**Lab 4：The Continuous-Time Fourier Transform**

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| **Introduction**   1. Using MATLAB orders to do CTFT. 2. Using MATLAB to look into properties of CTFT. 3. Using MATLAB to do calculations like practicing residue method as well as confirm it. 4. Using MATLAB to discover properties of filters by interesting examples.   **Lab results & Analysis**：      **Question 4.2(a)**    **Analysis 4.2(a)**  ,    **Question 4.2(b)**  1605796676(1)  1605797024(1)  Fig 4.2b  **Analysis 4.2(b)**  y(t)=x(t-5),thus for ,T=10, y(t) can be derived from for i=1:1000,y(i)=x(500+i), the graph of y(t) is shown in Fig 4.2b.  **Question 4.2(c)**  1605797493(1)    Fig 4.2c  **Analysis 4.2(c)**  The graph of  is illustrated in Fig 4.2c.  **Question 4.2(d)**  1605798481(1)  **Analysis 4.2(d)**  ; construct the w with the given equation.  **Question 4.2(e)**  **1605798680(1)**  **1605799310(1)**  Fig 4.2e  **Analysis 4.2(e)**  , which is shown in Fig 4.2e.  **Question 4.2(f)**    1605803391(1)  Fig 4.2f-1    Fig 4.2f-2  **Analysis 4.2(f)**  The phase angle and magnitude is of theoretical  and approximate  is shown in Fig 4.2f-1 clearly. While from Fig 4.2f-2, we can evidently see the phase angle of theoretical  is zero, and the phase angle of approximate  is very small but isn’t zero. Meanwhile, the magnitude of approximate is close to the theoretical  at low frequency, while it becomes more inaccurate with higher frequency.  **Question 4.2(g)**      Fig 4.2g  **Analysis 4.2(g)**  The phase angle and magnitude of  is clearly shown in the first two graphs in Fig 4.2g, compared to the theoretical , the phase of  is changing during with the changes of frequency, and the magnitude of  andare the same because  is gained through the translation of  without changing the magnitude.    **Question 4.5(a)**    **Analysis 4.5(a)**  Thus we get b1=[1 -2] and a1=[1 1.5 0.5].  **Question 4.5(b)**      **Analysis 4.5(b)**  By using residue() we get r1=[6;-5] and p1=[-1;-0.5]. Thus we can write the partial fraction expansion of. After recombine it we get the same answer as part(a), so they give us H1(jω).  **Question 4.5(c)**    **Analysis 4.5(c)**  By inverse Fourier transform we get and it is absolutely integrable because  **Question 4.5(d)**    **Analysis 4.5(d)**  Thus we get b1=[3 10 5] and a1=[1 7 16 12].  **Question 4.5(e)**        **Analysis 4.5(e)**  By using residue() we get r2=[2;1;-3] and p2=[-3;-2;-2]. Thus we can write the partial fraction expansion of. After recombine it we get the same answer as part(a), so they give us H2(jω).  **Question 4.5(f)**    **Analysis 4.5(f)**  By inverse Fourier transform we get and it is absolutely integrable because  **Question 4.5(g)**    **Analysis 4.5(g)**  Thus we get b1=[-4] and a1=[1 0 -4].  **Question 4.5(h)**      **Analysis 4.5(h)**  By using residue() we get r3=[-1;1] and p3=[2;-2]. Thus we can write the partial fraction expansion of. After recombine it we get the same answer as part(a), so they give us H2(jω).  **Question 4.5(i)**    **Analysis 4.5(i)**  By inverse Fourier transform we get and it is absolutely integrable because. It is not causal because when t<0, h3(t) does not equal to zero.        **Question 4.6(a)**    **4.6a**  Fig 4.6a  **Analysis 4.6(a)**  Z=[dash dash dot dot]. Fig 4.6a shows us the signal z(t).  **Question 4.6(b)**    **4.6b**  Fig 4.6b-1  4.6b2  Fig 4.6b-2  **Analysis 4.6(b)**  Fig 4.6b-1 shows us the plot of frequency response in magnitude and phase. We can also see from Fig 4.6b-2 that the filter is a lowpass filter.  **Question 4.6(c)**    **4.6c**  Fig 4.6c  **Analysis 4.6(c)**  Fig 4.6c shows us the plot of dash & ydash as well as dot & ydot. We find that they have the same shape, but ydash and ydot have a time shifting of 0.05.  **Question 4.6(d)**    **D:\SUSTECH2020春\信号和系统\lab\HW4\4.6d.png4.6d**  Fig 4.6d  **Analysis 4.6(d)**  Fig 4.6d shows us the plot of signal y(t) and yo(t). We find that yo(t) is very small compared to y(t). Therefore, we conclude that after be modulated by cos(2πf1t), most of the energy in the Fourier transform move outside the passband of the filter.  **Question 4.6(e)**    **Analysis 4.6(e)**    In the same way,  **Question 4.6(f)**    **D:\SUSTECH2020春\信号和系统\lab\HW4\4.6f.png4.6f**  Fig 4.6f  **Analysis 4.6(f)**  We multiply x(t) by cos(2πf1t). Using the results from 4.6e, . After passing the lowpass filter. We only have  left, and the others are moved outside of the passband. Therefore, we can get the signal m1(t). Fig 4.6f shows us the signal m1(t). It matches [dash dot dot] and we find the letter in Morse code table, which is “D”.  **Question 4.6(g)**    **D:\SUSTECH2020春\信号和系统\lab\HW4\4.6g.png4.6g**  Fig 4.6g  **Analysis 4.6(g)**  Using the similar way as 4.6f, we can get the signals m1(t) and m2(t). Fig 4.6g shows us the signal m2(t) and m3(t). It matches [dot dot dot] & [dot dash dash dot] and we find the letter in Morse code table, which are “S” & “P”. Therefore we can answer the question “Agent 008, where does the future of technology lie?” -- It lies in DSP (Digital Signal Process).  **Note**: Please indicate meaning of the symbols in all expressions. Please indicate the coordinate and unit in all figures. | |
| **Experience**  This time we use MATLAB to do CTFT and verify some properties of it. These problems are somehow connected with what we’ve learned during the lecture.  In this lab we learn about continuous-time Fourier transformation, we compare the transformation with one approximation method, and learn how to apply it like making a filter to recognize and process the signals.What I gain in this lab is that we signals can be classified into low frequency signals and high frequency signals, which remarkably impacts the application of CTFT. While in some situations confronted with signals with higher frequency, more methods need to be taken to avoid the distortion of the signals, which contributes to the demands for high quality signal filters including high-pass, low-pass, band-pass, band-gap filters.  In 4.5, we find that using MATLAB to solve the poles and partial fraction is very convenient, compared with handling it manually. MATLAB may be quite necessary for our future study.  In 4.6, we use the properties of lowpass filter. When we multiply the signal with a cosine function, it moves out of the pass band of the filter, which can help us separate the single signal, eventually get DSP, the answer for 4.6g.  After practicing, we manage to finished most of the tasks and gain more understandings. Thanks Dr. Wu for teaching us MATLAB skills and understanding of Fourier series, also thanks TA for marking our work and giving feedback. | |
| **Score** |  |

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Code

%4.2b

clc;

clear;

b1=[1 -2];

a1=[1 1.5 0.5];

[r,p,k]=residue(b1,a1);

tau=0.01;

N=1000;

T=10;

t1=[0:tau:T-tau];

t=t1;

t2=[-T:tau:-tau];

k=[0:N-1];

g1=exp(-2.\*t1);

g2=exp(2.\*t2);

for i=1:1000

x(i)=g2(i);

end

for i=1001:2000

x(i)=g1(i-1000);

x3(i-1000)=g1(i-1000);

end

for i=1:1000

y(i)=x(500+i);

End

%4.2c

Y=fftshift(tau\*fft(y));

subplot(2,1,1)

plot(t1,real(Y))

ylabel('real(Y(j\omega))')

xlabel('\omega');

title('real part of Y(j\omega)')

subplot(2,1,2)

plot(t1,imag(Y))

xlabel('\omega');

ylabel('imag(Y(j\omega))');

title('imaginary part of Y(j\omega)')

%4.2d

w=-(pi/tau)+(0:N-1)\*(2\*pi/(N\*tau));

%4.2e

w=-(pi/tau)+(0:N-1)\*(2\*pi/(N\*tau));

X2=Y.\*exp(j.\*w.\*5);

subplot(2,1,1)

plot(w,real(X2))

xlabel('\omega')

ylabel('real(X(j\omega))')

title('real part of X(j\omega)')

subplot(2,1,2)

plot(w,imag(X2))

xlabel('\omega')

ylabel('imag(X(j\omega))')

title('imaginary part of X(j\omega)')

%4.2f

tau=0.01;

N=1000;

T=10;

t1=[0:tau:T-tau];

t=t1;

t2=[-T:tau:-tau];

k=[0:N-1];

g1=exp(-2.\*t1);

g2=exp(2.\*t2);

for i=1:1000

x(i)=g2(i);

end

for i=1001:2000

x(i)=g1(i-1000);

x3(i-1000)=g1(i-1000);

end

for i=1:1000

y(i)=x(500+i);

end

t3=[-T:tau:T-tau];

Y=fftshift(tau\*fft(y));

w=-(pi/tau)+(0:N-1)\*(2\*pi/(N\*tau));

X=[zeros(1,1000)];

for i=1:1000

X(i)=1/(2+1j.\*w(i))+1/(2-1j.\*w(i));

end

X3=Y.\*exp(j\*(5)\*w);

figure(1)

subplot(4,1,1)

semilogy(w,abs(X))

xlabel('\omega');

ylabel('abs(X(j\omega))')

title('the magnitude of theoretical X(j\omega) ')

subplot(4,1,2)

plot(w,angle(X))

xlabel('\omega');

ylabel('angle(X(j\omega))')

title('the angle of theoretical X(j\omega)')

subplot(4,1,3)

semilogy(w,abs(X3))

xlabel('\omega');

ylabel('abs(X(j\omega))')

title('the magnitude of aproximate X(j\omega)')

subplot(4,1,4)

plot(w,angle(X3))

ylabel('angle(X(j\omega))')

xlabel('\omega');

title('the angel of approximate X(j\omega)')

figure(2)

subplot(2,1,1)

semilogy(w,abs(X),w,abs(X3))

xlabel('\omega');

ylabel('abs(X(j\omega))')

title('the comparasion of the magnitude between two methods of X(j\omega) ')

legend('approximation X(j\omega)','theoretical X(j\omega)')

subplot(2,1,2)

plot(w,angle(X),w,angle(X3))

xlabel('\omega');

ylabel('angle(X(j\omega))')

title('the comoarasions of the angle between two methods of X(j\omega)')

legend('approximation X(j\omega)','theoretical X(j\omega)')

%4.2g

tau=0.01;

N=1000;

T=10;

t1=[0:tau:T-tau];

t=t1;

t2=[-T:tau:-tau];

k=[0:N-1];

g1=exp(-2.\*t1);

g2=exp(2.\*t2);

for i=1:1000

x(i)=g2(i);

end

for i=1001:2000

x(i)=g1(i-1000);

x3(i-1000)=g1(i-1000);

end

for i=1:1000

y(i)=x(500+i);

end

t3=[-T:tau:T-tau];

X3=fftshift(tau\*fft(x3));

Y=fftshift(tau\*fft(y));

w=-(pi/tau)+(0:N-1)\*(2\*pi/(N\*tau));

X=[zeros(1,1000)];

for i=1:1000

X(i)=1/(2+1j.\*w(i))+1/(2-1j.\*w(i));

end

subplot(4,1,1)

semilogy(w,abs(Y))

xlabel('\omega');

ylabel('abs(Y(j\omega))')

title('magnitude of Y(j\omega) ')

subplot(4,1,2)

plot(w,angle(Y))

xlabel('\omega');

ylabel('angle(Y(j\omega))')

title('angle of X(j\omega)')

subplot(4,1,3)

semilogy(w,abs(X),w,abs(Y))

xlabel('\omega');

ylabel('abs(Y(j\omega)and abs(X(j\omega))')

title('the comparasion of the magnitude between X(j\omega)and Y(j\omega) ')

legend('Y(j\omega)','theoretical X(j\omega)','location','northeastoutside')

subplot(4,1,4)

plot(w,angle(X),w,angle(Y))

xlabel('\omega');

ylabel('angle(Y(j\omega))and angle(X(j\omega))')

title('the coparasions of the angle between X(j\omega)and Y(j\omega)')

legend('Y(j\omega)','theoretical X(j\omega)','Location','Northeastoutside')

%4.5a

clc;

clear;

b1=[1 -2];

a1=[1 1.5 0.5];

[r,p,k]=residue(b1,a1);

%4.5d

b2=[3 10 5];

a2=[1 7 16 12];

[r2,p2,k2]=residue(b2,a2);

%4.5g

b3=[-4];

a3=[1 0 -4];

[r3,p3,k3]=residue(b3,a3);

clc;

clear;

load ctftmod.mat;

%4.6a

z=[dash dash dot dot];

plot(t,z),grid on,title('plot of z(t)'),xlabel('t'),ylabel('z(t)');

%4.6b

freqs(bf,af);

%4.6c

ydash=lsim(bf,af,dash,t(1:length(dash)));

ydot=lsim(bf,af,dot,t(1:length(dot)));

figure(1)

subplot(211),plot(t(1:length(dash)),dash),grid on,hold on;plot(t(1:length(dash)),ydash);title('plot of dash & ydash'),xlabel('t'),ylabel('dash & ydash)'),legend('dash','ydash');

subplot(212),plot(t(1:length(dot)),dot),grid on,hold on;plot(t(1:length(dot)),ydot);title('plot of dot & ydot'),xlabel('t'),ylabel('dot & ydot)'),legend('dot','ydot');

%4.6d

figure(2)

y=dash.\*cos(2\*pi\*f1\*t(1:length(dash)));

yo=lsim(bf,af,y,t(1:length(dash)));

subplot(211),plot(t(1:length(dash)),y);grid on,title('plot of y'),xlabel('t'),ylabel('y(t)');

subplot(212),plot(t(1:length(dash)),yo),grid on,title('plot of yo'),xlabel('t'),ylabel('yo(t)');

%4.6f

y=x.\*cos(2\*pi\*f1\*t);

m=2\*lsim(bf,af,y,t);

figure(3)

plot(t,m);title('plot of m1'),xlabel('t'),ylabel('m\_1(t)'),grid on;

%4.6g

y1=x.\*cos(2\*pi\*f1\*t);

m1=2\*lsim(bf,af,y1,t);

y2=x.\*sin(2\*pi\*f2\*t);

m2=2\*lsim(bf,af,y2,t);

y3=x.\*sin(2\*pi\*f1\*t);

m3=2\*lsim(bf,af,y3,t);

figure(4)

% subplot(311),plot(t,m1);title('plot of m1'),xlabel('t'),ylabel('m1(t)'),grid on;

subplot(211),plot(t,m2);title('plot of m2'),xlabel('t'),ylabel('m\_2(t)'),grid on;

subplot(212),plot(t,m3);title('plot of m3'),xlabel('t'),ylabel('m\_3(t)'),grid on;