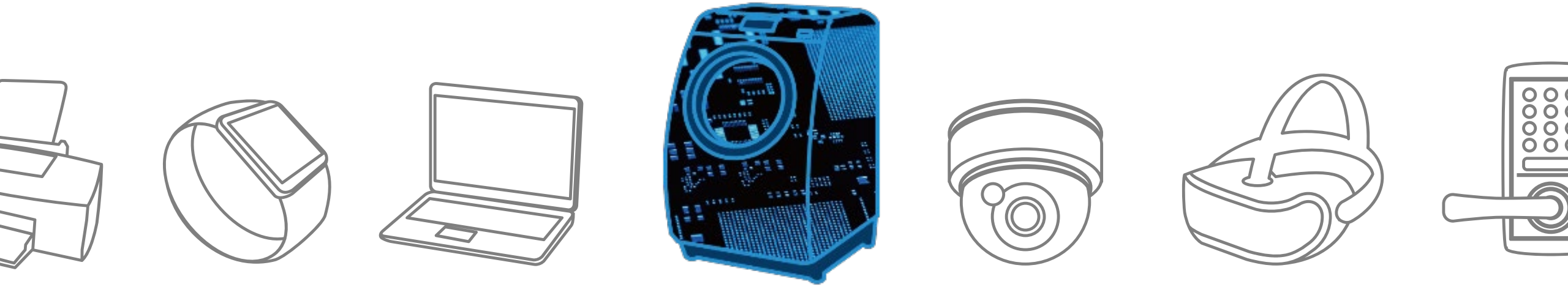
TOSHIBA

R23

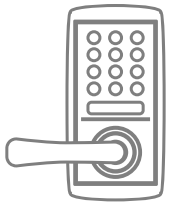
Washing Machine

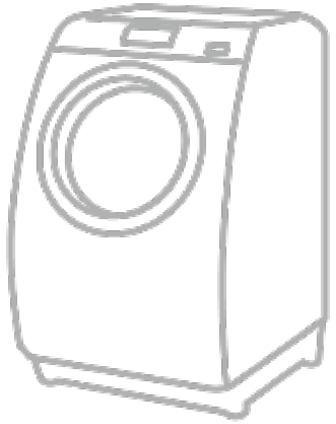
Solution Proposal by Toshiba



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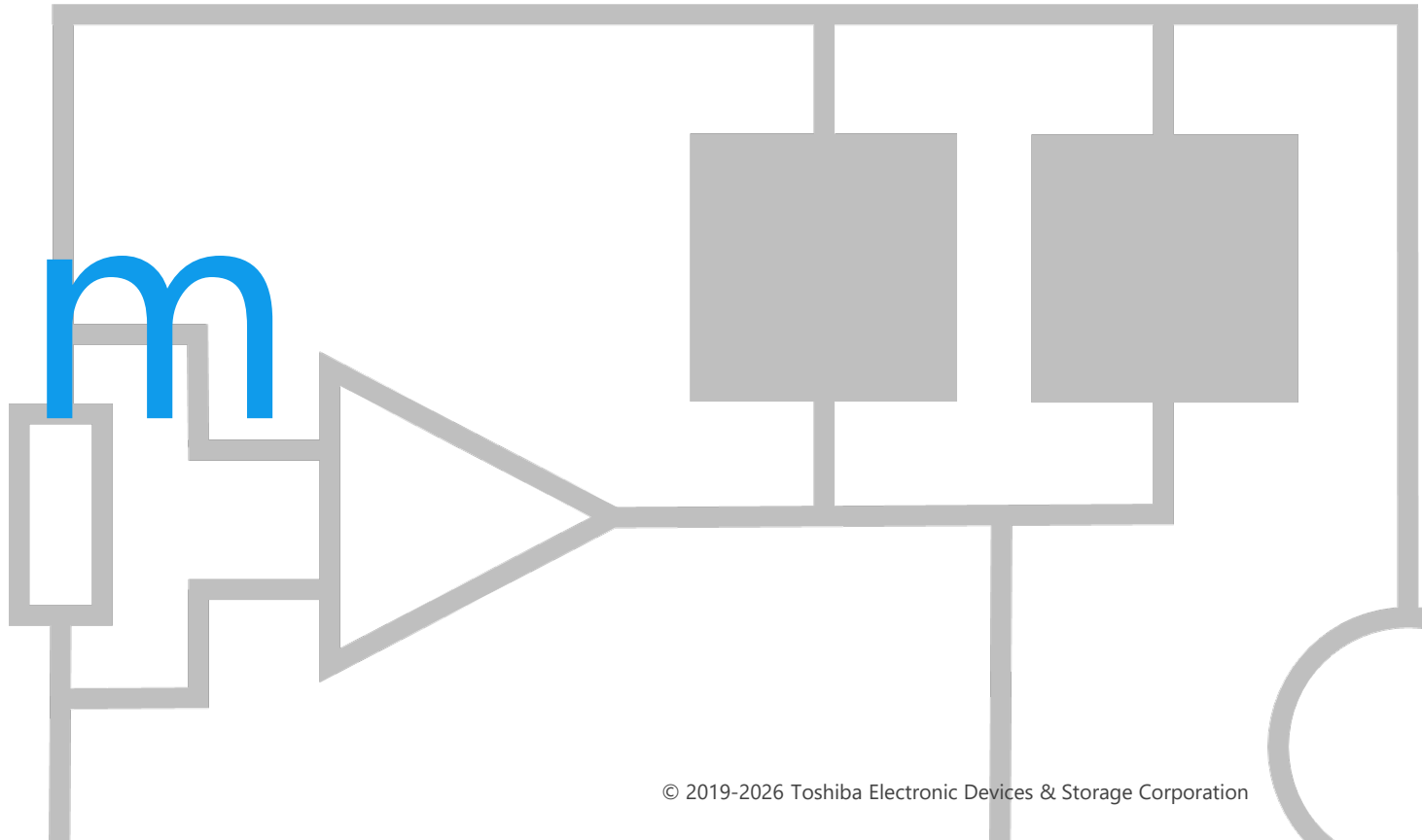
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.





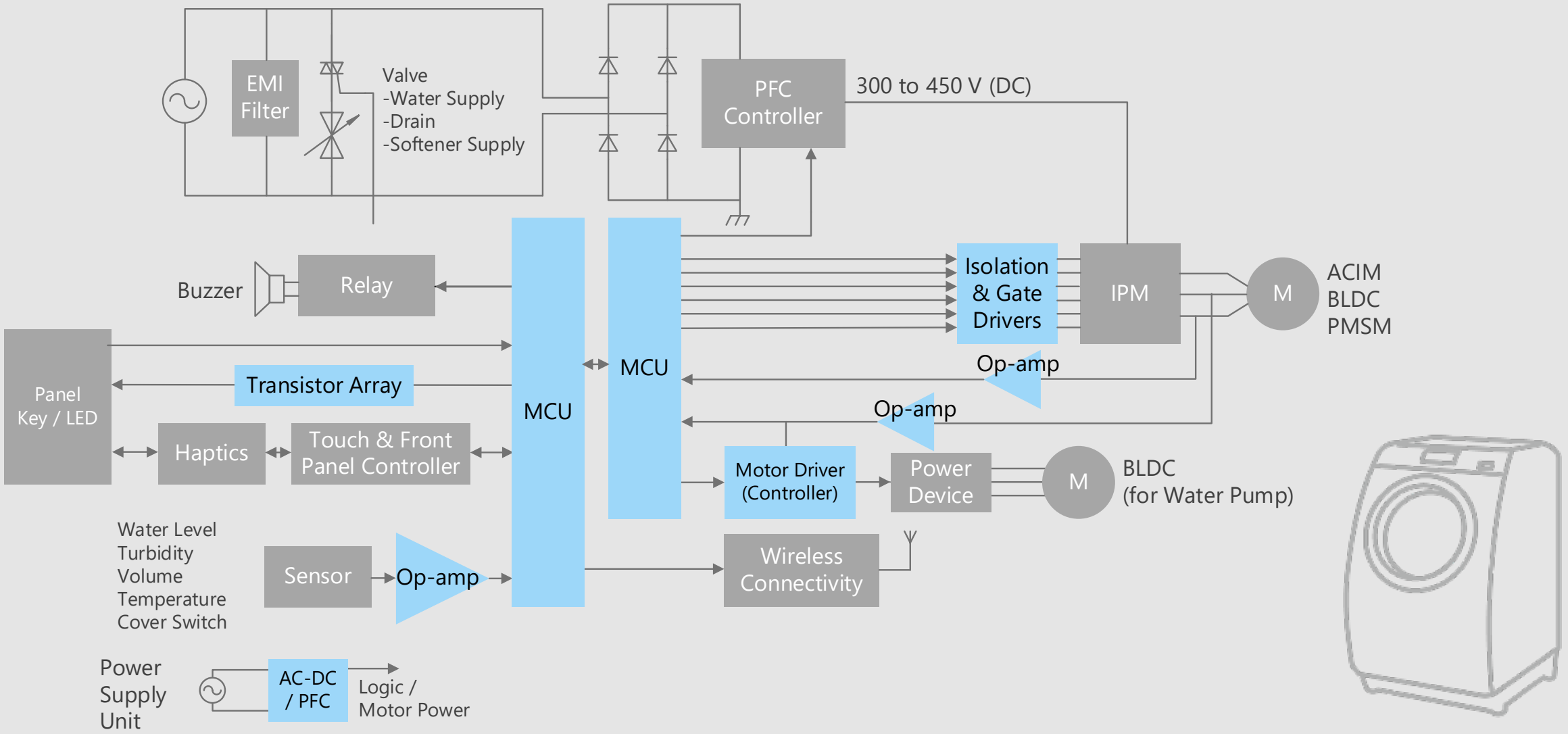
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Block Diagram



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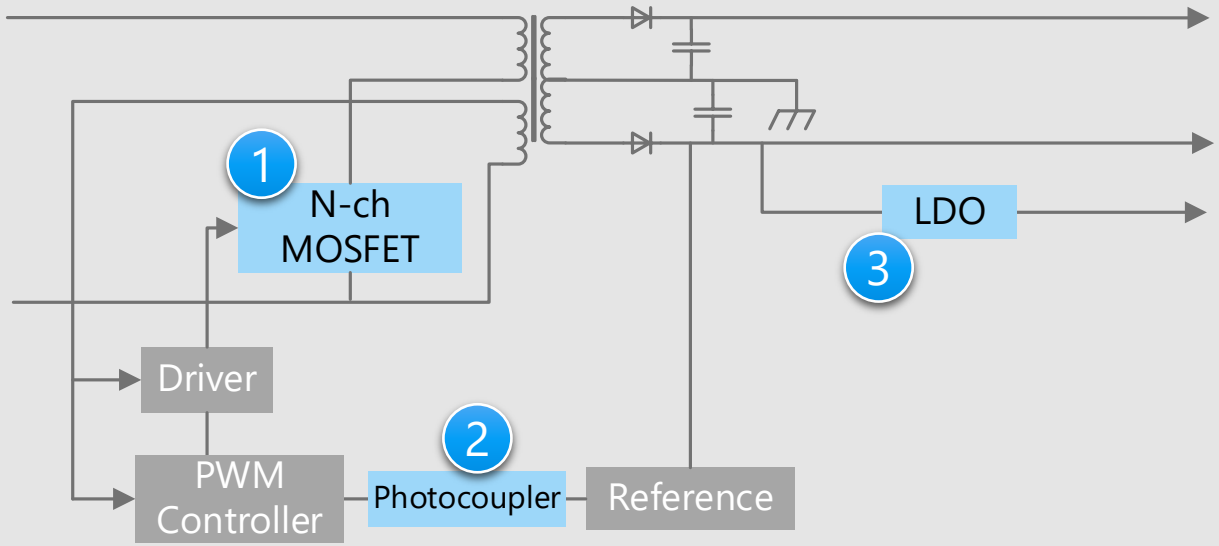
Washing Machine　Overall block diagram



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Washing Machine　Detail of AC-DC converter unit

AC-DC converter circuit



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

Criteria for device selection

- High voltage MOSFETs are suitable for switching on primary side of AC-DC converter.
- A photocoupler is suitable for isolating signals between the primary and secondary sides of an AC-DC converter.
- LDO regulators are suitable for power supply circuits with low ripple noise and stable voltage.

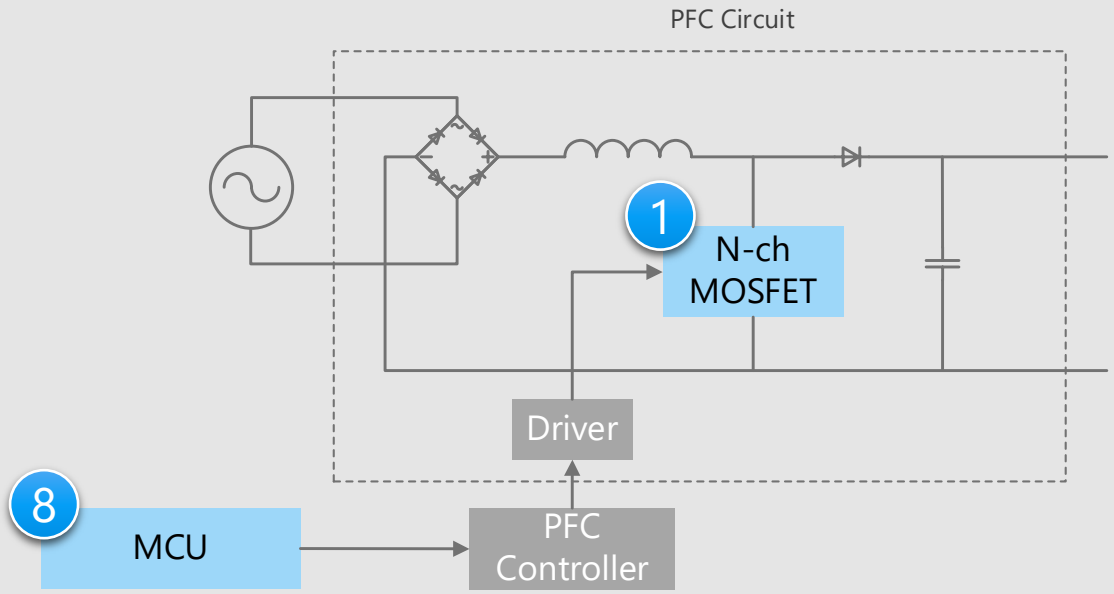
Proposals from Toshiba

- **Suitable for high efficiency power supply**
  DTMOSⅥ Series MOSFET　1
- **High current transfer ratio and high temperature operation are realized**
  Transistor output photocoupler　2
- **Supply the power with low noise**
  Small surface mount LDO regulator　3

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Washing Machine　Detail of PFC unit

PFC circuit



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

Criteria for device selection

- High voltage MOSFETs with high speed switching and low on-resistance are suitable for PFC circuit.
- MCU can be used for PFC control.

Proposals from Toshiba

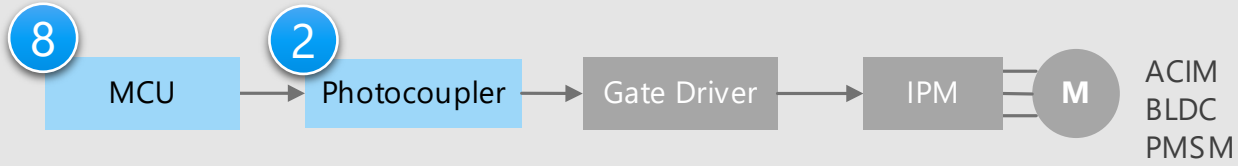
- **Suitable for high efficiency power supply**
  DTMOSⅥ Series MOSFET
- **Suitable for PFC and motor control**
  MCU M4K / M470 / M370 Group

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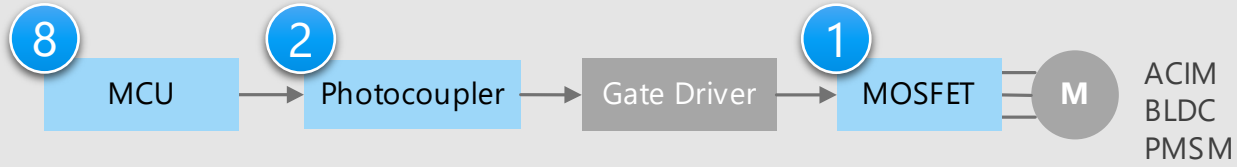
Washing Machine　Detail of motor drive unit

Main motor drive unit

MCU + gate driver + IPM

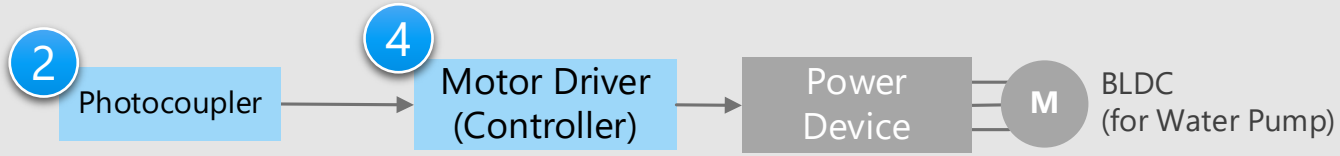


MCU + gate driver + MOSFET



Water pump drive unit

Motor driver (controller) + power device



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

Criteria for device selection

- MOSFET with short reverse recovery time is suitable for driving the motor.
- Transistor output photocouplers are suitable for signal isolation in the motor control section.
- By using three-phase brushless DC motor driver (controller), three-phase brushless DC motors can be controlled easily.

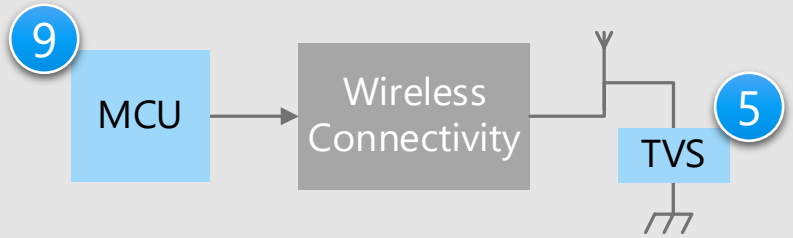
Proposals from Toshiba

- **Suitable for high efficiency power supply** 1
  DTMOSⅥ Series MOSFET
- **High current transfer ratio and high temperature operation are realized** 2
  Transistor output photocoupler
- **Easy motor drive** 4
  Three-phase brushless DC motor driver (controller)
- **Suitable for PFC and motor control** 8
  MCU M4K / M470 / M370 Group

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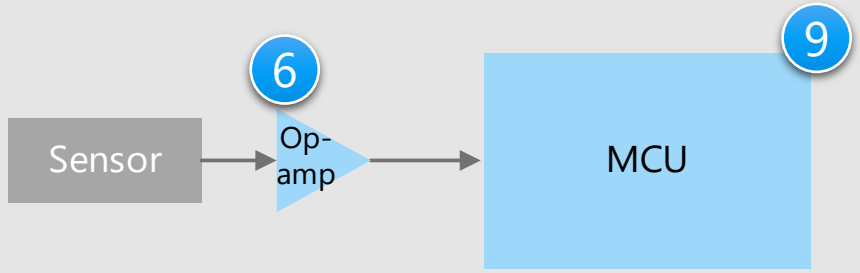
Washing Machine　Details of communication unit / sensor input unit

Communication unit



Sensor input unit

Sensor Input
Water Level
Turbidity
Volume
Temperature
Cover Switch



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

Criteria for device selection

- Lower capacity type TVS diodes are suitable for ESD protection from antennas because they have a small effect on RF signal transmission.
- The operational amplifier should be low current consumption or low noise device.

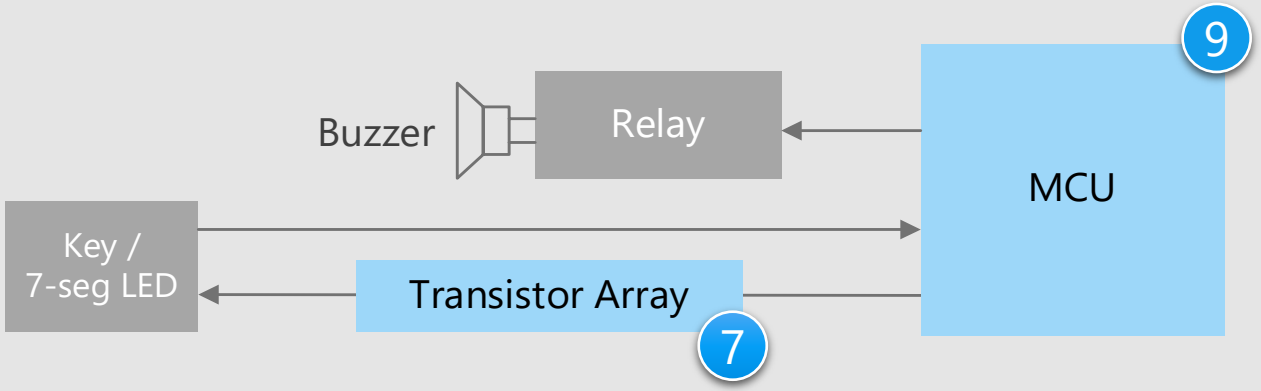
Proposals from Toshiba

- **Absorb static electricity (ESD) to prevent malfunction of the circuit**
  TVS diode　5
- **Amplification of detected very small signals**
  Low current consumption op-amp /
  Low noise op-amp　6
- **Easy software development using general purpose CPU cores**
  MCU M3H Group　9

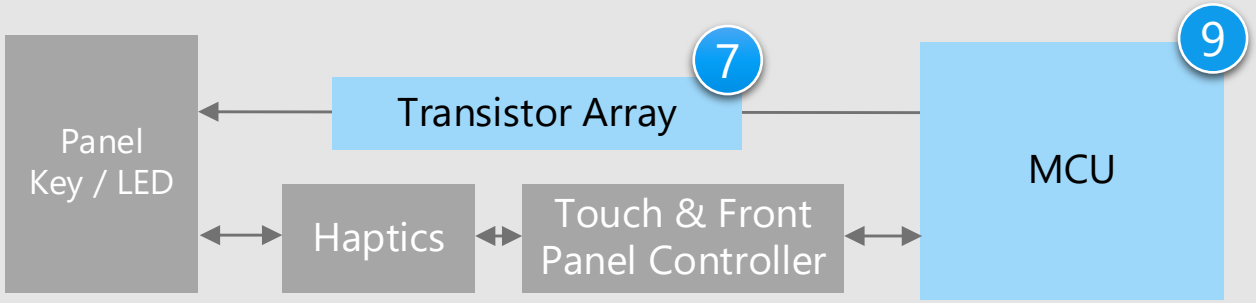
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Washing Machine　Detail of operation unit

Operation unit (Key/LED)



Operation unit (Touch panel)



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

Criteria for device selection

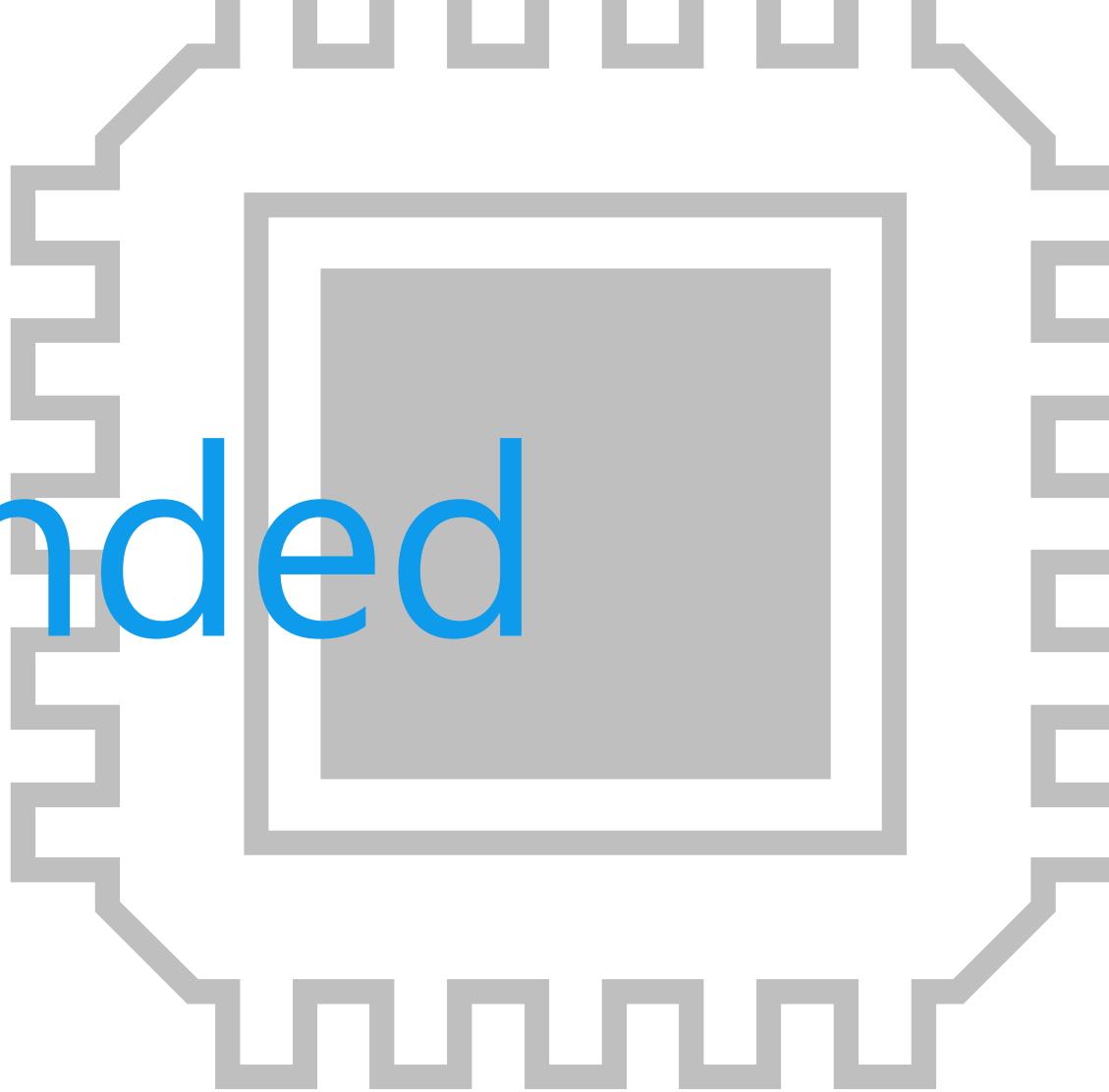
- Transistor array with low loss is suitable for driving LED or touch panel in operation unit.

Proposals from Toshiba

- **High current and high efficiency driver with DMOS FET**
  Transistor array 7
- **Easy software development using general purpose CPU cores**
  MCU M3H Group 9

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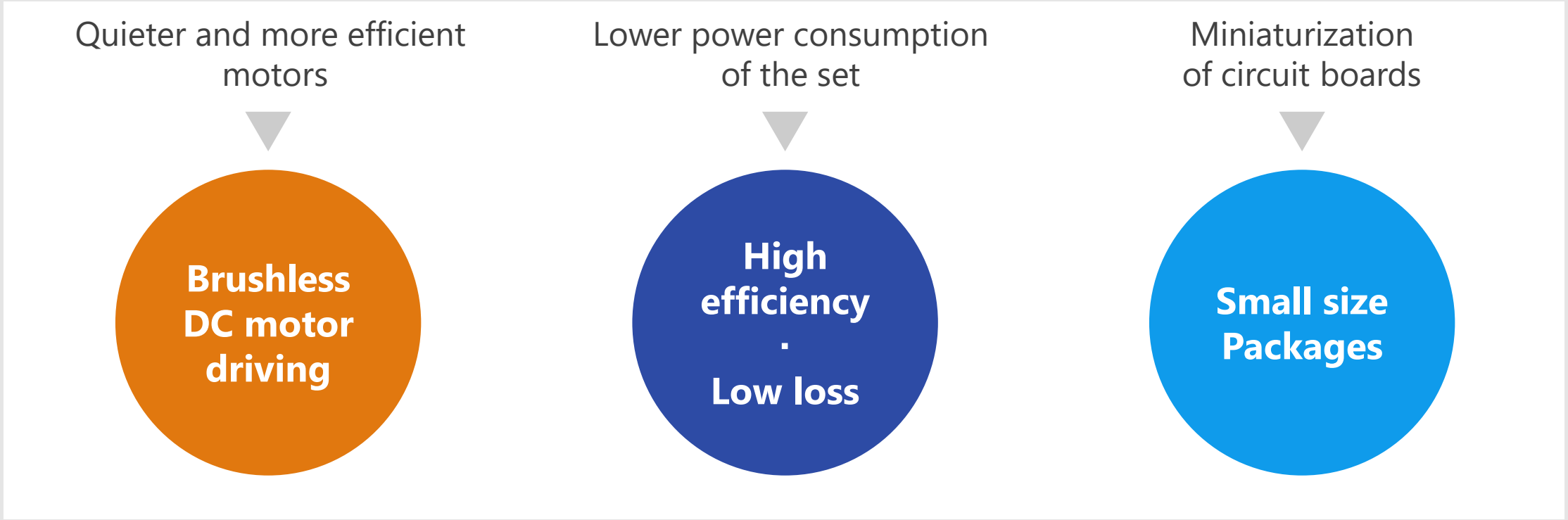
Recommended Devices



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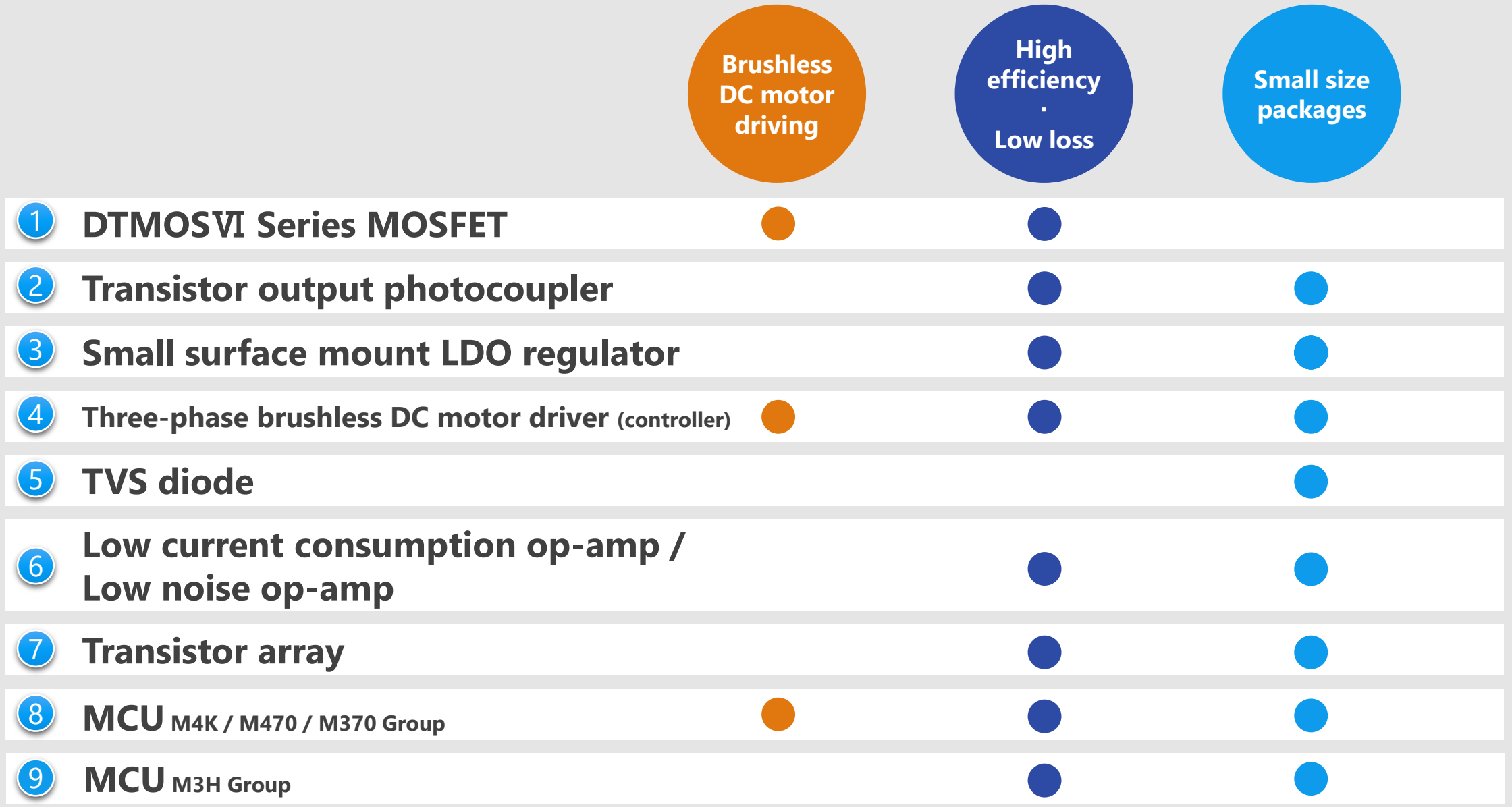
Device solutions to address customer needs

As described above, in order to design Washing Machine, **“Quieter and more efficient motors”**, **“Lower power consumption of the set”** and **“Miniaturization of circuit boards”** are important factors. Toshiba’s proposals are based on these three solution perspectives.



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Device solutions to address customer needs



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Value provided

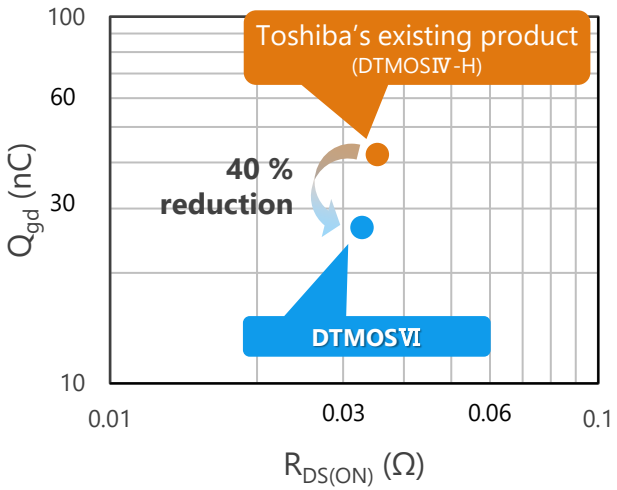
Improved performance index $R_{DS(ON)}$ x Q_{gd}, which shows switching characteristic, contributes to improvement of power supply efficiency.

1 $R_{DS(ON)}$ x Q_{gd} improvement

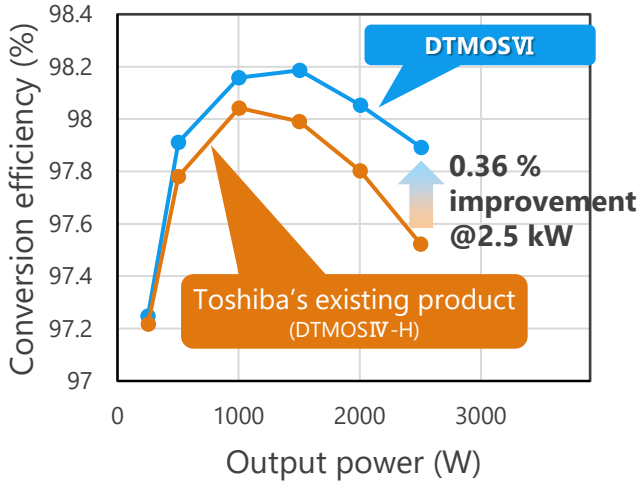
The $R_{DS(ON)}$ x Q_{gd} figure of merit has been reduced by 40 % with gate design and process optimization.
(Comparison with DTMOSⅣ-H products: Toshiba internal comparison)
This characteristic improvement reduces switching loss and contributes to improving power supply efficiency of equipment.

2 RonA improvement

The RonA figure of merit has been reduced by 18 %. (Comparison with DTMOSIV 650 V products: Toshiba internal comparison).
Achieves low on-resistance while ensuring high voltage compared to Toshiba's existing products, contributing to improved power supply efficiency of equipment.



[Note] Toshiba internal comparison



[Note] Toshiba internal comparison

Lineup

Part number		TK080N60Z1	TK090A65Z
Package		TO-247  Top view  Bottom view	TO-220SIS  Top view  Bottom view
V_{DSS} [V]		600	650
I_D [A]		30	
$R_{DS(ON)}$ [Ω] @V_{GS} = 10 V	Typ.	0.067	0.075
	Max	0.080	0.090
Polarity		N-ch	

◆Return to Block Diagram TOP

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2 Transistor output photocoupler

TLP383 / TLP293 / TLP385

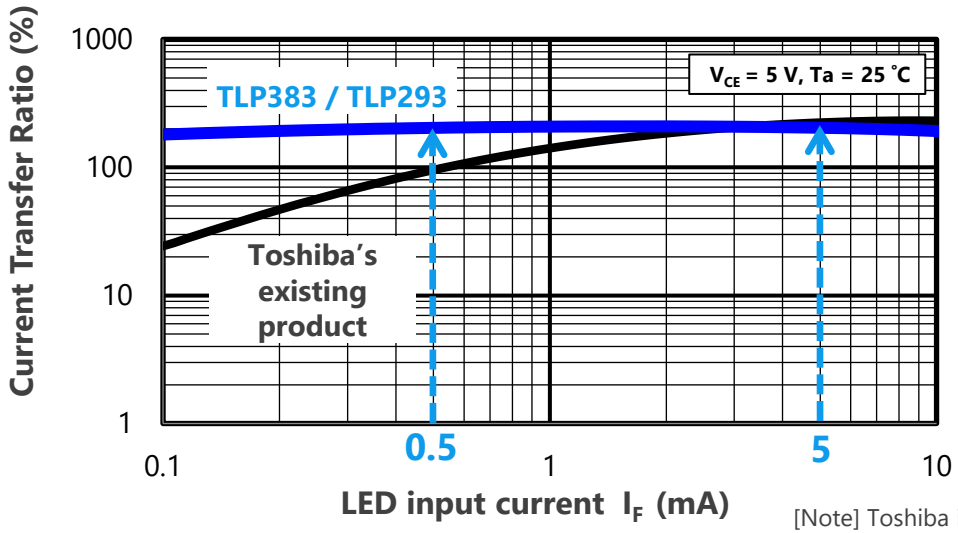
Brushless DC motor driving | High efficiency · Low loss | Small size packages

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 are high-isolation photocouplers that optically couple a phototransistor and high output infrared LED. Compared to Toshiba's existing products (TLP385), higher CTR (Current Transfer Ratio) in low input current range (@I_F = 0.5 mA) is realized.



[Note] Toshiba internal comparison

2 Designed for high temperature operation

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

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

◆Return to Block Diagram TOP

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3 Small surface mount LDO regulator

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

Brushless DC motor driving | High efficiency · Low loss | 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.

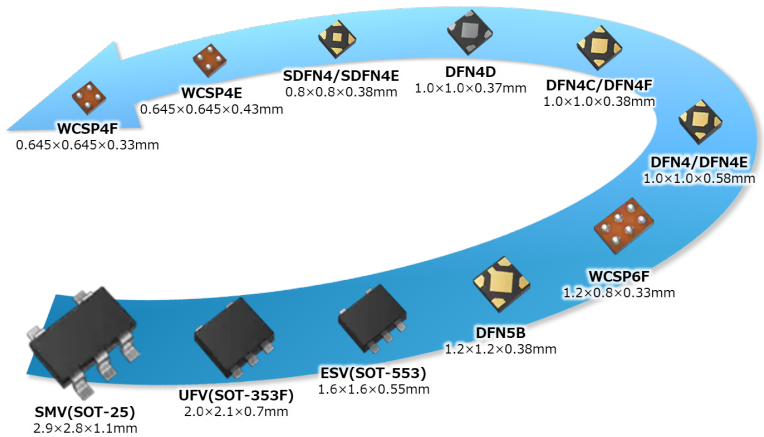
2 High PSRR Low output noise voltage

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 μA (typ.) @I_{OUT} = 0 mA, V_{OUT} ≦ 1.5 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 High PSRR		High PSRR Low noise Low current consumption			Low current consumption		Standard type		36 V Input voltage
I_{OUT} (Max) [A]	1.5	0.8	0.5		0.3					0.15
PSRR (Typ.) [dB] @f = 1 kHz	95	98	91	100	100	70	-	72	68	70
I_B (Typ.) [μA]	25	20	10	7	7	0.34	1	86	35	170

◆Return to Block Diagram TOP

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4 Three-phase brushless DC motor driver (controller)

TB6584FNG / TB6584AFNG / TB6634FNG

Brushless DC motor driving | High efficiency · Low loss | Small size packages

Value provided

By combining with external power devices, high voltage and high current brushless DC motors can be driven.

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 the 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
Operating supply voltage [V]	6 to 16.5		
Commutation output current [A]	0.002		
Drive system	Sine wave drive system		
Features	Phase control: Automatic (current feedback) Sensor input: Hall device / Hall IC compatible Internal regulator: 5 V / 30 mA (Max) Error detection: over current protection, abnormal position signal protection, under voltage lockout, motor restrained detection (TB6634FNG)		

◆Return to Block Diagram TOP

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5 TVS diode

DF2S6P1CT / DF2B7ASL / DF2B5M4SL / DF2B6M4SL

Brushless DC motor driving | High efficiency · Low loss | Small size packages

Value provided

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

1 Improved ESD pulse absorption

Improved ESD absorption compared to our conventional products. (50 % reduction in operating resistance) For some products, both low operating resistance and low capacitance are realized and ensure high signal protection performance and signal quality.

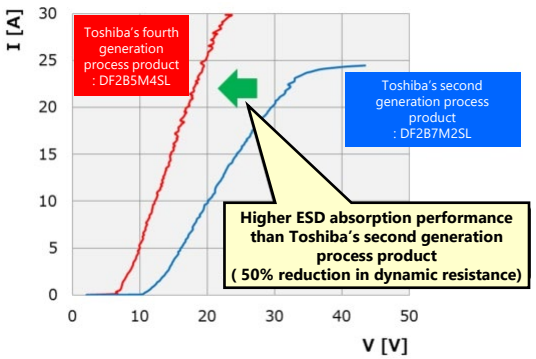
2 Suppress ESD energy by low clamp voltage

Protect the connected circuits and devices using Toshiba own technology.

3 Suitable for high density mounting

A variety of small size packages are available.

ESD Pulse Absorption Performance
(Toshiba internal comparison)

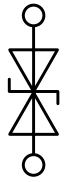


Unidirectional



Suitable for paths such as logic signals. There are lineups of 1in1, 2in1, 4in1, 5in1, 7in1.

Bidirectional



Suitable for paths with both polar signals such as audio signals.

Lineup

Part number	DF2S6P1CT	DF2B7ASL	DF2B5M4SL	DF2B6M4SL
Package	CST2  Top view  Bottom view	SL2	 Top view	 Bottom view
V_{ESD} [kV]	±30	±30	±20	±20
V_{RWM} (Max) [V]	5.5	5.5	3.6	5.5
C_t (Typ.) [pF]	90	8.5	0.2	0.2
R_{DYN} (Typ.) [Ω]	0.23	0.2	0.5	0.5

◆Return to Block Diagram TOP

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

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6 Low current consumption op-amp / Low noise op-amp

TC75S102F / TC75S67TU

Brushless DC motor driving | High efficiency · Low loss | Small size packages

Value provided

The lineup includes a low current consumption type that contributes to reducing power consumption and a low noise type that brings out performance of the sensor.

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 circuits.

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

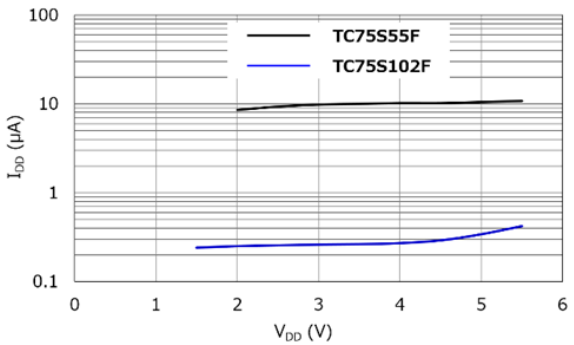
CMOS processes have been used to achieve lower current consumption. This contributes to lower power consumption of equipment.

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

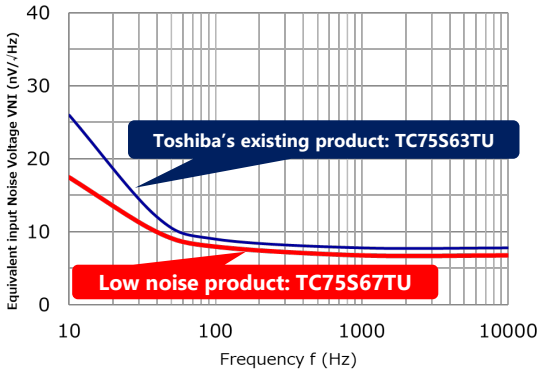
This CMOS operational amplifier can amplify minute signals detected by various sensors [Note] with low noises. By optimizing the process, the equivalent input noise voltage has been reduced.

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

TC75S102F
Current Consumption Characteristic
(Toshiba internal comparison)



TC75S67TU
Noise Characteristic
(Toshiba internal comparison)



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	-	6.0

◆Return to Block Diagram TOP

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7 Transistor array

TBD62003AFWG / TBD62083AFG / TBD62064AFAG

Brushless DC motor driving | High efficiency · Low loss | Small size packages

Value provided

DMOS FET is used for the output of drive circuit and realizes low loss. 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, HSOP, etc.) and source output type products.

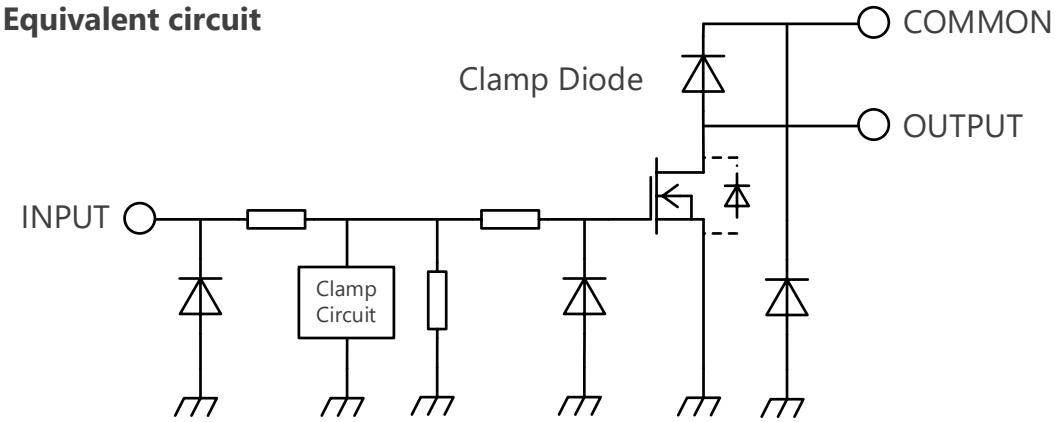
2 Built-in output clamp diode

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

3 Higher current drive is possible

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

Equivalent 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

◆Return to Block Diagram TOP

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8 MCU

TXZ+™ 4A Series M4K Group / TX04 Series M470 Group / TX03 Series M370 Group

Brushless DC motor driving | High efficiency · Low loss | Small size packages

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.

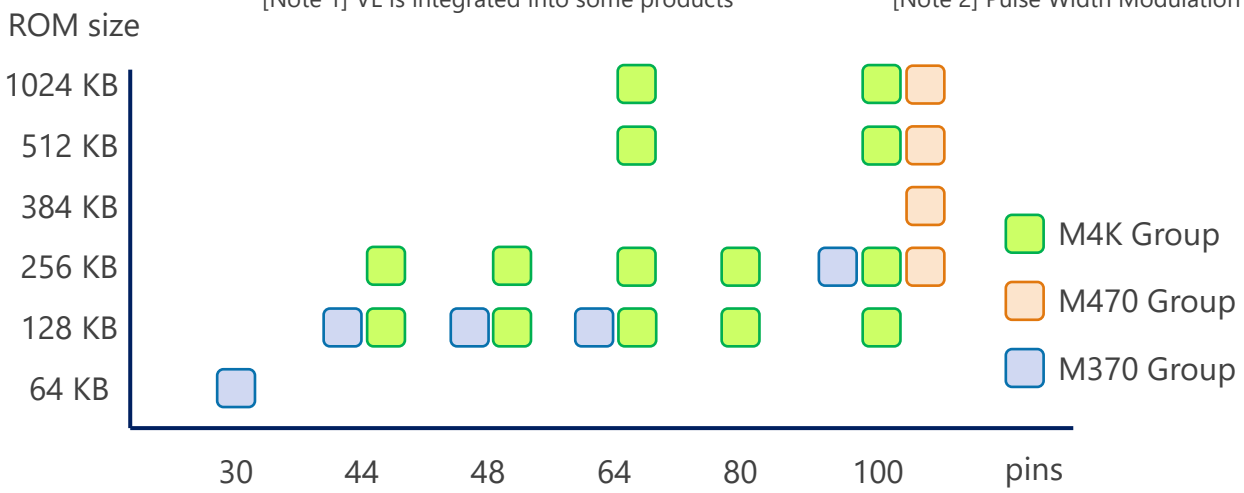
3 Provide development support tools

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

[Note 1] VE is integrated into some products

[Note 2] Pulse Width Modulation

[Note 3] MCU Motor Studio supports 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

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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.

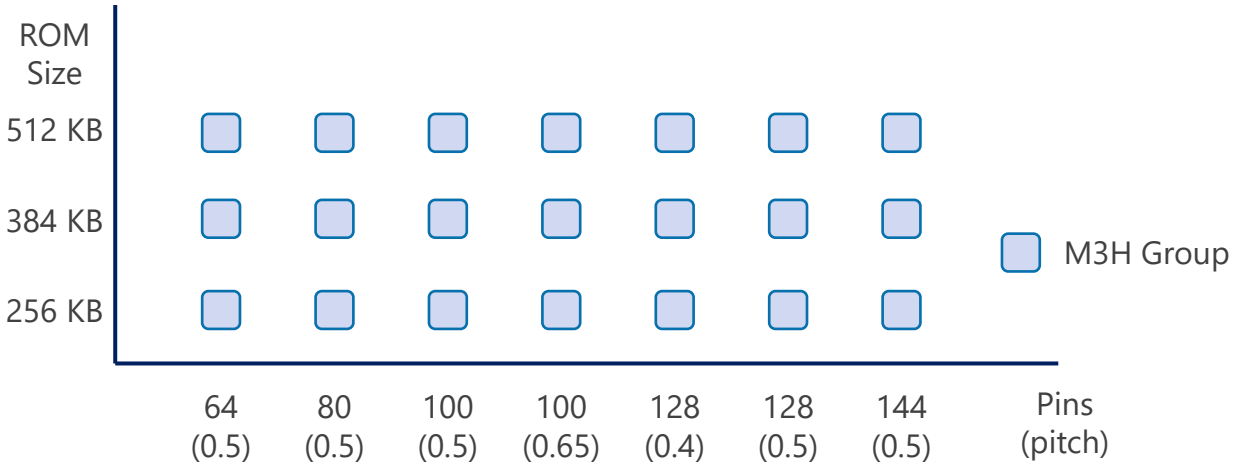
2 Various lineup of built-in memories and packages

M3H group integrates both 512 KB (Max) code and 32 KB data flash memories which support 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, I²C,12bit AD converter, 8bit DA converter, three-phase PWM output, 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

◆Return to Block Diagram TOP

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If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

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