California State University Long Beach

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CECS 463 – Digital Signal Processing

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Project 3

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**Part 1**

***Problem Description: In this section we tried to determine the resulting vector of x of coefficients and vector n of corresponding powers of z for the following polynomial operations in matlab. Then we did a z transform of each sequence using the definition and to output the region of convergence for the sequence and verify the z transform expressions.***

***1***

***a)***

***Solution: Results:***

|  |  |
| --- | --- |
| x= [1,0,0,1,-1,3,-2];  xn= -3:3;  y= [1,-2,4,3,-2,-1];  yn=-2:3;  [x], x[n]= conv\_m(x,xn,y,yn);  disp(x1);  disp(xln); |  |

***b)***

***Solution: Results:***

|  |  |
| --- | --- |
| sequence = [1,1,1];  sequence\_n= 0:2;  [x2,x2n]=conv\_m(sequence, sequence\_n,sequence, sequence\_n);  [x2,x2n] = conv\_m(sequence, sequence\_n,x2, x2n);  disp(x2);  disp(x2n); |  |

***c)***

***Solution: Results:***

|  |  |
| --- | --- |
| x= (z^3+-z^-1+3z^-2-2\*z^-3);  y= (z^2-2\*z+4+3z^-1-2\*z^-2+z^-3);  w = ((x-y)^2); |  |

***d)***

***Solution: Results:***

|  |  |
| --- | --- |
| x= (z^3+-z^-1+3z^-2-2\*z^-3);  y= (z^2-2\*z+4+3z^-1-2\*z^-2+z^-3);  w = (x)^2-(y)^2; |  |

**2.**

***a)***

***Solution: Results:***

|  |  |
| --- | --- |
| n=0:25; d=(n==0); x=(3/5).^n.\* (n>=0);  figure(1); clf(1); subplot(2,1,1); stem(n,x); grid on; title('2 A');  b=[1]; a= [1,-3/5]; y = filter(b, a, d);  subplot(2,1,2); stem(n,y); grid on;  error=max(abs(x-y));  if (error < eps)  fprintf(' Seqeuence: x=y on n=0:25\n');  else  fprintf(' Seqeunce: x!=y on n=0:25\n');  end |  |

***b)***

***Solution: Results:***

|  |  |
| --- | --- |
| display('Problem 2B ');  n=0:25;  d=(n==0);  x=((-2.^n).\*(n<=-1));  figure(2); clf(2);subplot(2,1,1); stem(n,x); grid on; title('2 B');  b=[1]; a= [1,-2]; y = filter(b, a, d);  subplot(2,1,2); stem(n,y); grid on;  error=max(abs(x-y));  if (error < eps)  fprintf(' Seqeuence: x=y on n=0:25\n');  else  fprintf(' Seqeunce: x!=y on n=0:25\n');  end |  |

***c)***

***Solution: Results:***

|  |  |
| --- | --- |
| b = [0 0 0.64]; a = [1 -0.8];  [d,n] = impseq(0,0,10); x1 = filter(b,a,d);  [u,n] = stepseq(2,0,10); x2 = ((0.8).^n).\*u;  error = max(abs(x1-x2));  fprintf(' (b) X(z)= 0.64/[z(z-0.8)]= 0.64z^-2/(1-0.8z^-1)\n');  fprintf(' ROC: |z|>0.8\n');  fprintf(' Error: %8.4f\n', error); | X(z)= 0.64/[z(z-0.8)]= 0.64z^-2/(1-0.8z^-1) ROC: |z|>0.8 Error: 0.0000 |

***d)***

***Solution: Results:***

|  |  |
| --- | --- |
| d. b = [1]; a = [1,-6, 9];  [d,n] = impseq(0,0,10); x1 = filter(b,a,d);  [u,n] = stepseq(0,0,10); x2 = ((n+1).\*3.0.^n).\*u;  error = max(abs(x1-x2)); fprintf(' (c) X(z)= (3/z)/(1-(3/z))^2 + 1/(1-(3/z)) \n'); fprintf(' = 1/(1-6^z^-1 +9z^-2)\n'); fprintf(' ROC: |z|>3\n'); fprintf(' Error: %8.4f\n', error); | X(z)= (3/z)/(1-(3/z))^2 + 1/(1-(3/z)) = 1/(1-6^z^-1 +9z^-2) ROC: |z|>3 Error: 0.0000 |

***Encountered problems: The problems that we encountered for this section was understanding what the problem wants. In the beginning we were just thinking to plug in the formula but we thought that was to easy and so we kept thinking harder even thought it was basically plugging in the formula to the equation.***

**Part 2**

***Problem Description: In this section we determined the z-transformed of certain sequences using the z-transform table. Then we determined the region of convergence and verified results in matlab. At last we divided the two non causal sequences.***

***1.***

***Solution: Results:***

|  |  |
| --- | --- |
| %% Problem 1A  clc; close all;  b = [0, 0, 2, 1]; a = [1, -1];  n = 0:25; % pick a range  d=(n==0);  y = filter(b, a, d);  % both x and y should be the same  x = 2\*(n==2) + 3\*(n>=3) % delta func .. step func  error = max(abs(y - x));  fprintf(' 1(a) X(z)= 2(z^-2)+3(z^-3)(1/(1-z^-1) = (2z^-2 +1z^-3)/(1-z^-1)\n');  fprintf(' ROC: |z|>1\n');  fprintf(' Error: %8.4f\n', error);  figure(1); clf(1);[Hz,Hp,Hl]=zplane(b,a); %set(Hz,'linewidth',2); set(Hp,'linewidth',2);  title('Pole-Zero Plot'); | x =  Columns 1 through 16  0 0 2 3 3 3 3 3 3 3 3 3 3 3 3 3  Columns 17 through 26  3 3 3 3 3 3 3 3 3 3  1(a) X(z)= 2(z^-2)+3(z^-3)(1/(1-z^-1) = (2z^-2 +1z^-3)/(1-z^-1)  ROC: |z|>1  Error: 0.0000 |

***B.***

***Solution: Results:***

|  |  |
| --- | --- |
| b=(3/2)\*[0,1,0,-4/9]; a=[1,-8/3,8/3,-32/27,16/81];  [d,n] = impseq(0,0,10); x1 = filter(b,a,d);  [u\_1,n] = stepseq(1,0,10); x2 =n.^2 .\* (2/3).^(n-2).\*u\_1;  error = max(abs(x1-x2));  fprintf('\n');  fprintf(' 1(b) X(z)=(3/2)[z^-1-(4/9)z^-3]/[1-(8/3)z^-1+(8/3)z^-2-(32/27)z^-3+(16/81)z^-4]\n');  fprintf(' ROC: |z|>2/3\n');  fprintf(' Error: %8.4f\n', error);  figure(2); clf(2);[Hz,Hp,Hl]=zplane(b,a); %set(Hz,'linewidth',2); set(Hp,'linewidth',2);  title('Pole-Zero Plot'); |  |

**2.**

***Solution: Results:***

|  |  |
| --- | --- |
| fprintf('\n');  fprintf(' X(z)=Z[x(n)]=1/(1+0.5z^-1) for |z|>0.5\n');  fprintf(' 2(a) Use frequency shifting property:\n');  fprintf(' X1(z) = Z[(1/2)^n x(n-2)] = Z[x(n-2)]with z => z/(1/2)=2z \n');  fprintf(' = (z^-2 X(z)) ROC: |z|>0.5 with z=2z \n');  fprintf(' = z^-2/(1+0.5z^-1) and now substitute z=2z (and also into ROC: |z|>0.5)\n');  fprintf(' = 0.25z^-2/(1-0.25z^-1)\n');  fprintf(' ROC: |z|>0.25\n'); | X(z)=Z[x(n)]=1/(1+0.5z^-1) for |z|>0.5  2(a) Use frequency shifting property:  X1(z) = Z[(1/2)^n x(n-2)] = Z[x(n-2)]with z => z/(1/2)=2z  = (z^-2 X(z)) ROC: |z|>0.5 with z=2z  = z^-2/(1+0.5z^-1) and now substitute z=2z (and also into ROC: |z|>0.5)  = 0.25z^-2/(1-0.25z^-1)  ROC: |z|>0.25 |

**B.**

***Solution: Results:***

|  |  |
| --- | --- |
| fprintf('\n');  fprintf(' 2(b) Use convolution property\n');  fprintf(' X1(z) = Z[x(n+2)\*x(n-2)] = z^2 X(z) z^-2 X(z) = X(z)^2\n');  fprintf(' = 1/(1-0.5z^-1)^2\n');  fprintf(' ROC: |z|>0.5\n'); | X1(z) = Z[x(n+2)\*x(n-2)] = z^2 X(z) z^-2 X(z) = X(z)^2  = 1/(1-0.5z^-1)^2  ROC: |z|>0.5 |

**3.**

***Solution: Results:***

|  |  |
| --- | --- |
| x = -2:0.1:2;  a = 1; b=0; c=.5;  u = a\*exp(-((x-b).^2)/(2\*c^2));  figure(1)  plot(x, u), hold on,  a = 0.1; b=0; c=.5;  h = a\*exp(-(x-b).^2/(2\*c^2));  y = conv(h, u);  y2plot = conv(h, u,'same');  figure(1)  plot(x, y2plot, 'r')  legend('input func', 'output func')  u1 = deconv(y ,h);  figure  plot(x, u1,'g') |  |

***Encountered problems: While solving for the solutions, a lot of time was spent looking for the correct formulas/ equations necessary to solve each problem. Also a lot of time was also spent doing the math by hand and checking to see if the results were right by matlab but other than that this part was very straightforward and easy to accomplish.***

**Part 3**

***Problem Description: In this section we determined the inverse z transform using the partial fraction expansion method. The for the linear and time invariant system described by the following impulse responses. Then we solved the difference equation for y(n) using the one sided z transform approach and then generated 20 samples. At last, we determined the zero input response and the zero state response of the system***

***1***

***a)***

***Solution: Results:***

|  |  |
| --- | --- |
| **disp('Problem 1a');**  **%figure(1); clf(1);**  **b=[1,-1,-4,4]; a=[1,-2.75,1.625,-0.25]; [R,p,c]=residuez(b,a)**  **Rmag=abs(R); Rang=angle(R); pmag=abs(p); pang=angle(p);**  **fprintf('X(z)= ');**  **for k=1:length(R)**  **if(abs(R(k))>0.000001)**  **fprintf('(%6.4f exp(j(%6.4f))/(1-(%6.4f) exp(j(%6.4f))z^-1)\n +',... Rmag(k),Rang(k),pmag(k),pang(k));**  **end**  **End**  **for k=1:length(c)**  **fprintf('(%6.4f)\n',c(k));**  **End**  **fprintf('\b\n');**  **fprintf('Hence: X(z)= -16 -10/(1-0.5z^-1) + 27/(1-0.25z^-1)\n');**  **fprintf(' x(n) = -16d(n)-10(0.5)^n u(n) + 27(0.25)^n u(n) \n');** | **R =**  **0.0000**  **-10.0000**  **27.0000**  **p =**  **2.0000**  **0.5000**  **0.2500**  **c =**  **-16 X(z)= (10.0000 exp(j(3.1416))/(1-(0.5000) exp(j(0.0000))z^-1) +(27.0000 exp(j(0.0000))/(1-(0.2500) exp(j(0.0000))z^-1) +(-16.0000)**  **Hence: X(z)= -16 -10/(1-0.5z^-1) + 27/(1-0.25z^-1) x(n) = -16d(n)-10(0.5)^n u(n) + 27(0.25)^n u(n)** |

***b)***

***Solution: Results:***

|  |  |
| --- | --- |
| disp('Problem 1b');  %figure(2); clf(2);  b=[0,0,1]; a=[1,2,1.25,0.25]; [R,p,c]=residuez(b,a)  Rmag=abs(R); Rang=angle(R);  pmag=abs(p); pang=angle(p); fprintf('X(z)= ');  for k=1:length(R) if(abs(R(k))>0.0000001)  fprintf('(%6.4f exp(j(%6.4f))/(1-(%6.4f) exp(j(%6.4f))z^-1)\n +',... Rmag(k),Rang(k),pmag(k),pang(k));  end  End  for k=1:length(c) fprintf('(%6.4f)\n',c(k));  End  fprintf('\b\n');  fprintf('Hence: X(z)= (4)/(1+z^-1) + (-8z) 0.5z^-1/(1-0.5z^-1)^2 \n'); fprintf(' x(n) = 4(-1)^n u(n) - 8(0.5)^(n+1) u(n+1) \n') | R =  4.0000  0.0000 - 0.0000i  -4.0000 + 0.0000i  p =  -1.0000  -0.5000 + 0.0000i -0.5000 - 0.0000i (a repeated root)  c = []    X(z)= (4.0000 exp(j(0.0000))/(1-(1.0000) exp(j(3.1416))z^-1) +(4.0000 exp(j(3.1416))/(1-(0.5000) exp(j(-3.1416))z^-1)  Hence: X(z)= (4)/(1+z^-1) + (-8z) 0.5z^-1/(1-0.5z^-1)^2 x(n) = 4(-1)^n u(n) - 8(0.5)^(n+1) u(n+1) |

***2.***

***Solution: Results:***

|  |  |
| --- | --- |
| disp('Problem 3');  figure(4); clf(4);  fprintf('(a) h(n)= 5(0.25)^n u(n)\n'); fprintf(' (i) H(z) = 5/(z-0.25z^-1) |z|>0.25 \n'); b=5; a=[1,-0.25]; fprintf(' (ii) y(n) = 5x(n) + 0.25y(n-1) \n');  fprintf(' (iii) Pole-Zero Plot -- see Figure 4 \n'); zplane(b,a); title('Figure 4: Pole-Zero Plot for y(n) = 5x(n) + 0.25y(n-1)');  fprintf(' (iv) Z[0.25^n u(n)] = 1/(1-0.25z^-1), |z|>0.25 \n');  fprintf(' Y(z)=H(z)X(z) = [5/(1-0.25z^-1)][1/(1-0.25z^-1)]= (20z)(0.25)z^-1/(10.25z^-1)^2, |z|>0.25 \n');  fprintf(' y(n) = 20(n+1)(0.25)^(n+1) u(n+1) \n'); figure(5); clf(5);  fprintf('(b) h(n)= [2-sin(pi n)]u(n) = 2 u(n)\n'); fprintf(' (i) H(z) = 2/(1-z^-1) |z|>1 \n'); b=2; a=[1,-1]; fprintf(' (ii) y(n) = 2x(n) + y(n-1) \n');  fprintf(' (iii) Pole-Zero Plot -- see Figure 4 \n'); zplane(b,a); title('Figure 5: Pole-Zero Plot for y(n) = 2x(n) + y(n-1)');  fprintf(' (iv) Z[0.25^n u(n)] = 1/(1-0.25z^-1), |z|>1 \n');  fprintf(' Y(z)=H(z)X(z) = [2/(1-z^-1)][1/(1-0.25z^-1)]=(8/3)/(1-z^-1)+ (2/3)/(1-0.25z^-1) |z|>1 \n'); b=2; a=poly([1,0.25]); [R,p,k]=residuez(b,a); fprintf(' Y(z) = '); for k=1:length(R) fprintf('(%6.4f)/(1-(%6.4f)z^-1) +',R(k),p(k)); end fprintf('\b\n'); fprintf(' y(n) = (8/3) u(n) + (-2/3)(1/4)^n u(n) \n'); | (a) h(n)= 5(0.25)^n u(n)  (i) H(z) = 5/(z-0.25z^-1) |z|>0.25  (ii) y(n) = 5x(n) + 0.25y(n-1)  (iii) Pole-Zero Plot -- see Figure 4  (iv) Z[0.25^n u(n)] = 1/(1-0.25z^-1), |z|>0.25 Y(z)= H(z)X(z) = [5/(1-0.25z^-1)][1/(1-0.25z^-1)] = (20z)(0.25)z^-1/(1-0.25z^-1)^2, |z|>0.25 y(n) = 20(n+1)(0.25)^(n+1) u(n+1)  (b) h(n)= [2-sin(pi n)]u(n) = 2 u(n) (i) H(z) = 2/(1-z^-1) |z|>1  (ii) y(n) = 2x(n) + y(n-1)  (iii) Pole-Zero Plot -- see Figure 4  (iv) Z[0.25^n u(n)] = 1/(1-0.25z^-1), |z|>1 Y(z)=H(z)X(z) = [2/(1-z^-1)][1/(1-0.25z^-1)] =(8/3)/(1-z^-1)+ (-2/3)/(1-0.25z^-1) |z|>1 Y(z) = (2.6667)/(1-(1.0000)z^-1) +(-0.6667)/(1-(0.2500)z^-1) y(n) = (8/3) u(n) + (-2/3)(1/4)^n u(n) |

***3.***

***Solution: Results:***

|  |  |
| --- | --- |
| disp('Problem 4');  figure(5); clf(5);  fprintf('Difference Eqn: y(n)=0.81y(n-2)+x(n)-x(n−1), n>=0; y(-2)=1; y(-1)=0;\n');  fprintf('Take 1-sided z-transform: Y+(z)=0.81[(y(-2)+z^-1y(-1)+z^-2Y+(z)] + X+(z)-1[x(1)+z^-1X+(z)]\n'); fprintf('Notice: x(n=-1)=1/7; x(n>=0) = 0.7^n u(n) \n');  fprintf('Substitute for X+(z): x(-1)=1/7 and X+(z)=1/1-(0.7)z^-1) and simplify:\n'); fprintf('Y+(z) = [(1-z^-1)/(1-0.81z^-2)][(1/(1-0.7z^-1)]+[(0.1914+1.62z^-1)/(1-0.81z^2)]\n'); num=conv([1,-0.7],[0.1914,1.62]); num(1)=num(1)+1;  num(2)=num(2)-1; b=num; a=poly([0.9,-0.9,0.7]);  [R,p,c]=residuez(b,a); zplane(b,a); title('Figure 5 -- Pole-Zero Plot of y(n)=0.81y(n-2)+x(n)-x(n-1)'); fprintf('Partial fractions: Y+(z) = '); for k=1:length(R) fprintf('(%6.4f)/(1-(%6.4f)z^-1) +',R(k),p(k)); end  fprintf('\b\n'); n=0:19; y = R(1)\*(p(1).^n) + R(2)\*(p(2).^n) + R(3)\*(p(3).^n); y20=zeros(1,20); y\_2=2; y\_1=2; x\_1=0.7^-1; n=0:20; x=(0.7).^n; y20(1)=0.81\*y\_2+x(1)-x\_1; y20(2)=0.81\*y\_1+x(2)-x(1); for k=3:20 y20(k) = 0.81\*y20(k-2) + x(k) - x(k-1); end %for k=1:20 fprintf('y(%2i)=%6.4f\ty20(%2i)=%6.4f \n',k,y(k),k,y20(k)); end  fprintf('y(n)= '); for k=1:length(R) fprintf('%6.4f(%4.2f)^n u(n) +',R(k),p(k)); end fprintf('\b\n'); fprintf('y20(n)=y20(n-2)+x(n)-x(n-1) n>=0; y(-2)=y(-1)=2; x(-1)=1/7\n'); error=max(abs(y-y20));  fprintf('error = max|y-y20|= %6.4f\n',error); | Difference Eqn: y(n)=0.81y(n-2)+x(n)-x(n−1), n>=0; y(-2)=1; y(-1)=0; Take 1-sided z-transform: Y+(z)=0.81[(y(-2)+z^-1y(-1)+z^-2Y+(z)] + X+(z)-1[x(-1)+z^-1X+(z)] Notice: x(n=-1)=1/0.7; x(n>=0) = 0.7^n u(n) Substitute for X+(z): x(-1)=1/0.7 and X+(z)=1/1-(0.7)z^-1) and simplify: Y+(z) = [(1-z^-1)/(1-0.81z^-2)][(1/(1-0.7z^-1)]+[(0.1914+1.62z^-1)/(1-0.81z^-2)] Partial fractions: Y+(z) = (-0.2106)/(1-(-0.9000)z^-1) +(0.7457)/(1-(0.9000)z^-1) +(0.6563)/(1-(0.7000)z^-1) y(n)= -0.2106(-0.90)^n u(n) +0.7457(0.90)^n u(n) +0.6563(0.70)^n u(n) y20(n)=y20(n-2)+x(n)-x(n-1) n>=0; y(-2)=y(-1)=2; x(-1)=1/7 error = max|y-y20|= 0.0000 |

**4.**

***Solution: Results:***

|  |  |
| --- | --- |
| disp('Problem 5'); %figure(6); clf(6); fprintf('Difference Equation: y(n)=0.980y(n-2)+x(n)+2x(n-1)+x(n-2), n>=0; y(-2)=1, y(1)=0\n'); fprintf('Input: x(n)=5(-1)^n u(n) so X(z)= 5/(1+z^-1)\n'); fprintf('1-sided z-transform: Y+(z)= 0.9801[y(-2)+y(-1)z^-1+Y+(z)z^-2\n'); fprintf(' +X+(z) +2[x(-1)+X+(z)z^-1]+[x(-2)+x(-1)z^1+X+(z)z^-2]\n'); fprintf('Simplifying: Y+(z) = 5(1+2z^-1+z^-2)/[(1+z^-1)(1-0.9801z^-2)] + 0.9801/(10.9801z^-2)\n'); fprintf(' = H(z)X(z) + H(z)XIC(z)\n'); fprintf('H(z) = 1/(1-0.9801z^-2); X(z)=5(1+2z^-1+z^-2)/(1+z^-1); XIC(z)= 0.9801\n');    b=[5,10,5]; a=conv([1,0,-0.9801],[1,1,0]); a(5)=[]; [R,p,c]=residuez(b,a) fprintf('Partial fraction expansion:\n Y+(z) = H(z)X(z) ='); for k=1:length(R) fprintf('(%6.4f)/(1-(%5.2f)z^-1) +',R(k),p(k)); end fprintf('\b\n'); fprintf(' yzs(n)= %6.4f (%5.2f)^n + %6.4f (%5.2f)^n \n',R(2),p(2),R(3),p(3)); n=0:500; yzs = R(1)\*(p(1).^n) + R(2)\*(p(2).^n) + R(3)\*(p(3).^n);    b=[0.9801]; a=[1,0,-0.9801]; [R,p,c]=residuez(b,a) fprintf('Partial fraction expansion:\n Y+(z) = H(z)XIC(z) ='); for k=1:length(R) fprintf('(%6.4f)/(1-(%5.2f)z^-1) +',R(k),p(k)); end fprintf('\b\n'); fprintf(' yzi(n)= %6.4f (%5.2f)^n + %6.4f (%5.2f)^n \n',R(1),p(1),R(2),p(2)); n=0:500; yzi = R(1)\*(p(1).^n) + R(2)\*(p(2).^n); y=yzs+yzi;    y500=zeros(1,501); y\_2=1; y\_1=0; x\_2=0; x\_1=0; n=0:500; x=5\*(-1).^n;    y500(1)=0.9801\*y\_2 +x\_2 +2\*x\_1 +x(1); y500(2)=0.9801\*y\_1 +x(2) +2\*x(1) +x\_1; for k=3:501 y500(k) = 0.9801\*y500(k-2) +x(k) +2\*x(k-1) +x(k-2); end error=max(abs(y-y500)); fprintf('error = max|y-y500|= %6.4f\n',error); | Problem 5 Difference Equation: y(n)=0.980y(n-2)+x(n)+2x(n-1)+x(n-2), n>=0; y(-2)=1, y(-1)=0 Input: x(n)=5(-1)^n u(n) so X(z)= 5/(1+z^-1) 1-sided z-transform: Y+(z)= 0.9801[y(-2)+y(-1)z^-1+Y+(z)z^-2 +X+(z) +2[x(-1)+X+(z)z^-1]+[x(-2)+x(-1)z^-1+X+(z)z^-2] Simplifying: Y+(z) = 5(1+2z^-1+z^-2)/[(1+z^-1)(1-0.9801z^-2)] + 0.9801/(1-0.9801z^-2) = H(z)X(z) + H(z)XIC(z) H(z) = 1/(1-0.9801z^-2); X(z)=5(1+2z^-1+z^-2)/(1+z^-1); XIC(z)= 0.9801 R = 0 -0.0253 5.0253 p = -1.0000 -0.9900 0.9900 c = []      Partial fraction expansion: Y+(z) = H(z)X(z) =(0.0000)/(1-(-1.00)z^-1) +(-0.0253)/(1-(-0.99)z^-1) +(5.0253)/(1-( 0.99)z^-1) yzs(n)= -0.0253 (-0.99)^n + 5.0253 ( 0.99)^n R = 0.4900 0.4900 p = 0.9900 -0.9900 c = [] Partial fraction expansion: Y+(z) = H(z)XIC(z) =(0.4900)/(1-( 0.99)z^-1) +(0.4900)/(1-(-0.99)z^-1) yzi(n)= 0.4900 ( 0.99)^n + 0.4900 (-0.99)^n error = max|y-y500|= 0.000 |

***Encountered problems:*** ***The hardest part of this part was doing the math by hand and checking to see if the results were right by matlab but other than that this part was very straightforward and easy to accomplish.***