

Small-Signal Semiconductors

Toshiba Small-Signal Devices

Rely on Toshiba's advanced process and packaging technologies to add features, improve performance, and reduce power consumption to enhance your system applications.

Load Switch ICs

One-chip switch solutions with ultra-low on-resistance and various protection features



WCSP4

WCSP6B

Pages 6-7

LDO Regulator (Low-Dropout Regulators)

Added 500-mA-output type with ultra-low power loss and low output voltage



SDFN4

ESV
(SOT-553)

Pages 10-11

Power Multiplexer ICs

High-performance power source selector switches with protection features



WCSP9

WCSP16C

Pages 8-9

MOSFETs

Combined with ultra-low on-resistance and ultra-small packaging to reduce the device power loss



UDFN6B
(SOT-1220)

SOT-23F

Pages 12-13

ESD Protection Diodes

Line-up expanded with the addition of low-dynamic-resistance type with low capacitance, for improved protection performance.



SL2

DFN5

Pages 14-15

MOSFETs for Automotive Applications

MOSFETs for automotive relay and LED drive applications



UFM

SOT-23F

Pages 18-19

ESD Protection Diodes for Automotive Interface Applications

ESD protection diodes for automotive CAN and LIN interface applications



USC
(SOD-323)

USM
(SOT-323)

Pages 16-17

Mobile Application Examples

Page 4

Automotive Application Examples

Page 5

AEC-Q100/101-Compliant Automotive Devices

Page 20

Web Simulator

Page 21

Packaging information

Pages 22-23

Visit our website for detailed information about the devices shown herein and various other types of devices.

- Discretes: MOSFETs, bipolar transistors, bias resistor built-in transistors (BRTs), Schottky barrier diodes, ESD protection diodes, switching diodes
- Linear ICs: Load switch ICs, power multiplexers, LDO regulators, operational amplifiers, comparators, magnetic sensors
- Logic ICs: CMOS logic ICs, one-gate logic
(Automotive applications: AEC-Q100/101-compliant devices, general-purpose logic ICs with an extended operating temperature range)

For the latest information, visit our website: <http://toshiba.semicon-storage.com/>

Recommended Products by Application

Mobile Applications

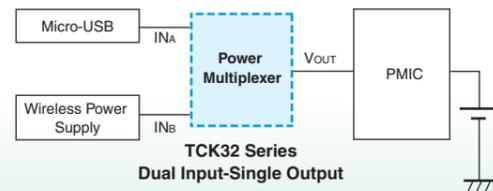


The smartphone and tablet market will continue to expand. Smartphones and tablets require a battery pack with an even higher capacity as they provide more and more versatile features such as a high-resolution camera, WiFi, NFC and FeliCa™. Toshiba offers high-performance and feature-rich devices for these mobile applications.

NFC: Near Field Communication
* FeliCa is a trademark of Sony Corporation

2-Channel 2-A Battery Charger

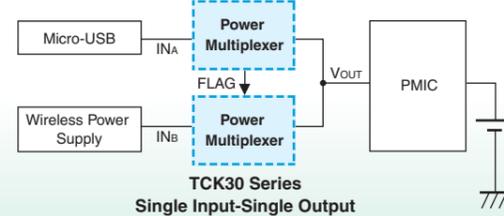
2-channel charging circuit using a 2-to-1 power multiplexer IC



See pages 8 and 9.

2-Channel 3-A Battery Charger

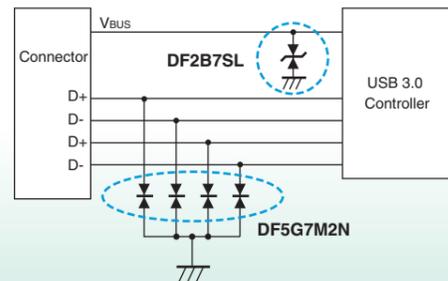
Battery charging at up to 3 A using power multiplexer ICs



See pages 8 and 9.

ESD Protection Circuit

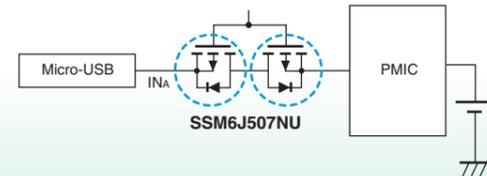
Designed for a high-speed interface, and protects ICs from ESD



See pages 14 and 15.

High-Current Charging Circuit

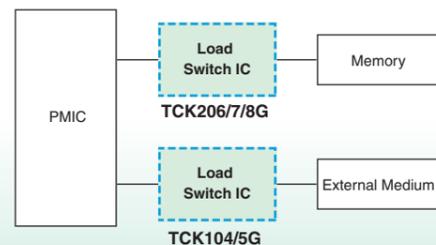
Battery charging at 3 A or higher using low-on-resistance MOSFETs



See pages 12 and 13.

On-Chip Power Supply Circuit — 1

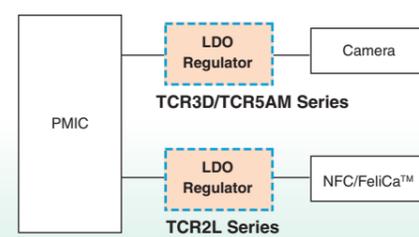
Low-voltage operation and various protection features



See pages 7 and 8.

On-Chip Power Supply Circuit — 2

Outstanding low-noise performance and voltage regulation



See pages 10 and 11.

PMIC: Power Management IC

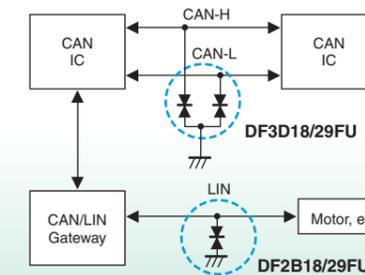
Automotive Applications



Electronic control units (ECUs) are becoming increasingly sophisticated and complex. With this trend on the upswing, more and more semiconductor devices are being integrated into vehicles. Consequently, the need for small semiconductor packages is increasing to meet the demand for high-density ECU assembly. Toshiba offers semiconductor devices in small packages for various automotive applications that provide automotive-grade reliability.

ESD Protection Circuit

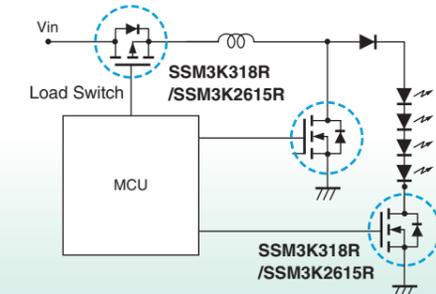
Robust protection improves the reliability of automotive systems.



See pages 16 and 17.

LED Control Circuitry

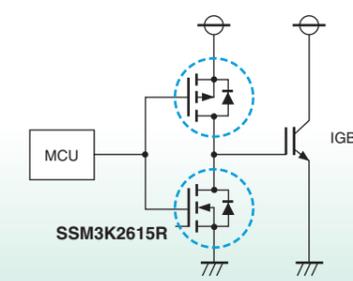
60-V devices are suitable for serial LED driver.



See pages 18 and 19.

Drive Circuit

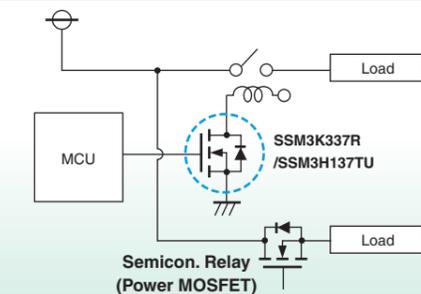
Low-voltage devices that can be driven directly by an MCU



See pages 18 and 19.

Mechanical Relay or Solenoid Driver

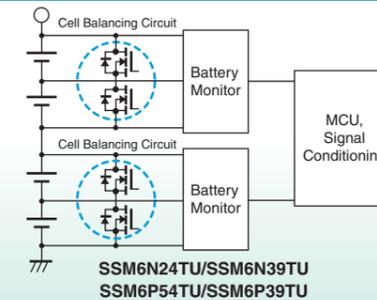
Active clamp structure that is less affected by inductive loads such as relays



See pages 18 and 19.

Battery Cell Balancing Circuit

Low on-resistance devices are suitable for high cell balance current.



See pages 18 and 19.

Visit our website for various application circuit examples.
For the latest information, visit our website:
<http://toshiba.semicon-storage.com/>

Load Switch ICs

Load switch ICs are designed to allow intricate power sequencing in order to reduce the system power consumption. Toshiba's load switch ICs feature a wide operating voltage range and low on-resistance and provide additional functions. Our product portfolio includes load switch ICs for mobile applications that are housed in ultra-small packages approximately one millimeter square.

Features

1. Wide operating voltage range

Toshiba's load switch ICs support a wide operating voltage range from 0.75 V to 5.5 V

2. Low on-resistance

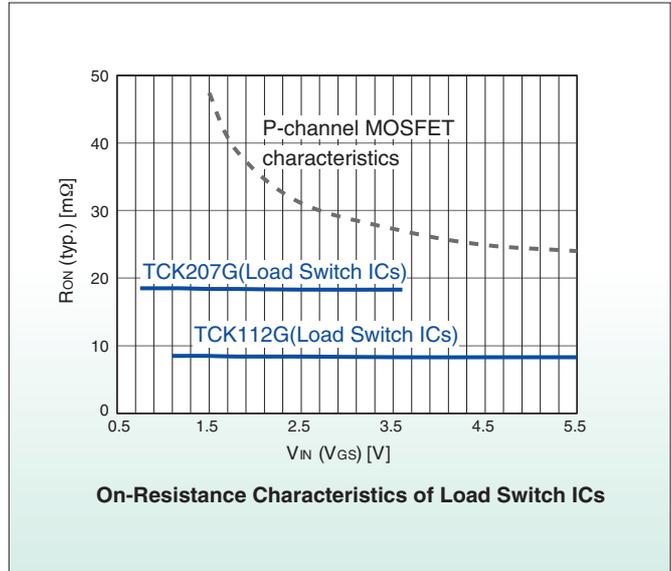
A small-geometry process and an advanced circuit technology combine to deliver low on-resistance, contributing to a reduction of a system's power loss.

3. Additional features

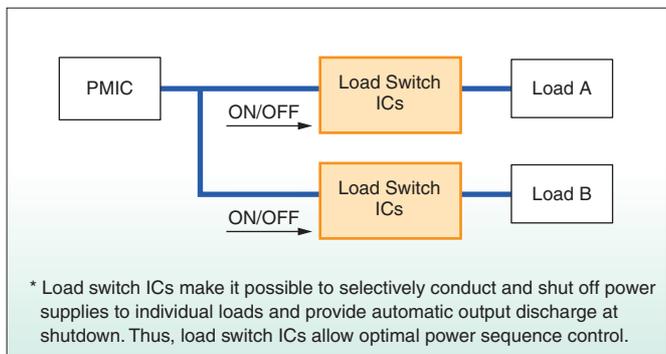
Load switch ICs simplify the design of a power supply circuit that would become complicated if composed of discrete devices.

● Additional features

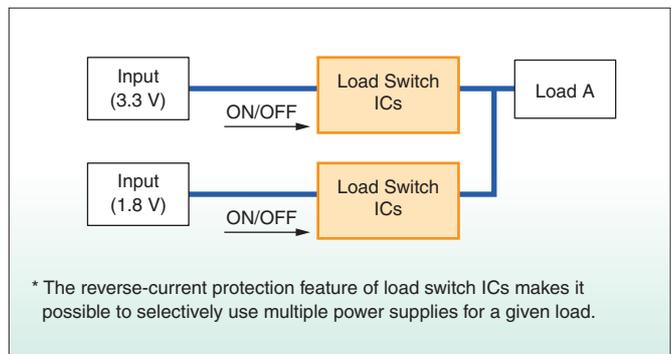
- Inrush current reducing
- Output discharge
- Reverse-current blocking
- Overcurrent protection
- Thermal shutdown



■ Application Example: Power distribution control circuit

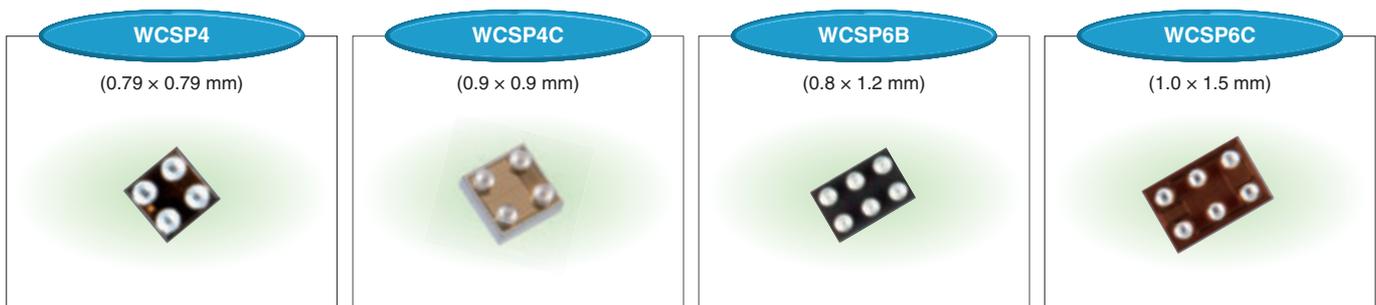


■ Application Example: Power source selection circuit



4. Ultra-small packages

Saves board space due to the use of WCSP packages



To allow selective use of two power sources: Power multiplexers.....Pages 8–9

To build a load switch circuit with an additional advantage of low on-resistance: MOSFETs..... Pages 12–13

New Products

3-A load switch ICs with reverse-current and overtemperature protection

TCK11 Series

Electrical Characteristics: Ultra-low on-resistance

$R_{ON} = 8.5 \text{ m}\Omega$ (typ.) @ $V_{IN} = 1.1 \text{ V}$, $I_{OUT} = -1.5 \text{ A}$

$R_{ON} = 8.3 \text{ m}\Omega$ (typ.) @ $V_{IN} = 5.0 \text{ V}$, $I_{OUT} = -1.5 \text{ A}$

Product Lineup

Part Number	Package	Operating Voltage (V)	I _{OUT} (A)	Functions					Control
				Inrush Current Reducing	Output Discharge	Reverse-Current Blocking	Over current Protection	Thermal Shutdown	
TCK111G	WCSP6C	1.1 to 5.5	3	○	-	○	-	○	Active H
TCK112G				○	○	○	-	○	Active H

0.75 V operating, small load switch IC with reverse current blocking

TCK20 Series

Electrical Characteristics: Ultra-low on-resistance

$R_{ON} = 18.4 \text{ m}\Omega$ (typ.) @ $V_{IN} = 0.75 \text{ V}$, $I_{OUT} = -1.5 \text{ A}$

$R_{ON} = 18.1 \text{ m}\Omega$ (typ.) @ $V_{IN} = 3.3 \text{ V}$, $I_{OUT} = -1.5 \text{ A}$

Product Lineup

Part Number	Package	Operating Voltage (V)	I _{OUT} (A)	Functions					Control
				Inrush Current Reducing	Output Discharge	Reverse-Current Blocking	Over current Protection	Thermal Shutdown	
TCK206G	WCSP4C	0.75 to 3.6	2	○	-	○	-	○	Active H
TCK207G				○	○	○	-	○	Active H
TCK208G				○	○	○	-	○	Active L

Ultra-small load switch ICs featuring low power consumption

TCK10 Series

Electrical Characteristics: Low current consumption

$I_{QON} = 0.08 \text{ }\mu\text{A}$ (typ.) @ $V_{IN} = 5.0 \text{ V}$ (TCK106/7/8G)

$I_{QON} = 8 \text{ }\mu\text{A}$ (typ.) @ $V_{IN} = 5.0 \text{ V}$ (TCK101/2G)

Ultra-low on-resistance

$R_{ON} = 49 \text{ m}\Omega$ (typ.) @ $V_{IN} = 5.0 \text{ V}$ (TCK106/7/8G)

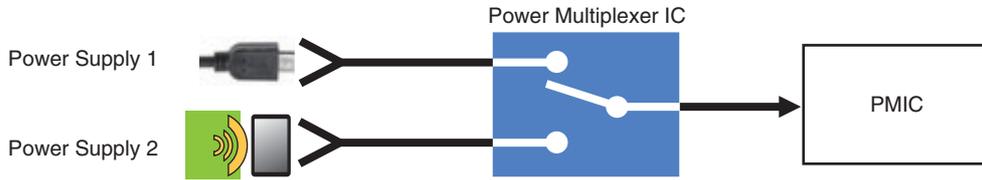
$R_{ON} = 50 \text{ m}\Omega$ (typ.) @ $V_{IN} = 5.0 \text{ V}$ (TCK101/2/4/5G)

Product Lineup

Part Number	Package	Operating Voltage (V)	I _{OUT} (A)	Functions					Control
				Inrush Current Reducing	Output Discharge	Reverse-Current Blocking	Over current Protection	Thermal Shutdown	
TCK101G	WCSP6B	1.1 to 5.5	1	○	○	-	-	○	Active H
TCK102G				○	-	-	-	○	Active H
TCK104G			0.5	○	○	-	○	○	Active H
TCK105G			0.8	○	○	-	○	○	Active H
TCK106G	WCSP4	1.1 to 5.5	1	○	-	-	-	-	Active H
TCK107G				○	○	-	-	-	Active H
TCK108G				○	○	-	-	-	Active L

Power Multiplexer

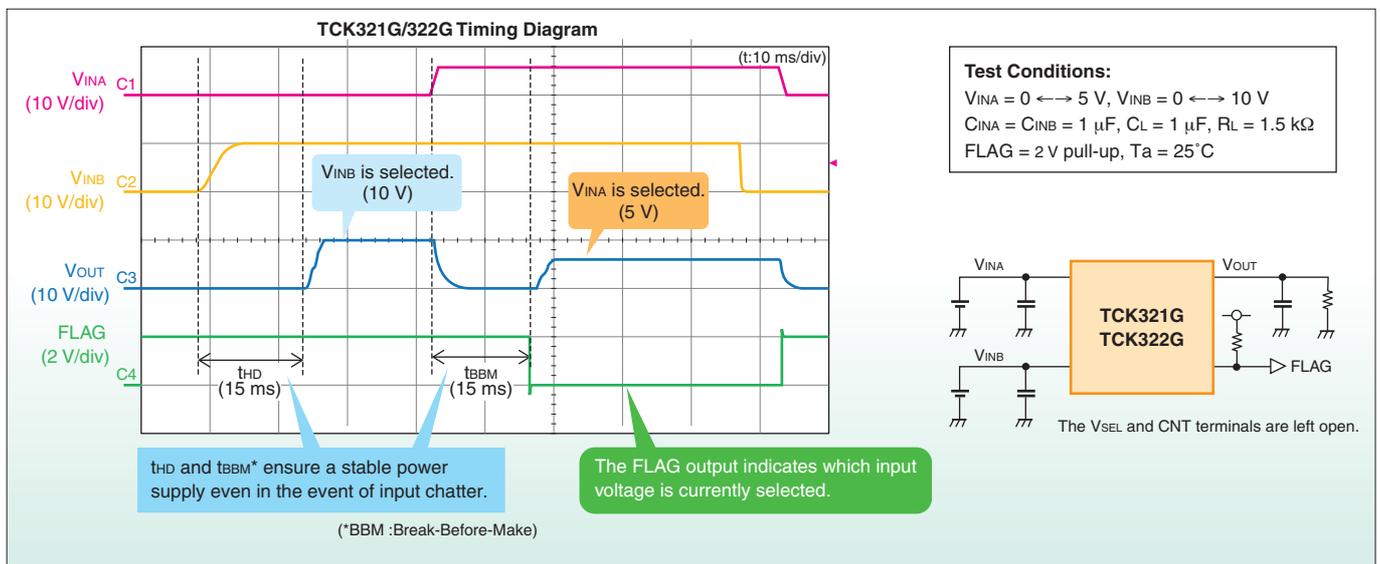
Designed for mobile applications, power multiplexer ICs make it possible to select one of two power sources. As there is an increasing variety of charging specifications, power multiplexer ICs help simplify the control of multiple charging channels. Power multiplexer ICs can select a power source automatically or allow a mobile device to select one via an external signal.



Features

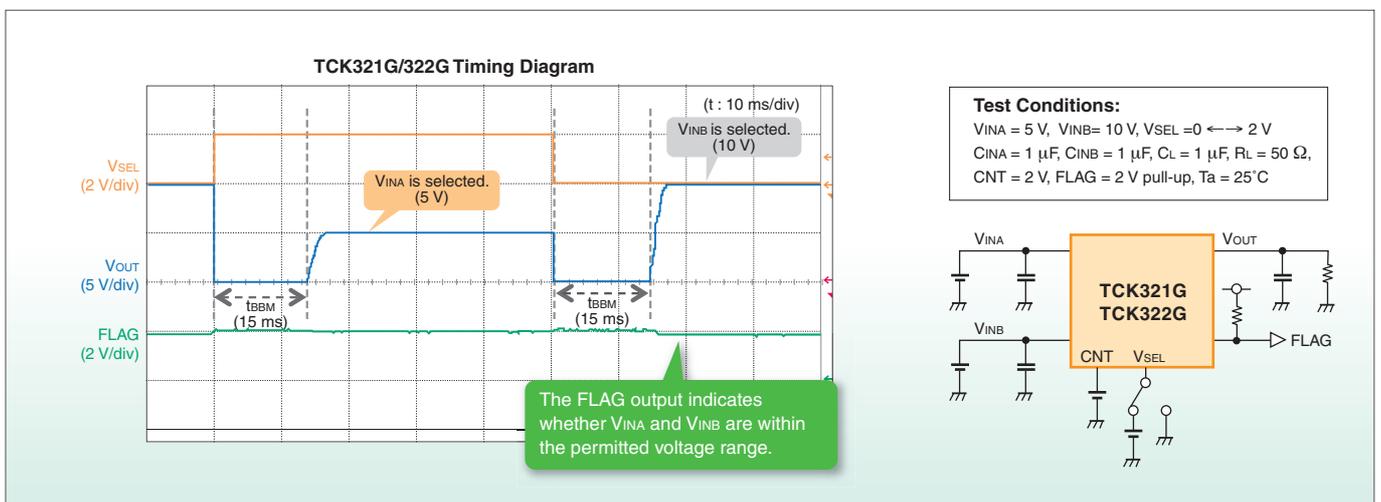
1. Auto Power Select Mode

In Auto Select mode, when voltage is applied to V_{INA} , the conduction path of the V_{INB} voltage is disconnected, and the V_{INA} voltage is passed to the output instead.



2. Manual Selection of a Power Source via an External Input

The V_{SEL} terminal allows the selection of either the V_{INA} or V_{INB} voltage.



New Products

Power multiplexers that provide independent control of two power sources for 36-V charger applications

TCK321G/322G/323G

■ Features

- 2-line-to-1-line
- Input voltage $V_{IN(max)}$: 36 V
- Auto and manual select modes
- Various protection features

■ Key Characteristics

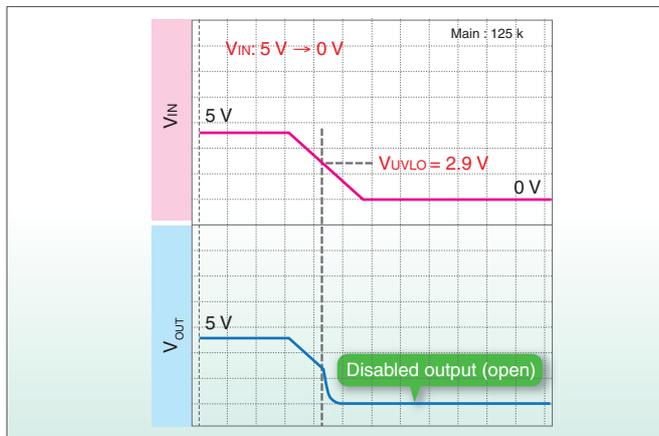
- Output current $I_{OUT(DC)}$: 2 A
- On-resistance:
 $R_{ON} = 98 \text{ m}\Omega(\text{typ.})(@ V_{IN} = 4.5 \text{ V}, I_{OUT} = -1.0 \text{ A})$
- UVLO threshold = 2.9 V, OVLO threshold = 12 V/15 V



WCSP16C
1.9 x 1.9 mm

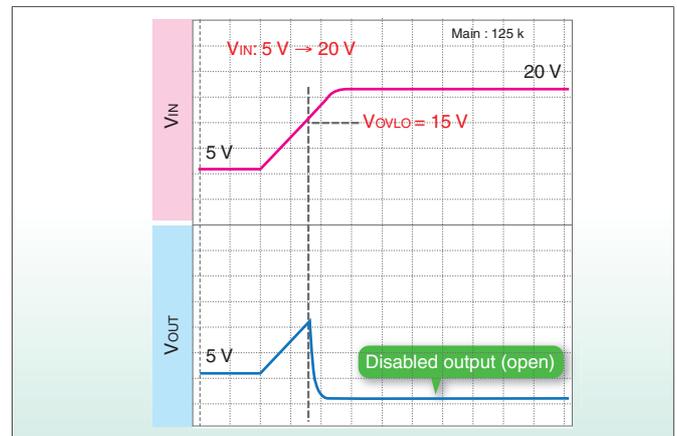
■ UVLO (Undervoltage Lockout)

In the event that the input voltage drops below the UVLO threshold, the output is disabled.



■ OVLO (Overvoltage Lockout)

In the event that the input voltage exceeds the OVLO threshold, the output is disabled.



Part Number	OVLO threshold		FLAG Output (in Auto Select mode)	
	V_{INA} (V)	V_{INB} (V)	Monitored Input	Active Signal Level
TCK321G	12.0	12.0	V_{INA}	Low
TCK322G	15.0	15.0	V_{INA}	Low
TCK323G	15.0	15.0	V_{INB}	Low

Power multiplexers with up to 3-A current capability

TCK301G/302G/303G/304G/305G

■ Features

- 1-line-to-1-line
- Output current $I_{OUT(DC)}$: 3 A
- Various protection features

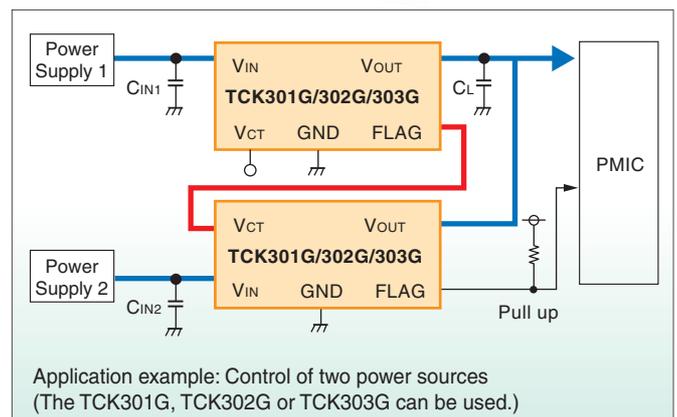
■ Key Characteristics

- Input voltage $V_{IN(max)}$: 28 V
- On-resistance $R_{ON} = 73 \text{ m}\Omega(\text{typ.})(@ V_{IN} = 4.5 \text{ V}, I_{OUT} = -1.0 \text{ A})$
- UVLO threshold = 2.9 V
- OVLO threshold = 6.5 V/10.5 V/15.5 V

Part Number	OVLO Threshold (V)	VCT Control	FLAG Output (When Active*)
TCK301G	6.6	Active-High	Low
TCK302G	10.5	Active-High	Low
TCK303G	15.5	Active-High	Low
TCK304G	6.6	Active-Low	Low
TCK305G	10.5	Active-Low	Low



WCSP9
1.5 x 1.5 mm



* "Active" means that the input voltage, V_{IN} , is $UVLO < V_{IN} < OVLO$.

LDO Regulator (Low-Dropout Regulators)

LDO regulators are housed in ultra-small packages. Toshiba offers wide array of LDO regulators, ranging from general-purpose regulators to high-performance regulators targeting analog applications that require low noise, highly accurate output voltage regulation.

Features

1. Low dropout voltage

Provides approximately half the voltage dropout of the predecessor due to the use of a new process.

2. Fast load transient response

All LDO regulators with fast load transient response and provide accurate voltage regulation even in the presence of abrupt changes in output current.

3. Low noise

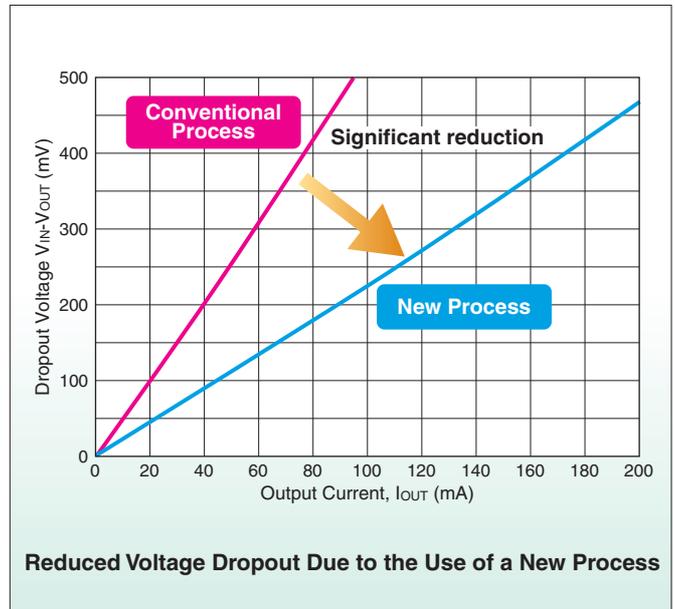
Ideal for radio-frequency (RF) and analog power supply applications for small mobile devices.

4. Available packages

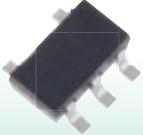
LDO regulators are available in various packages, ranging from general-purpose packages to ultra-small packages less than one millimeter square. Small packages help improve board space utilization.

5. Added functions

Provides overcurrent protection, automatic output discharge, thermal shutdown and inrush current reduction to protect both the LDO regulator and the system board



Product Lineup

TCR5AM Series 500 mA Low Input and Output Voltages Low dropout voltage	TCR3D Series 300 mA Low noise, High-Speed Response Low dropout voltage, Low Inrush Current	TCR2L Series 200 mA Low current consumption (<2 μA)	TCR2E Series 200 mA Low noise, High-Speed Response
	TCR3DF SOT-25 (2.8 × 2.9 mm) 	TCR2LF SOT-25 (2.8 × 2.9 mm) 	TCR2EF SOT-25 (2.8 × 2.9 mm) 
TCR5AM DFN5B (1.2 × 1.2 mm) 	TCR3DM DFN4 (1.0 × 1.0 mm) 	TCR2LE SOT-553 (1.6 × 1.6 mm) 	TCR2EE SOT-553 (1.6 × 1.6 mm) 
		TCR2LN SDFN4 (0.8 × 0.8 mm) 	TCR2EN SDFN4 (0.8 × 0.8 mm) 

New products

The TCR5AM Series of 500-mA LDO regulators provide low dropout voltage in the low-input-voltage region and thus help improve power efficiency.

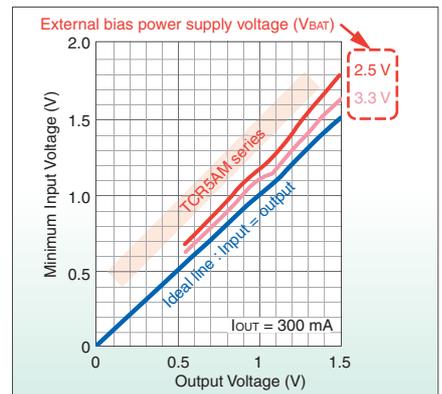
TCR5AM Series

Features

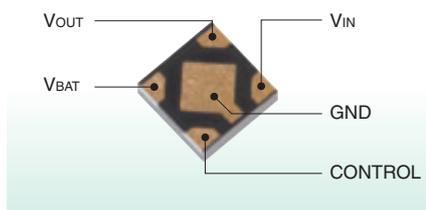
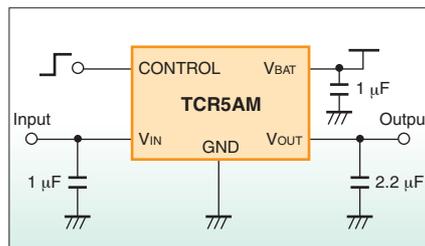
- Output voltage: 0.55 V to 3.6 V
- Low dropout voltage: 0.090 V (typ.)
 $V_{OUT} = 1.0\text{ V}$, $V_{BAT} = 3.3\text{ V}$, $I_{OUT} = 300\text{ mA}$
- Low current consumption: 35 μA (typ.)
- Protection circuits
 Overvoltage protection, overcurrent protection, thermal shutdown, undervoltage lockout

With voltage applied to the external bias power supply terminal (V_{BAT}), the TCR5AM Series provides low dropout voltage. V_{BAT} consumes a low current of 35 μA (typ.).

Dropout Characteristics of the TCR5AM Series



Recommended Circuit



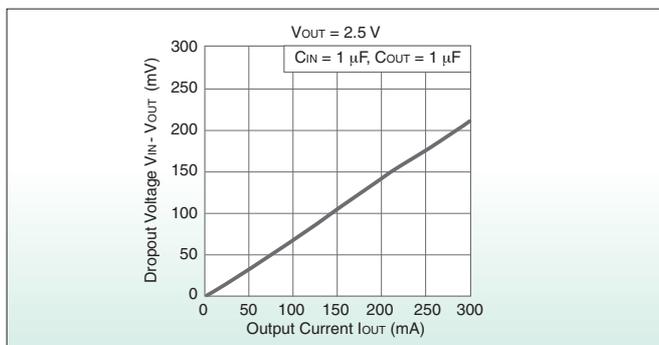
Provides a high ripple rejection ratio and low-noise performance, and is ideal for camera sensor and other applications requiring a precisely regulated voltage

TCR3D Series

Features

- Low output noise voltage: 38 μV_{rms} (typ.) @ 2.5 V
- Output current $I_{OUT}(DC)$: 300 mA

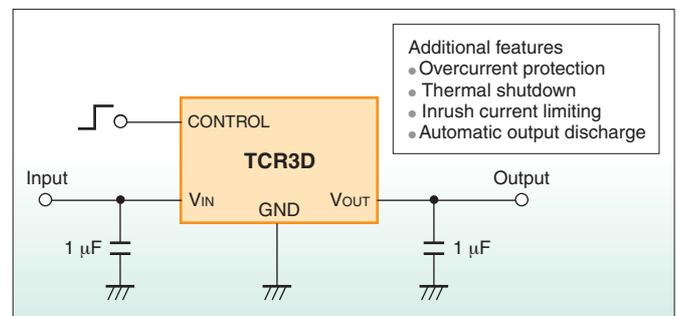
Dropout Voltage vs. Output Current



Key Characteristics

- V_{OUT} : 1.0 to 4.5 V (in steps of 50 mV)
- Dropout voltage: 210 mV (typ.) @ 2.5 V, 300 mA
- High ripple rejection ratio: 70 dB (typ.) @ 1 kHz, 2.5 V

Recommended Circuit



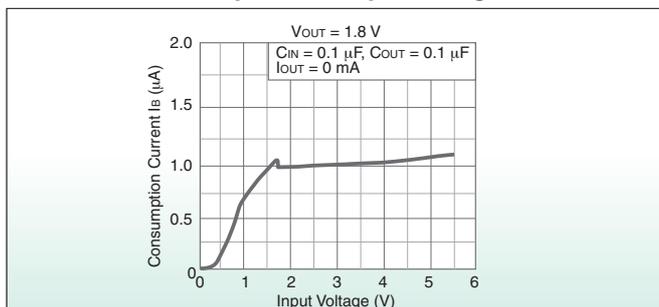
The low current consumption of the TCR2L Series makes it ideal for reducing the power consumption of applications that remain in standby mode for long periods of time such as near-field communication (NFC) devices.

TCR2L Series

Features

- Low bias current: 2 μA max (over the entire operating temperature range)
- Output current $I_{OUT}(DC)$: 200 mA

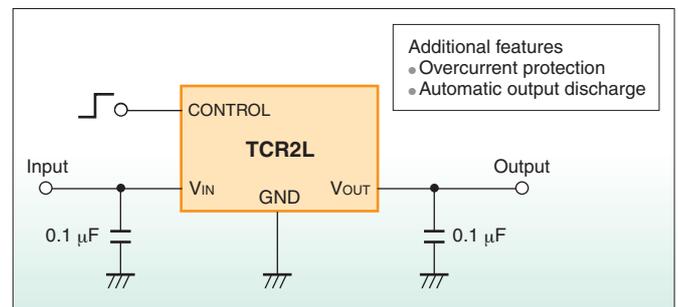
Current Consumption vs. Input Voltage



Key Characteristics

- V_{OUT} : 0.8 to 3.6 V (in steps of 50 mV)
- Dropout voltage: 150 mV (typ.) @ 3.3 V, 150 mA

Recommended Circuit



Toshiba offers an extensive array of MOSFETs with wide ranges of on-resistance, breakdown voltage and packages, allowing you to choose the ones that best suit you need.

Features

1. MOSFETs in small packages with an output current ranging from a few amperes to tens of amperes

Toshiba offers MOSFETs with on-resistance as low as 10 mΩ* that help reduce power loss due to high-current operation and improve power supply efficiency.

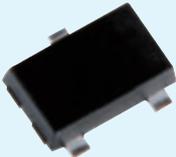
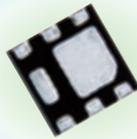
→ **Low-on-resistance MOSFET series**

2. Extensive lineup of MOSFETs with a V_{DSS} of 30 V or higher

Toshiba has expanded its product portfolio with MOSFETs having a V_{DSS} of 30 V to 60 V. Toshiba also offers many low-on-resistance MOSFETs to meet the needs of applications that require both high V_{DSS} and high current drive capability.

→ **30-, 40- and 60-V MOSFET series**

Combination of small form factor and low on-resistance

Conventional device SSM3J334R	→	New device NEW SSM6J507NU
		
On-resistance: 105 mΩ		On-resistance: 28 mΩ

Fabricated using the latest trench process, the new MOSFET has on-resistance that is 30% less than its predecessor. Additionally, the new MOSFET is housed in a small package that occupies less than 40% of the board space required by its predecessor..
(Comparison with a conventional MOSFET with a P-channel V_{DSS} of -30 V)

3. Ultra-small packages suitable for high-density board assembly

Toshiba offers MOSFETs in ultra-small packages measuring less than 1.0 mm by 1.0 mm. These MOSFETs occupy less board space and help reduce the size of electronic devices. They are suitable for use as general-purpose switches for drive-circuit and communication-line applications and can be placed anywhere on PC boards.

→ **MOSFET series in ultra-small packages**

New Products

Low on-resistance helps reduce the loss of power lines caused by high-current drive.

Low-On-Resistance MOSFET Series

Features

Fabricated using the latest trench process, the low-on-resistance series exhibits on-resistance as low as 10 mΩ*. The low-on-resistance series is housed in small packages with high permissible power dissipation, and thus can be mounted anywhere on a board without any concern for the heat generated.

*SSM6J511NU: $R_{DS(ON)}$ (max) = 10 mΩ (@ $V_{GS} = 4.5$ V)

Product Lineup

Polarity	Part Number	Package	V_{DS} (V)	V_{GS} (V)	I_D (A)	$R_{DS(ON)}$ (max)(mΩ) @ $V_{GS} = -4.5$ V
P-ch	SSM6J511NU**	UDFN6B (SOT-1220)	-12	±10	-14	10
P-ch	SSM6J512NU**	UDFN6B (SOT-1220)	-12	±10	-10	19
P-ch	SSM3J338R**	SOT-23F	-12	±10	-6	22
P-ch	SSM6J414TU	UF6	-20	±8	-6	22.5
P-ch	SSM6J216FE	ES6 (SOT-563)	-12	±8	-4.8	32
P-ch	SSM6J771G	WCSP6C	-20	±12	-5	35

** : Under development. The specifications are subject to change.

Available with a V_{DS} of 30 V and 60 V

30-V, 40-V and 60-V Series

Features

Toshiba offers 30- to 60-V MOSFETs with low on-resistance and thus low conduction loss. Because of the high V_{DS} , even power and USB lines can be driven without being affected by voltage transients.

Product Lineup

Polarity	Part Number	Package	V_{DS} (V)	V_{GS} (V)	I_D (A)	$R_{DS(ON)}$ (max)(mΩ)	V_{GS} (V)
N-ch	SSM3K2615TU**	UFM	60	±20	1.8	580	3.3
N-ch	SSM3K2615R	SOT-23F	60	±20	2	580	3.3
N-ch	SSM3K318R	SOT-23F	60	±20	2.5	145	4.5
N-ch	SSM3K59CTB	CST3B	40	±12	2	228	4.5
N-ch	SSM6K217FE	ES6 (SOT-563)	40	±12	1.8	208	4.5
N-ch	SSM3K339R	SOT-23F	40	±12	2	198	4.5
N-ch	SSM6K504NU	UDFN6B (SOT-1220)	30	±20	9	26	4.5
P-ch	SSM6J507NU	UDFN6B (SOT-1220)	-30	-25/+20	-10	28	-4.5

** : Under development. The specifications are subject to change.

Housed in ultra-small packages measuring less than 1.0 mm x 1.0 mm

Ultra-Small Package Series

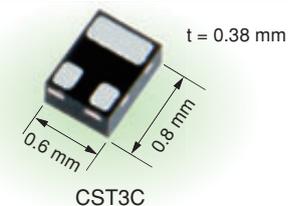
Features

The newly developed CST3C package measuring only 0.8 mm × 0.6 mm helps save board space and thus reduce the size of end products. The CST3C package has one-third the footprint of the industry-standard SOT-723 package, making it ideal for high-density board assembly.

Product Lineup

Polarity	Part Number	Package	V_{DS} (V)	V_{GS} (V)	I_D (A)	$R_{DS(ON)}$ (max)(mΩ) @ $ V_{GS} = 4.5$ V
N-ch	SSM3K35CTC	CST3C	20	±10	0.25	1100
N-ch	SSM3K72CTC	CST3C	60	±20	0.15	4700
P-ch	SSM3J35CTC**	CST3C	-20	±10	-0.25	1100

** : Under development. The specifications are subject to change.



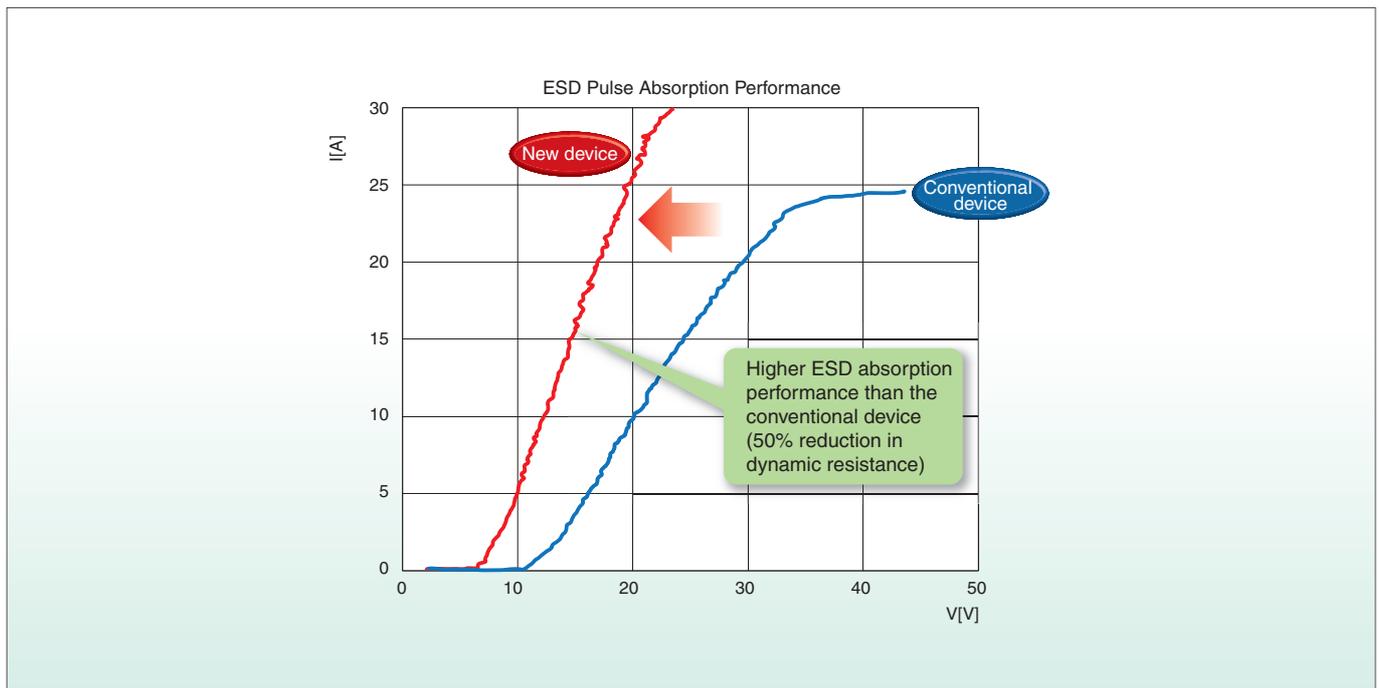
ESD Protection Diodes

Toshiba's ESD protection diodes combine low dynamic resistance, ultra-low capacitance and low clamping voltage to protect high-speed interface circuits from electrostatic discharge (ESD). To address the need for improving the reliability of communication and information systems, Toshiba offers ESD protection diodes that provide ESD protection performance exceeding the requirements for Level 4 of IEC 61000-4-2. These ESD protection diodes are ideal for high-speed interface applications such as USB 3.0/3.1, HDMI™ and DisplayPort™.

* HDMI is a trademark or a registered trademark of HDMI Licensing LLC.

* DisplayPort is a trademark or a registered trademark of the Video Electronics Standards Association.

Features



The latest ESD protection diodes (including automotive devices) provide these benefits:

1. Combines ultra-low dynamic resistance and low capacitance and thus provides outstanding ESD performance and signal integrity

Damps ESD pulses instantaneously to protect a receiver IC at a high-speed interface

2. Exhibits low clamping voltage and thus suppresses ESD energy

Provides the receiver IC with reliable ESD protection by virtue of the original snapback technology

3. Improves the reliability of communication and information systems

Provides ESD performance exceeding the requirements for Level 4 of IEC 61000-4-2

4. Simplifies optimal high-density board layout

Available in various packages, including those with single and multiple flow-through paths

New Products

New process that provides industry's highest-class ESD performance

DF2B5M4SL/DF2B6M4SL: SL2 Package

Because of the significantly reduced dynamic resistance, the DF2B5M4SL and DF2B6M4SL damp ESD pulses instantaneously and thus provide enhanced ESD protection. Furthermore, the DF2B5M4SL and DF2B6M4SL have low clamping voltage for reliable protection of a receiver IC.

■ Features: DF2B5M4SL (example)

- Industry's lowest-class dynamic resistance: $R_{DYN} = 0.5 \Omega$ (typ.)
- Low ESD clamping voltage: $V_{clamp} = 6 V$ typical (IEC61000-4-5, $I_{PP} = 1 A$)
- Outstanding ESD immunity: $V_{ESD} \geq 20 kV$ (IEC61000-4-2, Level4)

■ Electrical Characteristics

Characteristic	Conditions	DF2B5M4SL	DF2B6M4SL
Rated Voltage (V_{RWM})	–	3.6 V(max)	5.5 V(max)
Reverse Breakdown Voltage (V_{BR})	$I_{BR} = 1 mA$	4.5 V(min)	6 V(min)
Reverse Current (I_R)	At V_{RWM}	100 nA(max)@3.6 V	100 nA(max)@5.5 V
Dynamic Resistance (R_{DYN})	$t_p = 100 ns$	0.5 Ω	
Total Capacitance (C_i)	$V_R = 0 V, f = 1 MHz$	0.2 pF(typ.)	
ESD Immunity (V_{ESD})	IEC61000-4-2 (contact discharge)	$\geq \pm 20 kV$	

Low-capacitance ESD protection diodes with multiple flow-through paths ideal for high-speed interface applications

DF5G7M2N(4in1): DFN5 Package

The DF5G7M2N allows a flow-through layout arrangement without any concern for wire inductance. The DF5G7M2N provides high signal integrity and ESD protection performance.

■ Features

- Eases board layout

■ Electrical Characteristics

Characteristic	Conditions	DF5G7M2N(4 bit)
Rated Voltage (V_{RWM})	–	5.5 V(max)
Reverse Breakdown Voltage (V_{BR})	$I_{BR} = 1 mA$	6 V(min)
Reverse Current (I_R)	$V_{RWM} = 5.5 V$	0.5 μA (max)
Dynamic Resistance (R_{DYN})	$t_p = 100 ns$	1 Ω
Total Capacitance (C_i)	$V_R = 0 V, f = 1 MHz$	0.2 pF(typ.)
ESD Immunity (V_{ESD})	IEC61000-4-2 (contact discharge)	$\geq \pm 12 kV$

Ultra-small thin package (0.4 mm x 0.2 mm) with the industry's lowest-class capacitance

DF2B5M4CL/DF2B6M4CL: CL2 Package

Despite the ultra-small thin package, the DF2B5M4CL and DF2B6M4CL provide the same ESD protection as the conventional products.

■ Features

- Ideal for high-density board assembly

■ Electrical Characteristics

Characteristic	Conditions	DF2B5M4CL	DF2B6M4CL
Rated Voltage (V_{RWM})	–	3.6 V(max)	5.5 V(max)
Reverse Breakdown Voltage (V_{BR})	$I_{BR} = 1 mA$	4.5 V(min)	6 V(min)
Reverse Current (I_R)	At V_{RWM}	100 nA(max)@3.6 V	100 nA(max)@5.5 V
Dynamic Resistance (R_{DYN})	$t_p = 100 ns$	0.4 Ω	
Total Capacitance (C_i)	$V_R = 0 V, f = 1 MHz$	0.2 pF(typ.)	
ESD Immunity (V_{ESD})	IEC61000-4-2 (contact discharge)	$\geq \pm 20 kV$	

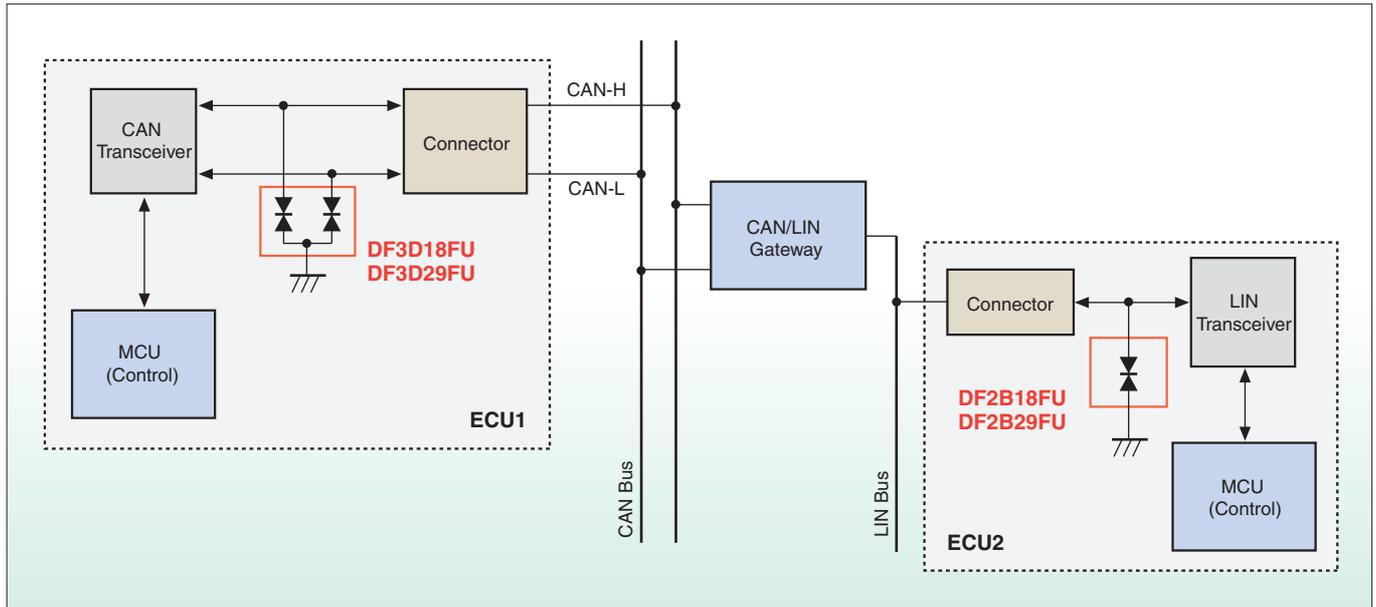
ESD Protection Diodes for Automotive Interface Applications

For in-vehicle networks such as CAN^{*1}, LIN^{*2} and FlexRay™ as well as other automotive interfaces, higher reliability is required against electrostatic discharge and noise. To satisfy the requirement, the introduction of system ESD, such as ISO 10605, is currently under way. ESD protection diodes are primarily used for the protection of these in-vehicle bus interfaces. Toshiba's ESD protection diodes exhibit the industry's lowest-class dynamic resistance and provide excellent ESD performance for the protection of transceiver ICs. These ESD protection diodes help improve system reliability.

(*1) CAN: Controller Area Network
 (*2) LIN: Local Interconnect Network

* FlexRay is a trademark of Daimler AG.

Application Circuit Example (Protection of CAN and LIN Bus Lines)



Features

Outstanding ESD performance due to the industry's lowest-class dynamic resistance

- $R_{DYN} = 0.8 \Omega$ (typ.) (DF2B18FU, DF3D18FU)
- $R_{DYN} = 1.1 \Omega$ (typ.) (DF2B29FU, DF3D29FU)

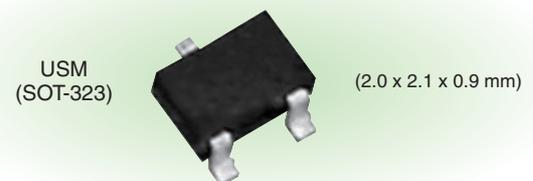
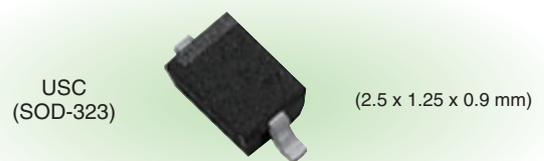
High ESD immunity and high reliability

- ISO10605 (contact discharge) $V_{ESD} \geq \pm 30$ kV
- AEC Q101

Compatible with a wide range of bus standards due to low capacitance

- $C_t = 9$ pF (typ.) (@ $V_R = 0$ V, $f = 1$ MHz)
- Compatible with 10-kbps LIN to 10-Mbps FlexRay™ bus lines
- Contributes to the unification of parts

Industry-standard small packages (SOD-323, SOT-323)



New Products

Small high-performance ESD protection diodes ideal for automotive applications

The industry's top-class ESD protection performance helps improve the reliability of automotive systems.

DF2B18FU/DF2B29FU (1in1 Type)

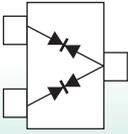
DF3D18FU/DF3D29FU (2in1 Type)

Major Applications

Protection of transceiver ICs on automotive networks (LIN, CAN and FlexRay™ bus lines)

Product Lineup and Key Specifications

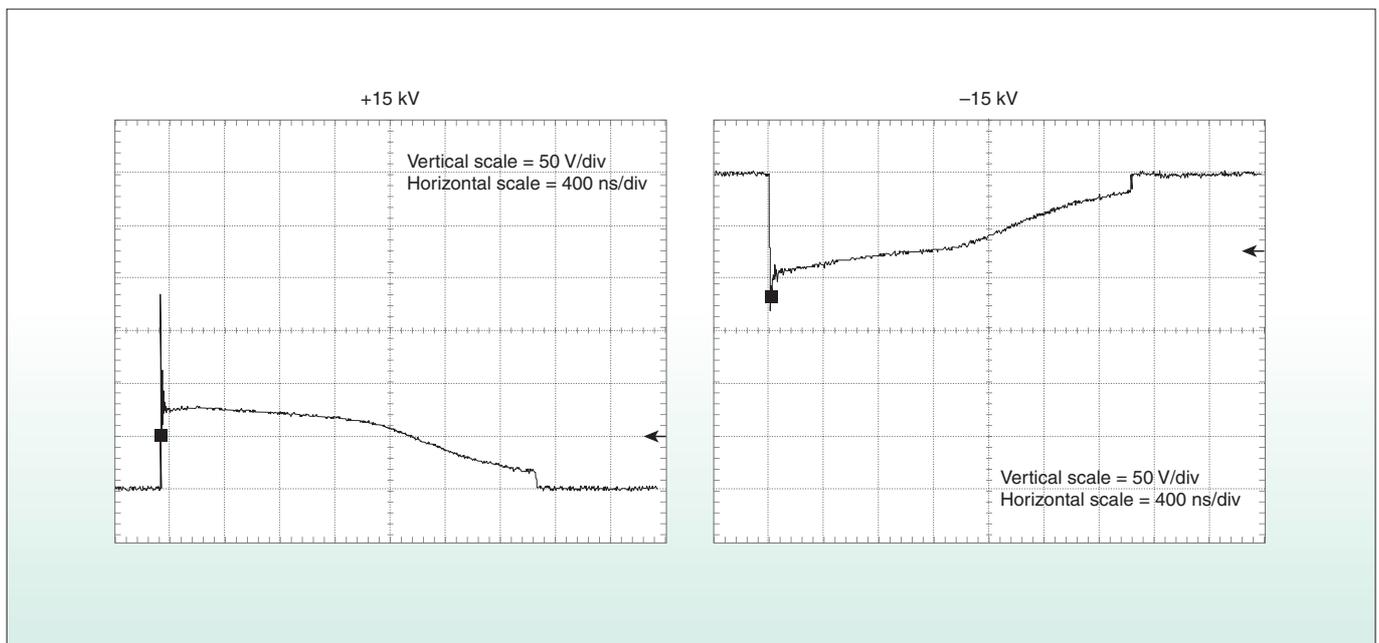
Toshiba offers 1-in-1 ESD protection diodes suitable for LIN bus lines and flexible layout as well as 2-in-1 variants ideal for CAN and FlexRay™ bus lines.

Internal Connections	V_{RWM} (V)	Part Number	$V_{BR}(\text{min to max})$ @ $I_{BR} = 1 \text{ mA}$ (V)	$I_R(\text{max}) @ V_{RWM}$ (nA)	$C_t @ 0 \text{ V}(\text{typ.})$ (pF)	$R_{DYN} @ 8-16 \text{ A}$ (typ.)(Ω)	V_{ESD} @ ISO10605 ^{(*)3}
	12	DF2B18FU	16.2 to 20.5	100	9	0.8	±30 kV min
	24	DF2B29FU	26.0 to 32.0	100	9	1.1	±30 kV min
	12	DF3D18FU	16.2 to 20.5	100	9	0.8	±30 kV min
	24	DF3D29FU	26.0 to 32.0	100	9	1.1	±30 kV min

*3 In compliance with ISO 10605-compliant (330 pF, 2 k Ω , 10 contact discharges)

Typical ESD Waveforms

(For reference only) DF2B29FU, in compliance with ISO10605 (330 pF, 2 k Ω , contact discharge)



MOSFETs for Automotive Applications

Toshiba offers MOSFETs ideal for various automotive applications, including those designed for mechanical-relay and LED drive.

Features

1. All Toshiba's automotive-grade MOSFETs are AEC-Q101-qualified.

2. High V_{DS} and low-voltage drive

Fabricated using the latest trench process, automotive MOSFETs are available with a V_{DS} of 40 V and 60 V and a low V_{GS} .

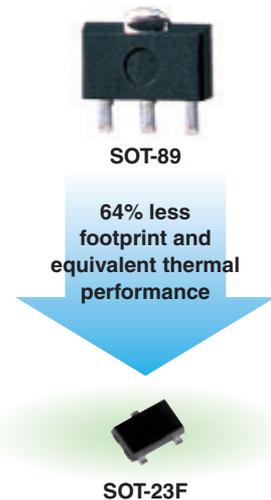
3. Small packages

The thermally enhanced SOT-23F package saves board space (64% less footprint than the conventional SOT-89 package) without compromising thermal performance.

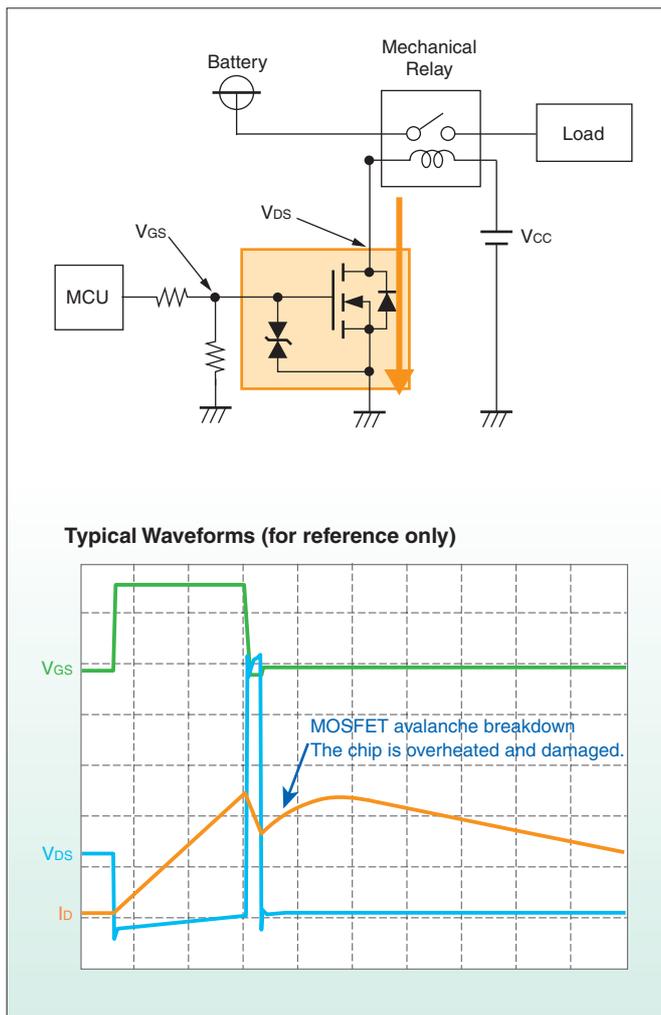
4. Integration of neighboring parts

External resistors, protective Zener diodes and other neighboring parts are integrated in the same package.

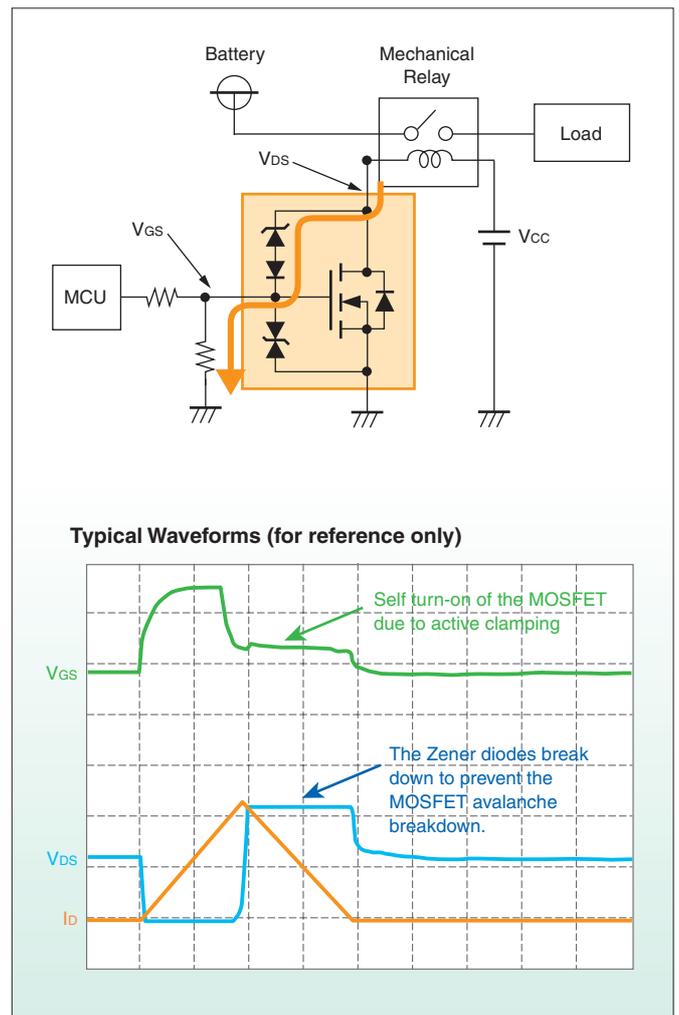
The built-in Zener diodes for active clamping, which are less susceptible to transients due to mechanical relays and other inductive loads, prevent damage to MOSFETs.



■ MOSFETs



■ MOSFET with Zener Diodes



New Products

60-V N-channel MOSFETs with low on-resistance and low-voltage drive SSM3K318R/SSM3K2615R

The SSM3K318R and SSM3K2615R are N-channel MOSFETs with a V_{DS} of 60 V suitable for driving series-connected LEDs.

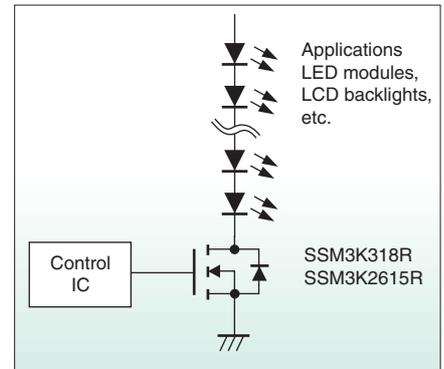
The SSM3K318R provides low on-resistance to support high-current drive, and the SSM3K2615R supports low-voltage (3.3-V) drive.

Features

- Drain-source voltage: 60 V
- AEC-Q101
- Housed in the small SOT-23F package (2.4 mm × 2.9 mm) with high permissible power dissipation (1W, DC)

Product Lineup

Part Number	Features	V_{DS} (V)	V_{GS} (V)	I_D (A)	$R_{DS(ON)}(max)$			C_{iss} (pF)	Package
					$V_{GS} = 3.3$ V (m Ω)	$V_{GS} = 4.0$ V (m Ω)	$V_{GS} = 10$ V (m Ω)		
SSM3K318R	Low on-resistance	60	±20	2.5	–	145	107	235	SOT-23F (2.9 × 2.4 mm)
SSM3K2615R	Low-voltage drive (3.3 V)	60	±20	2	580	440	300	150	SOT-23F (2.9 × 2.4 mm)



Active-clamp MOSFET for mechanical-relay and solenoid drive applications SSM3K337R/SSM3H137TU

SSM3K337R/SSM3H137TU

The SSM3K337R and SSM3H137TU MOSFETs have an active clamp structure that is less susceptible to relay and other inductive load transients.

These MOSFETs have approximately half the on-resistance of that of their predecessor (TPCP8R01). The SSM3K337R is housed in the small and thermally enhanced SOT-23F package, and the SSM3H137TU is physically small and provides high ESD immunity.

Features

- Zener diode between drain and gate
- AEC-Q101

Product Lineup

Part Number	Features	V_{DS} (V)	V_{GS} (V)	I_D (A)	$R_{DS(ON)}(max)$		ESD (typ.) (kV)(Air)	Package
					$V_{GS} = 4.0$ V (m Ω)	$V_{GS} = 10$ V (m Ω)		
SSM3K337R	Active clamp structure	43±5	±20	2	200	150	±23	SOT-23F (2.9 × 2.4 mm)
SSM3H137TU	Active clamp structure, small form factor, high ESD immunity	36±2	±20	2	295	240	±30	UFM (2.1 × 2.0 mm)

Cell-balancing MOSFETs

Low-On-Resistance MOSFET Series

Toshiba offers cell-balancing MOSFETs designed to equalize the state of charge of series-connected lithium-ion battery cells for electric vehicles.

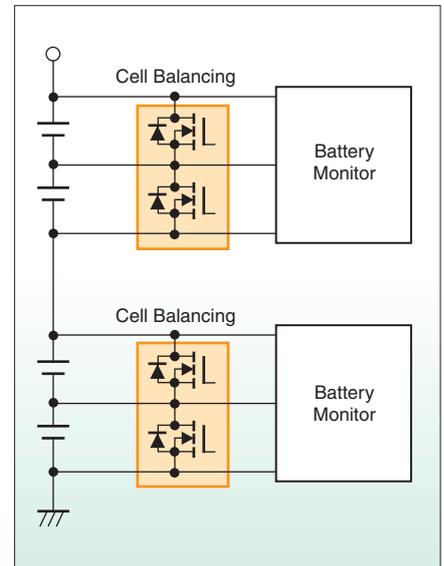
Features

- Low-on-resistance devices are suitable for high cell balance current.

Product Lineup

Part Number	Polarity	V_{DS} (V)	V_{GS} (V)	I_D (A)	$R_{DS(ON)}(max)$	Package
SSM6N60TU**	Nch x 2	20	±8	0.8	470 m Ω @1.2 V	UF6 (2.1 × 2.0 mm)
SSM6N39TU	Nch x 2	20	±20	1.6	247 m Ω @1.5 V	
SSM6P54TU	Pch x 2	-20	±8	-1.2	555 m Ω @-1.5 V	
SSM3J328R	Pch	-20	±8	-6.0	88.4 m Ω @-1.5 V	SOT-23F (2.9 × 2.4 mm)
SSM3J332R	Pch	-30	±12	-6.0	144 m Ω @-1.8 V	
SSM3K324R	Nch	30	±12	4.0	109 m Ω @1.8 V	
SSM3K329R	Nch	30	±12	3.5	109 m Ω @1.8 V	

** : Under development



Information on AEC-Q100/101- Qualified Automotive Devices

Toshiba is expanding its portfolio of automotive small-signal devices to qualify AEC-Q100, AEC-Q101. For the latest information about these devices, visit our website.

AEC-Q100-Qualified General-Purpose Logic

Toshiba will expand the portfolio of AEC-Q100-qualified (Grade1) general-purpose logic ICs and provide an extended operating temperature range of up to 125°C.

General-Purpose Logic ICs	Series	Part Number	Package	Operating Voltage Range (V)	Output Current (mA)	Input	Operating Temperature Range (°C)
CMOS Logic ICs	VHC Series	74VHC□□FT	TSSOP14B	2.0 to 5.5	±8	CMOS	-40 to 125
		74VHCT□□FT	TSSOP16B	4.5 to 5.5	±8	TTL	-40 to 125
		74VHCV□□FT	TSSOP20B (JEDEC-Compliant)	1.8 to 5.5	±16	CMOS	-40 to 125
One-Gate Logic ICs (L-MOS)	VHS Series	TC7SH□□FU	USV (SOT-353)	2.0 to 5.5	±8	CMOS	-40 to 125
		TC7SET□□FU		4.5 to 5.5	±8	TTL	-40 to 125
	SHS Series	TCSZ□□FU		1.8 to 5.5	±24	CMOS	-40 to 125

* Availability: The above AEC-Q100-qualified devices are being released in stages, from April 2015 onward.

* Contact your Toshiba sales representative for their formal part numbers and AEC-Q100-qualified codes.

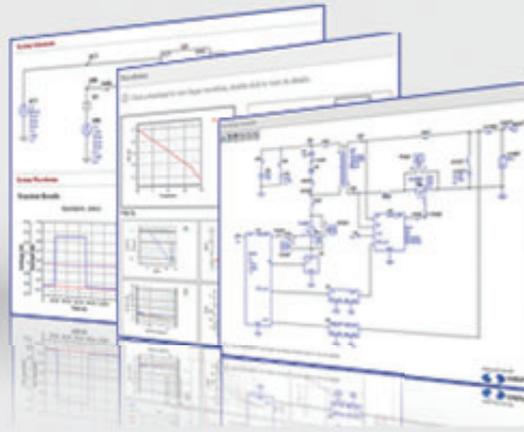
AEC-Q101-Qualified Small-Signal Discrete Devices

Toshiba has been expanding the portfolio of AEC-Q101-qualified small-signal devices.

Type	Part Number (Typical Products)	Package
Bipolar Transistors	2SA1162	S-Mini (SOT-346) (SC-59)
	2SC2712	
	2SA1586	USM (SOT-323) (SC-70)
	2SC4116	
MOSFET	SSM3K337R	SOT-23F
	SSM3K2615R	
Switching Diodes	1SS184	S-Mini (SOT-346) (SC-59)
	1SS193	
	1SS226	
	1SS301	USM (SOT-323)(SC-70)
	1SS352	
	1SS403	
Bias Resistor Built-in Transistors (BRT)	RN1401	S-Mini (SOT-346) (SC-59)
	RN1402	
	RN1403	
	RN1404	
	RN1406	
	RN1407	
	RN2401	
	RN2402	
	RN2404	
	RN2407	
	RN2409	

Toshiba Semiconductor Web Simulator

MOSFETs
Load Switch ICs
Low-Drop Out Regulator ICs

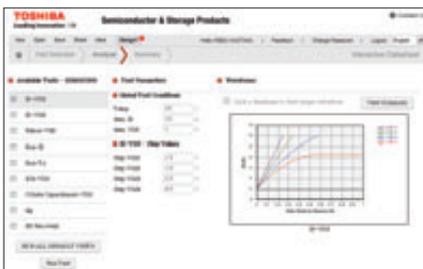


Toshiba offers an online tool that allows you to perform circuit simulation on MOSFETs, load switch ICs and LDO regulators.

- The Toshiba Semiconductor Web Simulator allows you to simulate the MOSFET performance under various voltage and temperature conditions.
- You can analyze the switching waveforms of MOSFETs in AC/DC and DC/DC converter applications.
- You can also simulate PFC, full-bridge, flyback and synchronous buck converters.
- In addition, you can simulate the behaviors of load switch ICs and LDO regulators.

* User registration is required to use the Web Simulator.

MOSFETs

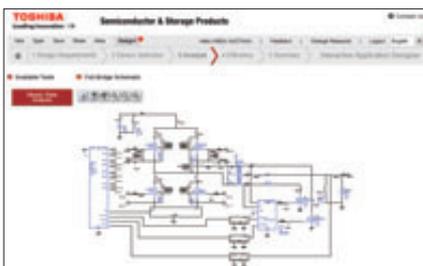


Interactive Datasheet <Device characteristics simulation>

Allows you to check the performance characteristics curves shown in datasheets under arbitrary conditions.

Simulatable characteristics

I_D - V_{DS} , I_D - V_{GS} , $R_{DS(ON)}$ - V_{GS} , $R_{DS(ON)}$ - I_D , $R_{DS(ON)}$ - T_a , I_{DR} - V_{DS} , C - V_{DS} , Q_g and other curves



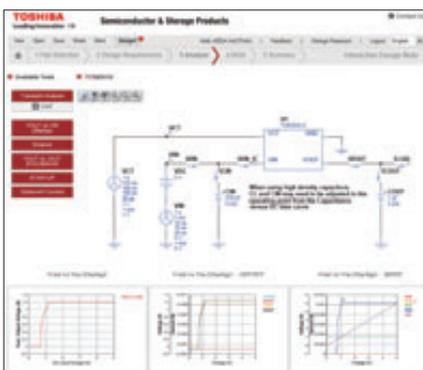
Interactive Application Designer <Circuit simulation>

Allows you to perform circuit simulation on MOSFET circuits in AC/DC and DC/DC converters.

Supported power supply topologies

- Power factor correction (PFC) circuits
- Full-bridge converters
- Flyback converters
- Buck converters

Load Switch ICs/LDO Regulator



Interactive Design Note <Circuit simulation>

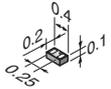
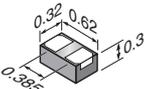
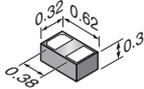
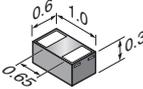
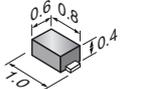
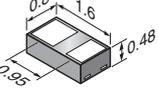
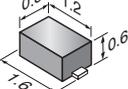
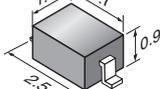
You can perform circuit simulation on load switch ICs and LDO regulators.

Supported simulation

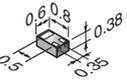
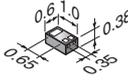
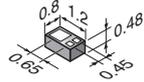
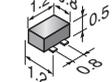
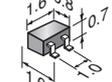
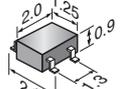
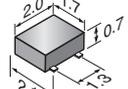
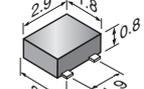
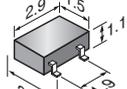
- Transient analysis
- Startup analysis
- $R_{DS(ON)}$ - V_{IN} and $R_{DS(ON)}$ - I_{OUT} characteristics
- Inrush current

List of Packages

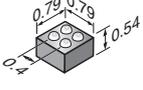
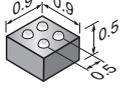
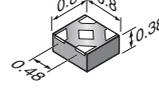
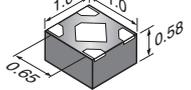
2-Pin Packages

CL2  MOQ: 10000 pcs	SL2  MOQ: 10000 pcs	SC2  MOQ: 10000 pcs	CST2 (SOD-882)  MOQ: 10000 pcs	SOD-923  MOQ: 10000 pcs
CST2C  MOQ: 10000 pcs	ESC (SOD-523)  MOQ: 8000 pcs	USC (SOD-323)  MOQ: 3000 pcs		

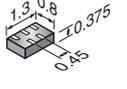
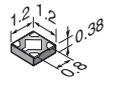
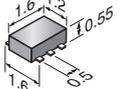
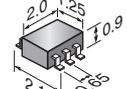
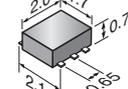
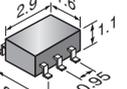
3-Pin Packages

CST3C  MOQ: 10000 pcs	CST3 (SOT-883)  MOQ: 10000 pcs	CST3B  MOQ: 10000 pcs	VESM (SOT-723)(SC-105AA)  MOQ: 8000 pcs	SSM (SOT-416)(SC-75)  MOQ: 3000 pcs	
USM (SOT-323)(SC-70)  MOQ: 3000 pcs	UFM  MOQ: 3000 pcs	SOT-23F  MOQ: 3000 pcs	S-Mini (SOT-346)(SC-59)  MOQ: 3000 pcs		

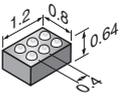
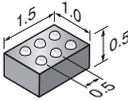
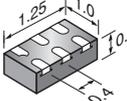
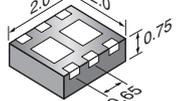
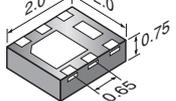
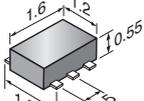
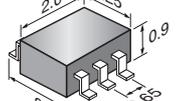
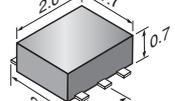
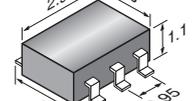
4-Pin Packages

WCSP4  MOQ: 3000 pcs	WCSP4C  MOQ: 3000 pcs	SDFN4  MOQ: 10000 pcs	DFN4  MOQ: 10000 pcs
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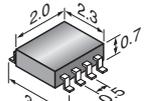
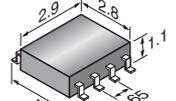
5-Pin Packages

DFN5  MOQ: 5000 pcs	DFN5B  MOQ: 5000 pcs	ESV (SOT-553)(SC-107BB)  MOQ: 4000 pcs	USV (SOT-353)(SC-88A)  MOQ: 3000 pcs	UFV  MOQ: 3000 pcs
SMV (SOT-25)(SC-74A)  MOQ: 3000 pcs				

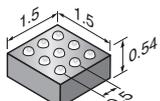
6-Pin Packages

WCSP6B  MOQ: 3000 pcs	WCSP6C  MOQ: 3000 pcs	DFN6  MOQ: 3000 pcs	UDFN6 (SOT-1118)  MOQ: 3000 pcs	UDFN6B (SOT-1220)  MOQ: 3000 pcs
ES6 (SOT-563)(SC-107C)  MOQ: 4000 pcs	US6 (SOT-363)(SC-88)  MOQ: 3000 pcs	UF6  MOQ: 3000 pcs	SM6 (SOT-26)(SC-74)  MOQ: 3000 pcs	

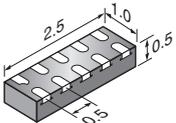
8-Pin Packages

US8 (SOT-765)  MOQ: 3000 pcs	SM8 (SOT-505)  MOQ: 3000 pcs
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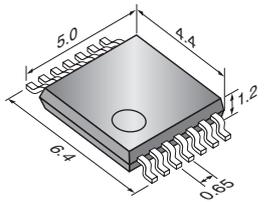
9-Pin Packages

WCSP9  MOQ: 5000 pcs
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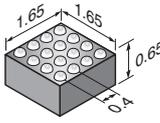
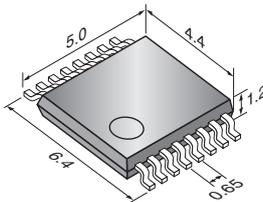
10-Pin Packages

DFN10  MOQ: 3000 pcs
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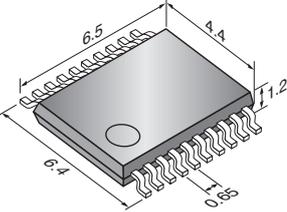
14-Pin Packages

TSSOP14B  MOQ: 2500 pcs

16-Pin Packages

WCSP16  MOQ: 5000 pcs	TSSOP16B  MOQ: 2500 pcs
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20-Pin Packages

TSSOP20B  MOQ: 2500 pcs

Unit: mm

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