Fourier Analysis of AC-DC convertion used in stereo amplifier

Raktim Gautam Goswami and Abhishek Bairagi

***Abstract*—In this manual we will be showing the fourier analysis of the AC - DC conversion used in the stereo amplifier.**

1 Ac To Rectified Ac Conversion

Problem 1.1. Type the following code in python to draw plot the expected rectified sinusoidal output.

```
import numpy as np
import matplotlib.pyplot as plt

A = 16
x = np.linspace(-0.01*np.pi, 0.01*
    np.pi,100000)

y = np.absolute(A*np.sin(2*np.pi
    *50*x))

plt.plot(x,y)
plt.ylabel("Rectified Output")
plt.xlim(-0.01*np.pi, 0.01*np.pi)
plt.xlabel("Time")
plt.grid()
plt.show()
```

Solution: The output is as shown in the Fig. 1.1

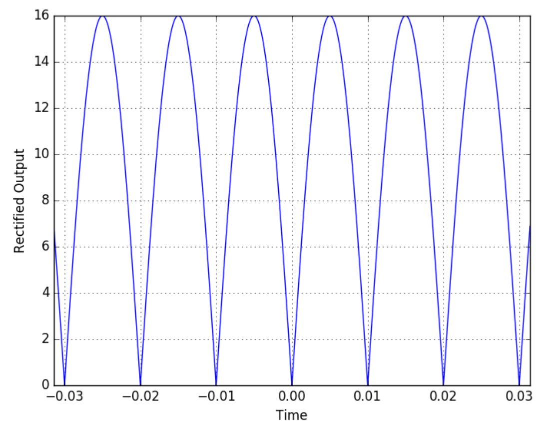

Fig. 1.1: Expected Rectified Wave

2 Fourier Analysis

Problem 2.1. Find the frequency and amplitude of the not rectified wave.

Solution: The frequency is 50 Hz and amplitude is approximately 16 V.

Problem 2.2. The following expression

$$g(t) = \sum_{n=0}^{\infty} a_n \cos 2\pi n f t + b_n \sin 2\pi n f t \tag{2.2.1}$$

is known as the Fourier series expansion of $g(t)$, where $f = \frac{1}{T}$. Find

$$a_n = \frac{2}{T}\int_0^T g(t)\cos 2\pi n f t\, dt \tag{2.2.2}$$

$$b_n = \frac{2}{T}\int_0^T g(t)\sin 2\pi n f t\, dt \tag{2.2.3}$$

Using this find the fourier series coefficients of the rectified outputs.

Solution:

$$a_0 = \frac{2A}{\pi} \tag{2.2.4}$$

$$= \frac{32}{\pi} \tag{2.2.5}$$

and

$$a_n = \frac{-2A}{\pi(4n^2 - 1)} \tag{2.2.6}$$

Similarly,

$$b_n = 0 \tag{2.2.7}$$

Problem 2.3. Write a code for the plotting the same graph as that in problem 1.1

Solution:

```
import numpy as np
import matplotlib.pyplot as plt
import cmath


T_0 = 0.01

    # defining amplitude, frequency, no. of terms
T = 0.02
f = 1/T
A = 16
r = 100
g = 0

t = np.linspace(-0.01*np.pi, 0.01*np.pi,100000)

for n in range(-r,r):
        if n == 0:
                g = g +  2.0*A/np.pi;
        else:
                print n
                an = (-2.0*A/np.pi)*(1.0/(4*n*n-1))     # finding an for each n
                cos = np.cos(n*2*np.pi*f*t)
                g = g + an*cos

                    # adding the fourier series terms



plt.plot(t,g)

    # plotting the output
plt.grid ()
plt.xlabel('$t$')
plt.xlim(-0.01*np.pi,0.01*np.pi)
plt.ylabel('$Rectified sine wave$')
plt.show()
```

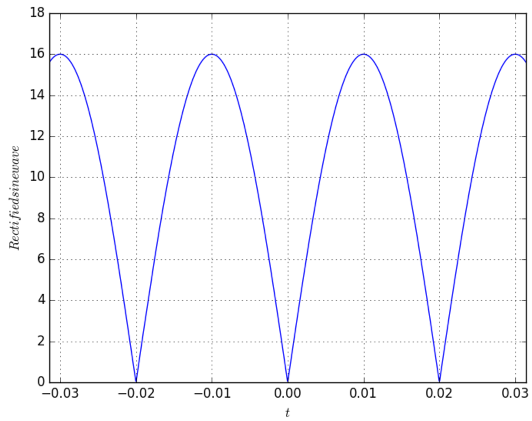

Fig. 2.3: Rectified Wave from fourier series

3 Rectified Ac to Dc

Problem 3.1. Type the following code in python to plot the amplitude of the frequencies present in the rectified wave.

```
import numpy as np
import matplotlib.pyplot as plt
import cmath


T_0 = 0.01

    # defining amplitude, frequency, no. of terms
T = 0.02
f = 1/T
A = 16
r = 20
g = 0
an = []
no = np.linspace(-r, r,2*r )

for n in range(-r,r):
        if n == 0:
                an.append(2.0*A/np.pi)
        else:
                print n
                x =(-2.0*A/np.pi)*(1.0/(4*n*n-1))
                an.append(x)

                    # an is list for amplitudes
```

```
plt.plot(no,an,'.')                                    #
    plotting the output
plt.grid ()
plt.xlabel('$f$')
plt.xlim(-r-1,r+1)
plt.ylabel('$Amplitudes$')
plt.show()
```

Solution: The output is as shown in the Fig. **??**

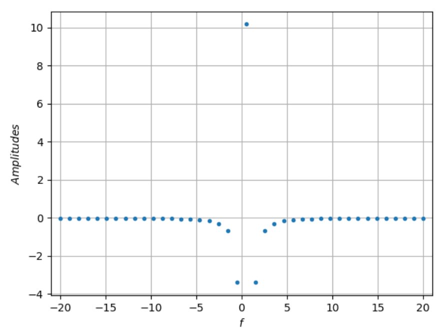

Fig. 3.1: Frequencies

Problem 3.2. Find the response of the RC filter used.

Solution: The RC response can be shown to be as folows.

$$H(s) = \frac{1}{(sCR + 1)} \tag{3.2.1}$$

$$|H(s)| = \frac{1}{\sqrt{((sCR)^2 + 1)}} \tag{3.2.2}$$

$$\tag{3.2.3}$$

Problem 3.3. Substitute $s = \jmath 2\pi f, \jmath = \sqrt{-1}$ in Equation 3.2.1 to obtain $H(f)$. $H(f)$ is known as the frequency response. Given that $R = 1\Omega$ and $C = 1000\,\mu F$.

Problem 3.4. The given figure 3.4 contains 2 plots. Blue graph is a plot of fourier series coeffiecients of rectified AC wrt frequency. The orange plot is the frequency response of an RC circuit. We have used a capacitor of 1000uf and Resistance is very low(it is mainly due to wires only).The peak of the graph is at 0 and at other points, it decays exponentially. So it works as a low pass filter and only thfrequencies near 0 frequencies are passed. Thus we get DC output.

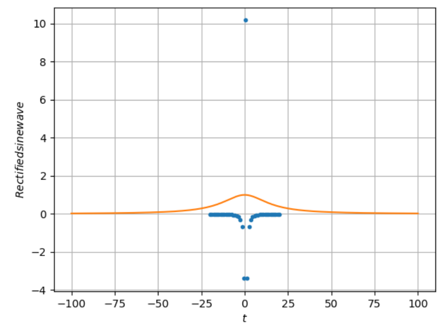

Fig. 3.4: Rectified Wave with Capacitive filter

4 Final Output

Final Output will look like the red part Fig. 4.0

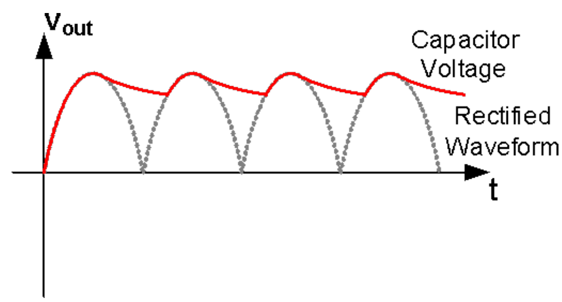

Fig. 4.0: DC