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Final Report

Introduction and Motivation:

Our project description called for us to change the audio amplifier block of a superheterodyne AM receiver kit to yield a higher power output, while maintaining coverage over a significant part or all of the frequency bands from 5kHz- 30MHz. The specifications for the previous audio amplifier block put out .2 watts of power through an 8 ohm, 1.5 watt rated speaker. Our job was to replace the four-transistor audio amplifier in use with one that increased the power output to 2 watts from .2watts. In particular, we needed to redesign the AF amplifier in order to achieve an output power gain of about 10 times the original.

There were three separate design approaches that could have been taken to solve the problem: Design a completely new audio amplifier, design another amplifier stage to further increase the output of the current audio amplifier, or to alter the parameters of the current audio amplifier to achieve power output gain. All three could have yielded the same result, but with cost and complexity issue taken into consideration, we felt it would be best to take what was already in place in the audio amplifier and simply change a few parameters to achieve the desired gain.

Along the course of working on the project we came to the conclusion that in consideration of market trends and marketability of a product, which seemed to also be emphasized as a consideration of the project, simply altering the power output of an AM radio and repackaging it would not be in our best interest, since AM radio is a dying, lowfidelity technology that is being replaced by the higher quality digital media market. We decided to instead alter the audio amplifier portion of the project and apply it to the mp3/digital audio user market, rather than restricting it to only one application by putting the newly designed audio amplifier into an AM radio. We finally settled on the idea of making it a stand-alone speaker system, to be used with anything that has an audio jack.

Design Approach: We began the design process with the recommended superheterodyne radio kit, and decided to take the audio amplifier in place and simulate it in PSPICE circuit simulation software to see how it responded over the range of frequencies. Once we had its response plotted, reverse engineering was employed to the circuit to understand how changes to parameters in the different locations of the amplifier would affect the behavior of the amplifier. Once we understood these responses, we adjusted the parameters of four resistors we observed to have a net affect on the overall power gain. We fine tuned the resistor values until we obtained the desired simulation results of power gain over the spectrum of frequencies. Once our expected results were obtained through simulations, we began building the audio amplifier in the lab and testing it to see if measured results matched that of the expected results obtained through simulations. Once the actual results resembled that of the simulations, we began putting together a finished prototype. Packaging of the prototype was the final step in the design process, followed by final testing with input from an apple iPod to see how the finished product worked in real-world application.

Results

Resistor Responses

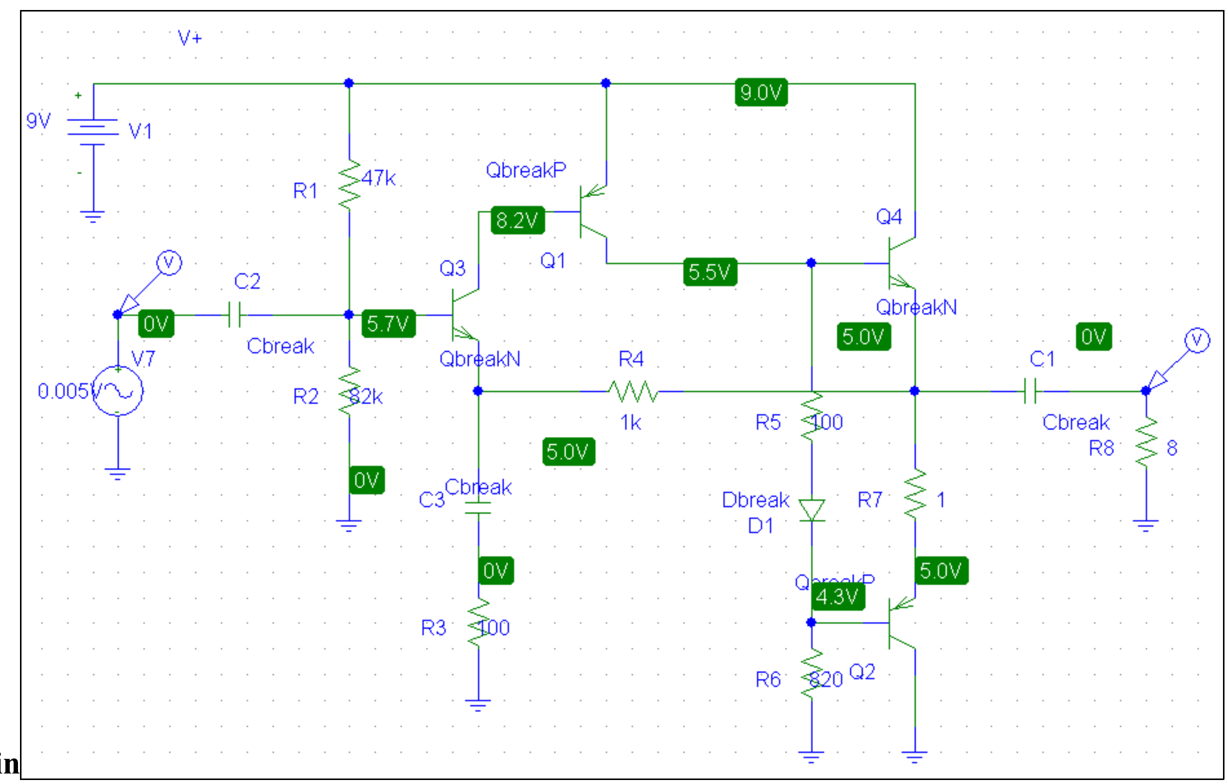
R1: Directly affected the biasing of the overall circuit. Lowering the voltage gave an increase in overall AC gain. From 47k->30k Ohms

R3: The emitter resistor was lowered to increase the dc bias of the second stage. From 100->39 Ohms

R4: Impacted the overshoot in our frequency response. We used this to ensure that our circuit was able to reach its peak voltage at lower frequencies to enable a consistent AC gain throughout the entire bandwidth. From 1k->3.9k

R5: Increasing the resistor R5 enhanced the current flow through Q4 because it is the least resistive path. Slight changes in R5 provided large changes in the amplifier output. From 100->130 Ohms

Original Circuit



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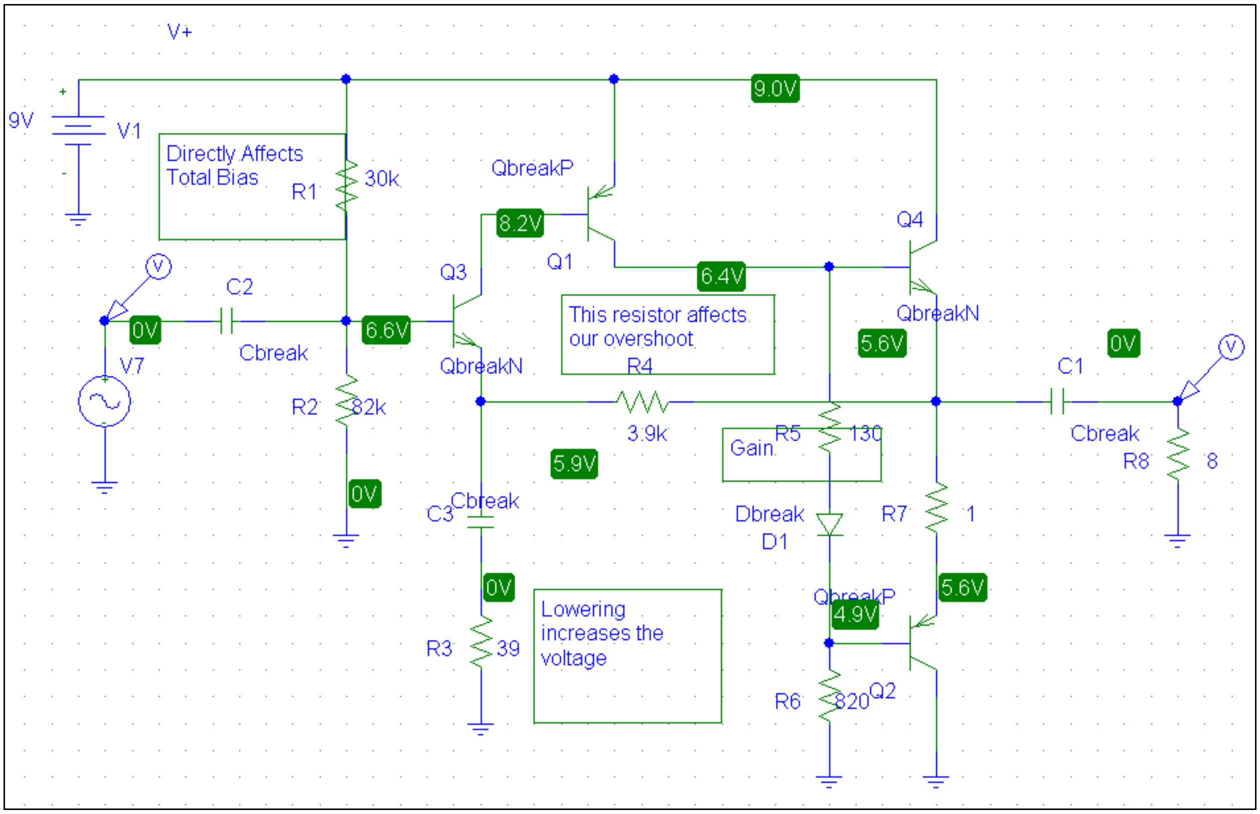
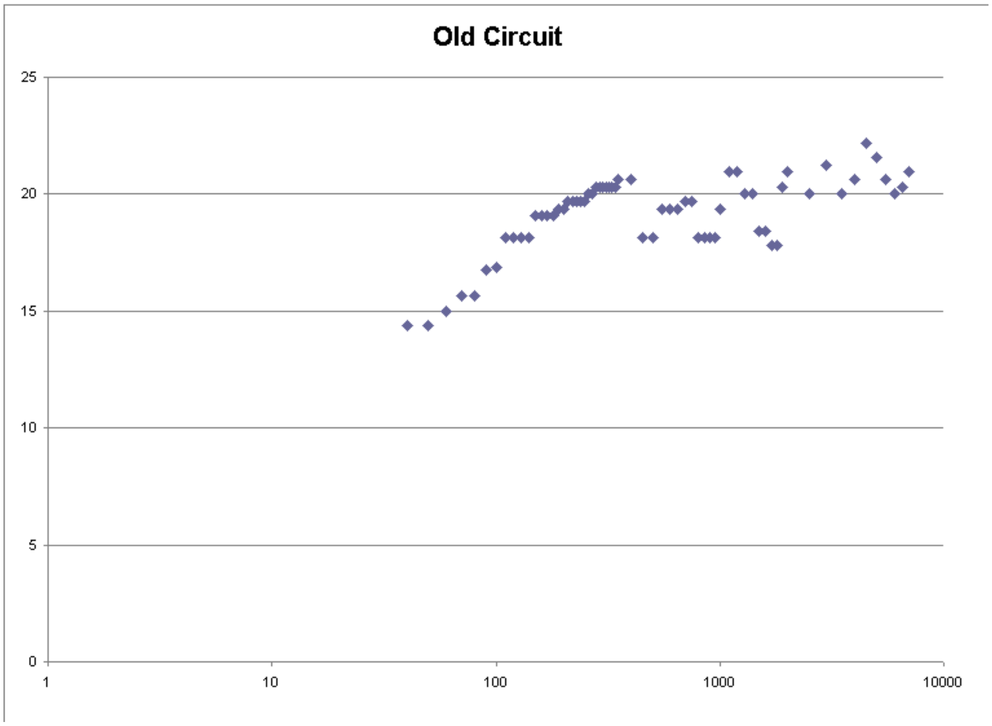
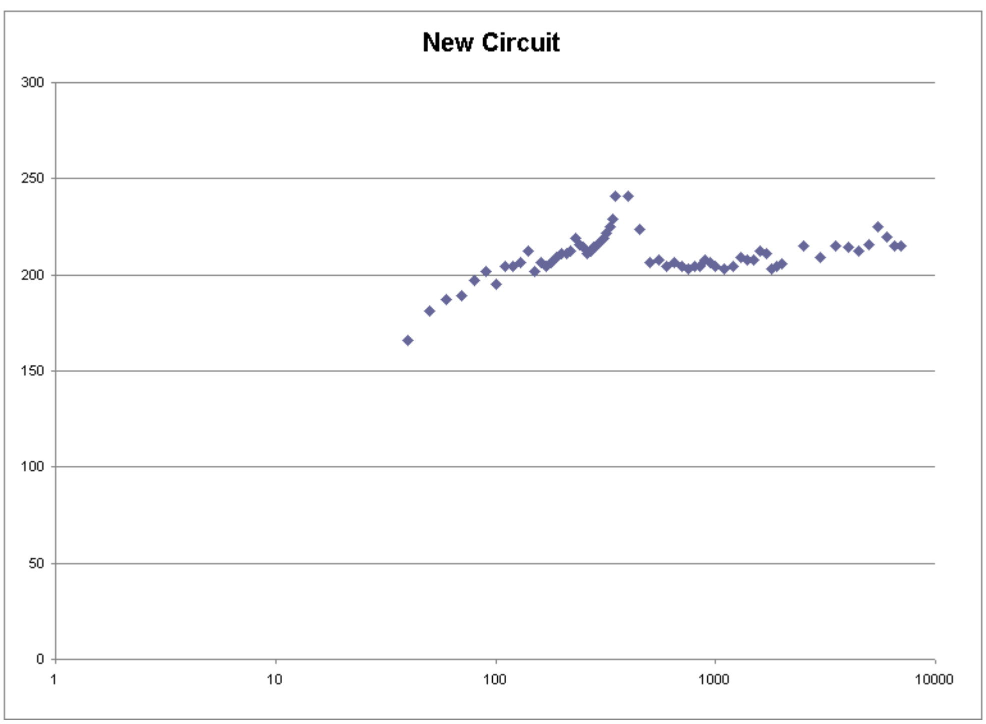

V+
9V
V1
Directly Affects
Total Bias
R1
30k
QbreakP
Q1
8.2V
9.0V
Q4
6.4V
Q3
C2
0V
6.6V
Cbreak
QbreakN
V7
This resistor affects
our overshoot
R4
3.9k
5.6V
0V
C1
R2
82k
QbreakN
5.9V
Gain
R5
130
Cbreak
R8
8
0V
C3
Cbreak
Dbreak
D1
R7
1
0V
QbreakP
4.9V
5.6V
Lowering
increases the
voltage
R3
39
R6
820
Q2

Lab Measurements

Vin = 5mV	Final	
Frequency	Output Old	Output New
40	14.38	165.6
50	14.38	181.2
60	15	187.5
70	15.63	189.1
80	15.63	196.9
90	16.74	201.9
100	16.87	195.3
110	18.13	204.7
120	18.13	204.7
130	18.13	206.1
140	18.13	212.7
150	19.06	201.6
160	19.06	206.3
170	19.06	204.7
180	19.06	206.2
190	19.37	209.3
200	19.37	210.9
210	19.69	210.9
220	19.69	212.5
230	19.69	218.7
240	19.69	215.6
250	19.69	214.1
260	20	210.9
270	20	212.5
280	20.31	214.4
290	20.31	215.6
300	20.31	217.2
310	20.31	218.7
320	20.31	221.9
330	20.31	225
340	20.31	229
350	20.63	240.6
400	20.63	240.6

Vin = 5mV	Final	
Frequency	Output Old	Output New
450	18.13	223.4
500	18.13	206.2
550	19.37	207.8
600	19.37	204.7
650	19.37	206.2
700	19.69	204.7
750	19.69	203.1
800	18.13	204.7
850	18.13	204.7
900	18.13	207.8
950	18.13	206.3
1000	19.37	204.7
1100	20.94	203.1
1200	20.94	204.7
1300	20	209.4
1400	20	207.9
1500	18.4	207.8
1600	18.4	212.5
1700	17.81	210.9
1800	17.81	203.1
1900	20.31	204.7
2000	20.94	206
2500	20	215
3000	21.25	209
3500	20	215
4000	20.63	214.1
4500	22.19	212.5
5000	21.56	215.6
5500	20.63	225
6000	20	220
6500	20.31	215
7000	20.94	215





as the data in the table show, we were able to increase the power output by 100 times, which was our expected result, consistently over the range of frequencies. Actual plots from simulation could not be reproduced electronically, but were included in professor's hard copy and in presentation packet given to professor's during group presentation.

Discussion:

Areas of improvement: We believe that improvements to the design did exist and would be beneficial to overall attractiveness of the product. An integrated circuit could be used to bring down cost of parts, and would also allow for smaller overall product packaging due to smaller surface area, and more compact product suitable for portability. The use of higher quality audio components would also provide better sound quality capturing the audiophile market. The application of brand/item specificity would also much improve the designs overall function. For example, the integration of brand specific components such as an iPod docking station would make it more desirable.

non technical problems and how to improve: scheduling became a pretty large issue throughout the design process. It was difficult to find times when everyone could meet on a frequent basis, and was also difficult to work our schedules in with the professor's when we had weekly meetings with him. This will always be a problem inherent in working in groups with people, but it does provide a significant challenge to progress. Another problem we encountered was our lack of soldering abilities. It became a nuisance when it began introducing noise into the circuit, so much so we decided to use a breadboard in the final prototype design to eliminate this issue. Because of bad soldering, time was wasted obtaining results with error introduced into them, and also caused us to have to waste multiple components of the design to rebuilding.

Team work

The team worked well together, and contributed equally. Everyone got together to simulate and characterize the amplifier, working together until the right resistor values were chosen. In the lab the circuit was built together, and we all obtained the data together, resulting in an amplifier yielding the expected results. We all got together and built the packaging for the speaker system together, with emphasis on not simply designing something that works, but on designing a complete package, one which also looks good and is marketable. Part of marketability is also the desire to produce high quality at a low cost, and by keeping this in mind we were able to build a prototype with a production cost of $28.50 per unit, much less than the expected budget of about $100.

Summary: Overall, from start to finish, the project turned out to be much more challenging then we anticipated as well as rewarding. We began with the initial motivation to change an AM radio audio amplifier to output ten times the power, and ended up designed a stand-alone speaker system with a redesigned audio amplifier outputting one hundred times the power. Improvement to design and implementation can still be made, but from concept to finished product, it was a prime example of the steps from design to product and all the things to be considered along the way.

Appendix:
(Components/software used)
Resistor
Speaker
Project enclosure
Capacitor
Transistor
Diode
9V battery
Breadboard
Headphone jack
Switch
OrCAD PSPICE simulation software
Oscilloscope
Digital multimeter
Signal function generator
DC power supply