4.Modify filter\_16.py to avoid run-time overflow errors even if gain is very high, by clipping the signal as necessary. To do this, insert an if statement to verify that the sample value is in the allowed range. If it is not, then set the value to its maximum (positive or negative) allowed value, before writing it to the audio stream. Test your program by setting the gain to a high value. What effect does this have on the sound produced by the program?

**Python code: 4.py**

from math import cos, pi

import pyaudio

import struct

# Fs : Sampling frequency (samples/second)

Fs = 8000

# Also try other values of 'Fs'. What happens? Why?

# Fs = 16000

# Fs = 32000

# Fs = 5000

T = 1 # T : Duration of audio to play (seconds)

N = T\*Fs # N : Number of samples to play

# Difference equation coefficients

a1 = -1.9

a2 = 0.998

# Initialization

y1 = 0.0

y2 = 0.0

gain = 10000.0

# Also try other values of 'gain'. What is the effect?

# gain = 1000.0

# Create an audio object and open an audio stream for output

p = pyaudio.PyAudio()

stream = p.open(format = pyaudio.paInt16,

channels = 1,

rate = Fs,

input = False,

output = True)

# paInt16 is 16 bits/sample

# Run difference equation

for n in range(0, N):

# Use impulse as input signal

if n == 0:

x0 = 1.0

else:

x0 = 0.0

# Difference equation

y0 = x0 - a1 \* y1 - a2 \* y2

# Delays

y2 = y1

y1 = y0

# Output

output\_value = gain \* y0

if output\_value > 2\*\*15-1:

output\_value = 2\*\*15-1

elif output\_value < -2\*\*15:

output\_value = -2\*\*15

output\_string = struct.pack('h', int(output\_value)) # 'h' for 16 bits

stream.write(output\_string)

print("\* Finished \*")

stream.stop\_stream()

stream.close()

p.terminate()

**Comment:**

From the python code we can see output value is equal to y0 multiply gain. When the wav file is set as 16 bits/sample, it is means signed 16 bits. The rank of the output is from -215 to 215-1. If the output value more than or less than this rank the code will be error for overflow. After put the if loop in the code, the overflow part will be set to the max or min which could clip the signal and make the sound could not be changed when it reach the peak or bottom.