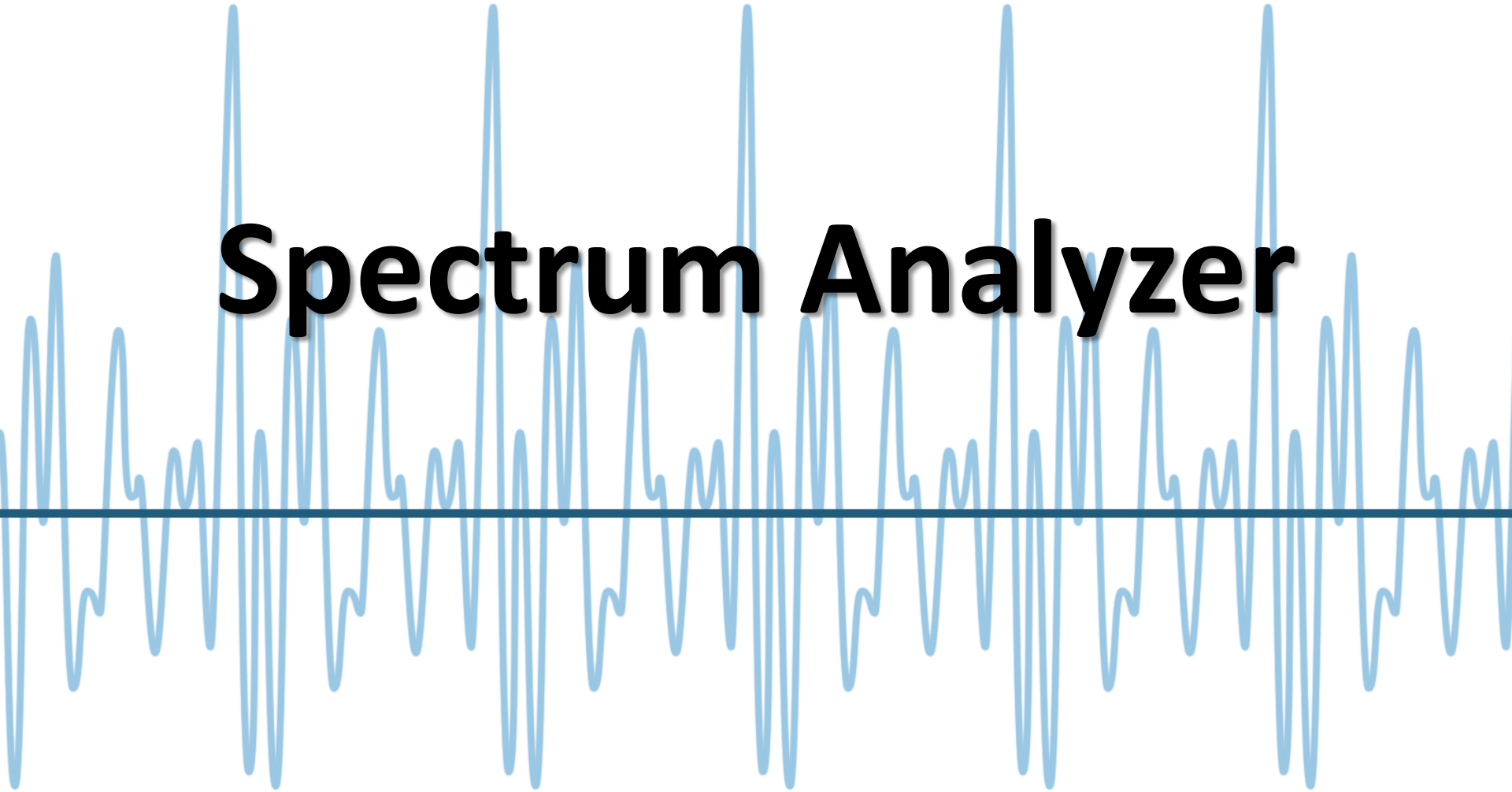
Spectrum Analyzer



Introduction

Spectrum - Frequency range of waves

Analyze - subject to an analysis

Applications:

- Measure spectral purity of multiplex signals
- Measure Modulation Characteristics of AM, FM
- Measuring Frequency Response of Devices

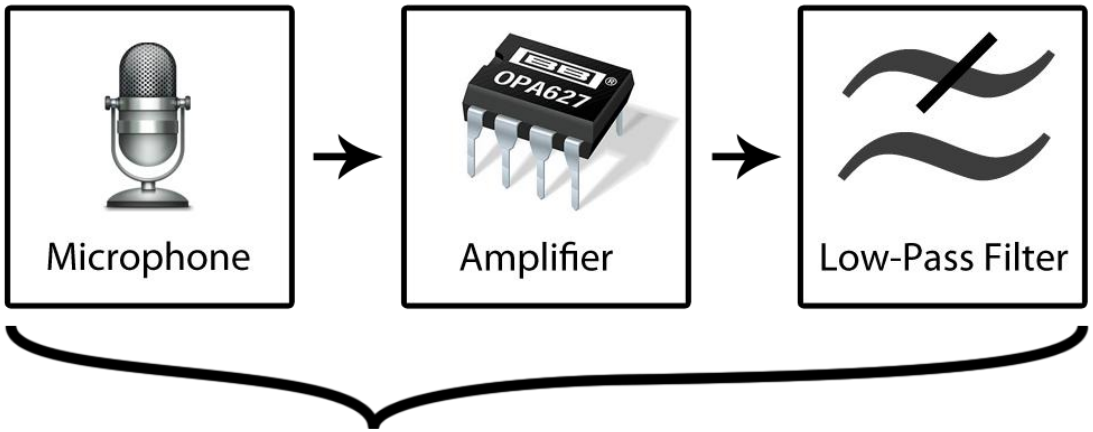
** Measure Audio Spectrum **

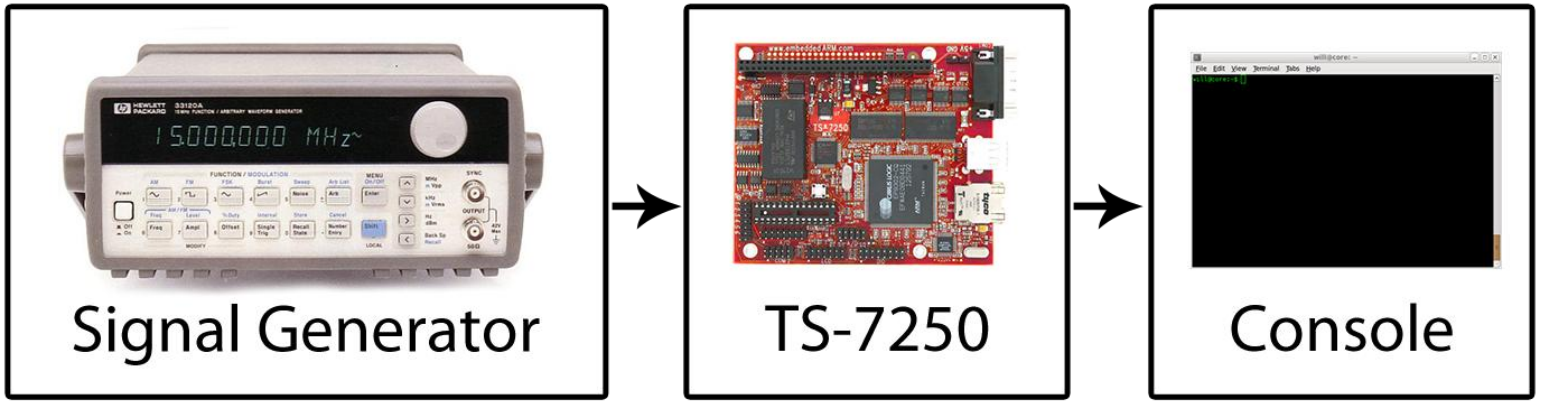
Introduction (Cont'd)

Topics Applied From Class:

- Dynamic Memory Allocation
- Pthreads
- Real Time Tasks
- Consumer / Producer Model
- Round Robin Scheduling
- Semaphores

Hardware Diagram





Design (Sampling)

Freq Range: (100Hz – 22kHz)

Sample Rate: $2 * f_{max}$ = 44.1kHz = CD Quality

Min Samples: $2\left(\frac{T_{max}}{T_{min}}\right) = 2\left(\frac{\frac{1}{100}}{\frac{1}{44100}}\right) = 441 \approx 512$

Expected Time: $512\left(\frac{1}{44100}\right) = 0.0116\ sec$

Design (FFT)

FFT requires factor of 2^N inputs (64,128,256,512,etc..)

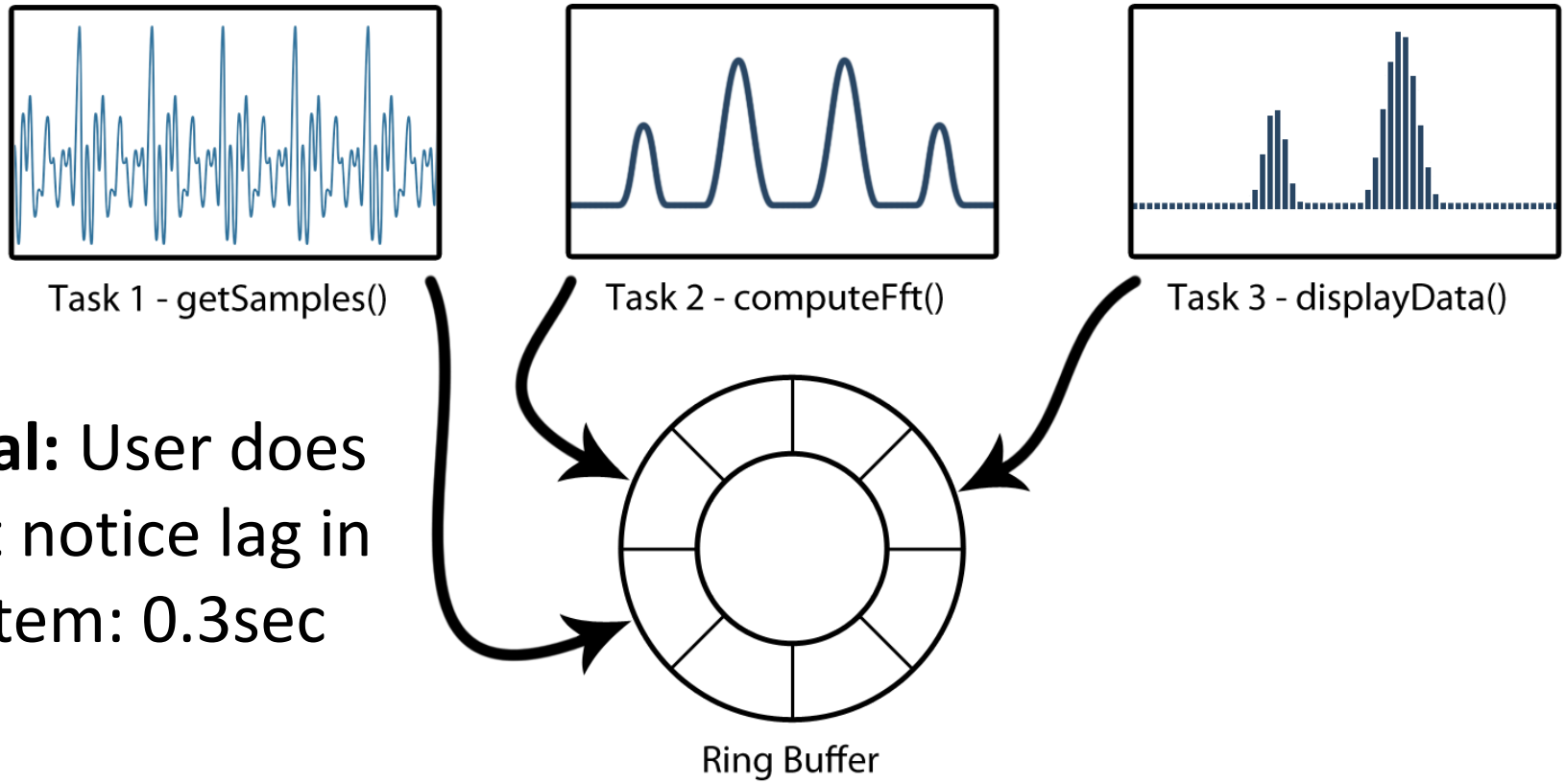
Complexity: $M \log M$, $M = 2^N, 2^N \log 2^N = N2^N \log 2$

Symmetric Output, Discard Negative Frequencies

Design (Display)

- Problem: No VGA controller
- Solution:
  - Output 2D Matrix to create bar graph
- Frequency increase linearly to the right.

Software Diagram / UML



Goal: User does not notice lag in system: 0.3sec

Closer Look at Ring Buffer

Offset	Data Type	
+0x00	enum status:	OPEN, LOCKED
+0x04	enum stage:	OVERWRITE, RAW_DATA, FFT_DATA
+0x08	double vReal[512]:	0
+0x10		1
…		…
		511
	double vImag[512]:	0
		1
		…
		511

Real Time Constraint

- DAC
  - Analog to Digital Conversion (ADC) via the onboard MAX 197 chip (MIN: 12 µS)
  - Periodic Real Time Tasks to ensure consistent sampling of signal

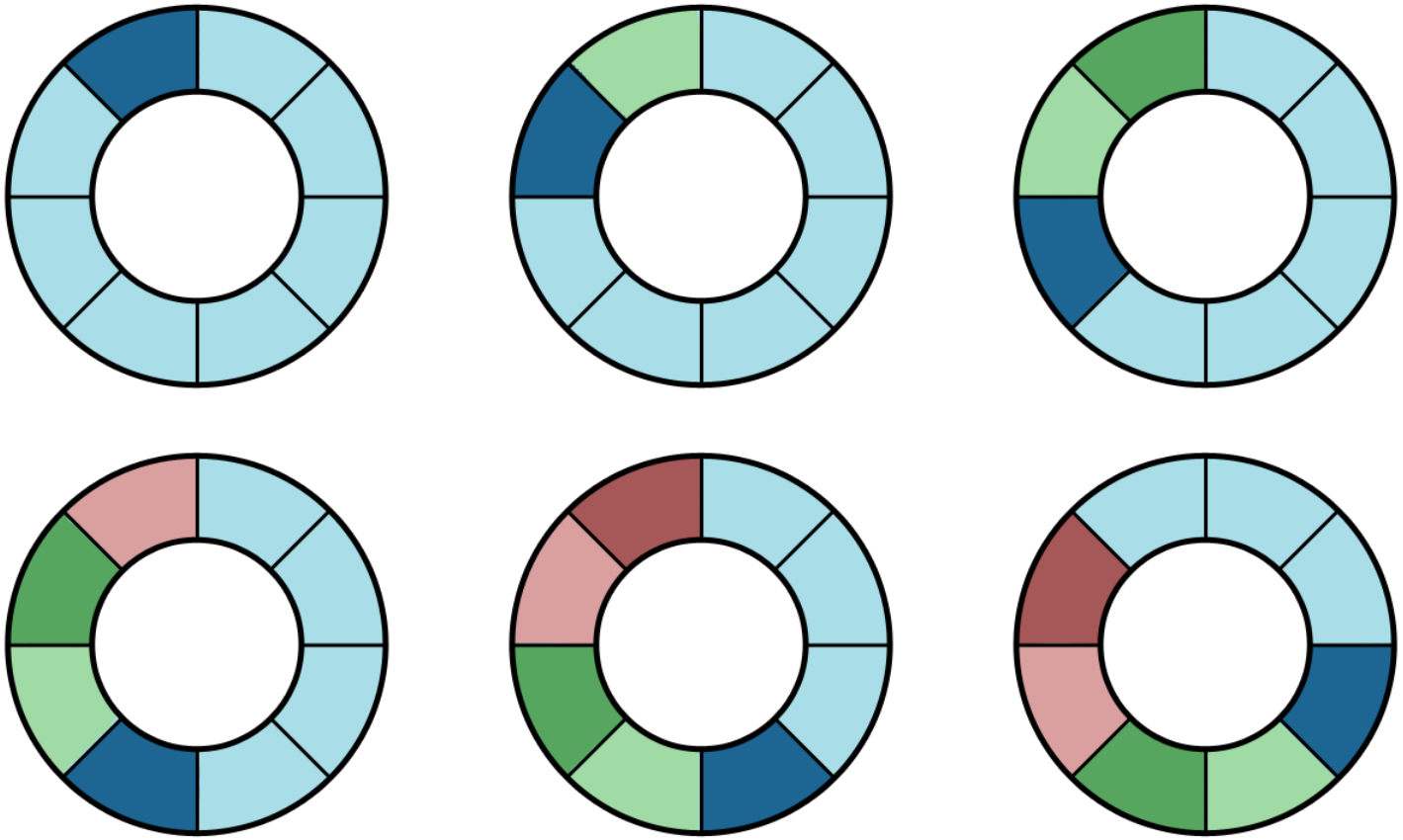
C/P Model - RR Scheduling

- Each of the threads has different execution time
- With Priority / Time slice RR: FFT thread and Display thread can be processing on another buffer while waiting for DAC conversion

Semaphores

- Use Counting Semaphores to Denote Available Resources
- get_samples() semaphore is initialized to the total number of buffers in the ring (10)
- Each thread signals the semaphore for the next thread.

Visual Buffer/Semaphores

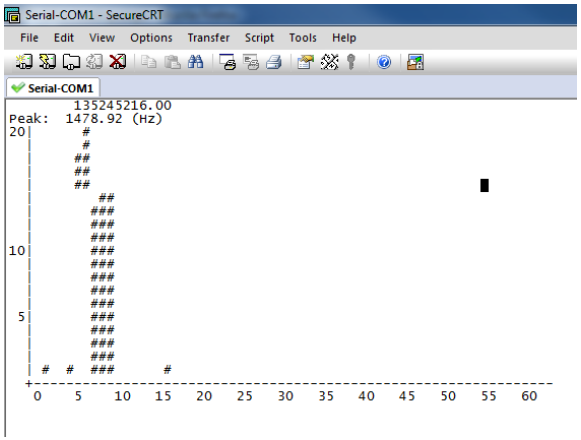


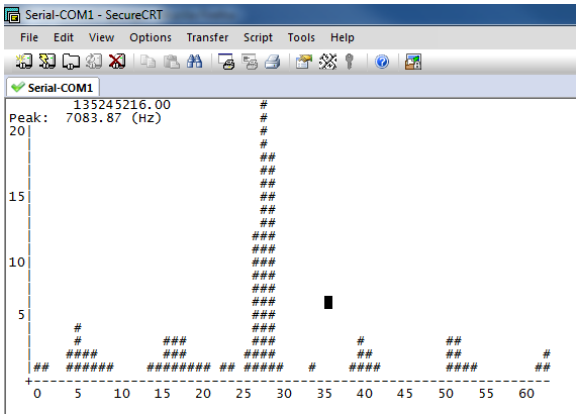
Results

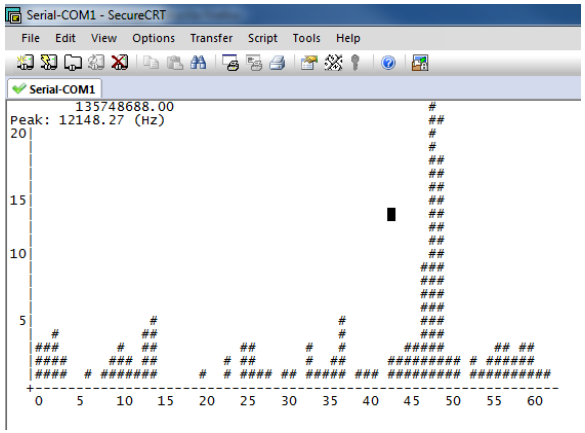
Samples	Avg. Delay (ns)
64	75.87
128	158.23
256	N/A
512	N/A
1024	N/A
2048	N/A

Input Frequency (Hz)	Measured Frequency (Hz)
1000	970 – 1005
2000	1970 – 2010
4000	3900 – 4050
6000	5900 – 6070
8000	5900 – 8050
10000	6700 – 10100
12000	7000 – 12100
14000	8000 – 14200

Results


Serial-COM1 - SecureCRT
File Edit View Options Transfer Script Tools Help
Serial-COM1
135245216.00
Peak: 1478.92 (Hz)


Serial-COM1 - SecureCRT
File Edit View Options Transfer Script Tools Help
Serial-COM1
135245216.00
Peak: 7083.87 (Hz)


Serial-COM1 - SecureCRT
File Edit View Options Transfer Script Tools Help
Serial-COM1
135748688.00
Peak: 12148.27 (Hz)

Possible Improvements

- ** Fix Sample Limitation
- * Find Optimal Conversion Factor
- Be able to discard buffers that have old data
- Improve algorithm for finding next buffer
- Upgrade Graphical Display
- Build full DAC setup with breakout serial cable and Microphone

Questions