Equalization Basics

TI Precision Labs – Audio Fundamentals

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What is Equalization?

- Process of flattening a frequency response
- Originally used on telephone lines
- Now means any intended manipulation of a frequency response
- Useful in audio applications for either a technical or musical goal

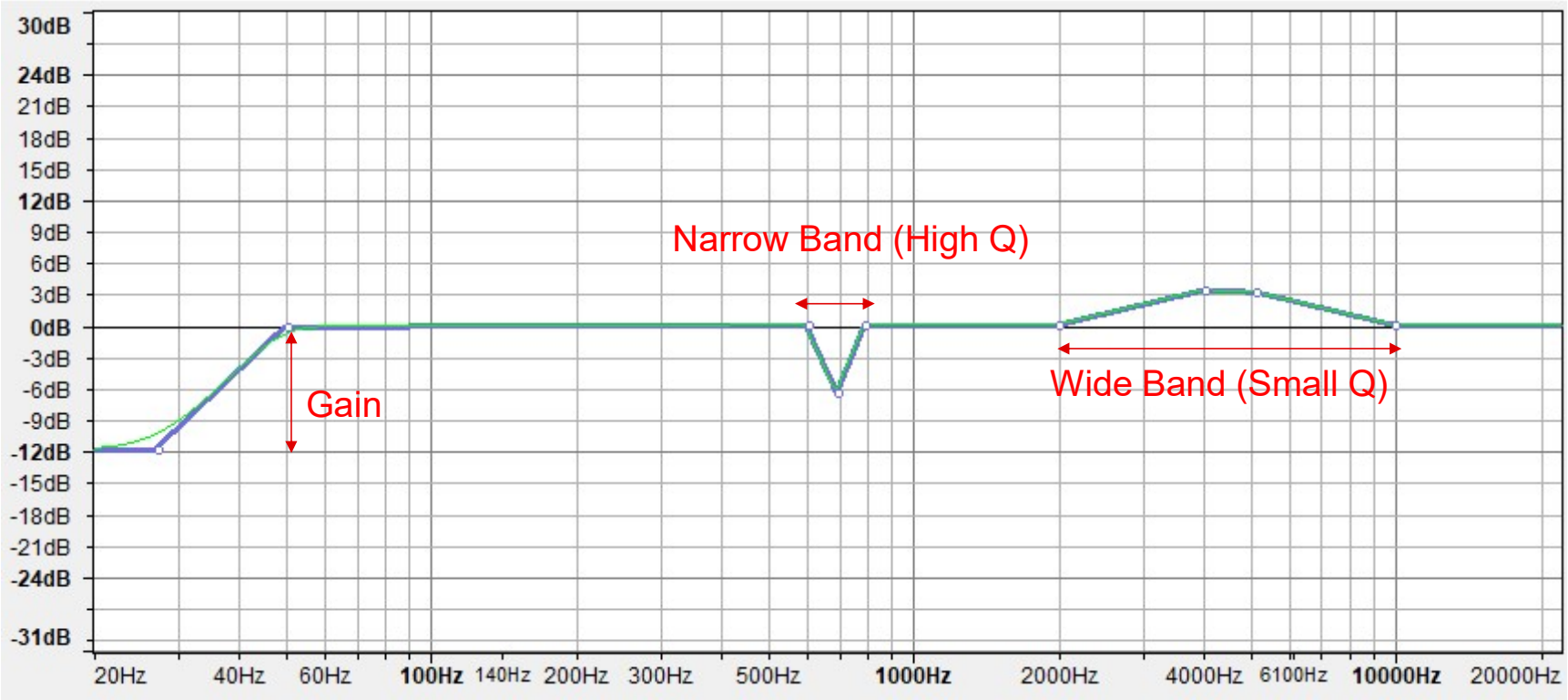
Equalization Terminology

- EQ
  - Shorthand for Equalization
- Frequency domain
  - The plot of frequency vs amplitude; all equalization happens here
- Band
  - A specific region/group of frequencies to be manipulated
- Gain
  - How much a band is increased or reduced in volume/amplitude
- Q (Quality Factor)
  - How steep the transition is from the center of the band to the outside of the band

Equalization Terminology

- Low Pass
  - Filter type that only allows frequencies that are lower than a given threshold to pass
- High Pass
  - Filter type that only allows frequencies that are higher than a given threshold to pass
- Band Pass
  - Filter type that only allows frequencies that are within a given range to pass
- Low/High Shelf
  - Filter type that has a frequency roll off that doesn't go on forever, like the high/low pass filters do

Equalization Visualized

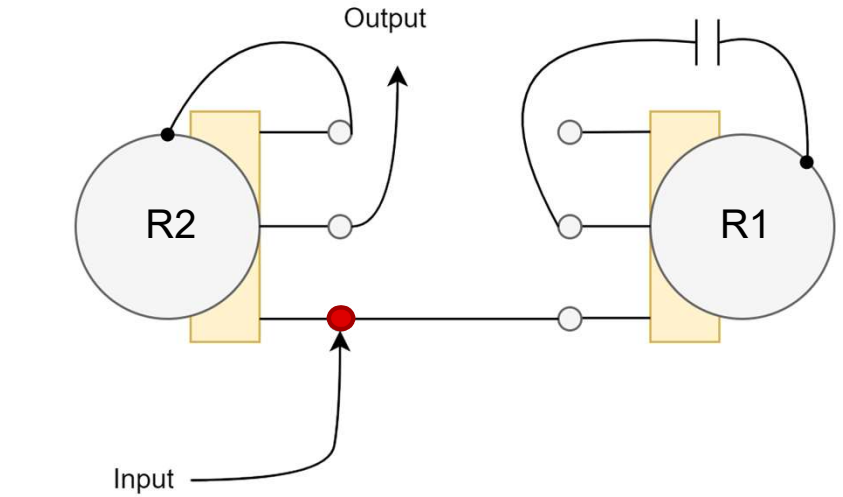


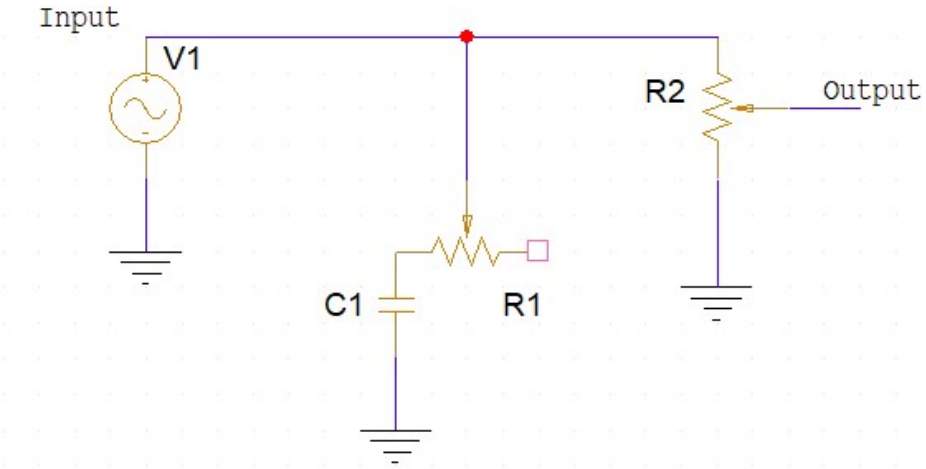
Analog Equalization

- Cascading LRC filters or other passive components
- Op Amps provide gain as an alternative to passive EQ
- Good for if you know the desired response ahead of time
- Potentiometers allow some flexibility based on use case

Analog Equalization

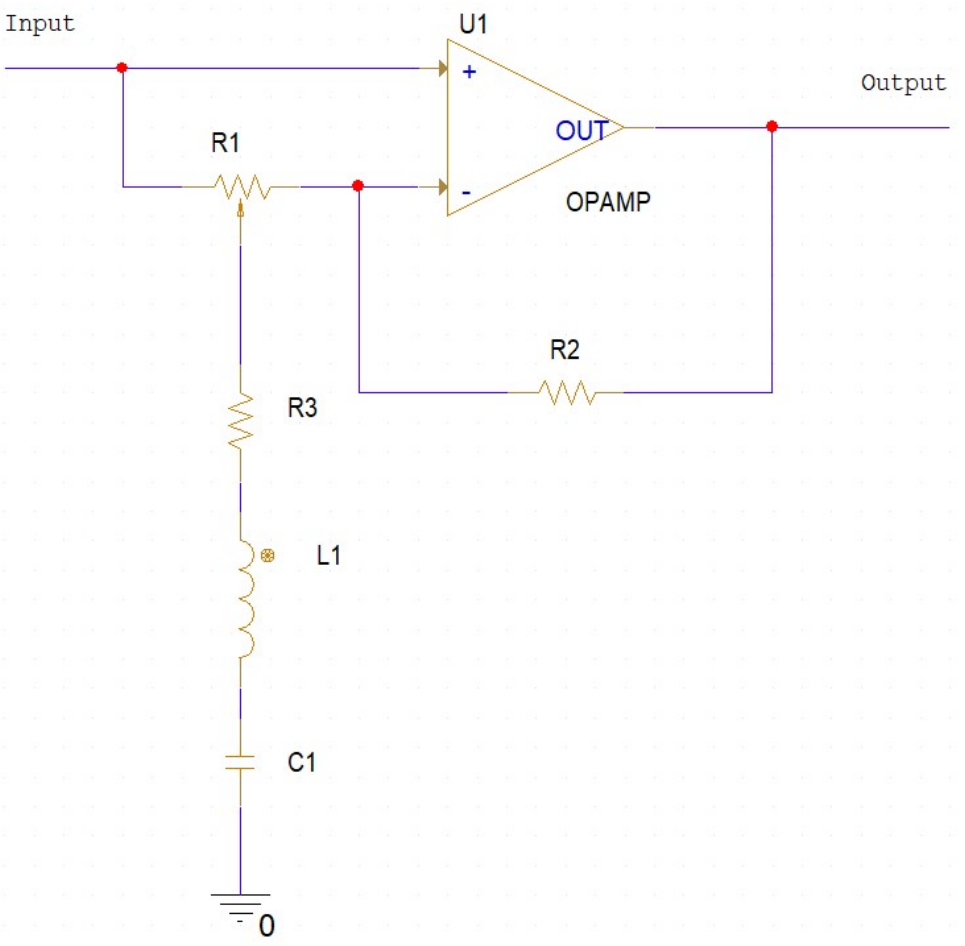
- EQ can be done with only passive components (“subtractive EQ”)
- Simple example is the tone control on an electric guitar
- Capacitor acts as a high-pass shunt that is tapered by the potentiometer, resulting in a variable low pass filter





Analog Equalization

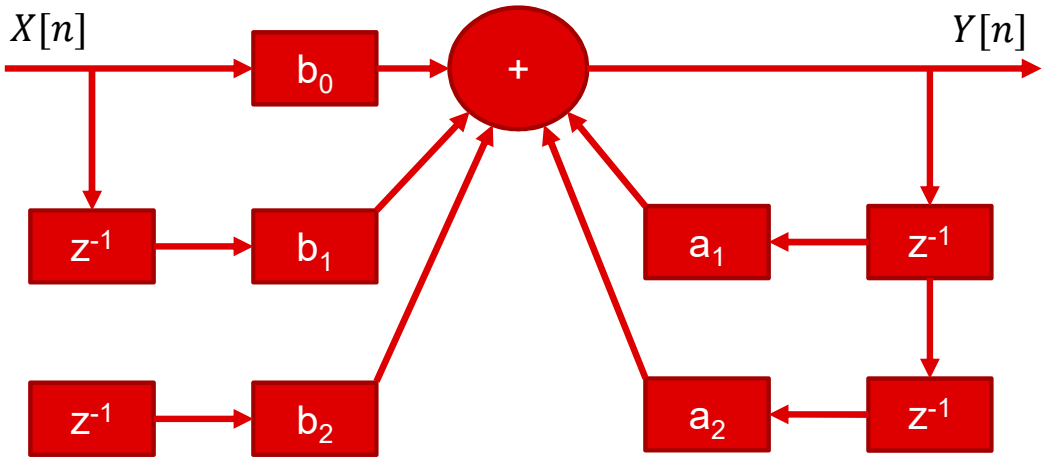
- When RLC path is swung left, resonant frequencies shunt to ground (cut)
- When RLC path is swung right, resonant frequencies have higher gain
- Can be repeated in parallel to achieve multiple bands



Digital Equalization

- Biquad filters (IIR) are a very common way to implement digital filtering due to less number of operations being required

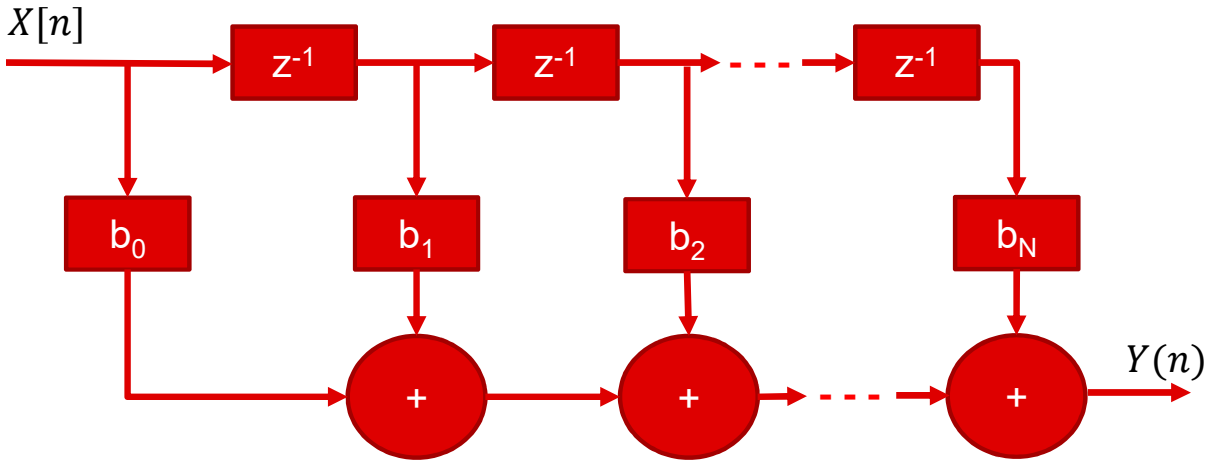
$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{1 + a_1 z^{-1} + a_2 z^{-2}}$$



Digital Equalization

- FIR filters are also a very common way to implement digital filtering due to their linear phase response

$$y[n] = \sum_{i=0}^{N} b_i * x[n-i]$$



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Digital Equalization

FIR		IIR	
Pros	Cons	Pros	Cons
• Linear Phase Response • Stability • Generally Simpler to design	• Memory Intensive • Higher Latency	• Memory Efficient • Lower Latency • Better approximation for analog filters	• Susceptible to Quantization Error • Unstable • Non-Linear Phase Response

Digital Equalization

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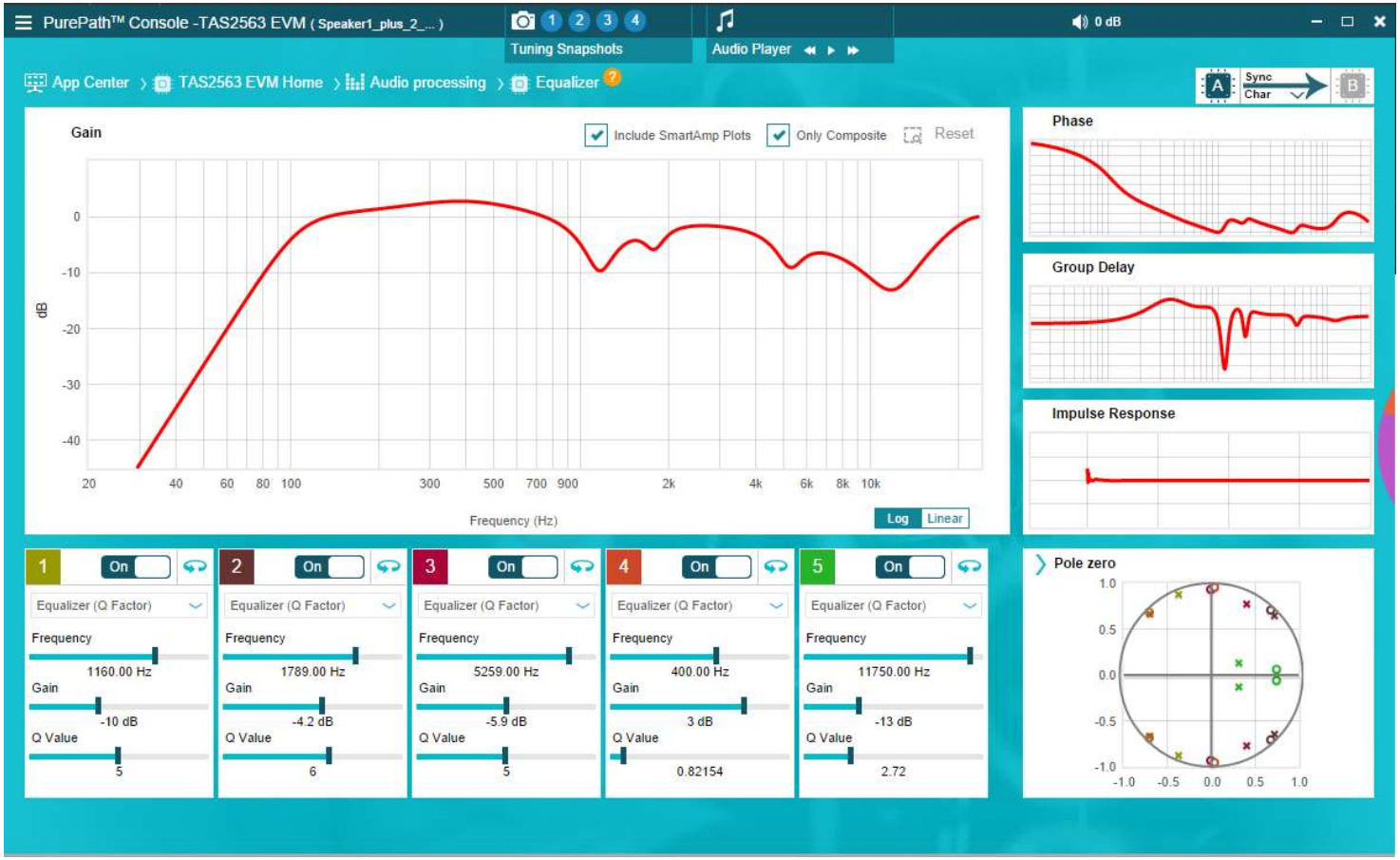
Digital Equalization



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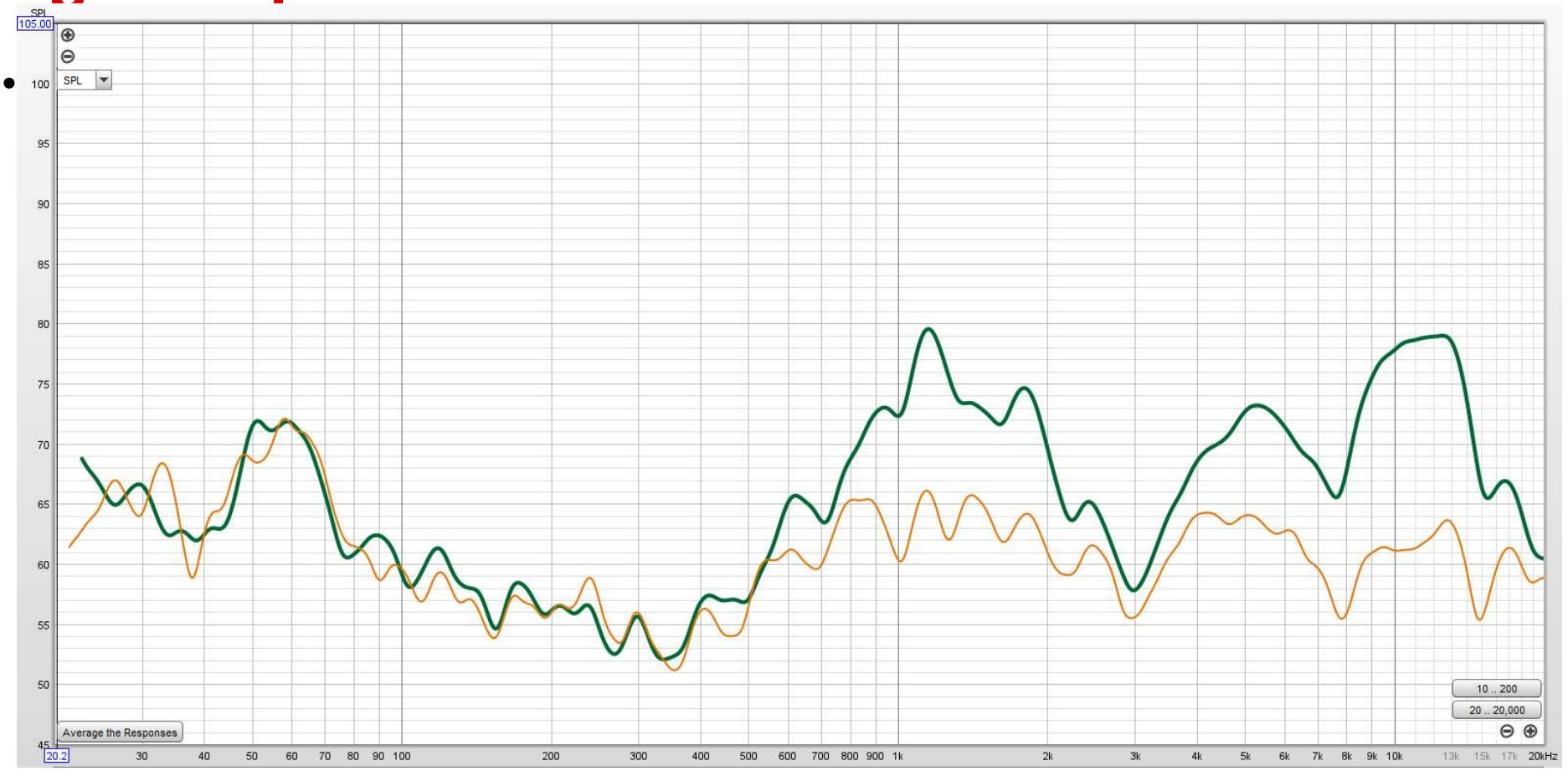
Digital Equalization



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Take Aways

- Equalization (Analog or Digital) is a powerful tool over the frequency domain
- There are many ways to implement filtering, judge based on your use case
- Don’t forget about phase

- To find more Audio technical resources and search products, visit https://www.ti.com/audio-ic/overview.html.