

Spring 2008  
TESTING OF  
ULTRA LARGE SCALE INTEGRATED CIRCUITS  
16:332:576  
Homework 8  
Assigned March 14, 2008 – Due April 4, 2008

Reading Assignment: Chapter 10

## 1 DSP-Based Analog and Mixed-Signal Test

10.15 *Unit test period.* For an analog *radio frequency* (RF) circuit, the test frequency  $F_t = 20 \text{ GHz}$  and the sampling frequency in the DSP ATE is  $7980 \text{ s/s}$ . Compute the minimum *unit test period* and the corresponding *primitive frequency*.

10.16 *Correlation.* Use MATLAB to calculate the normalized correlation of these two signals:

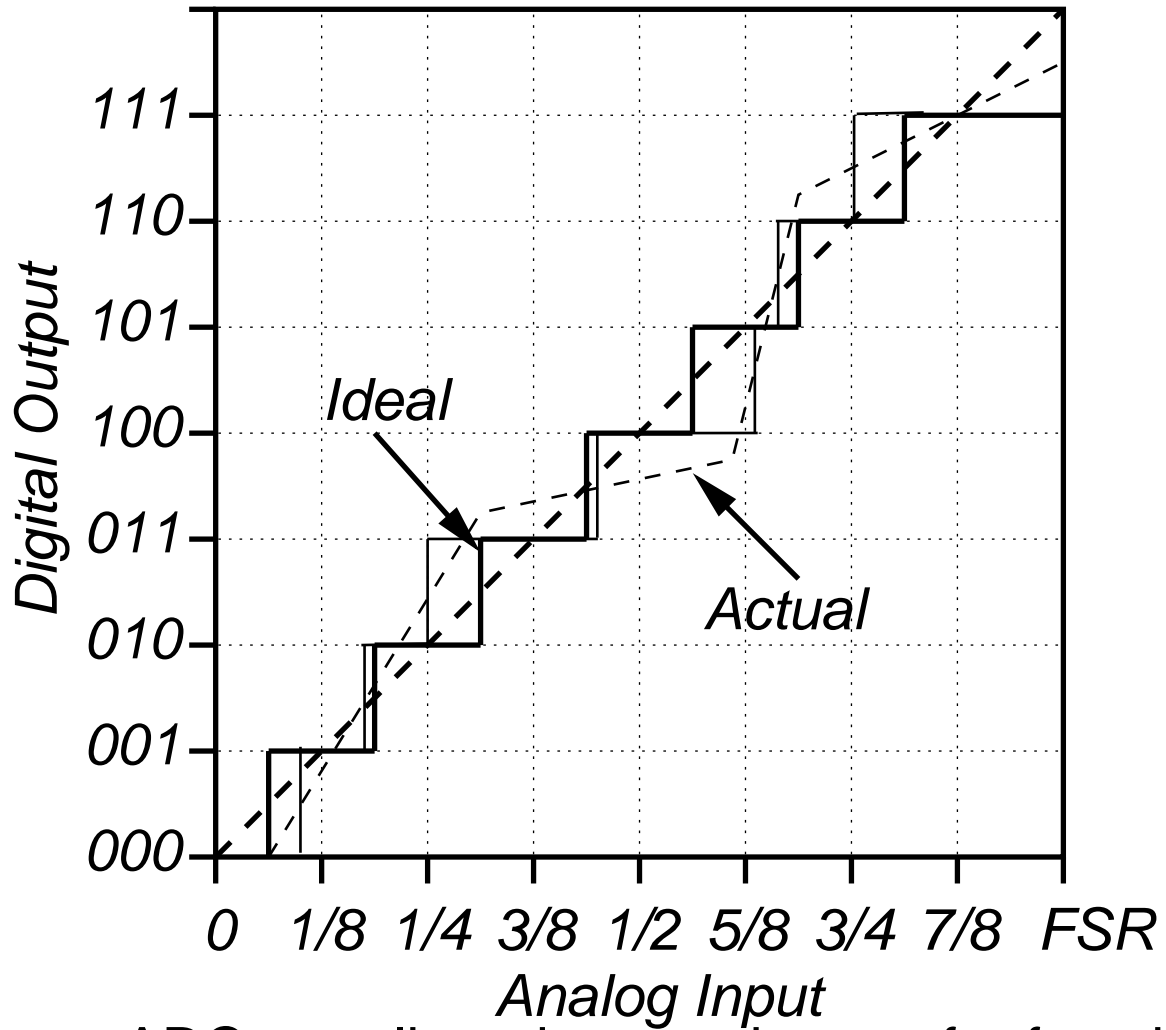
$$\begin{aligned}A(t) &= 5 \cos(4\pi t) \\B(t) &= \cos(4\pi t + 10) + 10 \sin(4\pi t + 20)\end{aligned}$$

10.17 *Multi-tone testing.* A filter is tested with tones at frequencies  $7f$ ,  $23f$ , and  $27f$ . Calculate these frequencies in the FFT spectrum of the response in the DSP ATE:

- (a) All first harmonics
- (b) All second harmonics
- (c) All third harmonics
- (d) All fourth harmonics
- (e) All second-order intermodulation products
- (f) All third-order intermodulation products.

10.18 *ADC DLE and ILE.* For the ADC in Figure 1:

- (a) Calculate and graph the DLE function.
- (b) What is the DNL?
- (c) Calculate and graph the ILE function.
- (d) What is the INL?



ADC non-linearity error in transfer function.

Figure 1: ADC waveforms for Problem 10.18.

- 10.19 *Multi-tone testing.* Redraw Figure 10.44 to show the outcome when the three frequencies  $4f$ ,  $9f$ , and  $13f$  are summed for multi-tone testing.
- (a) The *primitive frequency* for testing is  $\Delta = 20 \text{ Hz}$  and the test waveform frequency is  $F_t = 2020 \text{ Hz}$ . What DSP ATE sampling frequency  $F_s$  will guarantee 600 unique samples during coherent testing?
  - (b) Unfortunately, this sampling frequency leads to a very expensive analog tester. Please explain how to nearly halve the required sampling frequency, while still guaranteeing 600 unique samples, and compute  $\Delta$ ,  $M$ ,  $N$ , and  $F_s$ .
  - (c) During analog testing, the circuit is stimulated with a multi-tone waveform with frequencies  $4f$ ,  $9f$ , and  $13f$ . What FFT frequency bins should be examined to look at 2nd-order *Harmonic Distortion*?
  - (d) Again using the test frequencies  $4f$ ,  $9f$ , and  $13f$ , what FFT frequency bins should be examined to look at 2nd-order *Intermodulation Distortion*?
  - (e) Please provide a word definition of *Total Harmonic Distortion*, and explain how it is measured.