Binary Acoustic Technology

Digital Acoustic Processing

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Digital Compensation

Creating the ideal sensor

This application note discusses and compares the performance of two ultrasonic sensors that are employed in research quality equipment; the Polaroid 600 sensor, which is employed in the AR125, and the FG electret, which is employed in the Pettersson D240. It also describes a new technique, **digital compensation**, that has been added to SPECT'R Version 2.1.4.

In general, the ideal sensor for collecting and recording bat calls has a completely uniform ("flat") frequency response. In addition, it should also have high sensitivity and low self-noise. As you might imagine, real sensors don't meet all of these ideal requirements and picking sensors for analysis and recording purposes can be quite an art. Real sensors are designed with tradeoffs. They are either optimized for a uniform response or they are optimized for sensitivity. This is especially true for the wideband sensors that are employed in bat vocalization research.

This effort was originally begun to address the concerns of several users who noticed that high frequency content was missing when AR125 recordings were analyzed using SonoBat^{tm}. In researching the issue it became apparent that SonoBat^{tm} works best with a flat or uniform frequency response. This is what the new digital compensator is designed to provide. The result of this effort produced a significant new technology that produces a nearly ideal sensor response.

The remainder of this note compares the sensors and discusses the performance of the new digital compensator.

Sensor Comparison

Figure 1 is a sensitivity comparison between a Polaroid 600 and an FG electret. The graph shows how the sensors respond to a 1 PA (92 dB) signal pressure level. At first glance, the Polaroid 600 is the obvious winner; greater dynamic range, lower thermal noise floor, greater frequency response, and a smoother overall response.

At it's best, the Polaroid can sense sounds down to nearly 0 dB SPL (the faintest sound a human can hear). Compare this to the FG electret, which can only sense sounds down to between 40 and 45 dB. This means that the Polaroid sensor will detect bats at a much larger distances.

The only disadvantage is that the Polaroid is not quite as flat over the 40KHz to 120KHz region. It peaks at 50KHz and then drops to a plateau at 80KHz with an overall excursion of 20dB. Compare this to the FG response over the same region. If you ignore the dropout at 80KHz, the FG maximum excursion is only 15dB with most of high frequency response within 10dB.

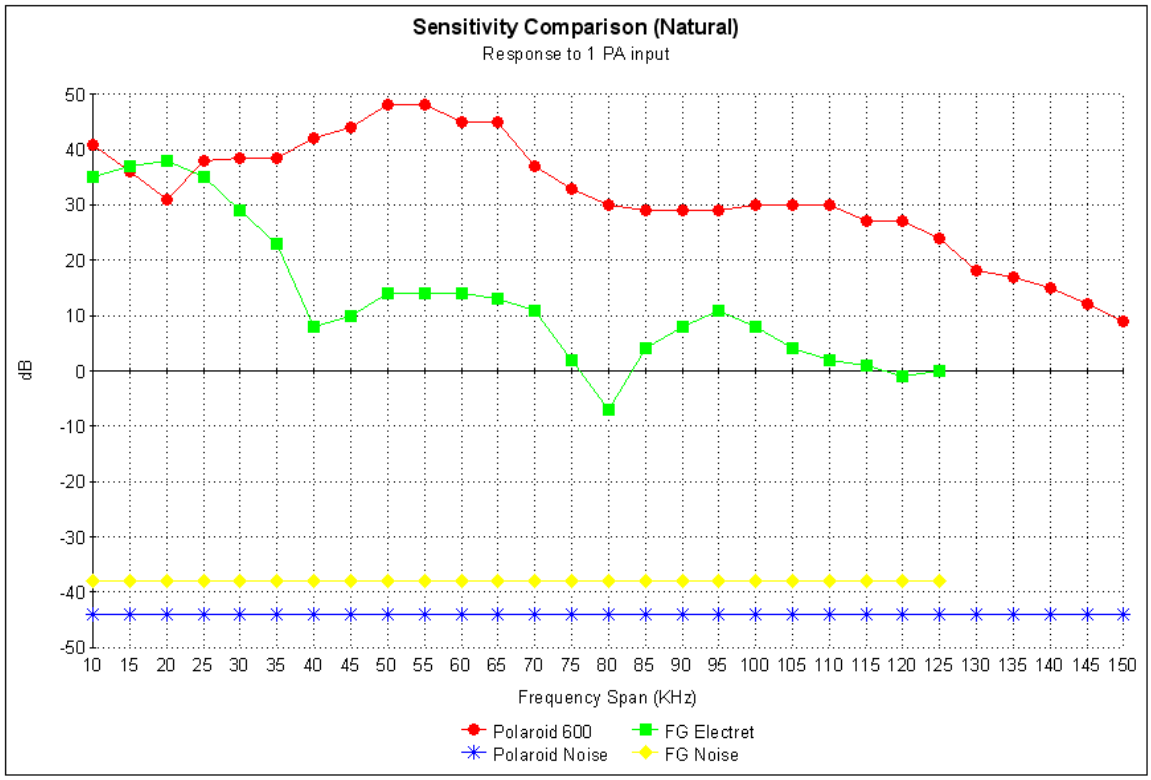

Figure 1: Sensitivity Comparison

Digital Compensation Comparison

While not flat, the relatively smooth response of the Polaroid 600 allows us to compensate, or correct the response, to create a relatively uniform response over the entire frequency range. Figure 2 is a comparison between a digitally compensated Polaroid 600 and the FG electret (uncompensated). Notice that the compensation does a great job. The response is nearly uniform, due mainly to the fact that the Polaroid itself has a relatively smooth response, without abrupt drop-out regions. Also notice that the excursion across the entire 10 to 125KHz frequency range is reduced to only 10dB with most of the frequency band within 5dB.

At it's worst, the compensated sensor maintains a 75 dB dynamic range and it can hear sounds down to about 17dB SPL (worst case). Even at it's worst, it is still more sensitive than the FG electret and it will detect bats at a greater distances.

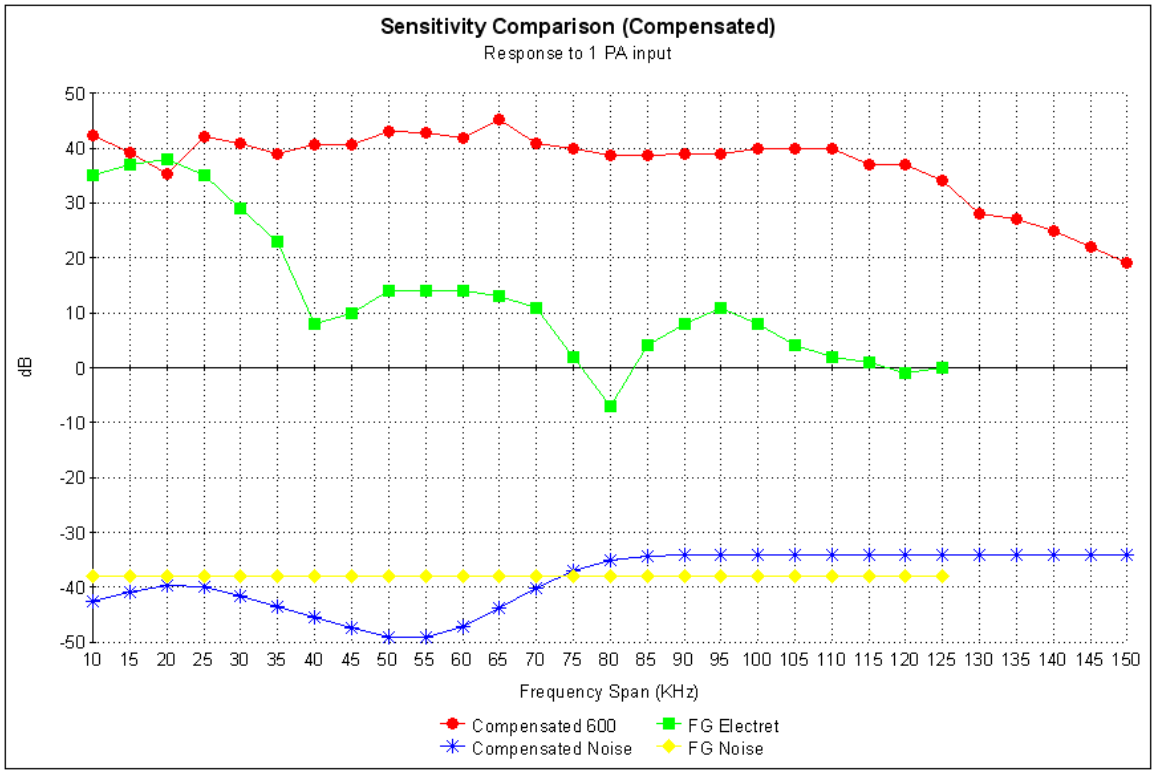

Figure 2: Compensated Comparison

Selecting the Response in SPECT'R

SPECT'R 2.1.4 provides two response options, **Natural** and **Digitally Compensated**. If Natural response is selected, no compensation will be performed and the standard response characteristic of the Polaroid sensor (Figure 1) will be used. If Digitally Compensated is selected, then the compensator will be engaged to flatten out the response (Figure 2). To select an option, click the appropriate option in the *Setup => Response* menu as illustrated by figure 3.

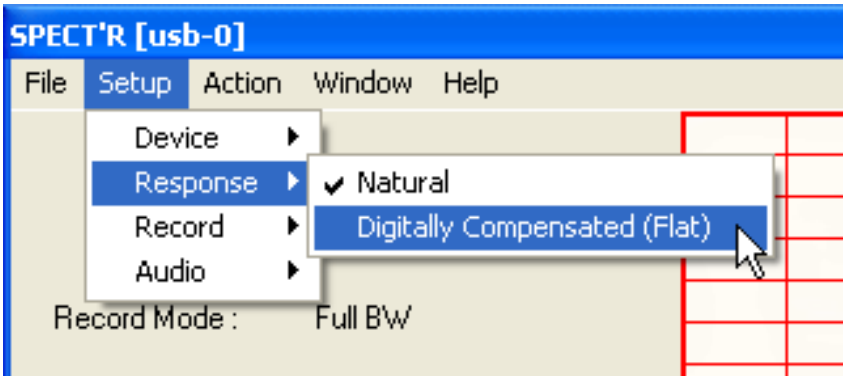

Figure 3 : Response selection

The digital compensator is designed to work either live, with an AR125 receiver, or off-line, with files recorded by an AR125 receiver. In fact, files can be compensated or decompensated by using SPECT'R to re-recording them using the appropriate response setting. It makes no difference what response was used in the original recording. To compensate a file, simply select the digitally compensated response and playback a file while recording a to a new file in full-bandwidth record mode. To decompensate a file, select the Natural response and re-record the file in the same way.

Conclusion

The Polaroid 600 is known to be the most sensitive sensor for bat applications in the 40 to 70 KHz range. It's only detraction is that it is not quite as flat as the FG electret (which is not entirely flat either!). However, because the Polaroid has a smooth response and plenty of dynamic range, the response can be digitally compensated to produce a response that is nearly ideal; nearly uniform response, high sensitivity, and low thermal noise.

While the digital compensator is a new technology, it is highly recommended, especially for AR125 users that apply SonoBat[tm] to analyze the recordings. Please be aware of the possibility that the maximum range of the AR125 is slightly reduced when the digital compensator is selected.

Acknowledgements

The results of the effort produced a significant improvement in SPECT'R and the AR125 system. I am very grateful and indebted to the AR125 users for their feedback and suggestions. I would also like to acknowledge the designer of SonoBat[tm] , Joe Szewczak, for his support and insightful discussions.