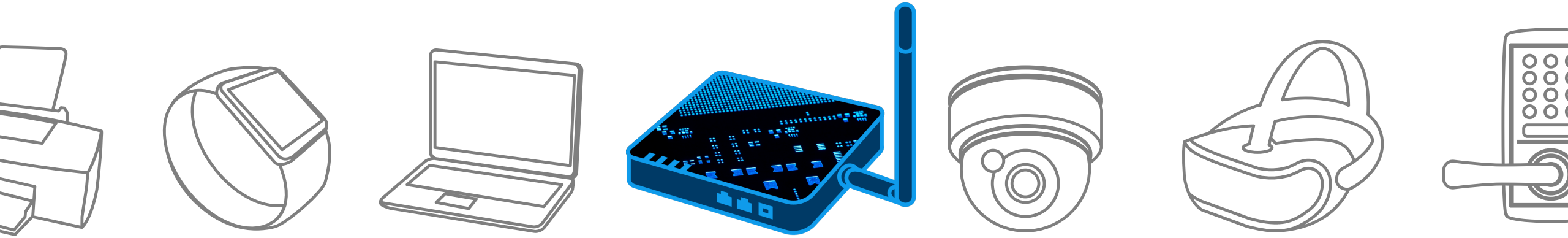
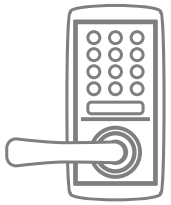
TOSHIBA

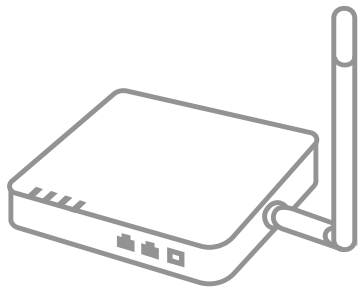
R20

IoT Sensor

Solution Proposal by Toshiba

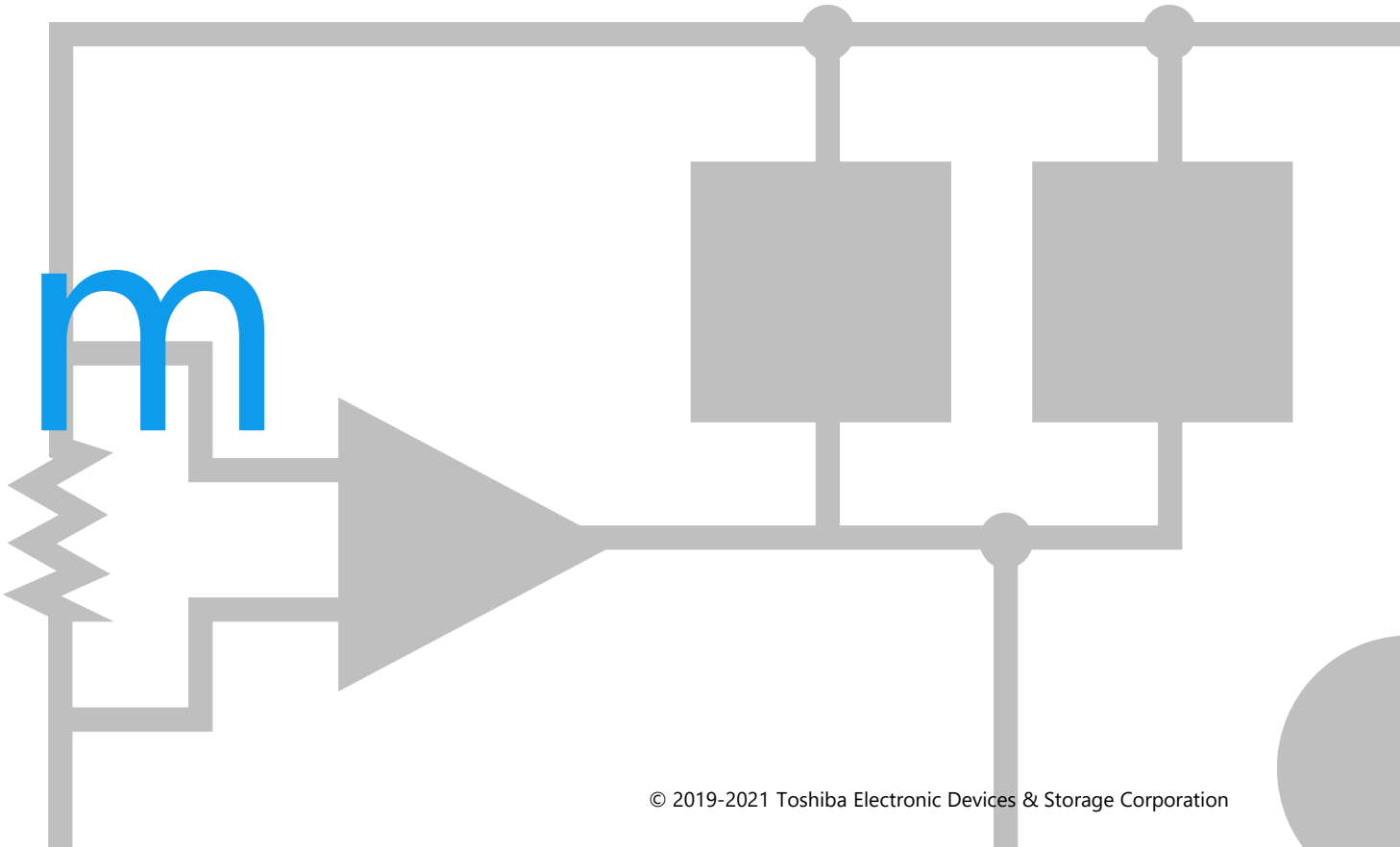




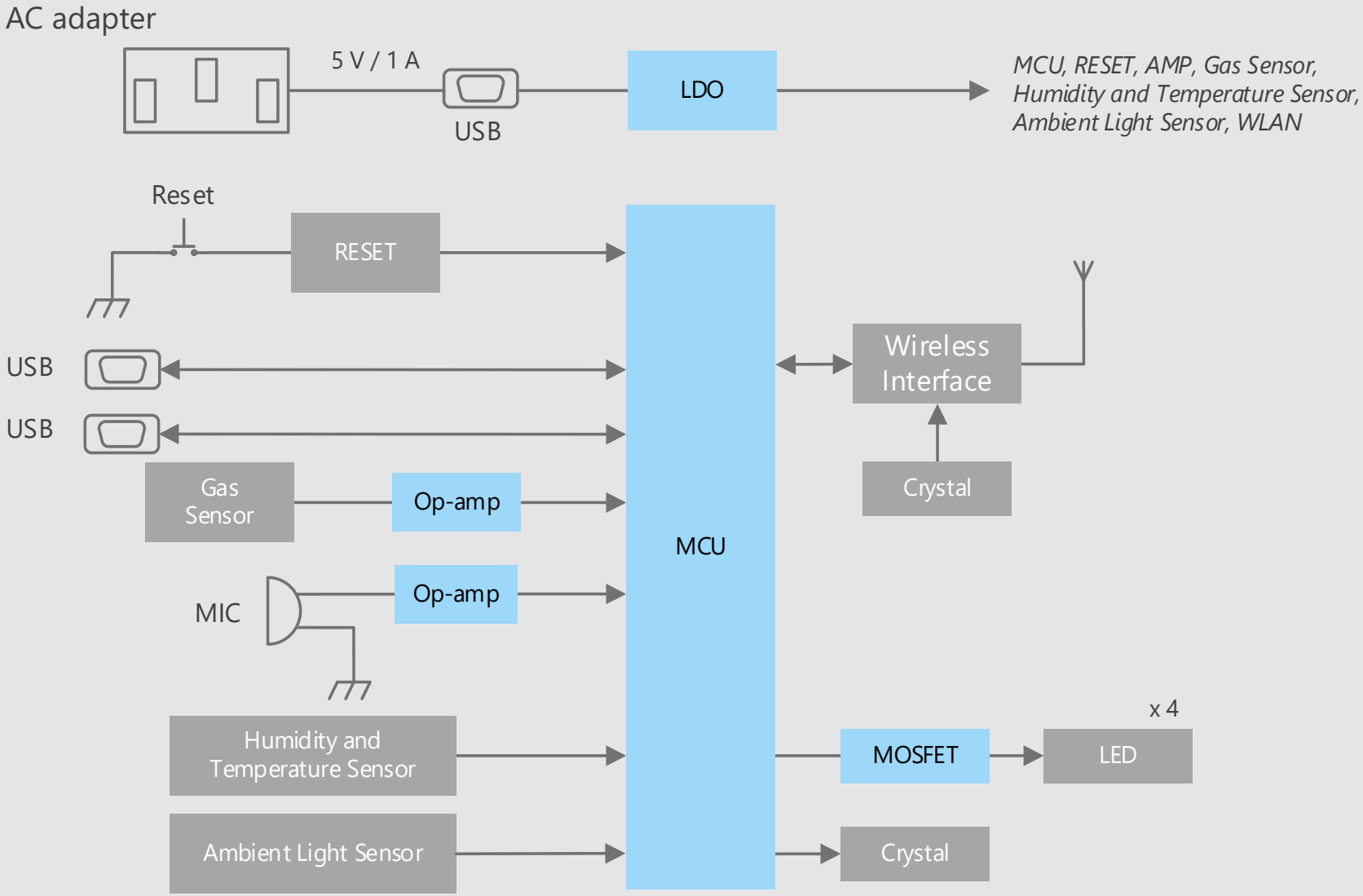


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

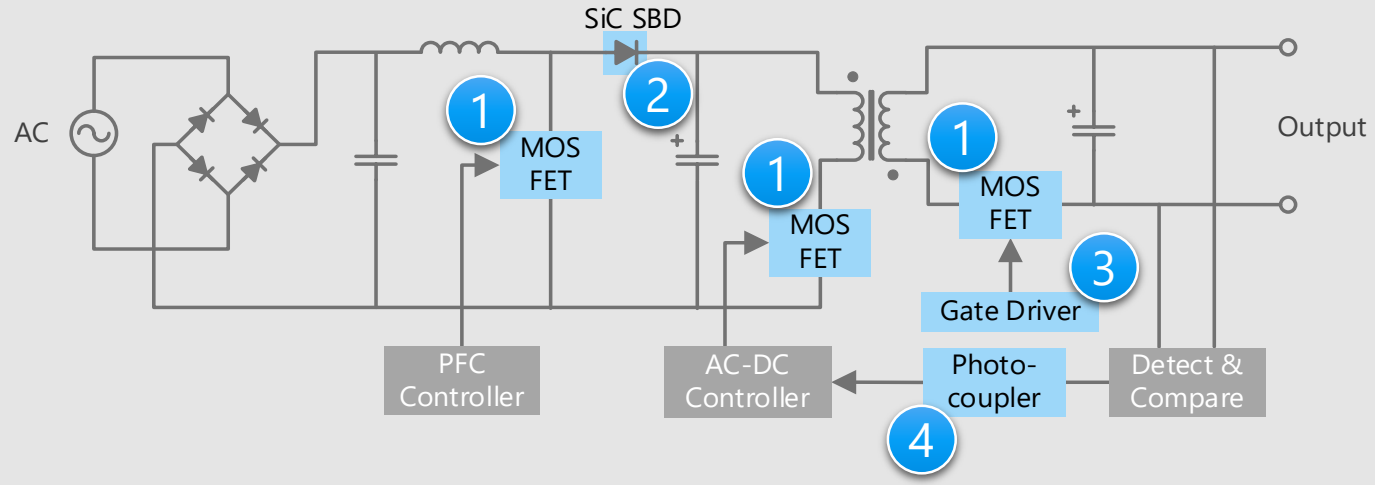


IoT Sensor　Overall Block Diagram

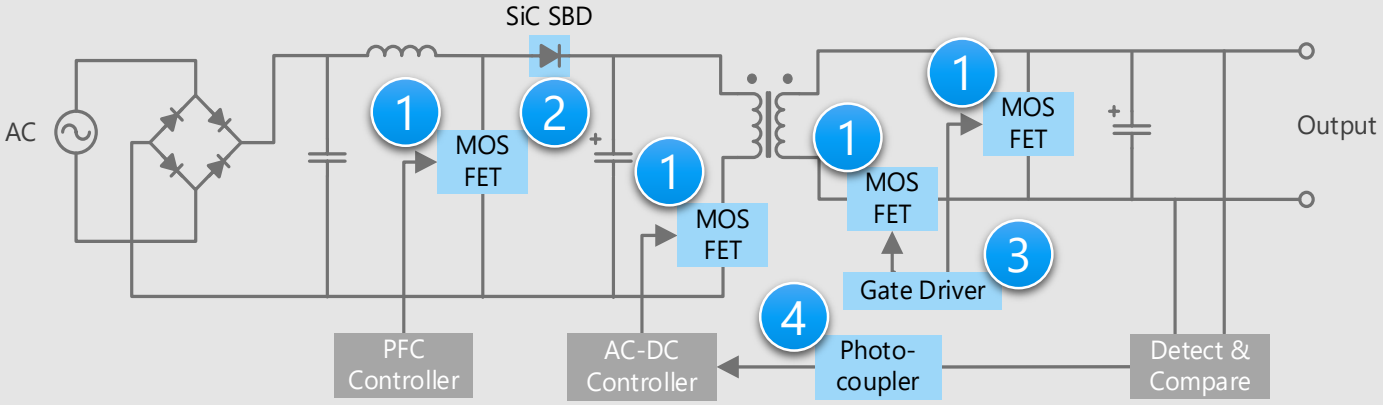


IoT Sensor　Detail of power supply unit

AC-DC flyback power supply



AC-DC forward power supply



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

Criteria for device selection

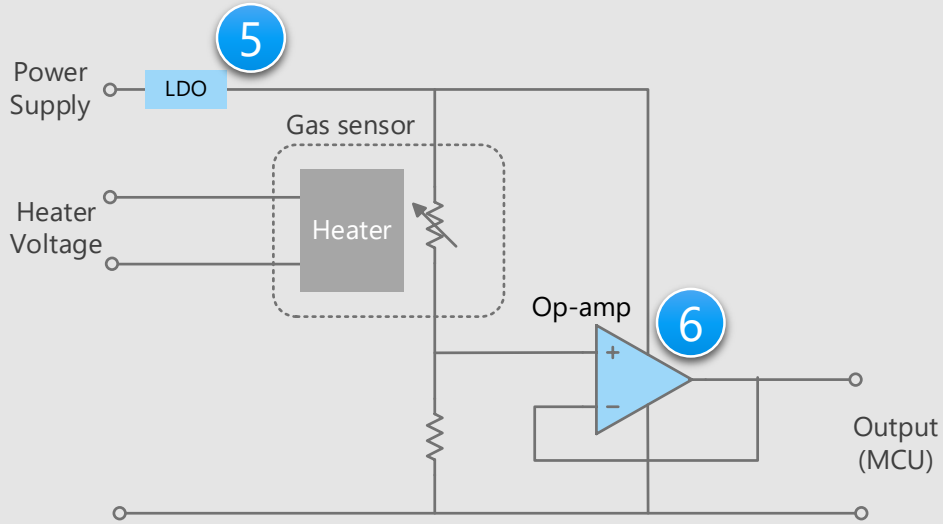
- The V_{DSS} is critical to choosing a MOSFET. The MOSFET breaks for operations exceeding its V_{DSS} rating.
- MOSFETs with high V_{DSS} tend to have high on-resistance $R_{DS(on)}$.

Proposals from Toshiba

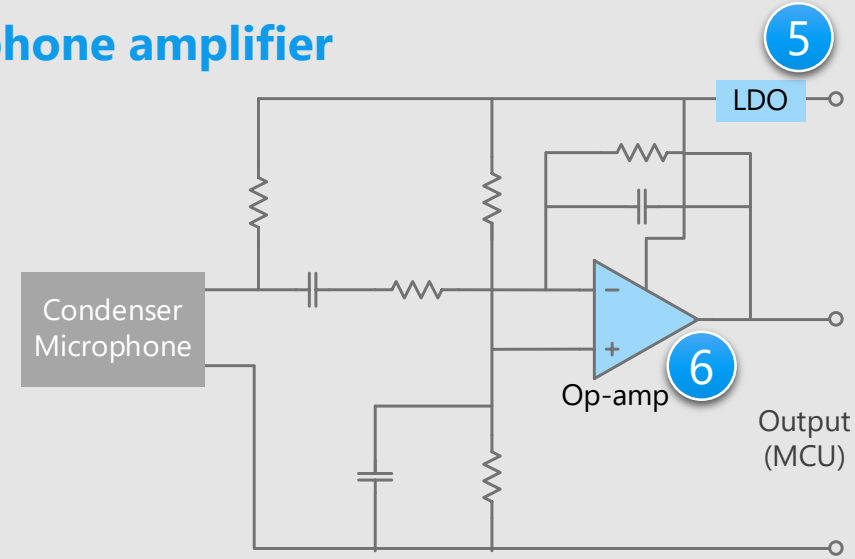
- **Suitable for high efficiency power supply switching**
  MOSFET (1)
- **High current surge resistance and low switching loss**
  SiC Schottky barrier diode (2)
- **Suitable for high speed gating of MOSFET**
  Bipolar transistor (3)
- **Photocoupler with excellent environmental resistance**
  IC output photocoupler (4)

IoT Sensor　Detail of sensor signal detection unit

Gas detection



Microphone amplifier



Criteria for device selection

- Low noise operational amplifiers are required to improve measurement accuracy.
- The use of small packages reduces the board area.

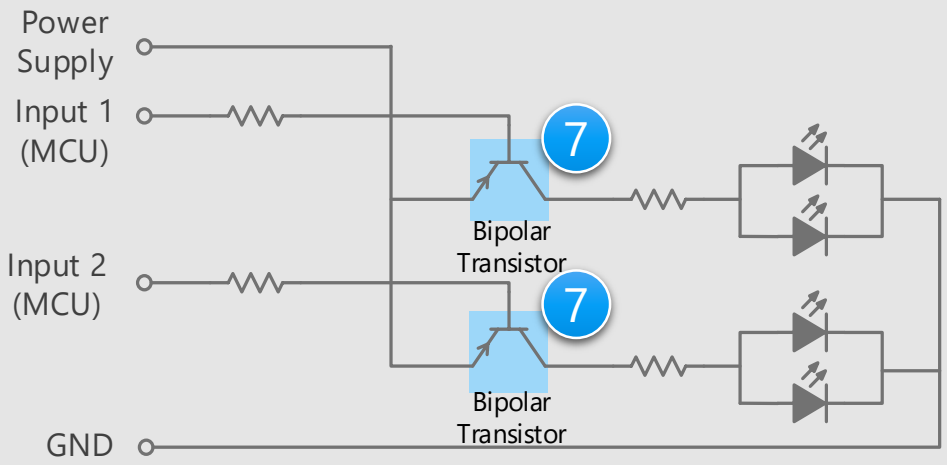
Proposals from Toshiba

- **Support for stable sensor operation**
  Small surface mount LDO regulator　5
- **Amplify the detected small signal with low noise.**
  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



Criteria for device selection

- LED current, MCU output voltage, base-emitter voltage of transistor and DC current are important factors in selecting LED driving transistors.
- The use of small packages reduces the board area.

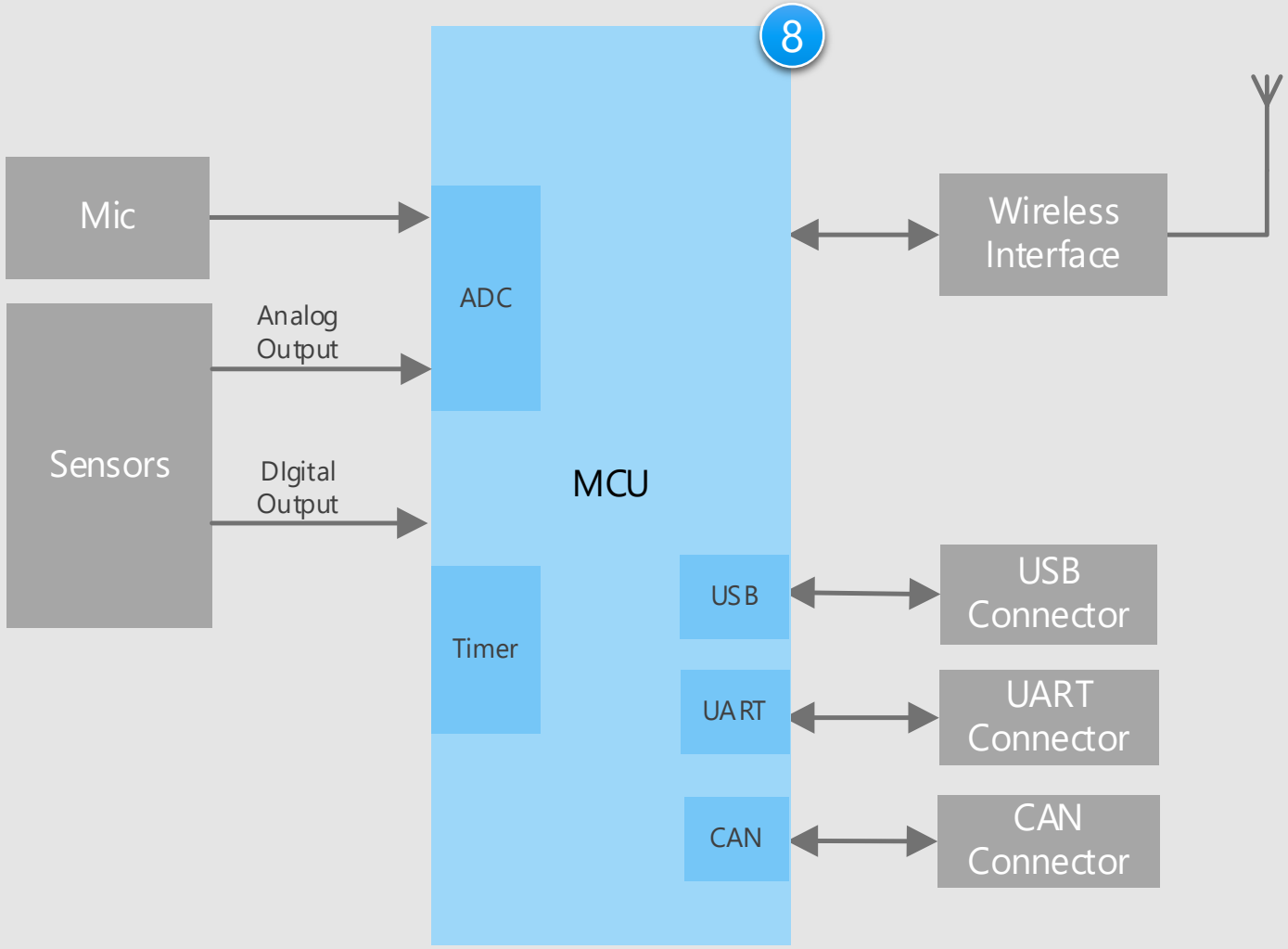
Proposals from Toshiba

- **Compact 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 at realtime.
- The communication channel is required to upload sensor data and analysis results to the cloud.

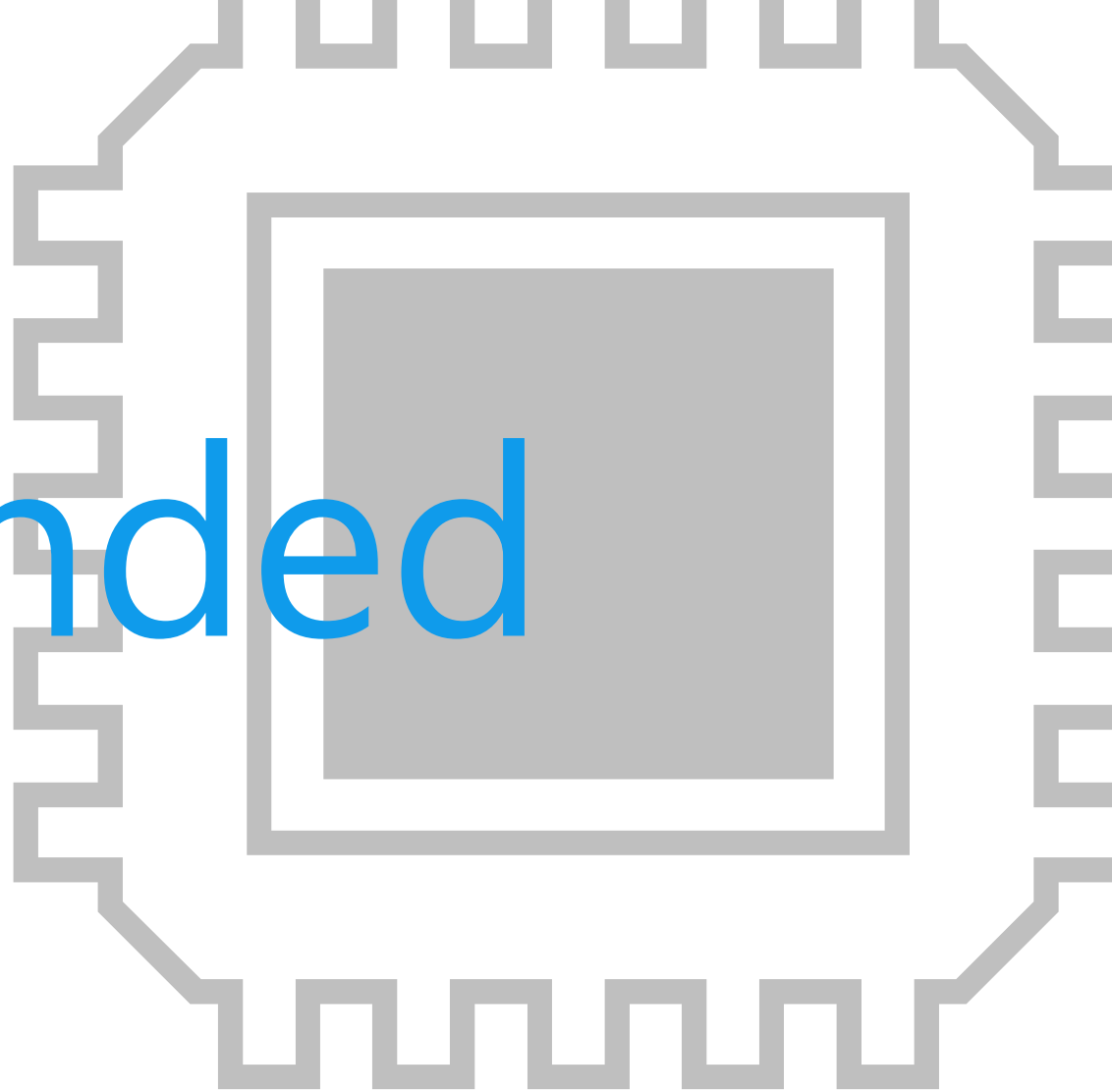
Proposals from Toshiba

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

8

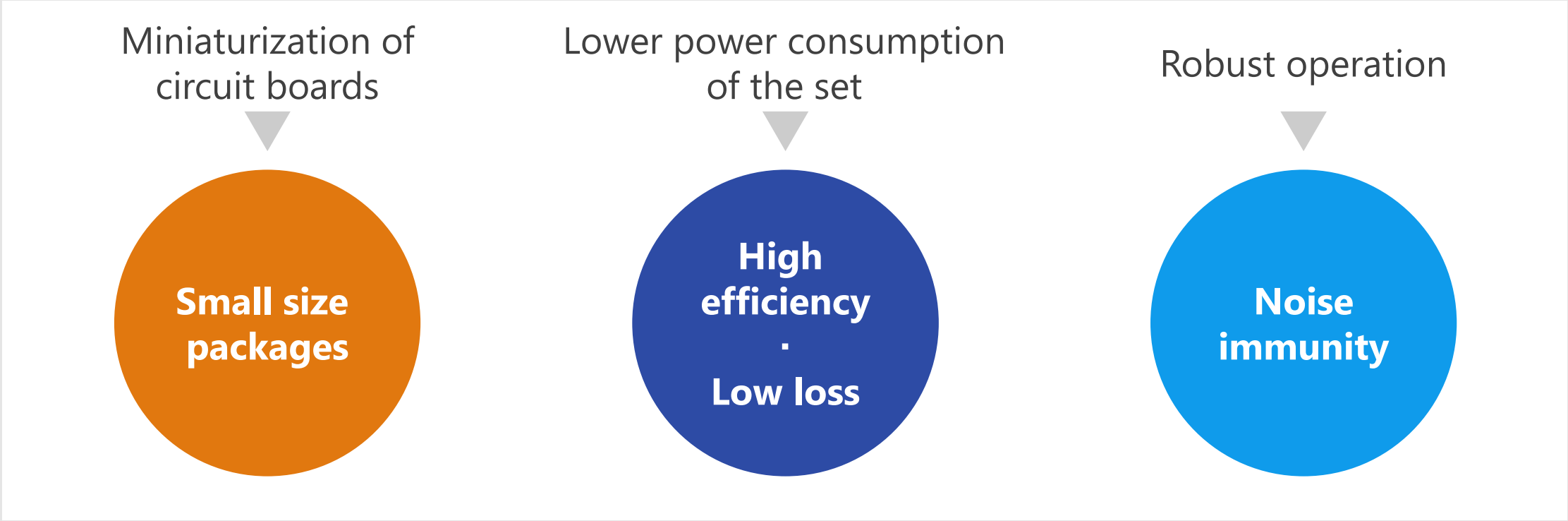
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

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 sets"** 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	●	●	●
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	●	●	

1 MOSFET
TK18A50D / TK12P50W

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

Value provided

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

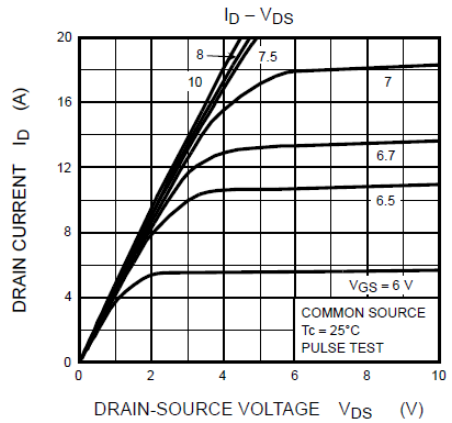
1 Low on-resistance

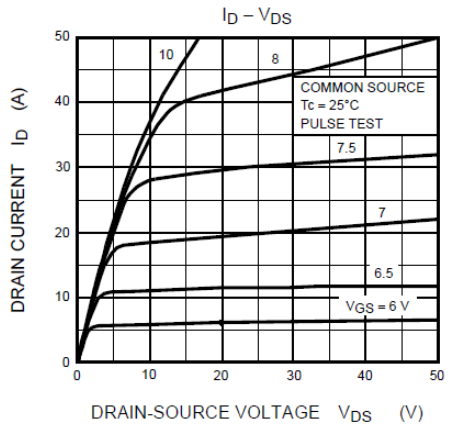
By keeping the on-resistance between the drain and source low, heat generation and power consumption can be also kept low.

2 Low leakage current

Drain leakage current
I_{DSS} = 10 μA (Max) (@V_{DS} = 500 V)

TK18A50D Characteristics Curves





Line up

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

TRS4A65F / TRS4E65F

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

Value provided

Contribute to higher efficiency and miniaturization of power supply.

1 High current surge resistance

I_{FSM} = 37 [A] / 39 [A] (Note 1)

By using the improved JBS structure, the surge current is about doubled compared to Toshiba first generation products.

2 Low leakage current

I_R (max) = 20 [μA] (Note 1)

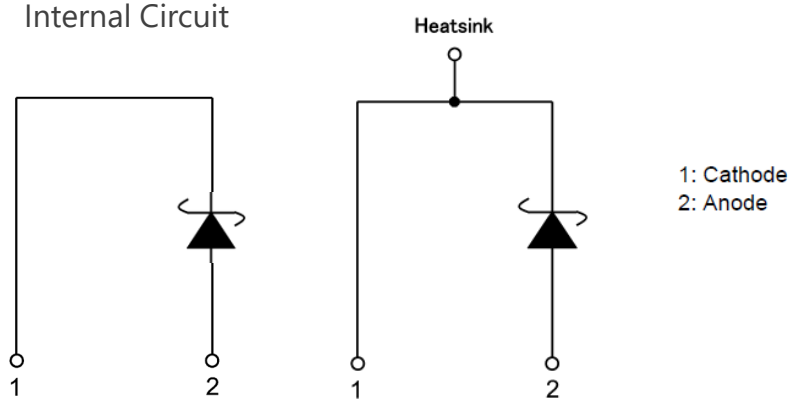
By using the improved JBS structure, the leakage current is reduced about 30 % compared to Toshiba first generation products.

3 Low switching loss

Q_{cj} (Typ.) = 10.4 [nC] (Note 1) (Note 2)

By using the thin wafer technology, the total charge amount Q_{cj} is suppressed and switching loss is reduced about 30 % compared to Toshiba first generation products.

Internal Circuit



TO-220F-2L (Isolation type)

TO-220-2L

1: Cathode
2: Anode

Note 1 : TRS4A65F / TRS4E65F product data

Note 2 : $Q_{cj} = \int Cj \times V_R \, dv$, V_R = 0.1 to 400 V

Line up

Part number	TRS4A65F	TRS4E65F
Package	TO-220F-2L 	TO-220-2L 
V_{RRM} (Max) [V]	650	650
$I_{F(DC)}$ (Max) [A]	4	4
I_{FSM} (Max) [A]	37	39
I_R (Typ. / Max) [μA]	0.2 / 20	0.2 / 20
Q_{cj} (Typ.) [nC]	10.4	10.4

◆Return to Block Diagram TOP

3 Bipolar transistor
HN4B101J / HN4B102J

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

Value provided

Bipolar transistor suitable for MOSFET gating.

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 @ I_C = -0.12 [A]

NPN: h_{FE} = 200 to 500 @ I_C = 0.12 [A]

3 Low collector-emitter saturation voltage

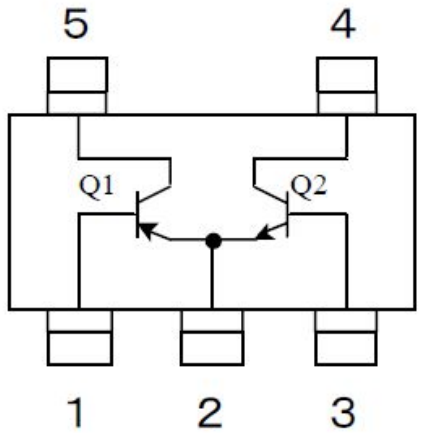
HN4B101J

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

HN4B102J

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

HN4B101J
Circuit configuration



Line up

Part number	HN4B101J	HN4B102J
Package	SMV 	SMV 
V_{CEO} (Max) [V] @Q1/Q2	-30/50	30/30
I_C (Max) [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)

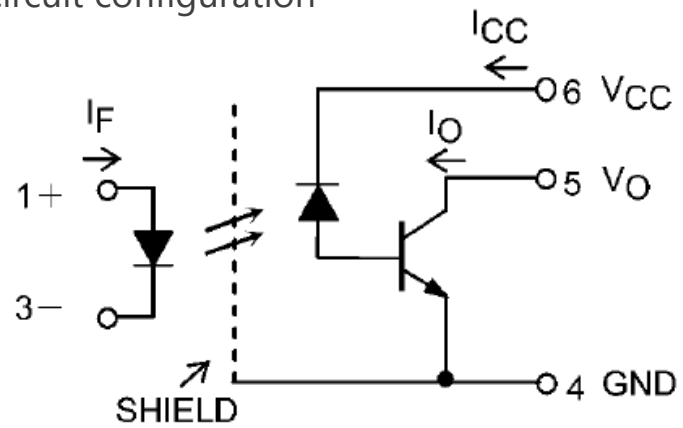
For applications where high dV/dt is applied to both ends of the photocoupler, high CMTI[Note] is required. Our device realizes the CMTI of 15 kV/μs(Min) by adapting shield between the input and output. (TLP2309)

[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



Line up

Part number	TLP2309	TLP2719(LF4)
Package	5pin SO6 	SO6L(LF4) 
BV_S (Min) [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 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.

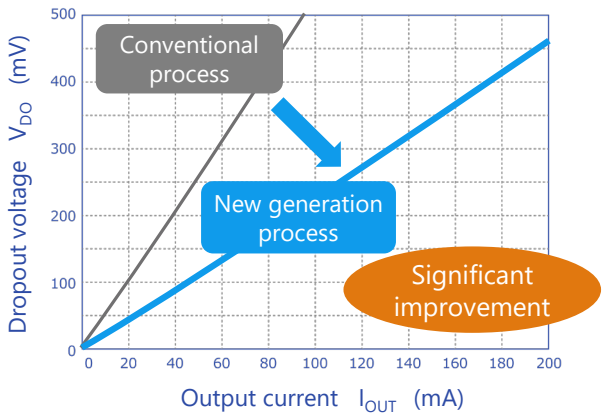
2 High PSRR Low output noise voltage

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

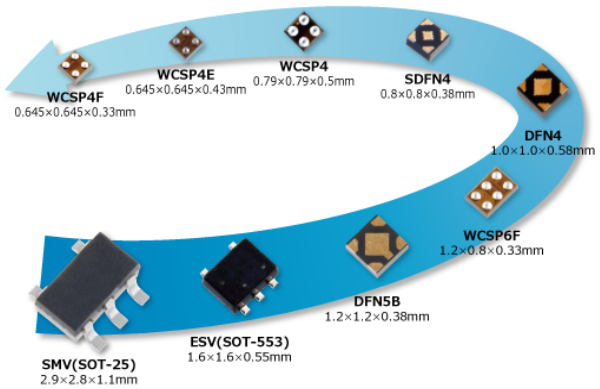
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.

Low dropout voltage



Note: Toshiba internal comparison

Rich package line up



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

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

TC75S102F / TC75S103F / TC75S67TU

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

Value provided

Low current consumption type and low noise type operational amplifiers that 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)

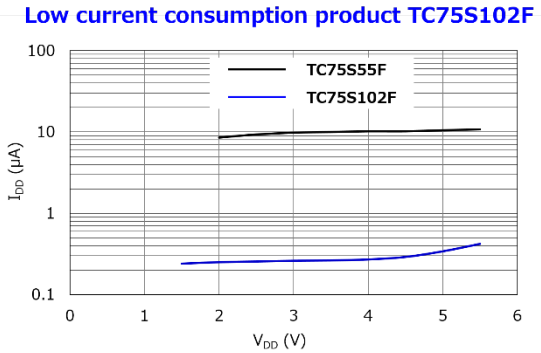
CMOS processes have been used to achieve lower current consumption. This contributes to lower power consumption and longer life of IoT equipment.

3 Low noise (TC75S67TU)

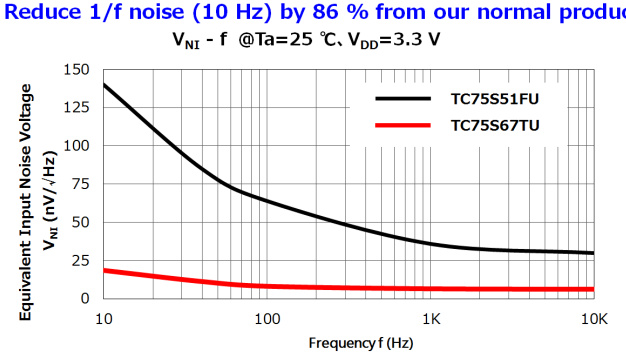
This CMOS operational amplifier can amplify minute signals detected by various sensors [Note1] with very low noises. By optimizing the process, we have achieved the industry's top level [Note2] low equivalent input noise voltage.

[Note 1] Sensor types: vibration, shock, acceleration, pressure, infrared, temperature, etc.
[Note 2] Based on our survey (as of Sep. 2021)

TC75S102F
Current Consumption Characteristic
(Toshiba internal comparison)



TC75S67TU
Noise Characteristic
(Toshiba internal comparison)



Line up

Part number	TC75S102F	TC75S103F	TC75S67TU
Package	SMV 		UFV 
V_{DD} - V_{SS} [V]	1.5 to 5.5	1.8 to 5.5	2.2 to 5.5
V_{IO} (Max) [mV]	1.3	1.5	3
CMV_{IN} (Max) [V]	V_{DD}	V_{DD}	1.4 (@V_{DD} = 2.5 V)
I_{DD} (Typ. / Max) [μA]	0.27 / 0.46 (@V_{DD} = 1.5 V)	100 / 165 (@V_{DD} = 1.8 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

Suitable for low frequency, low power amplification and greatly contributes to miniaturization.

1 High voltage

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

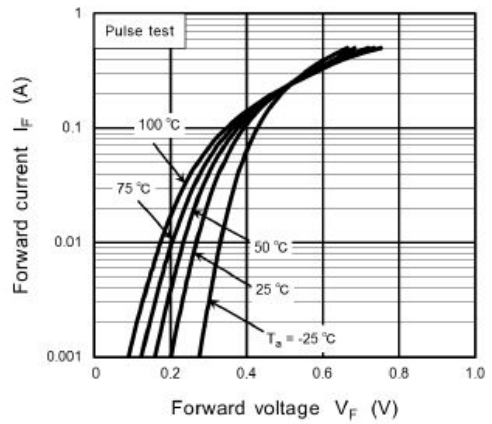
2 Complementary products

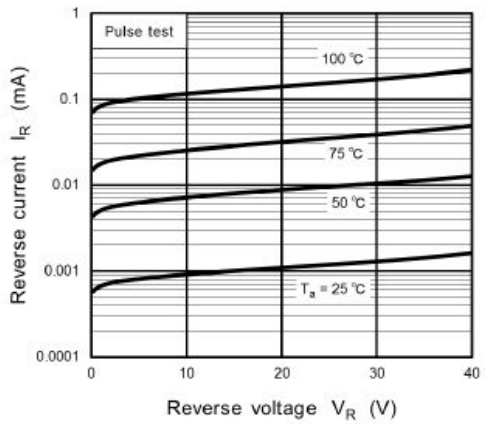
It is complementary to 2SC3325.

3 Larger collector current

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

2SA1313 Characteristics





Line up

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

◆Return to Block Diagram TOP

Value provided

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

1 Built-in Arm® Cortex®-M3/M4 CPU core

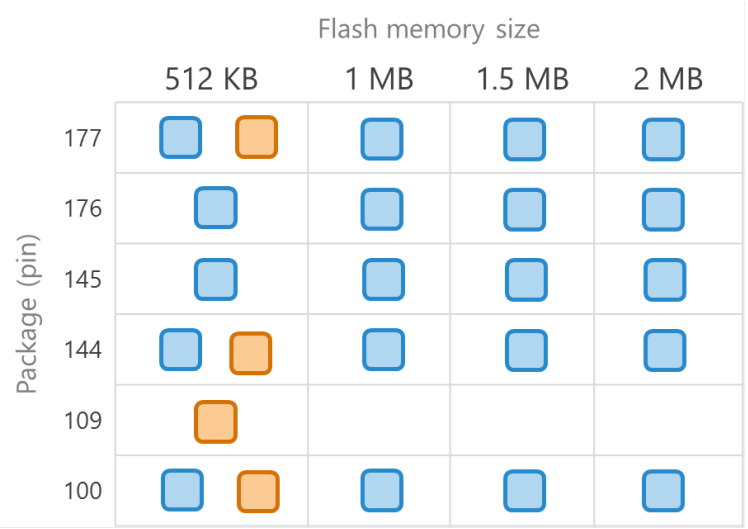
The product lineup is equipped with Arm Cortex-M3/M4 cores. It is suitable for processing sensor data at real time. Various development tool and their partners allow users many options.

2 System cost down and development efficiency improvement

These devices executes sensing data monitoring and processing efficiently by combining built-in multi-channel ADC and timer. In addition, M4N Group products have a lineup of 20 products to provide suitable products for the set.

3 Various communication interfaces

These devices supports major communication interfaces such as USB, CAN, UART, FUART, SPI, I^2C and External bus. User can construct a communication system easily with a cloud.



Line up

Family	Group	Function
TX Family	M360 Group	Arm Cortex-M3, Max. 80MHz operation frequency. M368 / M369 products.
TXZ+™ Family	M4N Group	Arm Cortex-M4, Max. 200MHz operation frequency.

◆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

Terms of use

This terms of use is made between Toshiba Electronic Devices and Storage Corporation (“We”) and customers who use documents and data that are consulted to design electronics applications on which our semiconductor devices are mounted (“this Reference Design”). Customers shall comply with this terms of use. Please note that it is assumed that customers agree to any and all this terms of use if customers download this Reference Design. We may, at its sole and exclusive discretion, change, alter, modify, add, and/or remove any part of this terms of use at any time without any prior notice. We may terminate this terms of use at any time and for any reason. Upon termination of this terms of use, customers shall destroy this Reference Design. In the event of any breach thereof by customers, customers shall destroy this Reference Design, and furnish us a written confirmation to prove such destruction.

1. Restrictions on usage
   1. This Reference Design is provided solely as reference data for designing electronics applications. Customers shall not use this Reference Design for any other purpose, including without limitation, verification of reliability.
   2. This Reference Design is for customer's own use and not for sale, lease or other transfer.
   3. Customers shall not use this Reference Design for evaluation in high or low temperature, high humidity, or high electromagnetic environments.
   4. This Reference Design shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

2. Limitations
   1. We reserve the right to make changes to this Reference Design without notice.
   2. This Reference Design should be treated as a reference only. We are not responsible for any incorrect or incomplete data and information.
   3. Semiconductor devices can malfunction or fail. When designing electronics applications by referring to this Reference Design, customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of semiconductor devices could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Customers must also refer to and comply with the latest versions of all relevant our information, including without limitation, specifications, data sheets and application notes for semiconductor devices, as well as the precautions and conditions set forth in the "Semiconductor Reliability Handbook".
   4. When designing electronics applications by referring to this Reference Design, customers must evaluate the whole system adequately. Customers are solely responsible for all aspects of their own product design or applications. WE ASSUME NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.
   5. No responsibility is assumed by us for any infringement of patents or any other intellectual property rights of third parties that may result from the use of this Reference Design. No license to any intellectual property right is granted by this terms of use, whether express or implied, by estoppel or otherwise.
   6. THIS REFERENCE DESIGN IS PROVIDED "AS IS". WE (a) ASSUME NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (b) DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO THIS REFERENCE DESIGN, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

3. Export Control
   Customers shall not use or otherwise make available this Reference Design for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). This Reference Design may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of this Reference Design are strictly prohibited except in compliance with all applicable export laws and regulations.

4. Governing Laws
   This terms of use shall be governed and construed by laws of Japan.

RESTRICTIONS ON PRODUCT USE

- Toshiba Electronic Devices & Storage Corporation, and its subsidiaries and affiliates (collectively "TOSHIBA"), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively "Product") without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**.
- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE"). ** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative or contact us via our website.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Product may include products using GaAs (Gallium Arsenide). GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**