main

December 28, 2022

1

- 04-105

[ ]:
```
import matplotlib.pyplot as plt
import ipywidgets
import numpy as np
import pandas as pd
import scipy as sp
from scipy.io import wavfile
from scipy import signal
from scipy.signal import periodogram as periodogram_f
from scipy.fft import fftfreq, fftshift
from scipy.fft import fft, ifft, fft2, ifft2
import IPython
```

1.0.1 RC

10 . ,

.

:

$$U_{out} = U_{in}\frac{X_c}{\sqrt{R^2 + X_C^2}}\ ,X_C = \frac{1}{2\pi\nu C}$$

:

$$f_{cutoff} = \frac{1}{2\pi RC}$$

:

[ ]:
```
#                  ,

def plotAFR(Resis = 0.1,C = 100):
    fig,ax = plt.subplots(figsize = (16,9))
    plt.grid()
    plt.xlabel("     $ $")
    plt.ylabel("     ")
    plt.xlim(20,22000)
    plt.xticks(np.arange(20,22000,1000))
    plt.ylim(0,1)
    R = Resis*1000
    cutoff = 1/(2*np.pi * R* C)
    freq = np.linspace(20,22000,22000) #
    X_c = 1/(2*np.pi*freq*(C*np.power(0.1,9)))
    amp = X_c/np.sqrt(np.power(R,2)+np.power(X_c,2))
    plt.plot(freq,amp,color = 'blue')
ipywidgets.interact(plotAFR,Resis = (0.1,10,0.2),C = (0.1,500,5))
```

```
interactive(children=(FloatSlider(value=0.1, description='Resis', max=10.0,␣
 ↪min=0.1, step=0.2), FloatSlider(va…
```

[ ]:
```
<function __main__.plotAFR(Resis=0.1, C=100)>
```

<> $50\ nF$. , - $0.1\ \mu F$. LPF, HPF.

[ ]:
```
C: float = 0.1 * np.power(0.1,6) #
```

1.0.2

:

$$k = 1 + \frac{100}{4.7} = 22.3$$

<>,

$96\ dB$.

[ ]:
```
ampl_k = 22.3
```

-

[ ]:
```
def getAfr(freq: np.ndarray,R_hpf: float,R_lpf: float) -> np.ndarray:
    R1 = R_hpf*1000
    R2 = R_lpf*1000
    X_c = 1/(2*np.pi*freq*C)
    A_hpf = R1/np.sqrt(np.power(X_c,2)+np.power(R1,2))
    A_lpf = X_c/np.sqrt(np.power(X_c,2)+np.power(R2,2))
    A_result = A_hpf*A_lpf
    return A_result
```

[ ]:
```
def plotAFR(R_hpf = 1, R_lpf = 1):
    fig, ax = plt.subplots(figsize = (16,9))
    plt.grid()
    plt.xlabel("     $ $")
    plt.ylabel("     ")
    plt.xlim(20,22000)
    plt.xticks(np.arange(20,22000,1000))
    plt.ylim(0,int(ampl_k))
    ####
    R1 = R_hpf*1000
    R2 = R_lpf*1000
    freq = np.linspace(20,22000,20000)
    X_c = 1/(2*np.pi*freq*C)
    A_hpf = R1/np.sqrt(np.power(X_c,2)+np.power(R1,2))
    A_lpf = X_c/np.sqrt(np.power(X_c,2)+np.power(R2,2))
    A_result = ampl_k*A_hpf*A_lpf
    plt.plot(freq,A_hpf,label = "               ")
    plt.plot(freq,A_lpf,label = '               ')
    plt.plot(freq,A_result,label = '      ',color = "red")
    plt.title("       -                  ")
    plt.legend()
```

```
[ ]: ipywidgets.interact(plotAFR,R_hpf = (0.1,10,0.2),R_lpf = (0.1,10,0.2))
```

```
interactive(children=(FloatSlider(value=1.0, description='R_hpf', max=10.0,␣
↪min=0.1, step=0.2), FloatSlider(va…
```

```
[ ]: <function __main__.plotAFR(R_hpf=1, R_lpf=1)>
```

- :

$$F = \frac{1}{2\pi C\sqrt{R_{lpf}}\sqrt{R_{hpf}}}$$

```
[ ]: def getLpfPhase_shift(freq,R_lpf):
         phase_shift = - np.arctan(2*np.pi*freq*R_lpf*C*1000)
         return phase_shift
     def getHpfPhase_shift(freq,R_hpf):
         phase_shift = np.arctan(1/(2*np.pi*freq*R_hpf*C*1000))
         return phase_shift
     def getPhaseShift(freq,R_hpf,R_lpf):
         return getLpfPhase_shift(freq,R_lpf)+getHpfPhase_shift(freq,R_hpf)
     def getMaxAmpFreq(R_hpf,R_lpf):
         return 1/(2*np.pi*C*np.sqrt(R_hpf*1000)*np.sqrt(R_lpf*1000))
```

```
[ ]: def multiple_formatter(denominator=2, number=np.pi, latex='\pi'):
         def gcd(a, b):
             while b:
                 a, b = b, a%b
             return a
         def _multiple_formatter(x, pos):
             den = denominator
             num = int(np.rint(den*x/number))
             com = gcd(num,den)
             (num,den) = (int(num/com),int(den/com))
             if den==1:
                 if num==0:
```

```
                return r'$0$'
            if num==1:
                return r'$%s$'%latex
            elif num==-1:
                return r'$-%s$'%latex
            else:
                return r'$%s%s$'%(num,latex)
        else:
            if num==1:
                return r'$\frac{%s}{%s}$'%(latex,den)
            elif num==-1:
                return r'$\frac{-%s}{%s}$'%(latex,den)
            else:
                return r'$\frac{%s%s}{%s}$'%(num,latex,den)
    return _multiple_formatter

def PFR(R_hpf = 1,R_lpf = 1):
    fig, ax = plt.subplots(figsize = (16,9))
    plt.ylim(-np.pi/2,np.pi/2)
    plt.xlabel("     $ $")
    plt.ylabel("       $   $")
    plt.xlim(20,22000)
    plt.yticks(np.arange(-np.pi/2,np.pi/2+np.pi/12,np.pi/12))
    plt.xticks(np.arange(20,22000,1000))
    freq = np.linspace(20,22000,20000)
    plt.plot(freq,getHpfPhase_shift(freq,R_hpf),label = "            ")
    plt.plot(freq,getLpfPhase_shift(freq,R_lpf),label = "           ")
    plt.plot(freq,getPhaseShift(freq,R_hpf,R_lpf),label = "     ", color =␣
 ↪'red')
    plt.title("   -              ")
    ax.axhline(0, color='black', lw=2)
    maxAmp = getMaxAmpFreq(R_hpf,R_lpf)
    ax.axvline(maxAmp,color = 'black',lw = 2)
    ax.yaxis.set_major_locator(plt.MultipleLocator(np.pi / 2))
    ax.yaxis.set_minor_locator(plt.MultipleLocator(np.pi / 12))
    ax.grid(True)
    print("               : "+str(maxAmp))
    ax.yaxis.set_major_formatter(plt.FuncFormatter(multiple_formatter()))
    plt.legend()
ipywidgets.interact(PFR,R_hpf = (0.1,10,0.1),R_lpf = (0.1,10,0.1))
```

```
interactive(children=(FloatSlider(value=1.0, description='R_hpf', max=10.0,␣
↪min=0.1), FloatSlider(value=1.0, d…
```

```
[ ]: <function __main__.PFR(R_hpf=1, R_lpf=1)>
```

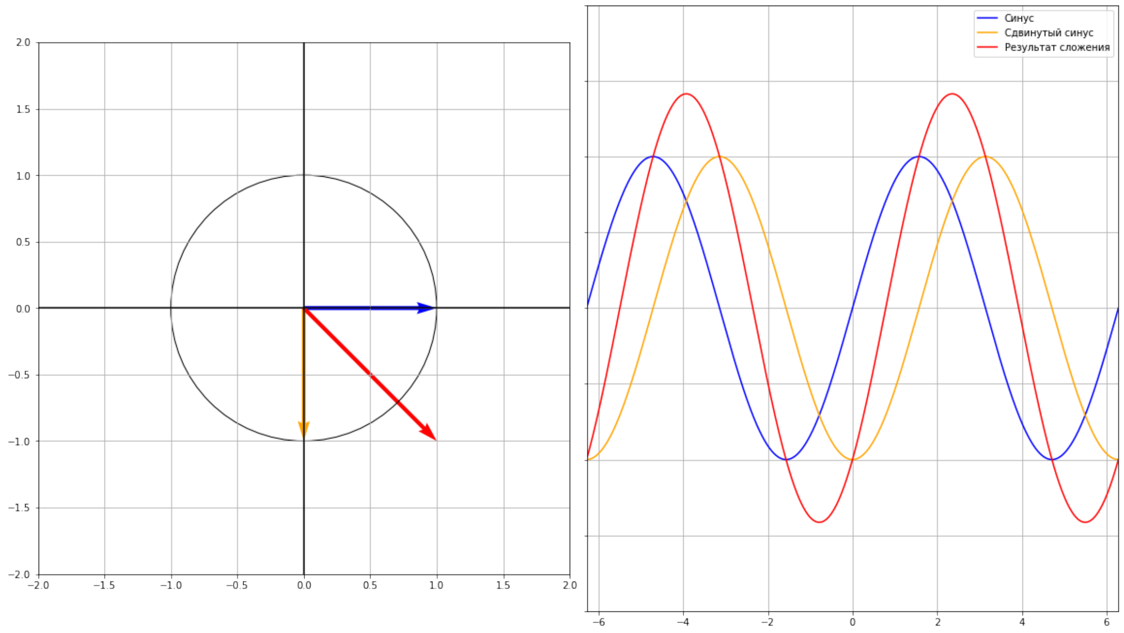
[ ]:

```
def plotShift(shift: float):
    fig = plt.figure(figsize = (16,9),constrained_layout = True)
    gs = fig.add_gridspec(1, 2, hspace=0, wspace=0)
    (ax1,ax2) = gs.subplots(sharex='col', sharey='row')
    eyeCircle = plt.Circle((0, 0), 1, color='black',fill = False)
    ax1.set_xlim(-2,2)
    ax1.set_ylim(-2,2)
    ax1.axvline(0,color = 'black')
    ax1.axhline(0,color = 'black')
    ax1.grid(True)
    # ax2.set_aspect('equal')
    ax1.set_aspect('equal')
    ax1.add_patch(eyeCircle)
    V = np.array([[1,0], [np.cos(shift),np.sin(shift)], [1+np.cos(shift),np.
↪sin(shift)]])
    origin = np.array([[0, 0, 0],[0, 0, 0]]) # origin point

    ax1.quiver(*origin, V[:,0], V[:,1],␣
↪color=['b','orange','r'],scale_units='xy', scale=1)
    ax2.set_xlim(-np.pi*2,2*np.pi)
    ax2.set_ylim(-2,2)
    xAxes = np.linspace(-np.pi*2,np.pi*2,1000)
    ax2.plot(xAxes,np.sin(xAxes),color = 'blue',label = "   ")
    ax2.plot(xAxes,np.sin(xAxes+shift),color = 'orange',label = "         ")
    ax2.plot(xAxes,np.sin(xAxes+shift)+np.sin(xAxes),color = 'red',label =␣
↪'          ')
    ax2.legend()
    ax2.grid(True)
    plt.show()
```

[ ]:

```
shifts = [3*np.pi/2,5*np.pi/3,7*np.pi/4,11*np.pi/6,0,np.pi/6,np.pi/4,np.pi/3,np.
↪pi/2]
for i in shifts:
    plotShift(i)
```


Синус
Сдвинутый синус
Результат сложения
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.0
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−1.0
−0.5
0.0
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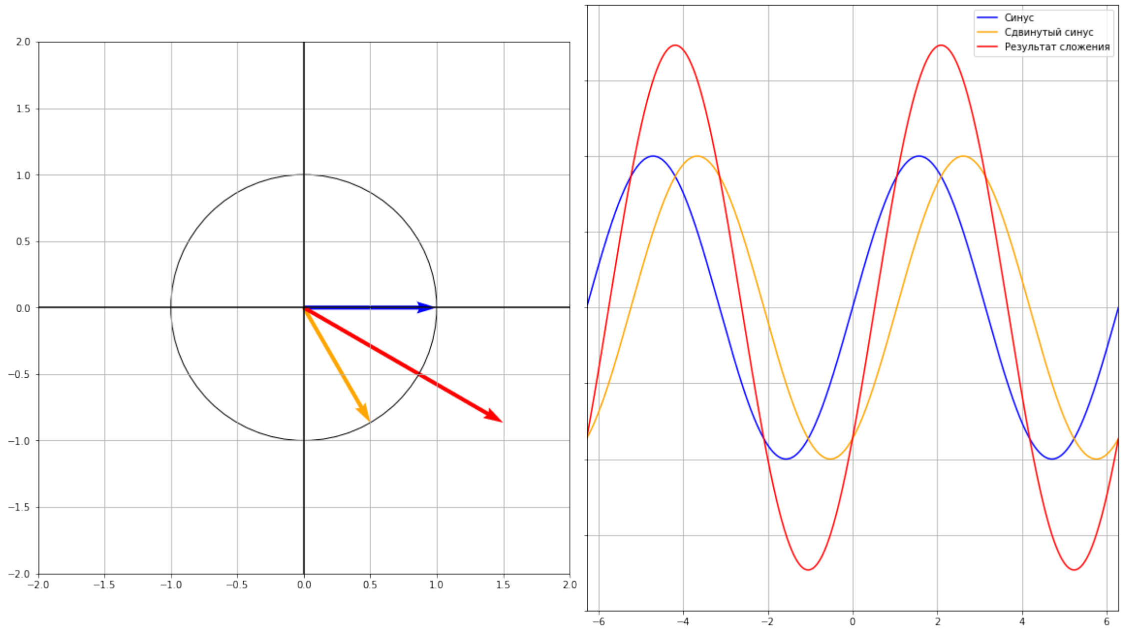
2.0
−6
−4
−2
0
2
4
6


Синус
Сдвинутый синус
Результат сложения
2.0
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1.0
0.5
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−1.0
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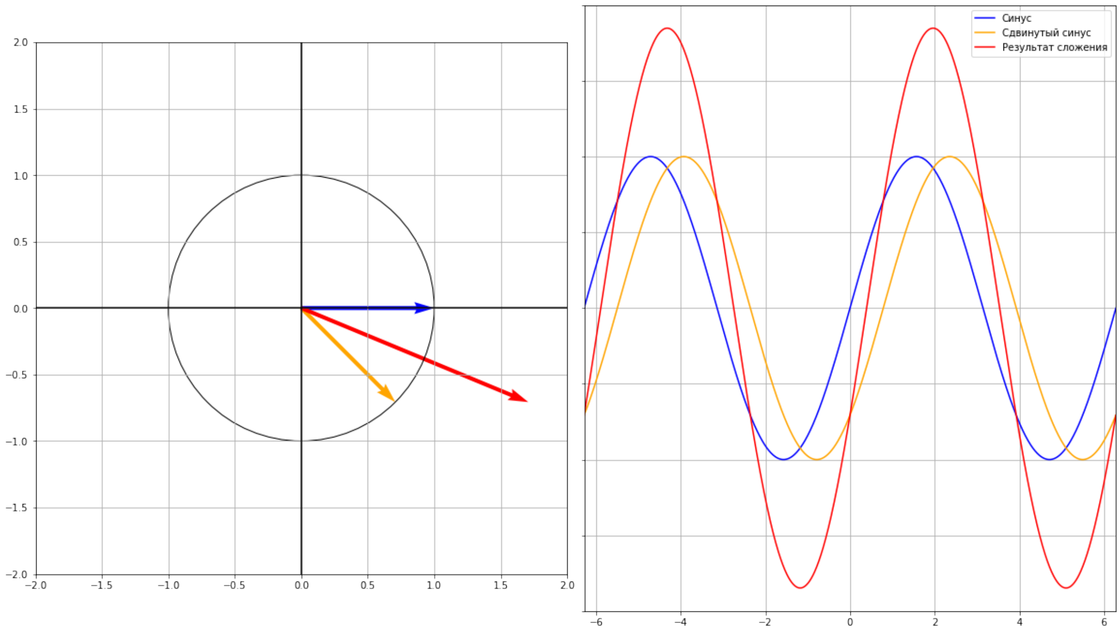
1.5
2.0
−6
−4
−2
0
2
4
6


2.0
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Синус
Сдвинутый синус
Результат сложения
−6
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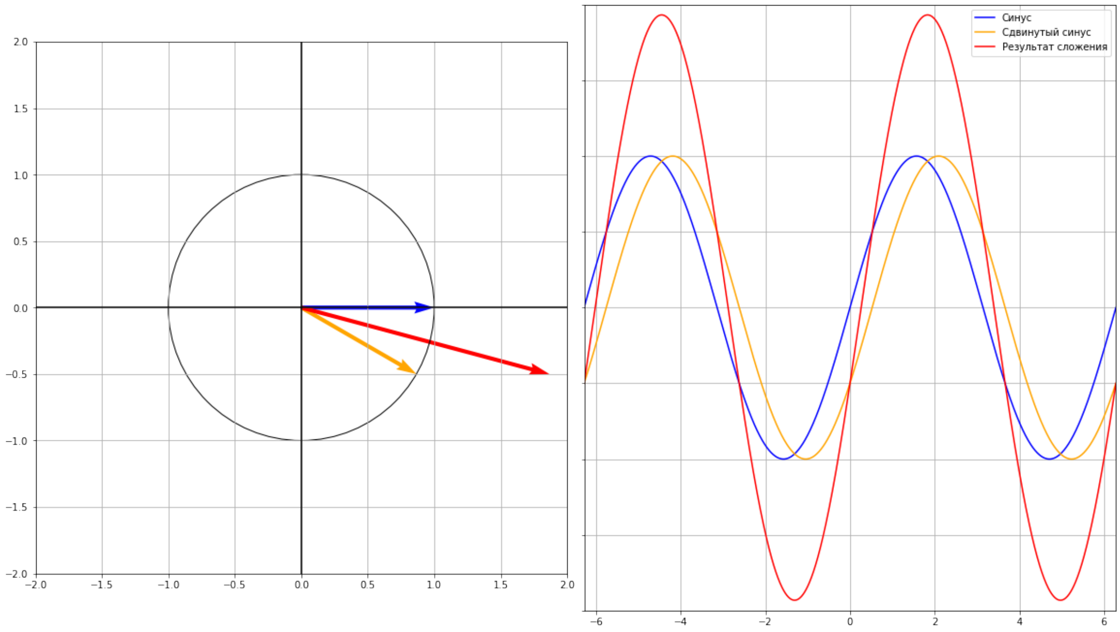
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Синус
Сдвинутый синус
Результат сложения
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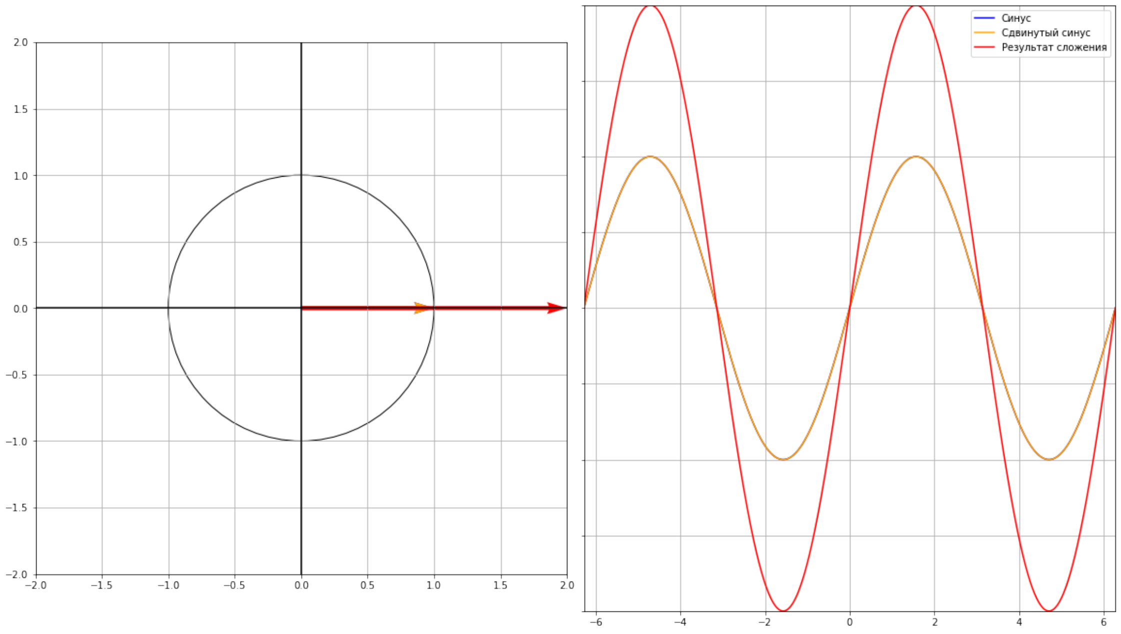
2.0
1.5
1.0
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0.5
1.0
1.5
2.0
Синус
Сдвинутый синус
Результат сложения
−6
−4
−2
0
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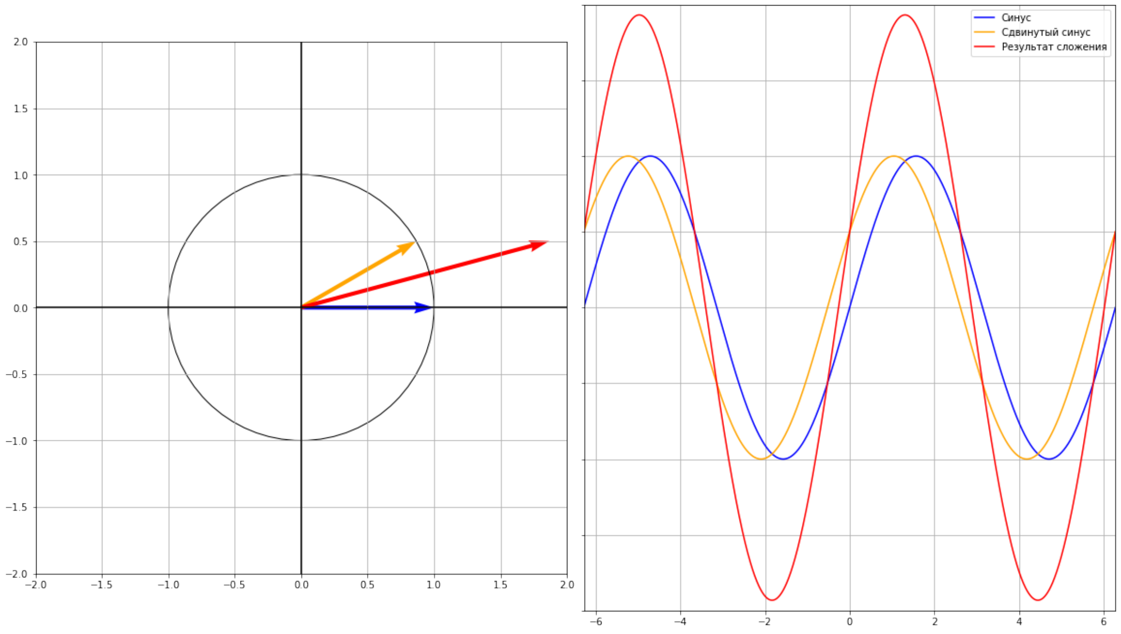
6


2.0
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Синус
Сдвинутый синус
Результат сложения
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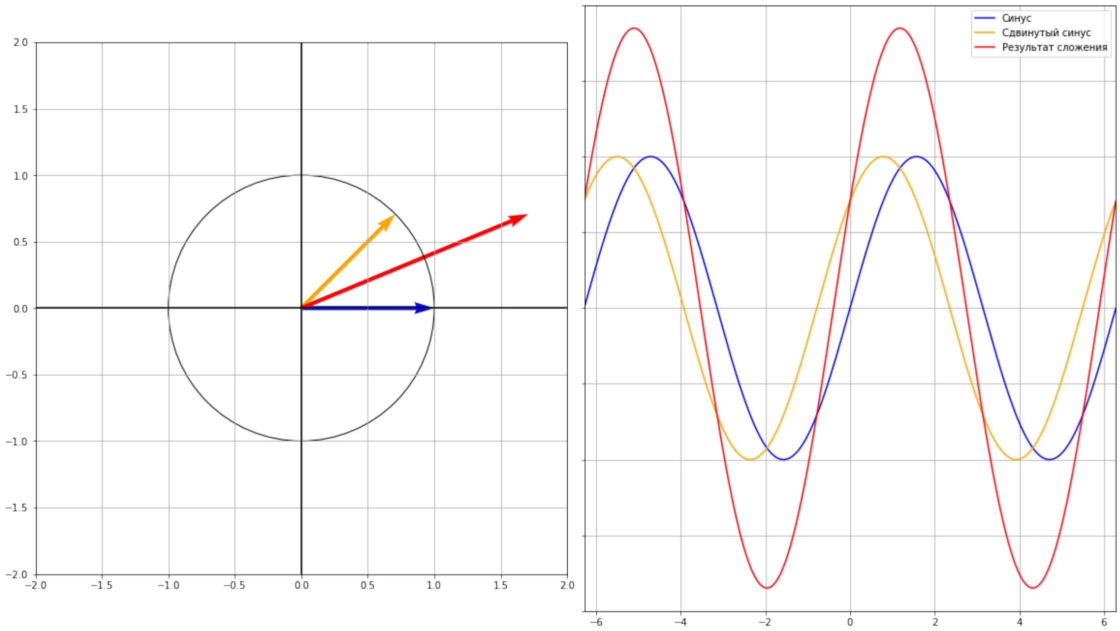
2.0
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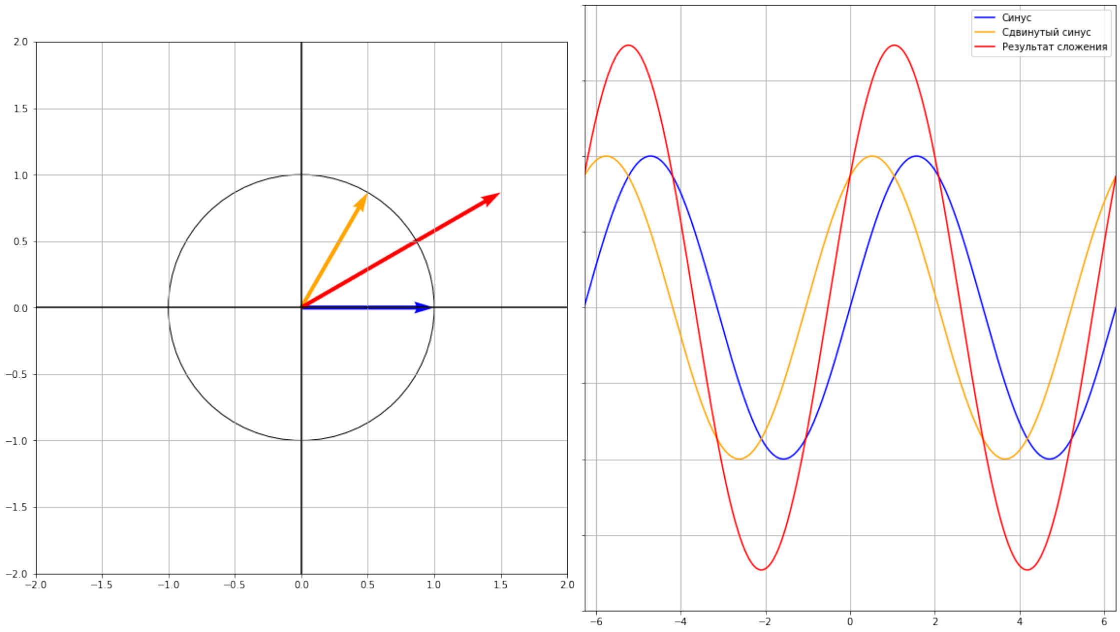
−2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0
Синус
Сдвинутый синус
Результат сложения
−6 −4 −2 0 2 4 6


2.0
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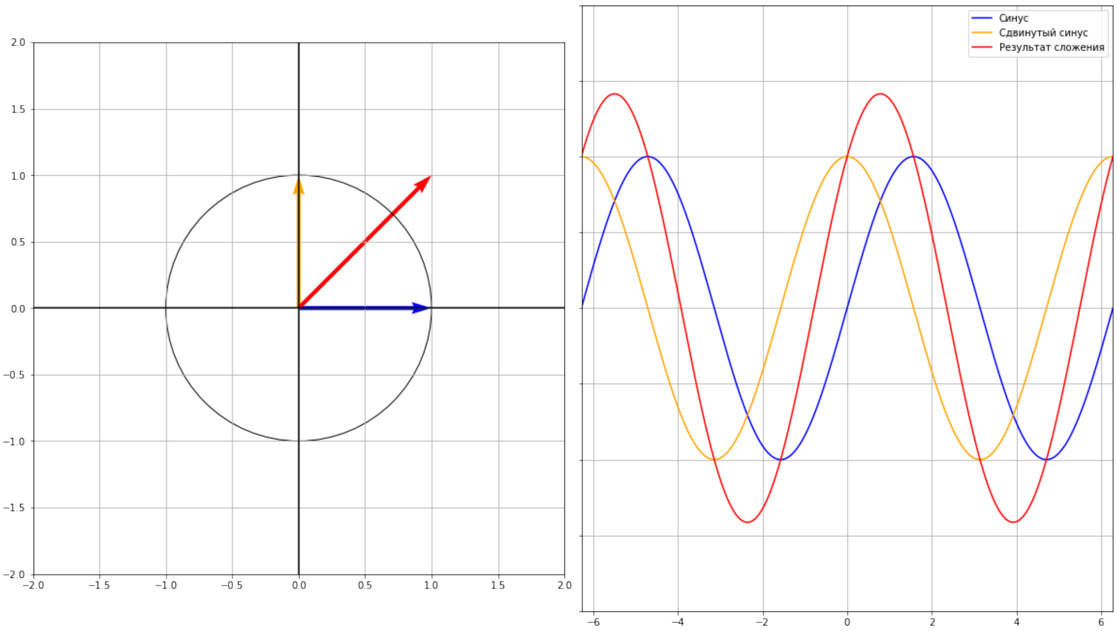
−0.5
−1.0
−1.5
−2.0
−2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0
Синус
Сдвинутый синус
Результат сложения
−6 −4 −2 0 2 4 6



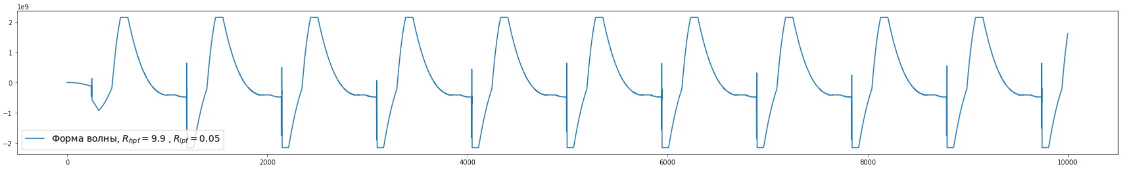
1.0.3 1 - <>

1.1 -

[ ]:
```
rate, data = sp.io.wavfile.read('DR0000_0229.wav')
data=data[:,0]
time = np.arange(0, len(data), 1)/rate
R_hpf,R_lpf = 9.9,0.05
```

```
C:\Users\     \AppData\Local\Temp\ipykernel_15004\1130674698.py:1:
WavFileWarning: Chunk (non-data) not understood, skipping it.
  rate, data = sp.io.wavfile.read('DR0000_0229.wav')
```

[ ]:
```
plt.figure(figsize=(30,4))
plt.plot(data[0:10000],label = "       , $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} =␣
  ↪"+str(R_lpf)+"$")
plt.legend(fontsize = 14)
plt.show()
```



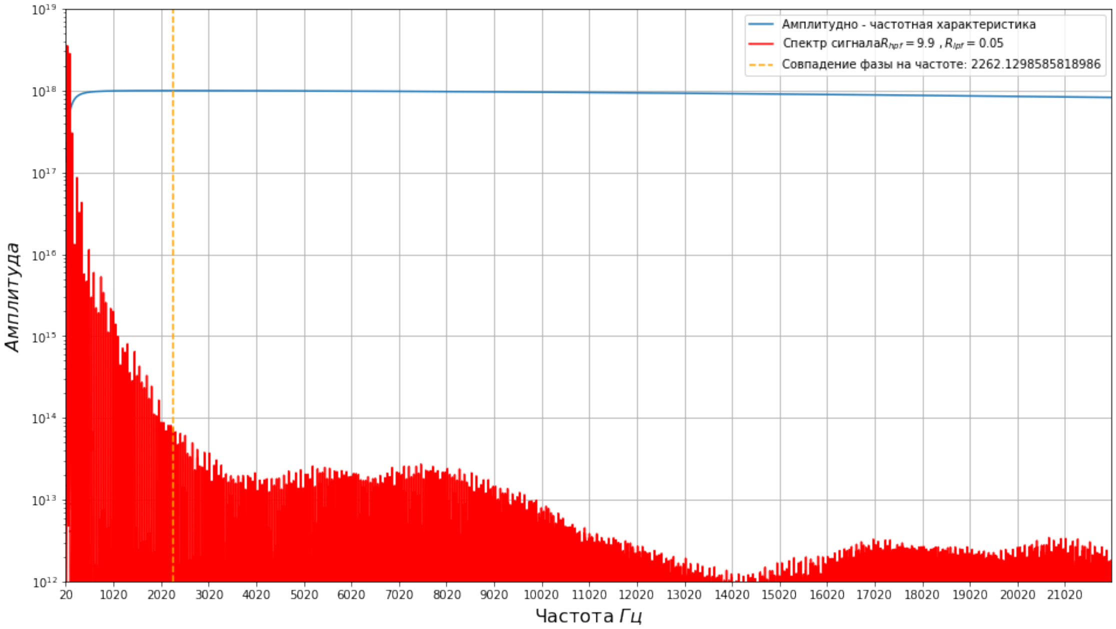
[ ]:
```
IPython.display.Audio("DR0000_0229.wav")
```

```
[ ]: <IPython.lib.display.Audio object>
```

```
[ ]: periodogram = np.abs(fft(data))**2 / (rate * len(data))
     frequencies = fftfreq(len(data), d=1/rate)
     frequencies
```

```
[ ]: array([ 0.        ,  0.06624271,  0.13248543, …, -0.19872814,
            -0.13248543, -0.06624271])
```

```
[ ]: freq = np.linspace(22,22000,20000)
     amp = 1e18
     plt.figure(figsize=(16,9))
     plt.plot(freq,getAfr(freq,R_hpf,R_lpf)*amp,label = '       -               ')
     plt.plot(fftshift(frequencies), fftshift(periodogram), color='red',label = "   ␣
      ↪    $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} = "+str(R_lpf)+"$")
     plt.xlim(22,22000)
     plt.axvline(x=getMaxAmpFreq(R_hpf=R_hpf,R_lpf=R_lpf),
                 label = "               :␣
      ↪"+str(getMaxAmpFreq(R_hpf=R_hpf,R_lpf=R_lpf)),
                 linestyle = 'dashed',
                 color = 'orange')
     plt.ylim((1e12,1e19))
     plt.xlabel('     $ $', fontsize = 16)
     plt.ylabel('$     $',fontsize = 16)
     plt.legend()
     plt.grid()
     plt.semilogy()
     plt.xticks(np.arange(20,22000,1000))
     plt.show()
```

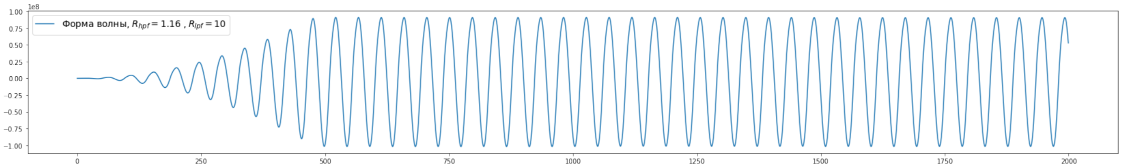


1.2 - -

[ ]:
```
rate, data = sp.io.wavfile.read('DR0000_0230.wav')
data=data[:,0]
time = np.arange(0, len(data), 1)/rate
R_hpf,R_lpf = 1.16,10
```

```
C:\Users\     \AppData\Local\Temp\ipykernel_15004\3860120285.py:1:
WavFileWarning: Chunk (non-data) not understood, skipping it.
  rate, data = sp.io.wavfile.read('DR0000_0230.wav')
```

[ ]:
```
plt.figure(figsize=(30,4))
plt.plot(data[:2000],label = "       , $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} =␣
  ↪"+str(R_lpf)+"$")
plt.legend(fontsize = 14)
plt.show()
```



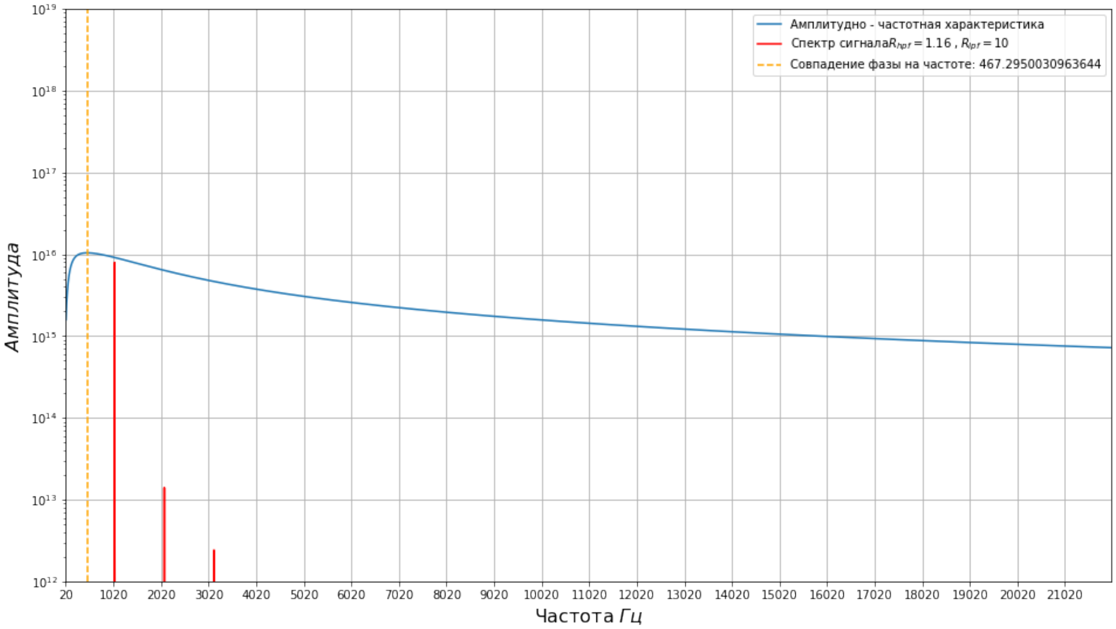
[ ]:
```
IPython.display.Audio("DR0000_0230.wav")
```

```
[ ]: <IPython.lib.display.Audio object>
```

```
[ ]: periodogram = np.abs(fft(data))**2 / (rate * len(data))
     frequencies = fftfreq(len(data), d=1/rate)
     frequencies
```

```
[ ]: array([ 0.        ,  0.1393534,  0.2787068, …, -0.4180602, -0.2787068,
            -0.1393534])
```

```
[ ]: freq = np.linspace(22,22000,20000)
     amp = 1e17
     plt.figure(figsize=(16,9))
     plt.plot(freq,getAfr(freq,R_hpf,R_lpf)*amp,label = '       -               ')
     plt.plot(fftshift(frequencies), fftshift(periodogram), color='red',label = "   ␣
      ↪    $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} = "+str(R_lpf)+"$")
     plt.axvline(x=getMaxAmpFreq(R_hpf=R_hpf,R_lpf=R_lpf),
                 label = "               :␣
      ↪"+str(getMaxAmpFreq(R_hpf=R_hpf,R_lpf=R_lpf)),
                 linestyle = 'dashed',
                 color = 'orange')
     plt.xlim(22,22000)
     plt.ylim((1e12,1e19))
     plt.xlabel('    $ $', fontsize = 16)
     plt.ylabel('$    $',fontsize = 16)
     plt.legend()
     plt.grid()
     plt.semilogy()
     plt.xticks(np.arange(20,22000,1000))
     plt.show()
```



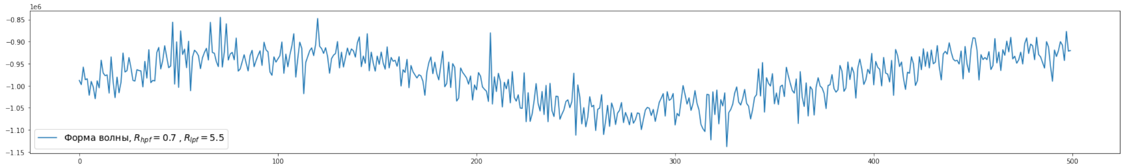
$-\pi/6$

1.0.4 1.3 - +

```
[ ]: rate, data = sp.io.wavfile.read('DR0000_0232.wav')
     data=data[:,0]
     time = np.arange(0, len(data), 1)/rate
     R_hpf,R_lpf = 0.7,5.5
```

```
C:\Users\     \AppData\Local\Temp\ipykernel_15004\3387931043.py:1:
WavFileWarning: Chunk (non-data) not understood, skipping it.
  rate, data = sp.io.wavfile.read('DR0000_0232.wav')
```

```
[ ]: plt.figure(figsize=(30,4))
     plt.plot(data[2000:2500],label = "       , $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf}␣
       ↪= "+str(R_lpf)+"$")
     plt.legend(fontsize = 14)
     plt.show()
```



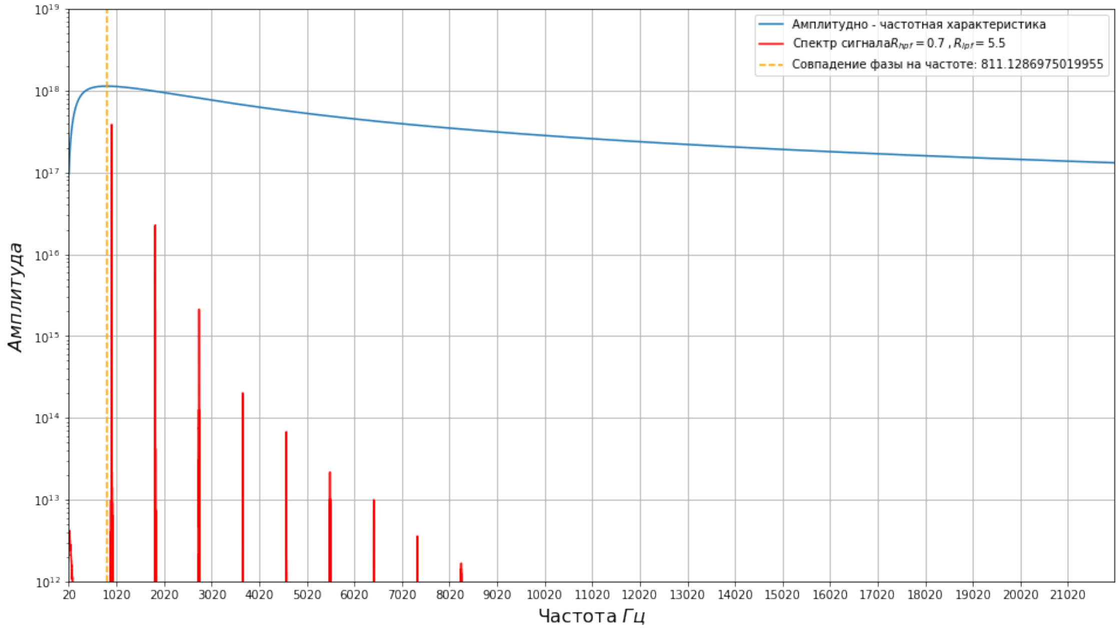
```
[ ]: IPython.display.Audio("DR0000_0232.wav")
```

```
[ ]: <IPython.lib.display.Audio object>
```

```
[ ]: periodogram = np.abs(fft(data))**2 / (rate * len(data))
     frequencies = fftfreq(len(data), d=1/rate)
     frequencies
```

```
[ ]: array([ 0.        ,  0.10212418,  0.20424837, …, -0.30637255,
            -0.20424837, -0.10212418])
```

```
[ ]: freq = np.linspace(22,22000,20000)
     amp = 1e19
     plt.figure(figsize=(16,9))
     plt.plot(freq,getAfr(freq,R_hpf,R_lpf)*amp,label = '       -               ')
     plt.plot(fftshift(frequencies), fftshift(periodogram), color='red',label = "    ⊔
      ↪    $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} = "+str(R_lpf)+"$")
     plt.axvline(x=getMaxAmpFreq(R_hpf=R_hpf,R_lpf=R_lpf),
                 label = "               :⊔
      ↪"+str(getMaxAmpFreq(R_hpf=R_hpf,R_lpf=R_lpf)),
                 linestyle = 'dashed',
                 color = 'orange')
     plt.xlim(22,22000)
     plt.ylim((1e12,1e19))
     plt.xlabel('     $ $', fontsize = 16)
     plt.ylabel('$     $',fontsize = 16)
     plt.legend()
     plt.grid()
     plt.semilogy()
     plt.xticks(np.arange(20,22000,1000))
     plt.show()
```



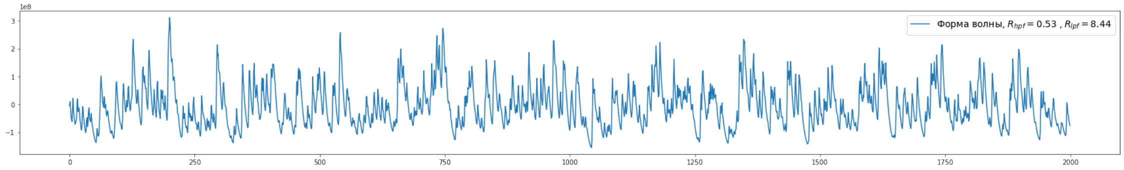
1.0.5 2 -

2.1 - <>

[ ]:
```
rate, data = sp.io.wavfile.read('DR0000_0237.wav')
data=data[:,0]
time = np.arange(0, len(data), 1)/rate
R_hpf,R_lpf = 0.53,8.44
```

```
C:\Users\     \AppData\Local\Temp\ipykernel_15004\912230510.py:1:
WavFileWarning: Chunk (non-data) not understood, skipping it.
  rate, data = sp.io.wavfile.read('DR0000_0237.wav')
```

[ ]:
```
plt.figure(figsize=(30,4))
plt.plot(data[500:2500],label = "        , $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf}␣
  ↪= "+str(R_lpf)+"$")
plt.legend(fontsize = 14)
plt.show()
```



[ ]:

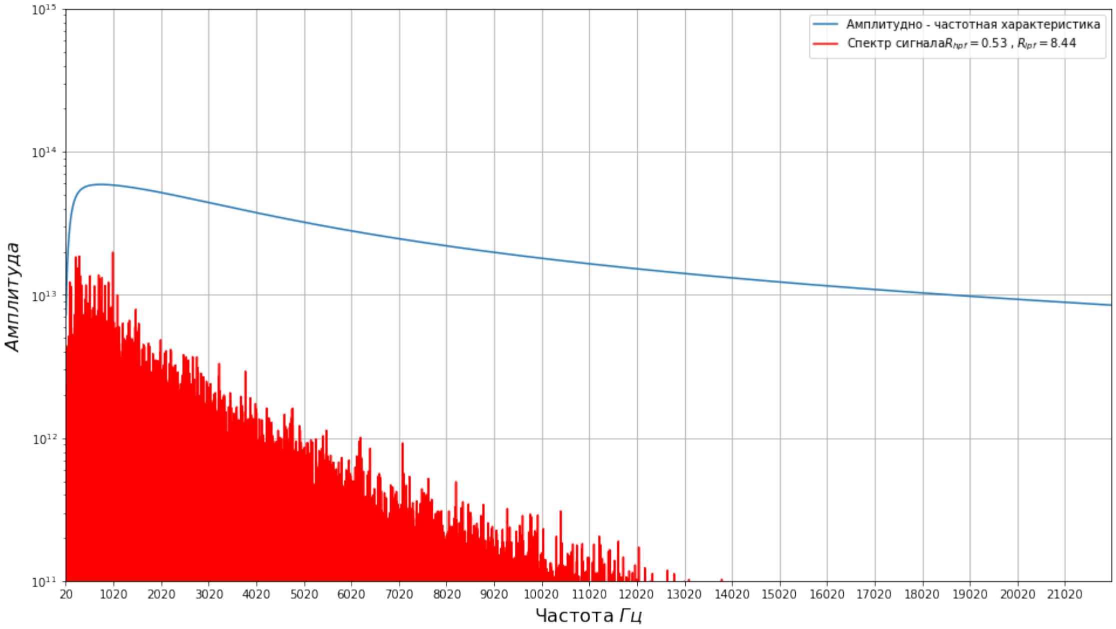
```
IPython.display.Audio("DR0000_0237.wav")
```

[ ]:

```
<IPython.lib.display.Audio object>
```

[ ]:

```
periodogram = np.abs(fft(data))**2 / (rate * len(data))
frequencies = fftfreq(len(data), d=1/rate)
freq = np.linspace(22,22000,20000)
amp = 1e15
plt.figure(figsize=(16,9))
plt.plot(freq,getAfr(freq,R_hpf,R_lpf)*amp,label = '       -               ')
plt.plot(fftshift(frequencies), fftshift(periodogram), color='red',label = "    ␣
 ↪   $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} = "+str(R_lpf)+"$")
plt.xlim(22,22000)
plt.ylim((1e11,1e15))
plt.xlabel('     $ $', fontsize = 16)
plt.ylabel('$     $',fontsize = 16)
plt.legend()
plt.grid()
plt.semilogy()
plt.xticks(np.arange(20,22000,1000))
plt.show()
```



2.2 -

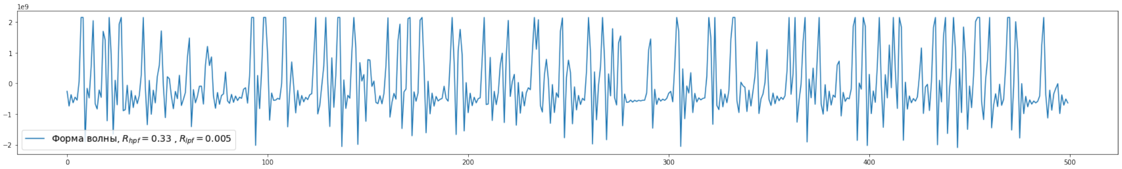
[ ]:

```
rate, data = sp.io.wavfile.read('DR0000_0238.wav')
data=data[:,0]
time = np.arange(0, len(data), 1)/rate
```

```
R_hpf,R_lpf = 0.33,0.005
```

```
C:\Users\     \AppData\Local\Temp\ipykernel_15004\1410607889.py:1:
WavFileWarning: Chunk (non-data) not understood, skipping it.
  rate, data = sp.io.wavfile.read('DR0000_0238.wav')
```

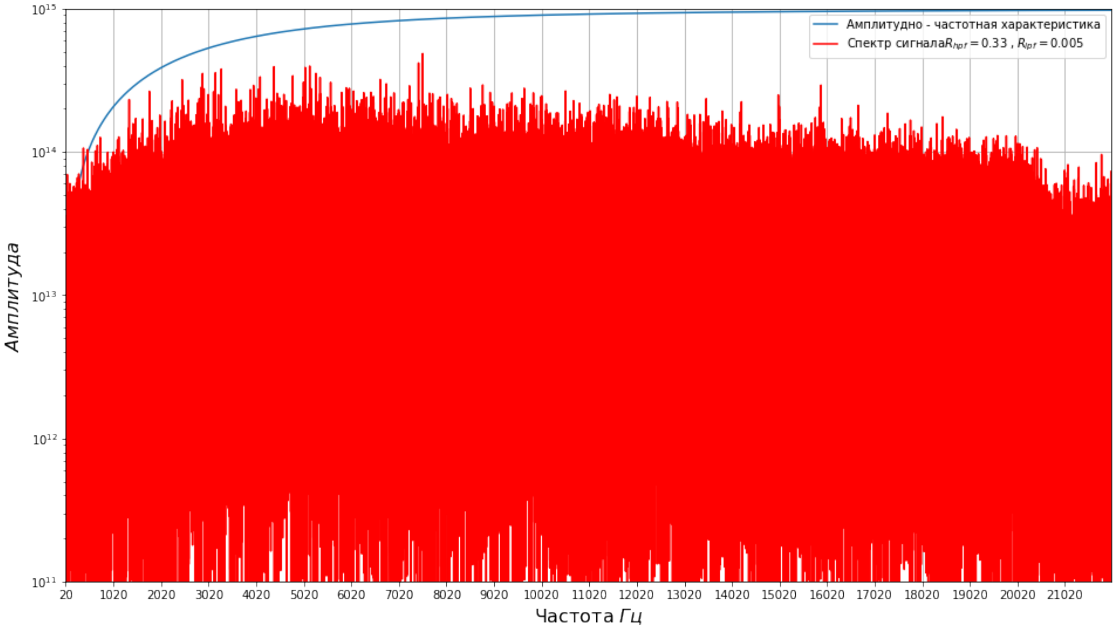
```
[ ]: plt.figure(figsize=(30,4))
     plt.plot(data[500:1000],label = "        , $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf}␣
      ↪= "+str(R_lpf)+"$")
     plt.legend(fontsize = 14)
     plt.show()
```



```
[ ]: IPython.display.Audio("DR0000_0238.wav")
```

```
[ ]: <IPython.lib.display.Audio object>
```

```
[ ]: periodogram = np.abs(fft(data))**2 / (rate * len(data))
     frequencies = fftfreq(len(data), d=1/rate)
     freq = np.linspace(22,22000,20000)
     amp = 1e15
     plt.figure(figsize=(16,9))
     plt.plot(freq,getAfr(freq,R_hpf,R_lpf)*amp,label = '       -               ')
     plt.plot(fftshift(frequencies), fftshift(periodogram), color='red',label = "    ␣
      ↪     $R_{hpf} = "+str(R_hpf)+"\ , R_{lpf} = "+str(R_lpf)+"$")
     plt.xlim(22,22000)
     plt.ylim((1e11,1e15))
     plt.xlabel('     $ $', fontsize = 16)
     plt.ylabel('$     $',fontsize = 16)
     plt.legend()
     plt.grid()
     plt.semilogy()
     plt.xticks(np.arange(20,22000,1000))
     plt.show()
```


Амплитудно - частотная характеристика
Спектр сигнала$R_{hpf} = 0.33$, $R_{lpf} = 0.005$
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
Амплитуда
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Частота *Гц*