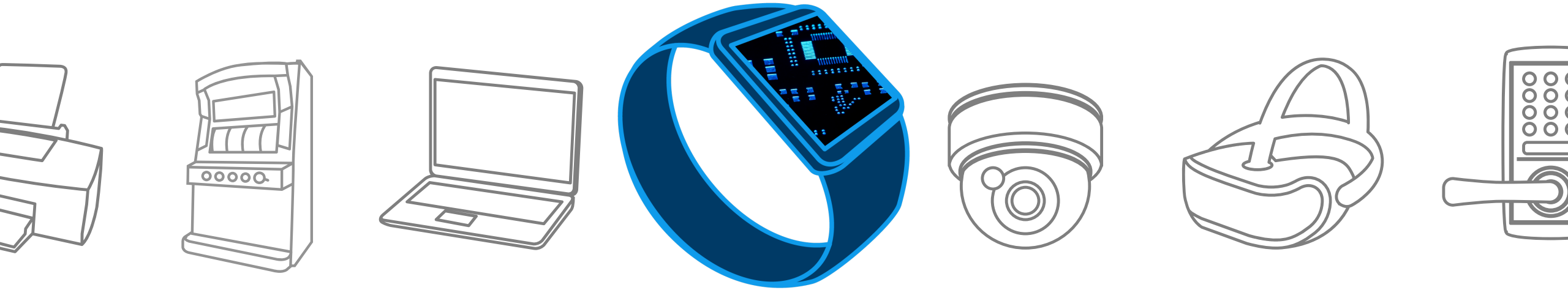
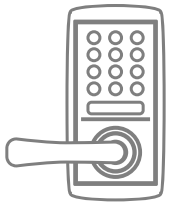
TOSHIBA

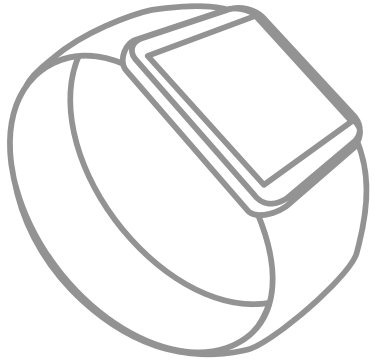
R24

Smart Watch

Solution Proposal by Toshiba

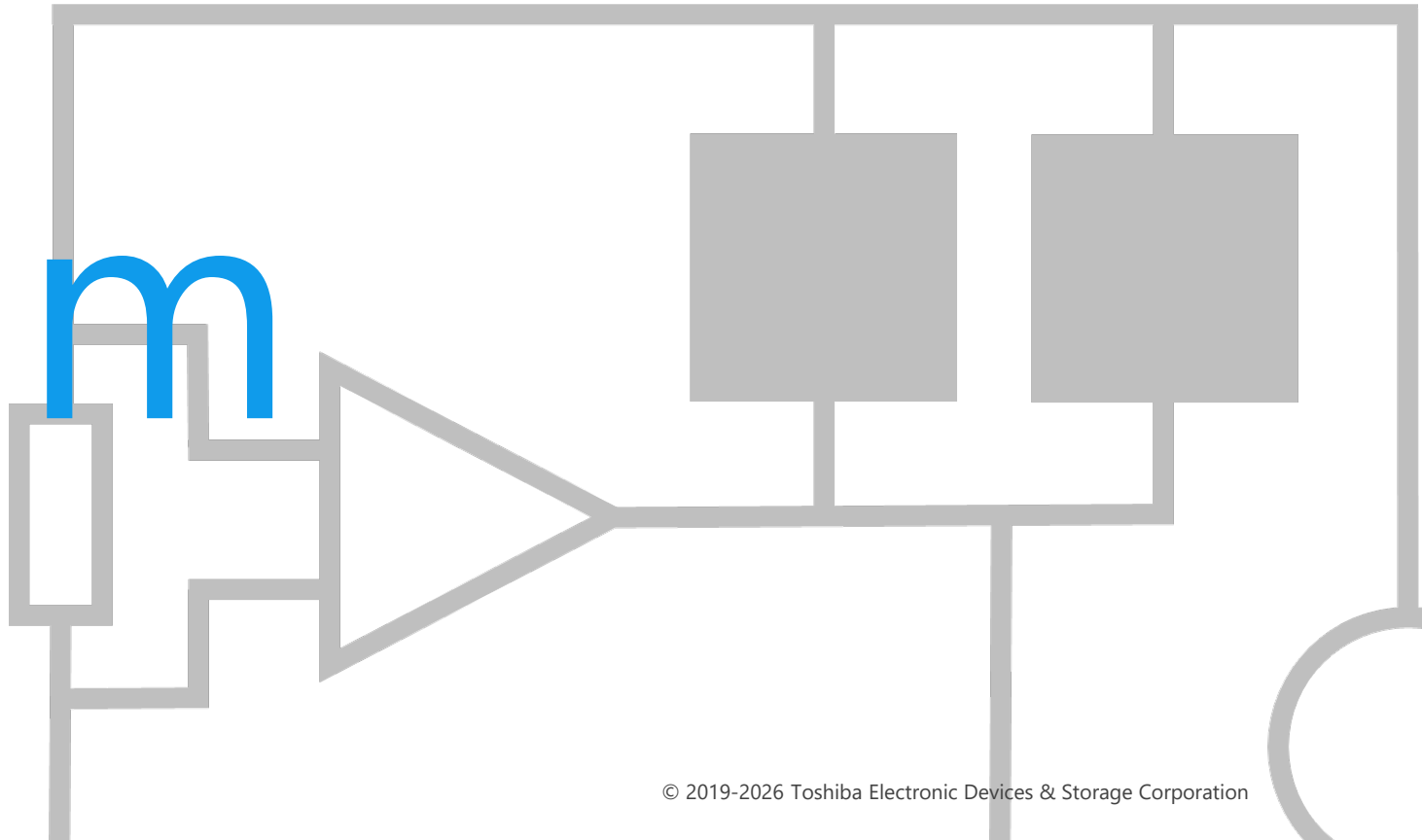




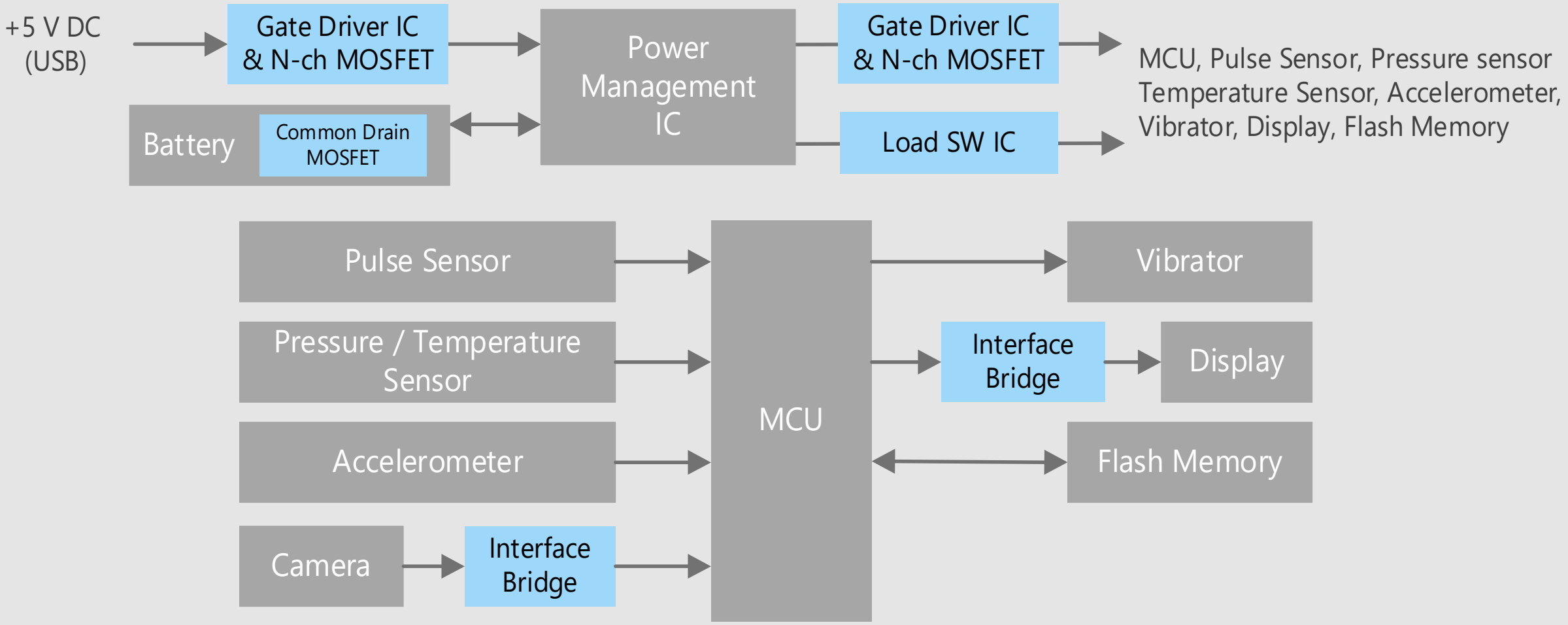


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



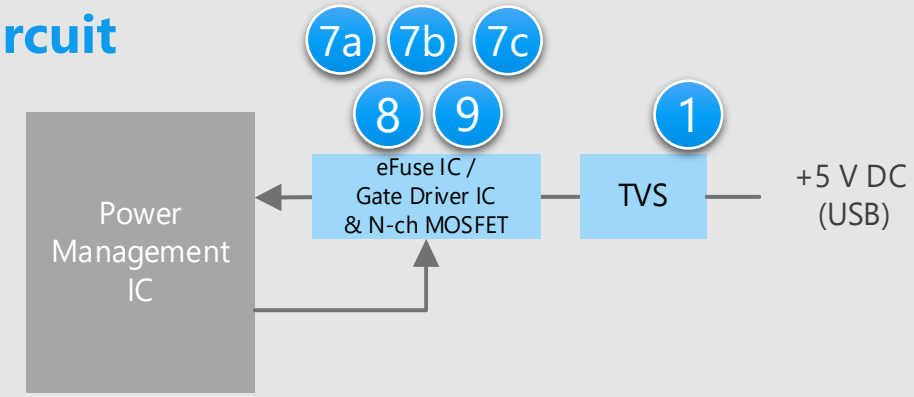
Smart Watch　Overall block diagram



Smart Watch　Detail of power supply unit

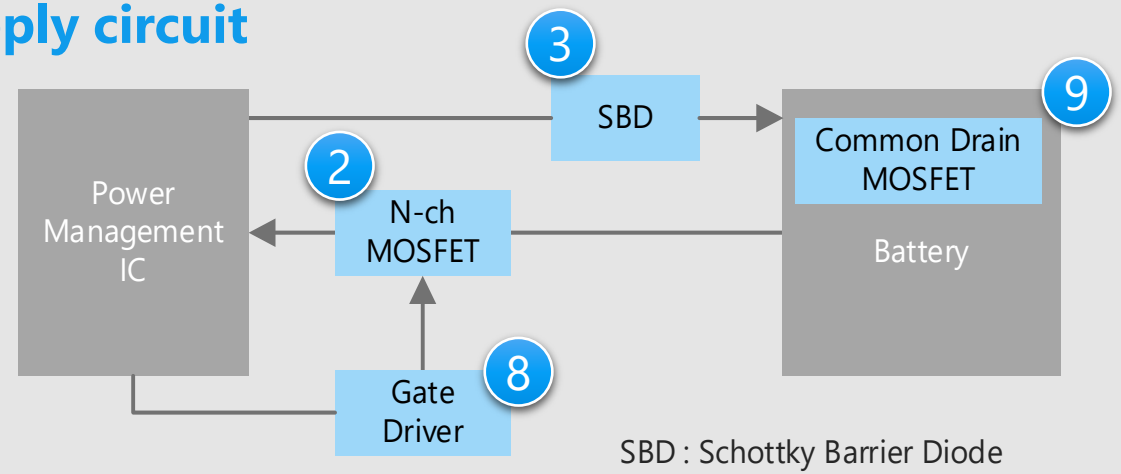
Power supply circuit

USB type



Power supply circuit

Battery type



SBD : Schottky Barrier Diode

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

Criteria for device selection

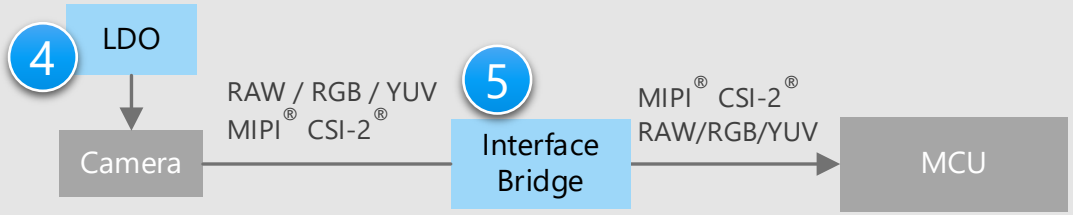
- MOSFETs with low on-resistance are suitable for the control of USB and battery powered supply circuits.
- TVS diodes are suitable for ESD protection of power line.

Proposals from Toshiba

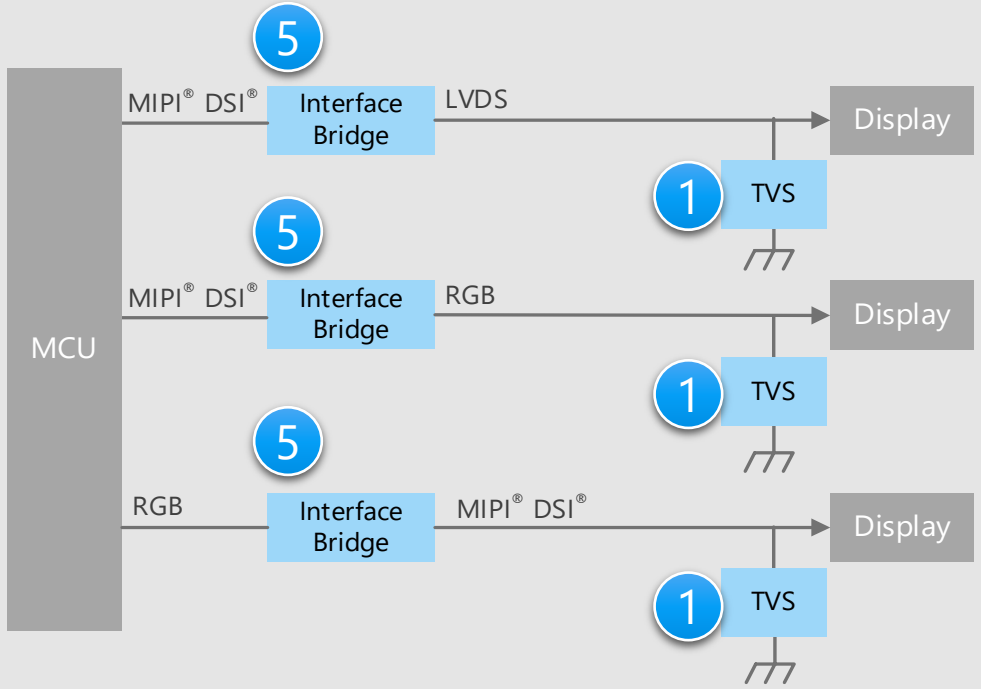
- **Prevent circuit malfunctions by absorbing static electricity (ESD) from external terminals** (1)
  TVS diode
- **Realize the set with low power consumption by low on-resistance** (2)
  Small signal MOSFET
- **High speed, low loss** (3)
  Schottky barrier diode
- **Built-in protection function against short circuit, over current, over voltage, etc.** (7a) (7b) (7c)
  Electronic fuse (eFuse IC)
- **Small package and built-in over voltage protection function** (8)
  N-ch MOSFET gate driver IC
- **Low on-resistance and small package** (9)
  N-ch common drain MOSFET

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

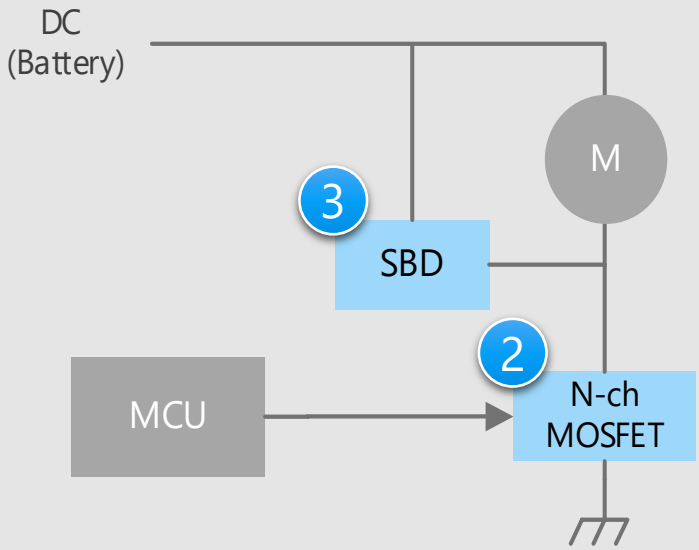
- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- By using interface bridge, display and camera components can be selected without any concern for interface standards.

Proposals from Toshiba

- **Prevent circuit malfunctions by absorbing static electricity (ESD) from external terminals** 1
  TVS diode
- **Supply the power with low noise** 4
  Small surface mount LDO regulator
- **Absorb differences in interfaces** 5
  Interface bridge

Smart Watch　Detail of motor control unit

Motor control for vibrators



SBD : Schottky Barrier Diode

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

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.

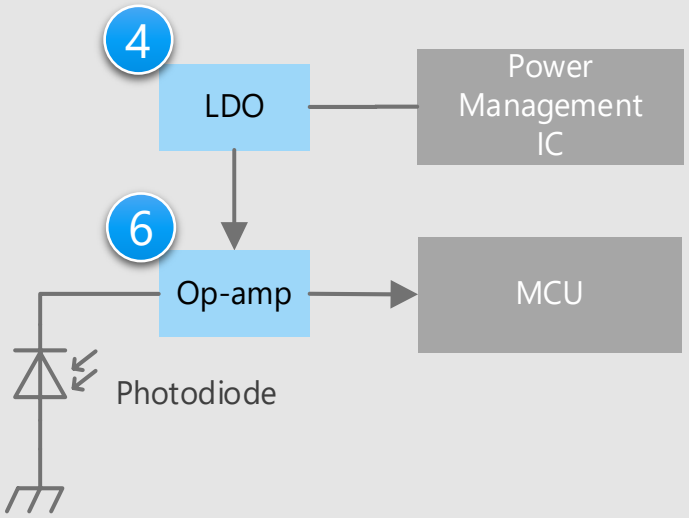
Proposals from Toshiba

- **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

Smart Watch　Detail of pulse detection unit

Pulse detection circuit

Light detection side



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

Criteria for device selection

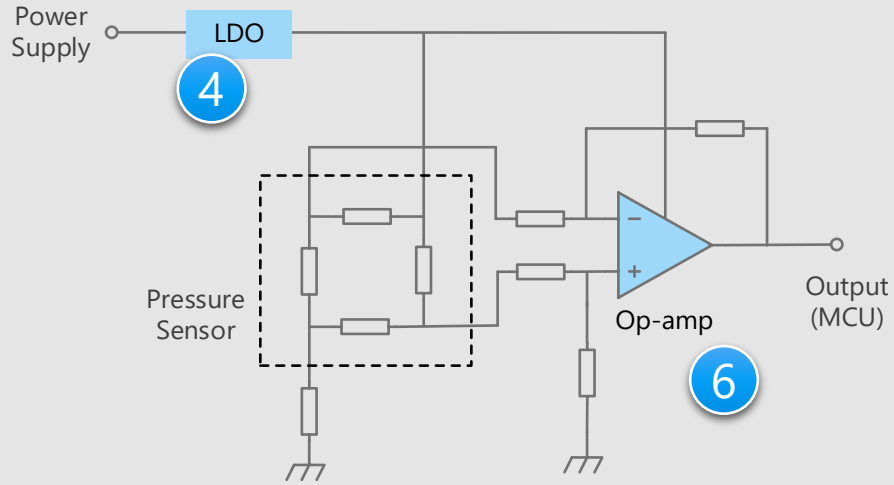
- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- The operational amplifier should be low current consumption or low noise device.

Proposals from Toshiba

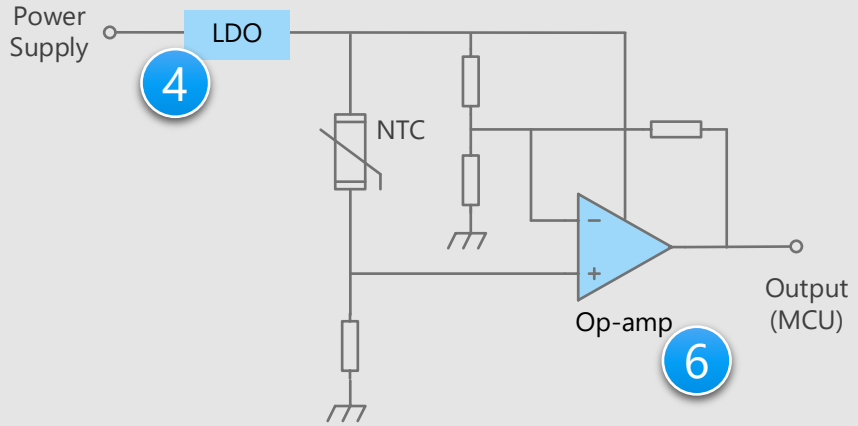
- **Supply the power with low noise**
  Small surface mount LDO regulator　4
- **Amplification of detected small signal with low noise**
  Low current consumption op-amp / Low noise op-amp　6

Smart Watch　Detail of sensor units

Atmospheric pressure sensor circuit



Temperature sensor circuit



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

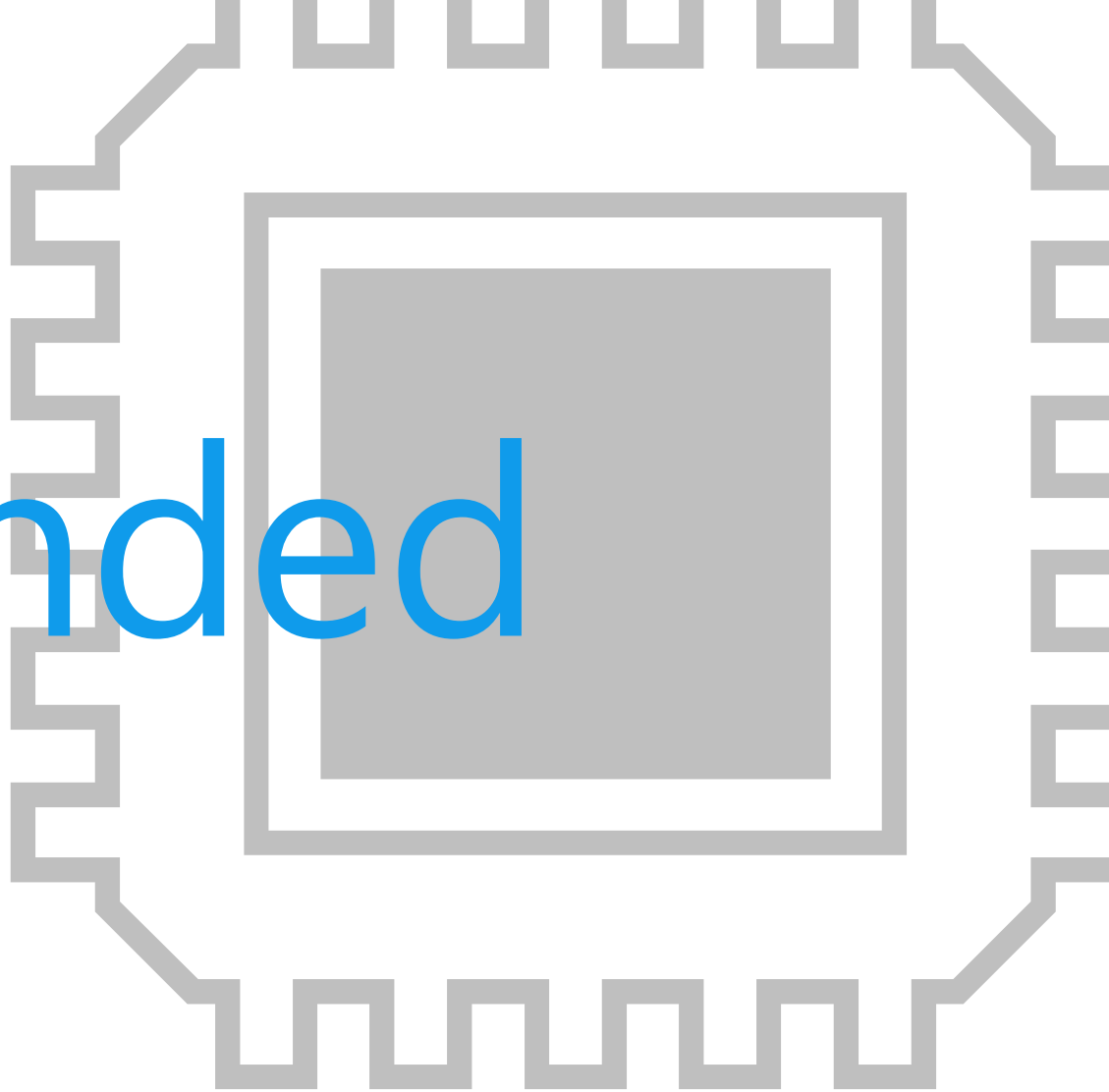
Criteria for device selection

- 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.

Proposals from Toshiba

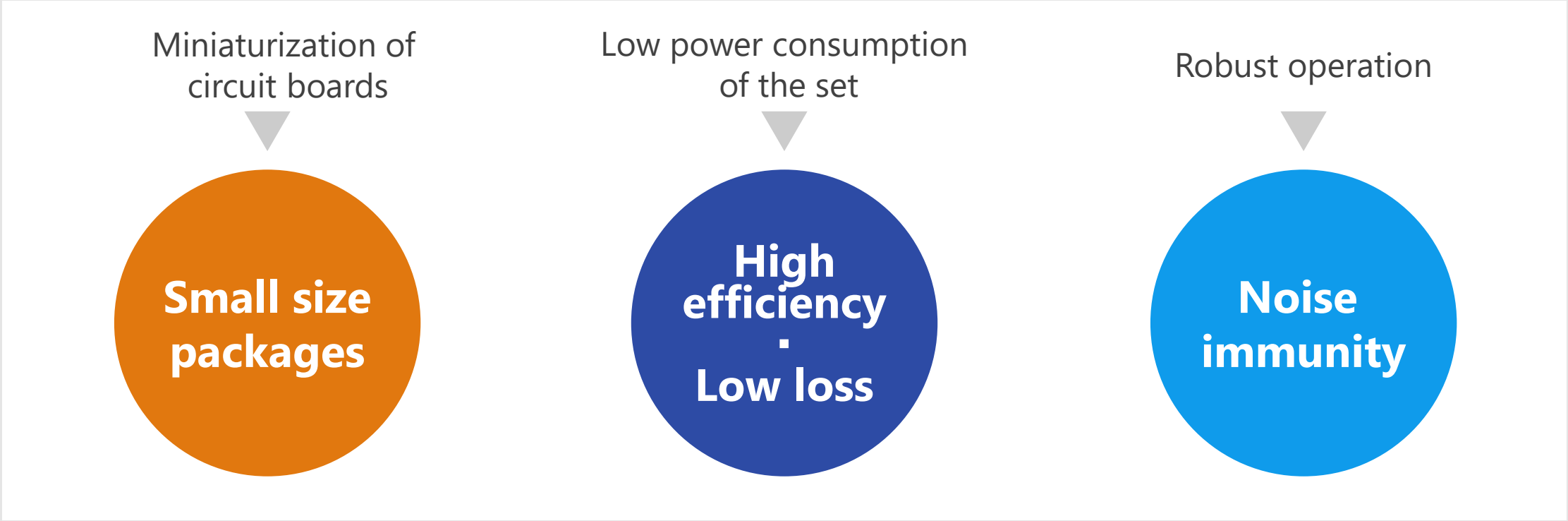
- **Supply the power with low noise**
  Small surface mount LDO regulator　4
- **Amplification of detected small signal with low noise**
  Low current consumption op-amp / Low noise op-amp　6

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 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
1	TVS diode	●	●	●
2	Small signal MOSFET	●	●	
3	Schottky barrier diode	●	●	●
4	Small surface mount LDO regulator	●	●	●
5	Interface bridge	●		●
6	Low current consumption op-amp / Low noise op-amp	●	●	
7	Electronic fuse (eFuse IC)	●	●	
8	N-ch MOSFET gate driver IC	●	●	
9	N-ch common drain MOSFET	●	●	

1 TVS diode

DF2B6M4SL / DF2B6M4BSL / DF2B20M4SL / DF2B5BSL / DF2B5PCT / DF2B7PCT

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

Value provided

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

1 High ESD pulse absorption performance

Improved ESD absorption compared to Toshiba's existing 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.

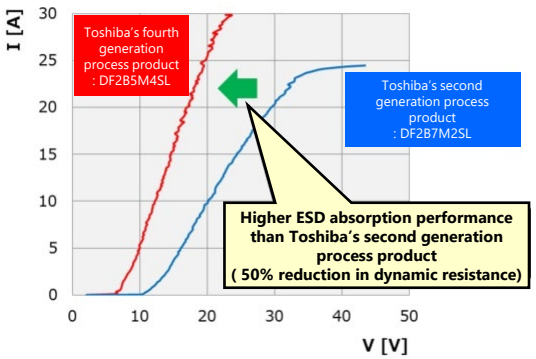
2 Suppress ESD energy by low clamp voltage

Protect the connected circuits and devices using Toshiba own technology.

3 Suitable for high density mounting

A variety of small size packages are available.

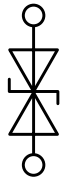
ESD Pulse Absorption Performance
(Toshiba internal comparison)



Unidirectional

Suitable for paths such as logic signals. There are lineups of 1in1, 2in1, 4in1, 5in1, 7in1.

Bidirectional



Suitable for paths with both polar signals such as audio signals.

Lineup

Part number	DF2B6M4SL	DF2B6M4BSL	DF2B20M4SL	DF2B5BSL	DF2B5PCT	DF2B7PCT
Package	SL2	Top view / Bottom view			CST2	Top view / Bottom view
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.) [Ω]	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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2 Small signal MOSFET

SSM3J64CTC / SSM3K78CTC

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

Value provided

Suitable for power management, contributes to miniaturization.

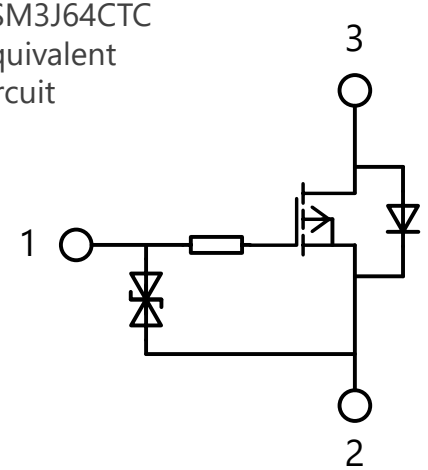
1 Low driving voltage

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

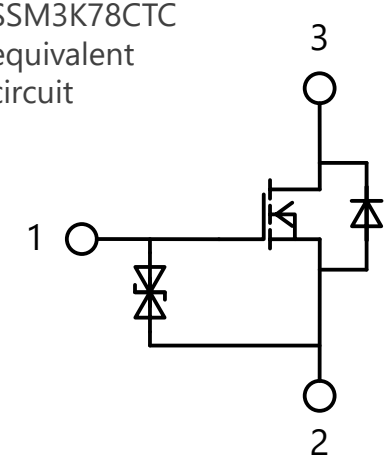
2 Low on-resistance

The drain-source on-resistance is low, as a result heat generation and power consumption can be kept low.

SSM3J64CTC equivalent circuit



SSM3K78CTC equivalent circuit



Lineup

Part number	SSM3J64CTC	SSM3K78CTC
Package	CST3C  Top view  Bottom view	
$R_{DS(ON)}$ (Typ.) [Ω] @$\lvert V_{GS}$ = 2.5 V$\rvert$	0.4	1.1
I_D [A]	-1.0	0.25
V_{DSS} [V]	-12	20
V_{GSS} [V]	±10	±10
Polarity	P-ch	N-ch

◆Return to Block Diagram TOP

3 Schottky barrier diode
CTS05S30

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

Value provided

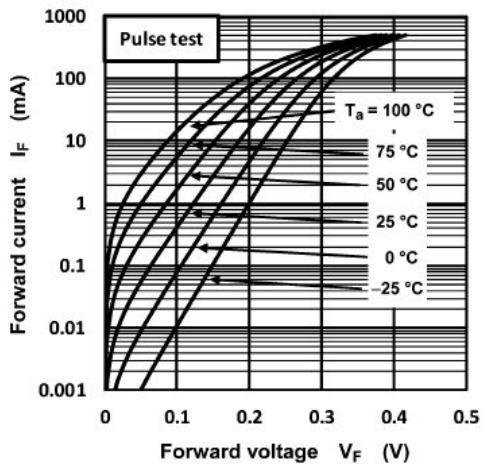
Fast, low loss, small package and suitable for many applications

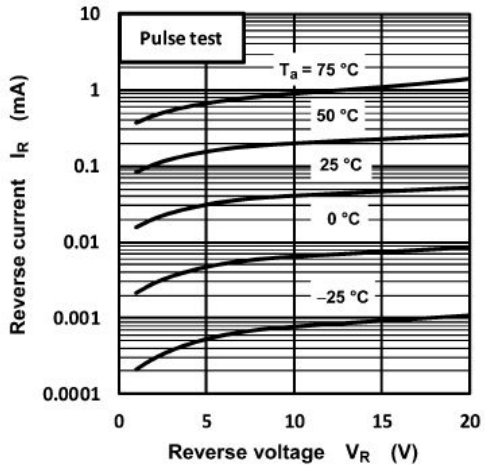
1 Fast switching

Suitable for fast switching applications.

2 Small size package

Sealed in a CST2 type small size package.





Lineup

Part number	CTS05S30
Package	CST2  Top view  Bottom view
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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4 Small surface mount LDO regulator

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

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

Value provided

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

1 Low dropout voltage

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

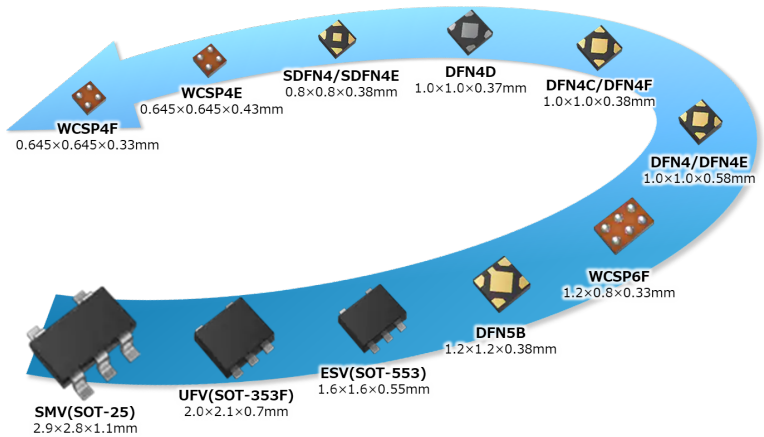
2 High PSRR Low output noise voltage

Many product series that realize both high PSRR (Power Supply Rejection Ratio) and low output noise voltage characteristics are provided. They are suitable for stable power supply for analog circuit.

3 Low current consumption

$I_{B(ON)}$ of 0.34 μA (typ.) @I_{OUT} = 0 mA, V_{OUT} ≦ 1.5 V is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

Rich package lineup



Lineup

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

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5 Interface bridge

TC358774XBG / TC358767AXBG / TC358768AXBG / TC358746AXBG

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

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.

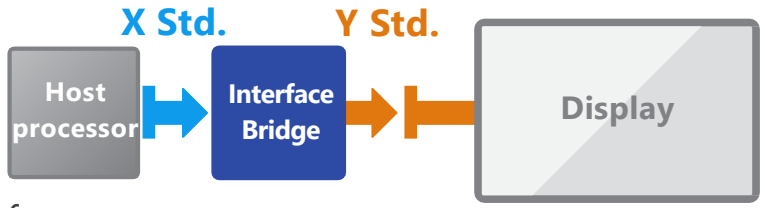
2 Noise immunity

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

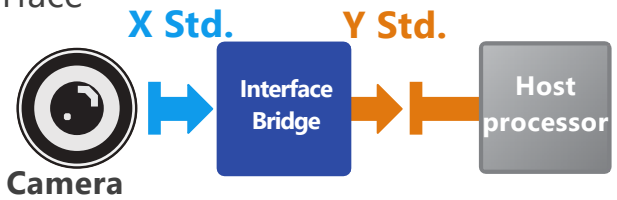
3 Less cabling

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	VFBGA49	VFBGA81	VFBGA72	VFBGA72
Input	MIPI® DSI® 1.01 4Lanes x 1ch	(1) MIPI® DSI® 1.01 (2) MIPI® DPI℠ 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℠ 2.0	MIPI® DSI® 1.02	(1) Parallel 24bit (2) MIPI® CSI-2®

◆Return to Block Diagram TOP

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

TC75S102F / TC75S67TU

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

Value provided

The lineup includes a low current consumption type that contributes to reducing power consumption and a low noise type that brings out performance of the sensor.

1 Low voltage operation

We have a lineup of low power supply voltage-driven operational amplifiers using CMOS process for low power supply voltage-driven wearable 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 wearable equipment.

3 Low noise (TC75S67TU)

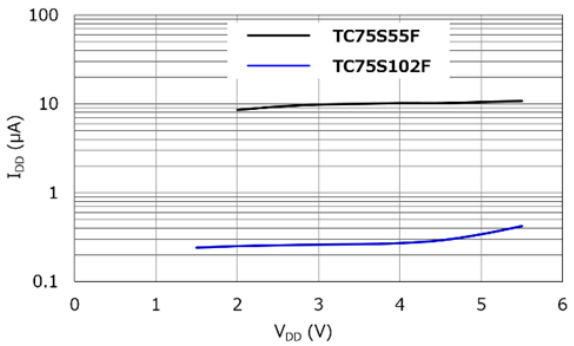
V_{NI} = 6.0 [nV/√Hz] (Typ.) @f = 1 kHz

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

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

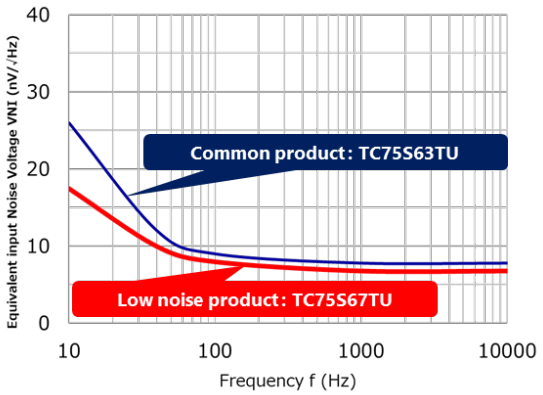
TC75S102F

Current Consumption Characteristic
(Toshiba internal comparison)



TC75S67TU

Noise Characteristic
(Toshiba internal comparison)



Lineup

Part number	TC75S102F	TC75S67TU
Package	SMV 	UFV 
V_{DD} - V_{SS} [V]	1.5 to 5.5	2.2 to 5.5
V_{IO} (Max) [mV]	1.3	3
CMV_{IN} (Max) [V]	V_{DD}	1.4 (@V_{DD} = 2.5 V)
I_{DD} (Typ. / Max) [µA]	0.27 / 0.46 (@V_{DD} = 1.5 V)	430 / 700 (@V_{DD} = 2.5 V)
V_{NI} (Typ.) [nV/√Hz] @f = 1 kHz	-	6.0

◆Return to Block Diagram TOP

7a 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

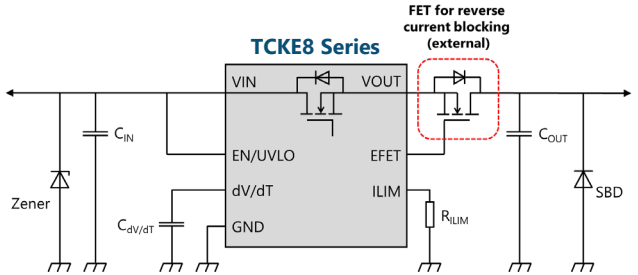
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

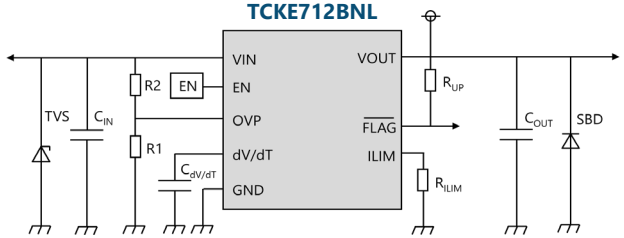
TCKE8 Series: short circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shutdown, inrush current suppression, backflow prevention (optional), etc.

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

Example of peripheral circuit for TCKE8 Series



Example of peripheral circuit for TCKE7 Series



Lineup

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSON10B 3.0 x 3.0 x 0.75 mm  Top view  Bottom view			WSON10 3.0 x 3.0 x 0.75 mm 
V_{IN} [V]	4.4 to 18.0			4.4 to 13.2
R_{ON} (Typ.) [mΩ]	28			53
Fault response	NA: Auto-retry NL: Latched (external signal control)			Latched (external signal control)
V_{OVC} (Typ.) [V]	-	6.04	15.1	Adjustable

◆Return to Block Diagram TOP

7b Electronic fuse (eFuse IC)

TCKE9 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 Product selection is possible according to usage

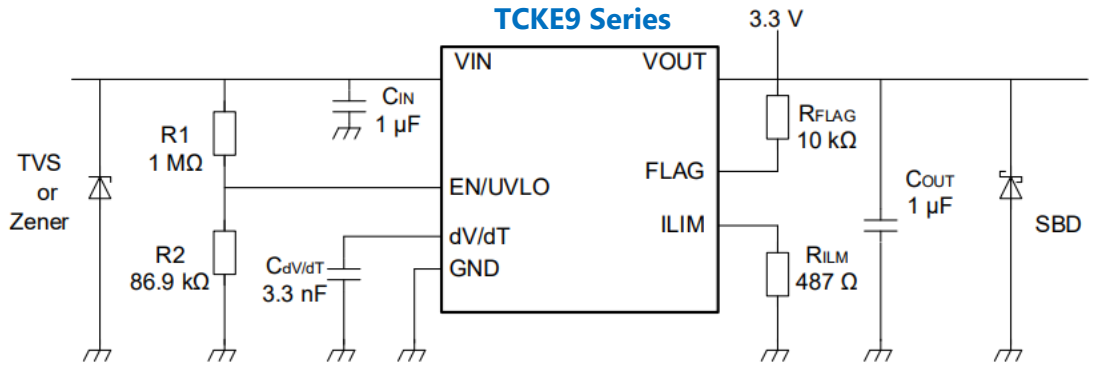
Suitable product with suitable failure response can be selected according to usage.

NA: Auto-retry type
QNA: Auto-retry with quick output discharge type
NL: Latched type

3 Rich protection functions

TCKE9 Series feature many protection functions such as adjustable over current limit, short circuit protection, over voltage clamp, adjustable slew rate control, adjustable under voltage Protection, and thermal shutdown.

Example of peripheral circuit for TCKE9 Series



Lineup

Part number	TCKE903NA/NL/QNA	TCKE905ANA/NL/QNA	TCKE912NA/NL	TCKE920NA/NL
Package	WSON8 2.0 x 2.0 x 0.75 mm	 Top view	 Bottom view	
V_{IN} [V]	2.7 to 23			
R_{ON} (Typ.) [mΩ]	34			
Fault response	NA: Auto-retry (QNA: with quick output discharge), NL: Latched			
V_{OVC} (Typ.) [V]	3.87	5.7	13.7	22.2

◆Return to Block Diagram TOP

7c Electronic fuse (eFuse IC)

TCKE6 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 Product selection is possible according to usage

Suitable product can be selected according to usage.

FLAG function: TCKE601RA/RL

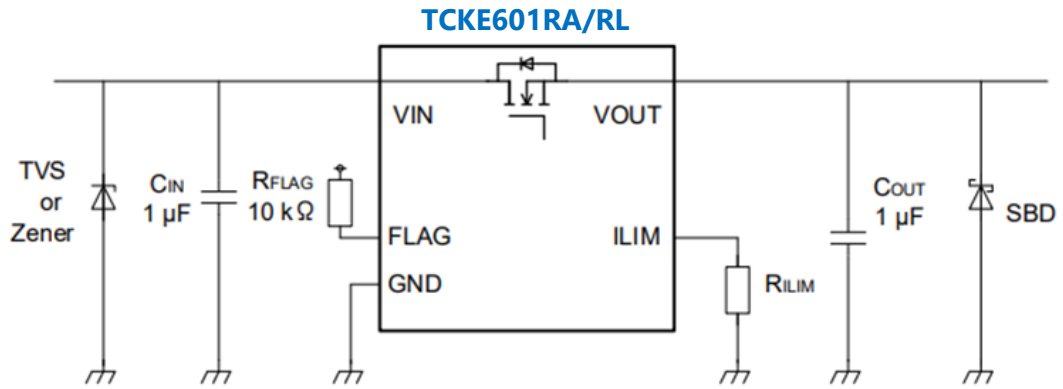
MODE function (selectable recovery mode): TCKE602

EN (enable) function: TCKE603RA/RL

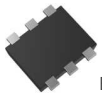
3 Rich protection functions

TCKE6 Series feature many protection functions such as adjustable over current limit, short circuit protection, under voltage protection, and thermal shutdown.

Example of peripheral circuit for TCKE601RA/RL



Lineup

Part number	TCKE601RA	TCKE601RL	TCKE602RM	TCKE603RA	TCKE603RL
Package	TSOP6F  Top view  Bottom view				
V_{IN} [V]	4.4 to 30				
R_{ON} (Typ.) [mΩ]	52				
Function	FLAG		MODE	EN	
Fault response	Auto-retry	Latched	Selectable type	Auto-retry	Latched

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8 N-ch MOSFET gate driver IC

TCK4xx Series

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

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.

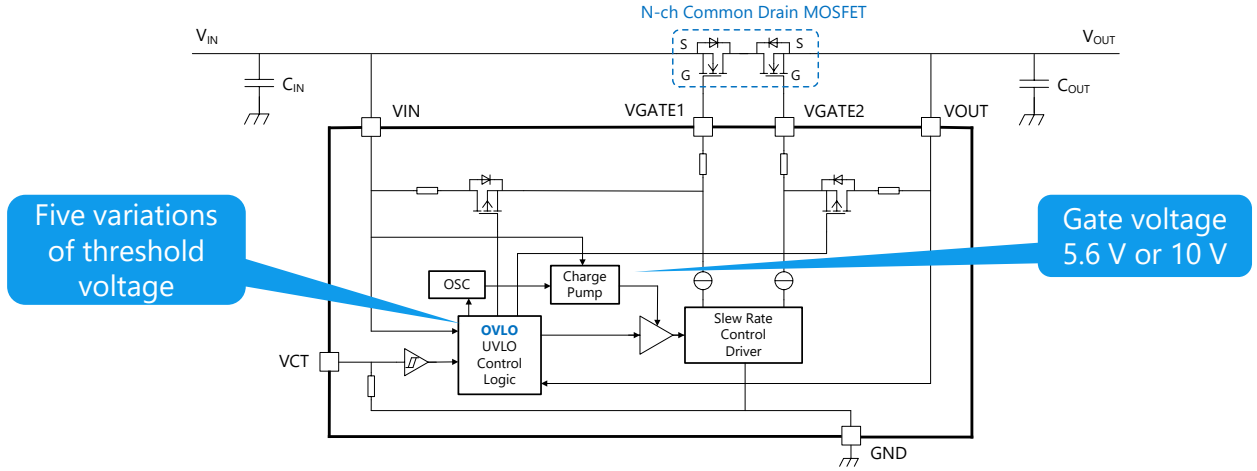
[Note 2] OVLO: Over Voltage Lock Out
[Note 3] V_{IN_OVLO}: V_{IN} OVLO threshold

3 Small size 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} ≥ 12 V)	Single high side Common Source	WCSP6E
TCK402G				
TCK420G	26.50 / 28.50	10 / 11 (V_{IN} ≥ 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			

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9 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

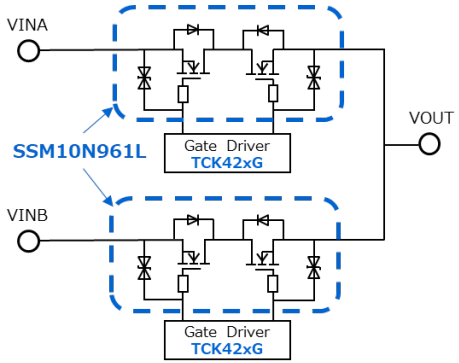
While in a dual configuration, it is a small and thin chipLGA package products.
This contributes to miniaturization of set.

3 Low gate-source leakage current

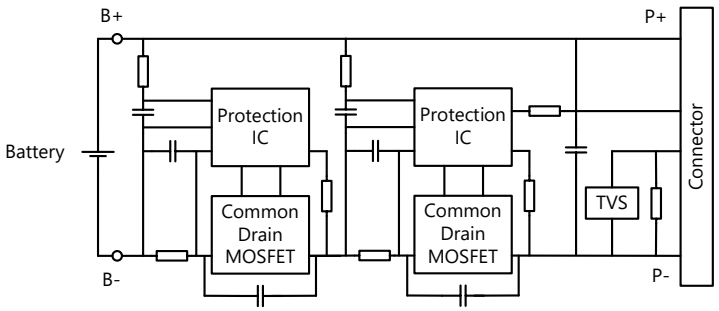
Low gate-source leakage current characteristics enable low standby power and contribute to long term operation of battery used sets.

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]	±8			±20
Source current (DC) I_S [A]	20.0	13.5	8.0	14.0
$R_{SS(ON)}$ (Typ.) [mΩ] @V_{GS} = 3.8 V	1.1	2.2	4.6	-
$R_{SS(ON)}$ (Typ.) [mΩ] @V_{GS} = 10 V	-	-	-	9.9

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