*Федеральное государственное бюджетное образовательное учреждение высшего профессионального образования*

***«Московский государственный технический университет имени Н.Э. Баумана»***

***(МГТУ им. Н.Э. Баумана)***

ФАКУЛЬТЕТ Информатики и систем управления

КАФЕДРА Проектирования и технологии производства ЭА

# С е м и н а р № 3

## п о к у р с у « Ц и ф р о в а я о б р а б о т к а с и г н а л о в »

Студент Корчагин А.И.

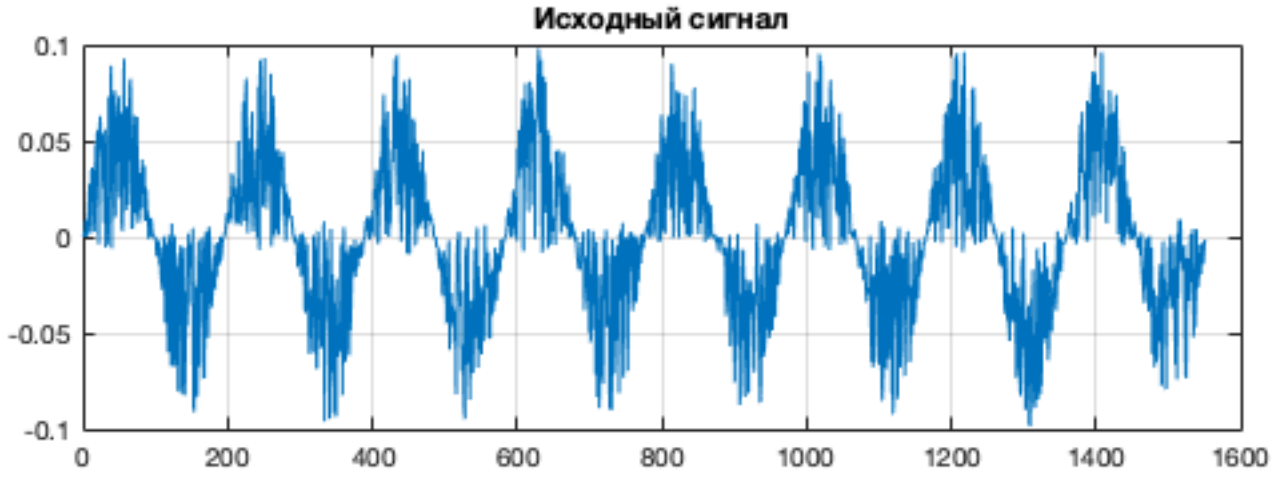
(Подпись, дата) (И.О.Фамилия)

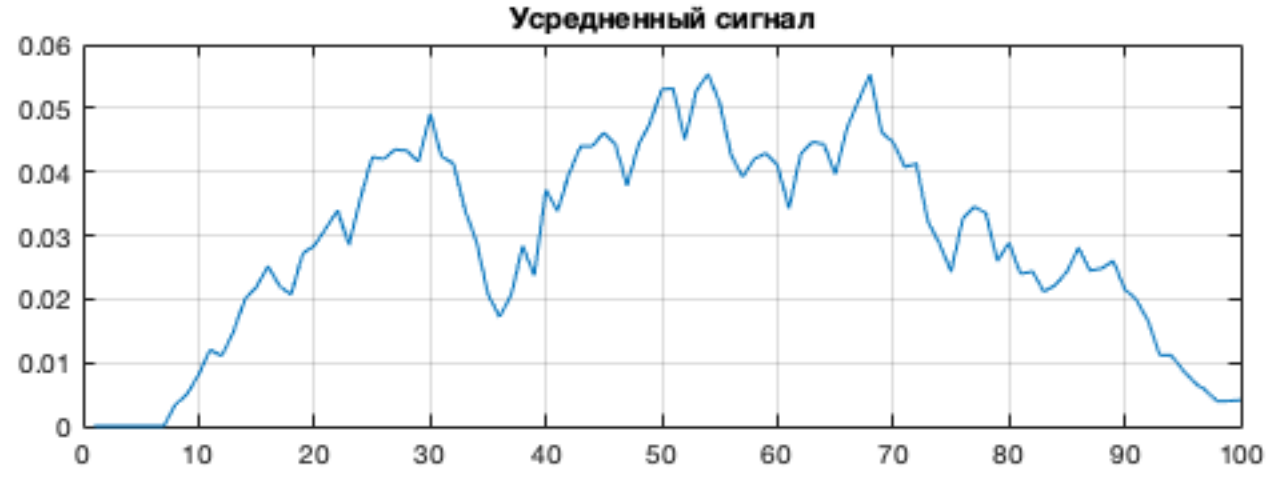
Преподаватель Леонидов В.В.

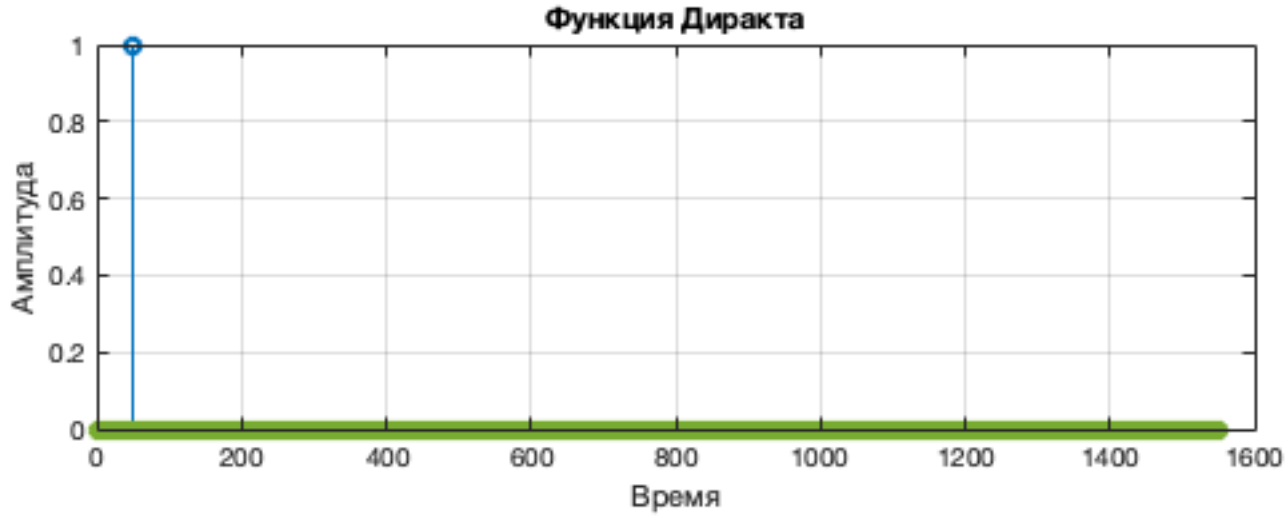
(Подпись, дата) (И.О.Фамилия)

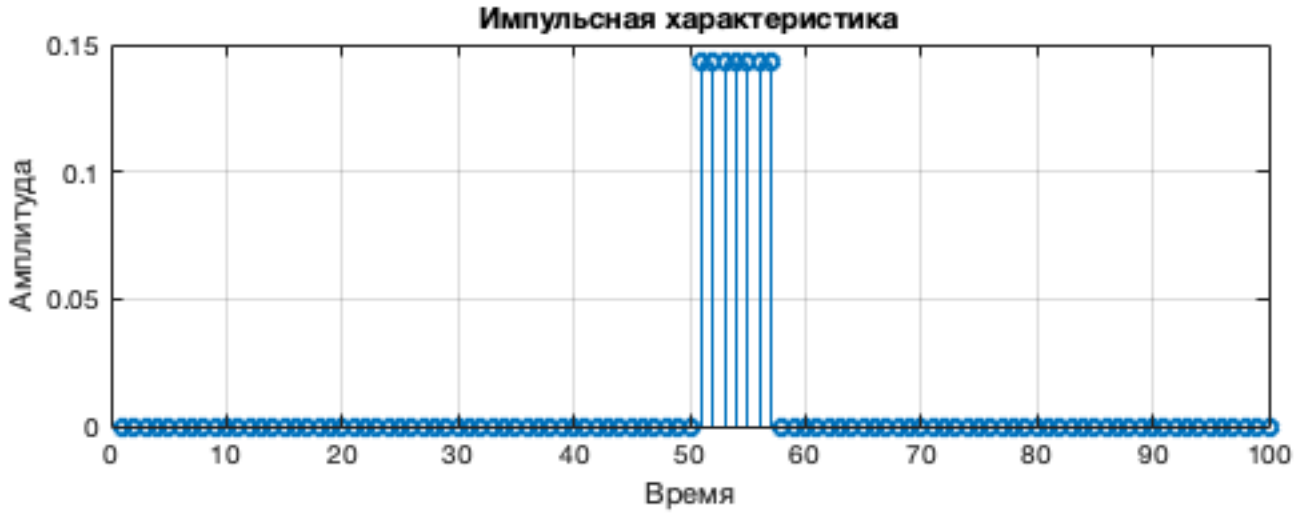
Москва, 2020

```
%### 1 БЕРЕМ СРЕДНЕЕ ###%
clear;
close all;


Fs = 97;
ts = 0: 1/Fs : 16-1/Fs;
N = length(ts);

% параметры случайного сигнала
a = -0.01;
b = 0.1;

% Задаем случайные сигналы
%x = zeros(N);
%x(5) = 1;
x = (a + (b - a) * rand(1, N)).*sin(2*pi*0.5*ts);

figure;
subplot(2,1,1);
plot(x); grid on; title('Исходный сигнал');

y = zeros(1,N+8);
for i = 8 : length(x)
   y(i) = (x(i - 1) + x(i - 2) + x(i - 3) + x(i - 4)...
       + x(i - 5) + x(i - 6) + x(i - 7)) / 7;
end

subplot(2,1,2);
plot(y(1:100)); grid on; title('Усредненный сигнал');

%Функция Диракта
x = zeros(N);
x(50) = 1;

figure;
subplot(2, 1, 1);
stem(x); grid on; title('Функция Диракта');
xlabel('Время'); ylabel('Амплитуда');

z = zeros(1, N + 8);
for i = 8 : length(x)
    y(i) = (x(i - 1) + x(i - 2) + x(i - 3) + x(i - 4)...
        + x(i - 5) + x(i - 6) + x(i - 7)) / 7;
end

subplot(2, 1, 2);
stem(y(1: 100)); grid on; title('Импульсная характеристика')
xlabel('Время'); ylabel('Амплитуда');
```


Исходный сигнал
0.1
0.05
0
-0.05
-0.1
0
200
400
600
800
1000
1200
1400
1600


Усредненный сигнал
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
70
80
90
100



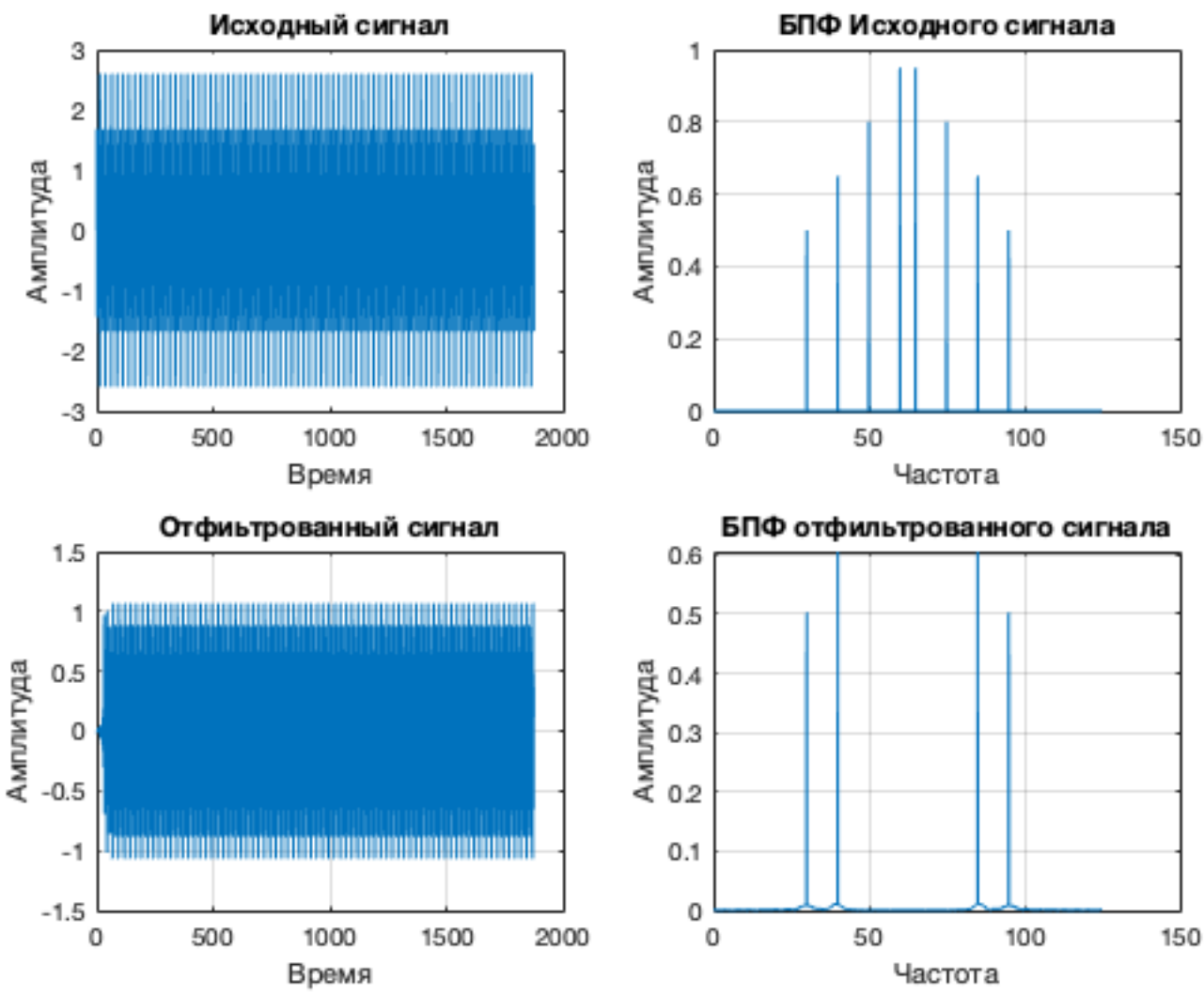

---

*Published with MATLAB® R2018b*

```
%### 2 Филтьтр ###%
function Hd = FIR1
%FIR1 Returns a discrete-time filter object.

% MATLAB Code
% Generated by MATLAB(R) 9.5 and DSP System Toolbox 9.7.
% Generated on: 14-Apr-2020 10:04:34

% Equiripple Lowpass filter designed using the FIRPM function.

% All frequency values are in Hz.
Fs = 125;  % Sampling Frequency

Fpass = 40;               % Passband Frequency
Fstop = 45;               % Stopband Frequency
Dpass = 0.057501127785;  % Passband Ripple
Dstop = 0.0001;           % Stopband Attenuation
dens  = 20;               % Density Factor

% Calculate the order from the parameters using FIRPMORD.
[N, Fo, Ao, W] = firpmord([Fpass, Fstop]/(Fs/2), [1 0], [Dpass, Dstop]);

% Calculate the coefficients using the FIRPM function.
b  = firpm(N, Fo, Ao, W, {dens});
Hd = dfilt.dffir(b);

Ts = 0 : 1/Fs : 15 - 1/Fs;
N = length(Ts);

f1 = 30;
f2 = 40;
f3 = 50;
f4 = 60;

x = 0.5*sin(2*pi*f1*Ts) + ...
    0.65*sin(2*pi*f2*Ts) + ...
    0.8*sin(2*pi*f3*Ts) + ...
    0.95*sin(2*pi*f4*Ts);

subplot(2, 2, 1);
plot(x); hold on; title('Исходный сигнал');
xlabel('Время'); ylabel('Амплитуда');
X = abs(fft(x));

Xm = 2*abs(X)/N;
X = (0: N - 1) * Fs / N;
subplot(2, 2, 2);
plot(X, Xm); grid on; title('БПФ Исходного сигнала');
xlabel('Частота'); ylabel('Амплитуда');

y = filter(Hd, x);
```

```
X = abs(fft(y));

subplot(2, 2, 3);
plot(y); grid on; title('Отфильтрованный сигнал');
xlabel('Время'); ylabel('Амплитуда');
Xm = 2 * abs(X) / N;
X = (0: N - 1) * Fs / N;
subplot(2, 2, 4);
plot(X, Xm); grid on; title('БПФ отфильтрованного сигнала');
xlabel('Частота'); ylabel('Амплитуда');
```

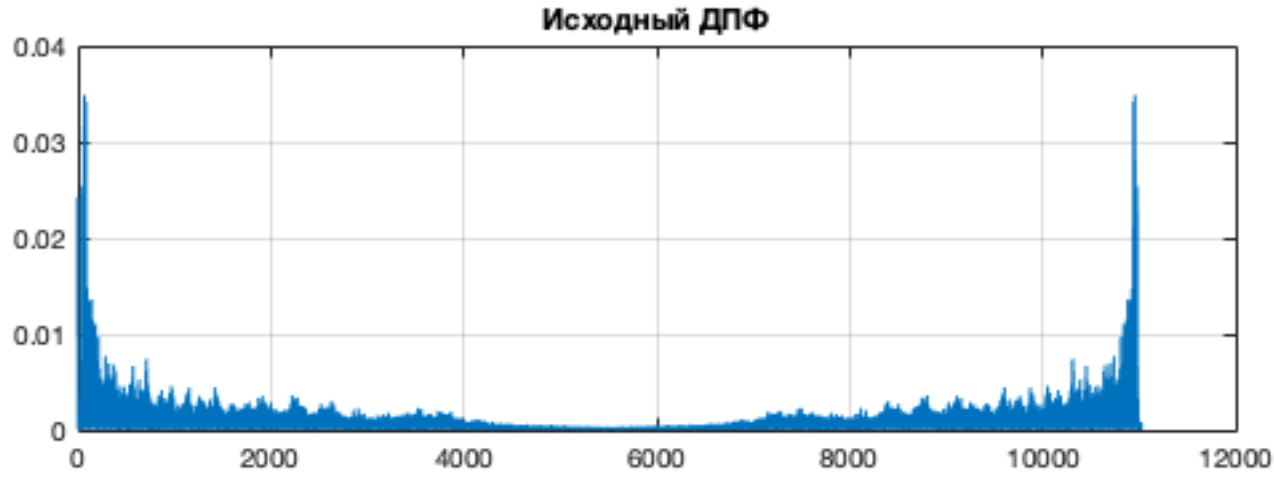
```
ans =

     FilterStructure: 'Direct-Form FIR'
          Arithmetic: 'double'
           Numerator: [1x64 double]
    PersistentMemory: false
```

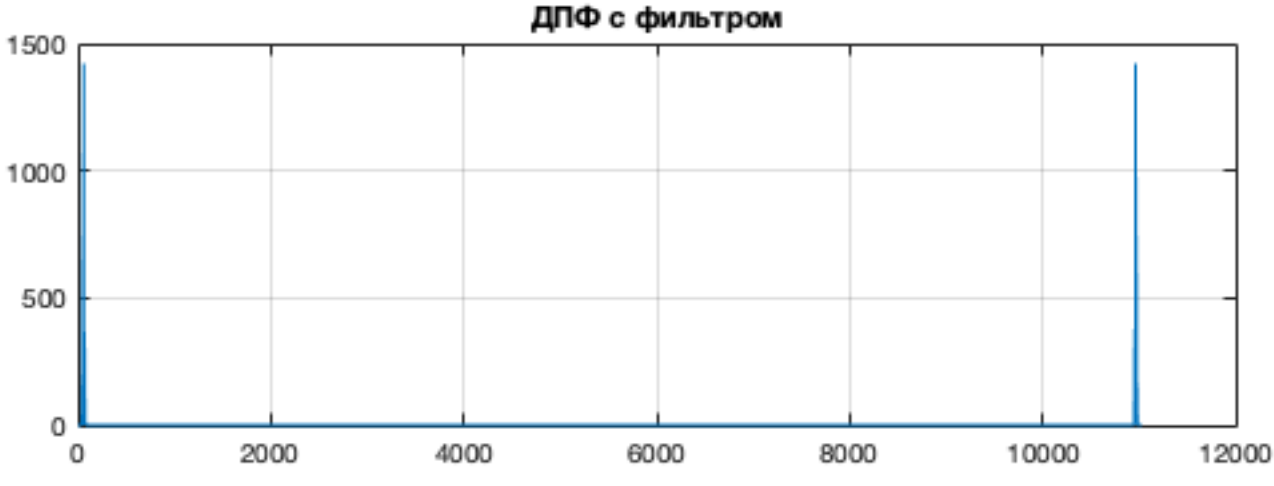



*Published with MATLAB® R2018b*

```
%### 2 Филтьтр WAV ###%
function Hd = FIR_WAV
%FIR_WAV Returns a discrete-time filter object.

% MATLAB Code
% Generated by MATLAB(R) 9.5 and DSP System Toolbox 9.7.
% Generated on: 14-Apr-2020 10:28:58

% Equiripple Bandpass filter designed using the FIRPM function.

% All frequency values are in Hz.
Fs = 25000;  % Sampling Frequency

Fstop1 = 20;               % First Stopband Frequency
Fpass1 = 40;               % First Passband Frequency
Fpass2 = 80;               % Second Passband Frequency
Fstop2 = 200;              % Second Stopband Frequency
Dstop1 = 0.001;            % First Stopband Attenuation
Dpass  = 0.057501127785;   % Passband Ripple
Dstop2 = 0.0001;           % Second Stopband Attenuation
dens   = 20;               % Density Factor

% Calculate the order from the parameters using FIRPMORD.
[N, Fo, Ao, W] = firpmord([Fstop1 Fpass1 Fpass2 Fstop2]/(Fs/2), [0 1 ...
                          0], [Dstop1 Dpass Dstop2]);

% Calculate the coefficients using the FIRPM function.
b  = firpm(N, Fo, Ao, W, {dens});
Hd = dfilt.dffir(b);

% [EOF]

[x, fs] = audioread('rock.wav');

zone = x(: ,1);
N = length(zone);

Xm = 2*(abs(fft(zone)))/N;
F = (0 : N - 1) * fs / N;
subplot(2, 1, 1);
plot(F, Xm); grid on; title('Исходный ДПФ');

filteredx = filter(Hd, zone);
xfft = abs(fft(filteredx(: ,1)));
Xm = 2*(xfft)/N;
F = (0 : N - 1) * fs / N;
subplot(2, 1, 2);
plot(F, Xm); grid on; title('ДПФ с фильтром');
sound(3*filteredx, fs);
```

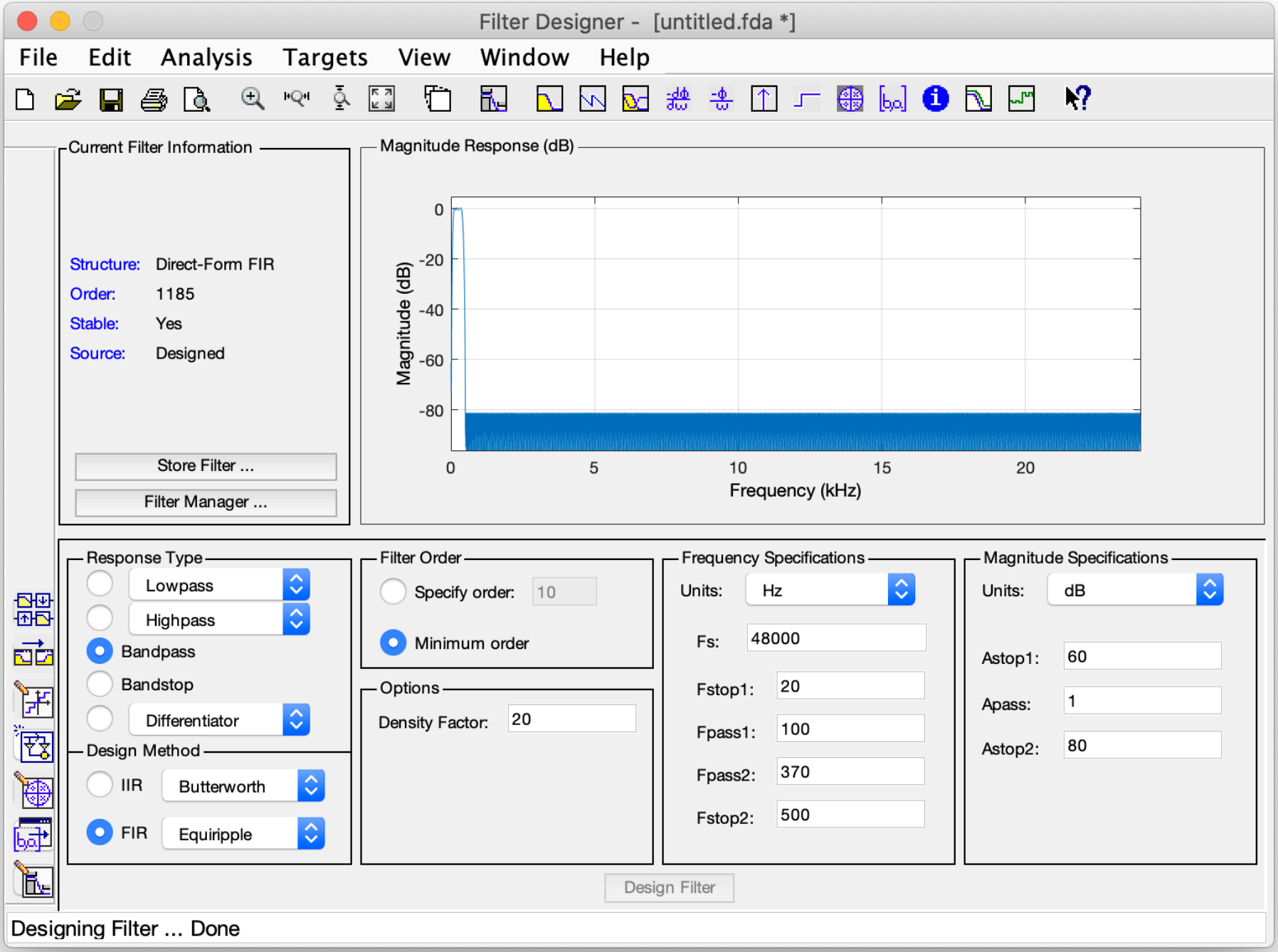
```
ans =

     FilterStructure: 'Direct-Form FIR'
          Arithmetic: 'double'
           Numerator: [1x2468 double]
    PersistentMemory: false
```

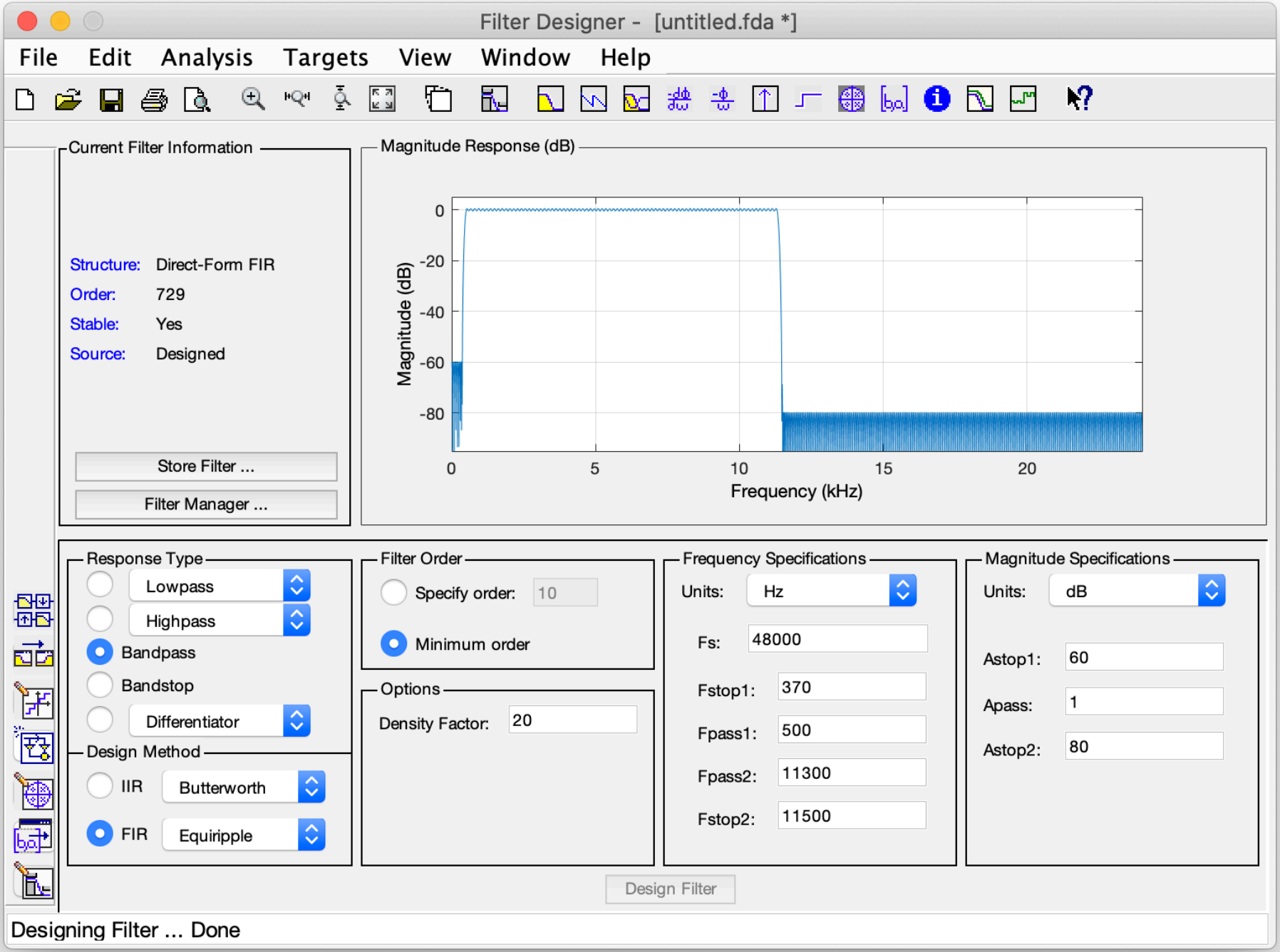



---

*Published with MATLAB® R2018b*


Filter Designer - [untitled.fda *]
File Edit Analysis Targets View Window Help
Current Filter Information
Structure: Direct-Form FIR
Order: 1185
Stable: Yes
Source: Designed
Store Filter ...
Filter Manager ...
Magnitude Response (dB)
Magnitude (dB)
0
-20
-40
-60
-80
0
5
10
15
20
Frequency (kHz)
Response Type
Lowpass
Highpass
Bandpass
Bandstop
Differentiator
Design Method
IIR
Butterworth
FIR
Equiripple
Filter Order
Specify order: 10
Minimum order
Options
Density Factor: 20
Frequency Specifications
Units: Hz
Fs: 48000
Fstop1: 20
Fpass1: 100
Fpass2: 370
Fstop2: 500
Magnitude Specifications
Units: dB
Astop1: 60
Apass: 1
Astop2: 80
Design Filter
Designing Filter ... Done


Filter Designer - [untitled.fda *]
File Edit Analysis Targets View Window Help
Current Filter Information
Structure: Direct-Form FIR
Order: 729
Stable: Yes
Source: Designed
Store Filter ...
Filter Manager ...
Magnitude Response (dB)
Magnitude (dB)
0
-20
-40
-60
-80
0
5
10
15
20
Frequency (kHz)
Response Type
Lowpass
Highpass
Bandpass
Bandstop
Differentiator
Design Method
IIR
Butterworth
FIR
Equiripple
Filter Order
Specify order: 10
Minimum order
Options
Density Factor: 20
Frequency Specifications
Units: Hz
Fs: 48000
Fstop1: 370
Fpass1: 500
Fpass2: 11300
Fstop2: 11500
Magnitude Specifications
Units: dB
Astop1: 60
Apass: 1
Astop2: 80
Design Filter
Designing Filter ... Done

Filter Designer - [untitled.fda *]

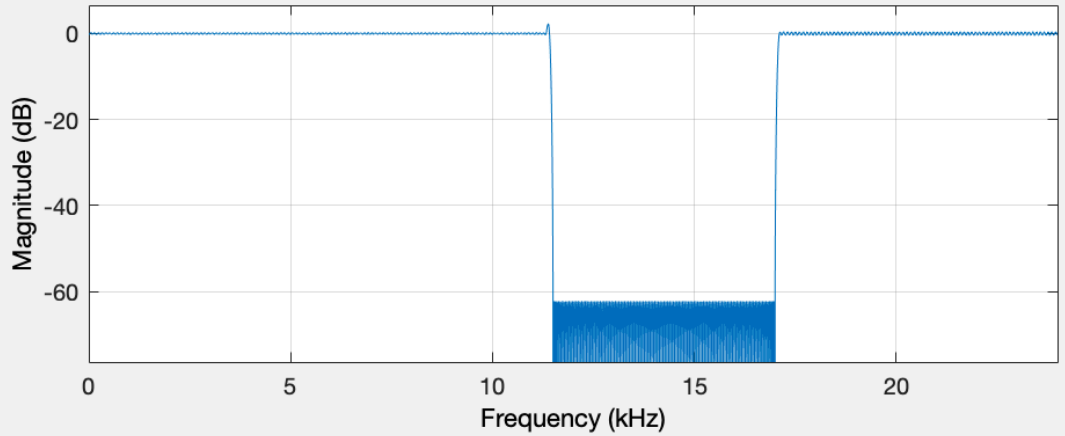
File Edit Analysis Targets View Window Help

Current Filter Information

Structure: Direct-Form FIR
Order: 1022
Stable: Yes
Source: Designed

Store Filter ...
Filter Manager ...

Magnitude Response (dB)




Response Type

- Lowpass
- Highpass
- Bandpass
- Bandstop
- Differentiator

Design Method

- IIR: Butterworth
- FIR: Equiripple

Filter Order

- Specify order: 10
- Minimum order

Options

Density Factor: 20

Frequency Specifications

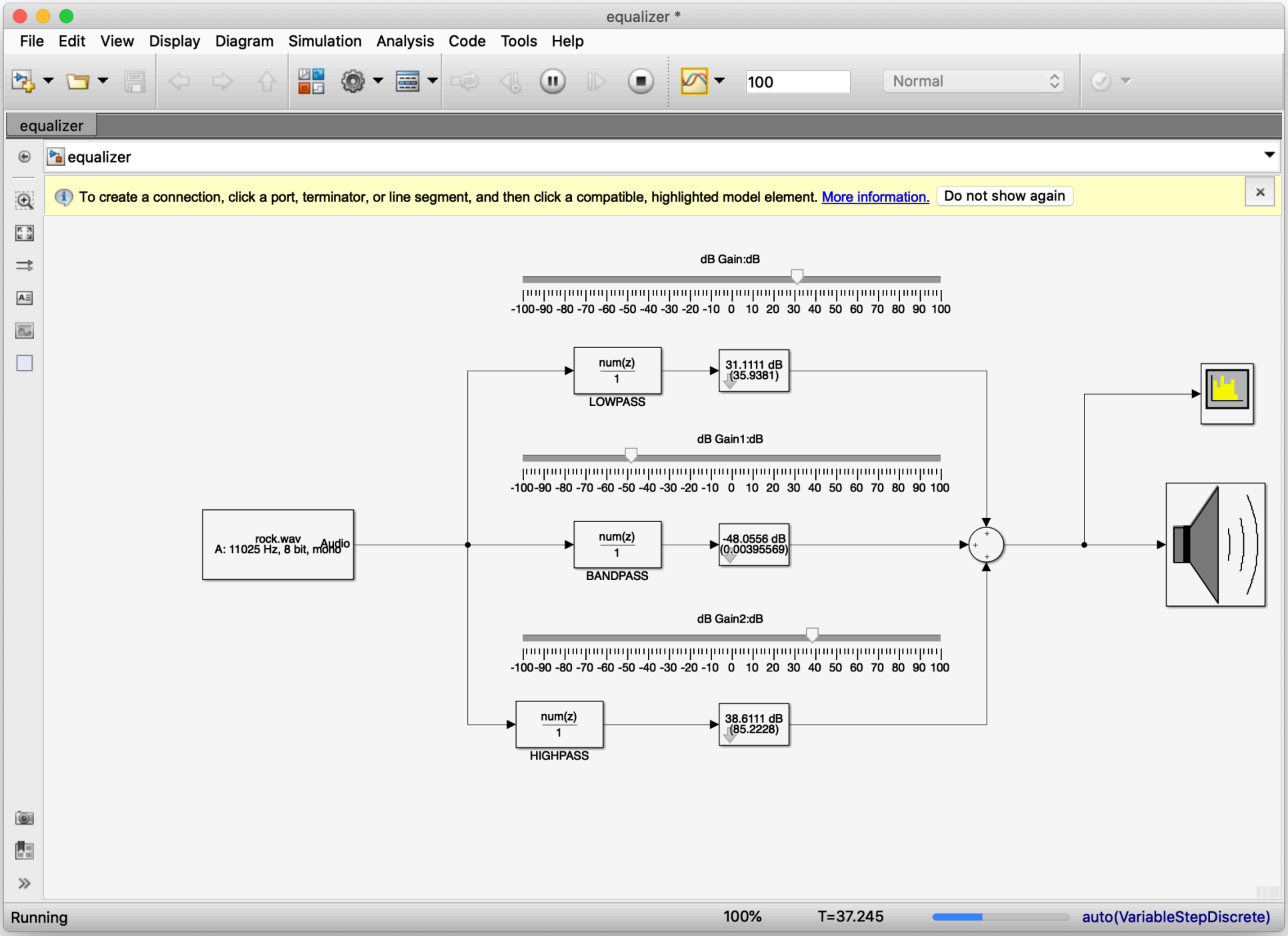
Units: Hz
Fs: 48000
Fpass1: 11300
Fstop1: 11500
Fstop2: 17000
Fpass2: 17100

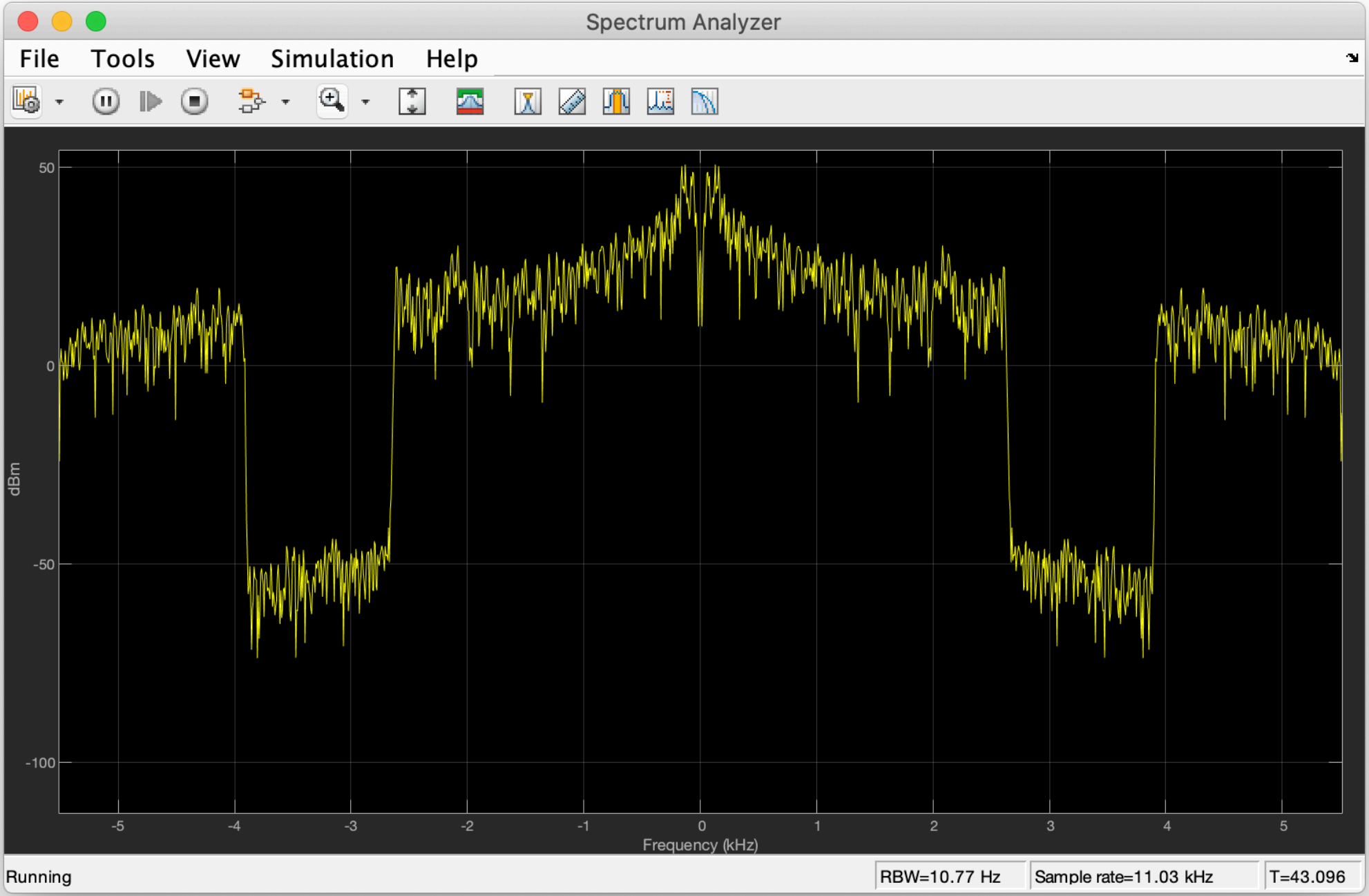
Magnitude Specifications

Units: dB
Apass1: .5
Astop: 60
Apass2: 1

Design Filter

Designing Filter ... Done


equalizer *
File Edit View Display Diagram Simulation Analysis Code Tools Help
100
Normal
equalizer
equalizer
To create a connection, click a port, terminator, or line segment, and then click a compatible, highlighted model element. More information. Do not show again
dB Gain:dB
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100
num(z)
1
LOWPASS
31.1111 dB
(35.9381)
dB Gain1:dB
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100
rock.wav
A: 11025 Hz, 8 bit, mono
Audio
num(z)
1
BANDPASS
-48.0556 dB
(0.00395569)
dB Gain2:dB
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100
num(z)
1
HIGHPASS
38.6111 dB
(85.2228)
Running
100%
T=37.245
auto(VariableStepDiscrete)


Spectrum Analyzer
File
Tools
View
Simulation
Help
50
0
-50
-100
dBm
-5
-4
-3
-2
-1
0
1
2
3
4
5
Frequency (kHz)
Running
RBW=10.77 Hz
Sample rate=11.03 kHz
T=43.096