# COMP.SGN.100 Introduction to Signal Processing
# Exercise 11: Task 1,2,3

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**Task 1**

EXERCISE 11

TASK 1

Original Sampling Rate = 12KHz

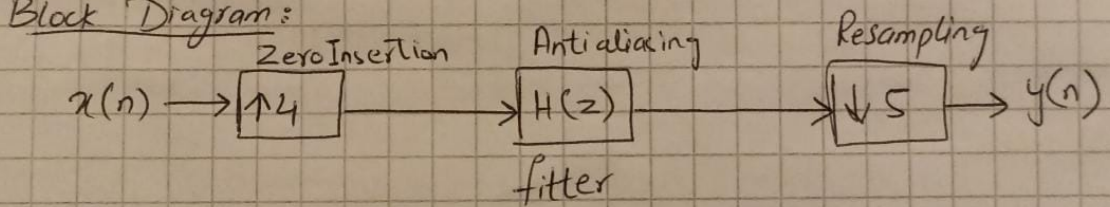
Converted Sampling Rate = 15KHz

To find $\frac{L}{M}$ values, we take ratio of these two.

$$\frac{L}{M} = \frac{12KHz}{15KHz} = \frac{4}{5}$$

So $L = 4$ and $M = 5$

Block Diagram:

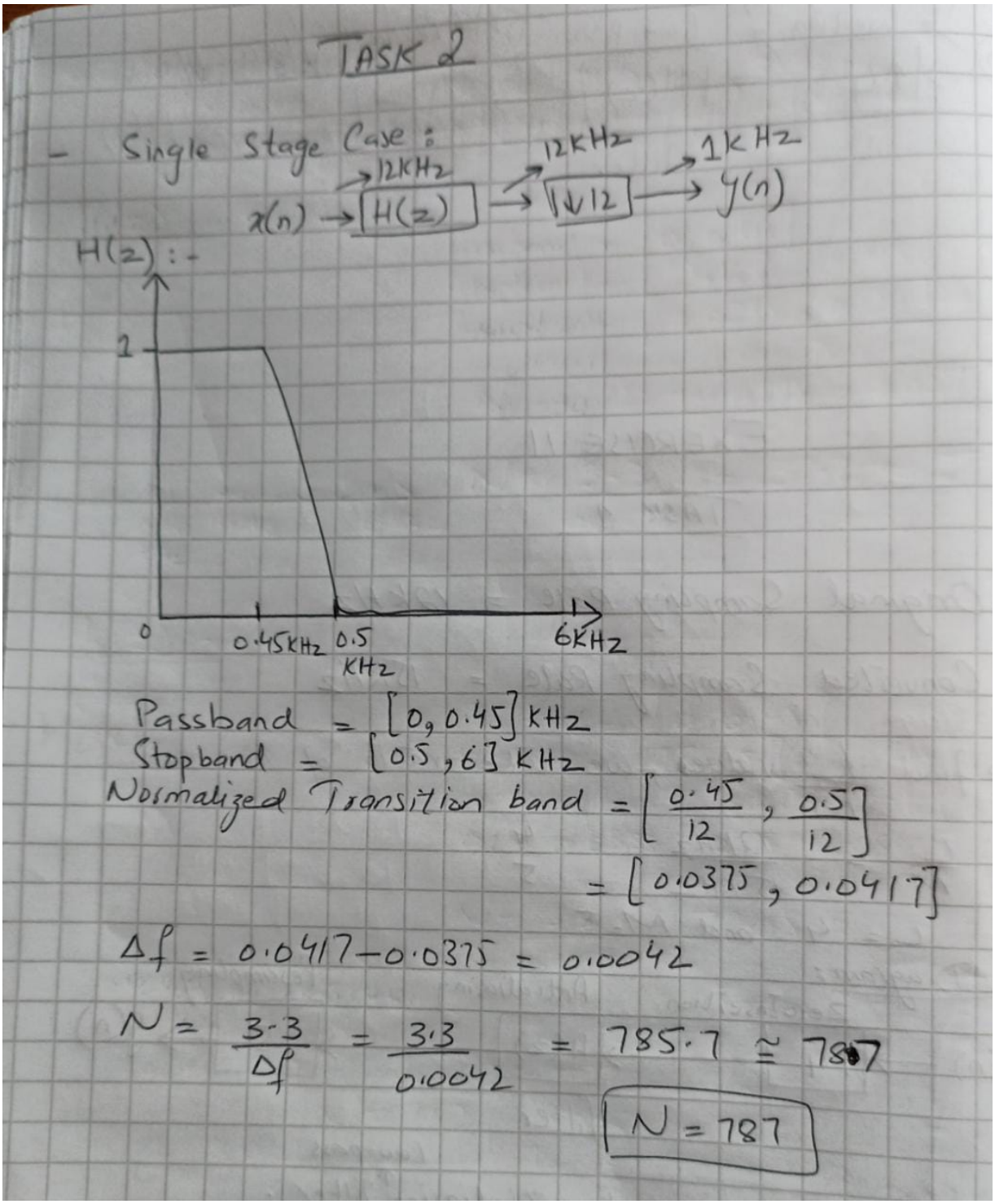



As $M > L$, So we took antialiasing Low-pass filter.

Passband of $H(z) = [0, 5 \cdot 5]$

Stopband of $H(z) = \left[\frac{1}{2M}, \frac{1}{2}\right] = \left[\frac{1}{10}, \frac{1}{2}\right]$

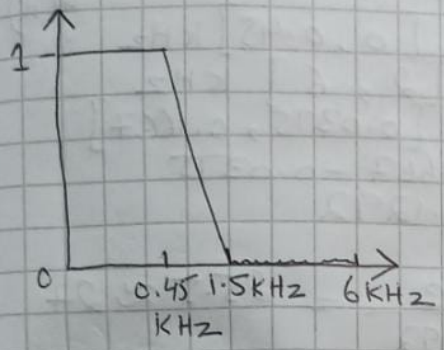
**Task 2**


TASK 2
- Single Stage Case :
12KHz
x(n) → H(z) → ↓12 → y(n)
12KHz
1KHz
H(z) :-
1
0
0.45KHz
0.5 KHz
6KHz
Passband = [0, 0.45] KHz
Stopband = [0.5, 6] KHz
Normalized Transition band = [0.45/12, 0.5/12]
= [0.0375, 0.0417]
Δf = 0.0417 − 0.0375 = 0.0042
N = 3.3/Δf = 3.3/0.0042 = 785.7 ≅ 787
N = 787

- 2-Stage Case :-

$x(n) \xrightarrow{12\text{KHz}} [H_1(z)] \xrightarrow{12\text{KHz}} [\downarrow 4] \xrightarrow{3\text{KHz}} [H_2(z)] \xrightarrow{3\text{KHz}} [\downarrow 3] \xrightarrow{1\text{KHz}} y(n)$

$H_1(z)$ :-

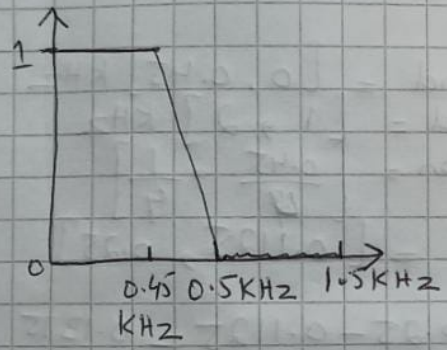



Passband = [0, 0.45] KHz
Stopband = [1.5, 6] KHz
Transition = [0.0375, 0.125]

$\Delta f = 0.125 - 0.0375 = 0.0875$

$N = \frac{3.3}{0.0875} = 37.7 \cong 39$

$H_2(z)$ :-




Passband = [0, 0.45] KHz
Stopband = [0.5, 1.5] KHz
Transition = $\left[\frac{0.45}{3}, \frac{0.5}{3}\right]$
= [0.15, 0.166]

$\Delta f = 0.1667 - 0.15 = 0.0167$

$N = \frac{3.3}{0.0167} = \cancel{206.25 \cong 207}$

$N = 197.6 \cong 199$

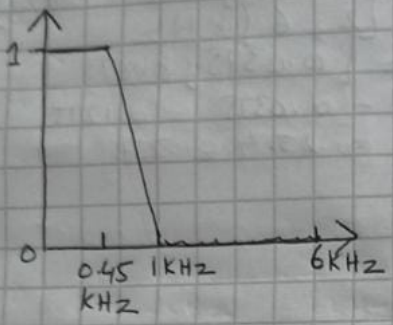
Total = 39 + 199 = 238

**N = 238**

- 2-Stage Case :

$x(n)$ —12kHz→ $H_1(z)$ —12kHz→ $\downarrow 6$ —2kHz→ $H_2(z)$ —2kHz→ $\downarrow 2$ —1kHz→ $y(n)$

$H_1(z)$ :-



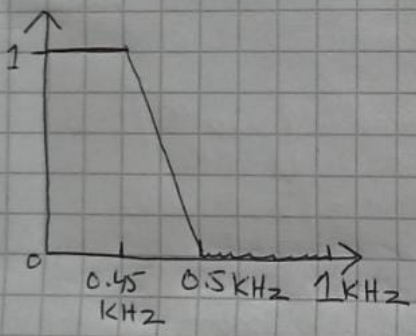

Passband = $[0, 0.45]$ kHz
Stopband = $[1, 6]$ kHz
Transition = $[0.0375, 0.0833]$

$\Delta f = 0.0833 - 0.0375$
$= 0.0458$

$N = \frac{3.3}{\Delta f} = \frac{3.3}{0.0458} = 72.05$

$\boxed{N = 73}$

$H_2(z)$ :-




Passband = $[0, 0.45]$ kHz
Stopband = $[0.5, 1]$ kHz
Transition = $\left[\frac{0.45}{2}, \frac{0.5}{2}\right]$
$= [0.225, 0.25]$

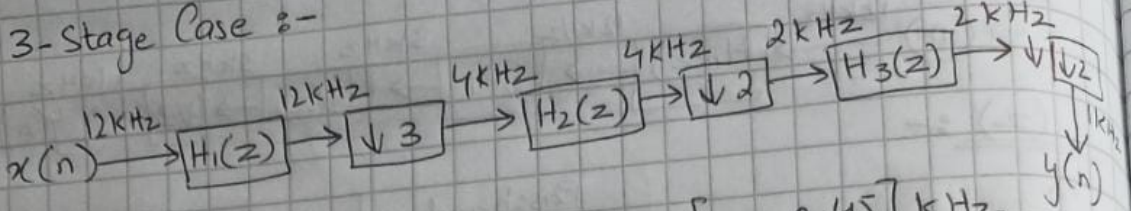
$\Delta f = 0.25 - 0.225 = 0.025$

$N = \frac{3.3}{0.025} = 132 \approx 133$

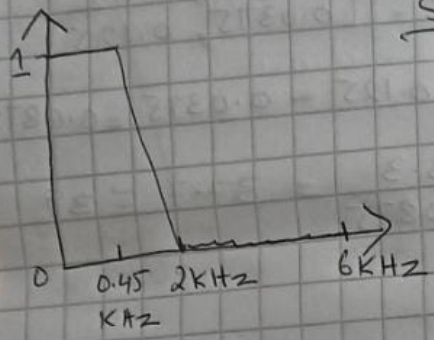
Total No. of coefficients = $73 + 133 = 206$

$\boxed{N = 206}$

- 3-Stage Case :-



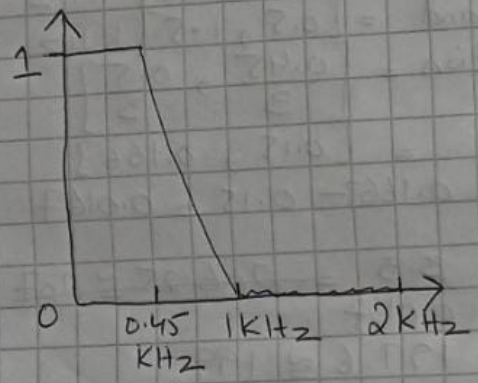

$H_1(z)$ :-




Passband = [0, 0.45] KHz
Stopband = [2, 6] KHz
Transition = [0.0375, 0.1667]
$\Delta f = 0.1667 - 0.0375 = 0.1292$

$N = \frac{3.3}{0.1292} = 25.5 \approx 27$

$H_2(z)$ :-

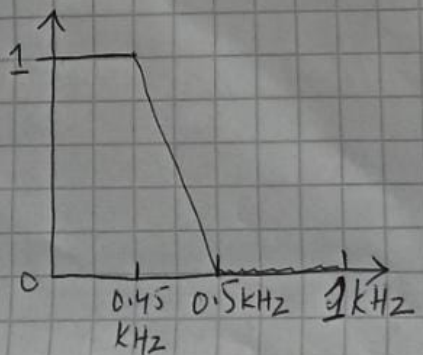



Passband = [0, 0.45] KHz
Stopband = [1, 2] KHz
Transition = $\left[\frac{0.45}{4}, \frac{1}{4}\right]$
= [0.1125, 0.25]

$\Delta f = 0.25 - 0.1125 = 0.1375$

$N = \frac{3.3}{0.1375} = 24 \approx 25$

$H_3(z)$ :-




Passband = [0, 0.45] KHz
Stopband = [0.5, 1] KHz

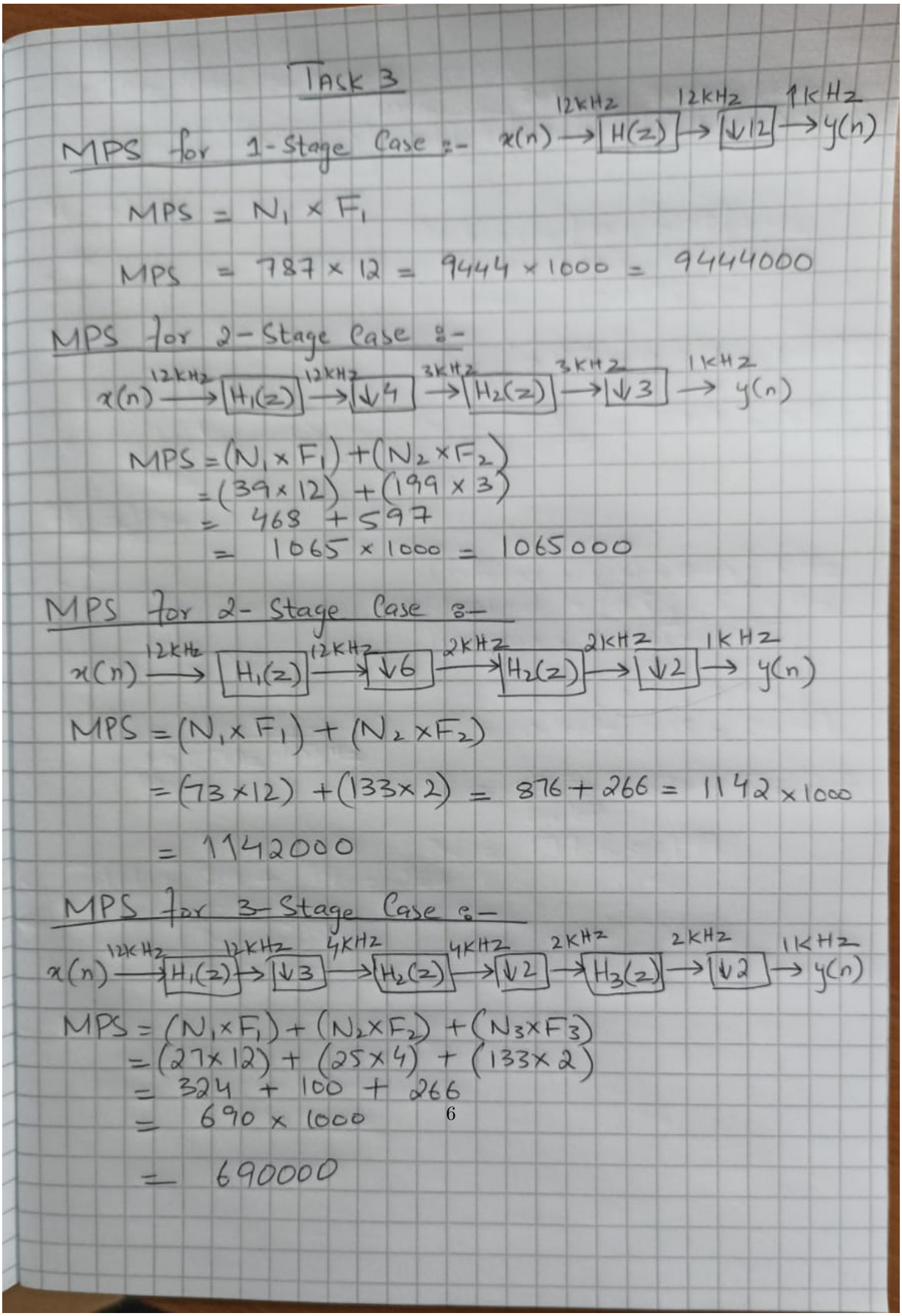
Transition = $\left[\frac{0.45}{2}, \frac{0.5}{2}\right]$
= [0.225, 0.25]

$\Delta f = 0.25 - 0.225 = 0.025$

$N = 3.3/0.025 = 132 \cong 133$

Total N = 27 + 25 + 133 = 185 **N = 185**

**Task 3**


TASK 3
MPS for 1-Stage Case :-
x(n) → H(z) → ↓12 → y(n)
12kHz 12kHz 1kHz
MPS = N1 × F1
MPS = 787 × 12 = 9444 × 1000 = 9444000
MPS for 2-Stage Case :-
x(n) → H1(z) → ↓4 → H2(z) → ↓3 → y(n)
12kHz 12kHz 3kHz 3kHz 1kHz
MPS = (N1 × F1) + (N2 × F2)
= (39 × 12) + (199 × 3)
= 468 + 597
= 1065 × 1000 = 1065000
MPS for 2-Stage Case :-
x(n) → H1(z) → ↓6 → H2(z) → ↓2 → y(n)
12kHz 12kHz 2kHz 2kHz 1kHz
MPS = (N1 × F1) + (N2 × F2)
= (73 × 12) + (133 × 2) = 876 + 266 = 1142 × 1000
= 1142000
MPS for 3-Stage Case :-
x(n) → H1(z) → ↓3 → H2(z) → ↓2 → H3(z) → ↓2 → y(n)
12kHz 12kHz 4kHz 4kHz 2kHz 2kHz 1kHz
MPS = (N1 × F1) + (N2 × F2) + (N3 × F3)
= (27 × 12) + (25 × 4) + (133 × 2)
= 324 + 100 + 266
= 690 × 1000
= 690000