**Problem 1**  
  
Show that as the sampling period approaches zero, the formula for the discrete-time Fourier transform given in approaches the formula for the Fourier transform.

Answer:

The sampling period . So, it can be rewritten.

As approaches zero, the discrete time , approaches continuous time . Moreover, the summation over approaches the equation below.

approaches the continuous FT . So, the formula for the DFT approaches the formula for the FT:

as the sampling period approaches zero.

**Problem 2**

the interpolation formula can be written like this

Prove the equation below.

Answer:

**Problem 3**

Specify the Nyquist rate and the Nyquist interval for each of the following signals:  
(a)   
(b)

Answer

Sinc is rectangular with 2B BW in FT domain. Sinc2 is the convolution of two rectangular signal that extends the BW to 4BW. Sinc3 extends the BW 3 times and Sinc4  extends the BW 4 times.

a)

Sinc BW is 100Hz.

Sinc2 BW is 200 Hz.

Sinc3 BW is 300 Hz. So, Nyquist rate is 600Hz and Nyquist interval is 1.66667ms

b)

Sinc4 BW is 400 Hz. And this is the highest signal frequency in (b). S0, Nyquist rate is 800 Hz, and Nyquist interval is 1.25 ms.

**Problem 4**

Consider uniform sampling of the sinusoidal wave

Determine the Fourier transform of the sampled waveform for the following sampling period:  
(a)   
(b)   
(c)

**Answer**

This is a cosine wave with angular frequency:

So, its Fourier Transform is:

If is sampled at period , the sampled signal is:

In the frequency domain, this gives:

So:  
The spectrum becomes periodic with spacing , and each replica is scaled by .

Case (a)

* No aliasing occurs, because

Replicas will be centered at:

So:

Plugging in :

Case (b)

* Critical Nyquist rate

Replicas are at:

No aliasing, but spectrum just touches at the boundary.

Case (c)

* Now: Aliasing occurs

Aliased frequency:

Try :

So the peaks are now incorrectly shifted due to aliasing.

**Problem 5**

Problem 5.9  
Using Eqs. (5.23) and (5.25), respectively, derive the slope characteristics of Eqs. (5.24) and (5.26).

Solution  
(a) The logarithmic law is defined by (see Eq. (5.23)

Therefore, differentiation with respect to yields

Equivalently, we may write

(b) The A-law is defined by (see Eq. (5.25):

Hence, differentiation of with respect to yields

Equivalently, we may write

**Problem 6**

Consider a sinusoidal wave of frequency and amplitude , applied to a delta modulator of step size . Show that slope-overload distortion will occur if

where is the sampling period. What is the maximum power that may be transmitted without slope-overload distortion?

Answer:

The modulating wave is

The slope of is given by

The maximum slope of is therefore equal to .  
The maximum average slope of the approximating signal produced by the delta modulator is , where is the step size and is the sampling period. The limiting value of is therefore given by

Assuming a load of 1 ohm , the transmitted power is . Therefore, the maximum power that nay be transmitted without slope-overload distortion is equal to .

Problem 7