Data Sheet No. PD-4.011

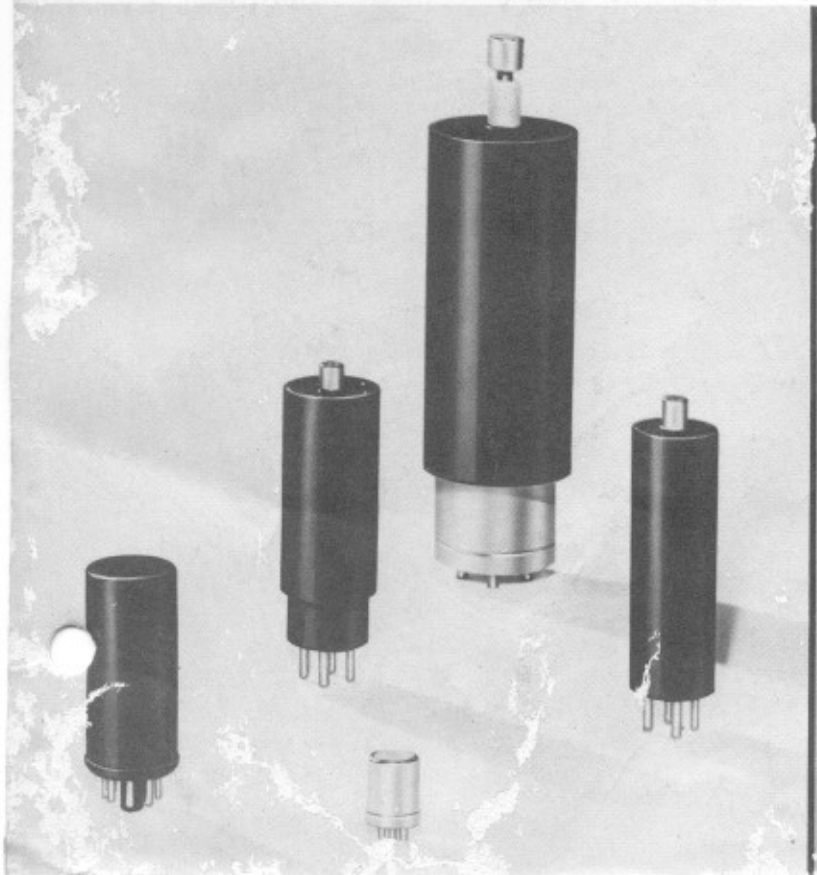
INTERNATIONAL RECTIFIER IOR

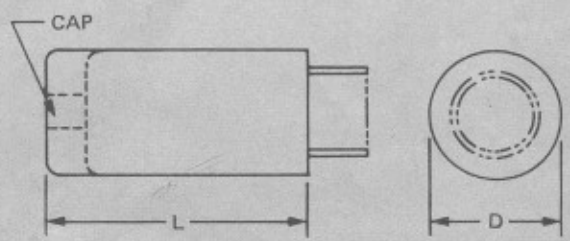
SOLID STATE TUBE REPLACEMENTS

molded circuit assemblies

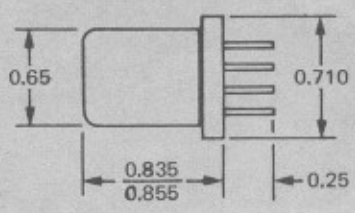
Retrofit for Mercury-Vapor and Vacuum Rectifier Tubes

- No filament supply required
- No warm-up
- Long-life
- High mechanical shock resistance
- Identical pin locations as tube replaced
- Reduces service calls to remote locations





Cap used on ST-7A, ST-9, ST-10, ST-11, ST-12, ST-15, ST-16, 1N2637
Case Style D-18A



Case Style D-18B

All Dimensions in Inches.

SOLID STATE TUBE REPLACEMENTS—RETROFIT FOR MERCURY-VAPOR AND VACUUM RECTIFIER TUBES, DATA SHEET NO. PD-4.011

Each tube replacement is equipped with the identical pin locations and connections as the tube it is designed to replace. In some cases it may be necessary to add resistance to the circuit to protect the load from excess voltages or to protect the tube replacement from surge currents.

LOAD VOLTAGE LIMITING RESISTOR

When replacing gas or mercury vapor tubes, it is not necessary to increase total circuit resistance to simulate tube voltage drop. The slight increase in output voltage is generally not large enough to damage other circuit components. However, it is necessary to add a series resistance when replacing high vacuum rectifiers; otherwise the resulting higher output voltage could damage other circuit components.

CALCULATING THE RESISTOR FOR LIMITING LOAD VOLTAGE

To calculate the required series resistance:

$$R_D = \frac{V_{F(tube)}}{I_{FM}} \quad (1)$$

Where: $V_{F(tube)}$ = Forward voltage drop of vacuum tube being replaced

I_{FM} = Peak output current of tube.

R_D = Series voltage dropping resistor.

The value of $V_{F(tube)}$ may be obtained from the tube rating sheets or from operational characteristics curves. The value of I_{FM} may be approximated for most cases by multiplying the dc output of the tube (I_O) by π (3.14). (If very large peak currents are expected, a more accurate calculation of I_{FM} should be made.)

Thus: $$R_D \approx \frac{V_{F(tube)}}{\pi \times I_O} \quad (2)$$

To calculate the power rating of the resistor:

$$P = (I_{F(rms)})^2 \times R_D \quad (3)$$

Where: R_D = Resistance calculated in Equation 2.

$I_{F(rms)}$ = The RMS current through the resistor.

It will be necessary to estimate the value of $I_{F(rms)}$ because of the current wave form. A good approximation is made by multiplying the average current by 1.6 for choke input filters, or by 2.2 for capacitor filters.

Thus: $$P = (1.6 \times I_O)^2 \times R_D = 2.56\ R_D\ I_O^2$$ (choke input filter) (4)

EXAMPLE

When IR's ST-2 is used to replace a 5U4 vacuum tube operating at 300VRMS and 200mAdc, the forward voltage drop, from the tube rating tables, is approximately 45Vdc. Therefore;

$$R_D = \frac{V_{F(tube)}}{\pi \times I_O} = \frac{45}{\pi \times .200} = 70.7 \text{ Ohms}$$

$$P = 2.56\ R_D\ I_O^2 = 2.56 \times 70.7 \times (.200)^2 = 7.3 \text{ Watts}$$

Thus a 70Ω, 10 Watt (min.) resistor should be connected between the cathode tube pin and the filter and load circuit.

SURGE PROTECTION

When tube replacements are used with capacitive loads and when no voltage limiting resistance is added to the circuit, the tube replacement must be protected from current surges by a current limiting series resistance. This resistance must limit the surge current to a value which the tube replacement can withstand.

CALCULATING SURGE CURRENT PROTECTION

The required surge limiting resistance is computed from:

$$R_{(surge)} = \frac{E_{pf}}{I_{FM(surge)}} \quad (5)$$

Where: E_{pf} = Peak value of the transformer phase voltage

$I_{FM(surge)}$ = Maximum allowable surge current rating (peak Amperes)

$R_{(surge)}$ = Resistance of surge limiting resistor

This value of resistance includes the resistance offered by the transformer secondary phase winding.

The power rating of the resistor is calculated as in Equation 4; but R_D is replaced with $R_{(surge)}$:

$$P = 2.56\ R_{(surge)}\ I_O^2 \quad (6)$$

EXAMPLE

Using the same conditions as in the previous example, the 300VRMS operating voltages must be converted to the peak operating voltage.

$$E_{pf} = 300 \times \sqrt{2} = 425V$$

Then the resistance must be computed:

$$R_{(surge)} = \frac{E_{pf}}{I_{FM(surge)}} = \frac{425}{50} = 8.5 \text{ Ohms}$$

The transformer resistance can now be subtracted from the required series resistance:

$$R_{(surge)} - R_{transformer} = 8.5 - 1.0 = 7.5 \text{ Ohms}$$

(The transformer resistance listed is for example only.)

Now the power rating of the resistor can be calculated:

$$P = 2.56\ R_{(surge)}\ I_O^2 = 2.56 \times 7.5 \times (.200)^2 = .77 \text{ Watts}$$

Thus a 7.5Ω, 1 Watt (min.) resistor should be connected in series with the tube replacement to limit surge currents to the rectifier.

INSTALLATION

It should be recognized that where the calculated value of the series voltage dropping resistor R_D is greater than the required value for the surge limiting resistor $R_{(surge)}$, it is not necessary to include both in the circuit. Only R_D would be necessary.

Furthermore, when a surge limiting resistor is necessary, it may be placed in either of the two locations indicated in Figure 1.

For voltage dropping and surge limiting resistors, it is usually good practice to use a resistor wattage rating at least two times the calculated minimum value.

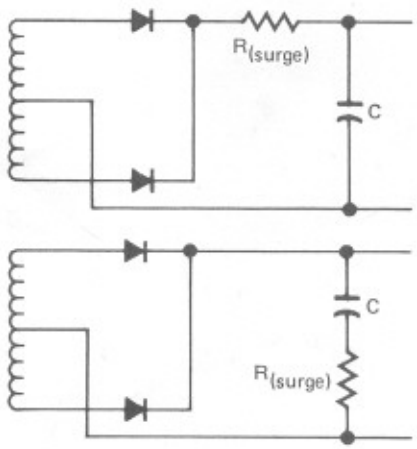


Fig. 1

ELECTRICAL SPECIFICATIONS AND CHARACTERISTICS

IR Part Number	$V_{RM(rep)}$ Per Leg (V)	$V_{r(RMS)}$ – Max. RMS Input (V)	$I_{FM(AV)}$ – Max. DC Output Current @ 70°C (mA)	$I_{FM(surge)}$ – Max. Peak One-Cycle Non-repetitive Surge Current (A)	V_{FM} – VDC Per Leg (VDC) @ 0.5 ADC @ 25°C	Max. Dimensions (Case D-18A) L	Max. Dimensions (Case D-18A) D	Circuit Diagram	Replaces
1N570 (ST-1A)	1,500*	1,050*	75	50	1.8	(Case D-18B)		C	MIL-6X4, MIL-12X4
1N1150A	1,600*	1,130*	750 ①	50	3.0	2.65	1.25	B	5Z3, 80, 82, 83, 83V
1N1237	1,600*	1,130*	750 ①	50	3.0	2.65	1.25	A	0Z4, 5X4, 5Y4, 6AX5, 6X5
1N1238	1,600*	1,130*	750 ①	50	3.0	2.65	1.25	D	5AV4, 5AW4, 5AZ4, 5T4, 5U4, 5V4, 5W4, 5Y3, 5Z4
1N1239	2,800*	1,950*	500 ①	50	6.0	3.75	1.38	D	5R4
1N1262 (ST-7)	4,500*	3,200	250 ①	50	4.5	2.65	1.25	G	6AU4, 6AX4, 6BL4, 6W4, 12AX4, 17AX4, 25W4
1N2389	1,600*	–	600	50	5.3 ②	1.50	1.44	L	5AV4, 5AW4, 5AX4, 5T4, 5U4, 5V4, 5W4, 5Y3, 5Z4, 6004
1N2490	1,600*	1,130	500 ①	50	3.0	1.56	0.87	E	6X4
1N2630 (ST-1)	1,500*	1,050*	85	50	1.8	1.81	0.88	C	6X4, 12X4
1N2631 (ST-2)	1,600*	1,130*	600	50	1.8	2.65	1.25	D	5AW4, 5AX4, 5AZ4, 5T4, 5U4, 5Y3, 6004
1N2632	2,800*	1,950*	200	50	2.7	2.65	1.25	D	5R4, 5R4W
1N2633 (ST-3)	1,600*	1,130*	600	50	1.8	2.65	1.25	A	0Z4, 5X4, 6AX5, 6W5, 6X5, 6ZY5, 5839, 5852
1N2634 (ST-4)	1,600*	1,130*	600	50	3.6	2.65	1.28	B	5Z3, 80, 82, 83, 83V
1N2635 (ST-5)	1,500*	1,050*	85	50	3.6	1.81	0.88	E	High Altitude 6X4 & 12X4
1N2636 (ST-6)	1,500*	1,050*	85	50	3.6	2.45	1.19	F	84/6Z4
1N2637 (ST-7A)	10,400*	7,300*	250	50	11.0	5.05	1.38	J	3B28, 249B, 866, 866A
ST-8	1,250	880	80	50	6.2 ②	1.10	1.40	H	0Z4, 6X5
ST-9 ①	10,000	7,000	1,250	50	14.0	8.05	2.31	M	8008
ST-10 ①	10,000	7,000	1,250	50	14.0	8.05	2.31	M	872A
ST-11 ①	7,500	5,300	125	50	8.1	4.20	1.20	J	816
ST-12 ①	40,000	28,000	100	50	54.0	7.90	2.40	J	8020
ST-13	1,275	900	130	50	1.8	2.00	0.82	K	6BW4, 12BW4
ST-14	1,600	1,130	600	50	5.3 ②	1.50	1.44	L	5AV4, 5AW4, 5AX4, 5T4, 5U4, 5Y4, 5W4, 5Y3, 5Z4, 6004, 5AR4, GZ34
ST-15 ①	15,000	10,600	1,750	200	15.0	9.65	3.88	M	673
ST-16 ①	15,000	10,600	1,750	200	15.0	9.65	3.88	M	575A

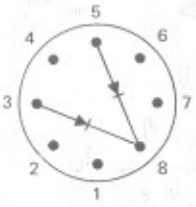
* JEDEC registered values.

① @ 100°C

② Including internal current limiting resistor.

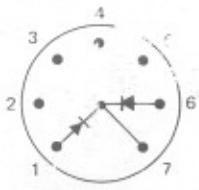
③ Incorporates compensating R-C networks.

CIRCUIT DIAGRAMS

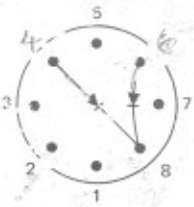


A
Octal Base

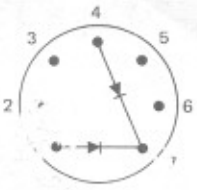
B
A4-9 Base



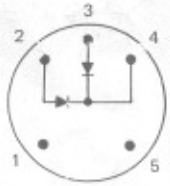
C
E7-1 Base



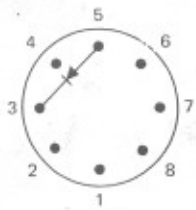
D
Octal Base



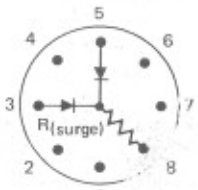
E
E7-1 Base



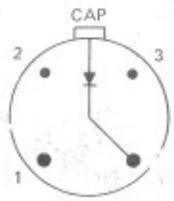
F
A5-11 Base



G
Octal Base



H
Octal Base



J

Replacement	Base
ST-7A	A4-10
ST-11	A4-5
ST-12	A4-10

K
E9-1 Base

L
Octal Base

M

Replacement	Base
ST-9	A4-18
ST-10	A4-29
ST-15	A4-18
ST-16	A4-29

CROSS REFERENCE

Tube Replaced	IR Tube Replacement
GZ34	ST-14
0Z4	ST-3, ST-8, 1N1237, 1N2633
3B28	ST-7A, 1N2637
5AR4	ST-14
5AV4	ST-14, 1N1238, 1N2389
5AW4	ST-2, ST-14, 1N1238, 1N2389, 1N2631
5AX4	ST-2, ST-14, 1N2389, 1N2631
5AZ4	ST-2, 1N1238, 1N2631
5R4	ST-2A, 1N1239, 1N2632
5R4W	ST-2A, 1N2632
5T4	ST-2, ST-14, 1N1238, 1N2389, 1N2631
5U4	ST-2, ST-14, 1N1238, 1N2389, 1N2631
5V4	ST-14, 1N1238, 1N2389
5W4	ST-14, 1N1238, 1N2389
5X4	ST-3, 1N1237, 1N2633
5Y3	ST-2, ST-14, 1N1238, 1N2389
5Y4	1N1237
5Z3	ST-4, 1N1150A, 1N2634
5Z4	ST-14, 1N1238
6AU4	ST-7, 1N1262
6AX4	ST-7, 1N1262
6AX5	ST-3, 1N1237, 1N2633
6BL4	ST-7, 1N1262
6BW4	ST-13
6W4	ST-7, 1N1262
6W5	ST-3, 1N2633
6X4	ST-1, 1N2490, 1N2630
6X4 (MIL)	ST-1A, 1N570
6X4 (High altitude)	ST-5, 1N2635
6X5	ST-3, ST-8, 1N1237, 1N2633

Tube Replaced	IR Tube Replacement
6ZY5	ST-3, 1N2633
12AX4	ST-7 1N1262
12BW4	ST-13
12X4	ST-1, 1N2630
12X4 (MIL)	ST-1A, 1N570
12X4 (High altitude)	ST-5, 1N2635
17AX4	ST-7, 1N1262
25W4	ST-7, 1N1262
80	ST-4, 1N1150A, 1N2634
82	ST-4, 1N1150A, 1N2634
83	ST-4, 1N1150A, 1N2634
83V	ST-4, 1N1150A, 1N2634
84/6Z4	ST-6, 1N2636
249B	ST-7A, 1N2637
575A	ST-16
673	ST-15
816	ST-11
866	ST-7A, 1N2637
866A	ST-7A, 1N2637
872A	ST-10
5839	ST-3, 1N2633
5852	ST-3, 1N2633
6004	ST-2, ST-14, 1N2389, 1N2631
8008	ST-9
8020	ST-12

INTERNATIONAL RECTIFIER IOR

Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245 • Telex 67-4666 • Phone (213) 678-6281

Manufacturing facilities in United States, Canada, Great Britain, India, Italy and Japan. Sales offices and distributors in major cities throughout the world.

Printed in U.S.A. 2/73