Co-location in C-BAND
Strategies for reducing risk

More spectrum, more interference

By Tony Montalvo

When the wireless revolution began some 30 years ago, there were only a handful of bands, mostly confined below 900 MHz and typically 1 or 2 bands per country. Today, driven by exponential growth, there are 76 LTE and 5G bands in FR1 alone. This is pushing frequencies higher up to find available spectrum. The recently completed C-band auction in the US (at 3700-3980MHz) highlights this. Now, as the industry pivots from buying spectrum to building the network, they will find that C-band is *very* different from previous deployments from an RF perspective. In particular, some radio architectures in C-band, when co-locating with legacy radios, could lead to a site management nightmare due to interference.

We've all seen the increasingly crowded macro towers and marveled at the weight and wind-load that the towers must be supporting. Initial deployments of C-band will most likely re-use these sites which means that C-band radios will be *co-located* with LTE and GSM devices. Consider that at the top of the tower, one radio may be transmitting at 100W or more while another radio just a meter (or less) away is receiving a signal at less than 100 nW or about 10 billion times lower power. This has been the case previously, but a new twist to the mix is the increased potential for aliases, or signal interference, because of C-band's higher frequencies.

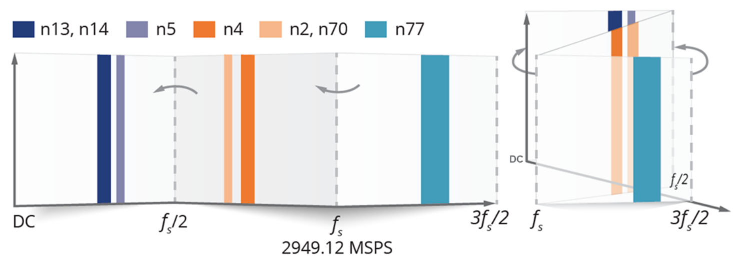
Aliasing, Blocking, and Nyquist Zones

Remember Nyquist Zones from your Signal Processing class? To summarize the sampling criteria, Nyquist zones subdivide the spectrum into regions, spaced uniformly at intervals of $F_s/2$. Each Nyquist zone contains a copy of the spectrum of the desired signal or a mirror image of it known as an alias. The signals below and above the sample rate, by an equal amount, fold on top of each other as aliases at the analog to digital converter (ADC) output.

Radios reject interference from other radios using filters. The choice of core RF architecture in the radio unit makes this either somewhat hard to solve, or very hard to solve. In this context, hard means expensive. If the radio architecture uses particular sampling rates, the sensitivity to aliases increases, resulting in heavier, more expensive filters. Unfortunately, the sensitivity problem may not be identified until the back half of the design cycle, when core architecture decisions have been made.

Zero IF radios reduce co-location problems by converting only the band of interest, while Direct RF architectures convert all the bandwidth and use filters to capture band of interest. A common Direct RF analog to digital sampling rate is between 3GHz and 4GHz. For C-band, this means that there's a Nyquist boundary at around the desired band, which means that signals below and above the sample rate by the same amount fold on top of each other at the ADC output. All frequencies that could alias on top of the desired signal need to be filtered enough to not affect the receiver's sensitivity. The stronger the signals at these frequencies, the larger, more expensive, and heavier the filter. The worst – and most expensive case – is when the source of the interfering signal is a co-located transmitter. As it turns out, C-band frequencies and some of the most commonly used FDD bands interfere with each other when using devices based on these ADCs.

Co-location Challenges in RF Sampling System



This illustrates spectrum folding back onto the first and second Nyquist zone creating aliases. Using a common sample rate, 2949.12, band n77 (C-Band) will alias with bands n2, n4, n5, n13, n14 and n70, increasing filter requirements, adding weight, and cost.

The Bottom Line

You need to know how your radio's architecture addresses co-location at the beginning of the design cycle. It's worth knowing what radio architecture is being selected and the sampling rate it includes. **To recap:**

- Filters may account for 30 to 40% of the weight of a C-band radio. The aliasing problem may increase their weight by 50% compared to filters paired with Analog Devices' ZiF radios.
- Radios already installed can be at risk because the aliasing problem is reciprocal. That is, a deployed radio at around 2GHz could stop working once a C-band radio is deployed on the same tower.
- And, past performance is not a guarantee for future results. New spectrum is constantly being allocated. A radio with this aliasing sensitivity that works today may not work in the future.

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