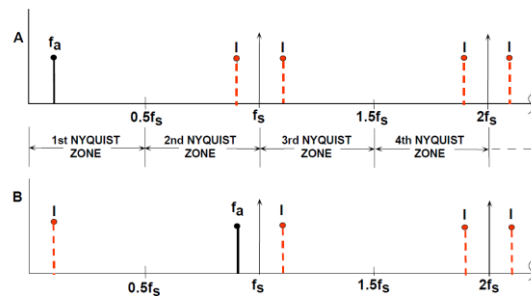


Analog Systems Design

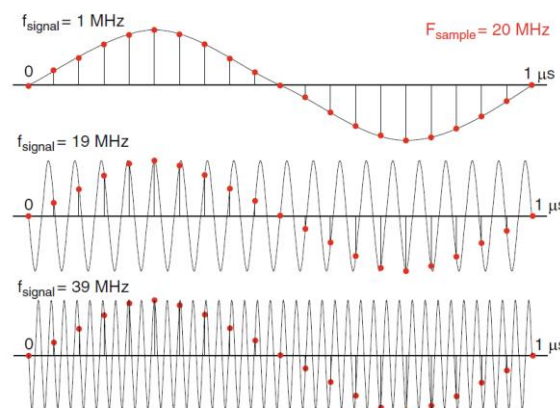
2. Sampling

1. Aliasing and subsampling in Frequency / Time domain

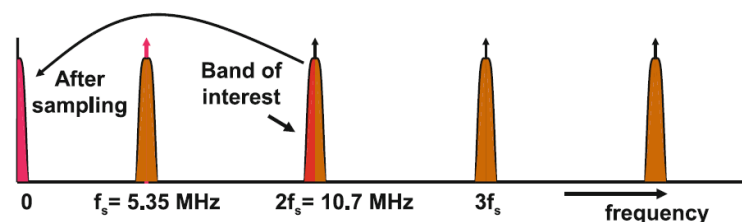
- The sampled signal does not have to be a base-band signal
 - Images appears at $|\pm kf_s \pm f_a|$ where $k = 0, 1, 2, \dots$
- If $f_s < 2f_{\max}$ under sampling (band-pass sampling) is happening
- The signal with $f_{\max} = f_a$ in fig. B is down converted to a base-band signal as $f_s < 2f_{\max}$



- 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 $f_s < 2f_{\max}$

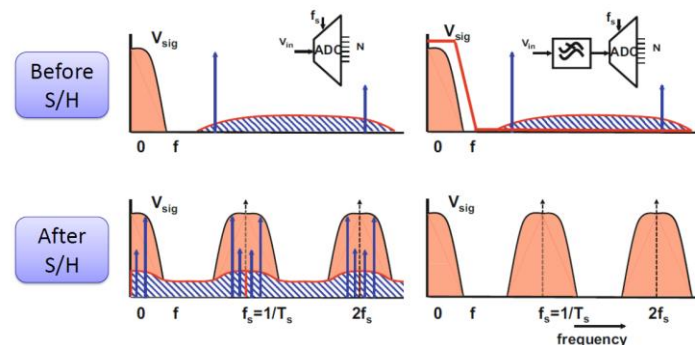


- Example: FM signal of 100 kHz bandwidth at 10.7 MHz, The signal is down converted by a MHz sampling clock
 - As the signal appears at f_s and its multiples and its image at $f_{\text{signal}} = 2f_s = 10.7$ MHz, so $f_s = 5.35$ MHz



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
 - Continuous 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 : $f_s = 2 f_{max}$ so not a valid option
 - b) 39 MHz : $f_s < 2 f_{max}$ so, it is a valid option
 - c) 19.5 MHz : $f_s < 2 f_{max}$ so, it is a valid option
 - d) 13 MHz : $f_s < 2 f_{max}$ 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