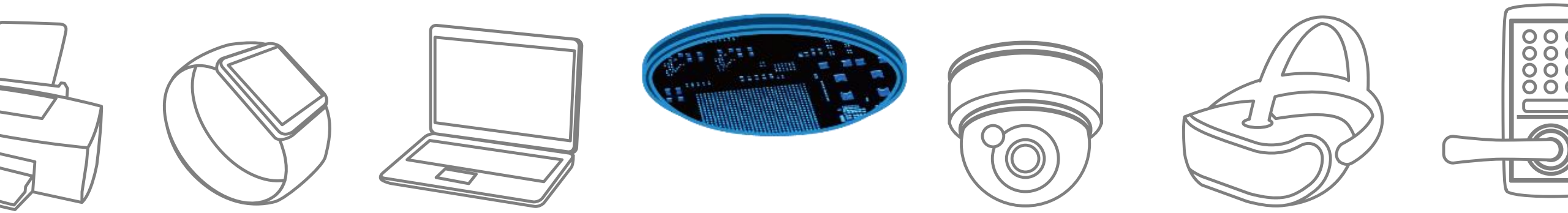
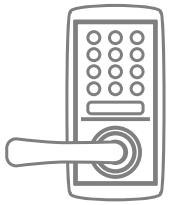
TOSHIBA

R23

LED Lighting

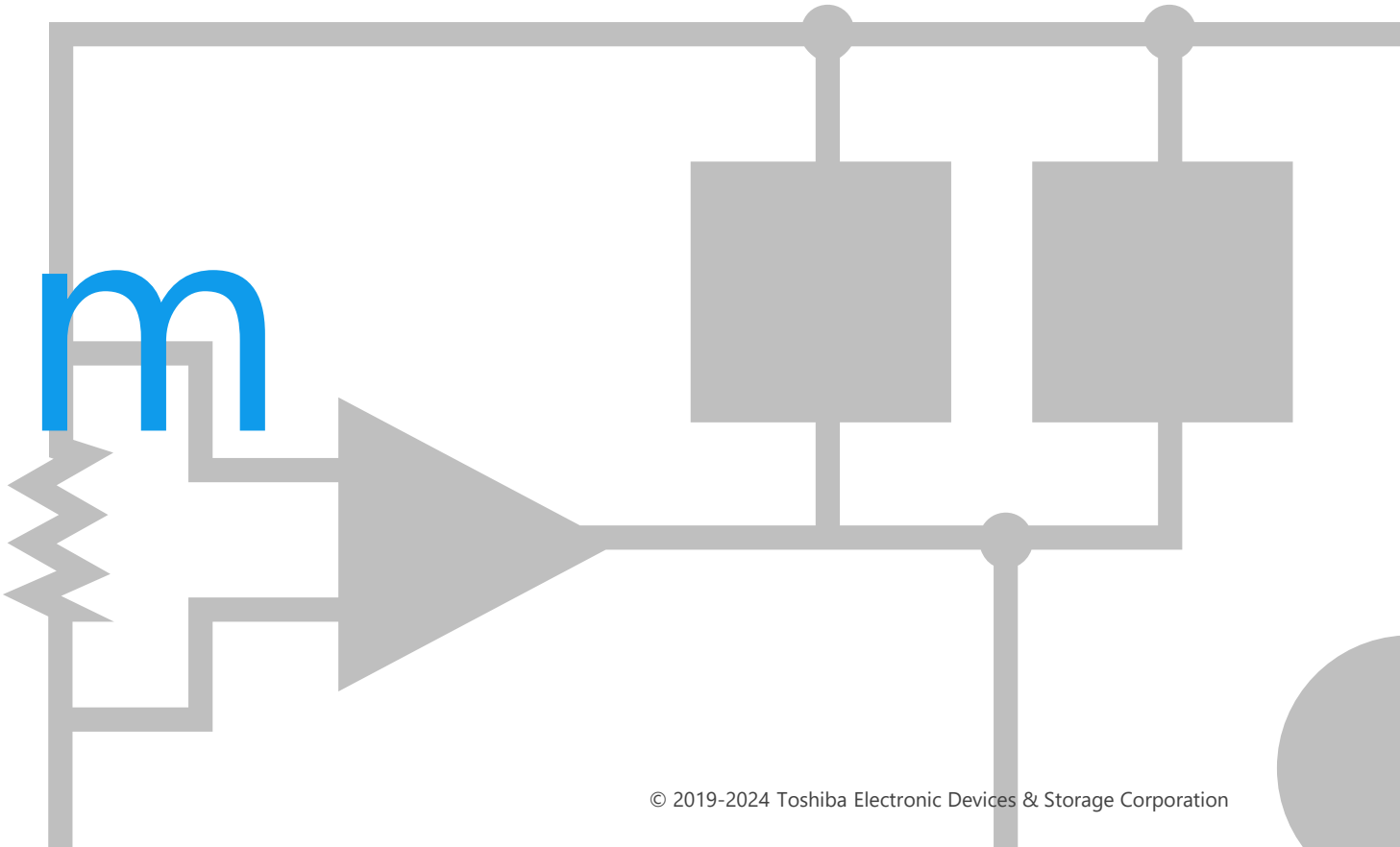
Solution Proposal by Toshiba



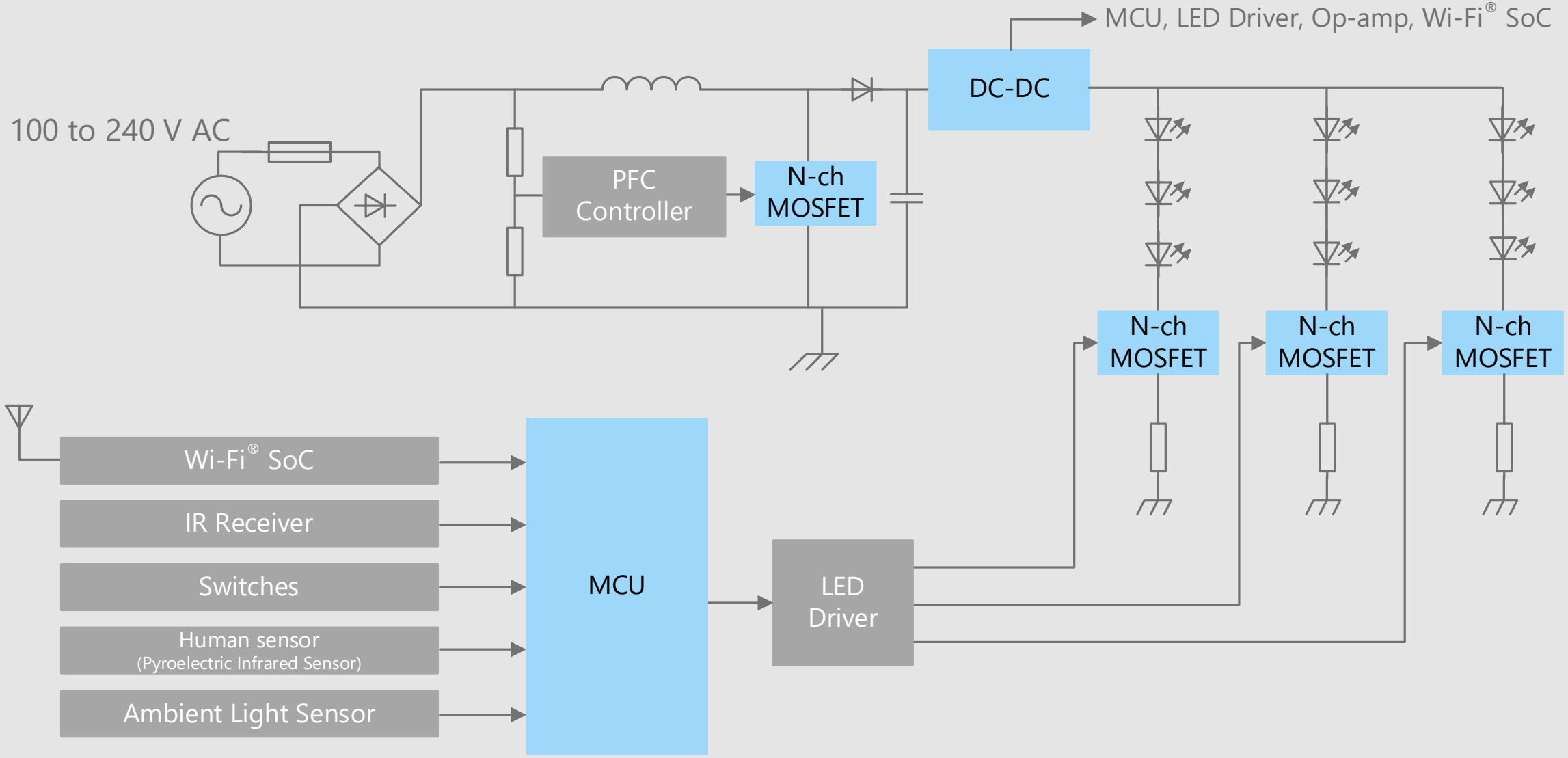


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



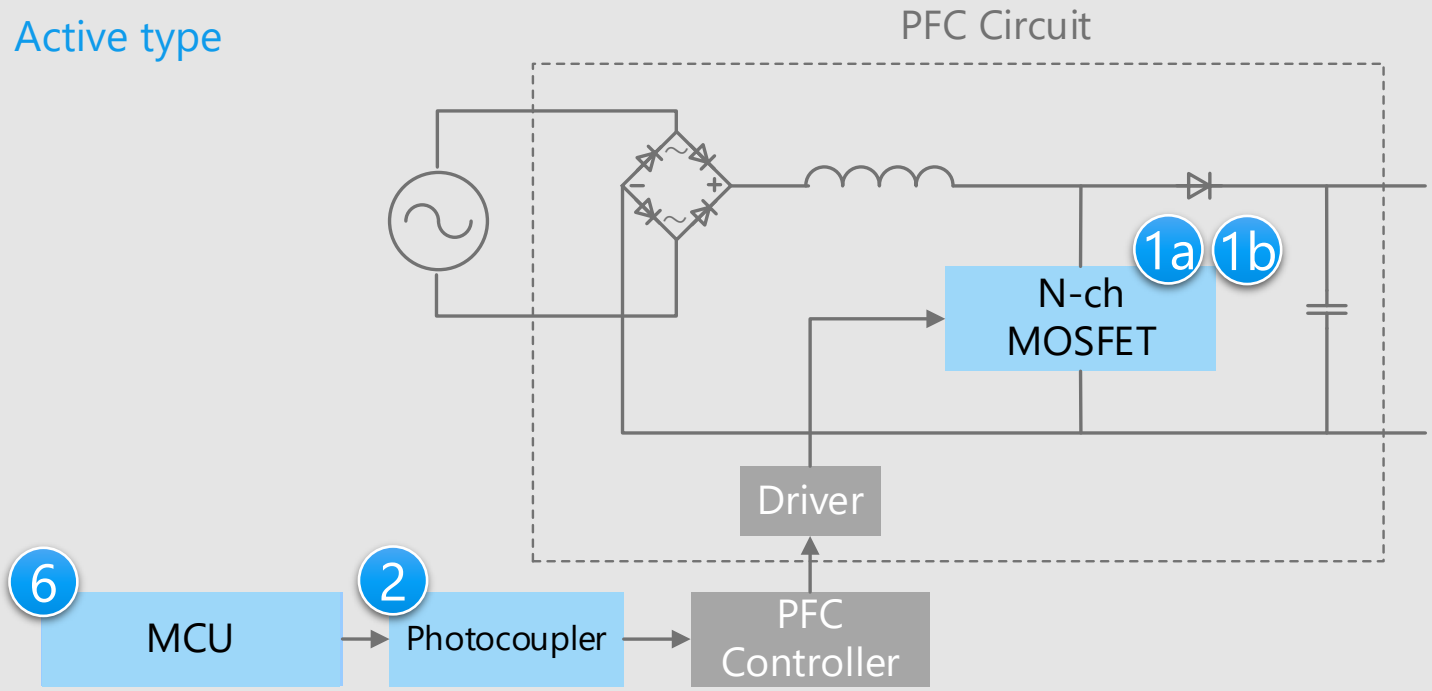
LED lighting　Overall block diagram



LED lighting　Detail of power supply unit (1)

PFC circuit

Active type



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

Criteria for device selection

- MOSFET is suitable for active type PFC circuit.
- The transistor output photocoupler is for signal isolation.
- An MCU can also be used for PFC control.

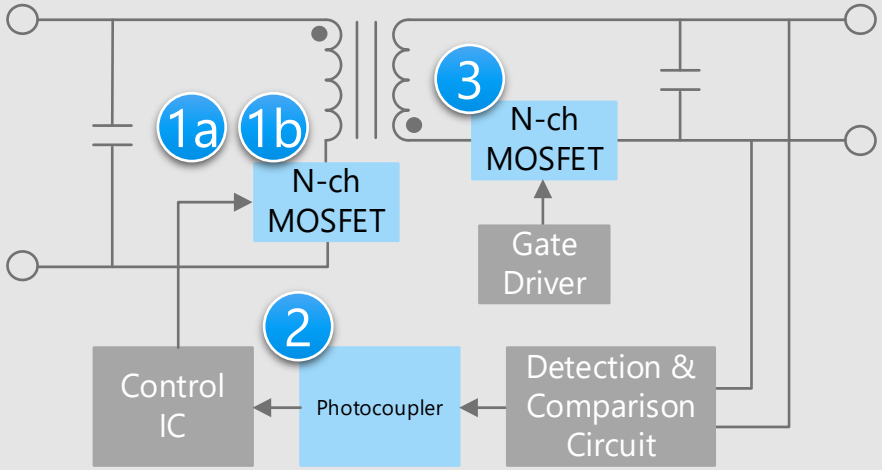
Proposals from Toshiba

- **Suitable for high efficiency power supply switching**
  DTMOSⅥ Series MOSFET
  SiC MOSFET
  1a 1b
- **High current transfer ratio and high temperature operation are realized**
  Transistor output photocoupler
  2
- **Built-in analog interface for sensing, low power consumption and efficient software development**
  MCU M3H Group
  6

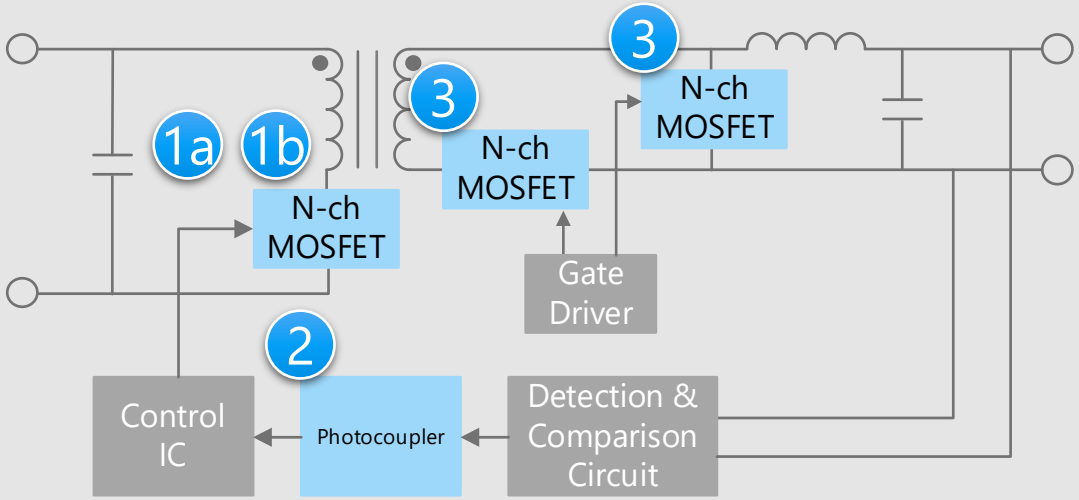
LED lighting　Detail of power supply unit (2)

DC-DC converter circuits

Flyback type



Forward type



* 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.
- The transistor output photocoupler is for signal isolation.
- Small package products contribute to the reduction of circuit board area.

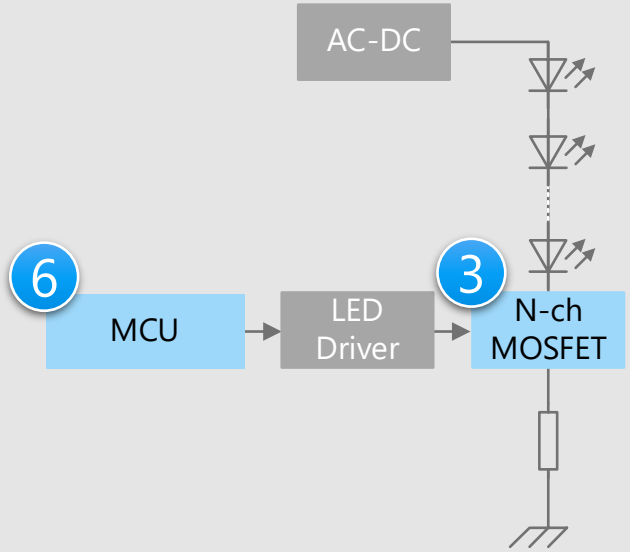
Proposals from Toshiba

- **Suitable for high efficiency power supply switching**
  DTMOSⅥ Series MOSFET
  SiC MOSFET
- **High current transfer ratio and high temperature operation are realized**
  Transistor output photocoupler
- **MOSFET with low on-resistance and high heat dissipation efficiency**
  U-MOS Series MOSFET

1a 1b 2 3

LED lighting　Detail of LED drive unit

LED drive circuit



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

Criteria for device selection

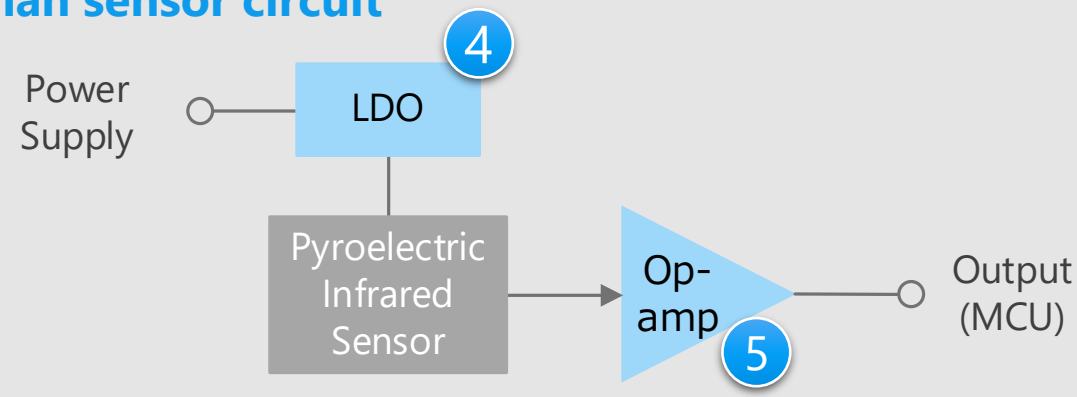
- By using a MOSFET with low on-resistance and high heat dissipation efficiency, a set having low heat generation and low power consumption is realized.

Proposals from Toshiba

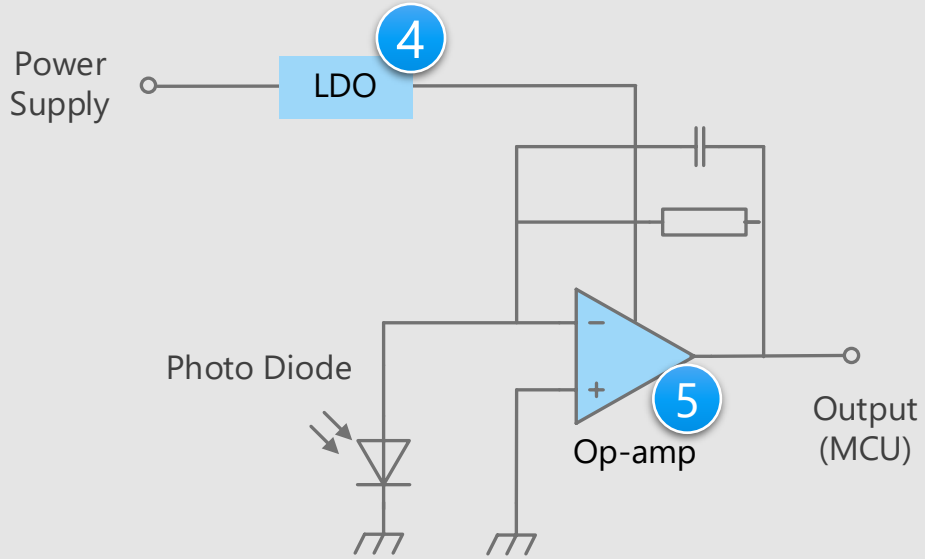
- **MOSFET with low on-resistance and high heat dissipation efficiency**
  U-MOS Series MOSFET 3
- **Built-in analog interface for sensing, low power consumption and efficient software development**
  MCU M3H Group 6

LED lighting　Detail of sensor signal input unit

Human sensor circuit



Ambient light sensor circuit



* Click on the blue circled numbers above to view detailed descriptions.

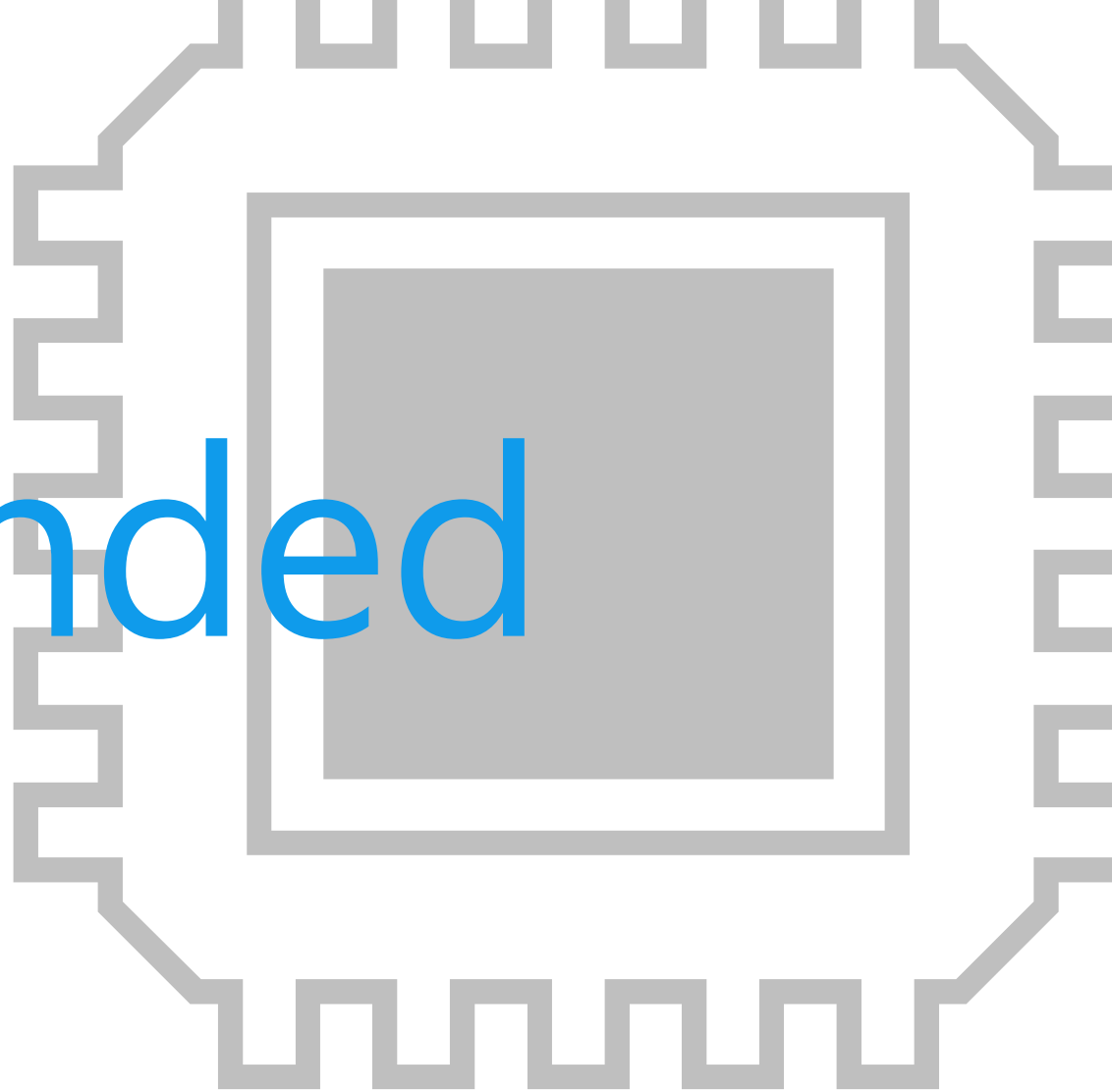
Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor circuits.
- The operational amplifier should be low current consumption or low noise device.

Proposals from Toshiba

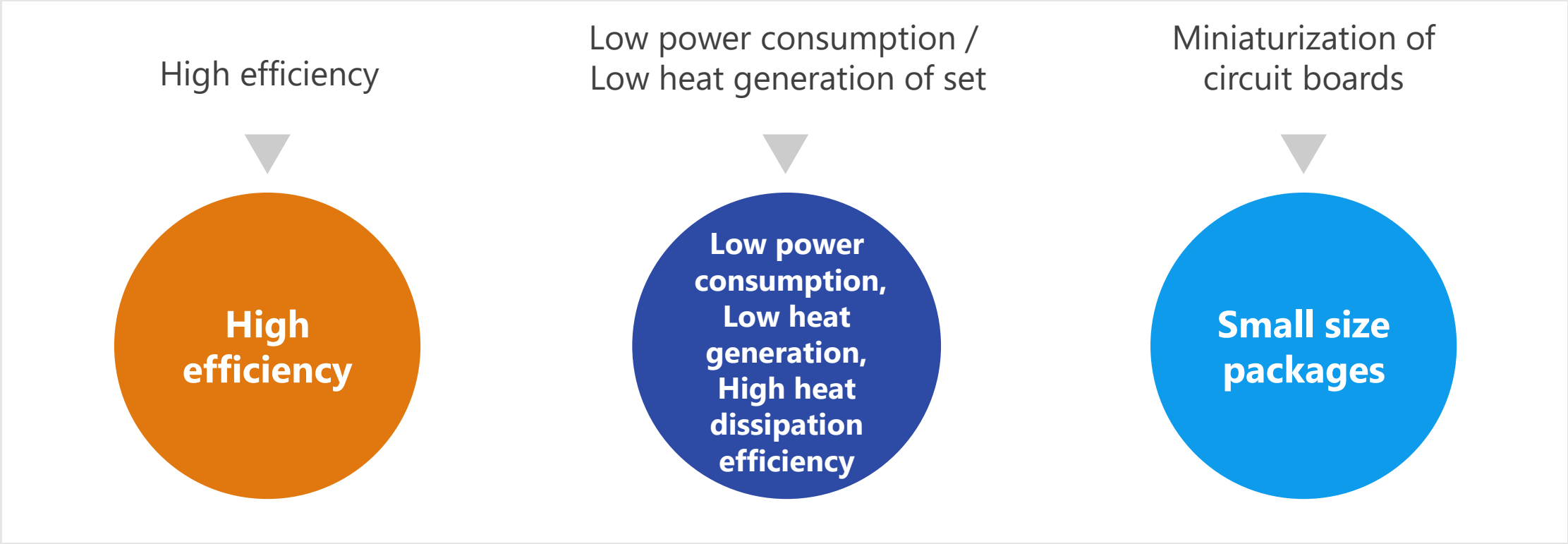
- **Supply the power with low noise**
  Small surface mount LDO regulator 4
- **Amplification of detected weak signal with low noise**
  Low current consumption op-amp / Low noise op-amp 5

Recommended Devices

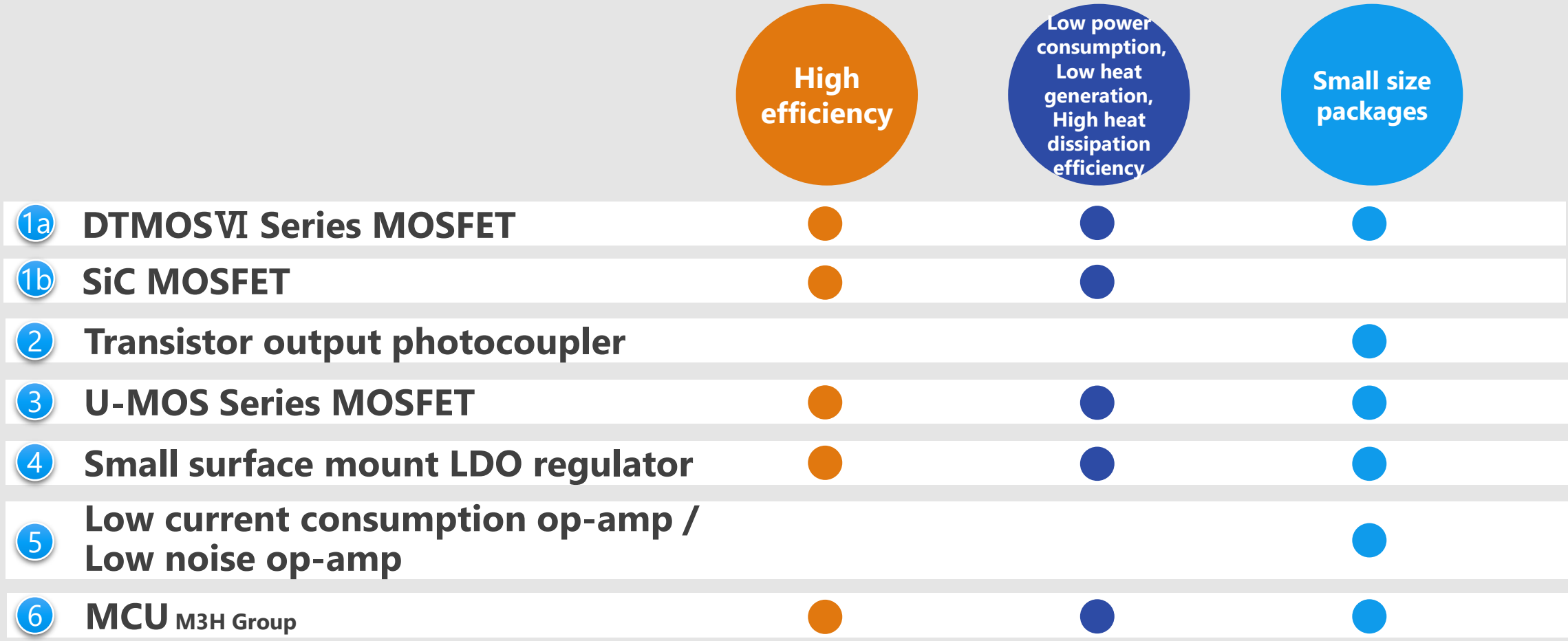


Device solutions to address customer needs

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.



Device solutions to address customer needs



DTMOSⅥ Series MOSFET

TK065U65Z / TK040N65Z

High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | Small size packages

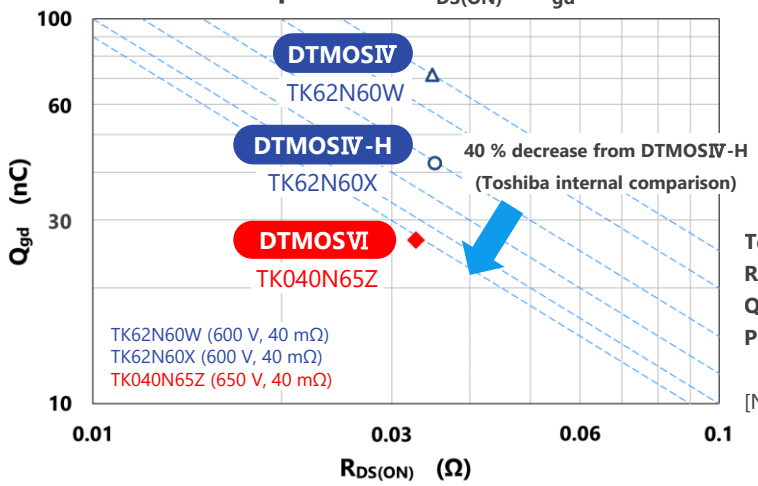
Value provided

Realizes improvement of power supply efficiency by 40 % (comparison of Toshiba's conventional products) reduction of $R_{DS(ON)}$ x Q_{gd}.

1 $R_{DS(ON)}$ x Q_{gd} reduced by 40 %

Using a single epitaxial process, the figure of merit $R_{DS(ON)}$ x Q_{gd} was reduced by 40 % by optimizing the structure (comparison of Toshiba's DTMOSⅣ-H 600 V products). By realizing low $R_{DS(ON)}$ x Q_{gd}, device switching loss was reduced contributing to improvement in power supply efficiency of equipment.

Comparison of $R_{DS(ON)}$ x Q_{gd} [Note 2]



Test Condition
$R_{DS(ON)}$: I_D = 28.5 A, V_{GS} =10 V
Q_{gd}: V_{DD} = 400 V, I_D = 57 A, V_{GS} = 10 V
Plots the mean of the measured values.

[Note 2] As of March 2023.

2 RonA reduced by 18 %

The figure of merit RonA of the latest generation [Note1] DTMOSⅥ has been reduced by 18 % compared with the previous generation (Toshiba's DTMOSⅥ 650 V products). Achieving low on-resistance while maintaining high voltage contributes to high efficiency of equipment.

[Note1] As of March 2023

Lineup

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

◆Return to Block Diagram TOP

1b SiC MOSFET

TW107N65C / TW140N120C / TW107Z65C / TW140Z120C

High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | Small size packages

Value provided

The performance index $R_{DS(ON)}$ x Q_{gd}, which shows switching characteristics, is reduced by 80 % compared with Toshiba's existing products. This contributes to lower loss of power supply in application.

1 Low $R_{DS(ON)}$ x Q_{gd}

For the latest products, the performance index $R_{DS(ON)}$ x Q_{gd}, which shows the relation between conduction loss and switching loss, is reduced by 80 % compared with Toshiba's existing products by optimizing its cell structure.

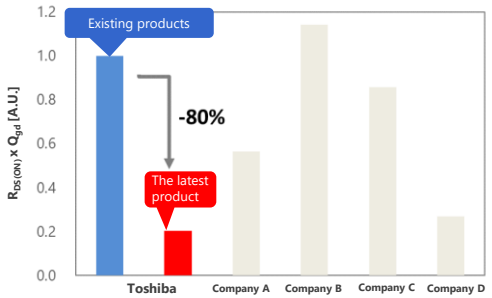
2 Wide V_{GSS} specification

The specification of the gate-source voltage is -10 to 25 V, which is wider than that of other companies' products, allows a wider margin for the drive voltage and makes gate drive design considering overshoot easier. (Recommended drive voltage: 18 V)

3 Built-in Schottky barrier diode

Built-in Schottky barrier diode reduces V_{DSF} during reverse conduction to 1.35 V (typ.). In addition, by energizing the Schottky barrier diode, fluctuation in $R_{DS(ON)}$ caused by the spread of defects is suppressed.

Comparison of $R_{DS(ON)}$ x Q_{gd}



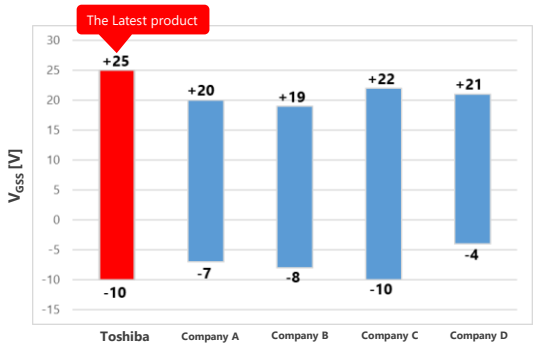
Measurement conditions

$R_{DS(ON)}$: V_{GS} = 18 V, I_D = 20 A, T_a = 25 °C

Q_{gd}: V_{DD} = 800 V, V_{GS} = 18 V, I_D = 20 A, T_a = 25 °C

(Toshiba internal comparison, as of May 2022)

Comparison of V_{GSS} specification



(Toshiba internal comparison based on the datasheet of each company's 1200 V voltage products as of July 2023.)

Lineup

Part number		TW107N65C	TW140N120C	TW107N65C	TW140Z120C
Package		TO-247 		TO-247-4L(X) 	
V_{DSS} [V]		650	1200	650	1200
I_D [A]		20	20	20	20
$R_{DS(ON)}$ [Ω] @V_{GS} =18 V	Typ.	0.107	0.140	0.107	0.140
	Max	0.145	0.182	0.152	0.191
Polarity		N-ch	N-ch	N-ch	N-ch

◆Return to Block Diagram TOP

2 Transistor output photocoupler

TLP383 / TLP293 / TLP385

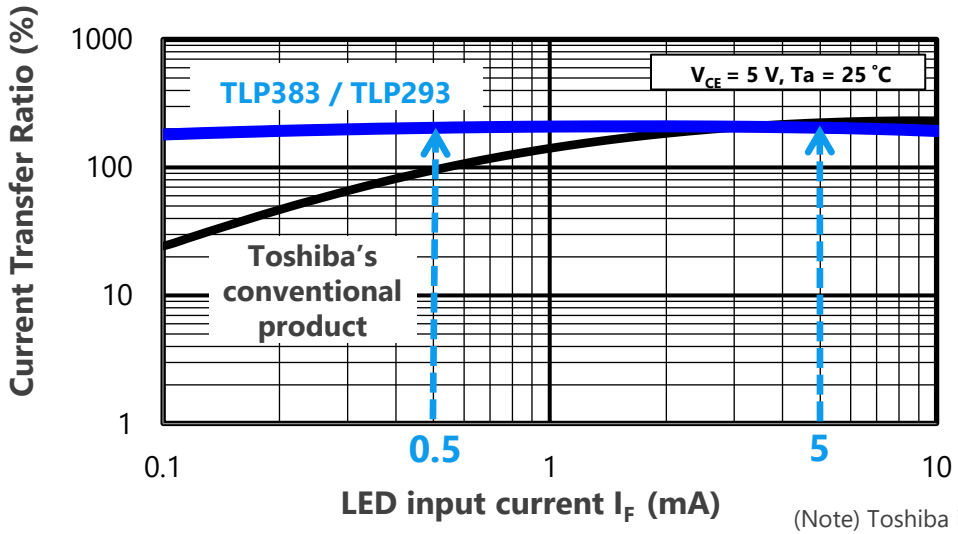
High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | Small size packages

Value provided

High CTR (Current Transfer Ratio) is realized even in low input current range (I_F = 0.5 mA).

1 High current transfer ratio

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



(Note) Toshiba internal comparison

2 Designed for high temperature operation

The TLP383 and TLP293 are designed to operate even under severe ambient temperature conditions.

Lineup

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

◆Return to Block Diagram TOP

U-MOS Series MOSFET (30 V / 40 V)

TPWR6003PL / TPWR8004PL / TPHR7404PU / TPHR8504PL

High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | Small size packages

Value provided

Contributes to lower heat generation of system by providing low on-resistance and a highly heat dissipation package (DSOP Advance).

1 Low $R_{DS(ON)}$ (on-resistance)

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

2 Small Q_{oss} (output charge)

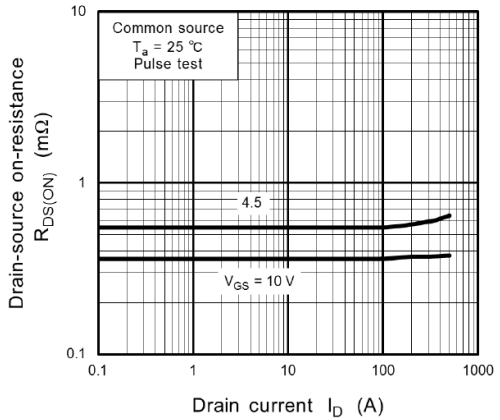
Contributes low loss due to small Q_{OSS}. TPWR8004PL's performance index $R_{DS(ON)}$ x Q_{OSS} is deducted to 5 % [Note] than competitor's products.

3 Variety of packages

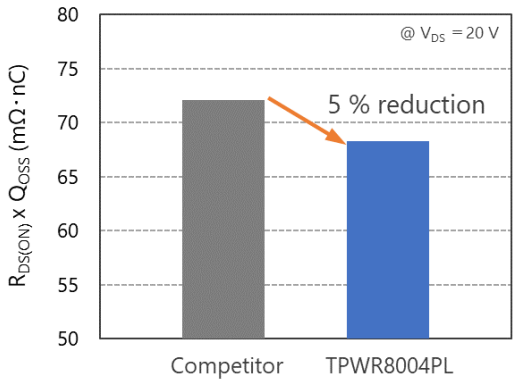
Adding SOP Advance of industry standard package, DSOP Advance of double-side heat dissipation package on same footprint had been prepared. Packages can be selected according to the set.

[Note] Comparison with competitor's product with equivalent ratings. As of March 2023. Based on Toshiba's measurement data.

Low on-resistance
TPWR6003PL



$R_{DS(ON)}$ x Q_{OSS}
TPWR8004PL [Note]



Lineup

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

3b U-MOS Series MOSFET (80 V)

TPH Series / TPN Series / TK Series

High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | Small size packages

Value provided

Lineup of low on-resistance products is provided and improvement of trade-off between on-resistance and capacitance contribute to higher efficiency of power supply.

1 High speed switching

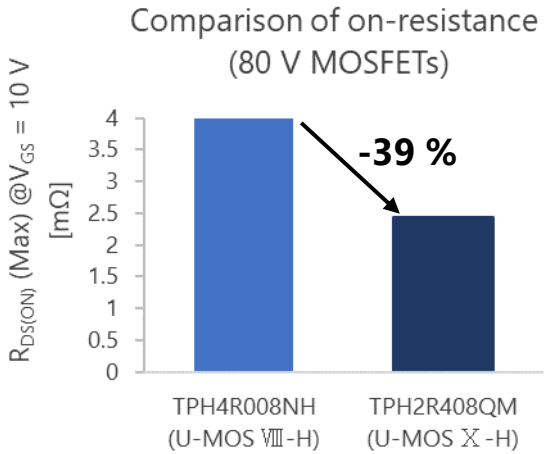
Reducing switching loss through high speed operation contributes to higher power supply efficiency.

2 Small gate input charge

Small gate input charge reduces the performance required for driving the MOSFET. It contributes to improving switching characteristics.

3 Low on-resistance

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



[Note] Toshiba internal comparison

Lineup

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-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H

*: Silicon limit

◆Return to Block Diagram TOP

4 Small surface mount LDO regulator

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

High efficiency

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

Small size packages

Value provided

Wide lineup from general purpose type to small package type are provided.
Contribute to realize a stable power supply.

1 Low dropout voltage

The originally developed latest process significantly improved the dropout voltage characteristics.

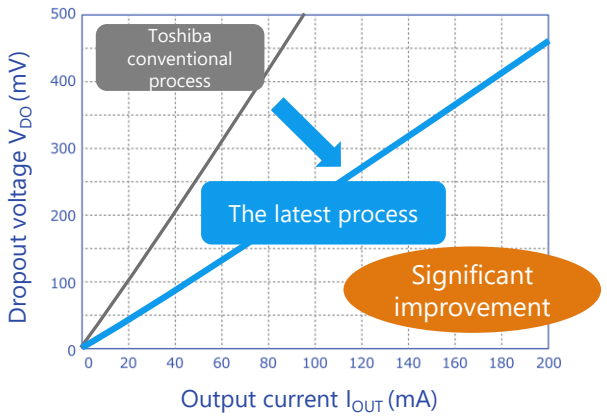
2 High PSRR Low output noise voltage

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

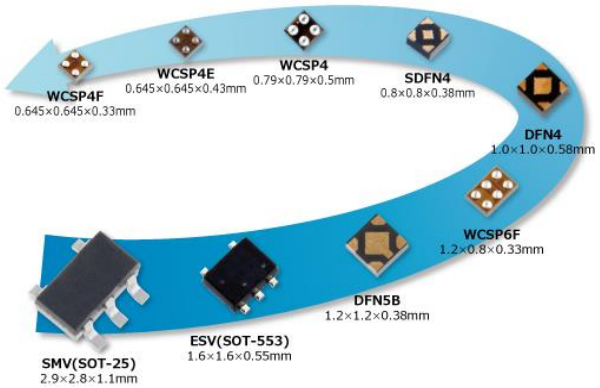
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

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

◆Return to Block Diagram TOP

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

TC75S102F / TC75S67TU

High efficiency

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

Small size packages

Value provided

Lineup includes low current consumption type that contributes to low power consumption and a low noise type that maximizes the performance of high performance sensors.

1 Low voltage operation

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

2 Low current consumption

(TC75S102F) I_{DD} = 0.27 [µA] (Typ.)

CMOS processes have been used to achieve lower current consumption.

3 Low noise (TC75S67TU)

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

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

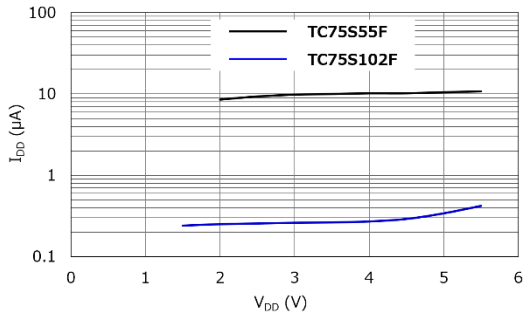
[Note] Sensor types: vibration, shock, acceleration, pressure, infrared, temperature, etc.

TC75S102F

Current Consumption Characteristic

(Toshiba internal comparison)

Low current consumption product TC75S102F

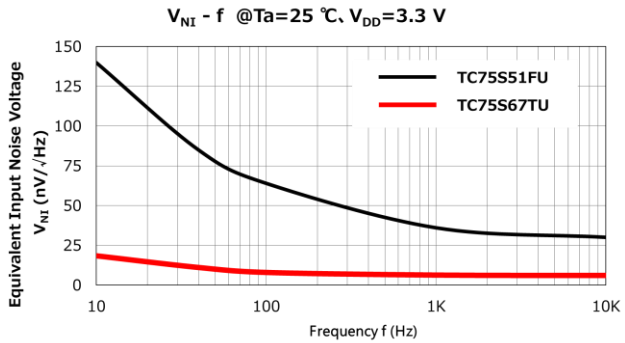


TC75S67TU

Noise Characteristic

(Toshiba internal comparison)

Reduce 1/f noise (10 Hz) by 86 % from our normal products



Lineup

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

◆Return to Block Diagram TOP

High efficiency | Low power consumption, Low heat generation, High heat dissipation efficiency | Small size packages

Value provided

AD converters, timers, and PWM [Note 1] output circuit are built in. The system-control runs at low power.

[Note 1] Pule Width Modulation

1 Built-in Arm® Cortex®-M3 CPU core

The product lineup is equipped with Arm Cortex-M3 core (maximum operation frequency of 120 MHz).
Various development tool and their partners allow users many options.

2 Enhancement of system functionality

Built-in multifunctional timers and A-PMD [Note 2] control circuit generate PWM. AD converters with monitoring capabilities are also built in. They provide efficient monitoring of the various parts of the system and lighting control. Also, products with flash ROM 1024KB support FOTA [Note 3].

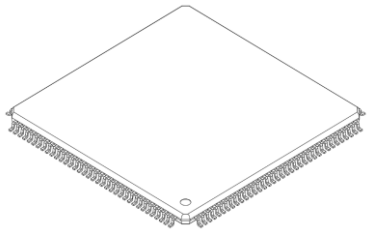
[Note 2] Advanced Programmable Motor Control Circuit

3 Small package, low power consumption

Several low power modes are available to support low power consumption.
Package lineup of LQFP144 from small LQFP64 is provided.

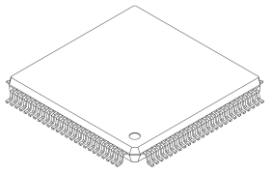
[Note 3] Firmware update Over The Air

TMPM3HQF10BFG
TMPM3HQFDAFG



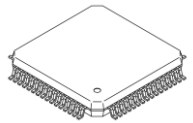
P-LQFP144-2020-0.50-002

TMPM3HNF10BFG
TMPM3HNFDAFG



P-LQFP100-1414-0.50-002

TMPM3HLF10BUG
TMPM3HLFDAUG



P-LQFP64-1010-0.50-003

Lineup

Part number	M3H(2)	TMPM3HQF10BFG	TMPM3HNF10BFG	TMPM3HLF10BUG
	M3H(1)	TMPM3HQFD/Z/YAFG	TMPM3HNFD/Z/YAFG	TMPM3HLFD/Z/YAUG
Max. operation frequency		120 MHz		
ROM (flash)	M3H(2)	1024 KB (512 KB x 2 area, compatible with FOTA)		
	M3H(1)	512 / 384 / 256 KB		
RAM	M3H(2)	130 KB (with parity)		
	M3H(1)	66 KB (with parity)		
Timer		32bit x 8ch (16bit x 16ch)		
AD converter		21ch (12bit)	17ch (12bit)	12ch (12bit)
Serial communication		UART: 8ch, I^2C: 4ch, TSPI: 5ch	UART: 8ch, I^2C: 3ch, TSPI: 4ch	UART: 7ch, I^2C: 2ch, TSPI: 1ch
Package		P-LQFP144-2020-0.50-002	P-LQFP100-1414-0.50-002	P-LQFP64-1010-0.50-003

◆Return to Block Diagram TOP

If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

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