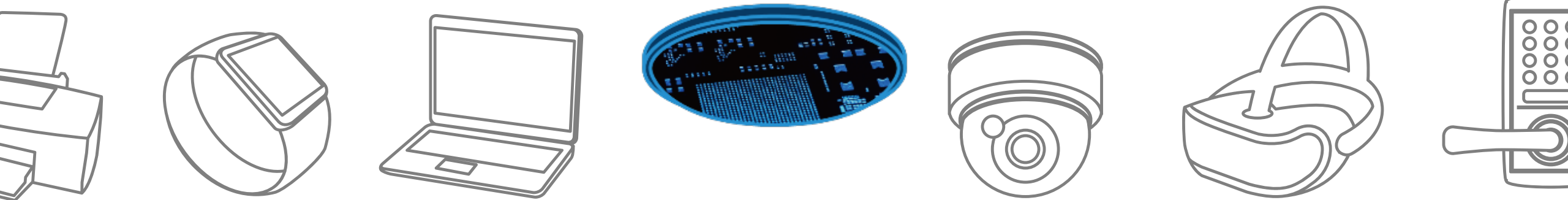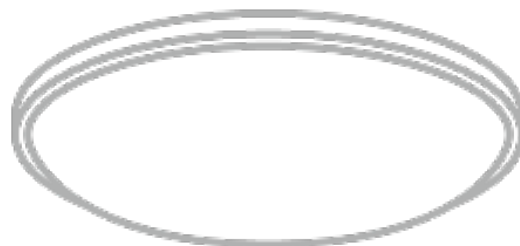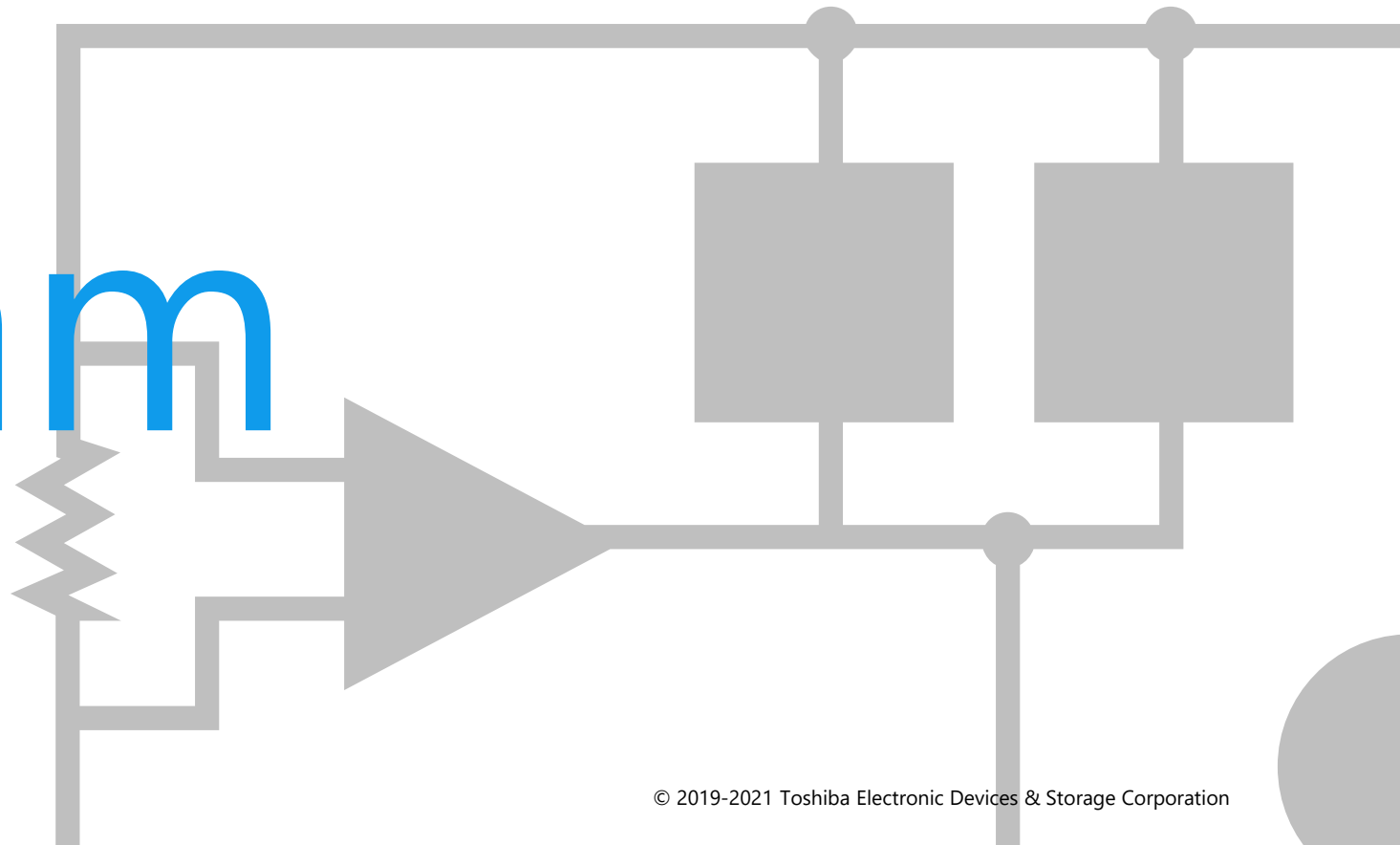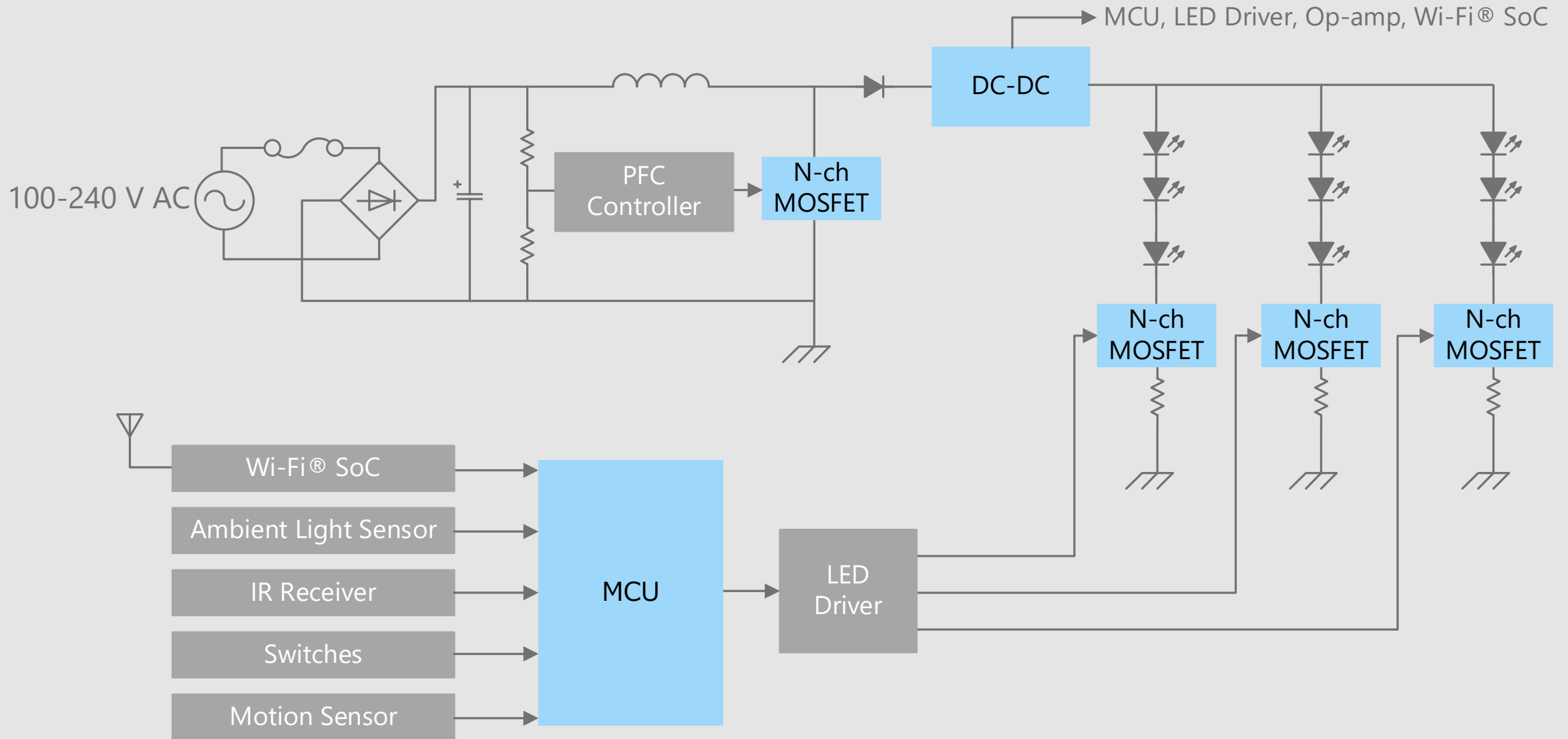# LED Lighting

Solution Proposal by Toshiba

R20

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.
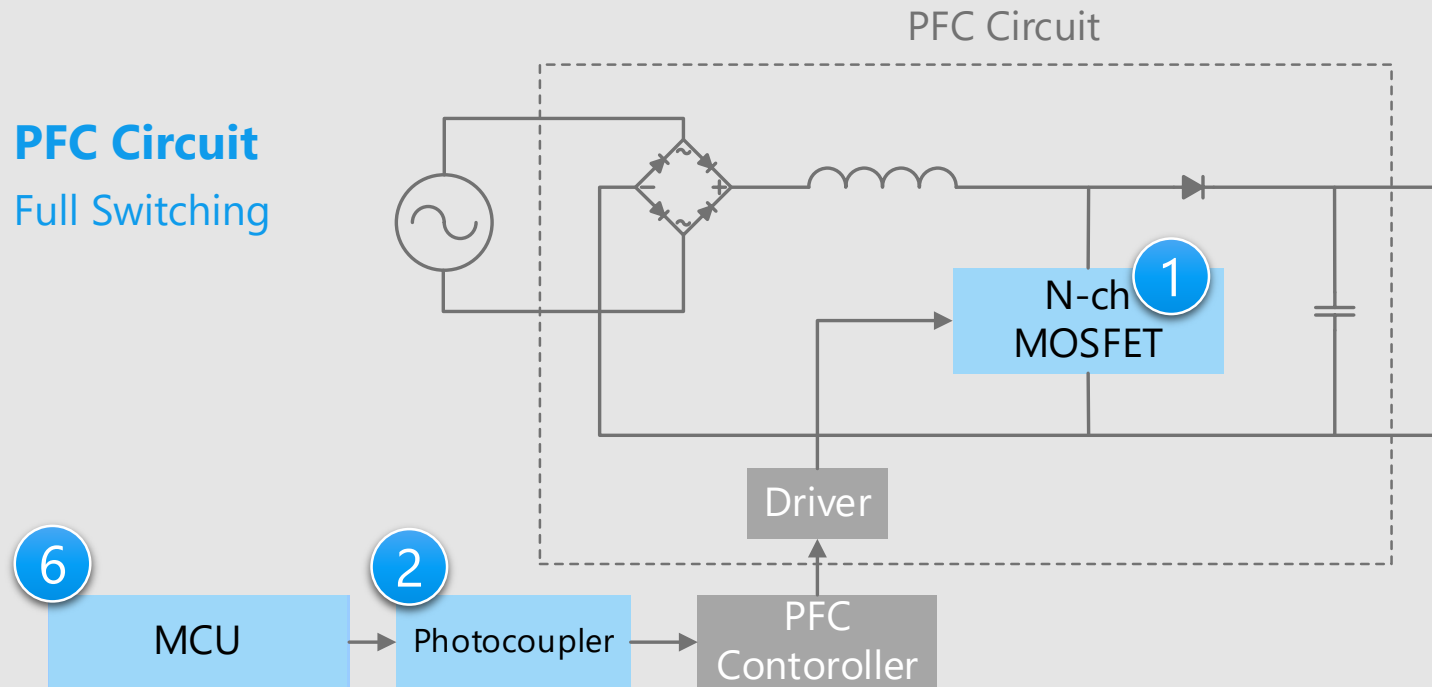
Block Diagram

MCU, LED Driver, Op-amp, Wi-Fi® SoC

DC-DC

PFC Controller

N-ch MOSFET

100-240 V AC

N-ch MOSFET

N-ch MOSFET

N-ch MOSFET

Wi-Fi® SoC

Ambient Light Sensor

IR Receiver

Switches

Motion Sensor

MCU

LED Driver

Criteria for device selection

- MOSFET is suitable for full-switching solutions.
- The transistor coupler is for signal isolation.
- A microcomputer can be used for PFC control.

PFC Circuit

Full Switching

PFC Circuit

N-ch MOSFET **1**

Driver

6 MCU **2** Photocoupler → PFC Contoroller

Proposals from Toshiba

- **Suitable for high-efficiency power supply switching**
  DTMOS VI Series power MOSFET **1**
- **Photocoupler with excellent environmental resistance**
  Transistor output photocoupler **2**
- **Built-in analog input interface at low power consumption and efficient software development**
  MCU **6**

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

DC-DC Circuits

Flyback System

DC-DC Circuits

Forward Method

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

Criteria for device selection

- By using a MOSFET with low on-resistance and high heat dissipation efficiency, a set having low heat generation and low power consumption is realized.
- Transistor coupler is for signal isolation.
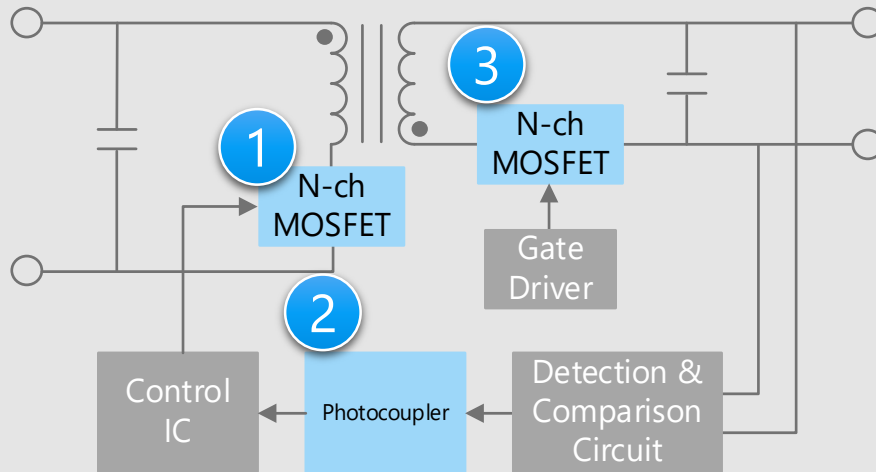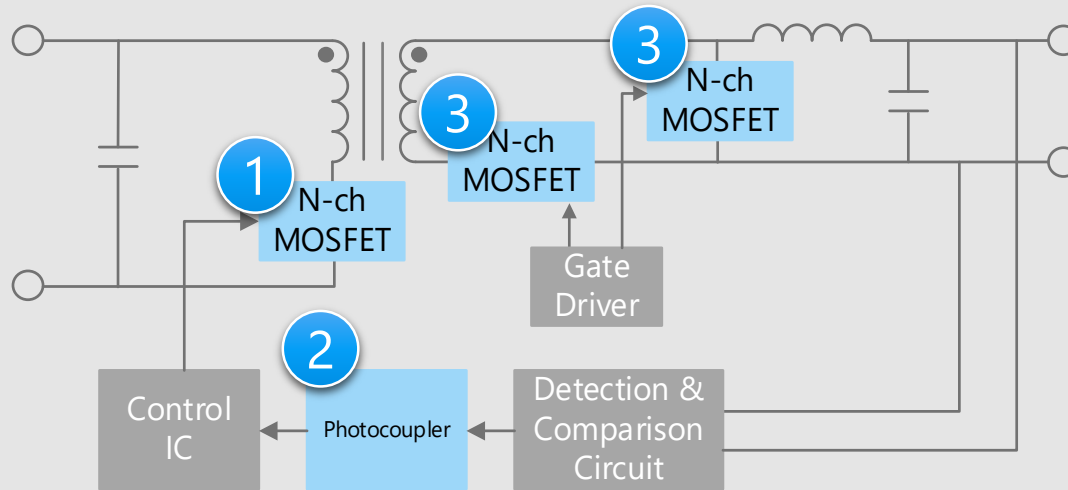- Circuit board area can be reduced by adopting a Small Package.

Proposals from Toshiba

- **Suitable for high-efficiency power supply switching**
  DTMOS VI Series power MOSFET
- **Photocoupler with excellent environmental resistance**
  Transistor output photocoupler
- **MOSFET with low on-resistance and high heat dissipation efficiency**
  U-MOS Series power MOSFET

LED Drive Circuit

AC-DC

⑥ MCU → LED Driver → ③ N-ch MOSFET

Sensor Input Circuit

④ LDO

Sensors → ⑤ Op-amp → ⑥ MCU

※ Click on the number in the circuit diagram to jump to the detailed description page
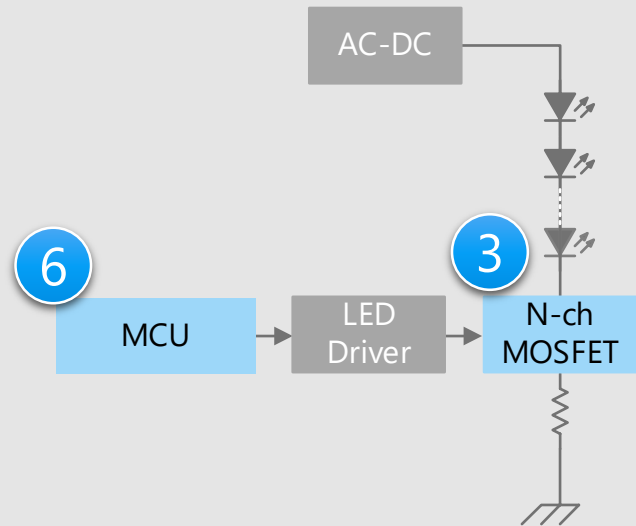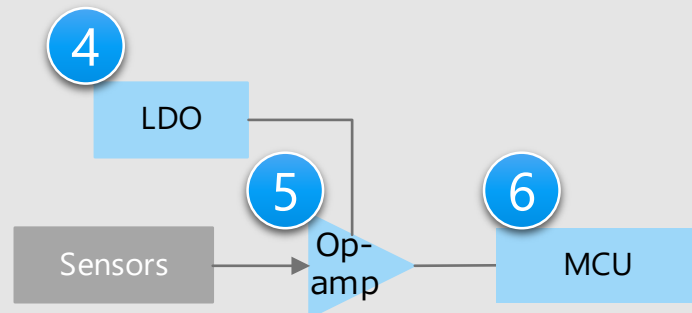
Criteria for device selection

- By using a MOSFET with low on-resistance and high heat dissipation efficiency, a set having low heat generation and low power consumption is realized.
- A stable system is realized by adopting an operational amplifier and an LDO power supply that are resistant to noise generated from the set.

Proposals from Toshiba

- **MOSFET with low on-resistance and high heat dissipation efficiency**
  U-MOS Series power MOSFET ③
- **High-precision power supply with less noise**
  Small surface mount LDO regulator ④
- **Accurately capturing changes in current consumption, etc.**
  Low noise operational amplifier ⑤
- **Built-in analog input interface at low power consumption and efficient software development**
  MCU ⑥

Recommended Devices
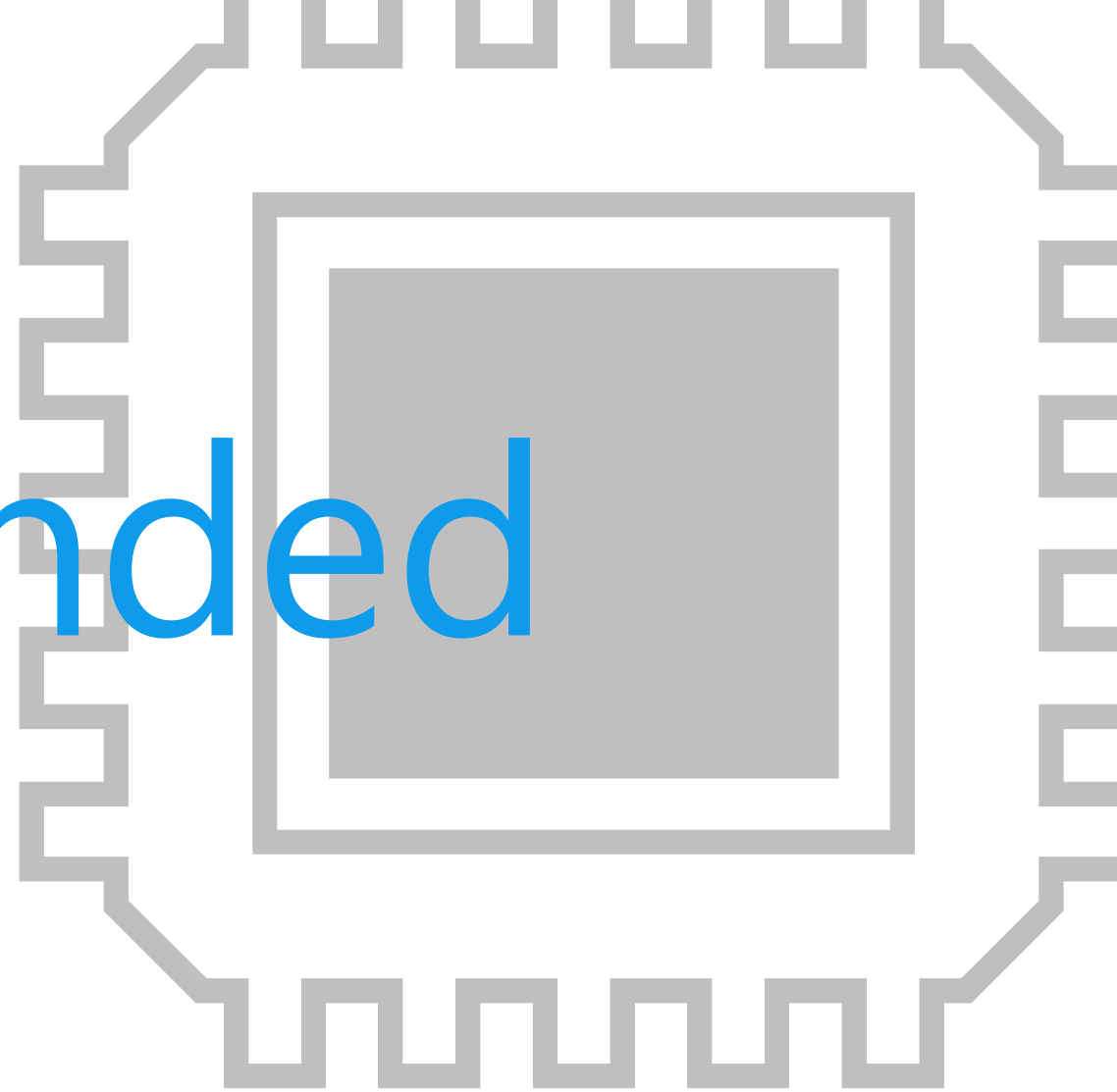
Device solutions to address customer needs

As described above, in the design of LED lighting, **"High efficiency"**, **"Low power consumption/Low heat generation of set"** and **"Miniaturization of circuit boards"** are important factors. Toshiba's proposals are based on these three solution perspectives.

High efficiency

Low power consumption /
Low heat generation of the set

Miniaturization of
circuit boards

▼

▼

▼

High efficiency

Low power consumption, Low heat generation, High heat dissipation efficiency

Small size packages
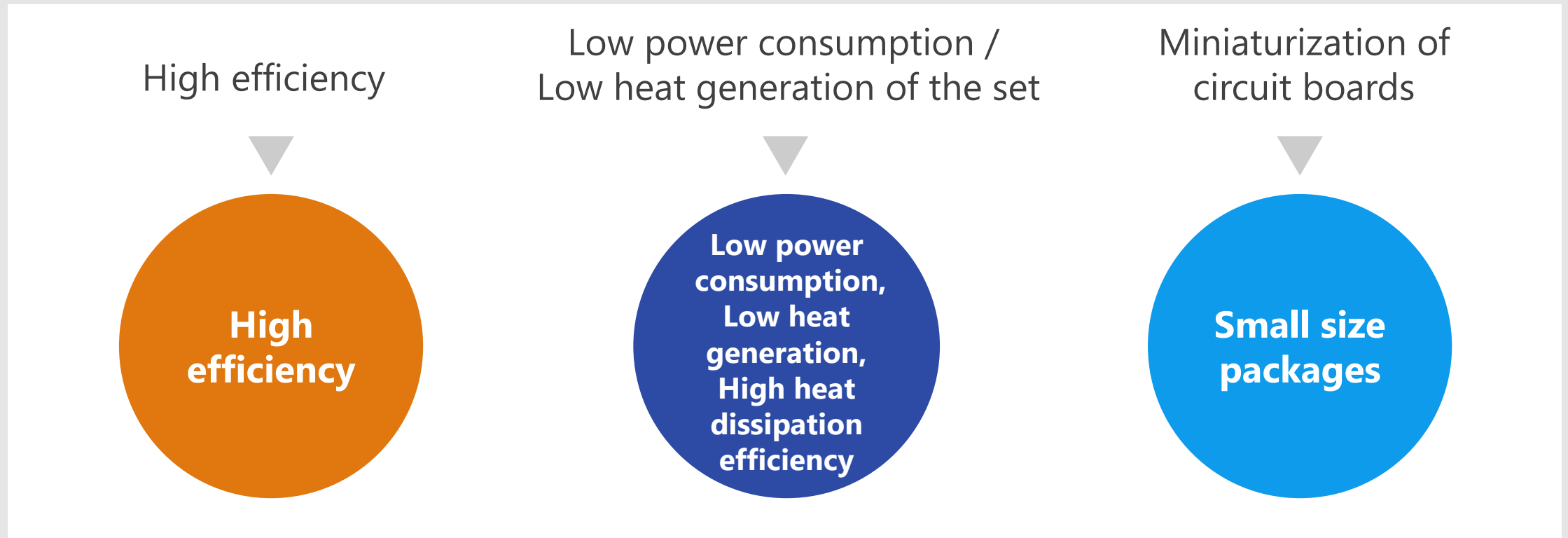
Device solutions to address customer needs

	High efficiency	Low power consumption, Low heat generation, High heat dissipation efficiency	Small size packages
① DTMOS VI Series power MOSFET	●	●	●
② Transistor output photocoupler			●
③ U-MOS Series power MOSFET	●	●	●
④ Small surface mount LDO regulator	●	●	●
⑤ Low noise operational amplifier			●
⑥ MCU	●	●	●

Value provided

40 % reduction in $R_{DS(ON)}$ x Q_{gd} performance index (compared with Toshiba conventional products), improving power supply efficiency.
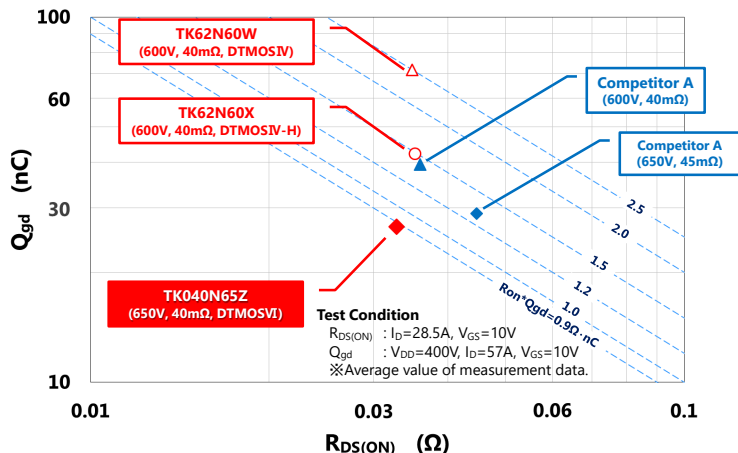
1 $R_{DS(ON)}$ x Q_{gd} 40 % reduction

The performance index $R_{DS(ON)}$ x Q_{gd} was reduced by 40 % by using a single epitaxial process and structural optimization (compared with DTMOSIV-H 600 V products from Toshiba). By realizing low $R_{DS(ON)}$ x Q_{gd}, switching loss of devices is reduced and power supply efficiency is improved.

2 RonA 18 % reduction

The performance index RonA of the latest-generation DTMOSVI was reduced by 18 % compared to the previous generation (compared to DTMOSIV 650 V products from Toshiba). Low on-resistance is realized while ensuring high voltage compared to previous generations, which contributes to higher efficiency of equipment.

■ $R_{DS(ON)}$-Q_{gd} performance trends

TK62N60W
(600V, 40mΩ, DTMOSIV)

TK62N60X
(600V, 40mΩ, DTMOSIV-H)

Competitor A
(600V, 40mΩ)

Competitor A
(650V, 45mΩ)

TK040N65Z
(650V, 40mΩ, DTMOSVI)

Test Condition
$R_{DS(ON)}$: I_D=28.5A, V_{GS}=10V
Q_{gd} : V_{DD}=400V, I_D=57A, V_{GS}=10V
※Average value of measurement data.

Ron*Qgd=0.9Ω・nC
2.5 2.0 1.5 1.2 1.0

Q_{gd} (nC)

$R_{DS(ON)}$ (Ω)

Note : Based on Toshiba's measurement data

Line up

Part number		TK065U65Z	TK040N65Z
Package		TOLL	TO-247
V_{DSS} [V]		650	650
I_D [A]		38	57
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	0.051	0.033
	Max	0.065	0.04
Polarity		N-ch	N-ch
Generation		DTMOSVI	DTMOSVI

Value provided

Reduction in required circuit board area and improving reliability enabling maintenance-free operation.

1 **High current transfer ratio**

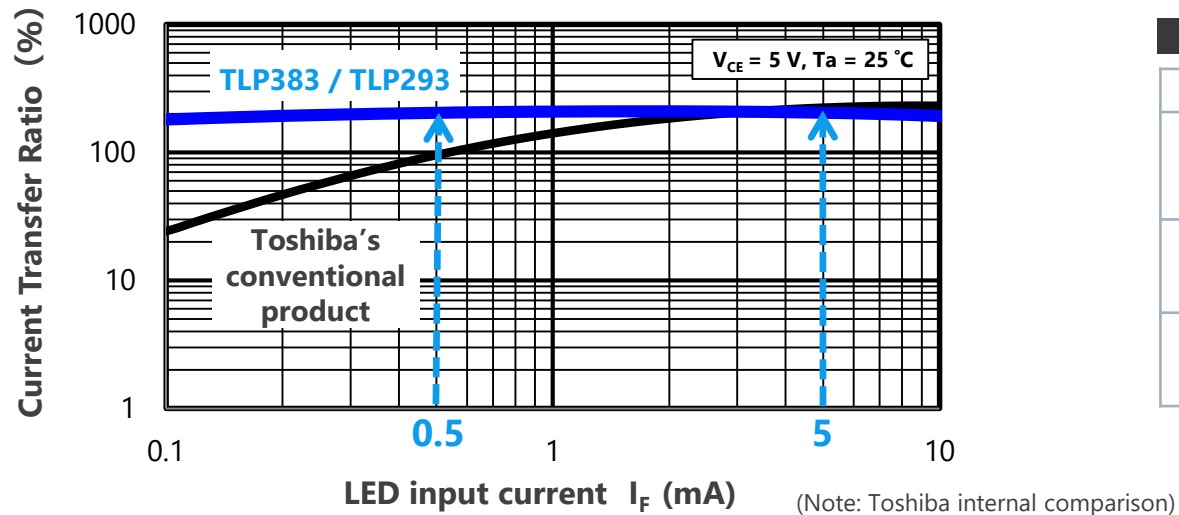The TLP383 / TLP293 is a high-isolation photocoupler that optically couples a phototransistor and high output infrared LED. Compared to Toshiba's conventional products (TLP785 / TLP385), higher CTR (Current Transfer Ratio) in low input current range (@ I_F = 0.5 mA) is realized.

2 **Operating temperature is expanded to 125 °C**

The TLP383 / TLP293 are designed to operate under extreme conditions of ambient temperature such as inverter devices, robots, machine tools and high output power supplies.

Current Transfer Ratio (%) vs LED input current I_F (mA)

TLP383 / TLP293

V_{CE} = 5 V, Ta = 25 °C

Toshiba's conventional product

0.5   5

(Note: Toshiba internal comparison)

Line up

Part number	TLP383	TLP293	TLP785	TLP385
Package	SO6L (4 pin)	SO4	DIP4	SO6L (4 pin)
BV_S (Min) [Vrms]	5000	3750	5000	5000
T_{opr} [°C]	-55 to 125	-55 to 125	-55 to 110	-55 to 110

◆Return to Block Diagram TOP

Value provided

Contributes to lower heat generation of system by providing lineup of low on-resistance type and high heat dissipation package (DSOP Advance).
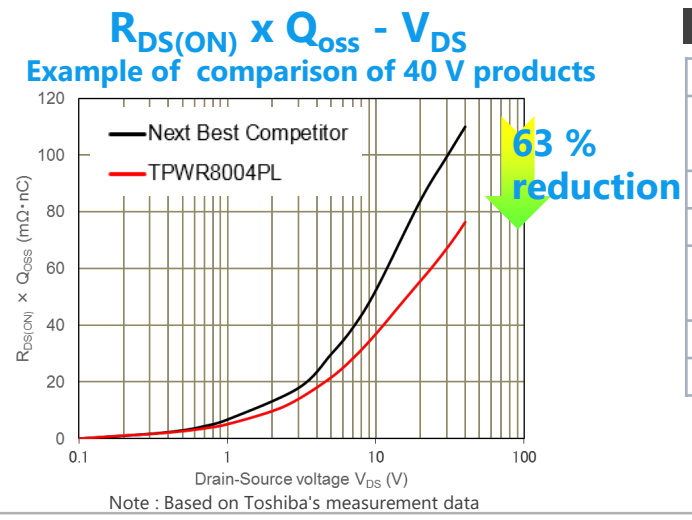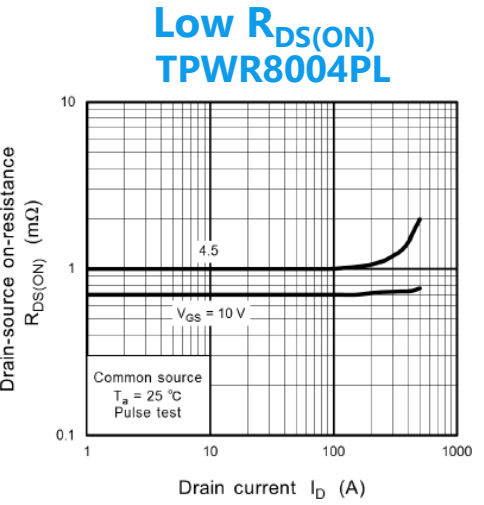
1 Low on-resistance

By keeping the drain-source on-resistance low, heat generation and power consumption can be reduced. Products are provided from low on-resistance ($R_{DS(ON)}$) of 0.36 mΩ.

2 Small Q_{oss}

Contributes low output loss due to small Q_{oss}. Performance index $R_{DS(ON)}$ x Q_{oss} is deducted to 63 % than competitor's next generation product.

3 Variety of packages

Adding SOP Advance of industries' standard package, DSOP Advance of double-side heat dissipation package on same footprint had been provided.

Low $R_{DS(ON)}$
TPWR8004PL

$R_{DS(ON)}$ x Q_{oss} - V_{DS}
Example of comparison of 40 V products

63 % reduction

Note : Based on Toshiba's measurement data

Line up

Part number		TPWR6003PL	TPWR8004PL	TPHR7404PU	TPHR8504PL
Package		DSOP Advance		SOP Advance	
V_{DSS} [V]		30	40	40	40
I_D [A]		150 (412*)	150 (340*)	150 (400*)	150 (340*)
$R_{DS(ON)}$ [mΩ] @V_{GS} = 10 V	Typ.	0.36	0.65	0.51	0.7
	Max	0.6	0.8	0.74	0.85
Polarity		N-ch	N-ch	N-ch	N-ch
Generation		U-MOSIX-H	U-MOSIX-H	U-MOSIX-H	U-MOSIX-H

* : Silicon limit

◆Return to Block Diagram TOP
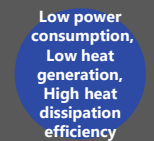
Value provided

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

1 Low on-resistance

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

Approx. 40 % reduction

TPH4R008NH (U-MOSⅧ-H)
TPH2R408QM (U-MOSⅩ-H)

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

Approx. 30 % reduction

TPH4R008NH (U-MOSⅧ-H)
TPH2R408QM (U-MOSⅩ-H)
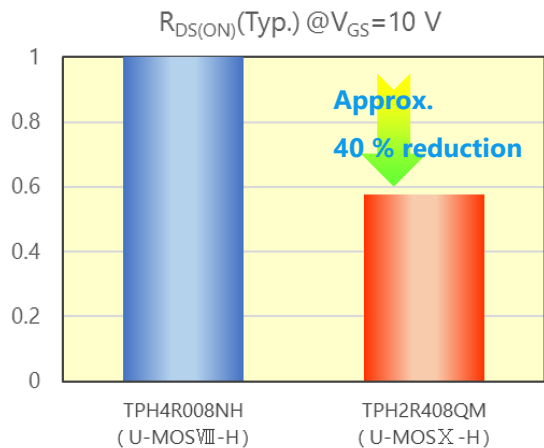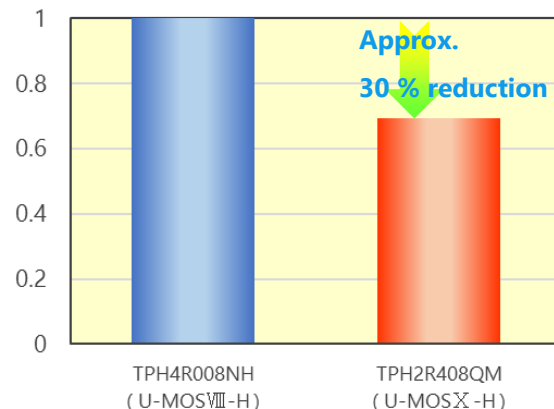
Note: Toshiba internal comparison

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

High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | 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.

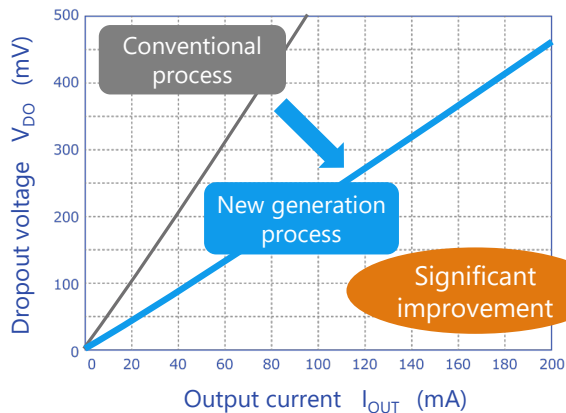## 2 High PSRR Low output noise voltage

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

Conventional process

New generation process

Significant improvement

Dropout voltage V_{DO} (mV)

Output current I_{OUT} (mA)

Note: Toshiba internal comparison

Rich package line up

WCSP4F 0.645×0.645×0.33mm
WCSP4E 0.645×0.645×0.43mm
WCSP4 0.79×0.79×0.5mm
SDFN4 0.8×0.8×0.38mm
DFN4 1.0×1.0×0.58mm
WCSP6F 1.2×0.8×0.33mm
DFN5B 1.2×1.2×0.38mm
ESV(SOT-553) 1.6×1.6×0.55mm
SMV(SOT-25) 2.9×2.8×1.1mm
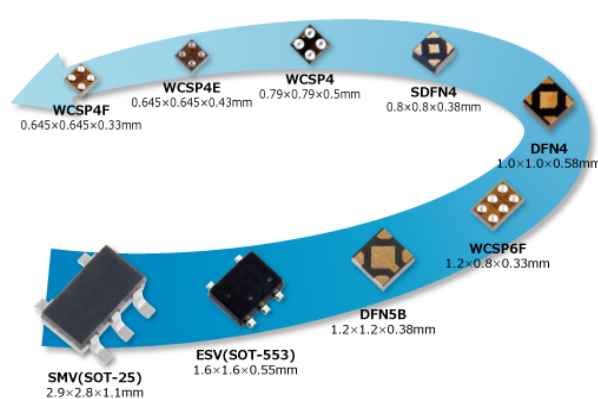
Line up

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

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 using CMOS operational amplifier by optimizing the processing. We achieved one of the industry's lowest[Note 2] input equivalent noise voltage.

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

The low current consumption characteristics of CMOS processing contributes to the extension of battery life of the compact IoT devices[Note 3].

3 **Low supply voltage operation**

V_{DD} = 2.2 to 5.5 V

Low noise characteristic
(Toshiba internal comparison)

Conventional products :TC75S63TU

New product :TC75S67TU

Equivalent input noise voltage V_{NI} (nV/√Hz)

Frequency f(Hz)

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_{DD} = 2.5 V)
V_{NI} (Typ.) [nV/√Hz] @f = 1 kHz	6
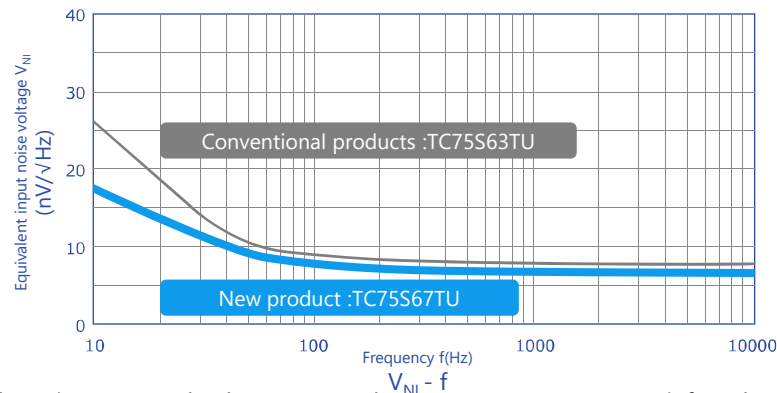
[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, and temperature sensor, etc.
[Note 2] Based on Toshiba data (as of May 2017) [Note 3] Compared with Toshiba's operational amplifier using bipolar processing

◆Return to Block Diagram TOP

High efficiency

Low power consumption, Low heat generation, High heat dissipation efficiency

Small size packages

Value provided

Built-in 50 % duty control function in UART, compatible with Home Bus System (HBS).

1 Built-in Arm® Cortex®-M3 CPU core

TMPM381FWFG and TMPM383FUSG implement Cortex-M3 core with 40 MHz maximum operation frequency. Various development tool and their partners allow users many options.

2 Compatible with HBS

UART function is equipped with 50 % duty control function and is compatible with HBS. A control system composed of HBS can be easily constructed using centralized management systems or thermostats.

3 Small package and very low power consumption

TMPM381FWFG and TMPM383FSUG execute sensing data monitoring and processing efficiently by combining built-in analog function such as ADC and CPU system. The original NANOFLASH™ is possible to rewrite at high-speed. It reduces user software development time period.

TMPM381FWFG
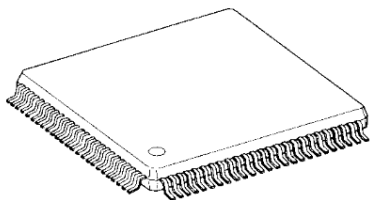
TMPM383FSUG

LQFP100
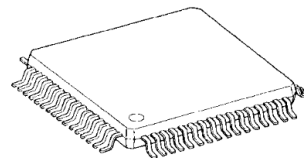
LQFP64

Line up

Part number	TMPM381FWFG	TMPM383FSUG
Maximum operation frequency	40 MHz	40 MHz
Instruction ROM	128 KB	64 KB
RAM	10 KB	8 KB
Timer	16bit x 8ch	16bit x 8ch
UART / SIO	3ch	2ch
UART(50% duty)	1ch	1ch
ADC	18ch (12bit)	10ch (12bit)

If you are interested in these products and
have questions or comments about any of them,
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