



SNS COLLEGE OF TECHNOLOGY

**Coimbatore-35
An Autonomous Institution**

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DEPARTMENT OF BIOMEDICAL ENGINEERING

19BMB302 - BIOMEDICAL SIGNAL PROCESSING

III YEAR/ V SEMESTER

Unit 1 : TRANSFORMS

19BMB302 - Biomedical Signal Processing / Unit-1 / Dr. K. Manoharan, ASP / BME / SNSCT



TRANSFORMS

- Introduction and Sampling theorem
- ECG signal conversion system
- Discrete Fourier Transform (DFT)
- Decimation in time FFT
- Decimation in time FFT Problems
- Decimation in frequency FFT
- Decimation in frequency FFT Problems
- Multi rate Signal Processing
- Wavelet Transform



Multi rate Signal Processing

Single-rate v.s. Multi-rate Processing

- **Single-rate processing:** the digital samples before and after processing correspond to the same sampling frequency with respect to (w.r.t.) the analog counterpart.
 - e.g.: LTI filtering can be characterized by the freq. response.
- **The need of multi-rate:**
 - fractional sampling rate conversion in all-digital domain:
 - e.g. 44.1kHz CD rate \iff 48kHz studio rate
- **The advantages of multi-rate signal processing:**
 - Reduce storage and computational cost
 - e.g.: polyphase implementation
 - Perform the processing in all-digital domain without using analog as an intermediate step that can:
 - bring inaccuracies – not perfectly reproducible
 - increase system design / implementation complexity



Sampling rate conversion

Decimation

- Decrease the sampling rate

Interpolation

- Increase the sampling rate

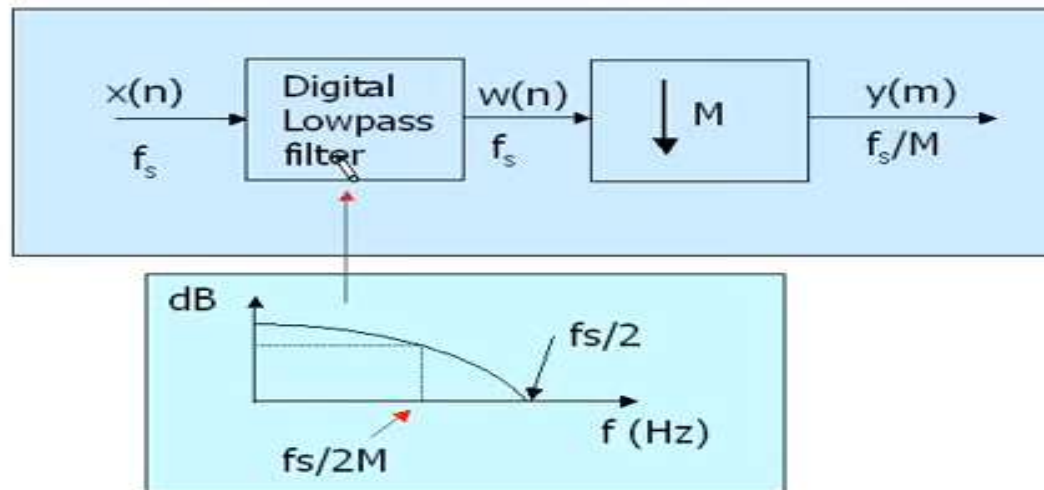


- **Multirate systems used for audio and video processing, communications systems, and transform analysis to name but a few.**
- **In most applications multirate systems are used to improve the performance, or for increased computational efficiency.**
- **The two basic operations in a Multirate system are decreasing (**decimation**) and increasing (**interpolation**) the sampling-rate of a signal.**
- **Multirate systems are sometimes used for sampling-rate conversion, which involves both decimation and interpolation.**



The diagram below shows a block representations of a times M decimator.

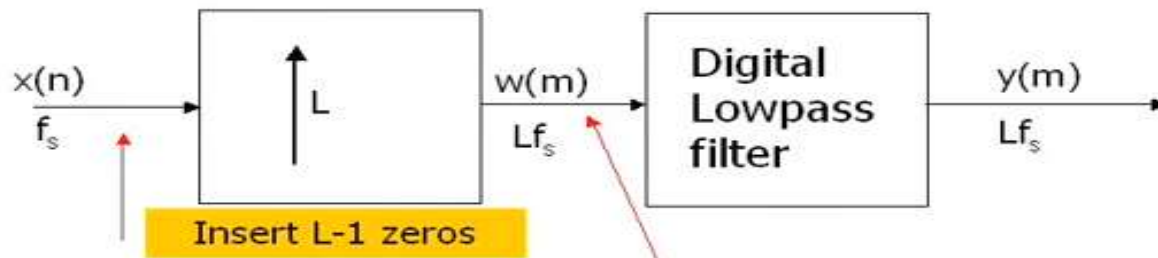
The signal $x(n)$ is first passed through a lowpass filter that attenuates the band from $\{f_s/2\}/M$ to $f_s/2$ to prevent aliasing.



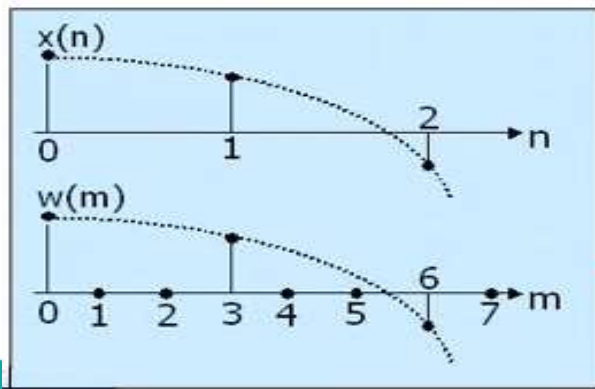


Interpolator

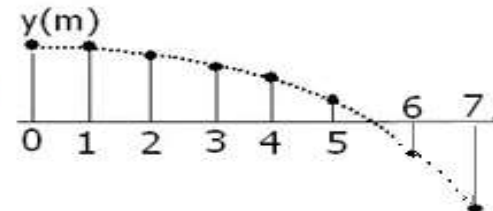
Interpolator



Example: $x(n) = \{1, 0.9, -0.5\}$; Let $L = 3$: $w(m) = \{1, 0, 0, 0.9, 0, 0, -0.5, 0, 0\}$



The lowpass filter joins all the samples of $w(m)$ to produce a waveform as if $x(n)$ had been sampled at Lf_s





Thank You!