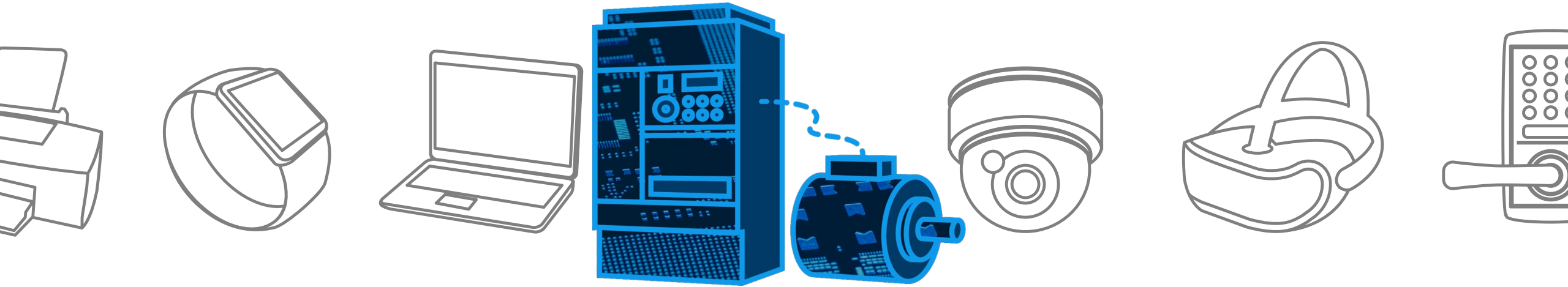
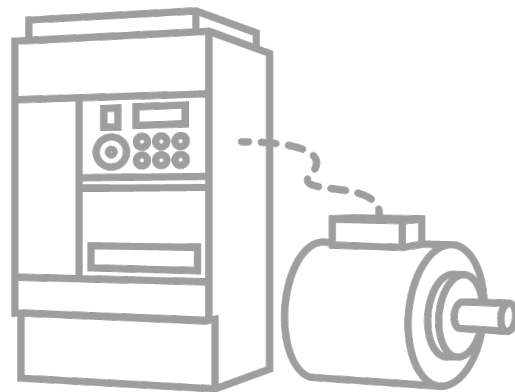
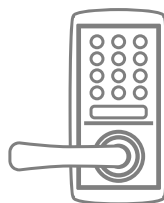


Inverter/Servo

Solution Proposal by Toshiba

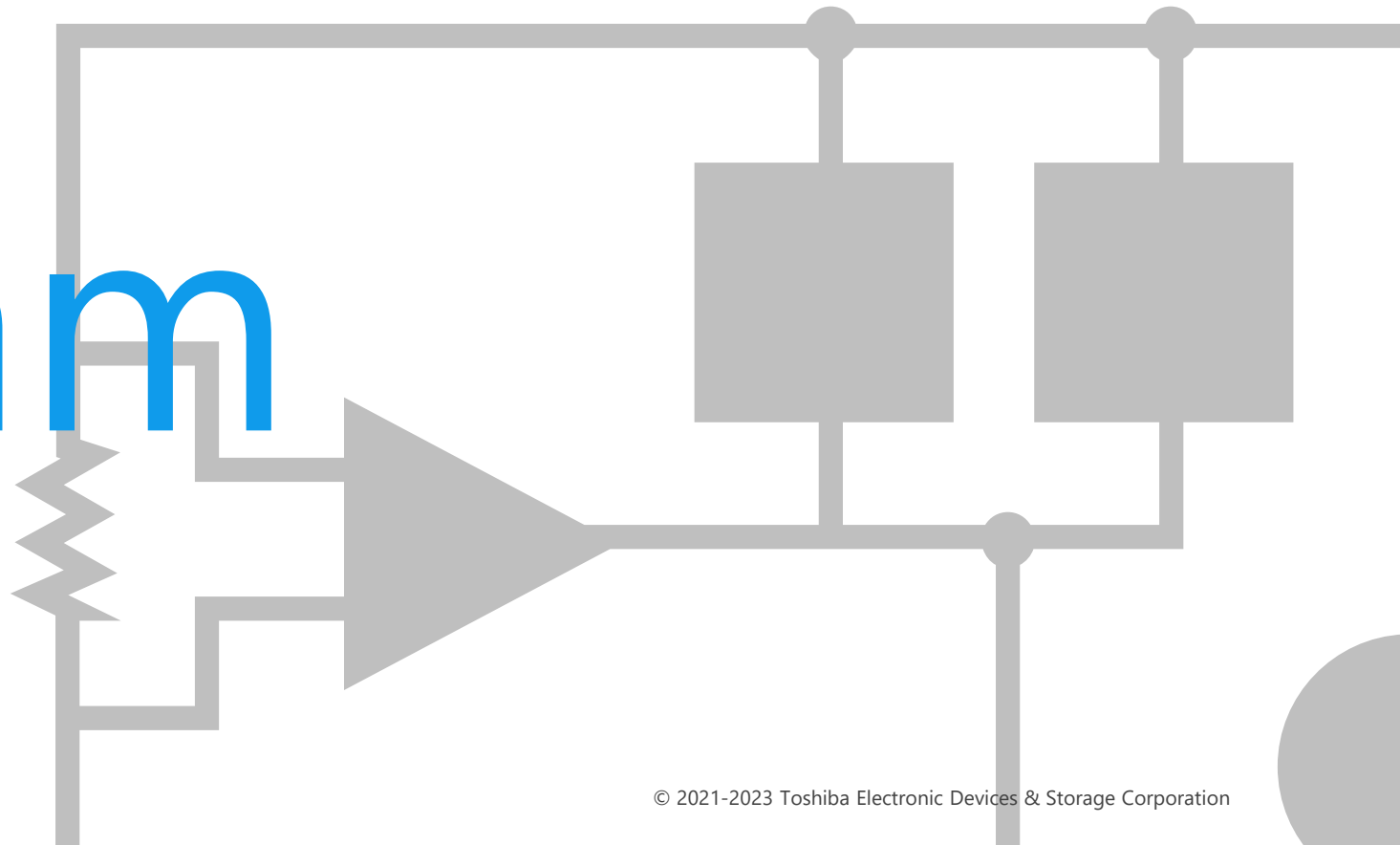




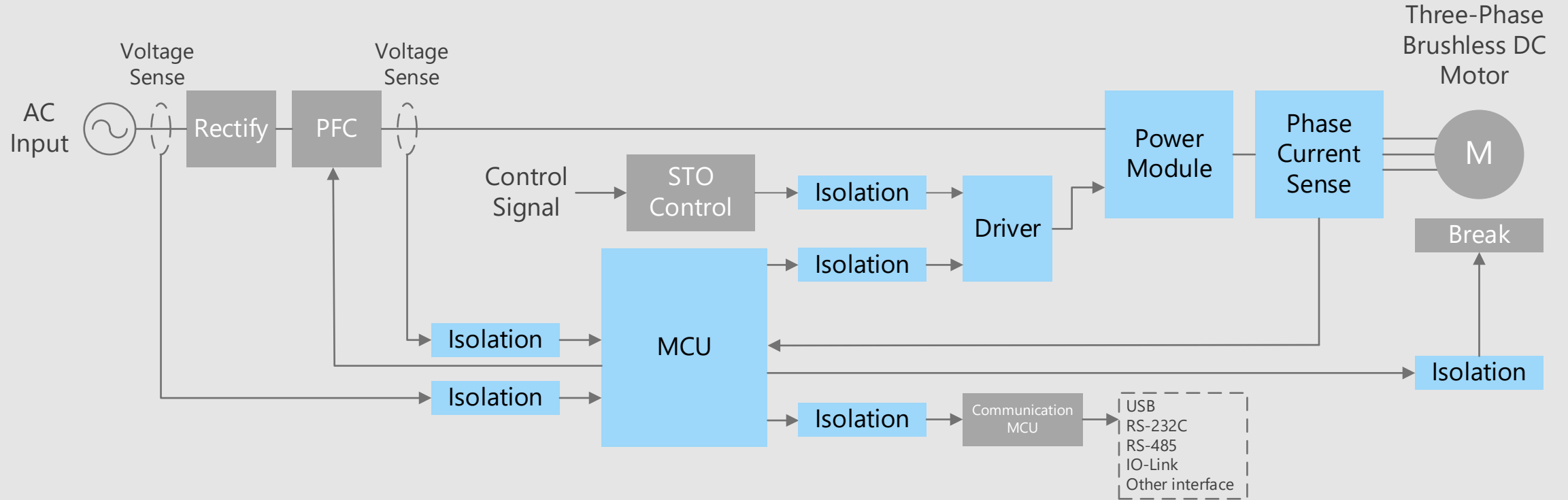
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.



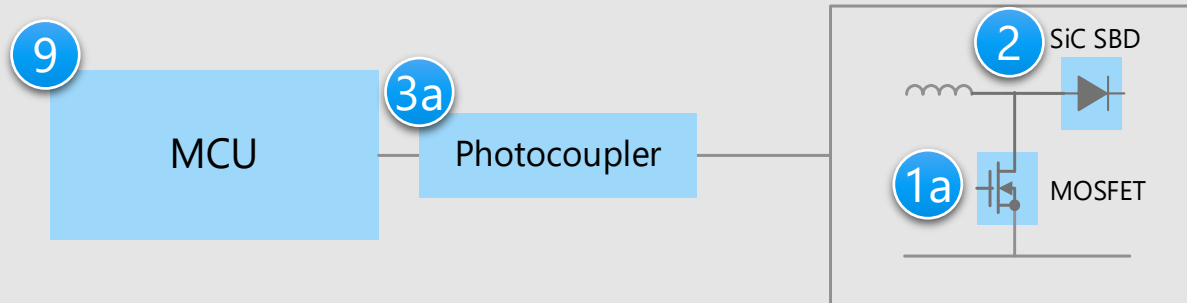
Block Diagram



Inverter/Servo Overall block diagram

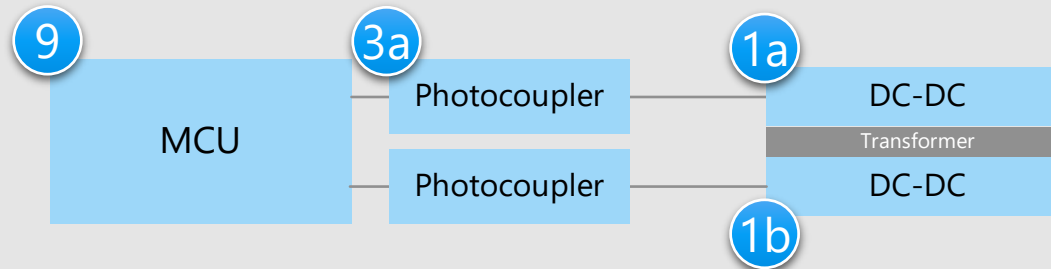


Improvement of power factor (PFC)



SBD: Schottky Barrier Diode

DC-DC converter



Criteria for device selection

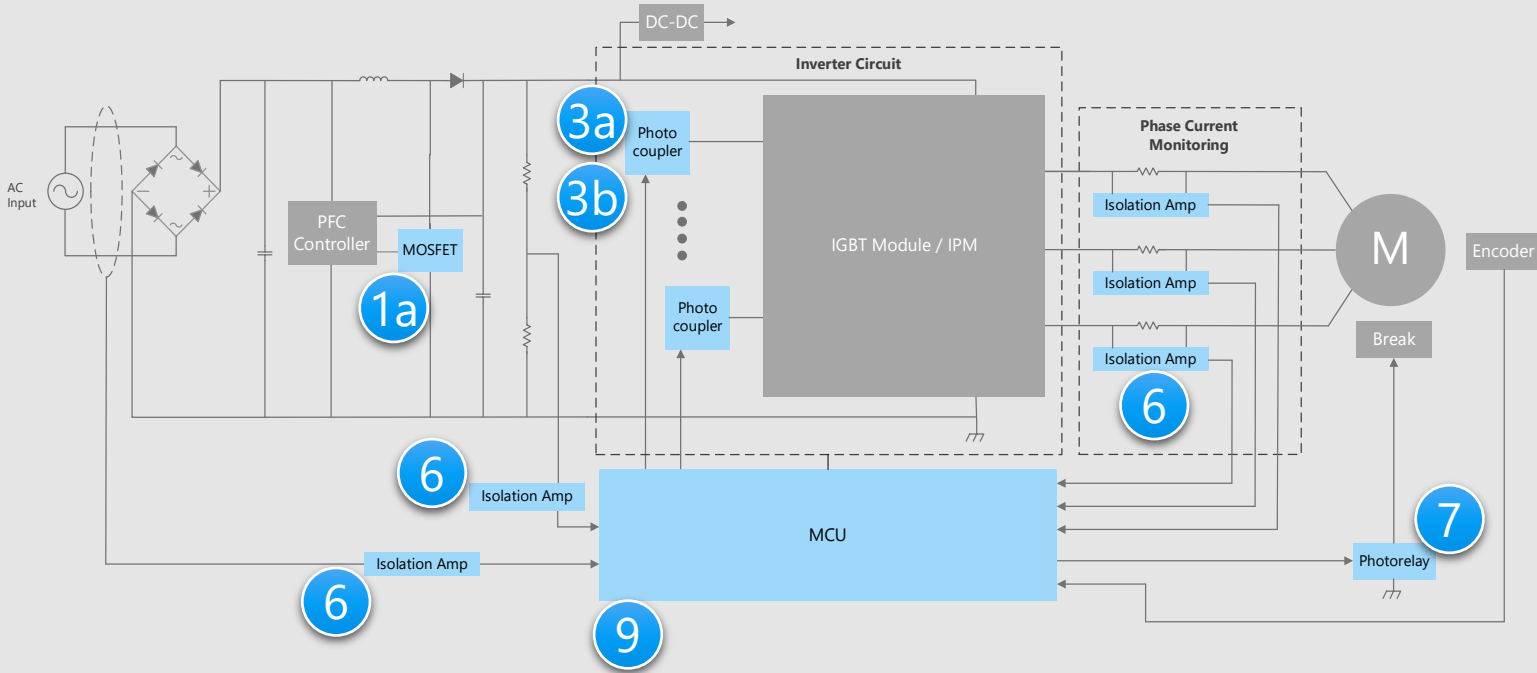
- A high voltage MOSFET with high speed recovery diodes is suitable for PFCs and DC-DC converters.
- SiC type Schottky barrier diodes are suitable for PFC circuits.
- Both high voltage MOSFET and low voltage MOSFET are used for DC-DC converters.

Proposal from Toshiba

- **Suitable for high efficiency power supply switching** 1a
DTMOS Series MOSFET 1b
U-MOS Series MOSFET
- **Small $V_F \times Q_C$ and high surge current capability** 2
SiC Schottky barrier diode
- **Photocoupler that is resistant to noise and can operate at high temperature** 3a
Gate driver photocoupler (for MOSFET/IPM driving)
- **Easy software development using general purpose CPU cores** 9
MCU M370 Group

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Motor driving circuit (with IGBT Module/IPM)



Criteria for device selection

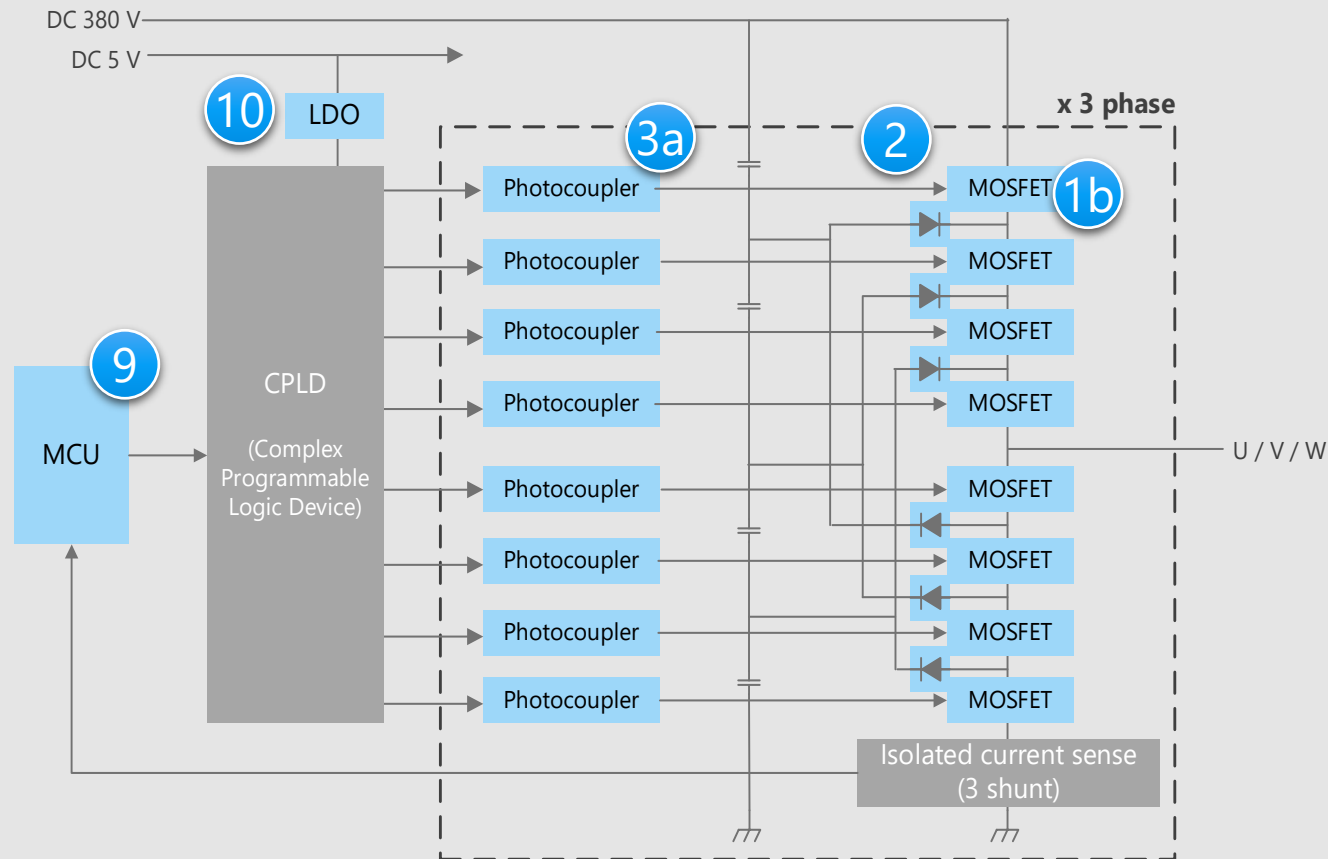
- The use of photocouplers and photorelays realizes the signal transmission between the systems with different voltage levels, and suppress the noise influences.
- The use of photorelays instead of mechanical relays eliminates the life limitation caused by contact wear and welding at the contact points, enabling long life and quieter operation.

Proposal from Toshiba

- **Suitable for high efficiency power supply switching**
DTMOS Series MOSFET 1a
- **Photocouplers that are resistant to noise and can operate at high temperature**
Gate driver photocoupler (for MOSFET/IPM driving) 3a
Gate driver photocoupler (for IGBT driving) 3b
- **Isolation amplifiers suitable for current and voltage detection circuits**
Isolation amplifier 6
- **Photorelays suitable for replacing mechanical relays**
Photorelay 7
- **Easy software development using general purpose CPU cores**
MCU M370 Group 9

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Multi-level motor driving circuit (with MOSFETs)



Criteria for device selection

- In a multi-level motor driving circuit, switching devices with low voltage and low on-resistance can be used, enabling efficient power conversion.
- The use of photocouplers and photorelays realizes the signal transmission between the systems with different voltage levels, and suppress the noise influences.

Proposals from Toshiba

- **Suitable for high efficiency power supply switching**
U-MOS Series MOSFET
- **Small $V_F \times Q_C$ and high surge current capability**
SiC Schottky barrier diode
- **Photocoupler that is resistant to noise and can operate at high temperature**
Gate driver photocoupler (for MOSFET/IPM driving)
- **Easy software development using general purpose CPU cores**
MCU M370 Group
- **Supply the power with low noise**
Small surface mount LDO regulator

1b

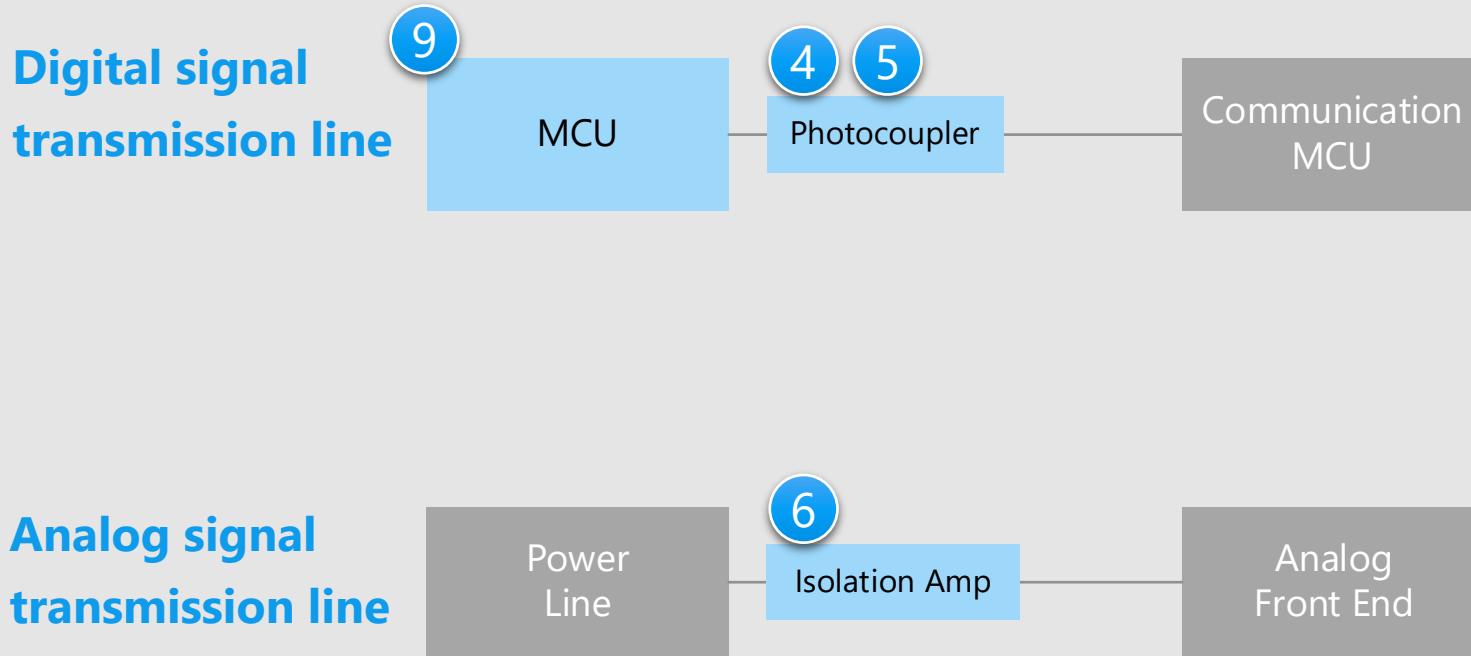
2

3a

9

10

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page



Criteria for device selection

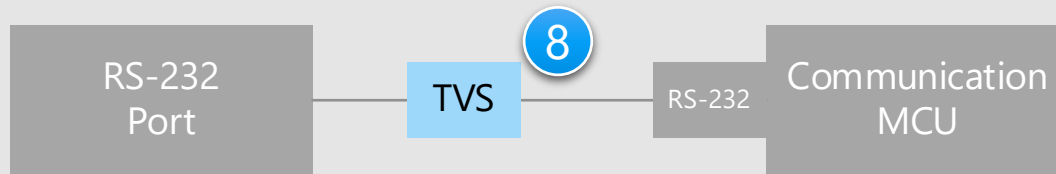
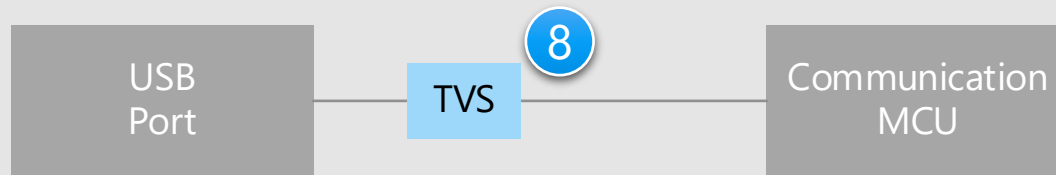
- Photocouplers are suitable for isolation in digital signal transmission lines.
- Isolation amplifiers are suitable for isolation between the high voltage circuit and various detection circuits.

Proposal from Toshiba

- **Photocouplers that are resistant to noise and can operate at high temperature** (4)
Photocoupler for high speed communication
Transistor output photocoupler (5)
- **Isolation amplifiers suitable for current and voltage detection circuits** (6)
Isolation amplifier
- **Easy software development using general purpose CPU cores** (9)
MCU M370 Group

* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Interface circuits



Criteria for device selection

- TVS diode with a low capacitance is suitable for ESD protecting the USB signal line.

Proposal from Toshiba

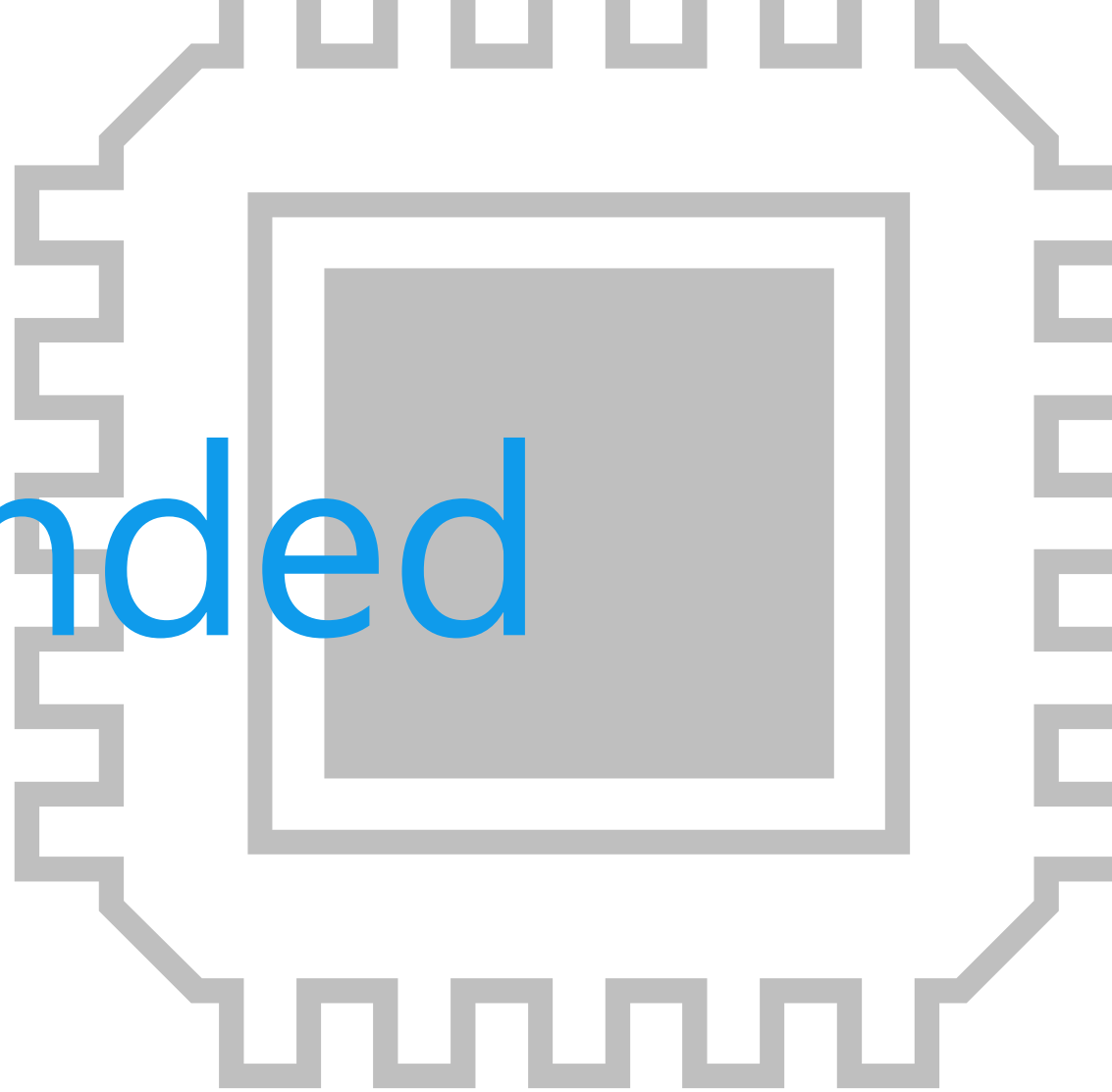
- **Prevent circuit malfunctions and protect devices by absorbing electrostatic discharge from external terminals**

TVS diode

8

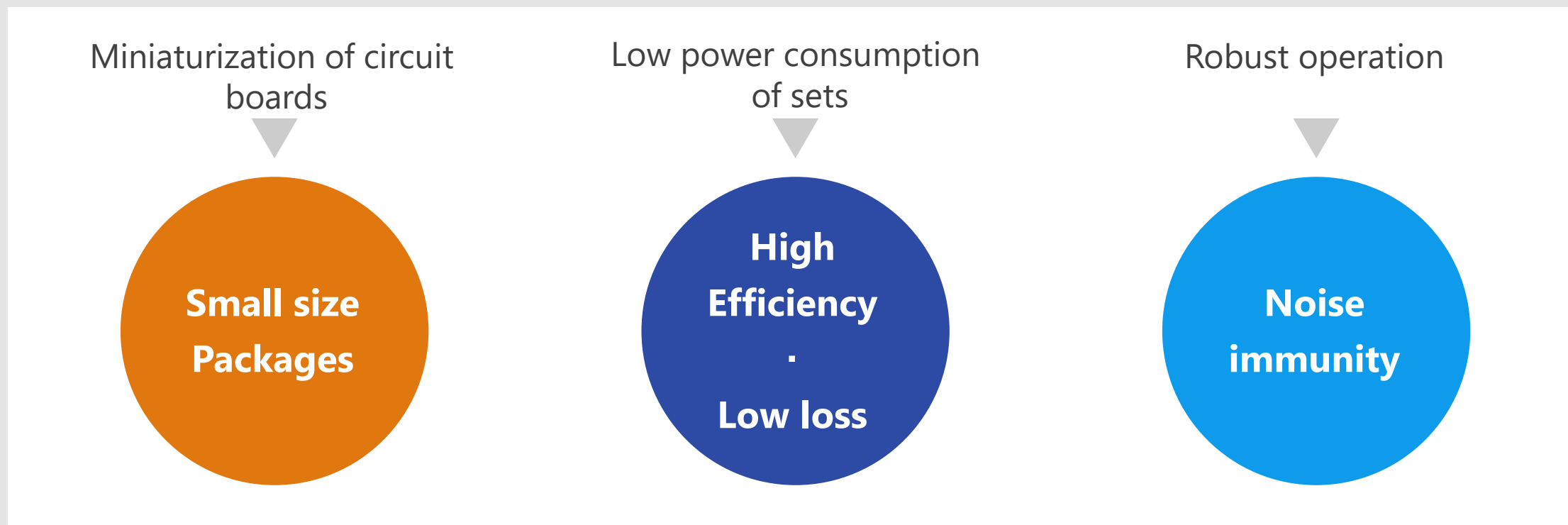
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Recommended Devices



Device solutions to address customer needs

As described above, in the design of inverter/servo system, "**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 address customer needs

Small size packages

High Efficiency
·
Low loss

Noise immunity

1a	DTMOS Series MOSFET	●	●	●
1b	U-MOS Series MOSFET	●	●	●
2	SiC Schottky barrier diode	●	●	●
3a	Gate driver photocoupler (for MOSFET/IPM driving)	●	●	●
3b	Gate driver photocoupler (for IGBT driving)	●	●	●
4	Photocoupler for high speed communication	●	●	●
5	Transistor output photocoupler	●	●	●
6	Isolation amplifier	●	●	●
7	Photorelay	●	●	●

Device solutions to address customer needs

Small size packages

High Efficiency
-
Low loss

Noise immunity

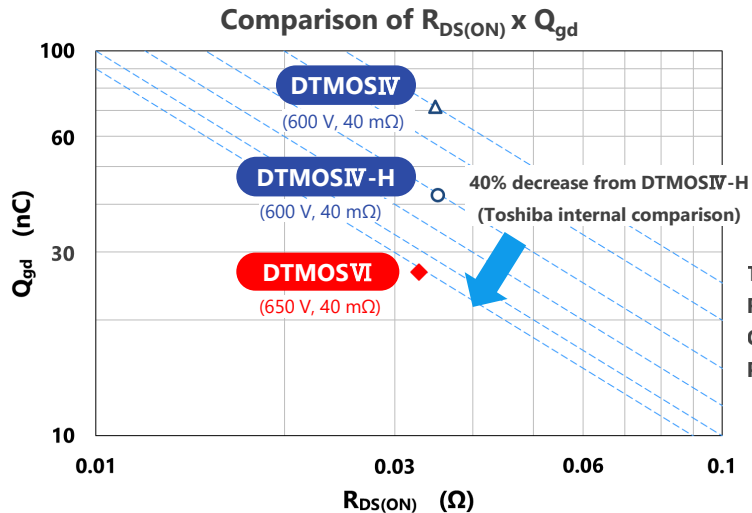
8	TVS diode	●		●
9	MCU M370 Group	●	●	
10	Small surface mount LDO regulator	●	●	●

Value provided

DTMOS series contribute to provide highly efficient power supply by improving $R_{DS(on)} \times Q_{gd}$.

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

In the DTMOSVI series, the $R_{DS(ON)} \times Q_{gd}$ 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 higher 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
	Max	0.125	0.23	0.11	0.19	0.11
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

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_{gr} , 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 SMD to lead 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 / 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
	Max	0.019	0.00243	0.004
Polarity	N-ch	N-ch	N-ch	N-ch
Generation	U-MOSX-H	U-MOSX-H	U-MOSX-H	U-MOSX-H

*: Silicon limit

[Return to Block Diagram TOP](#)

Value provided

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

1 High efficiency

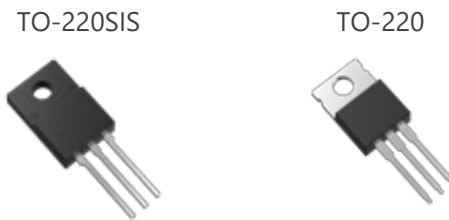
Low on-resistance ($R_{DS(ON)}$) achieved by fine integration process.
Trade off between $R_{DS(ON)}$ and Q_{gr} , Q_{swr} , Q_{oss} have been improved by optimization of cell structure.

2 Wide variety of lineup

Voltage from 20 to 250 V are lined up.
Wide variety of packages from SMD to lead 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	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
	Max	0.00244	0.00244
Polarity	N-ch	N-ch	N-ch
Generation	U-MOSX-H	U-MOSX-H	U-MOSVIII-H

*: Silicon limit

[◆Return to Block Diagram TOP](#)

Value provided

Can be applied to power factor correction circuits and a wide range of power supply control applications, and contributes to miniaturization of set.

1 High surge current tolerance

The non-repetitive peak forward surge current $I_{FSM} = 97$ A (Max) (TRS12E65F). Surge current is increased around 2 times by using improved JBS (Junction Barrier controlled Schottky) structure incorporating the concept of the Merged PiN Schottky (MPS) structure. (Comparison with Toshiba's first generation products)

2 Second generation chip design

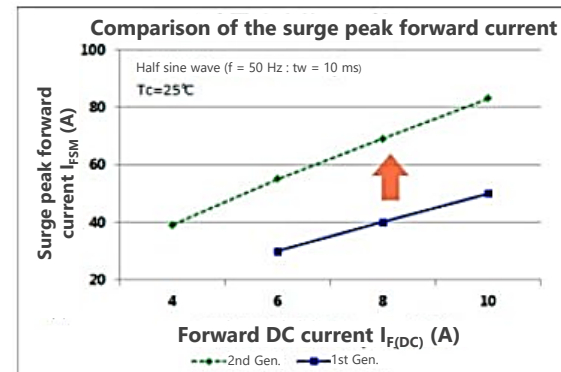
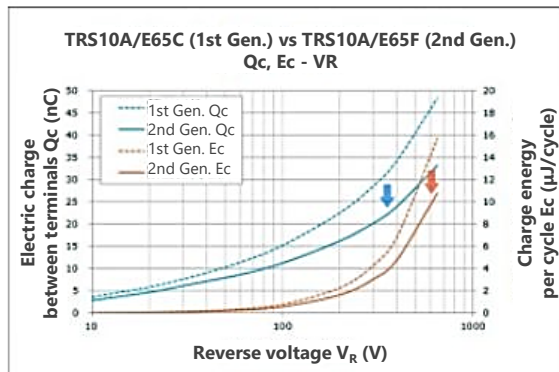
The figure of merit ($V_F \times Q_C$) [Note] is improved by 30 % and the non-repetitive peak forward surge current (I_{FSM}) is improved, thereby contributing to higher efficiency of the power supply. (Comparison with Toshiba's first generation products)

3 High heat radiation package





Provided in TO-220 and TO-247 through hole type packages.

[Note] The $V_F \times Q_C$ (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 the first and second generations products



Lineup

Part number	TRS4A65F	TRS4E65F	TRS12E65F	TRS12N65FB	TRS16N65FB	TRS20N65FB	TRS24N65FB
Package	 TO-220F-2L	 TO-220-2L	 TO-220-2L	 TO-247 (Center tap)			
V_{RRM} [V]	650	650	650	650	650	650	650
$I_{F(DC)}$ [A]	4	4	12	6 / 12 *	8 / 16 *	10 / 20 *	12 / 24 *
I_{FSM} [A]	37	39	97	52 / 104 *	65 / 130 *	79 / 158 *	92 / 184 *
V_F (Typ.) [V]	1.45 @ $I_F = 4$ A	1.45 @ $I_F = 4$ A	1.45 @ $I_F = 12$ A	1.45 @ $I_F = 6$ A	1.45 @ $I_F = 8$ A	1.45 @ $I_F = 10$ A	1.45 @ $I_F = 12$ A

* Per Leg / Both Legs

[Return to Block Diagram TOP](#)

[Note 1] IPM : Intelligent Power Module

Value provided

Combines an infrared light emitting diode with high optical output and a light receiving IC chip with high gain and high speed.

1 High noise immunity

The products have internal faraday shield that provides high CMTI (Common Mode Transient Immunity).

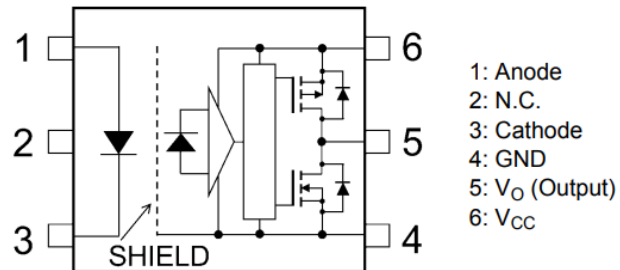
2 High isolation voltage

The isolation voltage BV_S is 5000 [Vrms].
[Note 2] $BV_S = 3750$ [Vrms] for TLP152.

3 High temperature operation

The products are designed to operate even under severe ambient temperature conditions, such as inverters, robots and machinery, etc.

Internal circuit configuration
(TLP5774H)



UL-recognized UL1577, File No.E67349



cUL-recognized CSA Component Acceptance Service No.5A File No.E67349

VDE-recognized EN60747-5-5, EN62368-1 [Note 3]

CQC-recognized GB4943.1, GB8898

[Note 3] When a VDE approved type is needed, please designate the Option (D4).

Lineup

Part number	TLP152	TLP5774H	TLP2745	TLP2719
Package	5pin SO6 	SO6L 		
Application	MOSFET driving		IPM driving	
CMTI (Min) [kV/ μ s]	± 20	± 35	± 30	± 10
T_{opr} [$^{\circ}$ C]	-40 to 100	-40 to 125	-40 to 110	-40 to 100
Propagation delay time (Max) [ns]	190	150	120	2000
Overcurrent protection	-	-	-	-

[Return to Block Diagram TOP](#)

Value provided

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

1 High noise immunity

The products have internal faraday shield that provides high CMTI (Common Mode Transient Immunity).

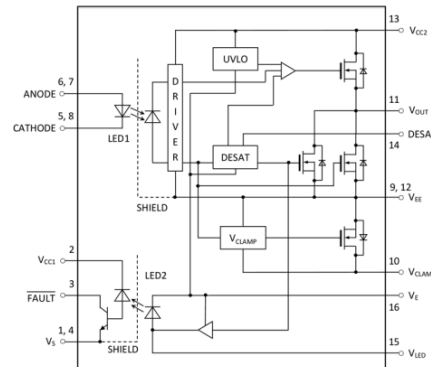
2 High temperature operation

The products are designed to operate even under severe ambient temperature conditions, such as inverters, robots and machinery, etc.

3 Wide output current ratings lineup

Wide product lineup suitable for both gate drive and pre gate drive enables to choose product suitable for each driving.

Internal circuit configuration (TLP5212)



UL-recognized UL1577, File No.E67349

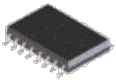
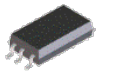
cUL-recognized CSA Component Acceptance Service No.5A File No.E67349

VDE-recognized EN60747-5-5, EN62368-1 [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

Combines an infrared light emitting diode with high optical output and a light receiving IC chip with high gain and high speed.

1 High noise immunity

The products have internal faraday shield that provides high CMTI (Common Mode Transient Immunity).

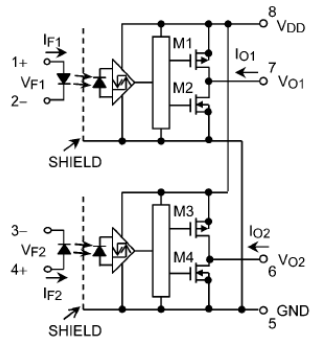
2 High isolation voltage

The isolation voltage BV_S is 5000 [Vrms].

3 High temperature operation

The products are designed to operate even under severe ambient temperature conditions, such as inverters, robots and machinery, etc.

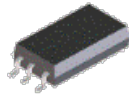
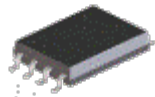
Internal circuit configuration (TLP2210)



- 1: Anode 1
- 2: Cathode 1
- 3: Cathode 2
- 4: Anode 2
- 5: GND
- 6: VO 2 (output 2)
- 7: VO 1 (output 1)
- 8: VDD

UL-recognized UL1577, File No.E67349
 cUL-recognized CSA Component Acceptance Service No.5A File No.E67349
 VDE-recognized EN60747-5-5, EN62368-1 [Note]
 CQC-recognized 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(LF4) 		
Channel	1			2		
Data rate [Mbps]	5	15	20	5	15	20
T _{opr} [°C]	-40 to 125	-40 to 125	-40 to 125	-40 to 125	-40 to 125	-40 to 125

[Return to Block Diagram TOP](#)

5 Transistor output photocoupler

TLP383 / TLP293 / TLP385

Small size packages

High efficiency
Low loss

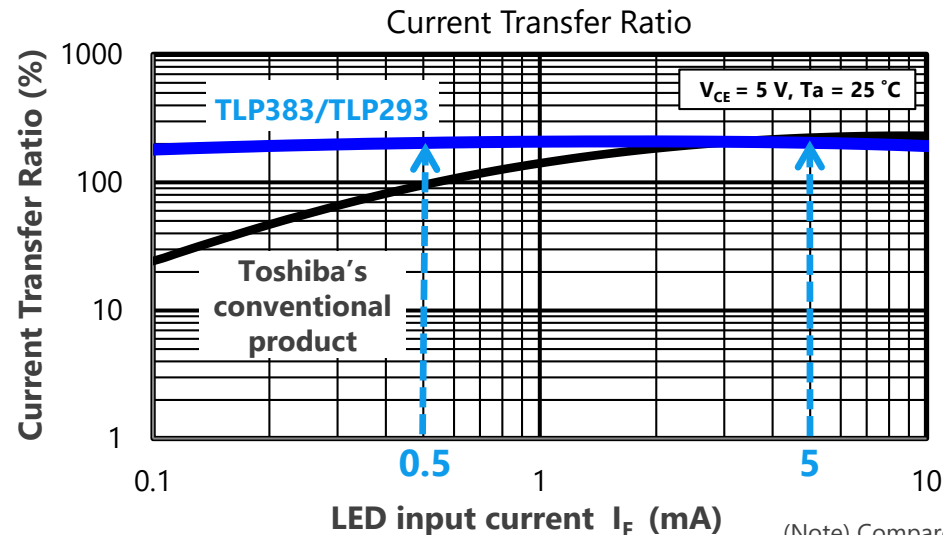
Noise immunity

Value provided

High CTR (Current Transfer Ratio) is realized even in low input current range ($I_F = 0.5 \text{ mA}$).

1 High current transfer ratio




The TLP383 and TLP293 are high isolation photocouplers that optically couple a phototransistor and high output infrared LED. Compared to Toshiba's conventional products (TLP385), higher CTR (Current Transfer Ratio) in low input current range (@ $I_F = 0.5 \text{ mA}$) is realized.



(Note) Compared with Toshiba conventional products

2 High temperature operation

The products are designed to operate even under severe ambient temperature conditions, such as inverters, robots and machinery, etc.

Lineup			
Part number	TLP383	TLP293	TLP385
Package	4pin SO6L 	SO4 	4pin SO6L 
BV_S [Vrms]	5000	3750	5000
T_{opr} [$^\circ\text{C}$]	-55 to 125	-55 to 125	-55 to 110

[Return to Block Diagram TOP](#)

Value provided

This is an isolation amplifier suitable for current and voltage detection of motors and inverters.

1 High isolation performance

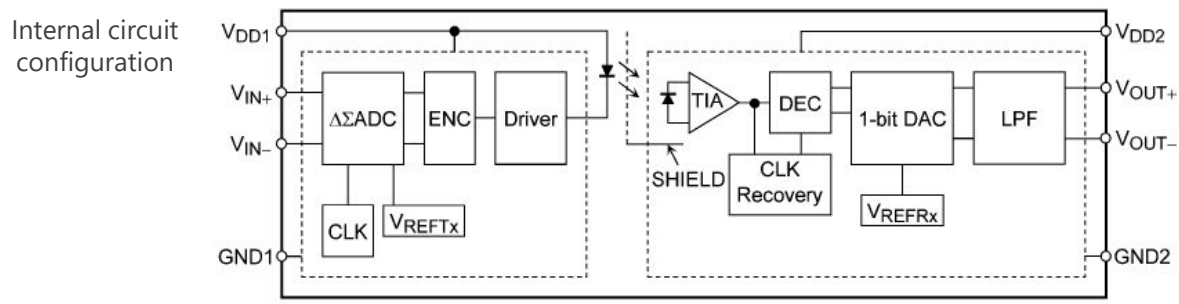
This optical coupling type isolation amplifier has a high-precision $\Delta\Sigma$ AD conversion circuit on the input side and a high precision DA conversion circuit on the output side.

2 Support for common mode

Common-mode transient immunity is provided with CMTI [Note 1] = 15 kV/ μ s (Min).
[Note 1] CMTI : Common Mode Transient Immunity

3 5 V system power supply voltages


Input power supply voltage
 V_{DD1} = 4.5 to 5.5 V
Output power supply voltage
 V_{DD2} = 3.0 to 5.5 V



Note: A 0.1- μ F bypass capacitor 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: EN 60747-5-5, EN 62368-1 [Note 2]

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

Lineup	
Part number	TLP7820
Package	SO8L(LF4) 
BV _S [Vrms]	5000
T _{opr} [°C]	-40 to 105
CMTI (Min) [kV/ μ s]	15

[Return to Block Diagram TOP](#)

Value provided

Photorelay consists of an infrared light emitting diode optically coupled to a photo-MOSFET and is suitable for replacing mechanical relays.

1 Low on-resistance

On-resistance $R_{ON} = 0.05 \Omega$ (Typ.)
(TLP3547: A connection) [Note 1]

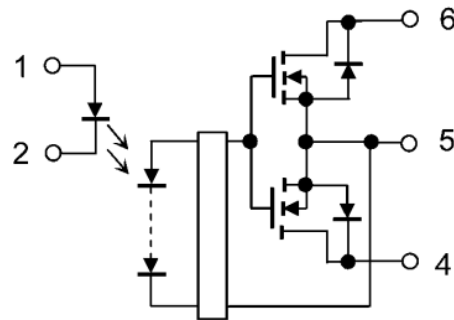
2 Wide current range

Wide range of allowed ON current I_{ON} ,
suitable for power line control.
 $I_{ON} = 5.0 \text{ A}$ (Max)
(TLP3547: A connection) [Note 1]

3 Lineup of package and isolation voltage

The lineup of isolation voltage and package for freedom of design are provided.

TLP3545A
Internal equivalent circuit



[Note 1] Please refer to the technical data sheet for connection.

Safety Standards

UL approved: UL1577, File No.E67349

cUL approved: CSA Component Acceptance Service No. 5A, File No.E67349





UL-recognized: UL 508, File No.E499232 [Note 2]

VDE-approved: EN 60747-5-5 [Note 3]

[Note 2] Please refer Absolute Maximum Ratings (UL-recognized UL 508) for UL 508 products.

[Note 3] When a VDE approved type is needed, please designate the Option (D4).

Lineup

Part number	TLP3122A	TLP170AM	TLP3545A	TLP3547	TLP240A	TLP241B
Package	4pin SO6 		DIP6 	DIP8 	DIP4 	
I_{ON} [A]	1.4	0.7	4.0	5.0	0.5	2.0
V_{OFF} [V]	60	60	60	60	60	100
R_{ON} (Max) [Ω]	0.25	0.3	0.06	0.05	2.0	0.2
BV_S [Vrms]	3750	3750	2500	2500	5000	5000

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Value provided

Absorbs static electricity from external terminals, prevents circuit malfunction and protects devices.

1 High ESD pulse absorption performance

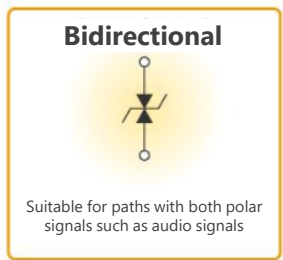
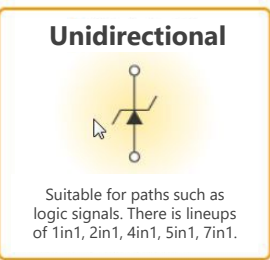
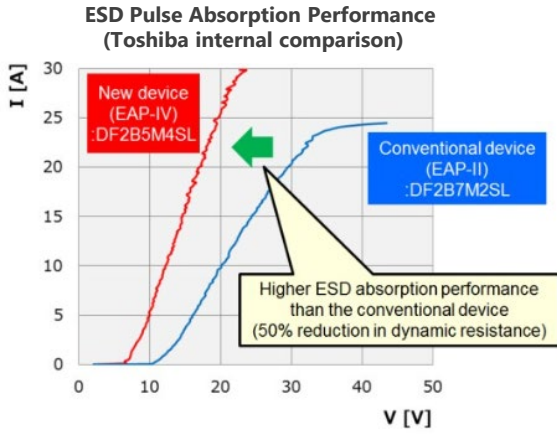
Improved ESD absorption compared to our conventional products. (50 % reduction in operating resistance) For some products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

2 Suppress ESD energy by low clamp voltage

Protect the connected circuits/devices using proprietary technology.

3 Suitable for high density mounting

A variety of small packages are available.



Lineup

Part number	DF2B6M4BSL	DF2B20M4SL	DF2B5PCT	DF2B7PCT	DFS2S14P2CTC
Package	SL2		CST2		CST2C
V_{ESD} [kV]	±8	±15	±30	±30	±30
V_{RWM} (Max) [V]	5.5	18.5	3.6	5.5	12.6
C_t (Typ.) [pF]	0.12	0.2	41	45	270
R_{DYN} (Typ.) [Ω]	1.05	0.2	0.1	0.1	0.08
Purpose	Signal line protection		Power line protection		

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

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Value provided

Based on the global standard Arm[®] Cortex[®]-M3 core, it provides high performance and a full set of basic functions

1 Motor controller logic circuit

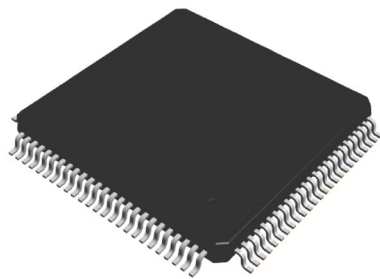
Three-phase brushless motor controller, execute PWM output for square wave drive and sine wave drive.

2 Built-in vector engine

Vector engine that supports vector control, control the motor more smoothly and efficiency with a low CPU load.

3 Analog circuit for motor control

AD converters with high speed and high accuracy allow conversion timing and PWM output to be linked.



LQFP100 Package
14 x 14 mm

Lineup

Part number	Flash ROM	RAM	Package
TMPM370FYFG	256 KB	10 KB	LQFP100-P-1414-0.50H
TMPM372FWUG	128 KB	6 KB	LQFP64-P-1010-0.50E
TMPM373FWDUG	128 KB	6 KB	LQFP48-P-0707-0.50C
TMPM374FWUG	128 KB	6 KB	LQFP44-P-1010-0.80B
TMPM375FSDMG	64 KB	4 KB	SSOP30-P-300-0.65
TMPM376DFDG	512 KB	32 KB	LQFP100-P-1414-0.50H
TMPM37AFSQG	64 KB	4 KB	P-VQFN32-0505-0.50-003

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10 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.

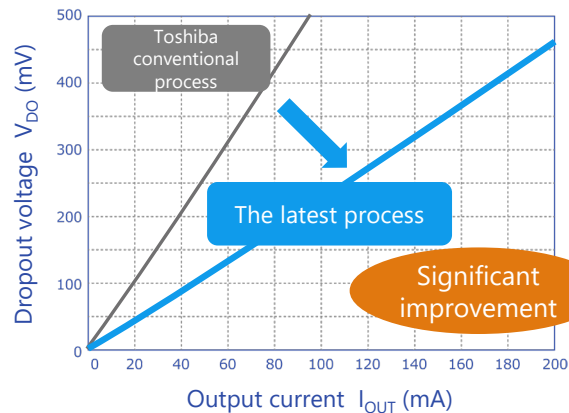
2 High PSRR Low output noise voltage

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

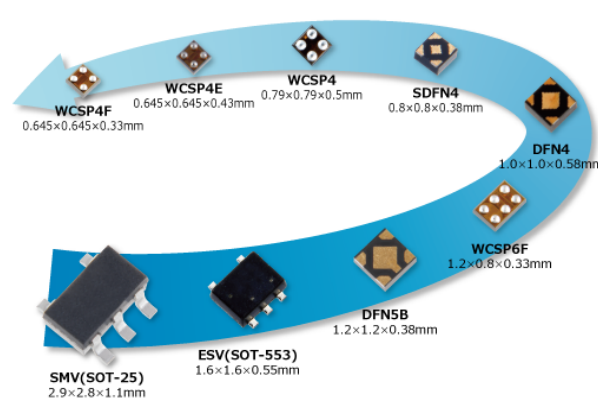
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

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

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