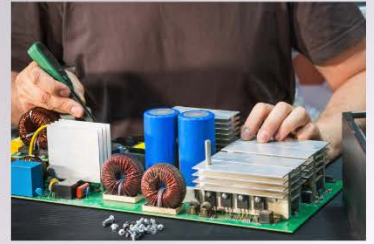




**POWER**



# Power Supply Solutions

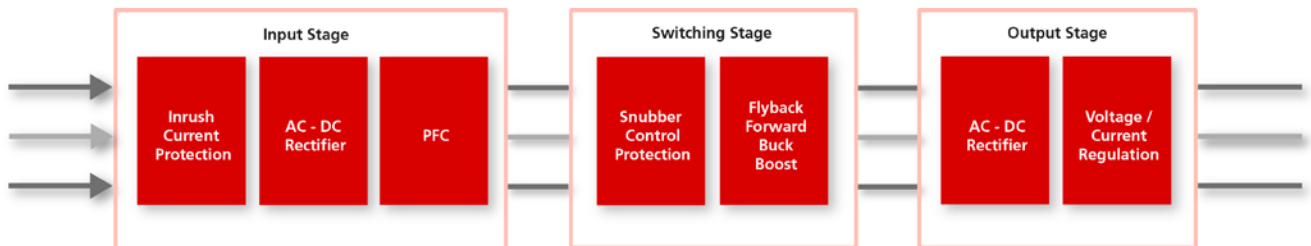
In recent decades, many efficiency standards have been developed worldwide to reduce global energy consumption and thus to lower CO<sub>2</sub> emissions. This rapid development of standards requires highly efficient power supplies. For that purpose, the latest energy-saving technologies and components are to be used: From the input bridge via Power Factor Correction (PFC) to the switching stage such as flyback, forward, buck or boost topology and the output stage, all including protection and control circuits.

Diode offers a wide range of dedicated products for almost every need:

- **Three-phase Bridge Rectifiers** such as the DBI25-18A, which stay "cool" underload and meet the surge voltage requirements of EN61000-4-5
- **Controlled Avalanche Rectifiers** in SMA and Melf packages like the AM2000, for the auxiliary stage or the use at highly disturbed input mains
- **Super Fast Efficient Rectifiers** like the MUR860 for Power Factor Correction
- Low RDS(on) and fast switching **MOSFETs** for the converter stage
- **Bootstrap diodes** for the upper gate driver supply, e. g. the SA265 or BYG23T
- The **TVS/blocking diode combination** TGL200U06 for the snubber circuit
- **3rd Generation Schottky Diodes**, which ensure lower power losses at the output stage
- **Voltage Regulators** with internal current limitation and thermal shut down
- **Shunt Regulators** such as the MMTL431A used as voltage reference and error amplifier
- Easy drive of signal LEDs with **Current Limiting Diodes**, e. g. the CL10MD

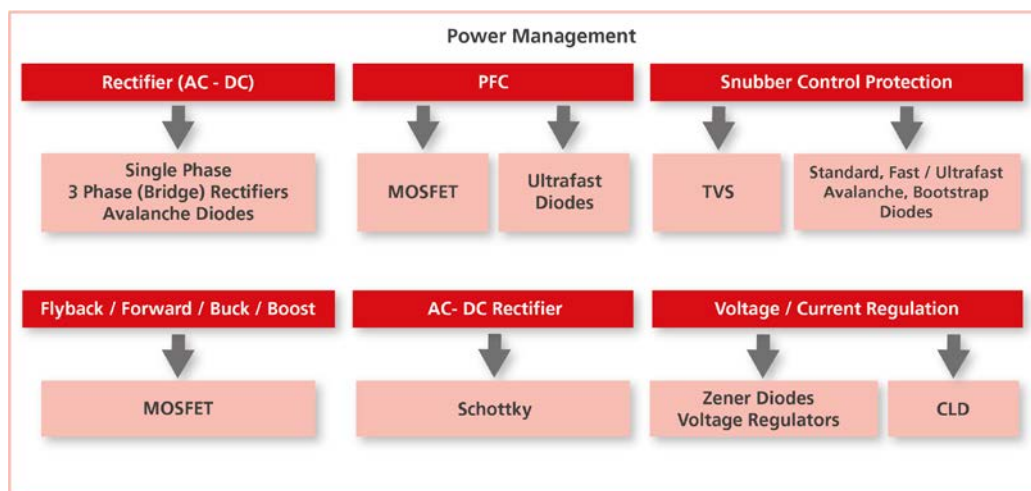
All these parts support designers in finding the best possible solutions with highest efficiency. Power losses are reduced, energy savings are increased and consequently the overall performance can be improved.

The following block diagram shows energy alteration procedure from an alternating AC voltage to a constant DC output voltage. In case of a pure DC to DC converter, the first block is omitted.



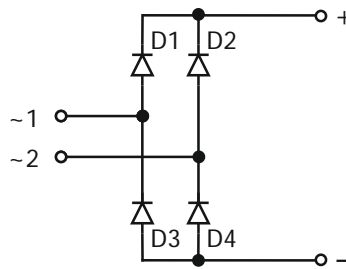
Block diagram of a typical AC to DC power supply

Typical components used in the separate function blocks are shown here:



## AC – DC Rectification

### Single Phase Bridge Rectifiers



Typical 1- bridge circuit

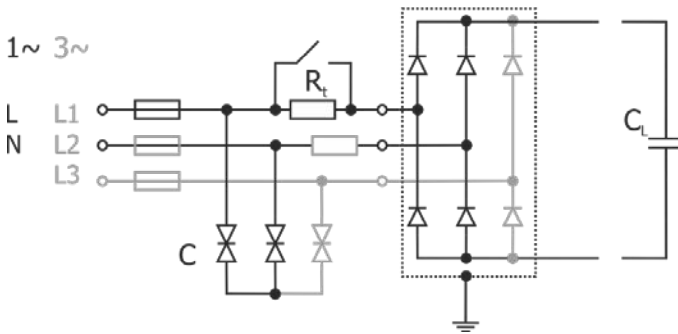
- IL Industrial Lighting
- IMC Industrial Motor Control
- Con Consumer
- SM Smart Meters
- AL Automotive Lighting
- AVE Audio, Video and Entertainment
- PT Battery Powered Tools
- APS Auxiliary Power Supply

Part Number	Package	$I_{FAV}$	$V_{RRM}$	Applications
MYS250 ... MYS380	MicroDIL	1 A	600 ... 800 V	IL Con AVE
MB6S ... MB10S	TO-269AA/MiniDIL Slim	0.5 A	600 ... 1000 V	IL Con
S250 ... S500	TO-269AA/MiniDIL Slim	0.8 A	600 ... 1000 V	IL Con
S125K, S250K	TO-269AA/MiniDIL Slim	1 A	250 ... 600 V	IL Con PT
ABS6 ... ABS10	ABS	0.8 A	600 ... 1000 V	IL Con PT
ABS15J ... ABS15M	ABS	1.5 A	600 ... 1000 V	IL Con PT
B250S15A ... B500S15A	SO-DIL Slim	1.5 A	600 ... 1000 V	IL Con PT
B250S2A ... B380S2A	SO-DIL Slim	2.3 A	600 ... 800 V	IL Con PT
B250S ... B500S	SO-DIL Slim	1 A	600 ... 1000 V	IL Con
B250D ... B500D	DIL	1 A	600 ... 1000 V	IL Con

Part Number	Package	$I_{FAV}$	$V_{RRM}$	Applications
B250R ... 500R	D9 x 5.1 (~WOG)	2 A	600 ... 1000 V	IL

Part Number	Package	$I_{FAV}$	$V_{RRM}$	Applications
GBI Series	30 x 20 x 3.6	10 ... 40 A	50 ... 1600 V	IMC Con AVE
GBU Series	21.5 x 18.2 x 3.4	4 ... 12 A	50 ... 1000 V	IMC Con AVE
KBPC10/15/25xx Series	28.6 x 28.6 x 7.3	10/15/25 A	100 ... 1600 V	IMC
KBPC250xxI Series	28.6 x 28.6 x 7.3	25A	100 ... 100 V	IMC
KBPC35xxFP/WP Series	28.6 x 28.6 x 7.3	35 A	100 ... 1600 V	IMC
KBPC35xxI Series	28.6 x 28.6 x 7.3	35A	100 ... 1000 V	IMC
KBPC50xxFP/WP Series	28.6 x 28.6 x 7.3	50 A	100 ... 1600 V	IMC

### Three Phase Bridge Rectifiers



Typical 1~ / 3~ bridge circuit

- IL Industrial Lighting
- IMC Industrial Motor Control
- Con Consumer
- SM Smart Meters
- AL Automotive Lighting
- AVE Audio, Video and Entertainment
- PT Battery Powered Tools
- APS Auxiliary Power Supply

Part Number	Package	$I_{FAV}$	$V_{RRM}$	Applications
<b>DBI20 Series (+ ~ ~ ~ -)</b>	35 x 25 x 4	20 A	800 ... 1600 V	<span style="background-color: #20998b; color: white; padding: 2px;">IMC</span>
<b>DBI25 Series (- ~ ~ ~ +)</b>	35 x 25 x 4	25 A	800 ... 1800 V	<span style="background-color: #20998b; color: white; padding: 2px;">IMC</span>
<b>DB15/25 Series</b>	28.5 x 28.5 x 10	15/25 A	100 ... 1600 V	<span style="background-color: #20998b; color: white; padding: 2px;">IMC</span>
<b>DB35 Series</b>	28.5 x 28.5 x 10	35 A	100 ... 1600 V	<span style="background-color: #20998b; color: white; padding: 2px;">IMC</span>

### Single Rectifiers

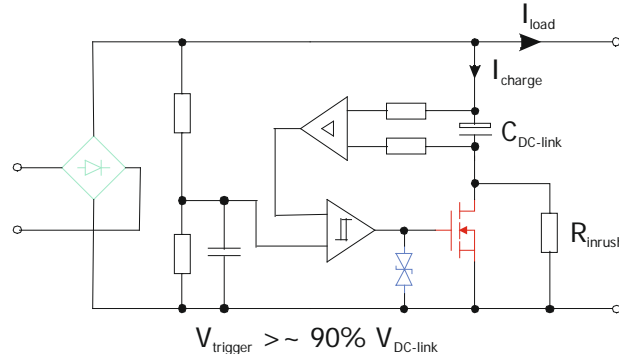
Part Number	Package	$I_{FAV}$	$V_{RRM}$	$E_{RSM}$	Applications
<b>S1J ... S1Y</b>	DO-214AC/SMA	1 A	600 ... 2000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #9b59b6; color: white; padding: 2px;">SM</span>
<b>S2J ... S2Y</b>	DO-214AA/SMB	2 A	600 ... 2000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #9b59b6; color: white; padding: 2px;">SM</span>
<b>S3J ... S3Y</b>	DO-214AB/SMC	3 A	600 ... 2000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #34495e; color: white; padding: 2px;">AVE</span>
<b>S5J ... S3Y</b>	DO-214AB/SMC	5 A	600 ... 2000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #34495e; color: white; padding: 2px;">AVE</span>
<b>SM4005 .... SM2000</b>	DO-213AB/ Melf	1 A	600 ... 2000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #9b59b6; color: white; padding: 2px;">SM</span>
<b>AM2000 <sup>1)</sup></b>	DO-213AB/ Melf	1 A	1600 V	5 mJ	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span> <span style="background-color: #9b59b6; color: white; padding: 2px;">SM</span>
<b>BYG10J ... BYG10M <sup>1)</sup></b>	DO-214AB/SMA	1 A	600 ... 1000 V	20 mJ	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>AL1J ... AL1M <sup>1)</sup></b>	DO-213AA/MiniMelf	1 A	600 ... 1000 V	20 mJ	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>GL1J ... GL1M</b>	DO-213AA/MiniMelf	1 A	600 ... 1000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>SL1J ... SL1M</b>	SOD-123FL	1 A	600 ... 1000 V	N/A	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span> <span style="background-color: #34495e; color: white; padding: 2px;">AVE</span>
<b>SRL1G, SRL1J</b>	Power SOD-323	1A	400, 600 V	N/A	<span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>SWL1J</b>	SOD-323	1A	600 V	N/A	<span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>

<sup>1)</sup> Controlled Avalanche

Part Number	Package	$I_{FAV}$	$V_{RRM}$	Applications
<b>1N4005 ... 1N4007</b>	DO-41	1 A	600 ... 1000 V	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>1N5397 ... 1N5399</b>	DO-15	1.5 A	600 ... 1000 V	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>1N5061 ... 1N5062</b>	DO-15	1.5 A	600 ... 800 V	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>1N5406K ... 1N5408K</b>	DO-15	1.5 A	600 ... 1000 V	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>
<b>BY253 ... BY255</b>	~DO-201	3 A	600 ... 1300 V	<span style="background-color: #4a5568; color: white; padding: 2px;">IL</span> <span style="background-color: #c0392b; color: white; padding: 2px;">Con</span>

## Active Inrush Current Limitation

The below circuit shows a simple but anyway “smart” and energy saving way of inrush current limitation for all circuits having a DC link capacitor, followed by a (switching) power stage.



When the mains is turned on, the resistor is limiting the inrush current to a value which is acceptable for the input bridge and the link capacitor. If the capacitor voltage reaches approximately 90% of the minimum appearing DC voltage, the Schmitt trigger turns on the MOSFET. One has to note that the DC voltage is overlaid by an AC value; design has to consider this fluctuation.

The turned-on MOSFET is bypassing the resistor and reduces therefore significantly the power losses. The MOSFET has to carry only the repeated charging currents of the link capacitor, but not the (bigger) load current. The output of the Schmitt trigger must be able to provide the required gate charge current for the MOSFET; an additional driver circuit might be necessary. The TVS diode protects the gate against excessive voltages.

In case the mains fails and the capacitor voltage drops below 90% of the minimum appearing DC voltage, the MOSFET turns off as well. If mains is coming back, the resistor is again limiting the inrush current. This makes the shown circuit more safe than simple inrush current limitation by using an NTC, which might require up to several minutes for cooling down and to become high resistive again.

Diotec can offer the input bridge, the TVS diode and the MOSFET in above circuit.

### TVS Diodes

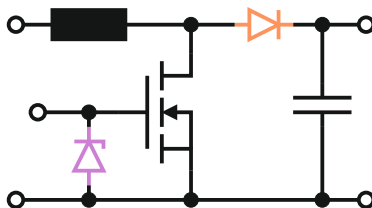
Part Number	Package	P <sub>PPM</sub>	V <sub>WM</sub>	V <sub>BR</sub>	Applications
TGL34-...	DO-213AA/MiniMelf	150 W	5.5 ... 171 V	6.8 ... 200 V	IL Con AVE SM
SMF...	SOD-123F	200 W	5.0 ... 220 V	6.8 ... 260 V	IL Con AVE SM
TGL41-...	DO-213AB/Melf	400 W	5.5 ... 423 V	6.8 ... 520 V	IL Con AVE SM
P4SMA...	DO-214AC/SMA	400 W	5.0 ... 495 V	6.8 ... 550 V	IL Con AVE SM
P6SMB...	DO-214AA/SMB	600 W	5.0 ... 495 V	6.8 ... 550 V	IL Con AVE SM
1.5SMC...	DO-214AB/SMC	1500 W	5.0 ... 495 V	6.8 ... 550 V	IL Con AVE SM

### Power MOSFETs

Part Number	Package	I <sub>D</sub>	V <sub>DS</sub>	R <sub>DS(on)</sub>	Applications
DIJ004N65*	ITO-220AB	4 A	650 V	2.3 Ω	IL Con AVE SM
DIJ013N65*	ITO-220AB	13 A	650 V	0.28 Ω	IL Con AVE SM
DIJ020N60*	ITO-220AB	20 A	600 V	0.13 Ω	IL Con AVE SM

\*under development

## Power Factor Correction (PFC)



Required at input power bigger than 75W. The operation frequencies are usually high: For reduction of power losses in the MOSFET (affected highly by reverse recovery behaviour of the diode!), the boost diode must have very low reverse recovery but also low forward voltage drop. Superfast Efficient Rectifiers fulfil this requirement.

## Power MOSFETs

Part Number	Package	$I_D$	$V_{DS}$	$R_{DS(on)}$	Applications
DIJ004N80*	ITO-220AB	4 A	800 V	2.8 $\Omega$	IL
DIJ006N80*	ITO-220AB	6 A	800 V	1.4 $\Omega$	IL
DIJ010N80*	ITO-220AB	10 A	800 V	0.9 $\Omega$	IL

\*under development

## Superfast Efficient Rectifiers

Part Number	Package	$I_{FAV}$	$V_{RRM}$	$T_{rr}$	Applications
MUR460	DO-201	4 A	600 V	50 ns	IL
MUR860	TO-220AC	8 A	600 V	50 ns	IL
MURF2060CT	ITO-220AB	20 A	600 V	25 ns	IL
ERJ3006	ITO-220AC	30 A	600 V	50 ns	IMC

## Ultrafast Diodes

Part Number	Package	$I_{FAV}$	$V_{RRM}$	Applications
ES3JSMB	DO-214AA/SMB	3 A	600 V	AVE
ES3J	DO-214AB/SMC	3 A	600 V	AVE
ER3J	DO-214AB/SMC	3 A	600 V	AVE
UGB8JT	TO-263AB/D <sup>2</sup> PAK	8 A	600 V	AVE
UFT800J	TO-220AB	8 A	600 V	AVE

## Switching Stage

Typical "isolated" converter topologies are Flyback and Forward. Here the primary and secondary side are separated by a transformer, which manages additionally the up or down conversion of the voltage. Buck and Boost converters are non-isolated circuits using a coil for voltage conditioning. All of these use typically Power MOSFETs as a high frequent switching element.

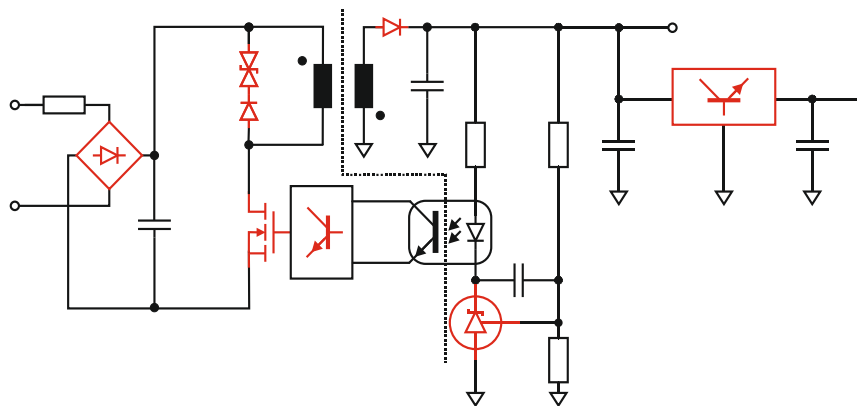
## Power MOSFETs

Part Number	Package	I <sub>D</sub>	V <sub>DS</sub>	R <sub>DS(on)</sub>	Applications
<b>DIJ004N80*</b>	ITO-220AB	4 A	800 V	2.8 Ω	IL APS
<b>DIJ006N80*</b>	ITO-220AB	6 A	800 V	1.4 Ω	IL APS
<b>DIJ010N80*</b>	ITO-220AB	10 A	800 V	0.9 Ω	IL APS
<b>DIT050N06</b>	TO-220AB	50 A	60 V	0.014	IL APS
<b>DIT090N06</b>	TO-220AB	90 A	65 V	0.0057	IL APS
<b>DIT095N08</b>	TO-220AB	95 A	80 V	0.0066	IL APS
<b>DIT100N10</b>	TO-220AB	100 A	100 V	0.0099	IL APS
<b>DIT120N08</b>	TO-220AB	120 A	80 V	0.0049	IL APS
<b>DIT150N03</b>	TO-220AB	150 A	30 V	0.0023	IL APS
<b>DIT95N08</b>	TO-220AB	195 A	85 V	0.0041	IL APS

\*under development

## Protection

Flyback converters require a special network, the so called snubber at the primary side, in order to protect the MOSFET respectively switching IC against excessive voltage spikes. The snubber usually consists of a TVS diode and an Ultrafast rectifier; depending on switching frequency also a Fast or even Standard Recovery type might be used.



Typical Flyback circuit

## TVS Diodes

Part Number	Package	P <sub>PPM</sub>	V <sub>WM</sub>	V <sub>BR</sub>	Applications
TGL34-...	DO-213AA/MiniMelf	150 W	5.5 ... 171 V	6.8 ... 200 V	Con AVE APS
SMF...	SOD-123F	200 W	5.0 ... 220 V	6.8 ... 260 V	Con AVE APS
TGL41-...	DO-213AB/Melf	400 W	5.5 ... 423 V	6.8 ... 520 V	Con AVE APS
P4SMA...	DO-214AC/SMA	400 W	5.0 ... 495 V	6.8 ... 550 V	Con AVE APS
P6SMB...	DO-214AA/SMB	600 W	5.0 ... 495 V	6.8 ... 550 V	Con AVE APS
1.5SMC...	DO-214AB/SMC	1500 W	5.0 ... 495 V	6.8 ... 550 V	Con AVE APS
P6KE	DO-15/ DO-204AC	600 W	5.0 ... 444 V	6.8 ... 520 V	Con AVE APS

## Ultrafast Diodes

Part Number	Package	I <sub>FAV</sub>	V <sub>RRM</sub>	Applications
USL1A ... M	SOD-123F	1 A	50 ... 1000 V	Con AVE APS
US1A ... M	DO-214AC/SMA	1 A	50 ... 1000 V	Con AVE APS
US3A ... M	DO-214AB/SMC	3 A	50 ... 1000 V	Con AVE APS

## TVS and Ultrafast in one package

Part Number	Package	P <sub>PPM</sub>	V <sub>R</sub>	V <sub>BR</sub>	Applications
TGL200U06...10	DO-213AB/Melf	300 W	600 ... 1000V	200 V	IL APS
TGL200F08	DO-213AB/Melf	300 W	600 ... 1000V	200 V	IL APS
PKC-136	DO-15/ DO-204AC	600 W	700 V	160 V	IL APS

The TGL200U Series, by Diotec combines a 200V TVS and a Ultrafast diode with V<sub>rrm</sub> of 600V to 1000V, in a single DO-213AB/Melf package. It thus helps to save board save in this usually rather tightly assembled circuits. Further available are the Fast Recovery version TGL200F08.



## Output Stage

### Schottky Diodes

Part Number	Package	I <sub>FAV</sub>	V <sub>RRM</sub>	Applications
SK1H10 (HT)	DO-214AC/SMA	1 A	100 V	AL Con SM PT AFS
SGL2-40-3G	DO-213AA/MiniMelf	2 A	40 V	AL Con SM PT AFS
SKL34 ... 36	SOD-123F	3 A	40 ... 60 V	AL Con SM PT AFS
SMS340 ... 3100 (-3G)	DO-213AB/Melf	3 A	40 ... 100 V	AL Con SM PT AFS
SK34SMA-3G ... 315SMA	DO-214AC/SMA	3 A	40 ... 150 V	AL Con SM PT AFS
SK3H10SMB ... 3H15SMB (HT)	DO-214AA/SMB	3 A	100 ... 150 V	AL Con SM PT AFS
SK420	DO-214AB/SMC	4 A	200 V	AL Con SM PT AFS
SK54-3G ... 515 (-3G)	DO-214AA/SMB	5 A	40 ... 150 V	AL Con SM PT AFS
SK84-3G ... 815 (-3G)	DO-214AB/SMC	8 A	40 ... 150 V	AL Con SM PT AFS

-3G: Available in 3rd Generation Schottky Technology with low V<sub>F</sub> and low I<sub>R</sub>

### Power Schottky Diodes




















Part Number	Package	I <sub>FAV</sub>	V <sub>RRM</sub>	Applications
PPS1040 ... 60 (-3G)	Power SMD	10 A	40 ... 60 V	IL IMC
PPS1540 ... 60 (-3G)	Power SMD	15 A	40 ... 60 V	IL IMC
SK1040...100D1 )-3G)	D-PAK	10A	40...100 V	IL IMC
SK1040...100D2 (-3G)	D2-PAK single	10A	40...100 V	IL IMC
SK2040...100CD2 (-3G)	D2-PAK dual	2x 10A	20...100 V	IL IMC AVE
SK3040...100CD2 (-3G)	D2-PAK dual	2x 15A	40...100 V	IL IMC
SK4040...45CD2 (-3G)	D2-PAK dual	2x 20A	40...45 V	IL IMC
SBT1040...100 (-3G)	TO-220AC	10A	40 ... 100 V	IL IMC
MBR10100 (HT)	TO-220AC	10A	100 V	IL IMC AL
SBCT1040...100 (-3G)	TO-220AB dual	2x 5A	40 ... 100 V	IL IMC
SBCT2040...100 (-3G)	TO-220AB dual	2x 10A	40 ... 100 V	IL IMC AVE
MBR20100CT...200CT (HT)	TO-220AB dual	2x 10A	100 ... 200 V	IL IMC AL
SBCT30100...150	TO-220AB dual	2x 15A	100 ... 150 V	IL IMC

-3G: Available in 3rd Generation Schottky Technology with low V<sub>F</sub> and low I<sub>R</sub>








IL	Industrial Lighting
IMC	Industrial Motor Control
Con	Consumer
SM	Smart Meters
AL	Automotive Lighting
AVE	Audio, Video and Entertainment
PT	Battery Powered Tools
AFS	Auxiliary Power Supply









## Voltage and Current Regulation

### Linear Voltage Regulators













Part Number	Package	I <sub>out</sub>	V <sub>out</sub>	Applications
<b>LDI1117 Series</b>	SOT-89, SOT-223	1.0 A	Adjustable, Fixed: 1.2 ... 5 V	   
<b>DI78L05 Series</b>	SO-8, SOT-89	0.1 A	3.3 ... 24 V	   
<b>DI79L Series</b>	TO-92	0.1 A	5 ... 24 V	   
<b>DI78M Series</b>	SO8, SOT-89	0.5 A	5 ... 24 V	   
<b>DI6206 Series</b>	SOT-23	0.2 A	1.2 ... 5.0V	  

### Shunt Regulators

Part Number	Package	I <sub>K</sub>	V <sub>out</sub>	Applications
<b>MMTL431A / AR</b>	SOT-23	1.0 ... 100 A	Adjustable: 2.495 ... 36 V	  
<b>MMTV4041</b>	SOT-23	0.1 ... 20 mA	Fixed: 1.24 V	 
<b>MMTV431A</b>	SOT-23	0.1 ... 20 mA	Adjustable: 1.24 ... 20 V	 

	Industrial Lighting
	Industrial Motor Control
	Consumer
	Smart Meters
	Automotive Lighting
	Audio, Video and Entertainment
	Battery Powered Tools
	Auxiliary Power Supply

### CLD (Constant Current Regulator)

Part Number	Package	I <sub>Pnom</sub>	V <sub>AK</sub>	Applications
<b>CL05M6F</b>	SOD-123FL	5 mA	190 V	  
<b>CL10MD ... 30MD</b>	DO-213AA/MiniMelf	20 ... 40 mA	90 V	  
<b>CL15M35 ... 40M35</b>	DO-214AC/SMA	15 ... 40 mA	90 V	  
<b>CL15M45 ... 40M45</b>	DO-214AA/SMB	15 ... 40 mA	90 V	  

#### Disclaimer

This application note describes device proposals and shall not be considered as assured and proven solution for any circuit. No warranty or guarantee, expressed or implied is made regarding the capacity, performance or suitability of any device, circuit etc.