Designing power supplies

Ray Fautley describes an easy-to-use procedure for designing reliable full-wave rectifiers of the centre-tapped secondary variety.

In this version of the full-wave rectifier, the bridge rectifier is simplified to two diodes, but the transformer needs a centre tap, which becomes the ground connection.

Alternating voltage is applied to rectifier diodes $D_{1,2}$ where it is rectified and the output smoothed by reservoir capacitor C.

Fundamental frequency of the ripple voltage is twice that of the supply frequency. Resistance R_s represents the source of the supply and V_{sec} is the voltage across the whole of the secondary winding.

Design procedure

1) Specify required dc output voltage at full load $E_{dc(load)}$ (V).
2) Specify required maximum load current $I_{dc(load)}$ (A).
3) Specify maximum voltage ripple acceptable $V_{r(rms)}$ (V).
4) Specify the ac mains supply voltage $V_{pri(rms)}$ (V).
5) Specify the frequency of the mains supply f (Hz).
6) Determine the value of the equivalent load resistance R_L:

$$R_L = \frac{E_{dc}}{I_{dc(load)}}$$

where E_{dc} is the design value of the dc output voltage. It is the required voltage across the load, $E_{dc(load)}$, added to the voltage drop across one of the diodes. As the voltage drop across the diodes occurs only while they are conducting, and they conduct alternately, the effective drop is that of just one diode.

$$E_{dc}=E_{dc(load)}+V_{rec}$$

where V_{rec} (the drop across the rectifier diode) is 0.9V, so:

$$R_L = \frac{E_{dc(load)}+0.9}{I_{dc(load)}}$$

7) Determine average current through each diode. Half the average current, I_o, will flow through each diode.

$$I_o=I_{dc(load)}/2$$

8) Determine a value for source resistance of the supply, R_s. If the mains transformer winding resistances are known – and it rarely is – refer to step 8 in the design preocedure the the full-wave rectifier (September 1996 issue) for the method of evaluating R_s. Otherwise, assume that R_s is about 5% of R_L. Then for low resistance loads:

$$R_s = \frac{R_L \times 5}{100} + \frac{0.9}{I_o}$$

For high resistance loads, where the transformer winding resistance predominates:

$$R_s = \frac{R_L \times 5}{100}$$

9) Calculate the ratio of R_s to R_L as a percentage:

$$\frac{R_s}{R_L} \times 100\%$$

10) Determine percentage ripple voltage from the specified maximum ripple and the dc output voltage:

Full-wave rectification using a transformer with centre tap needs two fewer diodes than the full-wave bridge rectifier.

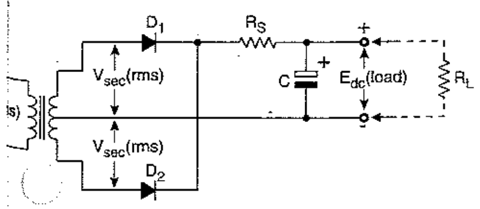

Table 1. Finding the value for X.

V_r%	R_S/R_L% 0.1	0.3	1.0	3.0	5.0	10	30
0.1	771	740	709	646	614	583	463
0.2	381	368	354	324	309	294	233
0.3	257	247	237	218	208	199	158
0.4	195	188	177	162	154	147	120
0.5	154	148	141	129	122	116	95
0.6	128	123	117	108	103	98	81
0.7	110	106	102	94	89	85	69
0.8	97	93	88	81	77	74	61
0.9	86	82	78	72	68	65	54
1.0	78	75	71	65	62	59	49
2.0	38	37	36	33	31	30	25
3.0	26	25	24	22	21	20	16
4.0	19	19	18	17	16	15	12
5.0	15	15	14	13	12.5	12	10
6.0	13	12	12	11	10.5	10	8
7.0	10.6	10.3	9.9	9.2	8.8	8.5	7.0
8.0	9.1	8.8	8.5	8.0	7.7	7.4	6.0
9.0	8.0	7.7	7.5	7.0	6.7	6.5	5.3
10	7.1	7.0	6.8	6.4	6.1	5.9	4.9
20	2.9	2.8	2.7	2.6	2.5	2.4	2.2
30	1.6	1.6	1.5	1.5	1.4	1.4	1.2
40	0.9	0.9	0.9	0.9	0.8	0.8	0.7

$$V_r\% = \frac{V_{r(rms)}}{E_{dc(load)}} \times 100\%$$

11) From the figures in **Table 1**, determine the value of X required to provide the percentage ripple voltage, V_r% in step 10) above, for (R_s/R_L)% calculated in 9).

12) Calculate reservoir capacitor C, required to provide the ripple voltage $V_{r(rms)}$ from:

$$C = \frac{X(10^6)\mu F}{2\pi f R_L}$$

The term used for frequency is f and not $2f$ (the ripple frequency in a full-wave centre-tap rectifier circuit being twice the supply frequency) because the figures in Table 1 allow for the difference.

13) Find the nearest standard (or available) value for the reservoir capacitor C, close to (preferably just above) the value calculated in step 12). If the value of the capacitor is different from that in 12), call it C_1 and determine a new value for X (call it X_1) from:

$X_1 = 2\pi f C_1 R_L$

with C_1 in µF,

$$X_1 = \frac{2\pi f C_1 R_L}{10^6}$$

14) From the figures in **Table 2** determine the value of Y for X in step 11), or X_1 in step 13), and (R_s/R_L)% in step 9).

15) Determine the transformer secondary voltage $V_{sec(rms)}$ required, from the value for Y in step 14):

$$V_{sec(rms)} = \frac{E_{dc}}{\sqrt{2} \times Y}$$

where $E_{dc} = E_{dc(load)} + V_{rec}$

Table 2. Finding the Value of Y

X	R_S/R_L% 0.05	0.1	0.5	1.0	2	4	6	8	10	12.5
0.1	0.64	0.64	0.64	0.63	0.62	0.61	0.60	0.57	0.57	0.56
0.2	0.64	0.64	0.64	0.63	0.62	0.62	0.60	0.58	0.57	0.57
0.3	0.64	0.64	0.64	0.63	0.63	0.62	0.61	0.59	0.58	0.57
0.4	0.64	0.64	0.64	0.63	0.63	0.62	0.61	0.60	0.58	0.58
0.5	0.65	0.64	0.64	0.63	0.63	0.62	0.61	0.60	0.59	0.58
0.6	0.65	0.65	0.64	0.64	0.64	0.63	0.62	0.60	0.59	0.58
0.7	0.66	0.65	0.65	0.65	0.64	0.63	0.62	0.61	0.60	0.59
0.8	0.66	0.66	0.66	0.65	0.65	0.64	0.63	0.62	0.60	0.59
0.9	0.67	0.66	0.66	0.66	0.65	0.64	0.63	0.62	0.61	0.60
1.0	0.68	0.68	0.67	0.67	0.66	0.65	0.64	0.63	0.62	0.61
1.5	0.72	0.71	0.70	0.70	0.69	0.68	0.67	0.65	0.64	0.62
2.0	0.76	0.76	0.76	0.76	0.75	0.73	0.71	0.70	0.67	0.65
2.5	0.77	0.77	0.77	0.77	0.76	0.74	0.72	0.71	0.68	0.66
3.0	0.79	0.78	0.78	0.78	0.77	0.75	0.73	0.72	0.69	0.68
4.0	0.82	0.82	0.80	0.79	0.79	0.78	0.75	0.73	0.71	0.69
5.0	0.85	0.85	0.84	0.84	0.82	0.80	0.77	0.75	0.73	0.70
6.0	0.86	0.86	0.85	0.85	0.84	0.80	0.77	0.75	0.73	0.70
7.0	0.88	0.87	0.86	0.86	0.85	0.82	0.78	0.75	0.74	0.71
8.0	0.89	0.88	0.87	0.87	0.86	0.82	0.78	0.76	0.74	0.71
9.0	0.90	0.90	0.88	0.88	0.87	0.83	0.79	0.76	0.74	0.72
10	0.92	0.91	0.90	0.89	0.88	0.84	0.80	0.77	0.75	0.72
15	0.95	0.93	0.91	0.90	0.89	0.85	0.80	0.77	0.75	0.72
20	0.96	0.95	0.94	0.92	0.90	0.86	0.80	0.78	0.75	0.73
25	0.96	0.96	0.95	0.93	0.90	0.86	0.81	0.78	0.75	0.73
30	0.97	0.96	0.95	0.93	0.91	0.86	0.82	0.78	0.76	0.73
40	0.98	0.97	0.96	0.93	0.91	0.86	0.82	0.78	0.76	0.73
50	0.98	0.98	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
60	0.98	0.98	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
70	0.99	0.99	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
80	0.99	0.99	0.96	0.94	0.91	0.86	0.82	0.79	0.76	0.73
90	0.99	0.99	0.97	0.94	0.91	0.86	0.82	0.79	0.76	0.73
100	0.99	0.99	0.97	0.94	0.91	0.86	0.82	0.79	0.76	0.73
200	1.0	0.99	0.97	0.94	0.91	0.86	0.82	0.79	0.76	0.73
300	1.0	0.99	0.97	0.95	0.91	0.86	0.82	0.79	0.76	0.73
1000	1.0	0.99	0.97	0.95	0.91	0.86	0.82	0.79	0.76	0.73

$$= \frac{0.707 \times E_{dc}}{Y}$$

Voltage $V_{sec(rms)}$ is only half the required secondary voltage of the transformer, which has a centre-tapped winding. So the *total* secondary winding will be:

$V_{sec(rms)}$–0–$V_{sec(rms)}$

16) Determine the peak voltage (or PIV, peak inverse voltage) that each of the rectifier diodes must withstand.

$PIV = 2\times V_{sec(peak)} = 2\times\sqrt{2}\times V_{sec(rms)}$
$= 2.828 V_{sec(rms)}$

The factor 2 occurs because each rectifier diode has both halves of the secondary winding in series applied in alternate half cycles.

17) Find the value for Z from **Table 3** for $2X$ (or $2X_1$), where X was found in step 11), or X_1 in step 13), and for $(R_s/2R_L)$%. The value for (R_s/R_L)% was found in step 9).

$Z = I_{(rms)}/I_o$

18) From the value of Z found in step 17), determine current through each rectifier diode:

$I_{(rms)} = I_o \times Z$

19) Determine recurrent peak current $I_{(peak)}$ through each rectifier diode. From the figures in **Table 4** for $2X$ (or $2X_1$) and $(R_s/2R_L)$% find W, which is $I_{(peak)}/I_o$.

Thus find $I_{(peak)} = I_o \times W$.

20) Determine initial swich-on current I_{on}. As C (or C_1) will be initially discharged, the load on the rectifier diodes will be nearly a short-circuit at the instant of switch-on, limited only by the source resistance R_s. Then:

$$I_{on} = \frac{V_{sec(peak)}}{R_s}$$

This very high current flows for only a very short time, but the rectifier diodes must be capable of withstanding it. If suitable devices with such high pulse ratings are not available, source resistance R_s must be increased by adding an external resistor R_{ext} between the rectifier and the reservoir capacitor C, or C_1. The value of R_{ext} to limit the switch-on current to an acceptable lower value $I_{on(L)}$ is determined in step 28).

21) Decide on a suitable rectifier diode type to be used. The device must have *all* its ratings equal to, or greater than, the following:

PIV or $2\times V_{sec(peak)}$ (sometimes V_{RRMT}) see step 16)

Initial switch-on current or I_{on} (sometimes I_{FSMT}), see step 20)

Average current or I_o (sometimes $I_{F(AV)}$), see step 7)

Table 2 continued.

X	R_S/R_L% 15	20	25	30	35	40	50	60	70	80	90	100
0.1	0.56	0.54	0.51	0.49	0.47	0.46	0.44	0.40	0.38	0.35	0.33	0.32
0.2	0.56	0.54	0.51	0.49	0.47	0.46	0.44	0.40	0.38	0.35	0.33	0.32
0.3	0.56	0.54	0.51	0.49	0.47	0.46	0.44	0.40	0.38	0.36	0.33	0.32
0.4	0.56	0.54	0.51	0.49	0.48	0.46	0.44	0.40	0.38	0.36	0.33	0.32
0.5	0.57	0.54	0.51	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.34	0.32
0.6	0.57	0.54	0.51	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.34	0.32
0.7	0.57	0.55	0.52	0.50	0.48	0.46	0.44	0.41	0.38	0.37	0.34	0.32
0.8	0.58	0.55	0.52	0.50	0.48	0.47	0.44	0.41	0.39	0.38	0.34	0.33
0.9	0.58	0.55	0.53	0.51	0.49	0.47	0.45	0.41	0.39	0.38	0.34	0.33
1.0	0.59	0.56	0.53	0.51	0.49	0.47	0.45	0.42	0.40	0.38	0.35	0.33
1.5	0.60	0.57	0.55	0.52	0.50	0.48	0.45	0.42	0.40	0.38	0.35	0.33
2.0	0.63	0.59	0.56	0.53	0.51	0.49	0.46	0.43	0.41	0.38	0.35	0.33
2.5	0.64	0.60	0.57	0.54	0.52	0.50	0.47	0.43	0.41	0.38	0.36	0.34
3.0	0.65	0.61	0.58	0.55	0.52	0.50	0.47	0.43	0.41	0.38	0.36	0.34
4	0.66	0.62	0.59	0.55	0.53	0.51	0.47	0.44	0.41	0.38	0.36	0.34
5	0.67	0.63	0.60	0.56	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
6	0.68	0.63	0.60	0.56	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
7	0.68	0.64	0.60	0.57	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
8	0.68	0.64	0.60	0.57	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
9	0.69	0.64	0.60	0.57	0.54	0.52	0.48	0.44	0.42	0.39	0.37	0.35
10	0.69	0.65	0.61	0.58	0.55	0.52	0.48	0.44	0.43	0.39	0.37	0.35
15	0.69	0.65	0.61	0.58	0.55	0.52	0.48	0.44	0.43	0.39	0.37	0.35
20	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.44	0.43	0.39	0.37	0.35
25	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.39	0.37	0.35
30	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.39	0.37	0.35
40	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.39	0.37	0.35
50	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
60	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
70	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
80	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
90	0.70	0.65	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.35
100 to 1000	0.70	0.66	0.61	0.58	0.55	0.53	0.49	0.45	0.43	0.40	0.38	0.36

22) Determine rms ripple current $I_{c(rms)}$, flowing through reservoir capacitor C (or C_1):

$$I_{c(rms)} = \sqrt{2(I^2_{rms}) - (I^2_{dc(load)})}$$

for $I_{(rms)}$, see step 18), and for $I_{dc(load)}$, see step 2).

23) Decide on the specification for the reservoir capacitor to be used. The capacitor must have ratings equal to, or greater than, the following:

Capacitance C (or C_1) see step 12) or 13)

DC working voltage $V_{sec(peak)}$, step 16)

Ripple current $I_{c(rms)}$, step 22)

24) Total transformer secondary current $I_{t(rms)}$ is the same as the current through each diode, I_{rms}, i.e. $I_{t(rms)}=I_{rms}$.

25) Transformer VA (or volt-amp) rating T_{VA} for each half of the secondary winding is: $V_{sec(rms)} \times I_{t(rms)}$ so total VA, $T_{VA}=2 \times V_{sec(rms)} \times I_{t(rms)}$. This determines the size of the transformer.

26) Transformer requirements are:

Volt-amp rating T_{VA}, see step 25)

Primary winding $V_{pri(rms)}$, step 4)

Secondary winding $V_{sec(rms)}$–0–$V_{sec(rms)}$, see step 15)

Secondary current $I_{t(rms)}$, step 24)

Table 3. Finding the value for Z.

2X	$R_S/2R_L$% 0.02	0.05	0.1	0.2	0.5	1.0	2	5	10	30	100
1	1.80	1.80	1.79	1.79	1.79	1.78	1.77	1.77	1.73	1.70	1.66
2	2.03	2.02	2.01	2.00	1.99	1.98	1.97	1.96	1.89	1.77	1.67
3	2.19	2.17	2.16	2.14	2.13	2.11	2.10	2.03	1.95	1.79	1.67
4	2.32	2.30	2.28	2.26	2.24	2.22	2.17	2.08	1.98	1.80	1.68
5	2.43	2.40	2.36	2.32	2.27	2.23	2.19	2.10	2.01	1.82	1.68
6	2.50	2.48	2.46	2.44	2.42	2.40	2.28	2.13	2.04	1.83	1.68
7	2.58	2.53	2.51	2.49	2.47	2.45	2.31	2.16	2.05	1.84	1.68
8	2.66	2.63	2.61	2.60	2.58	2.50	2.35	2.17	2.06	1.84	1.68
9	2.73	2.70	2.68	2.66	2.64	2.57	2.38	2.18	2.07	1.85	1.68
10	2.80	2.78	2.75	2.73	2.70	2.62	2.40	2.19	2.08	1.86	1.68
20	3.30	3.20	3.17	3.15	2.83	2.82	2.53	2.26	2.12	1.88	1.68
30	3.64	3.50	3.40	3.29	3.05	2.89	2.59	2.30	2.15	1.90	1.68
40	3.91	3.72	3.55	3.40	3.13	2.92	2.62	2.32	2.16	1.90	1.68
50	4.08	3.87	3.68	3.48	3.22	2.93	2.64	2.33	2.17	1.91	1.68
60	4.23	3.97	3.78	3.55	3.25	2.94	2.66	2.35	2.18	1.91	1.68
70	4.35	4.03	3.87	3.60	3.27	2.95	2.67	2.36	2.18	1.91	1.68
80	4.45	4.10	3.94	3.65	3.30	2.96	2.68	2.36	2.18	1.91	1.68
90	4.52	4.18	3.98	3.67	3.31	2.97	2.68	2.37	2.19	1.91	1.68
100	4.62	4.23	4.02	3.69	3.32	2.98	2.69	2.37	2.19	1.91	1.68
200	5.03	4.60	4.27	3.86	3.37	3.00	2.69	2.38	2.19	1.91	1.68
300	5.20	4.79	4.33	3.88	3.38	3.00	2.69	2.38	2.19	1.91	1.68
400	5.35	4.86	4.37	3.88	3.38	3.00	2.70	2.38	2.19	1.91	1.68
500	5.45	4.90	4.38	3.89	3.38	3.00	2.70	2.39	2.19	1.91	1.68
600	5.51	4.93	4.38	3.89	3.39	3.00	2.70	2.39	2.19	1.91	1.68
700	5.60	4.96	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68
800	5.67	4.98	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68
900	5.70	4.99	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68
1000	5.75	5.00	4.39	3.90	3.39	3.01	2.70	2.39	2.19	1.91	1.68

27) When a suitable transformer has been chosen, measure resistance of *half* of the total secondary winding and the resistance of the primary winding. If the measured source resistance:

$$R_{s(m)} = \frac{R_{sec}}{2} + \frac{R_{pri}}{N^2} + R_{rec}$$

is *less* than R_s calculated in step 8), then an external resistor:

$$R_{ext}=R_s-R_{s(m)}$$

must be added, see step 28), to limit I_{on} to the value found in 20). For low resistance loads, it is unlikely that any external resistance will be necessary as the diode resistance R_{rec} will tend to limit the switch-on current rather than the resistance of the transformer windings.

28) If an external resistor R_{ext} was found necessary in step 20) or 27) to be fitted between the rectifiers and reservoir capacitor C (or C_1) to limit the switch-on current to a lower level $I_{on(L)}$, its value will be:

$$R_{ext} = \frac{V_{sec(peak)}}{I_{on(L)}} - R_s$$

29) Power dissipated in R_{ext} (if used) is given by:

$$P_r=[I_{t(rms)}{}^2] \times R_{ext}$$

A suitable resistor should have a power rating of about twice the value of P_r for reliable operation.

30) If an external resistor R_{ext} is used the regulation of the supply can be improved by the addition of a shorting-out device as recommended for the bridge rectifier circuit in the September issue.

Putting the procedure to work

Now for the worked example. A supply of 1200V at 0.5A is required for a valve rf power amplifier. An acceptable ripple on the supply would be 12V rms.

1) $E_{dc(load)}$=1200V
2) $I_{dc(load)}$=0.5A
3) $V_{r(rms)}$=12Vrms
4) $V_{pri(rms)}$=240Vrms
5) f=50Hz
6)
$$R_L = \frac{E_{dc}}{I_{dc(load)}} = \frac{E_{dc(load)} + V_{rec}}{I_{dc(load)}}$$

As V_{rec} is only 0.9V it can be ignored. So,

$$R_L = \frac{E_{dc}}{I_{dc(load)}} = \frac{1200}{0.5} = 2400\Omega$$

7)
$$I_o = \frac{I_{dc(load)}}{2} = \frac{0.5}{2} = 0.25A$$

8)
$$R_s = \frac{2400 \times 5}{100} = 120\Omega$$

9)
$$\frac{R_s}{R_L} \times 100\% = \frac{120}{2400} \times 100\% = 5\%$$

10
$$V_r\% = \frac{V_{r(rms)}}{E_{dc(load)}} \times 100\%$$
$$= \frac{12}{200} \times 100\% = 1\%$$

11) Find the value of X for V_r% and (R_s/R_L)%, i.e.

$$V_r\% = 1 \text{ and } \frac{R_s}{R_L} = 5$$

from Table 1 is found to be 62.

12)
$$C = \frac{X(10^6)}{2\pi f R_L}\mu F = \frac{62 \times 10^6}{2\pi \times 50 \times 2400}\mu F$$
$$= 82.2\mu F$$

13) To obtain a high enough voltage rating for the reservoir capacitor, four capacitors connected in series are necessary. Four 330μF, 385V working-voltage capacitors would be suitable A resistor of about 100kΩ (2W rating) should be connected across each of the four capacitors to equalise the dc voltage across each capacitor.

14) From Table 2, the value of Y for X and (R_s/R_L)%, i.e. X=62 and (R_s/R_L)%=5, is found to be 0.84.

15)
$$V_{sec(rms)} = \frac{0.707 \times E_{dc}}{Y} = \frac{0.707 \times 1200}{0.84}$$
$$= 1010V_{rms}$$

Total secondary winding will be: $V_{sec(rms)}$-0-$V_{sec(rms)}$ or 1010V-0-1010V.

16) PIV=2.828$V_{sec(rms)}$=2.828×1010=2856V

17) From step 11), X = 62 and from step 9), $(R_s/2R_L)$%=5. Find the value of Z for 2X and for $(R_s/2R_L)$%, i.e.

$$2X = 2 \times 62 = 124 \text{ and } \frac{R_s}{2R_L} = \frac{5}{2} = 2.5,$$

which from Table 3 is found to be 2.64.

18) From step 17), Z=2.64 and from step 7), I_o=0.25A, so,

$I_{(rms)}=I_o \times Z$=2.64×0.25=0.66A

19) From step11), X=62 and from step 9), (R_s/R_L)%=5 so the value of W for 2X and $(R_s/2R_L)$%, where 2X=124 and $(R_s/2R_L)$%=2.5, from Table 4 is found to be 7.92. As a result,

$I_{(peak)}=I_o \times W$=0.25×7.92=1.98

20)
$$I_{on} = \frac{V_{sec(peak)}}{R_s} = \frac{1.414V_{sec(rms)}}{R_s}$$
$$= \frac{1.414 \times 1010}{120} = 11.9A$$

21) Diode ratings required are,

$PIV(V_{RRMT})$=2856V

$I_{on}(I_{FSMT})$=11.9A

$I_o(I_{F(ave)})$=0.25A

To obtain a PIV of 2856V it would be necessary to wire three BYX38-1200 diodes in series for each of the two diodes required.

22)
$$I_{c(rms)} = \sqrt{2I_{rms}^2 - I_{dc(load)}^2}$$
$$= \sqrt{2 \times 0.66^2 - 0.5^2}$$
$$= \sqrt{2 \times 0.4356 - 0.25}$$
$$= \sqrt{0.6212} = 0.79A$$

23) Reservoir capacitor ratings required are,

C=82.2μF

$V_{sec(peak)}=V_{dc(wkg)}=\sqrt{2}\times1010$=1428V

Ripple current $I_{c(rms)}$=0.79A

Four capacitors in series of 330μF, each with a working voltage of 385V dc would be suitable. To ensure that a quarter of the output voltage appears across each capacitor, a 100kΩ, 3W resistor should be wired across each of them.

24) $I_{t(rms)}=I_{rms}$=0.66A

25) Transformer VA
=2×$V_{sec(rms)}$×$I_{t(rms)}$
=2×1010×0.66
=1333.2VA

26) Mains transformer ratings required are,

T_{VA}=1333VA

Primary winding $V_{pri(rms)}$=240V rms

Secondary winding $V_{sec(rms)}$
=1010V-0-1010V

Secondary current $I_{t(rms)}$=0.66A

Previous articles in this power-supply design series covered the full-wave bridge rectifier, September 1996 issue, and the half-wave single-diode rectifier, December 1996 issue. A subsequent article will deal with the voltage doubler. ■

Table 4. Finding the value for W.

2X	R_S/R_L%										
	0.02	0.05	0.1	0.2	0.5	1.0	2	5	10	30	100
1	3.70	3.70	3.70	3.64	3.62	3.60	3.60	3.59	3.58	3.57	3.46
2	4.60	4.57	4.55	4.53	4.52	4.50	4.28	4.20	4.08	3.72	3.51
3	5.50	5.40	5.33	5.30	5.20	5.10	5.00	4.67	4.33	4.00	3.55
4	6.20	6.17	6.13	6.10	6.00	5.98	5.45	5.20	4.95	4.05	3.57
5	7.30	6.95	6.90	6.85	6.80	6.75	6.51	5.60	5.00	4.10	3.62
6	8.00	7.90	7.70	7.60	7.50	7.30	6.90	5.84	5.09	4.19	3.63
7	8.70	8.55	8.50	8.30	8.10	7.82	7.30	6.00	5.10	4.22	3.64
8	9.60	9.50	9.35	9.00	8.50	8.20	7.69	6.15	5.14	4.23	3.64
9	10.3	9.80	9.60	9.50	9.10	8.55	7.72	6.23	5.21	4.25	3.65
10	10.9	10.7	10.5	10.1	9.50	8.64	7.74	6.30	5.28	4.26	3.66
20	16.0	15.0	14.4	13.0	11.1	9.44	7.83	6.47	5.29	4.27	3.66
30	19.7	18.0	16.3	14.3	11.7	9.60	7.92	6.50	5.31	4.27	3.66
40	21.9	20.0	17.3	14.7	12.1	9.64	8.01	6.51	5.33	4.28	3.66
50	23.7	20.8	18.2	15.2	12.2	9.70	8.10	6.51	5.34	4.28	3.66
60	24.9	21.1	18.5	15.4	12.3	9.77	8.12	6.51	5.34	4.29	3.66
70	25.9	21.4	18.9	15.6	12.4	9.84	8.14	6.51	5.34	4.29	3.66
80	26.7	21.8	19.4	15.7	12.4	9.90	8.16	6.51	5.34	4.30	3.66
90	27.5	22.2	19.5	15.8	12.5	9.93	8.18	6.51	5.34	4.30	3.66
100	28.5	22.5	19.7	15.9	12.5	9.96	8.19	6.52	5.35	4.31	3.66
200	30.5	23.0	20.0	16.3	12.6	10.0	8.19	6.52	5.36	4.31	3.67
300	31.6	23.3	20.5	16.9	12.7	10.0	8.20	6.53	5.38	4.32	3.67
400	32.8	23.5	20.9	17.0	12.7	10.0	8.20	6.54	5.40	4.32	3.67
500	33.3	23.8	21.0	17.1	12.8	10.0	8.20	6.55	5.42	4.33	3.68
600	33.8	24.0	21.1	17.2	12.8	10.1	8.20	6.56	5.44	4.33	3.68
700	34.2	24.5	21.2	17.3	12.9	10.1	8.20	6.57	5.46	4.33	3.69
800	34.4	24.9	21.4	17.4	12.9	10.1	8.20	6.58	5.48	4.33	3.69
900	34.5	25.8	21.5	17.5	13.0	10.1	8.20	6.59	5.52	4.33	3.70
1000	34.7	27.0	21.6	17.6	13.0	10.1	8.20	6.60	5.56	4.33	3.70