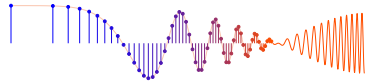


PROBLEM:

Let $x(t) = 13\sin(22\pi t)$. In each of the following the discrete-time signal $x[n]$ is obtained by sampling $x(t)$ at a rate f_s; and the resultant $x[n]$ can be written:

$$x[n] = A\cos(\hat{\omega}_0 n + \phi)$$

So for each part below, determine the values of A, ϕ and ω_0. In addition, state whether or not the signal has been oversampled or undersampled.

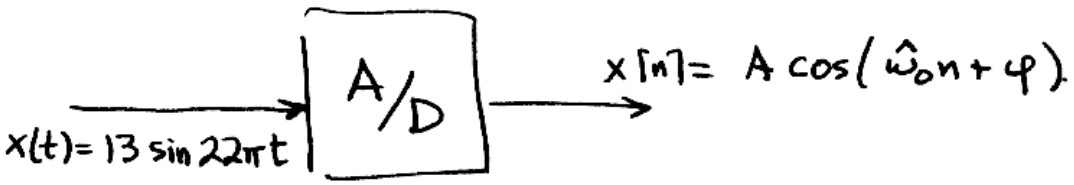
(a) Let the sampling frequency be $f_s = 10$ samples/sec.

(b) Let the sampling frequency be $f_s = 25$ samples/sec.

(c) Let the sampling frequency be $f_s = 15$ samples/sec.

McClellan, Schafer and Yoder, *Signal Processing First*, ISBN 0-13-065562-7.
Prentice Hall, Upper Saddle River, NJ 07458.

SOLUTION



(a) $f_s = 10$ samples/sec.

INPUT FREQ = 11 Hz, thus **UNDERSAMPLED**

$$x(t)\Big|_{t=n/10} = 13\cos\left(22\pi\left(\tfrac{n}{10}\right) - \pi/2\right)$$

$$= 13\cos(2.2\pi n - \pi/2)$$

$$x[n] = 13\cos(0.2\pi n - \pi/2)$$

$A = 13,\ \hat{\omega}_0 = 0.2\pi,\ \varphi = -\pi/2$

(b) $f_s = 25$ samples/sec.

$f_s > 2(11) \Rightarrow$ **OVERSAMPLED**

$$x[n] = 13\cos\left(22\pi\left(\tfrac{n}{25}\right) - \pi/2\right)$$

$$= 13\cos\left(2\pi\left(\tfrac{11}{25}\right)n - \pi/2\right)$$

$$= 13\cos(2\pi(0.44)n - \pi/2)$$

$A = 13$
$\varphi = -\pi/2$
$\hat{\omega}_0 = 0.88\pi$

(c) $f_s = 15$ samples/sec

NOT greater than 2 times 11.
this is FOLDING.

$$x[n] = 13\cos\left(22\pi\left(\tfrac{n}{15}\right) - \pi/2\right)$$

$$= 13\cos\left(2\pi\left(\tfrac{11}{15}\right)n - \pi/2\right)$$

$$= 13\cos\left(2\pi\left(\tfrac{4}{15}\right)n + \pi/2\right)$$

$A = 13$
$\varphi = +\pi/2$
$\hat{\omega}_0 = \frac{8\pi}{15}$