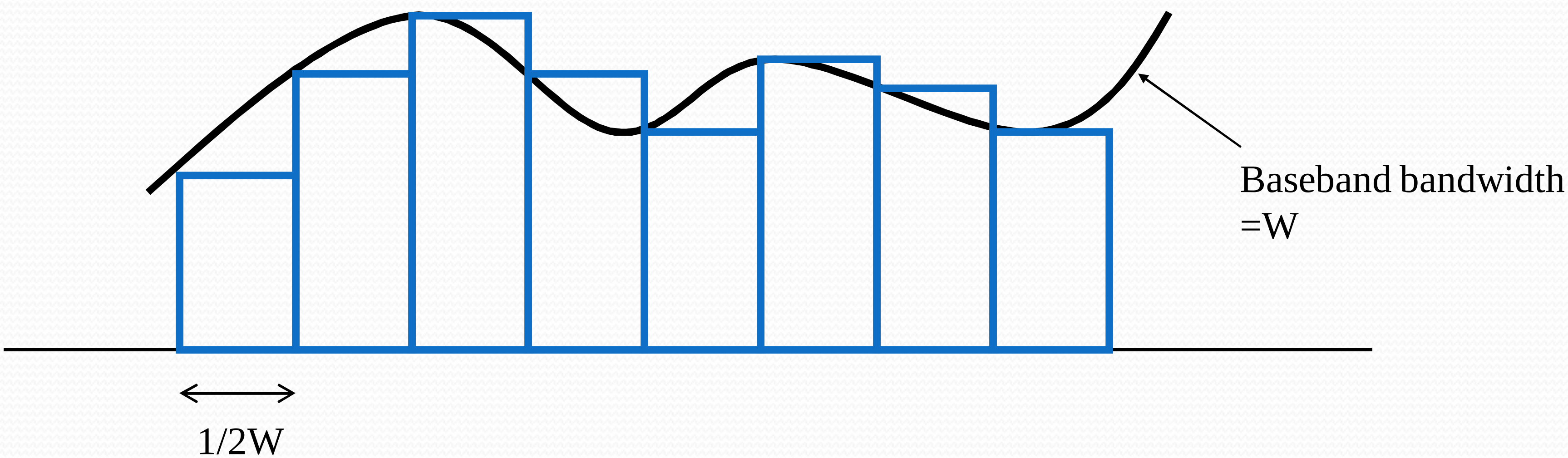
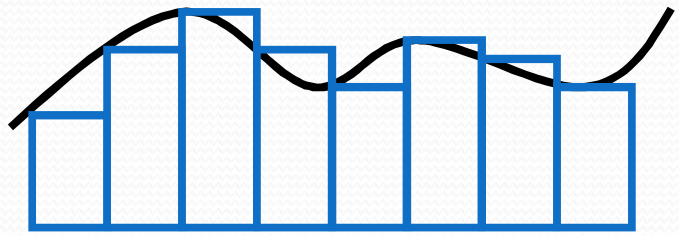
Piece-wise approximation of baseband

- Look at the following representation



Corresponding FM signal



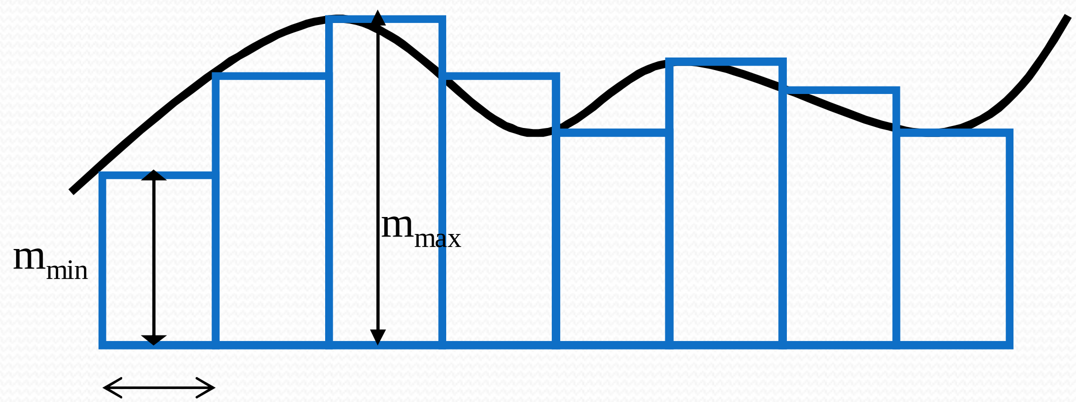
- FM version of the above is an RF pulse for each square pulse.
- The frequency of the kth RF pulse at $t=t_k$ is given by the height of the pulse. i.e.

[redacted]

Range of frequencies?

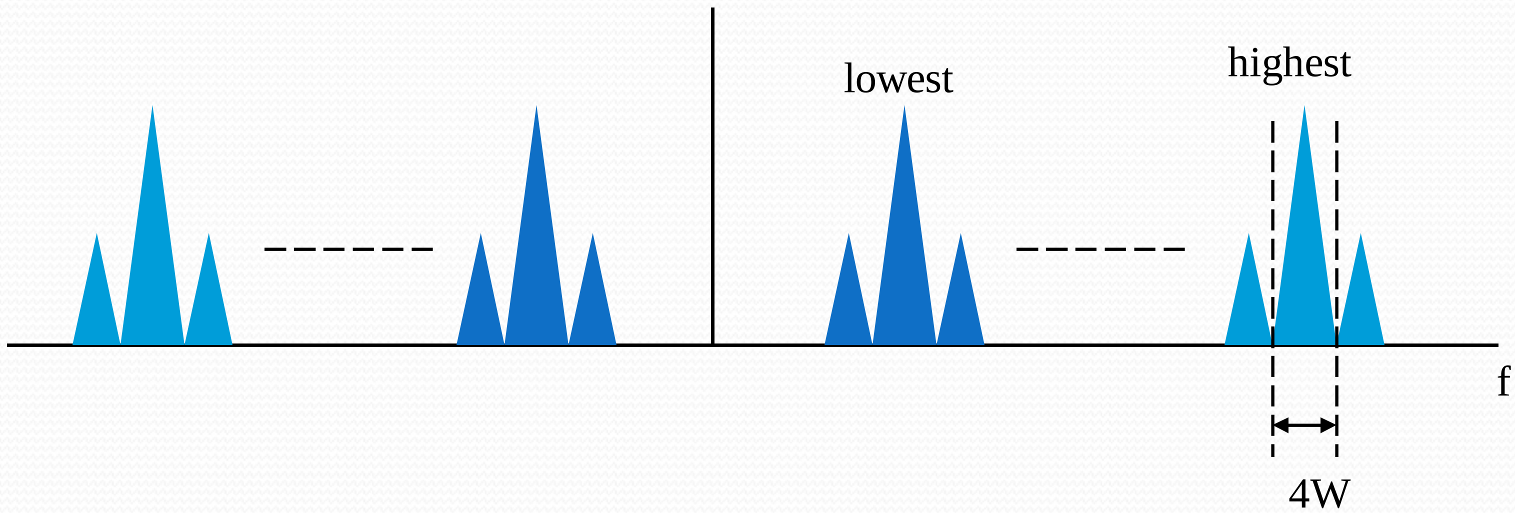
- We have a bunch of RF pulses each at a different frequency.
- Inst.freq corresponding to square pulses lie in the following range

[redacted]



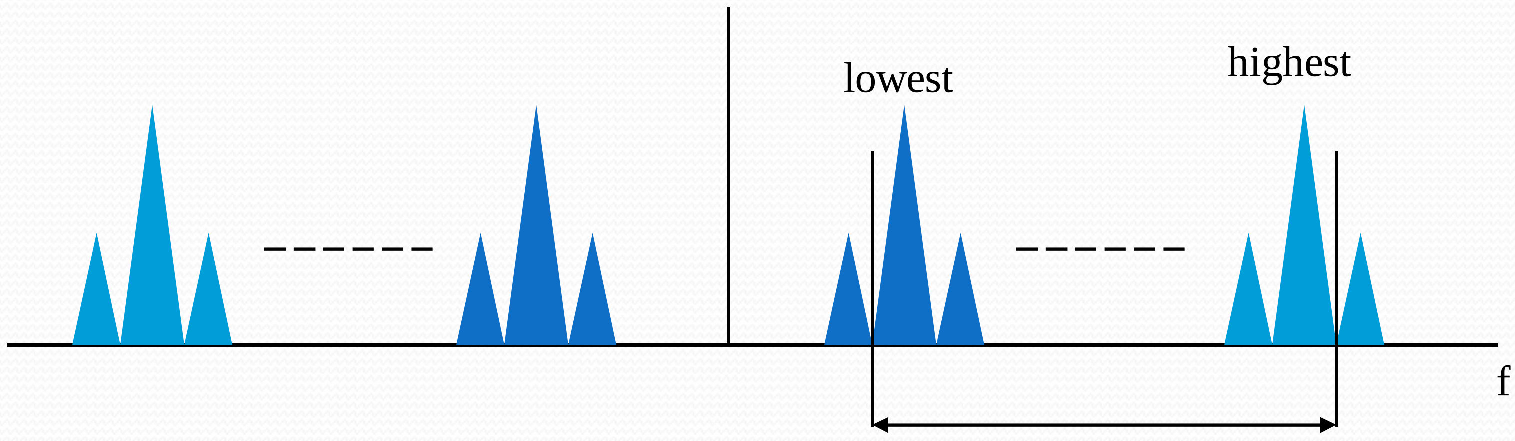
A look at the spectrum

- We will have a series of RF pulses each at a different frequency. The collective spectrum is a bunch of sincs



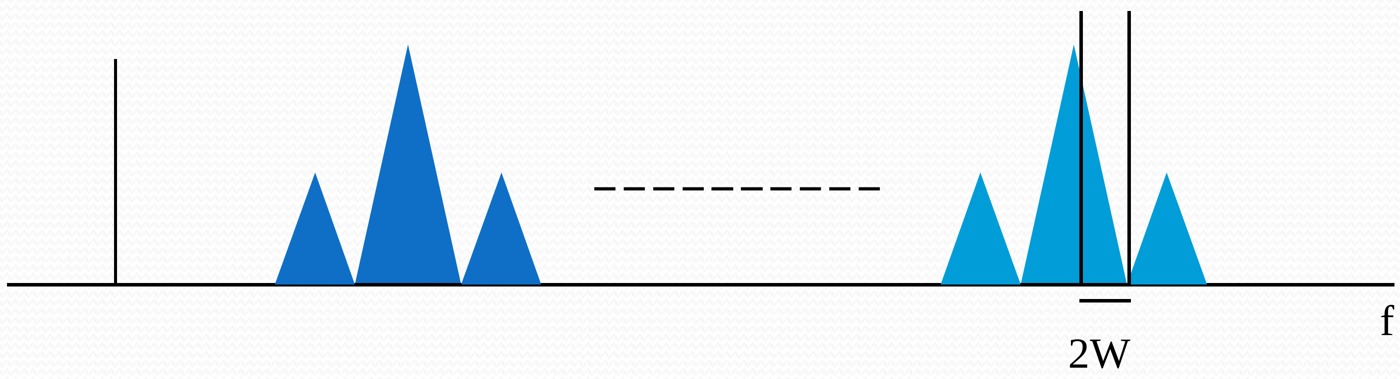
So what is the bandwidth?

- Measure the width from the first upper zero crossing of the highest term to the first lower zero crossing of the lowest term

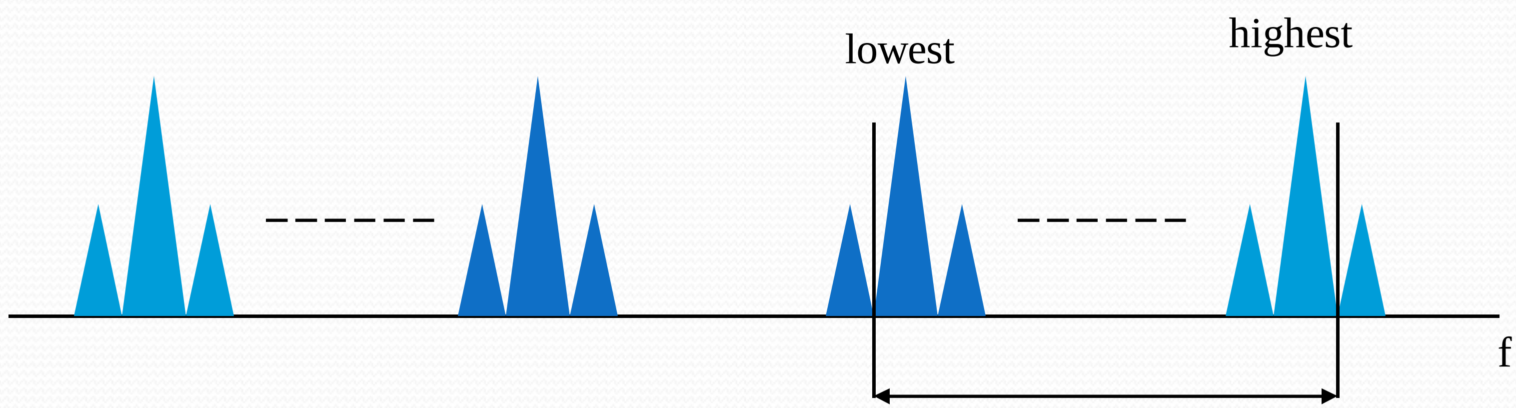


Closer look

- The highest sinc is located at $f_c+k_fm_p$
- Each sinc is 1/2W wide. Therefore, their zero crossing point is always 2W above the center of the sinc.



Range of frequenices



- Above range lies

$$<f_c-k_fm_p-2W,f_c+k_fm_p+2W>$$

FM bandwidth

- The range just defined is one expression for FM bandwidth. There are many more!

$$B_{FM}=4W+2k_f m_p$$

- Using $\beta=\Delta f/W$ with $\Delta f=k_f m_p$

$$B_{FM}=2(\beta+2)W$$

Carson’s Rule

- A popular expression for FM bandwidth is Carson’s rule. It is a bit smaller than what we just saw

$$B_{FM}=2(\beta+1)W$$

Commercial FM

- Commercial FM broadcasting uses the following parameters
  - Baseband;15KHz
  - Deviation ratio:5
  - Peak freq. Deviation=75KHz

$$B_{FM}=2(\beta+1)W=2x6x15=180KHz$$

Wideband vs. narrowband FM

- NBFM is defined by the condition
  - $\Delta f << W$ ➡ $B_{FM}=2W$
  - This is just like AM. No advantage here
- WBFM is defined by the condition
  - $\Delta f >> W$ ➡ $B_{FM}=2\ \Delta f$
  - This is what we have for a true FM signal

Boundary between narrowband and wideband FM

- This distinction is controlled by β
  - If $\beta>1$ --> WBFM
  - If $\beta<1$-->NBFM
- Needless to say there is no point for going with NBFM because the signal looks and sounds more like AM