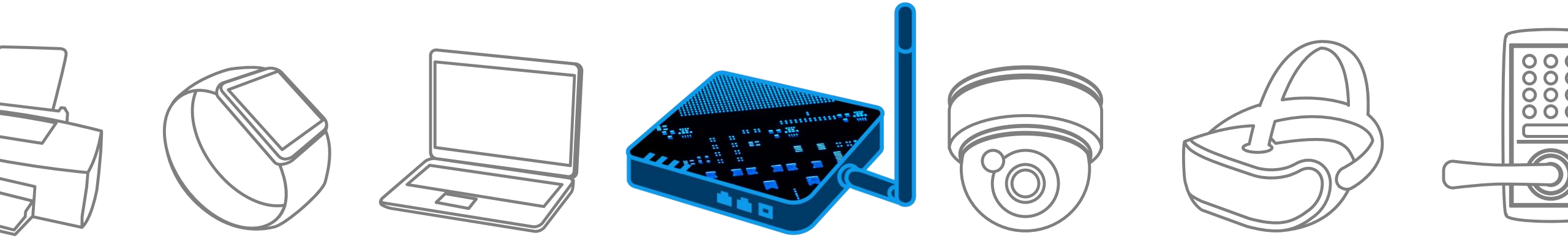
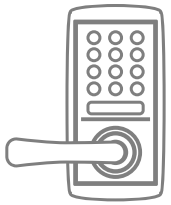
TOSHIBA

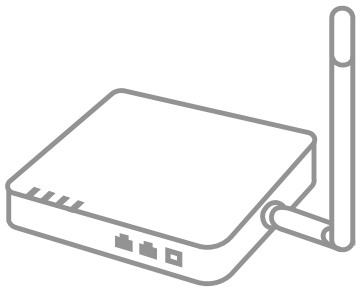
R23

IoT Sensor

Solution Proposal by Toshiba

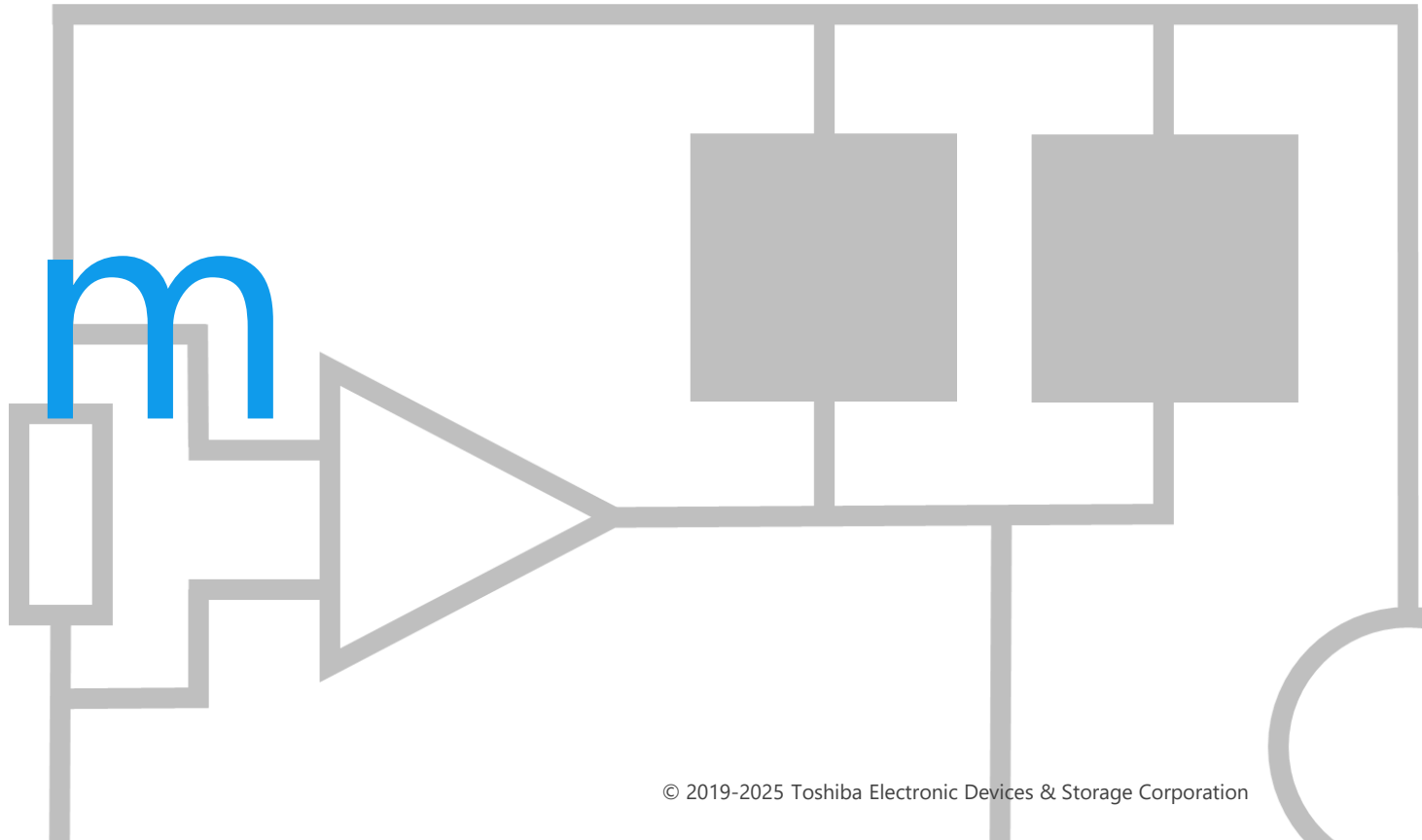




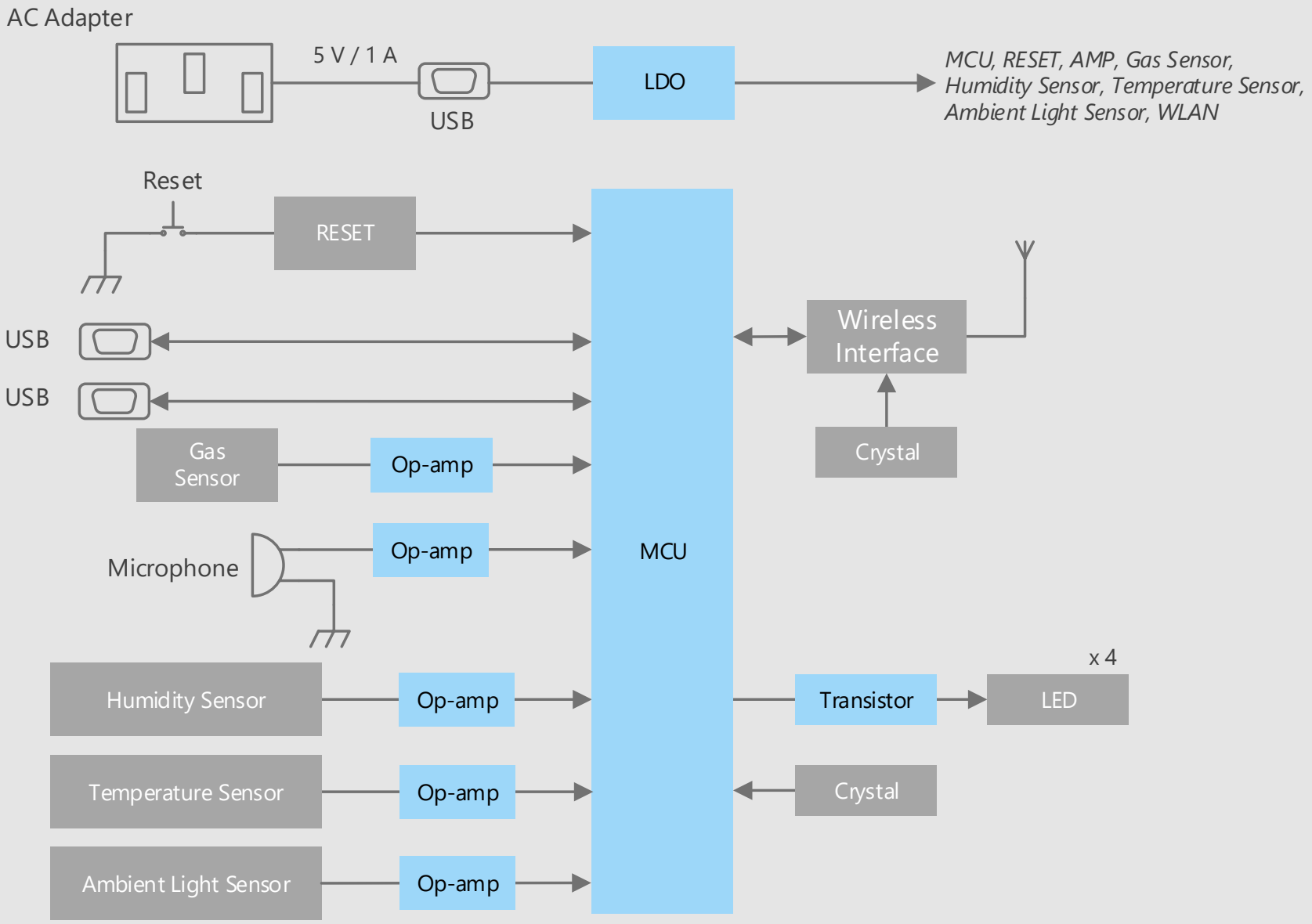


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

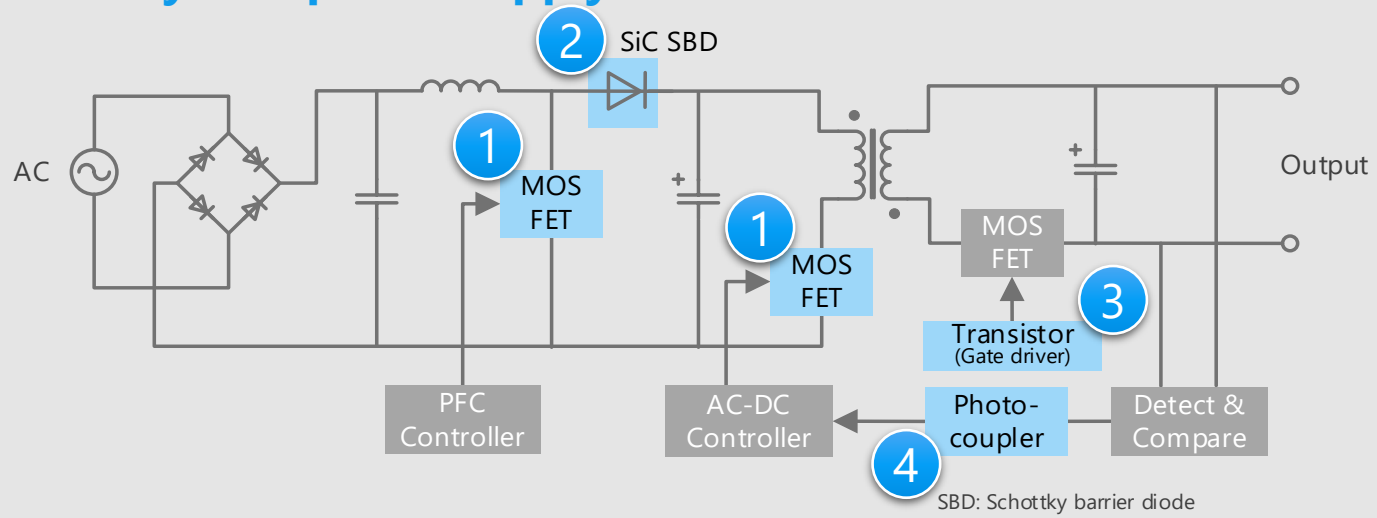


IoT Sensor　Overall block diagram



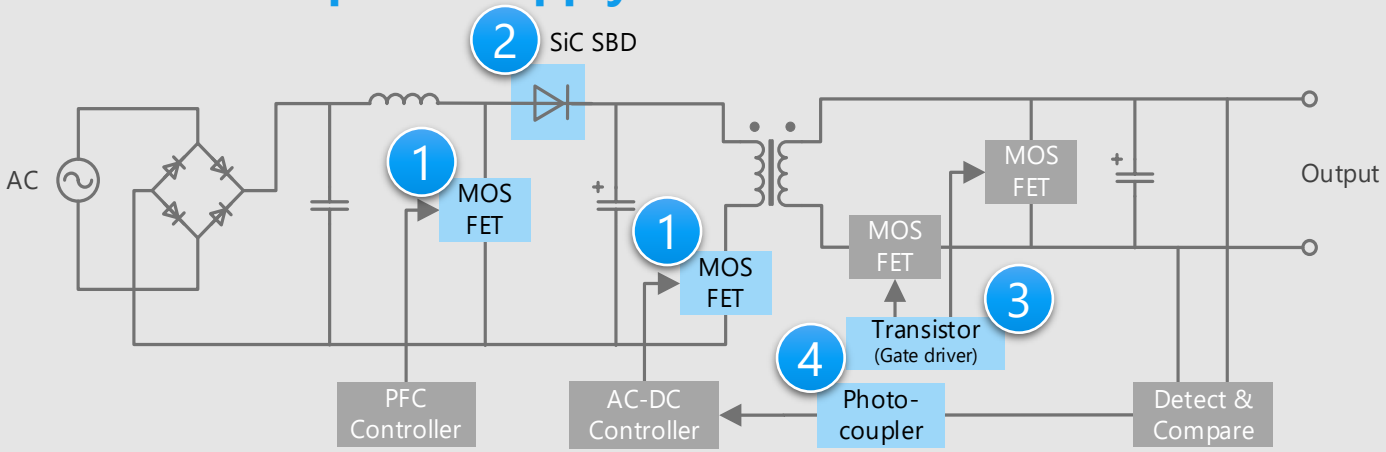
IoT Sensor　Detail of power supply unit

AC-DC flyback power supply



SBD: Schottky barrier diode

AC-DC forward power supply



SBD: Schottky barrier diode

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

Criteria for device selection

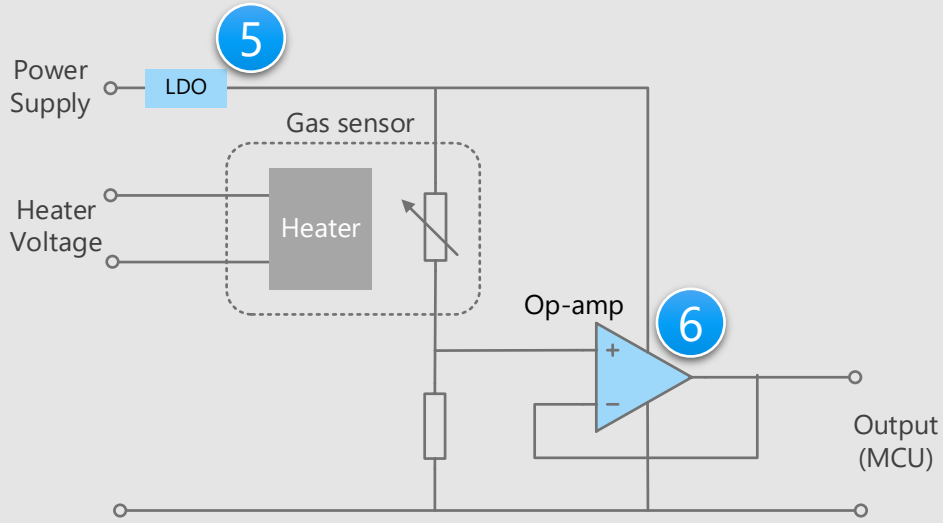
- High voltage MOSFETs are suitable for primary side of AC-DC converters.
- SiC type Schottky barrier diodes are suitable for PFC circuits.

Proposals from Toshiba

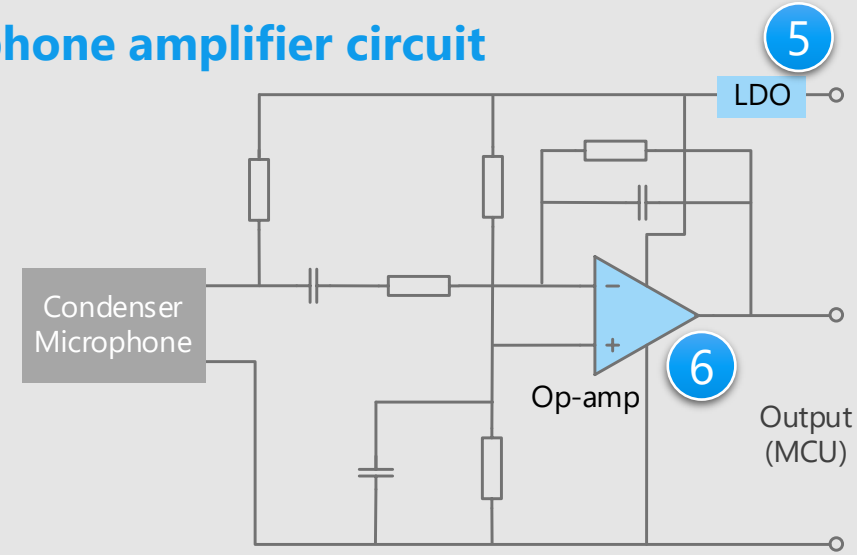
- **Suitable for high efficiency power supply switching**
  MOSFET (1)
- **High current surge resistance and low switching loss**
  SiC Schottky barrier diode (2)
- **Suitable for high speed gate driving of MOSFET**
  Bipolar transistor (Gate driver) (3)
- **Suitable for power supply feedback circuit**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

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.

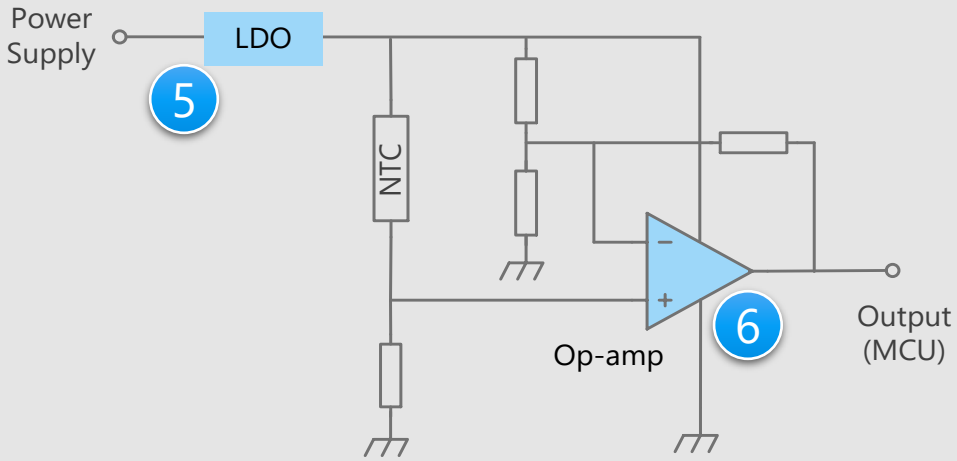
Proposals from Toshiba

- **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

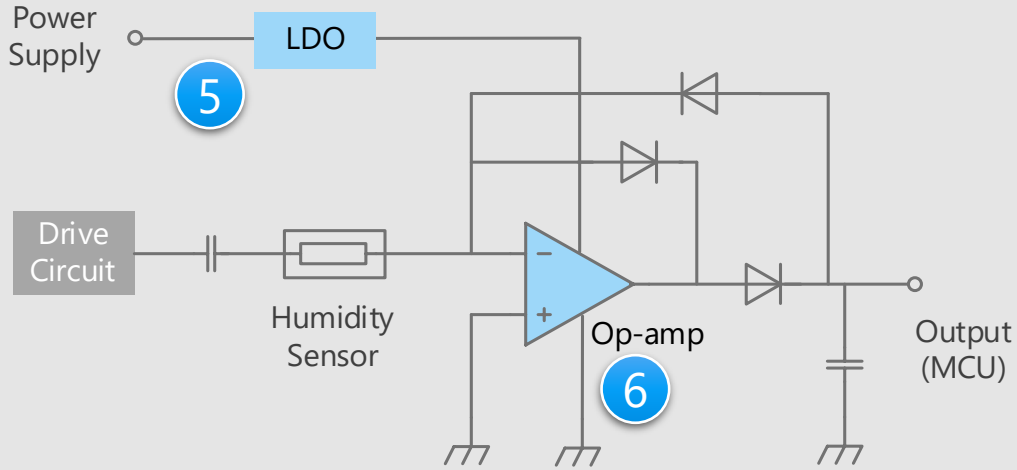
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

IoT Sensor　Detail of sensor units

Temperature detection circuit



Humidity detection circuit



Criteria for device selection

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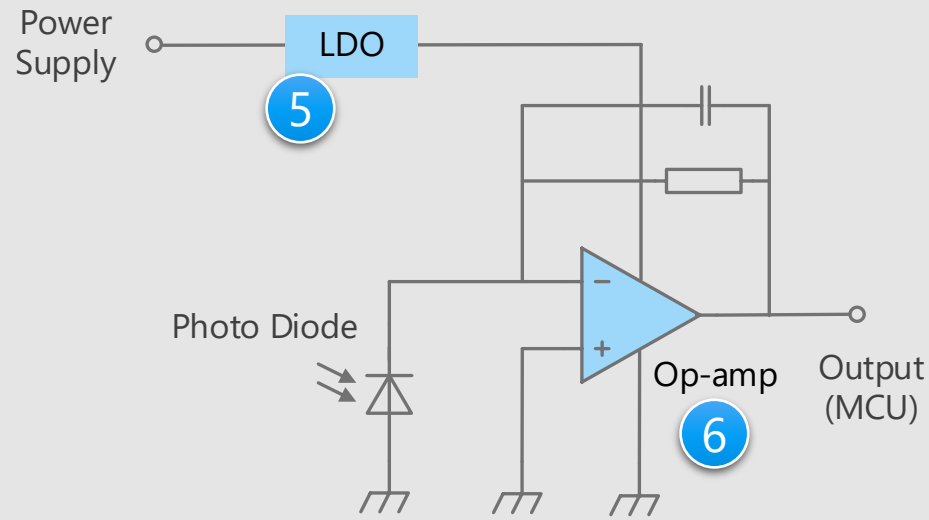
  Small surface mount LDO regulator　5
- **Amplification of detected very small signals**
  Low current consumption op-amp / Low noise op-amp　6

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

IoT Sensor　Detail of sensor unit

Ambient light detection circuit



Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor circuits.
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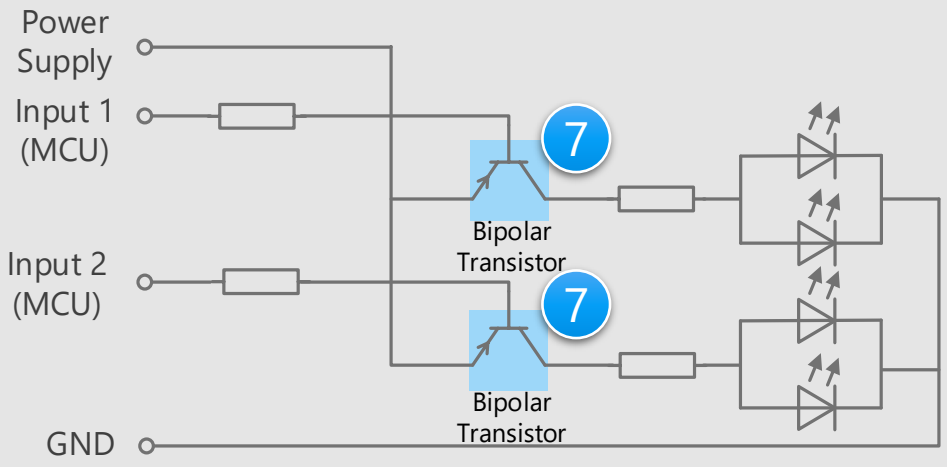
Proposals from Toshiba

- **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 LED drive unit

LED drive circuit



Criteria for device selection

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

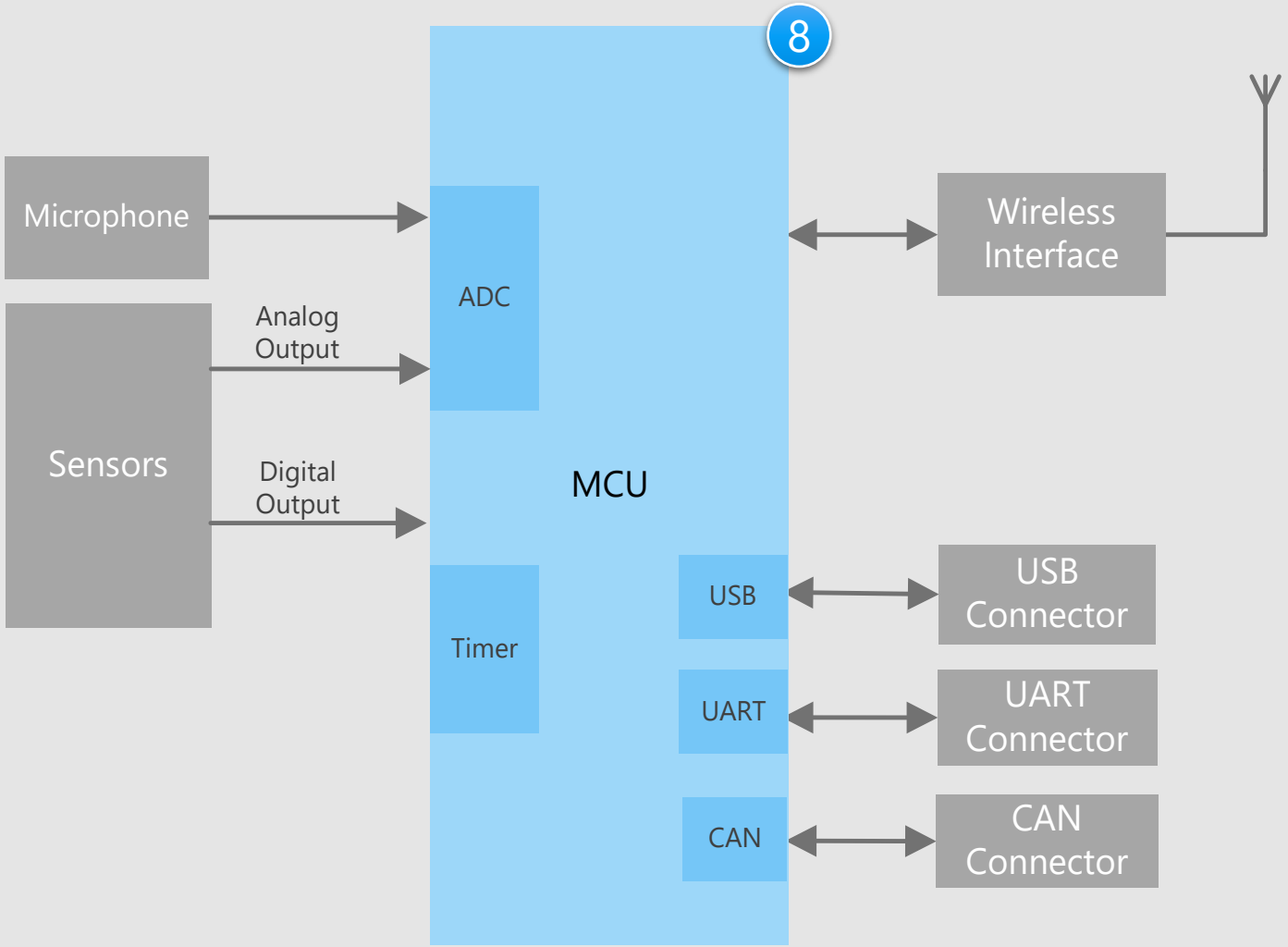
Proposal from Toshiba

- **Small package products with high breakdown voltage and high h_{FE}**
  Bipolar transistor 7

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

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.

Proposal from Toshiba

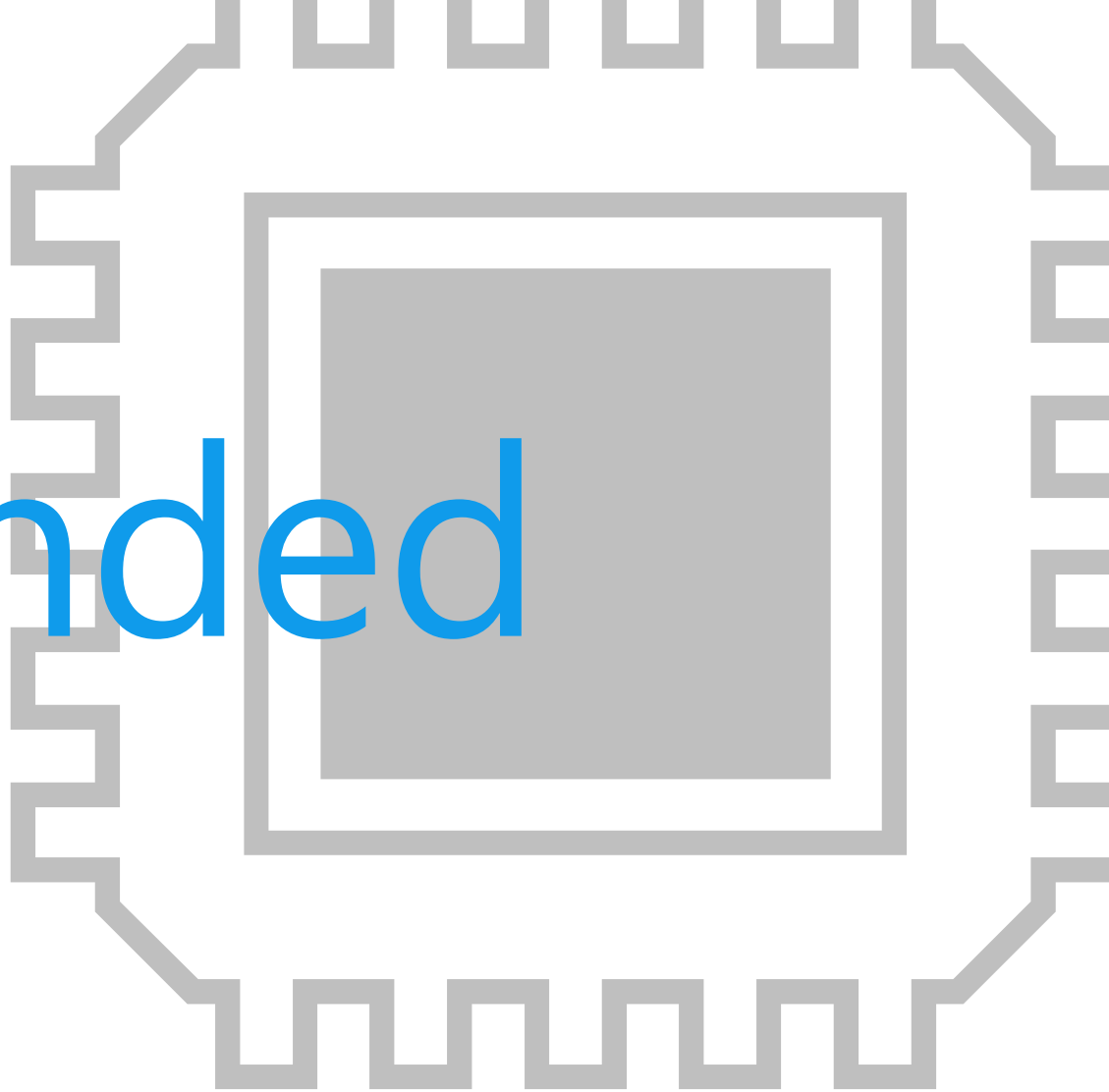
- **High processing performance MCU supports multi-channel sensor interfaces and various communication standards**

  MCU M4N Group

8

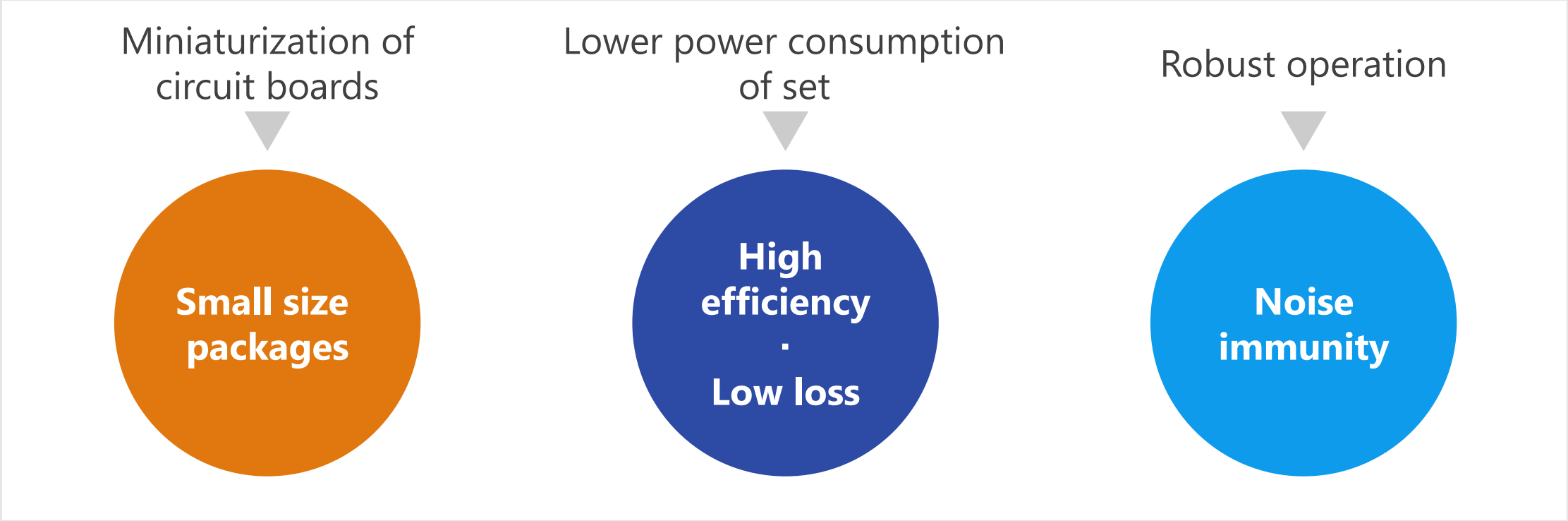
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

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.

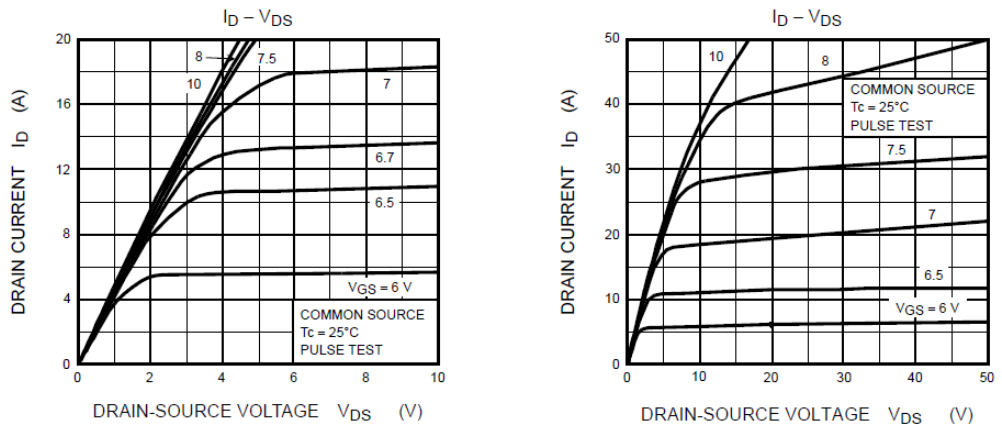
1 Low on-resistance

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

2 Low leakage current

Drain leakage current
I_{DSS} = 10 μA (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

2 SiC Schottky barrier diode

TRS24N65FB / TRS2E65H / TRS8E65H / TRS12E65H / TRS4V65H / TRS12V65H

Small size packages | High efficiency · Low loss | Noise immunity

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 third generation 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 Toshiba's existing products. V_F is reduced by about 17%.

2 Improvement of power supply efficiency

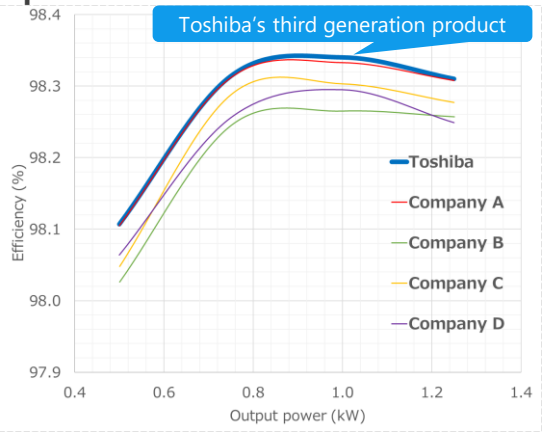
Compared with Toshiba's existing products, the trade off of V_F x Q_C [Note2] of the third generation products have improved. About 0.1% of conversion efficiency improvement have also achieved under 800 W output condition in our test.

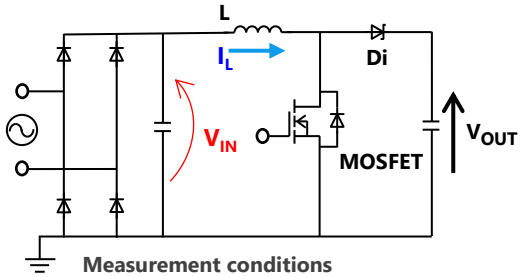
3 Expansion of package series

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

[Note2] The V_F x 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.

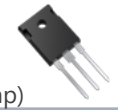
Comparison between Toshiba's third generation product and competitor products





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 July 2023)

Lineup

Part number	TRS24N65FB	TRS2E65H	TRS8E65H	TRS12E65H	TRS4V65H	TRS12V65H
Package	TO-247 (Center tap) 	TO-220-2L 			DFN8x8 	
V_{RRM} [V]	650	650	650	650	650	650
$I_{F(DC)}$ [A]	12 / 24 *	2	8	12	4	12
I_{FSM} [A]	92 / 184 *	19	56	74	28	60
V_F (Typ.) [V]	1.45 @I_F = 12 A	1.2 @I_F = 2 A	1.2 @I_F = 8 A	1.2 @I_F = 12 A	1.2 @I_F = 4 A	1.2 @I_F = 12 A

*: 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 (h_{FE})

HN4B101J, HN4B102J

PNP: h_{FE} = 200 to 500

NPN: h_{FE} = 200 to 500

3 Low collector-emitter saturation voltage

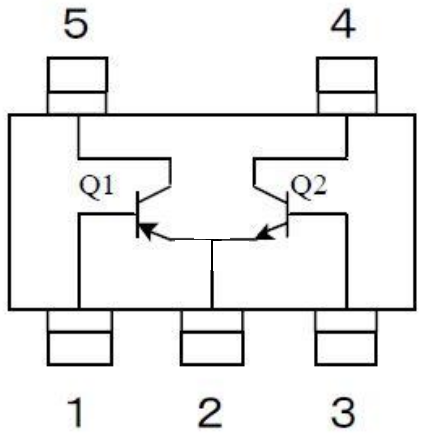
HN4B101J

$V_{CE(sat)}$ = -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

4 IC output photocoupler

TLP2309 / TLP2719(LF4)

Small size packages | High efficiency · Low loss | Noise immunity

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)

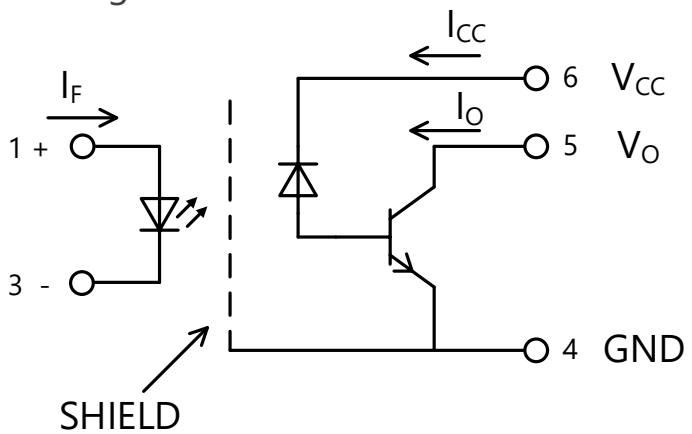
For applications where high dV/dt is applied to both ends of the photocoupler, high CMTI [Note] is required. Our device realizes the CMTI of 15 kV/μs (Min) by adapting shield between the input and output. (TLP2309)

[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 Toshiba's 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

5 Small surface mount LDO regulator

TCR15AG / TCR8BM / TCR5FM / TCR5RG / TCR3RM / TCR3U / TCR3LM / TCR3D / TCR3EM / TCR1HF Series

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

Wide lineup from general purpose type to WCSP (Wafer Level Chip Size Package) type are provided. Contribute to realize a stable power supply.

1 Low dropout voltage

Low dropout voltage characteristic has been realized by the originally developed process.

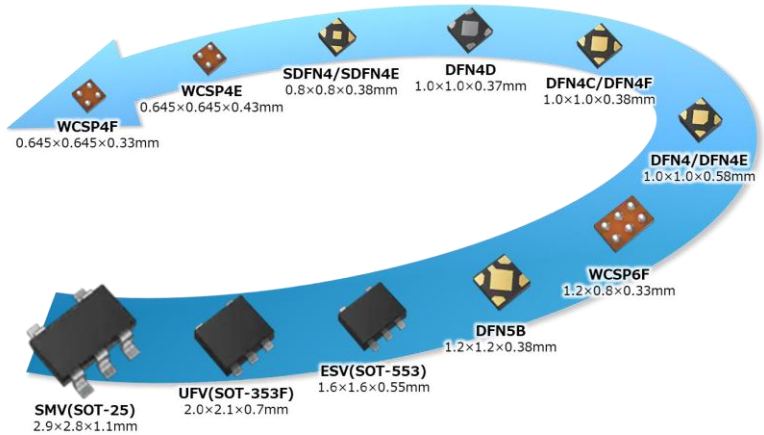
2 High PSRR Low output noise voltage

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)

Rich package lineup



Lineup

Part number	TCR15AG Series	TCR8BM Series	TCR5FM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR3LM Series	TCR3D Series	TCR3EM Series	TCR1HF Series
Features	Low dropout voltage High PSRR		High PSRR Low noise Low current consumption			Low current consumption		Standard type		36 V Input voltage
I_{OUT} (Max) [A]	1.5	0.8	0.5		0.3					0.15
PSRR (Typ.) [dB] @f = 1 kHz	95	98	91	100	100	70	-	72	68	70
I_B (Typ.) [μA]	25	20	10	7	7	0.34	1	86	35	170

◆Return to Block Diagram TOP

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

TC75S102F / TC75S67TU

Small size packages | High efficiency · Low loss | Noise immunity

Value provided

The lineup includes a low current consumption type that contributes to reducing power consumption 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 circuit.

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 of IoT equipment.

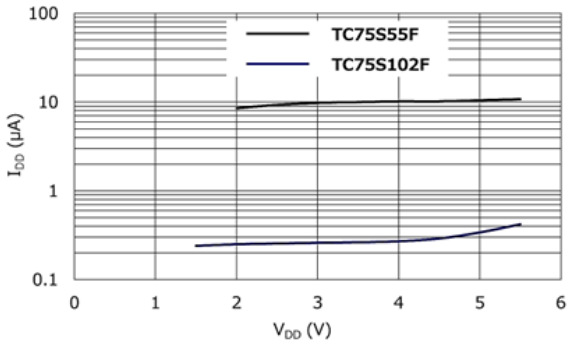
3 Low noise (TC75S67TU)

V_{NI} = 6.0 nV/√Hz (Typ.) @f =1 kHz

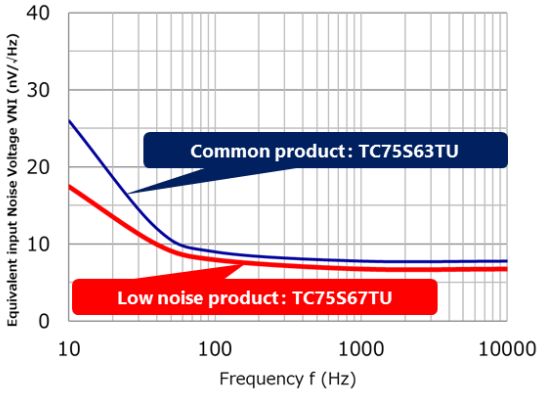
This CMOS operational amplifier can amplify minute signals detected by various sensors [Note] with very low noises. By optimizing the process, the equivalent input noise voltage has been reduced.

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

TC75S102F
Current Consumption Characteristic
(Toshiba internal comparison)



TC75S67TU
Noise Characteristic
(Toshiba internal comparison)



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

7 Bipolar transistor
2SA1313

Small size packages | High efficiency · Low loss | Noise immunity

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).

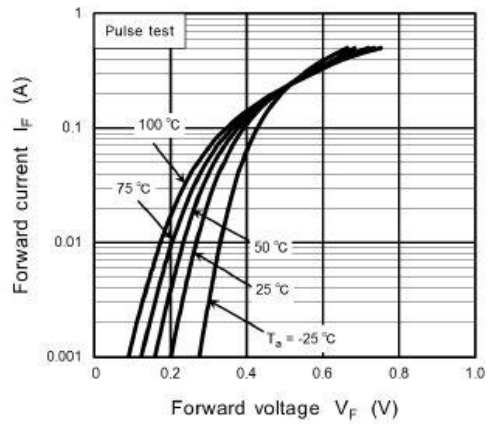
2 Complementary product

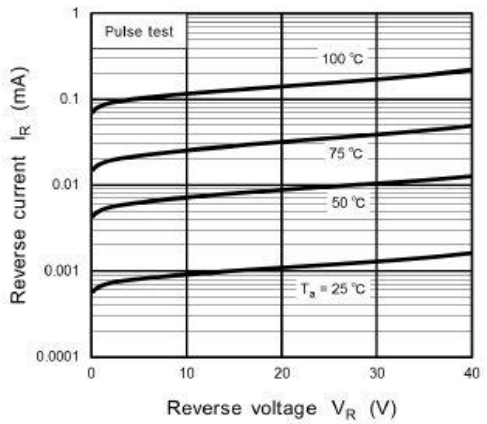
It is complementary to 2SC3325.

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.

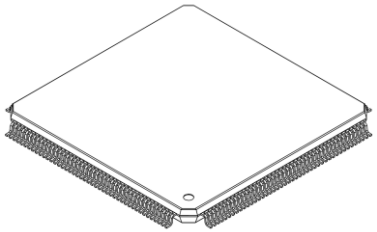
2 System cost down and development efficiency improvement

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, I^2C, CAN, USB and ethernet controller (ETHM). User can construct a communication system easily with a cloud.

TMPM4NRF**FG



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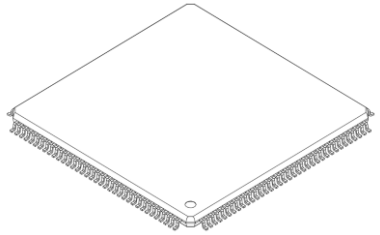
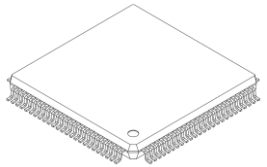
TMPM4NQF**FG



P-LQFP144-2020-0.50-002

TMPM4NNF**FG



P-LQFP100-1414-0.50-002

Lineup

Part number	TMPM4NRF20/15/10/D/FG TMPM4NRF20/15/10/D/XBG	TMPM4NQF20/15/10/D/FG TMPM4NQF20/15/10/D/XBG	TMPM4NNF20/15/10/D/FG
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^2C: 5ch, TSPI: 9ch, TSSI: 2ch	UART: 5ch, FUART: 2ch, I^2C: 5ch, TSPI: 8ch, TSSI: 1ch	UART: 3ch, FUART: 1ch, I^2C: 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-VFBGA177-1313-0.80-001	P-LQFP144-2020-0.50-002 P-VFBGA145-1212-0.80-001	P-LQFP100-1414-0.50-002

◆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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