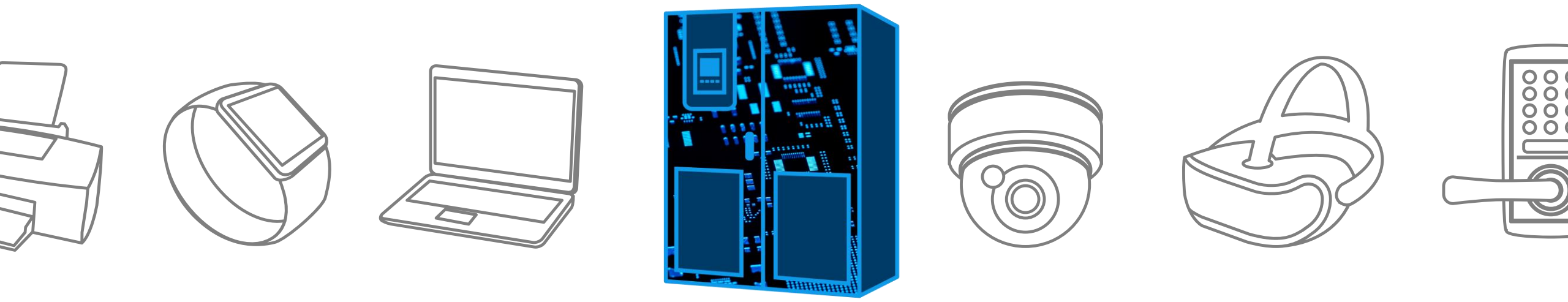
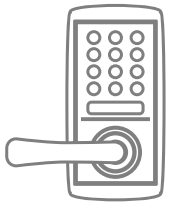
TOSHIBA

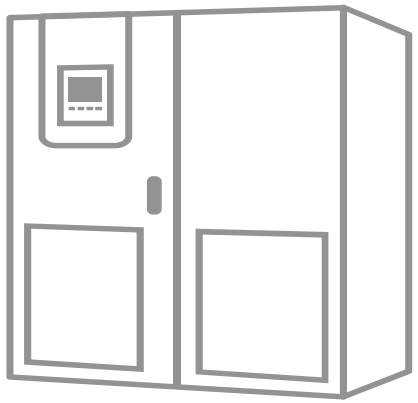
R22

Uninterruptible Power Supply

Solution Proposal by Toshiba

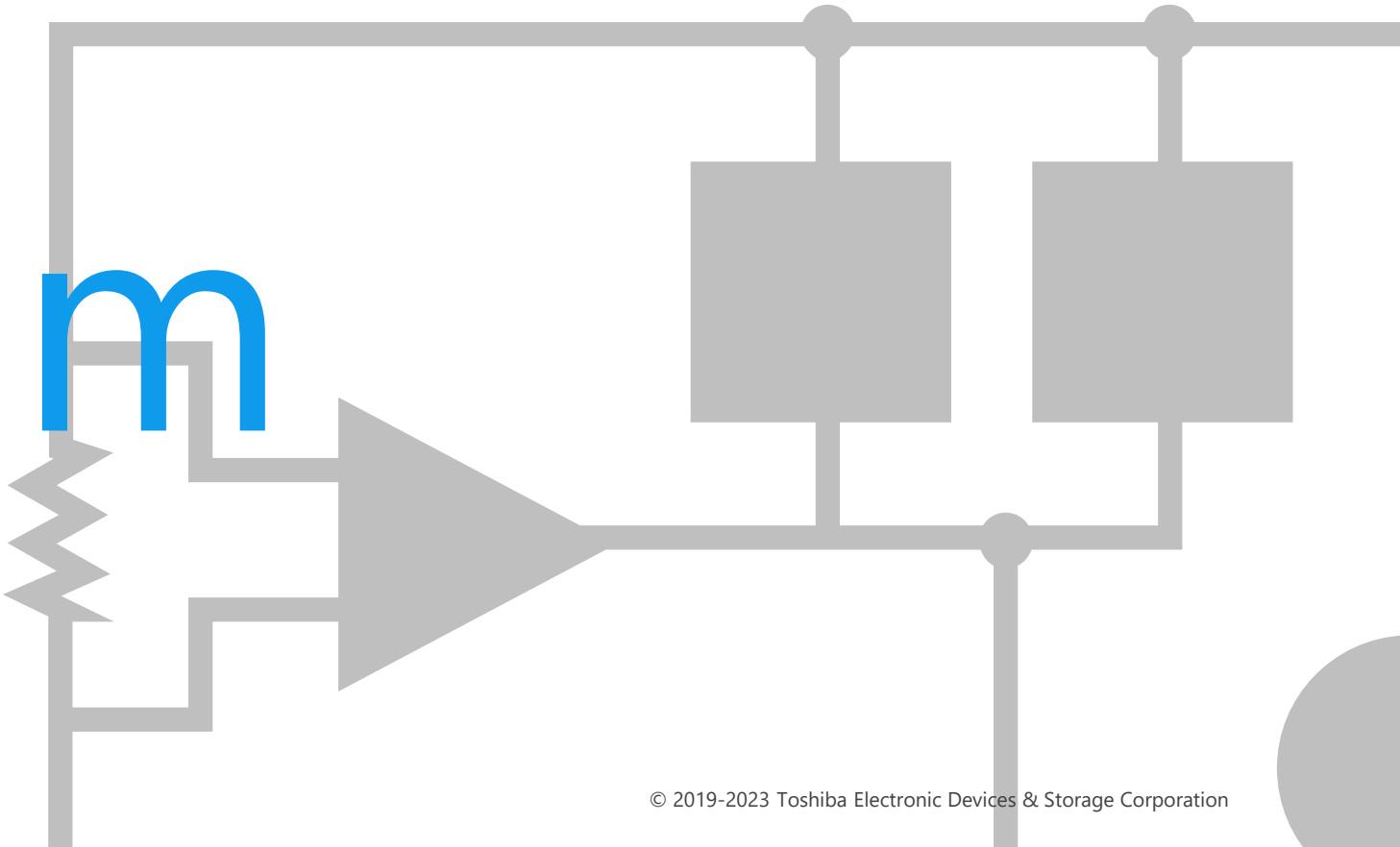




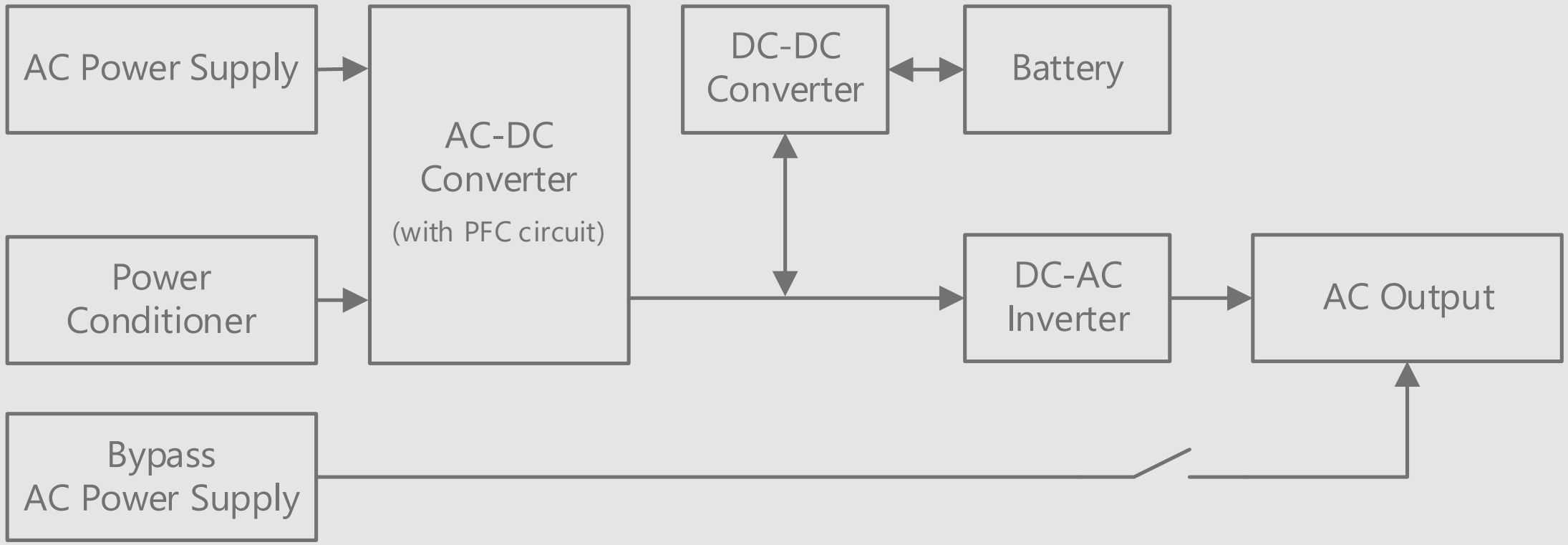


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

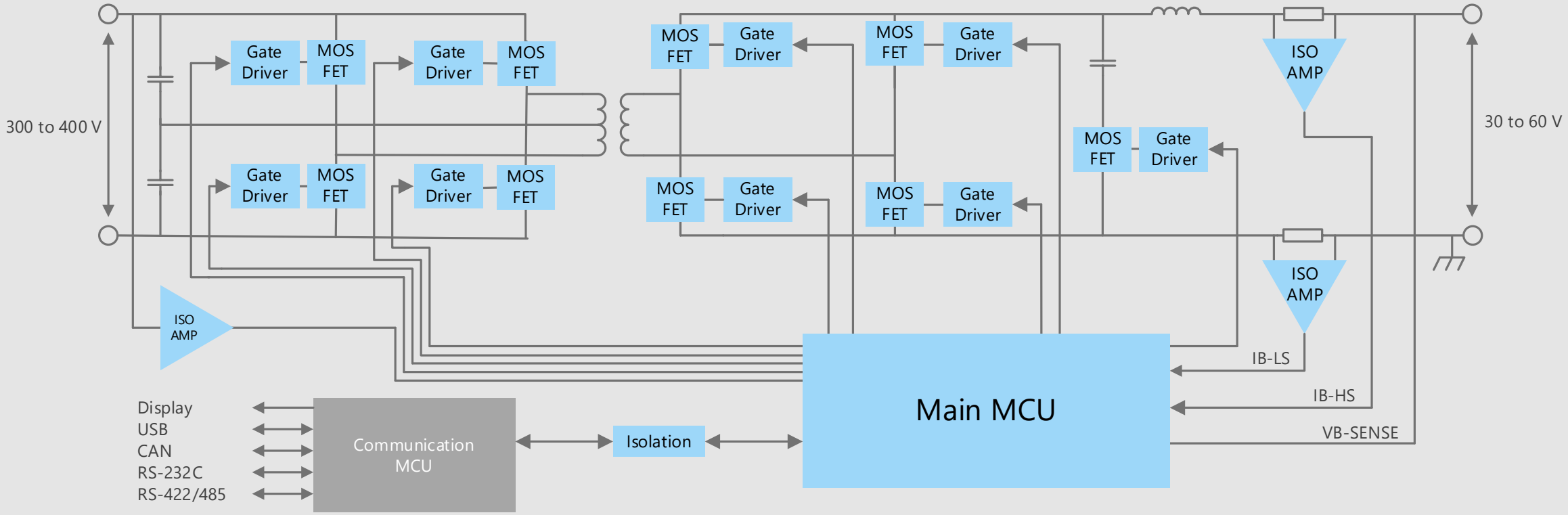
Block Diagram



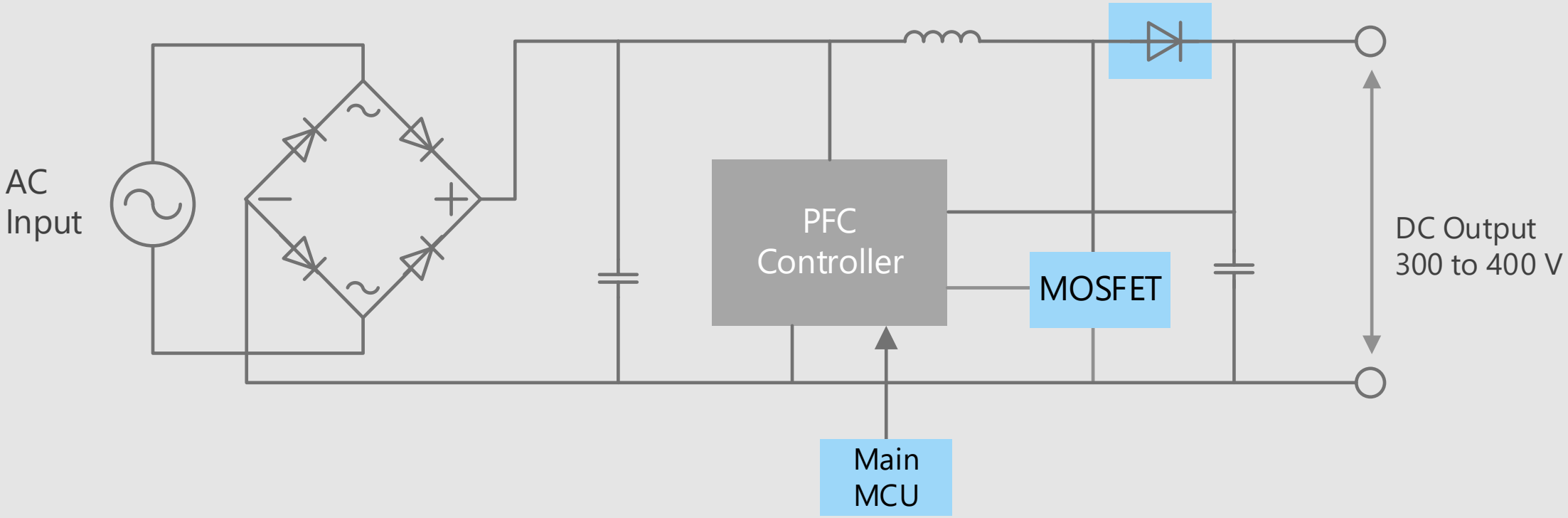
UPS　Overall block diagram (power system diagram)



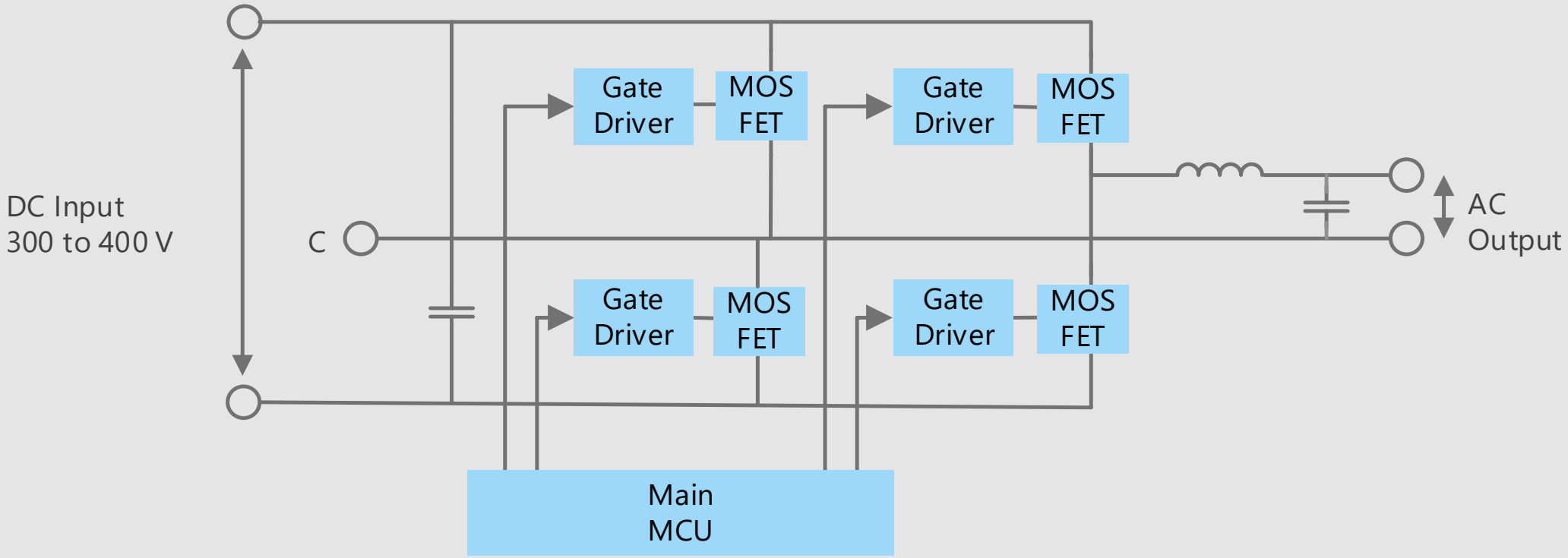
UPS　DC-DC converter block (Bidirectional type)



UPS　AC-DC converter block (with PFC circuit)

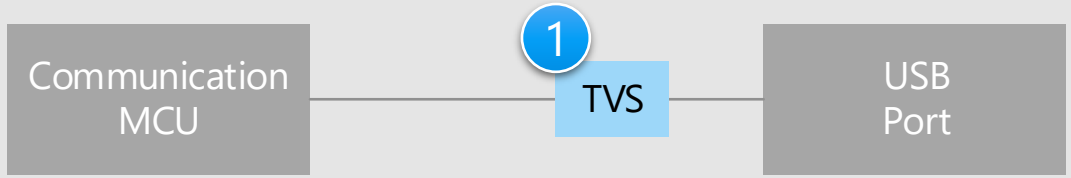


UPS　DC-AC inverter block



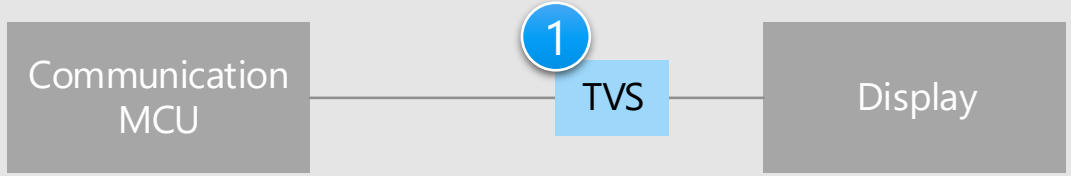
UPS　Details of Interface unit

USB interface



RS-232 interface

Display unit



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

Criteria for device selection

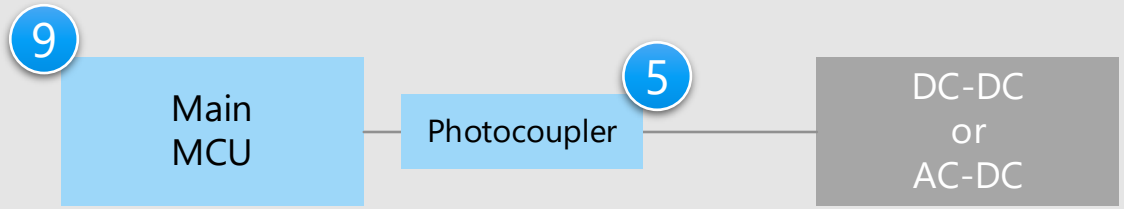
- TVS diodes with low capacitance are suitable for protecting the USB signal line.
- Low dynamic resistivity (R_{DYN}) is the key characteristic to determine the protective tolerance.

Proposals from Toshiba

- **Prevent circuit malfunctions by absorbing electrostatic discharge (ESD) from external terminals**
  TVS diode　1

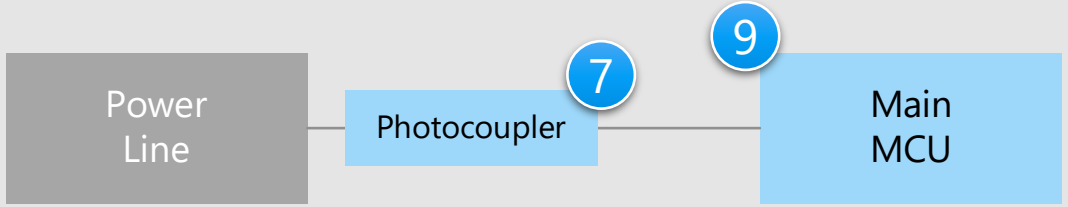
UPS　Details of signal transmission line

Control signal transmission line between MCU and converter



Communication signal transmission line between MCUs

Voltage and current detection signal transmission line



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

Criteria for device selection

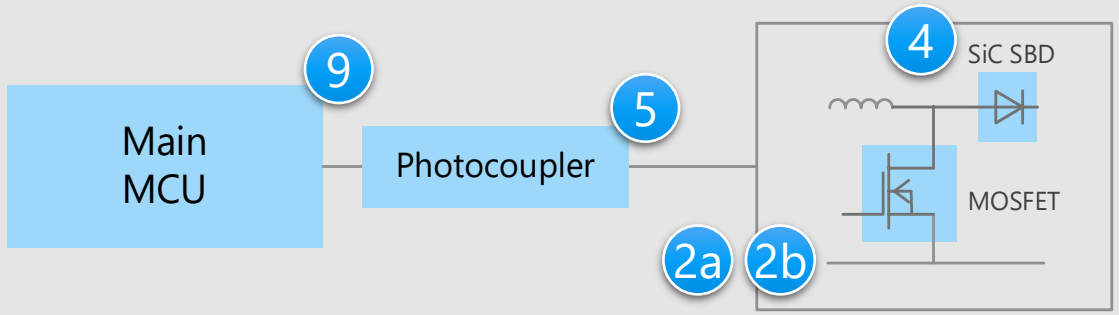
- It is necessary to isolate the DC-DC converter and the control MCU.
- It is also necessary to isolate the MCU for control and the MCU for communication from each other.

Proposals from Toshiba

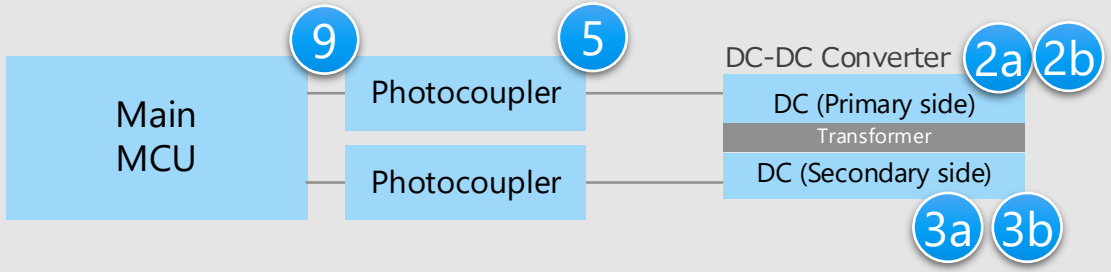
- **Achieves both high isolation and high functionality**
  - Gate driver photocoupler 5
  - Photocoupler for high speed communication 6
  - Isolation amplifier 7
- **Major interface standards are supported**
  - MCU M4N Group 9

UPS　Details of converter/inverter unit

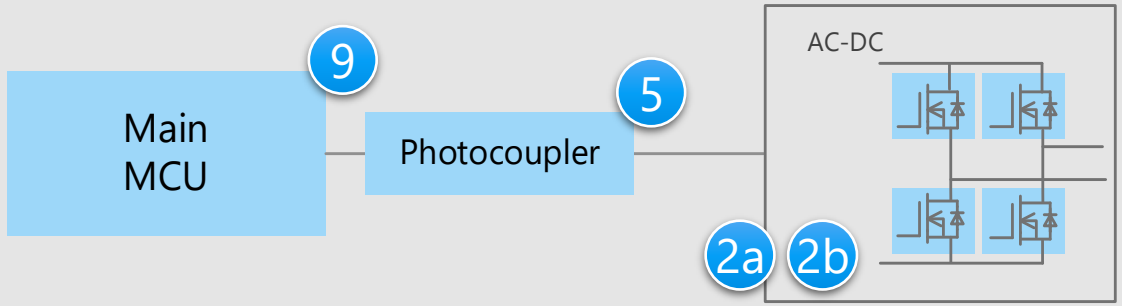
AC-DC converter (with PFC circuit) and control circuit



DC-DC converter and control circuit



DC-AC inverter and control circuit



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

Criteria for device selection

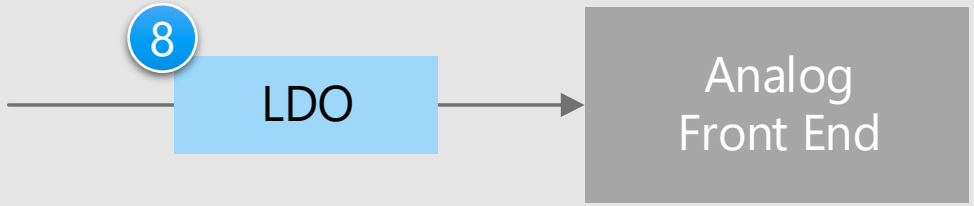
- High voltage MOSFETs with high speed recovery diode are used for DC-DC converters.
- SiC Schottky barrier diodes are suitable for PFC circuits.

Proposals from Toshiba

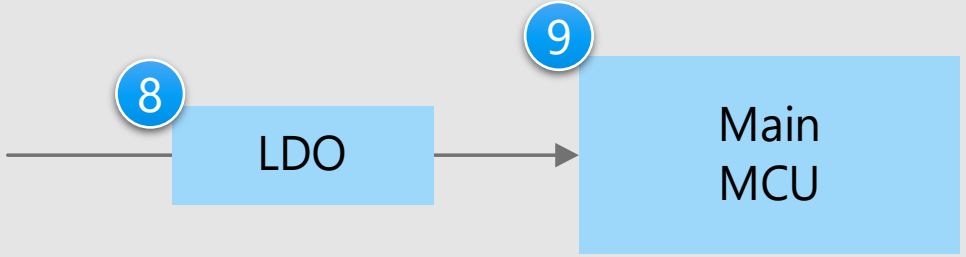
- **Suitable for high efficiency power supply switching** (2a, 2b, 3a, 3b)
  DTMOS Series MOSFET
  SiC MOSFET
  U-MOS Series MOSFET
- **High current surge resistance and low switching loss** (4)
  SiC Schottky barrier diode
- **Achieves both high isolation and high functionality** (5)
  Gate driver photocoupler
- **Built-in three-phase PWM output for inverter control** (9)
  MCU M4N Group

UPS　Details of power supply unit

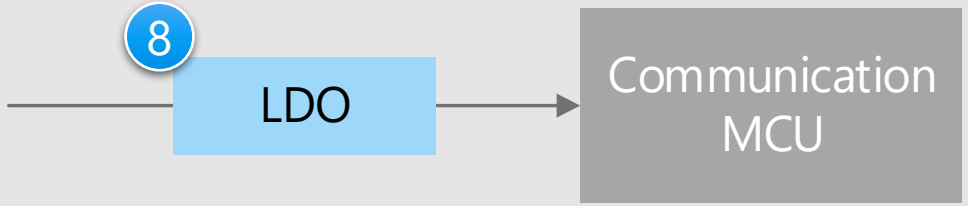
Power supply to analog front end



Power supply to main MCU



Power supply to communication MCU



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

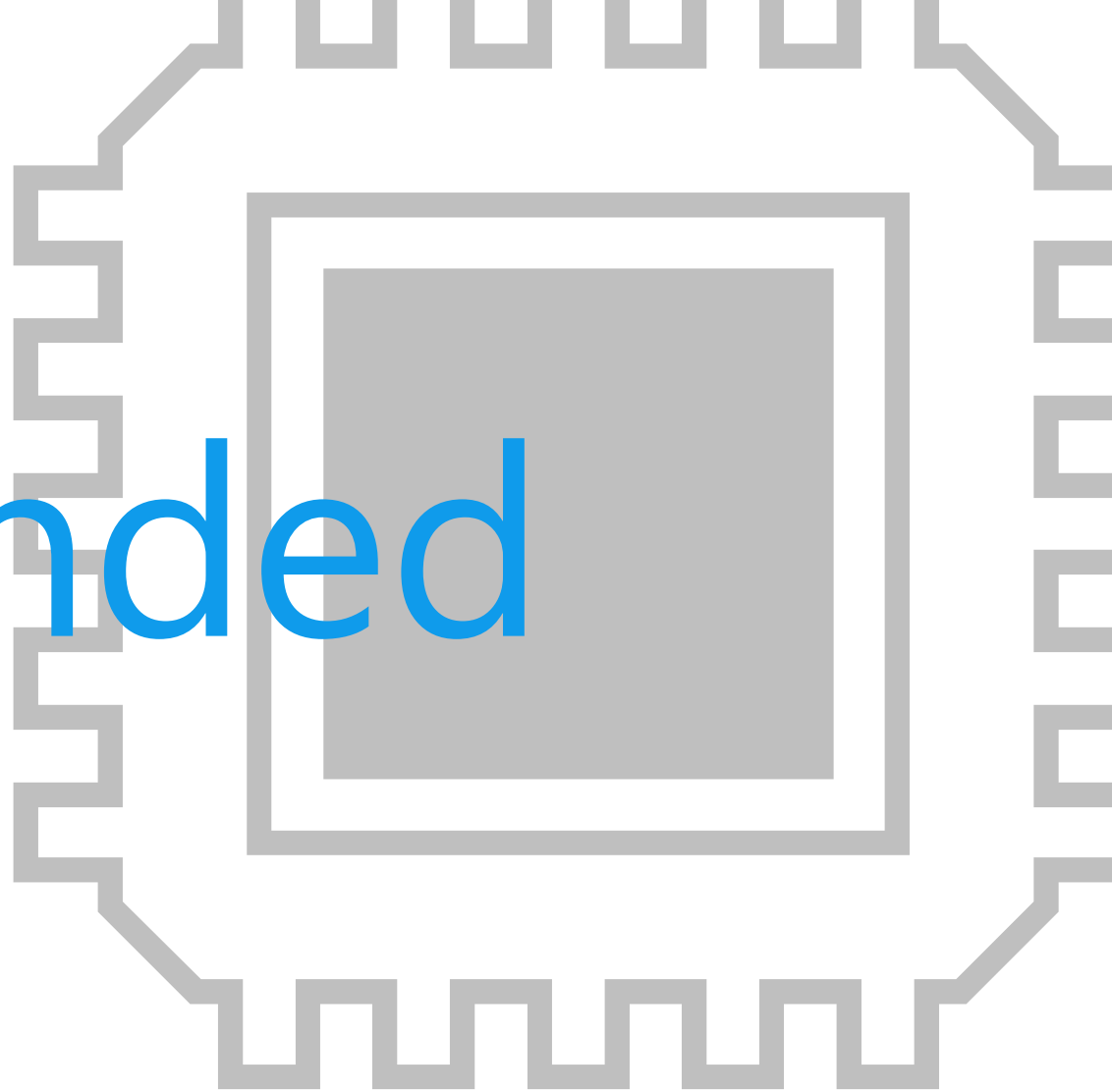
Criteria for device selection

- PSRR (Power Supply Rejection Ratio) in LDO regulator is the key characteristic for radio systems.

Proposals from Toshiba

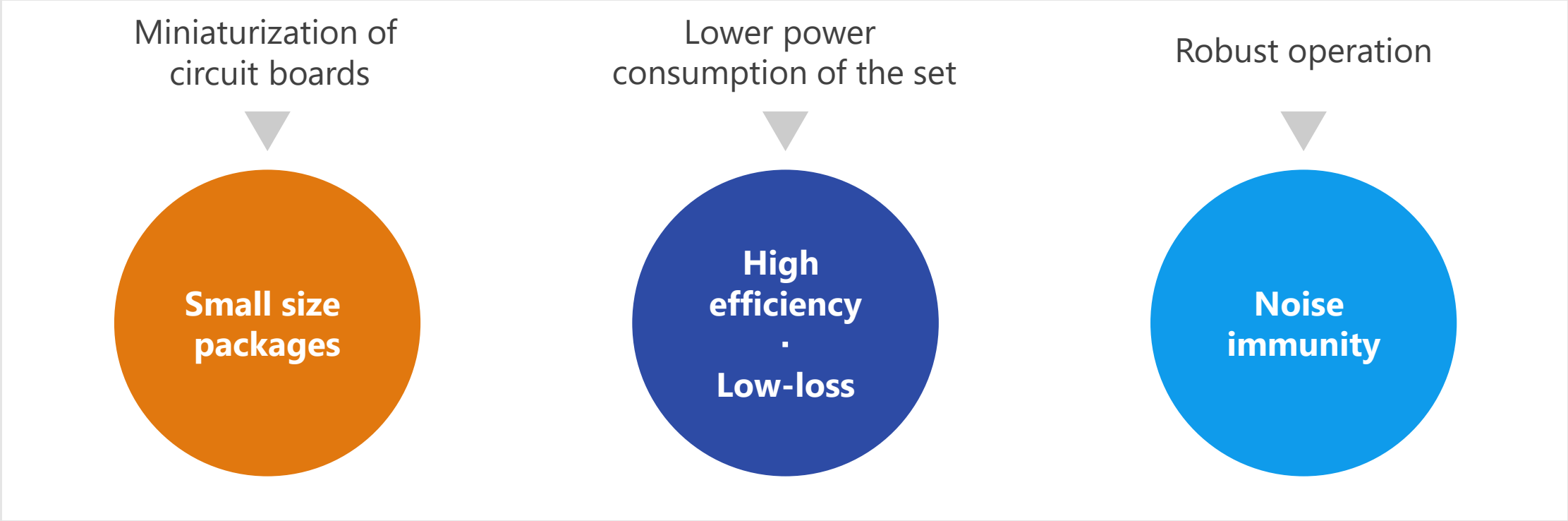
- **Supply the power with low noise**
  Small surface mount LDO regulator 8
- **Built-in three-phase PWM output for inverter control**
  MCU M4N Group 9

Recommended Devices



Device Solutions to Solve Customer Problems

As described above, in the design of a UPS, **"Miniaturization of circuit boards"**, **"Low power consumption of sets"** and **"Robust operation"** are important factors. Toshiba's proposals are based on these three solution perspectives.



Device Solutions to Solve Customer Problems

		Small size packages	High efficiency · Low-loss	Noise immunity
1	TVS diode	●		●
2a	DTMOS Series MOSFET	●	●	●
2b	SiC MOSFET		●	●
3	U-MOS Series MOSFET	●	●	●
4	SiC Schottky barrier diode	●	●	●
5	Gate driver photocoupler	●	●	●
6	Photocoupler for high speed communication	●	●	●
7	Isolation amplifier	●	●	●
8	Small surface mount LDO regulator	●	●	●
9	MCU	●	●	

1 TVS diode

DF2B7ASL / DF2B5M4SL / DF2B6M4SL

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

Value provided

Absorbs static electricity 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.

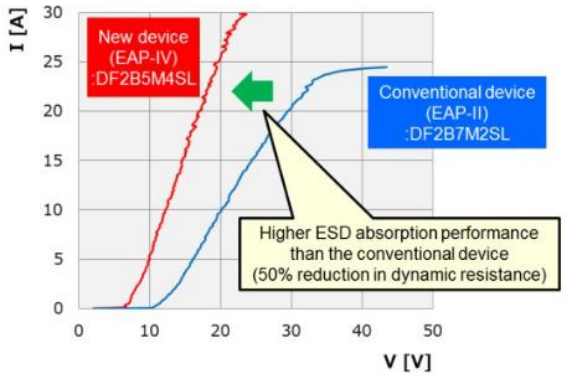
2 Suppress ESD energy by low clamp voltage

Protect the connected circuits and devices using proprietary technology.

3 Suitable for high density mounting

A variety of small packages are available.

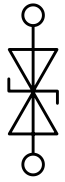
ESD Pulse Absorption Performance
Toshiba internal comparison



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	DF2B7ASL	DF2B5M4SL	DF2B6M4SL
Package	SL2 		
V_{ESD} [kV]	±30	±20	±20
V_{RWM} (Max) [V]	5.5	3.6	5.5
C_t (Typ.) [pF]	8.5	0.2	0.2
R_{DYN} (Typ.) [Ω]	0.2	0.5	0.5
Purpose	Power line protection	Signal line protection	

[Note] This product is an ESD protection diode and cannot be used for purposes other than ESD protection.

◆Return to Block Diagram TOP

DTMOS Series MOSFET

TK25A60X / TK16A60W5 / TK110A65Z / TK190A65Z / TK110U65Z / TK190U65Z

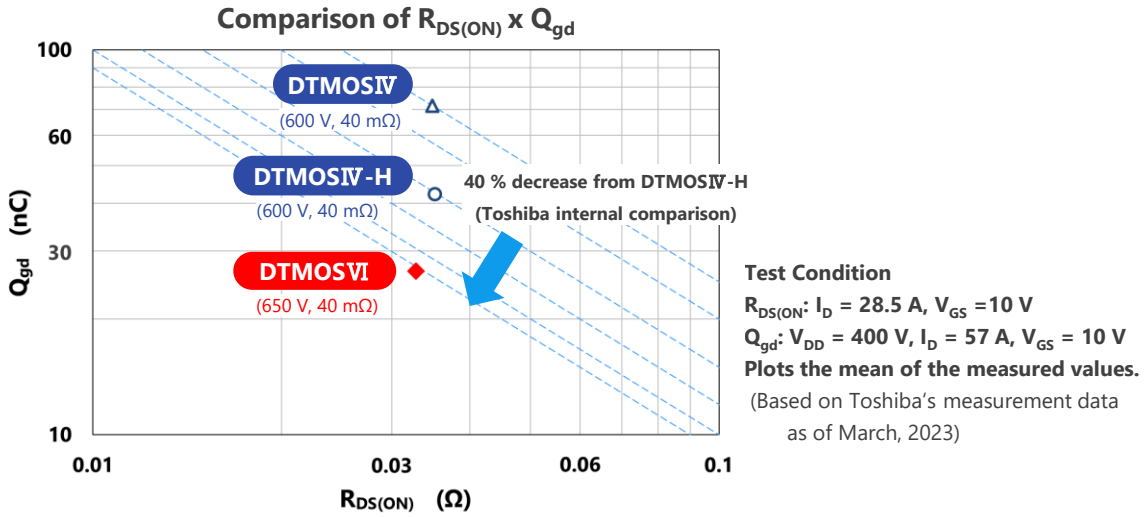
Small size packages | High efficiency · Low-loss | Noise immunity

Value provided

DTMOS series contribute to high efficiency of power supply by improving the performance index $R_{DS(on)}$ x Q_{gd}.

1 $R_{DS(ON)}$ x Q_{gd} improvement

In the DTMOSⅥ series, the performance index $R_{DS(ON)}$ x Q_{gd} is reduced by approximately 40 % compared with Toshiba's conventional DTMOSⅣ-H series product by optimizing the gate structure design and processes. (Based on Toshiba's measurement data as of March, 2023)



Test Condition
$R_{DS(ON)}$: I_D = 28.5 A, V_{GS} =10 V
Q_{gd}: V_{DD} = 400 V, I_D = 57 A, V_{GS} = 10 V
Plots the mean of the measured values.
(Based on Toshiba's measurement data as of March, 2023)

2 Body diode reverse recovery characteristics

High speed body diode reduces recovery loss and contributes to high efficiency of power supply.
(TK16A60W5)

Lineup

Part number		TK25A60X	TK16A60W5	TK110A65Z	TK190A65Z	TK110U65Z	TK190U65Z
Package		TO-220SIS 				TOLL 	
V_{DSS} [V]		600	600	650	650	650	650
I_D [A]		25	15.8	24	15	24	15
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	0.105	0.18	0.092	0.158	0.086	0.149
	Max	0.125	0.23	0.11	0.19	0.11	0.19
Polarity		N-ch	N-ch	N-ch	N-ch	N-ch	N-ch
Generation		DTMOSⅣ-H	DTMOSⅣ(HSD)	DTMOSⅥ	DTMOSⅥ	DTMOSⅥ	DTMOSⅥ

◆Return to Block Diagram TOP

Value provided

The performance index $R_{DS(ON)}$ x Q_{gd}, which shows switching characteristics, is reduced by 80 % compared with Toshiba's existing products. This contributes to lower loss of power supply in application.

1 Low $R_{DS(ON)}$ x Q_{gd}

For the latest products, the performance index $R_{DS(ON)}$ x Q_{gd}, which shows the relation between conduction loss and switching loss, is reduced by 80 % compared with Toshiba's existing products by optimizing its cell structure.

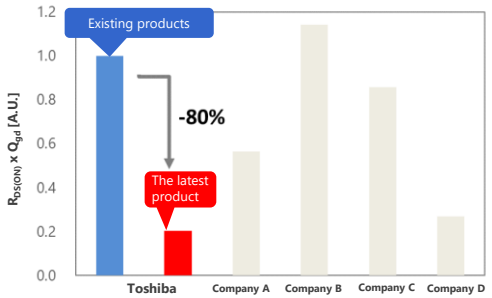
2 Wide V_{GSS} specification

The specification of the gate-source voltage is -10 to 25 V, which is wider than that of other companies' products, allows a wider margin for the drive voltage and makes gate drive design considering overshoot easier. (Recommended drive voltage: 18 V)

3 Built-in Schottky barrier diode

Built-in Schottky barrier diode reduces V_{DSF} during reverse conduction to 1.35 V (typ.). In addition, by energizing the Schottky barrier diode, fluctuation in $R_{DS(ON)}$ caused by the spread of defects is suppressed.

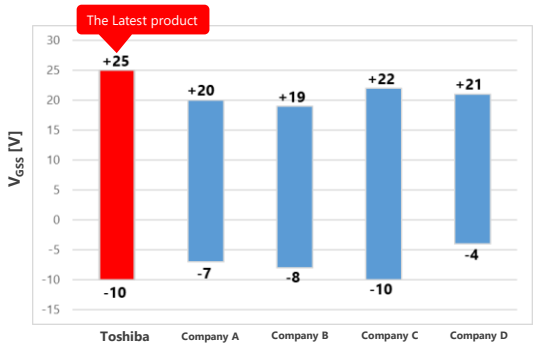
Comparison of $R_{DS(ON)}$ x Q_{gd}



Measurement conditions

$R_{DS(ON)}$: V_{GS} = 18 V, I_D = 20 A, T_a = 25 °C
Q_{gd}: V_{DD} = 800 V, V_{GS} = 18 V, I_D = 20 A, T_a = 25 °C
(Toshiba internal comparison, as of May 2022)

Comparison of V_{GSS} specification



(Toshiba internal comparison based on the datasheet of each company's 1200 V voltage products as of July 2023.)

Lineup

Part number		TW015N65C	TW015N120C	TW015Z65C	TW015Z120C
Package		TO-247 		TO-247-4L(X) 	
V_{DSS} [V]		650	1200	650	1200
I_D [A]		100	100	100	100
$R_{DS(ON)}$ [Ω] @V_{GS} =18 V	Typ.	0.015	0.015	0.015	0.015
	Max	0.021	0.020	0.022	0.021
Polarity		N-ch	N-ch	N-ch	N-ch

◆Return to Block Diagram TOP

U-MOS Series MOSFET

TPN19008QM / TPH2R408QM / TPH4R008QM / TPH9R00CQ5

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

Value provided

Contribution to energy saving and efficiency increasing with wide variety of lineup and easy design.

1 High efficiency

Low on-resistance ($R_{DS(ON)}$) achieved by fine integration process.
Trade off between $R_{DS(ON)}$ and Q_g, Q_{sw}, Q_{oss} have been improved by optimization of cell structure.

2 Wide variety of lineup

Voltage from 20 to 250 V are lined up.
Wide variety of packages from surface mount type to through hole type are provided.

3 Easy to design

Low V_{DS} spike and ringing have been realized by parasitic snubber.
High avalanche capability.

Wide variety of packages

Lineup

Part number		TPN19008QM	TPH2R408QM	TPH4R008QM	TPH9R00CQ5
Package		TSON Advance	SOP Advance / SOP Advance(N)	SOP Advance(N)	SOP Advance / SOP Advance(N)
V_{DSS} [V]		80	80	80	150
I_D [A]		34 (38*)	120 (200*)	86 (140*)	64 (108*)
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	0.0147	0.0019	0.0031	0.0073
	Max	0.019	0.00243	0.004	0.0090
Polarity		N-ch	N-ch	N-ch	N-ch
Generation		U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅨ-H

*: Silicon limit

◆Return to Block Diagram TOP

U-MOS Series MOSFET

TK2R4A08QM / TK2R4E08QM / TK100E10N1

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

Value provided

Contribution to energy saving and efficiency increasing with wide variety of lineup and easy design.

1 High efficiency

Low on-resistance ($R_{DS(ON)}$) achieved by fine integration process.
Trade off between $R_{DS(ON)}$ and Q_g, Q_{sw}, Q_{oss} have been improved by optimization of cell structure.

2 Wide variety of lineup

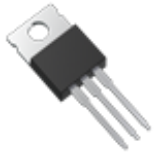
Voltage from 20 to 250 V are lined up.
Wide variety of packages from surface mount type to through hole type are provided.

3 Easy to design

Low V_{DS} spike and ringing have been realized by parasitic snubber.
High avalanche capability.

TO-220SIS

TO-220



Wide variety of packages

Lineup

Part number		TK2R4A08QM	TK2R4E08QM	TK100E10N1
Package		TO-220SIS 	TO-220 	
V_{DSS} [V]		80	80	100
I_D [A]		100 (116*)	120 (290*)	100 (207*)
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	0.00188	0.00197	0.0028
	Max	0.00244	0.00244	0.0034
Polarity		N-ch	N-ch	N-ch
Generation		U-MOSⅨ-H	U-MOSⅨ-H	U-MOSⅧ-H

*: Silicon limit

◆Return to Block Diagram TOP

4 SiC Schottky barrier diode

TRS12A65F / TRS24N65FB / TRS2E65H / TRS12E65H / TRS4V65H / TRS12V65H

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

Value provided

SiC SBDs [Note1] with low loss and high efficiency are realized by adopting new metal and optimizing device design.

[Note1] SBD: Schottky barrier diode

1 Low forward voltage (V_F)

For the latest products, new metal and thin wafer technology are introduced. V_F = 1.2 V (Typ.) is realized as compared with V_F = 1.45 V (Typ.) of our existing products. V_F is reduced by about 17 %.

2 Improvement of power supply efficiency

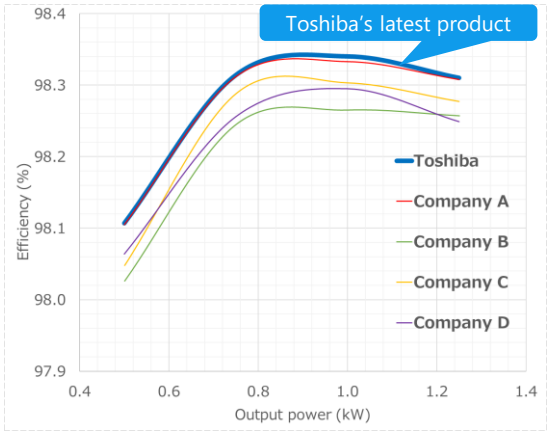
Compared with our existing products, the trade off of V_F x Q_C [Note2] of the latest products have improved. About 0.1 % of conversion efficiency improvement have also achieved under 800 W output condition in our test.

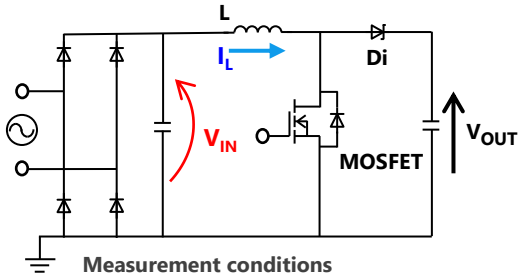
3 Expansion of package series

In addition to the existing package series, DFN8x8 surface mount package type has prepared. It contributes to miniaturization and high power density of equipment.

[Note2] The V_F x Q_c (product of forward voltage and total charge) is an index representing the loss performance of the SiC SBD. When comparing the products with the same current rating, the smaller the index, the lower the loss.

Comparison between Toshiba's latest product and competitor products





Measurement conditions

V_{IN} = 200 V AC
V_{OUT} = 400 V DC
f = 65 kHz
MOSFET: TK040Z65Z
MOSFET external gate resistance = 4.7 Ω
T_a = 25 °C (Toshiba internal comparison, as of November 2021)

Lineup

Part number	TRS12A65F	TRS24N65FB	TRS2E65H	TRS12E65H	TRS4V65H	TRS12V65H
Package	 TO-220F-2L	 TO-247 (Center tap)	 TO-220-2L		 DFN8x8	
V_{RRM} [V]	650	650	650	650	650	650
$I_{F(DC)}$ [A]	12	12 / 24 *	2	12	4	12
I_{FSM} [A]	92	92 / 184 *	19	74	28	60
V_F (Typ.) [V]	1.45 @I_F = 12 A	1.45 @I_F = 12 A	1.2 @I_F = 2 A	1.2 @I_F = 12 A	1.2 @I_F = 4 A	1.2 @I_F = 12 A

*: Per Leg / Both Legs

◆Return to Block Diagram TOP

5 Gate driver photocoupler

TLP5214A / TLP5212 / TLP5222 / TLP5231 / TLP5754H / TLP5705H

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

Value provided

High isolation by opto-coupling solution and characteristics suitable for gate driving help to simplify circuit design.

1 High noise immunity

Light receiving IC has internal Faraday shield that provides high CMTI (Common Mode Transient Immunity).

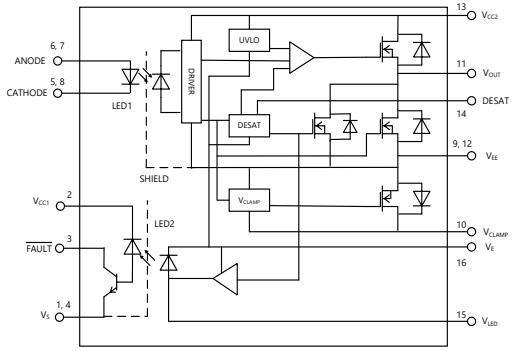
2 High temperature operation

The products are designed to operate even under severe ambient temperature conditions such as UPS.

3 Wide product lineup

Wide product lineup about output current suitable for both gate drive and pre gate drive enables to choose product suitable for each driving. Products with overcurrent protection function are also available.

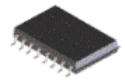
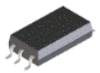
Internal circuit configuration (TLP5212)



UL-recognized UL1577, File No.E67349
cUL-recognized CSA Component Acceptance Service No.5A File No.E67349
VDE-recognized EN60747-5-5, EN62368-1 (TLP5212 approved only for EN60747-5-5) [Note]
CQC-recognized GB4943.1, GB8898

[Note] When a VDE approved type is needed, please designate the Option (D4).

Lineup

Part number	TLP5214A	TLP5212	TLP5222	TLP5231	TLP5754H	TLP5705H
Package	SO16L 				SO6L 	
CMTI (Min) [kV/μs]	±35	±25			±35	±50
T_{opr} [°C]	-40 to 110				-40 to 125	
Peak output current [A]	±4.0	±2.5			±4.0	±5.0
Overcurrent protection	✓				-	

◆Return to Block Diagram TOP

6 Photocoupler for high speed communication

TLP2710 / TLP2761 / TLP2770 / TLP2210 / TLP2261 / TLP2270

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

Value provided

High isolation performance using the optical coupling enables stable and high speed isolated communication.

1 High noise immunity

Light receiving IC has internal Faraday shield that provides high CMTI (Common Mode Transient Immunity).

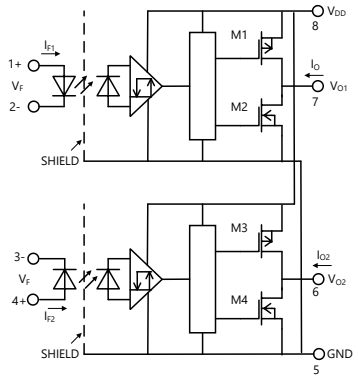
2 High temperature operation

The products are designed to operate even under severe ambient temperature conditions, such as UPS, inverters, robots and machinery, etc. (-40 to 125 °C)

3 High speed communication

Suitable product can be selected from the wide range of data transfer rate from 1 to 50 Mbps.

Internal circuit configuration (TLP2210)



1: Anode 1
2: Cathode 1
3: Cathode 2
4: Anode 2
5: GND
6: V_O 2 (output 2)
7: V_O 1 (output 1)
8: V_{DD}

UL-approved: UL1577, File No.E67349
cUL-approved: CSA Component Acceptance Service No.5A File No.E67349
VDE-approved: EN60747-5-5, EN 62368-1 [Note]
CQC-approved: GB4943.1, GB8898

[Note] When a VDE approved type is needed, please designate the Option (D4).

Lineup

Part number	TLP2710	TLP2761	TLP2770	TLP2210	TLP2261	TLP2270
Package	SO6L 			SO8L 		
Number of channel	1			2		
CMTI (Min) [kV/μs]	±25	±20		±25	±20	
Data transfer rate [Mbps]	5	15	20	5	15	20

◆Return to Block Diagram TOP

7 Isolation amplifier

TLP7820 / TLP7830

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

Value provided

High isolation performance by the optical coupling is realized. High precision current and voltage detection are also realized.

1 High accuracy and linearity

A high precision ΔΣ AD converter on the input side enables high accuracy and linearity analog signal detection.

2 High noise immunity

Light receiving IC has internal Faraday shield that provides high CMTI (Common Mode Transient Immunity) of 15 kV/μs (Min).

3 Selectable output type

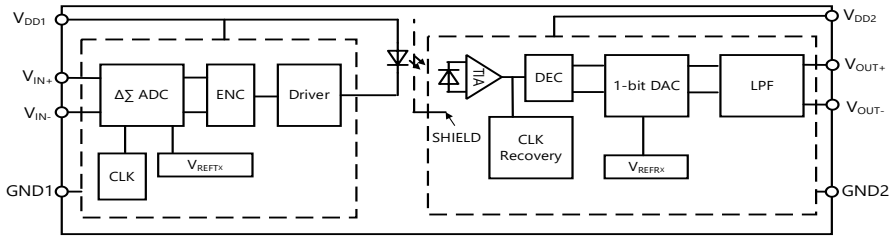
Analog output type (TLP7820):

analog signal multiplied by gain is output.

Digital output type (TLP7830):

1bit stream data correspond to input analog signal is output.

Internal circuit configuration (TLP7820)

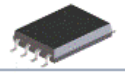


[Note 1] Bypass capacitor of 0.1 μF must be connected between 1 and 4 pins and between 5 and 8 pins.

UL-approved: UL1577, File No.E67349
cUL-approved: CSA Component Acceptance Service No.5A File No.E67349
VDE-approved: EN60747-5-5, EN 62368-1 [Note 2]
CQC-approved: GB4943.1, GB8898

[Note 2] When a VDE approved type is needed, please designate the Option (D4).

Lineup

Part number	TLP7820	TLP7830
Package	SO8L 	
BV_S [Vrms]	5000	
Operating temperature [°C]	-40 to 105	
Gain [%]	±0.5 / ±1.0 / ±3.0 (Selectable)	±1.0
Non-linearity (Typ.)	0.02 %	4 LSB

◆Return to Block Diagram TOP

8 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.

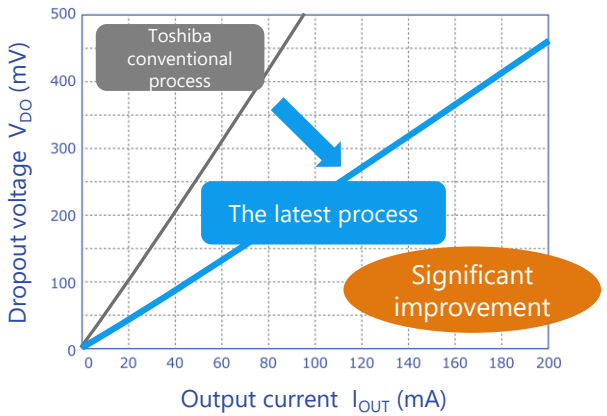
2 High PSRR Low output noise voltage

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

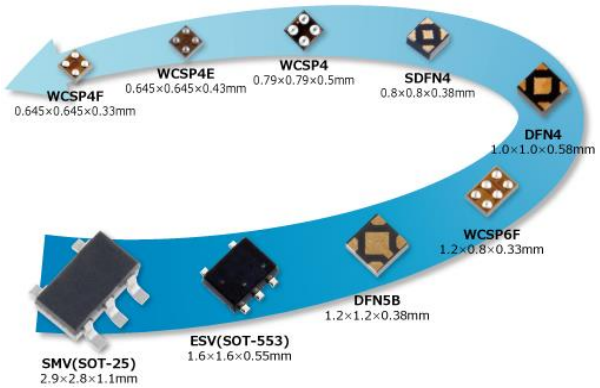
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

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		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

◆Return to Block Diagram TOP

Value provided

Monitoring sensor at low power consumption by using built-in AD converters, timers and various communication interfaces.

1 Built-in Arm® Cortex®-M4 CPU core

The product lineup is equipped with Arm Cortex-M4 core (maximum operation frequency of 200 MHz). It is suitable for processing sensor data at real time. Various development tool and their partners allow users many options.

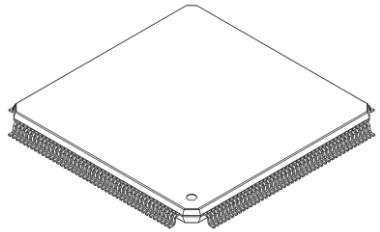
2 System cost down and development efficiency improvement

These products execute sensing data monitoring and processing efficiently by combining built-in multi-channel AD converters and timers. In addition, M4N group has a lineup of 20 products to provide suitable products for the set.

3 Various communication interfaces

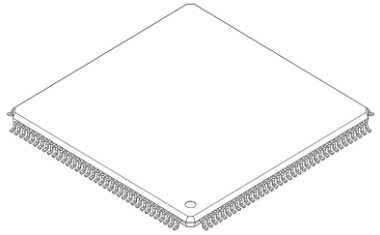
These products support major communication interfaces such as UART, FUART, TSPI, TSSI, I^2C, CAN, USB and ethernet controller (ETHM). User can construct a communication system easily with a cloud.

TMPM4NRF**FG



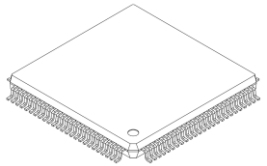
P-LQFP176-2020-0.40-002

TMPM4NQF**FG



P-LQFP144-2020-0.50-002

TMPM4NNF**FG



P-LQFP100-1414-0.50-002

Lineup

Part number	TMPM4NRF20/15/10/DFG TMPM4NRF20/15/10/DXBG	TMPM4NQF20/15/10/DFG TMPM4NQF20/15/10/DXBG	TMPM4NNF20/15/10/DFG
Operation frequency	200 MHz (Max)		
Flash ROM	Code: 2048/1536/1024/512 KB + Data: 32 KB		
RAM	256 KB + 2 KB (Backup RAM)		
Timer	32bit x 16ch (16bit x 32ch)		
AD converter	24ch (12bit)		16ch (12bit)
Communication interface	UART: 6ch, FUART: 2ch, I^2C: 5ch, TSPI: 9ch, TSSI: 2ch	UART: 5ch, FUART: 2ch, I^2C: 5ch, TSPI: 8ch, TSSI: 1ch	UART: 3ch, FUART: 1ch, I^2C: 3ch, TSPI: 5ch, TSSI: 1ch
	CAN: 2 units, USB: 2 units, ETHM: 1 unit		CAN: 2 units, USB: 1 unit, ETHM: 1 unit
Package	P-LQFP176-2020-0.40-002 P-VFBGA177-1313-0.80-001	P-LQFP144-2020-0.50-002 P-VFBGA145-1212-0.80-001	P-LQFP100-1414-0.50-002

◆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.**