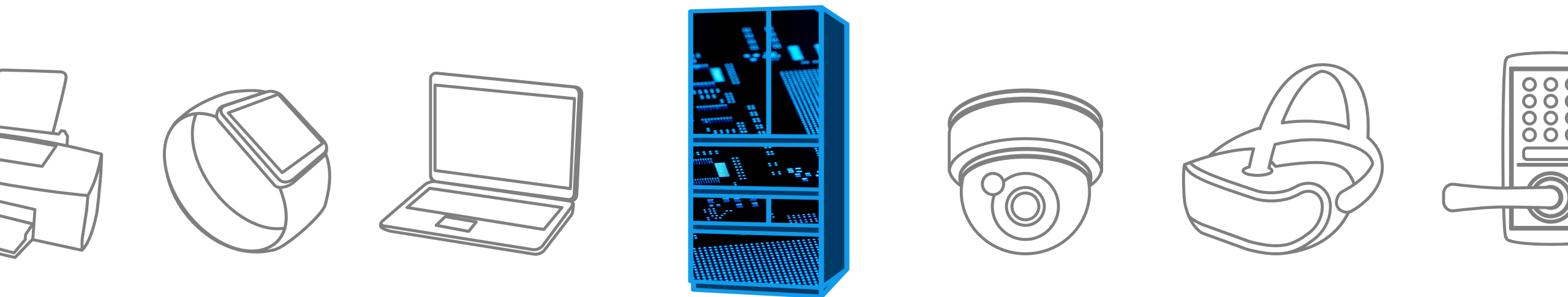
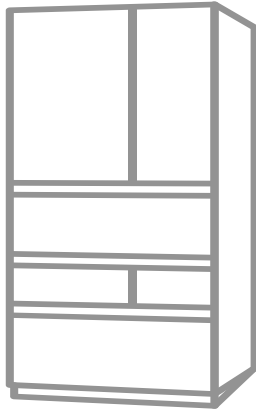
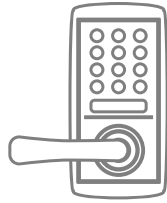
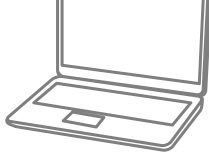


# Refrigerator

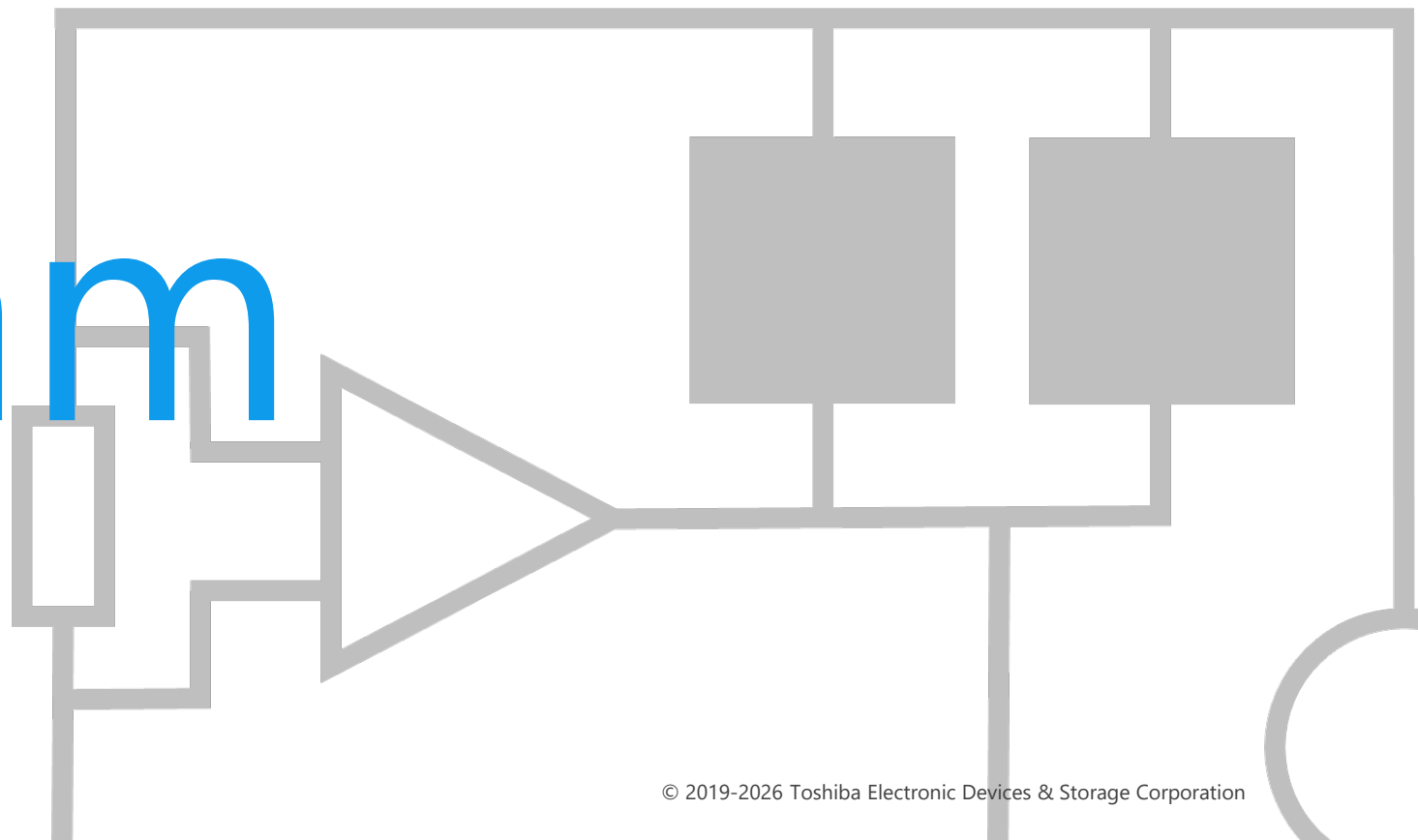
**Solution Proposal by Toshiba**



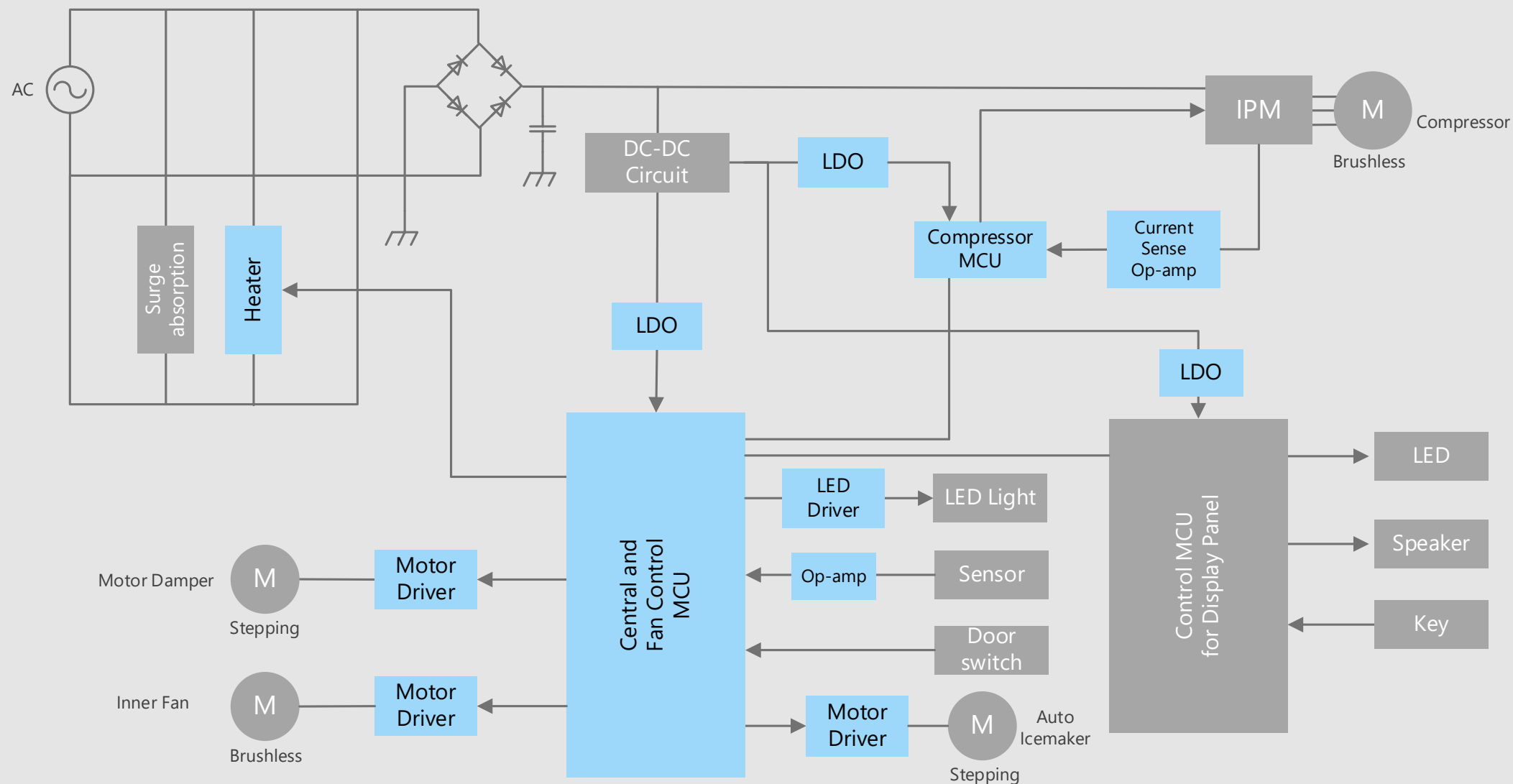


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

# Block Diagram

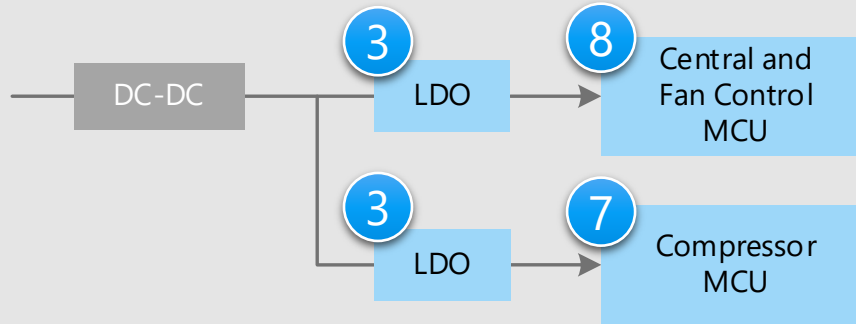


# Refrigerator Overall block diagram

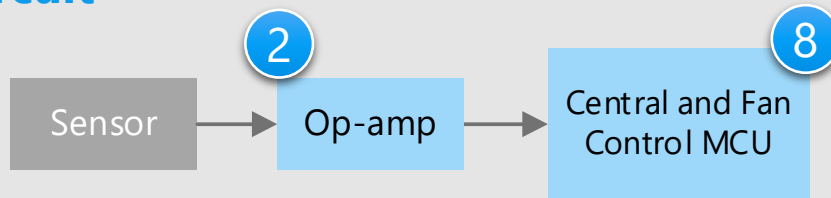


# Refrigerator Details of MCU power supply / Sensor input unit

## MCU power supply circuit



## Sensor input circuit



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

## Criteria for device selection

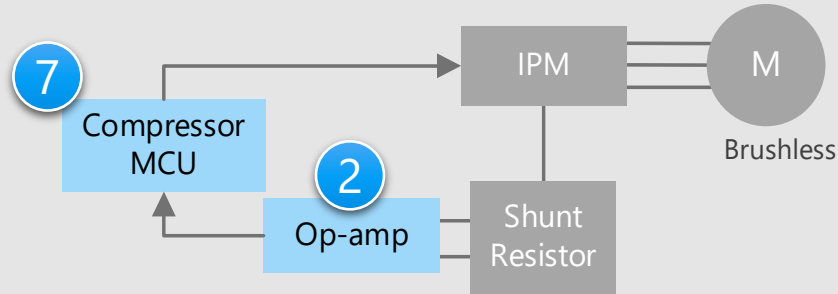
- LDO Regulator is suitable for stable power supply to MCU.
- An operational amplifier is used for amplifying signals from sensor.

## Proposals from Toshiba

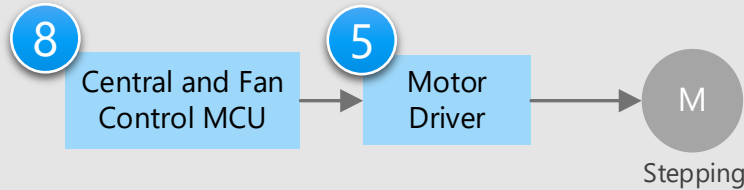
- **Operational amplifier with built-in phase compensation circuit** 2  
General purpose operational amplifier
- **Power supply suitable for noisy environments** 3  
Small surface mount LDO regulator
- **MCU suitable for motor control** 7  
MCU M4K / M470 / M370 Group
- **Easy software development using general purpose CPU cores** 8  
MCU M3H Group

# Refrigerator Details of motor driving unit

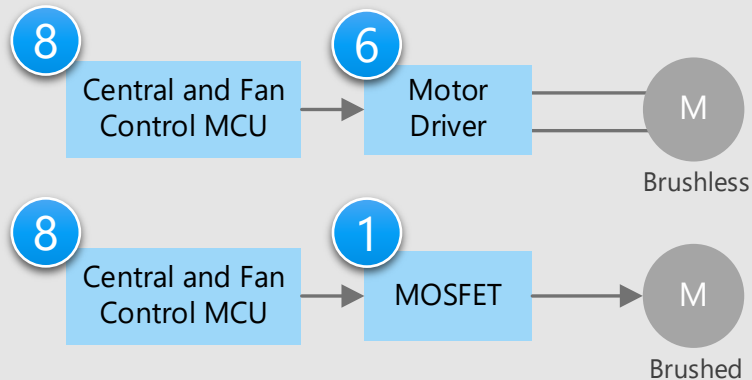
## Compressor drive circuit



## Damper drive circuit



## Fan drive circuit



## Criteria for device selection

- Motor drivers are suitable for driving stepping motors and brushless DC motors.
- An operational amplifier is used for amplifying signals such as current sensing.

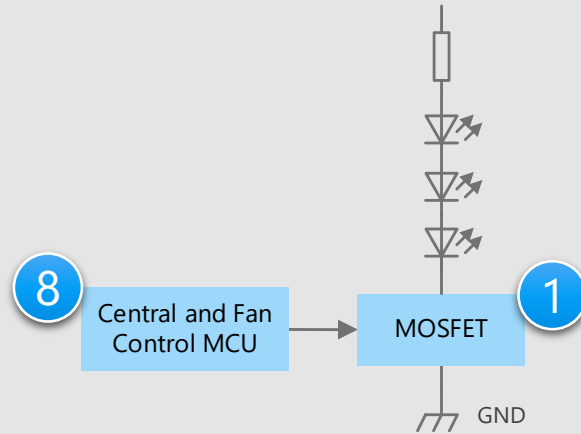
## Proposals from Toshiba

- **Realize low power consumption by low on-resistance**  
Small signal MOSFET
- **Operational amplifier with built-in phase compensation circuit**  
General purpose operational amplifier
- **Stepping motor can be easily driven**  
Stepping motor driver
- **Brushless DC motor can be easily driven**  
Single-phase brushless DC motor driver
- **MCU suitable for motor control**  
MCU M4K / M470 / M370 Group
- **Easy software development using general purpose CPU cores**  
MCU M3H Group

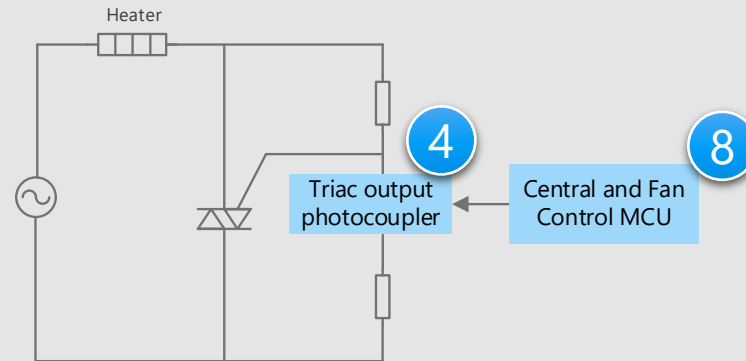
\* Click the number in the circuit diagram to jump to the detailed description page.

# Refrigerator Details of LED driving / Heater control unit

## LED driving circuit



## Heater control circuit



## 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**  
Small signal MOSFET
- **Efficient control of AC load**  
Triac output photocoupler
- **Easy software development using general purpose CPU cores**  
MCU M3H Group

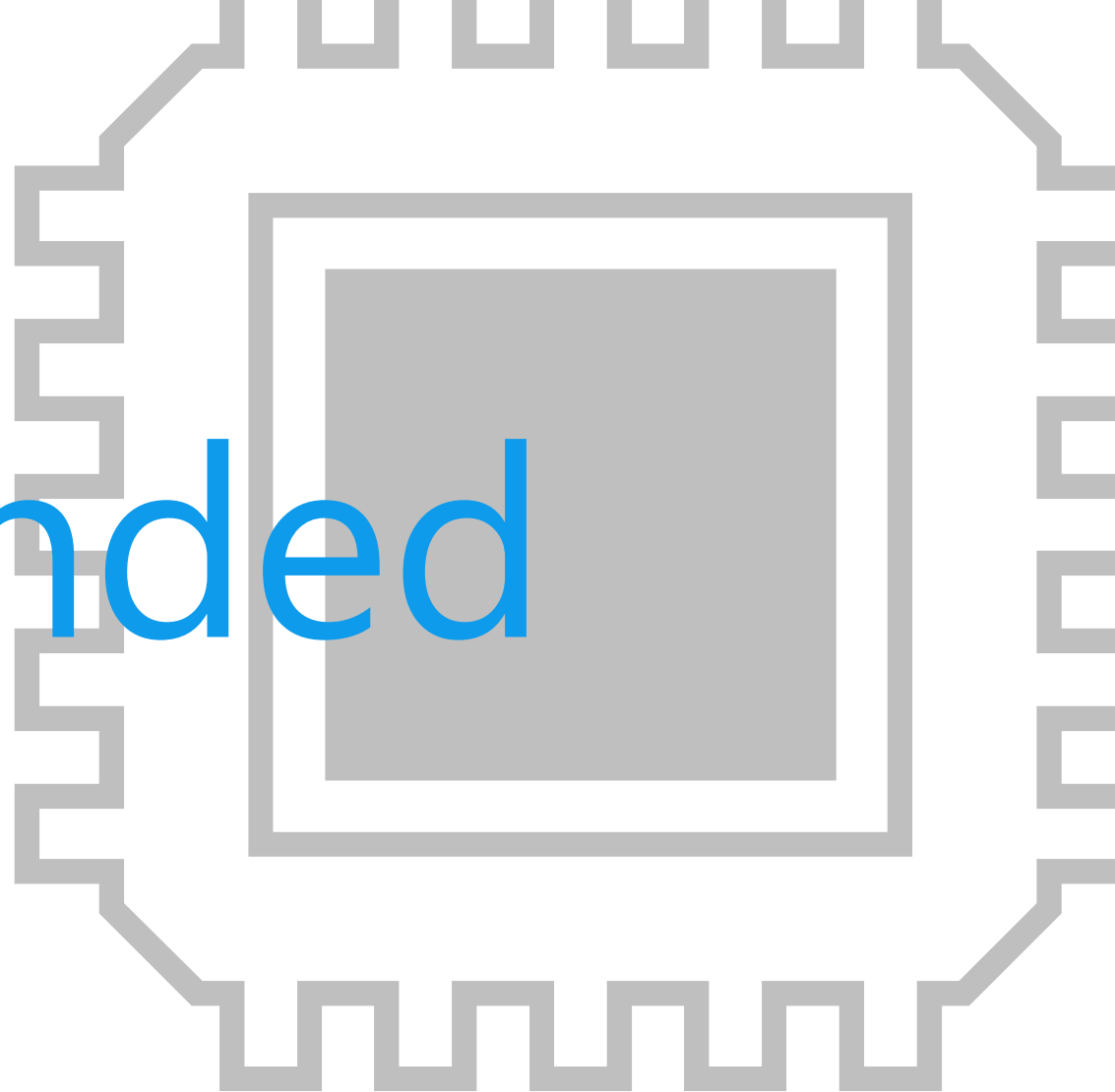
1

4

8

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

# Recommended Devices





# Device solutions to address customer needs

As described above, in the design of refrigerators, "**Low power consumption of the 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 General purpose operational amplifier  | ● | ● | ● |
| ③ Small surface mount LDO regulator      | ● | ● | ● |
| ④ Triac output photocoupler              | ● | ● | ● |
| ⑤ Stepping motor driver                  | ● |   | ● |
| ⑥ Single-phase brushless DC motor driver | ● |   | ● |
| ⑦ MCU M4K / M470 / M370 Group            | ● |   | ● |
| ⑧ MCU M3H Group                          | ● |   | ● |

Value provided

Suitable for power management switches and contributes to miniaturization.

## 1 Low voltage operation

$V_{GS} = 4.5 \text{ V}$  operation (SSM3K333R)

$V_{GS} = 1.2 \text{ V}$  operation (SSM3K35AFS)

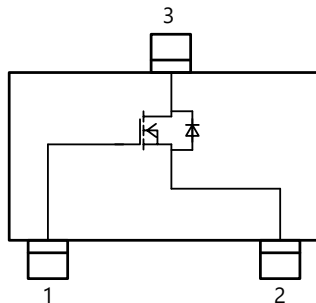
## 2 Low on-resistance

The low on-resistance between drain and source helps reduce heat generation and power consumption.

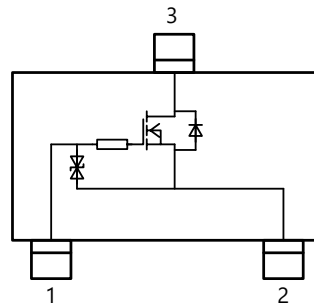
## 3 Small size package

Small size package is suitable for high density mounting.

SSM3K333R  
Equivalent Circuit



SSM3K35AFS  
Equivalent Circuit



### Lineup

| Part number                                                     | SSM3K333R                                                                                    | SSM3K335R | SSM3J332R | SSM3J334R | SSM3K35AFS                                                                               |
|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------|-----------|-----------|------------------------------------------------------------------------------------------|
| Package                                                         | SOT-23F  |           |           |           | SSM  |
| $V_{DS}$ [V]                                                    | 30                                                                                           | 30        | -30       | -30       | 20                                                                                       |
| $I_D$ [A]                                                       | 6                                                                                            | 6         | -6        | -4        | 0.25                                                                                     |
| $R_{DS(ON)}$ (Max) [ $\Omega$ ]<br>@ $ V_{GS}  = 4.5 \text{ V}$ | 0.042                                                                                        | 0.056     | 0.05      | 0.105     | 1.1                                                                                      |
| Polarity                                                        | N-ch                                                                                         |           | P-ch      |           | N-ch                                                                                     |

[◆Return to Block Diagram TOP](#)

Value provided

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

## 1 Low voltage operation

Compared with bipolar general purpose operational amplifiers, this operational amplifier operates at low voltage [Note].

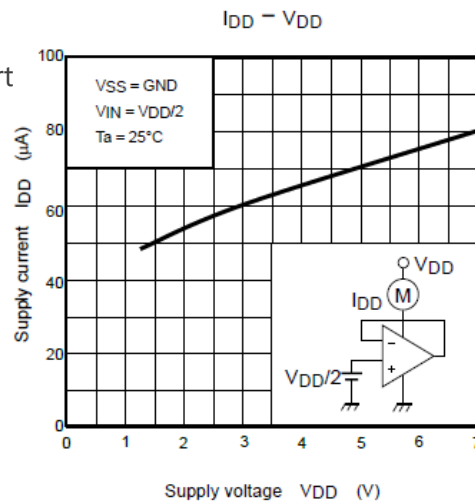
$$V_{DD} = \pm 0.75 \text{ to } \pm 3.5 \text{ V or } 1.5 \text{ to } 7 \text{ V (for TC75S51FU)}$$

[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) [ $\mu\text{A}$ ] | 60 / 200 (@ $V_{DD} = 3.0 \text{ V}$ )                                                   | 100 / 165 (@ $V_{DD} = 3.3 \text{ V}$ )                                                  |
| $f_T$ (Typ.) [MHz]                      | 0.6                                                                                      | 0.36                                                                                     |
| Input, Output Full Range                | -                                                                                        | ✓                                                                                        |

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# 3 Small surface mount LDO regulator

TCR15AG / TCR8BM / TCR5FM / TCR5RG / TCR3RM / TCR3U / TCR3LM / TCR3D / TCR3EM / TCR1HF Series

High efficiency  
Low loss

Noise immunity

Small size packages

Value provided

Wide lineup from general purpose type to WCSP (Wafer Level Chip Size Package) type are provided. Contribute to realize a stable power supply.

## 1 Low dropout voltage

Low dropout voltage characteristic has been realized by the originally developed process.

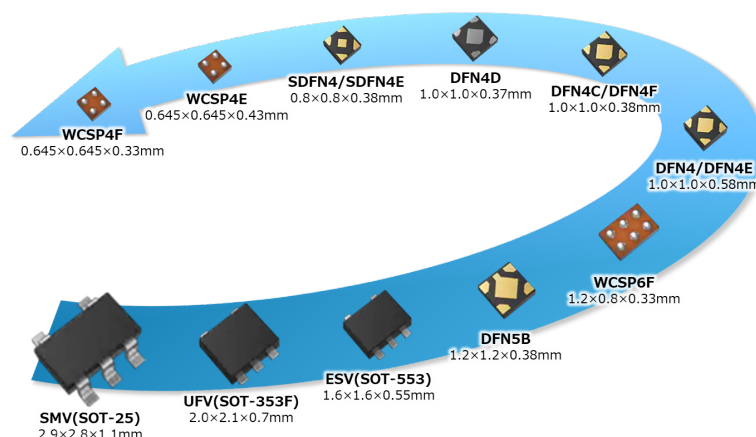
## 2 High PSRR Low output noise voltage

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

$I_{B(ON)}$  of 0.34  $\mu\text{A}$  (typ.) @  $I_{OUT} = 0 \text{ mA}$ ,  $V_{OUT} \leq 1.5 \text{ V}$  is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

### Rich package lineup



### Lineup

| Part number                    | TCR15AG Series                   | TCR8BM Series | TCR5FM Series                                     | TCR5RG Series | TCR3RM Series | TCR3U Series            | TCR3LM Series | TCR3D Series  | TCR3EM Series | TCR1HF Series      |      |
|--------------------------------|----------------------------------|---------------|---------------------------------------------------|---------------|---------------|-------------------------|---------------|---------------|---------------|--------------------|------|
| Features                       | Low dropout voltage<br>High PSRR |               | High PSRR<br>Low noise<br>Low current consumption |               |               | Low current consumption |               | Standard type |               | 36 V Input voltage |      |
| I <sub>OUT</sub> (Max) [A]     | 1.5                              | 0.8           | 0.5                                               |               |               | 0.3                     |               |               |               |                    | 0.15 |
| PSRR (Typ.) [dB]<br>@f = 1 kHz | 95                               | 98            | 91                                                | 100           | 100           | 70                      | -             | 72            | 68            | 70                 |      |
| I <sub>B</sub> (Typ.) [μA]     | 25                               | 20            | 10                                                | 7             | 7             | 0.34                    | 1             | 86            | 35            | 170                |      |

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# 4 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.

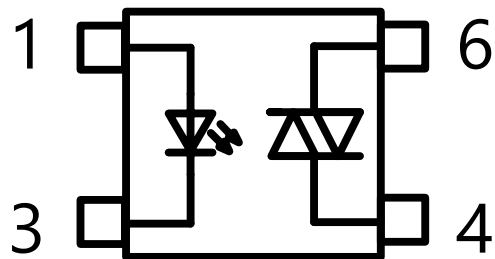
### 2 Switching characteristic

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

### 3 Reduction 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                | 4pin SO6  | 5pin DIP6  |
| $V_{\text{DRM}}$ [V]   | 600                                                                                           |                                                                                                |
| $BV_{\text{S}}$ [Vrms] | 3750                                                                                          | 5000                                                                                           |
| $T_{\text{opr}}$ [°C]  | -40 to 100                                                                                    |                                                                                                |
| Type                   | Non zero crossing                                                                             |                                                                                                |

[Return to Block Diagram TOP](#)

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).

## 2 Low current consumption

Standby current (IC total) is 2  $\mu$ A or less (IC total) for power saving of devices.

## 3 Error detection functions

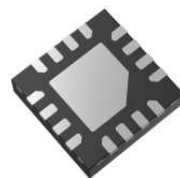
Over current detection (ISD), thermal shutdown (TSD) and under voltage lockout (UVLO) are available.



P-TSSOP16-0505-0.65-001  
(5.0 x 6.4 x 1.2 mm)



Top view



Bottom view

P-VQFN16-0303-0.50-001  
(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                    |
| $R_{on(U+L)}$ (Typ.) [ $\Omega$ ] | 0.8                        | 0.48                                                      | 0.48                   |
| Control interface                 | PHASE input                | IN/PHASE inputs                                           |                        |
| Excitation mode                   | 2phase/1-2phase excitation | 2phase/1-2phase excitation                                |                        |
| Motor power supply voltage        | 2.5 V (Min)                | 2.5 V (Min)<br>Built-in Advanced Current Detection System |                        |
| Error detection function          | ISD, TSD, UVLO             | ISD, TSD, UVLO                                            |                        |
| Package                           | P-TSSOP16-0505-0.65-001    |                                                           | P-VQFN16-0303-0.50-001 |

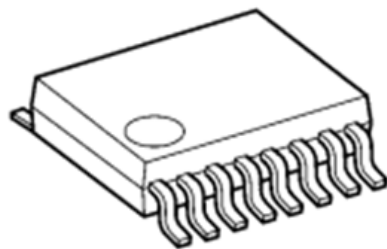
[Return to Block Diagram TOP](#)

Value provided

This driver realizes simple, low noise and low vibration fan motor drive.

## 1 Suitable for small fan motor

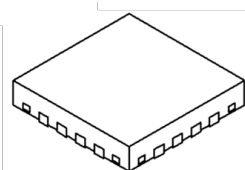
Suitable for driving simple and compact brushless DC fan motors by single-phase full wave drive.



SSOP16-P package  
(5.0 x 6.4 x 1.2 mm)

## 2 Low noise and low vibration for motor

Equipped with a soft switching drive function, it contributes to low noise and low vibration during motor operation through smooth current waveforms.



P-WQFN16 package  
(3.0 x 3.0 x 0.75 mm)

## 3 Small size package

Small size P-WQFN16 package with high heat dissipation. (TC78B002FTG)

### 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<br>Quick start, Hall bias circuit<br>Error detection: Over current protection, Thermal shutdown |                        |
| Package       | SSOP16-P-225-0.65B                                                                                                                | P-WQFN16-0303-0.50-002 |

[◆Return to Block Diagram TOP](#)



Value provided

## System cost reduction, higher efficiency and less development work.

### 1 Equipped with motor control co-processor

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

[Note 1] VE is integrated only into some products

### 2 Equipped with motor control circuit

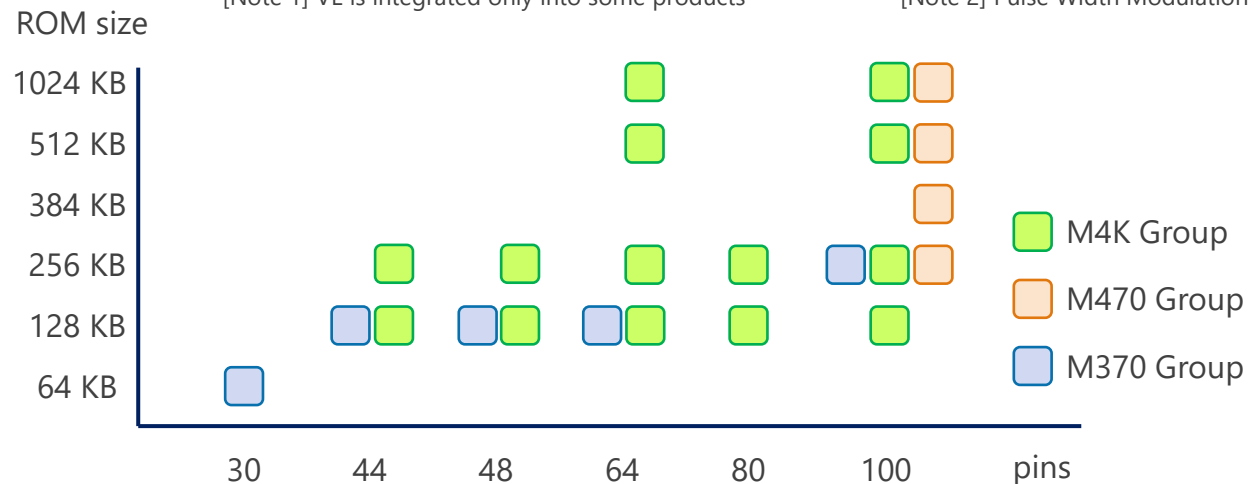
A variety of three-phase PWM [Note 2] waveforms and AD converters enable highly efficient, low noise control. The Advanced Encoder (A-ENC) reduces the load of CPU process in detecting the position performed for each PWM.

[Note 2] 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 also offered new, simple, versatile motor control software development kits (MCU Motor Studio). [Note 3]

[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)                   |

[Return to Block Diagram TOP](#)

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

These implement Arm® Cortex®-M3 core with 120 MHz maximum operation frequency. Various development tools and their partners allow users many options.

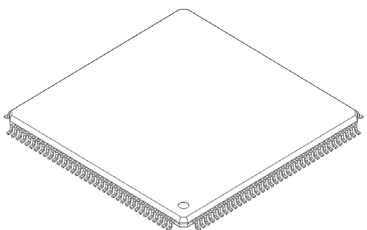
## 2 System cost down / development efficiency improvement

These execute sensing data monitoring and motor control efficiently by multiple built-in AD converters and timers. It also has a built-in FLASH memory that can be rewritten 0.1 million times. The product with 1 MB ROM can rewrite the codes while the microcomputer continues operation.

## 3 Small size package / low power consumption

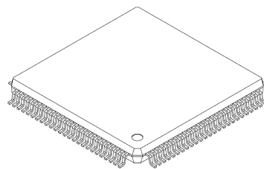
These support low power consumption library and stand by function and contribute to reduce power consumption. The packages lineup includes small LQFP64 to LQFP144.

TMPM3HQF10BFG  
TMPM3HQFDAFG



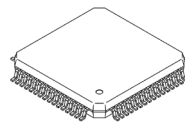
P-LQFP144-2020-0.50-002  
(22.0 x 22.0 x 1.7 mm)

TMPM3HNF10BFG  
TMPM3HNFDAFG



P-LQFP100-1414-0.50-002  
(16.0 x 16.0 x 1.7 mm)

TMPM3HLF10BUG  
TMPM3HLFDAUG



P-LQFP64-1010-0.50-003  
(12.0 x 12.0 x 1.7 mm)

### Lineup

| Part number               | M3H (2) | TMPM3HQF10BFG                               | TMPM3HNF10BFG                               | TMPM3HLF10BUG                               |
|---------------------------|---------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
|                           | M3H (1) | TMPM3HQFD/Z/Y/AFG                           | TMPM3HNFD/Z/Y/AFG                           | TMPM3HLFD/Z/Y/AUG                           |
| Operating frequency (Max) |         | 120 MHz                                     |                                             |                                             |
| ROM (Flash)               | M3H (2) | 1024 KB                                     |                                             |                                             |
|                           | M3H (1) | 512 / 384 / 256 KB                          |                                             |                                             |
| RAM                       | M3H (2) | 130 KB (with parity)                        |                                             |                                             |
|                           | M3H (1) | 66 KB (with parity)                         |                                             |                                             |
| Timer                     |         | 32bit x 8ch (16bit x 16ch)                  |                                             |                                             |
| AD converter              |         | 21ch (12bit)                                | 17ch (12bit)                                | 12ch (12bit)                                |
| Serial communication      |         | UART: 8ch, I <sup>2</sup> C: 4ch, TSPI: 5ch | UART: 8ch, I <sup>2</sup> C: 3ch, TSPI: 4ch | UART: 7ch, I <sup>2</sup> C: 2ch, TSPI: 1ch |
| Package                   |         | P-LQFP144-2020-0.50-002                     | P-LQFP100-1414-0.50-002                     | P-LQFP64-1010-0.50-003                      |

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