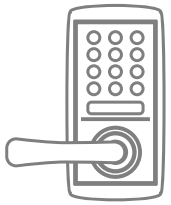
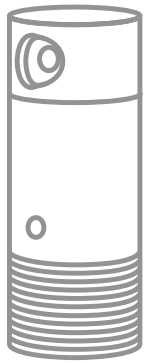
TOSHIBA

R21

Smart Speaker

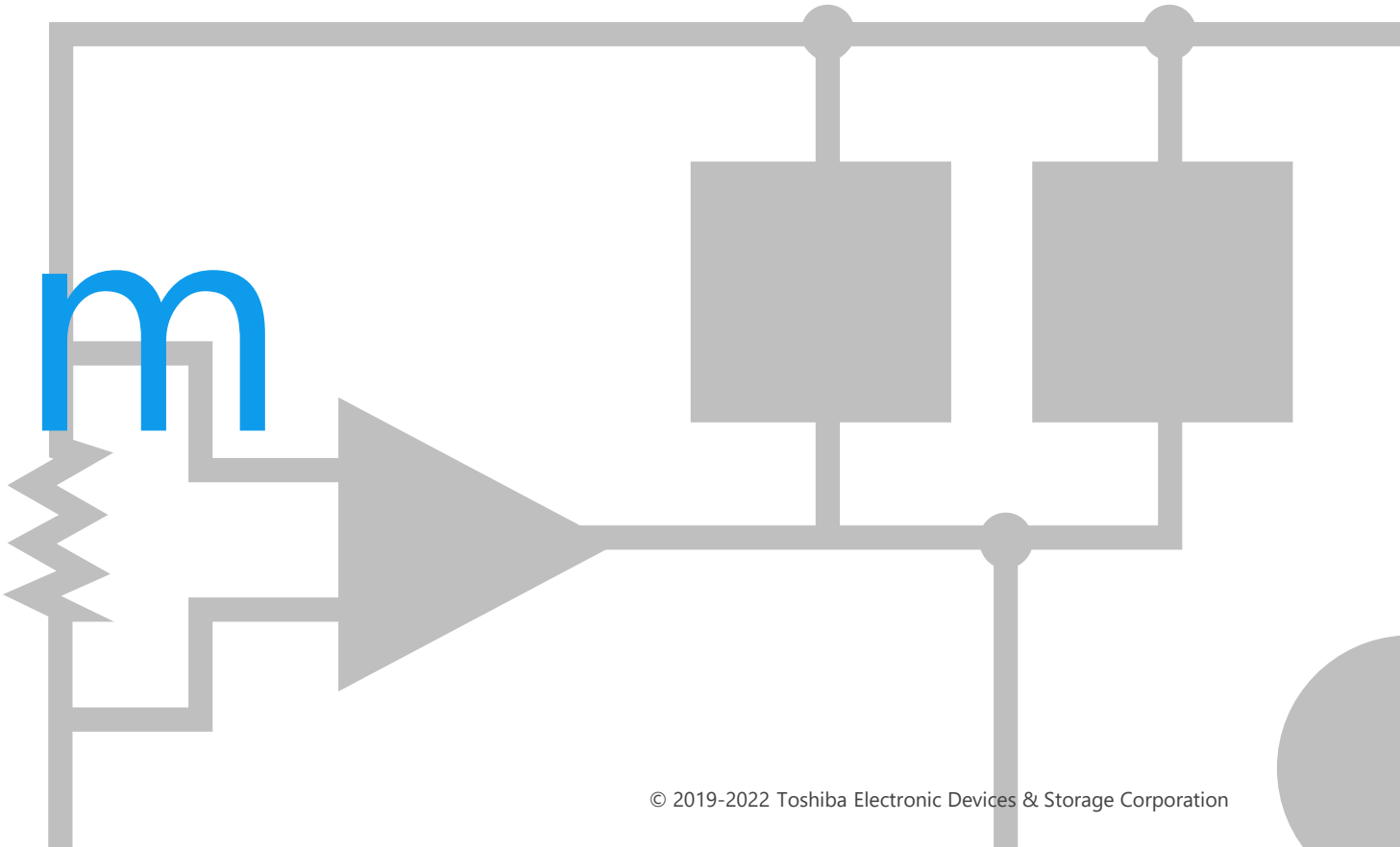
Solution Proposal by Toshiba



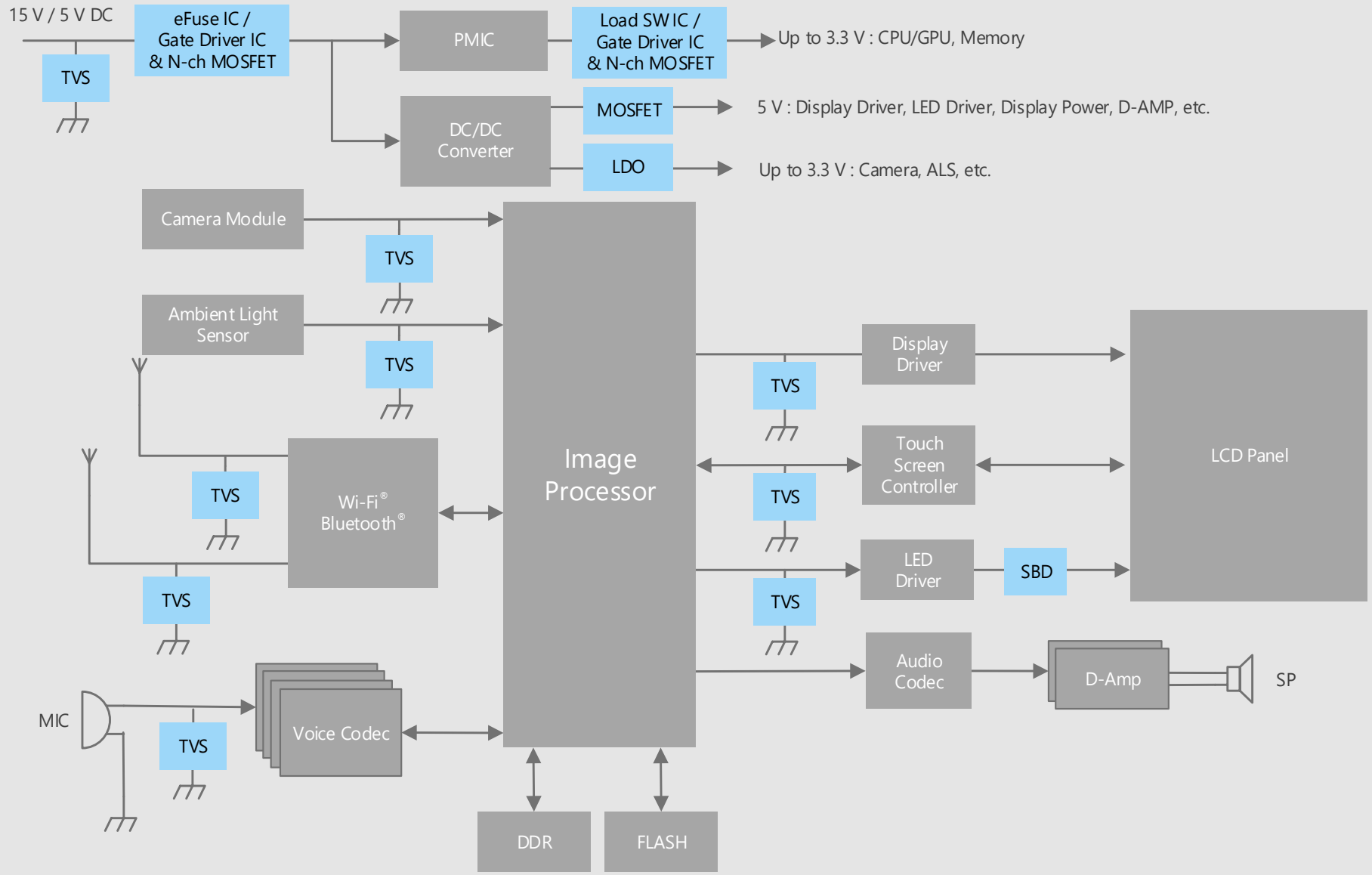


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

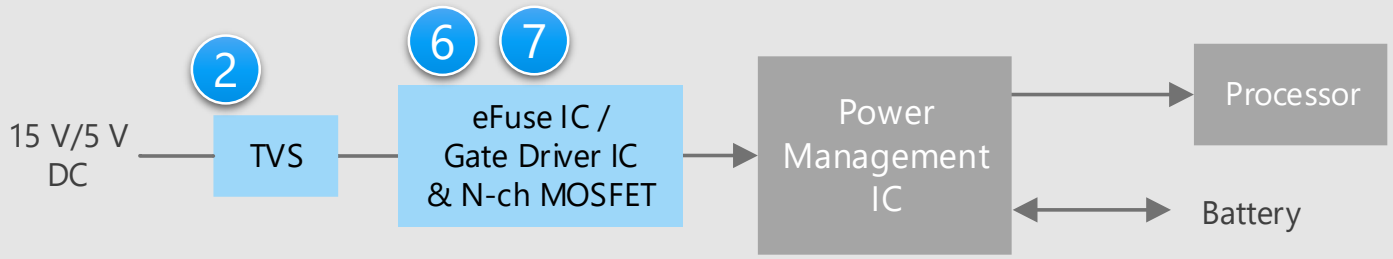


Smart Speaker　Overall block diagram

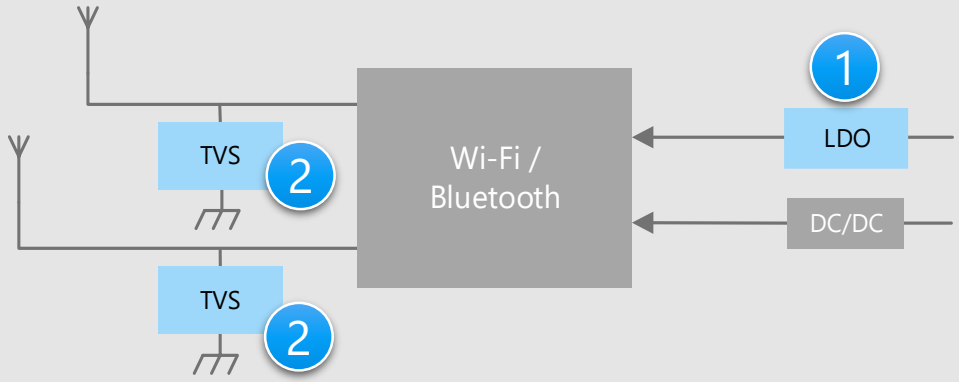


Smart Speaker　Details of power supply and Wi-Fi® / Bluetooth® section

Power supply circuit



Wi-Fi / Bluetooth solution



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

Criteria for device selection

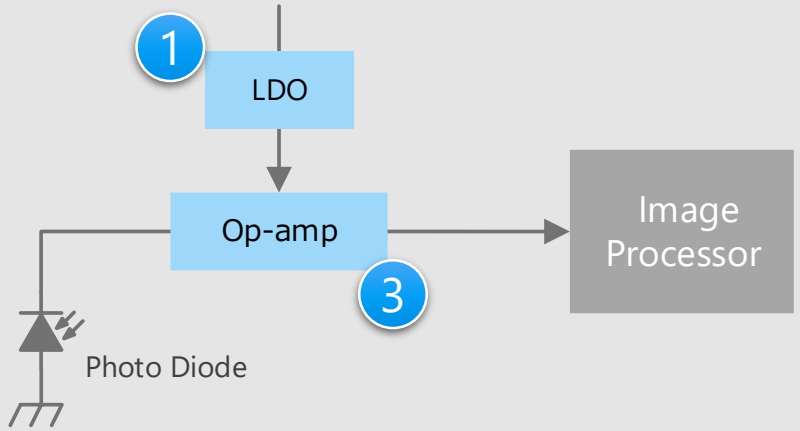
- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for wireless system.
- Small package products contribute to the reduction of circuit board area.
- A small Transient Voltage Suppressor (TVS) with low C_t is suitable for ESD protection without attenuating the antenna signal.

Proposals from Toshiba

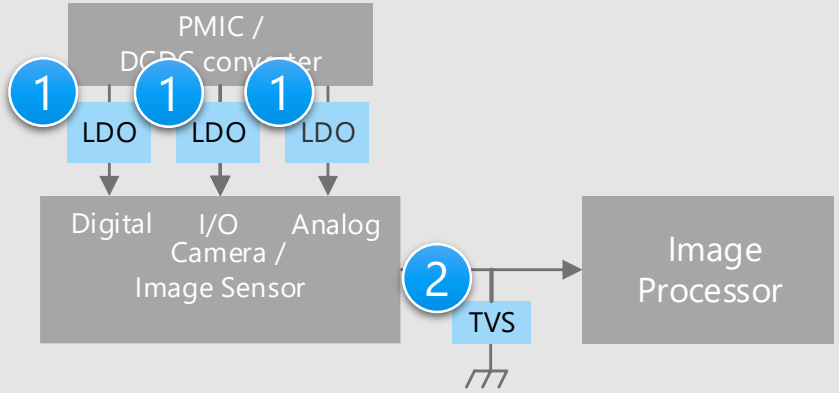
- **Supply the power with low noise** 1
  Small surface mount LDO regulator
- **Absorb Electro Static Discharge (ESD) from antennas and prevent malfunction of the circuit** 2
  TVS diode
- **Built-in protection function against short circuit, over current, over voltage, etc.** 6
  Electronic fuse (eFuse IC)
- **Small package and built-in over voltage protection function** 7
  N-ch MOSFET gate driver IC

Smart Speaker　Details of sensor / camera section

Ambient light sensor



Camera modules



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

Criteria for device selection

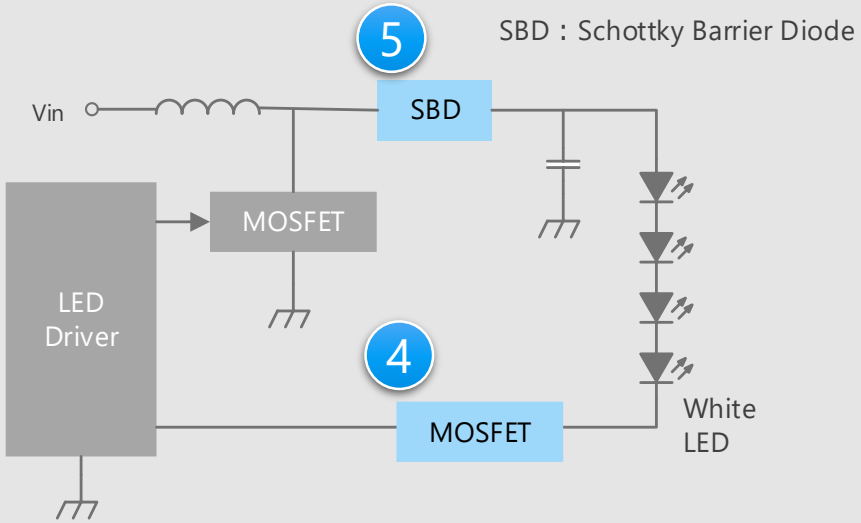
- Operational amplifiers with low noise are suitable for the sensor block.
- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for wireless system.
- The low C_t, small package transient voltage suppressor (TVS) is ideal for ESD protection.

Proposals from Toshiba

- **Supply the power with low noise** 1
  Small surface mount LDO regulator
- **Absorb Electro Static Discharge (ESD) from external terminals and prevent malfunction of the circuit** 2
  TVS diode
- **Amplify the detected very small signal with low noise** 3
  Low noise operational amplifier

Smart Speaker　Detail of boost converter for LCD backlight

LCD backlight



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

Criteria for device selection

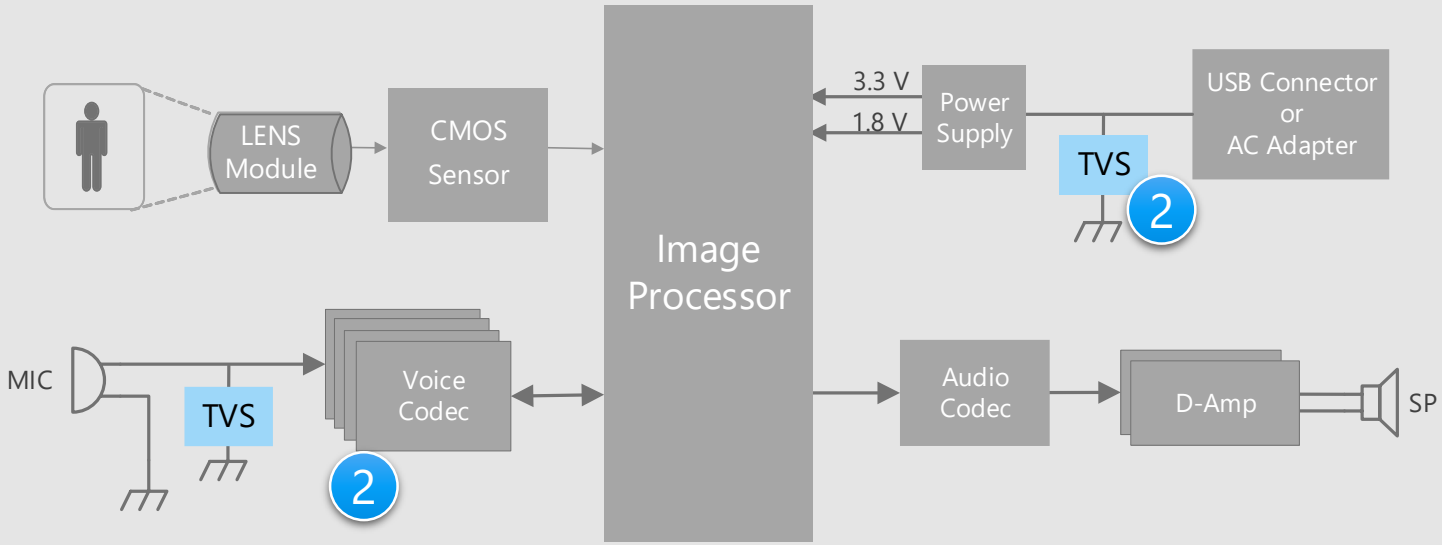
- Schottky Barrier Diode (SBD) requires low V_F and low I_R.
- High voltage MOSFET is suitable for the boost converter.

Proposals from Toshiba

- **Realize a set with low power consumption by low on-resistance**
  Small signal MOSFET　4
- **High speed and low loss diode with a small surface mount package**
  Schottky barrier diode　5

Smart Speaker　Detail of image processing section

Image processing section



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

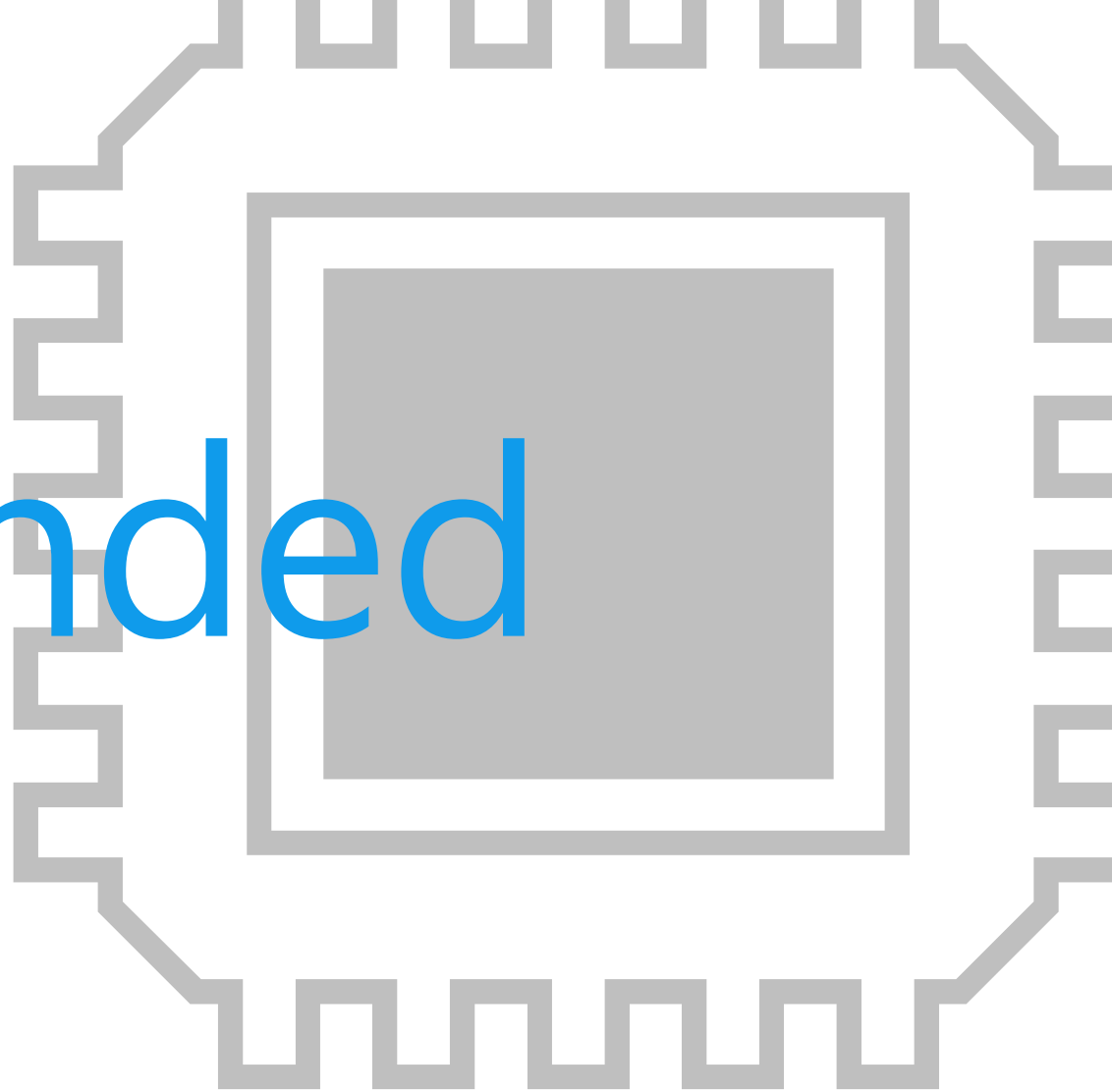
Criteria for device selection

- The low C_t, small package transient voltage suppressor (TVS) is suitable for ESD protection.

Proposals from Toshiba

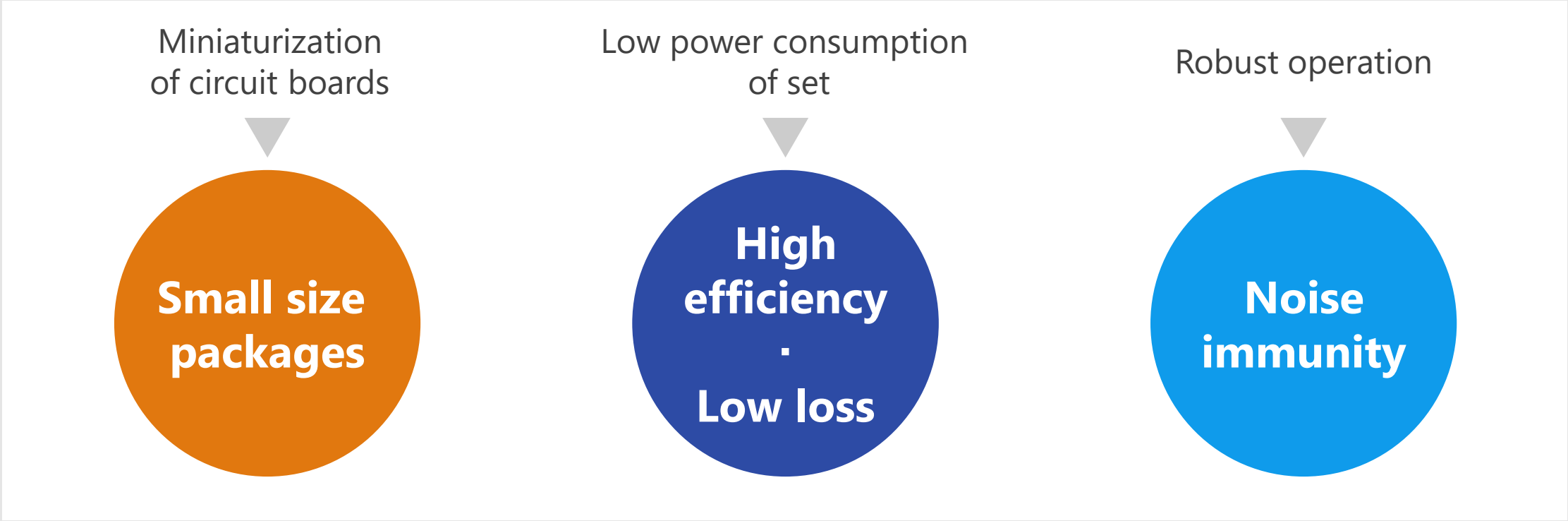
- **Absorb Electro Static Discharge (ESD) from external terminals and prevent malfunction of the circuit**
  TVS diode 2

Recommended Devices



Device solutions to address customer needs

As described above, in the design of smart speakers, **“Miniaturization of circuit boards”**, **“Low power consumption of set”** and **“Robust operation”** are important factors. Toshiba’s proposals are based on these three solution perspectives.



Device solutions to address customer needs

	Small size packages	High efficiency · Low loss	Noise immunity
1 Small surface mount LDO regulator	●	●	●
2 TVS diode	●	●	●
3 Low noise operational amplifier	●	●	
4 Small signal MOSFET	●	●	
5 Schottky barrier diode	●	●	
6 Electronic fuse (eFuse IC)	●	●	●
7 N-ch MOSFET gate driver IC	●	●	

1 Small surface mount LDO regulator

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

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

Value provided

Wide lineup from general purpose type to small package type are provided.
Contribute to realize a stable power supply not affected by fluctuation of battery.

1 Low dropout voltage

The originally developed latest process significantly improved the dropout voltage characteristics.

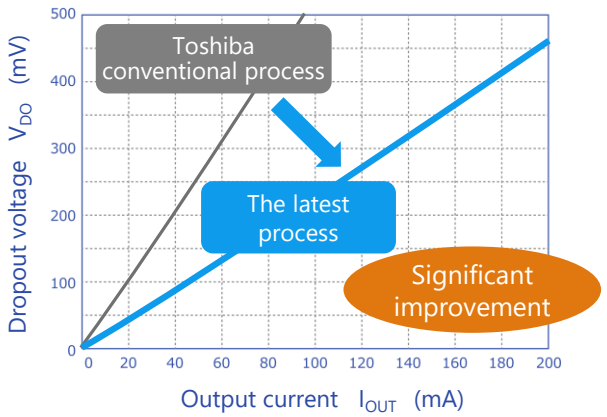
2 High PSRR Low output noise voltage

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

3 Low current consumption

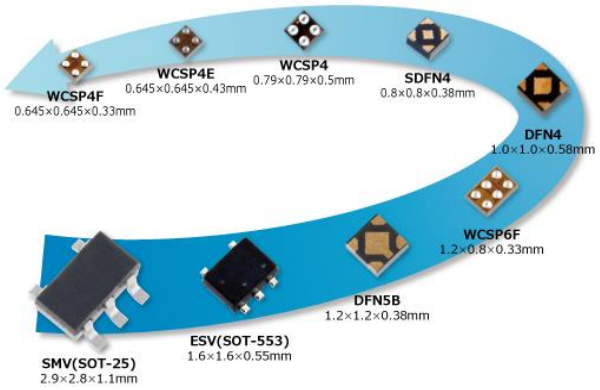
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

Low dropout voltage



Note: Toshiba internal comparison

Rich package lineup



Lineup

Part number	TCR15AG Series	TCR13AG Series	TCR8BM Series	TCR5BM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR2L Series	TAR5 Series
Features	Low dropout voltage High PSRR				High PSRR Low noise Low current consumption		Low current consumption		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	56	20	19	7	7	0.34	1	170

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2 TVS diode

DF2B6M4SL / DF2B6M4BSL / DF2B20M4SL / DF2B5BSL / DF2B5PCT / DF2B7PCT

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

Value provided

Absorbs static electricity (ESD) 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.

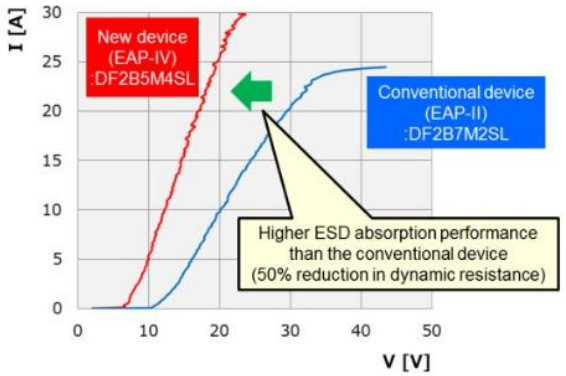
2 Suppress ESD energy by low clamp voltage

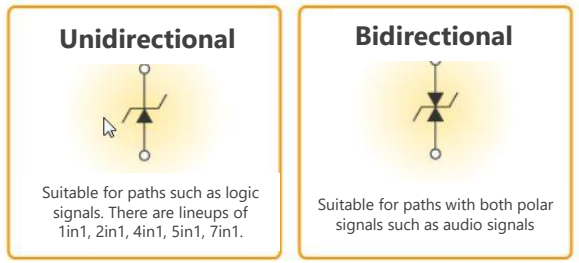
Protect the connected circuits/devices using Toshiba own technology.

3 Suitable for high density mounting

A variety of compact packages are available.

ESD Pulse Absorption performance (Toshiba internal comparison)





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.) [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.

◆Return to Block Diagram TOP

3 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.

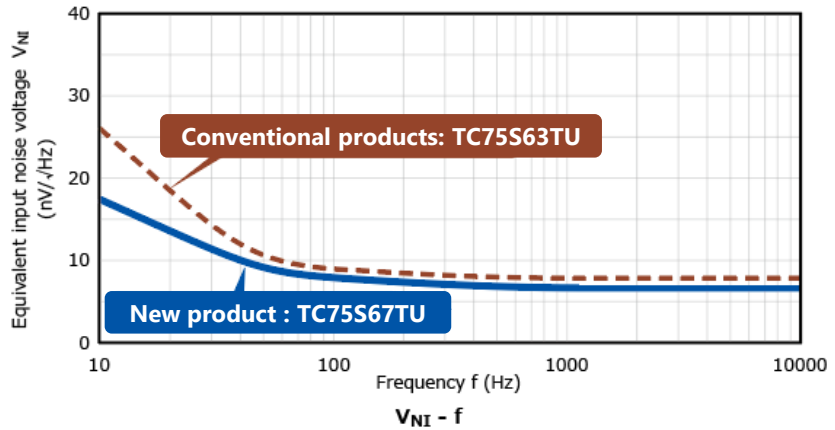
1 Low noise
V_{NI} = 6.0 [nV/√Hz] (Typ.) @f = 1 kHz

Very small signals detected by various sensors [Note 1] can be amplify with low noise using CMOS operational amplifier by optimizing the processing. We achieved low 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 2].

Low noise characteristic
(Toshiba internal comparison)



V_{NI} - f

Lineup

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/√Hz] @f = 1 kHz	6

[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, and temperature sensor, etc.
[Note 2] Compared with Toshiba's operational amplifier using bipolar processing

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4 Small signal MOSFET

SSM3K341R / SSM6K514NU / SSM3K15ACT

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

Value provided

Suitable for power management switches and greatly contributes to miniaturization.

1 Low voltage operation

Operates down to V_{GS} = 4.0 V. (SSM3K15ACT)

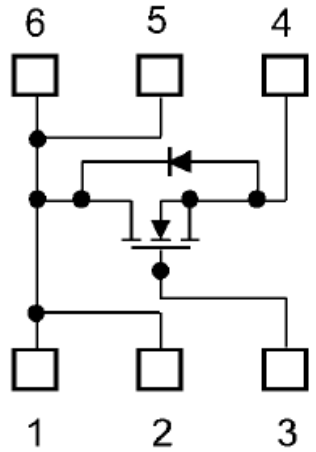
2 Low on-resistance

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

3 Small package

Small package is suitable for high density mounting.

SSM6K514NU
Equivalent circuit



Lineup

Part number		SSM3K341R	SSM6K514NU	SSM3K15ACT
Package		SOT-23F 	UDFN6B 	CST3 
Polarity		N-ch	N-ch	N-ch
V_{DSS} [V]		60	40	30
I_D [A]		6	12	0.1
$R_{DS(ON)}$ [mΩ] @V_{GS} = 4.5 V	Typ.	36	11.2	2.3 @V_{GS} = 4 V
	Max	51	17.3	3.6 @V_{GS} = 4 V

◆Return to Block Diagram TOP

5 Schottky barrier diode

CUS10F30 / CTS05F40

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

Value provided

Schottky barrier diode with low V_F and low I_R is suitable for high efficiency diode rectification application.

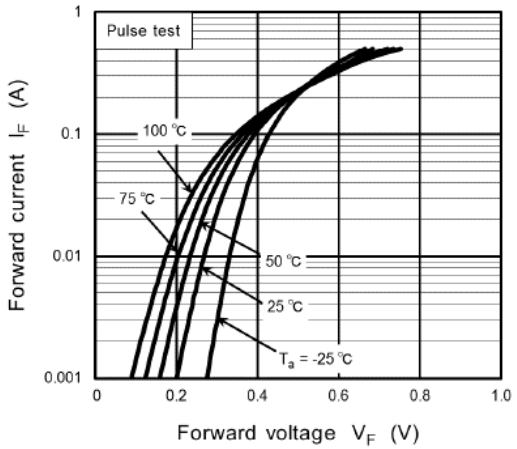
1 High speed switching

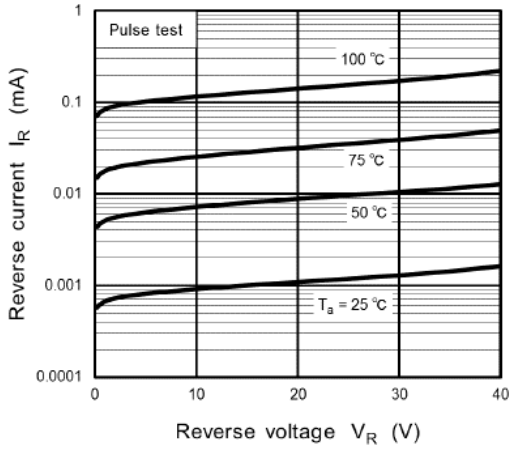
Suitable for high speed switching applications.

2 Small package

Small package is suitable for high density mounting.

CTS05F40 Characteristics Curves





Lineup

Part number		CUS10F30	CTS05F40
Package		USC 	CST2 
Absolute maximum ratings	V_R [V]	30	40
	I_O [A]	1.0	0.5
V_F (Max) [V]		0.50	0.81
I_R (Max) [μA]		50	15

◆Return to Block Diagram TOP

6 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

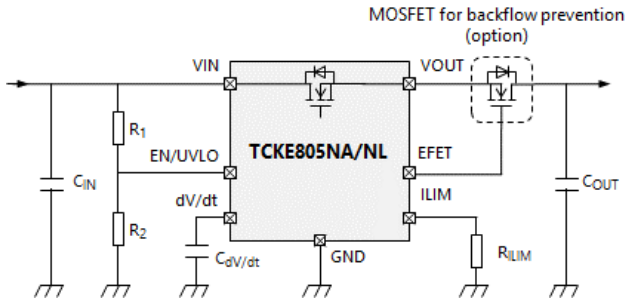
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

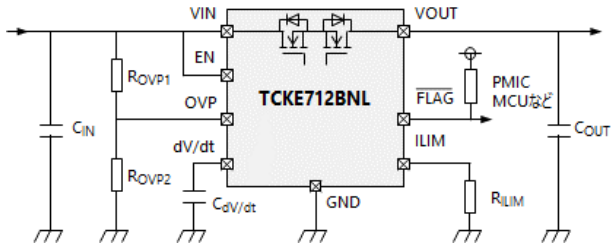
TCKE8 Series: short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

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

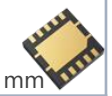
Reference circuit example of TCKE8 Series



Reference circuit example of TCKE7 Series



Lineup

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSON10B 3.0 x 3.0 x 0.75 mm  			WSON10 3.0 x 3.0 x 0.75 mm 
V_{IN} [V]	4.4 to 18			4.4 to 13.2
R_{ON} (Typ.) [mΩ]	28			53
Return function	NA: Automatic return NL: Latch type (external signal control)			Latch type (external signal control)
V_{OVC} (Typ.) [V]	-	6.04	15.1	Adjustable

◆Return to Block Diagram TOP

7 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 3 types of connection of N-ch MOSFET can be driven

The following types of connection of N-ch 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.

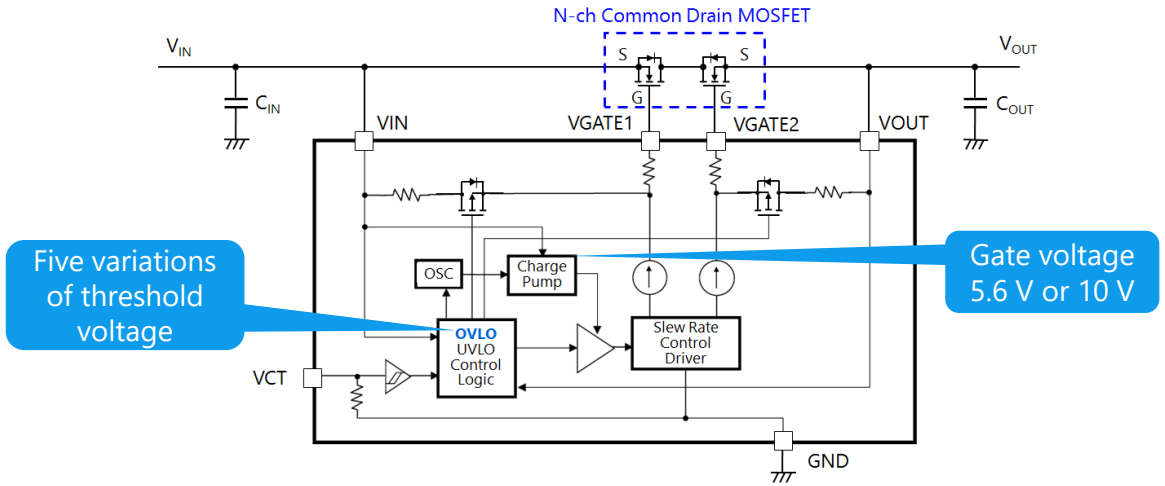
[Note 2] OVLO : Over Voltage Lock Out
[Note 3] V_{IN_OVLO} : V_{IN} OVLO threshold

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} ≥ 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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