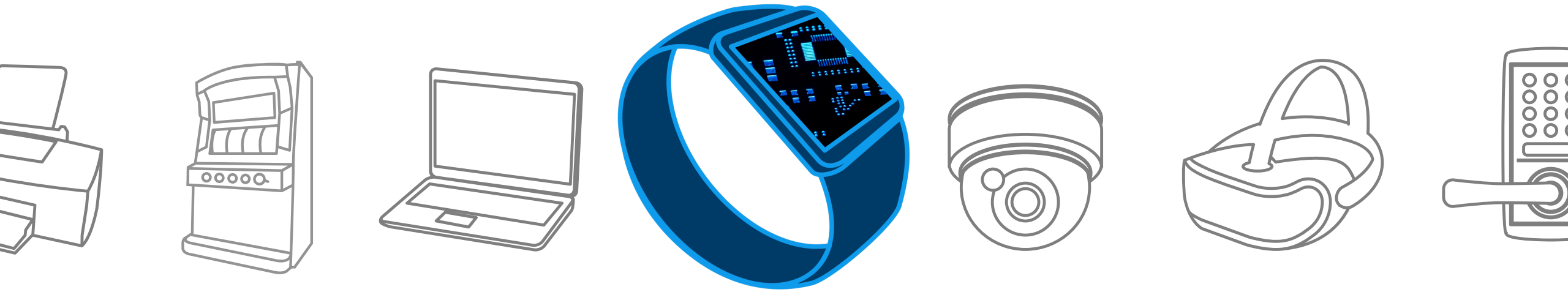
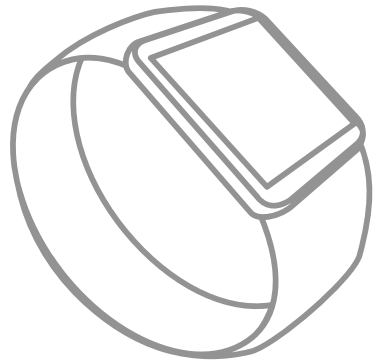
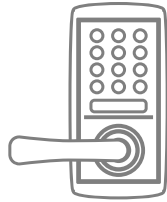


# Smart Watch

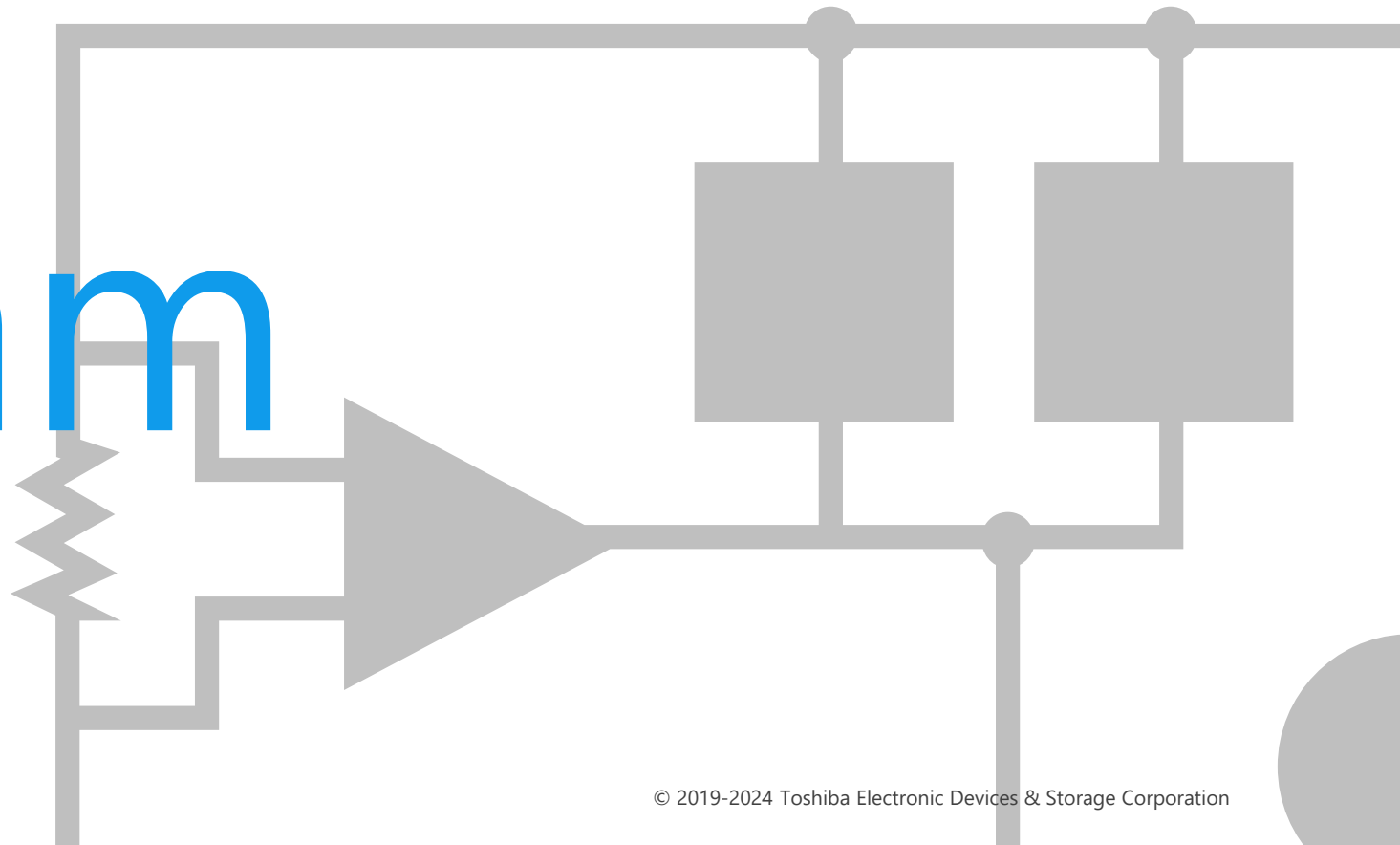
**Solution Proposal by Toshiba**



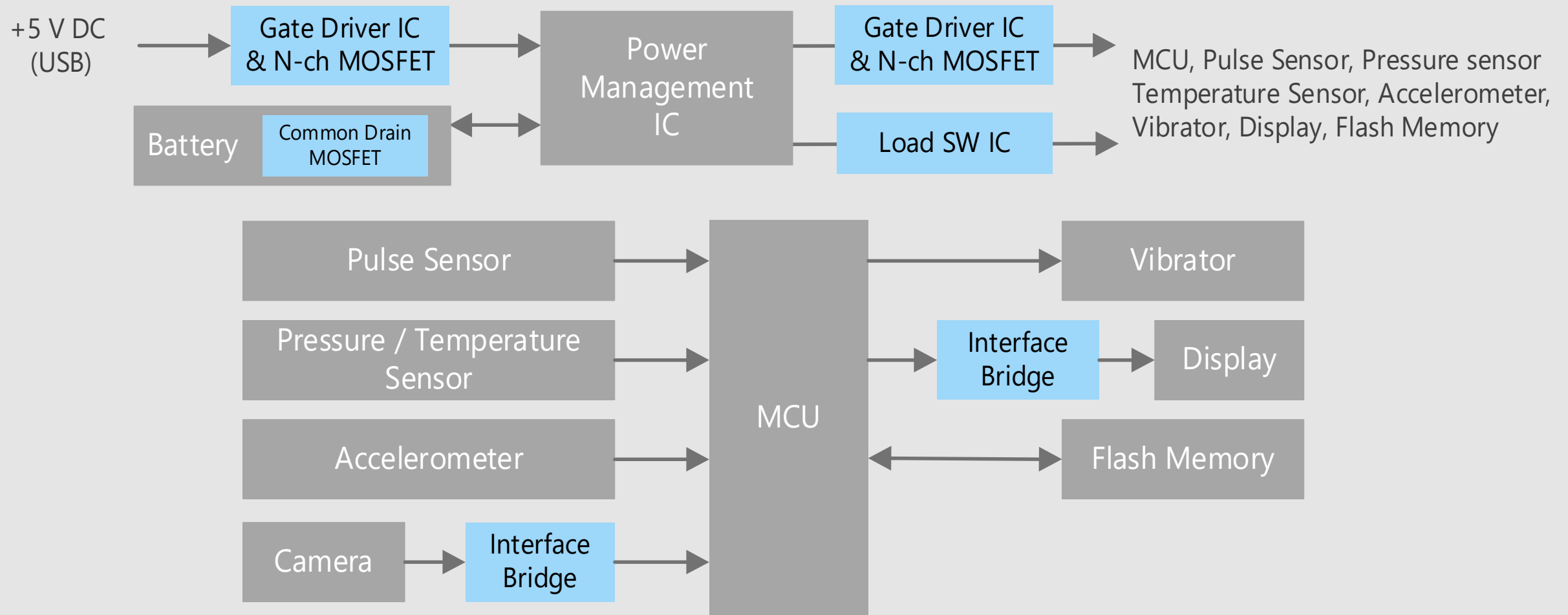


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

# Block Diagram



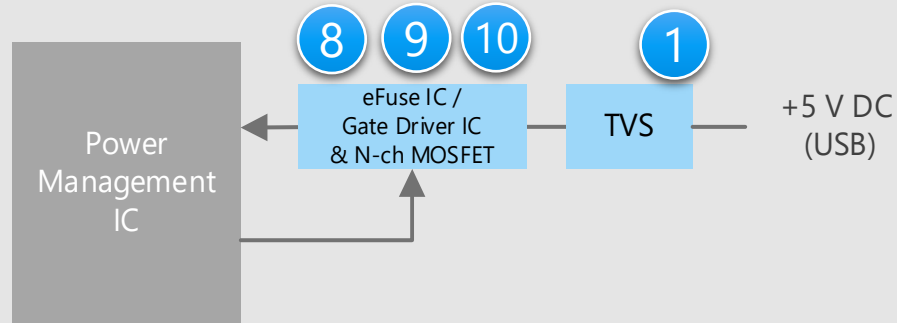
# Smart Watch Overall block diagram



# Smart Watch Detail of power supply unit

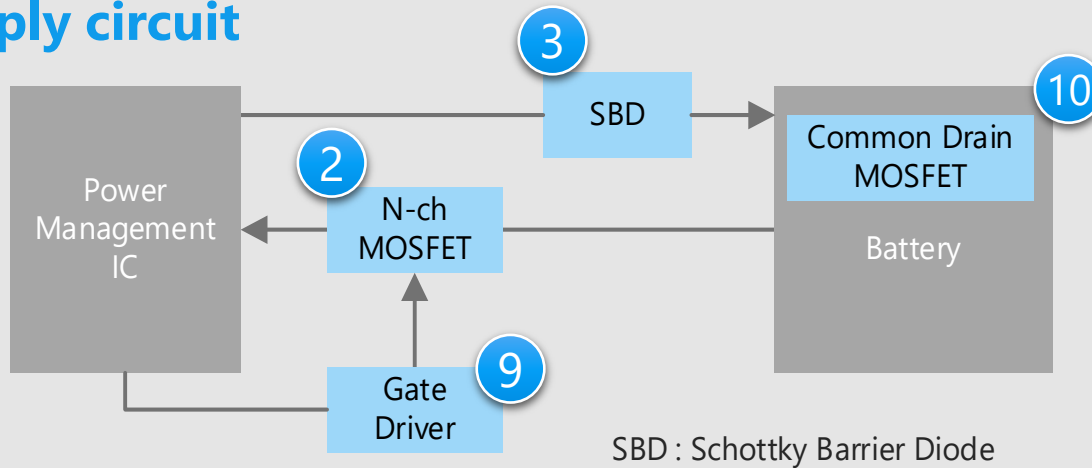
## Power supply circuit

USB type



## Power supply circuit

Battery type



\* Click on the blue circled numbers above to view detailed descriptions.

## Criteria for device selection

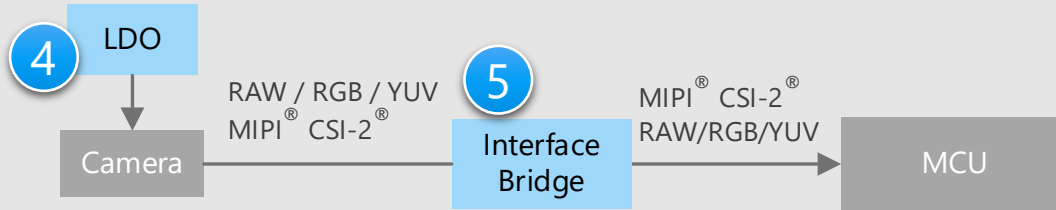
- MOSFETs with low on-resistance are suitable for the control of USB and battery powered supply circuits.
- TVS diodes are suitable for ESD protection of power line.

## Proposal from Toshiba

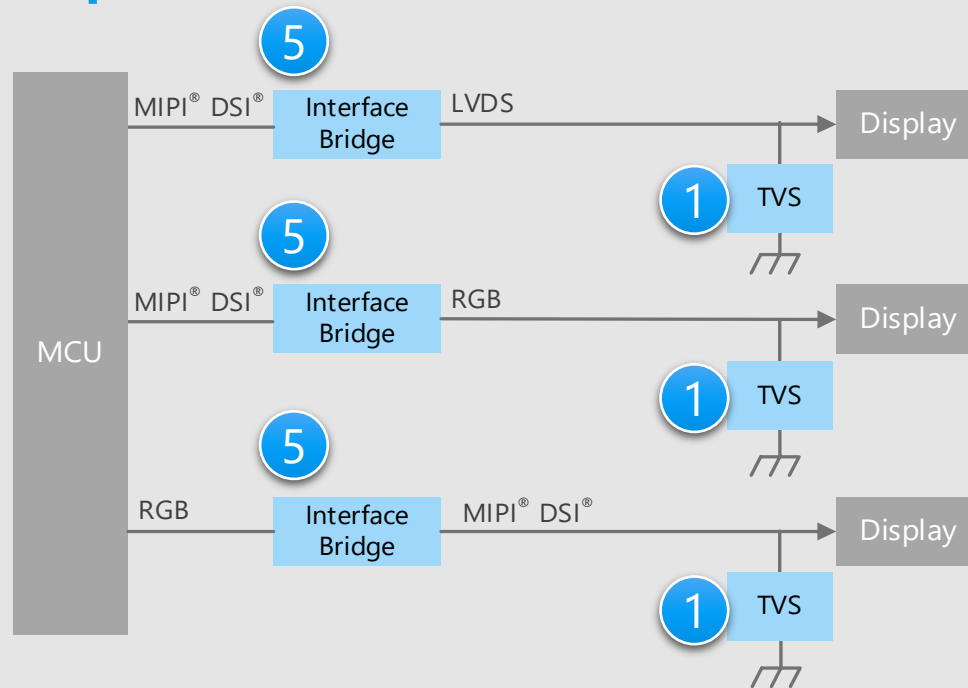
- **Prevent circuit malfunctions by absorbing static electricity from external terminals**  
TVS diode (1)
- **Realize the set with low power consumption by low on-resistance**  
Small single MOSFET (2)
- **High speed, low loss**  
Schottky barrier diode (3)
- **Built-in protection function against short circuit, over current, over voltage, etc.**  
Electronic fuse (eFuse IC) (8)
- **Small package and built-in over voltage protection function**  
N-ch MOSFET gate driver IC (9)
- **Low on-resistance and small package**  
N-ch common drain MOSFET (10)

# Smart Watch Detail of peripheral unit

## Camera input circuit



## Display output circuit



\* Click on the blue circled numbers above to view detailed descriptions.

## Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- By using interface bridge, display and camera components can be selected without any concern for interface standards.

## Proposal from Toshiba

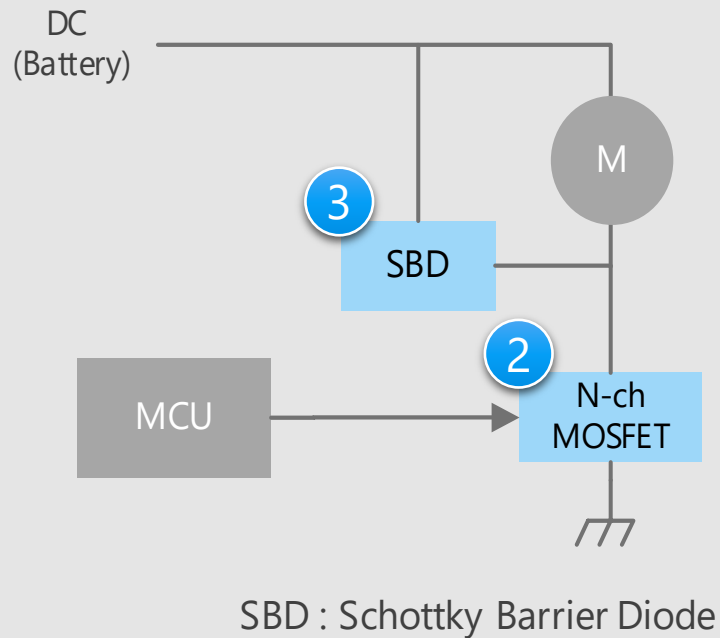
- **Prevent circuit malfunctions by absorbing static electricity from external terminals**  
TVS diode
- **Supply the power with low noise**  
Small surface mount LDO regulator
- **Absorb differences in interfaces**  
Interface bridge

1

4

5

## Motor control for vibrators



## Criteria for device selection

- MOSFETs with low on-resistance are suitable for motor driving.
- By using a Schottky barrier diode with low  $V_F$  and low  $I_R$ , the power consumption of the set can be reduced.

## Proposal from Toshiba

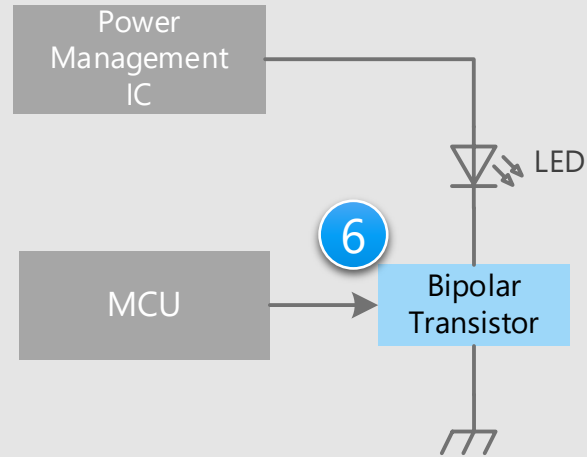
- **The set with low power dissipation can be realized by low on-resistance**  
Small signal MOSFET 2
- **High speed, low loss**  
Schottky barrier diode 3

\* Click on the blue circled numbers above to view detailed descriptions.

# Smart Watch Detail of pulse detection unit

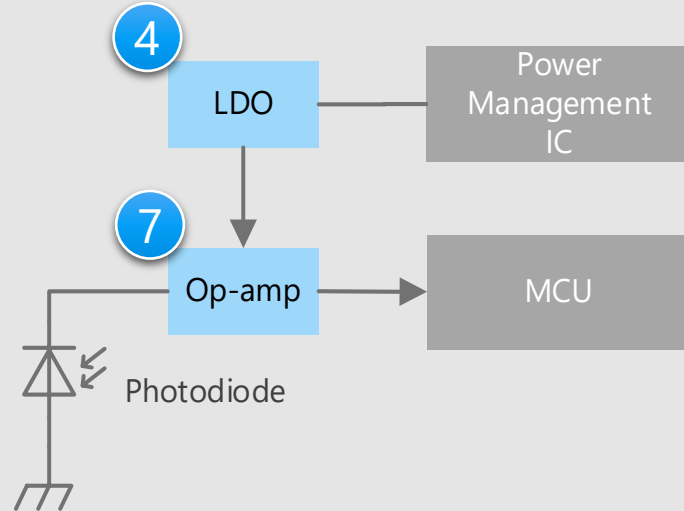
## Pulse detection circuit

Light emission side



## Pulse detection circuit

Light detection side



\* Click on the blue circled numbers above to view detailed descriptions.

## Criteria for device selection

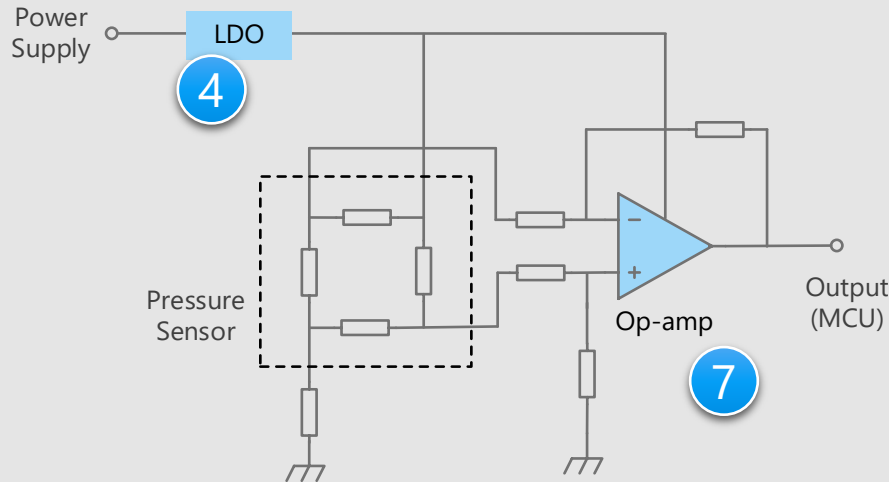
- Transistors with small package and low collector-emitter saturation voltage are required.
- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- The operational amplifier should be low current consumption or low noise device.

## Proposal from Toshiba

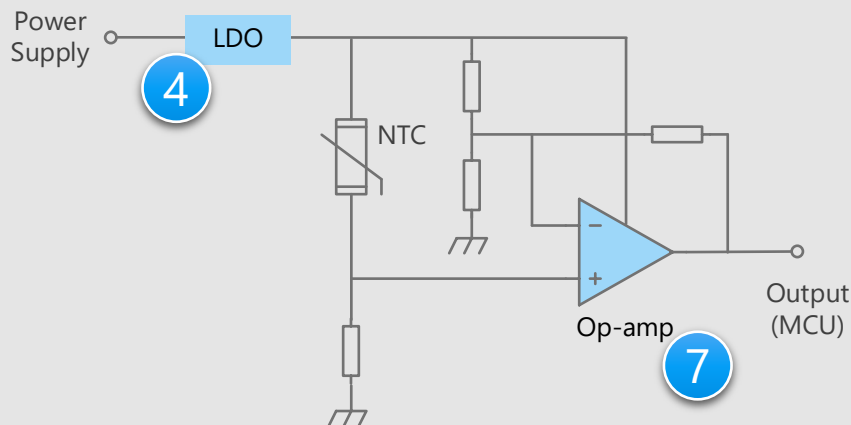
- **Small package, low  $V_{CE(sat)}$**  Bipolar transistor 6
- **Supply the power with low noise** Small surface mount LDO regulator 4
- **Amplification of detected small signal with low noise** Low current consumption op-amp / Low noise op-amp 7



## Atmospheric pressure sensor circuit



## Temperature sensor circuit



\* Click on the blue circled numbers above to view detailed descriptions.

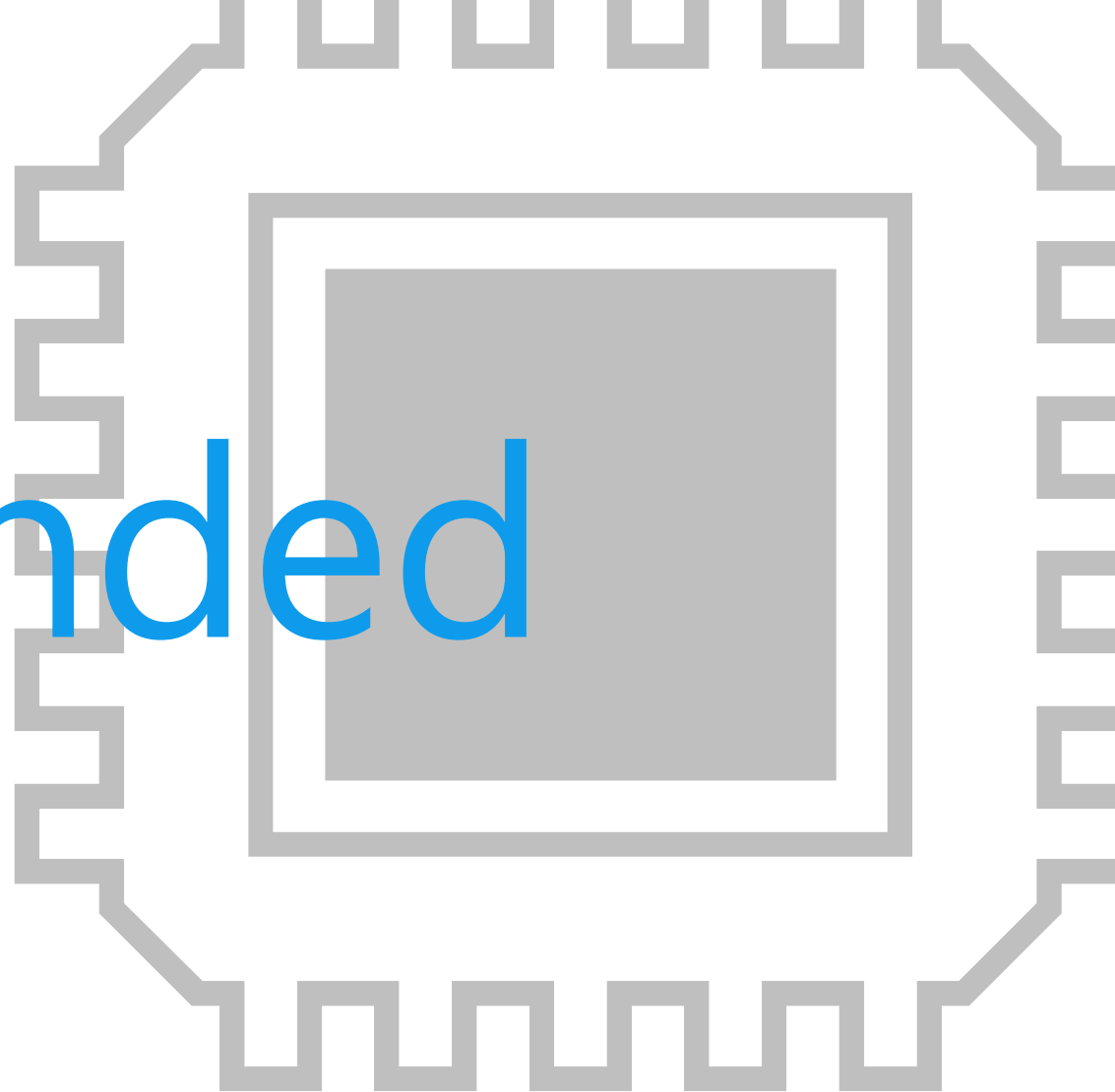
## Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- The operational amplifier should be low current consumption or low noise device.

## Proposal from Toshiba

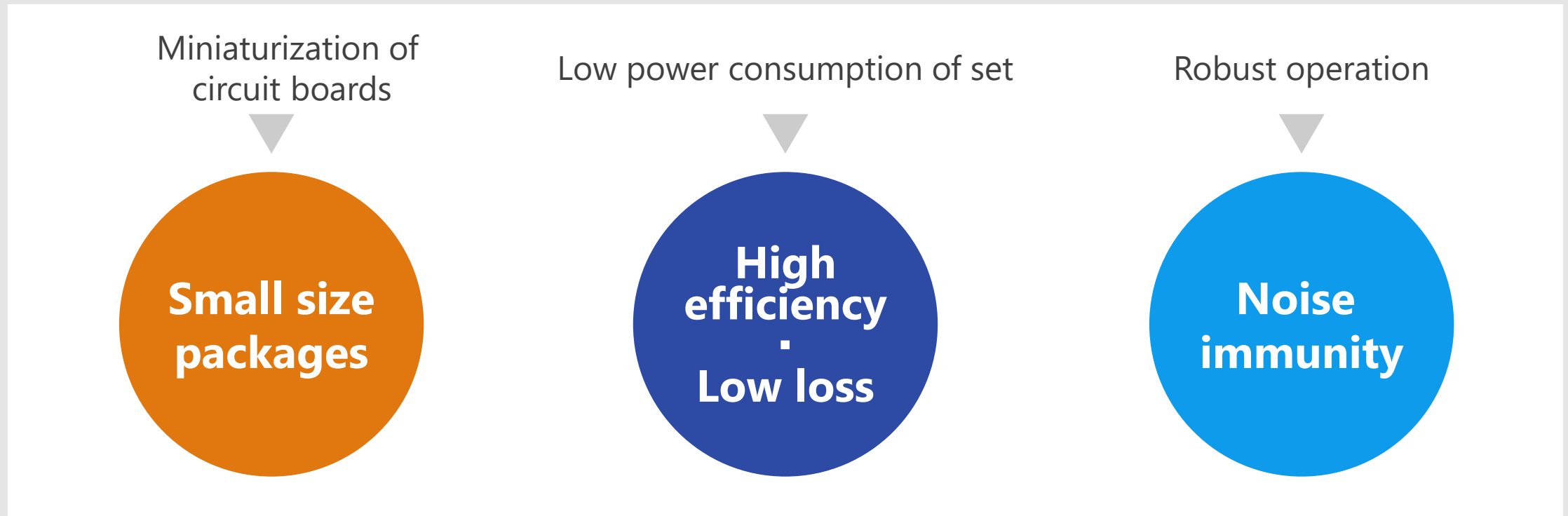
- **Supply the power with low noise** 4  
Small surface mount LDO regulator
- **Amplification of detected small signal with low noise** 7  
Low current consumption op-amp / Low noise op-amp

# Recommended Devices



# Device solutions to address customer needs

As described above, in the design of a smart watch, “**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

	Small size packages	High efficiency · Low loss	Noise immunity
1 TVS diode	●	●	●
2 Small signal MOSFET	●	●	
3 Schottky barrier diode	●	●	●
4 Small surface mount LDO regulator	●	●	●
5 Interface bridge	●		●
6 Bipolar transistor	●	●	
7 Low current consumption op-amp / Low noise op-amp	●	●	
8 Electronic fuse (eFuse IC)	●	●	
9 N-ch MOSFET gate driver IC	●	●	
10 N-ch common drain MOSFET	●	●	

Value provided

This absorbs static electricity from external terminals, prevents circuit malfunction and protects devices.

## 1 High ESD pulse absorption performance

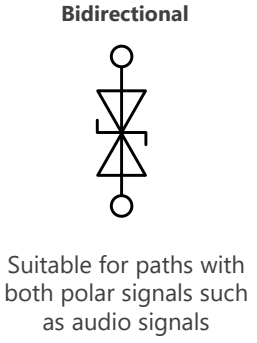
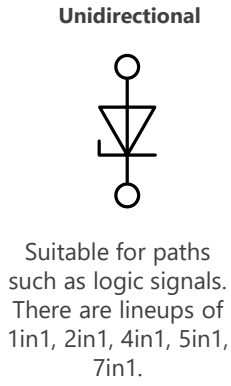
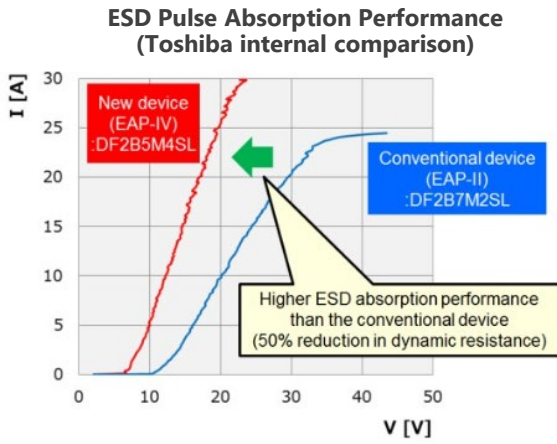
Improved ESD absorption compared to our conventional products. (50 % reduction in operating resistance) For some products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

## 2 Suppress ESD energy by low clamp voltage

Protect the connected circuits and devices using Toshiba own technology.

## 3 Suitable for high density mounting

A variety of small packages are available.



Lineup						
Part number	DF2B6M4SL	DF2B6M4BSL	DF2B20M4SL	DF2B5BSL	DF2B5PCT	DF2B7PCT
Package	SL2			CST2		
$V_{ESD}$ [kV]	±20	±8	±15	±23	±30	±30
$V_{RWM}$ (Max) [V]	5.5	5.5	18.5	3.3	3.6	5.5
$C_t$ (Typ.) [pF]	0.2	0.12	0.2	11	41	45
$R_{DYN}$ (Typ.) [ $\Omega$ ]	0.5	1.05	0.2	0.2	0.1	0.1
Purpose	Signal line	Signal line	Signal line Power line	Power line	Power line	Power line Audio line

(NOTE) This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

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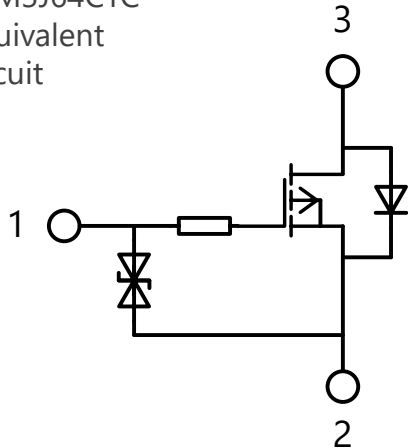
Value provided

Suitable for power management, contributes to miniaturization.

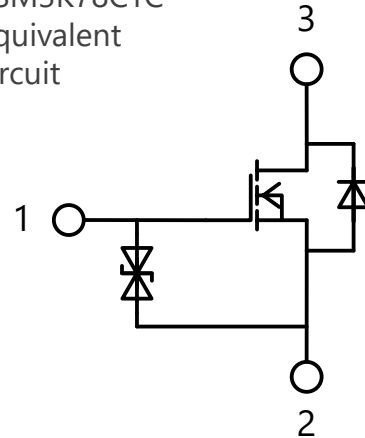
## 1 Low voltage operation

Operates down to  $|V_{GS}| = 1.2 \text{ V}$

SSM3J64CTC  
equivalent  
circuit





SSM3K78CTC  
equivalent  
circuit



## 2 Low on-resistance

By reducing drain and source on-resistance, heat radiation and power dissipation is minimized.

### Lineup

Part number	SSM3J64CTC	SSM3K78CTC
Package	CST3C 	CST3C 
$R_{DS(ON)}$ (Typ.) [ $\Omega$ ] @ $ V_{GS}  = 2.5 \text{ V}$	0.4	1.1
$I_D$ [A]	-1	0.25
$V_{DSS}$ [V]	-12	20
$V_{GSS}$ [V]	$\pm 10$	$\pm 10$
Polarity	P-ch	N-ch

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Value provided

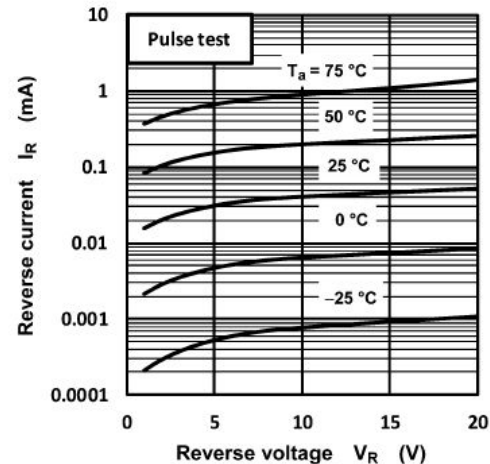
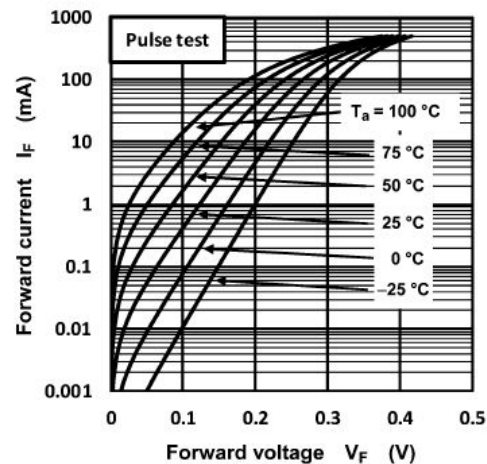
Fast, low loss, small package and suitable for many applications

## 1 Fast switching


Suitable for fast switching applications.

## 2 Small package

Sealed in a CST2 type package.



### Lineup

Part number	CTS05S30
Package	CST2 
$I_O$ [A]	0.5
$V_R$ [V]	20
$V_F$ (Typ.) [V] @ $I_F = 0.1$ A	0.28
$I_R$ (Max) [mA] @ $V_R = 10$ V	0.15

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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 originally developed latest process significantly improved the dropout voltage characteristics.

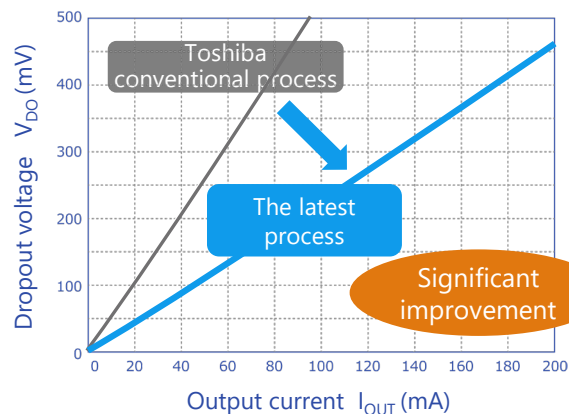
## 2 High PSRR Low output noise voltage

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

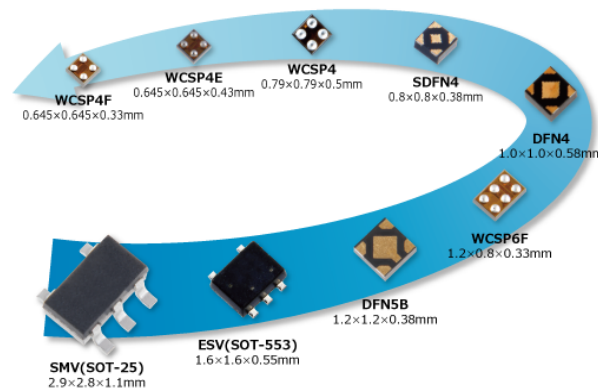
0.34  $\mu\text{A}$  of  $I_{B(ON)}$  is realized by utilizing CMOS process and unique circuit technology.  
(TCR3U Series)

### Low dropout voltage



(Note) Toshiba internal comparison with TCR3U series.

### 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.) [ $\mu\text{A}$ ]	25	56	20	19	7	7	0.34	1	170

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Value provided

Eliminating the interface gap between host and display/camera allows more options of component selection.

### 1 Wider component selection

Conversion of the interface allows shared procurement with other products as well as adoption of less inexpensive parts.

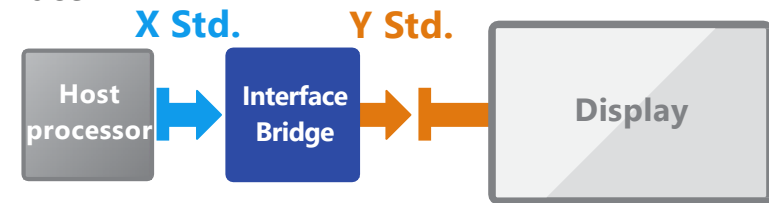
### 2 Noise immunity

Converting parallel communication to serial improves noise tolerance and suppresses noise generation to the surroundings.

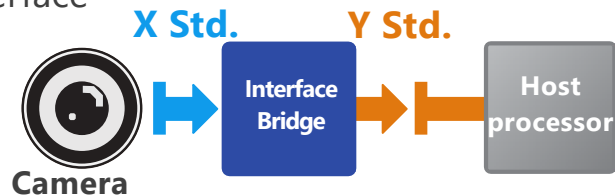
### 3 Less cabling

Converting from parallel communication to serial reduces total number of wires and the risks of wire breakage.

■ Display interface



■ Camera interface



Lineup

Part number	TC358774XBG	TC358767AXBG	TC358768AXBG	TC358746AXBG
Package	VFPGA49	VFPGA81	VFPGA72	VFPGA72
Input	MIPI® DSI® 1.01 4Lanes x 1ch	(1) MIPI® DSI® 1.01 (2) MIPI® DPI <sup>SM</sup> 2.0 (3) MIPI® DSI® 1.01	RGB	(1) MIPI® CSI-2® (2) Parallel 24bit
Output	LVDS Single Link (5 pairs/link)	(1)(2) VESA DisplayPort™ 1.1a (3) MIPI® DPI <sup>SM</sup> 2.0	MIPI® DSI® 1.02	(1) Parallel 24bit (2) MIPI® CSI-2®

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Value provided

## Suitable for low frequency switching and contributes to miniaturization

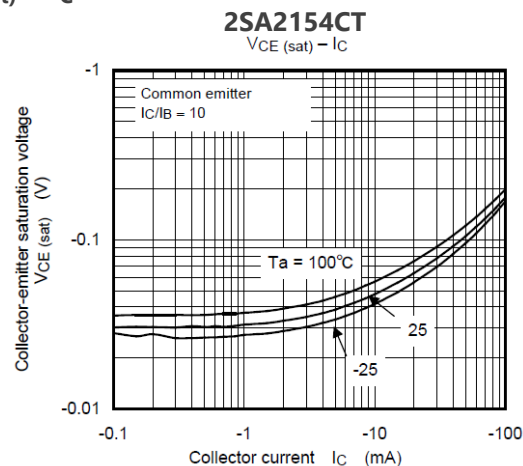
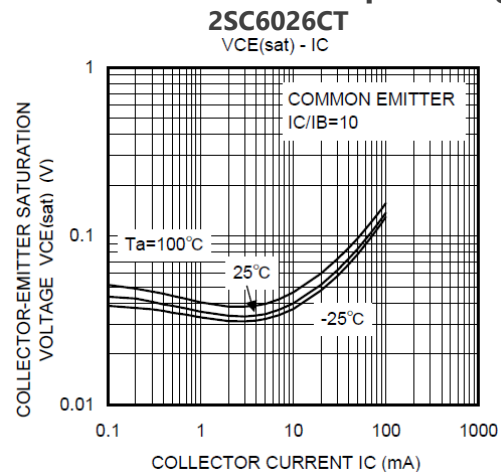
### 1 Many package lineups

A large number of packages, such as flat lead and leadless, are available, allowing you to choose products that suit your board.

### 2 Low collector-emitter saturation voltage

The saturation voltage between the collector and emitter is low and the power consumption is low.

Examples of  $V_{CE(sat)} - I_C$  characteristic



#### Lineup

Part number	2SC6026CT	2SA2154CT
Package	CST3 	CST3 
$V_{CEO}$ [V]	50	-50
$I_C$ [mA]	100	-100
$V_{CE(sat)}$ (Max) [V]	0.25	-0.3
Polarity	NPN	PNP

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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 wearable equipment.

## 2 Low current consumption (TC75S102F) $I_{DD} = 0.27$ [ $\mu\text{A}$ ] (Typ.)

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

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

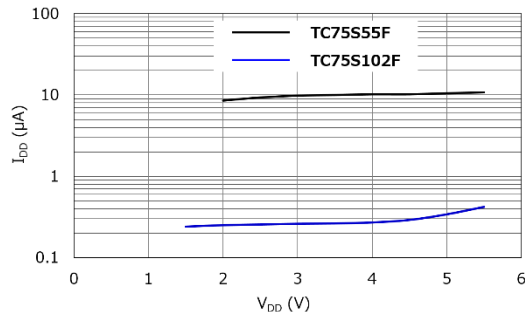
This CMOS operational amplifier can amplify minute signals detected by various sensors [Note] with low noises. By optimizing the process, the equivalent input noise voltage has been reduced.

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

### TC75S102F

Current Consumption Characteristic  
(Toshiba internal comparison)

Low current consumption product TC75S102F

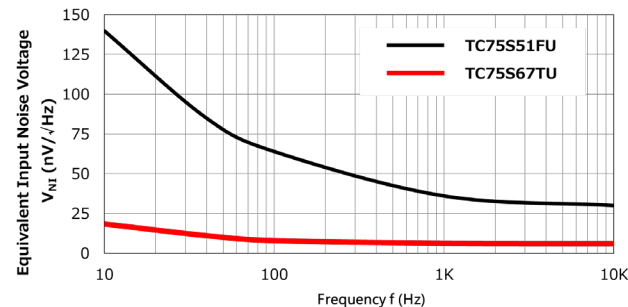


### TC75S67TU



Noise Characteristic  
(Toshiba internal comparison)

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

$V_{NI} - f$  @  $T_a = 25$  °C,  $V_{DD} = 3.3$  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) [ $\mu\text{A}$ ]	0.27 / 0.46 (@ $V_{DD} = 1.5$ V)	430 / 700 (@ $V_{DD} = 2.5$ V)
$V_{NI}$ (Typ.) [ $\text{nV}/\sqrt{\text{Hz}}$ ] @ $f = 1$ kHz	-	6

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# 8 Electronic fuse (eFuse IC)

TCKE8 Series / TCKE7 Series

Small size packages

High efficiency  
Low loss

Noise immunity

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as overcurrent and overvoltage.

## 1 Can be used repeatedly

When overcurrent flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. It is not destroyed by a single overcurrent and can be used repeatedly.

## 2 IEC 62368-1 certified

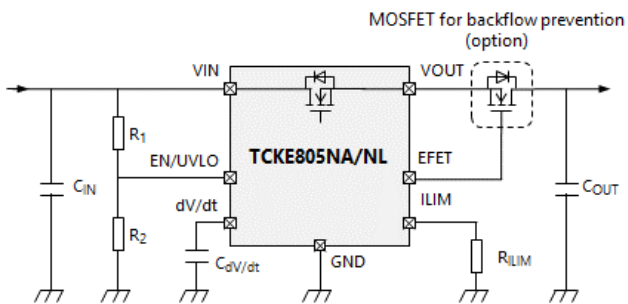
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

## 3 Rich protection functions

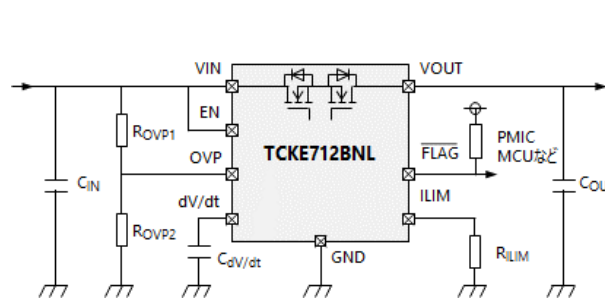
TCKE8 Series: Short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

TCKE7 Series: Short-circuit protection, overcurrent protection, overvoltage protection, thermal shut down, FLAG signal output, backflow prevention (built-in), etc.

Reference circuit example of TCKE8 Series



Reference circuit example of TCKE7 Series



### Lineup

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSO10B 3.0 x 3.0 x 0.75 mm			WSO10 3.0 x 3.0 x 0.75 mm
V <sub>IN</sub> [V]	4.4 to 18			4.4 to 13.2
R <sub>ON</sub> (Typ.) [mΩ]	28			53
Return function	NA: Automatic return NL: Latch type (external signal control)			Latch type (external signal control)
V <sub>OVC</sub> (Typ.) [V]	-	6.04	15.1	Adjustable

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Value provided

It is N-ch MOSFET gate driver IC with OVP [Note 1] function. It contributes to reduction of power consumption and miniaturization of load switch circuit.

[Note 1] OVP: Over Voltage Protection

## 1 Three types of N-ch MOSFET can be driven

The following types of MOSFET can be driven:  
 TCK40xG: Single high side connection  
           Common source connection  
 TCK42xG: Single high side connection  
           Common drain connection

## 2 Wide operating voltage range and various OVLO [Note 2] threshold voltage

Operating voltage  $V_{opr}$ : 2.7 to 28 V  
 Maximum input voltage: 40 V  
 $V_{IN\_OVLO}$  [Note 3] lineups suitable for 5 to 24V power supply line.

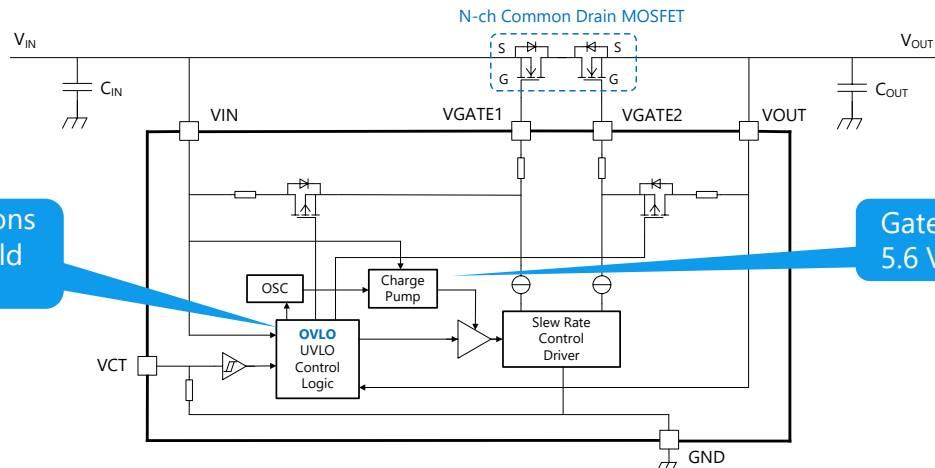
[Note 2] OVLO: Over Voltage Lock Out  
 [Note 3]  $V_{IN\_OVLO}$ :  $V_{IN}$  OVLO threshold

## 3 Small packages



It contributes to reduction of the mounting area and miniaturization of the circuit board :

WCSP6E: 1.2 x 0.8 mm, t: 0.55 mm  
 WCSP6G: 1.2 x 0.8 mm, t: 0.35 mm

### Circuit example of TCK42xG with N-ch common drain connection MOSFET



### Lineup

Part number	$V_{IN\_OVLO}$ Min / Max [V]	$V_{GS}$ Typ. / Max [V]	N-ch MOSFET type can be driven	Package
TCK401G	Over 28	Max 10 ( $V_{IN} \geq 12$ V)	Single high side Common Source	WCSP6E 
TCK402G				
TCK420G	26.50 / 28.50	10 / 11 ( $V_{IN} \geq 5$ V)	Single high side Common Drain	WCSP6G 
TCK421G	22.34 / 24.05			
TCK422G	13.61 / 14.91			
TCK423G	13.61 / 14.91	5.6 / 6.3		
TCK424G	10.35 / 11.47			
TCK425G	5.76 / 6.87			

[Return to Block Diagram TOP](#)

# 10 N-ch common drain MOSFET

## SSMxN9 Series

Small size packages

High efficiency  
·  
Low loss

Noise immunity

Value provided

This is low on-resistance MOSFET with small and thin package. It contributes to suppressing heat generation during charging and discharging, as well as to reducing the size of set.

### 1 Low on-resistance

Low on-resistance is achieved by applying a low resistance diffusion process. This contributes to suppression of heat generation.

### 2 Small and thin package

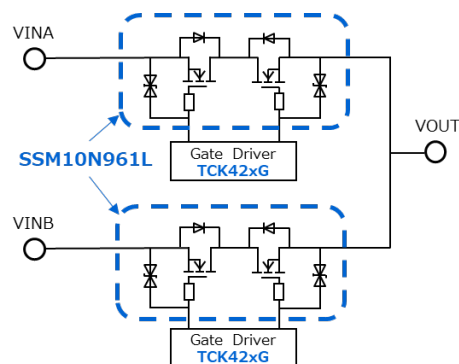
While in a dual configuration, it is a small and thin chipLGA package products. This contributes to miniaturization of set.

### 3 Low gate-source leakage current

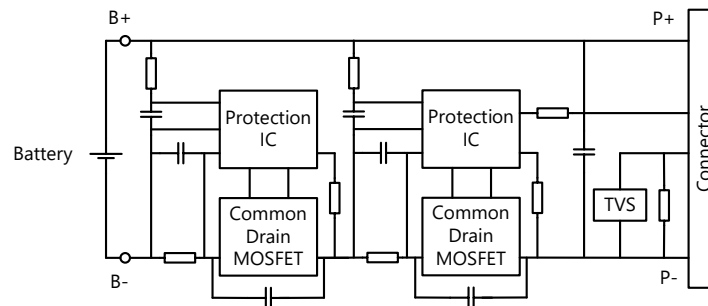
Low gate-source leakage current characteristics enable low standby power and contribute to long term operation of battery used sets.

## Examples of common drain MOSFET application




### Power multiplexer



### Li-ion battery protection circuit



## Lineup

Part number	SSM14N956L	SSM10N954L	SSM6N951L	SSM10N961L
Package	 TCSPED-302701	 TCSPAC-153001	 TCSP6A-172101	 TCSPAG-341501
Source-source voltage $V_{SSS}$ [V]	12			30
Gate-source voltage $V_{GSS}$ [V]	$\pm 8$			$\pm 20$
Source current (DC) $I_S$ [A]	20.0	13.5	8.0	14.0
$R_{SS(ON)}$ (Typ.) [m $\Omega$ ] @ $V_{GS} = 3.8$ V	1.1	2.2	4.6	-
$R_{SS(ON)}$ (Typ.) [m $\Omega$ ] @ $V_{GS} = 10$ V	-	-	-	9.9

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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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