MODIFIED TLH

DSP First, 2/e

Sampling & Aliasing

CHAPTER 4 PRESENTATION1

Chapter 4 on Course Website Sampling and Aliasing

Chapter 4: HW3_ Lecture4_1 Lecture4_3 Ch4References

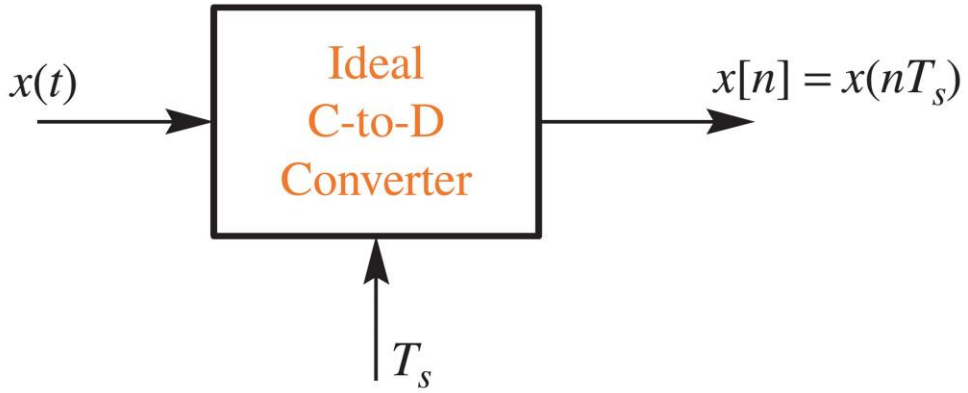
ProblemSession1_Ch4 ProblemSession2_Ch4

Sampling

Figure 4-1: Block diagram representation of the ideal continuous-to-discrete (C-to-D)

converter. The parameter T_s specifies uniform sampling of the input signal every T_s seconds.

n = 1,2,3,4… nTs in seconds



Sometimes ADC, A2D, Analog-to-Digital

LECTURE OBJECTIVES

- SAMPLING can cause ALIASING
  - Sampling Theorem
  - **Sampling Rate > 2(Highest Frequency)**
- Spectrum for digital signals, x[n]
  - Normalized Frequency

$$\hat{\omega} = \omega T_s = \frac{2\pi f}{f_s} + 2\pi\ell$$

ALIASING

PERIODIC !!

CH4 PROBLEM SESSION

PLOS

Consider

$$x[n] = x(nT_s) = A\cos(\omega nT_s + \phi)$$

$$= A\cos(\hat{\omega} n + \phi)$$

$\therefore$ $\hat{\omega}$ is DISCRETE TIME FREQUENCY!

(sometimes Ω); $F = \Omega/2\pi$ radians/sample

ω is continuous rad/sec / $\omega = 2\pi f$

Define f_s = sampling rate = samples/sec

(sometimes given as δH_3); $T_s = \frac{1}{f_s}$ sec

SUMMARY

If $x(t)$ contains frequencies 0 to f_{max}

for no Aliasing

1. $f_s = S > 2f_{max}$ Pg 111

2. $-\pi < \hat{\omega}_0 = \omega_0 T_s < \pi$ (4.9)

$= 2\pi f_0 T_s < \pi$

If Aliased

Example

$\cos(200\pi t + \theta)$ $\quad f = 100$ Hz

a) Need $f_s = S > 200$ samples/sec

b) frequencies

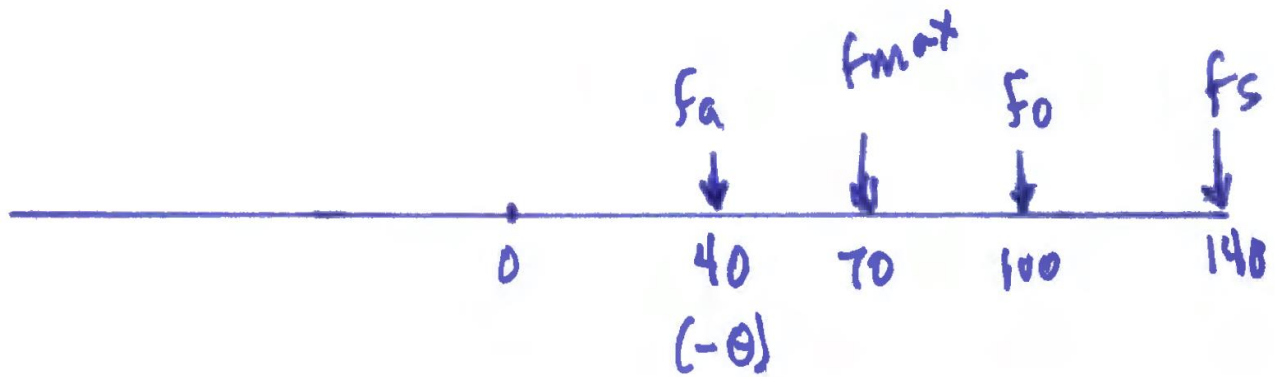
$f_s = 240$ Hz $\quad f = 100$ Hz $\quad$ OK

$f_s = 140$ Hz - Aliased

$f_a = 100 - 140 = -40$ Hz

$x_a(t) = \cos(-2\pi(40)t + \theta) = \cos(80\pi t - \theta)$

Phase Reversal



SYSTEMS Process Signals

- PROCESSING GOALS:
  - Change x(t) into y(t)
    - For example, more BASS, pitch shifting
  - Improve x(t), e.g., image deblurring
  - Extract Information from x(t)

SAMPLING x(t)

- SAMPLING PROCESS
  - Convert x(t) to numbers x[n]
  - "n" is an integer index; x[n] is a sequence of values
  - Think of "n" as the storage address in memory
- UNIFORM SAMPLING at $t = nT_s$
  - IDEAL: $x[n] = x(nT_s)$