3/25/2019 Lecture

1

Review

Ch 4 pg 105 $x[n] = x(nT_s)$ $\hat{\omega} = \omega T_s = \omega / f_s$

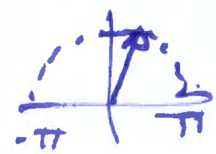
$-\pi \le \hat{\omega} \le \pi$ $= 2\pi \, f/f_s$

P106 $x(t) = \cos(200\pi t) = \cos(2\pi \cdot 100 t)$

$f_0 = 100\ Hz$ Let $f_s = 500\ Hz$

Figure 4-3

$\hat{\omega} = \dfrac{2\pi\, 100}{500} = 0.4\pi$ 72°



Alias Note

$\cos(2.4\pi n) = \cos(0.4\pi n + 2\pi n)$

Proof $\cos(0.4\pi n + 2\pi n) = \cos(0.4\pi n)\cos 2\pi n - \sin(0.4\pi n)\sin(2\pi n)$

$\cos 2\pi n = 1$, $\sin(2\pi n) = 0$

So $\hat{\omega} = \dfrac{2\pi f}{500} = 2.4\pi$ $f = \dfrac{2.4 \times 500}{2} = 1.2 \times 500 = 600\ Hz$

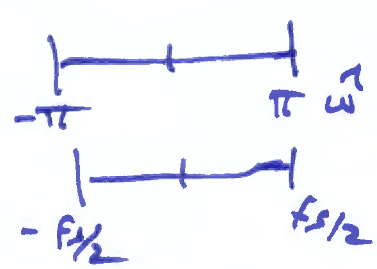
$f_{alias} = \underset{f_0}{600\ Hz} - \underset{f_s}{500\ Hz} = 100\ Hz$

P109 So $-\pi < \hat{\omega}_0 = \omega_0 T_s < \pi$ $\omega_0 = 2\pi f_0$

$T_s = 1/f_s$

$-\pi < 2\pi \dfrac{f_0}{f_s} < \pi$

So $-\dfrac{1}{2} < f_0/f_s < 1/2$



If result is < 0; Negate Phase

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Pg 113

$x[n] = x[nT_s] = x[n/f_s] =$

$A\cos[(\omega_0/f_s)n + \phi] = A_+ e^{j\omega_0/f_s n} + A_- e^{-j\frac{\omega_0}{f_s}n}$

$A_+ = \frac{1}{2} A e^{j\phi} \quad A_- = \frac{1}{2} A e^{-j\phi}$

Frequencies Eq 4.13

$\hat{\omega} = \omega_0/f_s + 2\pi l \quad l = 0, \pm 1 \cdots$

$\hat{\omega} = -\omega_0/f_s + 2\pi l$

$f_s = 125 \text{ s/s (Hz)} \quad f_0 = 100 \text{ Hz}$

Alias Pg 117

$\hat{\omega} = \pm 2\pi (100/125) = \pm 1.6\pi$

So shift to $\pm\pi$ for Aliased frequency

$\hat{\omega} = 1.6\pi + 2\pi l \quad 2\pi$

$\hat{\omega} = \underline{-1.6\pi} + 2\pi \cdot 1 = \underline{+0.4\pi}$

So $f = 0.4\pi \, f_s/2\pi = \frac{0.4}{2} \times 125 = \boxed{25 \text{ Hz}}$

phase change $+\phi$ to $-\phi$

or $F_{alias} = 100 \text{ Hz} - 125 \text{ Hz} = -25 \text{ Hz}$

so $\cos(\omega_0 t + \phi) \Rightarrow \cos(\omega_a t - \phi)$

$\omega_0 = 2\pi \cdot 100 \quad \omega_a = 2\pi \cdot 25$

CH 5

P 169 OUTPUT OF FIR FILTER

CONVOLVE $y[n] = \sum_{k=0}^{M} b_k x[n-k]$ Eq 5.24

ASSUMING $h[m] = 0$ for $m < 0$

$y[n] = \sum_{k=0}^{M} h[k] x[n-k]$ Eq 5.13 P 161

↑ Impulse Response

but $h[n] = \sum_{k=0}^{M} b_k \delta[n-k] = \begin{cases} b_n & n = 0, 1, \cdots M \\ 0 & \text{otherwise} \end{cases}$

Eq pg 160

MATLAB conv(hn, xn)
or use filter

VIDEOS speaking IN "CHURCH"
FIR NOTCH
SHOW MATLAB
Rotating VECTOR

HW6 GO OVER

suggest Review
CH1 References
Test Review 1 + summary for FINAL
Euler_convolve Review

CH 6

p195 SPECIAL INPUT

$A e^{j[\hat{\omega} n + \phi]}$ complex sinusoid

so $y[n] = H(\hat{\omega}) A e^{j\phi} e^{j\hat{\omega} n}$ Eg 6.2

To get $H(\hat{\omega}) \equiv H(e^{j\hat{\omega}}) =$ Eg 6.4 p196

$$H(e^{j\hat{\omega}}) = \sum_{k=0}^{M} b_k e^{-j\hat{\omega} k} = \sum_{k=0}^{M} h[k] e^{j\hat{\omega} k}$$

FREQUENCY RESPONSE

EXAMPLE 6.1 $b_k = \{\overset{\uparrow}{1}, 2, 1\}$ so

$$H(e^{j\hat{\omega}}) = 1 + 2e^{-j\hat{\omega}} + e^{-j\hat{\omega} 2}$$

write as $= e^{-j\hat{\omega}}(2 + 2\cos\hat{\omega})$ To plot

$$-\pi < \hat{\omega} < \pi$$

This is $|H(e^{j\hat{\omega}})| \angle -\hat{\omega}$

Ex 6.2 what does $H(e^{j\hat{\omega}})$ do?

pg 197 CHANGES FREQUENCY OF OUTPUT

JUST MULTIPLY AT FREQUENCIES

$$y[n] = H(e^{j\pi/3}) \cdot \left(2e^{j\pi/4} e^{j\pi n/3}\right)$$

$$= \left[e^{-j\pi/3} \cdot (2 + 2\overset{1/2}{\cos\pi/3})\right] x[n]$$

$$= 3e^{-j\pi/3} x[n] =$$

$$\underline{6 e^{-j\pi/12} e^{j\pi n/3}}$$

$$2 e^{j\pi/4} e^{j(\pi/3)n} = x[n]$$

$$y[n] = 6 \, e^{-j\pi/12} \, e^{j\pi n/3}$$

Rewrite as multiple of $e^{\alpha \pi/3}$

$$e^{-j\pi/12} = e^{j\pi/4} e^{-j\pi/3}$$

So $y[n] = 6 e^{j\pi/4} \, e^{j\pi n/3} \cdot e^{-j\pi/3}$

$$= 6 e^{j\pi/4} \, e^{j\pi(n-1)/3}$$

delay 1

CH 6

6

P199 cosine input

$$x[n] = 3\cos\left(\frac{\pi}{3}n - \frac{\pi}{2}\right)$$

$$H(e^{j\pi/3}) = e^{-j\pi/3}(2 + 2\cos\pi/2)$$
$$= 3e^{-j\pi/3}$$
$$= 3\angle{-\pi/3}$$

$$H(e^{j\pi/3}) \cdot x[n] = (3)\cdot 3\left(\cos\left[\frac{\pi}{3}n - \frac{\pi}{3} - \frac{\pi}{2}\right)\right.$$
$$= 9\cos\left(\frac{\pi}{3}(n-1) - \frac{\pi}{2}\right)$$

delay 1

$\boxed{\text{Look at}}$

Equation page 203
Time $\longleftrightarrow$ freq

$$h[n] = \sum_{0}^{M} h[k]\,\delta[n-k] \longleftrightarrow$$
$$H(e^{j\hat{\omega}}) = \sum_{0}^{M} h[k]\,e^{-j\hat{\omega}k}$$

SH

meaning of shift in n - page 206

$$y[n] = x[n - n_0]$$
$$H(e^{j\hat{\omega}}) = 1 - e^{-j\hat{\omega}}$$
$$|H(e^{j\hat{\omega}})| = |e^{-j\hat{\omega}n_0}| = 1$$
$$\angle e^{-j\hat{\omega}n_0} = -n_0\hat{\omega}$$

slope is $-n_0$

see figure 6-2