TOSHIBA

R20
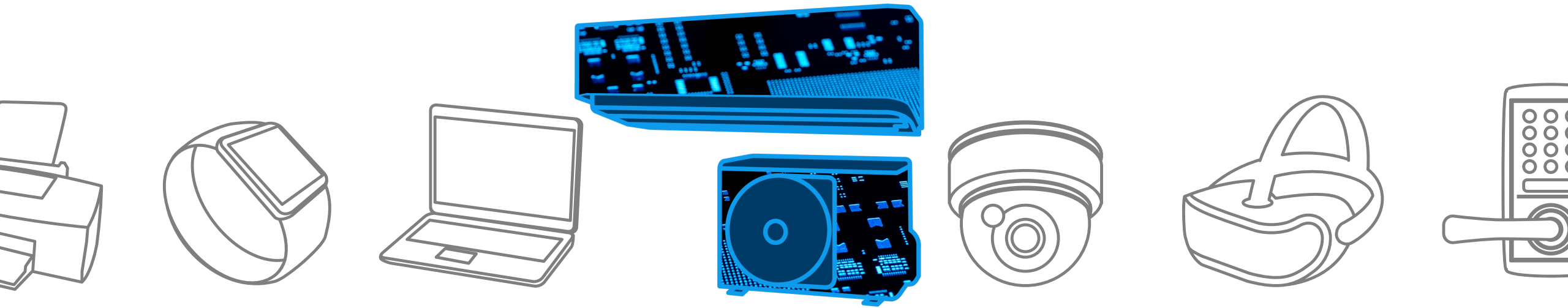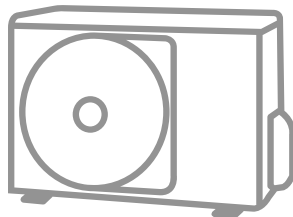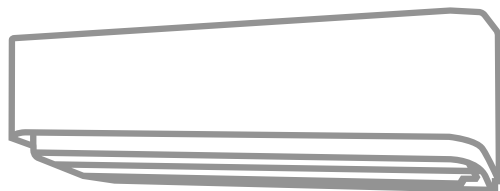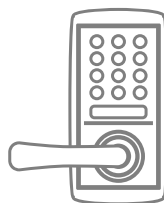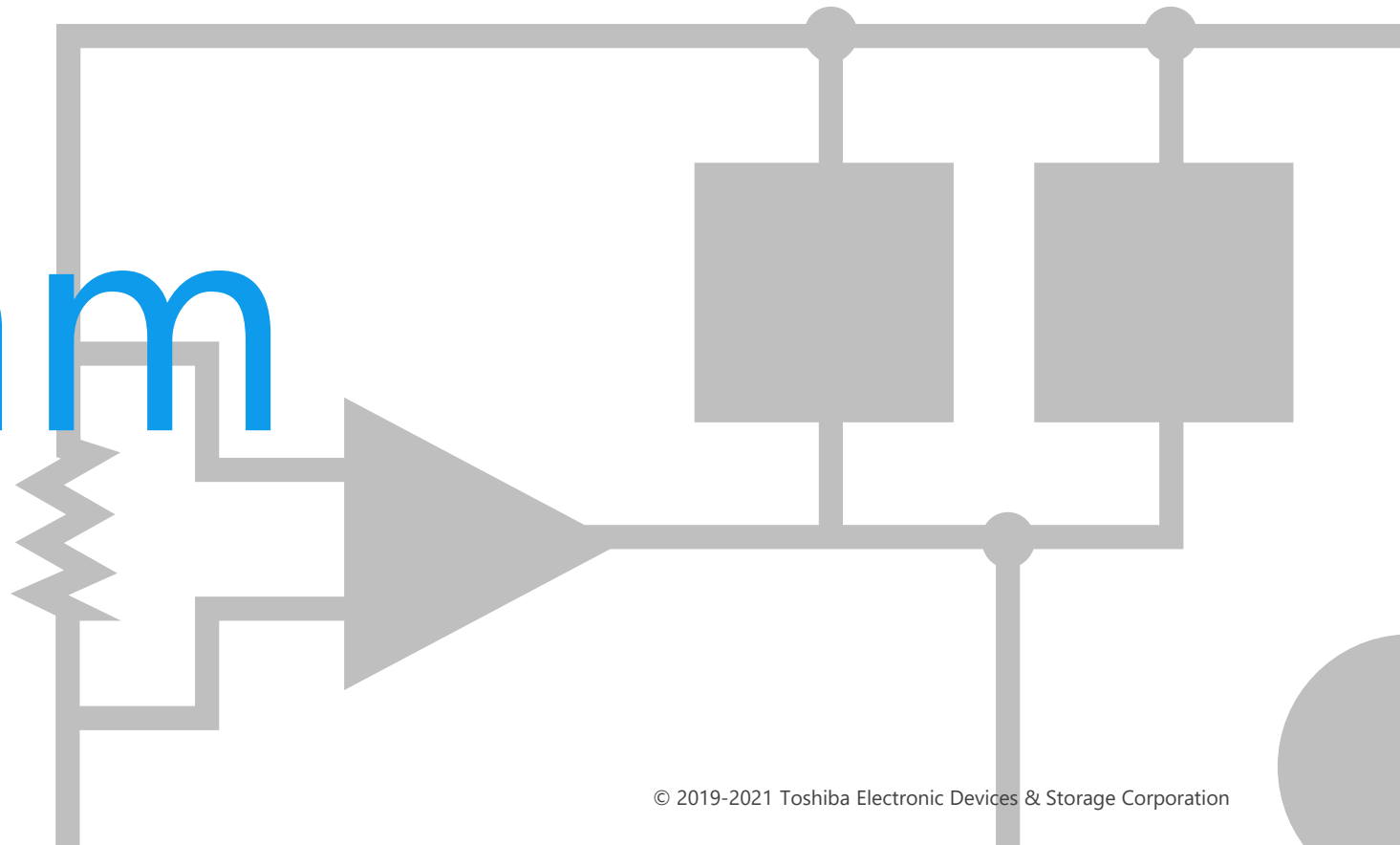
Air Conditioner
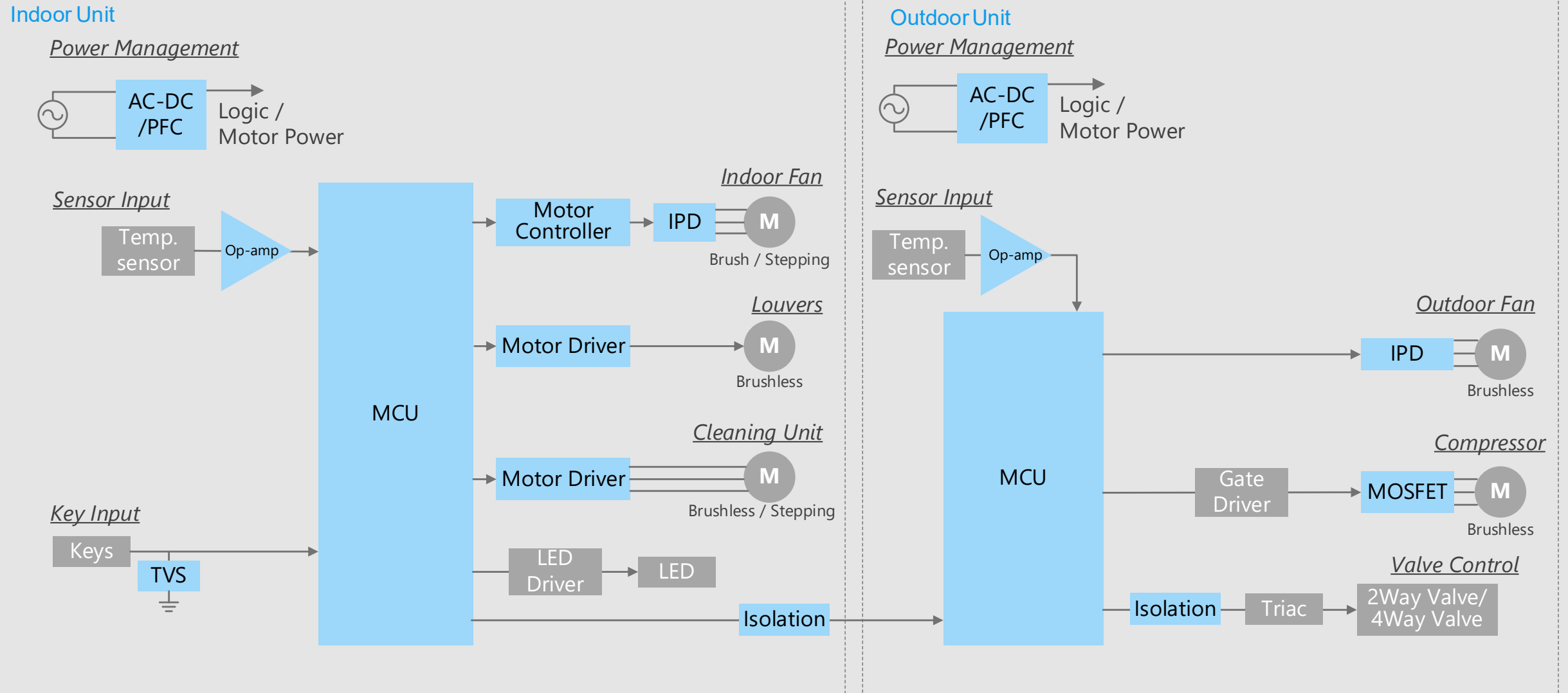
Solution Proposal by Toshiba

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

Air Conditioner Overall Block Diagram

AC-DC circuit

Outdoor unit

12 V

5 V

3.3 V

1a

N-ch MOSFET

Driver

2a

PWM Controller

Photo coupler

Reference

DC-DC
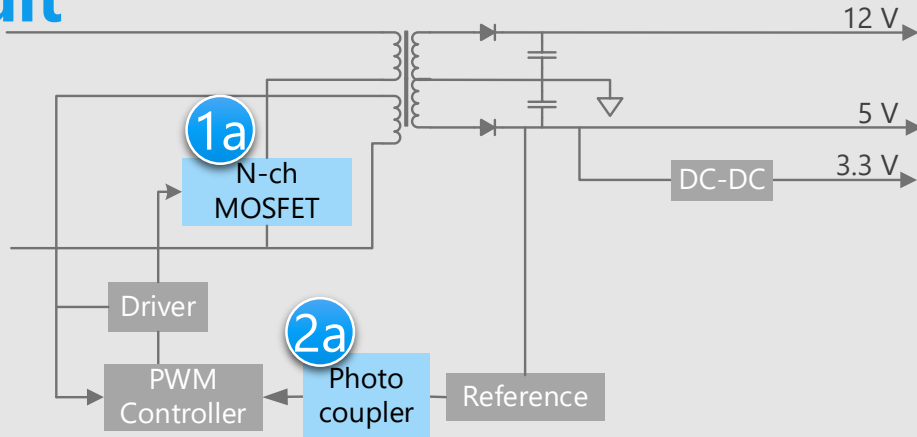
AC-DC circuit

Indoor unit
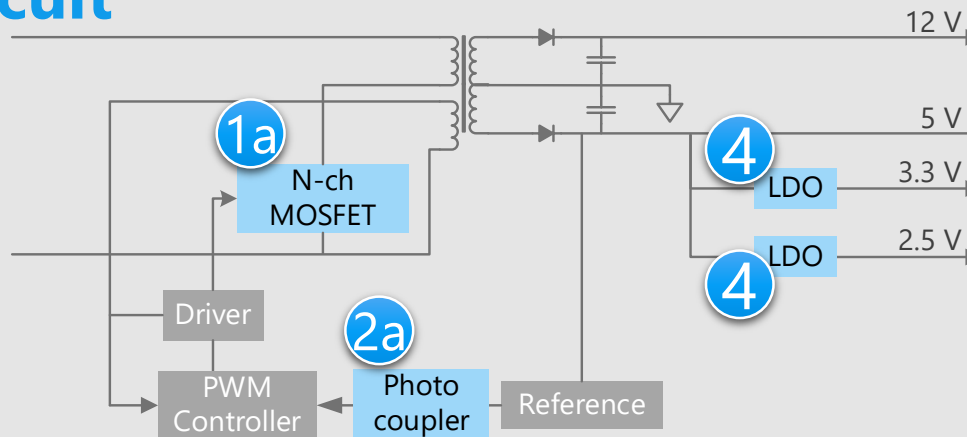
12 V

5 V

3.3 V

2.5 V

1a

N-ch MOSFET

Driver

2a

PWM Controller

Photo coupler

Reference

4

LDO

4

LDO

※Click on the blue circled numbers above to view detailed explanations.

Criteria for device selection

- High voltage MOSFETs are recommended for primary switching of AC-DC converters.
- Transistor output photocouplers are for output voltage feedback.

Proposal from Toshiba

- **Suitable for high efficiency voltage switching**
  π-MOSⅧ Series power MOSFET
- **Environmentally resistant photocoupler**
  Transistor output photocoupler
- **Resistant to power supply noise**
  Small surface mount LDO regulator

1a

2a

4

PFC circuit

Full switching system

PFC Circuit

1b

N-ch MOSFET / IGBT

3

7

MCU

Driver

PFC Controller

PFC circuit
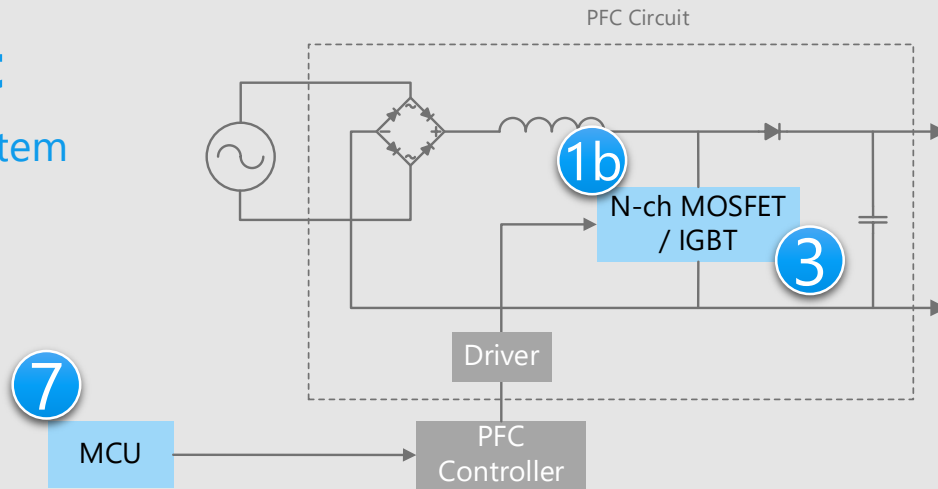
Partial switching system
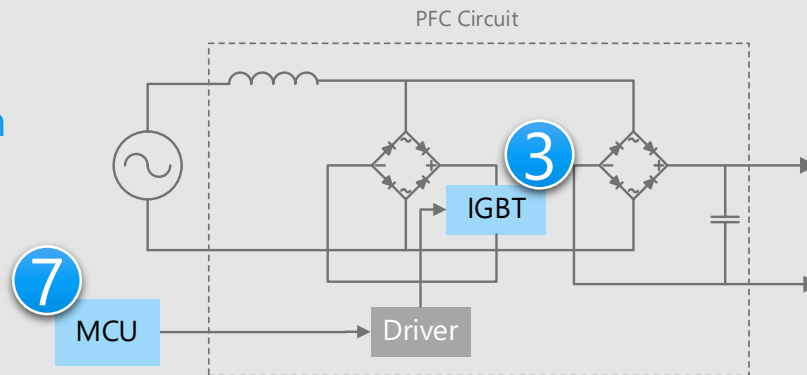
PFC Circuit

3

IGBT

7

MCU

Driver

※ Click on the blue circled numbers above to view detailed explanations.

Criteria for device selection

- MOSFETs are suitable for full switching solutions.
- IGBTs are good for partial switching solutions.
- MCUs can be used for PFC control.

Proposal from Toshiba

- **Suitable for high efficiency power supply switching**
  DTMOSⅥ Series power MOSFET
- **IGBT which is suitable for high voltage and high current system**
  Discrete IGBT Silicon N-ch
- **Easy software development using general purpose CPU cores**
  MCU

1b

3

7

Fan section（indoor/outdoor units）

High voltage IPD

(7) → MCU → (5b) IPD → M Brushless

MCD (controller)＋high voltage IPD

(7) → MCU → (6b) Motor Control Driver / (6c) → (5a) IPD → M Brushless
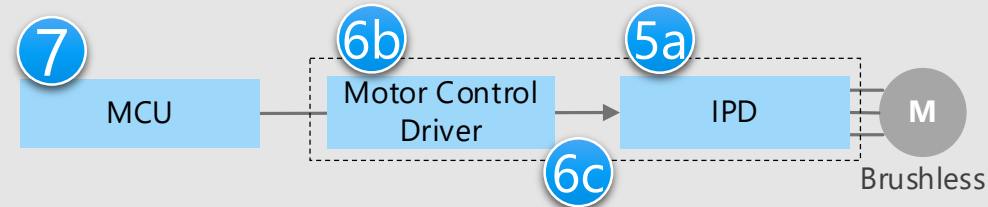
MCU (3-phase integrated controller)＋high voltage IPD
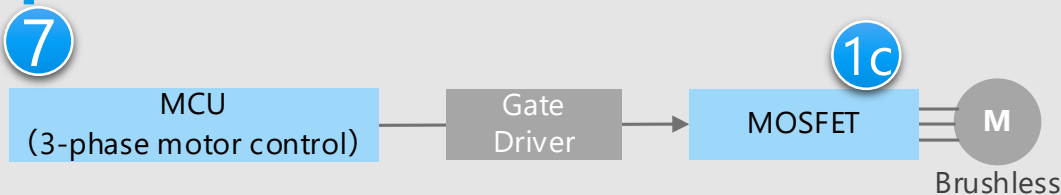
(7) → MCU (3-phase motor control) → (5a) IPD → M Brushless

Compressor section

(7) → MCU (3-phase motor control) → Gate Driver → (1c) MOSFET → M Brushless
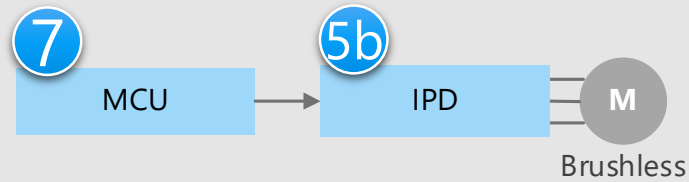
※Click on the blue circled numbers above to view detailed explanations.

Criteria for device selection

- IPD are suitable for indoor & outdoor units.
- MOSFET with reverse recovery time similar to FRD (Fast Recovery Diode) is suitable for compressors.
- Using brushless motor drivers, 3-phase brushless motors can be easily controlled.

Proposal from Toshiba

- **Suitable for inverter**
  DTMOSⅣ(HSD) Series power MOSFET (1c)
- **High voltage motor driver circuit**
  High voltage IPD (5a) (5b)
- **Easy control of motors**
  Motor driver IC (6b) (6c)
- **Easy software development using general purpose CPU cores**
  MCU (7)

Cleaning section
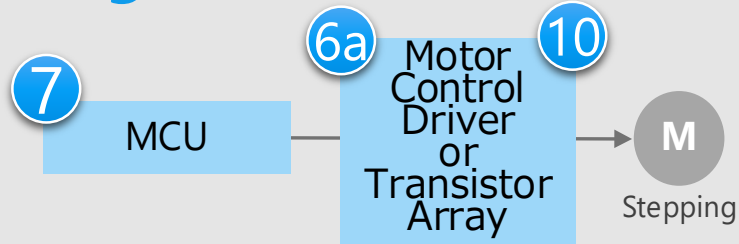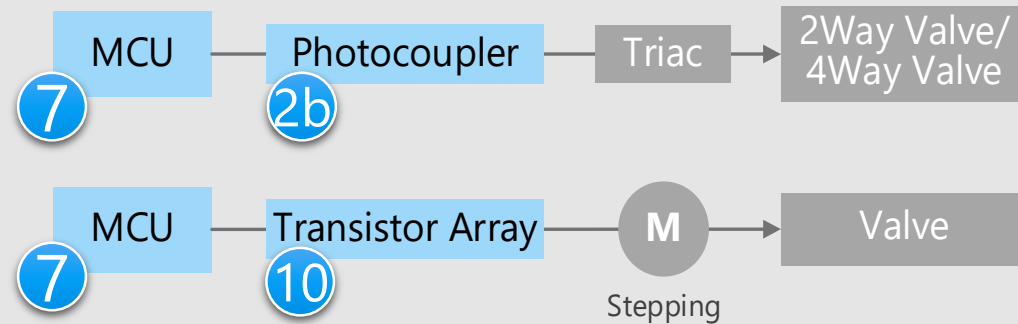
⑦ MCU ──── ⑥a ⑩ Motor Control Driver or Transistor Array ──→ M
Stepping

Louver section

⑦ MCU ──── ⑩ Transistor Array ──→ M
Stepping or Brush

Valve control section

MCU ── Photocoupler ── Triac ──→ 2Way Valve/ 4Way Valve
⑦   ②b

MCU ── Transistor Array ──→ M ──→ Valve
⑦   ⑩   Stepping

※Click on the blue circled numbers above to view detailed explanations.

Criteria for device selection

- Brushless motor driver allows easy control of 3-phase brushless motor using inverter control.
- Stepping motor driver enables efficient motor control by optimizing real-time current to the motor.
- Brush motor driver allows low power consumption.

Proposal from Toshiba

- **Easy motor operation**
  Motor driver IC ⑥a
- **Environmentally resistant photocoupler**
  Triac output photocoupler ②b
- **Easy software development using general purpose CPU cores**
  MCU ⑦
- **High efficiency and high current driver with built-in low loss DMOS FET**
  Transistor array ⑩

Microcontroller section

Power control block for outdoor unit

AC-DC → ④ LDO → ⑦ MCU
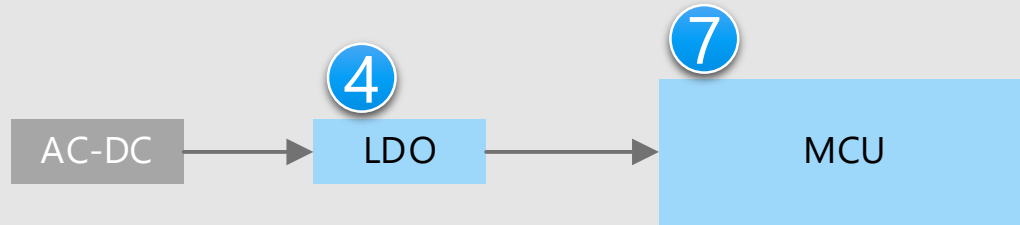
Isolation circuit

Compressor block between outdoor / indoor units

Indoor Unit — ⑦ MCU ↔ ②a Photocoupler ↔ ⑦ MCU — Outdoor Unit

※Click on the blue circled numbers above to view detailed explanations.

Criteria for device selection

- Isolation devices such as transistor output photocouplers are effective when voltage differences exists between outdoor and indoor GND.
- MCUs are suitable for system monitoring and control.

Proposal from Toshiba

- **Environmentally resistant photocoupler**
  Transistor output photocoupler   ②a
- **High noise resistance**
  Small surface mount LDO regulator   ④
- **General purpose CPU core allows easy software development**
  MCU   ⑦

Sensor input section

Indoor unit
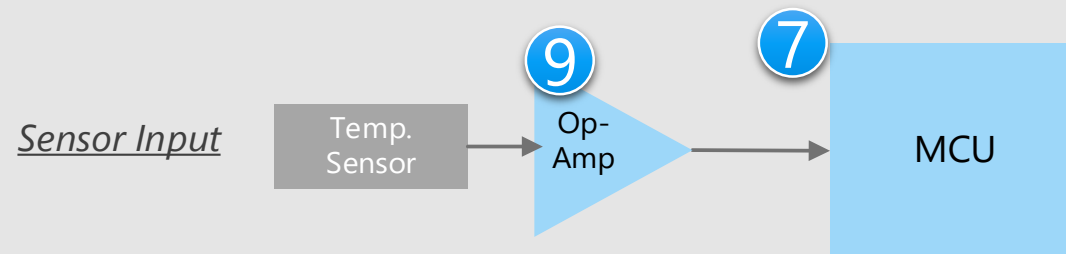
Sensor Input

Temp. Sensor → ⑨ Op-Amp → ⑦ MCU

Key Input

Keys → ⑧ TVS → MCU

Outdoor unit

Sensor Input

Temp. Sensor → ⑨ Op-Amp → ⑦ MCU

※Click on the blue circled numbers above to view detailed explanations.

Criteria for device selection

- To achieve good usability, voice commands require fast responses.
- Stable system operation is assured by using operational amplifiers and LDO power supplies having high motor noise immunity.

Proposal from Toshiba

- **General purpose CPU core allows easy software development**
  MCU ⑦
- **Avoid faulty circuit operation by absorbing ESD from external connectors**
  TVS diode ⑧
- **Accurate tracking changes in weak sensor signal**
  Low noise operational amplifier ⑨

Recommended Devices
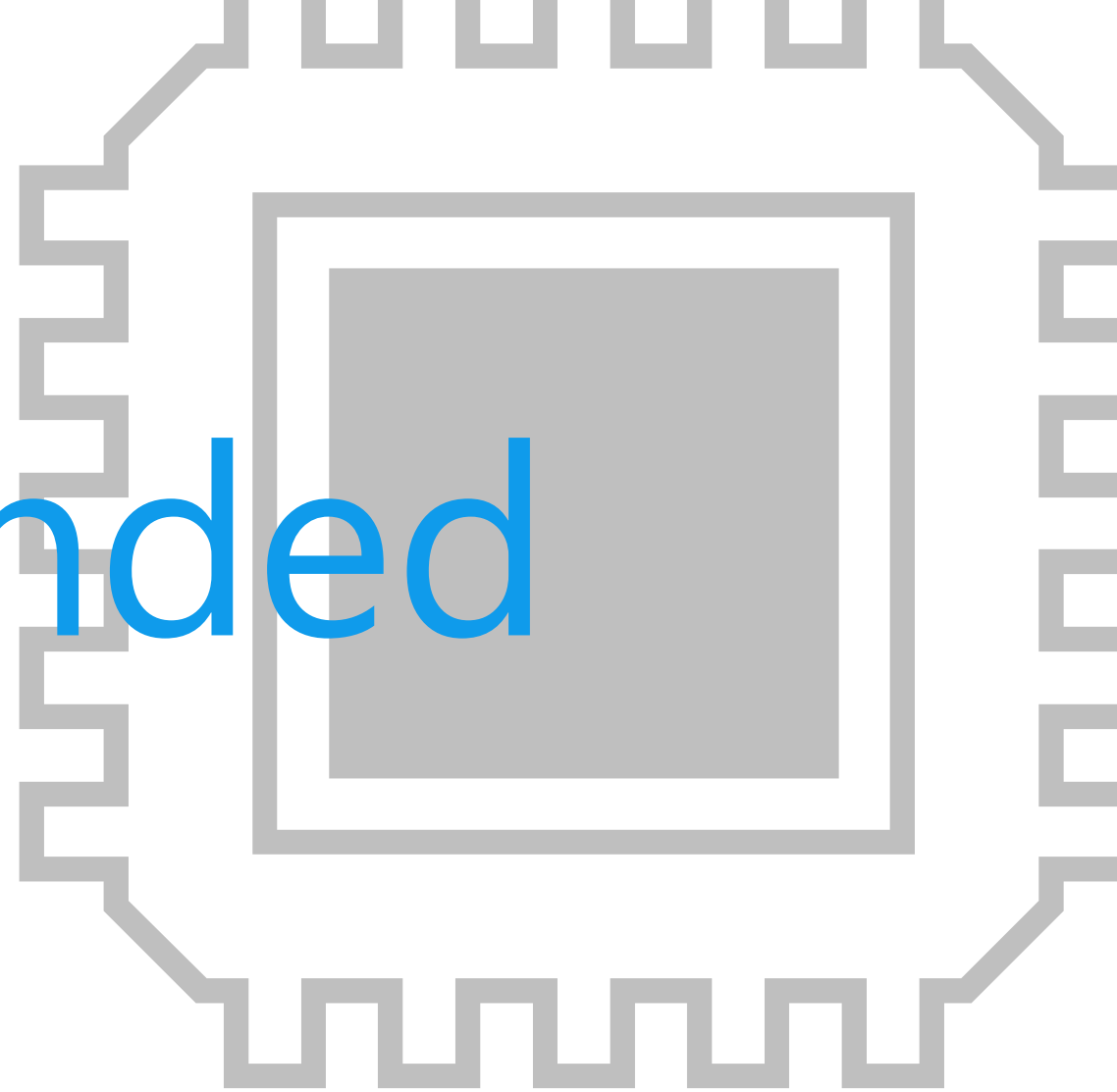
Device solutions to address customer requirements

As described above, in the design of air conditioner, **"Quietness/efficiency of motors"**, **"Low power consumption of final product"** and **"Miniaturization of circuit boards"** are important factors. Toshiba's proposals are based on these three solution perspectives.

Quietness/efficiency of motors

Low power consumption of final product

Miniaturization of circuit boards

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages
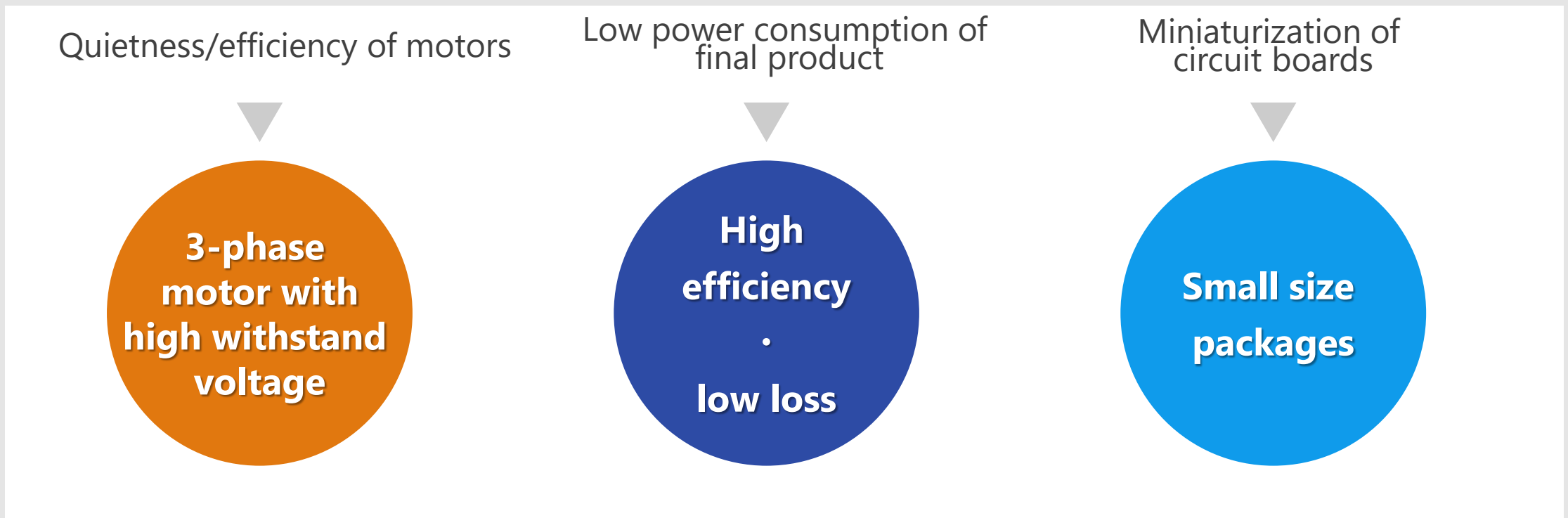
Device solutions to address customer requirements

	3-phase motor with high withstand voltage	High efficiency. low loss	Small size packages
1. π-MOSⅧ / DTMOSⅥ / DTMOSⅣ (HSD) Series power MOSFET	●	●	●
2. Transistor output photocoupler / Triac output photocoupler		●	●
3. Discrete IGBT Silicon N-ch	●	●	●
4. Small surface mount LDO regulator		●	●
5. High voltage IPD	●	●	●
6. Motor driver IC	●	●	●
7. MCU	●	●	●
8. TVS diode			●
9. Low noise operational amplifier		●	●
10. Transistor array		●	●

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages

Value provided

Realizes improvement of power supply efficiency by reduction of RonA by 24 % (comparison of Toshiba's conventional products) and contributes higher miniaturization of set.

1 RonA reduced by 24 %

By using latest generation(*) π-MOSⅧ chip design, figure of merit RonA is reduced by 24 % (comparison of Toshiba's π-MOSⅣ products).

2 Q_g reduced by 23 %

By using latest generation(*) π-MOSⅧ chip design, Q_g is reduced by 23 % (comparison of Toshiba's π-MOSⅣ products).
Reduction of switching loss is expected.

3 C_{OSS} reduced by 18 %

By using latest generation(*) π-MOSⅧ chip design, C_{OSS} is reduced by 18 % (comparison of Toshiba's π-MOSⅣ products). Improvement for light load conditions is expected.

*: As of August 2021

Turn-on waveform

【condition】
V_{DD}=400 V, I_D=4.5 A(I_D×1/2), T_c=25 °C

2SK3878

TK9J90E

$R_{G(off)}$=25 Ω

$R_{G(off)}$=25 Ω

V_{GS}:10 V/div
6 /ns
52 ns
I_D:2 A/div
V_{DS}:100 V/div
t:40 ns/div

10 V/ns
32 ns

(Note: Toshiba internal comparison)
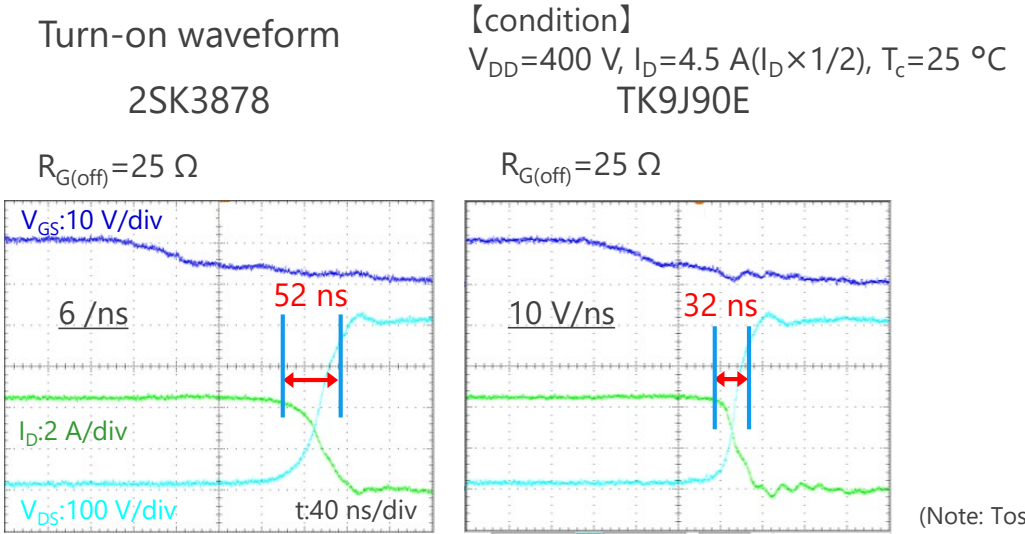
Line up

Part number		TK6A80E	TK10A80E	TK9J90E
Package		TO-220SIS		TO-3P(N)
V_{DSS} [V]		800	800	900
I_D [A]		6	10	9
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	1.35	0.7	1
	Max	1.7	1	1.3
Polarity		N-channel	N-channel	N-channel

◆Return to Block Diagram TOP

Value provided

Realizes improvement of power supply efficiency by 40 % (comparison of Toshiba's conventional products) reduction of $R_{DS(ON)}$ x Q_{gd} .

1 $R_{DS(ON)}$ x Q_{gd} reduced by 40 %

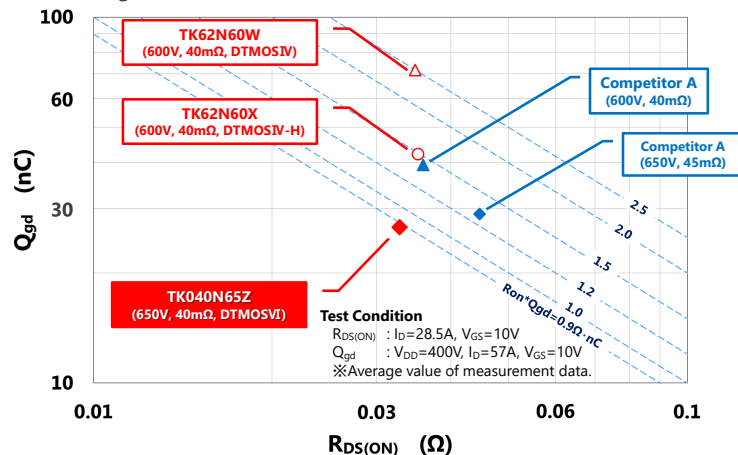Using a single epitaxial process, the figure of merit $R_{DS(ON)}$ x Q_{gd} was reduced by 40 % by optimizing the structure (comparison of DTMOS IV-H 600 V products). By realizing low $R_{DS(ON)}$ x Q_{gd} , device switching loss was reduced contributing to improvement in power supply efficiency of equipment.

2   RonA reduced by 18 %

The figure of merit RonA of the latest generation(*) DTMOS VI has been reduced by18 % compared with the previous generation (DTMOS IV 650 V products). Achieving low on-resistance while maintaining high voltage contributes to high efficiency of equipment.

■ $R_{DS(ON)}$ vs Q_{gd} performance trend

TK62N60W (600V, 40mΩ, DTMOSIV)
TK62N60X (600V, 40mΩ, DTMOSIV-H)
Competitor A (600V, 40mΩ)
Competitor A (650V, 45mΩ)
TK040N65Z (650V, 40mΩ, DTMOSVI)

Ron*Qgd=0.9Ω·nC

Test Condition
$R_{DS(ON)}$: I_D=28.5A, V_{GS}=10V
Q_{gd} : V_{DD}=400V, I_D=57A, V_{GS}=10V
※Average value of measurement data.

$R_{DS(ON)}$ (Ω)

(Note: Toshiba internal comparison)

*：As of August 2021

Line up

Part number	TK065U65Z		TK040N65Z
Package	TOLL		TO-247
V_{DSS} [V]	650		650
I_D [A]	38		57
$R_{DS(ON)}$ [Ω] @V_{GS}=10 V	Typ.	0.051	0.033
	Max	0.065	0.04
Polarity	Nch		Nch

◆Return to Block Diagram TOP

15

DTMOSⅣ (HSD) Series power MOSFET
TK20A60W5

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages

Value provided

Realizes improvement of power supply efficiency by reduction of RonA by 30 % (comparison of Toshiba's conventional products) and contributes higher miniaturization of set.

1 RonA reduced by 30 %

Using a newly developed single epitaxial process, the figure of merit RonA was reduced by 30 % (comparison of DTMOSⅢ products).

2 $R_{DS(ON)}$ increase suppressed at high temperatures

Using a single epitaxial process, the increase in $R_{DS(ON)}$ is suppressed at high temperatures.

3 Optimized gate switching speed

C_{OSS} reduction (12 % compared to our earlier model) and low $R_{DS(ON)}$ (super junction DTMOS structure) allows optimized gate switching speed.

Note: Toshiba internal comparison
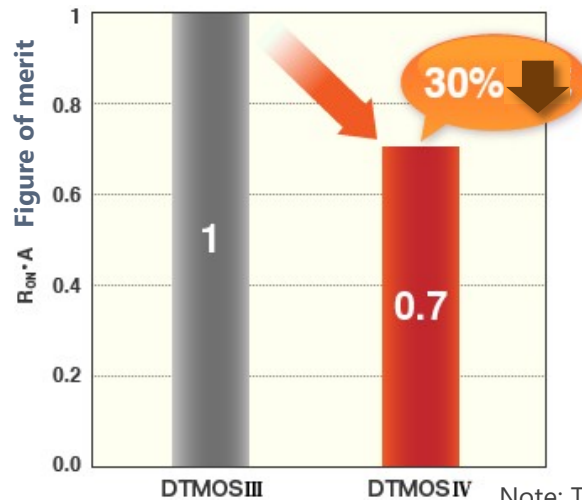
Line up		
Part number		TK20A60W5
Package		TO-220SIS
V_{DSS} [V]		600
I_D [A]		20
$R_{DS(ON)}$ [Ω] @V_{GS}=10 V	Typ.	0.15
	Max	0.175
Polarity		N-channel

◆Return to Block Diagram TOP

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages

Value provided

Reduction in required circuit board area and improving reliability enabling maintenance-free operation.

1 High current transfer ratio

The TLP383 / TLP293 is a high-isolation photocoupler that optically couples a phototransistor and high output infrared LED. Compared to Toshiba's conventional products (TLP785 / TLP385), higher CTR (Current Transfer Ratio) in low input current range (@ I_F = 0.5 mA) is realized.
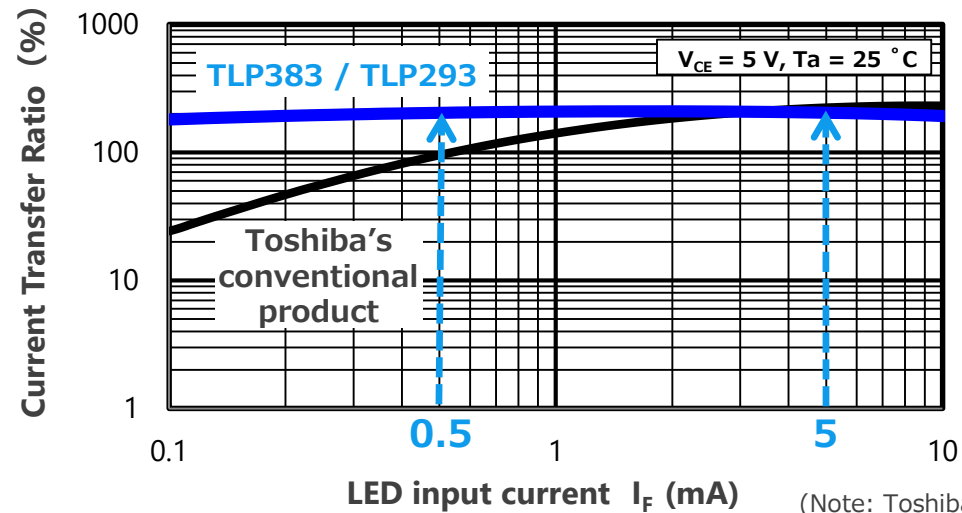
2 Operating temperature is expanded to 125 ℃

The TLP383 / TLP293 are designed to operate under extreme conditions of ambient temperature such as inverter devices, robots, machine tools and high output power supplies.

Current Transfer Ratio (%) vs LED input current I_F (mA)

TLP383 / TLP293

V_{CE} = 5 V, Ta = 25 ℃

Toshiba's conventional product

(Note: Toshiba internal comparison)

Line up

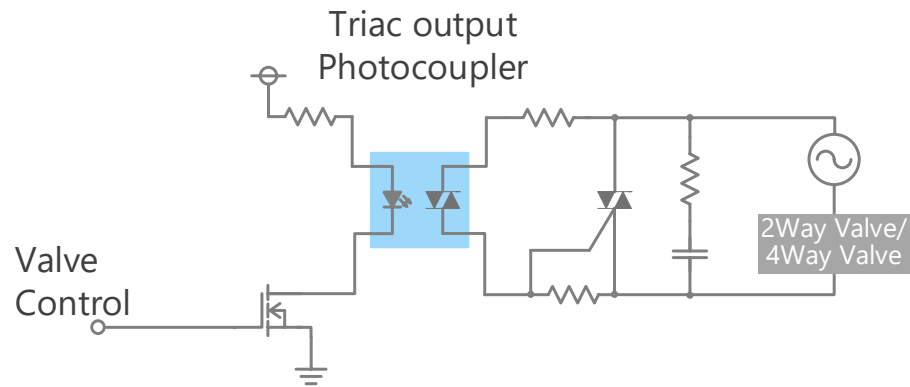| Part number	TLP383	TLP293	TLP785	TLP385
Package	SO6L (4pin)	SO4	DIP4	SO6L (4pin)
BV_S (Min) [Vrms]	5000	3750	5000	5000
T_{opr} [°C]	-55 to 125	-55 to 125	-55 to 110	-55 to 110

Value provided

Using a triac with high dv/dt pre-driver for solenoid control suppresses false turn-on.

1 Low input and zero-crossing input control

This device optically couples a photo triac and a high power infrared LED, providing high isolation equivalent to an electromagnetic relay. Capable of low input operation, the photo coupler can be directly controlled by a microcontroller.

2 High dv/dt

The TLP 3083 is a triac having a high dv/dt of 2000 V/μs (Typ.) . With a high OFF-state voltage of 800 V, it can work with a variety of AC power supply lines.

■ **Example of AC switch using triac output photocoupler**

Triac output Photocoupler

Valve Control

2Way Valve/ 4Way Valve

Line up

Part number	TLP3083	TLP3073
Package	5pin DIP6	
Output Type	Zero-crossing functionary (ZC)	Non-zero-crossing functionary (NZC)
BV_S (Min) [Vrms]	5000	
T_{opr} [°C]	-40 to 100	

◆Return to Block Diagram TOP

Value provided

Switching devices for high voltage (from 600 V) and high current (from 30 A) application. Lineup of low $V_{CE(sat)}$ products are effective in reducing conduction loss.

1 High speed, low saturation voltage

By adopting a thin wafer punch-through structure, high speed turn-off characteristics and low $V_{CE(sat)}$ characteristics are realized.

2 High breakdown tolerance

We offer a product line with high breakdown tolerance (short circuit withstand time t_{sc} and reverse bias safe operating area RBSOA).

3 Enhancement type

Since collector current does not flow when gate voltage is not applied for enhancement devices, handling is easy.

■ **Full switching PFC circuit example using discrete IGBT (GT50JR22)**

Vout

IGBT

fsw=20 to 35 kHz
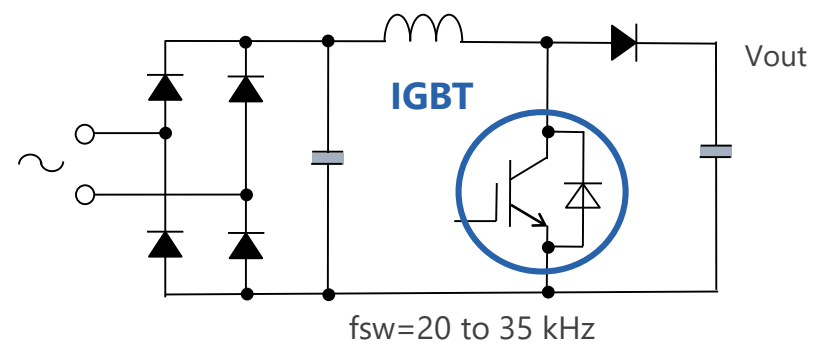
Line up

Part Number		GT50JR22	GT30J122A	GT50J123
Package		TO- 3 P(N)		
Built-in FRD		✓ (RC structure)	-	-
V_{CSS} [V]		600	600	600
I_C [A]		50	50	50
$V_{CE(sat)}$ [V] @I_C=50 A, V_{GE}=15 V, T_a=25 °C	Typ.	1.55	1.70	1.90
	Max	2.20	2.80	2.50
Breakdown tolerance	t_{sc} [µs]	-	-	5
	RBSOA	-	-	120 A, 600 V (full square)

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages

Value provided

Wide line up 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 newly developed new generation 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.
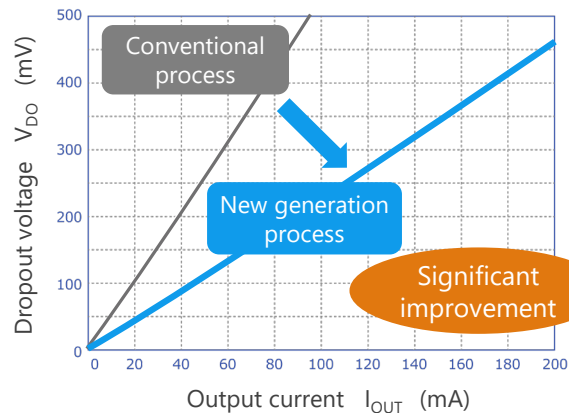
3 Low current consumption

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

Low dropout voltage

Dropout voltage V_{DO} (mV) vs Output current I_{OUT} (mA)

Conventional process

New generation process

Significant improvement

Note: Toshiba internal comparison

Rich package line up

WCSP4F 0.645×0.645×0.33mm
WCSP4E 0.645×0.645×0.43mm
WCSP4 0.79×0.79×0.5mm
SDFN4 0.8×0.8×0.38mm
DFN4 1.0×1.0×0.58mm
WCSP6F 1.2×0.8×0.33mm
DFN5B 1.2×1.2×0.38mm
ESV(SOT-553) 1.6×1.6×0.55mm
SMV(SOT-25) 2.9×2.8×1.1mm
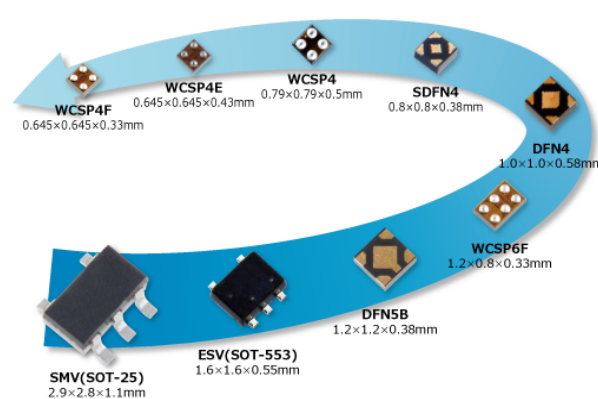
Line up

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		15V 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	52	20	19	7	7	0.34	1	170

◆Return to Block Diagram TOP

Value provided

High voltage brushless motors can be driven using Toshiba's proprietary high voltage IC process

1 **Various circuits for driving the motor are included**

High side driver, low side driver, and output MOSFET for level-shifting are included.

2 **Pin placement separated by control and drive functions**

Complexity of the wiring are eliminated by separating the high voltage/high current pins and the control pins

3 **Advanced protection circuits**

Over-current protection, over-temperature protection, and over-voltage protection function are built in.

TPD4204F
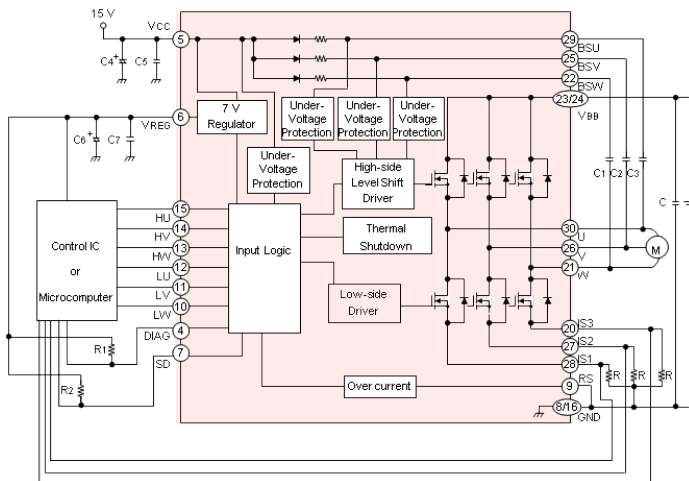
Line up

Part number	TPD4204F
Package	SSOP30
V_{BB} [V]	600
I_{OUT} [A]	2.5
V_{CC} [V]	13.5 to 16.5

◆Return to Block Diagram TOP

3-phase motor with high withstand voltage

High efficiency + low loss

Small size packages

Value provided

High voltage brushless motors can be driven using Toshiba's proprietary high voltage IC process

1 **3-phase controller for brushless motor included**

Includes controller, PWM circuit, 3-phase distribution circuit, level shift Type high side driver and low side drivers, output IGBT and FRD

2 **Separate pin placement for control and drive functions**

Complexity of the wiring are eliminated by separating the high voltage/high current pins and the control pins
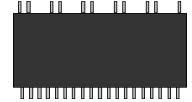
3 **Advanced protection circuits**

Over-current protection, over-temperature protection, and over-voltage protection function are built in.

TPD4152F
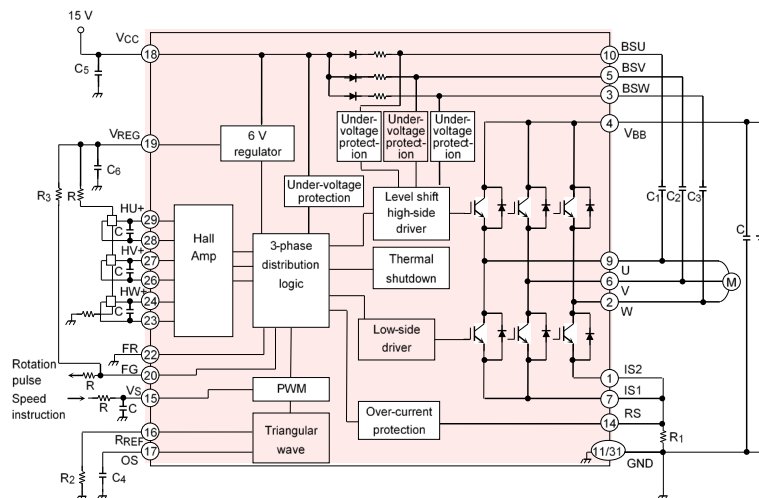
Line up

Part number	TPD4152F
Package	HSSOP31
V_{BB} [V]	600
I_{OUT} [A]	0.7
V_{CC} [V]	13.5 to 17.5

◆Return to Block Diagram TOP

Stepping motor & Brushed DC motor driver IC
TC78H621FNG / TC78H660FNG / TC78H660FTG

3-phase motor with high withstand voltage

High efficiency・low loss

Small size packages

Value provided

Support for low voltage motor driving (2.5 V (Min)) with low power consumption.

1 Low voltage operation

Motor driving voltage is 2.5 V (Min) for low voltage applications such as battery operation devices.

2 Low current consumption

Standby current is below 2 µA (IC total) for power saving of devices.
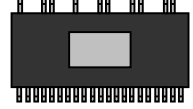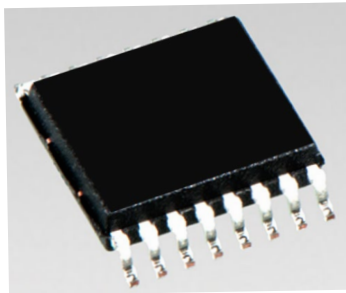
3 Abnormality detection functions

Over current detection (ISD), Over heat detection (TSD) & Low voltage detection (UVLO) are available for safe motor driving.

TSOP16 Package（5.0 mm x 6.4 mm x 1.2 mm） QFN16 Package（3.0 mm × 3.0 mm x 0.9 mm）
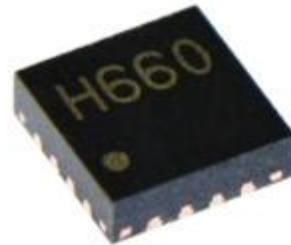
Line up

Part Number	TC78H621FNG	TC78H660FNG	TC78H660FTG
V_M (Max) [V]	18	18	18
I_{OUT} (Max) [A]	1.1	2.0	2.0
$R_{on(upper\ and\ lower\ sum)}$ (Typ.) [Ω]	0.8	0.48	0.48
Control Interface	PHASE inputs	IN/PHASE inputs	IN/PHASE inputs
Step	2phase/1-2phase excitation	2phase/1-2phase excitation	2phase/1-2phase excitation
Motor driving voltage	2.5 V min	2.5 V min. RS resister less	2.5 V min. RS resister less
Abnormality detection function	Over heat, Over current, Low voltage	Over heat, Over current, Low voltage	Over heat, Over current, Low voltage
Package	TSSOP16	TSSOP16	QFN16

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6b

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages

Value provided

Toshiba's proprietary technology eliminates the need for phase adjustment and achieves high efficiency for a wide range of rotation speeds

**1** High efficiency in a wide range of rotation speeds

Toshiba's automatic lead angle control technology realizes a high efficiency drive regardless of motor speed, load torque or power supply voltage.

2 Motor control with low noise, and low vibration

The use of a sinusoidal drive system featuring a smooth current waveform contributes to the low noise and low vibration of the motor, as compared to a square wave drive system.

3 Small package

VQFN32 package is adopted for TC78B042FTG, which requires small space. SSOP30 package is adopted for TC78B041FNG as conventional Type.
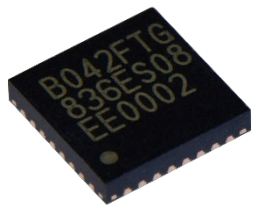
VQFN32 Package
(5 mm x 5 mm x 1 mm)

SSOP30 Package
(10.2 mm x 7.6 mm x 1.6 mm)

Line up

Part Number	TC78B041FNG	TC78B042FTG
Power supply voltage	6 to 16.5 V	
Drive Type	Sinusoidal	
Features & Others	Auto lead angle control for optimizing voltage & current phases	
	Hall element or hall IC input	
	Forward / reverse rotation switch	
	Motor lock detection	
	Selectable pulse number of rotation pulse signal output	
	Built-in 5 V regulator, VREF / VREF2 pins	Built-in 5 V regulator, VREF pin
	Error detection positive / negative input	Error detection positive input
Package	SSOP30	VQFN32

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Three-phase brushless DC motor driver IC
TB6584FNG / TB6584AFNG / TB6634FNG

3-phase motor with high withstand voltage

High efficiency · low loss

Small size packages

Value provided

High voltage, large current brushless motor drive using external MOSFET

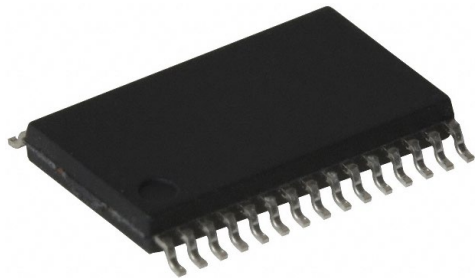**1 Efficient motor control using auto lead angle control**

In addition to fixed angle control using voltage input (32 steps), auto lead angle control using current feedback is possible.

2 Low noise, low vibration motor control

A sinusoidal drive system with a smooth current waveform contributes to low noise and low vibration of the motor compared with conventional rectangular drive systems.

3 Full development support

Third party evaluation boards and PSpice® data can be provided to support customer development and design.

TSOP30 package (10.2 mm x 7.6 mm x 1.6 mm)

Line up

Part Number	TB6584FNG	TB6584AFNG	TB6634FNG
Supply voltage range	6 to 16.5 V		
Output current range	0.002 A (for MOSFET driver)		
Drive mode	Sine wave drive		
Other features	Lead angle control: Auto phase control (current feedback) Sensor input: Hall device/ Hall IC compatible Internal regulator: 5 V / 30 mA (max) Error detection: over current protection, position signal error, low voltage/current, motor constraint detection (TB6634FNG)		

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Value provided

1 package of motor controller & 600 V/2 A IGBT for high voltage solution

1 SiP: 1 package solution

1 package of sinusoidal current drive motor controller & 600 V/2 A IGBT to reduce mounting PCB space.

2 Motor control with low noise, and low vibration

The use of a sinusoidal drive system featuring a smooth current waveform contributes to the low noise and low vibration of the motor, as compared to a square wave drive system.

3 High heat dissipation

HDIP30 package is adopted for TB67B000AHG, which has high heat dissipation. HSSOP30 package is adopted for TB67B000AFG, which is smaller than HDIP30.

HDIP30
(32.8 mm x 13.5 mm x 3.525 mm)

HSSOP34
(17.5 mm x 11.93 mm x 2.2 mm)

Line up

Part Number	TB67B000AHG	TB67B000AFG
Operating voltage range	Power supply for control: 13.5 to 16.5 V	
	Power supply for motor drive: 50 to 450 V	
Output current	2 A	
Drive Type	Sinusoidal current drive / Pseudo sinusoidal current drive	
PWM frequency	14 kHz to 23 kHz	
Lead angle control	0 to 58 degrees 32 steps / 0 to 28 degrees 16 steps	
Speed command input voltage	Motor operation: 2.1 to 5.4 V	
Features & Others	IGBT 3-Phase bridge, Oscillation circuit, Built-in bootstrap resistor, Current limit, Thermal shutdown, Low voltage monitor, Lock detection	
Package	HDIP30	HSSOP34

Value provided

Contributes to 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.

2 Equipped with motor control logic circuit

Versatile three-phase PWM (Note) output with high efficiency and low noise control made possible by sense timing.
The advanced encoder lightens CPU load of each PWM processing.

3 Equipped with analog circuit for motor control

Multiple high speed and high accuracy AD converters are integrated, allowing conversion timing and PWM output to be linked. Such as high performance operational amplifier is integrated on-chip.

(Note) : Pulse Width Modulation

Arm® Core	Arm® Cortex®-M0	Arm® Cortex®-M3	Arm® Cortex®-M4
TXZ+™ Family Advanced Class ~ 200 MHz		TXZ+™3A Series — Coming Soon M3H	TXZ+™4A Series — \<Group\> M4K M4M M4G M4N
TXZ™ Family ~ 160 MHz		TXZ™3 Series — \<Group\> M3H(1) M3H(2)	TXZ™4 Series — \<Group\> M4K(1) M4K(2) M4G(1) M4L(1)
TX Family ~ 120 MHz	TX00 Series — \<Group\> M030 M060	TX03 Series — \<Group\> M310 M330 M340 M360 M370 M380	TX04 Series — \<Group\> M440 M460 M470
TXZ+™ Family Entry Class ~ 40 MHz		TXZ+™3E Series — Coming Soon	
Toshiba Core	**8bit**	**32bit**	
TLCS Family TX Family	TLCS 870/C1 Series, TLCS 870/C1E Series	TLCS 900 Series, TX19 Series	

Line up		
Series	Group	Function
TX03 Series	M370 Group	Arm® Cortex®-M3, includes 1st gen VE
TX04 Series	M470 Group	Arm® Cortex®-M4, includes 3rd gen VE
TXZ+™4A Series	M4K Group	Arm® Cortex®-M4, includes 4th gen VE

Value provided

Protecting devices from static electricity and preventing circuit malfunctions
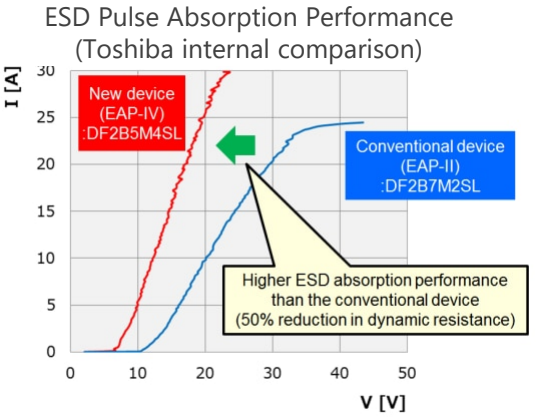
1 **Higher ESD absorbency**

Improved ESD absorption compared to Toshiba's 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 **Suppresses ESD energy with a low clamp voltage**

Thanks to proprietary technology, connected devices are firmly protected.

3 **Suitable for high density mounting**

Various packages (single to multi flow-through) are available.

ESD Pulse Absorption Performance
(Toshiba internal comparison)

I [A]

New device (EAP-IV) :DF2B5M4SL

Conventional device (EAP-II) :DF2B7M2SL

Higher ESD absorption performance than the conventional device (50% reduction in dynamic resistance)

V [V]

Uni-directional

Bi-directional

Note: This device is for ESD protection only and cannot be used for other purposes such as, but not limited to, constant voltage source circuits.

Line up

Part number	DF2B7ASL	DF2S14P1CT	DF2B5M4SL	DF2B6M4SL
Package	SL2	CST2	SL2	SL2
V_{ESD} [kV]	±30	±30	±20	±20
V_{RWM} (Max) [V]	5.5	12.6	3.6	5.5
C_t (Typ.) [pF]	8.5	40	0.2	0.2
R_{DYN} (Typ.) [Ω]	0.2	0.5	0.5	0.5

Value provided

Amplifying very weak signals detected by sensors with low noise operational amplifiers

1 Low noise V_{NI}=6.0 [nV/√Hz] (Typ.) @f=1 kHz

This low noise CMOS operational amplifier is capable of amplifying low-level signals detected by various sensors [Note 1]. By optimizing the process, the industry's top level equivalent input noise performance was achieved [Note 2].
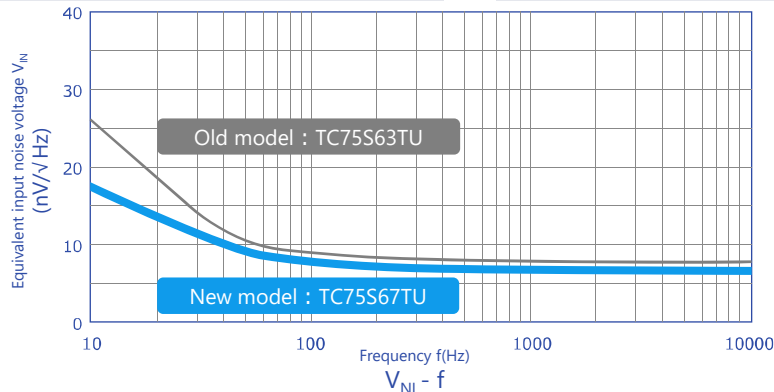
2 Low dissipation current I_{DD}=430 [µA] (Typ.)

The low current dissipation of CMOS devices enables the long battery life of small IoT equipment.

3 Low voltage power supply

Can operate at V_{DD}=2.2 to 5.5 V

Low noise characteristics
(Toshiba internal comparison)

Old model : TC75S63TU
New model : TC75S67TU
Equivalent input noise voltage V_{IN} (nV/√Hz)
Frequency f(Hz)
V_{NI} - f

Line up

Part number	TC75S67TU
Package	UFV
$V_{DD,SS}$ (Max) [V]	±2.75
$V_{DD,SS}$ (Min) [V]	±1.1
I_{DD} (Max) [µA]	700
V_{NI} (Typ.) [nV/√Hz] @f=1 kHz	6

[Note 1] Sensor Typ.es: vibration sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, temperature sensor, etc
[Note 2] Based on Toshiba survey on May 2017.

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Value provided

DMOS FET is used for the output of drive circuit and realizes low loss compared to bipolar transistor output type, and CMOS input can control directly from controller's I/O etc.

1 **Rich product line up**

In addition to the listed products, we offer a wide line up of products, including packaged products such as lead-insertion DIPs, small surface mount SOLs, SOPs, HSOPs, and small SSOP types, as well as source output types.
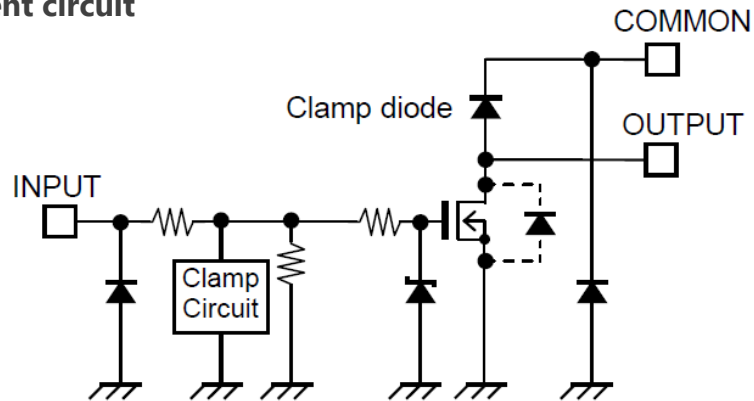
2 **Output clamp diode is incorporated.**

Incorporated output clamp diode regenerates the back electromotive force generated by switching of an inductive load into the load power supply.

3 **Large current drive is possible.**

Larger currents can also be driven by connecting multiple outputs in parallel.

Equivalent circuit

Note: Equivalent circuit may be simplified for explanatory purpose.

Line up

Part number	TBD62003AFWG	TBD62083AFG	TBD62064AFG
Package	SOL16	SOP18-P-375-1.27	HSOP16
Output type	Sink	Sink	Sink
Number of channels	7ch	8ch	4ch
Input level	H	H	H
I_{OUT} (Max) [mA]	500	500	1500
V_{OUT} (Max) [V]	50	50	50

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