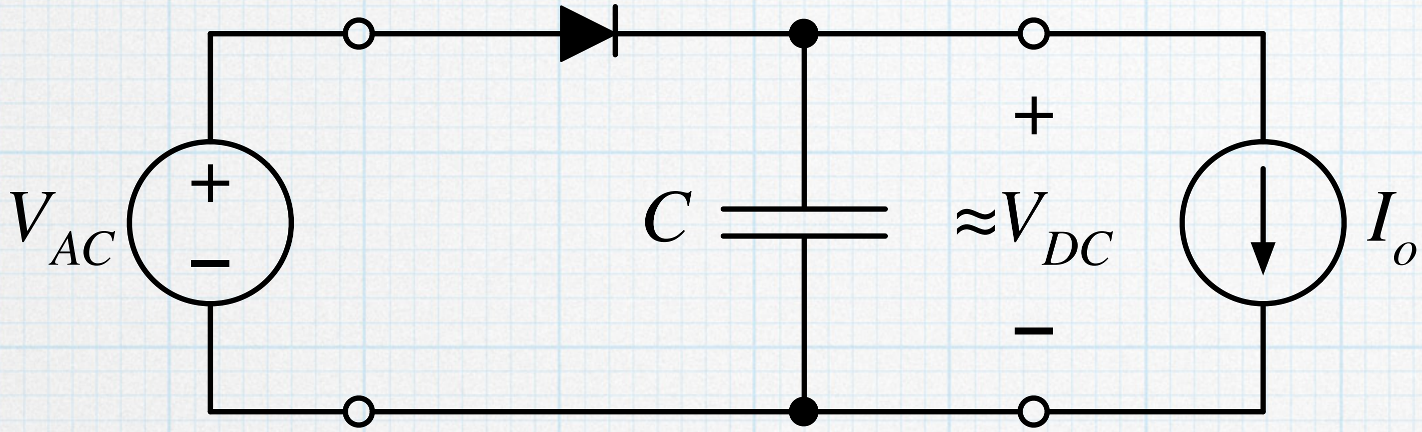
Rectifiers – another view

Recall that the job of a rectifier circuit is to convert a sinusoidal waveform into a (sort of) DC voltage.



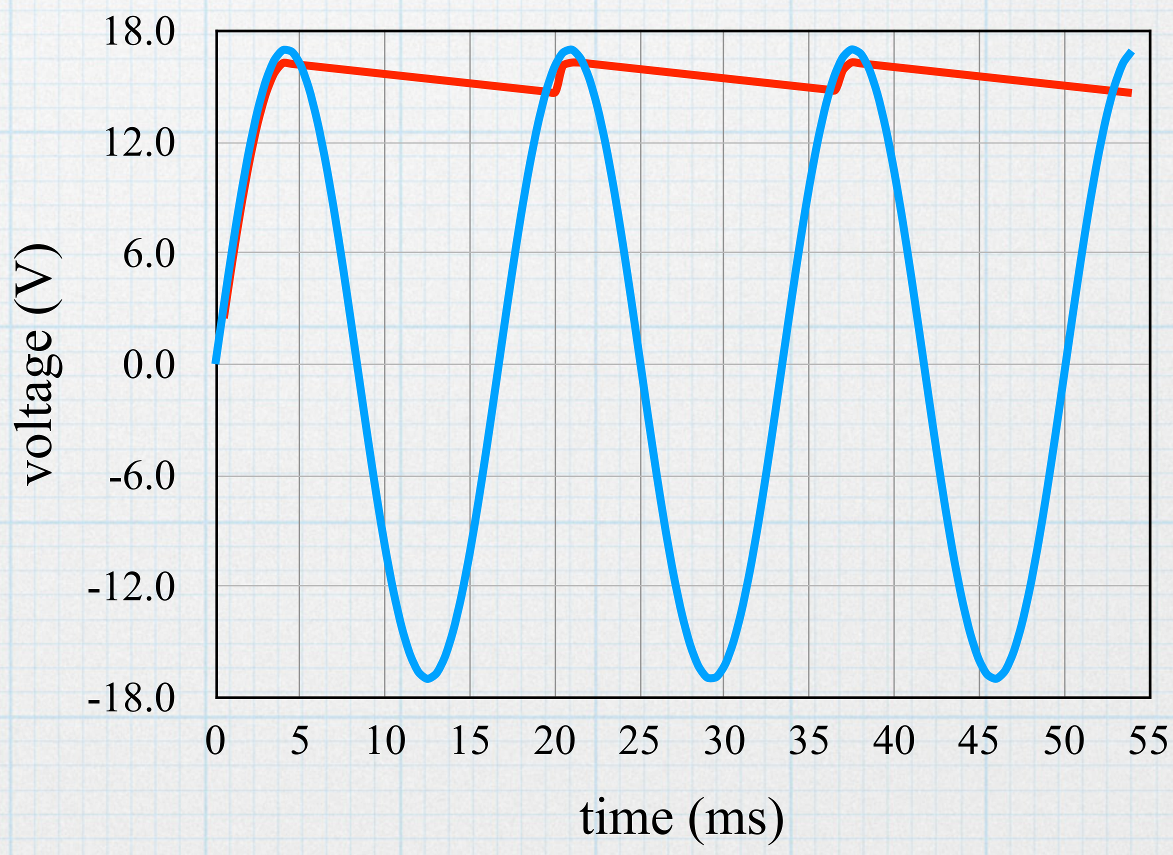
$C = 10{,}000\ \mu F$

Assume that the input is the sinusoid from a 10:1 step-down transformer: $V_P \approx 17$ V with $f = 60$ Hz ($T = 16.7$ ms). Let $I_o = 1$ A.

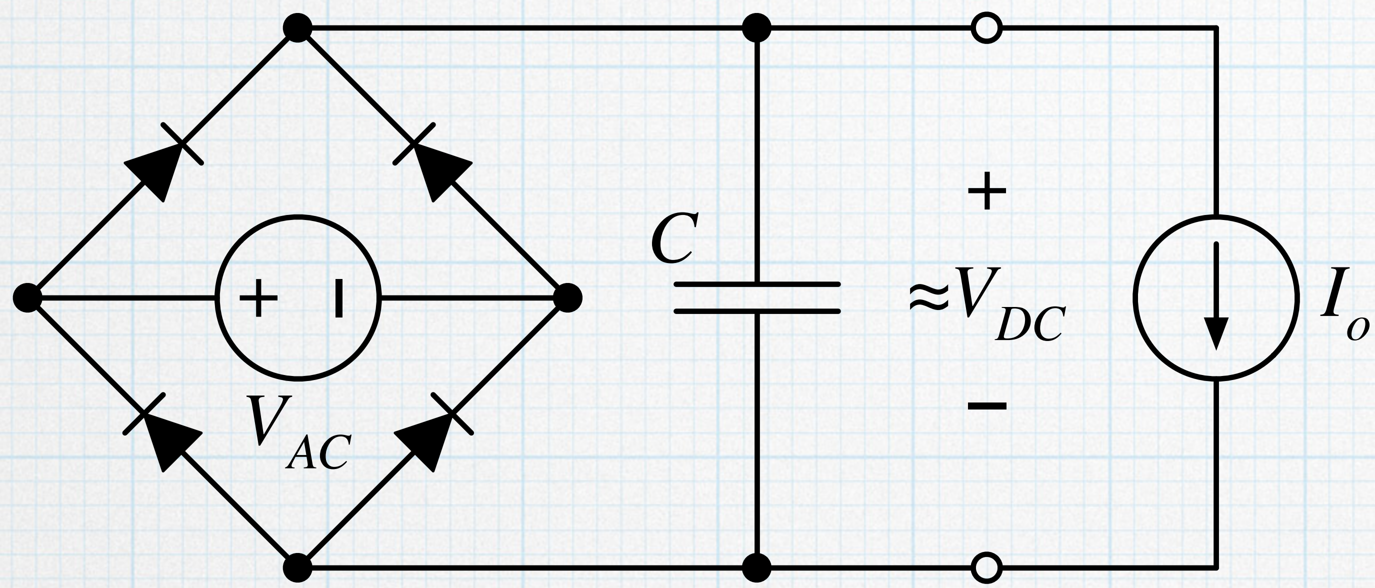
$$V_{AC}(t) = V_P \sin \omega t$$

$V_{DC} \approx 16$ V.

$$V_{ripple} \approx \frac{I_o T}{C} = 1.67\ \text{V}$$

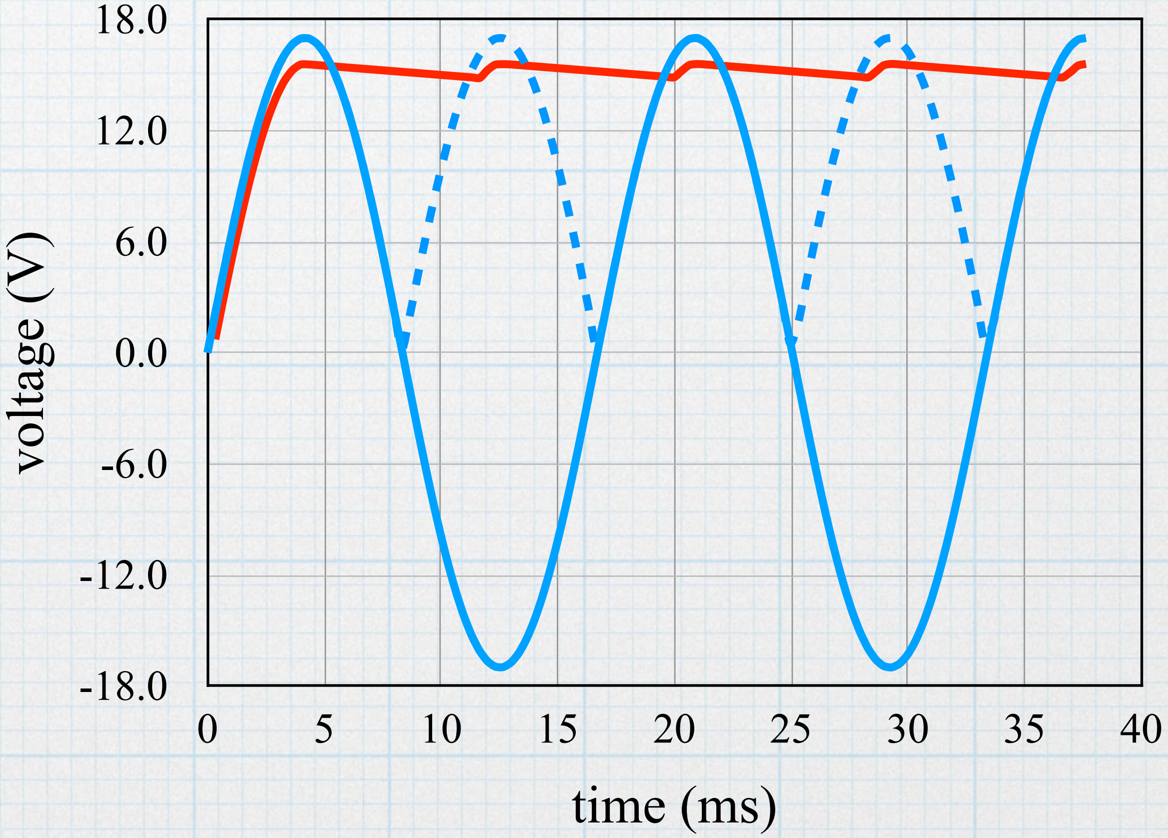


Of course, a full-wave rectifier is more common:



Same source and load current.

$C = 10{,}000\ \mu\mathrm{F}$

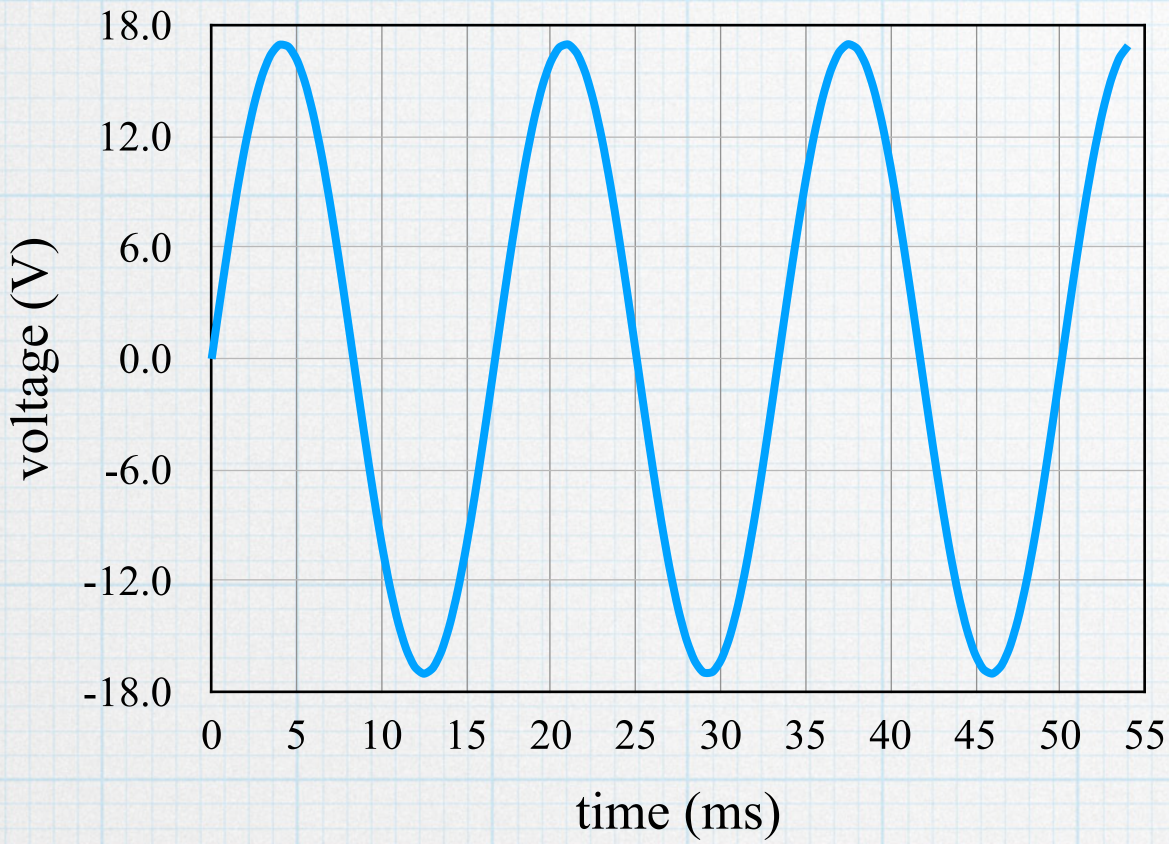


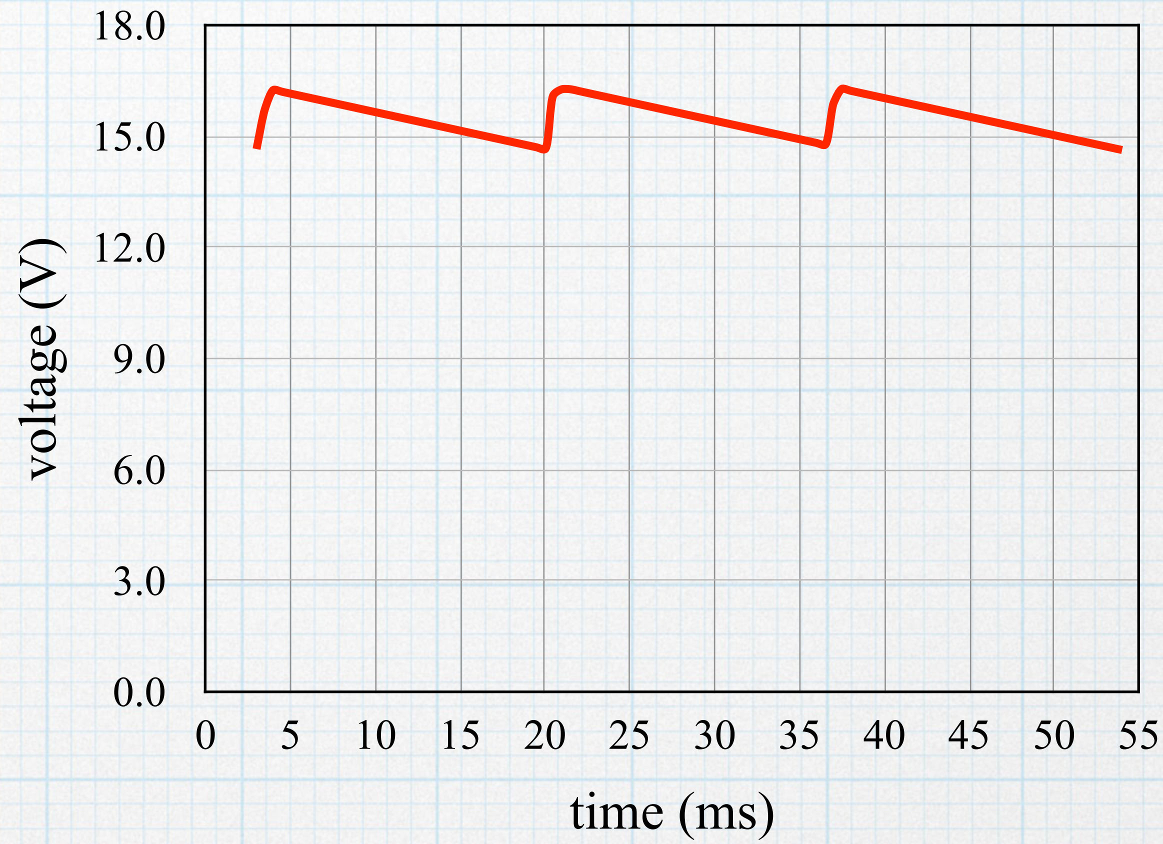
$V_{DC} \approx 15$ V.

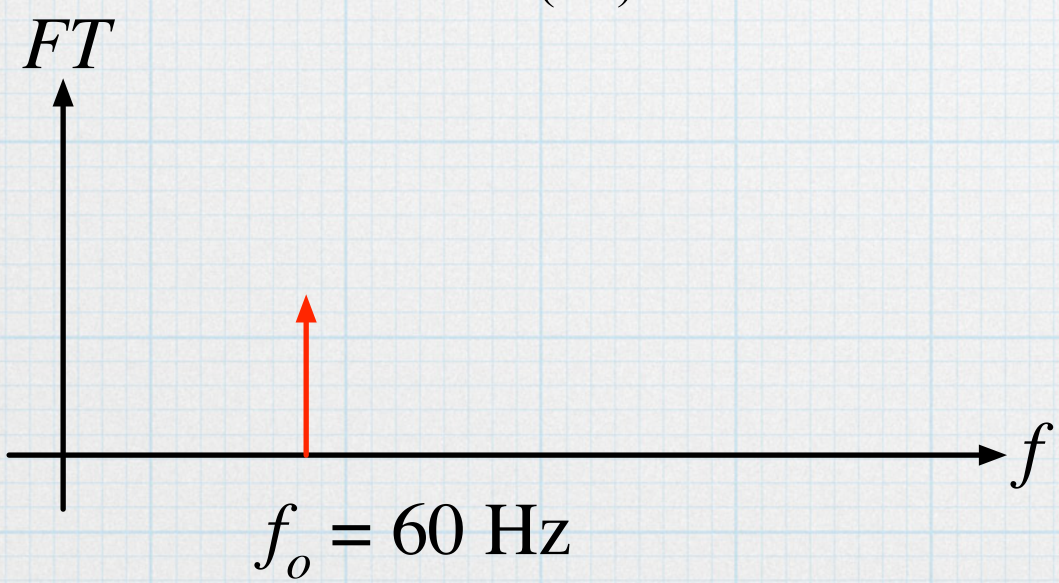
$$V_{ripple} \approx \frac{I_o T}{2C} = 0.84\ \mathrm{V}$$

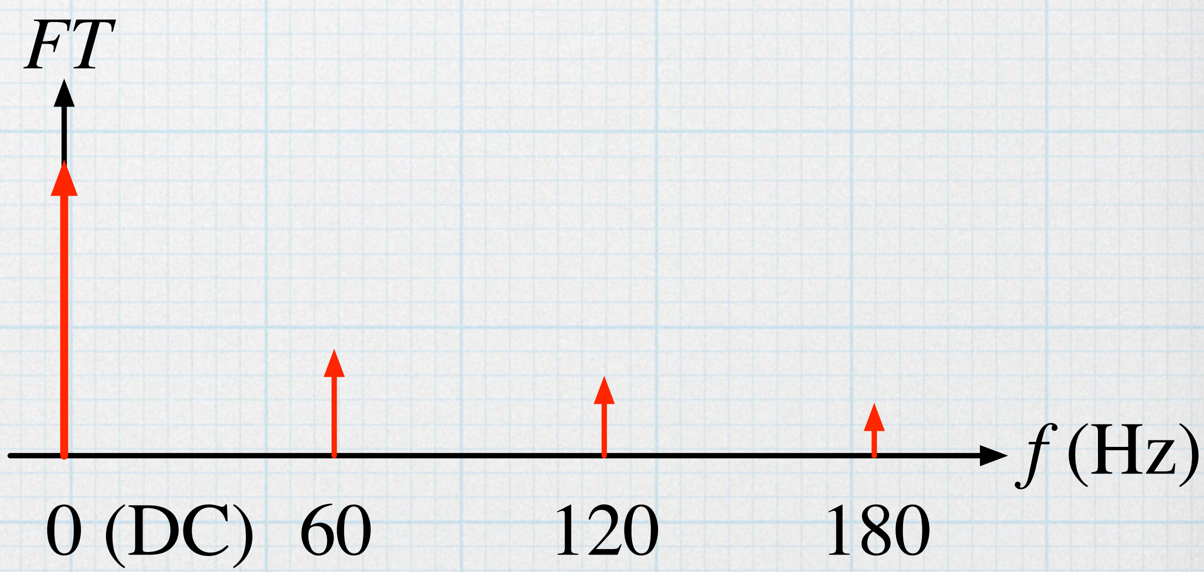
Question: Why is the full-wave version more commonly used?

Let’s view the situation as if we were in EE 224. Take the Fourier transform of the signals.





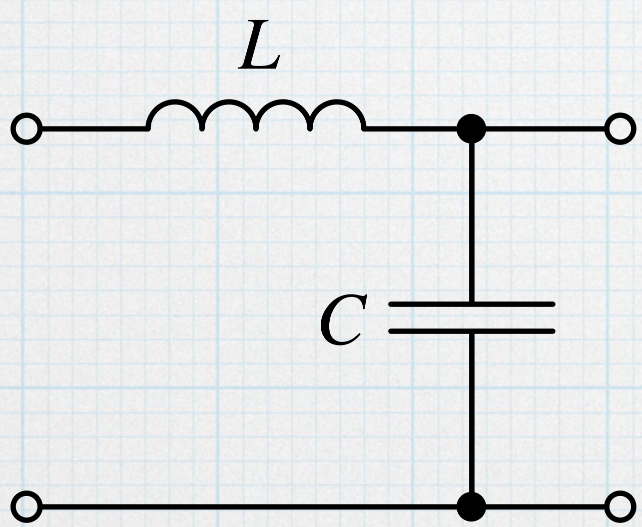




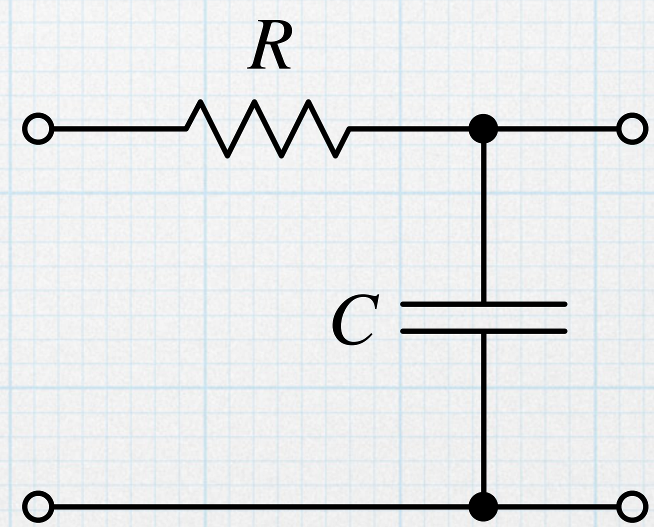
The rectifier has converted a pure sine wave into a DC with some harmonic components.

Ideally, we would like all of the harmonics to go away. The capacitor is working towards that end by serving as a low-pass filter. Increasing the value of the capacitor moves the pole of the filter to lower frequency and creates stronger attenuation of the higher frequency components.

If filtering is good, we could add more. Add a series inductor to make a second order filter — should reduce ripple even further.

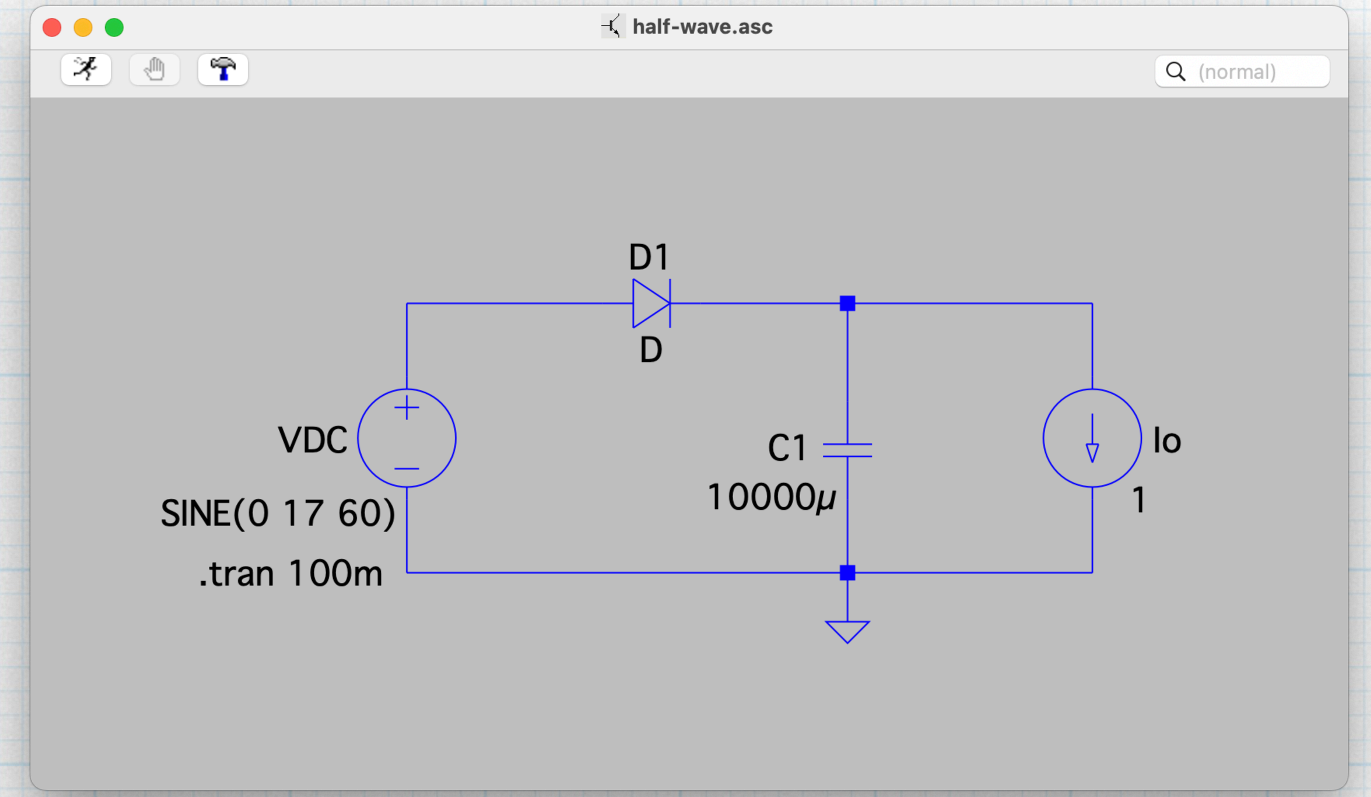


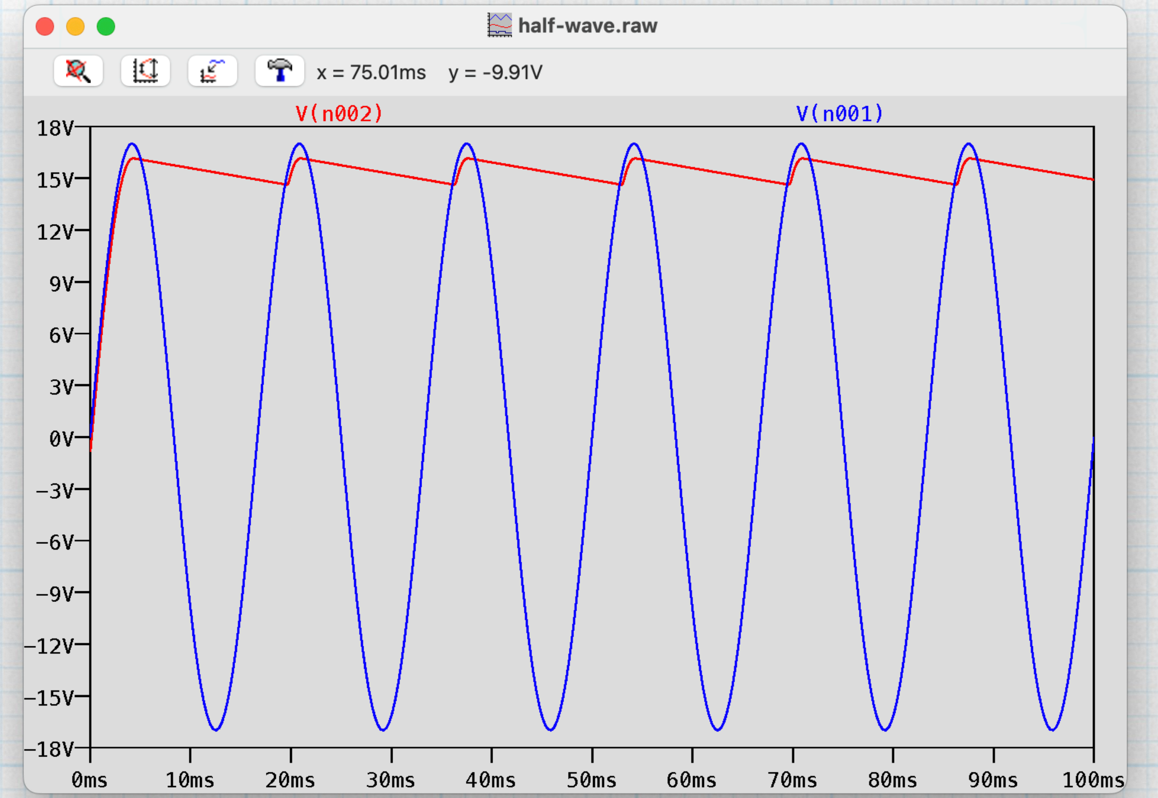
This filter would help.

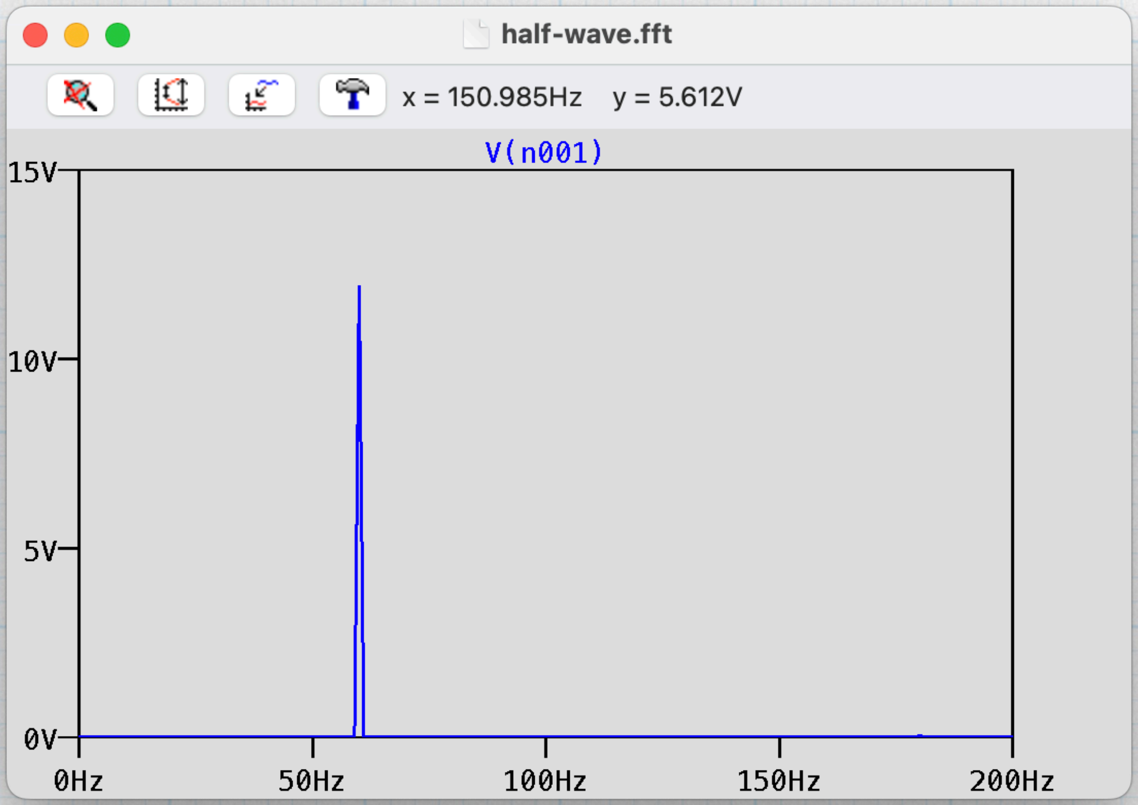


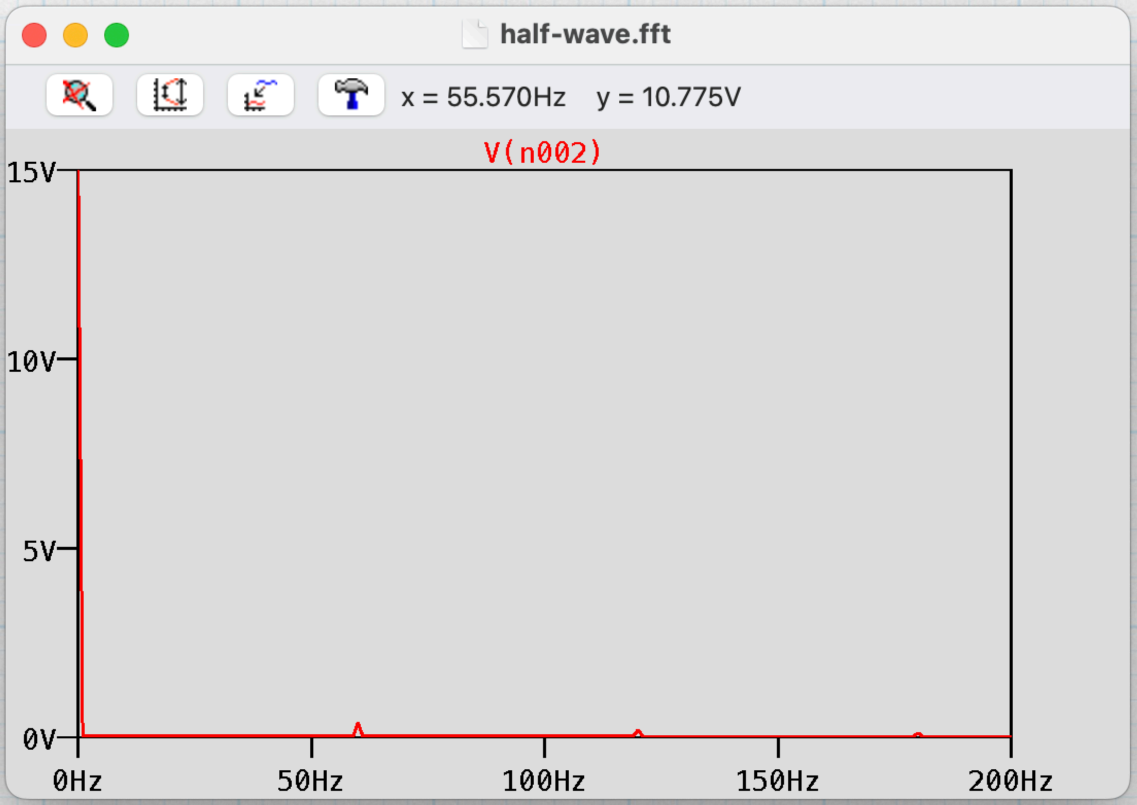
But this filter has a problem.

(What?)


half-wave.asc
D1
D
VDC
SINE(0 17 60)
.tran 100m
C1
10000μ
Io
1


half-wave.raw
x = 75.01ms y = -9.91V
V(n002)
V(n001)


half-wave.fft
x = 150.985Hz y = 5.612V
V(n001)


half-wave.fft
x = 55.570Hz y = 10.775V
V(n002)

This is all very interesting. It looks like we can reduce the ripple by adding more filtering at the output.

But we still have the fundamental problem that the DC output voltage is approximately equal to the peak voltage of the sine wave minus a couple of diode drops.

We need regulator circuits that will provide the exact voltage that we desire for the power system and have very low ripple.