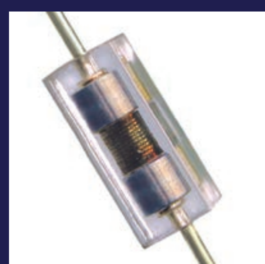
VOLTAGE MULTIPLIERS INC.

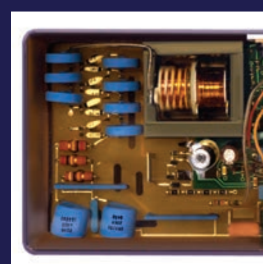
High Voltage Innovation

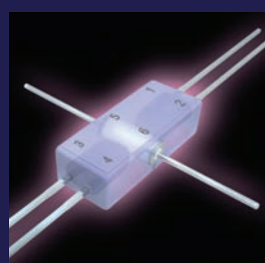
Designed for High Voltage Applications

Diodes
Optocouplers
Multipliers
Power Supplies
Bridges
Rectifiers

and more...







www.VoltageMultipliers.com

VOLTAGE MULTIPLIERS INC.

High Voltage Innovation

Facilities

44,000 sq. ft. in Visalia CA USA
34,000 sq. ft. manufacturing
10,000 sq. ft. office

Wafer Fab

All wafers are doped, diffused, and metallized in our Visalia CA facility.

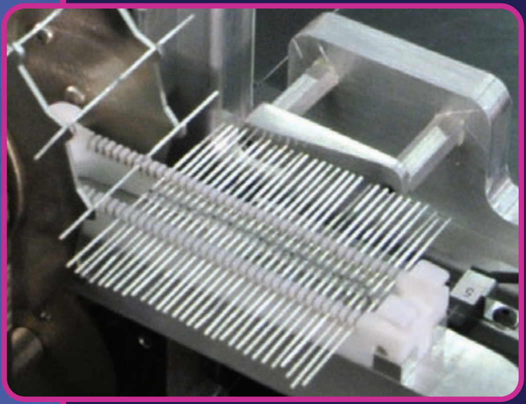
Products

- High Voltage Diodes
- Surface Mount Diodes
- Surface Mount Multipliers
- Rectifiers
- Single Phase Bridges
- Three Phase Bridges
- Optocouplers
- Power Supplies

People

270 Employees
20 Engineers / Technical

VMI is partnered with CalRamic LLC, manufacturer of high voltage ceramic capacitors.



Voltage Multipliers Inc. (VMI) manufactures high voltage diodes, optocouplers, multipliers, rectifiers, and power supplies. Diodes range from 2kV to 20kV. Standard SMD type multipliers achieve outputs of up to 14kV. Our rectifiers and single phase bridges will block up to 45kV per leg, while power supply outputs can reach 123kV or 50W.

VMI assists you in product development from the design stage through to production manufacturing.

We offer extensive testing, design verification, production support, and custom design services.

Our products are made in Visalia CA USA.

VMI is ISO9001:2015 certified.

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Quick Selection Guide

Quick Selection Guide

From Diodes to Power Supplies

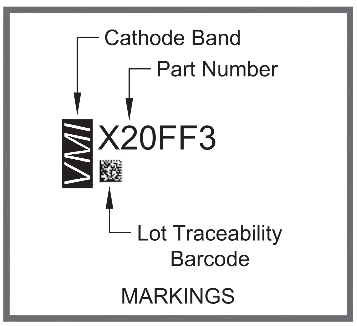
Sections Guide

High Voltage Diodes - Surface Mount

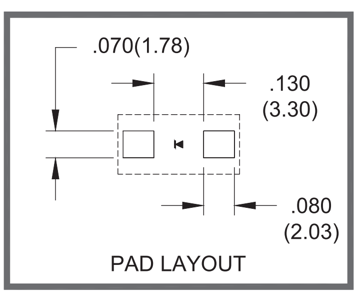
0.42A • 30ns

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS													
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	°C/W	pF	
SXF20FF3	2000	0.42	0.21	1.0	20	7.5	0.42	16	3	30	20	4.0	X20FF3

(1)TC=55°C (2)TC=100°C (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp. -65°C to +175°C Stg.Temp. -65°C to +200°C

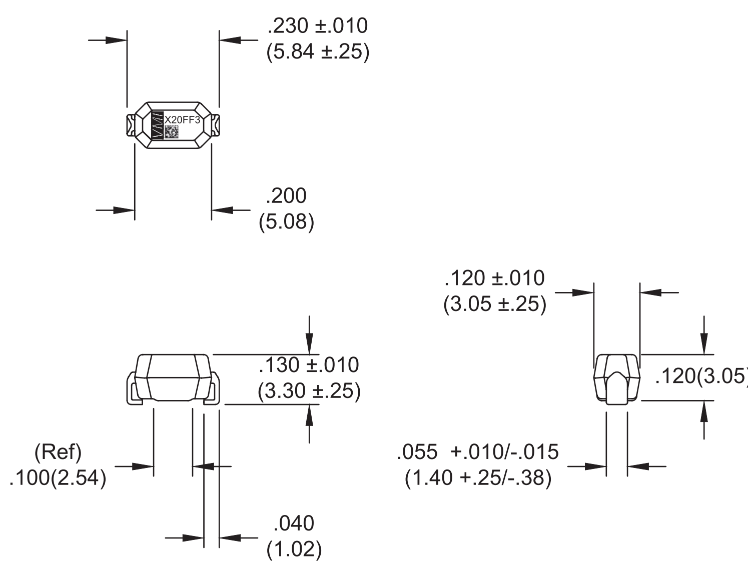


MARKINGS



PAD LAYOUT

Tolerance:
.XXX ±.005(.13)



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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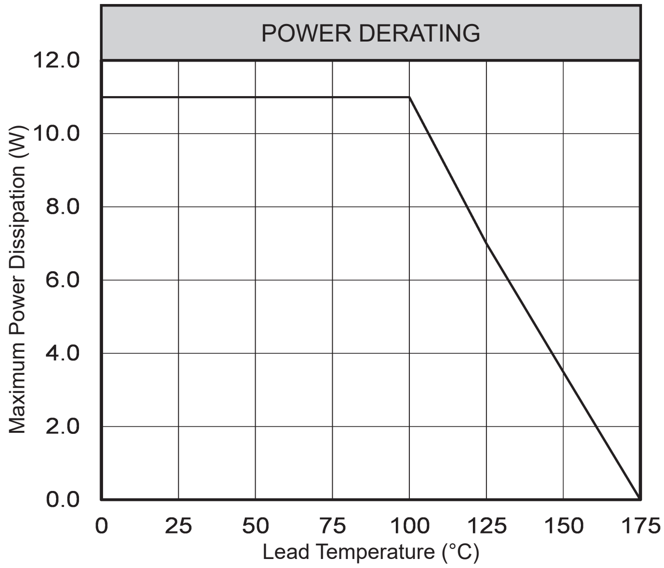
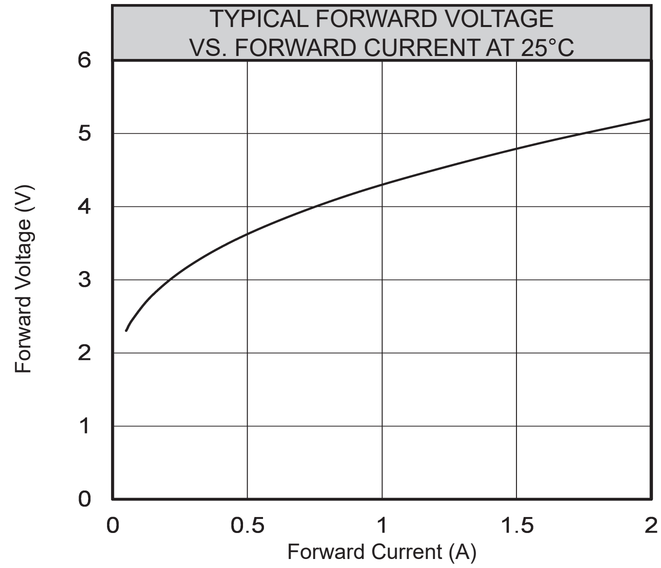
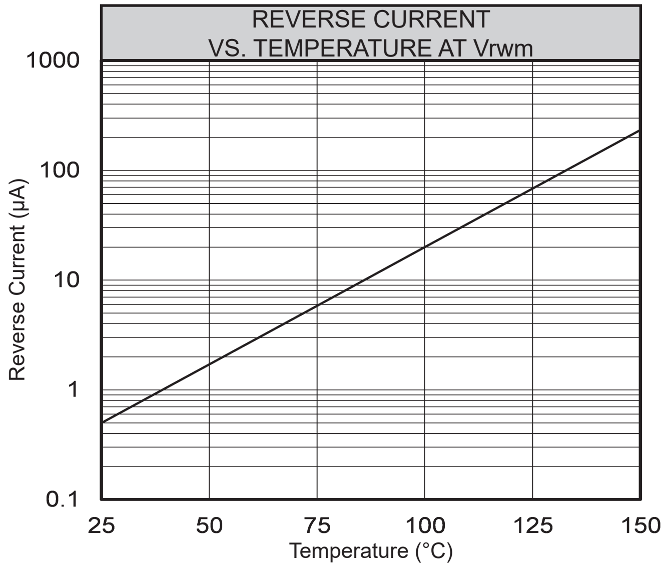
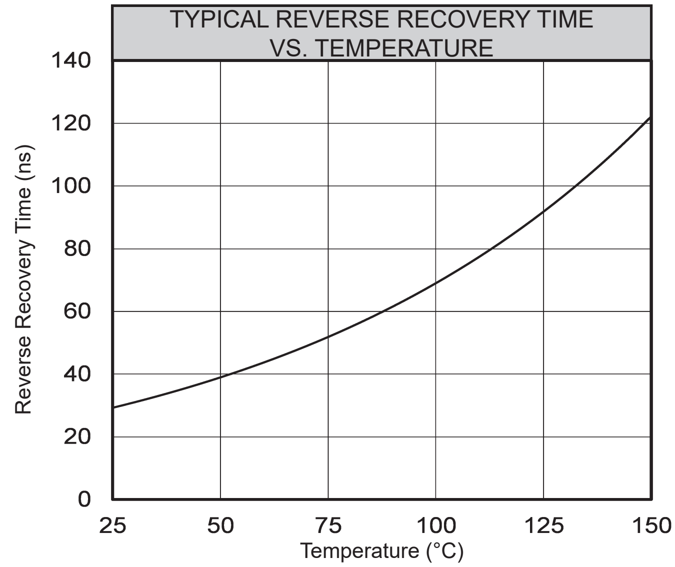
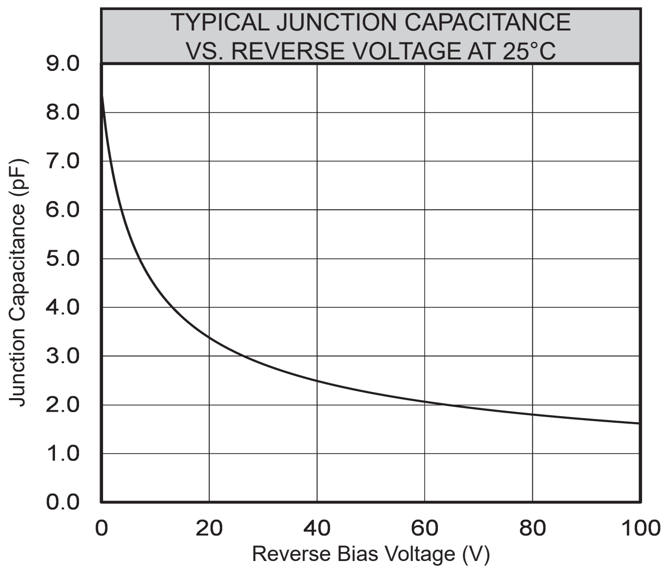

POWER DERATING
Maximum Power Dissipation (W)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
6
5
4
3
2
1
0
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
Reverse Bias Voltage (V)

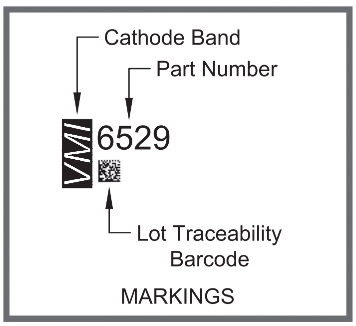
High Voltage Diodes - Surface Mount

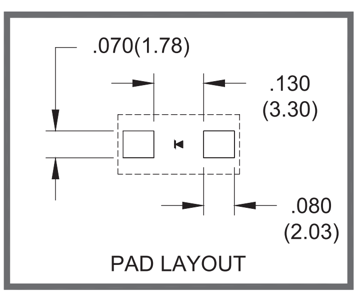
50mA - 250mA • 70ns

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

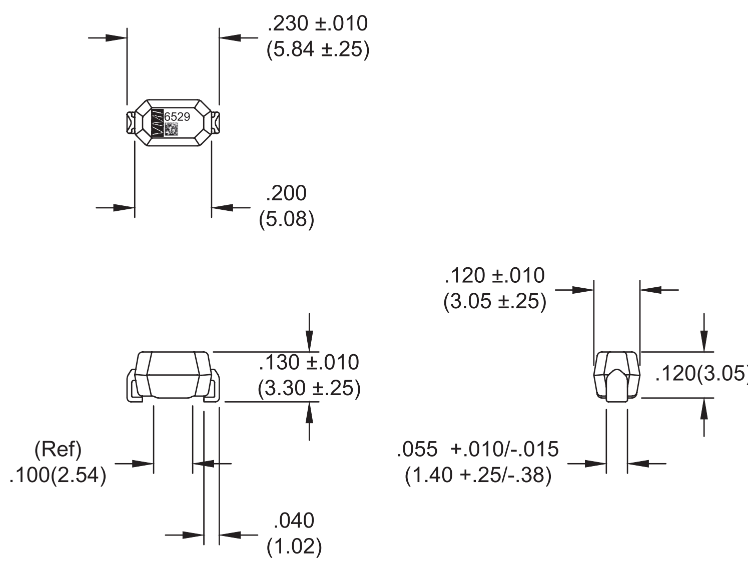
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	pF	
SMF6529	2000	250	125	0.1	10	3.0	25	10	1.50	70	20	4.0	6529
SMF6531	3000	100	50	0.1	10	7.0	25	8	1.25	70	20	2.0	6531
SMF6533	5000	50	25	0.1	10	9.0	25	4	0.75	70	20	1.0	6533

(1)TC=55°C (2)TC=100°C (3)If=12.5mA, Ir=25.0mA, Irr=6.3mA *Op.Temp. -65°C to +175°C Stg.Temp. -65°C to +200°C





Tolerance:
.XXX ±.005(.13)



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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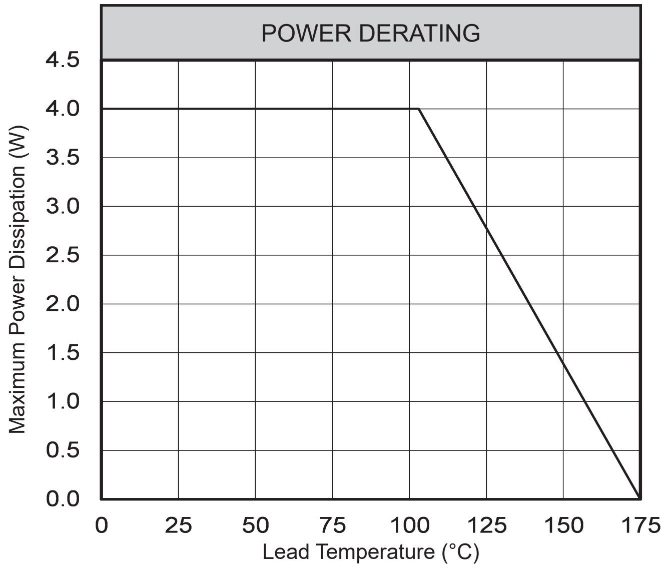
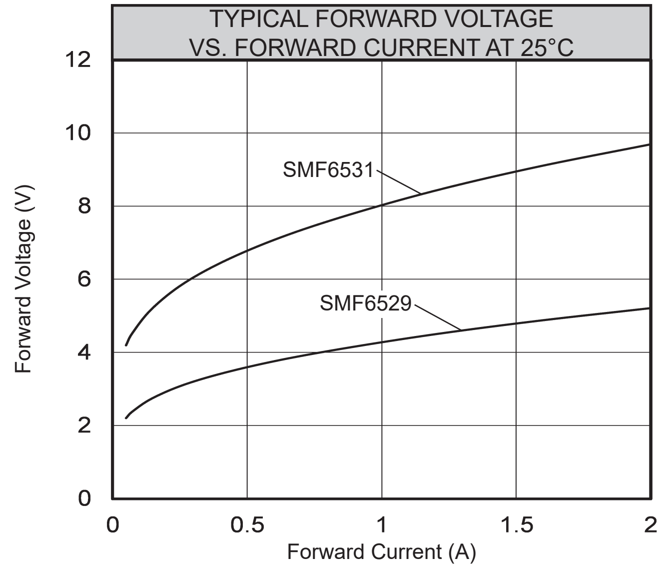
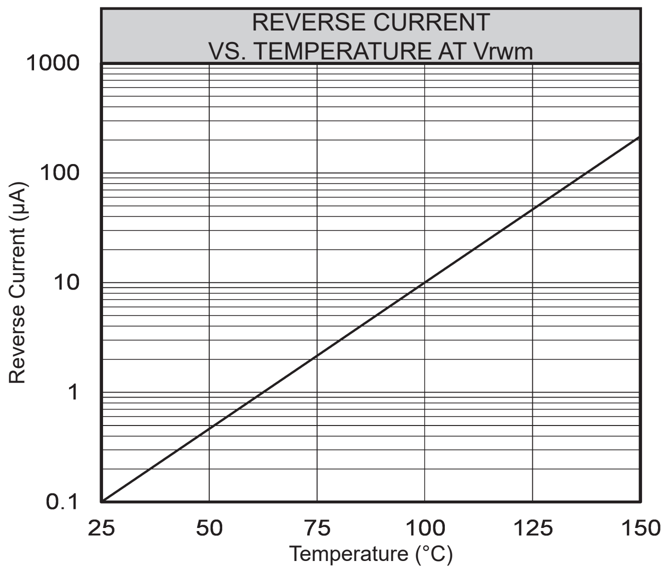
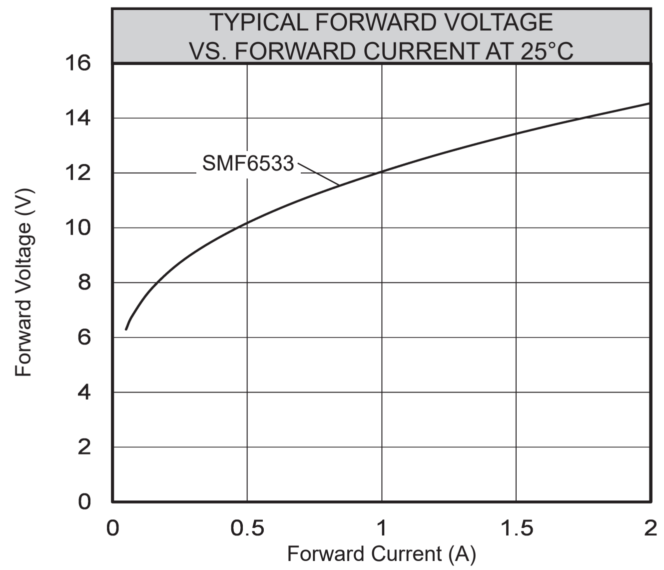
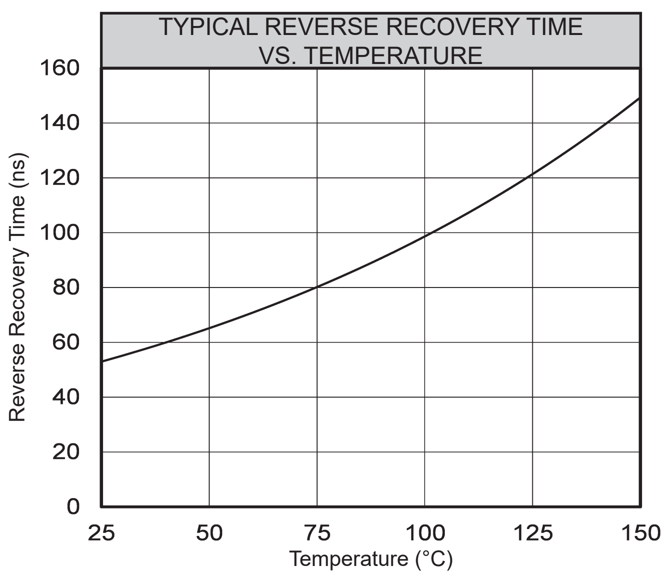
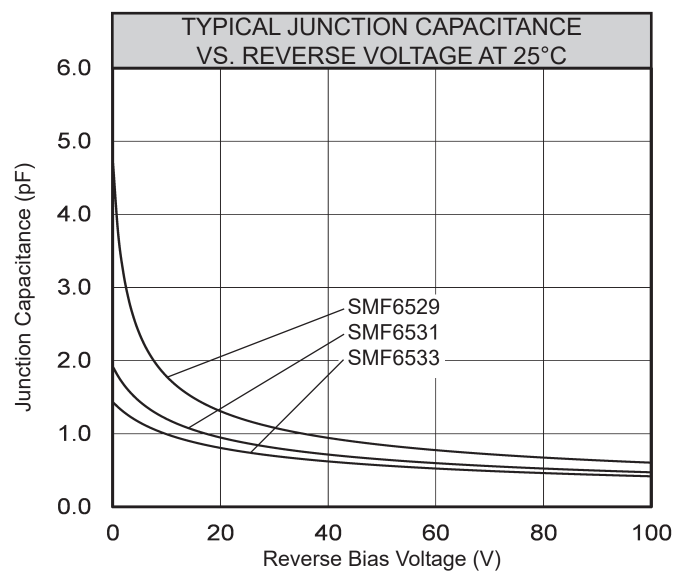

POWER DERATING
Maximum Power Dissipation (W)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
12
10
8
6
4
2
0
SMF6531
SMF6529
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
16
14
12
10
8
6
4
2
0
SMF6533
0
0.5
1
1.5
2
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
160
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
SMF6529
SMF6531
SMF6533
0
20
40
60
80
100
Reverse Bias Voltage (V)

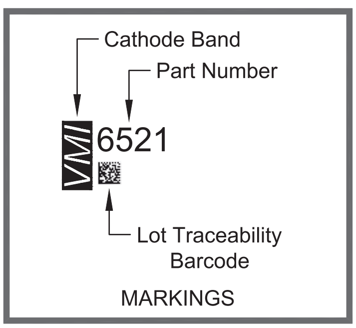
High Voltage Diodes - Surface Mount

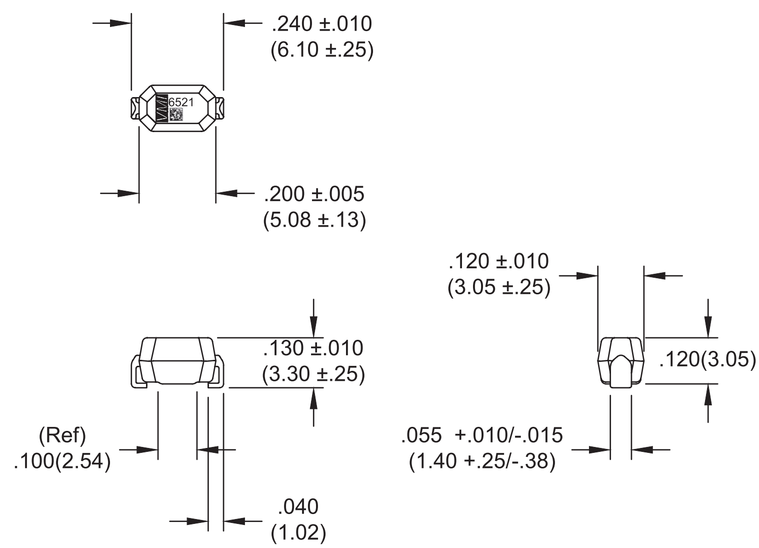
500mA • 70ns

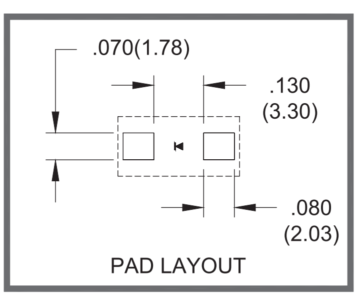
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS													
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	pF	
SXF6521	2000	500	250	0.5	20	3.0	500	25	5	70	7.0	8.0	6521

(1)TC=55°C (2)TC=100°C (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp. -65°C to +175°C Stg.Temp. -65°C to +200°C

Tolerance:
.XXX ±.005(.13)







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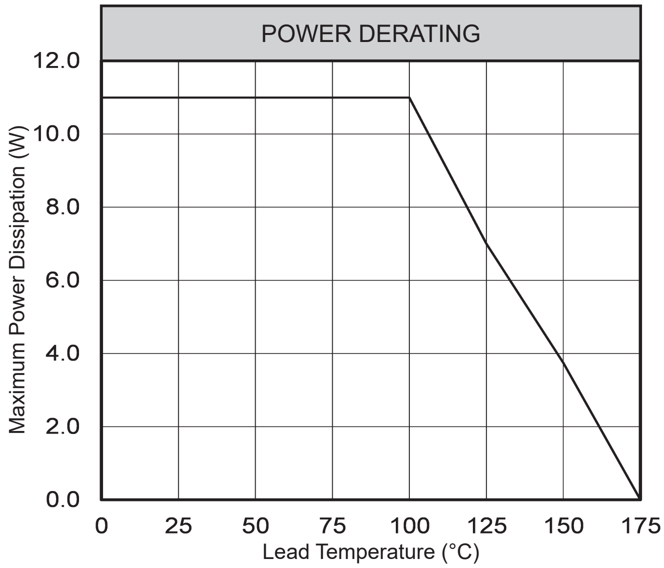
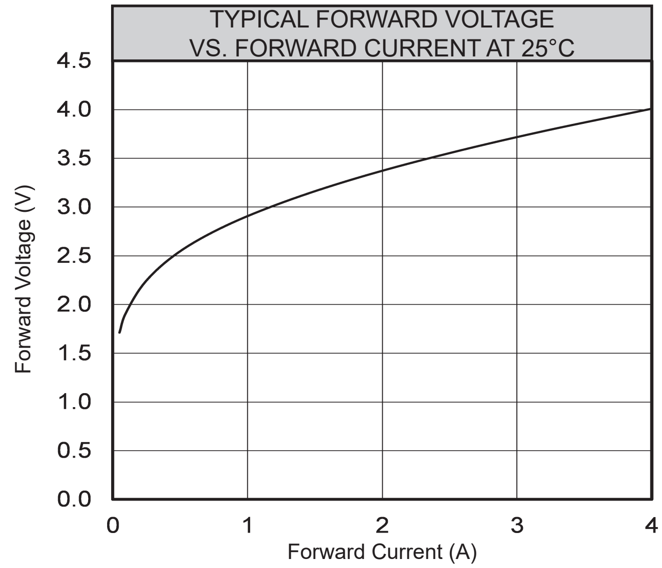
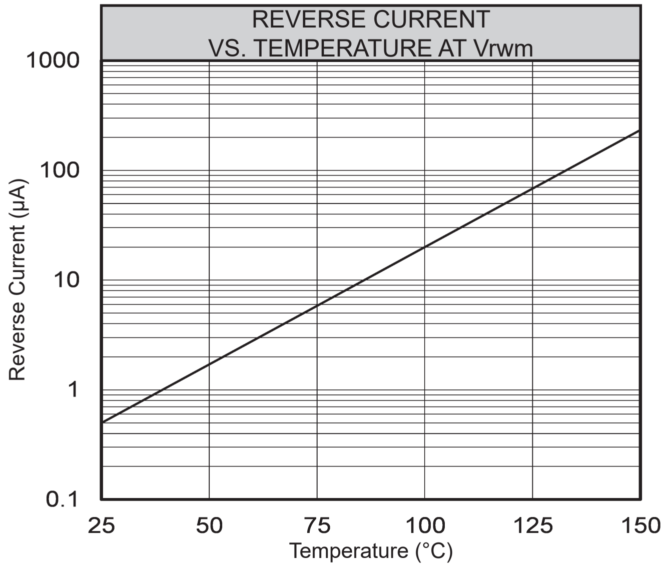
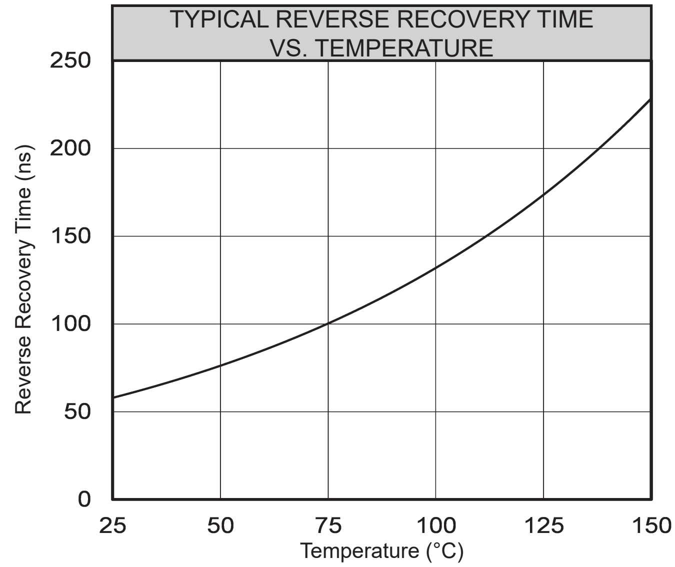
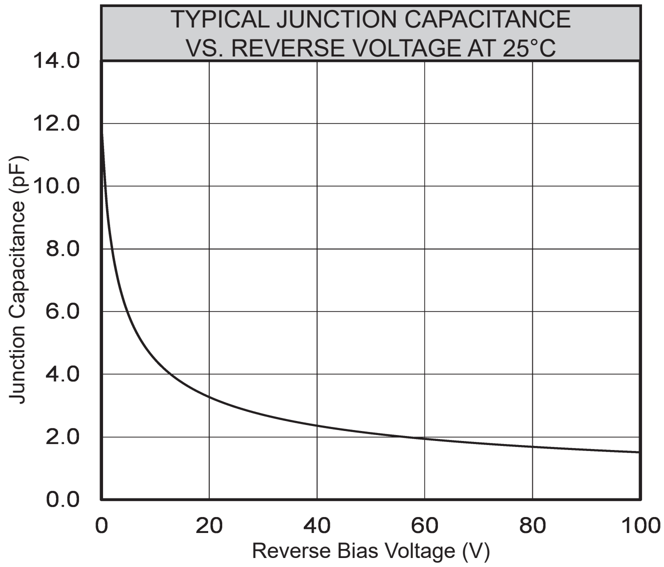

POWER DERATING
Maximum Power Dissipation (W)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Surface Mount

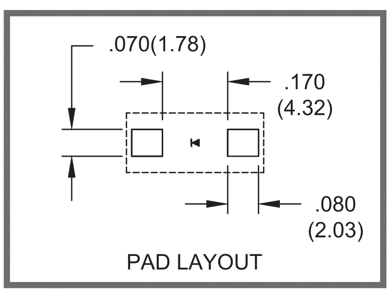
150mA - 250mA • 70ns

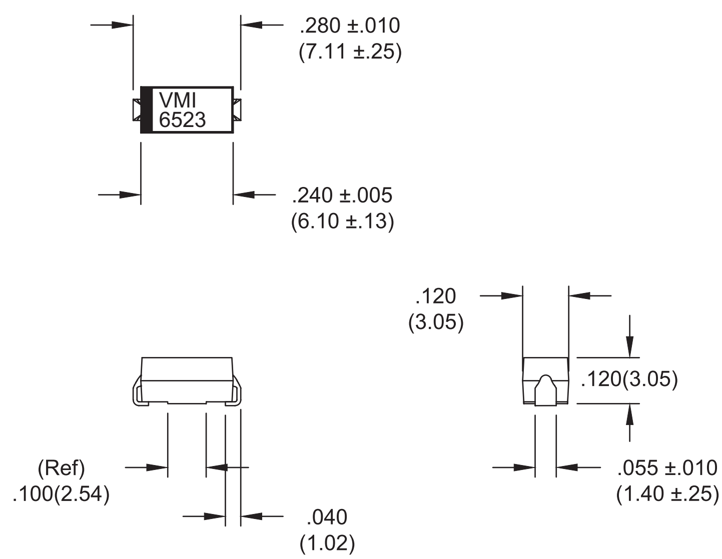
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	pF	
SXF6523	3000	250	125	0.5	20	5.0	250	15	3	70	7.0	4.0	6523
SXF6525	5000	150	75	0.5	20	7.0	150	10	2	70	7.0	3.0	6525

(1)TC=55°C (2)TC=100°C (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp. -65°C to +175°C Stg.Temp. -65°C to +200°C

Tolerance:
.XXX ±.005(.13)





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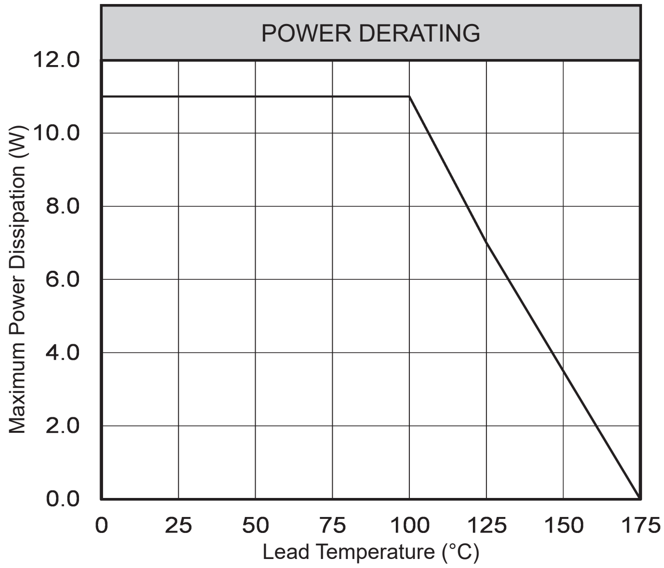
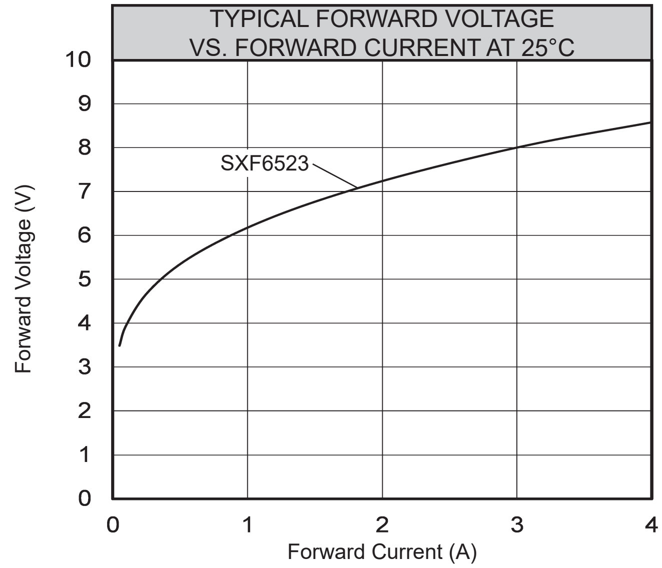
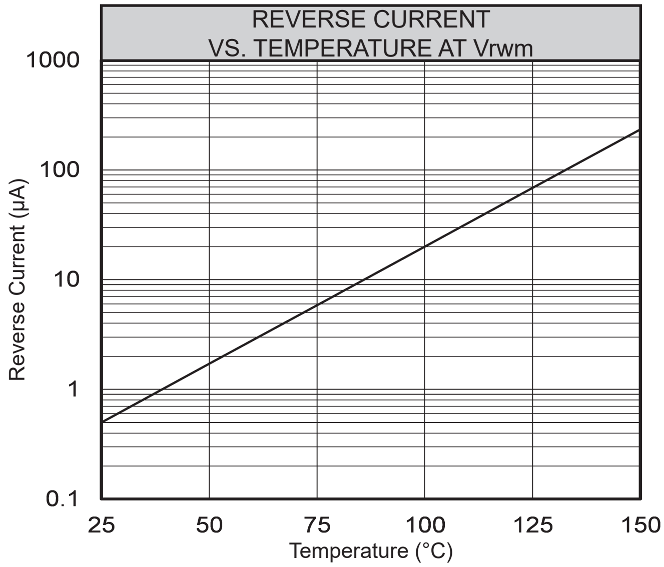
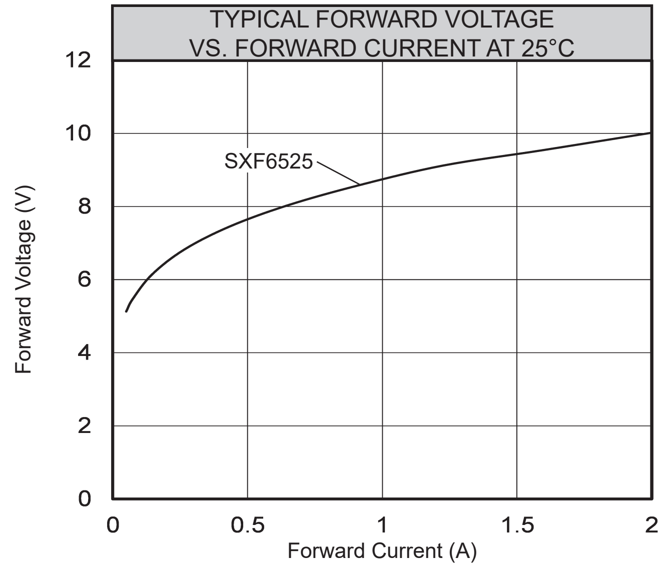
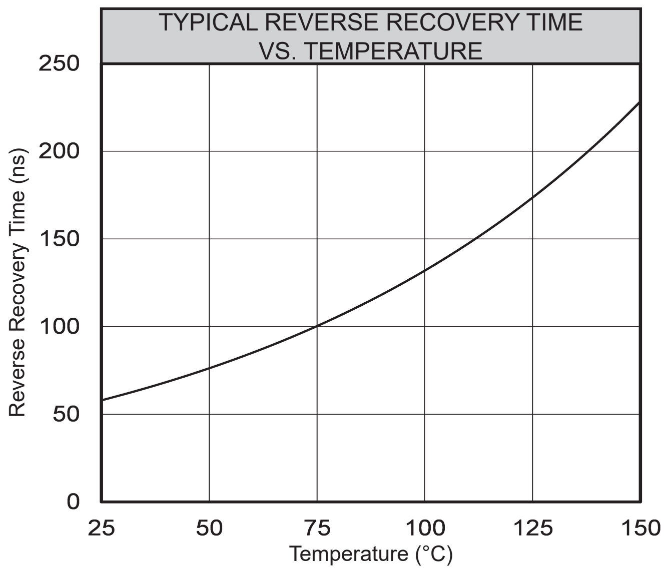
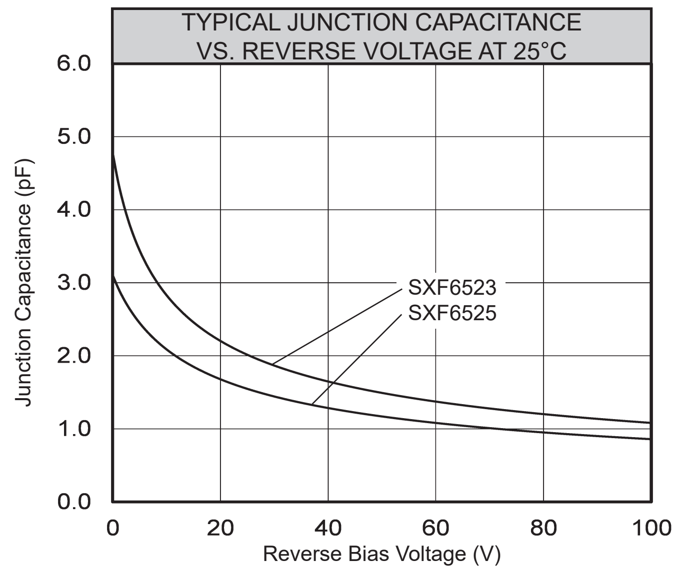

POWER DERATING
Maximum Power Dissipation (W)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
SXF6523
10
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
SXF6525
12
10
8
6
4
2
0
0
0.5
1
1.5
2
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
SXF6523
SXF6525
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Surface Mount

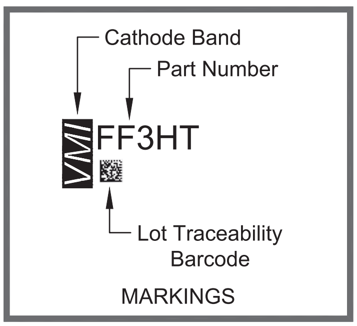
0.42A • 30ns

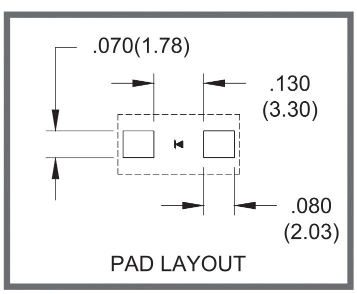
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

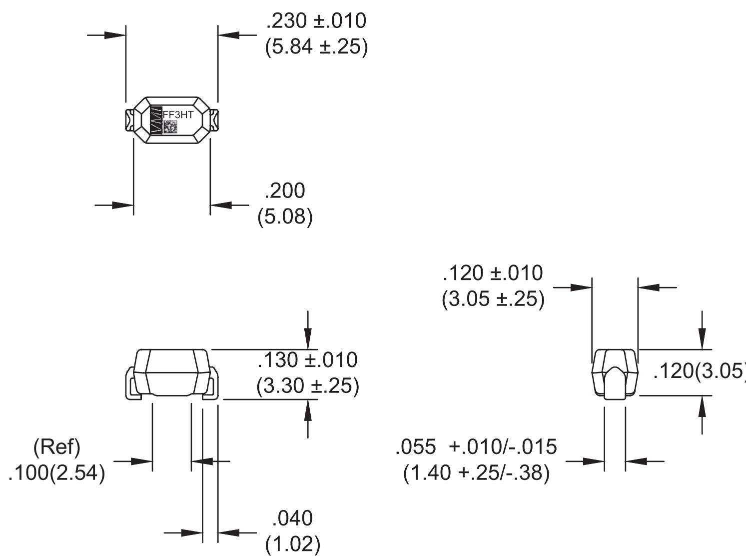
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	°C/W	pF	
SXF20FF3HT	2000	0.42	0.21	1.0	25	7.5	0.42	16	3	30	20	4.0	FF3HT

(1)TC=55°C (2)TC=100°C (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp. -65°C to +175°C Stg.Temp. -65°C to +200°C

Tolerance:
.XXX ±.005(.13)







Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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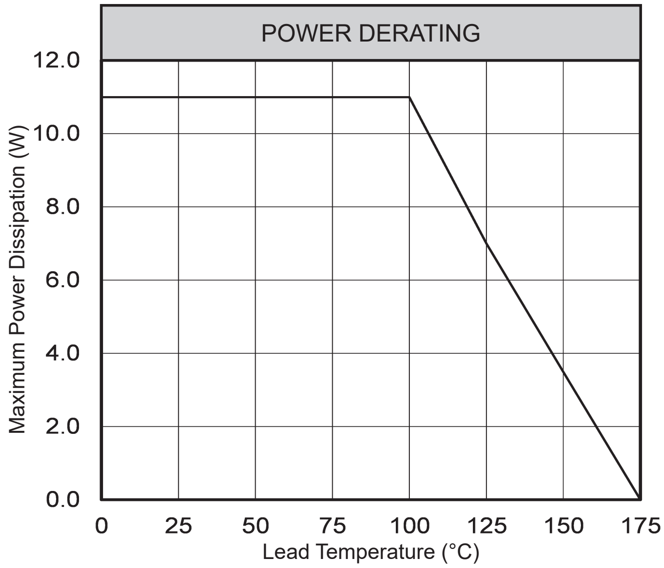
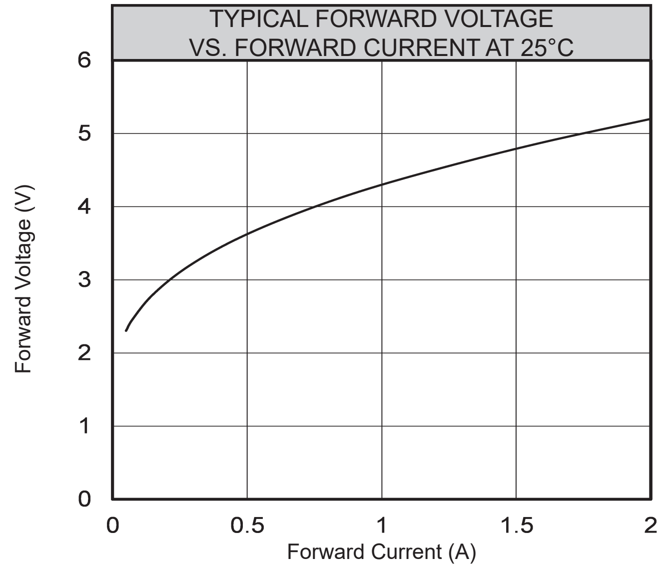
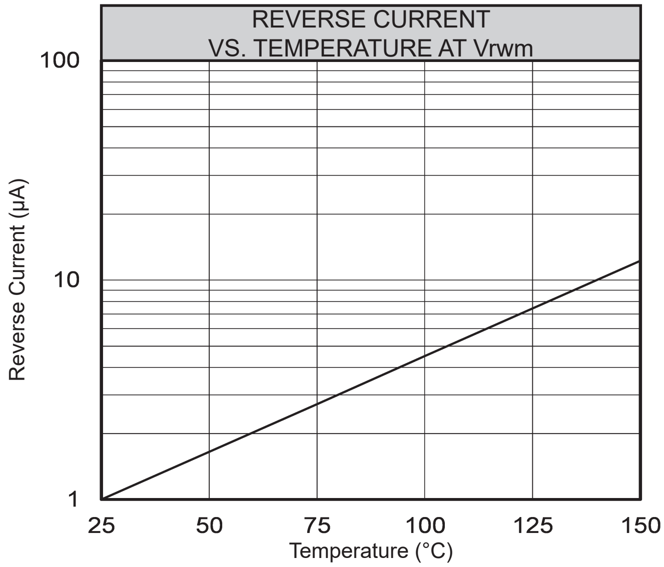
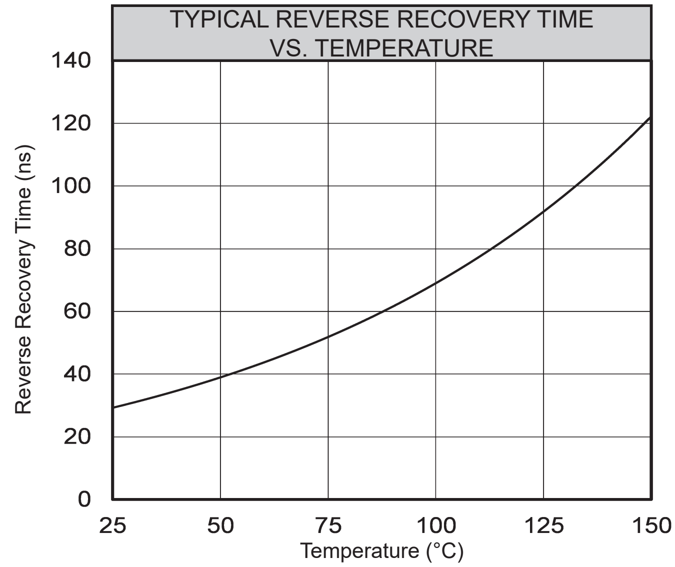
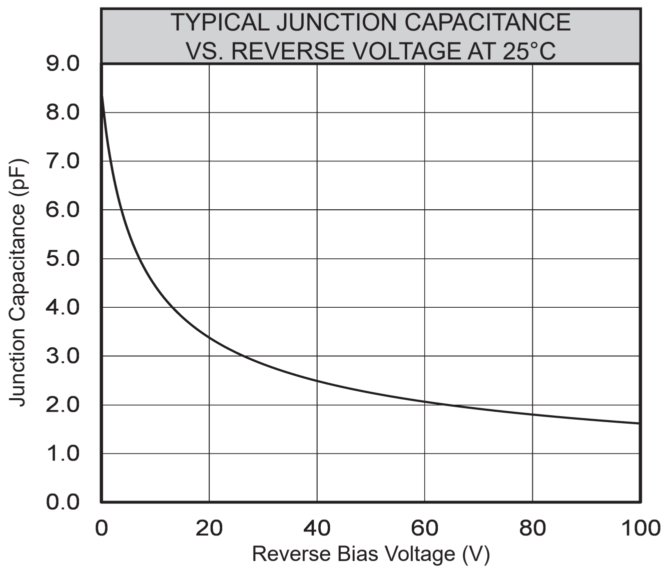

POWER DERATING
Maximum Power Dissipation (W)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
6
5
4
3
2
1
0
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
Reverse Bias Voltage (V)

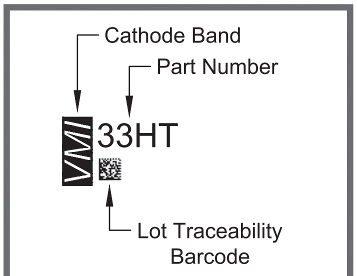
High Voltage Diodes - Surface Mount

50mA • 70ns

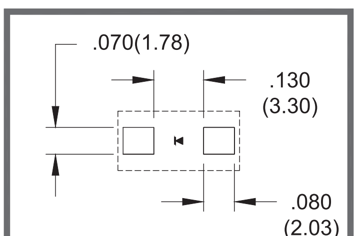
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
				(Vrwm)	2.5kV								
		55°C(1)	100°C(2)	25°C	175°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	pF	
SMF6533HT	5000	50	25	0.1	10	9.0	25	4	0.80	70	20	1.0	33HT

(1) TL=55°C (2) TL=100°C (3) If=12.5mA, Ir=25.0mA, Irr=6.3mA *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C

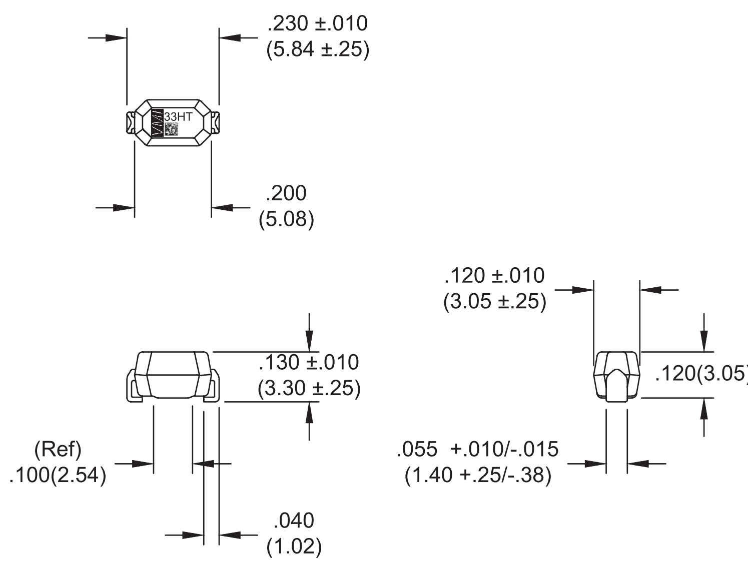


MARKINGS



PAD LAYOUT

Tolerance:
.XXX ±.005(.13)



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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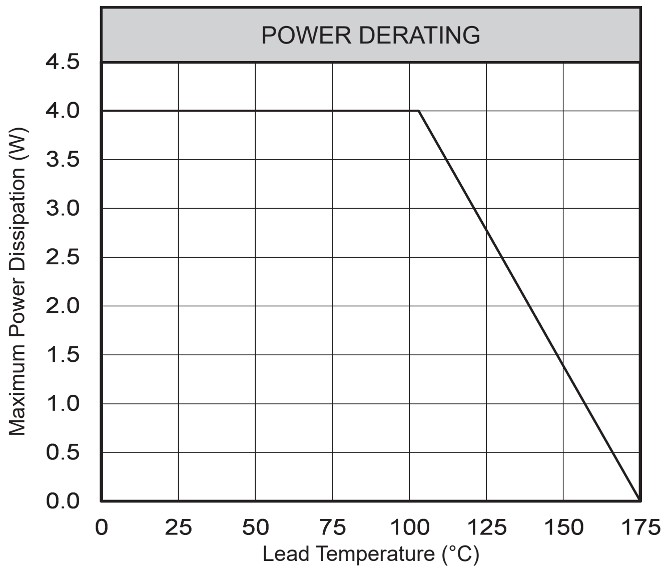
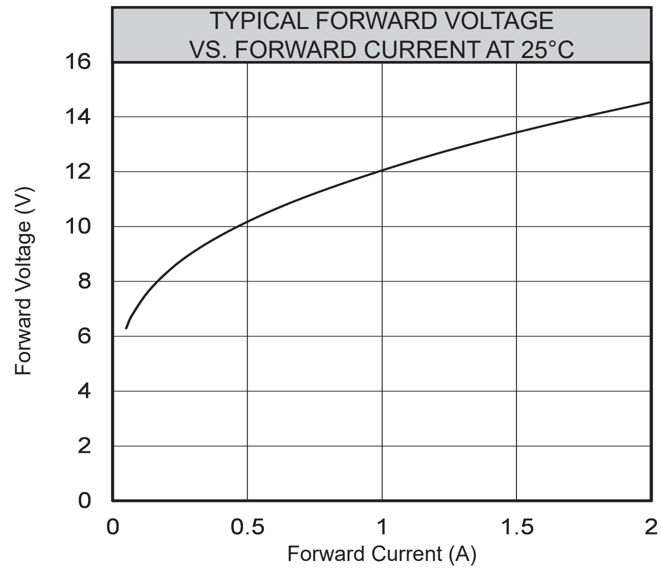
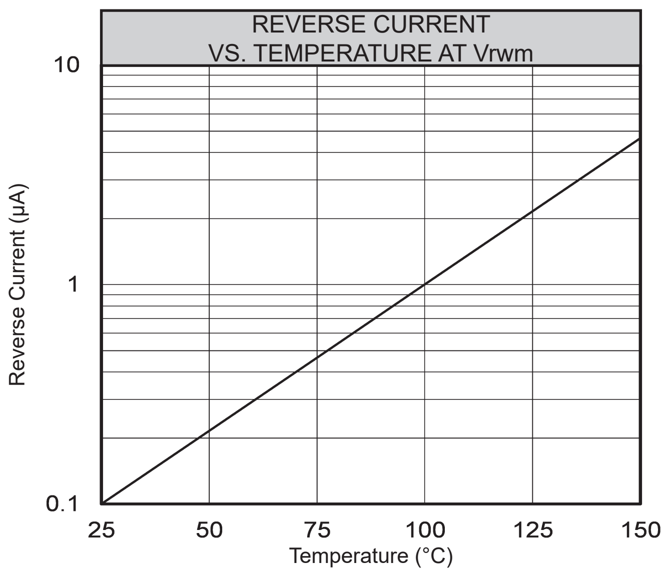
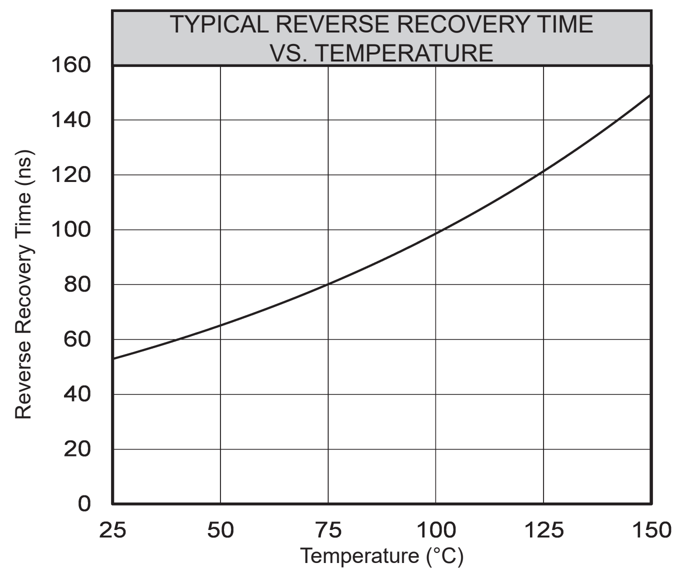
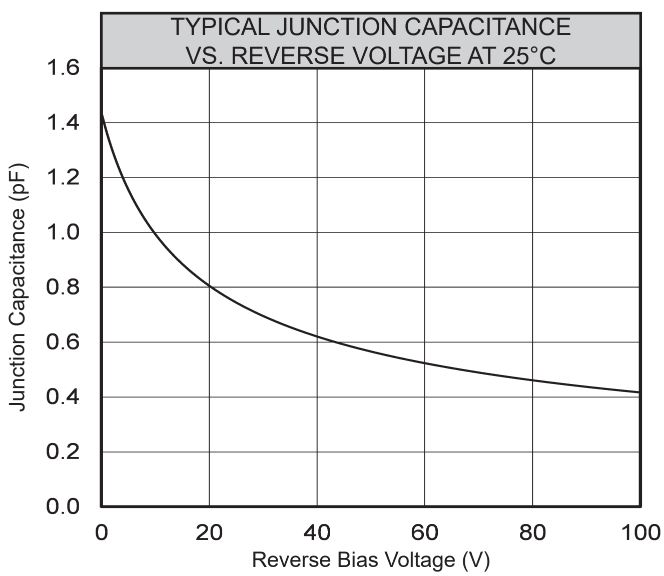

POWER DERATING
Maximum Power Dissipation (W)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
160
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Reverse Bias Voltage (V)

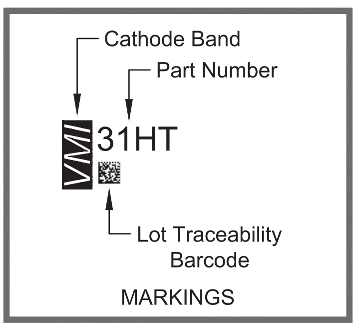
High Voltage Diodes - Surface Mount

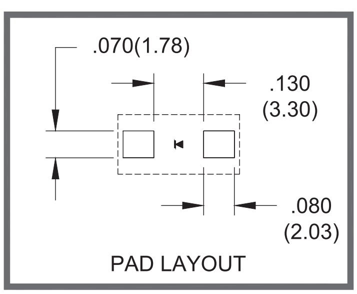
100mA • 70ns

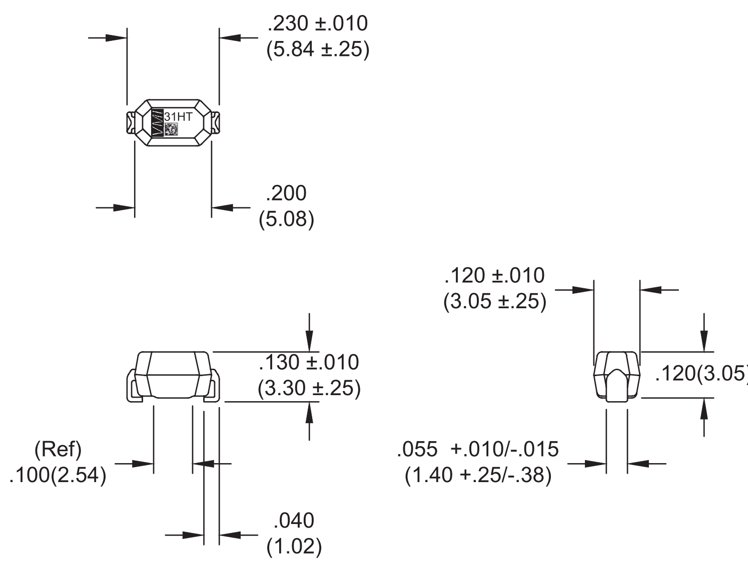
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS													
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir) (Vrwm)	Reverse Current @ Vrwm (Ir) 1.5kV	Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
		55°C(1)	100°C(2)	25°C	175°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	pF	
SMF6531HT	3000	100	50	0.1	10	7.0	25	8	1.25	70	20	2.0	31HT

(1) TL=55°C (2) TL=100°C (3) If=12.5mA, Ir=25.0mA, Irr=6.3mA *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C

Tolerance:
.XXX ±.005(.13)







Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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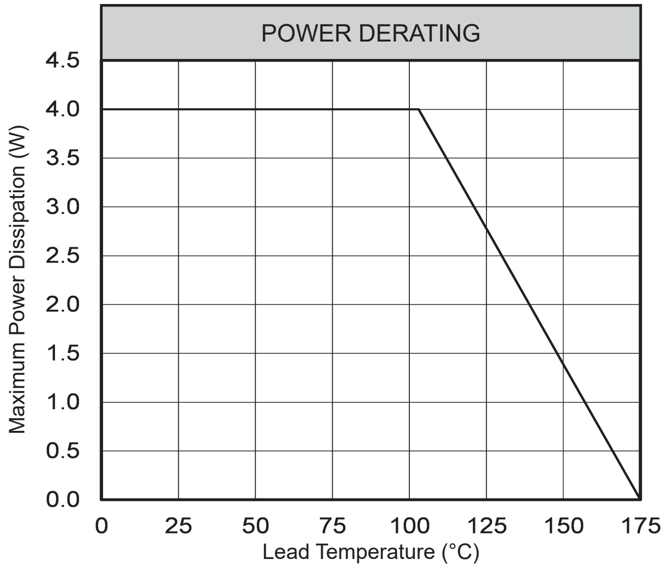
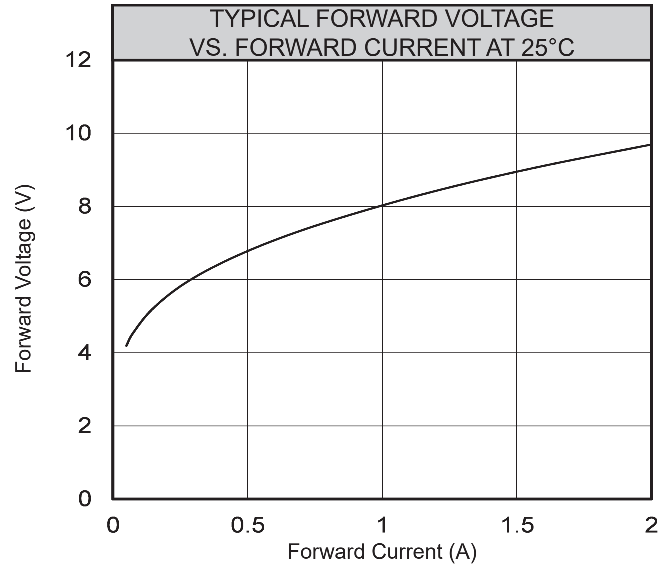
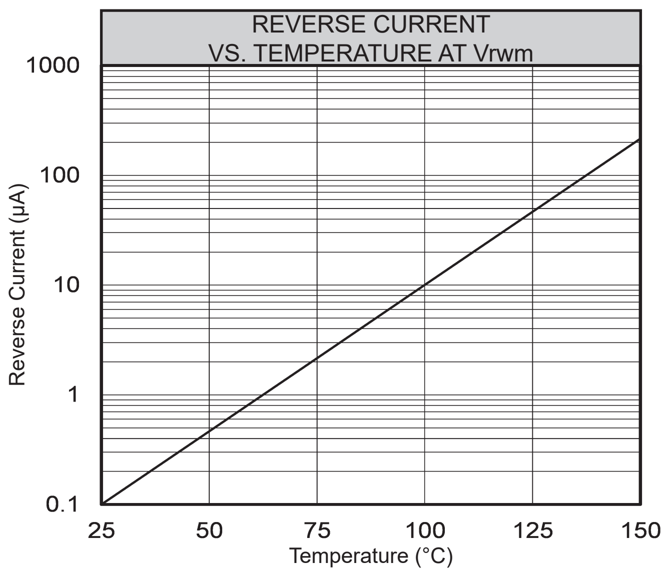
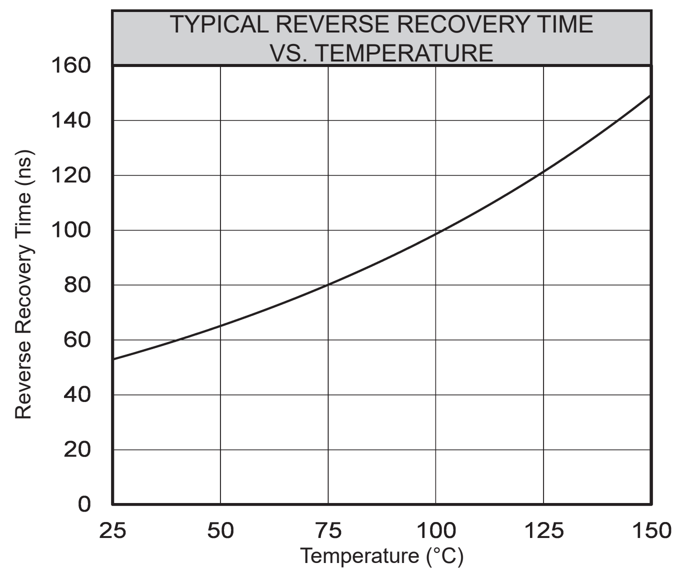
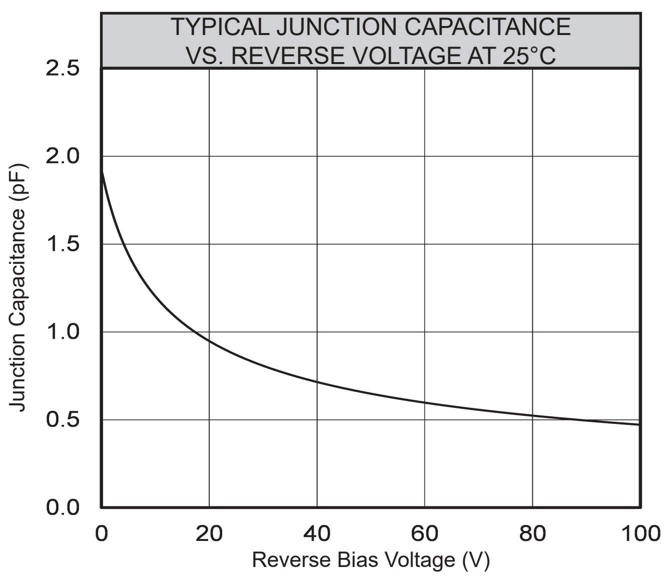

POWER DERATING
Maximum Power Dissipation (W)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
12
10
8
6
4
2
0
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
160
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)

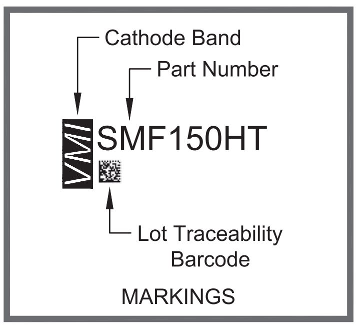

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Reverse Bias Voltage (V)

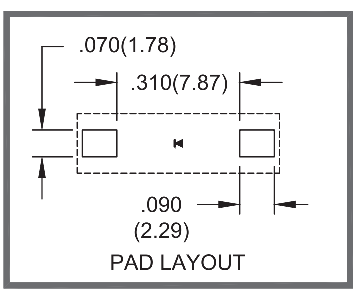
High Voltage Diodes - Surface Mount

0.10mA • 100ns

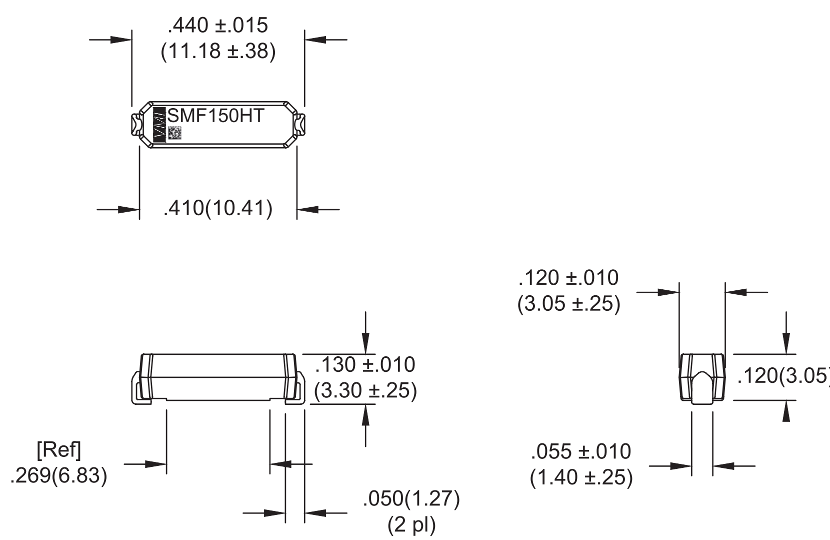
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS													
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-L}	Junction Cap. @50VDC @ 1kHZ (Cj)	Markings
				(Vrwm)	7.5kV								
		55°C(1)	100°C(2)	25°C	175°C	25°C		25°C	25°C	25°C	25°C	25°C	
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	pF	
SMF150HT	15000	10	5	0.1	10	35.0	10	1.0	0.20	100	40	0.5	150HT

(1) TL=55°C (2) TL=100°C (3) If=12.5mA, Ir=25.0mA, Irr=6.3mA *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C





Tolerance:
.XXX ±.005(.13)



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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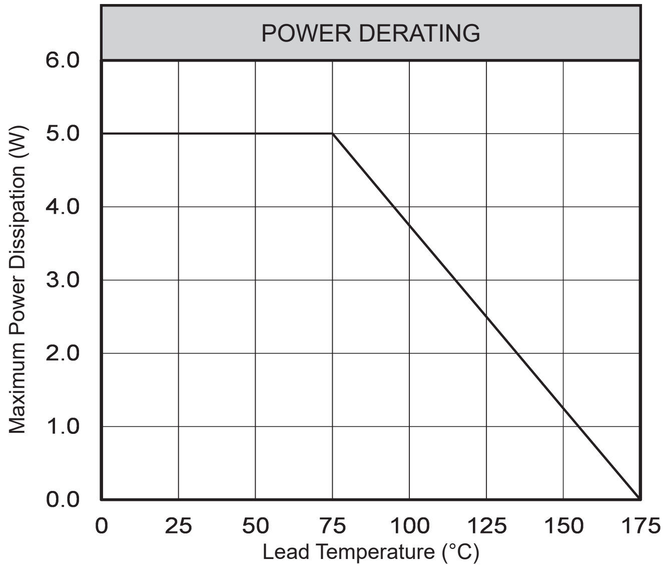
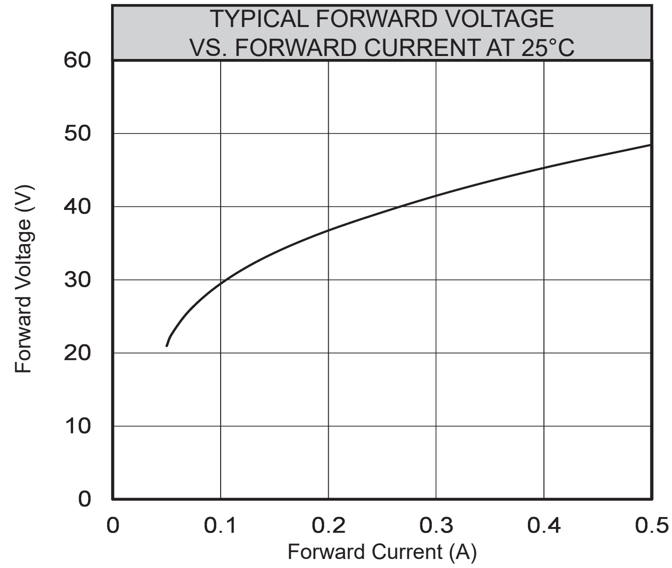
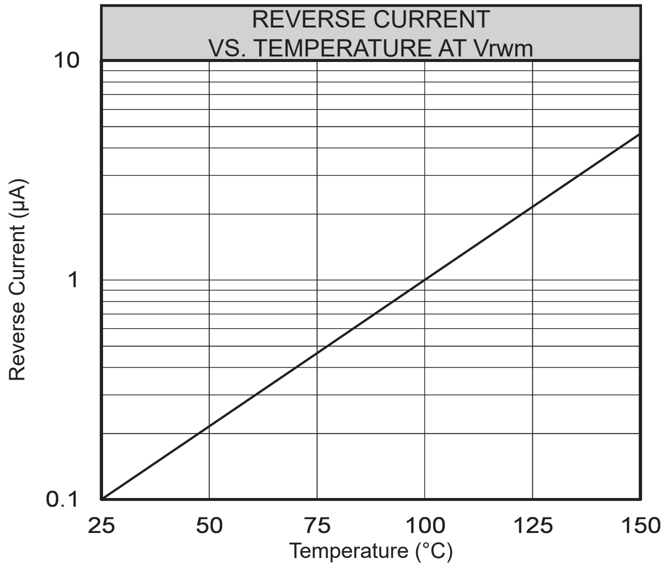
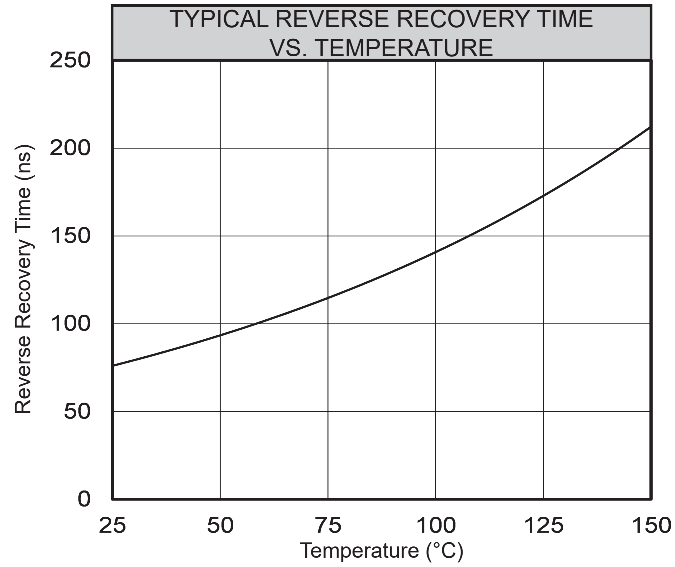
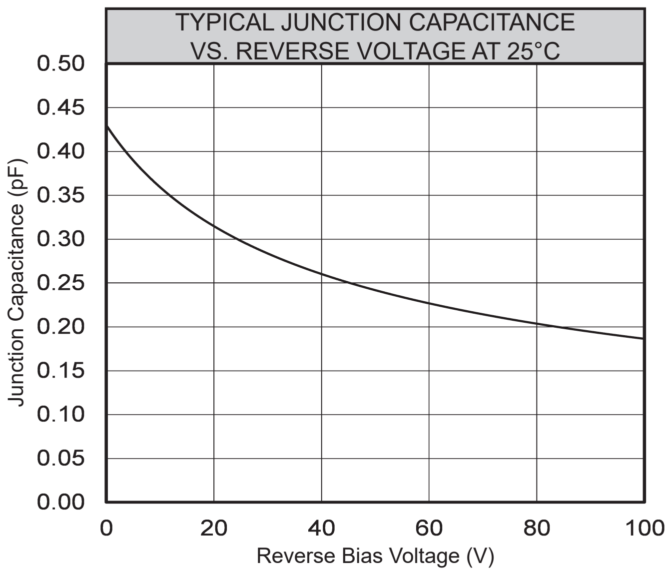

POWER DERATING
Maximum Power Dissipation (W)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
Reverse Bias Voltage (V)

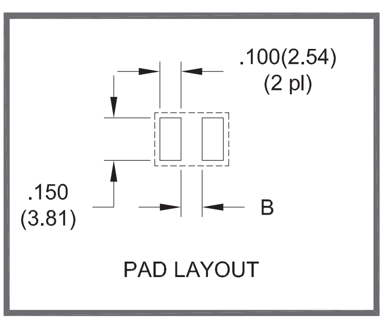
High Voltage Diodes - Formed Lead

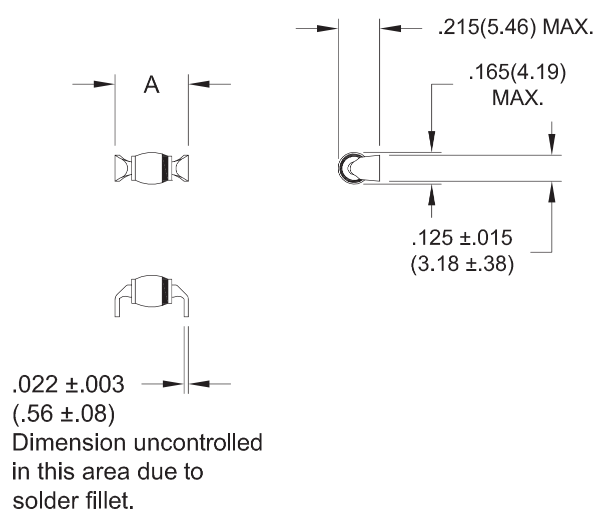
0.75A - 2.00A • 30ns - 50ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS												
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-C}	Junction Cap. @50VDC @1kHz (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C
	Volts	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	°C/ W	pF
1N6837LL	5000	0.75	0.50	1.0	25	12.0	0.50	20	4	30	5.0	16
1N6838LL	2000	2.00	1.50	1.0	25	4.5	1.50	60	10	50	5.0	20
1N6839LL	5000	1.00	0.60	1.0	25	10.0	0.60	30	6	50	5.0	16

(1)TC=55°C (2)TC=100°C (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C

Part	A	B
1N6837LL	.390(9.91) MAX.	.260 (6.60)
1N6838LL	.350(8.89) MAX.	.220 (5.59)
1N6839LL	.390(9.91) MAX.	.260 (6.60)





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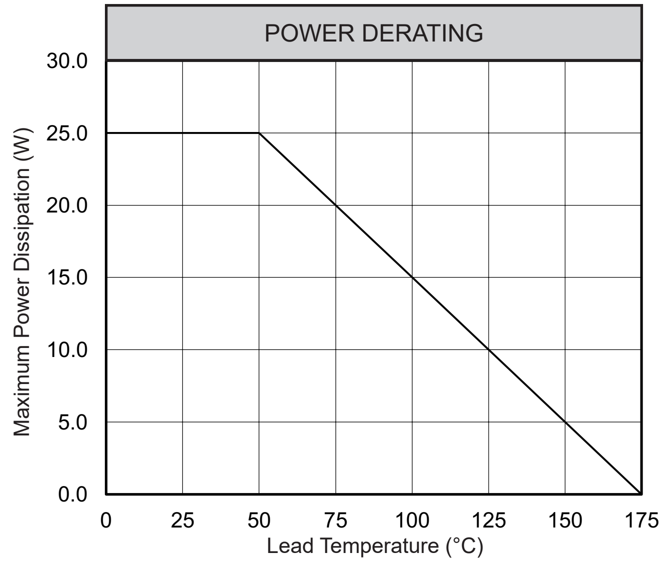
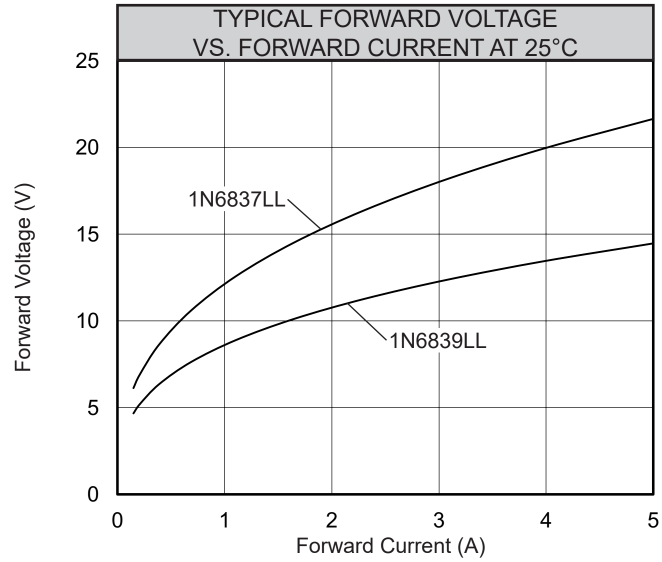
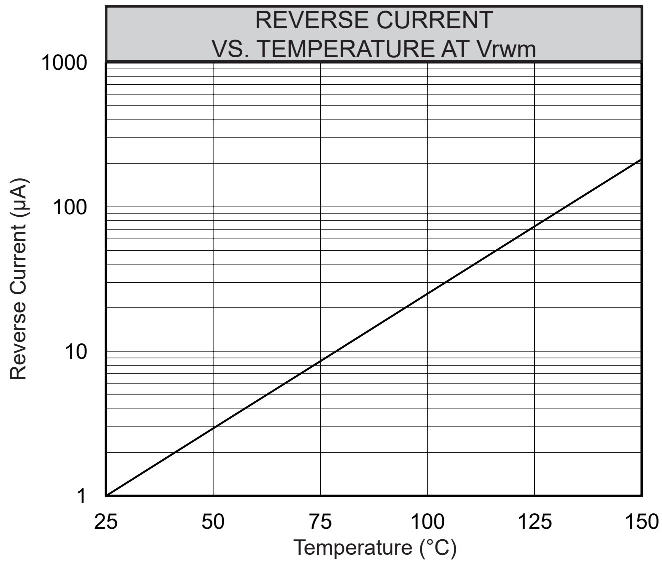
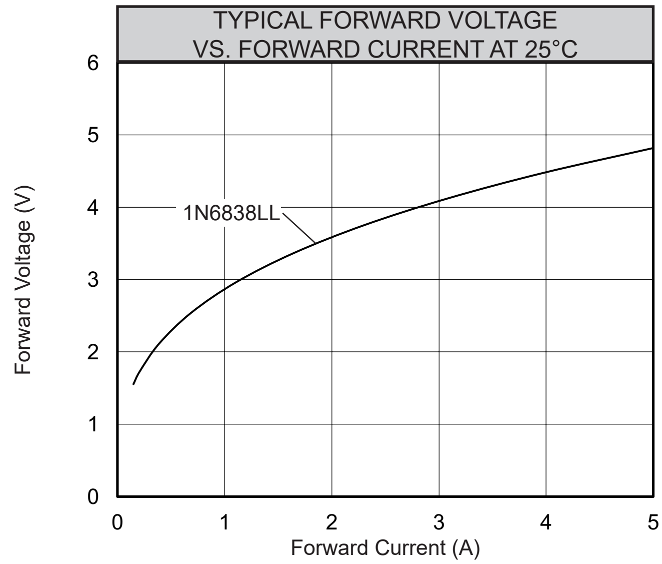
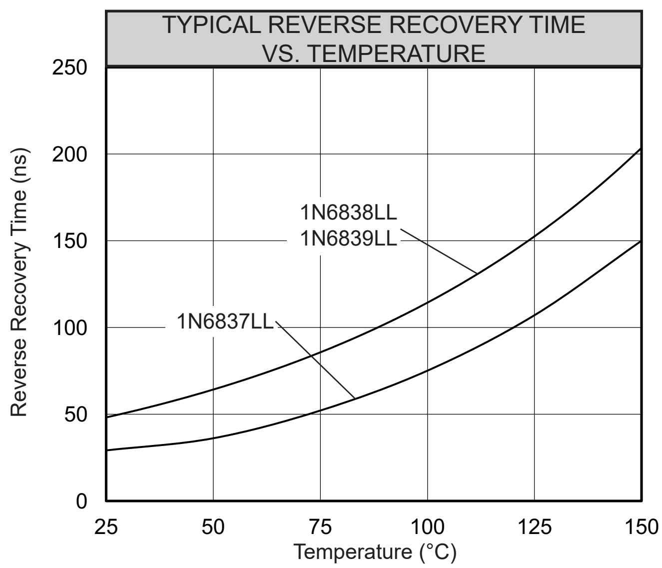
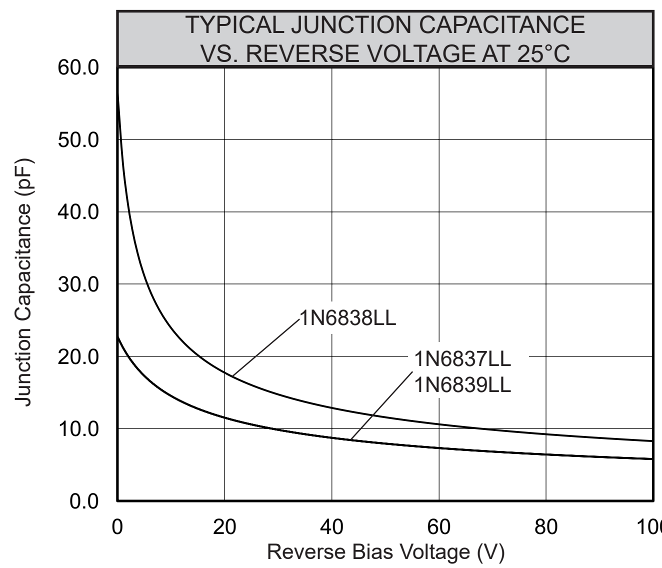

POWER DERATING
Maximum Power Dissipation (W)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
1N6837LL
1N6839LL
0
1
2
3
4
5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
6
5
4
3
2
1
0
1N6838LL
0
1
2
3
4
5
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
250
200
150
100
50
0
1N6838LL
1N6839LL
1N6837LL
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1N6838LL
1N6837LL
1N6839LL
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Formed Lead

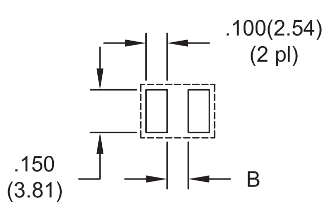
0.8A - 2.0A • 30ns - 50ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

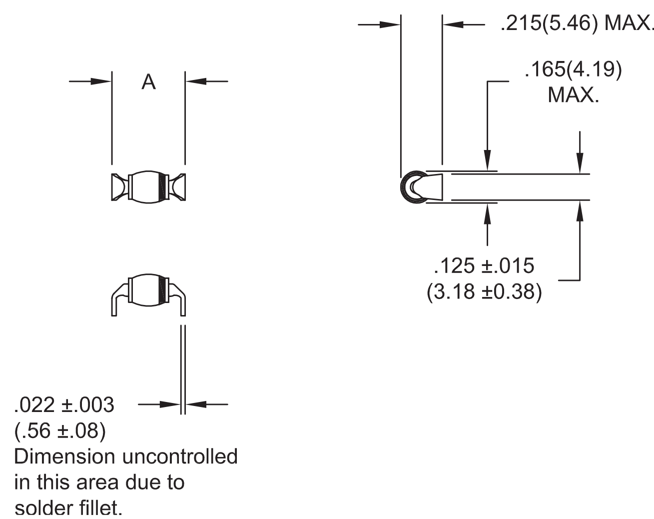
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-C}	Junction Cap. @50VDC @1kHz (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	°C/ W	pF
Z20FF3LL Z50FF3LL	2000 5000	2.0 0.8	1.2 0.4	1.0 1.0	25 25	6.0 12.5	0.75 0.36	65 22	10 4	30 30	5.0 5.0	20 16
Z20FF5LL Z50FF5LL	2000 5000	2.0 0.8	1.2 0.4	1.0 1.0	25 25	6.0 12.5	0.75 0.36	65 22	10 4	50 50	5.0 5.0	20 16

(1)TC=55°C (2)TC=100°C (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C

Part	A	B
Z20FF3LL Z20FF5LL	.350(8.89) MAX. .320(8.13) MIN.	.220 (5.59)
Z50FF3LL Z50FF5LL	.390(9.91) MAX. .350(8.89) MIN.	.260 (6.60)



PAD LAYOUT



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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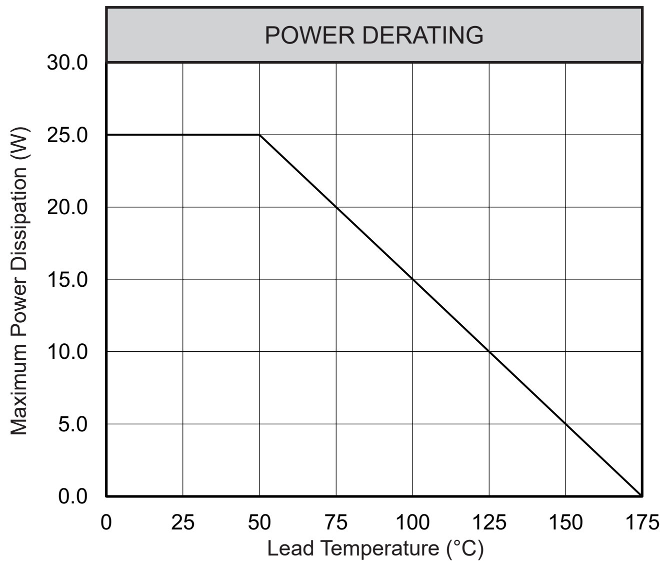
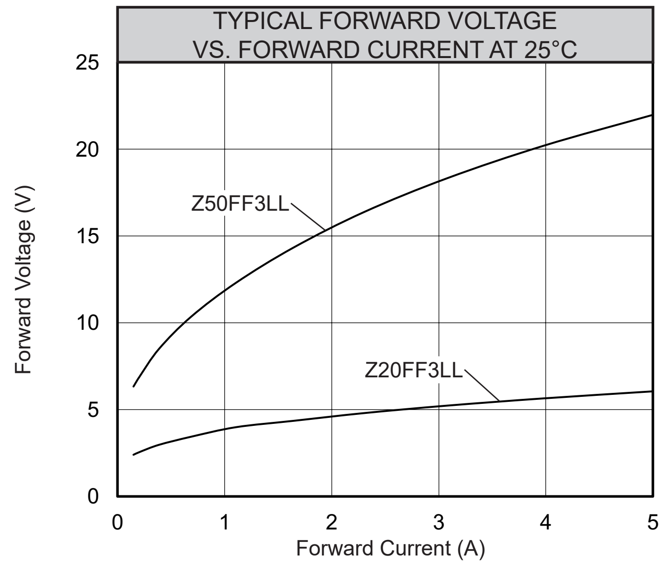
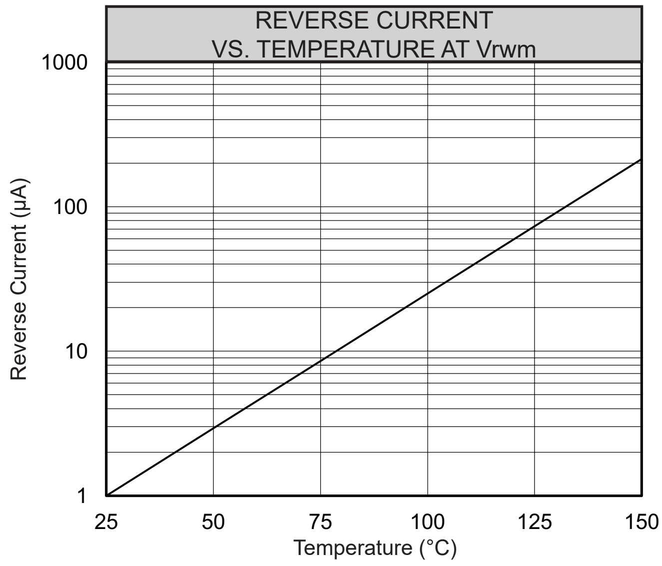
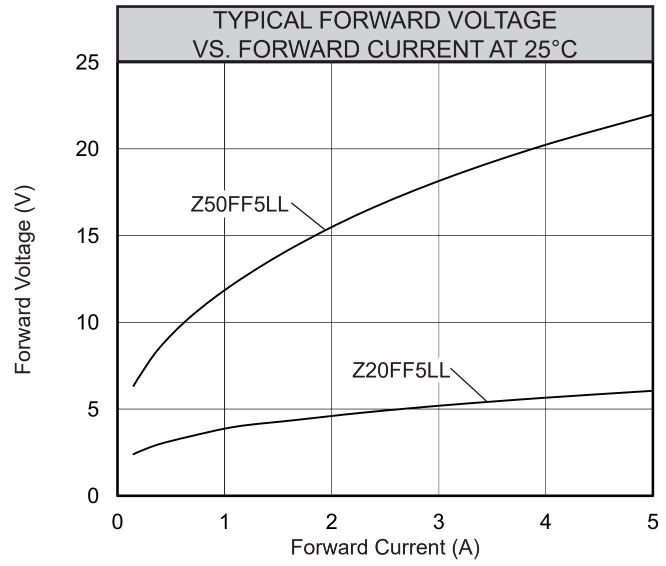
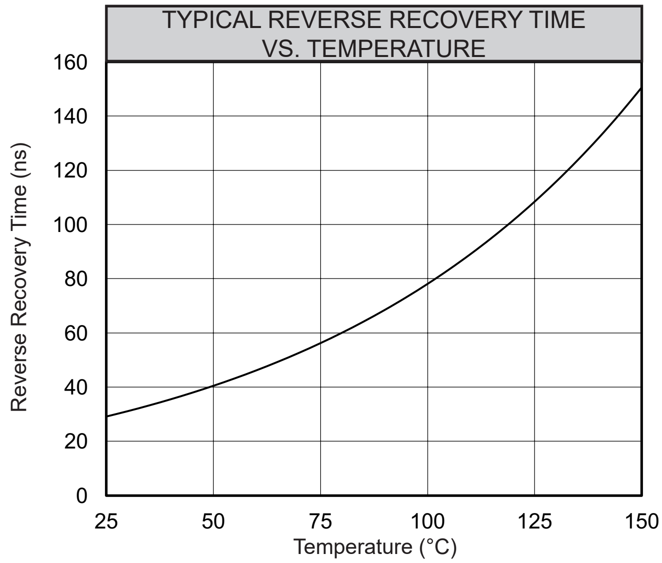
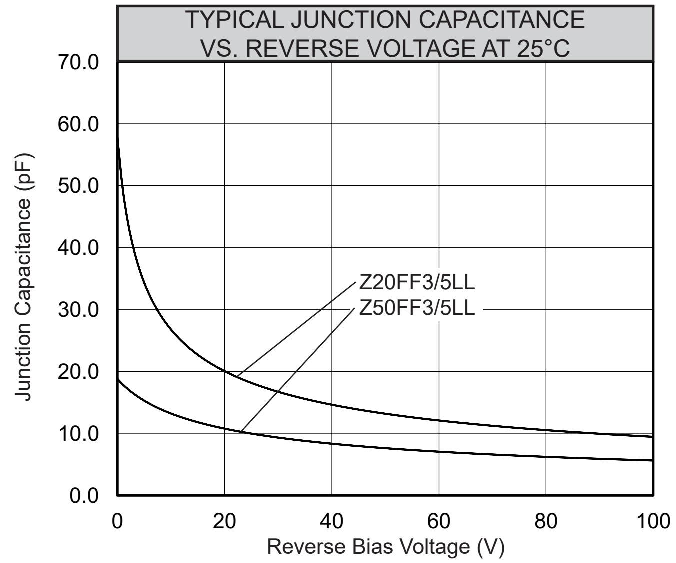

POWER DERATING
Maximum Power Dissipation (W)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
Z50FF3LL
Z20FF3LL
0
1
2
3
4
5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
Z50FF5LL
Z20FF5LL
0
1
2
3
4
5
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
160
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Z20FF3/5LL
Z50FF3/5LL
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Formed Lead

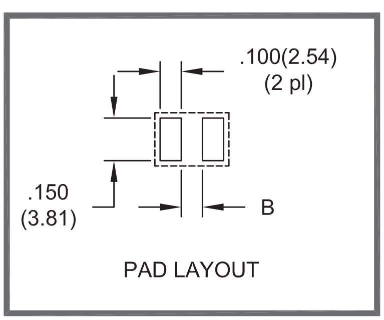
1.5A - 3.5A • 70ns • Hermetic • JANTX • JANTXV

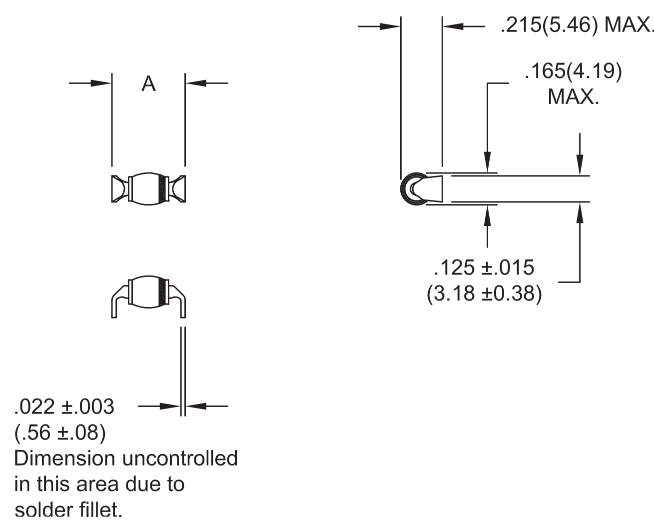
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impd. θ_{J-C}	Junction Cap. @50VDC @1kHz (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	25°C	25°C
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	°C/ W	pF
1N6513LL	2000	3.5	2.4	1.0	25	3.5	2.0	80	15	70	5.0	25
1N6515LL	3000	2.5	1.5	1.0	25	6.0	1.5	60	10	70	5.0	20
1N6517LL	5000	1.5	1.0	1.0	25	8.0	1.0	40	8	70	5.0	16

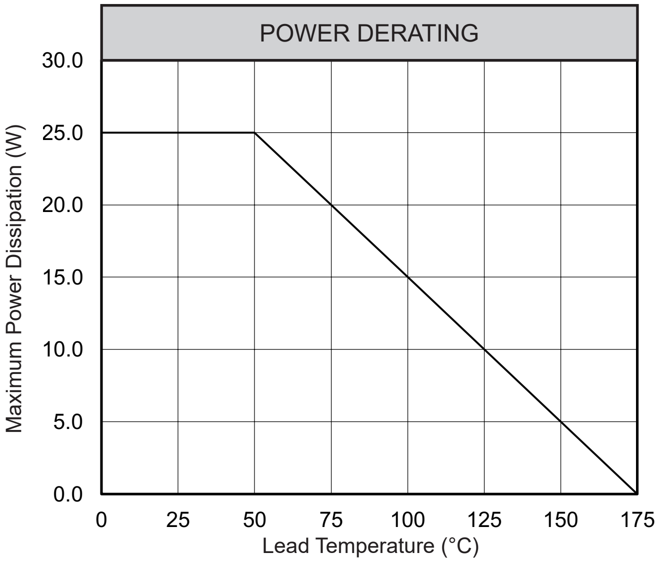
(1)TC=55°C (2)TC=100°C (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C

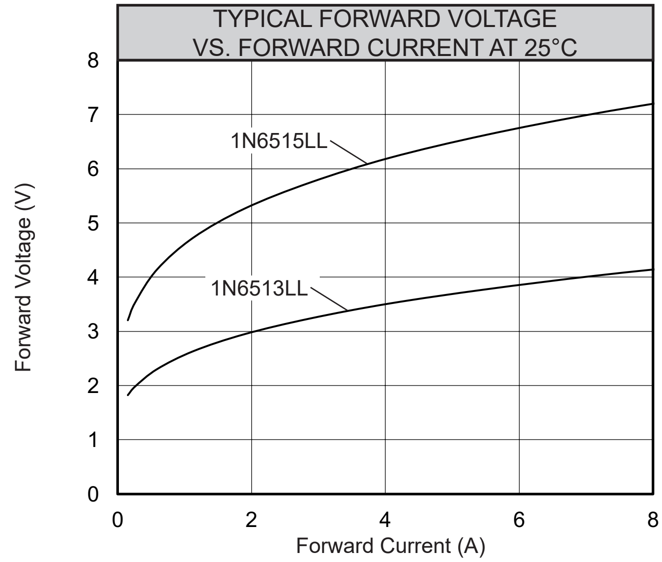
Part	A	B
1N6513LL	.345(8.76) MAX. .315(8.00) MIN.	.210 (5.33)
1N6515LL	.365(9.27) MAX. .335(8.51) MIN.	.230 (5.84)
1N6517LL	.380(9.65) MAX. .350(8.89) MIN.	.250 (6.35)

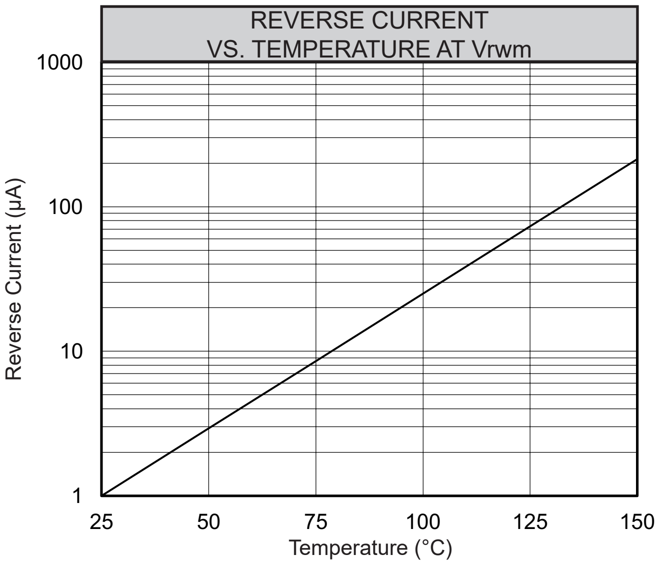


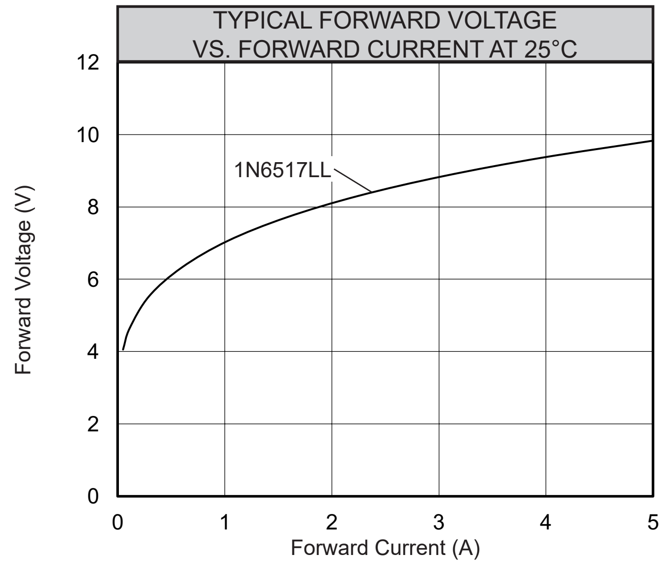


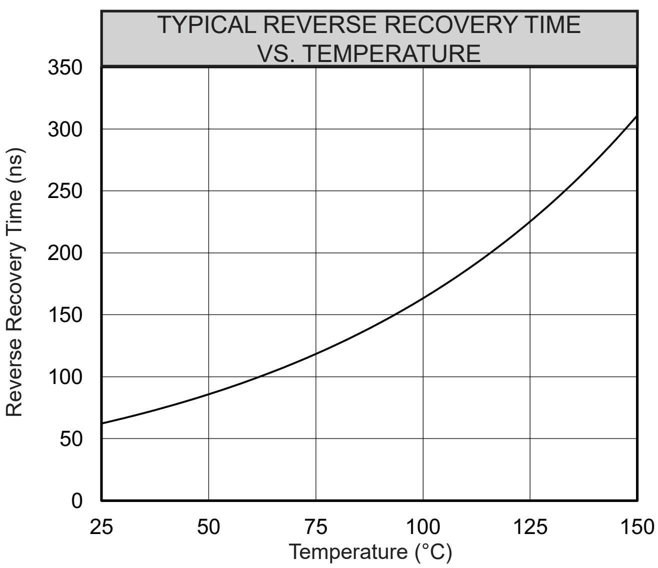
Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

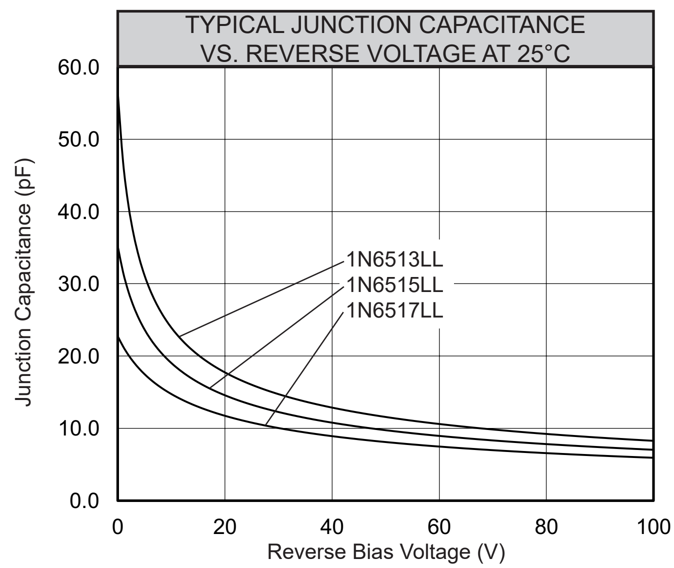

POWER DERATING
Maximum Power Dissipation (W)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
8
7
6
5
4
3
2
1
0
1N6515LL
1N6513LL
0
2
4
6
8
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
12
10
8
6
4
2
0
1N6517LL
0
1
2
3
4
5
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
350
300
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)

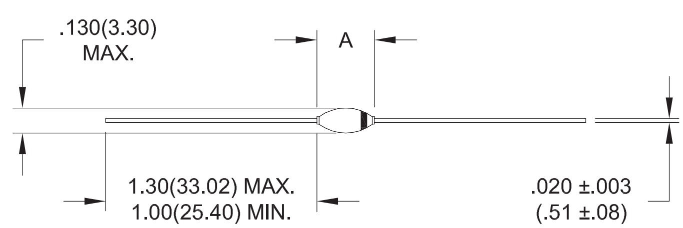

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1N6513LL
1N6515LL
1N6517LL
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Axial Lead

20mA - 40mA • 30ns - 50ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance $\theta_{J\text{-}L}$			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
M50FF3	5000	40	20	0.1	10	12.5	40	2.0	0.4	30	18	30	50	1.0
M100FF3	10000	20	10	0.1	10	25.0	20	1.0	0.2	30	18	30	50	0.5
M50FF5	5000	40	20	0.1	10	12.5	40	2.0	0.4	50	18	30	50	1.0
M100FF5	10000	20	10	0.1	10	25.0	20	1.0	0.2	50	18	30	50	0.5

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=12.5mA, Ir=25mA, Irr=6.3mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
M50FF3	.225(5.72) MAX.
M100FF3	.300(7.62) MAX.
M50FF5	.225(5.72) MAX.
M100FF5	.300(7.62) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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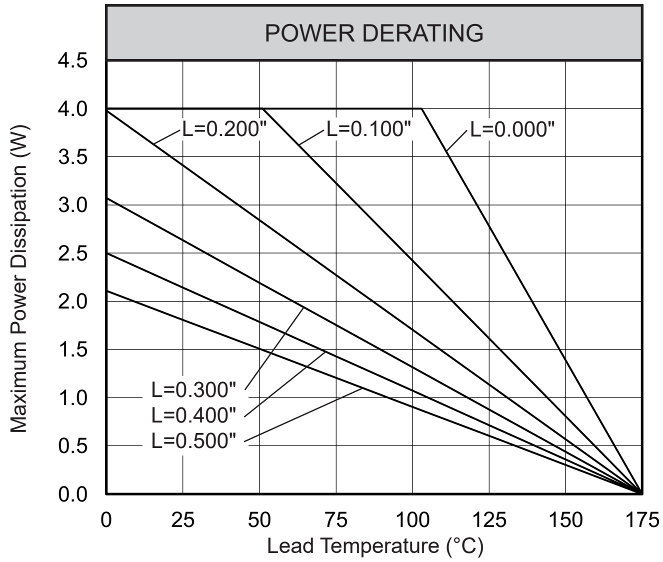
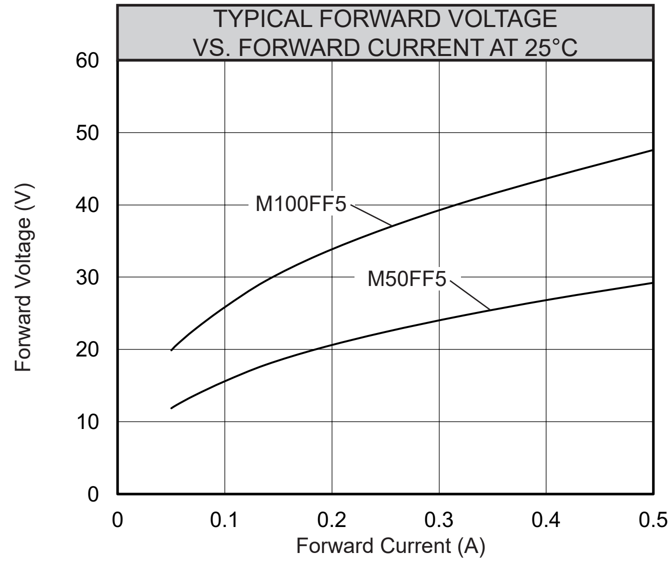
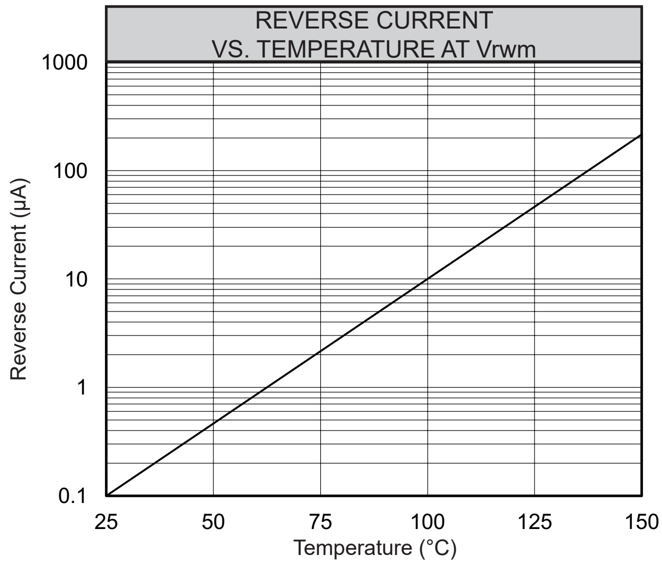
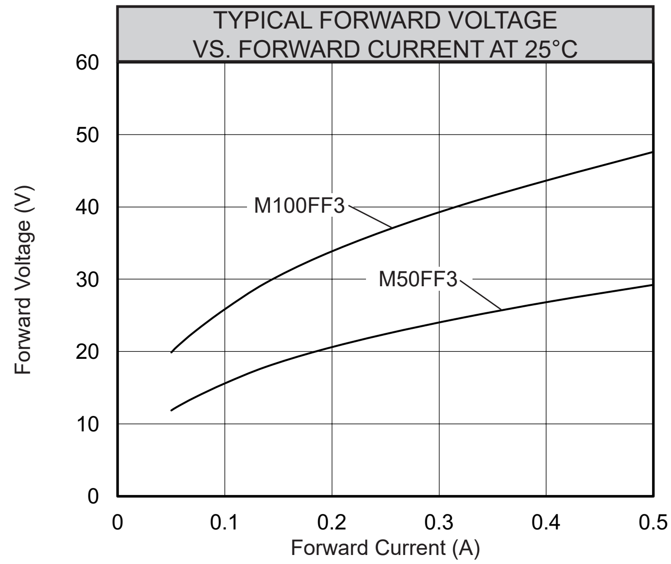
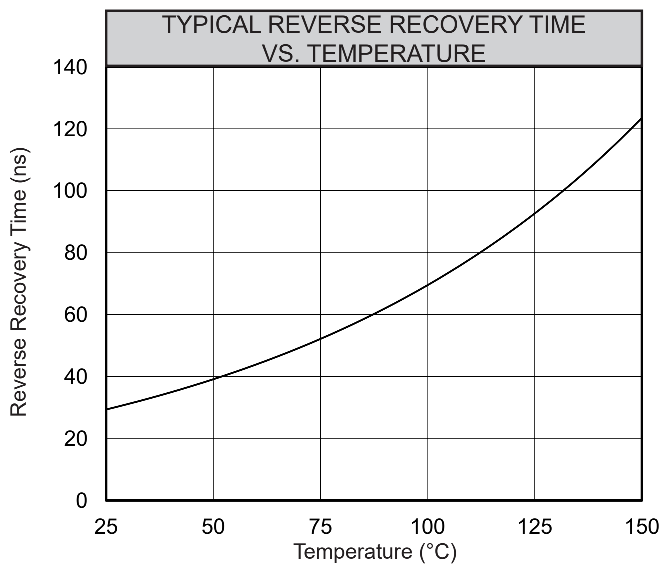
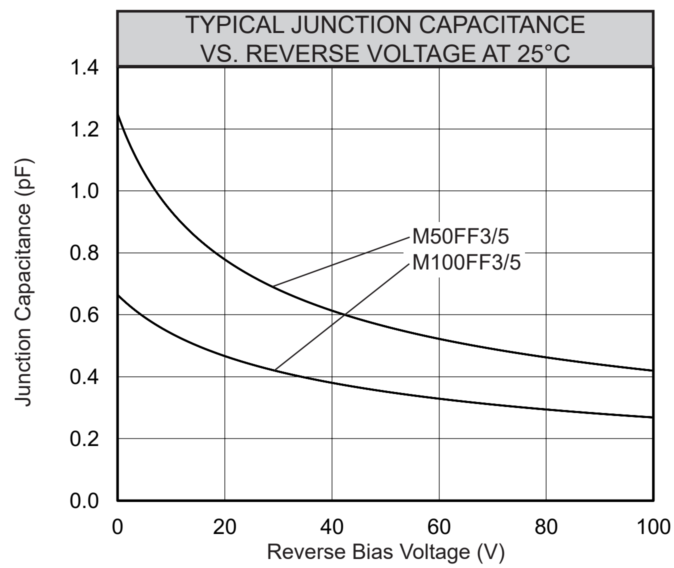

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
0 25 50 75 100 125 150 175


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
M100FF5
M50FF5
0 10 20 30 40 50 60
0 0.1 0.2 0.3 0.4 0.5


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
Temperature (°C)
0.1 1 10 100 1000
25 50 75 100 125 150


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
M100FF3
M50FF3
0 10 20 30 40 50 60
0 0.1 0.2 0.3 0.4 0.5


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)
0 20 40 60 80 100 120 140
25 50 75 100 125 150


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
M50FF3/5
M100FF3/5
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4
0 20 40 60 80 100

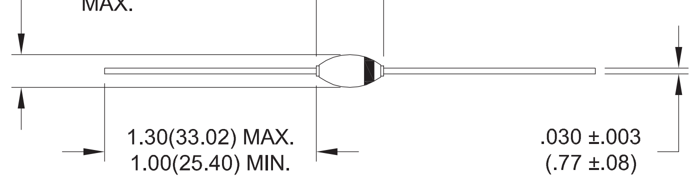
3

High Voltage Diodes - Axial Lead

50mA - 420mA • 30ns - 50ns • Hermetic

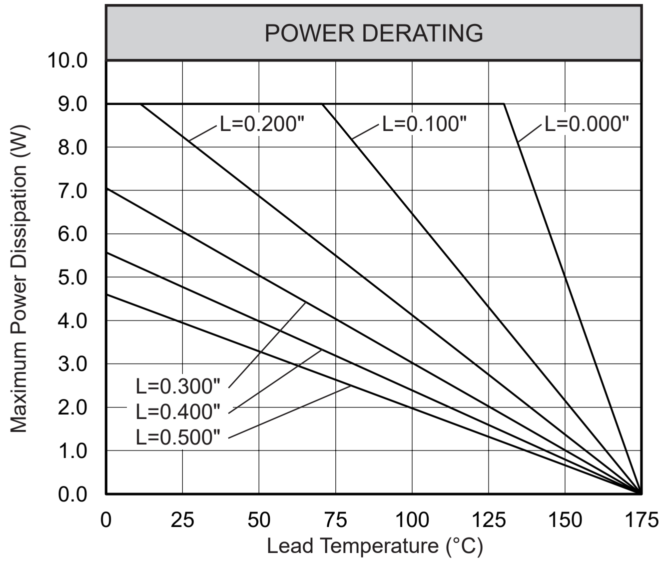
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
X20FF3	2000	420	210	1.0	20	7.5	420	16.0	3.0	30	5	12	22	4.0
X50FF3	5000	150	75	1.0	20	12.5	150	10.0	1.0	30	5	12	22	3.0
X100FF3	10000	80	40	1.0	20	25.0	80	2.0	0.5	30	5	12	22	2.0
X150FF3	15000	50	25	1.0	20	37.5	50	1.6	0.3	30	5	12	22	2.0
X20FF5	2000	420	210	1.0	20	7.5	420	16.0	3.0	50	5	12	22	4.0
X50FF5	5000	150	75	1.0	20	12.5	150	10.0	1.0	50	5	12	22	3.0
X100FF5	10000	80	40	1.0	20	25.0	80	2.0	0.5	50	5	12	22	2.0
X150FF5	15000	50	25	1.0	20	37.5	50	1.6	0.3	50	5	12	22	2.0

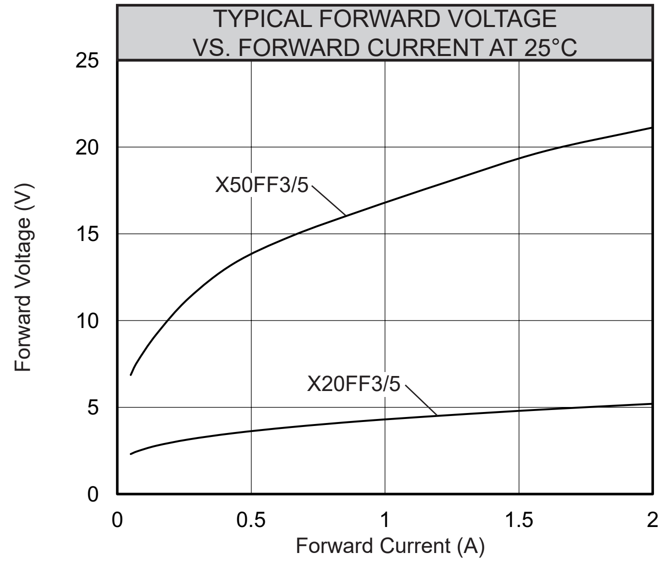
(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



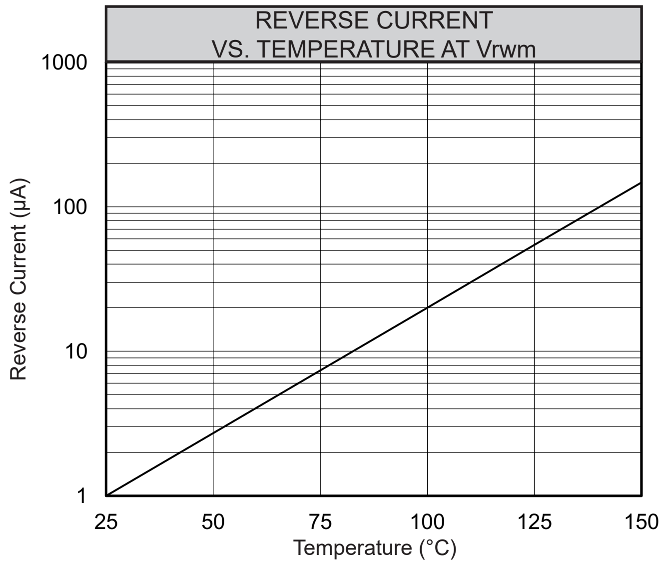
Part	A
X20FF(X)	.240(6.10) MAX.
X50FF(X)	.260(6.60) MAX.
X100FF(X)	.320(8.13) MAX.
X150FF(X)	.360(9.14) MAX.

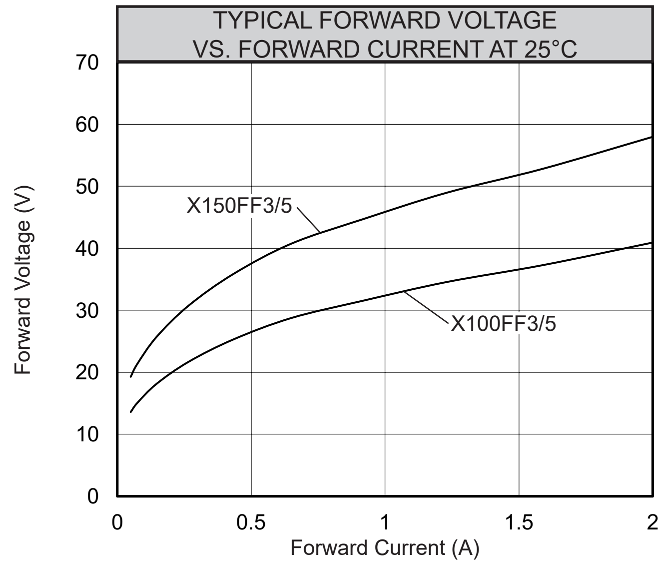
Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

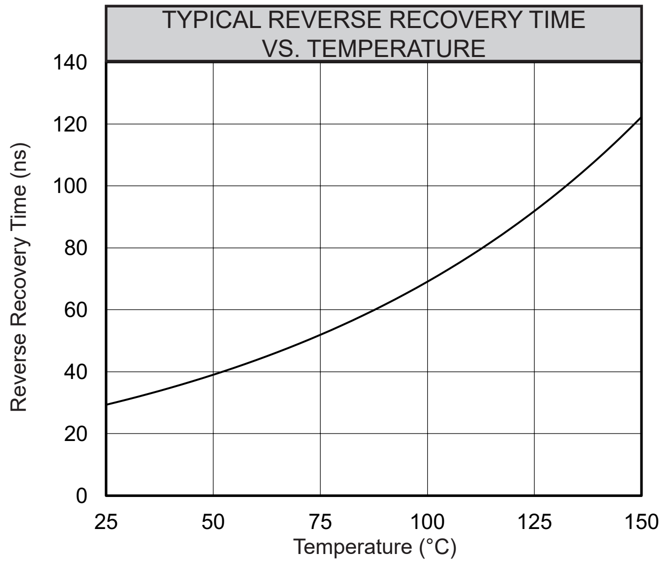

POWER DERATING
Maximum Power Dissipation (W)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)

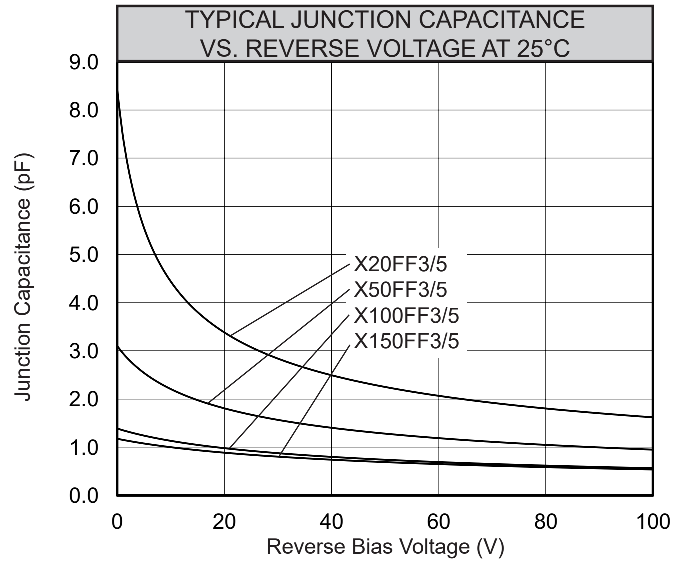

TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
X50FF3/5
X20FF3/5
0
0.5
1
1.5
2
Forward Current (A)

3


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
70
60
50
40
30
20
10
0
X150FF3/5
X100FF3/5
0
0.5
1
1.5
2
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)

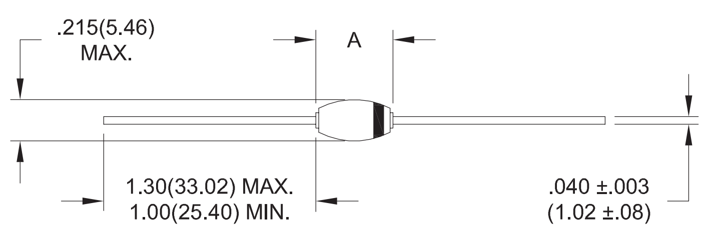

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
X20FF3/5
X50FF3/5
X100FF3/5
X150FF3/5
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Axial Lead

180mA - 1000mA • 30ns - 50ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
Z20FF3	2000	1000	750	1.0	25	6.0	750	65.0	10.0	30	3	6	12	20.0
Z50FF3	5000	360	180	1.0	25	12.5	360	20.0	4.0	30	3	6	12	16.0
Z100FF3	10000	180	90	1.0	25	25.0	180	10.0	2.0	30	3	6	12	8.0
Z20FF5	2000	1000	750	1.0	25	6.0	750	65.0	10.0	50	3	6	12	20.0
Z50FF5	5000	360	180	1.0	25	12.5	360	20.0	4.0	50	3	6	12	16.0
Z100FF5	10000	180	90	1.0	25	25.0	180	10.0	2.0	50	3	6	12	8.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
Z20FF(X) Z50FF(X)	.350(8.89) MAX.
Z100FF(X)	.400(10.16) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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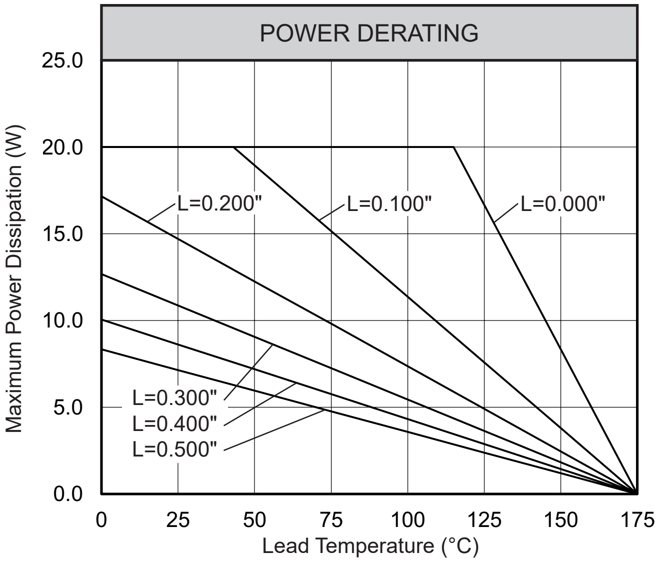
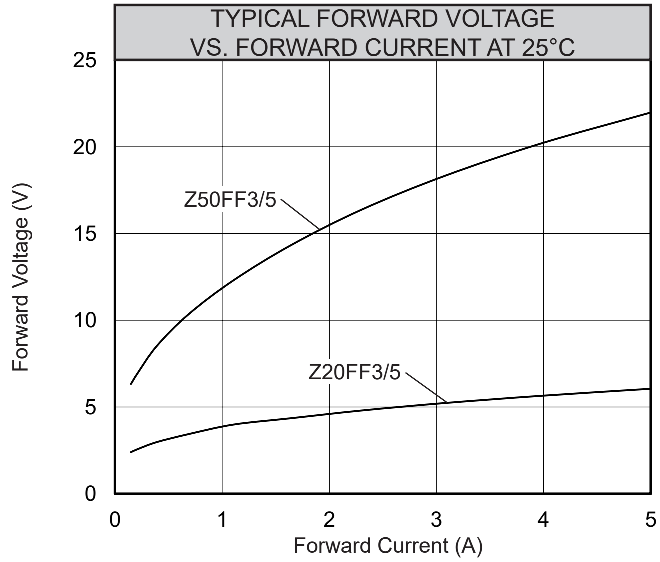
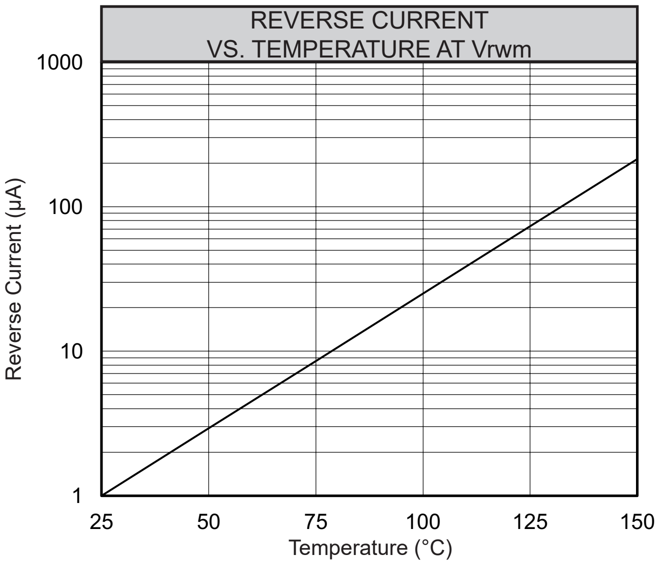
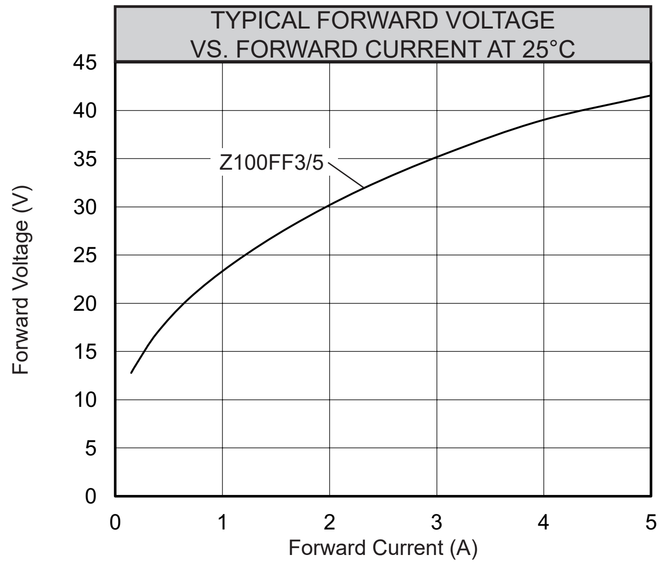
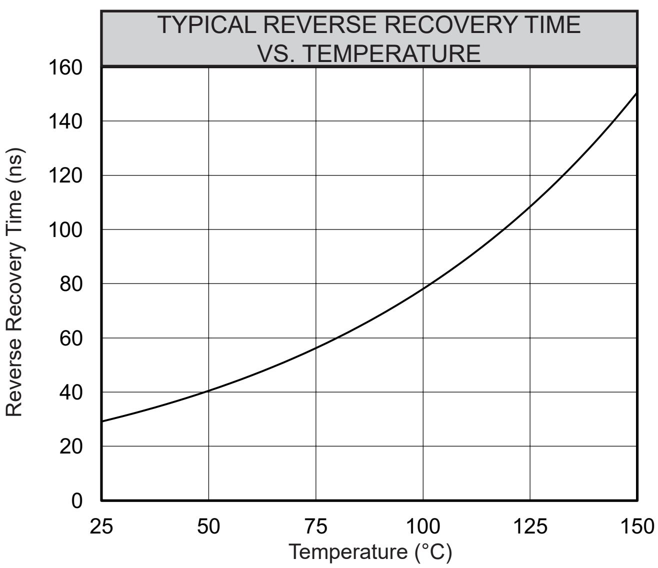
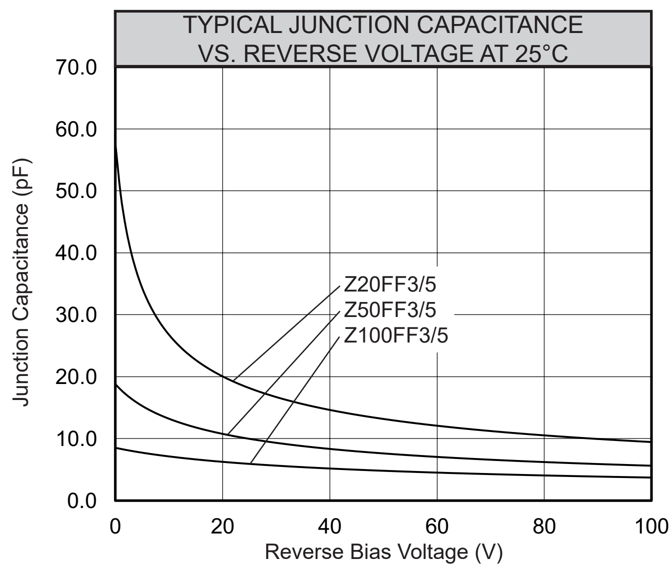

POWER DERATING
Maximum Power Dissipation (W)
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
Z50FF3/5
Z20FF3/5
0
1
2
3
4
5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
45
40
35
30
25
20
15
10
5
0
Z100FF3/5
0
1
2
3
4
5
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
160
140
120
100
80
60
40
20
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Z20FF3/5
Z50FF3/5
Z100FF3/5
0
20
40
60
80
100
Reverse Bias Voltage (V)

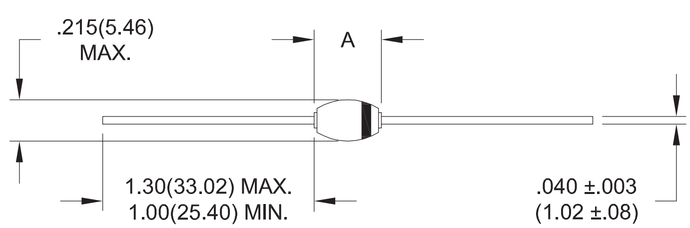
High Voltage Diodes - Axial Lead

500mA - 1500mA • 30ns - 50ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.125	L=.250	25°C
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
1N6837	5000	500	250	1.0	25	12.0	500	20.0	4.0	30	3	6	12	16.0
1N6838	2000	1500	1000	1.0	25	4.5	1500	60.0	10.0	50	3	6	12	20.0
1N6839	5000	600	500	1.0	25	10.0	600	30.0	6.0	50	3	6	12	16.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
1N6837	.350(8.89) MAX.
1N6838	
1N6839	

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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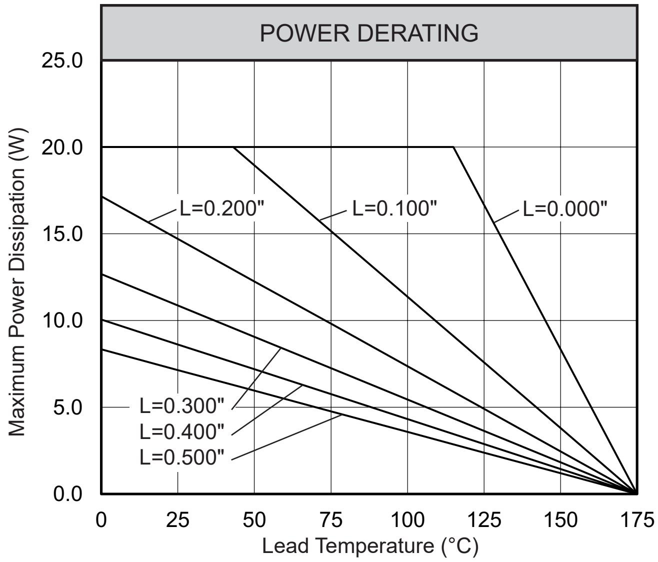
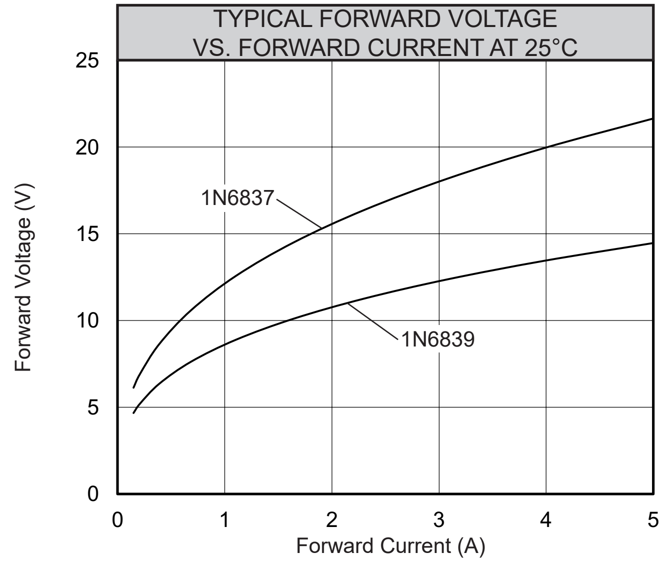
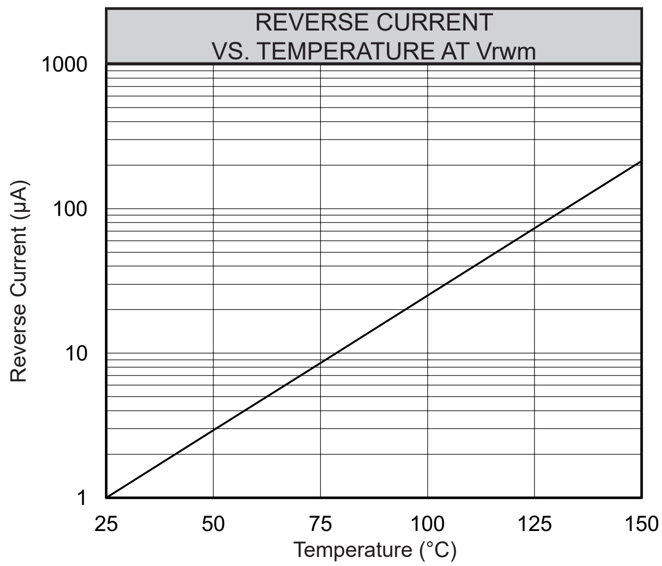


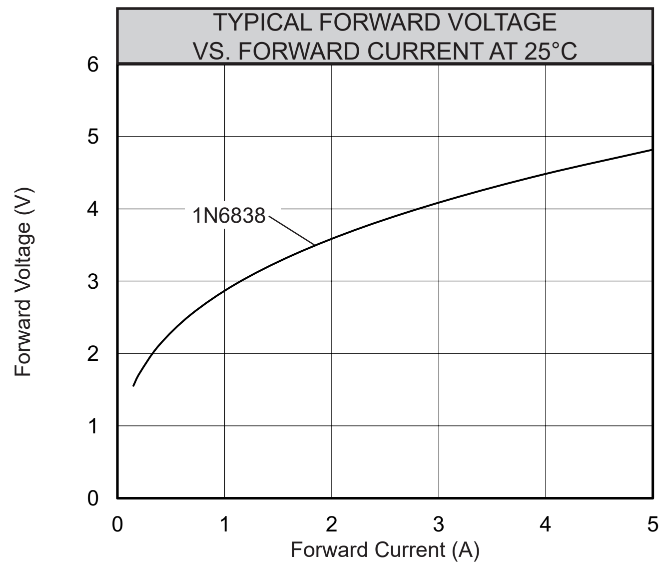
POWER DERATING
Maximum Power Dissipation (W)
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)



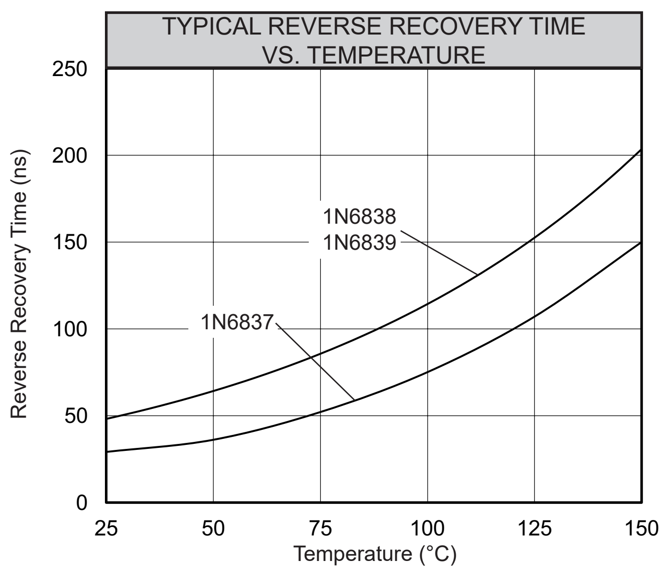
TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
1N6837
1N6839
0
1
2
3
4
5
Forward Current (A)



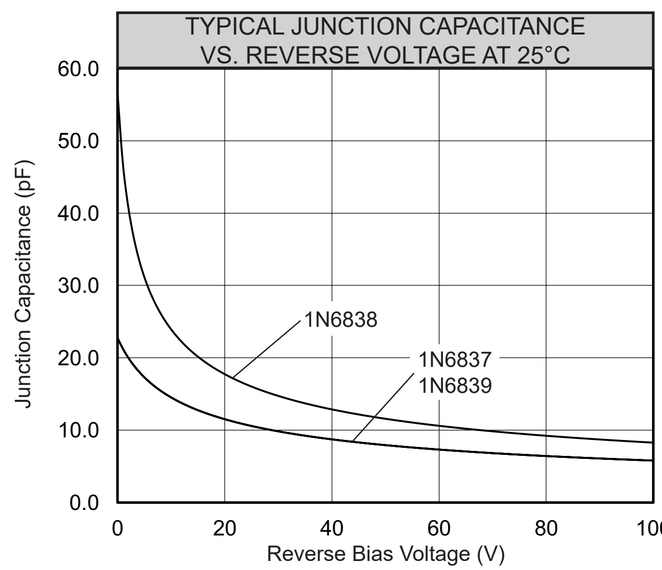
REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)



TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
6
5
4
3
2
1
0
1N6838
0
1
2
3
4
5
Forward Current (A)



TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
250
200
150
100
50
0
1N6838
1N6839
1N6837
25
50
75
100
125
150
Temperature (°C)



TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1N6838
1N6837
1N6839
0
20
40
60
80
100
Reverse Bias Voltage (V)

3

High Voltage Diodes - Axial Lead

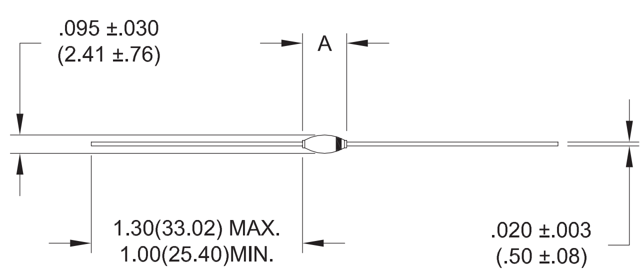
25mA - 250mA • 70ns • Hermetic • JANTX • JANTXV

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
1N6529	2000	250	125	0.1	10	3.0	25	10	1.50	70	18	30	50	4.0
1N6531	3000	100	50	0.1	10	7.0	25	8	1.25	70	18	30	50	2.0
1N6533	5000	50	25	0.1	10	9.0	25	4	0.75	70	18	30	50	1.0
1N6535	10000	25	12	0.1	10	14.0	25	2	0.38	70	18	30	50	0.5

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=12.5mA, Ir=25mA, Irr=6.25mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C

Part	A
1N6529	.200(5.08) MAX. .140(3.56) MIN.
1N6531	.220(5.59) MAX. .160(4.06) MIN.
1N6533	.240(6.10) MAX. .180(4.57) MIN.
1N6535	.300(7.62) MAX. .240(6.10) MIN.



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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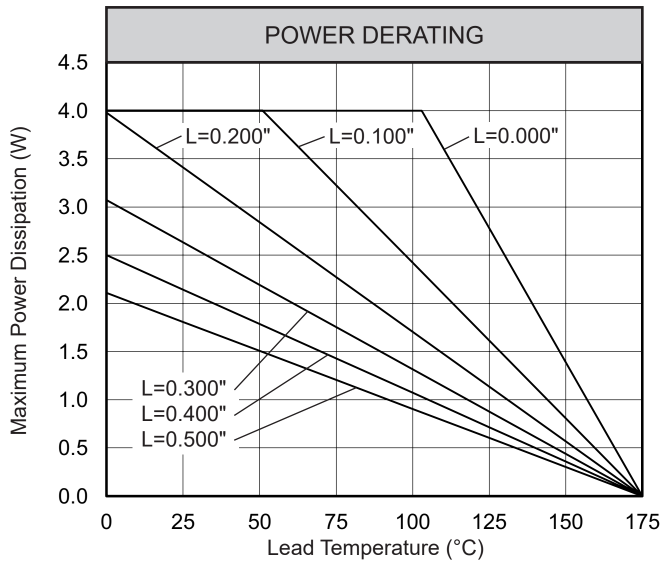
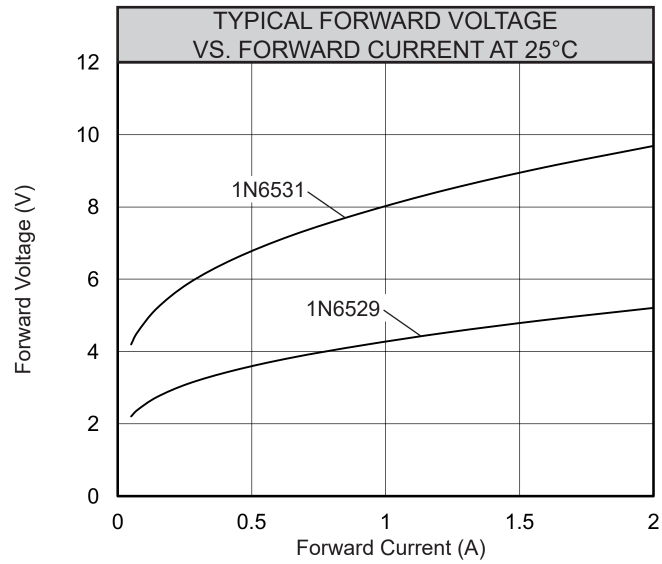
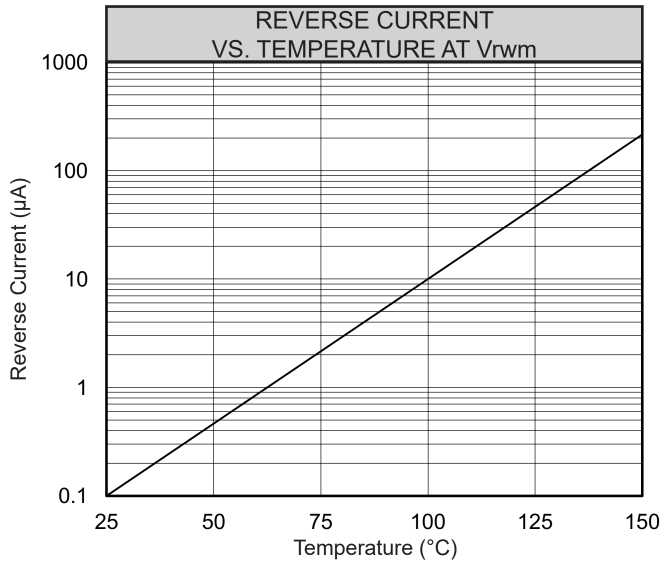
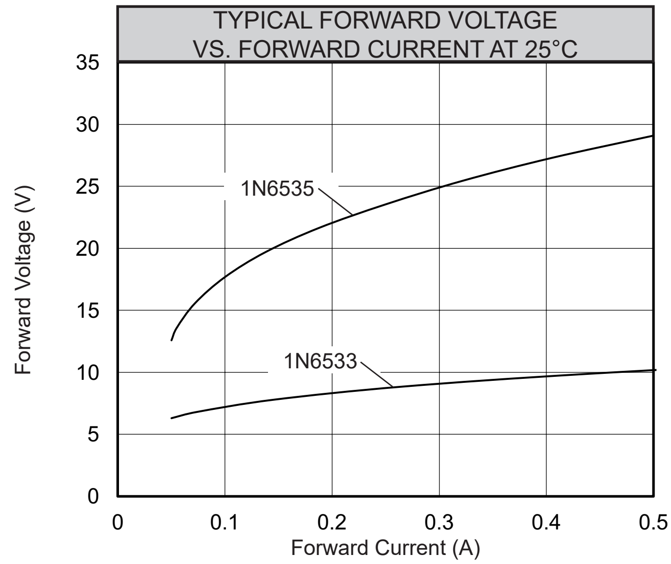
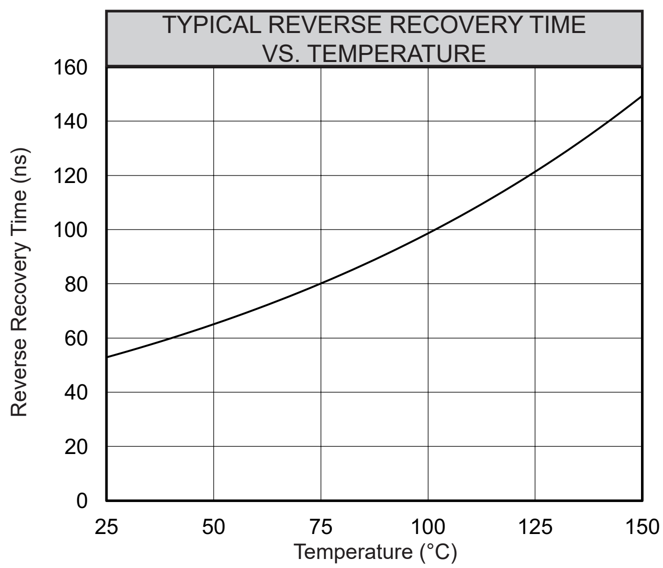
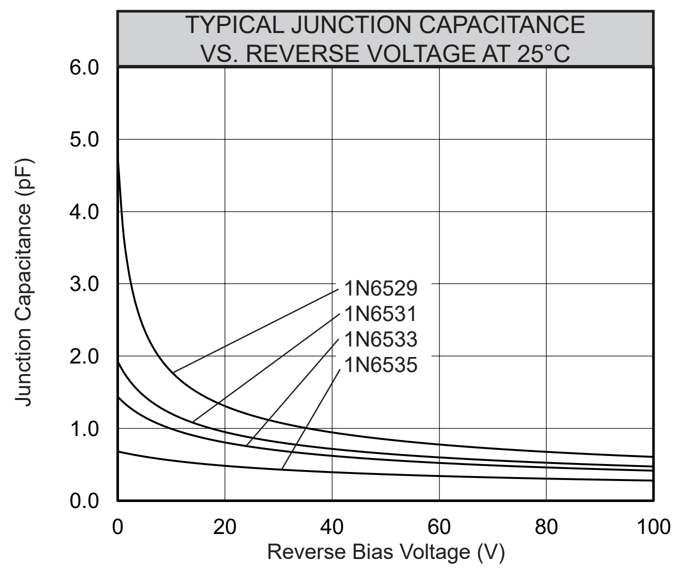

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.000"
L=0.100"
L=0.200"
L=0.300"
L=0.400"
L=0.500"
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
25
50
75
100
125
150
175


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
1N6531
1N6529
0
2
4
6
8
10
12
0
0.5
1
1.5
2


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
Temperature (°C)
0.1
1
10
100
1000
25
50
75
100
125
150


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
1N6535
1N6533
0
5
10
15
20
25
30
35
0
0.1
0.2
0.3
0.4
0.5


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)
0
20
40
60
80
100
120
140
160
25
50
75
100
125
150


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
1N6529
1N6531
1N6533
1N6535
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0
20
40
60
80
100

High Voltage Diodes - Axial Lead

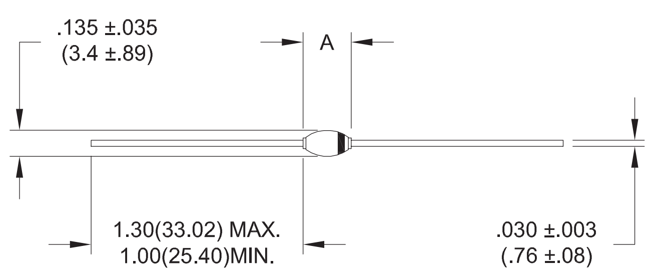
100mA - 500mA • 70ns • Hermetic • JANTX • JANTXV

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
1N6521	2000	500	250	0.5	20	3.0	500	25	5.00	70	5	12	22	8.0
1N6523	3000	250	125	0.5	20	5.0	250	15	3.00	70	5	12	22	4.0
1N6525	5000	150	75	0.5	20	7.0	150	10	2.00	70	5	12	22	3.0
1N6527	10000	100	50	0.5	20	12.0	100	5	1.00	70	5	12	22	2.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C

Part	A
1N6521	.220(5.59) MAX. .160(4.06) MIN.
1N6523	.240(6.10) MAX. .180(4.57) MIN.
1N6525	.260(6.60) MAX. .200(5.08) MIN.
1N6527	.320(8.13) MAX. .260(6.60) MIN.



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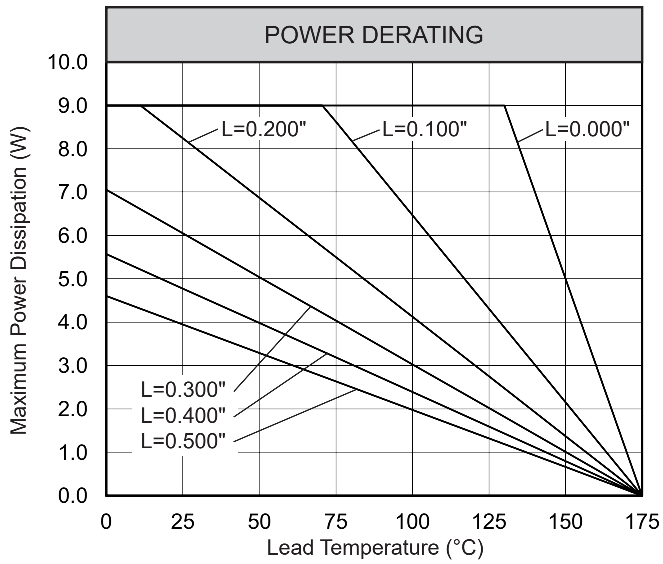
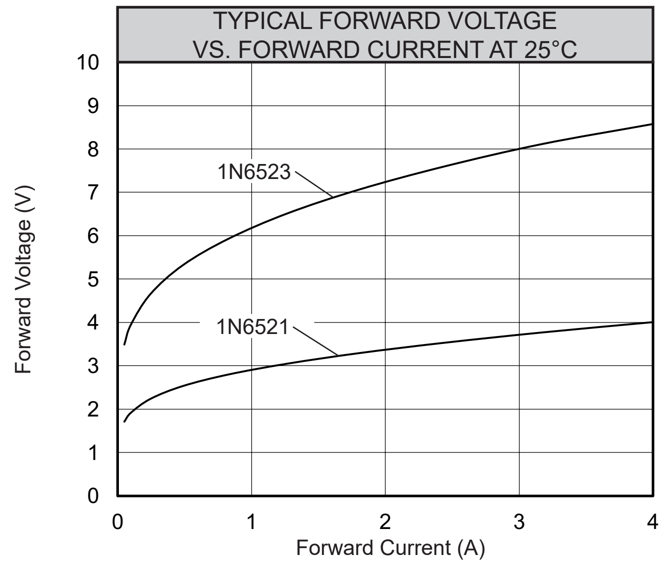
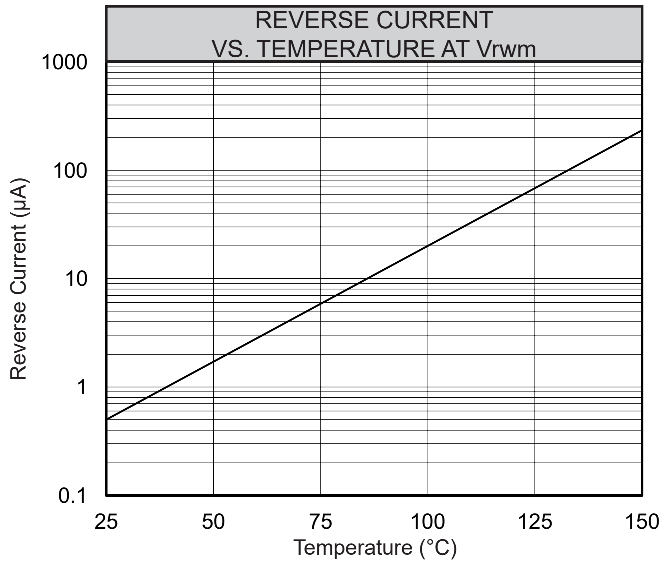
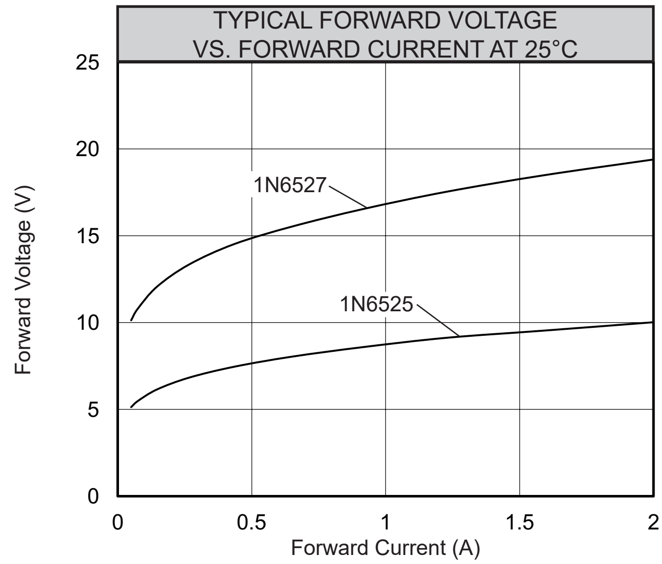
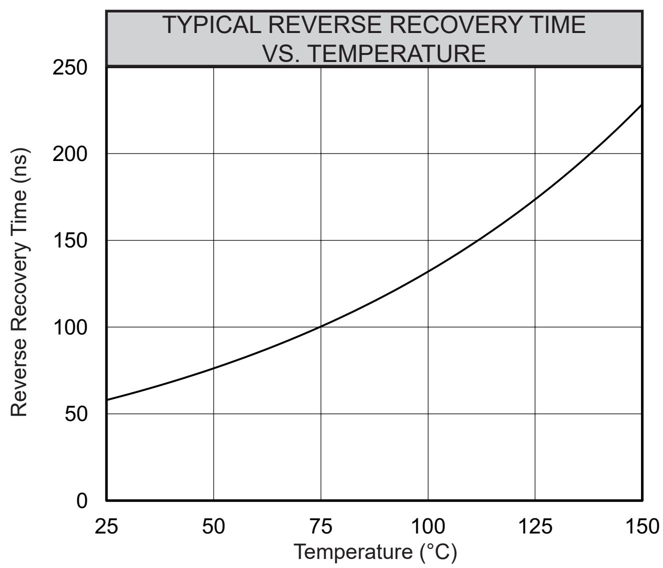
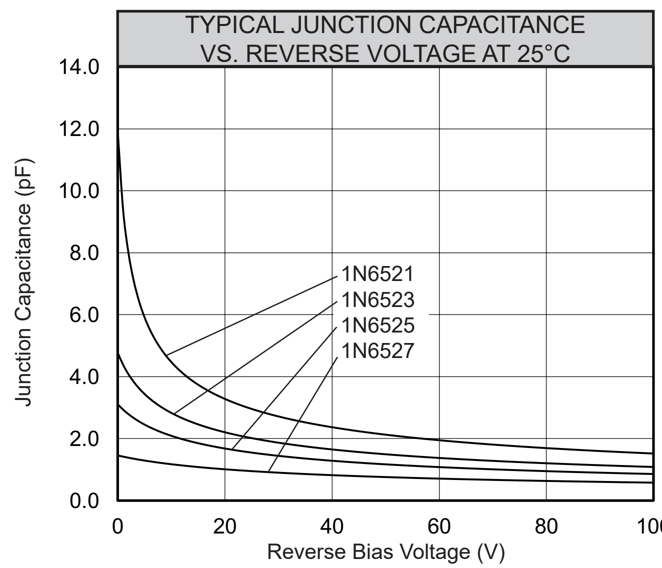

POWER DERATING
Maximum Power Dissipation (W)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
10
9
8
7
6
5
4
3
2
1
0
1N6523
1N6521
0
1
2
3
4
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
1N6527
1N6525
0
0.5
1
1.5
2
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1N6521
1N6523
1N6525
1N6527
0
20
40
60
80
100
Reverse Bias Voltage (V)

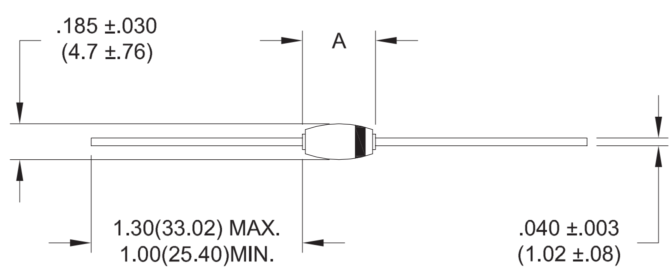
High Voltage Diodes - Axial Lead

0.5A - 2.0A • 70ns • Hermetic • JANTX • JANTXV

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
1N6513	2000	2.00	1.50	1.0	25	3.5	2.00	100	15.00	70	3	6	12	25.0
1N6515	3000	1.50	1.00	1.0	25	6.0	1.50	60	10.00	70	3	6	12	20.0
1N6517	5000	1.00	0.50	1.0	25	8.0	1.00	40	8.00	70	3	6	12	16.0
1N6519	10000	0.50	0.25	1.0	25	13.0	0.50	25	5.00	70	3	6	12	8.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -65°C to +175°C Stg. Temp.= -65°C to +200°C

Part	A
1N6513	.310(7.82) MAX. .250(6.35) MIN.
1N6515	.330(8.38) MAX. .270(6.85) MIN.
1N6517	.350(8.89) MAX. .290(7.37) MIN.
1N6519	.400(10.16) MAX. .340(8.64) MIN.



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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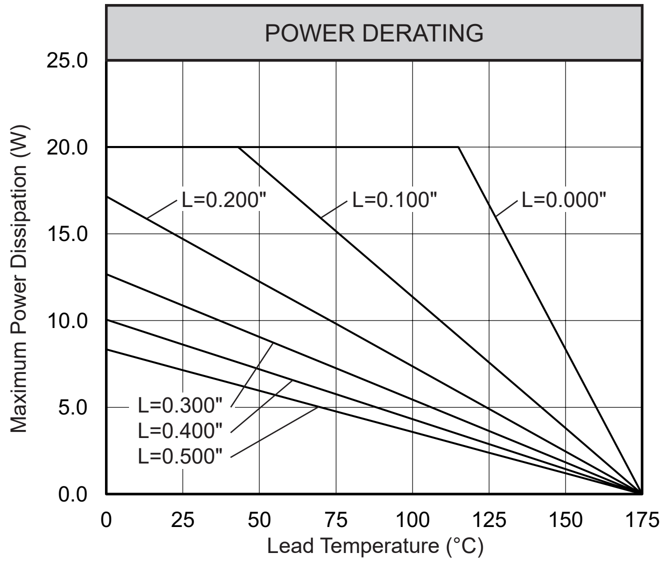
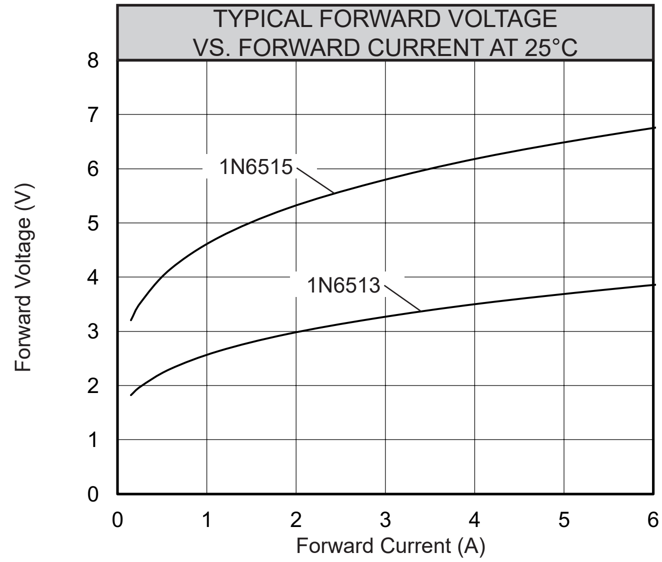
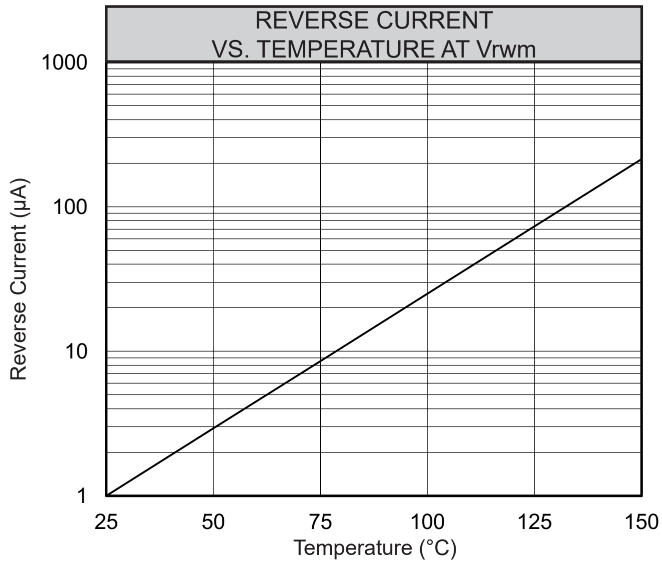
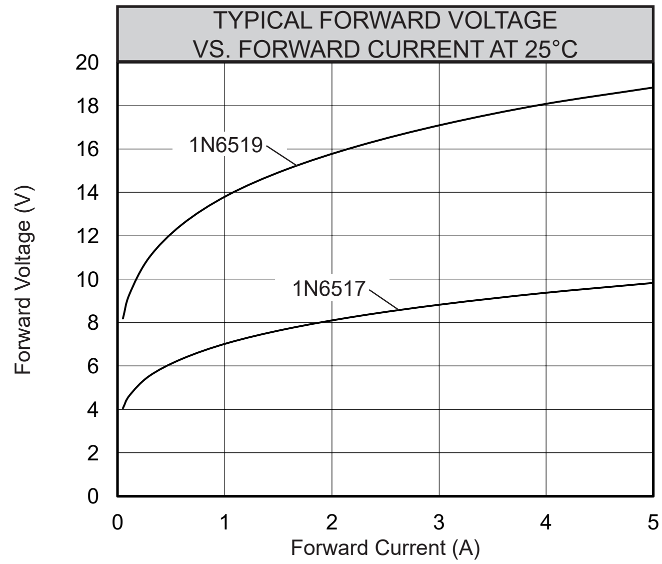
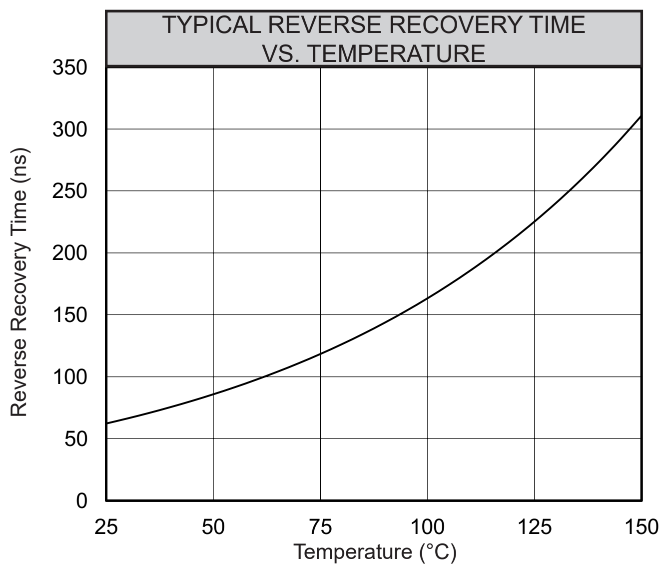
1N6513 1N6515 1N6517 1N6519

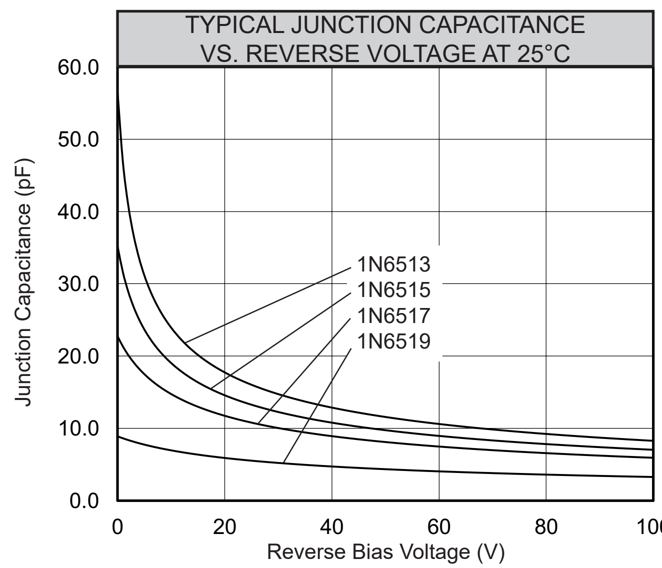












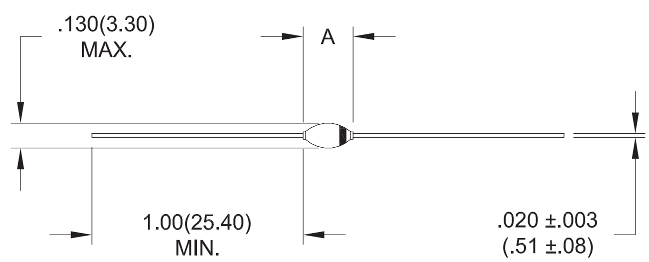
High Voltage Diodes - Axial Lead

10mA - 100mA • 100ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
M25UFG	2500	100	50	0.1	10	7.0	25	8.0	1.3	100	18	30	50	2.0
M50UFG	5000	50	25	0.1	10	9.0	25	4.0	0.8	100	18	30	50	1.0
M100UFG	10000	25	12	0.1	10	14.0	25	2.0	0.4	100	18	30	50	0.5
M160UFG	16000	10	5	0.1	10	35.0	10	1.0	0.2	100	33	45	65	0.5

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=12.5mA, Ir=25mA, Irr=6.3mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
M25UFG	.200(5.08) MAX.
M50UFG	.225(5.72) MAX.
M100UFG	.300(7.62) MAX.
M160UFG	.350(8.89) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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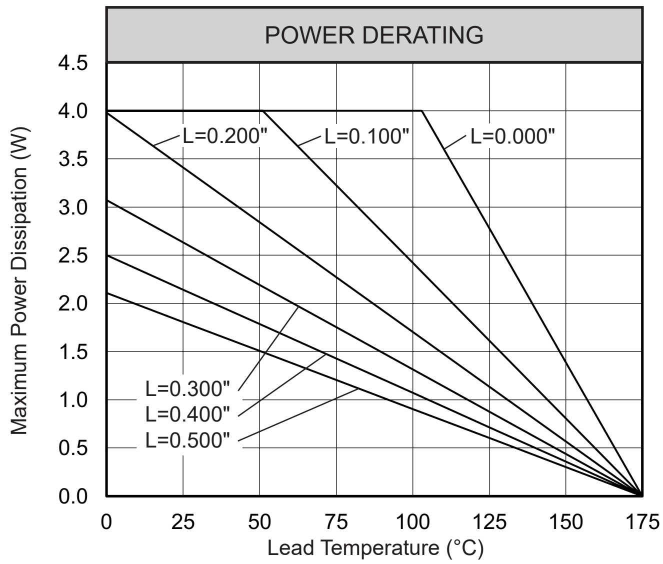
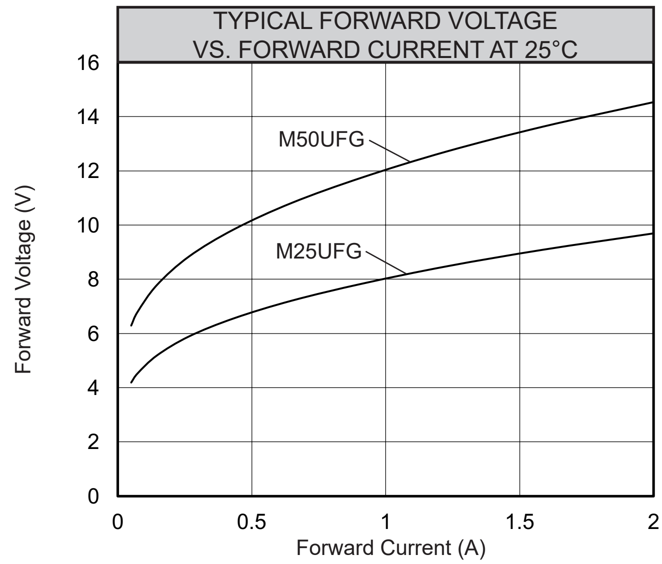
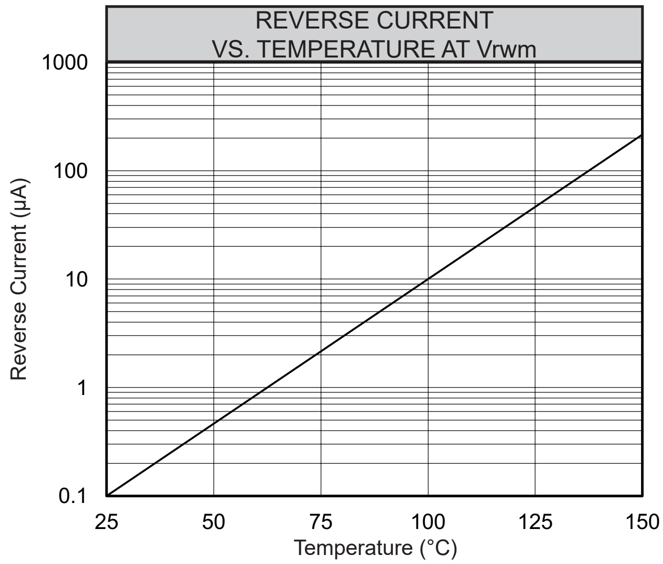
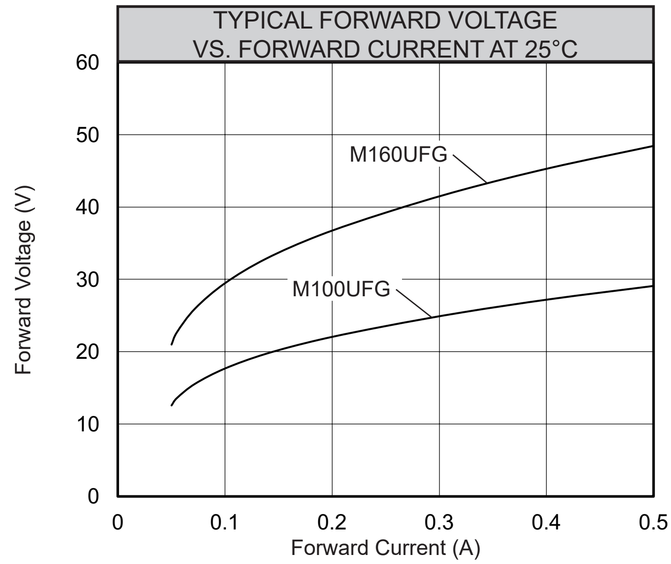
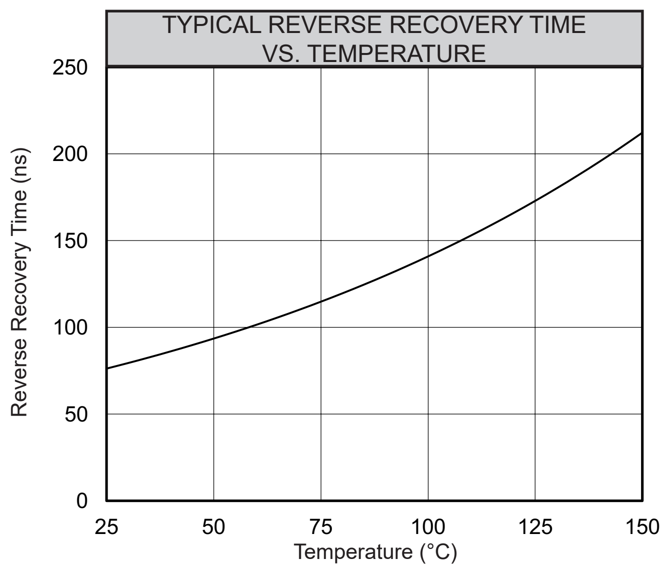
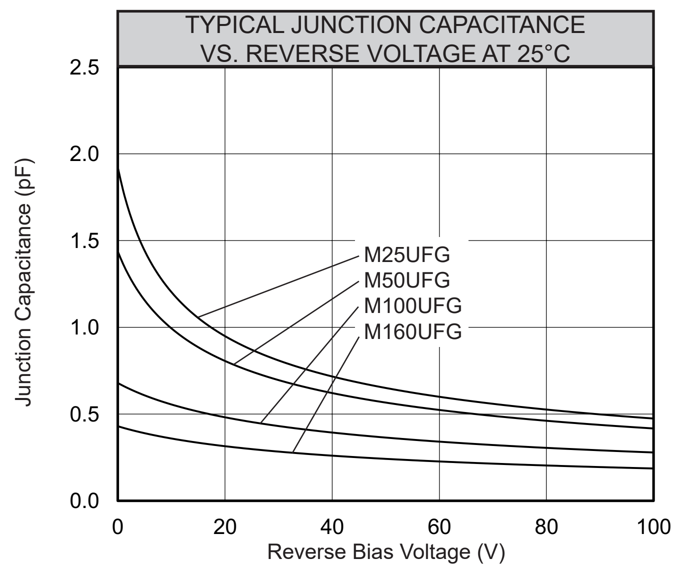

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"


TYPICAL FORWARD VOLTAGE VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
M50UFG
M25UFG


REVERSE CURRENT VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
Temperature (°C)


TYPICAL FORWARD VOLTAGE VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
M160UFG
M100UFG


TYPICAL REVERSE RECOVERY TIME VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)

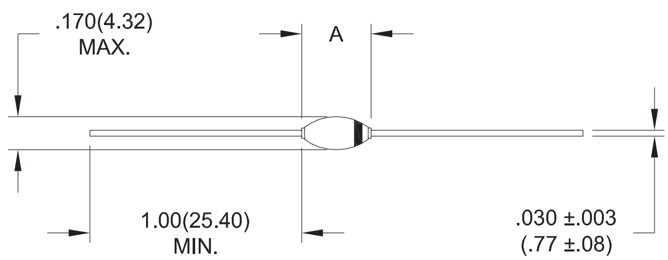

TYPICAL JUNCTION CAPACITANCE VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
M25UFG
M50UFG
M100UFG
M160UFG

High Voltage Diodes - Axial Lead

25mA - 250mA • 100ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
X25UFG	2500	250	125	1.0	20	7.0	100	15.0	3.0	100	5	12	22	4.0
X50UFG	5000	150	75	1.0	20	9.0	100	10.0	2.0	100	5	12	22	3.0
X100UFG	10000	100	50	1.0	20	14.0	100	5.0	1.0	100	5	12	22	2.0
X150UFG	15000	50	25	1.0	20	22.0	100	3.0	0.5	100	5	12	22	2.0
X200UFG	20000	25	13	1.0	20	30.0	50	2.0	0.5	100	5	12	22	2.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
X25UFG	.240(6.10) MAX.
X50UFG	.260(6.60) MAX.
X100UFG	.320(8.13) MAX.
X150UFG	.360(9.14) MAX.
X200UFG	.380(9.65) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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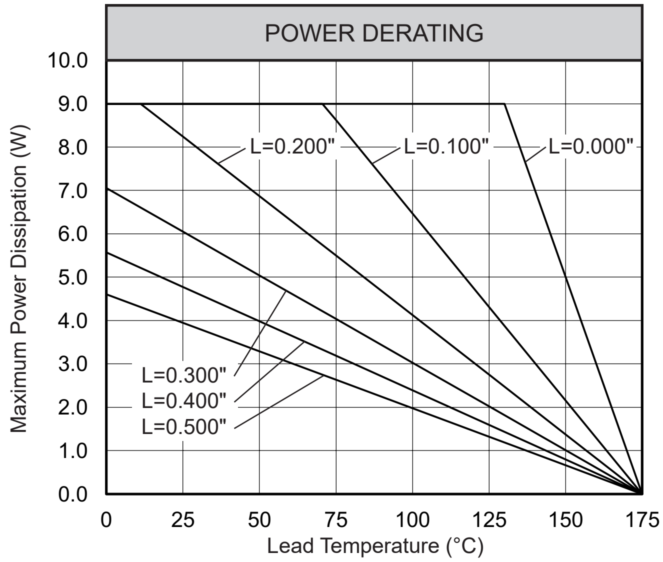
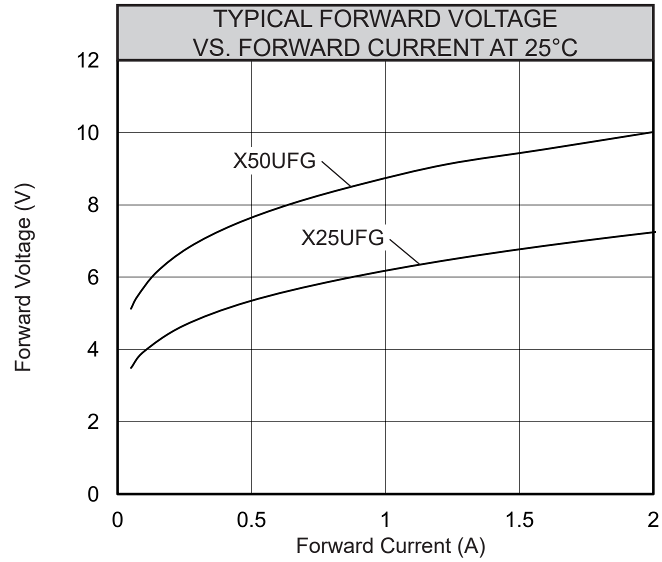
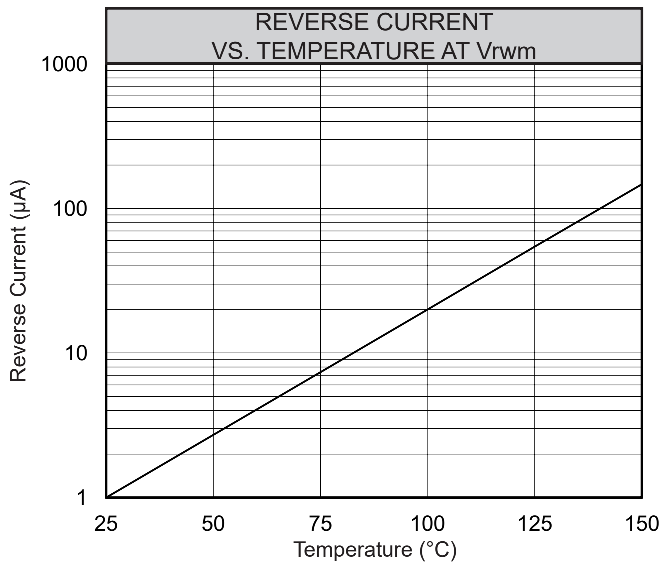
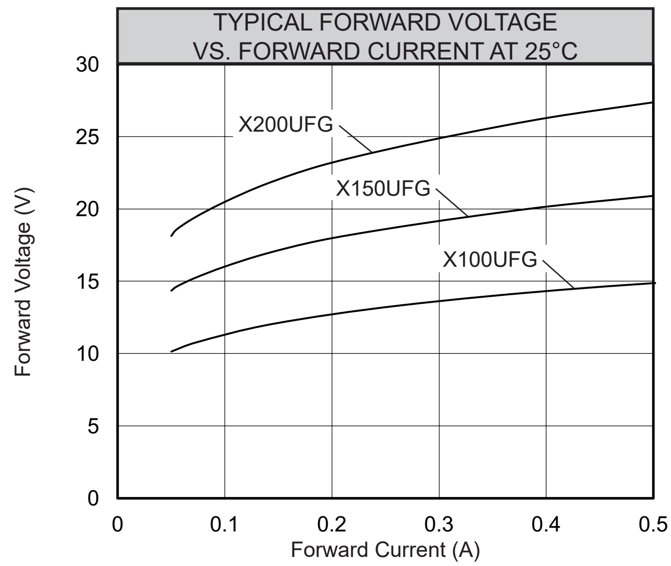
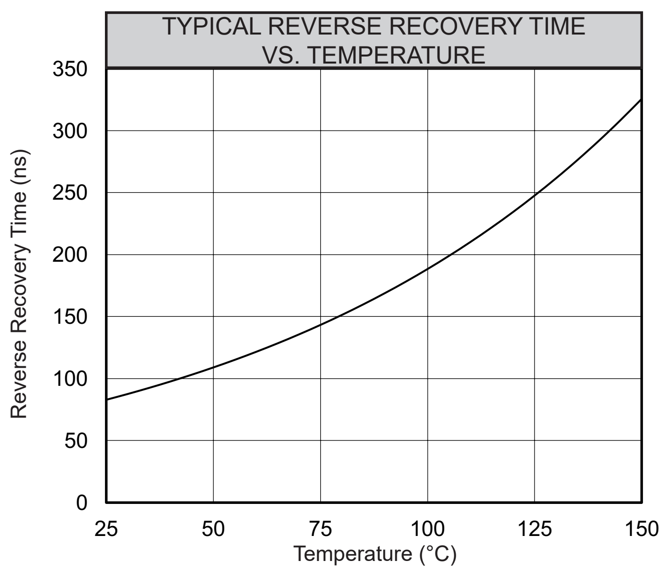
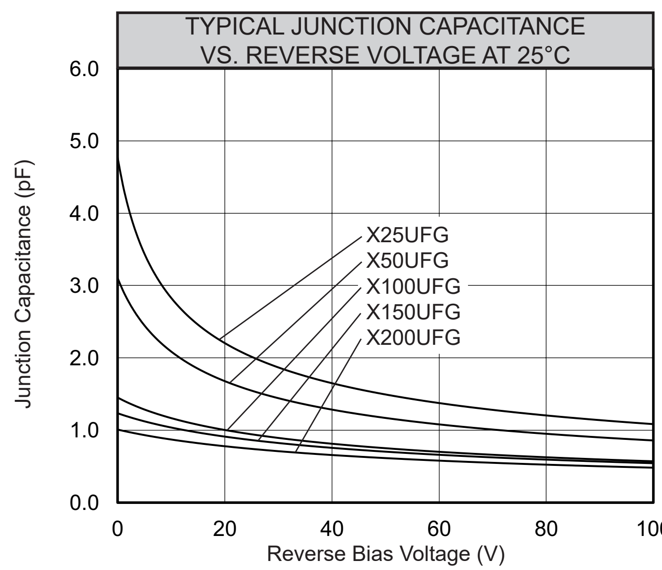

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
25
50
75
100
125
150
175


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
X50UFG
X25UFG
12
10
8
6
4
2
0
0
0.5
1
1.5
2


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
Temperature (°C)
1000
100
10
1
25
50
75
100
125
150


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
X200UFG
X150UFG
X100UFG
30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)
350
300
250
200
150
100
50
0
25
50
75
100
125
150

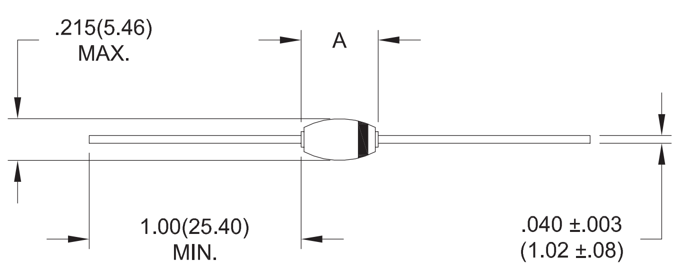

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
X25UFG
X50UFG
X100UFG
X150UFG
X200UFG
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100

High Voltage Diodes - Axial Lead

300mA - 1500mA • 100ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance $\theta_{J\text{-}L}$			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
Z25UFG	2500	1500	1000	1.0	25	7.5	2000	60.0	10.0	100	3	6	12	20.0
Z50UFG	5000	1000	500	1.0	25	10.5	1000	40.0	8.0	100	3	6	12	16.0
Z100UFG	10000	500	250	1.0	25	14.0	600	25.0	5.0	100	3	6	12	8.0
Z150UFG	15000	300	150	1.0	25	22.0	300	10.0	2.0	100	3	6	12	5.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
Z25UFG	.290(7.37) MAX.
Z50UFG	.330(8.38) MAX.
Z100UFG	.400(10.16) MAX.
Z150UFG	.450(11.43) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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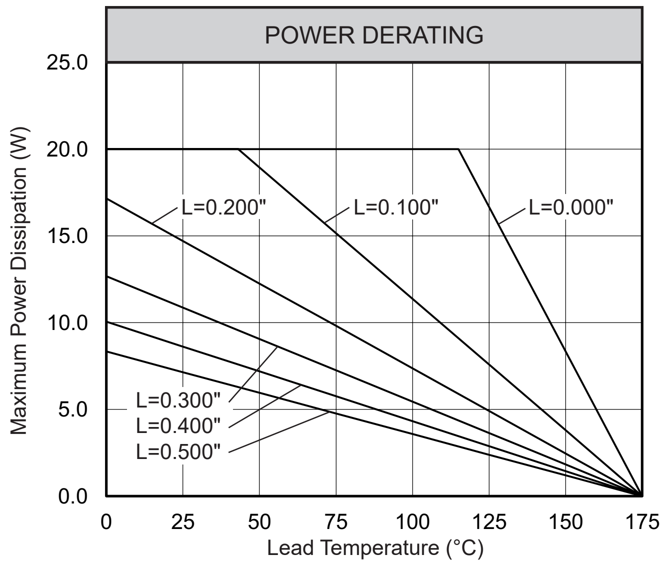
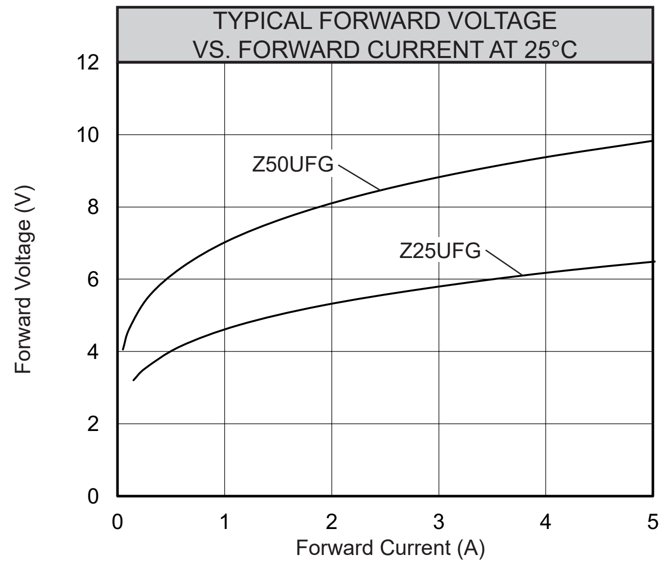
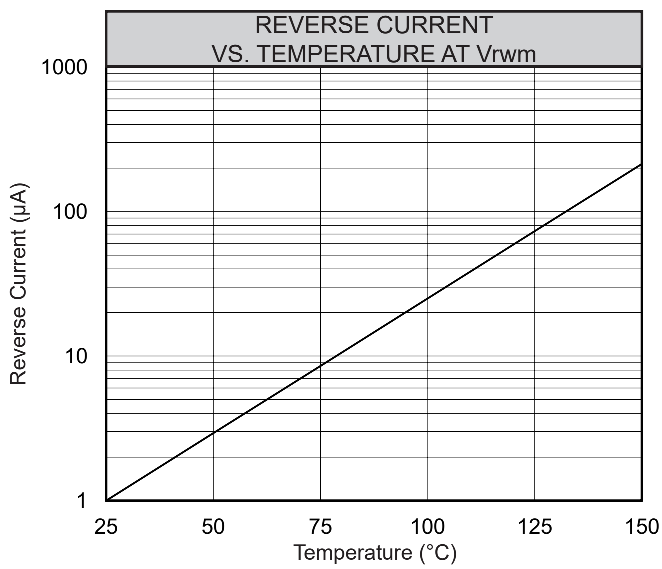
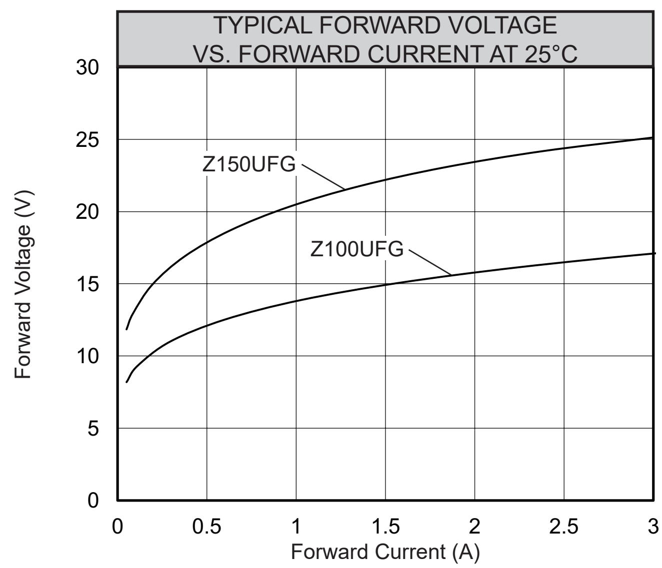
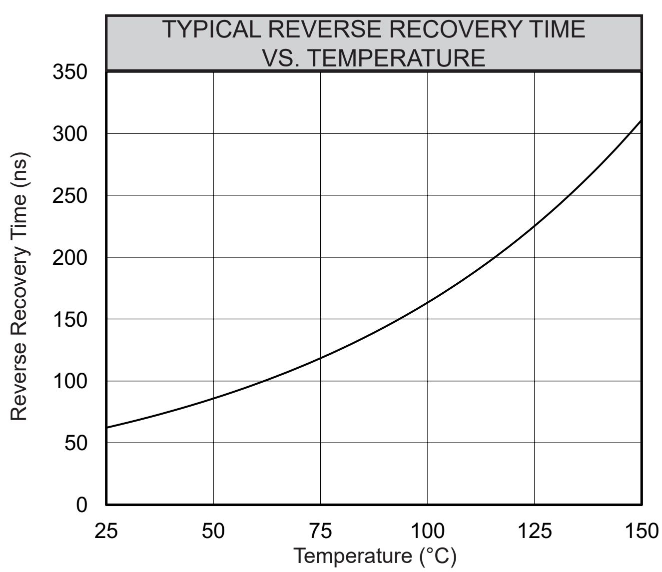
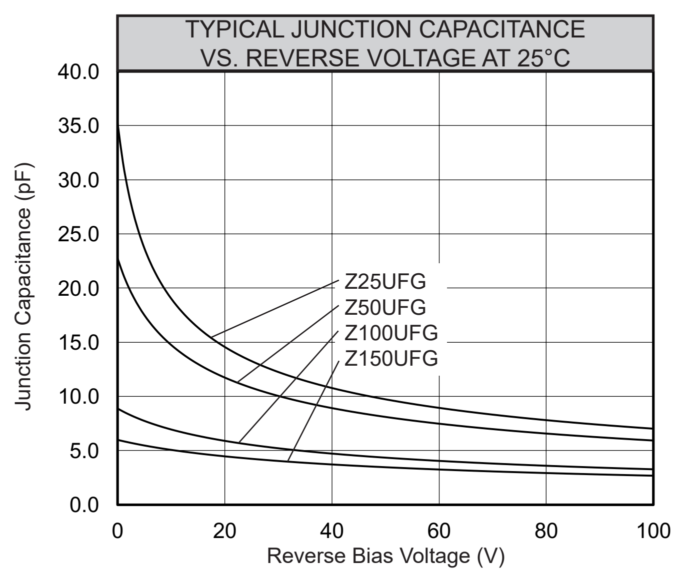

POWER DERATING
Maximum Power Dissipation (W)
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
12
10
8
6
4
2
0
Z50UFG
Z25UFG
0
1
2
3
4
5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
30
25
20
15
10
5
0
Z150UFG
Z100UFG
0
0.5
1
1.5
2
2.5
3
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
350
300
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)

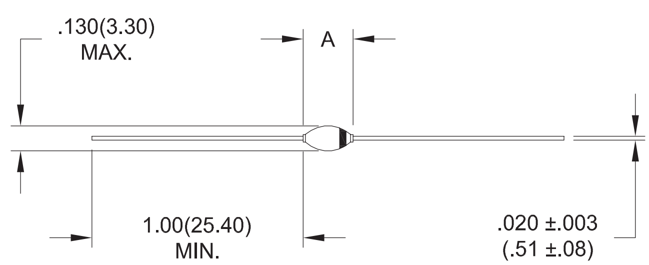

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z25UFG
Z50UFG
Z100UFG
Z150UFG
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Axial Lead

10mA - 100mA • 200ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
M25FG	2500	100	50	0.1	10	6.0	25	8.0	1.3	200	18	30	50	2.0
M50FG	5000	50	25	0.1	10	8.0	25	4.0	0.8	200	18	30	50	1.0
M100FG	10000	25	12	0.1	10	13.0	25	2.0	0.4	200	18	30	50	0.5
M160FG	16000	10	5	0.1	10	35.0	10	1.0	0.2	200	33	45	65	0.5

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=12.5mA, Ir=25mA, Irr=6.3mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
M25FG	.200(5.08) MAX.
M50FG	.225(5.72) MAX.
M100FG	.300(7.62) MAX.
M160FG	.350(8.89) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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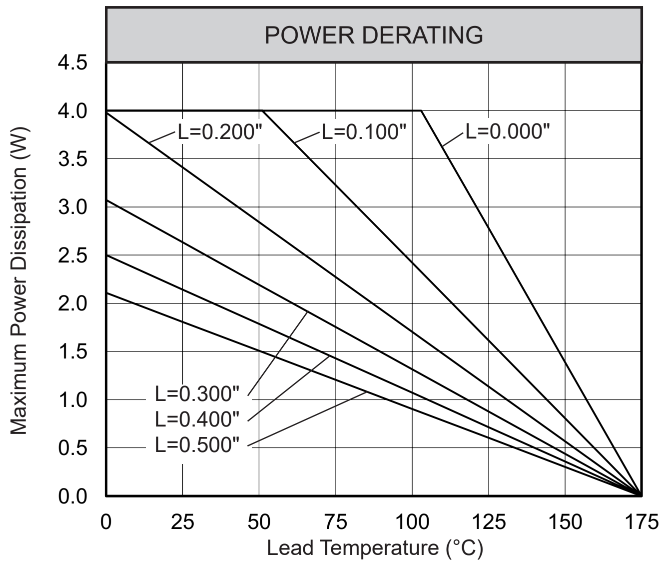
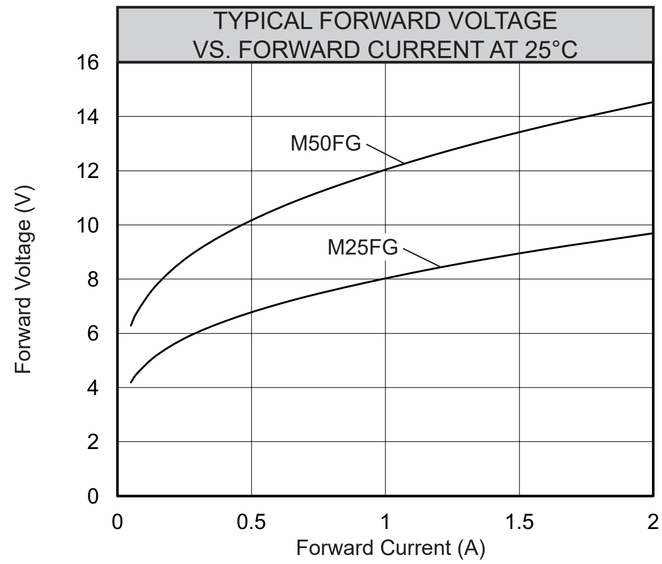
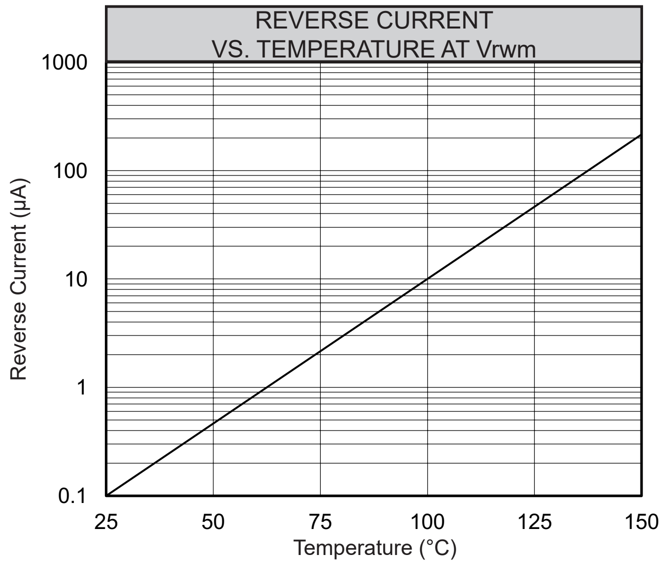
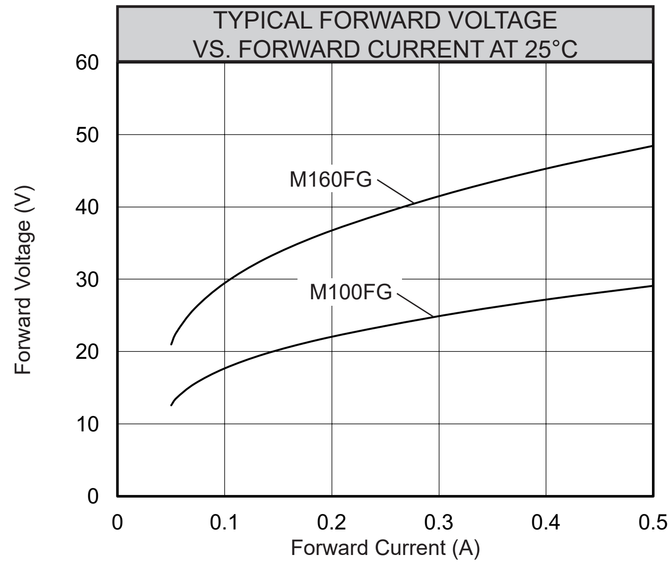
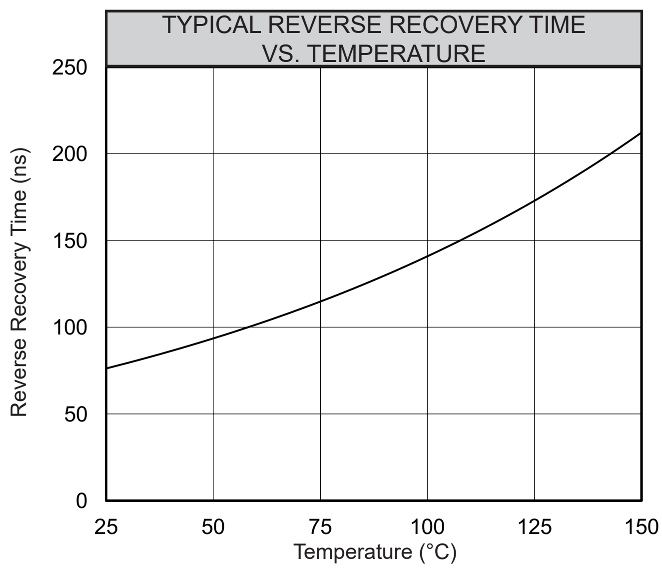
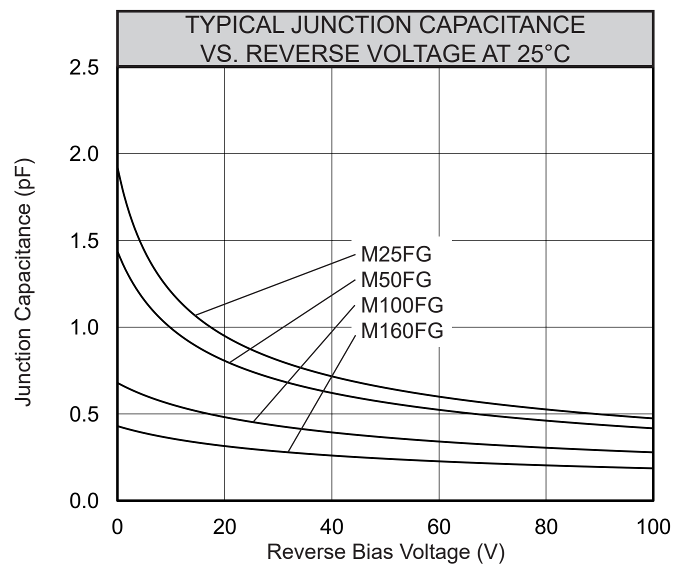

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
M50FG
M25FG
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
Temperature (°C)
1000
100
10
1
0.1
25
50
75
100
125
150


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
M160FG
M100FG
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)
250
200
150
100
50
0
25
50
75
100
125
150

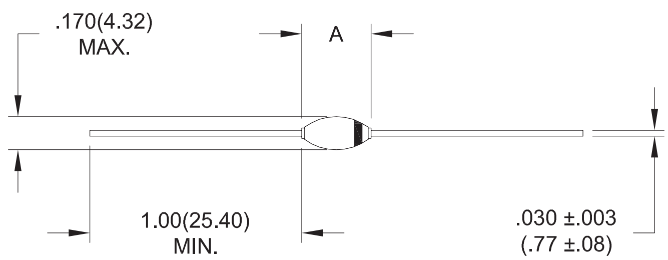

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
M25FG
M50FG
M100FG
M160FG
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100

High Voltage Diodes - Axial Lead

25mA - 250mA • 200ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
X25FG	2500	250	125	1.0	20	6.0	100	15.0	3.0	200	5	12	22	4.0
X50FG	5000	150	75	1.0	20	8.0	100	10.0	2.0	200	5	12	22	3.0
X100FG	10000	100	50	1.0	20	13.0	100	5.0	1.0	200	5	12	22	2.0
X150FG	15000	50	25	1.0	20	20.0	100	3.0	0.5	200	5	12	22	2.0
X200FG	20000	25	13	1.0	20	28.0	50	2.0	0.5	200	5	12	22	2.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
X25FG	.240(6.10) MAX.
X50FG	.260(6.60) MAX.
X100FG	.320(8.13) MAX.
X150FG	.360(9.14) MAX.
X200FG	.380(9.65) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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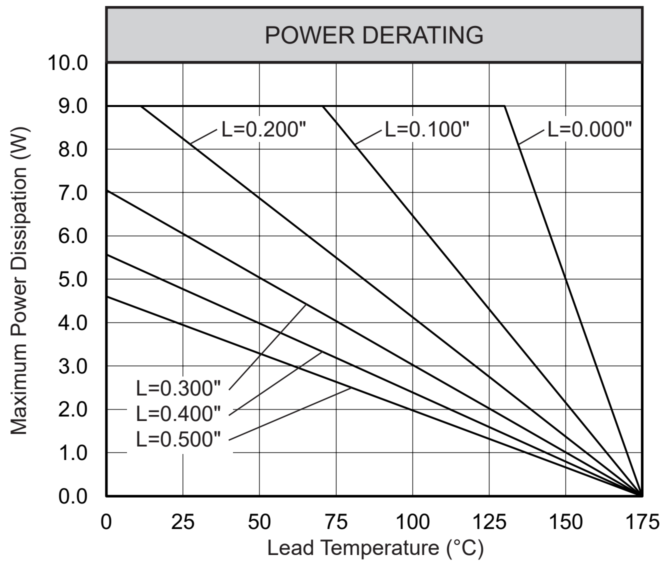
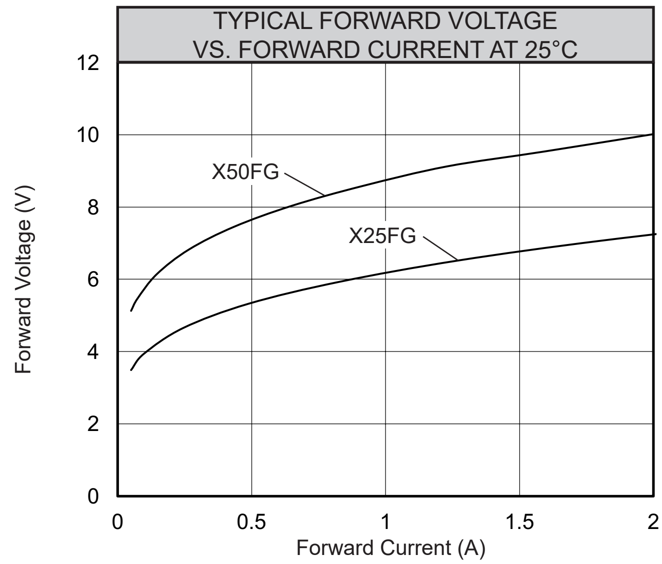
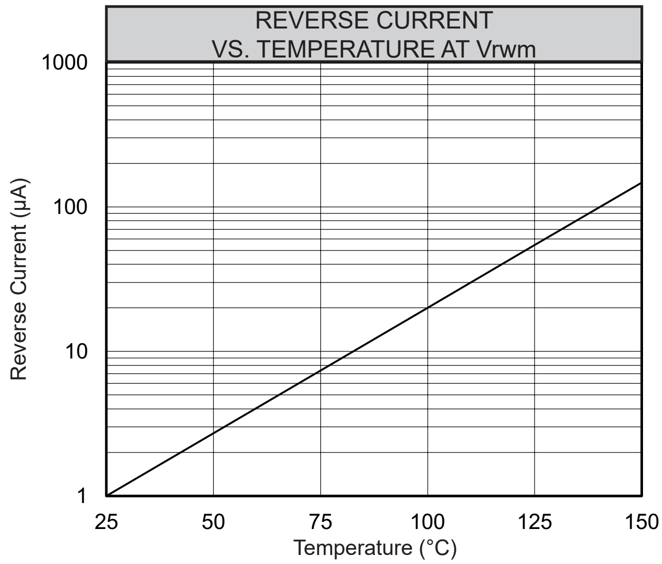
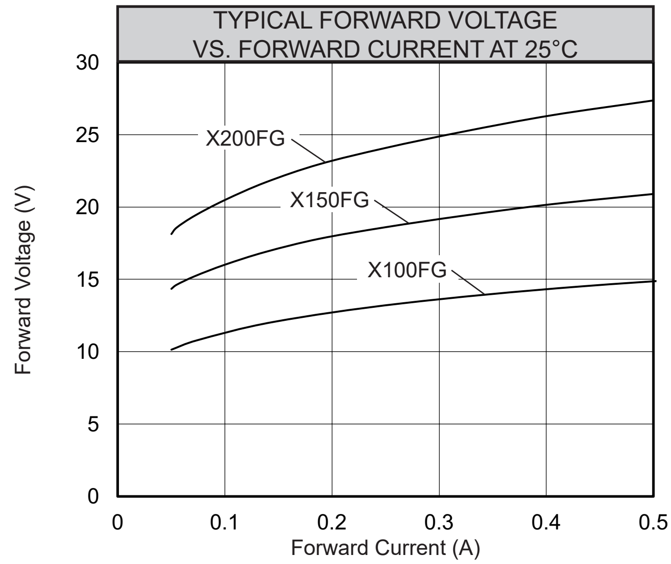
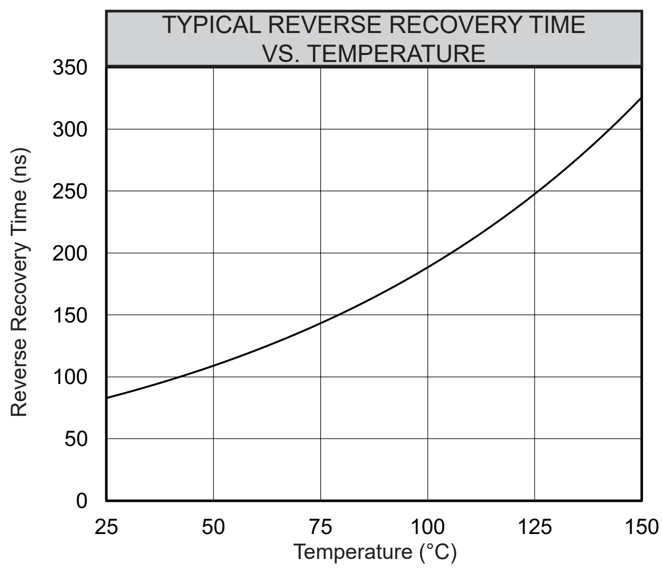
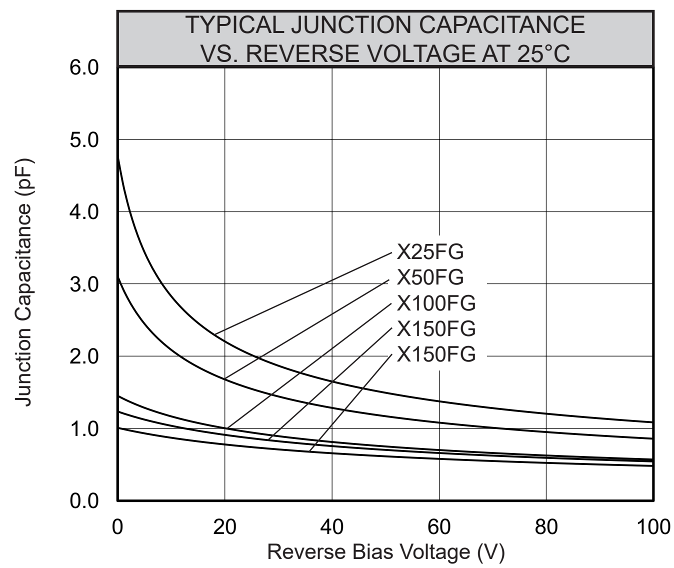

POWER DERATING
Maximum Power Dissipation (W)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
12
10
8
6
4
2
0
X50FG
X25FG
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
30
25
20
15
10
5
0
X200FG
X150FG
X100FG
0
0.1
0.2
0.3
0.4
0.5
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
350
300
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
X25FG
X50FG
X100FG
X150FG
X150FG
0
20
40
60
80
100
Reverse Bias Voltage (V)

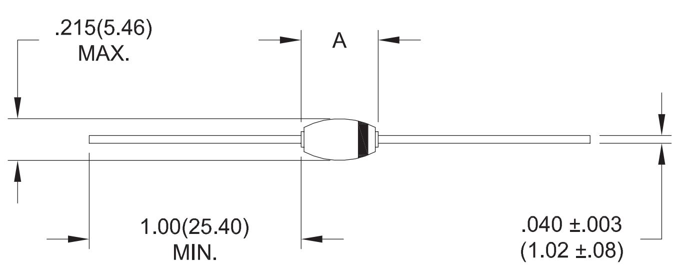
High Voltage Diodes - Axial Lead

300mA - 1500mA • 200ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
Z25FG	2500	1500	1000	1.0	25	6.5	2000	60.0	10.0	200	3	6	12	20.0
Z50FG	5000	1000	500	1.0	25	9.5	1000	40.0	8.0	200	3	6	12	16.0
Z100FG	10000	500	250	1.0	25	13.0	600	25.0	5.0	200	3	6	12	8.0
Z150FG	15000	300	150	1.0	25	20.0	300	10.0	2.0	200	3	6	12	5.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
Z25FG	.290(7.37) MAX.
Z50FG	.330(8.38) MAX.
Z100FG	.400(10.16) MAX.
Z150FG	.450(11.43) MAX.

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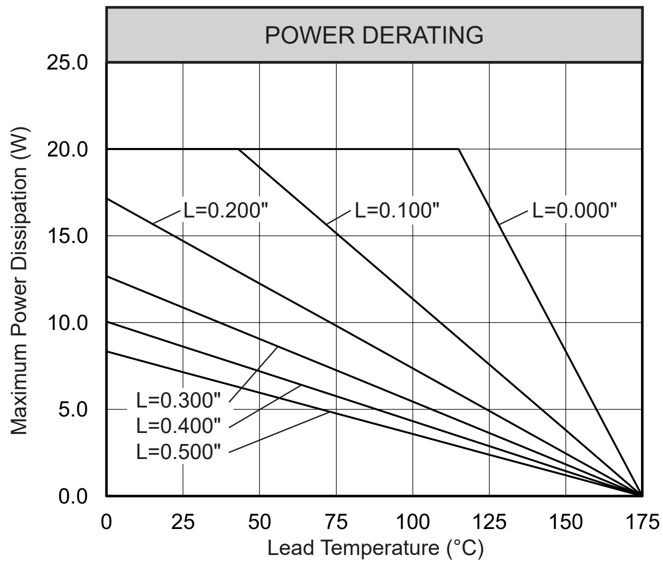
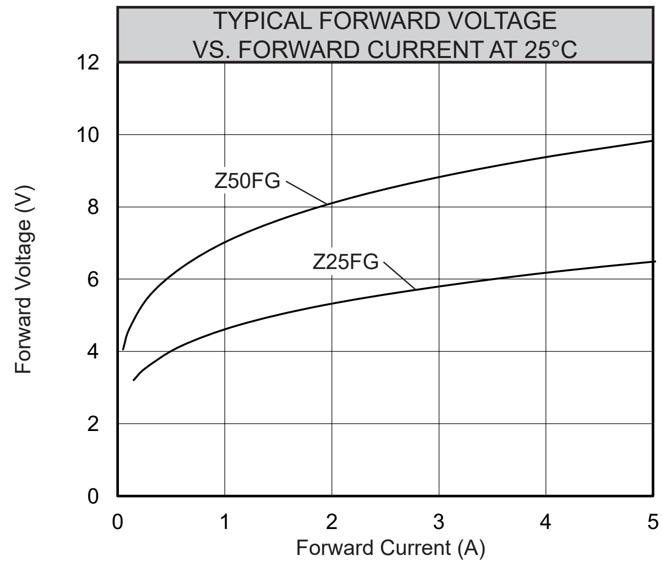
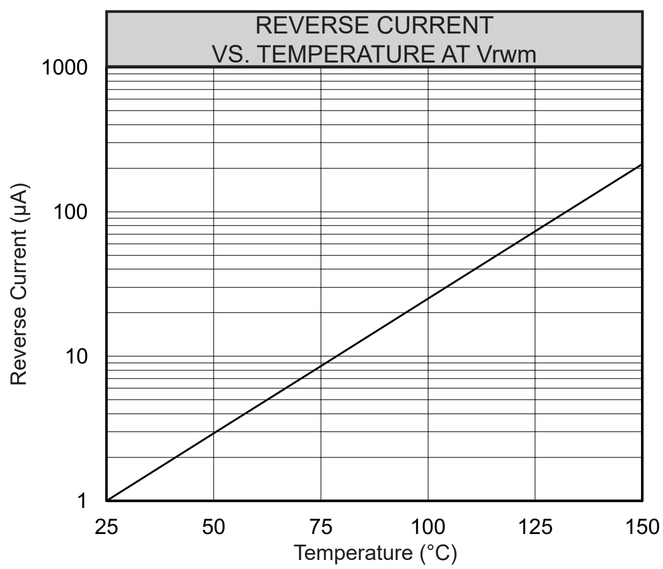
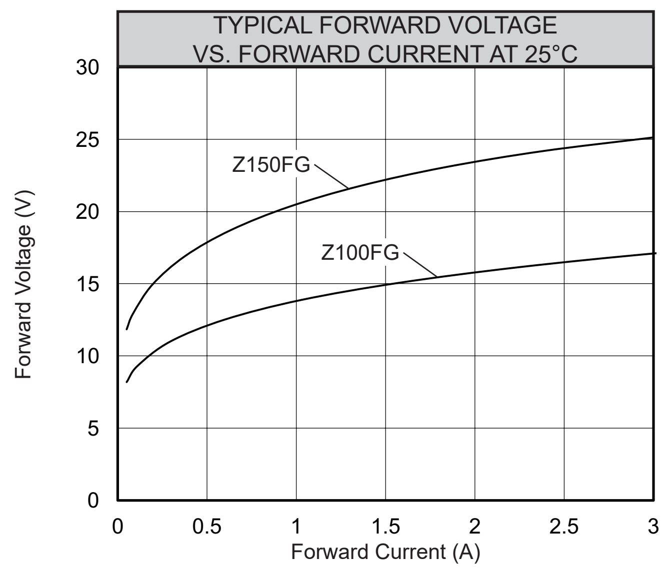
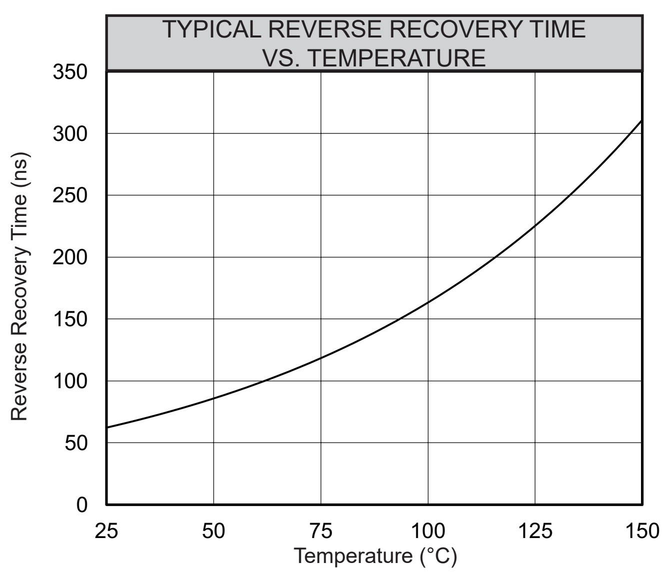
Z25FG Z50FG Z100FG Z150FG

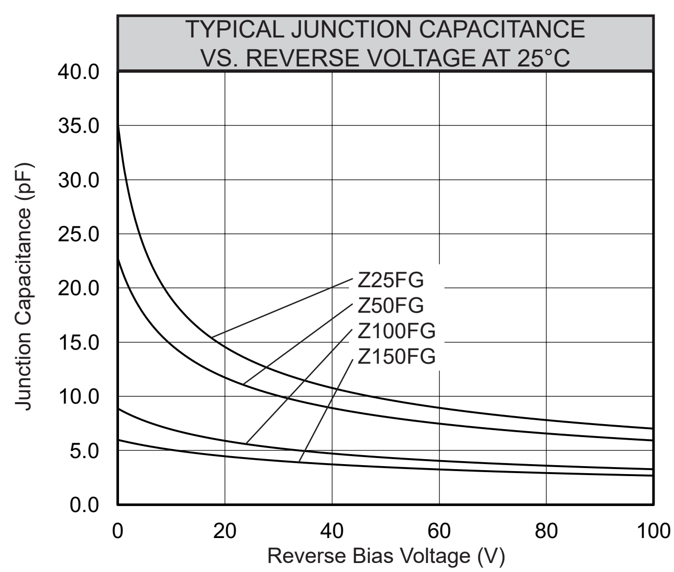










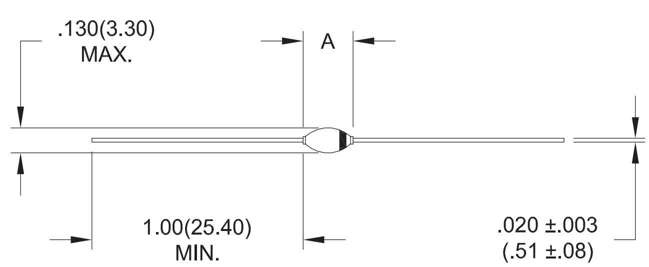


High Voltage Diodes - Axial Lead

10mA - 100mA • 3000ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
M25SG	2500	100	50	0.1	10	6.0	25	8.0	1.2	3000	18	30	50	2.0
M50SG	5000	50	25	0.1	10	8.0	25	4.0	0.8	3000	18	30	50	1.0
M100SG	10000	25	12	0.1	10	13.0	25	2.0	0.4	3000	18	30	50	0.5
M160SG	16000	10	5	0.1	10	35.0	10	0.5	0.1	3000	33	45	65	0.5

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=12.5mA, Ir=25mA, Irr=6.3mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
M25SG	.200(5.08) MAX.
M50SG	.225(5.72) MAX.
M100SG	.300(7.62) MAX.
M160SG	.350(8.89) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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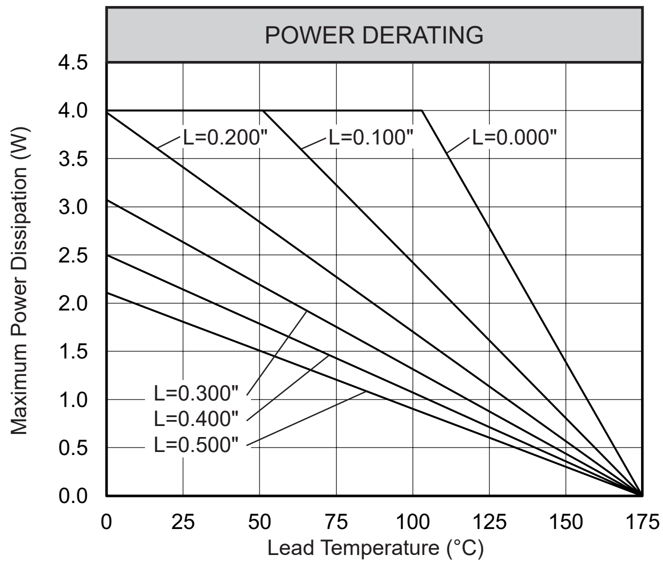
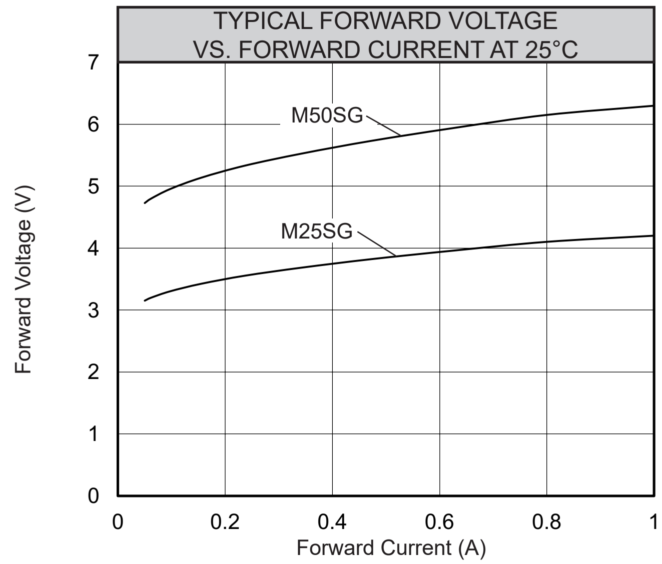
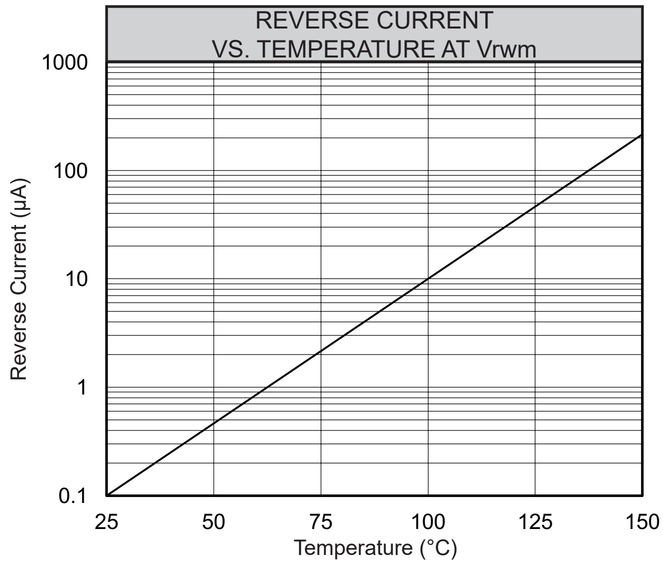
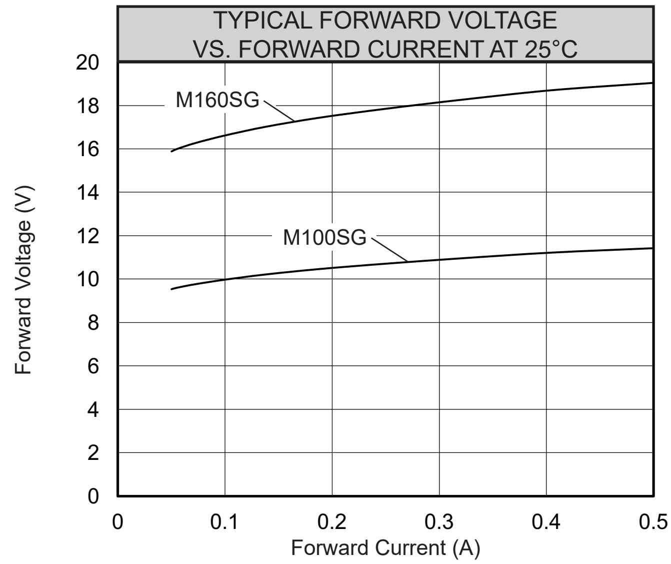
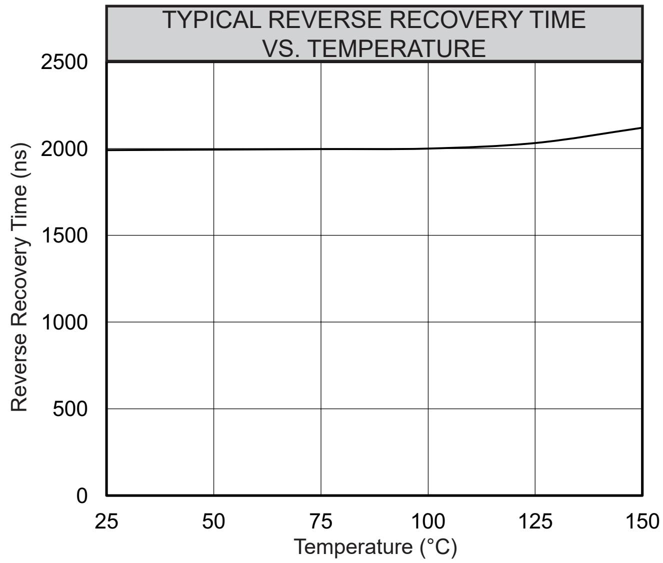
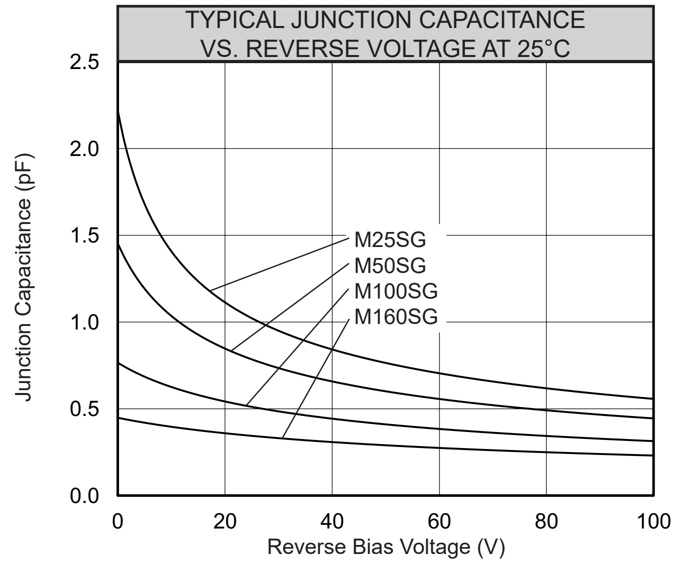

POWER DERATING
Maximum Power Dissipation (W)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
7
6
5
4
3
2
1
0
M50SG
M25SG
0
0.2
0.4
0.6
0.8
1
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
20
18
16
14
12
10
8
6
4
2
0
M160SG
M100SG
0
0.1
0.2
0.3
0.4
0.5
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
2500
2000
1500
1000
500
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
2.5
2.0
1.5
1.0
0.5
0.0
M25SG
M50SG
M100SG
M160SG
0
20
40
60
80
100
Reverse Bias Voltage (V)

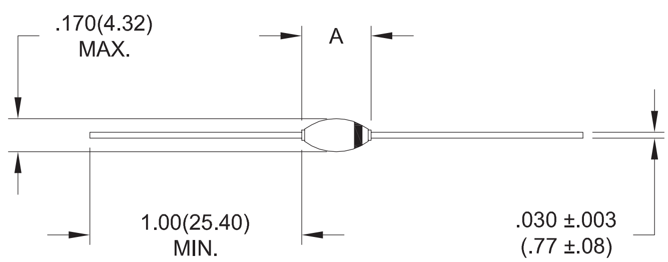
High Voltage Diodes - Axial Lead

25mA - 250mA • 3000ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
X25SG	2500	250	125	1.0	20	6.0	100	15	3.0	3000	5	12	22	4.0
X50SG	5000	150	75	1.0	20	8.0	100	10	2.0	3000	5	12	22	3.0
X100SG	10000	100	50	1.0	20	13.0	100	5	1.0	3000	5	12	22	2.0
X150SG	15000	50	25	1.0	20	20.0	100	1	0.5	3000	5	12	22	2.0
X200SG	20000	25	13	1.0	20	26.0	50	2	0.5	3000	5	12	22	2.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=125mA, Ir=250mA, Irr=63mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
X25SG	.240(6.10) MAX.
X50SG	.260(6.60) MAX.
X100SG	.320(8.13) MAX.
X150SG	.360(9.14) MAX.
X200SG	.380(9.65) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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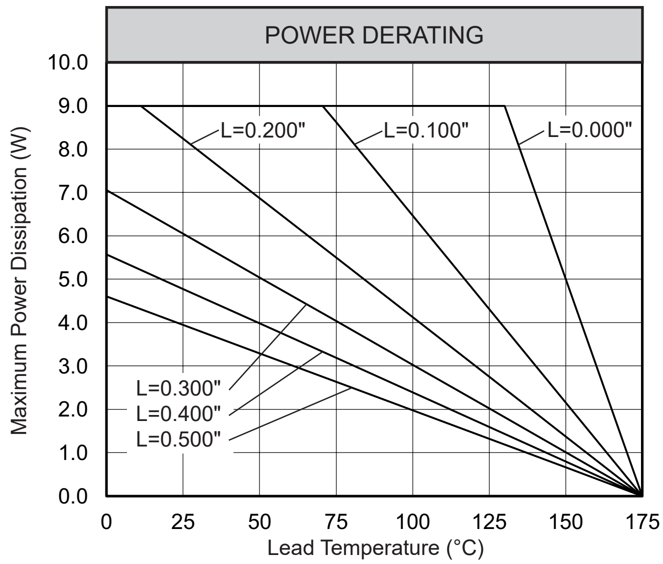
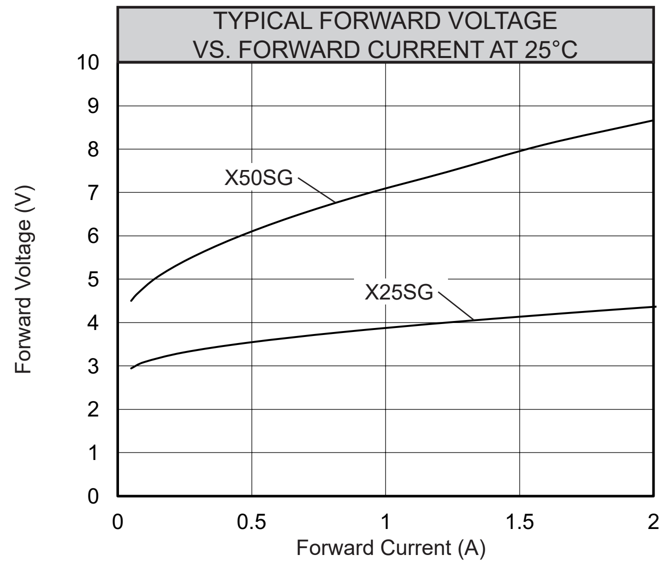
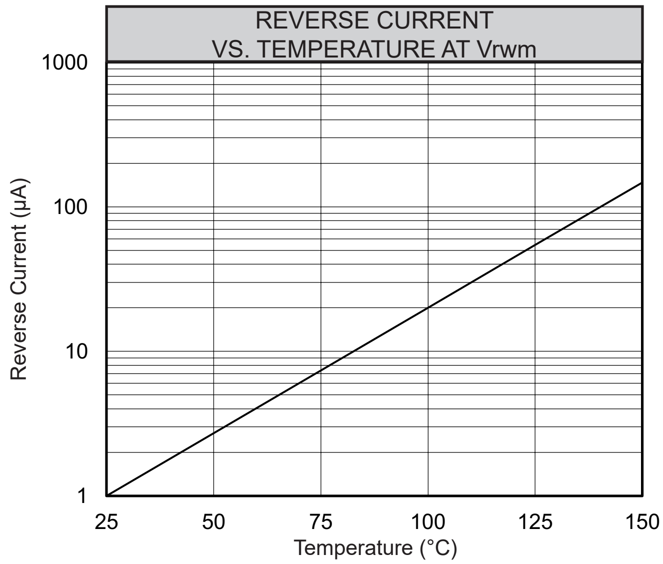
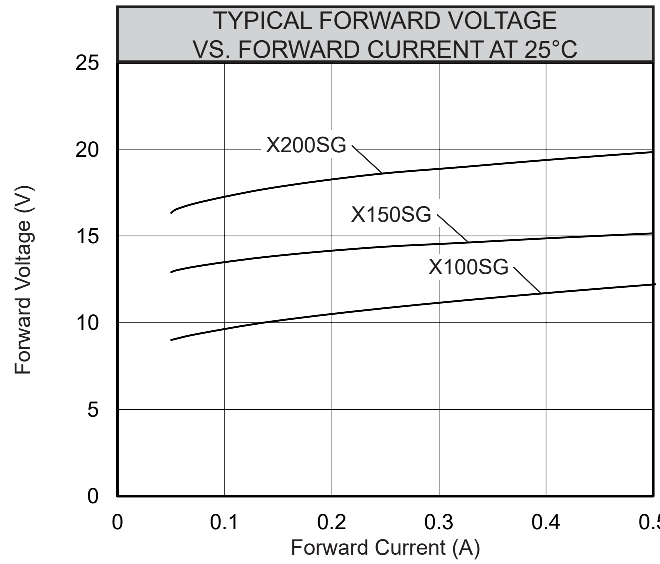
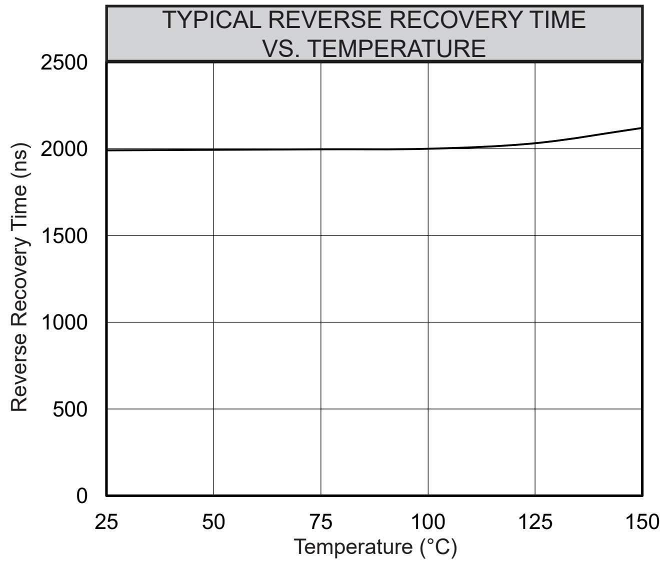
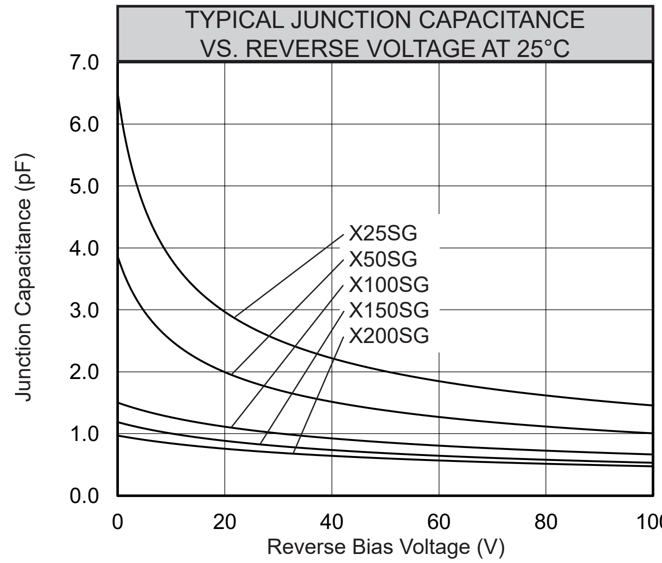

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.000"
L=0.100"
L=0.200"
L=0.300"
L=0.400"
L=0.500"


TYPICAL FORWARD VOLTAGE VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
X50SG
X25SG


REVERSE CURRENT VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
Temperature (°C)


TYPICAL FORWARD VOLTAGE VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
X200SG
X150SG
X100SG


TYPICAL REVERSE RECOVERY TIME VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
X25SG
X50SG
X100SG
X150SG
X200SG

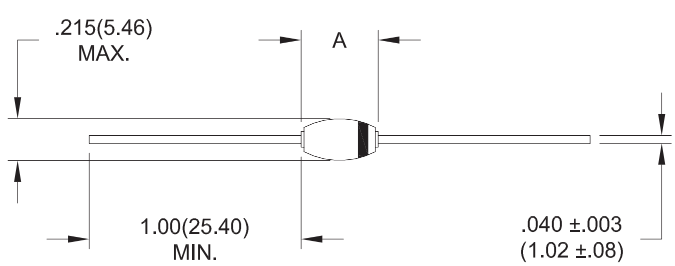
High Voltage Diodes - Axial Lead

300mA - 1500mA • 3000ns • Hermetic

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
Z25SG	2500	1500	1000	1.0	25	5.5	2000	60	10.0	3000	3	6	12	20.0
Z50SG	5000	1000	500	1.0	25	8.5	1000	40	8.0	3000	3	6	12	16.0
Z100SG	10000	500	250	1.0	25	12.0	600	25	5.0	3000	3	6	12	8.0
Z150SG	15000	300	150	1.0	25	18.0	300	10	2.0	3000	3	6	12	5.0

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Part	A
Z25SG	.290(7.37) MAX.
Z50SG	.330(8.38) MAX.
Z100SG	.400(10.16) MAX.
Z150SG	.450(11.43) MAX.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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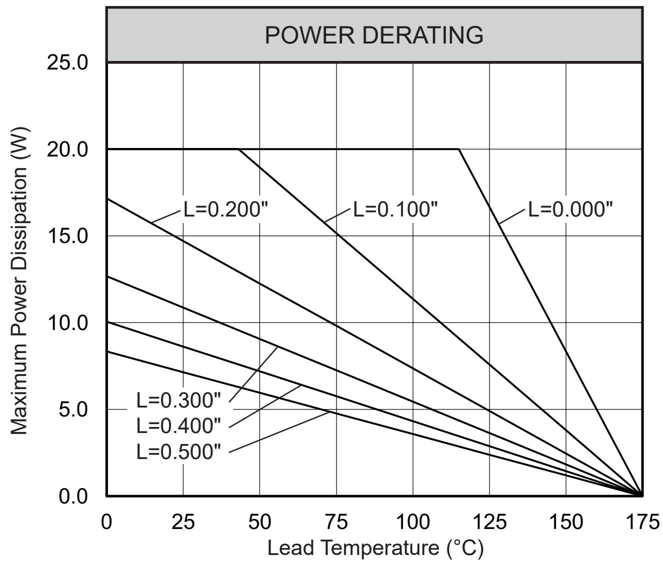
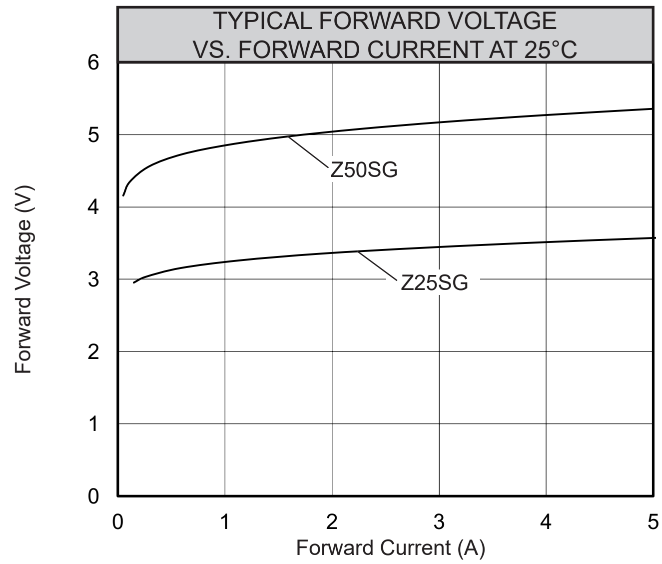
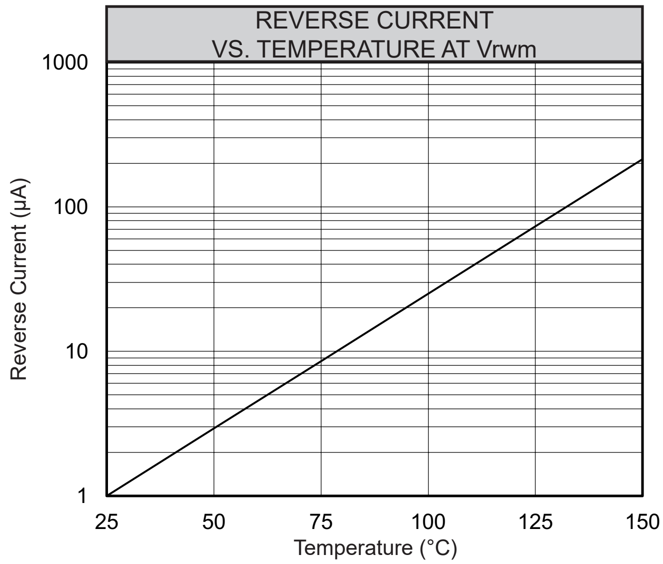
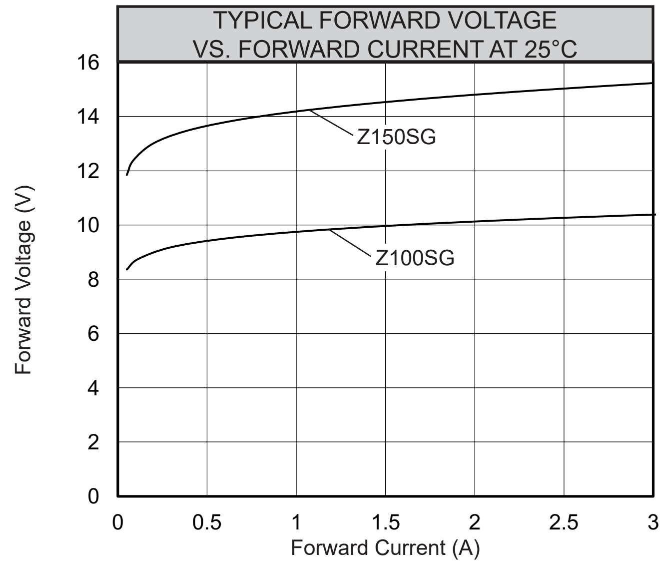
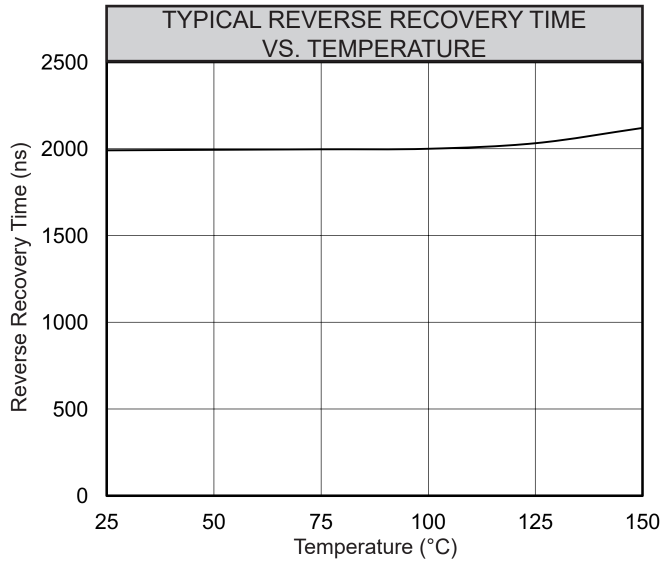
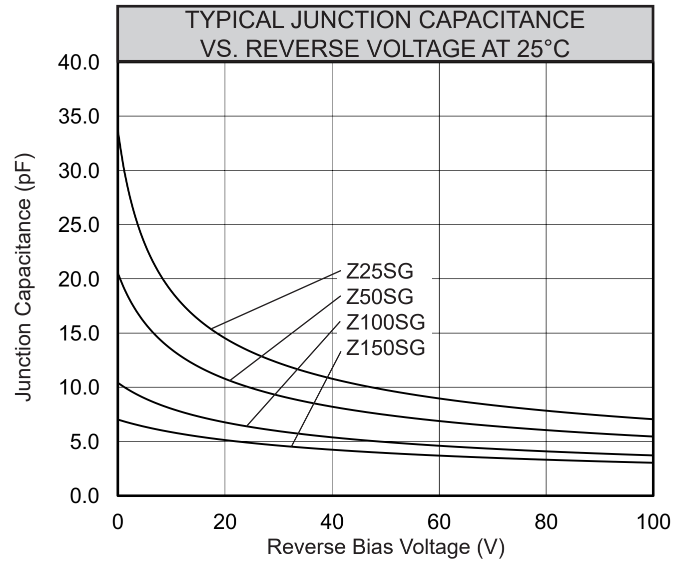

POWER DERATING
Maximum Power Dissipation (W)
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
6
5
4
3
2
1
0
Z50SG
Z25SG
0
1
2
3
4
5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
16
14
12
10
8
6
4
2
0
Z150SG
Z100SG
0
0.5
1
1.5
2
2.5
3
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
2500
2000
1500
1000
500
0
25
50
75
100
125
150
Temperature (°C)

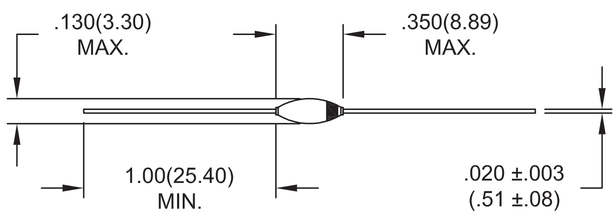

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Z25SG
Z50SG
Z100SG
Z150SG
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage High Temp Diode - Axial Lead

10mA • 100ns

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}			Junction Cap. @50VDC @ 1kHZ (Cj)
				Vrwm	8kV									
		55°C(1)	100°C(2)	25°C	175°C	25°C		25°C	25°C	25°C	L=.000	L=.125	L=.250	25°C
	Volts	mA	mA	μA	μA	Volts	mA	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
M160UFGHT	16000	10	5	0.1	10.0	35	10	1.0	0.2	100	33	45	65	0.5

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=12.5mA, Ir=25mA, Irr=6.3mA *Op.Temp.= -65°C to +175°C Stg.Temp.= -65°C to +200°C



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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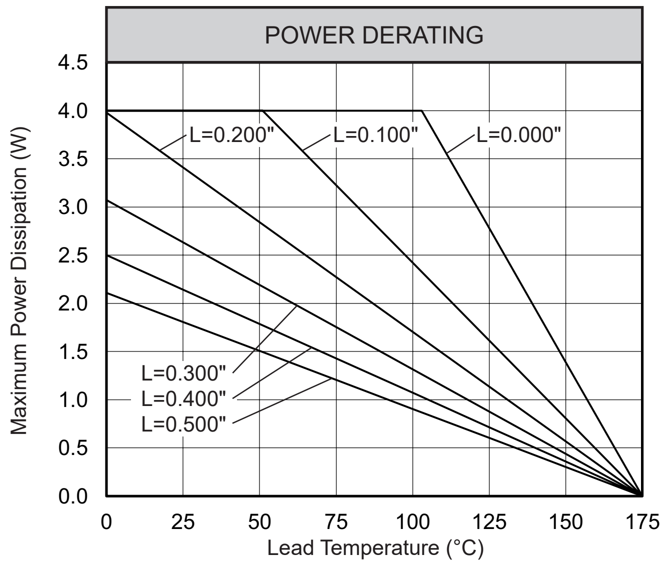
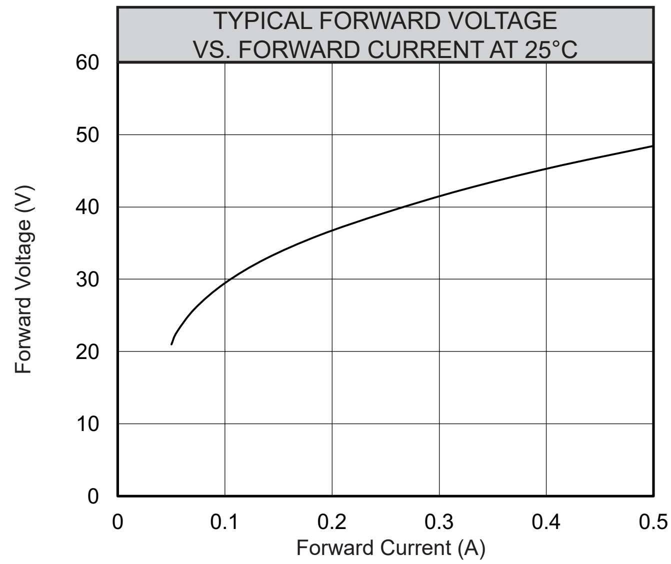
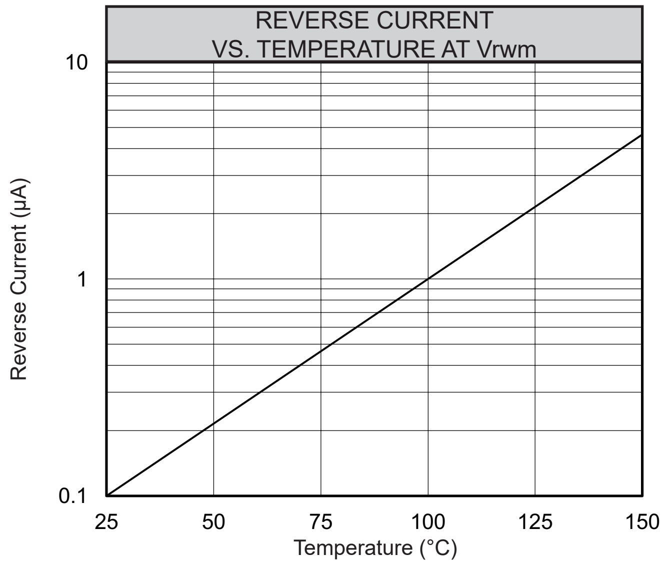
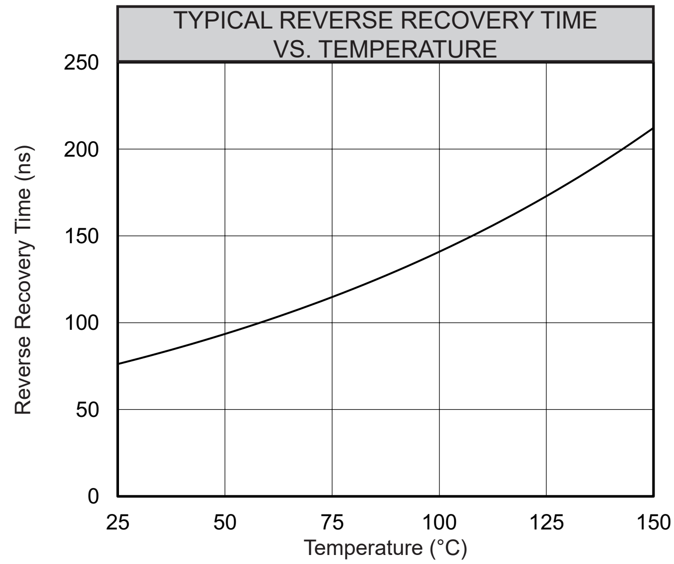
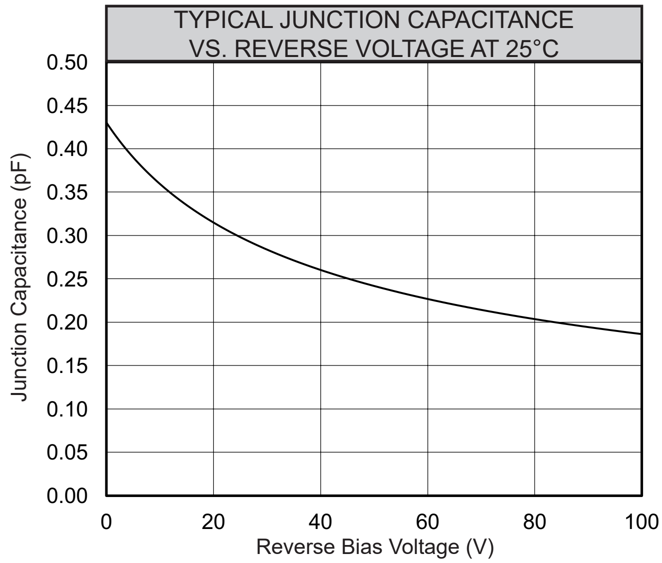

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
0 25 50 75 100 125 150 175


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
0 10 20 30 40 50 60
0 0.1 0.2 0.3 0.4 0.5


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
Temperature (°C)
0.1 1 10
25 50 75 100 125 150


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)
0 50 100 150 200 250
25 50 75 100 125 150


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
0 20 40 60 80 100

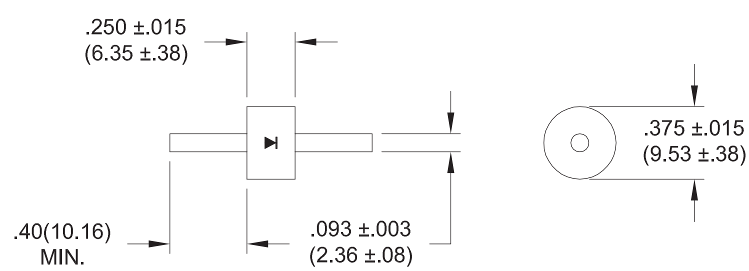
4

High Voltage Diodes - Epoxy Molded

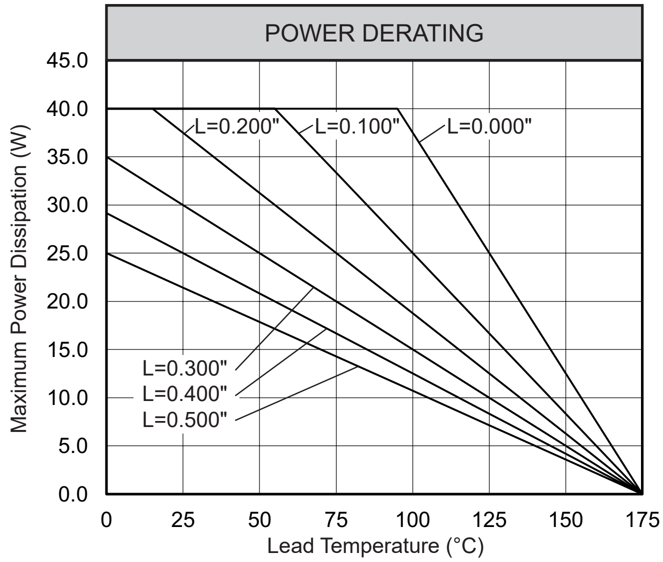
1.5A - 3.0A • 100ns • Axial Leaded

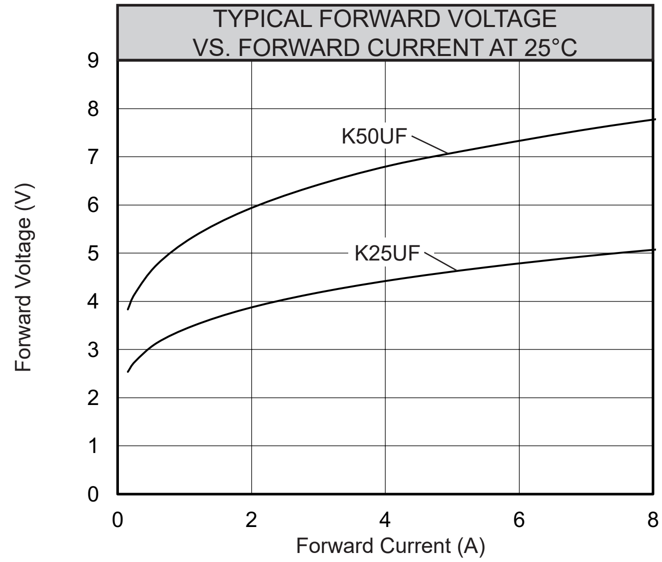
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Foward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance θ_{J-L}		Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.250	25°C
	Volts	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	°C/W	°C/W	pF
K25UF	2500	3.00	1.50	2.0	100	7.5	3.0	200	50	100	2.0	4.5	70
K50UF	5000	2.20	1.10	2.0	100	10.5	2.2	150	35	100	2.0	4.5	50
K100UF	10000	1.50	0.75	2.0	100	14.0	1.5	100	25	100	2.0	4.5	35

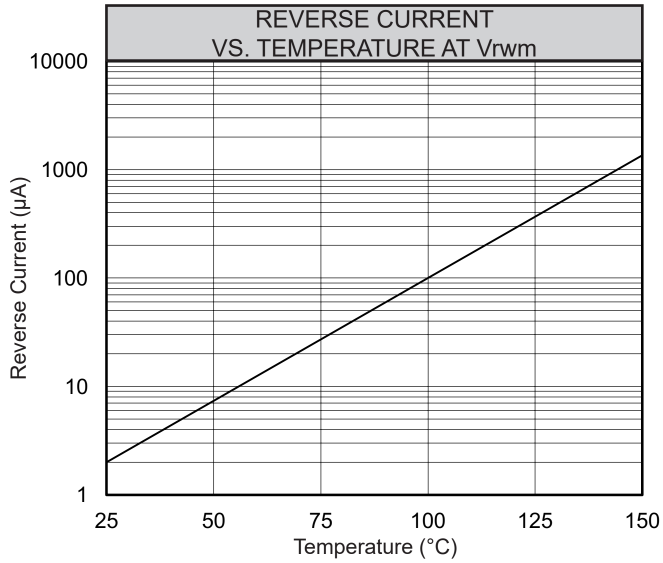
(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +175°C

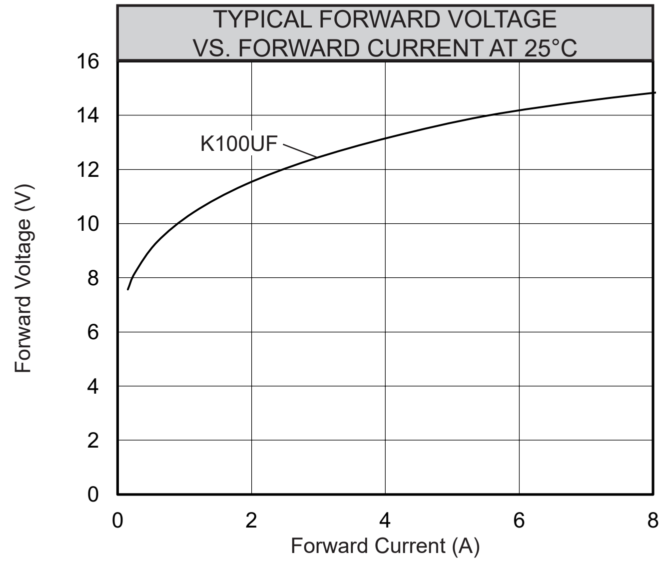


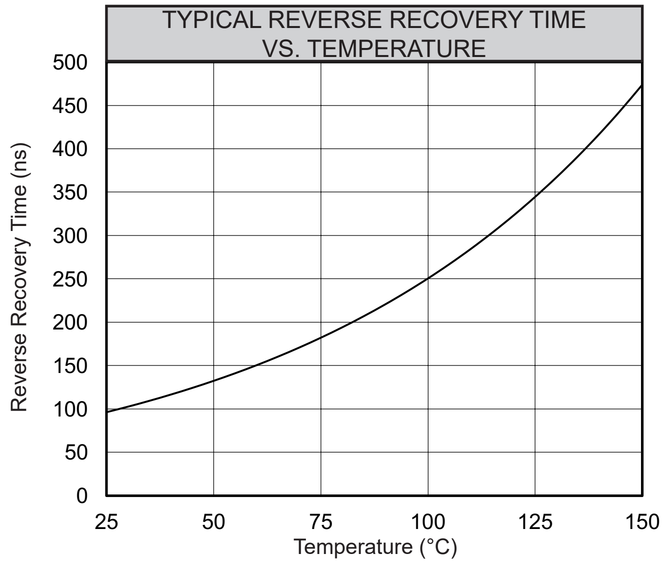
Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

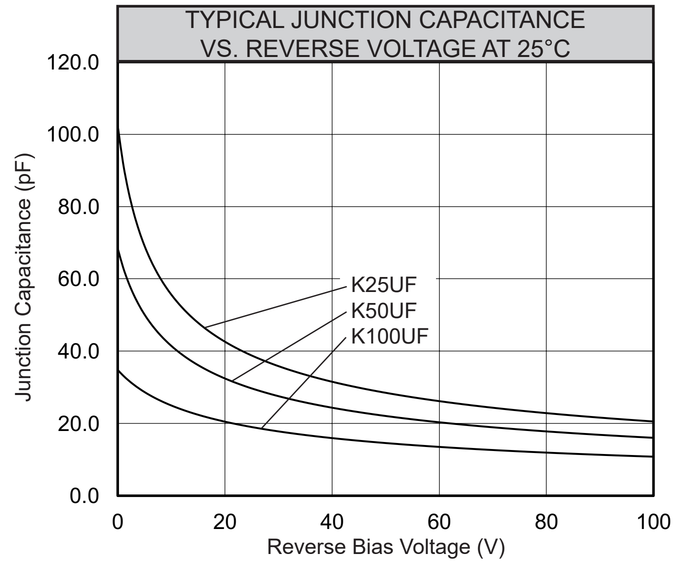

POWER DERATING
Maximum Power Dissipation (W)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
9
8
7
6
5
4
3
2
1
0
K50UF
K25UF
0
2
4
6
8
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
10000
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
16
14
12
10
8
6
4
2
0
K100UF
0
2
4
6
8
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
500
450
400
350
300
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)

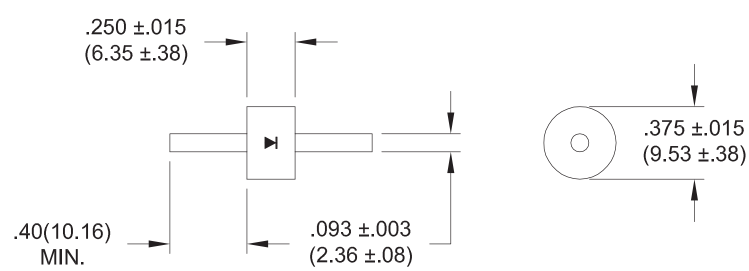

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
K25UF
K50UF
K100UF
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Epoxy Molded

1.5A - 3.0A • 200ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS													
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Foward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance $\theta_{J\text{-}L}$		Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.250	25°C
	Volts	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	°C/W	°C/W	pF
K25F	2500	3.00	1.50	2.0	100	6.5	3.0	200	50	200	2.0	4.5	70
K50F	5000	2.20	1.10	2.0	100	9.5	2.2	150	35	200	2.0	4.5	50
K100F	10000	1.50	0.75	2.0	100	13.0	1.5	100	25	200	2.0	4.5	35

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +175°C



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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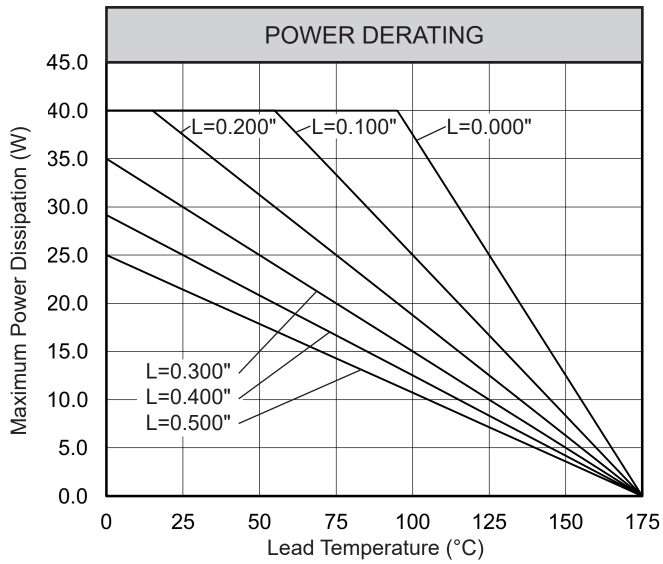
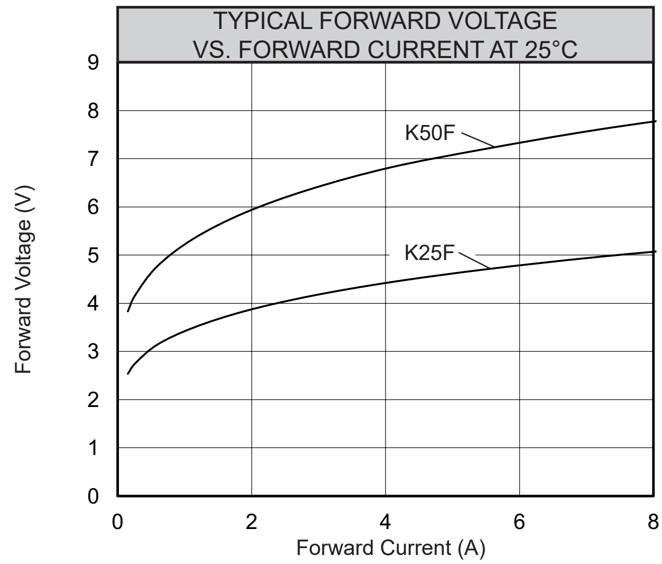
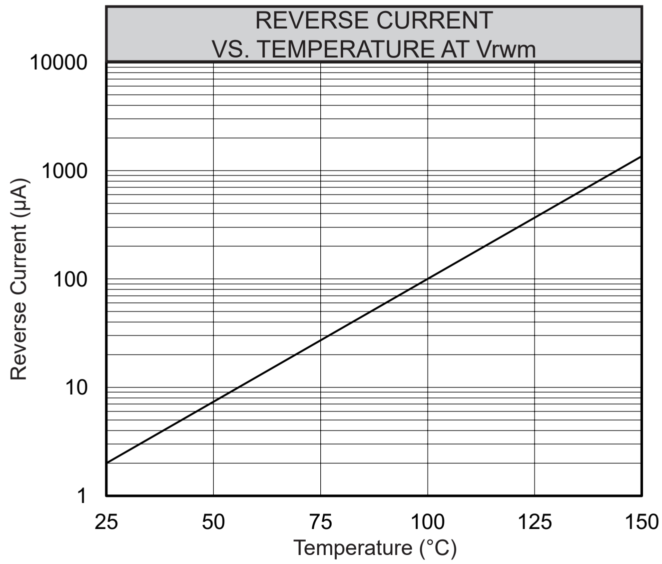
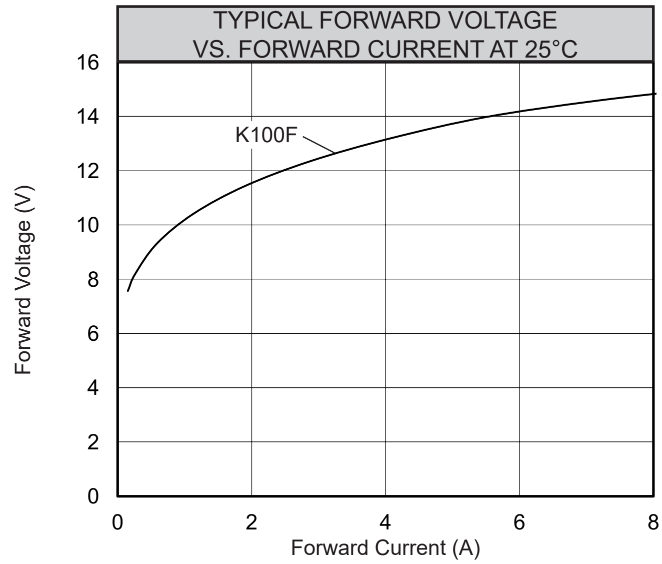
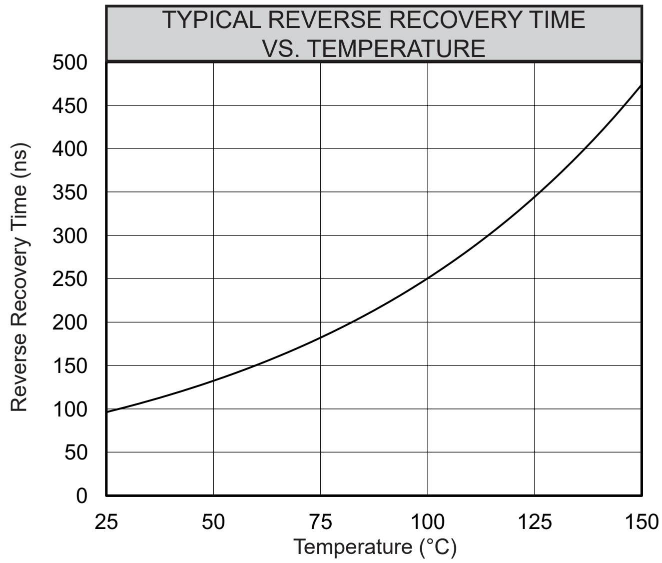
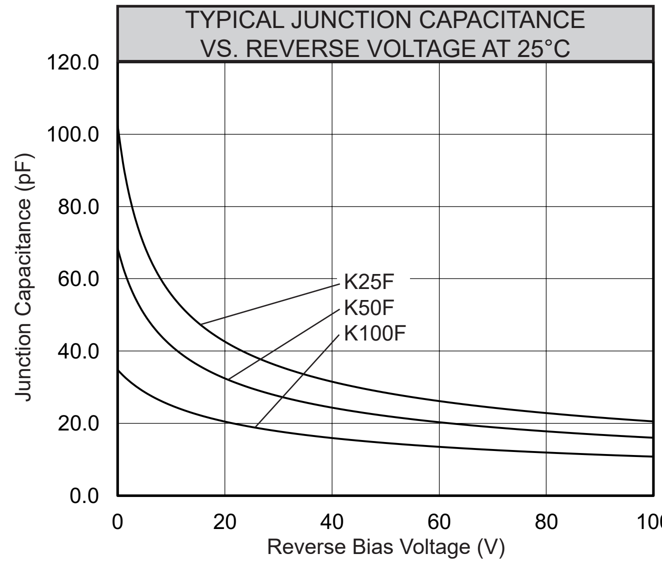

POWER DERATING
Maximum Power Dissipation (W)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
9
8
7
6
5
4
3
2
1
0
K50F
K25F
0
2
4
6
8
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
10000
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
16
14
12
10
8
6
4
2
0
K100F
0
2
4
6
8
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
500
450
400
350
300
250
200
150
100
50
0
25
50
75
100
125
150
Temperature (°C)

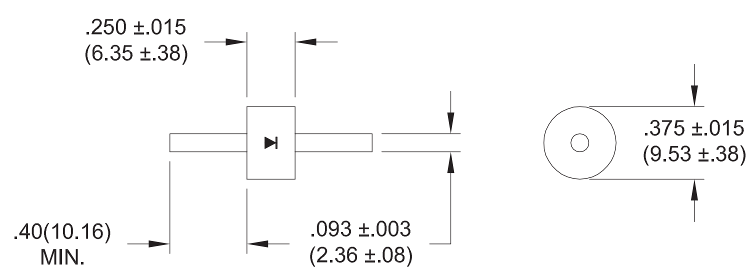

TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
K25F
K50F
K100F
0
20
40
60
80
100
Reverse Bias Voltage (V)

High Voltage Diodes - Epoxy Molded

1.5A - 3.0A • 3000ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS													
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Foward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance $\theta_{J\text{-}L}$		Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=.000	L=.250	25°C
	Volts	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	°C/W	°C/W	pF
K25S	2500	3.00	1.50	2.0	100	5.5	3.0	200	50	3000	2.0	4.5	70
K50S	5000	2.20	1.10	2.0	100	8.5	2.2	150	35	3000	2.0	4.5	50
K100S	10000	1.50	0.75	2.0	100	12.0	1.5	100	25	3000	2.0	4.5	35

(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +175°C



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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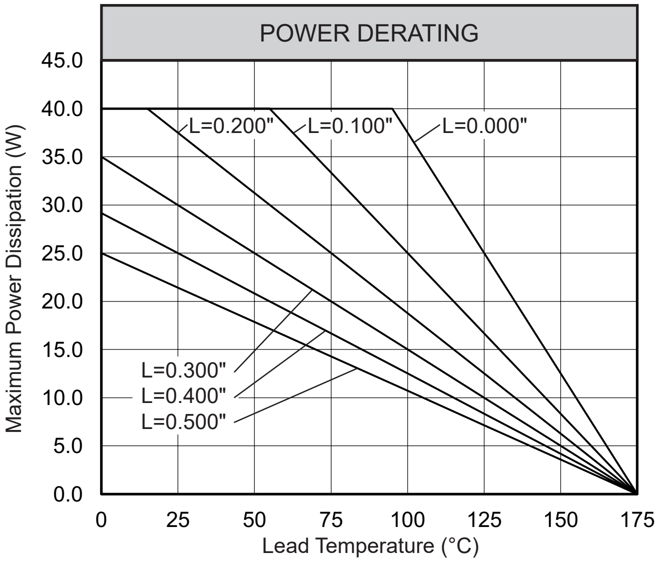
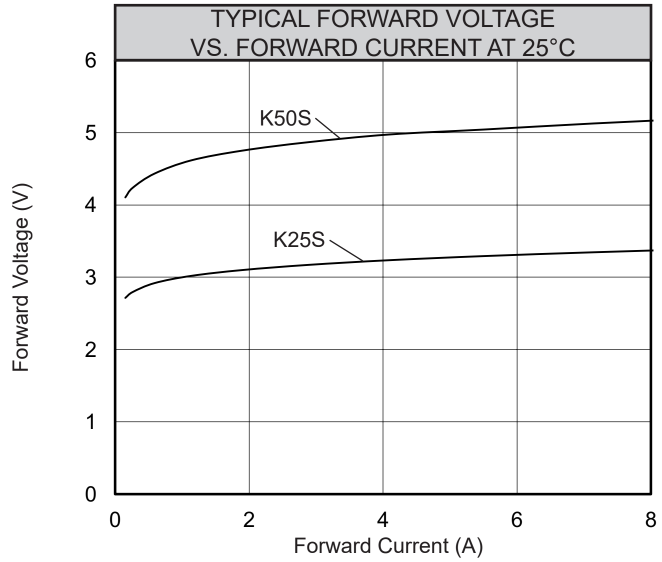
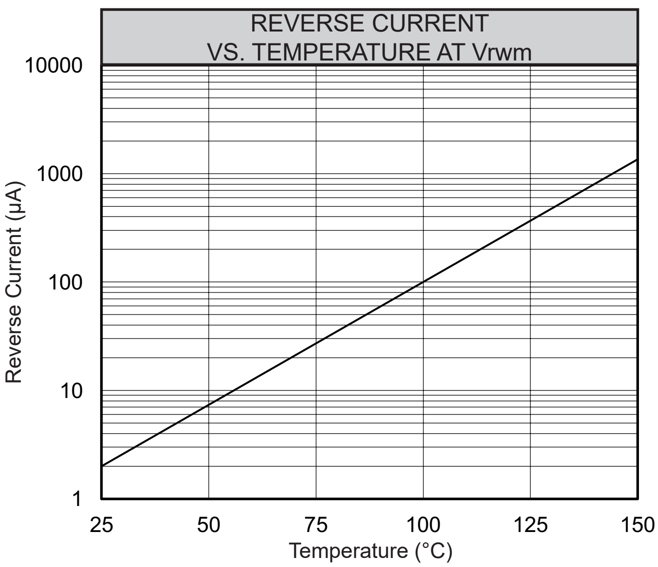
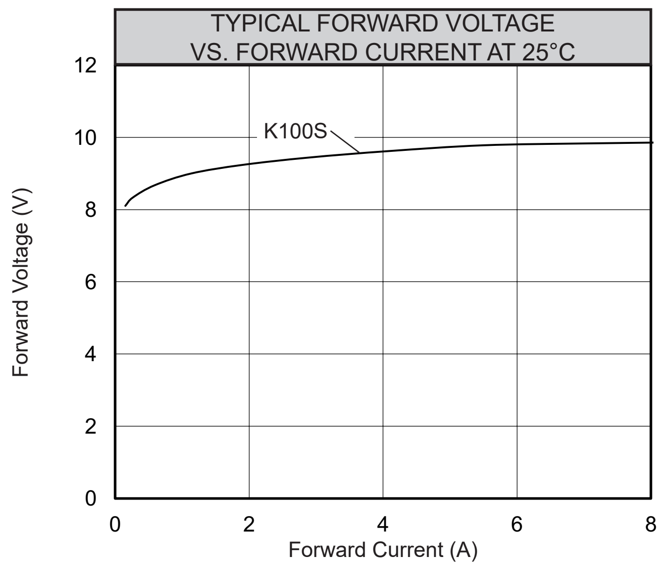
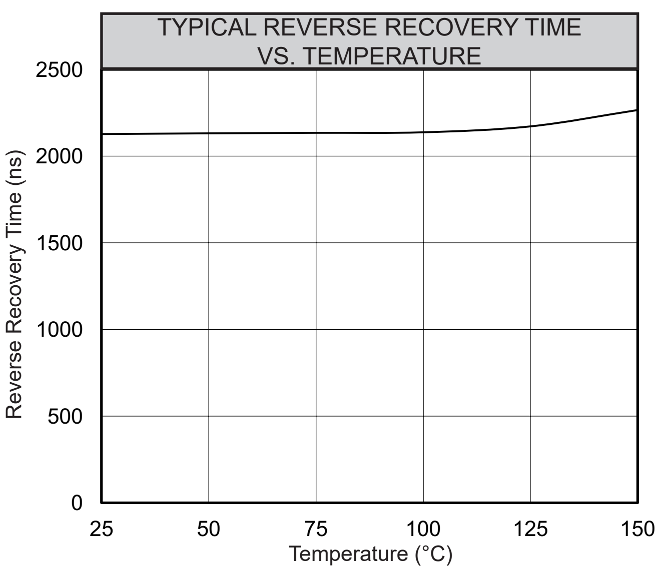
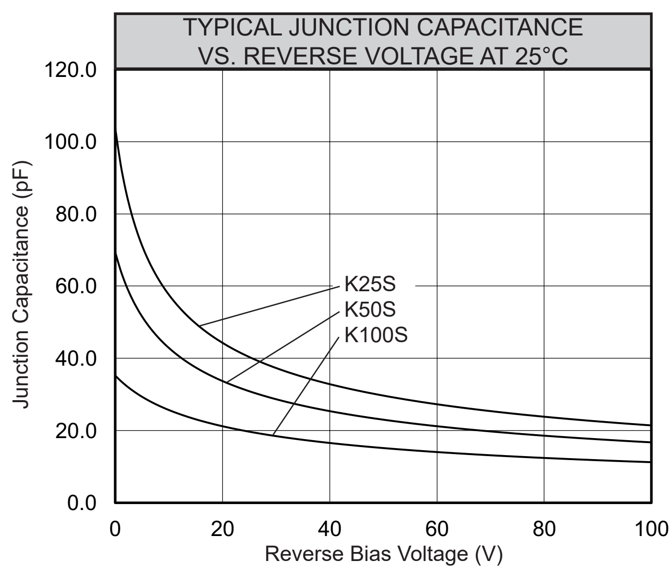

POWER DERATING
Maximum Power Dissipation (W)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
L=0.200"
L=0.100"
L=0.000"
L=0.300"
L=0.400"
L=0.500"
0
25
50
75
100
125
150
175
Lead Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
6
5
4
3
2
1
0
K50S
K25S
0
2
4
6
8
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
10000
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
12
10
8
6
4
2
0
K100S
0
2
4
6
8
Forward Current (A)


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
2500
2000
1500
1000
500
0
25
50
75
100
125
150
Temperature (°C)


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
K25S
K50S
K100S
0
20
40
60
80
100
Reverse Bias Voltage (V)

5

High Voltage Opto-diode - Axial Lead

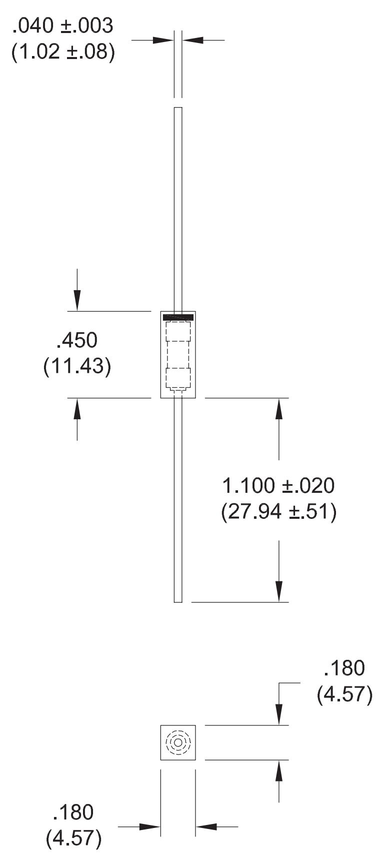
0.30A - 0.50A • 3000ns

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS														
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (3) (Trr)	Thermal Impedance $\theta_{J\text{-}L}$			Junction Cap. @50VDC @ 1kHZ (Cj)
		55°C(1)	100°C(2)	25°C	100°C	25°C		25°C	25°C	25°C	L=000	L=.125	L=.250	25°C
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	°C/W	°C/W	°C/W	pF
OZ100SG	10000	0.50	0.25	1.0	25	12.0	0.60	25	5.0	3000	6	9	15	8
OZ150SG	15000	0.30	0.15	1.0	25	18.0	0.30	10	2.0	3000	6	9	18	5

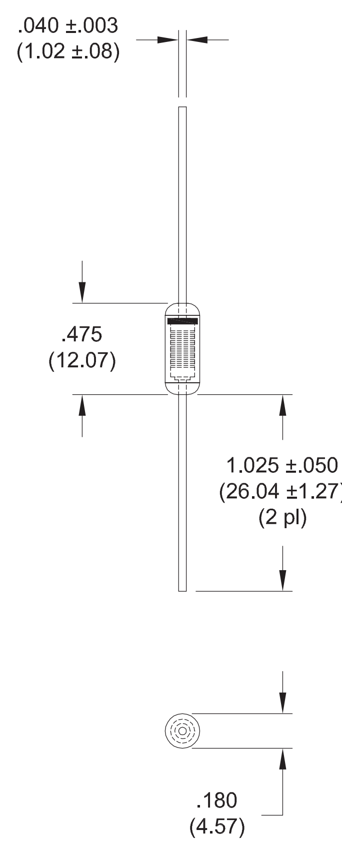
(1)TL=55°C L=0.375" (2)TL=100°C L=0.375" (3)If=0.5A, Ir=1.0A, Irr=0.25A *Op.Temp.= -40°C to +70°C Stg.Temp.= -40°C to +100°C

Tolerance:
.XXX ±.010

OZ100SG



OZ150SG



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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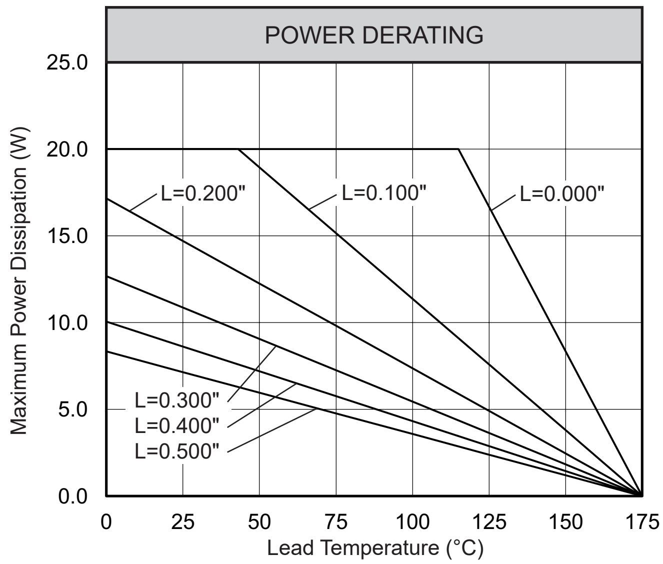
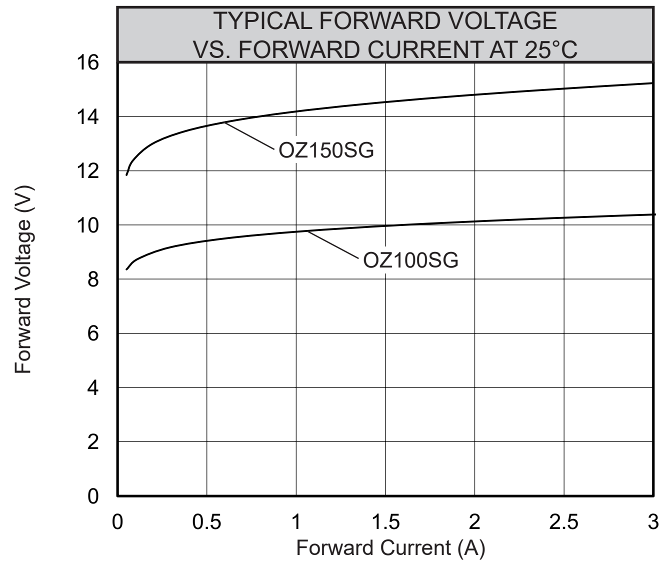
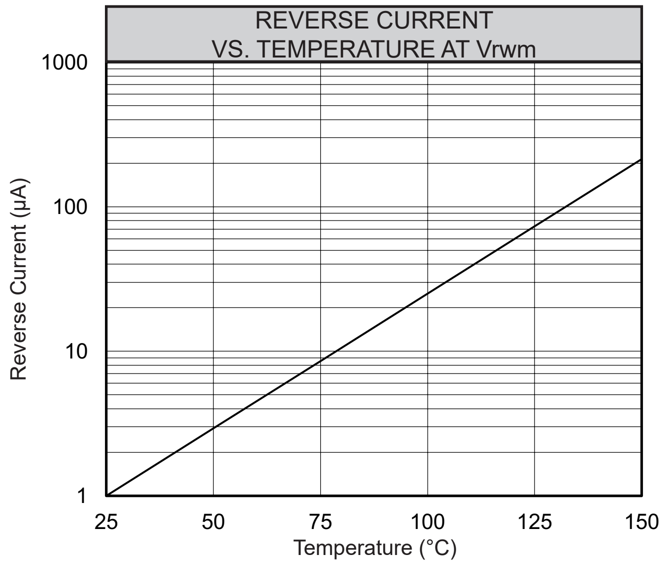
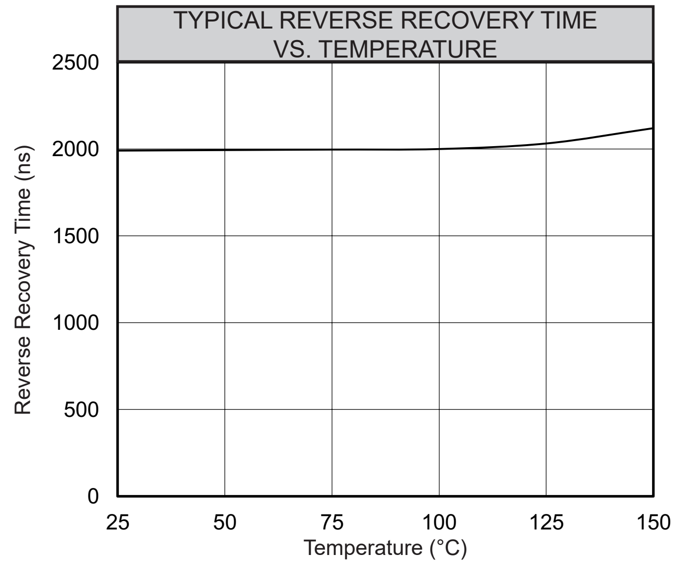
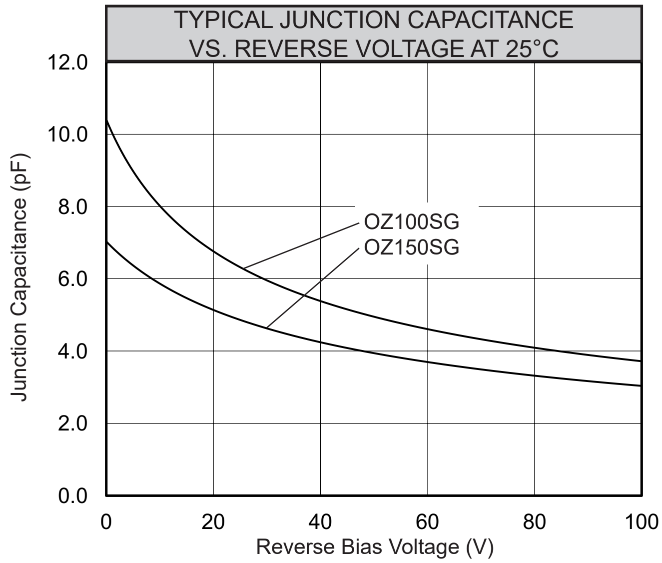

POWER DERATING
Maximum Power Dissipation (W)
Lead Temperature (°C)
L=0.000"
L=0.100"
L=0.200"
L=0.300"
L=0.400"
L=0.500"
25.0
20.0
15.0
10.0
5.0
0.0
0
25
50
75
100
125
150
175


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
Forward Current (A)
OZ150SG
OZ100SG
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
Temperature (°C)
1000
100
10
1
25
50
75
100
125
150


TYPICAL REVERSE RECOVERY TIME
VS. TEMPERATURE
Reverse Recovery Time (ns)
Temperature (°C)
2500
2000
1500
1000
500
0
25
50
75
100
125
150


TYPICAL JUNCTION CAPACITANCE
VS. REVERSE VOLTAGE AT 25°C
Junction Capacitance (pF)
Reverse Bias Voltage (V)
OZ100SG
OZ150SG
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100

6

OC100G OC100HG

Optocoupler • Axial Leaded • Epoxy Molded

ABSOLUTE MAXIMUM RATINGS

	OC100G	OC100HG
LED		
Forward DC Current	100mA	
Surge Current	(tp = 100 µs) 1.5A	(tp = 100 µs) 1.0A
Reverse Voltage	5V	
Power Dissipation	(25°C) 160 mW	(25°C) 180 mW
Photodiode		
Reverse Voltage	10,000 V	
Power Dissipation	1.0 W	

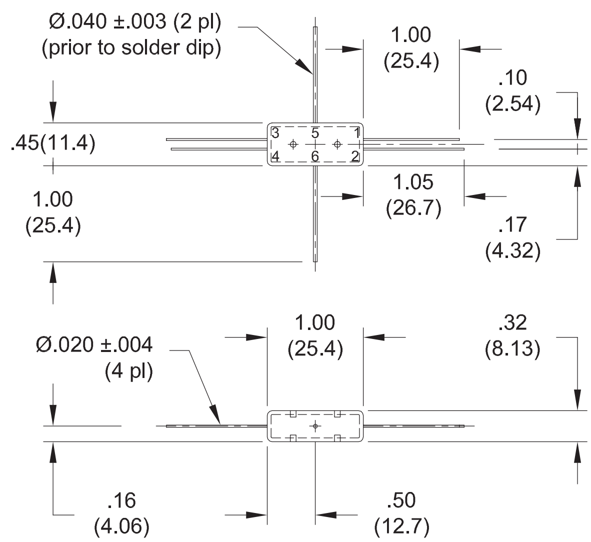
- Storage Temperature -40°C to +100°C
- Operating Temperature -40°C to +70°C
- Isolation Test Voltage 25 kV (From Pins 1, 2, 3 & 4 to Pins 5 & 6)

ELECTRICAL CHARACTERISTICS

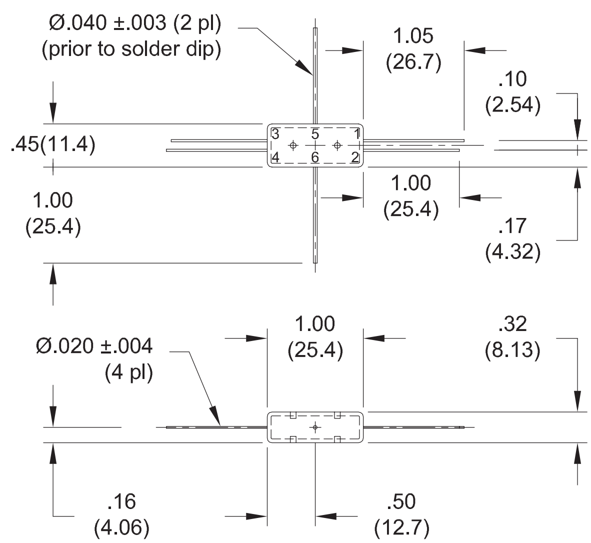
	OC100G	OC100HG
LED		
Forward Voltage	(If = 100mA) 1.5V	
Photodiode		
Forward Voltage	(If = 0.6 A) 12.0 V MAX	
Reverse Leakage Current		
VR = 10kV, I_{LED} = 0 mA	250 nA Typical	
VR = 10kV, I_{LED} = 50 mA	200 µA Typical	250 µA Typical
Coupled		
DC Current Transfer Ratio		
I_{LED} = 50 mA VR = 10kV	0.32% MIN	0.38% MIN
t_{ON} = (Typical)	2 µs	
t_{OFF} = (Typical)	2 µs	

(25°C UNLESS OTHERWISE NOTED)

OC100HG

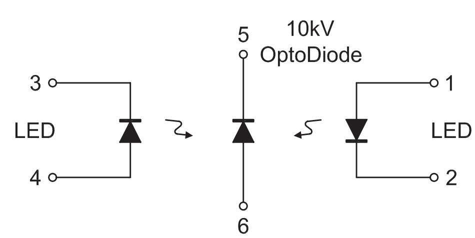


OC100G



Tolerance:
.XX ±.020

Simplified Circuit Schematic



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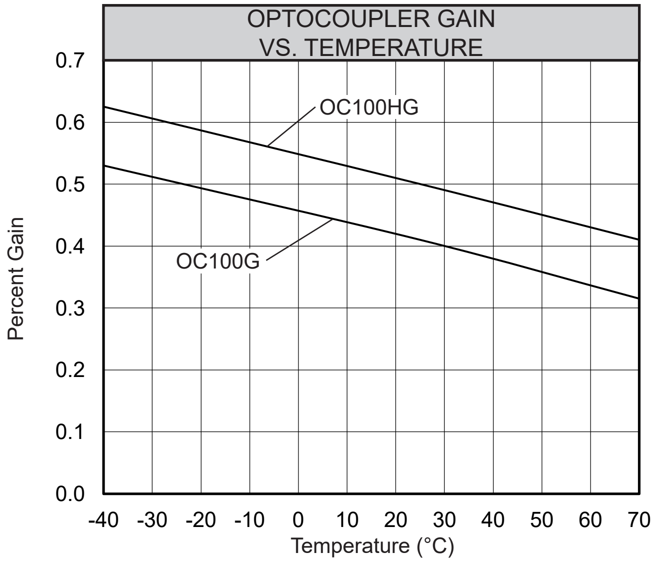
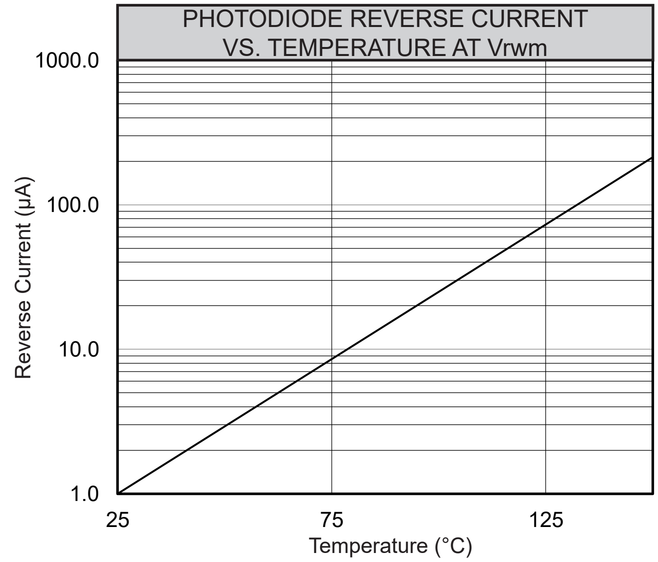
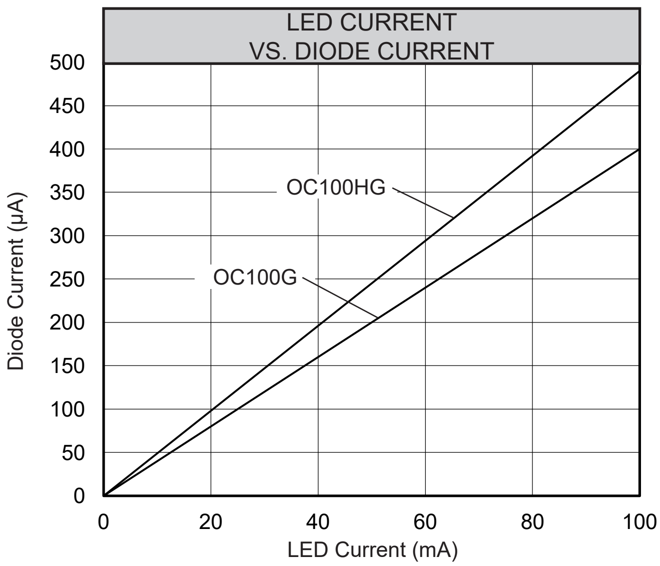
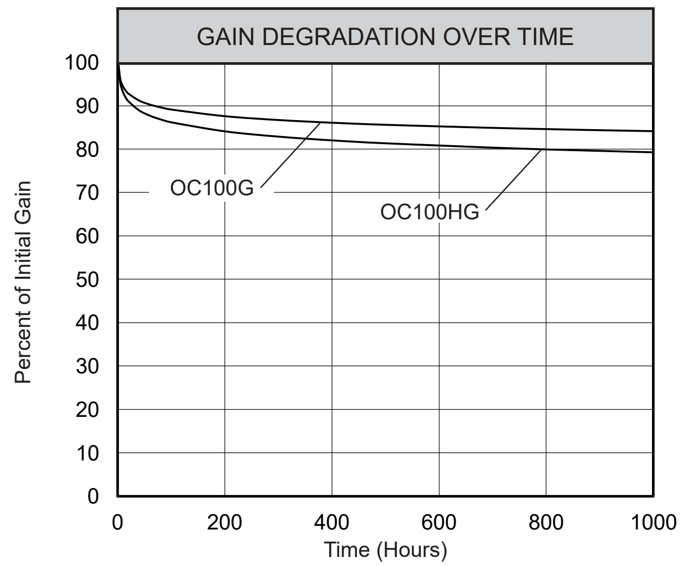
OC100G OC100HG









7

OC150G   OC150HG

Optocoupler • Axial Leaded • Epoxy Molded

ABSOLUTE MAXIMUM RATINGS

	OC150G	OC150HG
LED		
Forward DC Current	100mA	
Surge Current	(tp = 100 µs) 1.5A	(tp = 10 µs) 1.5A
Reverse Voltage	5 V	
Power Dissipation	(25°C) 190 mW	(25°C) 180 mW
Photodiode		
Reverse Voltage	15,000 V	
Power Dissipation	1.0 W	

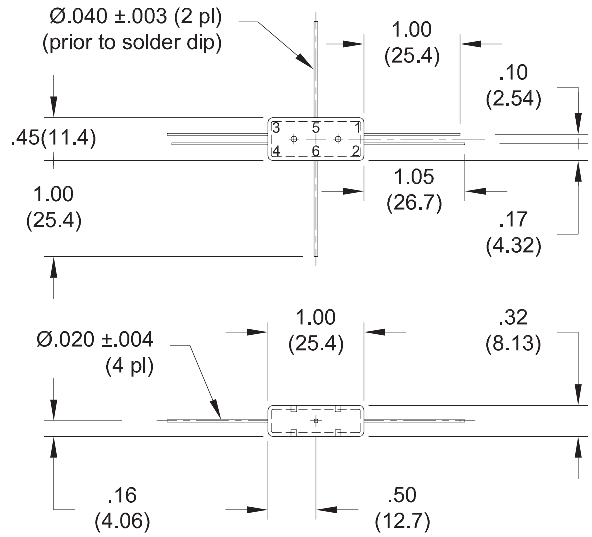
- Storage Temperature: -40°C to +100°C
- Operating Temperature: -40°C to +70°C
- Isolation Test Voltage: 25 kV (From Pins 1, 2, 3 & 4 to Pins 5 & 6)

ELECTRICAL CHARACTERISTICS

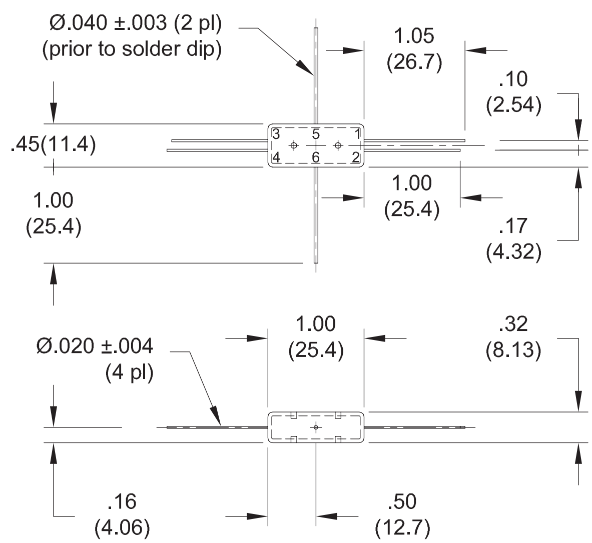
	OC150G	OC150HG
LED		
Forward Voltage	(If = 100 mA) 1.5 V	
Reverse Leakage Current VR = 5 V	10 µA	
Photodiode		
Forward Voltage	(If = 0.3 A) 18.0 V MAX	
Reverse Leakage Current		
VR = 10 kV, I_{LED} = 0 mA	250 nA Typical	
VR = 10 kV, I_{LED} = 50 mA	185 µA Typical	210 µA Typical
Coupled		
DC Current Transfer Ratio		
I_{LED} = 50 mA, VR = 10 kV,	0.20% MIN	0.28% MIN
t_{ON} = (Typical)	2 µs	
t_{OFF} = (Typical)	2 µs	

(25°C UNLESS OTHERWISE NOTED)

OC150HG

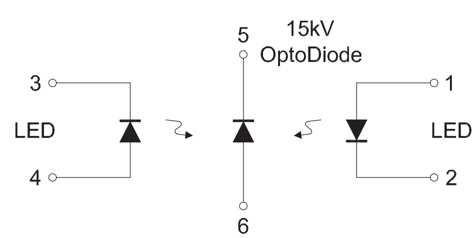


OC150G



Tolerance:
.XX ±.020

Simplified Circuit Schematic



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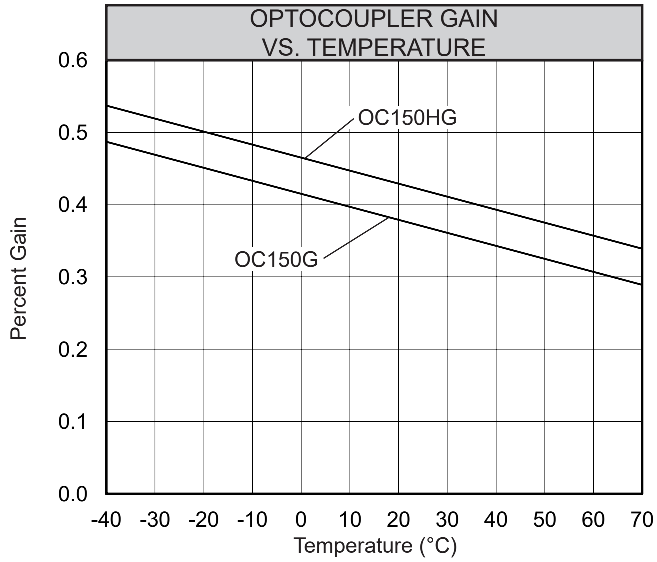
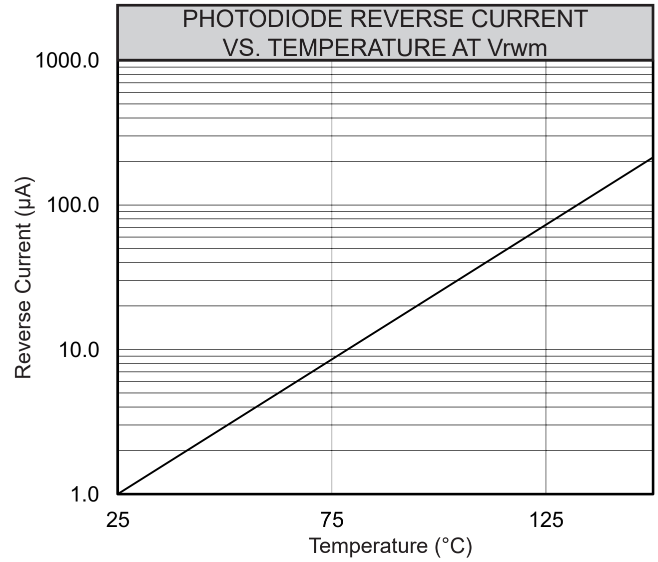
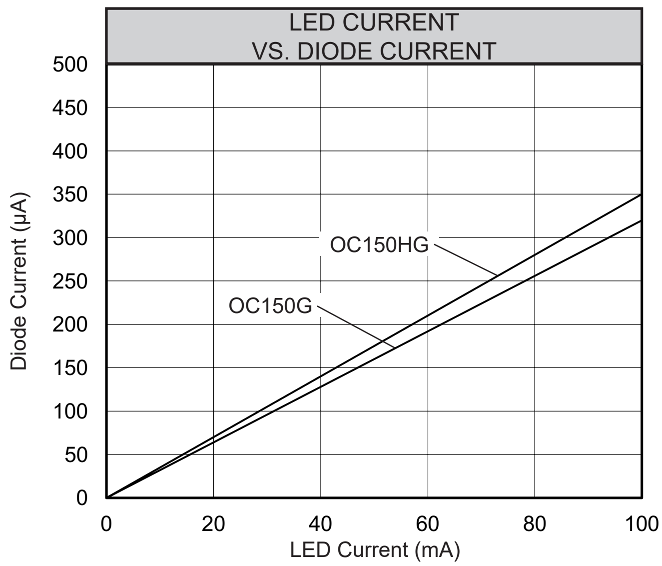
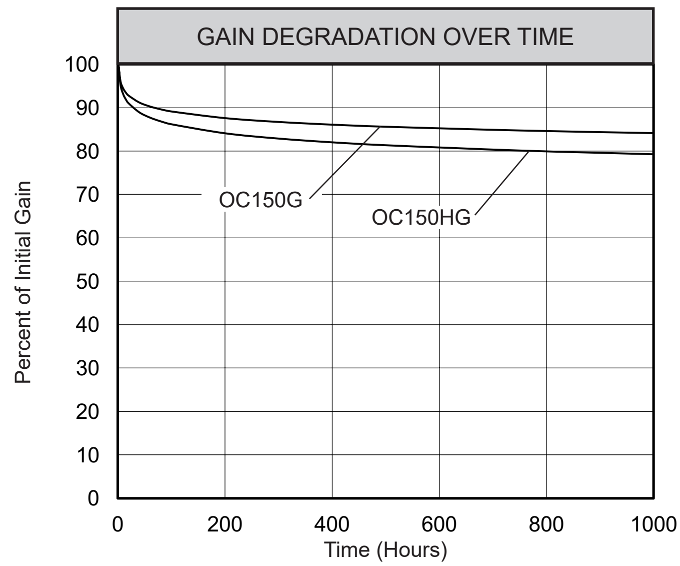

OPTOCOUPLER GAIN
VS. TEMPERATURE
Percent Gain
0.6
0.5
0.4
0.3
0.2
0.1
0.0
OC150HG
OC150G
-40 -30 -20 -10 0 10 20 30 40 50 60 70
Temperature (°C)


PHOTODIODE REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
1000.0
100.0
10.0
1.0
25 75 125
Temperature (°C)


LED CURRENT
VS. DIODE CURRENT
Diode Current (μA)
500
450
400
350
300
250
200
150
100
50
0
OC150HG
OC150G
0 20 40 60 80 100
LED Current (mA)


GAIN DEGRADATION OVER TIME
Percent of Initial Gain
100
90
80
70
60
50
40
30
20
10
0
OC150G
OC150HG
0 200 400 600 800 1000
Time (Hours)

OC 250

Opto Coupler • Epoxy Molded

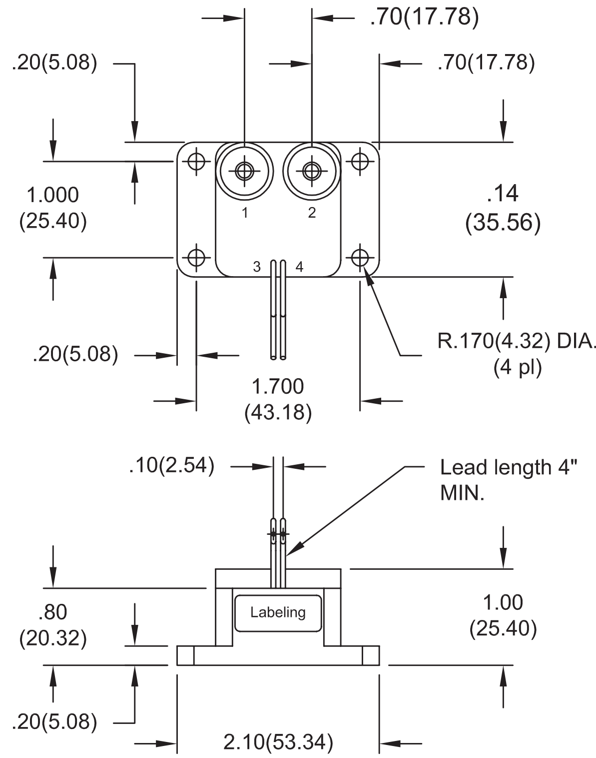
ABSOLUTE MAXIMUM RATINGS

LED	
• Forward DC Current	100 mA
• Surge Current	2.5 A
• Reverse Voltage	20 V
• Power Dissipation (25°C)	1.0 W
Photodiode	
• Reverse Voltage	25,000 V
• Power Dissipation	2.5 W
• Storage Temperature	-40°C to +125°C
• Operating Temperature	-40°C to +100°C
• Isolation Test Voltage	25 kV (Pins 1 and 2 to - Pins 3 and 4)

ELECTRICAL CHARACTERISTICS

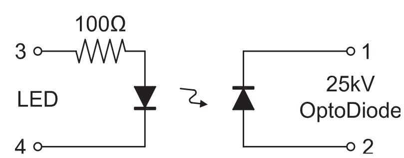
LED	
• Forward Voltage (If = 100 mA)	9.0 V
• Reverse Leakage Current VR = 20 V	10nA
Photodiode	
• Foward Voltage (If = 0.6 A)	36 V MAX
• Reverse Leakage Current	
VR = 25 kV, I_{LED} = 0 mA	250 nA Typical
VR = 25 kV, I_{LED} = 100 mA	100 µA Typical
Coupled	
• DC Current Transfer Ratio (I_{LED} = 50 mA, VR = 25 kV)	0.068%
• T_{ON}	2 µs
• T_{OFF}	2 µs

(25°C UNLESS OTHERWISE NOTED)



Tolerance:
.XX ±.020
.XXX ±.010

Simplified Circuit Schematic



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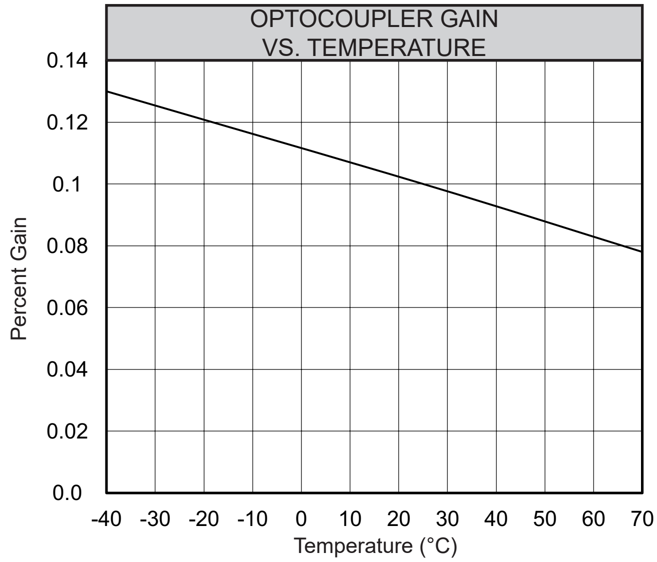
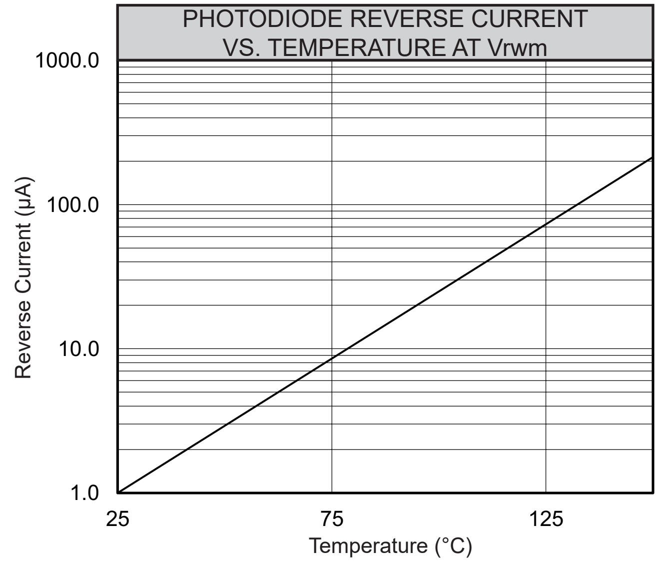
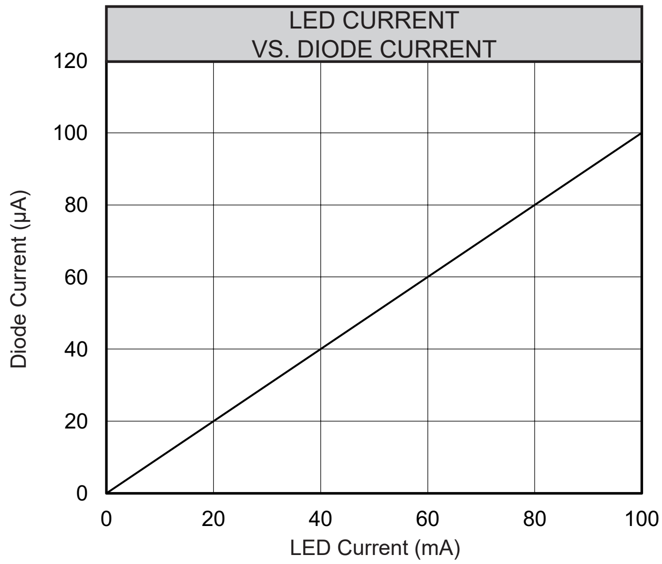
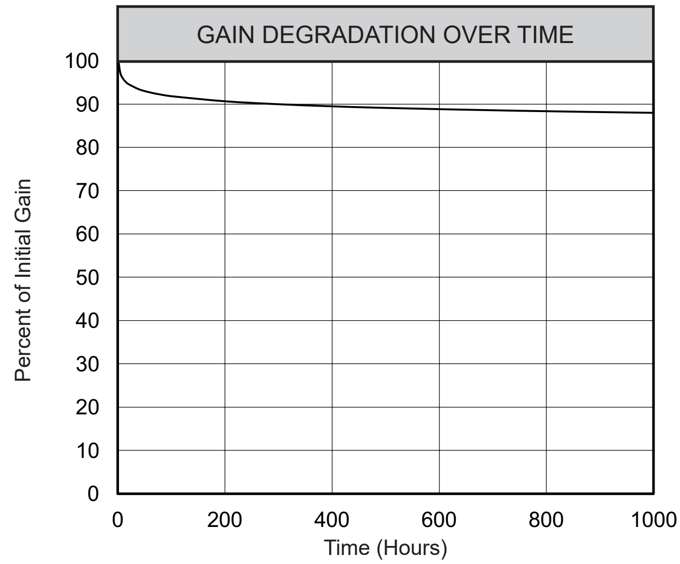

OPTOCOUPLER GAIN
VS. TEMPERATURE
Percent Gain
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0.0
-40 -30 -20 -10 0 10 20 30 40 50 60 70
Temperature (°C)

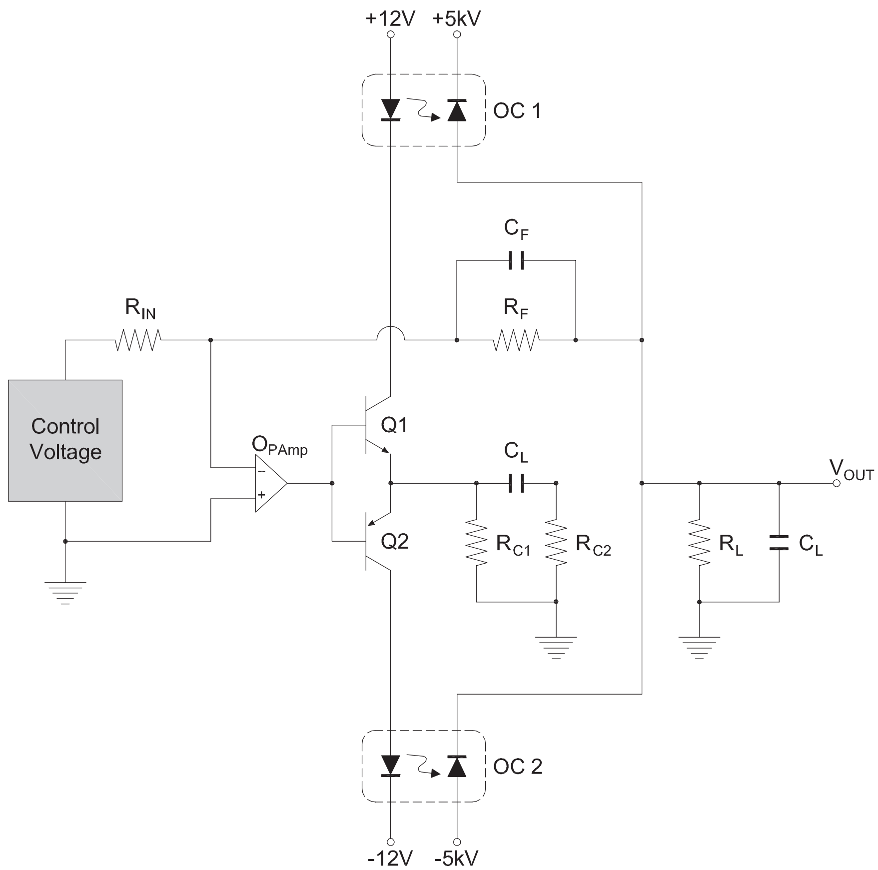

PHOTODIODE REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
1000.0
100.0
10.0
1.0
25
75
125
Temperature (°C)


LED CURRENT
VS. DIODE CURRENT
Diode Current (μA)
120
100
80
60
40
20
0
0 20 40 60 80 100
LED Current (mA)


GAIN DEGRADATION OVER TIME
Percent of Initial Gain
100
90
80
70
60
50
40
30
20
10
0
0 200 400 600 800 1000
Time (Hours)

Optocoupler Application Note

Example of a High Voltage OP AMP



Circuit Notes / Application Considerations

- Complimentary transistor pair (Q1 and Q2) drives optocoupler LED's producing complimentary photo currents in optocoupler HV diodes.
- Gain of OP-AMP output set by the ratio of R_F/ R_{IN} , inverting the input voltage to the OP-AMP.
- Feedback resistor (R_F) should be as large as practically possible to reduce loading on the output stage.
- The value of C_F must be carefully controlled to optimize stability, reduce ringing, and improve frequency response. C_F should also be kept small to reduce charge stored in the capacitor that could damage the low voltage circuitry.

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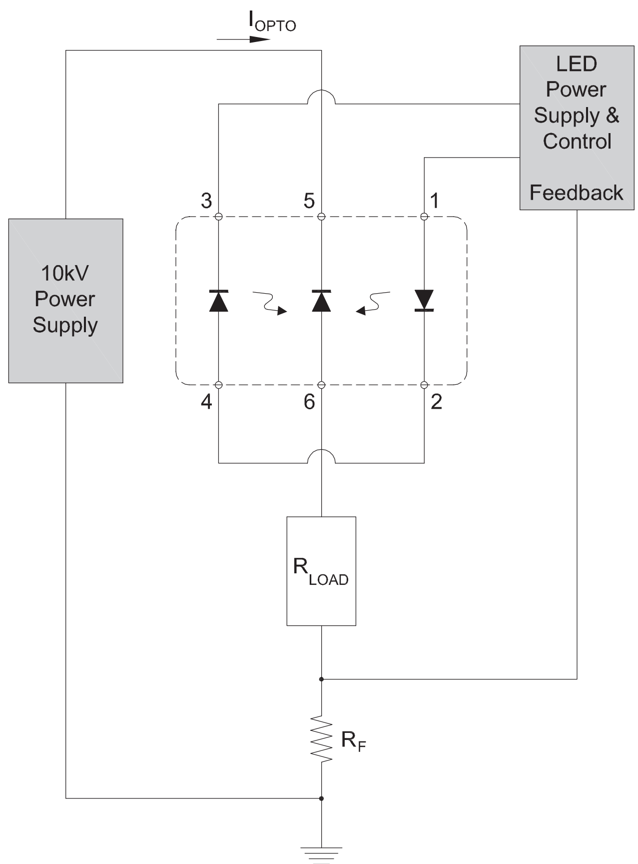
Optocoupler Application Note

Example of a High Voltage Linear Regulator Circuit



7

Circuit Notes / Application Considerations

- Gain of optocoupler dependent on applied voltage and individual device charateristics.
- Output voltage can be determined with the following formula:
  $V_{LOAD} = (I_{OPTO}) * (R_{LOAD})$
  $= (I_{LED} * \text{Gain}) * (R_{LOAD})$
  For $R_F << R_{LOAD}$
- A resistor can be placed in series with the load and high voltage diode to limit the current through the HV diode and to the load.
- The LED feedback circuit is necessary to account for changes in the gain of the device that can arise from applied voltage to the HV diode, changes in device temperature, and LED aging.

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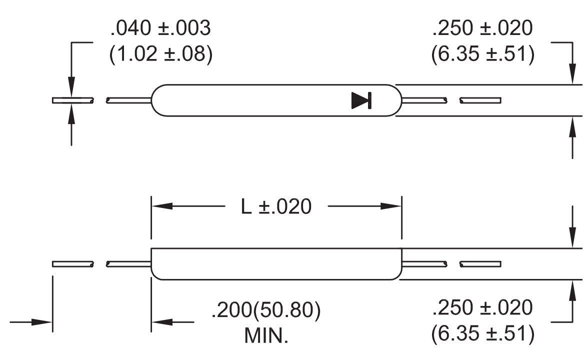
High Voltage Rectifier Stacks

50mA • 70ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (in oil) (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)
		55°C	100°C	25°C	100°C	25°C		25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	in.
SPJ100F	10000	50	30	0.50	20	12	10	5	1	70	1.00
SPJ200F	20000	50	30	0.50	20	24	10	5	1	70	1.15
SPJ300F	30000	50	30	0.50	20	36	10	5	1	70	1.65
SPJ400F	40000	50	30	0.50	20	48	10	5	1	70	2.10

(1)Trr Testing: If=125mA, Ir=250mA, Irr=63mA *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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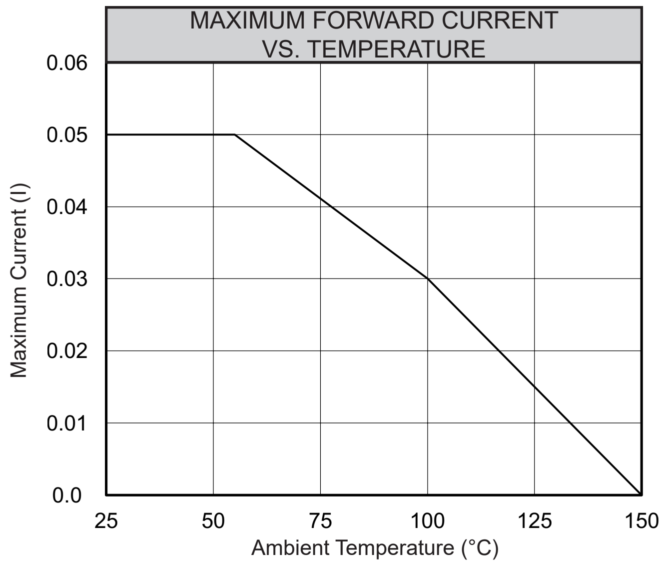
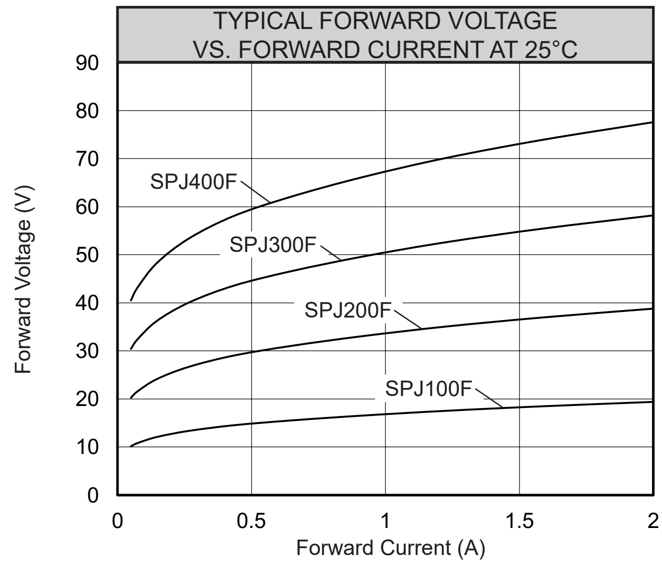
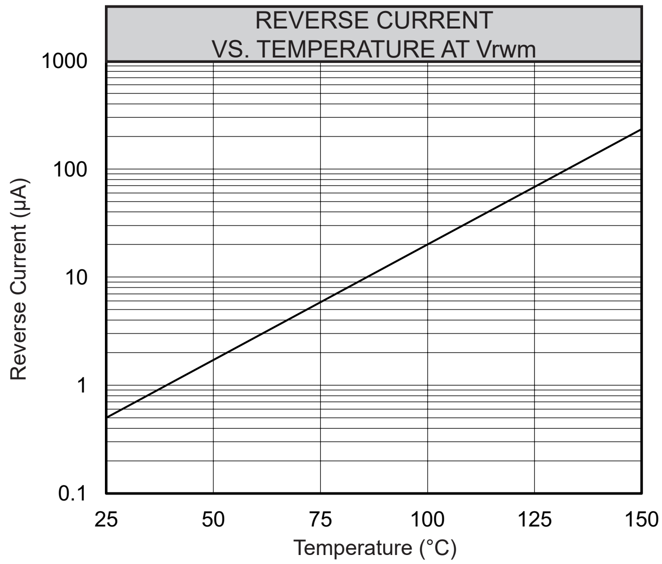

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
Maximum Current (I)
0.06
0.05
0.04
0.03
0.02
0.01
0.0
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
90
80
70
60
50
40
30
20
10
0
SPJ400F
SPJ300F
SPJ200F
SPJ100F
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)

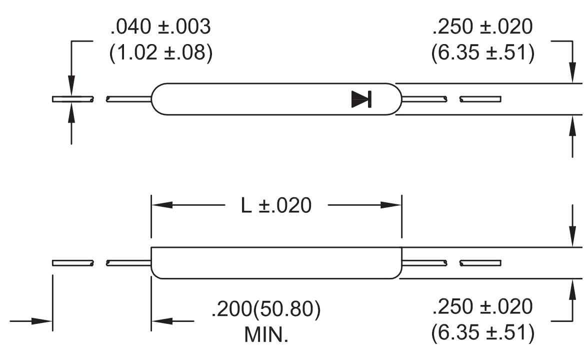
8

High Voltage Rectifier Stacks

50mA • 3000ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS											
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (in oil) (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)
		55°C	100°C	25°C	100°C	25°C		25°C	25°C	25°C	
	Volts	mA	mA	µA	µA	Volts	mA	Amps	Amps	ns	in.
SPJ100S	10000	50	30	0.50	20	10	10	5	1	3000	1.00
SPJ200S	20000	50	30	0.50	20	20	10	5	1	3000	1.15
SPJ300S	30000	50	30	0.50	20	30	10	5	1	3000	1.65
SPJ400S	40000	50	30	0.50	20	40	10	5	1	3000	2.10

(1)Trr Testing: If=125mA, Ir=250mA, Irr=63mA *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C



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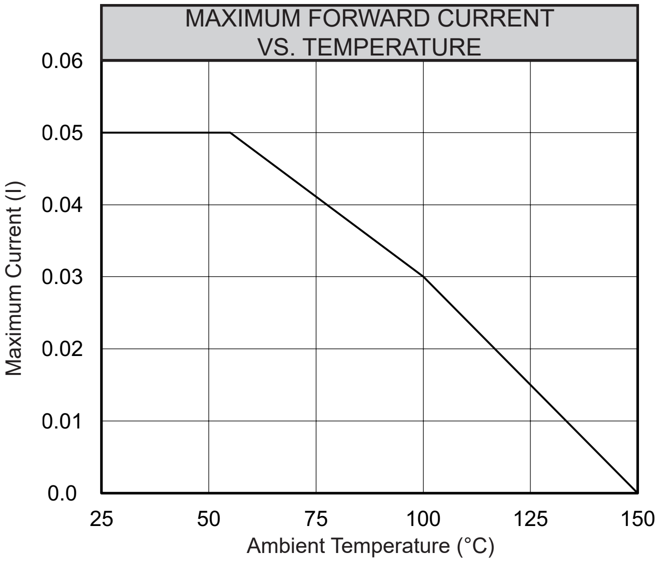
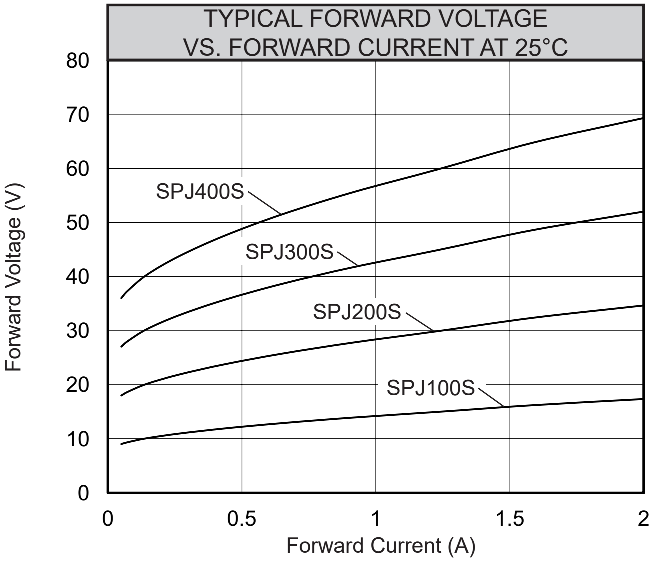
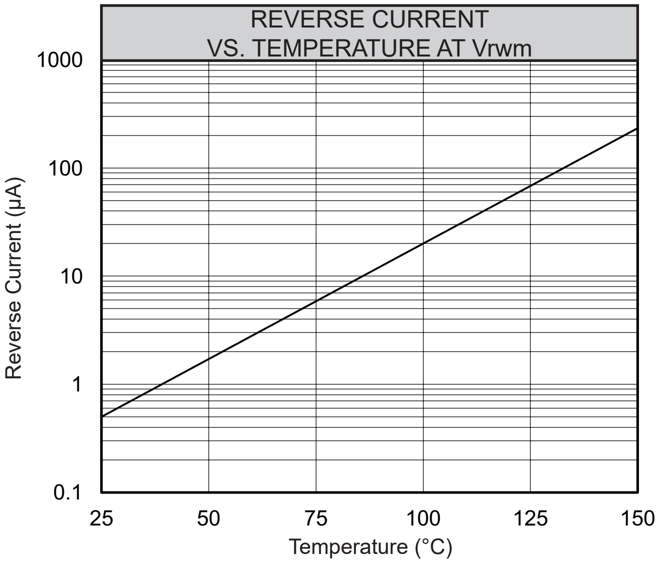

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
Maximum Current (I)
0.06
0.05
0.04
0.03
0.02
0.01
0.0
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
80
70
60
50
40
30
20
10
0
SPJ400S
SPJ300S
SPJ200S
SPJ100S
0
0.5
1
1.5
2
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
0.1
25
50
75
100
125
150
Temperature (°C)

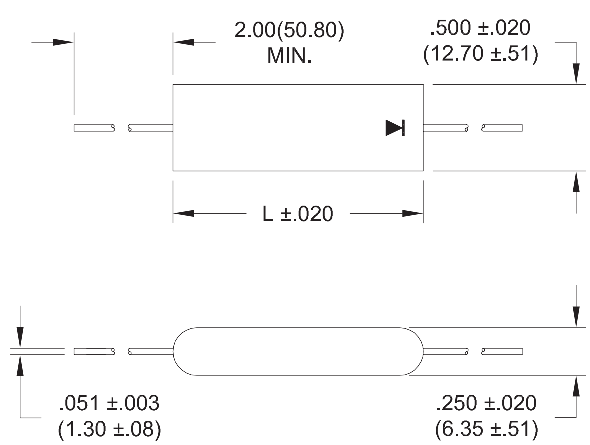
8

High Voltage Rectifier Stacks

0.5A • 70ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS											
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (in oil) (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)
		55°C	100°C	25°C	100°C	25°C		25°C	25°C	25°C	
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	in.
SP50UF	5000	0.5	0.33	1.0	25	11.0	1.0	40	8	70	2.00
SP100UF	10000	0.5	0.33	1.0	25	16.0	1.0	40	8	70	3.50
SP150UF	15000	0.5	0.33	1.0	25	24.0	1.0	40	8	70	4.25
SP200UF	20000	0.5	0.33	1.0	25	32.0	1.0	40	8	70	4.25

(1)Trr Testing: If=0.5mA, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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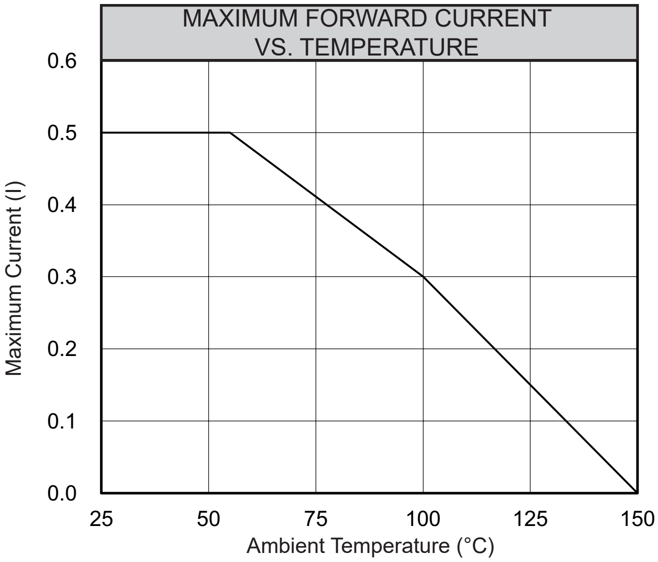
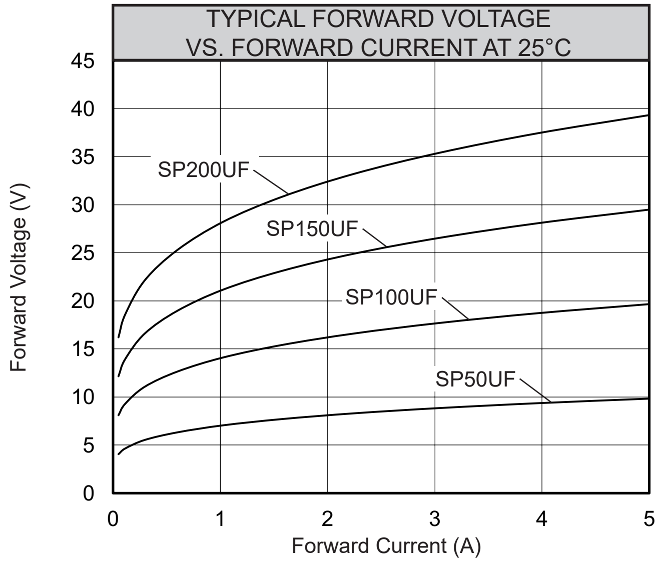
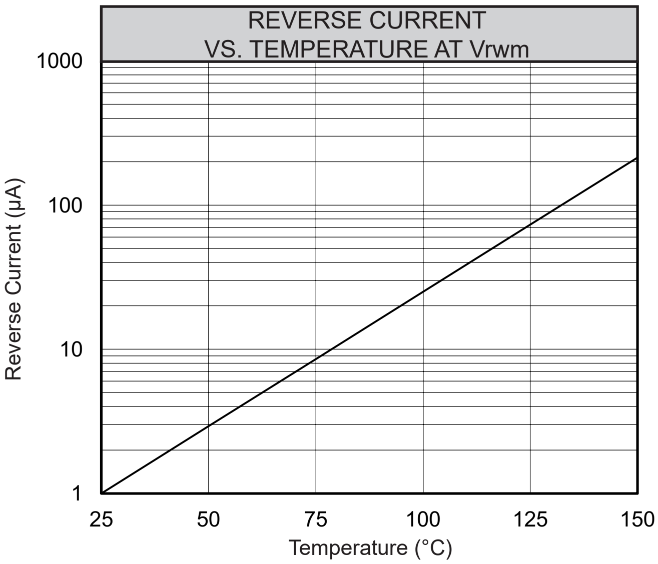

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
Maximum Current (I)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
45
40
35
30
25
20
15
10
5
0
SP200UF
SP150UF
SP100UF
SP50UF
0
1
2
3
4
5
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)

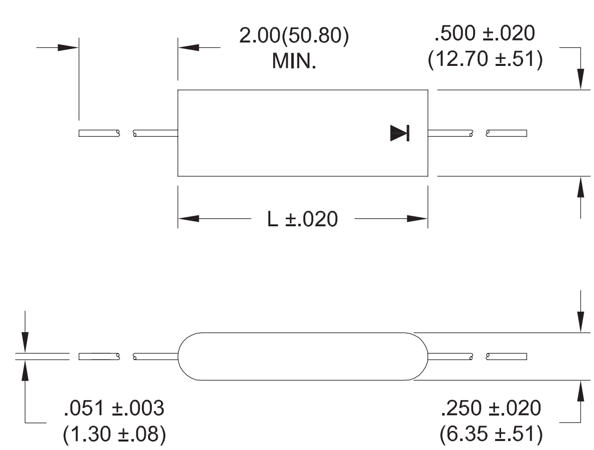
8

High Voltage Rectifier Stacks

0.5A • 3000ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS											
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (in oil) (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)
		55°C	100°C	25°C	100°C	25°C		25°C	25°C	25°C	
	Volts	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	in.
SP50S	5000	0.5	0.33	1.0	25	8.5	1.0	40	8	3000	1.13
SP100S	10000	0.5	0.33	1.0	25	17.0	1.0	40	8	3000	2.00
SP150S	15000	0.5	0.33	1.0	25	25.5	1.0	40	8	3000	2.75
SP200S	20000	0.5	0.33	1.0	25	34.0	1.0	40	8	3000	3.50

(1)Trr Testing: If=0.5mA, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C



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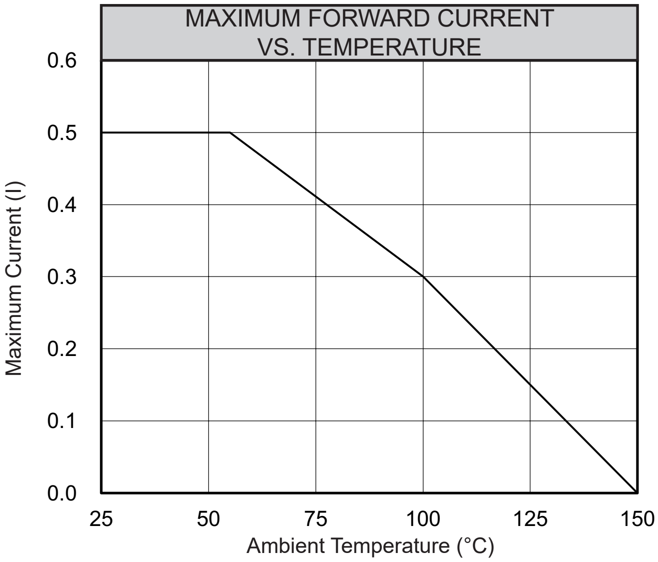
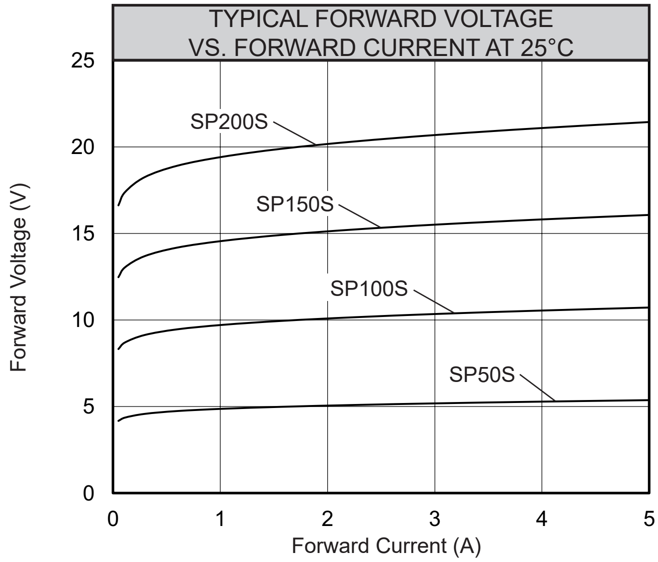
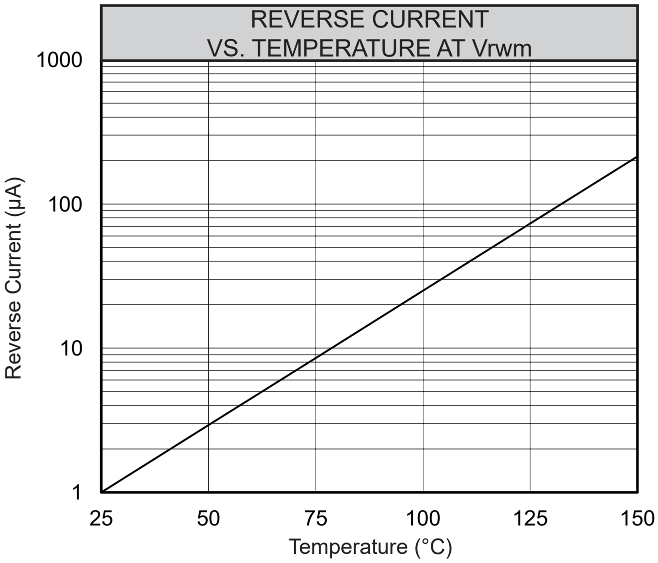

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
Maximum Current (I)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
25
20
15
10
5
0
SP200S
SP150S
SP100S
SP50S
0
1
2
3
4
5
Forward Current (A)

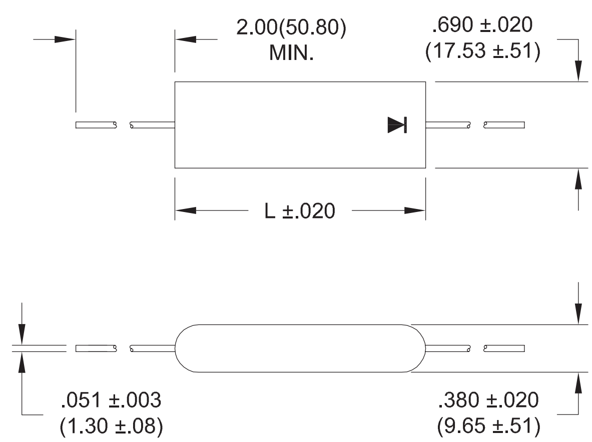

REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)

High Voltage Rectifier Stacks

2.2A • 70ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS										
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (in oil) (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)
		55°C	100°C	25°C	100°C	25°C		25°C	25°C	25°C	
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	in.
FP50UF	5000	2.2	1.30	2.0	50	13.0	3.0	120	20	70	2.50
FP100UF	10000	2.2	1.30	2.0	50	24.0	3.0	120	20	70	4.50
FP150UF	15000	2.2	1.30	2.0	50	36.0	3.0	120	20	70	6.50
FP200UF	20000	2.2	1.30	2.0	50	48.0	3.0	120	20	70	6.50

(1)Trr Testing: If=0.5mA, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C



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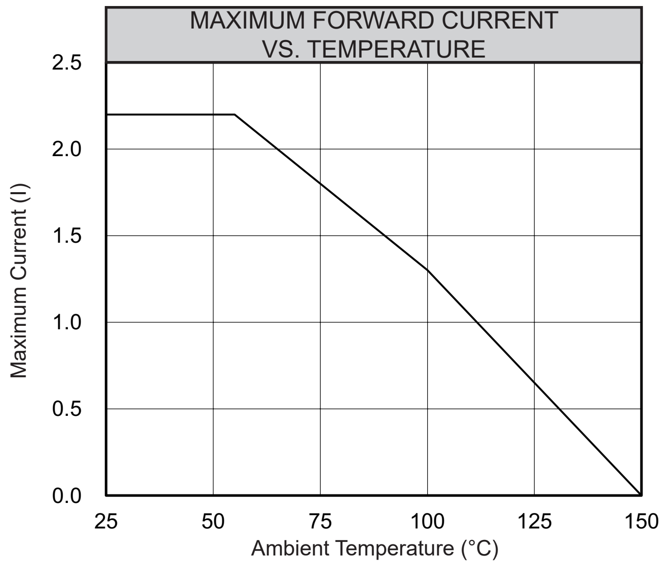
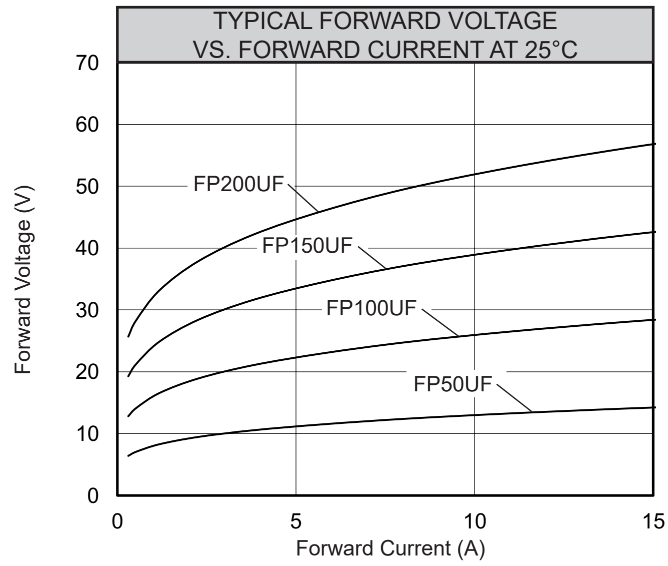
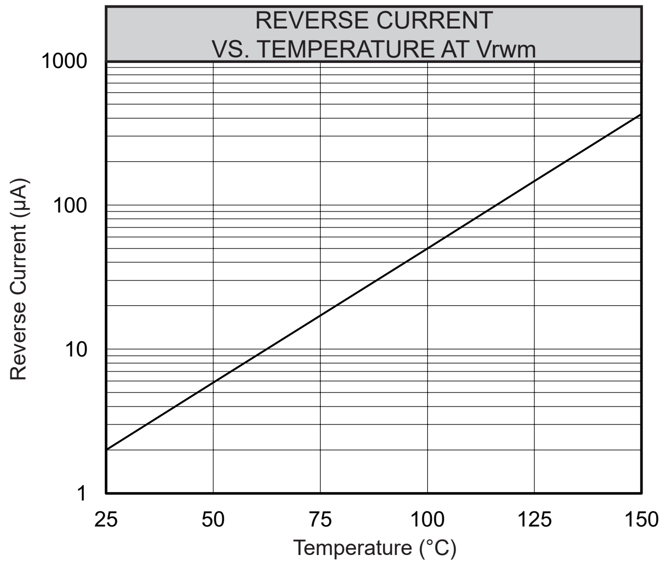

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
Maximum Current (I)
2.5
2.0
1.5
1.0
0.5
0.0
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
70
60
50
40
30
20
10
0
FP200UF
FP150UF
FP100UF
FP50UF
0
5
10
15
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (µA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)

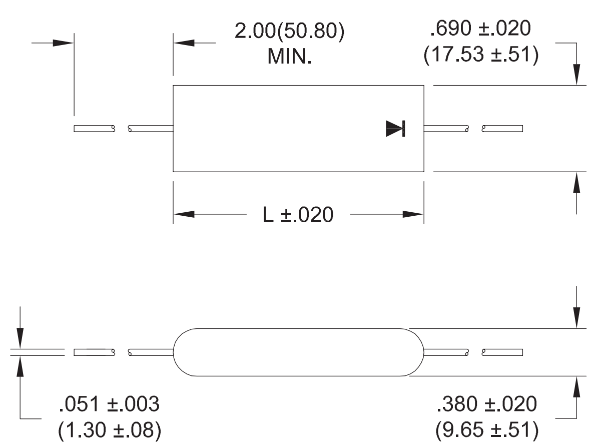
8

High Voltage Rectifier Stacks

2.2A • 3000ns • Axial Leaded

ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS											
Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (in oil) (Io)		Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)
		55°C	100°C	25°C	100°C	25°C		25°C	25°C	25°C	
	Volts	Amps	Amps	μA	μA	Volts	Amps	Amps	Amps	ns	in.
FP50S	5000	2.2	1.30	2.0	50	11.0	4.0	120	20	3000	2.50
FP100S	10000	2.2	1.30	2.0	50	22.0	4.0	120	20	3000	4.50
FP150S	15000	2.2	1.30	2.0	50	33.0	4.0	120	20	3000	6.50
FP200S	20000	2.2	1.30	2.0	50	44.0	4.0	120	20	3000	6.50

(1)Trr Testing: If=0.5mA, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C



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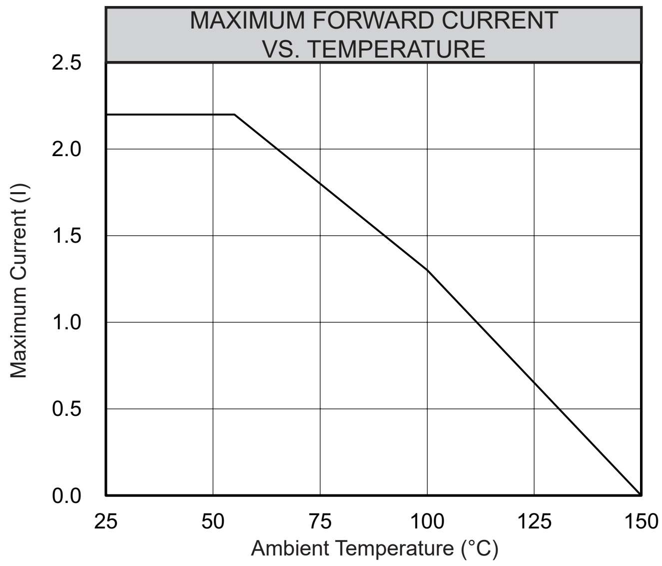
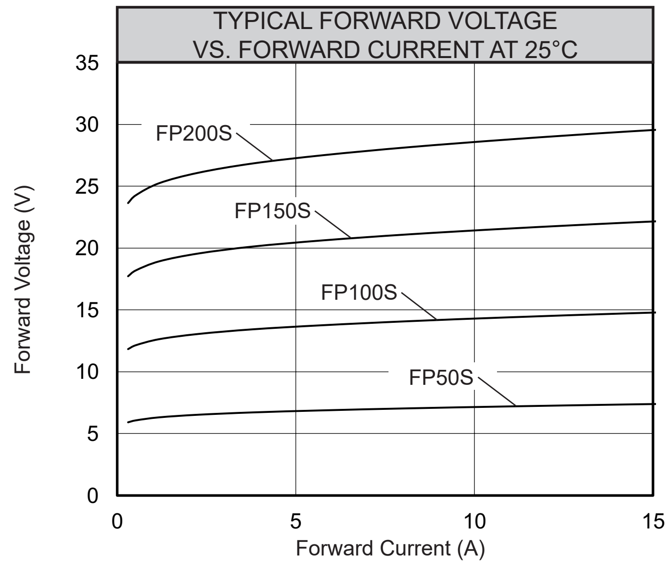
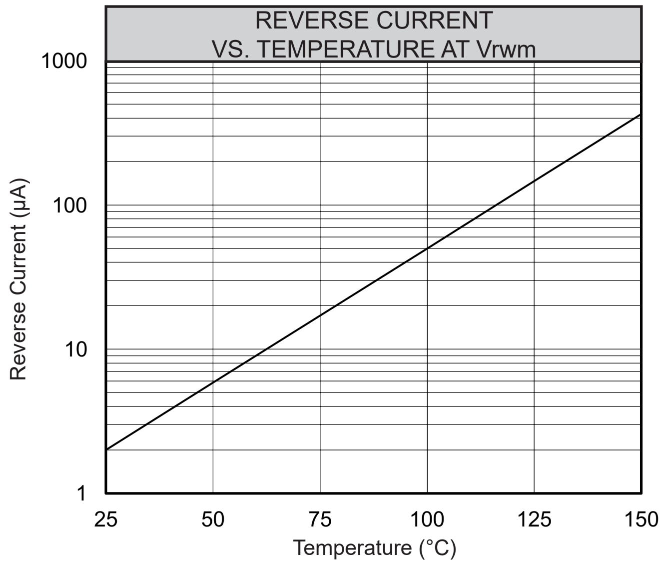

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
Maximum Current (I)
2.5
2.0
1.5
1.0
0.5
0.0
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
Forward Voltage (V)
35
30
25
20
15
10
5
0
FP200S
FP150S
FP100S
FP50S
0
5
10
15
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
Reverse Current (μA)
1000
100
10
1
25
50
75
100
125
150
Temperature (°C)

8

Single Phase Bridge - High Voltage SPB Series

2.0A • 70ns

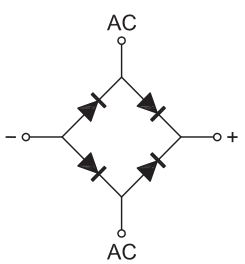
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

Part Number	Working Reverse Voltage (Vrwm)	Average Rectified Current (Io)			Reverse Current @ Vrwm (Ir)		Forward Voltage (Vf)		1 Cycle Surge Current tp=8.3ms (Ifsm)	Repetitive Surge Current (Ifrm)	Reverse Recovery Time (1) (Trr)	Case Length (L)	Terminal Dim. (A)
		70°C Oil	55°C Heatsink	25°C No Heatsink	25°C	100°C	25°C		25°C	25°C	25°C		
	Volts	Amps	Amps	Amps	µA	µA	Volts	Amps	Amps	Amps	ns	in.	in.
SPB50UF(X)	5000	2.0	1.5	0.70	1.0	25	12.0	1.5	50	10	70	1.50	1.50
SPB100UF(X)	10000	2.0	1.5	0.70	1.0	25	18.0	1.5	50	10	70	1.75	1.50
SPB150UF(X)	15000	2.0	1.5	0.70	1.0	25	30.0	1.5	50	10	70	2.25	1.80
SPB200UF(X)	20000	2.0	1.5	0.70	1.0	25	36.0	1.5	50	10	70	2.50	1.50

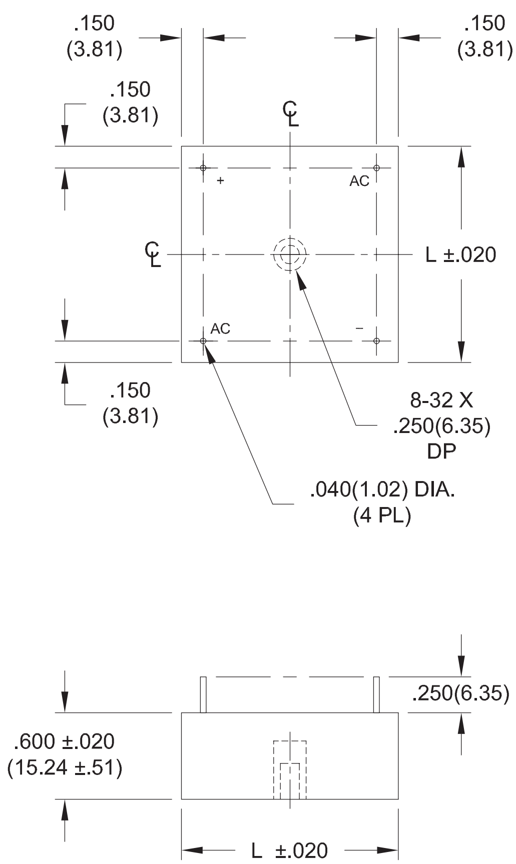
(1)Trr Testing: If=0.5A, Ir=1.0A, Irr=0.25A *Op. Temp.= -55°C to +150°C Stg. Temp.= -55°C to +150°C

To complete Part # for Terminal style:
(X) =
A - Pins
B - 4-40 Inserts

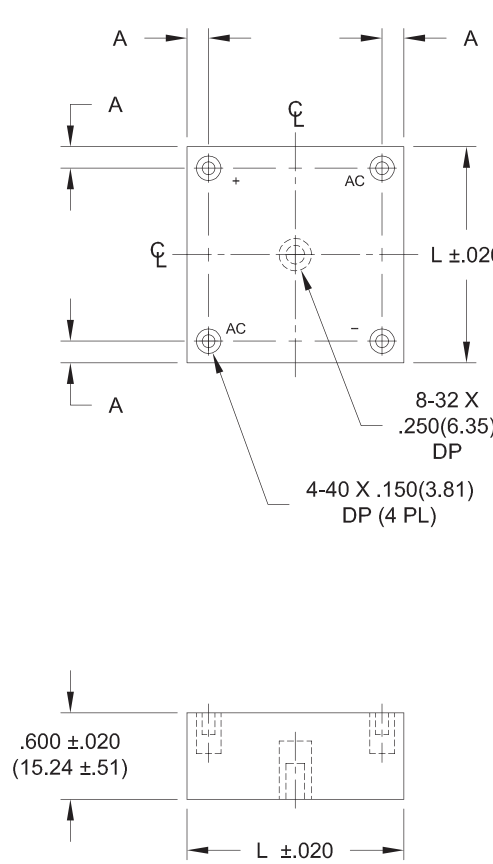
Tolerance:
.XXX ±.010
.XX ±.010



Pin Terminal



Insert Terminal



Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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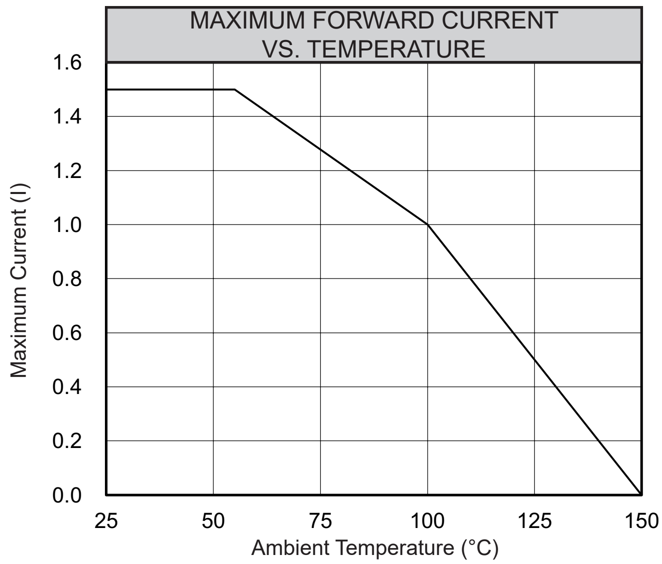
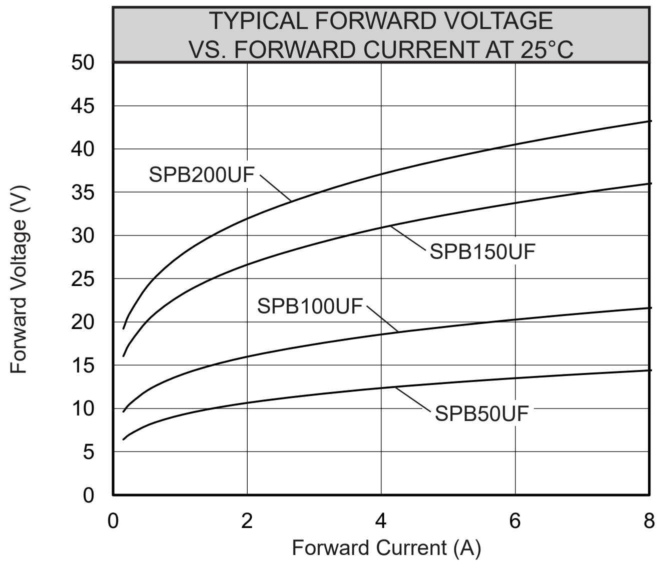
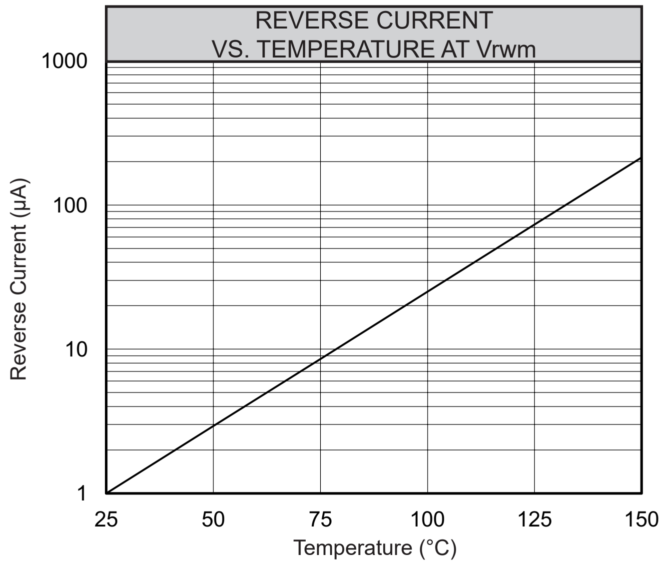

MAXIMUM FORWARD CURRENT
VS. TEMPERATURE
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Maximum Current (I)
25
50
75
100
125
150
Ambient Temperature (°C)


TYPICAL FORWARD VOLTAGE
VS. FORWARD CURRENT AT 25°C
50
45
40
35
30
25
20
15
10
5
0
Forward Voltage (V)
SPB200UF
SPB150UF
SPB100UF
SPB50UF
0
2
4
6
8
Forward Current (A)


REVERSE CURRENT
VS. TEMPERATURE AT Vrwm
1000
100
10
1
Reverse Current (µA)
25
50
75
100
125
150
Temperature (°C)

9

-2,000V Surface Mount Multiplier

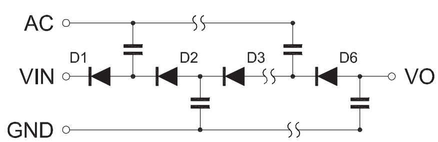
0µA - 50.0µA • 6 Stages

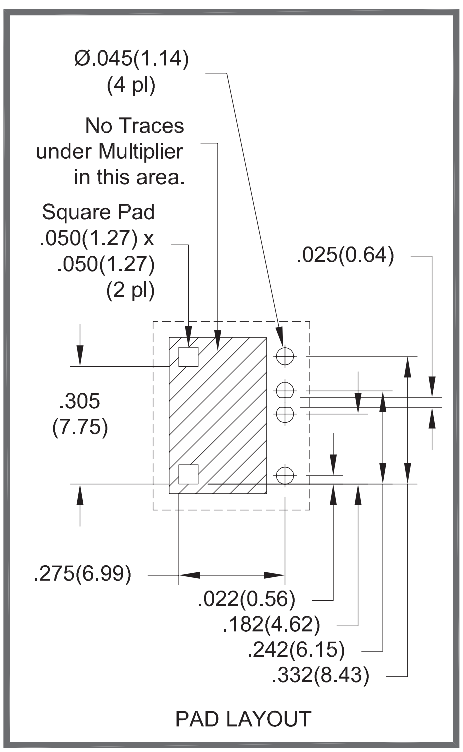
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS						
Part Number	Maximum A.C. Input Voltage	Maximum D.C. Output Voltage (One Multiplier) (2)	Maximum D.C. Output Voltage (Two Multipliers in Series or Floating) (2)	Typical Output Current Range (1)	Typical Frequency	Number of Stages
	V_{PP}	V_{DC}	V_{DC}	µA	kHz	
VM1738	800	-2000	-4000	0 - 50.0	10 - 100	6
Operating Temp: -55°C to +150°C Storage Temp. -55°C to +150°C						

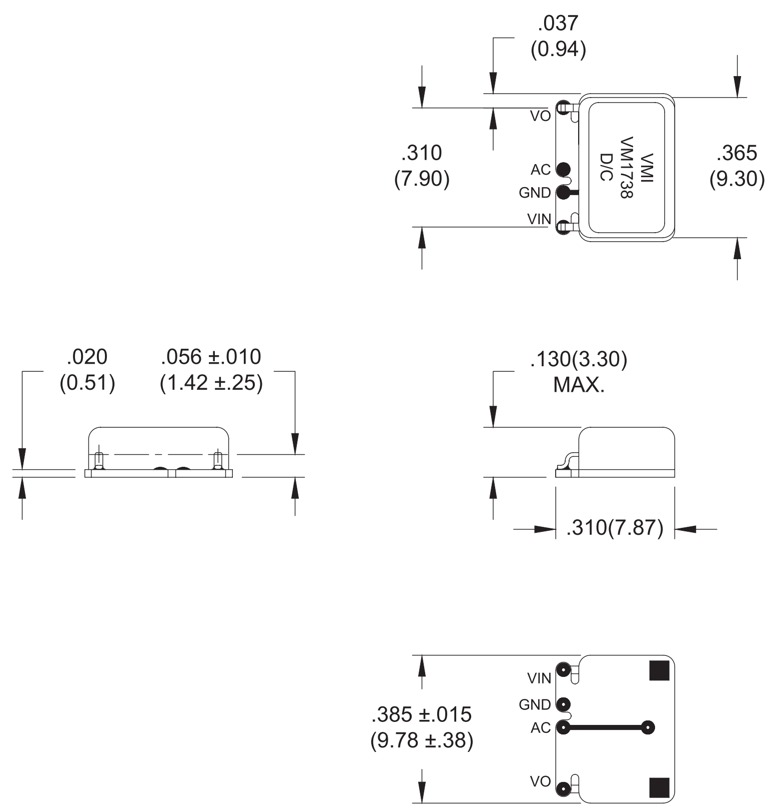
(1) Refer to load lines on next page (2) Over-encapsulation recommended when operating at, or near, rated DC output voltages.

Plating:
Electroless Nickel / Immersion Gold
(ENIG) per IPC-4552

Tolerance:
.XXX ±.010







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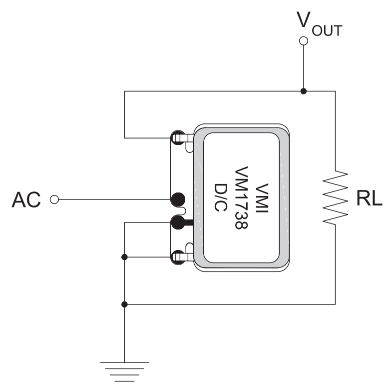
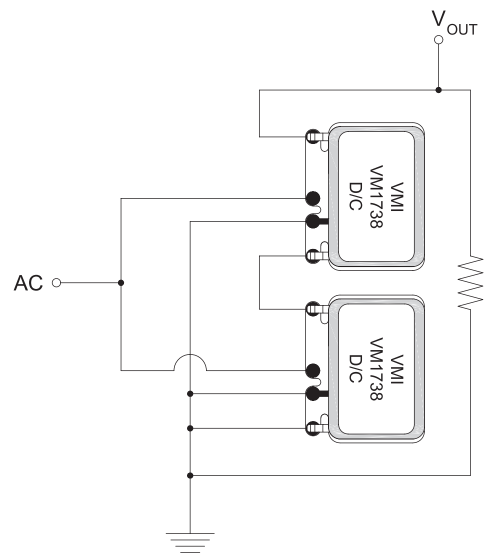
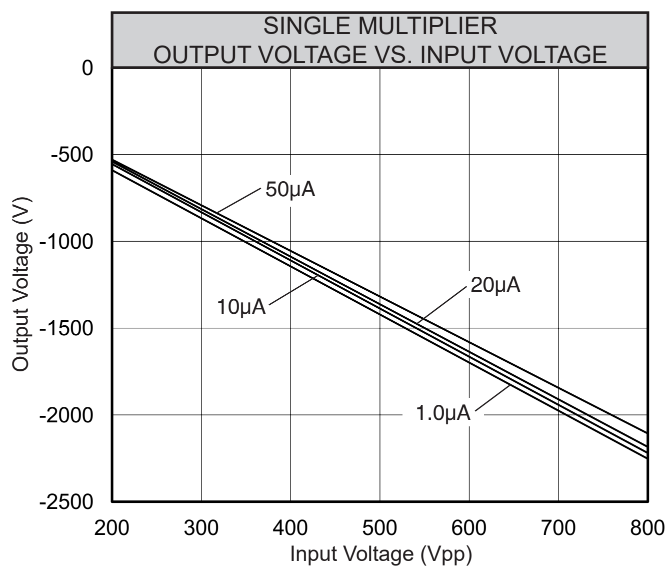
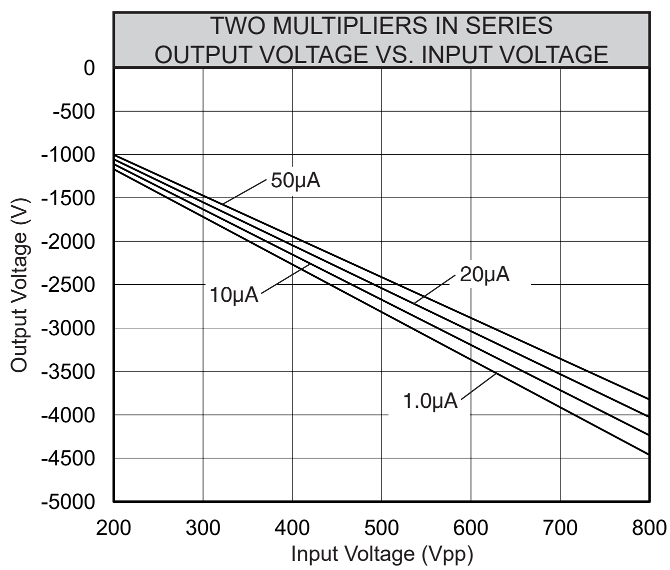
Typical Single Multiplier Circuit



Typical Circuit
Showing Two Multipliers in Series







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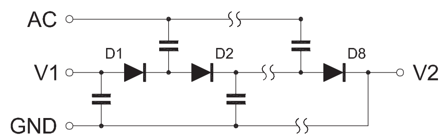
3,000V Surface Mount Multiplier

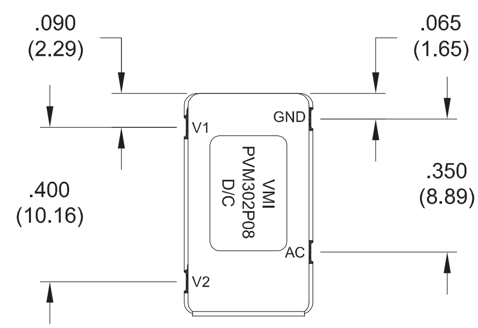
0µA - 50.0µA • 8 Stages

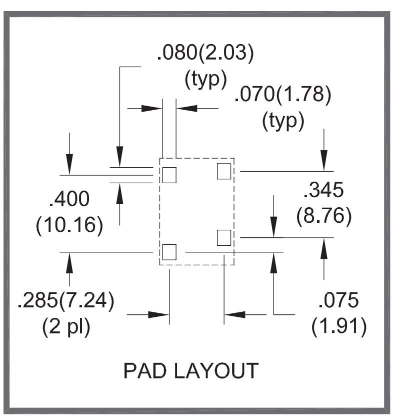
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS						
Part Number	Maximum A.C. Input Voltage	Maximum D.C. Output Voltage (One Multiplier) (2)	Maximum D.C. Output Voltage (Two Multipliers in Series or Floating) (2)	Typical Output Current Range (1)	Typical Frequency	Number of Stages
	V_{PP}	V_{DC}	V_{DC}	µA	kHz	
PVM302P08	800	3000	6000	0 - 50.0	10 - 100	8
Operating Temp: -55°C to +150°C Storage Temp. -55°C to +150°C						
(1) Refer to load lines on next page (2) Over-encapsulation recommended when operating at, or near, rated DC output voltages.						

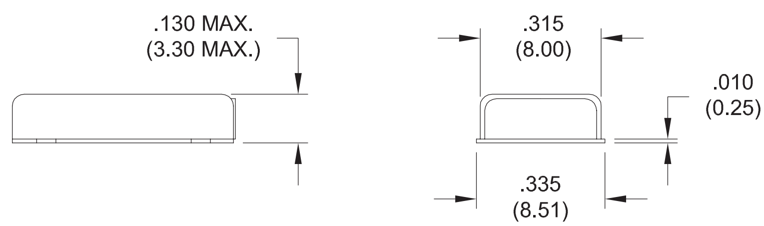
Plating:
Electroless Nickel / Immersion Gold
(ENIG) per IPC-4452

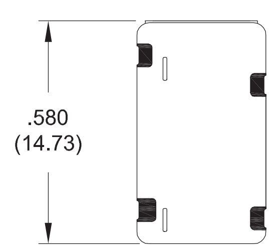
Tolerance:
.XXX ±.010











Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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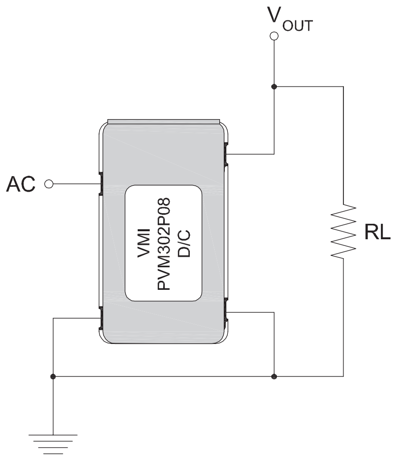
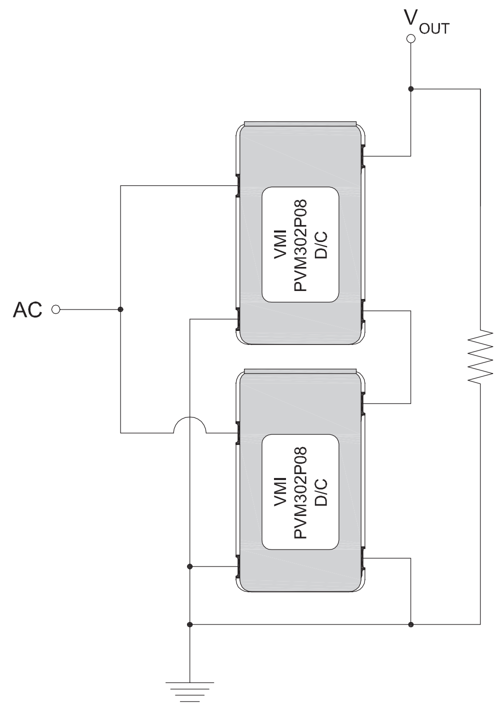
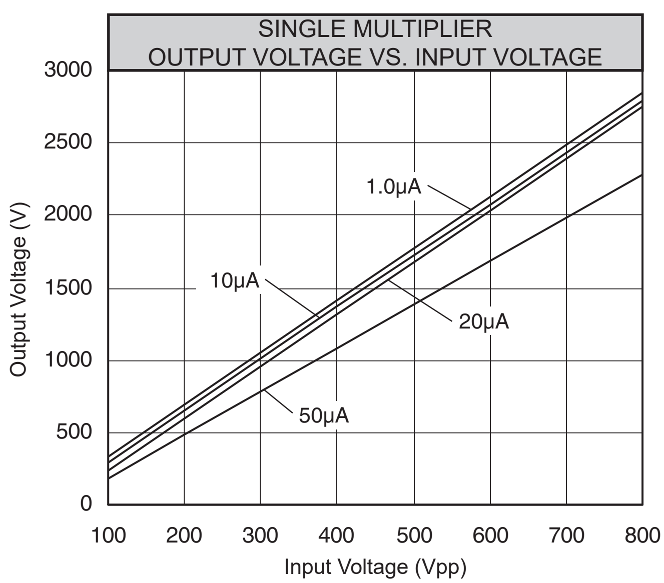
PVM302P08

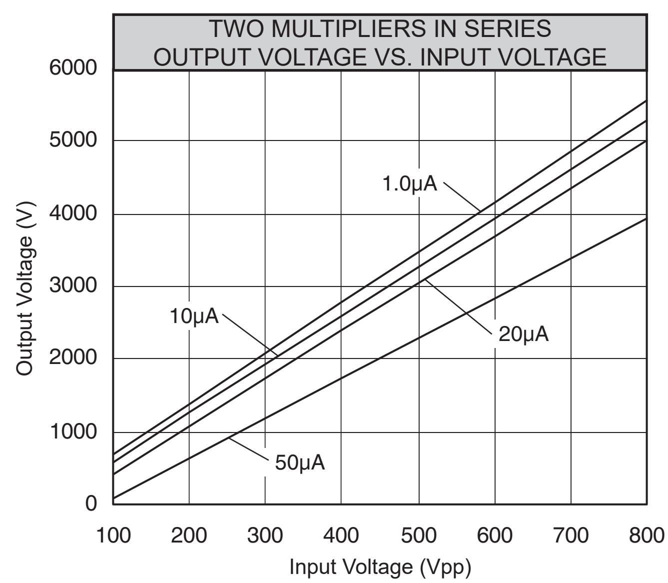
Typical Single Multiplier Circuit



Typical Circuit
Showing Two Multipliers in Series







10

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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3,000V Surface Mount Multiplier

0µA - 50.0µA • 8 Stages

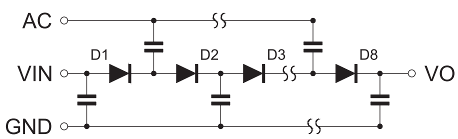
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS

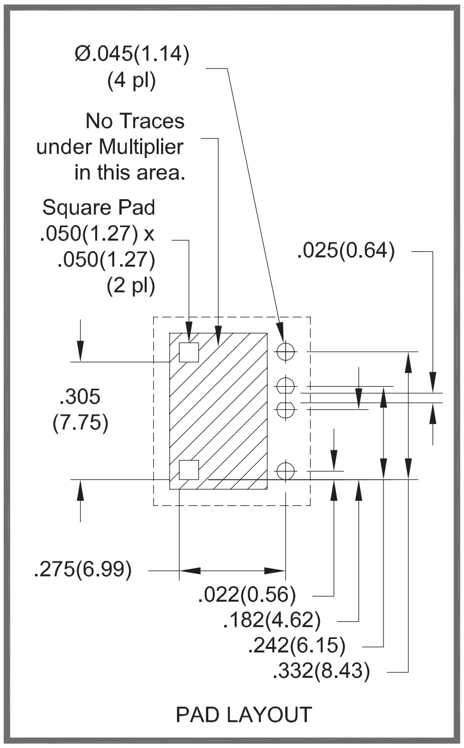
Part Number	Maximum A.C. Input Voltage	Maximum D.C. Output Voltage (One Multiplier) (2)	Maximum D.C. Output Voltage (Two Multipliers in Series or Floating) (2)	Typical Output Current Range (1)	Typical Frequency	Number of Stages
	V_{PP}	V_{DC}	V_{DC}	µA	kHz	
VM1724	800	3000	6000	0 - 50.0	10 - 100	8
Operating Temp: -55°C to +150°C	Storage Temp. -55°C to +150°C					

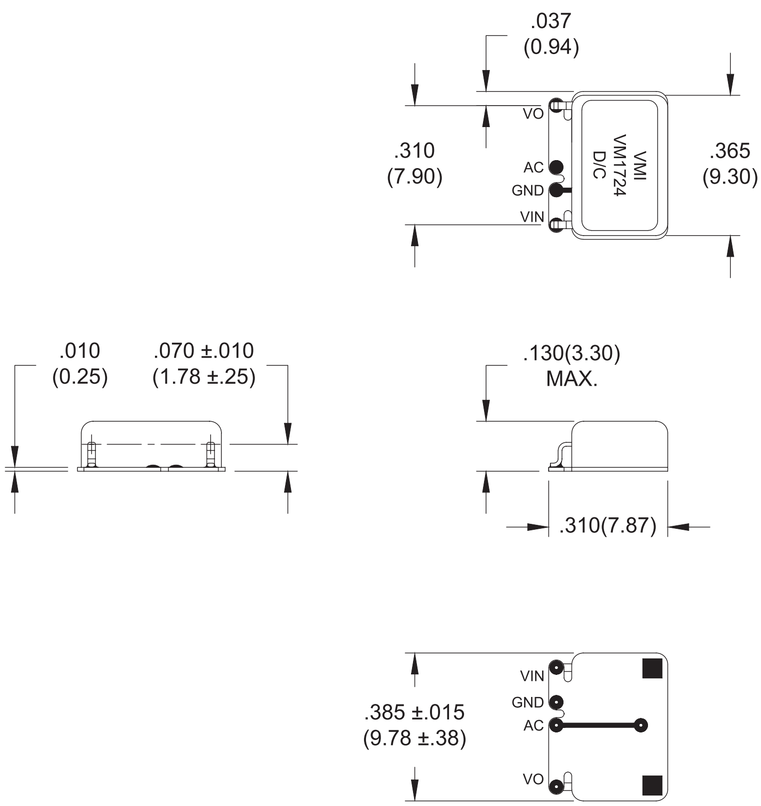
(1) Refer to load lines on next page (2) Over-encapsulation recommended when operating at, or near, rated DC output voltages.

Plating:
Electroless Nickel / Immersion Gold
(ENIG) per IPC-4552

Tolerance:
.XXX ±.010







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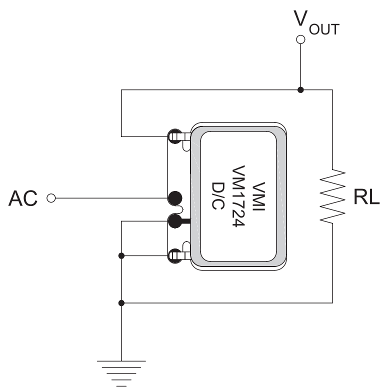
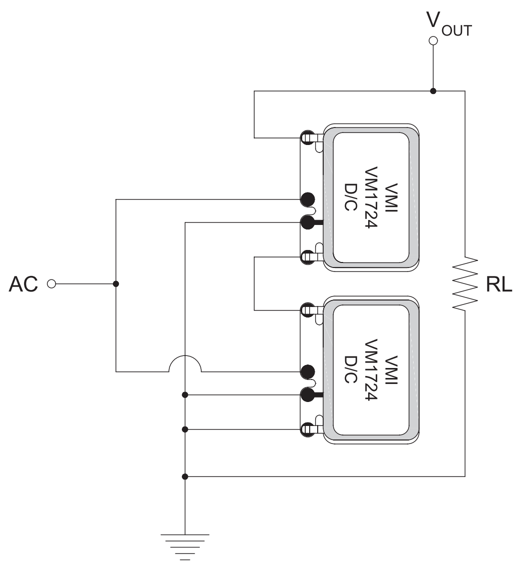
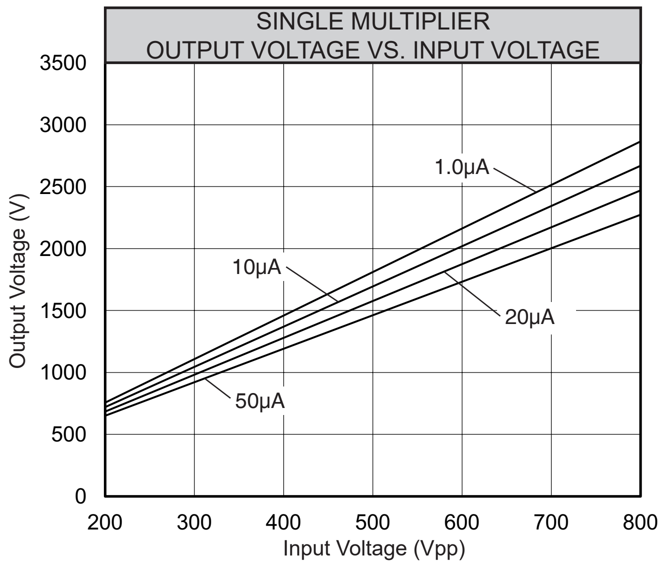
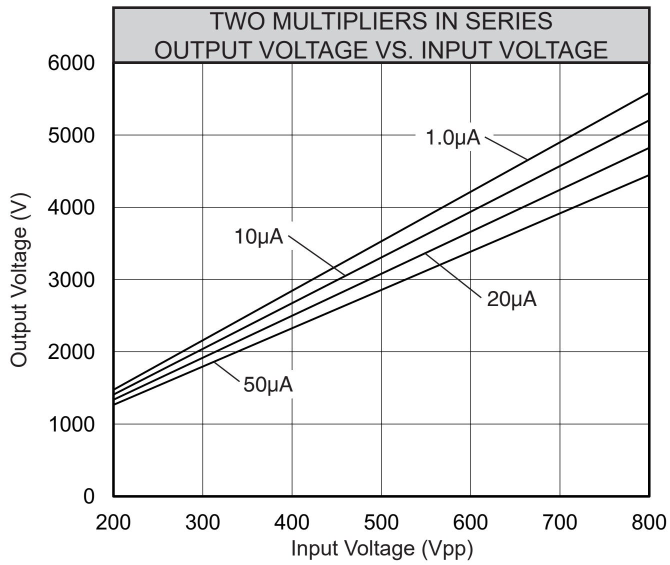
Typical Single Multiplier Circuit



Typical Circuit Showing Two Multipliers in Series







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3,000V Surface Mount Multiplier

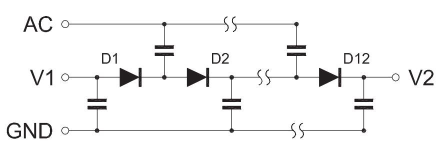
0μA - 50.0μA • 12 Stages

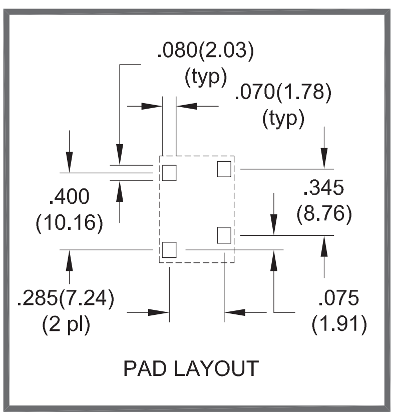
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS						
Part Number	Maximum A.C. Input Voltage	Maximum D.C. Output Voltage (One Multiplier) (2)	Maximum D.C. Output Voltage (Two Multipliers in Series or Floating) (2)	Typical Output Current Range (1)	Typical Frequency	Number of Stages
	V_{PP}	V_{DC}	V_{DC}	μA	kHz	
PVM302P12	600	3000	6000	0 - 50.0	10 - 100	12
Operating Temp: -55°C to +150°C Storage Temp. -55°C to +150°C						

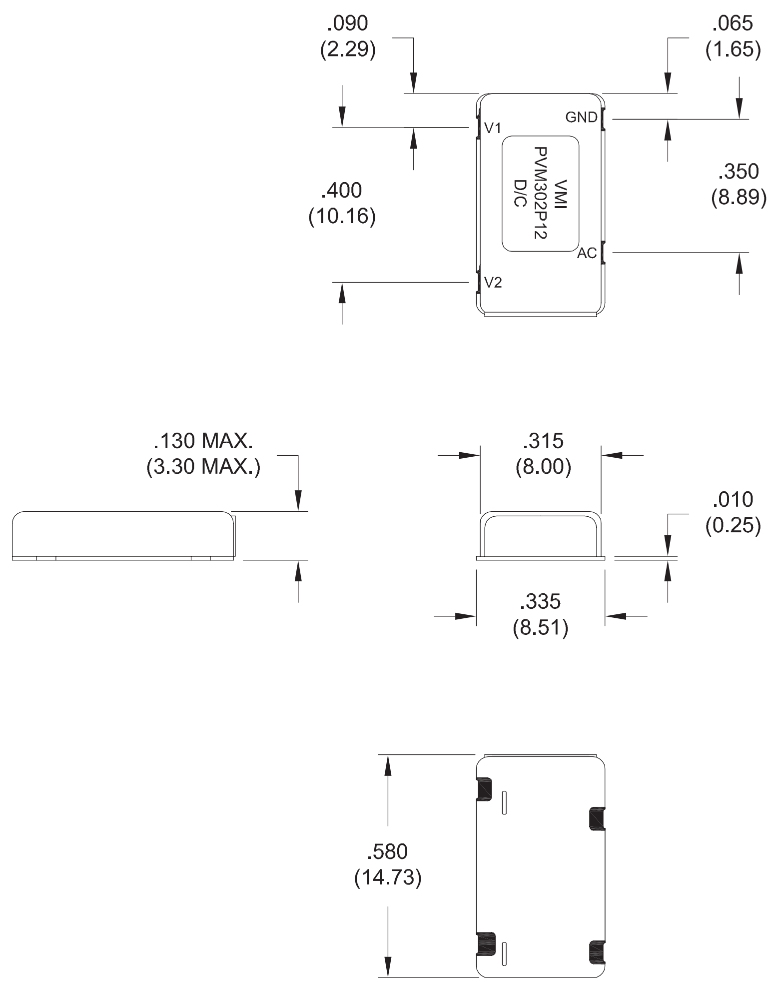
(1) Refer to load lines on next page (2) Over-encapsulation recommended when operating at, or near, rated DC output voltages.

Plating:
Electroless Nickel / Immersion Gold
(ENIG) per IPC-4452

Tolerance:
.XXX ±.010







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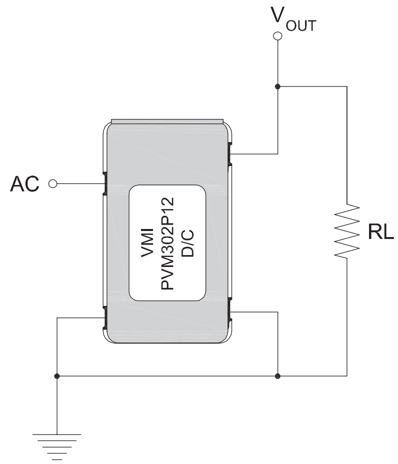
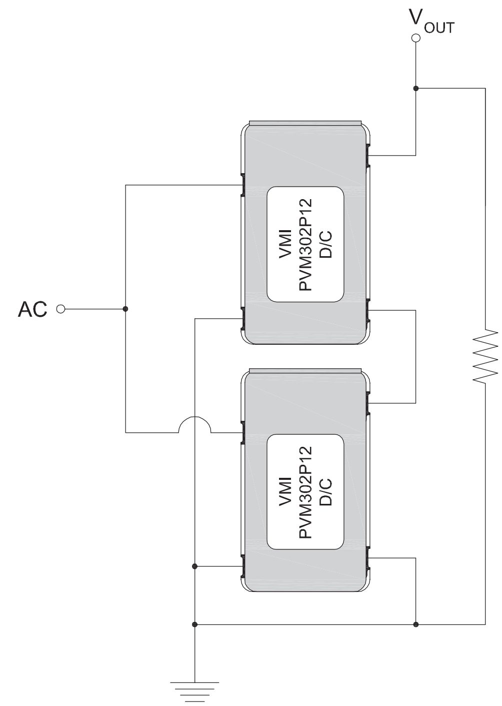
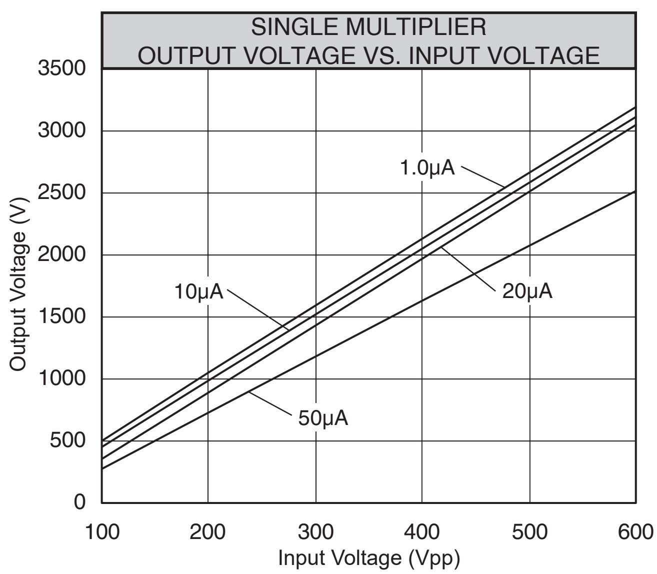
PVM302P12

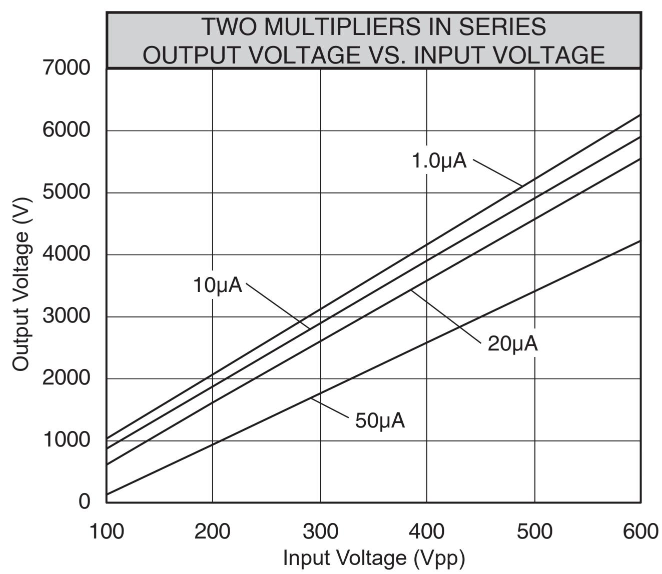
Typical Single Multiplier Circuit



Typical Circuit
Showing Two Multipliers in Series







10

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

3,000V Surface Mount Multiplier

0µA - 50.0µA • 12 Stages

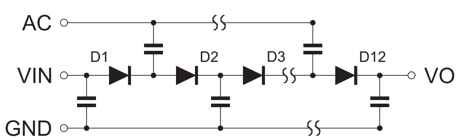
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS						
Part Number	Maximum A.C. Input Voltage	Maximum D.C. Output Voltage (One Multiplier) (2)	Maximum D.C. Output Voltage (Two Multipliers in Series or Floating) (2)	Typical Output Current Range (1)	Typical Frequency	Number of Stages
	V_{PP}	V_{DC}	V_{DC}	µA	kHz	
VM1725	600	3000	6000	0 - 50.0	10 - 100	12

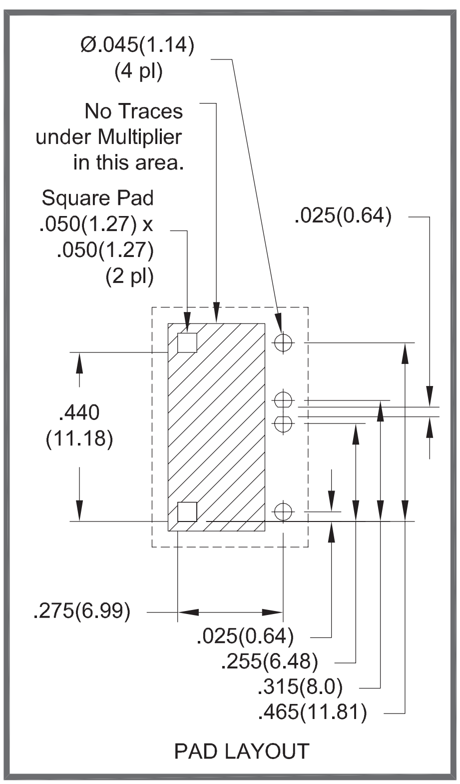
Operating Temp: -55°C to +150°C   Storage Temp. -55°C to +150°C

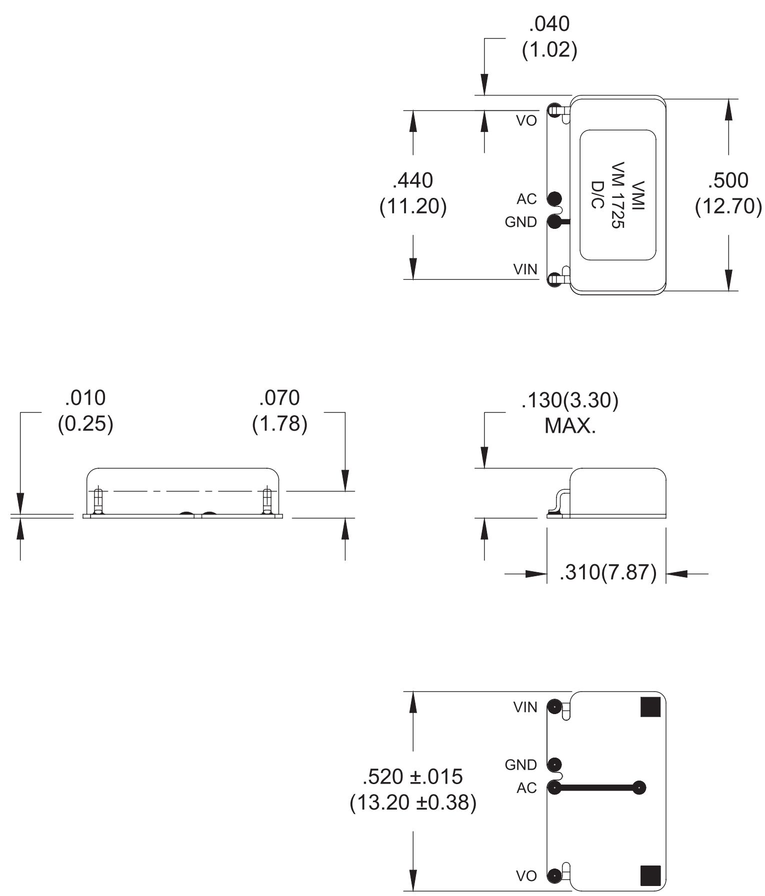
(1) Refer to load lines on next page (2) Over-encapsulation recommended when operating at, or near, rated DC output voltages.

Plating:
Electroless Nickel / Immersion Gold (ENIG) per IPC-4552

Tolerance:
.XXX ±.010







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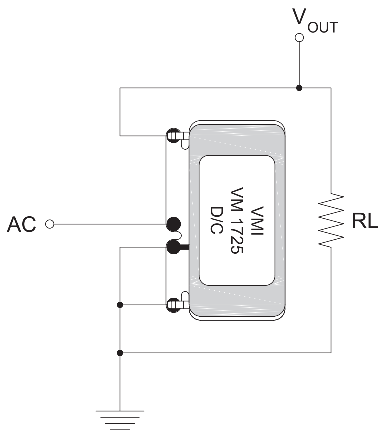
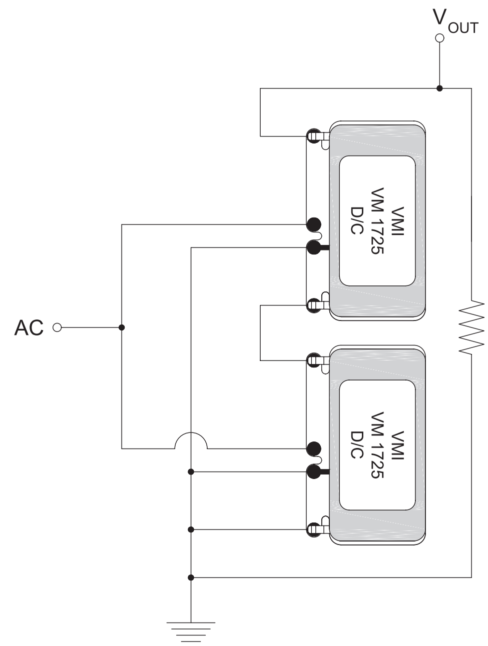
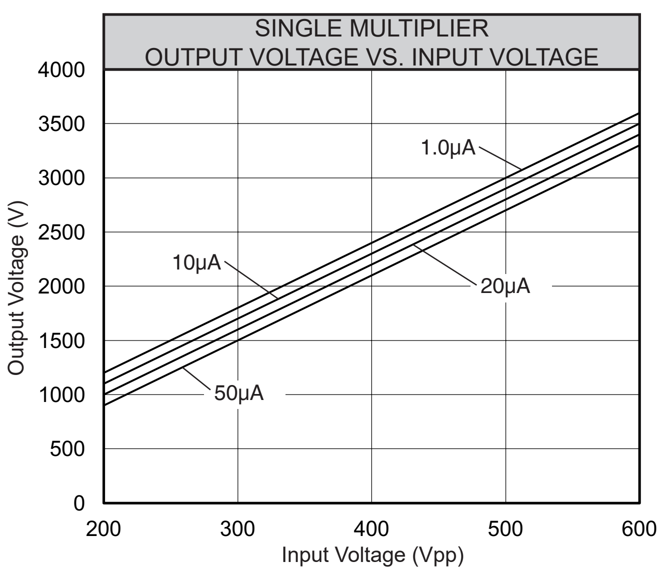
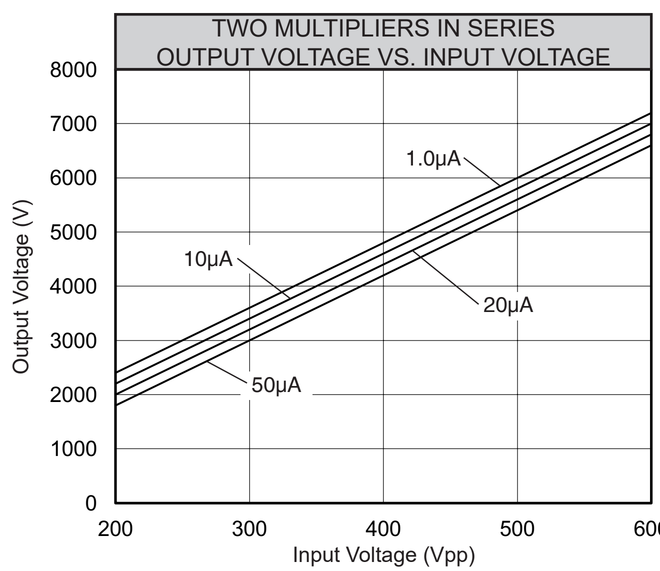
Typical Single Multiplier Circuit



Typical Circuit
Showing Two Multipliers in Series







Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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7,000V Surface Mount Multiplier

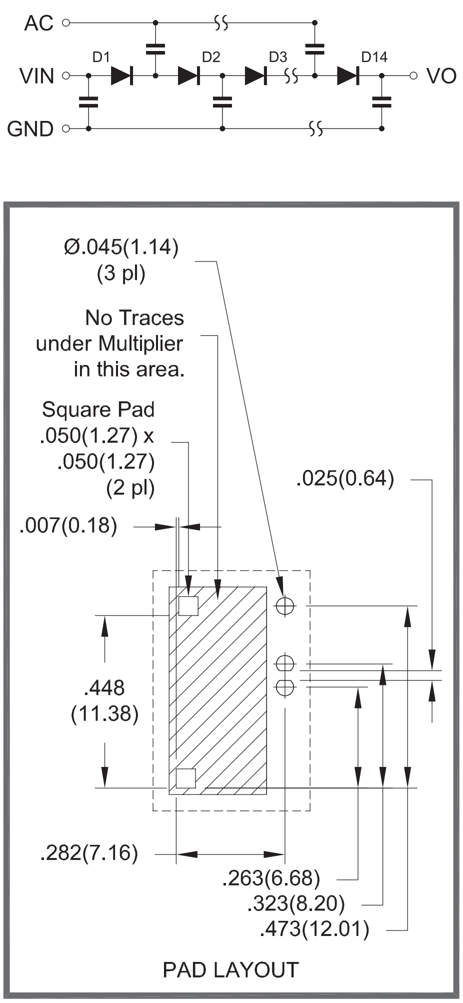
0µA - 50.0µA • 14 Stages

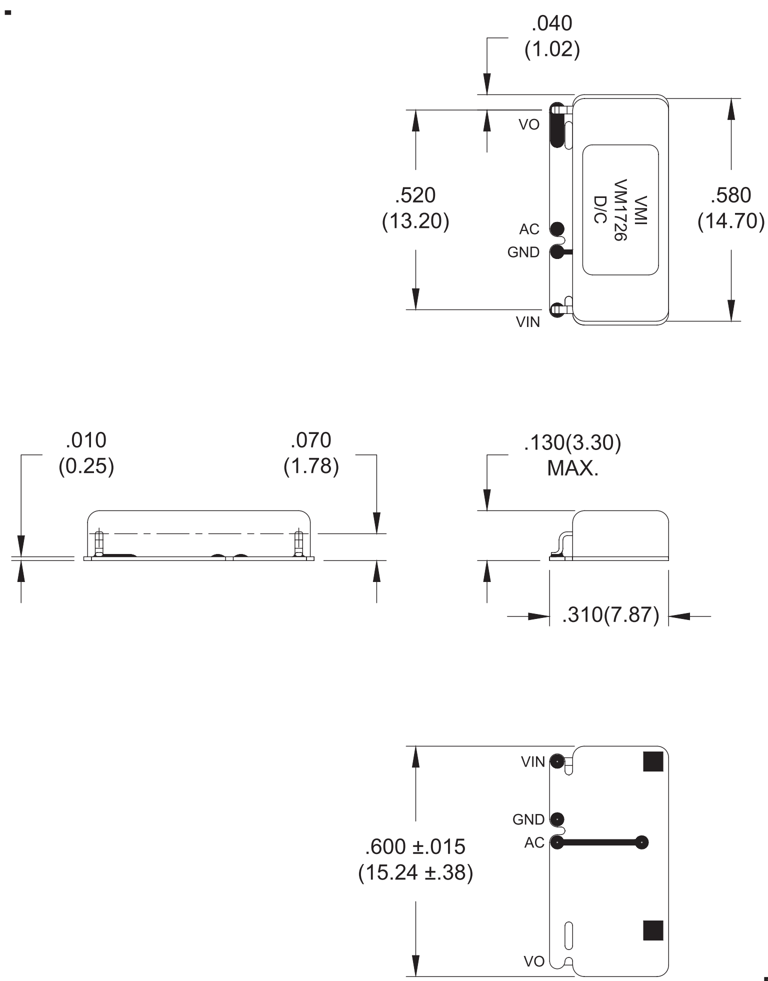
ELECTRICAL CHARACTERISTICS AND MAXIMUM RATINGS						
Part Number	Maximum A.C. Input Voltage	Maximum D.C. Output Voltage (One Multiplier) (2)	Maximum D.C. Output Voltage (Two Multipliers in Series or Floating) (2)	Typical Output Current Range (1)	Typical Frequency	Number of Stages
	V_{PP}	V_{DC}	V_{DC}	µA	kHz	
VM1726	1200	7000	+ 7000	0 - 50.0	10 - 100	14
Operating Temp: -55°C to +150°C Storage Temp. -55°C to +150°C						

(1) Refer to load lines on next page (2) Over-encapsulation recommended when operating at, or near, rated DC output voltages.

Plating:
Electroless Nickel / Immersion Gold
(ENIG) per IPC-4552

Tolerance:
.XXX ±.010





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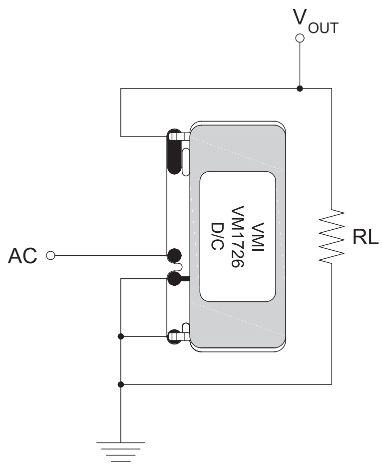
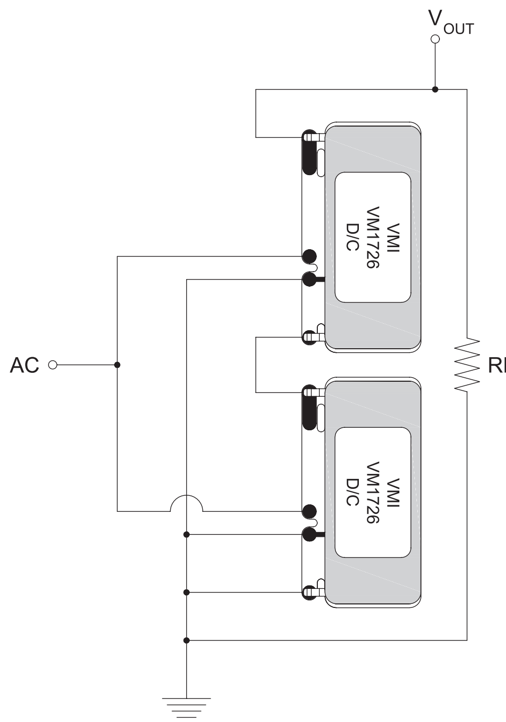
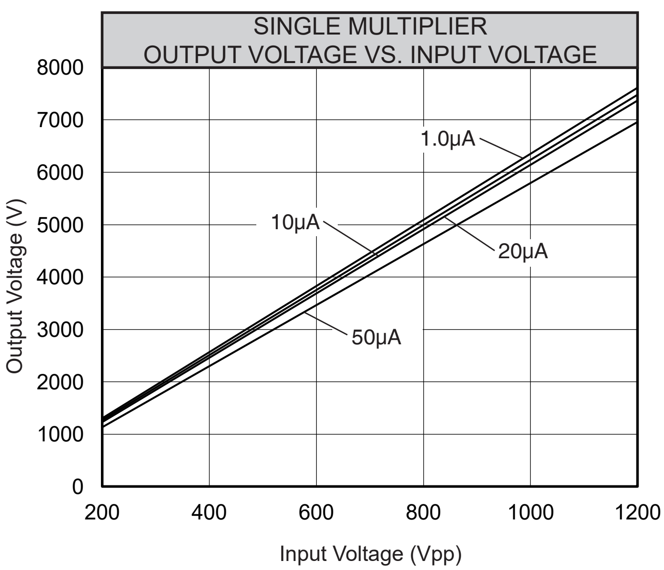
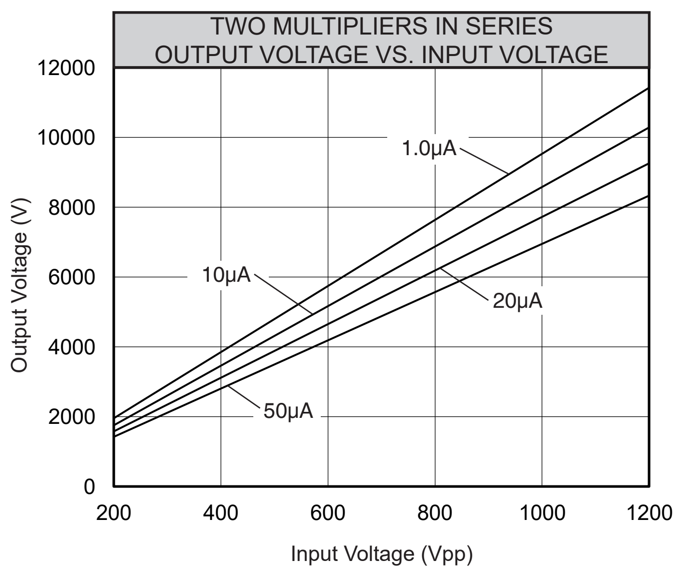
Typical Single Multiplier Circuit



Typical Circuit
Showing Two Multipliers in Series







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CRT Power Supply

CRS110G50 • CRS180G60

ELECTRICAL RATINGS

Part Number	V_0	$G2_{(MAX)}$
	kV	V
CRS110G50	11.0	500
CRS180G60	18.0	600

SPECIFICATIONS

CRS110G50:	
Anode Output Voltage:	6-11kVDC adjustable
G2 Output Voltage:	200 to 500VDC adjustable
CRS180G60:	
Anode Output Voltage:	11-18kVDC adjustable
G2 Output Voltage:	200 to 600VDC adjustable
Electrical:	**CRS Series**
Input Voltage:	+24VDC ± 10%
Anode Output Current:	0 to 550µA
Anode Ripple Voltage:	< 1% peak to peak
Anode Load Regulation:	< 0.1% for NL to FL change
G2 Output Current:	0 to 50µA
G2 Ripple Voltage:	< 1% peak to peak
G2 Load Regulation:	< 0.1% for NL to FL change
Environmental:	
• Storage Temperature	-40°C to +85°C
• Operating Temperature	0°C to +50°C

Features:

- Low ripple
- Excellent regulation
- Arc and short circuit protection
- Adjustable anode voltage

CRS Series

The CRS110G50 & CRS180G60 power supplies provide 11kV and 18kV anode voltages as well as G2 voltage adjustable to 500V & 600V respectively. These supplies feature excellent regulation, low ripple and adjustable anode voltage.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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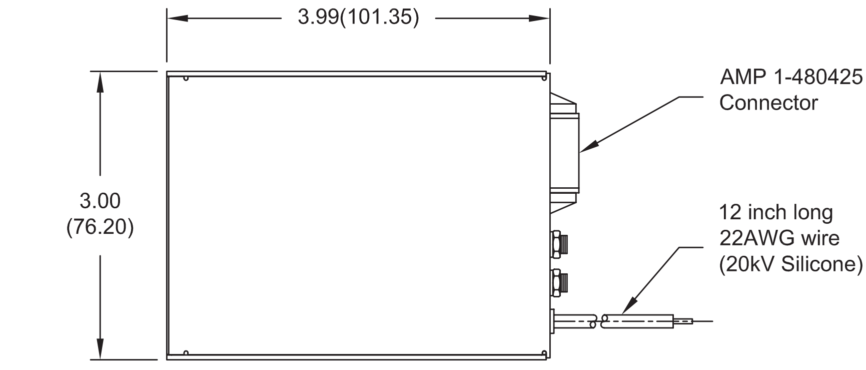
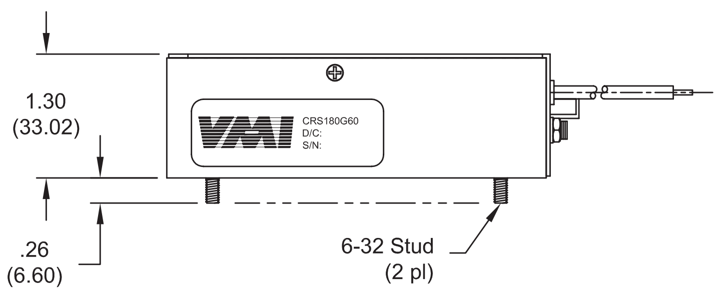
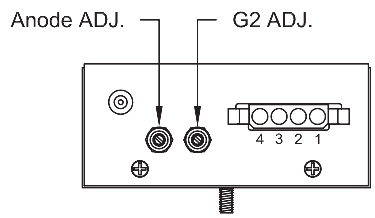
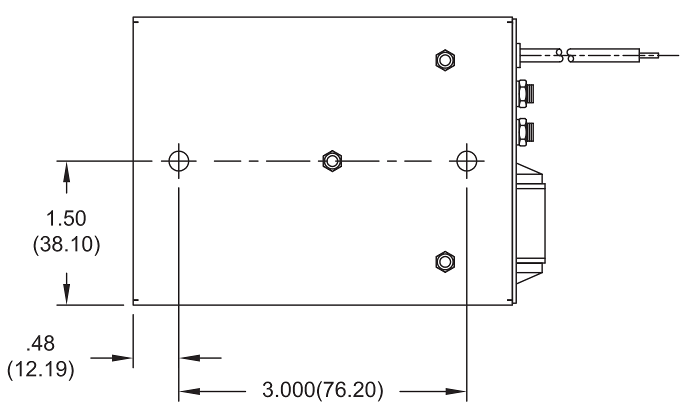
Tolerance:
.XX ±.020
.XXX ±.010









INTERFACE PIN ASSIGNMENT	
1	G2 Out
2	+24VDC
3	Factory use only
4	Ground

11

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HeNe Laser Power Supply

LP6100P Series

PART NUMBER SPECIFICATION

LP6 | 100 | P | XXX | YY

- LP6: Series Name — Laser Power Supply, 6W
- 100: 10.0kV Start Voltage
- P: Output Polarity — P = Positive
- XXX = Run Current
  - Range = 200 to 500
  - (ex. 200 = 2.0mA
  - 500 = 5.0mA)
- YY = VinDC
  - -05 = 5V
  - -12 = 12V
  - -15 = 15V
  - -24 = 24V

Features:

- Low ripple current
- High efficiency
- Excellent load & line regulation
- Short circuit protection

SPECIFICATIONS

Electrical:	**LP6100P Series**
Input Voltage:	5, 12, 15, or 24VDC
Start Voltage:	> 10kV
Run Current:	2.0 to 5.0 mA
Run Voltage:	1000-1750VDC
Current Ripple:	< 0.1%rms
Current Regulation:	+/- 0.1mA
Efficiency:	> 75%
Power:	6W
Input/Output:	
• Input Connector	Molex 09-50-7031
• Output Lead	#22AWG, 20kV Wire
• Output Connector	Optional, Contact Factory
Environmental:	
• Storage Temperature	-40°C to +85°C
• Operating Temperature	-5°C to +60°C

LP6 Series

The LP6 series of power supplies is designed for critical Helium Neon laser applications.

Standard features include short circuit protection, 75% or higher efficiency, and excellent regulation.

The LP6 is especially suitable for precision applications where low ripple is essential.

Rugged and light weight, the LP6 series is extremely reliable.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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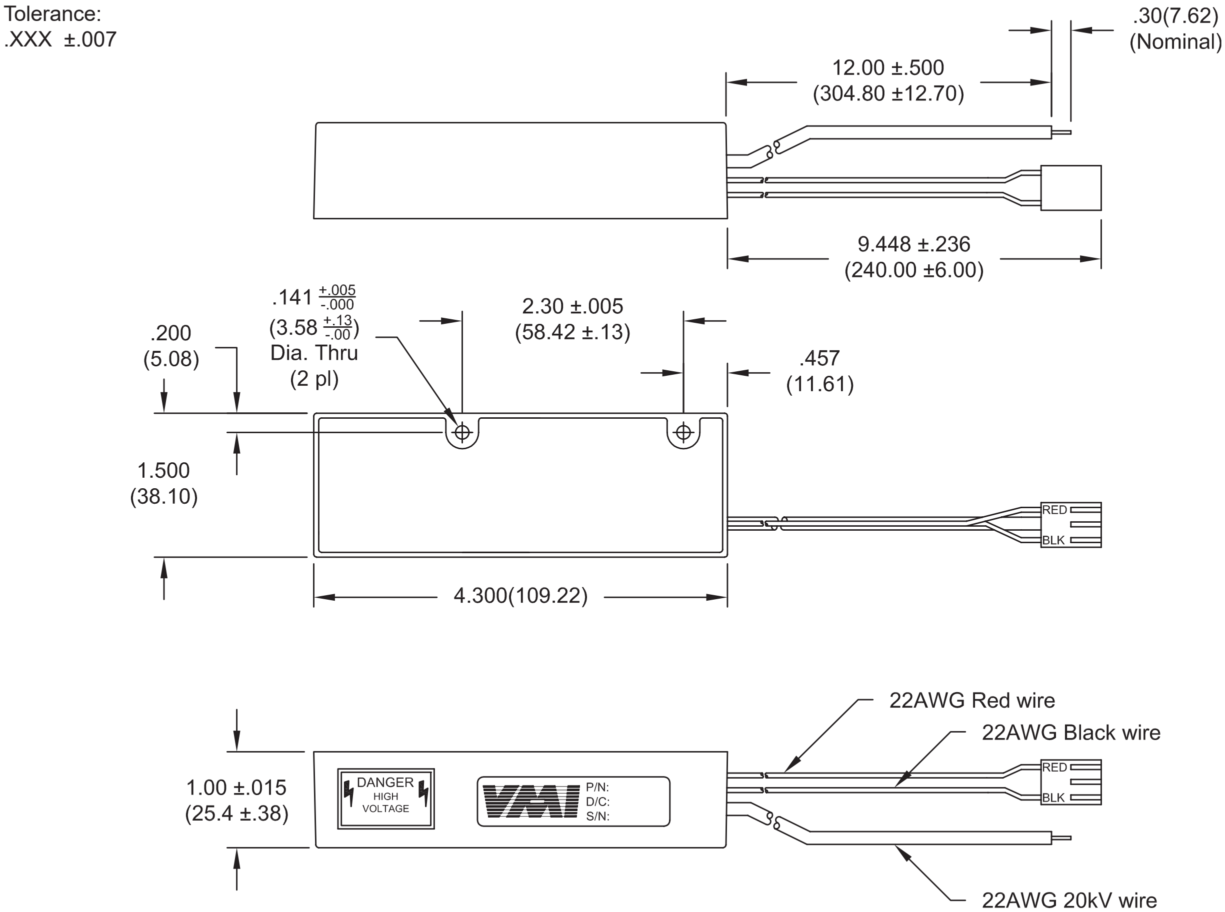

11

Input	Nominal V_{IN} DC	Range
RED	+5V	4.75V TO 6.0V
	+12V	10.8V TO 13.2V
	+15V	13.5V TO 16.5V
	+24V	21.6V TO 26.4V
BLACK	GND	—

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LPS Laser Power Supply

LPS Series

PART NUMBER SPECIFICATION

LPS 08 A 30 15 M

- **LPS** – Series Name
- **08** – Start Voltage:
  - 08 = >8kV
  - 10 = >10kV
- **A** – Run Voltage:
  - A = 1100 to 1800VDC
  - B = 1800 to 2200VDC
- **30** – Run Current:
  - 2.5 to 5.0mA (factory set)
  - 25 = 2.5mA
  - 50 = 5.0mA
- **15** – Input Voltage:
  - 12 = 12VDC
  - 15 = 15VDC
  - 24 = 24VDC
- **M** – Options:
  - M = Low ripple (includes additional input and output filtering plus external Cu foil shield to minimize radiated emissions)
  - N = Remote Enable
  - S = Time delay
  - T = Epoxy potting

SPECIFICATIONS

Electrical:	
Input Voltage:	12, 15, or 24VDC +/-10%
Start Voltage:	> 8kV, or > 10kV
Run Current:	2.5 to 5.0 mA (factory set)
Run Voltage:	1100-1800VDC, or 1800-2200VDC
Current Ripple:	Std -0.6%(p-p), 0.2%(rms)
	Low Ripple Option - 0.3%(p-p), 0.1%(rms)
Current Regulation:	1% Line & Load
Efficiency:	> 80% (Standard UL 94 V-0 silicone potting)
	> 75% (Optional UL 94 V-0 epoxy potting)
Output Power:	11W MAX.
Remote Enable:	Connect Yellow wire to GND to Enable.
Time Delay:	3-5 seconds (cut Violet loop to disable)
Dimensions:	3.75" X 1.5" X 1.0" (95mm X 38mm X 25mm)
HV Connector:	Alden D100 Style
Input Leads:	#22AWG
Environmental:	
• **Storage Temperature**	-40°C to +85°C
• **Operating Temperature**	-5°C to +60°C

Features:

- Low ripple current
- High efficiency
- Excellent load & line regulation
- Short circuit protection

LPS Series

The LPS series of power supplies is designed for critical Helium Neon laser applications.

Standard features include short circuit protection, >80% efficiency, and excellent regulation.

The LPS is especially suitable for precision applications where low ripple is essential.

Rugged and light weight, the LPS series is extremely reliable.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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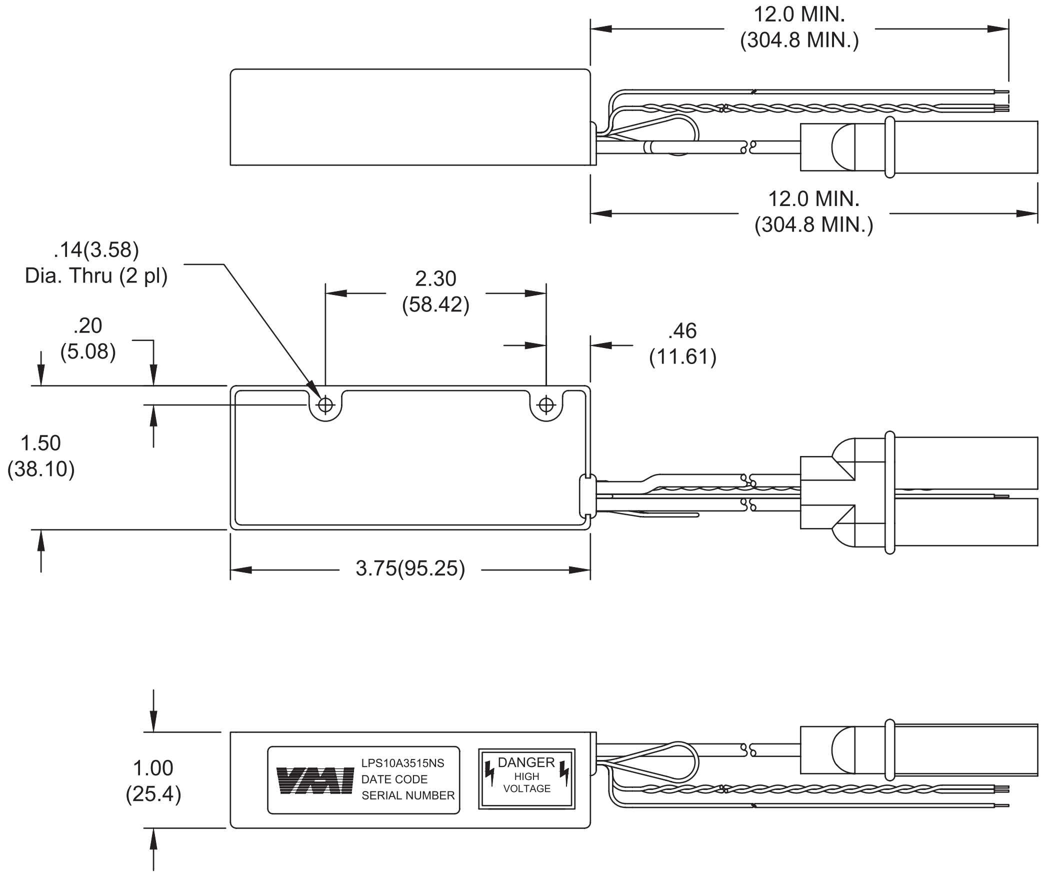
LPS Series



LEAD ASSIGNMENTS	
COLOR	FUNCTION
RED	+V INPUT
BLACK	-V INPUT (GND)
YELLOW	ENABLE
VIOLET	DELAY
RED	+HV
BLACK	HV RETURN

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Portable X-Ray Power Supply

XRS040N100 • XRS050N200

ELECTRICAL RATINGS

Part Number	V_{MAX}	I_{MAX}
	kV	µA
XRS040N100	-40	100
XRS050N200	-50	200

SPECIFICATIONS

XRS040N100:	
Input Voltage:	7-12VDC
Reverse Polarity Protection:	Series Diode
Max. Output Power:	4 Watts
Output Voltage Range:	-10kVDC to -40kVDC
Output Current:	0 to 100µA
XRS050N200:	
Input Voltage:	9-12VDC
Reverse Polarity Protection:	None
Max. Output Power:	10 Watts
Output Voltage Range:	-10kVDC to -50kVDC
Output Current:	0 to 200µA
Electrical:	**XRS Series**
Output Ripple Voltage:	< 1% peak to peak
Load Regulation:	1% for NL to FL change
Line Regulation:	1% over input range
Filament Voltage:	2Vrms nominal
Filament Current:	300mA Max.
Interface Signals:	
• Output Voltage Control	0-4V = 0-100%
• Output Voltage Monitor	0-4V = 0-100%
• Output Current Control	0-4V = 0-100%
• Output Current Monitor	0-4V = 0-100%
• Enable	+5VDC = ON, <1VDC = OFF
Environmental:	
• Storage Temperature	-40°C to +85°C
• Operating Temperature	-10°C to +50°C

Features:

- Voltage & current programming
- Voltage & current monitoring
- Low ripple
- Excellent load & line regulation
- Light weight

XRS Series

The XRS series power supplies provide 4 to 10 watts of output power up to -40kV and -50kV max. The outputs are fully adjustable over the specified operating range. Rugged and light weight, the XRS series brings you the features you need with the proven reliability and quality built into all VMI's products.

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

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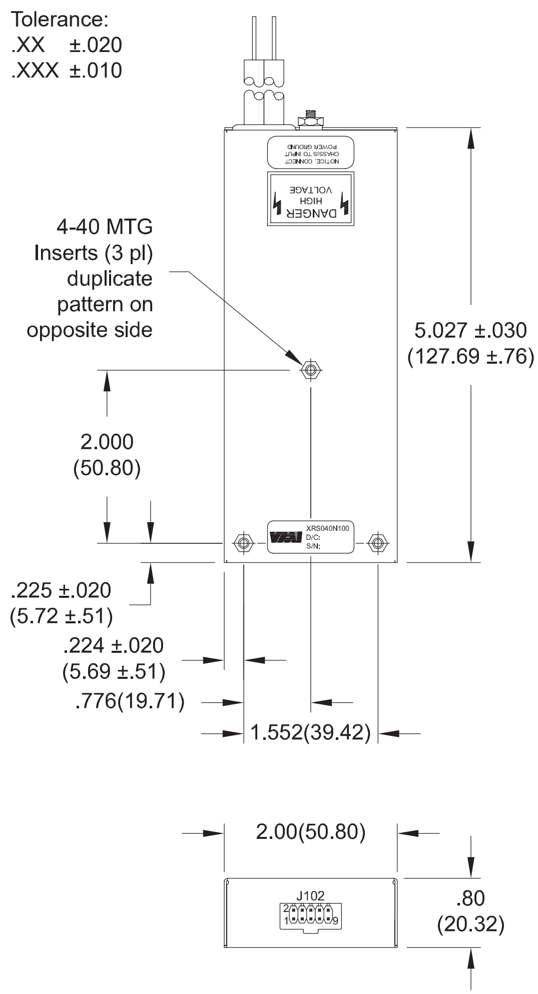
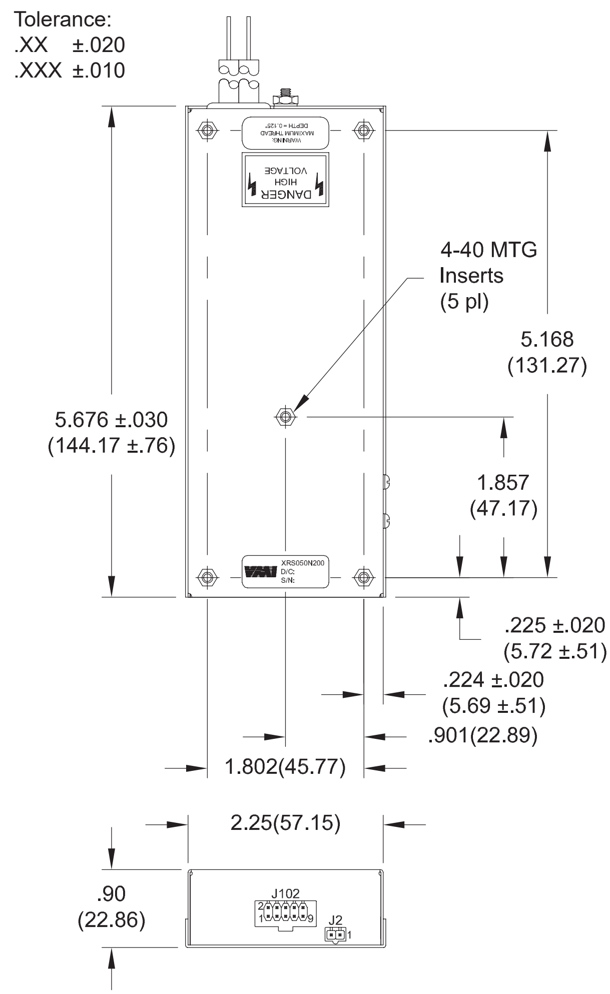
XRS040N100 XRS050N200

XRS040N100



XRS050N200



J102

PIN	FUNCTION
1	10V Input
2	10V Input
3	GND
4	GND
5	Current Control
6	HV Control
7	FIL Ready
8	HV Enable
9	HV Monitor
10	Current Monitor

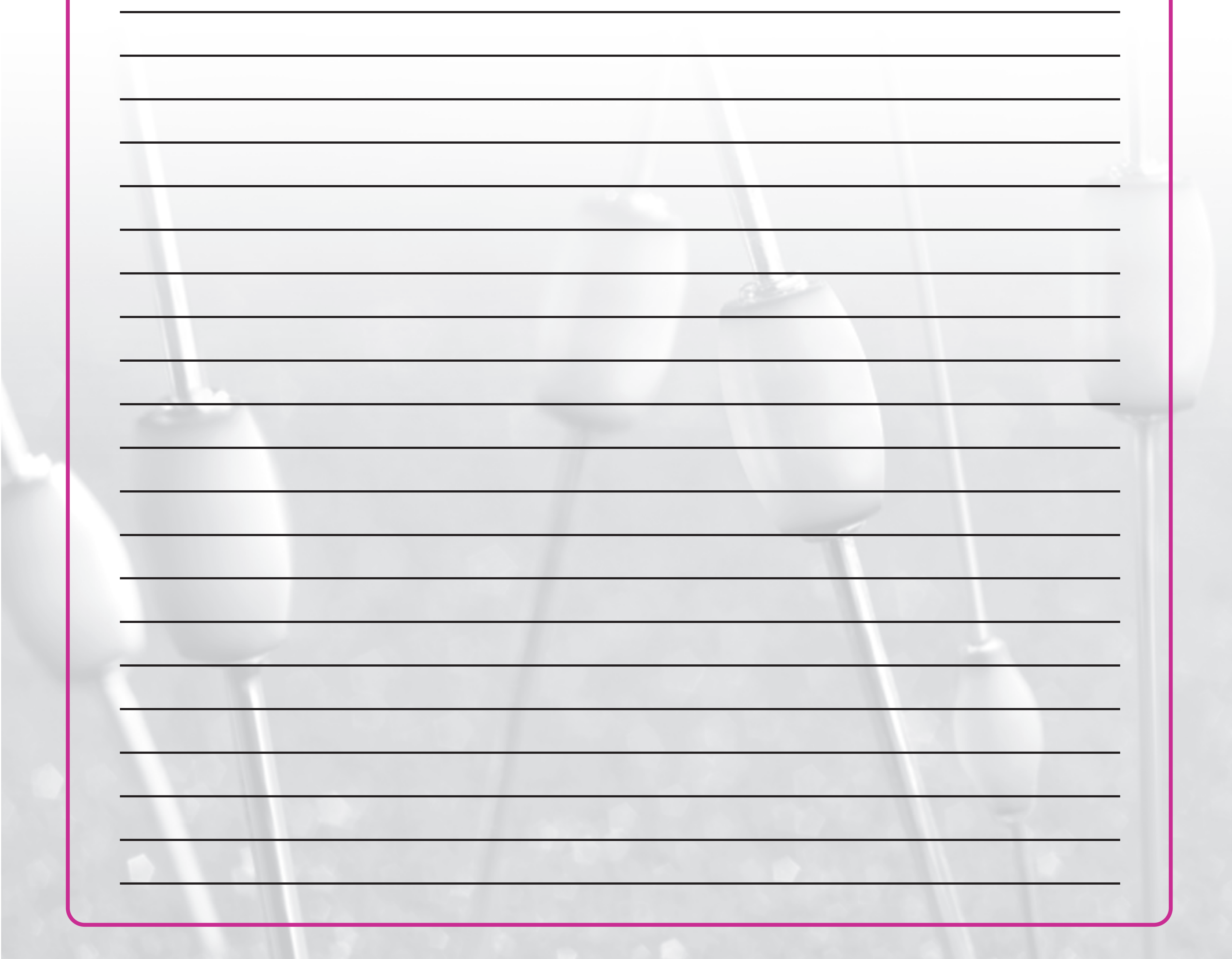
J2

PIN	FUNCTION
1	10V Input
2	GND

11

Dimensions: In. (mm) • All temperatures are ambient unless otherwise noted. • Data subject to change without notice.

Notes:



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Custom Rectifier Assemblies

VMI is a world leader in the design & manufacture of quality custom rectifier assemblies. This section is intended to provide the user with:
1) General background information on certain diode and rectifier assembly characteristics.
2) Basic guidance in identifying specific application requirements necessary for the design of a custom rectifier assembly.

Contact us with your custom design.

OUTLINE OF RECTIFIER DESIGN PROCESS

I. Assembly Type

- **Single phase bridge**
- **Three phase bridge**
- **Center tap (positive or negative)**
- **Doubler**
- **Special configuration**
- **Other**

II. Electrical Operating Conditions

- **Input voltage**
- **Output current**
- **Operating frequency/pulse waveform**
- **Transient conditions**

III. Physical Characteristics

- **Package size**
- **Mounting**
- **Terminations**

IV. Environmental Conditions

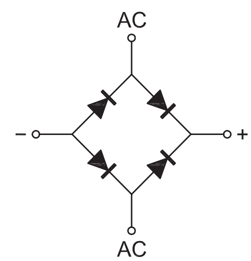
- **High altitude**
- **Chemical exposure**
- **Humidity**
- **Extreme temperatures**

I. Assembly Type

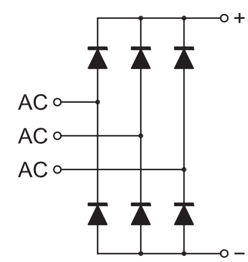
The schematics shown are a small sample of the types of custom rectifier assembly elements typically encountered. It is not uncommon to have combinations of these circuit types within the same package. In such cases, it is important to specify the electrical characteristics of each element as well as the interconnections and/or isolation requirements between elements.

DESIGN GUIDE

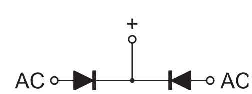
Single Phase Bridge



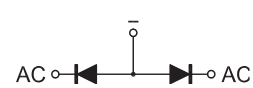
Three Phase Bridge



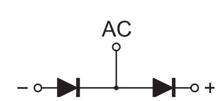
Positive Center Tap



Negative Center Tap



Doubler



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II. Electrical Operating Conditions

Custom rectifier assembly electrical requirements can be specified in many different ways. To develop a design that will meet performance requirements and provide high reliability, it is important to know about the currents, voltages, & operating frequencies or pulse wave shapes, to which the individual legs of the assembly will be subject during operation. When applicable, this information needs to account for transient effects as well.

- **Input Voltage:**

The input voltage to the assembly (including known or expected transient conditions) must be identified to determine what diodes are best suited for the application. This is based primarily on the maximum reverse working voltage (V_{RWM}) rating.

In a particular application, it is possible to allow for additional margin by using diodes with higher reverse voltage ratings. However, as the reverse voltage capability of a diode increases, the forward voltage drop increases. This may result in undesirable forward power disspation in the junction.

VMI diodes are tested for minimum PIV using a rectified 60Hz reverse voltage with carefully controlled reverse current limiting.

- **Output Current:**

In any rectifier assembly, one of the more important design considerations is heat dissipation. In many applications, the power dissipated due to the forward voltage drop is typically the greatest contribution to junction heat generation.

The forward voltage is a function of the silicon resistivity, the number of junctions and the level of forward current. As the forward current in the diode increases, the forward voltage drop also increases in a non-linear manner.

The output current from the assembly (including known or expected current transient conditions) must be known to address heat dissipation in the assembly. Various factors, including diode junction size, diode type, heat sink provisions and/or special mounting requirements, all contribute the thermal impedance of the assembly, and therefore its ability to dissipate the heat generated.

Since the forward voltage decreases as the junction temperature rises, most thermal design calculations for forward power dissipation use the V_F data at 25°C as a worst case value. If the assembly is mounted to a cold plate, it is important to know the maximum output current at the maximum controlled cold plate temperature.

- **Operating Frequency / Pulse Waveshape:**

Another potentially significant source of heat generation in an assembly is caused by reverse recovery losses. Reverse current flowing through the diode during its transition from forward conduction to reverse blocking mode causes reverse recovery losses. The speed at which the diode recovers into its steady-state voltage blocking mode is related to the amount of stored charge in the silicon junction and the rate at which the applied reverse voltage changes.

As the voltage switching frequency increases and/or as the rate of rise of reverse voltage decreases, the reverse recovery losses are increased for a given diode. For this reason, it is particularly important to identify the frequency and waveform characteristics of the applied voltage.

In some applications, faster diodes are necessary to reduce the reverse losses. However, reduced reverse recovery time comes at the expense of added forward voltage drop, causing additional forward power dissipation. It is important also to note that the reverse recovery time increases as the junction temperature of the diode increases. If a diode is not fast enough for the application, the reverse recovery losses can cause the junction temperature to increase, corresponding in a further increase in reverse recovery time, thereby adding to the reverse recovery losses. Such a condition is known as thermal runaway and results in subsequent diode failure.

- **Transient Conditions:**

It is also important to specify any known or expected transient voltage or current conditions to which the assembly may be subjected. Voltage or current levels, along with transient duration and frequency of occurance are important factors to evaluate when determining the best possible design for the application.

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III. Physical Characteristics

• **Size:**

One of the benefits of using custom rectifier assemblies is that the customer can usually specify the size and shape of the package. The customer may also specify special physical characteristics desired for the application provided such specifications do not compromise design constraints. Actual design of the package size/shape must account for adequate cooling and voltage isolation issues.

Clearly defining the dimensions and tolerances is necessary. When the specific shape and/or size is not defined, as much information as possible should be provided regarding the enclosure where the part will be installed and/or the customer's preferred physical characteristics. Typically, packaging that is "as small as possible" is desired. However, an indication of preferences and expectations, with respect to package size, will aid in the development of a suitable package design.

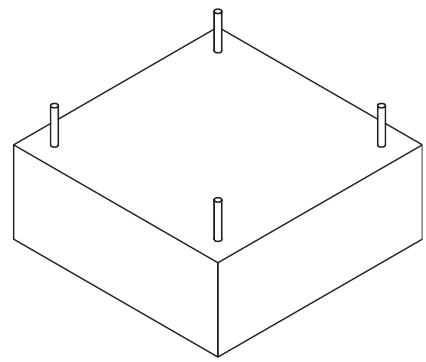
• **Mounting:**

The preferred end-application mounting or installation provisions need to be specified. Through holes, integral threads, encapsulated inserts, pcb mount and suspension are some examples of mounting techniques.

• **Terminations:**

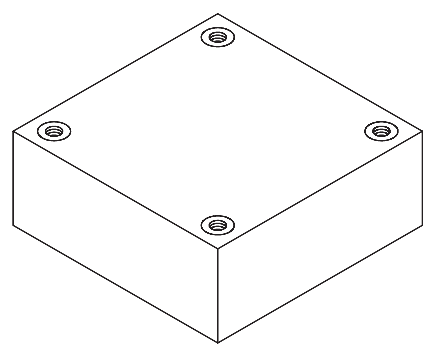
Custom rectifier assemblies can have a large variety of terminations. Some possibilities include leads (see Figure 1), and threaded inserts (see Figure 2). Other termination possibilities include high voltage leads/connectors, pcb pins, contact pads, quick disconnect terminals, turret terminals, or combinations of these configurations. Special terminal plating requirements should also be noted.

Figure 1



Leaded Rectifier

Figure 2



Insert Terminal Rectifier

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Properties of dielectric materials used in encapsulating the components of the assembly as well as those used to encapsulate an assembly in its installation are greatly influenced by environmental effects. Basic environmental conditions such as operating and storage temperature ranges for the rectifier will need to be defined. However, other special conditions, if applicable, need to be identified for proper design.

- **High Altitude:**

High altitudes can amplify what would, at lower altitudes, be relatively benign design issues. For example, some dielectric materials will outgas in low pressure or vacuum installations causing degradation of the dielectric and/or contamination from insulating film deposition. Also, corona problems will generally vary non-linearly with increased altitude.

- **Chemical Exposure:**

The level of exposure an assembly receives to various chemicals should be identified. Many applications use dielectric oils or gases to surround the custom rectifier assembly. While these materials can provide excellent isolation, reduced corona effects, minimal mechanical stresses, and usually good cooling, they can also damage or degrade some encapsulants and remove assembly labeling. As such, materials compatibility must be addressed during the design stage.

- **Humidity:**

Environments with high humidity can sometimes cause certain types of dielectric materials to absorb moisture. Also, humidity severely limits the voltage isolation capabilities of air-insulated applications. As a result, it may be necessary to overpot, or otherwise insulate any exposed high voltage connections.

- **Extreme Temperatures:**

Assembly exposure to very high or very low temperature extremes requires special consideration. This is due to the electrical and mechanical effects of materials used in the assembly construction. For example, very high temperature extremes, such as in excess of 150°C, can sigificantly reduce the voltage isolation capabilities of some encapsulants. Additionally, high temperatures can induce significant mechanical stresses, due to mismatches in material thermal expansion coefficients.

Similarly, very low temperature extremes can induce mechanical stresses due to material thermal expansion mismatches. Low temperatures can also cause radical changes in the physical characteristics of the encapsulant, making it brittle, or causing the encapsulant to exhibit non-linear shrinkage effects.

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Custom Multiplier Assemblies

VMI is a world leader in the design & manufacture of quality custom multiplier assemblies. This section is intended to provide the user with:
1) General background information on certain multiplier assembly characteristics.
2) Basic guidance in identifying specific application requirements necessary for the design of a custom multiplier assembly.
Contact us with your custom design.

OUTLINE OF MULTIPLIER DESIGN PROCESS

I. Introduction

- **What is a multiplier?**
- **How does a multiplier work?**
- **Common multiplier applications**

II. Assembly Type

- **Half wave series multiplier**
- **Half wave parallel multiplier**
- **Full wave series multiplier**
- **Series vs. parallel design considerations**

III. Electrical Operating Conditions

- **Reasonable ranges**
- **Input & output voltage**
- **Output current**
- **Operating frequency**

IV. Physical Characteristics

- **Size**
- **Mounting**
- **Terminations**

V. Environmental Conditions

- **High altitude**
- **Chemical exposure**
- **Humidity**
- **Extreme temperatures**
- **Practical limits**

VI. Other Design Concerns

- **Stray capacitance**
- **Corona**
- **Leakage currents**
- **Reasonable ranges**

DESIGN GUIDE

I. Introduction

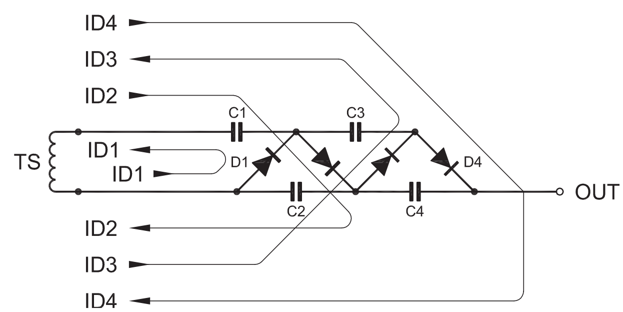
• **What is a Multiplier?**

Voltage multipliers are AC-to-DC power conversion devices using diodes and capacitors that produce a high potential DC voltage from a lower voltage AC source. Multipliers are made up of multiple stages. Each stage is comprised of one diode and one capacitor.

• **How Does a Multiplier Work?**

The most commonly used multiplier circuit is the half-wave series multiplier. All multiplier circuits can be derived from its basic operating principles. Thus, the half-wave series multiplier circuit is shown in Figure 1 to exemplify general multiplier operation. This example also assumes no losses and represents sequential reversals of transformer (T_S) polarity.

Figure 1



1) T_S = Negative Peak:	C_1 charges through D_1 to E_{pk}
2) T_S = Positive Peak:	E_{pk} of T_S adds arithmetically to existing potential C_1, thus C_2 charges to $2E_{pk}$ thru D_2.
3) T_S = Negative Peak:	C_3 is charged to $2E_{pk}$ through D_3.
4) T_S = Positive Peak:	C_4 is charged to $2E_{pk}$ through D_4. Therefore, output voltage = E_{pk} x N (where N = the number of stages).

• **Common Multiplier Applications:**

Originally used for television CRTs, voltage multipliers are now used for lasers, x-ray systems, traveling wave tubes (TWTs), photomultiplier tubes, ion pumps, electrostatic systems, copy machines, and many other applications that utilize high voltage DC.

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Custom Multiplier Assemblies

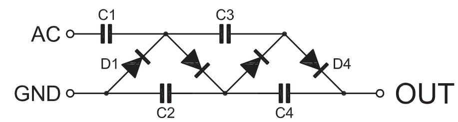
DESIGN GUIDE

II. Assembly Type

• **Half-Wave Series Multiplier:**

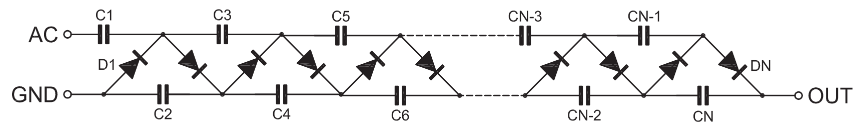
Characteristics:
1) Most common circuit
2) Very versatile
3) Uniform stress per stage on diodes & capacitors
4) Wide range of multiplication stages
5) Low cost

A Typical 4X Circuit Schematic

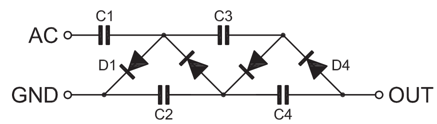


The following schematics show some of the many variations which are available for a half-wave series multiplier configuration

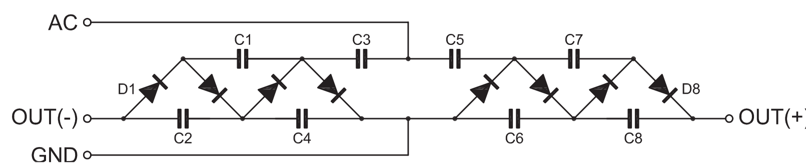
A large number of stages are available.



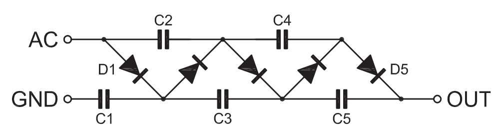
Negative output is achieved through reversing diode polarity.



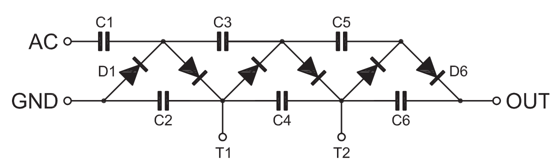
Dual polarity output voltage is achieved through joining positive and negative multipliers.



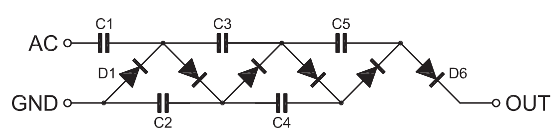
Odd or even numbers of stages can be produced.



Voltage may be tapped at any point along the capacitor filter bank.



Any capacitor may be eliminated on the capacitor filter bank, if the load is capacitive.



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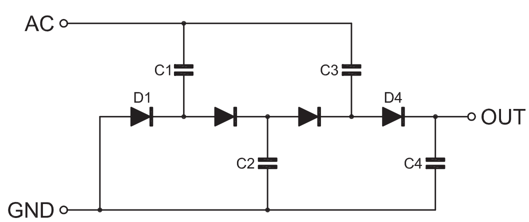
II. Assembly Type (Continued)

- **Half-Wave Parallel Multiplier:**

Characteristics:
1) Small size
2) Highly efficient
3) Uniform stress on diodes
4) Increasing voltage stress on capacitors with successive stages

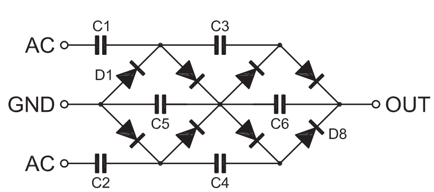
A Typical Schematic



- **Full-Wave Series Multiplier:**

Characteristics:
1) Highly efficient
2) Uniform stress on diodes
3) Uniform voltage stress on capacitors with successive stages
4) High power capability

A Typical Schematic



- **Series vs. Parallel Design Considerations:**

In the process of deciding which type of multiplier assembly best suits the end application, it is necessary to address the series and parallel multiplier formats.

The theory of operation is the same in both series and parallel multiplier assembly types. They are similar also in package volume, but are slightly different in package shape capability. Parallel multipliers require less capacitance per stage than do their series counterparts.

However, parallel multipliers also require higher voltage ratings on each successive stage. The limit on output voltage in parallel multipliers is determined by the voltage capability of the capacitors (common single-layer ceramic capacitors do not exceed 20kV).

Regulation Voltage:
DC output voltage drops as DC output current is increased. Regulation is the drop, from the ideal, in DC output voltage at a specified DC output current (assuming AC input voltage and AC input frequency are constant). A close approximation for series half-wave multipliers can be expressed as:

$$V_{REG} = \frac{I\left(N^3 + \frac{9N^2}{4} + \frac{N}{2}\right)}{12fC}$$

Where: N = # of stages, (1 capacitor and 1 diode = 1 stage)
f = AC input frequency (Hz)
C = Capacitance per stage (F)
I = DC output current (A)

Example: Calculate the regulation voltage of a 6 stage multiplier with 1000pF capacitors, 50kHz input frequency (sine wave), 1mA DC output current, 20kV DC output voltage:

$$V_{REG} = \frac{(1 \times 10^{-3})\left(6^3 + \frac{9(6^2)}{4} + \frac{6}{2}\right)}{12 \times 50{,}000 \times (1 \times 10^{-9})}$$

This would require increasing the input voltage 167Vp-p (V_{REG} / 3 DC capacitors) to maintain 20kV DC output voltage at 1mA.

An equivalent *parallel multiplier* would require each capacitor stage to equal the total series capacitance of the AC capacitor bank. In the above example, the 3 capacitors in the AC bank would equal 1000pF/3 or 333pF. The parallel equivalent would require 333pF capacitors in each stage. See series multiplier and parallel multiplier charts on following page.

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Custom Multiplier Assemblies

II. Assembly Type (Continued)

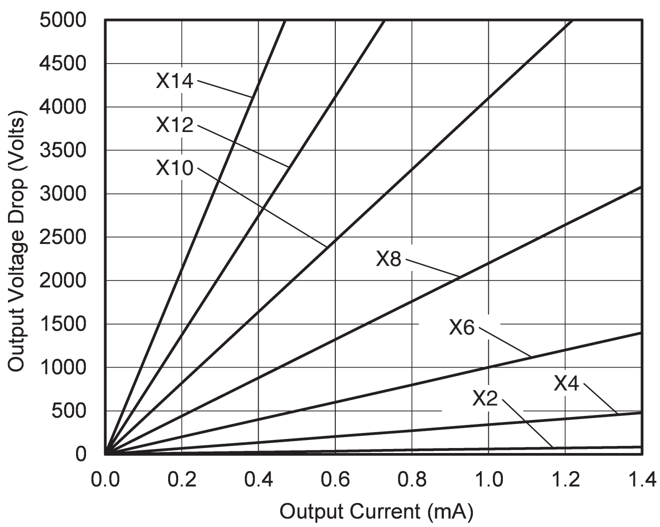
Ripple Voltage:
Ripple voltage is the magnitude of fluctuation in DC output voltage at a specific output current (assuming AC input voltage and AC input frequency are constant). A close approximation for series half-wave multipliers can be expressed as:

$$V_{RIP} = \frac{I\left(N^2 + \frac{N}{2}\right)}{8fC}$$

Example: Calculate the ripple voltage of a 6 stage multiplier with 1000pF capacitors, 50kHz input frequency (sine wave), 1mA DC output current, 20kV DC output voltage:

$$V_{RIP} = \frac{(1 \times 10^{-3})\left(6^2 + \frac{6}{2}\right)}{8 \times 50{,}000 \times (1 \times 10^{-9})}$$

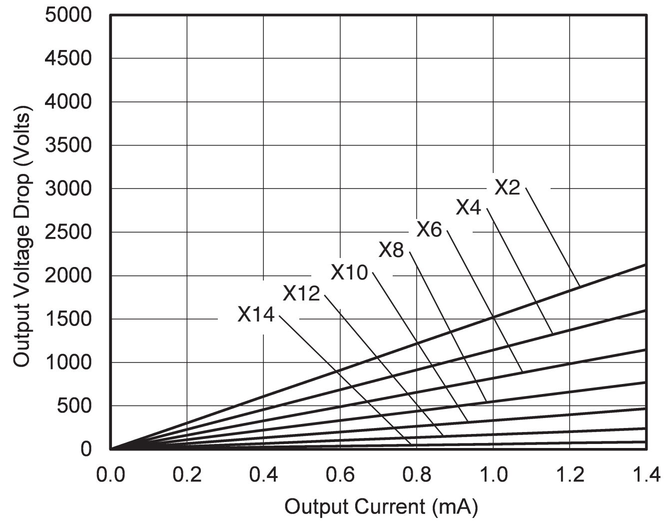
Series Multiplier



(Efficiency comparison series perfect multiplication)

1) X ( ) = # of stages
2) Capacitance = 1000pF/stage
3) Diodes = 12 chips/diodes
4) Frequency = 25kHz

Parallel Multiplier



(Efficiency comparison parallel perfect multiplication)

1) X ( ) = # of stages
2) Capacitance = 1000pF/stage
3) Diodes = 12 chips/diodes
4) Frequency = 25kHz

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Custom Multiplier Assemblies

III. Electrical Operating Conditions

• **Reasonable Ranges:**

Practical limits do exist, which determine multiplier design and application. Here are some typical rules of thumb for the most commonly used VMI multipliers:

1) AC Input Voltage: 0 to 15kV p-p
2) AC Input Frequency: 5kHz to 100kHz
3) DC Output Voltage: 1kV to 150kV
4) DC Output Power: 0 to 50W

Table 1 can be used to determine reasonable ranges for VMI multipliers, utilizing rugged epoxy encapsulation and single layer ceramic capacitors. Input frequency is assumed to be from 5kHz to 100kHz.

Table 1

DC Output Voltage (VDC)	Output Power (W)	AC Input Voltage (VAC p-p)	Half Wave	Full Wave	Other Type Caps	Other Type Encap.
1k	0-50	200-1000	X			
	50-200	500-1000		X		
	>200	500-1000		X	X	X
2.5k	0-50	250-2500	X			
	50-200	1000-2500		X		
	>200	1000-2500		X	X	X
5k	0-50	250-5000	X			
	50-200	2500-5000		X		
	>200	2500-5000		X	X	X
10k	0-50	2500-10000	X			
	50-200	5000-10000		X		
	>200	5000-10000		X	X	X
20k	0-50	2500-10000	X			
	50-200	5000-10000		X		
	>200	5000-10000		X	X	X
30k	0-50	2500-10000	X			
	50-200	5000-10000		X		
	>200	5000-10000		X	X	X
50k	0-30	5000-10000	X			
	30-100	5000-10000		X		
	>100	5000-15000		X	X	X
75k	0-30	7500-15000	X			
	>30	>5000		X	X	X
100k	0-30	7500-15000	X			
	>30	>5000		X	X	X
150k	0-30	7500-15000	X			
	>30	>5000		X	X	X

Note: Multipliers are available that exceed the limits (as listed on the column to the left), but may require other types of capacitors, encapsulation, etc.

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III. Electrical Operating Conditions (Continued)

• **Input & Ouput Voltage:**

The input voltage is usually specified as peak, or peak-to-peak voltage. The theoretical no-load output voltage is equal to the number of stages times the peak input voltage. In most cases, the output voltage will be reduced from the theoretical value due to the effects of regulation and stray capacitance.

In most applications, the output voltage from the multiplier is a primary requirement. The input voltage may need to be increased to provide the required output voltage. Care must be taken to insure that the voltage stresses on the components do not exceed ratings during multiplier operation at maximum output voltage and current.

• **Output Current:**

For typical multipliers, output current can range from 1µA to 5mA. Due to the effects of regulation, output current can affect the voltage stresses on a multiplier's diodes and capacitors. Since regulation is directly proportional to output current, and as input voltage is usually increased to compensate for regulation, the diodes and capacitors near the input side of the multiplier will be subjected to higher voltage stress at higher output currents.

For higher current ratings, it is important to insure that diode junction temperature does not exceed 125°C. A thermal analysis may be necessary to evaluate junction temperature.
Typically, for output currents less than 1.0mA, the power dissipated in the diodes is low enough to prevent overheating.

• **Operating Frequency:**

The lower the operating frequency for a multiplier, the larger its capacitors will need to be to maintain electrical performance. For low frequency multipliers, the operational characteristics must be calculated to determine feasibility.

The upper limit to operating frequency will be affected by diode recovery time, stray capacitance, and inductance effects. Diode recovery time can be a factor at frequencies above 100kHz. The effects of stray capacitance and inductance will depend on component layout, potting material used, and the choice of components.

IV. Physical Characteristics

• **Size:**

Custom multiplier assemblies can usually be constructed in a wide variety of shapes and sizes to meet customer needs. The customer may also specify special physical characteristics, provided such specifications do not compromise design constraints.

• **Size (Continued):**

Actual design of the package size/shape must account for internal mechanical stresses and voltage isolation issues.
Clearly defining the dimensions and necessary tolerances is very helpful. When the specific shape and/or size is not defined, as much information as possible should be provided regarding the enclosure where the part will be installed and/or the customer's preferred physical characteristics. Typically, packaging that is "as small as possible", is desired. However, an indication of preferences and expectations, with respect to package size, will aid in the development of a suitable package design.

• **Mounting:**

The preferred end-application mounting or installation provisions need to be specified. Through holes, integral threads, encapsulated inserts, pcb mount and suspension are some examples of mounting techniques.

• **Terminations:**

Multiplier assemblies can have a large variety of terminations. Some possibilities include: turret terminal, bus wire, high voltage leads, high voltage connectors, inserts, pcb pins, or combinations of these configurations. Special terminal plating requirements should be noted as required.

V. Environmental Conditions

• **High Altitude:**

High altitudes can amplify what would, at lower altitudes, be relatively benign design issues. For example, some dielectric materials will outgas in low pressure or vacuum installations, causing degradation of the dielectric and/or contamination from insulating film deposition. Also, corona problems will generally vary non-linearly with increased altitude.

• **Chemical Exposure:**

The level of exposure an assembly receives to various chemicals should be identified if known. Many applications use dielectric oils or gases to surround the custom multiplier assembly. While these materials can provide excellent isolation, reduced corona effects, minimal mechanical stresses, and usually good cooling, they can also damage or degrade some encapsulants and remove assembly labeling. As such, materials compatibility must be addressed during the design stage.

• **Humidity:**

Environments with high humidity can sometimes cause certain types of dielectric materials to absorb moisture. Also, humidity severely limits the voltage isolation capabilities of air-insulated applications.

As a result, it may be necessary to overpot, or otherwise insulate any exposed high voltage connections.

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Custom Multiplier Assemblies

V. Environmental Conditions (Continued)

• **Extreme Temperature:**

The input voltage to the assembly (including known or expected transient conditions) must be identified to determine what diode(s) is best suited for the application. Assembly exposure to high or low temperature extremes requires special consideration. This is due to the electrical and mechanical effects of the materials used in the assembly construction. For example, very high temperature extremes, such as in excess of 150°C, can sigificantly reduce the voltage isolation capabilities of some encapsulants.

Additionally, high temperatures can induce significant mechanical stresses, due to mismatches in material thermal expansion coefficients.

Similarly, very low temperature extremes can induce mechanical stresses due to material thermal expansion mismatches. Low temperatures can also cause radical changes in the physical characteristics of the encapsulant, making it brittle, or causing the encapsulant to exhibit non-linear shrinkage effects.

• **Practical Limits:**

Practical limits do exist, which determine multiplier design and application. Here are some environmental rules of thumb for the most commonly used VMI multipliers:

1) Operating Temp Range:	-55°C to +125°C
2) Relative Humidity:	0 to 100%
3) Altitude:	0 to space

Note: Altitude and humidity affect materials, terminations, plating, etc. Please specifiy.

VI. Other Design Concerns

• **Stray Capacitance:**

Stray capacitance becomes an important consideration as input frequency increases. As the following expression indicates, an increase in frequency decreases the capacitive reactance, resulting in increased current flow through the insulating materials.

$$X_C = \frac{1}{2\pi f C}$$

Power losses through insulation, which are negligible at 60Hz, become significant at high frequency.

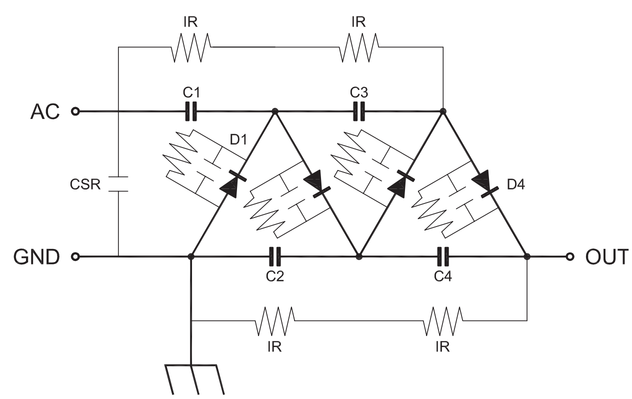
• **Corona:**

Corona is the result of gas ionization (air, oxygen, etc.), due to a high voltage field.This extremely destructive phenomena usually results in slow degradation of the insulating materials, causing latent failures. Careful design, consistent manufacturing processes, eliminating air entrapment in encapsulation, and a thorough understanding of what causes corona will minimize this problem.

• **Leakage Currents:**

Losses due to leakage in diodes, capacitors and insulation are significant considerations in applications using very low capacitor values (i.e. night vision power supplies) and in applications, which operate at high temperatures (>125°C). (Figure 2) represents some of the factors affecting multiplier efficiency.

Figure 2



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Application Note A

High Voltage Diodes

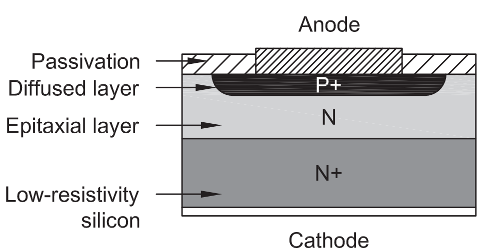
High Voltage! The sight of this familiar warning jars the senses and triggers caution in even the most experienced engineer. High voltage is a relative term, however, as warnings are similar whether applied to 100 volts or 100 kilovolts.

High-voltage rectification is also a relative term. As it surrounds our lives in CRT supplies, TWT supplies, X-Ray supplies and a host of other devices; the concept of high-voltage rectification must be clearly defined.

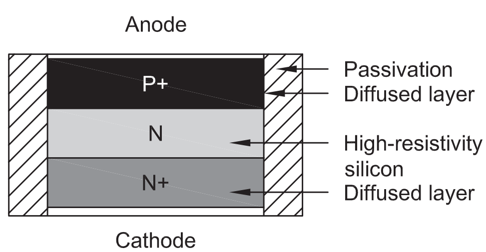
Ideally a high voltage diode is a single-junction diode, which blocks the required voltage quickly without leaking reverse current, or generating heat from power losses in the process. However in reality, high-voltage diode offer complex trade-offs. To begin, a choice must be made between multi-junction, high-voltage, silicon diodes and strings of single-junction, silicon diodes.

Before a decision between single and multiple-junction diodes can be made, it is necessary to examine the fundamental characteristics of PN junctions. Two common techniques for fabricating high-voltage PN junctions come into play. They are **planar junction fabrication** and **deep-diffused junction fabrication** as shown. Many variations of each technique exist. Severe angles, for example, are often present on a deep-diffused junction, creating a "mesa" appearance. Also, epitaxially-grown silicon may be used in either technique and a variety of dopants may be used.

The following Illustration shows Cross-Sections of Typical Planar and Deep Diffused diode junctions



Planar Junction



Deep-Diffused Junction

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Application Note A

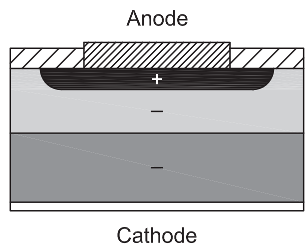
Reverse Voltage & the Depletion Region

The depletion region increases in the direction of the weakest field (area of highest resistivity) as reverse voltage is applied. As the reverse voltage is increased, this expansion continues until the field stress threshold is reached.

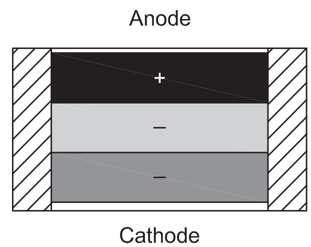
Epitaxially-grown layers have very abrupt differences in the depletion-region movement. Deep diffusion results in depletion-region movement in the N+ and P+ directions. During which, abrupt junctions develop in depletion-region expansion, primarily toward the N+ layer.

The following Illustrations show Depletion region as a function of reverse bias in Typical Planar and Deep Diffused diode junctions

No Reverse Bias:
No Depleted Region:

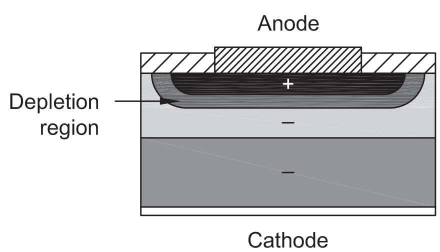


Planar Junction

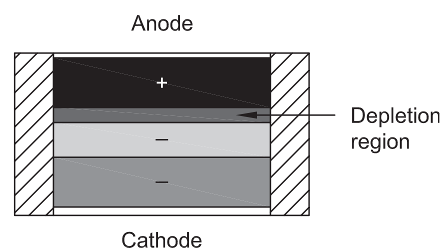


Deep-Diffused Junction

Slight Reverse Bias:
Increased Depleted
Region:

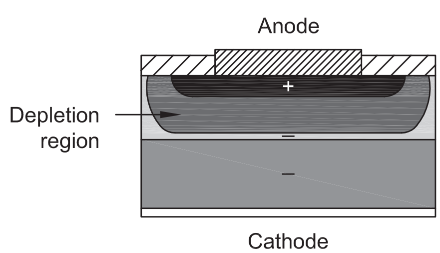


Planar Junction

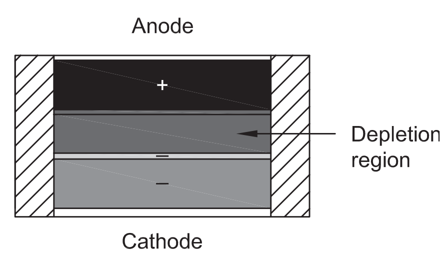


Deep-Diffused Junction

Full Reverse Bias:
High-resistivity Layer
Fully Depleted:



Planar Junction



Deep-Diffused Junction

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Application Note A

Reverse Breakdown Voltage

Semiconductors have practical reverse-voltage limitations. The reverse breakdown voltage (VBR) of silicon is determined primarily by three factors: the resistivity of the silicon (avalanche), the depletion region width (punch-through or reach-through) and the surface stress at the junction/passivation (zener) interface.

Reverse breakdown occurs when the voltage stress across one of these three areas exceeds the withstanding threshold, triggering a high reverse current across the entire junction area as shown below. This condition is non-destructive in a properly designed device, provided the reverse current is limited to a level that minimizes thermal dissipation. This phenomenon should be seen as "water flowing over a spillway" and not as a failure of the dielectric material.

Zener diodes routinely operate in this mode and are designed for breakdown to be initiated by resistivity limitations rather than punch-through or avalanche. It should be noted, however, that high voltage zener diodes are less practical. This is because the higher-resistivity silicon and deeper diffusion depths required to achieve the higher voltage ratings make it difficult to predict the voltage at which breakdown occurs.

Three non-destructive breakdown mechanisms:

Breakdown By:	Descriptive Term:
Depletion region	Punch through or reach through
Junction/passivation interface	Avalanche
Resistivity	Zener

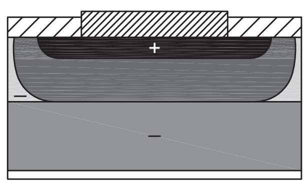
In the past, the term "controlled avalanche diodes" referred to those diodes which exhibited "sharp" breakdown characteristics. They must additionally survive over-voltage with controlled reverse current. The term "non-controlled avalanche diodes" typically referred to those diodes which possessed very high reverse currents at considerably lower than breakdown voltages. This high reverse current leads to overheating and very round breakdown curves.

Diodes are generally subjected to a peak inverse voltage (PIV) test to identify their breakdown characteristics. This test is performed by applying 60-hertz half-wave reverse voltage at a sufficient amplitude to initiate breakdown. During the test, the reverse current is usually limited to 50 micro-amps. The resulting waveform is observed on an oscilloscope to determine the sharpness of the "knee" at the point of breakdown. Both planar and deep-diffusion processes yield controlled avalanches under PIV test conditions.

The following Illustrations show Reverse breakdown mechanisms for Typical Planar and Deep Diffused diode junctions

Punch through:
Depletion region extends into low-resistivity area; surface strength > reverse voltage.

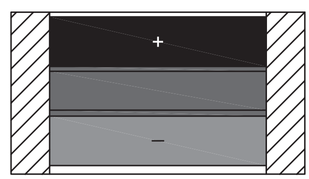
Anode



Cathode

Planar Junction

Anode

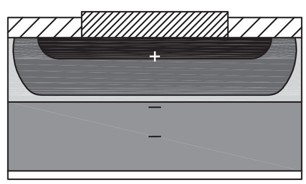


Cathode

Deep-Diffused Junction

Avalanche:
Depletion region strength > surface strength.

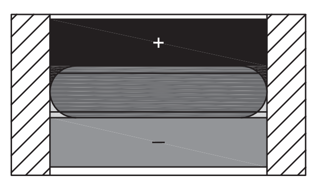
Anode



Cathode

Planar Junction

Anode

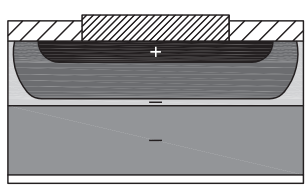


Cathode

Deep-Diffused Junction

Zener:
N region does not sustain reverse voltage depletion region into N+.

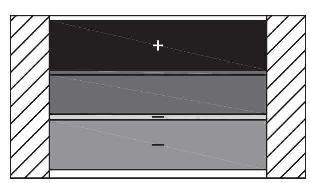
Anode



Cathode

Planar Junction

Anode



Cathode

Deep-Diffused Junction

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Application Note A

DIODES

Reverse Leakage

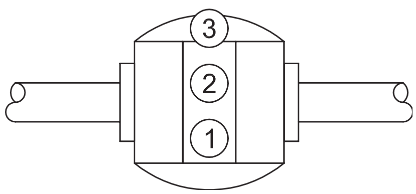
Reverse current (I_R) flows through the diode junction when reverse voltage is applied.

Factors Influencing the Amplitude of the Reverse Current Include:

A) Thickness of the silicon
B) Amplitude of the reverse voltage
C) Junction temperature
D) Cross-sectional area of the junction
E) Exposure of the junction to light
F) Dopants used
G) Amount of radiation impinging on the junction

A common approximation is to assume that I_R doubles every 10°C. However, the actual value of the reverse current is the sum of three distinct current flows:

1) Current due to diffusion
2) Current due to surface leakage
3) Current due to charge generation.



Leakage current paths

High-voltage junctions differ from their low-voltage counterparts in that, at room temperature, the dominant leakage path is usually along the surface. Current due to junction capacitance is much lower in amplitude. For this reason, it is important to pay careful attention to the leakage source.

For example, it is common to match the reverse current measurements of diodes connected in a string at 25°C. The string is then subjected to elevated temperatures. In such a scenario, it is probable that at even slightly elevated temperatures the reverse current flowing through the diodes would change significantly, resulting in a severe mismatch. This, in turn, would result in an over-voltage condition on some of the diodes.

To appreciate how this can happen, consider a situation in which two diodes exhibit exactly the same reverse current at 25°C.

Table 1

Diode	T_A = +25°C	T_A = +100°C
1	I_R (diffusion) = 10nA + I_R (surface) = 500nA I_R (total) = 510nA	I_R (diffusion) = 10µA + I_R (surface) = 500nA I_R (total) = 15.5µA
2	I_R (diffusion) = 500nA + I_R (surface) = 10nA I_R (total) = 510nA	I_R (diffusion) = 75µA + I_R (surface) = 10nA I_R (total) = 75.1µA

Thus a pair of diodes, which were perfectly matched at a temperature of 25°C, would be terribly mismatched at higher temperatures.

Forward Voltage:
V_F varies with:

A) Resistivity
B) Thickness of silicon
C) Level of dopant concentration
D) Type of dopant
E) Temperature
F) Current density

Forward drop is not usually as important an issue in a high voltage rectifier as it is in low-voltage applications. Consider, for example, a 1000-watt, 5-volt power supply. If its rectifiers exhibit a 0.7-volt forward drop, the power loss with 20 amps flowing, would be 140 watts, or 14 percent of the power being handled. In contrast, the rectifier's forward drop, in a typical 1000-watt, 1000-volt supply, ranges between 1 and 1.5 volts. At full output, the current is 1 amp. With a 1.5-volt forward drop, this translates to a 1.5-watt power loss. This represents less than two-tenths of one percent of the power being passed through the rectifier.

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Application Note A

Reverse Leakage (Continued)

Reverse Recovery Time:
T_{RR} varies with:

A) Resistivity
B) Dopant concentration
C) Type of dopant
D) Junction width
E) Forward current
F) Temperature
G) Change in reverse current with time (dI/dT)

In applications, these factors cause high voltage junctions to exhibit slower recovery times than similarly doped low voltage junctions.

As a result, high-voltage junctions typically contain considerably higher concentrations of dopants, like platinum or gold, than their similar-speed, low-voltage junction counterparts. The higher dopant concentrations cause higher forward voltage drops and reverse leakage currents.

Creating High-Voltage Rectifiers

There are three differing approaches to creating high-voltage rectifiers. Two of these involve connecting a number of low-voltage, single-junction diodes in series. The simplest series, called a high-voltage stick, consists of tying the required number of diodes end-to-end.

This connection method requires consideration of such factors as voltage sharing, junction temperature, and matching reverse-recovery characteristics. To account for these factors, compensation networks of resistor/capacitor strings are frequently employed. The resulting network, called an R/C-compensated diode string, is usually employed in applications exceeding 30 watts of power.

At lower power levels, such as those encountered in CRT power supplies, multi-junction diodes are used. Deep-diffused junctions are ideal for high-voltage, mult-junction designs. The greatest advantage of the multi-junction process is the capability of stacking diodes during the wafer stage. This allows high-temperature bonding, reducing metallization to almost zero. In addition, fabricating all the diode junctions on the same wafer provides a simple method of matching junction characteristics.

Multi-Junction Reverse Recovery Time

Deep-diffused, multi-junction diodes ideally address the problem of mismatched reverse recovery times between individual diodes. The question is, how does one prevent the faster diode from reacting to the combined reverse voltage while the slower diodes are recovering?

As stated earlier, reverse recovery time varies with temperature, resistivity, and dopant concentrations. The concentric use of matched wafers ensures closely matched dice, which, with temperature, track much better than discrete diodes. Also, each die can survive, while operating in the reverse avalanche mode, in the event that one chip recovers more quickly than another.

The worst-case temperature of the center junction is often perceived as an uncontrollable problem, when it is, in fact, controlled through thermal management. Silicon is a very good thermal conductor, comparing favorably with some aluminum alloys. As a result, it provides an efficient thermal path, through the multi-junction stack, to the leads.

An important factor in any high-voltage application is corona. A partial discharge resulting from air ionization in a voltage-stressed gap, the presence of corona destroys insulation over time. It is particularly destructive in trapped-air voids near high-voltage sources. As the multi-junction, deep-diffused diode is cylindrical and free of voids, it addresses the corona issue geometrically. The elimination of unnecessary air traps through encapsulation in a dielectric material and the use of multi-junction diodes often leads to fewer corona problems in potted assemblies.

Conclusion

High-voltage rectification presents unique challenges to the designer. Careful examination of the application requirements is essential when selecting the best solution for size, cost, and reliability. Diode parameters are interdependent and the decision of whether to employ high or low voltage diodes require a completely different thought process.

Stray parameters become major influences with voltage. Diodes become more temperature-dependent and mismatches increase in significance. As a result of these factors, deep-diffused, multi-junction diodes offer solutions to many high-voltage rectification problems.

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Application Note B

Diode Thermal Analysis

Controlling junction temperature is key to reliable semiconductor package design. High voltage diodes present unique junction temperature problems which must be addressed. In high voltage diodes, heat is generated primarily by:

1) Forward Voltage
2) Reverse Leakage Current
3) Reverse Recovery Losses

Each of these factors change differently and must be considered carefully over the intended operating range. The following examples depict the typical relative change in heat sources:

Diode Losses vs. Temperature:

Diode = 1N6515
T_{RR} = 70ns
PIV = 3000V
V_F = 4.0V @ 0.5A

Circuit Conditions:

Operating Frequency = 50kHz
Voltage Rise Time = 100ns
Average Rectified Current = 0.5A per diode
Reverse Voltage = 2000V Peak

Table 1

TJ = +25°C Heat Source		TJ = +75°C Heat Source		TJ = +125°C Heat Source	
VF	2.00 watts	VF	1.850 watts	VF	1.600 watts
IR	0.002 watts	IR	0.030 watts	IR	0.080 watts
TRR	0.100 watts	TRR	0.250 watts	TRR	2.500 watts
Total	2.102 watts	Total	2.130 watts	Total	4.180 watts

Controlling Junction Temperature

In the previous example, the junction temperature would exceed +150°C, if the package thermal impedance exceeds 6.25°C/watt. Thus, total heat source consideration is necessary. The deceptive difference, in high voltage application recovery losses, is primarily a result of the high voltage bias, as applied while the diode is recovering from forward bias to a blocking mode. The problem presented can be addressed by:

A) Decreasing the forward voltage
B) Decreasing the reverse recovery losses
C) Improving the thermal impedance
D) Operating over a reduced temperature range

Both forward voltage and reverse recovery losses are dependent on the diode used in the circuit, as well as the circuit characteristics. In many cases, there are trade-offs to any change made in diode characteristics. For instance, decreasing the reverse recovery time in a diode will generally cause its forward voltage to increase. However, reducing a diode's reverse blocking voltage in order to facilitate a reduction in its forward voltage may increase the risk of exceeding the voltage rating on the part.

Once a diode has been selected for an application, it is necessary to optimize the thermal impedance of the diode package. Rectifier thermal impedance is the resistance against heat energy movement, from the rectifier junction to a heat sink or heat dissipation reservoir. The thermal path for the rectifier will vary depending on the part's packaging configuration. The remainder of Appendix B will list some typical rectifier packaging schemes to address these issues.

Reverse Recovery Power Loss Measurement

In high voltage, high frequency diode applications, reverse recovery losses can significantly contribute to the power dissipated in the diodes. Reverse recovery losses occur during the transition from forward current to reverse voltage. When reverse voltage is applied to a diode, it will conduct in the reverse direction for a short time (the reverse recovery time). While the diode is conducting in the reverse direction, the power dissipated is equal to the reverse recovery current multiplied by the reverse voltage.

Unfortunately, it is not possible to determine the reverse recovery losses for a diode in a circuit without actually testing the circuit. While the reverse recovery time rating of a diode gives a relative indication of its speed, the rating is based on controlled laboratory conditions. In an actual circuit, the conditions which affect reverse recovery time, such as forward operating current, dv/dt of the voltage waveform, reverse voltage, and termperature, can vary considerably.

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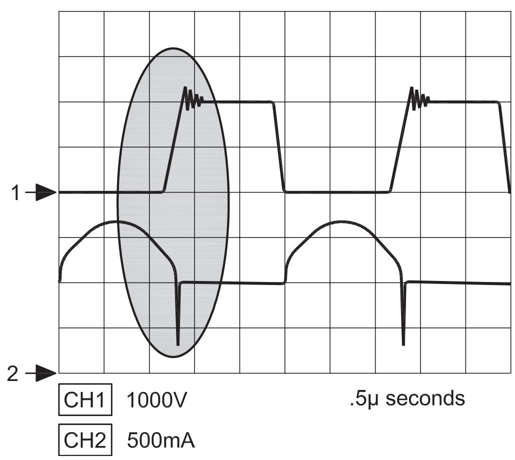
Application Note B

Diode Thermal Analysis

Reverse Recovery Power Loss Measurement (Continued)

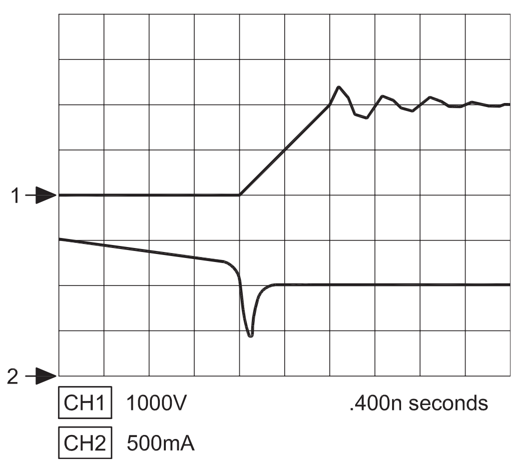
The best way to evaluate reverse recovery losses is to monitor diode current and reverse voltage waveforms while the diode is operating in the circuit. Chart 1 shows waveforms for a simulated circuit. The voltage waveform (CH1) shows a peak reverse voltage of 2400V and a nominal reverse voltage of 2000V. The current waveform (CH2) shows a peak forward current of 600mA and a peak reverse recovery current of 600mA. The operating frequency is 40kHz.

Chart 1



Simulated Current Waveforms:
CH1 Voltage Waveform / CH2 Current Waveform

Chart 2



Area of the waveform circled in Chart 1. Expanded in time to show reverse recovery current in detail:
CH1 Voltage Waveform / CH2 Current Waveform

Theoretically, reverse recovery power losses can be calculated by integrating reverse recovery current times reverse voltage over the time region in which reverse recovery time is a factor and then multiplying the result by the operating frequency. It is not practical to integrate the waveforms, though. An estimate of reverse recovery losses can be found by multiplying reverse recovery time by reverse voltage, multiplying that result by the measured reverse recovery time, and then multiplying by operating frequency (Chart 2).

P_{Trr} = 0.5 x 0.6A x 250V x 200ns x 40kHz = 0.6 watts

The factor of 0.5 was used because the reverse recovery current waveform is triangular. A peak recovery current of 0.6A was used, along with an average reverse voltage during recovery of 250 V. A recovery time of 200ns was used in the calculation. Factors that influence reverse recovery losses include the diode recovery time, operating frequency, dv/dt of the voltage waveform, and operating temperature. The faster the recovery time of the diode, the lower the reverse recovery losses will be. Higher operating frequencies and a faster dv/dt will cause higher reverse recovery losses.

The reverse recovery time of a diode is dependent on its junction temperature. The reverse recovery time of a 70ns diode will increase by approximately two and a half times from 25°C to 100°C, so that its reverse recovery losses will also increase by at least two and a half times at 100°C. It is important, when evaluating reverse recovery losses, to take measurements at the maximum operating temperature of the circuit. If reverse recovery losses are too high, the diodes can go into a thermal runaway condition and can fail catastrophically.

Diode Mounted on a PC Board

The two major thermal paths for a mounted diode are through the diode leads to the PC board and through the diode body and leads to the surrounding air or other medium. The thermal resistances of VMI diodes are given for several lead lengths in the diode data sheets. The diode's temperature rise over the temperature of it's mounting location can be determined by multiplying the diode's thermal resistance through its leads by the power dissipated in the diode. The temperature or thermal impedance of the diode will have a major effect on the junction temperature of the diode. This is because any mounting location temperature rise will be added to temperature rise of the diode itself.

The medium surrounding the diode can reduce the diode's junction temperature by adding a parallel thermal path. If the surrounding medium is air, its cooling effect will depend largely on its temperature and on its movement. Forced air can significantly reduce a diode's junction temperature. However, still air, such as would be present in an enclosed box, may have very little cooling effect on the diode junction. If the surrounding medium is a potting material, its cooling effect on the diode junction will depend on the temperature and thermal conductivity of the material, the power dissipation of any neighbor components, and on the thermal path through the material to any outside surface or heat sink.

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Diode Thermal Analysis

Diode Operating in Oil

The heat generated by a diode operating in oil will be largely dissipated to the oil through the diode leads. A small percentage of the heat will also be dissipated to the oil through the diode body. Thus, typically oil operation is an excellent way to remove heat from the diode. As such, it is generally possible to drive the diode at increased forward current levels (up to twice the VMI published ratings), when operating in an oil environment. For oil operation, use the zero lead length power derating curve.

Diode Encapsulated in a Potting Material

The heat generated, in a diode encapsulated in potting material, must be dissipated through the material to an outside surface or heat sink. The thermal conductivity of the potting material used can be critical. Silicon potting materials typically have a lower thermal conductivity than rigid epoxies. However, there are other characteristics of a silicon potting material that may make it more desirable.

Other potting materials, such as glass or alumina, can be added to the potting material to increase its thermal conductivity. Thermal conductivities for various materials are given in Table 2, which are commonly used in potted rectifier assemblies.

Table 2

Material	Thermal Conductivity W/in°C	Linear Thermal Expansion ppm/°C
Silver 99.9%	10.500	23.5
Copper OFC	10.000	17.0
Tungsten	4.250	4.5
Aluminum 6061T6	3.960	23.5
Silicon (pure)	3.700	3.0
Molybdenum	3.400	5.1
Beryllia 95%	3.000	7.5
Tin	1.600	23.5
Solder 63Sn-37Pb	1.270	25.0
Aluminum 96%	.890	6.4
Lead	.880	29.0
Solder 96.5Sn-3.5Ag	.840	30.0
Epoxy Stycast 2850KT	.106	28.8
Epoxy Stycast 2850MT	.075	29.2
PC Board G-10 (unclad)	.052	21.1
Epoxy Stycast 2850FT	.036	29.0
RTV 1200 HTC	.036	80.0
Glass	.031	3.3
Epoxy Scotchcast 281	.013	150.0
RTV 3120	.008	350.0
RTV 615	.005	270.0

The mechanical configuration of the diode in the package will also have an effect on thermal impedance. Thermal impedance may be calculated with the following formula:

$$\theta jc = \frac{L}{\sigma \times A}$$

Where **"θjc"** is the thermal impedance from the diode to the heat sink or outside surface, "A" is the area of the thermal path,**"σ"** is the thermal conductivity as given in Table 2, and "L" is the length of the thermal path from the diode to the heat sink.

In many practical cases, the area or length of a thermal path may be difficult to determine exactly. Also, in some cases there are several thermal paths that must be considered in parallel. The above formula should be used to arrive at a close approximation of the thermal impedance of the package. Calculation of thermal impedance should be followed by an actual test of the diode junction temperature in the package.

As the above formula indicates, thermal impedance is inversely proportional to the thermal area. Thus, thermal impedance and junction temperature can be reduced by increasing the thermal area. One way to increase the thermal area is to add metal heat dissipators to the diode leads. Also, the shorter the distance between the diode and the heat sink (or outside surface), the lower the thermal impedance.

In high voltage applications, the minimum distance required between the diode and outside surfaces will depend on the package voltage stress and on the dielectric strength of the potting material. See figure 2 for a typical potted rectifier configuration. Thermal impedance for conduction may be calculated with the following formulas:

$$Q = \frac{\sigma \times A \times T}{L} \quad \text{or} \quad \theta = \frac{L}{\sigma \times A}$$

Where:
- Q = Heat conducted (watts)
- A = Cross-section area of heat path (in^2)
- σ = Thermal conductivity (watts/in°C)
- L = Length of heat path (in)
- T = Temperature difference (T1-T2)
- θ = Thermal resistance (°C/watt)

Surface Mount Diode

In a surface mount application, the diode is mounted to a ceramic substrate or PC board. The heat generated in the junction of the diode flows through the end tabs or formed leads directly to the substrate or PC board. The thermal impedance of the diode (given in the diode data sheet) is added to the thermal resistance of the substrate or PC board to obtain the total thermal impedance of the package. See Figures 3 and 4 for a typical surface mount configuration.

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Application Note B

Diode Thermal Analysis

Surface Mount Diode (Continued)

Total thermal impedance may be calculated with the following formula:

$$\theta j\text{-}ms = \theta jc + \theta substrate$$

Where **"θjc"** is the thermal impedance from the diode to the substrate. **"θ"** substrate is the thermal impedance through the PC board or substrate.

The total thermal impedance of the package is the sum of the thermal impedance from the diode junctions to the internal surface of the PC board or substrate, plus the thermal impedance through the substrate to the external mounting surface. In order to assure reliable operation, heat generated by the diode must be transmitted away from the base plate, PC board or mounting surfaces. Common methods of conducting heat away form the mounting surfaces include forced-air cooling, the use of water-cooled base plates, and oil operation. All of these methods help to maintain a constant operating temperature.

The following Ilustrations show Typical Diode configurations

Axial Lead Diode, PCB Mounted:
Isolation
Voltage = 15kV
Diode = Z25SG
L = .375
$\theta_{J\text{-}PCB}$ = 18°C/Watt

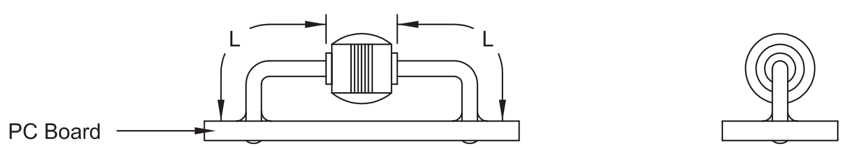

Figure 1

Axial Lead Diode with Copper Heat sink:
Isolation
Voltage = 15kV
$\theta_{J\text{-}MS}$ = 12°C/Watt

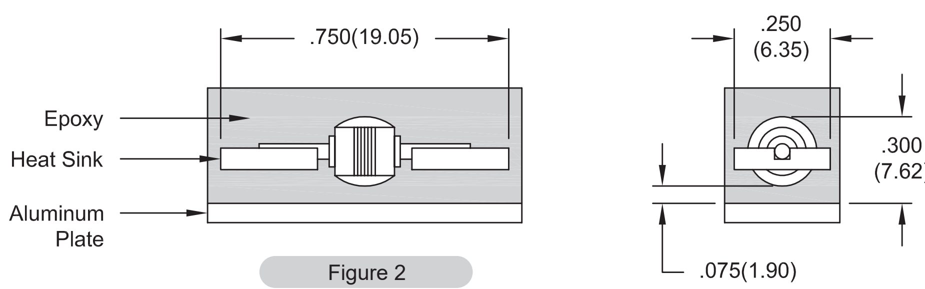

Figure 2

Surface Mounted:
Isolation
Voltage = 15kV
$\theta_{J\text{-}MS}$ = 7°C/Watt

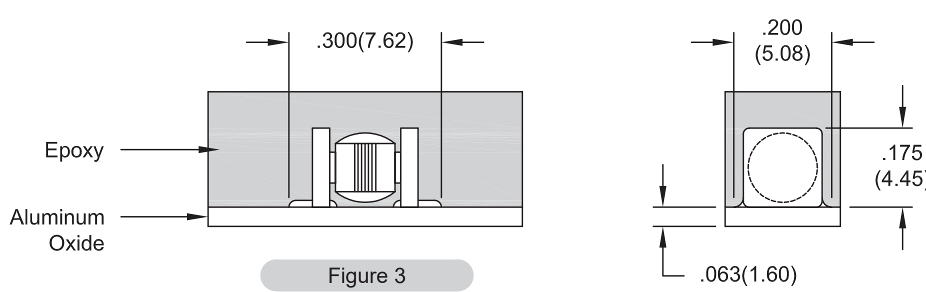

Figure 3

Formed Lead Diode, PCB Mounted:
Isolation
Voltage = 15kV
$\theta_{J\text{-}MS}$ = 8°C/Watt

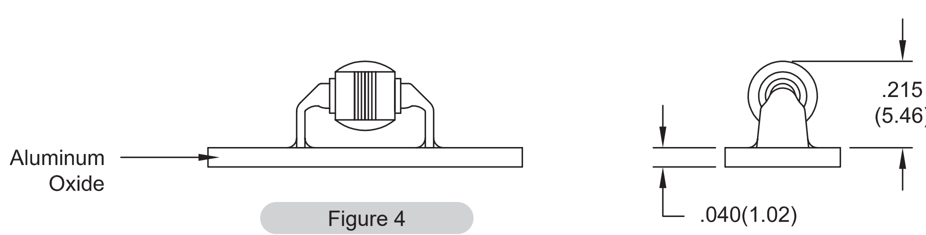

Figure 4

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Application Note C

Reverse Recvoery Time (T_{RR})

Factors influencing Reverse Recovery Time:

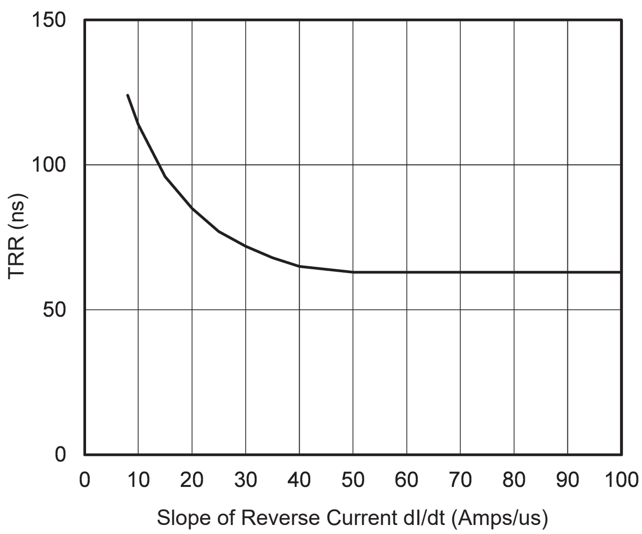
Circuit/Environmental Influences:
A) dI/dT
B) Junction Temperature

Other Factors:
C) Silicon Resistivity
D) Peak Inverse Voltage
E) Manufacturing Process stages.

Circuit Effects: (dI/dT)

In general, T_{RR} decreases as dI/dT increases. The rate of change varies with the manufacturing process and the speed of the device. Typically, slower devices exhibit less change in T_{RR} as dI/dT changes. The following example reflects data taken from a high-speed, 1000V, 3Amp, platinum-doped, VMI power rectifier:

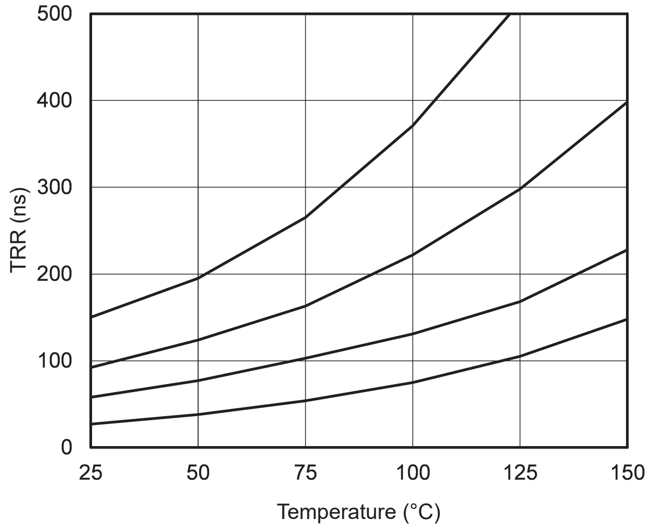
Table 1



Environmental Effects: (Junction Temp)

Typically, T_{RR} increases with junction temperature. The rate of change varies with the manufacturing process and the speed of the device. Higher speed devices, of the same manufacturing process, change more with temperature than slower devices. The following graph reflects data taken from a range of VMI fast and ultra-fast diodes (Reverse Recovery Time vs. Temperature):

Table 2



Silicon Resistivity:

In general, T_{RR} increases as silicon resistivity increases. The primary factor is the level of doping during the silicon ingot growing process. (Subsequent doping at the wafer level may yield greater variations in T_{RR} than during ingot manufacturing.)

Peak Inverse Voltage PIV:

As PIV increases, T_{RR} generally increases. The primary factor is the high resistivity of the starting material. Fewer recombination centers available to sweep out the junction area also contributes to slower devices.

Manufacturing Process:

Many processes are used to manufacture high speed devices (e.g. platinum doping, gold doping, irradiation, etc.). Each process results in different diode behavior. VMI uses a platinum diffusion technique to optimize the following characteristics:

A) **Low Reverse Leakage** - Typically < 1μA at the rated voltage and at room temperature. (Other processes may exhibit > 1mA at the rated voltage and at room temperature.)

B) **Low High Temp Reverse Leakage** - Typically < 20μA at the rated voltage and at a junction temperature of 100°C. Thermal runaway, due to reverse leakage, is rarely seen on VMI devices operated within the rated parameters and at temperatures of up to +175°C.

C) **High Voltage** - The plantinum doping process provides high voltage break down characteristics exceeded by no other manufacturer of similar devices.

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VMI
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Application Note D

Optocoupler

• **What is an Optocoupler?**

An optocoupler is a device used to electrically interface between two current-isolated systems. It does this by way of light transmission.

• **How does it work?**

When connected in a linear regulator configuration, the external system supplies current to the Light Emitting Diodes (LED's). Refer to OC-100 and/or OC-250 data sheets. As the level of LED current fluctuates, so does the light intensity of the LED. The light from the LED falls on the light-sensitive junctions of the high voltage diode. The high voltage diode is reverse-biased, so that the leakage current through the diode varies in response to the light levels from the LED's.

• **Description of the OC-100, OC-100HG and OC-250 devices:**

Assembly Methods:

OC-100
The 10kV diode and two LED's are precisely positioned in a mold and injection molded with an optically clear potting material. The diode is coated with a thin layer of glass, which makes the junctions more sensitive to light.

OC-100HG
The 10kV diode and two high intensity LED's are precisely positioned in a mold and injection molded with an optically clear potting material. The high voltage diode is coated with a thin layer of polyimide silicone allowing light to pass through to the diode junctions.

OC-250
Three OC-100 assemblies are soldered together (in series) and potted in a shell with a standard hard epoxy. Normal potting procedures are followed.

Physical Characteristics:

OC-100
A six leaded device containing one HV diode and two LED's. The LED's are positioned on either side of the HV diode to maximize the exposure of the junctions to light emitted from the LED's. Approximate physical dimensions are 1" length x .45" width x .32" height.

OC-100HG
A six leaded device containing one HV diode and two LED's. The LED's are positioned on either side of the HV diode to maximize the exposure of the junctions to light emitted from the LED's. Approximate physical dimensions are 1" length x .45" width x .32" height.

Optocoupler Notes

OC-250
A four terminal device-two flying leads and two solder turrets-that contains three HV diodes and six LED's. Approximate physical dimensions are 2.10" length x 1.40" width x 1.0" height.

• **Optocoupler advatanges:**

- High isolation voltage
- High voltage (Up to 25kV)
- Remote sensing
- Excellent voltage gain ratio

• **Typical Optocoupler uses:**

- Elimination of ground loops
- Interfacing circuits operating at different voltage levels
- Increasing the noise immunity of a system
- Reducing effects of electrical noise (motor control systems)
- Protection of equipment & user from high voltages
- Interfacing safe & hazardous areas in intrinsic safety appplications

• **Typical Optocoupler applications:**

- HV switching
- Contact closure
- External voltage sensing
- HV isolation
- Mass spectrometry

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RoHS Compliance

Customer requirements regarding RoHS compliance and the use of restricted materials is of utmost importance to VMI.

Many of our products are inherently RoHS compliant, or compliant via exemption, especially the hermetically sealed, axial-leaded diodes.

Changes to exempt devices such as those used in military and aerospace are not implemented without prior notification.

Due to changing requirements, the best source for RoHS compliant status of VMI's standard products is our website.
Visit us at:
https://www.voltagemultipliers.com/support/environmental/

If you have any questions, please contact our Visalia headquarters.

Disclaimer

The information contained in this shortform has been carefully reviewed and is believed to be accurate; however, no responsibility is assumed for inaccuracies.

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Voltage Multipliers Incoporated (VMI) reserves the right to make changes without further notice to any of the products described in this shortform to improve reliability, function or design. Further, VMI does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights nor the rights of others.

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VMI Commitment to Quality

Responsibilities

Each employee and supplier will be responsible for their involvement in design, procurement, manufacture, support, delivery, service, or management.

Supplier/customer relationships

We will build a chain of supplier/customer relationships that begins with our external suppliers and continues through our organization and includes our external customers. We will use our supplier/customer relationships (internal and external) to assure that our individual work quality meets the requirements of the next person in the chain. Through this chain of relationships, we will assure that our product quality meets our customer's requirements.

Commitment of resources

We will provide our people with the necessary tools, work insturctions, procedures, equipment, raw materials, and training, to achieve our product quality goals.

Employee freedom

We will insure that our people have the freedom to identify, report, and solve problems, affecting product quality.

Role of assurance quality manager

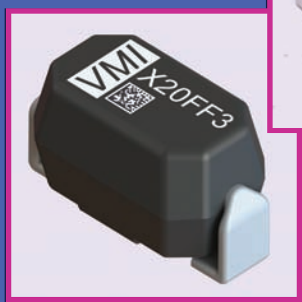
The Quality Assurance manager is assigned the authority and responsibility for the definition, administration, and review, of the quality program. This position is authorized to resolve all conflicts between this quality program and any other policies, procedures, or operations, within the company, and implement the necessary changes.

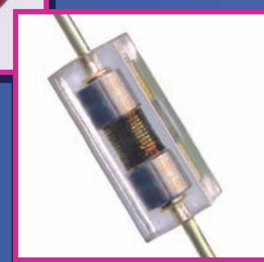
Dennis Kemp
President

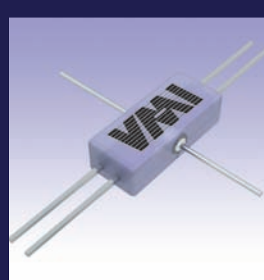
Voltage Multipliers Inc. (VMI) began operations in November 1980. VMI initially designed and produced voltage multipliers. The addition of diode manufacturing capabilities led the way to expanding company facilities and product lines. All silicon wafers are doped, diffused, and metalized in our Visalia CA facility. VMI has comprehensive in-house testing capabilities which include PIV, Vf, Ir and Trr. Our products are 100% tested.

VMI has complete environmental testing capabilities. Our equipment, procedures, and processes are DSCC certified to Mil-Prf-19500, and we are ISO9001:2015 certified.

High Voltage Innovation







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