1 Rumble Filter (1 point)

AE 1-3\textsuperscript{1}, slightly altered. Design a “rumble filter” for audio signals (3dB down at 10Hz). (Note that “rumble” is low-frequency noise.) Assume a load of 10k.

\textsuperscript{1}“AE” refers to the “Additional Exercises” at the end of a chapter. AE1 appears at the end of the Text’s Chapter 1.
2  **RC step response (2 points)**

Draw the *time-domain* picture (what you’d see on a scope screen) soon after a 0 to 10V step at the input of the circuit below. Indicate voltage out and show the value of the output’s “time constant.”

![RC Circuit Diagram](image)

**Figure 1: RC step response**

3  **Current source feeding cap (1 point)**

Do Text exercise 1.15: constant current drives capacitor. Draw the waveform you would see on a scope as you watched the capacitor driven by such a current source. Include units.

![Current Source Feeding Cap](image)

**Constant current feeding cap: voltage versus time (your plot)**
4 Line Noise Filter (3 points)

You are faced with an input that includes signal with the period range shown, but mixed with 60Hz “line” noise:

![Figure 2: Signal and line noise, mixed](image)

4.1 Design (2 points)

Design a circuit to remove the line noise, while trying not to alter the “signal” waveform much. You should explain briefly the rationale for your component choices. Assume $R_{LOAD} = 100k$.

4.2 Attenuations (1 point) (This is a little harder)

State approximate attenuations (say, to ±10%) of noise and signal frequencies, given your filter design. Recall the general RC filter slope of “±6dB/octave,” and note a few other numbers, perhaps useful: attenuation at 2X$f_{3dB}$ (hi-pass) or 0.5X$f_{3dB}$ (low-pass): attenuation ≈ 10%; at 10X$f_{3dB}$ (hi-pass) or 0.1X$f_{3dB}$ (low-pass): attenuation ≈ 1%. State these attenuations as fractions and also in dB.
5 Scratch Filter (2 points, total)

a. A Scratch Filter

Here’s a text problem (AE1-4), slightly altered: Design a “scratch filter”\(^2\) for audio signals (3dB down at 10kHz). Assume a source impedance of 100Ω, and make sure your filter doesn’t load the source excessively (but make the filter impedances no larger than necessary).

b. Defective Scratch Filter

If you designed the filter in (a), above, assuming a source impedance of 100Ω and then moved the filter to a source whose \(R_{OUT}\) (or \(R_{Thevenin}\)) was 1kΩ, would the filter still work properly? (We know what answer we hope for—but your answer is going to depend on what you designed for the preceding part, and we’ll accept an answer that’s consistent with that design.) Please give a quantitative answer; if Yes, then why?; if No, then what now differs?

\(^2\)Historical note for the very young: What does “scratch” mean? Once upon a time, people used to listen to vinyl records, and these often got scratched. The scratch introduced nasty high-frequency noise into the music. There’s still nasty noise in what the youth of America listens to on CD’s, but it’s put there on purpose, as you know: it’s called pop music. Oh—sorry; I’m getting old.
6 Decibels (2 points)

This way of talking about amplitudes may seem awkward, but it’s very widely used (even your function generator’s front panel labels its “attenuator” switch [-]”20dB” instead of “0.1”), and it’s useful for describing quantities that vary over a very large range. By definition, as you know, when speaking of amplitudes, 
\[ dB = 20 \log_{10}(A_2/A_1) \]
(Note that dB always describes a ratio, and that the definition just stated does not apply to power, another use of dB that you may have seen).

Tell us, and yourself, what amplitude ratios the following dB correspond to (this is one of the rare moments in this course when you will need a calculator):

**dB Amplitude Ratio \((A_2/A_1)\)**

\[
6 = 20 \log \text{ratio} \\
\log \text{ratio} = 6/20 = 3/10 \\
\text{ratio} = 10^{3/10} = 2
\]

-6

3

-3

-20

60

100
7 Rise & Fall (*2 points*)

Please draw a curve that rises at 6dB/octave, and another that falls at -6dB/octave. An “octave” is a doubling of frequency. Note that we have defined a starting amplitude and frequency for you, in each case.

![Figure 3: rise at 6dB/octave, fall at -6dB/octave](image)

Incidentally, this behavior is sometimes described as ”20dB/decade.” Make sense? (Explain in a very few words.)
8 Split power supply (5 points)

Show a design for a “split” power supply, to put out both positive and negative voltages, simultaneously, from a single transformer.

Here are the specifications:

<table>
<thead>
<tr>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{in}$: 60Hz, 115V AC (rms)</td>
</tr>
<tr>
<td>$V_{out}$ +17V and -17V (minimum amplitudes)*</td>
</tr>
<tr>
<td>ripple about 2V</td>
</tr>
<tr>
<td>load current 1A</td>
</tr>
</tbody>
</table>

*You may be inclined to protest that these are crazy and arbitrary numbers. In fact, they’re not: a typical voltage regulator IC, a device that stabilizes its output at a given voltage, needs a couple of volts difference between input and output (this is called its “dropout voltage”). So, to get ±15V regulated outputs, you need at least ±17V inputs.

**DRAW the supply.** Here’s what we’d like you to specify:

- transformer secondary voltage (rms) Assume that you are to use a center-tapped transformer, and that the following voltages are available (rms): 10, 12.6, 14, 18, 24, 26.8, 35, all center-tapped; between center-tap and either end of the winding you see half the rated voltage, as you probably know.
- transformer current rating
- filter capacitors
- fuse value (primary side, as you know). **EXPLAIN** your choice of value.

 hw2_as_608.tex; June 24, 2008