Communication Systems Lab
Assignment - 1

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1 Convolution

- It can be understood as the summation of the product of the two functions after one is reversed and shifted. The summation is evaluated for all values of shift, producing the convolution function.
- The convolution of two sequences x[n] and h[n] is given as

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]\ h[n-k]$$

- It is used in wireless communication and signal processing

2 Correlation

- The correlation between two different signals or functions or waveforms is defined as the measure of similarity or coherence between one signal and the time-delayed version of another signal.
- The correlation of two sequences x[n] and y[n] is given as

$$R_{xy}[k] = \sum_{n=-\infty}^{\infty} x[n]\ y[n-k]$$

- It is used to find the amount of similarity between two signals.
- It is used for synchronization between the base station and mobile station.

3 Downsampler

- It is used to make a digital audio signal smaller by lowering its sampling rate or sample size (bits per sample).
- Downsampling is done to decrease the bit rate when transmitting over a limited bandwidth or to convert to a more limited audio format.
- Time domain relation between input and output -

$$y[n] = x[Mn]$$

  Where M is the factor of downsampling.
- We can see that it is a Linear Time Varying (LTV) system.
- Frequency domain relation between input and output -

$$Y(e^{j\omega}) = \frac{1}{M} \sum_{k=0}^{N-1} X(e^{j\frac{(\omega-2\pi k)}{M}})$$

4 Upsampler

- To make a digital audio signal higher quality by increasing the sample rate, and interjecting new samples in between existing samples.
- The sample size is also increased for finer granularity. The objective is to have a smoother digital wave going into the digital-to-analog converter
- Time domain relation between input and output -

$$y[n] = \begin{cases} x[n/L] & \text{, if n is multiple of L} \\ 0 & \text{, otherwise} \end{cases}$$

  Where L is the factor of upsampling.
- We can see that it is a Linear Time Varying (LTV) system.
- Frequency domain relation between input and output -

$$Y(e^{j\omega}) = X(e^{j\omega L})$$