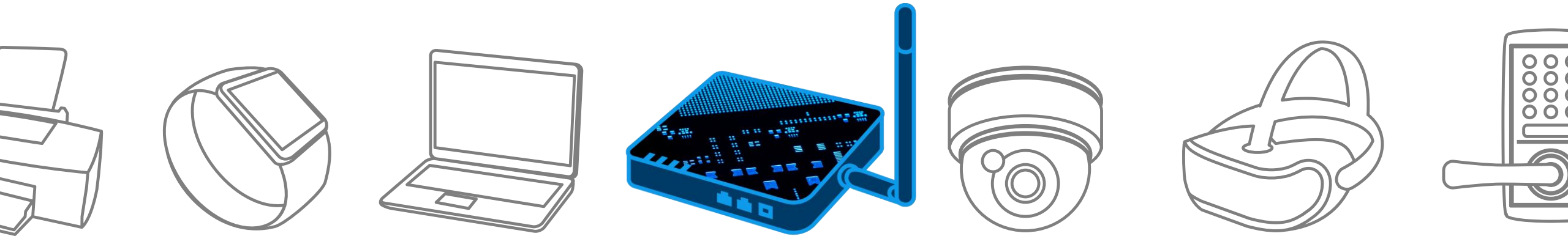
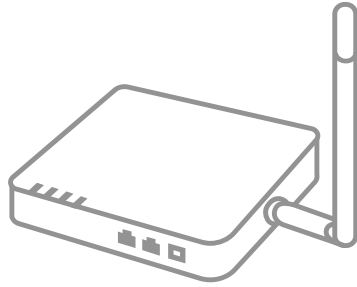
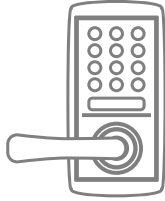
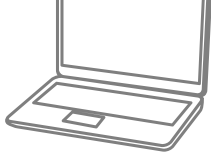


IoT Sensor

Solution Proposal by Toshiba

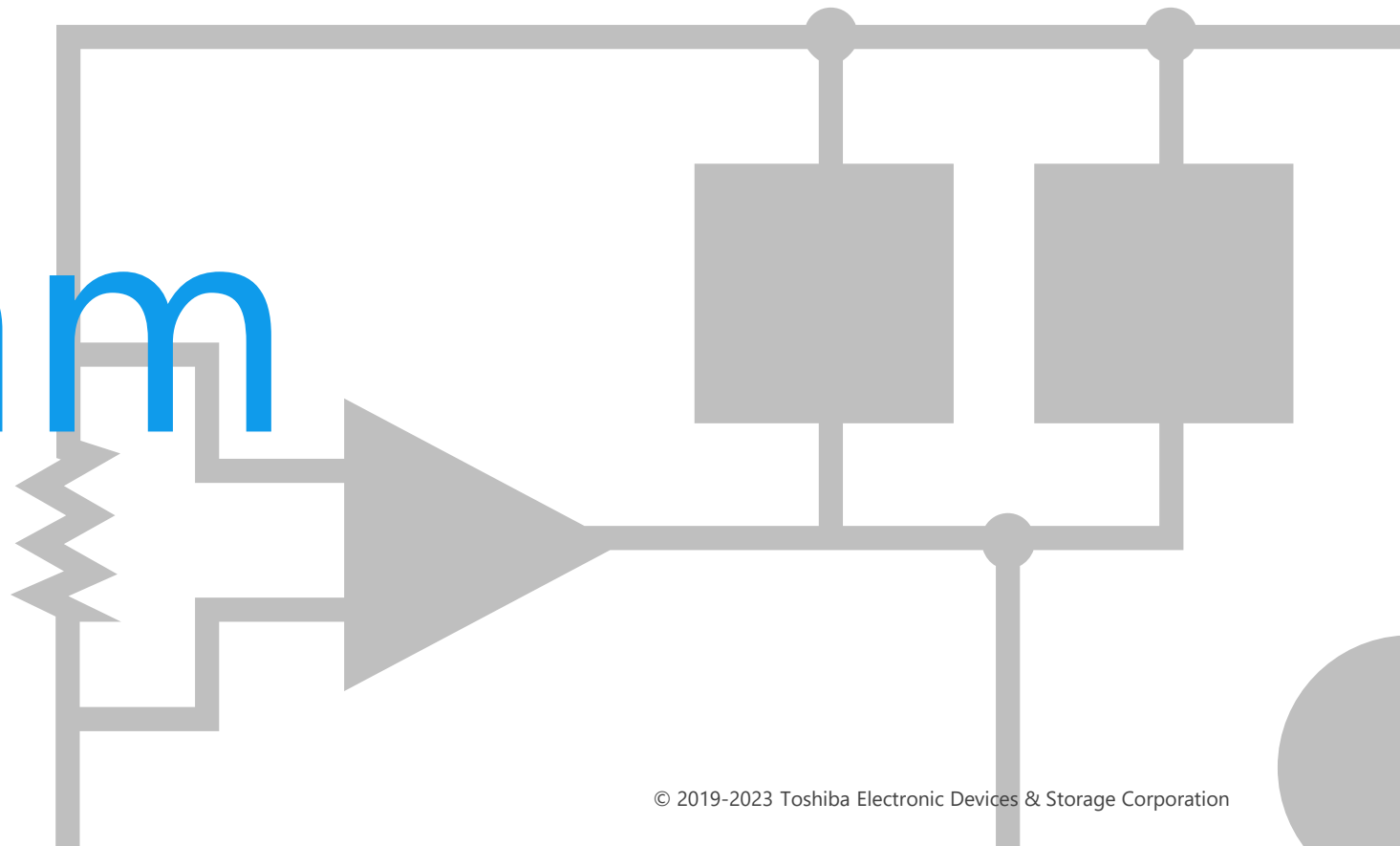




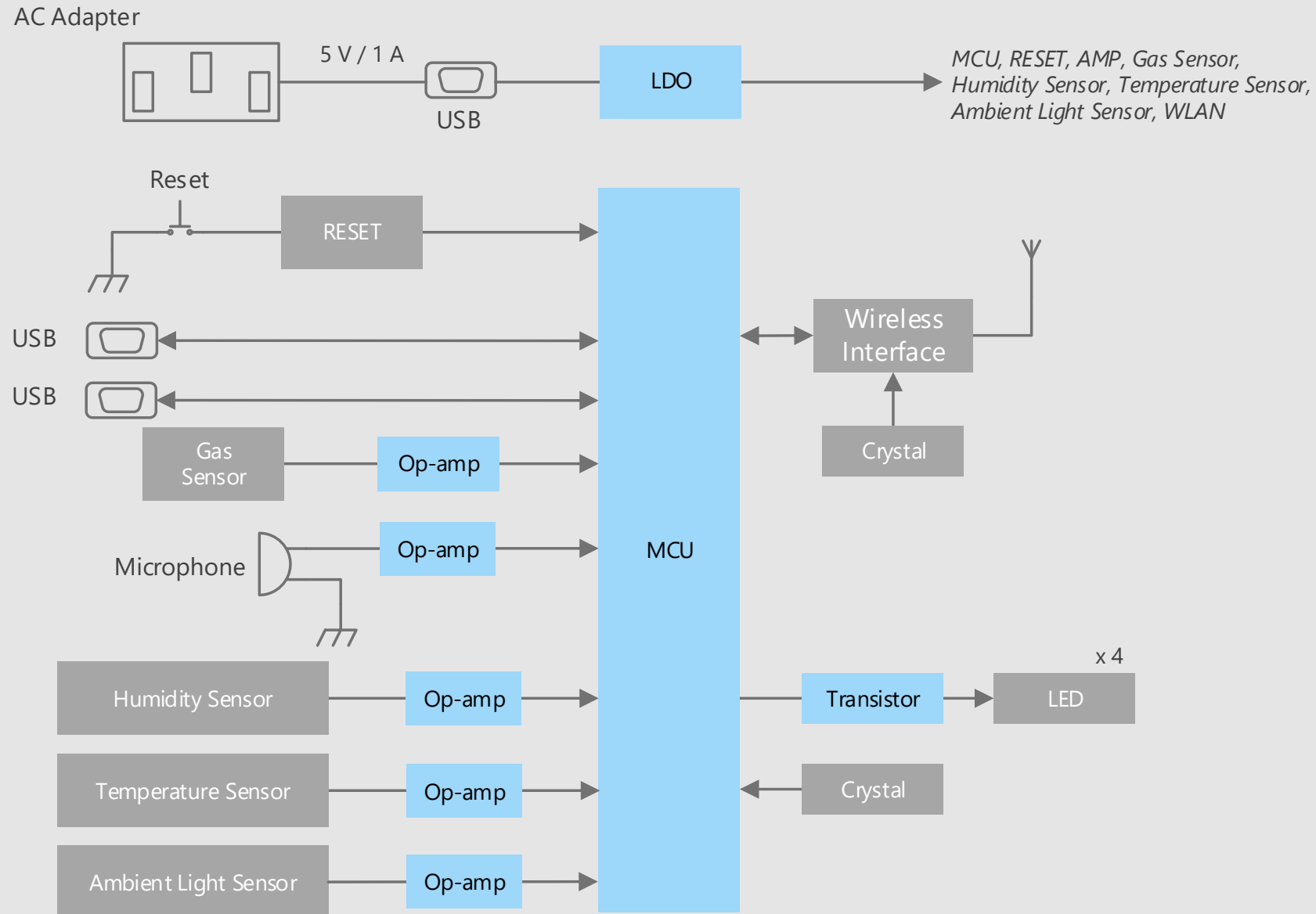
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.



Block Diagram

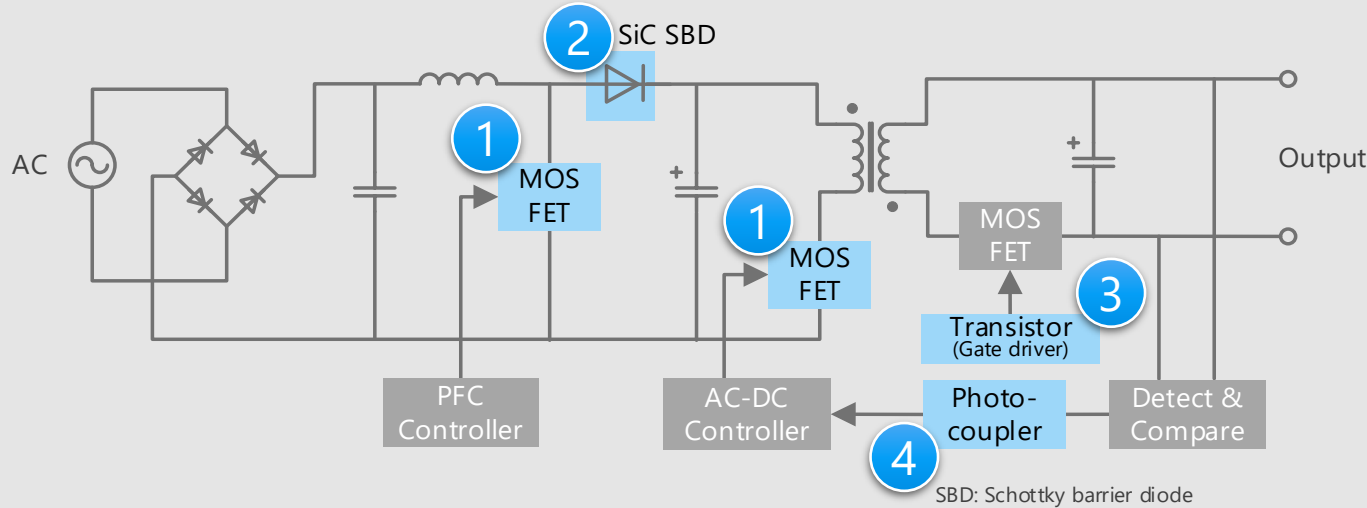


IoT Sensor Overall block diagram

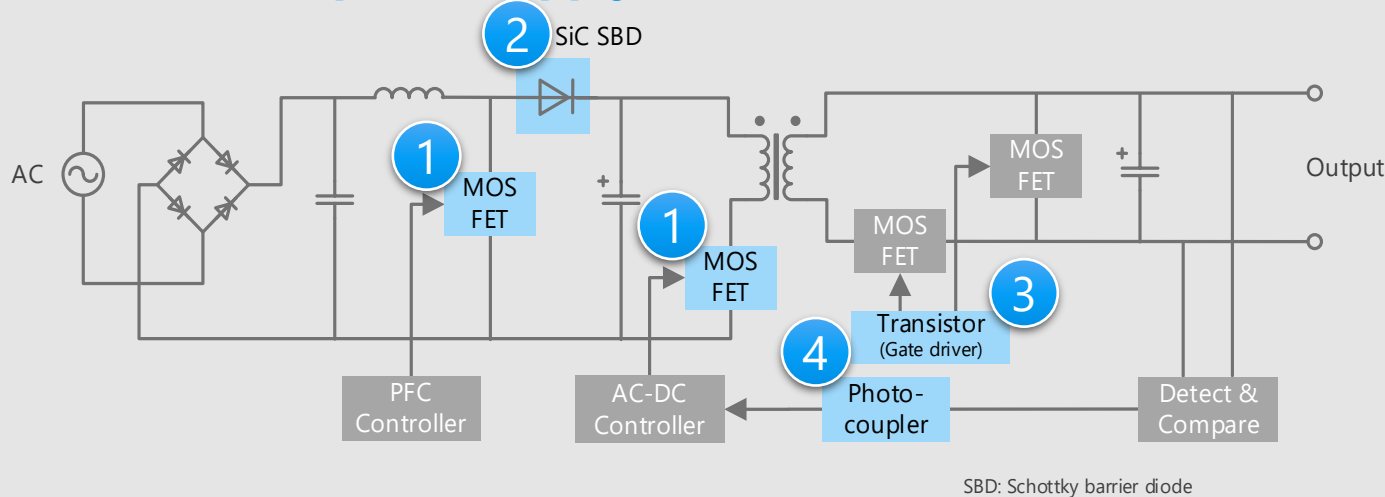


IoT Sensor Detail of power supply unit

AC-DC flyback power supply



AC-DC forward power supply



Criteria for device selection

- High voltage MOSFETs are suitable for primary side of AC-DC converters.
- SiC type Schottky barrier diodes are suitable for PFC circuits.

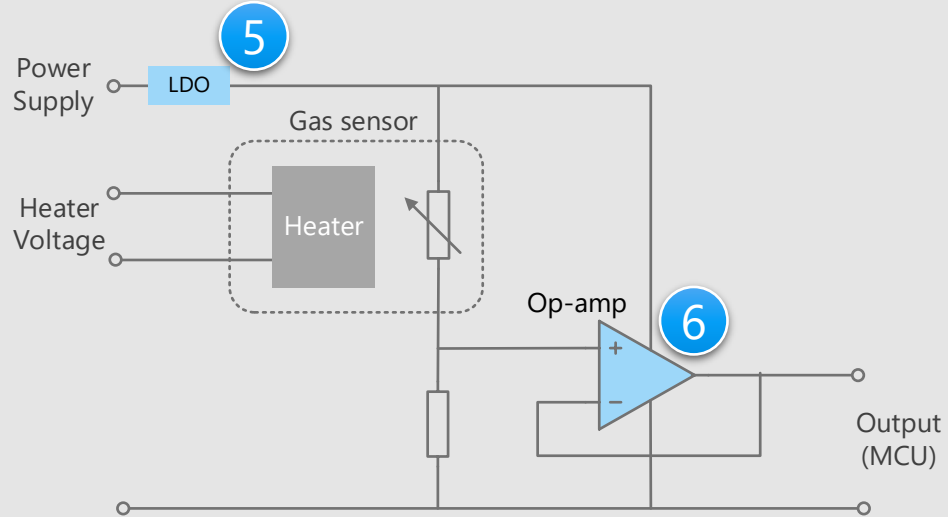
Proposals from Toshiba

- **Suitable for high efficiency power supply switching**
MOSFET ①
- **High current surge resistance and low switching loss**
SiC Schottky barrier diode ②
- **Suitable for high speed gate driving of MOSFET**
Bipolar transistor (Gate driver) ③
- **Suitable for power supply feedback circuit**
IC output photocoupler ④

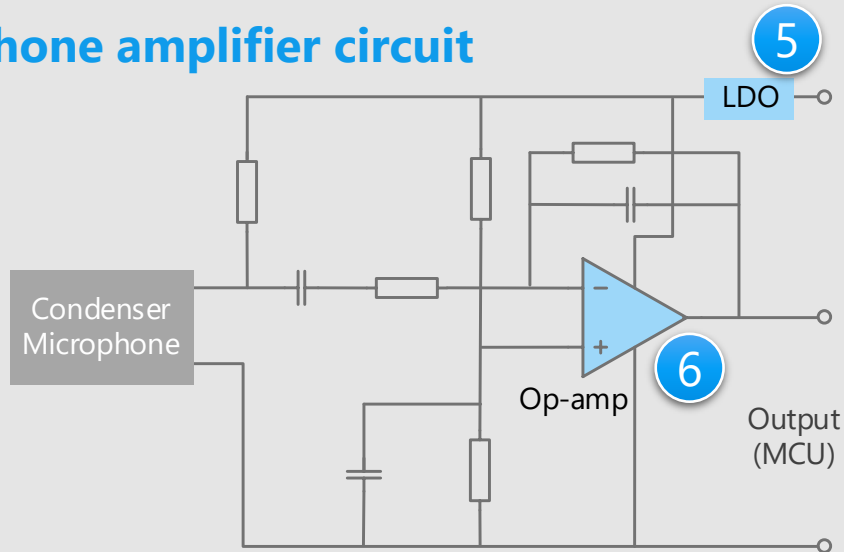
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

IoT Sensor Detail of sensor units

Gas detection circuit



Microphone amplifier circuit



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.
- Small package products contribute to the reduction of circuit board area.

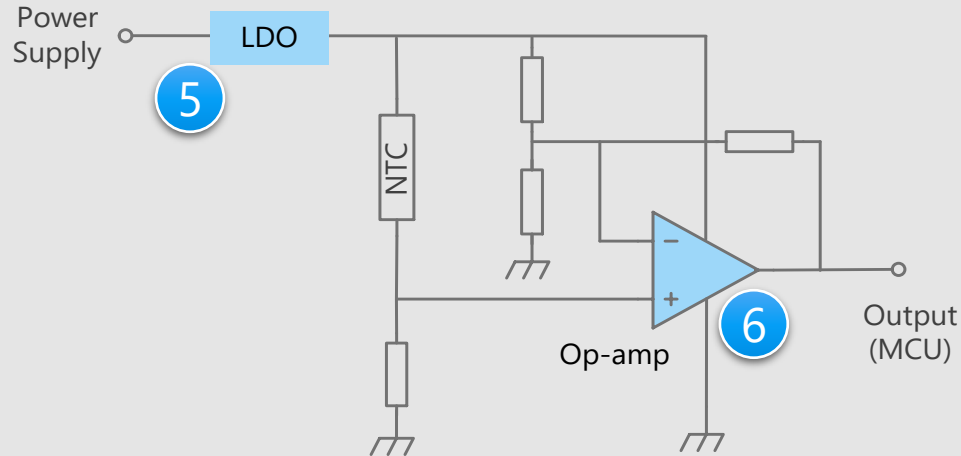
Proposals from Toshiba

- **Supply the power with low noise**
Small surface mount LDO regulator 5
- **Amplification of detected very small signals**
Low current consumption op-amp / Low noise op-amp 6

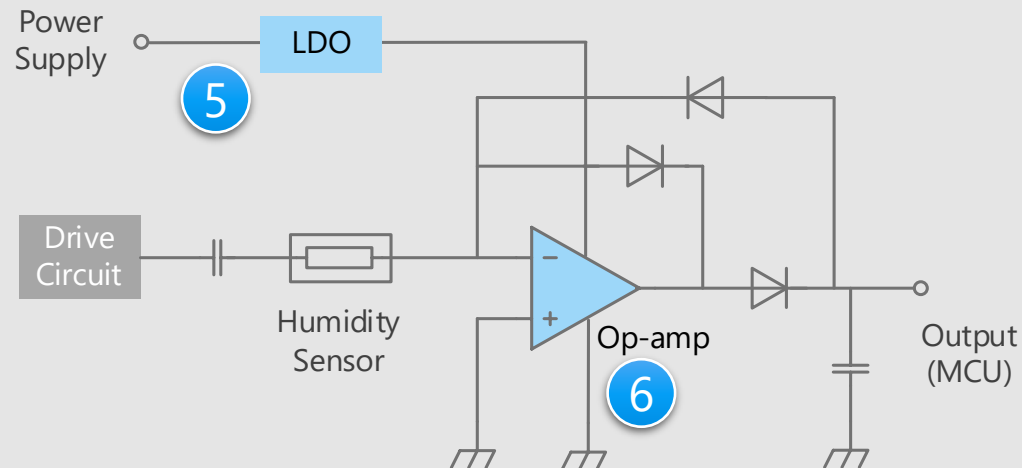
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

IoT Sensor Detail of sensor units

Temperature detection circuit



Humidity detection circuit



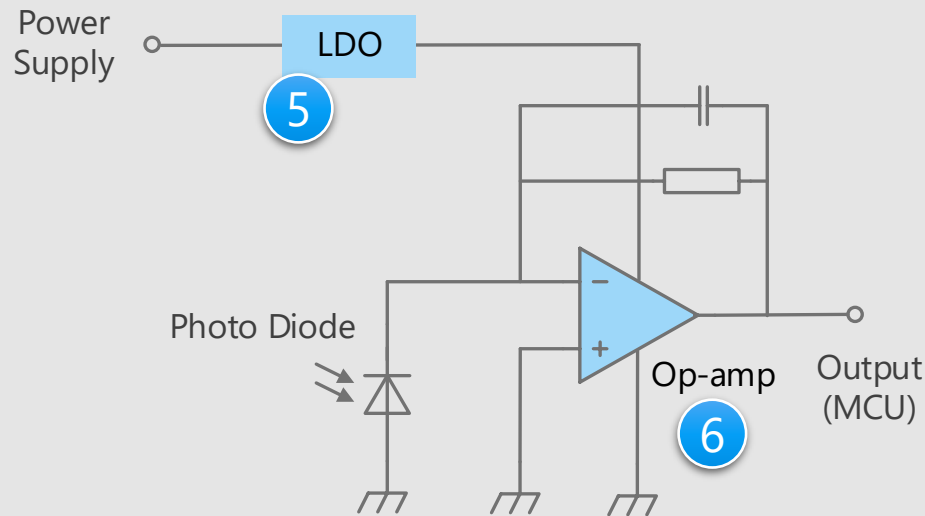
Criteria for device selection

- 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.
- Small package products contribute to the reduction of circuit board area.

Proposals from Toshiba

- **Supply the power with low noise**
Small surface mount LDO regulator (5)
- **Amplification of detected very small signals**
Low current consumption op-amp / Low noise op-amp (6)

Ambient light detection circuit



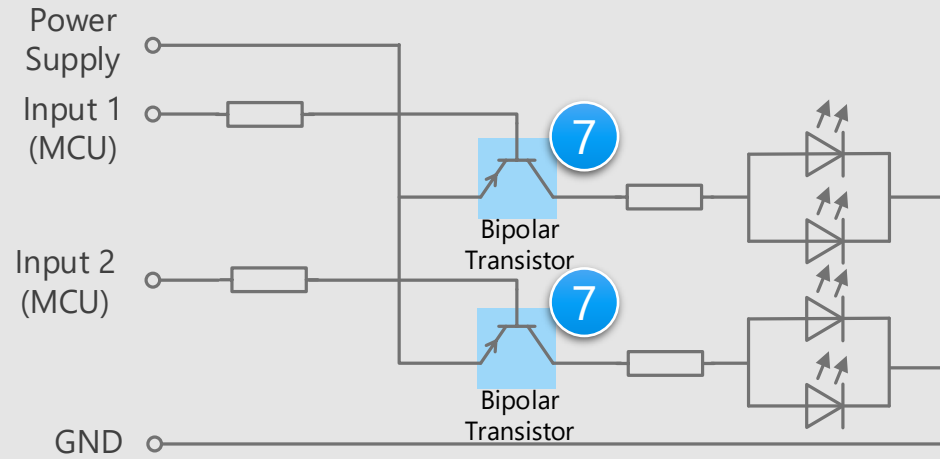
Criteria for device selection

- 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.
- Small package products contribute to the reduction of circuit board area.

Proposals from Toshiba

- **Supply the power with low noise**
Small surface mount LDO regulator 5
- **Amplification of detected very small signals**
Low current consumption op-amp /
Low noise op-amp 6

LED drive circuit



Criteria for device selection

- Small package products contribute to the reduction of circuit board area.

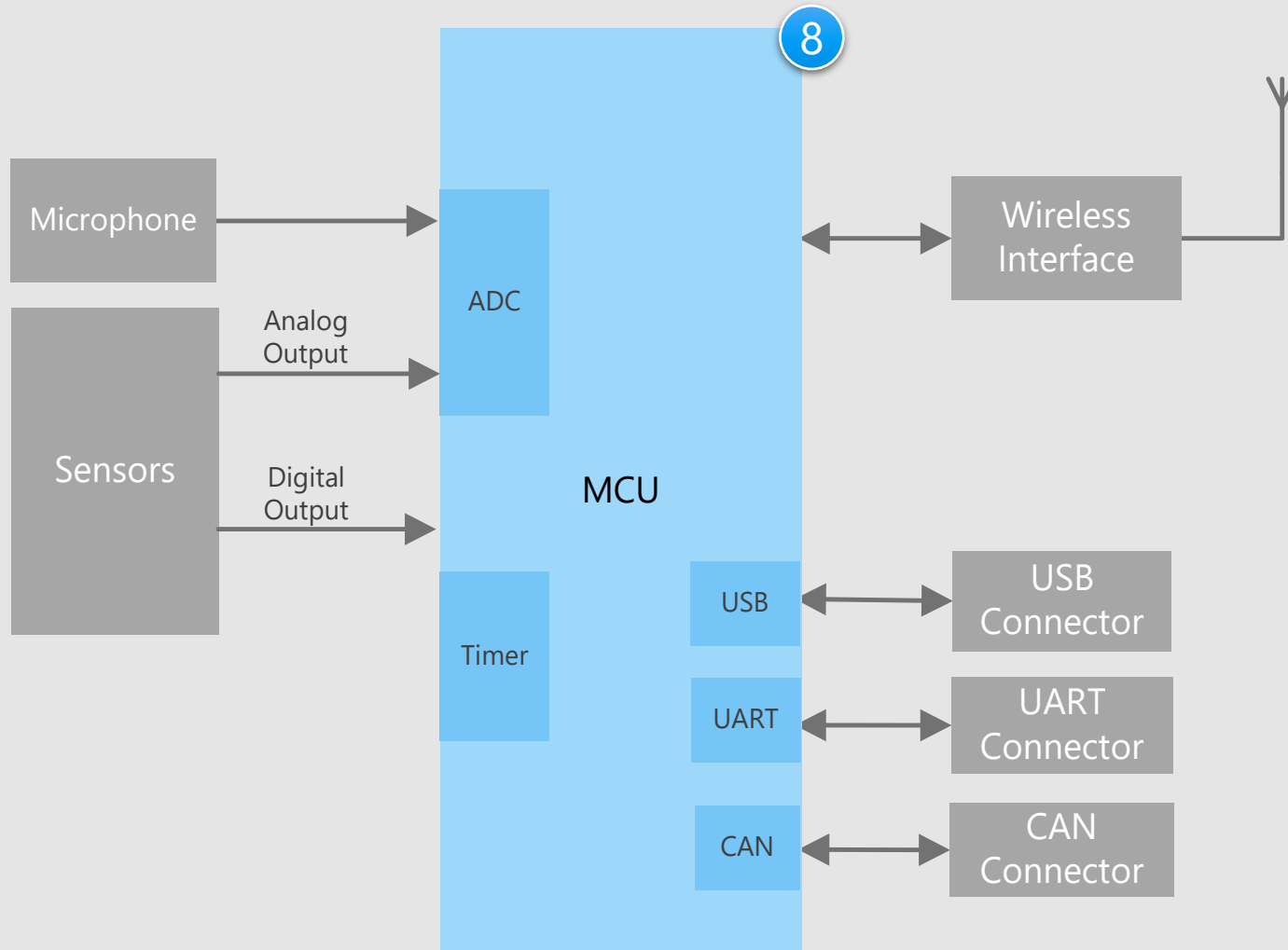
Proposals from Toshiba

- **Small package products with high breakdown voltage and high h_{FE}**
Bipolar transistor

7

IoT Sensor Detail of main control unit

Main control section



Criteria for device selection

- Multi-channel analog or digital interfaces are needed for monitoring various sensor output.
- High performance of data processing is required to analyze sensor data in real time.
- The communication channel is required to upload sensor data and analysis results to the cloud.

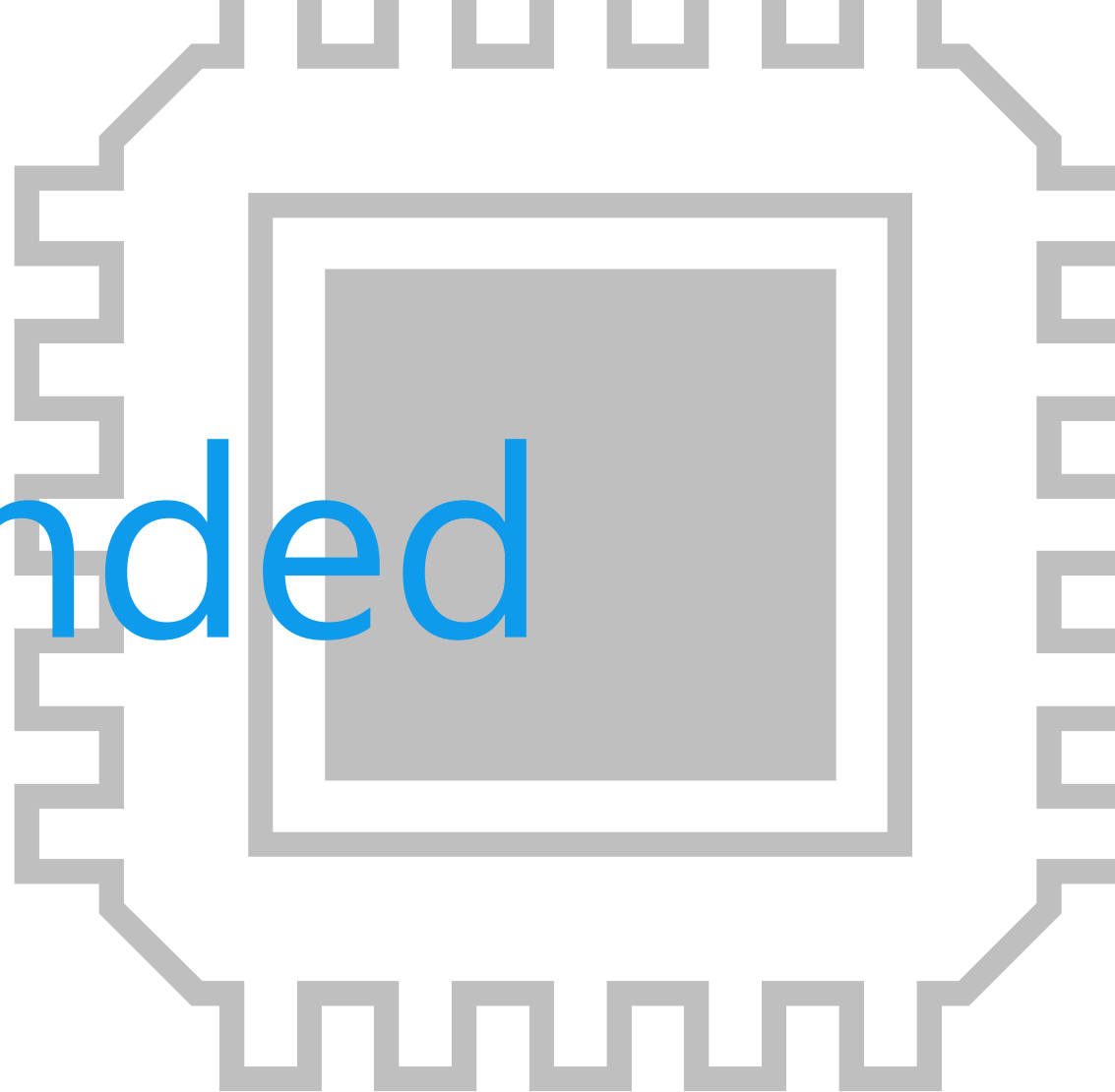
Proposals from Toshiba

- **High processing performance MCU supports multi-channel sensor interfaces and various communication standards**

MCU M4N Group

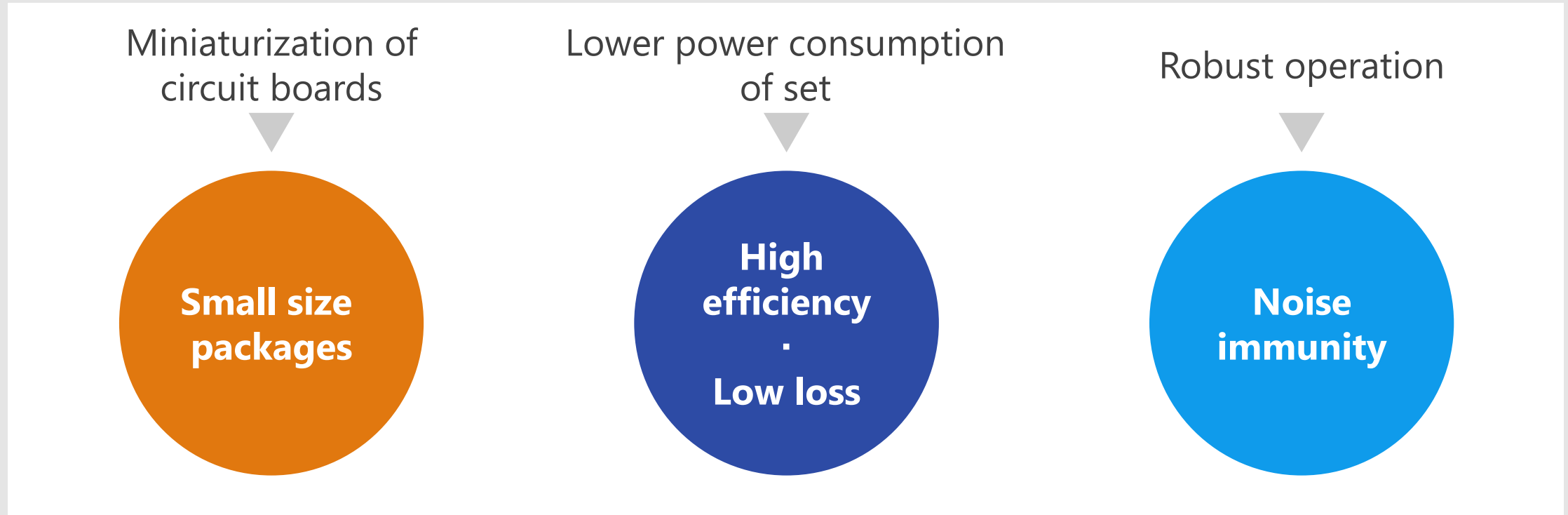
8

Recommended Devices



Device Solutions to address customer needs

As described above, in the design of IoT sensor, "**Miniaturization of circuit boards**", "**Low power consumption of set**" and "**Robust operation**" are important factors. Toshiba's proposals are based on these three solution perspectives.



Device Solutions to address customer needs

	Small size packages	High efficiency · Low loss	Noise immunity
① MOSFET	●	●	●
② SiC Schottky barrier diode	●	●	●
③ Bipolar transistor (Gate driver)	●	●	●
④ IC output photocoupler	●	●	●
⑤ Small surface mount LDO regulator	●	●	●
⑥ Low current consumption op-amp / Low noise op-amp	●	●	
⑦ Bipolar transistor	●		●
⑧ MCU M4N Group		●	

Value provided

Suitable for switching regulators and easy to handle and contributes to miniaturization.

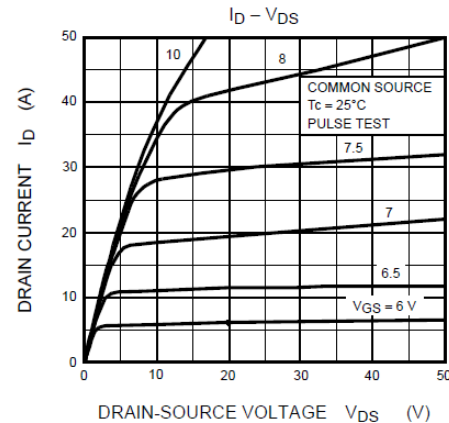
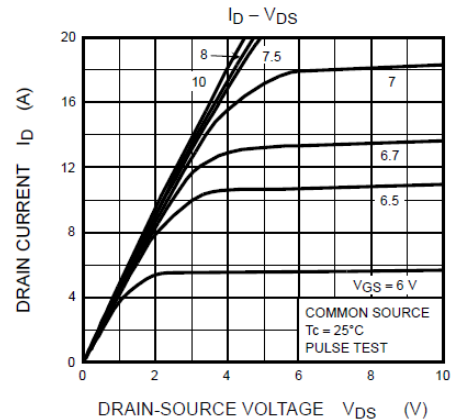
1 Low on-resistance

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

2 Low leakage current

Drain leakage current
 $I_{DSS} = 10 \mu A$ (Max) (@ $V_{DS} = 500 V$)

TK18A50D Characteristics Curves



Lineup

Part number	TK18A50D	TK12P50W
Package	TO-220SIS 	DPAK 
V_{DSS} (Max) [V]	500	500
I_D (Max) [A]	18	11.5
P_D (Max) [W]	50	100
C_{iss} (Typ.) [pF]	2600	890
$R_{DS(ON)}$ (Max) [Ω]	0.27	0.34
Polarity	N-ch	N-ch

[Return to Block Diagram TOP](#)

Value provided

SiC SBDs ^[Note1] with low loss and high efficiency are realized by adopting new metal and optimizing device design.

[Note1] SBD: Schottky barrier diode

1 Low forward voltage (V_F)

For the new products, new metal and thin wafer technology are introduced. $V_F = 1.2$ V (Typ.) is realized as compared with $V_F = 1.45$ V (Typ.) of our existing products. V_F is reduced by about 17%.

2 Improvement of power supply efficiency

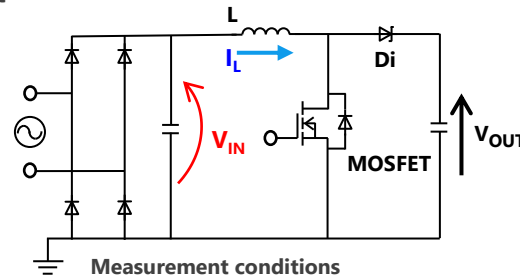
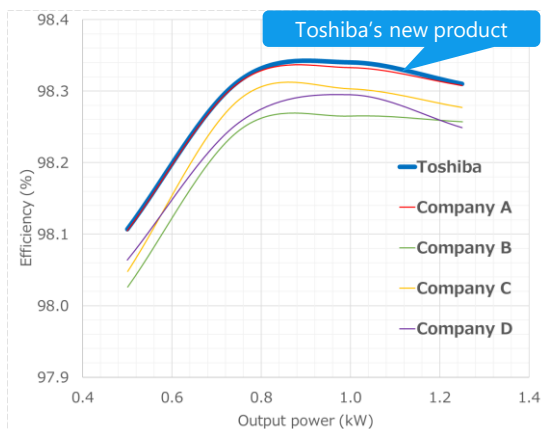
Compared with our existing products, the trade off of $V_F \times Q_C$ ^[Note2] of the new products have improved. About 0.1% of conversion efficiency improvement have also achieved under 800 W output condition in our test.

[Note2] The $V_F \times Q_C$ (product of forward voltage and total charge) is an index representing the loss performance of the SiC SBD. When comparing the products with the same current rating, the smaller the index, the lower the loss.

3 Expansion of package series

In addition to the existing package series, DFN8x8 surface mount package type has prepared. It contributes to miniaturization and high power density of equipment.

Comparison between Toshiba's new product and competitor products



Measurement conditions

 $V_{IN} = 200$ V AC $V_{OUT} = 400$ V DC $f = 65$ kHz

MOSFET: TK040Z65Z

MOSFET external gate resistance = 4.7 Ω $T_a = 25$ °C

(Toshiba internal comparison, as of November 2021)

Lineup

Part number	TRS12A65F	TRS24N65FB	TRS2E65H *	TRS12E65H *	TRS4V65H *	TRS12V65H *
Package	 TO-220F-2L	 TO-247 (Center tap)	 TO-220-2L		 DFN8x8	
V_{RRM} [V]	650	650	650	650	650	650
$I_{F(DC)}$ [A]	12	12 / 24 **	2	12	4	12
I_{FSM} [A]	92	92 / 184 **	19	74	28	60
V_F (Typ.) [V]	1.45 @ $I_F = 12$ A	1.45 @ $I_F = 12$ A	1.2 @ $I_F = 2$ A	1.2 @ $I_F = 12$ A	1.2 @ $I_F = 4$ A	1.2 @ $I_F = 12$ A

*: New product

**: Per Leg / Both Legs

[Return to Block Diagram TOP](#)

3 Bipolar transistor (Gate driver) HN4B101J / HN4B102J

Small size
packages

High
efficiency
·
Low loss

Noise
immunity

Value provided

Bipolar transistor suitable for MOSFET gate driving.

1 High speed switching

HN4B101J

$t_f = 45 / 50$ ns (Typ.) (PNP / NPN)

HN4B102J

$t_f = 40 / 45$ ns (Typ.) (PNP / NPN)

2 High DC current gain

HN4B101J, HN4B102J

PNP: $h_{FE} = 200$ to 500

NPN: $h_{FE} = 200$ to 500

3 Low collector-emitter saturation voltage

HN4B101J

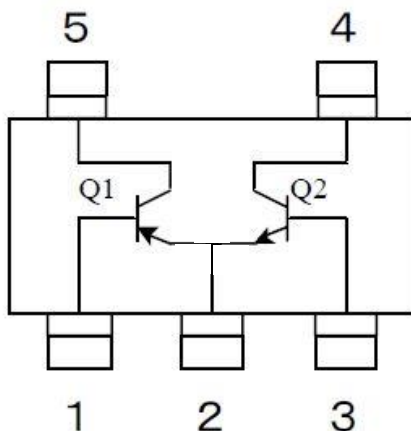
$V_{CE(sat)} = -0.20 / 0.17$ V (Max) (PNP / NPN)

HN4B102J

$V_{CE(sat)} = -0.20 / 0.14$ V (Max) (PNP / NPN)

HN4B101J / HN4B102J

Circuit configuration



Lineup

Part number	HN4B101J	HN4B102J
Package	SMV 	SMV 
V_{CEO} [V] @Q1 / Q2	-30 / 30	-30 / 30
I_C [A] @Q1 / Q2	-1.0 / 1.2	-1.8 / 2
h_{FE} (Min / Max)	200 / 500	200 / 500
Polarity	Q1: PNP + Q2: NPN	Q1: PNP + Q2: NPN

[◆Return to Block Diagram TOP](#)

Value provided

This photocoupler combines an infrared light emitting diode with high optical output power and a light receiving IC chip with high gain and high speed.

1 Analog output

The output current changes in an analog manner according to the input LED current. It is suitable for power supply feedback circuits.

2 Common mode transient immunity 15 kV/μs (TLP2309)

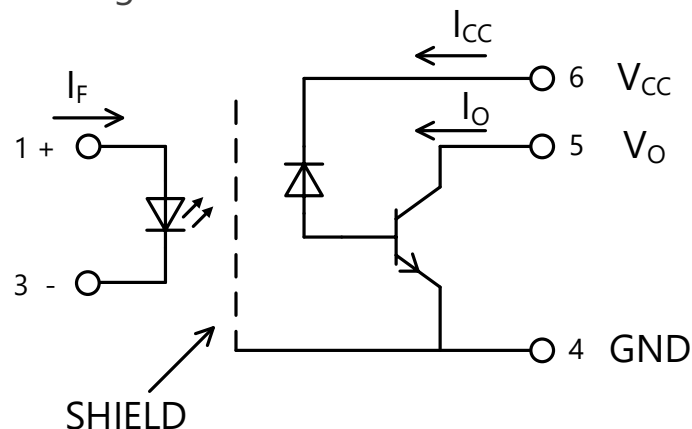
For applications where high dV/dt is applied to both ends of the photocoupler, high CMTI [Note] is required. Our device realizes the CMTI of 15 kV/μs (Min) by adapting shield between the input and output. (TLP2309)

[Note] Common Mode Transient Immunity

3 High speed

Propagation delay time is 1 μs (Max) in operation temperature range. The design is easier than when using our transistor output photocoupler. (TLP2309)

Internal circuit configuration



Lineup

Part number	TLP2309	TLP2719(LF4)
Package	5pin SO6 	SO6L(LF4) 
BV_S [Vrms]	3750	5000
NRZ (Typ.) [Mbps]	1	1
CM_H, CM_L (Min) [kV/μs]	±15	±10

[Return to Block Diagram TOP](#)

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 latest process significantly improved the dropout voltage characteristics.

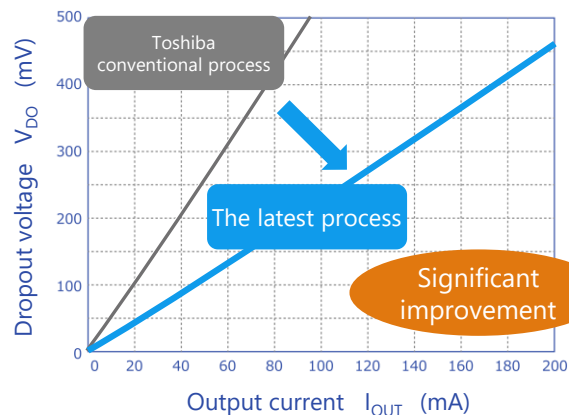
2 High PSRR Low output noise voltage

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

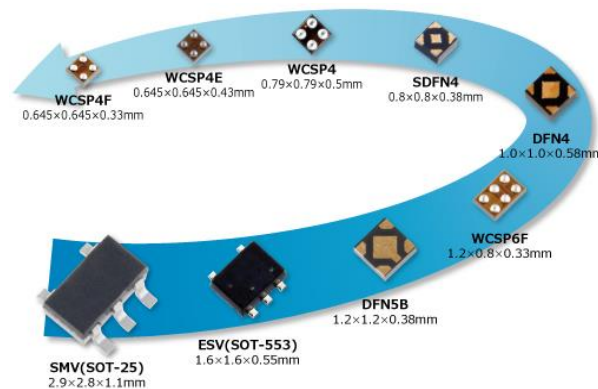
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

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](#)

Value provided

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

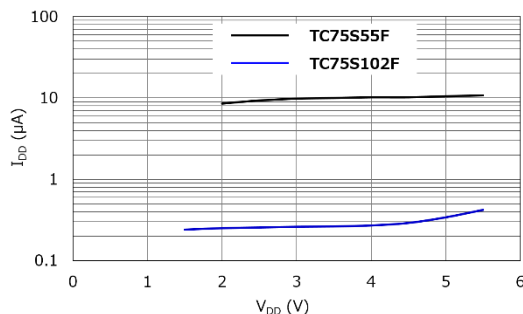
1 Low voltage operation

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

TC75S102F

Current Consumption Characteristic
(Toshiba internal comparison)

Low current consumption product TC75S102F



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 IoT equipment.

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

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.

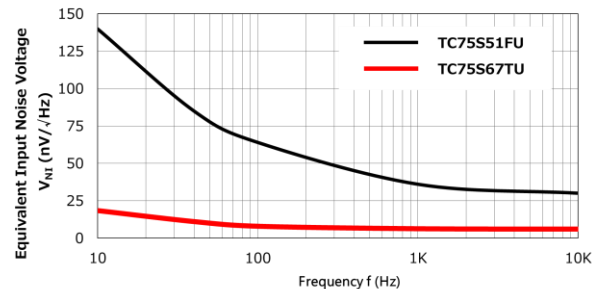
[Note] Sensor types: vibration, shock, acceleration, pressure, infrared, temperature, etc.

TC75S67TU

Noise Characteristic
(Toshiba internal comparison)

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

$V_{NI} - f$ @ $T_a = 25^\circ\text{C}$, $V_{DD} = 3.3 \text{ V}$



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 (@ $V_{DD} = 2.5 \text{ V}$)
I_{DD} (Typ. / Max) [μA]	0.27 / 0.46 (@ $V_{DD} = 1.5 \text{ V}$)	430 / 700 (@ $V_{DD} = 2.5 \text{ V}$)
V_{NI} (Typ.) [$\text{nV}/\sqrt{\text{Hz}}$] @ $f = 1 \text{ kHz}$	-	6

[Return to Block Diagram TOP](#)

Value provided

With wide product lineup, Toshiba provides products that meet the needs of customers.

1 High voltage

V_{CEO} can be applied up to -50 V (Max).

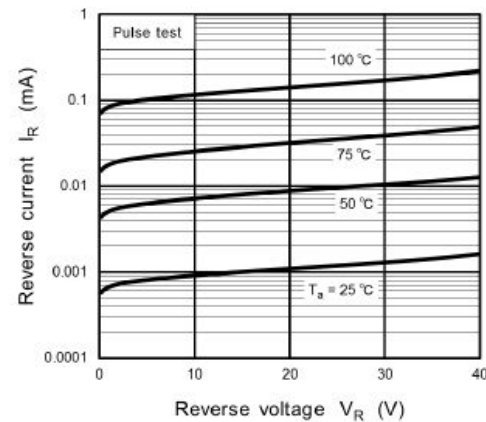
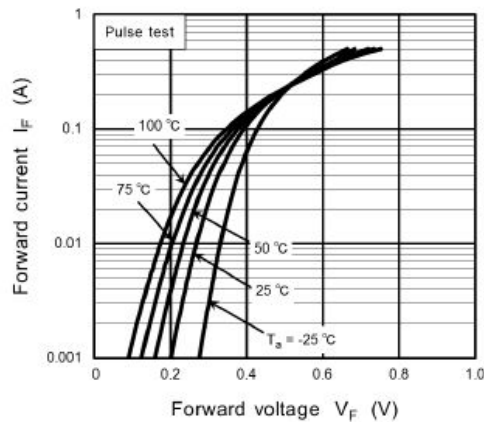
2 Complementary products

It is complementary to 2SC3325.

3 High collector current

I_C can be applied up to -500 mA (Max).

2SA1313 Characteristics



Lineup

Part number	2SA1313
Package	S-Mini 
V_{CEO} [V]	-50
I_C [mA]	-500
P_C [mW]	200
Polarity	PNP

[Return to Block Diagram TOP](#)

Value provided

Monitoring sensor at low power consumption by using built-in AD converters, timers and various communication interfaces.

1 Built-in Arm® Cortex®-M4 CPU core

The product lineup is equipped with Arm Cortex-M4 core (maximum operation frequency of 200 MHz). It is suitable for processing sensor data at real time. Various development tool and their partners allow users many options.

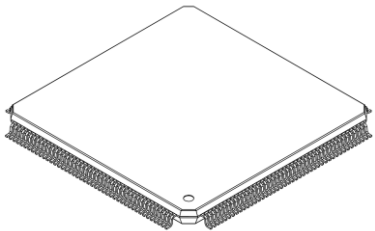
2 System cost down and development efficiency improvement

These products execute sensing data monitoring and processing efficiently by combining built-in multi-channel AD converters and timers. In addition, M4N Group has a lineup of 20 products to provide suitable products for the set.

3 Various communication interfaces

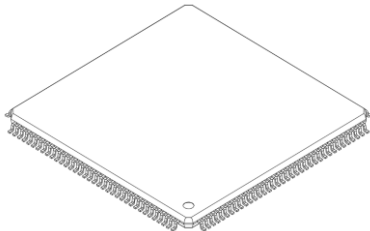
These products support major communication interfaces such as UART, FUART, TSPI, TSSI, I²C, CAN, USB and ethernet controller (ETHM). User can construct a communication system easily with a cloud.

TMPM4NRF**FG



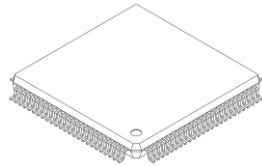
P-LQFP176-2020-0.40-002

TMPM4NQF**FG



P-LQFP144-2020-0.50-002

TMPM4NNF**FG



P-LQFP100-1414-0.50-002

Lineup

Part number	TMPM4NRF20/15/10/DFG TMPM4NRF20/15/10/DXBG	TMPM4NQF20/15/10/DFG TMPM4NQF20/15/10/DXBG	TMPM4NNF20/15/10/DFG
Operation frequency	200 MHz (Max)		
Flash ROM	Code: 2048/1536/1024/512 KB + Data: 32 KB		
RAM	256 KB + 2 KB (Backup RAM)		
Timer	32bit x 16ch (16bit x 32ch)		
AD converter	24ch (12bit)		16ch (12bit)
Communication interface	UART: 6ch, FUART: 2ch, I ² C: 5ch, TSPI: 9ch, TSSI: 2ch		UART: 3ch, FUART: 1ch, I ² C: 3ch, TSPI: 5ch, TSSI: 1ch
	CAN: 2 units, USB: 2 units, ETHM: 1 unit		CAN: 2 units, USB: 1 unit, ETHM: 1 unit
Package	P-LQFP176-2020-0.40-002	P-LQFP144-2020-0.50-002	P-LQFP100-1414-0.50-002
	P-VFBGA177-1313-0.80-001	P-VFBGA145-1212-0.80-001	

[◆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:

Contact address: <https://toshiba.semicon-storage.com/ap-en/contact.html>



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