Chapter 12
MATLAB PROBLEMS

Introduction

Consider an instrumentation system or software radio receiver where the input data has amplitudes that range from 1 μV to 1 V. The goal is to have the system digitize the signal such that the quantization error will not exceed 0.5 μV for signals under 100 μV.

You have the use of 8, 16 and 24 bit analog-to-digital converters (ADCs). These ADCs have ± 10 volt inputs and therefore you will have to scale the input signal to maximize the ADCs dynamic range. There are tremendous costs with the higher order ADCs and therefore, it is desirable to use the lowest order ADC that will provide the 0.5 μV accuracy for signals under 100 μV.

To determine which ADCs are suitable, you will are to simulate 255-law, $\log_{10} x$ and square root companders.

In this project, write a computer program to calculate and plot quantization error for the various ADCs and companders to determine the most economical solution.

Procedure

1. Write the input and output expressions for each of the above companders. Note Eqs. (12) and (13) in Sect. 12.1 describe 255-law compander, but you will have to derive another set of Eqs. for the $\log_{10} x$ and square root companders.

2. Discuss the possible rational for $\log_{10} x$ versus square root companding, and then these versus 255-law.

3. Discuss the rational for specifying quantization accuracies for both 1 μV and 100 μV signal levels.

4. Write a program that will calculate and plot quantization error versus input signal level for each of the above compander-ADC combinations. Thus you should have 9 graphs. For each compander-ADC combination, have the input voltages range from 0.1 μV to 1 V. Of course you may scale the input to fit within the ± 10 volt input range of the ADC. You might want to do zoom plots to illustrate quantization errors for signals from 0 to 1 millivolt.

5. For comparison purposes, calculate and plot the quantizaton errors without companding for each of the 9 combinations.

6. Interpretation and analysis:
    a. State which systems will meet the original stated requirement, including systems that don't use companding
    b. For a given ADC, which companding system meets the stated requirements and yet has the lowest errors for inputs above 10 μV?
    c. Discuss any other findings and/or make any other conclusions.