Silicon Rectifiers and Bridges VARO SEMICONDUCTOR 1981/1982

YOUR RECTIFIER SUPERMARKET

Silicon Rectifiers and Bridges

1981/1982

VARO ®

VARO SEMICONDUCTOR

VARO:
the world's leading rectifier company

Varo Semiconductor is the largest producer of high voltage diodes in the United States, and is a leading manufacturer of silicon rectifiers, diodes, bridges and multipliers for customers throughout the world.

VARO FIRSTS

First to offer a high voltage diode to the television industry, paving the way for a "100% solid state" color and b & w chassis.

First to offer a full-wave bridge in a DIP package.

First (and currently, only) to offer a full-wave bridge utilizing Schottky rectifiers in a DIP package.

First U.S. company to manufacture high voltage glass encapsulated diodes.

VARO QUALITY

All of Varo's manufacturing facilities are located in Garland, Texas. This enhances process monitoring and control, leading to high product quality and reliability. Every Varo device is mechanically inspected and electrically tested prior to shipment: no AQL or lot sampling. Only 100% testing.

HOW TO USE THIS CATALOG

Standard devices are listed in the table of contents, and are grouped into four classifications. Find your general area of interest, then locate the specific device by page number. Application Notes are listed by subject matter.

HOW TO ORDER VARO PRODUCTS

Phone or write/cable/telex:

Varo Sales Representative
Varo Distributor (many of Varo's items are stocked by local Varo Distributors)
Varo Semiconductor, Marketing Department

TERMS

Net 30 days. FOB Point: Varo Factory; Garland, Texas

WARRANTY

The seller warrants that at time of shipment the products manufactured by Seller and sold hereunder will be free from defects in material and workmanship and will conform to the specifications furnished or approved in writing by the Seller. Seller's obligation under this warranty, however, is expressly limited to replacing, repairing, or issuing credit for (at Seller's option) any products returned to Seller during the schedule period shown below and if (a) Seller has received written notice within 30 days after discovery of any defect by Buyer, (b) the defective products are returned to Seller, transportation charges prepaid by Buyer, and (c) Seller's examination of such products discloses to Seller's satisfaction that defects in such products have not been caused by misuse, neglect, improper installation, repair, alteration, or accident. This warranty is in lieu of all other warranties (express; implied, including merchantability and fitness; or statutory), and in no event shall Seller be liable to Buyer for loss of profits, loss of use, or damages of any kind based upon a claim for breach of warranty.

Warranty schedule is as follows:

Standard Products — All products identified with an EIA number or Varo model, series, or print number are warranted for one year from date of shipment.

VARO

VARO SEMICONDUCTOR, INC. P.O. BOX 40676, 1000 NORTH SHILOH, GARLAND, TEXAS 75040, (214) 271-8511 TWX 910-860-5178

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North American Representatives

June 1981

ALABAMA
Rep, Inc. 205/881-9270
P.O. Box 4286 Huntsville, AL 35802

ARIZONA
Summit Sales 602/998-4850
7825 E. Redfield Rd.
Scottsdale, AZ 85260

ARKANSAS
Ammon & Rizos Co. 405/942-2552
P.O. Box 12274
Oklahoma City, Ok 73112

CALIFORNIA (Northern)
W. W. Posey Co. 408/746-0771
1265 Oakmead Pkwy Sunnyvale, CA 94086

CALIFORNIA (Southern)
Corcoran Assoc. 213/823-4589 or 823-2425
P.O. Box 45897 Los Angeles, CA 90045

CALIFORNIA (Orange County)
Corcoran Assoc. 714/848-4380
8281 Forelle Huntington Beach, CA 92646
Attention: Herman Miller

COLORADO
Technology Mktg. Assoc., Inc. 303/841-3435
P.O. Box 626 Parker, CO 80134
Shipping Address: 6559 E. Parker Rd. Suite 204

CONNECTICUT
Comp Rep Assoc. 203/239-9762 & 239-1411
605 Washington Ave. North Haven, CT 06473

CONNECTICUT (Fairfield County)
Cooper-Simon & Co. 516/487-1142
38 Middle Neck Rd. Great Neck, L.I., NY 11021

DELAWARE
Knowles Associate 215/947-5641
1 Fairway Plaza, Suite 310.
Huntingdon Valley, PA 19006

FLORIDA
OEM Mktg. Corp. 305/299-1000
1221 Lee Rd. Orlando, FL 32810

GEORGIA
Rep, Inc. 404/938-4358
1944 Cooledge Rd. Tucker, GA 30084

ILLINOIS (Northern)
D. Dolin Sales Co. 312/286-6200
6232 Pulaski Rd. Chicago, IL 60646

ILLINOIS (Southern)
KEBCO 314/576-4111
75 Worthington Maryland Heights, MO 63043

INDIANA
C-S Electronic Sales 317/659-1874
1157-B S. Jackson Frankfort, IN 46041

IOWA
D. Dolin Sales Co. 312/286-6200
6232 Pulaski Rd. Chicago, IL 60646

KANSAS
KEBCO 913/649-1051
7070 W. 107th – Suite 160 Overland Park, KS 66212

LOUISIANA
Ammon & Rizos Co. 214/233-5591
4255 LBJ Freeway, Suite 251 Dallas, TX 75234

MAINE
Comp Rep Assoc., Inc. 617/329-3454
100 Everett St. Westwood, MA 02090

MARYLAND
Professional Rep, Inc. 301/653-3600
107 Sudbrook Lane Baltimore, MD 21208

MASSACHUSETTS
Comp Rep Assoc. Inc. 617/329-3454
100 Everett St. Westwood, MA 02090

MICHIGAN
Amtech Representatives, Inc. 313/474-8300
22725 Orchard Lake Rd., Suite 7
Farminton, MI 48024

MINNESOTA
Nortec Sales, Inc. 612/835-7414
4530 W. 77th St., Suite 148 Minneapolis, MN 55345

MISSISSIPPI
Rep, Inc. 205/881-9270
P.O. Box 4286 Huntsville, AL 35802

MISSOURI
KEBCO 314/576-4111
76 Worthington Maryland Heights, MO 63043

NEBRASKA
KEBCO 913/649-1051
P.O. Box 4805 Overland Park, KS 66204

NEW JERSEY (Northern)
Cooper-Simon & Co. 516/487-1142
38 Middle Neck Rd. Great Neck, L.I. NY 11021

Continued

NEW JERSEY (Southern)
Knowles Associates 215/947-5641
1 Fairway Plaza, Suite 310
Huntingdon Valley, PA 19006

NEW YORK (Metro Area)
Cooper-Simon & Co. 516/487-1142
38 Middle Neck Rd. Great Neck, L.I. NY 11021

NEW YORK (Upstate)
Bob Dean, Inc. 607/272-2187
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June 1981

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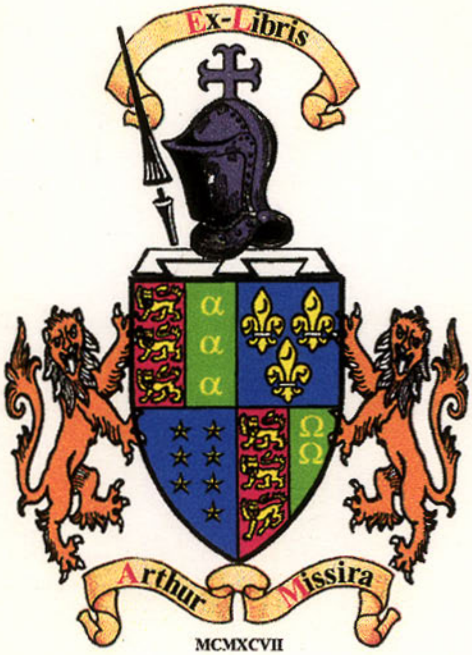
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Arthur Missira
MCMXCVII

VARO

Low Voltage Rectifiers

Epoxy Bridge Rectifiers

1 Amp Dual In-line Bridge 11
1 Amp 13
1 Amp Fast Recovery 15
2 Amp 17
2 Amp Fast Recovery 19
5 Amp Fast Recovery 21
6 Amp 23
10 Amp 25
10 Amp Fast Recovery 27
15 Amp 29
30 Amp 31
30 Amp Fast Recovery 33

Integrated Bridge Rectifiers

10 Amp 35
25 Amp 37
25 Amp Fast Recovery 39
36 Amp, 3-Phase 41

TO-3 Package

30 Amp 43

t_{rr} Test Set **45**

Axial Lead Rectifiers

3 Amp, 100 Amp Peak Surge 47
3 Amp, 200 Amp Peak Surge 49

Schottky Barrier Rectifiers

750 mAmp Dual In-line Bridge 51
1 Amp 53
3 Amp 57
5 Amp 61
6 Amp, T0220 65
12 Amp, T0220 67
15 Amp 69
30 Amp 73
30 Amp, Center Tapped 77
40 Amp 81
60 Amp 85
60 Amp, Braided Lead 89

Schottky Barrier Rectifiers, High Temperature

30 Amp 93
60 Amp 95
75 Amp 97

High Efficiency Rectifiers

10 Amp, T0220 99
20 Amp, T0220 Center Tapped 101
30 Amp 103
50 Amp 105
70 Amp 107

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DLS 051

DIB 1 Amp Dual In-Line Bridge VM Series

June 1981

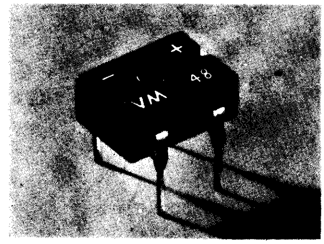
25V, 50V, 100V, 200V, 400V, 600V, 800V and 1000V V_{RRM} Ratings

25 Amps Peak One Half Cycle Surge Current

Glass Passivated Diodes

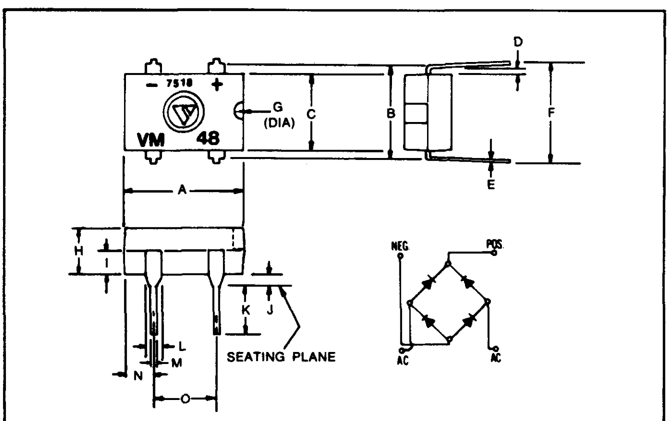
Standard .10" —2,54MM Dip Lead Spacing
2 Dibs Will Fit Into Standard 14 Pin Dip Socket

Moisture Resistant Epoxy Case



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	VM08	VM18	VM28	VM48	VM68	VM88	VM108	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
Peak Surge Current, ½ Cycle at 60 Hz (non-rep) and T_A = 40°C (Fig. 2)	I_{FSM}	25							Amps
Peak Surge Current, 1 sec at 60 Hz and T_A = 40°C (Fig. 2)	I_{FRM}	11							Amps
Avg. Forward Current at T_A = 40°C (Fig. 1)	I_O	1							Amp
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−50 to +150							°C
Max. Soldering Temperature and Time	10 sec. at 265°C								

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop (per diode) at 1 Amp (Fig. 3)	V_{FM}	1.2	Volts
Maximum Reverse Current (per diode) at Rated V_{RRM} and T_A = 25°C (Fig. 4)	I_{RM}	3.0	μA
Maximum Reverse Current (per diode) at Rated V_{RRM} and T_A = 125°C (Fig. 4)	I_{RM}	0.5	mA



LTR	INCHES	MILLIMETERS
A	.370-.390	9,40-9,91
B	.280-.320	7,11-8,13
C	.240-.260	6,10-6,60
D	.010-.020	0,25-0,51
E	.008-.015	0,20-0,38
F	.380 MAX	9,65 MAX
G	.057-.067	1,45-1,70
H	.140-.160	3,56-4,06
I	.070-.080	1,78-2,03
J	.055 MAX	1,40 MAX
K	.120-.130	3,05-3,30
L	.040-.060	1,02-1,52
M	.016-.020	0,41-0,51
N	.080-.100	2,03-2,54
O	.190-.210	4,83-5,33

DC FORWARD CURRENT & ALLOWABLE POWER DISSIPATION vs AMBIENT TEMPERATURE

CAPACITIVE LOAD DERATING CURVE

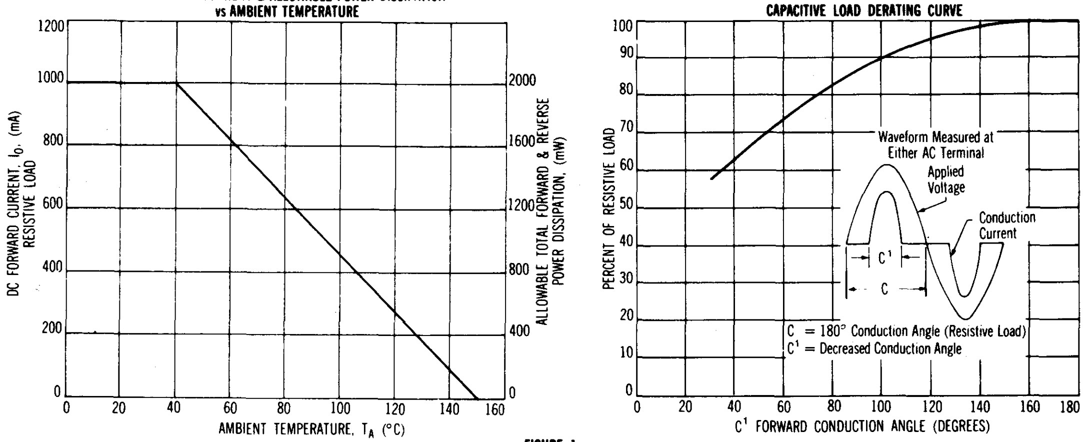


FIGURE 1

PEAK SURGE CURRENT vs NUMBER OF CYCLES AT 60 Hz (SINE WAVE INPUT) AND T_A = 40 C

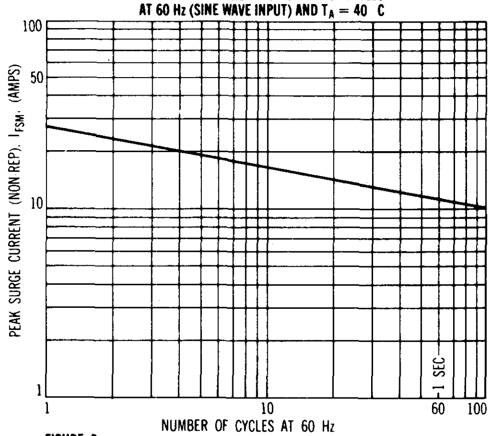


FIGURE 2

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP vs DC FORWARD CURRENT

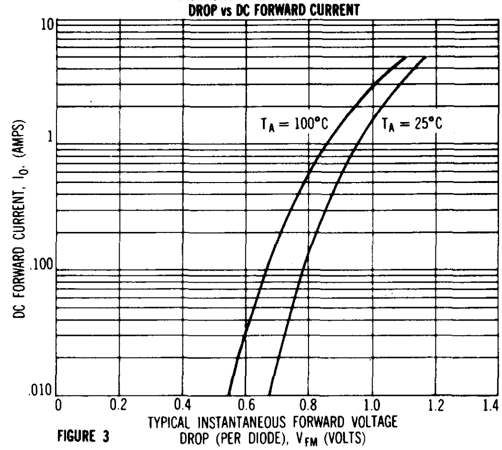


FIGURE 3

REVERSE CURRENT vs AMBIENT TEMPERATURE AT DC BLOCKING VOLTAGE

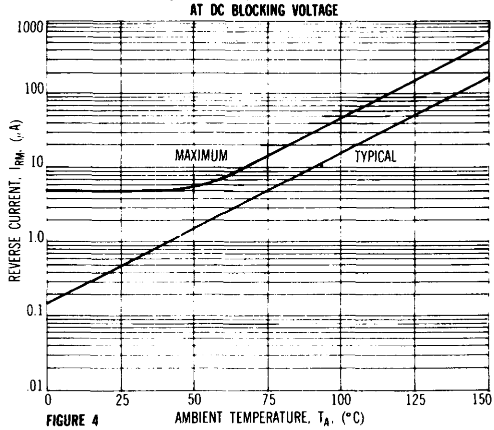


FIGURE 4

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DLS 028

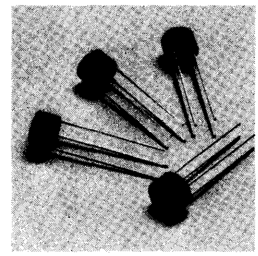
EBR 1 Amp Epoxy Bridge Rectifiers VE Series

June 1981

Controlled Avalanche Series with 250V, 450V, 650V, and 850V Minimum Avalanche Ratings

Non-controlled Avalanche Series with 25V, 50V, 100V, 200V, 400V, 600V, 800V, and 1000V V_{RRM} Ratings

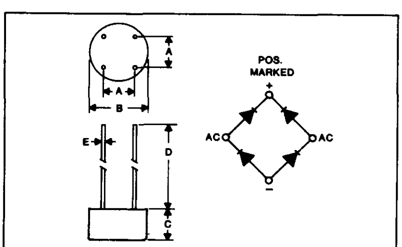
Glass Passivated Silicon Chips



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE								UNITS
Series Number		VE27	VE47	VE67	VE87	W110	VE08	VE18	VE28	VE48	VE68	VE88	VE108	
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	200	400	600	800	25	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	560	17	35	70	140	280	420	560	700	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 µSEC Square Wave	P_{RM}	200				NA								Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_A = 65°C	P_R	1				NA								Watts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) at T_A = 65°C (Fig. 2)	I_{FSM}	25												Amps
Peak Surge Current, 1 sec. at 60 Hz and T_A = 65°C (Fig. 2)	I_{FRM}	4												Amps
Avg. Forward Current at T_A=65°C (Fig. 1)	I_O	1												Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−50 to +150												°C
Max Soldering Temperature & Time		10 Sec at 265°C												

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE								UNITS
Series Number		VE27	VE47	VE67	VE87	W110	VE08	VE18	VE28	VE48	VE68	VE88	VE108	
Minimum Avalanche Voltage	$V_{(BR)}$	250	450	650	850	NA								Volts
Maximum Avalanche Voltage	$V_{(BR)}$	700	900	1100	1300	NA								Volts
Maximum Instantaneous Forward Voltage Drop (Per Diode) at 1 Amp (Fig. 3)	V_{FM}	1.2												Volts/ Leg
Maximum Reverse Current at Rated V_{RM}	I_{RM}	5												µA
Maximum Reverse Current at Rated V_{RM} at T_J=125°C (Fig. 4)	I_{RM}	500												µA
Insulation Strength from Circuit to Case (Min.)		2000												v dc

VE Series Bridges have been recognized under the component program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.185-.215	4,70-5,46
B	.350-.365	8,89-9,27
C	.190-.215	4,83-5,46
D	1.0 MIN.	25,4 MIN.
E	.022-.028 DIA.	,558-,711 DIA.

DC FORWARD CURRENT
VS AMBIENT TEMPERATURE

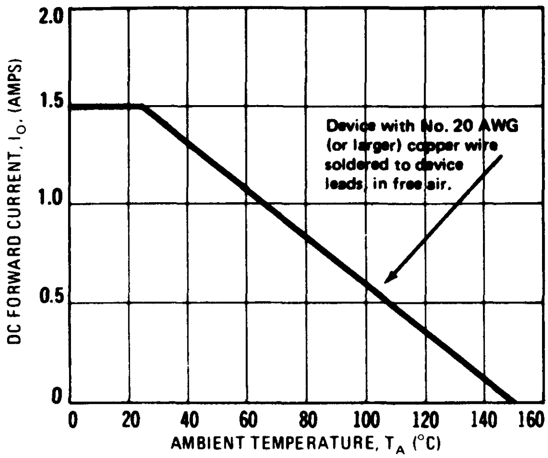


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT 60 Hz (SINE WAVE INPUT) AND T_A = 65°C

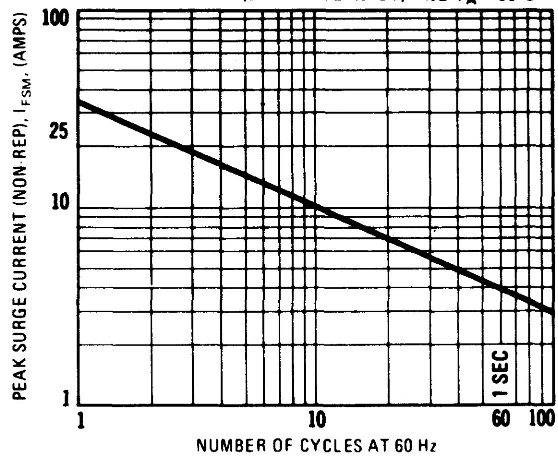


FIGURE 2

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP
(PER LEG)
VS FORWARD CURRENT

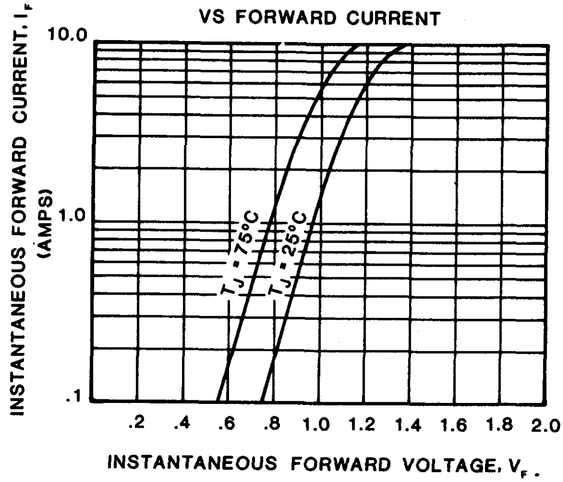


FIGURE 3 (VOLTS), PER LEG

REVERSE CURRENT VS JUNCTION
TEMPERATURE AT DC BLOCKING VOLTAGE

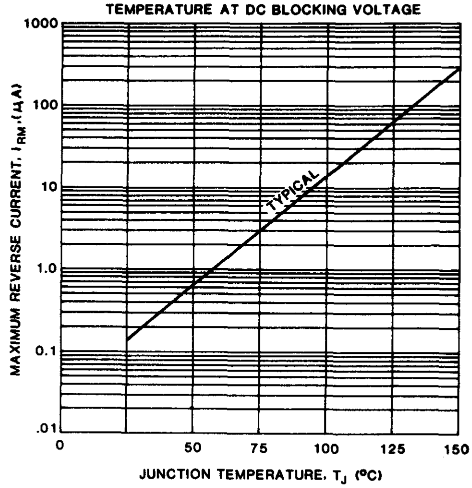
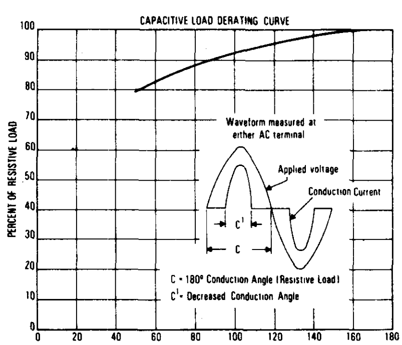


FIGURE 4



VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 043

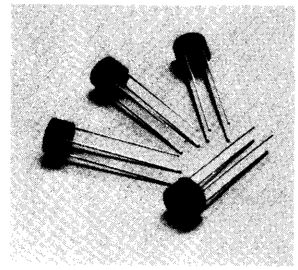
EBR 1 Amp Fast Recovery Time Epoxy Bridge Rectifiers

June 1981

200 Nanosecond Reverse Recovery Time

50V, 100V, 200V, 400V, and 600V V_{RRM} Ratings

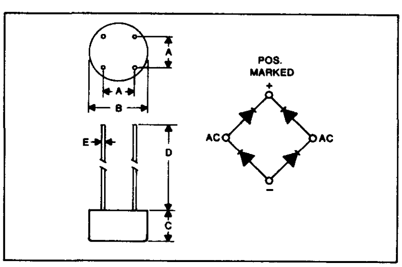
Glass Passivated Silicon Chips



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	VE08X	VE18X	VE28X	VE48X	VE68X	UNITS
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage,	V_{RM} V_{RWM} V_{RRM}	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_A = 40°C (Fig. 2)	I_{FSM}	17					Amps
Peak Surge Current, 1 sec. at 60 Hz and T_A = 40°C (Fig. 2)	I_{FRM}	3					Amps
Avg. Forward Current at T_C=40°C, (Fig. 1)	I_O	1					Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−50 to +135					°C
Max Soldering Temperature & Time		10 Sec. at 265°C					

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop (Per Diode) at 1 Amp (Fig. 3)	V_{FM}	1.5	Volts/ Leg
Maximum Reverse Recovery Time, I_F = 1 Amp, I_R = 2 Amp (Fig. 5)	t_{rr}	200	nsec
Maximum Reverse Current at Rated V_{RM}	I_{RM}	10	μA
Maximum Reverse Current at Rated V_{RM} at T_A = 125°C (Fig. 4)	I_{RM}	2	mA
Insulation Strength Circuit to Case (Min.)		2000	v dc

VE Series Bridges have been recognized under the components program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.185-.215	4,70-5,46
B	.350-.365	8,89-9,27
C	.190-.215	4,83-5,46
D	1.0 MIN.	25,4 MIN.
E	.022-.028 DIA.	,558-,711 DIA.

DC FORWARD CURRENT
VS AMBIENT TEMPERATURE

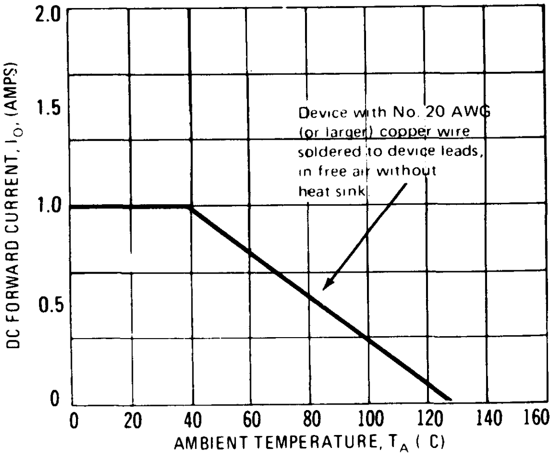


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT 60 Hz (SINE WAVE INPUT) AND $T_A = 40°C$

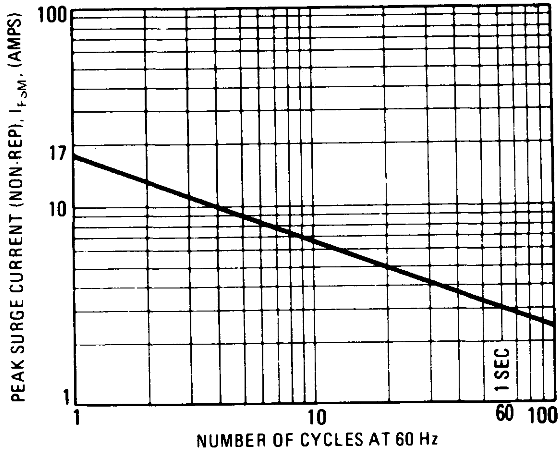


FIGURE 2

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP (PER LEG) VS DC FORWARD CURRENT

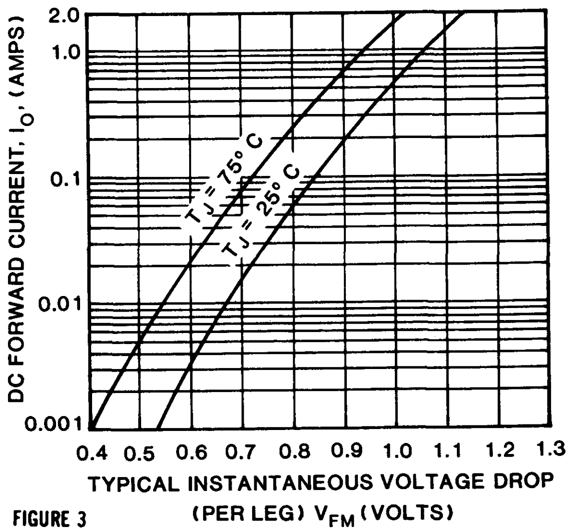


FIGURE 3

REVERSE CURRENT VS AMBIENT TEMPERATURE AT DC RATED VOLTAGE

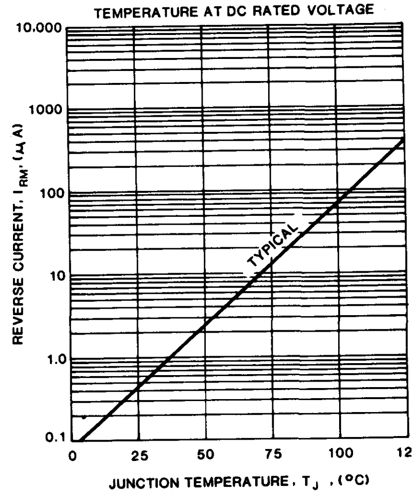


FIGURE 4

TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

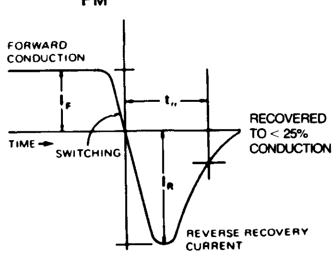


FIGURE 5

CAPACITIVE LOAD DERATING CURVE

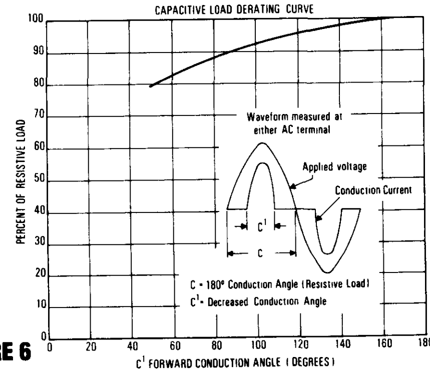


FIGURE 6

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 021

EBR 2 Amp Epoxy Bridge Rectifiers VS Series

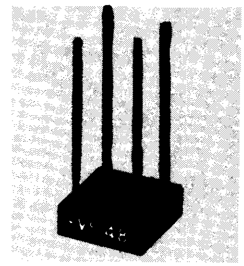
June 1981

Glass Passivated Silicon Chips

Controlled Avalanche Series with 250V, 450V, 650V, and 850V Minimum Avalanche Ratings

Non-Controlled Avalanche Series with 50V, 100V, 200V, 400V, 600V, 800V and 1000 V V_{RRM} Ratings

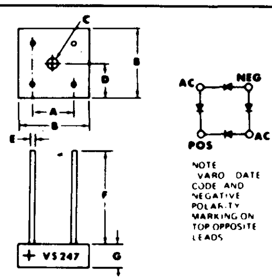
50 Amps Peak One Half Cycle Surge Current



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE							UNITS
Series Number		VS247	VS447	VS647	VS847	VS048	VS148	VS248	VS448	VS648	VS848	VS1048	
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage,	V_{RM} V_{RWM} V_{RRM}	200	400	600	800	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	560	35	70	140	280	420	560	700	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 μsec Square Wave	P_{RM}	300				NA							Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_A = 60°C	P_R	1				NA							Watts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_A = 60°C (Fig. 2)	I_{FSM}	50											Amps
Peak Surge Current, 1 sec. at 60 Hz and T_A = 60°C (Fig. 2)	I_{FRM}	8											Amps
Avg. Forward Current at T_A = 60°C (Fig. 1)	I_O	2											Amps
Junction Operating and Storage Temperature Range,	T_J, T_{STG}	50 to +150											°C
Maximum Soldering Temperature & Time		10 Seconds at 265° C											
Fusing Data	I^2t	10											Amps²-Sec.

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE							UNITS
Series Number		VS247	VS447	VS647	VS847	VS048	VS148	VS248	VS448	VS648	VS848	VS1048	
Minimum Avalanche Voltage,	$V_{(BR)}$	250	450	650	850	NA							Volts
Maximum Avalanche Voltage,	$V_{(BR)}$	700	900	1100	1300	NA							Volts
Maximum Instantaneous Forward Voltage Drop (per diode) at 2 Amps (Fig. 3)	V_{FM}	1.2											Volts/Leg
Maximum Reverse Current at Rated V_{RM}	I_{RM}	5											μA
Maximum Reverse Current at Rated V_{RM} at T_A = 125°C	I_{RM}	500											μA
Insulation Strength From Circuit to Case (min.)		2000											Volts DC

Part Nos. VS247, VS447, VS647, VS847, VS048, VS148, VS248, VS448, VS648, and VS848 have been recognized under the Component Program of Underwriters Laboratories, Inc.



LT	INCHES	MILLIMETERS
A	.411 - .441	10.44 - 11.20
B	.590 - .610	14.99 - 15.49
C	.137 - .167 Dia.	3.48 - 4.24 Dia.
D	.295 - .305	7.49 - 7.75
E	.037 - .043 Dia.	.94 - 1.09 Dia.
F	1.0 Min.	25.4 Min.
G	.195 - .205	4.95 - 5.21

DC FORWARD CURRENT
VS AMBIENT TEMPERATURE

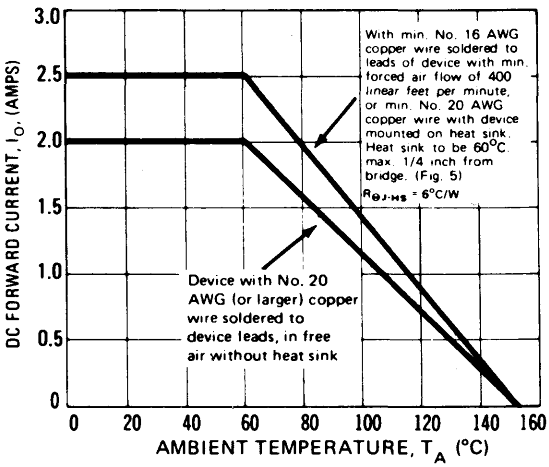


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT 60 Hz (SINE WAVE INPUT) AND T_A = 60°C

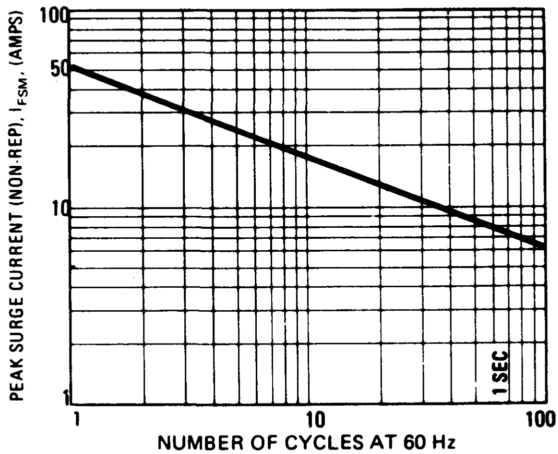


FIGURE 2

REVERSE CURRENT VS JUNCTION TEMPERATURE AT DC RATED VOLTAGE

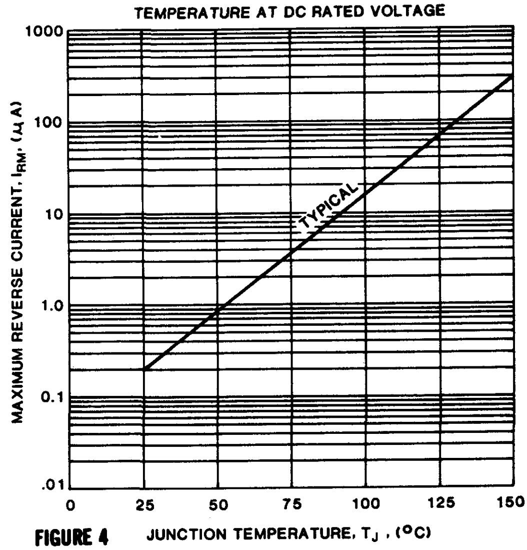


FIGURE 4

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP (PER LEG) VS FORWARD CURRENT

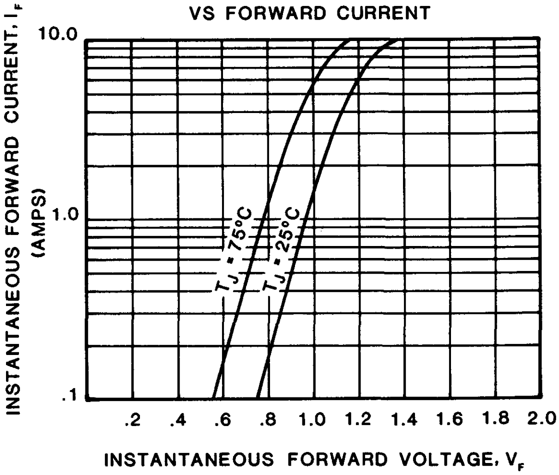


FIGURE 3

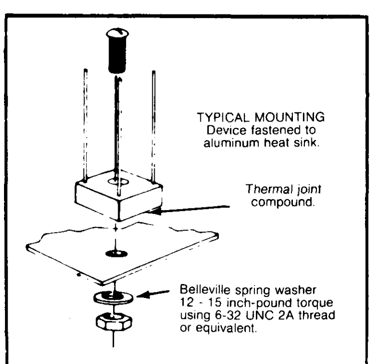


FIGURE 5

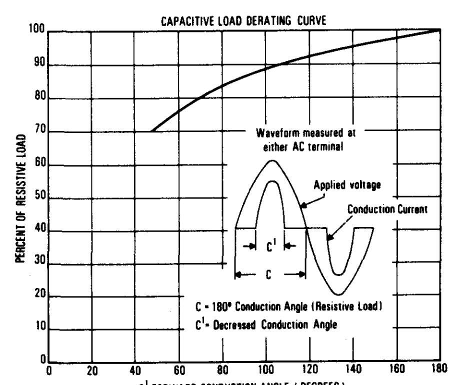


FIGURE 6

VARO

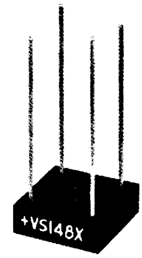
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 044

EBR 2 Amp Fast Recovery Time Epoxy Bridge Rectifiers

June 1981

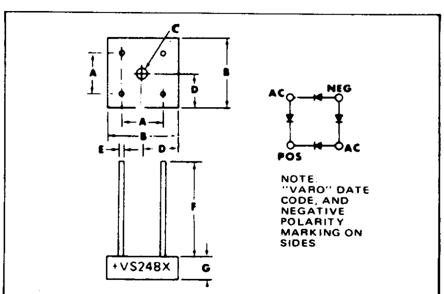
200 Nanosecond Maximum Reserve Recovery
50V, 100V, 200V, 400V, and 600V V_{RRM} Ratings
35 Amps Peak One Half Cycle Surge Current



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	VS048X	VS148X	VS248X	VS448X	VS648X	UNITS
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_A = 45°C (Fig. 2)	I_{FSM}	35					Amps
Peak Surge Current, 1 sec. at 60 Hz and T_A - 45°C (Fig. 2)	I_{FRM}	6					Amps
Avg. Forward Current at T_A = 45°C (Fig. 1)	I_O	2					Amps
Junction Operating and Storage Temperature Range	T_J,T_{STG}	−50 to +135					°C
Maximum Soldering Temperature & Time		10 Seconds at 265° C					

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop (Per Diode) at 2 Amps (Fig. 3)	V_{FM}	1.5	Volts/ Leg
Maximum Reverse Recovery Time, I_F = 1 Amp, I_R =2 Amps (Fig. 6)	t_{rr}	200	nsec
Maximum Reverse Current at Rated V_{RM}	I_{RM}	10	μA
Maximum Reverse Current at Rated V_{RM} at T_J = 125°C	I_{RM}	4	mA
Insulation Strength From Circuit to Case (min.)		2000	Volts DC

Part Nos. VS048X, VS148X, VS248X, VS448X and VS648X have been recognized under the Component Program of Underwriters Laboratories, Inc.



LT	INCHES	MILLIMETERS
A	.411 – .441	10.44 – 11.20
B	.590 – .610	14.99 – 15.49
C	.137 – .167 Dia.	3.48 – 4.24 Dia.
D	.295 – .305	7.49 – 7.75
E	.037 – .043 Dia.	.94 – 1.09 Dia.
F	1.0 Min.	25.4 Min.
G	.195 – .205	4.95 – 5.21

DC FORWARD CURRENT
VS AMBIENT TEMPERATURE

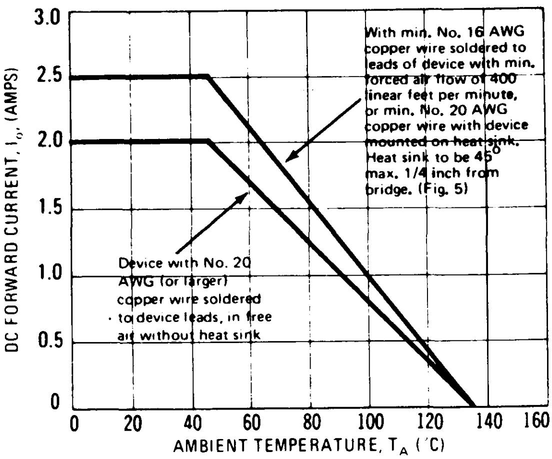


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT 60 Hz (SINE WAVE INPUT) AND T_A = 45°C

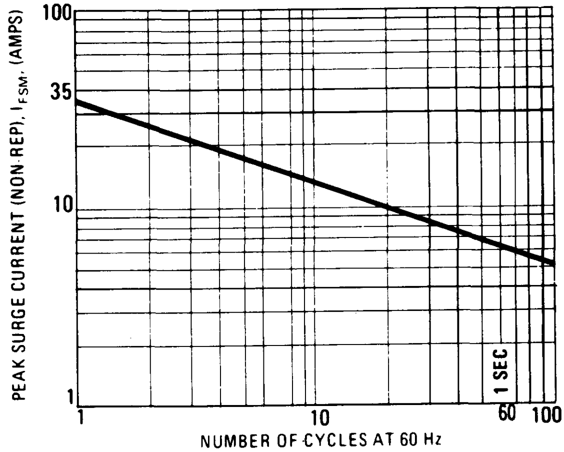


FIGURE 2

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP (PER LEG) VS DC FORWARD CURRENT

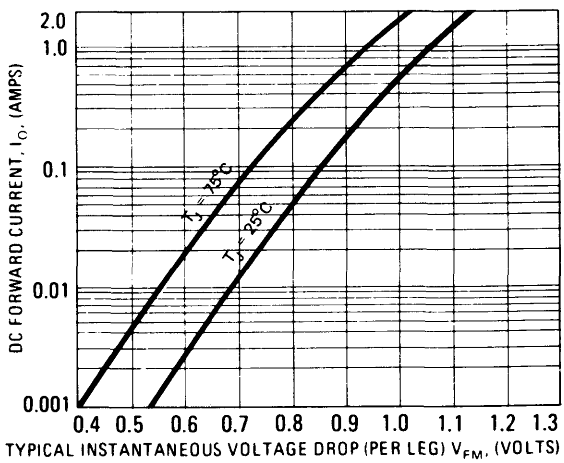


FIGURE 3

REVERSE CURRENT VS JUNCTION TEMPERATURE AT DC RATED VOLTAGE

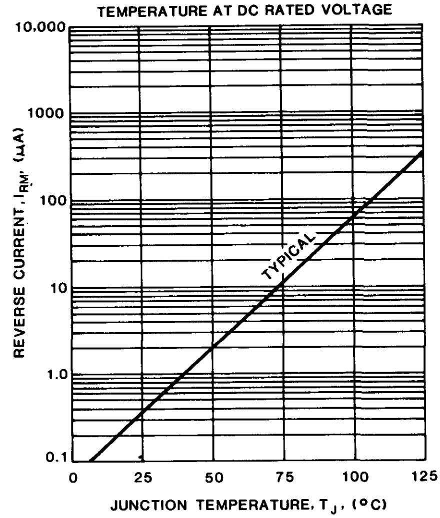


FIGURE 4

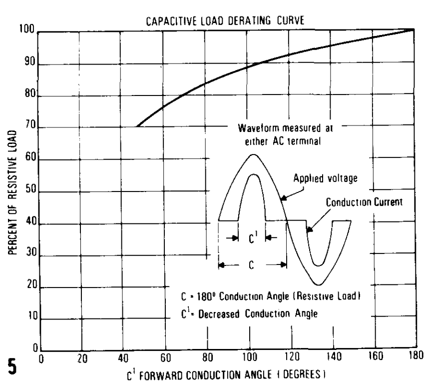
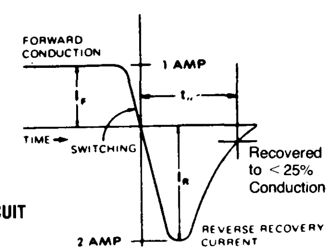


FIGURE 5



TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

FIGURE 6

FOR TYPICAL MOUNTING DETAIL, see page 18

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 040

June 1981

EBR 5 Amp Fast Recovery Time Epoxy Bridge Rectifiers

200 Nanosecond Recovery Time for 35, 70, 140, 280, and 420V RMS Operation

5 Amps DC Forward Current At T_{HS} = 60°C

65 Amps Peak One Half Cycle Surge Current

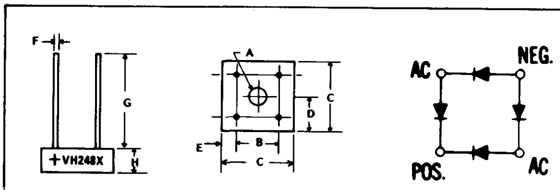
2000 V Minimum Circuit-to-Base Insulation

Glass Passivated Silicon Chips

MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	VH048X	VH148X	VH248X	VH448X	VH648X	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Peak Surge Current, ½ Cycle at 60Hz and T_{HS}=60°C (Non-Rep) (Fig. 2)	I_{FSM}	65					Amps
Peak Surge Current, 1 Sec. at 60 Hz and T_{HS}=60°C (Non-Rep) (Fig. 2)	I_{FRM}	18					Amps
Avg. Forward Current at T_{HS}=60°C (Fig. 1)	I_O	5					Amps
Junction Operating and Storage Temperature	T_J, T_{STG}	−50 to +135					°C
Maximum Soldering Temperature & Time		10 Seconds at 265°C					

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop (per diode) at I_F=5 Amps (Fig. 3)	V_{FM}	1.4	Volts/Leg
Maximum Reverse Recovery Time at I_F=1 Amp, I_R=2 Amps (Fig. 4)	t_{rr}	200	nsec
Maximum DC Reverse Current at Rated V_{RM}	I_{RM}	10	μA
Maximum DC Reverse Current at Rated V_{RM} and T_J = 125°C	I_{RM}	4	mA
Insulation Strength from Circuit to Case (min.)		2000	Volts DC

Part Nos. VH048X, VH148X, VH248X, VH448X, and VH648X have been recognized under the Component Program of Underwriters Laboratories, Inc.



"VARO" DATE CODE AND NEGATIVE POLARITY MARKING ON TOP OPPOSITE LEADS

LTR	INCHES	MILLIMETERS
A	.137–.167Dia.	3,48–4,24 Dia.
B	.411–.441	10,44–11,20
C	.590–.610	14,99–15,49
D	.295–.305	7,49–7,75
E	.087 Typ.	2,21
F	.038–.042	,97–1,07
G	1.0 Min.	25,40 Min.
H	.195–.205	4,95–5,21

DC FORWARD CURRENT VS TEMPERATURE

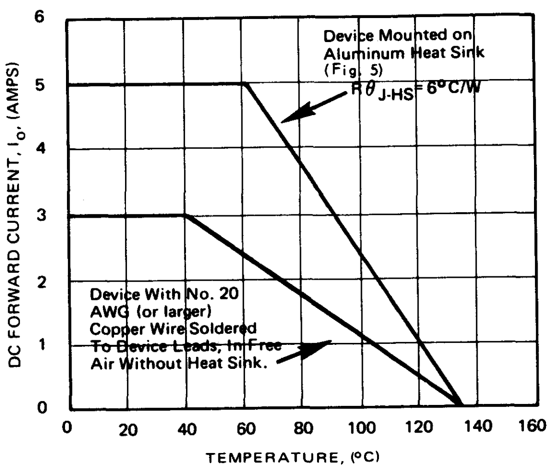


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT T_{HS} = 60°C AND SINE WAVE INPUT

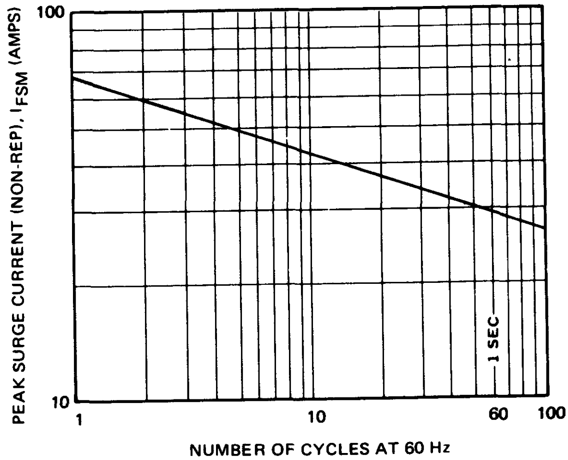


FIGURE 2

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP (PER LEG) VS DC FORWARD CURRENT

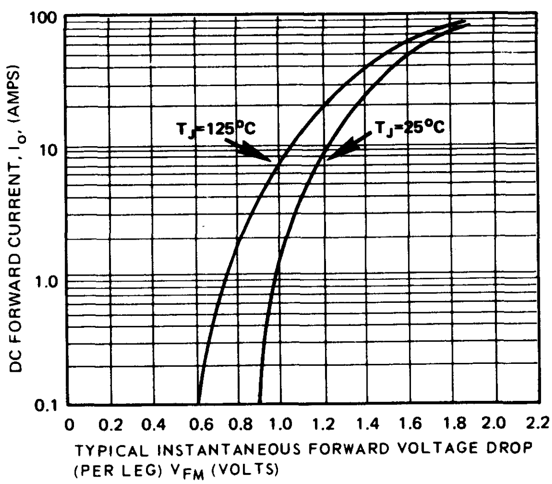
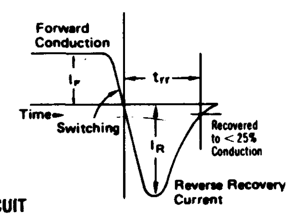


FIGURE 3

RECOVERY WAVE FORM

FIGURE 4



TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

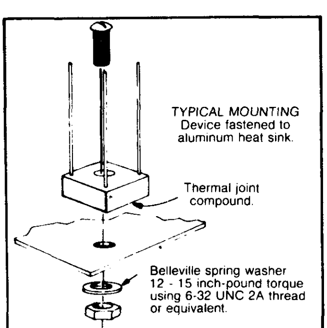


FIGURE 5

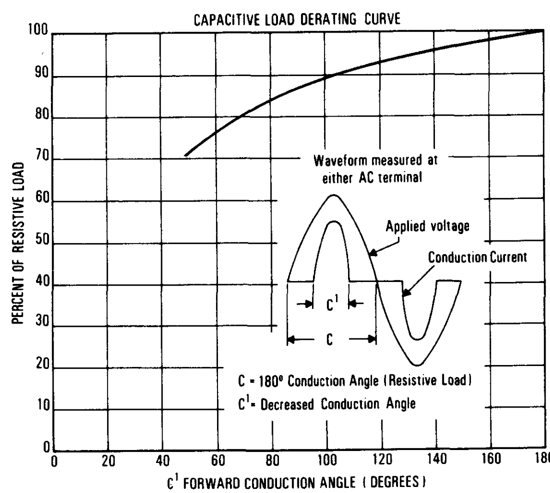


FIGURE 6

VARO

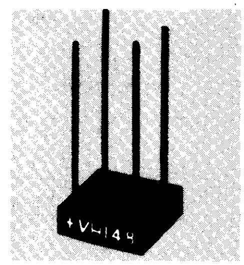
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 029

EBR 6 Amp Epoxy Bridge Rectifiers VH Series

June 1981

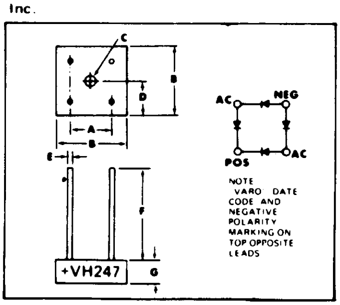
Glass Passivated Silicon Chips
Controlled Avalanche Series with 250V, 450V, 650V, and 850V Minimum Avalanche Ratings
Non-Controlled Avalanche Series with 50V, 100V, 200V, 400V, 600V, 800V, and 1000V V_{RRM} Ratings
100 Amps Peak One Half Cycle Surge Current



MAXIMUM RATINGS AT T_A=25 °C (Unless Otherwise Specified)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE							UNITS
Series Number		VH247	VH447	VH647	VH847	VH048	VH148	VH248	VH448	VH648	VH848	VH1048	
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage,	V_{RM} V_{RWM} V_{RRM}	200	400	600	800	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	560	35	70	140	280	420	560	700	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 µSEC Square Wave	P_{RM}	400				NA							Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_{HS} = 80 °C	P_R	2				NA							Watts
Fusing Data	I^2t	40											Amps² Sec.
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_{HS} = 80 °C (Fig. 2)	I_{FSM}	100											Amps
Peak Surge Current, 1 sec. at 60 Hz and T_{HS} = 80 °C (Fig. 2)	I_{FRM}	25											Amps
Avg. Forward Current at T_{HS} = 80°C (Fig. 1)	I_O	6											Amps
Junction Operating and Storage Temperature Range,	T_J, T_{STG}	50 to +150											°C
Maximum soldering temperature and time		10 Seconds at 265° C											

ELECTRICAL CHARACTERISTIC At T_A = 25 °C (Unless Otherwise Specified)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE							UNITS
Series Number		VH247	VH447	VH647	VH847	VH048	VH148	VH248	VH448	VH648	VH848	VH1048	
Minimum Avalanche Voltage,	$V_{(BR)}$	250	450	650	850	NA							Volts
Maximum Avalanche Voltage,	$V_{(BR)}$	700	900	1100	1300	NA							Volts
Maximum Instantaneous Forward Voltage Drop (per diode) at 6 Amps (Fig. 3)	V_{FM}	1.3											Volts/ Leg
Maximum Reverse Current at Rated V_{RM}	I_{RM}	5											µA
Maximum Reverse Current at Rated V_{RM} at T_J = 125°C	I_{RM}	1.0											MA
Insulation Strength From Circuit to Case (min.)		2000											Volts DC

Part Nos. VH247, VH447, VH647, VH847, VH048, VH148, VH248, VH448, VH648, and VH848 have been recognized under the Component Program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.411 - .441	10.44 - 11.20
B	.590 - .610	14.99 - 15.49
C	.137 - .167 Dia.	3.48 - 4.24 Dia.
D	.295 - .305	7.49 - 7.75
E	.037 - .043 Dia.	.94 - 1.09 Dia.
F	1.0 Min.	25.4 Min.
G	.195 - .205	4.95 - 5.21

DC FORWARD CURRENT VS TEMPERATURE

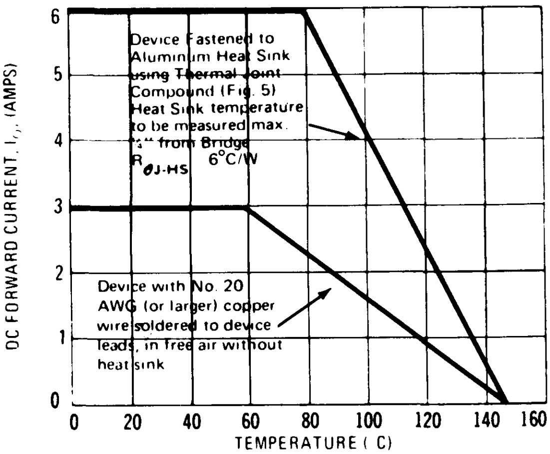


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT 60 Hz

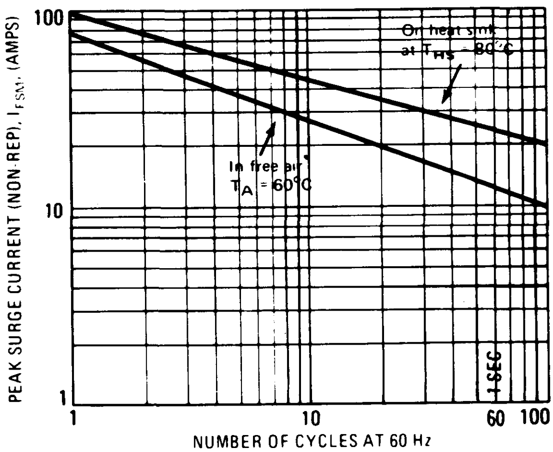


FIGURE 2

REVERSE CURRENT VS JUNCTION TEMPERATURE AT DC BLOCKING VOLTAGE

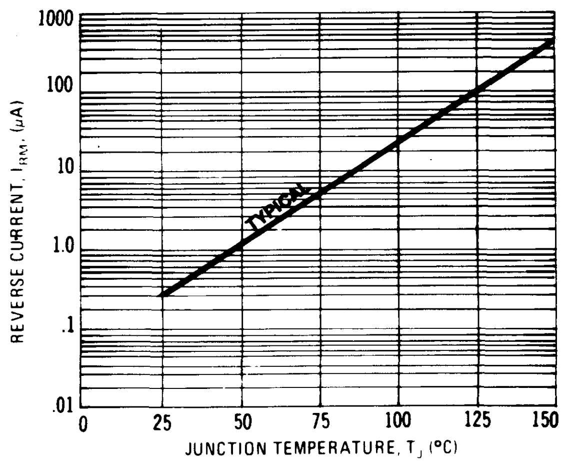


FIGURE 4

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP (PER LEG) VS DC FORWARD

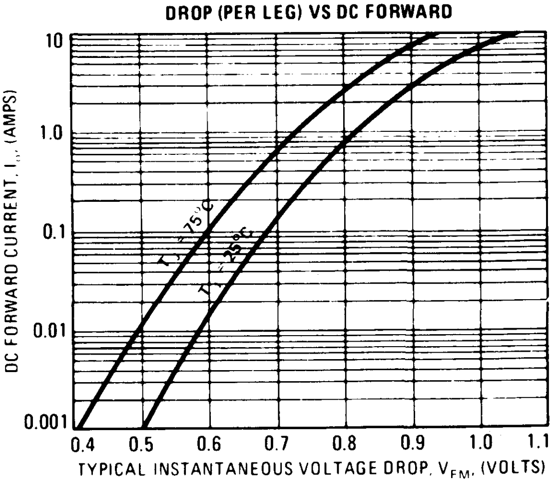


FIGURE 3

FIGURE 5

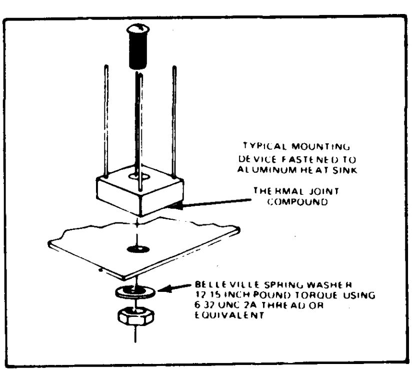
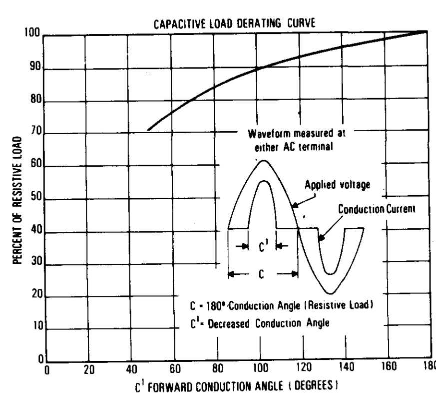


FIGURE 6



VARO

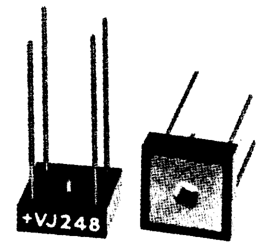
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 042

EBR 10 Amp Epoxy Bridge Rectifiers

June 1981

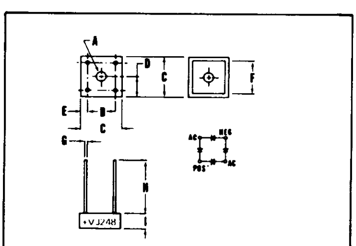
10 Amps DC Forward Current at T_C = 80° C
100 Amps Peak One Half Cycle Surge Current
2000 Volts Minimum Circuit-to-Case Insulation
Glass Passivated Silicon Chips.



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE							UNITS
Series Number		VJ247	VJ447	VJ647	VJ847	VJ048	VJ148	VJ248	VJ448	VJ648	VJ848	VJ1048	
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage	V_R, V_{RWM}, V_{RRM}	200	400	600	800	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	560	35	70	140	280	420	560	700	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 μ sec Square Wave	P_{RM}	400				NA							Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_C = 80°C (Fig. 2)	P_R	2				NA							Watts
Peak Surge Current, 1/2 Cycle at 60 Hz (Non-Rep.) and T_C = 80°C (Fig. 2)	I_{FSM}	100											Amps
Fusing Data	I^2t	40											Amp² -Sec
Peak Surge Current, 1 sec at 60 Hz and T_C = 80°C (Fig. 2)	I_{FRM}	30											Amps
Avg. Forward Current at T_C = 80°C (Fig. 1)	I_O	10											Amps
Junction Operating and Storage Temperature Range,	T_J, T_{STG}	−50 to +150											°C
Maximum Soldering Temperature & Time		10 Seconds at 265° C											

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE				NON-CONTROLLED AVALANCHE							UNITS
Series Number		VJ247	VJ447	VJ647	VJ847	VJ048	VJ148	VJ248	VJ448	VJ648	VJ848	VJ1048	
Minimum Avalanche Voltage,	$V_{(BR)}$	250	450	650	850	NA							Volts
Maximum Avalanche Voltage,	$V_{(BR)}$	700	900	1100	1300	NA							Volts
Maximum Instantaneous Forward Voltage Drop (per diode) at 10 Amps (Fig. 3)	V_{FM}	1.3											Volts/ Leg
Maximum Reverse Current at Rated V_{RM}	I_{RM}	5											μA
Maximum Reverse Current at Rated V_{RM} at T_J = 125°C	I_{RM}	2.0											mA
Insulation Strength From Circuit to Case (min.)		2000											Volts DC
Maximum Thermal Resistance, Junction to Case	$R_{\theta J-C}$	3											°C/W

Devices listed herein have been recognized under the component program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.137-.167 Dia.	3.48-4.24 Dia.
B	.411-.441	10.44-11.20
C	.590-.610	14.99-15.49
D	.295-.305	7.49-7.75
E	.087	2.21
F	.490-.510	12.45-12.95
G	.038-.042	.970-1.07
H	1.0 Min.	25.40 Min.
I	.195-.205	4.95-5.21

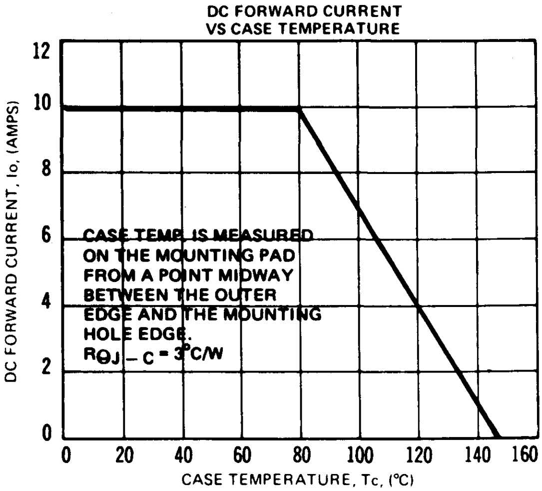


FIGURE 1

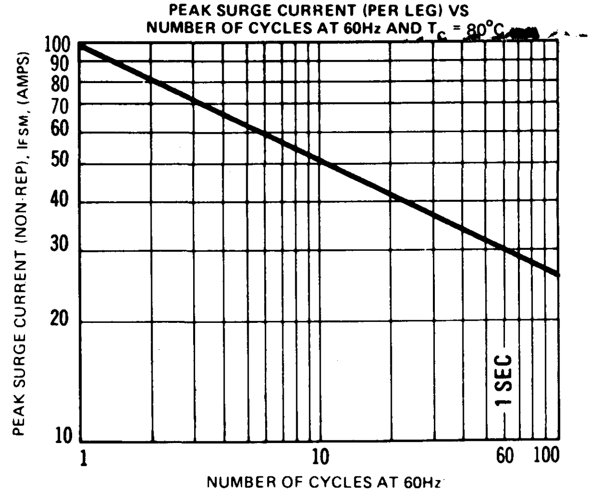


FIGURE 2

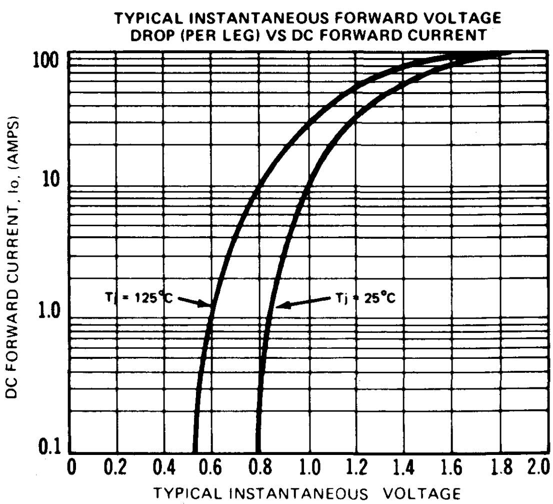


FIGURE 3

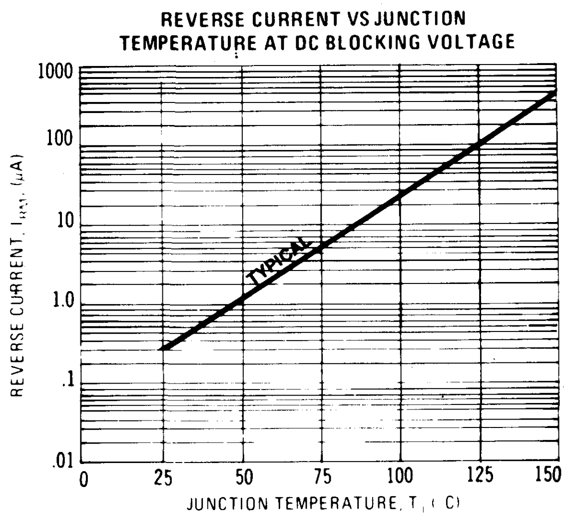


FIGURE 4

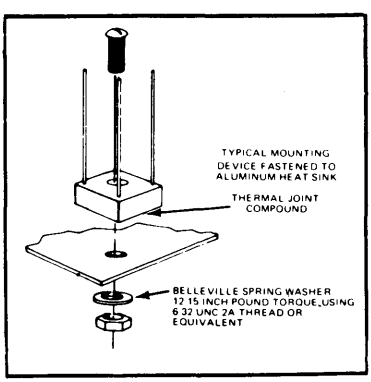


FIGURE 5

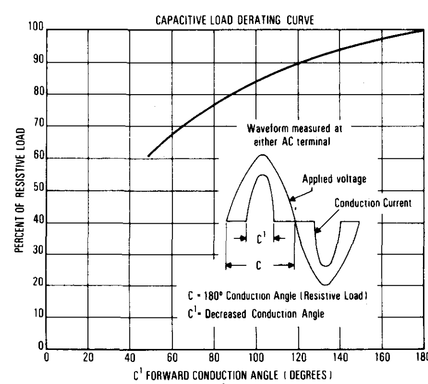


FIGURE 6

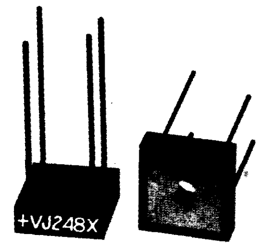
VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 046
June 1981

EBR 10 Amp Fast Recovery Time Epoxy Bridge Rectifiers

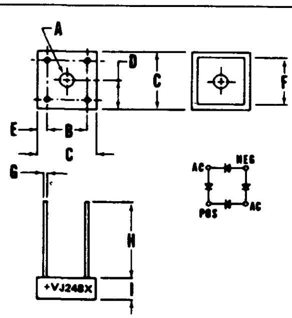
200 Nanosecond Reverse Recovery Time
10 Amps DC Forward Current at $T_C = 60°$ C
75 Amps Peak One Half Cycle Surge Current
2000Volts Minimum Circuit-to-Case Insulation
Glass Passivated Silicon Chips



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	VJ048X	VJ148X	VJ248X	VJ448X	VJ648X	UNITS
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage,	V_R V_{RWM} V_{RRM}	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_C=60°C (Fig. 2)	I_{FSM}	75					Amps
Peak Surge Current, 1 sec at 60 Hz and T_C=60°C (Fig. 2)	I_{FRM}	27					Amps
Avg. Forward Current at T_C = 60°C (Fig. 1)	I_O	10					Amps
Junction Operating and Storage Temperature Range,	T_J, T_{STG}	−50 to +135					°C
Maximum Soldering Temperature & Time		10 Seconds at 265° C					

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop (per diode) at 10 Amps (Fig. 3)	V_{FM}	1.5	Volts/ Leg
Maximum Reverse Recoverv Time, I_F = 1 Amp, I_R = 2 Amp (Fig. 6)	t_{rr}	200	nsec
Maximum Reverse Current At Rated V_{RM}	I_{RM}	10	µA
Maximum Reverse Current at Rated V_{RM} at T_J = 125°C	I_{RM}	4	mA
Insulation Strength From Circuit to Case (min.)		2000	Volts DC

Part Nos. VJ048X, VJ148X, VJ248X, VJ448X and VJ648X have been recognized under the component program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.137-.167 Dia.	3.48-4.24 Dia.
B	.411-.441	10.44-11.20
C	.590-.610	14.99-15.49
D	.295-.305	7.49-7.75
E	.087	2.21
F	.490-.510	12.45-12.95
G	.038-.042	.970-1.07
H	1.0 Min.	25.40 Min.
I	.195-.205	4.95-5.21

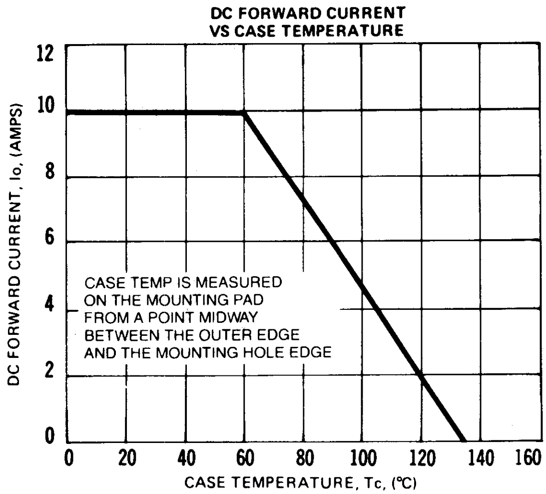


FIGURE 1

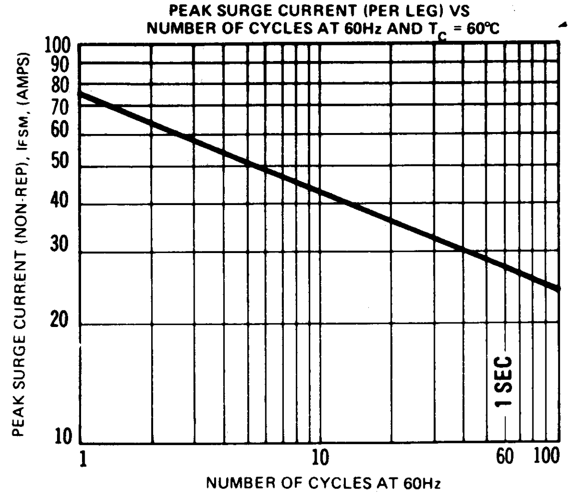


FIGURE 2

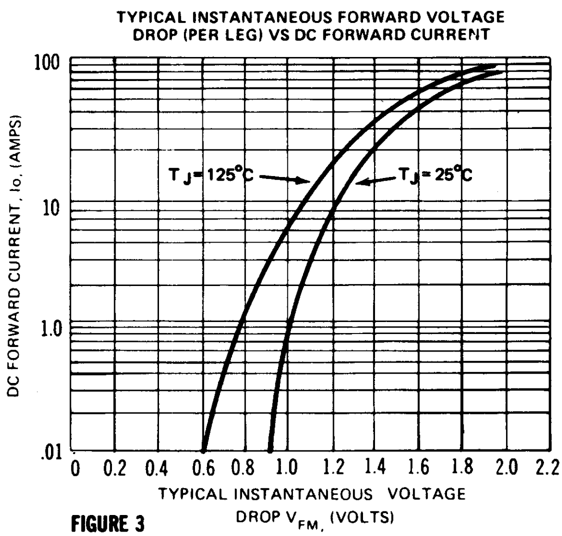


FIGURE 3

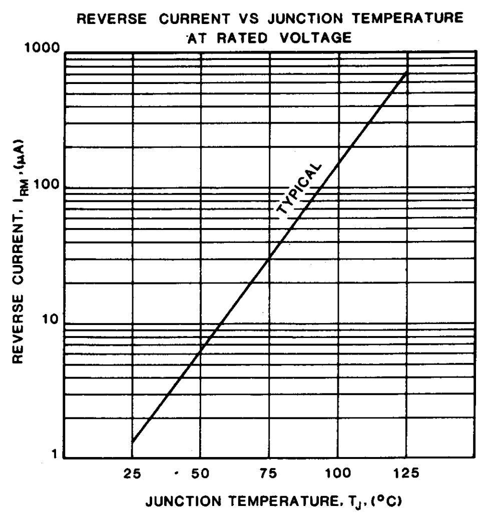


FIGURE 4

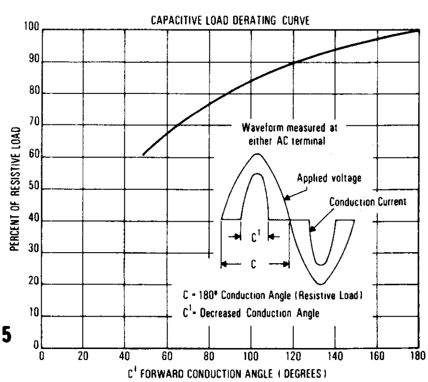


FIGURE 5

TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

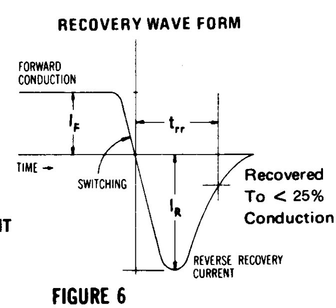


FIGURE 6

FOR TYPICAL MOUNTING DETAIL, see page 26

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 054

EBR 15 Amp Epoxy Bridge Rectifiers VL Series

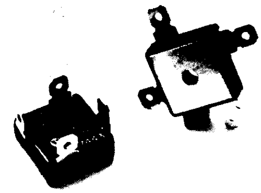
June 1981

15 Amps DC Forward Current at $T_C = 80°C$

100 Amps Peak One Half Cycle Surge Current

Externally Exposed Copper Mounting Pad for Low Thermal Resistance

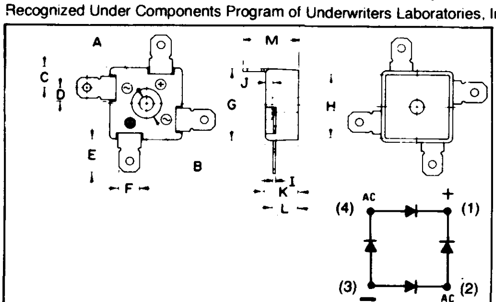
2200 Volts Minimum Circuit-to-Case Insulation



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	**SYMBOL**	**CONTROLLED AVALANCHE**			**NON-CONTROLLED AVALANCHE**							**UNITS**
Series Number		VL247	VL447	VL647	VL048	VL148	VL248	VL448	VL648	VL848	VL1048	
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage	V_R V_{RWM} V_{RRM}	200	400	600	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	35	70	140	280	420	560	700	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 µsec Square Wave	P_{RM}	600			NA							Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_C = 40°C	P_R	4			NA							Watts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_C = 80°C (Fig. 2)	I_{FSM}	100										Amps
Peak Surge Current, 1 sec at 60 Hz and T_C=80°C (Fig. 2)	I_{FRM}	30										Amps
Avg. Forward Current at T_C=80°C (Fig. 1)	I_O	15										Amps
Avg. Forward Current at T_A = 40°C (No Heat Sink)	I_O	5										Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−50 to +150										°C
Fusing Data	I^2t	40										Amp² Sec

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	**SYMBOL**	**CONTROLLED AVALANCHE**			**NON-CONTROLLED AVALANCHE**							**UNITS**
Series Number		VL247	VL447	VL647	VL048	VL148	VL248	VL448	VL648	VL848	VL1048	
Minimum Avalanche Voltage,	$V_{(BR)}$	250	450	650	NA							Volts
Maximum Avalanche Voltage	$V_{(BR)}$	700	900	1100	NA							Volts
Maximum Instantaneous Forward Voltage Drop (per diode) at 15 Amps (Fig. 3)	V_{FM}	1.4										Volts/ Leg
Maximum Reverse Current at Rated V_{RM} at T_J = 40°C, (Fig. 4)	I_{RM}	5										µA
Maximum Reverse Current at Rated V_{RM} at T_J = 175°C, (Fig. 4)	I_{RM}	.5										mA
Insulation Strength From Circuit to Case (min.)		2200										Volts DC
Maximum Thermal Resistance, Junction to Case	$R_{\theta J\text{-}C}$	1.5										°C/W

Recognized Under Components Program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.162–.168 Dia.	4,11–4,27 Dia.
B	.345–.355 Dia.	8,76–9,02 Dia.
C	.23–.27 Typ.	5,84–6,86 Typ.
D	.138–.158 Typ.	3,51–4,01 Typ.
E	.38–.42 Typ.	9,65–10,67 Typ.
F	.245–.255 Typ.	6,22–6,48 Typ.
G	.85–.89 Square	21,59–22,61 Square
H	.76–.78 Square	19,30–19,81 Square
I	.030–.034 Typ.	,76–,86 Typ.
J	.09–.11	2,29–2,79
K	.38–.42	9,65–10,67
L	.29–.30	7,37–7,62
M	.75 Max.	19,05 Max.

Overall package height with leads formed up at 90° angles from the mounting plan is .75" — 19.05mm maximum.

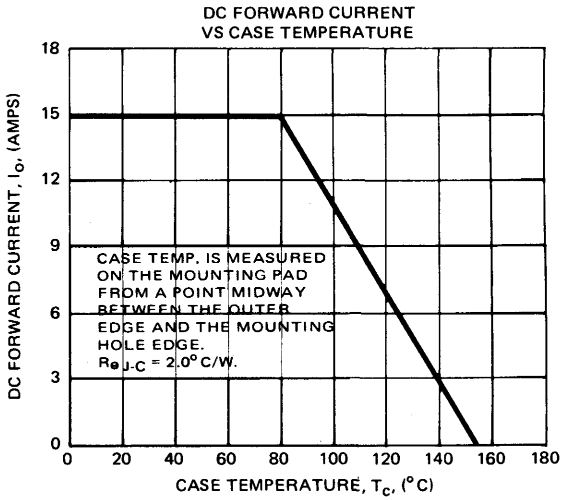


FIGURE 1

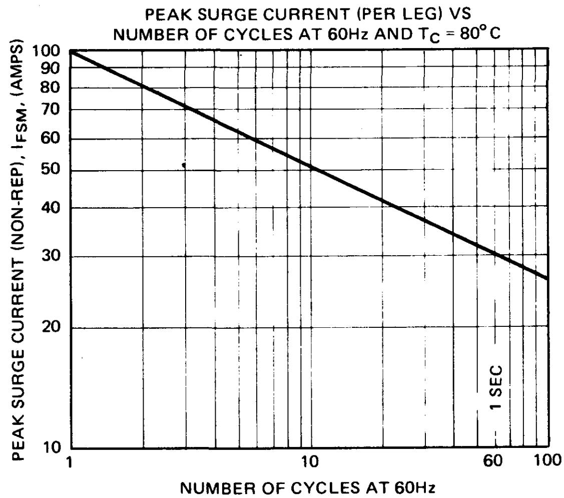


FIGURE 2

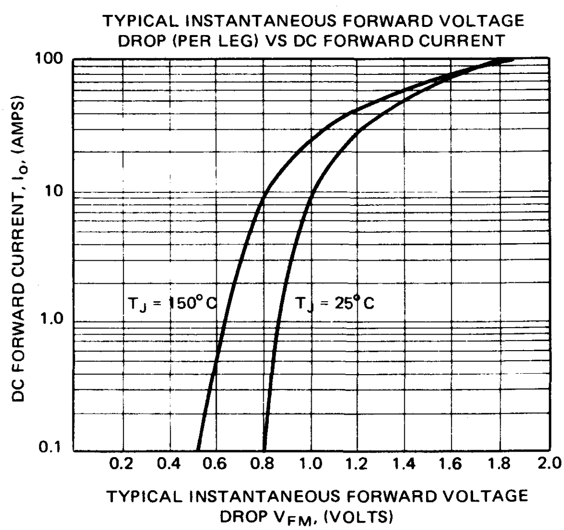


FIGURE 3

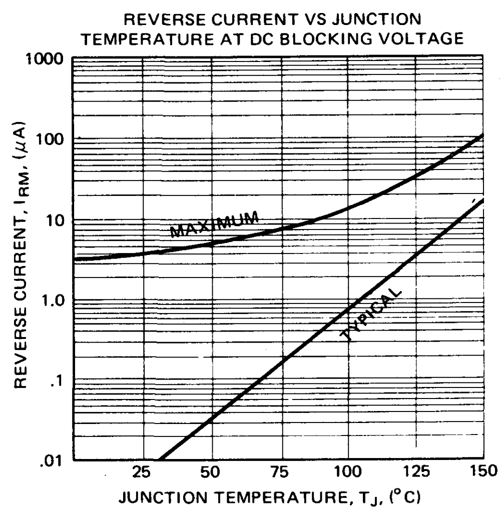


FIGURE 4

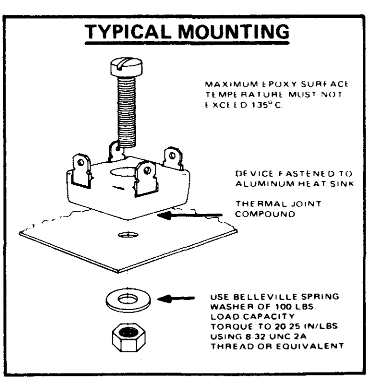
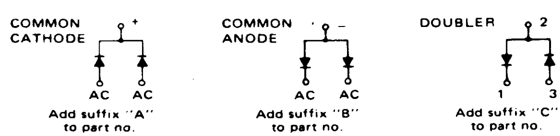


FIGURE 5

NOTES:

1. Standard parts have terminals bent up at 90° angle from mounting plane. To order terminals parallel to mounting plane (see front page photo), change the second digit of the part number from "4" to "3". Example: Change VL247 to VL237.
2. Also available with center-tap common cathode, common anode and doubler circuits as shown below.



VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 055

EBR 30 Amp Epoxy Bridge Rectifiers VK Series

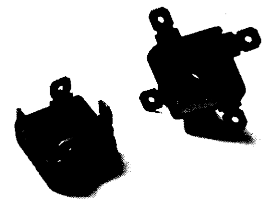
June 1981

30 Amps DC Forward Current at T_C = 80° C

300 Amps Peak One Half Cycle Surge Current

Externally Exposed Copper Mounting Pad For Low Thermal Resistance

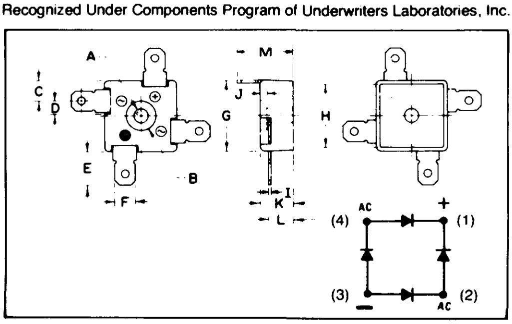
2200 Volts Minimum Circuit-to-Case Insulation



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE			NON-CONTROLLED AVALANCHE							UNITS
Series Number		VK247	VK447	VK647	VK048	VK148	VK248	VK448	VK648	VK848	VK1048	
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage	V_R V_{RWM} V_{RRM}	200	400	600	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	35	70	140	280	420	560	700	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 μ sec Square Wave	P_{RM}	1500			NA							Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_C = 40°C	P_R	4			NA							Watts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_C = 80°C (Fig. 2)	I_{FSM}	300										Amps
Peak Surge Current, 1 sec at 60 Hz and T_C=80°C (Fig. 2)	I_{FRM}	75										Amps
Avg. Forward Current at T_C=80°C (Fig. 1)	I_o	30										Amps
Avg. Forward Current at T_A=40°C (No Heat Sink)	I_o	5										Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−50 to +150										°C
Fusing Data	I^2t	375										Amp²-Sec

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL	CONTROLLED AVALANCHE			NON-CONTROLLED AVALANCHE							UNITS
Series Number		VK247	VK447	VK647	VK048	VK148	VK248	VK448	VK648	VK848	VK1048	
Minimum Avalanche Voltage,	$V_{(BR)}$	250	450	650	NA							Volts
Maximum Avalanche Voltage	$V_{(BR)}$	700	900	1100	NA							Volts
Maximum Instantaneous Forward Voltage Drop (per diode) at 30 Amps (Fig. 3)	V_{FM}	1.4										Volts/Leg
Maximum Reverse Current at Rated V_{RM} at T_J = 40°C, (Fig. 4)	I_{RM}	10										μA
Maximum Reverse Current at Rated V_{RM} at T_J = 175°C, (Fig. 4)	I_{RM}	1.0										mA
Insulation Strength From Circuit to Case (min.)		2200										Volts DC
Maximum Thermal Resistance, Junction to Case	$R_{\theta J-C}$	1.0										°C/W

Recognized Under Components Program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.162–.168 Dia.	4,11–4,27 Dia.
B	.345–.355 Dia.	8,76–9,02 Dia.
C	.23–.27 Typ.	5,84–6,86 Typ.
D	.138–.158 Typ.	3,51–4,01 Typ.
E	.38–.42 Typ.	9,65–10,67 Typ.
F	.245–.255 Typ.	6,22–6,48 Typ.
G	.85–.89 Square	21,59–22,61 Square
H	.76–.78 Square	19,30–19,81 Square
I	.030–.034 Typ.	,76–,86 Typ.
J	.09–.11	2,29–2,79
K	.38–.42	9,65–10,67
L	.29–.30	7,37–7,62
M	.75 Max.	19,05 Max.

Overall package height with leads formed up at 90° angles from the mounting plan is .75" — 19,05mm maximum.

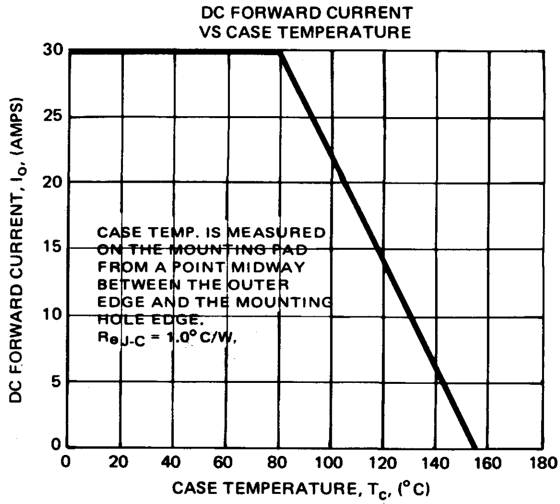


FIGURE 1

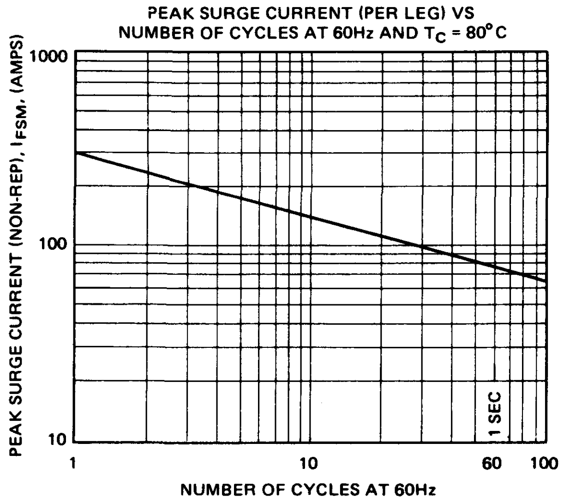


FIGURE 2

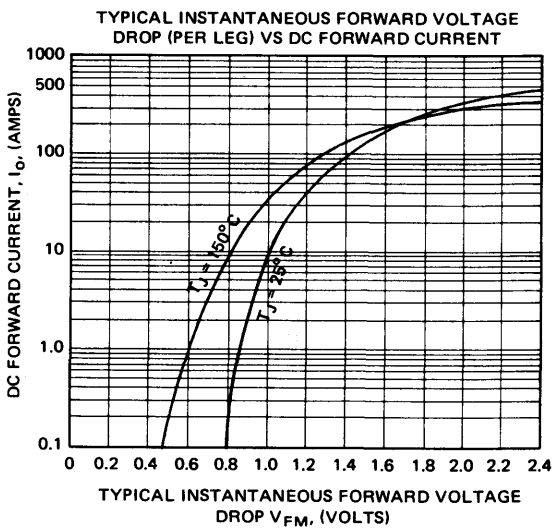


FIGURE 3

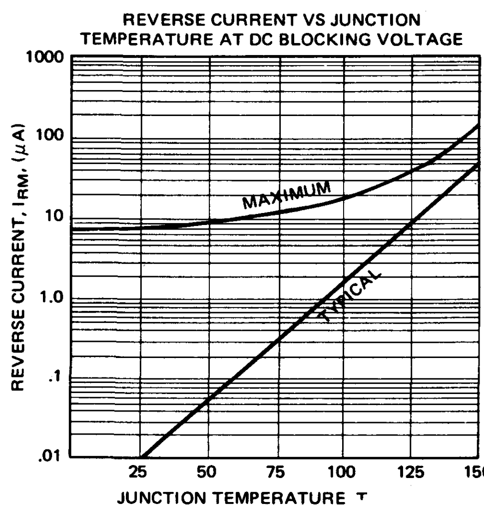


FIGURE 4

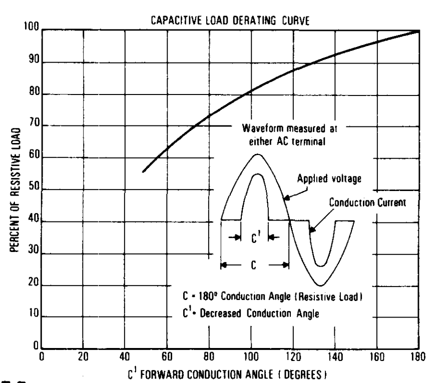
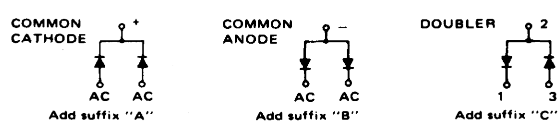


FIGURE 5

NOTES:

1. Standard parts have terminals bent up at 90° angle from mounting plane. To order terminals parallel to mounting plane (see front page photo), change the second digit of the part number from "4" to "3". Example: Change VK247 to VK237.
2. Also available with center-tap common cathode, common anode and doubler circuits as shown below.



FOR TYPICAL MOUNTING DETAIL, see page 30

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 082

EBR 30 Amp Fast Recovery Epoxy Bridge Rectifiers

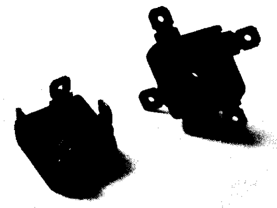
June 1981

30 Amps DC Forward Current At T_C = 60° C

150 Amps Peak One Half Cycle Surge Current

Externally Exposed Copper Mounting Pad For Low Thermal Resistance

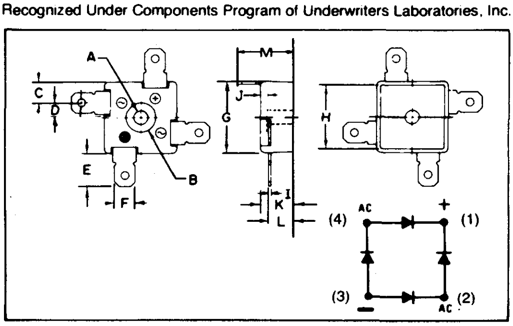
2200 Volts Minimum Circuit-to-Case Insulation



MAXIMUM RATINGS at T_A = 25°C (Unless Otherwise Specified)	SYMBOL						UNITS
Series Number		VK048X	VK148X	VK248X	VK448X	VK648X	
DC Blocking Voltage, Working Peak Reverse Voltage, Peak Repetitive Reverse Voltage	V_R V_{RWM} V_{RRM}	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_C = 60° C (Fig. 2)	I_{FSM}	150					Amps
Peak Surge Current, 1 sec at 60 Hz and T_C = 60° C (Fig. 2)	I_{FRM}	65					Amps
Avg. Forward Current at T_C = 60°C (Fig. 1)	I_O	30					Amps
Avg. Forward Current at T_A = 40°C (No Heat Sink)	I_O	4					Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−50 to +135					°C

ELECTRICAL CHARACTERISTICS at T_A = 25° C (Unless Otherwise Specified)	SYMBOL						UNITS
Series Number		VK048X	VK148X	VK248X	VK448X	VK648X	
Minimum Avalanche Voltage,	$V_{(BR)}$	NA					Volts
Maximum Avalanche Voltage	$V_{(BR)}$	NA					Volts
Maximum Instantaneous Forward Voltage Drop (per diode) at 30 Amps (Fig. 3)	V_{FM}	1.8					Volts/Leg
Maximum Reverse Current at Rated V_{RM} at T_J = 40° C, (Fig. 4)	I_{RM}	50.					μA
Maximum Reverse Current at Rated V_{RM} at T_J = 135° C, (Fig. 4)	I_{RM}	5.0					mA
Insulation Strength From Circuit to Case (min.)		2200					Volts DC
Maximum Thermal Resistance, Junction to Case	R_{θ} J-C	1.0					°C/W

Recognized Under Components Program of Underwriters Laboratories, Inc.



LTR	INCHES	MILLIMETERS
A	.162–.168 Dia.	4,11–4,27 Dia.
B	.345–.355 Dia.	8,76–9,02 Dia.
C	.23–.27 Typ.	5,84–6,86 Typ.
D	.138–.158 Typ.	3,51–4,01 Typ.
E	.38–.42 Typ.	9,65–10,67 Typ.
F	.245–.255 Typ.	6,22–6,48 Typ.
G	.85–.89 Square	21,59–22,61 Square
H	.76–.78 Square	19,30–19,81 Square
I	.030–.034 Typ.	,76–,86 Typ.
J	.09–.11	2,29–2,79
K	.38–.42	9,65–10,67
L	.29–.30	7,37–7,62
M	.75 Max.	19,05 Max.

Overall package height with leads formed up at 90° angles from the mounting plan is .75"—19,05mm maximum.

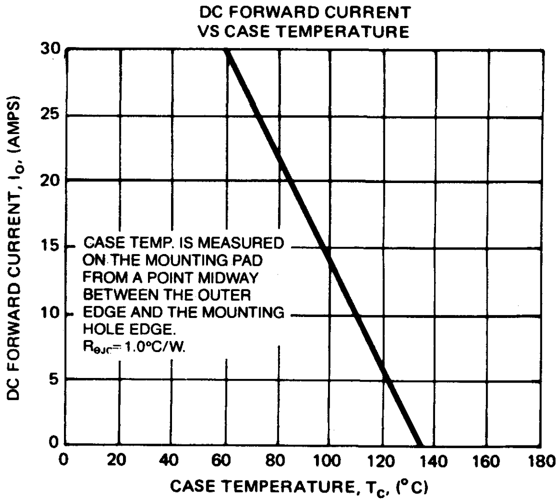


FIGURE 1

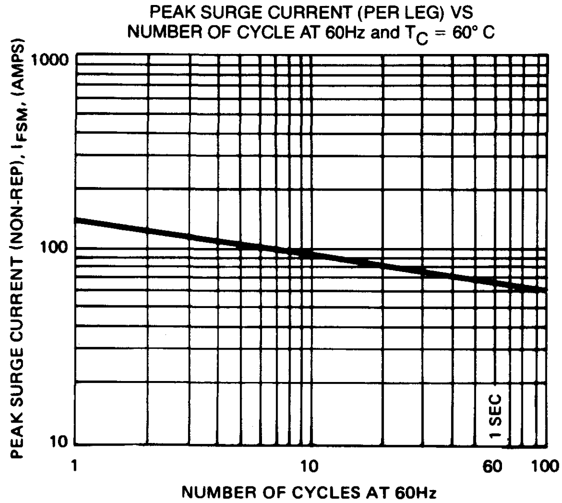


FIGURE 2

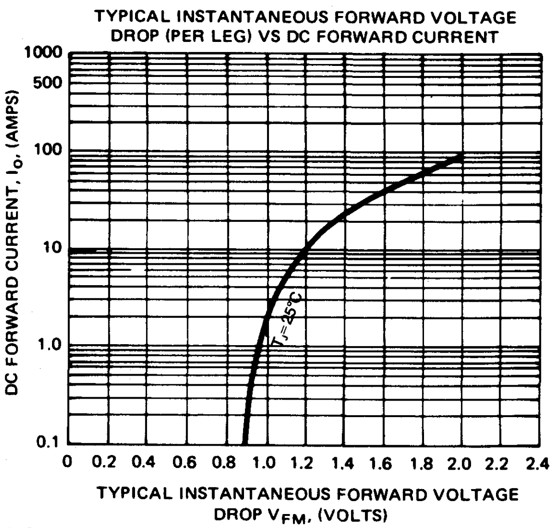


FIGURE 3

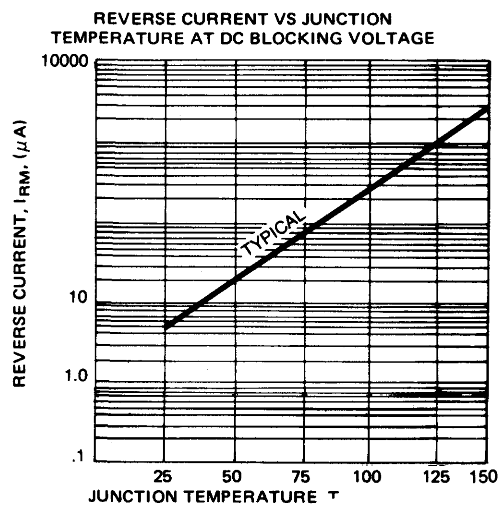


FIGURE 4

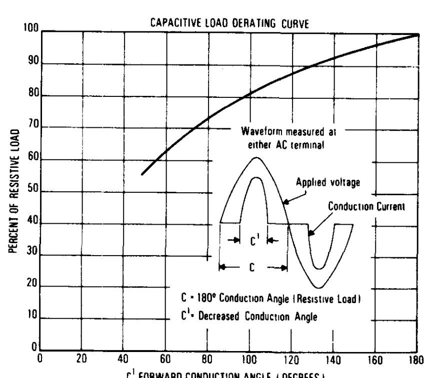
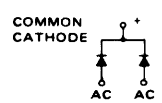


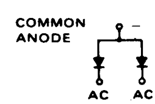
FIGURE 5

NOTES:

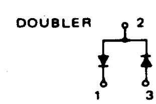
1. Standard parts have terminals bent up at 90° angle from mounting plane. To order terminals parallel to mounting plane (see front page photo), change the second digit of the part number from "4" to "3". Example: Change VK248X to VK238X.
2. Also available with center-tap common cathode, common anode and doubler circuits as shown below.



Add suffix "A" to part no.



Add suffix "B" to part no.



Add suffix "C" to part no.

FOR TYPICAL MOUNTING DETAIL, see page 30

VARO

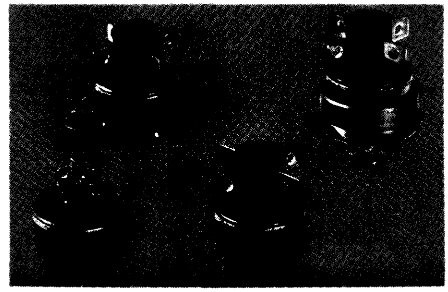
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 022

IBR® 10 Amp Silicon Avalanche Integrated Full Wave Bridge Rectifiers

June 1981

Controlled Avalanche Junctions with 250V, 450V, and 650V, Minimum Avalanche Ratings
10 Amps DC Forward Current at T_C = 100°C
100 Amps Peak One Half Cycle Surge Current
2000 Volts DC Minimum Circuit-To-Case Insulation



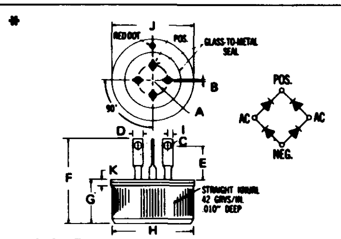
*ASTERISK DENOTES JEDEC REGISTERED INFORMATION

MAXIMUM RATINGS[1] (60Hz RESISTIVE AND INDUCTIVE LOAD)	SYMBOL	IN4436	IN4437	IN4438	UNITS
* DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	Volts
* Power Dissipation in $V_{(BR)}$ Region for 100 μsec Square Wave	P_{RM}		600		Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_C = 50°C	P_R		4		Watts/Leg
* Peak Surge Current, ½ Cycle at 60Hz, (Non-Rep) at T_C =100°C (Fig. 2)	I_{FSM}		100		Amps
Peak Surge Current, 1 sec. at 60Hz and T_C = 100°C (Fig. 2)	I_{FRM}		30		Amps
* Avg. Forward Current at T_C=100°C (Fig. 1)	I_O		10		Amps
* Junction Operating and Storage Temperature Range	T_J, T_{STG}		−65 to +160		°C

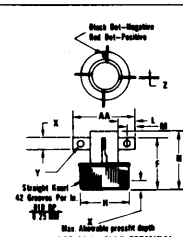
NOTE: All measurements taken at T_C = 25°C unless otherwise specified. Case Temperature, T_C, is measured on the bottom of the case within 0.125 inch of center.

ELECTRICAL CHARACTERISTICS (At T_C = 25°C unless otherwise specified)	SYMBOL	IN4436	IN4437	IN4438	UNITS
Minimum Avalanche Voltage	$V_{(BR)}$	250	450	650	Volts
Maximum Avalanche Voltage	$V_{(BR)}$	500	700	900	Volts
* Maximum Instantaneous Forward Voltage Drop at 10 Amps and T_C = 100°C (Fig. 3)	V_{FM}		1.2		Volts/Leg
Maximum Reverse Current at Rated V_{RM} and T_C=150°C	I_{RM}		0.2		mA
Maximum Thermal Resistance, Junction to Case	$R_{θJ-C}$		1.5		°C/W
Insulation Strength, Circuit to Case, Min.			2000		Volts DC

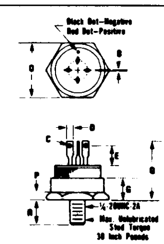
*



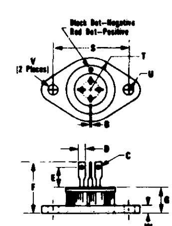
NOTE: Standard Device is Press Mount with Terminals as shown.



PRESS MOUNTING



SINGLE STUD



TO-3 OUTLINE MOUNTING FLANGE

LTR	INCHES	MILLIMETERS	LTR	INCHES	MILLIMETERS	LTR	INCHES	MILLIMETERS	LTR	INCHES	MILLIMETERS
A	*.130R	3,30	H	*.7505—.7545	19,06-19,16	O	.875	22,23	V	.151-.161 Dia.	3,83-4,08
B	*.018-.028 Typ.	0.46-0,71	I	*.060	1,52	P	.120	3,05	W	.135 Max.	3,42
C	*.070 Dia. Typ.	1,78	J	*.751-.756	19,06-19,20	Q	1.10	27,94	X	.187	4,75
D	*110-.130 Typ.	2,79-3,30	K	*.100 Max.	2,54	R	.34-.40	8,64-10,16	Y	.110 Dia.	2,79
E	*.290-.330	7,37-8,38	L	.25 Min.	6,35	S	1.177-1.197	29,89-30,40	Z	.032 Typ.	0,81
F	*.825 Max.	20,95	M	.125 Typ.	3,18	T	.525R Max.	13,33	AA	1.0 Max.	25,4
G	*.390-420	9,90-10,67	N	.930 Max.	23.62	U	.188R Max.	4,77			

The IN4436, IN4437, and IN4438, Integrated Bridge Rectifiers with SAR®(silicon avalanche rectifier) characteristics, offer single-phase, full-wave rectification in rigidly constructed, hermetically sealed, welded packages. The electrically isolated grooved packages offer minimum size and maximum ease in mounting.

SAR characteristics insure that the avalanche voltage occurs below the point where, in conventional rectifiers, the junction perimeter is degraded or destroyed under transient overvoltage conditions. SAR characteristics control the avalanche voltage of the internal junction so that avalanche occurs across the entire junction area. This eliminates the need to buy more expensive, overrated devices to provide adequate protection against voltage transients.

Proper heat sinking of the IN4436, IN4437, and IN4438, allows great flexibillity in DC output current range. This feature coupled with the electrically isolated case (insulation strength of 2000 volts minimum) allows the IBR to be used in many applications under conditions of reduced space, current, and cost than were previously possible.

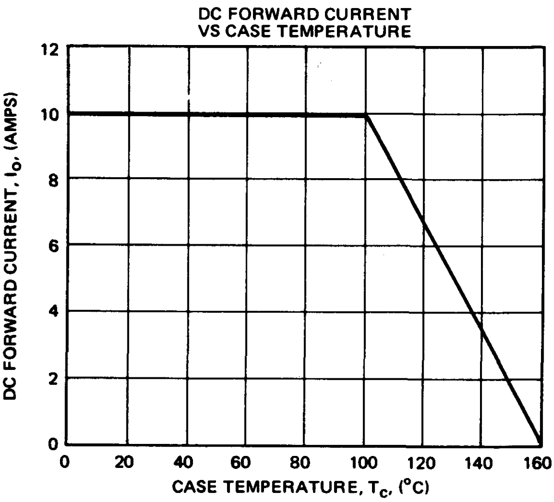


FIGURE 1

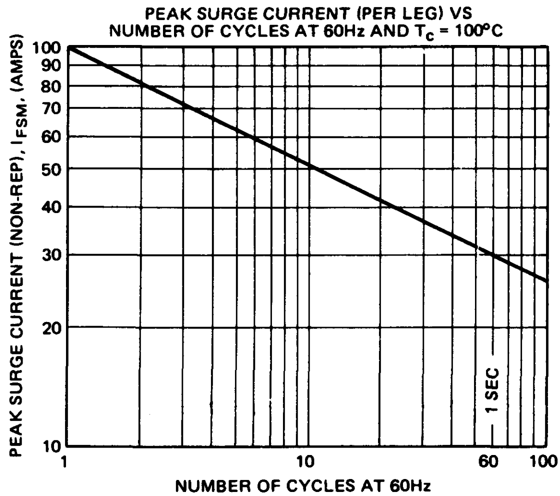


FIGURE 2

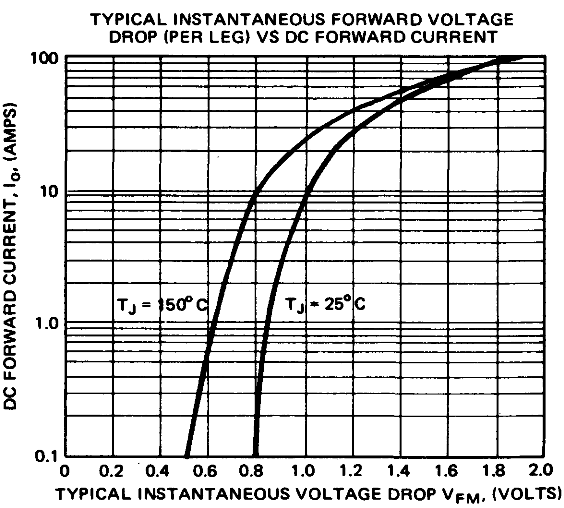


FIGURE 3

NOTE: Devices available with optional flag terminals (.187" —4,75mm) at no extra cost.

To order Flag Terminals, add suffix "F" to part no.
To order TO-3 Mount, add suffix "T" to part no.
To order Single Stud Mount, add suffix "S" to part no.

VARO

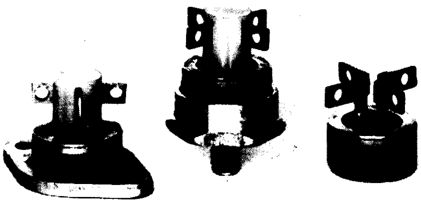
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 025

IBR® 25 Amp Silicon Avalanche Integrated Rectifiers — VT Series

June 1981

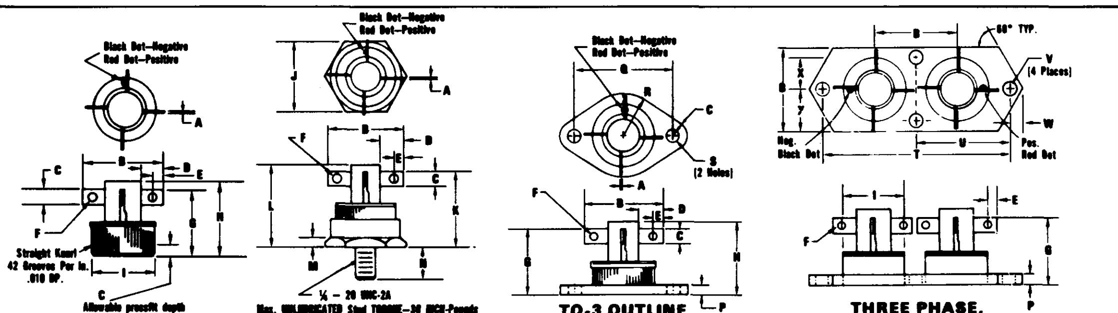
140V, 280V, and 420V RMS Operation
250V, 450V, and 650V Minimum Avalanche Voltages
25 Amp DC Output Current at $T_C = 100°C$
250 Amp One/Cycle Surge Current
2000V Min. Circuit-To-Case Insulation



MAXIMUM RATINGS(1) (60 Hz Resistive and Inductive Load)	SYMBOL	200V	400V	600V	UNIT	CIRCUIT(2)
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	200	400	600	Volt	ALL
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	Volt	ALL
Avg. Forward Current at $T_C = 100°C$ (Fig. 2)	Io	(Circuit Output) 25			Amp	ALL
Peak Surge Current, ½ Cycle @ 60 Hz (Non-Rep) at $T_C = 100°C$ (Fig. 3)	I_{FSM}	250			Amp/ Leg	ALL
Peak Surge Current, 1 sec at 60 Hz and $T_C = 100°C$ (Non-Rep)	$I_{F(RMS)}$	53			Amp/ Leg	ALL
Power Dissipation in $V_{(BR)}$ Region for 100 µsec., Square Wave (Fig. 4)	P_{RM}	1500			Watt	ALL
Continuous Power Dissipation in $V_{(BR)}$ Region at $T_C = 50°C$	P_R	4			Watt/ Leg	ALL
Junction Operating and Storage Temp. Range	T_J, T_{stg}	−65 to +150			°C	ALL

ELECTRICAL CHARACTERISTICS (At $T_C = 25°C$ unless otherwise specified)	SYMBOL	200V	400V	600V	UNIT	CIRCUIT(2)
Minimum Avalanche Voltage	$V_{(BR)}$	250	450	650	Volt	ALL
Maximum Avalanche Voltage	$V_{(BR)}$	700	900	1100	Volt	ALL
Max. Instantaneous Forward Voltage Drop at 25 Amps	V_{FM}	1.5			Volt/ Leg	ALL
Max. Reverse Current at Rated V_{RWM} and $T_C = 150°C$	I_{RM}	5			mA/ Leg	ALL
Max. Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	1(3)			°C/W	VT VTH
Insulation Strength, Circuit-to-Case		2000 (Min.)			VDC	ALL

Notes:
1. Case Temperature (Tc) is measured on bottom of case within 0.125" (3.18mm) of center of case.
2. See Reverse Side for Part Number and Circuit Selection Guide.
3. For Full Wave Bridge, Single-and Three-Phase.



PRESS MOUNTING — SINGLE STUD — TO-3 OUTLINE MOUNTING FLANGE — THREE PHASE, FULL WAVE BRIDGE

Ltr	Inches	Millimeters	Ltr	Inches	Millimeters	Ltr	Inches	Millimeters	Ltr	Inches	Millimeters
A	.032 Typ.	,81	G	.830 Max	21.08	M	.120	3,05	T	2.250	57,15
B	1.0 Max.	25,4	H	.930 Max.	23,62	N	.34-40	8,64-10,16	U	1.125	28,58
C	.187 Typ.	4,75	I	.7505-.7545	19,06-19,16	P	.135 Max.	3,43	V	.156 Dia.	3,96
D	.25 Min.	6,35	J	.875	22,23	Q	1.177-1.197	29,90-30,40	W	.164	4,17
E	.125 Typ.	3,18	K	1.10 Max.	27,94	R	.525R Max.	13,34	X	.375	9,53
F	.110 Dia.	2,79	L	1.20 Max.	30,48	S	.151-.161 Dia.	3,84-4,09	Y	.50	12,70

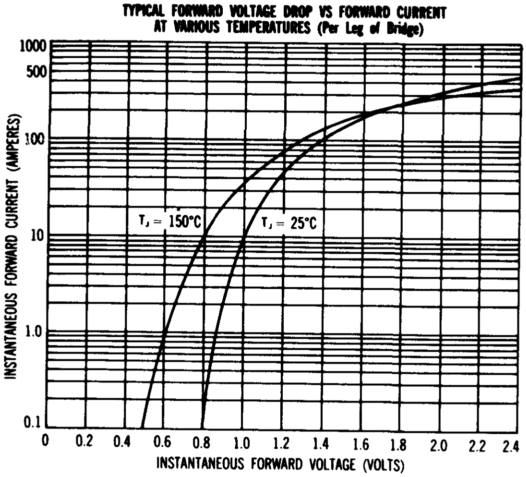


FIG. 1

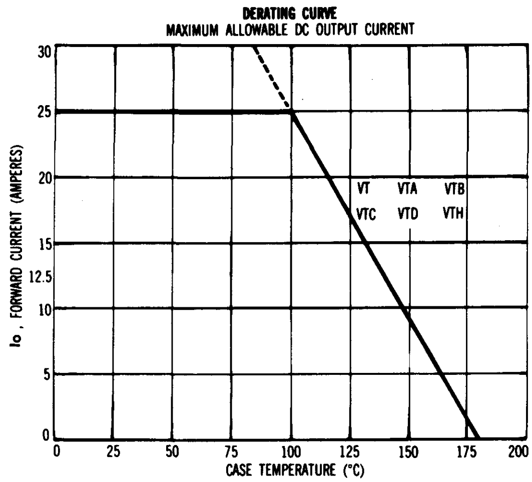


FIG. 2

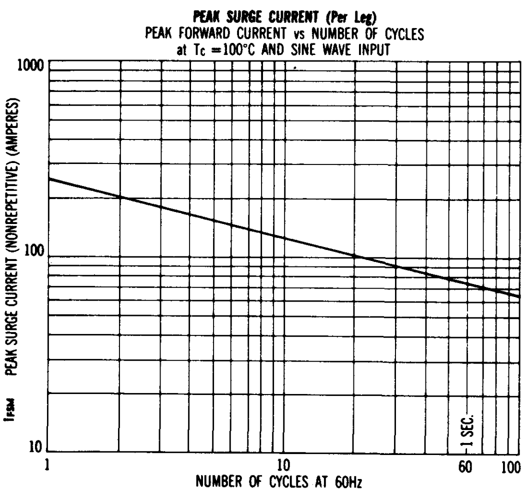


FIG. 3

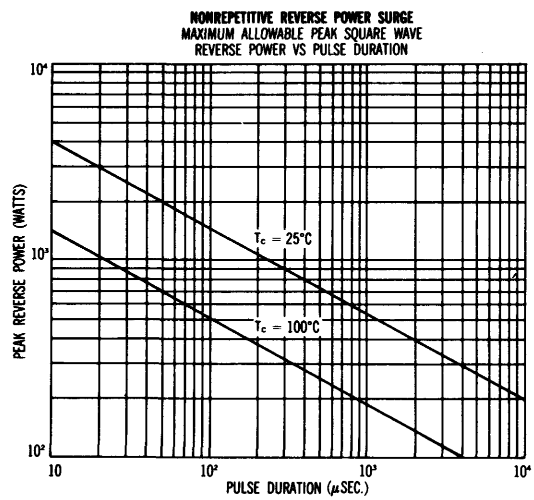


FIG. 4

PART NUMBER SELECTION CHART			
TYPE	200V	400V	600V
FULL WAVE BRIDGE	VT 200	VT 400	VT 600
CENTER TAP COMMON CATHODE	VTA200	VTA400	VTA600
CENTER TAP COMMON ANODE	VTB200	VTB400	VTB600
THREE PHASE COMMON CATHODE	VTC200	VTC400	VTC600
THREE PHASE COMMON ANODE	VTD200	VTD400	VTD600
THREE PHASE FULL WAVE BRIDGE*	VTH200	VTH400	VTH600

*Assembly of VTC and VTD (200V, 400V, or 600V) in single mounting flange. See drawing.

NOTE: Standard device has flags-only termination.
To order TO-3 Mount add /T to part no.
To order Single Stud Mount add /S to part no.

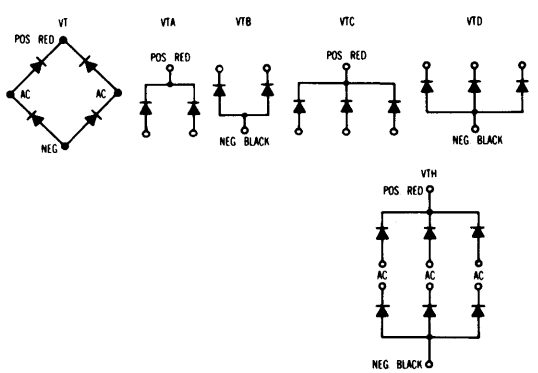


FIG. 5

VARO

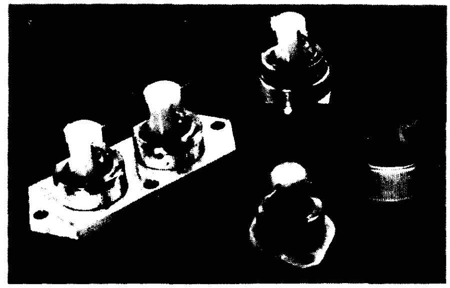
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 032

IBR 25 Amp Fast Recovery Time Integrated Rectifiers VY Series

June 1981

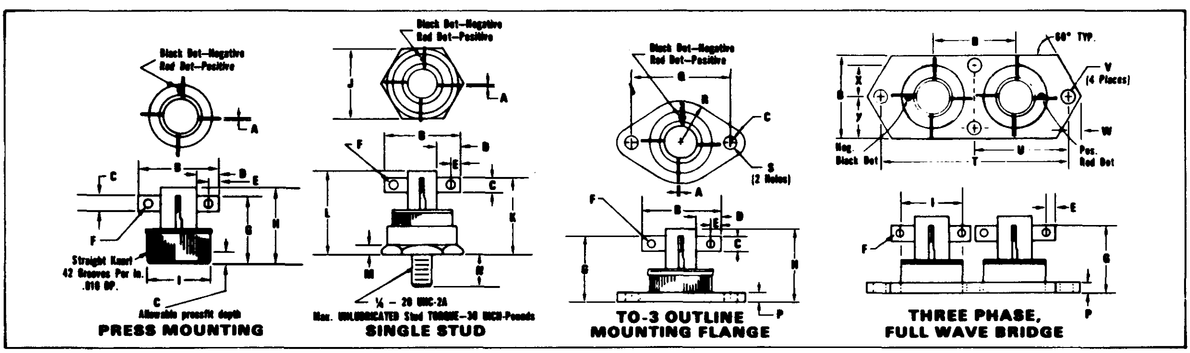
200 Nanosecond Reverse Recovery
100V, 200V, and 400V, V_{RRM} Ratings
150 Amps One Half Cycle Surge Current
2000V Minimum Circuit-To-Case Insulation



MAXIMUM RATINGS AT T_A = 25°C (unless otherwise specified)	SYMBOL	VY100X	VY200X	VY400X	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	100	200	400	Volts
Peak Reverse Voltage, ½ Cycle at $60H_z$ (non-rep)	V_{RM} (non-rep)	120	240	480	Volts
RMS Reverse Voltage	V_R (RMS)	70	140	280	Volts
Peak Surge Current, ½ Cycle at $60H_z$ (non-rep) per diode (Fig. 2)	I_{FSM}	150			Amps
Avg. Forward Current at T_C = 100°C (Fig. 1)	I_o	25			Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−65 to +150			°C

NOTE Case temperature (T_C) is measured on bottom of case within .125 inches of center.

ELECTRICAL CHARACTERISTICS AT T_A = 25°C (unless otherwise specified)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop at 25 Amps per diode (Fig. 3)	V_{FM}	1.8	Volts
Maximum Reverse Recovery Time, I_F = 1 Amp, I_R = 2 Amp (Fig. 4)	t_{rr}	200	nsec
Maximum Reverse Current at Rated V_{RM} and T_C = 150°C, per diode	I_{RM}	5	mA
Thermal Resistance, Junction to Case	$R_{\theta J\text{-}C}$	1	°C/W
Insulation Strength, Circuit to Case, Min.		2000	Volts DC



Ltr	Inches	Millimeters	Ltr	Inches	Millimeters	Ltr	Inches	Millimeters	Ltr	Inches	Millimeters
A	.032 Typ.	,81	G	.830 Max.	21,08	M	.120	3,05	T	2.250	57,15
B	1.0 Max.	25,4	H	.930 Max.	23,62	N	.34-.40	8,64-10,16	U	1.125	28,58
C	.187 Typ.	4,75	I	.7505-.7545	19,06-19,16	P	.135 Max.	3,43	V	.156 Dia.	3,96
D	.25 Min.	6,35	J	.875	22,23	Q	1.177-1.197	29,90-30,40	W	.164	4,17
E	.125 Typ.	3,18	K	1.10 Max.	27,94	R	.525R Max.	13,34	X	.375	9,53
F	.110 Dia.	2,79	L	1.20 Max.	30,48	S	.151-.161 Dia.	3,84-4,09	Y	.50	12,70

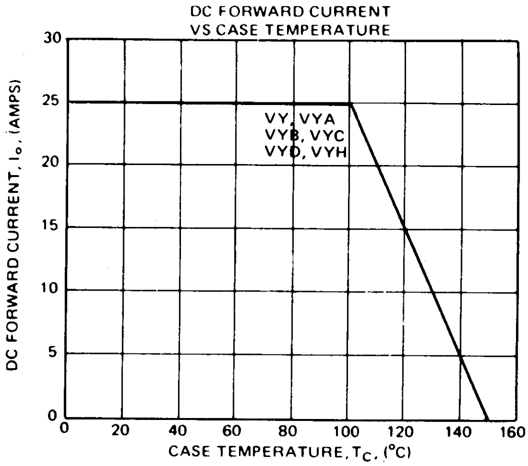


FIGURE 1

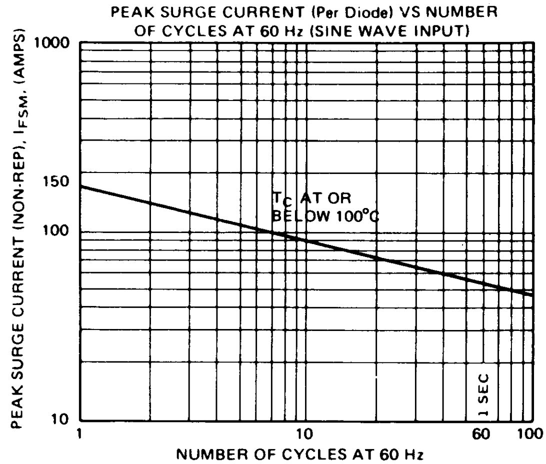


FIGURE 2

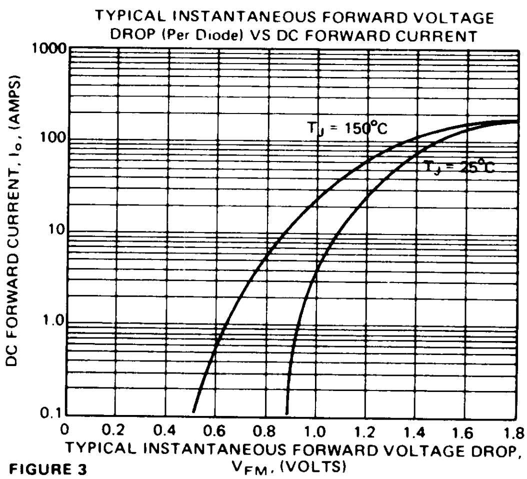
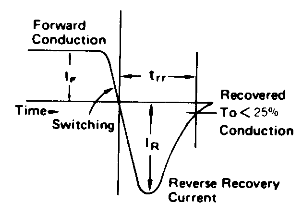


FIGURE 3

RECOVERY WAVE FORM

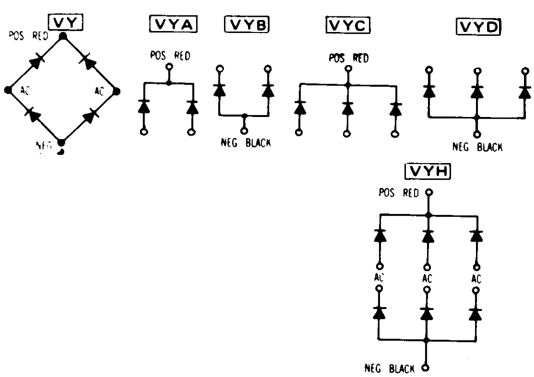


TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

FIGURE 4

ANY OF THE CIRCUITS SHOWN BELOW ARE AVAILABLE IN THE VY SERIES. SPECIFY BY ADDING LETTERS "A", "B", "C", ETC., AFTER THE "VY" IN THE PART NUMBER. SEE PART NUMBER SELECTION CHART.



CIRCUIT	100V	200V	400V
FULL WAVE BRIDGE	VY100X	VY200X	VY400X
CENTER TAP COMMON CATHODE	VYA100X	VYA200X	VYA400X
CENTER TAP COMMON ANODE	VYB100X	VYB200X	VYB400X
THREE PHASE COMMON CATHODE	VYC100X	VYC200X	VYC400X
THREE PHASE COMMON ANODE	VYD100X	VYD200X	VYD400X
* THREE PHASE FULL WAVE BRIDGE	VYH100X	VYH200X	VYH400X

*Assembly of VYC and VYD (100V, 200V, 400V) in single mounting flange. See drawing.

NOTE: Devices have standard flag terminals as shown (.187"-4.75mm).
To order TO-3 Mount add suffix "T" to part no.
To order Single Stud Mount add suffix "S" to part no.

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

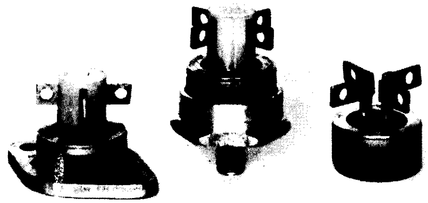
DLS 036

IBR® 36 Amp, 3 Phase Full-Wave Silicon Integrated Rectifiers

June 1981

R620 Controlled Avalanche Series with 250V, 450V, 650V and 850V Minimum Avalanche Ratings

R630 Series with 100V, 200V, 400V, 600V and 800VV_{RRM} Ratings



MAXIMUM RATINGS (At T_A = 25°C Unless Otherwise Specified)	SYMBOL	(CONTROLLED AVALANCHE)									UNITS
		R622	R624	R626	R628	R631	R632	R634	R636	R638	
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	200	400	600	800	100	200	400	600	800	Volt
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	560	70	140	280	420	560	Volt
Avg. Forward Current at T_C = 100°C	I_O	36				36					Amp
Peak Surge Current, ½ Cycle @ 60 Hz (Non-Rep) at T_C = 100°C (Fig 3)	I_{FSM}	250				250					Amp/ Leg
Peak Surge Current, 1 sec. @ 60 Hz, T_C = 100°C (Non-Rep)	$I_{F(RMS)}$	53				53					Amp/ Leg
Power Dissipation in $V_{(BR)}$ Region for 100 μsec. Square Wave	P_{RM}	1500				NA					Watt
Continuous Power Dissipation in $V_{(BR)}$ Region at T_C = 50°C	P_R	4				NA					Watt/ Leg
Junction Operating and Storage Temp. Range	T_J, T_{stg}	−65 to +150									°C

NOTE: 1. These values may be applied under three-phase, 60 Hz sine wave operation with resistive loads
2. Case Temperature (T_C) is measured on bottom of case within 0.125″ (3,18mm) of center

ELECTRICAL CHARACTERISTICS (At T_A = 25° unless otherwise specified)	SYMBOL	(CONTROLLED AVALANCHE)									UNITS
		R622	R624	R626	R628	R631	R632	R634	R636	R638	
Minimum Avalanche Voltage	$V_{(BR)}$	250	450	650	850	NA					Volt
Maximum Avalanche Voltage	$V_{(BR)}$	700	900	1100	1300	NA					Volt
Maximum Instantaneous Forward Voltage Drop per diode at 25 Amps (Fig 2)	V_{FM}	1.5				1.5					Volt/ Leg
Maximum Reverse Current at Rated V_{RWM}	I_{RM}	5 (T_C = 150°C)				5 (T_C = 150°C)					mA
Maximum Thermal Resistance, Junction-to-Case	$R\theta_{JC}$	0.75									°C/W

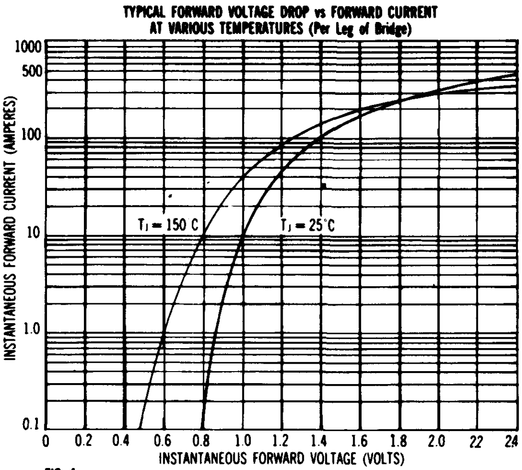


FIG. 1

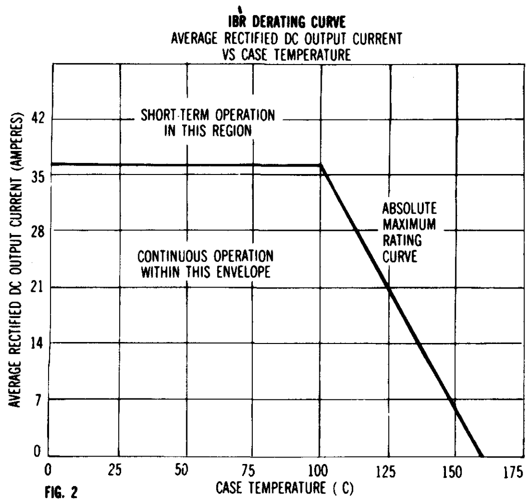


FIG. 2

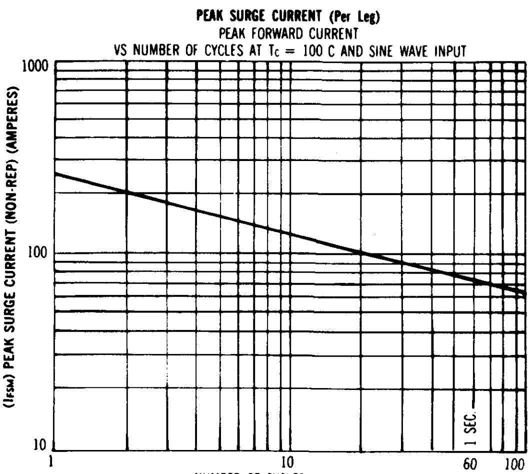
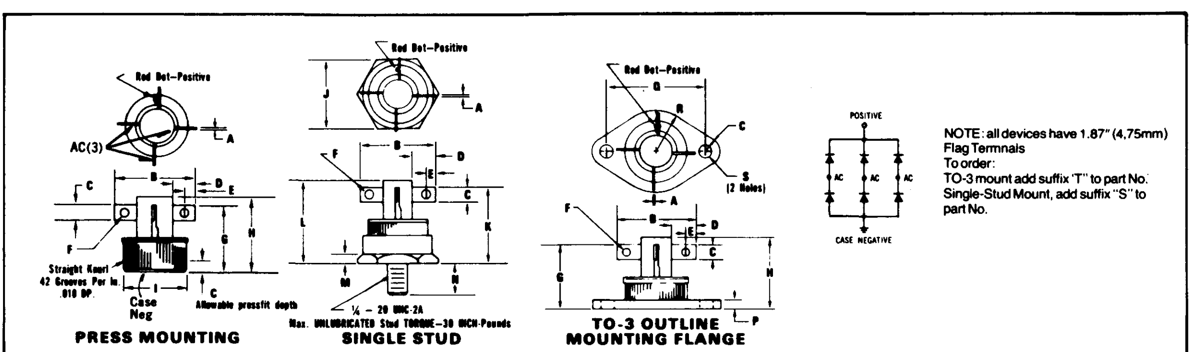


FIG. 3

Ltr	Inches	Millimeters
A	.032 Typ.	,81
B	1.0 Max.	25,4
C	.187 Typ.	4,75
D	.25 Min.	6,35
E	.125 Typ.	3,18
F	.110 Dia.	2,79
G	.830 Max.	21,08
H	.930 Max.	23,62
I	.7505-.7545	19,06-19,16
J	.875	22,23
K	1.10 Max.	27,94
L	1.20 Max.	30,48
M	.120	3,05
N	.34-.40	8,64-10,16
P	.135 Max.	3,43
Q	1.177-1.197	29,90-30,40
R	.525R Max.	13,34
S	.151-.161 Dia.	3,84-4,09



VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 048

TO 3 CASE

30 Amp Center Tapped Silicon Integrated Rectifiers

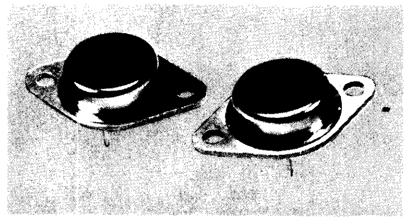
June 1981

Controlled Avalanche Types with 250V, 450V, and 650V Minimum Avalanche Ratings

Non-Controlled Avalanche Types with 100V, 200V, 400V and 600V V_{RRM} Ratings

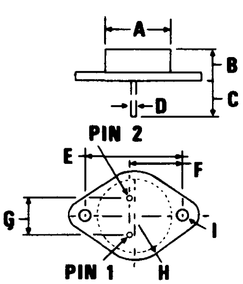
250 Amps Peak One Half Cycle Surge Current

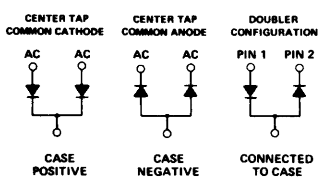
Fast Recovery Types with 200 Nanosecond Maximum t_{rr}



MAXIMUM RATINGS AT T_A=25°C (unless otherwise specified)	SYMBOL	CONTROLLED AVALANCHE			NON-CONTROLLED AVALANCHE				FAST RECOVERY TIME				UNITS
Series Number		R702	R704	R706	R711	R712	R714	R716	R711X	R712X	R714X	R716X	
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	200	400	600	100	200	400	600	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	70	140	280	420	70	140	280	420	Volts
Power Dissipation in $V_{(BR)}$ Region for 100 μsec Square Wave (Per diode)	P_{RM}	1500			NA				NA				Watts
Continuous Power Dissipation in $V_{(BR)}$ Region at T_C=100°C (Per diode)	P_R	4			NA				NA				Watts
Peak Surge Current, ½ Cycle at 60 Hz, (Non-Rep) and T_C=100°C (Per diode) (Fig. 2)	I_{FSM}				250				150				Amps
Peak Surge Current, 1 sec at 60 Hz and T_C=100°C (Per diode) (Fig. 2)	I_{FRM}				60				50				Amps
Avg. Forward Current at T_c=100°C (Per Diode)	I_O	15											Amps
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−65 to +150											°C

ELECTRICAL CHARACTERISTICS AT T_A=25°C (unless otherwise specified)	SYMBOL	CONTROLLED AVALANCHE			NON-CONTROLLED AVALANCHE				FAST RECOVERY TIME				UNITS
Series Number		R702	R704	R706	R711	R712	R714	R716	R711X	R712X	R714X	R716X	
Minimum Avalanche Voltage	V_{BR}	250	450	650	NA				NA				Volts
Maximum Avalanche Voltage	V_{BR}	700	900	1100	NA				NA				Volts
Maximum Instantaneous Forward Voltage Drop (Per diode) at 15 Amps (Fig. 3)	V_{FM}	1.2							1.4				Volts
Maximum Reverse Current at Rated V_{RM} at T_C=100°C	I_{RM}	1							5				mA
Maximum Reverse Recovery Time at I_F=1A, I_R=2A (Fig. 5)	t_{rr}	NA							200				nsec
Maximum Thermal Resistance, Junction to Case	$R_{\theta J\text{-}C}$	1.5											°C/W





NOTE: Standard device is common cathode. To order common anode, add "A" to part no. To order doubler, add "E" to part no.

All JEDEC TO-3 dimensions and notes are applicable.

LTR	INCHES	MILLIMETERS
A	.72 Dia.	18,29
B	.323-.342	8,20-8,69
C	.40 Min.	10,16
D	.038-.043 Dia.	,97-1,09
E	1.180-1.194	29,97-30,33
F	.665-.675	16,89-17,15
G	.426-.440	10,82-11,18
H	.525R Max.	13,34
I	.151-.161 Dia.	3,84-4,09

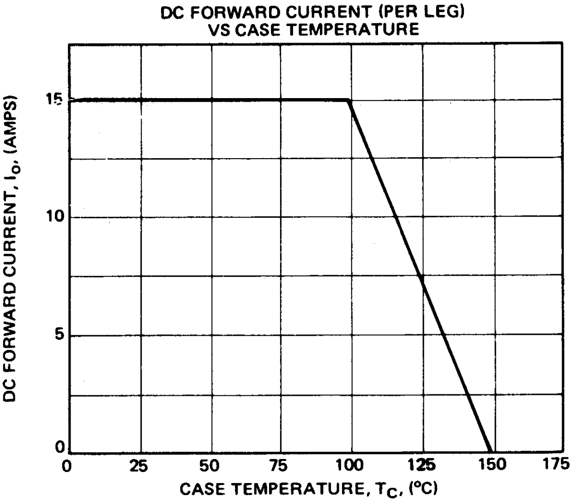


FIGURE 1

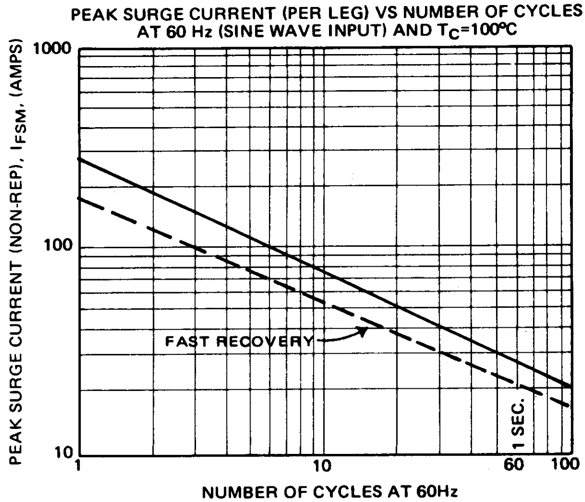


FIGURE 2

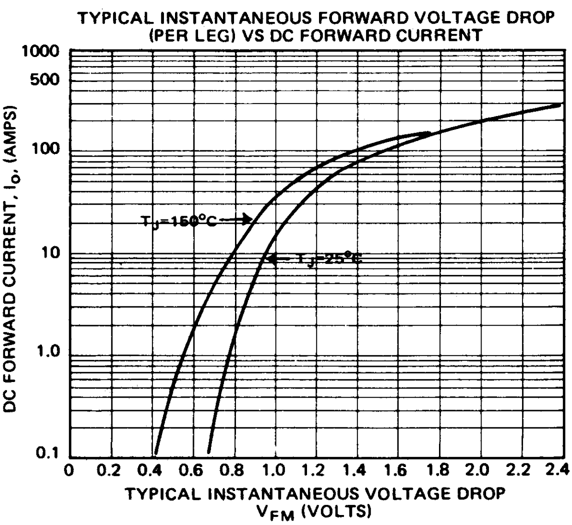


FIGURE 3

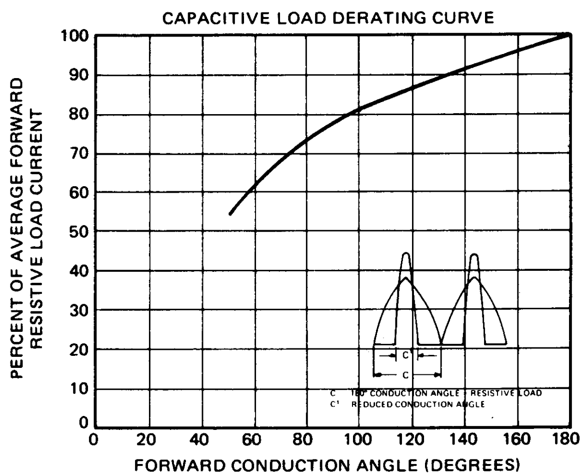


FIGURE 4

TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

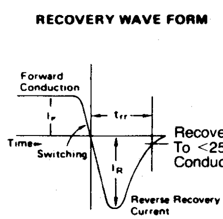


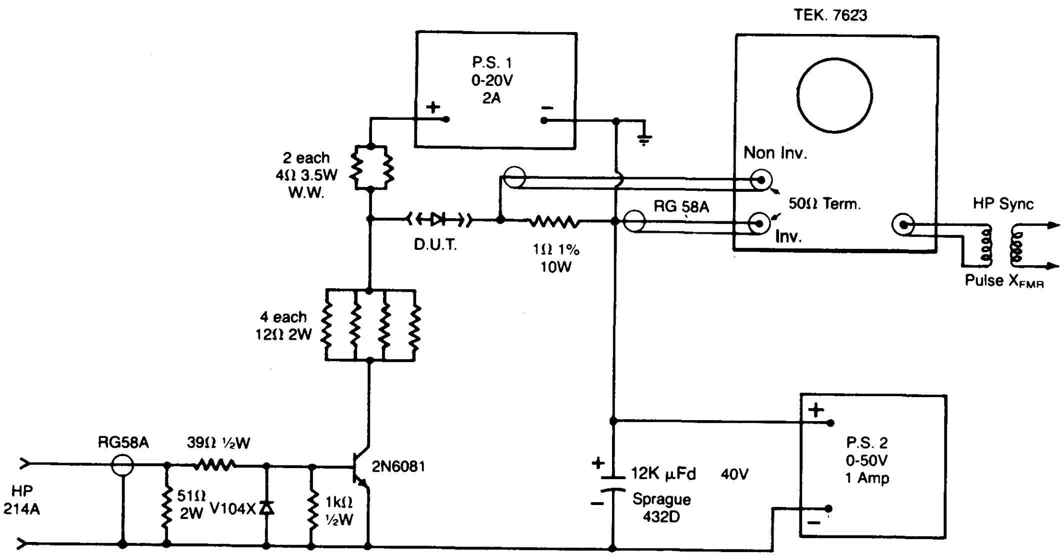
FIGURE 5

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

t_{rr} Test Set

January 1981



NOTE: 1. H. P. 214A and scope must be transformer isolated from test circuit
2. Signal coax to scope equal length
3. Adjust P.S. 1 to desired I Forward
Adjust P.S. 2 to desired I Reverse
4. H.P. 214A output
A. P.W. ≈ .5 μ Sec.
B. Pulse amplitude + 10V to + 15V as required to saturate 2N6081

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 052

3 Amp Diffused Silicon Epoxy Rectifiers with 100 Amp Peak Surge Rating

June 1981

Controlled Avalanche Types with 250V, 450V, 650V, and 850V Minimum Avalanche Ratings

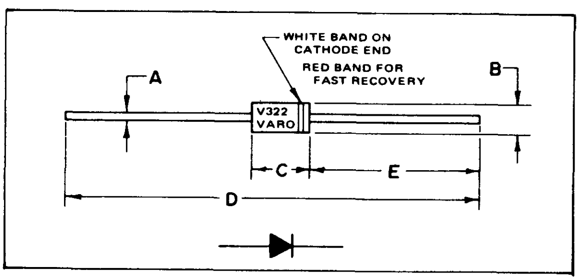
Non-Controlled Avalanche Types with 50V, 100V, 200V, 400V, 600V, 800V, and 1000V V_{RRM} Ratings

Fast Recovery Types with 200 Nanosecond Maximum t_{rr}

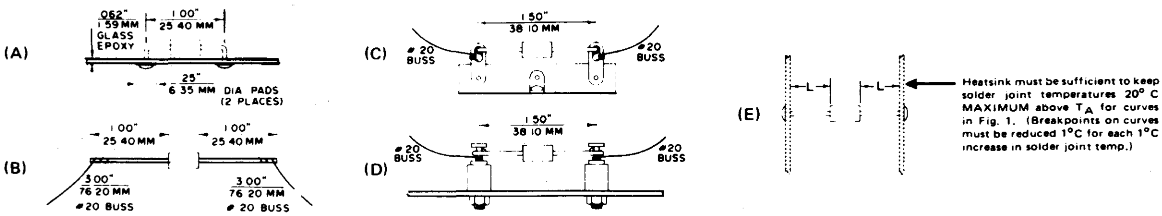
Minimum Sized, Low Cost Epoxy Encapsulation

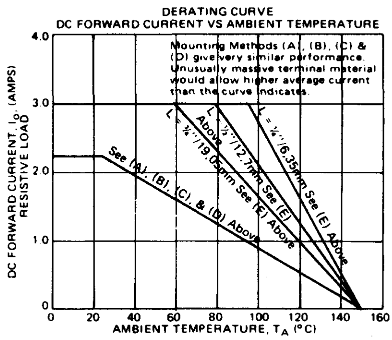
MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS AT T_A = 25°C (unless otherwise specified)

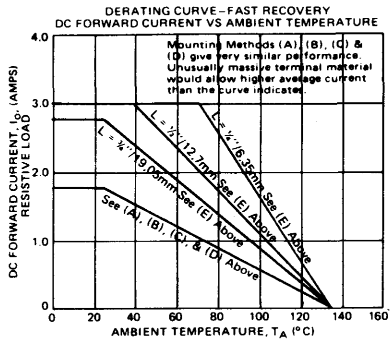
VARO PART NO.	Peak Repetitive Reverse Voltage (Volts)	RMS Reverse Voltage (Volts)	Power Dissipation in V(BR) Region For 100µsec Square Wave (Watts)	Peak Surge Current, ½ Cycle at 60 Hz (non-rep) (Fig. 2) (Amps)	Avg. Forward Current at T_A=40°C (Fig. 1) (Amps)	Junction Operating and Storage Temperature Range (°C)	Minimum Avalanche Voltage (Volts)	Maximum Avalanche Voltage (Volts)	Maximum Instantaneous Forward Voltage Drop at 3 Amps (Fig. 3) (Volts)	Maximum Reverse Current At Rated VRM (Fig. 4) µA	Maximum Reverse Recovery Time At I_F=1 Amp I_R=2 Amp (Fig. 5) (nsec)
	V_{RRM}	$V_{R(RMS)}$	P_{RM}	I_{FSM}	I_o	T_J, T_{STG}	$V_{(BR)}$	$V_{(BR)}$	V_{FM}	I_{RM}	t_{rr}
CONTROLLED AVALANCHE											
V322	200	140	500	100	3	-50 to +150	250	700	1.2	I_R T_J 5 @25°C 100@150°C	NA
V324	400	280					450	900			
V326	600	420					650	1100			
V328	800	560					850	1300			
NON-CONTROLLED AVALANCHE											
V330	50	35	NA	100	3	-50 to +150	NA	NA	1.2	I_R T_J 5 @25°C 100@150°C	NA
V331	100	70									
V332	200	140									
V334	400	280									
V336	600	420									
V338	800	560									
V3310	1000	700									
FAST RECOVERY											
V330X	50	35	NA	75	3	-50 to +135	NA	NA	1.4	I_R T_J 10 @25°C 4000@ 125°C	200
V331X	100	70									
V332X	200	140									
V334X	400	280									
V336X	600	420									



LTR	INCHES	MILLIMETERS
A	.048–.052 Dia.	1,22–1,32 Dia.
B	.20	5,08
C	.38	9,65
D	2.75	69,85
E	1.137–1.237	28,33–31,42







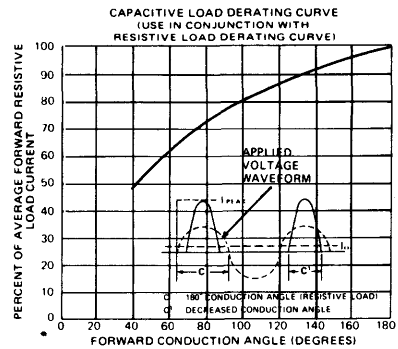


FIGURE 1

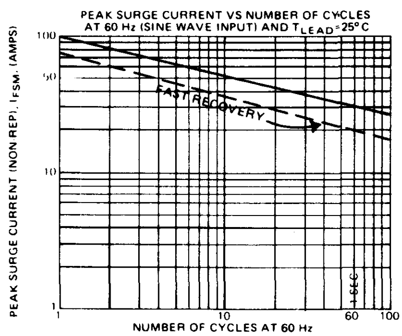


FIGURE 2

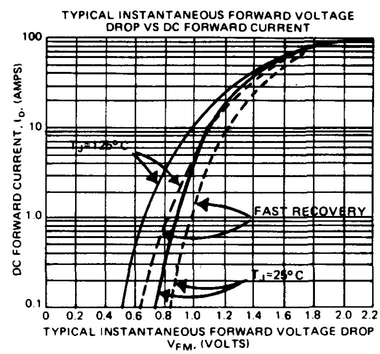


FIGURE 3

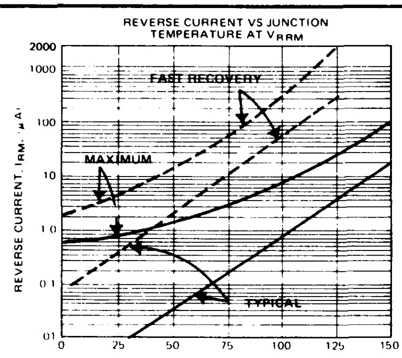
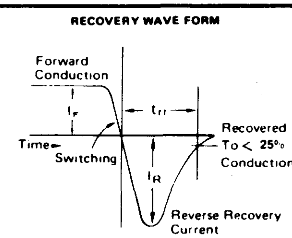


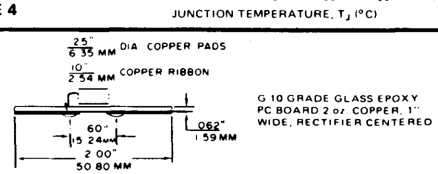
FIGURE 4



TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM

FIGURE 5



WAVE SOLDER TEMP. WHEN MOUNTED AS ABOVE IS 275 C MAXIMUM FOR 5 SECONDS MAXIMUM

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 053

3 Amp Diffused Silicon Epoxy Rectifiers with 200 Amp Peak Surge Rating

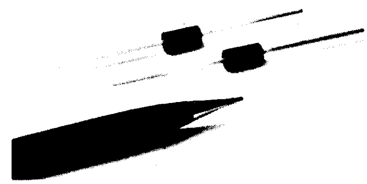
June 1981

Controlled Avalanche Types with 250V, 450V, 650V, and 850V Minimum Avalanche Ratings

Non-Controlled Avalanche Types with 50V, 100V, 200V, 400V, 600V, 800V, and 1000V V_{RRM} Ratings

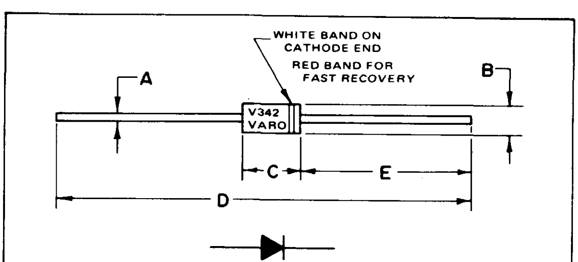
Fast Recovery Types with 200 Nanosecond Maximum t_{rr}

Minimum Sized, Low Cost Epoxy Encapsulation



MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS AT T_A = 25°C (unless otherwise specified)

VARO PART NO.	Peak Repetitive Reverse Voltage (Volts)	RMS Reverse Voltage (Volts)	Power Dissipation in V(BR) Region For 100μsec Square Wave (Watts)	Peak Surge Current, ½ Cycle at 60 Hz (non-rep) (Fig. 2) (Amps)	Avg. Forward Current at T_A=40°C (Fig. 1) (Amps)	Junction Operating and Storage Temperature Range (°C)	Minimum Avalanche Voltage (Volts)	Maximum Avalanche Voltage (Volts)	Maximum Instan-taneous Forward Voltage Drop at 3 Amps (Fig. 3) (Volts)	Maximum Reverse Current At Rated VRM (Fig. 4) μA	Maximum Reverse Recovery Time At I_F=1 Amp I_R=2 Amp (Fig. 5) (nsec)
	V_{RRM}	$V_{R(RMS)}$	P_{RM}	I_{FSM}	I_O	T_J, T_{STG}	$V_{(BR)}$	$V_{(BR)}$	V_{FM}	I_{RM}	t_{rr}
CONTROLLED AVALANCHE											
V342	200	140	900	200	3	−50 to +150	250	700	1.1	I_R T_J 5 @ 25°C 100 @ 150°	NA
V344	400	280					450	900			
V346	600	420					650	1100			
V348	800	560					850	1300			
NON-CONTROLLED AVALANCHE											
V350	50	35	NA	200	3	−50 to +150	NA	NA	1.1	I_R T_J 5 @ 25°C 100 @ 150°	NA
V351	100	70									
V352	200	140									
V354	400	280									
V356	600	420									
V358	800	560									
V3510	1000	700									
FAST RECOVERY											
V350X	50	35	NA	150	3	−50 to +135	NA	NA	1.4	I_R T_J 10 @ 25°C 4000 @ 125°	200
V351X	100	70									
V352X	200	140									
V354X	400	280									
V356X	600	420									



LTR	INCHES	MILLIMETERS
A	.048–.052 Dia.	1,22–1,32 Dia.
B	.20	5,08
C	.38	9,65
D	2.75	69,85
E	1.137–1.237	28,33–31,42

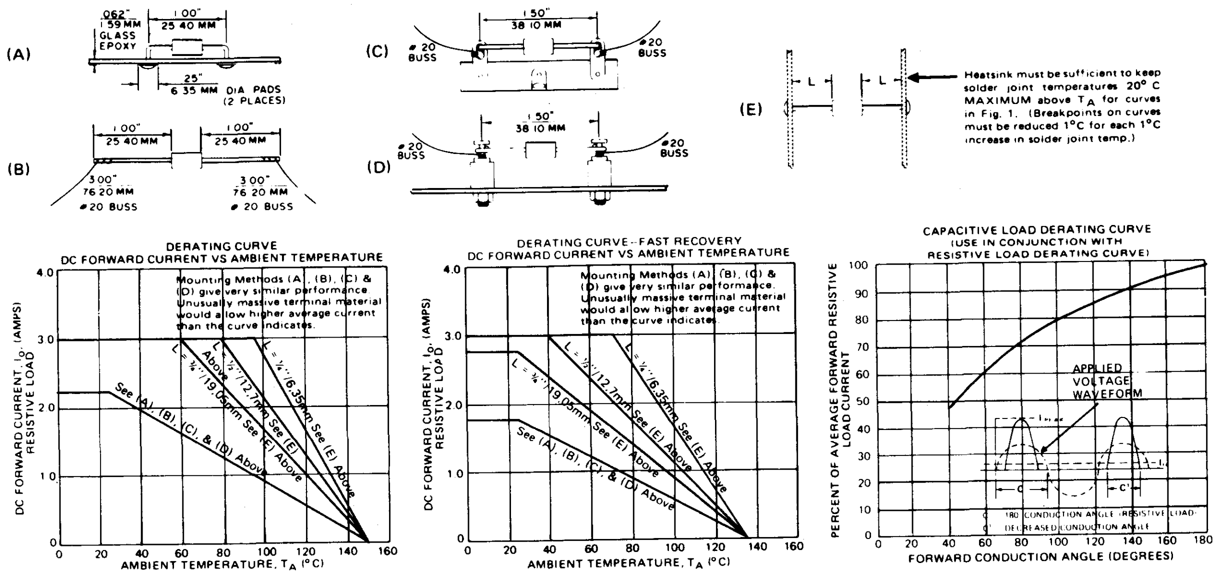


FIGURE 1

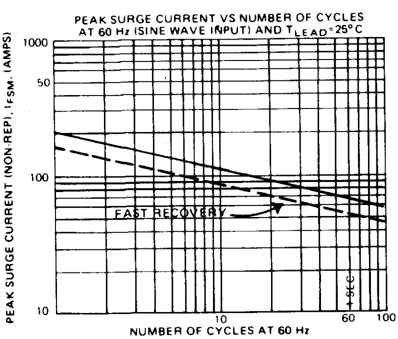


FIGURE 2

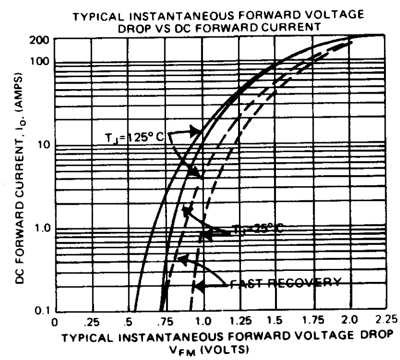


FIGURE 3

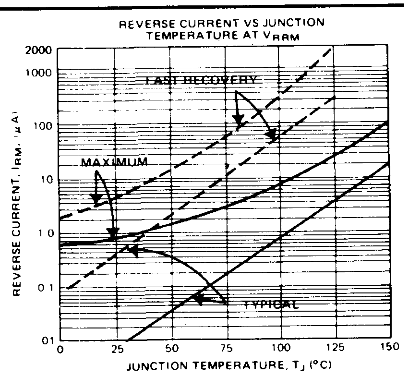
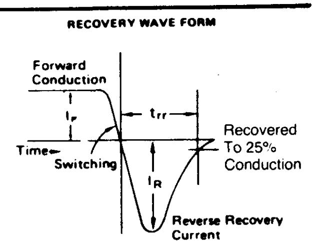


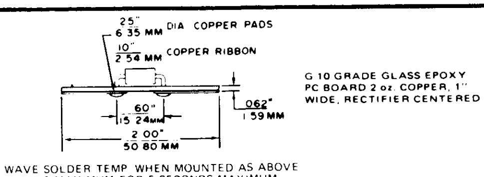
FIGURE 4



TYPICAL RECOVERY TEST CIRCUIT

SEE PAGE 45 FOR DIAGRAM.

FIGURE 5



WAVE SOLDER TEMP. WHEN MOUNTED AS ABOVE IS 275 C MAXIMUM FOR 5 SECONDS MAXIMUM

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

Schottky DIB 750 mA Dual In-Line Bridge

DLS 079

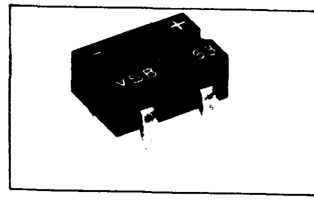
June 1981

20v, 30v and 40v V_{RRM}

.65Volt V_F Per Diode at 750 mA

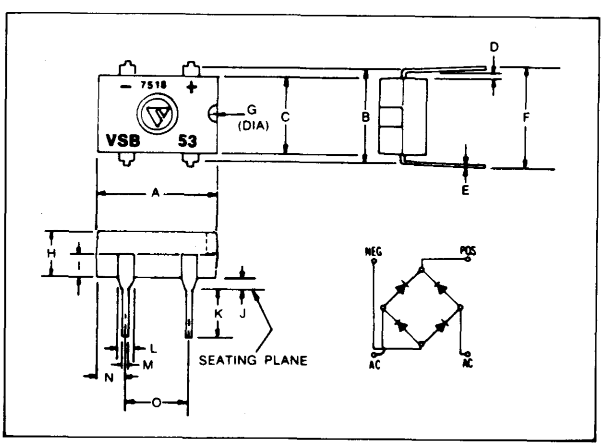
Standard .10"—2,54MM Dip Lead Spacing
2 Dibs Will Fit Into Standard 14 Pin Dip Socket

Moisture Resistant Epoxy Case



MAXIMUM RATINGS AT T_A = 25°C (unless otherwise specified)	**SYMBOL**	**VSB52**	**VSB53**	**VSB54**	**UNITS**
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RPM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Peak Surge Current, 100µ Sec. Pulse Width (non-rep) and T_A = 40°C	I_{FSM}		75		Amps
Peak Surge Current, ½ cycle at 60 Hz and T_A = 40°C	I_{FRM}		30		Amps
Avg. Forward Current at T_A = 40°C	I_O		750		mA
Junction Operating and Storage Temperature Range	T_J, T_{STG}		− 50 to + 150		°C
Max Soldering Temperature and Time			5 sec. at 265°C		

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	**SYMBOL**	**VSB52**	**VSB53**	**VSB54**	**UNITS**
Maximum Instantaneous Forward Voltage Drop per Diode i_F = 0.1 Amp i_F = 0.5 Amp i_F = 0.75 Amp	V_f		.41 .56 .65		Volts
Maximum Reverse Current (per diode) at Rated V_{RRM} T_A = 25°C T_A = 100°C	I_{RM}		2.0 5.0		mA



LTR.	INCHES	MILLIMETERS
A	.370-.390	9,40-9,91
B	.280-.320	7,11-8,13
C	.240-.260	6,10-6,60
D	.010-.020	0,25-0,51
E	.008-.015	0,20-0,38
F	.380 MAX	9,65 MAX
G	.057-.067	1,45-1,70
H	.140-.160	3,56-4,06
I	.070-.080	1,78-2,03
J	.055 MAX	1,40 MAX
K	.120-.130	3,05-3,30
L	.040-.060	1,02-1,52
M	.016-.020	0,41-0,51
N	.080-.100	2,03-2,54
O	.190-.210	4,83-5,33

FIG. 1

TYPICAL REVERSE CURRENT

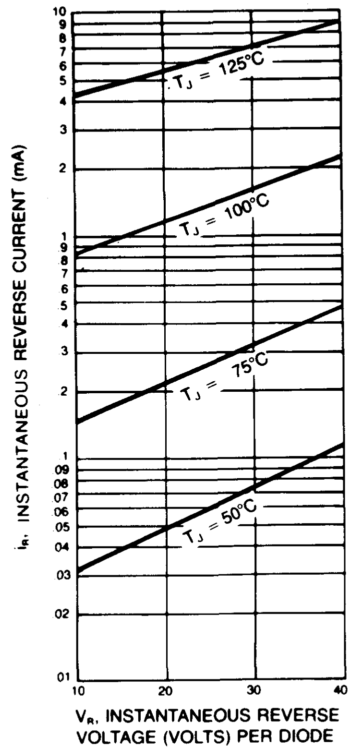


FIG. 2

TYPICAL FORWARD VOLTAGE

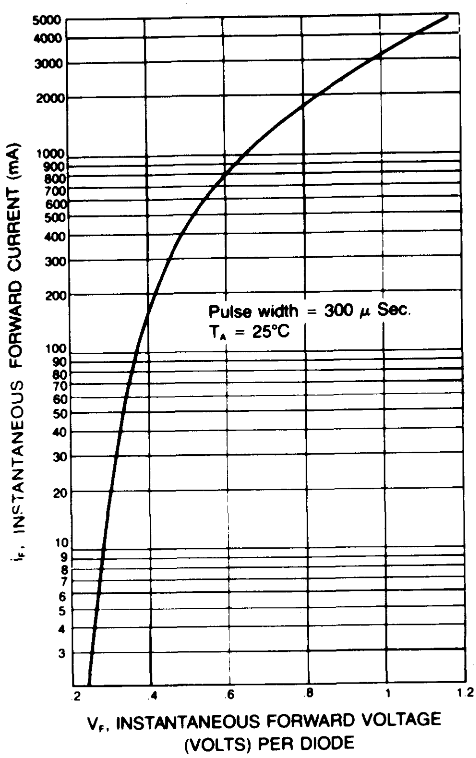


FIG. 3

CAPACITANCE VS. REVERSE VOLTAGE

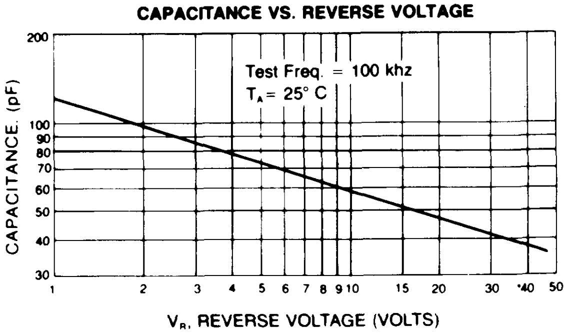
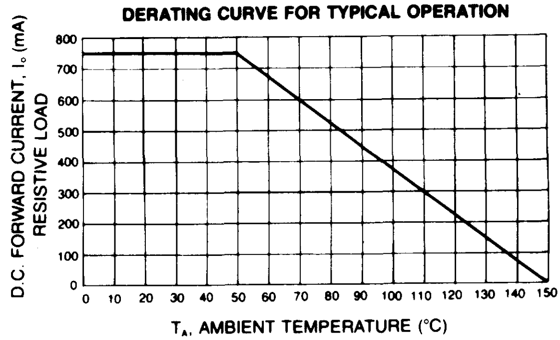


FIG. 4

DERATING CURVE FOR TYPICAL OPERATION



I. The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.
The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a variable capacitance equal in value to the junction capacitance. See Figure 3.

II. THERMAL CONSIDERATIONS

A. The derating curve of figure 4 may be used for initial design work.
B. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5° C of junction temperature increase.
C. We recommend that all designs be verified at an ambient temperature at least 10° C above the maximum at which the equipment will ever have to operate.

VARO

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1000 NORTH SHILOH, GARLAND, TEXAS 75040
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DLS 060

1 Amp Schottky Barrier Rectifiers

January 1980

20 Volt, 30 Volt and 40 Volt V_{RRM}

.550 Volt v_F at i_F = 1.0 Amp

Very Fast Recovery Time

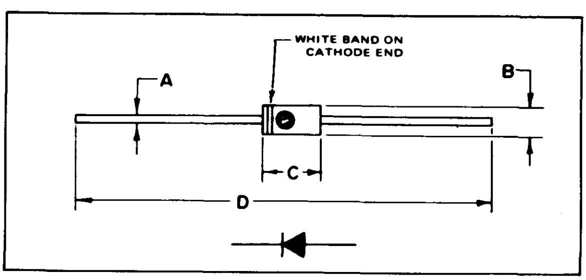
Minimum Sized, Low Cost Epoxy Encapsulation

MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL	VSK120	VSK130	VSK140	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current (Fig. 5 & 6)	I_o		1.0		Amps
Ambient Temp. @ Rated V_{RM}, $R_{\theta JA} \leq 50^o$ C/W	T_A	90	85	80	°C
Peak Surge Current (non-rep), 300µs Pulse Width (Fig.4)	I_{FSM}		100		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig. 4)	I_{FSM}		40		Amps
Operating Junction Temperature	T_J		−65 to +150*		°C
Storage Temperature	T_{STG}		−65 to +150		°C

*$V_{RM} \leq 0.1\ V_{RM}$ Max, $R_{\theta JA} \leq 35^o$ C/W

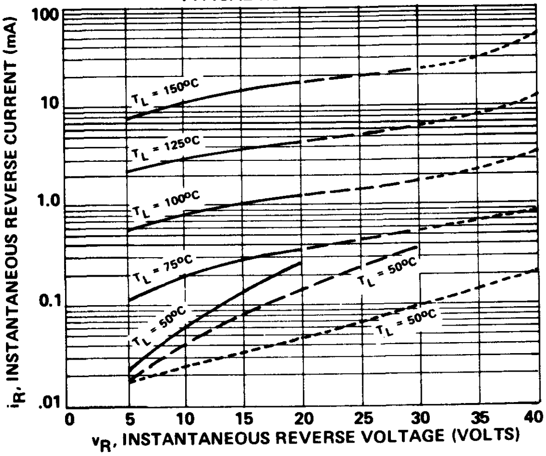
ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL	VSK120	VSK130	VSK140	UNITS
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F i_F =0.1 Amp i_F =1.0 Amp i_F =3.0 Amp	v_F		.370 .550 .850		Volts
Maximum Instantaneous Reverse Current at Rated V_{RM} (1) See Fig. 1 for Typical i_R T_L = 25° C T_L = 100° C	i_R		1.0 10.0		mA

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2%



LTR.	INCHES	MILLIMETERS
A	.030 — .034 Dia.	,76 — ,86 Dia.
B	.100 — .107 Dia.	2,54 — 2,72
C	.185 — .205	4,70 — 5,21
D	2.40	60,69

FIG. 1.
TYPICAL REVERSE CURRENT

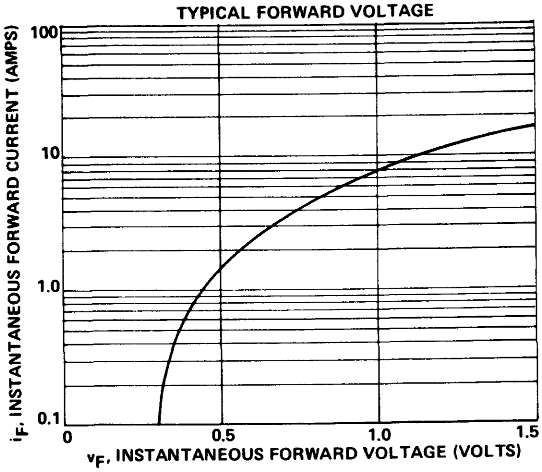


VSK120 (solid line)
VSK130 (dashed line)
VSK140 (dotted line)

PULSE WIDTH = 300 μsec

T_L = LEAD TEMP. MEASURED .03"–.79mm FROM RECTIFIER BODY WITH 40 GAUGE THERMOCOUPLE

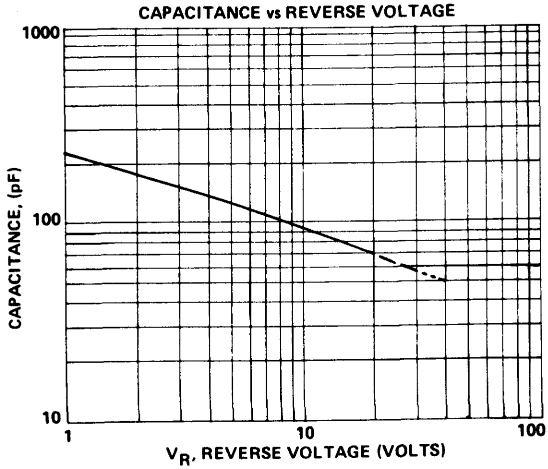
FIG. 2.
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°C

FIG. 3.
CAPACITANCE vs REVERSE VOLTAGE



VSK120 (solid line)
VSK130 (dashed line)
VSK140 (dotted line)

T_A = 25°C

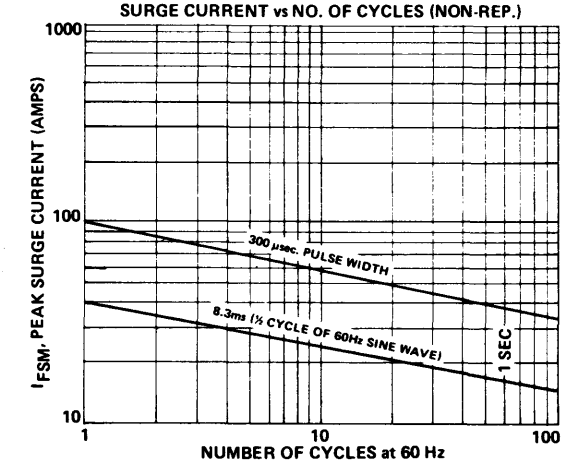
TEST FREQ = 100kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a variable capacitance equal in value to the junction capacitance. See Figure 3.

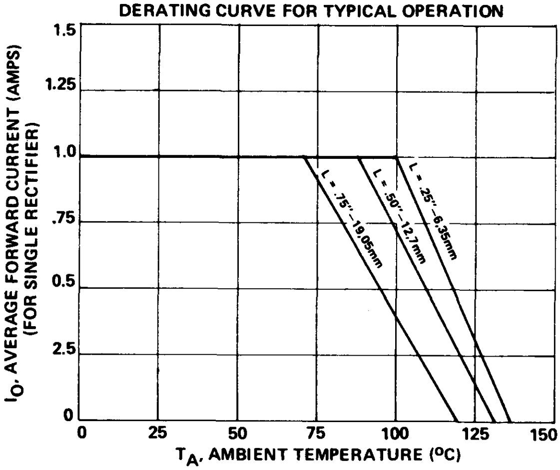
1 Amp Schottky Barrier Rectifiers

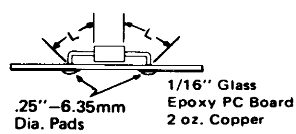
FIG. 4.
SURGE CURRENT vs NO. OF CYCLES (NON-REP.)



$T_A = 25^oC$

FIG. 5.
DERATING CURVE FOR TYPICAL OPERATION

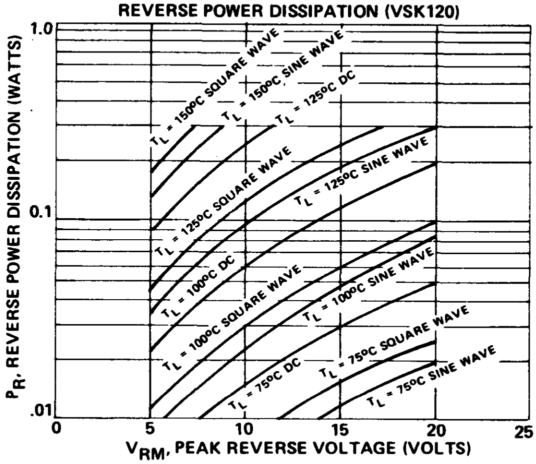


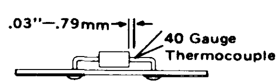


CONDITIONS:

- VSK120 RECTIFIER
- FULL WAVE CENTER TAP OPERATION.
- RECT. PEAK REVERSE VOLTAGE = 20V
- FILTER CAPACITOR = 4 μF.
- 20 KHz SQUARE WAVE

FIG. 6(A).
REVERSE POWER DISSIPATION (VSK120)





REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 6(A), 6(B), 6(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 6(B)
REVERSE POWER DISSIPATION (VSK130)

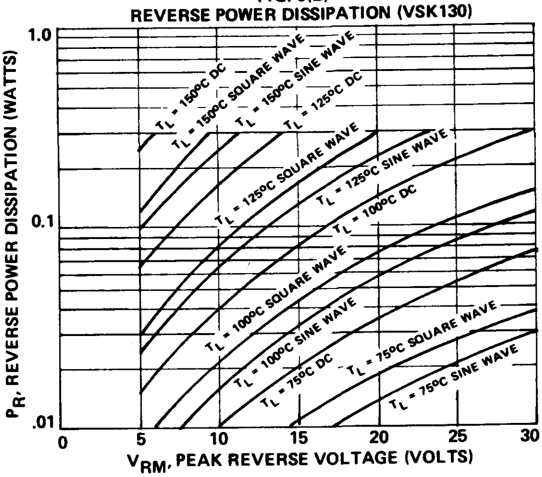


FIG. 6(C)
REVERSE POWER DISSIPATION (VSK140)

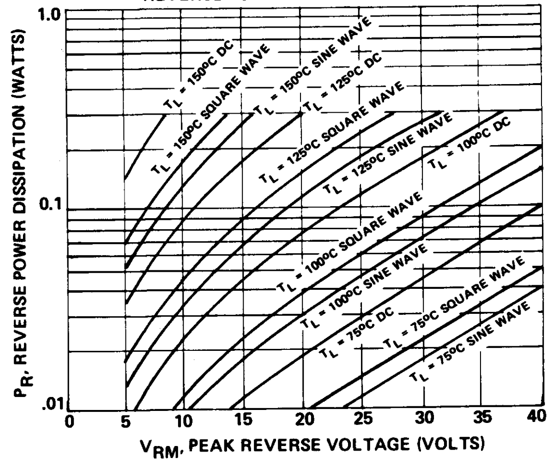


FIG. 6(D).
FORWARD POWER DISSIPATION
(VSK120, VSK130, VSK140)

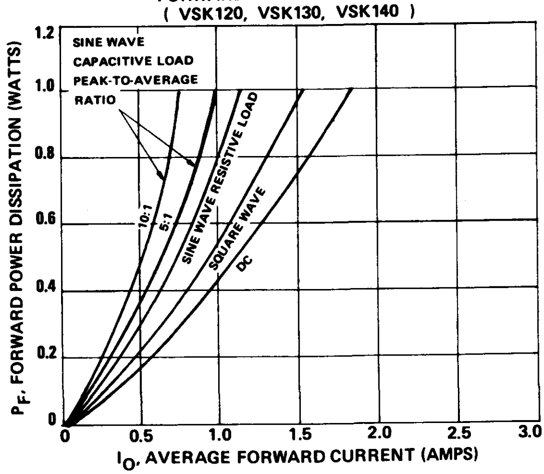
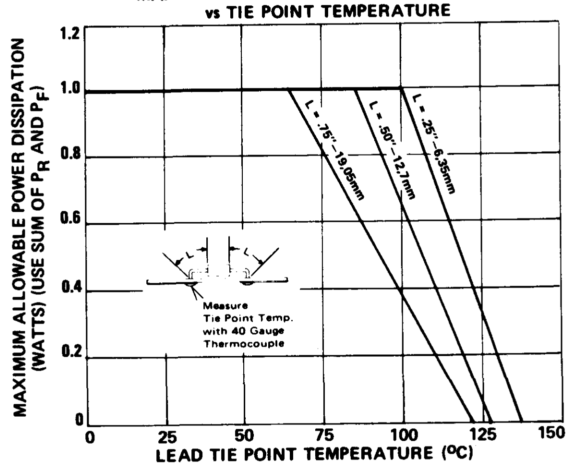


FIG. 6(E)
MAXIMUM ALLOWABLE POWER DISSIPATION
vs TIE POINT TEMPERATURE



Thermal Considerations:

1. The derating curve of figure 5 may be used for initial design work.
2. Use the curves of figure 6 to study the voltage / current / temperature parameters. These curves are helpful in determining the rectifier capability when connected to a tie point whose temperature is influenced by other heat producing components. To use these curves, add the reverse power dissipation from figure 6 (A), (B) or (C) to the forward power dissipation from figure 6 (D) then go to figure 6 (E) to find the maximum allowable tie point temperature.
3. The heat sink design (tie point) must be designed to keep the temperature at this point below that shown on the figure 6 (E) curve. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5° C of temperature increase.
4. The curves of figure 6 (E) were based on full rated reverse bias voltage. Slightly higher tie point temperatures can be tolerated at lower voltages. We recommend that all designs be verified at an ambient temperature at least 10° C higher than the maximum at which the equipment will ever have to operate.
5. If the application is such that DC reverse bias is applied nearly 100% of the time, all temperature points on curve 6 (E) should be reduced 13° C.
6. These thermal resistances apply: $R_{\theta JL}$ (measured 1/32" from epoxy) = 12°C/W and the lead = 50°C/W per inch when equal heatsinking is applied to each lead.

VARO

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DLS 061

3 Amp Schottky Barrier Rectifiers

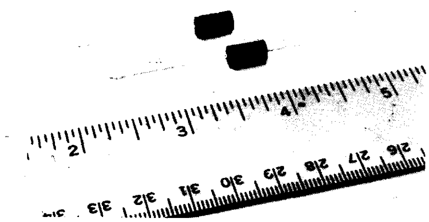
January 1980

20 Volt, 30 Volt and 40 Volt V_{RRM}

.475 Volt v_F at i_F = 3.0 Amp

Very Fast Recovery Time

Minimum Sized, Low Cost Epoxy Encapsulation

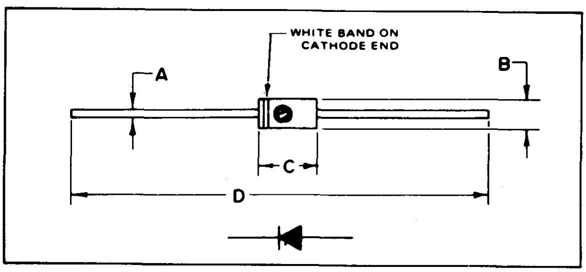


MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL	VSK320	VSK330	VSK340	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current (Fig. 5 & 6)	I_O		3.0		Amps
Ambient Temp. @ Rated V_{RM}, $R_{\theta JA} \leq 24^o$ C/W	T_A	85	80	75	°C
Peak Surge Current (non-rep), 300µs Pulse Width (Fig.4)	I_{FSM}		250		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig. 4)	I_{FSM}		150		Amps
Operating Junction Temperature	T_J		−65 to +150*		°C
Storage Temperature	T_{STG}		−65 to +150		°C

* $V_{RM} \leq 0.1\ V_{RM}$ Max, $R_{\theta JA} \leq 32^o$ C/W

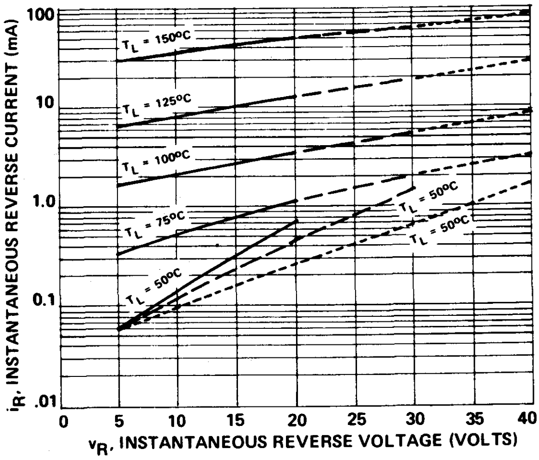
ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL	VSK320	VSK330	VSK340	UNITS
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F — i_F = 1.0 Amp i_F = 3.0 Amps i_F = 10.0 Amps	v_F		.400 .475 .750		Volts
Maximum Instantaneous Reverse Current at Rated V_{RM} (1) See Fig. 1 for Typical i_R — T_L = 25° C T_L = 100° C	i_R		3.0 30.0		mA

(1) Pulse Test: Pulse Width = 300µs, Duty Cycle = 2%



LTR.	INCHES	MILLIMETERS
A	.048 — .052 Dia.	1,22 — 1,32 Dia.
B	.190 — .225	4,83 — 5,72
C	.370 — .390	9,40 — 9,91
D	2.75	69,85

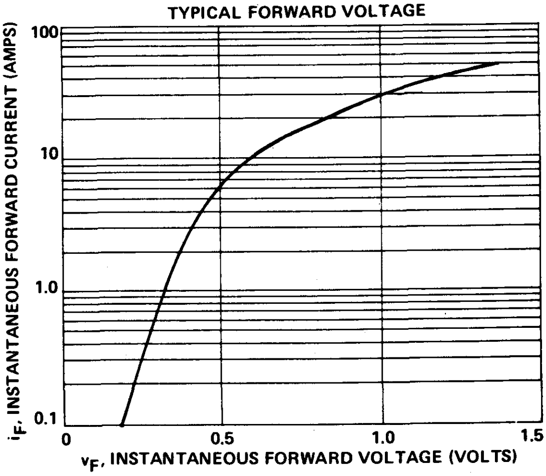
FIG. 1.
TYPICAL REVERSE CURRENT



VSK320
VSK330
VSK340
PULSE WIDTH - 300 μsec

T_L = LEAD TEMP. MEASURED .03"–.79mm FROM RECTIFIER BODY WITH 40 GAUGE THERMOCOUPLE

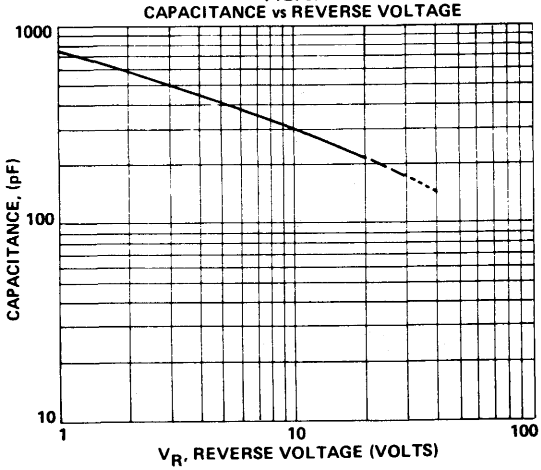
FIG. 2.
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°C

FIG. 3.
CAPACITANCE vs REVERSE VOLTAGE



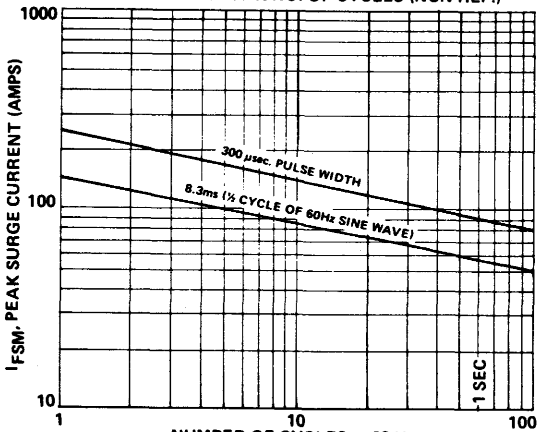
VSK320
VSK330
VSK340
T_A = 25°C
TEST FREQ. = 100 kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a variable capacitance equal in value to the junction capacitance. See Figure 3.

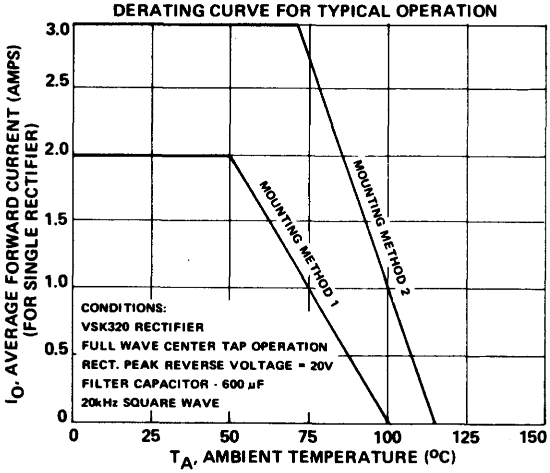
3 Amp Schottky Barrier Rectifiers

FIG. 4.
SURGE CURRENT vs NO. OF CYCLES (NON-REP.)

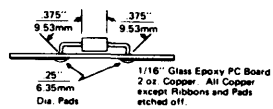


T_A = 25°C

FIG. 5.
DERATING CURVE FOR TYPICAL OPERATION



MOUNTING METHOD 1



MOUNTING METHOD 2 – TOP VIEW

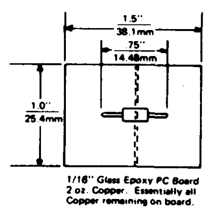
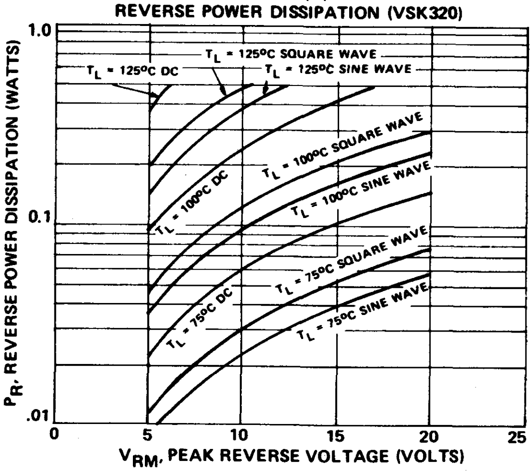
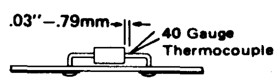


FIG. 6(A).
REVERSE POWER DISSIPATION (VSK320)





REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 6(A), 6(B), 6(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 6(B)
REVERSE POWER DISSIPATION (VSK330)

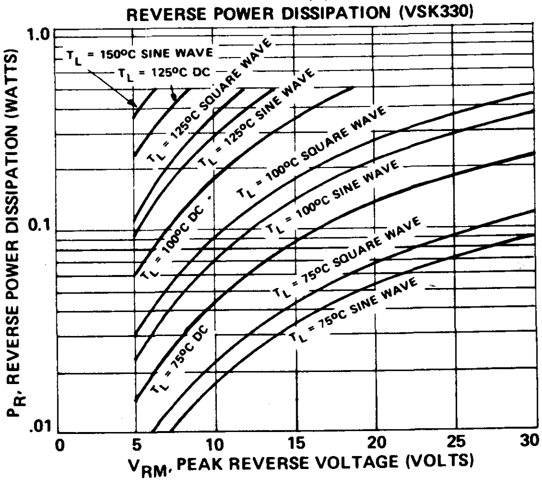


FIG. 6(C)
REVERSE POWER DISSIPATION (VSK340)

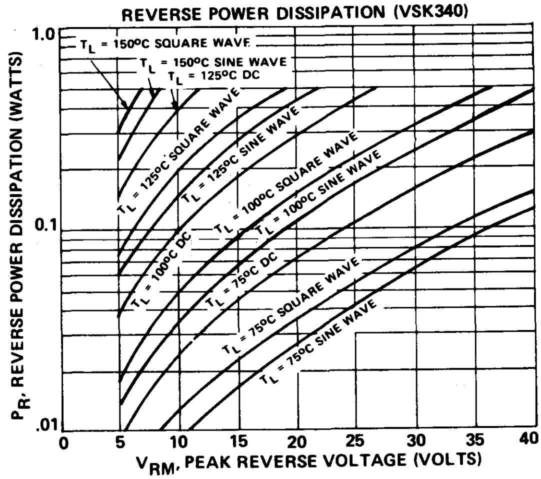


FIG. 6(D).
FORWARD POWER DISSIPATION
VSK320, VSK330, VSK340

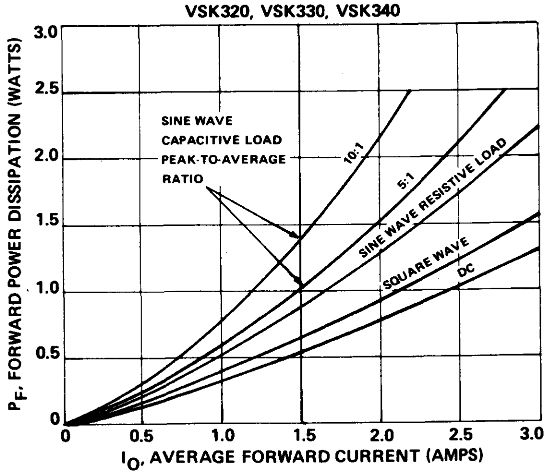
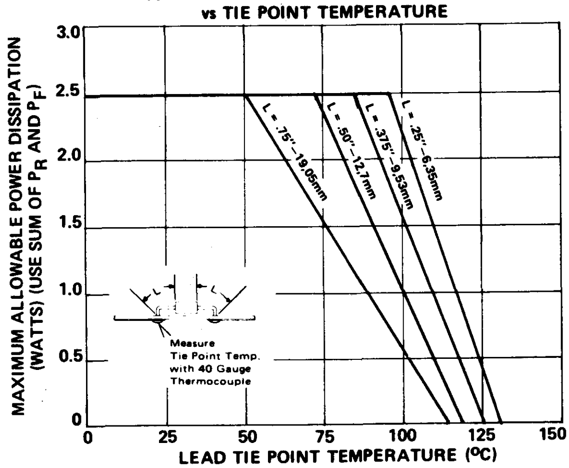


FIG. 6(E)
MAXIMUM ALLOWABLE POWER DISSIPATION
vs TIE POINT TEMPERATURE



Thermal Considerations:

1. The derating curve of figure 5 may be used for initial design work.
2. Use the curves of figure 6 to study the voltage / current / temperature parameters. These curves are helpful in determining the rectifier capability when connected to a tie point whose temperature is influenced by other heat producing components. To use these curves, add the reverse power dissipation from figure 6 (A), (B) or (C) to the forward power dissipation from figure 6 (D) then go to figure 6 (E) to find the maximum allowable tie point temperature.
3. The heat sink design (tie point) must be designed to keep the temperature at this point below that shown on the figure 6 (E) curve. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5° C of temperature increase.
4. The curves of figure 6 (E) were based on full rated reverse bias voltage. Slightly higher tie point temperatures can be tolerated at lower voltages. We recommend that all designs be verified at an ambient temperature at least 10° C higher than the maximum at which the equipment will ever have to operate.
5. If the application is such that DC reverse bias is applied nearly 100% of the time, all temperature points on curve 6 (E) should be reduced 13° C.
6. These thermal resistances apply: $R_{\theta JL}$ (measured 1/32" from epoxy) = 6° C/W and the lead = 25° C/W per inch when equal heatsinking is applied to each lead.

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DLS 062

5 Amp Schottky Barrier Rectifiers

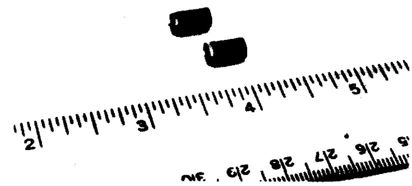
January 1980

20 Volt, 30 Volt and 40 Volt V_{RRM}

.450 Volt v_F at i_F = 5.0 Amp

Very Fast Recovery Time

Minimum Sized, Low Cost Epoxy Encapsulation

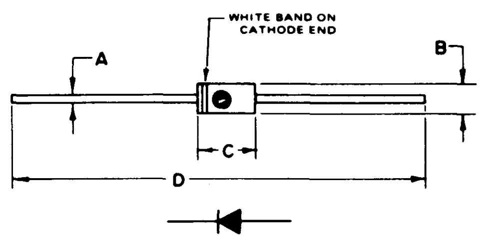


MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL	VSK520	VSK530	VSK540	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current (Fig. 5 & 6)	I_O		5.0		Amps
Ambient Temp. @ Rated V_{RM}, $R_{\theta JA} \leq 16^{o}$ C/W	T_A	70	65	60	°C
Peak Surge Current (non-rep), 300µs Pulse Width (Fig.4)	I_{FSM}		500		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig.4)	I_{FSM}		250		Amps
Operating Junction Temperature	T_J		−65 to +150*		°C
Storage Temperature	T_{STG}		−65 to +150		°C

*$V_{RM} \leq 0.1\ V_{RM}$ Max, $R_{\theta JA} \leq 12^{o}$ C/W

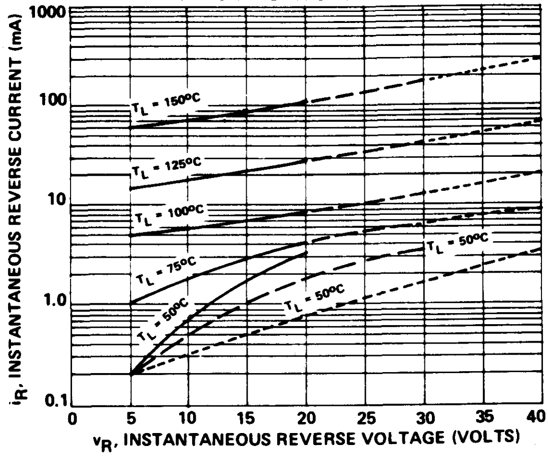
ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL	VSK520	VSK530	VSK540	UNITS
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F — i_F = 3.0 Amps i_F = 5.0 Amps i_F = 15.0 Amps	v_F		.400 .450 .625		Volts
Maximum Instantaneous Reverse Current at Rated V_{RM} (1) See Fig. 1 for Typical i_R — T_L = 25° C T_L = 100° C	i_R		10 75		mA

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2%



LTR.	INCHES	MILLIMETERS
A	.048 — .052	1.22 — 1.32 Dia.
B	.190 — .225	4.83 — 5.72
C	.370 — .390	9.40 — 9.91
D	2.75	69.85

FIG. 1.
TYPICAL REVERSE CURRENT

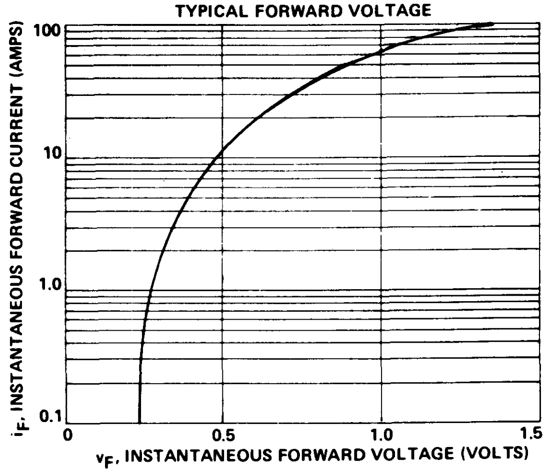


VSK520 (solid line)
VSK530 (long-dashed line)
VSK540 (short-dashed line)

PULSE WIDTH = 300 μsec

T_L = LEAD TEMP. MEASURED .03"–.79mm FROM RECTIFIER BODY WITH 40 GAUGE THERMOCOUPLE

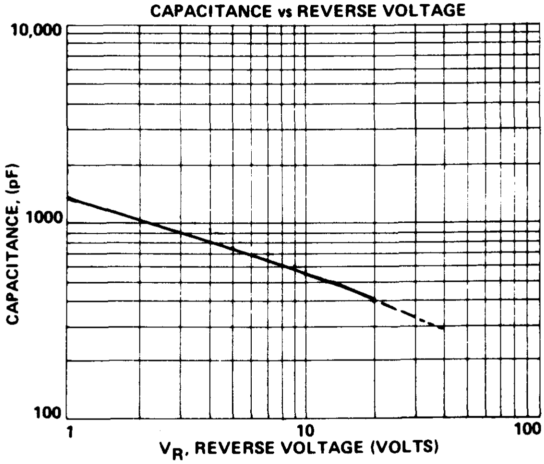
FIG. 2.
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°C

FIG. 3.
CAPACITANCE vs REVERSE VOLTAGE



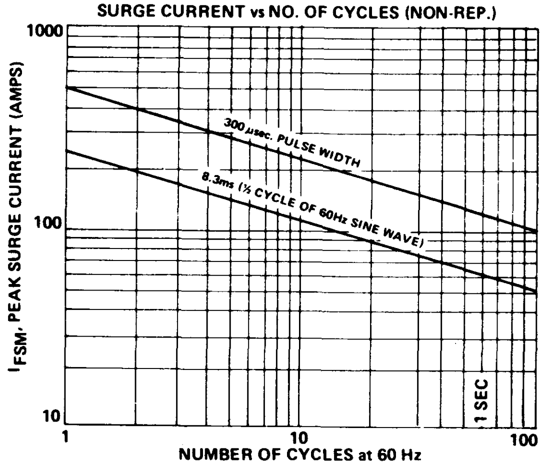
VSK520 (solid line)
VSK530 (long-dashed line)
VSK540 (short-dashed line)
T_A = 25°C
TEST FREQ = 100 kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a variable capacitance equal in value to the junction capacitance. See Figure 3.

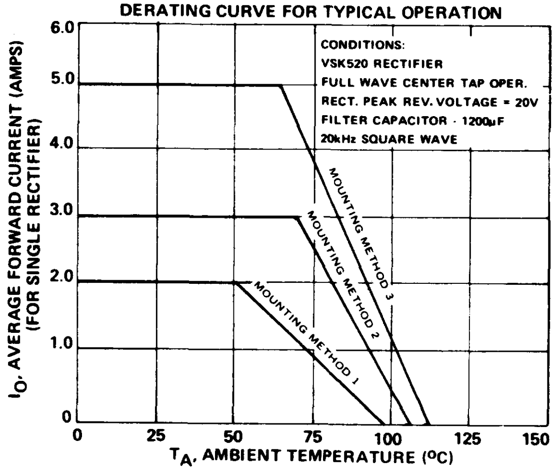
5 Amp Schottky Barrier Rectifiers

FIG. 4.
SURGE CURRENT vs NO. OF CYCLES (NON-REP.)

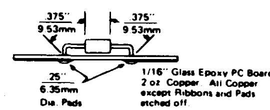


T_A = 25°C

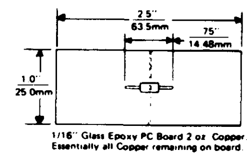
FIG. 5.
DERATING CURVE FOR TYPICAL OPERATION



MOUNTING METHOD 1



MOUNTING METHOD 2 – TOP VIEW



MOUNTING METHOD 3

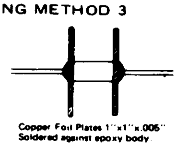
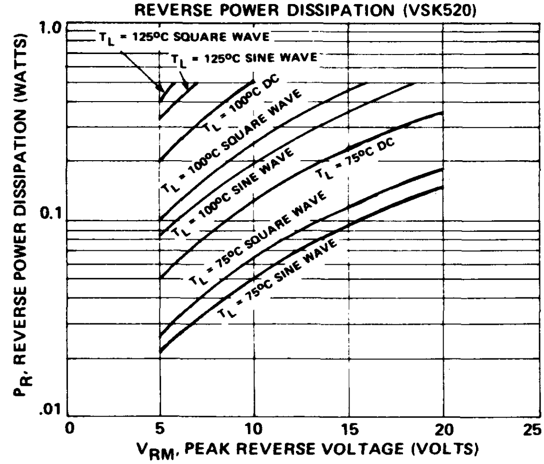
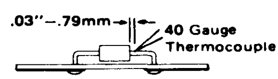


FIG. 6(A).
REVERSE POWER DISSIPATION (VSK520)





REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 6(A), 6(B), 6(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 6(B)
REVERSE POWER DISSIPATION (VSK530)

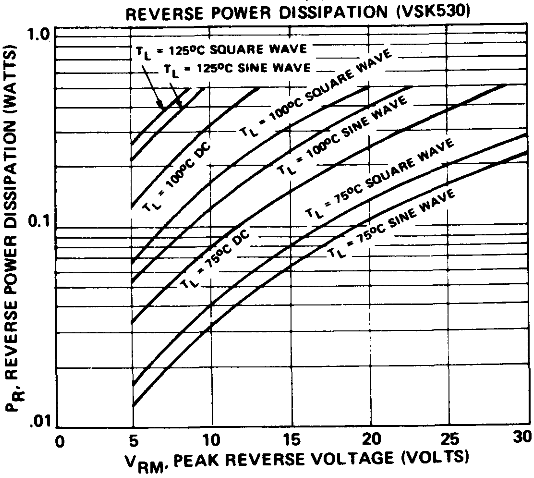


FIG. 6(C)
REVERSE POWER DISSIPATION (VSK540)

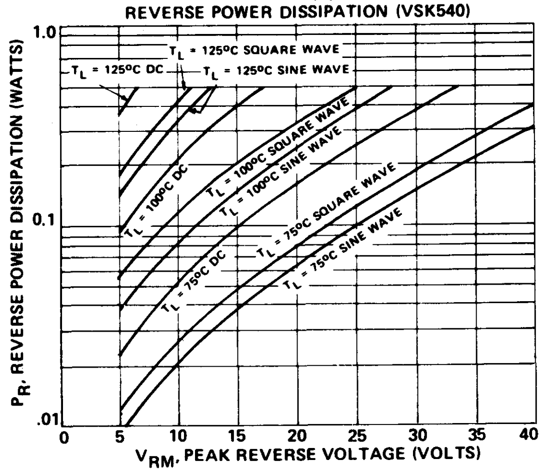


FIG. 6(D)
FORWARD POWER DISSIPATION
(VSK520, VSK530, VSK540)

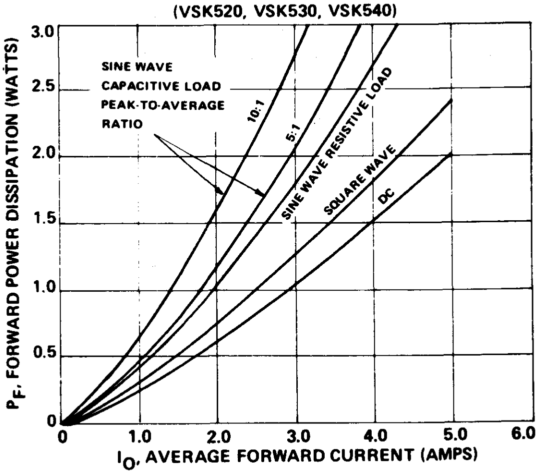
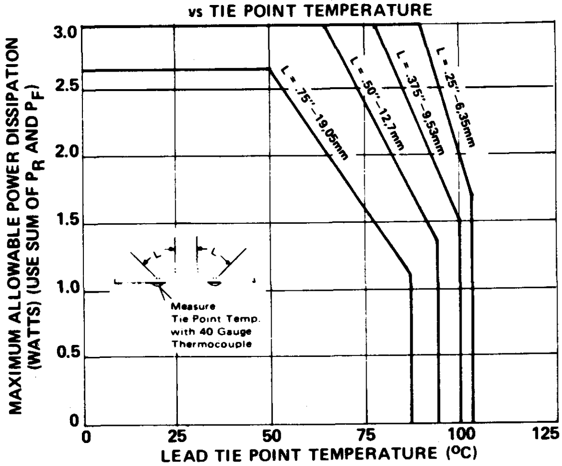


FIG. 6(E)
MAXIMUM ALLOWABLE POWER DISSIPATION
vs TIE POINT TEMPERATURE



Thermal Considerations:

1. The derating curve of figure 5 may be used for initial design work.
2. Use the curves of figure 6 to study the voltage / current / temperature parameters. These curves are helpful in determining the rectifier capability when connected to a tie point whose temperature is influenced by other heat producing components. To use these curves, add the reverse power dissipation from figure 6 (A), (B) or (C) to the forward power dissipation from figure 6 (D) then go to figure 6 (E) to find the maximum allowable tie point temperature.
3. The heat sink design (tie point) must be designed to keep the temperature at this point below that shown on the figure 6 (E) curve. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5° C of temperature increase.
4. The curves of figure 6 (E) were based on full rated reverse bias voltage. Slightly higher tie point temperatures can be tolerated at lower voltages. We recommend that all designs be verified at an ambient temperature at least 10° C higher than the maximum at which the equipment will ever have to operate.
5. If the application is such that DC reverse bias is applied nearly 100% of the time, all temperature points on curve 6 (E) should be reduced 13° C.
6. These thermal resistances apply: $R_{\theta JL}$ (measured 1/32" from epoxy) = 6 °C/W and the lead = 25 °C/W per inch when equal heatsinking is applied to each lead.

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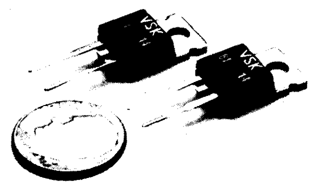
DLS093

6 Amp Schottky Rectifier

June 1981

20 Volt, 30 Volt, and 40 Volt (V_{RRM})
6 Amps Average Output Current (I_O)
Plastic T0220 Package

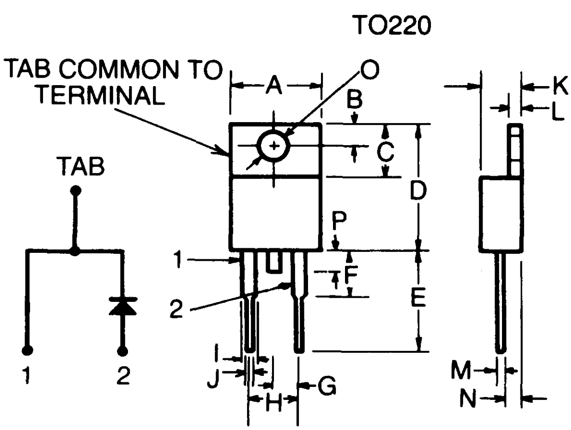


These units are designed to provide an economical 6 amp Schottky output. They should be used in high frequency power supplies where efficiency and reliability are of the utmost importance.

MAXIMUM RATINGS (At T_A = 25° C unless otherwise noted)	**SYMBOL**	**VSK62**	**VSK63**	**VSK64**	**UNITS**
DC Blocking Voltage (per diode) Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$VR_{(RMS)}$	14	21	28	Volts
Non-repetitive Peak Reverse Voltage	V_{RSM}	28	38	48	Volts
Average Rectified Forward Current	I_O		6		Amps
Peak Surge Current (Nonrep.) at 60Hz, ½ cycle.	I_{FSM}		140		Amps
Junction Operating & Storage Temperature Range	T_J, T_{STG}		−65 to +150		°C
Thermal Resistance, Junction-to-case	Θ_{JC}		5.0		°C/W

Electrical Characteristics (At T_A = 25° C unless otherwise noted)	**SYMBOL**	**VSK62**	**VSK63**	**VSK64**	**UNITS**
Maximum Instantaneous Forward Voltage Drop (300 µs pulse) at I_F	V_F	I_F = 5A I_F = 12A	0.55 0.77		Volts (1)
Maximum Instantaneous Reverse Current (300 µs pulse) at rated V_{RM}	I_R		5.0		mA (1)

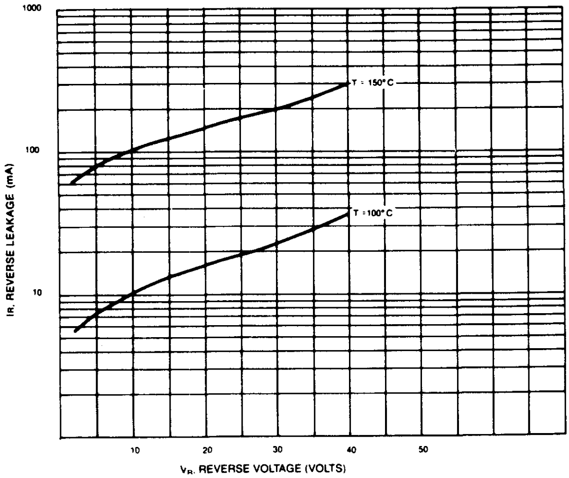
(1) 2% duty cycle



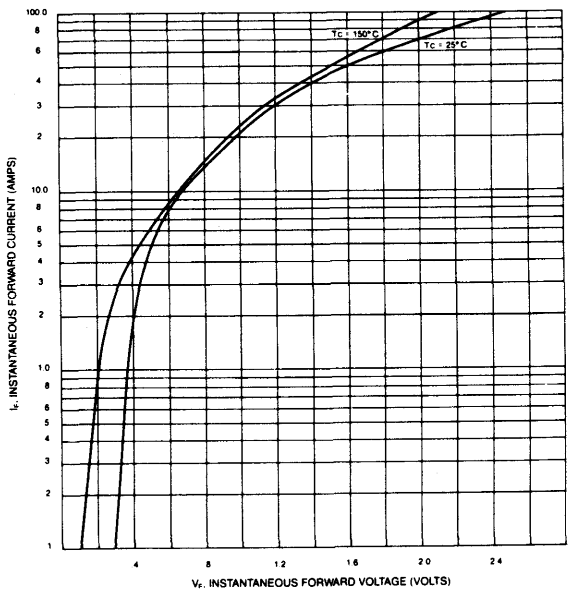
DIM (2)	INCHES	MILLIMETERS
A	0.415 Max	10.54 Max
B	.108	2.74
C	.248	6.3
D	0.605 Max	15.37 Max
E	0.552	14.02
F	0.240 Max	6.1 Max
G	0.100	2.54
H	0.200	5.08
I	0.050	1.27
J	0.032	0.81
K	.190 Max	4.83 Max
L	0.050	1.27
M	0.022	0.56
N	0.105	2.67
O	0.143	3.63
P	0.100 Max	2.54 Max

(2) Dimensions are typical values unless otherwise specified.

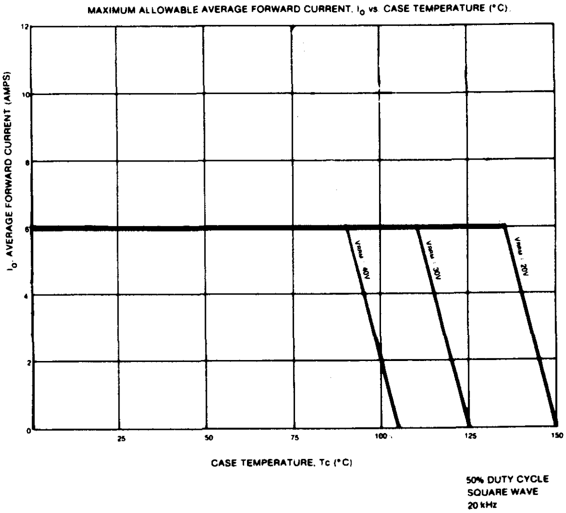
TYPICAL REVERSE LEAKAGE CHARACTERISTICS



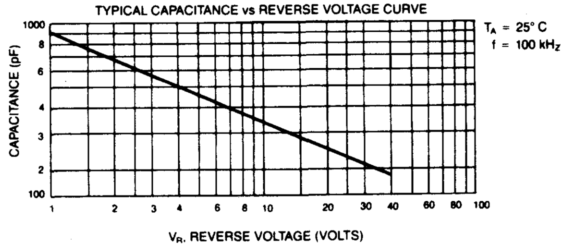
TYPICAL FORWARD VOLTAGE



MAXIMUM ALLOWABLE AVERAGE FORWARD CURRENT, I_O vs. CASE TEMPERATURE (°C)



TYPICAL CAPACITANCE vs REVERSE VOLTAGE CURVE



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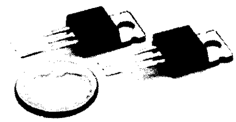
DLS092

12 Amp Full Wave Dual Schottky Rectifier

June 1981

20 Volt, 30 Volt, and 40 Volt (V_{RRM})
12 Amps Average Full Wave Output Current (I_o)
Plastic T0220 Package



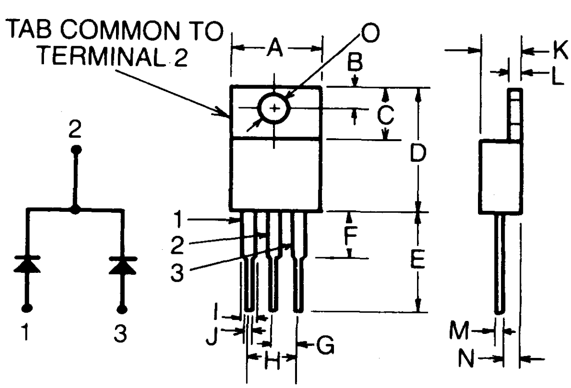
These units are designed to provide an economical 12 amp center tapped dual Schottky output. They should be used in high frequency power supplies where efficiency and reliability are of the utmost importance.

MAXIMUM RATINGS (At T_A = 25° C unless otherwise noted)	SYMBOL	VSK12	VSK13	VSK14	UNITS
DC Blocking Voltage (per diode) Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Non-repetitive Peak Reverse Voltage	V_{RSM}	28	38	48	Volts
Average Rectified Forward Current	I_o		12		Amps
Peak Surge Current (Nonrep.) at 60Hz, ½ cycle.	I_{FSM}		140		Amps
Junction Operating & Storage Temperature Range	T_J, T_{STG}		−65 to +150		°C
Thermal Resistance, Junction-to-case	θ_{JC}		3.0		°C/W

Electrical Characteristics (At T_A = 25° C unless otherwise noted)	SYMBOL	VSK12 VSK13 VSK14	UNITS
Maximum Instantaneous Forward Voltage Drop (300 µs pulse) at I_F	V_F	I_F = 5A 0.55 I_F = 12A 0.77	Volts (1)
Maximum Instantaneous Reverse Current (300 µs pulse) at rated V_{RM}	I_R	5.0	mA (1)

(1) 2% duty cycle

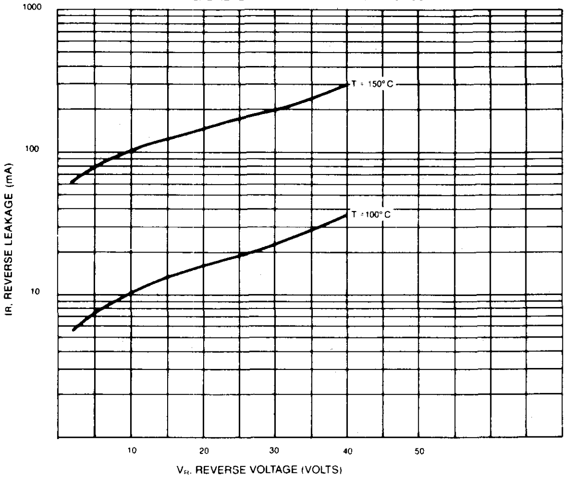
TO220



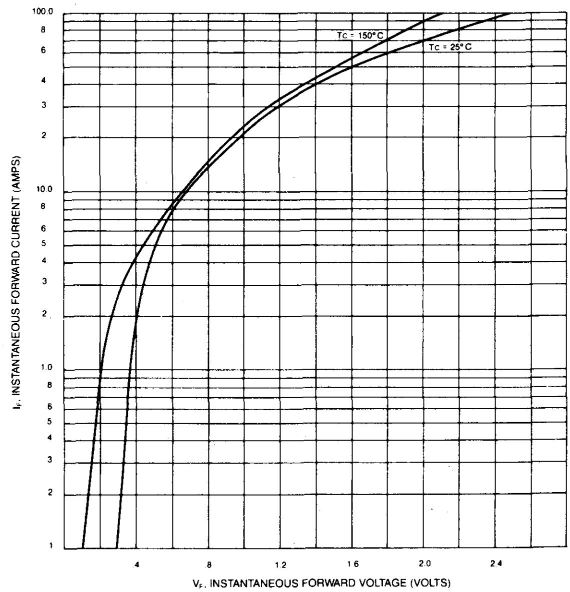
DIM (2)	INCHES	MILLIMETERS
A	0.415 Max	10.54 Max
B	.108	2.74
C	.248	6.3
D	0.605 Max	15.37 Max
E	0.552	14.02
F	0.240 Max	6.1 Max
G	0.100	2.54
H	0.200	5.08
I	0.050	1.27
J	0.035	0.89
K	.190 Max	4.83 Max
L	0.050	1.27
M	0.025 Max	0.64 Max
N	0.105	2.67
O	0.143	3.63

(2) Dimensions are typical values unless otherwise specified.

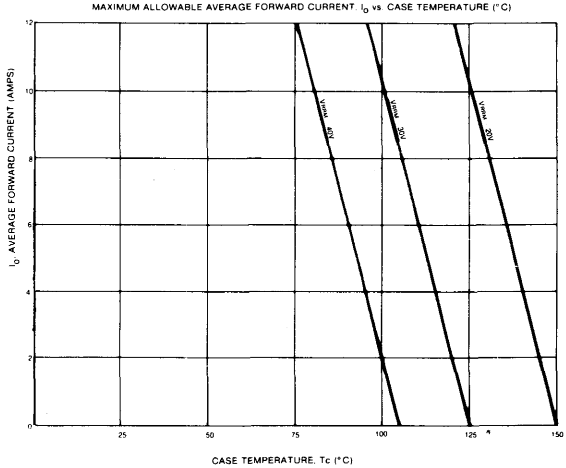
TYPICAL REVERSE LEAKAGE CHARACTERISTICS



TYPICAL FORWARD VOLTAGE

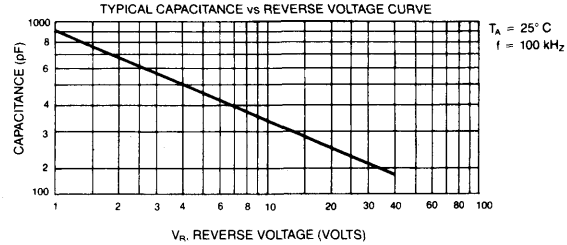


MAXIMUM ALLOWABLE AVERAGE FORWARD CURRENT, I_O vs. CASE TEMPERATURE (°C)



50% DUTY CYCLE
SQUARE WAVE
20 kHz

TYPICAL CAPACITANCE vs REVERSE VOLTAGE CURVE



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DLS 063

15 Amp Schottky Barrier Rectifiers

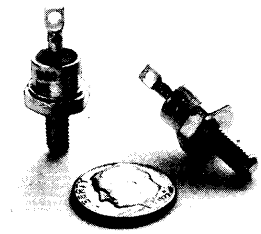
January 1980

20 Volt, 30 Volt and 40 Volt V_{RRM}

.600 Volt v_F AT i_F = 15.0 Amps

Very Fast Recovery Time

Standard DO 203AA (Formerly DO-4) Case

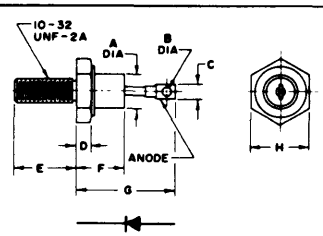


MAXIMUM RATINGS (At T_A = 25° C unless otherwise noted)	SYMBOL	VSK1520	VSK1530	VSK1540	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current (Fig. 5 & 6)	I_O	15.0			Amps
Ambient Temp. @ Rated V_{RM}, $R_{\theta JA} \leq$ 4.5° C/W	T_A	95	90	85	°C
Peak Surge Current (non-rep), 300μs Pulse Width (Fig.4)	I_{FSM}	500			Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig. 4)	I_{FSM}	300			Amps
Operating Junction Temperature	T_J	−65 to +150*			°C
Storage Temperature	T_{STG}	−65 to +150			°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5			°C/W

*$V_{RM} \leq$10V on VSK1520 or ≤15V on VSK1530 or ≤20V on VSK1540, $R_{\theta JA} \leq$4.5°C/W

ELECTRICAL CHARACTERISTICS (At T_A = 25° C unless otherwise noted)	SYMBOL	VSK1520	VSK1530	VSK1540	UNITS
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F — i_F = 8.0 Amps i_F = 15.0 Amps i_F = 45.0 Amps	v_F	 .500 .600 1.0			Volts
Maximum Instantaneous Reverse Current at Rated V_{RM} (1) See Fig. 1 for Typical i_R — T_C = 25°C T_C = 100°C	i_R	 10 75			mA

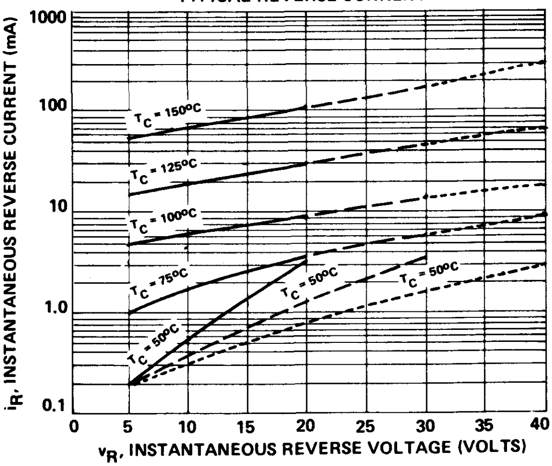
(1) Pulse Test: Pulse Width = 300μs, Duty Cycle = 2%



JEDEC Package

LTR.	INCHES	MILLIMETERS
A	.265 — .424	6,74 — 10,76
B	.060 — .095	1,53 — 2,41
C	.250 Max.	6,35 Max
D	.075 — .175	1,91 — 4,44
E	.422 — .453	10,72 — 11,5
F	.405 Max	10,28 Max
G	.800 Max.	20,32 Max
H	.423 — .438	10,75 — 11,12

FIG. 1.
TYPICAL REVERSE CURRENT

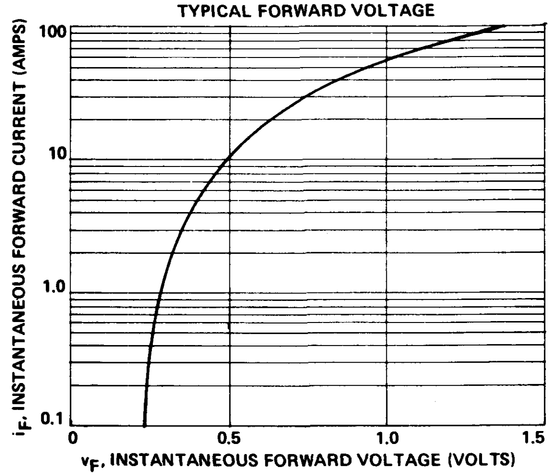


——————— VSK1520
— — — — — VSK1530
- - - - - - - - - - VSK1540

PULSE WIDTH = 300 μsec

T_C = CASE TEMP. MEASURED IN 3/32" DEEP HOLE IN ONE OF HEX FLATS.

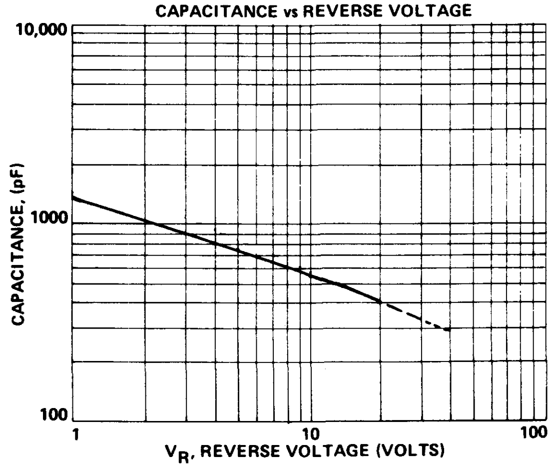
FIG. 2.
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°C

FIG. 3.
CAPACITANCE vs REVERSE VOLTAGE



——————— VSK1520
— — — — — VSK1530
- - - - - - - - - - VSK1540

T_A = 25°C

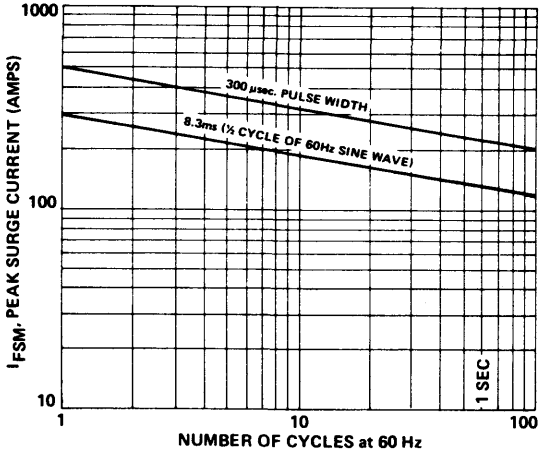
TEST FREQ = 100 kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a variable capacitance equal in value to the junction capacitance. See Figure 3.

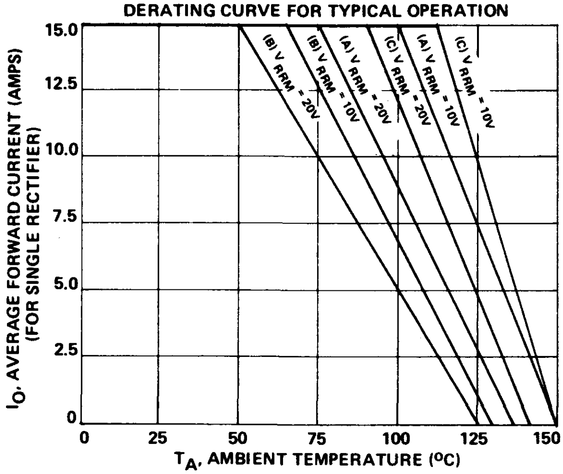
15 Amp Schottky Barrier Rectifiers

FIG. 4.
SURGE CURRENT vs NO. OF CYCLES (NON-REP.)



$T_A = 25^oC$

FIG. 5.
DERATING CURVE FOR TYPICAL OPERATION



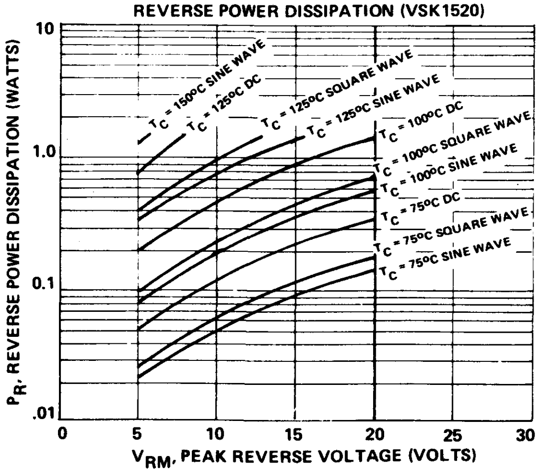
RECOMMENDED HEATSINKS

EACH RECTIFIER MUST BE ON A SEPARATE HEATSINK.

(A) THERMALLOY 6401B, Natural Convection
(B) WAKEFIELD NC680-1.25, Natural Convection
(C) WAKEFIELD NC68-1.25, 300'/Min. Air Flow.

CONDITIONS:
- VSK1520 RECTIFIERS.
- FULL WAVE CENTER TAPPED CIRCUIT.
- PEAK REVERSE VOLTAGE AS NOTED.
- FILTER CAP = 1200 µF
- 20 kHz SQUARE WAVE.

FIG. 6(A).
REVERSE POWER DISSIPATION (VSK1520)



REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 6(A), 6(B), 6(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 6(B).
REVERSE POWER DISSIPATION (VSK1530)

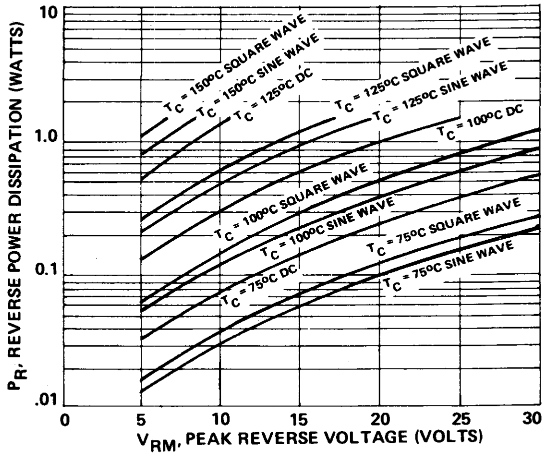


FIG. 6(C).
REVERSE POWER DISSIPATION (VSK1540)

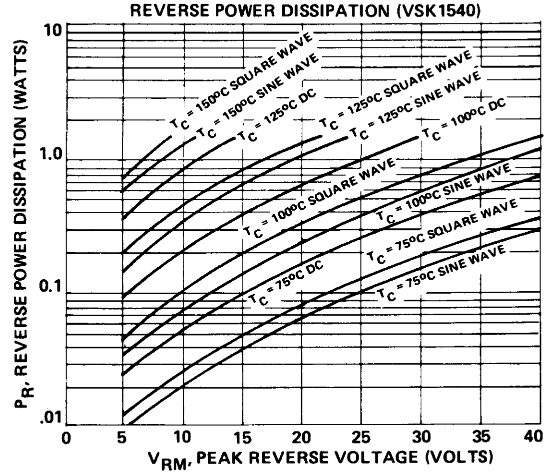


FIG. 6(D).
FORWARD POWER DISSIPATION
(VSK1520, VSK1530, VSK1540)

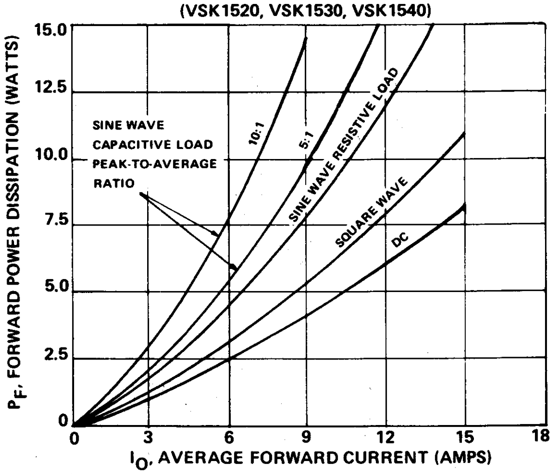
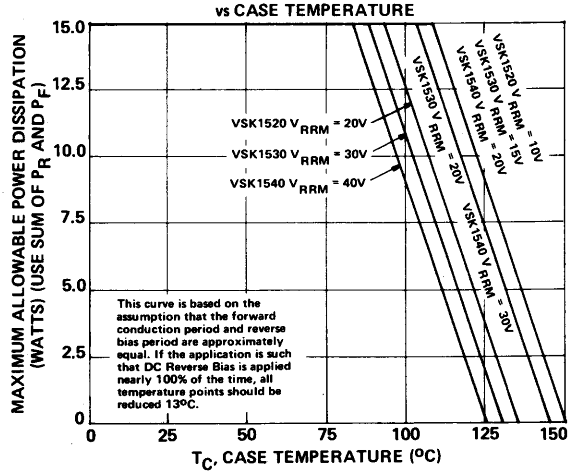


FIG. 6(E)
MAXIMUM ALLOWABLE POWER DISSIPATION
vs CASE TEMPERATURE



Thermal Considerations:

1. The derating curves of figure 5 may be used for initial design work; they are based on square wave operation.
2. Use the curves of figure 6 to study the voltage / current / temperature parameters. They are especially useful when studying heat sink design and for use with sine-waves. To use the curves, add the reverse power dissipation from figure 6 (A), (B) or (C) to the forward power dissipation from figure 6 (D). Then go to figure 6 (E) to find the maximum allowable case temperature.
3. **Therma** runaway is entirely possible on marginal designs due to the inherently large reverse *leakage* of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5° C of junction temperature increase.
4. Slightly higher case temperatures can be tolerated when the reverse voltage is lower than that shown in figure 6 (E).
5. If the application is such that DC reverse bias is applied nearly 100% of the time, all temperature points on curve 6 (E) should be reduced 13° C.
6. We recommend that all designs be verified at an ambient temperature at least 10° C higher than the maximum at which the equipment will ever have to operate.

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DLS 077

30 Amp Schottky Barrier Rectifiers

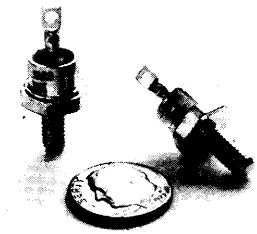
January 1980

20 Volt To 45 Volt V_{RRM}

.640 Volt V_F At i_F = 30.0 Amps

Very Fast Recovery Time

Standard DO 203AA (Formerly DO-4) Case

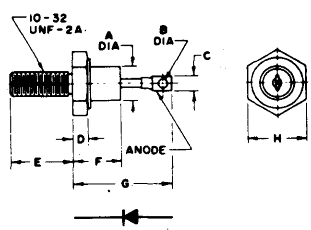


MAXIMUM RATINGS (At T_A = 25° C unless otherwise noted)	**SYMBOL**	**VSK41**	**VSK3020S**	**VSK3030S**	**VSK3040S**	**UNITS**
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	45	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	32	14	21	28	Volts
Average Rectified Forward Current (Fig. 5)	I_o	30.0				Amps
Ambient Temp. @ Rated V_{RM}, $R\theta_{JA} \leq 4.5$°C/W	T_A	80	90	85	80	°C
Peak Surge Current (non-rep), 300 μs Pulse Width (Fig. 4)	I_{FSM}	800	800			Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig. 4)	I_{FSM}	600	500			Amps
Operating Junction Temperature	T_J	−65 to +150*				°C
Storage Temperature	T_{STG}	−65 to +150				°C
Thermal Resistance, Junction to Case	$R\theta_{JC}$	2.0				°C/W

*At one-half rated V_{RRM}, $R\theta_{JA} \leq 3.5$°C/W

ELECTRICAL CHARACTERISTICS (At T_A = 25° C unless otherwise noted)	**SYMBOL**	**VSK41**	**VSK3020S**	**VSK3030S**	**VSK3040S**	**UNITS**
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F — i_F = 10.0 Amps i_F = 30.0 Amps i_F = 90.0 Amps	v_F	.55 @ 30 A 125°C	.510 .640 1.04			Volts
Maximum Instantaneous Reverse Current at Rated V_{RM}(1) See Fig. 1 for Typical i_R — (35V) T_C = 125°C T_C = 25°C T_C = 100°C	i_R	125	20 150			mA

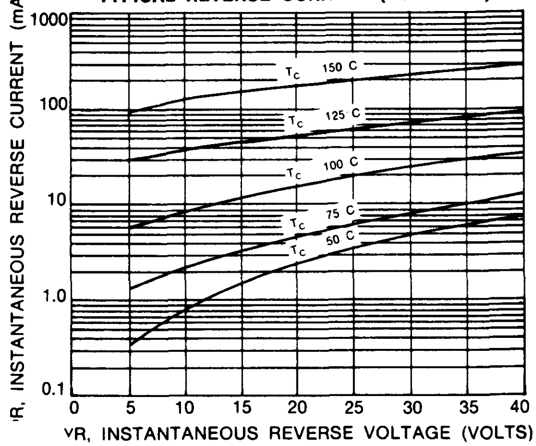
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%



JEDEC Package

LTR	INCHES	MILLIMETERS
A	.265 — .424	6,74 — 10,76
B	.060 — .095	1,53 — 2,41
C	.250 Max.	6,35 Max
D	.075 — .175	1,91 — 4,44
E	.422 — .453	10,72 — 11,5
F	.405 Max	10,28 Max
G	.800 Max.	20,32 Max
H	.423 — .438	10,75 — 11,12

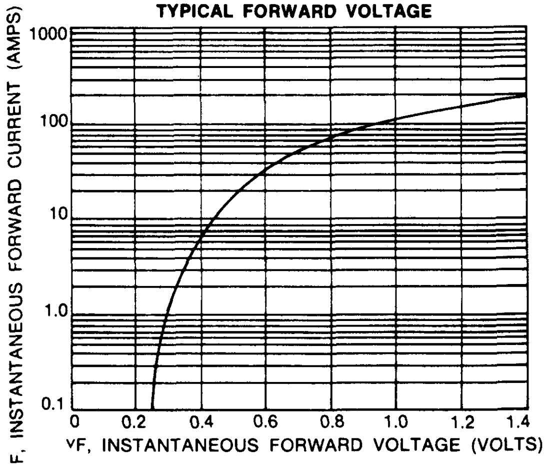
FIG. 1
TYPICAL REVERSE CURRENT (VSK 3040S)



PULSE WIDTH = 300 μsec

T_C = CASE TEMP. MEASURED IN 3/32" DEEP HOLE IN ONE OF HEX FLATS.

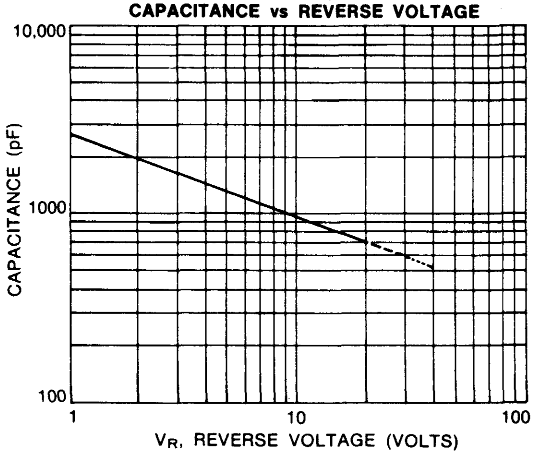
FIG. 2
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°

FIG. 3
CAPACITANCE vs REVERSE VOLTAGE



———————— VSK 3020S
— — — — — VSK 3030S
- - - - - - - - VSK 3040S

T_A = 25°C

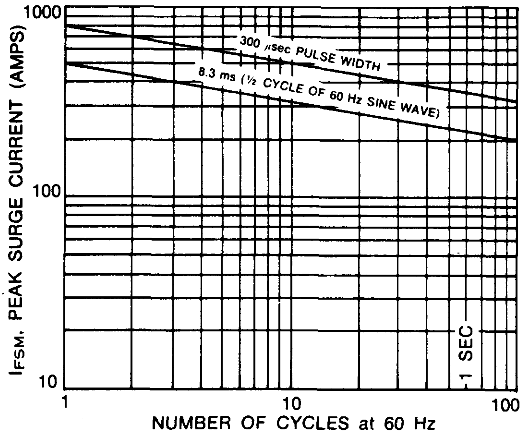
TEST FREQ = 100 kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a parallel capacitance equal in value to the junction capacitance. See Figure 3.

30 Amp Schottky Barrier Rectifiers

FIG. 4
SURGE CURRENT vs NO. OF CYCLES (NON-REP)



$T_A = 25°C$

FIG. 5(A)
REVERSE POWER DISSIPATION (VSK 3020S)

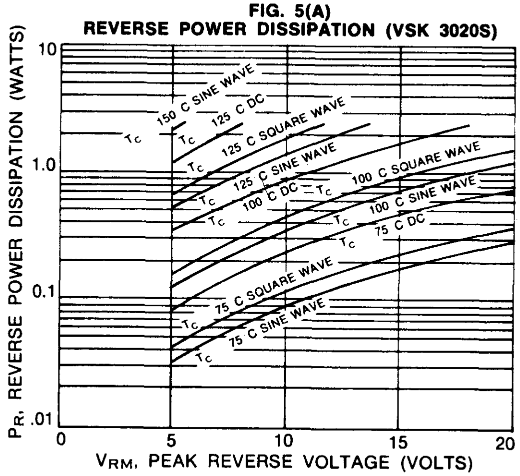
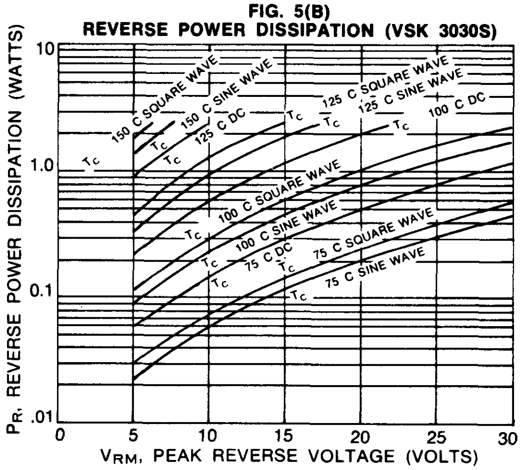


FIG. 5(B)
REVERSE POWER DISSIPATION (VSK 3030S)

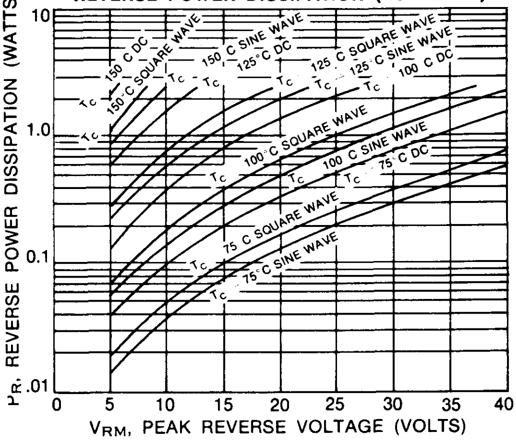


REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 5(A), 5(B), 5(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 5(C)
REVERSE POWER DISSIPATION (VSK 3040S)



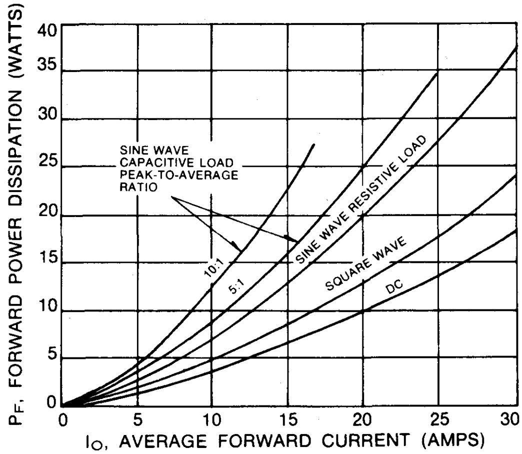
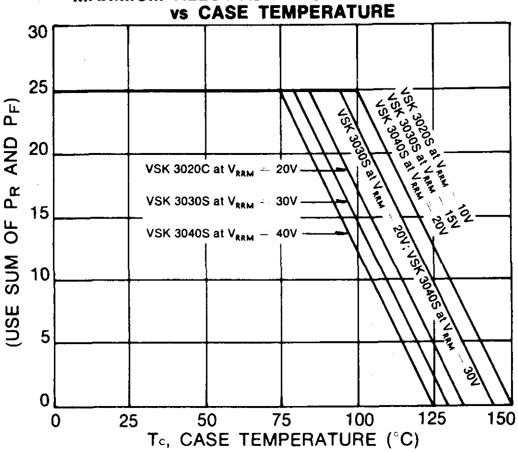


FIG. 5(E)
MAXIMUM ALLOWABLE POWER DISSIPATION
vs CASE TEMPERATURE



hermal Considerations:

Use the curves of Figure 5 to study the voltage/current/temperature parameters. To use the curves, add the reverse power dissipation from Figure 5 (A), (B) or (C) to the forward power dissipation from Figure 5 (D). Then go to Figure 5 (E) to find the maximum allowable case temperature.

2. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5°C of junction temperature increase.

3. Slightly higher case temperatures can be tolerated when the reverse voltage is lower than that shown in Figure 5 (E).

4. We recommend that all designs be verified at an ambient temperature at least 10°C higher than the maximum at which the equipment will ever have to operate.

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DLS 064

30 Amp Center Tapped Schottky Barrier Rectifiers

January 1980

20 Volt, 30 Volt and 40 Volt V_{RRM}

.640 Volt V_F at i_F = 15.0 Amps

Very Fast Recovery Time

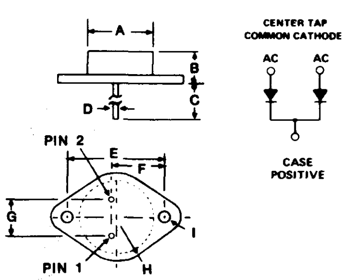
Standard To-3 Case

MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	**SYMBOL**	**VSK3020T**	**VSK3030T**	**VSK3040T**	**UNITS**
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current (Fig. 5)	I_o		30.0		Amps
Ambient Temp. @ Rated V_{RM}, $R_{\theta JA} \leq 4.5$°C/W Individual Junction	T_A	95	90	85	°C
Peak Surge Current (non-rep), 300 μs Pulse Width (Fig. 4)	I_{FSM}		500		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig 4)	I_{FSM}		300		Amps
Operating Junction Temperature	T_J		−65 to +150*		°C
Storage Temperature	T_{STG}		−65 to +150		°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$		1.5		°C/W

*At one-half rated V_{RRM}, $R_{\theta JA} \leq 4.5$°C/W

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	**SYMBOL**	**VSK3020T**	**VSK3030T**	**VSK3040T**	**UNITS**
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F — i_F = 8.0 Amps i_F = 15.0 Amps i_F = 45.0 Amps	v_F		.530 .640 1.04		Volts
Maximum Instantaneous Reverse Current at Rated V_{RM} (1) See Fig. 1 for Typical i_R — T_C = 25°C T_C = 100°C	i_R		10 75		mA

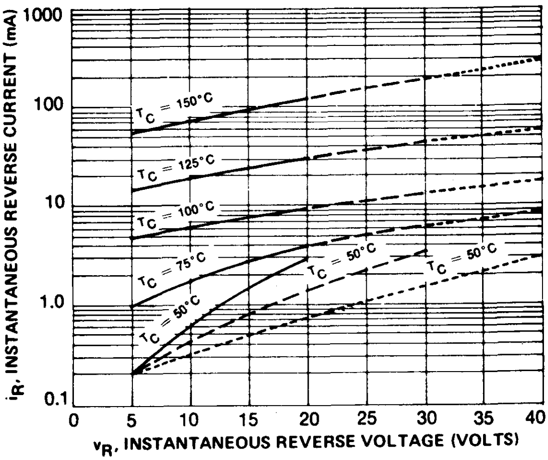
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%



All JEDEC TO-3 dimensions and notes are applicable.

LTR.	INCHES	MILLIMETERS
A	.72 Dia.	18,29
B	.323-.342	8,20-8,69
C	.40 Min.	10,16
D	.038-.043 Dia.	,97-1,09
E	1.180-1.194	29,97-30,33
F	.665-.675	16,89-17,15
G	.426-.440	10,82-11,18
H	.525R Max.	13,34
I	.151-.161 Dia.	3,84-4,09

FIG. 1.
TYPICAL REVERSE CURRENT



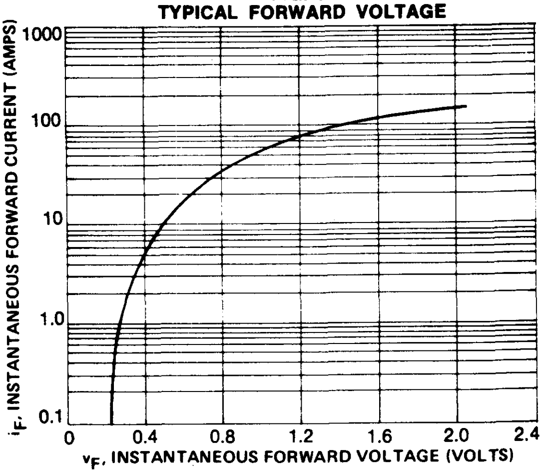
VSK3020T (solid line)
VSK3030T (long-dash line)
VSK3040T (short-dash line)

PULSE WIDTH = 300 μsec

T_C = CASE TEMP. MEASURED WITH SENSOR CENTERED ON BOTTOM OF CASE.

CURVES OF FIGURES 1, 2, 3 AND 4 ARE BASED ON INDIVIDUAL JUNCTIONS. CURVES OF FIGURE 5 ARE BASED ON TOTAL PACKAGE.

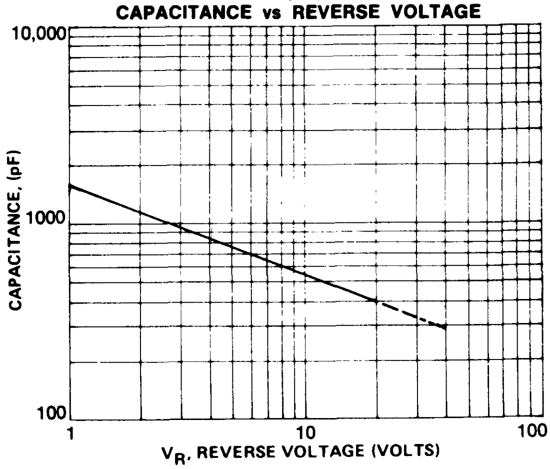
FIG. 2.
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°C

FIG. 3.
CAPACITANCE vs REVERSE VOLTAGE



VSK3020T (solid line)
VSK3030T (long-dash line)
VSK3040T (short-dash line)

T_A = 25°C

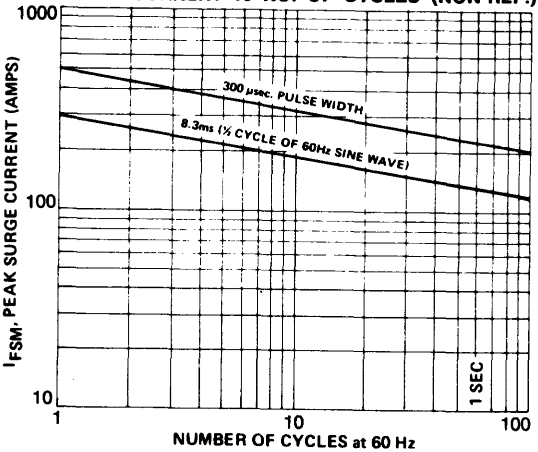
TEST FREQ = 100 kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a variable capacitance equal in value to the junction capacitance. See Figure 3.

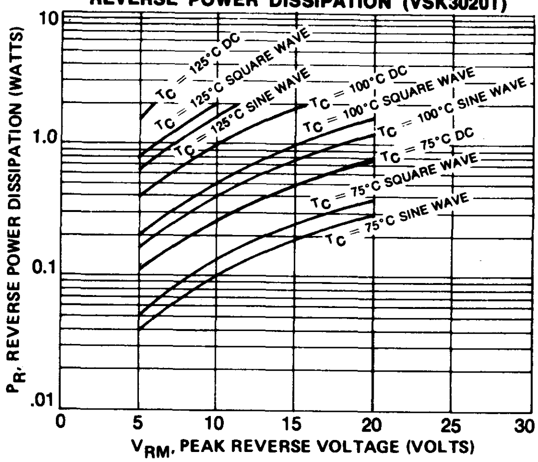
30 Amp Center Tapped Schottky Barrier Rectifiers

FIG. 4.
SURGE CURRENT vs NO. OF CYCLES (NON-REP.)



$T_A = 25°C$

FIG. 5(A).
REVERSE POWER DISSIPATION (VSK3020T)



REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 5(A), 5(B), 5(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 5(B).
REVERSE POWER DISSIPATION (VSK3030T)

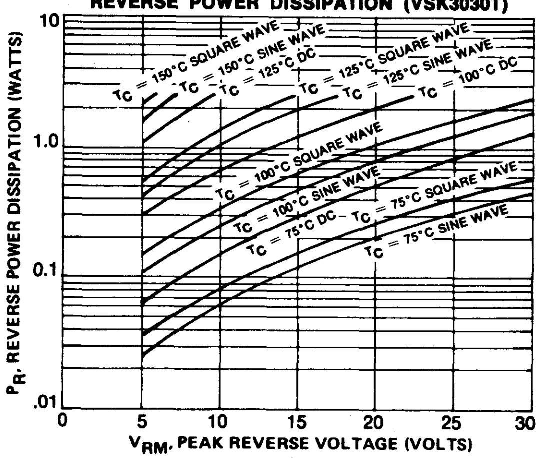


FIG. 5(C).
REVERSE POWER DISSIPATION (VSK3040T)

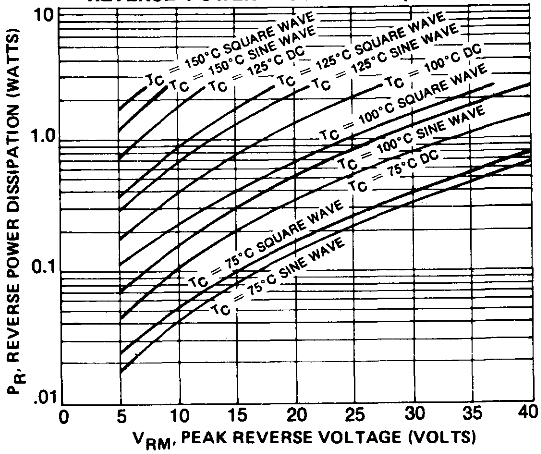


FIG. 5(D).
FORWARD POWER DISSIPATION
(VSK3020T, VSK3030T, VSK3040T)

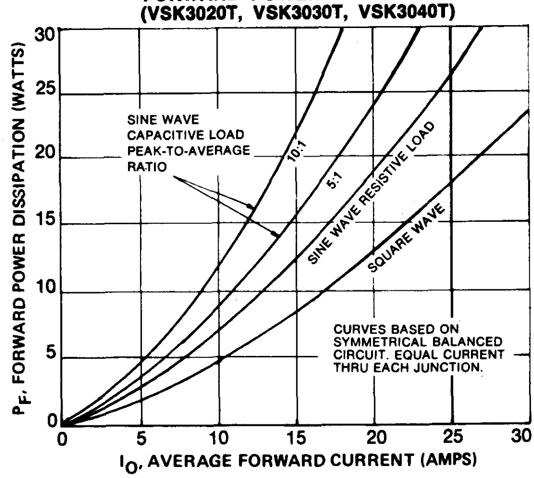
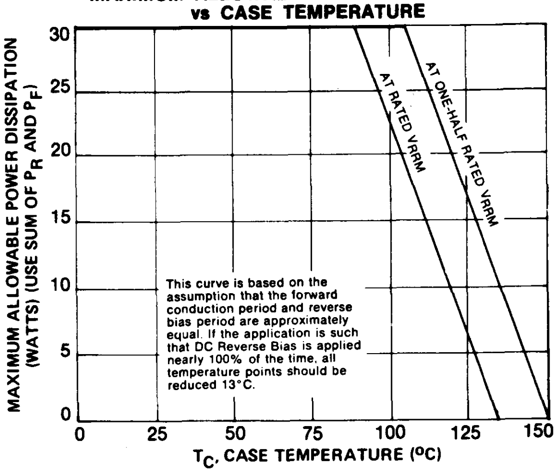


FIG. 5(E).
MAXIMUM ALLOWABLE POWER DISSIPATION
vs CASE TEMPERATURE



Thermal Considerations:

1. Use the curves of Figure 5 to study the voltage / current / temperature parameters. To use the curves, add the reverse power dissipation from Figure 5 (A), (B) or (C) to the forward power dissipation from Figure 5 (D). Then go to Figure 5 (E) to find the maximum allowable case temperature.
2. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5° C of junction temperature increase.
3. Slightly higher case temperatures can be tolerated when the reverse voltage is lower than that shown in Figure 5 (E).
4. We recommend that all designs be verified at an ambient temperature at least 10° C higher than the maximum at which the equipment will ever have to operate.

VARO

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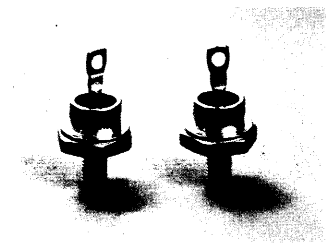
DLS 074

40 Amp Schottky Barrier Rectifiers

January 1980

20 Volt, 30 Volt and 40 Volt V_{RRM}
.620 Volt v_F At $i_F = 40.0$ Amps
Very Fast Recovery Time
Standard DO-5 Stud Mount Case

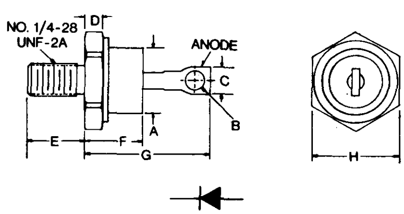


MAXIMUM RATINGS (At $T_A = 25°C$ unless otherwise noted)	SYMBOL	VSK 4020	VSK 4030	VSK 4040	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	20	30	40	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current	I_O		40.0		Amps
Ambient Temp. @ Rated V_{RM}, $R_{\theta JA} \leq 2.0°$ C/W	T_A	90	85	80	°C
Peak Surge Current (non-rep), 300μs Pulse Width (Fig. 4)	I_{FSM}		800		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz (Fig. 4)	I_{FSM}		500		Amps
Operating Junction Temperature	T_J		−65 to +150*		°C
Storage Temperature	T_{STG}		−65 to +150		°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$		1.0		°C/W

*$V_{RM} \leq 10V$ on VSK 4020 or $\leq 15V$ on VSK 4030 or $\leq 20V$ on VSK 4040, $R_{\theta JA} \leq 2.0°$ C/W

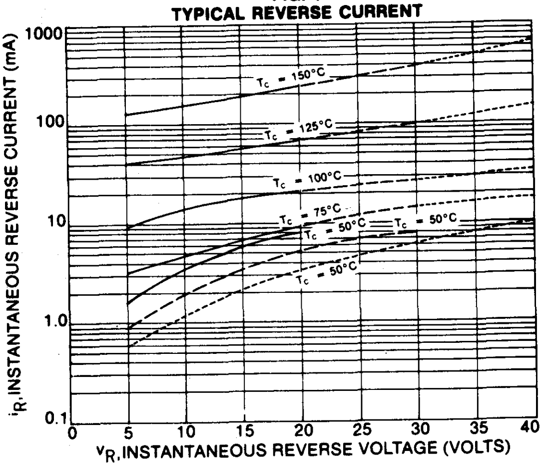
ELECTRICAL CHARACTERISTICS (At $T_A = 25°C$ unless otherwise noted)	SYMBOL	VSK 4020	VSK 4030	VSK 4040	UNITS
Maximum Instantaneous Forward Voltage Drop (1) See Fig. 2 for Typical v_F — i_F = 20 amps i_F = 40 Amps i_F = 120 Amps	v_F		 .510 .620 .960		Volts
Maximum Instantaneous Reverse Current at Rated V_{RM} (1) See Fig. 1 for Typical i_R — $T_C = 25°C$ $T_C = 100°C$	i_R		 20 150		

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%



LTR.	INCHES	MILLIMETERS
A	.492-.502 D.	12,50-12,75 D.
B	.140 Min. D.	3,56 Min. D.
C	.225 Max.	5,72 Max.
D	.115-.200	2,92-5,08
E	.422-.453	10,72-11,51
F	.450 Max.	11,43 Max.
G	1.000 Max.	25,40 Max.
H	.667-.687	16,94-17,45

FIG. 1
TYPICAL REVERSE CURRENT

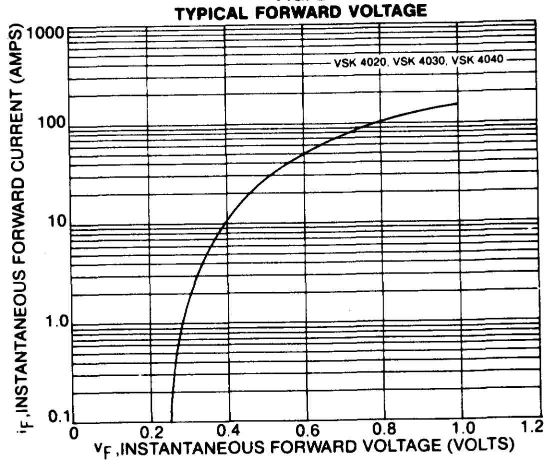


——————— VSK 4020
— — — — — —. VSK 4030
- - - - - - - - - -. VSK 4040

PULSE WIDTH = 300 μsec

T_C = CASE TEMP. MEASURED IN 3/32" DEEP HOLE IN ONE OF HEX FLATS.

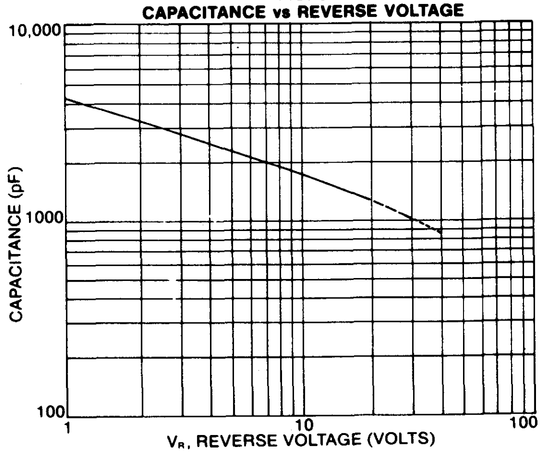
FIG. 2
TYPICAL FORWARD VOLTAGE



PULSE WIDTH = 300 μsec

T_A = 25°C

FIG. 3
CAPACITANCE vs REVERSE VOLTAGE



——————— VSK 4020
— — — — — —. VSK 4030
- - - - - - - - - - -. VSK 4040

T_A = 25°C

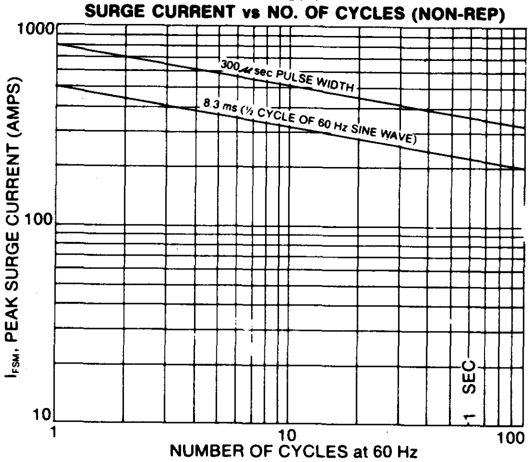
TEST FREQ = 100 kHz

The current flow in a Schottky barrier rectifier is due to majority carrier conduction and is not affected by reverse recovery transients due to stored charge and minority carrier injection as in conventional PN diodes.

The Schottky barrier rectifier may be considered for purposes of circuit analysis, as an ideal diode in parallel with a parallel capacitance equal in value to the junction capacitance. See Figure 3.

40 Amp Schottky Barrier Rectifiers

FIG. 4
SURGE CURRENT vs NO. OF CYCLES (NON-REP)



$T_A = 25°C$

FIG. 5(A)
REVERSE POWER DISSIPATION (VSK 4020)

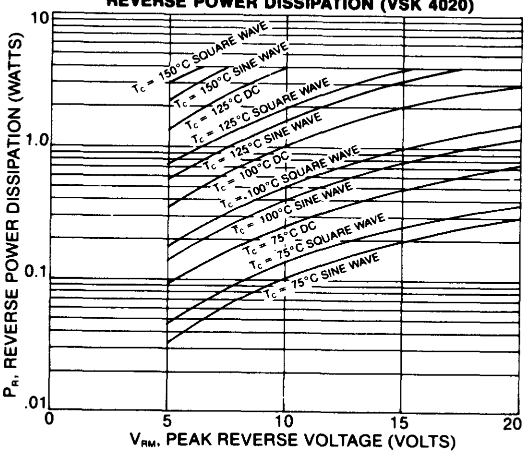
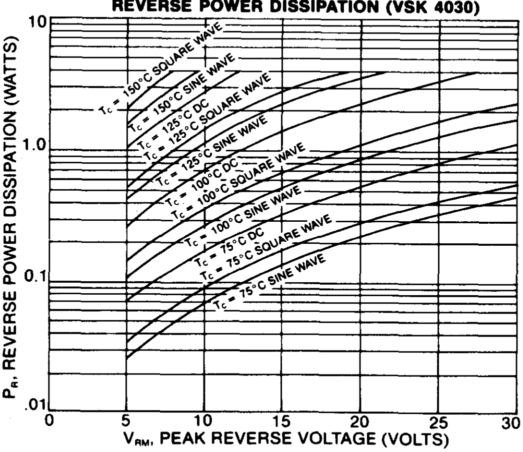


FIG. 5(B)
REVERSE POWER DISSIPATION (VSK 4030)



REVERSE POWER MULTIPLIES 1.32x FOR EACH 5°C TEMP. INCREASE.

USE THIS MULTIPLIER FOR INTERPOLATION BETWEEN CURVES SHOWN ON FIGURES 5(A), 5(B), 5(C).

USE 75°C CURVES FOR ALL CASE TEMP. BELOW 75°C.

FIG. 5(C)
REVERSE POWER DISSIPATION (VSK 4040)

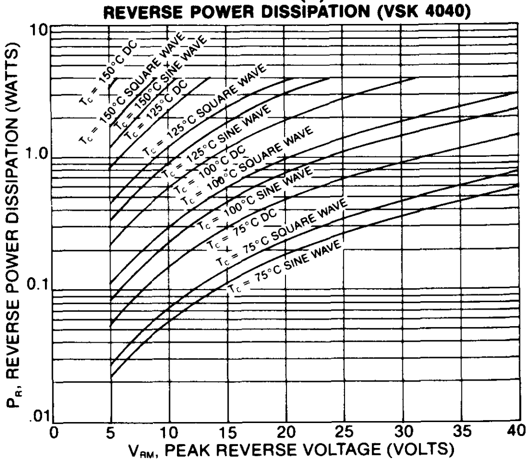


FIG. 5(D)
FORWARD POWER DISSIPATION
(VSK 4020, VSK 4030, VSK 4040)

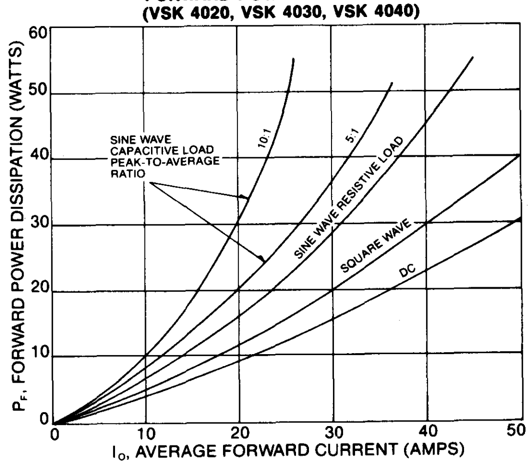
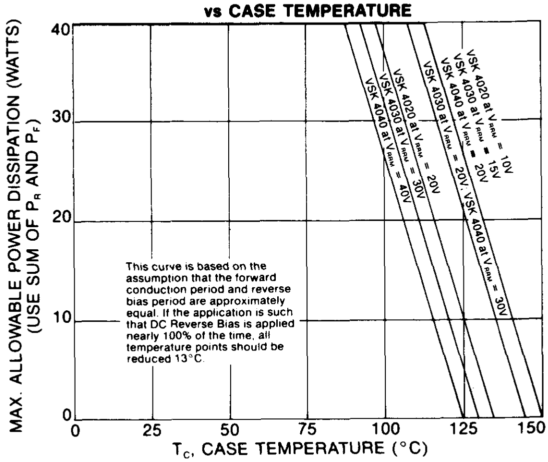


FIG. 5(E)
MAXIMUM ALLOWABLE POWER DISSIPATION
vs CASE TEMPERATURE



Thermal Considerations:

1. Use the curves of Figure 5 to study the voltage/current/temperature parameters. To use the curves, add the reverse power dissipation from Figure 5 (A), (B) or (C) to the forward power dissipation from Figure 5 (D). Then go to Figure 5 (E) to find the maximum allowable case temperature.
2. Thermal runaway is entirely possible on marginal designs due to the inherently large reverse leakage of Schottky barrier rectifiers and the fact that reverse power multiplies about 1.32 times for each 5°C of junction temperature increase.
3. Slightly higher case temperatures can be tolerated when the reverse voltage is lower than that shown in Figure 5 (E).
4. We recommend that all designs be verified at an ambient temperature at least 10°C higher than the maximum at which the equipment will ever have to operate.

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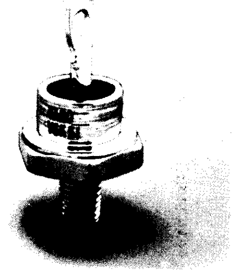
DLS 080

60Amp Schottky VSK51

January 1980

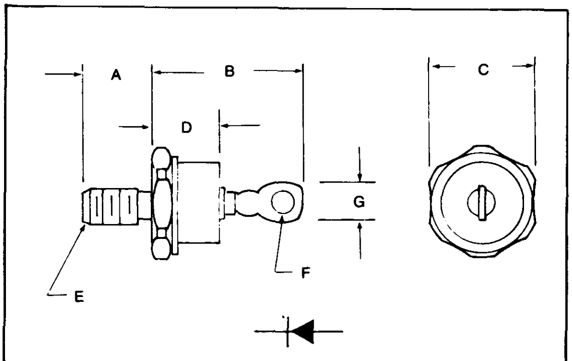
45 Volts V_{RRM}
.60 Volts V_F @ I_F = 60 Amps
Very Fast Recovery Time
Standard DO-5 Stud Mount Case



MAXIMUM RATINGS (At T_J = 25°C unless otherwise noted)	**SYMBOL**		**UNITS**
Peak Repetitive Reverse Voltage	V_{RRM}	45	Volts
Working Peak Reverse Voltage	V_{RWM}	35	
Peak Rectified Forward Current 50% Duty Cycle	I_F	120	Amps
Peak Surge Current (non-rep), 1/2 cycle, 60 Hz	I_{FSM}	800	Amps
Operating Junction Temperature	T_J	−65 to +150	°C
Storage Temperature	T_{STG}	−65 to +165	°C
Thermal Resistance, Junction to Case	$R\theta_{JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS (At T_J = 25°C unless otherwise noted)	**SYMBOL**		**UNITS**
Maximum Instantaneous Forward Voltage Drop (1) I_F = 60A I_F = 60 A, T_J = 125°C I_F = 120A I_F = 120A, T_J = 125°C	V_F	.70 .60 .87 .84	Volts
Maximum Instantaneous Reverse Current (2) V_R = 35V	i_R	50	mA
Maximum Instantaneous Reverse Current (2) V_R = 35V; T_J = 125°C	i_R	200	mA
Junction Capacitance V_R = 5V	C_J	4000	pF
Typical Reverse Recovery Time I_F = I_R = 1A, T_C = 125°C, 75% Recovery	t_{RR}	50	n-sec
Rate of Change (PIV VS. Time) V_R = 35 V max.	dv/dt	1000	V/μS

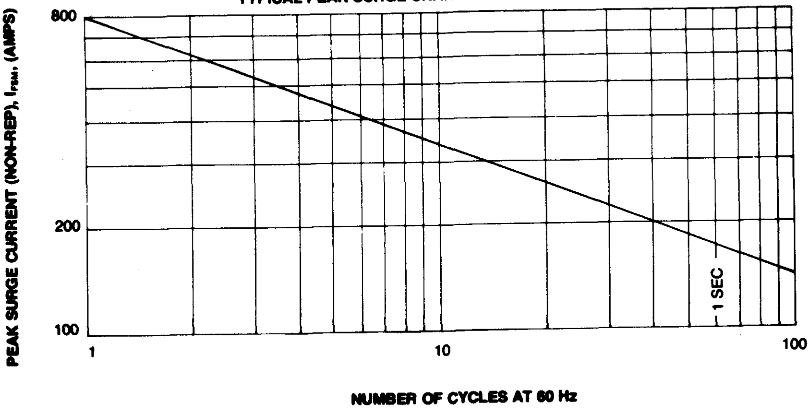
(1) Pulse test: pulse width = 300μSec., duty cycle 2%
(2) Pulse test: pulse width = 400μSec., duty cycle 1%



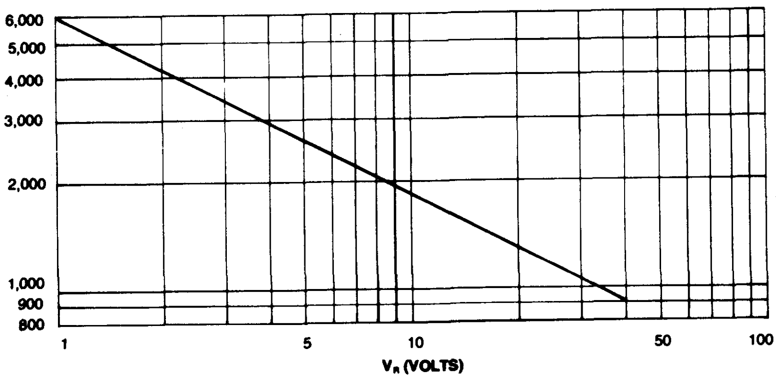
JEDEC Package 203AB (formerly DO-5)

Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	10.72	11.50	.422	.453
B	19.05	25.40	.750	1.000
C	17.00	17.47	.669	.688
D	—	11.43	—	.450
E	¼-28 UNF-2A	—	¼-28 UNF-2A	—
F	3.56	4.44	140	.175
G	—	9.52	—	.375

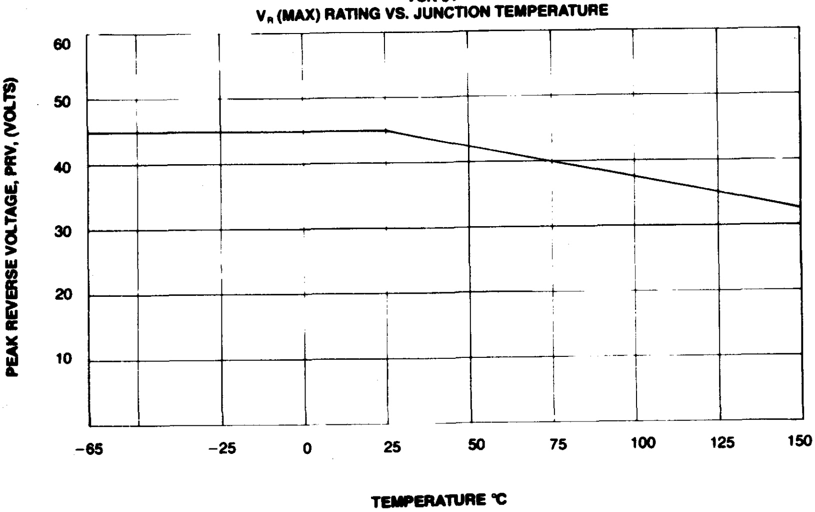
VSK 51
TYPICAL PEAK SURGE CHARACTERISTICS AT $T_A = 25°C$



VSK 51
TYPICAL JUNCTION CAPACITANCE VS. REVERSE VOLTAGE

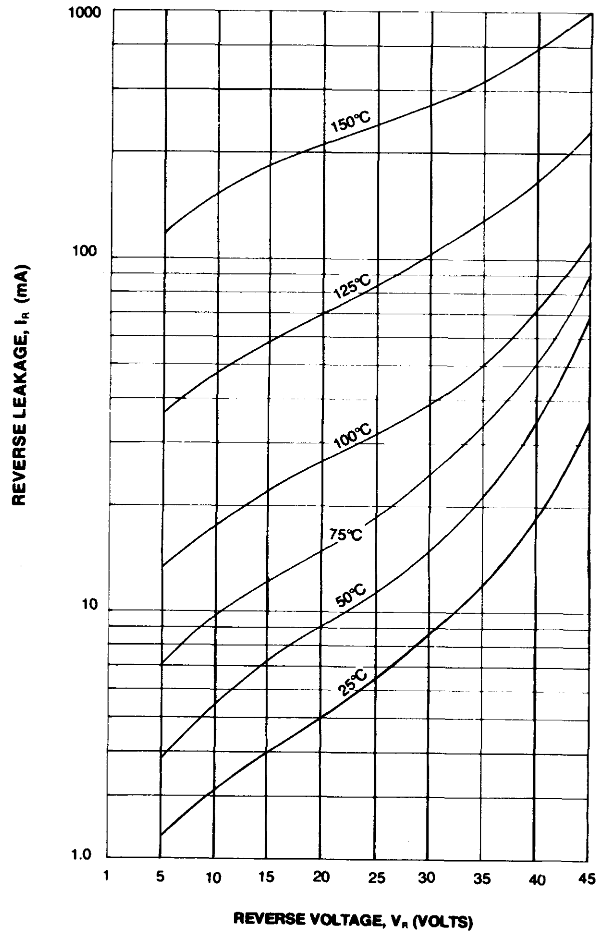


VSK 51
V_R (MAX) RATING VS. JUNCTION TEMPERATURE

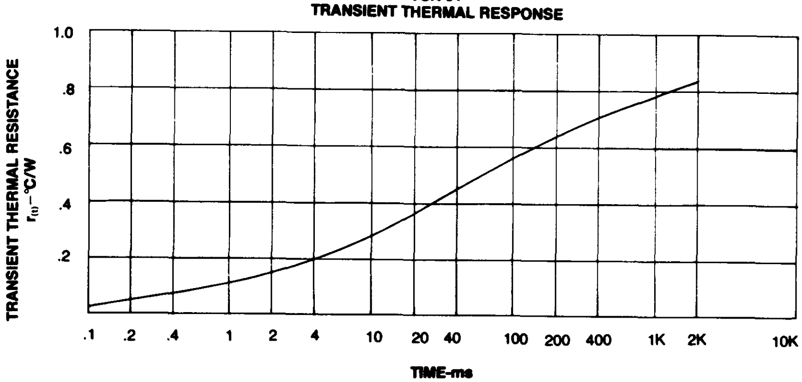


60 Amp Schottky

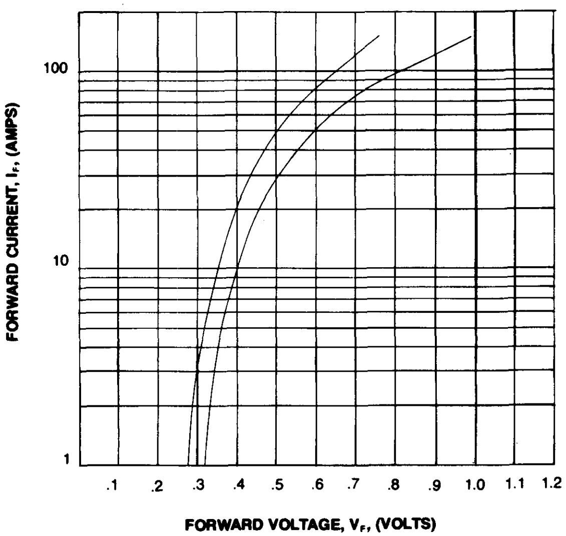
VSK 51
TYPICAL REVERSE CHARACTERISTICS



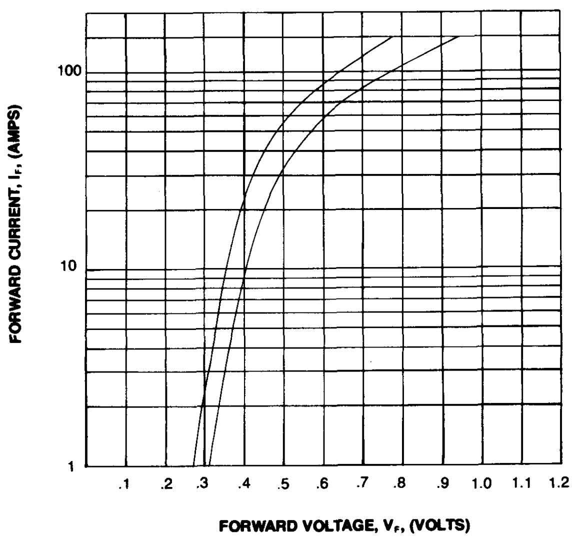
VSK 51
TRANSIENT THERMAL RESPONSE



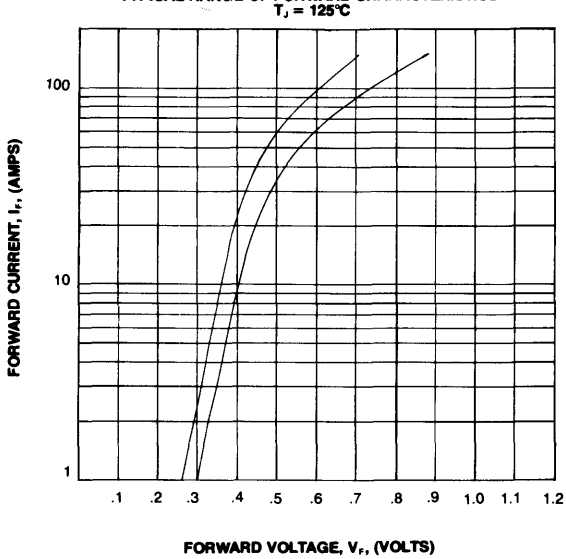
VSK 51
TYPICAL RANGE OF FORWARD CHARACTERISTICS
$T_J = 25°C$



VSK 51
TYPICAL RANGE OF FORWARD CHARACTERISTICS
$T_J = 75°C$



VSK 51
TYPICAL RANGE OF FORWARD CHARACTERISTICS
$T_J = 125°C$



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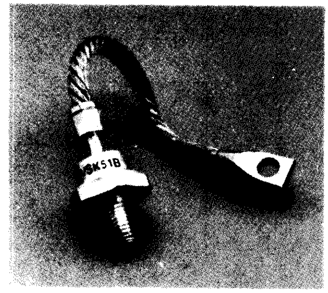
DLS 081

60Amp Schottky — Braided Lead VSK51B

January 1980

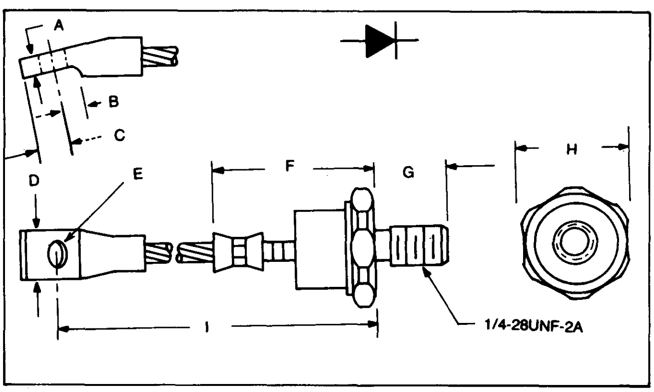
45 Volts V_{RRM}
.65 Volts V_F @ I_F = 60 Amps
Very Fast Recovery Time
Standard DO-5 Stud Mount Case with Braided Lead



MAXIMUM RATINGS (At T_J = 25°C unless otherwise noted)	SYMBOL		UNITS
Peak Repetitive Reverse Voltage	V_{RRM}	45	Volts
Working Peak Reverse Voltage	V_{RWM}	35	
Peak Rectified Forward Current 50% Duty Cycle	I_F	120	Amps
Peak Surge Current (non-rep), 1/2 cycle, 60 Hz	I_{FSM}	800	Amps
Operating Junction Temperature	T_J	−65 to +150	°C
Storage Temperature	T_{STG}	−65 to +165	°C
Thermal Resistance, Junction to Case	$R\theta_{JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS (At T_J = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Instantaneous Forward Voltage Drop (1) I_F = 60A I_F = 60 A, T_J = 125°C I_F = 120A I_F = 120A, T_J = 125°C	V_F	0.75 (3) 0.65 0.92 0.89	Volts
Maximum Instantaneous Reverse Current (2) V_R = 35V	i_R	50	mA
Maximum Instantaneous Reverse Current (2) V_R = 35V; T_J = 125°C	i_R	200	mA
Junction Capacitance V_R = 5V	C_J	4000	pF
Typical Reverse Recovery Time I_F = I_R = 1A, T_C = 125°C, 75% Recovery	t_{RR}	50	n-sec
Rate of Change (PIV VS. Time) V_R = 35 V max.	dv/dt	1000	V/μS

(1) Pulse test: pulse width = 300μSec., duty cycle 2%
(2) Pulse test: pulse width = 400μSec., duty cycle 1%
(3) includes voltage drop across flexible lead

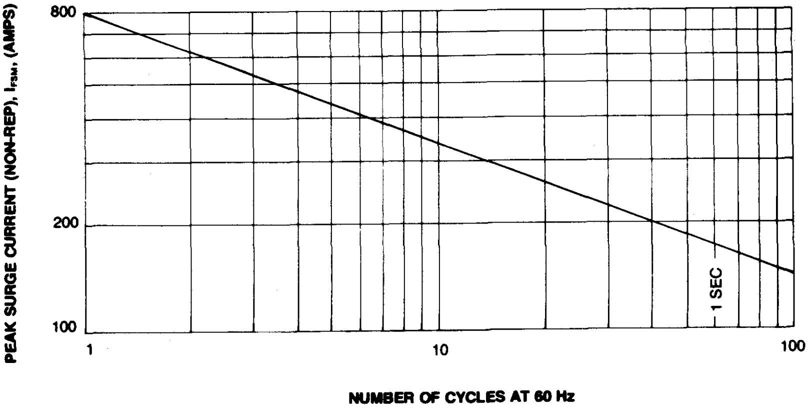


JEDEC package 203AB (formerly DO-5) except for braided lead extension

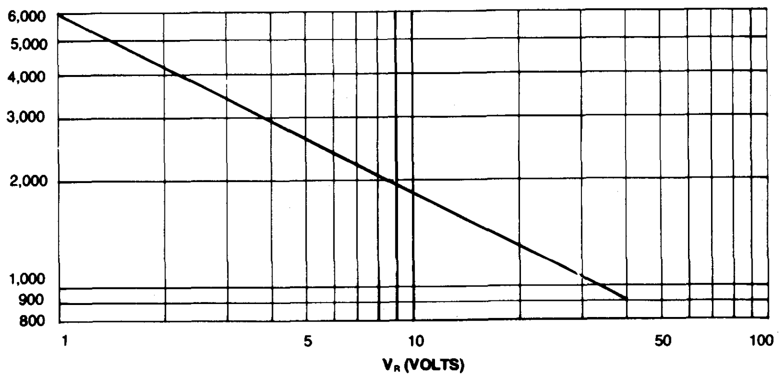
Dim.	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.78	3.30	.070	.130
B	5.84	—	.230	—
C	3.81	—	.150	—
D	7.62	10.16	.300	.400
E	—	4.78 dia.	—	.188 dia.
F	—	25.4	—	1.000
G	10.72	11.50	.422	.453
H	17.00	17.47	.669	.688
*I	93.98	101.60	3.700	4.000

*Other lengths available on request.

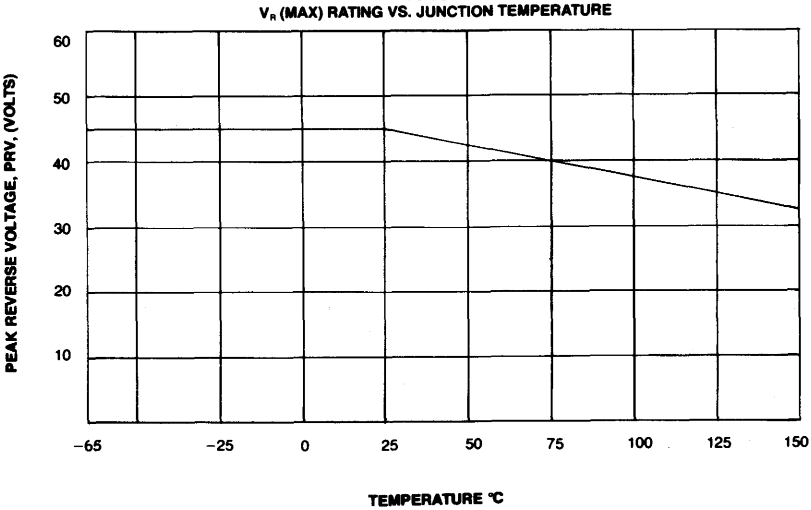
VSK 51B
TYPICAL PEAK SURGE CHARACTERISTICS AT T_A=25°C



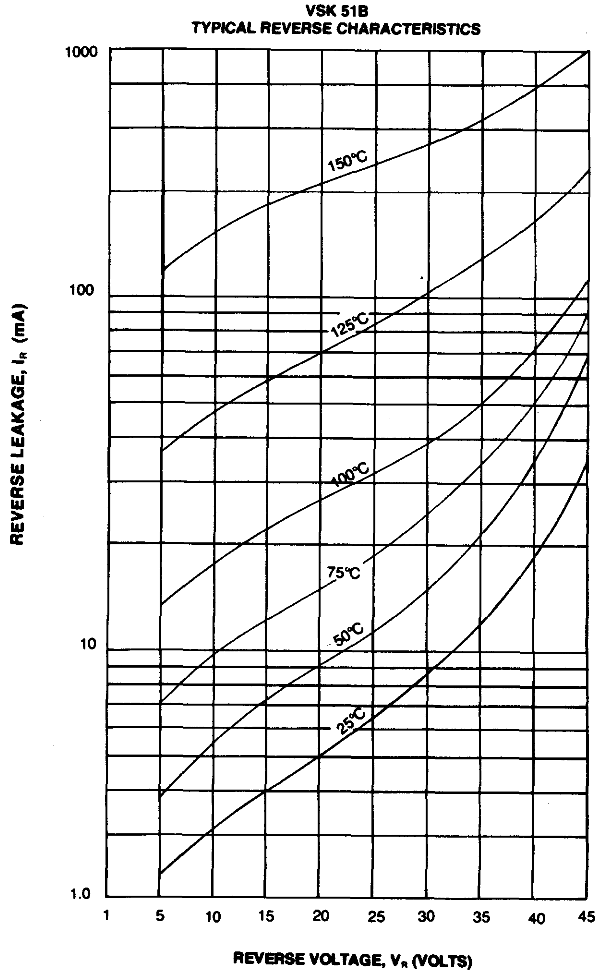
VSK 51B
TYPICAL JUNCTION CAPACITANCE VS. REVERSE VOLTAGE

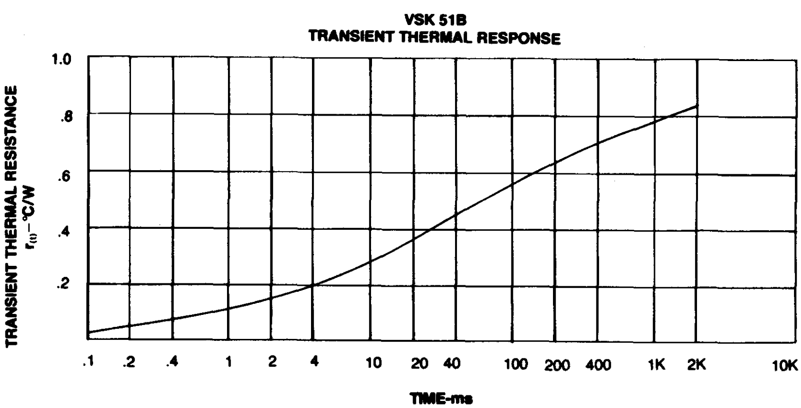


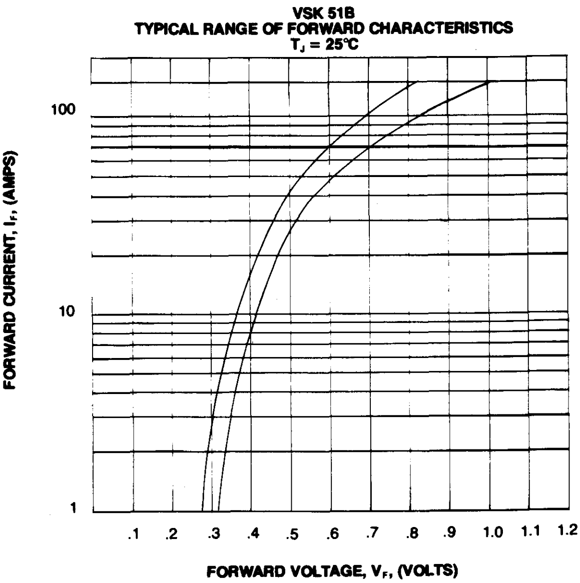
VSK 51B
V_R (MAX) RATING VS. JUNCTION TEMPERATURE

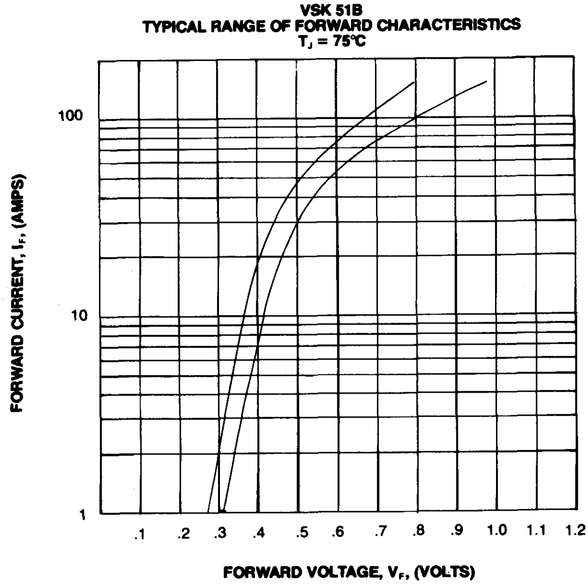


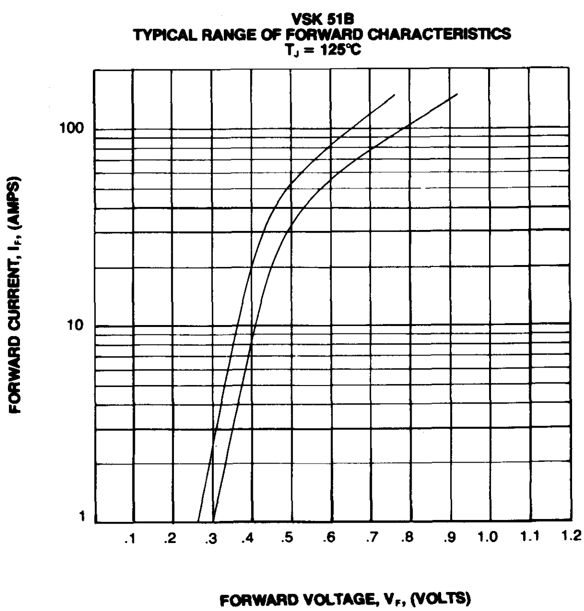
60 Amp Schottky — Braided Lead






VSK 51B
TYPICAL RANGE OF FORWARD CHARACTERISTICS
T_J = 25°C
FORWARD CURRENT, I_F, (AMPS)
100
10
1
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2
FORWARD VOLTAGE, V_F, (VOLTS)


VSK 51B
TYPICAL RANGE OF FORWARD CHARACTERISTICS
T_J = 75°C
FORWARD CURRENT, I_F, (AMPS)
100
10
1
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2
FORWARD VOLTAGE, V_F, (VOLTS)


VSK 51B
TYPICAL RANGE OF FORWARD CHARACTERISTICS
T_J = 125°C
FORWARD CURRENT, I_F, (AMPS)
100
10
1
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2
FORWARD VOLTAGE, V_F, (VOLTS)

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

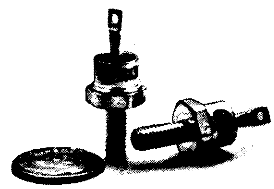
DLS099

30 Amp Schottky Barrier Rectifiers

VSK31, VSK32

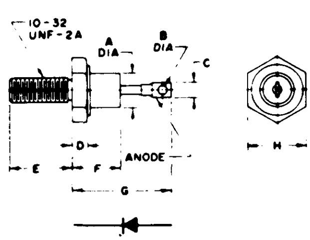
June 1981

50 Volts and 60 Volts V_{RRM}
30 Amps
175°C Junction Operating Temperature
Exceptional dv/dt: 2000 V/μs
D04 Package



MAXIMUM RATINGS **(At T_J = 25°C unless otherwise noted)**	**SYMBOL**	**VSK31**	**VSK32**	**Units**
Peak Repetitive Reverse Voltage	V_{RRM}	60	50	Volts
Working Peak Reverse Voltage	V_{RWM}	50	40	Volts
Peak Rectified Forward Current @ 50% Duty Cycle	I_F	60		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz	I_{FSM}	600		Amps
Operating Junction Temperature	T_J	−65 to +175		°C
Storage Temperature	T_{STG}	−65 to +175		°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.8		°C/W

Electrical Characteristics **(At T_J = 25°C unless otherwise noted)**	**SYMBOL**	**VSK31**	**VSK32**	**UNITS**
Maximum Instantaneous Forward Voltage Drop I_F = 30 Amps I_F = 60 Amps	V_F	25°C 150°C 175°C 0.68 — 0.53 0.80 0.75 0.70		Volts
Maximum Instantaneous Reverse Current I_F = 25°C I_F = 125°C I_F = 150°C	I_R	10 25 50		mA
Junction Capacitance	C_J	2000		pF
Typical Reverse Recovery Time $I_F = I_R$ = 1A, T_C = 125°C, 75% Recovery	t_{rr}	50		n-sec
Rate of Change (PIV vs Time) V_R = max	dv/dt	2000		V/μs
Maximum Repetitive Peak Reverse Current 20 μ sec pulse f = 2KHz	I_{RM}	4		Amps



JEDEC Package

LTR	INCHES	MILLIMETERS
A	.265 — .424	6.74 — 10.76
B	.060 — .095	1.53 — 2.41
C	.250 Max.	6.35 Max
D	.075 — .175	1.91 — 4.44
E	.422 — .453	10.72 — 11.5
F	.405 Max	10.28 Max
G	.800 Max.	20.32 Max
H	.423 — .438	10.75 — 11.12

TYPICAL FORWARD CHARACTERISTICS

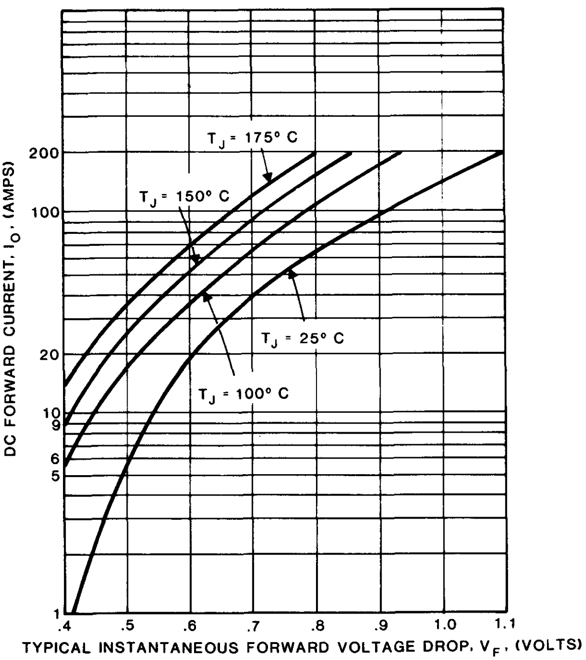


FIGURE 1

TYPICAL REVERSE CHARACTERISTICS

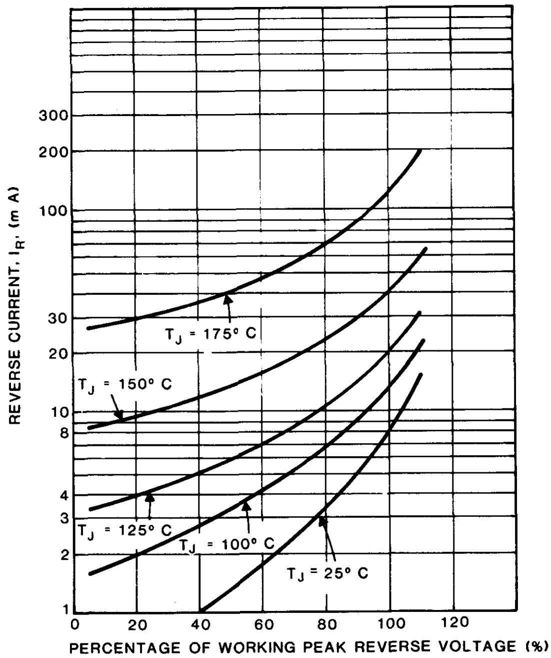


FIGURE 2

SURGE CURRENT VS NO. OF CYCLES (NON-REP.)

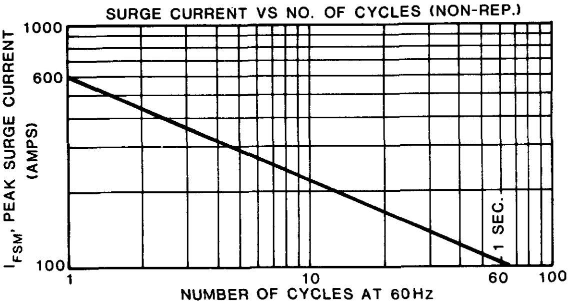


FIGURE 3

TYPICAL DEVICE CAPACITANCE VARIATIONS WITH REVERSE VOLTAGE

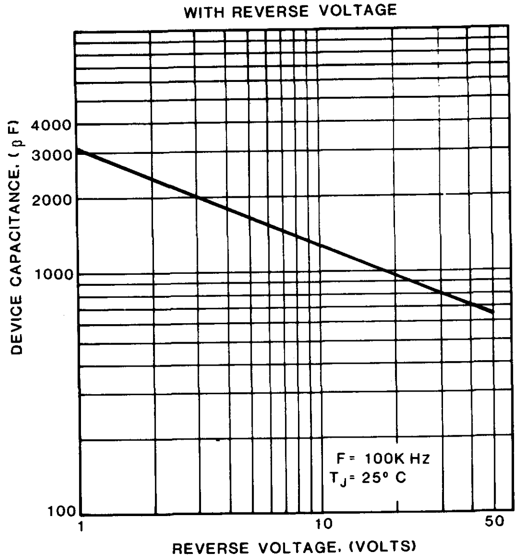


FIGURE 4

MAXIMUM OUTPUT CURRENT VS CASE TEMPERATURE

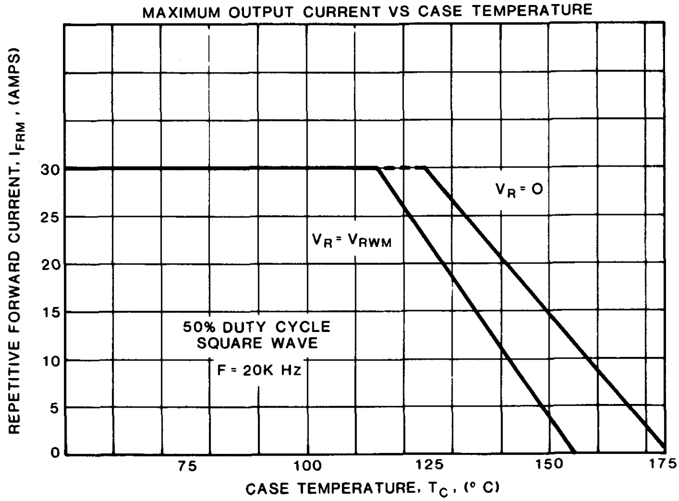


FIGURE 5

VARO

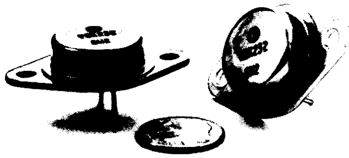
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS100

60 Amp Center Tapped Schottky Barrier Rectifiers

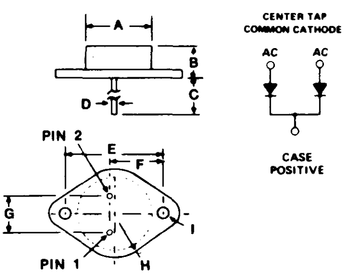
June 1981

50 Volt and 60 Volt V_{RRM}
30 Amps Per Leg
175°C Operating Junction Temperature
Low Forward Voltage Drop
Very Fast Recovery
Standard TO3 Package



MAXIMUM RATINGS (At T_J = 25°C unless otherwise noted)	SYMBOL	VSK231	VSK232	Units
Peak Repetitive Reverse Voltage	V_{RRM}	60	50	Volts
Working Peak Reverse Voltage	V_{RWM}	50	40	Volts
Peak Rectified Forward Current @ 50% Duty Cycle	I_F	60		Amps
Peak Surge Current (non-rep), ½ cycle, 60Hz	I_{FSM}	600		Amps
Operating Junction Temperature	T_J	−65 to +175		°C
Storage Temperature	T_{STG}	−65 to +175		°C
Thermal Resistance, Junction to Case	$R_{\Theta JC}$	1.4		°C/W

Electrical Characteristics (At T_J = 25°C unless otherwise noted)	SYMBOL	VSK 231	VSK 232	UNITS
Maximum Instantaneous Forward Voltage Drop per diode I_F = 30 Amps I_F = 60 Amps	V_F	25°C 0.74 0.92	175° C 0.6 0.82	Volts
Maximum Instantaneous Reverse Current per diode I_F = 25°C I_F = 125°C I_F = 150°C	I_R	10 25 50		mA
Junction Capacitance V_R = 5V	C_J	2000		pF
Typical Reverse Recovery Time $I_F = I_R$ = 1A, T_C = 125°C, 75% Recovery	t_{rr}	50		n-sec
Rate of Change (PIV vs Time) V_R = max	dv/dt	2000		V/µs
Maximum Repetitive Peak Reverse Current 20 µ sec pulse f = 2KHz	I_{RM}	4		Amps



All JEDEC TO-3 dimensions and notes are applicable.

LTR.	INCHES	MILLIMETERS
A	.72 Dia	18.29
B	.323 — .342	8.20 — 8.69
C	.40 Min.	10.16
D	.038 — .043 Dia	.97 — 1.09
E	1.180 — 1.194	29.97 — 30.33
F	.665 — .675	16.89 — 17.15
G	.426 — .440	10.82 — 11.18
H	.525R Max	13.34
I	.151 — .161 Dia	3.84 — 4.09

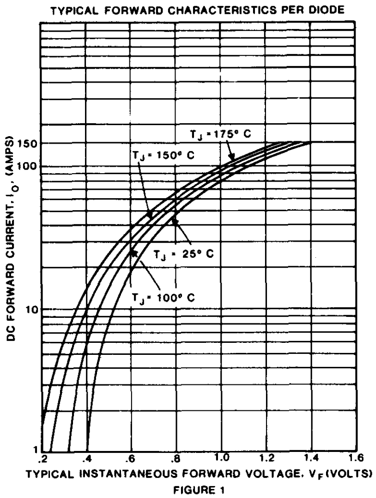


FIGURE 1

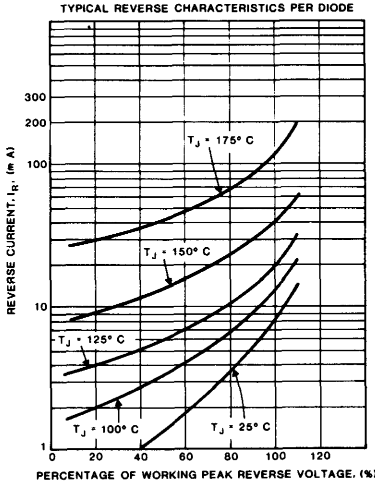


FIGURE 2

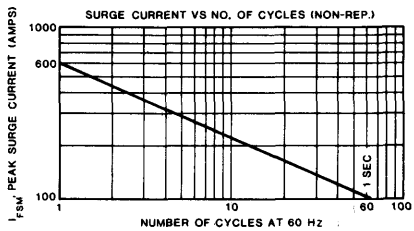


FIGURE 3

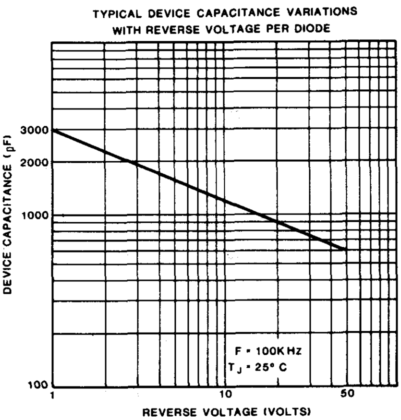


FIGURE 4

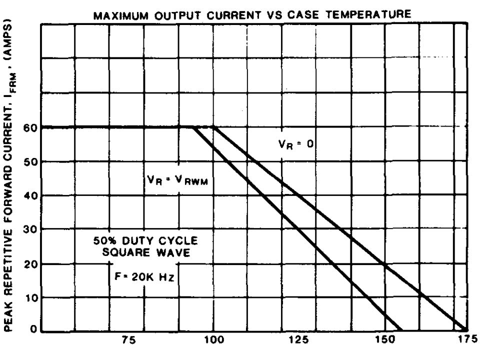


FIGURE 5

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

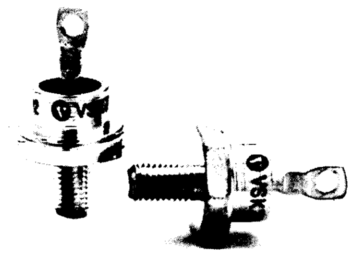
DLS101

75 Amp Schottky

VSK71, VSK72

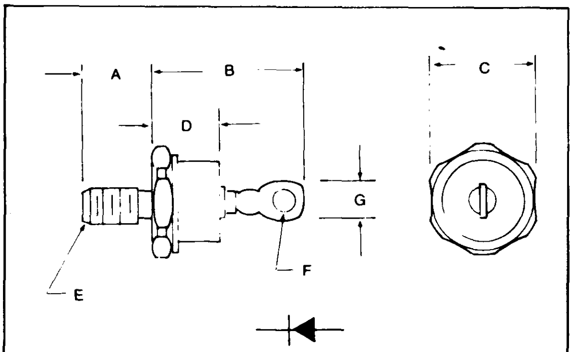
June 1981

50 Volts and 60 Volts V_{RRM}
75 Amps
175°C Junction Operating Temperature
Lowest I_R in the Industry
Exceptional dv/dt: 2000 V/$_{\mu}$S
DO5 Package



Maximum Ratings (At T_J = 25°C unless otherwise noted)	**SYMBOL**	**VSK71**	**VSK72**	**UNITS**
Peak Repetitive Reverse Voltage	V_{RRM}	60	50	Volts
Working Peak Reverse Voltage	V_{RWM}	50	40	Volts
Peak Rectified Forward Current @ 50% Duty Cycle	I_F	150		Amps
Peak Surge Current (non-rep), ½ cycle, 60 Hz	I_{FSM}	1000		Amps
Operating Junction Temperature	T_J	−65 to +175		°C
Storage Temperature	T_{STG}	−65 to +175		°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8		°C/W

Electrical Characteristics (At T_J = 25°C unless otherwise noted)	**SYMBOL**	**VSK71**	**VSK72**	**UNITS**
Maximum Instantaneous Forward Voltage Drop I_F = 60 Amps I_F = 75 Amps I_F = 150 Amps I_F = 220 Amps	V_F	25°C 125°C 175°C — 0.6 — 0.73 — 0.58 0.885 — 0.70 — 0.8 —		Volts
Maximum Instantaneous Reverse Current I_F = 25°C I_F = 125°C I_F = 150°C	I_R	20 50 100		mA
Junction Capacitance	C_J	4000		pF
Typical Reverse Recovery Time $I_F = I_R$ = 1A, t_C = 125°C, 75% Recovery	t_{rr}	50		n-sec
Rate of Change (PIV vs Time) V_R = max	dv/dt	2000		V/µs
Maximum Repetitive Peak Reverse Current 20 µ sec pulse, f = 2KHz	I_{RM}	5		Amps



JEDEC Package 203AB (formerly DO-5)

Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	10.72	11.50	.422	.453
B	19.05	25.40	.750	1.000
C	17.00	17.47	.669	.688
D	—	11.43	—	.450
E	¼-28 UNF-2A	—	¼-28 UNF-2A	—
F	3.56	4.44	140	.175
G	—	9.52	—	.375

TYPICAL FORWARD CHARACTERISTICS

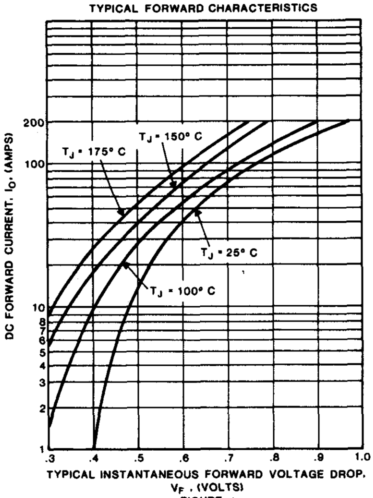


FIGURE 1

TYPICAL REVERSE CHARACTERISTICS

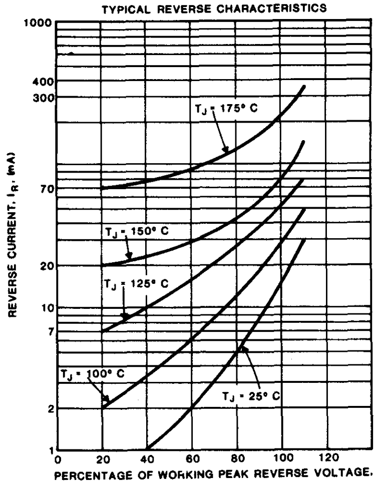


FIGURE 2

SURGE CURRENT VS NO. OF CYCLES (NON-REP.)

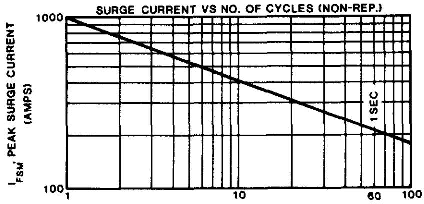


FIGURE 3

TYPICAL DEVICE CAPACITANCE VARIATIONS WITH REVERSE VOLTAGE

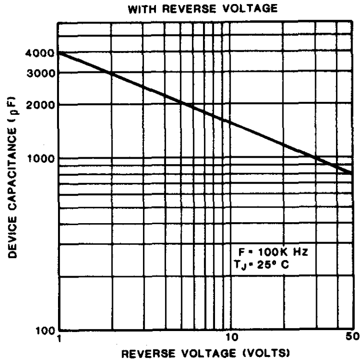


FIGURE 4

MAXIMUM OUTPUT CURRENT VS CASE TEMPERATURE

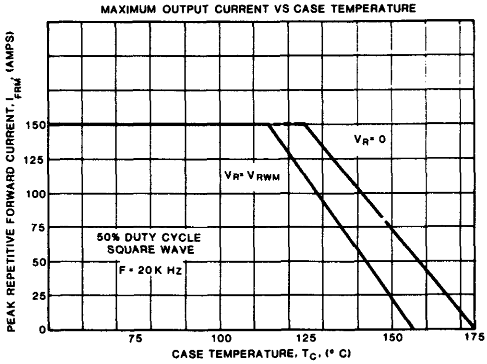


FIGURE 5

VARO

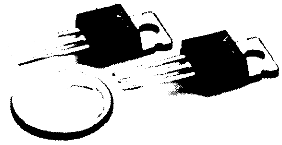
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS094

10 Amp High Efficiency Rectifiers

June 1981

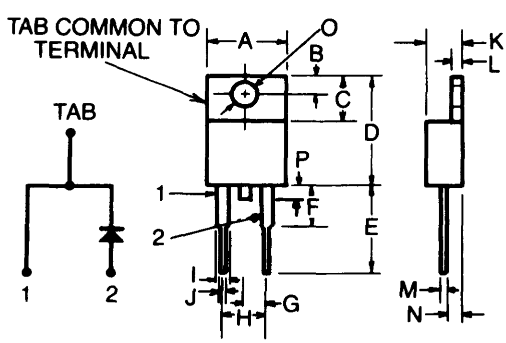
50 Volt, 100 Volt, 150 Volt and 200 Volt V_{RRM}
20% Non-repetitive Reverse Overvoltage Protection
Low Thermal Resistance
Extremely Low Leakage at High Temperature
High Surge Capability
Very Fast Switching Speeds
Economical TO220 Package
Glass Passivated



MAXIMUM RATINGS (At T_J = 25°C unless otherwise noted)	SYMBOL	VHE1401	VHE1402	VHE1403	VHE1404	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	150	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	105	140	Volts
Peak non-repetitive Reverse Voltage	V_{RM} (non-rep)	60	120	180	240	Volts
Average Rectified Forward Current @ T_C = 125°C	I_O	10				Amps
Peak Surge Current (non-rep), ½ cycle, 60 Hz	I_{FSM}	150				Amps
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.25				°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	− 65 to + 175				°C

Electrical Characteristics (At T_J = 25°C unless otherwise noted)	SYMBOL			UNITS
Maximum Instantaneous Forward Voltage per diode		T_J = 25°C	T_J = 100°C	
I_F = 4A	V_{FM}	0.9	0.8	Volts
I_F = 8A		0.975	0.895	
I_F = 10A		1.0	0.92	
I_F = 50A		1.4	1.3	
Maximum Reverse Current at Rated V_{RM} T_J = 25°C	I_{RM}	5		μA
T_J = 100°C		50		
T_J = 175°C		500		
Maximum Reverse Recovery Time I_F = ½A, I_R = 1A, I_{REC} = 0.25A	t_{rr}	35		n sec.
Maximum Capacitance, V_R = 10V	C_T	150		pF

TO220



DIM (2)	INCHES	MILLIMETERS
A	0.415 Max	10.54 Max
B	.108	2.74
C	.248	6.3
D	0.605 Max	15.37 Max
E	0.552	14.02
F	0.240 Max	6.1 Max
G	0.100	2.54
H	0.200	5.08
I	0.050	1.27
J	0.032	0.81
K	.190 Max	4.83 Max
L	0.050	1.27
M	0.022	0.56
N	0.105	2.67
O	0.143	3.63
P	0.100 Max	2.54 Max

(2) Dimensions are typical values unless otherwise specified.

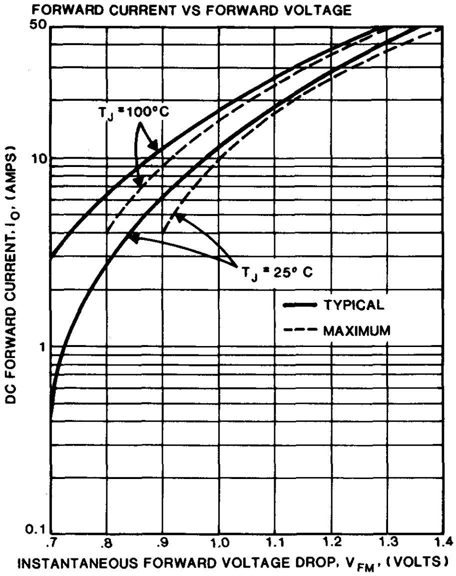


FIGURE 1

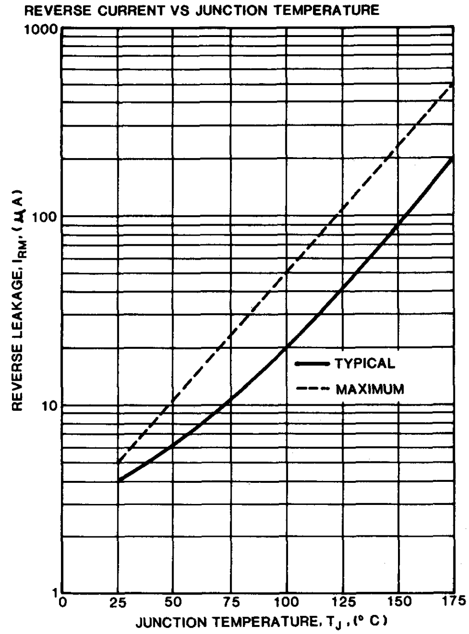


FIGURE 2

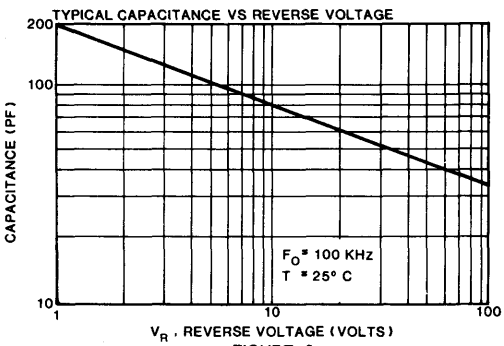


FIGURE 3

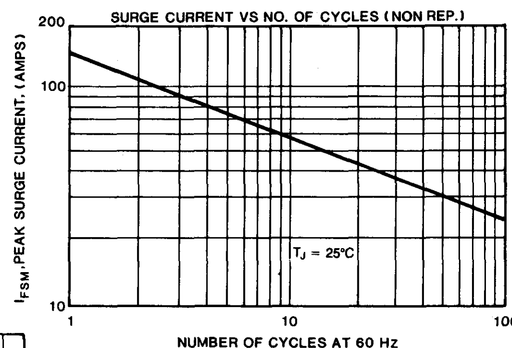


FIGURE 4

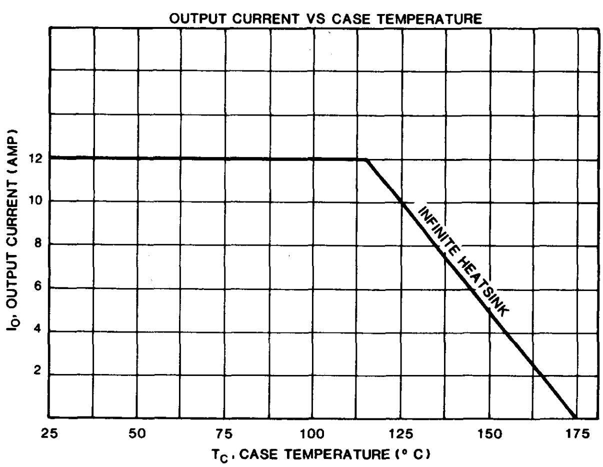


FIGURE 5

VARO

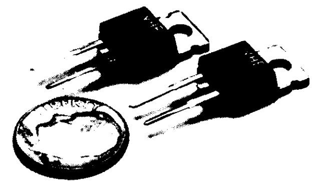
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS095

20 Amp Center Tapped High Efficiency Rectifiers

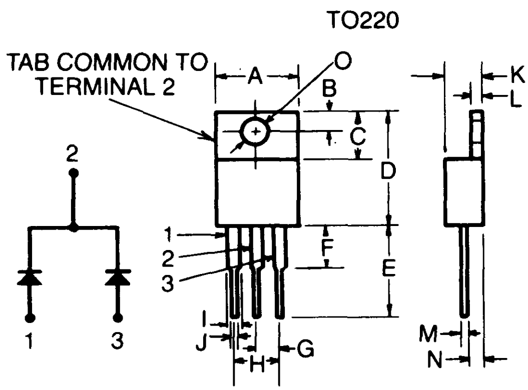
June 1981

50 Volt, 100 Volt, 150 Volt and 200 Volt V_{RRM}
20% Non-repetitive Reverse Overvoltage Protection
Low Thermal Resistance
Extremely Low Leakage at High Temperature
High Surge Capability
Very Fast Switching Speeds
Economical TO220 Package
Glass Passivated



MAXIMUM RATINGS (At $T_J = 25°C$ unless otherwise noted)	SYMBOL	VHE2401	VHE2402	VHE2403	VHE2404	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	150	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	105	140	Volts
Peak non-repetitive Reverse Voltage	V_{RM} (non-rep)	60	120	180	240	Volts
Average Rectified Forward Current @ $T_C = 125°C$	I_O	20				Amps
Peak Surge Current (non-rep), ½ cycle, 60 Hz	I_{FSM}	150				Amps
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5				°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	−65 to +175				°C

Electrical Characteristics (At $T_J = 25°C$ unless otherwise noted)	SYMBOL			UNITS
Maximum Instantaneous Forward Voltage per diode $I_F = 4A$ $I_F = 8A$ $I_F = 10A$ $I_F = 50A$	V_{FM}	$T_J = 25°C$ 0.9 0.975 1.0 1.4	$T_J = 100°C$ 0.8 0.895 0.92 1.3	Volts
Maximum Reverse Current at Rated V_{RM} $T_J = 25°C$ $T_J = 100°C$ $T_J = 175°C$	I_{RM}	5 50 500		µA
Maximum Reverse Recovery Time $I_F = ½A$, $I_R = 1A$, $I_{REC} = 0.25A$	t_{rr}	35		n sec.
Maximum Capacitance, $V_R = 10V$	C_T	150		pF



DIM (2)	INCHES	MILLIMETERS
A	0.415 Max	10.54 Max
B	.108	2.74
C	.248	6.3
D	0.605 Max	15.37 Max
E	0.552	14.02
F	0.240 Max	6.1 Max
G	0.100	2.54
H	0.200	5.08
I	0.050	1.27
J	0.035	0.89
K	.190 Max	4.83 Max
L	0.050	1.27
M	0.025 Max	0.64 Max
N	·0.105	2.67
O	0.143	3.63

(2) Dimensions are typical values unless otherwise specified.

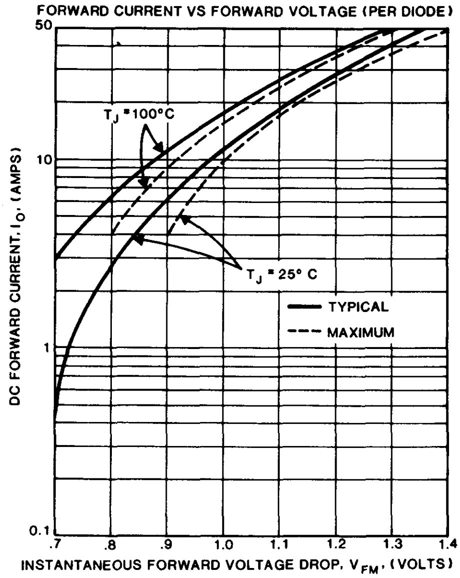


FIGURE 1

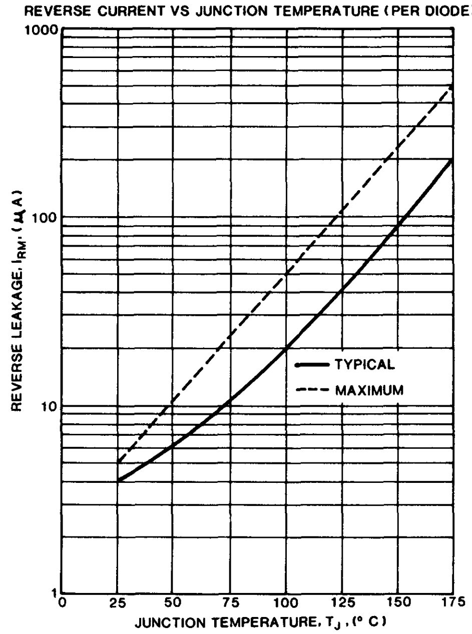


FIGURE 2

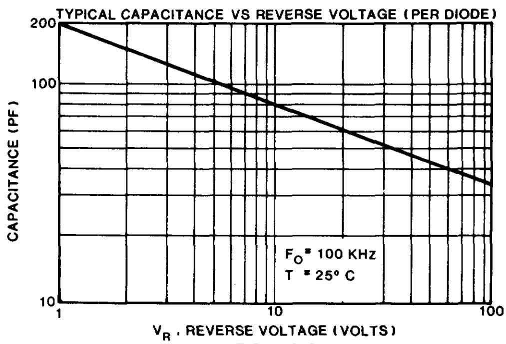


FIGURE 3

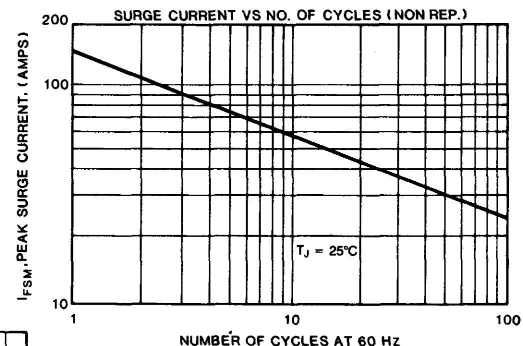


FIGURE 4

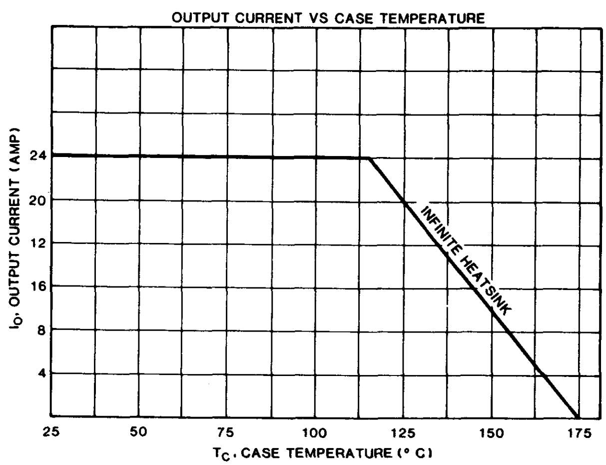


FIGURE 5

VARO

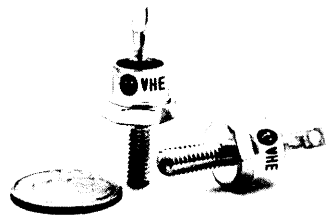
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS096

30 Amp High Efficiency Rectifiers

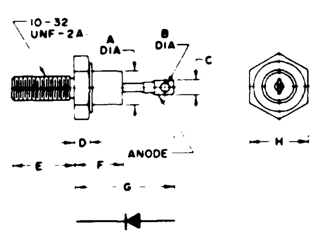
June 1981

50 Volt, 100 Volt, 150 Volt and 200 Volt V_{RRM}
20% Non-repetitive Reverse Overvoltage Protection
Low Thermal Resistance
Extremely Low Leakage at High Temperature
High Surge Capability
Very Fast Switching Speeds
Glass Passivated
Standard DO203AA Case (formerly DO4)



MAXIMUM RATINGS (At $T_J = 25°C$ unless otherwise noted)	SYMBOL	VHE701	VHE702	VHE703	VHE704	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	150	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	105	140	Volts
Peak non-repetitive Reverse Voltage	V_{RM} (non-rep)	60	120	180	240	Volts
Average Rectified Forward Current @ $T_C = 115°C$	I_O	30				Amps
Peak Surge Current (non-rep), ½ cycle, 60 Hz	I_{FSM}	500				Amps
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.25				°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	−65° to +175°				°C

Electrical Characteristics (At $T_J = 25°C$ unless otherwise noted)	SYMBOL			UNITS
Maximum Instantaneous Forward Voltage $I_F = 25A$ $I_F = 30A$ $I_F = 150A$	V_{FM}	$T_J = 25°C$ .95 .98 1.28	$T_J = 125°C$ .825 .90 1.20	Volts
Maximum Reverse Current at Rated V_{RM} $T_J = 25°C$ $T_J = 125°C$ $T_J = 175°C$	I_{RM}	20 200 1000		µA
Maximum Reverse Recovery Time, $I_F = ½A$, $I_R = 1A$, $I_{REC} = 0.25A$	t_{rr}	35		n sec.
Maximum Capacitance, $V_R = 10V$	C_T	500		pF



JEDEC Package

LTR	INCHES	MILLIMETERS
A	.265 — .424	6,74 — 10,76
B	.060 — .095	1,53 — 2,41
C	.250 Max.	6,35 Max
D	.075 — .175	1,91 — 4,44
E	.422 — .453	10,72 — 11,5
F	.405 Max	10,28 Max
G	.800 Max.	20,32 Max
H	.423 — .438	10,75 — 11,12

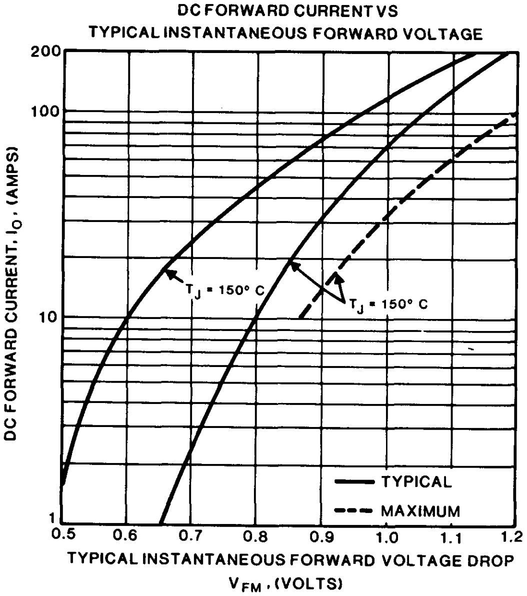


FIGURE 1

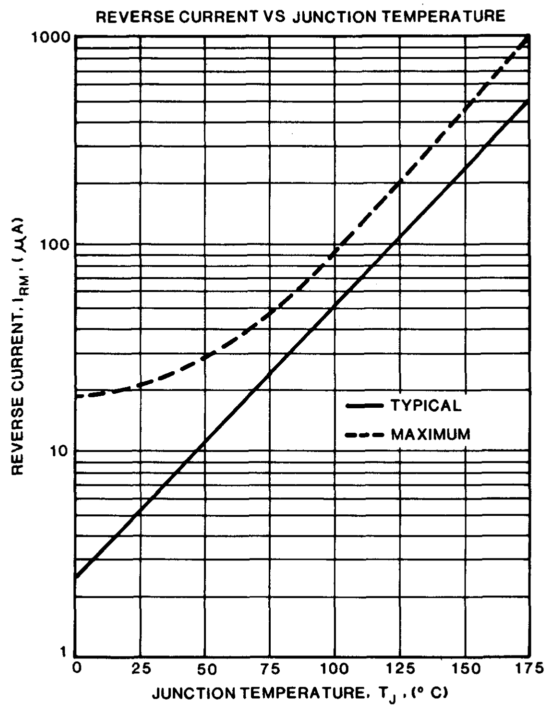


FIGURE 2

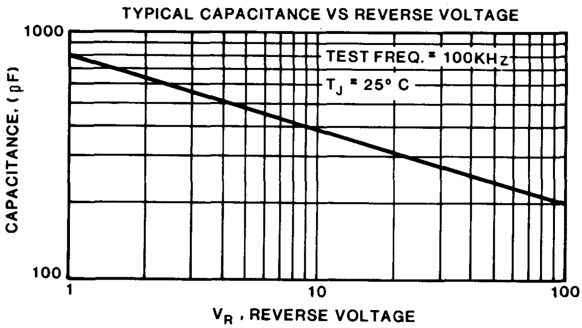


FIGURE 3

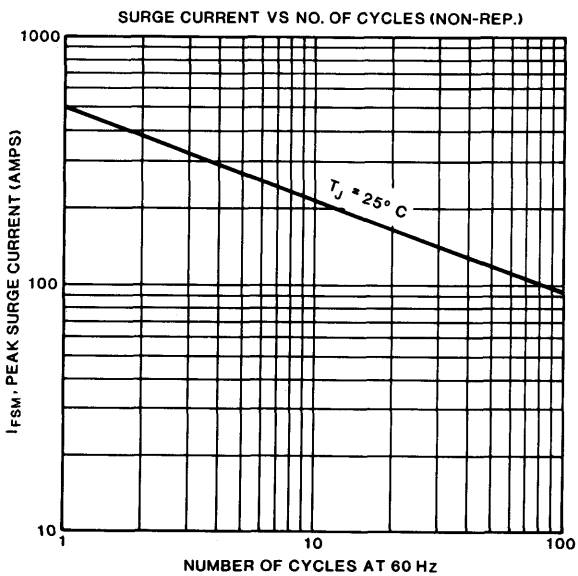


FIGURE 4

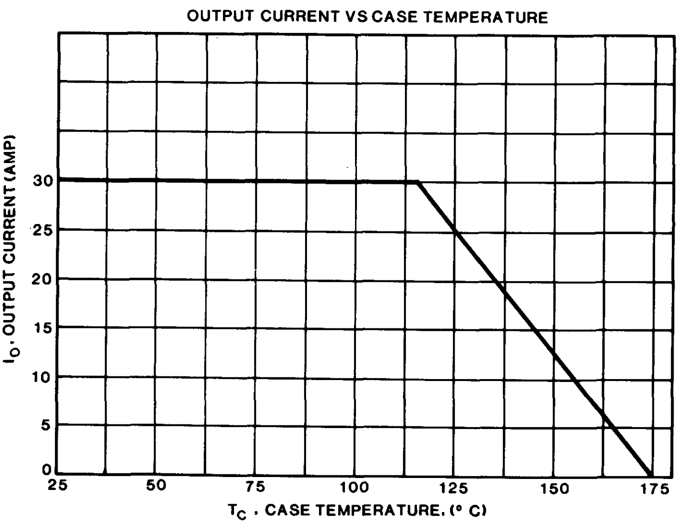


FIGURE 5

VARO

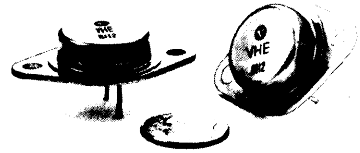
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS097

50 Amp Center Tapped High Efficiency Rectifiers

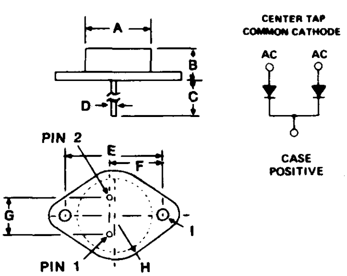
June 1981

50 Volt, 100 Volt, 150 Volt and 200 Volt V_{RRM}
20% Non-repetitive Reverse Overvoltage Protection
Low Thermal Resistance
Extremely Low Leakage at High Temperature
High Surge Capability
Very Fast Switching Speeds
Glass Passivated
Standard TO3 Case



MAXIMUM RATINGS (At $T_J = 25°C$ unless otherwise noted)	SYMBOL	VHE2601	VHE2602	VHE2603	VHE2604	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	150	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	105	140	Volts
Peak non-repetitive Reverse Voltage	V_{RM} (non-rep)	60	120	180	240	Volts
Average Rectified Forward Current @ $T_C = 115°C$	I_O	50				Amps
Peak Surge Current (non-rep), ½ cycle, 60 Hz	I_{FSM}	500				Amps
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8				°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	−65 to +175				°C

Electrical Characteristics (At $T_J = 25°C$ unless otherwise noted)	SYMBOL			UNITS
Maximum Instantaneous Forward Voltage per diode $I_F = 15A$ $I_F = 25A$ $I_F = 100A$	V_{FM}	$T_J = 25°C$ 0.93 1.0 1.4	$T_J = 125°C$ 0.8 0.87 1.3	Volts
Maximum Reverse Current at Rated V_{RM} per diode $T_J = 25°C$ $T_J = 125°C$ $T_J = 175°C$	I_{RM}	20 200 1000		µA
Maximum Reverse Recovery Time, $I_F = ½A$, $I_R = 1A$, $I_{REC} = 0.25A$	t_{rr}	35		n sec.
Maximum Capacitance, $V_R = 10V$	C_T	500		pF



All JEDEC TO-3 dimensions and notes are applicable.

LTR.	INCHES	MILLIMETERS
A	.72 Dia.	18.29
B	.323 — .342	8.20 — 8.69
C	.40 Min.	10.16
D	.038 — .043 Dia	.97 — 1.09
E	1.180 — 1.194	29.97 — 30.33
F	.665 — .675	16.89 — 17.15
G	.426 — .440	10.82 — 11.18
H	.525R Max.	13.34
I	.151 — .161 Dia	3.84 — 4.09

REVERSE CURRENT VS JUNCTION TEMPERATURE

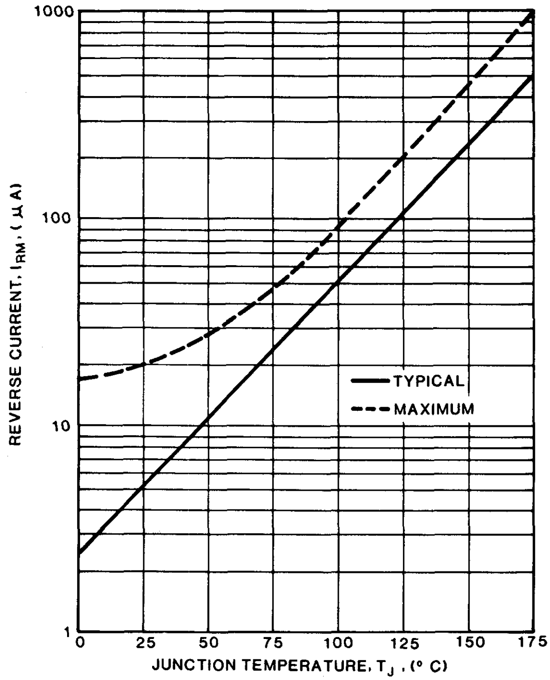


FIGURE 2

TYPICAL CAPACITANCE VS REVERSE VOLTAGE

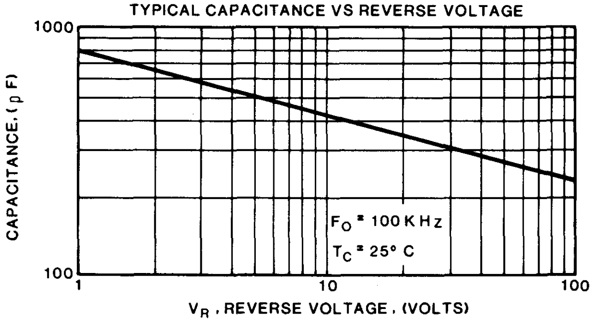


FIGURE 3

OUTPUT CURRENT VS CASE TEMPERATURE

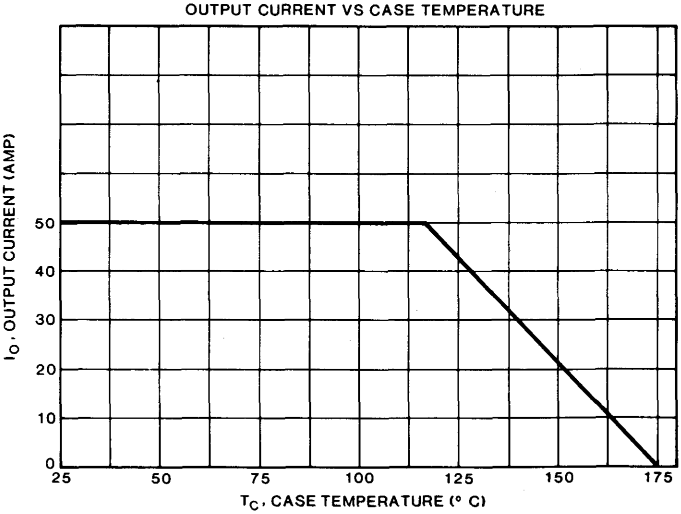


FIGURE 5

FORWARD CURRENT VS FORWARD VOLTAGE

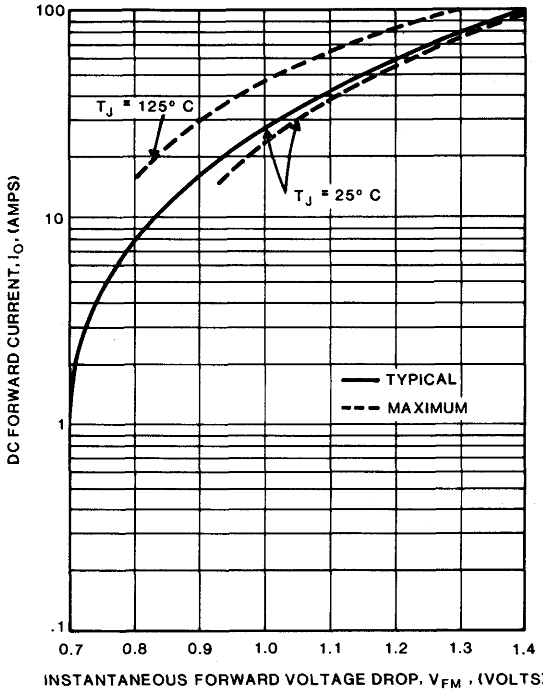


FIGURE 1

SURGE CURRENT VS NO. OF CYCLES (NON-REP.)

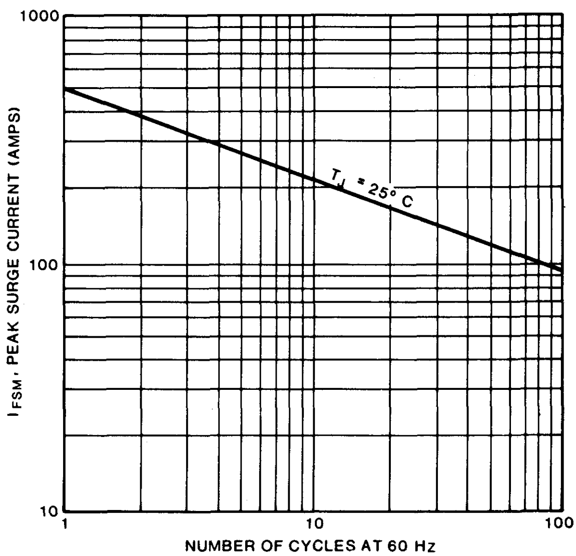


FIGURE 4

VARO

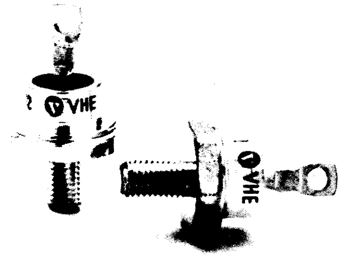
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS098

70 Amp High Efficiency Rectifiers

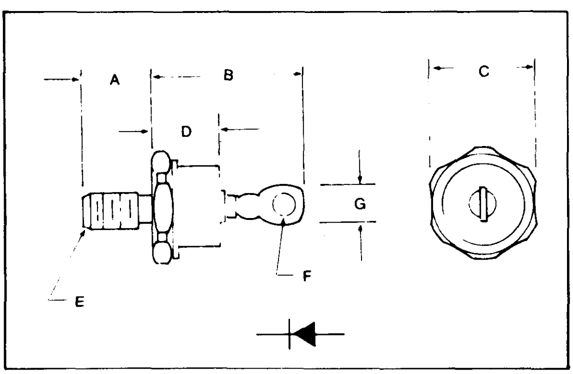
June 1981

50 Volt, 100 Volt, 150 Volt and 200 Volt V_{RRM}
20% Non-repetitive Reverse Overvoltage Protection
Low Thermal Resistance
Extremely Low Leakage at High Temperature
High Surge Capability
Very Fast Switching Speeds
Glass Passivated
Standard DO5 Case



MAXIMUM RATINGS (At T_J = 25°C unless otherwise noted)	SYMBOL	VHE801	VHE802	VHE803	VHE804	UNITS
DC Blocking Voltage Working Peak Reverse Voltage Peak Repetitive Reverse Voltage	V_{RM} V_{RWM} V_{RRM}	50	100	150	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	105	140	Volts
Peak non-repetitive Reverse Voltage	V_{RM} (non-rep)	60	120	180	240	Volts
Average Rectified Forward Current @ T_C = 100°C	I_O	70				Amps
Peak Surge Current (non-rep), ½ cycle, 60 Hz	I_{FSM}	1000				Amps
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8				°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	−65 to +175				°C

Electrical Characteristics (At T_J = 25°C unless otherwise noted)	SYMBOL			UNITS
Maximum Instantaneous Forward Voltage I_F = 70A I_F = 200A	V_{FM}	T_J = 25°C .975 1.2	T_J = 150°C .84 1.2	Volts
Maximum Reverse Current at Rated V_{RM} T_J = 25°C T_J = 150°C T_J = 175°C	I_{RM}	25 1000 2500		μA
Maximum Reverse Recovery Time, I_F = ½A, I_R = 1A, I_{REC} = 0.25A	t_{rr}	50		n sec.
Maximum Capacitance, V_R = 10V	C_T	700		pF



JEDEC Package 203AB (formerly DO-5)

Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	10.72	11.50	.422	.453
B	19.05	25.40	.750	1.000
C	17.00	17.47	.669	.688
D	—	11.43	—	.450
E	¼-28 UNF-2A	—	¼-28 UNF-2A	—
F	3.56	4.44	140	.175
G	—	9.52	—	.375

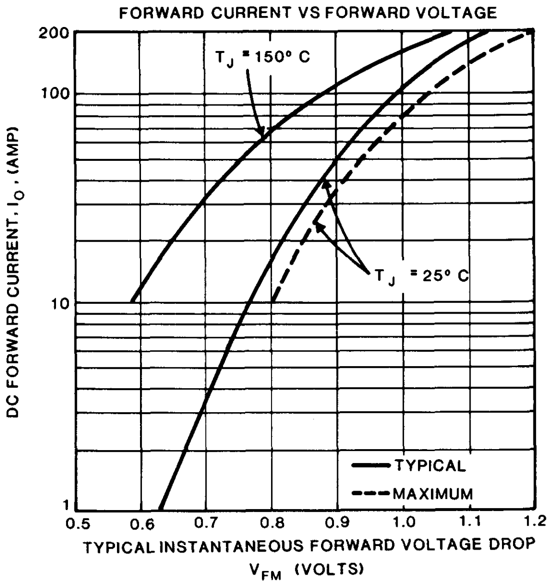


FIGURE 1

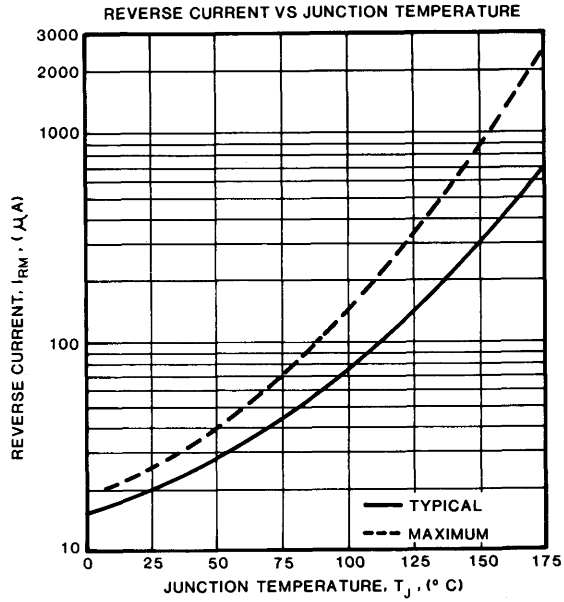


FIGURE 2

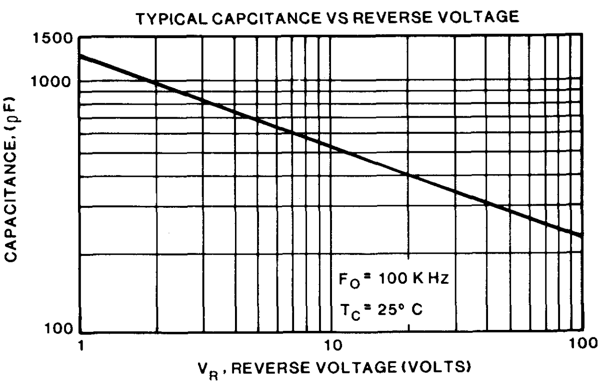


FIGURE 3

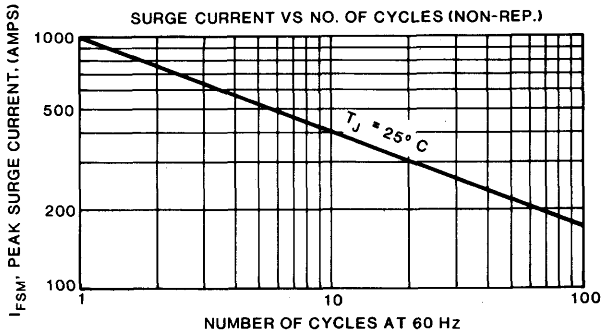


FIGURE 4

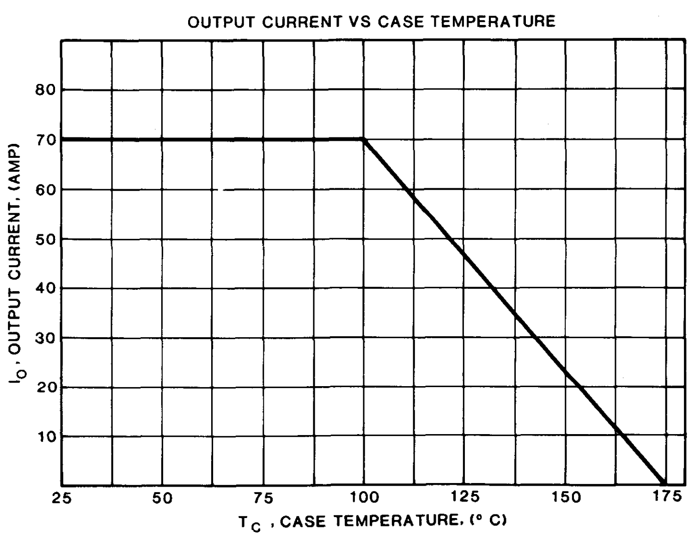


FIGURE 5

VARO

High Voltage Rectifiers

Industrial Applications

Full Wave Bridge 111
VA/VB Rectifiers, 1 kV to 6 kV 113
VG Rectifiers, 1 kV to 20 kV 115
VF Rectifiers, 5 kV to 20 kV 117
Assemblies for X-Ray Apparatus, 100 kV to 150 kV 119
Subassembly for X-Ray Apparatus, 7 kV 120
Assemblies for X-Ray Apparatus, 90 kV to 180 kV 121
Subassembly for X-Ray Apparatus, 9 kV 122
Power Rectifier Subassembly Diode 123
Power Rectifier Subassembly Diode, Fast Recovery 125
Power Rectifier Assemblies, 100 kV to 300 kV 127
VC Power Rectifiers, 2 kV to 8 kV 129

VARO:
the world's leading rectifier company

Varo Semiconductor is the largest producer of high voltage diodes in the United States, and is a leading manufacturer of silicon rectifiers, diodes, bridges and multipliers for customers throughout the world.

VARO FIRSTS

First to offer a high voltage diode to the television industry, paving the way for a "100% solid state" color and b & w chassis.

First to offer a full-wave bridge in a DIP package.

First (and currently, only) to offer a full-wave bridge utilizing Schottky rectifiers in a DIP package.

First U.S. company to manufacture high voltage glass encapsulated diodes.

VARO QUALITY

All of Varo's manufacturing facilities are located in Garland, Texas. This enhances process monitoring and control, leading to high product quality and reliability. Every Varo device is mechanically inspected and electrically tested prior to shipment: no AQL or lot sampling. Only 100% testing.

HOW TO USE THIS CATALOG

Standard devices are listed in the table of contents, and are grouped into four classifications. Find your general area of interest, then locate the specific device by page number. Application Notes are listed by subject matter.

HOW TO ORDER VARO PRODUCTS

Phone or write/cable/telex:

- Varo Sales Representative
- Varo Distributor (many of Varo's items are stocked by local Varo Distributors)
- Varo Semiconductor, Marketing Department

TERMS

Net 30 days. FOB Point: Varo Factory; Garland, Texas

WARRANTY

The seller warrants that at time of shipment the products manufactured by Seller and sold hereunder will be free from defects in material and workmanship and will conform to the specifications furnished or approved in writing by the Seller. Seller's obligation under this warranty, however, is expressly limited to replacing, repairing, or issuing credit for (at Seller's option) any products returned to Seller during the schedule period shown below and if (a) Seller has received written notice within 30 days after discovery of any defect by Buyer, (b) the defective products are returned to Seller, transportation charges prepaid by Buyer, and (c) Seller's examination of such products discloses to Seller's satisfaction that defects in such products have not been caused by misuse, neglect, improper installation, repair, alteration, or accident. This warranty is in lieu of all other warranties (express; implied, including merchantability and fitness; or statutory), and in no event shall Seller be liable to Buyer for loss of profits, loss of use, or damages of any kind based upon a claim for breach of warranty.

Warranty schedule is as follows:

Standard Products — All products identified with an EIA number or Varo model, series, or print number are warranted for one year from date of shipment.

VARO

VARO SEMICONDUCTOR P.O. BOX 40676, 1000 NORTH SHILOH, GARLAND, TEXAS 75040 (214) 271-8511 TWX 910-860-5178

VARO

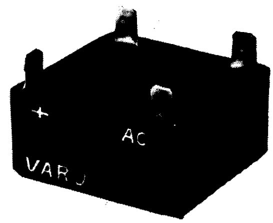
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 041

High Voltage Full Wave Bridge Rectifiers

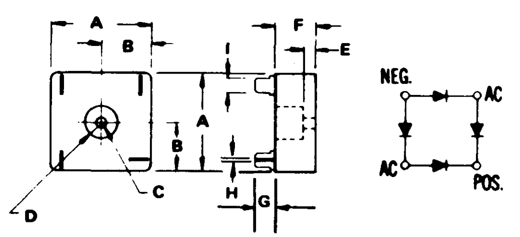
January 1981

2kV, 4kV, 6kV, 8kV, and 10kV V_{RRM} Ratings
.5 Amp to 1.5 Amp DC Forward Current
20 Amp Peak One Half Cycle Surge Current



ELECTRICAL CHARACTERISTICS AT $T_A = 25°C$ (Unless Otherwise Specified)	SYMBOL	H439	H440	H441	H442	H443	UNITS
Repetitive Peak Reverse Voltage	V_{RRM}	2	4	6	8	10	kV
RMS Reverse Voltage	$V_{R(RMS)}$	1.4	2.3	4.2	5.6	7.0	kV
Average Forward Current at $T_A = 50$ C (Fig. 1)	I_O	1.5	.65	.65	.50	.50	Amps
Peak Surge Current, ½ Cycle at 60 Hz (Non-Rep)	I_{FSM}	20					Amps
Storage Temperature Range	T_{STG}	−30 to +150					°C
Ambient Operating Temperature Range	T_A	−30 to +100					°C

MAXIMUM RATINGS AT $T_A = 25°C$ (Unless Otherwise Specified)	SYMBOL	H439	H440	H441	H442	H443	UNITS
Maximum Instantaneous Forward Voltage Drop (Per Diode)	V_{FM}	3.0	9.0	9.0	15.0	15.0	V
Maximum Reverse Current at Rated V_{RRM}	I_{RM}	1					µA



Terminals are .25" — 6,35mm Faston or Equivalent

LTR	INCHES	MILLIMETERS
A	1.85	46.99
B	.925	23.50
C	.187 Dia.	4.75 Dia.
D	.625 Dia.	15.88 Dia.
E	.189	4.80
F	.75	19.05
G	.35	8.89
H	.032	.813
I	.250	6.35

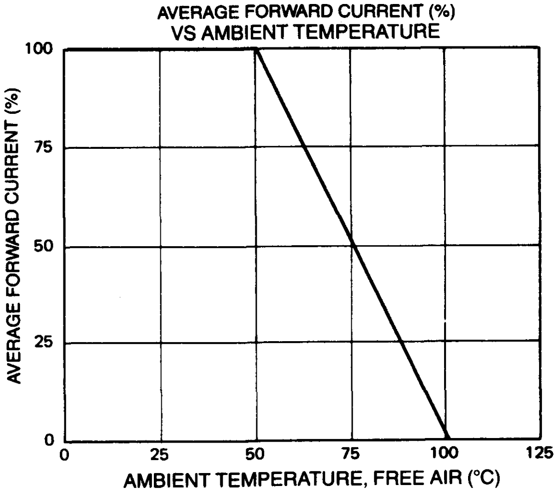

AVERAGE FORWARD CURRENT (%)
VS AMBIENT TEMPERATURE
100
75
50
25
0
AVERAGE FORWARD CURRENT (%)
0
25
50
75
100
125
AMBIENT TEMPERATURE, FREE AIR (°C)

FIGURE 1

VARO

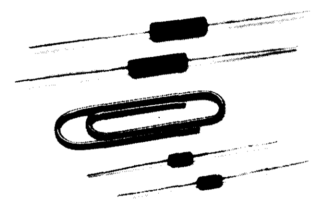
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 027

High Voltage Diffused Silicon Rectifiers VA & VB Series

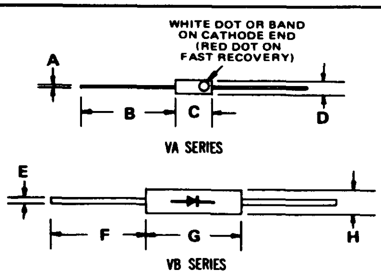
January 1981

1KV To 3.5KV V_{RRM} (VA Series)
1 KV To 15KV V_{RRM} (VB Series)
Low Leakage Current
Fast Recovery Series With 250 Nanosecond t_{rr}
Minimum Sized, Low Cost Epoxy Encapsulation



MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS at T_A = 25°C (unless otherwise specified)

VARO PART NO.	Peak Repetitive Reverse Voltage V_{RRM} (Volts)	Peak Surge Current ½ Cycle at 60 Hz I_{FSM} (Amps)	DC Forward Current at T_A = 40°C I_o (mA) (Fig. 1)	Ambient Operating Temperature Range T_A (°C)	Max. Inst. Forward Voltage Drop at I_o V_{FM} (Volts) (Fig. 2)	Max. Reverse Current At Rated V_{RMM} I_{RM} (μA) (Fig. 3)	Max. Reverse Current At Rated V_{RMM} I_{RM} (μA)	Max. Reverse Recovery Time at I_F = 2mA, I_R = 4mA t_{rr} (ns) (Fig. 4)
STANDARD TYPES								
VA-10	1000		140		4			
VA-15	1500		140		4			
VA-20	2000		140		4			
VA-25	2500		140		4			
VA-30	3000		140		6			
VA-35	3500		140		6			
VB-10	1000	3	150	−55 to + 150	5	.05	5.0 at T_A = 100°C	NA
VB-20	2000		150		5			
VB-30	3000		80		10			
VB-40	4000		80		10			
VB-50	5000		80		10			
VB-60	6000		80		10			
FAST RECOVERY TYPES								
VA-10X	1000		70		6			
VA-15X	1500		70		6			
VA-20X	2000		70		6			
VA-25X	2500		70		8			
VA-30X	3000		70		8			
VB-10X	1000	3	80	−55 to +85	6	0.3	20.0 at T_A = 85°C	250
VB-20X	2000		80		6			
VB-30X	3000		40		12			
VB-40X	4000		40		12			
VB-50X	5000		40		12			
VB-100X	10,000		25		16			
VB-150X	15,000	1	5		42			



Note: Specified lead diameter applies between 0.050" and .350" from the rectifier body. Outside of this zone the lead diameter is not controlled.

LTR	INCHES	MILLIMETERS
A	.015 DIA.	,381 DIA.
B	.40 MIN.	10,16 MIN.
C	.150	3,81
D	.060 DIA.	1,52 DIA.
E	.020 DIA.	,51 DIA.
F	.60 MIN.	15,24 MIN.
G	.40	10,16
H	.100 DIA.	2,54 DIA.

NOTES:

1. Suffix "X" added to Part No. denotes Fast Recovery.
2. Maximum Lead and Terminal Temperature for soldering, 3/8" from case, 5 seconds at 250°C

DC FORWARD CURRENT (PERCENT) VS AMBIENT TEMPERATURE (FREE AIR)

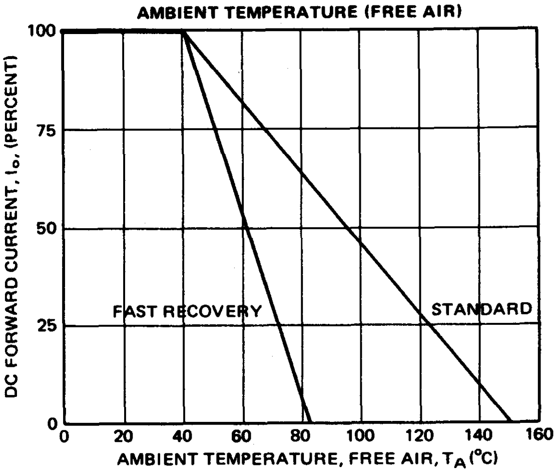


FIGURE 1

TYPICAL INSTANTANEOUS FORWARD VOLTAGE DROP (PERCENT) VS DC FORWARD CURRENT (PERCENT)

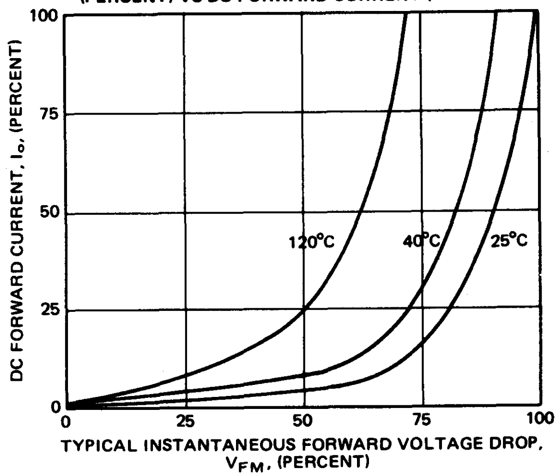


FIGURE 2

TYPICAL REVERSE CURRENT VS AMBIENT TEMPERATURE AT V_{RRM}

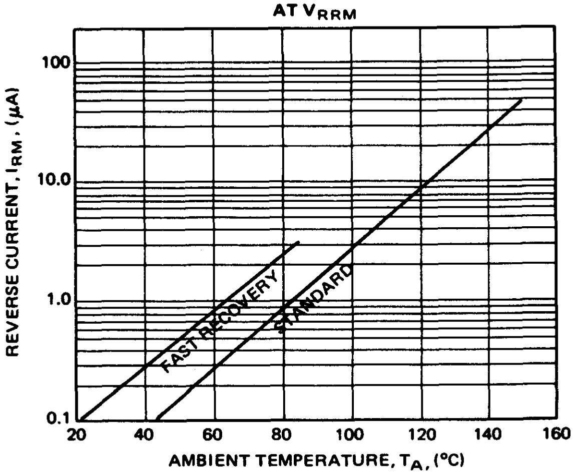
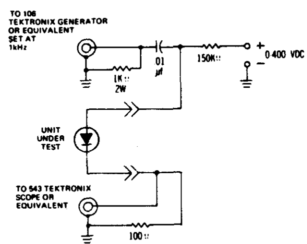


FIGURE 3

RECOVERY TEST CIRCUIT



RECOVERY WAVE FORM

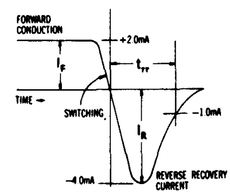


FIGURE 4

VARO
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 034

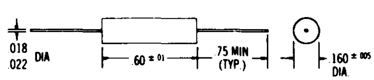
High Voltage Diffused Silicon Rectifiers VG Series

January 1980

Minimum size
PIV 1KV to 20KV
Diffused Silicon Junction
Low Leakage Current
250 Nanosec. Reverse Recovery*

VARO Type No.	Peak Inverse Voltage PIV (Volts)	Avg. Fwd. Current I_o @40°C (mA)	Max. Fwd. Voltage Drop @25°C and I_o V_F (Volts)
VG-1	1,000	200	6
VG-2	2,000	200	7
VG-3	3,000	200	8
VG-4	4,000	125	10
VG-5	5,000	125	12
VG-7	7,000	125	14
VG-10	10,000	80	16
VG-12	12,000	80	18
VG-15	15,000	60	25
VG-20	20,000	50	30

VARO Type No.	Peak Inverse Voltage PIV (Volts)	Avg. Fwd. Current I_o @40°C (mA)	Max. Fwd. Voltage Drop @25°C and I_o V_F (Volts)
VG-1X	1,000	70	8
VG-2X	2,000	70	10
VG-3X	3,000	70	12
VG-4X	4,000	45	12
VG-5X	5,000	45	14
VG-7X	7,000	35	18
VG-10X	10,000	35	20
VG-12X	12,000	35	22
VG-15X	15,000	15	30
VG-20X	20,000	15	34



The series VG high voltage and high voltage fast recovery time diffused silicon rectifiers are designed for industrial and commercial applications that require high reliability at an economical cost.
This series offers high voltage ranges in minimum-sized, epoxy-encapsulated packages with low leakage current. All ratings are obtained without the use of special heat sinks or mounting techniques. (See Note 3)
These recifiers can withstand 500 G's shock and vibration of 100 Hz with a peak acceleration of 10 G's.
These rectifiers are technically and economically suitable for use in television receivers, electrostatic power supplies, electrostatic copiers, electrostatic air filters and precipitators, and cathode ray tube power supplies.

ELECTRICAL CHARACTERISTICS (at T_A = 25°C Unless Otherwise Specified)	
Max. DC Reverse Current @ PIV and 25°C, I_R	1μA
Max. DC Reverse Current @ PIV and 100°C / 85°C, I_R	20μA / 30μA*
Max. Reverse Recovery Time, t_{rr} @ I_F=2mA and I_R=4mA, Recovery to 1.0mA (FIG. 4)	250 nanosec*
Ambient Operating Temperature Range, T_A	−55°C to +150°C / +85°C*
Storage Temperature Range, T_{STG}	−55°C to +150°C
Max. One-Half Cycle Surge Current, I_{FM} (Surge) @ 60 Hz	3 Amps

*Fast Recovery Series

NOTES:
1. Suffix (X) denotes Fast Recovery Series.
2. Maximum lead and terminal temperature for soldering, ⅜ inch from case, 5 seconds at 250°C.
3. If operated over 10,000 v/inch in length, devices should be immersed in oil or re-encapsulated.

TYPICAL REVERSE CURRENT CHARACTERISTICS
SERIES VG STANDARD AND FAST RECOVERY

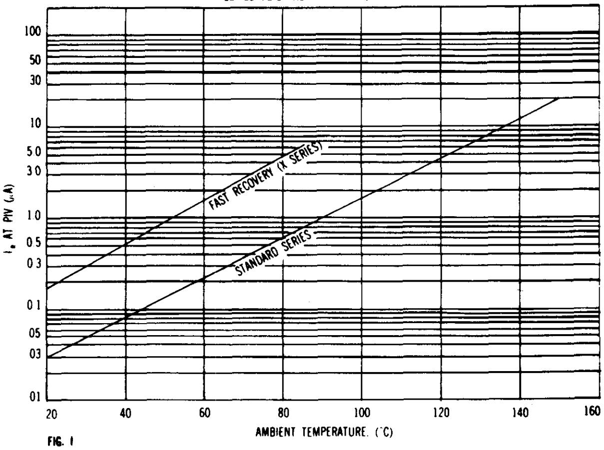


FIG. 1

RECTIFIER DERATING CURVE

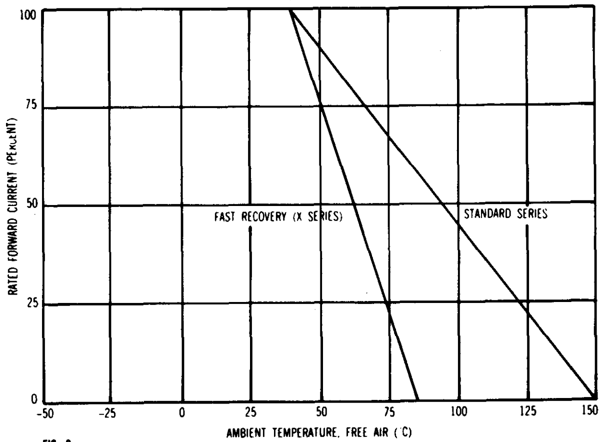


FIG. 2

TYPICAL FORWARD VOLTAGE CHARACTERISTICS

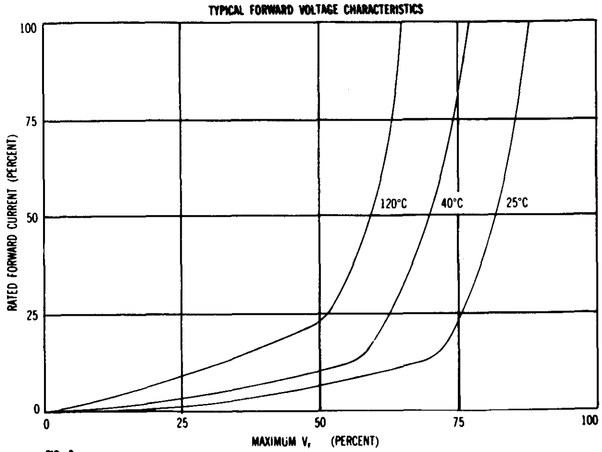


FIG. 3

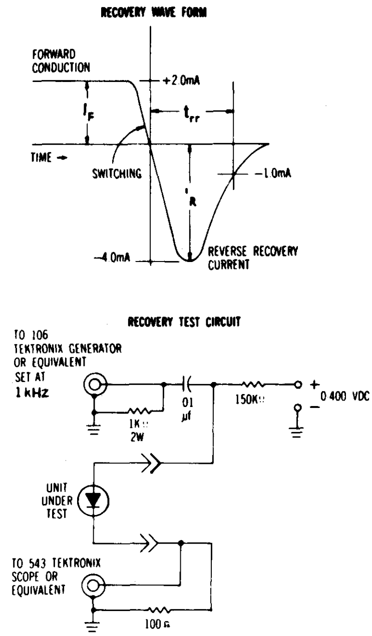


FIG. 4

VARO

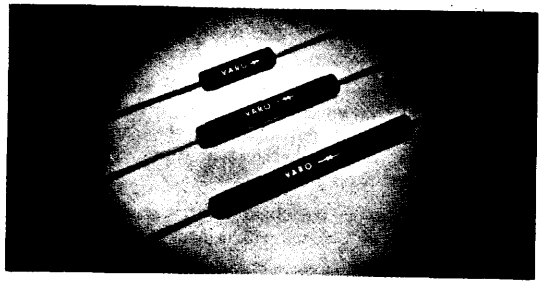
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 033

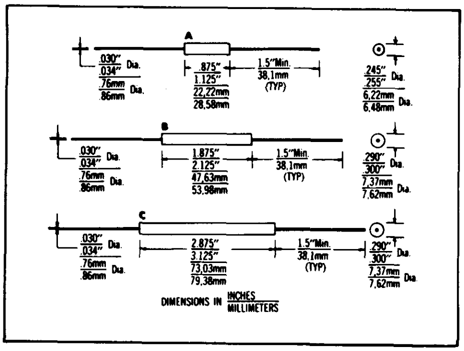
High Voltage Diffused Silicon Rectifiers VF Series

January 1980

Minimum Size
5KV to 50KV (V_{RRM})
Diffused Silicon Junction
Low Leakage Current
250 Nanosec. Reverse Recovery*



VARO Type No.	Peak Inverse Voltage PIV (Volts)	Avg. Fwd. Current I_o @ 40°C (mA)	Max. Fwd. Voltage Drop @ 25°C and I_o V_F (Volts)	Case Style	VARO Type No.	Peak Inverse Voltage PIV (Volts)	Avg. Fwd. Current I_o @ 40°C (mA)	Max. Fwd. Voltage Drop @ 25°C and I_o V_F (Volts)	Case Style
VF	5,000	130	10	A	VF 5X	5,000	60	12	A
VF 7	7,000	115	12	A	VF 7X	7,000	45	16	A
VF10	10,000	100	15	A	VF10X	10,000	40	18	A
VF12	12,000	100	18	A	VF12X	12,000	35	22	A
VF15	15,000	90	30	B	VF15X	15,000	30	34	B
VF20	20,000	90	32	B	VF20X	20,000	25	40	B
VF25	25,000	85	35	B	VF25X	25,000	25	44	B
VF30	30,000	80	45	C	VF30X	30,000	25	48	C
VF40	40,000	45	75	C	VF40X	40,000	25	75	C
VF50	50,000	40	80	C	VF50X	50,000	25	90	C



ELECTRICAL CHARACTERISTICS At T_A = 25°C (unless otherwise specified)	
Max. DC Reverse Current @ rated V_{RRM} and 25°C, I_{RM}	1μA
Max. DC Reverse Current @ rated V_{RRM} and $\frac{100°C}{85°C}$, I_{RM}	$\frac{20\mu A}{30\mu A^*}$
Max. Reverse Recovery Time, @ I_F = 2mA and I_R = 4mA, Recovery to 1.0mA (FIG. 4), t_{rr}	250 nanosec*
Ambient Operating Temperature Range, T_A	−55°C to $\frac{+150°C}{+85°C^*}$
Storage Temperature Range, T_{STG}	−55°C to +150°C
Max. One-Half Cycle Surge Current, @ 60 Hz, I_{FSM}	3 Amps

*Fast Recovery Series

NOTES:
1. Suffix (X) denotes Fast Recovery Series.
2. Maximum lead and terminal temperature for soldering, ⅜ inch from case, 5 seconds at 250°C.
3. If operated over 10,000 V/inch in length, devices should be immersed in oil or re-encapsulated.

SERIES VF

The series VF high voltage and high voltage fast recovery time diffused silicon rectifiers are designed for industrial and commercial applications that require high reliability at an economical cost.

This series offers high voltage ranges in minimum-sized, epoxy-encapsulated packages with low leakage current. All ratings are obtained without the use of special heat sinks or mounting techniques. (See Note 3)

These rectifiers can withstand 500 G's shock and vibration of 100 cps with a peak acceleration of 10 G's.

These rectifiers are technically and economically suitable for use in television receivers, electrostatic power supplies, electrostatic copiers, electrostatic air filters and precipitators, and cathode ray tube power supplies.

TYPICAL REVERSE CURRENT CHARACTERISTICS
SERIES VF STANDARD AND FAST RECOVERY

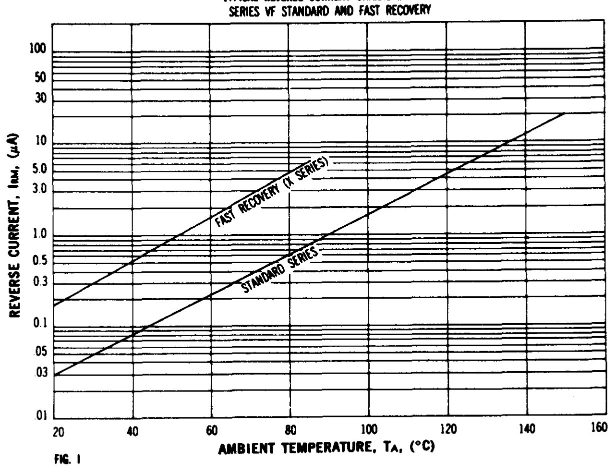


FIG. 1

RECTIFIER DERATING CURVE

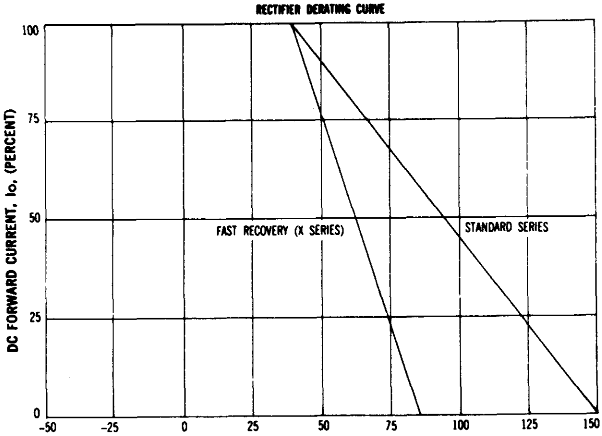
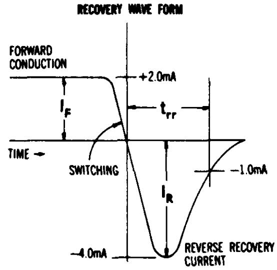


FIG. 2

RECOVERY WAVE FORM



TYPICAL FORWARD VOLTAGE CHARACTERISTICS

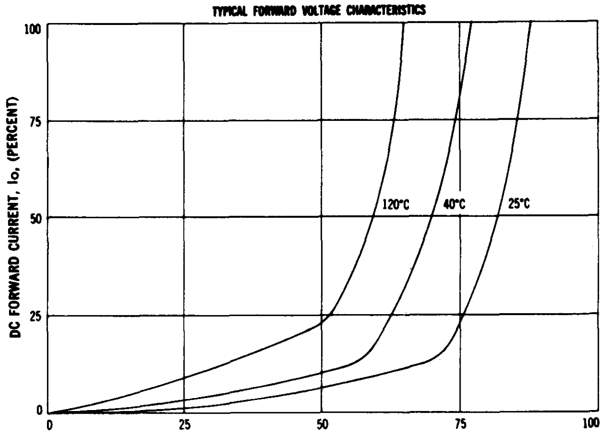


FIG. 3

RECOVERY TEST CIRCUIT

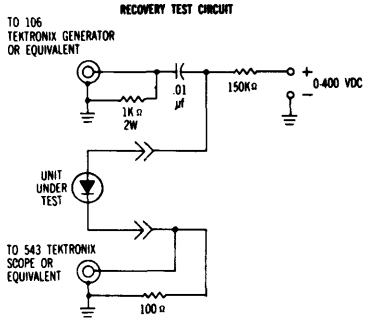


FIG. 4

VARO

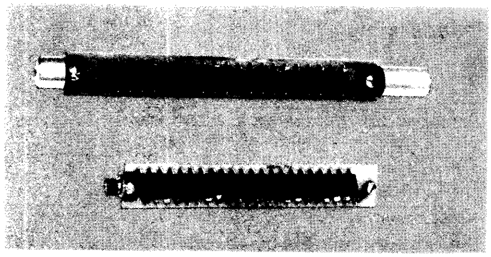
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 047

High Voltage Rectifier Assemblies For X-Ray Apparatus

January 1980

Varo Semiconductor has designed this series of high voltage rectifier assemblies for use in x-ray applications. The number of diodes mounted in series on a glass-epoxy printed circuit board is determined by the required peak reverse voltage. Each diode package contains a stack of controlled avalanche wafers.

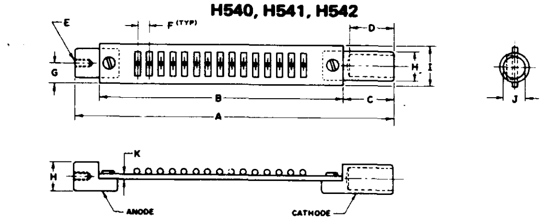


MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	H466-H540	H467-H541	H468-H542	UNITS
Peak Reverse Voltage - Operating (NOTE 1)	$V_{R(oper)}$	100	125	150	kV
Peak Reverse Voltage - Test	$V_{R(test)}$	125	150	175	kV
Peak Surge Current, ½ Cycle at 60 Hz (Non-Rep)	I_{FSM}		20		Amps
Peak Surge Current, 10 Cycles at 60 Hz	I_{FRM}		6		Amps
DC Forward Current in 55°C oil (NOTE 1)	I_O		220		mA
Junction Operating and Storage Temperature Range	T_J, T_{STG}		−55 to +125		°C

NOTE 1: To achieve rated current and voltage, diodes must be submerged in Shell Diala Oil AX electrical insulating oil or equivalent.

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL	H466-H540	H467-H541	H468-H542	UNITS
Maximum Instantaneous Forward Voltage Drop at I_F=50 mA	V_{FM}	190	230	265	Volts
Maximum Reverse Current at $V_{R(TEST)}$	I_{RM}		1		µA
Number of Diodes Per Board		16	19	22	

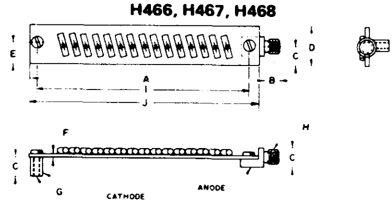
H540, H541, H542



LTR	INCHES H540	INCHES H541	INCHES H542	MILLIMETERS H540	MILLIMETERS H541	MILLIMETERS H542
A	8.12	9.25	10.25	206,24	234,95	260,35
B	6.20	7.33	8.33	157,48	186,18	24,58
C	1.30			33,02		
D	1.13			28,70		
E	#10-32 x .375 deep			*		
F	.30 Typ.			7,62		
G	.50			12,70		
H	.750 Dia.			19,05		
I	1.00			25,40		
J	.578 Dia.			14,68		
K	.125			3,18		

*Closest metric equivalent supplied on request.

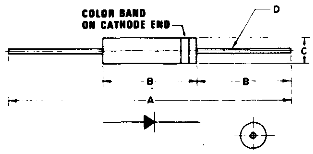
H466, H467, H468



LTR	INCHES	MILLIMETERS
A	6.00	152,40
B	.38	9,65
C	.50	12,70
D	1.00	25,40
E	.56	14,22
F	.094	2,39
G	#6-32 NC	*
H	.375-24 NF	*
I	5.64	143,25
J	5.94	150,88

*Closest metric equivalent supplied on request.

Although purchase of the complete x-ray board assembly is recommended, the high voltage avalanche diode used, a Varo type H463-5, may be purchased separately.



A	1.80	45,72
B	.60	15,24
C	.160 Dia.	4,06
D	.030-.034 Dia.	,76-,86

DIODE MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS AT T_A = 25°C (unless otherwise specified)	SYMBOL	H463-5	UNITS
Peak Reverse Voltage - Operating	$V_{R(oper)}$	7	kV
Peak Reverse Voltage - Test	$V_{R(test)}$	8	kV
Peak Surge Current, ½ Cycle at 60Hz (Non-Rep) (Fig. 2)	I_{FSM}	20	Amps
Peak Surge Current, 10 Cycles at 60Hz	I_{FRM}	6	Amps
DC Forward Current in 55°C oil (Note 1) (Fig. 1)	I_o	220	mA
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−55 to +125	°C

Maximum Instantaneous Forward Voltage Drop at I_F=50mA	V_{RM}	12	Volts
Maximum Reverse Current at $V_{R(test)}$	I_{RM}	1	µA

DC FORWARD CURRENT
VS AMBIENT TEMPERATURE

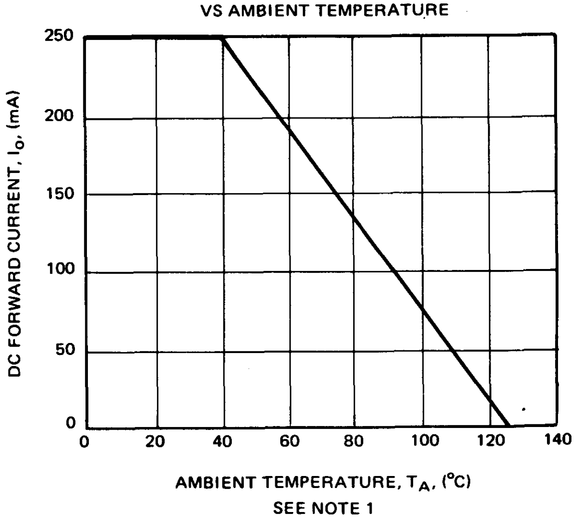


FIGURE 1

PEAK SURGE CURRENT (PER LEG) VS NUMBER OF CYCLES AT 60 Hz (SINE WAVE INPUT) AND T_A=25°C

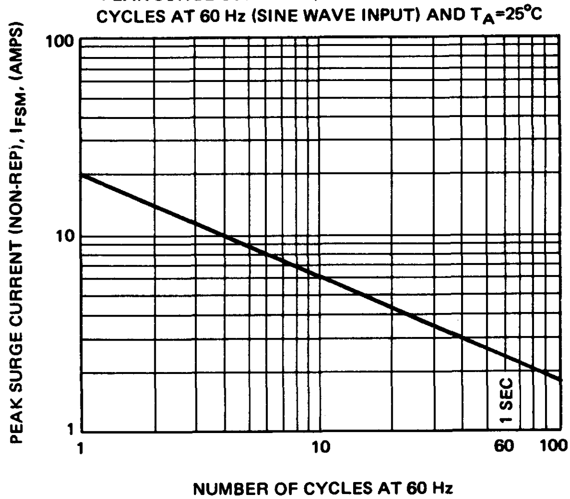


FIGURE 2

VARO

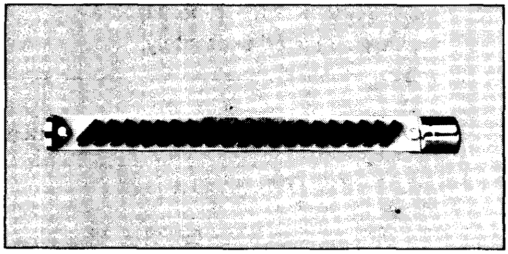
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 078

High Voltage Rectifier Assemblies For X-Ray Apparatus

June 1981

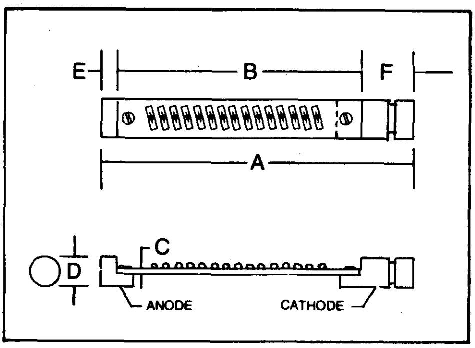
Varo Semiconductor has designed this series of high voltage rectifier assemblies for use in x-ray applications. The number of diodes mounted in series on a glass-epoxy printed circuit board is determined by the required peak reverse voltage. Each diode package contains a stack of avalanche wafers.



MAXIMUM RATINGS AT T_A=25°C (unless otherwise specified)	**SYMBOL**	**H701**	**H702**	**H703**	**H704**	**UNITS**
Peak Reverse Voltage - Operating (NOTE 1)	$V_{R(oper)}$	90	120	150	180	kV
Peak Reverse Voltage - Test	$V_{R(test)}$	100	135	170	200	kV
Peak Surge Current, ½ Cycle at 60 Hz (Non-Rep)	I_{FSM}	20				Amps
Peak Surge Current, 10 Cycles at 60 Hz	I_{FRM}	6				Amps
DC Forward Current in 55°C oil (NOTE 1)	I_O	220				mA
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−55 to +125				°C

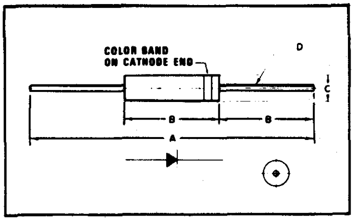
NOTE 1: To achieve rated current and voltage, diodes must be submerged in Shell Diala Oil AX electrical insulating oil or equivalent.

ELECTRICAL CHARACTERISTICS AT T_A=25°C (unless otherwise specified)	**SYMBOL**	**H701**	**H702**	**H703**	**H704**	**UNITS**
Maximum Instantaneous Forward Voltage Drop at I_F=50 mA	V_{FM}	120	168	204	240	Volts
Maximum Reverse Current at $V_{R(Oper)}$	I_{RM}	.5	.5	.5	.5	μA
Maximum Reverse Current at $V_{R(TEST)}$	I_{RM}	1	1	1	1	μA
Number of Diodes Per Board		10	14	17	20	



LTR	INCHES				MILLIMETERS			
	H701	H702	H703	H704	H701	H702	H703	H704
A	5.60	6.70	9.06	9.06	142	170	230	230
B	4.61	5.71	8.07	8.07	117	145	205	205
C	.125	.125	.125	.125	3, 18	3, 18	3, 18	3, 18
D	.787	.787	.787	.787	20	20	20	20
E	.197	.197	.197	.197	5	5	5	5
F	.787	.787	.787	.787	20	20	20	20

Although purchase of the complete x-ray board assembly is recommended, the high voltage, avalanche diode used, a Varo type H463-3, may be purchased separately.



Ltr.	Inches	Millimeters
A	1.80	45,72
B	.60	15,24
C	.160 Dia.	4,06
D	.030-.034 Dia.	,76-,86

DIODE MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS AT T_A=25°C	SYMBOL	H463-3	UNITS
Peak Reserve Voltage - Operating	$V_{R(Oper)}$	9	kV
Peak Reverse Voltage - Test	$V_{R(test)}$	10	kV
Peak Surge Current, ½ Cycle at 60Hz (Non-Rep) (Fig. 2)	I_{FSM}	20	Amps
Peak Surge Current, 10 Cycles at 60Hz	I_{FRM}	6	Amps
DC Forward Current in 55°C oil (Note 1) (Fig. 1)	I_O	220	mA
Junction Operating and Storage Temperature Range	T_J, T_{STG}	−55 to +125	°C
Avalanche Energy, 100μ sec Pulse Width		.3	Joules
Maximum Instantaneous Forward Voltage Drop at I_f=50mA	V_{FM}	12	Volts
Maximum Reverse Current at $V_{I(test)}$	I_{RM}	1	μA

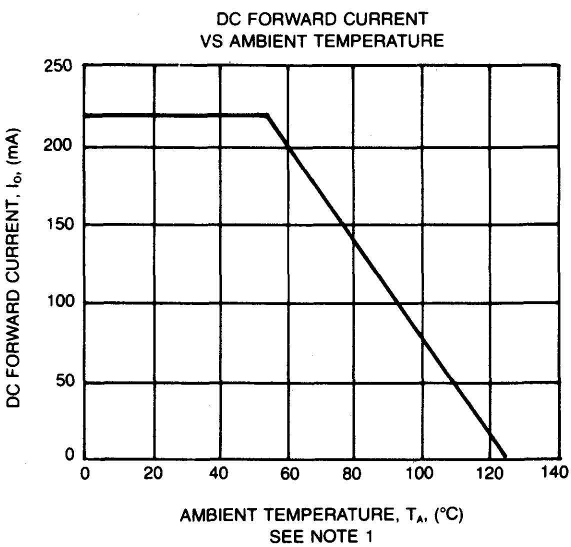


FIGURE 1

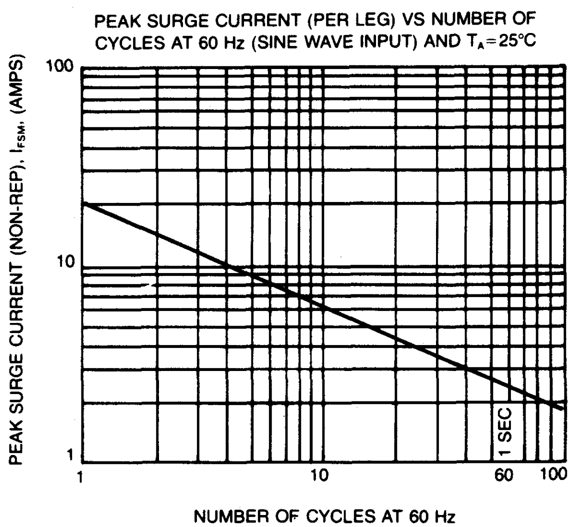


FIGURE 2

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

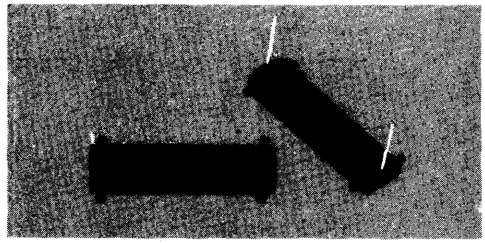
DLS 050

High Voltage Power Rectifier Subassembly Diode H655

June 1981

The H655 controlled avalanche subassembly diode is designed for use in the buildup of high voltage power rectifier assemblies. Total assembly cost is greatly reduced by the use of diodes with controlled avalanche junctions which eliminate the need for resistors and capacitors required when several non-controlled avalanche diodes are connected in series.

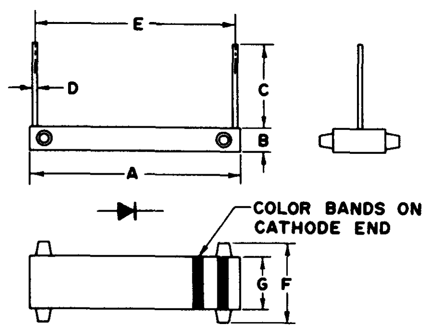
Typical applications for assemblies using the H655 include industrial electrostatic precipitator power supplies and radar power supplies.



MAXIMUM RATINGS (At T_A = 25°C Unless otherwise noted)	SYMBOL	H655	UNITS
Peak Reverse Voltage — Operating (Note 1)	$V_{R(oper)}$	8.3	kV
Peak Reverse Voltage — Test	$V_{R(test)}$	10	kV
Peak Surge Current, ½ Cycle at 60Hz (Non-Rep) (Fig. 2)	I_{FSM}	50	Amps
Peak Surge Current, 10 Cycle at 60Hz (Fig. 2)	I_{FRM}	15	Amps
Average Forward Current in 25°C Oil (Note 1) (Fig. 1)	I_O	1.7	Amps
Avalanche Energy, 100 µSec Pulse Width		.42	Joules
Ambient Operating Temperature Range	T_A	−55 to +100	°C
Storage Temperature Range	T_{STG}	−55 to +125	°C

NOTE 1: To achieve rated current and voltage, diodes must be submerged in Shell Diala Oil, AX Electrical Insulating Oil or equivalent.

ELECTRICAL CHARACTERISTICS (At T_A = 25°C Unless otherwise noted)	SYMBOL	H655	UNITS
Maximum Instantaneous Forward Voltage Drop at I_F = 1.6A	V_{FM}	15	V
Maximum Reverse Current at $V_{R(test)}$	I_{RM}	1	µA



LTR.	INCHES	MILLIMETERS
A	1.75	44,45
B	.20	5,08
C	.68 Min.	17,27
D	.040 Dia.	1,02
E	1.67	42,42
F	.67	17,02
G	.44	11,12

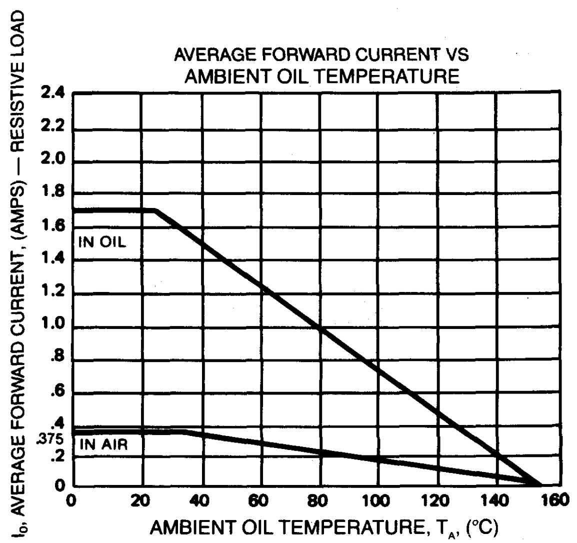


FIGURE 1

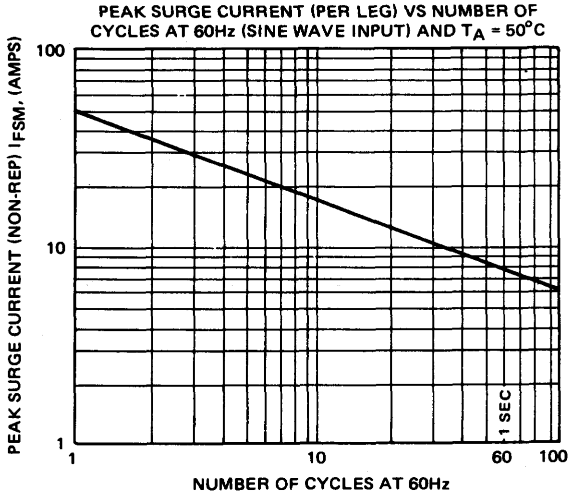


FIGURE 2

LARGER CELLS ARE AVAILABLE IN THE SAME DIODE PACKAGE IF GREATER AVALANCHE ENERGY AND HIGHER SURGE CURRENT RATINGS ARE NEEDED.

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

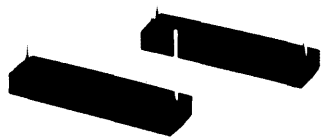
DLS 075

Fast Recovery High Voltage Power Rectifier Subassembly Diode

June 1981

The H850 subassembly diode is designed for use in the buildup of high voltage power rectifier assemblies. Total assembly cost is greatly reduced by the use of diodes with controlled avalanche junctions which eliminate the need for resistors and capacitors required when several non-controlled avalanche diodes are connected in series.

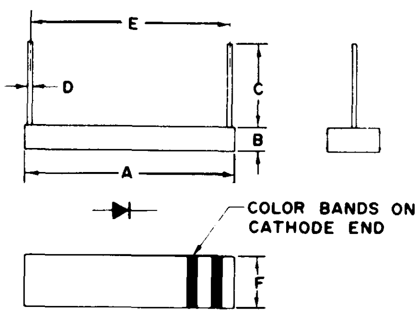
Typical applications for assemblies using the H850 include industrial electrostatic precipitator power supplies and radar power supplies.



MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	**SYMBOL**	**H850**	**UNITS**
Peak Reverse Voltage — Operating	$V_{R(oper)}$	9	kV
Peak Reverse Voltage — Test	$V_{R(test)}$	10	kV
Peak Surge Current, ½ Cycle at 60 Hz (Non-Rep) (Fig. 2)	I_{FSM}	35	Amps
Peak Surge Current, 10 Cycle at 60Hz (Fig. 2)	I_{FRM}	11	Amps
Average Forward Current in 50°C Oil (Note 1) (Fig. 1)	I_O	0.7	Amps
Ambient Operating Temperature Range	T_A	see figure 1	°C
Storage Temperature Range	T_{STG}	−55 to +125	°C

NOTE 1: To achieve rated current, diodes must be submerged in Shell Diala Oil, AX Electrical Insulating Oil or equivalent.

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	**SYMBOL**	**H850**	**UNITS**
Maximum Instantaneous Forward Voltage Drop at I_F = 1A	V_{FM}	16	V
Maximum Reverse Current at $V_{R(test)}$	I_{RM}	1	μA
Maximum Reverse Recovery Time	t_{rr}	300	ns



LTR	INCHES	MILLIMETERS
A	1.75	44,45
B	.20	5,08
C	.68 Min.	17,27
D	.040 Dia.	1,02
E	1.67	42,42
F	.44	11,12

LARGER CELLS ARE AVAILABLE IN THE SAME DIODE PACKAGE IF HIGHER SURGE CURRENT RATINGS ARE NEEDED.

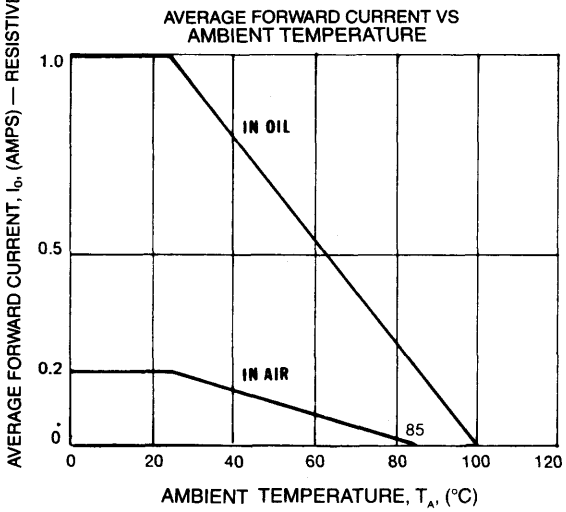


FIGURE 1

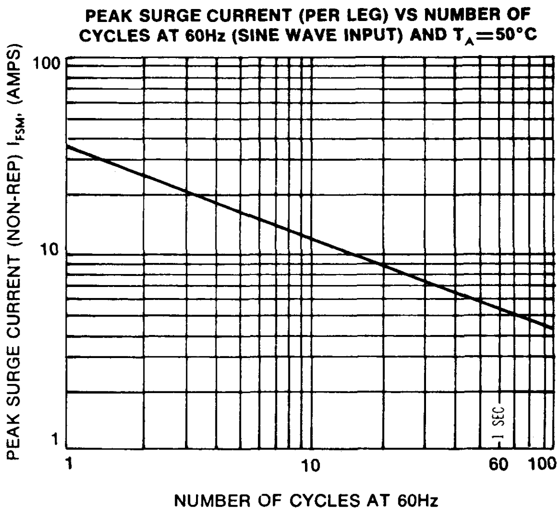


FIGURE 2

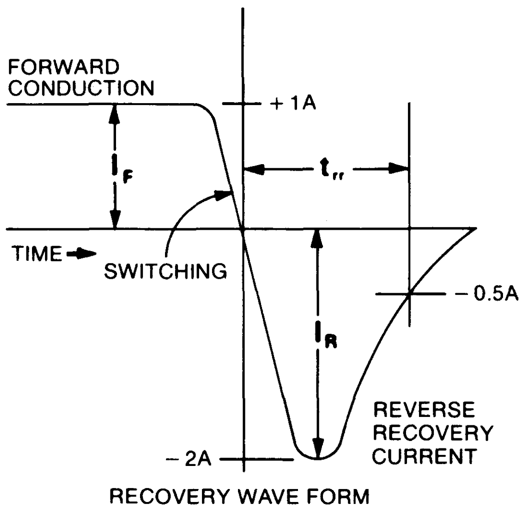


FIGURE 3

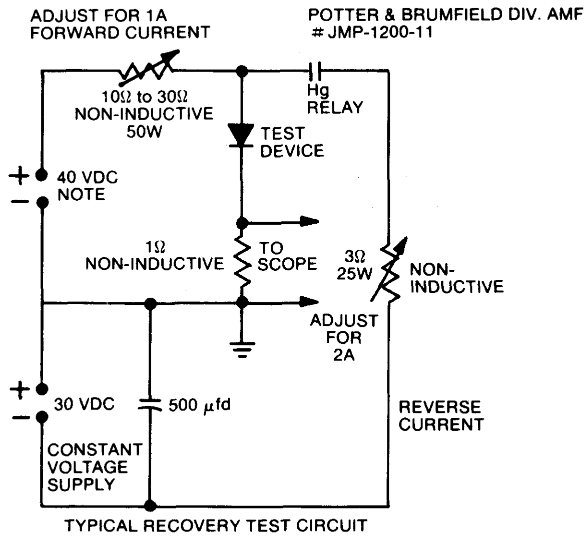


FIGURE 4

VARO

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1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 049

High Voltage Power Rectifier Assemblies

June 1980

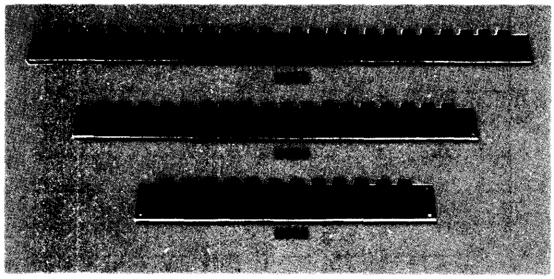
All Diodes Contain Controlled Avalanche Junctions

Standard Types With 100kV, 125kV, and 150kV Operating Peak Reverse Voltage

Center Tapped Types With 200kV, 250kV, and 300kV Operating Peak Reverse Voltage

Avalanche Energy of Up To 7.5 Joules With Standard Types and Up To 15 Joules With Center Tapped Types

2 Amps DC Forward Current



This series of high voltage power rectifier assemblies has been designed for use in electrostatic precipitators of the type used for removal of solid pollutants from the emission of industrial smoke stacks.

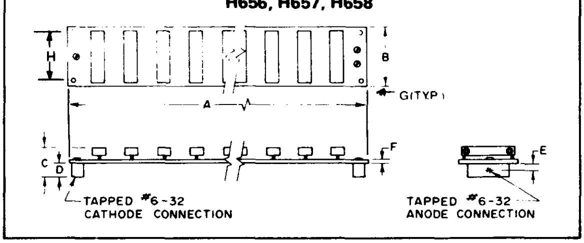
Most currently available high voltage power rectifier assemblies require a resistor and one or more capacitors across each diode to distribute the voltage and any possible transients equally across all diodes. By using controlled avalanche junctions, Varo Semiconductor has eliminated the need for resistors and capacitors making possible a very substantial savings in complete assembly cost.

Additional applications for this series include radar power supplies.

MAXIMUM RATINGS (At T_A=25°C unless otherwise noted)	SYMBOL	H656	H657	H658	H659	H660	H661	UNITS
Peak Reverse Voltage — Operating (Note 1)	$V_{R(oper)}$	100	125	150	200	250	300	kV
Peak Reverse Voltage — Test	$V_{R(test)}$	120	150	180	240	300	360	kV
Peak Surge Current, ½ Cycle at 60Hz (Non-Rep) (Fig.2)	I_{FSM}	50			50			Amps
Peak Surge Current, 10 Cycles at 60Hz (Fig. 2)	I_{FRM}	15			15			Amps
Average Forward Current in 25°C Oil (Note 1) (Fig. 2)	I_o	1.7			1.7			Amps
Avalanche Energy, 100 μsec pulse width		5.0	6.3	7.5	10.0	12.6	15.0	Joules
Storage Temperature Range	TSTG	−55 to +125			−55 to +125			°C

NOTE 1: To achieve rated current and voltage, diodes must be submerged in Shell Diala Oil, AX Electrical Insulating Oil or equivalent.

ELECTRICAL CHARACTERISTICS (At T_A=25°C unless otherwise noted)	SYMBOL	H656	H657	H658	H659	H660	H661	UNITS
Maximum Instantaneous Forward Voltage Drop at I_F = 2 Amps	V_{FM}	170	220	260	340	440	520	Volts
Maximum Reverse Current at $V_{R(test)}$	I_{RM}	1			1			μA
Number of Diodes Per Board		12	15	18	24	30	36	



	INCHES			MILLIMETERS		
LTR	H656	H657	H658	H656	H657	H658
A	10.25	12.5	14.75	260	318	375
B	2.0	2.0	2.0	50,8	50,8	50,8
C	1.0 Max	1.0 Max	1.0 Max	25,4	25,4	25,4
D	.5	.5	.5	12,7	12,7	12,7
E	.25	.25	.25	6,35	6,35	6,35
F	.12	.12	.12	3,05	3,05	3,05
G	.20	.20	.20	5,08	5,08	5,08
H	1.60	1.60	1.60	40,64	40,64	40,64
I	9.85	12.10	14.35	250.19	307.34	364.49

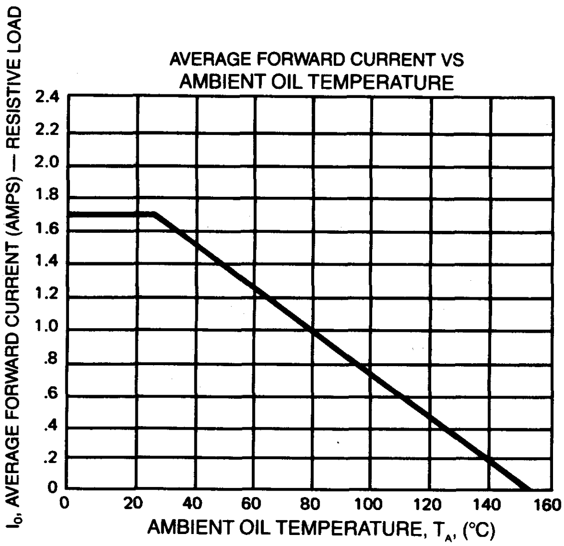


FIGURE 1

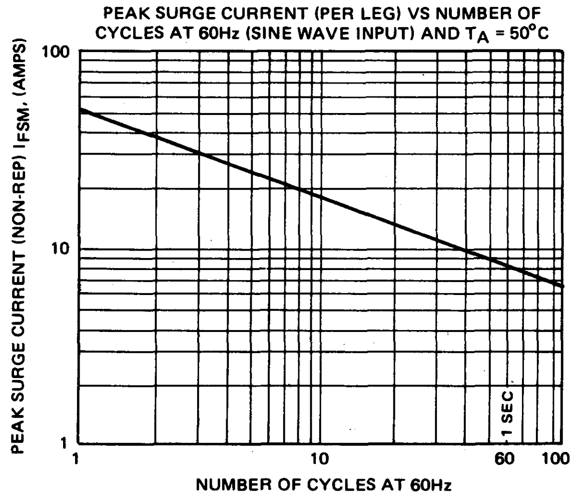
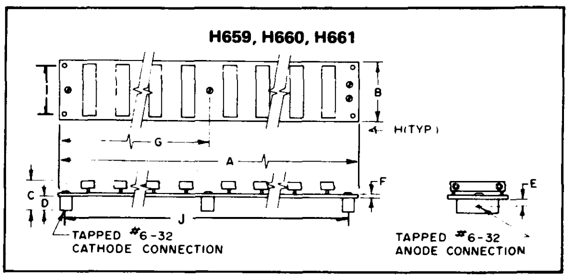


FIGURE 2

LARGER CELLS ARE AVAILABLE IN THE SAME DIODE PACKAGE IF GREATER AVALANCHE ENERGY AND HIGHER SURGE CURRENT RATINGS ARE NEEDED.



	INCHES			MILLIMETERS		
LTR	H659	H660	H661	H659	H660	H661
A	19.75	24.25	28.75	502	616	730
B	2.0	2.0	2.0	50,8	50,8	50,8
C	1.0 Max	1.0 Max	1.0 Max	25,4	25,4	25,4
D	.5	.5	.5	12,7	12,7	12,7
E	.25	.25	.25	6,35	6,35	6,35
F	.12	.12	.12	3,05	3,05	3.05
G	9.88	12.13	14.38	251	308	365
H	.20	.20	.20	5,08	5,08	5,08
I	1.60	1.60	1.60	40,64	40,64	40,64
J	19.35	23.85	28.35	491,49	605,79	720.09

VARO

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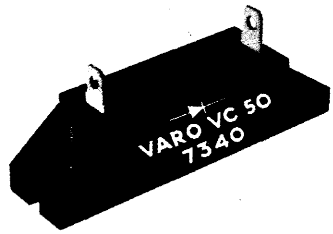
DLS 030

High Voltage Diffused Silicon Power Rectifiers

January 1980

2KV to 8KV PRV
300 Nanosecond Reverse Recovery Time on Fast Recovery Series
Low Leakage Current
1 to 2 Amps DC Output Current

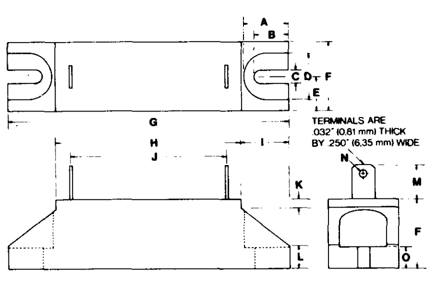


VARO PART NO.	PEAK REPETITIVE REVERSE VOLTAGE V_{RRM}(KV)	MAX. FORWARD VOLTAGE DROP @I_o= 100 MA V_{FM} (VOLTS) (FIG. 1)	DC FWD. CURRENT @T_c= 40°C I_o(AMPS) (FIG. 2)
VC 20	2	4	2
VC 30	3	6	2
VC 40	4	8	2
VC 50	5	10	1.5
VC 60	6	12	1.5
VC 70	7	12	1.5
VC 80	8	14	1

VARO PART NO.	PEAK REPETITIVE REVERSE VOLTAGE V_{RRM}(KV)	MAX. FORWARD VOLTAGE DROP @I_o= 100 MA V_{FM} (VOLTS) (FIG. 1)	DC FWD. CURRENT @T_c= 40°C I_o(AMPS) (FIG. 2)
VC 20X	2	4.8	2
VC 30X	3	7.2	2
VC 40X	4	9.6	2
VC 50X	5	12.0	1.5
VC 60X	6	14.4	1.5
VC 70X	7	14.4	1.5
VC 80X	8	16.8	1

MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS AT T_A @ 25° (Unless Otherwise Specified)	SYMBOL	VC	VCX*	UNITS
Peak Surge Current, ½ cycle at 60 Hz (Non-rep) (Fig. 3 & 4)	I_{FSM}	50	35	Amps
Maximum Reverse Current at Rated V_{RRM}	I_{RM}	1	2	μA
Maximum Reverse Current at Rated V_{RRM} and T_A = 125°C	I_{RM}	1	2	mA
Maximum Reverse Recovery Time, I_F = 1 Amp, I_R = 2 Amp, i_{rr} = 0.5A (Fig. 5)	t_{rr}		300	nsec
Case Operating Temperature Range	Tc	−50 to +125		°C
Insulation Strength, Terminal to Heat Sink		10,000		Volts

* Fast Recovery Series



LTR	INCHES	MILLIMETERS
A	.45-.51	11,43-12,95
B	.33-.39	8,38-9,91
C	.146-.166	3,71-4,22
D	.47-.53	11,94-13,46
E	.34-.40	8,64-10,16
F	.72-.78	18,29-19,81
G	2.96-3.02	75,18-76,71
H	1.91-2.01	48,51-51,05
I	.47-.57	11,94-14,48
J	1.64-1.74	41,66-44,20
K	.07-.13	1,78-3,30
L	.22-.28	5,59-7,11
M	.30-.42	7,62-10,67
N	.105-.115 DIA	2,67-2,92 DIA
O	.21-.27	5,33-6,86

TYPICAL FORWARD CURRENT VS FORWARD VOLTAGE DROP MULTIPLICATION FACTOR

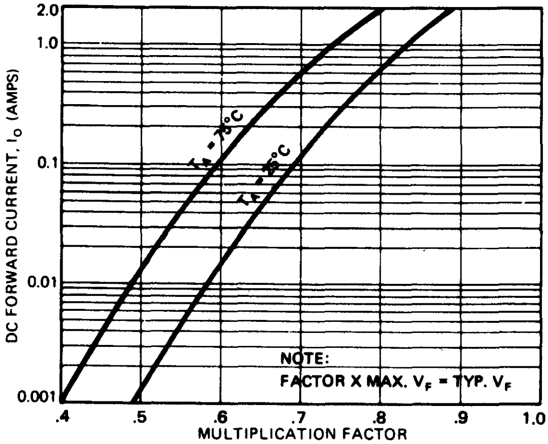


FIGURE 1

DC FORWARD CURRENT VS HEAT SINK TEMPERATURE

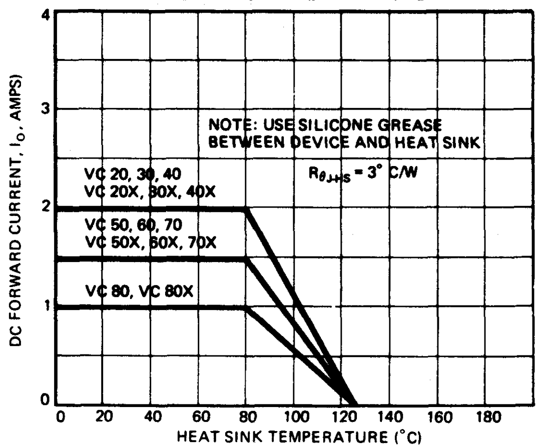


FIGURE 2

PEAK SURGE CURRENT VS NUMBER OF CYCLES–VC SERIES

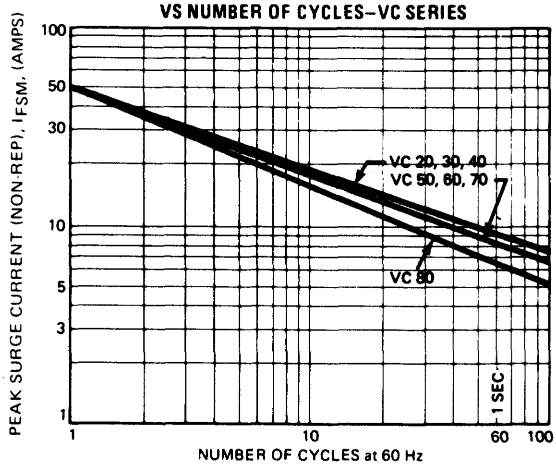


FIGURE 3

PEAK SURGE CURRENT VS NUMBER OF CYCLES–VCX SERIES

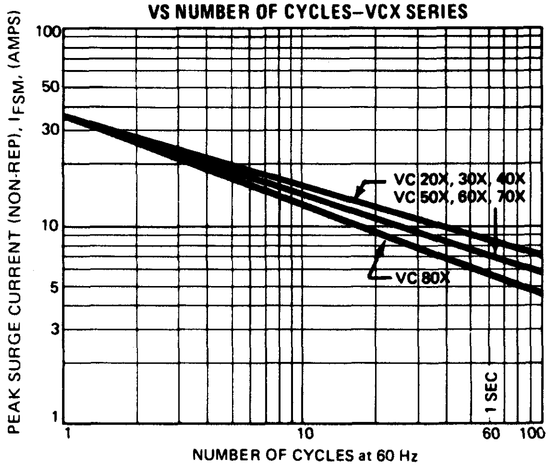


FIGURE 4

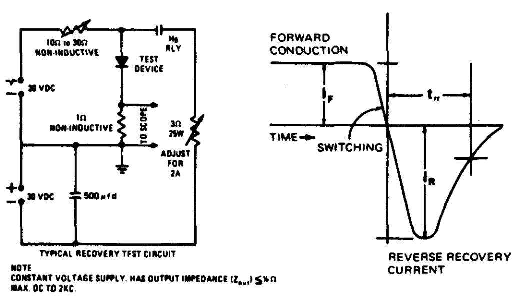


FIGURE 5

VARO

High Voltage Rectifiers

Television Applications **133**
Glass Passivated and Encapsulated Diodes, 9 kV to 15 kV 135
Diode, 13 kV @ 2mA 137
Diode, 13 kV @ 3mA 139
Diode, 22 kV @ 2.2mA 141
Diode, 30 kV @ 1.5mA 143
Diode, 30 kV @ 600μA 145
Diode, 45 kV @ 2.2mA 147

VARO:
the world's leading rectifier company

Varo Semiconductor is the largest producer of high voltage diodes in the United States, and is a leading manufacturer of silicon rectifiers, diodes, bridges and multipliers for customers throughout the world.

VARO FIRSTS

First to offer a high voltage diode to the television industry, paving the way for a "100% solid state" color and b & w chassis.

First to offer a full-wave bridge in a DIP package.

First (and currently, only) to offer a full-wave bridge utilizing Schottky rectifiers in a DIP package.

First U.S. company to manufacture high voltage glass encapsulated diodes.

VARO QUALITY

All of Varo's manufacturing facilities are located in Garland, Texas. This enhances process monitoring and control, leading to high product quality and reliability. Every Varo device is mechanically inspected and electrically tested prior to shipment: no AQL or lot sampling. Only 100% testing.

HOW TO USE THIS CATALOG

Standard devices are listed in the table of contents, and are grouped into four classifications. Find your general area of interest, then locate the specific device by page number. Application Notes are listed by subject matter.

HOW TO ORDER VARO PRODUCTS

Phone or write/cable/telex:

Varo Sales Representative
Varo Distributor (many of Varo's items are stocked by local Varo Distributors)
Varo Semiconductor, Marketing Department

TERMS

Net 30 days.   FOB Point: Varo Factory; Garland, Texas

WARRANTY

The seller warrants that at time of shipment the products manufactured by Seller and sold hereunder will be free from defects in material and workmanship and will conform to the specifications furnished or approved in writing by the Seller. Seller's obligation under this warranty, however, is expressly limited to replacing, repairing, or issuing credit for (at Seller's option) any products returned to Seller during the schedule period shown below and if (a) Seller has received written notice within 30 days after discovery of any defect by Buyer, (b) the defective products are returned to Seller, transportation charges prepaid by Buyer, and (c) Seller's examination of such products discloses to Seller's satisfaction that defects in such products have not been caused by misuse, neglect, improper installation, repair, alteration, or accident. This warranty is in lieu of all other warranties (express; implied, including merchantability and fitness; or statutory), and in no event shall Seller be liable to Buyer for loss of profits, loss of use, or damages of any kind based upon a claim for breach of warranty.

Warranty schedule is as follows:

Standard Products — All products identified with an EIA number or Varo model, series, or print number are warranted for one year from date of shipment.

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DLS 084

High Voltage Glass Diodes H1701

January 1980

Designed for Integrated Flyback Transformers and Voltage Multipliers

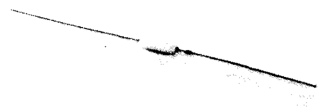
Glass Passivated

Glass Encapsulated

Platinum Doped

Aluminum Bonded

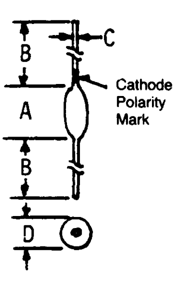
Uniform Chip-to-Chip Recovery



MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL	−9	−10	−11	−12	−15	UNITS
Repetitive Peak Reverse Voltage*	V_{RRM}	9	10	11	12	15	kV
Forward Current, Repetitive Peak	I_{FRM}			235			mA
Forward Current (Total RMS)	$I_{F(RMS)}$			14			mA
Average Rectified Forward Current, 15.75 kHz, 15% duty cycle, capacitive load	$I_{F(AV)}$			3			mA
Operating Junction Temperature	T_J			−40 to +120			°C
Operating Case Temperature	T_C			−40 to +110			°C
Storage Temperature	T_{STG}			−40 to +150			°C
Max. Soldering Temperature for 10 sec. Max., 0.125 inch min. from glass				260			°C

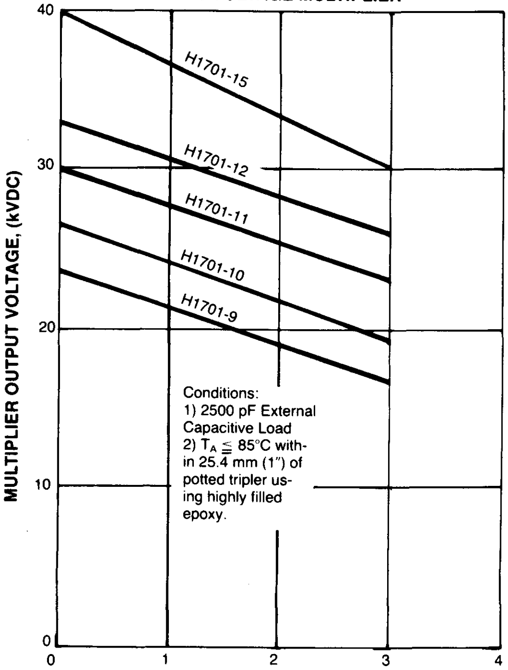
ELECTRICAL CHARACTERISTCS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Max. Forward Voltage, @ I_F = 5 mA	V_F	40	V
Max. Reverse Current, @ V_R = Rated V_{RRM}*	I_R	2	μA
Max. Reverse Recovery Time (Circuit Fig. 2)	t_{rr}	100	ns
Typ. Junction Capacitance, f = 100 kHz, V_R = 100 VDC	C_J	0.4	pF

*For reverse voltage testing, the rectifier must be in a suitable dielectric such as oil, pressurized nitrogen, Freon TF vapor, epoxy, or Fluorinert, FC-43.



NOMINAL DIMENSIONS		
LTR	INCHES	MM
A	$.360 \pm .030$	9,14
B	$1.19 \pm .03$	30,23
C	$.0236 \pm .0015$	0,6
D	.135 Max	3,43

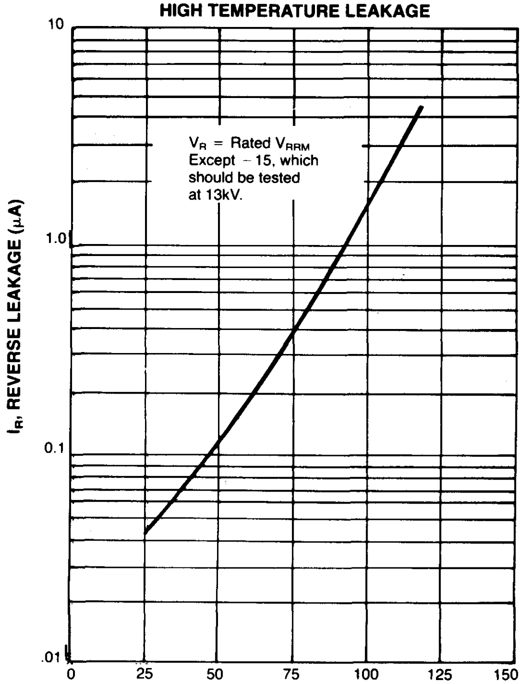
TYPICAL DERATING IN A TRIPLER TYPE VOLTAGE MULTIPLIER



I_O, AVERAGE OUTPUT CURRENT (mA)

FIG. 1

TYPICAL HIGH TEMPERATURE LEAKAGE



T_J, JUNCTION TEMP (°C)

FIG. 3

REVERSE RECOVERY TEST CIRCUIT

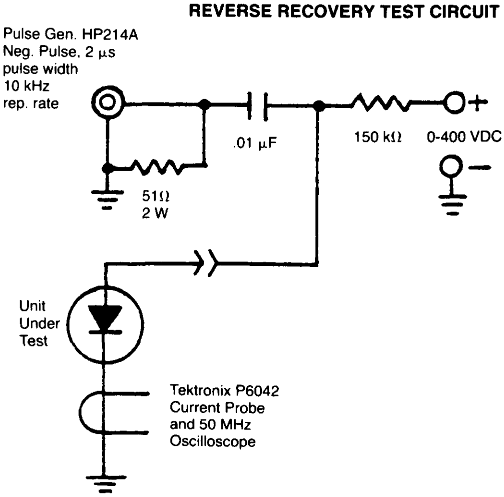
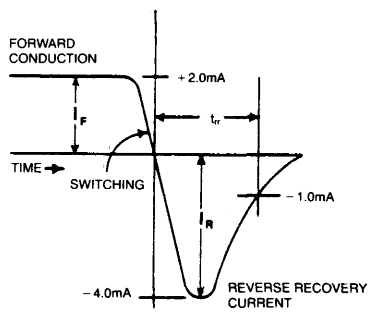


FIG. 2A

REVERSE RECOVERY WAVEFORM



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DLS 085

High Voltage Diode H500

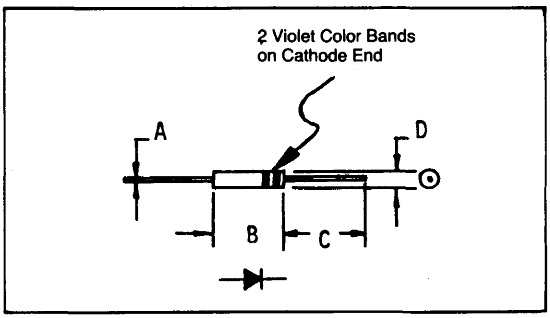
January 1980

Designed for Television Multipliers

MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Non-Repetitive Peak Reverse Voltage	V_{RSM}	13	kV
Repetitive Peak Reverse Voltage	V_{RRM}	12	kV
Non-Repetitive Peak Surge Current, 1/2 Cycle at 60 Hz	I_{FSM}	2	A
Average Forward Current, Capacitive Load @ $T_C \leq 75°C$ (Fig. 3)	$I_{F(AV)}$	2.0	mA
Storage Temperature Range	T_{STG}	−40 to +150	°C
Diode Case Temperature Operating Range	T_C	−40 to +75	°C

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Reverse Current @ V_R = 12 kV	I_R	1	μA
Minimum Reverse Voltage at I_R = 10μA DC	V_{BR}	13	kV
Maximum Forward Voltage at I_F = 10mA	V_{FM}	25	V
Maximum Reverse Recovery Time, I_F = 2mA, I_R = −4mA and I_{rr} = −1mA (Fig. 1)	t_{rr}	300	ns

NOTE: Rectifier Ratings Dependent Upon Final Encapsulation.



LTR	INCHES	MILLIMETERS
A	.020 Dia.	.508 Dia.
B	.60	15.2
C	.6 Min.	15.2 Min.
D	.16 Dia.	4.0 Dia.

FIG. 1A
Recovery Test Circuit

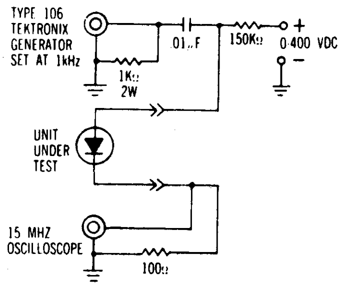


Figure 1B
Recovery Wave Form

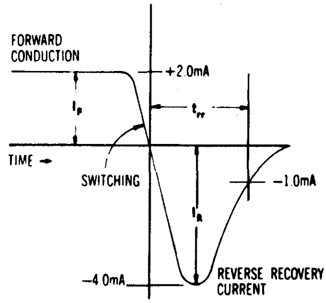


Fig. 2A
Typical Operating Circuit

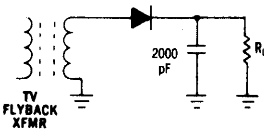


Fig. 2B
Typical Applied Voltage

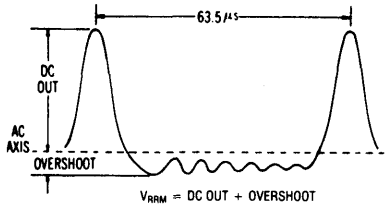


Fig. 3

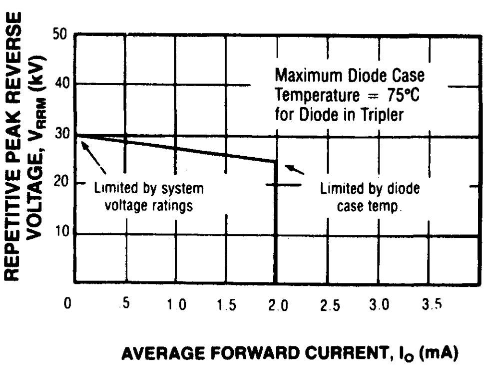
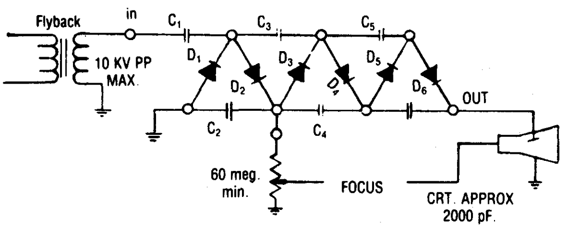
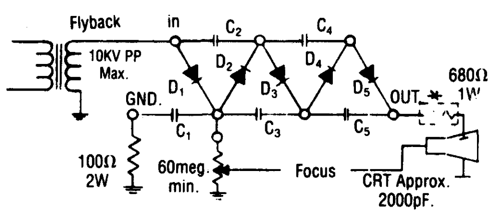


Fig. 4
All Capacitors = 1000pf, All Diodes = H500



Typical 6 Diode Tripler Circuit



***Res. for Arc protection**
Typical 5 Diode Tripler Circuit

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 086

High Voltage Diode H521

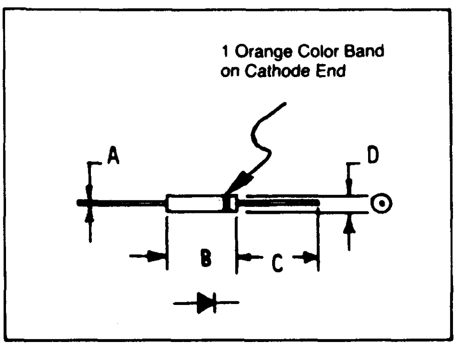
January 1980

Designed for Television Multipliers

MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Non-Repetitive Peak Reverse Voltage	V_{RSM}	13	kV
Repetitive Peak Reverse Voltage	V_{RRM}	12	kV
Non-Repetitive Peak Surge Current, 1/2 Cycle at 60 Hz	I_{FSM}	2	A
Average Forward Current, Capacitive Load @ $T_c \leq 85°C$ (Fig. 3)	$I_{F(AV)}$	3.0	mA
Storage Temperature Range	T_{STG}	−40 to +150	°C
Diode Case Temperature Operating Range	T	−40 to +85	°C

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Reverse Current @ V_R = 12kV	I_R	1	μA
Minimum Reverse Voltage at I_R = 10μA DC	V_{BR}	13	kV
Maximum Forward Voltage at I_F = 10mA	V_{FM}	25	V
Maximum Reverse Recovery Time, I_F = 2mA, I_R = -4mA and I_{rr} = -1mA (fig.1)	t_{rr}	300	ns

NOTE: RECTIFIER RATINGS DEPENDENT UPON FINAL ENCAPSULATION.



LTR	INCHES	MILLIMETERS
A	.020 Dia.	.508 Dia.
B	.60	15.2
C	.6 Min.	15.2 Min.
D	.16 Dia.	4.0 Dia.

FIG. 1A
Recovery Test Circuit

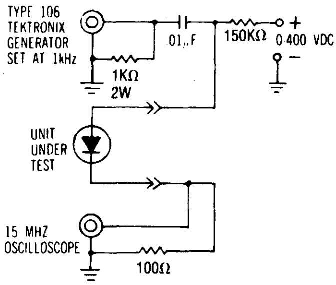


Figure 1B
Recovery Wave Form

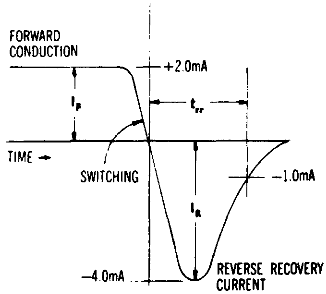


Fig. 2A
Typical Operating Circuit

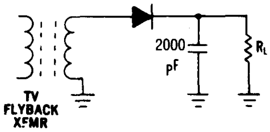


Fig. 2B
Typical Applied Voltage

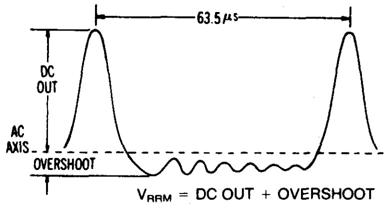


Fig. 3

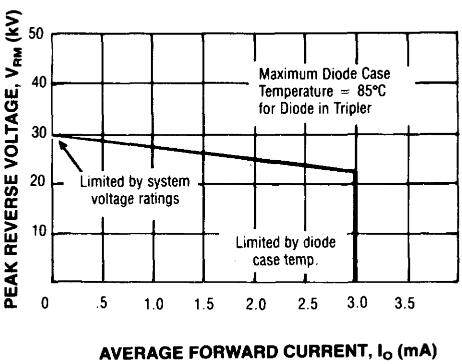
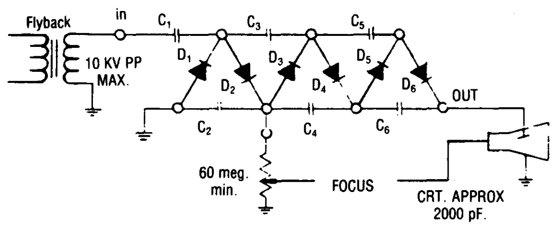
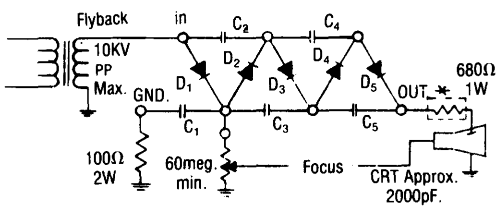


Fig. 4
All Capacitors = 1000pf, All Diodes = H521



Typical 6 Diode Tripler Circuit



***Res. for Arc protection**
Typical 5 Diode Tripler Circuit

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 087

High Voltage Diode H485-62

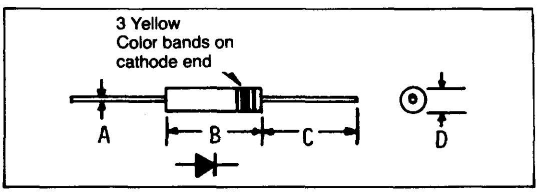
January 1980

Designed for Molding into Small Screen TV Flyback Transformers
Uniform Chip-to-Chip Recovery
Low Leakage at High Junction Temperatures

MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Repetitive Peak Reverse Voltage	V_{RRM}	22	kV
Forward Current, Repetitive Peak	I_{FRM}	150	mA
Forward Current (Total RMS) @ T_C = 115°C @ T_C = 100°C	$I_{F(RMS)}$	4.9 11	mA
Average Forward Current, Capacitive Load (Fig. 1) @ T_C = 100°C	$I_{F(AV)}$	2.2	mA
Non-Repetitive Peak Surge Current, 1/2 Cycle at 60 Hz	I_{FSM}	2	A
Storage Temperature Range	T_{STG}	−55 to +150	°C
Ambient Temperature Operating Range	T_A	−55 to +100	°C
Case Temperature Operating Range	T_C	−55 to +115	°C

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Reverse Current at V_R = 22 kVDC	I_R	1	μA
Typical Reverse Breakdown Voltage @ I_R = 10μA*	V_{BR}	25	kV
Maximum Forward Voltage at I_F = 10 mA	V_{FM}	70	V
Maximum Reverse Recovery Time, I_F = 2 mA, I_R = −4 mA and I_{rr} (rec) = −1 mA (Fig. 4)	t_{rr}	175	nsec
Soldering Temperature: 260°C Max. for 10 sec., 1/16" from epoxy			
Encapsulation into flyback transformers: See Varo Application Note "Design Considerations for HV Silicon Rectifiers Integrated into Flyback Transformers."			

*Rectifier must be in a suitable dielectric to prevent arcing between leads.



LTR	INCHES	MILLIMETERS
A	.020	0,508
B	.60	15,2
C	.6 min.	15,2 min.
D	.16	4,06

DERATING FOR USE AS HIGH VOLTAGE RECTIFIER IN 15.734 Hz DEFLECTION SYSTEM

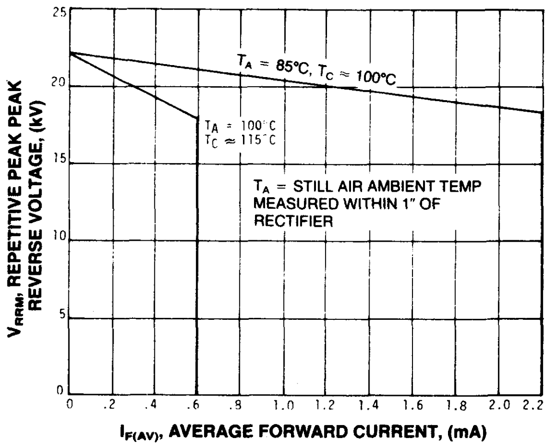


FIG. 1

NOTES:

(1) Air temp measured with calibrated laboratory-grade alcohol thermometer.

(2) Case temp ≃ 100°C when rectifier is operating at 18 kV V_{RRM}, 2.0 mA, in 85°C still air ambient.
Case temp. measured with Tempil "Tempilaq" Temp. Indicating Liquid.
Source: Tempil Division
Big Three Industries, Inc.
South Plainfield, NJ 07080

(3) All temperatures presented here are approx. 10°C below known thermal runaway points. We recommend that customers intentionally raise the still air ambient temp. on their designs to learn the actual thermal runaway point for their application. The final design should have at least 20°C safety factor.

TYPICAL OPERATING CIRCUIT

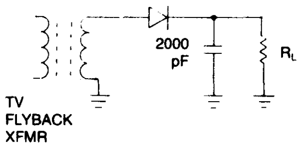
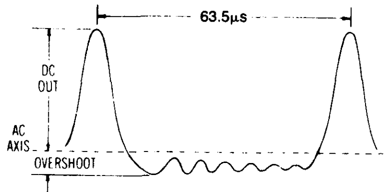


FIG. 2

TYPICAL APPLIED VOLTAGE



V_{RRM} = DC OUT + OVERSHOOT

FIG. 2B

REP. PEAK REV. VOLTAGE vs AMBIENT TEMPERATURE

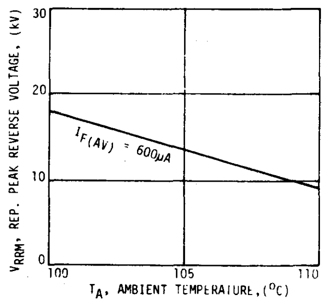


FIG. 3

RECOVERY WAVEFORM

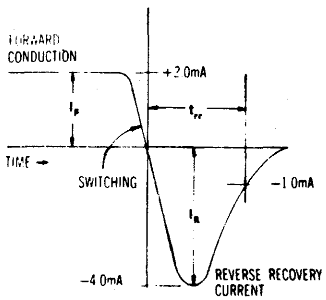


FIG. 4A

RECOVERY TEST CIRCUIT

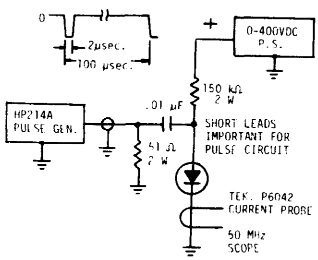


FIG. 4B

TYPICAL HIGH TEMPERATURE LEAKAGE

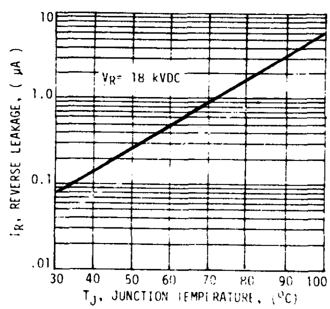


FIG. 5

VARO

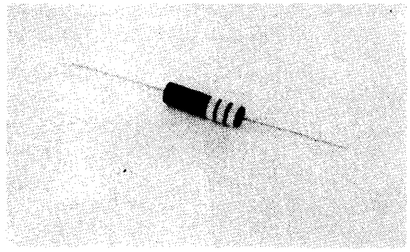
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 088

High Voltage Diode H1152

January 1981

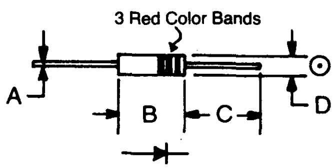
Designed for High Temperature Operation
Uniform Chip-to-Chip Recovery
Ideal for Small Screen B & W TV High Voltage Rectifier
Low RFI/EMI
Avalanche Quality Junctions for Exceptional Transient Voltage Reliability



MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Non-Repetitive Peak Reverse Voltage**	V_{RSM}	30	kV
Repetitive Peak Reverse Voltage**	V_{RRM}	25	kV
Non-Repetitive Peak Surge Current, 1/2 Cycle at 60 Hz	I_{FSM}	500	mA
Repetitive Peak Forward Current	I_{FRM}	100	mA
Forward Current (total RMS)	$I_{F(RMS)}$	10	mA
Average Forward Current (See Fig. 1)	$I_{F(AV)}$	1.5	mA
Storage Temperature Range	T_{STG}	−55 to +150	°C
Diode Case Temperature Operating Range	T_C	−55 to +100	°C

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Reverse Current at V_R = 25kV (note 1)	I_R	1	μA
Maximum Reverse Current at V_R = 20 KV, 85°C (note 1)	I_R	10	μA
Maximum Reverse Current at V_R = 30KV (note 1)	I_R	10	μA
Maximum Forward Voltage at I_F = 10 mA	V_{FM}	80	V
Maximum Reverse Recovery Time, I_F = 2mA, I_R = −4mA and I_{rr} = −1mA; Fig. 3A and 3B	t_{rr}	175	nS

**This rectifier must be re-encapsulated in adequate dielectric to operate at indicated voltages. The use of a highly filled epoxy is recommended.



LTR	INCHES	MILLIMETERS
A	.020 Dia.	.508 Dia.
B	.60	15.2
C	.8 min.	20 min.
D	.16 Dia.	4.0 Dia.

Derating for use as high voltage rectifier in 15,734 Hz deflection system

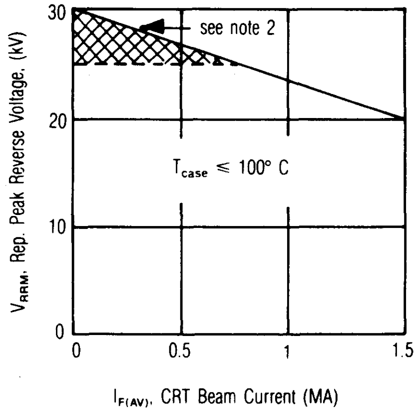


Figure 1

NOTES:

(1) For reverse voltage testing, the rectifier must be in a suitable dielectric such as oil, pressurized nitrogen, Freon TF vapor, epoxy, or other plastic encapsulant.

(2) Operating in cross-hatched region should be limited to occasional transient voltages.

(3) Case temp. measured with 101°C Tempil "Templiaq" Temp. Indicating Liquid.
Source: Tempil Division
Big Three Industries, Inc.
South Plainfield, NJ 07080

(4) All temperatures presented here are approx. 15°C below know thermal runaway points. We recommend that customers intentionally raise the still air ambient temp. on their designs to learn the actual thermal runaway point for their application. The final design should have at least 20°C safety factor in required ambient.

(5) Encapsulating Considerations:
See Varo Application Note "Design Considerations for HV Silicon Rectifiers Integrated into Flyback Transformers".

TYPICAL OPERATING CIRCUIT

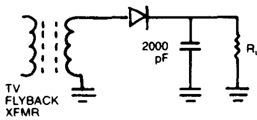


Figure 2A

TYPICAL APPLIED VOLTAGE

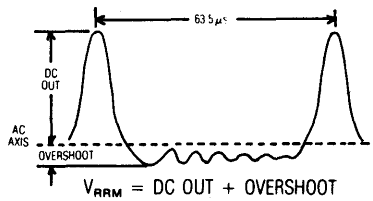


Figure 2B

RECOVERY WAVEFORM

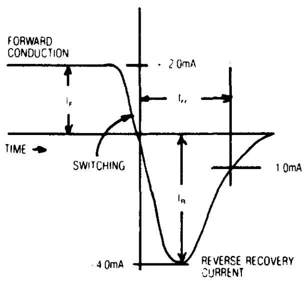


Figure 3A

RECOVERY TEST CIRCUIT

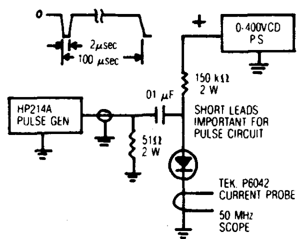


Figure 3B

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 089

High Voltage Diode H1802

January 1980

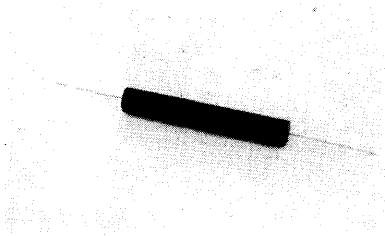
Designed for B & W TV High Voltage Rectifier up to 20 kVDC CRT Voltage

Avalanche Quality Rectifier Junctions

Molding Material Rated UL 94 V-O

Uniform Chip-to-Chip Recovery

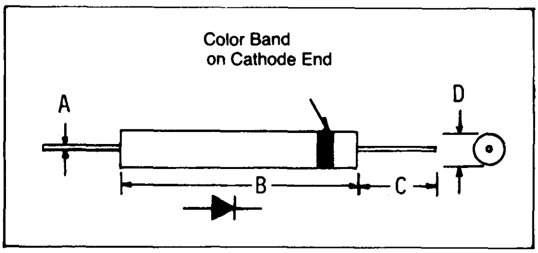
Low RFI in TV Circuits



MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Non-Repetitive Peak Reverse Voltage	V_{RSM}	30	kV
Repetitive Peak Reverse Voltage	V_{RRM}	28	kV
Forward Current (Average) See Fig. 1, 2 & 3	$I_{F(AV)}$	600	μA
Forward Current (Total RMS)	$I_{F(RMS)}$	4.6	mA
Repetitive Peak Forward Current	I_{FRM}	100	mA
Storage Temperature Range	T_{STG}	−40 to + 150	°C
Ambient Operating Temperature Range	T_A	−40 to + 75	°C

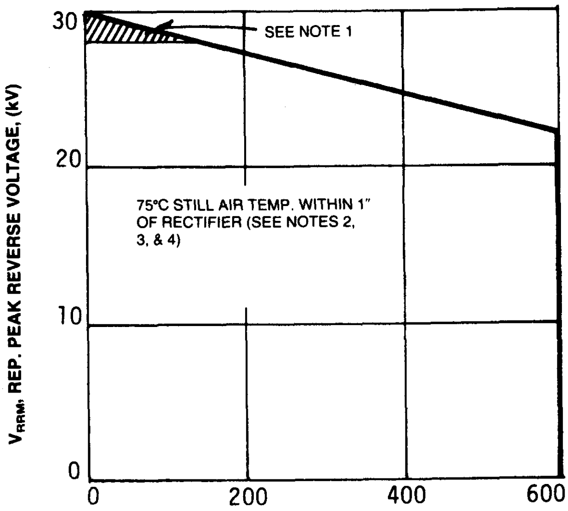
ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Reverse Current at V_R = 28 kV	I_R	1	μA
Maximum Forward Voltage Drop at I_F = 10 mA	V_{FM}	120	V
Reverse Recovery Time, I_F = 2 mA, I_R = − 4 mA and I_{rr} (rec) = −1 mA (Fig. 4)	t_{rr}	175	nsec
Soldering Temperature: 260°C Max. for 10 sec. max. 1/16" from epoxy			

Encapsulating Considerations: See Varo Application Note
"Design Considerations for HV Silicon Rectifiers Integrated into Flyback Transformers."



LTR	INCHES	MILLIMETERS
A	.020 Dia.	0,508 Dia.
B	1.5	38,10
C	.50 Min.	12,7 Min
D	.235	5,97

DERATING FOR USE AS HIGH VOLTAGE RECTIFIER IN 15,734 Hz DEFLECTION SYSTEM



$I_{F(AV)}$, CRT BEAM CURRENT (μA)

FIG. 1

NOTES:

1) Operation in cross-hatched region should be limited to less than 5 min.

2) Air temp. measured with calibrated laboratory-grade alcohol thermometer.

3) Case temp. ≈ 90°C when rectifier is operating at 22 kV V_{RRM}, 600 μA, in 75°C still air ambient.
Case temp. measured with 90°C Tempil "Templiaq" Temp. Indicating Liquid.
Source: Tempil Division
Big Three Industries, Inc.
South Plainfield NJ 07080

4) All temperatures presented here are approx. 10°C below known thermal runaway points. We recommend that customers intentionally raise the still air ambient temp on their designs to learn the actual thermal runaway point for their application. The final design should have at least 20°C safety factor.

TYPICAL OPERATING CIRCUIT

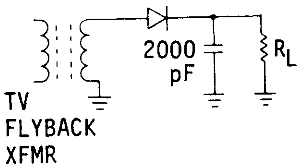
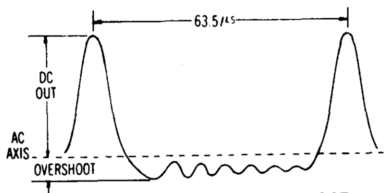


FIG. 2A

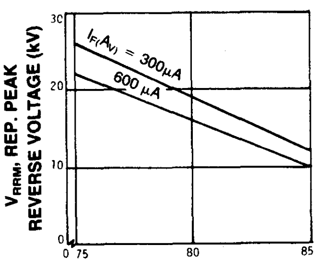
TYPICAL APPLIED VOLTAGE



V_{RRM} = DC OUT + OVERSHOOT

FIG. 2B

REP. PEAK REV. VS: AMBIENT TEMPERATURE



T_A, AMBIENT TEMPERATURE, (°C)

FIG. 3

RECOVERY WAVEFORM

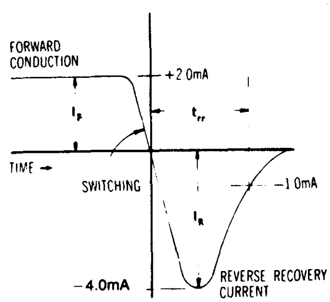


FIG. 4A

RECOVERY TEST CIRCUIT

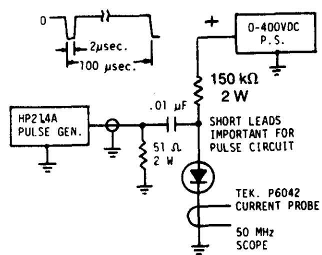


FIG. 4B

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 090

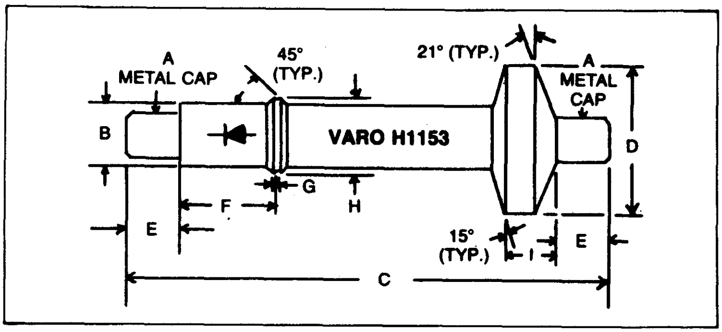
High Voltage Diode H1153

January 1981

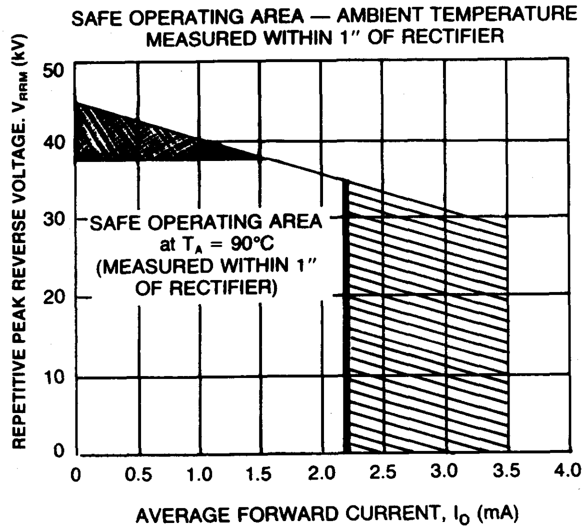
Designed for High Temperature Operation
Low RFI/EMI

MAXIMUM RATINGS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Repetitive Peak Reverse Voltage (Fig. 1)	V_{RRM}	45	kV
Average Forward Current (Fig. 1)	$I_{F(AV)}$	2.2	mA
Peak Surge Current, 1/2 Cycle at 60Hz, (Non-Rep)	I_{FSM}	200	mA
Maximum Ambient Operating Temperature	T_A	90	°C
These maximum ratings cannot necessarily be used simultaneously; see Fig. 1 — Safe Operating Areas.			

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)	SYMBOL		UNITS
Maximum Reverse Current @ V_R = 45KV	I_R	1	μA
Maximum Forward Voltage Drop @ I_F = 10 mA	V_{FM}	160	V
Max. Anode-to-Cathode Capacitance at V_R = 400V, f = 100kHz	C_J	0.75	pF
Reverse Recovery Time @ I_F = 2mA, I_R = −4mA and I_{RR} = −1mA (Fig. 4)	t_{rr}	175	ns.



LTR	INCHES	MILLIMETERS
A	.360 DIA.	9.14 DIA.
B	.50 DIA.	12.70 DIA.
C	3.7	94
D	1.18 DIA.	29.97 DIA.
E	.4	10.2
F	.750	19.05
G	.050	1.27
H	.60 DIA.	15.24
I	.40	10.16



Operation in crosshatched regions should be limited to less than 5 minutes.

Use Calibrated Laboratory Grade Alcohol Thermometer To Measure Air Temp. Approx. 1" Below Rectifier.

FIGURE 1

Typical Applied Voltage

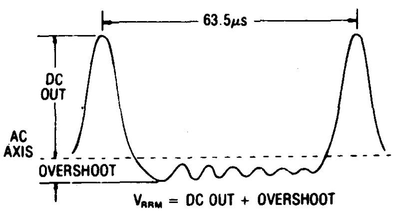


FIGURE 2

Typical Operating Circuit

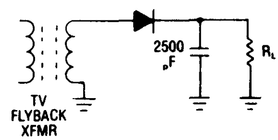


FIGURE 3

Recovery Wave Form

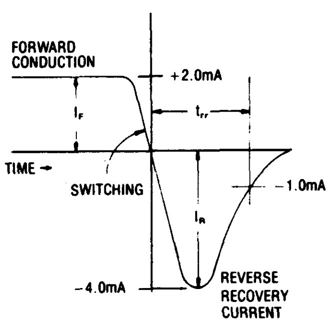


FIGURE 4A

Recovery Test Circuit

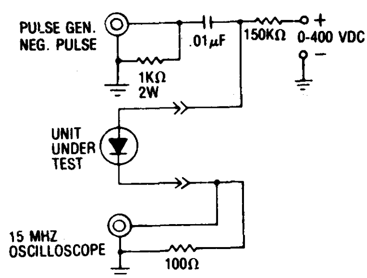


FIGURE 4B

VARO

High Voltage Rectifiers

Multipliers 150

VARO

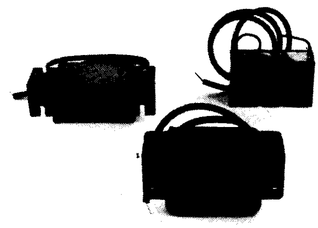
VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
(214) 271-8511 TWX 910-860-5178

DLS 091

Standard High Voltage Multipliers

January 1980

Varo's standard high voltage TV multipliers are designed for high reliability and maximum stability in sustained high temperature operation for color TV and CRT applications.



VARO TYPE	OUTPUT kV @ 0 mA, 75°C	OUTPUT kV @ Io, 75°C	OUTPUT mA MAX. @ 75°C	INPUT kVpp MAX. @ 0 mA	TYPICAL ImA REG. (Mohm)	MAX. INPUT pf	CASE STYLE	SCH. #
MH919	30	25	2.0	11	1.5	11.0	A	1
MH920	30	25	2.0	10	2.0	13.5	A	2
MH931	35	30	2.0	12	1.5	14.0	A	1
MH932	35	30	2.0	12	2.0	17.0	A	2
MH1001	32	30	2.0	12	1.0	14.0	B	3
MH1002	32	30	2.0	12	1.5	14.0	B	1*
MH1003	25	20	2.0	9	2.0	14.0	B	1*
MH1201	35	30	2.0	13	1.0	14.0	C	6
MH1203	35	30	2.0	13	1.5	14.0	C	4
MH1204	30	25	2.0	11	1.5	14.0	C	4
MH1209	30	25	2.0	10	2.0	17.0	C	5

*Less output series resistor

ALL MULTIPLIERS EXHIBIT THE FOLLOWING CONDITIONS:

All Materials Recognized by UL FILE E59887.

Maximum Forward Voltage Drop at I_F = 2 mA = 200 Volts

Maximum Reverse Current at Rated Full Load Output = 1 μA

Minimum Arcing Capability into 2000 pf Load at rated I_0 Output kV (Output to Ground Arc) = 60 arcs at 1 arc/sec.

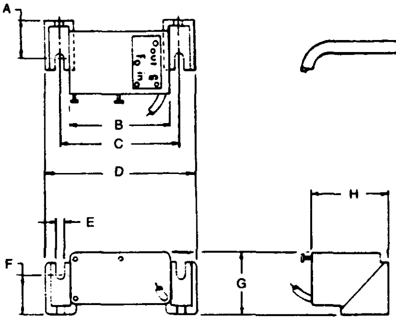
Minimum Output to Ground Short Circuit Capability = 1 min.

Operating Temperature range (Ambient Air) = −20°C to +75°C

Storage Temperature Range = −40°C to +100°C

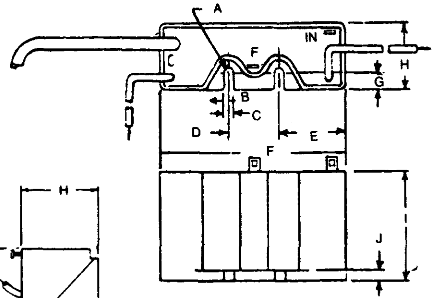
Other electrical and mechanical configurations are available. Call Varo for further information.

CASE STYLES



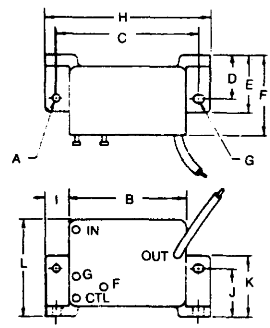
STYLE A

LTR	INCHES	MILLIMETERS
A	.94	23.88
B	2.75	69.85
C	3.38	85.85
D	4.25	107.95
E	.19	4.83
F	.94	23.88
G	1.63	41.40
H	2.13	54.10



STYLE B

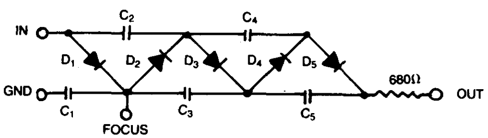
LTR	INCHES	MILLIMETERS
A	.188R	4,78R
B	.088	2,24
C	.176	4,47
D	.786	19,96
E	1.07	27,18
F	2.98	75,50
G	.24	6,10
H	1.05	26, 6
I	1.76	44,70
J	.162	4,12
K	.125 × .250 (nom)	3,18 × 6,35 (nom)



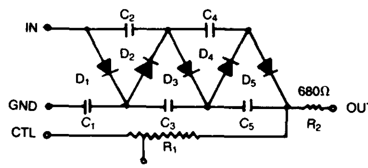
STYLE C

LTR	INCHES	MILLIMETERS
A	.190 Dia. Typ.	4,83
B	2.75	69,85
C	3.37-3.39	85,60-86,11
D	1.00 Typ.	25,4
E	1.31 Typ.	33,27
F	1.85	46,99
G	.190 × .250 Typ.	4,83 × 6,35
H	3.87	98,30
I	.56 Typ.	14,22
J	1.13 Typ.	28,70
K	1.45 Typ.	36,83
L	2.30	58,42

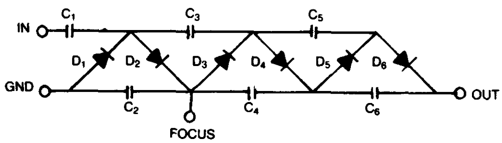
SCHEMATICS



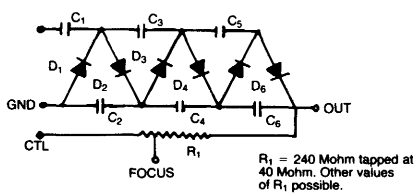
SCHEMATIC #1



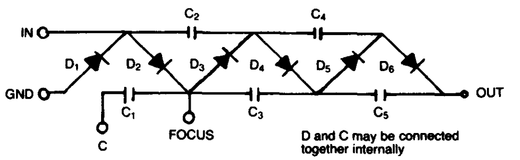
SCHEMATIC #4



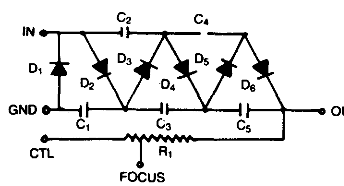
SCHEMATIC #2



SCHEMATIC #5

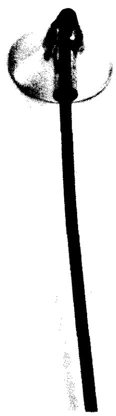


SCHEMATIC #3

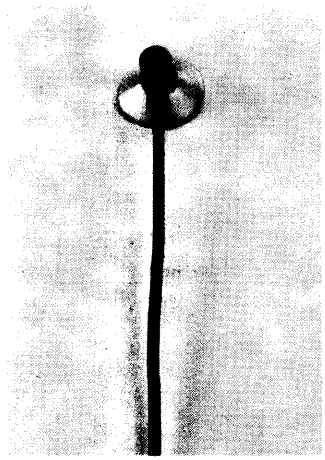


SCHEMATIC #6

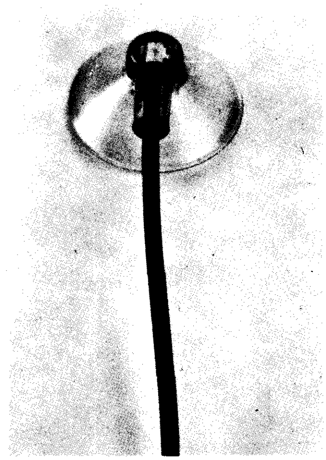
STANDARD ANODE CAPS AVAILABLE



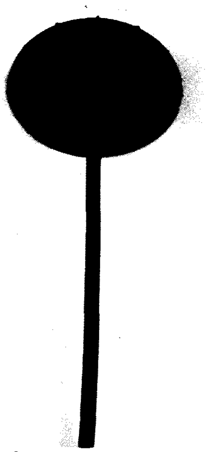
STYLE A: PVC 2" Cup, Hobson Bros. P127-23, 35 kV



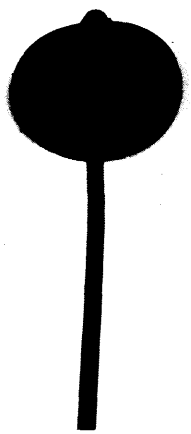
STYLE B: PVC 1¾" Cup, Hobson Bros. P125-23, 30 kV



STYLE C: PVC 2" Cup (Low Profile), Hobson Bros. P119-132, 35 kV



STYLE D: Silicone Rubber, 3" Cup, Stalwart S1552, 40 kV



STYLE E: Silicone Rubber, 2" Cup, Stalwart S1551, 40 kV

VARO

Application Notes

Application Notes

IBR Installation Data 155
Solving Thermal Impedance Problems, IBR 158
Controlled Avalanche Rectifiers 160
Cut Component Count and Improve Reliability with Controlled Avalanche Rectifiers 162
Fast Recovery Rectifiers 165
Selecting the Proper Half-Wave Rectifier for TV High Voltage Circuits 167
Design Considerations for HV Silicon Rectifiers Integrated into Flyback Transformers 170
High Voltage with Low Cost Multipliers 173
Keep Rectifiers Cool by Calibrating Forward Voltage Drop 178

VARO:
the world's leading rectifier company

Varo Semiconductor is the largest producer of high voltage diodes in the United States, and is a leading manufacturer of silicon rectifiers, diodes, bridges and multipliers for customers throughout the world.

VARO FIRSTS

First to offer a high voltage diode to the television industry, paving the way for a "100% solid state" color and b & w chassis.

First to offer a full-wave bridge in a DIP package.

First (and currently, only) to offer a full-wave bridge utilizing Schottky rectifiers in a DIP package.

First U.S. company to manufacture high voltage glass encapsulated diodes.

VARO QUALITY

All of Varo's manufacturing facilities are located in Garland, Texas. This enhances process monitoring and control, leading to high product quality and reliability. Every Varo device is mechanically inspected and electrically tested prior to shipment: no AQL or lot sampling. Only 100% testing.

HOW TO USE THIS CATALOG

Standard devices are listed in the table of contents, and are grouped into four classifications. Find your general area of interest, then locate the specific device by page number. Application Notes are listed by subject matter.

HOW TO ORDER VARO PRODUCTS

Phone or write/cable/telex:
- Varo Sales Representative
- Varo Distributor (many of Varo's items are stocked by local Varo Distributors)
- Varo Semiconductor, Marketing Department

TERMS

Net 30 days. FOB Point: Varo Factory; Garland, Texas

WARRANTY

The seller warrants that at time of shipment the products manufactured by Seller and sold hereunder will be free from defects in material and workmanship and will conform to the specifications furnished or approved in writing by the Seller. Seller's obligation under this warranty, however, is expressly limited to replacing, repairing, or issuing credit for (at Seller's option) any products returned to Seller during the schedule period shown below and if (a) Seller has received written notice within 30 days after discovery of any defect by Buyer, (b) the defective products are returned to Seller, transportation charges prepaid by Buyer, and (c) Seller's examination of such products discloses to Seller's satisfaction that defects in such products have not been caused by misuse, neglect, improper installation, repair, alteration, or accident. This warranty is in lieu of all other warranties (express; implied, including merchantability and fitness; or statutory), and in no event shall Seller be liable to Buyer for loss of profits, loss of use, or damages of any kind based upon a claim for breach of warranty.

Warranty schedule is as follows:

Standard Products — All products identified with an EIA number or Varo model, series, or print number are warranted for one year from date of shipment.

VARO

VARO SEMICONDUCTOR P.O. BOX 40676, 1000 NORTH SHILOH, GARLAND, TEXAS 75040 (214) 271-8511 TWX 910-860-5178

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
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VSP 100

January 1980

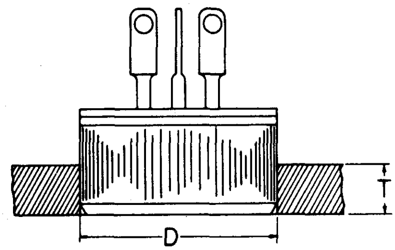
Application Notes IBR Installation Data

Recommended Plate Thickness,
"T" = 1/8 to 3/16 inches.

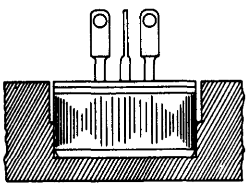
Hole Diameter,
"D" = 0.747 ± .001 inches.

Material, Aluminum with hardness (Brinnell 10/500) 55 to 75 tensile strength 24-35KPSI such as aluminum alloys:

5052 H 32	hardness 62,	Tensile 28,000 PSI
5052 H 34	hardness 67,	Tensile 31,000 PSI
3003 H 18	hardness 55,	Tensile 27,000 PSI



Other alloys may be used but the ranges of hardness and tensile strength shown above will give optimum results. Harder alloys may induce fracture of the glass seal or internal components and will require excessive insertion forces to seat. Softer alloys will work well if shock and vibration are not too great as factors in the particular application. Soft alloys will increase the possibility of degrading the thermal resistance of the mount if the assembly is exposed to severe temperature cycling. Relatively low forces are required to insert and remove the device from heat sinks made of soft aluminum.



If the IBR is to be mounted into a "thick" heat sink (one greater than 3/16 inch thick) it should be pressed only to 3/16 inch depth. If greater depth is required the mounting hole should be counterbored 25/32 inch diameter to a depth such that only the lower 3/16 inch of the device engages the heat sink. Possible damage to the glass seal may result with full depth pressing.

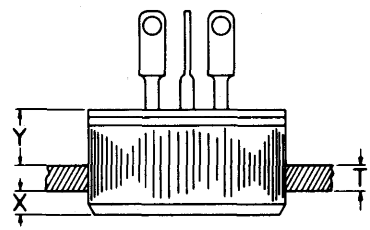
Thermal impedance from IBR case to heat sink, using the above mounting techniques, is less than 0.5^{o}C/watt.

For added ease in seating the device a small chamfer may be provided, but it is not required. If a chamfer is used it should not be more than 1/32" deep in 1/8" thick material or insufficient area will be available for engagement. The IBR itself is chamfered to reduce the need for chamfer in the mounting hole.

Plate Thickness,
"T" $<$ 1/8 inches*

Hole Diameter,
"D" = 0.747 ± .001 inches

Material,
Aluminum, same general requirements as for 1/8 to 3/16 inches thick plates.



The distance (x) from bottom surface of heat sink to bottom surface of IBR must be 3/64 or greater to clear chamfer on IBR case and insure adequate engagement of IBR case and heat sink.

The distance (y) from top surface of IBR case to top surface of heat sink must not be less than 1/8" to prevent damage to the glass seal.

It should be noted that if the rectifier is pressed to maximum depth, the case-to-heat-sink thermal impedance will be increased by approximately 125^{o}C/W over the minimum depth value of 0.5^{o}C/W.

Hole diameter and tolerance for depth of 3/16 to .300 will vary with material thickness and hardness Varo Special Products Engineering Department should be consulted for applications assistance.

*Press fitting is not recommended in plate less than 1/16 inch thick. Mounting should be accomplished with Varo supplied TO-3 flange or stud assembly.

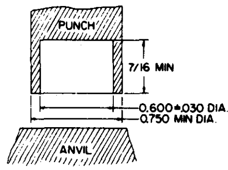
In all press fit applications the press force must be perpendicular to the mounting surface and must be smoothly applied. A press force of 2000 pounds should not be exceeded. The most suitable means of applying the insertion force is with a hydraulic press or hand arbor press with proper tooling.

Approximate insertion forces required to mount an IBR in typical aluminum plates 0. 125" thick, hole size 0. 747" diameter are as follows:

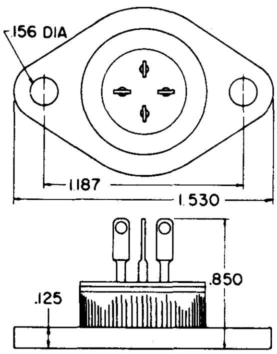
Aluminum alloy:	5052-T34	1200 - 1800	pounds
	5052-T32	800 - 1600	pounds
	5052-0	200 - 600	pounds

The die used for pressing should be selected with care to prevent damage to the glass seal and terminals of the device. The diagram at the right gives some minimum and maximum dimensions that must be observed.

For mounting with the case bottom flush with the bottom of the fin, use a flat anvil as shown. For deeper pressing, anvil must be relieved. The relief hole should be 13/16 inch diameter (25/32 minimum, 7/8 maximum).



IBR TO-3 OUTLINE FLANGE ASSEMBLY



The TO-3 flange assembly, shown at the right, was designed in order to provide a simple yet effective means of mounting the IBR . The IBR is press fitted to the flange by Varo.

When securely mounted, with silicone heat sink compound between flange and mounting surface, this assembly yields a case to heat sink thermal impedance of 0. 6°C/W. Dow Corning, Type 340, heat sink compound is recommended. Brass or steel screws (size 6-32) are recommended for mounting and may be tightened without fear of harming the IBR or loosening it from the flange, if the mounting surface is reasonably flat. This assembly is particularly recommended for use with fins or chassis less than 1/16 inch thick.

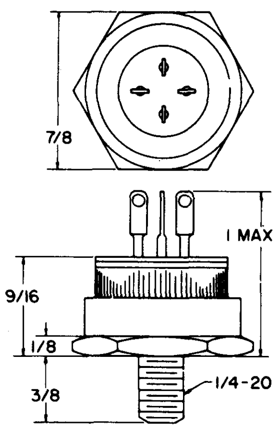
The flange itself is aluminum alloy 5052-T34 with an irridite finish. Approximately 1000 pounds force are required to dislodge the IBR from the flange.

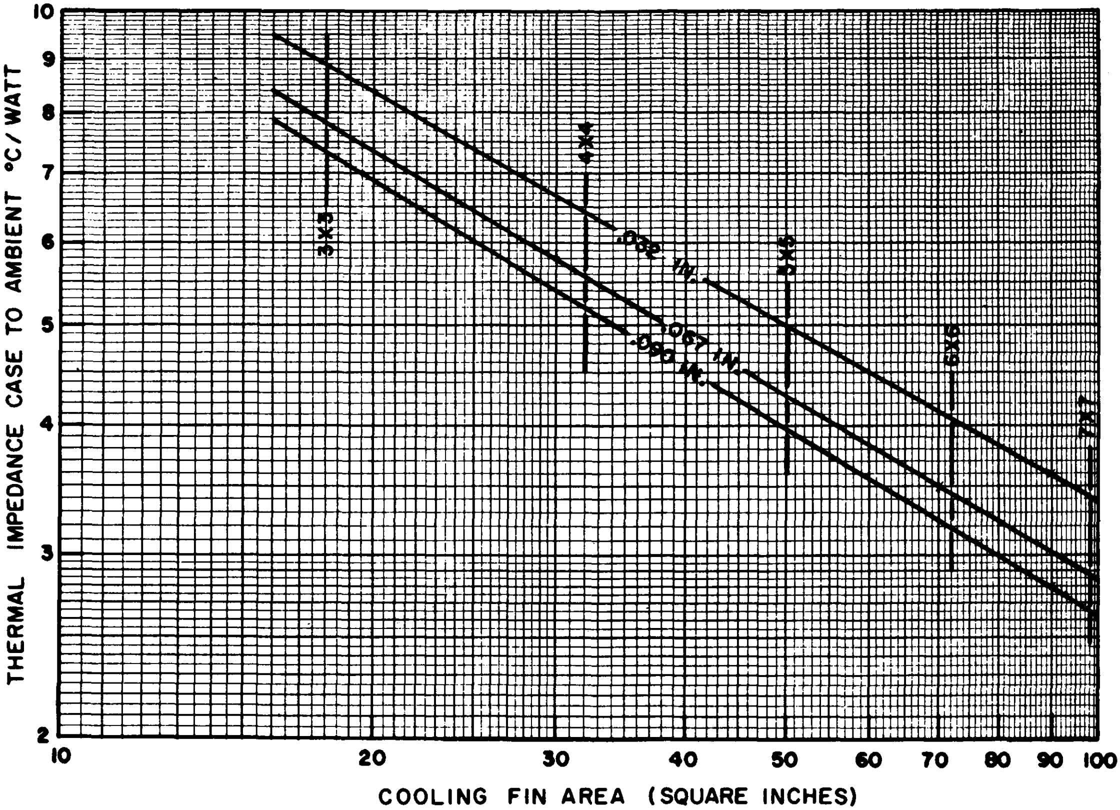
IBR THREADED STUD BASE ASSEMBLY

A threaded stud base assembly is available for those requirements most suitably met by this configuration. The IBR is press fitted by Varo into the irridite finish aluminum base. The threaded stud is cadmium plated steel. The combination of aluminum body and steel stud provide high thermal conductivity and excellent physical strength.

Mounting must be accomplished on a clean, flat surface. Care should be taken to remove any burrs around the mounting hole. Silicone heat sink compound should be applied to the bottom surface of the assembly and to the mounting surface prior to installation. Dow Corning Heat Sink Compound Type 340 is recommended. The retaining nut should be tightened to a maximum of 75 inch pounds. After mounting in this manner the thermal impedance from case to heat sink will be less than 0. 75°C/Watt dissipation.

A copper body is available in place of the aluminum on special order.





THERMAL IMPEDANCE IBR CASE TO AMBIENT

IBR mounted using T0-3 Flange Assembly and Dow Corning Type 340 heat sink compound. Cooling fins bare aluminum plates suspended vertically in free air. Fin configuration is square. Area shown includes both sides of plate. Units of thermal impedance are °C Temperature rise of IBR case above ambient temp per watt of device power dissipation (approximately 2. 2 watts per ampere output) versus cooling fin area in square inches and fin thickness in inches.

VARO

VARO SEMICONDUCTOR, INC., P.O. BOX 40676
1000 NORTH SHILOH, GARLAND, TEXAS 75040
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VSP101

Application Notes — Solving Thermal Impedance Problems for the IBR

June 1981

The Varo IBR® is an Integrated Bridge Rectifier providing single-phase, full-wave rectification in one small package. Its SAR® (silicon avalanche rectifier) characteristics control the avalanche voltage so that it occurs across the entire junction area. This greatly reduces the costly PRV safety factors that must be used in design considerations with conventional rectifiers, where the junction perimeter may be degraded or destroyed by transient overvoltages.

Selection of heat sinks for the IBR® is important, for proper heat sinking allows a great flexibility in DC output current range, and means the IBR® may be used where space, current, or cost factors have previously prevented the use of semiconductors.

This applications bulletin describes methods of solving thermal impedance problems in order to select heat sinks for the IBR® in two typical cases: a "worst-case" application, and a commercial heat sink application. The basic procedure is described and two sample problems are worked out in detail.

Basic information required is to be found in the IBR® data sheets and bulletins. All IBR® data sheets include a derating curve, and forward voltage drop vs. forward current at various temperatures. Varo's Bulletin VSP 100, Installation Data, contains other useful information, including a graph for determining cooling fin area once the desired thermal impedance is determined.

The IBR® is available in three versatile mounting configurations: press-fit, TO-3, and single stud. The sample solutions given are for TO-3 mount. Thermal impedance characteristics for all IBR® mounts are given below.

IBR® THERMAL IMPEDANCE

Case to Heat Sink, θ_{C-H}

Press-Fit	less than 0.5°C/W[1]
TO-3	0.6°C/W
Single Stud	less than 0.75°C/W

[1]Properly mounted; see VSP-100

"WORST-CASE" APPLICATION

The basic procedure is first to determine power dissipated, which is the product of the forward voltage drop times current. Data sheets give forward voltage drop **per leg**; in the IBR, two legs will conduct at any given time.

Maximum allowable case temperature will be given on the Derating Curve; the maximum rise in case temperature is maximum allowable temperature less ambient.

Thermal impedance is determined by dividing maximum rise in case temperature by power dissipation.

When the required thermal impedance characteristic is determined, size of heat sink is quickly found on the graph in VSP-100.

A typical problem is worked out step by step in the example below.

PROBLEM:

To determine the required size for an aluminum mounting fin capable of cooling an IBR during worst-case operation.

Selected Conditions:

(1) TO-3 mounted with silicone grease

(2) Average rectified current (load current): 7 Amps

(3) Ambient temperature (maximum), free air: $T_A = 50°C$

Relevant Data Sheet Information:

Forward voltage drop (per leg): approx. 1.0V avg.

Temperature derating curve (IBR)

Relevant Applications Note:

Varo IBR Installation Data, VSP 100. Use graph on last page.

SOLUTION:

(1) Calculate power dissipated by device:

$P_D = (V_{F(avg)})\,(I_{avg})$

$= (1.0V + 1.0V)\,(7A)$ Note: in a bridge circuit, two legs conduct at any given time

$= 14$ watts

(2) Consult device Derating Curve to determine maximum allowable case temperature at 7 amps average:

$T_C = 115°C$ max.

(3) Subtract T_A from T_C to obtain allowable ΔT_{C-A}.

$\Delta T_{C-A} = T_C - T_A$

$= 115°C - 50°C$

$= 65°C$

(4) To determine required thermal impedance characteristic of the heat sink, take the quotient:

$\frac{\Delta T_{C-A}}{P_D} = \theta_{C-A}$ (thermal impedance, case to ambient)

$= \frac{65°C}{14\ W}$

$= 4.64°C/W$

(5) Enter the graph on the last page of VSP 100 (IBR Installation Data) at 4.64°C/W and move horizontally to determine heat sink size. The required area (total of both sides of fin if both sides are exposed to free air) is dependent on fin thickness and is as follows:

.090" thick	38 sq. in.
.067" thick	44 sq. in.
.032" thick	57 sq. in.

These areas are minimums, and some safety factor may be allowed. If a square fin is used, the following sizes would be acceptable:

.090" thick	5"x 5" (50 sq. in.)
.067" thick	5"x 5" (50 sq. in.)
.032" thick	6"x 6" (72 sq. in.)

Approximately 5% more area should be allowed when stud mounting is used, because of the slightly higher mounting thermal impedance (0.15°C/W higher).

COMMERCIAL HEAT SINK APPLICATION

Manufacturers' data on commercial heat sinks give convection characteristics in terms of mounting surface temperature rise above ambient, ΔT_{M-A}, vs. power dissipation.

Power dissipation is determined by multiplying forward voltage drop times current.

Then the maximum allowable rise in mounting surface temperature is determined. First, temperature drop from case to heat sink is determined by multiplying the power dissipated times thermal impedance, case to heat sink (see table above). The maximum allowable rise in **mounting surface** temperature is then determined by taking the maximum allowable **case** temperature, subtracting the **temperature drop** from case to heat sink, and then subtracting the **ambient** temperature.

A typical problem is worked out step by step in the example below.

PROBLEM:

To select a commercial, natural convection, heat sink capable of cooling an IBR device during operation.

Selected Conditions:

(1) TO-3 mounted with silicone grease
(2) Average rectified current (load current): 7 Amps
(3) Ambient temperature (maximum), free air: $T_A = 50°C$

Relevant Data Sheet Information:

Forward voltage drop (per leg): approx. 1.0V avg.

Temperature derating curve (IBR)

Relevant Applications Note:

Varo IBR Installation Data, VSP 100. Mounting thermal impedance, case to heat sink, θ_{C-H}.

Other Information Required:

Heat sink manufacturer's data on convection characteristics

SOLUTION:

(1) Calculate power dissipated by device:

$P_D = (V_{F(avg)})\,(I_{avg})$

$= (1.0V + 1.0V)\,(7A)$ Note: In a bridge circuit, two legs conduct at any given time.

$= 14$ watts

(2) Consult device Derating Curve to determine maximum allowable case temperature at 7 amps average:

$T_C = 115°C$ max.

(3) To determine temperature drop from case to heat sink, multiply power dissipated, P_D, times thermal impedance, case to heat sink, θ_{C-H}:

$\Delta T_{C-H} = P_D \cdot \theta_{C-H}$

$= 14\ W \cdot 0.6°C/W$

$= 8.4°C$

(4) The maximum allowable mounting surface temperature is the maximum allowable case temperature less the temperature drop from case to heat sink:

$T_M = T_C - \Delta T_{C-H}$

$= 115°C - 8.4°C$

$= 106.6°C$

(5) The maximum allowable rise in mounting surface temperature above ambient (50°C in this case) is:

$\Delta T_{M-A} = T_M - T_A$

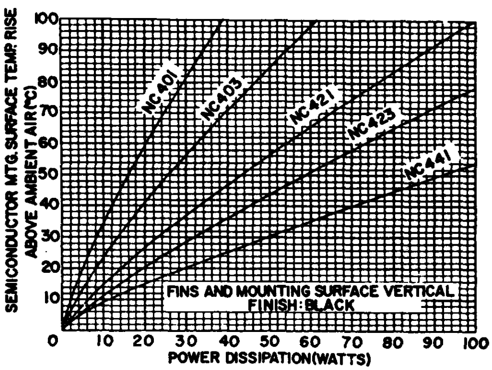
$= 106.6°C - 50°C$

$= 56.6°C$

(6) Refer to manufacturer's graph to determine suitable heat sink. Required data are:

P_D power dissipated (14 watts)

ΔT_{M-A} mounting surface temperature rise above ambient air (56.6°C)



EXAMPLE: Graph reproduced above (by permission from Wakefield Engineering, Inc.) shows the natural convection characteristics of several heat sinks, any of which would be suitable in the problem given.

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VSP 103

Application Notes — Controlled Avalanche Rectifiers

January 1980

Avalanche

Large reverse biases, when applied to silicon rectifiers, can cause the rectifier to avalanche. The term "avalanche" refers to that critical reverse voltage at which further increases in voltage result in rapidly increasing reverse current flow. This avalanche effect is commonly used in voltage regulator diodes which are frequently referred to as Zener, or breakdown diodes. Conventional power rectifiers are normally not designed for operation near this critical avalanche voltage level and can be destroyed if it is exceeded even momentarily.

Reverse biases sufficient to cause avalanche may be caused by transient overvoltages, voltage spikes in supply line power, line switching, feedback from line-connected equipment, arcing in the distribution system, lightning, or other causes.

However, the most common cause is inductive "kick" AC voltage many times higher than the impressed voltage is produced by the collapsing magnetic field in an inductive component when current through it is abruptly cut off. This voltage will rise until it causes sufficient current to flow to dissipate the stored energy, and may cause arcing in the switch, avalanching of the rectifier, or other component breakdown. Unless a safe channel is provided for the dissipation of this energy, destruction of one or more components may result. The inductive kicks generated by power transformers, filter chokes, motors, and magnetic devices such as solenoids are frequently sufficient to damage conventional silicon rectifiers.

Protecting Rectifiers Against Overvoltages

There are several methods of protecting rectifiers from the hazards of transient overvoltages. The use of shunting capacitors across the input and output of the rectifier circuit can prevent many problems by absorbing transient energy.

Selenium and silicon carbide varistor overvoltage transient protectors are available. These devices are essentially voltage regulators with large active areas which absorb energy by becoming conductive at a selected voltage thereby limiting the circuit voltage to a safe level. A recent product available for protection is the metal oxide varistor (MOV). They are quite effective in absorbing spikes.

Another method is to select silicon rectifiers with V_{RRM} ratings greater than the highest transient voltage expected to occur. This method is usually not economical and may not provide sufficient protection against inductive kicks.

The "Controlled Avalanche" Rectifier

There is another method available to the designer which will protect the rectifier from both input and load transients: the use of silicon rectifiers capable of absorbing large amounts of transient reverse avalanche energy without being destroyed.

Such devices are commonly called **CONTROLLED AVALANCHE RECTIFIERS** and generally have a minimum and maximum reverse breakdown voltage, specified $V_{(BR)}$. Special manufacturing processes are used to produce a silicon chip that avalanches uniformly across the entire area of the junction rather than at discrete points as in conventional devices. This process considerably increases the energy levels which the rectifier can absorb.

Besides possessing uniform area avalanching characteristics, the device is designed so that the avalanche voltage is sufficiently low to prevent internal or external arcing of the junction or package respectively.

Evaluating Controlled Avalanche Rectifiers

The most important characteristic, in design considerations, of the controlled avalanche rectifier is its ability to withstand transient overvoltages without damage. A principal indicator of this characteristic is its power dissipation rating in the avalanche region. Figure 1 shows a circuit for testing avalanche power dissipation, and a typical current pulse curve.

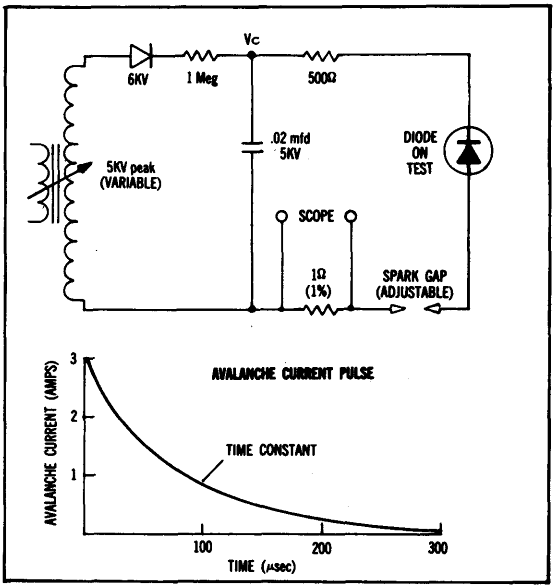

Figure 1: TRANSIENT AVALANCHE POWER DISSIPATION TEST CIRCUIT AND TYPICAL CURRENT PULSE CURVE
(V_C is variable through spark gap adjustment and its desired value is a function of diode avalanche voltage and desired power dissipation level.)

The avalanche knee $V_{(BR)}$ may be observed using the curve tracer circuit shown in fig. 2. A sharp knee is a general indicator of the quality of etching, junction passivation and packaging. It does not necessarily indicate the power handling capability of the rectifier chip in avalanche.

Controlled avalanche rectifiers manufactured by Varo Semiconductor are 100% tested for $V_{(BR)}$, I_{FM}, and V_{FM} after final assembly to assure maximum quality and performance.

Applications for Controlled Avalanche Rectifiers

A controlled avalanche rectifier is not a replacement for transient protection devices in all situations, but it does provide adequate protection wherever avalanche energy levels are within the rectifier specifications. Among such applications are permanent magnet motors, solenoid actuators, and transformer power supplies.

Advantages of Controlled Avalanche Rectifiers

- Greater inherent tolerance to transient overvoltages.
- Protection of other circuit elements that might be damaged with the use of high V_{RRM} rated devices.
- Higher circuit reliability.
- Potential cost savings in most applications through the use of lower-rated devices.
- Elimination of transient suppressors in many applications.
- Compatibility with inductive circuit and load elements.
- Greater device reliability resulting from improved internal design and tighter testing levels.

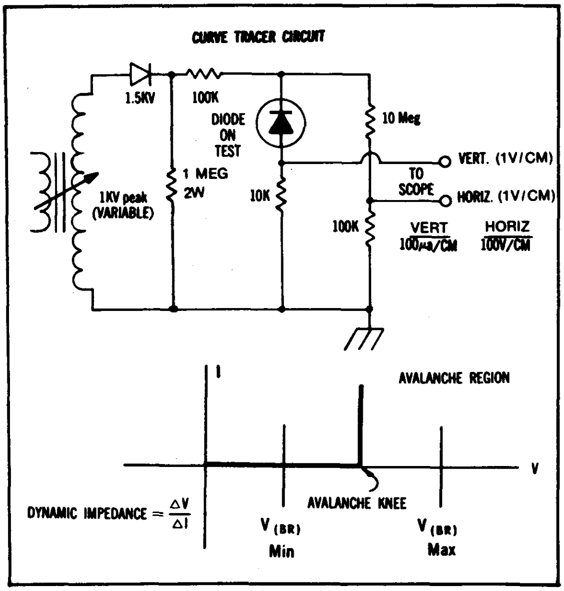

Figure 2: CURVE TRACER CIRCUIT AND TYPICAL REVERSE AVALANCHE CURVE

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VSP 115

Application Notes Cut Component Count and Improve Reliability with Controlled Avalanche Rectifiers

January 1980

Cut Component Count and Improve Reliability with Controlled-Avalanche Rectifiers. In High-Transient Circuits they also Protect Other Components.

Has a rectifier ever failed when you bread-boarded a circuit, because of transients not anticipated in your preliminary design? Or, has a rectifier—that functioned normally in a circuit—failed when operating as part of a larger system, because of power-line transients generated elsewhere in the system?

Use of a controlled-avalanche (CA) rectifier may solve problems associated with failures caused by transients in electronic equipment. A CA rectifier benefits nearly all transient-generating circuits.

The CA rectifier offers a couple of advantages when the transient energy falls within its capability:

1) Almost instantaneous response when clamping a voltage transient, due to the highly-regenerative nature of the rectifier's avalanche mode.

2) Reduction of the number of components that have to be designed in, bought, inspected, stored and finally wired into a circuit.

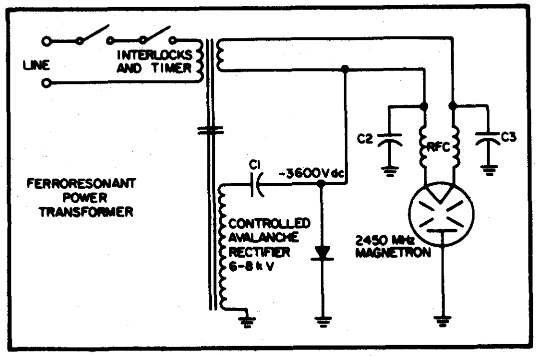
Typical applications for CA rectifiers include:

- microwave ovens.
- electrostatic copiers.
- power supplies and converters.
- voltage regulators.
- TV high-voltage circuits.

Since CA rectifiers cost more than conventional rectifiers, their use must be justified before a final choice is made. To simplify that decision, let's review the characteristics and limitations of CA rectifiers; see where they can be particularly helpful; then, go through the actual selection procedure.

What is a CA rectifier?

A controlled-avalanche junction in a silicon rectifier can absorb or dissipate—without failing—a relatively large amount of energy while in the "breakdown" or avalanche mode. Because of its contruction, a "conventional" junction can



1. **A controlled-avalanche rectifier** eliminates the need for a separate filament transformer and delay timer in the high-voltage section of a microwave-oven magnetron power supply.

withstand only a few microamperes in the reverse direction before failure.

Controlled-avalanche means that the reverse voltage rating of a rectifier is specified to range between a minimum and maximum value at a specified avalanche current rating. The present state-of-the-art allows avalanche junctions to withstand voltages in excess of 1300 V.

With limitations, the CA rectifier can solve problems associated with failures caused by transients in a system. Energy-handling capability is the principal limitation. When the transient energy is a fraction of a joule, a silicon junction can probably be found which will absorb the energy reliably. In high-voltage circuits, several junctions in series may be needed.

To protect circuits from transients that contain more than a few joules of energy, you probably will have to use some other type of protective devices. Many types are rated for over 1000 J. But these other devices tend to be much larger than silicon rectifiers.

Who needs one?

The microwave-oven application is a classic example of the use of a controlled-avalanche

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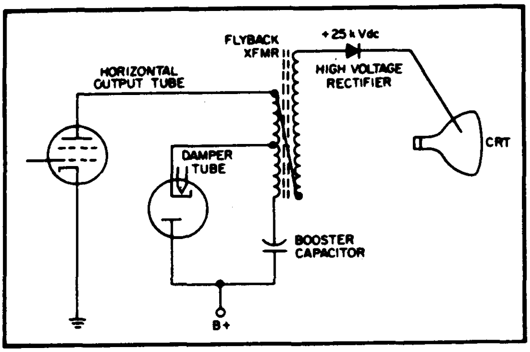
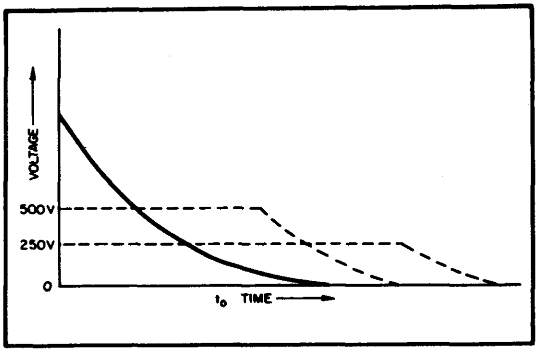


2. **About 50 junctions** in series are used to produce a controlled-avalanche rectifier that will withstand a repetitive reverse voltage of 32 to 36 kV in a color TV. Conventional rectifiers use about twice as many junctions.



3. **Controlled-avalanche rectifiers** can keep transients between acceptable limits. Such transients can occur when power to an inductor is suddenly switched off, and can damage conventional rectifiers.

rectifier. Fig. 1 is the basic circuit that is gaining wide popularity with oven manufacturers. Over-all reduced cost compared to earlier circuits justifies the popularity. The circuit is a half-wave doubler with shunt rectification. It provides a negative high-voltage to power the magnetron with an input of approximately 1500 W.

A characteristic problem occurs with magnetrons when high voltage is applied while the filament is warming up. The magnetron starts to oscillate, then suddenly ceases conduction. This may happen several times during each line cycle, for several tenths of a second, until the filament warms enough to sustain oscillation in the correct mode. Each time oscillation ceases, large, transient voltages are created on the high-voltage line due to sudden unloading of the power supply.

In this application, a controlled-avalanche rectifier serves the normal, rectifying function and also protects several other components from being damaged by transients. If the transients are not clamped, the voltage can rise high enough to break down the transformer insulation, the RF filter capacitors (C and C_3), or even the magnetron. The CA rectifier—using several series junctions, and selected to be within the range of 6-8 kV for this circuit—will ensure protection for these components. It will clamp the transients and absorb about 1 J of energy.

Color TV supplies

Hybrid color TV sets are another application of CA high-voltage rectifiers. Fig. 2 shows that the high-voltage rectifier consists of about 50 junctions in series. It can withstand a normal, repetitive reverse voltage of 32 to 36 kV. However, damper tubes tend to arc over occasionally as filament material flakes off. Because of arcing within the tube, or elsewhere, a transient voltage appears across the rectifier. This may destroy the rectifier if it can't absorb the energy in the transient-generating circuit.

In this case, it seems that junction avalanching protects the junction passivation from abnormally high, reverse voltages. A full explanation involves the stray capacitance from the rectifier to ground and the extremely fast-rising transient voltages in the circuit. The junction nearest the AC end probably avalanches first; the rest then "domino" until all junctions are finally avalanched, and the voltage is clamped.

In this application, about 50 avalanche junctions do a job that would, otherwise, have required about 90 conventional junctions and lots of luck. The actual breakdown level of a single conventional rectifier junction can exceed 3000 V. This voltage is impressed across the short silicon/passivation interface, and can cause passivation failure in circuits that use series junctions and have fast-rising voltage waveforms.

Selecting the avalanche rectifier

Selection of a controlled-avalanche rectifier involves three required characteristics: current rating, voltage range and energy rating. Start by looking for rectifiers with the necessary current ratings—both average and surge current. Then choose the minimum and maximum voltage range that can be tolerated. A tight range will cost considerably more than a loose one. Note, also, that for some commercially available avalanche-type rectifiers only the minimum voltage is specified.

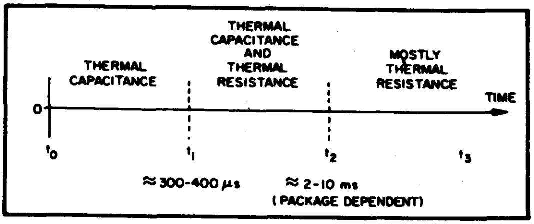
In most cases, the energy rating is much more difficult to select, because CA rectifiers are often used in circuits where transient conditions are difficult to repeat and measure. In such cases, trial-and-error may be the only satisfactory method of selection. Manufacturers can frequently supply devices that are similar in most characteristics except for the junction area. (Note that junction area also affects forward-surge and average-current ratings.)

When these options are available, start with the largest junction device, and work down in size to determine the smallest sized junction that will live in the circuit. Then the desired safety factor can be added, and selection is complete—except for providing the correct thermal environment.

When the transient is repeatable on demand, it can be studied for its energy content, and a more enlightened selection approach can be used. Fig. 3 shows the sort of transient waveform that might occur when power to an inductor is suddenly switched off.

Assume we need to limit the voltage to a range of 250 to 500 V. Alternately connect CA limit rectifiers of these two voltages to the circuit, and find the duration of energy within the rectifier. For this study, use the largest-junction rectifiers available.

Any energy that has to be absorbed in the time region, $t_0 - t_1$, (Fig. 4) is almost entirely absorbed by the thermal capacitance of the junction. In the region, $t_1 - t_2$, enough time has elapsed for some heat to flow into the rectifier package. Therefore, the energy rating of the rectifier will be higher if the transient extends beyond 300-400 μs. Beyond t_2, thermal resistance determines basically how much energy can be absorbed and dissipated by the CA rectifier; and, with increasing time, the energy rating reaches the dc dissipation of the device.



4. **Transient duration determines** whether the energy must be absorbed by the thermal capacitance of the junction ($t_0 > t > t_1$) or by the thermal resistance of the rectifier and its package ($t > t_2$).

To find average current in a clamped waveform, take a picture of the waveform displayed on a scope and use a planimeter (a mechanical device that measures area) to find the irregular waveform area. This is then expressed as a percentage of a square-cornered pulse having the same peak amplitude.

The peak voltage and time are also measured with an oscilloscope.

Energy is calculated from $E = VIt$, where
V = clamped voltage level,
I = average current, and
t = time in seconds.

Information obtained can be used to determine the optimum sized junction area and package required to absorb safely the energy present in the circuit, and to meet all other requirements.

The energy rating for any particular rectifier type is usually given at only one pulse width (frequently at 100 μs). As the pulse width exceeds the 300 μs to 10 ms period, the rectifier package and heat sink play an increasingly important role in over-all energy handling.

High-energy, high-voltage rectifiers can be made, using a series of avalanche junctions. For example, the 6-8 kV rectifier used in the circuit of Fig. 1 can be made of 10 junctions, each having an energy capability of > 0.15 J for a final rectifier rating guaranteed to be > 1.5 J. In this particular case, the rating is specified at 400 μs pulse width because this is the approximate energy pulse width seen in the circuit. ■■

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VSP 102

Application Notes Fast Recovery Rectifiers

January 1981

FAST RECOVERY RECTIFIERS

A silicon rectifier cannot make an instantaneous switch from forward conduction to reverse blocking. For a momentary period, prior to full blocking, the rectifier is a short circuit, conducting current freely in the wrong direction while the electrical charge that has been built up by forward conduction is "swept out."

In typical "slow" recovery silicon rectifiers, the time required for the rectifier to recover and perform its blocking function may be from 5 to 50 microseconds. In some types of applications, this may be too slow for efficient rectification. Furthermore, it results in a reverse spike of considerable energy which may be highly undesirable in certain conditions and applications.

The purpose of this bulletin is to discuss briefly the characteristics of, applications for, and advantages and disadvantages of fast recovery rectifiers.

Reverse Recovery Time (t_{rr}).

The period of time required for a silicon rectifier to develop its blocking ability after switching from forward conduction is termed "reverse recovery time," t_{rr}. Figure 1 shows a typical Recovery Wave Form for a rectifier, and how t_{rr} is measured. The actual time required for recovery will vary depending on the amount of forward current passed before switching; frequency or rapidity of switching; wave form (sine, sawtooth, or square); impedance of recovery current loop; reverse voltage applied; temperature; and, most important, the type of rectifier used in the circuit.

Manufacturers usually do not give t_{rr} specifications for the slow recovery rectifiers, and where there is no major effort made to control this particular characteristic, recovery time will not be consistent from one device to another. Typical values fall between 5 and 50 microseconds. Occasionally it is possible to select enough relatively fast rectifiers from a large lot to meet a particular applications requirement.

Characteristics of Fast Recovery Rectifiers

A rectifier is usually classified as "fast recovery" if it has a t_{rr} specification of less than 1 microsecond under specified test conditions. Figure 2 shows a typical test circuit.

Basic process changes must be introduced in device manufacture in order to produce a rectifier with fast recovery characteristics. The most common technique is diffusion of minute quantities of gold into the silicon junction structure before actual device fabrication.

Difficulties encountered in this process are basically those of control: the amount of gold applied to the silicon; gold diffusion time and temperature; silicon surface preparation before and after gold diffusion; silicon slice thickness; and previous diffusion steps required to form the rectifying junction. Each of these control points is critical.

The increased level of control (reflected to some extent in lower yields) and the additional process steps result in increased manufacturing costs and somewhat higher selling price.

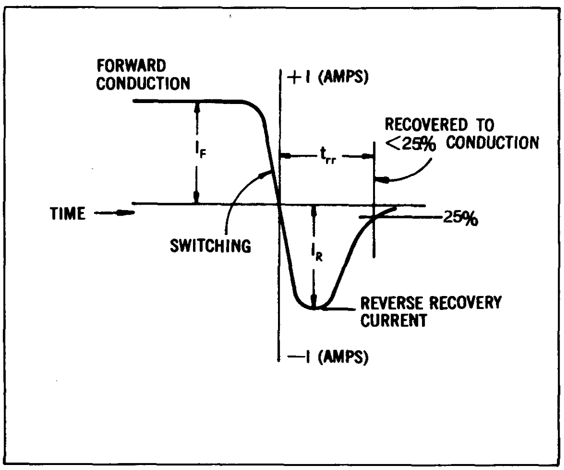

FIGURE 1. RECOVERY WAVE FORM

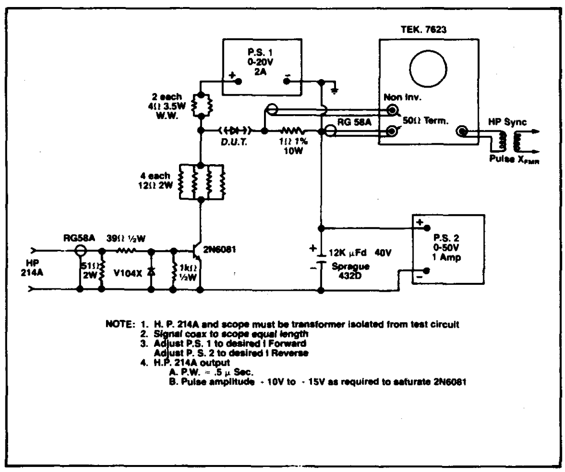

FIGURE 2. TYPICAL RECOVERY TEST CIRCUIT

The actual physical phenomena that result in a reduction of t_{rr} are beyond the scope of this note; it should be recognized, however, that decreasing recovery time for a given rectifier type generally results in an increase in forward voltage drop, an increase in reverse current, and a decrease in peak inverse voltage, PIV.

Forward voltage drop will be slightly higher (about 20%) at current less than, or equal to, rated values on fast recovery devices than with similar slow recovery devices; under surge conditions it will be considerably higher (up to 100%). Reverse current is approximately an order of magnitude higher than in similar slow recovery types. Maximum peak reverse voltages for fast recovery junctions are only about 70% that of slow recovery devices. All of these are reflected in data sheet specifications.

This means, for example, in a high voltage stack rated for a particular voltage, more junctions are required for a fast recovery type than for a slow recovery type.

Applications for Fast Recovery Rectifiers

The most obvious applications for fast recovery rectifiers are those involving high frequencies where slow recovery devices produce low rectification efficiencies, and overheat due to internal losses. Generally speaking, for rectifier purposes high frequencies may be defined as the band from 10 KHz to 200 KHz.

In addition, wave forms such as sawtooth or square waves have high frequency components, even though the repetition rate is low, and often require fast recovery rectifiers for satisfactory operation.

Actual rectification efficiencies are not easily determined analytically; the best practical method of determination is insertion of the rectifier in the actual circuit and observation of performance.

There is a group of applications for fast recovery rectifiers which is less immediately obvious. The reverse recovery "spike" itself has a high frequency content and therefore is a source of noise and radio frequency interference, RFI. Since RFI is related to spike energy, it can be reduced quite effectively through the use of fast recovery rectifiers, which can result in a reduction in the amount of supplementary RFI filtering required.

The spike-reducing characteristics of fast recovery rectifiers may also improve the ripple characteristics of DC power supplies (particularly with square wave inputs), while maintaining minimum values on filter components. This can mean savings in parts costs as well as significant contributions to size and weight reduction.

Figure 3 illustrates typical square wave and sine wave forms with slow recovery and fast recovery rectifiers.

TYPICAL APPLICATIONS

RF Power Supplies

Television:
- **High voltage power supplies**
- **Cameras**
- **Transmitters**
- **Receivers**

Cathode-ray Tubes
Geiger-Mueller Tubes
Travelling-wave Tubes
Klystron Tubes
X-Ray Tubes
High Frequency Photomultiplier Power Supplies
DC to DC Converters
Precision DC Power Supplies
Square-Wave Input DC Power Supplies

ADVANTAGES	DISADVANTAGES
Higher operating frequencies are possible.	Higher cost
Improved rectification efficiency at high frequencies.	Increased forward voltage drop
Reduced RFI	Increased reverse current
Reduced ripple	Decreased PIV
	Lower voltage ratings per junction

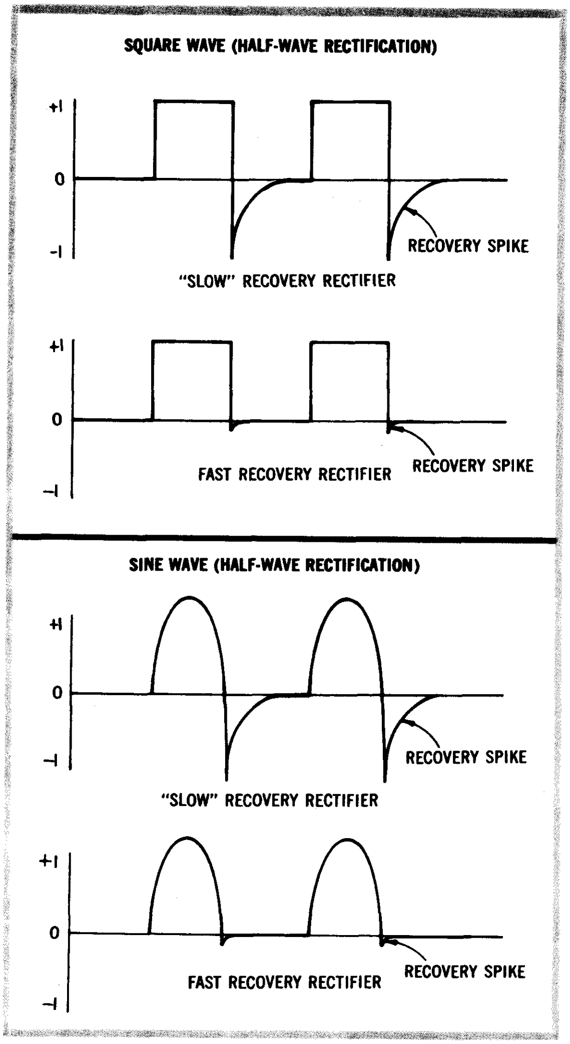

FIGURE 3. TYPICAL WAVEFORMS ILLUSTRATING RELATIVE RECOVERY CHARACTERISTICS IN HIGH FREQUENCY APPLICATIONS.

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VSP 108

Application Notes Selecting the Proper Half-Wave Rectifier for TV High Voltage Circuits

January 1980

This applications bulletin has been prepared to assist TV engineers in selecting the optimum Half-Wave rectifier for a given application. The optimum rectifier is one which just meets all necessary specifications, since it will be the lowest cost unit.

The checklist is provided to summarize maximum requirements and other considerations.

REQUIREMENTS:

Voltage (PRV) ______

Current (AVG) ______

Temperature (°C) ______

Altitude (Ft.) ______

CONSIDERATIONS:

Humidity

Damper Tube Arcing

Flame

Arc Tracking

Radio Frequency Interference

I. PACKAGES:

Varo rectifiers are supplied in the packages illustrated below, and tooling for large volumes is available. If the configurations shown do not meet your requirements, we invite you to discuss your design requirements with us.

Figure 1a. This is a versatile, low-cost package available with wires or caps, or a combination wire and cap. Its high altitude and high temperature performance will not equal that of the rectifier package shown in (Fig. 1b). With good socket hardware, the Fig. 1a package flashes over at about 28 KV DC (36 KV PRV) at 18,000 ft. altitude, and T_A=25°C.

Figure 1b. This package is intended for use where maximum performance is needed. It can be used in an ambient temperature as high as 85°C (depending on the type diode stack used). Altitude performance is similar to a 3A3 vacuum-tube rectifier. In an operating circuit, the package flashes over at about 32 KV DC (≈41 KV PRV) at 18,000 Ft. altitude, T_A=25°C.

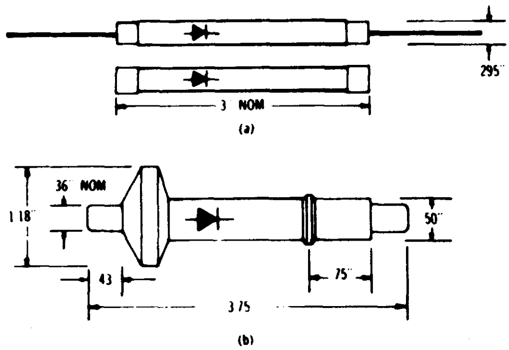

FIG 1

II. MOUNTING HARDWARE:

The rectifier mounting hardware has considerable influence on the high-altitude corona and flashover performance; also, the hardware can influence high-temperature operation if it forms a heat trap.

The package shown in Fig. 1a should be used with connectors having a smooth roll that extends beyond the edges of the metal end connectors.

An anode cap and cathode cup are illustrated in Fig 2. At lower voltages or altitudes, caps can be used on both ends.

The package shown in Fig. 1b requires an anode connector that fits snugly over the corona ring for minimum corona at high altitude.

The cathode connector should be a plastic cup about 2" to 2 1/2" diameter and about 2 1/4" tall. A ring has been provided on the package (Fig. 1b) to help lock the package into a connector if desired. Any locking lugs provided in the cup must be made of plastic and should not surround more than about 40 to 50% of the rectifier body to prevent trapping heat in a diode within the locking lug region. If locking lugs are not needed, a simple, smooth metal plate can be used in the cup for the cathode connection.

III. HIGH-TEMPERATURE OPERATION:

Heat is generated within the rectifier from several sources: reverse biased leakage; forward voltage drop; switching losses (t_{on}, t_{off}); and dissipation factor of the molding material. The internally generated heat must be conducted to the surface

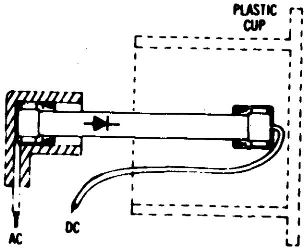

FIG. 2
MOUNTING HARDWARE
FOR RECTIFIER PACKAGE
SHOWN IN FIG. 1(a)

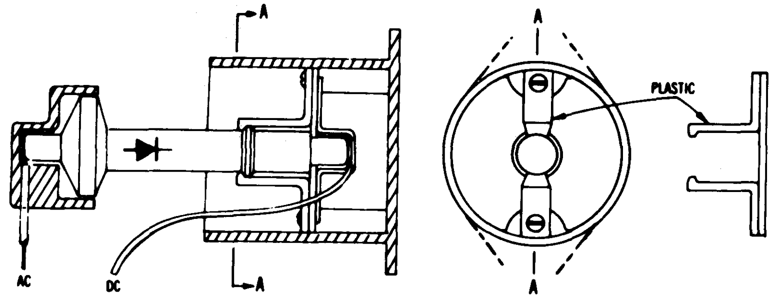

FIG. 3
MOUNTING HARDWARE
FOR RECTIFIER PACKAGE
SHOWN IN FIG. 1(b)

and convected to the surrounding air; also, there is considerable heat loss from the rectifier body by radiation. The air temperature must be low enough to prevent the rectifier junctions from going into thermal runaway. The junction leakage doubles approximately every 11°C and high-temperature leakage is the greatest contributor to internally generated heat; therefore, the threshold of thermal runaway is rather well defined within about a 10°C to 15°C range.

Varo TV rectifiers are characterized by operation in actual TV circuits and raising the temperature until the rectifier fails. The unit is operated at least 45 minutes at each temperature level with the temperature being increased in 5°C increments.

Several other items concerning rectifier placement must be considered. The ideal location from a thermal standpoint is to have the rectifier mounted horizontally, near the bottom of the chassis so that room ambient air can flow up past it. Also, any high-power tubes in a hybrid chassis must be mounted so that they do not radiate heat into the rectifier.

The mounting cup should not be so deep that it severely restricts air flow around the rectifier.

If the rectifier is mounted in a cage with the flyback transformer, it should be underneath the flyback. The cage should be vented to prevent heat generated by the flyback from raising the ambient beyond the rectifier's rating.

IV. VOLTAGE RATING (PRV):

The rectifier voltage rating must be greater than the highest repetitive PRV voltage that can be generated by the TV chassis under worst-case conditions.

An exception to this is the hybrid TV chassis where damper tube arcing or internal arcing of the horizontal output tube or flyback transformer can generate voltage transients equal to the DC output but of opposite polarity, so that the rectifier is reverse biased two-times the DC output voltage (66KV PRV at 33 KV DC output). Varo TV rectifiers are designed to absorb the energy in these transients without failure even though their rating is below the voltage transients generated.

Use the following waveshape to determine normal repetitive voltages.

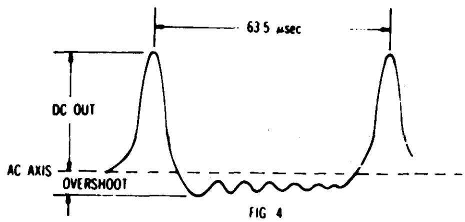

FIG. 4
PRV = DC OUT + OVERSHOOT

The waveshape is obtained by holding an oscilloscope probe in close proximity (≈2 1/2") to the flyback transformer high voltage overwind. The overshoot is proportional to the pulse producing the high voltage output; i.e., if the output pulse is 5 cm above the AC axis on the oscilloscope trace and is producing 25 KV DC output, each cm is equal to 5 KV. One cm of overshoot would equal 5 KV, thus, the PRV equals 25 KV + 5 KV = 30 KV.

A deflection circuit that is tuned for minimum ringing on the overshoot pulse will present a lower PRV to the rectifier. Ringing can become large and should be allowed for if the oscillator is running in excess of 100 Hz off frequency.

V. CURRENT RATING:

The current rating of Varo Half-Wave rectifiers is limited principally by ambient air temperature. The power generated due to forward voltage drop and added switching losses at higher currents forms part of the overall power that must be dissipated from the rectifier. The forward voltage drop is a function of the number of cells used in the rectifier and the cell count varies depending on the types of rectifier. Varo data sheets show current derating with increasing output voltage and the temperature held constant. The current specifications are determined empirically.

One current condition that must be considered in any TV chassis is the DC current that can flow through the rectifier when the high voltage wire is shorted to ground. This is due to the autoformer coupling of the flyback primary and secondary which is typical of nearly all tube-type and hybrid-type chassis.

Experiments have shown that the high-voltage rectifier will be permanently damaged if the high-voltage wire is shorted to ground more than a few seconds; the damage is due to excessive current flowing from the power supply through the relatively low DC resistance of the flyback windings.

If design requirements are such that the high-voltage rectifier must survive short circuiting to ground, the return of the flyback high-voltage overwind should be connected to ground rather than some portion of the flyback primary.

The rectifier can survive momentary bursts of high voltage arcing, such as the serviceman's procedure of testing for the presence of high voltage by arcing the CRT anode button to ground.

Brightness limiters should be designed into the TV chassis to prevent excessive CRT beam current from flowing through the high-voltage rectifier when the brightness control is set at maximum. Short-term operation at high beam current is permissible during factory adjustment. Sustained operation at high beam current in a high ambient temperature can destroy the rectifier.

VI. HUMIDITY

Varo rectifiers are manufactured of plastics and connectors capable of operation in humid atmospheres. Good socket hardware will help minimize corona.

All plastics used by Varo for these rectifiers can can be subjected to very high humidity and will perform normally after a short period of stabilization at room ambient.

VII. RADIO FREQUENCY INTERFERENCE:

RFI (causing "spooks") is perhaps the most difficult parameter to specify since so many factors influence whether or not RFI will cause problems.

All rectifiers generate RFI of some magnitude due to the rapid changing of current as they are driven on and off. There is some variation in switching times of rectifiers of the same type and there is considerable variation between the various types that Varo makes. There is normally some variation in magnitude and phase of the "spooks" (as viewed at the video detector) when the CRT beam current is changed from low to high brightness.

Since the rectifier functions during horizontal blanking, there is generally no problem with the viewed picture; however, RFI can cause problems with sync circuits and color demodulation circuits.

The most effective means of eliminating the problems caused by RFI is to provide maximum isolation between the horizontal deflection stage and the tuner and especially the monopole antenna, if used. Shielding around the rectifier and flyback helps contain RF noise within the shielding. Lead dress of the CRT high voltage lead considerably influences the problem of spooks.

In general, RFI has not been a severe problem and most manufactures have been able to use Varo silicon rectifiers without difficulty.

VIII. GENERAL INFORMATION:

Several advantages of Varo's silicon rectifiers are: excellent reliability; they can be expected to last the normal lifetime of the chassis; good regulation; no x-ray problem; capability of greater average power output than the ratings of most shadowmask type CRTs.

The rectifiers are encapsulated in black or very dark plastic to improve heat loss by radiation. They do not arc-track easily and have good flame and self-extinguishing characteristics.

The empirical data is gathered using third-harmonically-tuned deflection circuits operating at standard U. S. frequencies. Early indications are that all rectifier specifications still apply when used with fifth-harmonically-tuned flyback transformers.

The anode-cathode capacitance varies with the type of rectifier so it will probably be necessary to choose the rectifier before final design of a tuned flyback.

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VSP 111

Application Notes Design Considerations for HV Silicon Rectifiers Integrated Into Flyback Transformers

January 1980

The rapid acceptance of placing rectifiers in the same module as the flyback coil has created the need for guidelines to rectifier selection.

PURPOSE: To establish rectifier parameters needed and discuss other important factors.

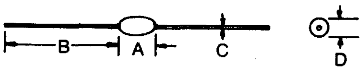
OVERALL CONSIDERATIONS:

1. Rectifier Packaging
2. Voltage Requirements
3. Current Requirements
4. Ambient Temperature
5. Rectifier Case Temperature
6. Temperature Cycling
7. Humidity
8. Altitude
9. Potting Considerations
10. Flame & Arc Tracking
11. Electro Magnetic Interference (EMI)

RECTIFIER PACKAGING

Packages are available in several sizes and Varo Semiconductor, Inc. is always ready to consider new designs where the volume warrants.

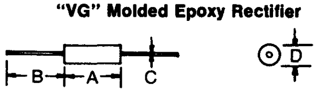
Glass Passivated Rectifier



	mm	Inches
A	9 max	.35 max
B	30,4 min	1.2 min
C	,58	.023
D	3,43 max	.135 max

Example: H1701

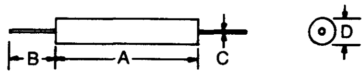
"VG" Molded Epoxy Rectifier



	mm	Inches
A	15,2	.6
B	15,2 min	.6 min
C	,508	.020
D	4	.16

Example: H485, H521-5, H500

1.5" x .235" Molded Epoxy Rectifier



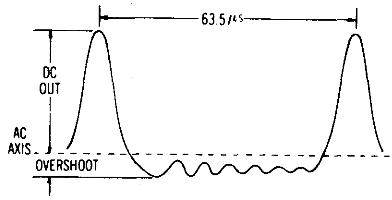
	mm	Inches
A	38,1	1.5
B	12,7 min	.5 min
C	,508	.020
D	5,97	.235

Example: H1802

VOLTAGE REQUIREMENTS

The normal reverse voltage requirements are relatively easy to determine as follows:

Hold a voltage probe in proximity (≈ 2-3 cm) (0.8"-1.2") to flyback tertiary and observe this waveform on an oscilloscope. V_{RRM} = DC output + overshoot.



The V_{RRM} should be determined for all expected conditions of line voltage or misadjustment of the horizontal oscillator. The rectifier V_{RRM} rating should be specified to exceed all repetitive voltage conditions.

Transients generated during CRT arcing are more difficult to determine, but to some degree, are not too important since the rectifiers are designed with avalanche-quality junctions. This means that even if **low energy** transients do appear across the rectifier and avalanche it, the rectifier will not be destroyed.

CURRENT REQUIREMENTS

The rectifiers normally recommended for these applications are usually capable of more than adequate current handling in conventional television circuits. Increased current will generate more heat due to forward conduction power loss. Also, the switching losses increase slightly with increasing conduction current. The largest power loss, however, is due to high temperature leakage. This will be discussed more under the heading of RECTIFIER CASE TEMPERATURE.

Average current can be measured with a D'Arsonval meter movement. RMS current can be calculated from the current waveform observed with a current probe on the DC lead of the rectifier.

Rectifier average current and RMS current should be determined for high line, off-frequency and brightness and contrast control extreme settings.

If it appears that rectifier ratings will be exceeded indefinitely under some conditions, it is recommended that brightness limiters be employed in the circuitry.

Short term (<5 minutes) overcurrent loads are permissible for factory set-up of controls, alignment, etc., but the rectifiers should not be operated above their current ratings for sustained periods.

AMBIENT TEMPERATURE

Ambient temperature directly affects the rectifier ratings. The rectifier's junction temperature is a function of its own power loss, as well as that of the transformer winding, core, potting dissipation factor losses and the ventilation surrounding the entire system.

We highly recommend that during initial design, the total flyback, including rectifiers, be potted or molded as close to desired size and shape as practical and temperature tests be made essentially as follows:

1. Use a **still air** ambient constructed by placing the flyback in a sealed, moderately-sized aluminum box; place this inside a high-speed forced-air chamber.
2. Operate the flyback at desired voltage and current.
3. Elevate the forced-air temperature 5°C approximately every 20 to 30 minutes (depending on flyback mass) until the rectifier goes into thermal runaway.
4. If the temperature in the sealed box cannot be controlled, it may be necessary to slightly ventilate the box. This should be done in such a way that there is no direct forced-air flow against the transformer.
5. Repeat this procedure with several flyback assemblies until the thermal runaway temperature is well established.
6. We recommend at least a 20°C safety factor below lowest thermal runaway temperature.

This method is thought to be the best practical approach to quickly determine the useful ambient temperature since it accounts for essentially all losses in all components that directly influence the rectifier. An unusual amount of heat radiated into the flyback from other components would have to be accounted for separately.

RECTIFIER CASE TEMPERATURE

The rectifier case temperature under operating conditions can be measured by opening a window through the potting and using an infrared temperature gun, or by using a calibrated wax such as *TEMPILAQ* available from Tempil Division, Big Three Industries, Inc., Hamilton Boulevard, South Plainfield, New Jersey 07080.

These methods deprive the rectifier of some of its cooling conduction path and while not highly accurate are probably satisfactory.

Typical case temperatures as determined by the calibrated wax will be stated on many Varo Semiconductor, Inc. data sheets.

Internal rectifier power loss occurs from several sources:

1. High temperature reverse leakage
2. Switching losses
3. Forward voltage drop
4. Dissipation factor of molding materials

High temperature reverse leakage is the most important consideration because it doubles with only an 11°C increase in junction temperature. A part that is absolutely stable at one ambient temperature can easily go into thermal runaway only 5° to 10°C above the stable temperature. For this reason we highly recommend that our customers establish the actual thermal runaway temperature for their designs as outlined under AMBIENT TEMPERATURE.

Switching losses are determined by silicon chip thickness, gold or platinum doping levels, rise and fall times of waveform and uniformity of recovery of the various chips. Temperature has some influence on these losses. Controllable switching losses are balanced against other factors to optimize a rectifier for a given application.

Forward voltage drop causes a power loss that is nearly proportional to the peak current. This power is normally the dominant loss at low temperature.

Dissipation factor loss in the rectifier package itself is normally insignificant; however, potting applied over the rectifier can be significant if a poor grade material is used.

TEMPERATURE CYCLING

Part of the final design verification should include temperature cycling to test for material cracking, separation from case (if used), or damage to the rectifier or other components.

Our recommended temperature cycling is:

−20°C for 3 hours
25°C for 1 hour
+85°C for 3 hours
25°C for 1 hour

This cycle should be repeated 5 times. The transformer should then be inspected for cracked potting, separation from case and proper electrical performance. Useful information can be obtained even if the 3-hour dwell times are reduced to 1 hour to speed testing.

Cracked potting is obviously unacceptable because the crack can trap moisture and/or could cause an insufficient air gap to support the voltage stress present. Also, the mechanical stress can damage other internal components.

Another problem is separation of the case (if used) from the potting, leaving a gap. If any high potential terminals or connections are normally touching the case, these could cause excessive leakage and failure due to moisture trapped in the gap. Locking ribs can hold the materials together but do not prevent moisture entrapment.

The only satisfactory design is one where the case and potting materials are molecularly bonded.

A good test for the case/potting interface is to cycle units 5 times per the recommended cycle except pull them before the last +85°C portion of the test. Allow them to warm to room temperature, wipe off any excess moisture, allow another hour to air dry at room temperature, then test for proper electrical performance. The units should be operated several hours to verify that no moisture is trapped.

It is not necessary to bond to the rectifier as long as the potting shrinks tightly around the entire rectifier body and the interface is clean.

HUMIDITY

The humidity characteristics of the final potting and case materials are more important than these characteristics in the rectifier itself.

The epoxies or glass used to passivate Varo Semiconductor, Inc. rectifiers are capable of withstanding short term (½ hour @ 15 PSI) pressure cooker tests. However, the epoxy molded rectifiers will not withstand long term (24-48 hours) pressure cooker tests without possible degradation. The epoxy itself is nearly impervious to moisture but there is some migration between the lead and epoxy and eventually moisture under high pressure will reach the junction passivation.

A more realistic test is to suspend the rectifiers in a steam atmosphere at room ambient pressure for 48 hours, then wipe off the excess moisture and allow to air dry for 1 hour and test. Neither epoxy nor glass passivated parts have shown any catastrophic change under these test conditions.

We recommend a bake step prior to potting when using glass-passivated rectifiers. Bake at 150°C for 15 minutes if all other materials can withstand this temperature. If they cannot, bake at 120°C for one hour. These are guidelines only; the customer should verify what is needed by measuring rectifier leakage before and after baking at the approximate operating voltage level.

The bakeout requirement will be dependent on the atmosphere in which assembly takes place, as well as storage and handling of the rectifiers and other components prior to assembly.

ALTITUDE

Altitude has no significant effect on the totally encapsulated rectifier. We do recommend that the complete flyback/rectifier assembly be tested in a vacuum chamber at about 15" (gauge) vacuum which is near 18,000′ altitude. The vacuum chamber should have a window so that a search for corona can be made with the flyback operating at maximum required voltage. Vacuum should be increased slowly while searching for corona spray from connectors and sharp points. Heat (such as 70°C) can be added to help aggravate corona.

If no corona is observed when operating at the desired conditions with some safety factor, the design can be considered acceptable.

POTTING OR MOLDING CONSIDERATIONS

A. **The potting serves several functions:**

1. Mechanical support
2. Electrical dielectric
3. Flame retardant over combustible materials
4. Heat conductor and dissipator for parts potted within it
5. Moisture barrier

B. **Types of potting or molding materials:**

1. Filled epoxy
2. Polyester
3. RTV silicon rubber
4. Tar
5. Thermoplastic

C. **Discussion:**

The potting material should bond to the case if a case is used; bonding prevents trapping of moisture in the interface, which can cause failure.

Bonding to the diodes is not so important because they are totally enclosed — at least to the extent that moisture is unlikely to reach the interface of the diode and potting. The one exception is a ½-wave rectifier stapled to a high voltage wire exiting from the epoxy surface. Ideally, this wire should be buried 2 to 3 cm (0.8" to 1.2") deep in the epoxy, depending on voltage requirement.

We prefer epoxy filled with mineral or aluminum oxide for two reasons: our own success with it and knowledge of problems other have had with such material as RTV and polyester. Tar and some thermoplastics are less desirable due to poor thermal conductivity and high electrical losses, but may be usable at low power levels.

Polyester will not cure properly in the presence of certain other materials. Where used, several flyback assemblies should be sectioned and inspected closely for thorough curing around all other applicable materials in the assembly.

For best thermal conduction the potting should be highly filled. The filler level is easily detected by sectioning a cured assembly and noting the color separation.

To get proper potting, it may be necessary to vacuum, then pressure-impregnate the flyback/rectifier assembly.

FLAME & ARC TRACKING

Flame and arc tracking characteristics required are determined by customer design philosophy and applicab' laws covering combustible and self-extinguishing materials.

Since the rectifier is surrounded by potting material for the designs considered in this paper, the flame and arc tracking characteristics of the rectifier(s) are of little consequence.

Keeping the potted and molded sections thick and avoiding sharp corners will aid in passing flammability tests.

As a matter of record, some types of Varo Semiconductor, Inc. rectifiers are available molded in materials which meet UL94V-0 self-extinguishing tests.

ELECTROMAGNETIC INTERFERENCE

All rectifiers generate EMI of some magnitude due to the rapidly changing currents as the rectifiers are driven into and out of conduction.

There is a small variation in switching times of rectifiers of the same type and there can be considerable variation between various types.

Since the rectifier functions during horizontal blanking in a TV receiver, there is generally no problem with the viewed picture except on weak incoming signals where EMI can interfere with horizontal sync, AGC, and color sync.

Another possible EMI problem is RF interference that reaches an adjacent TV set or other receiving equipment.

The chip-to-chip recovery of the rectifiers is controlled to a narrow range to help prevent EMI.

Rectifier-related EMI is affected by lead lengths, waveform rise and fall times, flyback position relative to antenna (especially monopole antennas) and effectivess of shielding around the flyback.

In general, EMI has not been a severe problem.

There is a trade-off between the maximum operating temperature and the turn-on time of the rectifier. A thick rectifier chip turns on relatively slowly, thus generating less EMI, but at the same time, internally-generated heat increases. Varo Semiconductor, Inc. rectifiers are balanced to give acceptable levels of performance on both EMI and high-temperature operation; should problems arise, we prefer to work on them individually.

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VSP 112

Application Notes High voltage with low-cost multipliers.

January 1980

Get High Voltage with Low-Cost Multipliers. If it's a low-current application, simple diode-capacitor networks can be cascaded to deliver any voltage you need.

If you need a power supply for a high-voltage, low-current application, your best bet is probably the voltage multiplier circuit. It's inexpensive. It's simple. And you can get any voltage you want by cascading multiplier stages. The voltage is limited only by the ratings of the components you use.

A voltage-multiplier circuit contains diodes and capacitors, with the devices connected to develop a dc output that is a multiple of the peak or peak-to-peak input voltage. There are two major variations of the circuit: multipliers that use an even number of diodes and those that use an odd number of diodes.

The basic rectifier circuits in Fig. 1 (equations assume perfect diodes and capacitors, loads are considered light) can be combined to form a complete family of half-wave multipliers. A full-wave multiplier can be made by combining two half-wave multiplier sections, one positive and one negative (Fig. 2). The major disadvantage of a full-wave multiplier is that the secondary side of the transformer nearest the core requires heavy insulation to withstand one-half the output voltage. Therefore inductive coupling is worse and efficiency lower than for a transformer used with the equivalent half-wave type. Thus half-wave multipliers are better for most high-voltage power supplies.

Fig. 3 shows the two variations of half-wave multipliers. Each of these circuits consists of identical sections cascaded, except for the first stage in Fig. 3a. The first section of a multiplier with an odd number of diodes is a simple half-wave rectifier. This first section of a multiplier with an even number of diodes is a half-

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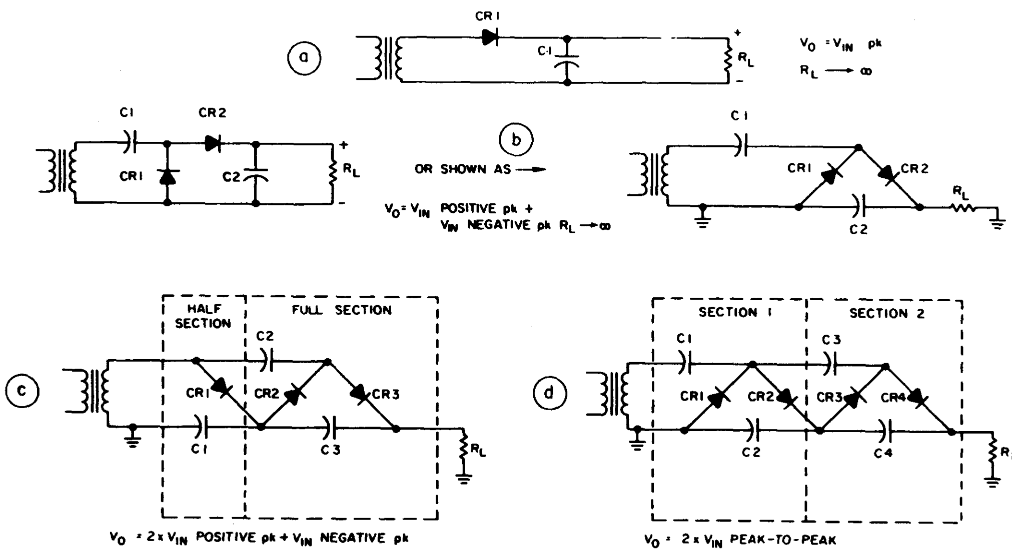
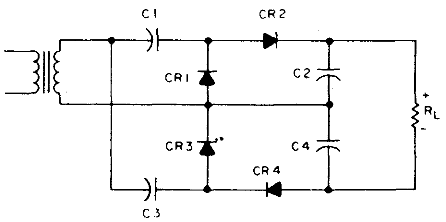


1. The basic half-wave rectifier circuit (a) can be modified to get a voltage doubler (b). If you add extra voltage multiplier sections, various output voltages can be obtained (c and d).

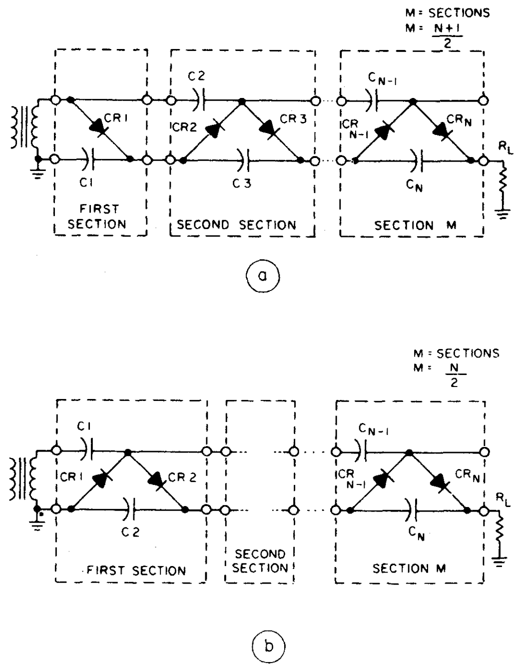
wave doubler. A basic rule of thumb for multiplier designs is: For waveforms that are symmetrical about ground, use an even number of diodes; for asymmetrical waveforms, use an odd number.

How the multipliers work

The multiplier circuit can handle any waveform, but the three most common for multiplication are sine, pulse (or square) and trapezoidal wave. The only waveform restrictions are that



2. **The full-wave voltage quadrupler circuit** requires a transformer with heavy secondary insulation.



3. **The multiplier with an odd number of diodes** works best for asymmetrical waveforms (a), while that with an even number of diodes works for symmetrical waveforms (b).

the rise and fall times of the input signal be slower than the diode switching time.

In the signal in Fig. 4, V_{in} is a recurring waveform composed of the positive peak V_1, the negative peak V_2 and an ac axis that can be displaced from dc ground by voltage V_{dc}.

Fig. 5 shows the voltages at each point of a 1.5-section multiplier. The half-wave, 1.5-section multiplier (three diode) operates as follows: During the positive peak of V_{in}, diode CR_1 conducts to charge C_1 to a voltage equal to $V_1 + V_{dc}$. Capacitor C_2 acts as a coupling capacitor to couple V_{in} to point C. Diode CR_2 conducts on the negative voltage peak at point C when the voltage tries to become more negative than the anode of CR_2 (the anode voltage of CR_2 is $V_1 + V_{dc}$). Diode CR_3 conducts on the positive peak at point C and charges C_3 to $V_1 + V_2$. The output, V_{out}, is the sum of the voltages on C_1 and C_3:

$$V_{out} = V_1 + V_{dc} + V_1 + V_2 = 2V_1 + V_2 + V_{dc}.$$

Only dc voltages are applied to C_1 and C_3; these capacitors are therefore dubbed "dc capacitors." An ac voltage is applied to C_2, which is called an "ac capacitor." If the input voltage is symmetrical about the zero axis, the multiplier output will be three times either peak voltage, $V_{out} = 3\ V_1$. This circuit is called a tripler. If, however, the waveform is such that V_1 is much greater than V_2, the output voltage is approximately twice V_1; the circuit could be called a doubler. For clarity, we can use the diode count to define multipler capability.

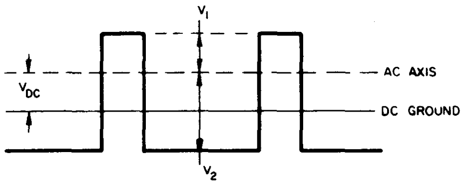
Diode count determines operation

The operation of the four-diode multiplier—a two-section, half-wave unit—is similar to that of the three-diode multiplier (Fig. 6). Capacitor C_1 blocks the dc bias from the remainder of the multiplier and acts as a coupling capacitor to couple V_{in} to point C. Diode CR_1 conducts when the negative voltage at point C becomes more negative than the anode of CR_1 (the anode of CR_1 is at 0 V). This causes C_1 to charge to a voltage equal to V_2 V_{dc} and simultaneously causes the positive peak at point C to reach $V_1 + V_2$.

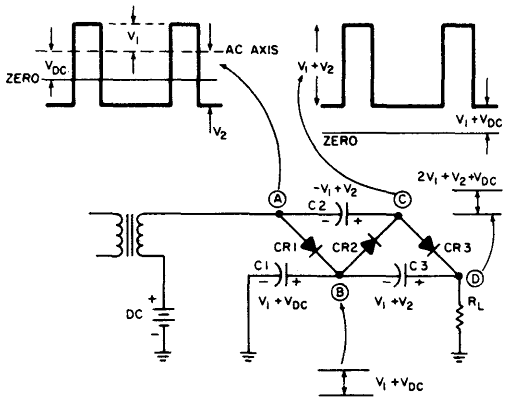
The positive voltage at point C turns on CR_2 and charges C_2 to $V_1 + V_2$. Capacitor C_3 acts as a coupling capacitor to couple the input waveform at point C to point E. Diode CR_3 conducts when the cathode voltage becomes more negative than the anode voltage (the voltage at point D). The positive peak will be at a voltage equal to the charge on C_3 plus the peak voltage at point C. This positive voltage will cause CR_4 to conduct and charge capacitor C_4 to $V_1 + V_2$. The output, V_{out}, is the sum of the voltage on C_2 and C_4:

$$V_{out} = (V_1 + V_2) + (V_1 + V_2) = 2\ V_1 + 2\ V_2.$$

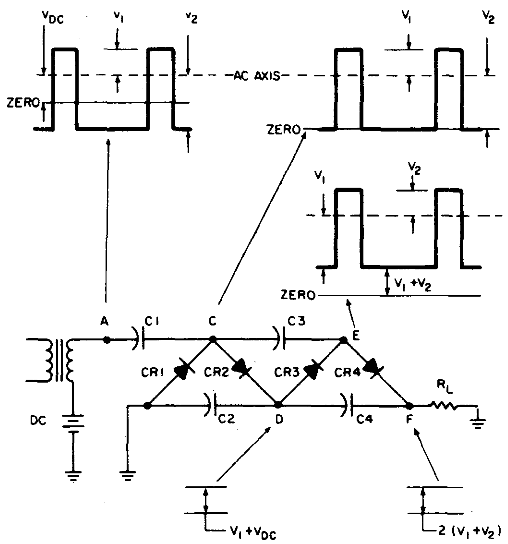
Both C_2 and C_4 are dc capacitors. Points D and



4. **A recurring waveform** with a positive peak V_1 and negative peak V_2 is used as an input for the voltage multiplier circuit described in Fig. 5.



5. **The voltage waveforms** at different points within the multiplier circuit with an odd number of diodes show the transformation of the pulse waveform described in Fig. 4 into a much higher dc voltage.



6. **The multiplier circuit with an even number of diodes** and the same input as described in Fig. 4 produces an even larger dc output voltage than the circuit of Fig. 5.

F are "dc points," and C_1 and C_3 are ac capacitors. In both the odd-diode and even-diode circuits, the diode peak-inverse voltage (PIV) ratings should be at least $V_1 + V_2$. In the even-diode multiplier, C_1 should have a voltage rating of at least V_2. In the odd-diode multiplier, C_1 should have a voltage rating of at least $V_1 + V_{dc}$. All the other capacitors should have a voltage rating of at least $V_1 + V_2$. Negative output voltages can be obtained if the diode polarities are reversed.

Calculating the output voltage

The regulation of a multiplier with a load is a function of the input's source impedance, the values of the capacitors in the multiplier, the forward drop of the diodes and the turn-on and turn-off times of the diodes.

To compute the output voltage (or the capacitances), use these formulas[1]:

$$V_{out\ (even)} = nV_{in} - \left[\frac{\left(\frac{n}{2}\right)^2}{C_{n-1}} + \frac{\left(\frac{n}{2}-1\right)^2}{C_{n-2}} + \frac{\left(\frac{n}{2}-1\right)^2}{C_{n-3}} + \frac{\left(\frac{n}{2}-2\right)^2}{C_{n-4}} + \frac{\left(\frac{n}{2}-2\right)^2}{C_{n-5}} + \cdots + \frac{1}{C_2} + \frac{1}{C_1} \right] \frac{I_o}{f} \quad (1)$$

$$V_{out\ (odd)} = nV_{in} - \left[\frac{\left(\frac{n-1}{2}\right)^2}{C_{n-1}} + \frac{\left(\frac{n-1}{2}\right)^2}{C_{n-2}} + \frac{\left(\frac{n-3}{2}\right)^2}{C_{n-3}} + \frac{\left(\frac{n-3}{2}\right)^2}{C_{n-4}} + \frac{1}{C_2} + \frac{1}{C_1} \right] \frac{I_o}{f}. \quad (2)$$

In these equations capacitor C_1 is the closest to the output, and n is the number of capacitors in the multiplier.

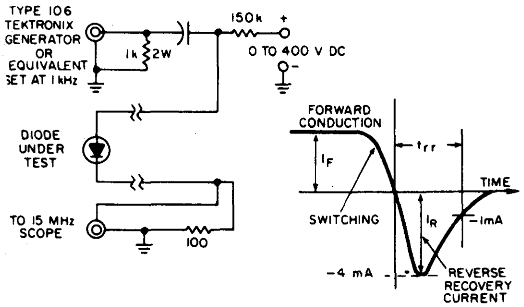
If we simplify the equations by assuming a sufficiently large load capacitance, equal value capacitors and ideal diodes, the voltage output is approximately

$$V_{out} = N \frac{(V_1 + V_2)}{2} - \frac{N^3}{12\,cf} I_{out}. \quad (3)$$

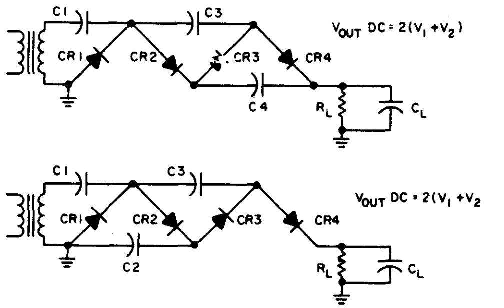
Here N is the number of diodes or capacitors used for circuits like those shown in Fig. 3; V_1 is the positive peak input voltage; V_2 is the negative peak input voltage; c is the capacitance in farads; f is the frequency of the input, and I_{out} is the current in amperes.

To distribute capacitance optimally within the multiplier chain, use the ratio of the square of the section number counted backwards from the high-voltage output to the total number of sections. For example, a two section multiplier requires a $2^2/2{:}1$ ratio for the first capacitor as compared with the last.

The optimized arrangement reduces the ef-



7. **A simple test circuit** to check diode reverse-recovery time will tell if the diodes are usable.



8. **To reduce component cost and count** if the load is capacitive, remove one of the doubling capacitors.

fective series impedance by about 25%. In production, capacitors of equal value offer savings in price and labor. And if there's no constraint on the maximum value, it is usually less expensive to standardize on a single, large, capacitance value throughout.

The over-all reactive impedance must be taken into account to determine how large the capacitor values should be.

Watch diode switching characteristics

The turn-on and turn-off times of the diodes are important. Junction thickness controls the turn-on time, while the amount of gold doping controls the turn-off. Both turn-on and turn-off must be kept fast, if regulation and efficiency are to be maintained. A simple test jig to determine diode recovery time is shown in Fig. 7.

The forward drop of the diodes is usually not a significant factor. For example, a typical multiplier, rated for 25 kV at 2 mA, has six diodes—each with a forward voltage drop of approximately 15 V at 10 mA. Thus this multiplier has less than a 100-V drop when operating.

The output regulation of voltage multipliers ranges from 100 V to 5 kV per milliamp of current. Some applications use regulation schemes to control power-supply output. Some common methods are shunt dc load, rectified pulse feedback and a saturable reactor in series with the high-voltage transformer. In other applications, it is desirable to have the output voltage sag with load—with very poor regulation built into the multiplier through selection of the capacitor's value.

The output voltage of a multiplier will always have some ripple in the output. Ripple is a function of load capacitance, input frequency, multiplier impedance and input-to-output coupling.

The load capacitance acts as a filter, and the effective series impedance of the multiplier limits voltage ripple. If regulation is not a consideration or if load current is almost constant, a series resistor can be added to the multiplier output. The series resistor will act with the load capacitance as an RC filter.

The high-frequency components of the input voltage are the most easily coupled into the output. But the higher frequencies are also easier to filter at the multiplier output when necessary. The most unpredictable ripple component, though, is generated by stray capacitive coupling of the input to the output terminal. This coupling is difficult to control. The mechanical layout of the multiplier can reduce it, and if more ripple reduction is required, an electrostatic shield can be used to isolate the output area further from the input. Also the encapsulating compound should have a low dielectric constant.

Variations for special applications

For applications with a very high load capacitance, any one of the dc capacitors can be omitted in the multiplier and it will still function (Fig. 8). While this appears to be a good way to reduce component costs and package size, consider what happens when the output terminal is arced to ground: The distribution of voltages on the diodes becomes unequal, which causes more stress on some diodes than others. The uneven distribution can cause a diode's peak inverse rating to be exceeded and a malfunction to occur. For better transient protection, leave all the capacitors in the circuit.

Many applications require a second voltage that is proportional to the output voltage. A tap at any dc point of the multiplier can be used. The ratio of the voltages can be determined if you examine the circuit up to the tap as a complete unit and the total multiplier as another.

Consider carefully the maximum average current. The multiplier current ratings are intended to keep the components cool enough to perform reliably. It will help, of course, if the high-voltage drive source has some maximum-load protection that reduces the input voltage if too much current is demanded.

The multiplier must withstand all arcing, including that between the output lead and ground, and also direct shorts of the output lead to ground. The multiplier must sustain the peak current drawn by the arc or short as the internal capacitors discharge.

A resistor in series with the output lead serves two functions: (1) It reduces the Q of the oscillator circuit that is established during arcing, thus reducing considerably the stress on the diodes, and (2) It limits the peak current to a value that the diodes can handle safely. The value of this resistance must be high enough to do the limiting job but not so high as to promote arcing around or through the resistor body or overheating at maximum current drain when the output arcs to ground.

Consider the mechanical layout

The mechanical design, mounting method and location of the multiplier can all affect current capability. The thermal conductivity of the encapsulating medium is the top consideration. The diodes, and to some extent the capacitors, dissipate heat because of forward-drop, switching and leakage losses, and this heat must be removed to prevent the diodes from going into thermal runaway. In addition the dielectric strength of the encapsulating medium must be great enough to prevent inter-component or inner-component-to-environment arcing or corona. High dielectric strength also permits denser packaging.

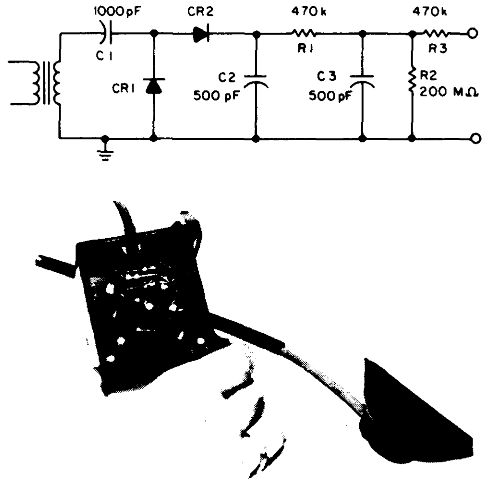
The dielectric constant of the encapsulating medium should be low to minimize the capacitance from components to the environment—usually ground. The input terminal-to-ground capacitance, in particular, should be a minimum to reduce unwanted ringing at the input terminal. The low dielectric constant also minimizes the chance of a corona from the multiplier case generating heat and causing rf radiation.

The terminal location and its shape should not cause arcing or corona regardless of temperature, humidity or altitude. When the terminal consists of an insulated wire emerging from the encapsulation medium, it must be protected at the point of exit against insulation fractures when the wire is flexed.

The encapsulating medium must withstand predetermined thermal-shock cycles with no damage to the inner components or loss of performance.

Some design examples

What information is needed to design a voltage multiplier? Input voltage, input frequency,



9. **A voltage doubler and filter** can be combined to give very-low-ripple outputs.

input waveshape, output voltage, output current, ripple limits and regulation.

Let's assume a 30-kHz, 5kV RMS , zero-centered sine wave is the input for a circuit that will deliver 10 kV at 50 μA out with a ripple of less the 4 V pk-pk and regulation of $\pm$150 V. Since there is voltage symmetry, a multiplier with an even number of diodes can be used. The 10-kV output means that only one doubling stage is needed, since 5 kV $\times$ $2\sqrt{2} = 14.14$ kV—more than enough for the output.

The basic circuit of Fig. 1b can be modified to produce the circuit of Fig. 9. The capacitor values can be calculated from Eq. 1, although for more complex multiplier circuits, Eq. 3 can be used for rough approximations. Capacitors C_2 and C_3 and resistors R_1, R_2 and R_3 form a pi-filter and bleeder network, with time constants adjusted for the 30 kHz input ripple.

As another example, consider an input signal with a pulse repetition rate of 14,734 pps and a pulse width of 12 μs. The input voltage is 9-kV pk, and the desired output voltage is 25 kV at 2 mA. To design this unit, start with a multiplier that has an odd number of diodes. Compute the number of stages needed—in this case, 9 kV $\times$ 3 = 27 kV. A voltage tripler is needed, such as the one shown in Fig. 3a. The capacitor values can be derived from Eqs. 1 or 2, or a simplified version of these equations, once some approximations are made. ■■

Reference

1. Brugler, J. S., "Theoretical Performance of Voltage Multiplier Circuits," *IEEE Journal of Solid State Circuits*, June, 1971, pp. 132-135.

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Application Notes Keep Rectifiers Cool by Calibrating Forward Voltage Drop

January 1980

Keep your Rectifiers Cool by Calibrating and Monitoring the Forward Voltage Drop. This Way You Can Keep an Eye on Junction Temperature — and Prevent Burnouts.

If your high-voltage silicon rectifier is failing—even though it seems to be operating within specs—check the junction temperature. It may be too high. A simple measurement lets you determine a rectifier's in-situ junction temperature or forward-current capabilities. If the thermal capabilities of the rectifier are exceeded, the silicon will be damaged.

Since a silicon rectifier's junction temperature is linearly related to forward-voltage drop, the drop can serve as a monitor during testing. But first you should calibrate the diode voltage-temperature relationship. To do that, you'll need a temperature-test chamber and a constant-current supply with a control range of 1 to 5 mA.

Place the diode in the chamber, then measure and record the forward drop with a sensing current of approximately 1% of the normal operating current. If that value is too small to achieve a stable voltage reading, you can use a relay with a 99%/1% duty cycle, and a higher sensing current. Bring the chamber up to the rectifier's maximum operating junction temperature. Allow several minutes for the diode temperature to stabilize, apply the sensing current, and hold it for a few minutes to allow stabilization.

The sensing current won't be much—perhaps 1% of the normal operating current—so it will cause little internal junction heating. After the unit reaches stability, record the oven temperature and the forward voltage at the sensing current.

Select two or three oven temperatures, each at least 25 C below the last selection, and repeat the process. Plot the data obtained from these tests. The calibration curve you develop will help determine the thermal impedance.

Be sure to operate the test rectifiers in a draft-free atmosphere, and to monitor the ambient constantly about one inch away from the rectifier.

Fig. 1 shows a typical setup for running thermal impedance with the rectifier in air. The thermometer should be below the rectifier under test, and its accuracy should be consistent with data requirements. Calibration marks of 1 C should suffice.

Walter Wills, Product Engineering Manager for High-Voltage Rectifiers, Varo Semiconductor, P.O. Box 676, 1000 N. Shiloh, Garland, TX 75040.

Reprinted from Electronic Design - May 10, 1978

Current wave shape plays a key role

The current wave shape in the rectifier should be similar to that of the intended application. Note that all tests can be made with a low-voltage circuit and the results applied to the high-voltage application.

Test circuits for a half-wave rectifier and for a single-phase, full-wave bridge are shown in Figs. 2 and 3. In both circuits, the sensing current and the simulated operational current can be applied simultaneously to the rectifier.

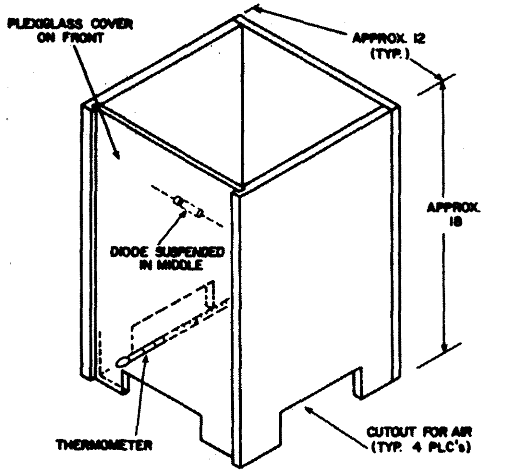
If the circuit doesn't permit simultaneous application, you must use a relay. With a relay, you can arrange the circuit so the rectifier operates 99% of the time with a current waveshape similar to that of the intended application, and the other 1% with the sensing current (Fig. 4). Don't forget to monitor the sensing current and voltage during the 1% calibration period.

Whether you use one of the circuits shown or a circuit of your own, the sense voltage will directly relate to the junction temperature. You can increase the simulated application current or ambient temperature by one step and hold the value until junction-temperature equilibrium is reached. Then go up one step. Repeat until the forward drop indicates that the junction has reached its maximum operating temperature. At that point, record the simulated application-current value and the forward-voltage drop during the simulated current wave.

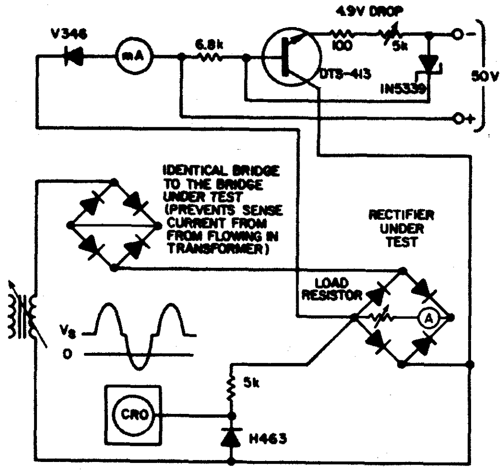
Getting the results

Now you can calculate the thermal impedance: Subtract the ambient temperature from the junction temperature to obtain a junction-to-ambient differential. Divide the differential by the power dissipated within the silicon to get the thermal impedance of the rectifier in °C per watt.

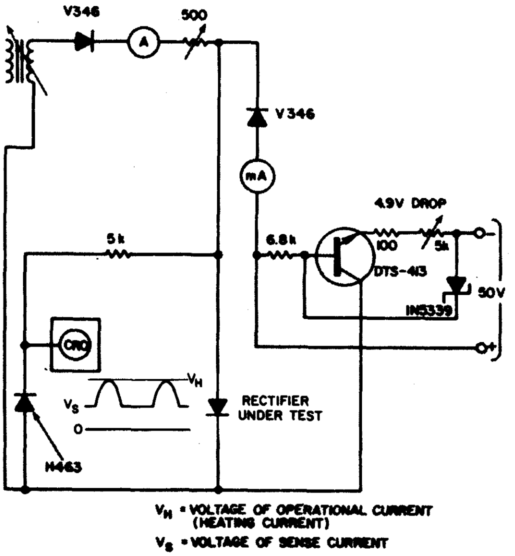
The added power drawn by the rectifier in blocking the high voltage can be subtracted from the forward-current power. This will reduce the forward-current limit to a safe level. (Note that switching losses, which



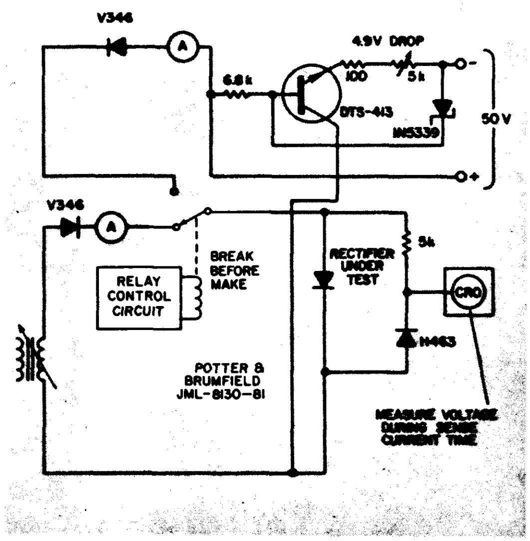
1. **A rectifier test chamber** for making thermal-impedance measurements in still air suspends the diode in the center and the thermometer beneath.



3. **Acting like a full-wave bridge rectifier,** this test circuit treats the diode as if it were in actual use in its intended circuit and applies sensing current as well.



2. **A typical test circuit for a rectifier** intended for a half-wave-circuit application applies both sensing current and a simulated operational current.



4. **When sensing and operational currents can't be applied together,** a relay arrangement switches to a sensing mode for 1% of the operating period.

may be significant, aren't included unless the simulated current wave shape includes such losses.) But bear in mind that thermal impedance may not be the main point of interest—it's usually the junction temperature during worst-case conditions.

If the rectifier is to be tested in an oven, you must keep the oven's air flow from cooling the rectifier package. Even small amounts of air flow add significant cooling, and this should be considered in light of the rectifier's final application. If the rectifier is to have air flow, then the test circuit should approximate it as closely as possible, including the amount of turbulence.

All the thermal tests can be applied no matter if the rectifier is potted, in oil or in any other environment. And since you can test the rectifier in a simulated environment, you can select the best rectifier for your application. ■■

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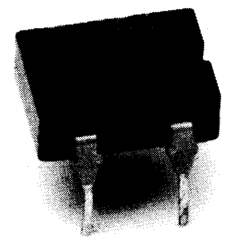

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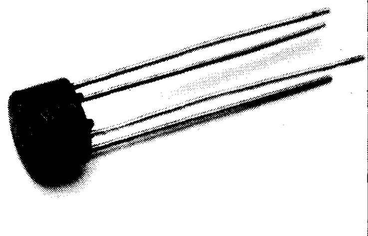

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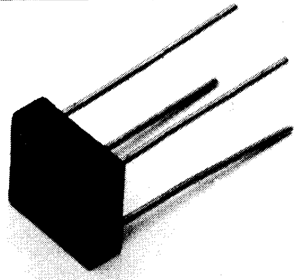

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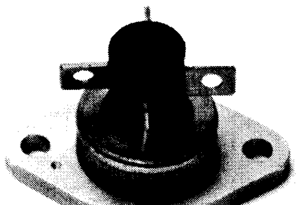

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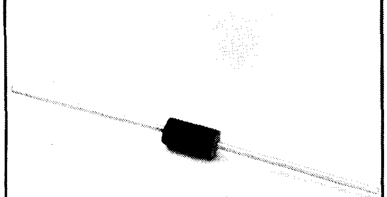

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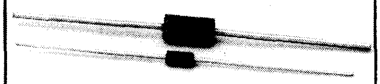
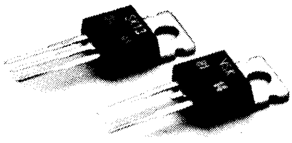


1 TO 5 AMP SCHOTTKY BARRIER RECTIFIERS. VSK Series: 20, 30, 40V with low V_F; extremely fast recovery.



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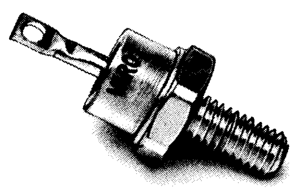

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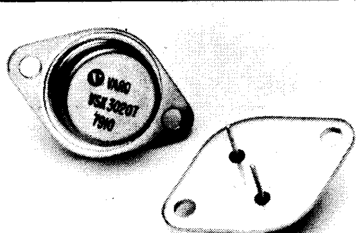

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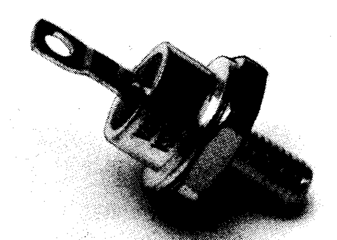

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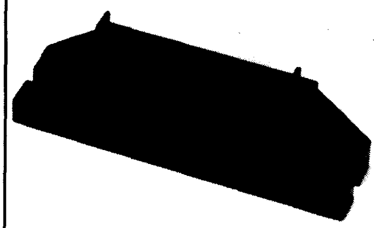

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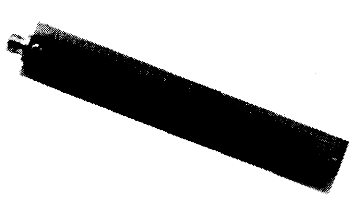

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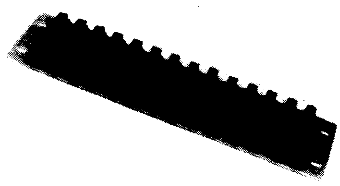

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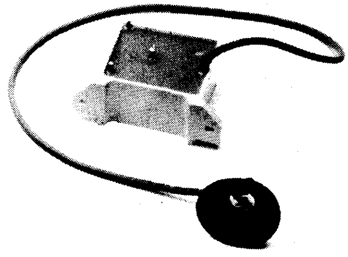

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Peak Surge Current (½ cycle, non-rep.)	150A	80A
Glass Passivated	Yes	No

200 VOLTS	OUR T0220 (VARO VHE2404)	THEIR T0220
Forward Current	20A	Not listed in 1980 catalog
Overvoltage Protection	20%	Not listed in 1980 catalog
Thermal Impedance	1.5°c/w	Not listed in 1980 catalog
High Temp. Leakage @ 100°C	50μA	Not listed in 1980 catalog
Peak Surge Current (½ cycle, non-rep.)	150A	Not listed in 1980 catalog
Glass Passivated	Yes	Not listed in 1980 catalog

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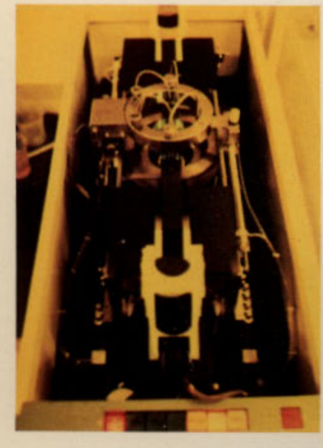

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