Imperial College
London

MODULE 5 CLASS

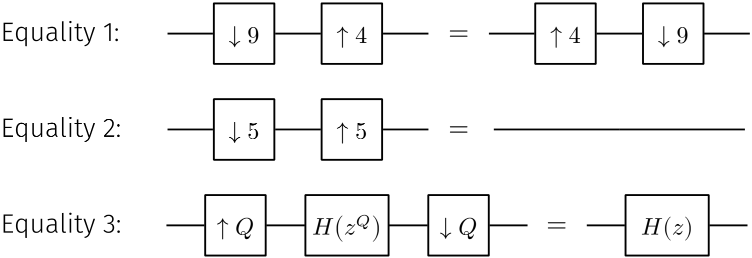
Aidan Hogg - 14 November 2019
ELEC96010 (EE3-07): Digital Signal Processing
Department of Electrical and Electronic Engineering

Method:

1: Conceptual question posed - students think quietly on their own and report initial answers on Mentimeter **(3 mins)**
2: Students discuss their answers in small groups **(2 mins)**
3: Explanation/discussion of correct answer **(3 mins)**

GO TO WWW.MENTI.COM AND USE THE CODE 49 74 47

Consider the following resampling cascades:



Which equality statements are true?

A: 3

B: 1 and 3

C: All of them

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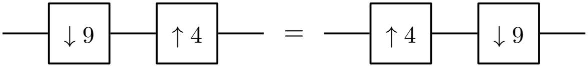
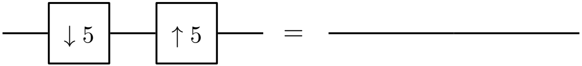
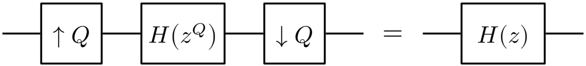
Equality 1:



Equality 2:



Equality 3:



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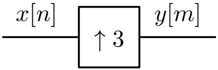
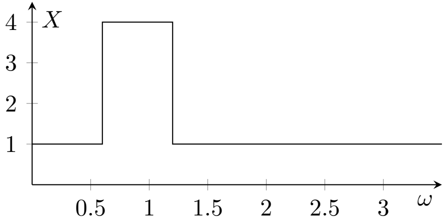
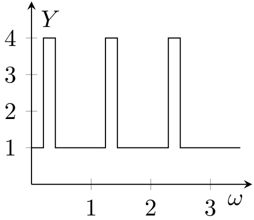
The signal $y[m]$ is obtained by upsampling $x[n]$ by a factor of 3.

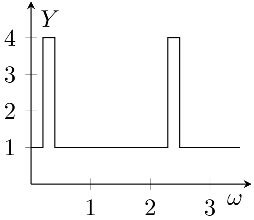




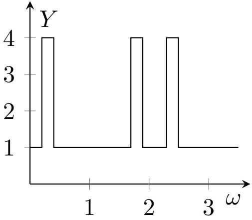
Which is the correct frequency spectrum for $y[m]$?



A



B



C

ANSWER

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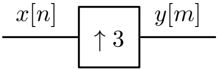

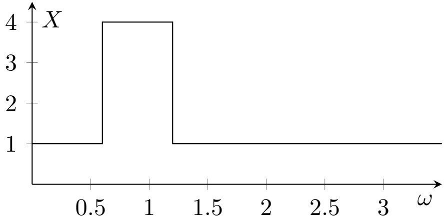

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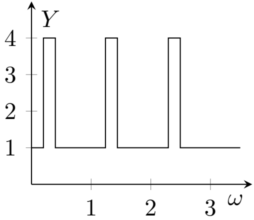

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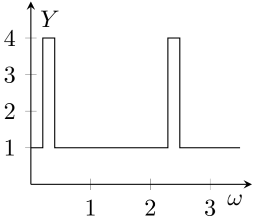

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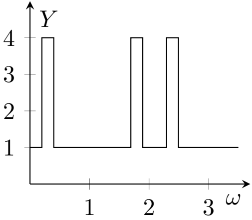

C

Consider the following resampling cascades which preserves information:

What cutoff frequency ω_c must the LPF have to preserve information while changing the sampling rate?

A: $\omega_c = \pi$

B: $\omega_c = \frac{\pi}{20}$

C: $\omega_c = \frac{\pi}{21}$

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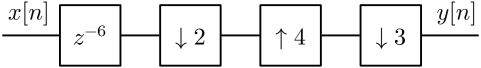

What is the correct expression for the output $y[n]$

A: $y[n] = \begin{cases} x[(2n/3) - 6], & n = 0, \pm 3, \pm 6, \cdots \\ 0, & \text{otherwise} \end{cases}$

B: $y[n] = \begin{cases} x[(3n/2) - 1], & n = 0, \pm 4, \pm 8, \cdots \\ 0, & \text{otherwise} \end{cases}$

C: $y[n] = \begin{cases} x[(3n/2) - 6], & n = 0, \pm 4, \pm 8, \cdots \\ 0, & \text{otherwise} \end{cases}$

ANSWER

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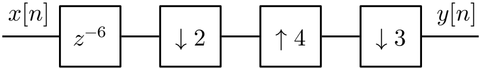

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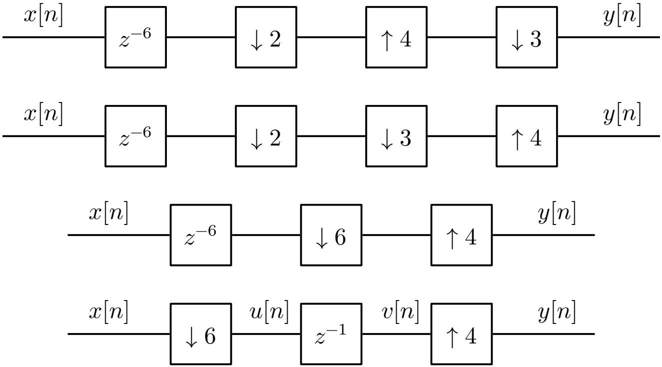
EXPLANATION



Thus $u[n] = x[6n], v[n] = u[n-1] = x[6n-6]$ and

$$y[n] = \begin{cases} v[n/4], & n = 0, \pm 4, \pm 8, \cdots \\ 0, & \text{otherwise} \end{cases} = \begin{cases} x[(3n/2) - 6], & n = 0, \pm 4, \pm 8, \cdots \\ 0, & \text{otherwise} \end{cases}$$

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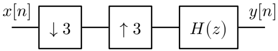
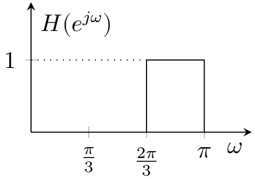
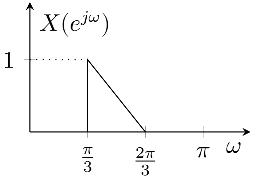
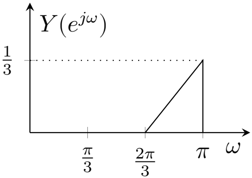


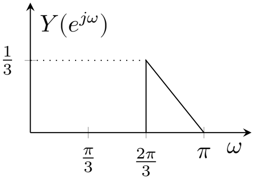




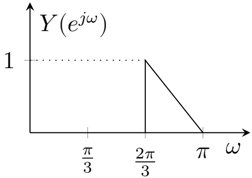
Which is the correct spectrum of the output?



A



B



C

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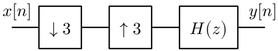

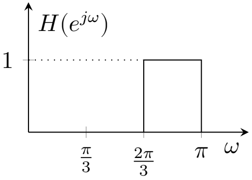

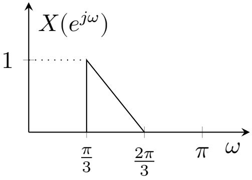

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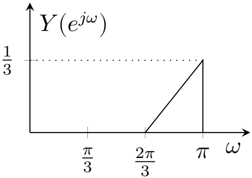

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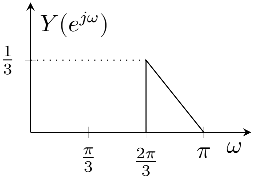

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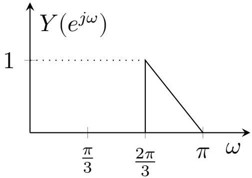


C

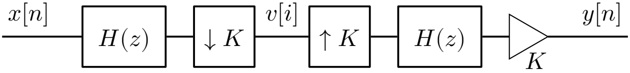
Filtering should always be performed at the lowest possible sampling rate, therefore, what is the actual computational saving that can be achieved by doing this?

A: K

B: $\frac{K}{2}$

C: $\frac{K}{4}$

Hint: Think about the polyphase decomposition of the complete filter:



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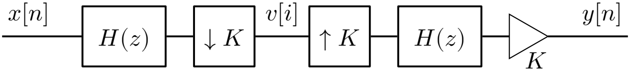
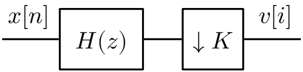
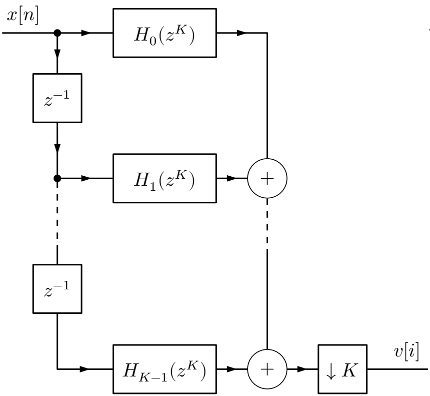
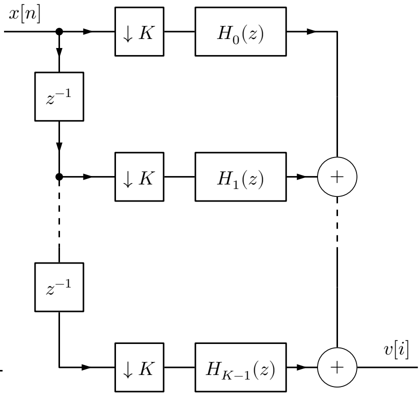


POLYPHASE DOWNSAMPLER







POLYPHASE UPSAMPLER