SIG 2

oev 50

a) $f_s = 8$ [kHz]   Tonevarighed $T_D = 40$ [ms]

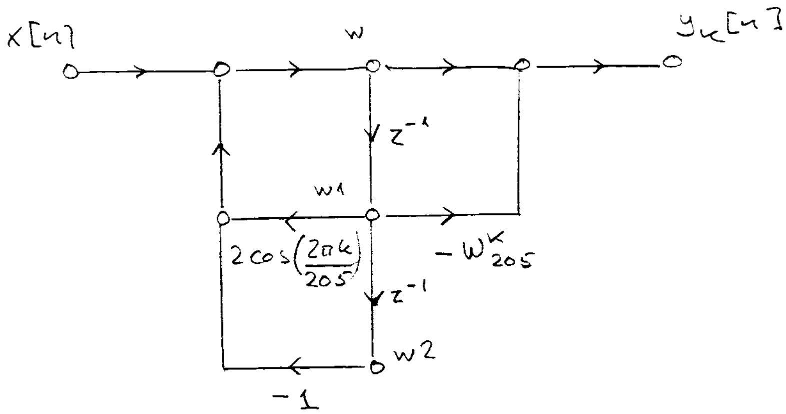
Antal mulige samples: $N_D = \frac{T_D}{T_s} = T_D \cdot f_s = 40 \cdot 10^{-3} \cdot 8 \cdot 10^3$

$= \underline{\underline{320}}$

b) $N = 205$

Ved FFT benyttes $N_F = 2^p$, dvs. nærmeste er $2^7 = 128$ eller $2^8 = 256$. $N = 205$ duer ikke.

c)



d) Fra DFT haves: $\Delta f = \frac{f_s}{N}$ og $f = \frac{f_s}{N} \cdot k$ (*)

$\Rightarrow k = \frac{f \cdot N}{f_s}$

$f = 697 \Rightarrow k = \frac{697 \cdot 205}{8 \cdot 10^3} = 17.86$ valg $\underline{\underline{k = 18}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 18 = \underline{\underline{702.44}}$ [Hz]

$f = 770 \Rightarrow k = \frac{770 \cdot 205}{8 \cdot 10^3} = 19.73$ valg $\underline{\underline{k = 20}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 19 = \underline{\underline{780.49}}$ [Hz]

$f = 852 \Rightarrow k = \frac{852 \cdot 205}{8 \cdot 10^3} = 21.83$ valg $\underline{\underline{k = 22}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 22 = \underline{\underline{858.54}}$ [Hz]

$f = 941 \Rightarrow k = \frac{941 \cdot 205}{8 \cdot 10^3} = 24.11$ valg $\underline{\underline{24}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 24 = \underline{\underline{936.59}}$ [Hz]

$f = 1209 \Rightarrow k = \frac{1209 \cdot 205}{8 \cdot 10^3} = 30.98$ valg $\underline{\underline{31}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 31 = \underline{1209.76}$ [Hz]

$f = 1336 \Rightarrow k = \frac{1336 \cdot 205}{8 \cdot 10^3} = 34.24$ valg $\underline{\underline{34}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 34 = \underline{\underline{1326.83}}$ [Hz]

$f = 1477 \Rightarrow k = \frac{1477 \cdot 205}{8 \cdot 10^3} = 37.85$ valg $\underline{\underline{38}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 38 = \underline{\underline{1482.93}}$ [Hz]

$f = 1633 \Rightarrow k = \frac{1633 \cdot 205}{8 \cdot 10^3} = 41.85$ valg $\underline{\underline{42}}$

$\Rightarrow f = \frac{8 \cdot 10^3}{205} \cdot 42 = \underline{\underline{1639.02}}$ [Hz]

$f_s = 8000$ [Hz] $\Rightarrow T_s = \frac{1}{f_s} = 125 \cdot 10^{-6}$ [s]

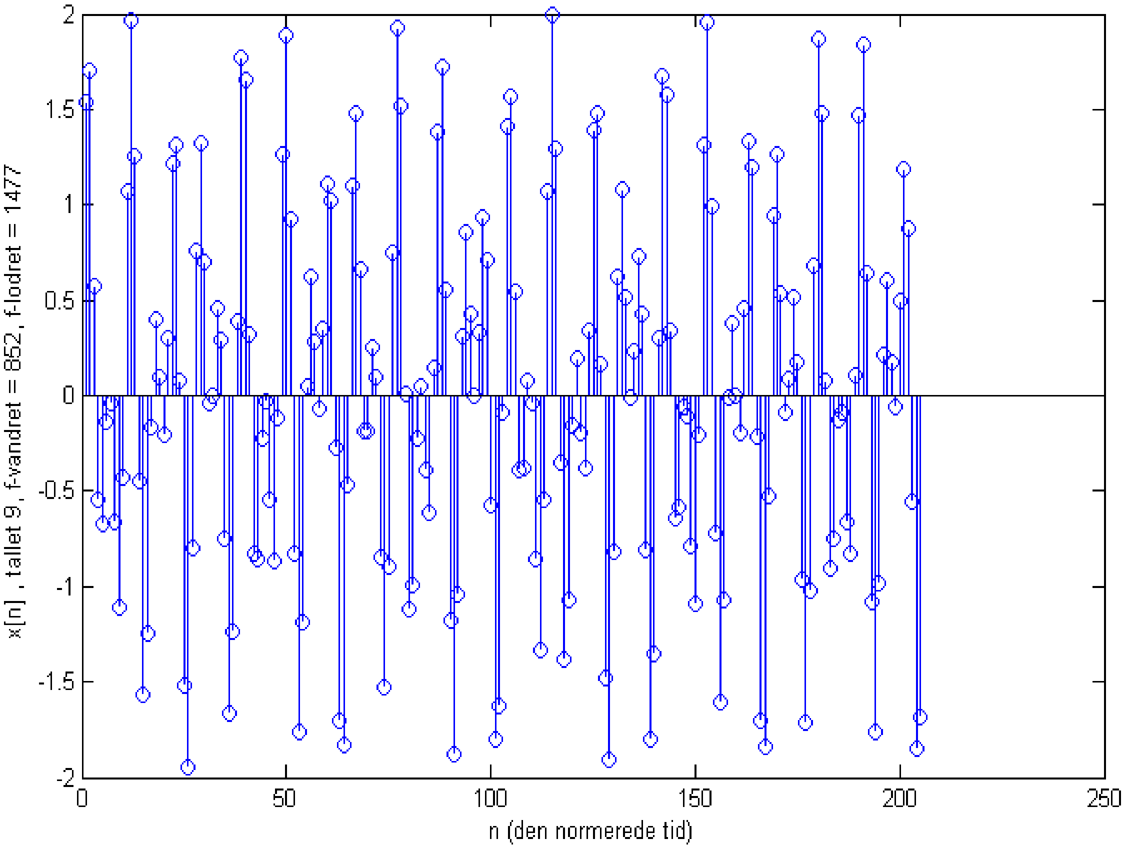
(*) Fra DFT-definitionen haves:

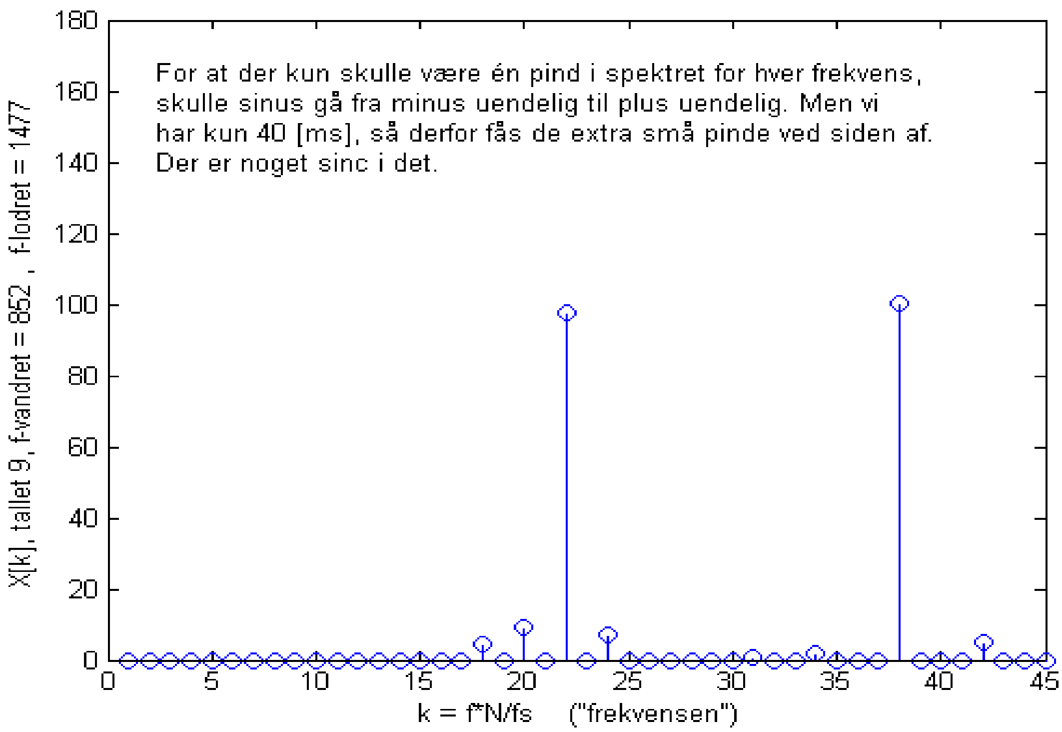
$$\omega = \frac{2\pi}{N} k \Leftrightarrow \Omega T_s = \frac{2\pi}{N} \cdot k \Leftrightarrow 2\pi f \cdot T_s = \frac{2\pi}{N} k$$

$$\Leftrightarrow f \cdot T_s = \frac{1}{N} k \Leftrightarrow f = \frac{1}{T_s} \cdot \frac{1}{N} \cdot k \Leftrightarrow f = \frac{f_s}{N} \cdot k$$

Da k er heltal bliver springet mellem to nabofrekvenser: $\Delta f = \frac{f_s}{N}$.

```
% Detektering af DTMF-toner ( Navn: Goertzel.m )
clf
clear
fvandret = input('f_vandret = ');
flodret = input ('f_lodret = ');

% Generering af DTMF-signal
n = 1:1:205;
x = sin(flodret*2*pi*125*0.000001*n) + sin(fvandret*2'pi*125*0.000001*n);
stem(x)
pause

% Beregning af spektret ved hjælp af Goertzels algoritme

MagX = zeros(1,45);
ReX = zeros(1,45);
ImX = zeros(1,45);

km = [18 20 22 24 31 34 38 42];
for k= 1:8
        w2 = 0;
        w1 = 0;
        w = 0;
                for n= 1:205
                        w = x(n) + 2*cos((2*pi*km(k))/205)*w1 - w2;
                        w2 = w1;
                        w1 = w;
                end
        w = 2*cos((2*pi*km(k))/205)*w1 - w2;

        ReX(km(k)) = w - w1*cos((2*pi*km(k))/205);
        ImX(km(k)) = w1*sin((2*pi*km(k))/205);
        MagX(km(k) = sqrt(ReX(km(k))^2+ImX(km(k))^2);

end

stem(MagX)
```


x[n] , tallet 9 , f-vandret = 852, f-lodret = 1477
n (den normerede tid)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
50
100
150
200
250


For at der kun skulle være én pind i spektret for hver frekvens, skulle sinus gå fra minus uendelig til plus uendelig. Men vi har kun 40 [ms], så derfor fås de extra små pinde ved siden af. Der er noget sinc i det.
X[k], tallet 9, f-vandret = 852 , f-lodret = 1477
k = f*N/fs ("frekvensen")
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
45