A2D Error and Motor Aliasing

A2D & ENCODERS

ERRORS

KLAFTER P238 – 242

A2D CONVERTER –

ACCURACY $\approx \frac{1}{2^m}$ FOR m-bits

10 bits $\frac{1}{1024} \times 100 \doteq 0.1\%$

IN EXAMPLE 4.5.1 HE USES 13 BITS

WOULD USE 14-bits

$2^{14} \doteq 16384$ about 0.0061%

FOR 10V Full scale $\Delta V \approx 610\ \mu V$.

ENCODER ACCURACY

200 lines or counts / revolution

$\Delta\theta = \frac{360^\circ}{200} \doteq 1.8^\circ$ measure as θ_1

$\frac{\theta_2}{\theta_1} = \frac{1}{50}$ so $\Delta\theta_2 = \frac{1}{50}\Delta\theta_1 = \frac{1.8^\circ}{50} = 0.036^\circ$

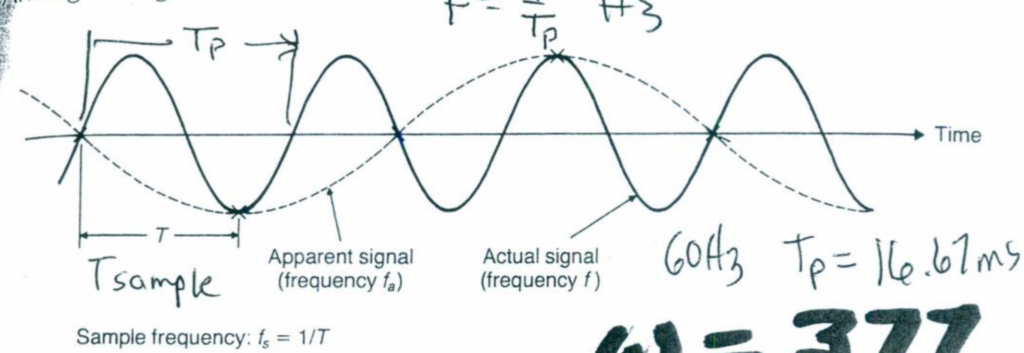

Figure 6.14 Apparent low-frequency signal as a result of aliasing due to $f \geq \frac{1}{2}f_s$.

practical to eliminate the source of high frequencies in a signal to be sampled, a low-pass analog **filter** is usually placed at the input to the A/D converter as shown in Fig. 6.13. The function of this filter is to remove (ideally) all frequencies that are not less than half the sample frequency.

SEE NYQUIST + SHANNON

Example 6.8 Aliasing Suppose that the power amplifier for a DC motor uses full-wave rectification of 60-Hz AC line voltage. Close examination of motor velocity reveals a 120-Hz ripple caused by the amplifier. Suppose further that motor velocity is to be controlled by a computer as shown in Fig. 6.15(a) via feedback from a tachometer, the output of which is sampled by an A/D converter. The sample period is to be $T = 0.008$ s.

As shown in Fig. 6.15(b), there is a 120-Hz ripple in the tachometer voltage. If no anti-aliasing filter is used, then with the sample frequency

$$f_s = \frac{1}{0.008 \text{ s}} = 125 \text{ Hz}$$

the apparent frequency of the ripple after sampling is obtained from Eq. (6.10) as

$$f_a = |120 - 125| = 5 \text{ Hz}$$

It therefore appears to the control computer that the motor velocity is oscillating at a frequency of 5 Hz. This is a relatively low frequency, and the computer corrects the perceived variation, resulting in a 5-Hz variation in actual motor velocity as shown in Fig. 6.15(c).

This aliasing problem can be prevented by filtering the feedback voltage from the tachometer to remove the ripple before it is sampled by the A/D converter. The cut-off frequency for the filter must be less than $fs/2$. That is,

$$f_c < 62.5 \text{ Hz} \quad \square$$

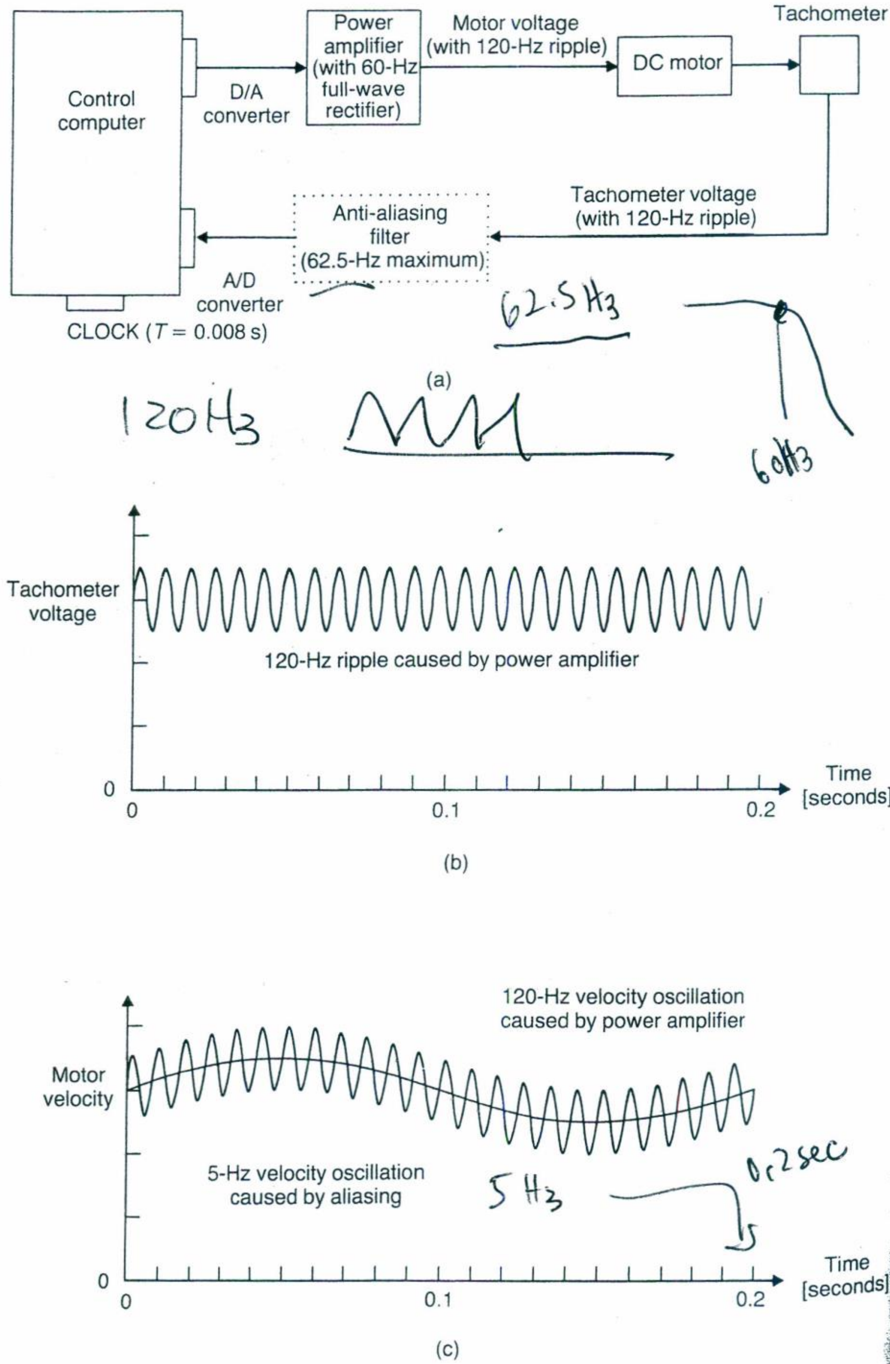

Figure 6.15 (a) Computer-controlled motor with 120-Hz ripple in amplifier voltage, (b) tachometer voltage with constant D/A output, and (c) motor velocity resulting from computer control when an anti-aliasing filter is not used.