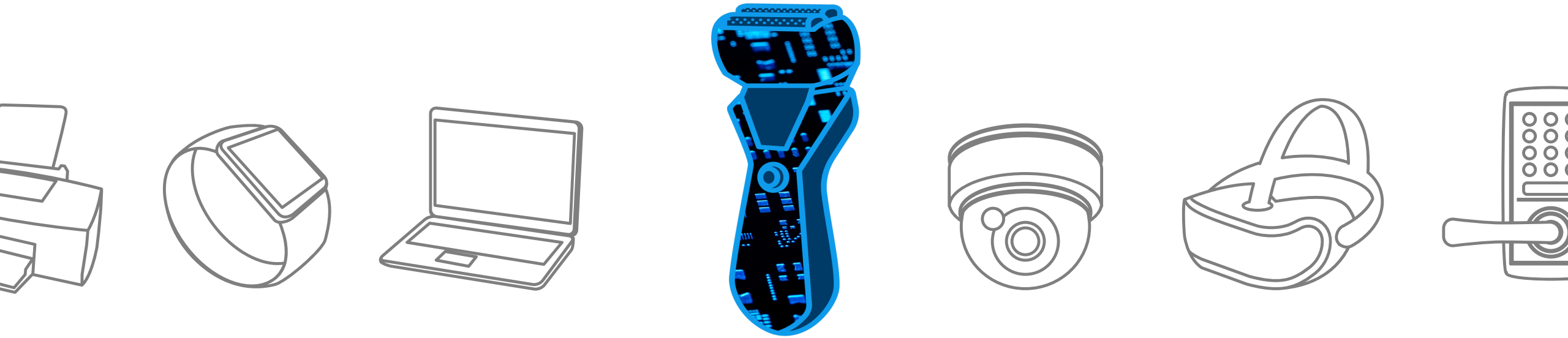
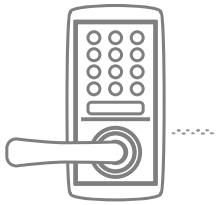
TOSHIBA

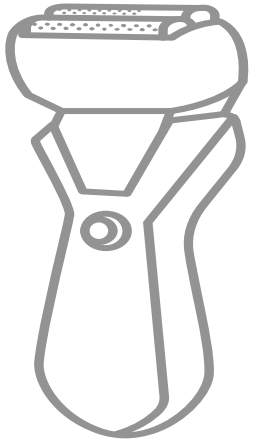
R22

Electric Shaver

Solution Proposal by Toshiba







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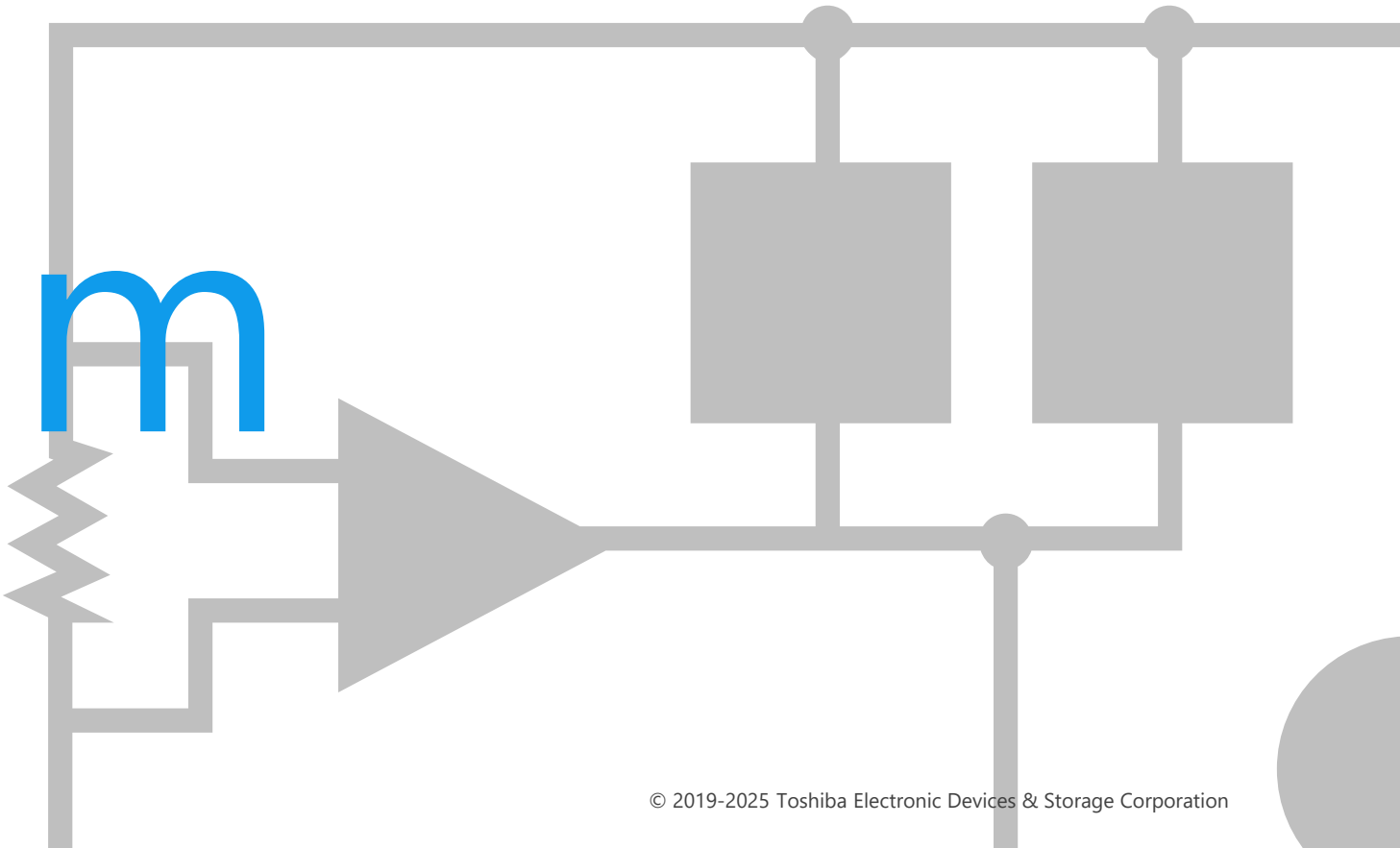
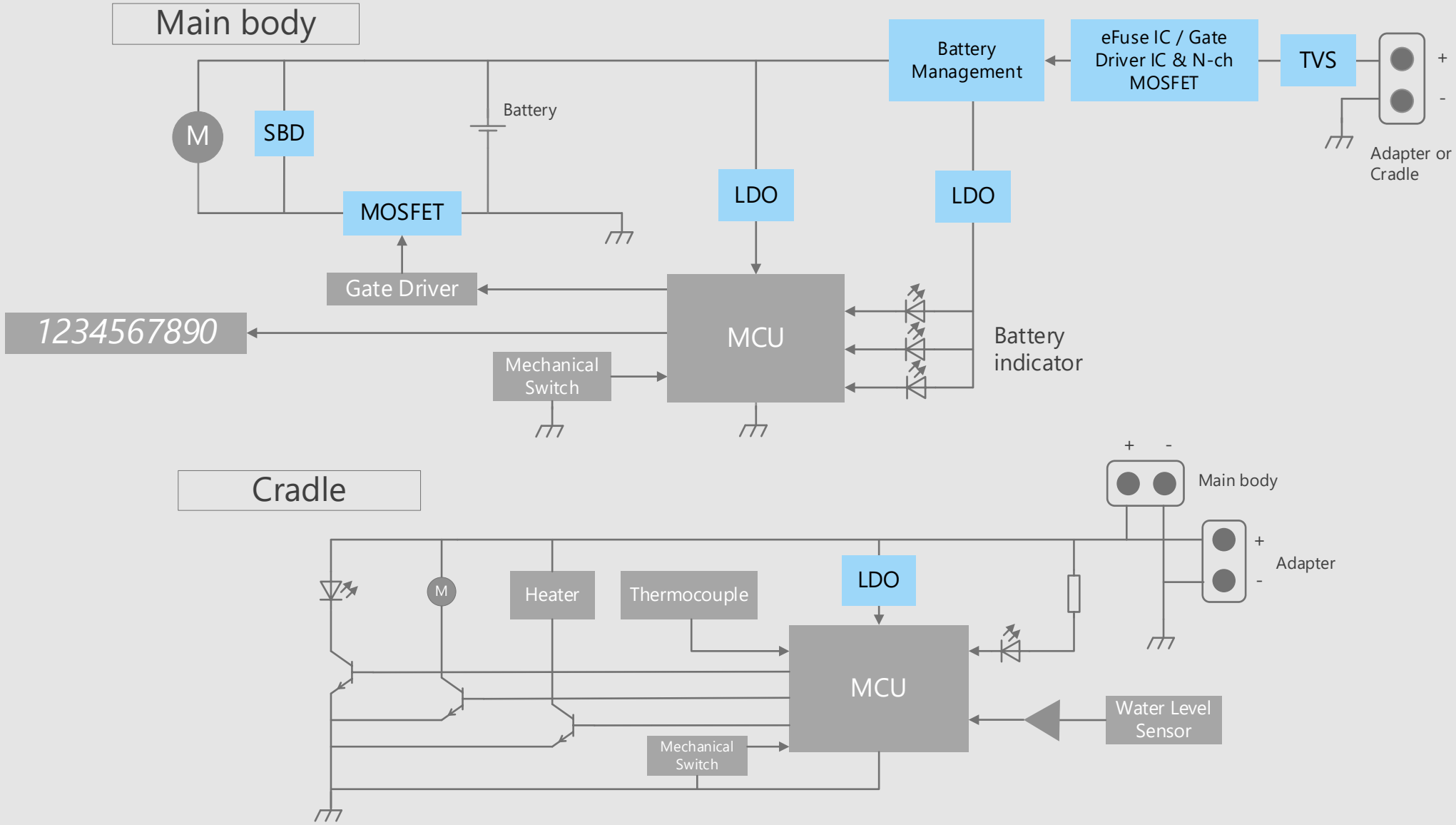
Block Diagram

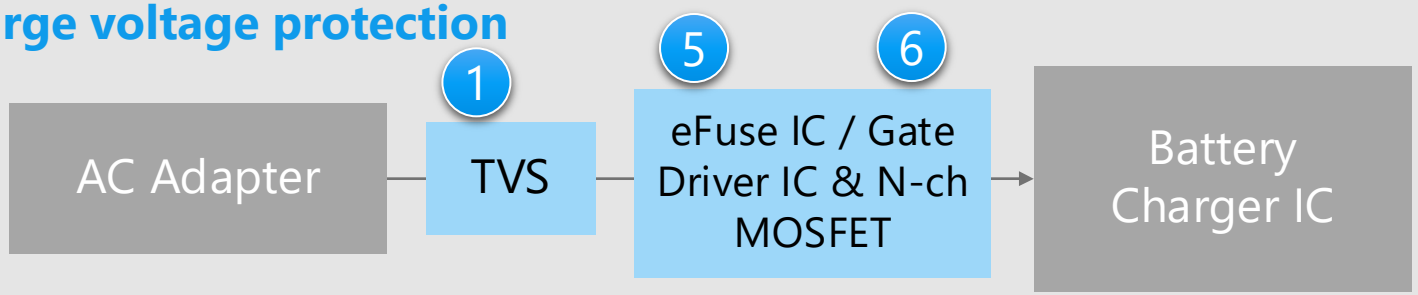


Electric Shaver　Overall block diagram

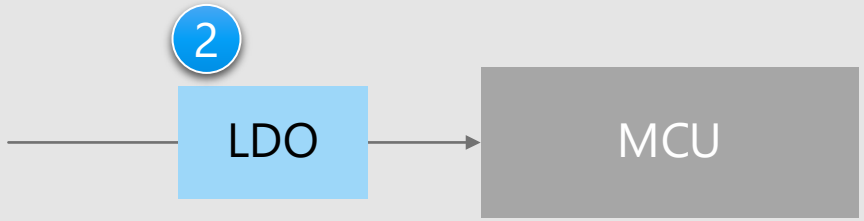


Electric Shaver　Detail of power supply line

Surge voltage protection



Control MCU power supply



Constant voltage supply circuit

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

Criteria for device selection

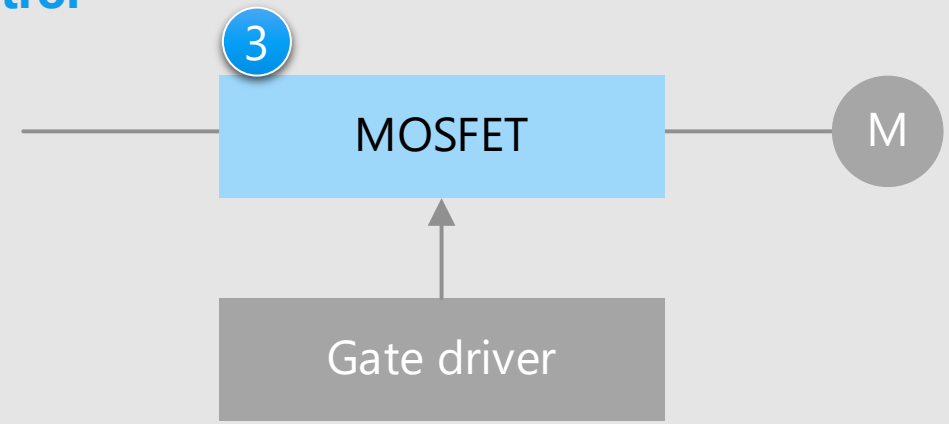
- ESD protection is required for the power line when the AC adapter is not connected.
- LDO regulators are suitable for supplying stable voltage.
- eFuse ICs with various protection functions are suitable for stable operation of the set.

Proposals from Toshiba

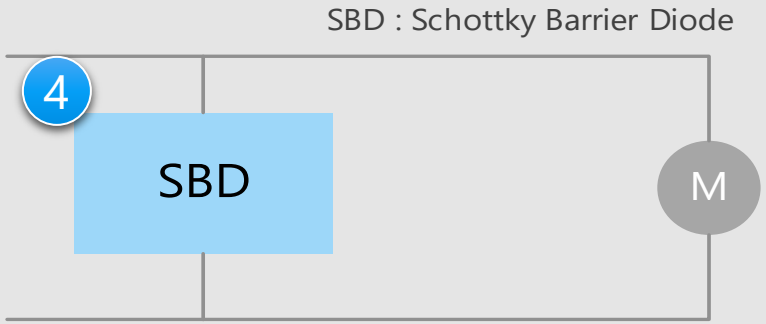
- **Static electricity (ESD) from external terminals is absorbed to prevent circuit malfunction and device breakdown** 1
  TVS diode
- **Stable voltage supply** 2
  Small surface mount LDO regulator
- **Built-in protection function against short circuit, over current, over voltage, etc.** 5
  Electronic fuse (eFuse IC)
- **Small package and built-in over voltage protection function** 6
  N-ch MOSFET gate driver IC

Electric Shaver　Detail of motor drive

Motor control



Motor protection



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

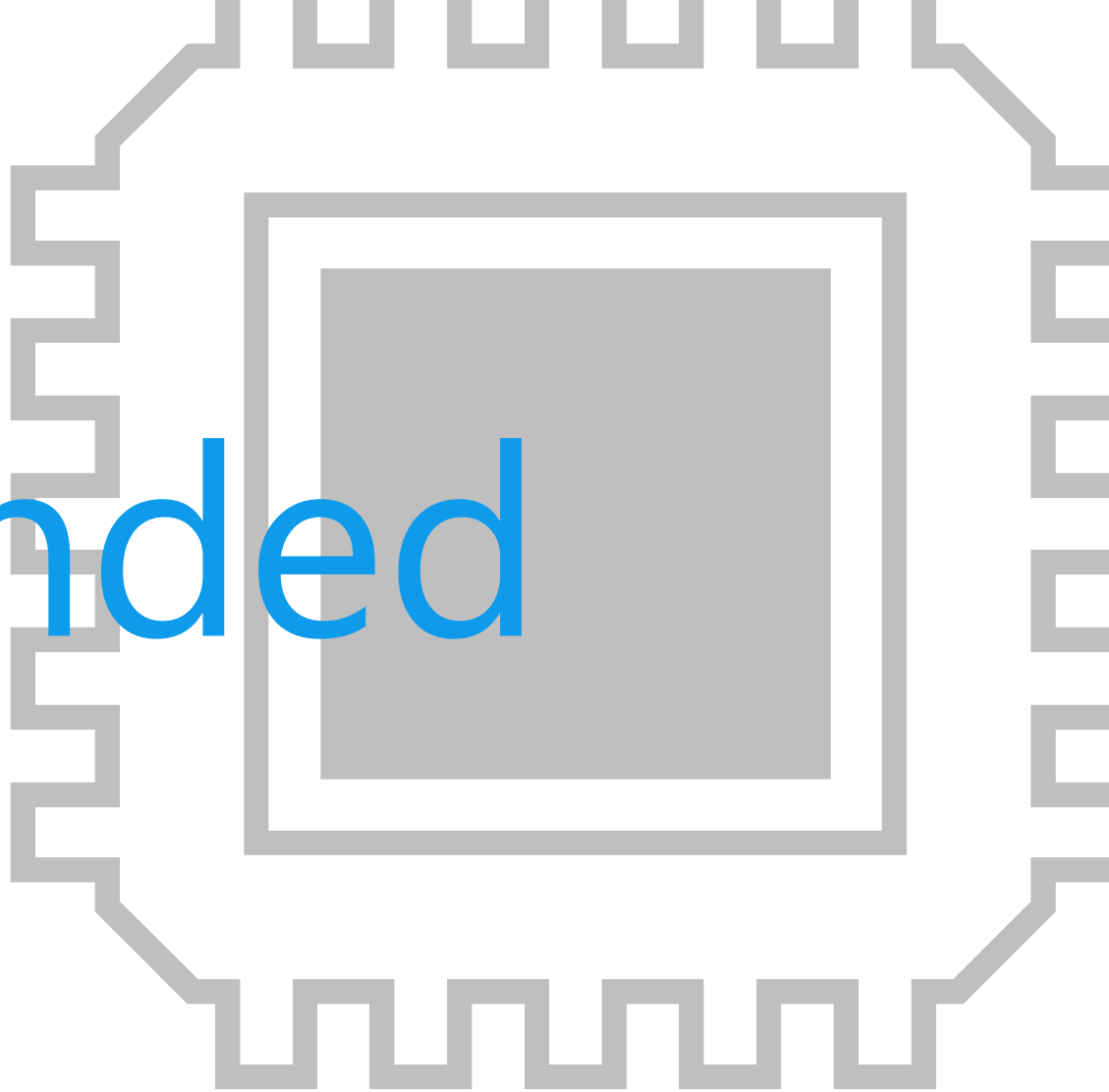
Criteria for device selection

- MOSFET with small package and low $R_{DS(ON)}$ is used to control the motors.
- Protection against regenerative current by the motor is necessary.

Proposals from Toshiba

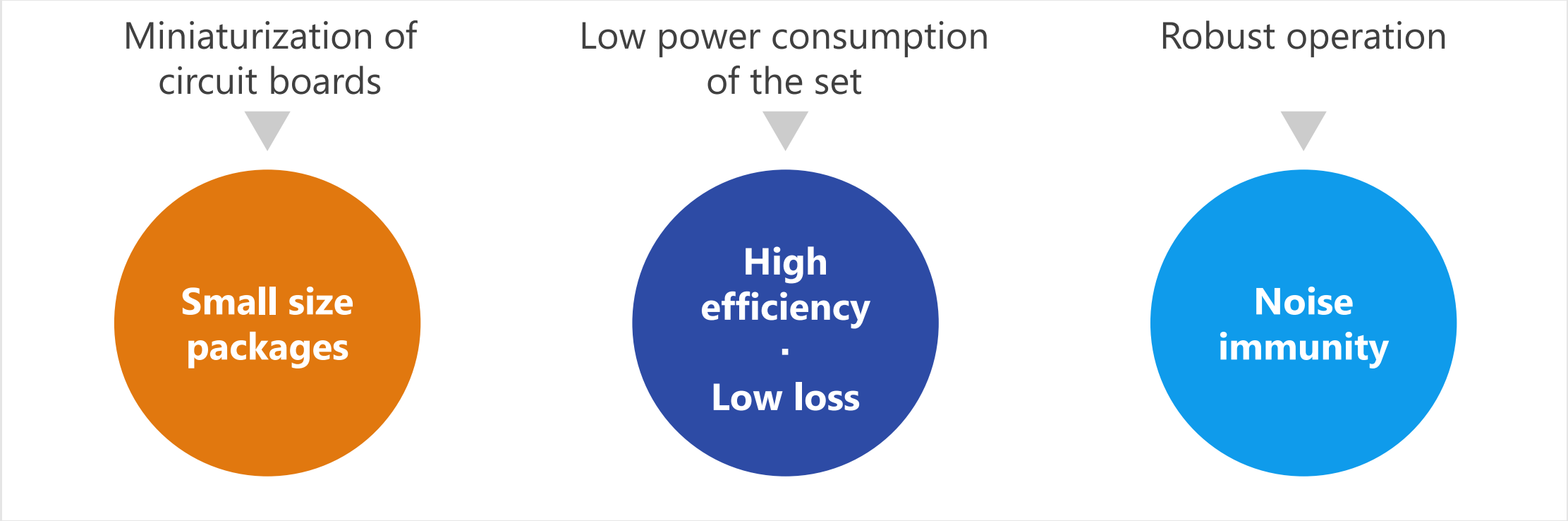
- **Realize a set with low power consumption by low on-resistance**
  Small signal MOSFET 3
- **Low forward voltage / Strong against surge current**
  Schottky barrier diode 4

Recommended Devices



Device solutions to address customer needs

As described above, in the design of electric shaver, **“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 surface mount LDO regulator	●	●	●
3 Small signal MOSFET	●	●	
4 Schottky barrier diode	●	●	●
5 Electronic fuse (eFuse IC)	●	●	
6 N-ch MOSFET gate driver IC	●	●	

1 TVS diode

DF2B7BSL / DF2B20M4SL / DF2B5PCT / DF2B7PCT / DF2B7AFU

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 Improved ESD pulse absorption

Improved ESD absorption compared to 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.

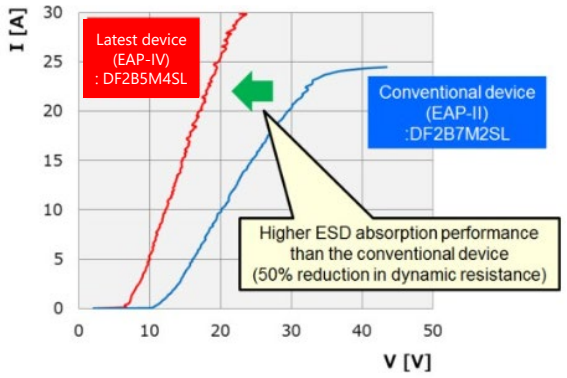
2 Suppress ESD energy by low clamp voltage

Protect the connected circuits/devices using proprietary technology.

3 Suitable for high-density mounting

A variety of compact packages are available.

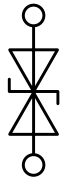
ESD Pulse Absorption Performance
(Note: Toshiba internal comparison)



Unidirectional

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

Bidirectional



Suitable for paths with both polar signals such as audio signals

Lineup

Part number	DF2B7BSL	DF2B20M4SL	DF2B5PCT	DF2B7PCT	DF2B7AFU
Package	SL2 		CST2 		USC 
V_{ESD} [kV]	±30	±15	±30	±30	±30
V_{RWM} (Max) [V]	5.5	18.5	3.6	5.5	5.5
C_t (Typ.) [pF]	12	0.2	41	45	8.5
R_{DYN} (Typ.) [Ω]	0.2	0.2	0.1	0.1	0.2

(NOTE): This product is designed for ESD protection purpose and cannot be used for purposes other than ESD protection.

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2 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 the latest generation process significantly improved the dropout voltage characteristics.

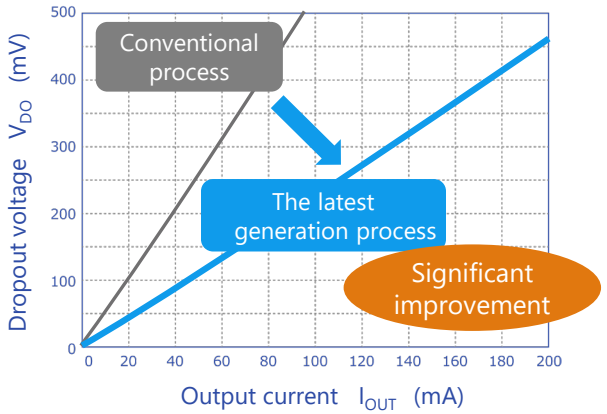
2 High PSRR Low output noise voltage

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

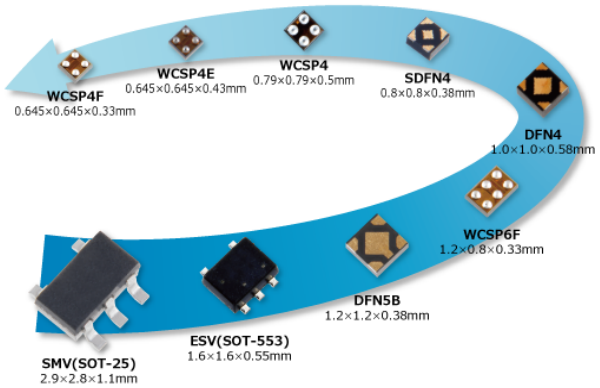
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

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		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.) [μA]	25	56	20	19	7	7	0.34	1	170

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3 Small signal MOSFET

SSM6K403TU / SSM3K35AMFV

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

Value provided

Suitable for power management switches and contributes to miniaturization.

1 Low voltage drive

Operate down to V_{GS} = 1.5 V

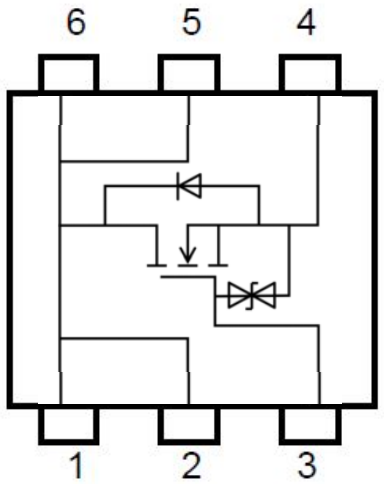
2 Low on-resistance

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

3 Small package

SOT-363F / VESM type packages.

SSM6K403TU
Internal connection



Lineup

Part number	SSM6K403TU	SSM3K35AMFV
Package	SOT-363F 	VESM 
Polarity	N-ch	N-ch
V_{DSS} [V]	20	20
I_D [A]	4.2	0.25
$R_{DS(ON)}$ (Max) [Ω] @V_{GS} = 1.5 V	0.066	3.1

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4 Schottky barrier diode
CUS357

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

Value provided

It can be applied to various applications at low loss, and contributes to miniaturization.

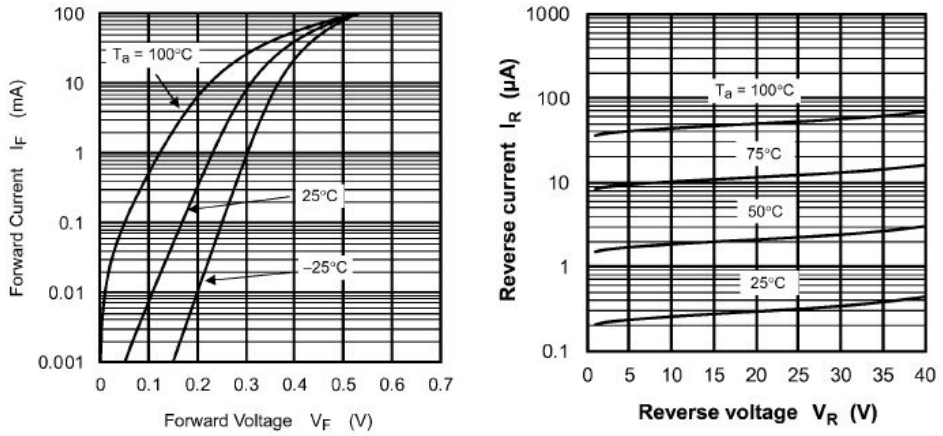
1 Low forward voltage

Since the forward voltage is low, it is suitable for use as a freewheel diode.

2 Small package

It is sealed in a USC package.

CUS357 Characteristics Curves



Lineup

Part number	CUS357
Package	USC 
I_O [A]	0.1
V_R [V]	40
V_F (Typ.) [V] @I_F = 100 mA	0.54

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5 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

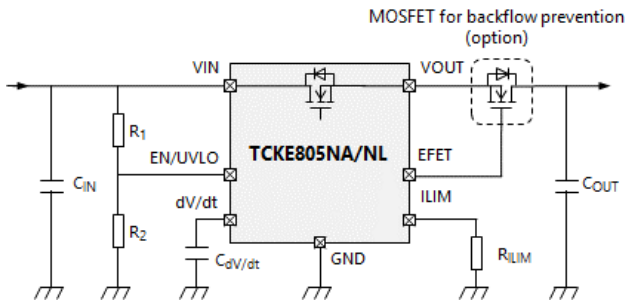
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

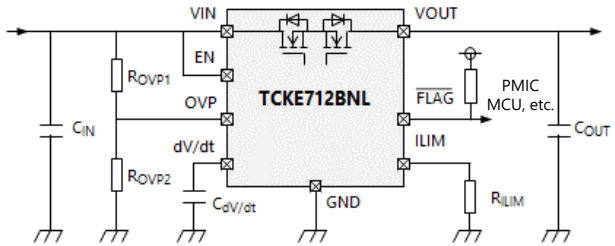
TCKE8 Series: short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

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

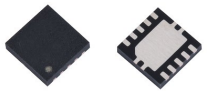
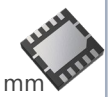
Reference circuit example of TCKE8 Series



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

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6 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[Note1] function. It contributes to reduction of power consumption and miniaturization of load switch circuit.

[Note1] OVP : Over Voltage Protection

1 Three types of connection 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[Note2] threshold voltage

Operating voltage V_{opr}: 2.7 to 28 V
Maximum input voltage: 40 V
V_{IN_OVLO}[Note3] lineups suitable for 5 to 24V power supply line.

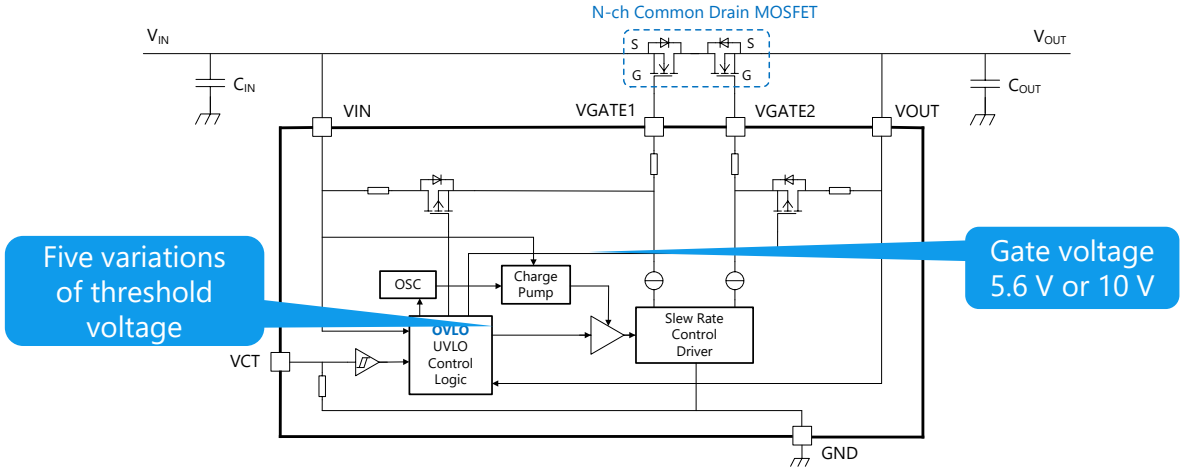
[Note2] OVLO: Over Voltage Lock Out
[Note3] V_{IN_OVLO}: V_{IN} OVLO threshold

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 TCK402G	Over 28	Max 10 (V_{IN} ≥ 12 V)	Single high side Common Source	WCSP6E
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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