

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  $y_0$  multiply gain. When the wav file is set as 16 bits/sample, it means signed 16 bits. The rank of the output is from  $-2^{15}$  to  $2^{15}-1$ . 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.