Lab #5: Filter effect in communication system

Objective

The objective of this experiment is to understand various Pulse Shaping techniques and related measurements. The students will be familiar with the following items:

- Nyquist criterion, raised cosine, ISI free filtering. Alpha factor, Time BW relations.
- Gaussian pulse shaping, ISI issues. Comparison of Gaussian, w.r.t. Nyquist.
- Study of various filters and their effect on the system, like spectrum shaping: CCDF and PAPR effects, EVM and BER effects, inter-symbol interference and eye diagram effects, vector (polar) diagram, etc.
- Discuss and simulate the effect of optimal match filtering under AWGN. Use match filter and use another filter to compare performances.
- Understand the effect of pulse shaping on eye diagram
- Understand the effect of pulse shaping on BW
- Understand the effect of pulse shaping on CCDF
- Details of RRC and impact of roll-off. Relation with synchronization and time-frequency signal

Pre-lab

- Read about the importance of pulse shaping (specially pulse shaping for Nyquist criterion)
- Read about inter-symbol-interference (ISI) and its effects in system


**Procedure**

Each bench transmits signals at different carrier frequency.

- Bench-1 at 913 MHz,
- Bench-2 at 917 MHz,
- Bench-3 at 920 MHz.

Amplitude of the signal should be set to -20 dBm.

Use Digital Modulation analysis for I, III, and IV. In digital modulation analysis mode, pick a screen layout of 2x3 and observe the following plots in each window: (A) Polar plot (B) Spectrum (C) EVM versus time (D) Syms/Errs (E) Constellation (F) Eye diagram.

Use Time-frequency analysis for II. In this mode use a 2x2 layout and see the following plots in each window (A) Spectrum (averaged – use peak hold) (B) CCDF (C) Main Time (D) Inst. Spectrum.

**I. RAISED COSINE FILTERING IN DETAIL**

Generate an NADC signal with RRC pulse shaping. Change the filter roll-off, \(\alpha = 0.1, \alpha = 0.35, \alpha = 0.5, \text{ and } \alpha = 0.95\).

- Take snapshots of spectrum, polar plot, and absolute time plot. In each case, record null-to-null BW and %95 BW.
- Comment on the results.

**II. EFFECT OF PULSE SHAPING ON CCDF**

Using the same alpha values as above, observe CCDF for each case and comment on the results.

- Observe (Take a snapshot) the absolute time signal
- Record the dynamic range of the signal. Comment.

**III. GAUSSIAN FILTERING IN DETAIL**

a) Generate a GSM signal (GMSK modulation). Change BT product as follows: BT=0.1, BT=0.3, BT=0.5 and BT=1. (BT=1 corresponds to MSK).
• Take snapshots of the spectrum, polar plot, and eye diagram with different BT products.

• In each case record %95 BW and EVM.

• Comment on the results (especially note the tradeoff between spectrum and eye diagram).

b) Using the same BT product values as above, observe the constellation plots and comment.

IV. MATCH FILTERING AND ITS EFFECT ON THE SYSTEM

a) Generate a NADC signal with -20 dBm. At the VSA receiver use the same filter as transmitted with alpha values of 0.35, 0.5, and 0.9. Observe the plots and record EVM in each case. - Comment on the results.

b) In this step, turn the measurement filter off at the receiver and make sure that the reference filter is the same as the filter used at the Tx (which is RRC).
   Observe the results (take snapshots), record EVM, and Comment.

c) Repeat the above step (b) with a transmitter filter of raised cosine (Nyquist) instead of RRC. Comment.

d) Repeat the above step (c) with 3 different spans, 30 kHz, 100 kHz, and 350 kHz.

V. OPTIONAL STEPS

a) Download the signals (in the previous steps) and process them in Matlab and observe similar type of graphs.

References

• Lecture notes