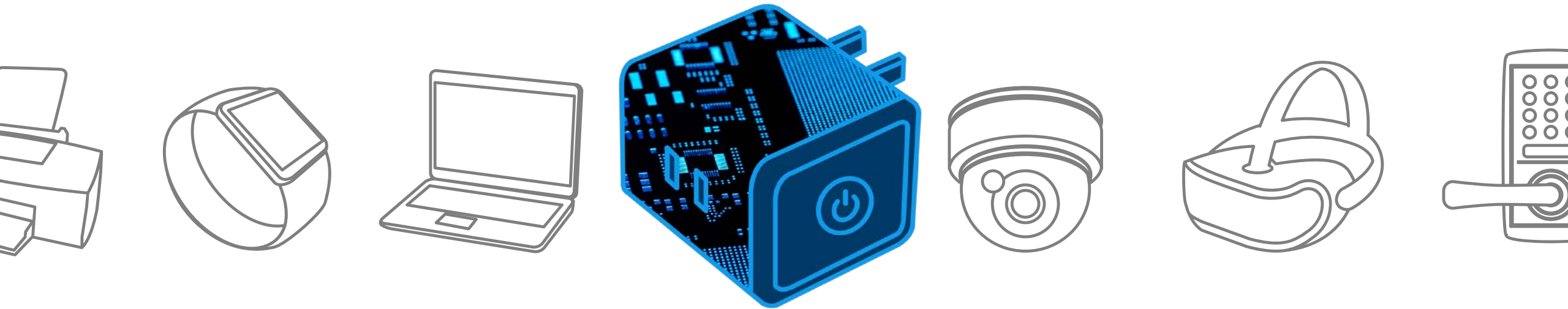
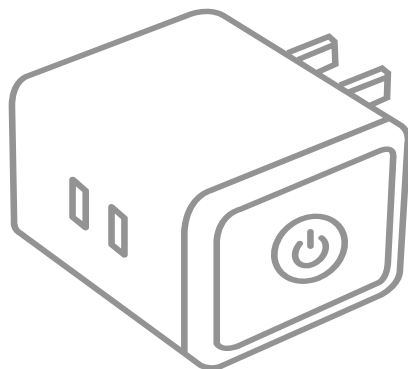
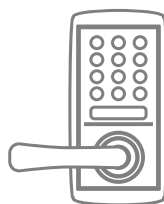


Smart Plug

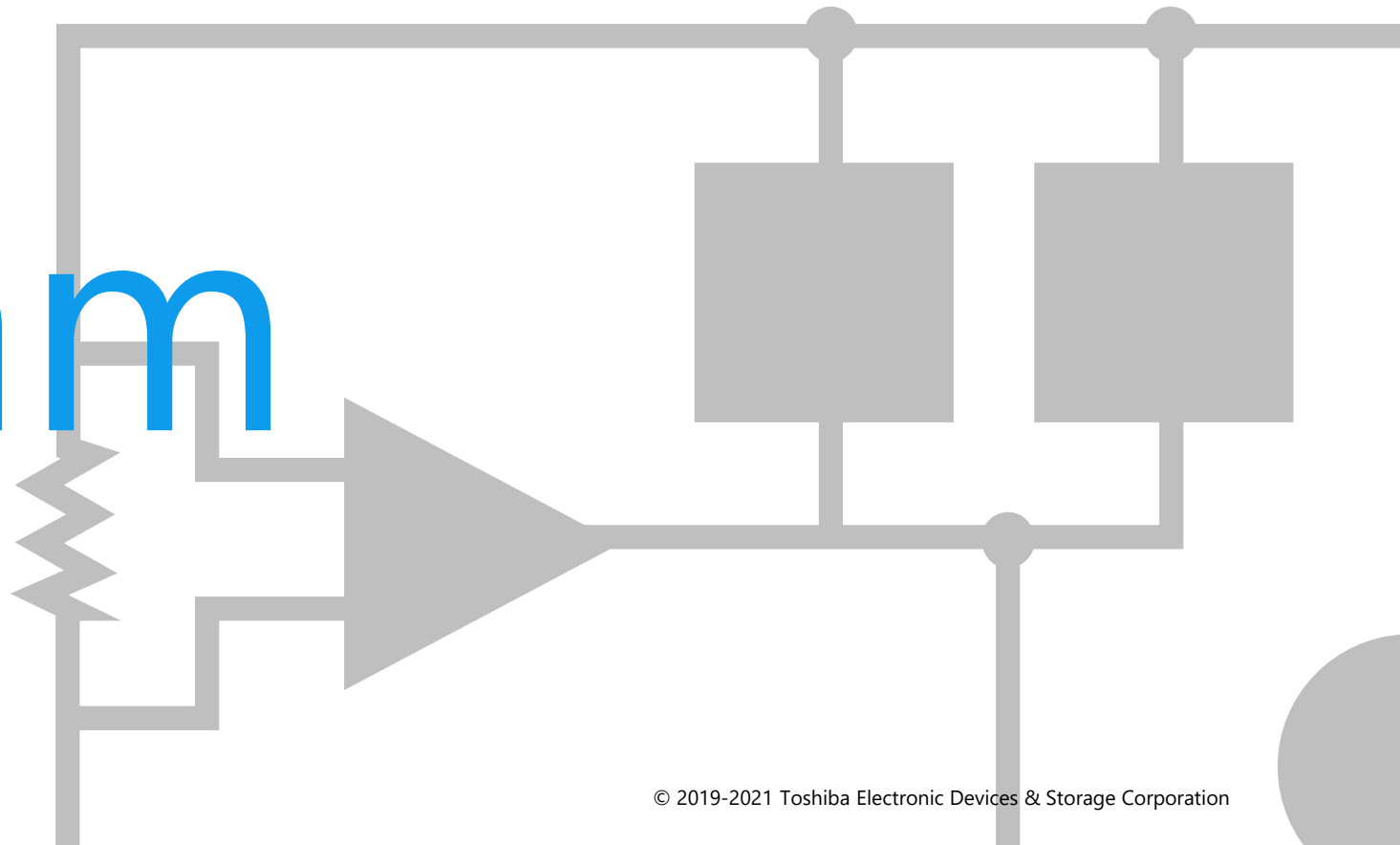
Solution Proposal by Toshiba



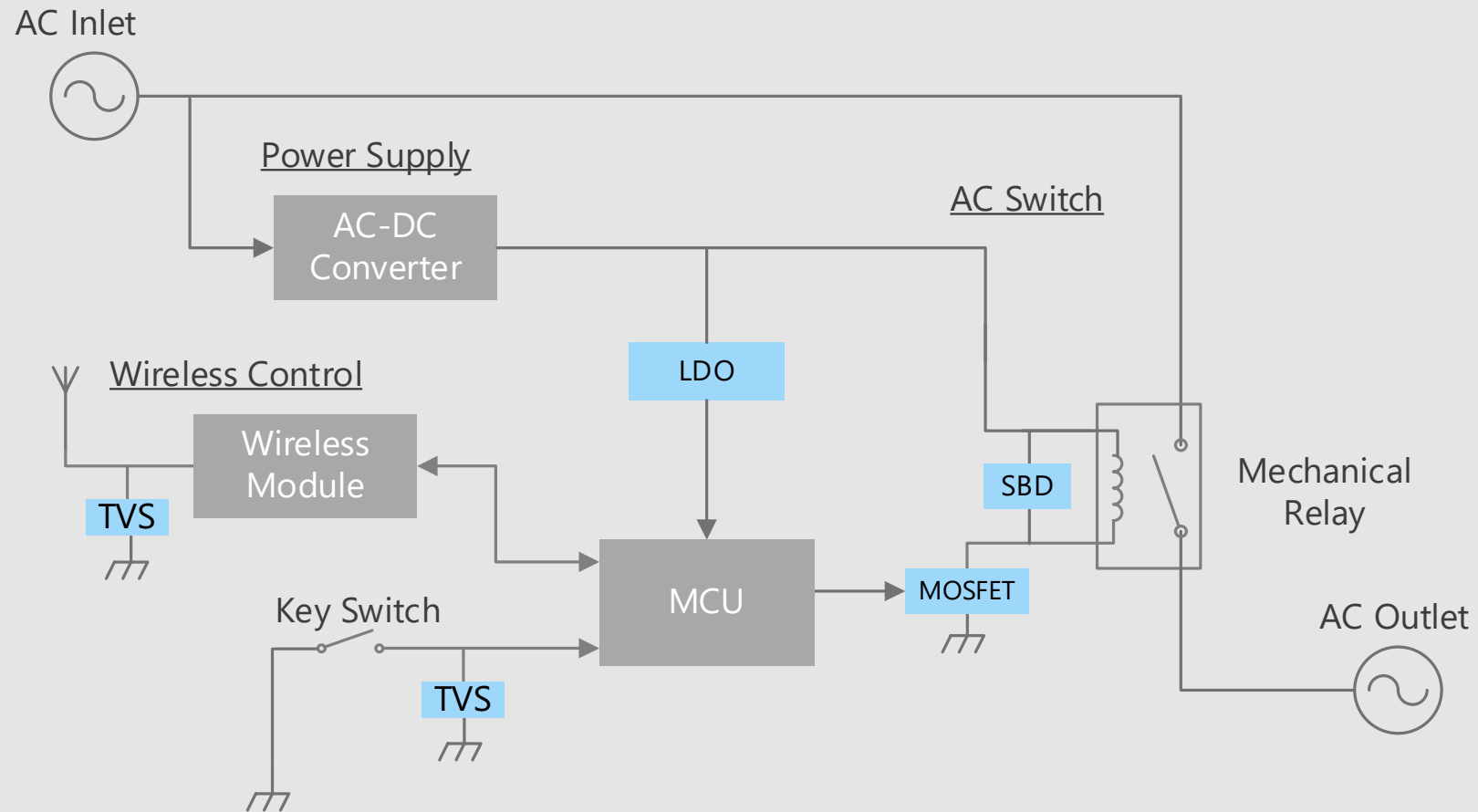


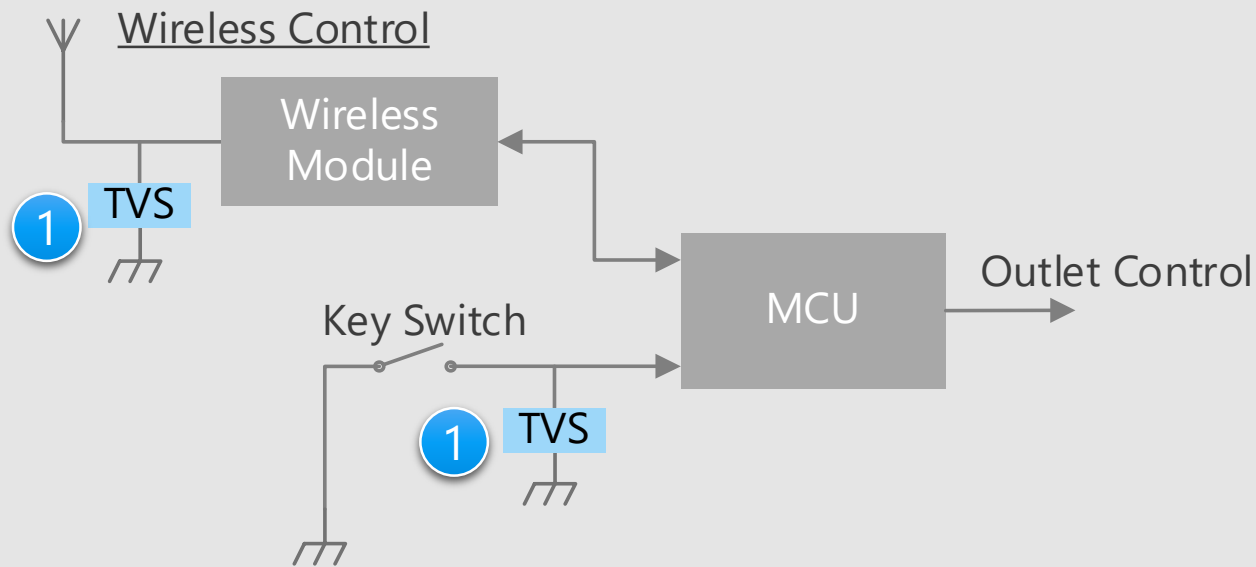
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



Smart Plug Overall block diagram





* Click on the blue circled numbers above to view detailed descriptions.

Criteria for device selection

- Since components such as key switches and antennas which may be exposed to the outside environment, protection circuitry may be required.

Proposal from Toshiba

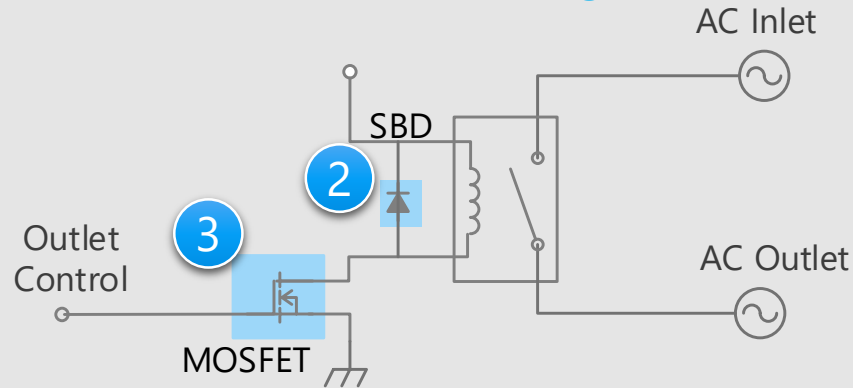
- **Prevent circuit malfunctions by absorbing electrostatic discharge (ESD) from external terminals**

TVS diode

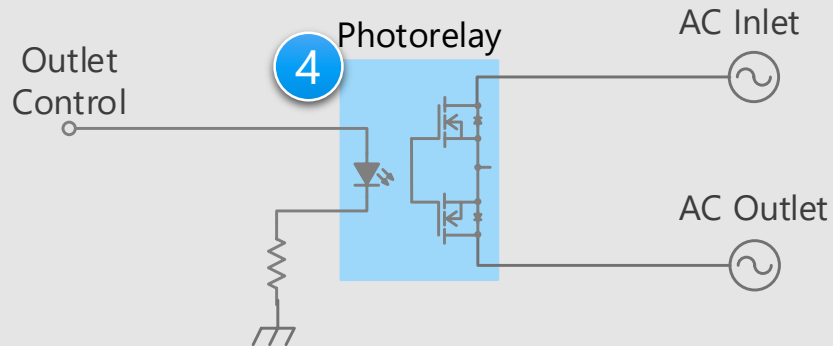
1

Smart Plug Detail of AC switch section (1)

AC switch implementation using mechanical relays



AC switch implementation using photorelays (under 0.3A)



Criteria for device selection

- Schottky barrier diodes are used for surge protection of inductive loads such as relays.
- Low power AC switches can be realized using photorelays.

Proposal from Toshiba

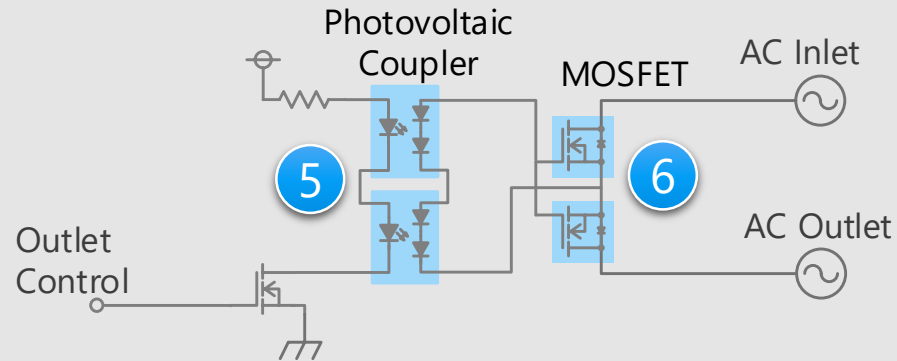
- **Diodes for surge current protection**
Schottky barrier diode (SBD) 2
- **Small package, low on-resistance MOSFET**
Small signal MOSFET 3
- **Designed for high AC isolation voltage**
Photorelay 4

* Click on the blue circled numbers above to view detailed descriptions.

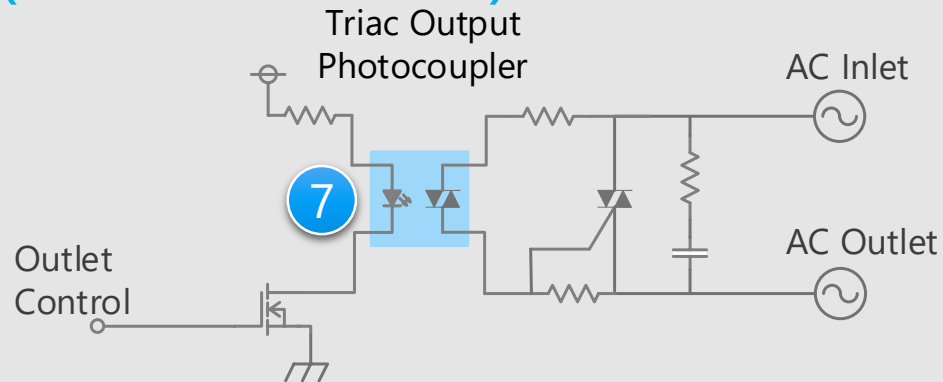
(Control of commercial AC requires regulatory compliance for each country.)

Smart Plug Detail of AC switch section (2)

AC switch example using photovoltaic output photocoupler and MOSFET (for currents around 0.3A to 1A)



AC switch example using triac and triac output photocoupler (for currents 1A or more)



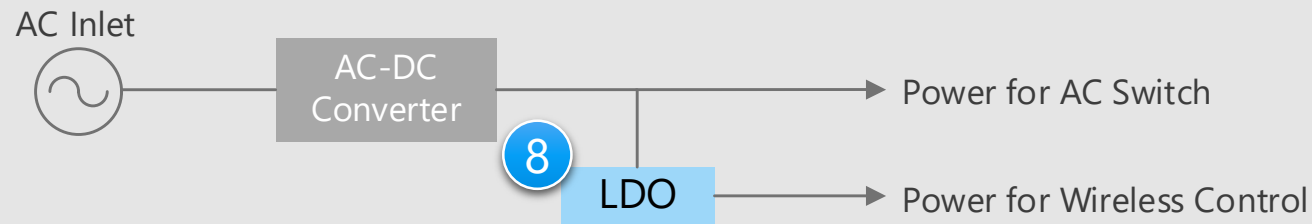
* Click on the blue circled numbers above to view detailed descriptions.
(Control of commercial AC requires regulatory compliance for each country.)

Criteria for device selection

- Isolated AC switch can be realized using a MOSFET driven by a photovoltaic output photocoupler.
- AC switch can be realized using a triac driven by a triac output photocoupler.

Proposal from Toshiba

- **Photocoupler for direct MOSFET driving** (5)
Photovoltaic output photocoupler
- **Suitable for high efficiency power switching** (6)
DTMOSIV Series power MOSFET
- **Photocoupler suitable for AC control** (7)
Triac output photocoupler



* Click on the blue circled numbers above to view detailed descriptions.

Criteria for device selection

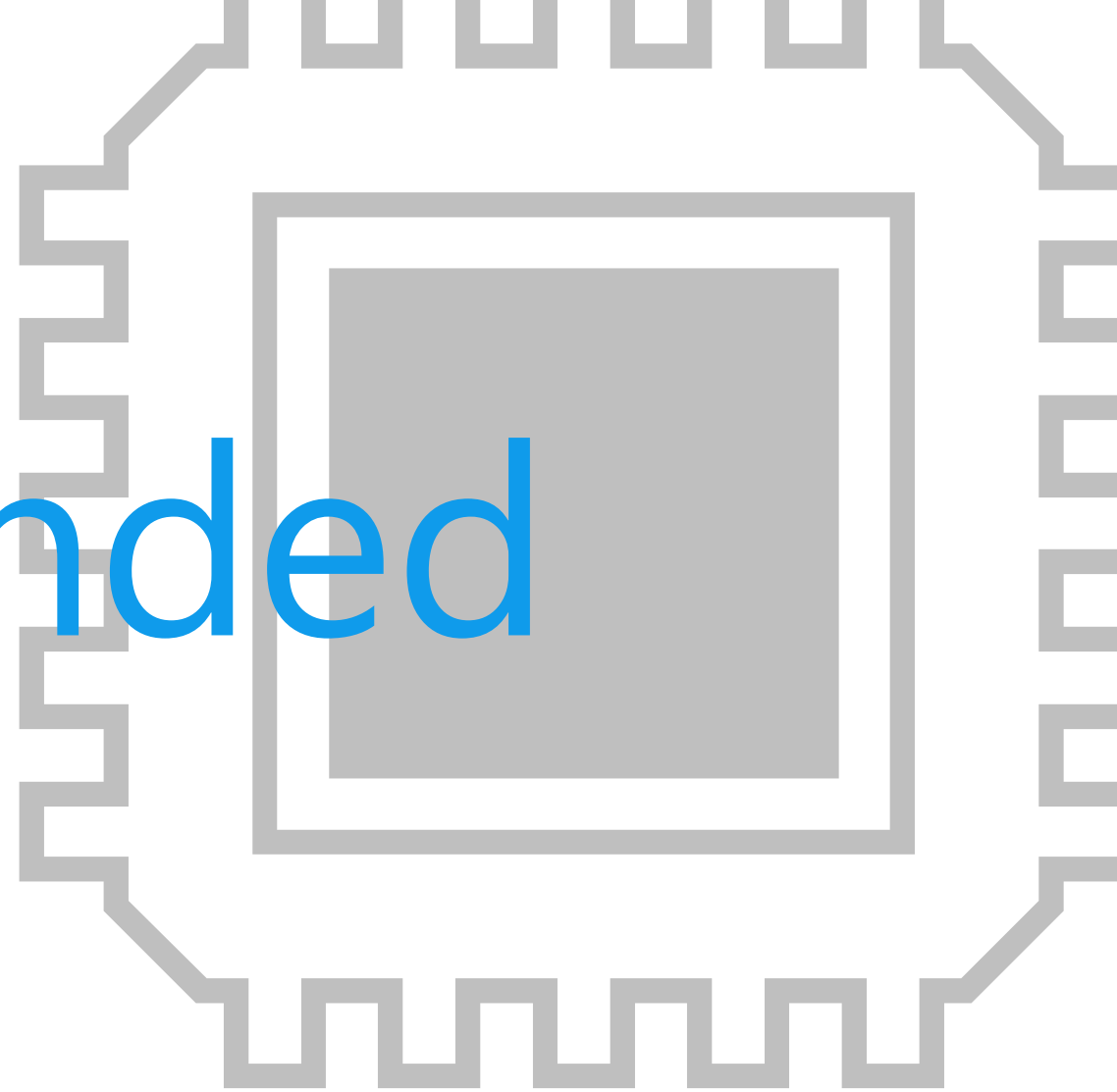
- For power supply ICs which include analog circuitry such as wireless, low noise is a requirement for stable operation.

Proposal from Toshiba

- **Resistant to power supply noise**
Small surface mount LDO regulator

8

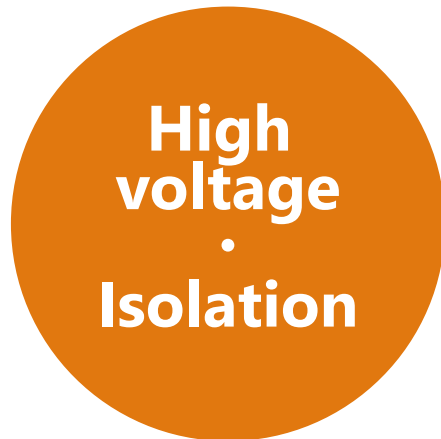
Recommended Devices



Device solutions to address customer needs

As described above, in the design of Smart Plug ,
"AC isolation", " High set efficiency " and "Miniaturization of
circuit boards" are important factors. Toshiba's proposals are
based on these three solution perspectives.

AC isolation



High set efficiency



Miniaturization of
circuit boards



Device solutions to address customer needs

High voltage
•
Isolation

High efficiency
•
Low loss

Small size packages

1	TVS diode		●	●
2	Schottky barrier diode (SBD)		●	●
3	Small signal MOSFET		●	●
4	Photorelay	●	●	●
5	Photovoltaic output photocoupler	●	●	●
6	DTMOSIV Series power MOSFET	●	●	●
7	Triac output photocoupler	●	●	●
8	Small surface mount LDO regulator		●	●

Value provided

Protects devices and prevents circuit malfunctions by absorbing ESD entering from external terminals.

1 High ESD pulse absorption performance

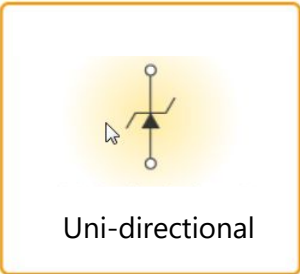
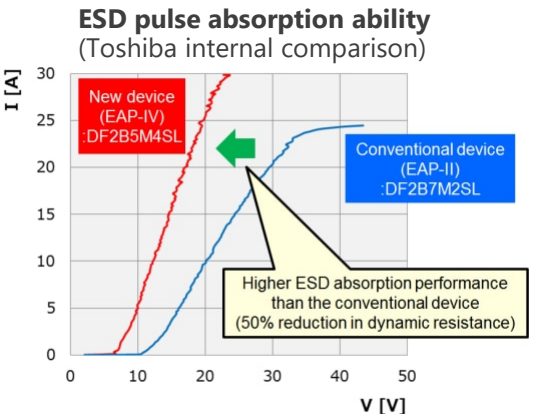
Improved ESD absorption compared to our conventional products. (50 % reduction in operating resistance)
For some products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

2 Suppress ESD energy by low clamp voltage

Steadily protect the connected circuits/devices using Toshiba own technology.

3 Suitable for high density mounting

A variety of compact packages are available.



Line up

Part number	DF2B7ASL	DF2S14P1CT	DF2B5M4SL	DF2B6M4SL
Package	SL2	CST2	SL2	SL2
V_{ESD} [kV]	±30	±30	±20	±20
V_{RWM} (Max) [V]	5.5	12.6	3.6	5.5
C_t (Typ.) [pF]	8.5	40	0.2	0.2
R_{DYN} (Typ.) [Ω]	0.2	0.5	0.5	0.5

Note: This device is for ESD protection only and cannot be used for purposes other than ESD protection.

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2 Schottky barrier diode (SBD)

CRS03 / CRS13

High Voltage
Isolation

High efficiency
Low loss

Small size packages

Value provided

Fast, low-loss, small package and suitable for many applications.

1 Fast switching

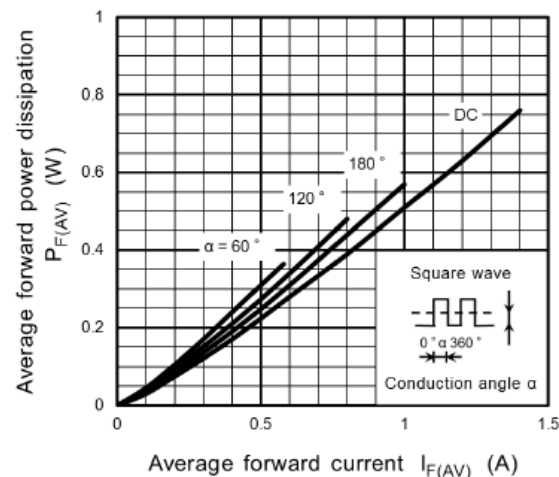
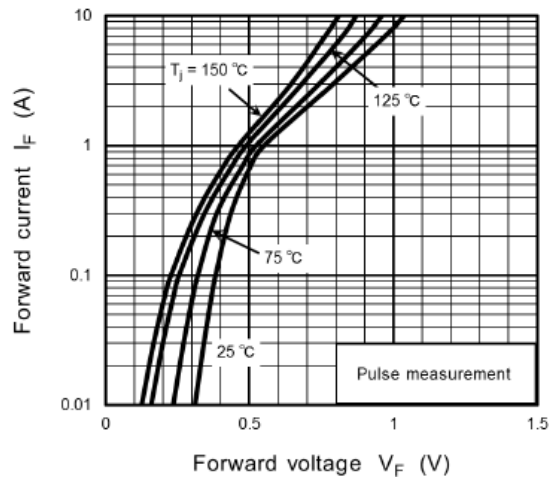
For fast switching applications.

2 High reverse voltage


High repetitive peak reverse voltage (V_{RRM})
(CRS13: rated at 60 V)

3 Small package

Small package form factor allows high density mounting.



Line up

Part number	CRS03	CRS13
Package	S-FLAT™ 	
V_{RRM} (Max) [V]	30	60
$I_{F(AV)}$ (Max) [A]	1.0	1.0
V_{FM} (Max) [V]	0.45	0.55
I_{RRM} (Max) [μ A]	100	50

[Return to Block Diagram TOP](#)

Value provided

Suitable for power management switching, with small package dimensions.

1 Low voltage operation

Can operate at $V_{GS} = 1.5\text{ V}$

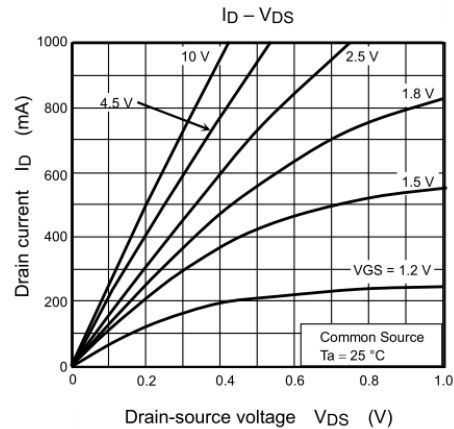
2 Strong ESD tolerance

ESD (HBM) tolerance up to about 2 kV

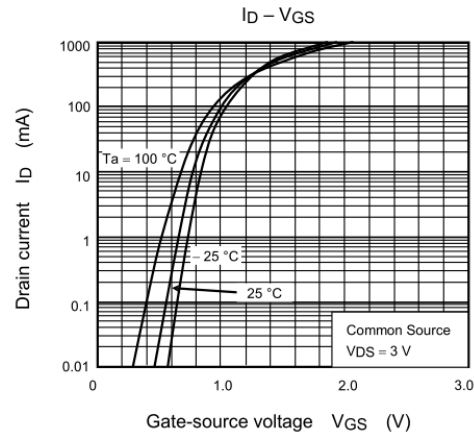
3 Low on-resistance

By reducing drain-source on-resistance, heat radiation and power dissipation is minimized.



SSM3K36FS



SSM3K36FS



Line up

Part number	SSM3K36FS	SSM3K56FS
Package	SSM 	SSM 
V_{DSS} [V]	20	20
I_D [A]	0.5	0.8
P_D [W]	0.15	0.15
$R_{DS(ON)}$ (Max) [Ω]	0.63	0.235
Polarity	N-ch	N-ch

[Return to Block Diagram TOP](#)

Value provided

8-pin DIP photorelay using a photo MOSFET optically coupled to an infrared LED.

1 Low on-resistance R_{ON}

Maximum on-resistance R_{ON} at turn-on is $2\ \Omega$ (at $I_{ON} = 0.6\text{ A}$).

2 Wide range of ON current I_{ON}

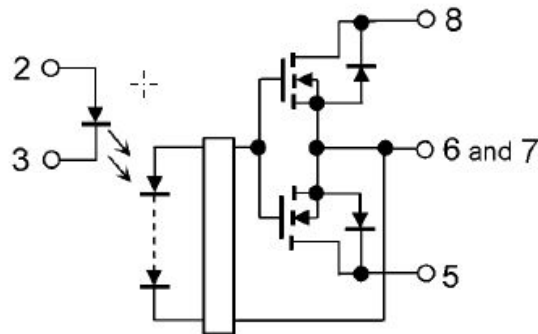
Wide range of allowed ON current I_{ON} , suitable for power line control (maximum 0.6 A: A connected) [Note 1]

3 Wide package selection

Small package allowing design freedom and forming option (through-hole type, lead forming option, taping option. Five total selections)


[Note 1] Please refer to the technical data sheet for connection.

Internal equivalent circuit



UL certified UL1577, File No. E67349
cUL certified CSA Component Acceptance Service No.5A File No. E67349

Line up

Part number	TLP3549
Package	DIP8 
V_{OFF} [V]	600
V_{DD} (Max) [V]	480
I_F (Max) [mA]	25
I_{ON} (Max) [A]	0.6
BV_S (Max) [Vrms]	2500

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5 Photovoltaic output photocoupler

TLP3906

High voltage
Isolation

High efficiency
Low loss

Small size packages

Value provided

Photocoupler containing optically coupled photo diode array and infrared LED.

1 Suitable for MOSFET driver

Photodiode is connected in series, suitable for driving the gate of MOSFET.

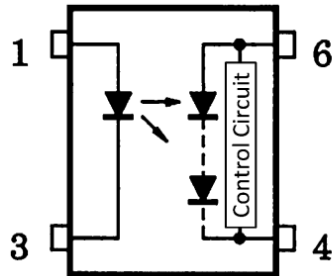
2 No need to use external discharging resistor

Since the control circuit is on the detector side, there is no need to connect an external discharging resistor.

3 Improved switching speed

t_{ON}/t_{OFF} is 1 ms maximum.

Internal equivalent circuit



1: Anode (Input)
3: Cathode (Input)
4: Cathode (Output)
6: Anode (Output)

UL certified UL1577, File No.E67349
cUL certified CSA Component Acceptance Service No.5A File No.E67349
VDE certified EN60747-5-5, EN60065, EN60950-1 (Note)

(Note): To specify a VDE certified model, request a (V4) model

Line up

Part number	TLP3906	
Package	4pin SO6	
I_F (Max) [mA]	15	
V_{OC} (Min) [V]	7	
I_{SC} (Min) [μ A]	12	
BV_S (Max) [Vrms]	3750	
Lateral spacing (Min) [mm]	5.0	

[◆Return to Block Diagram TOP](#)

Value provided

Performance index RonA reduced by 30 %*, power supply improved, allowing smaller set form factor.

* Toshiba product comparison

1 30 % reduction of RonA

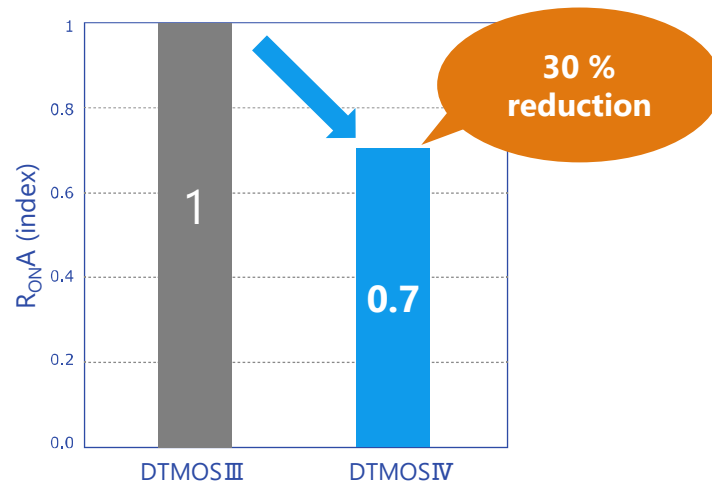
Using a new single epitaxial process, performance index RonA is reduced by 30 % (DTMOSIII comparison*)

2 Reduced increase in on-resistance at high temperature

Using a new single epitaxial process, rise of on-resistance at high temperature is kept low.



3 Optimized gate switching speed

Reduction of C_{oss} (12 % *) and on-resistance (super junction structure DTMOS) allows optimized gate switching speed.



Note: Toshiba internal comparison

Line up

Part number	TK5P60W	TK8P60W	TK16G60W
Package	DPAK 	DPAK 	D2PAK 
V_{DSS} [V]	600	600	600
I_D [A]	5.4	8.0	15.8
P_D [W]	60	80	130
C_{iss} [pF]	380	570	1350
$R_{DS(ON)}$ (Max) [Ω]	0.9	0.5	0.19
Polarity	N-ch	N-ch	N-ch

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7 Triac output photocoupler

TLP265J / TLP266J / TLP267J / TLP268J



Value provided

Photocoupler suitable for AC switching.

1 Small package (4pin SO6)

Thin 4pin SO6 (3.7 x 7.0 x 2.1 mm) package allows high density mounting

2 High isolation voltage (3750 Vrms)

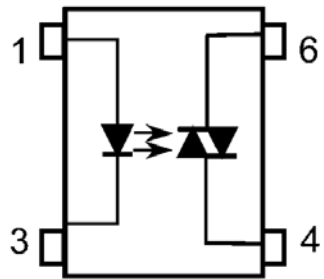
Isolation voltage is 3750 Vrms. Insulator thickness is 0.4 mm, creepage and clearance distances are 5.0 mm. Compliant with reinforced insulation safety standards.

3 Compatible with zero-cross output

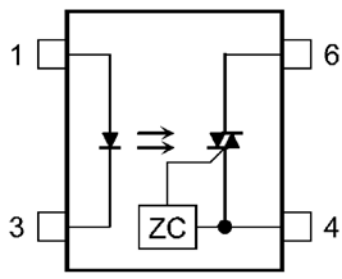
Maximum output current is 70 mA. Higher output is possible using main triac connection. Zero-cross (ZC) compatible output is also available.

Pin layout

TLP265J / TLP267J




TLP266J / TLP268J



- 1. Anode
- 3. Cathode
- 4. Triac pin
- 6. Triac pin

Line up

Part number	TLP265J	TLP266J	TLP267J	TLP268J
Package	4pin SO6 			
Output	Non-ZC	ZC	Non-ZC	ZC
V_{DRM} (Min) [V]	600			
I_F (Max) [mA]	10		3	
$I_{T(RMS)}$ (Max) [mA]	70			
BV_S (Max) [Vrms]	3750			

[◆Return to Block Diagram TOP](#)

8 Small surface mount LDO regulator

TCR15AG / TCR13AG / TCR8BM / TCR5BM / TCR5RG / TCR3RM / TCR3U / TCR2L / TAR5 Series

High Voltage
Isolation

High efficiency
Low loss

Small size packages

Value provided

Wide line up from general purpose type to small package type are provided. Contribute to realize a stable power supply not affected by fluctuation of battery.

1 Low dropout voltage

The newly developed new generation process significantly improved the dropout voltage characteristics.

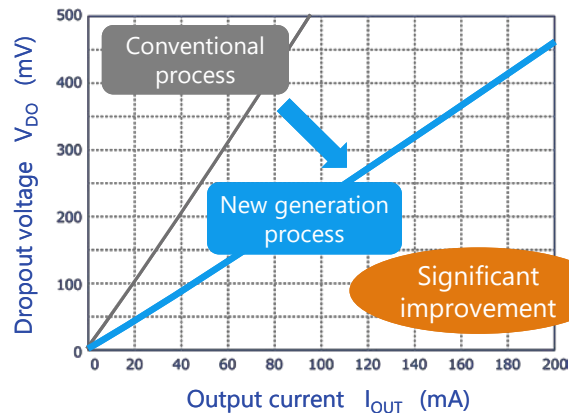
2 High PSRR Low output noise voltage

Many product series that realize both high PSRR (Power Supply Rejection Ratio) and low output noise voltage characteristics are provided. They are suitable for stable power supply for analog circuit.

3 Low current consumption

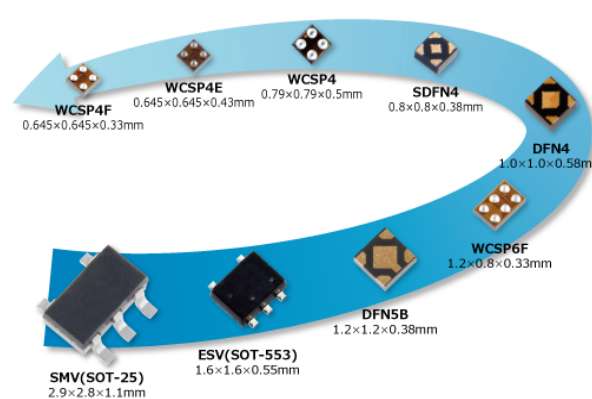
0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.

Low dropout voltage



Note: Toshiba internal comparison

Rich package line up



Line up

Part number	TCR15AG Series	TCR13AG Series	TCR8BM Series	TCR5BM Series	TCR5RG Series	TCR3RM Series	TCR3U Series	TCR2L Series	TAR5 Series
Features	Low dropout voltage High PSRR				High PSRR Low noise Low current consumption		Low current consumption		15V Input voltage Bipolar type
I_{OUT} (Max) [A]	1.5	1.3	0.8	0.5		0.3		0.2	
PSRR (Typ.) [dB] @f=1 kHz	95	90	98	98	100	100	70	-	70
I_B (Typ.) [μA]	25	52	20	19	7	7	0.34	1	170

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