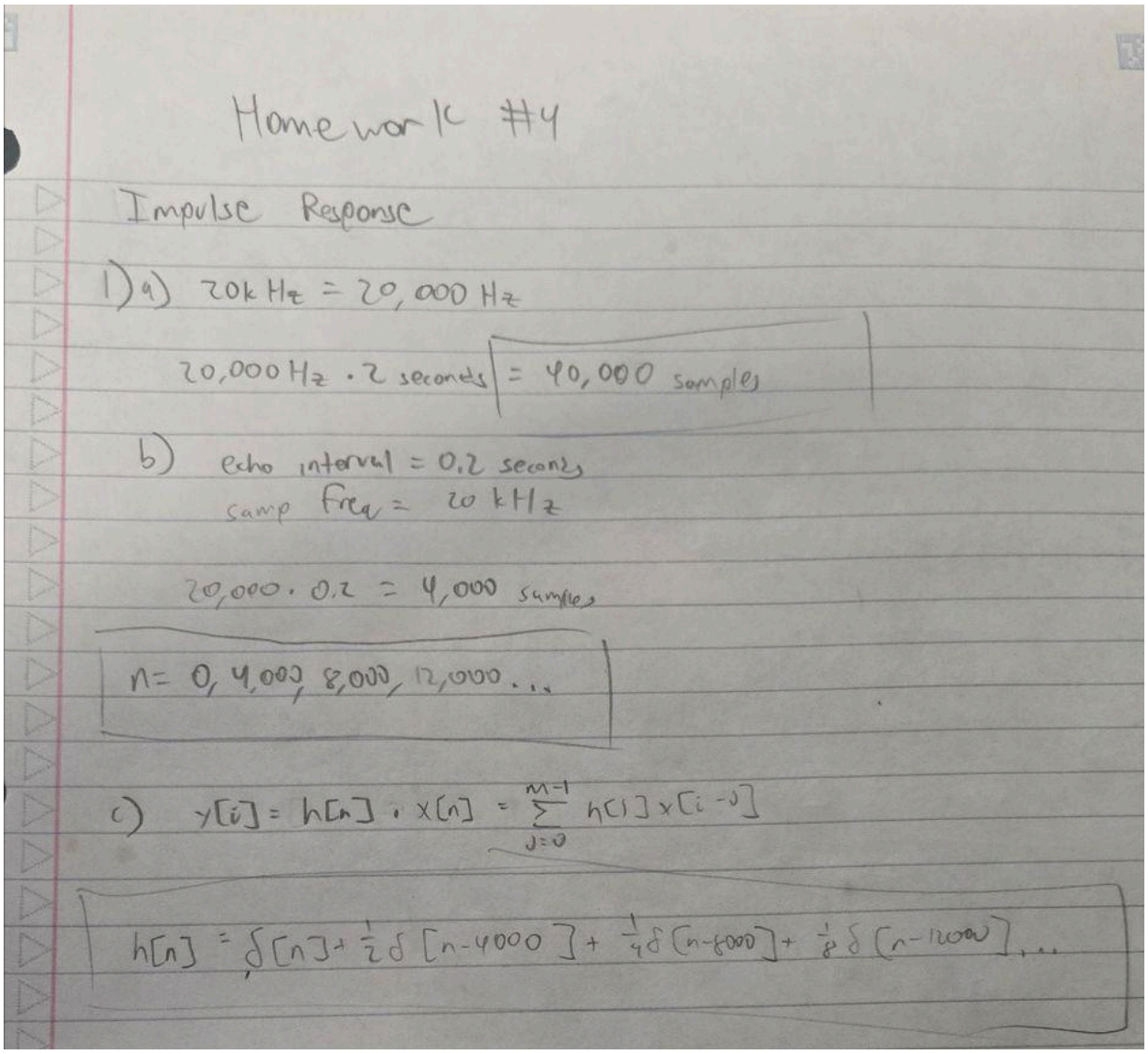
1.



Homework #4

Impulse Response

1) a) 20kHz = 20,000 Hz

20,000 Hz · 2 seconds = 40,000 samples

b) echo interval = 0.2 seconds
samp freq = 20 kHz

20,000 · 0.2 = 4,000 samples

n = 0, 4,000, 8,000, 12,000 ...

c) $y[i] = h[n] \cdot x[n] = \sum_{j=0}^{M-1} h[j]\, x[i-j]$

$h[n] = \delta[n] + \frac{1}{2}\delta[n-4000] + \frac{1}{4}\delta[n-8000] + \frac{1}{8}\delta[n-12000] \ldots$

```
>> k = 1;

>> while (k * int * sf < n_samp)
echo_index = round(k * int * sf);
echo_samp = [echo_samp, echo_index]
k = k + 1;
end
echo_samp = 4000
echo_samp =

   4000   8000

echo_samp =

    4000    8000   12000

echo_samp =

    4000    8000   12000   16000

echo_samp =

    4000    8000   12000   16000   20000

echo_samp =

    4000    8000   12000   16000   20000   24000

echo_samp =

    4000    8000   12000   16000   20000   24000   28000

echo_samp =

    4000    8000   12000   16000   20000   24000   28000   32000

echo_samp =

    4000    8000   12000   16000   20000   24000   28000   32000   36000

>> disp('Locations of non-zero samples (echoes):');
Locations of non-zero samples (echoes):
>> disp(echo_samp);
    4000    8000   12000   16000   20000   24000   28000   32000   36000
>>
```

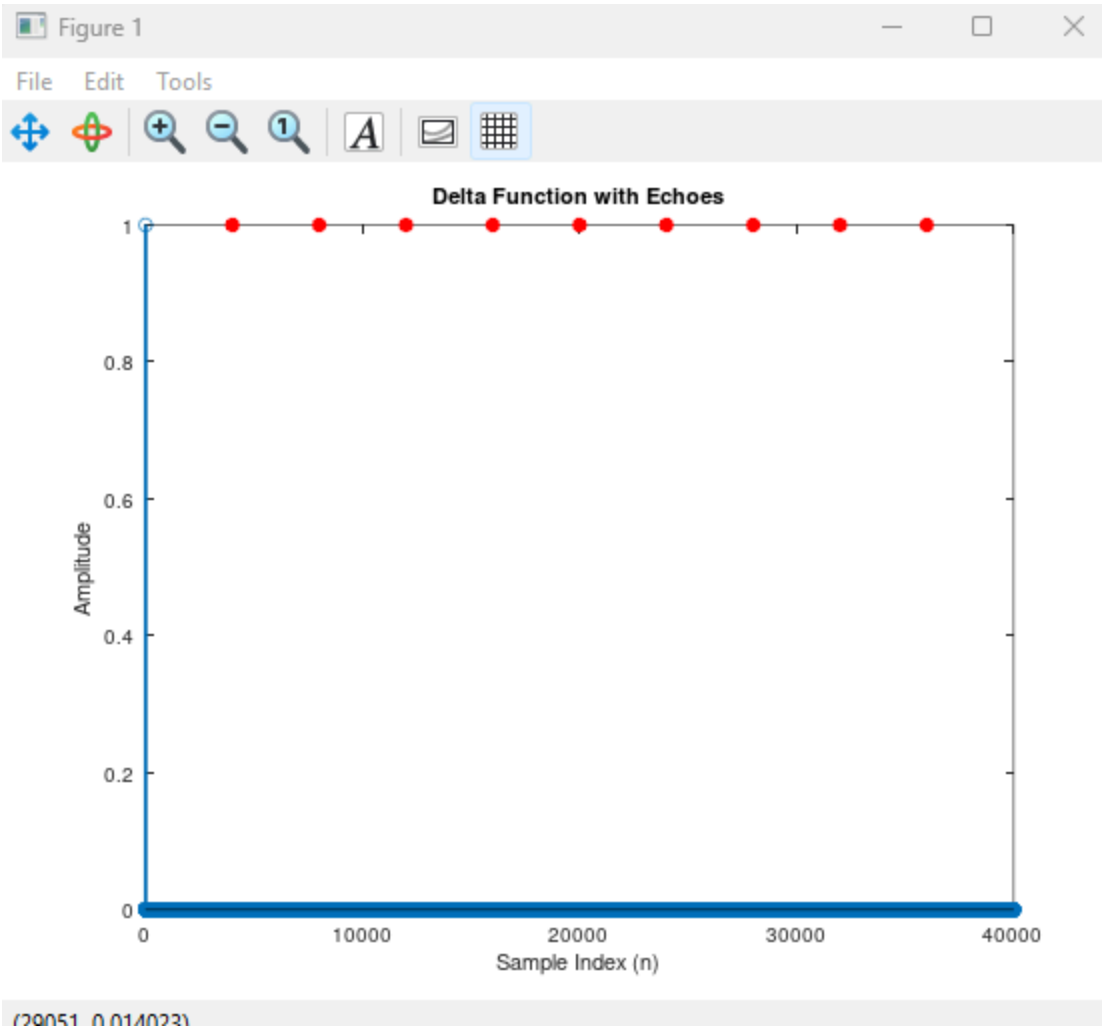
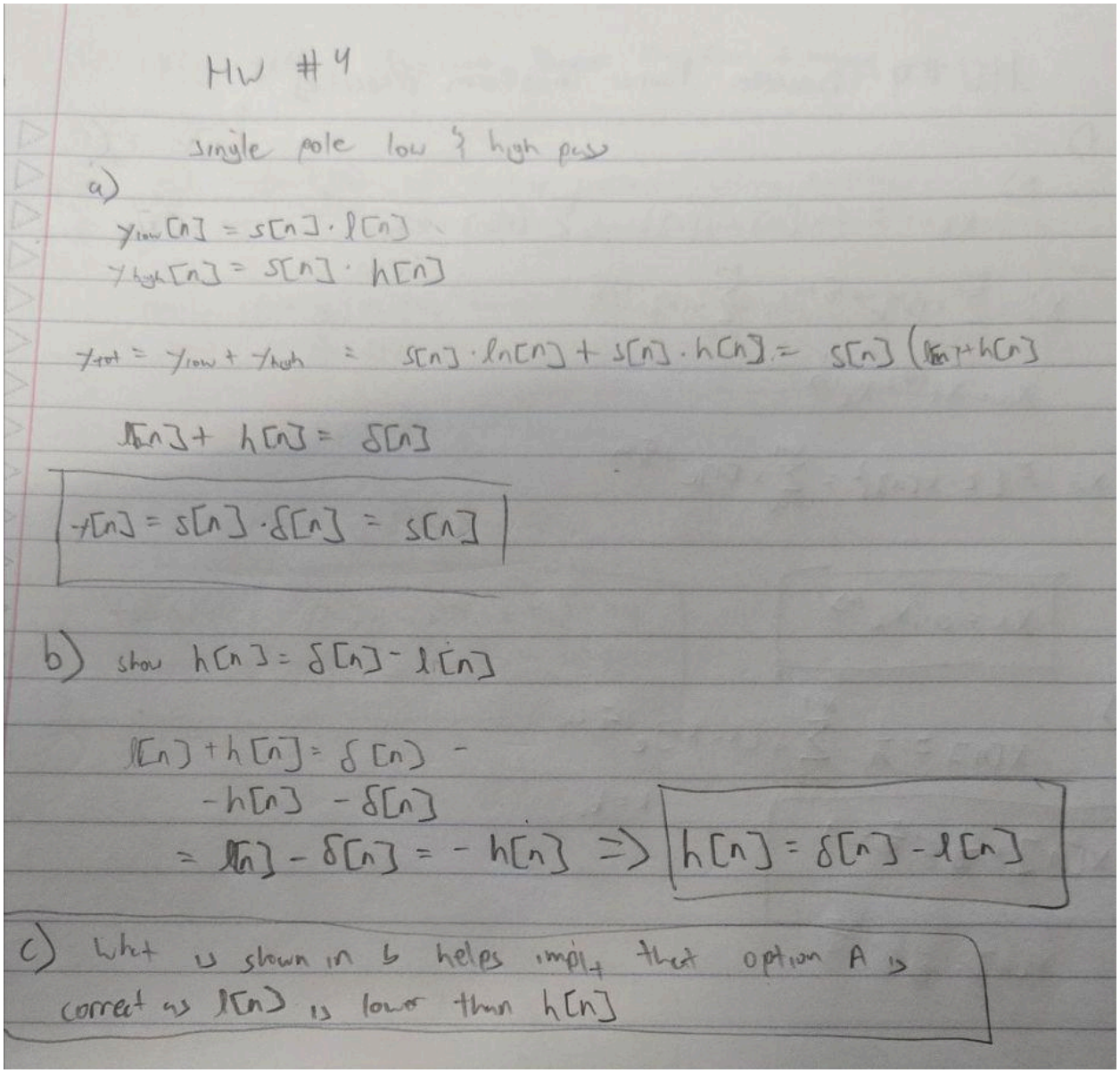


Figure 1
File Edit Tools
Delta Function with Echoes
Amplitude
Sample Index (n)
0
0.2
0.4
0.6
0.8
1
0
10000
20000
30000
40000

2.



HW #4

single pole low & high pass

a)

$y_{low}[n] = s[n] \cdot l[n]$

$y_{high}[n] = s[n] \cdot h[n]$

$y_{tot} = y_{low} + y_{high} = s[n] \cdot l[n] + s[n] \cdot h[n] = s[n](l[n] + h[n])$

$l[n] + h[n] = \delta[n]$

$$y[n] = s[n] \cdot \delta[n] = s[n]$$

b) show $h[n] = \delta[n] - l[n]$

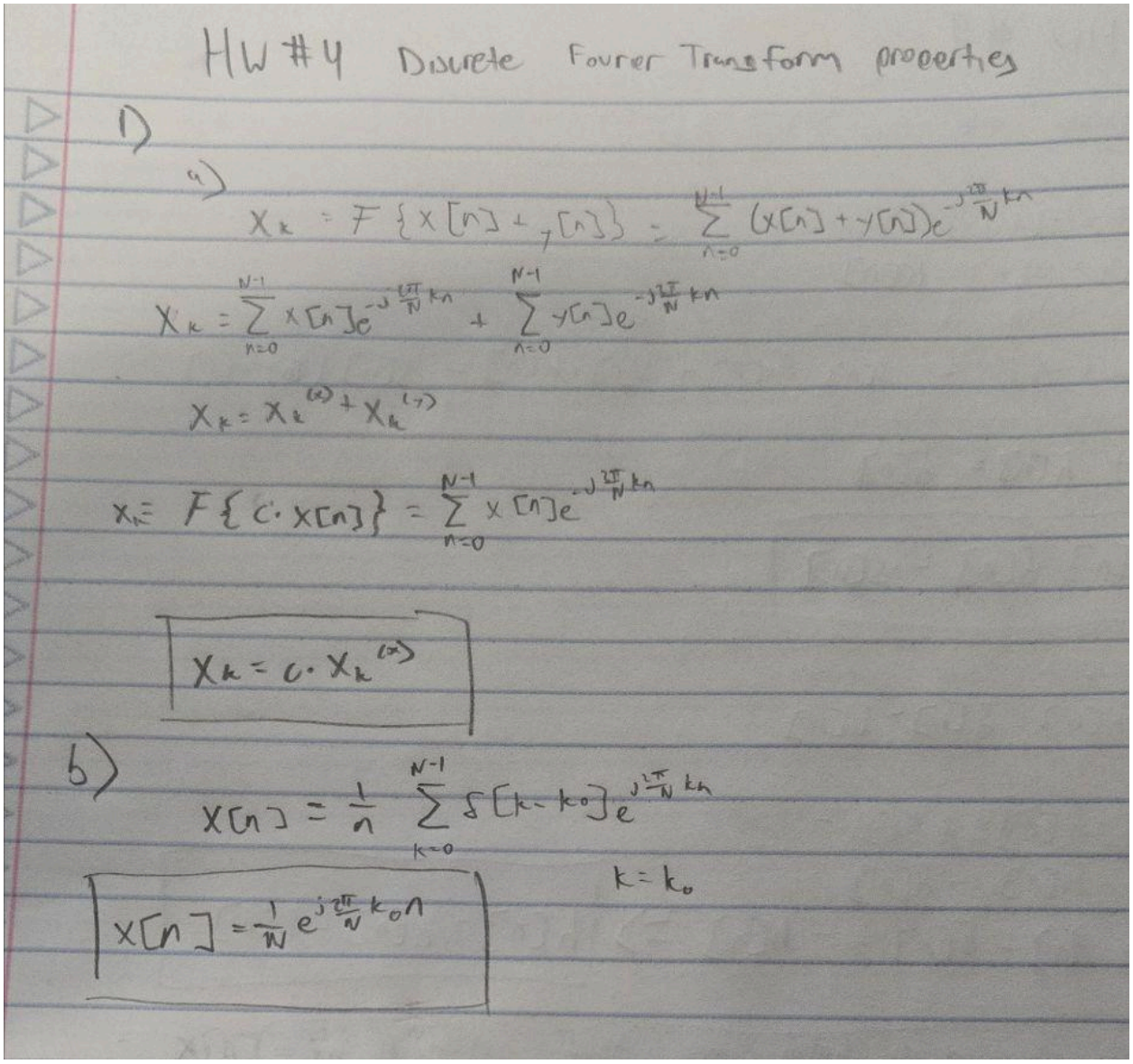
$l[n] + h[n] = \delta[n]$

$-h[n] \quad -\delta[n]$

$= l[n] - \delta[n] = -h[n] \Rightarrow$ $h[n] = \delta[n] - l[n]$

c) What is shown in b helps imply that option A is correct as $l[n]$ is lower than $h[n]$

3.



HW #4 Discrete Fourier Transform properties

1)

a)

$$X_k = F\{x[n] + y[n]\} = \sum_{n=0}^{N-1} (x[n] + y[n]) e^{-j\frac{2\pi}{N}kn}$$

$$X_k = \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N}kn} + \sum_{n=0}^{N-1} y[n] e^{-j\frac{2\pi}{N}kn}$$

$$X_k = X_k^{(x)} + X_k^{(y)}$$

$$X_k = F\{c \cdot x[n]\} = \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N}kn}$$

$$\boxed{X_k = c \cdot X_k^{(x)}}$$

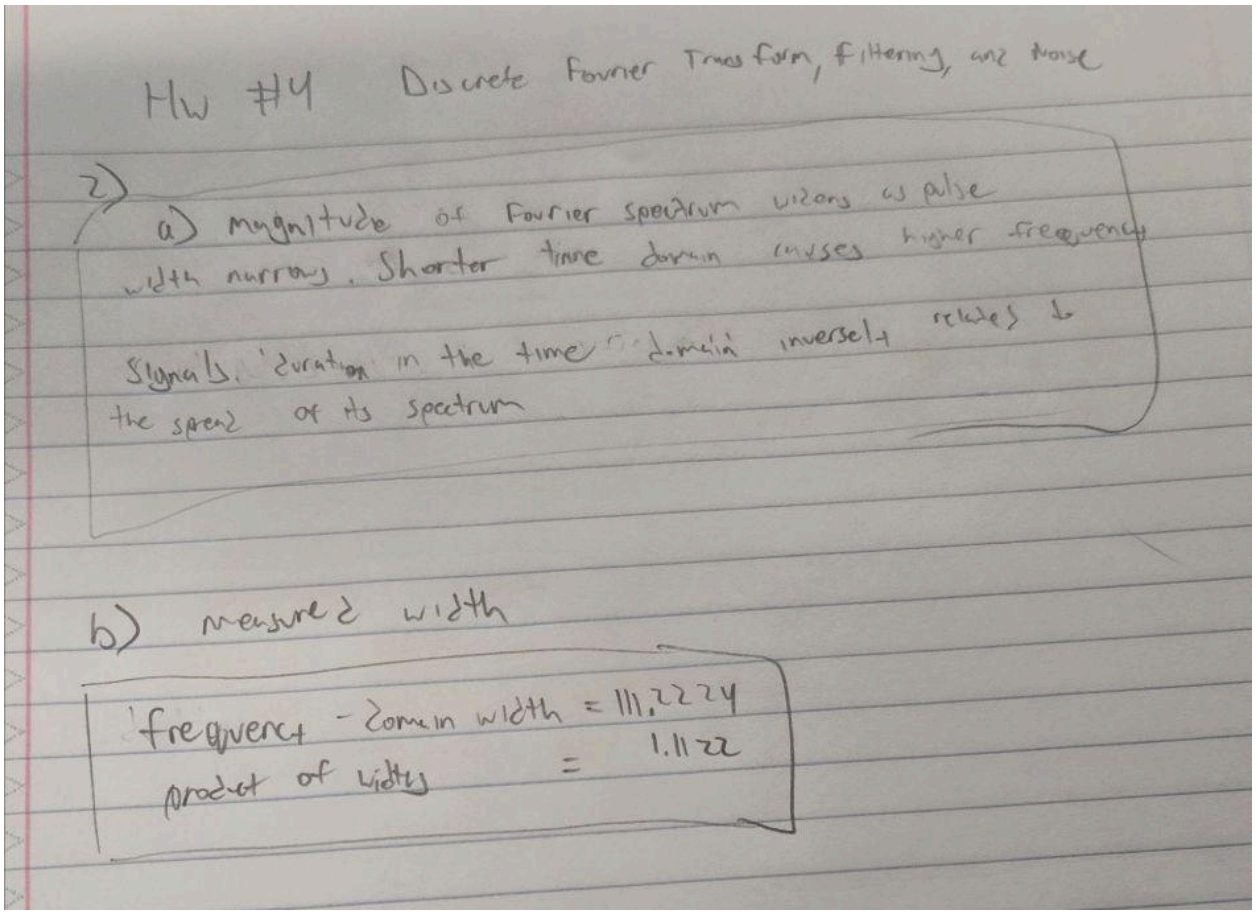
b)

$$x[n] = \frac{1}{n} \sum_{k=0}^{N-1} \delta[k - k_0] e^{j\frac{2\pi}{N}kn}$$

$k = k_0$

$$\boxed{x[n] = \frac{1}{N} e^{j\frac{2\pi}{N}k_0 n}}$$

4.



Hw #4 Discrete Fourier Transform, filtering, and noise

2)

a) magnitude of Fourier spectrum widens as pulse width narrows. Shorter time domain causes higher frequency signals. duration in the time domain inversely relates to the spread of its spectrum

b) measured width

frequency - domain width = 111.2224

product of widths = 1.1122