TOSHIBA

BLDC: Brushless Motor

Proposal for Electric Motor Applications

Toshiba Electronic Devices & Storage Corporation

2021.September

Contents

01 Overview of Toshiba Electronic Devices & Storage Corporation

02 Motor Applications

03 3-Phase BLDC Motor Control Devices

04 Power Devices

05 Small Signal & Opto Devices

01

Overview of Toshiba Electronic Devices & Storage Corporation

Toshiba Group Organization

(April, 2021)

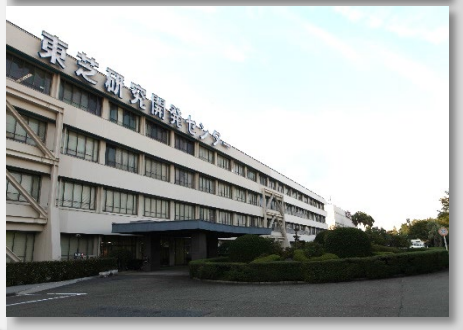
Toshiba Corp.

FY19 Sales
3,390 billion yen

President & CEO
Satoshi Tsunakawa

Finance
Common R&D
Strategy

R&D Center



Electronic Devices & Storage

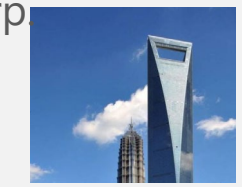
Toshiba Electronic Devices & Storage Corp.

FY19 Sales
746 billion yen

* incl. NuFlare Technology, Toshiba Materi and Toshiba Hokuto Electronics

Infrastructure

Toshiba Infrastructure Systems Corp.



FY19 Sales
1,796 billion yen

* incl. Toshiba TEC, Battery and Building Solutions businesses

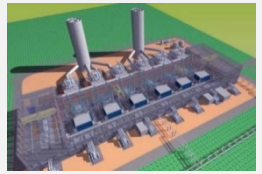
ICT Solutions

Toshiba Digital Solutions Corp.

FY19 Sales
252 billion yen

Energy

Toshiba Energy Systems Corp.



FY19 Sales
569 billion yen

Toshiba Electronic Devices & Storage Corp. Organization

of employee: 24,100 (consolidated), 4,000 (non-consolidated), as of September 30, 2020

(April, 2021)

Board of Directors

President & CEO
Hiroyuki Sato

SVP & CTO
Seiichi Mori

VP
Akitoshi Iwata

K. Kishimoto
T. Kamebuchi
T. Yamamoto
Y. Karakawa

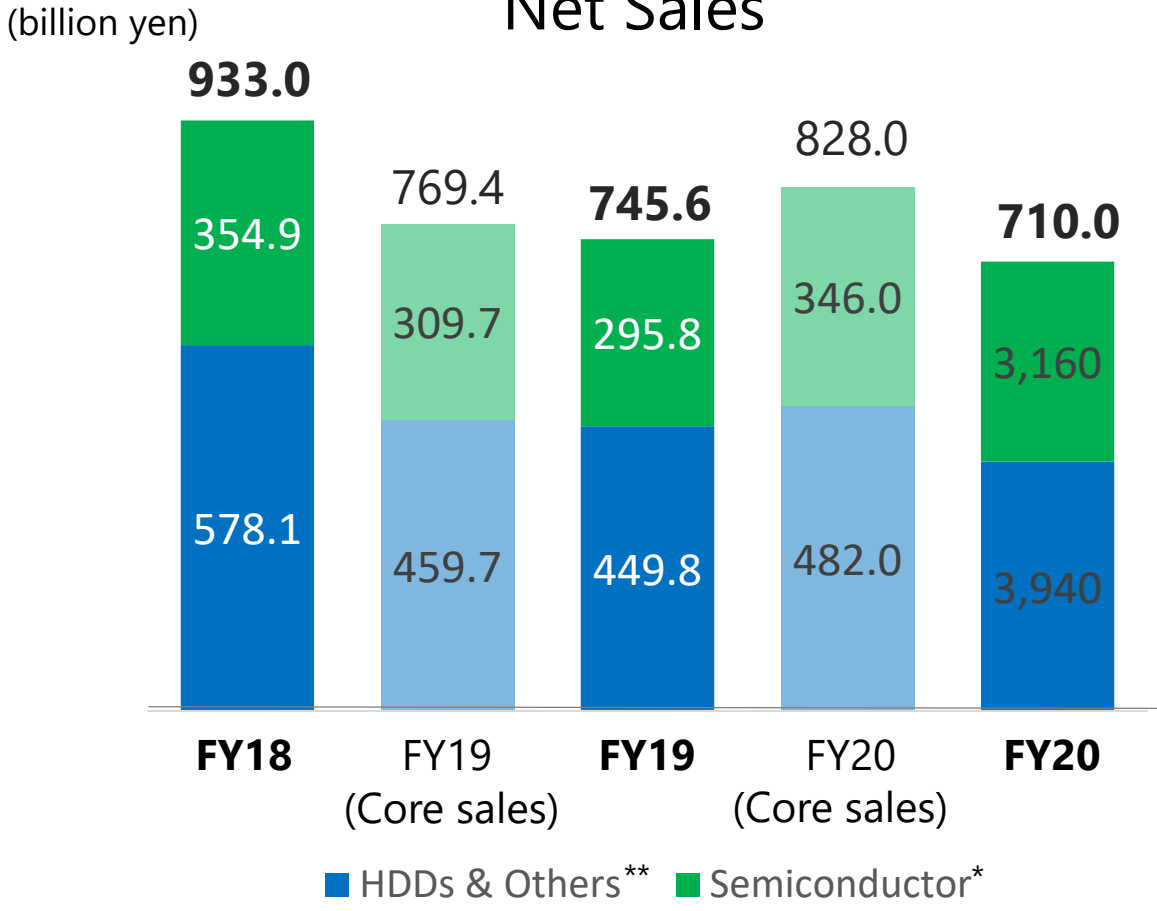
T. Miyamori
H. Kawagoe
M. Sakai
H. Ishii

- **Shared Services**
- **Semiconductor Division** — **T. Kamebuchi**
- **Storage Products Division** — **A. Iwata**
- **Electronic Devices & Storage R&D Center** — **T. Miyamori**

Toshiba Elec. Devices & Storage's Consolidated Sales Revenues & OPs

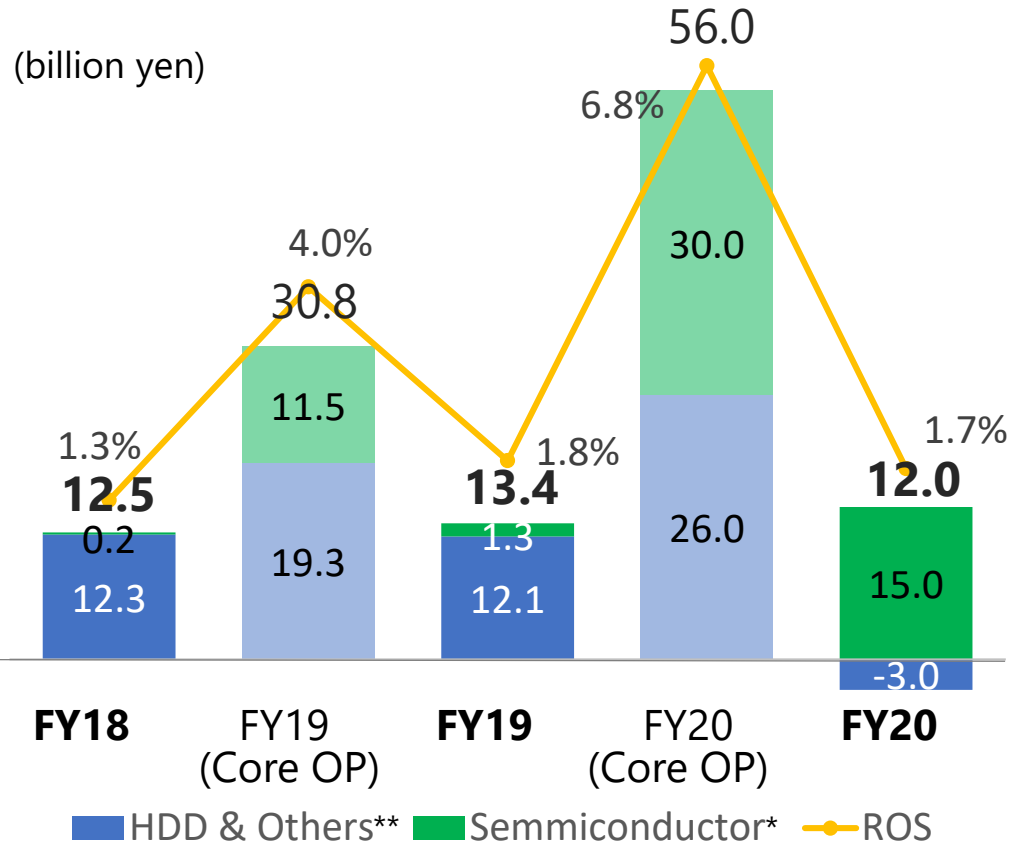
(Forecasts/results announced on February 12, 2021)

Net Sales



* Discrete, System LSI and NuFlare Technology ** HDD, Materials & Devices, and resale

Operating Incomes



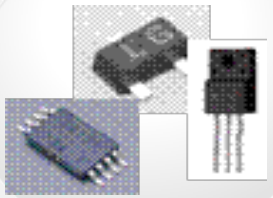
* 9.8 billion yen impairment for NFT, triggered by a decline in its stock price is included in FY18, and 4.9 billion yen and 8.0 billion yen restructuring costs in FY19 and FY20 respectively.

Note: Core Sales (OP) means sales revenue and operating income excluding restructuring cost, etc. and impact of COVID-19.

Our Solution for Customers

Broad product offering that solves customers' problems

Discrete Semiconductors



- Small signal device
- Power device
- Opto device

System Devices (System LSIs)

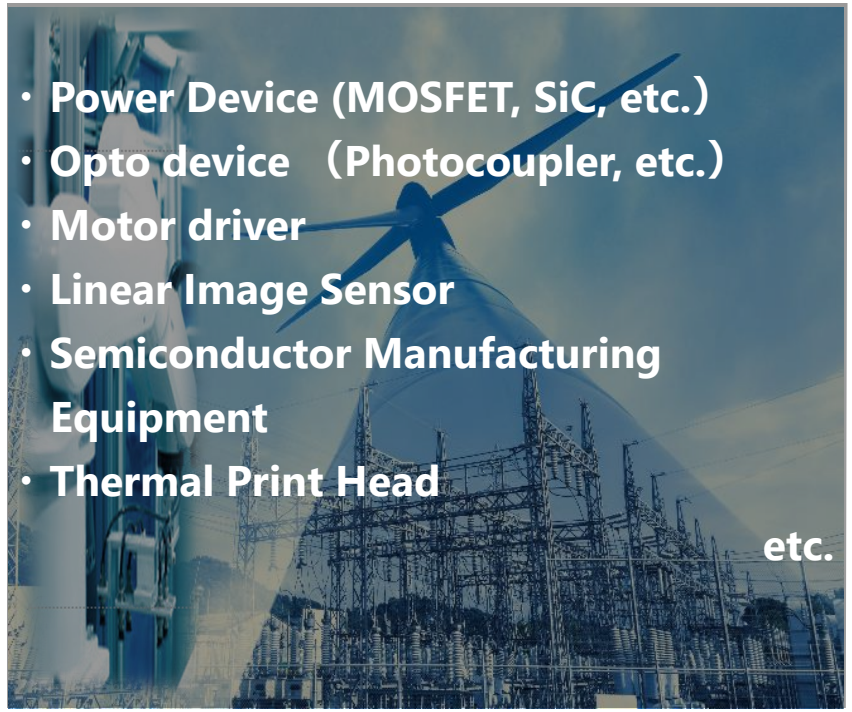
- Analog IC
- MCU

Storage Products

Enterprise HDD
Consumer HDD

Focus Areas

● Industrial



● Automotive

● Data Center

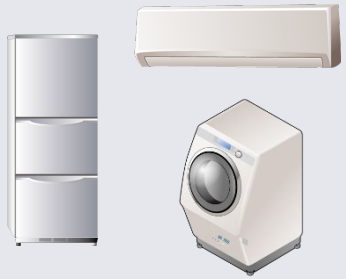
02

Motor Applications

Toshiba Motor control technologies

Over 40 years' experience in the semiconductor market and **high-power electronics** is Toshiba's strength. We can offer new system solutions across many applications.

Home appliance



A/C. REF , W/M

- **MCUs with vector engines TX and TXZ+ series**
- **MOSFET/IGBT**

Compressor

Fan

- **Three-Phase brushless and sensorless Motor controllers**
- **Discrete devices & IPDs**

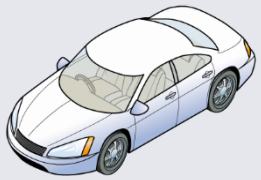
Cleaner

BLDC Motor

Stepping Motors

Brushed DC Motors

Automotive



Large Motors

Main Motors for EV/HEV

Medium-sized Motors

Blower Motors, cooling fans, and Motors for electric doors, electric power steering (EPS)

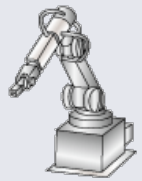
Small Motors

Oil pumps, fuel pumps, water pumps, mirrors, and electronic throttles

- **In-vehicle equipment Analog devices ASICs/ASSPs**
- **MOSFET/IGBT /IPD**

Industry

BLDC Motor



AGV, Garden tool, Robotics, Fan, Power tool, printer

- **MCUs with vector engines TX and TXZ+ series**
- **MOSFET/IGBT/IPD**
- **Motor control driver**

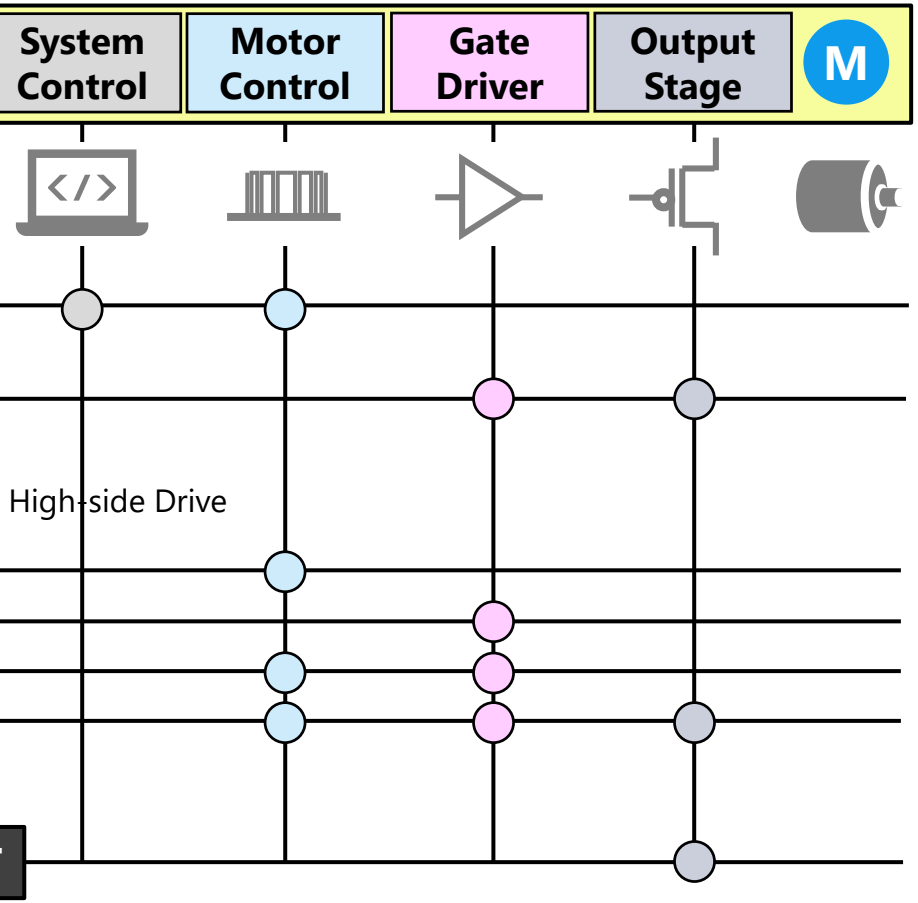
Brushed DC Motors

Stepping Motors

Motor Control IC Line-up & Toshiba Proposals

Toshiba Provides All Necessary ICs for Motor Control Based on General Motor Control Structure

Motor Control Structure



Control Devices

Microcontroller Unit

1. System Development TAT Improvement
2. High Efficiency Motor Control
3. Cost Down & Downsizing

HVIPD

1. Reduces Power Consumption (Loss)
2. Eliminates Need for Power Supply for High-side Drive
3. Reduces Acoustic Noise

Motor Control Driver

1. Low Power Consumption
2. Wide Line-up
3. Reduction of Complex Adjustment Work

- Controller Type
- Gate Driver Type
- Pre-Driver Type
- Driver Type

Power Devices

Discrete IGBT

1. Low Power Consumption
2. Reduction of Short-circuit Current
3. Low Emission Noise

Low Voltage MOSFET

1. High Efficiency (Energy Saving)
2. Wide Line-up
3. Ease of Use

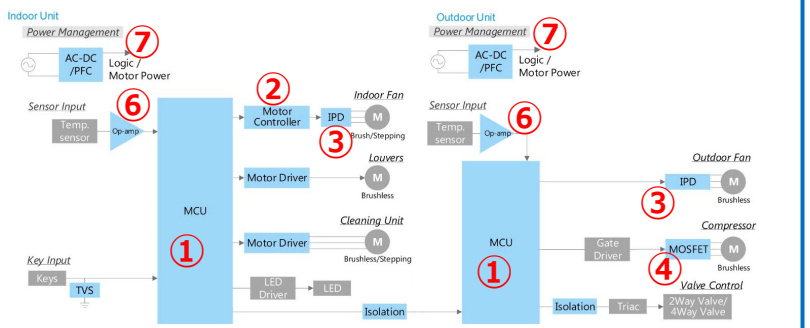
High Voltage MOSFET

1. For Power Factor Correction (PFC) : DTMOS Series
2. For Motor Drive & Inverter Circuits : MOSFET Series with Fast Reverse Recovery Diode
3. For Switching Devices in Primary Side of Auxiliary Power Supplies : High-voltage MOSFET Series

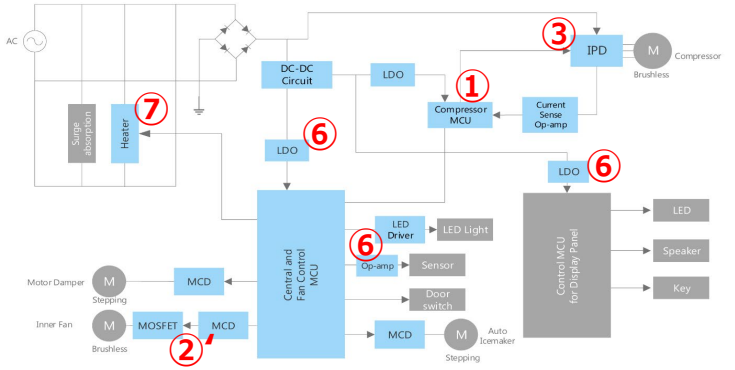
AC-Power-Input Applications

Toshiba provides best products from wide variety of lineup according to each application.

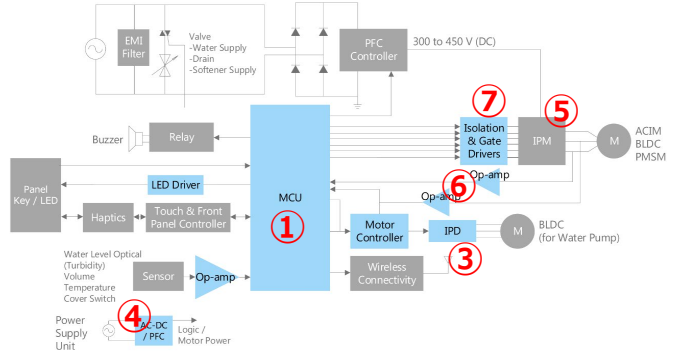
Air conditioner



Refrigerator



Washing machine



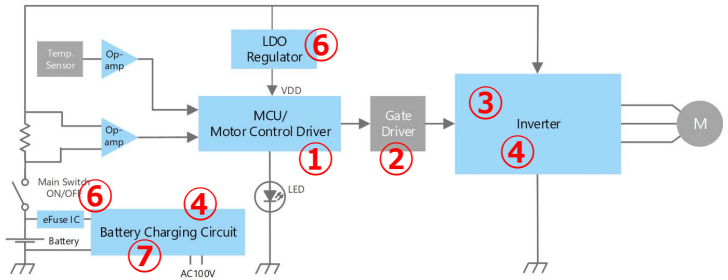
Request to application	Request to semiconductor	Slot	Recommended products	Features
Efficiency (energy savings)→	Low power consumption device	①	M4K, M3H, M470, M370 groups	Efficient development, high-efficiency Motor control, cost reduction, compact size
		②	TB6584, TC78B041, TC78B042, TB67B000A	Silent operation by 3-Phase & sine-wave drive
Silent & low vibration →	Sine-wave drive	②′	TC78B002	Single-Phase drive & small package
		③	HVIPD (square-wave & sine-wave)	Low power consumption, simplified design, Silent
Durability →	Low noise	④	HVMOS (DTMOSⅣ・Ⅵ-H 600 to 650V)	Low conduction & switching loss, durability
		⑤	D-IGBT for Motor (600 to 650V)	Low power loss, durability
Compact →	Small package	⑥	Small signal device (eFUSE IC, LDO, MOSFET etc)	Small package, accuracy, wide variety of lineup
		⑦	Photo coupler (Tr/Triac output)	High conversion ratio, high temperature operation guaranteed

Application website: https://toshiba.semicon-storage.com/jp/semiconductor/application.html?category=indu

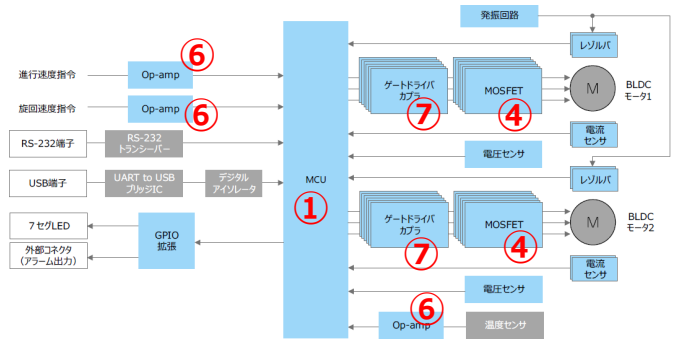
DC24/48V or Li-ion Battery　Application

Improve Application performance by best product offering for DC/battery voltage

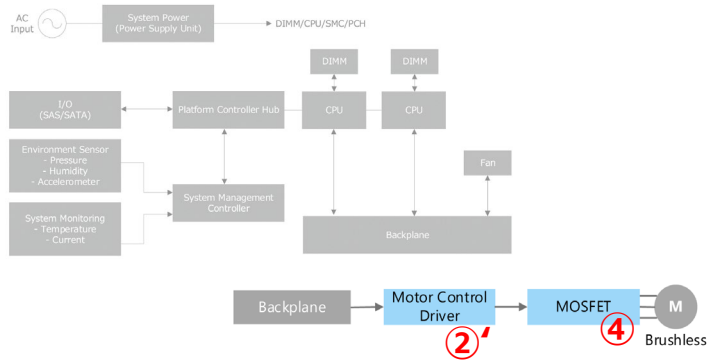
Cordless power tool



AGV



Sever fan（24/48V bus）



Request to application	Request to semiconductor	Slot	Recommended products	Features
Long-time operation →	Low power loss, high-efficiency drive	①	M4K, M3H, M470, M370 groups	Efficient development, high-efficiency Motor control, cost reduction, compact size
Silent & low vibration →	Sine-wave drive	②	Gate Driver (under development)	High voltage, Lineup by internal Reg/current sense/IF
Durability →	Vector engine	②'	TC78B025/027/009	Stable operation with closed loop control
Large torque →	Low noise	③	LVIPD for BLDC Motor	Protection & diagnosis function in small package
High-speed rotation control →	Large-current power device	④	LVMOS　U-MOS IX,X-H (30 to 100V)	Low conduction & switching loss, durability
Compact & light →	High-efficiency control(vector control)	⑥	Small signal device (eFUSE IC, LDO, MOSFET etc)	Small package, accuracy, wide variety of lineup
Large capacity →	High speed switching	⑦	Photo coupler (Tr/Triac output)	High conversion ratio, high temperature operation guaranteed
	Compact, good heat radiation, function integration			
	Wide variety of voltage lineup			

Application website: https://toshiba.semicon-storage.com/jp/semiconductor/application.html?category=indu

Proposal from Toshiba Electronic Devices & Storage Corporation

Best product offering for wide variety of AC/DC input voltage.

Input	Input voltage	Application	Solution	Recommended product series
AC	Single-Phase 100 to 120V Single-Phase 200 to 240V 3-Phase 200 to 240V	Air conditioner Refrigerator Washing machine	MCU+HVIPD MCD+HVIPD MCU+Pre driver+HVMOS/IGBT	MCU: M4K, M3H, M470, M370 MCD: TB6584・TC78B041/042 (Controller) TB67B000A (600V/2A) TC78B002 (for REF Fan, 12V) HVIPD: Square-wave & sine-wave HVMOS: DTMOSⅣ・Ⅵ-H (600 to 650V) IGBT: IGBT for Motor (600 to 650V)
DC	DC24/48V or Li-ion battery	AGV Power tool for Garden E-bicycle Sever fan Cordless power tool Cordless cleaner Robot cleaner Amusement device Printer Security camera	MCD MCU＋LVIPD MCU＋Pre driver+LVMOS	MCU: M4K, M3H, M470, M370 MCD: High-Voltage gate driver TC78B025/027/009 (for sever) TB67B001・TB67H450 (for robot cleaner) LVIPD: Low-voltage gate driver LVMOS: U-MOSⅧ・Ⅸ・X-H (30 to 100V)

Application website: https://toshiba.semicon-storage.com/jp/semiconductor/application.html?category=indu

03

3-Phase BLDC Motor Control Devices

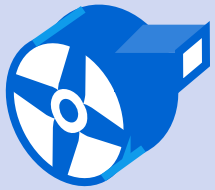
03-1

MCD: Motor Control Driver

Focused Application

Self-detection & No need adjustment are Keywords for next field.

HA	OA	Industrial	Fan	Battery Solution
A/C, Washing Machines, Refrigerator, Cleaner etc..	**IJP/LBP/MFP, Scanner etc..**	**ATM, Vending Machine, Amusement, Surveillance Camera, Robotics etc..**	**Server fan, Blower, Ventilation fan, Ceiling fan etc..**	**DSC, Toy, Electric lock, 5V USB or Battery powered instruments etc..**



Motor control drivers

Power saving | Commu-nication | Develop-ment support

Value provided

Toshiba's unique technologies and broad product portfolio provide outstanding capabilities for your Motor applications.

1 40 years' experience

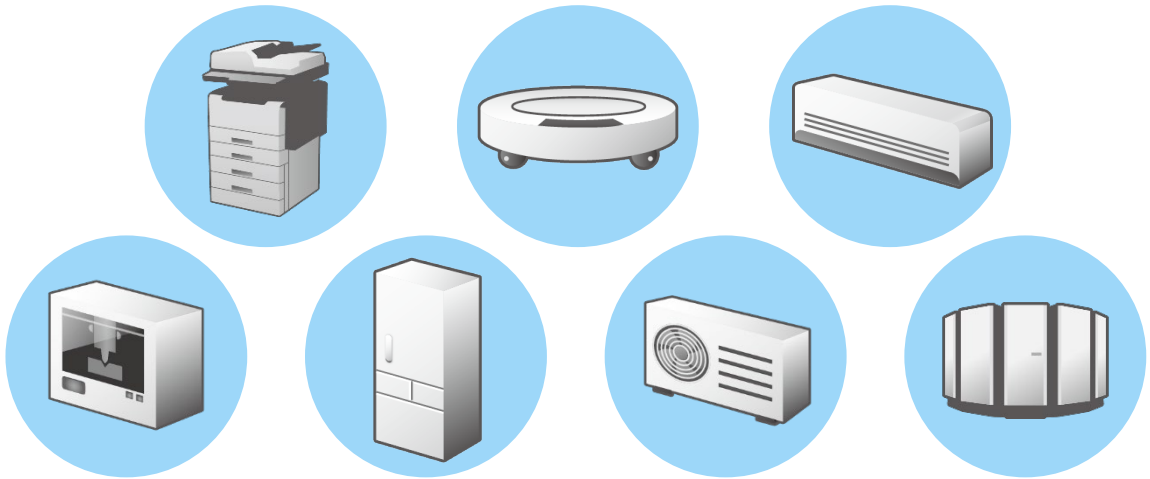
- More than 40 years' experience in the semiconductor market for home appliances, axial fans, and industrial equipment

2 Broad product portfolio (190 products)

- Solutions for many applications through a broad portfolio of Motor controllers and drivers

3 Unique technologies

- Real-time adjustment
  Automatic optimization of Motor drive
  → Intelligent Phase Control
  Active Gain Control



Customer value / Social subject contribution

- Efficient and stable Motor control
- Environmental protection
- Improvement of device performance and reduction in power consumption

Product lineup

- Products with Active Gain Control
  TB67S249 (4.5 A), TB67S279 (2 A), TB67S289 (3 A): Available (stepping Motor drivers)
  TB67S128: Available (128-step stepping Motor driver)
- Products with Intelligent Phase Control
  TC78B016: Available (40 V, 3 A driver)
  TC78B041: Available (18 V, 20 mA controller)

BLDC Motor drive technology : Intelligent Phase Control

Power saving | Commu-nication | Develop-ment support

Value provided

One-time adjustment provides highest efficiency over wide rotational speed range.

1 Highest efficiency over wide rotational speed range

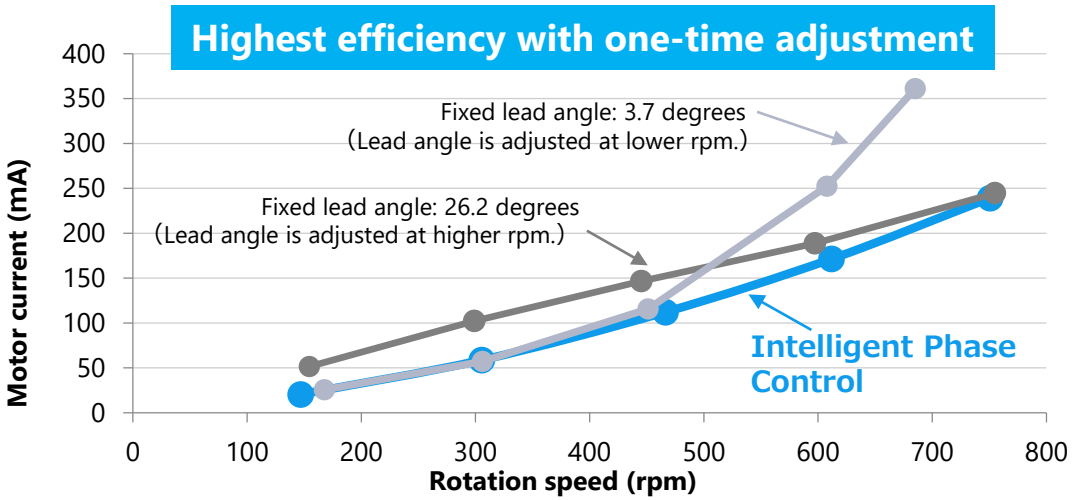
Automatically aligns Phases of voltage and current to achieve the highest efficiency

2 Adjustment is unnecessary to achieve optimum drive.

One-time adjustment optimizes Motor control over wide rotational speed range.

3 Low noise

Three-Phase sine-wave drive provides quiet and smooth Motor rotation.



Customer value / Social subject contribution

- Efficient and stable Motor control
- Environmental protection
- Improvement of device performance and reduction in power consumption

Product lineup

- Products with Intelligent Phase Control
  TC78B016FTG: Available (40 V, 3 A BLDC driver)
  TC78B041FNG: Available (18 V, 20 mA BLDC controller)

Brush less DC Motor Controller/Driver - Roadmap -

Power saving | Commu-nication | Develop-ment support

Intelligent Phase Control & Closed loop for 3 Phase BLDC

3Phase High Rating Voltage

- 12 pole Controller TB67B054
- New: Intelligent Phase Control TC78B041/042 → Intelligent Phase Control Next Generation
- 500V SIP TB67B000 (Driver) → New: 600V SIP TB67B000A

3Phase Low Rating Voltage

- 1-Hall /3-Hall Square Wave TB78B015/A/B/C
- 3-Hall Sine wave TC78B016
- New: 1-Hall Square Wave/Sine Wave TC78B025(Driver), TC78B027(Pre-driver) (Intelligent Phase Control, Closed Loop)
- Sensorless Square Wave (Driver) TC78B008 (Driver) TC78B001
- New: Sensorless Square Wave TC78B009 (Pre-driver) → Sensorless Sine Wave
- 3ch Half-Bridge TB67Z800 → High-voltage Gate Driver

Single Phase Low Rating Voltage

- TC78B002 (Driver) → TC78B006 (Pre-driver)

New Product

Under Planning Under development

~2019 | 2020 | 2021~

03-2

MCU: Microcontroller Unit

MCU

Low Power | Communi cation | Dev. Support

Value provided

Helps system development, efficiency up, cost down and downsizing

1 System Development TAT Improvement

- Integrated Motor control hardware (VE, PMD, ADC & Encoder) helps improve system development TAT for vector control.

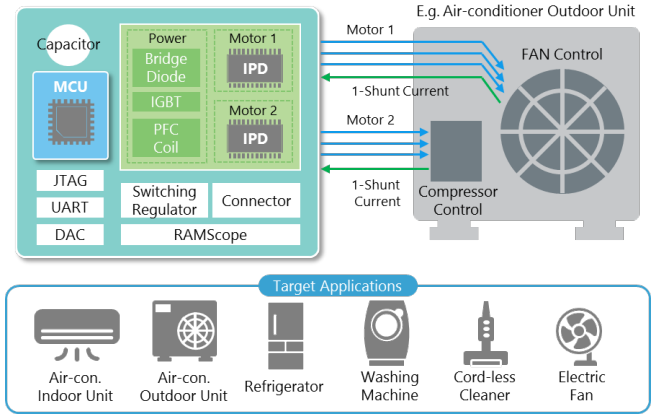
2 High Efficiency Motor Control

- VE & Encoder reduce CPU load by doing vector calculation & position estimation on behalf of CPU. Vector control improves system efficiency.

3 Cost Down & Downsizing

- Integrating external part (Op-Amp), supporting sensor-less 1-shunt (VE +PMD) and driving multiple Motors (CPU+PMD) optimize total system.

VE : Vector Engine (next page shows details)
PMD : Programmable Motor Driver (next page shows details)



1 MCU can control multiple Motors and other processes (e.g. PFC)

Customer value / Social subject contribution

- High efficiency & stable Motor control and low noise
- Environment friendly
- Contribution to performance up and power saving on equipment

Product lineup

- M370 series : Arm® Cortex®-M3 core with VE
- M470 series : Arm® Cortex®-M4 core with VE
- M4K series : Arm® Cortex®-M4 core with VE

System Development TAT Improvement

Shorten Development TAT by Motor Control Hardware

3-Phase PWM (PMD)

- ✓ 3-Phase complementary PWM output and AD converter co-working
- ✓ Ease of controlling BLDC Motor

AD Converter (ADC)

- ✓ 12-bit SAR type
- ✓ Conversion synchronizing with Motor control timing

Vector Engine (VE)

- ✓ Vector calculation hardware
- ✓ Co-work with ADC & PMD
- ✓ User-settable current command & Phase

Encoder (ENC)

- ✓ Ease of obtaining Motor position
- ✓ Supports direct-input of incremental encoder and hall sensor

M4K Group

* Supported functionality varies depending on MCU

Improve Motor Control Efficiency by Vector Control Hardware

Point 1 Vector Calculation

- Auto-calculation on coordinate transformation, PI control, etc.
- User-programmable on position & speed control.

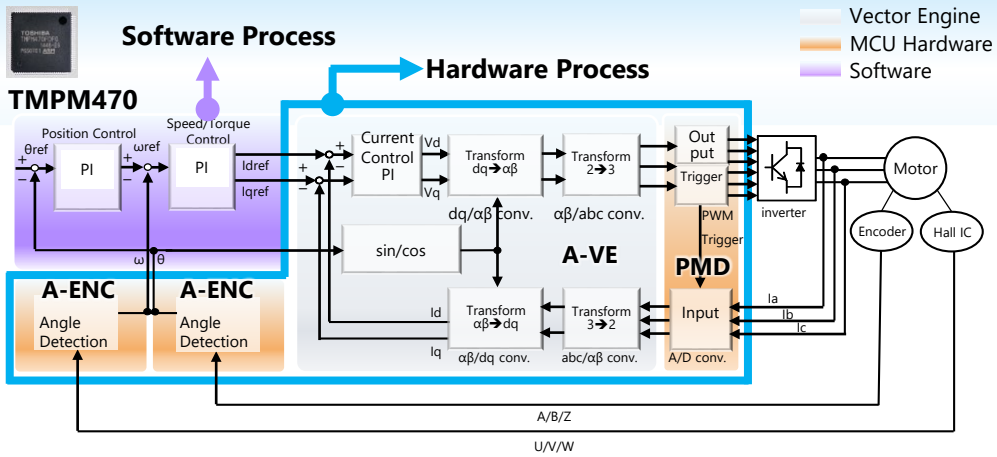
Point 2 Associated Functions

- Vector calculation with 3-Phase PWM output and AD converter reduces CPU processing time significantly.

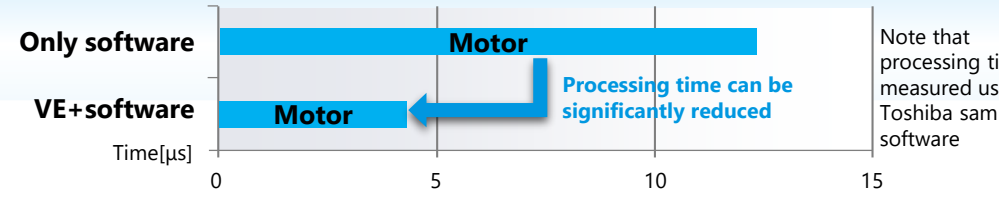
Point 3 Encoder & Hall Sensor

- Support 2- & 3-Phase incremental encoder with high accuracy count using both edges, rotation direction detection.
- Support hall sensor with direction, speed and RPM detection.

Structure of Motor Control (Vector Control)



Processing Time of Software (CPU clock 120MHz)



Significantly reduce CPU load,
High speed PWM & high accuracy vector control

Optimize Motor Control by Integration, 1-Shunt and Multi-Motor

Point 1 Built-in Op-Amp

- Built-in functions such as Op-Amp to amplify shunt current for vector control
- high accuracy oscillator and data flash reduce BOM

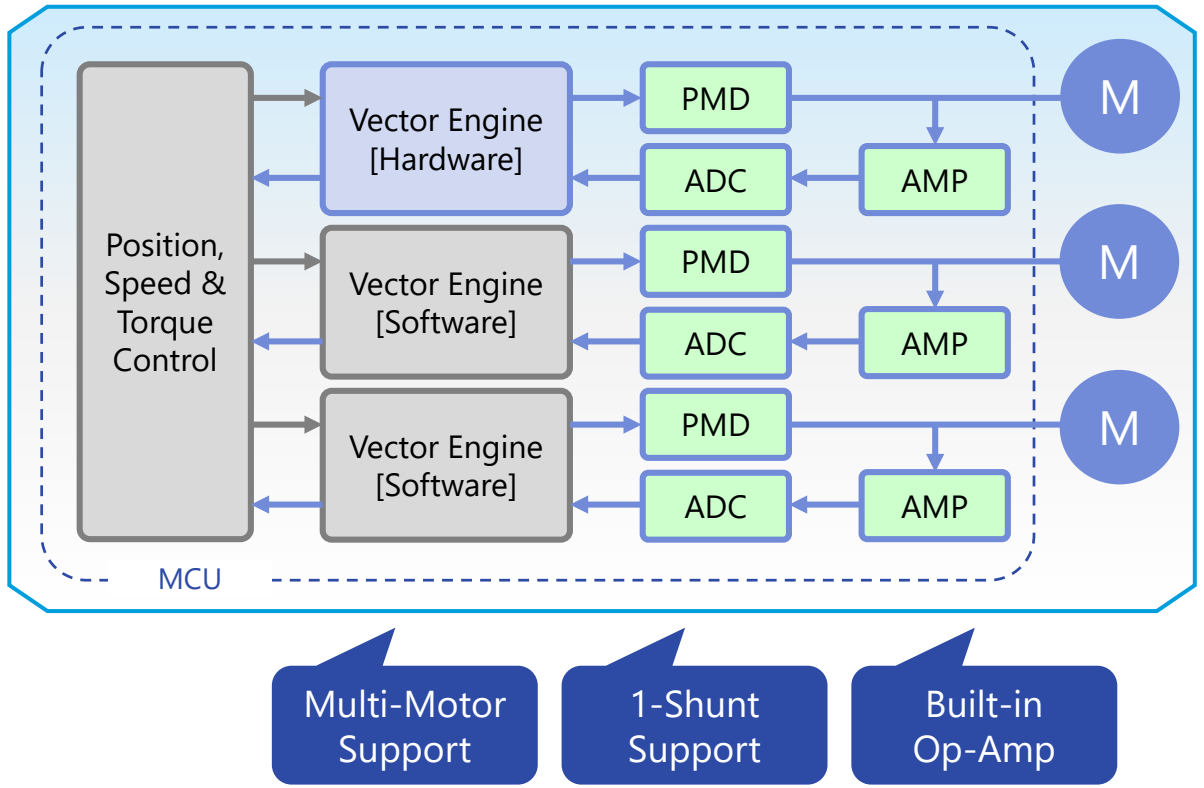
Point 2 1-Shunt Support

- PMD, a function to generate ADC trigger based on PWM waveform, supports 3-shunt as well as 1-shunt.

Point 3 Multi-Motor Control

- High speed CPU, vector engine and multiple PMDs support max. 3 Motor control.

Example : 3 Motor Control by M4K



03-3

BLDC Motor Drive Devices : <IPD>

BLDC Motor Control Devices: HV-IPDs

Value provided

Reduction in power consumption and efficiency improvement due to improved characteristics

1 Reduces power consumption (loss)

MOSFET modules provide roughly 36% reduction in power loss compared with conventional devices that use IGBTs at output stage.

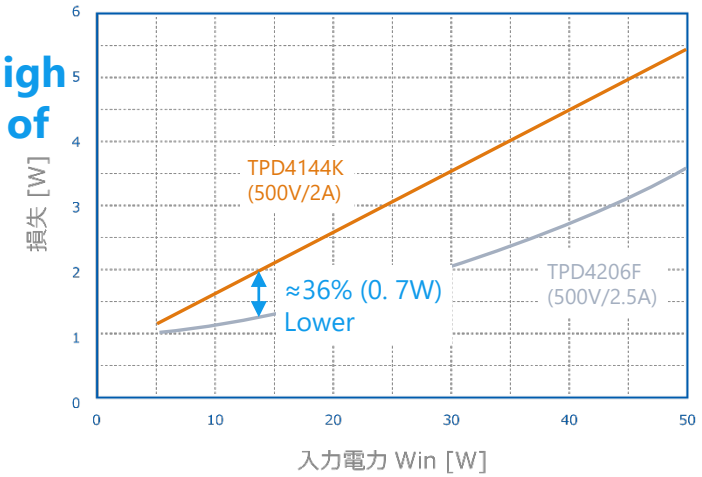
2 Eliminates need for power supply for high-side drive

Power supply for high-side drive is unnecessary owing to Toshiba's proprietary high-voltage SOI process and trench isolation structure as well as internal bootstrap diode.

3 Reduces acoustic noise

- Combination of MCU and MCD enables sine-wave drive.
- Smooth and quiet Motor operation

HV-IPDs provide high efficiency because of improved characteristics.



Customer value / Social subject contribution

- High-efficiency and high-performance Motor drive technology
- Environmental protection
- Improvement of system performance and reduction in power consumption

Product lineup

- MOS module-type HV-IPDs

TPD4204F (600 V/2.5 A, sine-wave type): Available
TPD4206F (500 V/2.5 A, sine-wave type): Available
TPD4207F (600 V/5.0 A, sine-wave type): Available

Low-Voltage IPD for Brushless Motor Drives (LVIPD)

Power saving | Commu-nication | Develop-ment support

Value provided

Protection and a diagnostic function are built in a compact package, and it contributes to the miniaturization of a set, and quality improvement.

1 Various functions High performance

- Built-in charge pump circuit for driving the N-channel MOSFET on the high side.
- High current output +1A/-1.5A.
- Driver power supply voltage, output voltage diagnosis.

2 Small package

- It is lineup about a SOP type and the non lead QFN type.

TPD7212F:WQFN32 5x5 mm (76% down)*

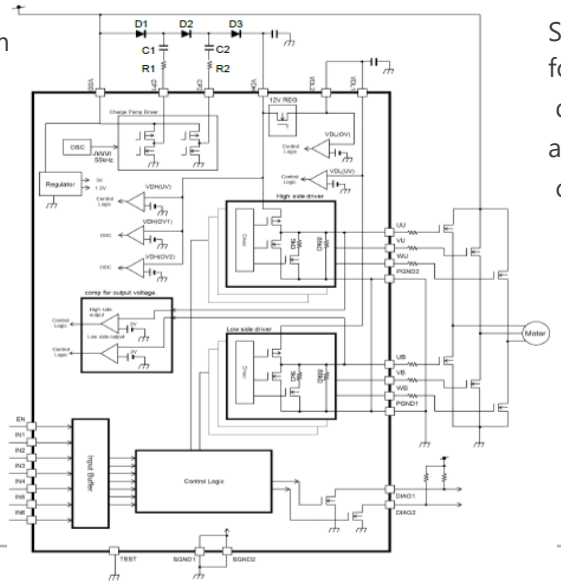
TPD7212FN:SSOP30 7.6x9.7 mm (29% down)*

*: A size ratio of conventional parts TPD7210F.

3 High added value

- AEC-Q100 conformity (TPD7212FN)

Internal block diagram / The example of an application circuit



Since the charge pump circuit for a high side N-channel MOSFET drive is built in, a three Phase full bridged circuit can be constituted easily.

Customer value / Social subject contribution

- A detailed process is adopted and produced commercially with a compact package from conventional parts, and it contributes to the miniaturization of a set.
- Various protection and a diagnostic function are corresponded to built-in and in-vehicle reliability, and it contributes to quality improvement of a set.

Product lineup

Part number	TPD7210F (conventional parts) *New design deprecated	TPD7212F	TPD7212FN
Package	SSOP24 (8x13mm) 	WQFN32 (5x5mm) 	SSOP30 (7.6x9.7mm)
Power supply voltage range of operation (Power supply voltage maximum rating)	4.5 to 18V (40V@pulse)	4.5 to 18V (40V@pulse)	4.5 to 18V (40V@pulse)
Output current	±1A	+1A/-1.5A	+1A/-1.5A
Operational temperature range (Junction temperature maximum rating)	-40 to 125℃ (150℃)	-40 to 150℃ (175℃)	-40 to 150℃ (175℃)

04

Power Devices

Low withstanding voltage MOSFET（LVMOS）

Low Power Consumption | Telecommunication | Development Support

Value provided

Wide lineup and easy-to-use design, contributing to energy saving and high efficiency

1 High Efficiency (Energy saving)

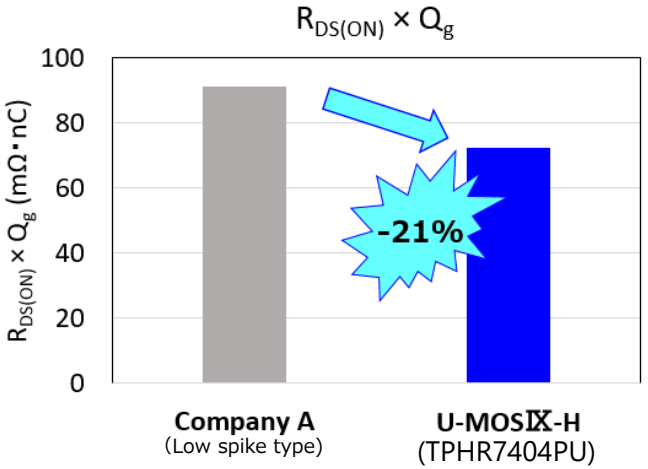
- Low On-Resistance Characteristics by Advanced Refinement Process
- Improves $R_{DS(ON)}$ and Q_g trade-off by optimization of cell structure

2 Wide Line up

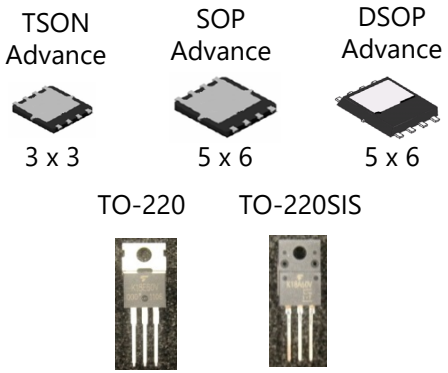
- Wide range of withstanding voltage lineups (20 to 250V)
- Support various packages from SMD to TO-220 type

3 Ease of Use

- Low Spike and Low Ringing Characteristics with Parasitic Snubbers
- Tch=175°C guaranteed (U-MOSIX-H, X-H)
- High avalanche tolerance



Better $R_{DS(ON)}$ x Q_g



Various package lineup

Customer value / Social subject contribution

- High-efficiency performance in line with increasing energy-saving requirements (low on-resistance, low charge)
- Optimized for secondary-side synchronous rectification of power supply circuits and inverter drive of Motors in conjunction with higher efficiency
- Achieved industry-leading FOM (performance indicator)*

*As of 10th May 2021(as surveyed by Toshiba)

Product lineup

- U-MOSX-H：80V
- U-MOSⅨ-H：30V, 40V, 45V, 60V, 100V
  40V(low spike type), 60V(low spike type)
- U-MOSⅧ-H：30V, 40V, 60V, 75V, 80V, 100V, 120V, 150V, 200V, 250V

High-voltage MOSFETs

Energy-saving | Communication | Development support

Value provided

Extensive product lineup allows you to select MOSFETs that best meet application requirements.

1 For power factor correction (PFC): DTMOS series

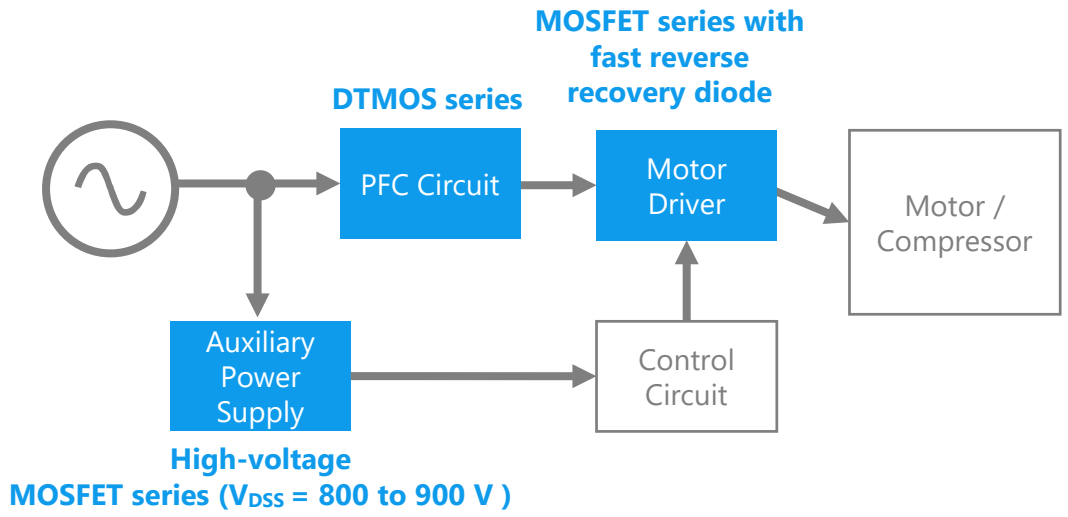
Reduces power loss and improves efficiency because of low gate capacitance, fast switching, and low on-resistance.

2 For Motor drive and inverter circuits: MOSFET series with fast reverse recovery diode

Reduces power loss and improves efficiency because of optimum reverse recovery characteristics of parasitic diode

3 For switching devices on primary side of auxiliary power supplies High-voltage MOSFET series (V_{DSS} = 800 to 900 V)

MOSFETs with V_{DSS} of 800 to 900 V are ideal as switching devices on primary side of small-capacity auxiliary power supplies for which flyback configuration is commonly used.



Customer value / Social subject contribution

- Efficiency improvement and reduction in power consumption
- Environmental protection

Product lineup

Product lineup

- PFC circuits: DTMOSVI series (650 V): Available
  DTMOSIV-H series (600 V, 650 V): Available
- Motor drivers: DTMOSIV (HSD) series (600 V, 650 V): Available
- Auxiliary power supplies: DTMOSIV series (800 V): Available
  High-voltage π-MOSVIII series (800 V, 900 V): Available

Discrete IGBT

Power saving | Commu-nication | Develop-ment support

Value provided

Low-loss device by fine integration & field-stop structure

1 Low power consumption

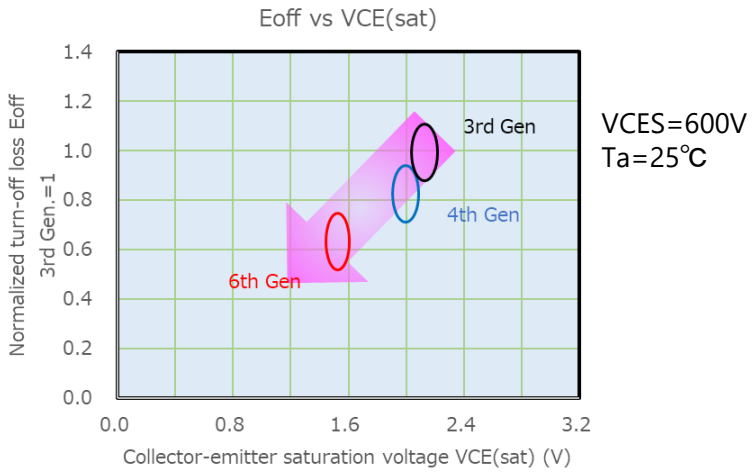
- Low VCE(sat) & high speed by field-stop structure
- Low capacitance with new gate structure
  → Low Switching & drive loss

2 Reduction of short-circuit current

- Reduction of short-circuit current by reducing collector-emitter saturation current

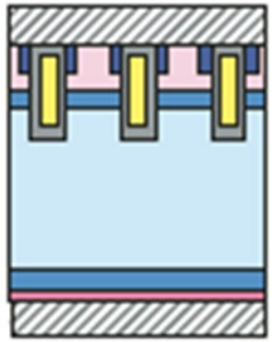
3 Low emission noise

- Optimized chip design
- High-speed performance by reducing emission noise



VCES=600V
Ta=25℃

Field-stop structure



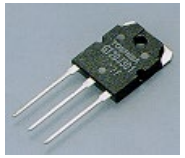
Customer value / Social subject contribution

- Low-loss device by field-stop structure
- Improved durability by reducing short-circuit current

Product lineup

- GT15J341 (TO-220SIS)
- GT20J341 (TO-220SIS)
- GT30J341 (TO-3PN)


TO-220SIS


TO-3PN

SiC MOSFET

Power saving | Commu-nication | Develop-ment support

Value provided

Designer-friendly product “Toshiba SiC MOSFET”

1 Wide V_{GSS} specification

- V_{GSS} specification is wider than that of competitors.
- SiC MOSFET V_{GSS} : -10V to 25V
  → designer-friendly product

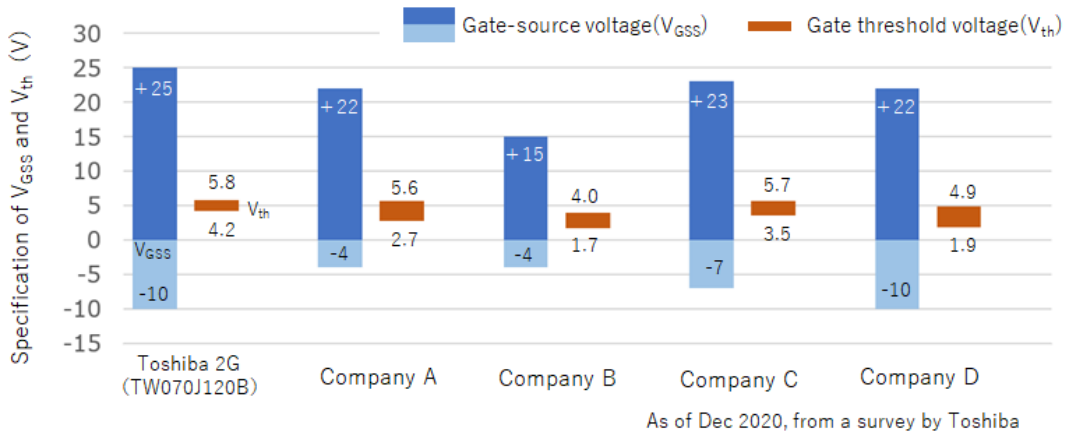
2 High Vth

- High V_{th} with low On resistance
- SiC MOSFET V_{th}: 5.0V(typ.)
  Spec: 4.2 to 5.8V
  → prevention from malfunction

3 SBD embedded in die

- Small diode VF
  V_{DSF} = −1.35V (typ.)

■Comparison in V_{GSS}と Vth specifications



As of Dec 2020, from a survey by Toshiba

Customer value / Social subject contribution

- Ease of design
- Prevention from malfunction
- Energy saving by high-efficiency performance

Product line-up

- 2nd generation 1200V SiC MOSFET (TW070J12B)
- 3rd generation 650/1200V SiC MOSFET (Under development)

SiC SBD

Value provided

Wide lineup of current & package, contributing to energy saving and high efficiency

1 Low IR

- Low IR by improved JBS structure
  IR : 50μA max @650V, 25℃

2 Low VF

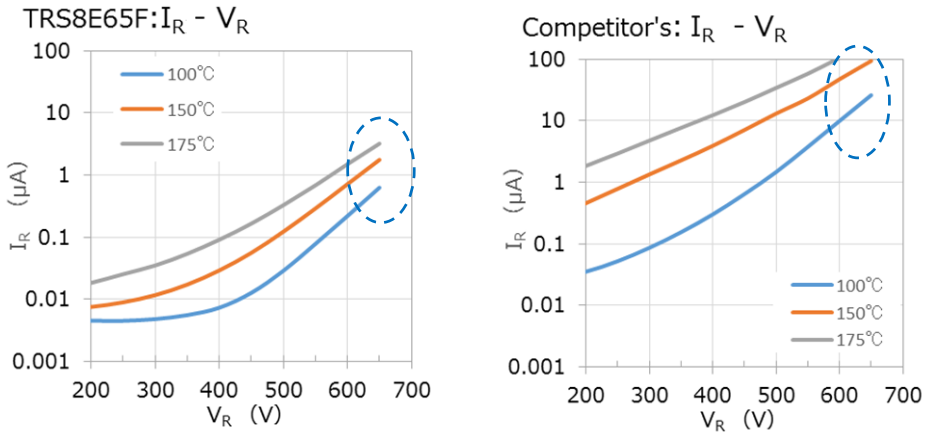
- Low VF by thinner-wafer technology
  VF spec, : 1.45V (typ.)

  ＊3rd generation
  (under development)=1.2V

3 High IFSM

- High IFSM by improved JBS structure
  (83A @ TRS10E65F)

I_R comparison at high temperature (highly better than competitor's)



Customer value / Social subject contribution

- Energy saving by low-power-loss performance
- High durability

Product lineup

- 2nd generation 650V SiC SBD
- 3rd generation 650V/1200V SiC SBD（under development）

05

Small Signal & Opto Devices

eFuse IC（Electronic Fuse）

Value provided

eFuse IC (Electronic Fuse) can protect circuits from abnormal conditions such as overcurrent and overvoltage repeatedly

1 High-speed short-circuit protection

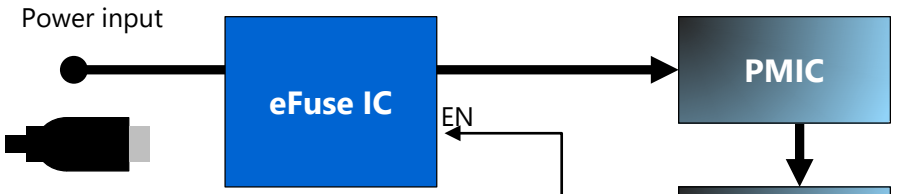
Fast Trip function instantaneously cuts off the output current when a short circuit occurs.
(150ns typ:TCK8xx)

2 Excellent protection characteristics

In the event of an overvoltage or overcurrent, the output voltage and output current are held stably by the overclamp.

3 IEC62368-1 certified

Complied with the International Safety Standard IEC62368-1 (G9: IC Current Limiter), it provides robust protection and simplifies designs.



- Short circuit protection
- Over Current protection
- Overvoltage protection
- Reverse current blocking
- Inrush current protection
- Thermal Shutdown
- International Safety Standards (IEC62368 – 1)

Product lineup

PN	Vin	OCP	OVP	Recovery	Flag	Package
TCKE805NA	4.4V~18V	0.5A~5.0A	6.04V	Auto retry	None	WSON10/10B 3x3mm
TCKE805NL	4.4V~18V	0.5A~5.0A	6.04V	Latched	None	
TCKE812NA	4.4V~18V	0.5A~5.0A	15.1V	Auto retry	None	
TCKE812NL	4.4V~18V	0.5A~5.0A	15.1V	Latched	None	
TCKE800NA	4.4V~18V	0.5A~5.0A	None	Auto retry	None	
TCKE800NL	4.4V~18V	0.5A~5.0A	None	Latched	None	
TCKE712BNL*	4.4V~15V	0.5A~3.65A	Adjustable	Latched	Available	

* Planned to obtain IEC62368-1 certification

Small package LDO regulator

Value provided

Low Dropout Voltage in various packages

1 Low Drop-out

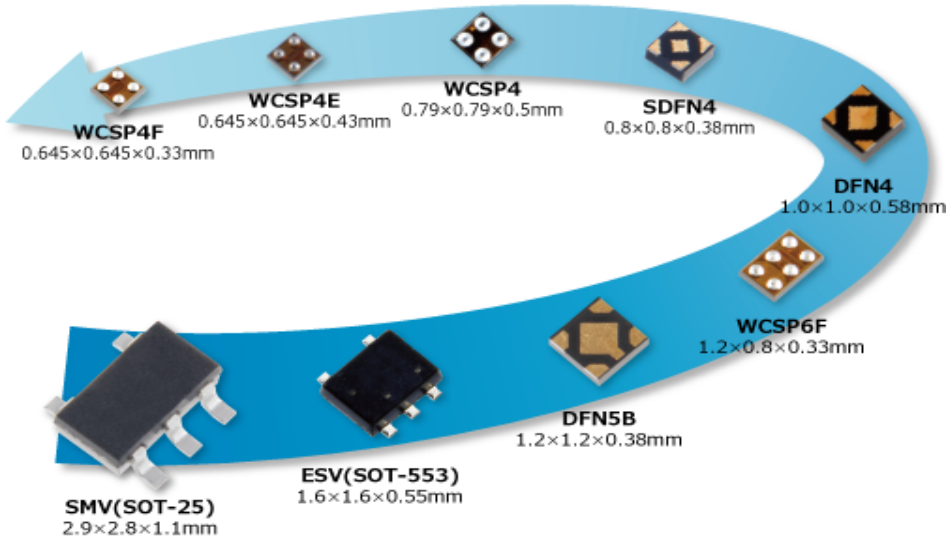
Improve drop-out performance by new process technologies
(50 % lower drop-out vs previous gen.)

2 High PSRR Low noise output

Suitable for RF, sensors, Camera and audio power supply

3 Low quiescent current

Achieved ultra low I_q (ON):0.34 uA: TCR3U series by using original circuit technologies



Product lineup

I_{OUT}(A)	Series	Future	PSRR(dB) typ@1kHz	I_Q (μA) typ
1.5	TCR15AG	Low drop-out・High PSRR	95@0.9V	25
1.3	TCR13AG	Low drop-out・High PSRR	90@0.9V	52
0.8	TCR8BM	Low drop-out・High PSRR	98@0.8V	20
0.5	TCR5RG	High PSRR・Low noise	100@2.8V	7
	TCR5BM	Low drop-oout・High PSRR	98@0.8V	19
0.3	TCR3RM	High PSRR・Low noise	100@2.8V	7
	TCR3U	Low Iq	70@0.8V	0.34
	TCR3D	Standard	70@2.5V	65
0.2	TCR2L	Low Iq	-	1
	TCR2E	Standard	73@2.5V	35
	TAR5	Vin 15V, Bipolar process	70	170

CMOS OPAMP for sensors

Value provided

Suitable small signal use case for various sensors required high accuracy

1 Low noise output

Achieved very low noise output, WW top class[1] by original process and circuit

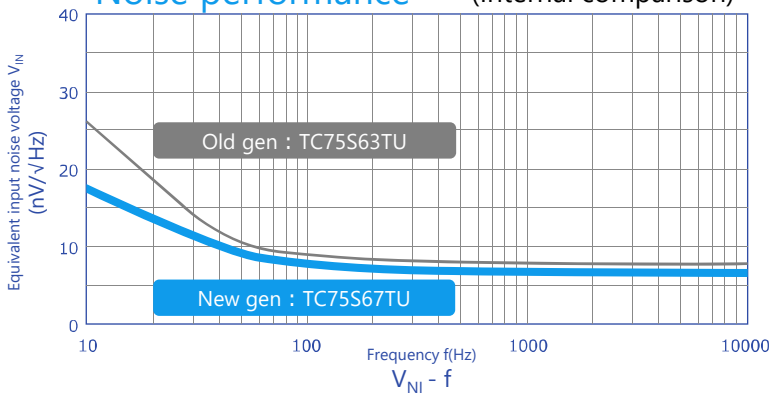
2 Low Off set

Achieved Low off set, V_{IO} max:1.3 mV (TC75S102/103)

3 Low quiescent cuurent

Achieved Low I_{DD}:0.3 μA, TC75S102

Noise performance (Internal comparison)



Product lineup

Spec	TC75S67TU	TC75S102xx	TC75S103xx
Type	Low noise	Low iq･VDD	Standard
V_{DD}, V_{SS}	2.2 to 5.5V	1.5 to 5.5V	1.8 to 5.5V
I_{DD}	430μA	0.3μA	100μA
VIO,VIO drift	3mV:Max	1.3mV:Max	1.3mV:Max
fT	3.5MHz	0.6kHz	350kHz
SR	1.0V/ms	0.35V/ms	0.6V/μs

[1] Toshiba original research in Dec 2020

Small package Schottky Barrier Diode

Power saving | Commu-nication | Develop-ment support

Value provided

Down sizing by new package US2H which is low Rth

1 Low Rth

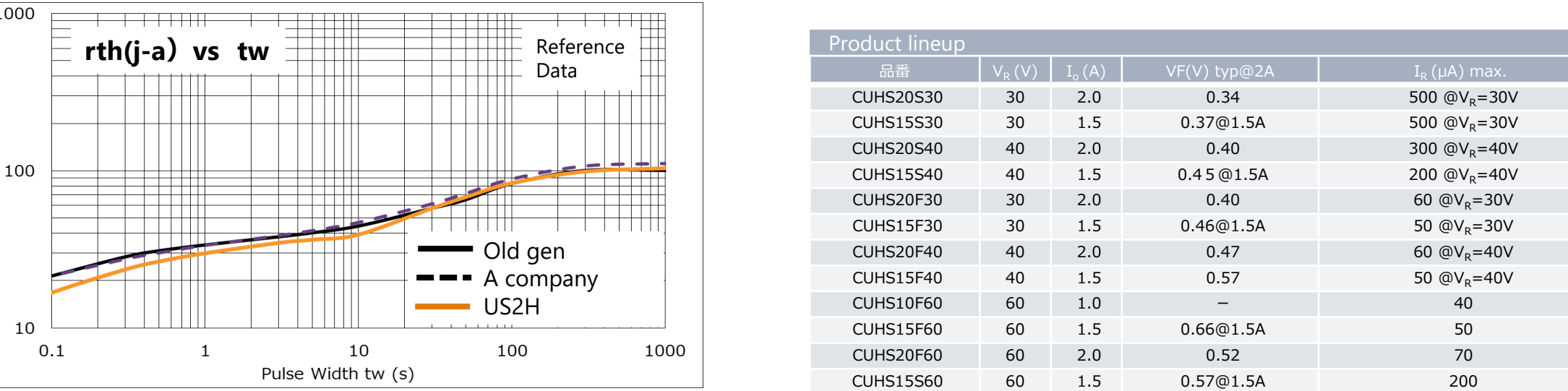
New US2H package is lower thermal resistance Rth compared with competitors

2 Low VF and Low IR

Improved key trade off performances (VF vs IR) for V_R:30 to 60V and I_O:1 to 2A products

3 Common footprint

US2H (SOD-323HE)
2.5x1.4x0.6 mm
is same footprint of competitors



Product lineup

品番	V_R (V)	I_o (A)	VF(V) typ@2A	I_R (μA) max.
CUHS20S30	30	2.0	0.34	500 @V_R=30V
CUHS15S30	30	1.5	0.37@1.5A	500 @V_R=30V
CUHS20S40	40	2.0	0.40	300 @V_R=40V
CUHS15S40	40	1.5	0.4 5 @1.5A	200 @V_R=40V
CUHS20F30	30	2.0	0.40	60 @V_R=30V
CUHS15F30	30	1.5	0.46@1.5A	50 @V_R=30V
CUHS20F40	40	2.0	0.47	60 @V_R=40V
CUHS15F40	40	1.5	0.57	50 @V_R=40V
CUHS10F60	60	1.0	–	40
CUHS15F60	60	1.5	0.66@1.5A	50
CUHS20F60	60	2.0	0.52	70
CUHS15S60	60	1.5	0.57@1.5A	200
CUHS20S60	60	2.0	0.46	650

Transistor output photocoupler

Value provided

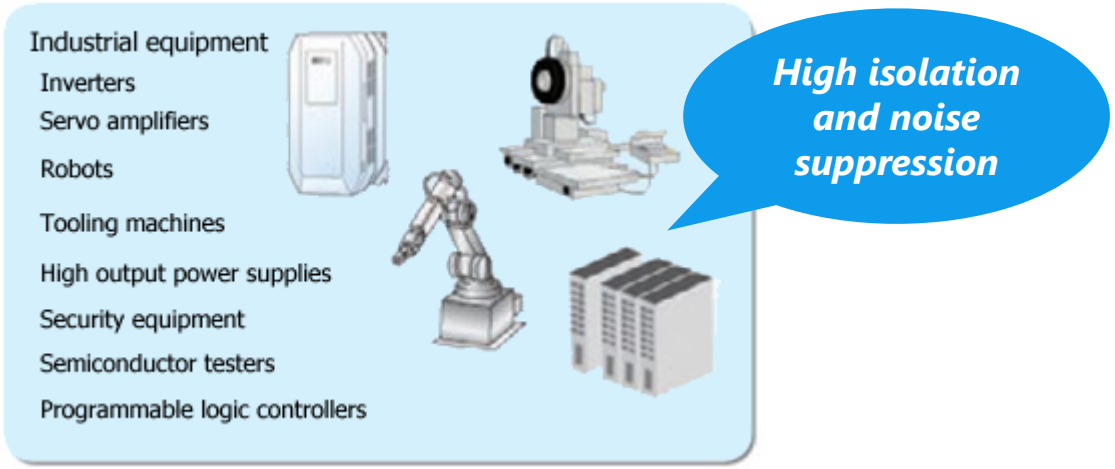
Reduction of board space and maintenance-free reliability are major merits

1 High conversion efficiency (I_F=5mA)

Optically coupled high-isolation photo coupler with a phototransistor and a high-power infrared LED, enabling low input current control and high conversion efficiency compared to conventional electromagnetic relays and isolation transformers.

2 Designed for high temperature operation up to 110℃

Designed to operate under extreme conditions of ambient temperature such as inverter devices, robots, machine tools and high output power supplies.



Product lineup

Part Number	TLP385
Package	4pin SO6L 
BV_S (Min) [Vrms]	5000
T_{opr} [°C]	-55 ～ 110

RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”.
Hardware, software and systems described in this document are collectively referred to as “Product”.

•TOSHIBA reserves the right to make changes to the information in this document and related 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.

•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.**


Our semiconductor and storage products
will always be a driving force to change the world
Toshiba Electronic Devices and Storage, together with our customers,
will accelerate our future journey.
We aim to be a company that will be chosen
for our pioneering technology and spirit embedded in our products.