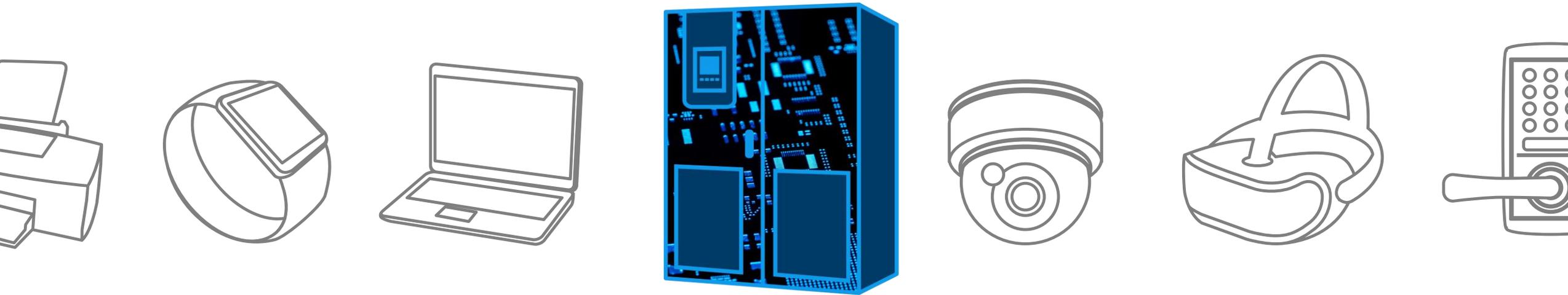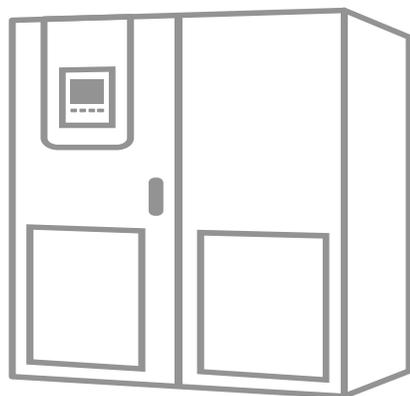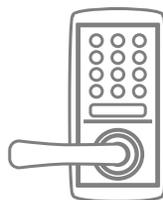**TOSHIBA**

R23

Uninterruptible Power Supply
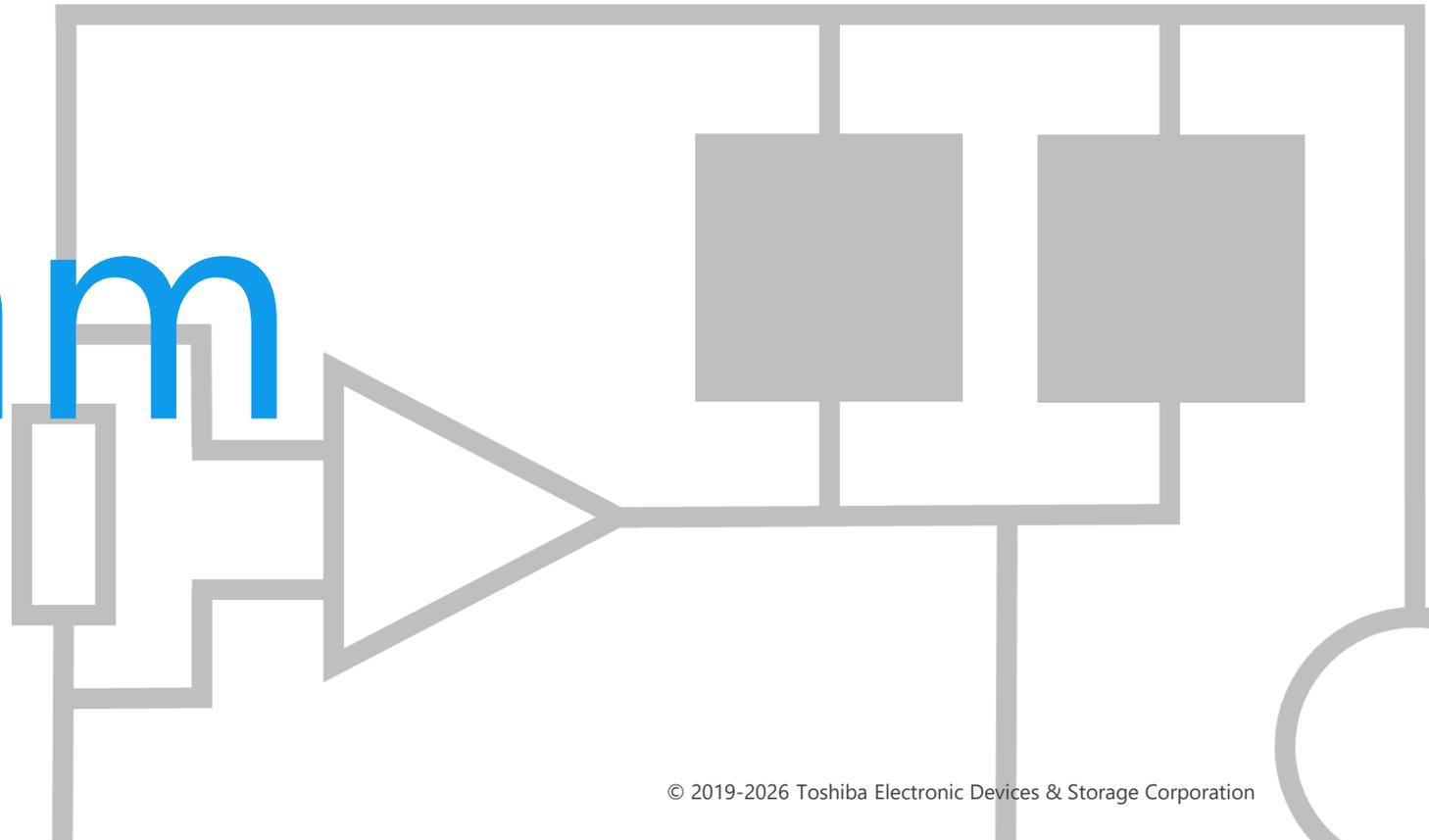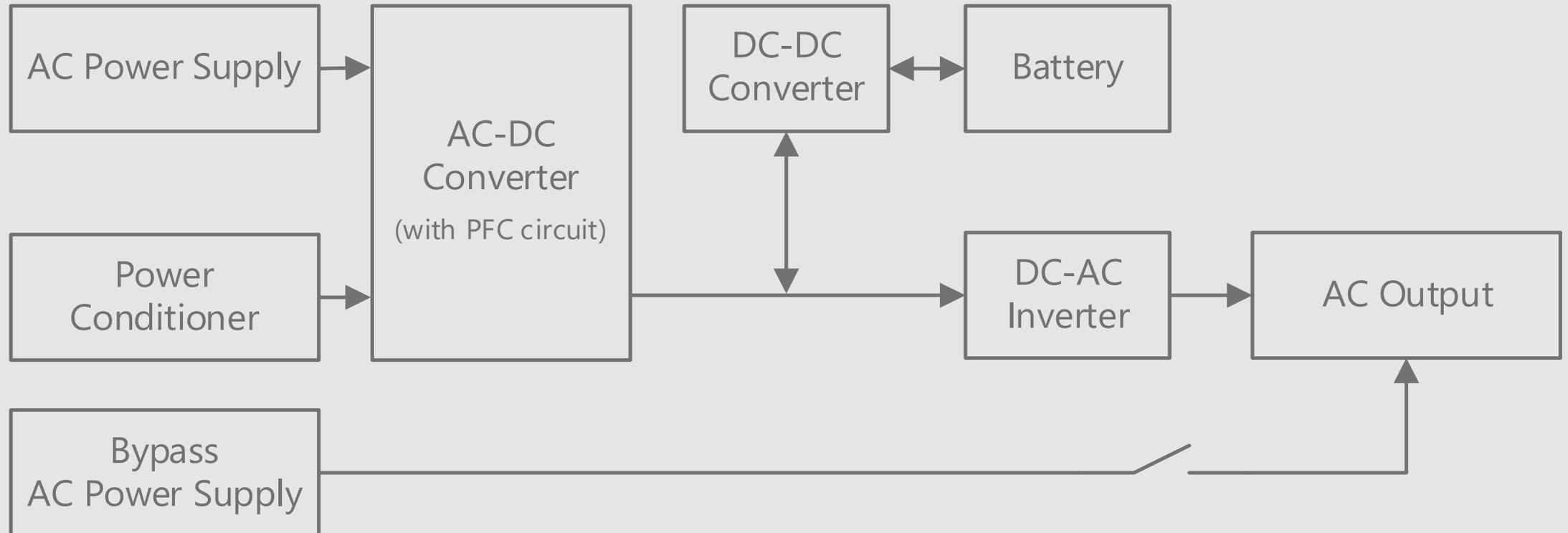
Solution Proposal by Toshiba

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

AC Input

PFC Controller

MOSFET

Main MCU

DC Output 300 to 400 V

USB interface

Communication MCU — ① TVS — USB Port

RS-232 interface

Communication MCU — RS-232 — ① TVS — RS-232 Port

Display unit

Communication MCU — ① TVS — Display
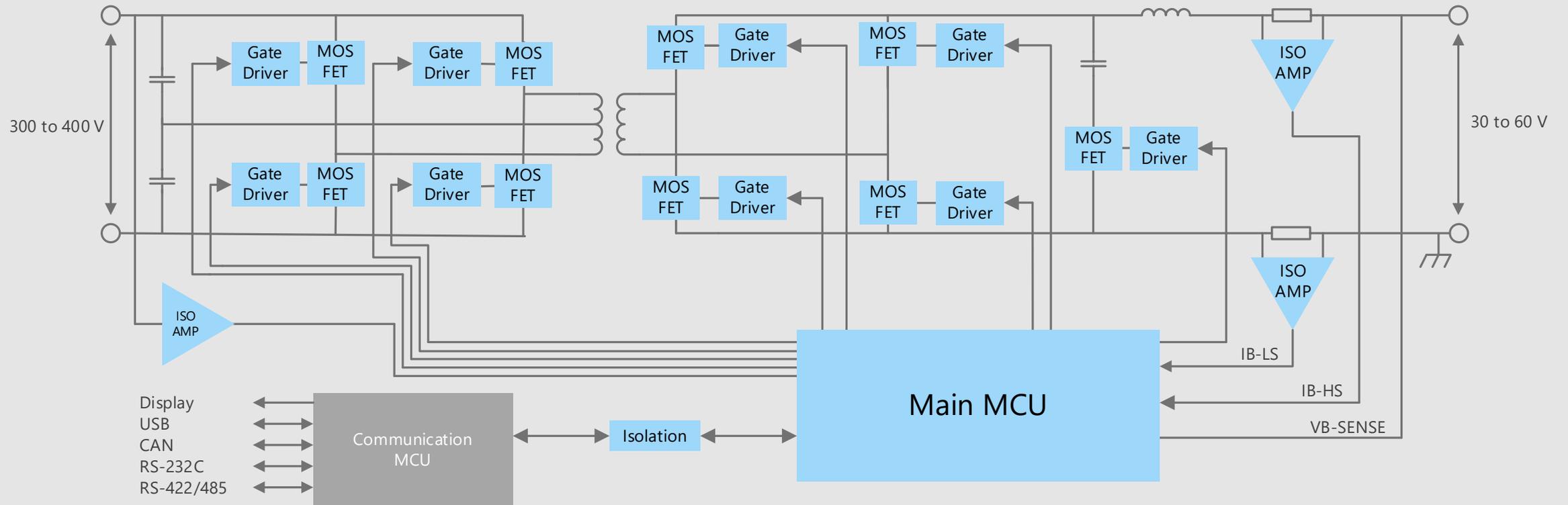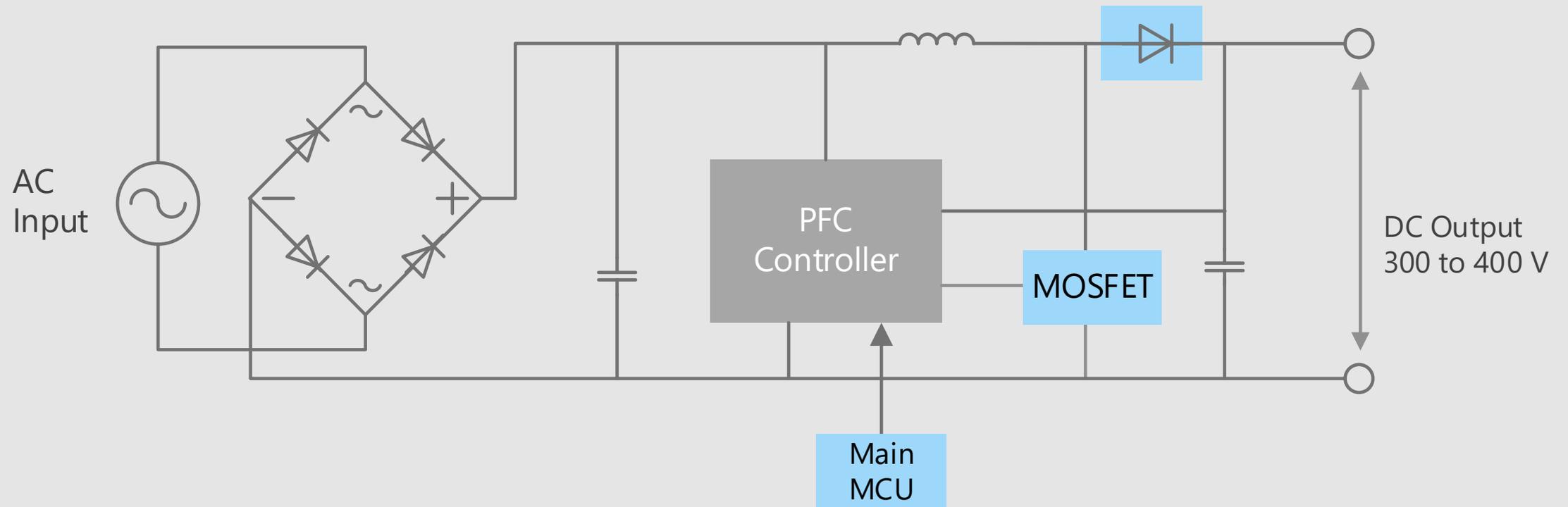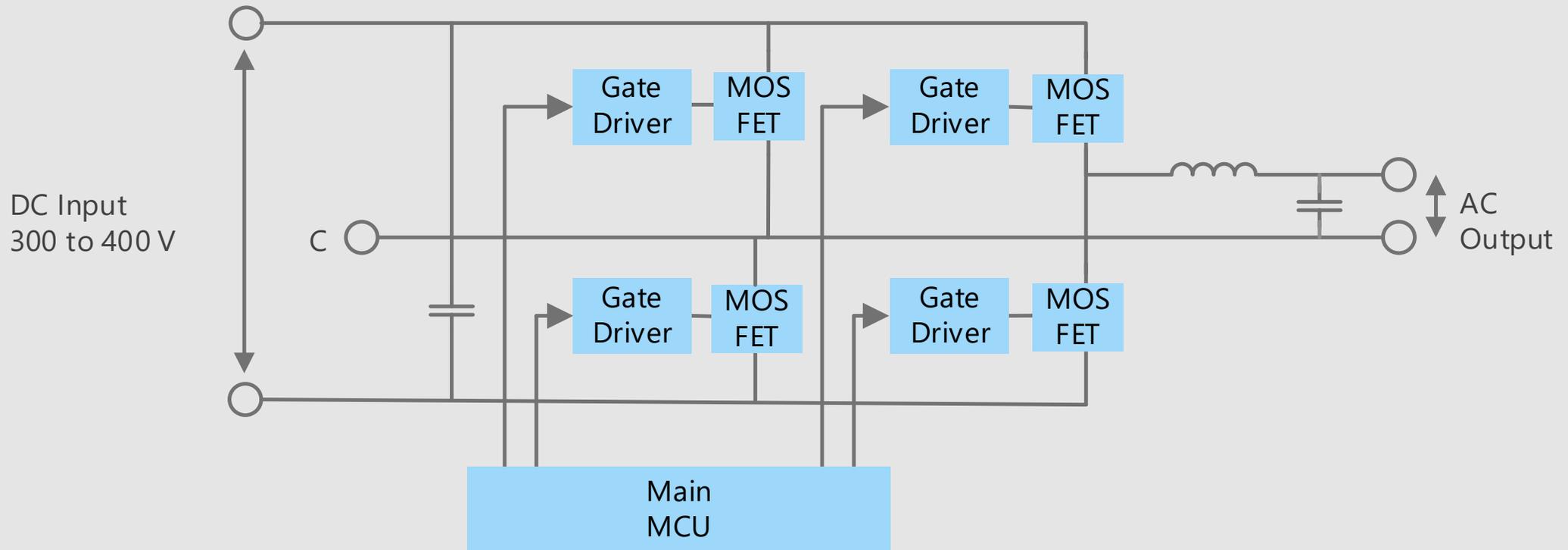
Criteria for device selection

- 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.

Proposal from Toshiba

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

①

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

Control signal transmission line between MCU and converter

(9) Main MCU → (5) Photocoupler → DC-DC or AC-DC

Communication signal transmission line between MCUs

(9) Main MCU → (6) Photocoupler → Communication MCU

Voltage and current detection signal transmission line

Power Line → (7) Photocoupler → (9) Main MCU

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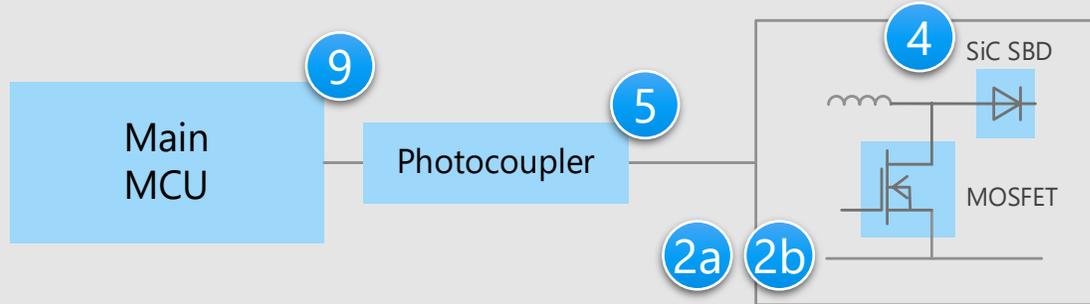- It is also necessary to isolate the MCU for control and the MCU for communication from each other.

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)

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

Main MCU — Photocoupler — (SiC SBD, MOSFET)
Labels: 9, 5, 4, 2a, 2b

DC-DC converter and control circuit
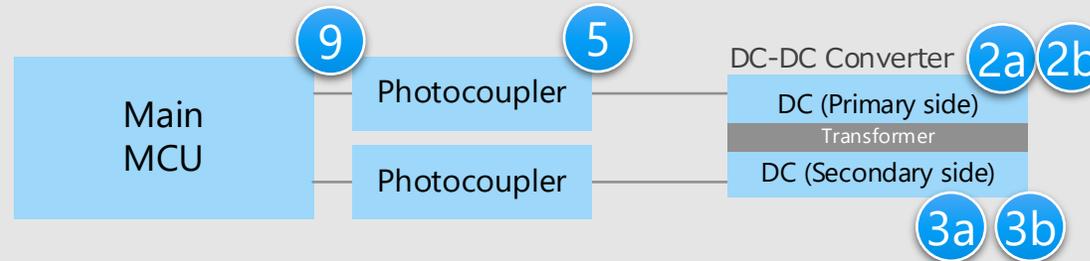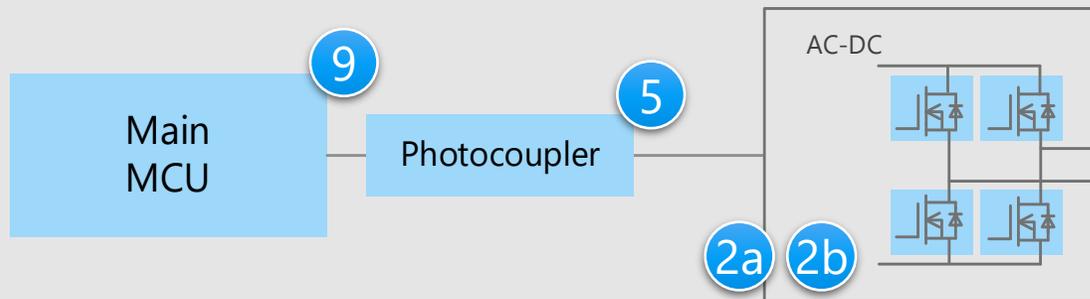
Main MCU — Photocoupler — DC-DC Converter: DC (Primary side), Transformer, DC (Secondary side)
Labels: 9, 5, 2a, 2b, 3a, 3b

DC-AC inverter and control circuit

Main MCU — Photocoupler — AC-DC
Labels: 9, 5, 2a, 2b

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

**Power supply
to analog front end**

(8) LDO → Analog Front End
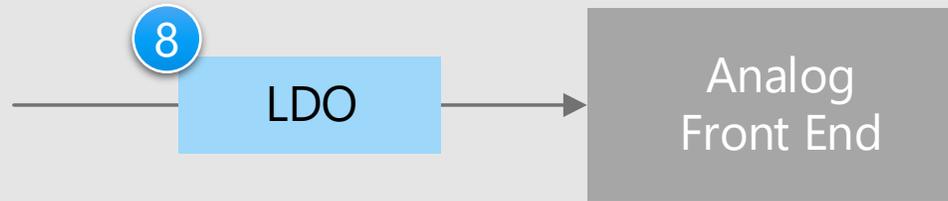
**Power supply
to main MCU**

(8) LDO → (9) Main MCU
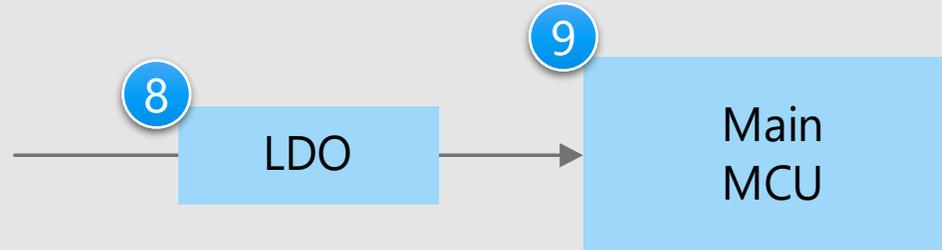
**Power supply
to communication MCU**
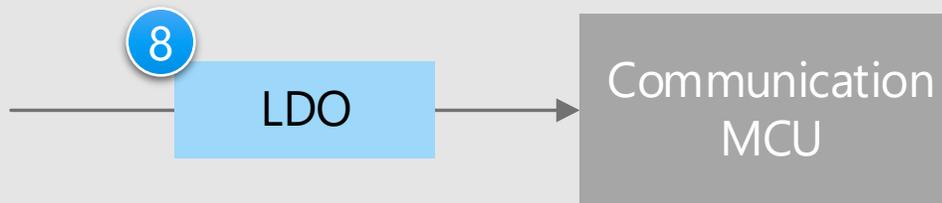
(8) LDO → Communication MCU

* 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
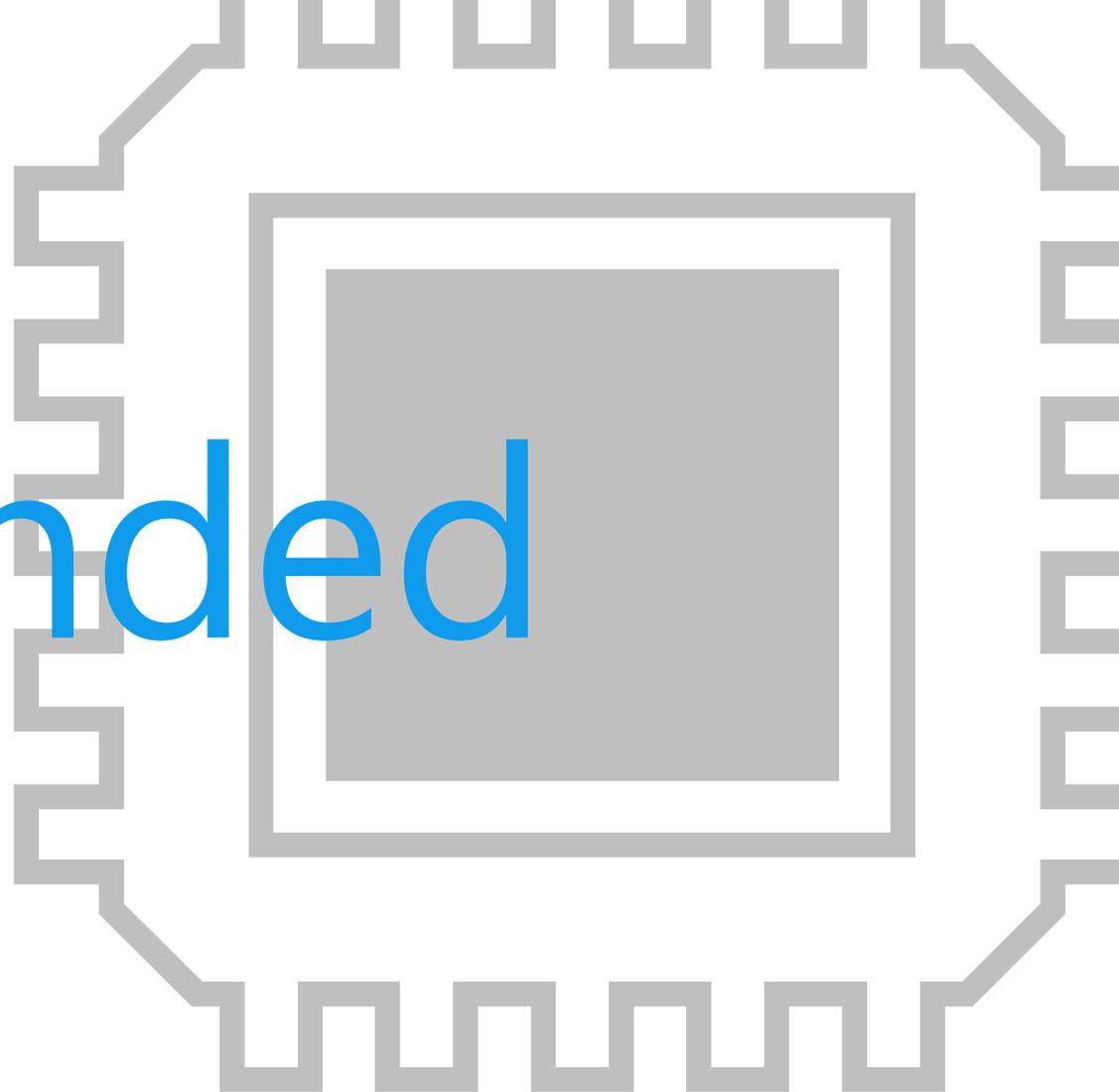
Device Solutions to Solve Customer Problems

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

Miniaturization of circuit boards

▼

Small size packages

Lower power consumption of the set

▼

High efficiency · Low-loss

Robust operation

▼
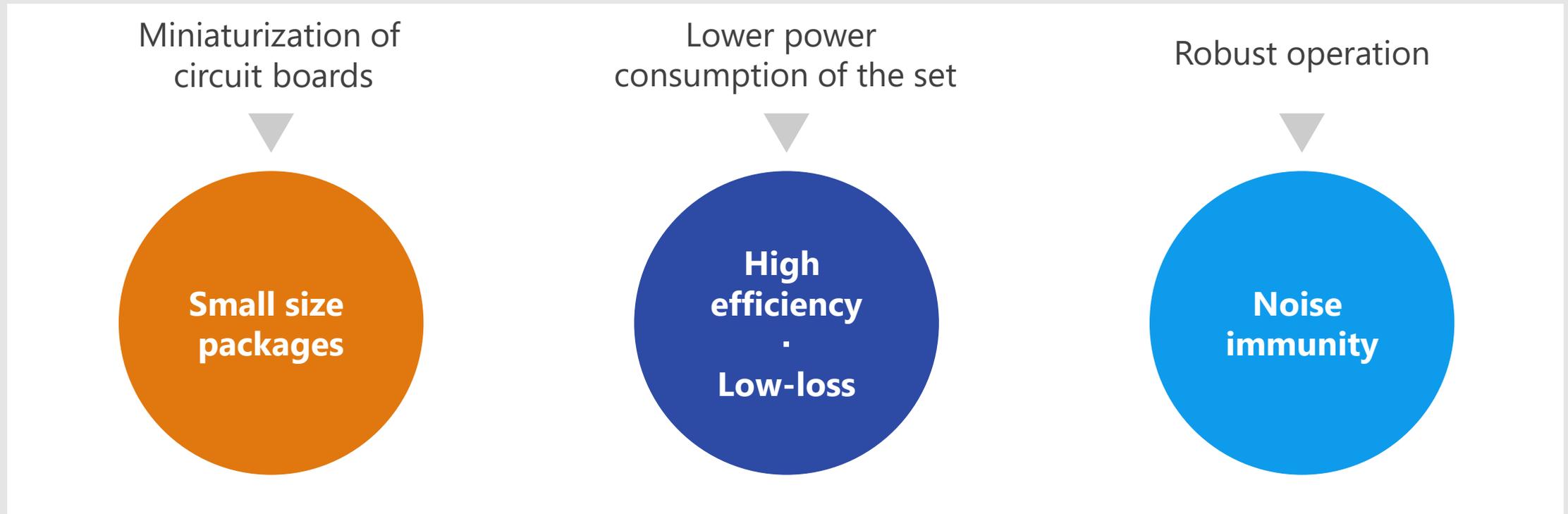
Noise immunity

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	●	●	

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 Toshiba's existing 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)

Toshiba's fourth generation process product : DF2B5M4SL

Toshiba's second generation process product : DF2B7M2SL

Higher ESD absorption performance than Toshiba's second generation process product (50% reduction in dynamic resistance)
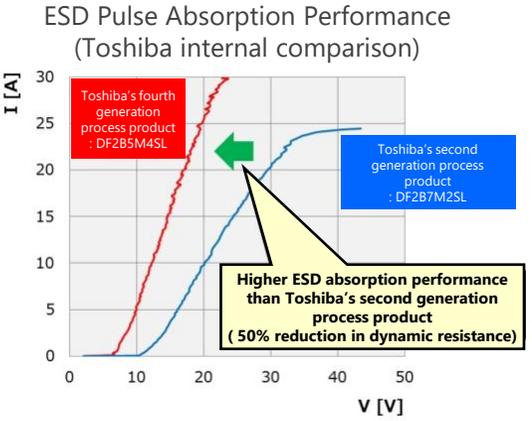
Unidirectional

Suitable for paths such as logic signals. There are 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	Top view	Bottom view
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	

◆Return to Block Diagram TOP

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

Value provided

Improved performance index $R_{DS(on)}$ x Q_{gd}, which shows switching characteristic, contribute to improve power supply efficiency and miniaturization of the set.

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

The $R_{DS(ON)}$ x Q_{gd} of figure of merit has been reduced by 40 % with gate design and process optimization.
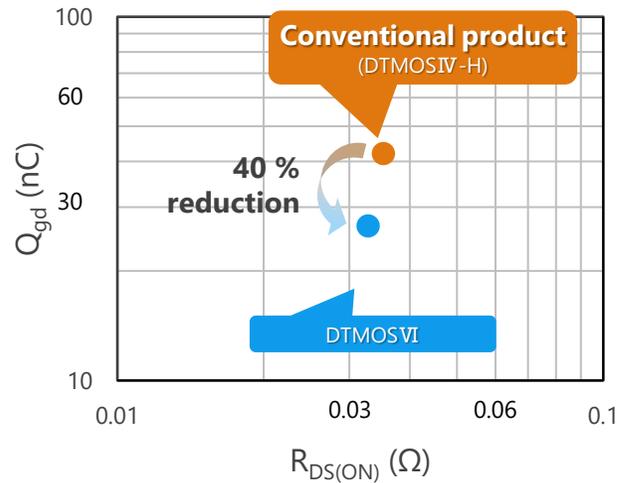 (Comparison of DTMOSIV-H Products: Toshiba internal comparison)

2 Body diode reverse recovery characteristics

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

Conventional product (DTMOSIV-H)
40 % reduction
DTMOSVI

Q_{gd} (nC) vs $R_{DS(ON)}$ (Ω)

(Note) Toshiba internal comparison

DTMOSVI
0.36 % improvement @2.5 kW
Conventional product (DTMOSIV-H)

Conversion efficiency (%) vs Output power (W)
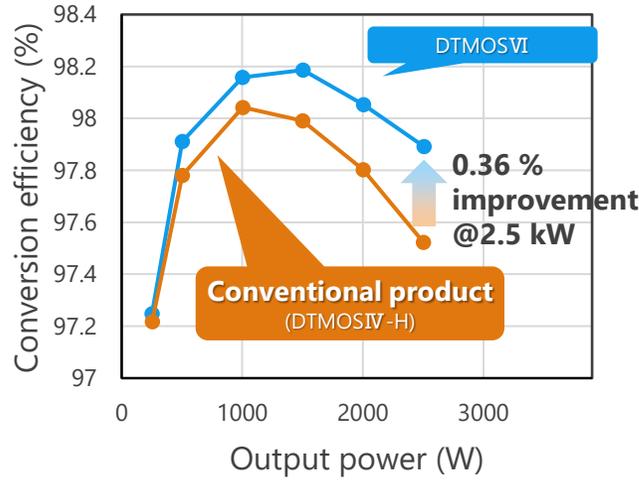
(Note) Toshiba internal comparison

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. This contributes to lower loss of power supply in equipment.

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

For Toshiba's third generation products, the performance index $R_{DS(ON)}$ x Q_{gd} , which shows the relation between conduction loss and switching loss, is reduced 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 [Note] , 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}

Third generation product
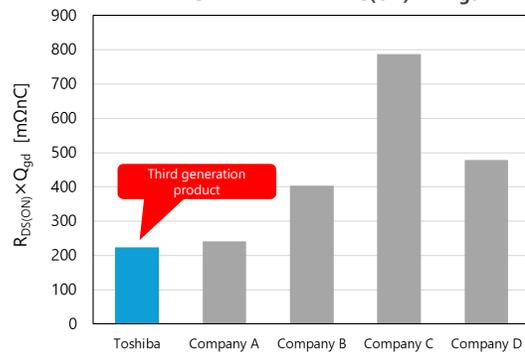
Measurement conditions
$R_{DS(ON)}$: V_{GS} = 18 V, I_D = 20 A, T_a = 25 °C
Q_{gd}: V_{DD} = 400 V, V_{GS} = 18 V, I_D = 20 A, T_a = 25 °C

V_{GSS} ratings and Recommended V_{GS}

Third generation product
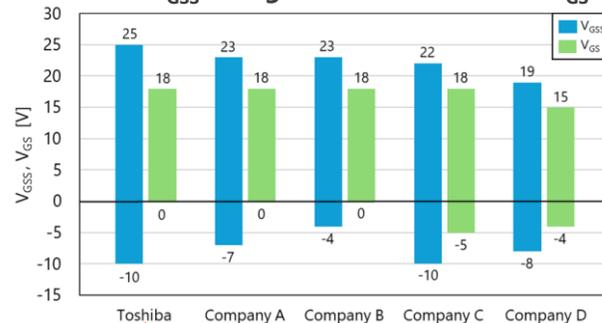
Lineup

Part number		TW015N65C	TW015N120C	TW015Z65C	TW015Z120C
Package		TO-247 (Top view / Bottom view)		TO-247-4L(X) (Top view / Bottom view)	
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

[Note] Based on Toshiba's measurement data, as of October 2025.

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.

TSON Advance

Top view   Bottom view

3.1 x 3.3 mm

SOP Advance(N)

Top view   Bottom view

4.9 x 6.1 mm

SOP Advance(E)

Top view   Bottom view

4.9 x 6.1 mm

Wide variety of packages

Lineup

Part number		TPN19008QM	TPH4R008QM	TPM1R908QM	TPM7R10CQ5
Package		TSON Advance	SOP Advance(N)	SOP Advance(E)	
V_{DSS} [V]		80	80	80	150
I_D [A]		34 (38*)	86 (140*)	238	120
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	0.0147	0.0031	0.0015	0.0057
	Max	0.019	0.004	0.0019	0.0071
Polarity		N-ch	N-ch	N-ch	N-ch
Generation		U-MOS Ⅹ-H	U-MOS Ⅹ-H	U-MOS Ⅹ-H	U-MOS Ⅹ-H

*: Silicon limit

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.
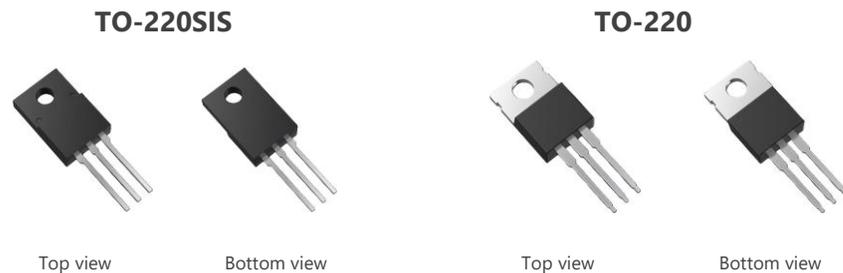
1 High efficiency

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

Top view   Bottom view

TO-220

Top view   Bottom view

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-MOSX-H	U-MOSX-H	U-MOSVIII-H

*: Silicon limit

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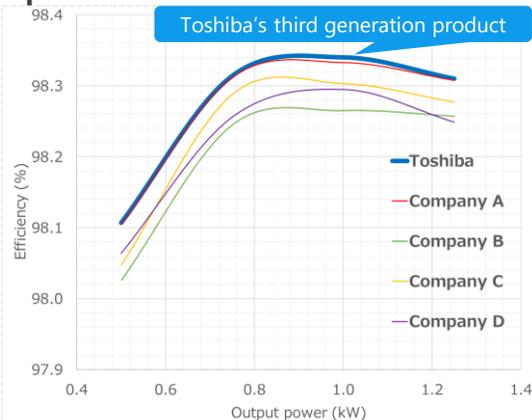
Value provided

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 Toshiba's third generation 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 %.
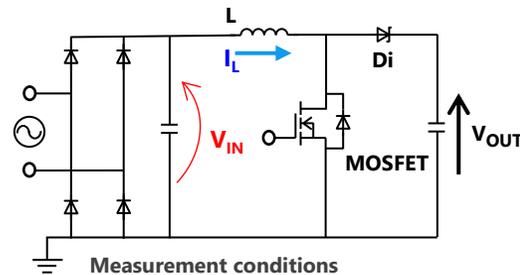
2 Improvement of power supply efficiency

Compared with our existing products, the trade off of V$_F$ x Q$_C$ [Note2] of Toshiba's third generation products have improved. About 0.1 % of conversion efficiency improvement have also achieved under 800 W output condition in our test.

[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.

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.

Comparison between Toshiba's third generation product and competitor products

Toshiba's third generation product

Efficiency (%) vs Output power (kW)
- Toshiba
- Company A
- Company B
- Company C
- Company D

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 July 2023)

Lineup

Part number	TRS24N65FB	TRS2E65H	TRS8E65H	TRS12E65H	TRS4V65H	TRS12V65H
Package	TO-247 (Center tap)	TO-220-2L	Top view / Bottom view		DFN8x8 Top view / Bottom view	
V$_{RRM}$ [V]	650	650	650	650	650	650
I$_{F(DC)}$ [A]	12 / 24 *	2	8	12	4	12
I$_{FSM}$ [A]	92 / 184 *	19	56	74	28	60
V$_F$ (Typ.) [V]	1.45 @I$_F$ = 12 A	1.2 @I$_F$ = 2 A	1.2 @I$_F$ = 8 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

Value provided

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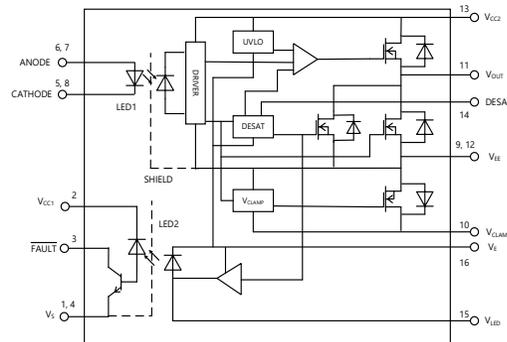
UL-recognized UL1577, File No.E67349
cUL-recognized CSA Component Acceptance Service No.5A File No.E67349
VDE-recognized EN60747-5-5, EN62368-1 (TLP5212 approved only for EN60747-5-5) [Note]
CQC-recognized GB4943.1, GB8898

[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

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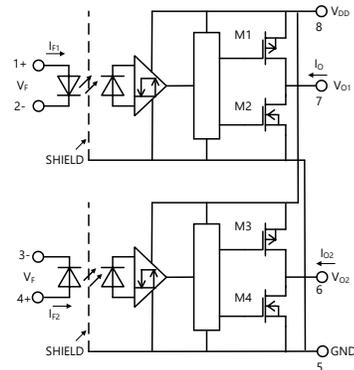
1: Anode 1
2: Cathode 1
3: Cathode 2
4: Anode 2
5: GND
6: $V_O 2$ (output 2)
7: $V_O 1$ (output 1)
8: V_{DD}

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

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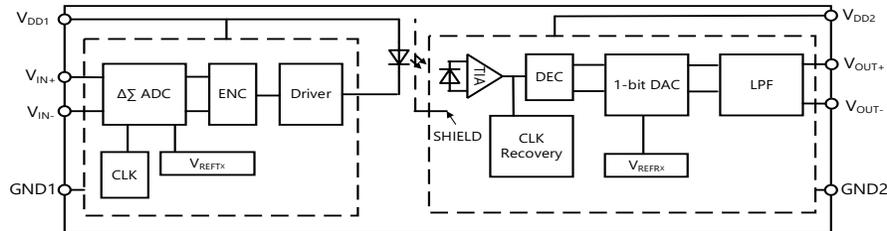
[Note 1] Bypass capacitor of 0.1 μF must be connected between 1 and 4 pins and between 5 and 8 pins.

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

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

Value provided

Wide lineup from general purpose type to WCSP (Wafer Level Chip Size Package) type are provided. Contribute to realize a stable power supply.

1 Low dropout voltage

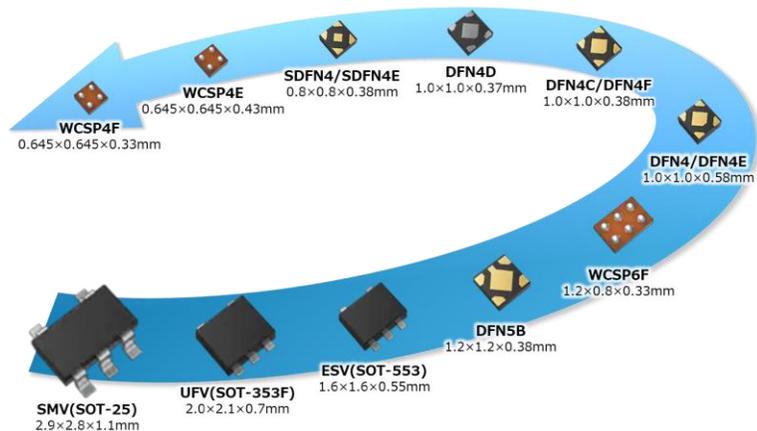Low dropout voltage characteristic has been realized by the originally developed process.

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

WCSP4F 0.645×0.645×0.33mm
WCSP4E 0.645×0.645×0.43mm
SDFN4/SDFN4E 0.8×0.8×0.38mm
DFN4D 1.0×1.0×0.37mm
DFN4C/DFN4F 1.0×1.0×0.38mm
DFN4/DFN4E 1.0×1.0×0.58mm
WCSP6F 1.2×0.8×0.33mm
DFN5B 1.2×1.2×0.38mm
ESV(SOT-553) 1.6×1.6×0.55mm
UFV(SOT-353F) 2.0×2.1×0.7mm
SMV(SOT-25) 2.9×2.8×1.1mm

Lineup

Part number	TCR15AG Series	TCR8BM Series	TCR5FM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR3LM Series	TCR3D Series	TCR3EM Series	TCR1HF Series
Features	Low dropout voltage High PSRR		High PSRR Low noise Low current consumption			Low current consumption		Standard type		36 V Input voltage
I_{OUT} (Max) [A]	1.5	0.8	0.5			0.3				0.15
PSRR (Typ.) [dB] @f = 1 kHz	95	98	91	100	100	70	-	72	68	70
I_B (Typ.) [μA]	25	20	10	7	7	0.34	1	86	35	170

◆Return to Block Diagram TOP

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

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.
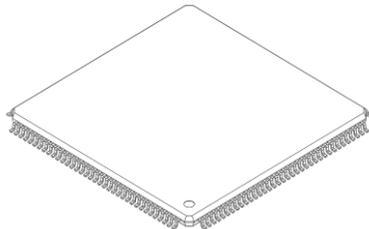
3 Various communication interfaces

These products support major communication interfaces such as UART, FUART, TSPI, TSSI, I^{2}C, CAN, USB and ethernet controller (ETHM). User can construct a communication system easily with a cloud.
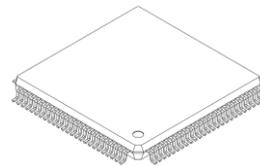
TMPM4NRF∗∗FG   TMPM4NQF∗∗FG   TMPM4NNF∗∗FG
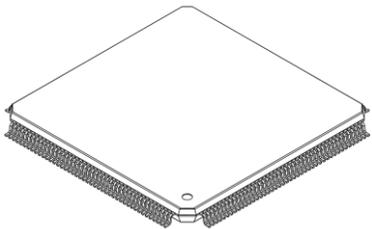
P-LQFP176-2020-0.40-002   P-LQFP144-2020-0.50-002   P-LQFP100-1414-0.50-002

Lineup

	TMPM4NRF20/15/10/D/FG TMPM4NRF20/15/10/D/XBG	TMPM4NQF20/15/10/D/FG TMPM4NQF20/15/10/D/XBG	TMPM4NNF20/15/10/D/FG
Part number	TMPM4NRF20/15/10/D/FG TMPM4NRF20/15/10/D/XBG	TMPM4NQF20/15/10/D/FG TMPM4NQF20/15/10/D/XBG	TMPM4NNF20/15/10/D/FG
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^{2}C: 5ch, TSPI: 9ch, TSSI: 2ch	UART: 5ch, FUART: 2ch, I^{2}C: 5ch, TSPI: 8ch, TSSI: 1ch	UART: 3ch, FUART: 1ch, I^{2}C: 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

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

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