

FRED Pt[®] DIODES

PFC Capabilities

FRED Pt[®] Diodes for Power Factor Correction (PFC): DCM, CRM, CCM

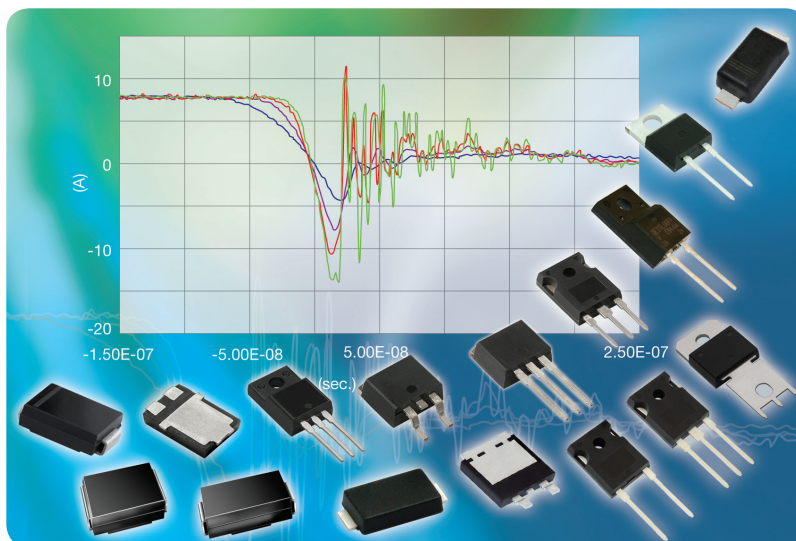


TABLE OF CONTENTS

Introduction	2
DCM, CRM, or CCM?	3
Vishay FRED Pt Product Portfolio	4



FRED Pt[®] DIODES

PFC Capabilities

Introduction

Power factor correction (PFC) can be defined as the reduction of the harmonic content induced in the AC distribution net. An appropriate circuit is often required to reduce this kind of disturbance. PFC can also be thought of as aligning the phase angle of the incoming current with respect to the voltage waveform, thus maximizing the real power drawn from the AC line.

Regulatory Drivers

With widening applicability of the harmonic reduction standard, more power supply designs are incorporating PFC capabilities. Different PFC regulations and standards have recently arisen, resulting in the following regulations:

- Europe – EN 61000-3-2
- UK – BSEN 61000-3-2
- Japan – JIC-C-61000-3-2
- China – CCC (China Compulsory Certificate)

Other standards apply in different ways to PFC circuits, especially in regards to efficiency, such as EPA Energy Star and 80 PLUS[®].

Topology Choices

The active PFC option is a well-established solution as it allows designers to meet regulatory requirements with minimal effort. Moreover, it provides other benefits such as simplifying the main power conversion stage and eliminating the number of bulky components.

A boost converter provides a natural means for achieving a high power factor because of the inductor being present on the input side. This inductor allows the shaping of the input current to be in phase with the line voltage.

Key Benefits

- Highest system efficiency compared to other hyperfast diodes
- Lowest switching losses for CCM PFC products with reduced ringing up to the highest di/dt to limit EMI
- Lowest V_F conduction losses for DCM PFC dedicated products

Applications

- Server power supplies
- High-end desktop power supplies
- Telecom power supplies
- Solar inverters
- Notebook adaptors



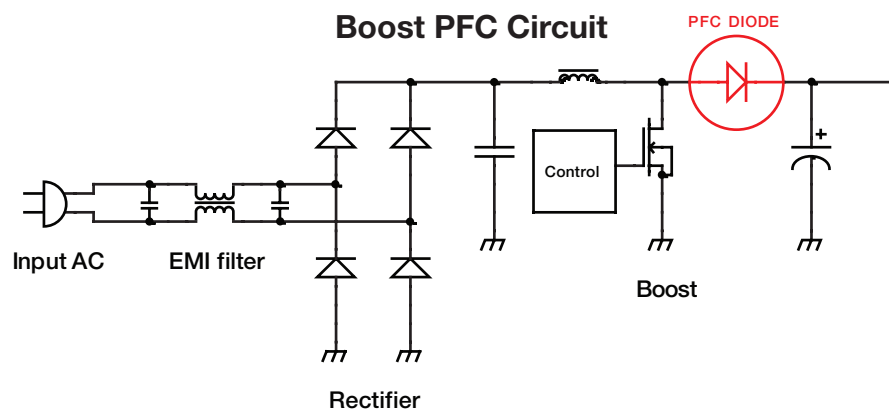
FRED Pt® DIODES

PFC Capabilities

DCM, CRM, or CCM?

A boost converter can operate in two modes: continuous conduction mode (CCM) or discontinuous conduction mode (DCM). The mode is defined by the current flowing into the boost inductor:

- DCM – Suitable for low- to medium-power applications due to reduced switching losses (forward voltage is a critical parameter)
- CRM – Border mode operation combines high efficiency maximizing the usage of inductive elements
- CCM – Better suited for medium- to high-power applications. Peak currents are lower, which reduces switching losses and requires less filtering (reverse recovery charge is a critical parameter)





FRED Pt® DIODES

PFC Capabilities

FRED Pt® (Fast Recovery Epitaxial Diodes)

$I_{F(AV)}$ (A)	Part Number	Package		V_{RRM} Range (V)	V_F at I_F		I_R @ V_{RRM} (μ A)	T_{rr} (μ s)	I_{FSM} (A)	T_J max (°C)
		Family	Type		(V)	(A)				
1	VS-1EFU06-M3/I	Plastic SMD	SMF (DO-219AB)	600	0.83	1	3	55	30	175
2	VS-2EFU06-M3/I	Plastic SMD	SMF (DO-219AB)	600	0.95	2	3	55	30	175
3	VS-3EGH06-M3	Plastic SMD	SMB (DO-214AA)	600	1.2	3	3	35	55	175
3	VS-3EGU06-M3	Plastic SMD	SMB (DO-214AA)	600	0.99	3	3	41	55	175
3	VS-3EMH06-M3	Plastic SMD	SMA (DO-214AC)	600	1.2	3	3	35	50	175
3	VS-3EMU06-M3	Plastic SMD	SMA (DO-214AC)	600	0.99	3	3	41	55	175
3	VS-3EJU06-M3	Plastic SMD	SlimSMA (DO-221AC)	600	1.15	3	3	45	43	175
4	VS-4ECH06-M3	Plastic SMD	SMC (DO-214AB)	600	1.15	4	3	30	90	175
4	VS-4ECU06-M3	Plastic SMD	SMC (DO-214AB)	600	0.88	4	3	45	120	175
4	VS-4EGH06-M3	Plastic SMD	SMB (DO-214AA)	600	1.2	4	3	30	55	175
4	VS-4EGU06-M3	Plastic SMD	SMB (DO-214AA)	600	0.94	4	3	45	100	175
5	VS-5ECH06-M3	Plastic SMD	SMC (DO-214AB)	600	1.2	5	3	30	110	175
5	VS-5ECU06-M3	Plastic SMD	SMC (DO-214AB)	600	0.92	5	3	45	130	175
5	VS-5EWH06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	1.2	5	5	18	70	175
5	VS-5EWL06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	0.85	5	5	59	80	175
5	VS-5EWX06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	1.55	5	20	14	50	175
6	VS-6ESH06-M3	Power-pack SMD	SMPC (TO-277A)	600	1.05	6	5	33	90	175
6	VS-6ESU06-M3	Power-pack SMD	SMPC (TO-277A)	600	0.95	6	5	42	120	175
6	VS-6EWH06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	1.26	6	5	18	70	175
6	VS-6EWL06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	0.87	6	5	59	80	175
6	VS-6EWX06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	1.65	6	20	14	50	175
8	VS-8ETH06-1PbF	Plastic Power-pack	TO-262AA	600	1.3	8	50	18	90	175
8	VS-8ETH06-N3	Isolated Power-pack	TO-220FP	600	1.3	8	50	18	90	175
8	VS-8ETH06FP-N3	Isolated Power-pack	TO-220FP	600	1.3	8	50	18	90	175
8	VS-8ETL06-1PbF	Plastic Power-pack	TO-262AA	600	0.81	8	5	60	175	175
8	VS-8ETL06-N3	Isolated Power-pack	TO-220FP	600	0.81	8	5	60	175	175
8	VS-8ETL06FP-N3	Isolated Power-pack	TO-220FP	600	0.81	8	5	60	175	175
8	VS-8ETL06SPbF	Power-pack SMD	D-PAK (TO-252AA)	600	0.81	8	5	60	175	175
8	VS-8ETX06-1PbF	Plastic Power-pack	TO-262AA	600	1.4	8	50	15	110	175

(1) Bold Text = New Products

(2) Dual center-tapped device (V_F limit @ I_F is per diode)

CAPABILITIES

© 2017 VISHAY INTERTECHNOLOGY, INC. ALL RIGHTS RESERVED.

4/9

THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc/91000

VMN-PL0404-1703
www.vishay.com



FRED Pt® DIODES

PFC Capabilities

FRED Pt® (Fast Recovery Epitaxial Diodes), continued

$I_{F(AV)}$ (A)	Part Number	Package		V_{RRM} Range (V)	V_F at I_F		I_R @ V_{RRM} (μ A)	T_{rr} (μ s)	I_{FSM} (A)	T_J max (°C)
		Family	Type		(V)	(A)				
8	VS-8ETX06-N3	Isolated Power-pack	T0-220FP	600	1.4	8	50	15	110	175
8	VS-8ETX06FP-N3	Isolated Power-pack	T0-220FP	600	1.4	8	50	15	110	175
8	VS-8ETX06SPbF	Power-pack SMD	D ² PAK (T0-263AB)	600	1.4	8	50	15	110	175
8	VS-8EWH06FN-M3	Power-pack SMD	D-PAK (T0-252AA)	600	1.3	8	50	18	90	175
8	VS-8EWL06FN-M3	Power-pack SMD	D-PAK (T0-252AA)	600	0.81	8	5	60	140	175
8	VS-8EWX06FN-M3	Power-pack SMD	D-PAK (T0-252AA)	600	1.4	8	50	15	90	175
8	VS-ETH0806-M3	Plastic Power-pack	2L T0-220AC	600	1.3	8	12	16	80	175
8	VS-ETH0806FP-M3	Isolated Power-pack	2L T0-220FP	600	1.3	8	12	16	80	175
8	VS-ETL0806-M3	Plastic Power-pack	2L T0-220AC	600	0.84	8	9	65	120	175
8	VS-ETL0806FP-M3	Isolated Power-pack	2L T0-220FP	600	0.84	8	9	65	120	175
8	VS-ETU0805-M3	Plastic Power-pack	2L T0-220AC	500	0.9	8	15	28	110	175
8	VS-ETU0805FP-M3	Isolated Power-pack	2L T0-220FP	500	0.9	8	9	28	110	175
8	VS-ETX0806-M3	Plastic Power-pack	2L T0-220AC	600	1.5	8	30	14	80	175
8	VS-ETX0806FP-M3	Isolated Power-pack	2L T0-220FP	600	1.5	8	30	14	80	175
10	VS-10CDH06-M3/I	Power-pack SMD ⁽²⁾	SMPD (T0-263AC)	600	1	5	3	35	110	175
12	VS-12CDU06-M3/I	Power-pack SMD ⁽²⁾	SMPD (T0-263AC)	600	0.89	6	5	45	200	175
12	VS-12EWH06FN-M3	Power-pack SMD	D-PAK (T0-252AA)	600	1.34	12	10	18	110	175
15	VS-15AWL06FN-M3	Power-pack SMD	D-PAK (T0-252AA)	600	0.85	15	10	60	180	175
15	VS-15ETH06-1PbF	Plastic Power-pack	T0-262AA	600	1.3	15	40	22	120	175
15	VS-15ETH06-N3	Isolated Power-pack	T0-220FP	600	1.3	15	50	22	120	175
15	VS-15ETH06FP-N3	Isolated Power-pack	T0-220FP	600	1.3	15	50	22	120	175
15	VS-15ETH06SPbF	Power-pack SMD	D ² PAK (T0-263AB)	600	1.3	15	50	22	120	175
15	VS-15ETL06-1PbF	Plastic Power-pack	T0-262AA	600	0.85	15	10	60	250	175
15	VS-15ETL06-N3	Isolated Power-pack	T0-220FP	600	0.85	15	10	60	250	175
15	VS-15ETL06FP-N3	Isolated Power-pack	T0-220FP	600	0.85	15	10	60	250	175
15	VS-15ETL06SPbF	Power-pack SMD	D ² PAK (T0-263AB)	600	0.85	15	10	60	250	175
15	VS-15ETX06-1PbF	Plastic Power-pack	T0-262AA	600	1.5	15	50	18	170	175
15	VS-15ETX06-N3	Isolated Power-pack	T0-220FP	600	1.5	15	50	18	170	175
15	VS-15ETX06FP-N3	Isolated Power-pack	T0-220FP	600	1.5	15	50	18	170	175

(1) Bold Text = New Products

(2) Dual center-tapped device (V_F limit @ I_F is per diode)

CAPABILITIES

© 2017 VISHAY INTERTECHNOLOGY, INC. ALL RIGHTS RESERVED.

5/9

THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc/91000VMN-PL0404-1703
www.vishay.com



FRED Pt® DIODES

PFC Capabilities

FRED Pt® (Fast Recovery Epitaxial Diodes), continued

$I_{F(AV)}$ (A)	Part Number	Package		V_{RRM} Range (V)	V_F at I_F		I_R @ V_{RRM} (μ A)	T_{rr} (μ s)	I_{FSM} (A)	T_J max (°C)
		Family	Type		(V)	(A)				
15	VS-15ETX06SPbF	Power-pack SMD	D ² PAK (TO-263AB)	600	1.5	15	50	18	170	175
15	VS-15EWH06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	1.2	15	50	22	120	175
15	VS-15EWL06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	0.85	15	10	60	180	175
15	VS-15EWX06FN-M3	Power-pack SMD	D-PAK (TO-252AA)	600	1.5	15	50	18	120	175
15	VS-C4ZU3006FP-E3	Plastic Power-pack ⁽²⁾	TO-3PF	600	1.08	15	15	37	180	175
15	VS-ETH1506-1-M3	Plastic Power-pack	TO-262AA	600	1.25	15	15	21	160	175
15	VS-ETH1506-M3	Plastic Power-pack	2L TO-220AC	600	1.25	15	15	21	160	175
15	VS-ETH1506FP-M3	Isolated Power-pack	2L TO-220FP	600	1.25	15	15	21	160	175
15	VS-ETH1506S-M3	Power-pack SMD	D ² PAK (TO-263AB)	600	1.25	15	15	21	160	175
15	VS-ETL1506-1-M3	Plastic Power-pack	TO-262AA	600	0.85	15	15	60	200	175
15	VS-ETL1506-1HM3	Plastic Power-pack	TO-262AA	600	0.85	15	15	60	200	175
15	VS-ETL1506-M3	Plastic Power-pack	2L TO-220AC	600	0.85	15	15	60	200	175
15	VS-ETL1506FP-M3	Isolated Power-pack	2L TO-220FP	600	0.85	15	15	60	200	175
15	VS-ETL1506S-M3	Power-pack SMD	D ² PAK (TO-263AB)	600	0.85	15	15	60	200	175
15	VS-ETL1506SHM3	Power-pack SMD	D ² PAK (TO-263AB)	600	0.85	15	15	60	200	175
15	VS-ETU1506-1-M3	Plastic Power-pack	TO-262AA	600	1.1	15	9	24	160	175
15	VS-ETU1506-M3	Plastic Power-pack	2L TO-220AC	600	1.1	15	15	24	160	175
15	VS-ETU1506FP-M3	Isolated Power-pack	2L TO-220FP	600	1.1	15	15	24	160	175
15	VS-ETU1506S-M3	Power-pack SMD	D ² PAK (TO-263AB)	600	1.1	15	15	24	160	175
15	VS-ETX1506-1-M3	Plastic Power-pack	TO-262AA	600	1.55	15	36	18	120	175
15	VS-ETX1506-M3	Plastic Power-pack	2L TO-220AC	600	1.55	15	36	18	120	175
15	VS-ETX1506FP-M3	Isolated Power-pack	2L TO-220FP	600	1.55	15	36	18	120	175
15	VS-ETX1506S-M3	Power-pack SMD	D ² PAK (TO-263AB)	600	1.55	15	36	18	120	175
16	VS-16CDU06-M3/I	Power-pack SMD ⁽²⁾	SMPD (TO-263AC)	600	0.94	8	5	45	200	175
16	VS-16EDU06-M3/I	Power-pack SMD ⁽²⁾	SMPD (TO-263AC)	600	0.91	16	15	55	160	175
20	VS-E4TU2006TFP-N3	Isolated Power-pack	TO-220FP	600	1.26	20	15	61	190	175
30	VS-30CDU06-M3/I	Power-pack SMD ⁽²⁾	SMPD (TO-263AC)	600	0.9	15	15	55	300	175
30	VS-30EPH06-N3	Plastic Power-pack	TO-247AC	600	1.34	30	50	28	300	175
30	VS-30EPU12L-N3	Plastic Power-pack	TO-247AD	1200	2.05	30	145	49	300	175
30	VS-30ETH06-1PbF	Plastic Power-pack	TO-262AA	600	1.34	30	50	28	200	175

(1) Bold Text = New Products

(2) Dual center-tapped device (V_F limit @ I_F is per diode)

CAPABILITIES

© 2017 VISHAY INTERTECHNOLOGY, INC. ALL RIGHTS RESERVED.

6/9

THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000VMN-PL0404-1703
www.vishay.com



FRED Pt® DIODES

PFC Capabilities

FRED Pt® (Fast Recovery Epitaxial Diodes), continued

$I_{F(AV)}$ (A)	Part Number	Package		V_{RRM} Range (V)	V_F at I_F		I_R @ V_{RRM} (μ A)	T_{rr} (μ s)	I_{FSM} (A)	T_J max (°C)
		Family	Type		(V)	(A)				
30	VS-30ETH06-N3	Plastic Power-pack	T0-220AC	600	1.34	30	50	23	200	175
30	VS-30ETH06FP-N3	Isolated Power-pack	T0-220FP	600	1.34	30	50	23	220	175
30	VS-30ETH06SPbF	Power-pack SMD	D ² PAK (T0-263AB)	600	1.34	30	50	28	200	175
30	VS-APH3006-N3	Plastic Power-pack	T0-247AC	600	1.4	30	30	27	220	175
30	VS-APH3006L-M3	Plastic Power-pack	T0-247AC	600	1.4	30	30	27	220	175
30	VS-APU3006-N3	Plastic Power-pack	T0-247AC	600	1.15	30	30	30	220	175
30	VS-APU3006L-M3	Plastic Power-pack	T0-247AD	600	1.15	30	30	30	220	175
30	VS-C4ZU6006FP-E3	Plastic Power-pack ⁽²⁾	T0-3PF	600	1.2	30	50	37	255	175
30	VS-CPH3006L-M3	Plastic Power-pack ⁽²⁾	T0-247AD	600	1.25	15	15	21	230	175
30	VS-EPH3006-N3	Plastic Power-pack	T0-247AC	600	1.4	30	30	27	220	175
30	VS-EPH3006L-M3	Plastic Power-pack	T0-247AD	600	1.4	30	30	27	220	175
30	VS-EPU3006-N3	Plastic Power-pack	T0-247AC	600	1.15	30	30	30	220	175
30	VS-EPU3006L-M3	Plastic Power-pack	T0-247AD	600	1.15	30	30	30	220	175
30	VS-ETH3006-1-M3	Plastic Power-pack	T0-262AA	600	1.4	30	30	27	180	175
30	VS-ETH3006-M3	Plastic Power-pack	2L T0-220AC	600	1.4	30	30	27	180	175
30	VS-ETH3006FP-M3	Isolated Power-pack	2L T0-220FP	600	1.4	30	30	27	180	175
30	VS-ETH3006S-M3	Power-pack SMD	D ² PAK (T0-263AB)	600	1.4	30	30	27	180	175
30	VS-ETU3006-1-M3	Plastic Power-pack	T0-262AA	600	1.15	30	30	30	200	175
30	VS-ETU3006-M3	Plastic Power-pack	2L T0-220AC	600	1.15	30	30	30	200	175
30	VS-ETU3006FP-M3	Isolated Power-pack	2L T0-220FP	600	1.15	30	30	30	200	175
30	VS-ETU3006S-M3	Power-pack SMD	D ² PAK (T0-263AB)	600	1.15	30	30	30	200	175
30	VS-APH3006L-N3	Plastic Power-pack	T0-247AD	600	1.4	30	30	26	240	175
30	VS-C4PU3006L-N3	Plastic Power-pack ⁽²⁾	T0-247AD	600	1.35	15	15	60	200	175
30	VS-C4PH3006L-N3	Plastic Power-pack ⁽²⁾	T0-247AD	600	1.35	15	15	50	200	175
30	VS-E4PH3006L-N3	Plastic Power-pack	T0-247AD	600	1.4	30	50	55	240	175
30	VS-E4PU3006L-N3	Plastic Power-pack	T0-247AD	600	1.2	30	50	65	240	175
30	VS-APU3006L-N3	Plastic Power-pack	T0-247AD	600	1.15	30	30	30	250	175
30	VS-EPU3006L-N3	Plastic Power-pack	T0-247AD	600	1.15	30	30	30	220	175
30	VS-ETH3007T-N3	Plastic Power-pack	2L T0-220AC	650	1.4	30	30	37	210	175
30	VS-ETX3007T-N3	Plastic Power-pack	2L T0-220AC	650	1.6	30	30	35	210	175

(1) Bold Text = New Products

(2) Dual center-tapped device (V_F limit @ I_F is per diode)

CAPABILITIES

© 2017 VISHAY INTERTECHNOLOGY, INC. ALL RIGHTS RESERVED.

7/9

THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000VMN-PL0404-1703
www.vishay.com



FRED Pt® DIODES

PFC Capabilities

FRED Pt® (Fast Recovery Epitaxial Diodes), continued

$I_{F(AV)}$ (A)	Part Number	Package		V_{RRM} Range (V)	V_F at I_F		I_R @ V_{RRM} (μ A)	T_{rr} (μ s)	I_{FSM} (A)	T_J max (°C)
		Family	Type		(V)	(A)				
60	VS-60APU06-N3	Plastic Power-pack	TO-247AC	600	1.11	60	50	34	600	175
60	VS-60CPU06-N3	Plastic Power-pack ⁽²⁾	TO-247AB	600	1.1	30	50	27	300	175
60	VS-60EPU06-N3	Plastic Power-pack	TO-247AC	600	1.11	60	50	34	600	175
60	VS-APU6006-N3	Plastic Power-pack	TO-247AC	600	1.05	60	30	32	600	175
60	VS-APU6006L-M3	Plastic Power-pack	TO-247AD	600	1.05	60	30	32	600	175
60	VS-EPU6006-N3	Plastic Power-pack	TO-247AC	600	1.05	60	30	32	600	175
60	VS-EPU6006L-M3	Plastic Power-pack	TO-247AD	600	1.05	60	30	32	600	175
60	VS-C4PH6006L-N3	Plastic Power-pack ⁽²⁾	TO-247AD	600	1.44	30	50	55	480	175
60	VS-C4PU6006L-N3	Plastic Power-pack ⁽²⁾	TO-247AD	600	1.23	30	50	65	480	175
60	VS-CPU6006L-N3	Plastic Power-pack ⁽²⁾	TO-247AD	600	1.1	30	30	26	500	175
60	VS-E4PH6006L-N3	Plastic Power-pack	TO-247AD	600	1.4	60	50	68	425	175
60	VS-E4PU6006L-N3	Plastic Power-pack	TO-247AD	600	1.33	60	50	74	450	175
60	VS-EPU6006L-N3	Plastic Power-pack	TO-247AD	600	1.1	60	30	32	600	175
150	VS-EBU15006-F4	Plastic Power-pack	PowerTab®	600	1.63	150	8	50	1200	175

(1) Bold Text = New Products

(2) Dual center-tapped device (V_F limit @ I_F is per diode)

**FRED Pt[®] DIODES**

PFC Capabilities

High Power Density
isoCink+[™] Bridge
Fast Response Time
Small-Signal Schottky
Low Capacitance
AEC-Q101
Automotive
FlipKY[®]
Small-Signal Switching
Zener
Ultrafast Recovery
Medium Power
Industrial
HEXFRED[®]
Green
Fast Recovery
Power Package
Low Forward Voltage Drop
Low Profile
High ESD Immunity
TRANSZORB[®] TVS
Load Dump
ESD Protection
EMI Filter
High Power
Surface-Mount
Standard Recovery
Halogen-Free
PAR[®] TVS
Space-Saving
FRED Pt[®] Bridge
eSMP[®] Series
Packages
TMBS[®]
Rectifiers
ESD Capability Rectifiers
Avalanche Schottky
High-Performance Planar
SUPERECTIFIER[®]