FILTER CAPACITOR

POWER SUPPLY BUILDING BLOCKS

prepared by:

Gyro A. Madrona

Electronics Engineer

TOPIC OUTLINE

Filter Capacitor

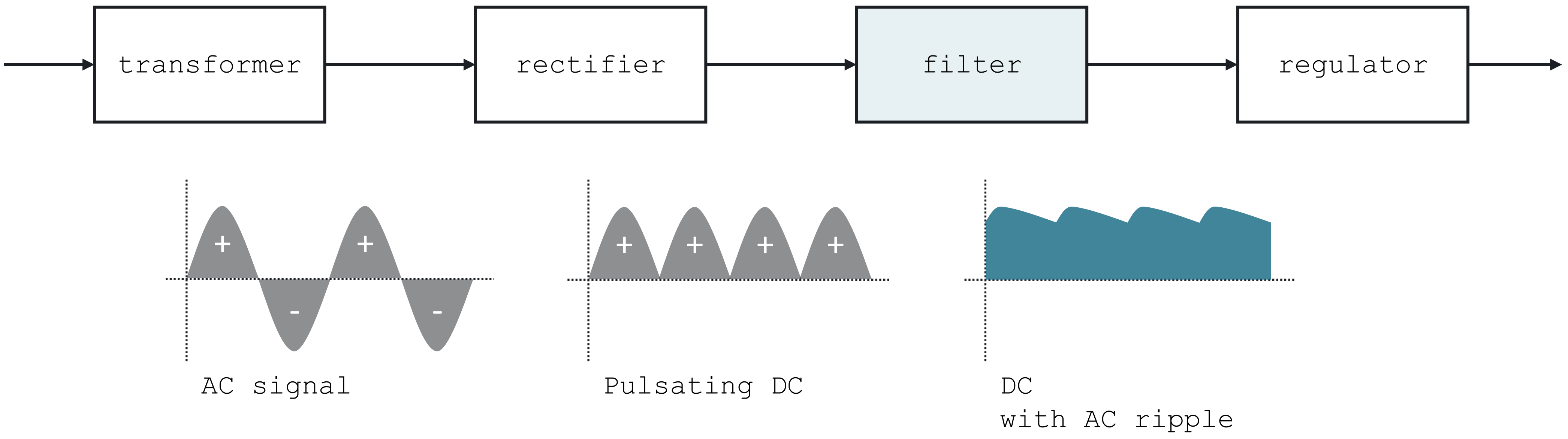
Smoothing Pulsating DC

FILTER CAPACITOR

FILTER CAPACITOR

A **filter capacitor** charges up when the voltage rises and discharges when the voltage drops, filling in the gaps of the pulsating DC waveform. This results in a **smoother DC** output.

Power Supply Block Diagram



SMOOTHING PULSATING DC

SMOOTHING HALF-WAVE

Discharging equation

$$v_c(t) = v_o e^{-\frac{t}{\tau}}$$

where: $\tau = RC$

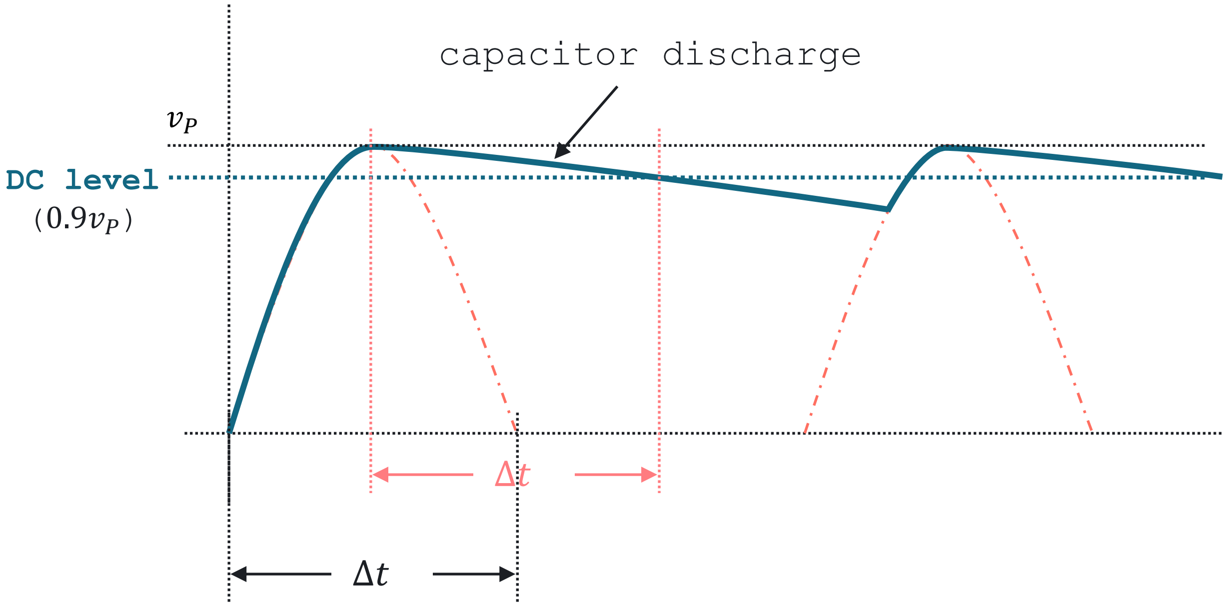
Let $\tau = 10\Delta t$

$$v_c(\Delta t) = v_o e^{-\frac{\Delta t}{10\Delta t}}$$

$$v_c(\Delta t) = 0.905 v_o$$

For half-wave, if the discharge time constant for the capacitor is 10 times the pulse duration, the average DC output level is approximately **90% of v_P**.

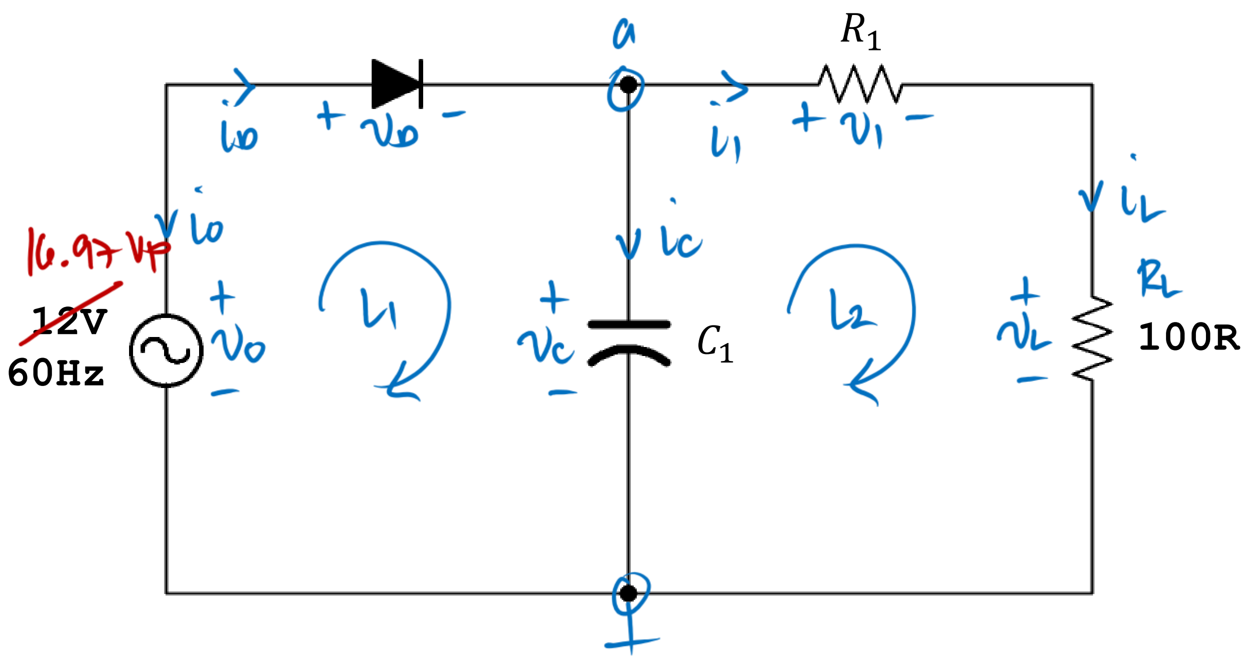
DC with AC Ripple



EXERCISE

The AC input to the given rectifier circuit is a $12V_{RMS}$, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.

v_L



Solution

Peak voltage @ a

$$V_{RMS} = \frac{V_p}{\sqrt{2}}$$

$$V_p = V_{RMS}\sqrt{2}$$

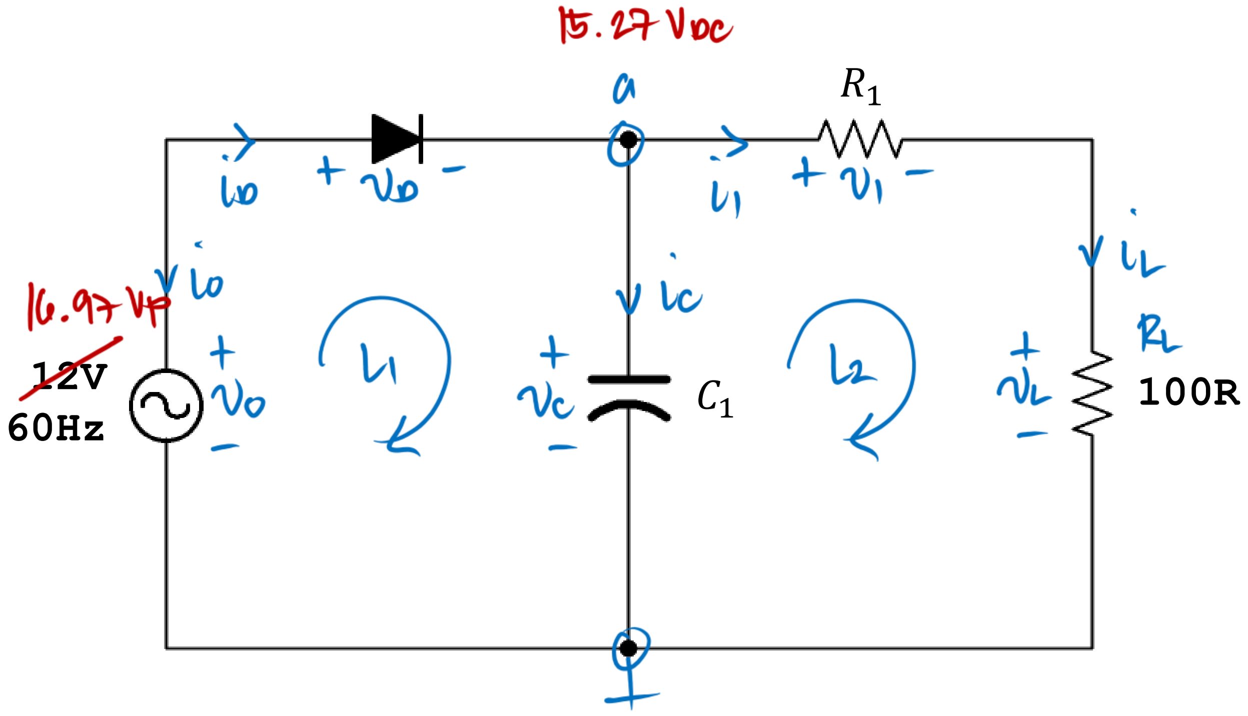
$$v_o = 12\sqrt{2}$$

$$v_o = 16.97\ V_p$$

EXERCISE

The AC input to the given rectifier circuit is a $12V_{RMS}$, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.

v_L



Solution

DC Level @ a

Let $\tau = 10\,\Delta t$, then

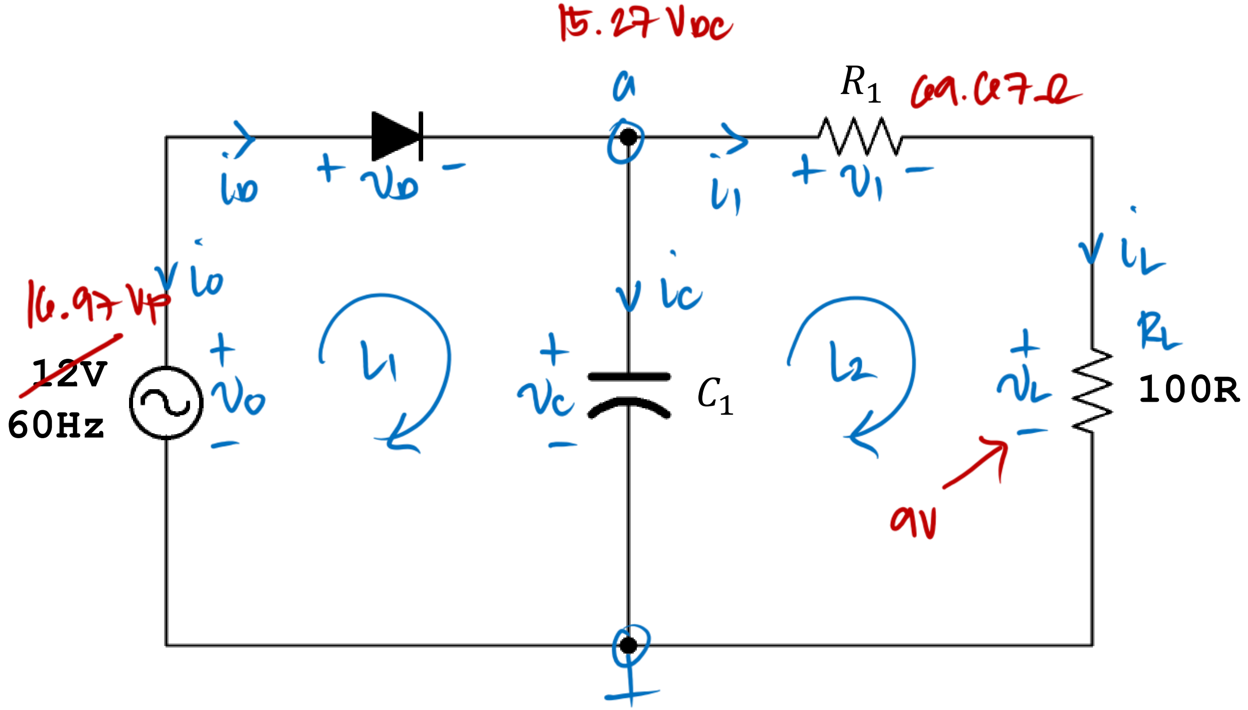
$v_{DC} = 0.9\, v_P$

$v_a(DC) = 0.9\,(16.97)$

$v_a(DC) = 15.27\ V$

EXERCISE

The AC input to the given rectifier circuit is a $12V_{RMS}$, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.



Solution

by VDT

$$v_L = v_a \frac{R_L}{R_1 + R_L}$$

$$R_1 + R_L = \frac{v_a R_L}{v_L}$$

$$R_1 = \frac{v_a R_L}{v_L} - R_L$$

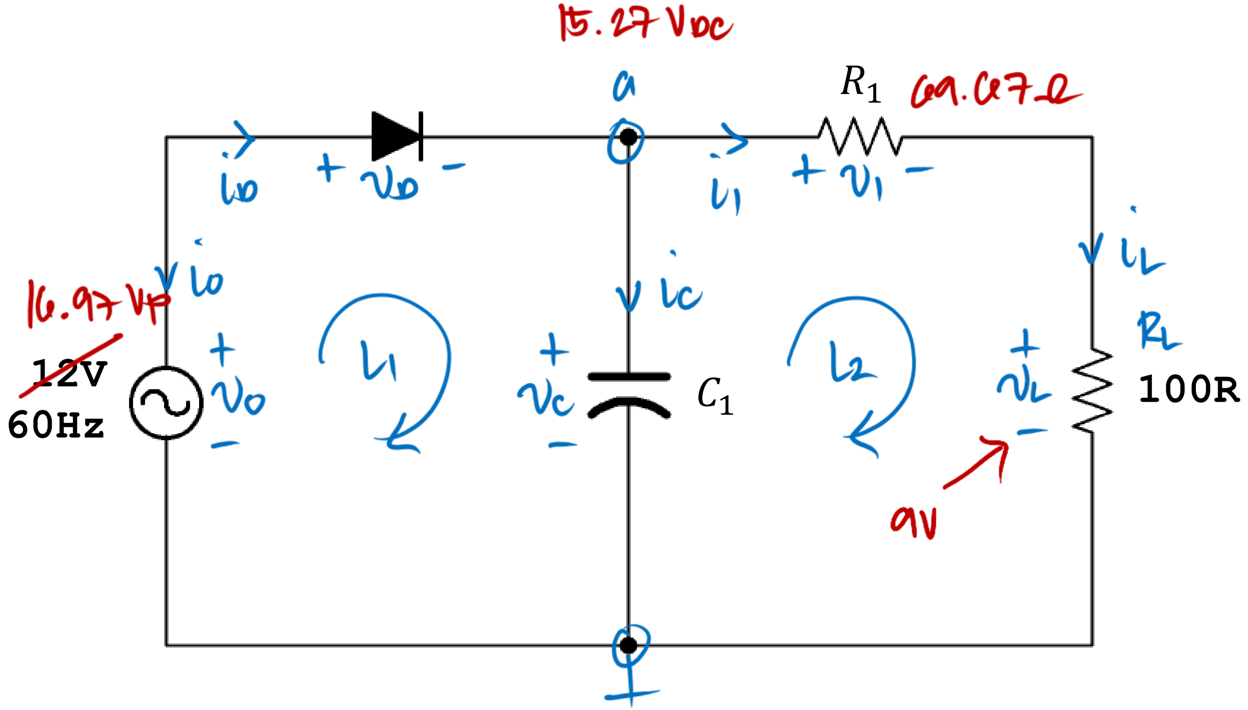
$$R_1 = \frac{15.27(100)}{9} - 100$$

$$\boxed{R_1 = 69.67\,\Omega}$$

ans

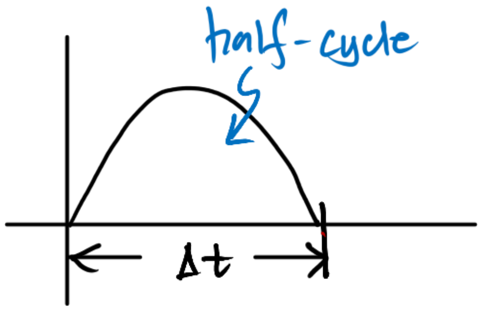
EXERCISE

The AC input to the given rectifier circuit is a 12V_{RMS}, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.



Solution

Pulse Duration



$$\Delta t = \frac{1}{2} \cdot \frac{1}{f}$$

$$\Delta t = \frac{1}{2(60)}$$

$$\Delta t = 8.33\ ms$$

for $\tau = 10\Delta t$

$$\tau = RC$$

$$C_1 = \frac{10\Delta t}{R_1 + R_L}$$

$$C_1 = \frac{10(8.33m)}{69.67 + 100}$$

$$\boxed{C_1 = 490.95\ \mu F}$$

ans

SMOOTHING FULL-WAVE

Discharging equation

$$v_c(t) = v_o e^{-\frac{t}{\tau}}$$

where: $\tau = RC$

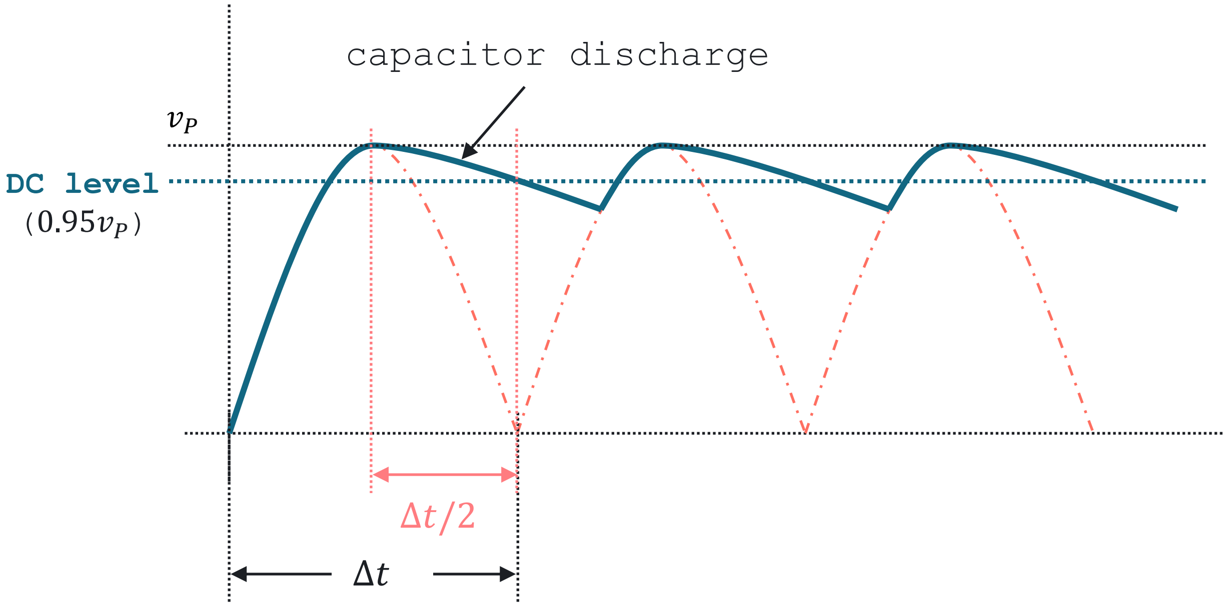
Let $\tau = 10\Delta t$

$$v_c(\Delta t/2) = v_o e^{-\frac{\Delta t/2}{10\Delta t}}$$

$$v_c(\Delta t/2) = 0.95 v_o$$

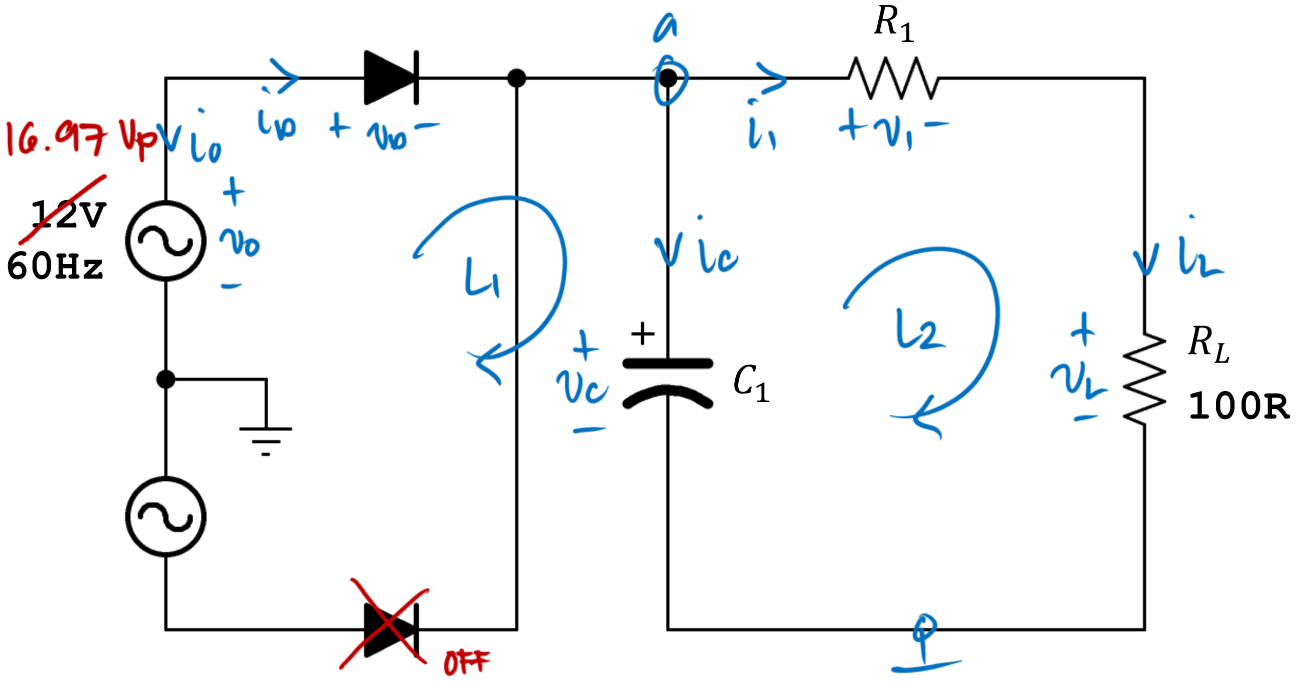
For full-wave, if the discharge time constant for the capacitor is 10 times the pulse duration, the average DC output level is approximately **95% of v_P**.

DC with AC Ripple



EXERCISE

The AC input to the given rectifier circuit is a 12V_{RMS}, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.



Solution

Peak voltage @ a

$$V_{RMS} = \frac{V_p}{\sqrt{2}}$$

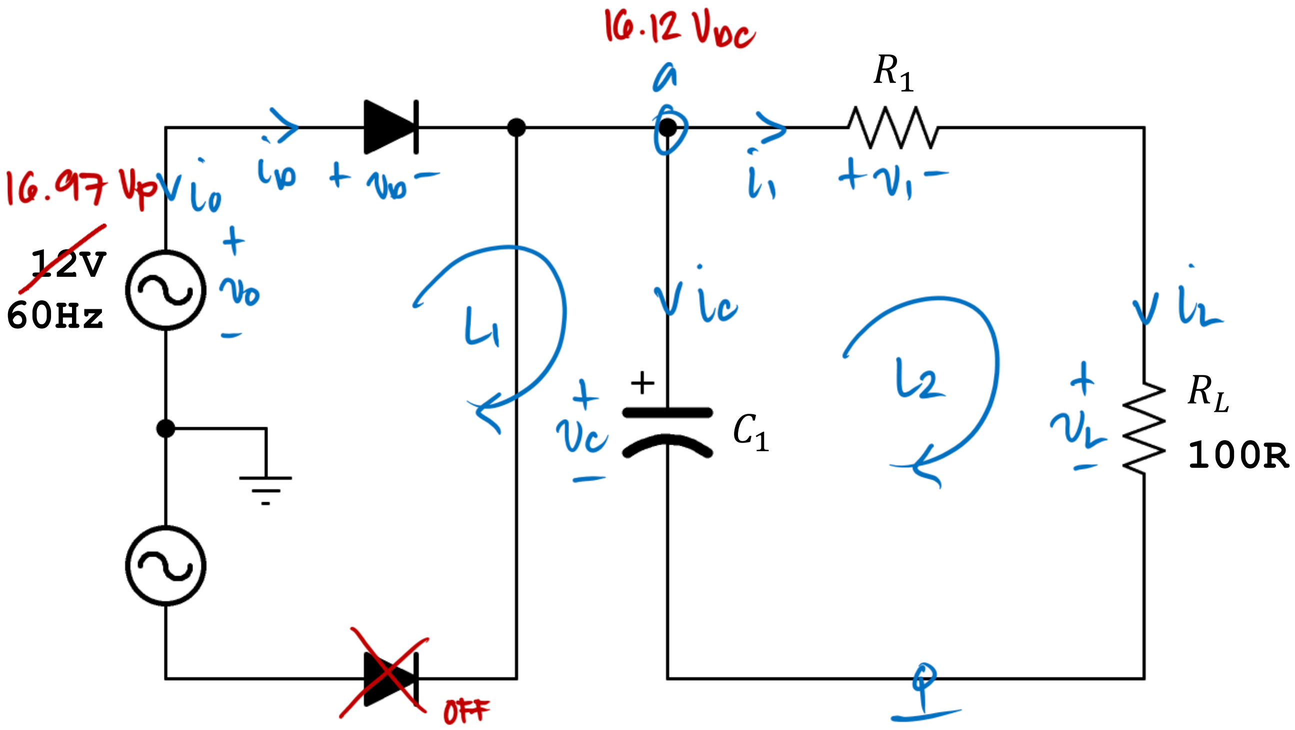
$$V_p = V_{RMS}\sqrt{2}$$

$$v_o = 12\sqrt{2}$$

$$v_o = 16.97\ V_p$$

EXERCISE

The AC input to the given rectifier circuit is a $12V_{RMS}$, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.



Solution

DC Level @ a

Let $\tau = 10\,\Delta t$, then

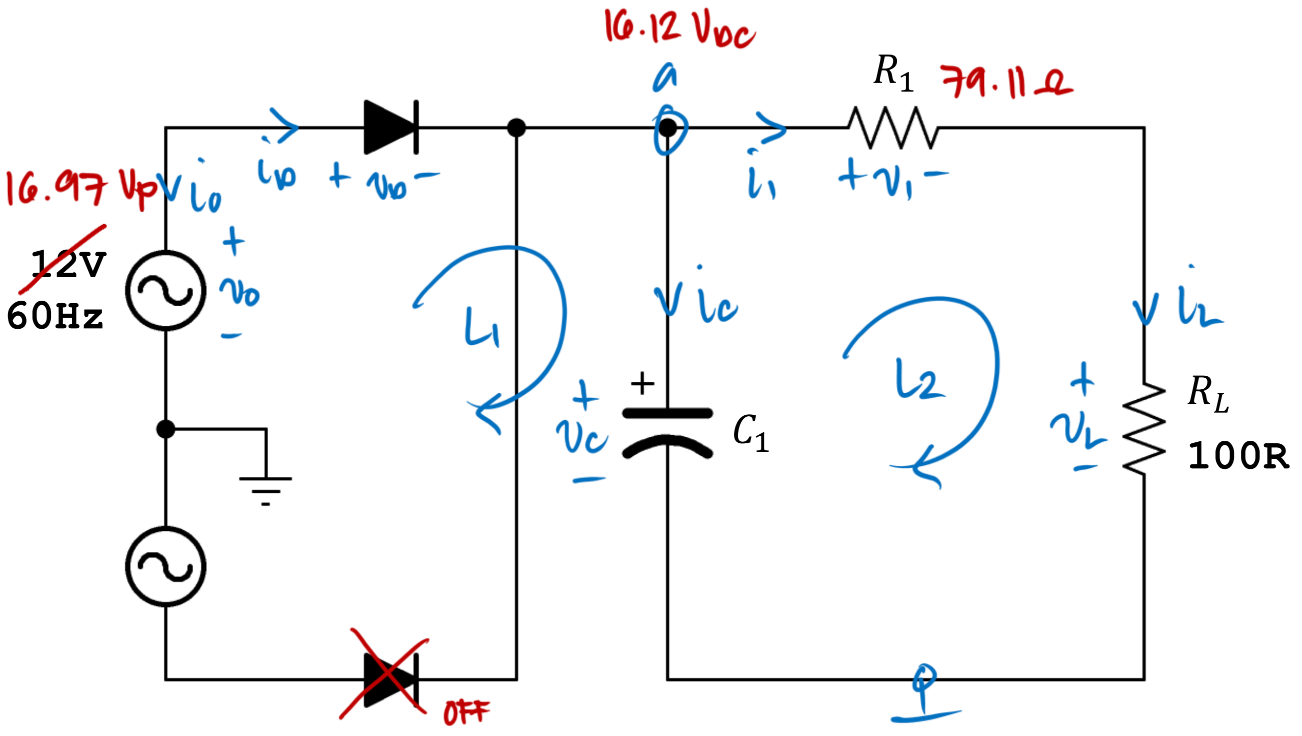
$V_{DC} = 0.95\, V_p$

$V_{a(DC)} = 0.95\,(16.97)$

$V_{a(DC)} = 16.12\ V$

EXERCISE

The AC input to the given rectifier circuit is a $12V_{RMS}$, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.



Solution

by VDT

$$v_L = v_a \frac{R_L}{R_1 + R_L}$$

$$R_1 + R_L = \frac{v_a R_L}{v_L}$$

$$R_1 = \frac{v_a R_L}{v_L} - R_L$$

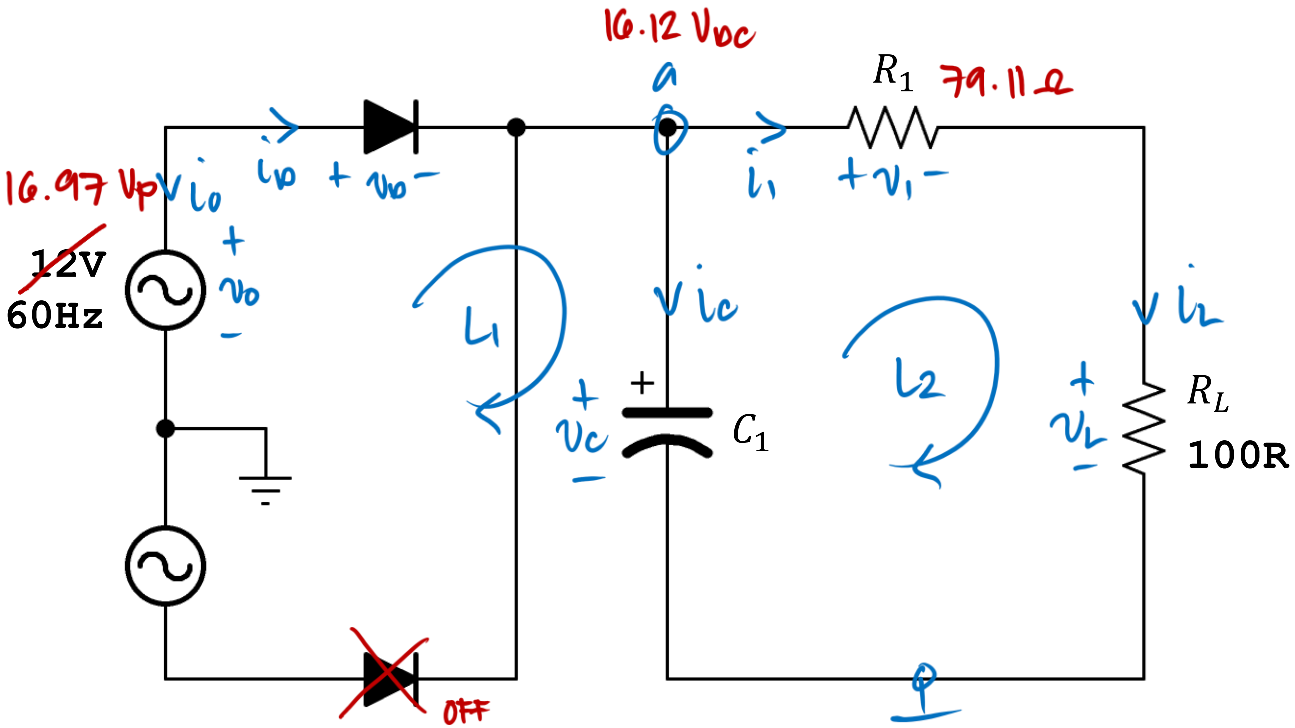
$$R_1 = \frac{16.12(100)}{9} - 100$$

$$\boxed{R_1 = 79.11\,\Omega}$$

ans

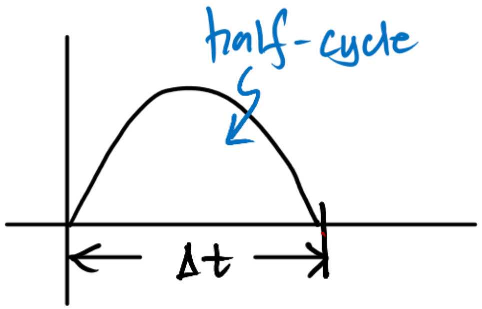
EXERCISE

The AC input to the given rectifier circuit is a $12V_{RMS}$, 60Hz sine wave. For this circuit, you need 9V DC across the 100Ω load resistor. Determine the value of R_1 and C_1.



Solution

Pulse Duration



$$\Delta t = \frac{1}{2} \cdot \frac{1}{f}$$

$$\Delta t = \frac{1}{2(60)}$$

$$\Delta t = 8.33\ \text{ms}$$

for $\tau = 10\Delta t$

$$\tau = RC$$

$$C_1 = \frac{10\Delta t}{R_1 + R_L}$$

$$C_1 = \frac{10(8.33m)}{79.11 + 100}$$

$$\boxed{C_1 = 465.08\ \mu F}$$

ans

LABORATORY