Lab #4: Effect of Pulse-shaping Filters in Communication Systems

<u>Objective</u>

The objective of this experiment is to study the impact of baseband pulse shaping filters on telecommunication system performance and comprehend related measurement methods. The students will be familiar with the following items:

- Study of various filters and their effects on the communication system performance.

- Gaussian pulse shaping, BT product and time-bandwidth (BW) relations.

- Nyquist criterion, raised cosine (RC) filters, roll-off factor and time-bandwidth (BW) relations, comparison of Nyquist filter w.r.t. Gaussian filter.

- The effect of filtering in EVM and BER performance, inter-symbol interference, and polar diagram.

- The effect of matched and unmatched filtering under AWGN.

- Understand the effect of pulse shaping in the time-domain through CCDF and eye diagram plots.

- Understand the effect of pulse shaping in the frequency-domain through power spectral density plot.

- Spectral mask and unwanted emissions.

Procedure

- Set the transmission parameters through the control panel as follows:
  - Amplitude: -20 dBm
  - Center frequency: 913 MHz, 915 MHz, or 917 MHz
  - Mode: Single-carrier
  - Modulation type: QPSK
  - Symbol rate: 20 ksps.
  - Ambiguity function: ON

- Use a 2x3 layout and observe the following plots:

  (A) Time   (B) CCDF   (C) I-Eye Diagram

  (D) Spectrum   (E) Polar   (F) Q-Eye diagram.

I.   GAUSSIAN FILTERING

- Generate a single-carrier signal using MSK modulation and the Gaussian filter.
- Sweep the bandwidth-time (BT) products: 0.10, 0.35, 0.50, and 1.00.
- Take snapshots for each BT product and compare the following:
  - Observe and comment on power spectrum. Record null-to-null BW and %99 BW.

  - Observe and comment on polar plots and eye-diagrams (note the tradeoff between the spectrum and eye diagrams).

- Observe CCDF plot for one of the BT products and comment on PAPR.

II.   RAISED COSINE FILTERING

- Generate a single-carrier signal using QPSK modulation and the RRC pulse-shaping filter.
- a) Sweep the roll-off factors: 0.10, 0.35, 0.50, and 0.95. Take snapshots for each roll-off factor (alpha) and compare the following:
  - Observe CCDF plots and comment on the alpha-PAPR relation. Also, compare the PAPR of RC with the PAPR of Gaussian filter.

  - Observe and comment on the magnitude fluctuation of the time-domain signals. Record the dynamic ranges as well.

  - Observe and comment on power spectrum. Record the %99 BW.

  - Observe and comment on polar plots and eye-diagrams.

b) Repeat part (a) by sweeping the filter spans: 4, 8, and 32 for a roll-off factor 0.1.

III.   MATCHED FILTERING AND ITS EFFECT ON PERFORMANCE

- Replace the CCDF with EVM vs time plot.

a) Non-Nyquist Filters w/o Matched Filtering:

- Generate a single-carrier signal using QPSK modulation and the RRC pulse-shaping filter with OSR of 16 and span of 16 symbols.

- Turn the receiver filter off.
- Sweep the roll-off factors: 0.10, 0.35, 0.50, and 0.95.
- Make sure that the reference filter and roll-off factor at the receiver is the same as the filter and roll-off factor used at the transmitter.

- Observe and comment on the changes in plots w.r.t. Part II.

b) Nyquist Filters w/o Matched Filtering:

- Repeat Part III-a with the RC pulse-shaping filter.

- Observe and comment on the results. Compare the changes in plots w.r.t. Part II and Part III-a.

c) Effect of AWGN Spectrum:

- Repeat Part III-b with 2 different spans: 240 kHz and 640 kHz.