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Semiconductors for Power Supplies

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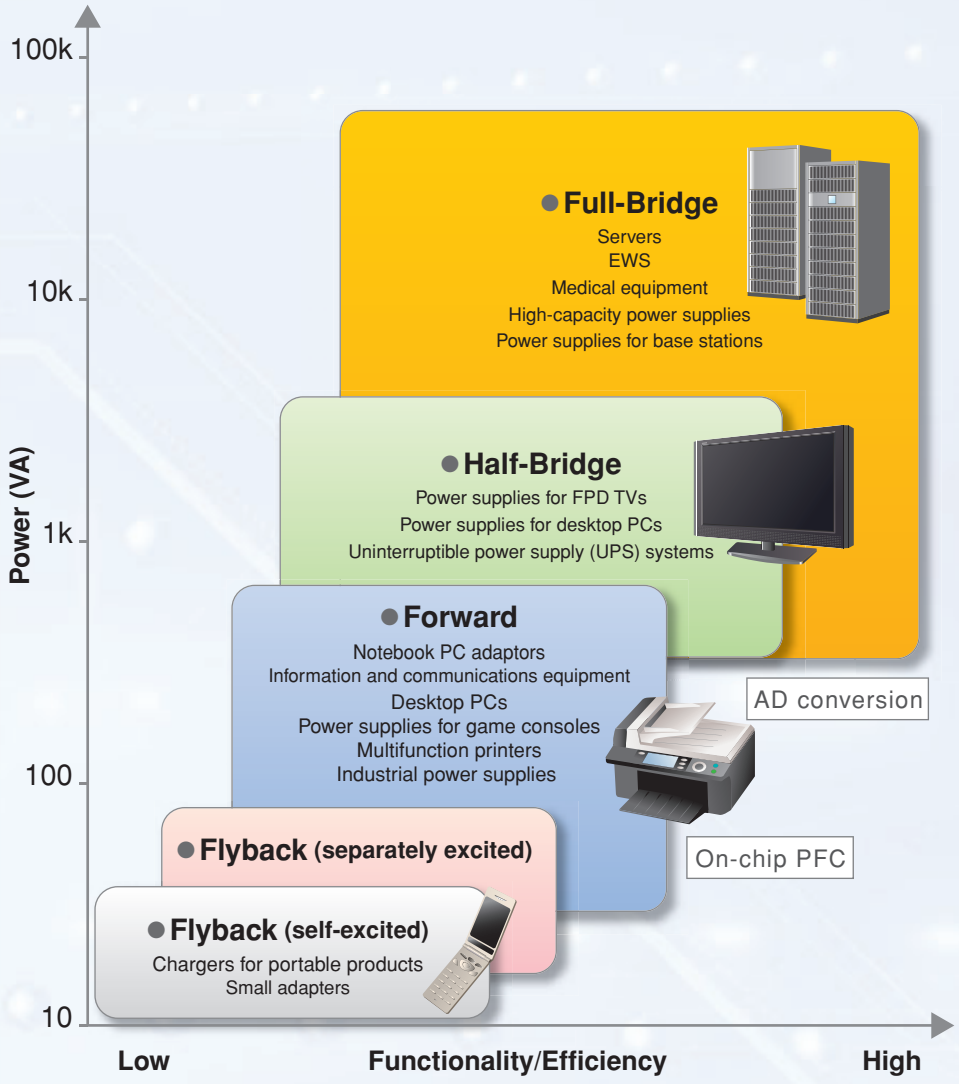
Types and Applications of Switching Power Supplies



Types of DC-DC converters embedded in various power supplies

① **Step-up chopper**
② **Step-down chopper**
③ **Charge pump**
(Synchronous rectification)

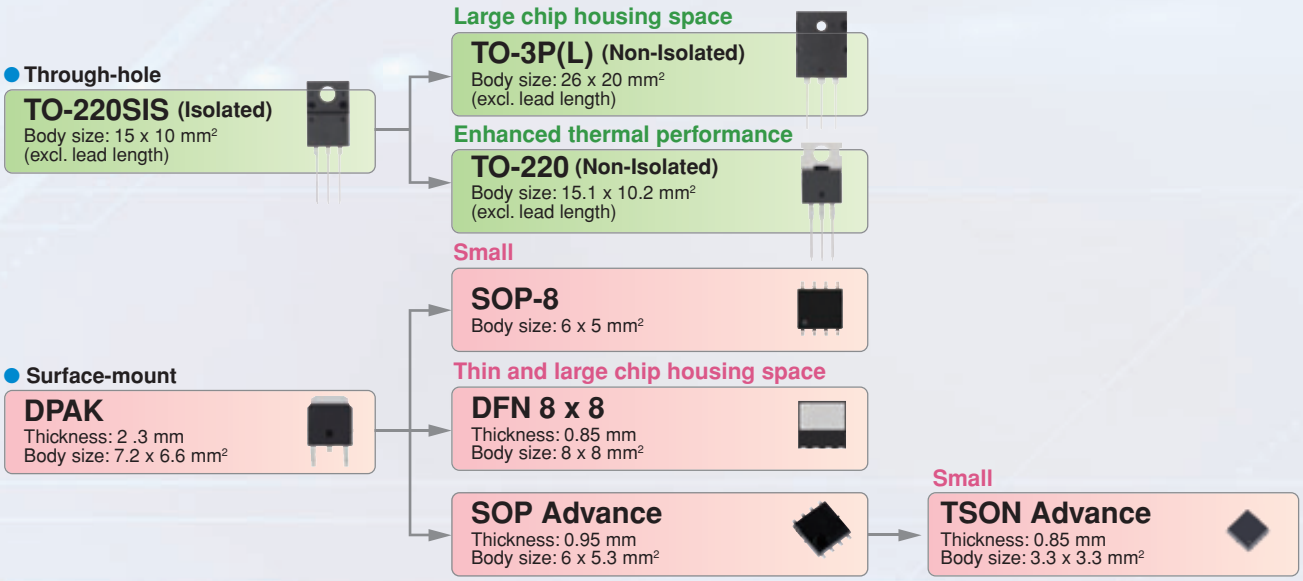
On-board DC-DC converters

- **Notebook PCs**
- **CPU power supply regulators**
- **DC-DC converters for communication applications**

Toshiba offers various semiconductor devices for power supply applications to meet a wide range of customer needs varying from low power to high power. These devices help to save energy and improve power efficiency.

The up-to-date information about our semiconductor devices for power supply applications is available on our website at: http://www.semicon.toshiba.co.jp/eng

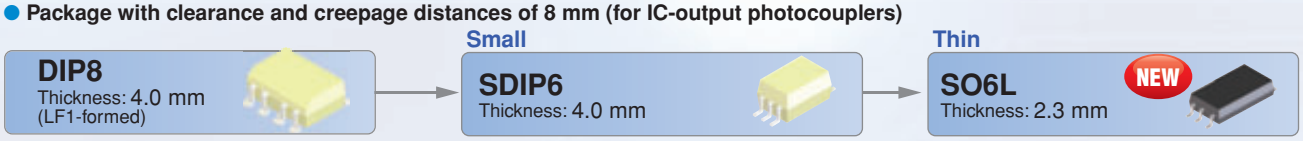
Packaging trend for power devices



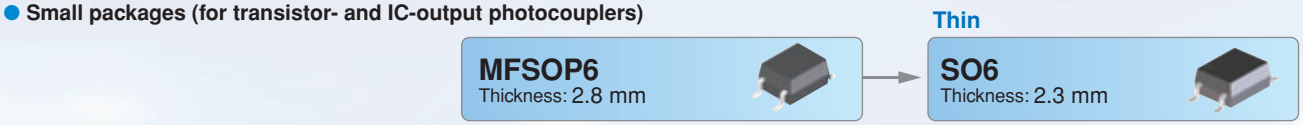
Packaging trend for photocouplers

To address the needs for power supply units requiring small, thin form factor, Toshiba is developing small, thin photocoupler packages.

● **Package with clearance and creepage distances of 8 mm (for IC-output photocouplers)**



● **Small packages (for transistor- and IC-output photocouplers)**



Contents

* Toshiba's schottky barrier diodes are silicon-based devices

Switching Power Supplies

AC-DC Flyback Power Supplies

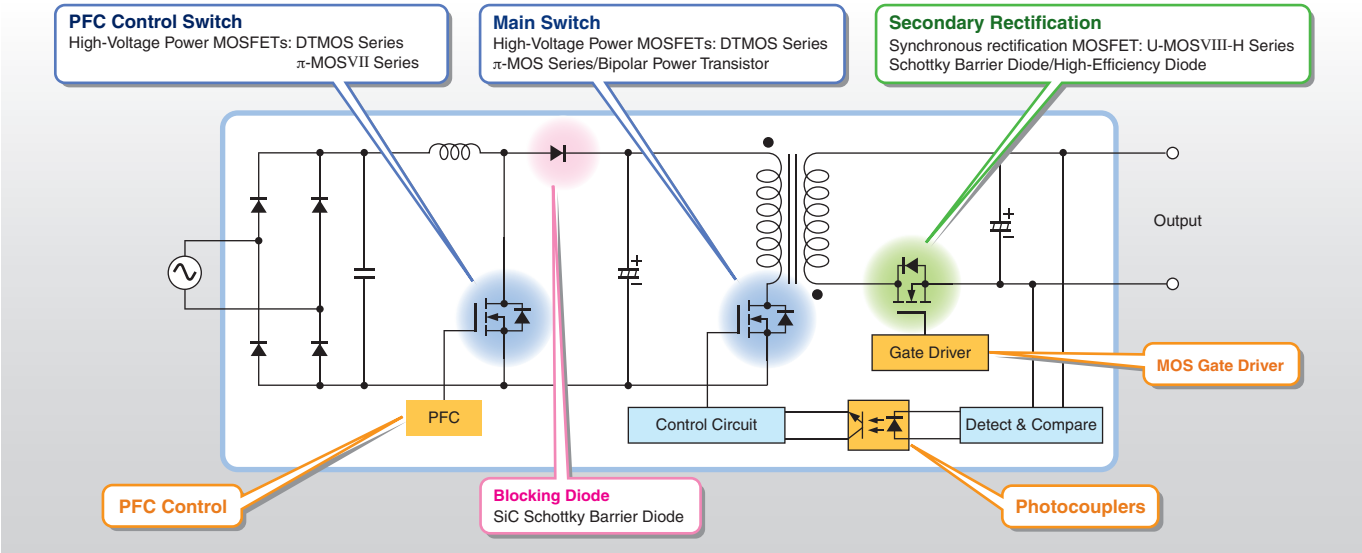
Features

- AC-DC flyback power supplies have a very simple circuit configuration that consists of a minimal part count. They are suitable for low-power power supplies.

Application Examples

- Notebook PC adaptors
- Power supplies
- PC peripherals
- LCD adaptors
- Chargers for portable products
- Standby power supplies and small adaptors

Circuit Example



Recommended Parts

Output Power (W)			Up to 10	Up to 20	Up to 50	Up to 100
PFC Control	PFC Controller ICs		TB6819AFG			
PFC Control Switch	High-Voltage Power MOSFETs	V_{DSS} = 500 V	TK3P50D,TK4A50D	TK5A50D,TK7P50D	TK8A50D,TK11A50D	TK12A50D,TK13A50D
		V_{DSS} = 600 V	TK5A60W, TK5P60W TK5Q60W	TK6A60W, TK6P60W TK7Q60W	TK8A60W, TK8P60W TK10A60W, TK10P60W	TK12A60W, TK16A60W TK12P60W
Blocking Diode	SiC Schottky Barrier Diode	V_{RRM} = 650V	TRS6A65C	TRS6A65C	TRS6A65C	TRS6A65C
Main Switch	High-Voltage Power MOSFETs	V_{DSS} = 600 V	TK2P60D, TK2Q60D TK5P60W, TK5Q60W	TK4Q60D, TK4P60DA TK5P60W, TK5Q60W	TK6A60W, TK6P60W TK6Q60W	TK7A60W, TK7P60W TK8A60W, TK8P60W
		V_{DSS} = 650 V	TK3A65DA TK8P65W**	TK7A65D TK8P65W**, TK11P65W**	TK8A65D TK11P65W**, TK11A65W	TK10A65D TK11A65W, TK14A65W
		V_{DSS} = 800 V	TK3P80E TK2P90E	TK3P80E, TK6A80E TK2P90E, TK7A90E	TK6A80E TK7A90E	TK10A80E TK9A90E
	Bipolar Power Transistor	100-Vac input	2SC5548A,TTC008			
		200-Vac input	2SC6142,TTC012			
Secondary Rectification	Schottky Barrier Diode/ High-Efficiency Diode	Output: Up to 3 V (V_{RRM} = 30 V)	CUS10I30A, CRS10I30A CRS10I30C	CRS20I30A, CRS20I30B CMS20I30A	CRS30I30A, CMS30I30A	
		Output: Up to 5 V (V_{RRM} = 40 V)	CUS10I40A, CRS10I40A CRS10I40B	CRS20I40A, CRS20I40B CMS20I40A	CMS30I40A	
		Output: Up to 12 V (V_{RRM} = 60 V)	CUS04, CRS12 CRS13	CMS14		
		Output: Up to 24 V (V_{RRM} = 200 V)	CRH01, CMH04 CMH07	CMH01		
	Synchronous Rectification MOSFET (Low-Voltage Power MOSFETs)	V_{DSS} = 60 V		TPN11006NL TPH11006NH		
		V_{DSS} = 100 V			TK22A10N1, TK34A10N1 TK22E10N1, TK34E10N1	TK40A10N1,TK65A10N1 TK40E10N1,TK65E10N1 TK65C10N1
		V_{DSS} = 120 V			TK32A12N1, TK42A12N1 TK32E12N1, TK42E12N1	TK56A12N1, TK72A12N1 TK56E12N1, TK72E12N1
MOS Gate Driver	Bipolar Power Transistor		TPCP8901,TPCP8902			
Output Error Feedback	Photocouplers	Analog feedback	TLP183, TLP293, TLP785			
		Digital feedback	TLP2309, TLP2355, TLP2358			

**: Under development

AC-DC Forward Power Supplies

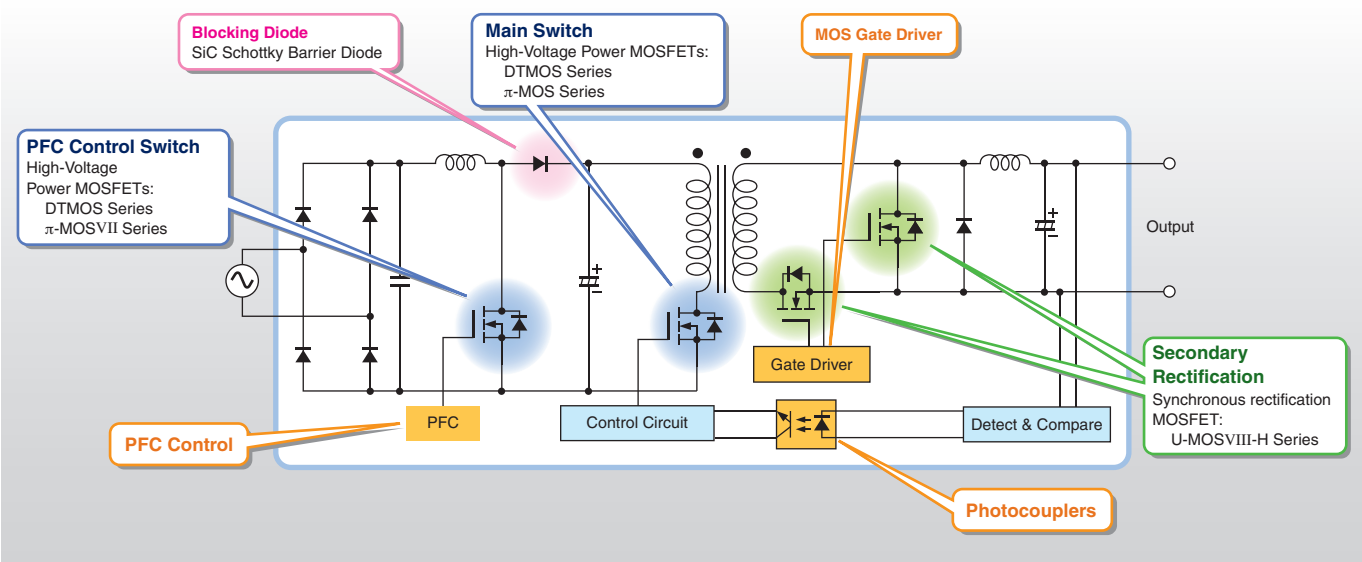
Features

- AC-DC forward power supplies with a relatively simple circuit configuration are widely used for 100-W to 500-W power supply applications. Forward power supplies have less ripple since the capacitor is continuously charged. Compared to flyback power supplies, they exhibit a higher transformer efficiency and thus can provide up to 500 W.

Application Examples

- Notebook PC adaptors
- Desktop PCs
- Power supplies for game consoles
- Information and communications equipment
- Multifunction printers
- Industrial power supplies

Circuit Example



Recommended Parts

Output Power (W)			Up to 100	Up to 150	Up to 200
PFC Control	PFC Controller ICs		TB6819AFG		
PFC Control Switch	High-Voltage Power MOSFETs	V_{DSS} = 500 V	TK12A50D, TK15A50D	TK15A50D, TK18A50D TK15J50D	TK18A50D, TK15J50D TK20J50D
		V_{DSS} = 600 V	TK16A60W, TK20A60W TK16E60W, TK20E60W	TK20A60W, TK25E60X** TK31A60W, TK31N60X	TK31A60W, TK39A60W TK31N60X, TK39N60X
Blocking Diode	SiC Schottky Barrier Diode	V_{RRM} = 650 V	TRS6A65C, TRS6E65C	TRS8A65C, TRS8E65C	TRS10A65C, TRS12A65C TRS10E65C, TRS12E65C
Main Switch	High-Voltage Power MOSFETs	V_{DSS} = 600 V	TK10A60W, TK12A60W TK12V60W	TK16A60W, TK20A60W TK12V60W, TK16V60W	TK20A60W, TK31A60W TK16V60W, TK20V60W
		V_{DSS} = 650 V	TK11A65W, TK14A65W	TK14A65W, TK17A65W	TK17A65W, TK28A65W**
Secondary Rectification	Synchronous Rectification MOSFET (Low-Voltage Power MOSFETs)	V_{DSS} = 60 V	TK30A06N1, TK30E06N1 TPH11006NH, TPN11006NH TPH14006NH, TPN14006NH	TK40A06N1, TK40E06N1 TPH7R506NH, TPN7R506NH	TK58A06N1, TK58E06N1 TPH4R606NH
		V_{DSS} = 80 V	TK35A08N1, TK35E08N1 TPH12008NH, TPN13008NH	TK46A08N, TK46E08N TPH8R008NH	TK72A08N1, TK72E08N1 TPH4R008NH
		V_{DSS} = 100 V	TK34A10N1, TK34E10N1 TPH1400ANH, TPN1600ANH	TK40A10N1, TK40E10N1 TPH8R80ANH	TK65A10N1, TK65E10N1 TK65C10N1, TPH4R50ANH
		V_{DSS} = 120 V	TK32A12N1, TK32E12N1	TK42A12N1, TK42E12N1	TK56A12N1, TK56E12N1
MOS Gate Driver	Bipolar Power Transistor		TPCP8901,TPCP8902		
Output Error Feedback	Photocouplers	Analog feedback	TLP183, TLP293, TLP785		
		Digital feedback	TLP2309, TLP2355, TLP2358		

**: Under development

Switching Power Supplies

AC-DC Half-Bridge Power Supplies

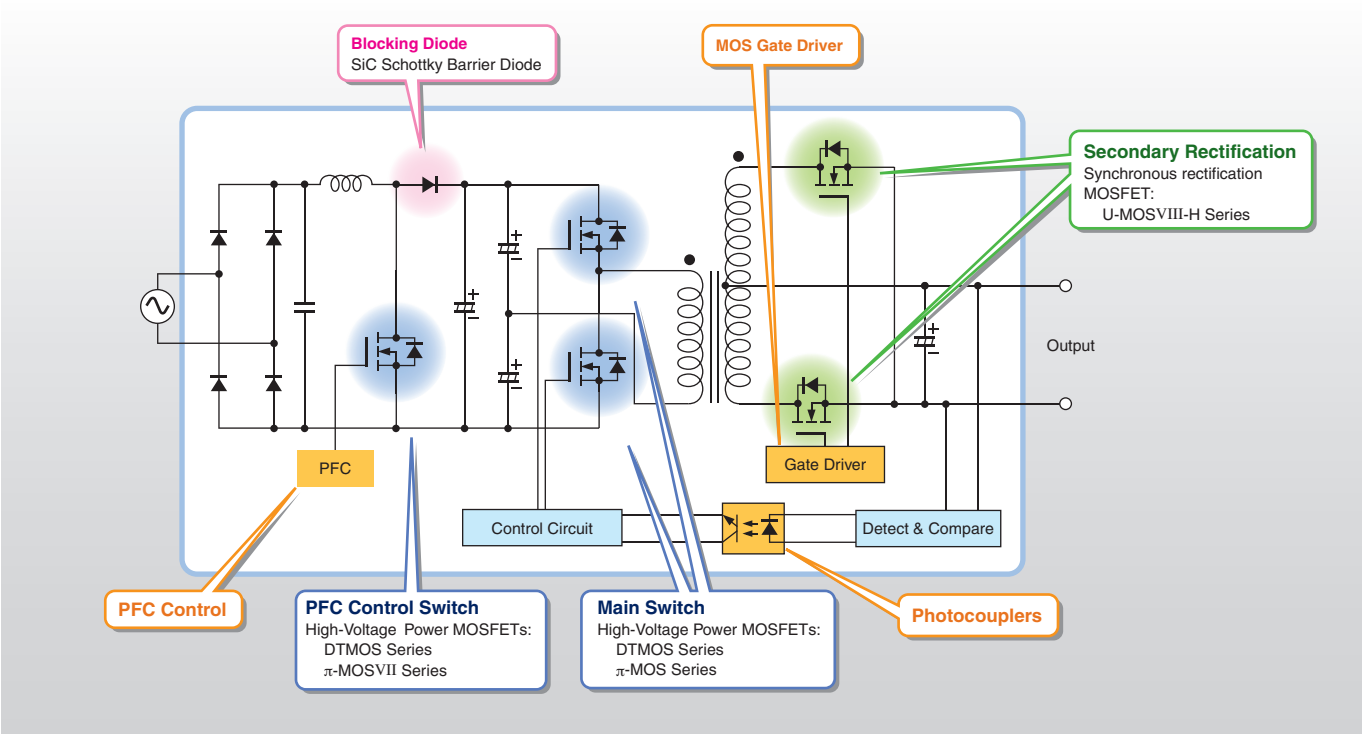
Features

- Resonant half-bridge power supplies are suitable for relatively high-power power supply applications in the range of 150 W to 1 kW. The two transistors connected in series with the input supply voltage reduce the input voltage applied to the primary side of the transformer by half. This makes it possible to use Low-Voltage transistors.

Application Examples

- Power supplies for FPD TVs
- Uninterruptible power supplies (UPS)
- Desktop PCs
- Servers

Circuit Example



Recommended Parts

Output Power (W)			Up to 100	Up to 200	Up to 400	Up to 800
PFC Control	PFC Controller ICs		TB6819AFG		TB6818FG	
PFC Control Switch	High-Voltage Power MOSFETs	V_{DSS} = 500 V	TK12A50D TK15A50D	TK18A50D, TK15J50D TK20J50D	TK20J50D	
		V_{DSS} = 600 V	TK16A60W, TK20A60W TK16E60W, TK20E60W	TK31A60W, TK39A60W TK31N60X, TK39N60X	TK39N60W, TK62N60W TK39N60X, TK62N60X	TK62J60W, TK62N60X TK100L60W
Blocking Diode	SiC Schottky Barrier Diode	V_{RRM} = 650 V	TRS6A65C, TRS6E65C	TRS10A65E, TRS12A65C TRS12E65C, TRS12N65D	TRS12N65D, TRS16N65D TRS20N65D	TRS20N65D, TRS24N65D
Main Switch	High-Voltage Power MOSFETs	V_{DSS} = 600 V	TK8A60W5, TK10A60W5 TK12A60W	TK16A60W5, TK20A60W5 TK20A60W	TK31N60W5, TK39N60W5 TK39A60W	TK39N60W5, TK62J60W5 TK62N60W
		V_{DSS} = 650 V	TK14A65W5, TK14E65W5 TK14A65W	TK14A65W5, TK17A65W5 TK17A65W	TK28N65W5, TK35N65W5 TK28N65W	TK35N65W5, TK49N65W5 TK49N65W
Secondary Rectification	Synchronous Rectification MOSFET (Low-Voltage Power MOSFETs)	V_{DSS} = 60 V	TK30A06N1, TK30E06N1 TPH11006NH, TPN11006NH TPH14006NH, TPN14006NH	TK40A06N1, TK40E06N1 TPH7R506NH, TPN7R506NH	TK58A06N1, TK58E06N1 TPH4R606NH	TK100A06N1, TK100E06N1 TPH2R306NH
		V_{DSS} = 80 V	TK35A08N1, TK35E08N1 TPH12008NH, TPN13008NH	TK46A08N, TK46E08N TPH8R008NH	TK72A08N1, TK72E08N1 TPH4R008NH	TK100A08N1, TK100E08N1 TPH4R008NH (2parallel)
		V_{DSS} = 100 V	TK34A10N1, TK34E10N1 TPH1400ANH, TPN1600ANH	TK40A10N1, TK40E10N1 TPH8R80ANH	TK65A10N1, TK65E10N1 TK65C10N1, TPH4R50ANH	TK100A10N1, TK100E10N1 TPH4R50ANH (2parallel)
		V_{DSS} = 120 V	TK32A12N1, TK32E12N1	TK42A12N1, TK42E12N1	TK56A12N1, TK56E12N1	TK72A12N1, TK72E12N1
MOS Gate Driver	Bipolar Power Transistor		TPCP8901, TPCP8902			
Output Error Feedback	Photocouplers	Analog feedback	TLP183, TLP293, TLP785			
		Digital feedback	TLP2309, TLP2355, TLP2358			

AC-DC Full-Bridge Power Supplies

Features

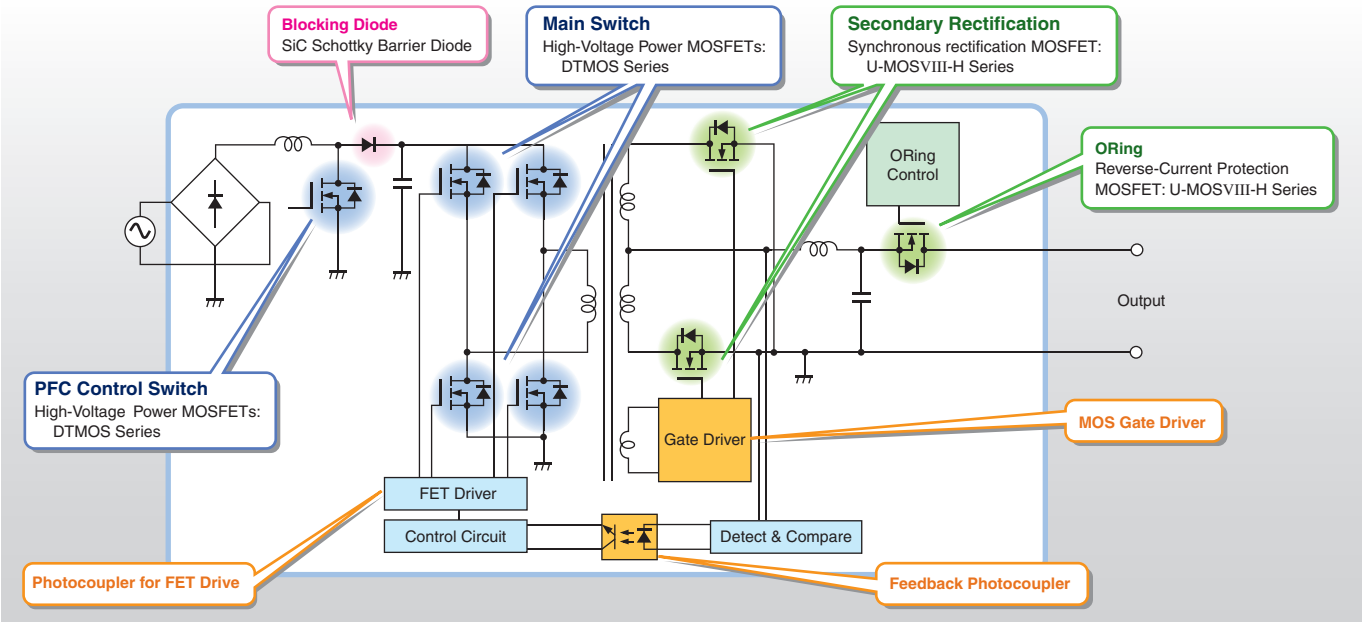
Full-bridge circuits are more complex than half-bridge circuits. However, since full-bridge power supplies provide higher efficiency, they are mainly used for large-capacity applications (with over 1-kW capacity).

- Because full-bridge power supplies evenly energize transformers bidirectionally, they do not cause magnetization in transformers. Thus, full-bridge power supplies do not need a demagnetization circuit.
- While the frequency and current ranges of a half-bridge power supply are limited by the capacitor used, full-bridge power supplies are free from this limit. Therefore, full-bridge power supplies can be used for relatively low-frequency, high-current applications.
- Because diodes in a full-bridge power supply form a current return circuit, it generates less noise than a half-bridge power supply.

Application Examples

- Power supplies for base stations
- EWS
- High-capacity power supplies
- Servers
- Medical equipment

Circuit Example



Recommended Parts

Output Power (W)			Up to 1000	Up to 2000	Up to 3000
PFC Control	PFC Controller ICs		TB6818FG		
PFC Control Switch	High-Voltage Power MOSFETs	V_{DSS} = 600 V	TK31N60X, TK39N60X TK62N60X	TK39N60X, TK62N60X TK100L60W	TK62N60X TK100L60W
Blocking Diode	SiC Schottky Barrier Diode	V_{RRM} = 650 V	TRS16N65D,TRS20N65D TRS24N65D	TRS20N65D TRS24N65D	TRS24N65D
Main Switch	High-Voltage Power MOSFETs	V_{DSS} = 600 V	TK39N60W5, TK62J60W5 TK62N60W	TK39N60W5 TK62J60W5	TK62J60W5
		V_{DSS} = 650 V	TK28N65W5, TK35N65W5 TK49N65W5	TK35N65W5 TK49N65W5	TK49N65W5
Secondary Rectification	Synchronous Rectification MOSFET (Low-Voltage Power MOSFETs)	V_{DSS} = 60 V	TK100A06N1 TK100E06N1 TPH2R306NH	TK100A06N1(2parallel) TK100E06N1(2parallel) TPH2R306NH (2parallel)	TK100A06N1(4parallel) TK100E06N1(4parallel) TPH2R306NH (4parallel)
		V_{DSS} = 80 V	TK100A08N1 TK100E08N1 TPH4R008NH (2parallel)	TK100A08N1(2parallel) TK100E08N1(2parallel) TPH4R008NH (4parallel)	TK100A08N1(4parallel) TK100E08N1(4parallel)
		V_{DSS} = 100 V	TK100A10N1 TK100E10N1 TPH4R50ANH (2parallel)	TK100A10N1(2parallel) TK100E10N1(2parallel) TPH4R50ANH (4parallel)	TK100A10N1(4parallel) TK100E10N1(4parallel)
		V_{DSS} = 120 V	TK72A12N1 TK72E12N1	TK72A12N1(2parallel) TK72E12N1(2parallel)	TK72A12N1(4parallel) TK72E12N1(4parallel)
MOS Gate Driver	Bipolar Power Transistor		TPCP8901,TPCP8902		
MOSFET Gate Driver	Photocouplers	1.0 to 2.5 A Output	TLP5701, TLP5702		
Output Error Feedback	Photocouplers	Analog feedback	TLP183, TLP293, TLP785		
		Digital feedback	TLP2309, TLP2355, TLP2358		
ORing	Reverse-Current Protection MOSFET	V_{DSS} = 30 V	TPHR9003NL (2parallel)	TPHR9003NL (4parallel)	TPHR9003NL (6parallel)
		V_{DSS} = 60 V	TPH2R306NH (2parallel)	TPH2R306NH (4parallel)	TPH2R306NH (6parallel)

DC-DC Converters (Non-Isolated)

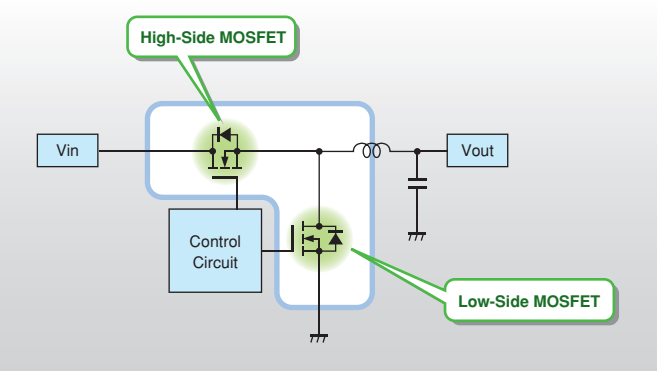
Features

A DC-DC converter is an electronic circuit which converts a direct current from one voltage level to another. While non-isolated DC-DC converters are primarily used for applications requiring less than 30 W, up to 100 W can be handled by adding a single MOSFET. Many DC-DC converters are deployed in cell phones and mobile devices that are becoming smaller, lighter and more feature-rich.

Application Examples

- POL modules
- On-board DC-DC converters
- CPU and memory power supplies
- Cell phones

Circuit Example



Recommended Parts

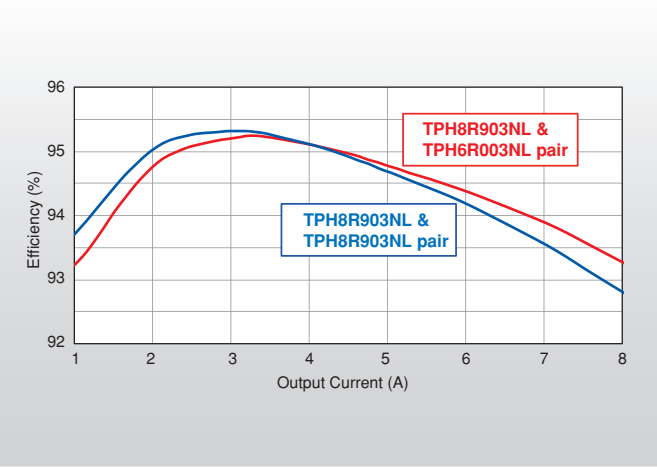
Input-to-Output Voltage Ratio*	Output Current (A)	Up to 10	Up to 15	Up to 20	Up to 25	Up to 30	Up to 40
Up to 0.08	High Side	**TPCC8066-H**	**TPCC8066-H** **TPN11003NL**	**TPN11003NL** **TPCC8065-H**	**TPCC8065-H** **TPN8R903NL**	**TPN8R903NL** **TPN6R003NL**	**TPN6R003NL** **TPH6R003NL**
	Low Side	**TPN8R903NL**	**TPN6R003NL**	**TPN4R303NL** **TPCA8059-H** **TPH6R003NL**	**TPN4R303NL** **TPCA8057-H**	**TPN2R703NL** **TPH3R203NL** **TPCA8055-H**	**TPH1R403NL**
Up to 0.15	High Side	**TPCC8066-H** **TPN11003NL**	**TPN11003NL** **TPCC8065-H**	**TPCC8065-H** **TPCA8065-H** **TPN8R903NL**	**TPN8R903NL** **TPN6R003NL**	**TPN6R003NL**	**TPN6R003NL** **TPH6R003NL** **TPN4R303NL** **TPH4R003NL**
	Low Side	**TPCC8065-H** **TPN8R903NL**	**TPN6R003NL**	**TPN4R303NL** **TPCA8059-H** **TPN6R003NL**	**TPN4R303NL** **TPCA8057-H**	**TPN2R703NL** **TPH3R203NL** **TPCA8055-H**	**TPH1R403NL**
Up to 0.5	High Side	**TPCC8065-H** **TPN8R903NL**	**TPN8R903NL** **TPN6R003NL**	**TPN4R303NL** **TPCA8059-H** **TPN6R003NL**	**TPN4R303NL** **TPCA8057-H**		
	Low Side	**TPCC8065-H** **TPN8R903NL**	**TPN6R003NL**	**TPN4R303NL** **TPCA8059-H** **TPN6R003NL**	**TPN4R303NL** **TPCA8057-H**		

* Input-to-Output Voltage Ratio: output_voltage / input_voltage

MOSFET Selection

The optimal pair of a high-side and a low-side MOSFET depends on the required output current.

The figure at right shows examples of efficiency curves when the input is at 19 V and the output is at 3.3 V (input-to-output voltage ratio = 0.17). Notice that, at up to 4 A, using the TPH8R903NL for both low and high sides delivers higher efficiency than using the TPH8R903NL/TPH6R003NL pair, and that at higher than 4 A, using the TPH8R903NL/TPH6R003NL pair as the high-side and low-side MOSFETs provides higher efficiency. The above table gives examples of recommended MOSFET pairs according to the output current requirement.



Detailed information about our MOSFETs is available on our website at: http://www.semicon.toshiba.co.jp/eng

DC-DC Converters (Isolated)

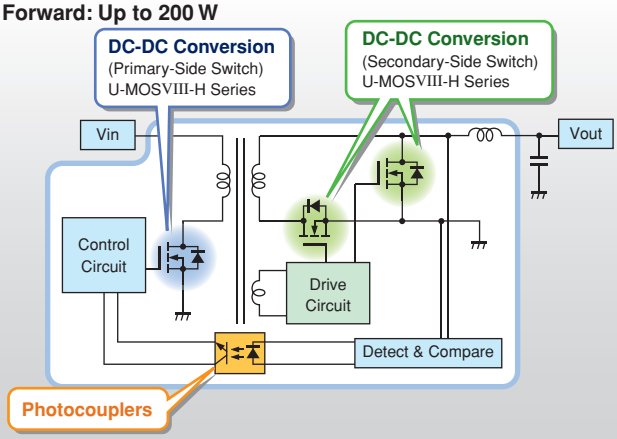
Features

Isolated DC-DC converters are widely used for applications in which there is a large difference between input and output voltages. Isolated half-bridge and full-bridge converters can handle up to 1 kW or so. Isolated DC-DC converters are used in power supplies for cell sites where direct-current distribution is utilized. They are used for both step-down and step-up voltage conversion.

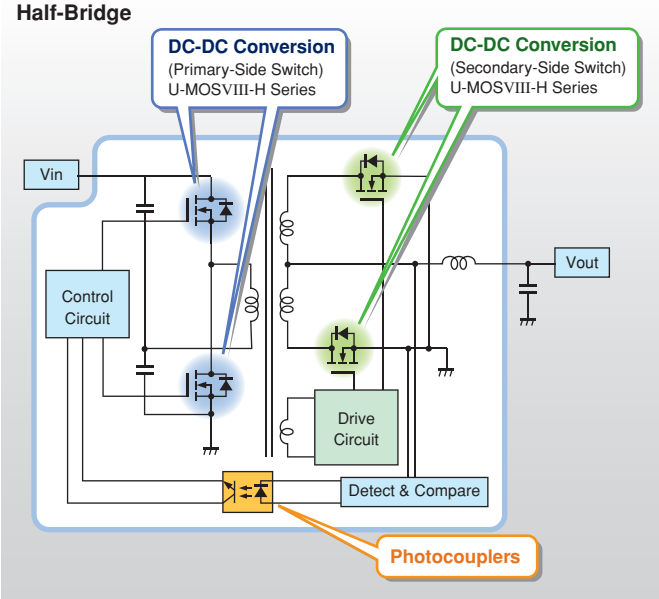
Application Examples

- DC-DC converters for communication applications
- Regulated power supplies

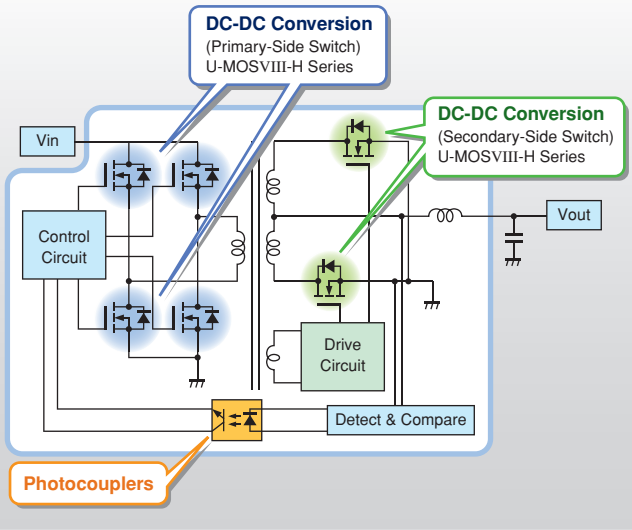
Forward: Up to 200 W



Half-Bridge



Full-Bridge: Up to 1 kW



Recommended Parts

Output Power (W)			Up to 50 Forward	Up to 150 Half-Bridge	Up to 300 Full-Bridge	Up to 500 Full-Bridge	Up to 1000 Full-Bridge
DC-DC Conversion (Primary-Side Switch)	Low-Voltage Power MOSFETs	V_{DSS} = 60 V			TPH4R606NH	TPH2R306NH	TPH2R306NH (2parallel)
		V_{DSS} = 80 V			TPH8R008NH	TPH4R008NH	TPH4R008NH (2parallel)
		V_{DSS} = 100 V			TPH8R80ANH	TPH4R50ANH	TPH4R50ANH (2parallel)
		V_{DSS} = 150 V		TPN5900CNH TPH3300CNH			
		V_{DSS} = 200 V	TPN1110ENH TPH1110ENH	TPH6400ENH			
		V_{DSS} = 250 V	TPH1110FNH				
DC-DC Conversion (Secondary-Side Switch)	Low-Voltage Power MOSFETs	V_{DSS} = 30 V (V_{OUT} = 3.3 V)	TPN6R003NL TPN4R003NL	TPH1R403NL TPHR9003NL	TPHR9003NL(2parallel)	TPHR9003NL(4parallel)	TPHR9003NL(8parallel)
		V_{DSS} = 40 V (V_{OUT} = 5 V)			TPHR8504PL	TPHR8504PL(2parallel)	TPHR8504PL(4parallel)
		V_{DSS} = 60 V (V_{OUT} = 12 V)	TPN22006NH	TPN1400ANH TPN7R506NH	TPH5R906NH TPH4R606NH	TPH2R306NH	TPH2R306NH(2parallel)
		V_{DSS} = 80 V (V_{OUT} = 12 V)	TPN30008NH	TPN13008NH TPH8R008NH	TPH4R008NH	TPH4R008NH(2parallel)	TPH4R008NH(4parallel)
		V_{DSS} = 100 V (V_{OUT} = 12 V)	TPN3300ANH	TPN1600ANH TPH8R80ANH	TPH4R50ANH	TPH4R50ANH(2parallel)	TPH4R50ANH(4parallel)
		V_{DSS} = 150 V (V_{OUT} = 24 V)	TPN5900CNH TPH5900CNH	TPH3300CNH	TPH1500CNH	TPH1500CNH(2parallel)	TPH1500CNH(4parallel)
		V_{DSS} = 200 V (V_{OUT} = 36 V)	TPN1110ENH TPH1110ENH	TPH6400ENH	TPH2900ENH	TPH2900ENH(2parallel)	TPH2900ENH(4parallel)
		V_{DSS} = 250 V (V_{OUT} = 48V)	TPN2010FNH TPH2010FNH	TPH1110ENH	TPH5200FNH	TPH5200FNH(2parallel)	TPH5200FNH(4parallel)
Output Error Feedback	Photocouplers	Analog feedback	TLP183, TLP293, TLP785				
		Digital feedback	TLP2309, TLP2355, TLP2358				

Detailed information about our MOSFETs is available on our website at: http://www.semicon.toshiba.co.jp/eng

CMOS LDO Regulators

Features

Linear power supplies are available in a wide range of packages from general-purpose SMV (SOT-25) to an ultra-small package with the industry's smallest form factor measuring 0.8 × 0.8 mm. Those in the DFN4, SDFN4 and WCSP4 packages, which are most widely used for small portable applications, are offered with various current/voltage ratings and additional features.

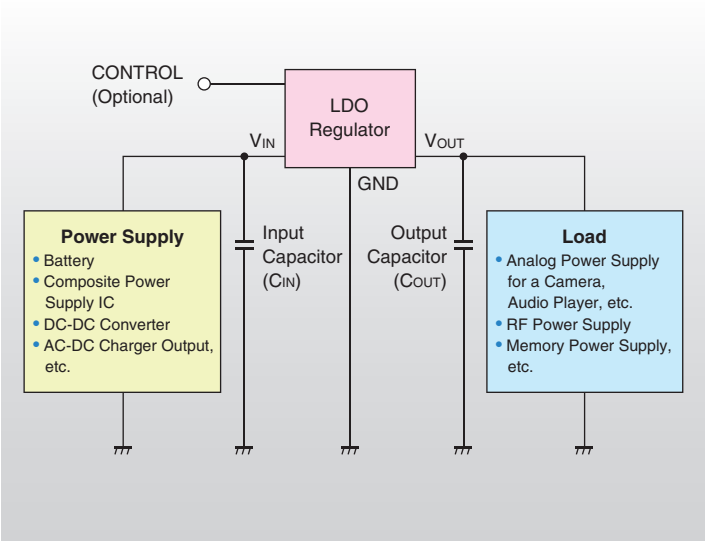
Additionally, the new LDO regulator series provides a significant reduction in voltage dropout thanks to reduced process geometries.

Application Examples

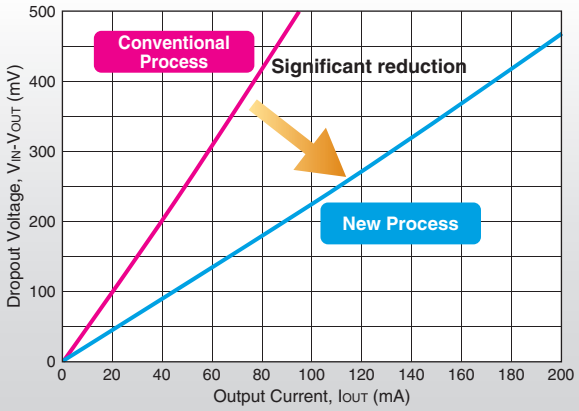
- Small portable devices

(Cell phones, Portable audio, Notebook PCs, Digital still camera, Digital video camera)

Circuit Example



Reduced Voltage Dropout Because of the Use of a New Process (Example: TCR2EN12 1.2-V output LDO regulator)

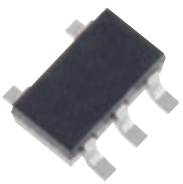
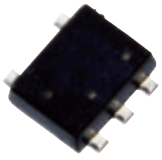


* For reference only; comparison of 200-mA LDO regulators with the same chip size

Recommended Parts

Series	Output Current (mA)	Output Voltage (V)	Features	Overcurrent Protection	Thermal Shutdown	Automatic Output Discharge	Package
TCR2DGxx	200	1.2 to 3.6	Low noise High ripple rejection ratio	✔	✔	✔	WCSP4
TCR2ENxx	200	1.0 to 3.6	Standard type	✔		✔	SDNF4
TCR2EExx		1.0 to 5.0		✔		✔	ESV
TCR2EFxx		1.0 to 5.0		✔		✔	SMV
TCR2LNxx	200	0.8 to 3.6	Low power consumption	✔		✔	SDNF4
TCR2LExx				✔		✔	ESV
TCR2LFxx				✔		✔	SMV
TCR3DMxx	300	1.0 to 4.5	Low dropout voltage Low inrush current	✔	✔	✔	DFN4
TCR3DFxx				✔	✔	✔	SMV

Package

SMV SOT-25 (2.8 x 2.9)	**ESV** SOT-553 (1.6 x 1.6)	**DFN4** (1.0 x 1.0)	**SDFN4** (0.8 x 0.8)	**WCSP4** (0.79 x 0.79)
				

* The unit of measure for values enclosed between parentheses is mm.

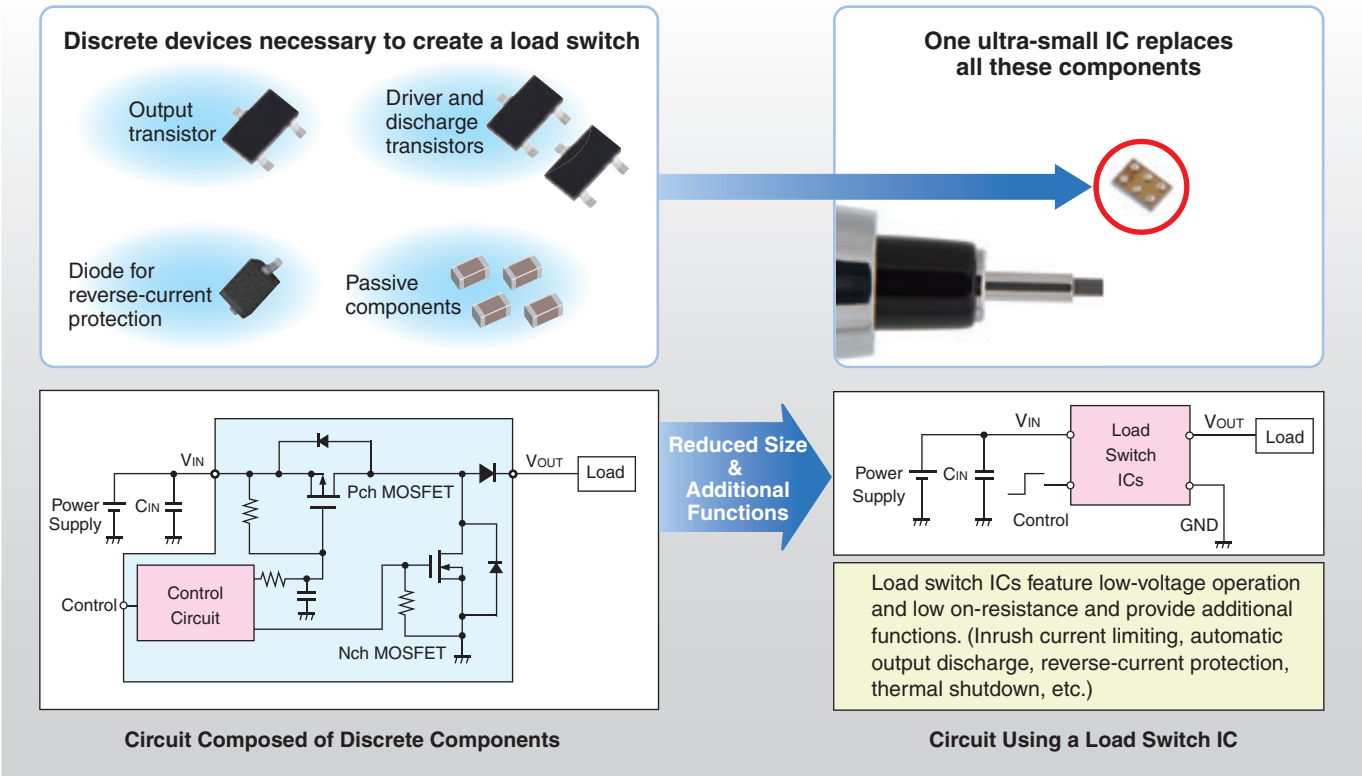
Load Switch ICs

Features

Load switch ICs control the supply of electric power to the downstream system loads. Their intended use is to shut off power supplies as their loads enter standby mode. Load switch ICs are power supply ICs fabricated using a CMOS process and contain an output transistor and an output driver. They provide a solution footprint much smaller than load switches composed of discrete components. Moreover, load switch ICs feature low-voltage operation, low on-resistance and low current consumption, and provide additional functions.

Application Examples

- Small portable devices (Cell phones, Portable audio, Notebook PCs, Digital still camera, Digital video camera)



Recommended Parts

Package (mm)	Part Number	Output Current (A)	Operating Voltage (V)	Inrush Current Limiting	Thermal Shutdown	Overcurrent Protection	Reverse-Current Protection	Automatic Output Discharge	Control Pin
WCSP6B (0812)	TCK101G	1	1.1 to 5.5	✔	✔			✔	Active High
	TCK102G	1		✔	✔				Active High
	TCK104G	0.5		✔	✔	✔		✔	Active High
	TCK105G	0.8		✔	✔	✔		✔	Active High
WCSP4 (0808)	TCK106G	1	1.1 to 5.5	✔					Active High
	TCK107G	1		✔				✔	Active High
	TCK108G	1		✔				✔	Active Low
WCSP6C (1015)	TCK111G	3	1.1 to 5.5	✔	✔		✔		Active High
	TCK112G	3		✔	✔		✔	✔	Active High
WCSP4C (0909)	TCK206G	2	0.75 to 3.6	✔			✔		Active High
	TCK207G	2		✔			✔	✔	Active High
	TCK208G	2		✔			✔	✔	Active Low

Power Supplies by Application

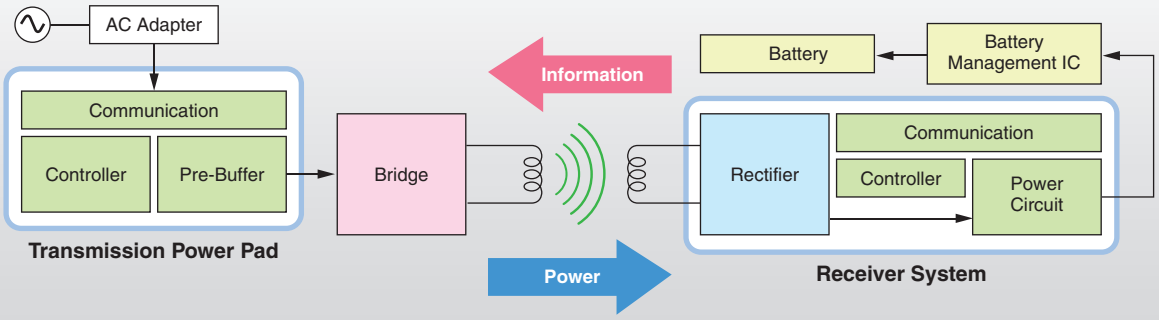
Wireless Power Transfer

Wireless Power Transfer Technology Recommended by Toshiba

Qi (pronounced *chee*) is an international standard for inductive charging technology developed by the Wireless Power Consortium (WPC).
Toshiba is a member of the WPC and is developing transmitter and receiver ICs to help promote wide market adoption of Qi for rechargeable mobile devices.

Wireless power transfer applications

System Block Diagram



Qi is a registered trademark of the Wireless Power Consortium.

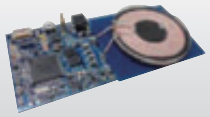
● Transmitter for Qi wireless power transfer applications

TB6865AFG

The TB6865AFG is a transmitter IC for wireless power transfer. It integrates dedicated analog circuitry and an ARM® Cortex®-M3 processor in the same package, simplifying the development of a Qi-compliant power transmission pad ("Base Station"). Toshiba also offers a receiver IC for Qi wireless power transfer applications. These transmitter and receiver ICs combine to make it possible to transfer power from the power transmitter to the power receiver.

- Features
  - Compliant with the A11, A12 and A14 power transmitter designs defined in the WPC low-power standard, Version 1.1
  - Analog power supply: 4.5 V to 15.0 V
  - Simultaneous charging of up to two mobile devices
  - Support for foreign object detection via Analog Ping
  - 100-pin LQFP
  - Qi-certified by means of an evaluation board
- Application Examples
  - WPC-compliant wireless power transmission pad for charging mobile devices
  - Mobile device accessories rated at 5 W or lower

TB6865AFG Evaluation Module



TB6865AFG EVM (A11)

● Qi-Certified Wireless Power Receiver

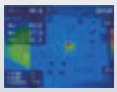
TC7761WBG

The TC7761WBG is a receiver IC for Qi wireless power transfer applications. Fabricated using a CMOS/DMOS hybrid process, the TC7761WBG delivers high efficiency and low heat generation.

The TC7761WBG generates system control protocols stipulated in the Qi standard in hardware, eliminating the need for an external MCU. This makes it possible to create a receiver module with a single chip.

- Features
  - On-chip Qi protocol control logic
  - Efficiency: 95% max.
  - 30% reduction in heat generation
  - Compliant with Version 1.1 of the WPC low-power standard, which contains an enhancement for foreign object detection (FOD)
  - 28-pin WCSP
  - Qi-certified by means of an evaluation board (3.5 W)
- Application Examples
  - WPC-compliant smartphones and other mobile devices
  - Mobile device accessories rated at 5 W or lower

TC7761WBG Heating Measurement



50 × 50 mm Board for S/V Output

TC7761WBG Evaluation Module

TC7761WBG EVM

● Recommended Parts

Wireless Power Transfer ICs

Part Number	Features	WPC Standard Version	Output Voltage (V)	Output Current (W)	FOD	Package
TB6860WBG	Receiver IC with a battery charging circuit; external MCU required; DC-DC converter output	v1.0	5	5		WCSP39
TB6862WBG	Receiver IC ; external MCU required; DC-DC converter output	v1.0	5	5		WCSP39
TC7761WBG	Receiver IC with a controller; LDO output	v1.1	5	3.5	✔	WCSP28
TC7763WBG**	Receiver IC with a controller; LDO output	v1.1	5	5	✔	WCSP28
TB6865AFG	Transmitter control IC; simultaneous charging of up to two devices; support for A11, A12 and A14	v1.1	–	5 x 2	✔	LQFP100

**: Under development

Low-Voltage Power MOSFETs for Bridge Applications

Part Number	Applications	Polarity	V_{DSS}(V)	V_{GSS}(V)	I_D(A)	$R_{DS(ON)}$ Max(mΩ)	Package
SSM6K504NU*	MOSFET for bridge applications	N-ch	30	±20	9	26	UDFN6
SSM6N55NU*	MOSFET for bridge applications	N-ch x 2	30	±20	4	64	UDFN6
SSM6P49NU*	MOSFET for bridge applications	P-ch x 2	30	±12	–4	56	UDFN6

*: New products

* ARM and Cortex are registered trademarks of ARM Limited in the EU and countries elsewhere.

Power Supplies by Application

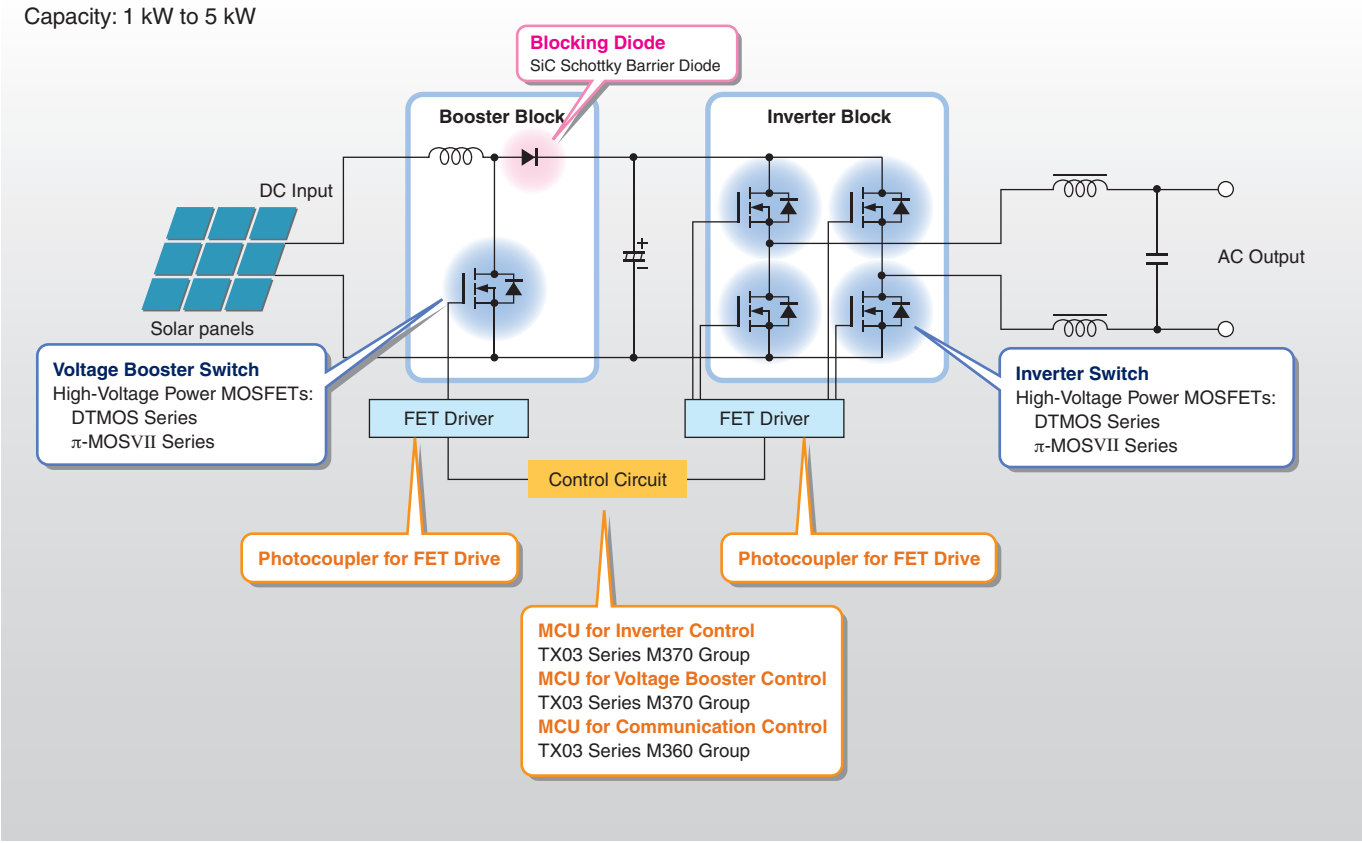
Solar Inverters (Power Conditioning Subsystems (PCS))

Features

- A solar inverter, also known as a power conditioning subsystems (PCS), is a device used to convert DC power generated by solar panels to AC power for use by home appliances. Since the voltage from solar panels varies with sunshine conditions, it is boosted to a constant level first. It is then converted to AC power by using an inverter and then applied to the grid.

Circuit Example

Capacity: 1 kW to 5 kW



Recommended Parts

Output Power (kW)			Up to 1.5	Up to 3	Up to 4.5	Up to 6
Inverter Switch	High-Voltage Power MOSFETs	150-Vdc Input / 200-Vdc Input	**TK39N60W5, TK62J60W5 TK35N65W5, TK49N65W5**	**TK62J60W5, TK62N60W TK49N65W5**		
	IGBT	100-Vac Input / 200-Vac Input	**GT30J341 GT50J342**	**GT30J341 GT50J342**		
Control Circuit	MCU for Inverter Control		**TMPM370FYDFG, TMPM370FYFG, TMPM372FWUG TMPM372FWFG**, TMPM373FWDUG, TMPM374FWUG TMPM375FSDMG, TMPM376FDDFG**, TMPM376FDFG**			
	MCU for Voltage Booster Control					
	MCU for Communication Control		**TMPM369FDFG, TMPM369FDXBG, TMPM368FDFG, TMPM368FDXBG****			
Voltage Booster Switch	High-Voltage Power MOSFETs	Up to 300-Vdc Output	**TK39N60X TK62N60X**	**TK62N60X TK100L60W**		
		Up to 700-Vdc Output				
	IGBTs	Up to 300-Vdc Output	**GT50JR22**	**GT50JR22**		
Blocking Diode	SiC Schottky Barrier Diode	Up to 300-Vdc Output / Up to 700-Vdc Output	**TRS12N65D, TRS16N65D TRS20N65D, TRS24N65D**	**TRS20N65D, TRS24N65D TRS24N65D**		
MOSFET Gate Drive	Photocouplers	0.6 to 6.0-A Peak Output	**TLP5701, TLP351H TLP155E**	**TLP5701, TLP351H TLP155E**	**TLP5702, TLP352 TLP152**	**TLP358H**

**: Under development

Rechargeable Lithium-Ion Batteries

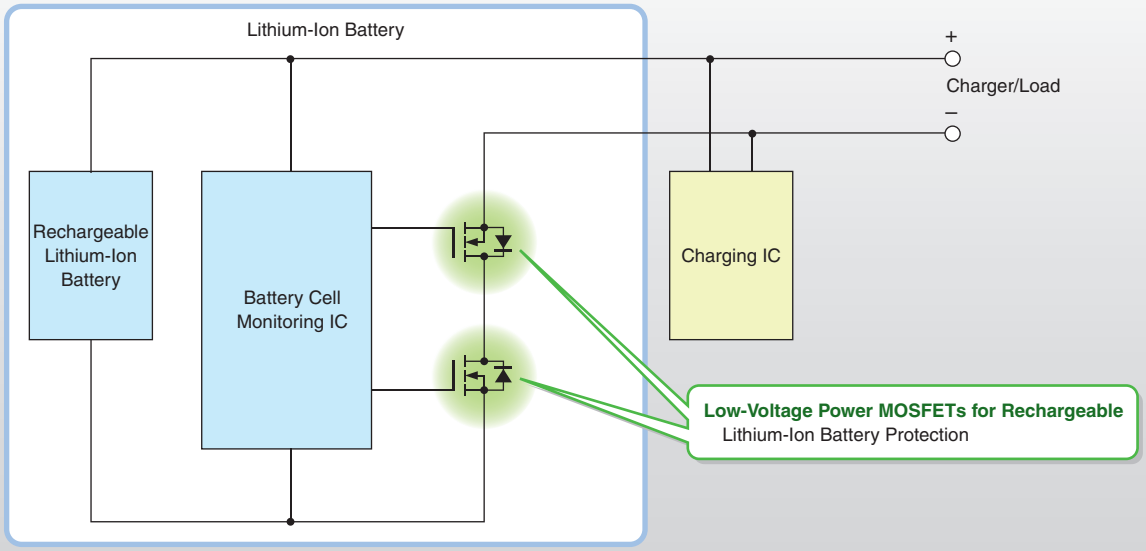
Features

Shown below is a design technique for protecting a rechargeable lithium-ion battery from overcharge, overdischarge and overcurrent.

Application Examples

- Notebook PCs
- Smartphone
- Bicycles
- Portable devices
- Tablet PCs
- UPS

Circuit Example



Recommended Parts

Number of Series Cells	Applications	Type	Part Number	Package
1-cell	Smartphones, cell phones	Charging IC	**TC7710WBG**	WCSP25
1- to 2-cell	Tablet PCs	Low-Voltage Power MOSFETs (U-MOSVII Series)	**TPCP8206** **TPCC8093**	PS-8 TSON Advance
3- to 4-cell	Notebook PCs	Low-Voltage Power MOSFETs (U-MOSVII Series)	**TPN2R203NC** **TPN2R503NC** **TPN4R203NC** **TPN6R303NC**	TSON Advance
5-cell or greater	Bicycles, UPS, etc.	Low-Voltage Power MOSFETs (U-MOSVII Series)	**TK65G10N1**	D2PAK

PFC Control ICs

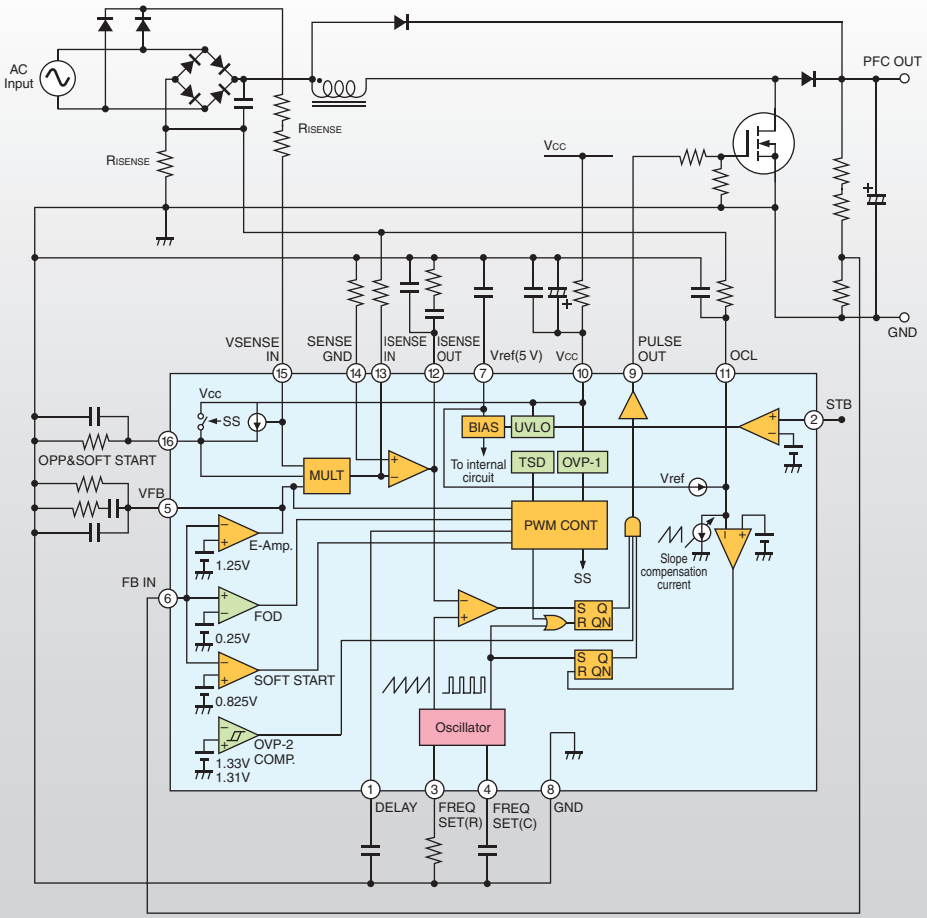
Toshiba has been developing power factor correction (PFC) controllers for reducing power factor degradation (or an increase in reactive power) and noise on AC mains due to harmonics current.

TB6818FG

Features

- Operating voltage range: 8.4 V (min) to 26 V (max)
- Startup voltage: 10.0 V (typ.)
- Pulse output mute function (starting)
- Avoiding PFC transformer noise
- Maximum drive current: 1.0 A (typ.)
- Consumption current: 250 μA (typ.)(Standby mode)
- AC instantaneously-stop detection
- Built-in protection circuits
  - DC input overvoltage protection (OVP-1)
  - PFC output overvoltage protection (OVP-2)
  - Undervoltage lockout (UVLO)
  - Feedback-loop open detection (FOD)
  - Thermal shutdown (TSD)

Block Diagram



Product Lineup

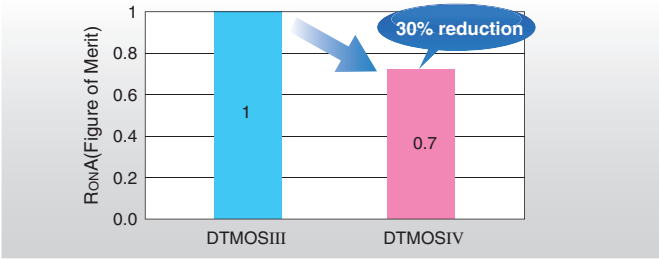
Part Number	Conduction	Supply Voltage (V)	Package	Features
TB6818FG	CCM	8.4 to 26	SSOP16	Reduced humming noise emitted by the PFC transformer
TB6819AFG	CRM	9.5 to 25	SOP8	Brownout protection (BOP)

Power MOSFETs for PFC Control and Switching Applications

Gen-4 Super-Junction 600-V DTMOSIV MOSFET Series

Toshiba has developed the Gen-4 super-junction 600-V DTMOSIV MOSFET series. Fabricated using the state-of-the-art single epitaxial process, DTMOSIV provides a 30% reduction in Ron.A, a figure of merit (FOM) for MOSFETs, compared to its predecessor, DTMOSIII. A reduction in RonA makes it possible to house lower-Ron chips in the same packages. This helps to improve the efficiency and reduce the size of power supplies.

30% reduction in RonA, a MOSFET figure of merit, compared to the predecessor (DTMOSIII)



DTMOSIV Lineup

• VDSS = 600 V DTMOSIV Series Improved performance because of reduced RonA Helps to improve the efficiency of various power supplies	**Standard DTMOSIV Series** **High-speed switching DTMOSIV-H Series** Low switching loss because of fast switching performance Approx. 30% reduction in Qgd compared with the standard series **DTMOSIV(HSD) Series with a high-speed diode** MOSFET with faster parasitic diode Body diode with the reverse recovery time approx. 1/3 that of the standard series
• VDSS = 650 V DTMOSIV Series Higher breakdown voltage thanks to an improvement of the 600-V version Easy to allow sufficient voltage tolerance margins for power supply designs	**Standard DTMOSIV Series** **DTMOSIV(HSD) Series with a high-speed diode** MOSFET with faster parasitic diode Body diode with the reverse recovery time approx. 1/3 that of the standard series

DTMOSIV Part Naming Conventions

Part number example

T	K	1	6	A	6	0	W	5
①		②		③	④		⑤	⑥

① N-channel transistor
② Rated current (rounded off to integer)
③ Package
④ Rated voltage (VDSS × 10%)
⑤ Process generation
W: DTMOSIV
X: High-speed switching DTMOSIV-H
⑥ Feature
5: Built-in high-speed diode

Product Lineup

Series	Part Number	Absolute Maximum Ratings VDSS (V)	Absolute Maximum Ratings ID (A)	RDS(ON) Max (Ω) VGS = 10 V	Package
Standard DTMOSIV	TK5A60W	600	5.4	0.9	TO-220SIS
	TK5P60W				DPAK
	TK5Q60W				IPAK
	TK7A60W		7	0.6	TO-220SIS
	TK7P60W				DPAK
	TK7Q60W				IPAK
	TK10A60W		9.8	0.38	TO-220SIS
	TK12A60W		11.5	0.3	TO-220SIS
	TK12E60W				TO-220
	TK12P60W			0.43	DPAK
	TK12Q60W				IPAK
	TK16A60W		15.8	0.19	TO-220SIS
	TK16E60W				TO-220
	TK16V60W				DFN8x8
	TK20A60W		20	0.155	TO-220SIS
	TK20E60W				TO-220
	TK20N60W				TO-247
	TK31A60W		30.8	0.088	TO-220SIS
	TK31E60W				TO-220
	TK31V60W			0.098	DFN8x8
	TK39A60W		38.8	0.065	TO-220SIS
	TK39N60W				TO-247
	TK62N60W		61.8	0.04	TO-247
	TK100L60W		100	0.018	TO-3P(L)
	TK11A65W	650	11.1	0.39	TO-220SIS
	TK14A65W		13.7	0.25	TO-220SIS
	TK14E65W				TO-220
	TK17A65W		17.3	0.2	TO-220SIS
	TK28N65W		27.6	0.11	TO-247
	TK35A65W		35	0.08	TO-220SIS
	TK35N65W				TO-247
	TK49N65W		49	0.055	TO-247

Series	Part Number	Absolute Maximum Ratings VDSS (V)	Absolute Maximum Ratings ID (A)	RDS(ON) Max (Ω) VGS = 10 V	Package
High-speed switching DTMOSIV-H	TK31N60X	600	30.8	0.088	TO-247
	TK39N60X		38.8	0.065	TO-247
	TK62N60X		61.8	0.04	TO-247
DTMOSIV(HSD)	TK7A60W5	600	7	0.65	TO-220SIS
	TK7P60W5			0.67	DPAK
	TK8A60W5		8	0.54	TO-220SIS
	TK8P60W5			0.56	DPAK
	TK10A60W5		9.8	0.45	TO-220SIS
	TK16A60W5		15.8	0.23	TO-220SIS
	TK16E60W5				TO-220
	TK16N60W5				TO-247
	TK20A60W5		20	0.175	TO-220SIS
	TK20J60W5				TO-3P(N)
	TK31N60W5		30.8	0.099	TO-247
	TK39N60W5		38.8	0.074	TO-247
	TK62J60W5		61.8	0.045	TO-3P(N)
	TK14A65W5	650	13.7	0.3	TO-220SIS
	TK14E65W5				TO-220
	TK14N65W5				TO-247
	TK17A65W5		17.3	0.23	TO-220SIS
	TK28N65W5		27.6	0.13	TO-247
	TK35A65W5		35	0.095	TO-220SIS
	TK35N65W5				TO-247
	TK49N65W5		49	0.057	TO-247

Detailed information about our MOSFETs is available on our website at: http://www.semicon.toshiba.co.jp/eng

Schottky Barrier Diodes (SBDs) for Power Factor Correction (PFC) Applications

650-V SiC Schottky Barrier Diodes

Silicon carbide (SiC), a wide-gap semiconductor, is expected to be a material for the next-generation high-voltage, low-loss power devices because its dielectric breakdown strength is more than eight times that of silicon (Si). Toshiba now offers the SiC Schottky barrier diodes listed below.

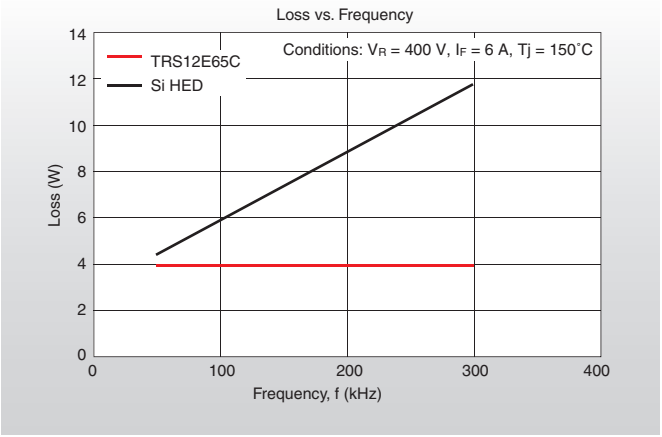
The following features of SiC Schottky barrier diodes make them ideal for power supply and inverter applications requiring high efficiency, such as those for servers, storage systems and photovoltaic power generators.

Features

- Majority carrier device with a Schottky barrier structure
- High-speed switching
- Temperature-independent reverse recovery time (trr)
- Low V_F temperature coefficient
- Excellent trade-off between leakage current (I_R) and forward voltage (V_F) at high temperatures

Physical property comparisons between Si and SiC

Item	Symbol	Si	SiC(4H)
Band gap	E	1.12eV	3.26eV
Electron mobility	μ	1400 cm²/Vs	1000 cm²/Vs
Relative dielectric constant	ε	11.8	9.7
Critical breakdown field	Ecr	0.3 MV/cm	2.5 MV/cm
Features		Easily available Easy to process Inexpensive	Suitable for reducing on-resistance Easy to guarantee high-temperature operations because of low leakage at high temperatures Easy to create designs with high withstand voltage
Transistor performance limit (at 600 V)	RonA	70 mΩ·cm²	0.14 mΩ·cm²



Product Lineup

Package	Part Number	Absolute Maximum Ratings		Electrical Characteristics	
		Repetitive Peak Reverse Voltage V_{RRM} (V)	Forward DC Current $I_{F(DC)}$ (A)	Peak Forward Voltage V_{FM} (V) Typ./Max	Repetitive Peak Reverse Current I_{RRM} (μA) Typ./Max
 TO-220-2L	**TRS6E65C**	650	6	1.5/1.7	0.3/90
	TRS8E65C	650	8	1.5/1.7	0.4/90
	TRS10E65C	650	10	1.5/1.7	0.42/90
	TRS12E65C	650	12	1.54/1.7	0.43/90
 TO-220F-2L	**TRS6A65C**	650	6	1.5/1.7	0.3/90
	TRS8A65C	650	8	1.5/1.7	0.4/90
	TRS10A65C	650	10	1.5/1.7	0.42/90
	TRS12A65C	650	12	1.54/1.7	0.43/90
 TO-247	**TRS12N65D**	650	12	1.5/1.7	0.3/90
	TRS16N65D	650	16	1.5/1.7	0.4/90
	TRS20N65D	650	20	1.5/1.7	0.42/90
	TRS24N65D	650	24	1.54/1.7	0.43/90

Switching Power Transistors

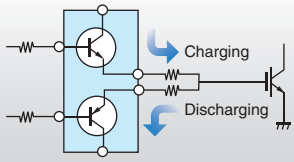
Product Lineup

Package	Part Number	Absolute Maximum Ratings			DC Characteristics						Switching Characteristics		
		V_{CBO} (V)	V_{CEO} (V)	I_C (A)	h_{FE} Min	V_{CE} (V)	I_C (A)	$V_{CE(sat)}$ Max (V)	I_C (A)	I_B (A)	t_r Max	t_{stg} Max	t_f Max
											(μs)		
PW-Mold	**2SC5548A**	600	400	2	40	5	0.2	1.0	0.8	0.1	0.5	3.0	0.3
	TTC008	600	285	1.5	100	5	0.3	1.0	0.5	0.0625	0.05(typ.)	3.3(typ.)	0.1(typ.)
	2SC6142	800	375	1.5	100	5	0.1	0.9	0.8	0.1	0.2(typ.)	3.5(typ.)	0.15(typ.)
	TTC012	800	375	2	100	5	0.3	0.5	0.5	0.0625	0.1(typ.)	4.4(typ.)	0.15(typ.)

Power Transistors for MOS Gate Drivers (for High-Speed Gate Drive of MOS Devices)

MOS gate drivers incorporate a pair of low-$V_{CE(sat)}$ PNP and NPN transistors in one package.
They are ideal for high-speed gate drive applications for high-power IGBTs and MOSFETs as well as for small-motor driver applications.

Application Example



MOS Gate Driver

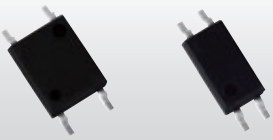
Product Lineup (2-in-1 Series)

Package	Part Number	Polarity	Absolute Maximum Ratings				h_{FE}				$V_{CE(sat)}$ Max		
			V_{CEO} (V)	I_C (A)	I_{CP} (A)	P_C (mW)	Min	Max	V_{CE} (V)	I_C (A)	(V)	I_C (A)	I_B (mA)
SMV	**HN4B101J**	PNP	–30	–1.0	–5	550	200	500	–2	–0.12	–0.2	–0.4	–13
		NPN	30	1.2	5	550	200	500	2	0.12	0.17	0.4	13
	HN4B102J	PNP	–30	–1.8	–8	750	200	500	–2	–0.2	–0.2	–0.6	–20
		NPN	30	2	8	750	200	500	2	0.2	0.14	0.6	20
VS-6	**TPC6901A**	PNP	–50	–0.7	–5	400	200	500	–2	–0.1	–0.23	–0.3	–10
		NPN	50	1	5	400	400	1000	2	0.1	0.17	0.3	6
	TPC6902	PNP	–30	–1.7	–8	700	200	500	–2	–0.2	–0.2	–0.6	–20
		NPN	30	2	8	700	200	500	2	0.2	0.14	0.6	20
PS-8	**TPCP8901**	PNP	–50	–0.8	–5	830	200	500	–2	–0.1	–0.2	–0.3	–10
		NPN	50	1	5	830	400	1000	2	0.1	0.17	0.3	6
	TPCP8902	PNP	–30	–2	–8	890	200	500	–2	–0.2	–0.2	–0.6	–20
		NPN	30	2	8	890	200	500	2	0.2	0.14	0.6	20

Transistor-Output Photocouplers

TLP183/TLP293

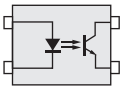
The TLP183 in the SO6 package and the TLP293 in the SO4 package are transistor-output photocouplers with low LED trigger current. These photocouplers guarantee the same current transfer ratio at the conventional LED trigger current (I_F) of 5 mA and at a paltry 0.5 mA, thanks to Toshiba's unique high-output LED. The maximum ambient temperature of 125°C makes them ideal for thermally demanding applications, including small power supplies and industrial equipment.


TLP183 TLP293

Other Features

- Thin SO6 and SO4 packages with a thickness of 2.3 mm
- Manufactured at a fab in Thailand

Pin Configuration



Product Lineup
(Photocouplers with transistor output providing isolated feedback from the secondary side to the primary side)

Package	Part Number	Absolute Maximum Ratings (Ta = 25°C)		Electrical Characteristics		Safety Standards		
		V_{CEO} (V)	Isolation voltage BVs (Vrms)	Current Transfer Ratio Ic/If (%)	Operating Ambient Temp. Topr (°C)	UL/ c-UL	VDE EN60747-5-5	CQC GB4943,GB8898
SO6 (4pin)	**TLP183**	80	3750	50 to 600	–55 to 125	✔	✔	✔
SO4	**TLP293**	80	3750	50 to 600	–55 to 125	✔	✔	✔
DIP4	**TLP785**	80	5000	50 to 600	–55 to 110	✔	✔	✔

Schottky Barrier Diodes (SBDs) and High-Efficiency Diodes (HEDs)

Product Lineup

Schottky Barrier Diodes (SBDs)

Package	Part Number	Absolute Maximum Ratings					Electrical Characteristics (Max)				
		V_{RRM} (V)	$I_{F(AV)}$ (A)	I_{FSM} (A)	T_j (°C)	T_{stg} (°C)	I_{RRM} (mA)	V_{FM} (V)	@I_{FM} (A)	C_j (pF)(Typ.)	Conditions
US-FLAT™	CUS05	20	1.0	20	125	−40 to 150	1.0	0.37	0.7	40	V_R = 10 V, f = 1 MHz
	CUS06			20	150	−40 to 150	0.03	0.45	0.7	40	
	CUS01	30		20	125	−40 to 150	1.5	0.37	0.7	40	
	CUS02			20	150	−40 to 150	0.1	0.45	0.7	40	
	CUS10I30A			20	150	−55 to 150	0.06	0.39	0.7	50	
	CUS15I30A		1.5	20	150	−55 to 150	0.06	0.46	1.5	50	
	CUS03	40	0.7	20	150	−40 to 150	0.1	0.52	0.7	45	
	CUS10I40A		1.0	20	150	−55 to 150	0.06	0.49	0.7	35	
	CUS04	60	0.7	20	150	−40 to 150	0.1	0.58	0.7	38	
S-FLAT™	CRS06	20	1.0	20	125	−40 to 150	1	0.36	1.0	60	V_R = 10 V, f = 1 MHz
	CRS01	30		20	125	−40 to 150	1.5	0.37	0.7	40	
	CRS03			20	150	−40 to 150	0.1	0.45	0.7	40	
	CRS05			20	150	−40 to 150	▽	0.45	1.0	60	
	CRS11			20	125	−40 to 150	1.5	0.36	1.0	60	
	CRS10I30A			20	150	−55 to 150	0.06	0.39	0.7	50	
	CRS10I30B			20	150	−55 to 150	0.06	0.42	1.0	50	
	CRS10I30C			30	150	−55 to 150	0.10	0.36	1.0	82	
	CRS08		1.5	30	125	−40 to 150	1	0.36	1.5	90	
	CRS09			30	150	−40 to 150	0.05	0.46	1.5	90	
	CRS15I30A			20	150	−55 to 150	0.06	0.46	1.5	50	
	CRS15I30B			30	150	−55 to 150	0.10	0.40	1.5	82	
	CRS14		2.0	30	150	−40 to 150	0.05	0.49	2.0	90	
	CRS20I30A			20	150	−55 to 150	0.06	0.49	2.0	50	
	CRS20I30B			30	150	−55 to 150	0.10	0.45	2.0	82	
	CRS15 ◇		3.0	30	150	−40 to 150	0.05	0.52	3.0	90	
	CRS30I30A			30	150	−55 to 150	0.10	0.49	3.0	82	
	CRS04	40	1.0	20	150	−40 to 150	0.1	0.49	0.7	47	
	CRS10I40A			20	150	−55 to 150	0.06	0.49	0.7	35	
	CRS10I40B			25	150	−55 to 150	0.10	0.45	1.0	62	
	CRS15I40A		1.5	20	150	−55 to 150	0.06	0.55	1.5	35	
	CRS20I40A		2.0	20	150	−55 to 150	0.06	0.60	2.0	35	
	CRS20I40B			25	150	−55 to 150	0.10	0.52	2.0	62	
	CRS12	60	1.0	20	150	−40 to 150	0.1	0.58	1.0	40	
	CRS13			20	150	−40 to 150	0.05	0.55	1.0	40	
M-FLAT™	CMS08	30	1.0	25	125	−40 to 150	1.5	0.37	1.0	70	V_R = 10 V, f = 1 MHz
	CMS09			25	150	−40 to 150	0.5	0.45	1.0	70	
	CMS10I30A			30	150	−55 to 150	0.10	0.36	1.0	82	
	CMS06		2.0	40	125	−40 to 150	3.0	0.37	2.0	130	
	CMS07			40	150	−40 to 150	0.5	0.45	2.0	130	
	CMS17			30	150	−40 to 150	0.1	0.48	2.0	90	
	CMS20I30A			30	150	−55 to 150	0.10	0.45	2.0	82	
	CMS01		3.0	40	125	−40 to 150	5.0	0.37	3.0	190	
	CMS03			40	150	−40 to 150	0.5	0.45	3.0	190	
	CMS30I30A			30	150	−55 to 150	0.10	0.49	3.0	82	
	CMS04		5.0	70	125	−40 to 150	8.0	0.37	5.0	330	
	CMS05			70	150	−40 to 150	0.8	0.45	5.0	330	
	CMS10	40	1.0	25	150	−40 to 150	0.5	0.55	1.0	50	
	CMS10I40A			25	150	−55 to 150	0.10	0.45	1.0	62	
	CMS15I40A		1.5	25	150	−55 to 150	0.10	0.49	1.5	62	
	CMS11		2.0	30	150	−40 to 150	0.5	0.55	2.0	95	
	CMS20I40A			25	150	−55 to 150	0.10	0.52	2.0	62	
	CMS16		3.0	30	150	−40 to 150	0.2	0.55	3.0	95	
	CMS30I40A			25	150	−55 to 150	0.10	0.55	3.0	62	
	CMS14	60	2.0	40	150	−40 to 150	0.2	0.58	2.0	77	
	CMS15		3.0	60	150	−40 to 150	0.3	0.58	3.0	102	

▽: I_{RRM} = 5 μA Max (V_R = 5 V) ◇: $I_{F(DC)}$ = 3 A

High-Efficiency Diodes (HEDs)

Package	Part Number	Absolute Maximum Ratings					Electrical Characteristics (Max)				
		V_{RRM} (V)	$I_{F(AV)}$ (A)	I_{FSM} (A)	T_j (°C)	T_{stg} (°C)	I_{RRM} (μA)	V_{FM} (V)	@I_{FM} (A)	trr(ns)	Conditions
S-FLAT™	CRH02	200	0.5	10	150	−40 to 150	10	0.95	0.5	35	I_F = 1 A, di/dt = −30 A/μs
	CRH01		1.0	15	150	−40 to 150	10	0.98	1.0	35	
M-FLAT™	CMH04		1.0	20	150	−40 to 150	10	0.98	1.0	35	
	CMH07		2.0	40	150	−40 to 150	10	0.98	2.0	35	
	CMH01		3.0	40	150	−40 to 150	10	0.98	3.0	35	

Synchronous Rectification MOSFETs

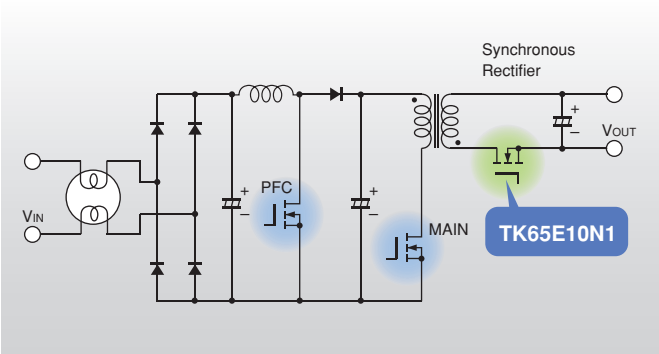
U-MOSVIII-H Series (V_{DSS} = 60 to 120 V)

Features

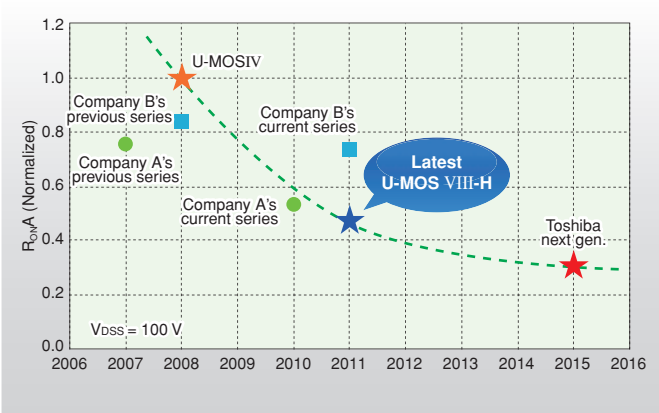
- 58% reduction in RonA compared with U-MOSIV
- Improved efficiency at light loads because of reduced Ciss
- Higher power supply efficiency than other manufacturers' products
- Voltage spike and ringing suppression via a parasitic snubber

Application Circuit Example

120-W flyback AC-DC converter



Roadmap for the U-MOS Series



Product Lineup

Part Number	Package	Absolute Maximum Ratings				$R_{DS(ON)}$ (mΩ) @V_{GS} = 10 V		Qg (nC) Typ.	Q_{sw} (nC) Typ.
		V_{DS} (V)	V_{GSS} (V)	I_D (A)	P_D (W)	Typ.	Max	V_{DD} = V_{DSS} x 0.8, I_D = $I_{D(DC)}$	
TK100E06N1	TO-220*	60	±20	263	255	1.9	2.3	140	56
TK58E06N1	TO-220*	60	±20	105	110	4.4	5.4	46	17
TK40E06N1	TO-220*	60	±20	60	67	8.4	10.4	23	10
TK30E06N1	TO-220*	60	±20	43	53	12.2	15	16	6.8
TK100E08N1	TO-220*	80	±20	214	255	2.6	3.2	130	53
TK72E08N1	TO-220*	80	±20	157	192	3.6	4.3	81	33
TK46E08N1	TO-220*	80	±20	80	103	6.9	8.4	37	16
TK35E08N1	TO-220*	80	±20	55	72	10	12.2	25	10
TK100E10N1	TO-220*	100	±20	207	255	2.8	3.4	140	55
TK65E10N1	TO-220*	100	±20	148	192	4.0	4.8	81	32
TK40E10N1	TO-220*	100	±20	90	126	6.8	8.2	49	21
TK34E10N1	TO-220*	100	±20	75	103	7.9	9.5	38	15
TK22E10N1	TO-220*	100	±20	52	72	11.5	13.8	28	12
TK72E12N1	TO-220*	120	±20	179	255	3.6	4.4	130	52
TK56E12N1	TO-220*	120	±20	112	168	5.8	7	69	29
TK42E12N1	TO-220*	120	±20	88	140	7.8	9.4	52	23
TK32E12N1	TO-220*	120	±20	60	98	11	13.8	34	15
TK65G10N1	D2PAK	100	±20	136	156	3.8	4.5	81	32

* MOSFETs housed in the fully molded TO-220SIS package are also available.

Detailed information about our MOSFETs is available on our website at: http://www.semicon.toshiba.co.jp/eng

Multiple-Output DC-DC Converter ICs

Features

Multiple-output DC-DC converter ICs are power management ICs (PMICs) that integrate several DC-DC converters on a single chip for space-saving applications. One PMIC can supply power to multiple peripheral devices and meet the needs for various applications. Multiple-output DC-DC converters are available with various output channel options to meet diverse requirements.

Application Examples

- Cell phones
- Digital still cameras

Product Lineup

Part Number	Application	Channels					Operating Input Voltage (V)	Switching Frequency (kHz)	Package
		Boost	Buck	Buck-Boost	Invert	LDO			
TC7731FTG	DDR2/3	–	1	–	–	1	2.7 to 5.5	500/1000	QFN40
TC7732FTG **	Cell phones	–	1	–	–	4	2.5 to 5.5	4000	QFN16

** Under development

Rechargeable Lithium-Ion Battery Charger

TC7710WBG

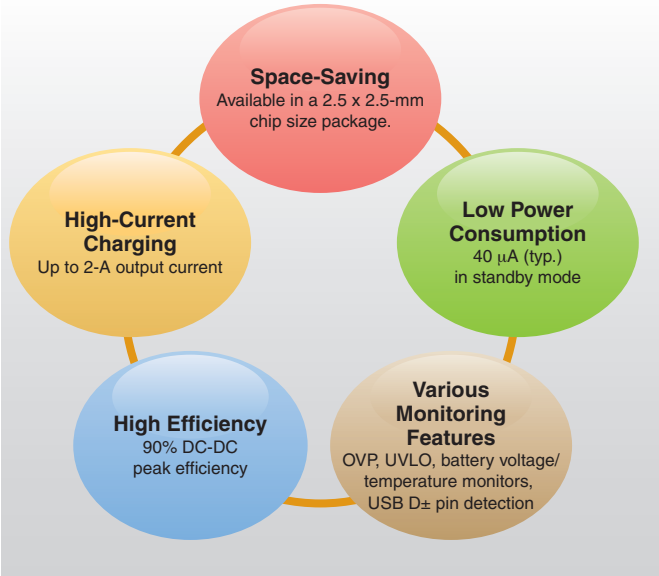
Features

Many mobile devices have an embedded high-capacity lithium-ion battery pack in order to deliver extended playtime for wide-ranging applications such as music, video and games. Manufacturers of mobile devices have been striving to keep its charge time equal to or less than the predecessor. The TC7710WBG provides the ideal solution for rechargeable lithium-ion battery chargers with a USB port. It is compliant with the Battery Charging Specification 1.2. Due to the adoption of a DC-DC converter, it offers high efficiency and a high charge current of 2 A.

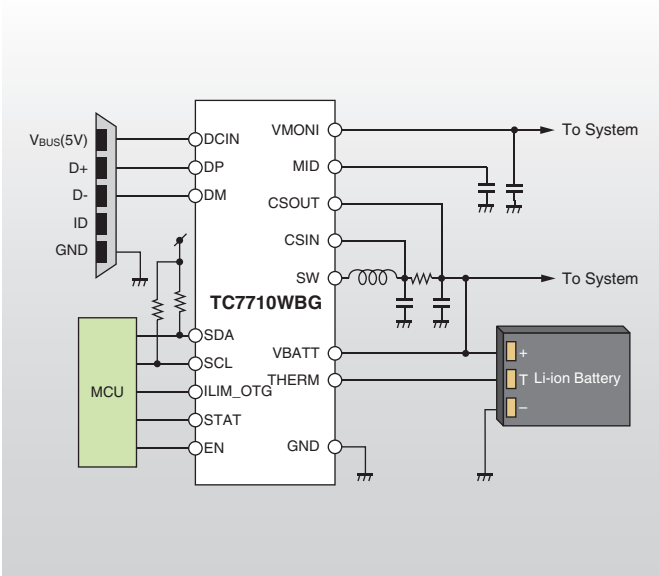
Application Examples

- Devices with a rechargeable lithium-ion battery (e.g., cell phones, digital still cameras)

Five Benefits



Application Circuit Example



Product Lineup

Part Number	Operating Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Switching Frequency (kHz)	Package
TC7710WBG *	4.3 to 6.5	2 (max)	3.46 to 4.72	2 (max)	3000	WCSP25

*: New package

Low-Voltage MOSFETs for DC-DC Converter Applications (V_{DSS} = 30 to 250 V)

By employing microfabrication technology and reducing the gate charge, the power MOSFET series achieves extremely high speed and low $R_{DS(ON)}$.

Features

• Low $R_{DS(ON)}$ • High-speed switching • Total gate charge (Qg) reduction • High avalanche capability

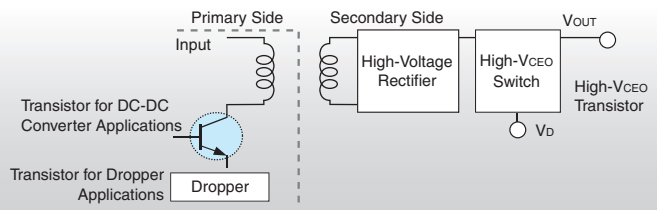
Product Lineup

Configuration	Absolute Maximum Ratings			Part Number	Package	$R_{DS(ON)}$ Max (mΩ)		Qsw(nC) Typ.
	V_{DSS} (V)	V_{GSS} (V)	I_D (A)			V_{GS} = 10 V	V_{GS} = 4.5 V	
N-ch	30	±20	31	TPN11003NL	TSON Advance	11	16	3.3
			37	TPN8R903NL		8.9	12.7	4.4
			56	TPN6R003NL		6	8.3	8.2
			63	TPN4R303NL		4.3	6.3	6.8
			90	TPN2R703NL		2.7	4.1	9.5
			32	TPH11003NL	SOP Advance	11	16	3.3
			38	TPH8R903NL		8.9	12.7	4.4
			57	TPH6R003NL		6	8.3	8.2
			68	TPH4R003NL		4	6.2	6.8
			84	TPH3R203NL		3.2	4.7	9.5
			150	TPH1R403NL		1.4	2.1	20
			220	TPHR9003NL		0.9	1.4	32
	60		21	TPN22006NH	TSON Advance	22	–	12
			33	TPN14006NH		14	–	15
			37	TPN11006NL		11.4	17	23
			53	TPN7R506NH		7.5	–	22
			34	TPH14006NH	SOP Advance	14	–	16
			40	TPH11006NL		11.4	17	23
			55	TPH7R506NH		7.5	–	31
			71	TPH5R906NH		5.9	–	38
			85	TPH4R606NH		4.6	–	49
			130	TPH2R306NH		2.3	–	72
	80		22	TPN30008NH	TSON Advance	30	–	11
			40	TPN13008NH		13.3	–	18
			44	TPH12008NH	SOP Advance	12.3	–	22
			63	TPH8R008NH		8	–	35
			100	TPH4R008NH		4	–	59
	100		21	TPN3300ANH	TSON Advance	33	–	11
			36	TPN1600ANH		16	–	19
			42	TPH1400ANH	SOP Advance	13.6	–	22
			59	TPH8R80ANH		8.8	–	33
			93	TPH4R50ANH		4.5	–	58
	150		18	TPN5900CNH	TSON Advance	59	–	7
			18	TPH5900CNH	SOP Advance	59	–	7
			29	TPH3300CNH		33	–	10.6
			50	TPH1500CNH		15.4	–	22
	200		13	TPN1110ENH	TSON Advance	114	–	7
			13	TPH1110ENH	SOP Advance	114	–	7
			21	TPH6400ENH		64	–	11.2
			36	TPH2900ENH		29	–	22
	250		9.9	TPN2010FNH	TSON Advance	198	–	7
			10	TPH2010FNH	SOP Advance	198	–	7
			15	TPH1110FNH		112	–	11
			27	TPH5200FNH		52	–	22

* All the above MOSFETs are U-MOSVIII-H devices. Other devices of the U-MOSVIII-H Series and the U-MOSVI-H Series are also available.

Bipolar Power Transistors for self-Excited DC-DC Converter Applications

The bipolar power transistors listed below are recommended for use as a primary-side switch in high-voltage power supplies. Their input voltage can be as high as 24 V (V_{CEO} = 80 V or higher). The DC current gain, hFE, is guaranteed in the low-current region.
Example: 2SC6061
h_{FE}: 100 or greater (@ V_{CE} = 2 V / Ic = 1 mA)



Product Lineup

Package	Part Number	Absolute Maximum Ratings				hFE				VCE(sat) Max		
		V_{CEX} (V)	V_{CEO} (V)	I_C (A)	P_C (W)	Min	Max	V_{CE} (V)	I_C (A)	(V)	I_C (A)	I_B (mA)
TSM	2SC6061	150	120	1	0.625 *1	120	300	2	0.1	0.14	0.3	10
PS-8	TPCP8510	150	120	1	1.1 *1	120	300	2	0.1	0.14	0.3	10
	TPCP8507	150	120	1	1.25 *1	120	300	2	0.1	0.14	0.3	10
PW-Mold	2SC6076	160	80	3	10 *2	180	450	2	0.5	0.5	1	100
PW-Mini	2SC6124	160	80	2	1 *1	100	200	2	0.5	0.5	1	100

*1: Mounted on FR4 board (Cu area: 645 mm²; glass epoxy; t = 1.6 mm) *2: Tc = 25˚C

Detailed information about our MOSFETs is available on our website at: http://www.semicon.toshiba.co.jp/eng

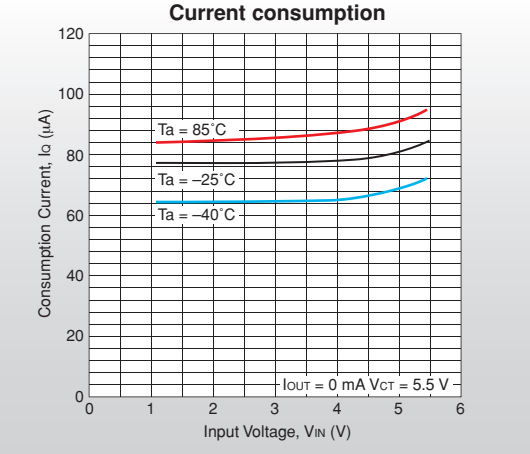
Load Switch ICs (Low On-Resistance, Low-Voltage Operation, Additional Features, Ultra-Small Package)

TCK106G/107G/108G

The TCK10xG Series features a wide operating voltage range from 1.1 V to 5.5 V and low current consumption. It is available with a maximum output current of up to 1 A and ideal for applications requiring power saving at relatively light loads. The TCK106G, TCK107G and TCK108G in the ultra-small WCSP4 package consume only 0.2 μA (max) during active operation (V_{IN} = 5.5V, I_{OUT} = 0 mA, Ta = -40 to 85°C). The TCK104G and TCK105G with reverse-current protection are also available.

Key Characteristics

- Wide operating voltage range: V_{IN} = 1.1 to 5.5 V
- Maximum output current: I_{OUT} = 1 A
- Low on-resistance: R_{ON} = 49 mΩ (typ.) @V_{IN} = 5.0 V, I_{OUT} = 500 mA
- Low current consumption: I_Q = 0.08 μA (typ.) @V_{IN} = V_{CT} = 5.5 V, I_{OUT} = 0 mA
- Low standby current: $I_{Q(OFF)}$ = 0.05 μA (typ.) @ standby mode
- Added functions: Inrush current reduction circuit
  Automatic output discharge (TCK107G, TCK108G)
- Ultra-small package: WCSP4 (0.79 mm × 0.79 mm, t: 0.5 mm (typ.))

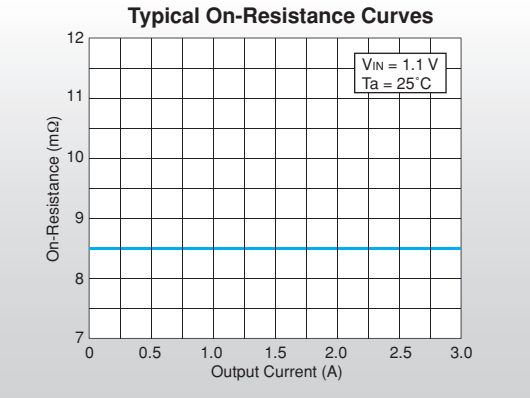


TCK111G/112G

The TCK11xG Series features a wide operating voltage range from 1.1 V to 5.5 V and ultra-low on-resistance. The TCK11xG Series provides an on-resistance of approximately 8 mΩ despite its small size and incorporates reverse-current protection and thermal shutdown. It can be used for diverse applications such as driver switches for the battery line and low-voltage switches rated at 1 A or higher.

Key Characteristics

- Wide operating voltage range: V_{IN} = 1.1 to 5.5 V
- Maximum output current: I_{OUT} = 3 A
- Ultra-low on-resistance
  R_{ON} = 8.5 mΩ (typ.) @V_{IN} = 1.1 V, I_{OUT} = –1.5 A
  R_{ON} = 8.3 mΩ (typ.) @V_{IN} = 5.0 V, I_{OUT} = –1.5 A
- Inrush current limited by slew rate control circuitry
- Reverse-current protection
- Thermal shutdown
- Automatic output discharge (TCK112G)
- Ultra-small package: WCSP6C (1.0 mm × 1.5 mm, t: 0.5 mm (typ.))

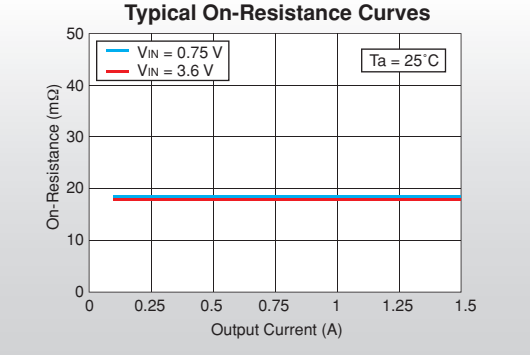


TCK206G/207G/208G

The TCK20xG Series features ultra-low-voltage operation as low as 0.75 V and low on-resistance. It also provides an on-resistance of approximately 18 mΩ despite using the ultra-small WCSP4C package and incorporates reverse-current protection. Those housed in the general-purpose SMV (SOT-25) package are under development.

Key Characteristics

- Ultra-low-voltage operation: V_{IN} = 0.75 to 3.6 V
- Maximum output current: I_{OUT} = 2 A
- Low on-resistance
  R_{ON} = 18.1 mΩ (typ.) @V_{IN} = 3.3 V, I_{OUT} = –1.5 A
  R_{ON} = 18.4 mΩ (typ.) @V_{IN} = 0.75 V, I_{OUT} = –1.5 A
- Inrush current limited by slew rate control circuitry
- Reverse-current protection
- Automatic output discharge (TCK207G, TCK208G)
- Ultra-small package: WCSP4C (0.9 mm × 0.9 mm, t: 0.5 mm (typ.))



*These waveforms only represent typical device characteristics and are not necessarily guaranteed.

CMOS LDO Regulators (Low Dropout Voltage and Low Noise)

TCR3DM/TCR3DF Series

The TCR3DM and TCR3DF Series are 300-mA single-output LDO regulators featuring low voltage dropout and low noise. In addition to overcurrent protection, thermal shutdown and auto output discharge, these LDO regulators contain an inrush current limiter. They are available in the small DNF4 package and the general-purpose SMV package.

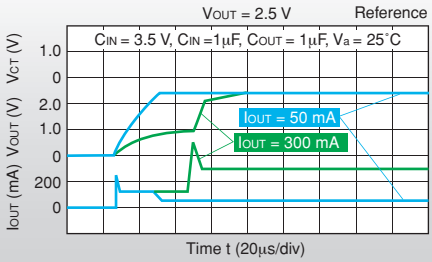
Key Characteristics

- Output voltage: 1.0 to 4.5 V (fixed)
- Output voltage regulation: ±1.0 % (V_{OUT} ≥ 1.8 V)
- Maximum output current: 300 mA
- Dropout voltage:
  V_{IN}-V_{OUT} = 210 mV (typ.) (@2.5 V output, I_{OUT} = 300 mA)
- Low output noise voltage:
  V_{NO} = 38 μVrms (typ.) (@2.5 V output, I_{OUT} = 10 mA, 10 Hz<f<100 kHz)
- Fast load transient response:
  ΔVOUT = ±80 mV (typ.) (@I_{OUT} = 1 mA↔300 mA, C_{OUT} = 1.0 μF)
- Inrush current limiter, automatic output discharge function
- Protection circuits: Overcurrent protection, thermal shutdown
- Packages: DFN4/SMV

DFN4 (1.0 x 1.0 mm)

SMV (2.8 x 2.9 mm)

Inrush Current (TCR3DM25)



TCR2EN/TCR2EE/TCR2EF Series

The TCR2EN, TCR2EE and TCR2EF Series are CMOS 200-mA single-output LDO regulators with low dropout voltage, low output noise and fast load transient response. They are suitable for various applications. There are 3 package that ultra-small SDFN4 package, and general-purpose SMV and ESV packages.

Key Characteristics

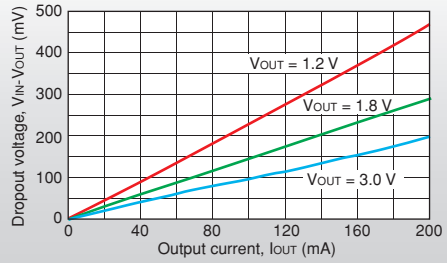
- Output voltage: 1.0 to 5.0 V (fixed)
- Output voltage regulation: ±1.0 % (V_{OUT} ≥ 1.8 V)
- Maximum output current: 200 mA
- Dropout voltage:
  V_{IN}-V_{OUT} = 160 mV (typ.) (@2.5 V output, I_{OUT} = 150 mA)
- Low output noise voltage:
  V_{NO} = 35 μVrms (typ.) (@2.5 V output, I_{OUT} = 10 mA, 10 Hz<f<100 kHz)
- High ripple rejection ratio:
  R.R. = 73 dB (typ.) (@2.5 V output, I_{OUT} = 10 mA, f = 1 kHz)
- Fast load transient response:
  ΔVOUT = ±55 mV (typ.) @I_{OUT} = 1 mA↔150 mA, C_{OUT} = 1.0 μF
- Automatic output discharge, overcurrent protection
- Allows use of small ceramic capacitors on the input and output lines.
- Packages: SDFN4/ESV/SMV

SDFN4 (0.8 x 0.8 mm)

ESV (1.6 x 1.6 mm)

SMV (2.8 x 2.9 mm)

Dropout Voltage (TCR2EN Series)



TCR2DG Series

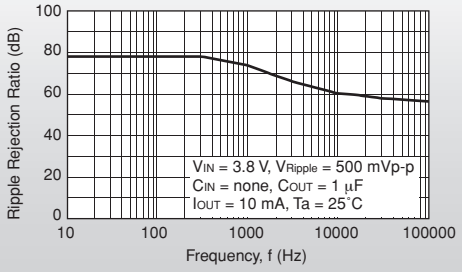
The TCR2DG series are CMOS single-output LDO regulators with 200-mA output current and high ripple rejection ratio. It is ideal for applications that require high-density board assembly such as mobile devices.

Key Characteristics

- Output voltage: 1.2 to 3.6 V (fixed)
- Output voltage regulation: ±1.0 %
- Maximum output current: 200 mA
- Dropout voltage:
  V_{IN}-V_{OUT} = 80 mV (typ.) (@2.5 V output, I_{OUT} = 100 mA)
- Low output noise voltage:
  V_{NO} = 18 μVrms (typ.) (@2.5 V output, I_{OUT} = 10 mA, 10 Hz<f<100 kHz)
- High ripple rejection ratio:
  R.R. = 75 dB (typ.) (@2.5 V output, I_{OUT} = 10 mA, f = 1 kHz)
- Fast load transient response:
  ΔVOUT = ±65 mV (typ.) (@I_{OUT} = 1 mA↔150 mA, C_{OUT} = 1.0 μF)
- Protection circuits: Overcurrent protection, thermal shutdown
- Packages: WCSP4

WCSP4 (0.8 x 0.8 mm)

Example of a Ripple Rejection Ratio vs. Frequency Curve (TCR2DG Series)



*These waveforms only represent typical device characteristics and are not necessarily guaranteed.

Search Functions on Our Website

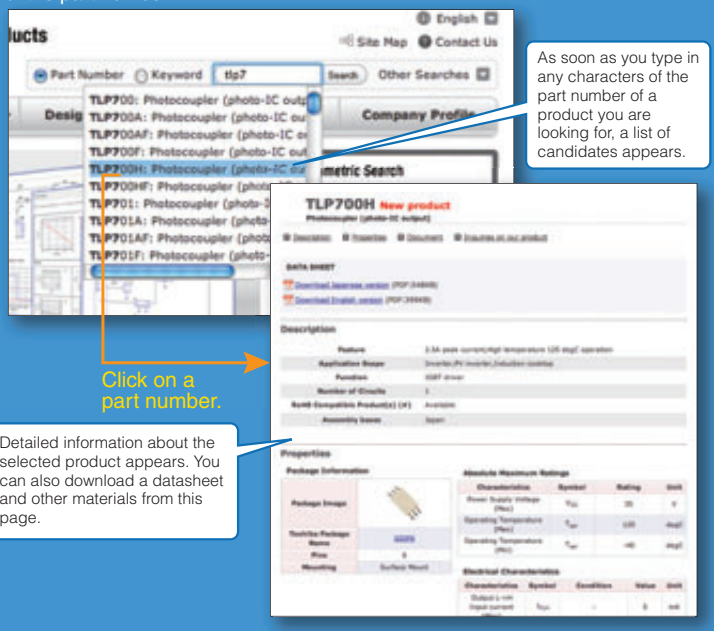
Our website provides parametric and cross-reference search engines. Parametric Search allows you to narrow down and find products that meet your parametric criteria. Cross-Reference Search returns a list of Toshiba's products that are functionally and electrically equivalent to other manufacturers' products you have specified.

Various search features

You can find products matching your search criteria.

■ Part number search

You can find information about any of our products by typing in any characters of the part number.



As soon as you type in any characters of the part number of a product you are looking for, a list of candidates appears.

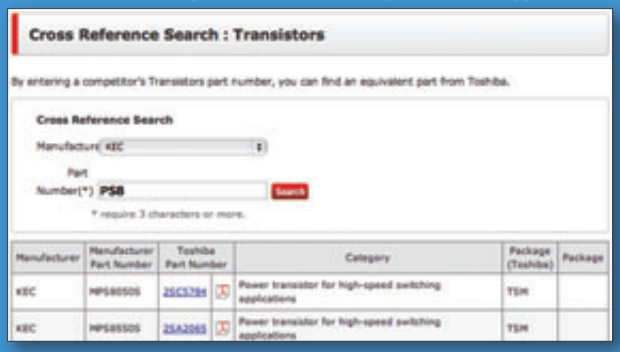
Detailed information about the selected product appears. You can also download a datasheet and other materials from this page.

■ Parametric search

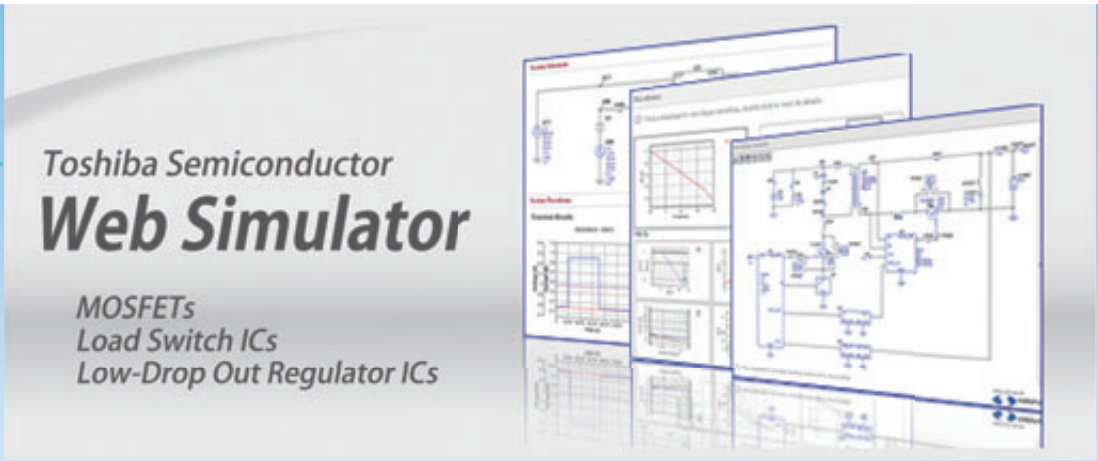
You can successively narrow down a list of products by choosing a product category and electrical characteristics.

■ Cross-reference search

As soon as you type in any characters of the part number of another company's product, a list of Toshiba products with similar specifications appears.



Web Simulator



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.

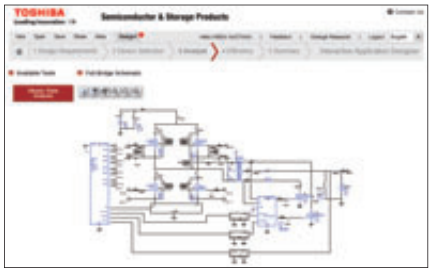
MOSFETs

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, $R_{DS(ON)}$-Ta, I_{DR}-V_{DS}, C-V_{DS}, Qg and other curves



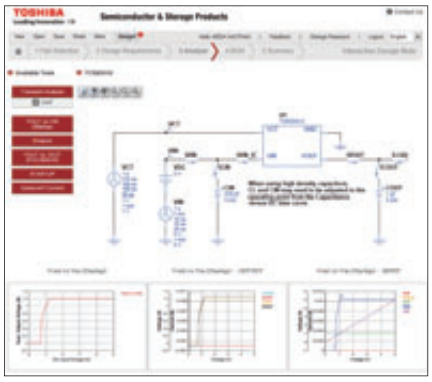
Interactive Application Designer <Circuit simulation>

Allows you analyze the switching waveforms and power efficiencies of 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

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