EEE-2103: Electronic Devices and Circuits

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Half-Wave Rectifier Power Supply

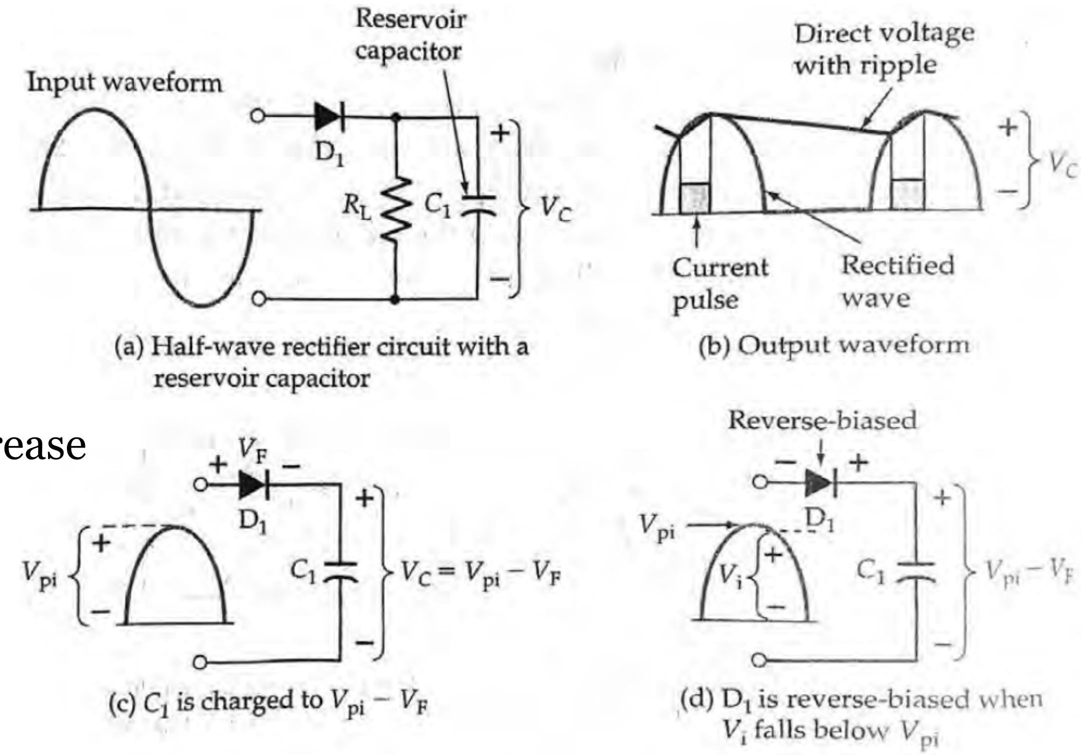
Capacitor filter circuit:
Smoothing circuit or filter →
to convert series of +ve/-ve half-cycles to dc voltage.

When D_1 is forward biased, C_1 is charged to Peak capacitor voltage →

$$V_C = V_{pi} - V_F$$

When D_1 is reverse biased, C_1 is discharged slowly through R_L.

Charge and discharge of C_1 cause small increase and decrease in V_C =
Output is direct voltage with small ripple.



(a) Half-wave rectifier circuit with a reservoir capacitor
(b) Output waveform
(c) C_1 is charged to $V_{pi} - V_F$
(d) D_1 is reverse-biased when V_i falls below V_{pi}

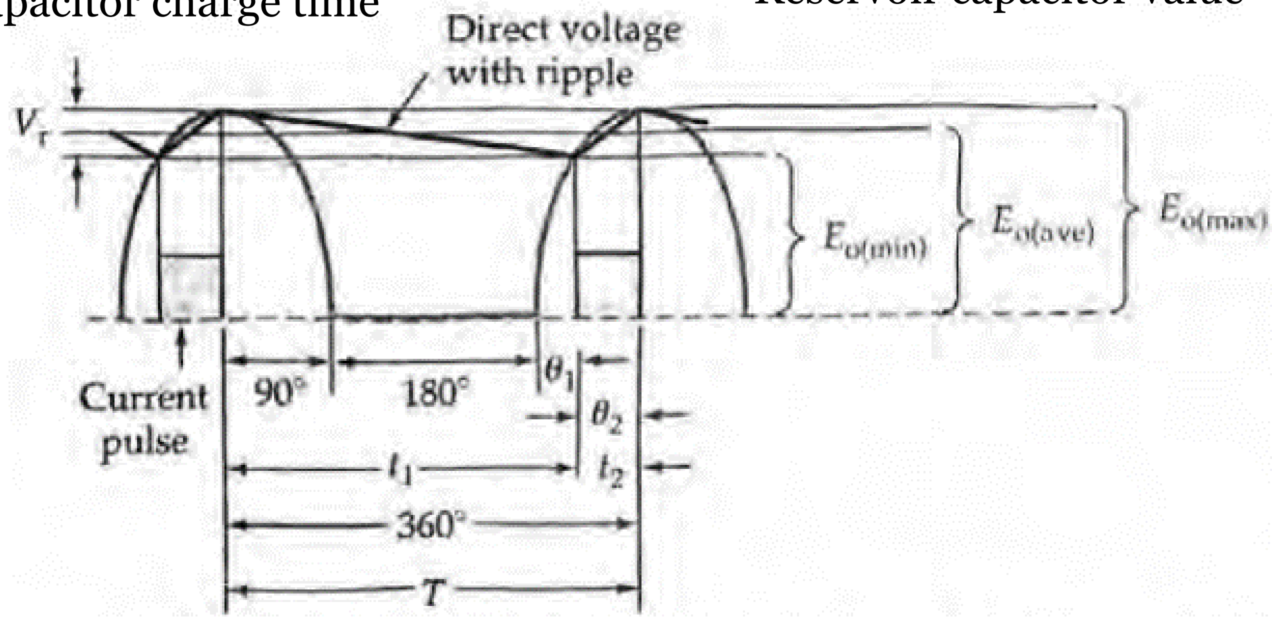
Half-Wave Rectifier Power Supply

Quantities of circuit output voltage waveform →
$E_{o(ave)}$ = average dc output voltage
$E_{o(max)}$ = maximum output voltage
$E_{o(min)}$ = minimum output voltage
V_r = ripple voltage peak-to-peak amplitude
T = time period of ac input waveform
t_1 = capacitor discharge time
t_2 = capacitor charge time

θ_1 = phase angle of input wave from zero to $E_{o(min)}$
θ_2 = phase angle of input wave from $E_{o(min)}$ to $E_{o(max)}$

Assumption → $t_1 >> t_2$

Reservoir capacitor value → $C_1 = I_L t_1 / V_r$
I_L = load current

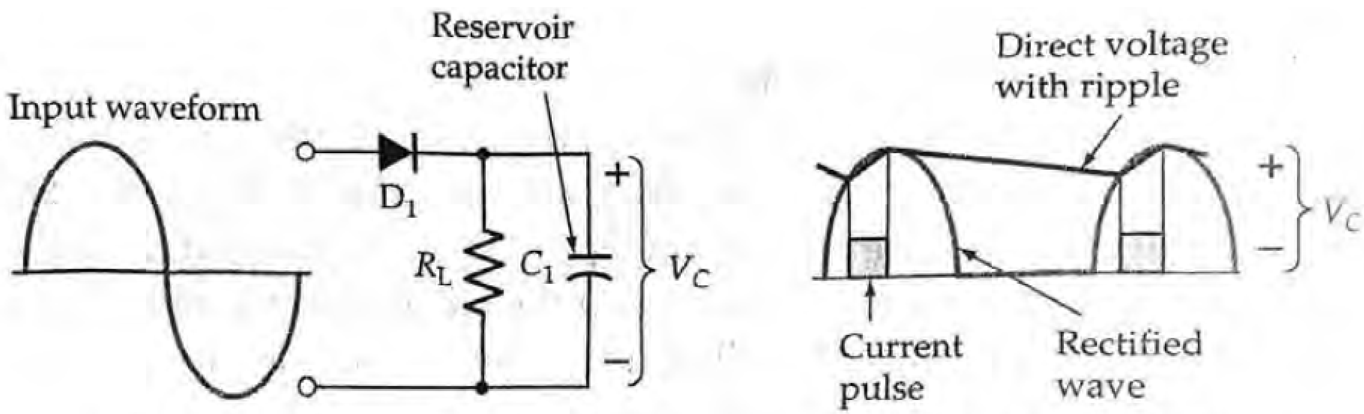


Half-Wave Rectifier Power Supply

Problem-7:

Determine the peak-to-peak ripple voltage for a half-wave rectifier and filter circuit which has a 680 μF reservoir capacitor, an average output of 28 V, and a 200 Ω load resistance. Frequency of the ac input waveform is assumed to be 60 Hz.

Load current, $I_L = E_{o(ave)}/R_L = 28/200 = 140$ mA
Time period of ac input waveform, $T = 1/f = 1/60 = 16.7$ ms
Capacitor discharge time, $t_1 \approx T = 16.7$ ms
Peak-to-peak ripple voltage, $V_r = I_L t_1/C_1 = (140\times10^{-3}\times16.7\times10^{-3})/680\times10^{-6} \approx 3.4$ V



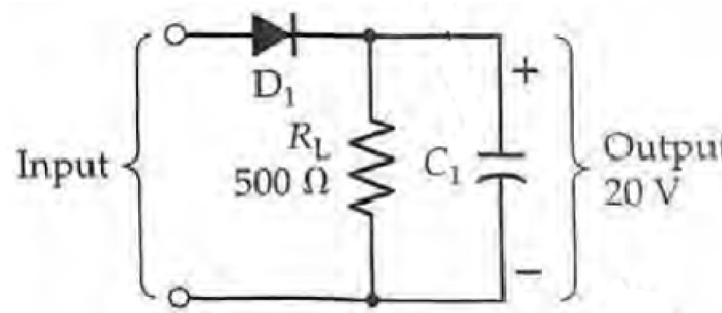
(a) Half-wave rectifier circuit with a reservoir capacitor

(b) Output waveform

Half-Wave Rectifier Power Supply

Problem-8:

A half-wave rectifier dc power supply is to provide 20 V to a 500 Ω load as shown in Fig. 8. The peak-to-peak ripple voltage is not to exceed 10% of the average output voltage, and the ac input frequency is 60 Hz. Calculate the required reservoir capacitance.



Time period of ac input waveform, $T = 1/f = 1/60 = 16.7$ ms

Capacitor discharge time, $t_1 \approx T = 16.7$ ms

Peak-to-peak ripple voltage, $V_r = 10\%$ of $E_{o(ave)}$

$= 20\times10/100 = 2$ V

Load current, $I_L = E_{o(ave)}/R_L = 20/500 = 40$ mA

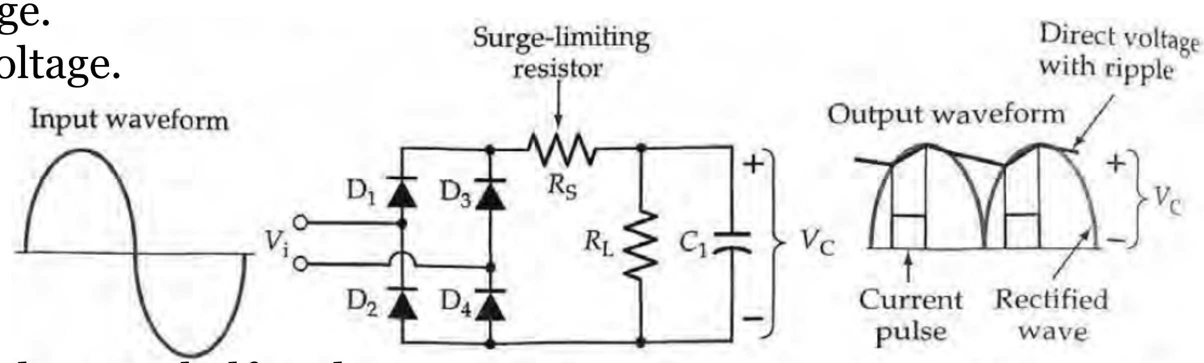
Reservoir capacitor value

$$C_1 = I_L t_1/V_r = (40\times10^{-3}\times16.7\times10^{-3})/2$$

$$= 334\ \mu\text{F (use 330 } \mu\text{F standard value)}$$

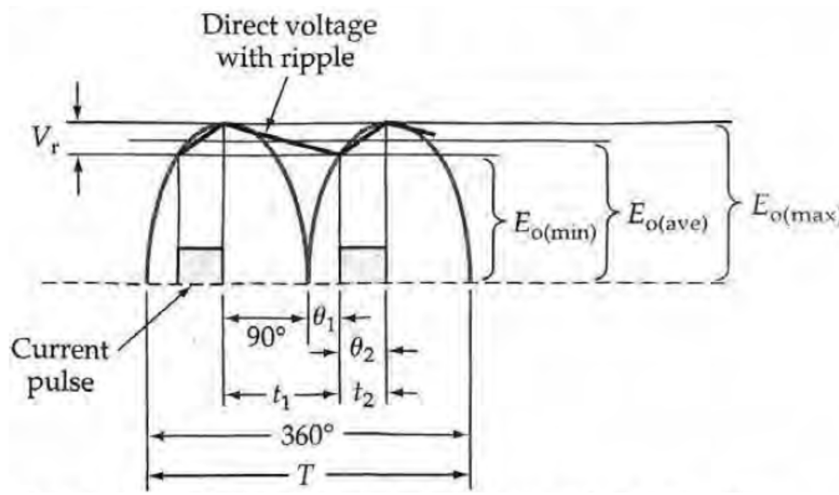
Full-Wave Rectifier Power Supply

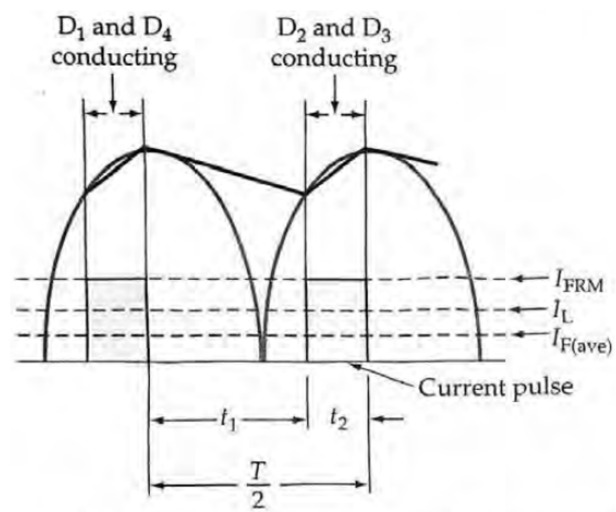
Convert output waveform to dc voltage.
Reservoir capacitor smooth output voltage.
Surge-limiting resistor protects diodes.



Reservoir capacitance, $C_1 = I_L t_1 / V_r$
Repetitive current, $I_{FRM} = I_L(t_1+t_2)/t_2$
Each pair of diodes conducts during alternate half-cycle.
Average forward current for each diode, $I_{F(ave)} = I_L/2$

Assumption → $t_1 >> t_2$
$t_1 = T/2 - t_2 \approx T/2$





Full-Wave Rectifier Power Supply

Problem-9:

The full-wave rectifier dc power supply in Fig. 9 is to supply 20 V to a 500 Ω load. The peak-to-peak ripple voltage is not to exceed 10% of the average output voltage, and the ac input frequency is 60 Hz. Calculate the required reservoir capacitor value.

Time period of ac input waveform, $T = 1/f = 1/60 = 16.7$ ms

Capacitor discharge time, $t_1 \approx T/2 = 16.7/2 = 8.35$ ms

Peak-to-peak ripple voltage, V_r = 10% of $E_{o(ave)}$

$= 20\times10/100 = 2$ V

Load current, $I_L = E_{o(ave)}/R_L = 20/500 = 40$ mA

Reservoir capacitor value

$C_1 = I_L t_1/V_r = (40\times10^{-3}\times8.35\times10^{-3})/2$

$= 167\ \mu$F (use 150 μF standard value)