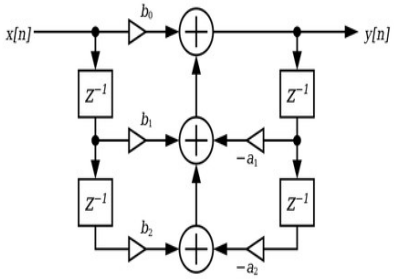
Goal: To determine the time domain response of the transfer function

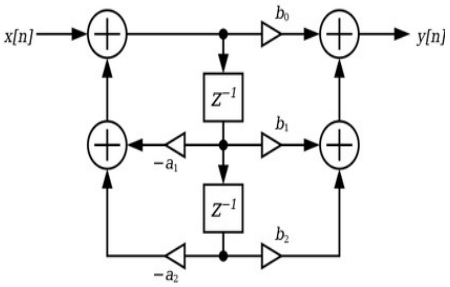
The transfer function for a linear, time-invariant, digital filter can be expressed as a transfer function in the Z-domain; if it is causal, then it has the form:[1]

$$H(z) = \frac{B(z)}{A(z)} = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2} + \cdots + b_N z^{-N}}{1 + a_1 z^{-1} + a_2 z^{-2} + \cdots + a_M z^{-M}}$$

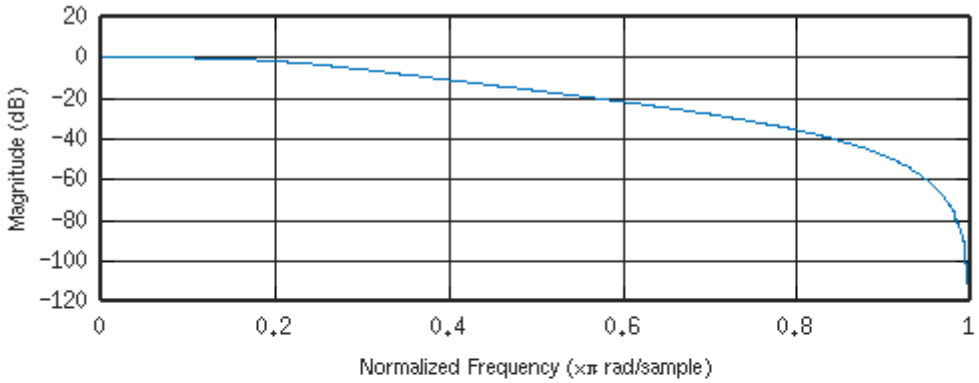
Direct Form 1

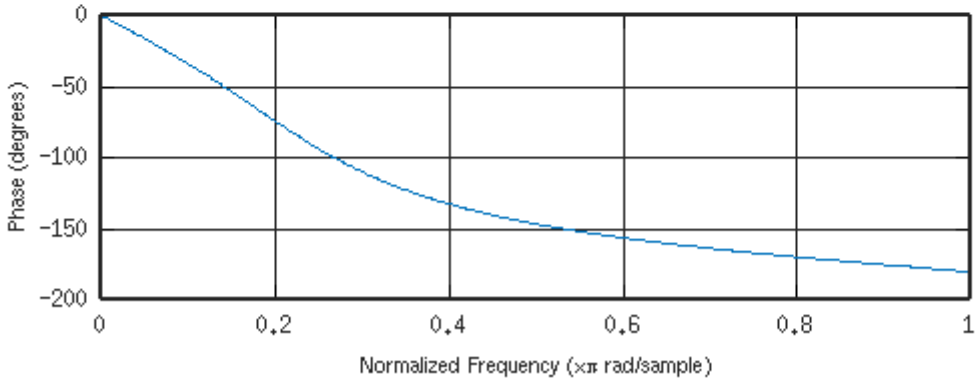


Direct Form II



Octave filter





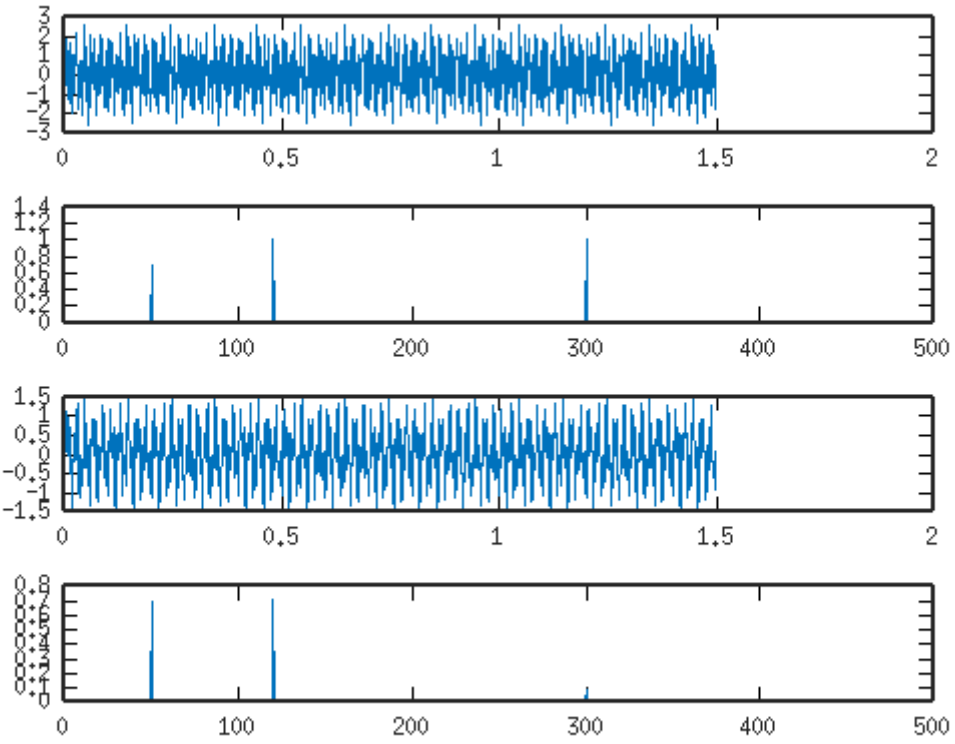
-0.167980, -265.000

Testcase
The first signal x is 3 sine waves 50, 120, and 300 Hz

The 2nd is the FFT of the signal x.

The 3rd is the filterd with the Butterworth filter.

The 4th show that only the 50 & 120 Hz are present.



421.525, 4.77541

Starting first with order 2
a = 1.00000 -0.98241 0.34767

b = 0.091315 0.182630 0.091315

[A,B,C,D] = tf2ss(b,a);

A =

5.5511e-17 3.4767e-01
-1.0000e+00 9.8241e-01

B =

-0.059568
0.272338

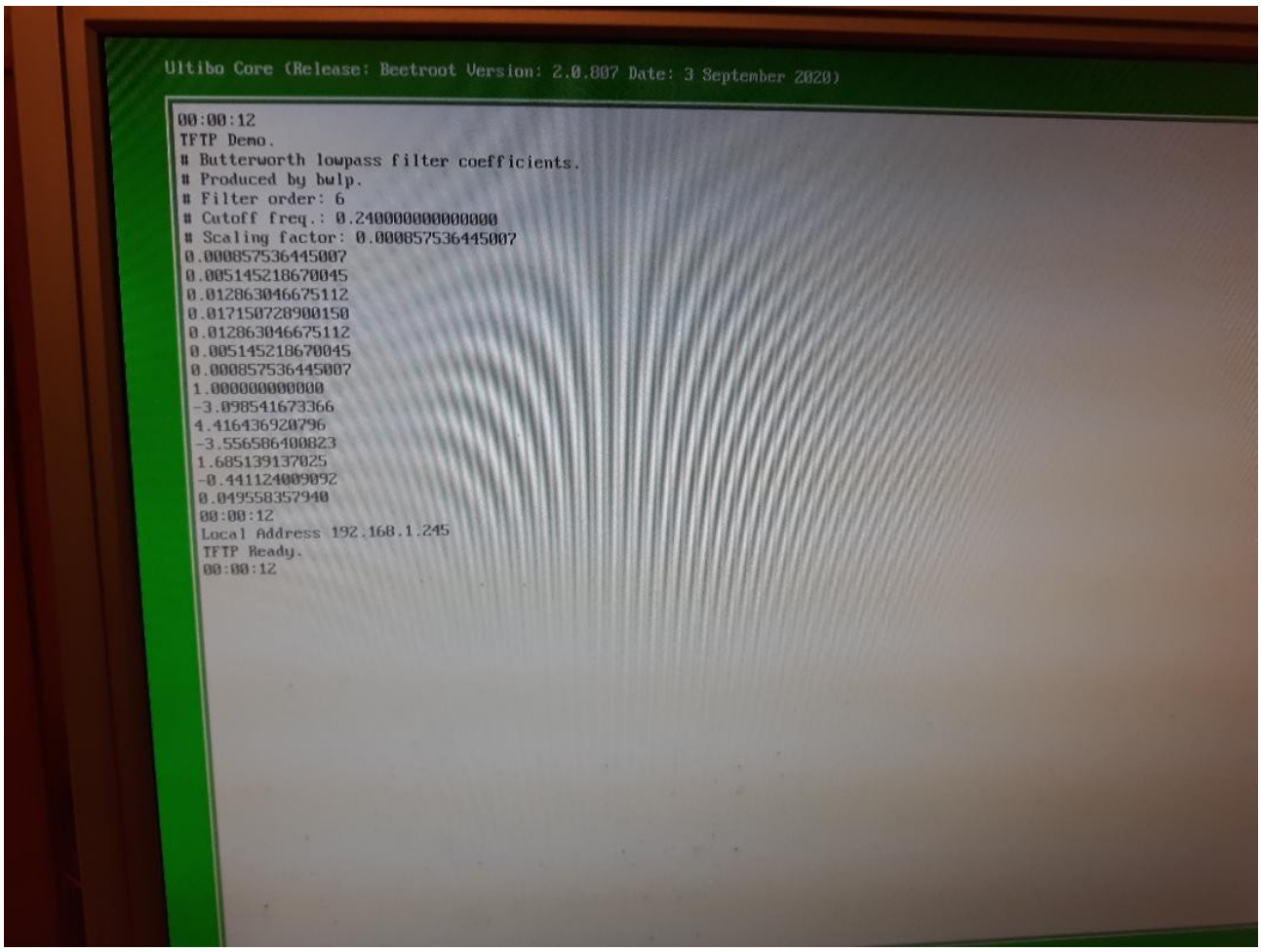
C =

0 1

D = 0.091315

butt6120lp
normalize freq
nf = 0.24000
zeros
ans =

```
  -1
  -1
  -1
  -1
  -1
  -1

poles
ans =

   0.61925 + 0.56170i
   0.49120 + 0.32617i
   0.43881 + 0.10665i
   0.43881 - 0.10665i
   0.49120 - 0.32617i
   0.61925 - 0.56170i

theta =

   0.73670
   0.58617
   0.23842
  -0.23842
  -0.58617
  -0.73670

b
b =

 Columns 1 through 6:

   0.00085754   0.00514522   0.01286305   0.01715073   0.01286305   0.00514522

 Column 7:

   0.00085754

a
a =

   1.000000  -3.098542   4.416437  -3.556586   1.685139  -0.441124   0.049558
```


Ultibo Core (Release: Beetroot Version: 2.0.807 Date: 3 September 2020)
00:00:12
TFTP Demo.
Butterworth lowpass filter coefficients.
Produced by bwlp.
Filter order: 6
Cutoff freq.: 0.240000000000000
Scaling factor: 0.000857536445007
0.000857536445007
0.005145218670045
0.012863046675112
0.017150728900150
0.012863046675112
0.005145218670045
0.000857536445007
1.000000000000
-3.098541673366
4.416436920796
-3.556586400823
1.685139137025
-0.441124009092
0.049558357940
00:00:12
Local Address 192.168.1.245
TFTP Ready.
00:00:12