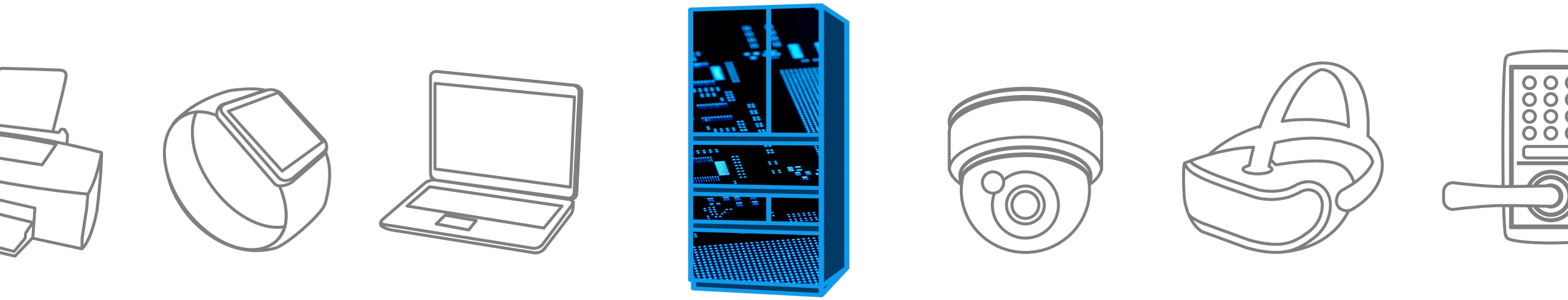
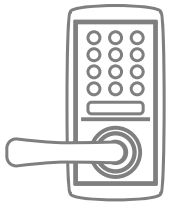
TOSHIBA

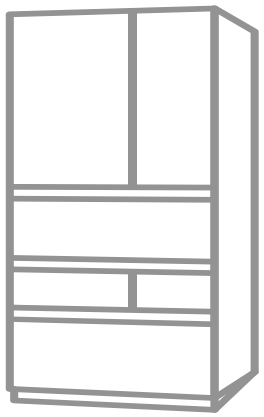
R22

Refrigerator

Solution Proposal by Toshiba

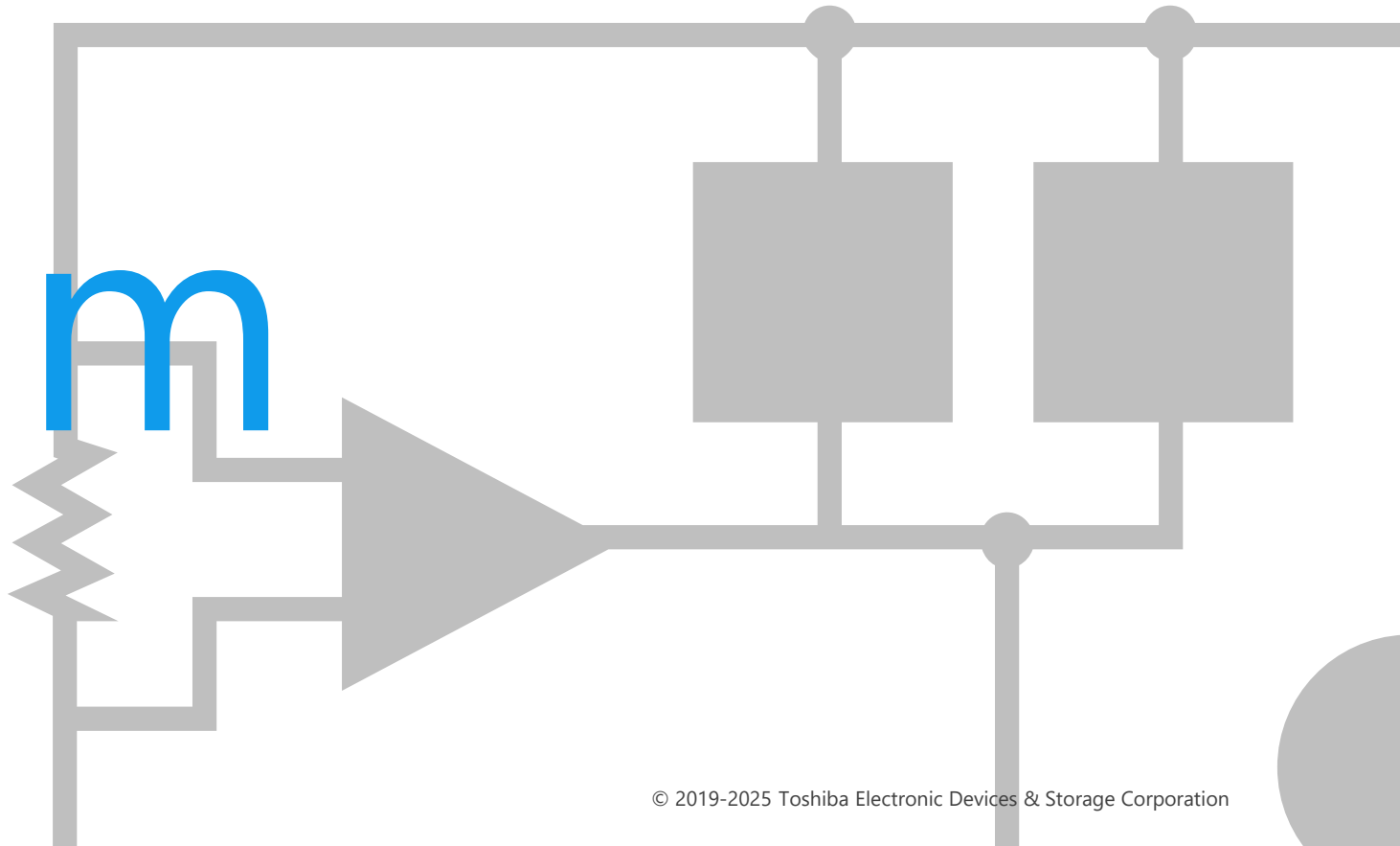




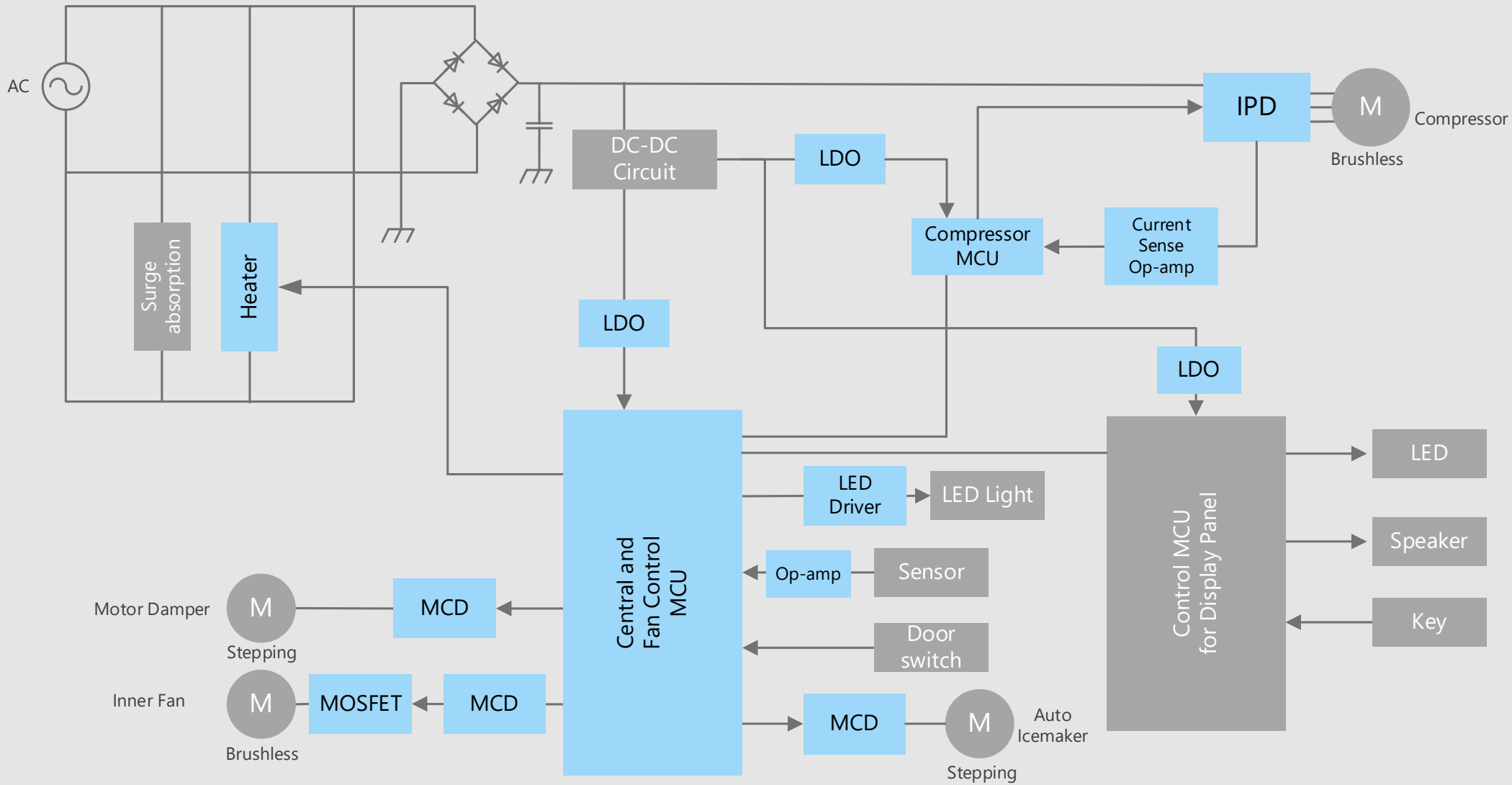


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

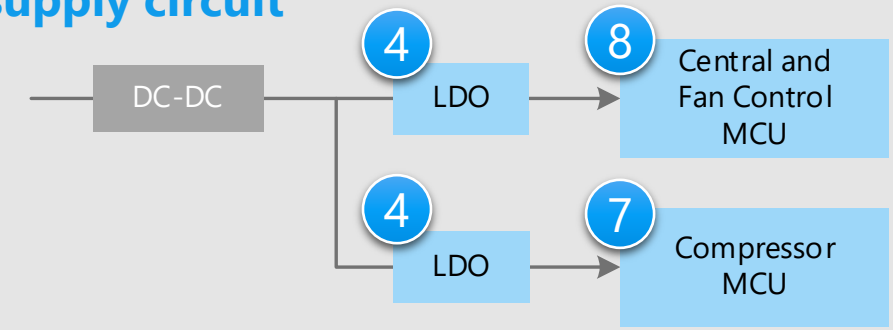


Refrigerator　Overall block diagram



Refrigerator　Details of MCU power supply unit

MCU power supply circuit



* Click the number in the circuit diagram to jump to the detailed description page.

Criteria for device selection

- LDO Regulator is suitable for stable power supply to MCU.

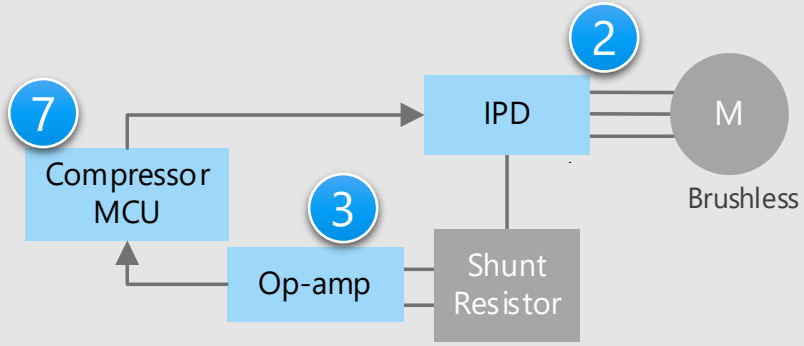
Proposals from Toshiba

- **Suitable power supply for environments with high power supply noise**
  Small surface mount LDO regulator
- **MCU suitable for motor control**
  MCU M4K / M470 / M370 Group
- **Easy software development using general purpose CPU cores**
  MCU M3H Group

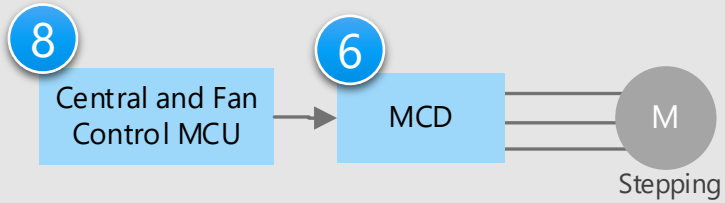
4
7
8

Refrigerator　Details of motor driving unit

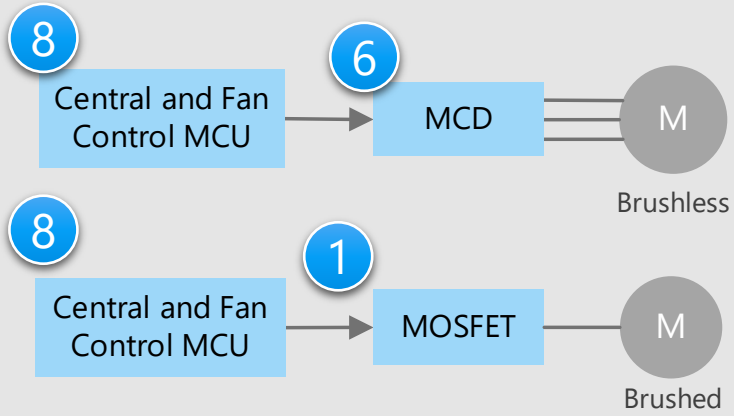
Compressor drive circuit



Damper drive circuit



Fan drive circuit



* Click the number in the circuit diagram to jump to the detailed description page.

Criteria for device selection

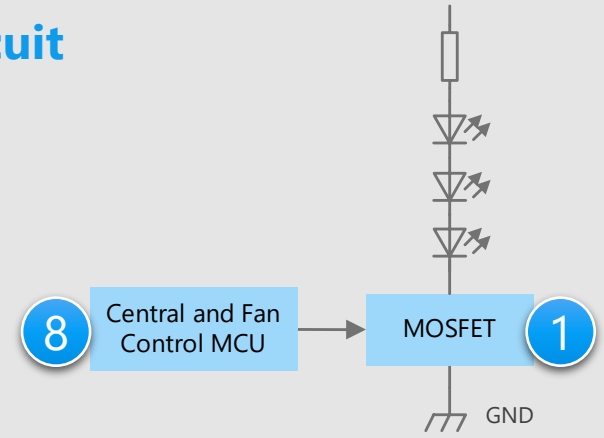
- Intelligent power devices (IPDs) are suitable for driving high voltage motors such as compressors.
- MCDs are used for driving stepping and brushless DC motors.
- An operational amplifier is used for amplifying signals such as current sensing.

Proposals from Toshiba

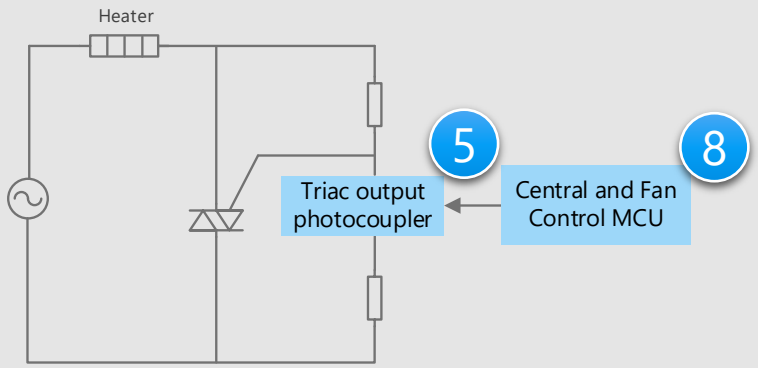
- **Realize low power consumption by low on-resistance** (1)
  Small signal MOSFET
- **Built-in high voltage MOSFET** (2)
  High voltage IPD
- **Operational amplifier with built-in phase compensation circuit** (3)
  General purpose operational amplifier
- **Easy control of motors** (6)
  Motor driver
- **MCU suitable for motor control** (7)
  MCU M4K / M470 / M370 Group
- **Easy software development using general purpose CPU cores** (8)
  MCU M3H Group

Refrigerator　Details of Lamp / Heater / Sensor unit

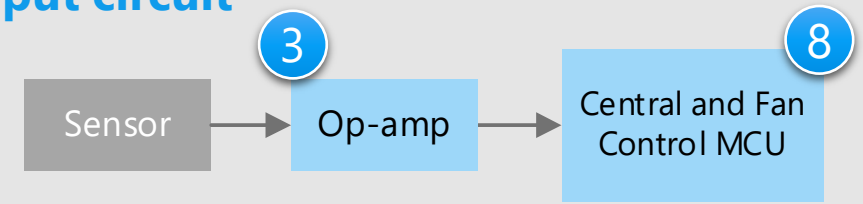
LED driving circuit



Heater control circuit



Sensor input circuit



* Click the number in the circuit diagram to jump to the detailed description page.

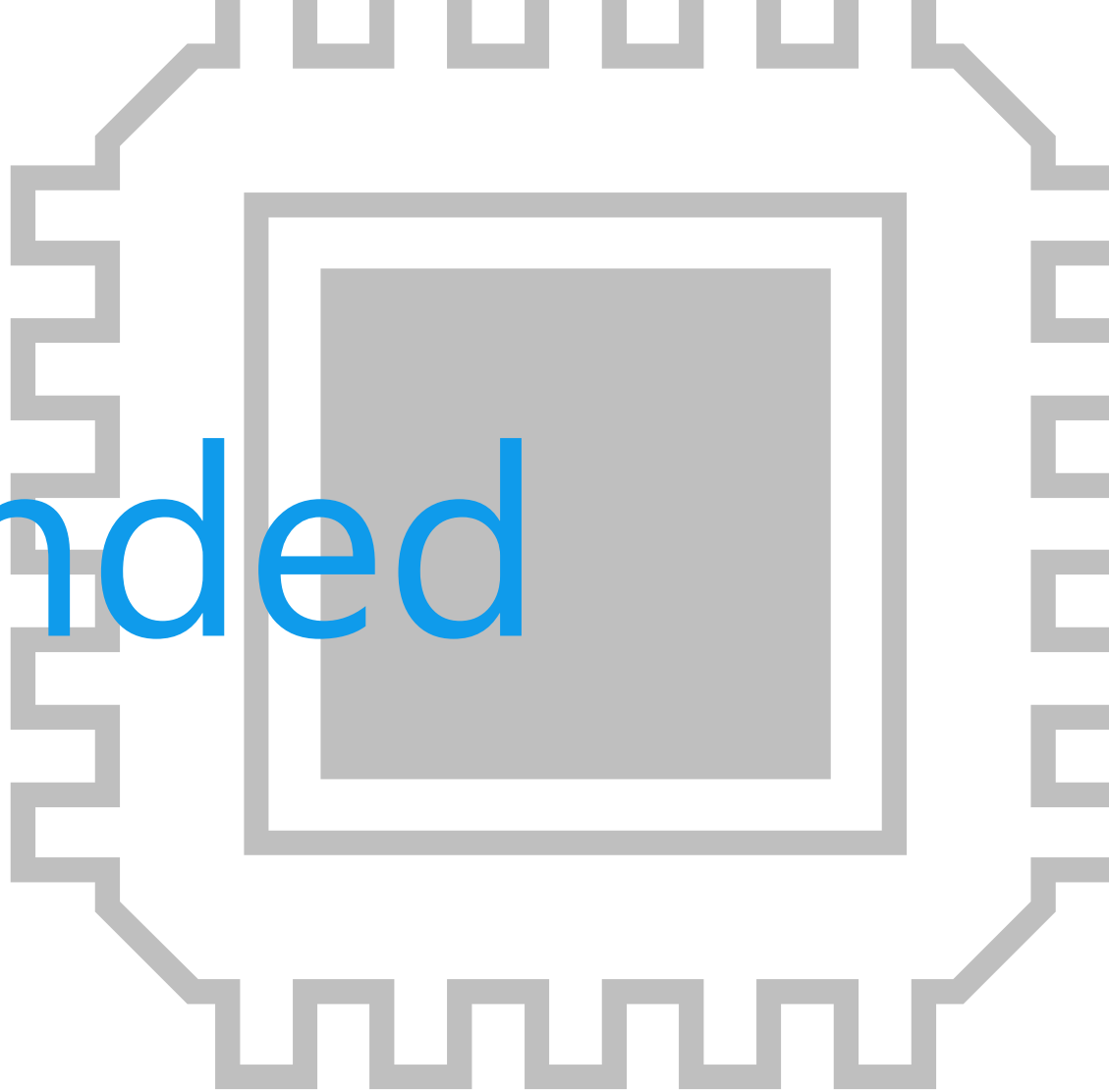
Criteria for device selection

- A triac output photocoupler is suitable for controlling the AC load.
- Small signal MOSFET is suitable for driving LED interior lights

Proposals from Toshiba

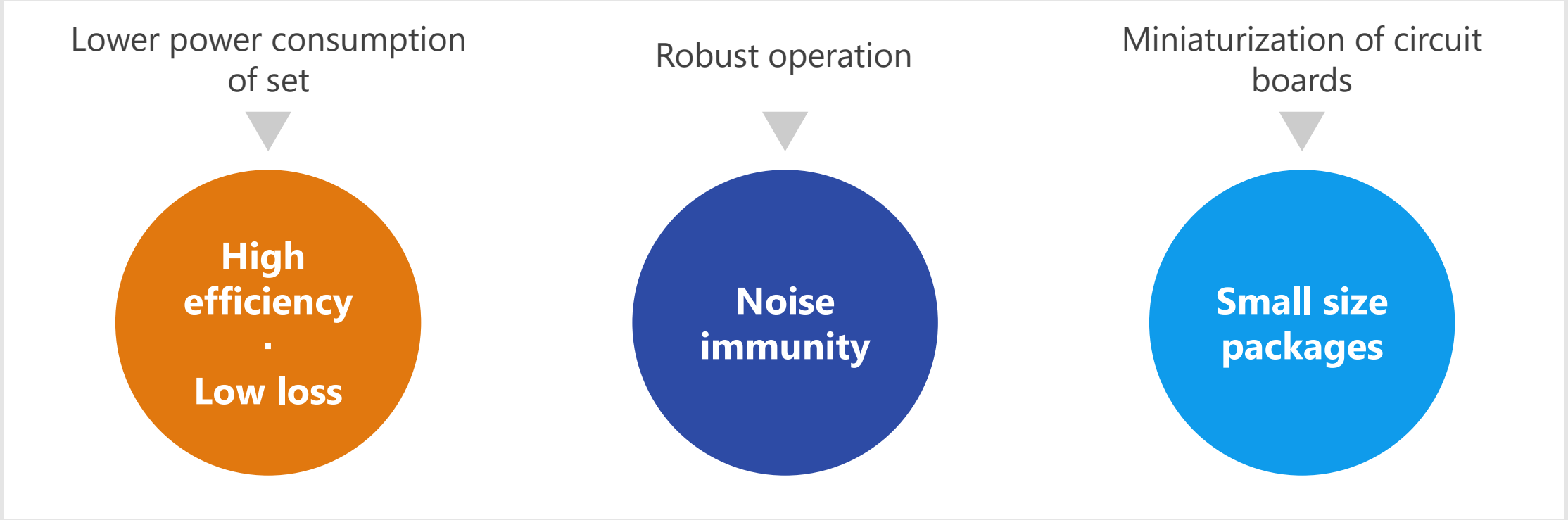
- **Switching with low on-resistance** 1
  Small signal MOSFET
- **Operational amplifier with built-in phase compensation circuit** 3
  General purpose operational amplifier
- **Efficient control of AC load** 5
  Triac output photocoupler
- **Easy software development using general purpose CPU cores** 8
  MCU M3H Group

Recommended Devices



Device solutions to address customer needs

As described above, in the design of refrigerators, **"Low power consumption of set"**, **"Robust operation"** and **"Miniaturization of circuit boards"** are important factors. Toshiba's proposals are based on these three solution perspectives.



Device solutions to address customer needs

	High efficiency · Low loss	Noise immunity	Small size packages
1 Small signal MOSFET	●		●
2 High voltage IPD	●		
3 General purpose operational amplifier	●	●	●
4 Small surface mount LDO regulator	●	●	●
5 Triac output photocoupler	●	●	●
6 Motor driver	●		●
7 MCU M4K / M470 / M370 Group	●		●
8 MCU M3H Group	●		●

1 Small signal MOSFET

SSM3K333R / SSM3K335R / SSM3J332R / SSM3J334R / SSM6P39TU / SSM3K35AFS

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

Value provided

Suitable for power management switches and greatly contributes to miniaturization.

1 Low voltage operation

V_{GS} = 4.5 V operation (SSM3K333R)
V_{GS} = 1.8 V operation (SSM6P39TU)
V_{GS} = 1.2 V operation (SSM3K35AFS)

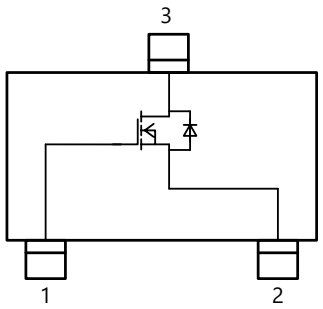
2 Low on-resistance

By keeping the on-resistance between the drain and source low, heat generation and power consumption can be kept low.

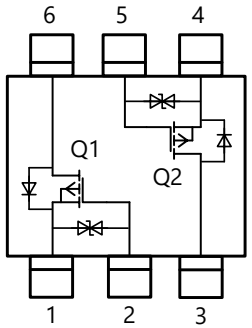
3 Small package

Small package is suitable for high density mounting.

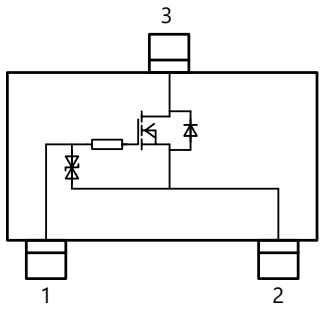
SSM3K333R
Equivalent Circuit



SSM6P39TU
Equivalent Circuit



SSM3K35AFS
Equivalent Circuit



Lineup

Part number	SSM3K333R	SSM3K335R	SSM3J332R	SSM3J334R	SSM6P39TU	SSM3K35AFS
Package	SOT-23F				UF6	SSM
V_{DSS} [V]	30	30	-30	-30	-20	20
I_D [A]	6	6	-6	-4	-1.5	0.25
$R_{DS(ON)}$ (Max) [Ω] @| V_{GS} | = 4.5 V	0.042	0.056	0.05	0.105	0.213 [Note]	1.1
Polarity	N-ch		P-ch		P-ch x 2	N-ch

[Note] @\| V_{GS} \| = 4 V

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2 High voltage IPD

TPD4207F

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

Value provided

A brushless DC motor driver with a built-in MOSFET 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 MOSFET.

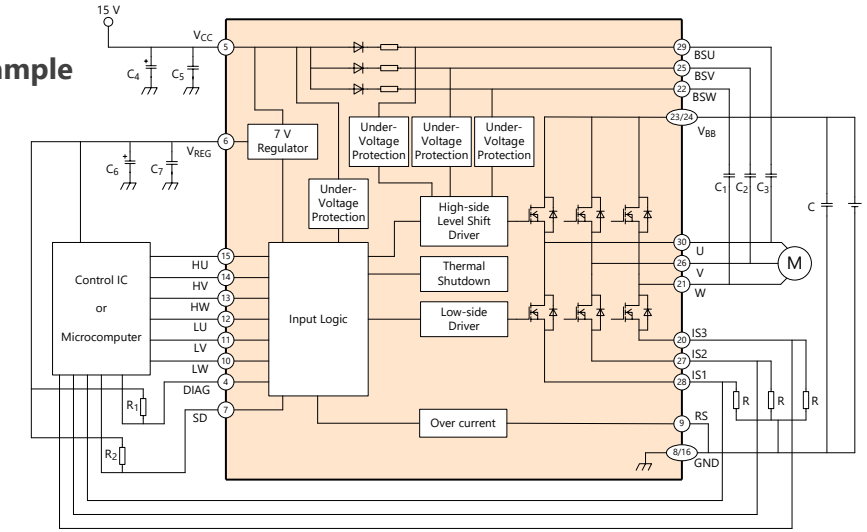
2 Motor drive terminals and control terminals are separated

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

3 Included protection functions

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

TPD4207F
Application Circuit Example



Lineup

Part number	TPD4207F
Package	SSOP30 
V_{BB} [V]	600
I_{OUT} [A]	5.0
V_{CC} [V]	13.5 to 16.5

◆Return to Block Diagram TOP

3 General purpose operational amplifier

TC75S51FU / TC75S103F

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

Value provided

CMOS single operational amplifier with a built-in phase compensation circuit, low voltage operation, and low current consumption.

1 Low voltage operation is possible.

Compared with bipolar general purpose operational amplifiers, low voltage operation is possible[Note].

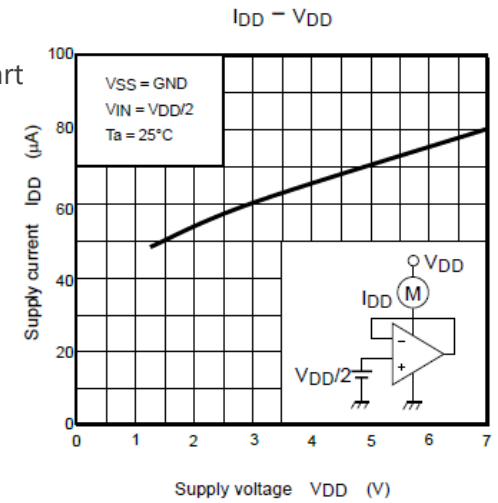
V_{DD} = ±0.75 to ±3.5 V or 1.5 to 7 V (for TC75S51FU)

[Note] Comparison with Toshiba's products

2 Built-in phase compensator circuit

Because the phase compensation circuit is built in, there is no need for any external device.

TC75S51FU
Characteristics chart



Lineup

Part number	TC75S51FU	TC75S103F
Package	USV 	SMV 
V_{DD} - V_{SS} [V]	1.5 to 7.0	1.8 to 5.5
I_{DD} (Typ. / Max) [μA]	60 / 200 (@V_{DD} = 3.0 V)	100 / 165 (@V_{DD} = 3.3 V)
f_T (Typ.) [MHz]	0.6	0.36
Input, Output Full Range	-	✓

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4 Small surface mount LDO regulator

TCR15AG / TCR13AG / TCR8BM / TCR5BM / TCR5RG / TCR3RM / TCR3U / TCR2L / TAR5 Series

High efficiency · Low loss | Noise immunity | 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 generation process significantly improved the dropout voltage characteristics.

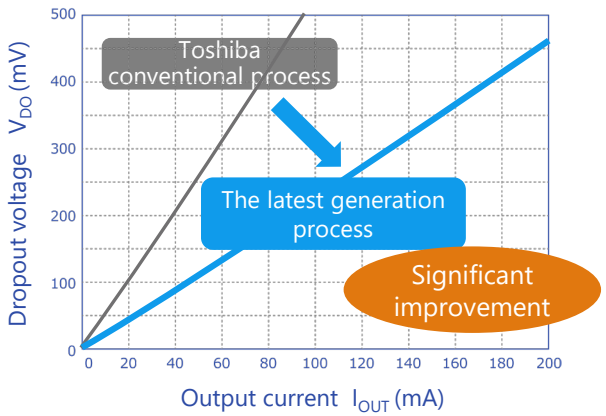
2 High PSRR Low output noise voltage

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

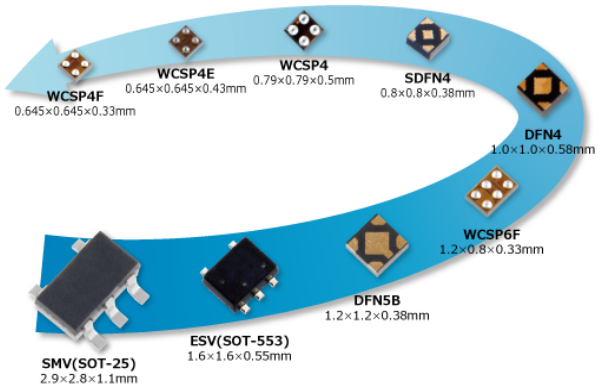
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

Low dropout voltage



(Note) Toshiba internal comparison with TCR3U series.

Rich package lineup



Lineup

Part number	TCR15AG Series	TCR13AG Series	TCR8BM Series	TCR5BM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR2L Series	TAR5 Series
Features	Low dropout voltage High PSRR				High PSRR Low noise Low current consumption		Low current consumption		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	56	20	19	7	7	0.34	1	170

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5 Triac output photocouplers

TLP267J / TLP3052A

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

Value provided

The photocoupler consists of a non zero cross type phototriac, optically coupled to an infrared light emitting diode.

1 Non zero cross type

This photocoupler is suitable for the case where the operation time is short and phase control is necessary.

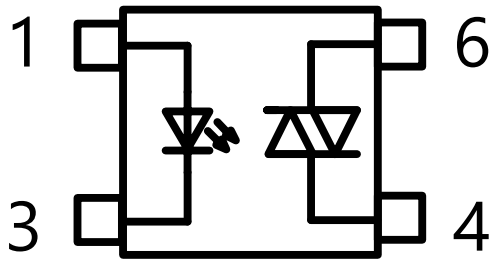
2 Switching characteristic

It has excellent features such as high speed, low noise and silence.

3 Miniaturization of mounting area

4pin SO6 packages have a size of 3.7 x 7.0 x 2.1 mm. (TLP267J)

TLP267J
Internal connection



UL-approved: UL1577, File No. E67349
cUL-approved: CSA Component Acceptance Service No.5A File No.E67349
VDE-approved: EN60747-5-5, EN62368-1 (Note)
(Note) When a VDE approved type is needed, please designate the Option (V4).

Lineup

Part number	TLP267J	TLP3052A
Package	4pim SO6 	5pin DIP6 
V_{DRM} [V]	600	600
BV_S [Vrms]	3750	5000
T_{opr} [°C]	-40 to 100	-40 to 100
Type	Non zero cross type	

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6a Stepping motor & Brushed DC motor driver IC

TC78H621FNG / TC78H660FNG

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

Value provided

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

1 Low voltage operation

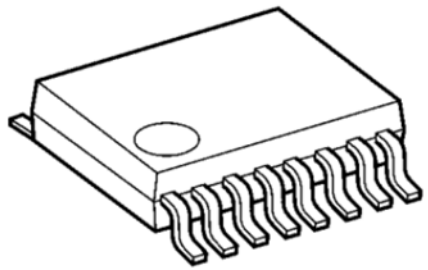
Motor driving voltage of 2.5 V (Min) is realized for low voltage applications.

2 Low current consumption

Standby current is below 2 µA (IC total).

3 Abnormality detection functions

Over current detection, thermal shutdown and under voltage lockout are available.



P-TSSOP16 Package (5.0 x 6.4 x 1.2 mm)

Lineup

Part number	TC78H621FNG	TC78H660FNG
V_M [V]	18	20
I_{OUT} [A]	1.1	2.0
$R_{on(upper\ and\ lower\ sum)}$ (Typ.) [Ω]	0.8	0.48
Control interface	ENABLE / PHASE inputs	ENABLE / PHASE inputs
Step	Full, Half step resolution	-
Feature	Motor driving voltage: 2.5 V (Min)	Motor driving voltage: 2.5 V (Min)
Abnormality detection function	Over heat, Over current, Low voltage	Over heat, Over current, Low voltage
Package	P-TSSOP16-0505-0.65-001	P-TSSOP16-0505-0.65-001

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6b Single-phase brushless DC motor driver IC

TC78B002FNG / TC78B002FTG

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

Value provided

Simple fan motor drive with low noise & low vibration.

1 Suitable for small fan motor

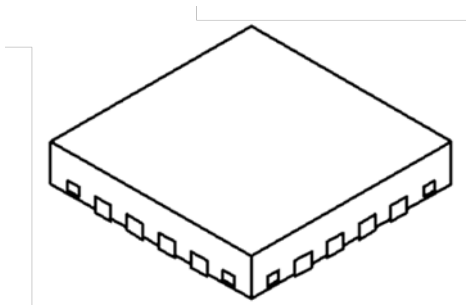
It is a single phase full wave driver and suitable for small brushless DC Fan motor.

2 Low noise and low vibration for motor

Smooth waveform by soft switching drive realizes low noise and low vibration driving of motor.

3 Small package

Small WQFN16 package with high heat dissipation. (TC78B002FTG)



P-WQFN16 Package (3 x 3 x 0.75 mm)

Lineup

Part number	TC78B002FNG	TC78B002FTG
V_M [V]	18	
I_{OUT} [A]	1.5	
Drive type	Single phase full wave drive	
Features	PWM control, Soft switching drive Quick start, Hall bias circuit Error detection: Current limit, Thermal shutdown	
Package	SSOP16-P-225-0.65B	P-WQFN16-0303-0.50-002

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Value provided

System cost reduction, higher efficiency and less development work.

1 Equipped with motor control co-processor

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

2 Equipped with motor control circuit

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

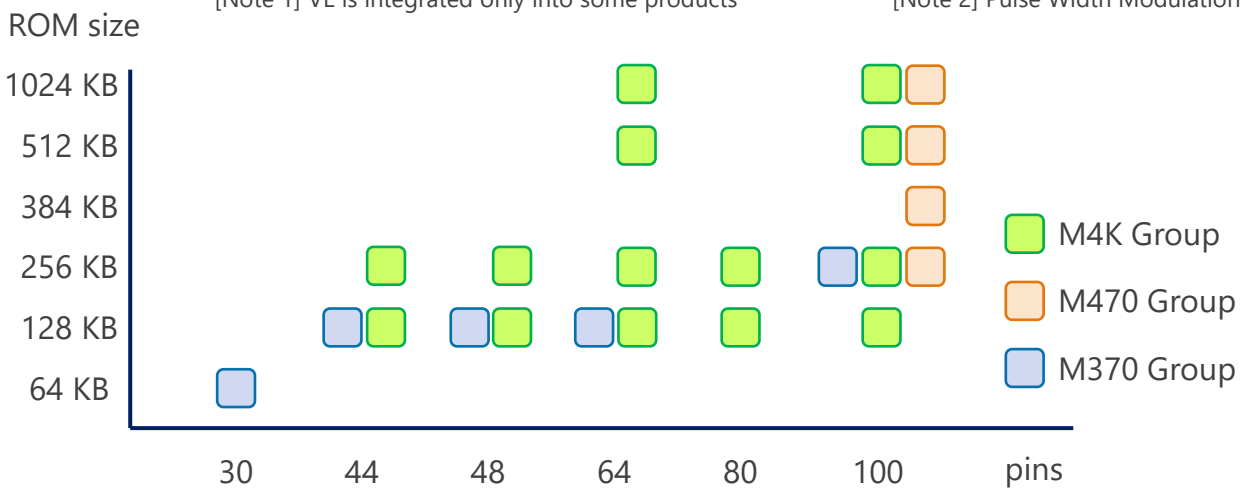
3 Provide development support tools

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

[Note 1] VE is integrated only into some products

[Note 2] Pulse Width Modulation

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



Lineup

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

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8 MCU

TXZ+™3A Series M3H Group

High efficiency · Low loss | Noise immunity | 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 Arm Cortex-M3 core.
Maximum operation frequency is 120 MHz.

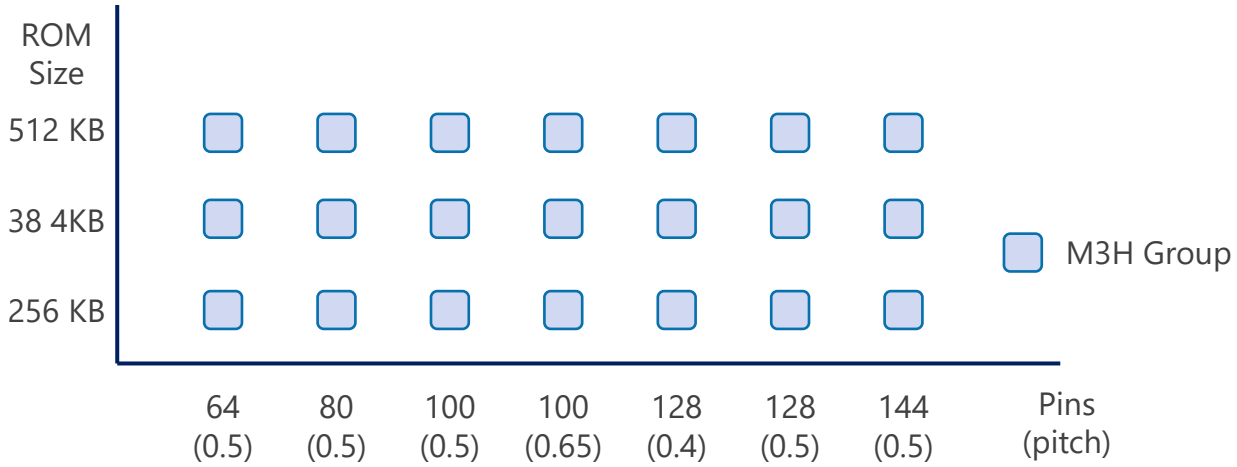
2 Various lineup built-in memories and packages

M3H group integrates both 512 KB code and 32 KB data flash memories which support maximum 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^2C, 12bit AD converter, 8bit DA converter, PMD, ENC and digital LCD driver [Note], etc.

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



Lineup

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

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