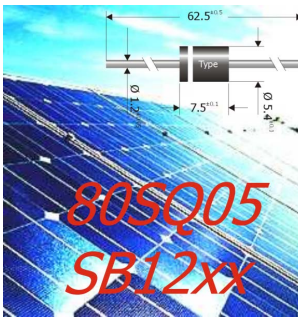
Diotec *Products*
for Solar Modules

Tailor-made “Solar Diodes” for Bypass Operation



„Low Vf“ Bipolar Diodes

P1200, F1200, FT2000

Reverse Voltage up to 400 V

= more rugged against voltage spikes

Lower leakage current than Schottky diodes

= reduced losses in normal mode of operation

Forward losses smaller than for standard rectifiers

= acceptable losses in bypass mode

Schottky Diodes

80SQ05, SB12xx, SBT10xx, SBCT20xx, SK10xx

Low Forward Voltage Drop

= reduced losses in bypass mode

Lower Leakage current than “ultra low Vf“ Schottky’s

= acceptable losses in normal mode of operation

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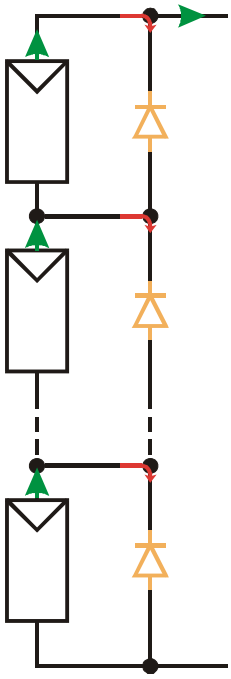
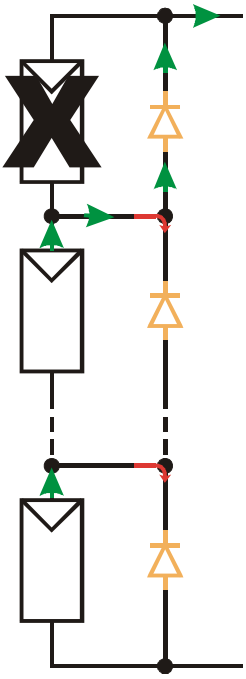
Function of Bypass Diodes



Normal Mode



Bypass Mode
(module partly shaded)

During construction of solar modules, single cells are switched in series to so called “strings” to achieve higher system voltages, see left picture above.

If one or more cells are shaded (e. g. by branches of trees, antennas, etc), the affected solar cells are no more acting like a current source, but as power consumers. Non-shaded cells are delivering further current through them, generating high power losses. “Hot spots” may occur and even cell breakdowns.

To avoid this problem bypass diodes are switched parallel to every single or some combined cells, bypassing current flow across the darkened strings, right picture above.

As every semiconductor device, also bypass diodes have got a certain leakage current, which in normal mode of operation reduces the current supplied by the cells and therefore decreases efficiency of the solar module (see red turn-down arrows in the picture above). Therefore leakage current especially at higher temperatures (full sun irradiation!) should be as low as possible. Compared to that, partly shading of modules is only an extreme operation mode which should be completely avoided or at least occurs only during short time periods. For this mode of operation,l low forward losses are desirable. Finally, the bypass diode has to be rugged against overvoltage spikes. Such spikes may occur during assembly of the system, if e. g. current conducting cables are interrupted, or during operation, caused by lightning etc.

Standards about Bypass Diode Operation

Some standard drafts (e. g. IEC 61730-2, IEC 61215) describe a bypass diode test, applying the module short circuit current for one hour, at an ambient temperature of 75°C. At this test, the junction temperature of the diode has to stay below the maximum admissible value. An estimation of the junction temperature can be done as follows:

$$T_j = T_{L/C} + R_{thL/C} * V_f * I_{SC}$$

T_j = junction temperature of the diode, maximum admissible value see datasheet
$T_{L/C}$ = temperature of contact leads (L) resp. cooling fin of case (C)
$R_{thL/C}$ = thermal resistance junction – contact lead (L) resp. cooling fin of case (C)
V_f = forward voltage drop across diode
I_{SC} = module short circuit current

To comply with the test, solar diodes by Diotec are offering several advantages:

V_f

Reduced power losses inside the diode by reduced forward voltage drop V_f. Possible through „Low Vf“-bipolar diodes as well as Schottky diodes.

T_j

Specification of higher admissible junction temperature T_j (up to 180 resp. 200°C!). The maximum admissible junction temperature is normally based on a DC load of 80% of the maximum reverse repetitive voltage V_{RRM}. If the actual occuring reverse voltage is much below this value, as typical for solar modules, a higher T_j can be specified. See parameters in the Diotec datasheets.

$R_{thL/C}$

At higher currents, the junction temperature can be reduced by suitable cooling measures. Ideally suited in this case are package outlines like TO-220 und D^2PAK, having low thermal resistance junction to case.

Standard Rectifier

+ Reverse voltage up to 1200 V
+ Rugged against over voltage
+ Low cost, since standard devices
+ Nominal current up to 10 Amp
+ Low leakage current, therefore reduced losses in normal mode of operation
- Higher forward voltage drop (typ. 1.0 Volt), therefore higher losses in bypass operation

Types e. g.
BY550, P600, P1000

„Low Vf“ Rectifier

“Low Vf” rectifier by Diotec are bipolar diodes, having also at higher temperatures a low leakage current. By optimizing the Si-chip it was possible to reduce forward losses compared to standard rectifiers by more than 10%, having positive impact on forward losses.

+ Reverse voltage up to 400 V
+ Rugged against over voltage
+ Nominal current up to 20 Amp
+ Reduced forward voltage drop (typ. 0.8 to 0.9 V), therefore lower losses/lower temperature in bypass operation
+ Low leakage current, therefore reduced losses in normal mode of operation

Types e. g.
P1200, F1200, FT2000

Schottky Rectifier

+ Reverse voltage up to 100 V
+ Nominal current up to 20 Amp
+ Low forward voltage drop (typ. 0.5 bis 0.7 Volt), therefore low losses/low temperature in bypass operation
- Higher leakage current, therefore higher losses in normal mode of operation

Types e. g.
SB5.., SB8.., 80SQ05, SB12.., SBT10.., SBCT20..
SK5.., SK8.., SK10..PM [1]), SK10..D2 L118 [1]), SK20...CD2

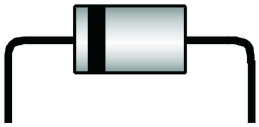
From some manufacturers offered “ultra low Vf” Schottky diodes have beside a very high hot leakage current also a lower maximum admissible junction temperature, and are therefore less suited for bypass operations.

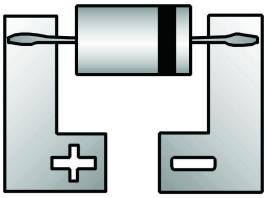
Datasheets of all mentioned products can be found at www.diotec.com – Products – Search Products.

[1]) Availability on request

Customer specific solutions

Normally bypass diodes can be found within the connection box of the solar module. On request Diotec delivers the leads bended for direct insertion into the connectors, thus saving time and effort during insertion at only small additional costs. Also possible is soldering or welding of contact sheets, connectors etc to the leads for direct connection of the module or wiring.

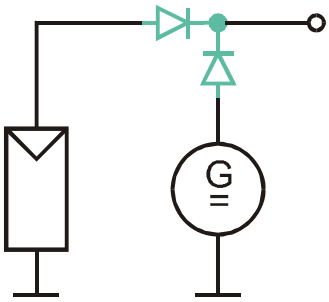




Further Products

Following parts from Diotec's product range are suitable for solar applications, of course all produced by Plasma-EPOS process:

- Rectifier cells AG3-, AG6- and AG12-Series: 3, 6, 12 A, 50 to 1000 V, within only 2.3 mm flat sandwich package
- Twin rectifiers D30VC- and D60VC-Series: center tapped configuration, 30 resp 60 A, 200 to 1200 V, for decoupling of two DC sources, see below.



Don't hesitate to contact us for further questions: Tel. +49 (0)7634-5266-0 or mail@diotec.com .

Diotec – situated in the SolarRegion Upper Rhine – near Freiburg/Germany.