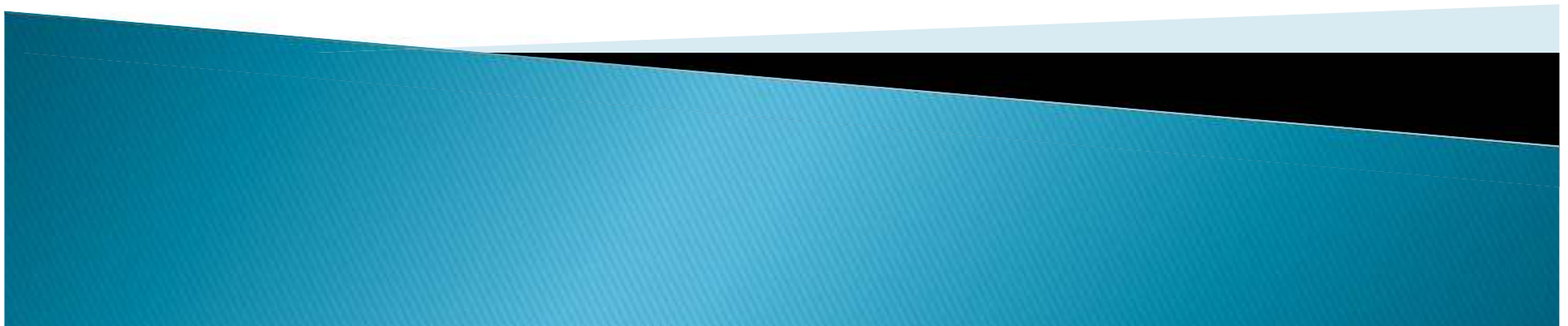


# Superhet Receiver Theory

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Presented 6/22/19



# Background

- ▶ A very large percentage of radio receivers in use today utilize mixers to translate the radio signal from the RF spectrum to a lower frequency that can be optimized for signal amplification and bandpass filtering
- ▶ Musicians are well aware of “beat frequencies” when they try to tune their instruments to others in their ensemble
- ▶ Two tones of 1000Hz and 1010 Hz are mixed in this embedded audio wave file, yielding a beat frequency of 10Hz



# Wave File View

1000Hz\_mixer\_mono

File Edit View Transport Tracks Generate Effect Analyze Help

Click to Start Monitoring

MME Microphone (3- USB Audio 2 (Stereo) Recor Speakers (3- USB Audio De

-1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

1000Hz\_mi 1.0  
Stereo, 44100Hz  
32-bit float  
Mute Solo  
L R

Project Rate (Hz): 44100 Snap To: Off Selection Start: 000,000 seconds End Length Audio Position: 000,000 seconds

Stopped. Click and drag to select audio, Ctrl-Click to scrub, Ctrl-Double-Click to scroll-scrub, Ctrl-drag to seek

## Background (2)

- ▶ The beat frequency is slowest when the two frequencies are nearly the same
- ▶ Radio Frequency mixers behave in the same way but the frequencies are not nearly so close together
- ▶ A trigonometric identity defines the behavior:  
$$\cos(f_1 * t) * \cos(f_2 * t) = \frac{1}{2} ( \cos((f_1 + f_2) * t) + \cos((f_1 - f_2) * t) )$$



# History

- ▶ Major Howard Armstrong filed (1917) and was granted a patent in 1919 for the super(sonic) heterodyne radio receiver
- ▶ He was hired by RCA in the early 1920s to create the first commercial, mass-produced implementation
- ▶ The first broadcast band receiver implementations created an intermediate frequency (IF) of  $\sim 45\text{K Hz}$



# Current Implementations

- ▶ Modern broadcast band AM radios use an intermediate frequency of 455KHz
- ▶ Modern broadcast band FM radios use an IF frequency of 10.7MHz
- ▶ All RF receivers in use today except for direct sampling SDRs use the superhet technique



# Additional Information

<https://www.youtube.com/watch?v=Mm7WfVzr1ao>

<https://www.youtube.com/watch?v=JuuKF1RFvBM>

<https://www.youtube.com/watch?v=7eTfF67Ka5w>

<https://www.youtube.com/watch?v=-3IXAunoZps>

