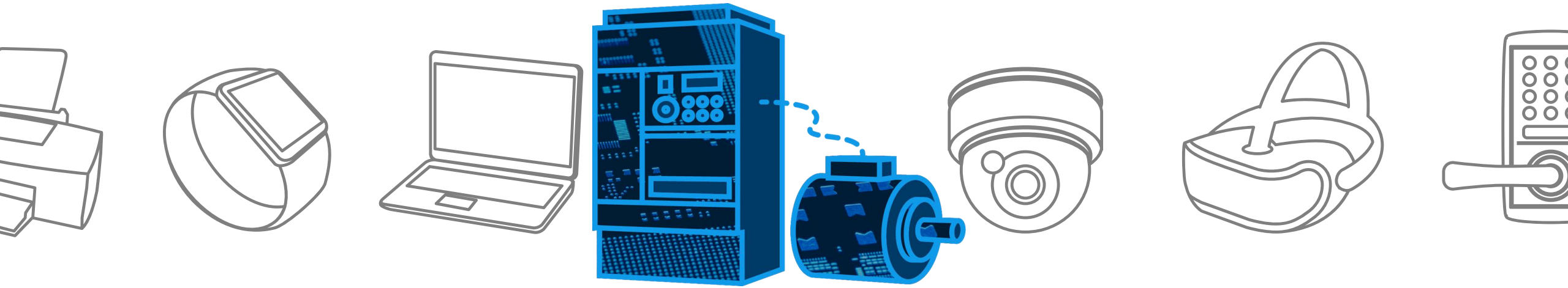
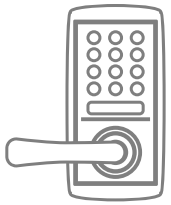
TOSHIBA

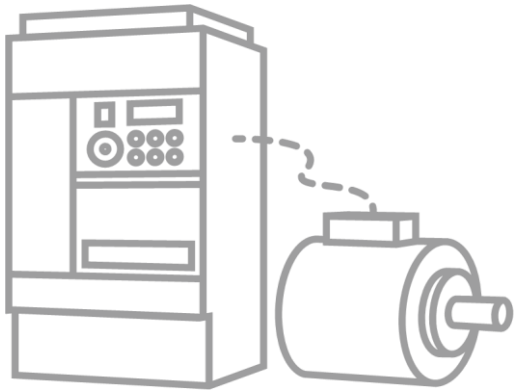
R23

Inverter/Servo

Solution Proposal by Toshiba

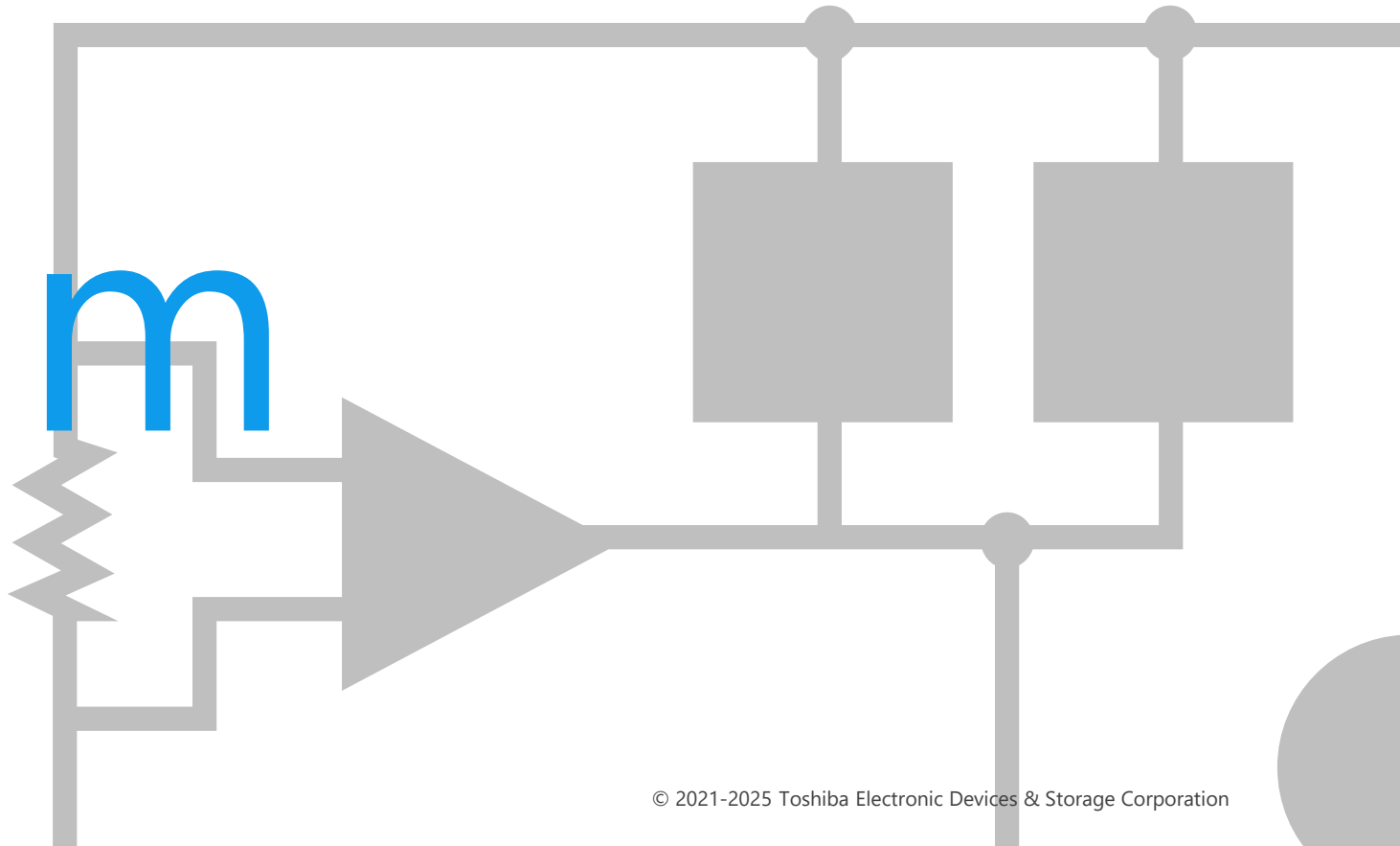




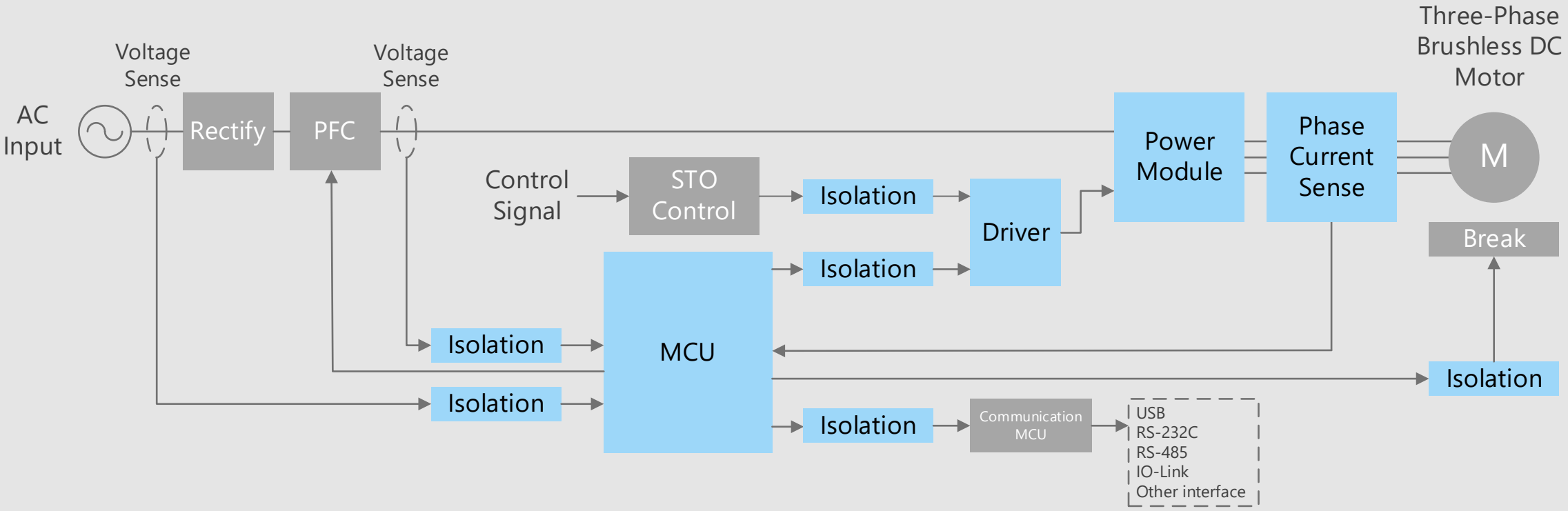


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

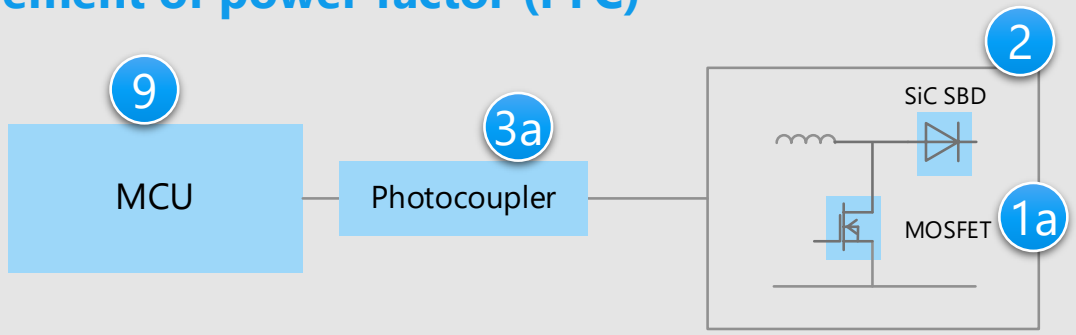


Inverter/Servo　Overall block diagram



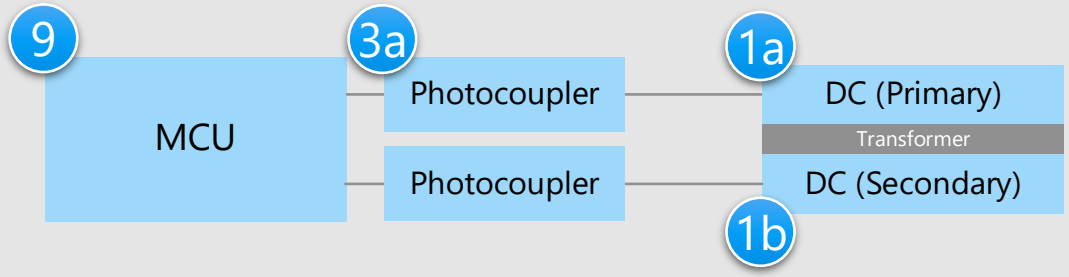
Inverter/Servo　Detail of power supply circuit

Improvement of power factor (PFC)



SBD: Schottky Barrier Diode

DC-DC converter



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

Criteria for device selection

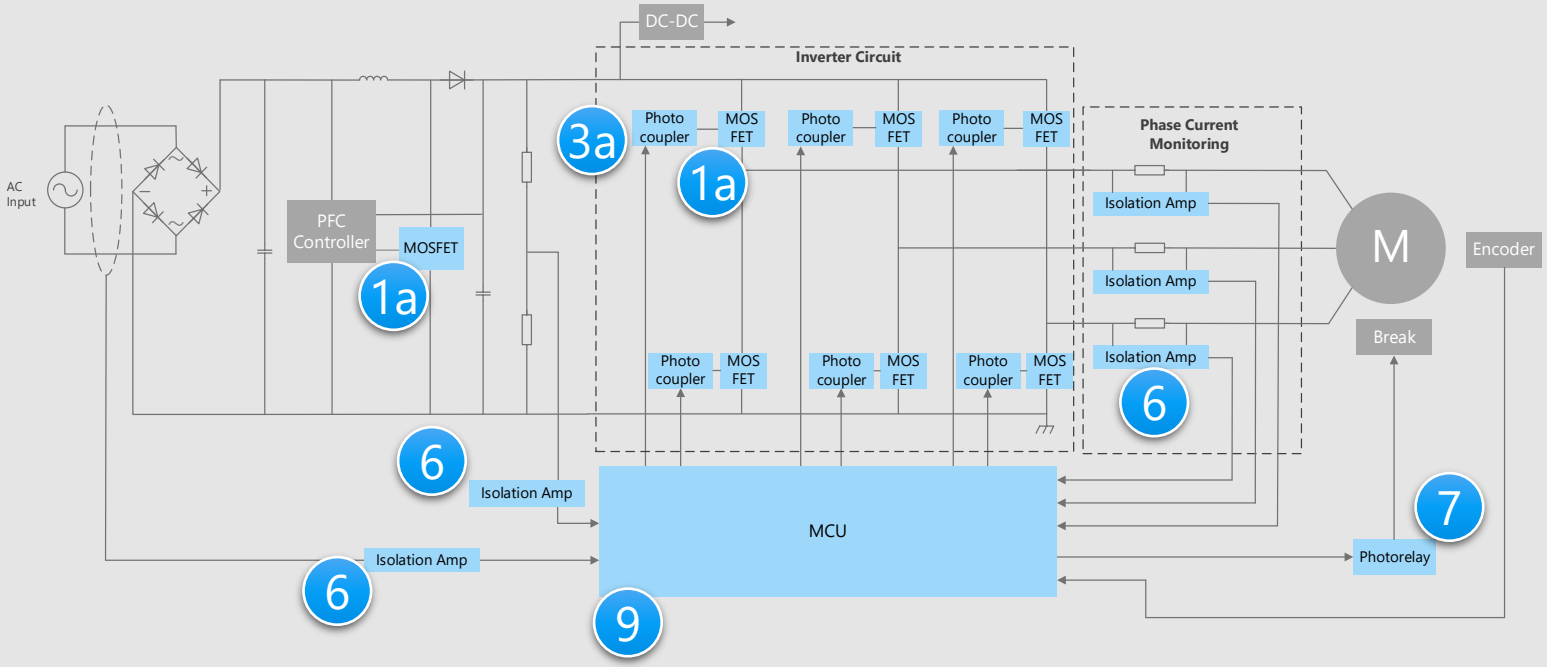
- A high voltage MOSFET with high speed recovery diodes is suitable for DC-DC converters.
- SiC type Schottky barrier diodes are suitable for PFC circuits.

Proposals from Toshiba

- **Suitable for high efficiency power supply switching** 1a
  DTMOS Series MOSFET
  U-MOS Series MOSFET 1b
- **Small V_F x Q_C and high surge current capability**
  SiC Schottky barrier diode 2
- **Photocoupler that is resistant to noise and can operate at high temperature**
  Gate diver photocoupler (for MOSFET/IPM driving) 3a
- **Easy software development using general purpose CPU cores**
  MCU M4K Group / M470 Group / M370 Group 9

Inverter/Servo　Detail of motor driving circuit (1)

Motor driving circuit (with MOSFETs)



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

Criteria for device selection

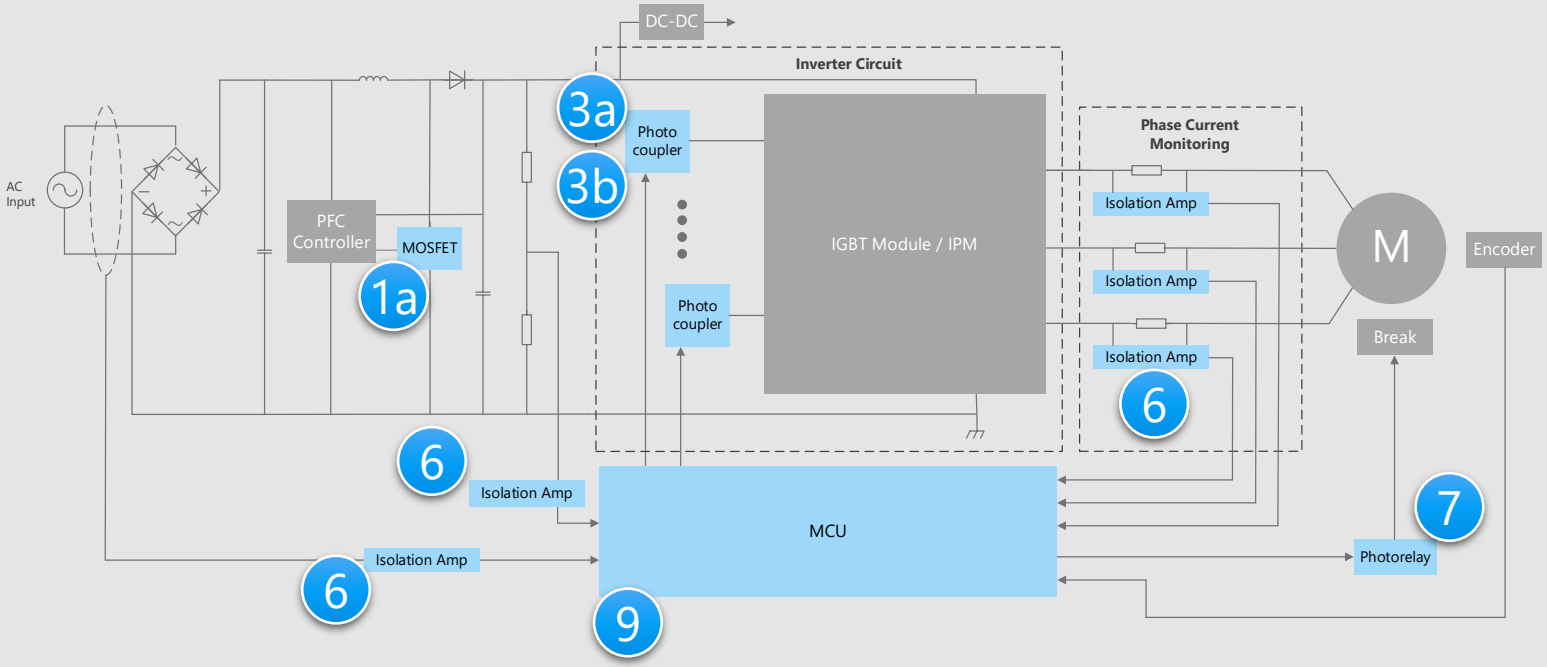
- The use of photocouplers and photorelays realizes the signal transmission between the systems with different voltage levels, and suppress the noise influences.
- The use of photorelays instead of mechanical relays eliminates the life limitation caused by contact wear and welding at the contact points,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

Proposals from Toshiba

- **Suitable for high efficiency power supply switching** 1a
  DTMOS Series MOSFET
- **Photocoupler that is resistant to noise and can operate at high temperature** 3a
  Gate driver photocoupler (for MOSFET/IPM driving)
- **Isolation amplifiers suitable for current and voltage detection circuits** 6
  Isolation amplifier
- **Photorelays suitable for replacing mechanical relays** 7
  Photorelay
- **Easy software development using general purpose CPU cores** 9
  MCU M4K Group / M470 Group / M370 Group

Inverter/Servo　Detail of motor driving circuit (2)

Motor driving circuit (with IGBT Module/IPM)



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

Criteria for device selection

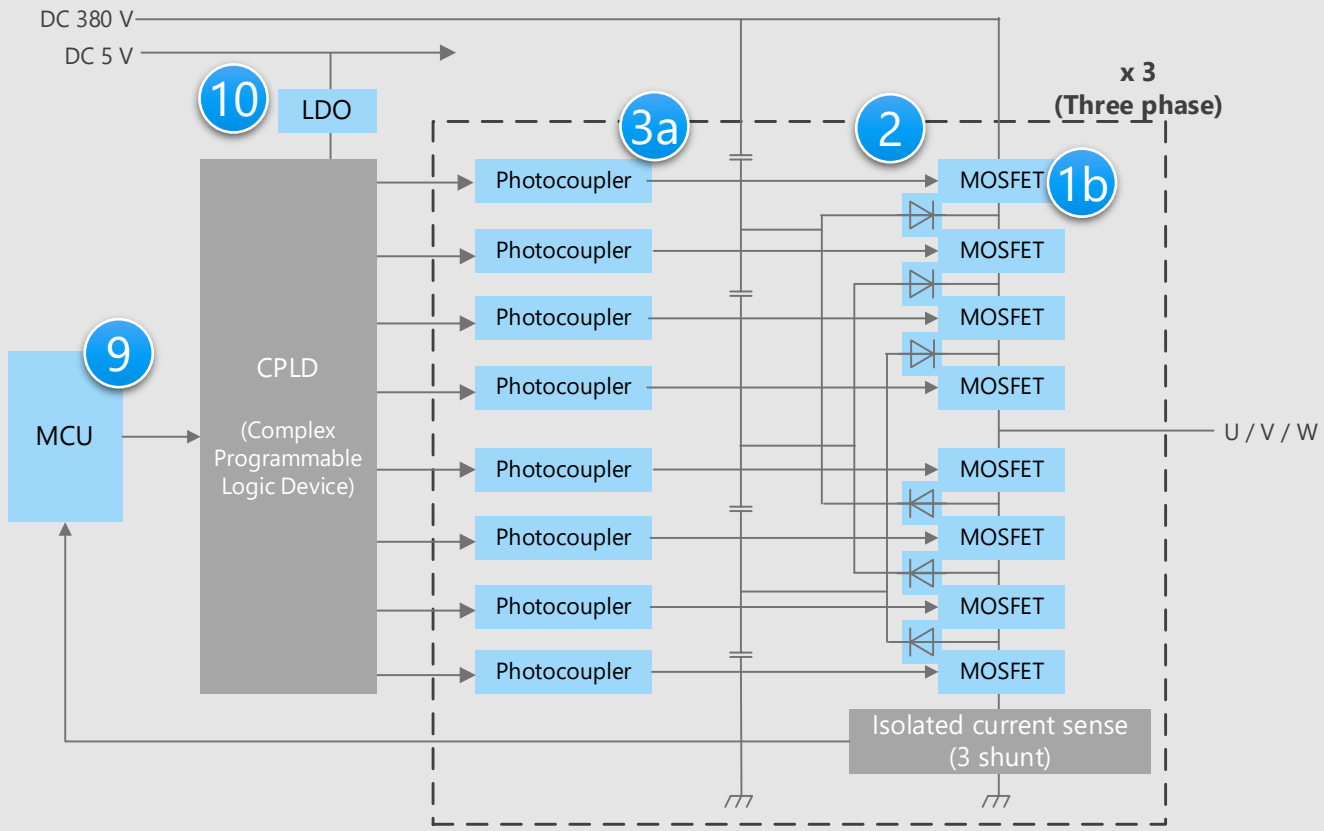
- The use of photocouplers and photorelays realizes the signal transmission between the systems with different voltage levels, and suppress the noise influences.
- The use of photorelays instead of mechanical relays eliminates the life limitation caused by contact wear and welding at the contact points,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

Proposals from Toshiba

- **Suitable for high efficiency power supply switching** 1a
  DTMOS Series MOSFET
- **Photocouplers that are resistant to noise and can operate at high temperature** 3a 3b
  Gate driver photocoupler (for MOSFET/IPM driving)
  Gate driver photocoupler (for IGBT driving)
- **Isolation amplifiers suitable for current and voltage detection circuits** 6
  Isolation amplifier
- **Photorelays suitable for replacing mechanical relays** 7
  Photorelay
- **Easy software development using general purpose CPU cores** 9
  MCU M4K Group / M470 Group / M370 Group

Inverter/Servo　Detail of motor driving circuit (3)

Multi-level motor driving circuit (with MOSFETs)



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

Criteria for device selection

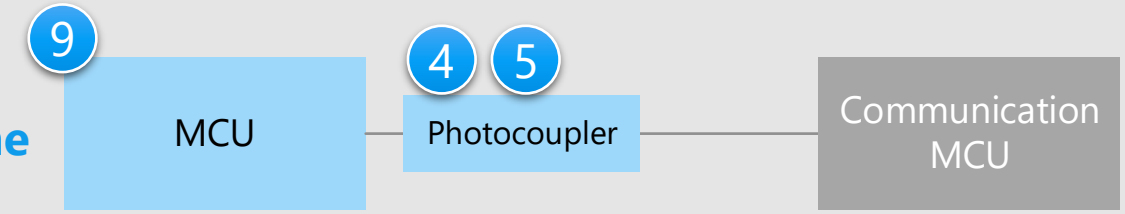
- In a multi-level motor driving circuit, switching devices with low voltage and low on-resistance can be used, enabling efficient power conversion.
- The use of photocouplers and photorelays realizes the signal transmission between the systems with different voltage levels, and suppress the noise influences.

Proposals from Toshiba

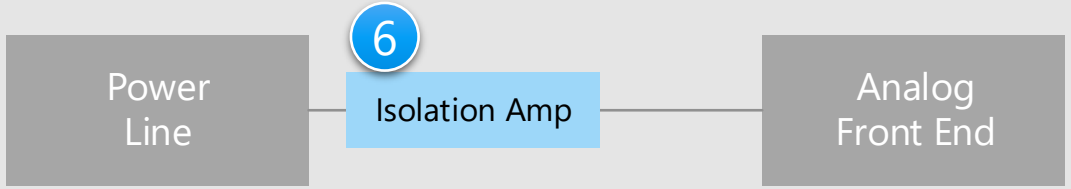
- **Suitable for high efficiency power supply switching** 1b
  U-MOS Series MOSFET
- **Small V_F x Q_C and high surge current capability** 2
  SiC Schottky barrier diode
- **Photocoupler that is resistant to noise and can operate at high temperature** 3a
  Gate diver photocoupler (for MOSFET/IPM driving)
- **Easy software development using general purpose CPU cores** 9
  MCU M4K Group / M470 Group / M370 Group
- **Supply the power with low noise** 10
  Small surface mount LDO regulator

Inverter/Servo　Details of signal transmission line

Digital signal transmission line



Analog signal transmission line



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

Criteria for device selection

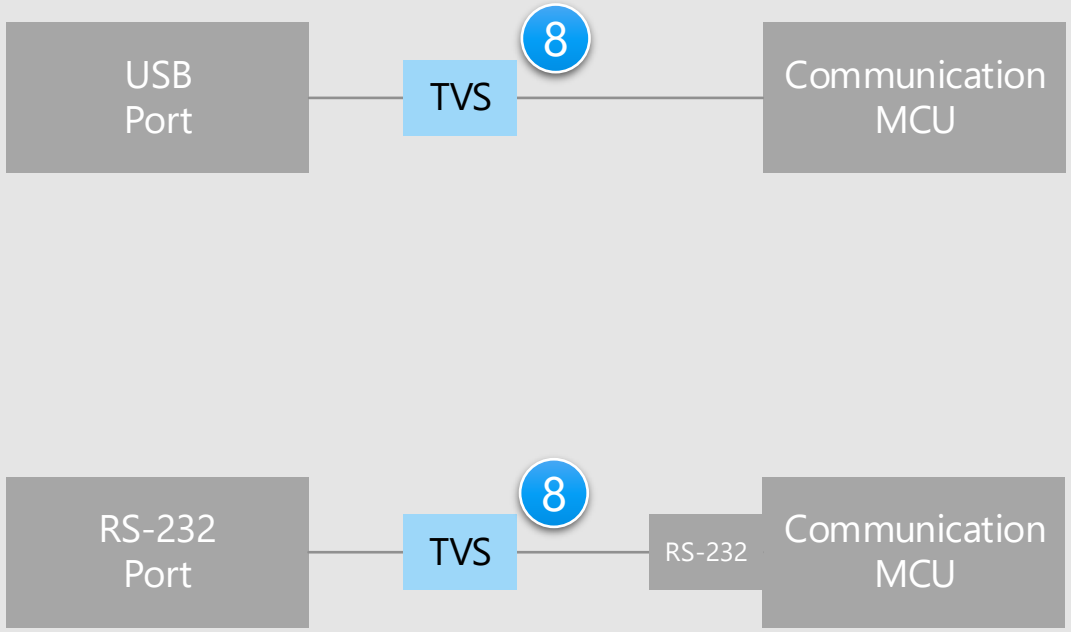
- Photocouplers are suitable for isolation in digital signal transmission lines.
- Isolation amplifiers are suitable for isolation between the high voltage circuit and various detection circuits.

Proposals from Toshiba

- **Photocouplers that are resistant to noise and can operate at high temperature** 4
  Photocoupler for high speed communication
  Transistor output photocoupler
- **Isolation amplifiers suitable for current and voltage detection circuits** 5 6
  Isolation amplifier
- **Easy software development using general purpose CPU cores** 9
  MCU M4K Group / M470 Group / M370 Group

Inverter/Servo　Detail of interface circuit

Interface circuits



Criteria for device selection

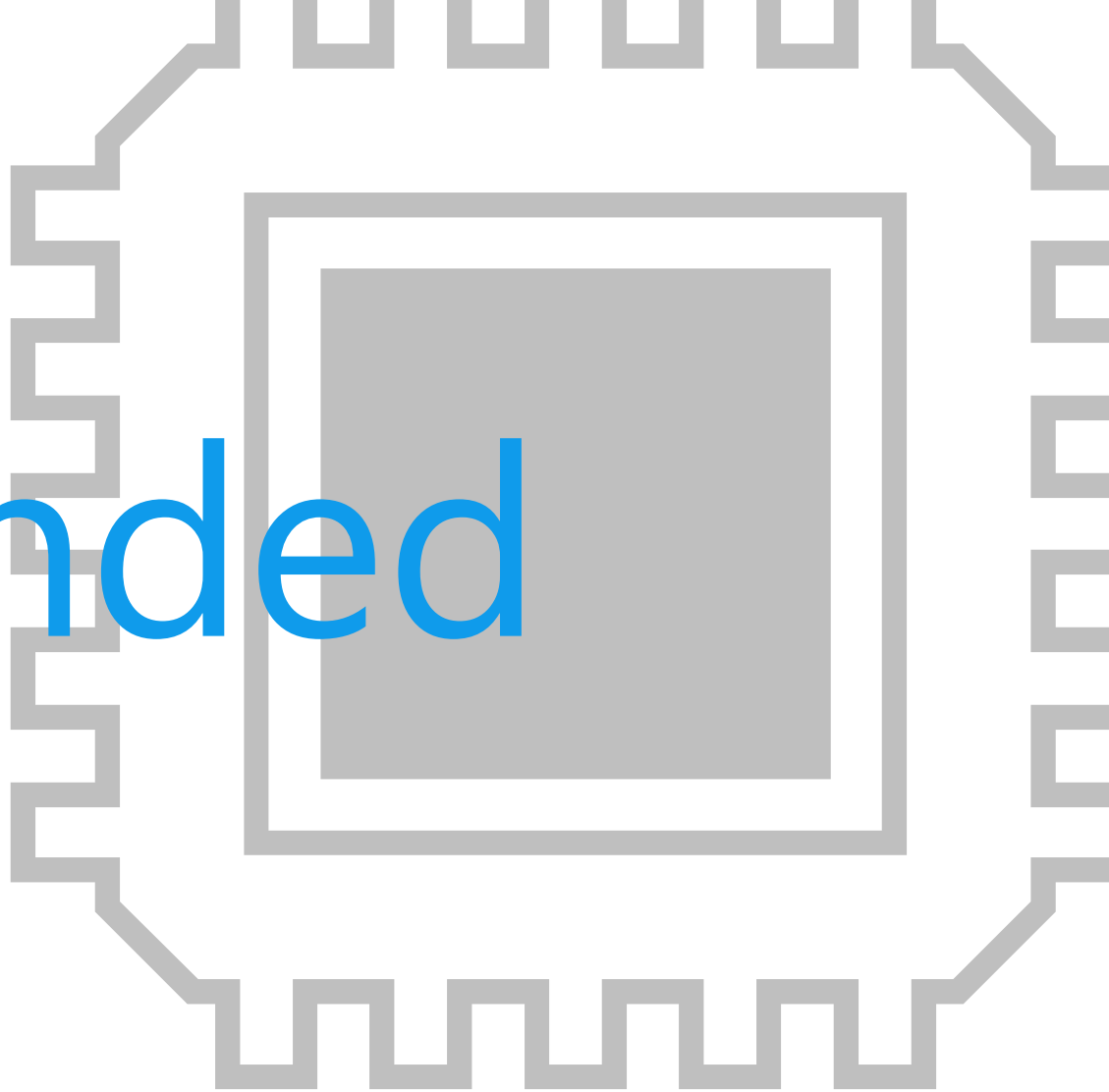
- TVS diode with a low capacitance is suitable for ESD protecting the USB signal line.

Proposal from Toshiba

- **Prevent circuit malfunctions and protect devices by absorbing electrostatic discharge from external terminals**
  TVS diode 8

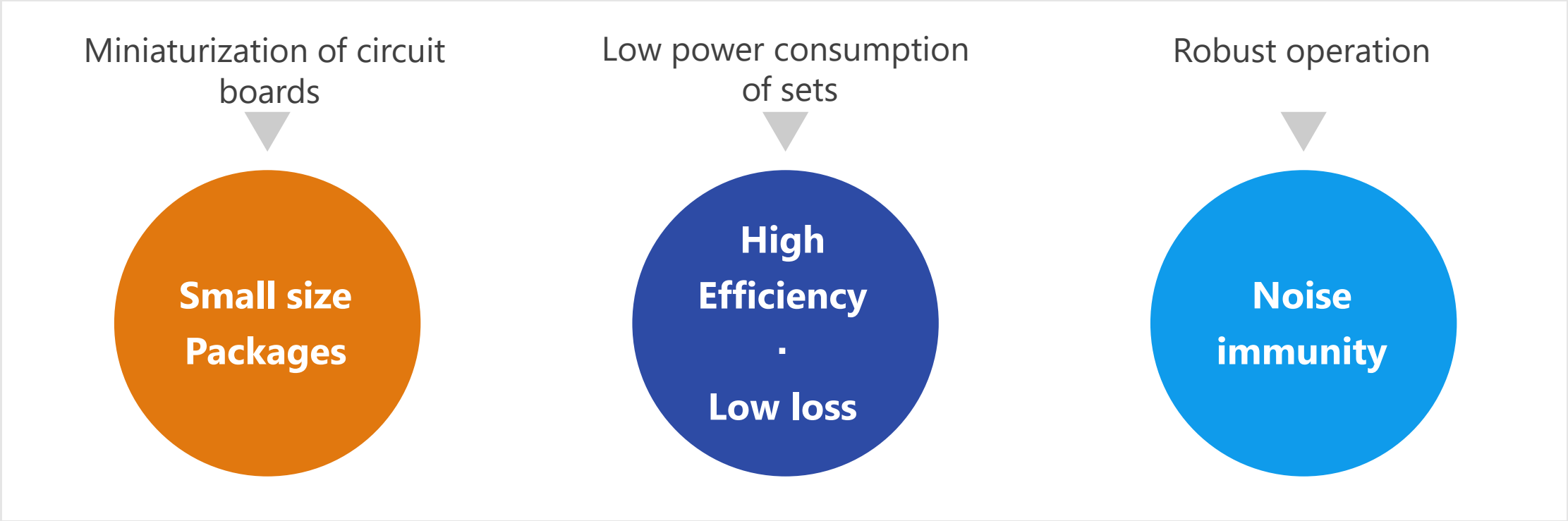
* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

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 M4K Group / M470 Group / M370 Group	●	●	
10 Small surface mount LDO regulator	●	●	●

DTMOS Series MOSFET

TK25A60X / TK16A60W5 / TK110A65Z / TK190A65Z / TK110U65Z / TK190U65Z

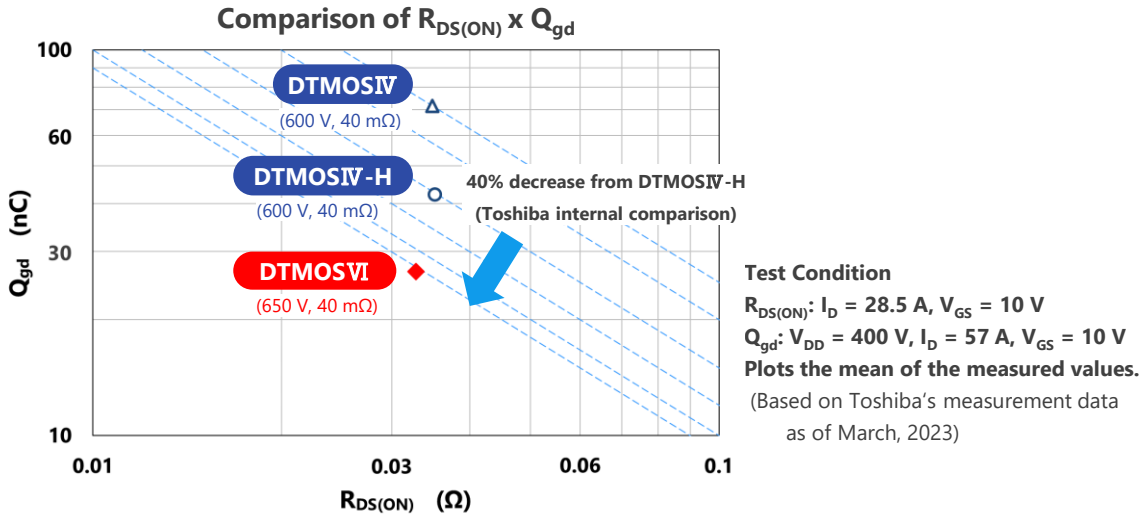
Small size packages | High efficiency · Low loss | Noise immunity

Value provided

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

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

In the DTMOSⅥ series, the $R_{DS(ON)}$ 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 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	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

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 low 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	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 low 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

2 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

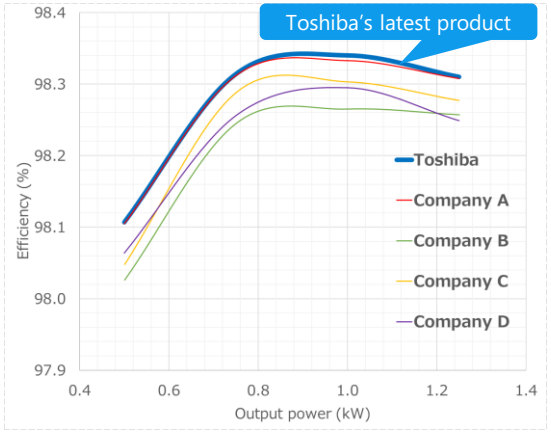
Compared with our existing products, the trade off of V_F x Q_C [Note2] of the latest products have improved. About 0.1% of conversion efficiency improvement have also achieved under 800 W output condition in our test.

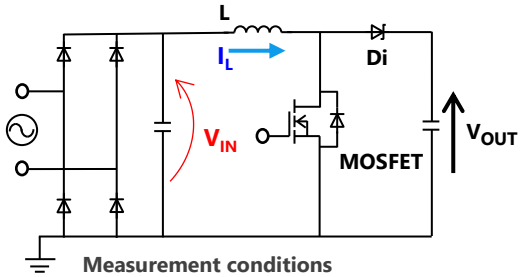
3 Expansion of package series

In addition to the existing package series, DFN8x8 surface mount package type has been 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

3a Gate driver photocoupler (for MOSFET/IPM [Note 1] driving)

TLP152 / TLP5774H / TLP2745 / TLP2719

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

[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

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

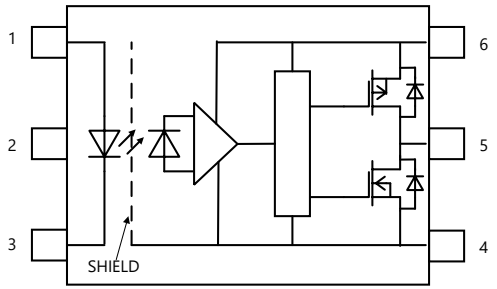
2 High isolation voltage

The isolation voltage BV_S is 5000 [Vrms]. (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)



1: Anode
2: N.C.
3: Cathode
4: GND
5: V_O (Output)
6: V_{CC}

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 2]
CQC-recognized GB4943.1, GB8898

[Note 2] 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/μs]	±20	±35	±30	±10
T_{opr} [°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

3b Gate driver photocoupler (for IGBT driving)

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).

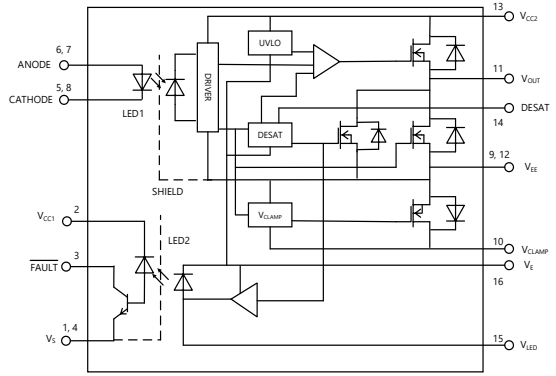
2 High temperature operation

The products are designed to operate even under severe ambient temperature conditions, such as 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.
The products with built-in overcurrent protection function are also provided.

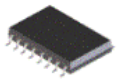
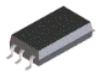
Internal circuit configuration (TLP5212)



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

4 Photocoupler for high speed communication

TLP2710 / TLP2761 / TLP2770 / TLP2210 / TLP2261 / TLP2270

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

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

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

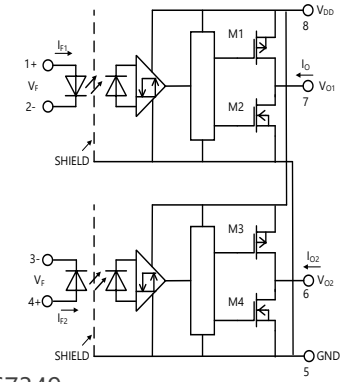
2 High isolation voltage

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. (-40 to 125 °C)

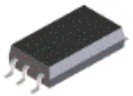
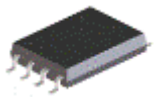
Internal circuit configuration (TLP2210)



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-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

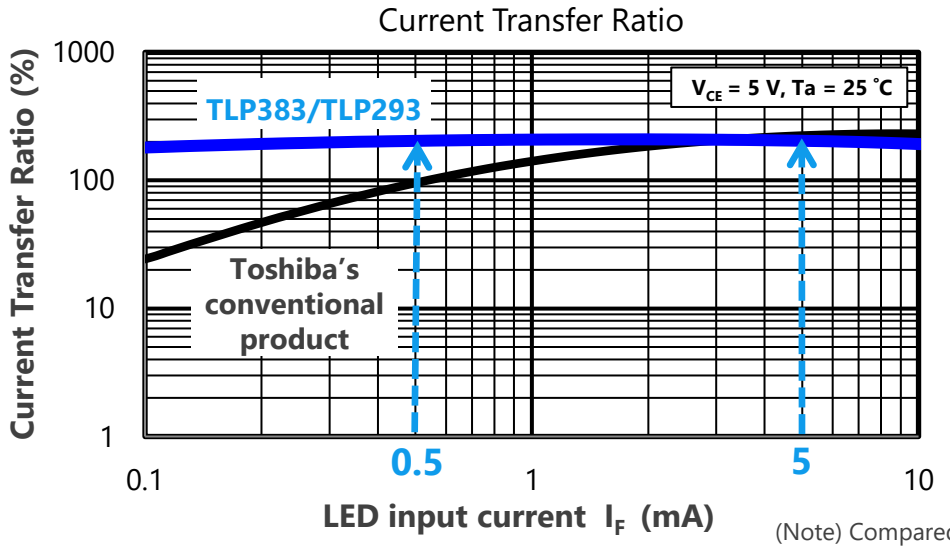
Small size packages | High efficiency · Low loss | Noise immunity

Value provided

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



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} [°C]	-55 to 125	-55 to 125	-55 to 110

(Note) Compared with Toshiba conventional products

◆Return to Block Diagram TOP

6 Isolation amplifier
TLP7820

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

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 ΔΣ AD conversion circuit on the input side and a high precision DA conversion circuit on the output side.

2 Support for common mode

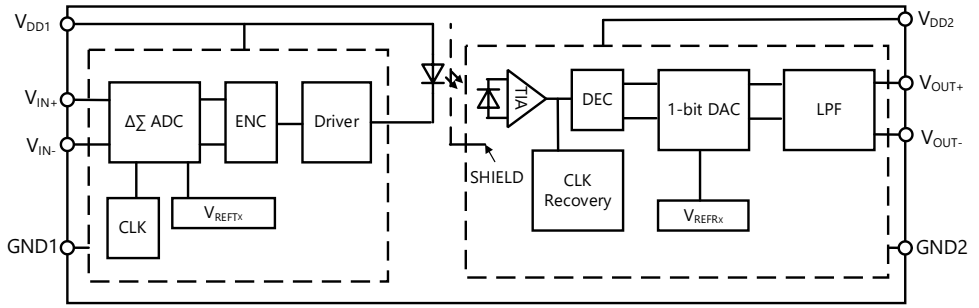
Common-mode transient immunity is provided with CMTI [Note 1] = 15 kV/μs (Min).

[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

Internal circuit configuration



[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: 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/μs]	15

◆Return to Block Diagram TOP

7 Photorelay

TLP3122A / TLP170AM / TLP3545A / TLP3547 / TLP240A / TLP241B

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

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 Ω (Max)
(TLP3547: A connection) [Note 1]

2 Wide current range

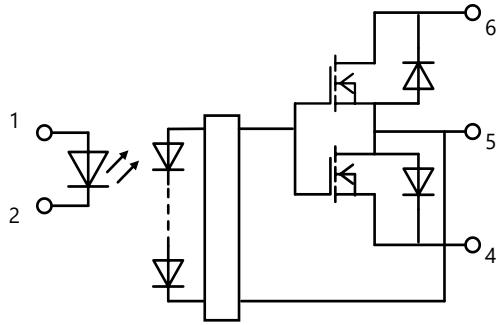
Wide range of allowed ON current I_{ON}, suitable for power line control.
I_{ON} = 5.0 A (Max)
(TLP3547: A connection) [Note 1]

3 Lineup of package and isolation voltage

The lineup of isolation voltage and package for improving design flexibility is provided.

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

TLP3545A
Internal equivalent circuit



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

◆Return to Block Diagram TOP

8 TVS diode

DF2B6M4BSL / DF2B20M4SL / DF2B5PCT / DF2B7PCT

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

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.

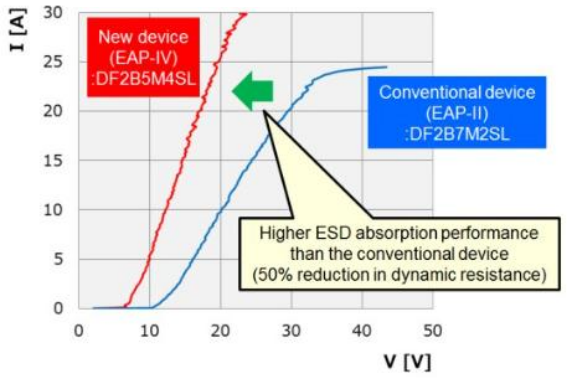
2 Suppress ESD energy by low clamp voltage

Protect the connected circuits and devices using proprietary technology.

3 Suitable for high density mounting

A variety of small packages are available.

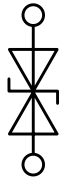
ESD Pulse Absorption Performance (Toshiba internal comparison)



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	DF2B6M4BSL	DF2B20M4SL	DF2B5PCT	DF2B7PCT
Package	SL2 		CST2 	
V_{ESD} [kV]	±8	±15	±30	±30
V_{RWM} (Max) [V]	5.5	18.5	3.6	5.5
C_t (Typ.) [pF]	0.12	0.2	41	45
R_{DYN} (Typ.) [Ω]	1.05	0.2	0.1	0.1
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.

◆Return to Block Diagram TOP

Value provided

System cost reduction, higher efficiency and less development work.

1 Equipped with motor control co-processor

Toshiba's original co-processor vector engine (VE) for motor control reduces CPU load and allows control of multiple motors and peripherals. [Note 1]

2 Equipped with motor control circuit

A variety of three-phase PWM [Note 2] waveforms and AD converters enable highly efficient, low noise control. The Advanced Encoder (A-ENC) reduces the load of CPU process in detecting the position performed for each PWM.

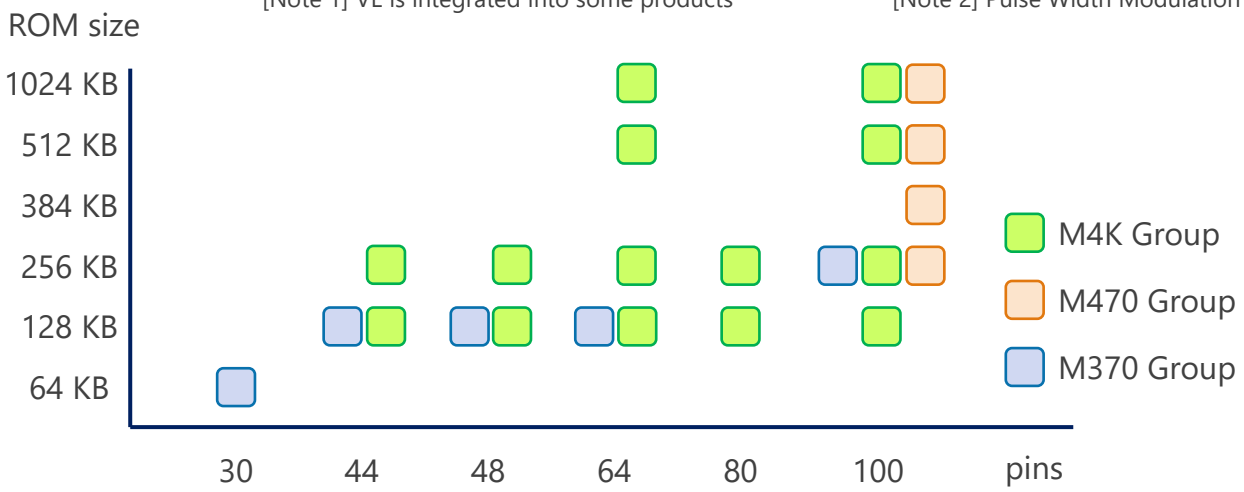
3 Provide development support tools

Third party evaluation boards and sample programs that can be used to shorten the development time are provided. Toshiba has begun offering a new, simple, versatile motor control software development kit (MCU Motor Studio). [Note 3]

[Note 1] VE is integrated into some products

[Note 2] Pulse Width Modulation

[Note 3] MCU Motor Studio supports some products and will expand in TXZ+™ family.



Lineup

Series	Group	Function
TXZ+™ 4A Series	M4K Group	Arm® Cortex®-M4, Max. 160 MHz operation 4.5 to 5.5 V, 3motor control (Max), Data Flash
TX04 Series	M470 Group	Arm® Cortex®-M4, Max. 160 MHz operation 4.5 to 5.5 V, 2motor control (Max)
TX03 Series	M370 Group	Arm® Cortex®-M3, 80 MHz operation 4.5 to 5.5 V, 2motor control (Max)

◆Return to Block Diagram TOP

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.

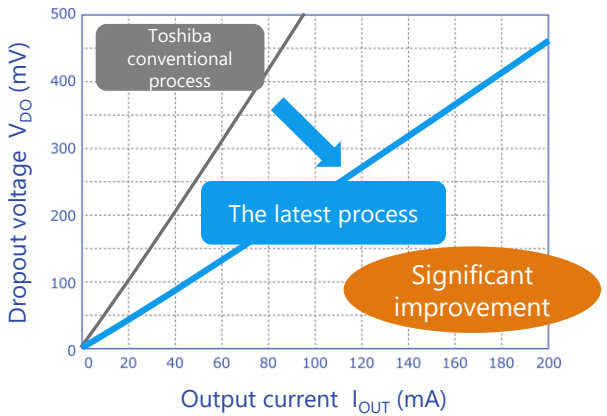
2 High PSRR Low output noise voltage

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

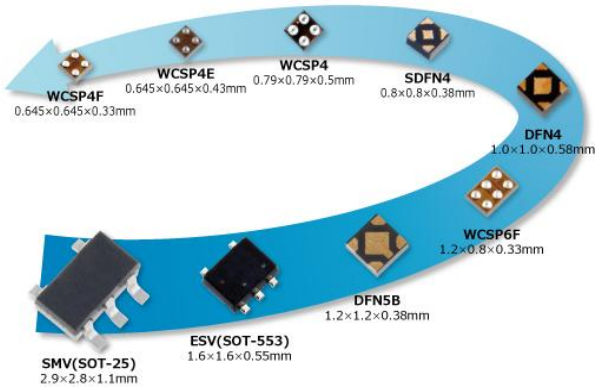
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

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

◆Return to Block Diagram TOP

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