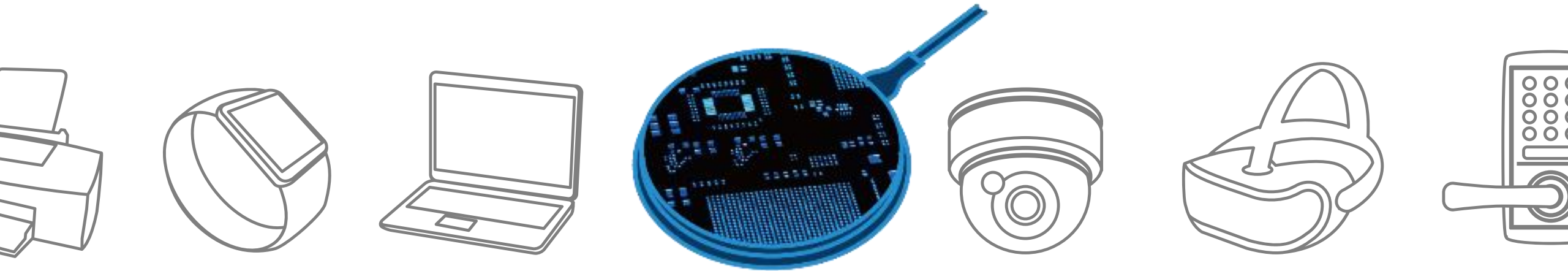
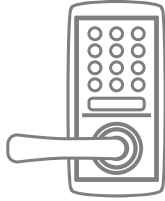
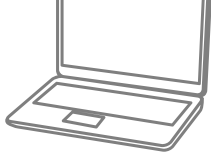


Wireless Charger

Solution Proposal by Toshiba

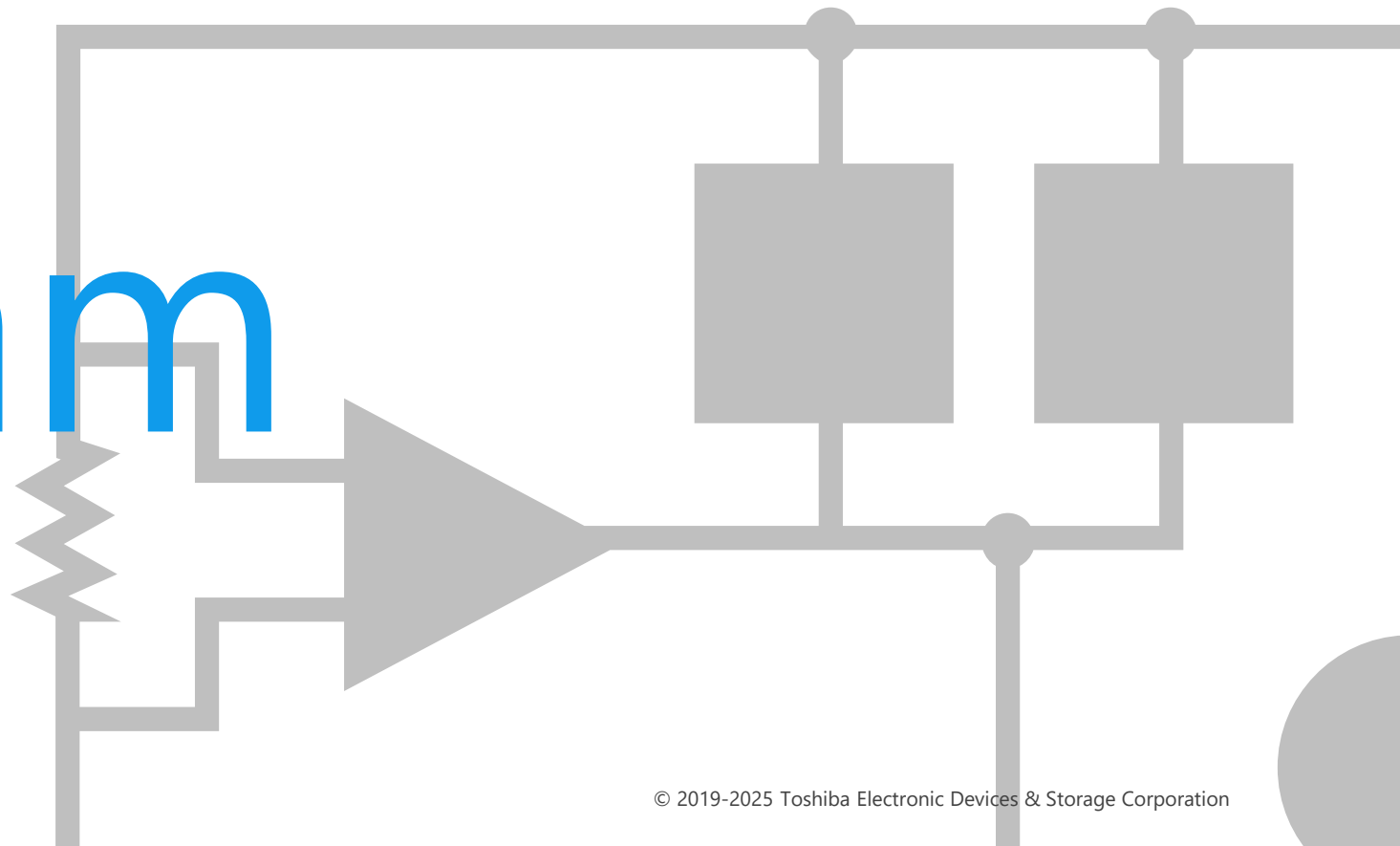




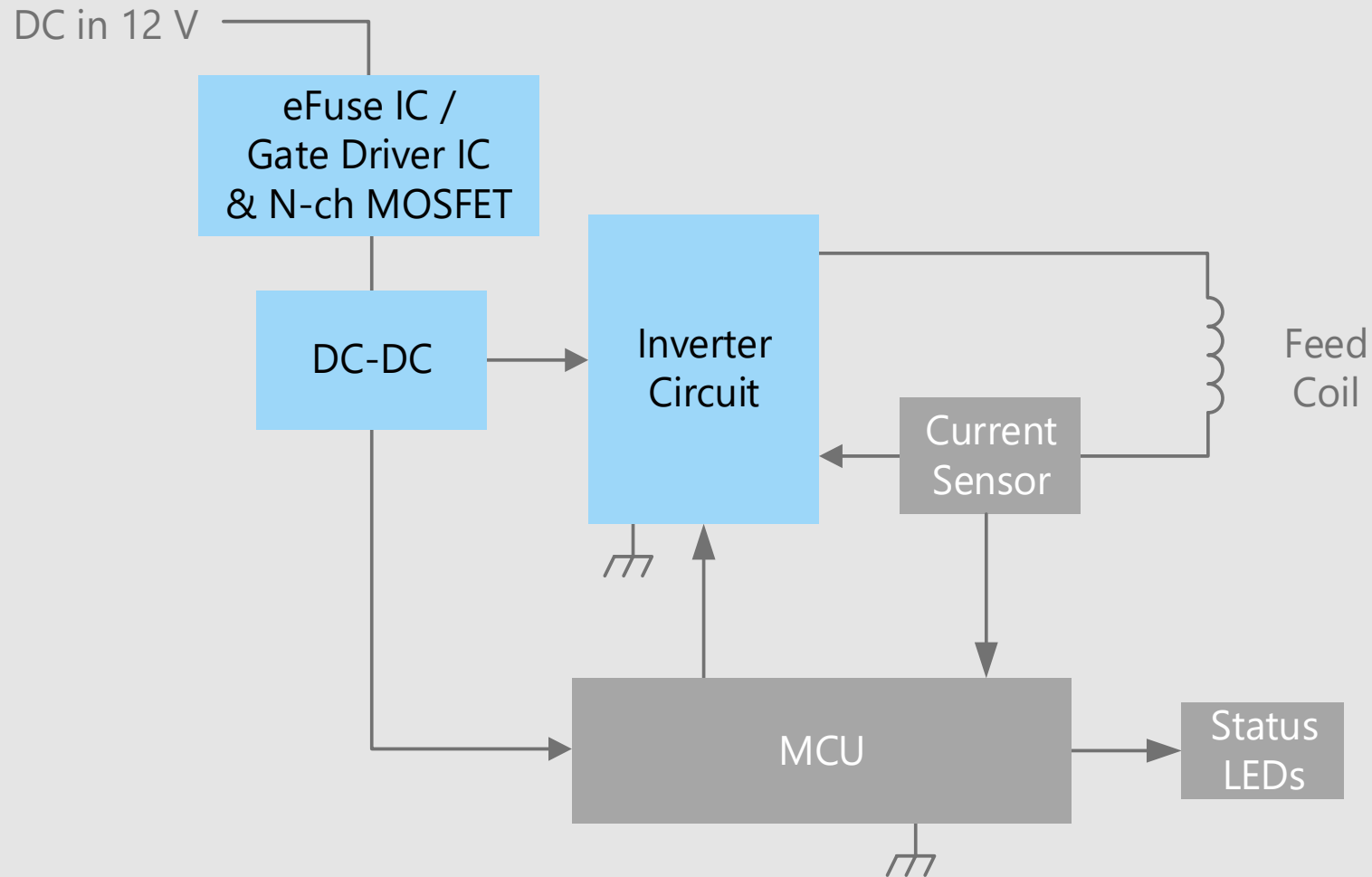
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.



Block Diagram

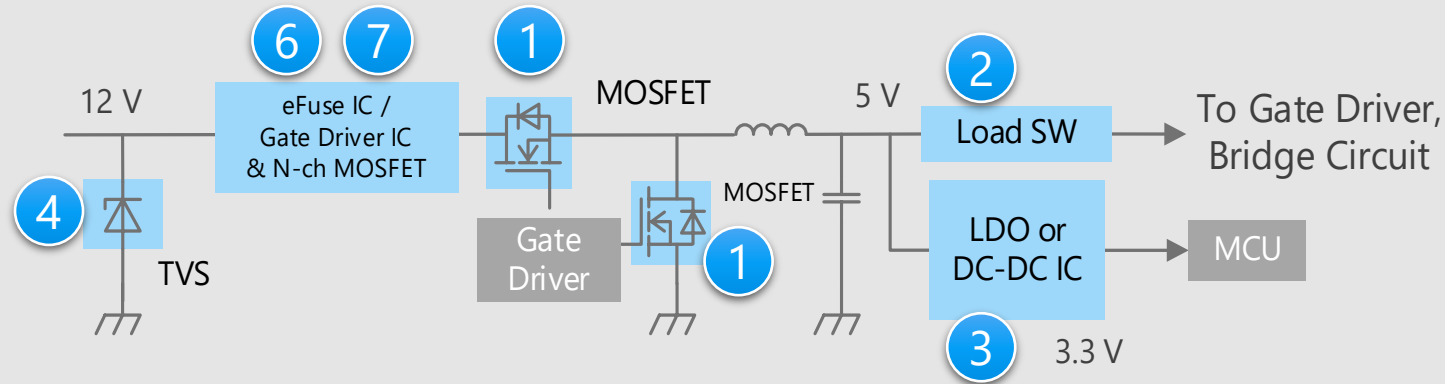


Wireless Charger Overall block diagram

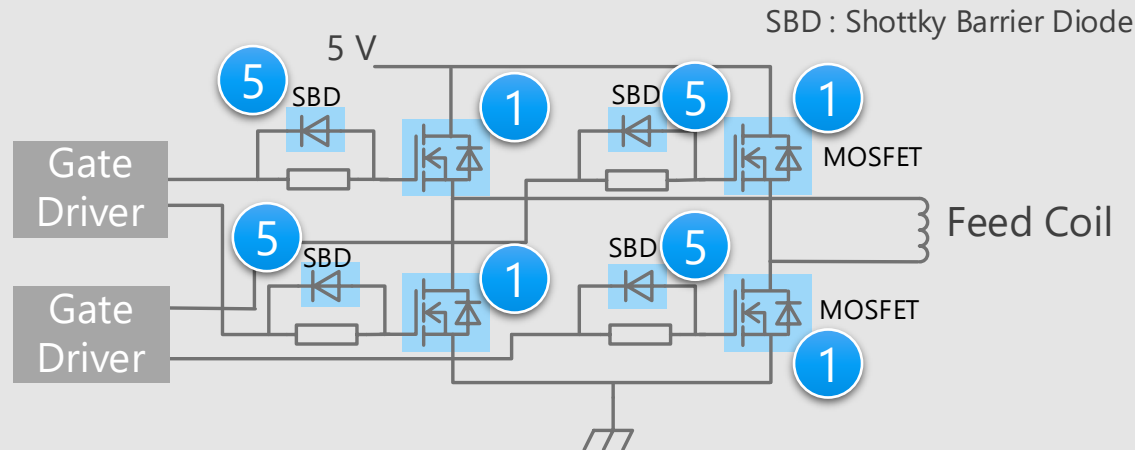


Wireless Charger Detail of power supply circuit unit

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

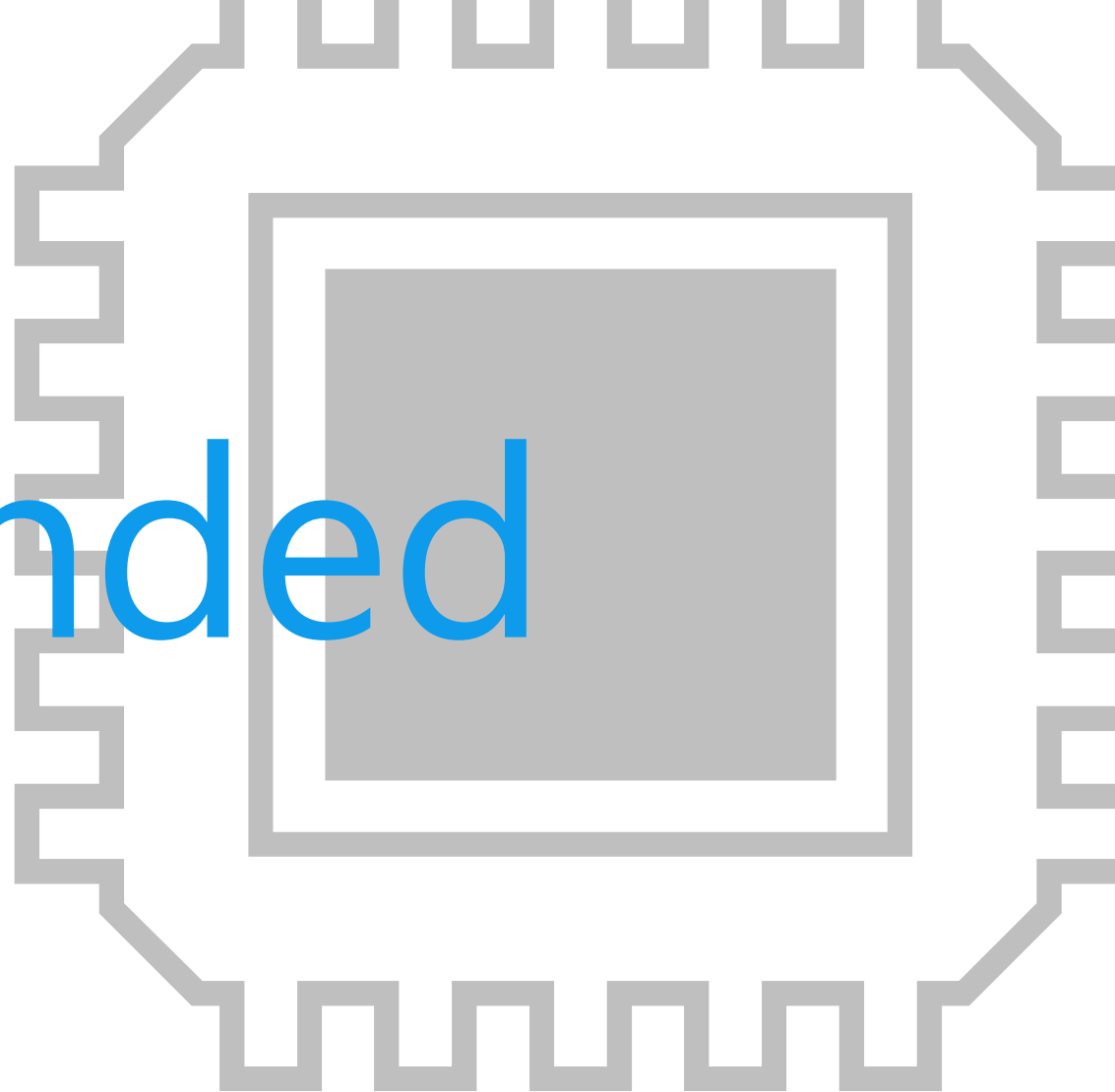
Criteria for device selection

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

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.

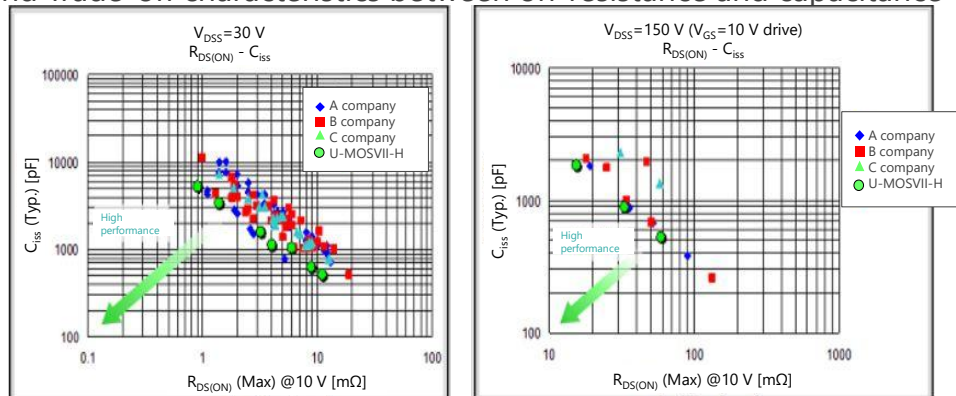
2 Small gate input charge

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 _{DS} [V]	40	80	80	40	60	80	80
I _D [A]	38 (68*)	32 (77*)	26 (60*)	48 (72*)	90	84 (105*)	62 (83*)
R _{DS(ON)} [mΩ]	Typ. 5.6		9.6	5.4	2.7	4.2	5.5
@V _{GS} = 10 V	Max 7.5		12.3	7.2	3.3	5.1	6.9
Polarity	N-ch		N-ch	N-ch	N-ch	N-ch	N-ch
Generation	U-MOSIX-H		U-MOSX-H	U-MOSIX-H	U-MOSVIII-H	U-MOSX-H	U-MOSX-H

* : Silicon limit

[◆Return to Block Diagram TOP](#)

Value provided

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

1 Low on-resistance

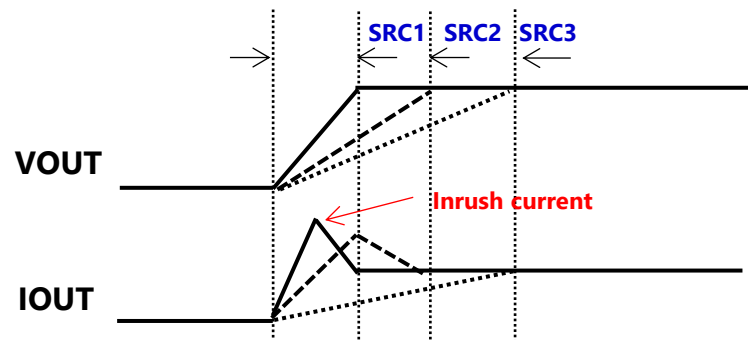
By keeping the on-resistance low, heat generation and power consumption can be kept low.

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.) [mΩ] @ $V_{IN} = 5$ V	25		46
Slew Rate	4.5 μs, 666 μs, 1.364 ms, 3.38 ms @ $V_{IN} = 5$ V		363 μs @ $V_{IN} = 3.3$ V
Auto-discharge	✓	N/A	✓

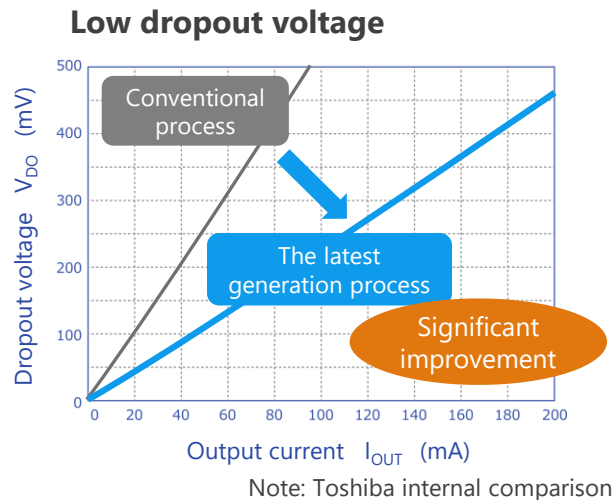
[◆Return to Block Diagram TOP](#)

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.



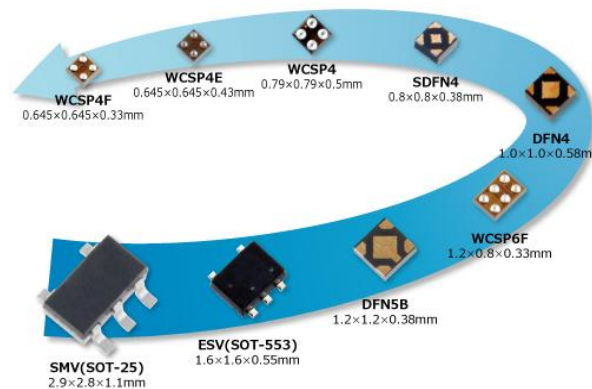
2 High PSRR Low output noise voltage

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)

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

[Return to Block Diagram TOP](#)

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

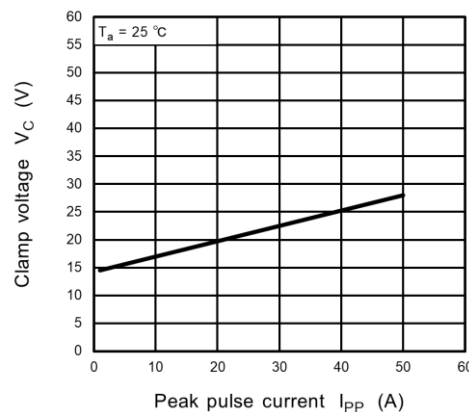
It can absorb high peak pulse current (I_{PP} ^[Note2]).

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] ^[Note1]	±30			
I_{PP} [A] ^[Note2]	80	60	50	14

[Note1] IEC61000-4-2 (contact)

[Note2] IEC61000-4-5

[◆Return to Block Diagram TOP](#)

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.

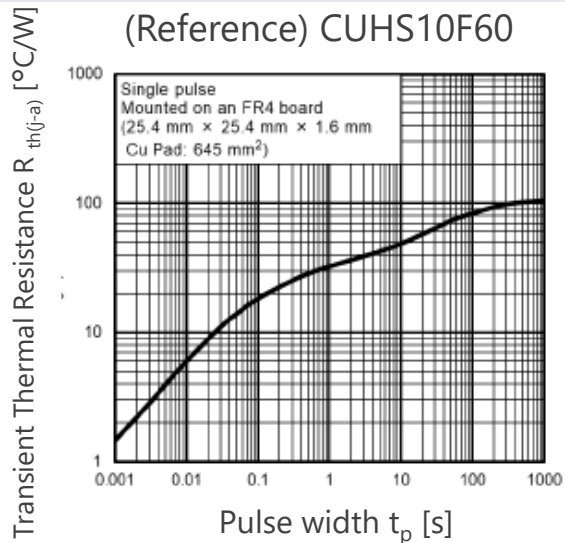
The US2H package is low thermal resistance. ($R_{th(ja)} = 105\text{ }^{\circ}\text{C/W}$)^[Note]

2 Lineup of various products

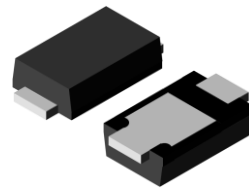
Products lineup offers products with reverse voltage V_R up to 30 V, 40 V and 60 V.

3 Switching characteristics

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



Note: FR4 board mounting (25.4 x 25.4 x 1.6 mm, Cu Pad: 25.4 x 25.4 mm)



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) [μA]	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 @ $V_R = 60\text{ V}$

[Return to Block Diagram TOP](#)

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

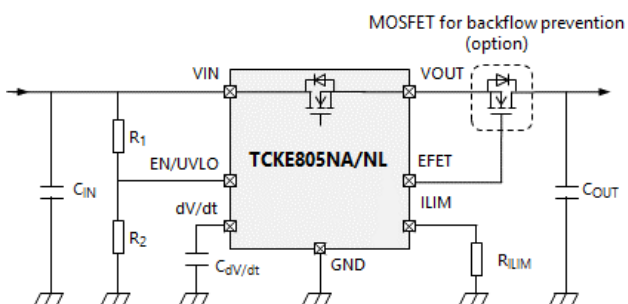
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

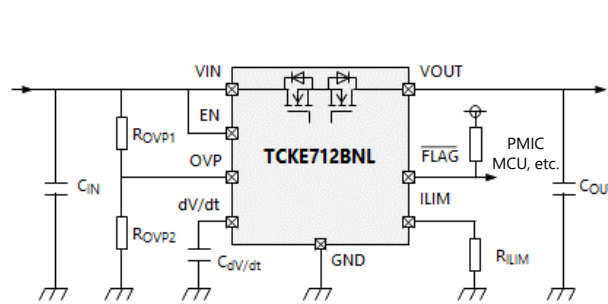
TCKE8 Series: short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

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	WSN10B 3.0 x 3.0 x 0.75 mm			WSN10 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](#)

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 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^[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

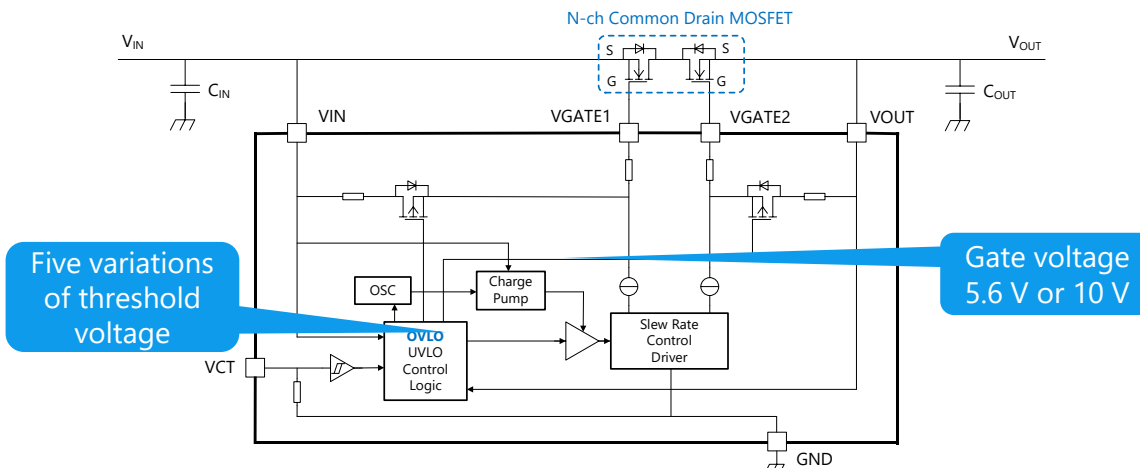
[Note3] V_{IN_OVLO} : V_{IN} OVLO threshold

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	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			

[Return to Block Diagram TOP](#)

If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

Contact address: <https://toshiba.semicon-storage.com/ap-en/contact.html>



Terms of use

This terms of use is made between Toshiba Electronic Devices and Storage Corporation ("We") and Customer who downloads or uses this Reference Design. Customer shall comply with this terms of use. This Reference Design means all documents and data in order to design electronics applications on which our semiconductor device is embedded.

Section 1. Restrictions on usage

1. This Reference Design is provided solely as reference data for designing electronics applications. Customer shall not use this Reference Design for any other purpose, including without limitation, verification of reliability.
2. Customer shall not use this Reference Design for sale, lease or other transfer.
3. Customer shall not use this Reference Design for evaluation in high or low temperature, high humidity, or high electromagnetic environments.
4. This Reference Design shall not be used for or incorporated into any product or system whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

Section 2. Limitations

1. We reserve the right to make changes to this Reference Design without notice.
2. This Reference Design should be treated as a reference only. WE ARE NOT RESPONSIBLE FOR ANY INCORRECT OR INCOMPLETE DATA AND INFORMATION.
3. Semiconductor devices can malfunction or fail. When designing electronics applications by referring to this Reference Design, Customer is responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of semiconductor devices could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Customer must also refer to and comply with the latest versions of all relevant our information, including without limitation, specifications, data sheets and application notes for semiconductor devices, as well as the precautions and conditions set forth in the "Semiconductor Reliability Handbook".
4. Designing electronics applications by referring to this Reference Design, Customer must evaluate the whole system sufficiently. Customer is solely responsible for applying this Reference Design to Customer's own product design or applications. WE ASSUME NO LIABILITY FOR CUSTOMER'S PRODUCT DESIGN OR APPLICATIONS.
5. WE SHALL NOT BE RESPONSIBLE FOR ANY INFRINGEMENT OF PATENTS OR ANY OTHER INTELLECTUAL PROPERTY RIGHTS OF THIRD PARTIES THAT MAY RESULT FROM THE USE OF THIS REFERENCE DESIGN. NO LICENSE TO ANY INTELLECTUAL PROPERTY RIGHT IS GRANTED BY THIS TERMS OF USE, WHETHER EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE.
6. THIS REFERENCE DESIGN IS PROVIDED "AS IS". WE (a) ASSUME NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (b) DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO THIS REFERENCE DESIGN, INCLUDING WITHOUT LIMITATION, WARRANTIES OR CONDITIONS OF FUNCTION AND WORKING, WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

Section 3. Terms and Termination

It is assumed that Customer agrees to any and all this terms of use if Customer downloads or uses this Reference Design. We may, at its sole and exclusive discretion, change, alter, modify, add, and/or remove any part of this terms of use at any time without any prior notice. We may terminate this terms of use at any time and without any cause. Upon termination of this terms of use, Customer shall eliminate this Reference Design. Furthermore, upon our request, Customer shall submit to us a written confirmation to prove elimination of this Reference Design.

Section 4. Export Control

Customer shall not use or otherwise make available this Reference Design for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). This Reference Design may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Act and the U.S. Export Administration Regulations. Export and re-export of this Reference Design is strictly prohibited except in compliance with all applicable export laws and regulations.

Section 5. Governing Laws

This terms of use shall be governed and construed by laws of Japan, without reference to conflict of law principle.

Section 6. Jurisdiction

Unless otherwise specified, Tokyo District Court in Tokyo, Japan shall be exclusively the court of first jurisdiction for all disputes under this terms of use.

RESTRICTIONS ON PRODUCT USE

- Toshiba Electronic Devices & Storage Corporation, and its subsidiaries and affiliates (collectively "TOSHIBA"), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively "Product") without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**
- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE").** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative or contact us via our website.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Product may include products using GaAs (Gallium Arsenide). GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**

TOSHIBA

* Company names, product names, and service names may be trademarks of their respective companies.