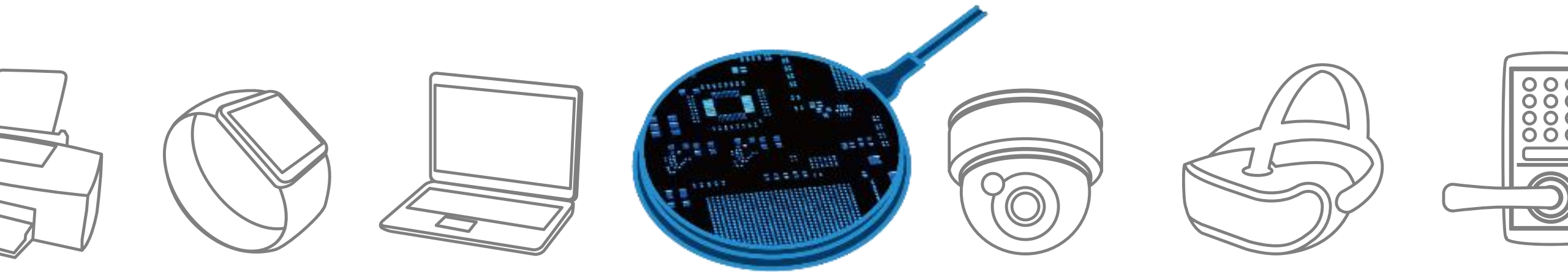
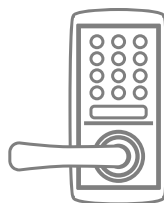


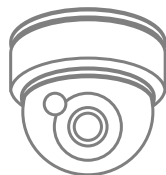
# Wireless Charger

Solution Proposal by Toshiba

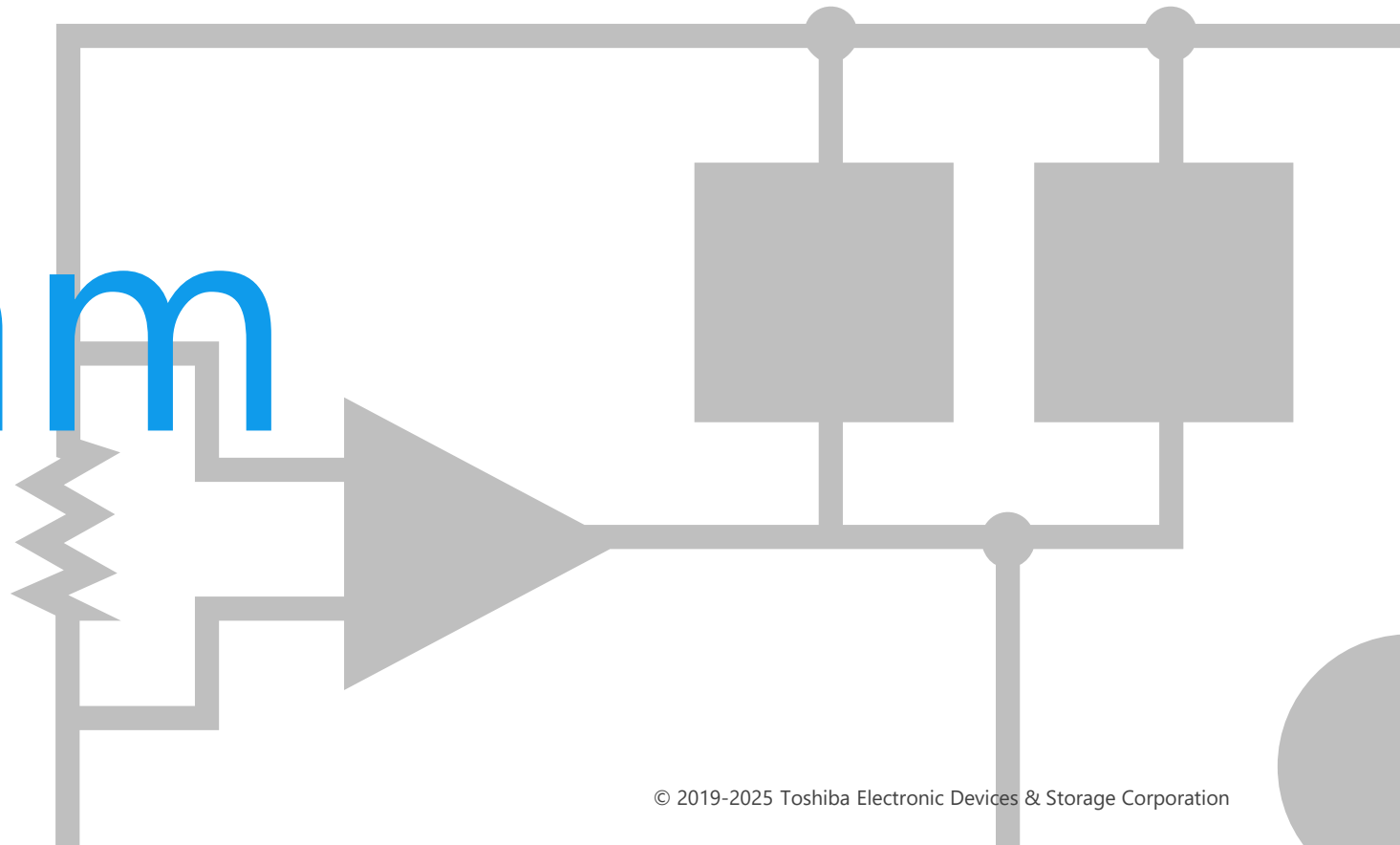




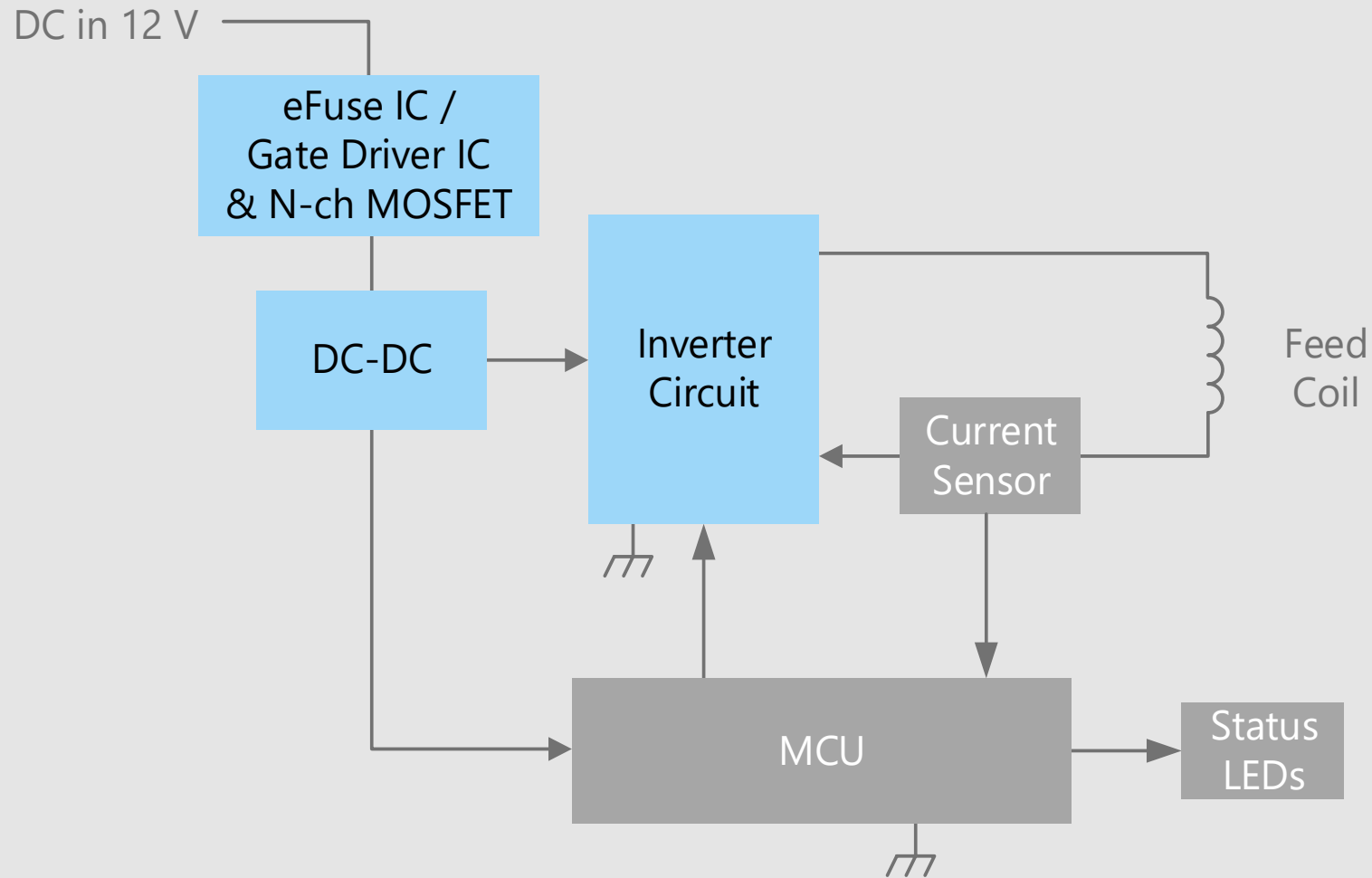
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.



# Block Diagram

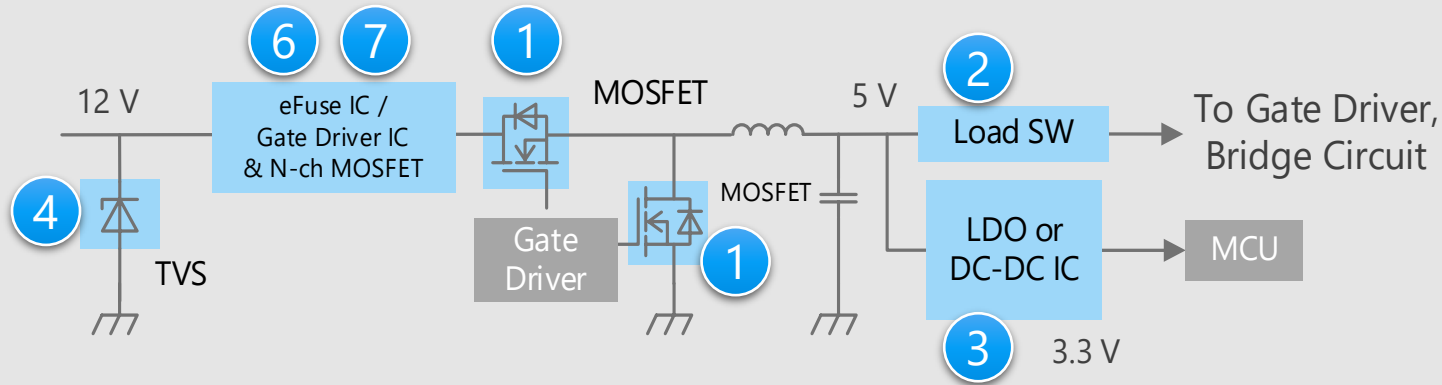


# Wireless Charger Overall block diagram

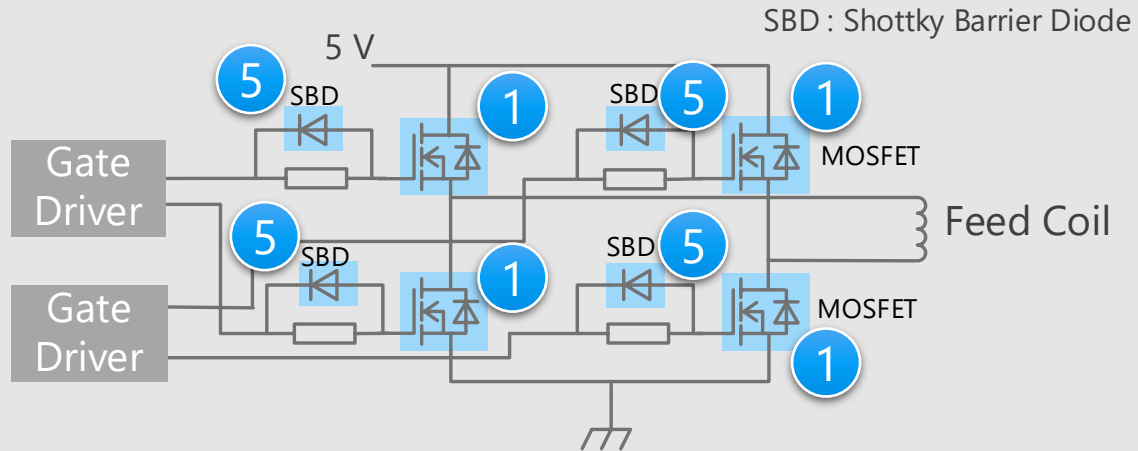


# Wireless Charger Detail of power supply circuit unit

## IC-driven DC-DC power supply circuit



## Full-bridge inverter circuit



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

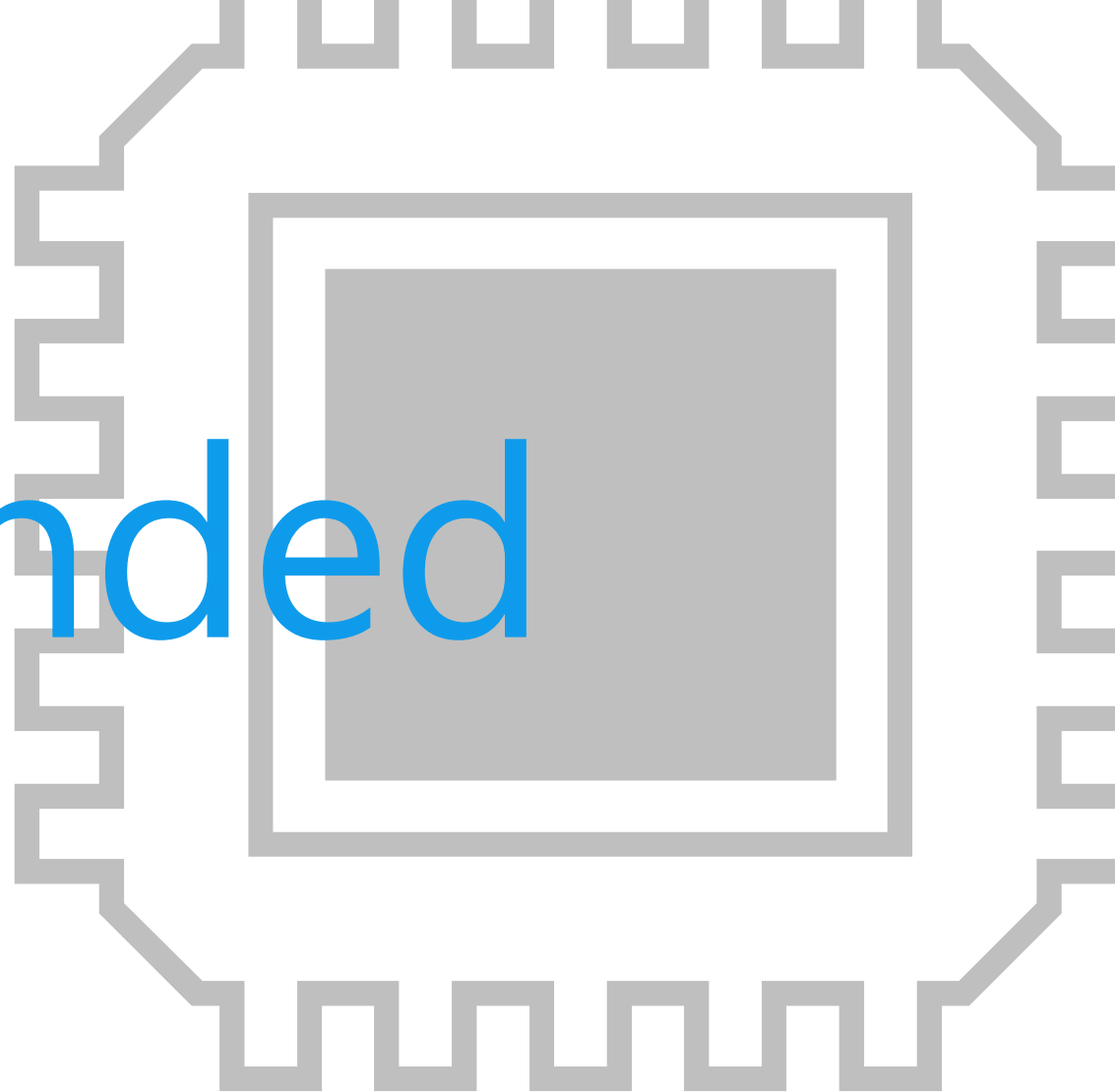
## Criteria for device selection

- A high voltage MOSFET is required considering such as counter electromotive force of the feed coil.
- The use of low consumption products can improve the overall efficiency of the system.
- Small package products contribute to the reduction of circuit board area.

## Proposals from Toshiba

- **The set of low power consumption is realized by the low on-resistance**  
U-MOS Series MOSFET
- **It contributes to low power consumption of the system.**  
Load switch IC
- **Low dropout LDO contributes to high efficiency**  
Small surface mount LDO regulator
- **Small size package is suitable for high density mounting**  
TVS diode
- **Suppress the through current by shortening the OFF time.**  
Schottky barrier diode
- **Built-in protection function against short circuit, over current, over voltage, etc.**  
Electronic fuse (eFuse IC)
- **Small package and built-in over voltage protection function**  
N-ch MOSFET gate driver IC

# Recommended Devices



# Device solutions to address customer needs

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

Low power consumption  
of the set



Improved reliability  
of the set



Miniaturization  
of circuit boards



# Device solutions to address customer needs

High efficiency  
-  
Low loss

Protection from  
Surge/ESD

Small size  
packages

①	<b>U-MOS Series MOSFET</b>	●		●
②	<b>Load switch IC</b>	●	●	●
③	<b>Small surface mount LDO regulator</b>	●		●
④	<b>TVS diode</b>		●	●
⑤	<b>Schottky barrier diode</b>	●		●
⑥	<b>Electronic fuse (eFuse IC)</b>	●	●	●
⑦	<b>N-ch MOSFET gate driver IC</b>	●		●



Value provided

Lineup of low on-resistance products is provided and trade-off between on-resistance and capacitance contribute to higher power supply efficiency.

## 1 Fast switching speed

Reducing switching loss through high speed operation contributes to higher power supply efficiency.

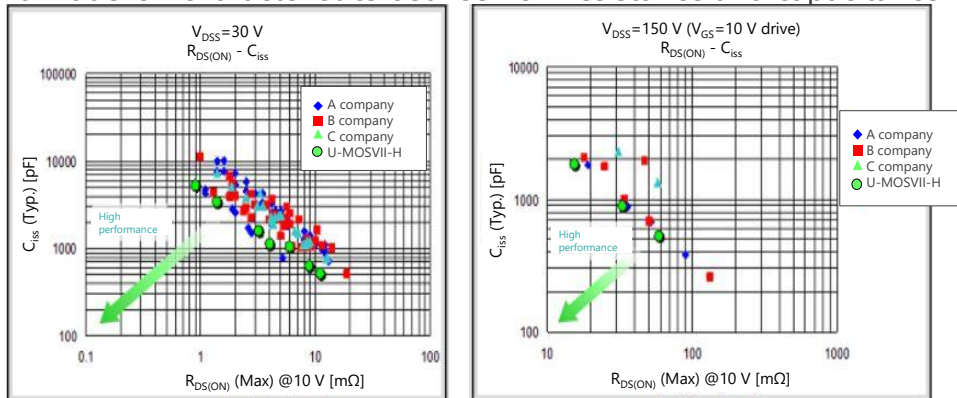
## 2 Small gate input charge

Small gate input charge reduces the performance required for driving the MOSFET. It contributes to improving switching characteristics.

## 3 Low on-resistance





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

Lineup of low on-resistance products and Trade-off characteristics between on-resistance and capacitance



Based on Toshiba's measurement data

### Lineup

Part number	TPN7R504PL	TPN8R408QM	TPN12008QM	TPH7R204PL	TK90S06N1L	TK5R1P08QM	TK6R9P08QM
Package	TSOP Advance 		SOP Advance 		DPAK+ 	DPAK 	
V <sub>DS</sub> [V]	40	80	80	40	60	80	80
I <sub>D</sub> [A]	38 (68*)	32 (77*)	26 (60*)	48 (72*)	90	84 (105*)	62 (83*)
R <sub>DS(ON)</sub> [mΩ] @V <sub>GS</sub> = 10 V	Typ.	5.6	6.5	9.6	5.4	2.7	4.2
	Max	7.5	8.4	12.3	7.2	3.3	5.1
Polarity	N-ch	N-ch	N-ch	N-ch	N-ch	N-ch	N-ch
Generation	U-MOSIX-H	U-MOSX-H	U-MOSX-H	U-MOSIX-H	U-MOSVIII-H	U-MOSX-H	U-MOSX-H

\* : Silicon limit

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Value provided

## Low on-resistance is realized and it contributes to high power supply efficiency.

### 1 Low on-resistance

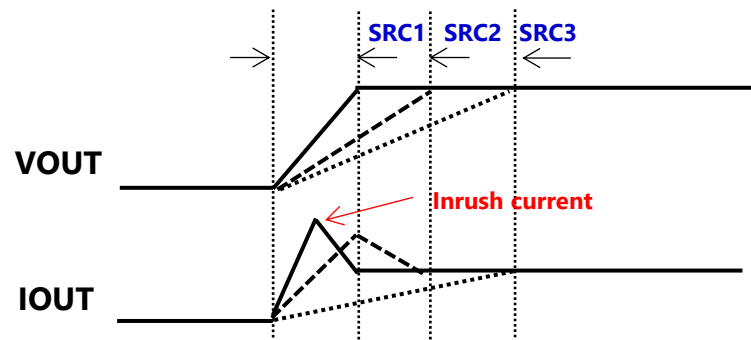
By keeping the on-resistance low, heat generation and power consumption can be kept low.

### 2 Adjusting the output rise time

It is possible to select products that are suitable for reducing power consumption, miniaturization of the system, sequence control and latch current suppression.



### 3 Suitable for high density mounting

The compact 0.4 mm pitch package WCSP6E (0.8 x 1.2 mm) and 0.35 mm pitch package WCSP4G (0.645 x 0.645 mm) enable high density mounting.



The inrush current can be reduced by selecting a slew rate (fixed value) suitable for the load.

#### Lineup

Part number	TCK2292xG	TCK2297xG	TCK127BG
Package	WCSP6E 		WCSP4G 
$V_{IN}$ [V]	1.1 to 5.5		1.0 to 5.5
$I_{OUT}$ [A]	2		1
$R_{ON}$ (Typ.) [m $\Omega$ ] @ $V_{IN} = 5$ V	25		46
Slew Rate	4.5 $\mu$ s, 666 $\mu$ s, 1.364 ms, 3.38 ms @ $V_{IN} = 5$ V		363 $\mu$ s @ $V_{IN} = 3.3$ V
Auto-discharge	✓	N/A	✓

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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

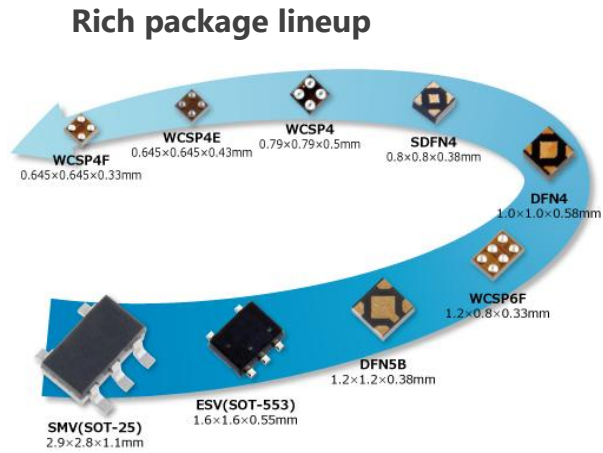
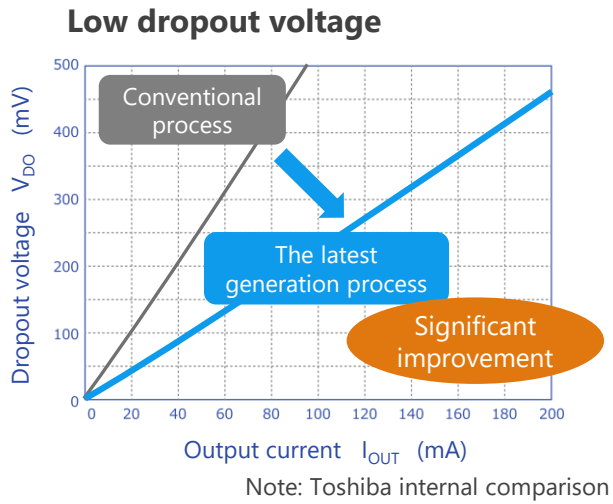
The originally developed the latest generation process significantly improved the dropout voltage characteristics.

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



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

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Value provided

Various products are provided, mainly compact package that is suitable for high density mounting.

## 1 Lineup according to voltage

Products can be selected according to the power supply voltage.

## 2 Absorb high surge current

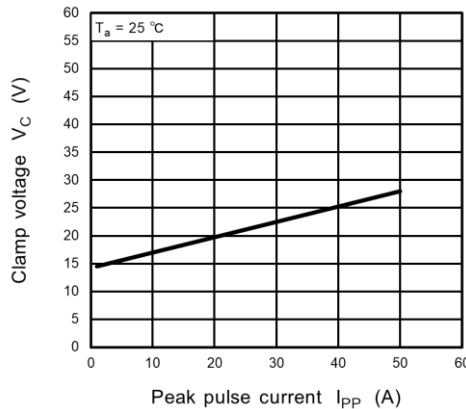
It can absorb high peak pulse current ( $I_{PP}$ <sup>[Note2]</sup>).


## 3 Small package

Small package is available.  
USC: 2.5 x 1.2 mm

High peak pulse current ( $I_{PP}$ ) can be absorbed.

(Reference) DF2S14P2FU



Lineup				
Part number	DF2S6P2FU	DF2S12P2FU	DF2S14P2FU	DF2S23P2FU
Package	USC 			
$V_{RWM}$ (Max) [V]	5.5	10	12.6	21
$V_{ESD}$ [kV] <sup>[Note1]</sup>	±30			
$I_{PP}$ [A] <sup>[Note2]</sup>	80	60	50	14

[Note1] IEC61000-4-2 (contact)

[Note2] IEC61000-4-5

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Value provided

**Wide voltage lineup using small package with high power dissipation. It contributes to shorten the turn off time of gate voltage.**

## 1 Small package with high power dissipation

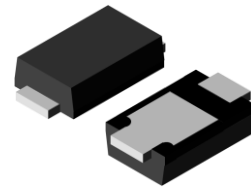
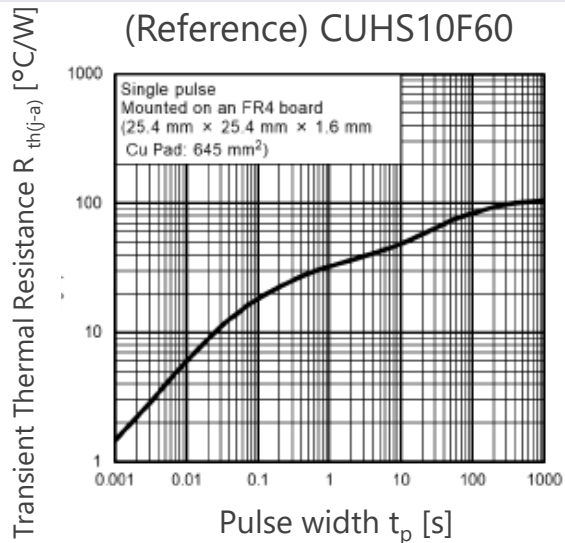
Products lineup is suitable for various power dissipation level.  
The US2H package is low thermal resistance. ( $R_{th(j-a)} = 105 \text{ }^\circ\text{C/W}$ )<sup>[Note]</sup>

## 2 Lineup of various products

Products lineup offers products with reverse voltage  $V_R$  up to 30 V, 40 V and 60 V.

## 3 Switching characteristics


Low forward voltage can turn off the gate voltage quickly and contributes to improvement of the switching characteristic.



**US2H**  
(2.5 x 1.4 mm)

Easy to thermal design by low transient thermal resistance

### Lineup

Part number	CUHS20F30	CUHS20F40	CUHS10F60	CUHS15F60	CUHS20F60	CUHS15S60	CUHS20S60
Package	US2H 						
$V_R$ [V]	30	40	60	60	60	60	60
$I_O$ [A]	2	2	1	1.5	2	1.5	2
$V_F$ (Typ.) [V] @ $I_F = 1 \text{ A}$	0.35	0.39	0.56	0.55	0.41	0.48	0.35
$I_R$ (Max) [ $\mu\text{A}$ ]	60 @ $V_R = 30 \text{ V}$	60 @ $V_R = 40 \text{ V}$	40 @ $V_R = 60 \text{ V}$	50 @ $V_R = 60 \text{ V}$	70 @ $V_R = 60 \text{ V}$	450 @ $V_R = 60 \text{ V}$	650 @ $V_R = 60 \text{ V}$

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# 6 Electronic fuse (eFuse IC)

TCKE8 Series / TCKE7 Series

High efficiency  
Low loss

Protection from  
Surge/ESD

Small size  
packages

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

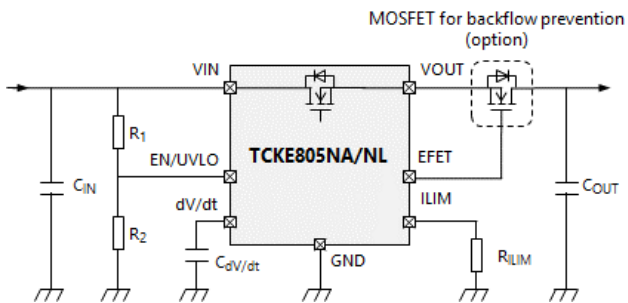
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

## 3 Rich protection functions

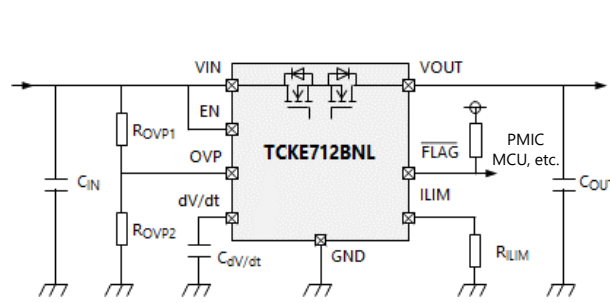
TCKE8 Series: short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

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 <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<sup>[Note1]</sup> 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 connection of N-ch MOSFET can be driven:  
 TCK40xG: Single high side connection  
           Common source connection  
 TCK42xG: Single high side connection  
           Common drain connection

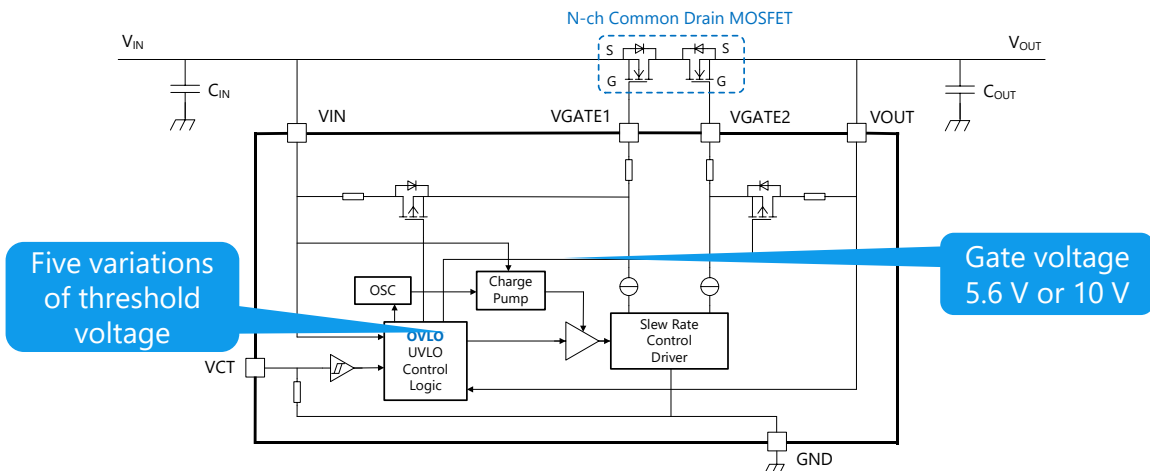
## 2 Wide operating voltage range and various OVLO<sup>[Note2]</sup> threshold voltage



Operating voltage  $V_{opr}$ : 2.7 to 28 V  
 Maximum input voltage: 40 V  
 $V_{IN\_OVLO}$ <sup>[Note 3]</sup> 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	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			

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