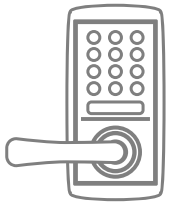
TOSHIBA

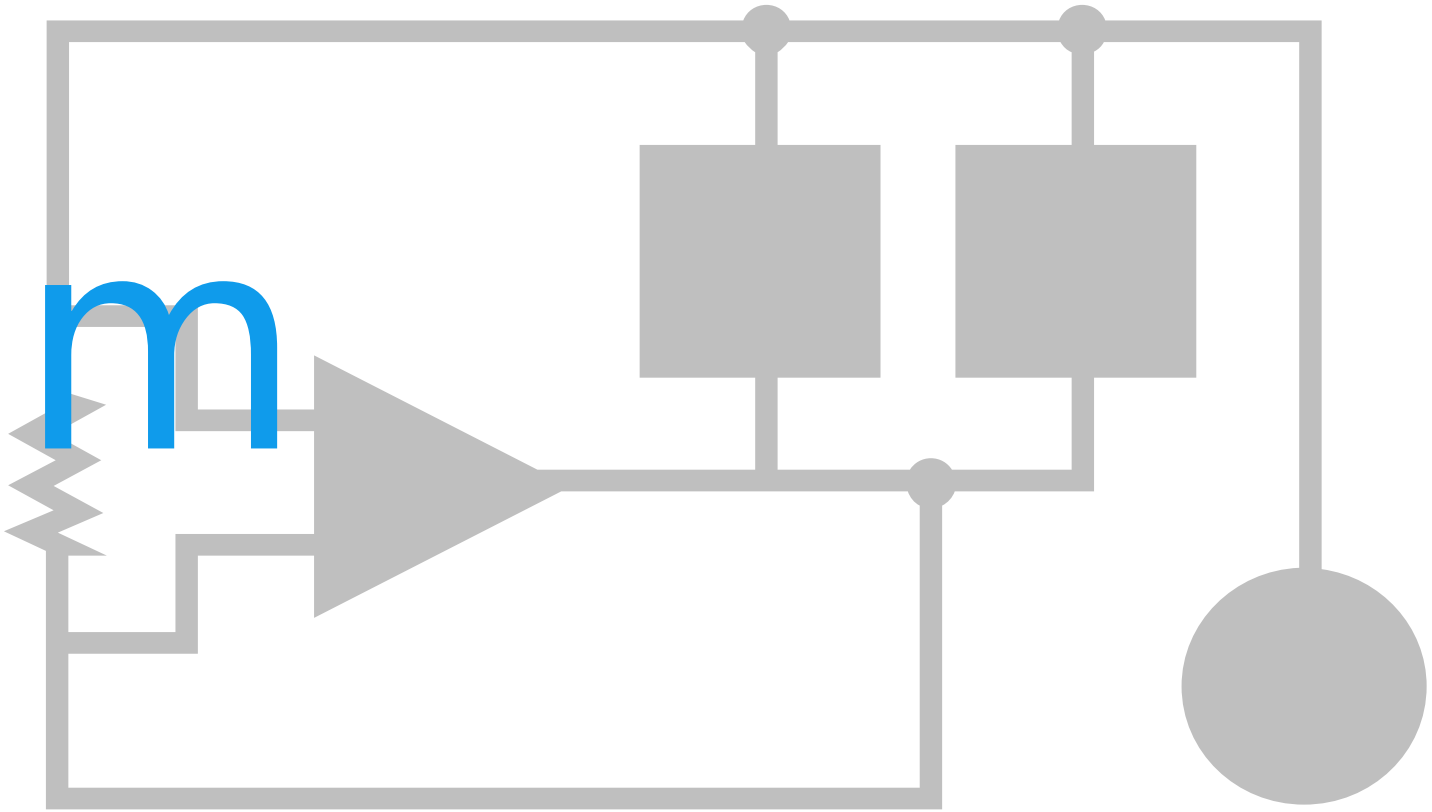
Robotics with an Emphasis on Servo Motors and Sensing/Display Solutions

Solution Proposal by Toshiba

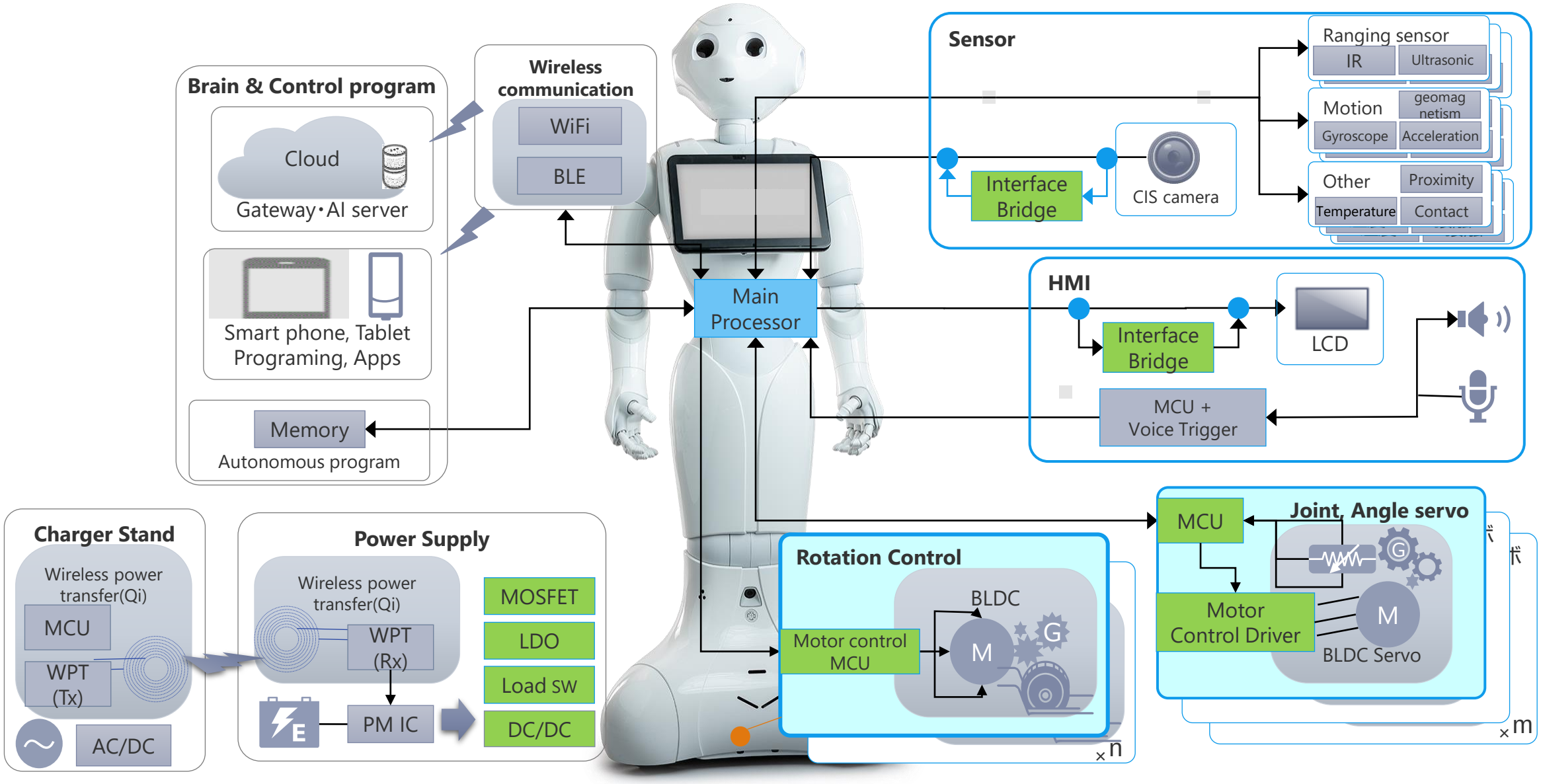


Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

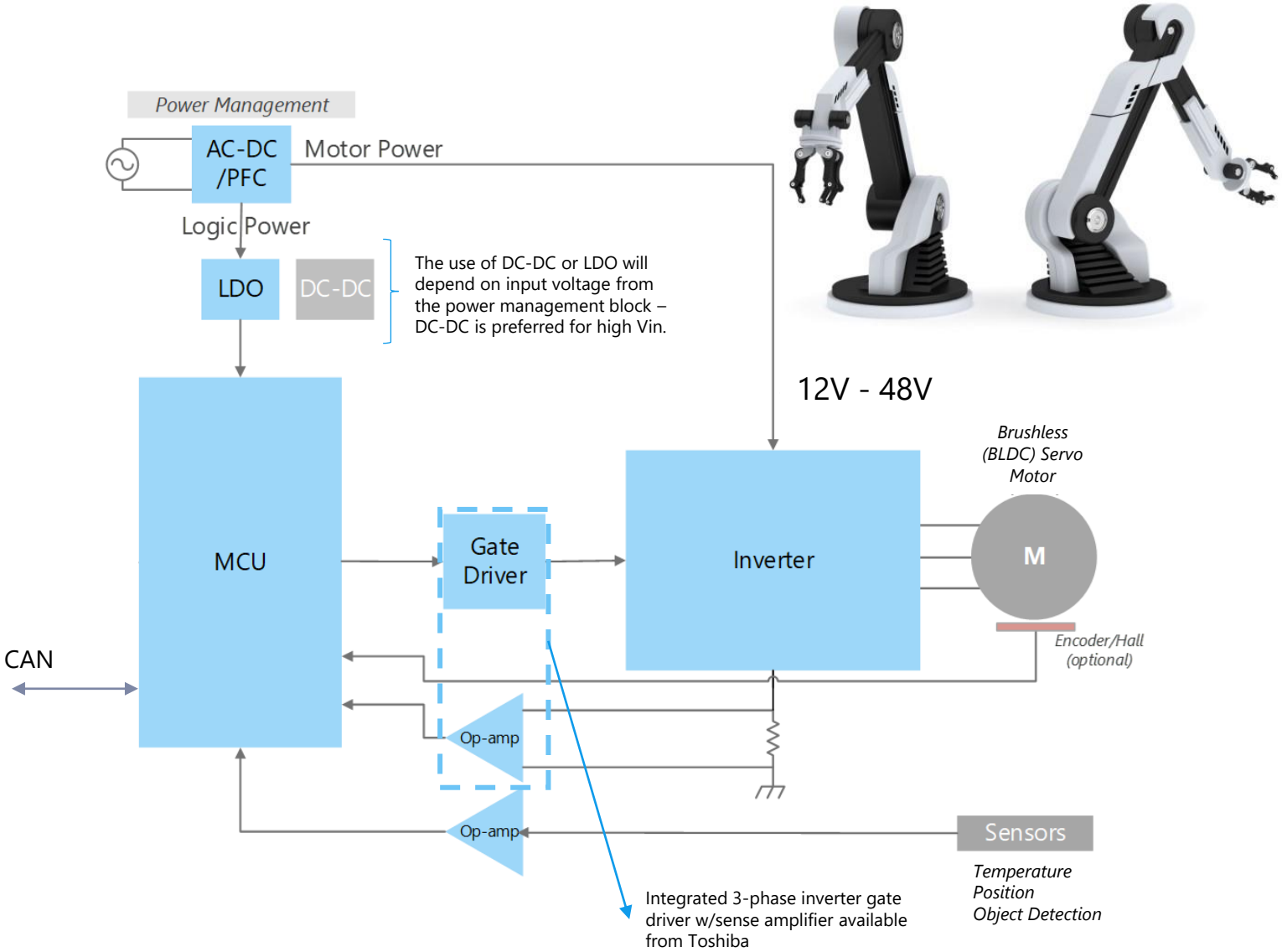
Block Diagram



Humanoid Robot Conceptual Block Diagram



Servo Motors for Robotics General Block Diagram



1: ACIM = AC Induction Motor
2: BLDC = Brushless DC Motor

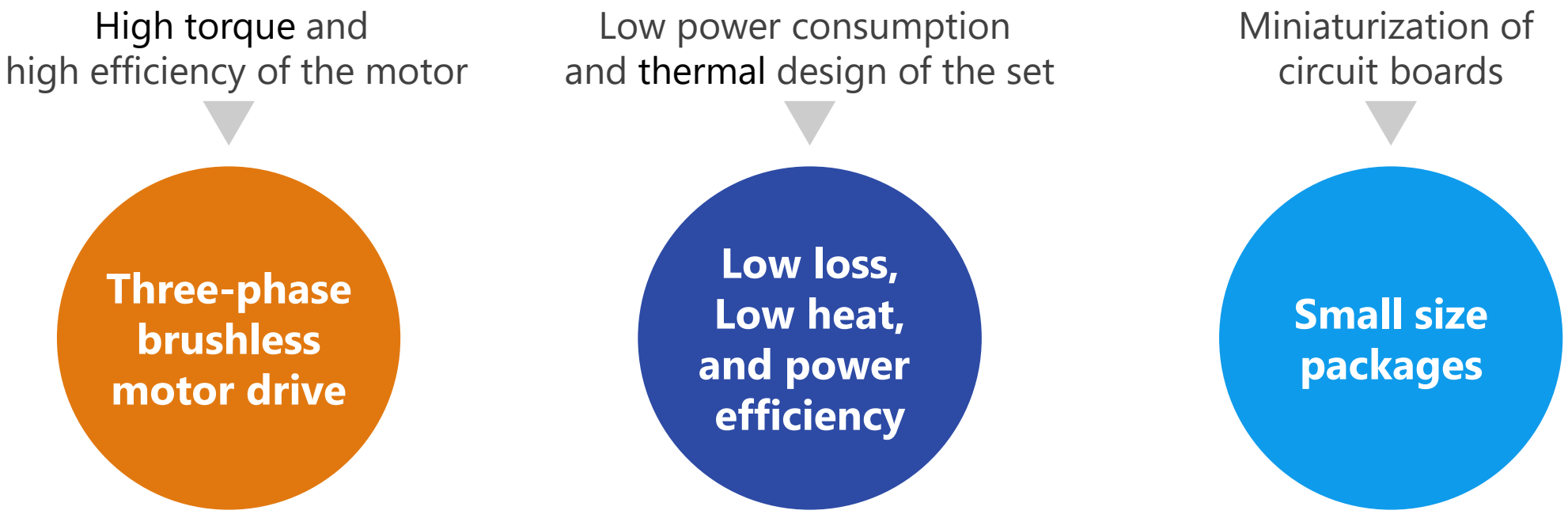
System Overview

- In one robot arm system, there could be up to 8+ motors to handle not only x-y-z positioning, but also rotational and grab/release motion.
- The general block diagram is showing supporting devices for one motor set up for a typical industrial robot using 12V-48V servo motors.
- Industrial power management systems can be as high as 400-600V that can be handled by Toshiba's IGBT and SiC Power MOSFETs.

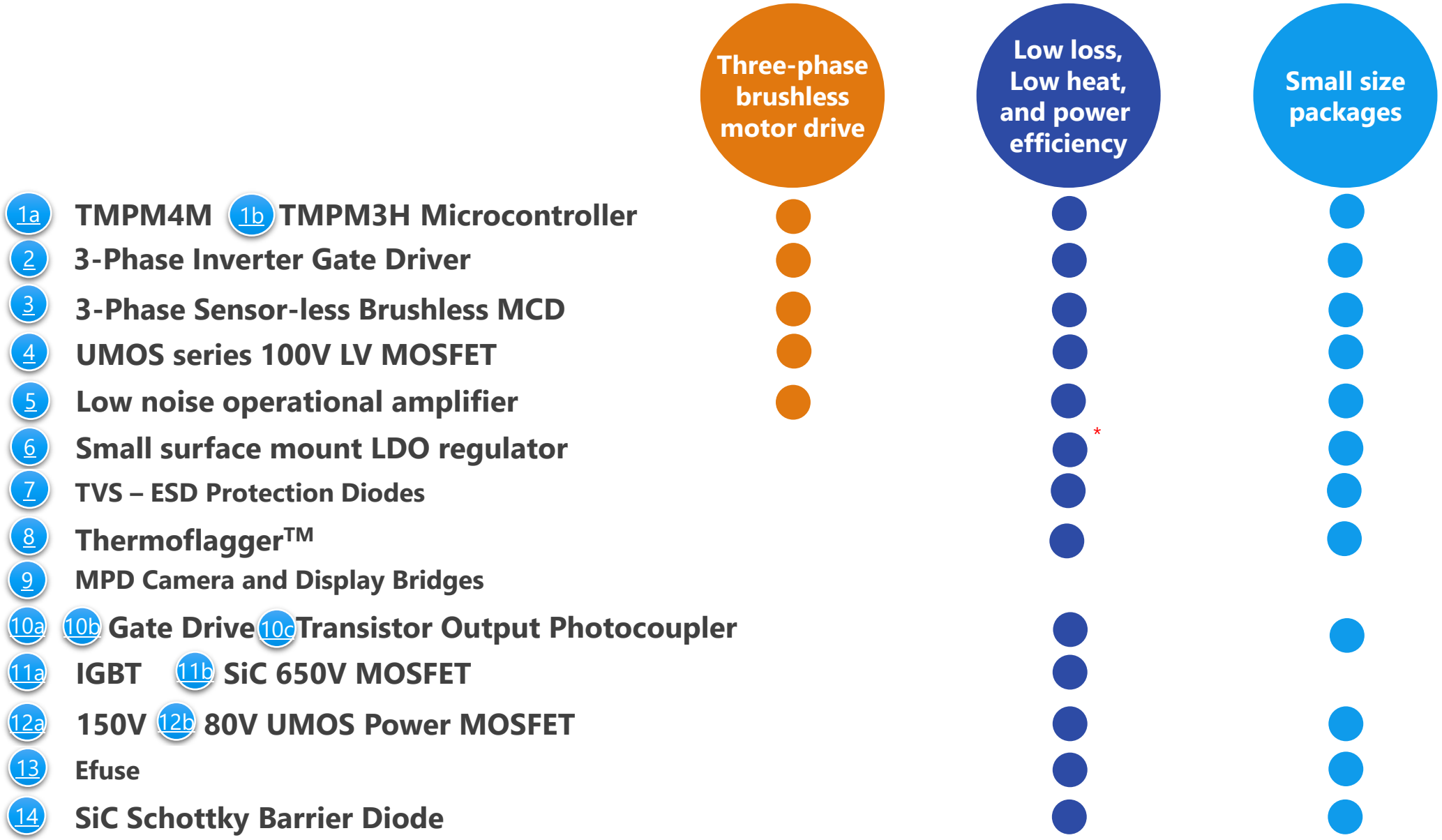
Primary Focus is on 12V-48V BLDC servo motor systems for this Solution Proposal.

Device solutions to address customer needs

Robot design criteria has many wide and various facets. Key focus areas would be **“Smooth precise control and high efficiency of the BLDC servo motor“, “Low power consumption with good power efficiency"** and **"Miniaturization of circuit boards."** Toshiba’s proposals are based on these three solution perspectives.

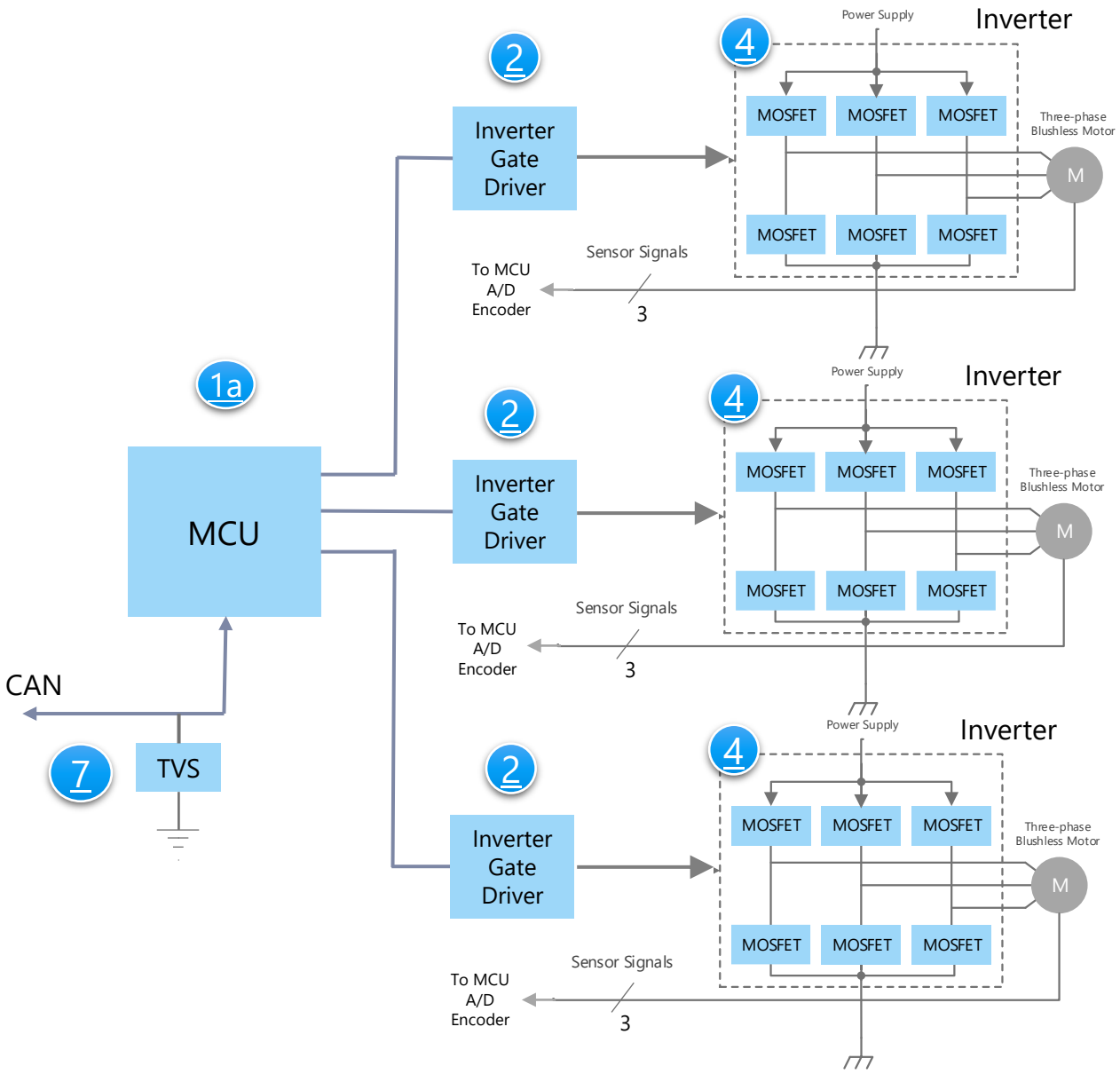


Device solutions to address customer needs



* For post DC-DC switching regulation

Motor Control MCU Driving Several Servo Motors



※ Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- By using dedicated motor control MCU, user can drive brushless DC motor with great performance cost effectively
- System can drive high-capacity brushless motor by using motor controller with external MOSFET.
- A set with low heat generation and low power consumption can be realized by using MOSFET with low on-resistance and high thermal dissipation characteristics as driver.

Proposal from Toshiba

Motor Control MCU for Inverter & PFC Control

MCU **TMPM4M Group**

U-MOS Series 100V MOSFET with low on-resistance and good thermal performance (1a)

TPH3R70APL, TPW3R70APL

TPH2R70AR5 (4)

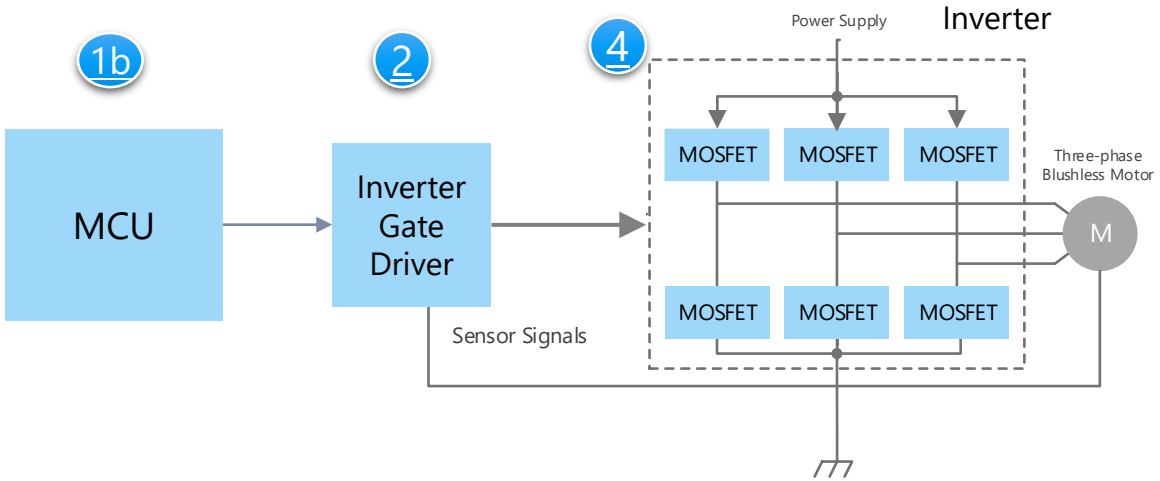
TVS to protect lines (7)

TCKE8 Series

Inverter Gate Driver can optimize FETs for the most demanding application

TB67Z8xx family of 3-Phase Inverter Gate Driver (2)

New Inverter Gate Driver Designed for Driving 3-Phase BLDC Motors



※ Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- By using a MCU with a dedicated 3-phase BLDC gate driver, a user can drive brushless DC motor with great performance cost effectively
- System can drive high-capacity brushless motor by using motor controller with external MOSFET.
- A set with low heat generation and low power consumption can be realized by using MOSFET with low on-resistance and high thermal dissipation characteristics as driver.

Proposal from Toshiba

Motor Control MCU

MCU **TMPM3H Group** 1b

Inverter Gate Driver can optimize FETs for the most demanding applications 2

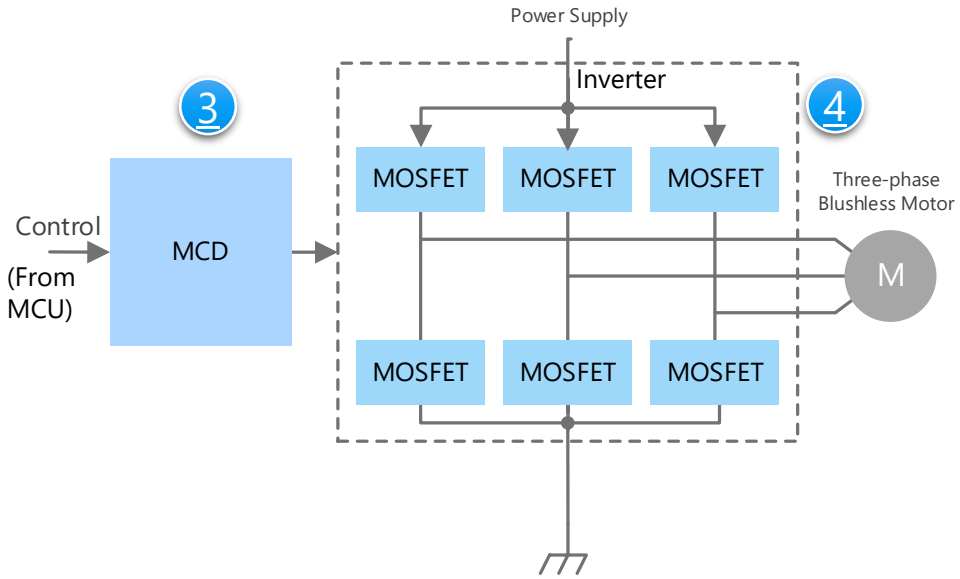
TB67Z8xx family of 3-Phase Inverter Gate Driver

U-MOS Series 100V MOSFET with low on-resistance and good thermal performance

TPH3R70APL, TPW3R70APL 4

TPH2R70AR5

Simplified Lower Performance Control for Sensor-less BLDC Servos



Criteria for device selection

- For Lower Performance/Lower Cost servo systems
- System can drive lower-capacity brushless motor by using MCD pre-driver with external MOSFET.
- Low gate Load (Ciss/Qg) MOSFETs capable of being driven by low source/sink gate driver

Proposal from Toshiba

Low-Cost Feature Rich Motor Control Device

TC78B009/TC78B011 3-Phase BLDC sensor-less pre-drivers (3)

U-MOS Series MOSFET with low Qg

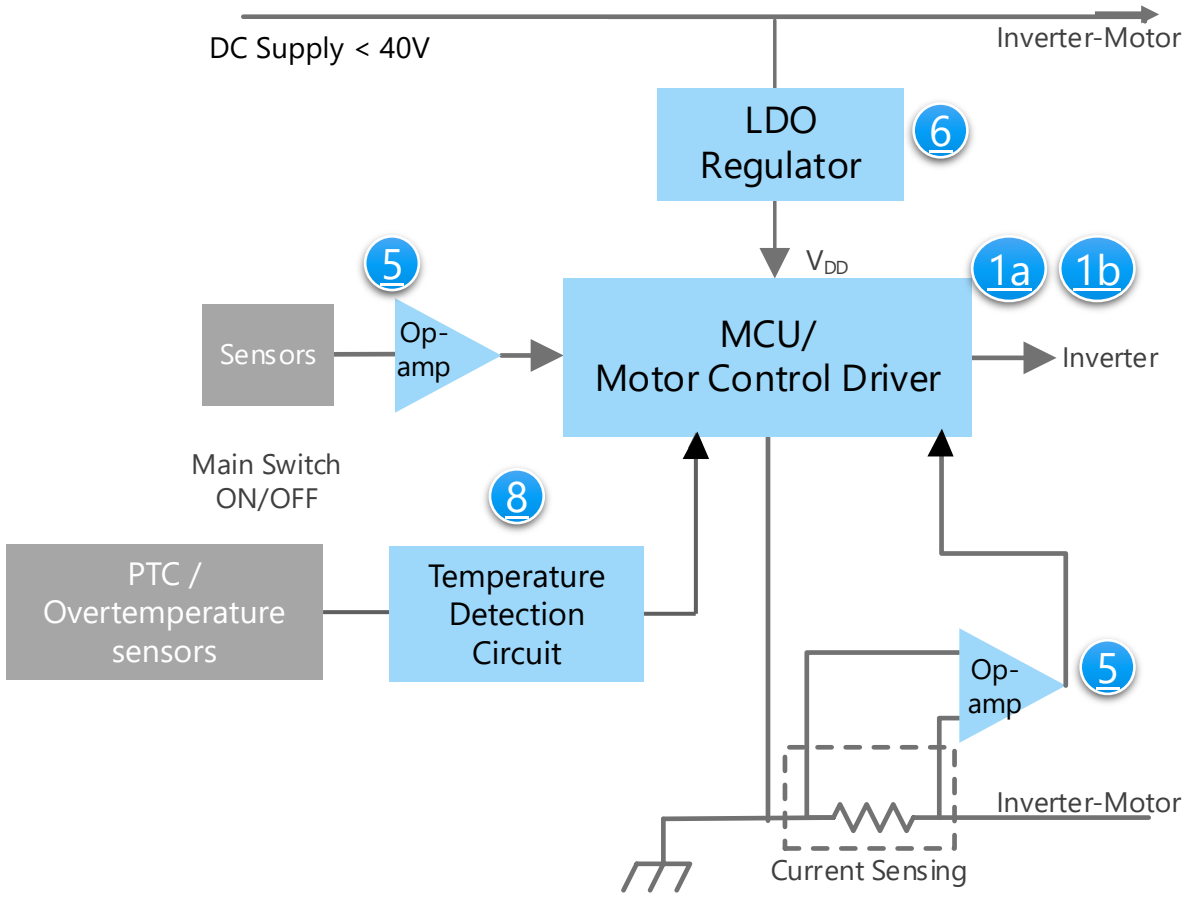
TPH3R70APL, TPW3R70APL
TPH2R70AR5 (4)

※ Click the number in the circuit diagram to jump to the detailed description page

MCD = Motor Control Driver

Microcontroller Peripheral Detail

MCU peripheral circuit



※ Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- By monitoring the system power supply current, detection of abnormal equipment state and battery overcurrent protection become possible.
- Stable system is realized by adopting op-amps and LDO power supplies resistant to noise from the motor drive section.
- General purpose microcontroller suitable for system control and monitoring.

Proposal from Toshiba

Motor Control MCU for Inverter & PFC Control

MCU **TMPM4M** 1a **TMPM3H** 1b

Low noise operational amplifier to capture fluctuations in current consumption accurately

Low noise operational amplifier 5

Small surface mount LDO regulator suitable systems having high noise

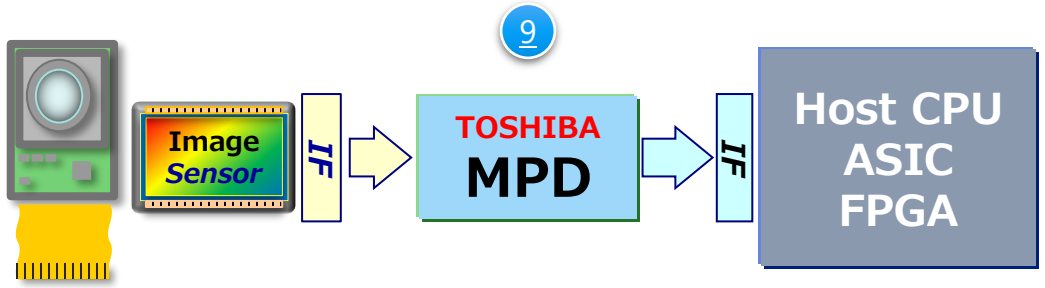
Small surface mount LDO regulator 6

Monitor temperature at multiple points with small package and low current consumption

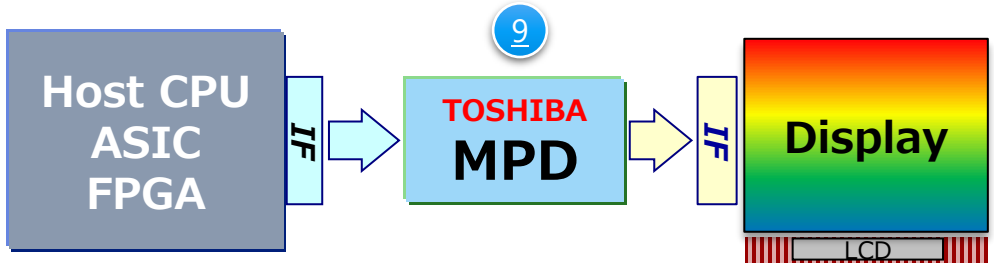
Over-temperature detection "Thermoflagger™" 8

Sensor / Display Block Diagram Detail

Camera Sensor Interface Bridging to Host CPU interface



Host CPU Interface Bridging to a Display Interface



※ Click the number in the circuit diagram to jump to the detailed description page

Criteria for device selection

- Peripheral device – camera or display - has a different interface to the Host CPU.
- A Toshiba MPD bridge device may be able to help connect the different interfaces
- Ease of design and programmability over I2C/SPI.

Proposal from Toshiba

Bridging different interfaces for cameras or displays

-TC358xxxXBG for commercial specs

- TC959xXBG for Industrial specs.

9

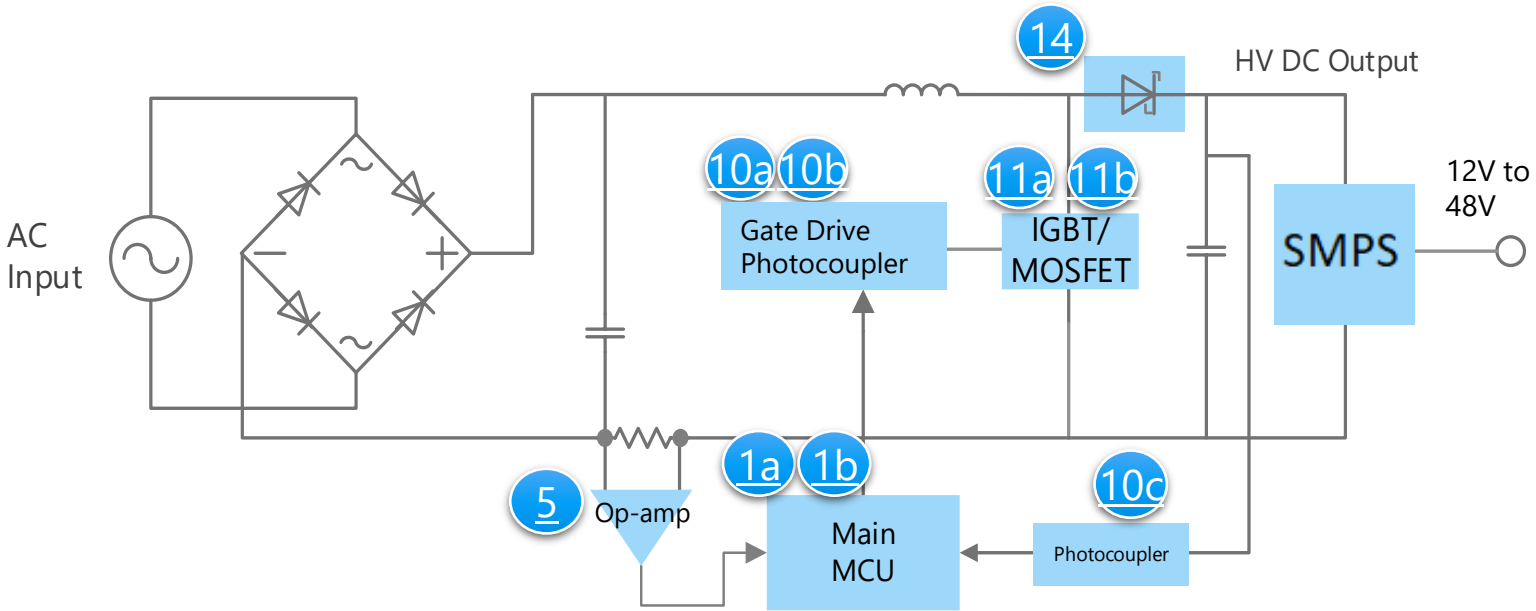
Display Interfaces includes:

- DPI℠(RGB), LVDS, MIPI® DSI℠,
- DisplayPort™/eDP, HDMI®

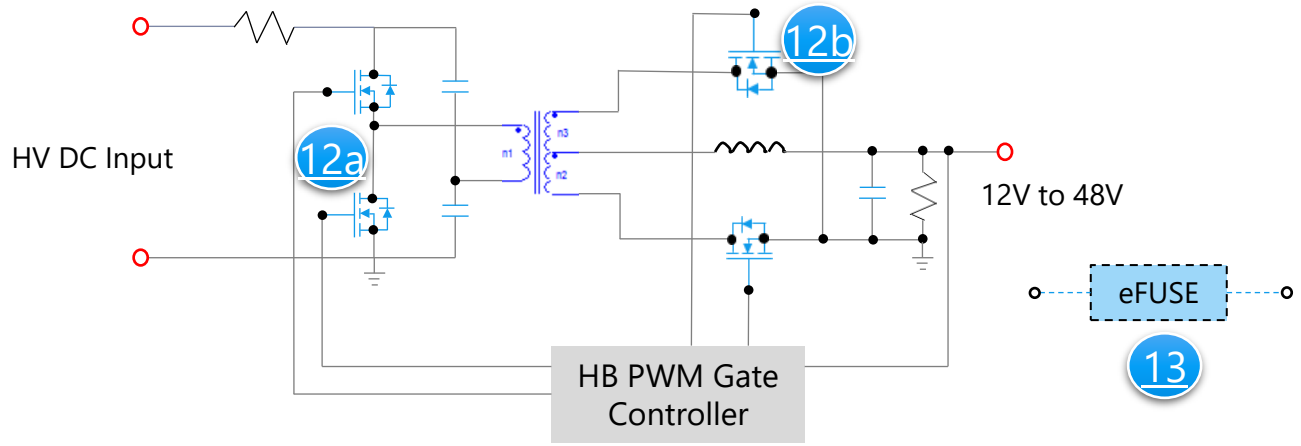
Camera Interfaces includes:

- Parallel (8bit/16bit), MIPI ® CSI-2℠

AC-DC / PFC



SMPS example using Half Bridge DC-DC:



Criteria for device selection

- Cost, not Efficiency typically main driver
- Main, Motor control MCU can be utilized for PFC control
- SiC Diodes & DTMOS MOSFETs suitable for PFC, SMPS
- U-MOS Series LV MOSFETs suitable for SMPS

Example Proposals from Toshiba

Suitable for power supply switching

IGBT **GT15J341** 11a 11b

SiC 650V MOSFET

U-MOS Series MOSFET **TPH3300CNH** 12a **TPH1400CQ5** 12b

Achieves both high isolation and high functionality

Gate drive photocoupler **TLP5772** 10a **TLP5814** 10b

Transistor Output photocoupler **TLP383** 10c

High current surge resistance and low switching loss

SiC Schottky barrier diode **TRS4E65H** 14

Motor Control MCU for Inverter & PFC Control

MCU **TMPM4M** 1a **TMPM3H** 1b

Low noise operational amplifier to capture fluctuations in current consumption accurately

Low noise operational amplifier 5

Protect from short/over voltage event

Efuse IC (optional for <18V lines) 13

※ Click the number in the circuit diagram to jump to the detailed description page

1a MCU w/ Vector Engine

M4M Series ARM Cortex-M4

Three-phase brushless motor drive | High efficiency · Low loss | Small size package

Back to AC-DC/PFC
Back Motor Control MCU
Back to Micro Peripheral Detail

Value provided

System cost down, high efficiency system, development efficiency improvement

1 Built-in Arm® Cortex®-M4 CPU core

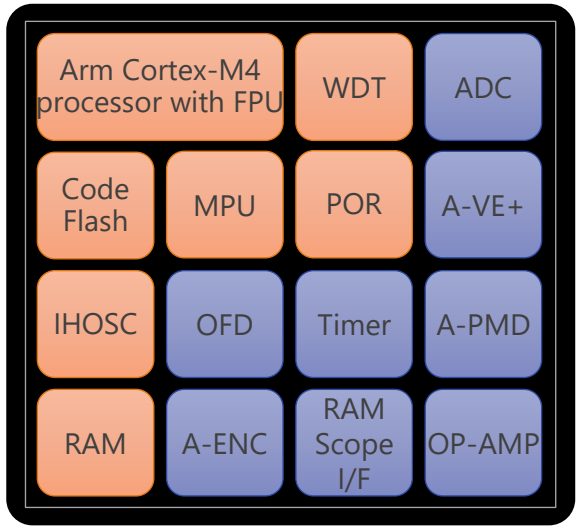
Built-in Cortex-M4 core with Thumb instruction set improves energy efficiency. Various development tool and their partners allow users many options.

2 Suitable for sensing analog signal

Built-in multi-channel ADC and CPU system executes sensing data processing efficiently at low cost

3 Vector Engine - fast precise control of brushless motors

Complicated FOC routines can be off-loaded from CPU to dedicated hardware (Vector Engine) for faster processing and handling of brushless motors



Line up

Sample Line Up

Part number	TMPM4MNFWAFG	TMPM4MNFWADFG
Package	LQFP 100	QFP 100
Maximum operation frequency	160 MHz	160 MHz
Code Flash	128 KB	128 KB
Data Flash	32 KB	32 KB
RAM	24 KB	24 KB
Timer	Up to 12ch	Up to 12ch
UART / SIO / CAN	4 / 2 / 1	4 / 2 / 1
I2C	2	2
ADC	32ch (12bit)	32ch (12bit)
I/O (Mux'd - MAX)	87	87

For additional information see: TPM4M

1a TX and TXZ+™ families line up

ARM® Core	M0	M3	M4
TX 16 to 120MHz	**TX00** M030 M060 groups — General Purpose	**TX03** M310 M330 M340 M360 M380 M370 — Motor Control	**TX04** M440 M460 M470 — Motor Control
TXZ+™ 120 to 200MHz		**TXZ3A+** M3H — General Purpose, Consumer Equipment	**TXZ4A+** M4K, M4M — Motor Control; M4G, M4N — Data Processing

TXZ+™3A Series

Consumer Equip General Purpose

M3H group	Cortex-M3 ~120MHz CPU	2.7~5.5V	~1MB ROM	32KB Data Flash	130KB RAM	ADC 12bit / DAC 8bit	General I/F SPI/UART /I2C	**Motor control**: PMD Programmable Motor Driver; ENC Encoder	Digital LCD Driver		

TXZ+™4A Series

High speed Data Processing

M4G group	Cortex-M4 ~200MHz CPU+FPU	2.7~3.6V	~2MB ROM	32KB Data Flash	~258KB RAM	ADC 12bit / DAC 8bit	General I/F SPI/UART /I2C	**Motor**: PMD Programmable Motor Driver	External Bus・Serial Memory I/F	Audio I/F I2S/FIR	
M4N group	Cortex-M4 ~200MHz CPU+FPU	2.7~3.6V	~2MB ROM	32KB Data Flash	~258KB RAM	ADC 12bit / DAC 8bit	General I/F SPI/UART /I2C	**Motor**: PMD Programmable Motor Driver	External Bus・Serial Memory I/F	Audio I/F I2S/FIR	CAN; Ether MAC; USB

Motor Control
2 BLDC motor non-VE
3 BLDC motor VE

M4K group	Cortex-M4 ~120MHz CPU+FPU	2.7~5.5V	~256KB ROM	N/A	~18KB RAM	ADC 12bit	General I/F SPI/UART /I2C	**Motor control**: PMD Programmable Motor Driver; ENC Encoder; N/A; VE Vector Engine
	Cortex-M4 ~160MHz CPU+FPU	4.5~5.5V	~1MB ROM	32KB Data Flash	~64KB RAM			

Motor Control
3 BLDC motor VE and CAN

M4M group	Cortex-M4 ~160MHz CPU+FPU	4.5~5.5V	~1MB ROM	32KB Data Flash	~64KB RAM	ADC 12bit	General I/F SPI/UART /I2C	**Motor control**: PMD Programmable Motor Driver; ENC Encoder; VE Vector Engine	CAN

TXZ+™4E Series

Motor Control
1 BLDC motor VE

M4L group	Cortex-M4 ~80MHz CPU+FPU	2.7~5.5V	~256KB ROM	16KB Data Flash	32KB RAM	ADC 12bit	General I/F SPI/UART /I2C	**Motor control**: PMD Programmable Motor Driver; ENC Encoder; VE Vector Engine	Serial Memory I/F

1a TMPM4M Vector Engine MCU for BLDC Servo Motor

Arm® Cortex®-M4 MCU 160MHz with Advanced motor control engine and high-precision analog circuits

Back to AC-DC/PFC
Back Motor Control MCU
Back to Micro Peripheral Detail

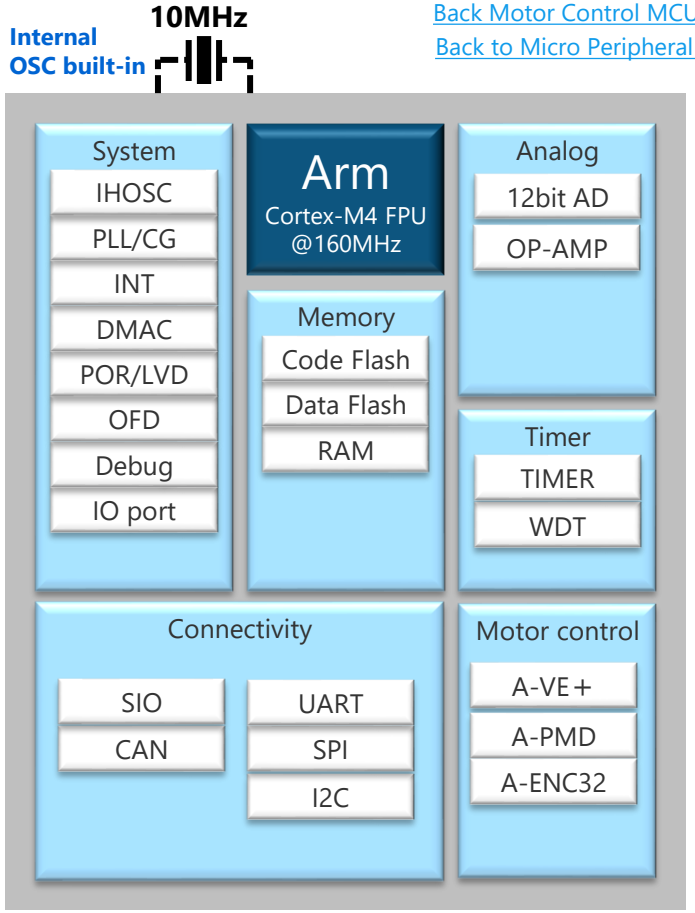
- **Cortex-M4 core, Memory, System Control**
  - Supply voltage 2.7 to 5.5V
  - Max frequency 160MHz
  - Operation temperature -40 to 105℃
  - Memory Code Flash 256KB to 128KB
    Data Flash 32KB (W/E 100k times)
    RAM 24KB
  - Low power Clock gear(1/1 to 1/16 dived)
    Stand-by mode(IDLE/STOP1)
  - Built-in OSC(IHOSC) 10MHz
  - External interrupt(INT) 22ch
  - DMAC 1unit
  - Power on reset(POR)/ Low voltage detection(LVD)
  - Frequency detection(OFD) 1ch
  - Debug circuit JTAG/SW,TRACE(4bit), NBDIF (80,64pins: SW only)
  - CRC calculation circuit(CRC) 1ch

- **Peripherals (Timer)**
  - 32(16)-bit timer 6(12)ch
  - Independent Watchdog timer(WDT) 1ch

- **Peripherals (Analog)**
  - 12-bit AD converter 32ch (3unit/min. 1μs)
  - OP-AMP 3ch

- **Peripherals (Connectivity & Motor Control)**
  - CAN 1ch
  - UART 4ch
  - TSPI(SPI/SIO) 2ch
  - I2C 2ch
  - Advanced Vector Engine plus(A-VE+) 1ch
  - Advanced programmable motor driver(A-PMD) 3ch
  - Advanced encoder input(A-ENC32) 3ch

Part number	Code Flash	Data Flash	RAM	Package
TMPM4MNFYAFG	256KB	32KB	24KB	P-LQFP100-1414-0.50-002
TMPM4MNFYADFG				P-QFP100-1420-0.65-001
TMPM4MMFYAFG				P-LQFP80-1212-0.50-003
TMPM4MLFYAUG				P-LQFP64-1010-0.50-003
TMPM4MLFYAFG				P-LQFP64-1212-0.65-001
TMPM4MNFWAFG	128KB			P-LQFP100-1414-0.50-002
TMPM4MNFWADFG				P-QFP100-1420-0.65-003
TMPM4MMFWAFG				P-LQFP80-1212-0.50-003
TMPM4MLFWAUG				P-LQFP64-1010-0.50-003
TMPM4MLFWAFG				P-LQFP64-1414-0.80-002



Note1) Specification given in this page is the maximum specification of M4M group(2).
Please refer to a function table for details.

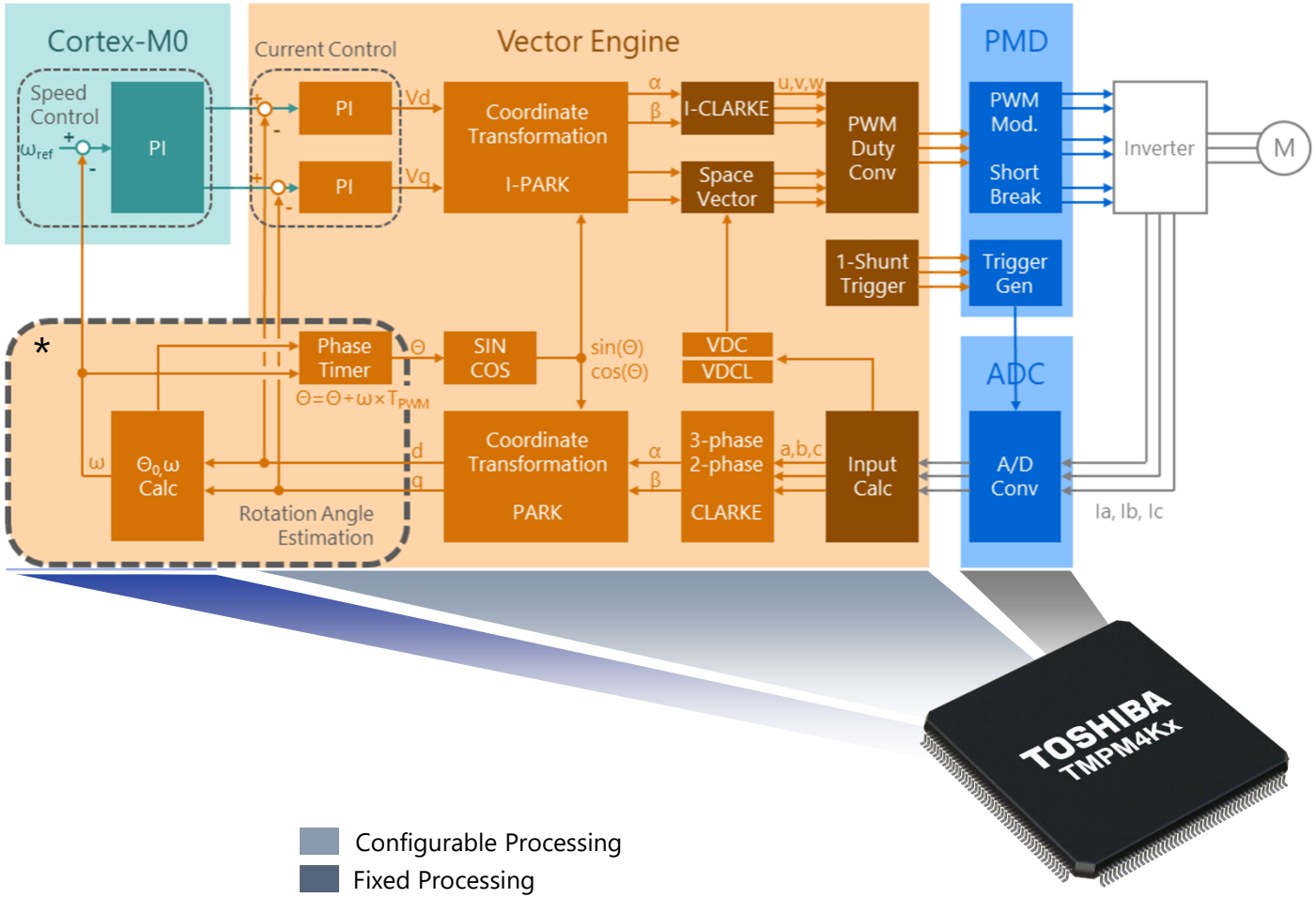
For additional information see: TPM4M

Vector Engine

Back to AC-DC / PFC
Back Motor Control MCU
Back to Micro Peripheral Detail

Powerful Hardware CPU Offload Engine for FOC

- PI for current control (d-/q-axis)
- Coordinate transformation (Park / I-Park)
- Phase transformation (Clarke / I-Clarke)
- Space Vector Modulation (SVM)
- Sine and Cosine calculation at phase θ
- Square Root and Arcus Tangent calculation*
- Scheduler for combination of tasks
- Supporting 3-shunt or 1-shunt, 2-phase sensor detection and 2-phase or 3-phase modulation
- PWM shift function (automatic PWM modification for 1-shunt measurement)
- ADC auto-trigger generation with wait function for noise reduction
- Phase timer performing automatic Theta (θ) integration for schedule repetition
- Synchronized interaction between VE, PMD and ADC



* available in VEα

Value provided

Standard MCUs that offer a wide range of lineups with low power consumption and high-performance

1 Global standard Arm® Cortex® -M core

High-performance Arm® Cortex® -M3 core, operating at up to 120MHz

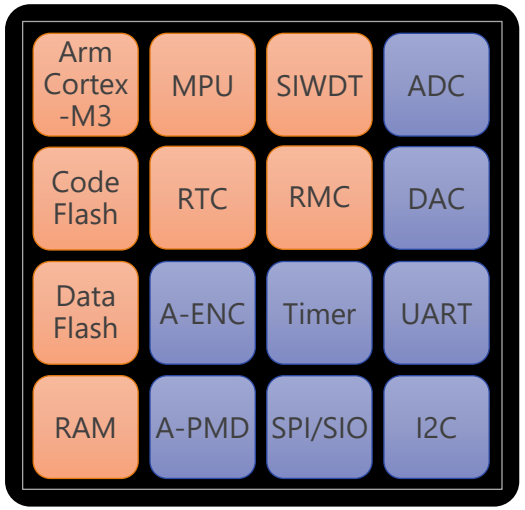
2 General-purpose microcontrollers for a wide range of applications

This group can be used for wide range of applications, such as motor control, consumer and industrial.

ADC, DAC, UART, timer, I2C, SPI/SIO, Programmable motor driver

3 A wide range of memory and package lineup

A wide range of memory and package lineup



Line up

Part number	Code Flash/RAM	Data Flash	Package
TMPM3HQFxyFG	10: 1024KB/130KB D: 512KB/66KB Z: 384KB/66KB Y: 256KB/66KB	32KB	P-LQFP144-2020-0.50
TMPM3HPFxyFG			P-LQFP128-1414-0.40
TMPM3HPFxyDFG			P-LQFP128-1420-0.50
TMPM3HNFxyFG			P-LQFP100-1414-0.50
TMPM3HNFxyDFG			P-QFP100-1420-0.65
TMPM3HMFxyFG			P-LQFP80-1212-0.50
TMPM3HLFxyUG			P-LQFP64-1010-0.50

Note1) “x” of Part number means symbol of code flash size.
Note2) “y” of Part number means revision. (A: 256KB to 512KB, B: 1024KB)

For more information, see: TMPM3

1b TX and TXZ+™ families line up

ARM® Core	M0	M3	M4
TX 16 to 120MHz	**TX00** M030 M060 groups — General Purpose	**TX03** M310 M330 M340 M360 M380 M370 — Motor Control	**TX04** M440 M460 M470 — Motor Control
TXZ+™ 120 to 200MHz		**TXZ3A+** M3H — General Purpose / Consumer Equipment	**TXZ4A+** M4K, M4M — Motor Control; M4G, M4N — Data Processing

TXZ+™3A Series

Consumer Equip / General Purpose

M3H group	Cortex-M3 ~120MHz CPU	2.7~5.5V	~1MB ROM	32KB Data Flash	130KB RAM	ADC 12bit / DAC 8bit	General I/F SPI/UART /I2C	Motor control: PMD Programmable Motor Driver; ENC Encoder	Digital LCD Driver		

TXZ+™4A Series

High speed Data Processing

M4G group	Cortex-M4 ~200MHz CPU+FPU	2.7~3.6V	~2MB ROM	32KB Data Flash	~258KB RAM	ADC 12bit / DAC 8bit	General I/F SPI/UART /I2C	Motor: PMD Programmable Motor Driver	External Bus・Serial Memory I/F	Audio I/F I2S/FIR			
M4N group	Cortex-M4 ~200MHz CPU+FPU	2.7~3.6V	~2MB ROM	32KB Data Flash	~258KB RAM	ADC 12bit / DAC 8bit	General I/F SPI/UART /I2C	Motor: PMD Programmable Motor Driver	External Bus・Serial Memory I/F	Audio I/F I2S/FIR	CAN	Ether MAC	USB

Motor Control
2 BLDC motor non-VE
3 BLDC motor VE

M4K group	Cortex-M4 ~120MHz CPU+FPU	2.7~5.5V	~256KB ROM	N/A	~18KB RAM	ADC 12bit	General I/F SPI/UART /I2C	Motor control: PMD Programmable Motor Driver; ENC Encoder; N/A; VE Vector Engine	
	Cortex-M4 ~160MHz CPU+FPU	4.5~5.5V	~1MB ROM	32KB Data Flash	~64KB RAM				

Motor Control
3 BLDC motor VE and CAN

M4M group	Cortex-M4 ~160MHz CPU+FPU	4.5~5.5V	~1MB ROM	32KB Data Flash	~64KB RAM	ADC 12bit	General I/F SPI/UART /I2C	Motor control: PMD Programmable Motor Driver; ENC Encoder; VE Vector Engine	CAN

TXZ+™4E Series

Motor Control
1 BLDC motor VE

M4L group	Cortex-M4 ~80MHz CPU+FPU	2.7~5.5V	~256KB ROM	16KB Data Flash	32KB RAM	ADC 12bit	General I/F SPI/UART /I2C	Motor control: PMD Programmable Motor Driver; ENC Encoder; VE Vector Engine	Serial Memory I/F

1b M3H Group Overview

Arm® Cortex®-M3 core max frequency 120MHz
Large code & data Flash, Motor control, LCD display control circuit

Back to AC-DC/PFC
Back to New Inverter Gate Driver
Back to Micro Peripheral Detail

- **Cortex-M3 core, Memory, System Control**

- Supply voltage	2.7 to 5.5V	
- Max frequency	**120MHz**	
- Operation temperature	-40 to **105℃**	
- Memory	Code Flash	1024KB to 256KB (W/E **100k times**)
	Data Flash	32KB (W/E **100k times**)
	RAM(with parity)	130KB to 66KB
- Low power	Clock gear(1/1 to 1/16 divided)	
	Stand-by mode(IDLE/STOP1/STOP2)	
- Built-in OSC(IHOSC)	10MHz	
- External interrupt(INT)	32ch	
- DMAC	2unit	
- Power on reset(POR)/ Voltage detection circuit(LVD)		
- Frequency detection(OFD)	1ch	
- Debug interface	JTAG/SWD/SWV, 2bit trace	
- CRC calculation circuit(CRC)	1ch CRC32, CRC16	

- **Peripherals (Analog)**

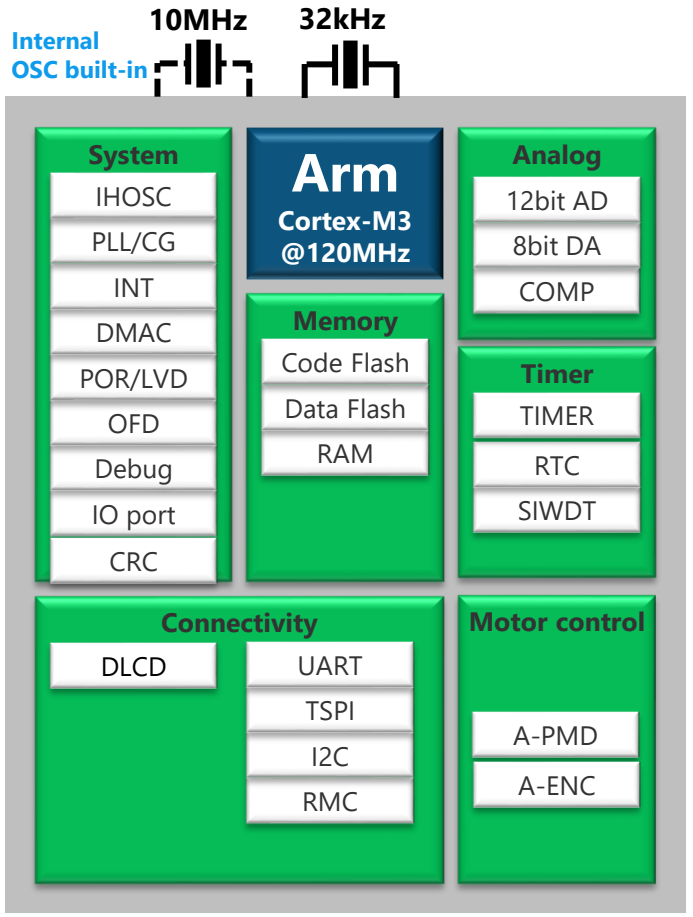
- 12-bit AD converter	21ch (1unit/min 1μs) Supporting functional safety design
- 8-bit DA converter	2ch
- Comparator(COMP)	※EMG

- **Peripherals (Timer)**

- 32(16)-bit timer	8(16)ch
- Real time clock(RTC)	1ch
- Independent Watchdog timer(SIWDT)	1ch

- **Peripherals (Connectivity & Motor Control)**

- **LCD display control circuit**	**40seg x 4com**
- UART	**8ch**
- TSPI(SPI/SIO)	5ch
- I2C	4ch
- Remote control signal processor(RMC)	1ch
- Advanced programmable motor driver(A-PMD)	1ch
- Advanced encoder input(A-ENC)	1ch



- **Memory, Package**

Part number	Code Flash/RAM	Data Flash	Package
TMPM3HQFxyFG	10: 1024KB/130KB D: 512KB/66KB Z: 384KB/66KB Y: 256KB/66KB	32KB	P-LQFP144-2020-0.50
TMPM3HPFxyFG			P-LQFP128-1414-0.40
TMPM3HPFxyDFG			P-LQFP128-1420-0.50
TMPM3HNFxyFG			P-LQFP100-1414-0.50
TMPM3HNFxyDFG			P-QFP100-1420-0.65
TMPM3HMFxyFG			P-LQFP80-1212-0.50
TMPM3HLFxyUG			P-LQFP64-1010-0.50

Note1) "x" of Part number means symbol of code flash size.
Note2) "y" of Part number means revision. (A: 256KB to 512KB, B: 1024KB)

Note3) Specification given in this page is the maximum specification of M3H group. Please refer to a function table for details.

1b M3H Group Function Table

Support wide range of applications by peripheral functions

Back to AC-DC/PFC
Back to New Inverter Gate Driver
Back to Micro Peripheral Detail

		M3H Group				
		M3HLFxy	M3HMFxy	M3HNFxy	M3HPFxy	M3HQFxy
Basic Features	CPU	Arm Cortex-M3				
	Max frequency	120MHz				
	Built-in oscillation frequency	10MHz (+/- 1.0%)				
	Number of IO	57(56†)	73(72†)	93(92†)	119(118†)	135(134†)
	External interrupt	12	15	19	31	34
Timer	32(16)-bit timer	8(16)				
	PWM output 32(16)-bit	6(12)	6(12)	7(14)	8(16)	8(16)
	Watchdog timer	Yes				
	RTC	Yes (using an external quartz resonator : 32.768kHz)				
Analog	12-bit ADC (input Ch/unit) Minimum conversion time:1.0µsec	12/1	12/1	17/1	19/1	21/1
	8-bit DAC	2	2	2	2	2
Connectivity	UART	7	7	8	8	8
	TSPI(SPI/SIO)	1	4	4	5	5
	I2C	2	3	3	4	4
Peripherals	DMA controller (Ch/unit)	54/2	62/2	62/2	64/2	64/2
	RMC	Yes				
	Advanced PMD (3 phase PWM)	1				
	Advanced encoder input	1				
	LCD driver (Digital)	–	26 x 4	32 x 4	40 x 4	40 x4
Supply voltage		2.7 to 5.5V				
Package	Pin count	64	80	100	128	144

(Note) "y" of Part number means revision. (A: 256KB to 512KB, B: 1024KB), †: Number of ports of revision B.

2 3-Phase Inverter Gate Driver IC (external MOSFET)

TB67Z830HFTG / TB67Z830SFTG / TB67Z833HFTG / TB67Z833SFTG

Three-phase brushless motor drive | Low-loss, low-heat, and power efficiency | Small size packages

Back Motor Control MCU
Back to New Inverter Gate Driver

Value Provided

3-phase Inverter gate driver IC simplifies connections between the MCU/controller, FET inverters stages and sensor feedback from BLDC motors

1 Excellent Flexibility with Multiple Modes of Operation

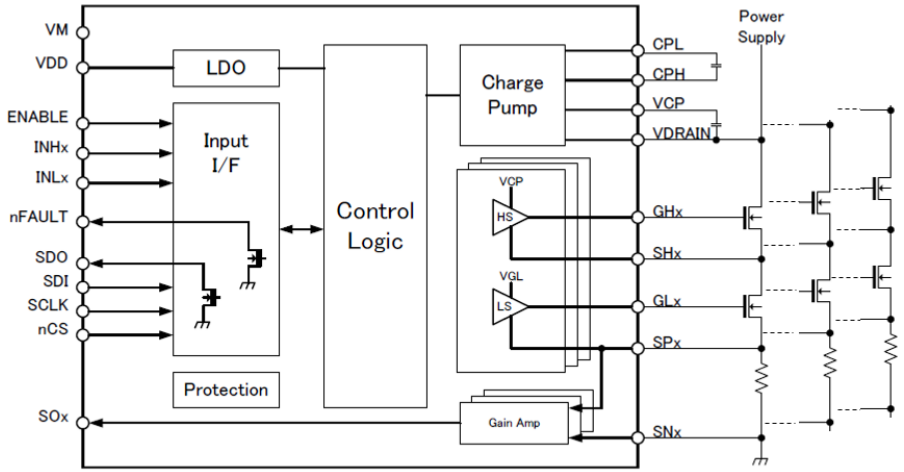
- 6 PWM input mode
- 3 PWM input mode
- Half input mode
- Independent PWM input mode

2 Strong Current Driving Capability with Wide Voltage Operating Range

- Power Supply Voltage: 8V to 75V
- Gate Drive Current: 1A Source/2A Sink
- Choice of Hardware or SPI interfaces

3 Low Loss and Power Efficiency

- Low standby power – 1uA (typ.)
- Adjustable Slew Rate Control
- Automatic Optimization of Source/Sink Currents



QFN32 5x5 or QFN40 6x6

Line Up

Part Number	TB67Z830HFTG	TB67Z830SFTG	TB67Z833HFTG	TB67Z833SFTG
Power Supply Voltage	8V to 75 V (operating range)			
Gate Drive Current	1A source, 2A sink			
Interface	Hardware	SPI	Hardware	SPI
Integrated Current Sense Amplifier			Yes - 3	Yes - 3
LDO Output	3.3V			
Other Features	Adjustable Slew Rate Control Automatic Optimization of Source/Sink Currents & Deadband Protections UVLO, CPUV, OCP, TSD, GDVM, nFault			
Package	QFN 32	QFN 32	QFN 40	QFN 40

For more information see: Inverter Gate Driver IC

2 TB67Z830H/833H/850H/853HFTG TB67Z830S/833S/850S/853SFTG Inverter Gate Drivers for <72V Brushless Applications (P2P compatible to TI DRV8320S/H and DRV8323S/H)

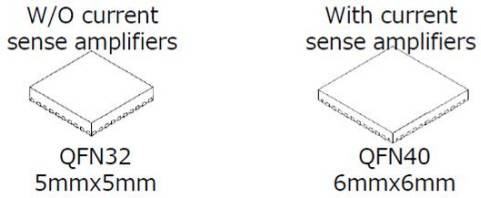
Back Motor Control MCU
Back to New Inverter Gate Driver

Target Applications

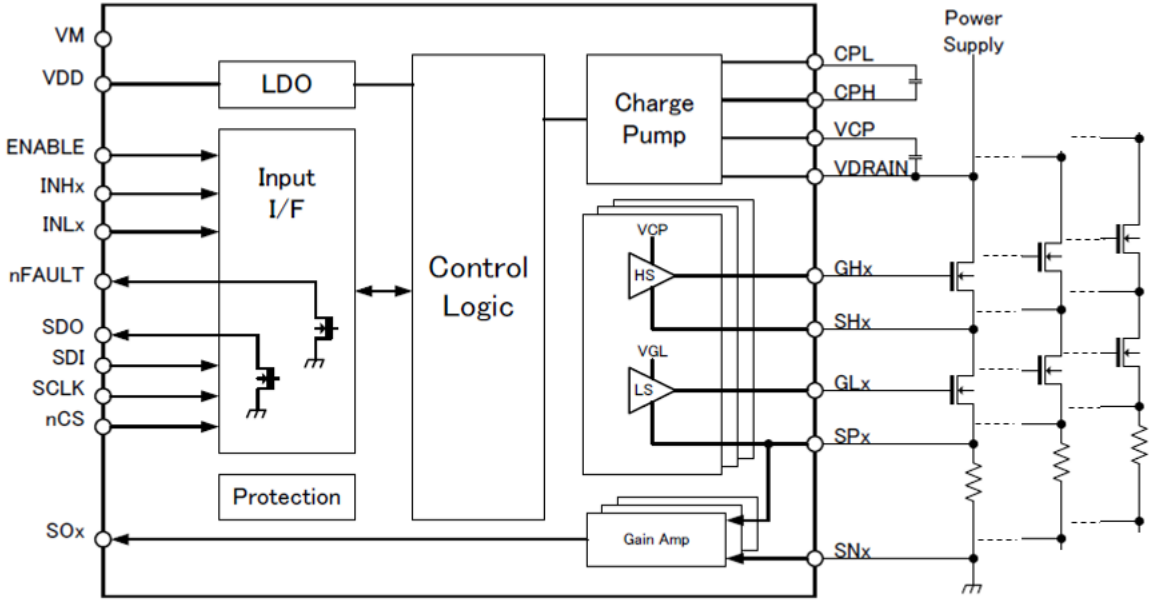
- **Power Tools, Gardening Equipment**, Garage Door and Gate Openers, Robotics, eBike, Handheld Construction Tools, Outboard Motors, LV Inverters

Features

- Pin-to-pin compatible to TI gate drivers
  - TB67Z830HFTG / TB67Z850HFTG → DRV8320H
  - TB67Z830SFTG / TB67Z850SFTG → DRV8320S
  - TB67Z833HFTG / TB67Z853HFTG → DRV8323H
  - TB67Z833SFTG / TB67Z853SFTG → DRV8323S
- Wide Operation Range **8 to 75V**
- Drive external Nch + Nch FETs
  - Source current – 0.01 to **1A**
  - Sink current – 0.02 to **2A**
- Low standby power **1uA** typ
- Built-in 3.3V (Z830/Z833) or 5V (Z850/Z853) linear regulator
- Built-in 3 current sense amplifiers (Z833 and Z853)
- Interface Hardware (xxxHFTG) or SPI (xxxSFTG)
- Adjustable Slew Rate Control
- Automatic Optimization of Source/Sink Currents & Deadband
- Protections UVLO, CPUV, OCP, TSD, GDVM, nFault
- Can also be used as Brushed Motor Controller with Gate Driver



Block Diagram



2 TB67Z830/833/850/853 Selection Guide

Back Motor Control MCU
Back to New Inverter Gate Driver

	Linear voltage Regulator	Current Sense Amplifier	Interface	Package	Pin Compatible TI Device
TB67Z830HFTG	3.3V	0	Hardware	QFN32	DRV8320H
TB67Z830SFTG			SPI		DRV8320S
TB67Z833HFTG		3	Hardware	QFN40	DRV8323H
TB67Z833SFTG			SPI		DRV8323S
TB67Z850HFTG	5V	0	Hardware	QFN32	DRV8320H
TB67Z850SFTG			SPI		DRV8320S
TB67Z853HFTG		3	Hardware	QFN40	DRV8323H
TB67Z853SFTG			SPI		DRV8323S

Product part number: TB67Z8 3 0 H FTG

Linear Voltage Regulator
3: 3.3V
5: 5.0V

Interface
H: Hardware
S: SPI

Number of Current Sense Amplifiers

2 TB67Z8xx Modes of Operation

Back Motor Control MCU
Back to New Inverter Gate Driver

Supports 4 Modes of Operation Simplifying Interfacing to Controllers

6-PWM Input Mode

- Each Half Bridge controlled Independently w/ 2 Pin input control
- Half Bridges can be set to LOW, HIGH or Hi-Z
- Typically used for more Flexible 3-Phase BLDC motor control

INLx	INHx	GLx	GHx	SHx
L	L	L	L	Hi-Z
L	H	L	H	H
H	L	H	L	L
H	H	L	L	Hi-Z

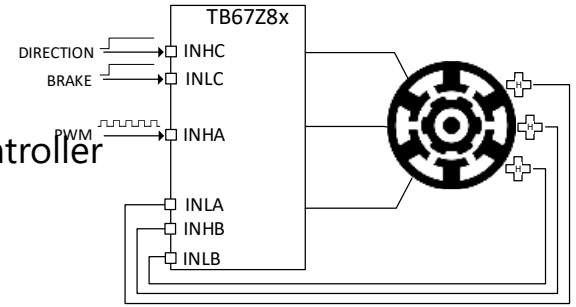
3-PWM Input Mode

- Each Half Bridge controlled w/ Single (INLx) input PWM for Simpler control
- Hi-Z set using INLx input as Enable

INLx (Enable)	INHx (PWM)	GLx	GHx	SHx
L	X	L	L	Hi-Z
H	L	H	L	L
H	H	L	H	H

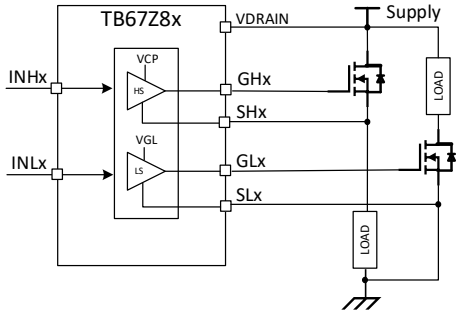
Hall Input Mode

- PWM Controlled by Single (INHA) Input controlling frequency and duty cycle
- For Easy Realization of 120-degree Commutation (6-Step)
- INLA, INHB & INLC Connect to HALL sensor outputs, can also connect to external controller
  - (eg for sensorless operation)
- INHC & INLC set direction and BRAKE respectively
- Typically for Synchronous Rectification but Async rectification possible w/ SPI



Independent PWM Mode

- Each High-Side and Low-Side gate driver can be controlled Independently
- Enables driving of separate Loads
- Typical uses include Brushed DC motors, HS & LS Switches & Solenoids
- Shoot through not prevented by TB67Z8xx in this mode

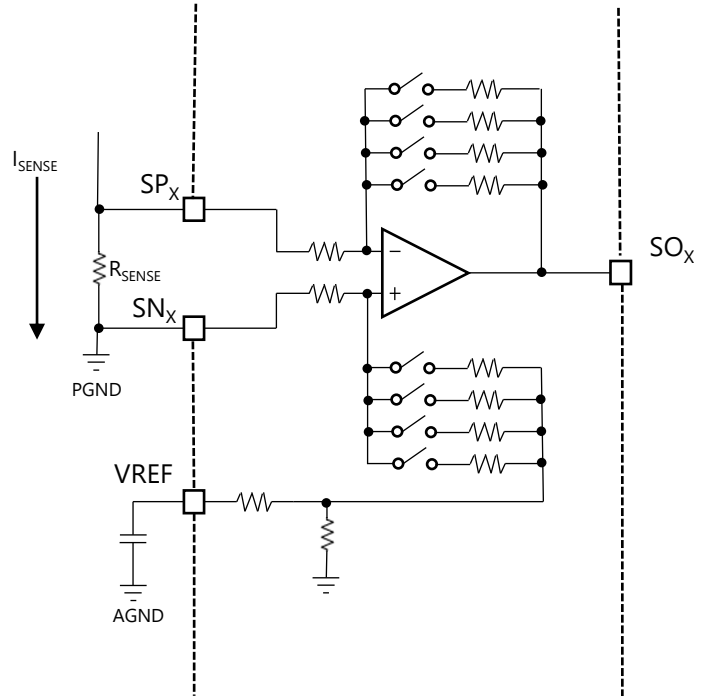


2 TB67Z8xx Sense Amplifiers & Protection Circuits

Back Motor Control MCU
Back to New Inverter Gate Driver

Integrated Sense Amplifiers

- Available in TB67Z8x3x Part Options
- 3 Separate Amplifiers for current Sensing
- Programmable gain 5,10,20 or 40V/V
- Calibration Function



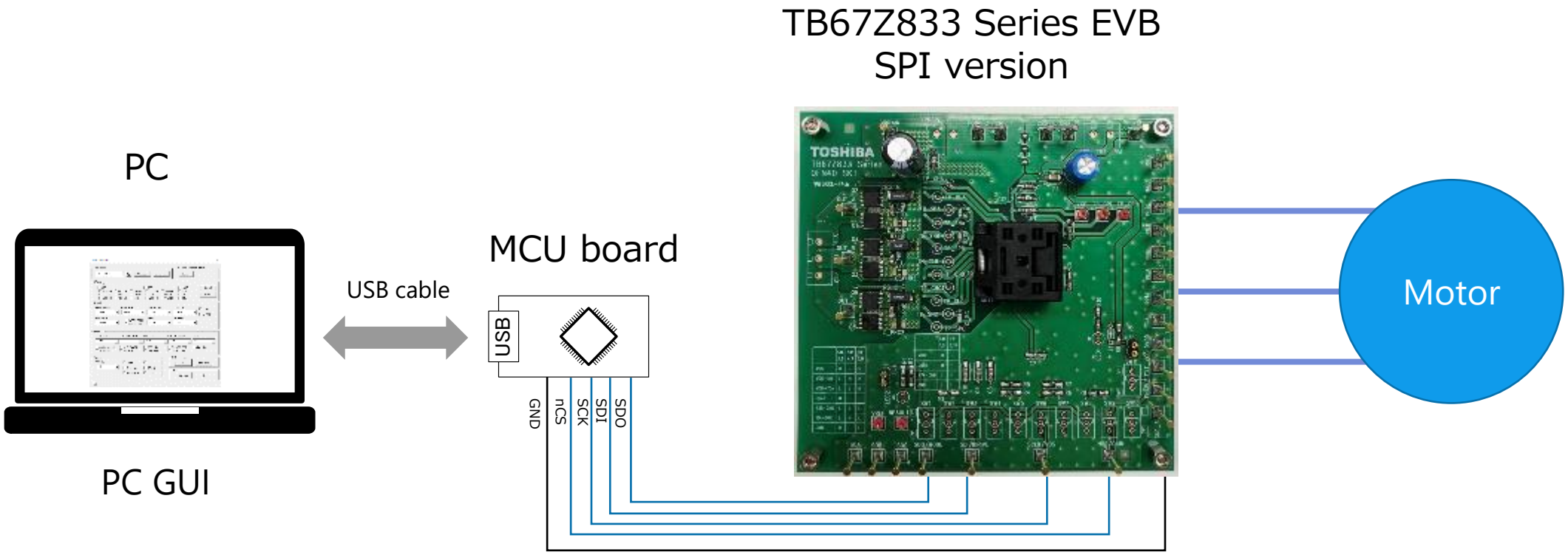
Multiple Built-in Protection Functions offloading burden on Controller

- VM Under Voltage Lockout
- Charge Pump Low Voltage Operation Prevention (CPUV)
- Overcurrent Protection (OCP)
  - Two modes, Vds OCP and Vsense OCP
- Gate Drive Voltage Monitor (GDVM)
  - Can Detect Gate shorts as well as insufficient Idrive or Tdrive setting
- Thermal Shutdown Circuit (TSD)
- Fault Flag Output (nFAULT)

2 Evaluation kit for SPI EVB

Back Motor Control MCU
Back to New Inverter Gate Driver

Configurable through SPI interface
On-board 3-phase inverter utilizing 80V/120A TPH2R408QM FETs
External 3-phase connection
GUI available for easy parameter setting

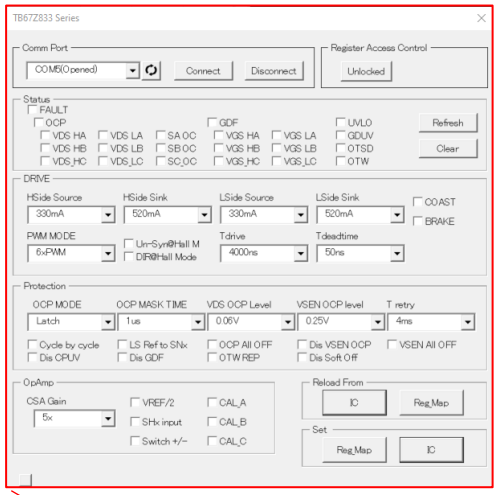


2 TC67Z853S Evaluation: Hybrid Evaluation System Demo w/ Motor Studio

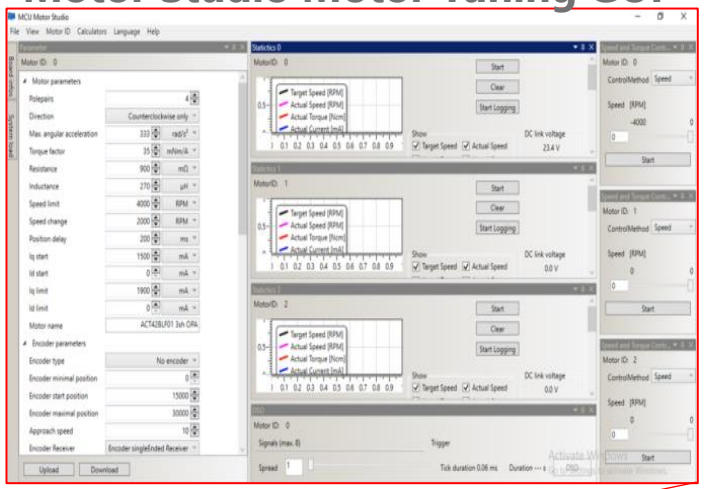
Combines Toshiba Inverter gate driver w/ Toshiba Vector Engine MCU for full motor Control Capability

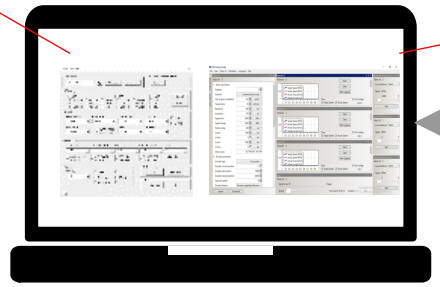
Back Motor Control MCU
Back to New Inverter Gate Driver

TC67Z853S GUI



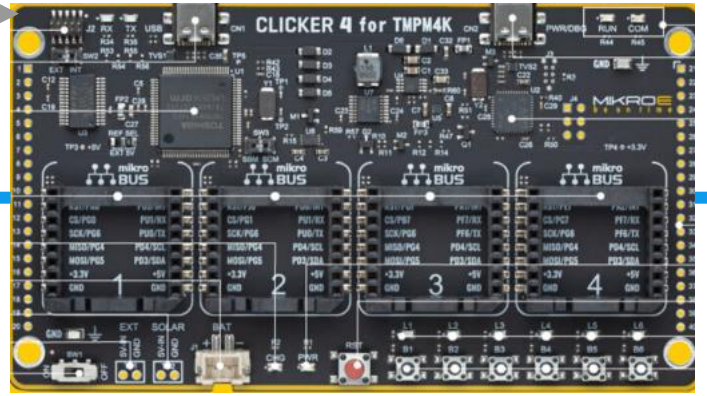
Motor Studio Motor Tuning GUI



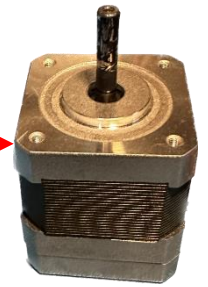


PC GUI

TMPM4K VE-MCU for Initialization & Motor Control



Inverter Shield w/ **TB67Z853S**



w/ **SSM6K819** FETs
Vdss 100V
Id=10A

3 3-Phase Sensor-less Brushless Motor Controller
TC78B009FTG/TC78B011FTG

Three-phase brushless motor drive | High efficiency · Low loss | Small size package

Back to Simplified Lower Performance

Value provided

A closed loop design allows these motor controllers to run without constant speed adjustment from a host MCU

1 Simple sensor-less brushless motor control

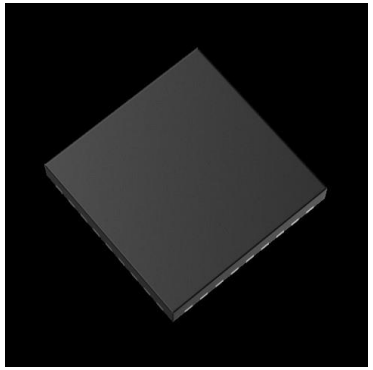
With built-in closed loop speed control with adjustable speed curve, no external MCU host is needed to constantly control these brushless motor control devices

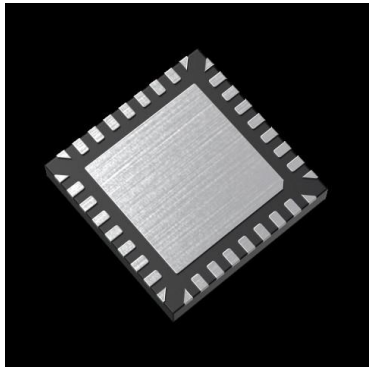
2 Integrated Gate Driver

. Integrated pre driver for high side and low side N-channel MOSFETs – helps reduce external components

3 Small package

In a small QFN36 package.





Line up

Part Number	TC78B009FTG	TC78B011FTG
Drive	Trapezoidal	Sinewave
V_M(Range) [V]	5.5V to 27	
Features	Lead angle can be set	Automatic lead angle control
	Capable of driving 3 or 4 wire WYE or Delta Configured Motors	
	PWM Duty / Analog voltage / I2C input	
	Current Monitoring function	
	Non-Volatile Memory Storage settings	
	Low-Standby Current 1uA	
	FG/Alert signal feedback	
	Error Detection (over current, temp, etc)	
Package	QFN 36 5mm x 5mm	

For more information see: 3phase sensorless BLDC

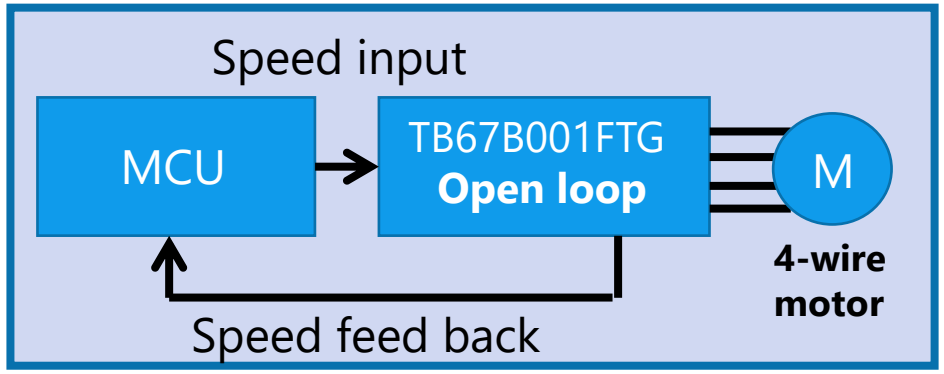
3 Choosing the control architecture – Open Loop or Closed Loop?

Back to Simplified Lower Performance

TC78B009FTG/TC78B011FTG can handle both open loop and closed loop control.

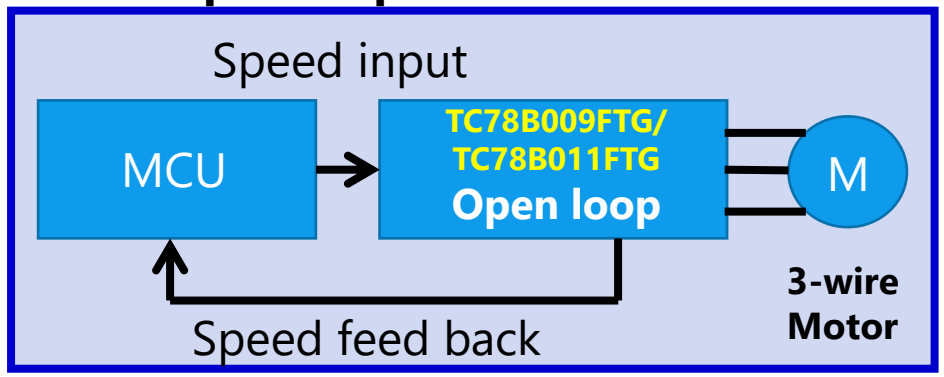
Case1: 4-wire WYE Configured BLDC motor

Motor speed controlled directly by MCU

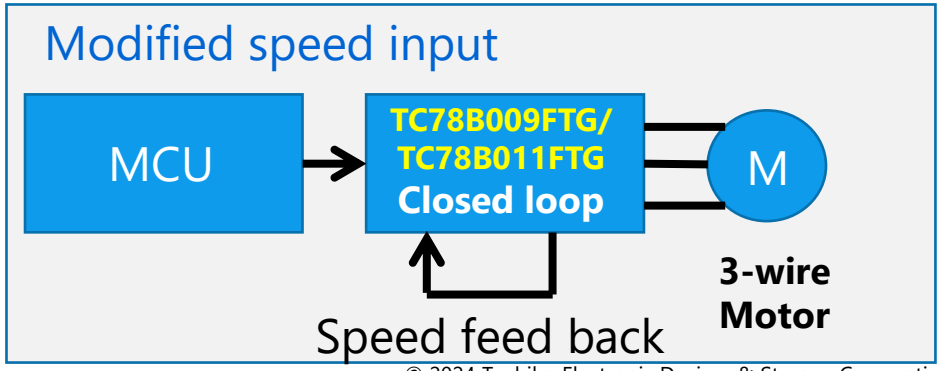


Case2: 3-wire WYE or Delta Configured BLDC motor

Same open loop control architecture



Speed controlled by TC78B009FTG



An open loop control is best used in an application where it often requires rapid change of speed. The motor speed is directly controlled by the MCU.

A closed loop control is best with steady speed and the speed does not change often. (i.e. Garage door and gate openers).

TC78B009FTG/TC78B011FTG can handle both configurations!

3 TC78B009FTG 30V, 3-Phase Sensorless Trapezoidal BLDC Controller+Gate-Driver

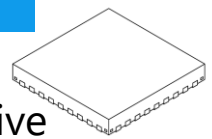
Back to Simplified Lower Performance

Features

- Wide Operating Range 5.5 - 27V
- Integrated 200mA Gate Driver w/Slew Rate Ctrl
- **Current Monitoring Function**
- **Closed Loop Speed Control Regulate Speed Automatically without a Host**
- **Analog, PWM, or I2C Control**
- Low Standby Current 1uA
- Non-Volatile Memory Storing Settings
- FG／Alert signal feedback
- Error Detection
  - Over current, Over Temp, Charge Pump Error, and Motor Lock Detections. Under voltage lockout
- **Drive 3/4-Wire Wye or Delta Configured Motors**

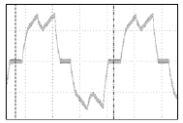
Package

- **Compact QFN36 5x5mm² Package**
- Pin to pin compatible to TC78B011FTG Sinewave Drive

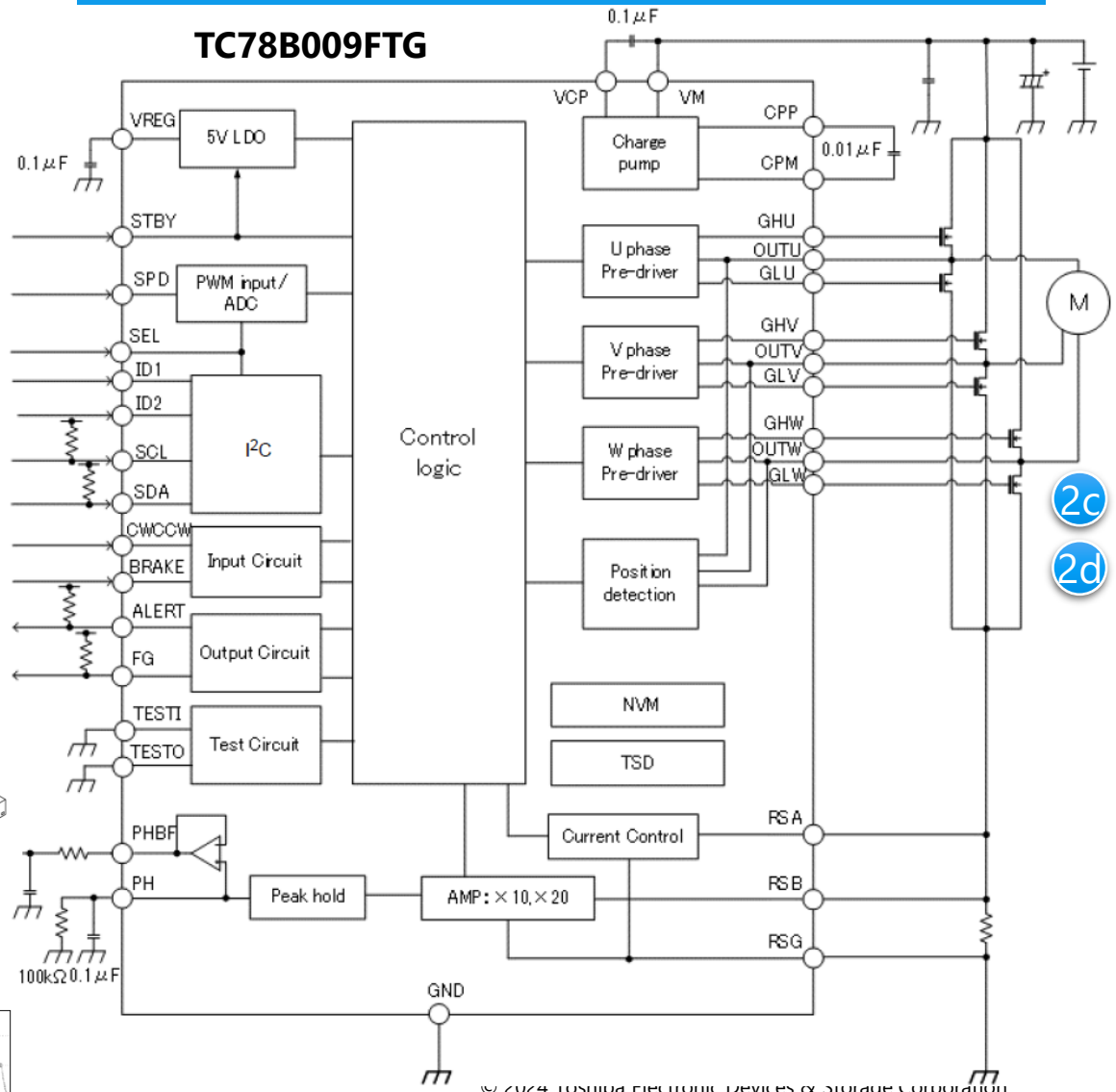


Applications

- Ideal for Fan, Pump and Garage/gate motors



Block Diagram



3 TC78B011FTG 30V, 3-Phase Sensorless Sinewave BLDC Controller+Gate-Driver

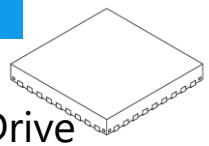
Back to Simplified Lower Performance

Features

- Wide Operating Range 5.5 - 27V
- Integrated 200mA Gate Driver w/Slew Rate Ctrl
- **Current Monitoring Function**
- **Closed Loop Speed Control Regulate Speed Automatically without a Host**
- **Analog, PWM, or I2C Control**
- Low Standby Current 1uA
- Non-Volatile Memory Storing Settings
- FG／Alert signal feedback
- Error Detection
  - Over current, Over Temp, Charge Pump Error, and Motor Lock Detections. Under voltage lockout
- **Drive 3/4-Wire Wye or Delta Configured Motors**

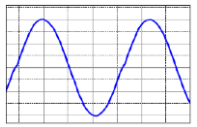
Package

- **Compact QFN36 5x5mm² Package**
- Pin to pin compatible to TC78B009FTG Trapezoidal Drive

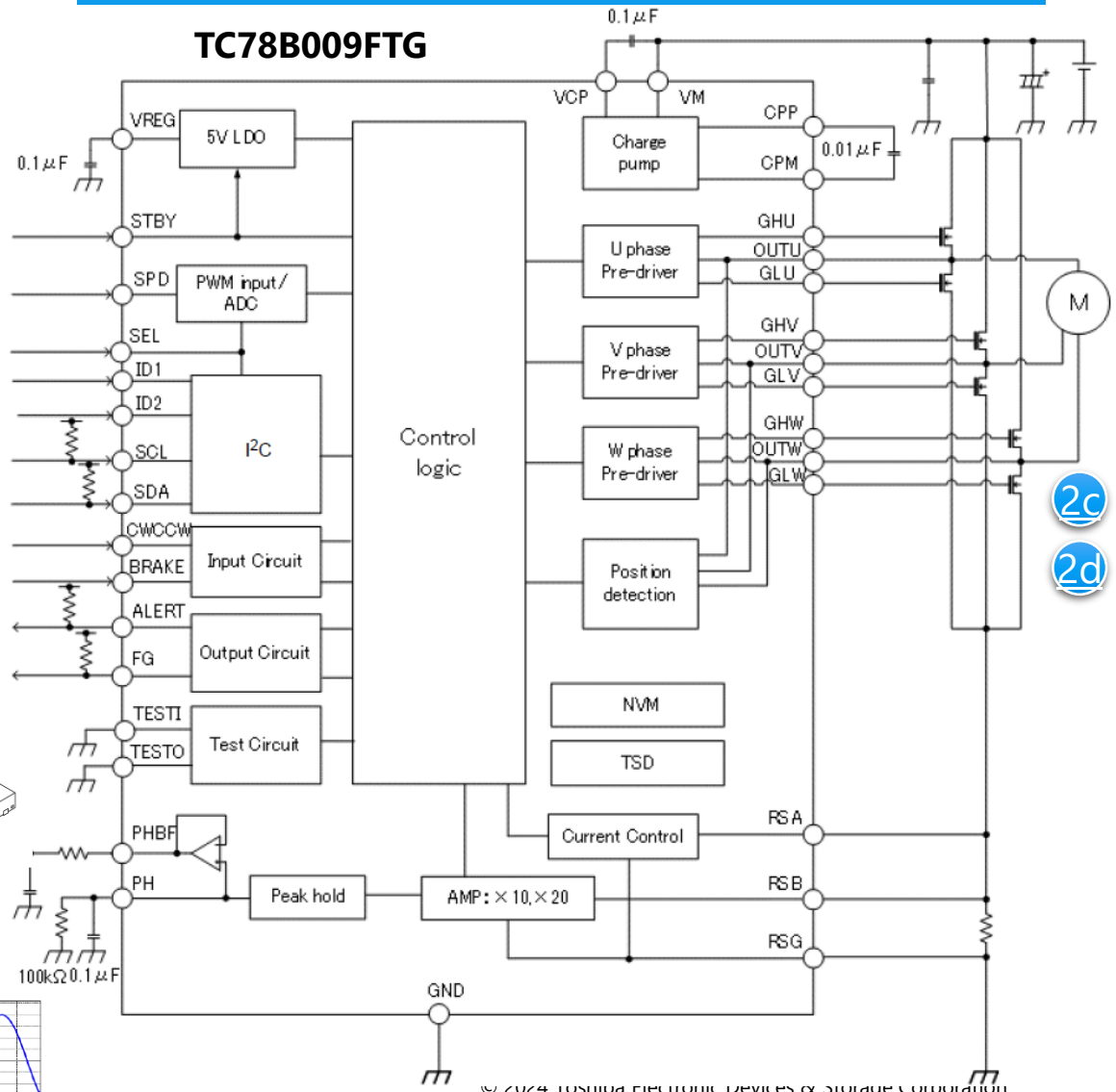


Applications

- Ideal for Fan, Pump and Garage/gate motors



Block Diagram



4 UMOS series 100V LV MOSFET
TPH3R70APL / TPW3R70APL / TPH2R70AR5

Three-phase brushless motor drive | Low-loss, low-heat, and power efficiency | Small size package

Back Motor Control MCU
Back to New Inverter Gate Driver
Back to Simplified Lower Performance

Value Provided

100V LV MOSFETs can be used in 3-phase inverter design to drive BLDC servo motors with highspeed power switching along with fast reverse recovery

1 Low R_{DSON}

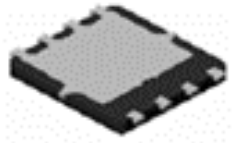
Low R_{DSON} specs can enable efficient driving of 48V BLDC motors up to 200W

2 Body Diode for fast recovery and response

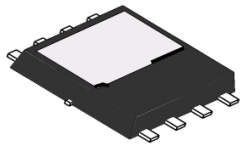
Faster response for BLDC servo motors can be expected from U-MOSIX-H process, and even a faster response from U-MOS11-HSD

3 Low I_{DSS}

Low leakage currents of 10μA @ V_{DS}=100V enables low power draw even when subjected to absolute ratings.



SOP Advanced 5x6
– 8 pin



Dual Sided Cooling DSPOP
Advanced 5x6
– 8 pin

Line Up

Part Number	TPH3R70APL	TPW3R70APL	TPH2R70ARS
Process	U-MOSIX-H	U-MOSIX-H	U-MOS11-HSD
R_{DSON} mΩ (typ.)	3.1	3.1	2.7
$Q_{rr(dI/dt=100A/us)}$ (nC)	74	74	59
Body Diode	Yes	Yes	Yes – High Speed
Package	SOP Advanced 8	DSPOP Advanced 8	SOP Advanced 8
MP Status	MP	MP	ES available (MP 2Q 2025)

For more information see: TPH3R70APL TPW3R70APL TPH2R70AR5

4 U-MOS11-H 100V Series

ES Available

New Product

Back Motor Control MCU
Back to New Inverter Gate Driver
Back to Simplified Lower Performance

Value

U-MOS11-H 100V series provides best-in class performance and improve the efficiency.

1 Low drive losses

- $R_{DS\ (ON)} \times Q_g$ reduction (Cell design optimization)
- Large contribution at high frequency, especially in light load

2 Low Switching losses

- $R_{DS\ (ON)} \times Q_{SW}$ reduction (Cell design optimization)
- Large contribution at high frequency, especially in light load

3 Low Recovery losses

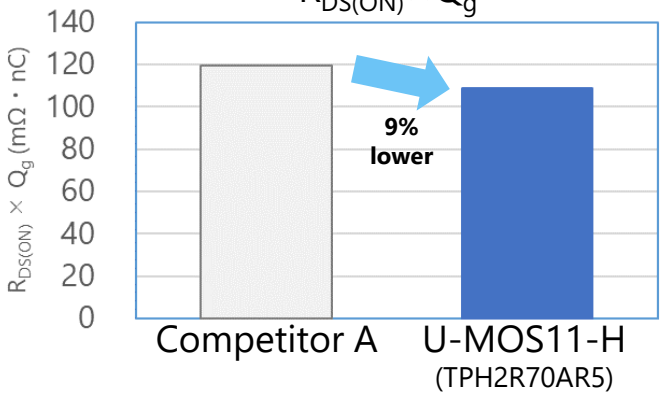
- Q_{rr} reduction (Applying Lifetime control technology)
- Large contribution at the secondary side synchronous rectifier circuit of the switching power supply unit

FOM Comparison with the Competition

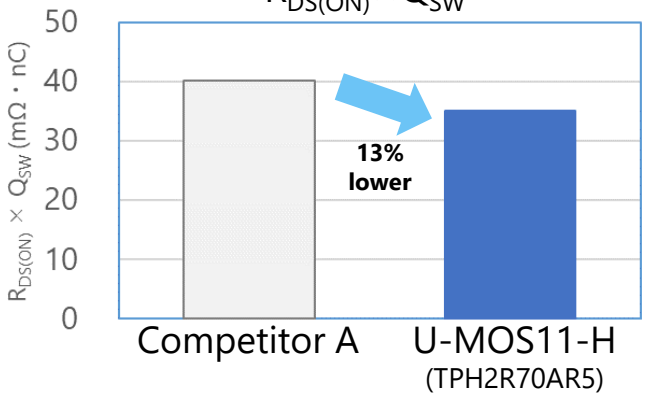
FOM：Figure of Merit

As of August 2023 (as surveyed by Toshiba)

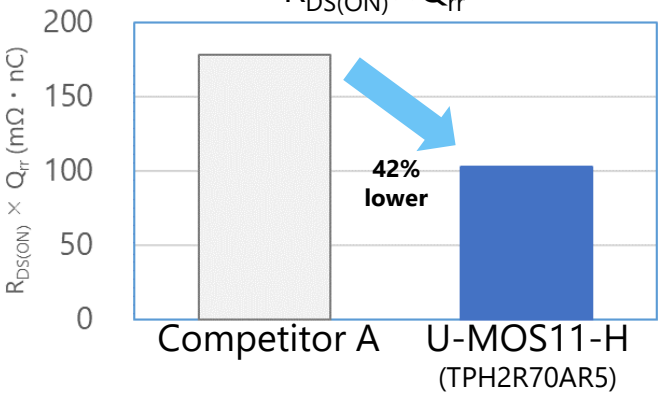
Conduction and drive losses
$R_{DS(ON)} \times Q_g$



Conduction and switching losses
$R_{DS(ON)} \times Q_{SW}$



Conduction and Body diode recovery losses
$R_{DS(ON)} \times Q_{rr}$



$R_{DS(ON)}$：On-resistance (figure of merit for conduction loss)
Q_g：Gate charge (figure of merit for drive loss)

Q_{sw}：Gate switch charge (figure of merit for switching loss)
Q_{rr}： Reverse recovery charge (figure of merit for body diode recovery loss)

4 U-MOS11-H 100V Development Plan

Under planning : STD Type
Under development : HSD Type

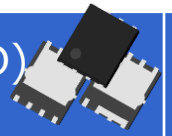
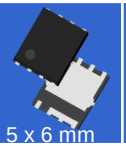
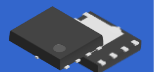
Back Motor Control MCU
Back to New Inverter Gate Driver
Back to Simplified Lower Performance

Performance of U-MOS11-H HSD is better than competitors.

Schedule (CY)	1Q 2023	2Q 2023	3Q 2023	4Q 2023	1Q 2024	2Q 2024	3Q 2024	4Q 2024
100V HSD type 2.7mohm Max					ES Feb. 2024		Order Available Sep. 2024	MP

STD version is planned also (ES Sep. 2024)

ES Available

Item	U-MOS11-H(HSD) (TPH2R70AR5)  5 x 6 mm		U-MOSIX-H (TPH3R70APL)  5 x 6 mm		Competitor A  5 x 6 mm		Competitor B  5 x 6 mm	
T_{ch}	175degC	★★★	175degC	★★★	175degC	★★★	150degC	★
V_{th}	2.9V～4.3V Drive voltage : 8V	★★	1.5V～2.5V Drive voltage : 4.5V	★★	2.3V～3.3V Drive voltage : 8V	★★	2.0V～4.0V Drive voltage : 6V	★
$R_{DS(ON)}$ @V_{GS}=10V typ.	2.3 mΩ	★★★	3.1 mΩ	★★	2.3 mΩ	★★★	3.3 mΩ	★
$Q_{g(VDS=50V)}$	49 nC	★★	67 nC	★	58 nC	★★	42 nC	★★★
$Q_{SW(VDS=50V)}$	16 nC	★★★	21 nC	★	17 nC	★★	16*1 nC	★★★
$Q_{oss(VDS=50V)}$	108 nC	★★	74 nC	★★★	107 nC	★★	116*1 nC	★
$Q_{rr(dI/dt=100A/us)}$ Significant Improvement	59*1 nC	★★★	74*1 nC	★★	81*1 nC	★	58*1 nC	★★★

*1 Measured value on same condition

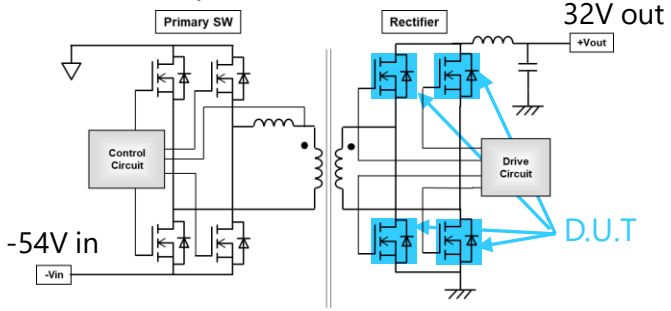
4 Comparison in 100V among U-MOS11-H HSD and Competitors

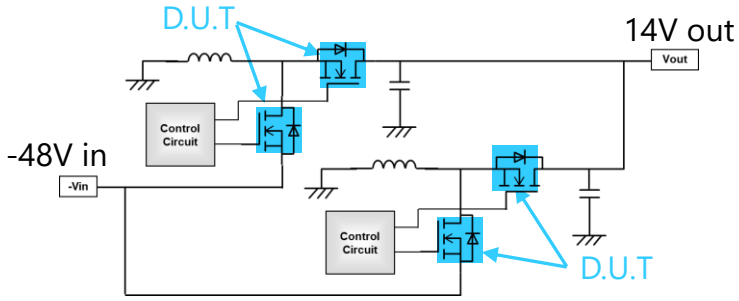
ES Available

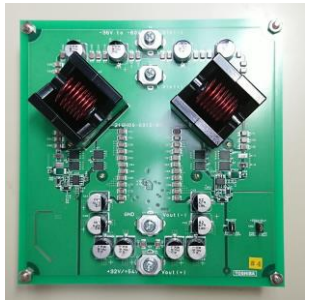
Performance of U-MOS11-H shows best performance.

Back Motor Control MCU
Back to New Inverter Gate Driver
Back to Simplified Lower Performance

Test circuit and picture

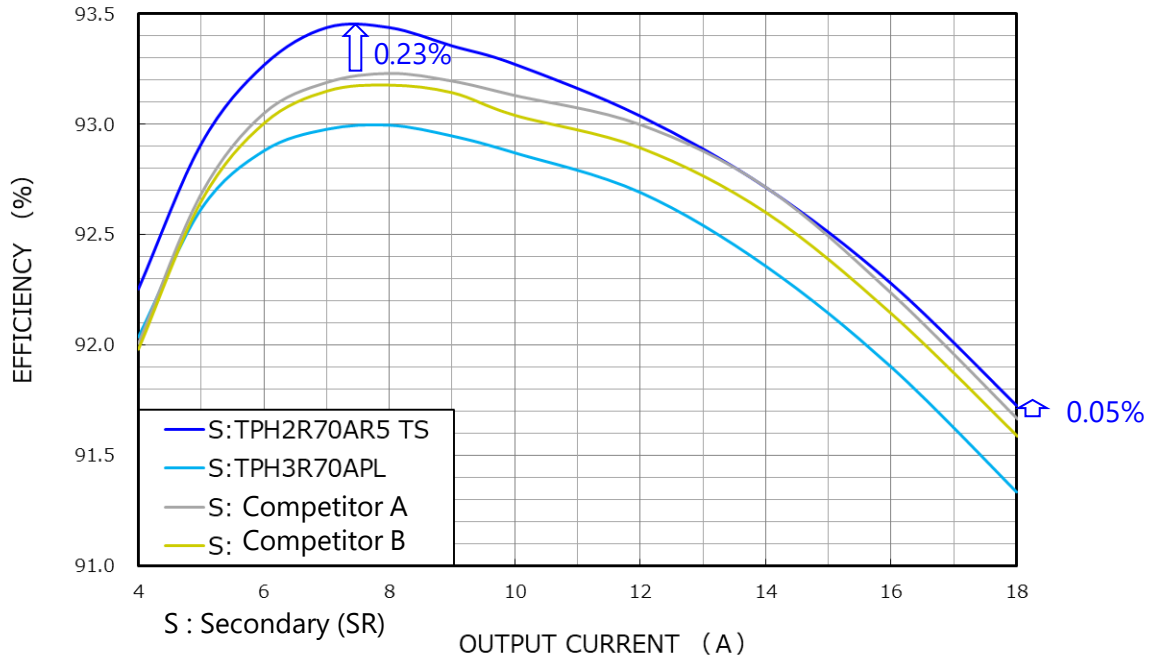






(Reference) 1kW Isolated DC-DC reference design result

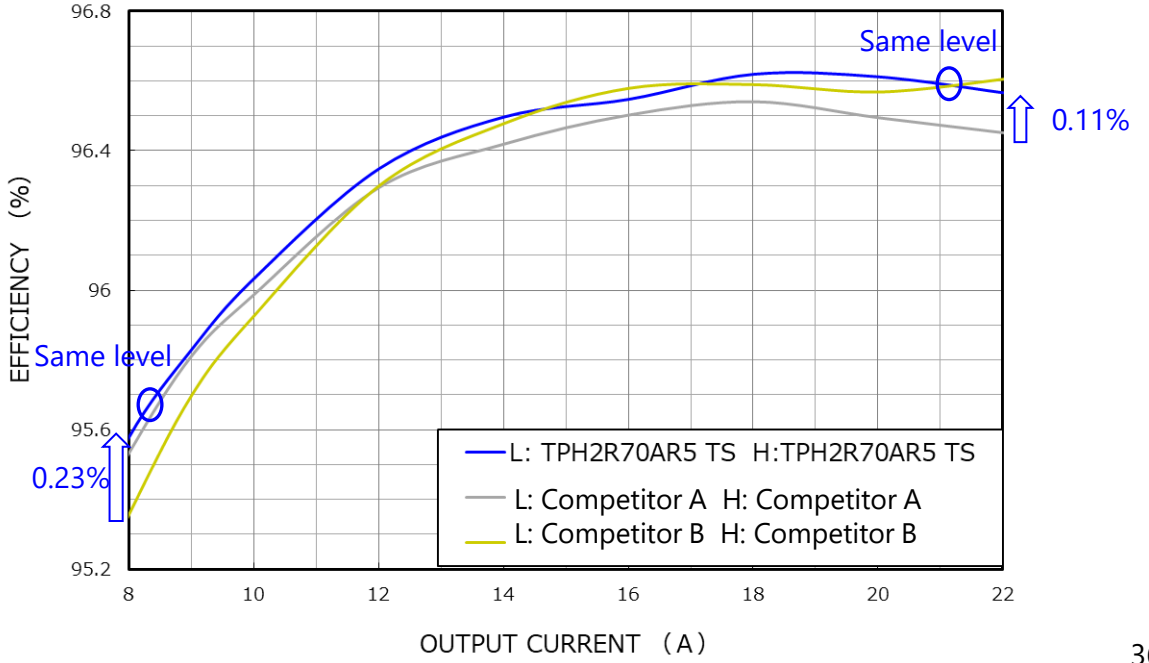
(Primary : TPH3R70APL Vout : 32V / f : 113kHz)



S : Secondary (SR)

(Reference) 1kW Buck-Boost reference design result

(Vin : -48V / Vout : 14.5V / f : 150kHz)



4 Line up plan of U-MOS 100V products

Under development：HSD Type

[Back Motor Control MCU](#)
[Back to New Inverter Gate Driver](#)
[Back to Simplified Lower Performance](#)

U-MOS11-H Line-up

(CY)

$R_{DS(ON)}$Max (V_{GS}= 10V) (mohm)	Package								
	DSOP Advance (5x6 dual sided cooling) 5 x 6 mm	SOP Advance(E) (5x6) 5 x 6 mm	SOP Advance(N) (5x6) 5 x 6 mm	SOP Advance (5x6) 5 x 6 mm	TSON Advance (3x3) 3 x 3 mm	L-TOGL (TOLL leaded) 10 x 12 mm	DPAK (TO-252)	TO-220	TO-220SIS (Fullpak)
50							TK7S10N1Z 48		
40									
30					TPN3300ANH 33		TK11S10N1L(L) 28		
20									
15				TPH1400ANH 13.6	TPN1600ANH 16			TK22E10N1 13.8	TK22A10N1 13.8
12					TPN1200APL(L) 11.5				
10							TK110P10PL(L) 10.6	TK110E10PL(L) 10.7	TK110A10PL(L) 10.8
								TK34E10N1 9.5	TK34A10N1 9.5
8				TPH8R80ANH 8.8	S1TR8 (N11-H) (ES Aug. 2024) 8.7		TK7R7P10PL(L) 7.7	TK40E10N1 8.2	TK40A10N1 8.2
			TPH8R10APL(L) (Order Mar. 2025) 8.1					TK7R2E10PL(L) 7.2	TK7R4A10PL(L) 7.4
6				TPH6R30ANL(L) 6.3			TK60S10N1L 6.11	TK6R4E10PL(L) 6.4	TK6R7A10PL(L) 6.7
				TPH5R60APL(L) 5.6					
5	TPW4R50ANH Conventional type 4.5		TPH4R50ANH1 4.5					TK65E10N1 4.8	TK65A10N1 4.8
4	TPW3R70APL(L) Conventional type 3.7		S1TP3 (N11-H) (ES Sep. 2024) 4.3	TPH4R10ANL(L) 4.1				TK3R9E10PL(L) 3.9	TK4R1A10PL(L) 4.1
			TPH3R70APL1(L) 3.7						TK100A10N1 3.8
3			TPH3R10AQM 3.1					TK100E10N1 3.4	TK3R2A10PL(L) 3.2
								TK2R9E10PL(L) 2.9	
2.5			TPH2R70AR5 (HSD) (Order Sep. 2024) 2.7						
2									
1						XPQ1R00AQB (Order 2H 2025) 1.03			

Under Investigation → Under Development → ES Available → Order Available → Under MP (Successor Available)

Note : Specifications and schedule of under development is just target and is subject to change without notice.

5 Low noise operational amplifier

TC75S67TU

Low-loss, low-heat, and power efficiency

Small size packages

Back to AC-DC / PFC
Back to Microcontroller Peripheral

Value Provided

Very small signals detected by various sensors can be amplified with very low noise.

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

Very small signals detected by various sensors [Note 1] can be amplify with low noise using CMOS operational amplifier by optimizing the processing, we achieved one of the industry's lowest [Note 2] input equivalent noise voltage.

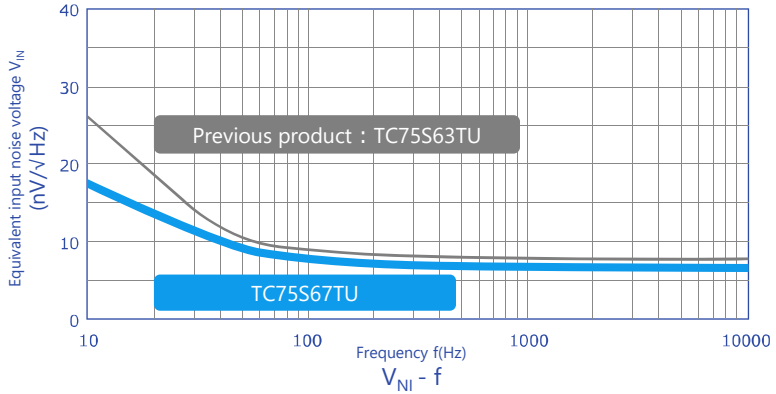
2 Low current consumption
I_{DD} = 430 [µA] (Typ.)

The low current consumption characteristics of the CMOS processing contributes to the extension of battery life of the compact IoT devices.

3 Low voltage operation

Can be operated in case of V_{DD} = 2.2 to 5.5 V.

Low noise characteristics
(Toshiba internal comparison)



V_{NI} - f

Line Up

Part number	TC75S67TU
Package	UFV 
$V_{DD,SS}$ (Max) [V]	±2.75
$V_{DD,SS}$ (Min) [V]	±1.1
I_{DD} (Max) [µA]	700
V_{NI} [nV/√Hz] (Typ.) @f = 1 kHz	6

[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, temperature sensor, etc. [Note 2] Based on Toshiba data (May 2017).

For more information see: TC75S67TU

Introduction of Toshiba operational amplifier types and applications

Back to AC-DC / PFC
Back to Microcontroller Peripheral

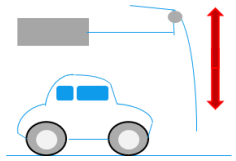
We have a lineup of Op amp suitable for various applications.

Low Noise type

TC75S67TU

Ideal for amplifying small signals .

Application example



Garage Door /
Gate Openers

low Quiescent current type

New!!

TC75S102F

Ideal for long-time operation equipment.

Application example

Battery-operated equipment such as PIR sensors, smoke sensors

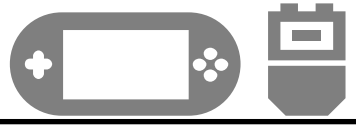
I/O Rail to Rail type

New!!

TC75S102F
TC75S103F

It can operate a wide voltage signal from GND to the power supply voltage, it is ideal for low power supply voltage operation.

Application example



Battery-operated Equipment,
Various sensors

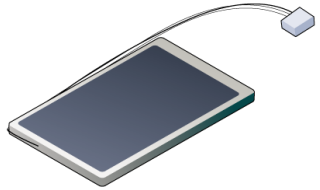
Ultra Low input offset voltage type

Under planning

TC75S105F

Ideal for high precision signal amplification.

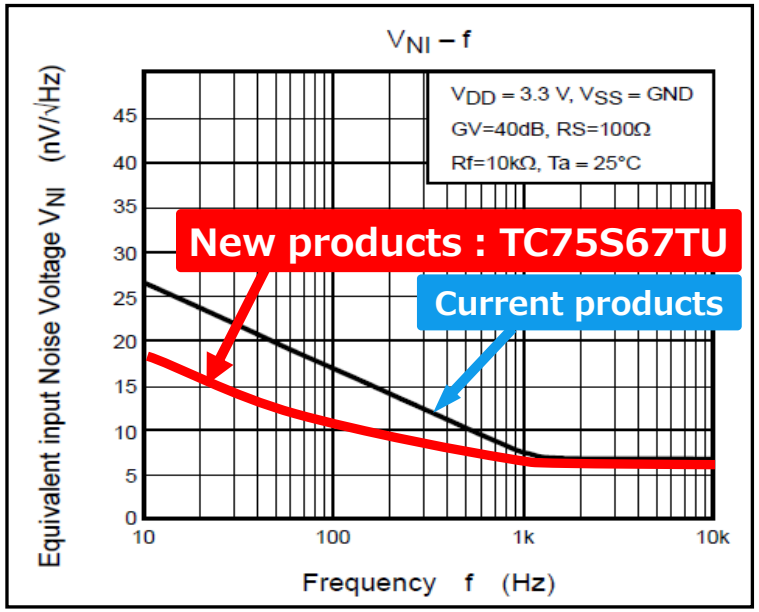
Application example



Current sensor

Toshiba operational amplifier ICs contribute to high-performance sensing technology with excellent performance.

Low Noise Performance

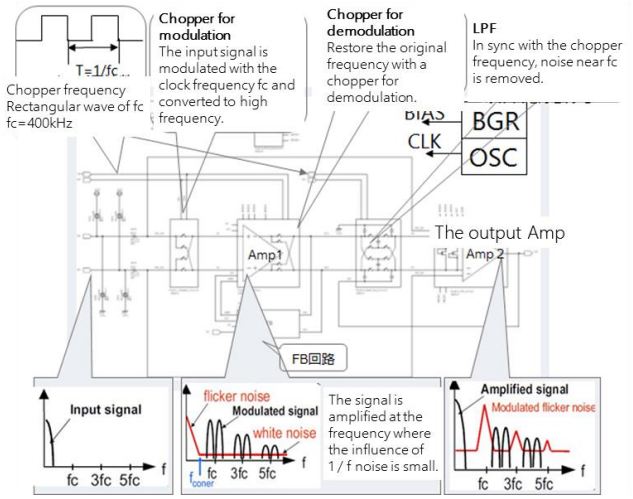


1/f noise and thermal noise reduced.

Under planning

Ultra low input offset voltage.

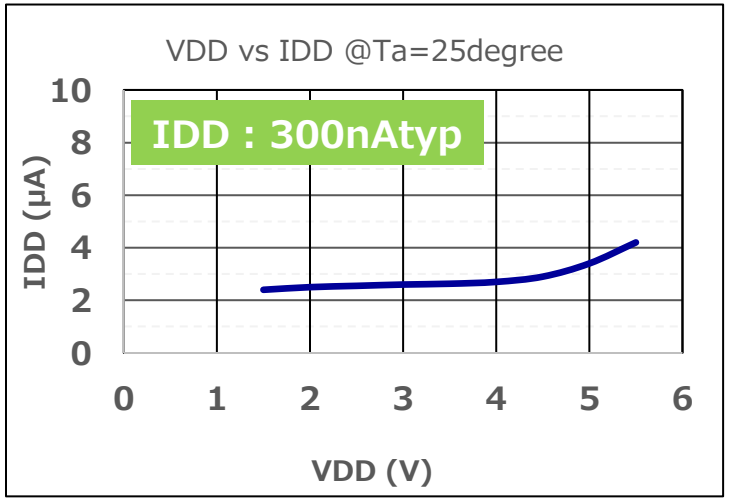
VIO : 40μVMax



We are developing ultra low offset voltage Op Amp using chopper circuit technology.

New!!

Ultra low Quiescent current.



TC75S102 series data.

It is a few μA, ultra low Quiescent current.

https://toshiba.semicon-storage.com/us/product/linear/opamp-and-comparator.html

5 Toshiba Op Amp Roadmap

Back to AC-DC / PFC
Back to Microcontroller Peripheral

~2021	2022	2023	2024~

Toshiba operational amplifiers contribute to high-performance sensing technology with various lineups

TC75S102F Low IDD

New!!

VDD 1.5 to 5.5V
Rail to Rail
IDD:0.3μA
VIO:1.3mV:Max

SOT-25
2.8x2.9mm

TC75S103F Low VIO

New!!

TC75S103F
VDD 1.8 to 5.5V
Rail to Rail
IDD:100μA
VIO:1.7mV:Max

SOT-25
2.8x2.9mm

Ultra Low input offset voltage

Low Quiescent current. Low input offset voltage

TC75S105 series*

Under planning

VDD 1.8 to 5.5V
Rail to Rail
VIO:40μV:Max

SOT-25
2.8x2.9mm

SOT-353 (UFV)
2.0x2.1mm

SOT-553 (ESV)
1.6x1.6mm

DFN5B
1.2x1.2mm

Low Quiescent current Low input offset voltage 1in1(small PKG)/2in1/4in1

Under planning

TC75S/W/Q102/103xx

SOT-553 (ESV)
1.6x1.6mm

SOT-353 (UFV)
2.0x2.1mm

US8
2.0x3.1x0.7mm

TSSOP14B
5.0 x 6.4 mm

＊Sequential development from SMV package

5 Ultra Low Noise Op Amp ICs TC75S67TU

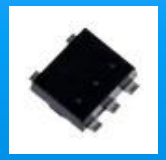
Back to AC-DC / PFC
Back to Microcontroller Peripheral

TC75S67TU

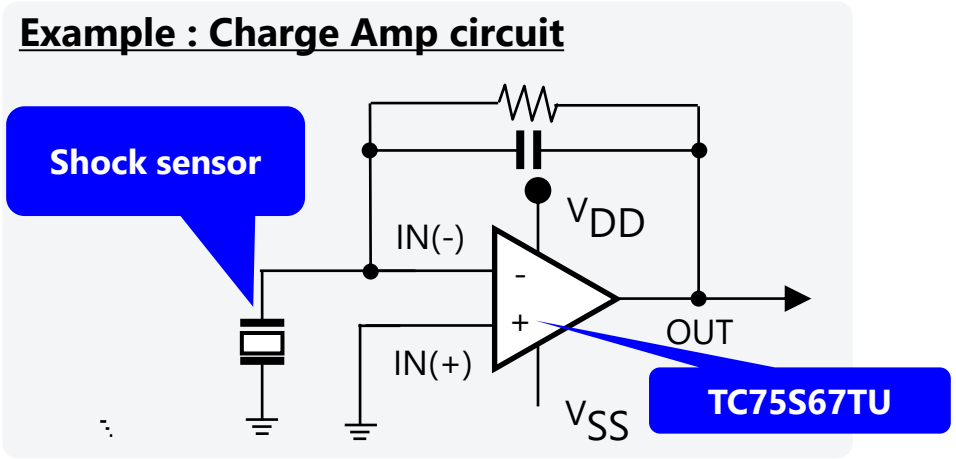
Ultra Low Noise OP-Amp

For sensor, IoT

SOT-353(UFV)
(2.1x2.0mm)



Example : Charge Amp circuit



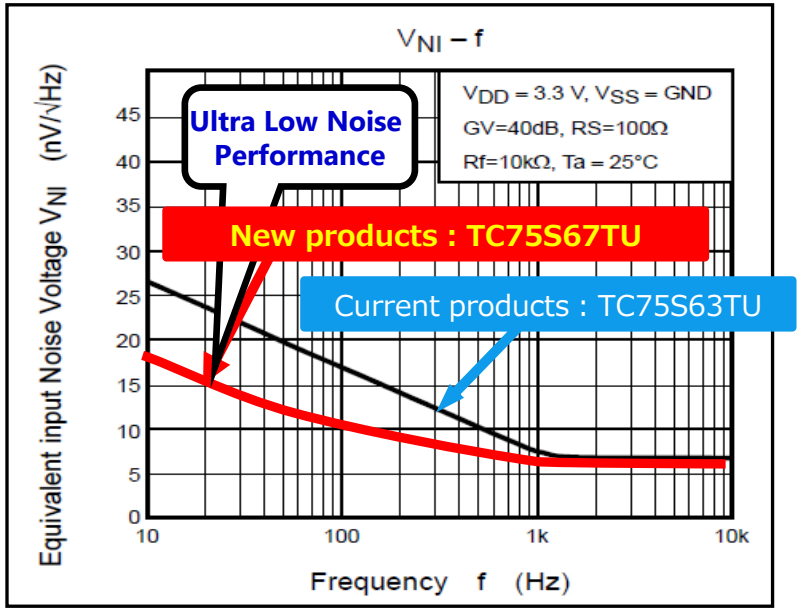
Feature

- Equivalent input Noise Voltage(V_{NI})
  6.0nV/√Hz (typ.)
  10nV /√Hz (max)
  @f=1kHz
- V_{DD} max.: 6V
- V_{IO} drift : 1μV/deg
- CMV_{IN} : 0 to 1.3V @VDD=2.5V
- CMRR:70dB (min)
- I_{DD}:500μA (typ.)

Characteristics

ITEM	Characteristics
V_{DD}/ V_{EE}	2.2 to 5.5V
I_{DD}	500μA (typ.)
Gv	80dB (min.)
V_{NI}@f=1kHz	10nV/√Hz (Max)
Slew rate	1.0V/μs (typ.)
fT	3.5MHz (typ.)
Type	Ultra low noise

Equivalent input Noise Voltage



5 Low Input Offset voltage type Op Amp ICs

Back to AC-DC / PFC
Back to Microcontroller Peripheral

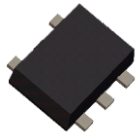
New!!

Under planning

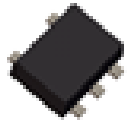
TC75S102/103xx

- Low Input Offset voltage
- Low VIO temperature drift
- I/O Full Range type

SOT-25(SMV)
2.8x2.9x1.1mm



SOT-353 (UFV)
2.0x2.1x0.7mm



SOT-553 (ESV)
1.6x1.6x0.55mm

Characteristics		CMOS process	
		TC75S102xx	TC75S103xx
V_{DD}, V_{SS}		1.5 to 5.5V	1.8 to 5.5V
I_{DD}		0.3μA	100μA
VIO,VIO drift		1.3mV:Max	1.3mV:Max
fT		0.6kHz	350kHz
SR		0.35V/ms	0.6V/μs
Type		Ultra low IDD	Low IDD
Single	SOT-25(SMV) (2.9x2.8mm)	New!! TC75S102F	TC75S103F New!!
	SOT-353(UFV) (2.0x2.1mm)	Under planning TEST Sample : Available TC75S102TU	TC75S103TU Under planning TEST Sample : Available
	SOT-553(ESV) (1.6x1.6mm)	Under planning TEST Sample : Available TC75S102FE	TC75S103FE Under planning TEST Sample : Available

5 Ultra low input offset voltage type Op Amp:
TC75S105xx

Back to AC-DC / PFC
Back to Microcontroller Peripheral

TC75S105xx

- Ultra low input offset voltage : Built-in chopper circuit
- Small thermal drift（Offset voltage）
- I/O Full Range type

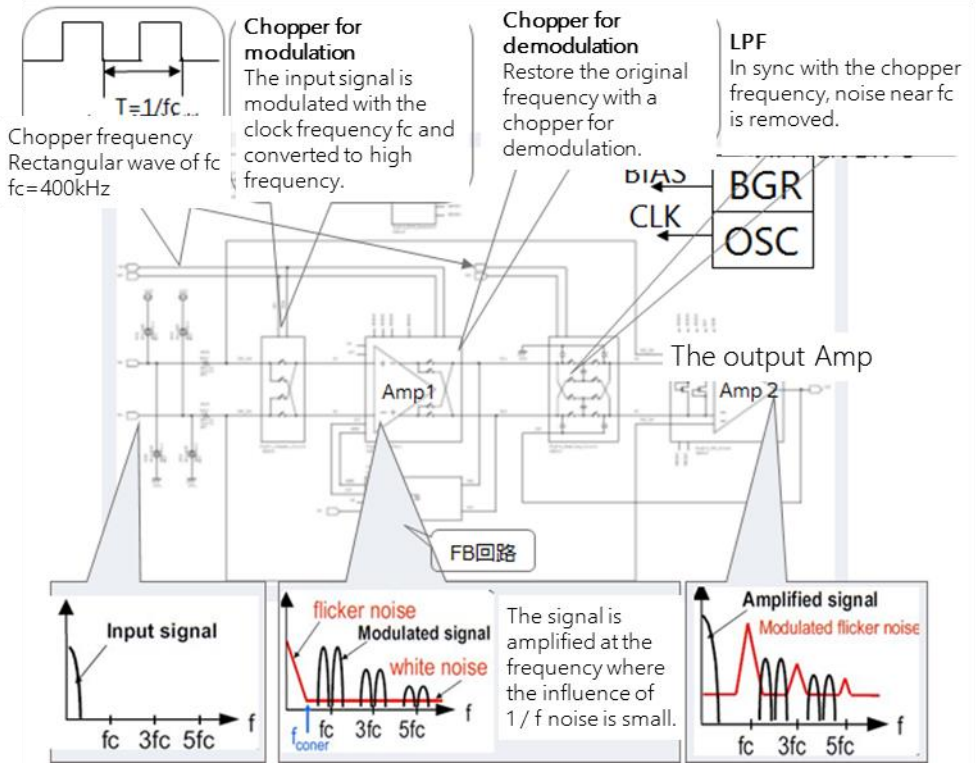
Under planning


SOT-25(SMV)
2.8x2.9x1.1mm


SOT-353（UFV）
2.0x2.1x0.7mm


SOT-553（ESV）
1.6x1.6x0.55mm

＊Sequential development from SMV package



Target spec
Ultra low input offset voltage

Characteristics	CMOS process
	TC75S105 Series
V_{DD},V_{SS}	1.8~5.5V
I_{DD}	75μA:Typ
VIO	40μV:Max
fT	790kHz

*Above target specification and schedule may change without notice

5 Operational Amplifier ICs line up

Back to AC-DC / PFC
Back to Microcontroller Peripheral

Operational Amplifier series
with small package


SOT-353 (USV)
2.0x2.1x0.9mm

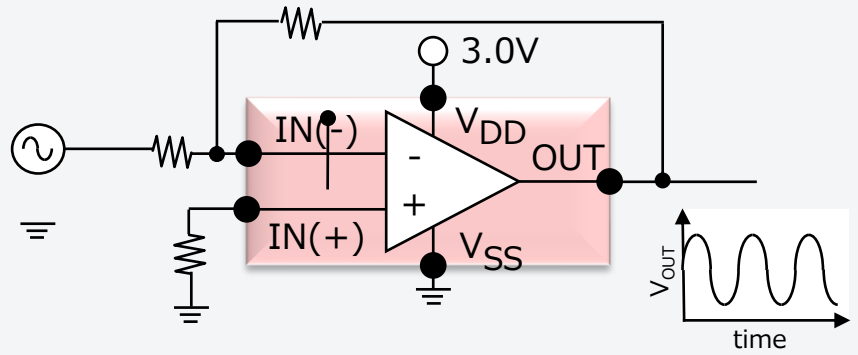

SOT-353 (UFV)
2.0x2.1x0.7mm


SOT-25(SMV)
2.8x2.9x1.1mm


US8
2.0x3.1x0.7mm


SM8
2.9x4.0x1.1mm

Application example: Sensor amp.



Features \ Series		Bi-polar		CMOS						
		TA75S01 TA75W01	TA75S558 TA75W558	TC75S51 TC75W51	TC75S54 TC75W54	TC75S55 TC75W55	TC75S63	TC75S67	TC75S102	TC75S103
V_{CC},V_{EE}/ V_{DD}, V_{SS}		3.0 to 12V	4 to 18V	1.5 to 7.0V	1.8 to 7.0V	1.8 to 7.0V	2.2 to 5.5V	2.2 to 5.5V	1.5 to 5.5V	1.8 to 5.5V
I_{CC}/ I_{DD}		0.4mA	2.5mA	60uA	100uA	10uA	500uA	430uA	0.27uA	100uA
Isink		20mA	40mA	---	700uA	450uA	1.5mA	3.5mA	0.4mA	2mA
Gv		100dB	100dB	70dB	70dB	70dB	100dB	100dB	139dB	100dB
VNI		---	2.5μVrms@f=30Hz to 30kHz	---	---	---	7.8nV/√Hz@f=1kHz	6nV/√Hz@f=1kHz	---	---
Slew rate		---	1.0V/μs	0.5V/μs	0.7V/μs	0.08V/μs	1.0V/μs	1.0V/μs	0.37V/ms	0.52V/us
fT		0.3MHz	3.0MHz	0.6MHz	0.9MHz	0.16MHz	3.5MHz	3.5MHz	0.5kHz	0.3MHz
Type		---	Low noise Wide band	Low voltage operation	Standard	Low I_{DD}	Low noise	Low noise	Input and output full range	Low I_{DD} Input and output full range
Single	SOT-353(USV) (2.0*2.1mm)	---	---	TC75S51FU	TC75S54FU	TC75S55FU	TC75S63TU*	TC75S67TU*	---	---
Single	SOT-25(SMV) (2.9*2.8mm)	TA75S01F	TA75S558F	TC75S51F	TC75S54F	TC75S55F	---	---	TC75S102F	TC75S103F
Dual	US8 (2.0*3.1mm)	---	---	TC75W51FK	TC75W54FK	TC75W55FK	---	---	---	---
Dual	SOT-505 (2.9*4.0mm)	TA75W01FU	TA75W558FU	TC75W51FU	TC75W54FU	TC75W55FU	---	---	---	---

* : UFV package

6 Small surface mount LDO regulator

TCR1HF Series

Low loss, Low heat, and power efficiency

Small size packages

Back to Microcontroller peripheral

Value Provided

To meet high performance demands with optimum products, we offer from general purpose to small package devices.

1 Low dropout voltage*

Dropout characteristics have been greatly improved by the newly developed process. (50 % improvement : Toshiba comparison)

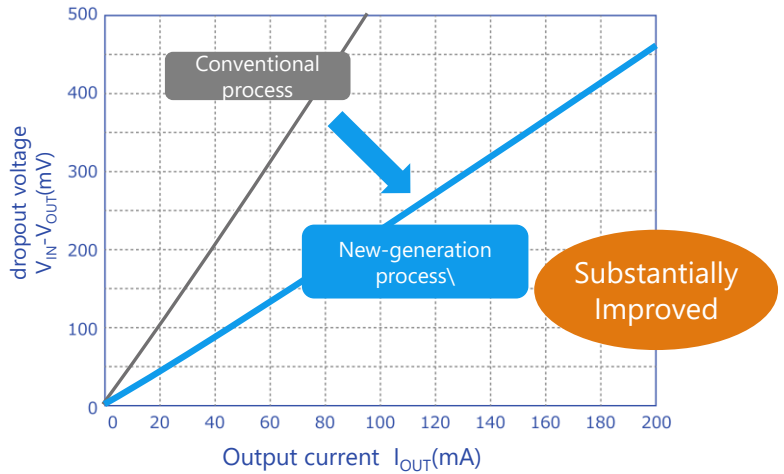
2 Low output noise voltage V_{NO}

The low output noise voltage V_{NO} is also reduced to 100 µVrms, making it even more applicable for analog circuits.

3 Can be used with ceramic capacitors

With improved dropout characteristics, it is now possible to use ceramic capacitors for external capacitor functions.

Low dropout voltage



Note: Toshiba internal comparison

* For post DC-DC switching regulation

Line Up

Part number	TCR1HF Series
Package	SOT25 
V_{IN} (Max) [V]	40
I_{OUT} (Max) [mA]	150
V_{IN} –V_{OUT} (Max) [V]	0.66
Output range [V]	1.8 to 5.0

For more information see: TCR1HF Series

6 What is Toshiba LDO ?

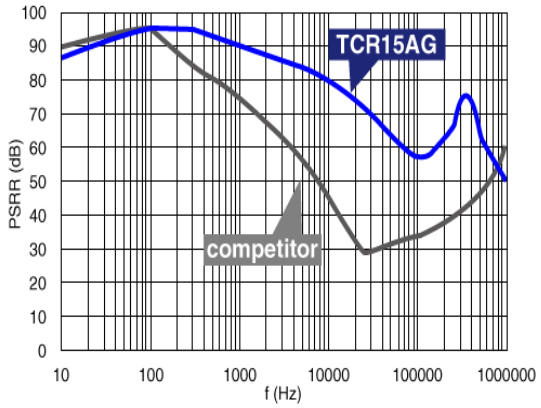
Low loss, Low heat, and power efficiency

Small size packages

Back to Microcontroller peripheral

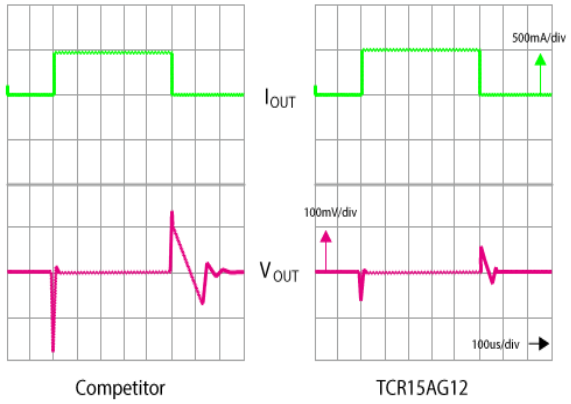
Toshiba LDOs offer Stable and Long operation

Remove Noise from Power line



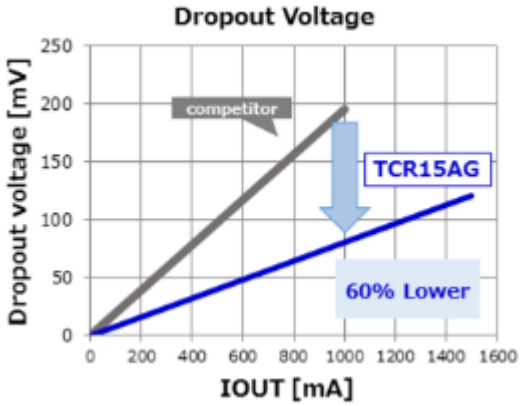
Remove Input noise by High PSRR advanced technology.

Keep Stable Output When Load changes



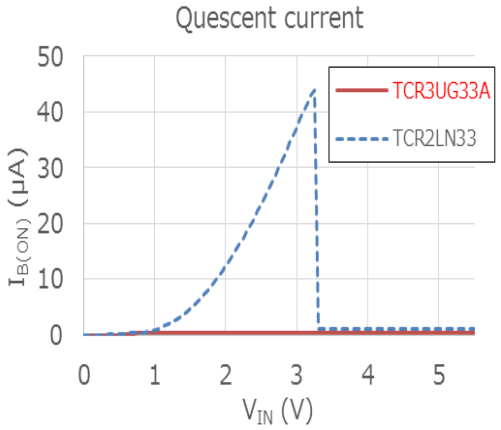
Keep Vout Stable when load current suddenly changes.

Low power Loss by Low Dropout*



Low input voltage is acceptable by low dropout

Long life operation By Low Quiescent



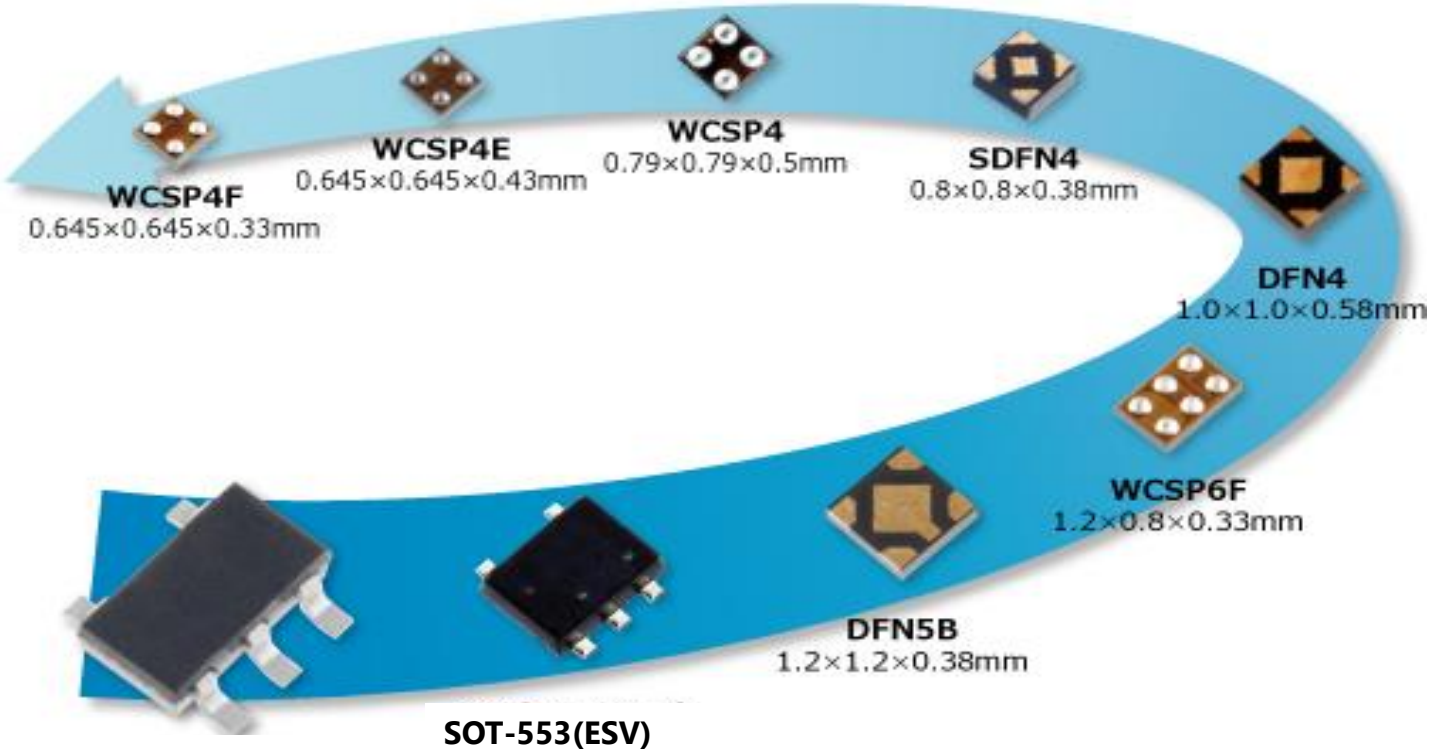
Keep Low IQ with Bypass mode when VIN is lower than VOUT.

https://toshiba.semicon-storage.com/ad/product/linear/ldo-regulator.html

* For post DC-DC switching regulation

Wide packaging options

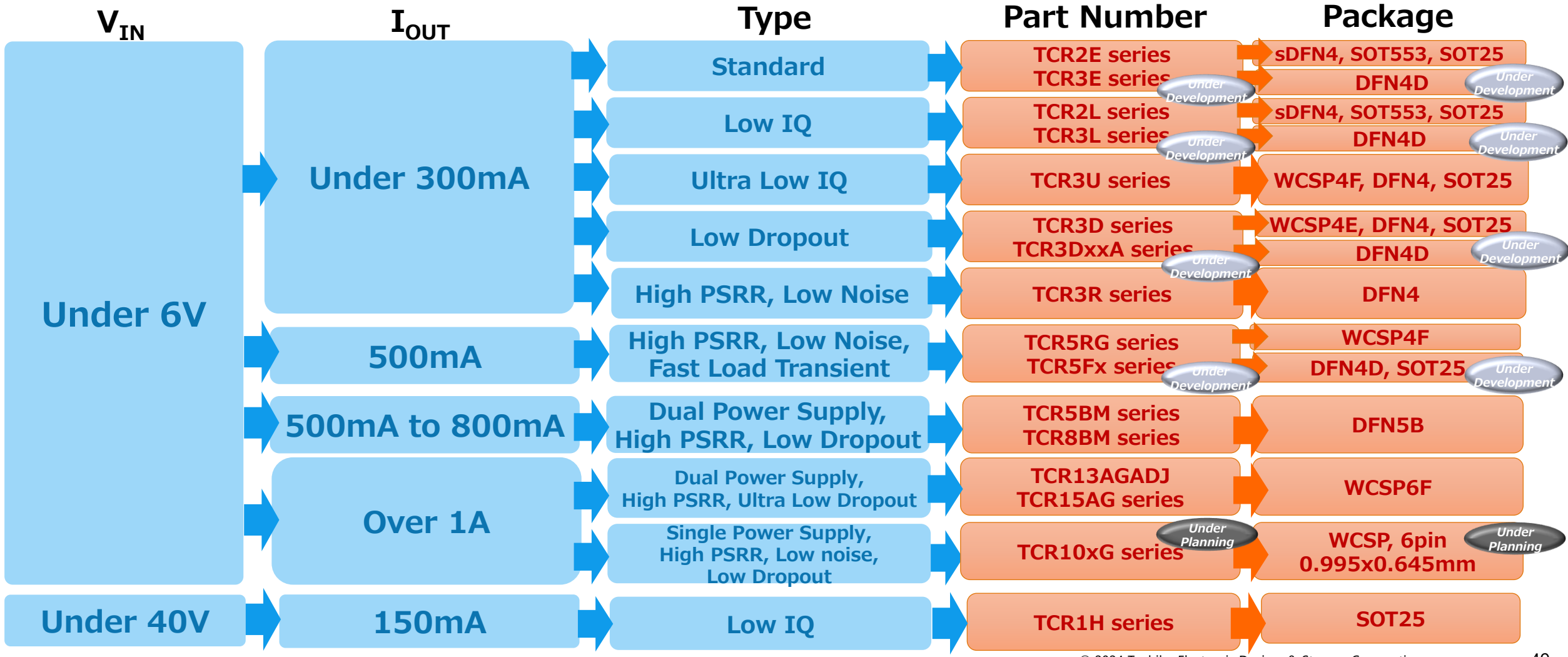
Toshiba's LDO regulators are available in a wide range of packages from general-purpose packages to ultra-small WCSP and SDFN4 packages.



6 LDO selection guide

Back to Microcontroller peripheral

You can choose according to your desired characteristics.



6 LDO Roadmap

Back to Microcontroller peripheral

*The below target characteristics and schedule are subject to change without notice.

~2021	2022	2023	2024

6V / 1A~1.5A

TCR15A series 1.5A
Ultra Low Dropout
Fix or Adjustable V_{OUT}
V_{OUT}: 0.6 to 3.6V
WCSP6F (1.2x0.8mm)

Smaller Size Lower VOUT

TCR10xG 1A P-ch — Under Planning
I_{OUT}=**1A~**, **Ultra High PSRR**
Low noise, Low Dropout
V_{OUT}: 1.8 to 5.0V
0.995x0.645mm

TCR15BG 1.5A N-ch — Under Planning
I_{OUT}=**1.5A~**, **Ultra High PSRR**
Low noise, Low Dropout
V_{OUT}: 0.4 to 1.8V
0.995x0.645mm

6V / 500mA

TCR5RG series 500mA — New!!
Ultra High PSRR
Low Noise
High accuracy
V_{OUT}: 0.9 to 5.0V
WCSP4F (0.65x0.65mm)

Improvement of Load transient

TCR5Fx series 500mA — Under Development
Ultra High PSRR, Low Noise
High accuracy
Fast transient response
V_{OUT}: 0.9 to 5.0V
SOT-25 (SMV)
DFN4D (1.0x1.0mm)
Sample(ES): 1H24
MP: 2H24

6V / 300mA

TCR3RM series 300mA — New!!
Ultra High PSRR
Low Noise
High accuracy
V_{OUT}: 0.9 to 4.5V
DFN4F (1.0x1.0mm)

TCR3Ux series 300mA
Low I_Q: 340nA
Bypass mode
V_{OUT}: 0.8 to 5.0V
WCSP4F (0.65x0.65mm)
DFN4E (1.0x1.0mm)
SOT-25 (SMV)

High quality and stable supply
Expansion line-up of Toshiba Thailand Factory

TCR3DMxxA series 300mA — Under Development
Low Dropout
V_{OUT}: 1.0 to 4.5V
DFN4D (1.0x1.0mm)
Sample(ES): OK
MP: Jun'23

TCR3EM series 300mA — Under Development
Standard
V_{OUT}: 0.8 to 5.0V
DFN4D (1.0x1.0mm)
Sample(ES): OK
MP: Jul.'23

TCR3LM series 300mA — Under Development — New!!
Low I_Q: 1.2μA
V_{OUT}: 0.8 to 5.0V
DFN4D (1.0x1.0mm)

15V~40V/150mA

TAR5S/5SB series 150mA — New!!
V_{IN}=15V max
V_{OUT}: 1.8 to 5.0V
SOT-25(SMV)

More High-voltage and Low IQ

TCR1HF series 150mA — Under Development — Under Planning
V_{IN}=**40V** abs max
Low I_Q: 1μA
V_{OUT}: 1.8 to 5.0V
SOT-25 — New!!
DFN4D (1.0x1.0mm)
WCSP4G(BSC) (0.65x0.65mm)

6 40V 150mA , Low IQ 1.0µA LDO

New

Back to Microcontroller peripheral

TCR1HF series

-	**Maximum Input Voltage**	**40V**
-	**Input Voltage**	**4V to 36V(*1)**
-	Output Current	150mA (*2)
-	Output Voltage	1.8V to 5.0V
-	**Quiescent Current**	**1µA (typ.)**
-	Operation Temperature Range	-40℃ to 125℃
-	Overcurrent Protection	
-	Thermal Shutdown	

(*1)VOUT=5V: 6V to 36V
(*2) I_{OUT} is Depended on Input voltage (Heat issue)

Package Lineup

SOT-25(SMV)
(2.9x2.8mm)

In MP

DFN6
(2.0x2.0mm)

DFN4D
(1.0x1.0mm)

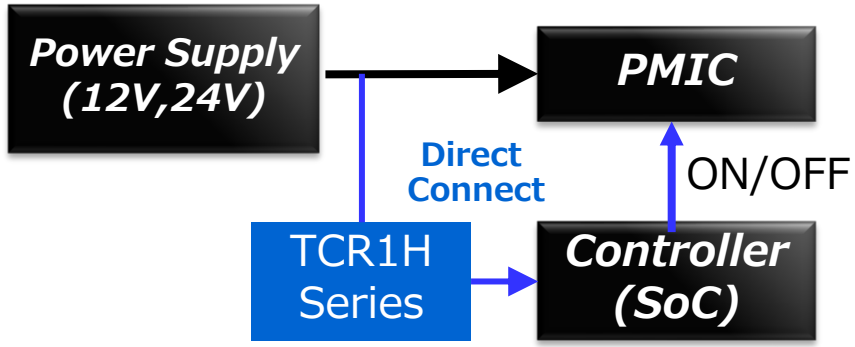
WCSP4
(0.645x0.645mm)

An industry-leading smallest class package
(as high voltage type LDO)

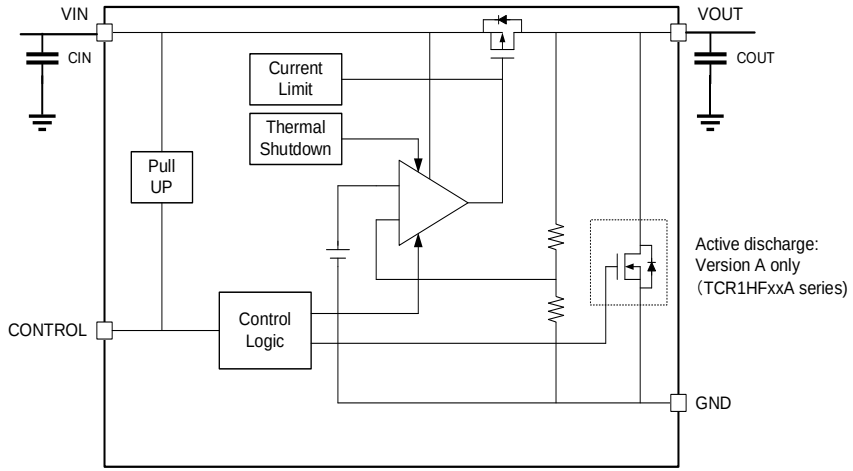
Application example

Ultra Low Power Consumption at Standby mode

Possible to supply high voltage to controller with low current consumption



Block Diagram



6 Toshiba LDO Line-up

Back to Microcontroller peripheral

Toshiba Thailand Factory PKG

	0.645x0.645mm WCSP4F, 4E t: 0.33mm(max) or 0.43mm(max)	0.8x0.8mm SDFN4E t: 0.38mm (typ.)	1.0x1.0mm DFN4E, 4F t: 0.58mm(typ.) or 0.38mm(max)	1.2x0.8mm WCSP6F t: 0.33mm (max)	1.2x1.2mm DFN5B t: 0.38mm (typ.)	1.0x1.0mm DFN4D t: 0.37mm (typ.)	1.6x1.6mm SOT553(ESV) t: 0.55mm (typ.)	2.9x2.8mm SOT-25(SMV) t: 1.1mm (typ.)
NMOS LDO For Low Voltage				**1.5A, Low Dropout** TCR15AG series	**800mA, Low Dropout** TCR8BM series			
				1.3A, Low Dropout TCR13AGADJ	**500mA, Low Dropout** TCR5BM series	MP: CY2Q.'24		MP: CY1Q.'24
PMOS LDO For Analog Voltage				**500mA Improvement of Load transient LDO Development**		**500mA, Low noise, Improvement of Load transient** TCR5FM series		**500mA, Low noise, Improvement of Load transient** TCR5FF series
	NEW **500mA, Low noise** TCR5RG series		NEW **300mA, Low noise** TCR3RM series					NEW
	NEW **300mA, Ultra Low IQ** TCR3UG series		NEW **300mA, Ultra Low IQ** TCR3UM series			Toshiba Thailand Factory New Line-up		**300mA, Ultra Low IQ** TCR3UF series
	300mA/420mA TCR3DG/4DG series		**300mA** TCR3DM series		MP: Jun.'23	**300mA** TCR3DMxxA series		**300mA** TCR3DF series
		200mA, Low IQ TCR2LN series			MP: OK	**300mA, Low IQ** TCR3LM series	**200mA, Low IQ** TCR2LE series	**200mA, Low IQ** TCR2LF series
		200mA TCR2EN series			MP: Jul'23	**300mA** TCR3EM series	**200mA** TCR2EE series	**200mA** TCR2EF series
High Voltage						MP: OK	**40V LDO Development**	**150mA, High Voltage** TCR1HF series

TVS diode

DF3D18FU / DF3D29FU / DF3D36FU / CUHZ36V

High efficiency · Low loss

Small size package

Back to Motor Control MCU

Value Provided

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

1 Improve ESD absorbability

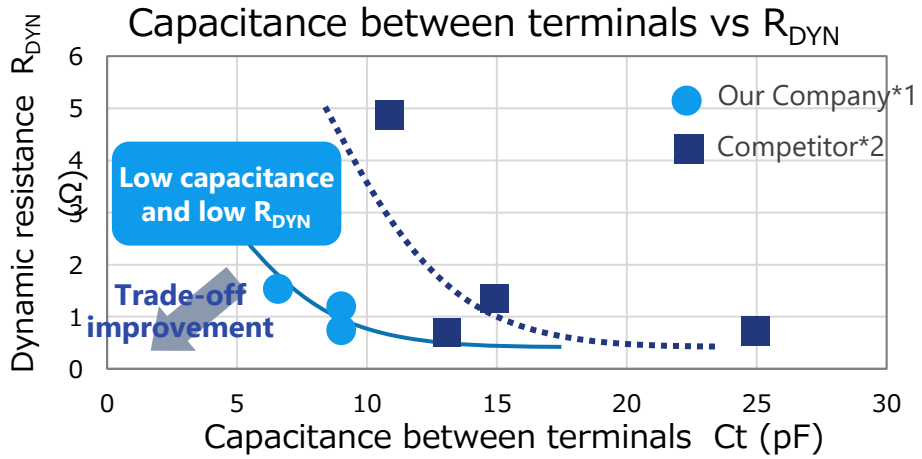
Improved absorption of ESD through our proprietary Zener process.
(Both low operating resistance R_{DYN} and low capacitance C_t)

2 High ESD immunity

Compliant products with
ISO10605 Standard > ±20 kV
IEC61000-4-2 Standard > ±20 kV
(L4)

3 Suitable for high density mounting

A variety of small packages are available.



Line Up

Part number	DF3D18FU	DF3D29FU	DF3D36FU	CUHZ36V
Package	USM (SOT-323)			US2H (SOD-323HE) 
V_{ESD} [kV] @ISO10605	±30	±30	±20	±20
V_{RWM} (Max) [V]	12	24	28	32.5
C_t (Typ./Max) [pF]	9 / 10		6.5 / 8	105
R_{DYN} (Typ.) [Ω]	0.8	1.1	1.5	0.39

(NOTE) : This product is an ESD protection diode and cannot be used for purposes other than ESD protection (including but not limited to constant voltage diode applications).

*1:TOSHIBA Electronic Device & Storage Corporation
*2:Measurements of the commercial product

For more information, see: TVS

8 Over temperature detection IC (Thermoflagger™)

TCTH Series

High efficiency · Low loss

Small size package

Back to Microcontroller peripheral

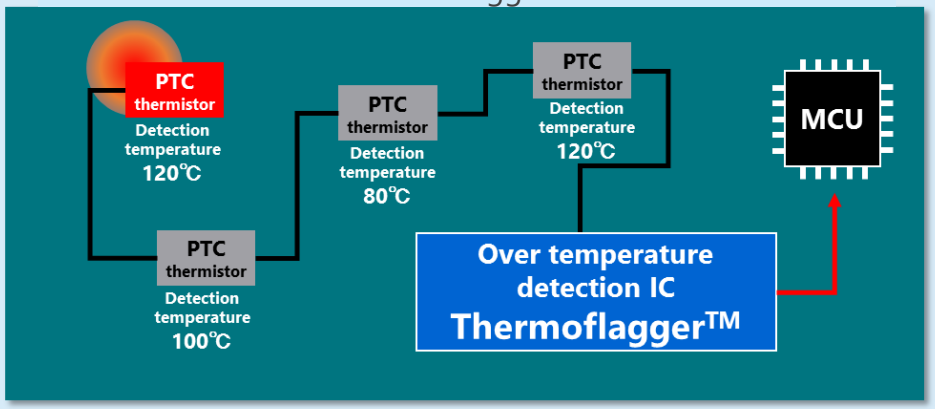
Value Provided

TCTH series can detect temperature rise at multiple points on the circuit board.

1 Temperature rise can be detected at multiple points

TCTH series detect an increase in resistance during over temperature by supplying a constant current (1 µA or 10 µA) to PTC (Positive Temperature Coefficient) thermistors. Multiple PTC thermistors connected in series enable to detect over temperature at multiple points on the circuit board.

Example of over temperature detecting circuit by Thermoflagger™.



2 Low current consumption and small package

TCTH01 series has I_{DD} = 1.8 µA (Typ.)
and TCTH02 series has I_{DD} = 11.3 µA (Typ.).
These packages are small size ESV type.

Line Up

Part number	TCTH011AE TCTH011BE	TCTH012AE TCTH012BE	TCTH021AE TCTH021BE	TCTH022AE TCTH022BE
Package	ESV 1.6 x 1.6 x 0.55 mm 			
V_{DD} [V]	1.7 to 5.5			
I_{DD} (Typ.) [µA]	1.8		11.3	
PTCO Output current (Typ.) [µA]	1	1	10	10
Abnormal latch function	-	Yes	-	Yes
Output circuit type	AE: push pull, BE: open drain			

For more Information, see: Thermoflagger

8 TCTH0 Series: 6V Low Consumption Current

New!!

Back to Microcontroller peripheral

Product Name	PTCO output current (I_{PTCO})	<Reference> PTC thermistor resistance at 25 ℃	Latching function for abnormal detection	PTCGOOD (FLAG) Output type	Status
TCTH011AE	1 μA	4.7 kΩ to 10 kΩ		Push-pull	In MP
TCTH012AE	1 μA	4.7 kΩ to 10 kΩ	✓	Push-pull	
TCTH021AE	10 μA	470 Ω to 1 kΩ		Push-pull	
TCTH022AE	10 μA	470 Ω to 1 kΩ	✓	Push-pull	
TCTH011BE	1 μA	4.7 kΩ to 10 kΩ		Open-drain	
TCTH012BE	1 μA	4.7 kΩ to 10 kΩ	✓	Open-drain	
TCTH021BE	10 μA	470 Ω to 1 kΩ		Open-drain	
TCTH022BE	10 μA	470 Ω to 1 kΩ	✓	Open-drain	

*The above target schedule is subject to change without notice.

9 MPD Bridges for Camera Sensor / Display Interfaces

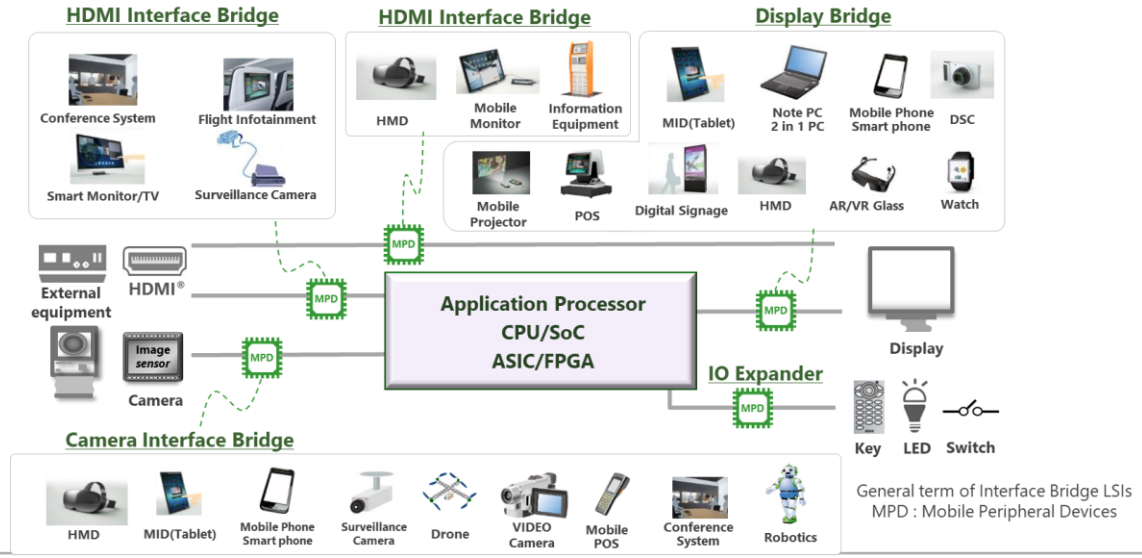
Back to Sensor / Display Block Diagram Detail

Value Provided

A simple way to bridge one camera interface / display interface to another.

1 Flexible Features and Operations

- Display bridge chips can support many display sizes clock speeds, interface speeds, etc.
- Camera bridge chips can support various RAW or pro-cessed video streams as well as interface speeds, etc.



2 Support tools to help design and initialize the bridge chip into your system

- Reference circuit schematics,
- Programming spreadsheet is available to take your system parameters and create initialization routines that can be sent via I2C or SPI into the MPD bridge device.

Line Up

Product	Input	Output	Package
Camera / HDMI Interface LSI			
TC358743XBG	HDMI (D2,1,0,CK)/ EDID,DDC,CEC	MIPI CSI2 4Lanes / SPD IF (I2S)	P-TFBGA64-0606-0.65
TC358746AXBG	MIPI CSI2 (4Lanes)/ Parallel (24bit)	Parallel (24bit) / MIPI CSI2 (4Lanes)	P-VFBGA72-0404-04
TC358748XBG	MIPI CSI2 (4Lanes)/ Parallel (24bit)	Parallel (24bit) / MIPI CSI2 (4Lanes)	P-VFBGA80-0707-0.65
TC358841XBG	HDMI (D2,1,0,CK)/ DDC,CEC	MIPI CSI2 4Lanes x 2Link / SPD IF (I2S), Slimbus	P-VFBGA80-0707-0.65
TC358871XBG	HDMI (D2,1,0,CK)/ DDC,CEC	MIPI DSI 4Lanes x 2Link / SPD IF (I2S), Slimbus	P-VFBGA80-0707-0.65
Display Interface LSI			
TC358767AXBG	MIPI DSI (4Lanes), I2C	Display Port 2 x Single Port, AUX x 2chMIPI DPI 24bit	P-VFBGA81-0505-0.50
TC358867XBG	MIPI DSI (4Lanes), I2C	Display Port 2 x Single Port, AUX x 2chMIPI DPI 24bit	P-VFBGA80-0707-0.65
TC358768AXBG	MIPI DPI(24bit)	MIPI DSI (4Lanes)	P-VFBGA72-0404-0.4
TC358778XBG	MIPI DPI(24bit)	MIPI DSI (4Lanes)	P-VFBGA80-0707-0.65
TC358777XBG	MIPI DSI (4Lanes) X2, I2S	Display Port 4 x Single Port (QuadLink), DPAUX	P-VFBGA80-0707-0.65
TC358774XBG	MIPI DSI (4Lanes)	LVDS (5Lanes(CLK,TX x 4))	P-TBGA49-0505-0.65
TC358775XBG	MIPI DSI (4Lanes)	LVDS (5Lanes(CLK,TX x 4)) x 2ch	P-TBGA64-0606-0.65
TC358860XBG	eDP v1.4 (4 lanes)	MIPI DSI (8 lanes with 1Gbps/lane)	P-TFBGA65-0505-0.5

For more information, see: Display Interface Bridges Camera Interface Bridges

9 MPD Bridge Line up

Back to Sensor / Display Block Diagram Detail

Bridge IC		OUT: DPI^{SM} (RGB I/F)	OUT: Parallel 8bit/16bit	OUT: LVDS	OUT: MIPI® DSI^{SM}	OUT: MIPI® CSI-2^{SM}	OUT: DisplayPort™ /eDP
IN	DPI^{SM} (RGB)			DSI^{SM} 4lane, WUXGA → TC358768A		DP 2lane, WUXGA→ TC358767A	
				DSI^{SM} 4lane, WUXGA, Wider ball pitch → TC358778		DP 2lane, WUXGA, Wider ball pitch → TC358867	
				DSI^{SM} 4lane, WUXGA, Wider ball pitch, Wider temp range → TC9594		DP 2lane, WUXGA, Wider ball pitch, Wider temp range → TC9595	
	Parallel 8bit/16bit				Parallel 24bit, CSI-2^{SM} 4lane → TC358746A		
					Parallel 24bit, CSI-2^{SM} 4lane, Wider ball pitch → TC358748		
					Parallel 24bit, CSI-2^{SM} 4lane, Wider ball pitch, Wider temp range → TC9591		
	MIPI® DSI^{SM}	TC358767A ← DSI^{SM} 4lane, PCLK 100MHz	DSI^{SM} 4lane, LVDS 1link, UXGA → TC358774			DSI^{SM} 4lane, DP 2lane, WUXGA → TC358767A	
		TC358867 ← DSI^{SM} 4lane, PCLK 100MHz, Wider ball pitch	DSI^{SM} 4lane, LVDS 1link, UXGA, Wider temp range → TC9592			DSI^{SM} 4lane, DP 2lane, WUXGA, Wider ball pitch → TC358867	
		TC9595 ← DP 2lane, WUXGA, Wider ball pitch, Wider temp range	DSI^{SM} 4lane, LVDS 2link, WUXGA → TC358775			DP 2lane, WUXGA, Wider ball pitch, Wider temp range → TC9595	
			DSI^{SM} 4lane, LVDS 2link, WUXGA, Wider temp range → TC9593			DSI^{SM} 8lane, DP 4lane,WQXGA, Wider ball pitch → TC358777	
	MIPI® CSI-2^{SM}		TC358746A ← CSI-2^{SM} 4lane, Parallel 24bit				
			TC358748 ← CSI-2^{SM} 4lane, Parallel 24bit, Wider ball pitch				
			TC9591 ← CSI-2^{SM} 4lane, Parallel 24bit, Wider ball pitch, Wider temp range				
	HDMI®				WUXGA60fps CSI-2^{SM} 4lane → TC358743		
					WUXGA60fps CSI-2^{SM} 4lane, Wider ball pitch → TC358743A		
					WUXGA60fps CSI-2^{SM} 4lane, Wider ball pitch, Wider temp range → TC9590		
					4k2k30fps/WQXGA60fps, DSI^{SM} 8lane→ TC358871	TC358841 ←4k2k30fps CSI-2^{SM} 8lane	

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Wide Ball Pitch Product

Wide Temp. Range Product

10a Series Rail-to-Rail Photocoupling Output Gate Driver

TLP57xx Series

Low-loss, low-heat, and power efficiency

Small size package

Back to AC-DC / PFC

Value provided

High performing rail-to-rail output gate drivers for MOSFETs, IGBTs and SiC MOSFETs

1 High Performance

High Speed: 150ns (max)
Low Skew : +/- 80ns
Wide operating temperatures available

2 Low Power

Supply current: 3mA (max)
Threshold current: 4mA (max)
Several output current versions available

3 Popular configurations

Direct replacements for
- ACPL-P340/W340 (TLP575x, TLP575x(LF4))
- ACPL-P345/P346 (TLP577x)

SO6L
Creepage : 8mm
DTI : 0.4mm
Bvs : 5000Vrms

Line up

Iop 1.0A	**TLP5751**	**TLP5751H**	**TLP5771**	**TLP5771H**
Iop 2.5A	**TLP5752**	**TLP5752H**	**TLP5772**	**TLP5772H**
Iop 4.0A	**TLP5754**	**TLP575H**	**TLP5774**	**TLP5774H**
Package	SO6L, SO6L(LF4)			
Operating Temp	-40°C ~110°C	-40°C ~125°C	-40°C ~110°C	-40°C ~125°C
Supply Voltage	15V ~ 30V		10V ~ 30V	
UVLO	13.5V (max)		9.5V (max)	
Supply Current	3mA (max)			
Propagation Delay	150ns (max)			
Propagation Skew	+/- 80ns			
Threshold Input Current	4mA (max)		2mA (max)	

For more information see: TLP75xx Series

10a Toshiba Gate Driver Couplers

For more efficient and reliable Systems

Back to AC-DC / PFC

Target Devices	MOSFET / IGBT	SiC MOSFET
Application		
Temp.	Ta : 110 ⇒ 125 ℃	Ta : 125 ℃
Frequency	Under 100 kHz	50 to **400 kHz**
CMTI	Under 50 kV/μs	50 to **100 kV/μs**
Gate Current	Around ±5 A	Around ±5 A
Gate Voltage	±10 V / +18 V, -10 V	+18 V, -5 V

Parameter

Existing Product Examples

TLP152 / TLP151A

Gate Driver for power **MOSFETs** and **IGBTs**

Main Specification:
100/110℃, 20kV/μs, ±2.5A, 10 to 30V

TLP5705H

Gate Driver for **IGBTs** and **SiC MOSFETs**

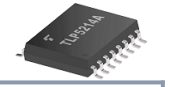
Main Specification:
125℃, 50kV/μs, ±5A, 15 to 30V

TLP5774H / TLP5754H

Gate Driver for power **MOSFETs, IGBTs** and **SiC MOSFETs**

Main Specification:
125℃, 35kV/μs, ±4A, 15/10 to 30V

TLP5212 / TLP5222



Smart Gate Driver for **IGBT s** and **SiC MOSFETs**

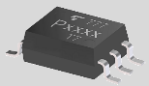
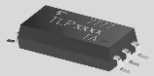
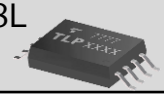
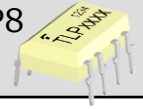
Main Specification:
110℃, 25kV/μs, ±2.5A, 15 to 30V

For more information see: Gate Drive Photo Coupler

10a IGBT/MOSFET gate driver coupler lineup

Back to AC-DC / PFC

Recommended package New Products Under development

Creepage & clearance		5mm	8mm	8mm	8mm	7 or 8mm
Isolation voltage		3750 Vrms	5000 Vrms	5000 Vrms	5000 Vrms	3750 Vrms
Peak output current	Propagation Delay time(max)	SO6 	SO6L 	SO8L 	SO16L 	DIP8 
6.0 A	500 ns					TLP358H*H
5.0 A	500 ns		**TLP5705H***H			
4.0 A	150 ns		**TLP5754***R **TLP5754H***R*H **TLP5774***R*10 **TLP5774H***R*H*10	**TLP5814H***AMC	**TLP5214***R*OC*AMC **TLP5214A***R*OC*AMC	
2.5 A	150 ns		**TLP5752***R **TLP5752H***R*H **TLP5772***R*10 **TLP5772H***R*H*10			
	200 ns	**TLP152***10	**TLP5702** **TLP5702H***H	**TLP5832**	**TLP5212***OC*AMC **TLP5222***OC*AMC *AR	TLP352*H
	300 ns				**TLP5231***R*OC	
	500 ns					TLP250H*H TLP350H*H
1.0 A	150 ns		**TLP5751***R **TLP5751H***R*H **TLP5771***R*10 **TLP5771H***R*H*10			
0.6 A	200 ns	**TLP155E***10				
	500 ns	**TLP151A***10	**TLP5701***10			TLP351A*10
	700 ns	**TLP151***10				TLP351H*10*H

*R＝Full swing output (rail to rail)
H =Operation temperature: 125 ℃ (max)
10 =Operation voltage: 10 V (min)

＊L =Low LED current: IFLH=2mA (max)
＊AR = Auto Reset from the protection mode
＊OC = AMC Over voltage detection (VDESAT)

＊AMC = Active Miller clamp

10b Smart Gate Driver for SiC MOSFET

TLP5214/TLP5214A/TLP5814H

Low-loss, low-heat, and power efficiency

Small size package

Back to AC-DC / PFC

Value provided

Highly integrated 4.0A output current SiC gate drive photocoupler in an efficient SO16L package

1 Protects against overcurrent of power devices

Gate driving with isolation with two LEDs

Feedback function for fault mode

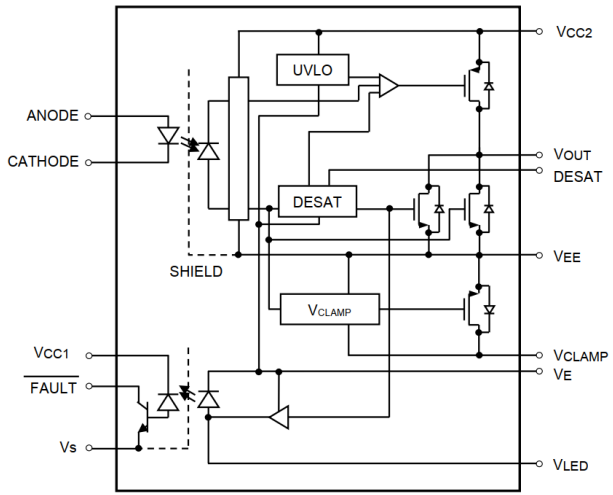
Built-in protective functions

2 2 Protective Functions

- Soft shut down in time to prevent the driven transistor from any short circuit breakdown
- Active mirror clamp to help flow damaging current away from driven device

3 Small Size Package

In an efficient SO16L package



Line up

Part number	TLP5214	TLP5214A	TLP5814H*
Total Supply Voltage (V)	15 to 30		15 to 23
Peak Output Current (A)	-4.0 / +4.0		-4.8 / +6.8
Supply Current (mA)	3.8		6.8
Threshold input current MAX (mA)	6		3.0
Switching time tpLH/tpHL MAX (ns)	150		150
DESAT leading edge blanking time Typ. (µs)	0.2	1.1	NONE
VtClamp threshold voltage for Mirror Clamp (V)	3.0	2.5	2.5
Package	SO 16L		SO 8L

* Under Development

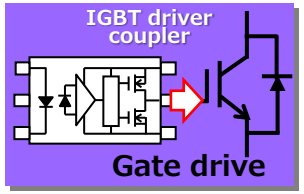
For more information see: Smart Gate Driver

10b Smart Gate Driver TLP5212, TLP5214/A Summary

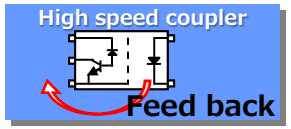
Back to AC-DC / PFC

SGD protects against overcurrent of power devices.

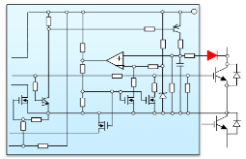
① gate driving with isolation

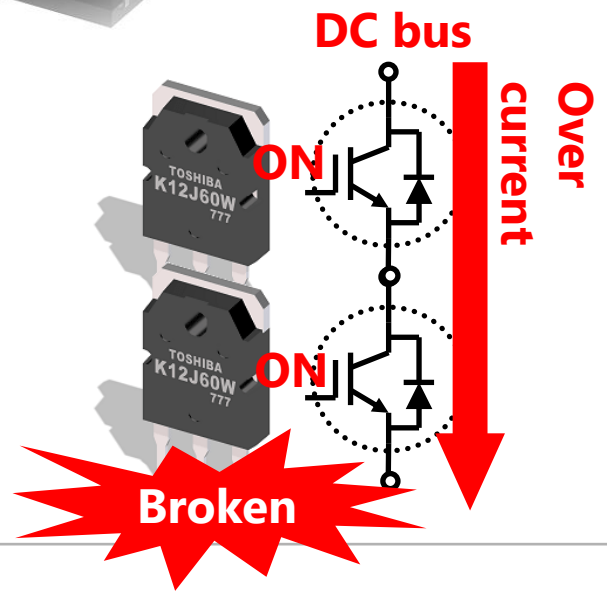


② Feed back function for fault mode

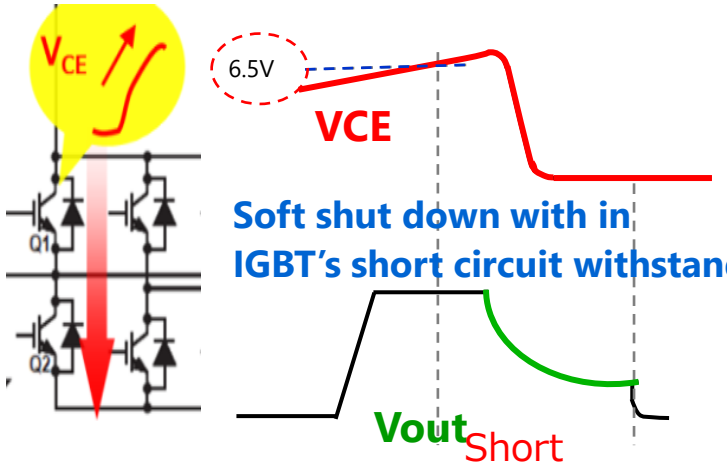


② Protective functions

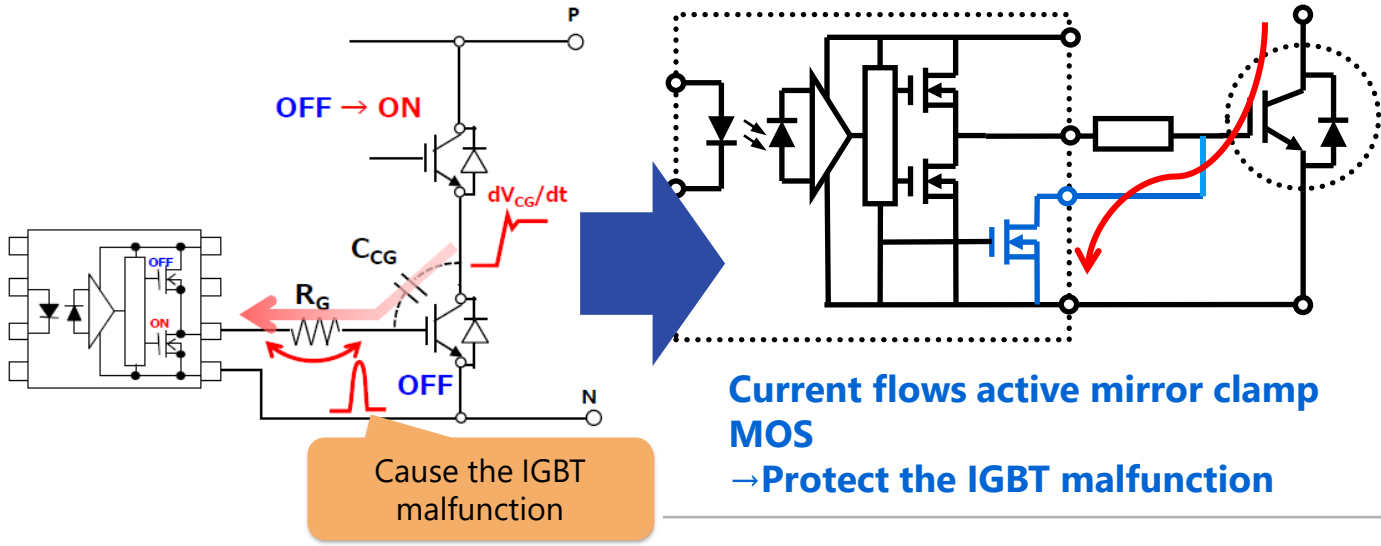




Protective function-1 Soft shut down



Protective function-2 Active mirror clamp



Current flows active mirror clamp MOS
→Protect the IGBT malfunction

10b Smart Gate Driver TLP5214A vs. TLP5214

Back to AC-DC / PFC

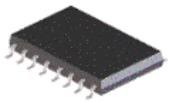
■ **Differences between TLP5214A and TLP5214**

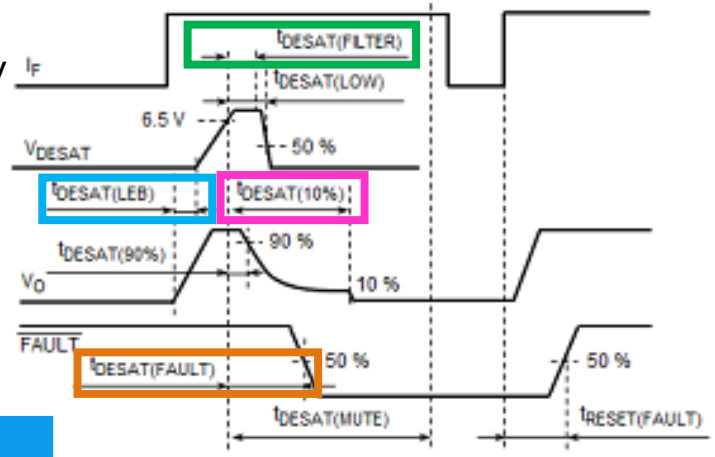
Longer **DESAT mask $t_{DESAT(LEB)}$(~0.2 → ~1.1$_{\mu s\ typ.}$)**

Longer **soft shutdown time (~3.5 → ~7$_{\mu s\ typ.}$)**

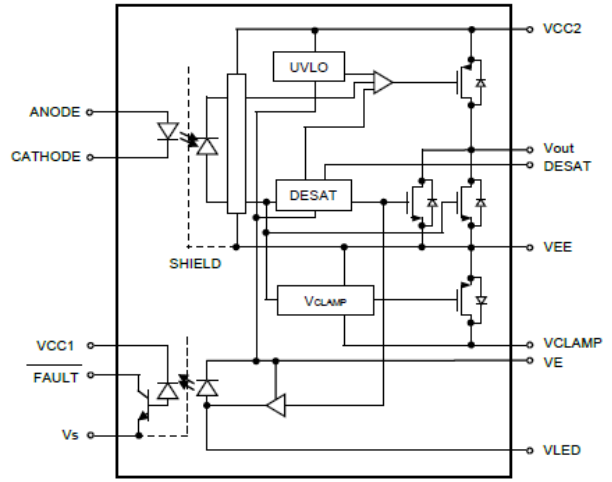
Added "**DESAT filter time**" for high noise immunity **(90$_{ns\ typ.}$)**

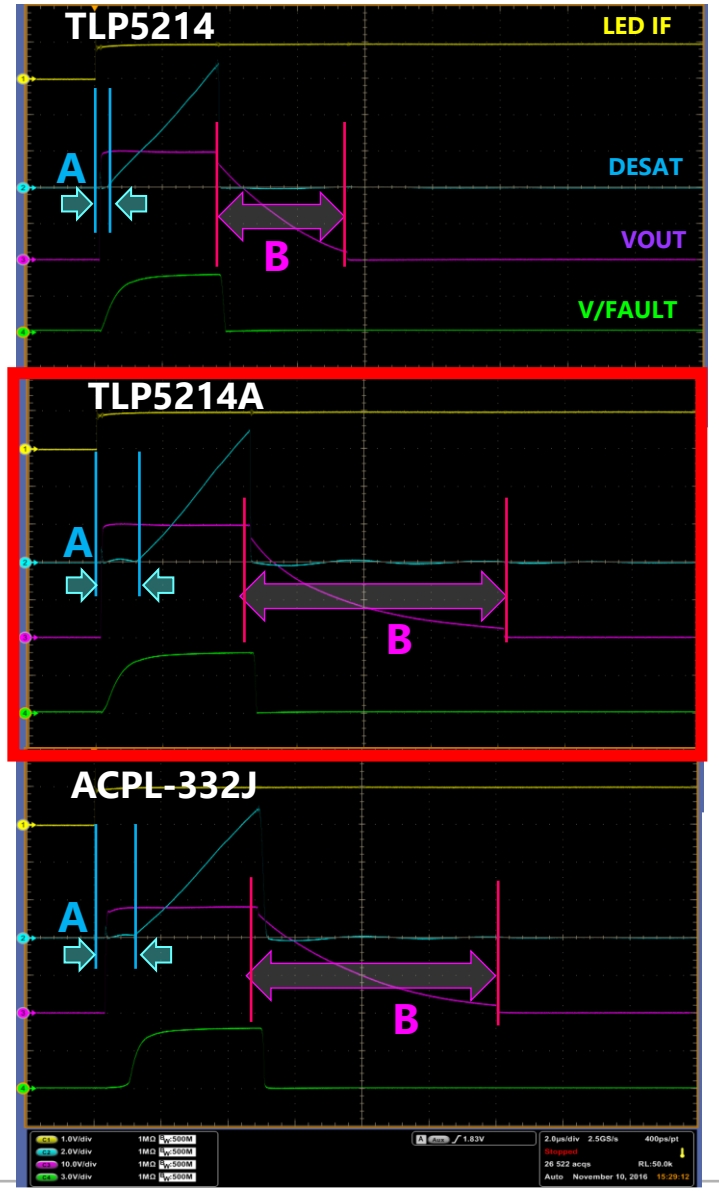
tDESAT(FAULT)(0.5us → 0.55us typ.)





	TLP5214	TLP5214A
tDESAT(LEB)	0.2μs（typ.）	1.1μs（typ.）
tDESAT(10%)	3.5μs（typ.）	7.0μs（typ.）
DESAT filter time	-	90ns（typ.）
tDESAT(FAULT)	0.5μs（max.）	0.55μ（max.）





Operation behavior [during protection mode]

10b Gate Driver Coupler with Active Miller Clamp function

TLP5814H *Under Development*

Built in MOSFET for miller clamp prevent self turn on of power devices easily.

Back to AC-DC / PFC

Feature

- Active Miller Clamp function
- High peak output current
- High CMTI

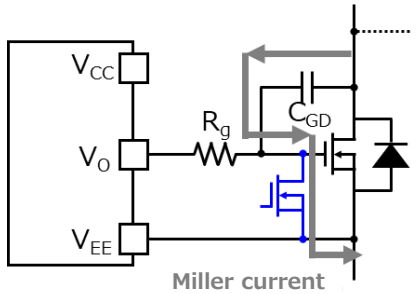
Part name	TLP5814H
Peak output current (Max.)	+6.8 / -4.8 A
Peak clamp sink current (Max.)	6.8 A
CMTI (Min.)	±70 kV/μs
Operating temp. (max)	125 ℃
Supply voltage	15 to 23 V

SO8L
Creepage : 8 mm
DTI : 0.4 mm
Bvs : 5000 Vrms

To avoid self turn-on.

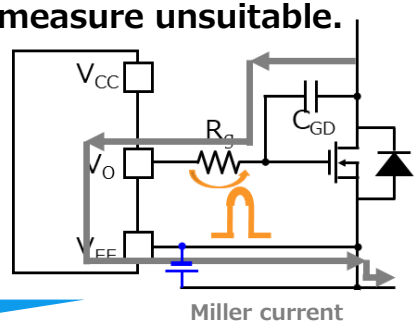
Adding a shunt circuit

It is necessary to add a bypass element and its control circuit.

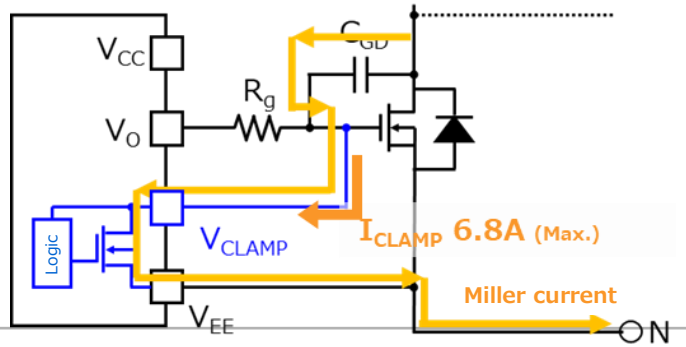


Using a negative gate power supply

SiC-MOSFETs have a low gate negative bias tolerance, making this countermeasure unsuitable.



Self turn on prevention with TLP5814H



SiC MOSFET

Provides robust self-turn-on prevention for SiC-MOSFETs

IGBT

Reduced negative bias power supply circuit

Development schedule and specifications are subject to change

10b Smart Gate Driver Comparison Table

*** Under development**

Back to AC-DC / PFC

Item	Symbol	TLP5214	TLP5214A	TLP5814H*
Total supply voltage	VCC2-VEE	15 ～ 30 V		13 ～ 23 V
Negative supply voltage	VE-VEE	-15 V ～ 0 V		-
Positive supply voltage	VCC2-VE	15V ～ 30 - (VE - VEE)		-
Positive supply voltage	VCC1	3.3 ～ 5.5 V		13 ～ 23 V
Threshold input current	IFHL	6 mA		3 mA
Peak output current	IOPH/IOPL	-4.0 / +4.0 A (max.)		-4.8 / +6.8 A
Propagation delay time	tpLH、tpHL	50 ～ 150 ns		150 ns max
Propagation delay skew	tpsk	-80 ～ +80 ns (max.)		-75 ～ +75 ns
DESAT threshold voltage	VDESAT	6 ～ 7.5 V	5.9 ～ 7.5 V	None
Blanking cap. charge current (typ.)	ICHG	-0.24 mA		
DESAT leading edge blanking time (typ.)	tDESAT(LEB)	0.2 µs	1.1 µs	
Soft shut down time (typ.)	tDESAT(10%)	3.5 µs	7.0 µs	
Clamp pin threshold voltage (typ.)	VtClanp	3.0 V	2.5 V	2.5 V
Clamp low level sinking current (typ.)	ICL	1.8 A	1.8 A	3.8 A
UVLO P threshold (typ.)	UVLO+	11.6 V	11.6 V	12.5 V
UVLO N threshold (typ.)	UVLO-	10.3 V	10.3 V	11.0 V
Common Mode Transient Immunity (min.)	CMTI	± 35 kV/µs	± 35 kV/µs	± 70 kV/µs
Fault reset method		LED trigger		LED trigger

https://toshiba.semicon-storage.com/us/semiconductor/product/isolators-solid-state-relays/detail.TLP5214.html

10c Transistor output photocoupler

TLP383

Low-loss, low-heat, and power efficiency

Small size packages

Back to AC-DC / PFC

Value Provided

Reduction in required board area and improving reliability enabling maintenance-free operation.

1 High current transfer ratio

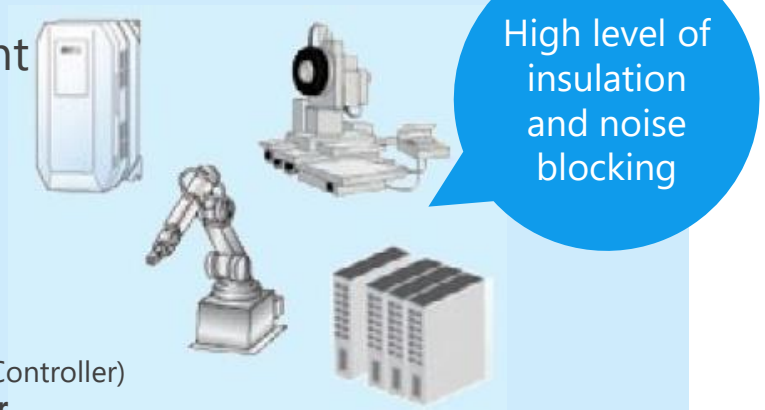
This is a high-isolation photocoupler that optically couples a phototransistor and a GaAs infrared light emitting diode. High current transfer ratio is realized at I_F = 5 mA.

2 Operating temperature is expanded to 110 °C

It is designed to operate even under severe temperature environments such as those for inverter devices, robots, machine tools, and high output power supplies.

Industrial equipment

General purpose inverter
Servo amplifier
Robot
Machine Tool
High output power supply
Security equipment
Semiconductor tester
PLC (Programmable Logic Controller)
Garage Door/Gate Opener



High level of insulation and noise blocking

Line Up

Part number	TLP383
Package	4 pin SO6L 
BV_S (Min) [Vrms]	5000
T_{opr} [deg.C]	-55 to 110

For more information see: Transistor Output Photocoupler

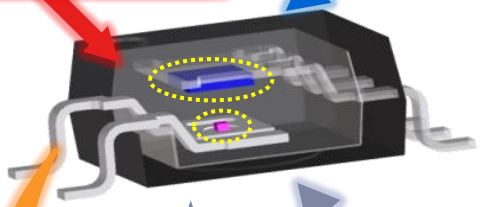
10c Advantage of TOSHIBA Isolation devices

Back to AC-DC / PFC

TOSHIBA

1 Long Life Time LED

2 High Performance Detector Chip

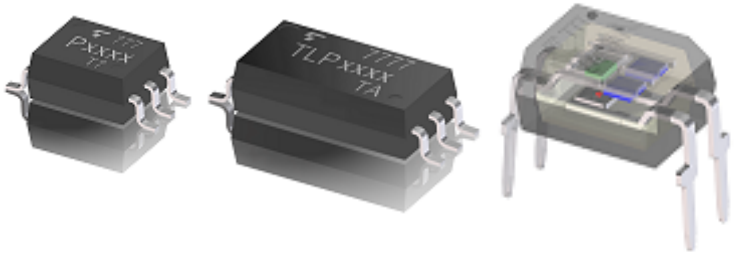


3 New Package

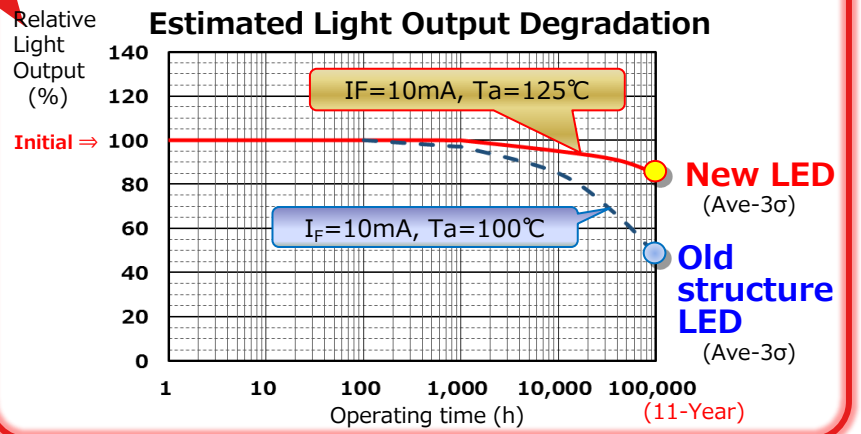
4 Latest Gen. MOSFET

High efficiency line products

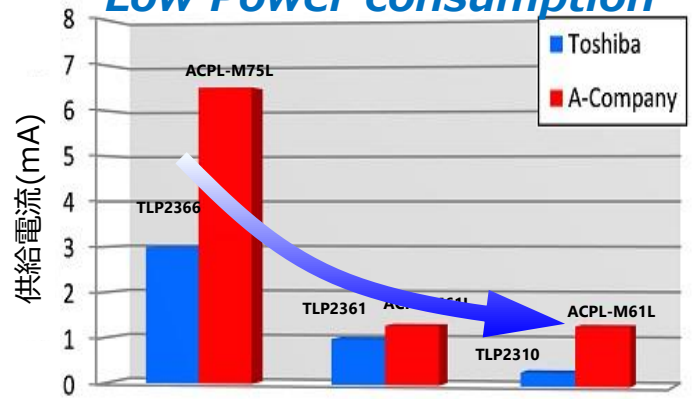
SO4、SO6、SO16
SO6L、SO8L、SO16L、DIP4



1

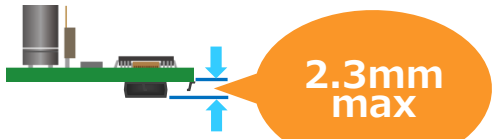


2 Low Power consumption

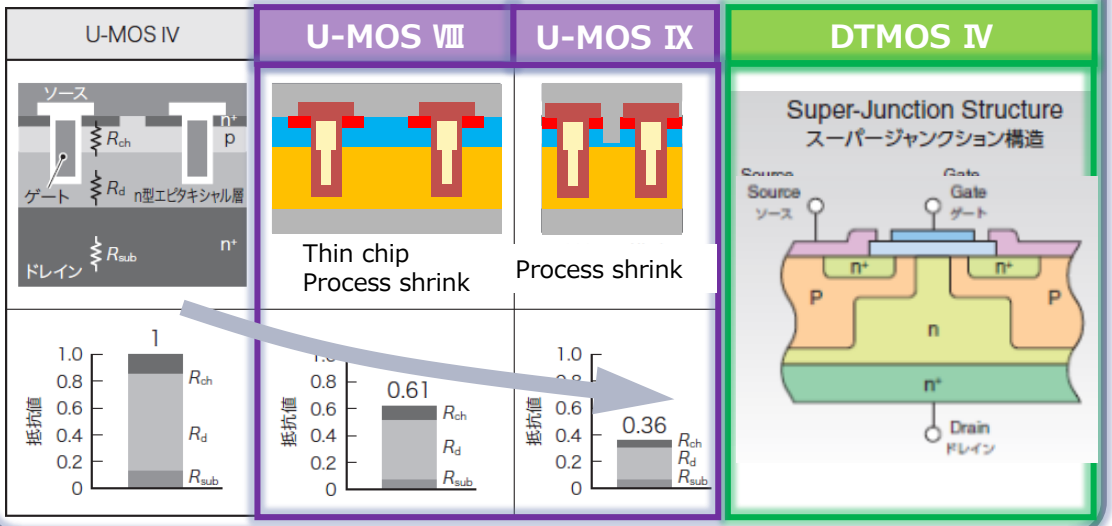


3 Thin package< 2.3 mm

Save space

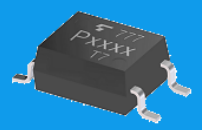
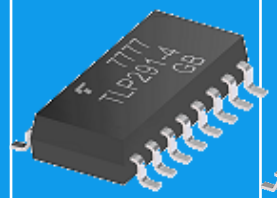
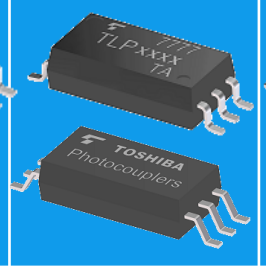
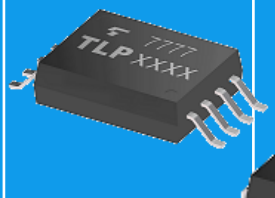
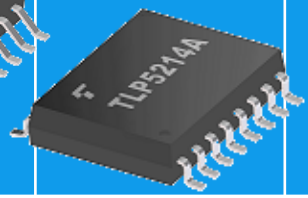
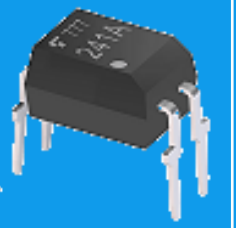


4 Implementation of the latest MOS process
Low voltage:U-MOSIX、high voltage:DTMOS



10c High efficiency line products

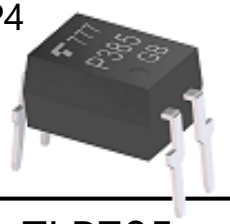
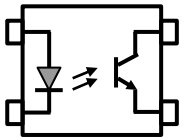
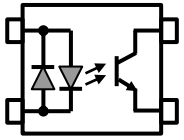
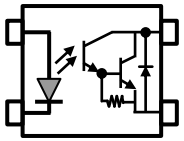
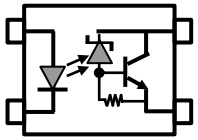
Back to AC-DC / PFC

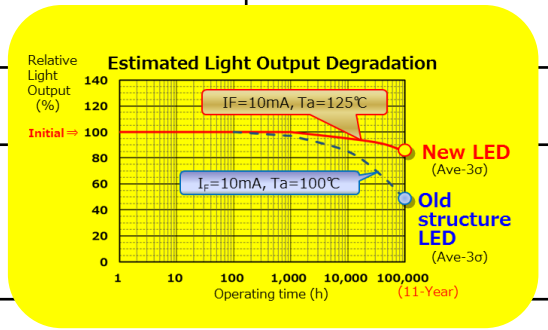
Package / Items	SO4	SO6	SO16	SO6L SO6L(LF4)	SO8L(LF4)	SO16L	DIP4	SOP4
								 White mold
Creepage	5mm			8mm				5mm
Internal clearance	0.4mm			0.4mm				TBD
BVs (min.)	3,750Vrms			5,000Vrms				1,500Vrms
Transistor	✓	✓ (4pin)	✓	✓ (4pin)			✓	
Gate driver		✓ (5pin)		✓ (6pin)	✓	✓		
IPM interface		✓ (5pin)		✓ (6pin)				
High speed logic		✓ (5pin)		✓ (6pin)	✓			
MOSFET relay		✓ (4pin)				✓ (U.D.)	✓	✓
Photo voltaic		✓ (4pin)						
TRIAC		✓ (4pin)						
Isolation amp.					✓			

DIP4 : SMD lead forming : LF1, LF4
(LF4) : Wide lead forming

10c Tr. Coupler line-up

Back to AC-DC / PFC

Creepage / Clearance		5 mm	5 mm	5 mm	8 mm	7 or 8 mm
Isolation Voltage		3750Vrms	2500/3750Vrms	3750Vrms	5000Vrms	5000Vrms
Feature \ Package		SO4 	SO16 	4pin-SO6 	4pin-SO6L 	DIP4 
	DC input	TLP291(SE	TLP291-4	TLP185(SE	TLP385	TLP785
	Low input	TLP293	TLP293-4	TLP183	TLP383	
	350V VCEO			TLP188	TLP388	TLP628M
	AC input	TLP290(SE	TLP290-4	TLP184(SE		
	Low input	TLP292	TLP292-4	TLP182		TLP620M
	Darlington					
	300V VCEO			TLP187	TLP387	TLP627M
	High speed Low input			TLP2301	TLP2701	



Using Long Life Time LED

For more information see: Transistor Output Photocoupler

Discrete Silicon N-Channel IGBT

GT15J341 / GT20J341 / GT30J341 / GT50J123 / GT30J65MRB

11a

Robustness

High efficiency · Low loss

Back to AC-DC / PFC

Value provided

Sixth generation hard switching devices capable for high voltage (600V or more) and high current (15A or more) application. Lineup of low $V_{CE(SAT)}$ products are effective in reducing conduction loss.

1 High speed, low saturation voltage

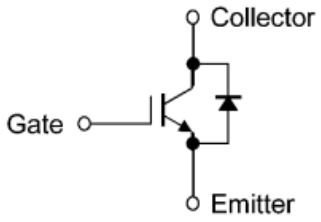
By adapting a thin wafer punch-through structure, high speed turn-off characteristics and low $V_{CE(SAT)}$ characteristics are realized.

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.



TO-220SIS

TO-3P(N)

Line up

Part Number	I_C (A)	$V_{CE(SAT)}$ @ IC (V, typ)	P_C (W)	Package
GT15J341	15	1.5	30	TO-220SIS
GT20J341	20	1.5	45	TO-220SIS
GT30J341	30	1.5	230	TO-3P(N)
GT50J123*	50	1.9	230	TO-3P(N)
GT30J65MRB	30	1.4	200	TO-3P(N)

* No built-in Body Diode

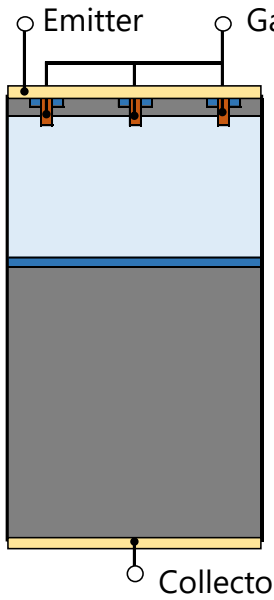
For more information see: GT15J341 GT20J341 GT30J341 GT50J123 GT30J65MRB

Product Generation and Performance (static characteristic)

Back to AC-DC / PFC

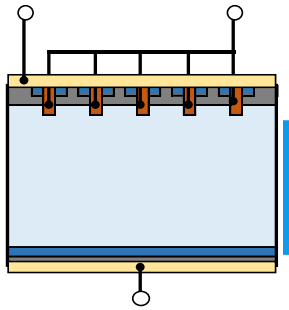
Toshiba continues to make improvements into the 7th Generation IGBT achieving Low $V_{CE(sat)}$ and high-speed switching by high density.

4th Generation
Punch-Thru type



Thin wafer
Fine cell

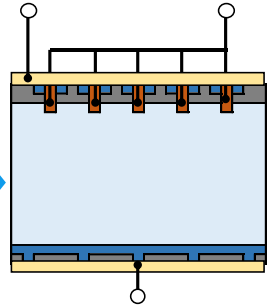
6th Generation
Field Stop type



Improved trade off
- **Low $V_{CE(sat)}$**
- **Fast switching**

Plus
"RC"

6.5th Generation
Field Stop type
with RC structure

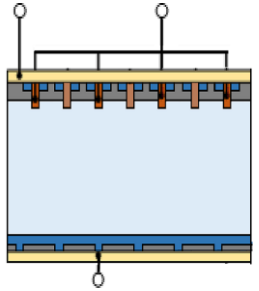


Monolithic
(IGBT & FRD)

◆Realized RC-IGBT because
it was easily short collector layer
due to transparent P collector layer

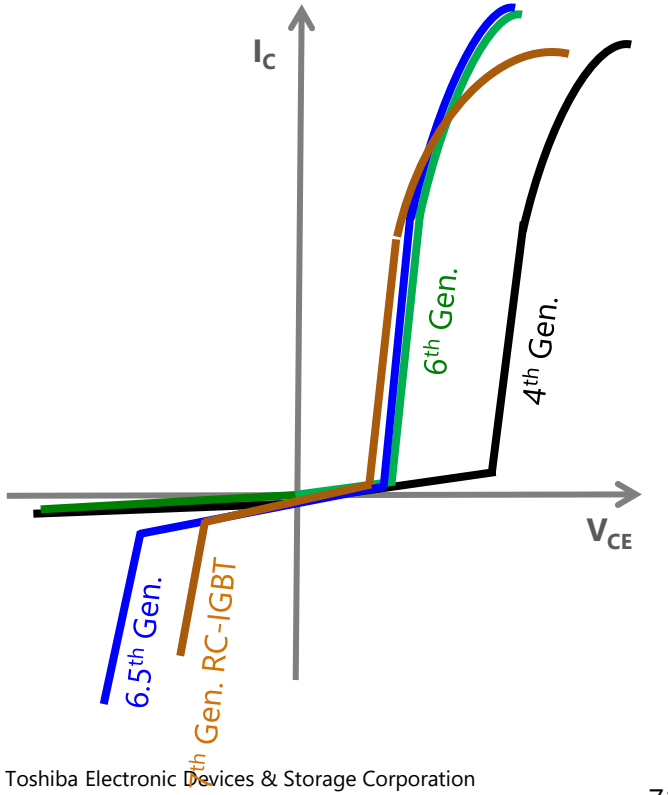
Narrow
Trench
Pitch

7th Generation
Field Stop type
with Narrow Trench
Pitch



Monolithic
or
2 chips in 1

Static performance
$I_C - V_{CE}$



(Note : N-(Drift layer) N+layer P+layer electrode Gate)

11a Product List of Toshiba Discrete IGBTs

Back to AC-DC / PFC

	Part number (Only out source)	Application example : ●(Main) ▲(Sub)						Design・Constructer・Package			Maximum ratings							
		Hard switching	Soft switching								IGBT part						Di part	
		General	General	Fast switching	Current resonance	Voltage resonance												
		○ Motor ○ Inverter	○ PFC (Percial Switching)	○ PFC (Active switching)	○IH cocker (Built-in) (All metal)	○ IH cocker (on table) ○ IH rice cocker ○ Micro Wave Oven	○ hot-water heater ○ Copier (toner heating)	Gen.	Built-in Di(*)	Package	Pc (W)	V_{CES} (V)	I_C (A)		I_{CP} (A)	tsc (μs)	I_F (A)	I_{FP} (A)
		○ Garage Door/Gate Openers ○ Air Conditioner	○Air conditioner (Power Supply)	○Air conditioner ○FA machine ○Welding machine		○ AC100V	○ AC200V				DC	DC	DC 25℃	DC 100℃	Pulse	Tj ≦ 150℃	DC	Pulse
	GT15J341	●	▲	▲				6th	Yes 2in1	TO-220SIS	30	600	15	8	60	5	15	
	GT20J121		●					6th	Non	TO-220SIS	40	600	20	-	80	-	–	–
	GT20J341	●	▲	▲				6th	Yes 2in1	TO-220SIS	45	600	20	11	80	5	20	
	GT30J122A		●					4th	Non	TO-3P(N)	120	600	30	-	100	-	–	–
	GT30J341	●	▲	▲	●			6th	Yes 2in1	TO-3P(N)	230	600	59	33	120	5	48	60
	GT50J123	●	▲	▲				6th	Non	TO-3P(N)	230	600	59	33	120	5	–	–
	GT50JR21				●			6.5th	Yes RC	TO-3P(N)	230	600	50	49	100	-	40	100
	GT50JR22(STA1			▲	●			6.5th	Yes RC	TO-3P(N)	230	600	50	44	100	-	40	100
	GT50JR22(S1WLD		▲	●	▲			6.5th	Yes RC	TO-3P(N)	230	600	50	40	100	-	40	100
New	GT30J65MRB		▲	●	▲			7th	Yes RC	TO-3P(N)	200	650	60	30	120	-	30	60
New	GT30J110SRA					●		6.5th	Yes RC	TO-3P(N)	312	1100	60	30	120	-	60	120
	GT60PR21					●		6.5th	Yes RC	TO-3P(N)	333	1100	60	53	120	-	30	120
	GT40QR21					●		6.5th	Yes RC	TO-3P(N)	230	1200	40	35	80	-	20	80
New	GT20N135SRA						●	6.5th	Yes RC	TO-247	312	1350	40	20	80	-	40	80
New	GT30N135SRA						●	6.5th	Yes RC	TO-247	348	1350	60	30	120	-	60	120
	GT40RR21						●	6.5th	Yes RC	TO-3P(N)	230	1350	40	33	80	-	20	80

*RC : 1 chip (reverse conduction structure)

*2in1 : 2 chips (IGBT + Di)

For more information see: IGBT

11a Product List of Toshiba Discrete IGBTs

Back to AC-DC / PFC

	Part number (Only out source)	Design・Constructer・Package			Maximum ratings							Electrical characteristics													
					IGBT part					Di part		IGBT part												Di part	
		Gen.	Built-in Di(*)	Package	Pc (W)	V_{CES} (V)	I_C (A)		I_{CP} (A)	tsc (μs)	I_F (A)	I_{FP} (A)	$V_{CE(sat)}$ (V)		$V_{GE(OFF)}$ (V)			Cies (pF)		Switching Time typ. (μs)				V_F (V)	
					DC	DC	DC 25℃	DC 100℃	Pulse	Tj ≦ 150℃	DC	Pulse	max	condition I_C/V_{GE}	min	max	condition Ic	typ.	condition V_{CE}	t_r	t_f	condition $V_{CE}/I_C/R_G$/Load	max	condition I_F
	GT15J341	6th	Yes 2in1	TO-220SIS	30	600	15	8	60	5	15		2.0	15A/15V	3.5	6.5	1.5mA	1390	10V	0.03	0.08	300V/15A/33Ω/L	2.0	15A
	GT20J121	6th	Non	TO-220SIS	40	600	20	-	80	-	–	–	1.8	20A/15V	4.5	7.5	20mA	2700	10V	0.1	0.27	300V/20A/39Ω/R	–	–
	GT20J341	6th	Yes 2in1	TO-220SIS	45	600	20	11	80	5	20		2.0	20A/15V	3.5	6.5	2mA	1790	10V	0.04	0.05	300V/20A/33Ω/L	2.1	20A
	GT30J122A	4th	Non	TO-3P(N)	120	600	30	-	100	-	–	–	2.8	50A/15V	3.0	6.0	50mA	2500	10V	0.2	0.2	300V/50A/39Ω/R	–	–
	GT30J341	6th	Yes 2in1	TO-3P(N)	230	600	59	33	120	5	48	60	2.0	30A/15V	3.5	6.5	3mA	2900	10V	0.06	0.04	300V/30A/24Ω/L	2.3	30A
	GT50J123	6th	Non	TO-3P(N)	230	600	59	33	120	5	–	–	2.5	50A/15V	4.5	6.5	3mA	2900	10V	0.06	0.04	300V/30A/24Ω/L	–	–
	GT50JR21	6.5th	Yes RC	TO-3P(N)	230	600	50	49	100	-	40	100	2.0	50A/15V	4.5	7.5	50mA	2700	10V	0.18	0.08	300V/50A/39Ω/R	2.1	15A
	GT50JR22(STA1	6.5th	Yes RC	TO-3P(N)	230	600	50	44	100	-	40	100	2.2	50A/15V	4.5	7.5	50mA	2700	10V	0.18	0.05	300V/50A/39Ω/R	2.1	15A
	GT50JR22(S1WLD	6.5th	Yes RC	TO-3P(N)	230	600	50	40	100	-	40	100	2.5	50A/15V	4.5	7.5	50mA	2700	10V	0.18	0.05	300V/50A/39Ω/R	2.1	15A
New	GT30J65MRB	7th	Yes RC	TO-3P(N)	200	650	60	30	120	-	30	60	1.8	30A/15V	4.2	6.2	30mA	2150	25V	0.03	0.04	400V/15A/56Ω/L	1.5	15A
New	GT30J110SRA	6.5th	Yes RC	TO-3P(N)	312	1100	60	30	120	-	60	120	1.8	30A/15V	5.0	7.0	60mA	2700	25V	0.14	0.17	600V/60A/10Ω/R	1.8	30A
	GT60PR21	6.5th	Yes RC	TO-3P(N)	333	1100	60	53	120	-	30	120	2.5	60A/15V	4.5	7.5	60mA	2350	10V	0.16	0.16	600V/60A/51Ω/R	2.5	15A
	GT40QR21	6.5th	Yes RC	TO-3P(N)	230	1200	40	35	80	-	20	80	2.7	40A/15V	4.5	7.5	40mA	1500	10V	0.12	0.2	600V/40A/39Ω/R	2.6	15A
New	GT20N135SRA	6.5th	Yes RC	TO-247	312	1350	40	20	80	-	40	80	2.4	40A/15V	5.3	7.3	40mA	2700	25V	0.09	0.25	600V/40A/10Ω/R	2.5	20A
New	GT30N135SRA	6.5th	Yes RC	TO-247	348	1350	60	30	120	-	60	120	2.6	60A/15V	5.3	7.3	60mA	2700	25V	0.14	0.25	600V/60A/10Ω/R	2.4	30A
	GT40RR21	6.5th	Yes RC	TO-3P(N)	230	1350	40	33	80	-	20	80	2.8	40A/15V	4.5	7.5	40mA	1500	10V	0.12	0.21	600V/40A/39Ω/R	2.8	15A

For more information see: IGBT

11b SiC Series 650 V MOSFET

TW015N120C / TW030N120C / TW045N120C / TW015Z120C / TW030Z120C / TW045Z120C

Robustness

High efficiency • Low loss

Back to AC-DC / PFC

Value provided

Efficient high-power switching with good heat conductivity.

1 Built-in SBD

Low V_F with built-in SBD
- Toshiba V_F=1.35V typ.
- Competitor V_F = 3.2~4.6V typ.

-> Good reliability due to no ON resistance drift!

2 Low R_{on} * Q_{gd}

Low R_{on} * Q_{gd} values allows for efficient and fast switching

Ron*A improves after each generation

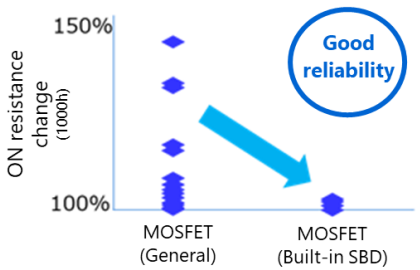
Low R_{on} temperature coefficient (tempco).

3 Wider V_{GSS} Rating

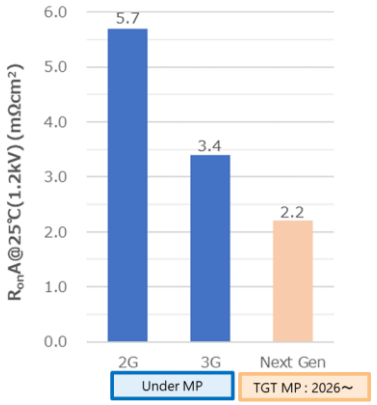
Wider VGSS ratings compared with the competition's SIC MOSFETs

VGSS: -10V ~ 25V (Recommend: 18V)

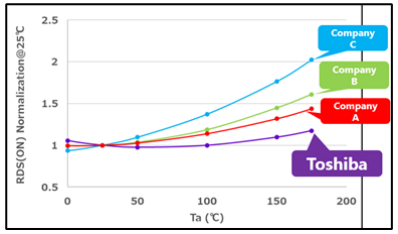
Built-in SBD prevents ON resistance drift over time, thus good reliability



Trend of R_{on}*A



Lowest R_{on} tempco



Line up

Part number	TW015N120C	TW030N120C	TW045N120C	TW015Z120C	TW030Z120C	TW045Z120C
Package	TO-247 			TO-247-4L 		
Abs Max I_D (A)	100	60	45	100	60	45
$R_{ds(on)}$ Typ **(Ω)**	15	30	45	15	30	45
Q_{gd} (nC)	158	82	57	158	82	57
C_{ISS} (VDS=300V) (pF)	6000	2925	1969	6000	2925	1969

For more information see: SiC 650V MOSFET

11b Line up of SiC MOSFET (650V)

※1 : V_{GSS} pulse
※2 : T_a=25 ℃
※3 : V_{GS}=18 V, T_a=25 ℃
※4 : V_{DS}=400 V, f = 100kHz

Back to AC-DC / PFC

Generation	Package	Part Number	Absolute Maximum Ratings					Electrical Characteristics			ES	CS	MP
			V_{DSS} (V)	V_{GSS} (V) ※1	I_D (A) ※2	T_j (℃)	T_{stg} (℃)	$R_{DS(ON)}$ typ. (mΩ)※3	Q_g typ. (nC)	C_{iss} typ. (pF)※4			
3rd Generation	TO-247	TW015N65C	650	-10～25	100	175	-55～175	15	128	4850	OK	OK	OK
		TW027N65C			58			27	65	2288	OK	OK	OK
		TW048N65C			40			48	41	1362	OK	OK	OK
		TW083N65C			30			83	28	873	OK	OK	OK
		TW107N65C			20			107	21	600	OK	OK	OK
	TO-247-4L	TW015Z65C			100			15	128	4850	OK	OK	OK
		TW027Z65C			58			15	128	4850	OK	OK	OK
		TW048Z65C			40			27	65	2288	OK	OK	OK
		TW083Z65C			30			48	41	1362	OK	OK	OK
		TW107Z65C			20			83	28	873	OK	OK	OK
	New TOLL	TW015U65C			100			15	128	4850	2Q 2024	3Q 2024	4Q 2024
		TW027U65C			58			27	65	2288	2Q 2024	3Q 2024	4Q 2024
		TW048U65C			40			48	41	1362	2Q 2024	3Q 2024	4Q 2024
		TW083U65C			30			83	28	873	2Q 2024	3Q 2024	4Q 2024
	New DFN8×8	TW(030)V65C			(58)			(30)	(65)	(2288)	2Q 2024	3Q 2024	4Q 2024
		TW(050)V65C			(40)			(50)	(41)	(1362)	2Q 2024	3Q 2024	4Q 2024
		TW(090)V65C			(30)			(90)	(28)	(873)	2Q 2024	3Q 2024	4Q 2024
		TW(120)V65C			(20)			(120)	(21)	(600)	2Q 2024	3Q 2024	4Q 2024

Note: The information in this table is subject to change without notice.

U-MOSX-H 150V Series

New Product

Back to AC-DC / PFC

Value

U-MOSX-H 150V series provides best-in class performance and improve the efficiency.

1 Low Switching losses

- $R_{DS\ (ON)}$ × Q_{SW} reduction (Cell design optimization)
- Large contribution at high frequency, especially in light load

2 Low Output charge losses

- $R_{DS\ (ON)}$ × Q_{OSS} reduction (Cell design optimization)

* Loss reduction of high-side MOSFET when used in low side of totem pole

3 Low Recovery losses

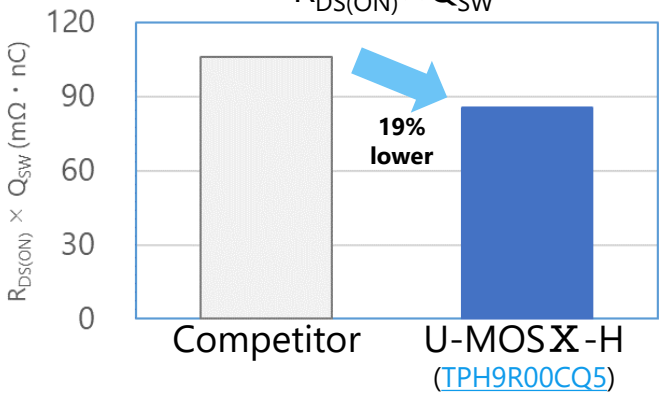
- Q_{rr} reduction (Applying Lifetime control technology)
- Large contribution at the secondary side synchronous rectifier circuit of the switching power supply unit

FOM Comparison with the nearest competitor

As of March 2021 (as surveyed by Toshiba)

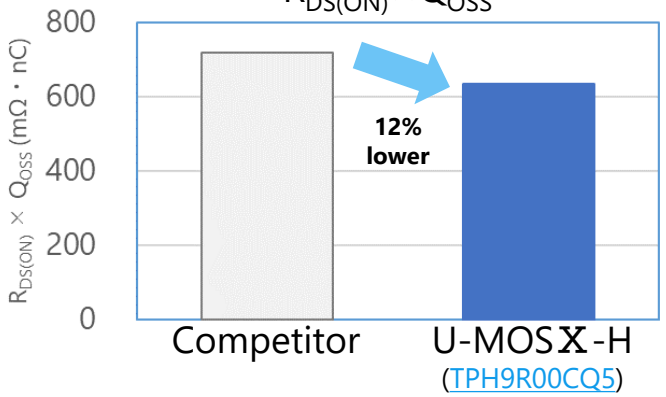
Conduction and switching losses

$R_{DS(ON)}$×Q_{SW}



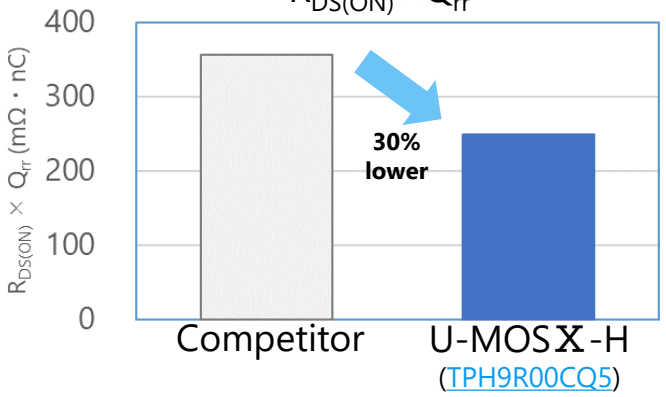
Conduction and output charge losses

$R_{DS(ON)}$×Q_{OSS}



Conduction and Body diode recovery losses

$R_{DS(ON)}$×Q_{rr}



FOM：Figure of Merit

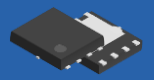
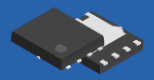
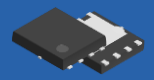
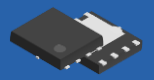
$R_{DS(ON)}$：On-resistance (figure of merit for conduction loss)
Q_{sw}：Gate switch charge (figure of merit for switching loss)
Q_{oss}：Output charge (figure of merit for output charge loss)
Q_{rr}： Reverse recovery charge (figure of merit for body diode recovery loss)

12a New Product Series U-MOSX 150V

New Product

Back to AC-DC / PFC

Performance of U-MOSX-H STD/HSD is better than that of either U-MOSVIII-H or competitors.

Item	U-MOSVIII-H (TPH1500CNH)  5 x 6 mm		U-MOSX-H(STD) (TPH9R00CQH)  5 x 6 mm		U-MOSX-H(HSD) (TPH9R00CQ5)  5 x 6 mm		Competitor A  5 x 6 mm		Competitor B  5 x 6 mm	
V_{DSS}	150 V	-	150 V	-	150 V	-	150 V	-	150V	-
V_{th}	2.0～4.0V	★	3.3～4.3V	★★★	3.1～4.5V	★★★	3.0～4.6V	★★	2.5～4.5V	★
T_{ch}	150 ℃	★★	175 ℃	★★★	175 ℃	★★★	150 ℃	★★	150 ℃	★★
$R_{DS(ON)}$ @VGS=10V typ.	13 mΩ	★	7.3 mΩ	★★★	7.3 mΩ	★★★	7.9 mΩ	★★	7.0 mΩ	★★★
$R_{DS(ON)}$*Q_{SW}	107 mΩ･nC	★	85*1 mΩ･nC	★★	85*1 mΩ･nC	★★	106 mΩ･nC	★	62*1 mΩ･nC	★★★
$R_{DS(ON)}$*Q_{oss}	(897) mΩ･nC	★	635 mΩ･nC	★★★	635 mΩ･nC	★★★	719 mΩ･nC	★★	707 mΩ･nC	★★
$R_{DS(ON)}$*Q_{rr}	(2483) mΩ･nC	★	971*1mΩ･nC	★★	248*1mΩ･nC	★★★	356*1mΩ･nC	★★★	826*1mΩ･nC	★★

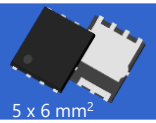
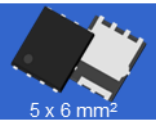
*1 Measured value on same condition

For more information see: U-MOS 150V MOSFET

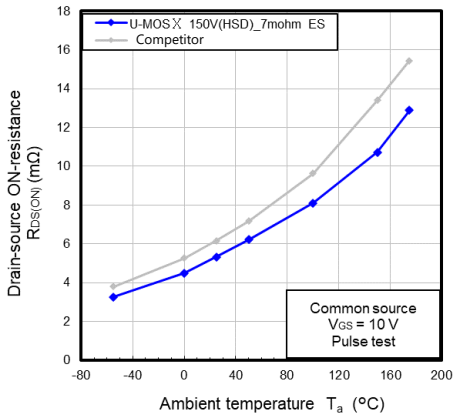
New Product Series U-MOSX 150V

Added a new product outperforming competitors in terms of $R_{DS(ON)}$.

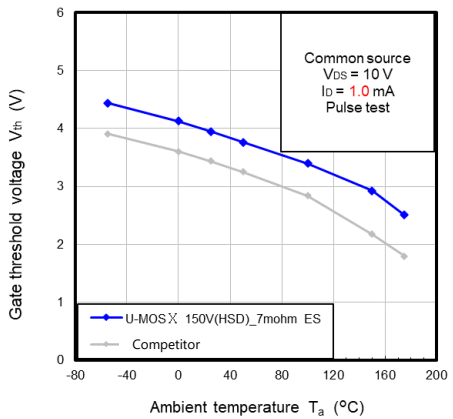
ES : Apr. 2024
Order Available : Oct. 2024

Item	U-MOSX-H(HSD) (TPM7R10CQ5) S1TN0  5 x 6 mm²		Competitor A  5 x 6 mm²	
Operation Temp	175degC	★★★	175degC	★★★
I_{DSStyp}(@100degC)	1.52 μA*1	★★	3.18μA*1	★
V_{th}	3.1V～4.5V	★★	3.0～4.6V	★
$R_{DS(ON)typ}$ at 10V	5.4*1 mΩ	★★★	6.2*1 mΩ	★★
$Q_{sw(VDS=75V)}$	18*1 nC	★★	15*1 nC	★★★
$Q_{oss(VDS=75V)}$	107*1 nC	★★	108*1 nC	★★
$Q_{rr(dI/dt=100A/us)}$	43*1 nC	★★★	55*1 nC	★★

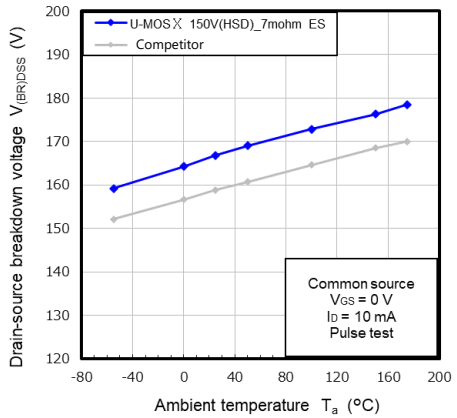
*1 Measured value on same condition (Toshiba devices are equal to datasheet).



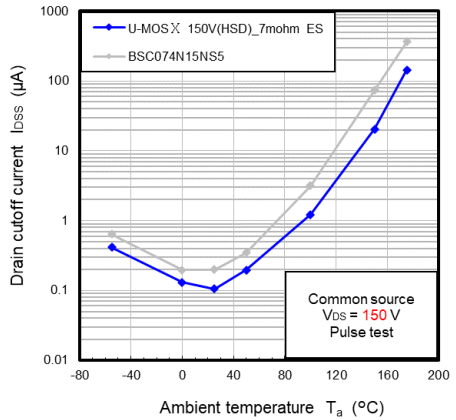
$R_{DS(ON)(Vgs①)}$ - Ta



V_{th} - Ta



$V_{(BR)DSS}$ - Ta



IDSS - Ta

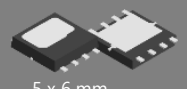
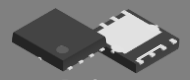
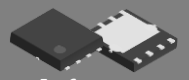
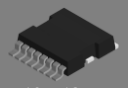
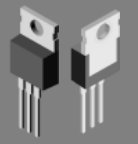
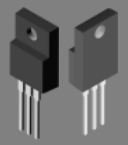
(Confidential)

12a Line up plan of U-MOS 150V products

New Product

Back to AC-DC / PFC

(CY)

$R_{DS(ON)}$ Max (V_{GS}= 10V) (mohm)	Package								
	DSOP Advance (dual sided cooling)  5 x 6 mm	SOP Advance(E) (5x6)  5 x 6 mm	SOP Advance(N) (5x6)  5 x 6 mm	SOP Advance (5x6)  5 x 6 mm	TSON Advance (3x3)  3 x 3 mm	L-TOGL (TOLL leaded)  10 x 12 mm	DPAK (TO-252) 	TO-220 	TO-220SIS (Fullpak) 
50				TPH5900CNH 59	TPN5900CNH 59 TPN4800CQH 48				
40									
30			TPH3300CQH (Order Mar. 2025) 33	TPH3300CNH 33	TPN3300CQH (ES Jan. 2025) 33 TPN3300CQ5 (HSD) (ES 3Q 2025) 33				
25									
20			TPH2200CQH (Order Mar. 2025) 22						
15	TPW1500CNH Conventional type 15.4		TPH1500CNH1 15.4 TPH1400CQH 14.1 TPH1400CQ5 (HSD) 14.1						
12									
10			TPH1100CQ5 (HSD) 11.1 TPH9R00CQH 9 TPH9R00CQ5 (HSD) 9	TPH9R00CQH 9				TK9R6E15Q5(HSD) (Order Jul. 2024) 9.6	TK9R7A15Q5(HSD) (Order Jul. 2024) 9.7
8	S1VM7 (HSD) (ES 2H 2025) 7.1	TPM7R10CQ5(HSD) (ES Oct. 2024) 7.1						TK7R2E15Q5(HSD) (Order Jul. 2024) 7.2	TK7R4A15Q5(HSD) (Order Jul. 2024) 7.4
6									
5								TK4R9E15Q5(HSD) (Order Jul. 2024) 4.9	TK5R0A15Q5(HSD) (Order Jul. 2024) 5.0

Under Investigation | Under Development | ES Available | Order Available | Under MP (Successor Available)

Note : Specifications and schedule of under development is just target and is subject to change without notice.

For more information see: U-MOS 150V MOSFET

U-MOS IX-H 80V Series

New Product

Back to AC-DC / PFC

Value

U-MOSX-H 80V series provides best-in class performance and improve the efficiency.

1 Low drive losses

- $R_{DS\ (ON)} \times Q_g$ reduction (Cell design optimization)
- Large contribution at high frequency, especially in light load

2 Low Output charge losses

- $R_{DS\ (ON)} \times Q_{OSS}$ reduction (Cell design optimization)

* Loss reduction of high-side MOSFET when used in low side of totem pole

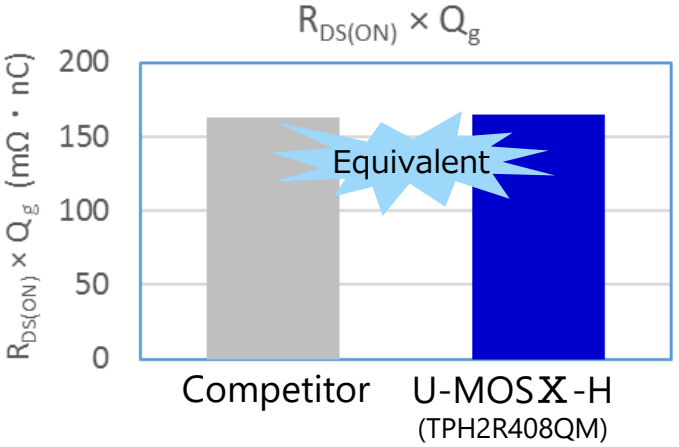
3 Low Recovery losses

- Q_{rr} reduction (Cell design optimization)
- Large contribution at the secondary side synchronous rectifier circuit of the switching power supply unit

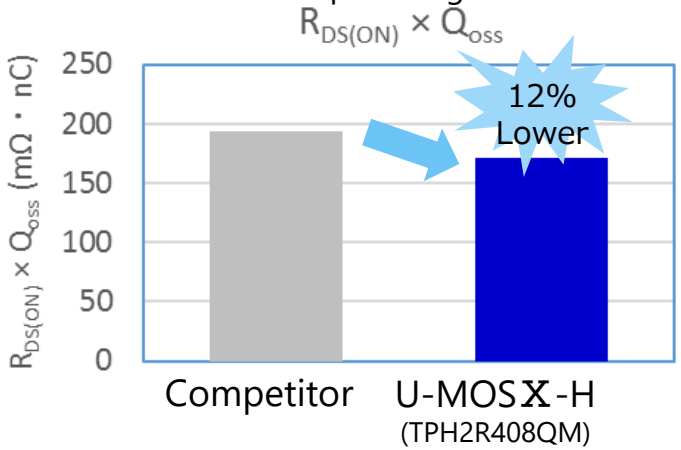
FOM Comparison with nearest competitor

As of March 2020 (as surveyed by Toshiba)

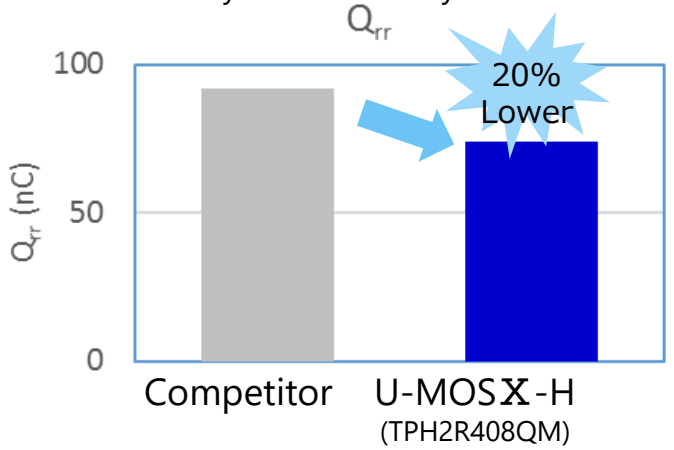
Conduction and drive losses



Conduction and output charge losses



Body diode recovery losses



FOM：Figure of Merit　$R_{DS(ON)}$：On-resistance (figure of merit for conduction loss)
Q_g：Gate charge (figure of merit for drive loss)

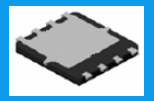
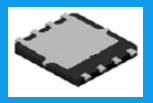
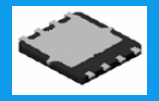
Q_{oss}：Output charge (figure of merit for output charge loss)
Q_{rr}： Reverse recovery charge

New Product Series U-MOSX-H 80V

New Product

Back to AC-DC / PFC

Performance of U-MOSX-H is better than that of either U-MOSVIII-H or Competitor

Item	U-MOSVIII-H [TPH4R008NH]  5 x 6mm		U-MOSX-H [TPH2R408QM]  5 x 6mm		Competitor  5 x 6mm	
V_{DSS}	80 V	-	80 V	-	80 V	-
V_{th}	2.0～4.0V	★	2.5～3.5V	★★★	2.2～3.8V	★★
T_{ch}	150 ℃	★★	175 ℃	★★★	150 ℃	★★
$R_{DS(ON)}$ @V_{GS}= 10V typ.	3.3 mΩ	★	1.9 mΩ	★★★	2.2 mΩ	★★
$R_{DS(ON)}$*Q_{sw}	59.4 mΩnC	★	53.2 mΩnC	★★★	55 mΩnC	★★
$R_{DS(ON)}$*Q_{oss}	247 mΩnC	★	171 mΩnC	★★★	194 mΩnC	★★
SOA	Standard	★	Wider	★★	Wider	★★

For more information see: U-MOS 80V MOSFET

12b Line up plan of U-MOS 80V products

New Product

Back to AC-DC / PFC

$R_{DS(ON)}$ Max (V_{GS}= 10V) (mohm)	Package								
	DSOP Advance (5x6 dual sided cooling) 5 x 6 mm	SOP Advance(E) (5x6) 5 x 6 mm	SOP Advance(N) (5x6) 5 x 6 mm	SOP Advance (5x6) 5 x 6 mm	TSON Advance (3x3) 3 x 3 mm	L-TOGL (TOLL leaded) 10 x 12 mm	DPAK (TO-252)	TO-220	TO-220SIS (Fullpak)
30					TPN30008NH 30				
25									
20					TPN19008QM 19				
15									
12				TPH12008NH 12.3	TPN13008NH 13.3 TPN12008QM 12.3			TK35E08N1 12.2	TK35A08N1 12.2
10									
8			TPH8R808QM 8.8	TPH8R008NH 8	TPN8R408QM 8.4			TK46E08N1 8.4 TK7R0E08QM 7	TK46A08N1 8.4
6			TPH6R008QM 6				TK6R9P08QM 6.9		TK6R8A08QM 6.8
5							TK5R1P08QM 5.1	TK5R3E08QM 5.3	TK5R1A08QM 5.1 TK72A08N1 4.5
4	S1SK0 (ES 1H 2026) 4 TPW4R008NH Conventional type 4		TPH4R008 4 TPH4R008QM 4					TK72E08N1 4.3	
3			TPH3R008QM 3					TK3R3E08QM 3.3 TK100E08N1 3.2	TK100A08N1 3.2 TK3R2A08QM 3.2
2.5			TPH2R408QM 2.43	TPH2R408QM 2.43				TK2R4E08QM 2.44	TK2R4A08QM 2.44
2	S1VM5 (ES 2H 2025) 2	TPM1R908QM (ES Feb. 2025) 1.94							
1									
0.8						XPQR8308QB (Order 2H 2025) 0.83			

Under Investigation | Under Development | ES Available | Order Available | Under MP (Successor Available)

Note : Specifications and schedule of under development is just target and is subject to change without notice.

For more information see: U-MOS 80V MOSFET

Electronic fuse (eFuse IC)

TCKE8 Series / TCKE7 Series

High efficiency · Low loss

Small size package

Back to AC-DC/PFC

Value provided

Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as overcurrent and overvoltage.

1 Can be used repeatedly

When overcurrent flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. It is not destroyed by a single overcurrent and can be used repeatedly.

2 IEC 62368-1 certified

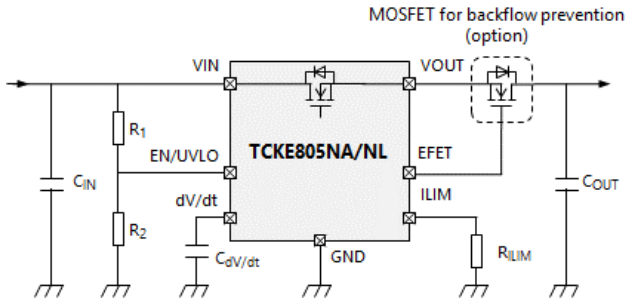
Toshiba's eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3 Rich protection functions

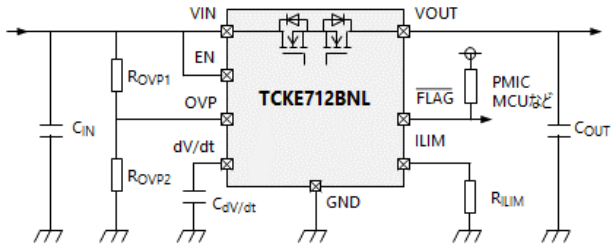
TCKE8 Series: Short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

TCKE7 Series: Short-circuit protection, overcurrent protection, overvoltage protection, thermal shut down, FLAG signal output, backflow prevention (built-in), etc.

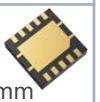
Reference circuit example of TCKE8 Series



Reference circuit example of TCKE7 Series



Line up

Part number	TCKE800NA/NL	TCKE805NA/NL	TCKE812NA/NL	TCKE712BNL
Package	WSON10B 3.0 x 3.0 x 0.75 mm  			WSON10 3.0 x 3.0 x 0.75 mm 
V_{IN} [V]	4.4 to 18			4.4 to 13.2
I_{OUT} (Max) [A]	5			3
R_{ON} (Typ.) [mΩ]	28			53
Return function	NA: Automatic return NL: Latch type (external signal control)			Latch type (external signal control)
V_{OVC} (Typ.) [V]	-	6.04	15.1	Adjustable

For more information, see: eFuse

SiC Schottky Barrier Diode

TRS4E65H

High efficiency · Low loss

Small size package

Back to AC-DC / PFC

Value provided

Toshiba 3rd generation SiC Schottky barrier diode provides low power loss and durable performance

1 Low V_F

Thin wafer technology and new metal adaption leads to industry lowest forward Voltage, V_F

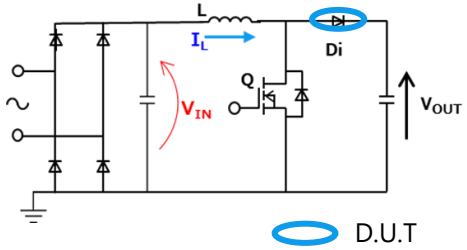
2 Low I_R

- Low reverse current I_R achieved by modified JBS structure and adjusting the process for 3rd generation

3 Large I_{FSM}

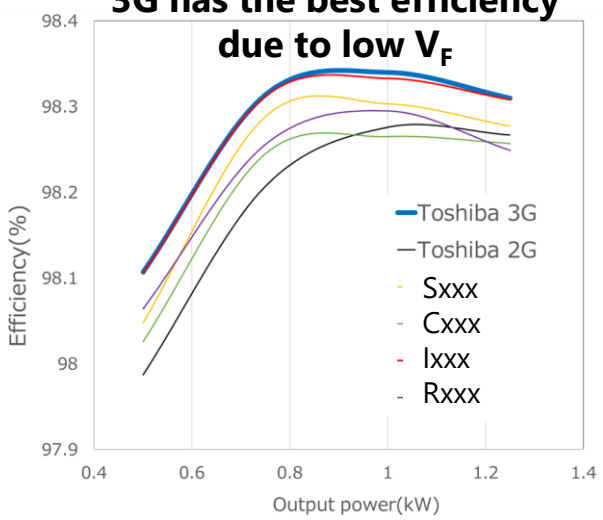
Large peak forward surge current I_{FSM} achieved by modified JBS structure and adjusting the process for 3rd generation

2.5kW PFC circuit



Operating condition:
V_{IN}=200V AC
V_{OUT}=400V DC
f=65kHz
MOSFET=TK040Z65Z w/external gate resistance=4.7Ω
T_a=25°C

3G has the best efficiency due to low V_F



Line up

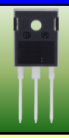
Part number	TRS6E65H
Forward Voltage V_F (V) Typ	1.2
Total Capacitive Charge Q_C (nC) Typ	17
Reverse Current IR (μA) Typ	1.1
N-R peak fwd surge current* IFSM (A)	41
N-R peak fwd surge current** IFSM (A)	310
Package**	TO-220-2L

*f=50Hz (half sine wave t=10ms) Tc=25°C
**Square wave t=10μs Tc=25°C
***Other packages available: TO247 and DFN8x8

For more information see: TRS4E65H SiC SBD Parametric

650V SiC SBD Lineup

Back to AC-DC / PFC

$I_{F(max)}$ (A)	TO-220F-2L	TO-220-2L		TO-247-CT	DFN8×8
					
	2nd gen.	2nd gen.	3rd gen.	2nd gen.	3rd gen.
	V_F=1.45V(typ.)	V_F=1.45V(typ.)	V_F=1.2V(typ.)	V_F=1.45V(typ.)	V_F=1.2V(typ.)
2		TRS2E65F MP	TRS2E65H MP		
3		TRS3E65F MP	TRS3E65H MP		
4	TRS4A65F MP	TRS4E65F MP	TRS4E65H MP		TRS4V65H MP
6	TRS6A65F MP	TRS6E65F MP	TRS6E65H MP		TRS6V65H MP
8	TRS8A65F MP	TRS8E65F MP	TRS8E65H MP		TRS8V65H MP
10	TRS10A65F MP	TRS10E65F MP	TRS10E65H MP		TRS10V65H MP
12	TRS12A65F MP	TRS12E65F MP	TRS12E65H MP	TRS12N65FB MP	TRS12V65H MP
16				TRS16N65FB MP	
20				TRS20N65FB MP	
24				TRS24N65FB MP	

Under Investigation → ES Under development → ES Available → Under MP

See: SIC SBD

Note.1: The information in this table is subject to change without notice.

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