

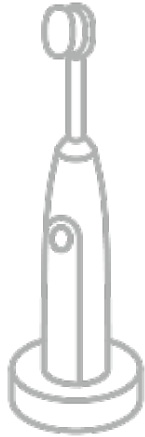
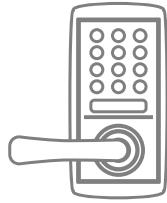
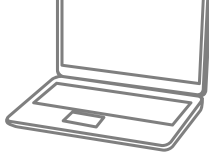
TOSHIBA

Electric Toothbrush

Solution Proposal by Toshiba

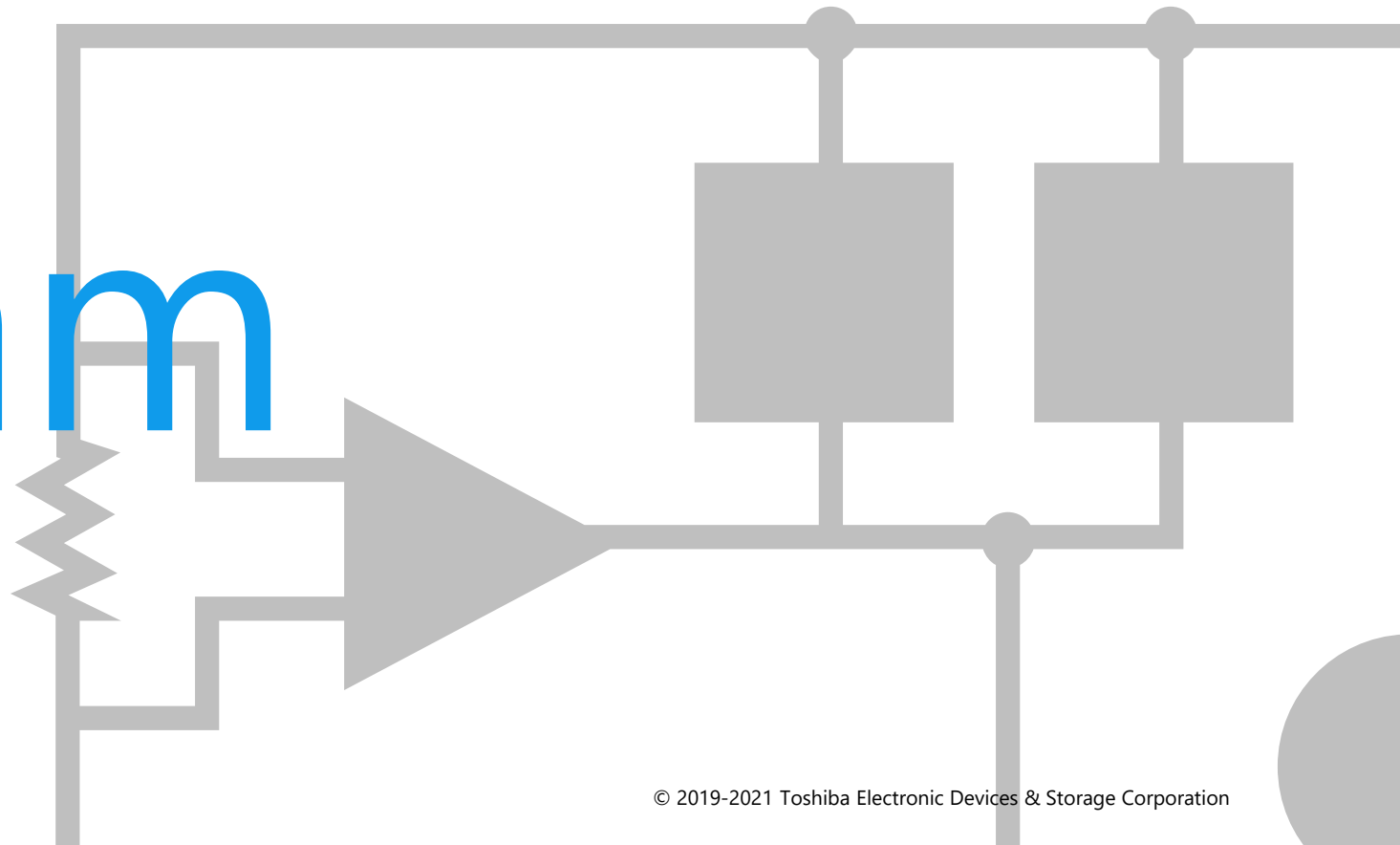
R20



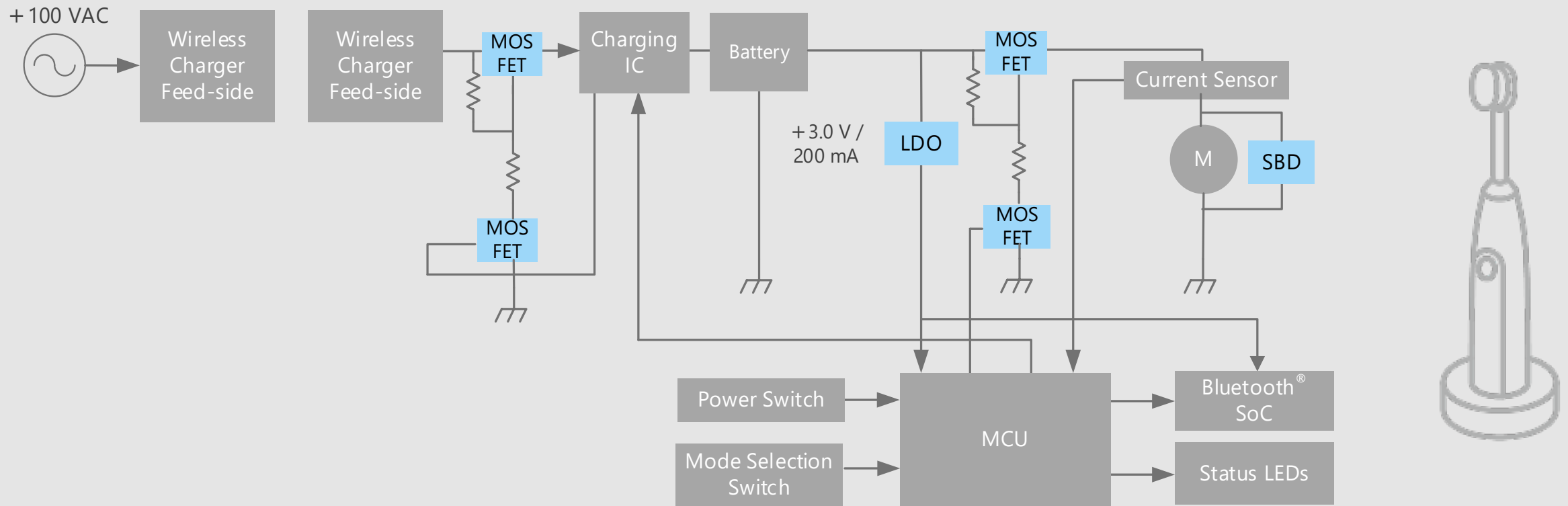


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Block Diagram

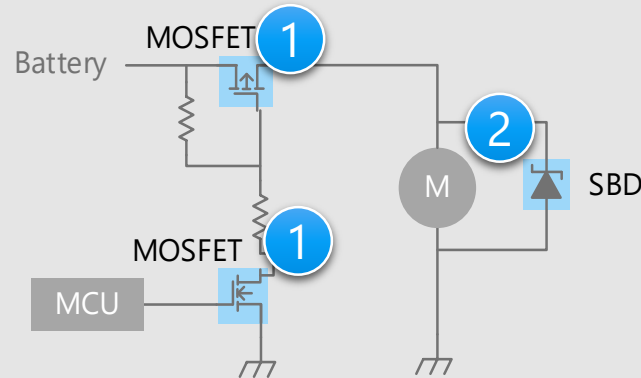


Electric Toothbrush Overall block diagram

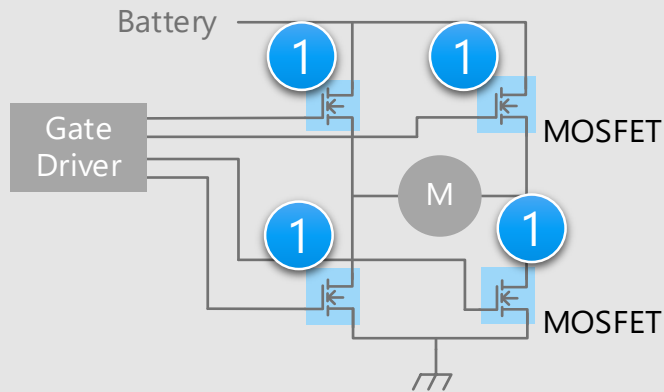


Electric Toothbrush Detail of circuit (1)

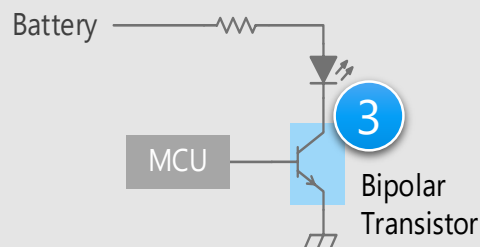
Motor control unit (1)



Motor control unit (2)



LED driver



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

Criteria for device selection

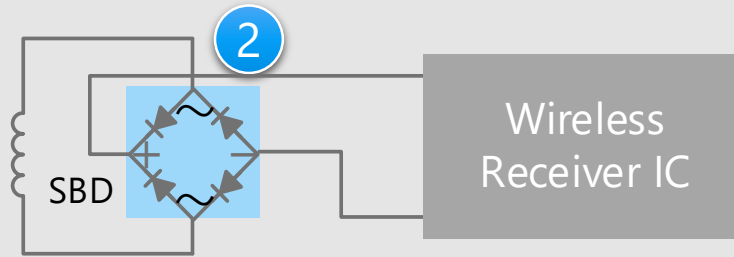
- Since a current is required for driving the motor, a MOSFET with low $R_{DS(ON)}$ is required for realizing low loss.
- The use of low consumption products can increase the overall efficiency of the system.
- The circuit board area can be reduced by adopting small package products.

Proposals from Toshiba

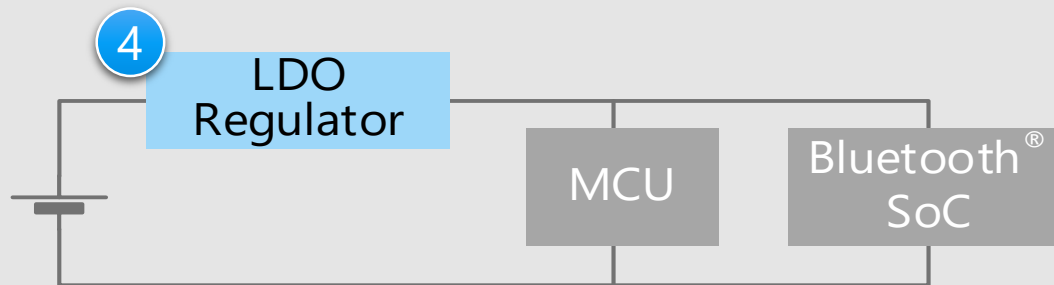
- **Realize a set with low power consumption by low on-resistance**
Small signal MOSFET ①
- **Schottky barrier diode (SBD), which realizes low V_F and low I_R**
Schottky barrier diode ②
- **Wide line-up of bipolar transistor**
Bipolar transistor ③

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

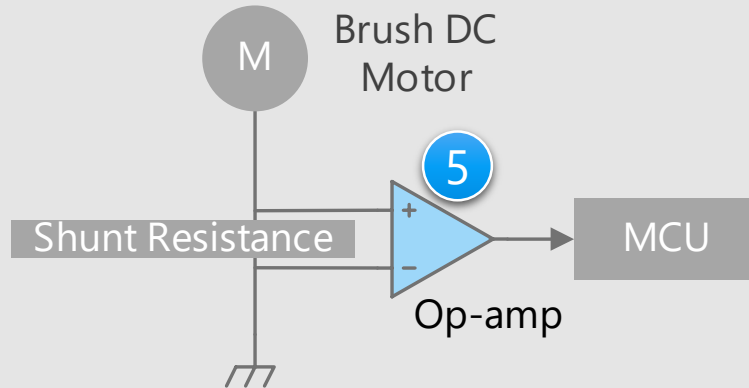
- The rectified current of the wireless power supply requires SBDs with a low V_F .
- The use of low consumption products can increase the overall efficiency of the system.
- The circuit board area can be reduced by adopting small package products.

Proposals from Toshiba

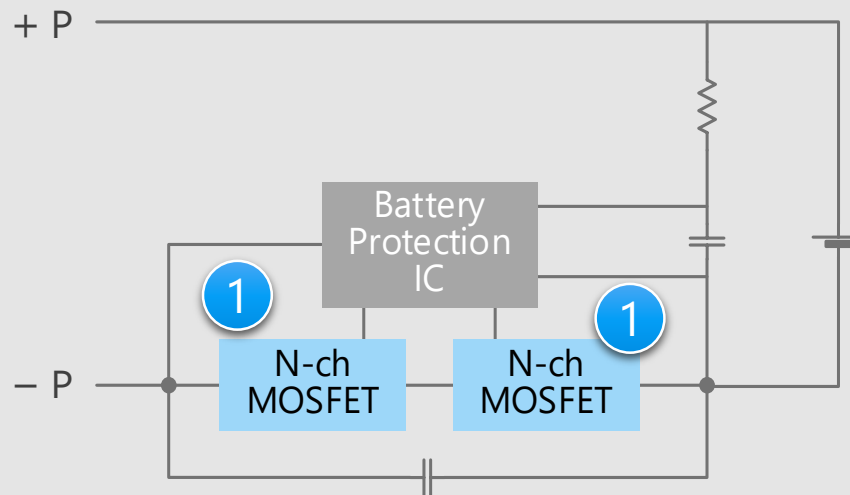
- **Rectifier diode suitable for high density mounting** 2
Schottky barrier diode
- **LDO regulator with low dropout characteristics** 4
Small surface mount LDO regulator

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

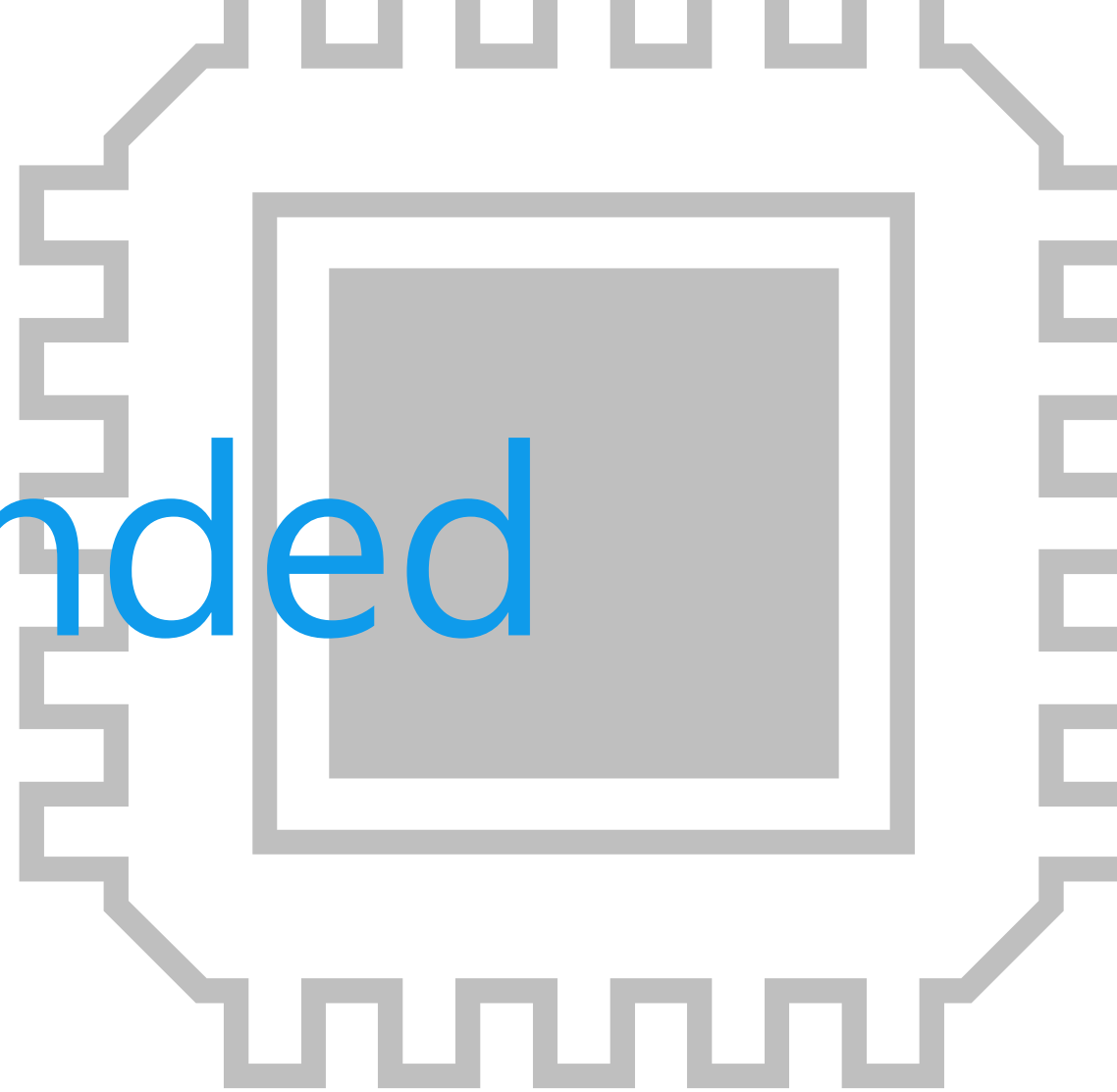
Criteria for device selection

- A low offset operational amplifier is required for high precision current sensing.
- The use of low consumption products can increase the overall efficiency of the system.
- The substrate area can be reduced by adopting small package products.

Proposals from Toshiba

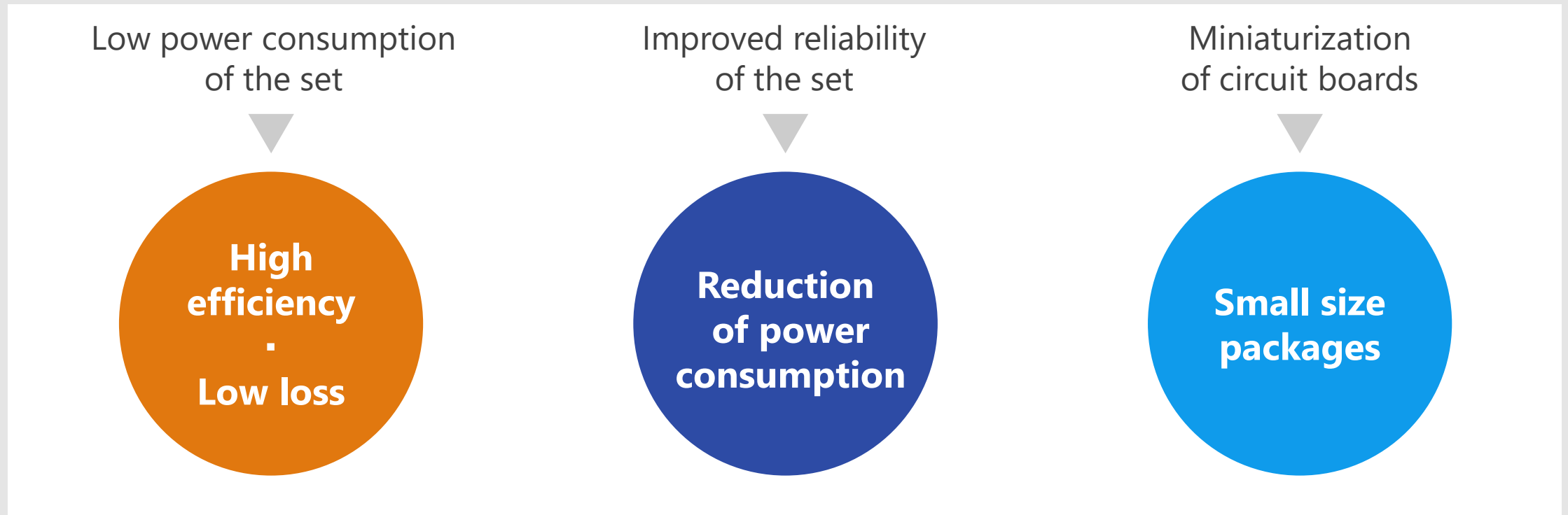
- **Low noise operational amplifier with low V_{IO}**
Low current consumption op-amp / 5
Low noise op-amp
- **Small signal MOSFET with low R_{ON}**
Small signal MOSFET 1

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	●	●	●

Value provided

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

1 Low on-resistance

By reducing on-resistance between the drain and source, heat generation and power consumption can be kept low.

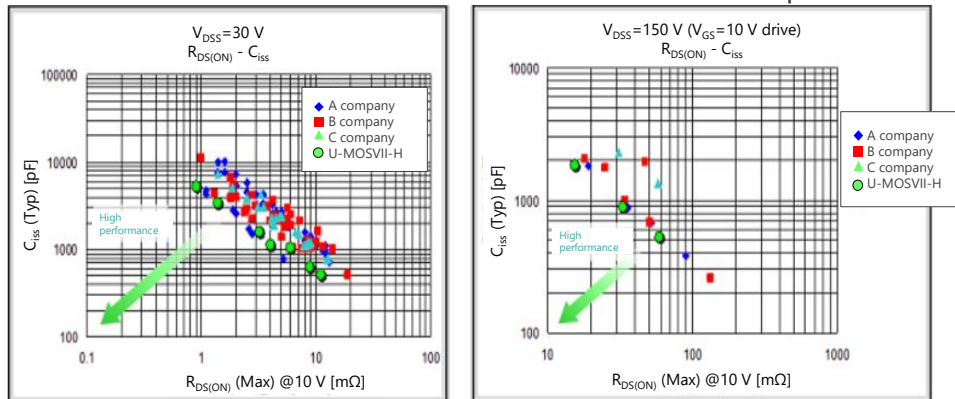
2 Small gate input charge

Switching characteristics is improved by suppressing required performance for driving MOSFET and reducing gate input charge.

3 Suitable for high-density mounting

Variety of packages are available.

Lineup of low on-resistance product and trade-off characteristics between on-resistance and capacitance



Note: Based on Toshiba's measurement data

Line up

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
	Max	5.1	20.2	56
				750
				1100

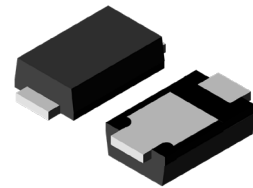
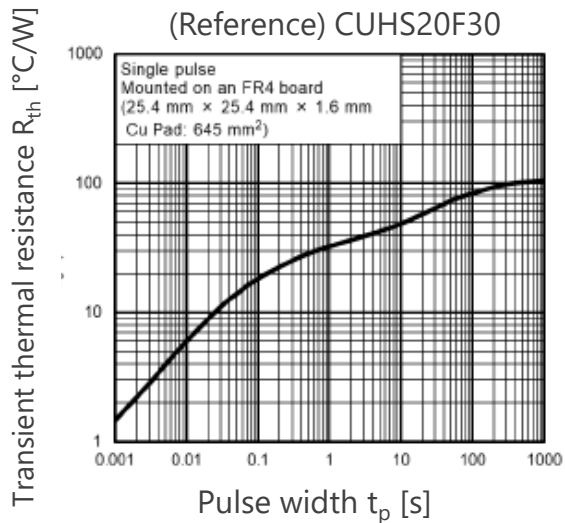
[Return to Block Diagram TOP](#)

Value provided

High voltage and low leakage are realized, and protects the circuit from counter electromotive force caused by motor drive.

1 Compact package with high power dissipation

Products are suitable for various power dissipation level.
Low thermal resistance ($R_{th(j-a)} = 105 \text{ }^\circ\text{C/W}$)



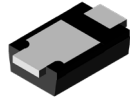
US2H
(2.5 x 1.4 mm)

Easy to thermal design by low transient thermal resistance

2 Line-up of various products

Products line-up offers products with reverse voltage V_R up to 30 V and 40 V.

Line up

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] @ $I_F = 1 \text{ A}$	0.35	0.39

[Return to Block Diagram TOP](#)

Value provided

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

1 Many package lineups

A large number of packages, such as flat lead and leadless, are available, allowing you to choose products that suit your board.

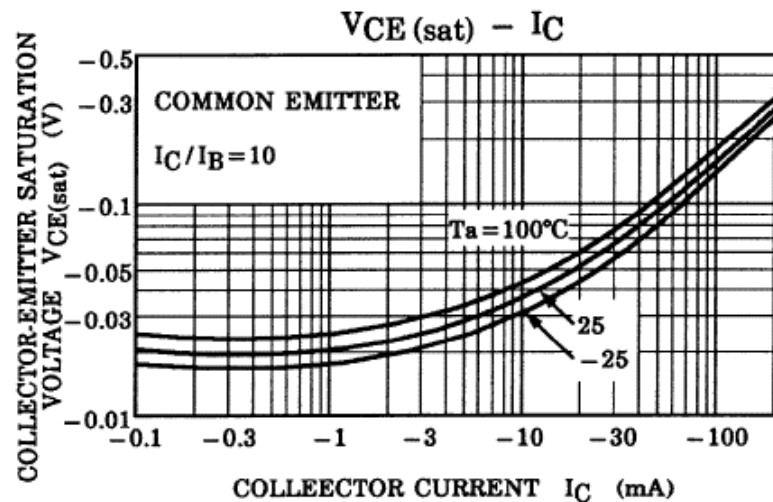
2 The collector-emitter saturation voltage is low.

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

3 Have high ESD tolerance

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

[Note] Comparison Toshiba's products



2SA1162

Line up

Part number	NPN	2SC2712	TBC847	HN1B01FU (NPN+PNP)
	PNP	2SA1162	TBC857	
Package		S-Mini 	SOT23 	US6 
V_{ce0} (Max) [V]		50	50	50
I_c [mA]		150	150	150

[Return to Block Diagram TOP](#)

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 drop-out voltage characteristics.

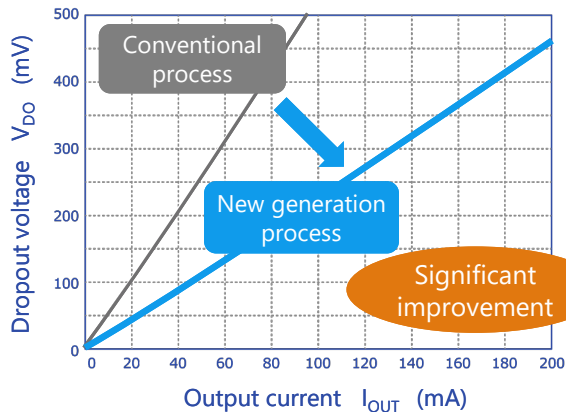
2 High PSRR Low output noise voltage

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

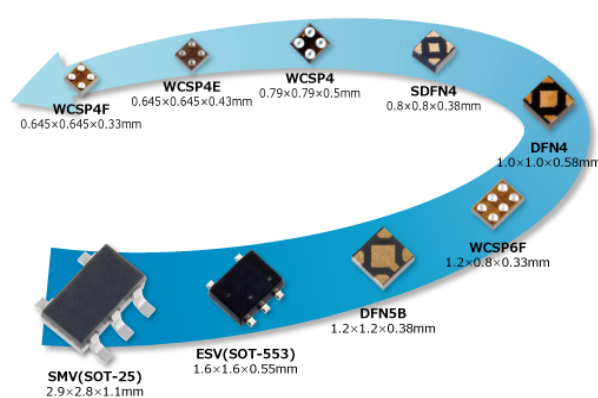
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.

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](#)

Value provided

Low current consumption type and low noise type operational amplifiers maximize the performance of system.

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.

TC75S102F

Current Consumption Characteristic
(Toshiba internal comparison)

2 Low current consumption (TC75S102F) $I_{DD} = 0.27[\mu\text{A}]$ (Typ.)

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

TC75S67TU

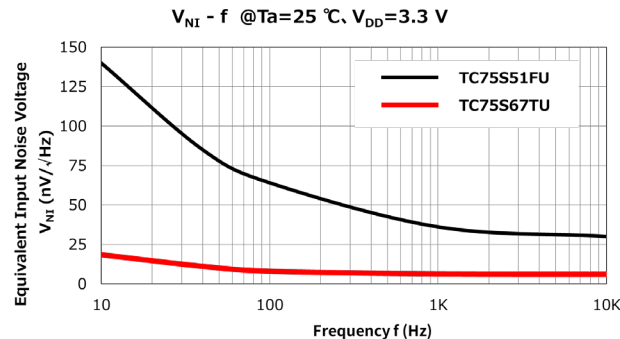
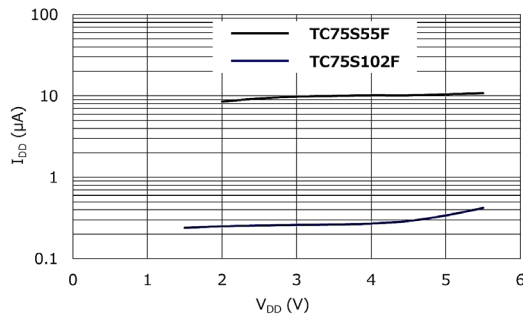
Noise Characteristic
(Toshiba internal comparison)

3 Low noise (TC75S67TU) $V_{NI} = 6.0$ [nV/ $\sqrt{\text{Hz}}$] (Typ.) @f=1 kHz



This CMOS operational amplifier can amplify minute signals detected by various sensors [Note 1] with very low noises. By optimizing the process, we have achieved the industry's top-level [Note 2] low equivalent input noise voltage.

[Note 1] Sensor types: vibration, shock, acceleration, pressure, infrared, temperature, etc.
[Note 2] Based on Toshiba survey as of May 2017.

Low current consumption product TC75S102F Reduce 1/f noise (10 Hz) by 86 % from our normal products



Line up

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/ $\sqrt{\text{Hz}}$] @f = 1 kHz	-	-	6

[Return to Block Diagram TOP](#)

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