Optical Transmission of Sound Using an Incandescent Lamp

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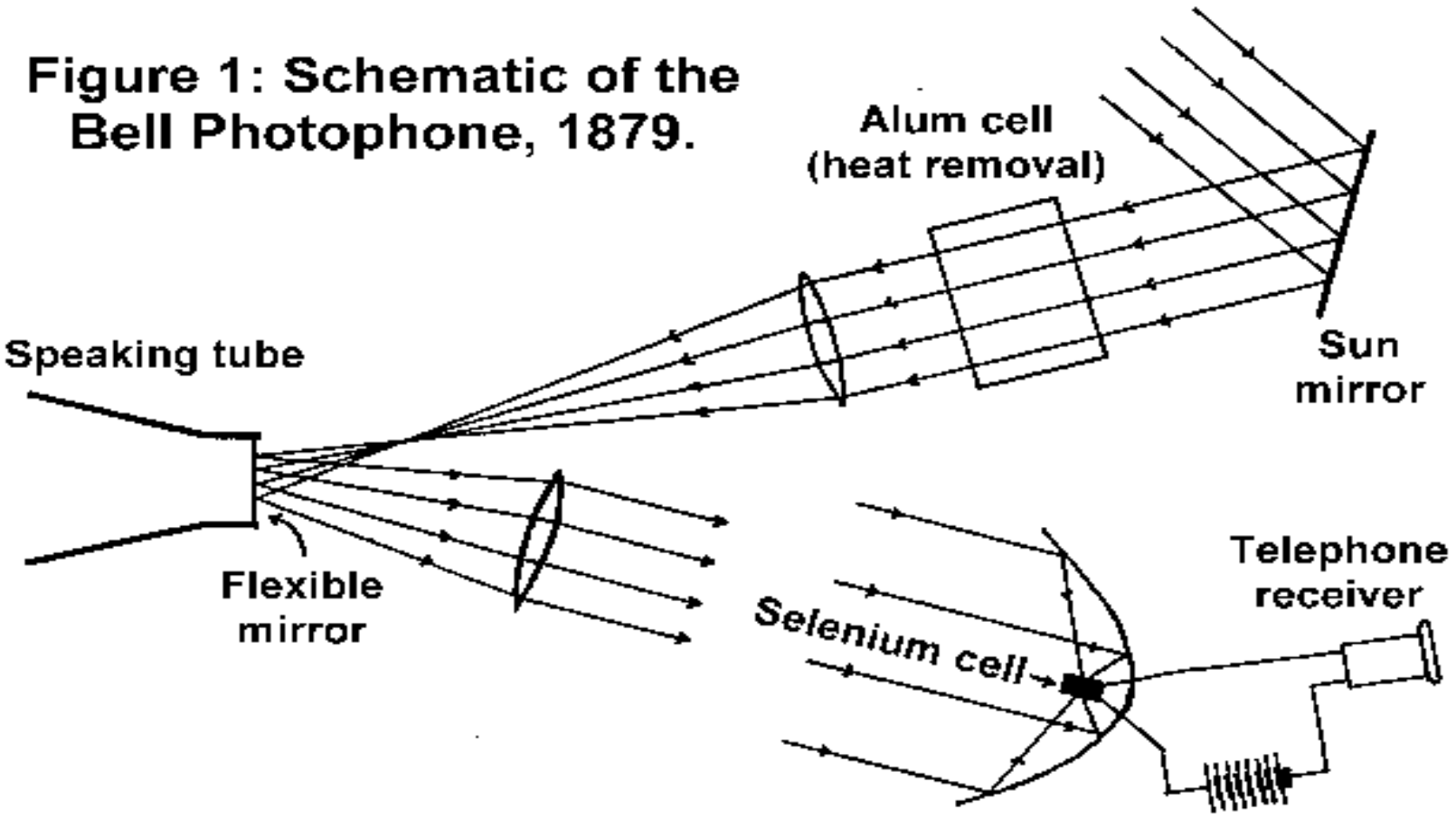
Introduction

- Use of light in open space to transmit sound is not new.
- “Photophone” 1870, Alexander Graham Bell considered this to be his greatest invention.
- Wanted to name his daughter *Photophone.*

External Modulation



• During WWII, US and German navies developed current modulated, high pressure vapor lamps for ship to ship communications.

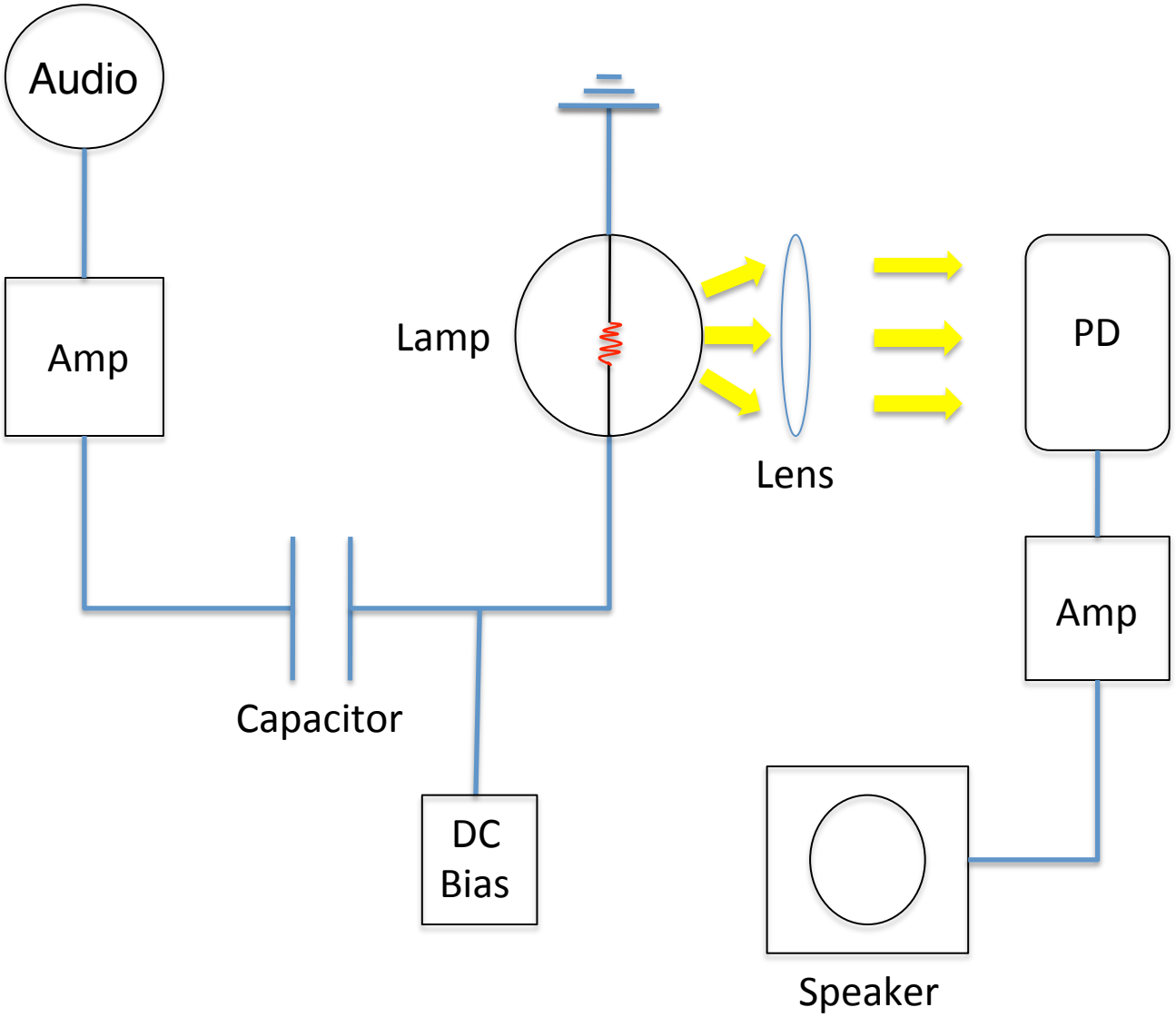
• Military work continued on arc lamps until ca. 1950.

• Amateur work on tungsten lamps produced “low quality” speech transmission until ca. 1970, when LED’s became available.

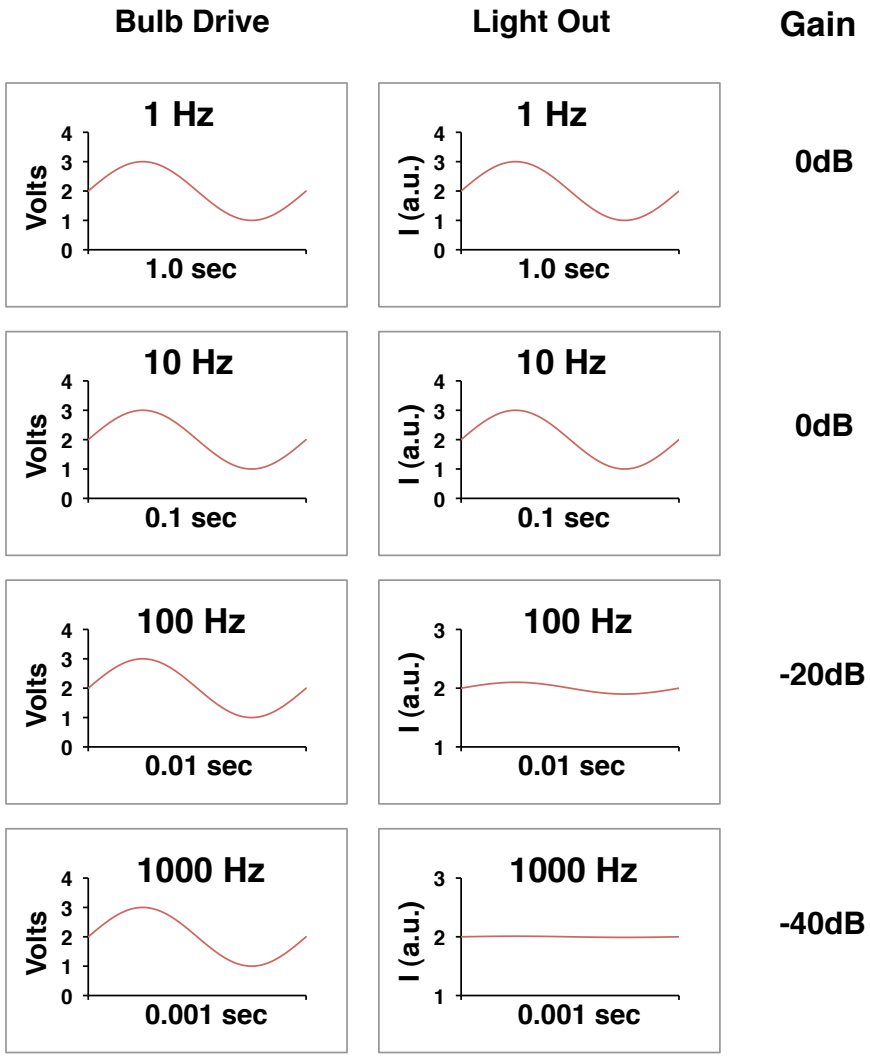
My Project

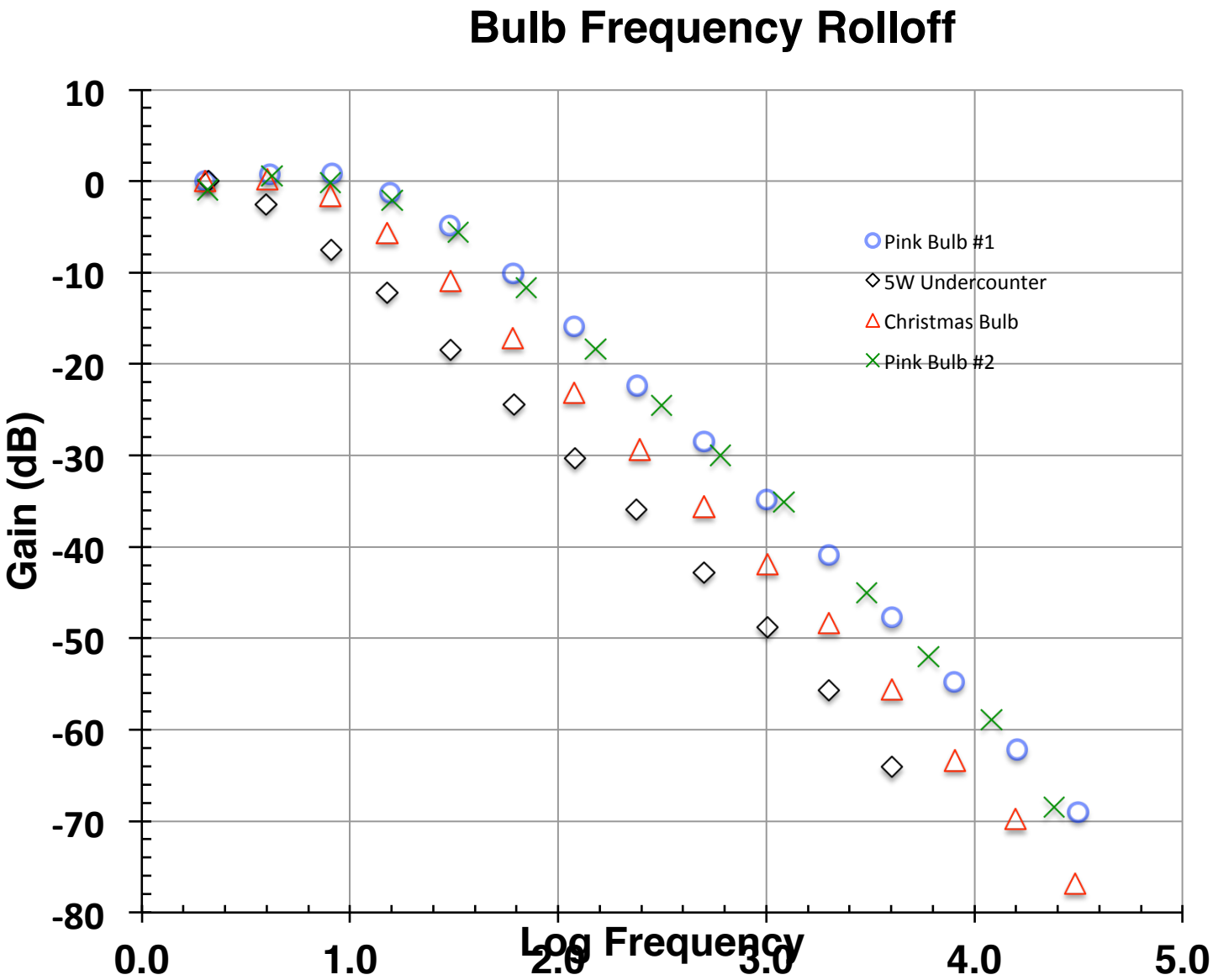
- Revisit direct modulation of tungsten filament lamps.
- Characterize acoustic bandwidth.
- Optimize transmission quality.
- Understand underlying physics.
- Propose possible applications.

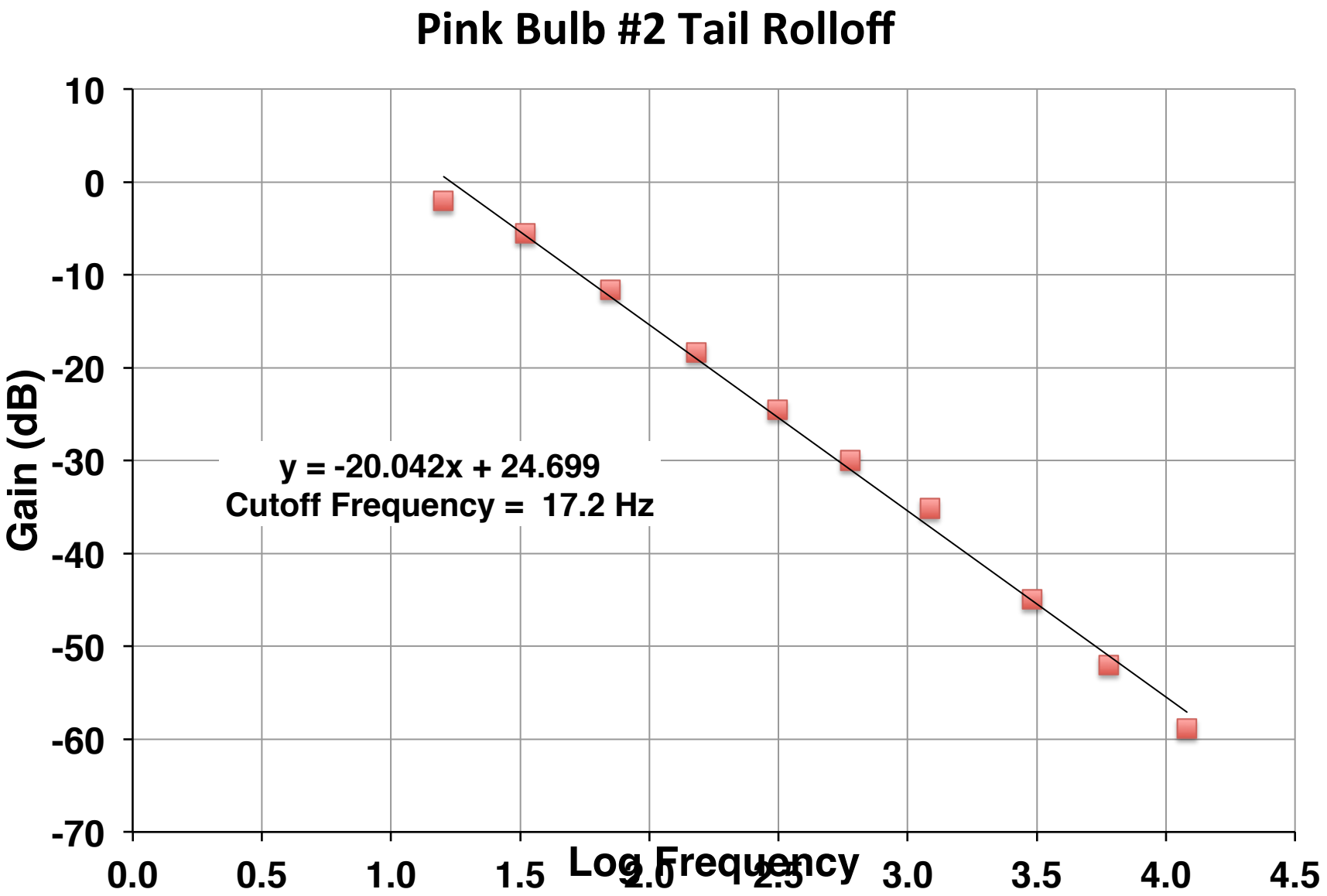
Experimental Setup



Bandwidth Issues




Bulb Frequency Rolloff
10
0
-10
-20
-30
-40
-50
-60
-70
-80
Gain (dB)
0.0
1.0
2.0
3.0
4.0
5.0
Log Frequency
Pink Bulb #1
5W Undercounter
Christmas Bulb
Pink Bulb #2


Pink Bulb #2 Tail Rolloff
10
0
-10
-20
-30
-40
-50
-60
-70
Gain (dB)
y = -20.042x + 24.699
Cutoff Frequency = 17.2 Hz
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Log Frequency

20 dB per decade (6 dB per octave) doesn't sound so bad!

Every 10 dB sounds like only 2X in loudness.

Easily compensated with treble and bass controls.

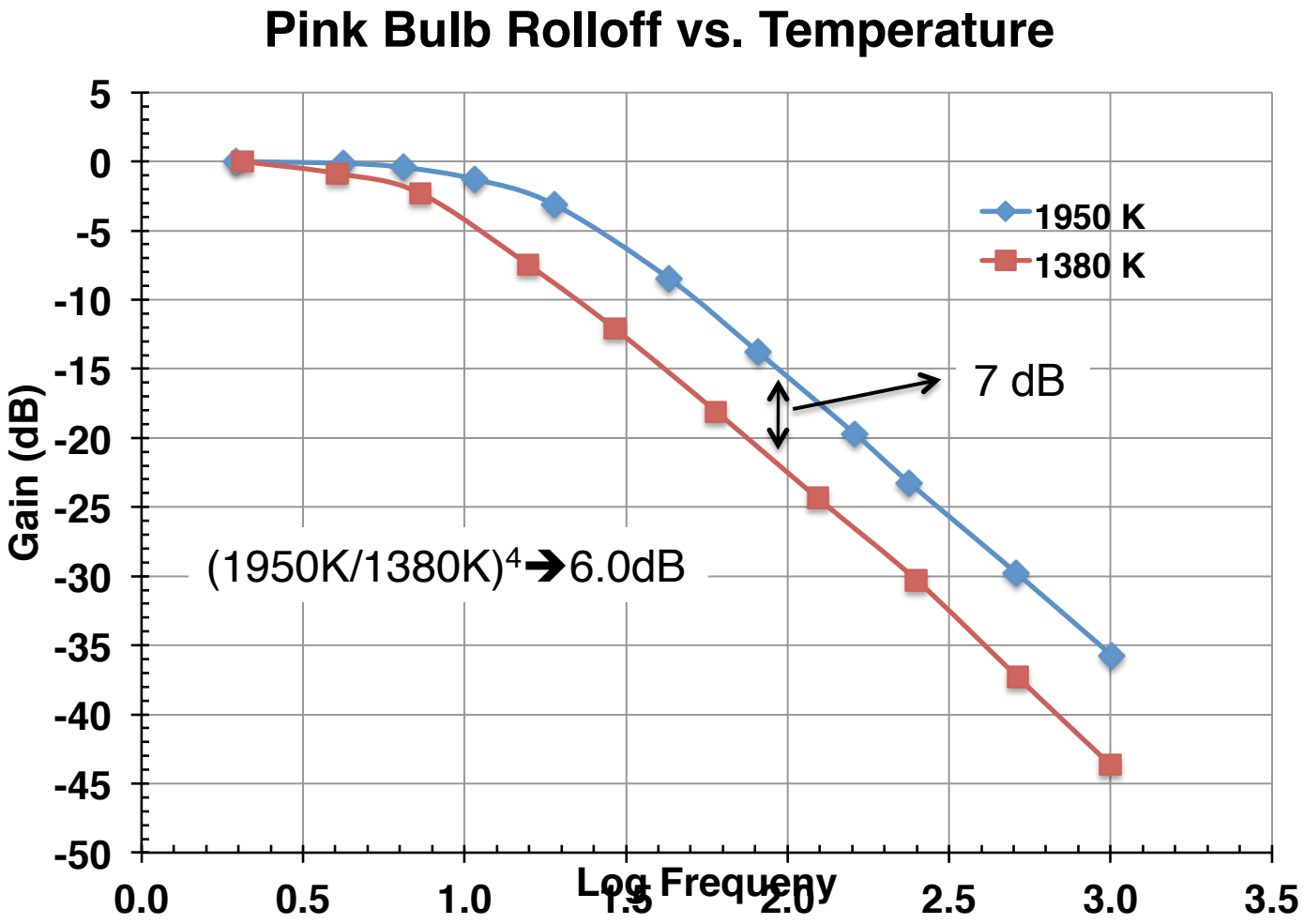
Enjoying the Music

Effects of Filament Temperature

Stefan-Boltzmann Law for Blackbody Radiation

$$P = Ae\sigma T^4$$

$$P/P' = (T/T')^4$$


Pink Bulb Rolloff vs. Temperature
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Gain (dB)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Log Frequency
1950 K
1380 K
7 dB
(1950K/1380K)4➔6.0dB

Conclusions

- It is possible to current modulate a low-wattage incandescent lamp at audio frequencies and obtain high quality sound.

- The high frequency rolloff depends on the thermal nature of the modulation, and is expected to be the same for all filaments.

- The cutoff frequency and modulation efficiency is however directly related to the thermal mass of the filament and the filament temperature.

Possible Applications

- Distributed audio in the home using preexisting lamps and fixtures.

- Inter-vehicular communication. Safety or identification codes could be broadcast over headlights of cars, planes or trains.

- Espionage (Bond, James Bond, ..007).

- Non-contact heat flow analysis in complex objects.

VOLB

Voice Over Light Bulb