EXPERIMENT#8

ANALYSIS OF POWER SPECTRAL DENSITY OF DIFFERENT PULSES

OBJECTIVE:

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Power Spectral Density:

Power spectral density function (PSD) shows the strength of the variations (energy) as a function of frequency. In other words, it shows at which frequencies variations are strong and at which frequencies variations are weak. The unit of PSD is energy per frequency (width) and you can obtain energy within a specific frequency range by integrating PSD within that frequency range. Computation of PSD is done directly by the method called FFT or computing autocorrelation function and then transforming it.

We study now about the PSD of different pulses and see which gives the *Most Efficient Band-Width*.

1. Rectangular Pulse

The rectangle function $\Pi(x)$ is a function that is 0 outside the interval $[-1/2, 1/2]$ and unity inside it. It is also called the gate function, pulse function, or window function.

Formula

$$\Pi(x) \equiv \begin{cases} 0 & \text{for } |x| > \frac{1}{2} \\ \frac{1}{2} & \text{for } |x| = \frac{1}{2} \\ 1 & \text{for } |x| < \frac{1}{2}. \end{cases}$$

PSD

$$\left|G_{Rectangular}\right|^2 = A^2T^2\left(\frac{\mathrm{Sin}(\pi f T)}{\pi f T}\right)^2$$

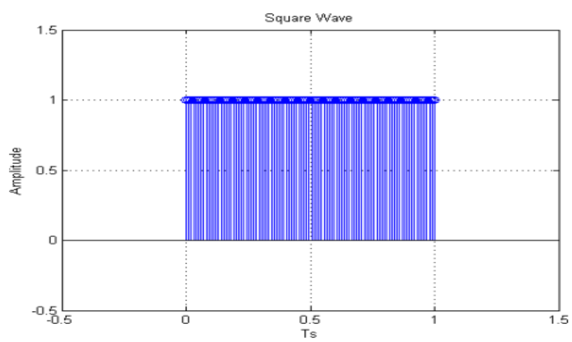

Fig 1.1 Rectangular Pulse

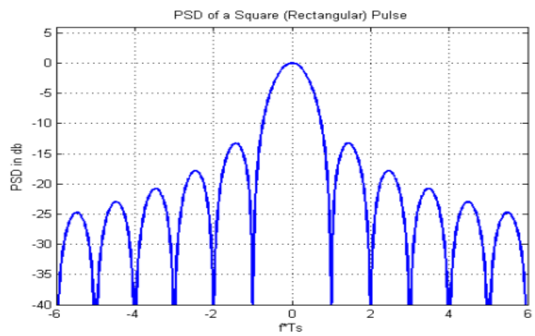

Fig 1.1 PSD of a Rectangular Pulse

2. Triangular Pulse

It is a non-sinusoidal waveform containing only odd harmonics bearing the shape of a triangle. However, the higher harmonics roll off much faster than in a square wave but in triangular wave, they roll off relatively slower.

Formula

$$f(x) = \begin{cases} 1 - 2(|t - Ts/2|), & x \leq t \leq Ts \\ 0, & else \end{cases}$$

PSD

$$\left|G_{Triangular}\right|^2 = \frac{A^2T^2}{4}\left(\frac{\mathrm{Sin}(\pi f T/2)}{\pi f T/2}\right)^4$$

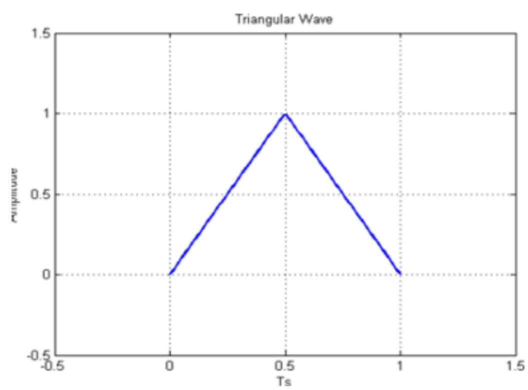

Fig 2.1 Triangular Pulse

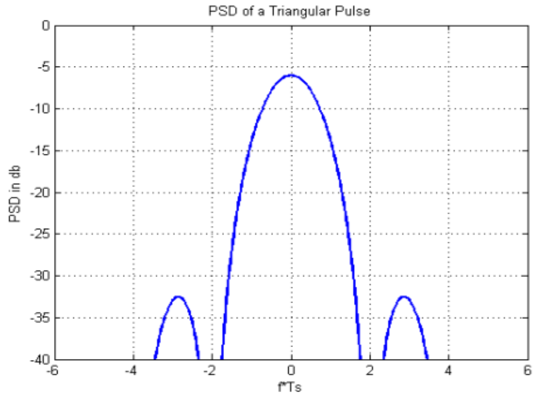

Fig 2.2 PSD of a Triangular Pulse

3. Raised Cosine Pulse

This pulse is a sinusoid but with altered parameters necessary to raise it i.e. expanding it in t-domain while contracting it in f-domain.

Formula

$$f(x) = \begin{cases} \frac{A}{2}.(1-\cos(2\pi/Ts)), & x \leq t \leq Ts \\ 0, & else \end{cases}$$

PSD

$$|G_{Raised\ Cosine}|^2 = \frac{A^2T^2}{4}\left(\frac{\text{Sin}(\pi fT/2)}{\pi fT/2}\right)^2\left(\frac{\text{Cos}(\pi fT/2)}{1-(fT)^2}\right)^2$$

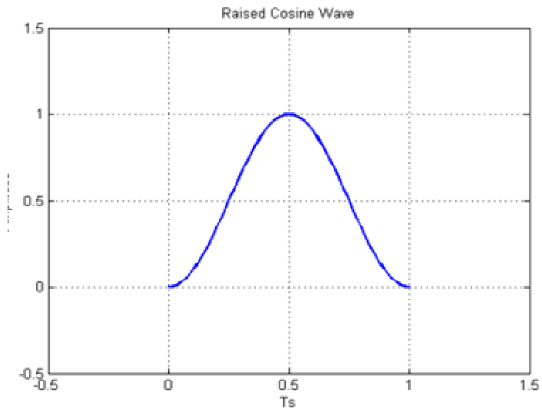

Fig 3.1 Raised Cosine Pulse

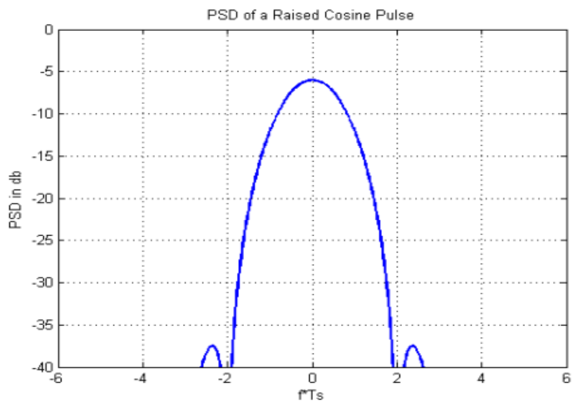

Fig 3.2 PSD of a Raised Cosine Pulse

4. Gaussian Pulse

This pulse has Gaussian distribution i.e. it is symmetrical about its origin and also it has the highest efficiency when it comes to Band-Width because almost all the power of this pulse lies in its main lobe (f-domain) making it the best choice for digital transmission.

Formula

$$f(x) = \begin{cases} a.exp(-\pi a^2 t^2), & x \le t \le Ts \\ 0, & else \end{cases}$$

PSD

$$|G_{Gaussian}|^2 = e^{\frac{-2\pi f^2}{a^2}}$$

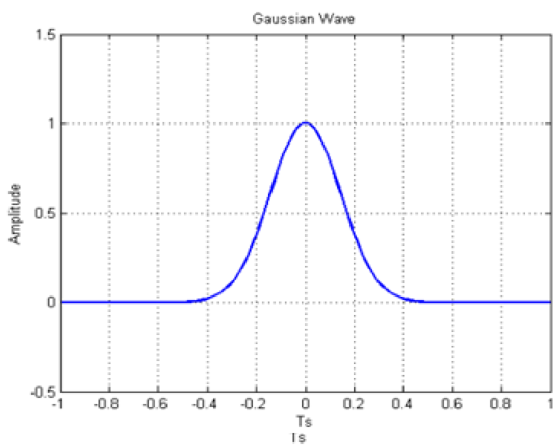

Fig 4.1 Gaussian Pulse

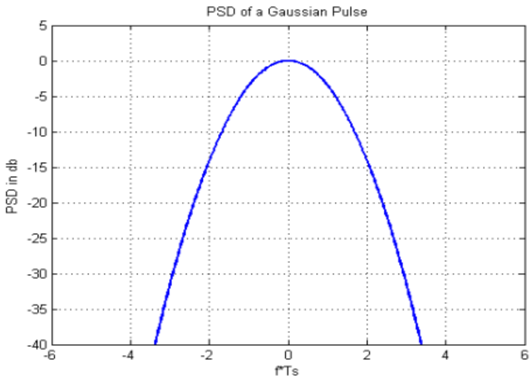

Fig 4.2 PSD of a Gaussian Pulse

SOFTWARE USED:

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Lab Task :

Analyze Power Spectral Density of different waves as discussed in lab using MATLAB, generate its pdf and attach the output.

CONCLUSION:

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Post Lab Questions

a) **How can we analyze power spectral density of different pulses using MATLAB?**

b) **Explain how a Gaussian pulse is distributed?**

c) **Is there any difference between Raised Cosine wave and Cosine wave?**