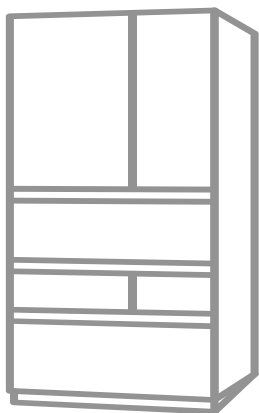


Refrigerator

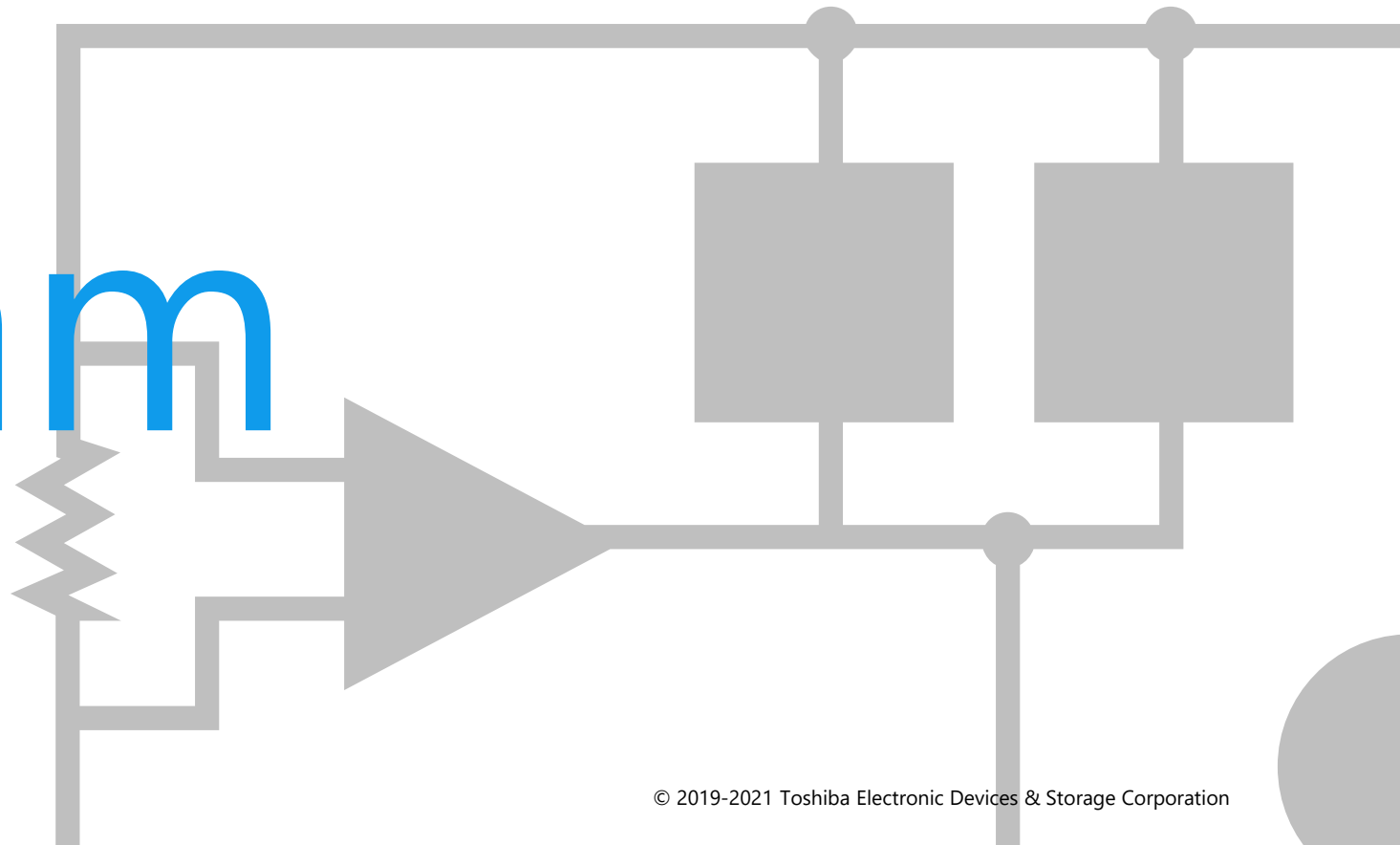
Solution Proposal by Toshiba



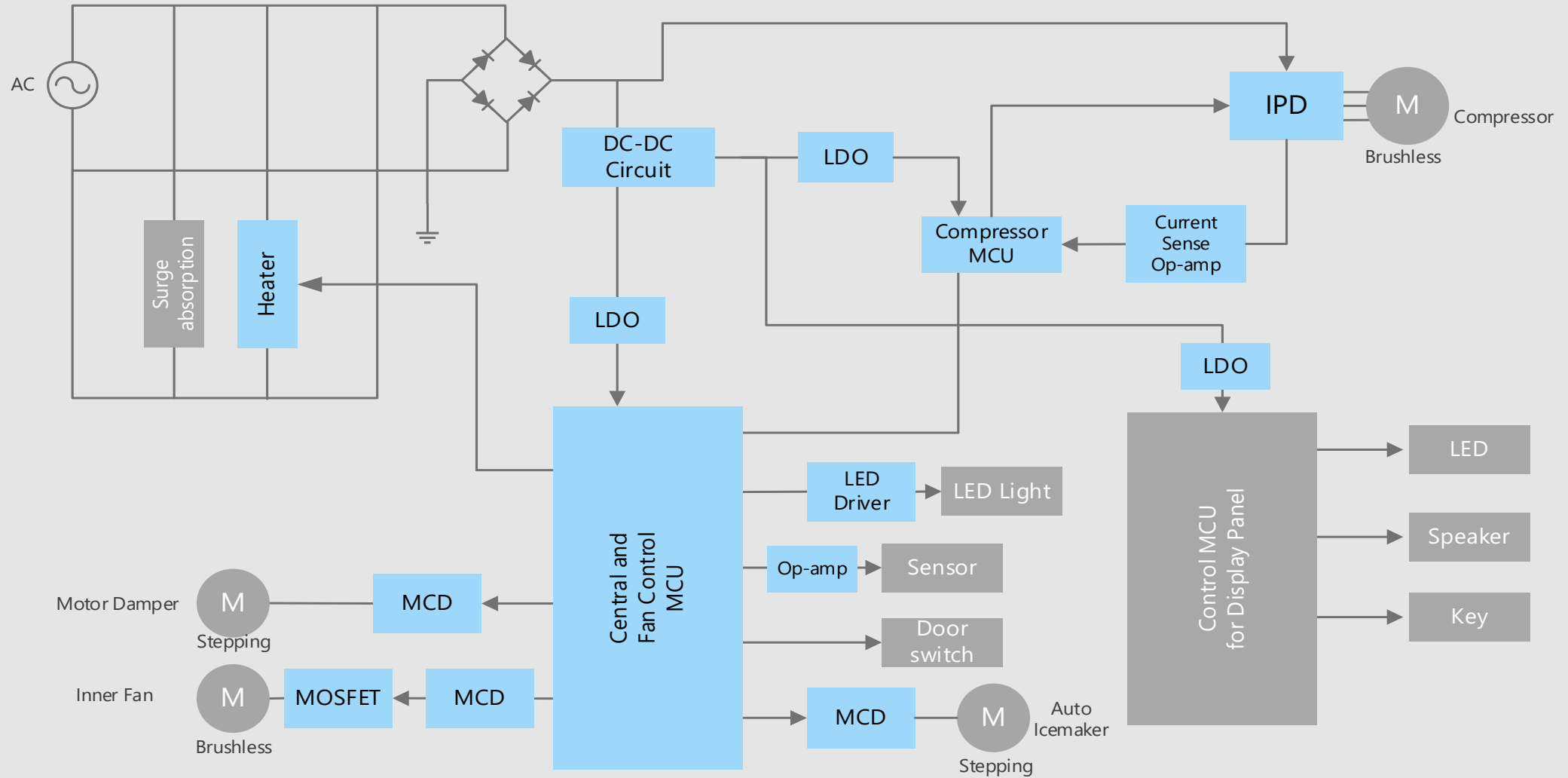


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram

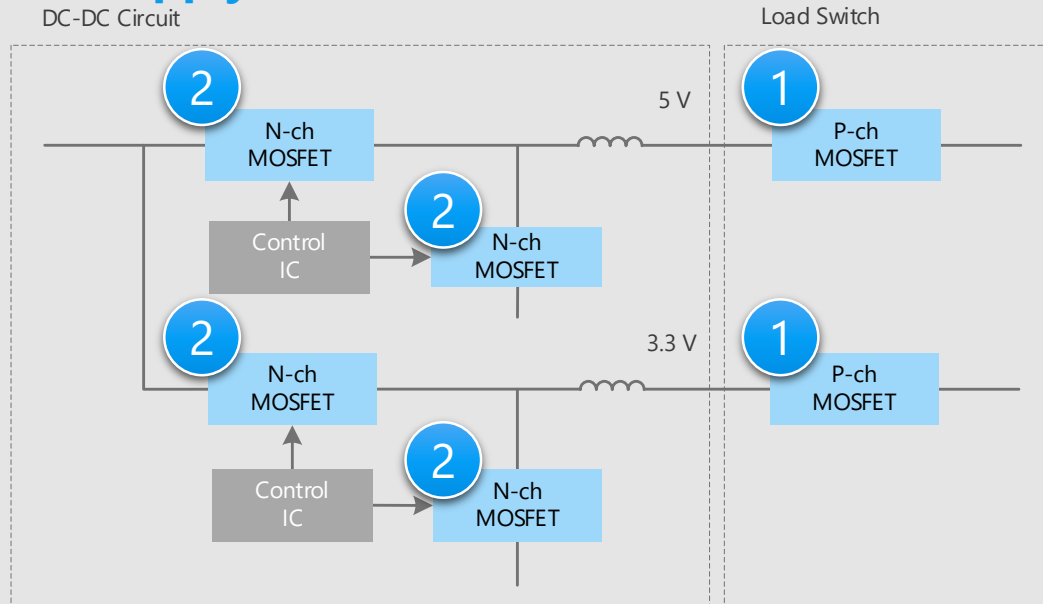


Refrigerator Overall block diagram

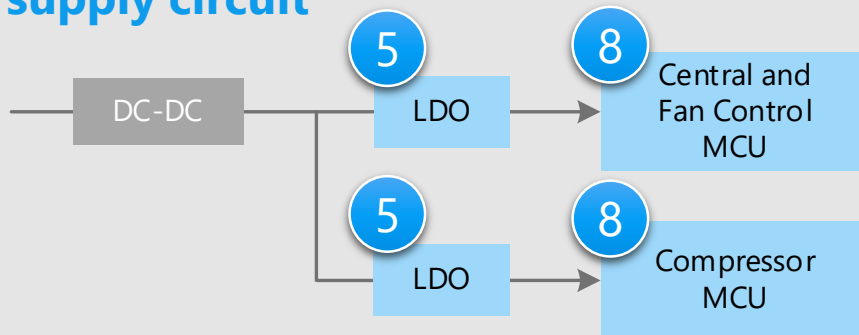


Refrigerator Details of DC-DC unit

DC-DC power supply circuit



MCU power supply circuit



Criteria for device selection

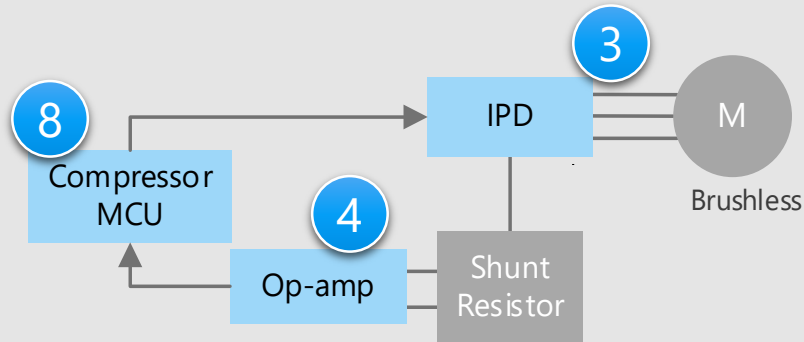
- Small signal MOSFET is suitable for DC-DC translation.
- LDO is suitable for stable power supply to MCU

Proposals from Toshiba

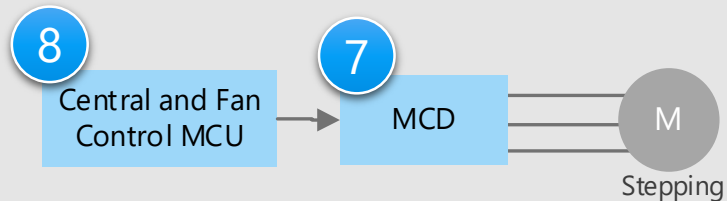
- **Setting of low power consumption with low on-resistance** 1
U-MOSVI Series MOSFET
- **Setting of low power consumption with low on-resistance** 2
Small signal MOSFET
- **Suitable power supply for environments with high power supply noise** 5
Small surface mount LDO regulator
- **Easy software development using general purpose CPU cores** 8
MCU

Refrigerator Details of Motor Driving unit

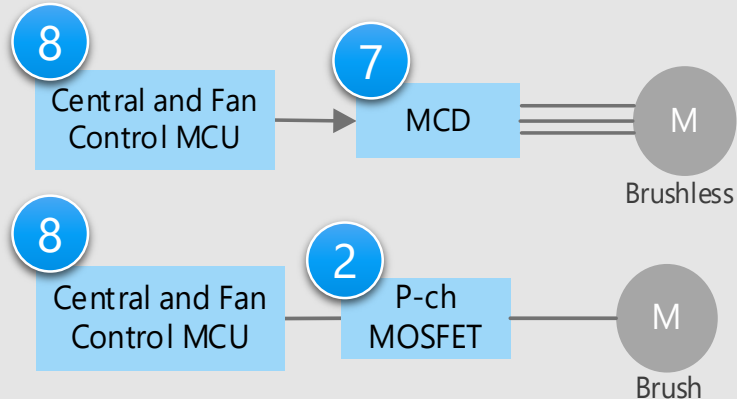
Compressor drive circuit



Damper drive circuit



Fan drive circuit



Criteria for device selection

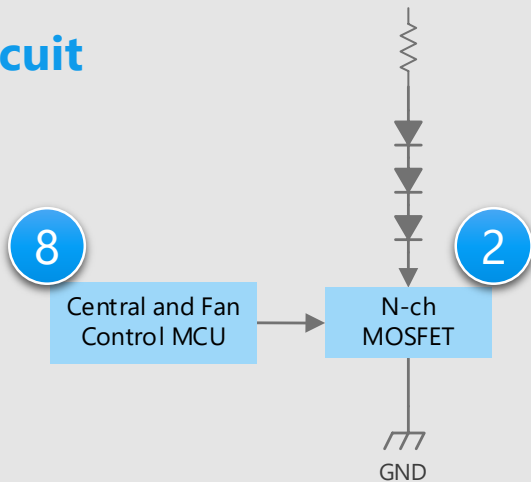
- Intelligent power devices (IPDs) are suitable for driving high voltage motors such as compressors.
- MCDs are used for driving stepping and brushless DC motors.
- An operational amplifier is used to amplify signals such as current sensing.

Proposals from Toshiba

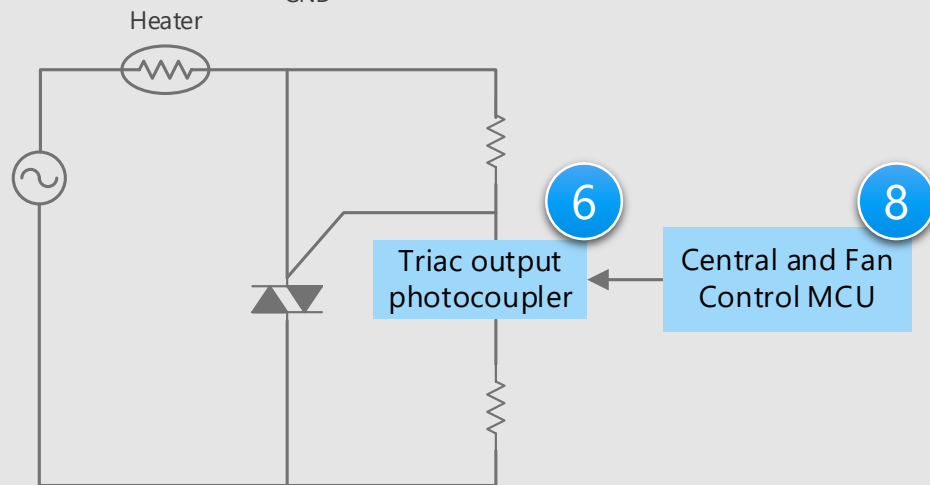
- **Setting of low power consumption with low on-resistance** (2)
Small signal MOSFET
- **Built-in high voltage power MOSFET** (3)
High voltage IPD
- **Operational amplifier with integrated phase compensation circuit** (4)
General purpose operational amplifier
- **Easy control of motors** (7)
Motor driver
- **Easy software development using general purpose CPU cores** (8)
MCU

Refrigerator Details of Lamp / Heater / Sensor unit

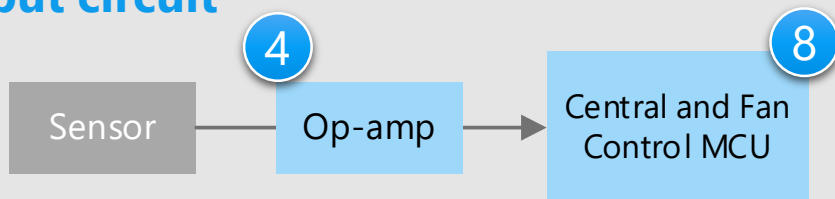
LED driving circuit



Heater control circuit



Sensor input circuit



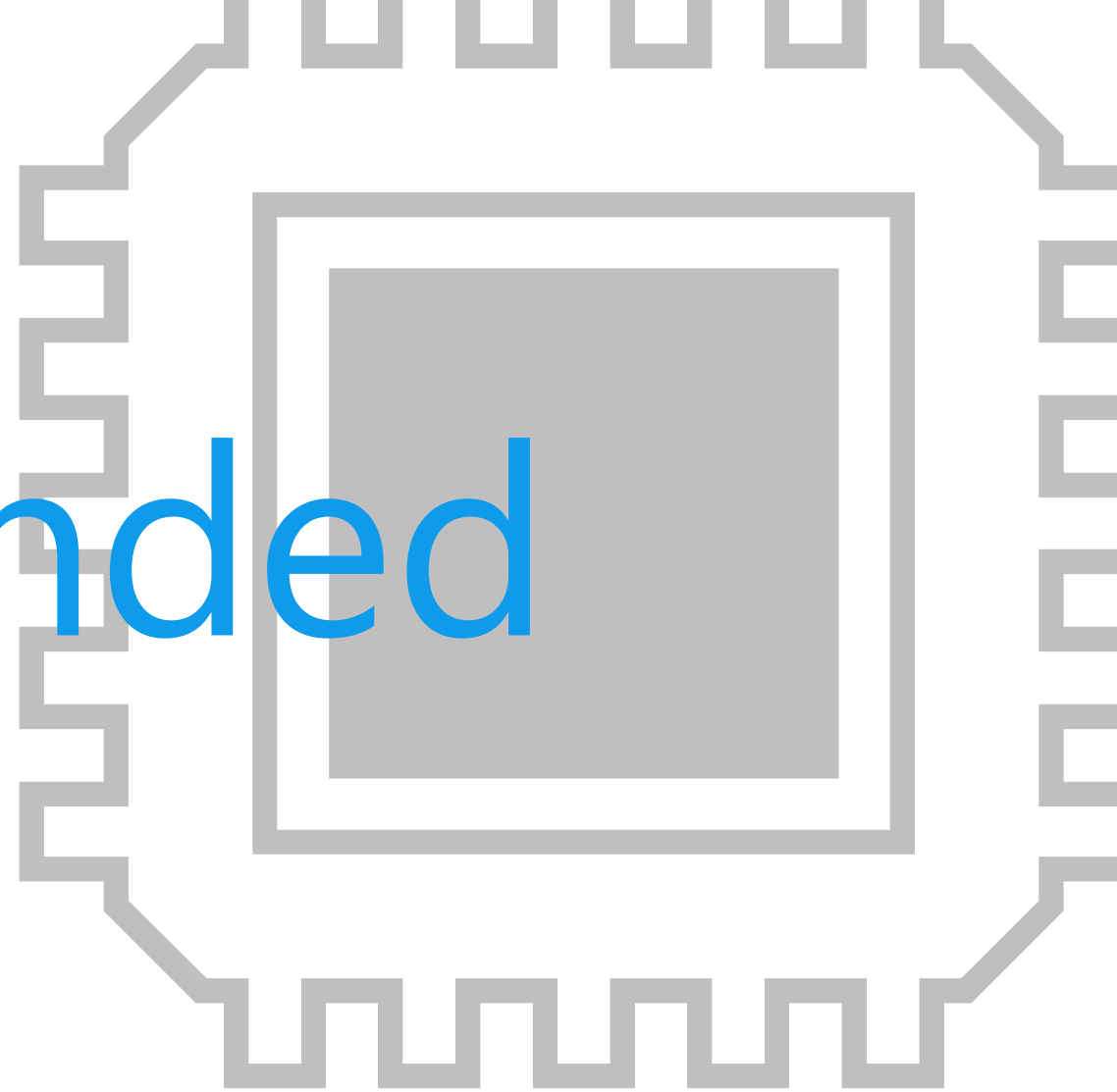
Criteria for device selection

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

Proposals from Toshiba

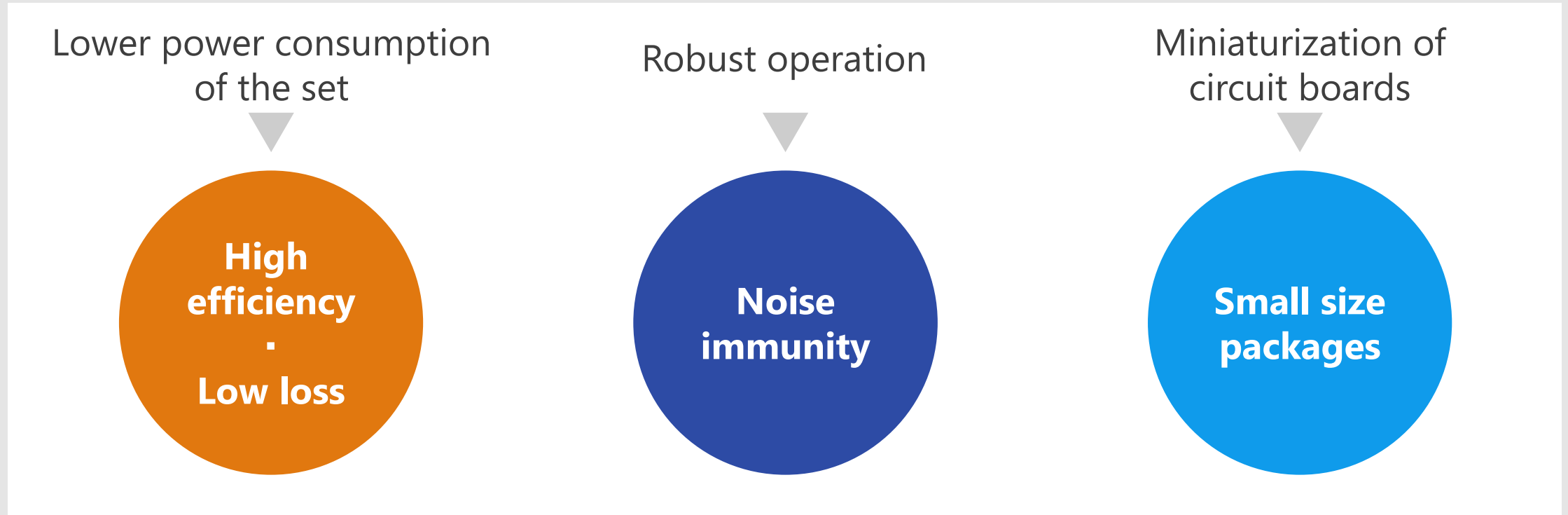
- **Switching with low on-resistance**
Small signal MOSFET 2
- **Operational amplifier with integrated phase compensation circuit**
General purpose operational amplifier 4
- **Efficient control of AC load**
Triac output photocoupler 6
- **Easy software development using general purpose CPU cores**
MCU 8

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 U-MOSVI Series MOSFET	●		●
2 Small signal MOSFET	●		●
3 High voltage IPD	●		
4 General purpose operational amplifier	●	●	●
5 Small surface mount LDO regulator	●	●	●
6 Triac output photocoupler	●	●	●
7 Motor driver	●		●
8 MCU	●		●

Value provided

Suitable for power management switches and easy to handle and greatly contributes to miniaturization.

1 Low on-resistance

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

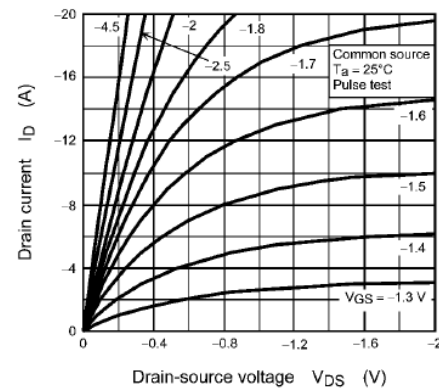
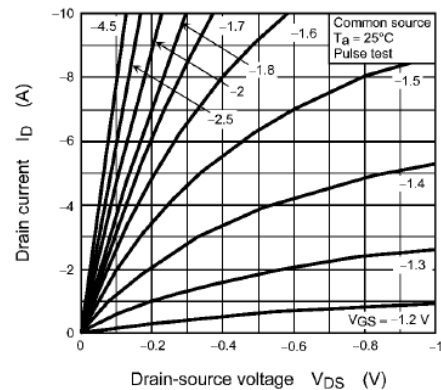
2 Low leakage current

Drain cut off current $I_{DSS} = 10 \mu\text{A}$ (Max)
($V_{DS} = -20 \text{ V}$)



3 Enhancement type

It is easy to handle because it is an enhancement type in which no collector current when no gate voltage is applied.

TPCC8136 Characteristics Curves



Line up

Part number	TPCC8136	SSM6J501NU
Package	TSON Advance 	SOT-1220 
V_{DSS} [V]	-20	-20
I_D [A]	-9.4	-8
P_D [W]	1.9	1
C_{iss} (Typ.) [pF]	2350	2500
$R_{DS(ON)}$ (Max) [mΩ] @ $V_{GS} = -4.5 \text{ V}$	16	15.4
Polarity	P-ch	P-ch

[Return to Block Diagram TOP](#)

Value provided

Suitable for power management switches and greatly contributes to miniaturization.

1 Low voltage drive

$V_{GS} = 4.5\text{ V}$ drive (SSM3K333R)
 $V_{GS} = 1.8\text{ V}$ drive (SSM6P39TU)
 $V_{GS} = 1.2\text{ V}$ drive (SSM3K35AFS)

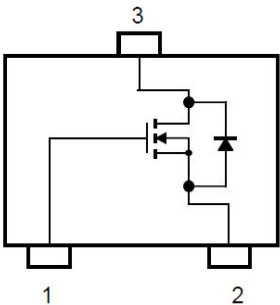
2 Low on-resistance

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

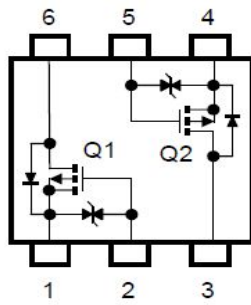
3 Small package

Small package is suitable for high-density mounting.

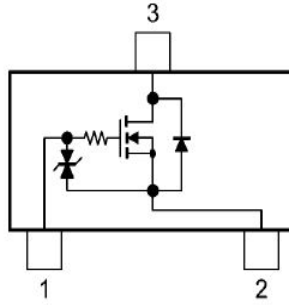
SSM3K333R
Equivalent Circuit



SSM6P39TU
Equivalent Circuit



SSM3K35AFS
Equivalent Circuit



Line up

Part number	SSM3K333R	SSM3K335R	SSM3J332R	SSM3J334R	SSM6P39TU	SSM3K35AFU
Package	SOT-23F				UF6	SSM
V_{DSS} (Min) [V]	30	30	-30	-30	-20	20
I_D (Max) [A]	6	6	-6	-4	-1.5	0.25
$R_{DS(ON)}$ (Max) [Ω] @ $V_{GS} = 4.5\text{ V}$	0.042	0.056	0.05	0.105	0.213	1.1
Polarity	N-ch		P-ch		P-ch x 2	N-ch

[Return to Block Diagram TOP](#)

Value provided

A DC brushless 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 power MOSFET.

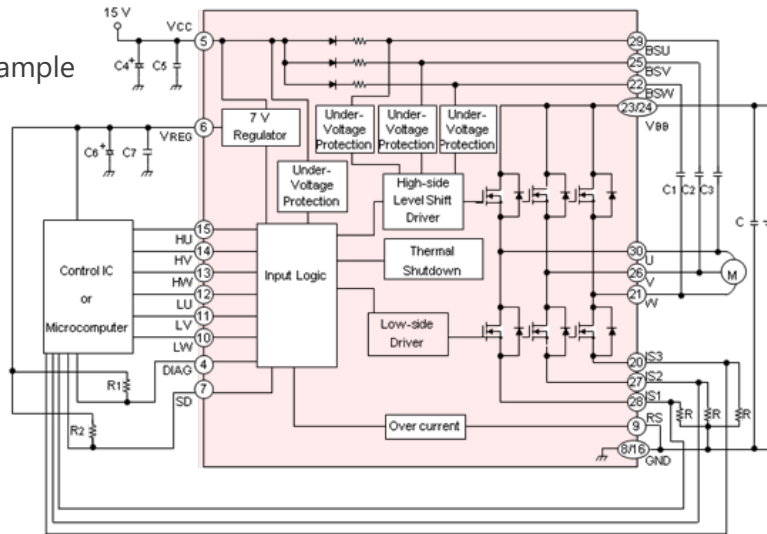
2 High voltage power terminals and control terminals are separated

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

It has built-in over current protection, thermal shutdown, shutdown (SD) and under voltage protection functions.

TPD4207F
Application Circuit Example



Line up

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

[Return to Block Diagram TOP](#)

4 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.

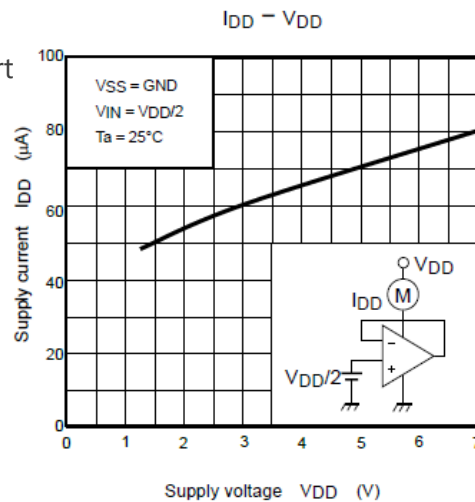
Compared with bipolar general purpose operational amplifiers, low voltage operation is possible. [Note]

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

[Note] Comparison with our products

TC75S51FU

Characteristics chart



2 Low current consumption I_{DD}=60 [µA] (Typ.)



The low current power supply characteristics of CMOS processes contribute to extend the battery life of small IoT devices. [Note]

[Note] Comparison with our bipolar process operational amplifier

3 Built-in phase compensator circuit

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

Line up

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		✓

[Return to Block Diagram TOP](#)

5 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 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.

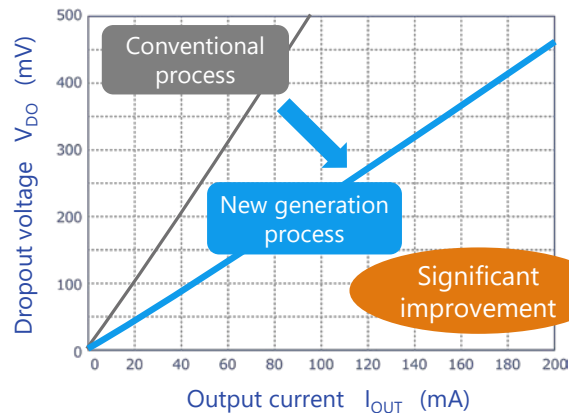
2 High PSRR Low output noise voltage

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

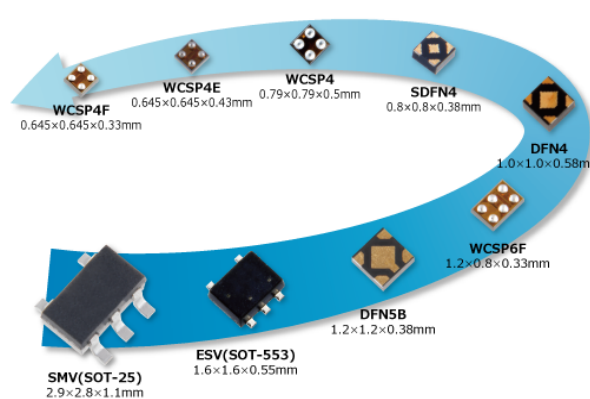
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.

Low dropout voltage



Note: Toshiba internal comparison

Rich package line up



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](#)

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

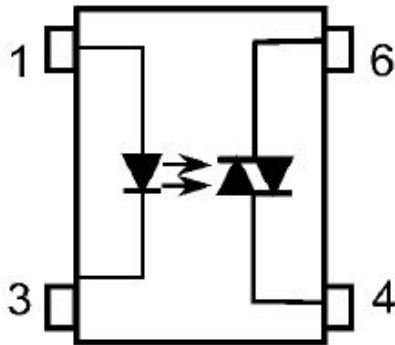
2 Switching characteristic

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

3 Miniaturization of mounting area



The minimum size is 3.7 x 7.0 x 2.1 mm. (SO6)

TLP267J
Internal connection diagram



UL-approved: UL1577, File No.E67349
 cUL-approved: CSA Component Acceptance Service No.5A File No.E67349
 VDE-approved: EN60747-5-5, EN60065 or EN60950-1 (Note)
 CQC-approved: GB4943.1, GB8898 Thailand Factory
 (NOTE) When a VDE approved type is needed, please designate the Option (V4).

Line up

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

[Return to Block Diagram TOP](#)

Value provided

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

1 Low voltage operation

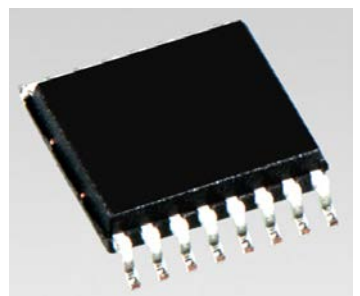
Motor driving voltage is 2.5 V (Min) for low voltage applications such as battery operation devices.

2 Low current consumption

Standby current is below 2 μ A (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.



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

Line up		
Part Number	TC78H621FNG	TC78H660FNG
VM (Max) [V]	18	20
I _{OUT} (Max) [A]	1.1	2.0
R _{on(upper and lower sum)} (Typ.) [Ω]	0.8	0.48
Control Interface	ENABE / PHASE inputs	ENABE / PHASE inputs
Step	Two phase excitation	
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	TSSOP16	TSSOP16

[Return to Block Diagram TOP](#)

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 & low vibration

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

3 Small package

Small QFN16 package with high heat dissipation.



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

Line up

Part Number	TC78B002FNG	TC78B002FTG
VM (Max) [V]	18	
I _{OUT} (Max) [A]	1.5	
Drive type	Single phase full wave drive	
Features & Others	PWM control Soft switching drive Quick start Hall bias circuit Error detection: Current limit, Thermal shutdown	

[◆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 logic circuit

Versatile three phase PWM (*) output and sensing timing make both high efficiency and low noise possible. The advanced encoder reduces 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.

(*) Pulse Width Modulation

Arm® Core	Arm® Cortex®-M0	Arm® Cortex®-M3	Arm® Cortex®-M4
TXZ+™ Family Advanced Class ~ 200 MHz		TXZ3A+ Series Coming Soon M3H	TXZ4A+ Series <Group> M4K M4M M4G M4N
TXZ™ Family ~ 160 MHz		TXZ3 Series <Group> M3H(1) M3H(2)	TXZ4 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		TXZ3E+ Series Coming Soon	
Toshiba Core	8bit	32bit	
TLCS Family TX Family	TLCS 870/C1 Series TLCS 870/C1E Series	TLCS 900 Series TX19 Series	

ラインアップ

Series	Group	Function
TX03 Series	M370 Group	Arm® Cortex®-M3, includes 1st gen VE
TXZ4A+ Series	M4K Group	Arm® Cortex®-M4, includes 4th gen VE

[◆Return to Block Diagram TOP](#)

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