Introduction

Too many guitar cabinets are just a few pieces of plywood thrown together with a couple of speakers attached to the front. Even professional companies seem to build the same kinds of cabs, with no regard for engineering. That is why I decided to build a custom guitar cabinet in order to shape and add to the tone of the overall guitar sound. There is much misinformation and conflicting viewpoints on cabinet design, so the research had to be carefully filtered.

Loudspeakers

The cabinet will be primarily used for recording, so there will be some unique goals. First, I wanted to be able to create a variety of sounds. While the cabinet will primarily be used for recording purposes, it may be used in a live situation in the future. Therefore flexibility is of the utmost importance. In order to establish versatility, two different drivers have been selected, with different purposes and tones. The first driver will be an Eminence Red Coat Ramrod 10-inch driver. The frequency response of the driver is plotted below.

![Figure 1: Frequency response of Eminence Red Coat Ramrod 10” woofer](image)

As seen, most of the response lies in the 100 Hz to 5kHz range. A guitar’s response usually resides between 82 Hz and 1050 Hz. However, the first harmonic of the 1050 Hz frequency would be about 2.2 kHz. At this frequency, there is a noticeable peak in the response of about 8 dB. This will contribute to a bit of a brighter sound in those higher frequencies, but given that the speaker will be used largely for low end distorted tone, this should not interfere too much. In fact it may provide a bit of sparkle on the high end tones that is lacking in the lower end sounds, and create a nice contrast. The low end of the spectrum is covered quite well for this speaker. The Thiele and Small parameters...
have been taken into consideration, and the Qts is 0.64. The lower Qts enables the frequency response to dip relatively low, and this value will give it a cleaner low end tone. It will also respond to transients better. The Vas is a value of 26.4 Litres. This is also quite a low number, which indicates it can be used with a relatively small enclosure (which we will discuss later.) The resonant frequency of the speaker is 101 Hz, which might be a bit high, but it is a tradeoff with overall response. Since this speaker will be used mostly for distorted tones, the sensitivity of 96-100 dB is quite good, as it has one of the highest sensitivities of any speaker I looked at and will contribute to the apparent sound level.

The second driver selected is a Celestion Tube 10 guitar speaker. This is a relatively inexpensive driver; however, it is designed to be used with tube amps, as it highlights the natural breakup of the tube amplifier. Celestion does not readily supply Thiele and Small Parameters, and even goes so far to explain on the website that those numbers are irrelevant in guitar speaker enclosure design because they represent frequencies below the operating range of the speakers. This seemed odd since all of the material I found based enclosure design on these parameters, but since the speaker will be housed in an open enclosure, they are inconsequential.

However, it has a free air resonance of 91 Hz, which is quite nice, considering the lack of low end, and its sensitivity is 94 dB, which will not likely cause a problem, because it is not meant to be driven hard, only being used for cleaner, bluesy tones. Again, the first harmonic of 1050 Hz, would be about 3kHz, where there is a large peak in response. This will contribute quite nicely to the sound as well. Since it will be used for clean tones, the extra brightness will give it extra punch, especially when driven with the tube amplifier chosen to be used, which lacks high end definition. The bass rolloff occurs at about 150 Hz, the same as the Red Coat, but it also has a lower SPL in the bass end of the response, so there will be less low end, and therefore will have a brighter tone than the Red Coat.

The different colors of these two drivers will create a nice choice of sound within the cabinet, which is one of the goals of the project. Power is not much of an issue as this will be primarily be a recording cabinet, but I chose to use drivers with high power handling in case it will be used for live sound. Both of these drivers are rated at 8 Ohms.

The choice of drivers was a hard decision. The first instinct was to go with a Celestion Vintage 30. This is basically the Holy Grail of guitar speakers. Marshall and Fender, amongst others, regularly use these speakers in their top-of-the-line cabinets, and
they have a sweet response. The max SPL on the Vintage 30 is about 108 dB, much louder than the speakers I chose, and it has a smoother bass, with high SPL output all the way down to 100 Hz. However, they are quite expensive, about $130, and at the time of the choice, there was not enough room in the budget. It is worth noting, that a company called Avatar speakers sells “broken-in” Vintage 30's for a much more reasonable price of $89.99 each. Another option on the speaker front was the Eminence Patriot Ragin’ Cajun. This speaker had a frequency response relatively similar to the Ramrod, but after listening to the audio clips on the Eminence website, I felt this was a little too bright, almost a bit twangy. Since I wanted a more British feel, I decided against this. Another loudspeaker that considered was the Weber Chicago Vintage Series CVA10, mostly because of their reputation for making good, replacement speakers for Fender cabinets. However, I could not find any specifications for the drivers, so this alternative was quickly thrown out. The same was true for Fender replacement speakers. Not listing the specifications was a major factor in opting to exclude these drivers early.

Enclosure

While the choice of drivers is key to the character of the sound of the speaker, the enclosure is also quite important. Many novices just slap some speakers into a box and call it a day. But just like a monitoring or PA loudspeaker, the enclosure of the guitar cab is integral to defining the sound. I have decided to construct a sealed enclosure for the Ramrod, as these tend to be more independent of the sound of the room, have a tighter low end, and offer a darker, warmer tone (much like the classic Marshall cabs). The Celestion Tube 10 will be housed in an open back cabinet, which will help bring out the high end sparkle, as well as a louder (albeit less defined) low end, and make it a bit like a Fender combo amplifier in sound. Figure 3 illustrates the frequency response charts for a sealed box and an open box. The cabinet will house both, but there will be a divider to separate the two, with one side sealed, and the other open backed. This will ensure the goal of having a variety of sounds to choose from with the cabinet. This will also eliminate any internal air circulation and standing wave problems when only one speaker is in operation. This rectangular box is fairly standard for a 2X10” woofer combination.

![Figure 3: Frequency response of open-back cabinet (left) and closed-back cabinet (right)](image)

The enclosure will be made from ¾” plywood, as it must withstand the bombardment of constant midrange and lower end frequencies. The front baffle will be constructed from ¾” CDX plywood. If the baffle was too thick, the SPL would take a
nosedive. If it were to be any thinner, the wood may begin to resonate too much and bow and bend due to the internal volume. This may color the sound. 13-ply Baltic Birch is an ideal material, as it is sturdy and has a nice resonance. It will resonate in congress with the speaker. It also is the standard for quality guitar cabinets, as well as other loudspeakers. A golden ratio box was the first idea considered, however, with a ratio of 0.6:1.0:1.6, the box would only be nine inches wide, which clearly would not house a 10” speaker. The internal volume of the sealed box has been calculated using the Qts and Vas number using Dickason’s book, and has been determined to be 3.15 cubic feet. However, when calculating box dimensions and using ratios found in Murphy’s book, I have decided to build a bit smaller than that, as the guitar cabinet can have a smaller size (as discussed later), and those equations were more intended for listening speakers with damping and size issues. The final internal dimensions of the box will be 14”x 14”x 14”, with an internal volume of 1.59 cubic feet. The Tube 10 side will also consist of these dimensions for symmetry, and the fact that it is an open back will make its volume less critical. This will allow a relatively smaller box that will fit the speakers with a few inches of space on each side and will be relatively deep to produce lower end response. Size is not as critical as it would be for a listening speaker, but too small a cabinet can destroy the low end of the frequency spectrum. There must also be a careful balance as a box that is too big may sound boomy and resonate too much. Originally, the design included a sloped front baffle will cut down on parallel surfaces and minimize standing wave modes. However, after a reread of the Study of Midrange Enclosures article (source #5), it was decided that those sloped surfaces did little to alleviate the standing wave problem. There were just as many peaks as a golden ratio box.

Figure 4: Two parallel 10” woofer design

The interior will require minimal damping material, because as stated before, resonance within the cabinet will add to the sound. While this is undesirable in listening speakers, with a guitar cabinet we are creating the sound, and resonance can enhance the tone of the instrument. Damping will also remove some of the high end “sparkle” or “life” (of course these are all qualitative terms describing high end clarity). We do not want a dead cabinet. Placement will be rather standard. The two 10” speakers will be placed parallel with each other (as opposed to offset).

Switch

The speaker cabinet houses two different drivers with two different sounds. To ensure absolute control over the sound of the speaker, an ABY switch will be constructed. This switch will be constructed as an outside footswitch for ease of use, as well as convenience. When the switch is not desired, it will not interfere with the speaker cabinet itself. Two switches will be incorporated into the box, one that will switch between the two individual loudspeakers and another that will activate them together in parallel. Since the Redcoat has a higher SPL, an L-pad will be built into the switch circuit in order to match the Celestion.
The equations \( R_2 = 10^{(A/20)} \times \frac{Z}{1-10^{(A/20)}} \) and \( R_1 = Z - (1/R_2 + 1/z)^{-1} \) where 
\( Z \) = total driver impedance and \( A \) = amount of required attenuation in \(-\)dB supply the necessary resistor values in order to pad the speaker.\(^9\) The switch circuit is shown below in Figure 5.

![Circuit Diagram for ABY switch](image)

**Budget**

The budget for this project will actually be quite reserved since there are only two drivers, and one overall box. I have put together a price list from various suppliers, but these are only for budget purposes. If there is a supplier with more inexpensive alternatives, that supplier will be used.

<table>
<thead>
<tr>
<th>Part</th>
<th>Cost ($)</th>
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<tbody>
<tr>
<td>(1) Celestion Tube 10 Driver</td>
<td>39.99</td>
</tr>
<tr>
<td>(1) Eminence Red Coat Ramrod Driver</td>
<td>69.99</td>
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<tr>
<td>Switch Parts</td>
<td>23</td>
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<td>(1) 3/4* 4' X 8' CDX Plywood</td>
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<td>1 sq. yard Red Vinyl</td>
<td>7.44</td>
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<tr>
<td><strong>Total</strong></td>
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The ultimate goal of the project is to break the cycle of under-designing guitar cabinets (especially in the Do-it-Yourself world). One only has to peruse the internet for a few minutes to discover the lack of thought that is put into a project like this. With this approach, I hope to create a unique, versatile guitar cabinet that will utilize acoustic principles such as resonance to its advantage, and sound as good as or better than even the most common, popular amplifier cabinets.

\(^2\) [http://www.duncanamps.com/technical/speaker_cab.html](http://www.duncanamps.com/technical/speaker_cab.html)
4 http://yellowcabamplification.com/design.htm
5 Jim Moriyasu, "A Study of Midrange Enclosures", *Speaker Builder*, (July 2000): 20, 21
7 John L. Murphy, *Introduction to Loudspeaker Design* (True Audio, 1998), 88, 89
8 http://professional.celeston.com/guitar/features/drdecibel/index.asp