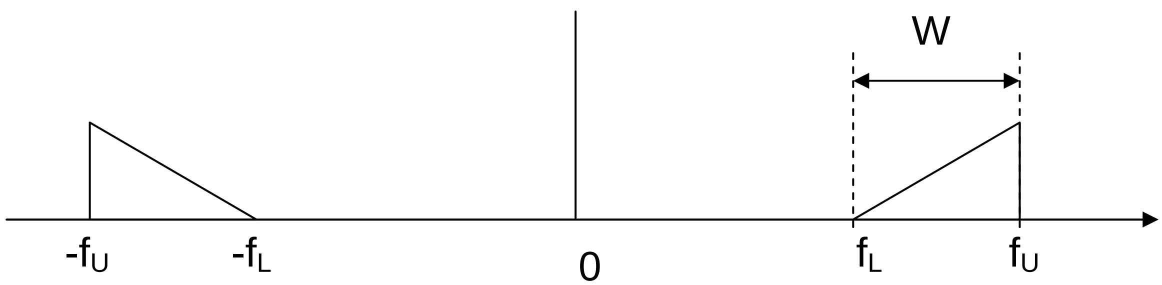
EE524 Homework 3

1. Bandpass Sampling

Bandpass sampling theory states, the minimum sampling rate depends upon the bandwidth, not the highest frequency in the signal. When sampling a non-baseband signal, the Shannon-Nyquist sampling theorem states that the sampling rate need only be greater than twice the bandwidth W if the frequency band is some interval, $[f_L, f_U]$. Given a continuous-time RF signal whose spectrum is shown below.



Let the sampling frequency be f_s Hz.

a. Prove that bandpass sampling gives an alias-free signal and give the conditions needed for this to occur (e.g., anti-aliasing filter specifications and the relationship between W and $(f_U-f_L)/2$).

b. Comment on the sensitivity of the algorithm to frequency stability and on why bandpass sampling is difficult to do in real life.

2. Non-ideal sampling.

Instantaneous impulses cannot be generated in real-world situations. Approximate sampling using periodic square pulses of the form:

$$p(t) = \begin{cases} 1 & |t| < \tau/2 \\ 0 & elsewhere \end{cases}$$

The period of sampling is T. The sampled signal takes the form:

$$x_s(t) = \sum_{n=-\infty}^{\infty} x(nT)\, p(t - nT)$$

a. Find and sketch the frequency spectrum of x_s if the spectrum of x(t) is:

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$$X(f) = \begin{cases} 1 - |f|/B & |f| < B \\ 0 & |f| \geq B \end{cases}$$

b. Find the spectrum when $\tau \ll T$.

c. Find the spectrum when $\tau = T/4$.

d. In this case, can you reconstruct the original signal from its samples? If yes, how would you do it?

3. Text problem: 6.9

4. Text problem 3.52 (Z transform)

5. Text problem 3.55