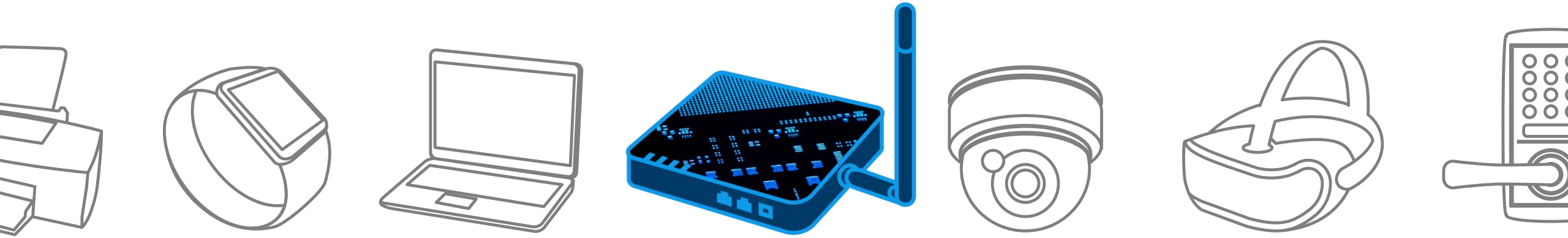
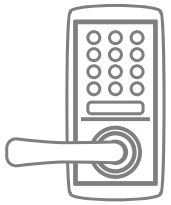
TOSHIBA

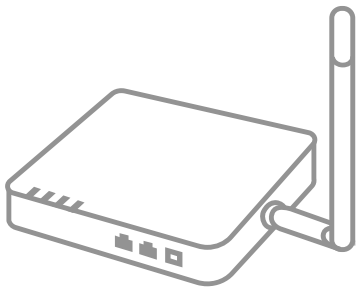
R22

# IoT Sensor

## Solution Proposal by Toshiba

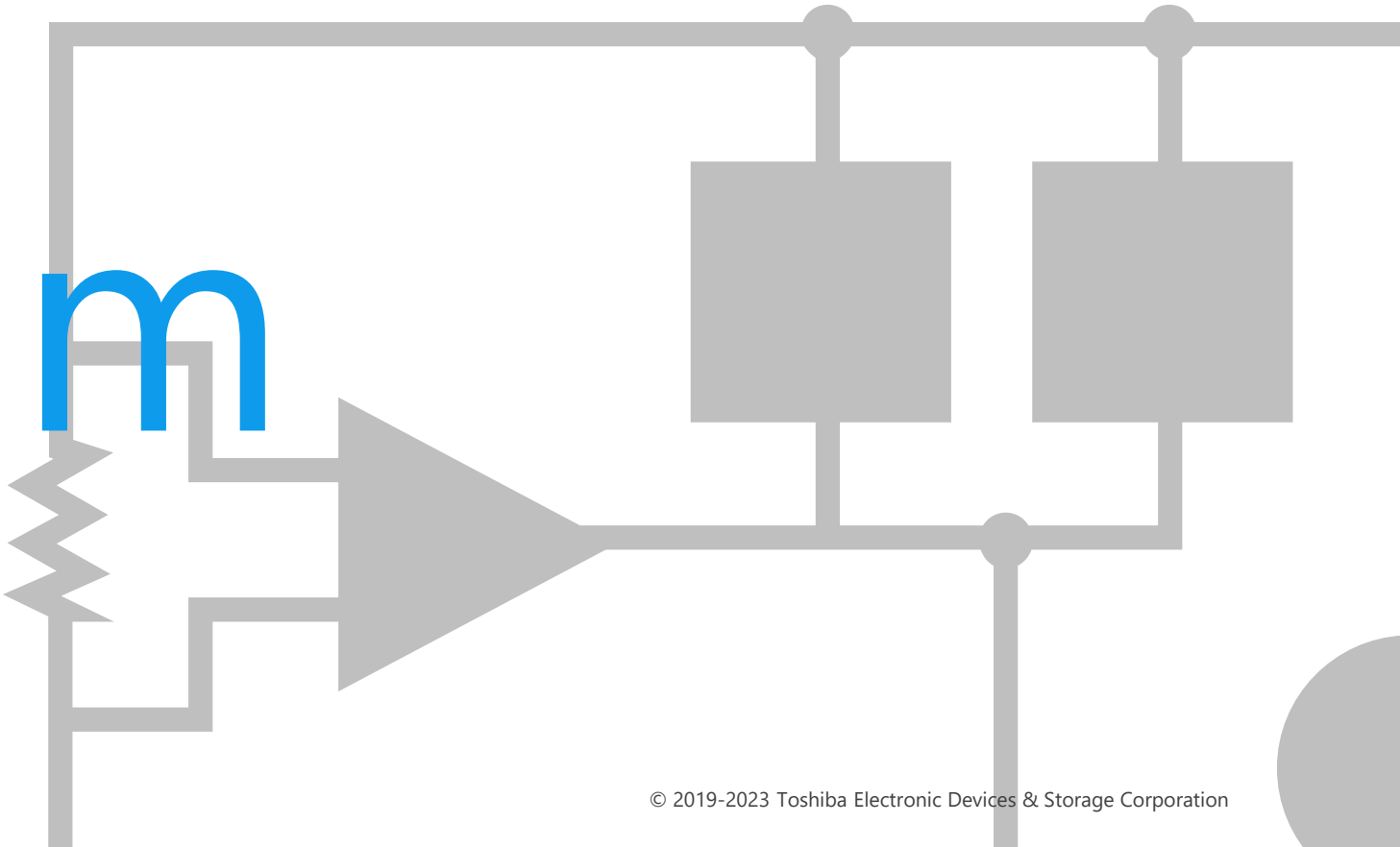




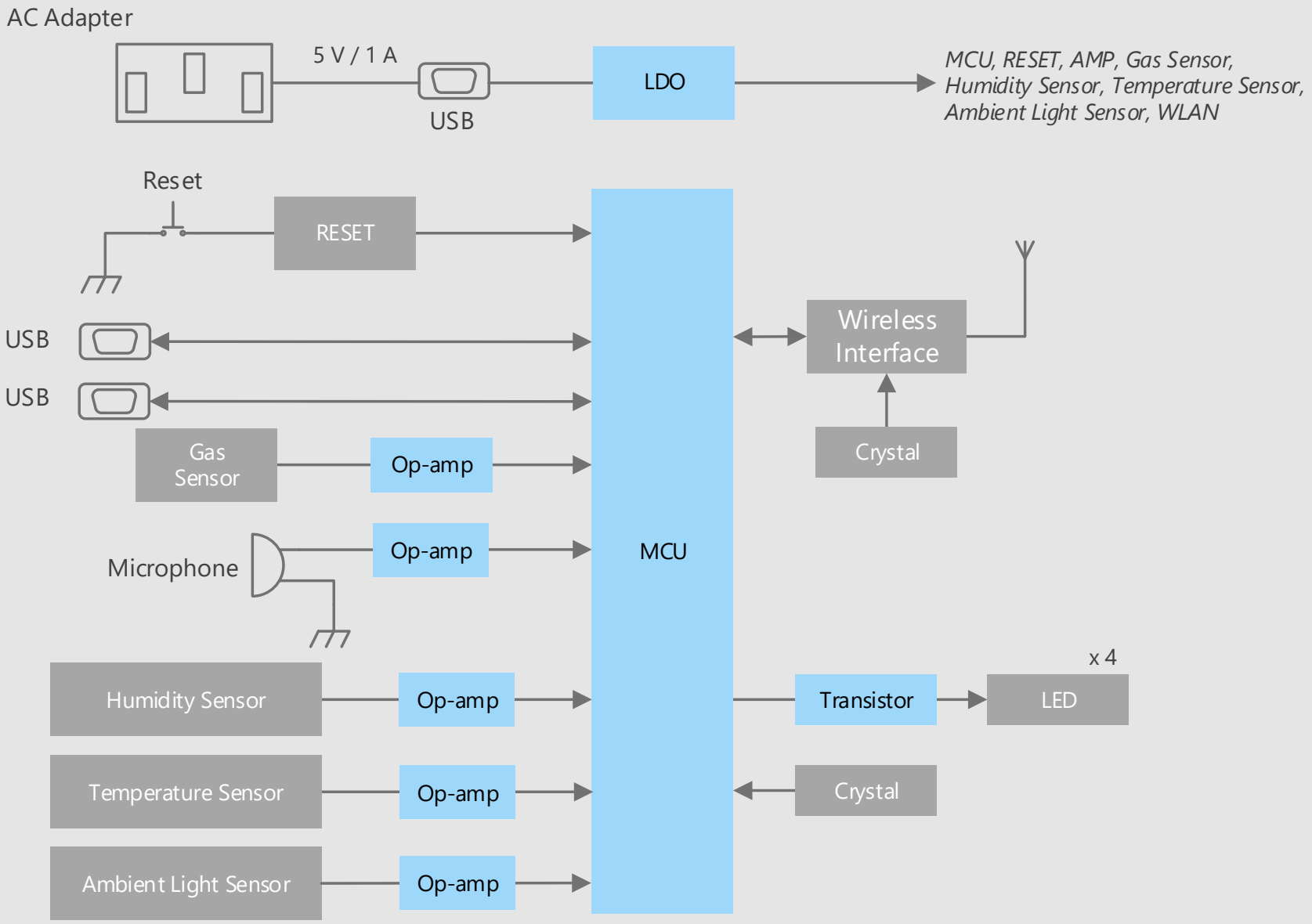


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

# Block Diagram

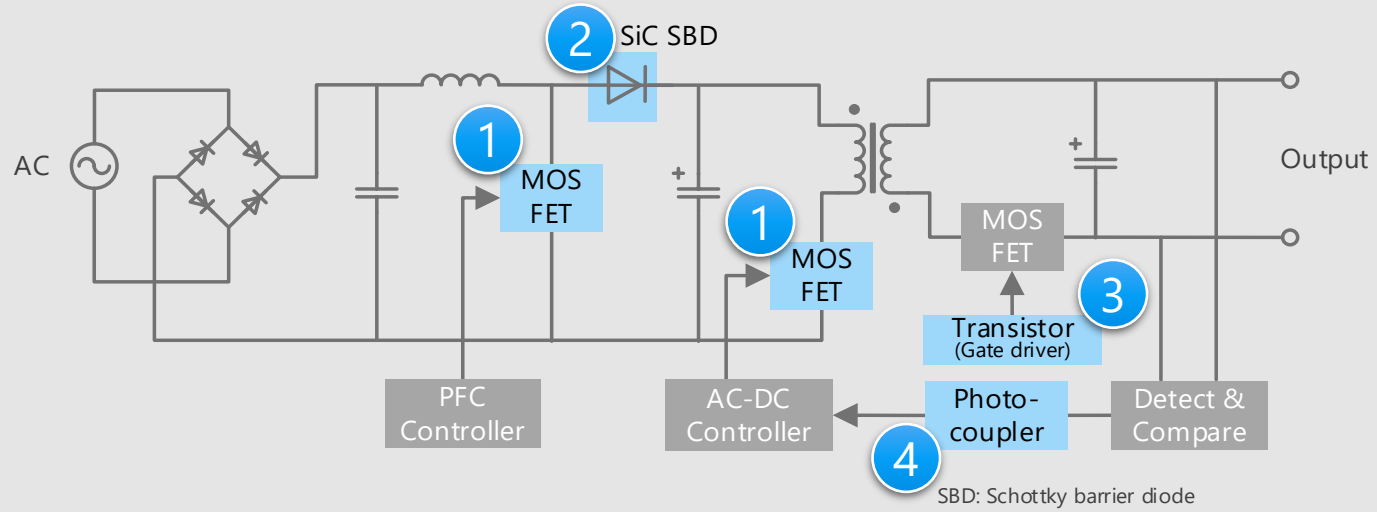


# IoT Sensor　Overall block diagram



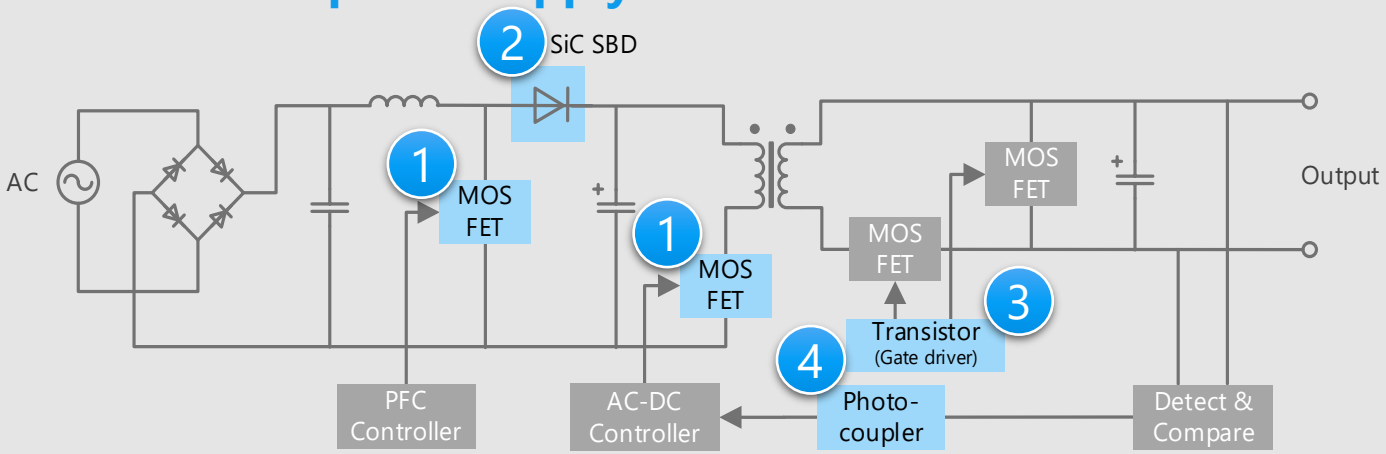
# IoT Sensor　Detail of power supply unit

## 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

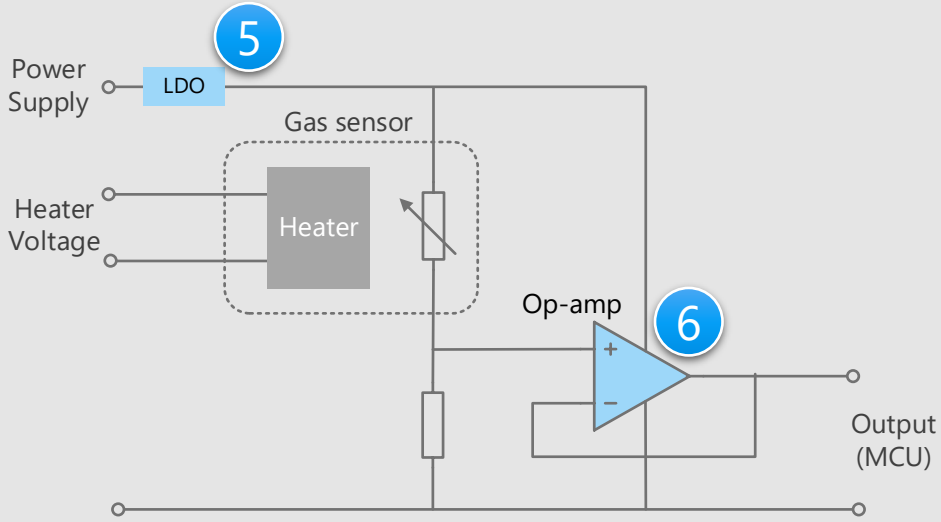
- High voltage MOSFETs are suitable for primary side of AC-DC converters.
- SiC type Schottky barrier diodes are suitable for PFC circuits.

## Proposals from Toshiba

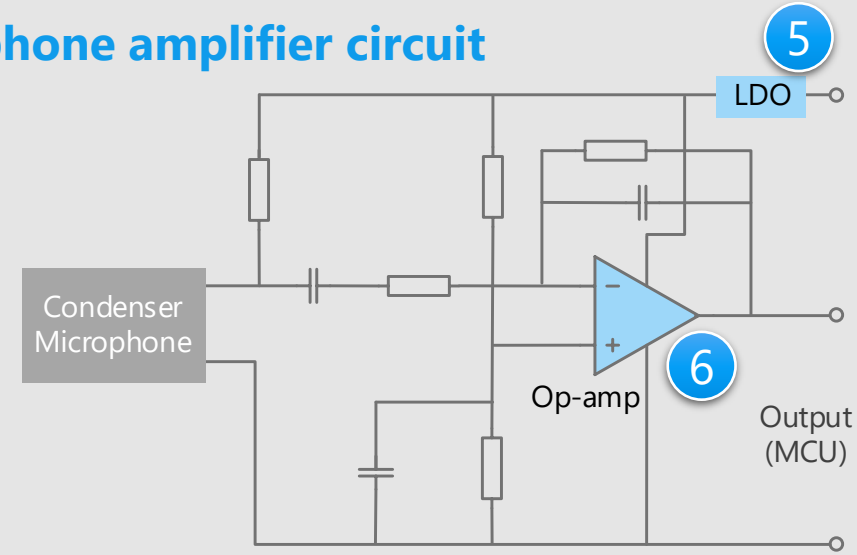
- **Suitable for high efficiency power supply switching**
  MOSFET (1)
- **High current surge resistance and low switching loss**
  SiC Schottky barrier diode (2)
- **Suitable for high speed gate driving of MOSFET**
  Bipolar transistor (Gate driver) (3)
- **Suitable for power supply feedback circuit**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

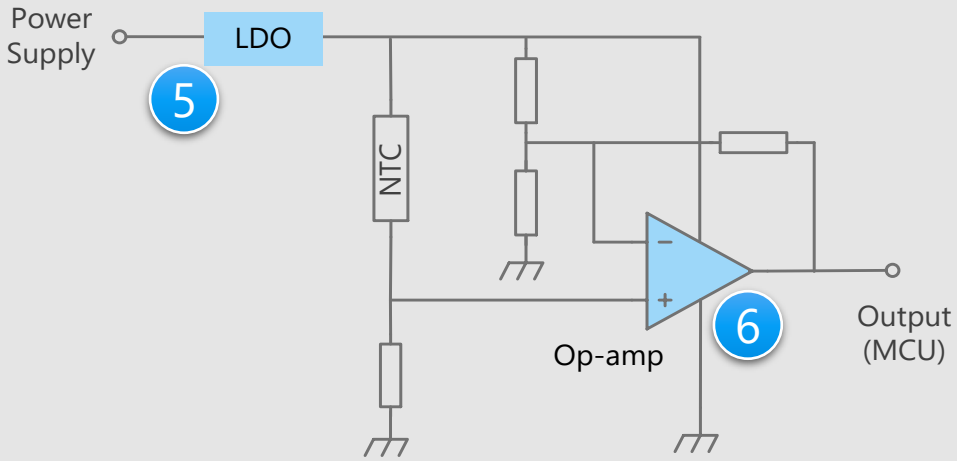
## Proposals from Toshiba

- **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

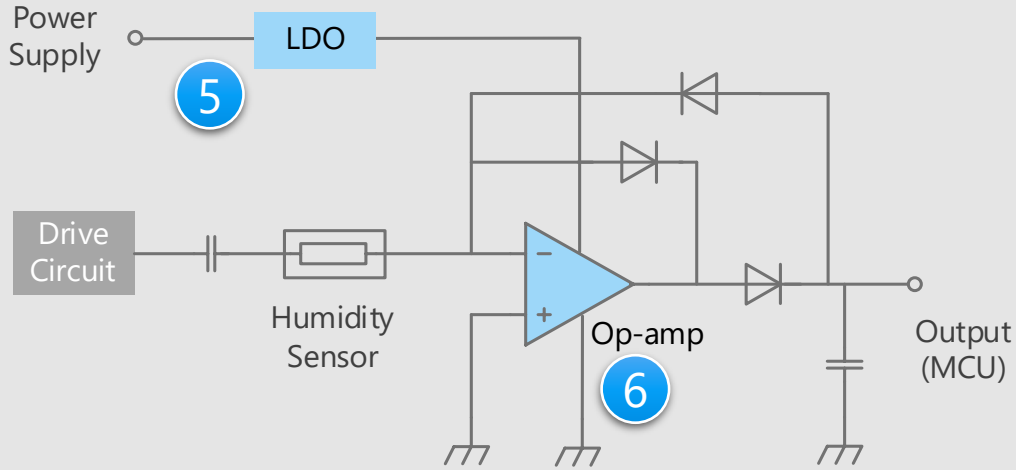
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

# IoT Sensor　Detail of sensor units

## Temperature detection circuit




## Humidity detection circuit




## Criteria for device selection

- 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.

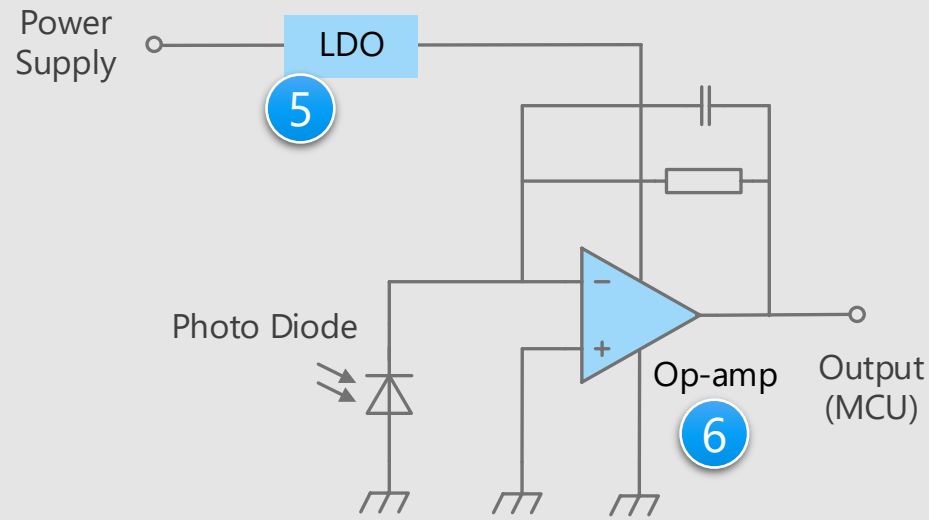
## Proposals from Toshiba

- **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 unit

## 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.

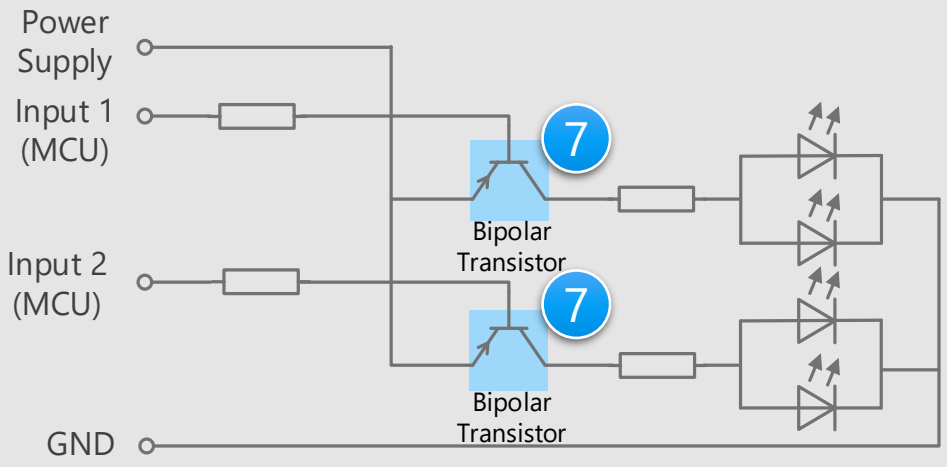
## Proposals from Toshiba

- **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

* 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.

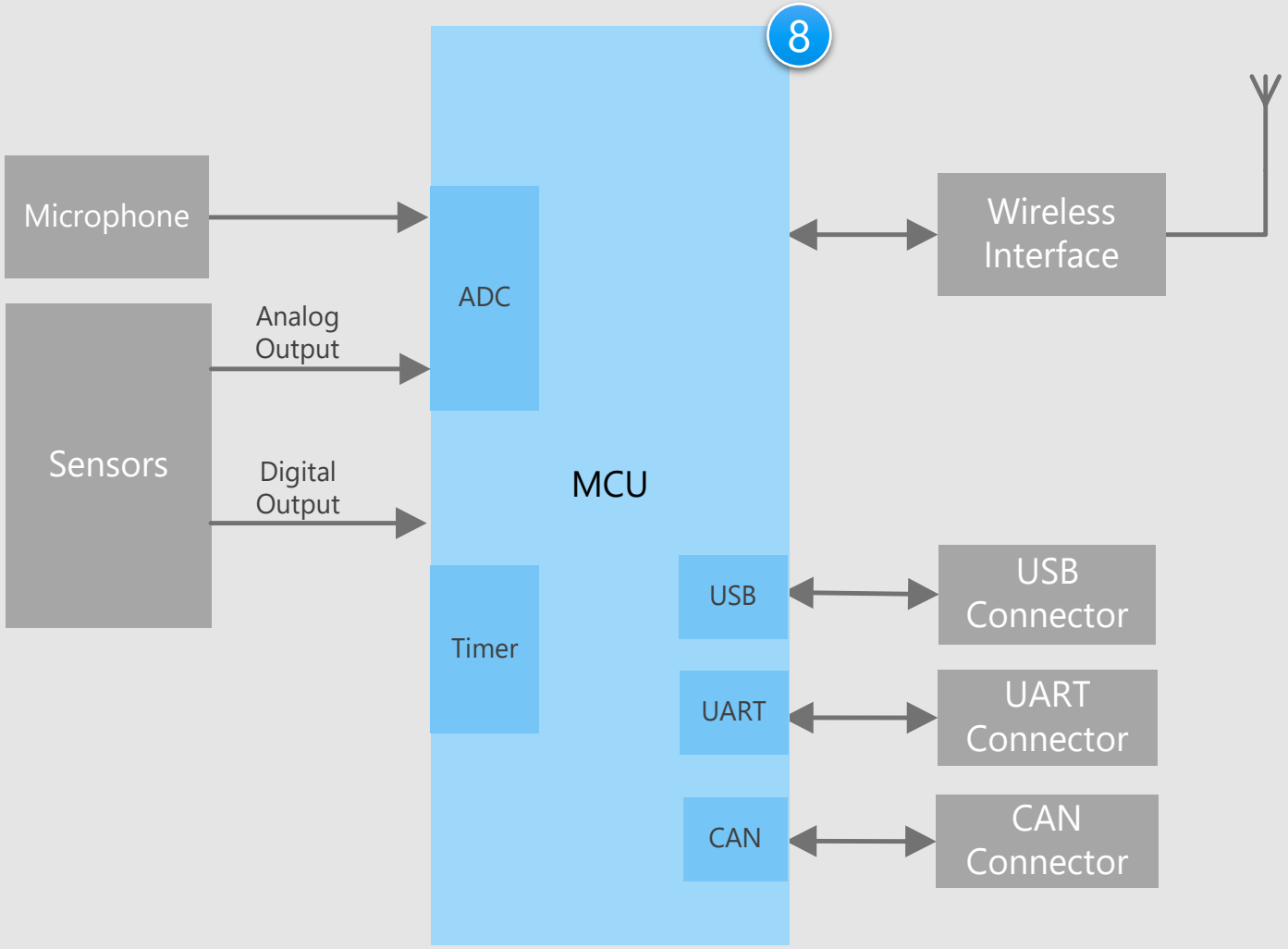
## Proposals from Toshiba

- **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.

## Proposals from Toshiba

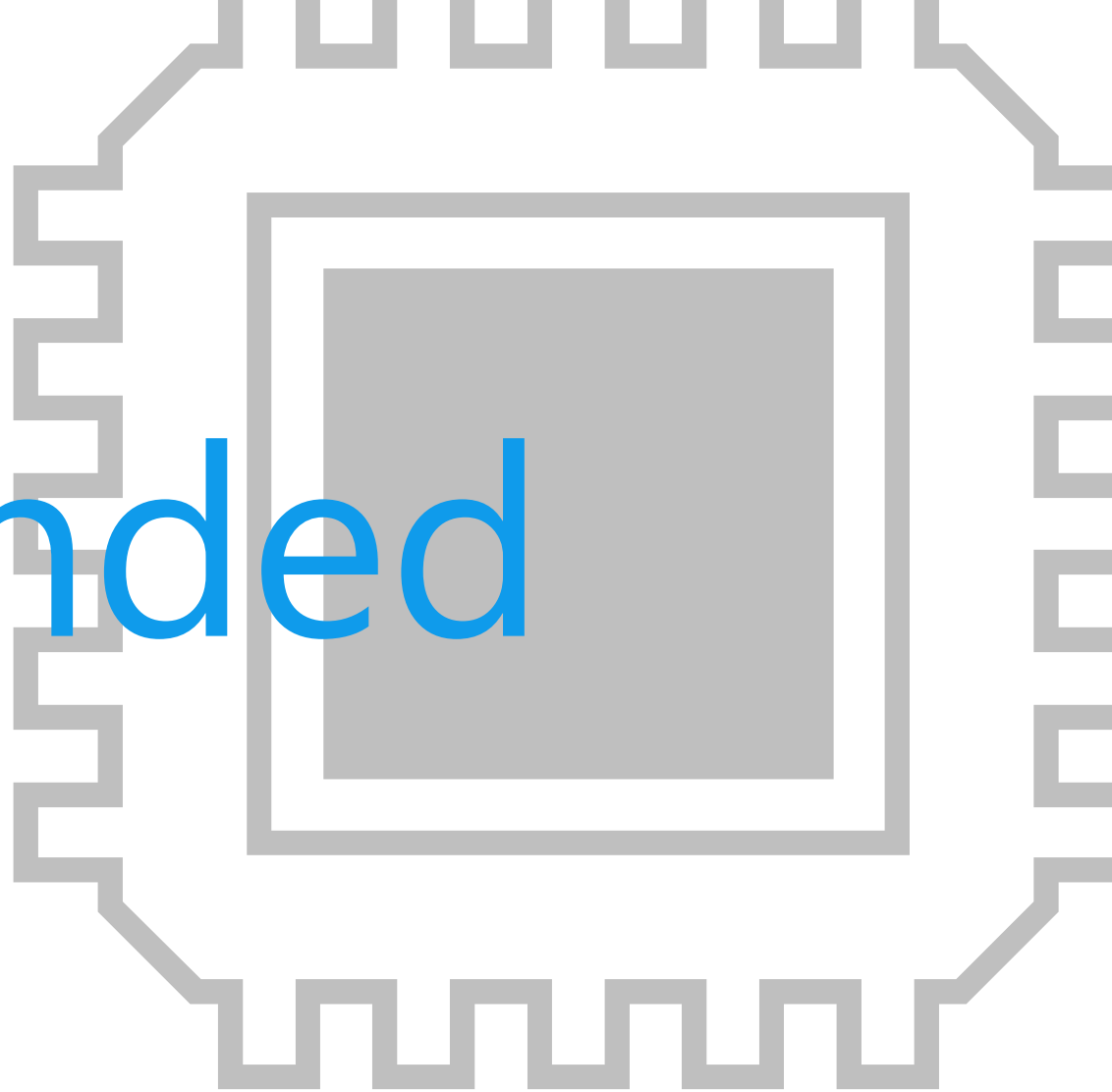
- **High processing performance MCU supports multi-channel sensor interfaces and various communication standards**

  MCU M4N Group

8

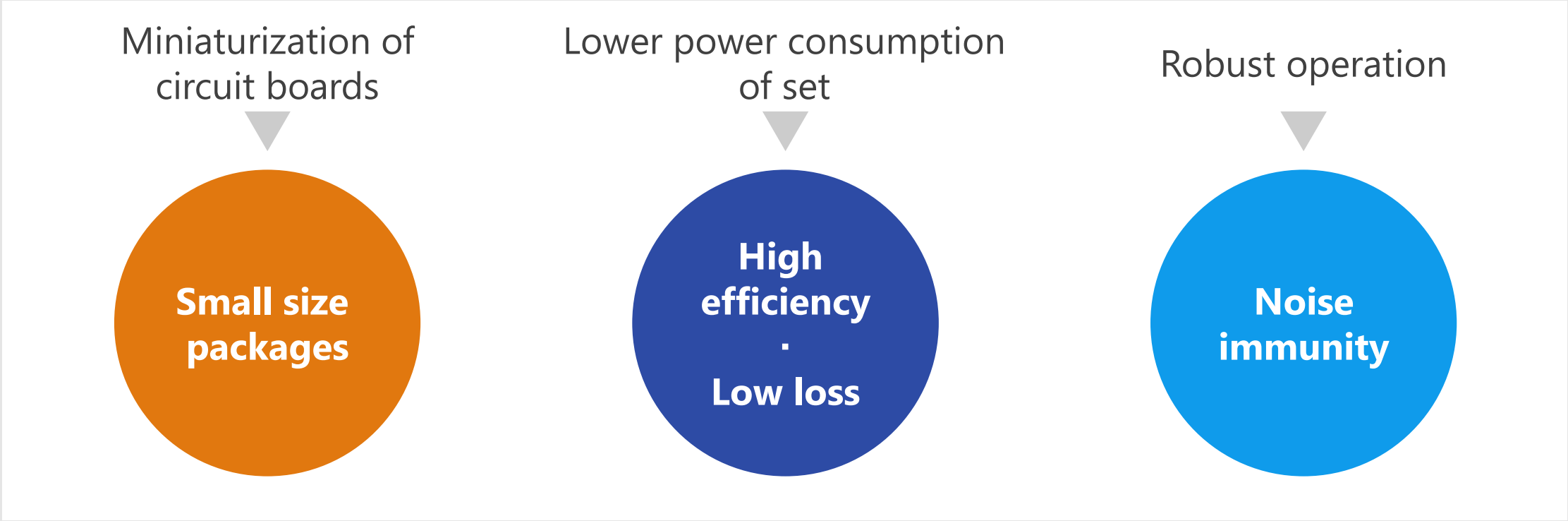
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

# 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 | | ● | |

# 1 MOSFET
## TK18A50D / TK12P50W

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

Value provided

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

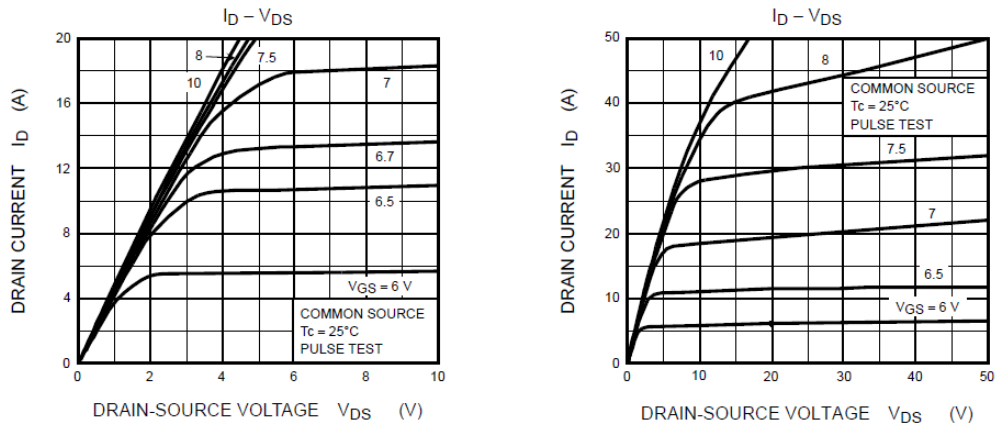
## 1 Low on-resistance

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 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

**TRS12A65F / TRS24N65FB / TRS2E65H / 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 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

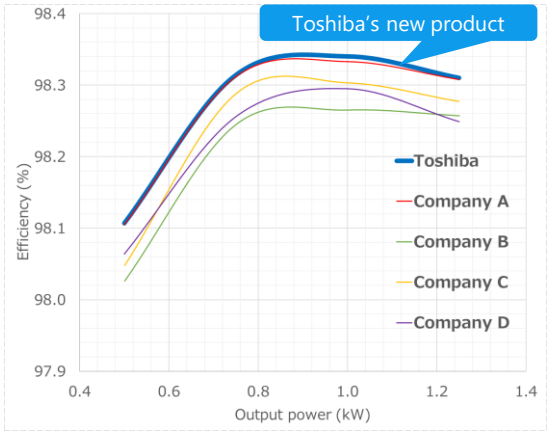
Compared with our existing products, the trade off of $V_F$ x $Q_C$ [Note2] of the new products have improved. About 0.1% of conversion efficiency improvement have also achieved under 800 W output condition in our test.

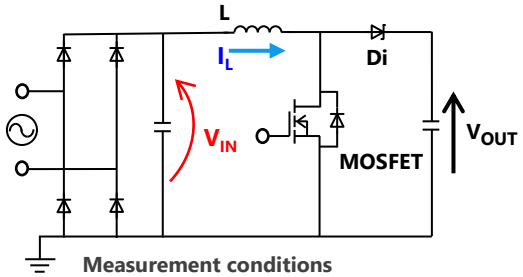
### 3 Expansion of package series

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 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

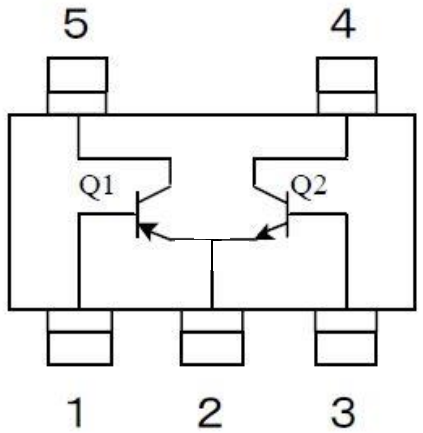
HN4B101J

$V_{CE(sat)}$ = -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

# 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)

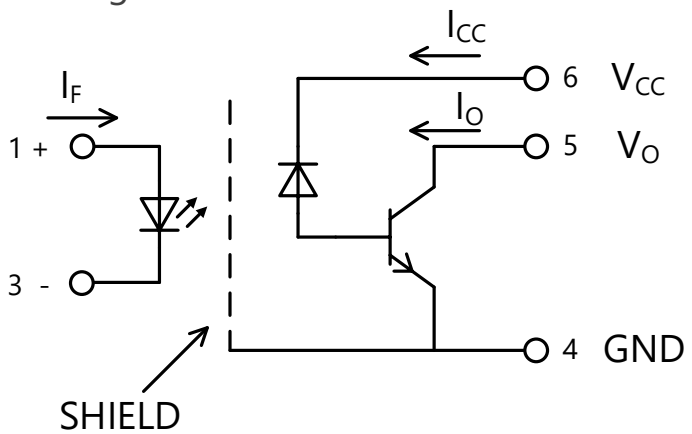
For applications where high dV/dt is applied to both ends of the photocoupler, high CMTI [Note] is required. Our device realizes the CMTI of 15 kV/μs (Min) by adapting shield between the input and output. (TLP2309)

[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 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

# 5 Small surface mount LDO regulator

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

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

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.

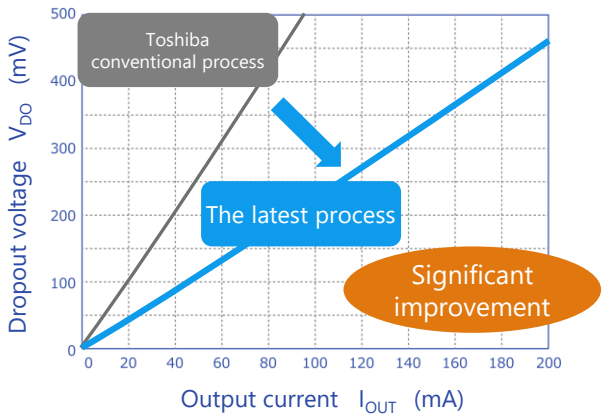
### 2 High PSRR Low output noise voltage

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

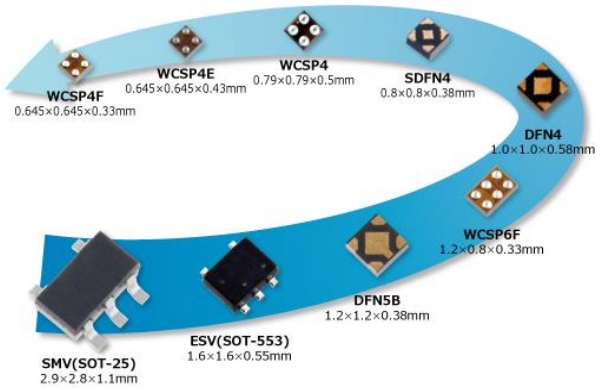
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

**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

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

## TC75S102F / TC75S67TU

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

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.

### 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 and longer life of IoT equipment.

### 3 Low noise (TC75S67TU)

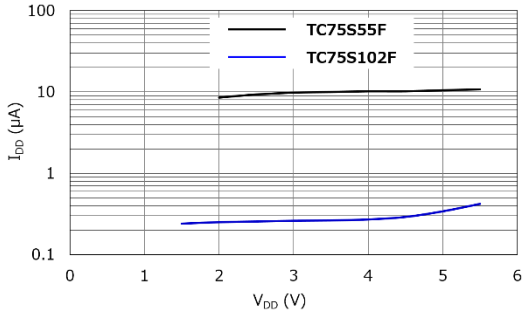
**$V_{NI}$ = 6.0 nV/√Hz (Typ.) @f =1 kHz**

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)

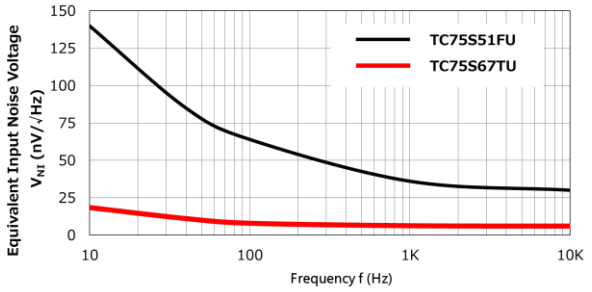
Low current consumption product TC75S102F




**TC75S67TU**
Noise Characteristic
(Toshiba internal comparison)

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

$V_{NI}$ - f @Ta=25 ℃, $V_{DD}$=3.3 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 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).

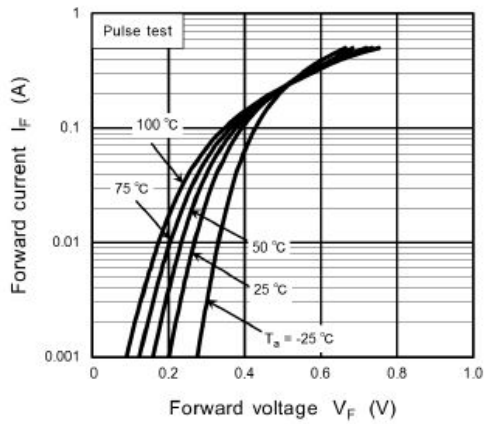
### 2 Complementary products

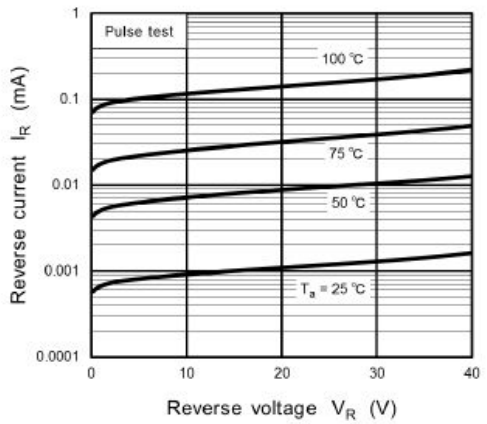
It is complementary to 2SC3325.

### 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.

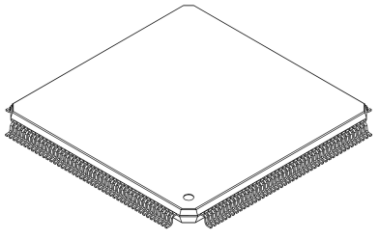
## 2 System cost down and development efficiency improvement

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

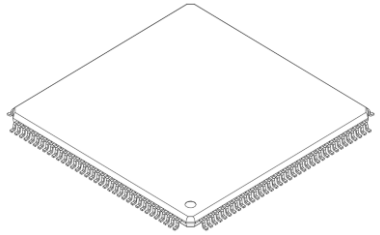
These products support major communication interfaces such as UART, FUART, TSPI, TSSI, $I^2C$, CAN, USB and ethernet controller (ETHM). User can construct a communication system easily with a cloud.

TMPM4NRF**FG



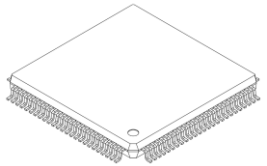
P-LQFP176-2020-0.40-002

TMPM4NQF**FG



P-LQFP144-2020-0.50-002

TMPM4NNF**FG



P-LQFP100-1414-0.50-002

Lineup

| Part number | TMPM4NRF20/15/10/DFG<br>TMPM4NRF20/15/10/DXBG | TMPM4NQF20/15/10/DFG<br>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,<br>$I^2C$: 5ch, TSPI: 9ch, TSSI: 2ch | UART: 5ch, FUART: 2ch,<br>$I^2C$: 5ch, TSPI: 8ch, TSSI: 1ch | UART: 3ch, FUART: 1ch,<br>$I^2C$: 3ch, TSPI: 5ch, TSSI: 1ch |
| | CAN: 2 units, USB: 2 units, ETHM: 1 unit | | CAN: 2 units, USB: 1 unit,<br>ETHM: 1 unit |
| Package | P-LQFP176-2020-0.40-002<br>P-VFBGA177-1313-0.80-001 | P-LQFP144-2020-0.50-002<br>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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