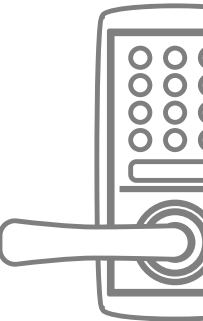
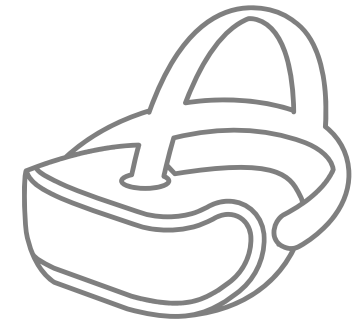
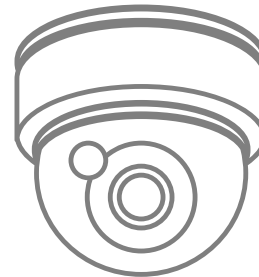
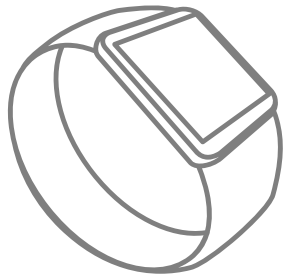
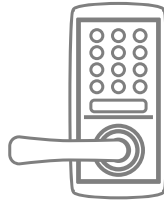


Thermostat

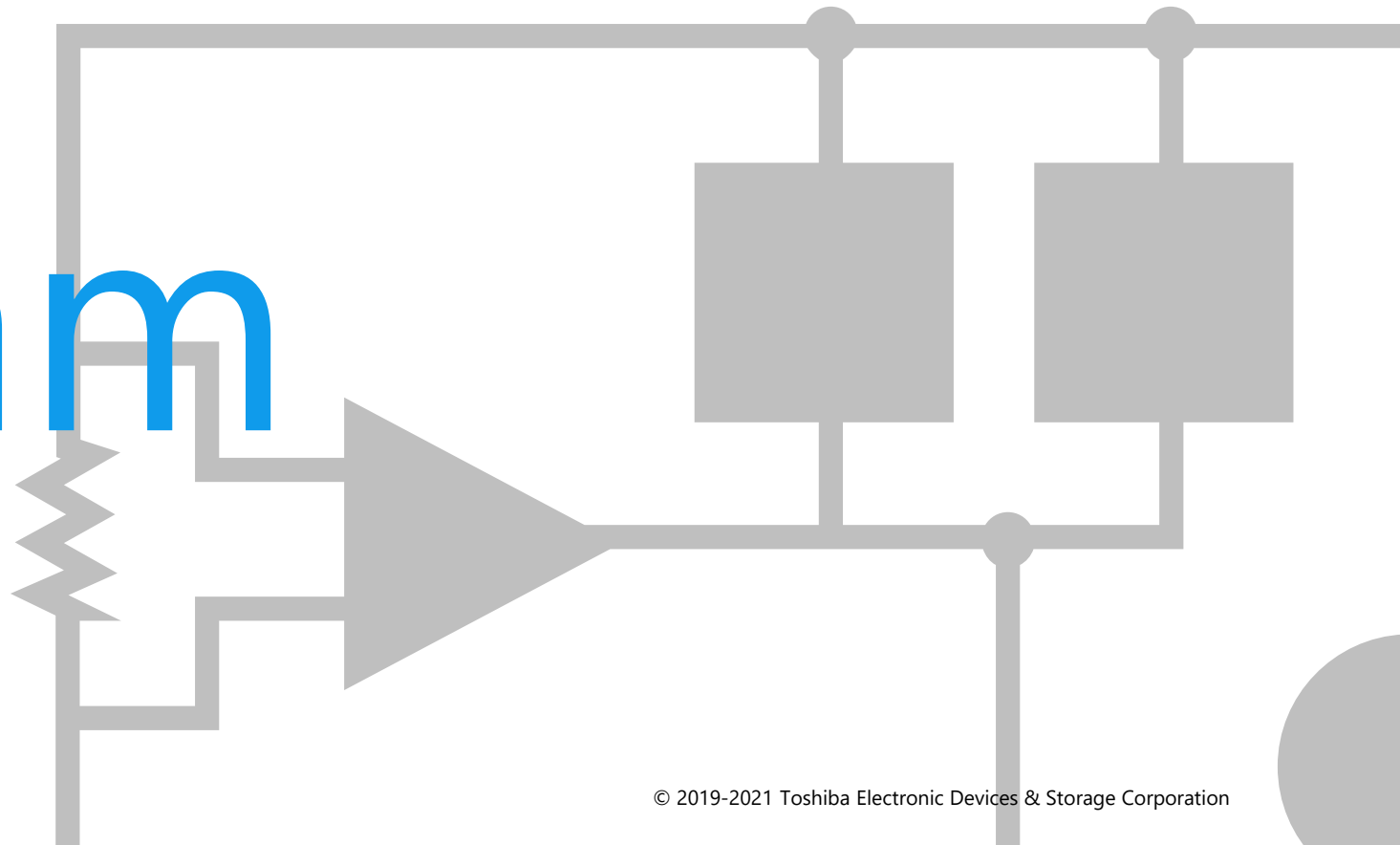
Solution Proposal by Toshiba



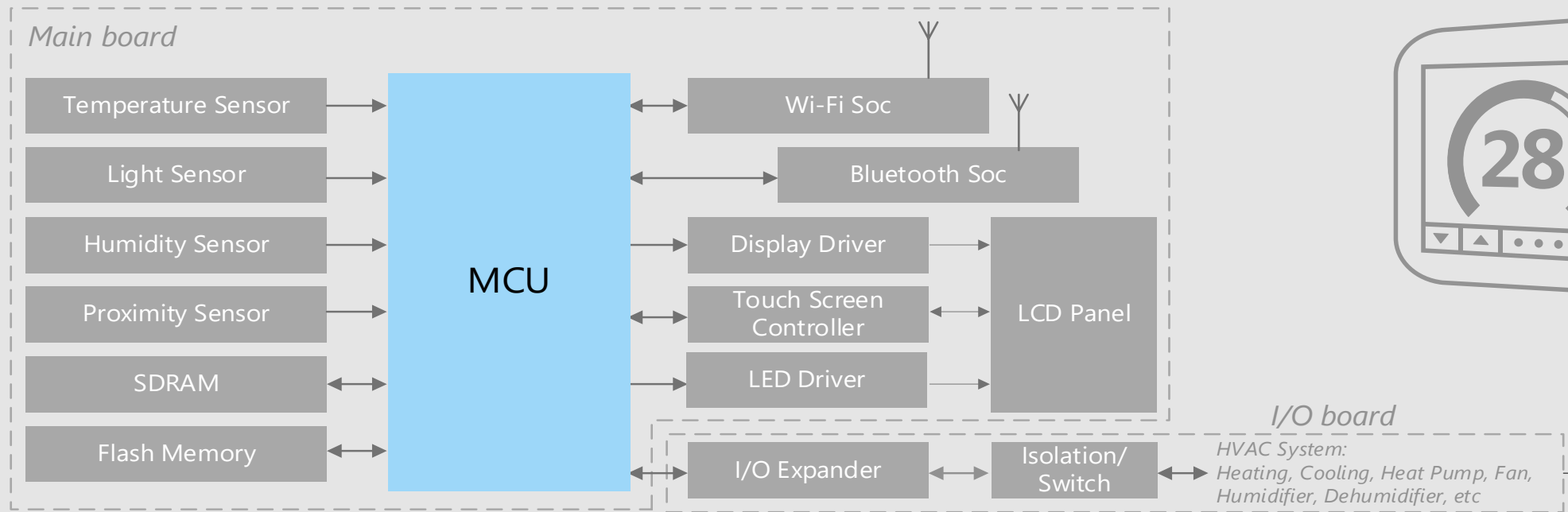
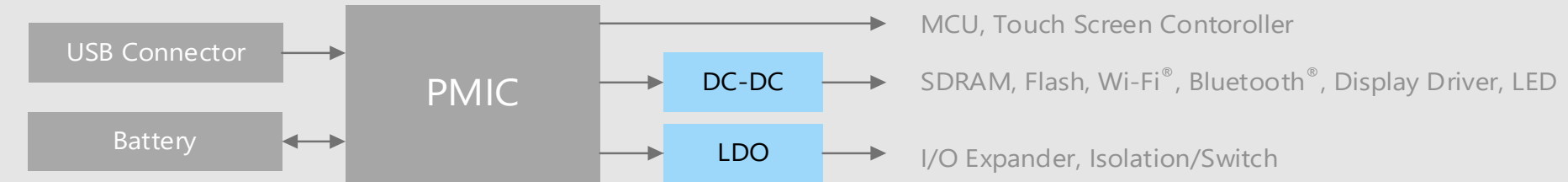


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

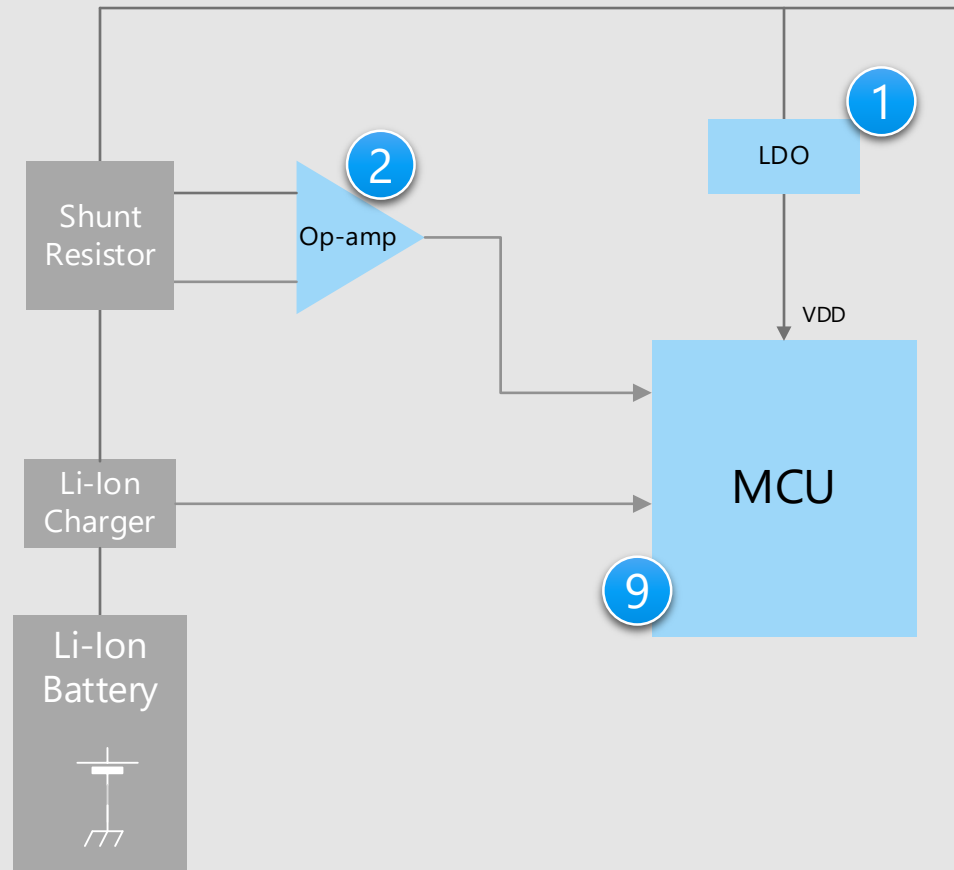


Thermostat Overall block diagram



Thermostat Detail of power supply circuit (1)

Power supply circuit



※ Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

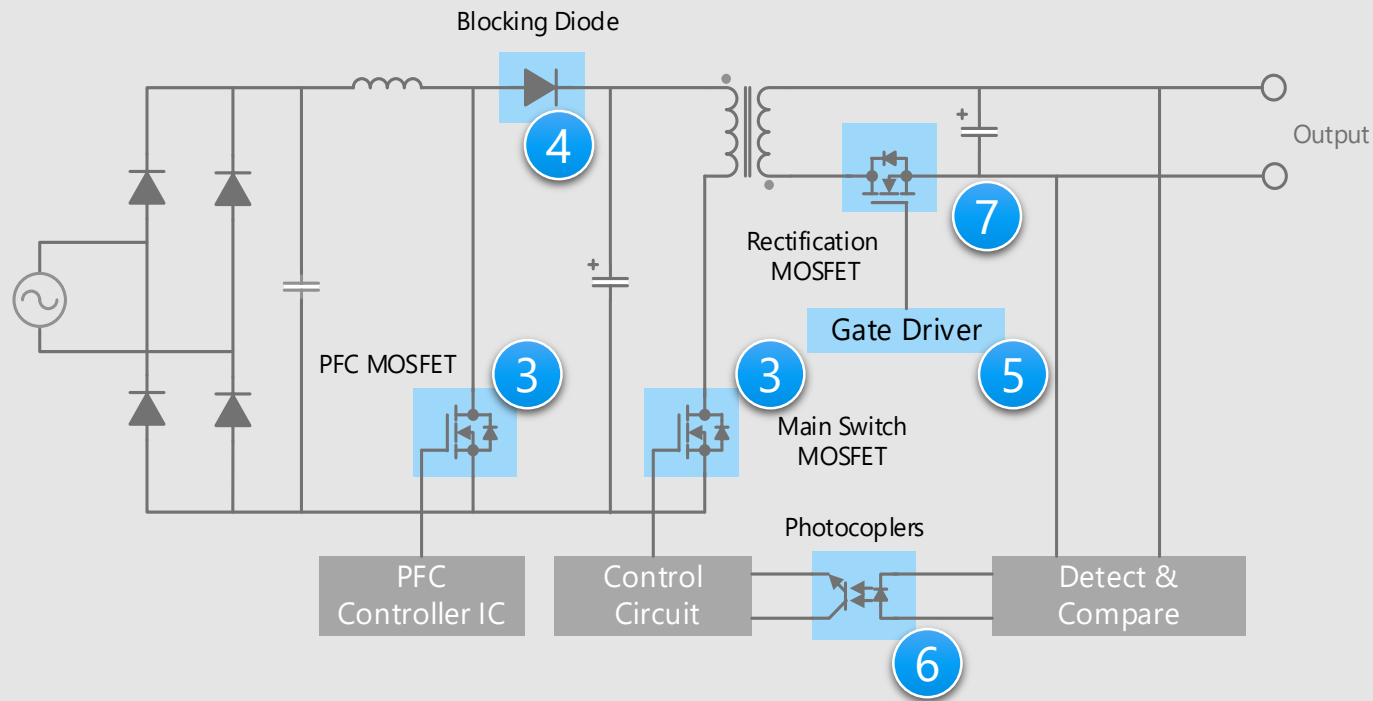
- LDO regulators with low drop-out characteristics are required to perform voltage conversion in a compact and efficient manner.
- The use of small packages reduces the circuit board area.
- Low noise operational amplifiers enable high-precision sensing.

Proposals from Toshiba

- **Small LDO regulator capable of applying a large current** ①
Small surface mount LDO regulator
- **Processing analog signals with low noise** ②
Low noise operational amplifier
- **Built-in analog input interface at low power consumption and efficient software development** ⑨
MCU

Thermostat Detail of power supply circuit (2)

Power supply circuit



Criteria for device selection

- The transistor coupler is for signal isolation.
- Low power consumption can be realized by using a MOSFET with low on-resistance and high heat dissipation efficiency.
- The use of small packages reduces the circuit board area.

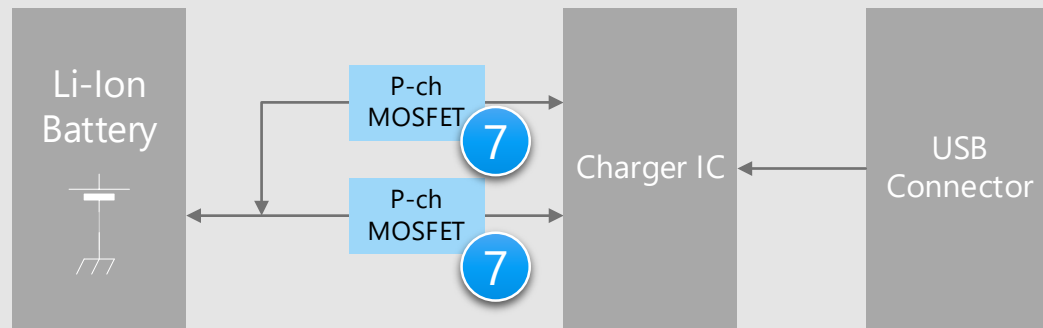
Proposals from Toshiba

- **MOSFET with low on-resistance and high heat dissipation**
π-MOSVII series MOSFET (planar type) 3
- **Contributing to higher efficiency and miniaturization of power supply**
SiC Schottky barrier diode 4
- **Optimal for MOSFET gate control**
Bipolar power transistors 5
- **Photocoupler with excellent environmental resistance**
Transistor output photocoupler 6
- **Realize a set with low power consumption by low on-resistance**
Small-signal MOSFET 7

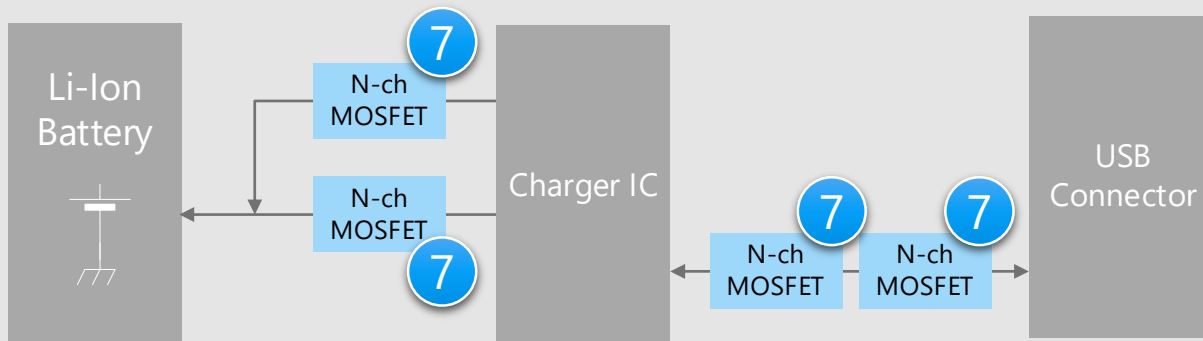
※ Click the number in the circuit diagram to jump to the detailed description page

Thermostat Detail of power supply circuit (3)

Power supply circuit using P-ch MOSFET



Power supply circuit using N-ch MOSFET



※ Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

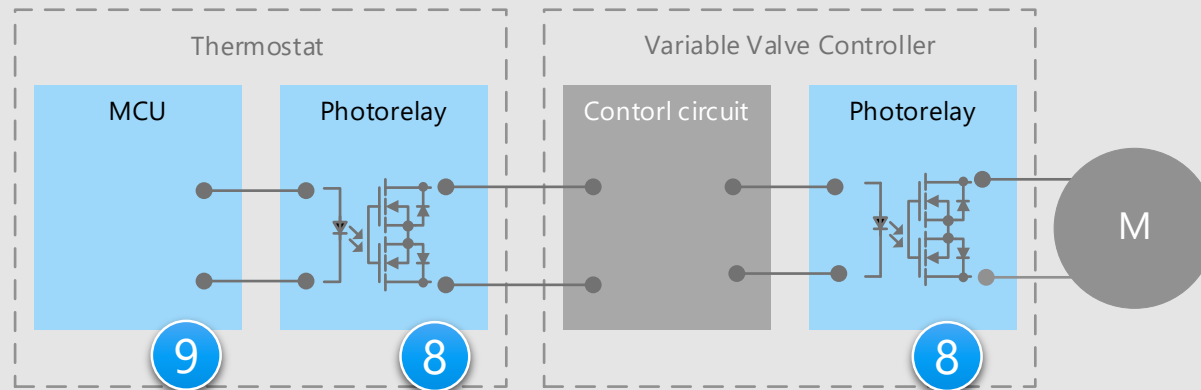
- Low power consumption can be realized by using a MOSFET with low on-resistance and high heat dissipation efficiency.
- The use of small packages reduces the circuit board area.

Proposals from Toshiba

- **Realize a set with low power consumption by low on-resistance** Small-signal MOSFET

7

Isolation circuit



※ Click the number in the circuit diagram to jump to the detailed description page

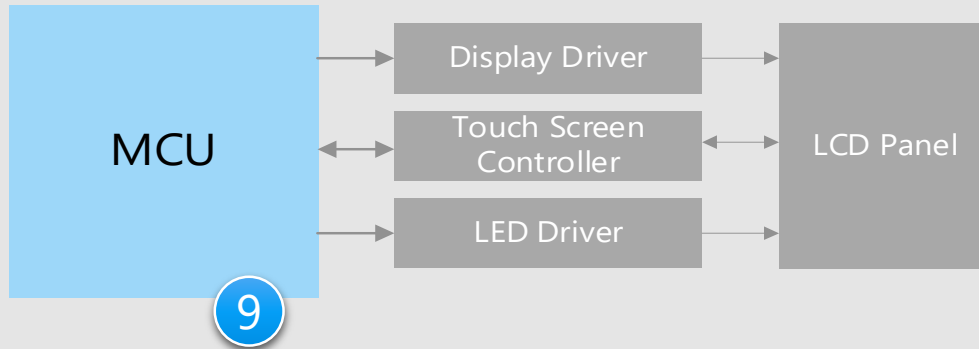
Criteria for device selection

- The use of photorelays instead of mechanical relays eliminates the life limitation caused by contact wear and welding at the contact points, enabling long life and quieter operation.
- The use of small packages reduces the circuit board area.

Proposals from Toshiba

- **Optimal for replacing mechanical relays**
Photorelay (8)
- **Built-in analog input interface at low power consumption and efficient software development**
MCU (9)

Panel display system



Criteria for device selection

- Data processing of various sensing data and feedback control of a system within very short time period

Proposals from Toshiba

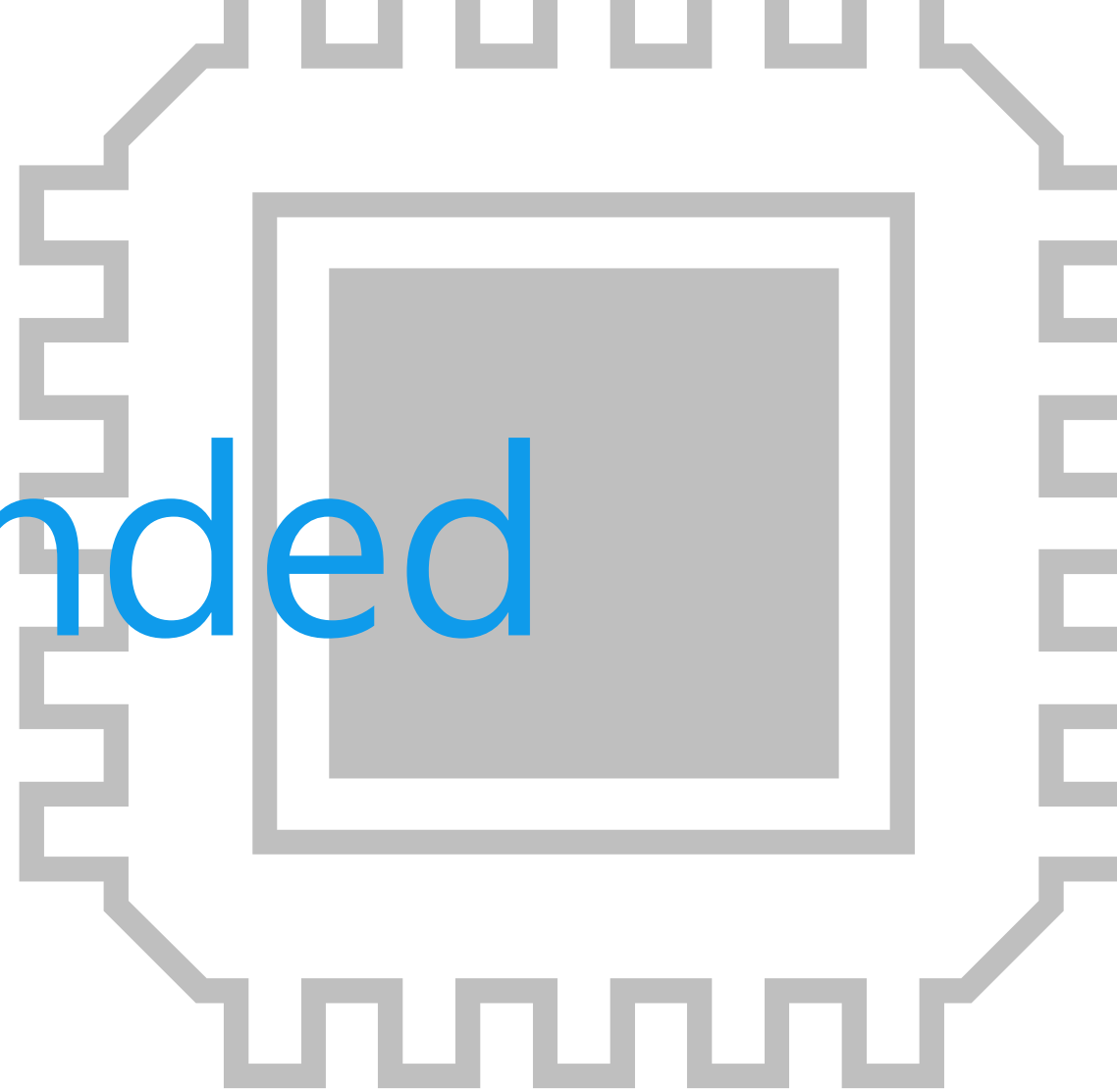
- **Built-in analog input interface at low power consumption and efficient software development**

MCU

9

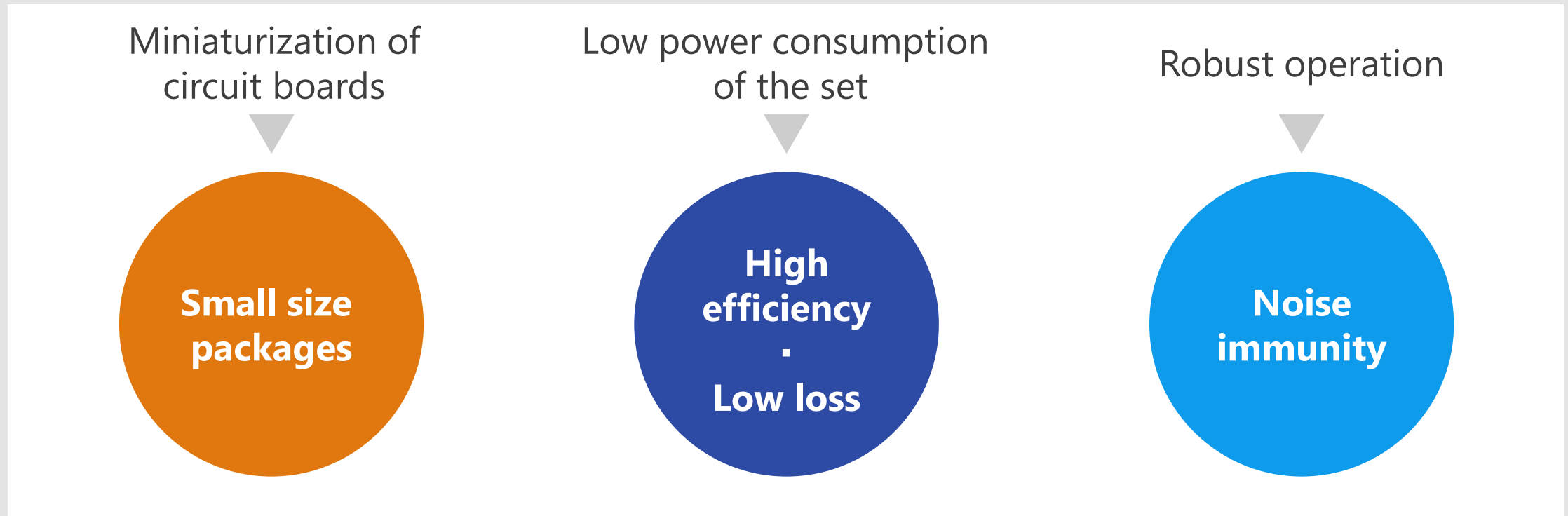
※ Click the number in the circuit diagram to jump to the detailed description page

Recommended Devices



Device solutions to address customer needs

As described above, in the design of thermostat, “**Miniaturization of circuit boards**”, “**Low power consumption of the 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

	Small size packages	High efficiency · Low loss	Noise immunity
① Small surface mount LDO regulator	●	●	●
② Low noise operational amplifier	●	●	
③ π-MOSVII Series MOSFET (planar type)	●	●	●
④ SiC Schottky barrier diode	●	●	
⑤ Bipolar power transistor	●	●	
⑥ Transistor output photocoupler	●	●	●
⑦ Small-signal MOSFET	●	●	
⑧ Photorelay	●	●	●
⑨ MCU	●	●	

1 Small surface mount LDO regulator

TCR2EF / TAR5SB Series

Small size packages

High efficiency
Low loss

Noise immunity

Value provided

To meet high-performance demands with optimum products, we offer from general-purpose to small package devices.

1 Low dropout voltage

The newly developed new-generation process significantly improved the dropout characteristics.

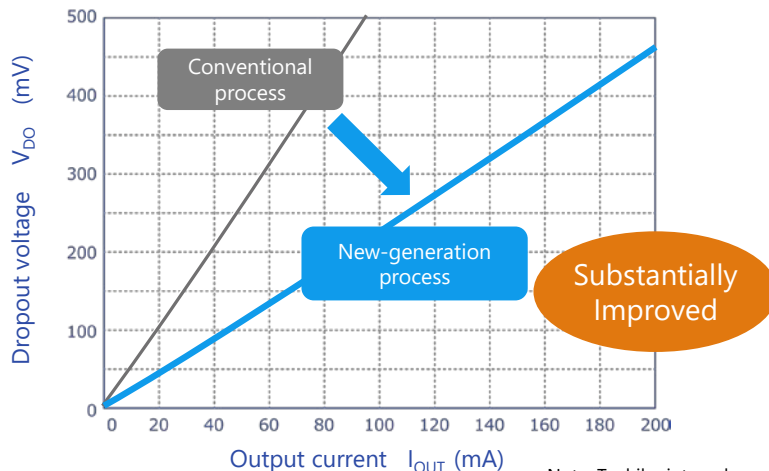
2 High ripple rejection ratio

"High ripple rejection ratio" remove the ripple effectively.

3 Can be used with ceramic capacitors



With improved dropout characteristics, it is possible to use ceramic capacitors as external capacitors.

Low dropout voltage



Note :Toshiba internal comparison

Line up

Part number	TCR2EF Series	TAR5SB Series
Package	SMV 	SMV 
V_{IN} (Max) [V]	5.5	15
I_{OUT} (Max) [mA]	200	200
Output voltage lineup [V]	1.0 to 5.0	1.5 to 5.0

[Return to Block Diagram TOP](#)

2 Low noise operational amplifier

TC75S67TU

Small size packages

High efficiency
Low loss

Noise immunity

Value provided

Very small signals detected by various sensors can be amplified with very low noise.

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

Very small signals detected by various sensors [Note 1] can be amplified with low noise using CMOS operational amplifier by optimizing the processing. We achieved one of the industry's lowest [Note 2] input equivalent noise voltage.

2 Low current consumption
 $I_{DD} = 430$ [μA] (Typ.)

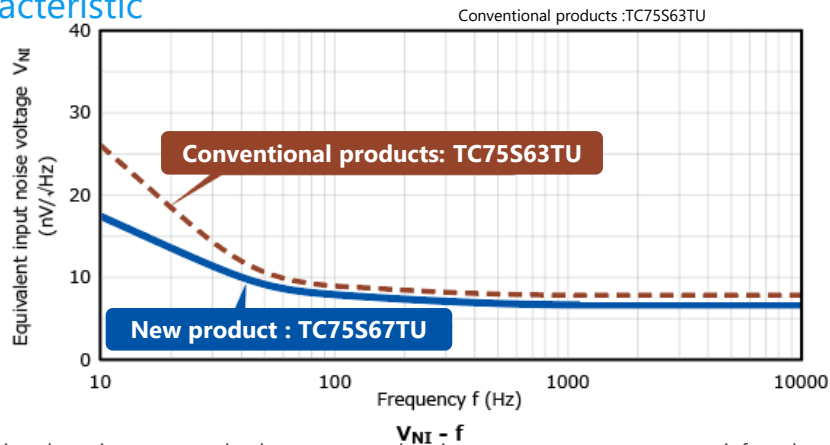
The low current consumption characteristics of CMOS processing contributes to the extension of battery life of the compact IoT devices [Note 3].


3 Enhancement type

It is easy to handle because it is an enhancement type in which no drain current flows when no gate voltage is applied.

Low noise characteristic

(Toshiba internal comparison)



Line up	
Part number	TC75S67TU
Package	UFV 
$V_{DD,SS}$ (Max) [V]	± 2.75
$V_{DD,SS}$ (Min) [V]	± 1.1
I_{DD} (Max) [μA]	700
V_{NI} (Typ.) [nV/ $\sqrt{\text{Hz}}$] @f = 1 kHz	6

[Note 1] Various sensors: vibration detection sensors, shock sensors, acceleration sensors, pressure sensors, infrared sensors, and temperature sensors, etc.

[Note 2] Based on our survey (as of May 2017).

[Note 3] Comparison with our bipolar process operational amplifier

[Return to Block Diagram TOP](#)

Value provided

This MOSFET is suitable for switching regulators and is easy to handle and greatly contributes to miniaturization.

1 Low on-resistance

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

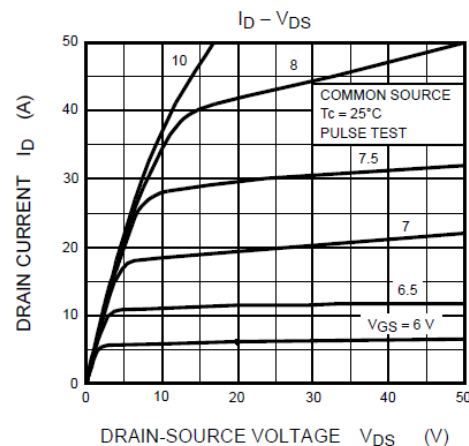
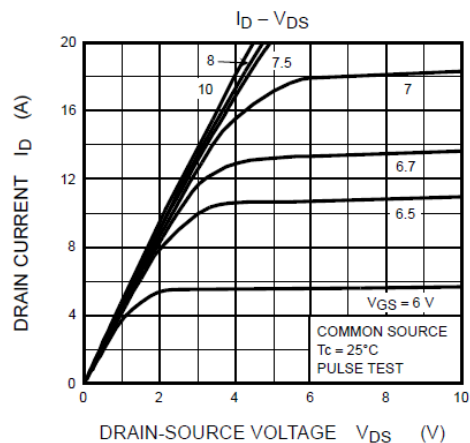
2 Low leakage current

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



3 Enhancement type

It is easy to handle because it is an enhancement type in which no collector current flows when no gate voltage is applied.

TK18A50D Characteristics



Line up

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

[Return to Block Diagram TOP](#)

Value provided

Contributing to higher efficiency and miniaturization of power supply.

1 High current surge resistance

$$I_{FSM} = 37 / 39 \text{ A [Note 1]}$$

Surge current is increased around 2 times of Toshiba's first generation products by using improved JBS structure.

2 Small leakage current

$$I_R (\text{Max}) = 20 \mu\text{A [Note 1]}$$

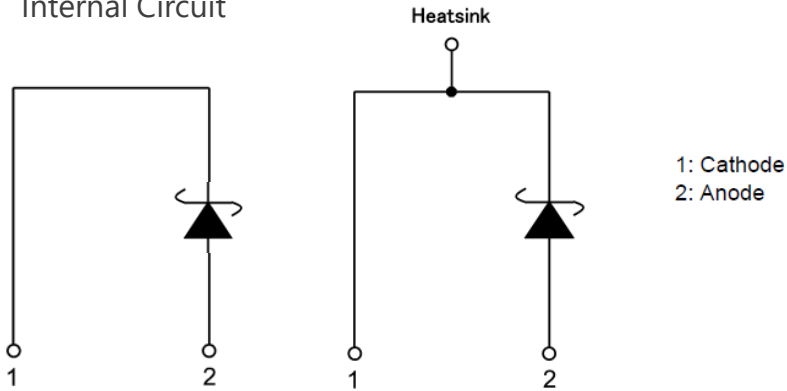
Leak current is reduced around 30 % of Toshiba's first generation products by using improved JBS structure.

3 Low switching loss

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

Reduce the total charge amount by thinning wafer technology, switching loss is reduced around 30 % of Toshiba's first generation products.

Internal Circuit





TO-220F-2L
(Isolation type)

TO-220-2L

[Note 1] : TRS4A65F / TRS4E65F product data
[Note 2] : $Q_{cj} = \int C_j \times V_R dv$ $V_R = 0.1 \text{ to } 400 \text{ V}$

Line up

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

[Return to Block Diagram TOP](#)

5 Bipolar power transistor

HN4B101J / HN4B102J

Small size packages

High efficiency
Low loss

Noise immunity

Value provided

Bipolar power transistor for high-speed switching applications, suitable for MOSFET gate control.

1 Fast switching time

HN4B101J

PNP: $t_f = 45$ ns (Typ.)

NPN: $t_f = 50$ ns (Typ.)

2 High h_{FE}

HN4B101J

$h_{FE} = 200$ to 500 A @ $I_C = -0.12$ A

3 Low collector-emitter saturation voltage

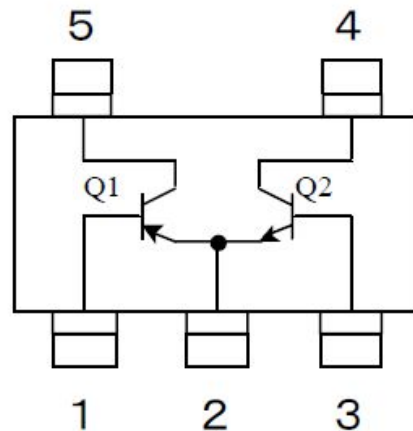
HN4B101J

PNP: $V_{CE(sat)} = -0.20$ V (Max)



NPN: $V_{CE(sat)} = 0.17$ V (Max)

HN4B101J

Internal connection diagram



Line up

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

[Return to Block Diagram TOP](#)

6 Transistor output photocoupler

TLP383 / TLP293 / TLP785 / TLP385

Small size packages

High efficiency
Low loss

Noise immunity

Value provided

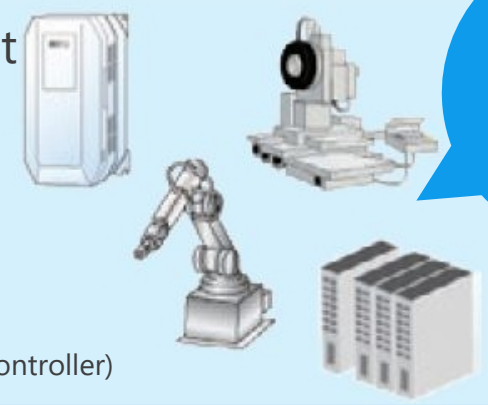
Reduction in required circuit board area and improving reliability enabling maintenance-free operation.

1 High conversion efficiency ($I_F = 0.5 \text{ mA}$)

The TLP383 / TLP293 is a high-isolation photocoupler that optically couples a phototransistor and high-output infrared LED. Compared to conventional electromagnetic relays and insulating transformers, it provides low-input current and higher conversion efficiency.

Industrial equipment

- General-purpose inverter
- Servo amplifier
- Robot
- Machine Tool
- High-output power supply
- Security equipment
- Semiconductor tester
- PLC (Programmable Logic Controller)



High level of isolation and noise blocking

2 High temperature operation guarantee

The TLP383 / TLP293 is designed to operate under severe conditions of ambient temperature environment, such as inverters, robots, machinery, and high-output power supplies.

Line up

Part number	TLP383	TLP293	TLP785	TLP385
Package	SO6L (4pin) 	SO4 	DIP4 	SO6L (4pin) 
BV_S (Min) [Vrms]	5000	3750	5000	5000
T_{opr} [°C]	-55 to 125	-55 to 125	-55 to 110	-55 to 110

[Return to Block Diagram TOP](#)

Value provided

Suitable for power management switches and greatly contributes to miniaturization.

1 Low voltage drive

Drive at $V_{GS} = 1.5\text{ V}$.

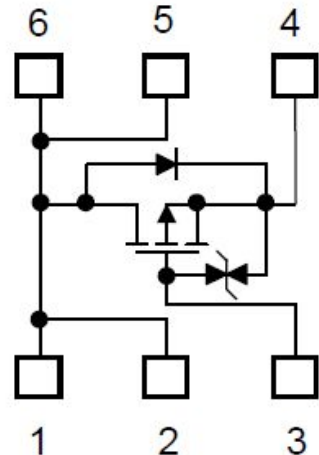
2 Low on-resistance

Heat generation and power consumption can be kept low by keeping the on-resistance between the source and drain low.




3 Small package

UDFN6B type packages.

SSM6J501NU
Equivalent circuit diagram



Line up

Part number	SSM6J501NU	SSM6K513NU	SSM6K514NU
Package	UDFN6B 	UDFN6B 	UDFN6B 
Polarity	P-ch	N-ch	N-ch
V_{DSS} [V]	-20	30	40
I_D [A]	-10	15	12
$R_{DS(ON)}$ (Max) [$m\Omega$] @ $V_{GS} = 4.5\text{ V}$	15.3	8	11.2

[◆Return to Block Diagram TOP](#)

Value provided

Photorelay consists of an infrared light emitting diode optically coupled to a photo-MOSFET and is suitable for replacing mechanical relays.

1 Low on-resistance R_{ON}

On-resistance $R_{ON} = 28 \text{ m}\Omega$ (Typ.)
(TLP3107A : A connection) [Note 1]

2 Wide current range I_{ON}

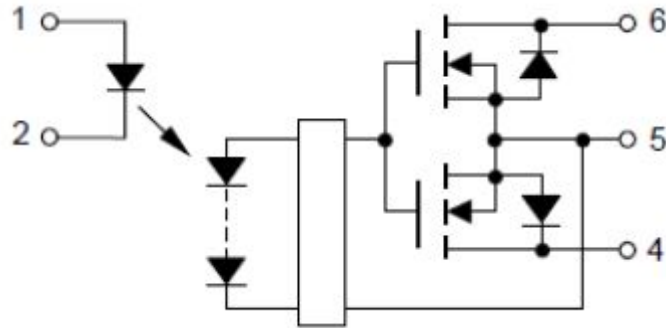
The range of on-state current I_{ON} is wide and suitable for power-line control.
 $I_{ON} = 4.0 \text{ A}$ (Max)
(TLP3107A : A connection) [Note 1]

3 Package

Packages to reduce the size of the set and improve the degree of freedom for design are provided.



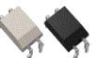
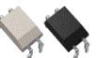


[Note 1] Please refer to the technical data sheet for connection.

TLP3107A
Internal equivalent circuit



Safety Standards
UL-recognized: UL 1577, File No.E67349
cUL-recognized: CSA Component Acceptance Service No.5A File No.E67349

Line up

Part number	TLP3107A	TLP3109A	TLP3555A	TLP241B	TLP3823	TLP3825
Package	2.54 SOP6 		DIP4 		DIP8 	
I_{ON} (Max) [A]	4.0	3.0	3.0	2.0	3.0	1.5
V_{OFF} (Max) [V]	60	100	60	100	100	200
R_{ON} (Max) [m Ω]	40	65	100	200	150	500
BV_S (Min) [Vrms]	1500	1500	1500	5000	2500	2500

[Return to Block Diagram TOP](#)

Value provided

System cost down, high efficiency system, development efficiency improvement

1 Built-in Arm® Cortex®-M0 CPU core

Built-in Cortex-M0 core with Thumb instruction set improves energy efficiency. Various development tool and their partners allow users many options.

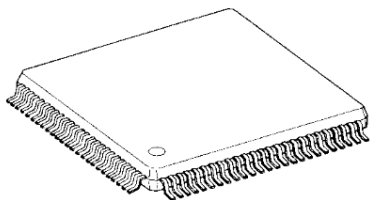
2 Suitable for sensing analog signal

Built-in multi-channel ADC and CPU system executes sensing data processing efficiently at low cost.

3 Small package and very low power consumption

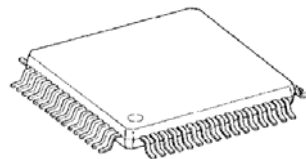
Cortex-M0 and original NANOFLASH™ technology bring to the small package and low power consumption. They contribute foot print and power consumption reduction.

TPM036FWFG



LQFP100

TPM037FWUG



LQFP64

Line up

Part number	TPM036FWFG	TPM037FWUG
Maximum operation frequency	20 MHz	20 MHz
Instruction ROM	128 KB	128 KB
RAM	16 KB	16 KB
Timer	14ch	10ch
UART / SIO	6	5
I2C	2	1
ADC	8ch (10bit)	8ch (10bit)

[Return to Block Diagram TOP](#)

Value provided

Built-in 50 % duty control function in UART, compatible with Home Bus System(HBS).

1 Built-in Arm® Cortex®-M3 CPU core

TPM381FWFG and TPM383FSUG implement Cortex -M3 core with 40 MHz maximum operation frequency. Various development tool and their partners allow users many options.

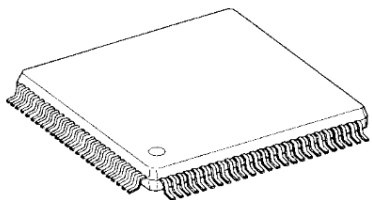
2 Compatible with HBS

UART function is equipped with 50 % duty control function and is compatible with HBS. A control system composed of HBS can be easily constructed using centralized management systems or thermostats.

3 Small package and very low power consumption

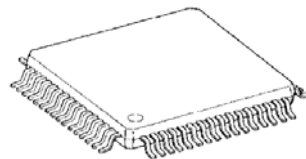
TPM381FWFG and TPM383FSUG execute sensing data monitoring and processing efficiently by combining built-in analog function such as ADC and CPU system. The original NANOFASH™ is possible to rewrite at high-speed. It reduces user software development time period.

TPM381FWFG



LQFP100

TPM383FSUG



LQFP64

Line up

Part number	TPM381FWFG	TPM383FWUG
Maximum operation frequency	40 MHz	40 MHz
Instruction ROM	128 KB	64 KB
RAM	10 KB	8 KB
Timer	16bit x 8ch	16bit x 8ch
UART / SIO	3ch	2ch
UART(50 %duty)	1ch	1ch
ADC	18ch (12bit)	10ch (12bit)

[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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