Brandon Smith

ET 471

Prof. Morton

Senior Project Proposal

Audio Spectrum Analyzer

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AUDIO SPECTRUM ANALYZER

Introductory Description:

Today’s audio world is the richest it has ever been, with home stereo and portable technology reaching new heights every day. As home stereos increase in complexity and capability, some pieces of equipment once found only in professional sound studios are making their way into private homes. I hereby propose to bring one of these pieces of equipment into a package small and simple enough for home use. The product that I offer is the Audio Spectrum Analyzer (ASA), a device which displays the energy level of sound waves at certain frequencies. The ASA will be easily attachable to home stereo equipment or portable media players, offering the user a continuous analysis of their audio signal.

Description:

The ASA will be implemented through Digital Signal Processing (DSP), which is a fundamental feature of the ASA’s construction. Instead of using analog filters or a dedicated DSP chipset, a microprocessor will be used to perform the filtering functions, along with handling the output display. The hardware block diagram on page 7 outlines the major hardware components, and the data flow between them.

The output display will be a series of five LED bar graphs, each graph representing a certain frequency. The frequencies to be analyzed will be 14 kHz, 8 kHz, 4 kHz, 1.0 kHz, and 250 Hz. The LED bar graphs will be driven by LED drivers, which in turn will be controlled by the microcontroller through the SPI port.

The microcontroller is the heart of the ASA, and the ASA will incorporate a Motorola HCS12. The HCS12 was chosen over the standard Motorola HC12 as the ASA’s
microcontroller for one specific quality – speed. Below is a table showing a basic comparison of
the HC12 and HCS12, as their performance pertains to the ASA.

<table>
<thead>
<tr>
<th></th>
<th>HC12</th>
<th>HCS12</th>
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</thead>
<tbody>
<tr>
<td>Processor Speed:</td>
<td>8 MHz</td>
<td>25 MHz</td>
</tr>
<tr>
<td>Max Frequency Analyzable:</td>
<td>~ 5 kHz</td>
<td>~ 15 kHz</td>
</tr>
<tr>
<td>Cost (EVB Package)</td>
<td>$102 (complete)</td>
<td>$99 (not incl. s/h, tax)</td>
</tr>
</tbody>
</table>

As we can see, using the HC12 would have been a liability to the ASA’s competitiveness, as the peak frequency would have been approximately 5 kHz, and lower frequencies at 3 kHz and lower. If the HC12 was used, one might regard the ASA to be more of a telephone signal analyzer. With the speed of the HCS12, a much wider range of audio frequencies is available.

The speed limitation on the microcontroller stems from the amount of work the microcontroller must perform in order to keep up with its highest band-pass frequency. The HCS12’s primary software function is to perform five sets of equations – five Infinite Impulse Response (IIR) functions, each one essentially being the band-pass filter equation for the given frequency. These equations must be completed, along with updating the LED arrays and other housekeeping tasks, between each audio sample. Therefore, the microcontroller’s performance is a critical issue with the ASA, and which is why the HCS12 has already been selected.

**Benefits:**

The HCS12-based ASA will be a simple and flexible spectrum analyzer. It will be cheaper than a dedicated DSP chipset, and its programmable nature will make it more flexible
and simplistic than a series of analog band-pass filters. An analog implementation of this product would require a considerable array of circuitry from a variety of suppliers, and modifications or tuning would require large circuit rebuilds.

Most modern commercial stereos in the medium- to low-cost range usually have ambiguous spectrum analysis features, such as a colored display that varies its design. These displays aren’t helpful for an informative analysis of the audio signal, as they serve as more of a colorful selling point. The ASA’s display will be straightforward and simple to read. Additionally, most audio spectrum analyzers on the market are coupled with a graphic equalizer system, while most every stereo system and/or receiver has built-in equalizing features. Therefore, the ASA offers the consumer the option of purchasing an informative and helpful audio spectrum analyzer without having to deal with a second equalizer.

**Comparison:**

There are very few audio spectrum analyzers available that aren’t tied to an audio equalizer. One example is the Audio2000 AEQ8010S, which is a ten-band audio equalizer with a spectrum display similar to what will be featured on the ASA. The Audio2000 offers twice as many frequency displays, but over the same approximate range as the ASA. The Audio2000 model retails for $165. More advanced equalizers can easily exceed $400. Therefore, in order to obtain an informative spectrum analyzer, one must purchase an expensive, un-needed equalizer in order to obtain the display. Therefore, the ASA fills a void in the market by offering a spectrum display without compounding equalizers.
**Project Development:**

The centerpiece of the ASA is the HCS12, which will be programmed by C-based software and debugged by the Noral Flex debugger. The HCS12 that is intended for use is sold by Technological Arts, on a development board that supports a BDM interface. Although this specific board has not been used in the Western labs, it is expected to be fully compatible with the standard HC12 debugging hardware, and only minor modifications required to the programming software. In short, the transition is expected to be minimal.

The ASA is based off a kit intended for use by the now-obscure HC16, which ran at 16 MHz. Given the different processor speeds and band-pass filtering specified above, all of the analog front end of the kit must be rebuilt, with emphasis on new anti-aliasing hardware.

Also given the advanced capabilities of the HCS12 over the HC16, and given that the kit’s LED drivers are useable but effectively obsolete, new LED drivers will be used to build an entirely new LED bar graph display. Known development issues with a new LED system are the calibrations required to show the decibel levels on the LEDs, along with proper multiplexing if multiple LED drivers are required.

Therefore, none of the original kit will be used in the construction of the ASA. The wiring diagrams will be referenced and adapted, however, with credits given to Motorola and EVM Products wherever applicable.

Therefore, there are three hardware component blocks to this design, termed *Analog Front End*, *Microcontroller*, and *LED Rear End*. The basic block diagram of these components is on page 7.

The ASA will be demonstrated at the end of spring quarter, and will be tested with a CD player. Radio and tape media can also be tested, but may not adequately exercise the ASA in the
upper frequency ranges. More importantly, the LED arrays will be calibrated for standard CD power levels.
CONCEPTUAL SKETCH