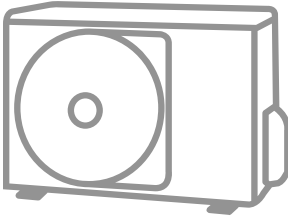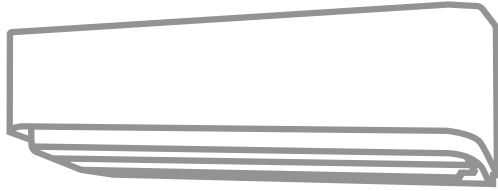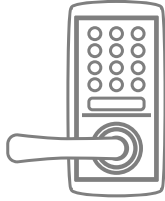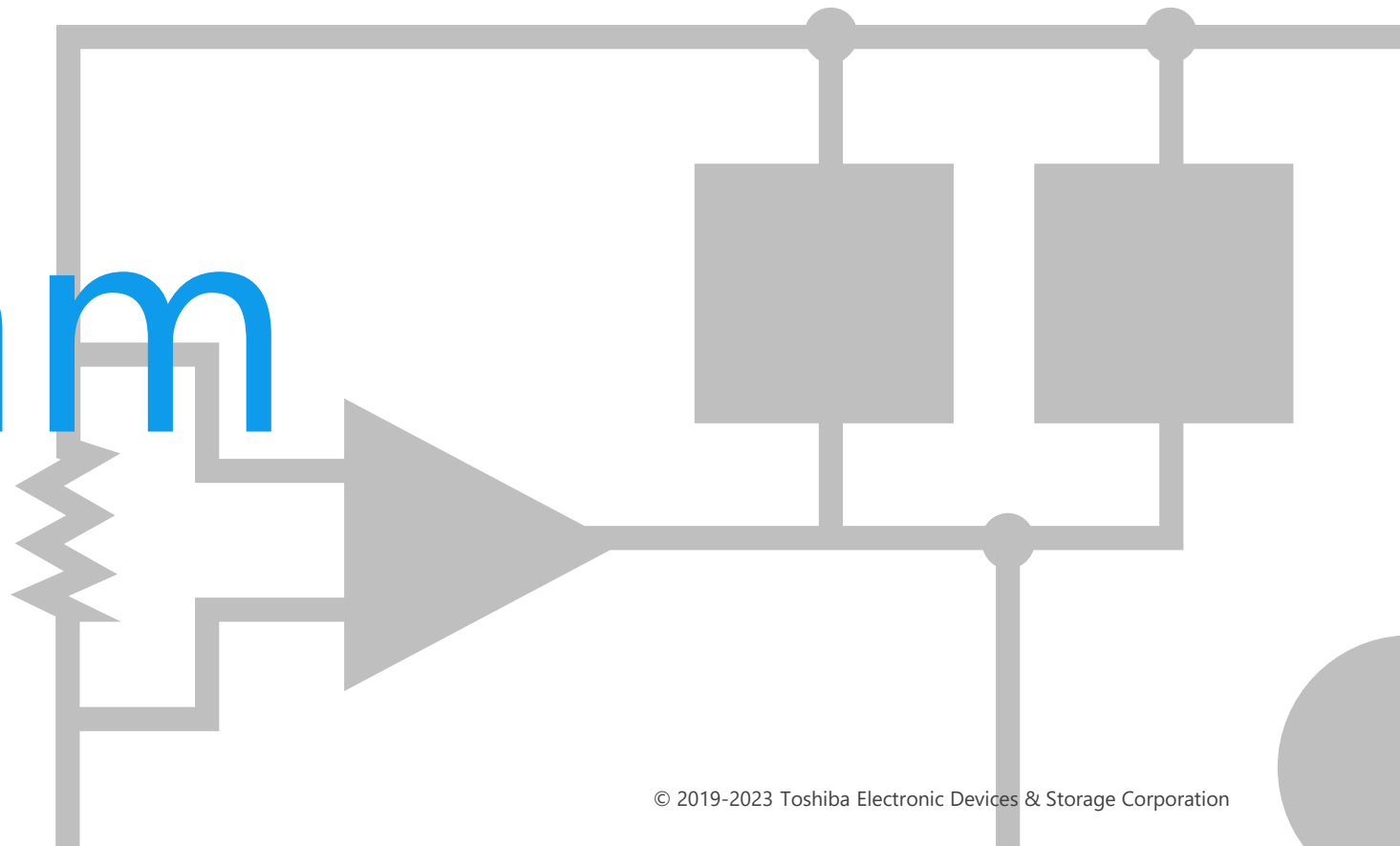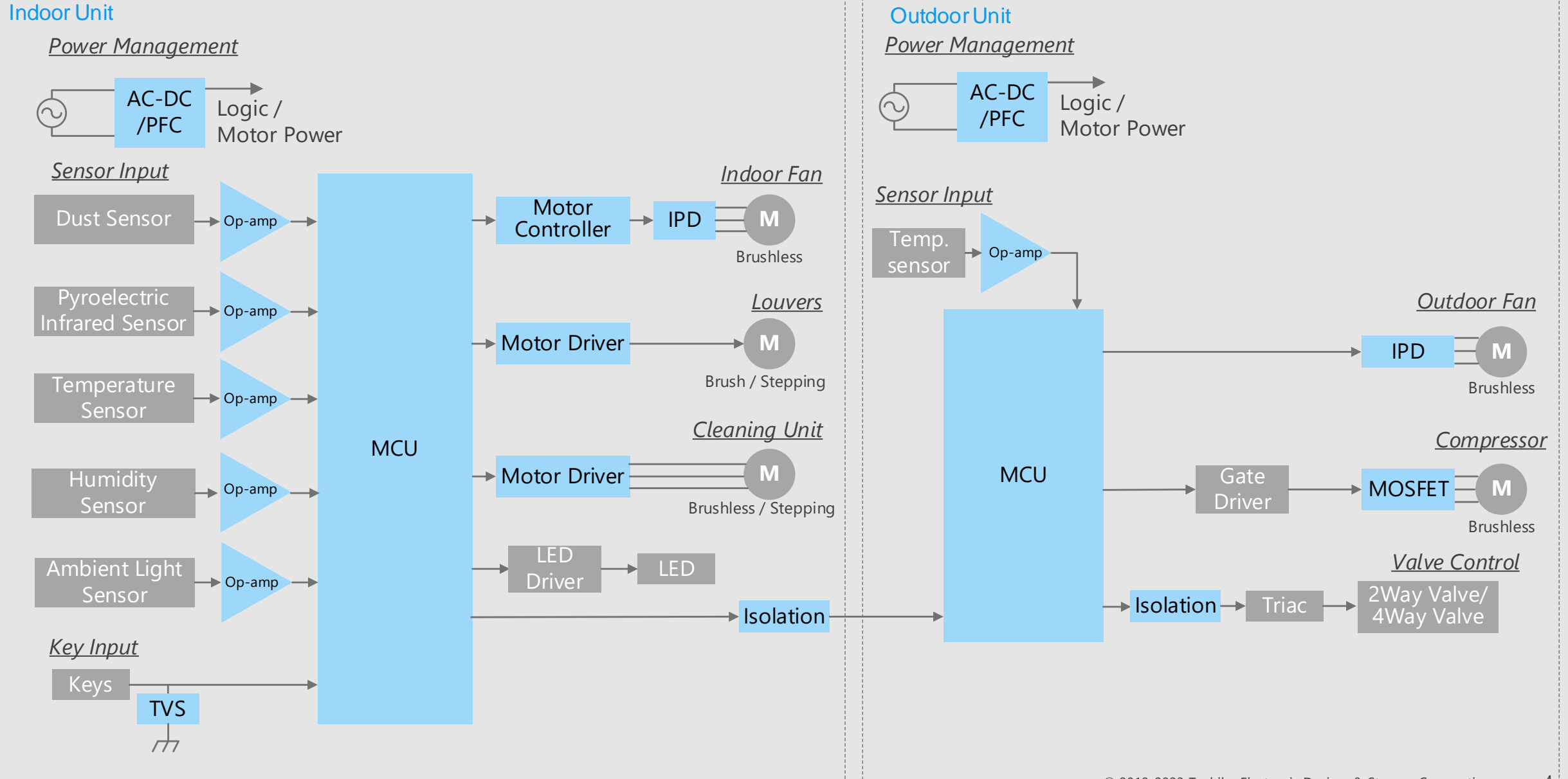# Air Conditioner

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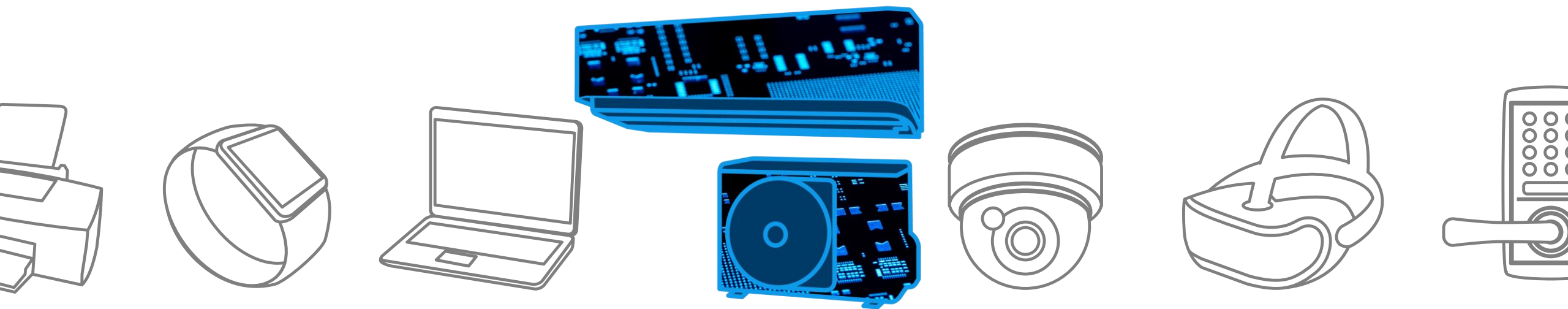
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

Air Conditioner　Overall Block Diagram

Indoor Unit

Power Management

AC-DC /PFC → Logic / Motor Power

Sensor Input

- Dust Sensor → Op-amp
- Pyroelectric Infrared Sensor → Op-amp
- Temperature Sensor → Op-amp
- Humidity Sensor → Op-amp
- Ambient Light Sensor → Op-amp

MCU

Indoor Fan
Motor Controller → IPD → M (Brushless)

Louvers
Motor Driver → M (Brush / Stepping)

Cleaning Unit
Motor Driver → M (Brushless / Stepping)

LED Driver → LED

Isolation

Key Input
Keys → TVS

Outdoor Unit

Power Management

AC-DC /PFC → Logic / Motor Power

Sensor Input

Temp. sensor → Op-amp

MCU

Outdoor Fan
IPD → M (Brushless)

Compressor
Gate Driver → MOSFET → M (Brushless)

Valve Control
Isolation → Triac → 2Way Valve/ 4Way Valve

AC-DC converter circuit

Outdoor unit

12 V

5 V

3.3 V

1a N-ch MOSFET

Driver

2a

PWM Controller

Photo coupler

Reference

DC-DC
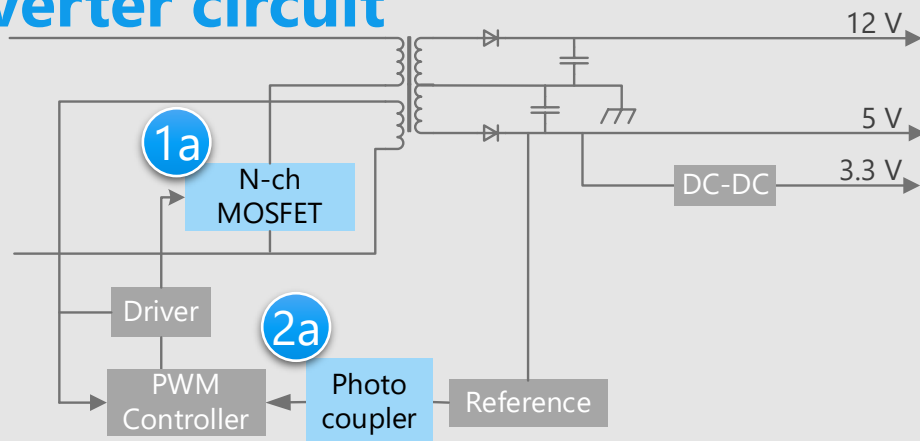
AC-DC converter circuit

Indoor unit

12 V

5 V

3.3 V

2.5 V

1a N-ch MOSFET

4 LDO

4 LDO

Driver

2a

PWM Controller

Photo coupler

Reference
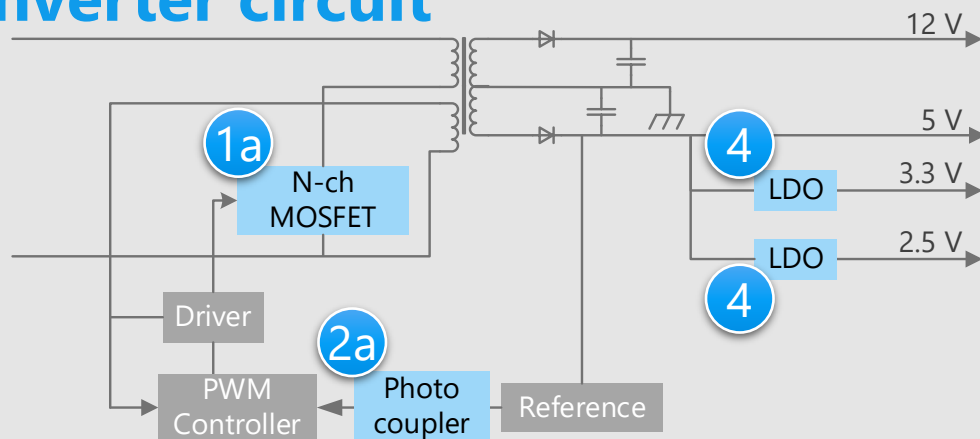
Criteria for device selection

- High voltage MOSFETs are suitable for primary switching of AC-DC converters.
- The transistor output photocoupler is for signal isolation.

Proposals from Toshiba

- **Suitable for high efficiency voltage switching**
  π-MOSⅧ Series MOSFET **1a**
- **High current transfer ratio and high temperature operation have been achieved**
  Transistor output photocoupler **2a**
- **Supply the power with low noise**
  Small surface mount LDO regulator **4**

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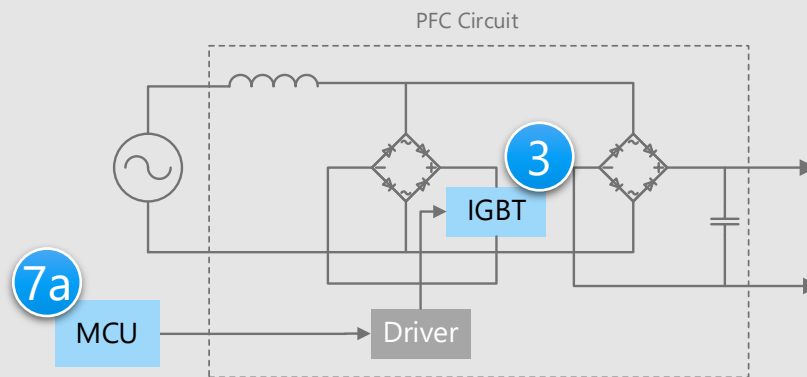
PFC circuit
Active type

PFC Circuit

1b

N-ch MOSFET / IGBT

3

Driver

7a

MCU

PFC Controller
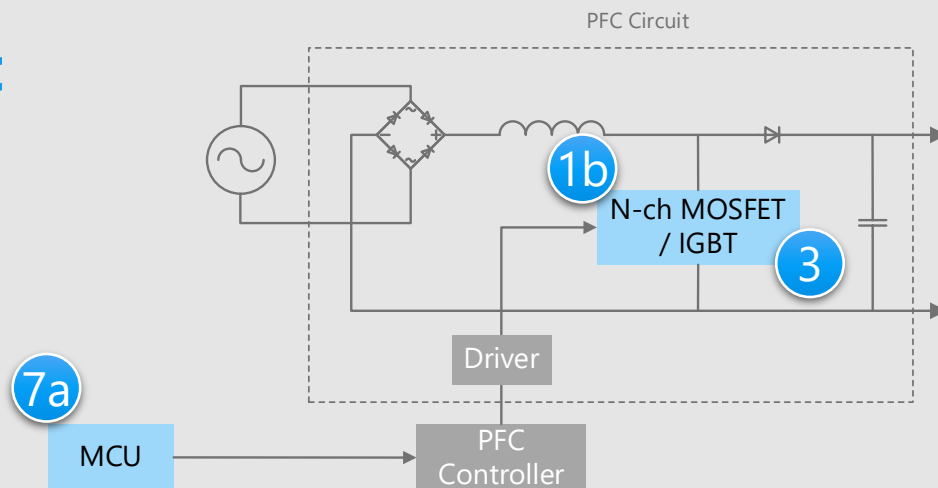
PFC circuit
Partial switching type

PFC Circuit

3

IGBT

7a

MCU

Driver

Criteria for device selection

- MOSFETs with high speed switching and low on-resistance are suitable for active type PFC circuit.
- IGBTs with low collector-emitter saturation voltage are suitable for partial switching type PFC circuit.
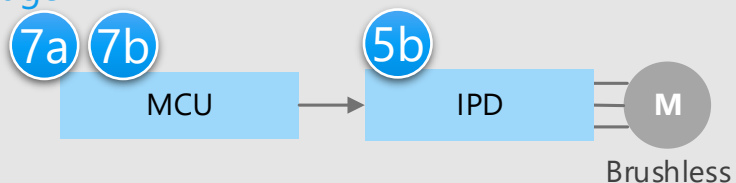
Proposals from Toshiba

- **Suitable for high efficiency power supply switching**
  DTMOSVI Series MOSFET   1b
- **IGBT which is suitable for high voltage and high current system**
  Discrete IGBT   3
- **Suitable for PFC and motor control**
  MCU M4K Group / M470 Group / M370 Group   7a

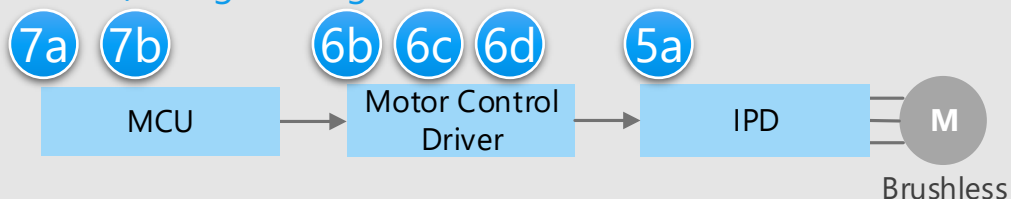* Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Fan section (indoor/outdoor units)

High voltage IPD

7a **7b** → MCU → **5b** IPD → **M** Brushless

MCD (controller) + high voltage IPD

7a **7b** → MCU → **6b** **6c** **6d** Motor Control Driver → **5a** IPD → **M** Brushless

MCU (Three-phase motor controller) + high voltage IPD
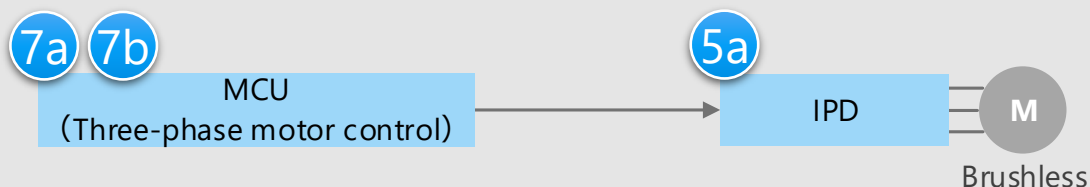
7a **7b** → MCU （Three-phase motor control） → **5a** IPD → **M** Brushless

Compressor section

7a → MCU （Three-phase motor control） → Gate Driver → **1c** MOSFET → **M** Brushless
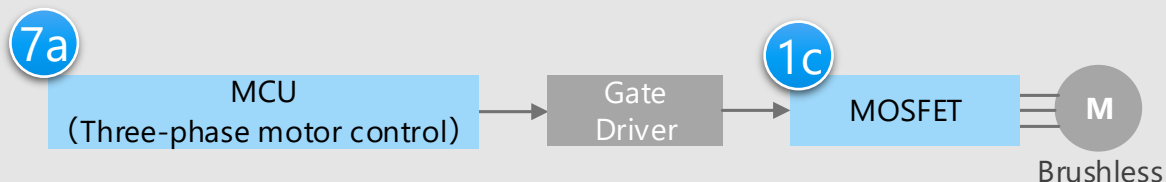
*Click on the numbers in the circuit diagram to jump to the detailed descriptions page

Criteria for device selection

- IPDs are suitable for fan motor drive in indoor & outdoor units.
- MOSFET with short reverse recovery time is suitable for motor drive in compressors.
- By using brushless motor drivers, three-phase brushless DC motors can be controlled easily.

Proposals from Toshiba

- **Suitable for inverter**
  DTMOSⅣ(HSD) [Note] Series MOSFET **1c**
- **High voltage motor driver circuit**
  High voltage IPD **5a** **5b**
- **Easy motor drive**
  Motor driver **6b** **6c** **6d**
- **Suitable for PFC and motor control**
  MCU M4K Group / M470 Group / M370 Group **7a**
- **Easy software development using general purpose CPU cores**
  MCU M3H Group **7b**

[Note] 4th generation DTMOS with high speed diode

Cleaning section

(7b) MCU → (6a) Motor Control Driver or Transistor Array (10) → M Stepping

Louver section

(7b) MCU → (10) Transistor Array → M Stepping or Brush

Valve control section

(7a) MCU → (2b) Photocoupler → Triac → 2Way Valve/ 4Way Valve

(7a) MCU → Transistor Array (10) → M Stepping → Valve
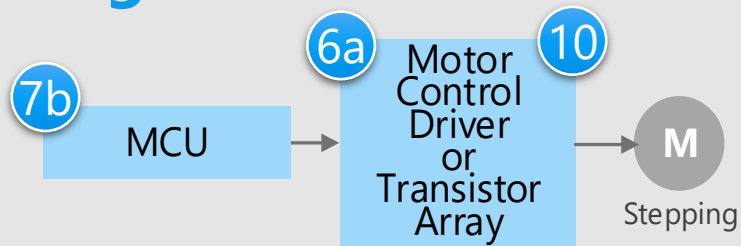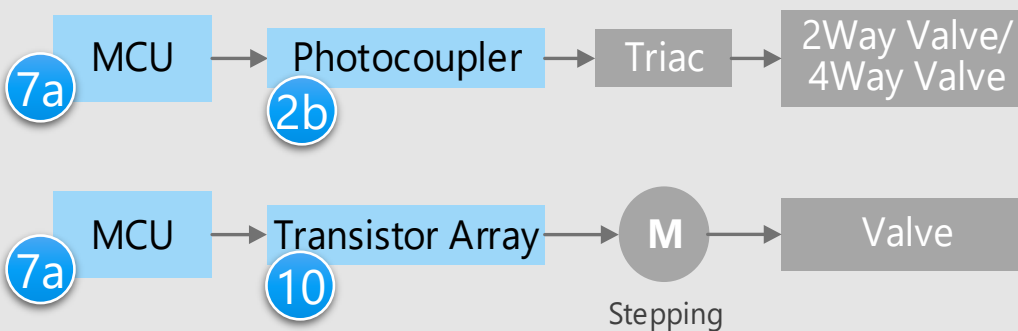
Criteria for device selection

- By using brushless DC motor drivers, three-phase brushless DC motors can be controlled easily.
- Stepping motor driver enables efficient motor control by optimizing real-time current to the motor.
- Brushed DC motor driver allows motor driving with low power consumption.

Proposals from Toshiba

- **Easy motor drive**
  Motor driver (6a)
- **Triac driver for high dv/dt**
  Triac output photocoupler (2b)
- **Suitable for PFC and motor control**
  MCU M4K Group / M470 Group / M370 Group (7a)
- **Easy software development using general purpose CPU cores**
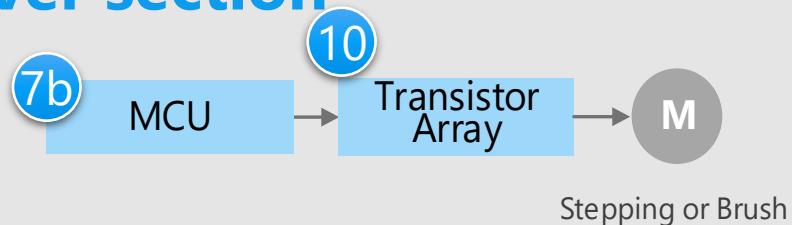 MCU M3H Group (7b)
- **High efficiency and high current driver with built-in low loss DMOS FET**
  Transistor array (10)

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

Microcontroller section

Power control block for outdoor unit

AC-DC → (4) LDO → (7a) MCU
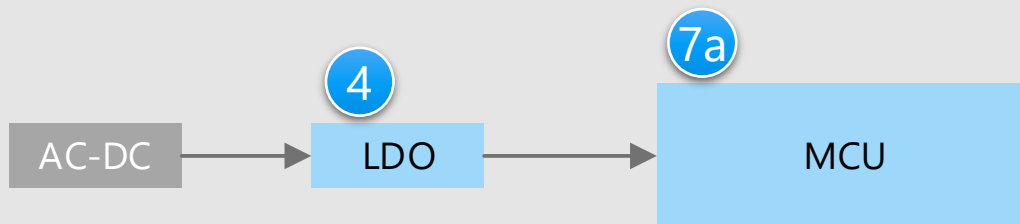
Isolation circuit

Between outdoor and indoor units

Indoor Unit

Outdoor Unit

(7b) MCU ↔ (2a) Photocoupler ↔ (7a) MCU

Criteria for device selection

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

Proposals from Toshiba

- **High current transfer ratio and high temperature operation have been achieved**
  Transistor output photocoupler　(2a)
- **Supply the power with low noise**
  Small surface mount LDO regulator　(4)
- **Suitable for PFC and motor control**
  MCU M4K Group / M470 Group / M370 Group　(7a)
- **Easy software development using general purpose CPU cores**
  MCU M3H Group　(7b)

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

Dust sensor circuit

Power Supply — LDO (4)

Drive Circuit — Dust Sensor — Op-amp (9) — Output (MCU)

Human sensor circuit

Power Supply — LDO (4)
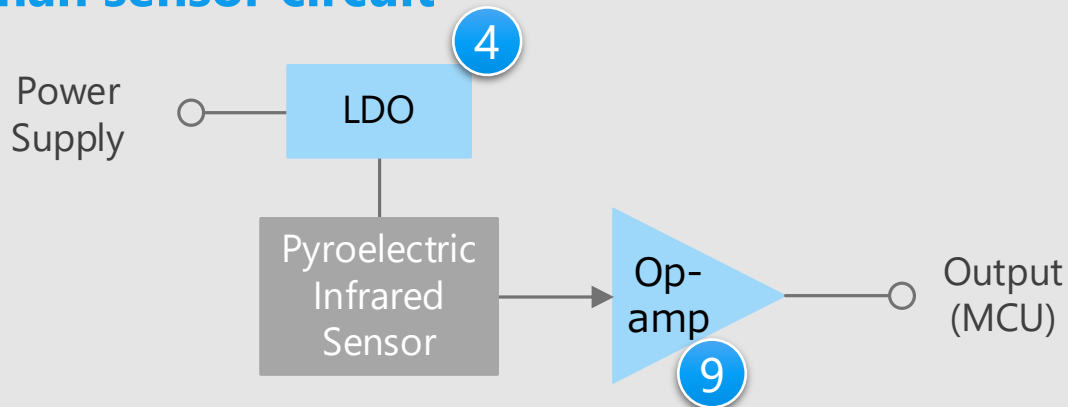
Pyroelectric Infrared Sensor — Op-amp (9) — Output (MCU)

Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- The operational amplifier should be low current consumption or low noise device.
- Small package products contribute to the reduction of circuit board area.

Proposals from Toshiba

- **Supply the power with low noise**
  Small surface mount LDO regulator (4)

- **Amplification of detected very small signal with low noise**
  Low current consumption op-amp / Low noise op-amp (9)

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

Temperature sensor circuit

Power Supply

4 LDO

NTC

Op-amp **9**

−

+

Output (MCU)

Humidity sensor circuit

Power Supply

4 LDO

Drive Circuit

Humidity Sensor

−

+

Op-amp **9**

Output (MCU)

Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- The operational amplifier should be low current consumption or low noise device.
- Small package products contribute to the reduction of circuit board area.
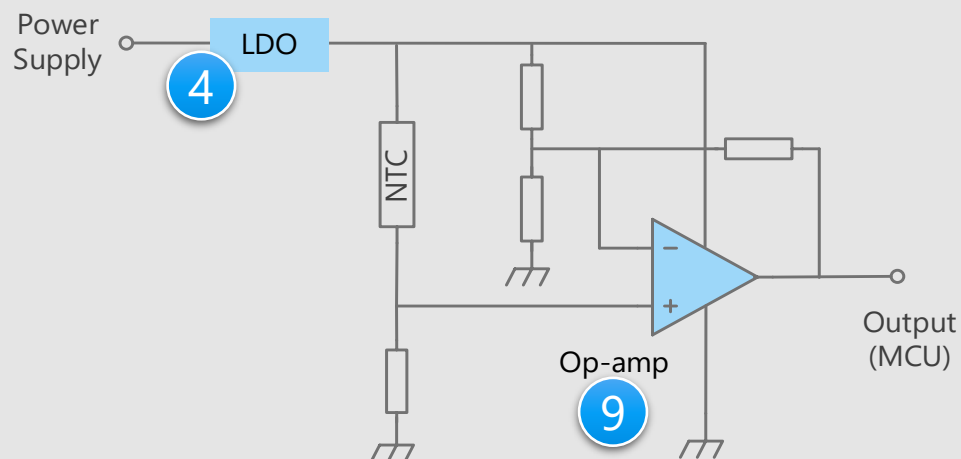
Proposals from Toshiba

- **Supply the power with low noise**
  Small surface mount LDO regulator **4**

- **Amplification of detected very small signal with low noise**
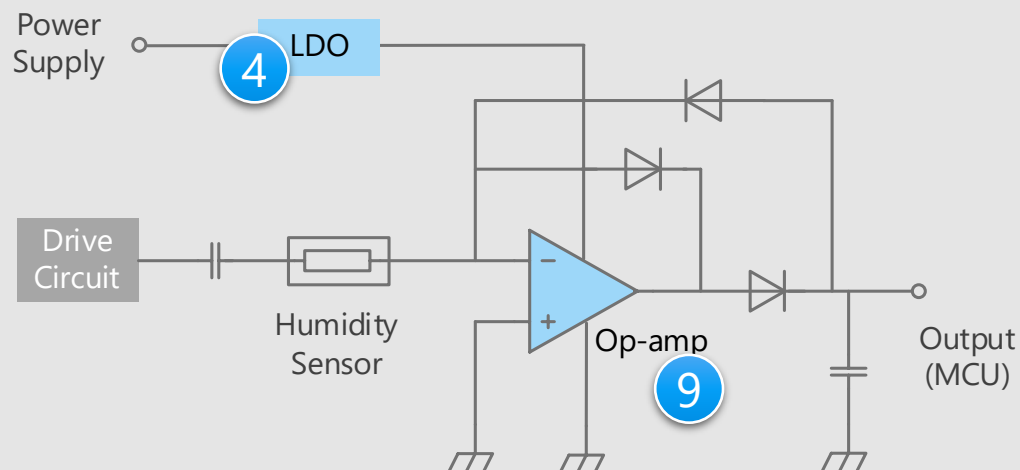 Low current consumption op-amp / Low noise op-amp **9**

Ambient light sensor circuit

Power Supply — LDO **4**

Photo Diode

Op-amp — **9**
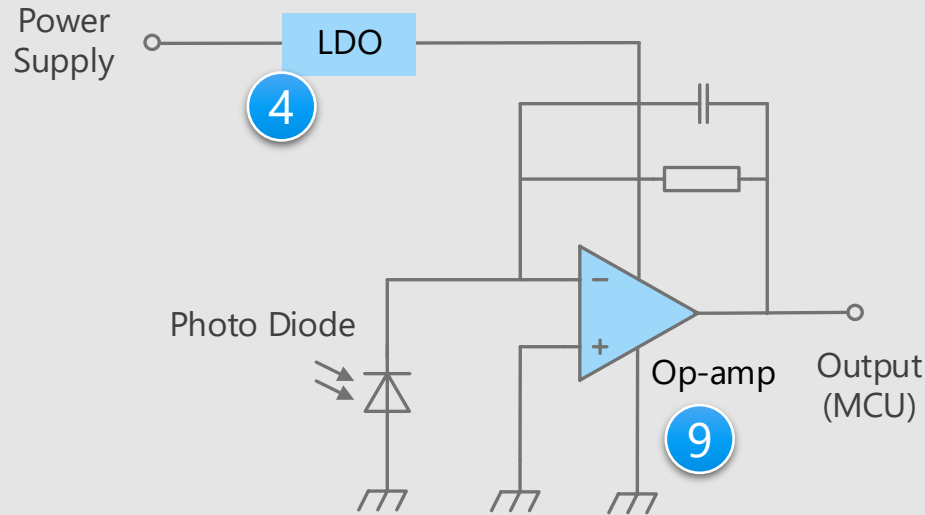
Output (MCU)

Criteria for device selection

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for sensor modules.
- The operational amplifier should be low current consumption or low noise device.
- Small package products contribute to the reduction of circuit board area.

Proposals from Toshiba

- **Supply the power with low noise**
  Small surface mount LDO regulator **4**

- **Amplification of detected very small signal with low noise**
  Low current consumption op-amp
  / Low noise op-amp **9**

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

Key input circuit

Key Input

Keys

7b

8 TVS

MCU
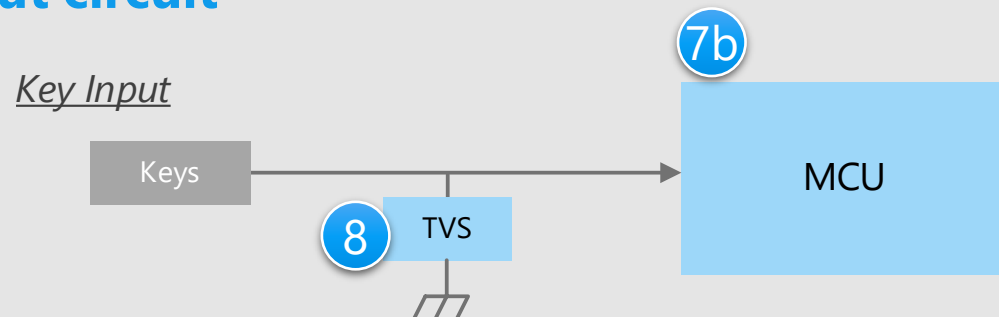
Criteria for device selection

- TVS diodes are suitable for protection from ESD pulses coming in key input unit.
- Small package products contribute to the reduction of circuit board area.

Proposals from Toshiba

- **Easy software development using general purpose CPU cores**
  MCU M3H Group **7b**
- **Absorb static electricity to prevent malfunction of the circuit**
  TVS diode **8**

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

Recommended Devices
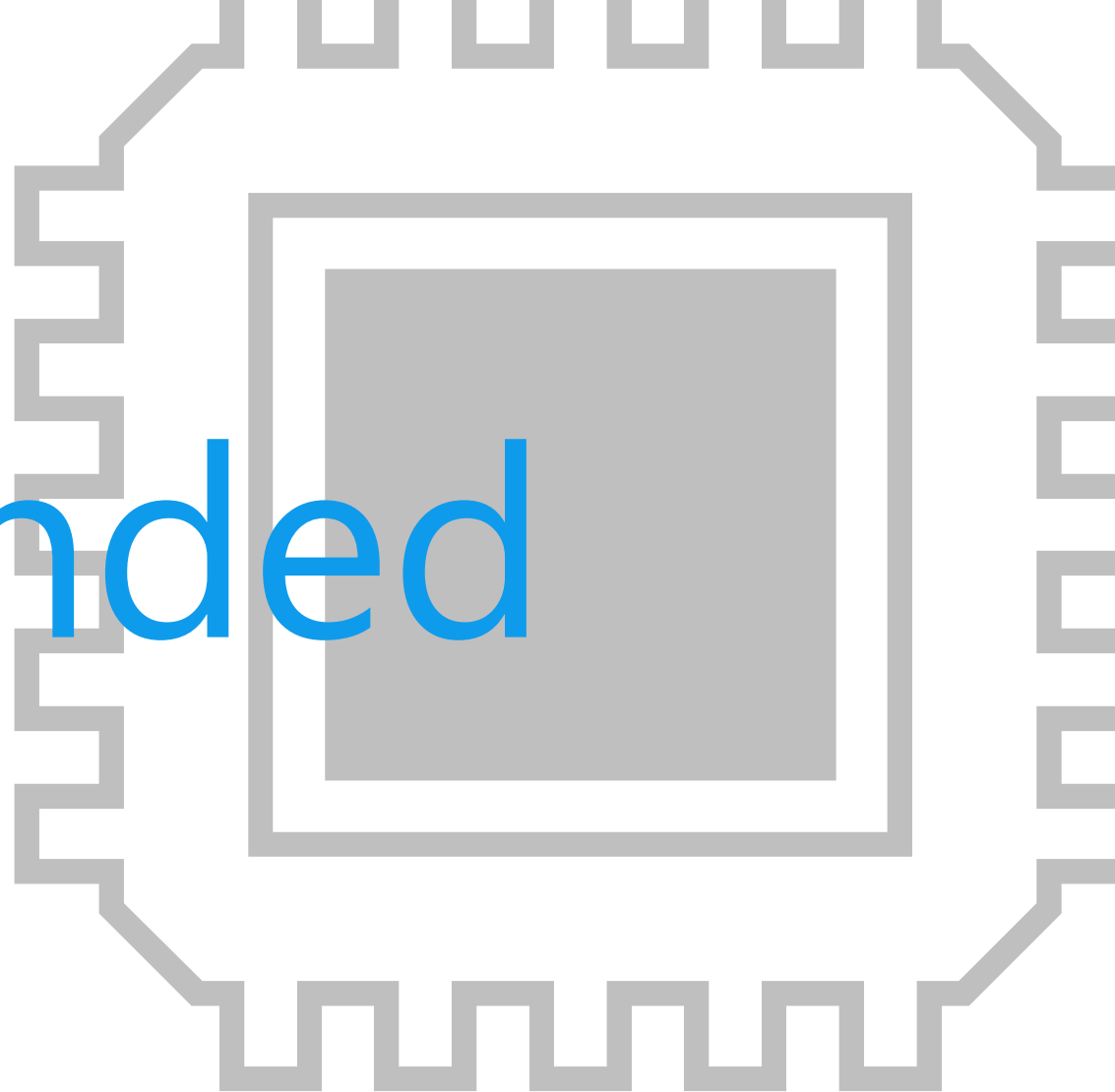
Device solutions to address customer needs

As described above, in the design of air conditioner, **"Quietness/efficiency of motors"**, **"Low power consumption of set"** 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 set

Miniaturization of circuit boards

Brushless DC motor drive

High efficiency · low loss

Small size packages

Device solutions to address customer needs

	Brushless DC motor drive	High efficiency. low loss	Small size packages
1. π-MOSⅧ / DTMOSⅥ / DTMOSⅣ(HSD) Series MOSFET	●	●	●
2. Transistor output photocoupler / Triac output photocoupler		●	●
3. Discrete IGBT	●	●	●
4. Small surface mount LDO regulator		●	
5. High voltage IPD	●	●	●
6. Motor driver	●	●	●
7. MCU M4K Group / M470 Group / M370 Group / M3H Group	●	●	●
8. TVS diode			●
9. Low current consumption op-amp / Low noise op-amp		●	●
10. Transistor array		●	●

Value provided

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

1 RonA reduced by 24 %

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

Turn-off waveform

Toshiba's conventional product

$R_{G(off)}$ = 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
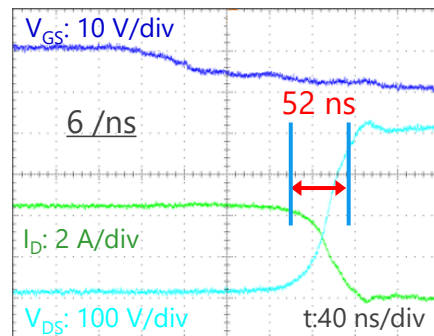
TK9J90E

$R_{G(off)}$ = 25 Ω 【condition】
V_{DD} = 400 V, I_D = 4.5 A, T_c = 25 °C

10 V/ns

32 ns
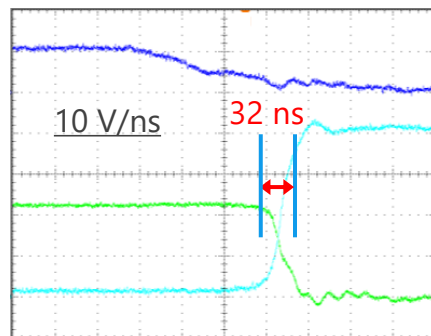
(Note) Toshiba internal comparison

Lineup

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-ch	N-ch	N-ch

Value provided

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

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 Toshiba's DTMOSⅣ-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.

Comparison of $R_{DS(ON)}$ x Q_{gd} [Note 2]

DTMOSⅣ TK62N60W
DTMOSⅣ-H TK62N60X
DTMOSⅥ TK040N65Z

40% decrease from DTMOSⅣ-H (Toshiba internal comparison)

TK62N60W (600 V, 40 mΩ)
TK62N60X (600 V, 40 mΩ)
TK040N65Z (650 V, 40 mΩ)

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.

[Note 2] As of March, 2023.
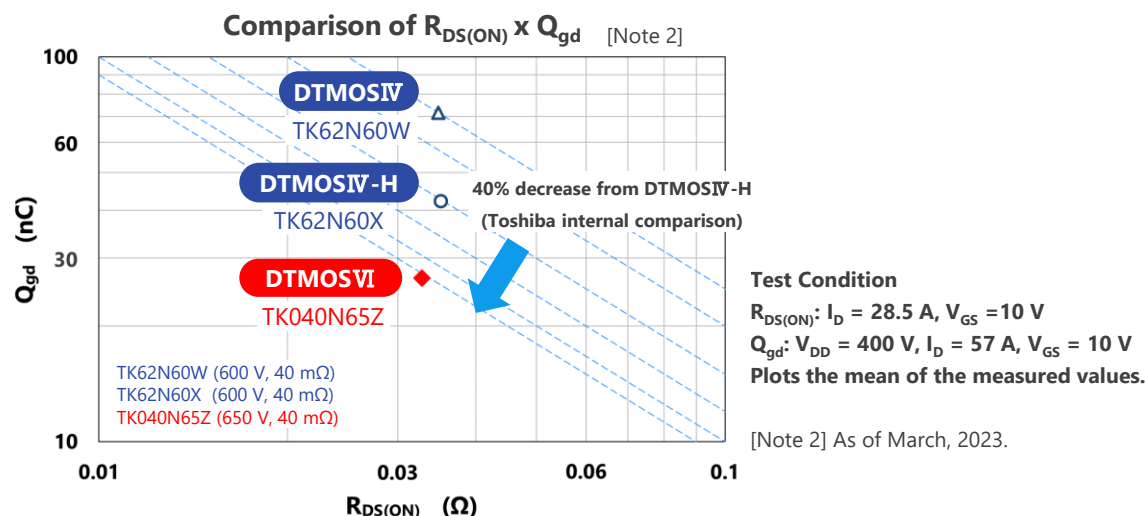
2 RonA reduced by 18 %

The figure of merit RonA of the latest generation [Note1] DTMOSⅥ has been reduced by 18 % compared with the previous generation (Toshiba's DTMOSⅣ 650 V products). Achieving low on-resistance while maintaining high voltage contributes to high efficiency of equipment.

[Note1] As of March 2023

Lineup

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	0.040
Polarity		N-ch	N-ch

◆Return to Block Diagram TOP

DTMOSⅣ (HSD) Series MOSFET
TK20A60W5

1c

Brushless DC motor drive

High efficiency · low loss

Small size packages

Value provided

The figure of merit RonA has been reduced by 30 % (compared with Toshiba conventional products), then contribute to improve efficiency of power supply.

1 RonA 30 % reduction

Adoption of newly developed single epitaxial process to reduce the figure of merit RonA by 30 %.
(Compared with Toshiba DTMOSⅢ products)

2 Reduction of on-resistance increase at high temperature

The single epitaxial process reduces the on-resistance increase at high temperature.

3 Optimization of switching speed

Optimization of switching speed has been achieved by reduction of C_{OSS} (by 12 %, compared with Toshiba conventional products) and other factors.

Reduced by 30 %

RonA (Figure of merit)

DTMOSⅢ: 1
DTMOSⅣ: 0.7
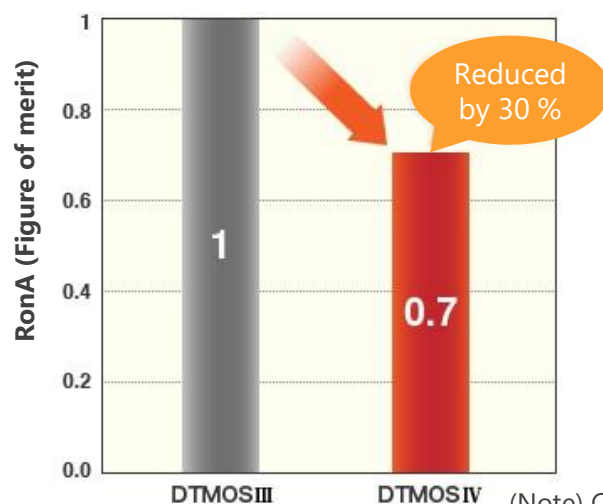
(Note) Compared with Toshiba conventional products

Lineup

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-ch

◆Return to Block Diagram TOP

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 is a high isolation photocoupler that optically couples 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.
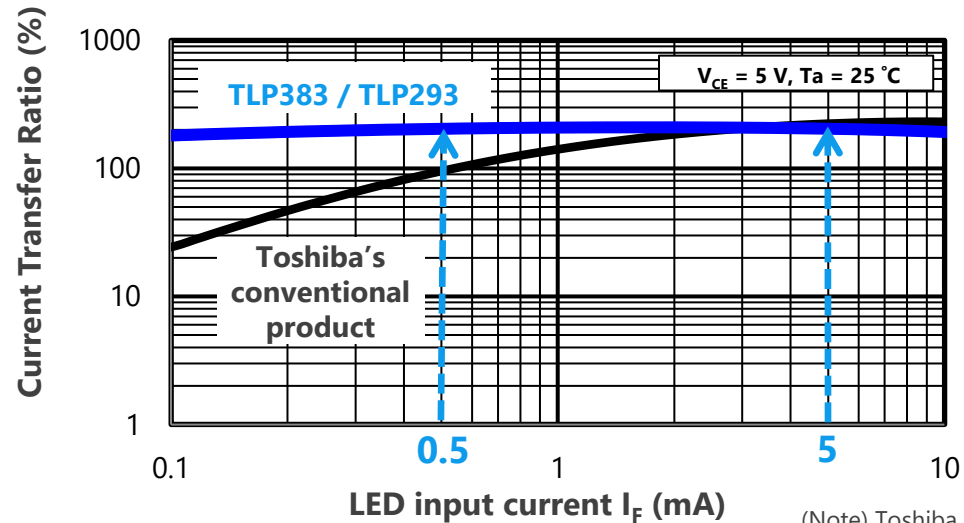
2 High temperature operation

The TLP383 and TLP293 are designed to operate even under severe ambient temperature conditions.

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

TLP383 / TLP293

V_{CE} = 5 V, Ta = 25 °C

Toshiba's conventional product

(Note) Toshiba internal comparison

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

Triac output photocoupler
TLP3083 / TLP3073

Value provided

Using a triac with high dv/dt pre-driver for solenoid valve 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 TLP3083 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 various AC power supplies.

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

Triac output Photocoupler

Valve Control

2Way Valve/ 4Way Valve

Lineup

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

Value provided

Switching devices for high voltage (600 V or more) and high current (30 A or more) 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

Toshiba has a lineup of products 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.

■ **Active type PFC circuit example using discrete IGBT (GT50JR22)**

IGBT

V_{out}
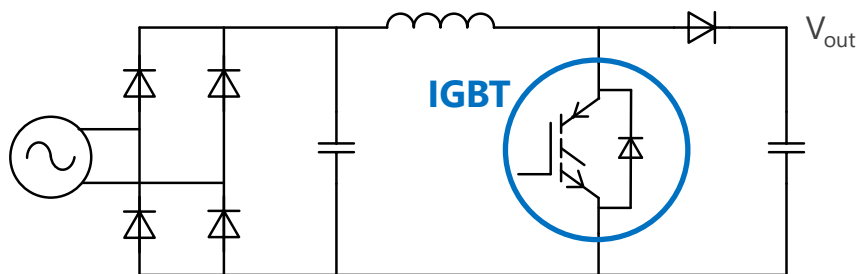
f_{sw} = 20 to 35 kHz

Lineup

Part number		GT50JR22	GT30J122A	GT50J123	GT30J65MRB
Package		TO-3P(N)			
Built-in FWD		✓ (RC structure)	-	-	✓ (RC structure)
V_{CES} [V]		600	600	600	650
I_C [A]		50	30	59	60
$V_{CE(sat)}$ [V] @I_C = 50 A, V_{GE} = 15 V, T_a = 25 °C	Typ.	1.55	1.7	1.90	1.40 @I_C = 30 A
	Max	2.20	2.8	2.50	1.80 @I_C = 30 A
Breakdown tolerance	t_{sc} [μs]	-	-	5	-
	RBSOA	-	-	120 A, 600 V (full square)	-

Small surface mount LDO regulator
TCR15AG / TCR13AG / TCR8BM / TCR5BM / TCR5RG / TCR3RM / TCR3U / TCR2L / TAR5 Series

Brushless DC motor drive · **High efficiency · low loss** · **Small size packages**

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

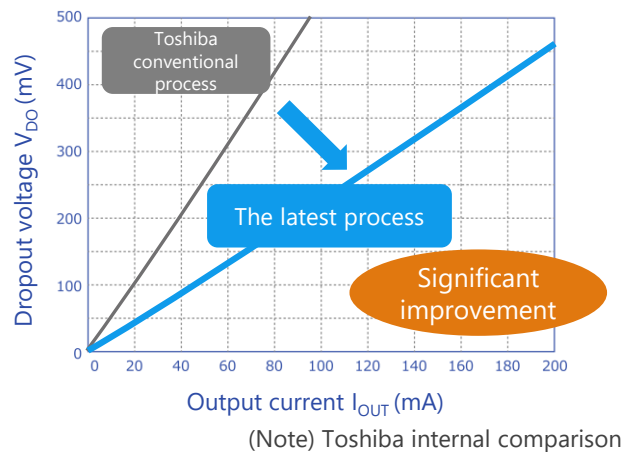0.34 µA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.
(TCR3U Series)

Low dropout voltage

- Dropout voltage V_{DO} (mV) vs Output current I_{OUT} (mA)
- Toshiba conventional process
- The latest process
- Significant improvement

(Note) Toshiba internal comparison

Rich package lineup

- 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
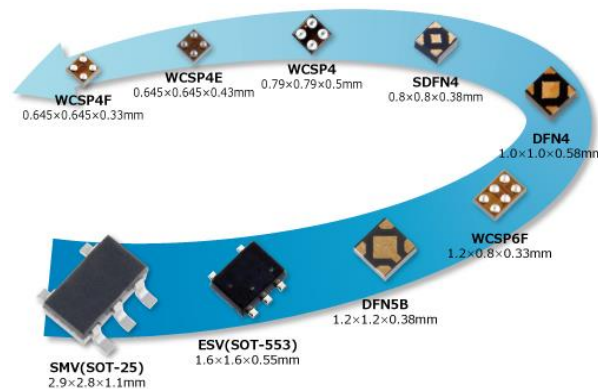
Lineup

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

Value provided

It is a brushless DC motor driver with built-in MOSFETs or IGBTs and can be driven at a variable speed by control signals from the MCU.

1 **Built-in circuitry required to drive the motor**

It contains a level shifting high side driver, low side driver and MOSFETs or IGBTs.

TPD4204F: MOSFET output
TPD4163F/TPD4164F: IGBT output

2 **Motor drive terminals and control terminals are separated**

High voltage and large current terminals and the control terminals are separated on both sides of the package, thereby eliminating the complexity of wiring.

3 **Various protection functions**

Over current and under voltage protection, shutdown and thermal shutdown functions are available.

TPD4163F Application Circuit Example
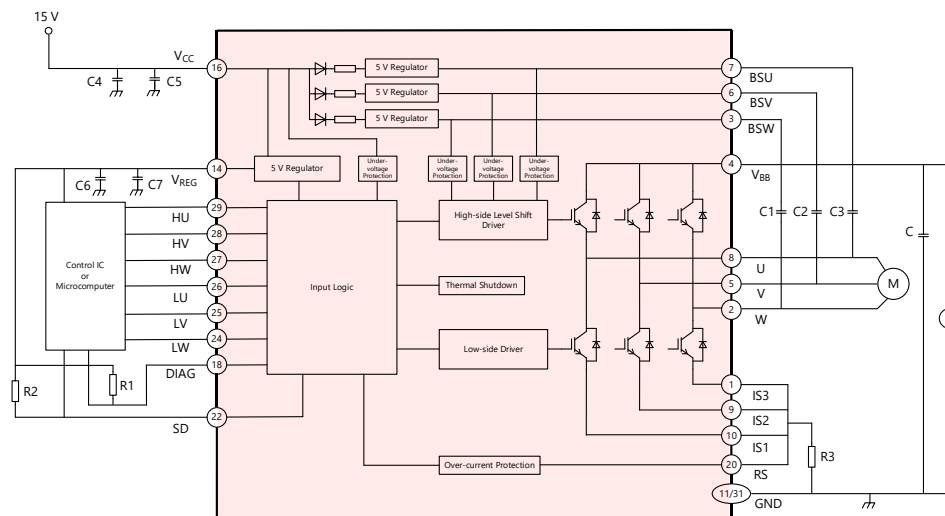
Lineup

Part number	TPD4204F	TPD4163F	TPD4164F
Package	P-SSOP30-1120-1.00-001	P-HSSOP31-0918-0.80-002	
V_{BB} [V]	600		
I_{out} [A]	2.5	1.0	2.0
V_{CC} [V]	13.5 to 16.5		

Brushless DC motor drive · **High efficiency · low loss** · **Small size packages**

This product optimizes for brushless DC motor driving and has the functions required for motor driving into one package.

1 Contributing to low power consumption

The power consumption can be reduced by replacing from the AC motor to a brushless DC motor.

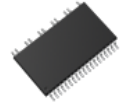## 2 Contributing to reducing the number of parts
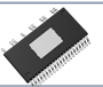
Built-in functions and protection functions required for inverter operation can reduce the number of parts.

3 Contributing to reduction of circuit board area

The use of small surface mount packages contributes to the reduction of circuit board area.

Built-in bootstrap diode

Support Hall devices

Built-in square wave energizing circuit

Built-in three-phase inverter circuit

Built-in protection functions
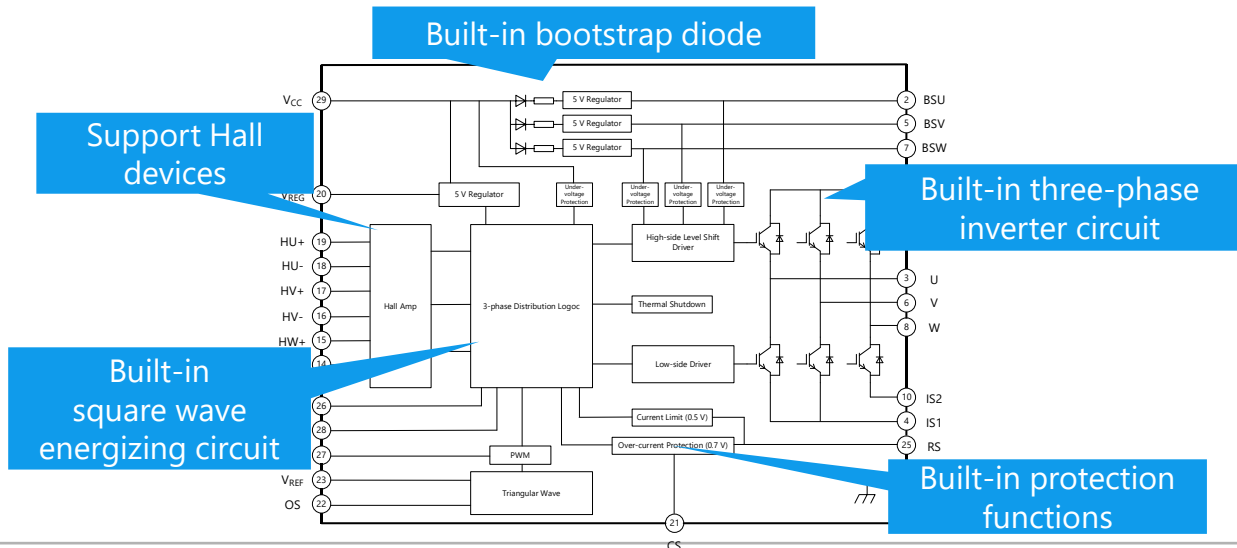
Lineup	
Part number	TPD4162F
Package	P-HSSOP31-0918-0.80-002
V_{BB} [V]	600
I_{out} [A]	0.7
V_{CC} (Max) [V]	17.5
Protective function	Current limitation, overcurrent protection, thermal shutdown, under voltage protection

Value provided

Support low voltage motor drive (2.5 V (Min)) and contributes to the power saving of set.

1 Low voltage operation
Motor power supply voltage is 2.5 V (Min) for low voltage applications such as battery operation devices.

2 Low current consumption
Standby current is 2 μA or less (IC total) for power saving of devices.

3 Error detection functions
Over current detection (ISD), thermal shutdown (TSD) and under voltage lockout (UVLO) are available.
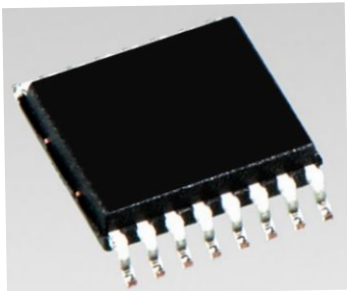
P-TSSOP16-0505-0.65-001 Package
(5.0 x 6.4 x 1.2 mm)
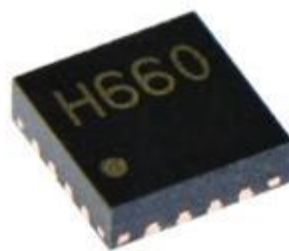
P-VQFN16-0303-0.50-001 Package
(3.0 x 3.0 x 0.9 mm)

Lineup

Part number	TC78H621FNG	TC78H660FNG	TC78H660FTG
V_M [V]	18	18	18
I_{OUT} [A]	1.1	2.0	2.0
$R_{on\ (upper\ and\ lower\ sum)}$ (Typ.) [Ω]	0.8	0.48	0.48
Control Interface	PHASE input	IN/PHASE inputs	IN/PHASE inputs
Step	2phase/1-2phase excitation	2phase/1-2phase excitation	2phase/1-2phase excitation
Motor power supply voltage	2.5 V (Min)	2.5 V (Min) RS resister less	2.5 V (Min) RS resister less
Error detection function	ISD, TSD, UVLO	ISD, TSD, UVLO	ISD, TSD, UVLO
Package	P-TSSOP16-0505-0.65-001	P-TSSOP16-0505-0.65-001	P-VQFN16-0303-0.50-001

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Brushless DC motor drive

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

Sine wave drive system with smooth current waveforms contributes to lower motor noise and vibration compared to conventional square wave drive system [Note].

3 Small package

VQFN32 package is adopted for TC78B042FTG, which requires small space. SSOP30 package is adopted for TC78B041FNG as conventional Type.

[Note] Comparison with Toshiba products

SSOP30-P-300-0.65 Package
(10.2 x 7.6 x 1.6 mm)

P-VQFN32-0505-0.50-005 Package
(5 x 5 x 1 mm)

Lineup

Part number	TC78B041FNG	TC78B042FTG
Power supply voltage	6 to 16.5 V (operating range)	
Drive Type	Sine wave drive	
Features	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 pin)	Built-in 5 V regulators (VREF/VREF2 pin)
	Error detection positive input	Error detection positive/negative input
Package	SSOP30-P-300-0.65	P-VQFN32-0505-0.50-005

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Three-phase brushless DC motor controller
TB6584FNG / TB6584AFNG / TB6634FNG

Brushless DC motor drive

High efficiency · low loss

Small size packages

Value provided

High voltage and high current brushless DC motor driving can be implemented by external IPD.

1 High efficient motor control by automatic phase control

Automatic phase controller by current feedback is integrated adding conventional fixed phase voltage input (32 steps).

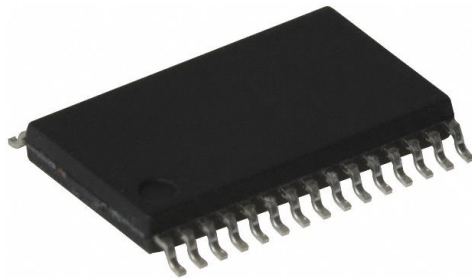**2** Motor control with low noise, and low vibration

Sine wave drive system with smooth current waveforms contributes to lower motor noise and vibration compared to conventional square wave drive system [Note].

3 Sufficient development support

Various supports such as third party evaluation board and PSpice® data for development and design are prepared.

[Note] Comparison with Toshiba products

TB6584FNG, TB6584AFNG
TB6634FNG

SSOP30-P-300-0.65 Package (10.2 x 7.6 x 1.6 mm)

Lineup

Part number	TB6584FNG	TB6584AFNG	TB6634FNG
Supply voltage	6 to 16.5 V (operating range)		
Output current	0.002 A (for MOSFET driver)		
Drive mode	Sine wave drive		
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: overcurrent protection, abnormal position signal protection, undervoltage lockout, motor restrained detection (TB6634FNG)		

◆Return to Block Diagram TOP

Three-phase brushless DC motor driver
TB67B000AHG / TB67B000AFG

Value provided

A motor control IC and IGBTs are integrated into one package, contributing to the miniaturization of circuit boards.

1 A motor control IC and IGBTs

A motor control IC with sine wave PWM drive function and IGBTs with 600 V and 2 A characteristics are integrated into one package.

2 Motor control with low noise, and low vibration

Sine wave drive system with smooth current waveforms contributes to lower motor noise and vibration compared to conventional square wave drive system [Note].

3 High heat dissipation

HDIP30 package is adopted for TB67B000AHG, which has high heat dissipation. HSSOP34 package is adopted for TB67B000AFG, which is smaller than HDIP30.

[Note] Comparison with Toshiba products

P-HDIP30-1233-1.78-001
(32.8 x 13.5 x 3.525 mm)

P-HSSOP34-0918-0.80-001
(17.5 x 11.93 x 2.2 mm)

Lineup

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	Sine wave PWM drive / Wide angle commutation	
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	IGBT three-phase bridge, oscillator circuit, built-in bootstrap diode, overcurrent protection, thermal shutdown, undervoltage lockout, motor lock detection	
Package	P-HDIP30-1233-1.78-001	P-HSSOP34-0918-0.80-001

◆Return to Block Diagram TOP

Value provided

System cost reduction, higher efficiency and less development work.

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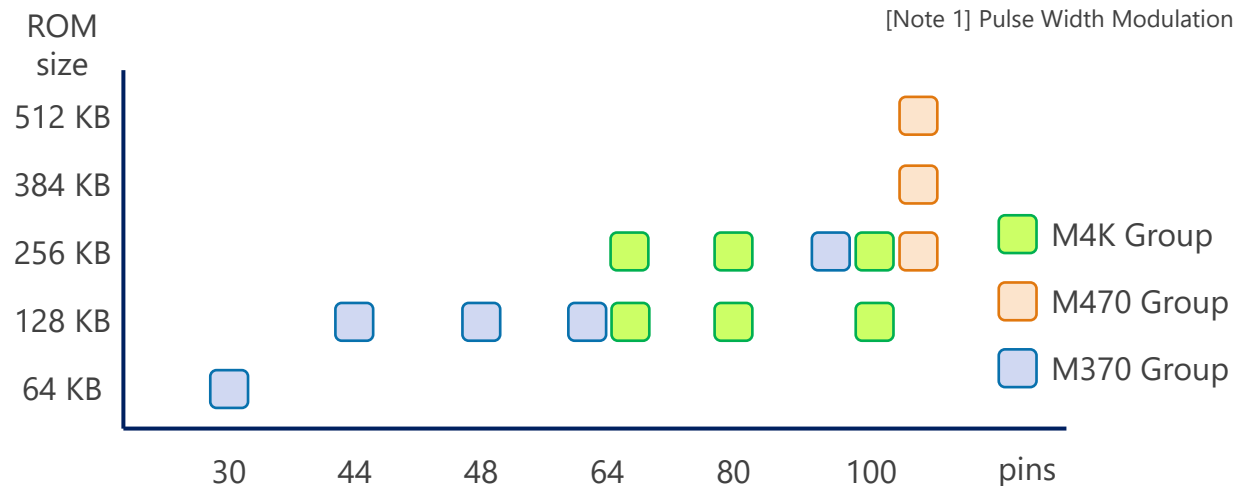
Toshiba's original co-processor vector engine (VE) for motor control reduces CPU load and allows control of multiple motors and peripherals.

2 **Equipped with motor control circuit**

A variety of three-phase PWM [Note 1] 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.

[Note 1] Pulse Width Modulation

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 2]

[Note 2] For M4K Group and will gradually expand for TXZ+™ Series products

ROM size plot (ROM size vs pins):
- 512 KB
- 384 KB
- 256 KB
- 128 KB
- 64 KB

pins: 30, 44, 48, 64, 80, 100

- 🟩 M4K Group
- 🟧 M470 Group
- 🟦 M370 Group

Lineup

Series	Group	Function
TXZ+™4A Series	M4K Group	Arm® Cortex®-M4, 160 MHz operation 4.5 to 5.5 V, three motor control (Max), Data Flash
TX04 Series	M470 Group	Arm® Cortex®-M4, 120 MHz operation 4.5 to 5.5 V, two motor control (Max)
TX03 Series	M370 Group	Arm® Cortex®-M3, 80 MHz operation 4.5 to 5.5 V, two motor control (Max)

MCU
TXZ+™3A Series M3H Group

Brushless DC motor drive

High efficiency · low loss

Small size packages

Value provided

MCU is equipped with many peripheral functions. MCU contributes to higher functionality as a system control MCU.

1 Built-in Arm® Cortex®-M3 CPU core

MCU is equipped with Arm Cortex-M3 core. Maximum operation frequency is 120 MHz.

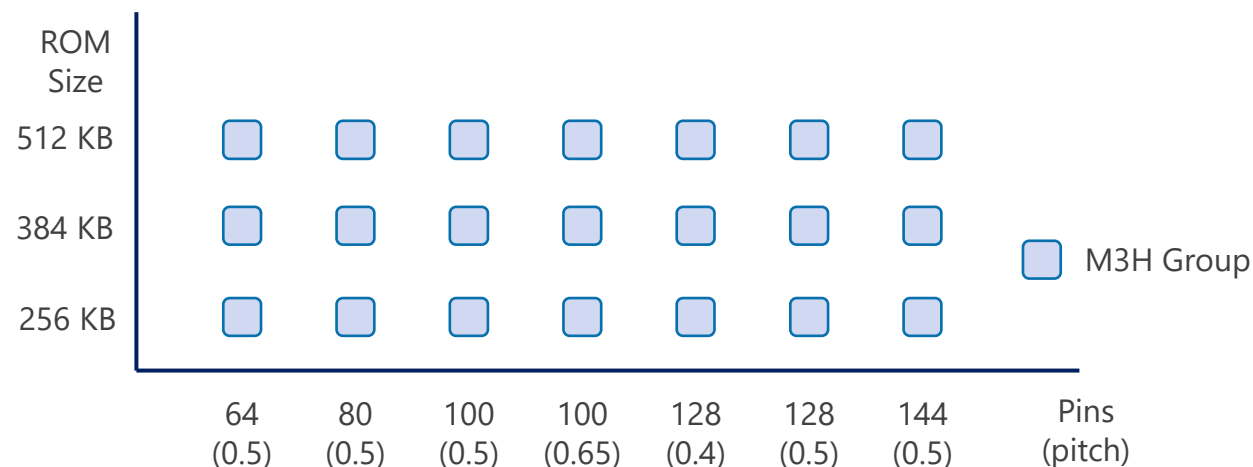## 2 Various lineup of built-in memories and packages

M3H group integrates both 512 KB (Max) code and 32 KB data flash memories which support 100,000 write cycle endurance, and has a wide lineup of package from 64 to 144 pins.

3 Equipped with many peripheral functions

M3H Group have many peripheral functions such as UART, SPI, I^{2}C, 12bit AD converter, 8bit DA converter, three-phase PWM [Note1] output, ENC and digital LCD driver [Note2], etc.

[Note 1] Pulse Width Modulation

[Note2] 64 pins product isn't equipped with digital LCD driver.

ROM Size

□ M3H Group

	64 (0.5)	80 (0.5)	100 (0.5)	100 (0.65)	128 (0.4)	128 (0.5)	144 (0.5)
512 KB	□	□	□	□	□	□	□
384 KB	□	□	□	□	□	□	□
256 KB	□	□	□	□	□	□	□

Pins (pitch)

Lineup

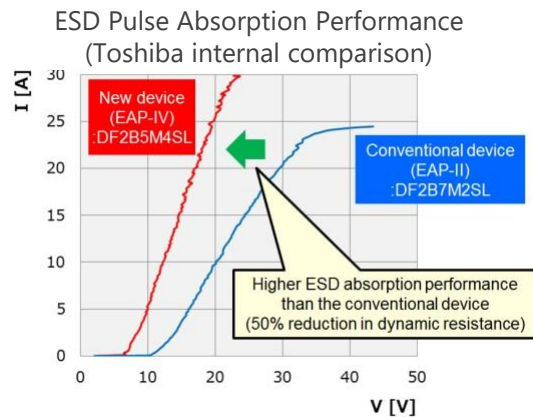| Series	Group	Function
TXZ+™3A Series	M3H Group	Arm® Cortex®-M3, 120 MHz, 2.7 to 5.5 V operation

◆Return to Block Diagram TOP

Value provided

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

| **1** High ESD pulse absorption performance | **2** Suppress ESD energy by low clamp voltage | **3** Suitable for high density mounting |

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.

Protect the connected circuits and devices using Toshiba own technology.

A variety of small packages are available.

ESD Pulse Absorption Performance
(Toshiba internal comparison)
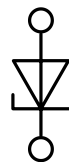
Unidirectional

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	DF2B7BSL	DF2B5M4SL	DF2B6M4SL
Package	SL2	SL2	SL2
V_{ESD} [kV]	±30	±20	±20
V_{RWM} (Max) [V]	5.5	3.6	5.5
C_t (Typ.) [pF]	12	0.2	0.2
R_{DYN} (Typ.) [Ω]	0.2	0.5	0.5

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

◆Return to Block Diagram TOP

Brushless DC motor drive

High efficiency · low loss

Small size packages

Value provided

Lineup includes low current consumption type that contributes to low power consumption and a low noise type that maximizes the performance of high performance sensors.

1 **Low voltage operation**

We have a lineup of low power supply voltage-driven operational amplifiers using CMOS process for low power supply voltage-driven wearable equipment.

2 **Low current consumption (TC75S102F)** I_{DD} = 0.27 [μA] (Typ.)

CMOS processes have been used to achieve lower current consumption. This contributes to lower power consumption and longer life of wearable equipment.

3 **Low noise (TC75S67TU)** V_{NI} = 6.0 [nV/√Hz] (Typ.) @f = 1 kHz

This CMOS operational amplifier can amplify minute signals detected by various sensors [Note] with very low noises. By optimizing the process, the equivalent input noise voltage has been reduced.

[Note] Sensor types: vibration, shock, acceleration, pressure, infrared, temperature, etc.

TC75S102F
Current Consumption Characteristic
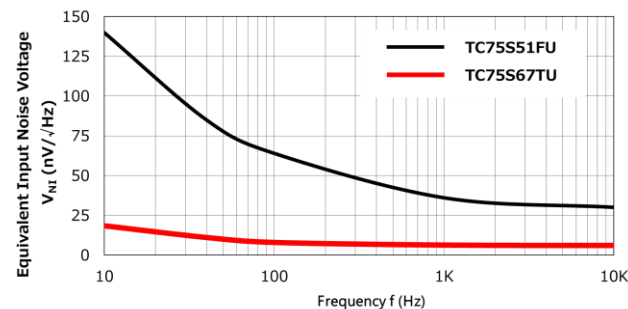(Toshiba internal comparison)

Low current consumption product TC75S102F
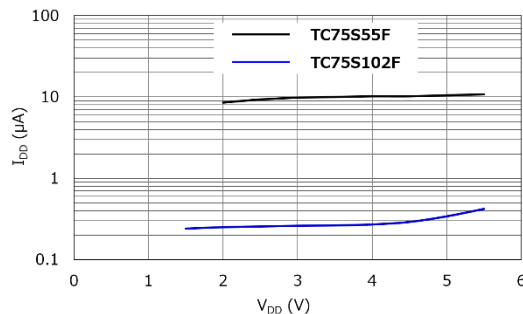
TC75S67TU
Noise Characteristic
(Toshiba internal comparison)

Reduce 1/f noise (10 Hz) by 86 % from our normal products

V_{NI} - f @Ta=25 ℃、V_{DD}=3.3 V

Lineup

Part number	TC75S102F	TC75S67TU
Package	SMV	UFV
V_{DD} - V_{SS} [V]	1.5 to 5.5	2.2 to 5.5
V_{IO} (Max) [mV]	1.3	3
CMV_{IN} (Max) [V]	V_{DD}	1.4 (@V_{DD} = 2.5 V)
I_{DD} (Typ. / Max) [μA]	0.27 / 0.46 (@V_{DD} = 1.5 V)	430 / 700 (@V_{DD} = 2.5 V)
V_{NI} (Typ.) [nV/√Hz] @f = 1 kHz	-	6

◆Return to Block Diagram TOP

Brushless DC motor drive **High efficiency · low loss** **Small size packages**

Value provided

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

1 Rich product lineup

In addition to the listed products, we have lineup of various packaged products (such as DIP, SOL, SOP, SSOP, etc.) and source output type products.
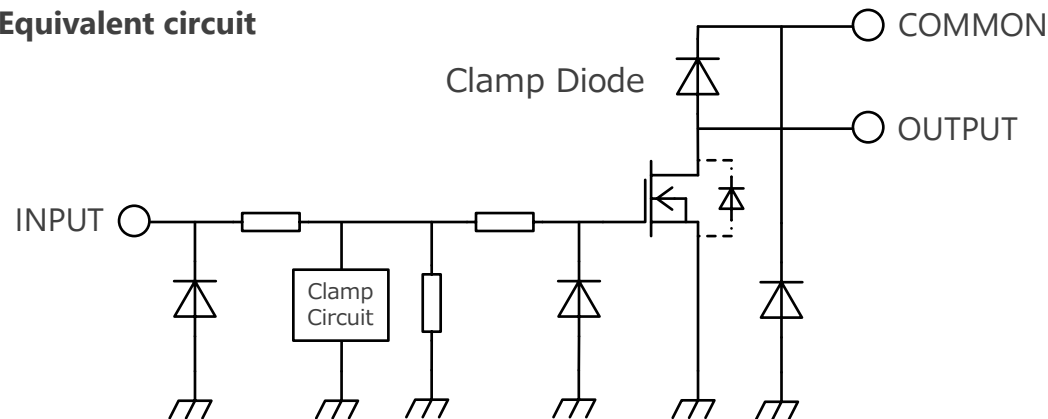
2 Built-in output clamp diode.

Built-in output clamp diodes regenerates the back electromotive force generated by switching of an inductive.

3 Higher current drive is possible.

The load can be driven with higher current by connecting multiple outputs in parallel.

Equivalent circuit

Clamp Diode

COMMON

OUTPUT

INPUT

Clamp Circuit

(Note) Equivalent circuit may be simplified for explanatory purpose.

Lineup

Part number	TBD62003AFWG	TBD62083AFG	TBD62064AFAG
Package	P-SOP16-0410-1.27-002	SOP18-P-375-1.27	P-SSOP24-0613-1.00-001
Output type	Sink	Sink	Sink
Number of channels	7ch	8ch	4ch
Input level	H	H	H
I_{OUT} [mA/ch]	500	500	1500
V_{OUT} [V]	50	50	50

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have questions or comments about any of them,
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