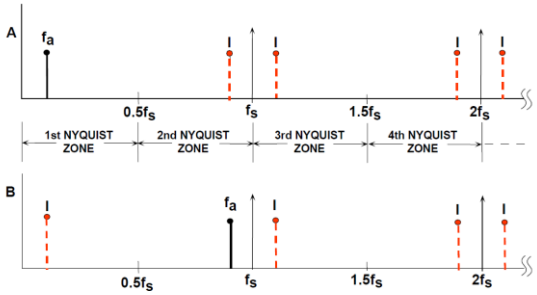
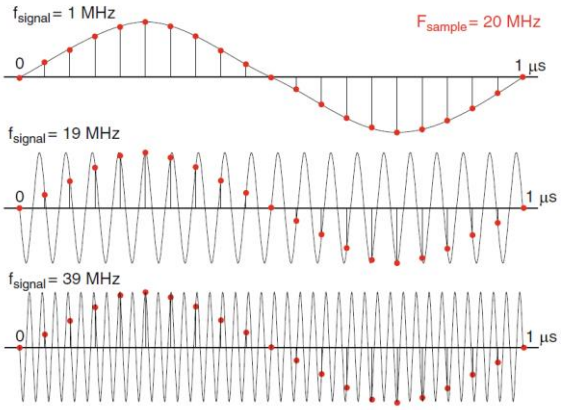
Analog Systems Design

2. Sampling

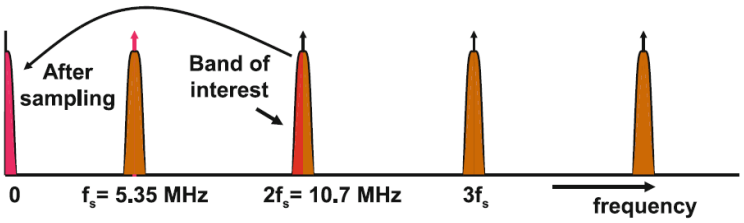
1. Aliasing and subsampling in Frequency / Time domain
   - The sampled signal does not have to be a base-band signal
     - Images appears at $|\pm kf_s \pm f_a|$ where $k = 0,1,2, \ldots$
   - If $f_s < 2f_{max}$ under sampling (band-pass sampling) is happening
   - The signal with $f_{max} = f_a$ in fig. B is down converted to a base-band signal as $f_s < 2f_{max}$



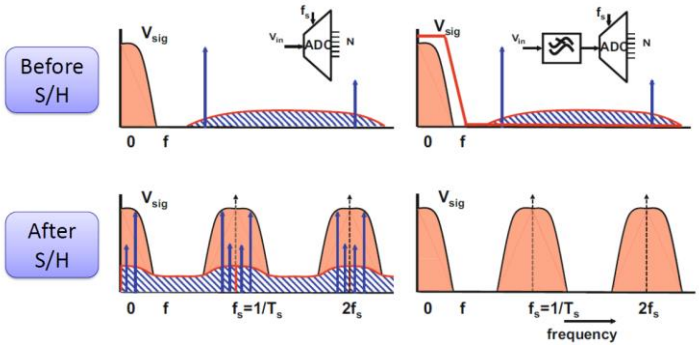
   - The subsampling can be used to demodulate (down convert) an RF signal
   - Samples of a 1 MHz signal is identical to a 19 MHz signal and 39 MHz Signal as they are sampled with $f_s = 20\ MHz$ where at 19 and 39 MHz signals $f_s < 2f_{max}$



   - Example: FM signal of 100 kHz bandwidth at 10.7 MHz, The signal is down converted by a ……. MHz sampling clock
     - As the signal appears at fs and its multiples and its image at fsignal = 2fs = 10.7 MHz, so fs = 5.35 MHz



2. Anti-Aliasing Filter (AAF)
   - To ensure the Nyquist criterion, we must ensure that the signal is band-limited signal, the problem is that, there is a duality between the time and band limited signals, as any time limited signal is band unlimited and vice versa
   - All real signals are time limited, so we need these signals to be limited at frequency domain to ensure the Nyquist criterion and avoid aliasing
   - This can be achieved by Anti-Aliasing Filters (AAF)
   - AAF can be
     - Active filters or Passive filter
     - Continues time or Discrete time
     - Low pass filters (for base band signals) or Band pass filters (for band pass filters)



   - Example: Signal band: 33 MHz to 39 MHz, Which sampling rate to choose to subsample the signal?
     a) 78 MHz : fs = 2 fmax so not a valid option
     b) 39 MHz : fs < 2 fmax so, it is a valid option
     c) 19.5 MHz : fs < 2 fmax so, it is a valid option
     d) 13 MHz : fs < 2 fmax so, it is a valid option

     Option b) has easier AAF requirements as it has a large relaxation region but its higher sampling rate means higher power consumption and higher memory
     Option d) needs a very complex AAF but with lower power consumption

     I choose option b) as the technology scaling tends to move all the complexity to digital domain