

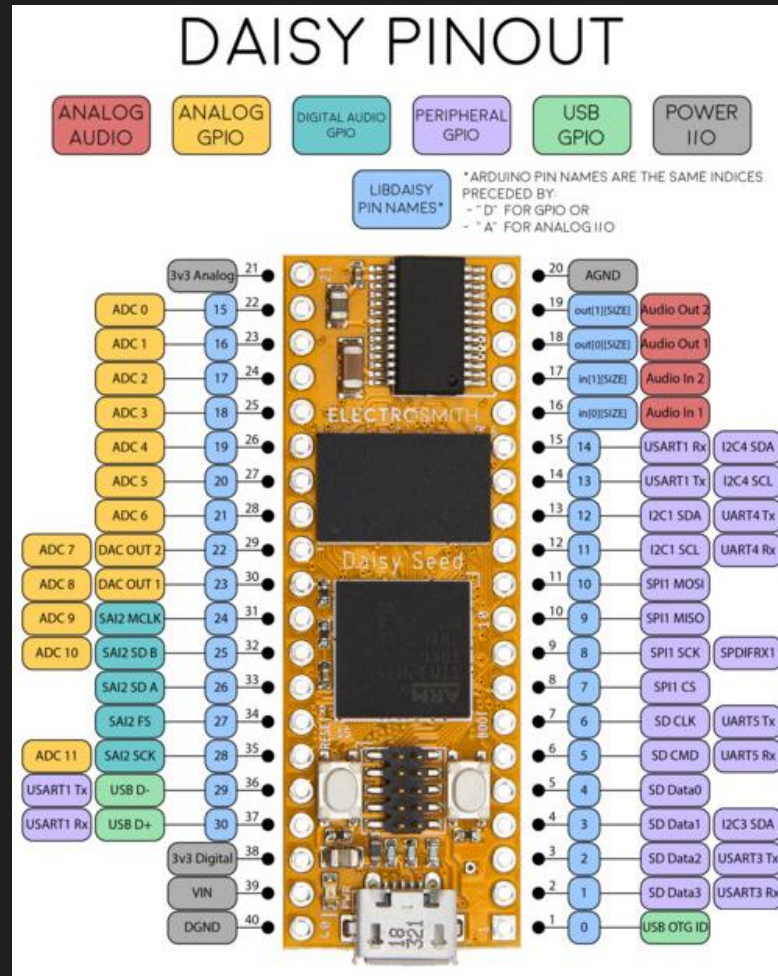
Tanahely

Digital audio processor

Tini Giorgadze

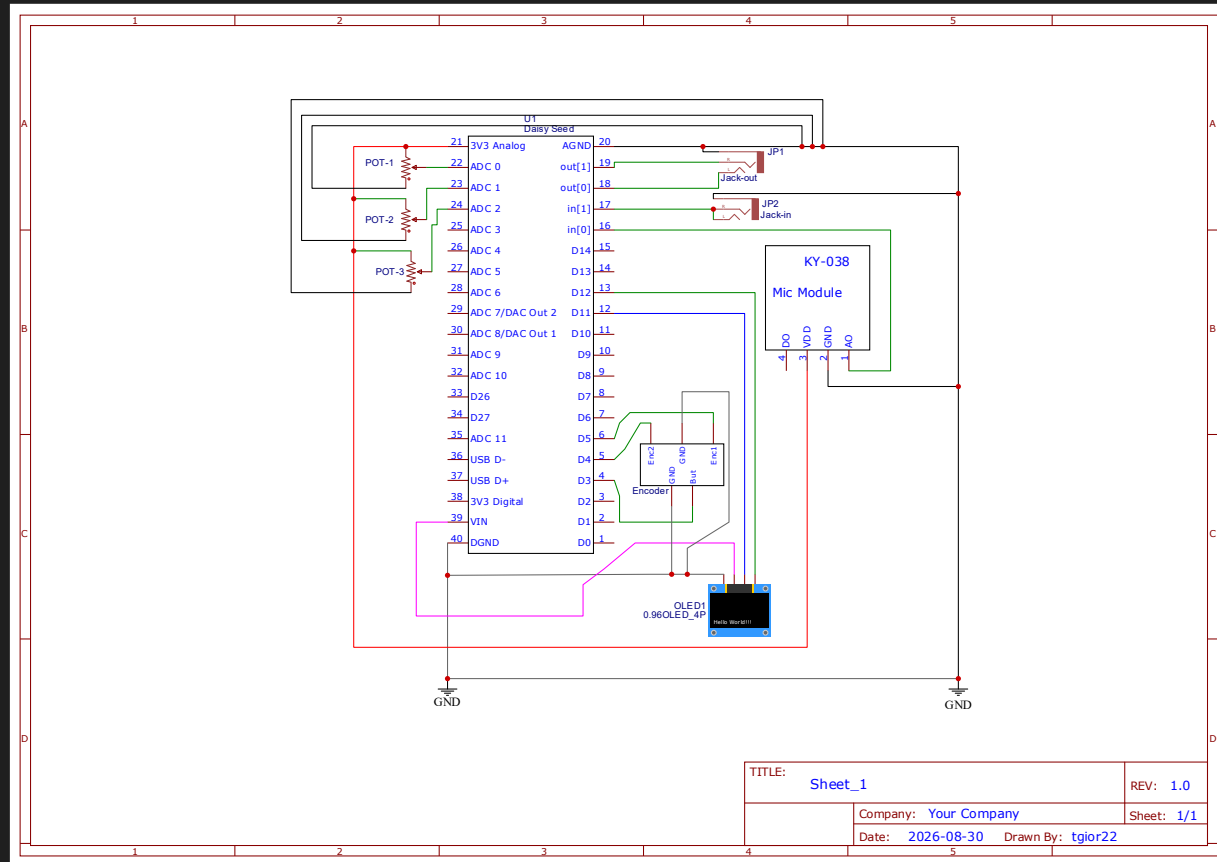
FUT

Microcontroller Board



- Stereo audio IO - 96kHz / 24-bit audio hardware (AC-Coupled)
- Programmable in: C++, Arduino, Max/MSP gen~, Pure Data
- x31 GPIO, x12 ADC inputs (16-bit), x2 DAC outputs (12-bit, DC-Coupled)
- ARM Cortex-M7 MCU, running at 480MHz
- 64MB of SDRAM for up to 10 minute long audio buffers, 8MB external flash
- SD card interface, PWM outputs, and various serial protocols for external devices (SPI, UART, SAI/I2S, I2C)
- Dedicated VIN pin for external power


```
enum FilterType {  
    AUTOPAN,  
    ROBOT_VOICE,  
    CHOPPER,  
    CHORUS,  
    BITCRUSH,  
    AUTOTUNE,  
    VOCODER,  
    REVERB,  
    ECHO,  
    PHASER,  
    CUSTOM,  
    CHAINS,  
};
```



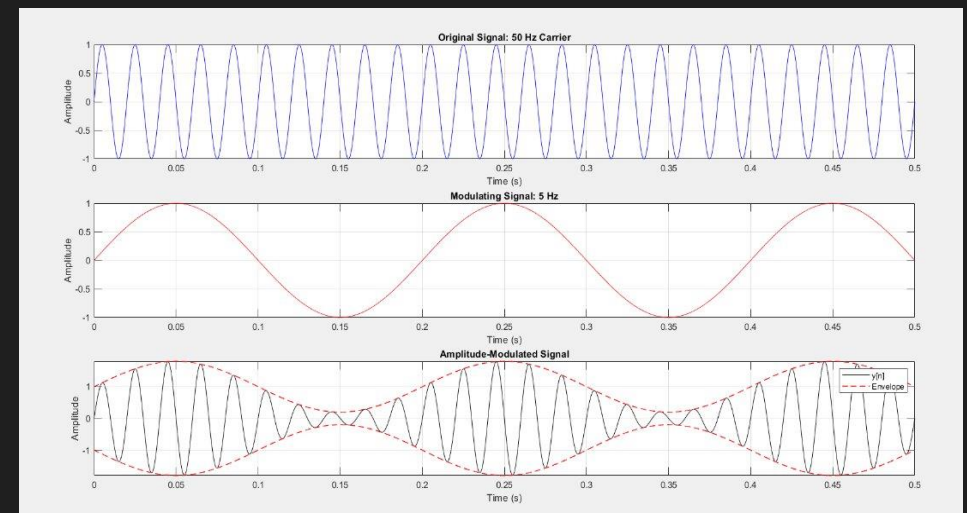
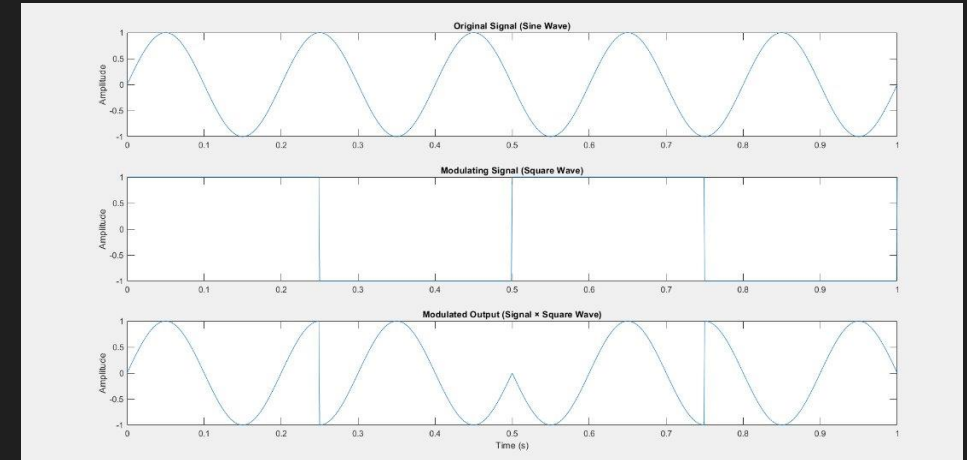
Functionality



autopan(): Applies pi-rad phase-shifted sinusoidal gain modulation directly to incoming audio channels using a low-frequency oscillator, creating a spacious effect.

robot_voice(): Applies a sine-modulation of a high frequency f , the value of which is read from an analog pin and adjusted using a potentiometer.

chopper(): Applies a square-wave modulation of a low frequency f , the value of which is read from an analog pin and adjusted using a potentiometer.

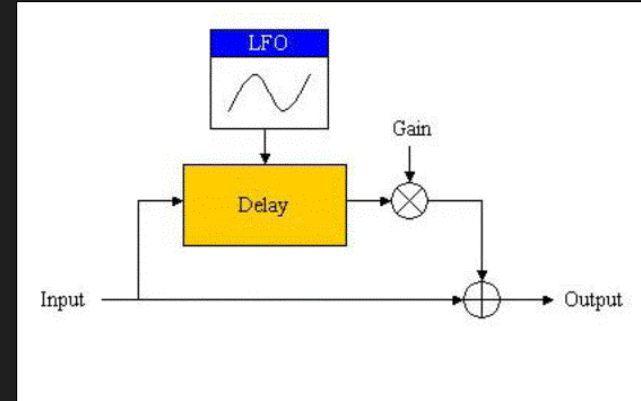


Functionality



chorus() - duplicates the input, delays it by a short time, slightly modulates its pitch using a low-frequency oscillator, and blends the copies back with the original.

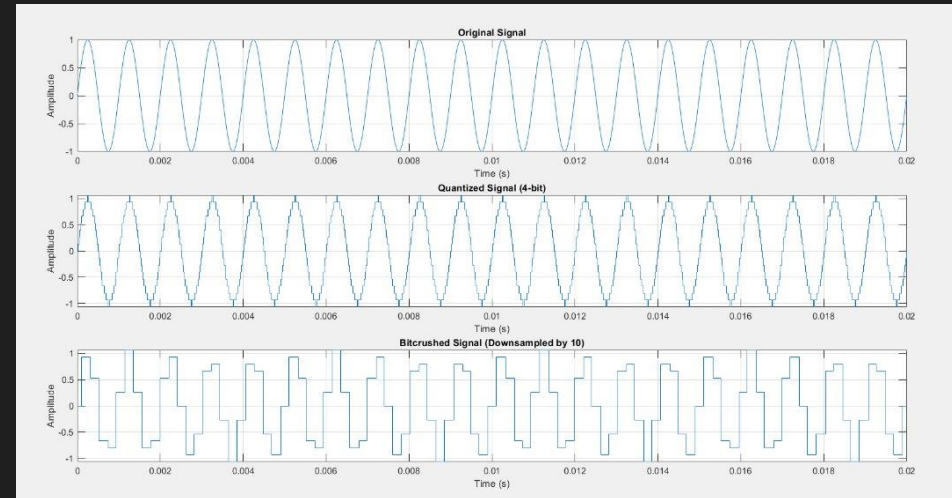
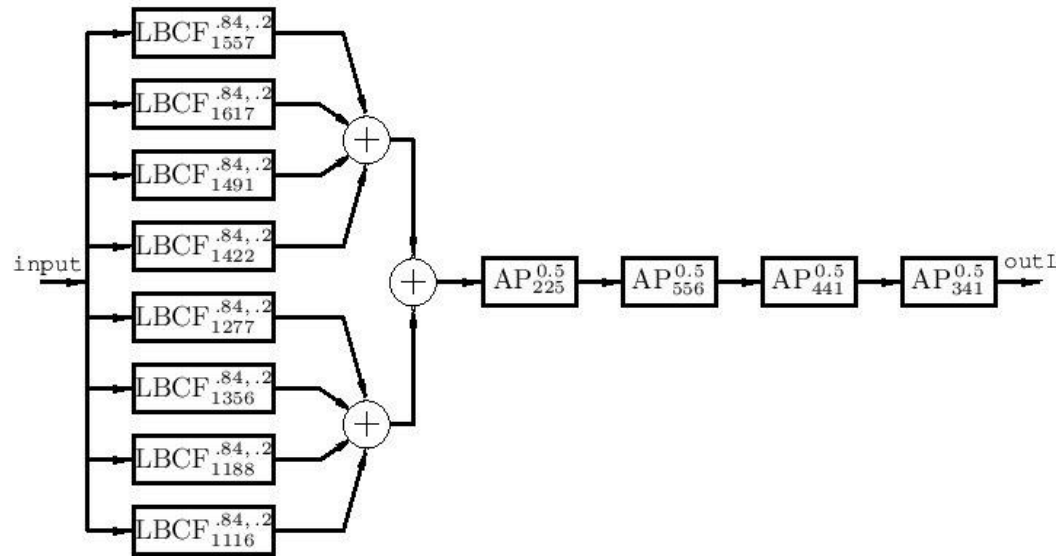
autotune() - detects the resonant freq of your voice, calculates the distance toward the nearest musical note, sine-modulates the input to shift it to the target freq, and mixes the result with some of the original signal.



Functionality



bitcrush() - down-samples the input signal by 10 and quantizes it by 8 bits



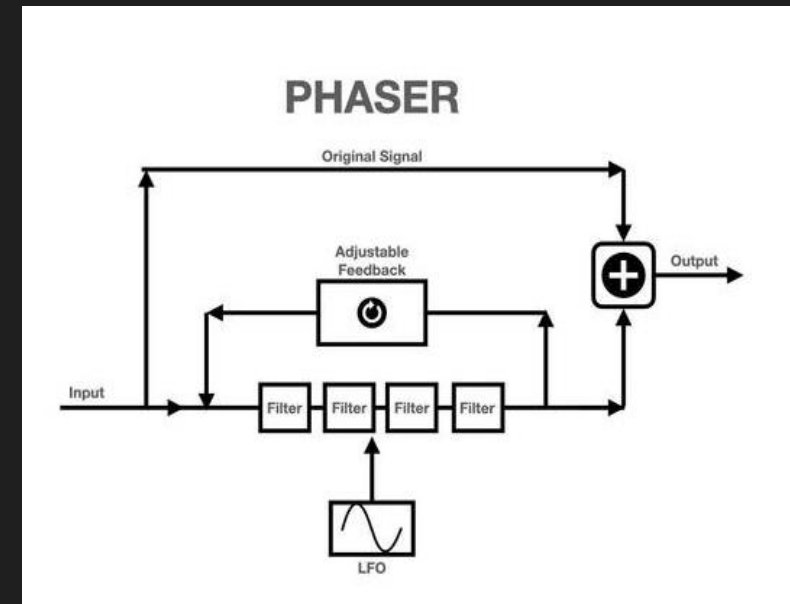
reverb() - a classic **Schroeder/Moorer Reverb architecture** (Parallel Low-Pass Comb Filters followed by Series All-Pass Filters)

Functionality



echo() - creates an echo effect by mixing the current audio with a delayed version of it, storing the result in a circular buffer, and sending the combined signal to both outputs

phaser() - creates a phaser effect by passing the audio through multiple all-pass filters with varying coeffs, using an LFO to vary their frequencies, then mixing the processed signal with the original and adding feedback.



$$H_{ap}(z) = \frac{z^{-1} - a^*}{1 - az^{-1}}$$

Custom filter class in C++ : biquad

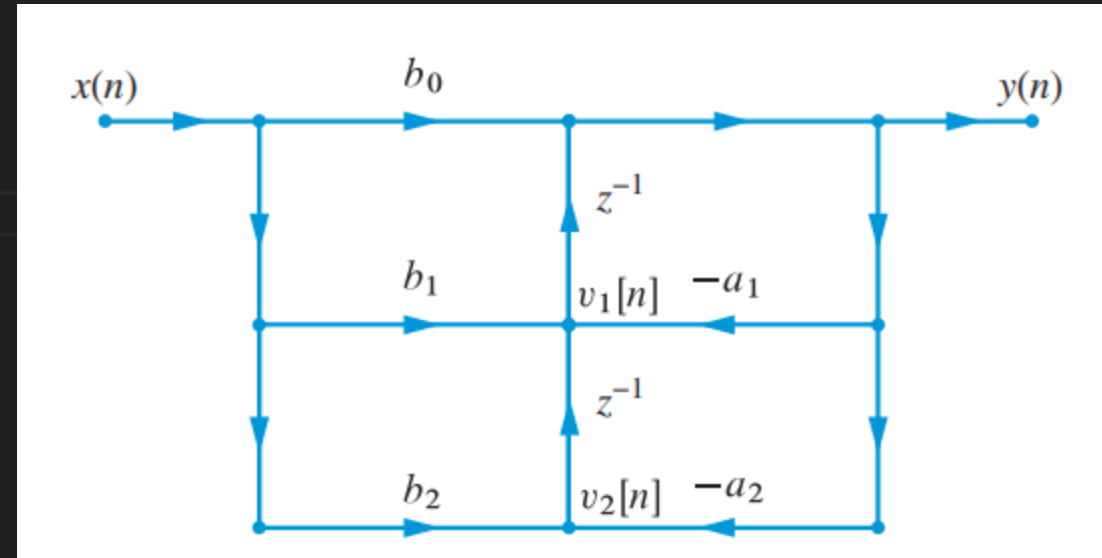


```
//The sos matrix is [b0,b1,b2,a0,a1,a2]
```

```
Biq::Biq(const std::vector<float>& sos2, float gain) {  
    a0 = sos2[3];  
    b0 = (sos2[0] * gain) / a0;  
    b1 = (sos2[1] * gain) / a0;  
    b2 = (sos2[2] * gain) / a0;  
    a1 = sos2[4] / a0;  
    a2 = sos2[5] / a0;  
    w1_prev = 0.0f; //w1[n-1]  
    w2_prev = 0.0f; //w2[n-1]  
}
```

```
//The equations would be  
//w2[n]=b2*x[n]-a2y[n];  
// w1=w2[n-1]+b1x[n]-a1y[n];  
// y[n]=b0x[n]+w1[n-1]
```

```
float Biq::process(float x) {  
  
    float y = b0 * x + w1_prev;  
    float w1 = w2_prev + b1 * x - a1 * y;  
    float w2 = b2 * x - a2 * y;  
  
    //update middle signals  
    w1_prev=w1;  
    w2_prev=w2;  
  
    return y;  
}
```



Custom filter class : an AI app



TONE4

Enter Sound Description

old cassette-player effect

Send Filter to Daisy Seed

Filter Details

Type: LOWPASS
Cutoff: 5500.0 Hz
Order: 10
AI Notes: Reduces high-frequency clarity, typical of older cassette recordings.

Type: HIGHPASS
Cutoff: 180.0 Hz
Order: 10

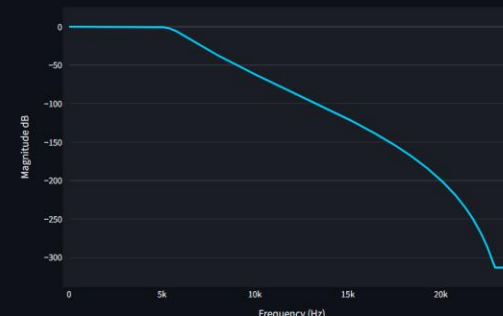
Effect Details

Effect: SINE_MODULATION
• frequency: 0.8
• depth: 0.07

Effect: BITCRUSH
• bits: 10
• sample_rate: 8000

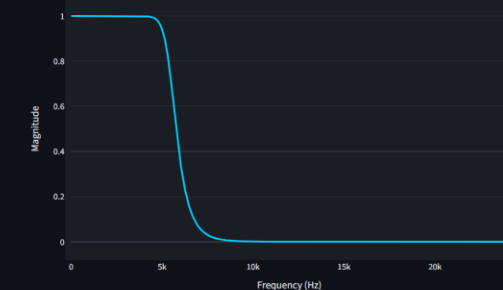
Filter Visualization

Magnitude (dB)



Filter Visualization

Magnitude (Linear)



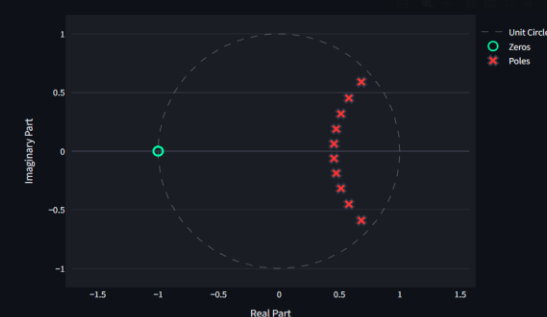
Filter Visualization

Phase



Filter Visualization

Pole-Zero



Custom filter class : an AI app



TONE

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old cassette-player effect

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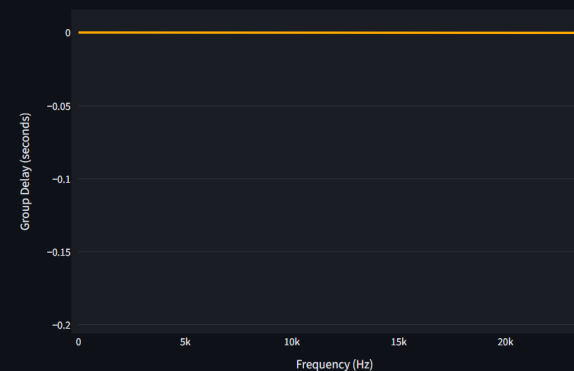
Effect Details

Effect: SINE_MODULATION
• frequency: 0.8
• depth: 0.07

Effect: BITCRUSH
• bits: 10
• sample_rate: 8000

Filter Visualization

Group Delay



SOS Matrix Data

	b0	b1	b2	a0	a1	a2
0	0.000005	0.00001	0.000005	1	-0.9106	0.2112
1	1	2	1	1	-0.9472	0.2599
2	1	2	1	1	-1.0255	0.364
3	1	2	1	1	-1.1573	0.5392
4	1	2	1	1	-1.3631	0.813