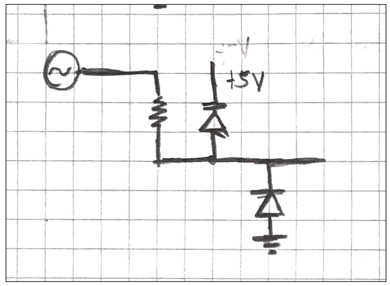
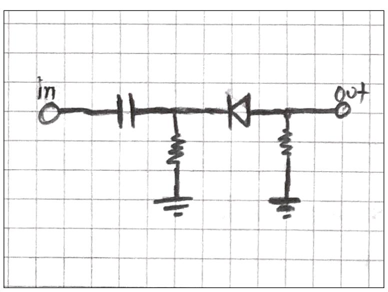
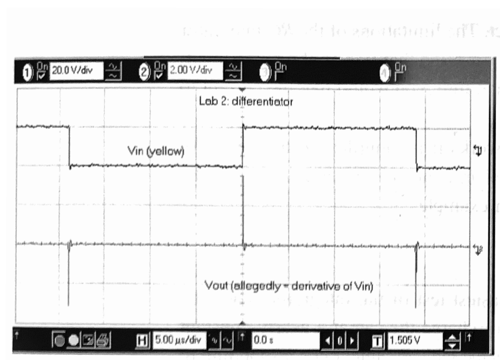
1 This waveform from That

A) I believe this a standard clamping circuit. (pg 119).



B) Tricky. I think this could de some form of a rectified differentiator. It's close to being a standard rectifier, however there are no high frequency peaks in response to the rising edge of the square wave input. Here's what I think





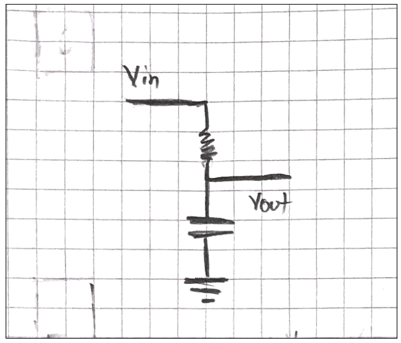
Standard differentiator output from a square wave.

Alternatively, maybe this could be a differentiator followed by a low-pass filter. The differentiator would pass that weird waveform that has high and low spikes (Figure 2N.10 pg 57), and then the low pass filter could chop off the

You need to make a change based on what is shown here.

"I wouldn't assume anything about what voltage is centered on from the diagrams in 1b or c — simply that the peak to peak amplitude of the output is less than 10V (1b) and much less than 10V (1c)."

C) This is a RC integrator circuit. Feed in a square wave and it outputs the “integral.”



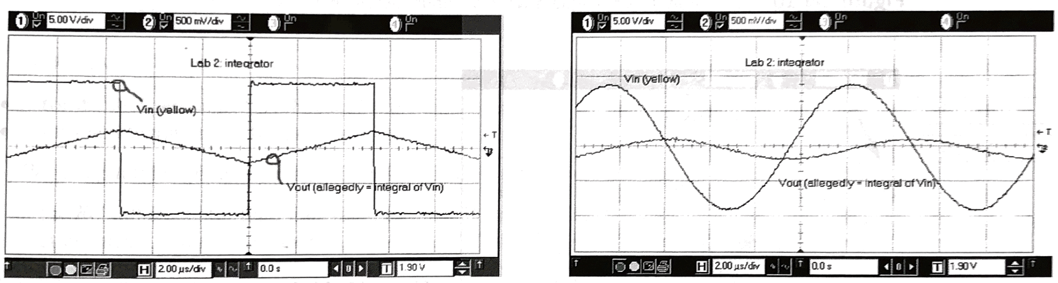
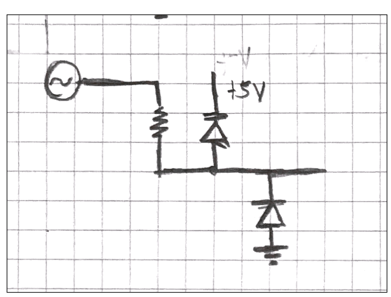


Figure 2N.13 Lab 2L's *RC* integrator responding to square wave and sinusoid (note scale change from IN to OUT: Ch1 is input).

C) I do not know what the difference is between A and this C. I see that there is an amplitude difference but I don’t know how to deal with that for the circuit. Ran out of time here. I’m copying my answer from A just to hedge my bets:



2 Zin for the next stage, given the circuit that is shown

Problem A

$$Z_{out} = R_{Thev}$$

$$R_{Thev} = R_{product}/R_{sum}$$

$$R_{Thev} = 5K$$

Z_{in} of Stage B needs to be 10x Z_{out} (R_{Thev}) of Stage A

Z_{in} of Stage B = 50K

Problem B

worst Z_{in} = cap looks like a short: Z_{in} = R (happens at highest freqs);

worst Z_{out}: cap doesn't help at all... R: Z_{out} = R (happens at lowest freqs);

So this is circuit is two RC filters connected together—a low pass then a high pass. According to these rules, worst case Z_{out} of the second filter, at a low frequency, is just its R.

$$Z_{out} = R$$

$$Z_{out} = 10K$$

Z_{in} of Stage B needs to be 10x Z_{out} of Stage A

Z_{in} of Stage B = 100K

Problem C

Little confused by this one but here's what I'm thinking. It says we can neglect the Xc (Z_{cap}) and so I will not use any of this equation: $Z_{cap} = 1/2\pi fc$. Instead I will literally neglect those.

I will consider this three stages:

Zout of A is the 5K R

Zin of B should therefore be 50K

Zout of B is indeed 50K:

$$Z_{out} = R_{Thev}$$

$$R_{Thev} = R_{product}/R_{sum}$$

$$R_{Thev} = 100K^2/200K = 50K$$

Z_{in} of Stage C needs to be 10x Z_{out} (R_{Thev}) of Stage B

Z_{in} of Stage C = 500K

I think this might be wrong, now that I read that the 100K "looks pointless, and is." So if the Cs and that R are negligible. Maybe the answer is:

$$Z_{out} = R_{Thev}$$

$$R_{Thev} = 5K \mid\mid 100K$$

$$R_{Thev} = R_{product}/R_{sum}$$

$$R_{Thev} = 100K*5K/105K = 4.8K$$

$$R_{Thev} = 4.8K$$

Z_{in} of Stage B needs to be 10x Z_{out} (R_{Thev}) of Stage A

Z_{in} of Stage B = 48K

I think this is the right answer.

3 Ripple

Given specs:
V_{diode_drop} = 1.2V;
V_{ripple} = 1V;
V_{in} = 6V
I_{out} = 20mA

Choose:
R_{load}
C

To Start

First I will choose an R_{load} that draws 20mA from the power supply. In order to find out R_{load} through Ohm's Law, I need to know the V_{out} of the rectifier circuit. When looking at the zigzag output wave, V_{out} is the lowest crest on that wave, as a worst case scenario. Here are the calculations for understanding V_{out}:

Determine Vout

$V_{out} = V_{in} - V_{diode\_drop} - V_{ripple}$
V_{out} = 6V - 1.2V - 1V
V_{out} = 3.8V (I am just going to call this 4V; the book rounds the V_{diode_drop} to 1 on pg 124)[1]
V_{out} = 4V

Determine R_{load}

Now I can solve for R_{load}:
R = V/I
$R_{load} = V_{out}/I_{out}$
R_{load} = 4/.02
R_{load} = 200 Ohms

Determine C

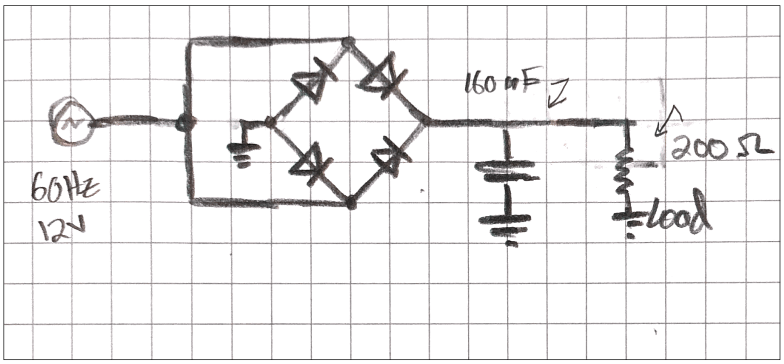
dV = V_{ripple} = 1V (again please see my note on rounding according to the book);
dT = 8ms aka 1/(2*60Hz) (this is US AC; for lab I simulated this with a function generator)

---

[1] I am having second thoughts about having rounded this. I am about to hand in the PSet and don't quite have time to go back. Permission to round this depends on which direction your approaching the problem from. Please note that I would have preferred to go back and just kept this at 3.8V but ran out of time here.

$$I = C(dV/dT)$$
$$C = I \times (dT/dV)$$
$$C = .02 \times (.008/1)$$
$$C = 160\mu F$$

Draw your design:



3.2 b) Troubleshoot

I am trying to solve for this away from my lab bench, which would be helpful right now. I completed this lab and thought it was excellent. I may not have the right answer to this but I will give it a shot. I have created a table of values and equations that provide me with a simulation of the lab circuit in order to see how V_{ripple} responds to turning other knobs in the circuit. The catch here though is that the question is saying I definitely have the component values right, so I can't change those.

Ok so my troubleshooting guess would be that maybe one of my diodes is blown or in the wrong orientation. According to my table with my equation built-in, I see that if I remove half of the diode drop (one diode's-worth of drop), then the ripple amplitude increases. See the highlighted squares.

There are problems with this however. The V_{ripple} does not increase by a factor of two. I also sense that a blown diode might not just increase V_{ripple} but may actually alter the shape of the desired output wave, an outcome that would not suffice in an answer to this question.

	V_{out}	V_{ripple}	V_{diode_drop}	$V_{out(peak)}$	V_{rms}	C	F_{in}	dt	R_{load}	I_{out}
Equation	$V_{out(peak)}-V_{diode\_drop}$	IT/C	constant	$V_{out} + V_{ripple}$ or $V_{transformer} - V_{diode\_drop}$	$V_{out(peak)}/\sqrt{2}$	known	known	1/(2*f) for US	given R	Vout/Rloud
Calculated	4.8	1.2	1.2	6	4.2	1.5E-05	60	0.008	2200	0.002
Calculated blown diode	5.4	1.4	0.6	6	4.2	1.5E-05	60	0.008	2200	0.002
Measured from Lab	5	2	1.2	6	4.2	1.5E-05	60	0.008	2200	0.002
Status	unknown	unknown	constant	known	known	known		known	known	known

Actually it looks one another thing to check would be the AC frequency input. Are you using the right one? Halving the frequency doubles the ripple amplitude. So you could have made a mistake converting F_{in} to dt. Maybe you forgot to 2x the f_{in} for that denominator value. Or you could have just spec'ed the AC power wrong somehow, more generally.

	V_{out}	V_{ripple}	V_{diode_drop}	$V_{out(peak)}$	V_{rms}	C	F_{in}	dt	R_{load}	I_{out}
Equation	$V_{out(peak)}-V_{diode\_drop}$	IT/C	constant	$V_{out} + V_{ripple}$ or $V_{transformer} - V_{diode\_drop}$	$V_{out(peak)}/\sqrt{2}$	known	known	1/(2*f) for US	given R	Vout/Rloud
Calculated	4.8	1.2	1.2	6	4.2	1.5E-05	60	0.008	2200	0.002
Calculated wrong dt	5.4	2.7	0.6	6	4.2	1.5E-05	60	0.017	2200	0.002
Measured from Lab	5	2	1.2	6	4.2	1.5E-05	60	0.008	2200	0.002
Status	unknown	unknown	constant	known	known	known		known	known	known

3.3 c) A little ripple is a good thing

Some ripple is good because there is an important relationship between $I_{Transformer}$ and the ripple. The larger the capacitor, the less the ripple, but the higher the surges of current going from the transformer into the cap. As the book states, "These [surges] heat the transformer more than a continuous flow of smaller current." (pg 143). So a little ripple relaxes transformer heating.

4 Current source (passive)

Question: What resistance is required in order to maintain no greater than 1% deviation (.1mA) from a 10mA current—the ideal constant current—if a foot voltage is changing up to +/-10V, starting from 10V?

The first question to answer is: With what resistance does a 10V swing incur a 10mA change in current?

The answer is 100K, just using Ohm's Law:

$$R = V/I$$
$$R = 10/.0001$$
$$R_{resistor} = 100K$$

Next, now that we have determined the required R for a relative 10V swing, we should determine the actual total voltage:

$$V = RI$$
$$V = 100000 \times 0.01$$
$$V_{total} = 1000V$$

So according to the previous calculation, we know V_{total} can actually be 1000V +/- 10V. This solves for the Vsink then.

$$V_{total} = 1000V \text{ or } 1010V \text{ or } 990V$$
$$V_{total} = V_{swing} + V_{sink}$$

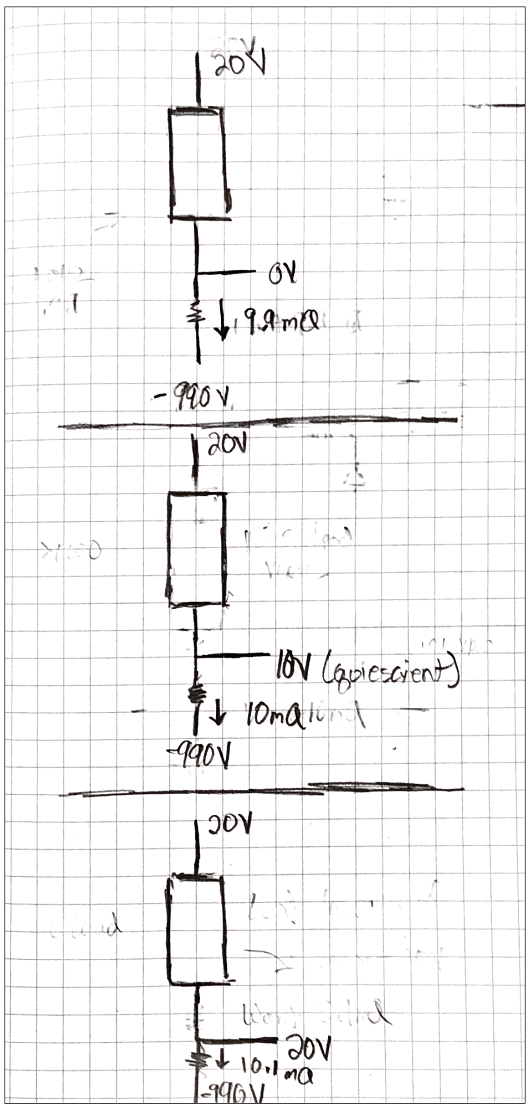
With what V_{sink} value is this equation true for all three V_{swing} values? It's -990V:

V_{total}	V_{swing}	V_{sink}
1010	20	990
1000	10	990
990	0	990

Back to the original question. Does the circuit hold the loads current constant at 10mA with less than +/- 1% deviation, under these various V_{foot} circumstances? Yes it does:

V_{foot}	V_{supply}	V_{sink}	V_{total}	$R_{resistor}$	I_{load}
given	given	solved	$V_{foot} + V_{sink}$	Solved above.	$V_{total}/R_{resistor}$
0	20	990	990	100000	9.90E-03
10	20	990	1000	100000	1.00E-02
20	20	990	1010	100000	1.01E-02

Here is a drawing:



5 Radio Design

Ran out of time!

From the text in the lab it tells you what to do: make the resonant frequency a megahertz for the AM radio station. Rectify it using the shotkey diode, then the leaky peak detector.

6 Fix Amplitude and DC Level

Ran out of time.

6.1 What’s the strategy here?

You can build an LC parallel resonant circuit like in the Lab 3L1.1, which I did successfully. You could put a square wave into at the resonant frequency and get a sine wave response, which is a “Fourier” component—that’s the Frenchman. You can also get sine waves of lower amplitude at various other fractions of the resonant frequency as outlined in Figure 3L.3. Here’s a video from my Lab. Maybe you also add a filter to the LC.