Entry 225 - PSoC Based Audio Analyzer

Abstract

A PSoC chip from Cypress Microsystems was used to implement an eight-band Audio Analyzer. The analyzer consists of two major functional blocks: a White Noise Generator to act as a broad-band stimulus, and an eight-band spectral analyzer to measure the frequency-specific system response and display the results.

White noise generation (Figure 1) is performed by clocking a 24-bit, pseudo random sequence generator at 40Khz and then moving the lower six bits to the input of a Digital to Analog converter. This produces a randomly fluctuating analog output with spectral components out to 20Khz and repetition rate of 7 minutes. An FFT of the data shows a frequency spectrum with a flat response out to 20Khz - equivalent to that expected of an ideal, band-limited white noise generator.

The Spectral Analyzer (Figure 2) takes advantage of two 2nd order band-pass filter functions to produce a 4th order Butterworth-response BPF. Changing the filter parameters allows fast modifications to the center frequency, which can is used to sweep across the audio range in 8 steps.

Signal processing begins by using a Programmable Gain Amplifier to boost the signal from an electret condenser microphone by a factor of sixteen. For the four lower frequency BPF configurations (110, 220, 440, and 880 Hz) the signal is routed through a 2Khz antialiasing filter. For the higher BPF frequencies of 1768, 3520, 7040, and 14,080 Hz, the signal is routed directly into the next gain stage.

The buffered signal is then sent to the 4th order BPF section. The filtered signal is passed to the Equalization amplifier, which has a unique gain for each filter to ensure a flat response under ideal conditions.

The gain-equalized signal is presented to an 8-bit Delta Sigma A/D with a sample rate of 31.25Khz. For the on-time duration of each filter, A/D samples are collected, converted to positive values, offset corrected, and compared to previous maximum values. If the new value is greater than the previous max, it is saved as the new maximum. At the end of the filter period, the maximum value is saved in an 8-byte, circular buffer. The values are averaged to produce an 8-bit value. The upper three bits of this value are used as an index into a lookup table that contains the bar-graph patterns for the 8X8 LED display. An array of eight bytes is used to store the pattern for each spectral band.

The display driver is an interrupt service routine that occurs 800 times per second. During each pass of the routine, a single column of the display is driven. With 8 columns and an update rate of 800 columns per second, the entire display is updated 100 times per second.

External transistors are used as column drivers while individual port pins drive the rows. The circuit depends on the maximum current of 25mA for the port pins to control the drive to the row LEDs.

To use the instrument, the user runs a stereo patch cable between the RCA jacks on the side of the unit to an appropriate input on the rear of the amplifier under test. The stereo should then be turned on and the input selected. While standing in the desired listening location, turn the instrument on, and select the stereo channel to test. White noise should be heard from the speaker. The user should then adjust the equalizer settings on the amplifier until a flat response is observed on the display of the analyzer.
24 Bit Pseudo Random Sequence Generator (PRS24) → Timer ISR → 6-Bit DAC (DAC6)

Microphone → MIC AMP → 2Khz LPF → 2:1 Mux

Programmable 4th Order BPF

Intermediate AMP

Peak Detector → 8 Stage Smoothing Filter → Display Code Generator

Figure 1 - White Noise Generator Block Diagram

8-bit Delta Sigma A/D Converter

Figure 2 - Block Diagram of Spectral Analyzer (Software Functions are Red and External Hardware is Blue)