SANKEN ELECTRIC CO., LTD.

Selection Guide

Diodes by Application

Description

- **Offline Non-isolated Circuit（Buck/Buck-boost)**
  - ✓ Freewheeling Diode
- **Offline Isolated Circuit (Flyback)**
  - ✓ Secondary-side Rectifier Diode
  - ✓ Auxiliary Switch Diode for Snubber (SARS Series)
- **Current Resonant Circuit**
  - ✓ Bootstrap Diode
  - ✓ Secondary-side Rectifier Diode
- **PFC Circuit**
  - ✓ Bypass Diode
  - ✓ Boost Diode

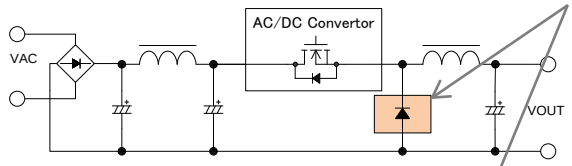
Diodes by Application

Sanken provides diodes used for peripheral power supply circuit.
For more information, refer to Sanken's website.

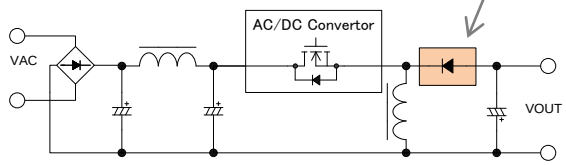
Offline Non-isolated Circuit (Buck/ Buck-boost)

- Low Power Application
- Motor Control Power Supply
- Auxiliary Power Supply
- LED Lighting, etc.

Off-line Buck Converter



Off-line Buck-boost Converter

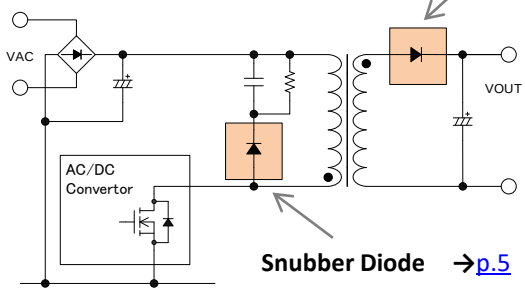


Freewheeling Diode

- Fast recovery diode →p.4

Offline Isolated Circuit (Flyback)

- Low to Middle Power Application
- Adapter
- Auxiliary Power Supply
- LED Lighting, etc.



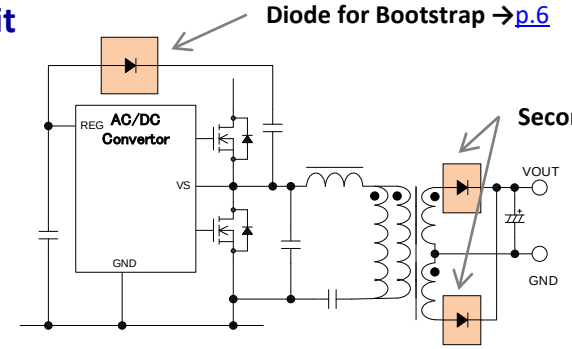
Secondary-side Rectifier Diode

- Schottky diode →p.3
- Fast Recovery diode →p.4

Snubber Diode →p.5

Current Resonant Circuit

- High Power Application
- OA, AV
- Industrial Equipment
- LED Street Light, etc.



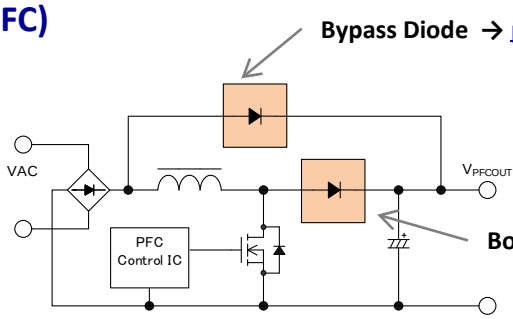
Diode for Bootstrap →p.6

Secondary-side Rectifier Diode

- Schottky diode →p.3
- Fast Recovery diode →p.4

Power Factor Correction (PFC)

- Application for ≥75 W
- Industrial Equipment
- LED Lighting, etc.



Bypass Diode → p.7

Boost Diode →p.8

Schottky Diode

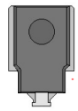
Features

- V_{RM} = 60 V to 150 V
- I_F = 1 A to 45 A
- $V_F \leq 1.1$ V

Package

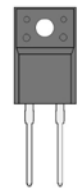
SJP

SZ-E10

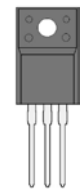


TO252-2L

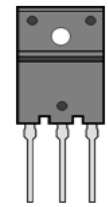
TO220F-2L



TO220F-3L



TO3PF-3L



V_{RM}	$I_{F(AV)}$	Part Number	Package	V_F (max.)	I_R	H・I_R
40 V	1 A	**SJPB-D4**	SJP	0.55 V	0.1 mA	35 mA
	2 A	**SJPB-H4**		0.55 V	0.2 mA	70 mA
	3 A	**SJPB-L4**		0.55 V	0.3 mA	100 mA
60 V	1 A	**SJPB-D6**	SJP	0.68 V	0.1 mA	30 mA
	1.5 A	**SJPW-F6**		0.70 V	1.0 mA	70 mA
	2 A	**SJPB-H6**		0.69 V	0.2 mA	55 mA
	3 A	**SJPB-L6**		0.70 V	0.3 mA	70 mA
	6 A	**FMB-G16L**	TO220F-2L	0.72 V	5.0 mA	200 mA
	15 A	**FMW-2156**	TO220F-3L	0.70 V	5.0 mA	175 mA
	30 A	**FMB-2306**		0.70 V	8.0 mA	400 mA
		FMW-4306	TO3PF-3L	0.70 V	3.0 mA	350 mA
80 V	20 A	**FMEN-2208**	TO220F-3L	0.76 V	0.2 mA	100 mA
	30 A	**FMEN-2308**		0.765 V	0.3 mA	150 mA
	45 A	**SZ-E10EF48**	SZ-E10	0.82 V	0.05 mA	50 mA
90 V	1 A	**SJPB-D9**	SJP	0.85 V	0.1 mA	30 mA
	2 A	**SJPB-H9**		0.85 V	0.2 mA	55 mA
100 V	10 A	**FMEN-210A**	TO220F-3L	0.85 V	0.1 mA	50 mA
	20 A	**FMEN-220A**		0.85 V	0.2 mA	100 mA
	30 A	**FMEN-430A**	TO3PF-3L	0.85 V	0.3 mA	150 mA
		FMEN-230A	TO220F-3L	0.85 V	0.3 mA	150 mA
150 V	3 A	**SJPE-L15***	SJP	0.95 V	0.06 mA	15 mA
	5 A	**SJPE-T15***		0.95 V	0.1 mA	25 mA
	10 A	**FMEN-210B**	TO220F-3L	0.92 V	0.1 mA	25 mA
		SPET-21015	TO252-2L	0.98 V	0.05 mA	25 mA
	15 A	**SPET-21515**		0.98 V	0.07 mA	35 mA
	20 A	**FMEN-220B**	TO220F-3L	0.95 V	0.2 mA	50 mA
	30 A	**FME-230B**		0.95 V	0.3 mA	75 mA
	45 A	**SZ-E10ET415**	SZ-E10	1.10 V	0.03 mA	35 mA

*Under development

Fast Recovery Diode

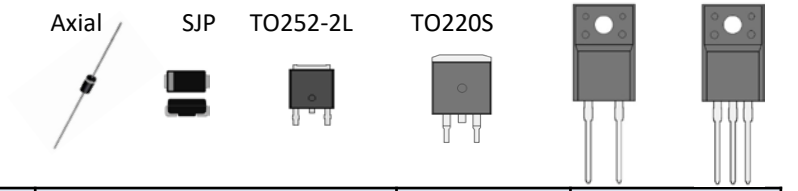
Since AC / DC converters in buck / buck-boost circuits operate at high frequencies, freewheeling diodes require fast recovery characteristics. To improve the circuit efficiency, select the diode with a low V_F.

Features

- Fast Recovery Characteristics
  $t_{rr} \leq 100$ ns
- V_{RM} = 200 V to 600 V
- I_F = 0.5 A to 10 A

Package

Axial SJP TO252-2L TO220S TO220F-2L TO220F-3L



V_{RM}	$I_{F(AVG)}$	Part Number	Package	V_F	t_{rr} (I_F : I_R=1 : 1)
200 V	1 A	**SJPL-D2**	SJP	0.98 V	50 ns
	1.5 A	**SJPX-F2**		0.98 V	30 ns
	2 A	**SJPL-H2**		0.98 V	50 ns
	3 A	**SJPL-L2**		0.98 V	50 ns
	5 A	**FML-G12S**	TO220F-2L	0.98 V	40 ns
		FMX-12S	TO220F-3L	0.98 V	30 ns
	10 A	**MPL-102S**	TO220S	0.98 V	40 ns
		SPXS-2102S	TO252	1.25 V	30 ns
		FMX-22S	TO220F-3L	0.98 V	30 ns
		FMX-12SL		1.25 V	30 ns
		FMX-G22S	TO220F-2L	0.98 V	30 ns
300 V	2 A	**SJPX-H3**	SJP	1.30 V	30 ns
	50 A	**FML-G13S**	TO220F-2L	1.30 V	50 ns
	10 A	**FMX-23S**	TO220F-3L	1.30 V	30 ns
400 V	0.7 A	**AG01**	Axial (ϕ2.4×2.9L/ϕ0.57)	1.80 V	100 ns
		EG01	Axial (ϕ2.7×5.0L/ϕ0.6)	2.00 V	100 ns
	0.8 A	**EG1**	Axial (ϕ2.7×5.0L/ϕ0.78)	1.80 V	100 ns
	1.5 A	**SJPL-F4**	SJP	1.30 V	50 ns
	3 A	**SJPL-L4**		1.30 V	50 ns
	10 A	**FML-24S**	TO220F-3L	1.30 V	50 ns
		FMXA-1104S	TO220F-2L	1.50 V	25 ns
500 V	1 A	**SJPD-D5**	SJP	1.40 V	40 ns
	3 A	**SJPD-L5**		1.40 V	50 ns
600 V	0.5 A	**AG01A**	Axial (ϕ2.4×2.9L/ϕ0.57)	1.80 V	100 ns
		EG01A	Axial (ϕ2.7×5.0L/ϕ0.6)	2.00 V	100 ns
	0.6 A	**EG1A**	Axial (ϕ2.7×5.0L/ϕ0.78)	2.00 V	100 ns
	2 A	**SJPL-H6**	SJP	1.50 V	50 ns
		SJPX-H6		1.50 V	30 ns
	10 A	**FMX-1106S**	TO220F-2L	1.60V	30 ns
		FMNS-1106S		1.30 V	100 ns
		FMXA-1106S		1.98 V	28 ns

Diode for Snubber Circuit (SARS Series)

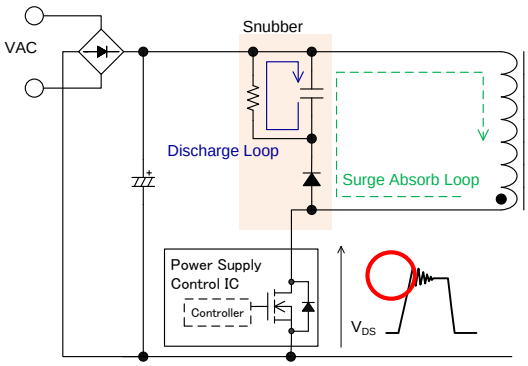
SARS series are snubber diodes that improve circuit efficiency by reducing noise.

Part Number	V_{RM}	$I_{F\ (AVG)}$	I_{FSM} 50 Hz Half Wave	V_F		t_{rr} $I_F : I_R=1 : 1$	Package
				V_F (max.)	I_F		
SARS01	800 V	1.2 A	110 A	0.92 V	1.2 A	2 µs to 18 µs	Axial (ϕ2.7×5.0L/ϕ0.6)
SARS05	800 V	1.0 A	30 A	1.05 V	1.0 A	2 µs to 19 µs	SJP 

The following shows a comparison of the flyback circuit operation when a fast recovery diode is used for the snubber circuit and when the SARS series are used.

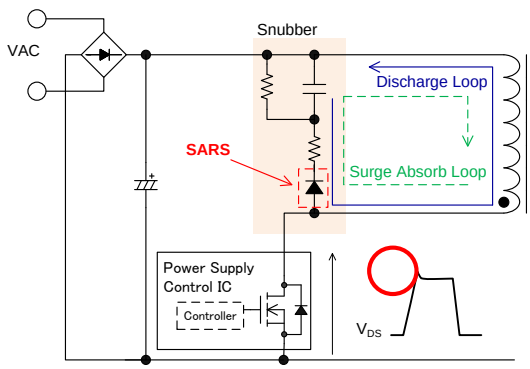
Using FRD

When a power MOSFET turns off, surge current flows on “Surge Absorb Loop”, and is absorbed by the capacitor.
The electrical charge of capacitor is discharged through ”Discharge Loop”. This energy is not transferred to the secondary side, and becomes power dissipation.
When the capacitor is discharged, the recovery current of the diode flows to the power MOSFET. For reducing damage of the power MOSFET, use a fast recovery diode whose t_{rr} is short.
Note that using a fast recovery diode may cause noises, and may increase components of input filter.



Using SARS Series

When SARS is used, the electrical charge of the capacitor is discharged through ”Discharge Loop” in recovery period of the SARS, and is transferred to the secondary side. This results in improvement of circuit efficiency.
When the capacitor is discharged, the instantaneous recovery current of the diode flows to the power MOSFET. To reduce the damage of power MOSFET by the instantaneous current, add a resistor in series with SARS.
The SARS series have long t_{rr} characteristics and reduce ringing, which enables simplifying the filter as well as preventing MOSFET damage (patented circuit).



Bootstrap Diode

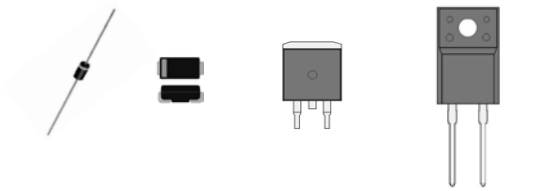
Bootstrap Diode is used for a high-side driver circuit.
Since the recovery current flows to the diode depending on the switching frequency of the driver IC, select a diode that has fast recovery characteristic. When the bootstrap diode is selected, the applied voltage to a power MOSFET and the high-side sink current should be taken into account.

Features

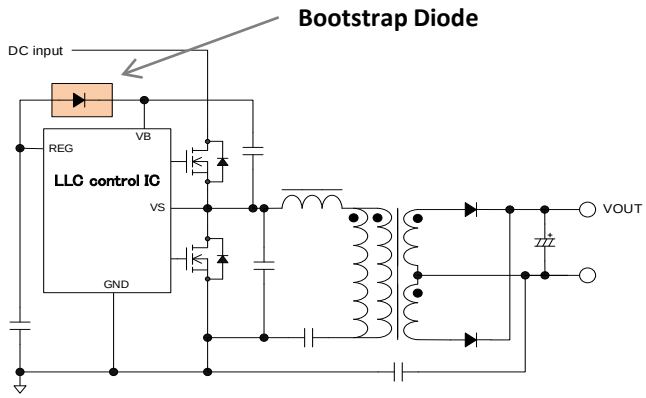
- Fast Recovery Characteristics
  t_{rr} ≤ 100 ns
- V_{RM} = 600 V to 1000 V
- I_F = 0.5 A to 10 A

Package

Axial SJP TO220S TO220F-2L



V_{RM}	$I_{F(AVG)}$	Part Number	Package	V_F	t_{rr} (I_F : I_R=1 : 1)
600 V	0.5 A	**AG01A**	Axial (ϕ2.4×2.9L/ϕ0.57)	1.8 V	100 ns
		EG01A	Axial (ϕ2.7×5.0L/ϕ0.6)	2.0 V	100 ns
	0.6 A	**EG1A**	Axial (ϕ2.7×5.0L/ϕ0.78)	2.0 V	100 ns
	2.0 A	**SJPL-H6**	SJP	1.5 V	50 ns
		SJPX-H6	SJP	1.5 V	30 ns
	10 A	**FMX-1106S**	TO220F-2L	1.6 V	30 ns
		FMNS-1106S	TO220F-2L	1.3 V	100 ns
		FMXA-1106S	TO220F-2L	1.98 V	28 ns
1000 V	0.5 A	**EG01C**	Axial (ϕ2.7×5.0L/ϕ0.6)	3.3 V	100 ns



Bypass Diode

For the bypass diode of the PFC circuit, select a diode with a large current capability in a short period and a lower forward voltage than boost diode.

Features

- $V_F \leq 1.05$ V
- V_{RM} = 600 V to 1000 V
- I_{FSM} = 35 A to 80 A

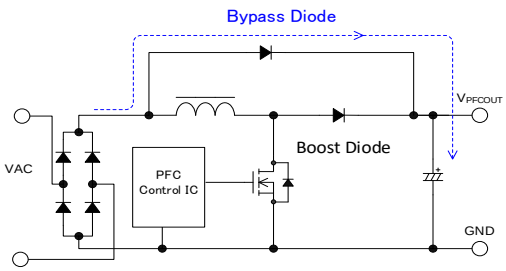
Package

Axial

V_{RM}	$I_{F(AVG)}$	Part Number	Package	V_F (max.)	I_{FSM} 50 Hz Half Wave
600 V	1.0 A	**AM01A**	Axial (ϕ2.4×2.9L/ϕ0.57)	0.98 V	35 A
	1.0 A	**EM01A**	Axial (ϕ2.7×5.0L/ϕ0.6)	0.97 V	45 A
	1.0 A	**EM1A**	Axial (ϕ2.7×5.0L/ϕ0.78)	0.97 V	45 A
	1.2 A	**EM2A**	Axial (ϕ2.7×5.0L/ϕ0.78)	0.92 V	80 A
800 V	1.0 A	**EM1B**	Axial (ϕ2.7×5.0L/ϕ0.78)	1.05 V	35 A
	1.2 A	**EM2B**	Axial (ϕ2.7×5.0L/ϕ0.78)	0.92 V	80 A
1000 V	1 A	**EM01C**	Axial (ϕ2.7×5.0L/ϕ0.6)	1.05 V	35 A
	1.0 A	**EM1C**	Axial (ϕ2.7×5.0L/ϕ0.78)	1.05 V	35 A

◆ Bypass Diode Operation

Bypass diodes have two main operations.



- **For Protecting Power MOSFET and Rectification Diode from Inrush Current**

  When the inductance is saturated by an inrush current, a large current flows to the rectification diode and may cause to break the diode. In addition, when the power MOSFET turns on during saturation state of the inductance, the power MOSFET may be broken. Thus, flow the inrush current to the bypass diode.
  This prevents the inductance saturation, and protects the power MOSFET and the rectification diode.

- **For Protecting Bridge Diode from Lightning Surge**

  If the lightning surge is applied to the circuit, bridge diode may be broken. To prevent this, the lightning surge is charged to the electrolytic capacitor through the bypass diode.

◆ Electrical Characteristics of Bypass Diode

In order to flow the inrush current or lightning surge current through the bypass diode, the forward voltage of the bypass diode must be lower than that of the boost diode.
While the PFC output voltage is higher than the input voltage, the bypass diode turns off (i.e., There is no need to consider t_{rr}).

Boost Diode

A fast recovery diode is used for the boost diode in the PFC circuit. Loss can be reduced by selecting a suitable fast recovery diode according to the PFC operation mode.

◆PFC Operation Mode

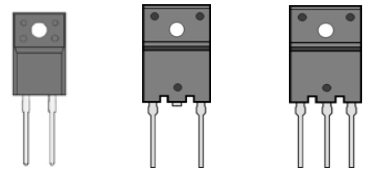
	Discontinuous Conduction Mode (DCM)	Critical Conduction Mode (CRM)	Continuous Conduction Mode (CCM)
Advantages	■ Switching noise is small ■ No recovery loss for boost diode		■ Peak current of power MOSFET is small ■ Ripple of input current is small ■ Normal mode noise is small
Disadvantages	■ Peak current of power MOSFET is large ■ Ripple of input current is large ■ Normal mode noise is large		■ Switching noise is large ■ Large recovery loss for boost diode

◆Fast Recovery Diode for DCM, CRM

In these modes, when the power MOSFET turns on, no recovery current flows because the current flowing through the boost diode is zero. Therefore, select the diode with a low forward voltage, prioritizing forward voltage over t_{rr} characteristics.

Package

TO220F-2L TO3PF-2L TO3PF-3L



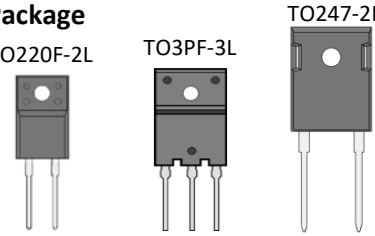
V_{RM}	$I_{F(AVG)}$	Part Number	Package	V_F	t_{rr} (I_F : I_R=1 : 1)
600 V	10 A	**FMNS-1106S**	TO220F-2L	1.3 V	100 ns
	30 A	**FMN-4306S**	TO3PF-3L	1.3 V	100 ns
	60 A	**FMNS-4606S**	TO3PF-3L	1.3 V	150 ns

◆Fast Recovery Diode for CCM

In this mode, when the power MOSFET turns on, a recovery current flows through the boost diode. Therefore, select the diode with fast t_{rr} characteristics.

Package

TO220F-2L TO3PF-3L TO247-2L



V_{RM}	$I_{F(AVG)}$	Part Number	Package	V_F	t_{rr} (I_F : I_R=1 : 1)
600 V	10 A	**FMX-1106S**	TO220F-2L	1.6 V	30 ns
		FMNS-1106S		1.3 V	100 ns
		FMXA-1106S		1.98 V	28 ns
	15 A	**FMN-1156S**	TO220F-2L	1.3 V	100 ns
	20 A	**FMD-4206S**	TO3PF-3L	1.7 V	50 ns
		FMLD-4206S		1.7 V	50 ns
		FMXR-1206S	TO220F-2L	2.5 V	60 ns
	30 A	**CTXS-5306S**	TO247-2L	1.7 V	35 ns
		FMN-4306S	TO3PF-3L	1.3 V	100 ns
	60 A	**CTXS-5606S**	TO247-2L	1.7 V	50 ns

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