Using RF Digital Signal Processing to Maximize the RF Physical Layer of a Wireless Network to Add Capacity, Recover Lost Capacity or Protect Performance

ISCO International
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Abstract

Using now available RF Digital Signal Processing to condition the uplink spectrum, wireless service providers can deploy more carriers in existing spectrum, recover capacity lost to physical layer impairments or protect network performance and data throughput from degradation. At a high level, this paper illustrates the benefits of actively conditioning the RF physical layer of a wireless network to achieve maximum spectrum utilization. The theory is simple: deliver the best possible Carrier to Interference ratio (C to I), Adjacent Channel Selectivity (ACS) and Adjacent Channel Interference Ratio (ACIR) to maximize spectrum utilization.

The RF Physical Layer (Layer 1)

The RF Physical Layer is critical to the performance of the wireless network. No different than how it applies to wired Ethernet, voice and fiber networks, the ISO 7-Layer model applies to wireless networks. Having a solid, verifiable physical RF layer for the wireless network is essential to achieving consistent performance, maximum capacity and low operating costs.

The Carrier to Interference ratio (C to I), Adjacent Channel Selectivity (ACS) and Adjacent Channel Interference Ratio (ACIR) indicators are critical to the performance of RF carriers, whether UMTS or CDMA. Typically, these parameters are maintained with conventional filters, healthy guard bands and offsets and the assumption that interference does not exist and "cannot happen to me." But, standard off sets and guard bands waste spectrum. High-power adjacent RF from other operators, adjacent GSM or RF from uncontrollable sources can affect performance. Co-channel RF energy such as narrow band interference is real and will degrade C to I and cause physical layer impairments. In all cases, a degradation in any of these parameters means performance will be reduced. RSSI and RTWP are evaluated reducing

coverage area and capacity, and data throughput and data rates are reduced. By actively conditioning the RF spectrum using Digital Signal Processing that only passes the carriers of interest free and clean of narrow band co-channel interference, smaller guard bands are possible and lower RSSI can be maintained maximizing spectrum utilization, capacity and network performance.

Typical Applications for RF Digital Signal Processing

The following applications are only a sampling of what is possible when using RF Digital Signal Processing. The exact application, requirements and configurations will vary depending on the specific situation, Node B equipment and bands being used. Additional consideration for the transmit forward link also needs to be taken into account since this paper is exclusively focused on what is possible for the reverse RF uplink.

Add Capacity - Reduce Guard Bands to Allow more Carriers

Using RF Digital Signal Processing, adjacent RF such as GSM uplink transmission can be targeted and rejected allowing the use of smaller guard bands and possibly reduced center frequency offsets, resulting in more carriers -- CDMA, UMTS or GSM – and more capacity.

Figure 1a and 1b shows two typical scenarios depicting the concept.

- ✓ Improve adjacent channel selectivity
- ✓ Lower Node B adjacent channel interference ratio (ACIR)
- ✓ Minimize GSM channel loss
- ✓ Eliminate capacity loss due to adjacent channel GSM interference
- ✓ *Maximize spectrum spectral efficiency*

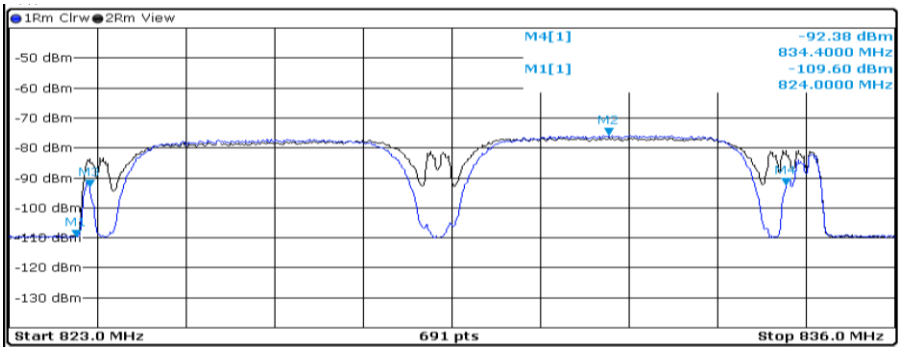


Figure 1a – RF Digital Signal Processing applied to UMTS to enable 2 UMTS carriers and more GSM channels.

The size of the current guard band can be reduced enabling more carriers.

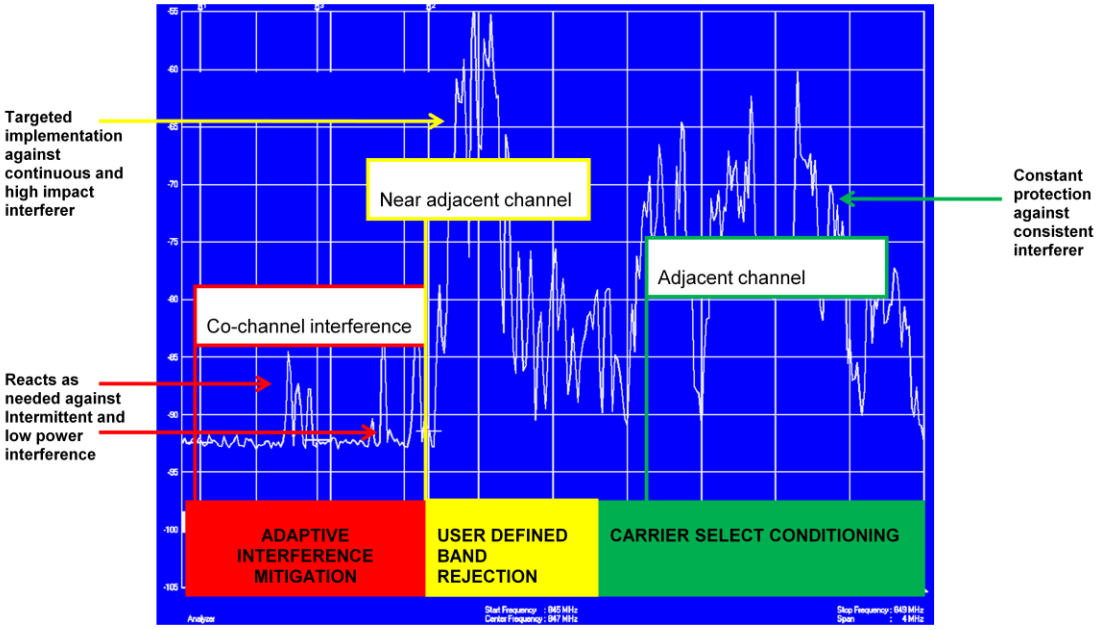


Figure 1b – RF Digital Signal Processing applied to CDMA for a 9th carrier.

Removed co-channel GSM, suppress high-power adjacent GSM and guards against other adjacent RF outside the CDMA carriers of interest.

Protect Performance - PCS Band Selectivity

With RF Digital Signal Processing, a service provider can create a band-pass filter using Carrier Select Conditioning (CSC) to pass only the desired band (one of the 6 bands A to F) to the base station. U.S. carriers have deployed band specific filters in PCS early on but came to realize that they do not own a particular license nationwide. The result was the need for multiple filter models. This made life very difficult for supply chain price negotiation and field operations since numerous filter types needed to be maintained nationwide.

To achieve some level of commonality, a typical PCS site would have a full band PCS filter allowing all 6 bands to pass through the receive filter. This negatively impacts performance since all the energy of the entire PCS band slams the base station receiver, desensitizing the front end. This extra energy reduces the maximum capacity of the base station and results in sub-optimal capital efficiency. By passing only the band or bands being used and clear of any co-channel interference, Adjacent Channel Selectivity (ACS) is improved, and capacity is maximized.

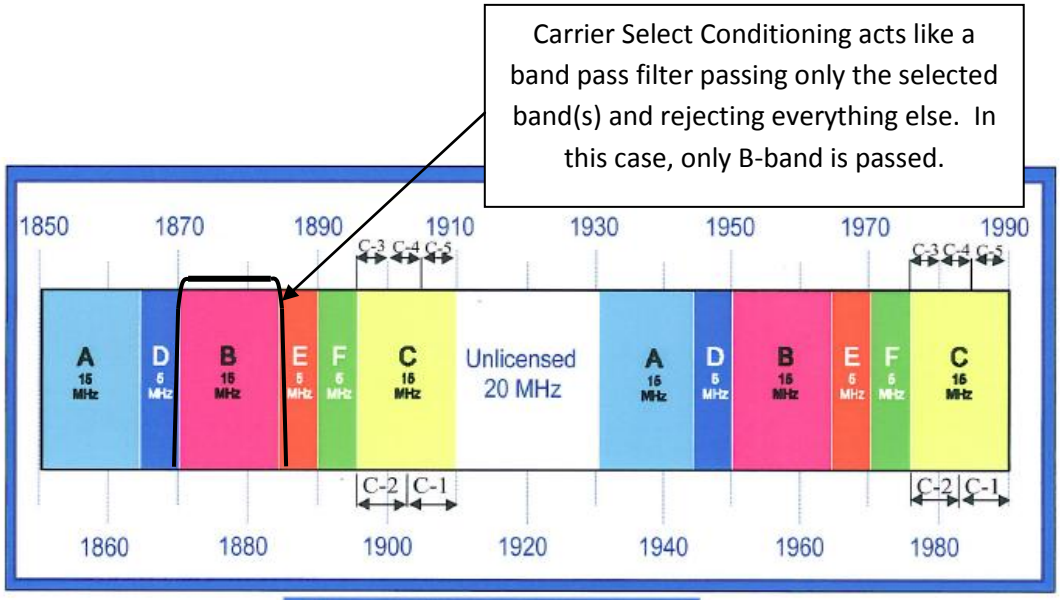


Figure 2 –Carrier Select Conditioning can be applied to a specific carrier in the PCS band.

This example illustrates passing only the 15MHz B-band while rejecting the remaining portion of the PCS band.

Recover Lost Capacity - Reducing RSSI to Increase Coverage and Capacity

When narrow band co-channel interference occurs, the physical layer is impaired. Immediately channel power is increased and the coverage area and data throughput are reduced. For CDMA cell sites not at capacity, traffic will be diverted to other CDMA carriers. But, during high-traffic periods when the cell site is operating at capacity there is no margin or excess capacity available to compensate for interference. In these situations the impact is immediate. Capacity is reduced, dropped calls increase, ineffective attempts increase, data throughput and data rates are reduced.

For UMTS this situation is more significant. Once co-channel interference occurs, channel performance is immediately degraded and in cases where there is not another UMTS carrier or the other carrier is already at capacity, the degradation will be severe.

Through RF Digital Signal Processing, co-channel interference is automatically, adaptively removed and service levels along with capacity are recovered immediately. Figure 3 below shows a real life situation measuring the before and after performance of a cell during equivalent busy hour periods. “Before” shows KPIs for an unconditioned cell site. ”After” shows KPIs after RF Digital Signal Processing is applied.

	Before	After	
Measured Site KPI's	Without Active Spectrum Conditioning	RF Digital Signal Processing is Deployed	% KPI Improvement
Average CS Calls	2833	4448	57%
Average CS Erlangs	103	168	63%
Average PS Calls	8288	14041	69%

Figure 3 – Before and After analysis of a 3-sector cell site.

Approximately 63% improvement for the entire cell site after RF Digital Signal Processing is applied.

Recover Lost Capacity – Enabling UMTS and GSM to Co-Exist at 900 MHz

As 3G UMTS grows around the world, service providers are looking for ways to most efficiently deploy the service. Typically services are deployed in the 1700, 1900 or 2100 MHz bands. But, having the ability to deploy at 900 MHz provides operators numerous benefits such as reducing capital, greater in-build penetration and coverage. The challenge is to deploy UMTS in the same band currently using GSM. With RF Digital Signal Processing, GSM can be automatically removed from a UMTS uplink allowing operators an option to deploy in the 900MHz band. Figure 4 gives a brief illustration of the performance and response of RF Digital Signal Processing when it is applied to mitigate the effects of GSM in the UMTS uplink.

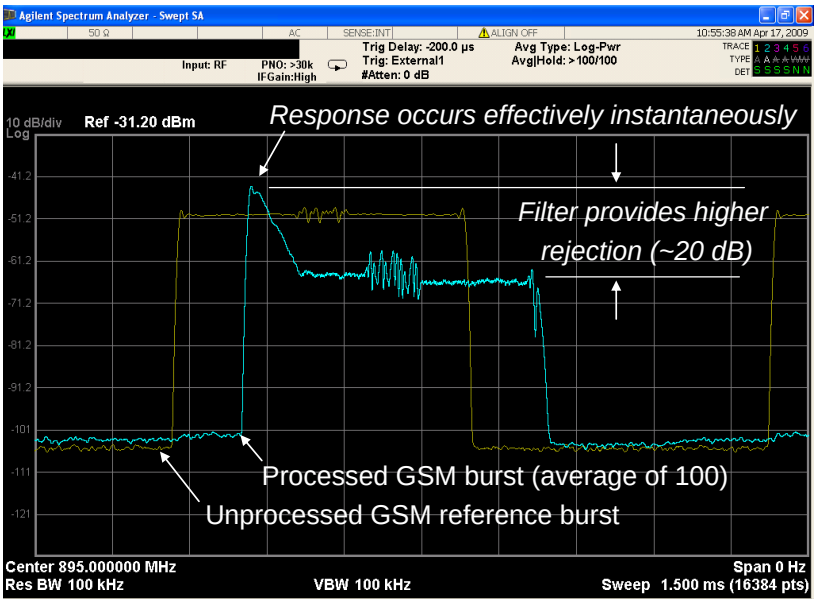
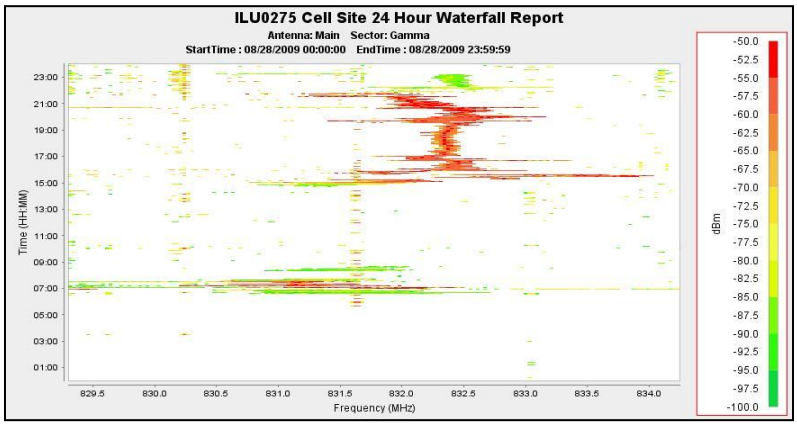


Figure 4 – RF Digital Signal Processing can instantly mitigate GSM in the 900MHz band.

Where GSM and UMTS occupy the same 900MHz band in transition zones, the impact of GSM on the UMTS uplink can be mitigated.

<u>Protect Performance</u> – Maintaining Performance at Special Event Sites

Whether it is special event sites such as sports venues, high-profile sites delivering services to valuable customers, or dense urban areas where capacity is at a premium, actively conditioning the RF uplink to prevent physical layer impairments will ensure optimal network operations. These high-profile sites typically operate at capacity and have no margin available for loss to high-power adjacent RF energy or co-channel interference. Additionally these sites will typically service higher densities of population driving up the statistical probability of an interference event. In some cases these sites exist in unpredictable or changing surrounding environments adding more risk and increasing the probability of a problem. This is very typical for CoW/CoLTs since they are usually deployed for high-traffic or disaster situations. Actively conditioning the high-profile cell sites, including CoWs and CoLTs, will protect the performance of those sites. As an added benefit, since the RF digital signal processing is performed by an intelligent piece of equipment, the service provider gains visibility into the spectrum providing valuable data not currently available.



<u>Figure 5 – Spectrum at a typical special event.</u>

Interference at special event sites is real and more likely to occur given the unpredictable environment and density of population. In this real-life case the CoW experienced interference at a -50dBm level.

Conclusion – RF Digital Signal Processing can Add More Capacity, Recover Lost Capacity and Protect Performance of Critical Sites.

Global mobile data traffic has increased by 160% in the past year, growing more than 10 times faster than voice to 90 petabytes per month, or the equivalent of 23 million DVDs. This requires wireless operators to squeeze as much capacity as possible from the existing spectrum they own – maximum utilization is a must. Up to now networks could afford and compensate for the loss of capacity to guard bands, interference and unpredictable environments. Today that is not the case. Idle capacity is simply not available and certainly not available during busy hour periods.

Now, with RF Digital Signal Processing, smaller guard bands and offsets to increase spectrum available for carriers is possible. Mitigating co-channel interference, whether random or self induced -- such as GSM in the 900 band, can recover vital capacity being unnecessarily wasted. And actively conditioning high-profile, high-traffic sites from the statistically determinable occurrence of co-channel interference or high-power adjacent RF can maintain capacity, performance and throughput.

For more information about how to Add Capacity, Recover Capacity or Protect Performance for maximum spectrum utilization contact your ISCO International representative.

About ISCO International:

ISCO International operates on the "front lines" of 3G – and soon – 4G communications by enhancing the integrity of a mobile operator's "physical layer" assets – the cell site and acquired spectrum. ISCO understands that wireless communications depend heavily on the user's RF connection to the base station and the company's "spectrum conditioning" product line ensures that this connection performs as expected even in the most hostile and unpredictable environments. ISCO's new Proteus™ product, based on the latest PurePass™ digital signal processing technology, adaptively identifies and corrects the physical layer impairments (PLI) that decrease a cell site's coverage, capacity, data throughput and KPI performance. In sum, ISCO allows wireless carriers to get the most out of their existing base stations and spectrum (possibly eliminating the need to build additional ones in certain situations), reduce operating expense and deliver a consistently high quality of service. Please visit www.iscointl.com for more information.

More information about all ISCO wireless solutions can be obtained from the ISCO website at www.iscointl.com.

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