# Spectrograms

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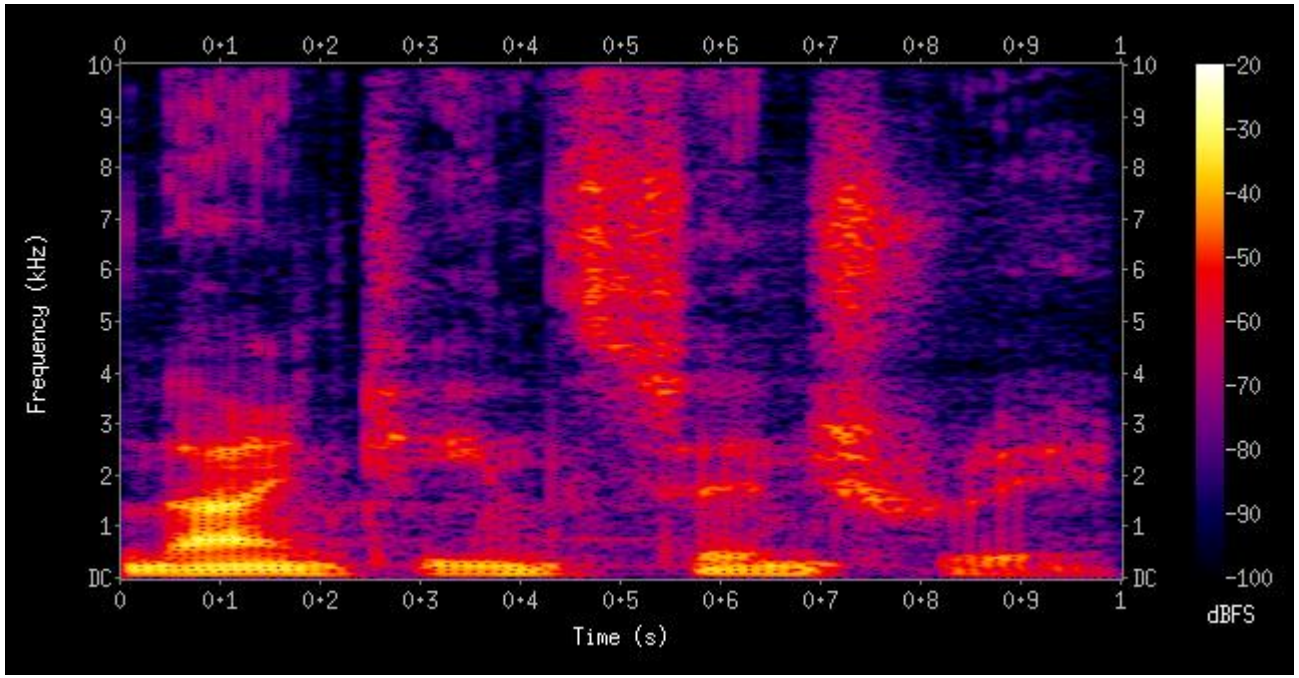
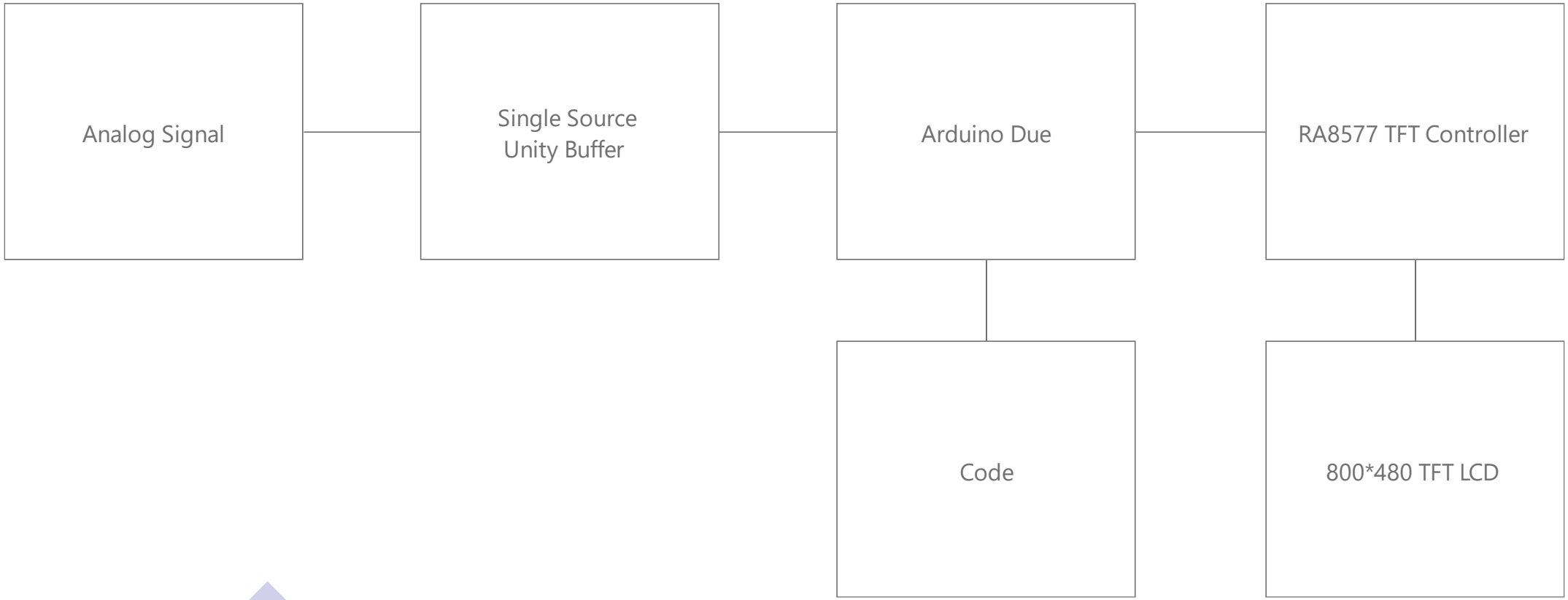
Phys 3P92

# Objective

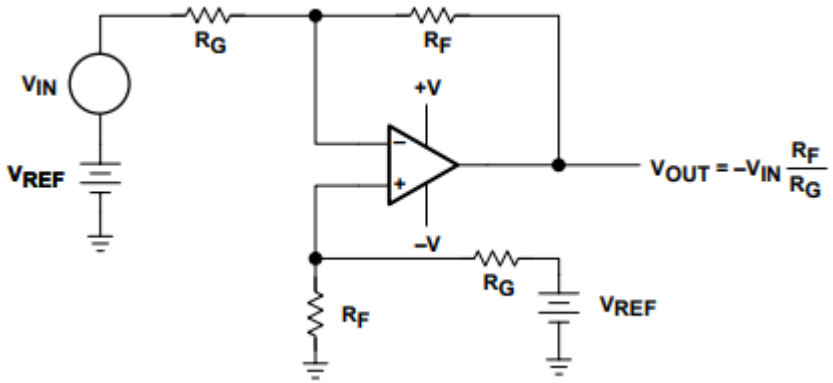
- A 3D graph of  a signal with frequency along the Y axis, time along the top and colour to represent amplitude.
- The goal was to create a portable spectrogram generator which would take input in the form of an audio signal.



# Block Diagram

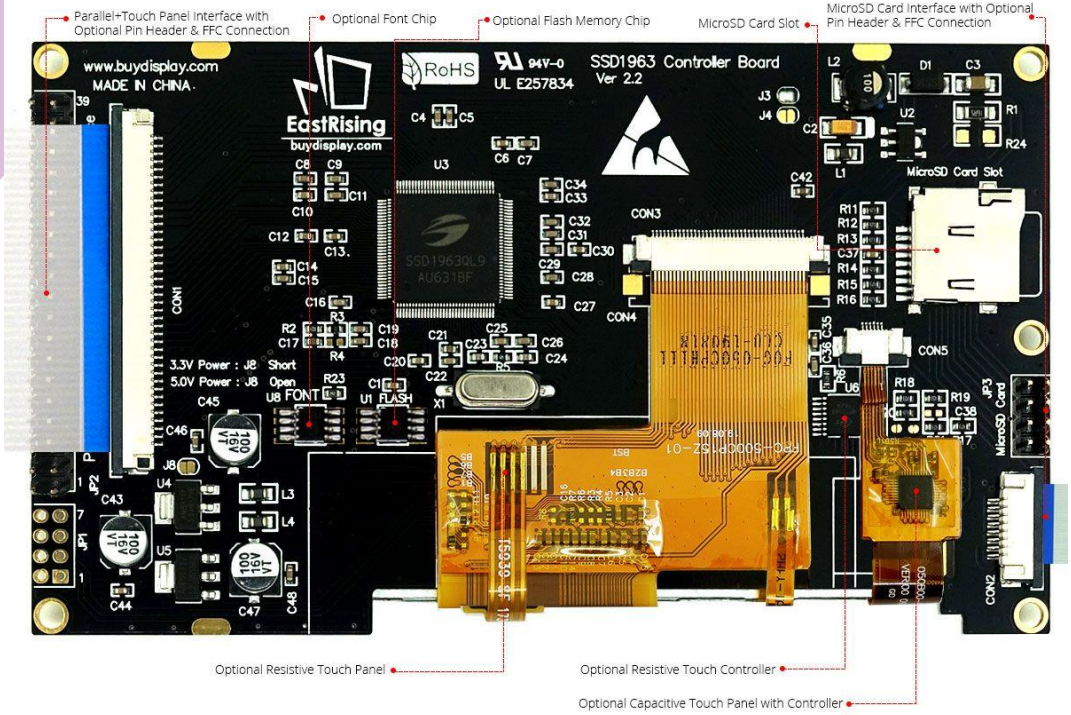


# Components

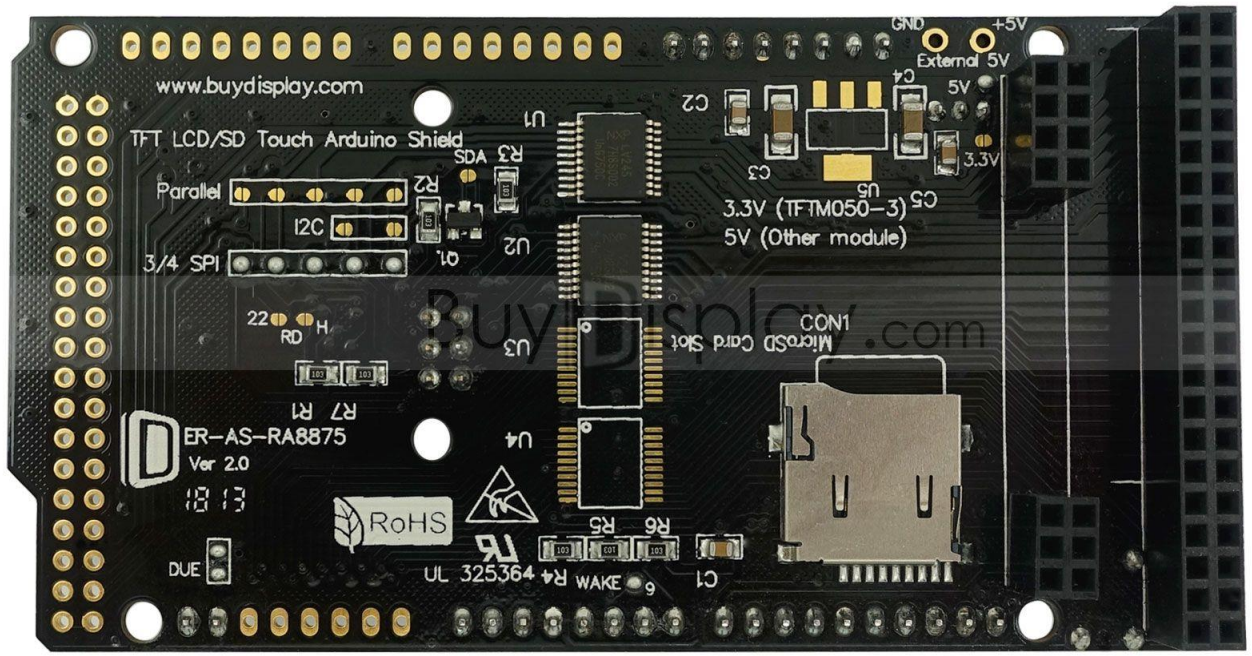



A single supply op-amp used as a unity buffer.
This makes the output swing between 0 and 3.3V centered around 1.65V.
The output from my computer has no bias so this is to make sure the whole waveform is caught.
The waveform from an audio jack is usually less than 2V.

Arduino Due operates at 3.3 and can be powered by USB.
It has a 12bit ADC – limits the resolution between 0 and 4095.
It has 96 KB of SRAM
42 MHz Clock




TFT Screen with RA8875 Controller
800*480 Pixels
This one didn't have touch capabilities
Able to work in a variety of addressing modes (SPI, I2C)
Allowed the Arduino to interface with only 14 pins.
On board microSD if you need more memory




TFT Shield to interface with the Arduino. The 14 pins on the TFT match with the shield. Various surface mount jumpers need to be soldered for proper operation.
Addressing mode
DUE
Voltage

# Code

Arduino is programmed using variant C++
Libraries were used to support FFT and TFT operations.

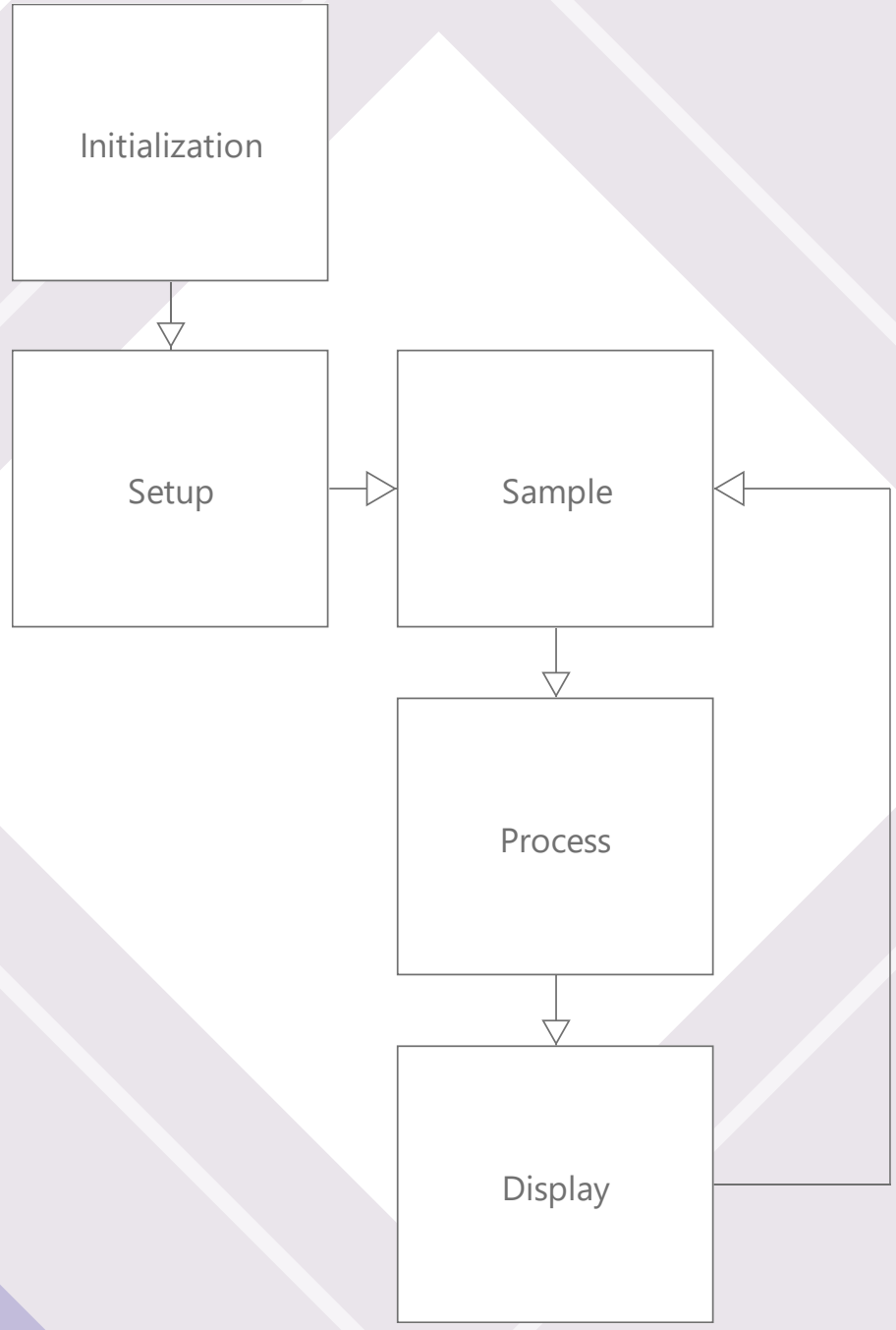
Initialization: Registers, Pin settings

Setup: Graphics, initial values

Sample: Receiving and storing signal data

Process: Performing FFT Operations

Display: Spectrogram and input display



# Sampling

- Sampling is performed by calling analogRead(pin);

- By calling analogRead Sample Frequency is limited to  12KHz. It’s possible to go up to 1MHz by using tracking mode and reading the pins directly.

- The DUE has a 12 bit ADC which means up to 4096 discrete possibilities. Frequency Ranges larger than that will have less than 1Hz of resolution. Can also operate with 10 bit ADC with 1,024 bins.

- The higher the sampling frequency, the higher the lowest frequency detectable is for the same number of samples.
  - (if the period is shorter than the sampling time)

- The number of samples has to be a power of 2. This is because root operations are performed during FFT. More samples = higher accuracy, slower response.

# Process

- FFT performed by functions provided by the library.
- Signal values are the real values
- Imaginary values are 0.
- Windowing is performed
- Magnitudes are calculated

```
/*FFT using the FFT arduino built in library, there can be
  FFT_WIN_TYP_RECTANGLE
  FFT_WIN_TYP_HAMMING
  FFT_WIN_TYP_HANN
  FFT_WIN_TYP_TRIANGLE // triangle (Bartlett)
  FFT_WIN_TYP_NUTTALL
  FFT_WIN_TYP_BLACKMAN
  FFT_WIN_TYP_BLACKMAN_NUTTALL // blackman nuttall
  FFT_WIN_TYP_BLACKMAN_HARRIS // blackman harris
  FFT_WIN_TYP_FLT_TOP // flat top
  FFT_WIN_TYP_WELCH // welch
*/
FFT.Windowing(vReal, SAMPLES, FFT_WIN_TYP_HAMMING, FFT_FORWARD);/* Weigh data */
FFT.Compute(vReal, vImag, SAMPLES ,FFT_FORWARD); /* Compute FFT */
FFT.ComplexToMagnitude(vReal, vImag, SAMPLES);/* Compute magnitudes */
peak = FFT.MajorPeak(vReal, SAMPLES, SAMPLING_FREQUENCY);
```

# TFT Screen

- The library makes it pretty straightforward
- Had to make sure I had the addressing right and the shield had the correct configuration
- (0,0) at top left corner
- Hex colours xFFFF which is RGB565.
- So I spread my bins across 31 shades of green which limits the resolution of amplitude and looks like *The Matrix*.

```
// Colors (RGB565)
#define RA8875_BLACK            0x0000
#define RA8875_BLUE             0x001F
#define RA8875_RED              0xF800
#define RA8875_GREEN            0x07E0
#define RA8875_CYAN             0x07FF
#define RA8875_MAGENTA          0xF81F
#define RA8875_YELLOW           0xFFE0
#define RA8875_WHITE            0xFFFF
```

# Variables

- Sample Size: Power of 2
- Sampling Frequency: 2 * highest desired frequency, up to 10K
- FFT Windowing Type: Rectangle, Hamming, Blackman, etc.
- Scrolling: Yes or no. Scrolling looks nice but is 50 times slower.

# Improvements

True Portability

- battery operated
- Mic circuit onboard.
- Ability to change settings on the fly (Touch screen)
- Better amplitude resolution by adding a legend and using more colours
- Saving outputs to memory card.

Questions?