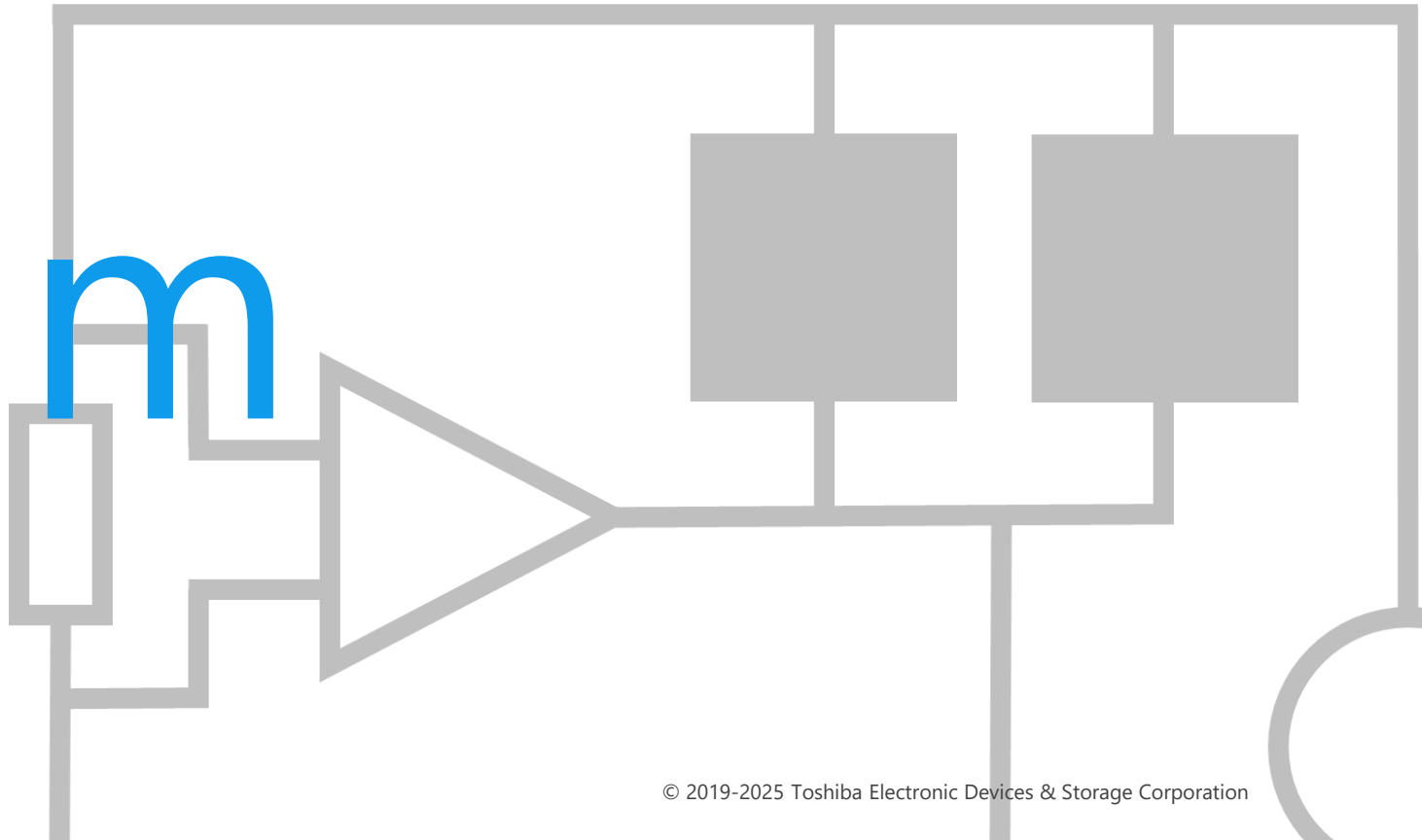
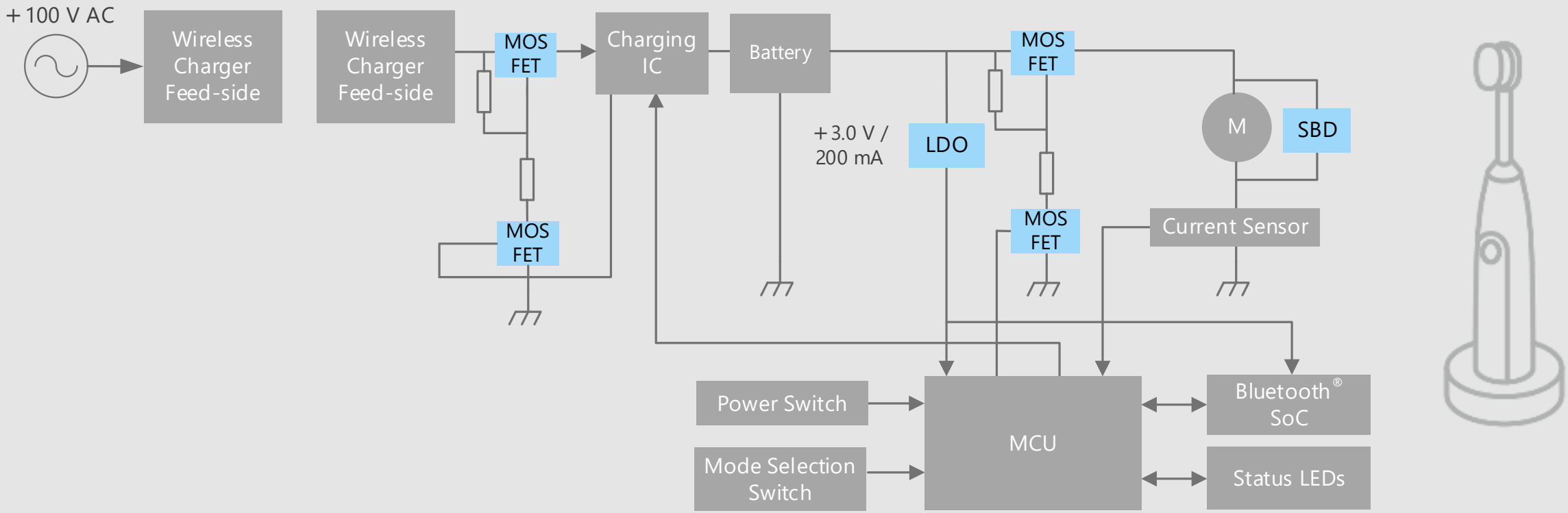
Block Diagram

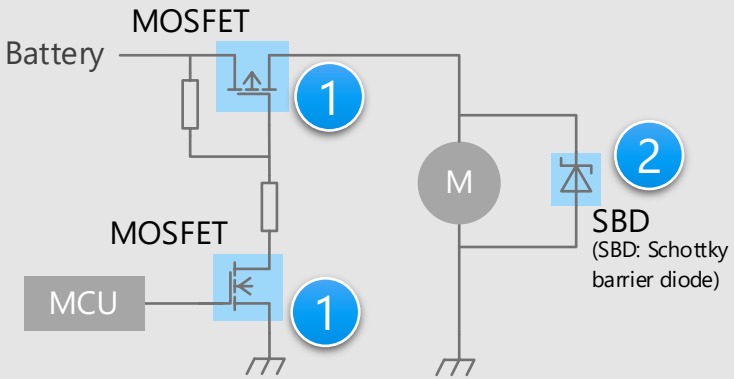


Electric Toothbrush　Overall block diagram

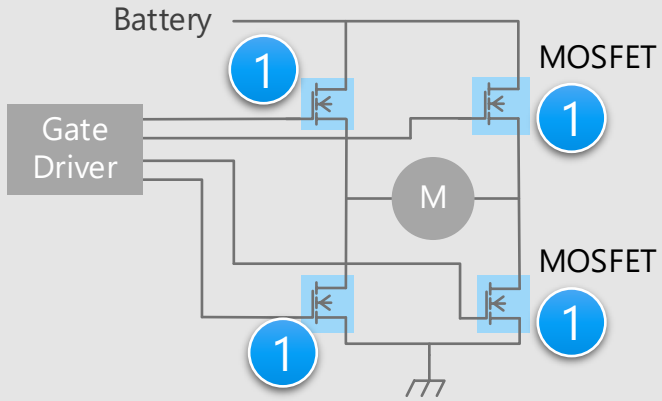


Electric Toothbrush　Detail of circuit (1)

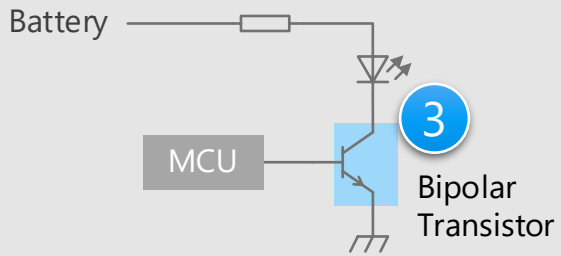
Motor control unit (1)



Motor control unit (2)



LED driver



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

Criteria for device selection

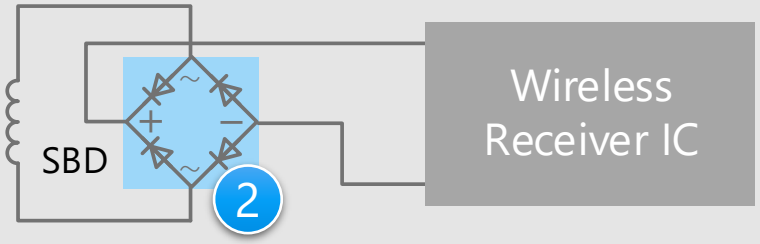
- MOSFETs with low on-resistance are suitable for motor drive applications to achieve low loss.
- The use of low power consumption devices help to reduce system power consumption.

Proposals from Toshiba

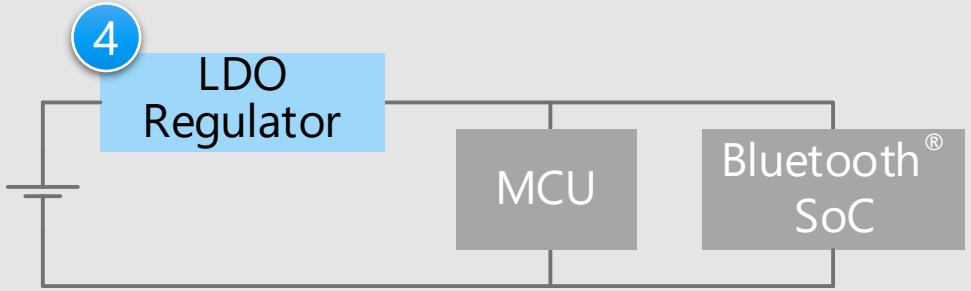
- **Small signal MOSFET with low on-resistance**
  Small signal MOSFET 1
- **Schottky barrier diode with high voltage and low leakage current**
  Schottky barrier diode 2
- **Wide lineup of bipolar transistor**
  Bipolar transistor 3

Electric Toothbrush　Detail of circuit (2)

Wireless power supply receiving unit
Rectifying circuit



Power supply circuit



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

Criteria for device selection

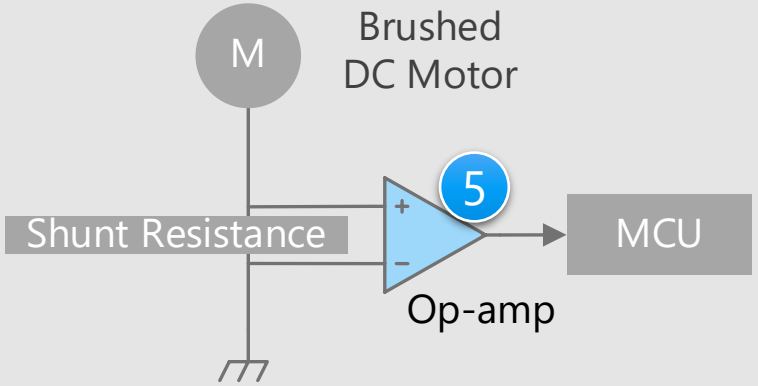
- The SBD with lower V_F is required for the current rectification of the wireless power supply.
- PSRR (Power Supply Rejection Ratio) is a key characteristic for power supply of microcontroller.

Proposals from Toshiba

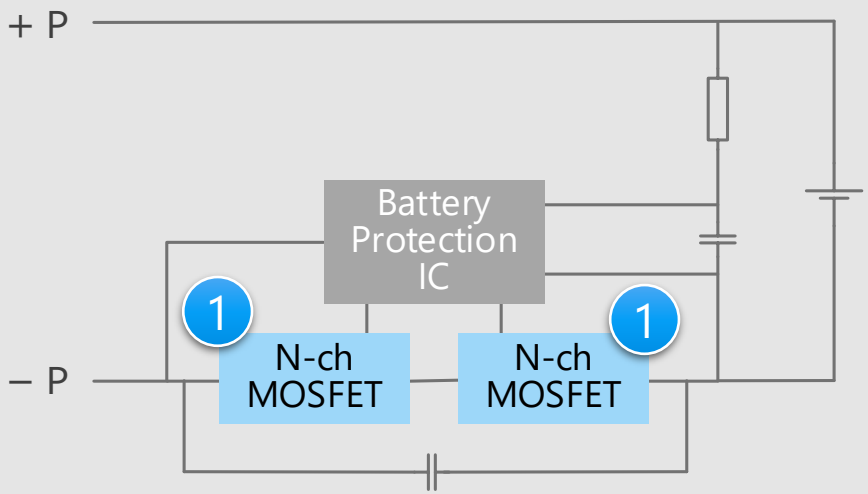
- **Schottky barrier diode with high voltage and low leakage current**
  Schottky barrier diode　2
- **Supply the power with low noise**
  Small surface mount LDO regulator　4

Electric Toothbrush　Detail of circuit (3)

Current sensor circuit



Battery management



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

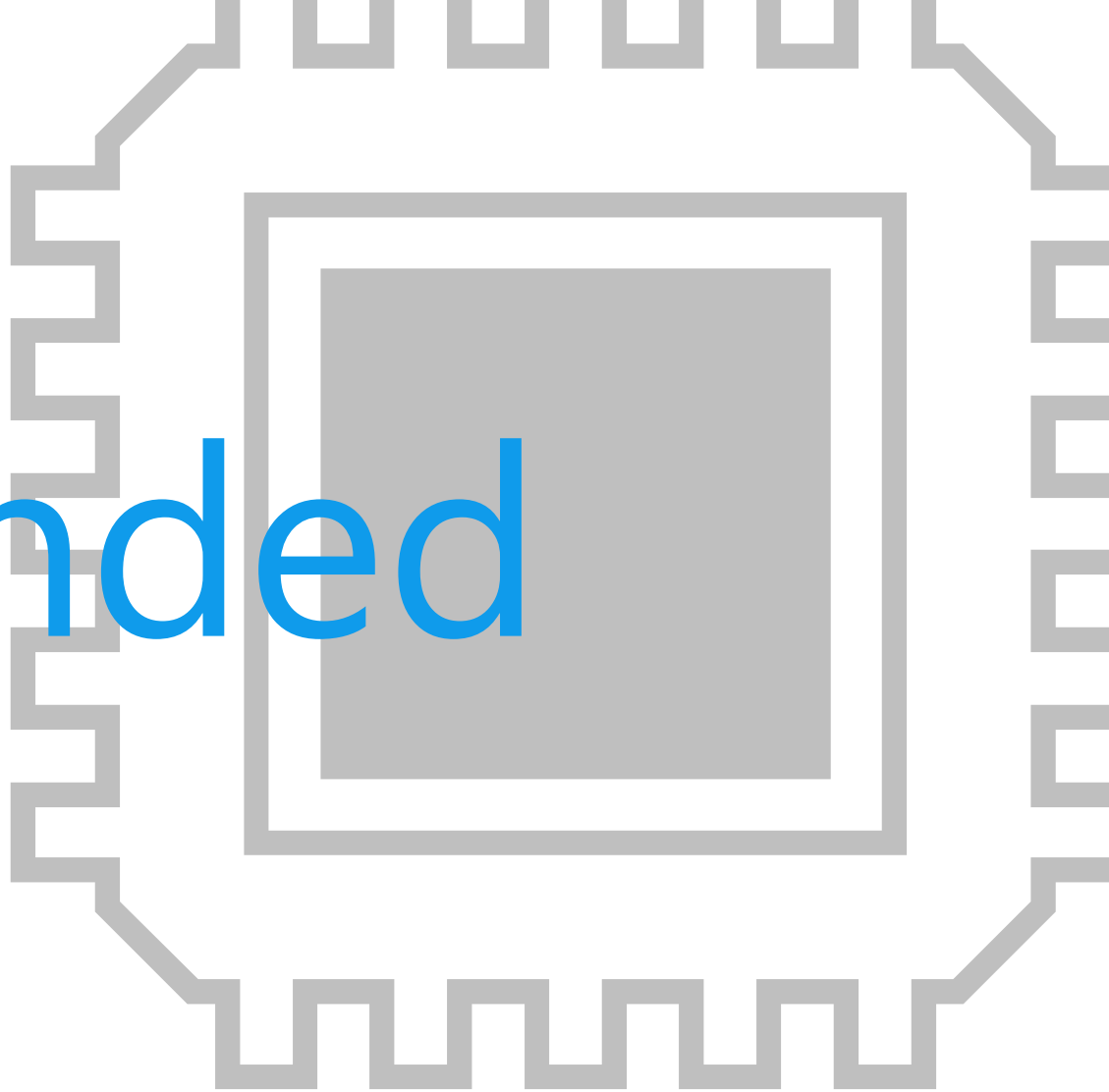
Criteria for device selection

- A low offset and low noise operational amplifier is suitable for high precision current sensing.
- To extend battery life, use of products with low current consumption is effective.

Proposals from Toshiba

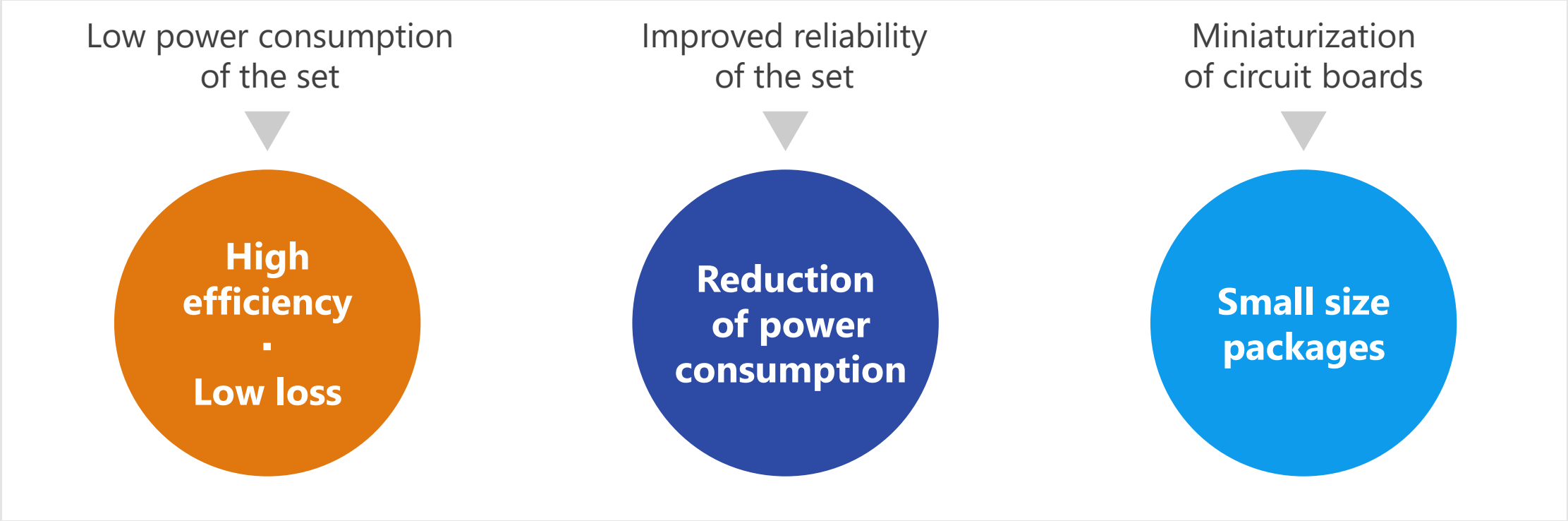
- **Amplify the detected small signal with low noise**
  Low current consumption op-amp / Low noise op-amp　5
- **Small signal MOSFET with low on-resistance**
  Small signal MOSFET　1

Recommended Devices



Device solutions to address customer needs

As described above, in the design of electric toothbrush, **“Low power consumption of the set”**, **“Improved reliability of the set”** 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 · Low loss	Reduction of power consumption	Small size packages
1 Small signal MOSFET	●	●	●
2 Schottky barrier diode	●		●
3 Bipolar transistor	●		●
4 Small surface mount LDO regulator	●	●	●
5 Low current consumption op-amp / Low noise op-amp	●	●	●

1 Small signal MOSFET

SSM6N951L / SSM3J338R / SSM3K324R / SSM3K35AMFV

High efficiency · Low loss | Reduction of power consumption | Small size packages

Value provided

Suitable for power management switches and contribute to reduction of power consumption and miniaturization of the set.

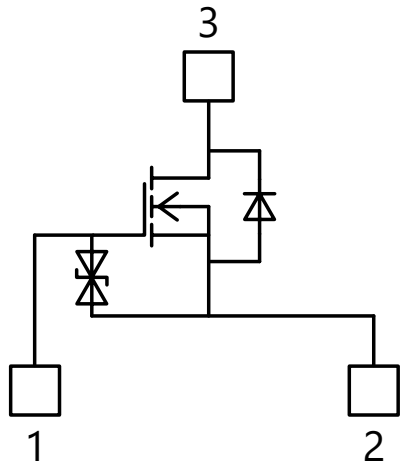
1 Low on-resistance

Low on-resistance between drain and source reduces heat generation and power consumption.

2 Small gate input charge

Reducing the gate input charge required for driving MOSFET improves switching characteristics.

SSM3K324R
Internal circuit diagram



Lineup

Part number		SSM6N951L	SSM3J338R	SSM3K324R	SSM3K35AMFV
Package		TCSP6A -172101 (2.14 x 1.67 mm)	SOT-23F (2.9 x 2.4 mm)		VESM (1.2 x 1.2 mm)
Polarity		N-ch x 2	P-ch	N-ch	N-ch
V_{DSS} / V_{SSS} [V]		12	-12	30	20
I_D / I_S [A]		8	-6	4	0.25
$R_{DS(ON)}$ / $R_{SS(ON)}$ [mΩ] @$\|V_{GS}\|$ = 4.5 V	Typ.	4.4	15.9	45	750
	Max	5.1	20.2	56	1100

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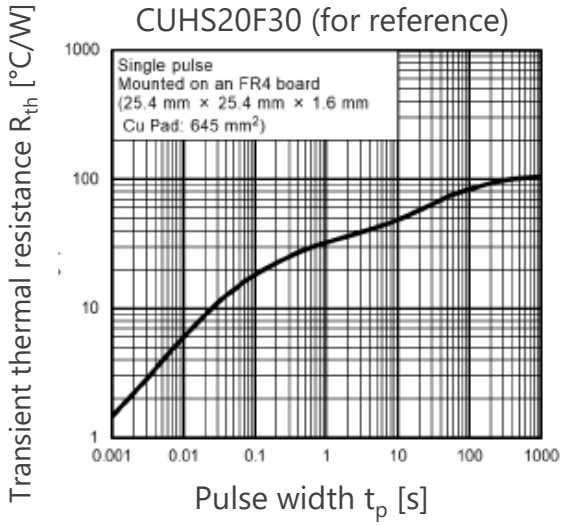
Value provided

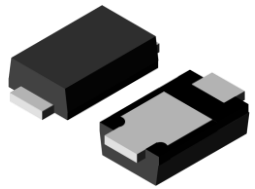
High voltage and low leakage protect the circuit from counter electromotive force caused by motor drive.

1 Small size and high power dissipation package

Products with small size and high power dissipation are available.
Thermal resistance is low. ($R_{th(j\text{-}a)}$ = 105 °C/W)

CUHS20F30 (for reference)





US2H
(2.5 x 1.4 mm)

Low thermal resistance and easy to thermal design.

2 Lineup of various products

The lineup offers products with reverse voltage V_R up to 30 V and 40 V.

Lineup

Part number	CUHS20F30	CUHS20F40
Package	US2H (2.5 x 1.4 mm) 	
V_R [V]	30	40
I_O [A]	2	2
V_F (Typ.) [V] @I_F = 1 A	0.35	0.39

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3 Bipolar transistor

2SC2712 / 2SA1162 / TBC847 / TBC857 / HN1B01FU

High efficiency · Low loss | Reduction of power consumption | Small size packages

Value provided

Offering products that meet customer needs with an extensive product lineup.

1 Various package lineups

A variety of packages, such as flat lead and leadless, are available, and products can be selected according to the circuit board.

2 Low collector-emitter saturation voltage

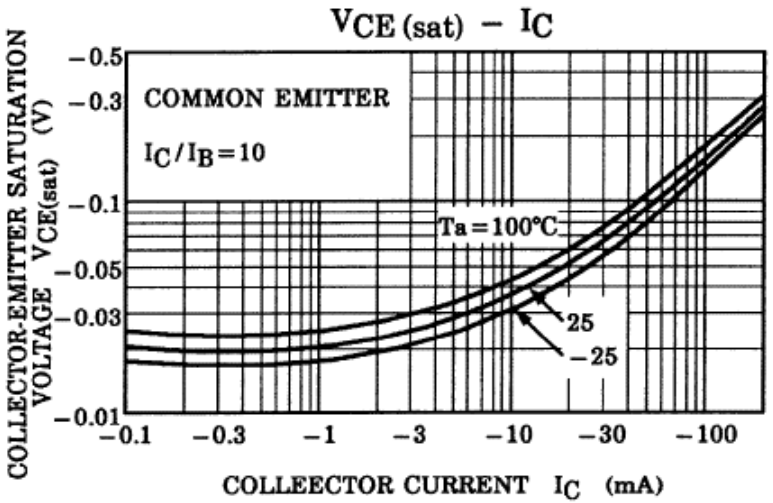
The saturation voltage between the collector and emitter is low and the power consumption is low.

3 High ESD tolerance

In applications where static electricity is likely to occur, bipolar transistors with higher ESD resistance than MOSFET[NOTE] are suitable.

[Note] Compared to Toshiba's products

Characteristic example of 2SA1162



Lineup

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

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4 Small surface mount LDO regulator

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

High efficiency · Low loss | Reduction of power consumption | Small size packages

Value provided

Wide lineup 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 originally developed the latest generation process significantly improved the dropout voltage characteristics.

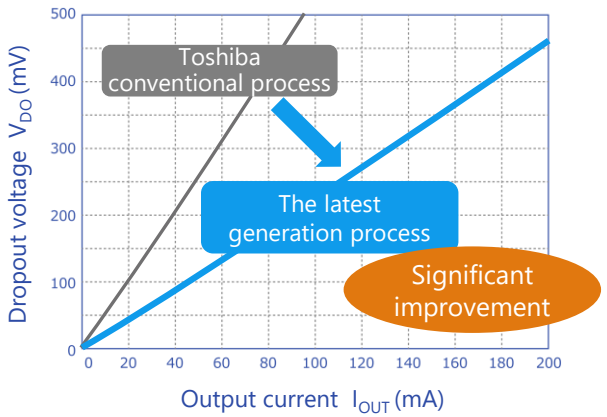
2 High PSRR Low output noise voltage

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

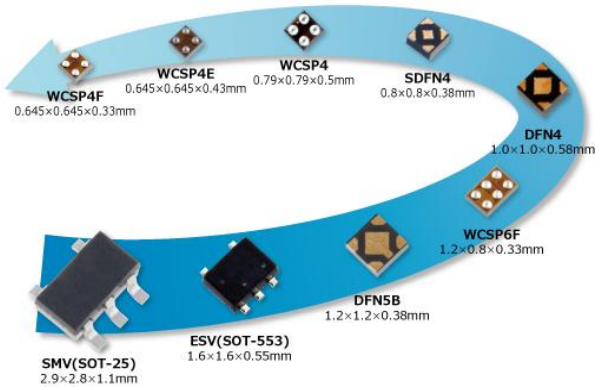
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

Low dropout voltage



(Note) Toshiba internal comparison

Rich package lineup



Lineup

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		15 V 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	56	20	19	7	7	0.34	1	170

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5 Low current consumption op-amp / Low noise op-amp

TC75S102F / TC75S103F / TC75S67TU

High efficiency · Low loss | Reduction of power consumption | Small size packages

Value provided

The lineup includes a low current consumption type that contributes to improved operating time with a battery, and a low noise type that brings out performance of the sensor.

1 Low voltage operation

We have a lineup of low power supply voltage-driven operational amplifiers using CMOS process for low power supply voltage-driven electric toothbrush.

2 Low current consumption

(TC75S102F) I_{DD} = 0.27[μA] (Typ.)

CMOS processes have been used to achieve lower current consumption. This contributes to lower power consumption and longer battery life of electric toothbrush.

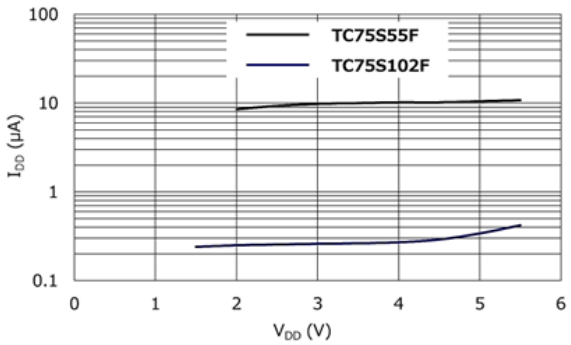
3 Low noise (TC75S67TU)

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

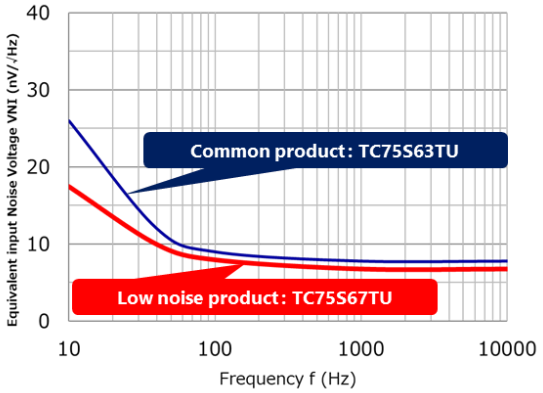
This CMOS operational amplifier can amplify weak signals detected by various sensors [Note] with very low noises.
By optimizing the process, low equivalent input noise voltage is achieved.

[Note] Sensor types: vibration, shock, acceleration, pressure, infrared, temperature, etc.

TC75S102F
Current Consumption Characteristic
(Toshiba internal comparison)



TC75S67TU
Noise Characteristic
(Toshiba internal comparison)



Lineup

Part number	TC75S102F	TC75S103F	TC75S67TU
Package	SMV (2.9 x 2.8 mm)		UFV (2.0 x 2.1 mm)
V_{DD} - V_{SS} [V]	1.5 to 5.5	1.8 to 5.5	2.2 to 5.5
V_{IO} (Max) [mV]	1.3	1.5	3
CMV_{IN} (Max) [V]	V_{DD}	V_{DD}	1.4 (@V_{DD} = 2.5 V)
I_{DD} (Typ. / Max) [μA]	0.27 / 0.46 (@V_{DD} = 1.5 V)	100 / 165 (@V_{DD} = 1.8 V)	430 / 700 (@V_{DD} = 2.5 V)
V_{NI} (Typ.) [nV/√Hz] @f = 1 kHz	-	-	6

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