COMMSCOPE®

White paper

Densifying with grace: the resurgence of RF conditioning devices

Erik Lilieholm, manager, technical sales

Contents

Executive summary

Wireless networks are becoming more complex and new sites are becoming more difficult to secure. One way to grow capacity and coverage is network densification—the practice of increasing coverage and capacity through the deployment of more numerous but smaller cells, or splitting existing cells into more sectors. However, these practices also increase the likelihood that interference will drag down network performance.

RF conditioning mitigates the detrimental effects of densification by improving link performance in the RF path between radio and antenna. As space and weight considerations force many remote radio units (RRUs) back to the base of the tower, RF conditioning becomes even more important to network quality and reliability.

RF conditioning is the key to leveraging many of today's most important technologies and practices, including MIMO, VoLTE, small cells and others—plus, it will become increasingly important as newly-released spectrum unleashes the next wave of network densification.

Introduction

Since the earliest analog radio systems, RF conditioning devices have played an important role in wireless base station architecture. RF conditioning consists of both hardware and software solutions designed with features, designs and applications that have evolved over time, and the trend continues today with new product developments and adaptations designed to support increasingly complex cell sites.

This white paper examines current and future applications of RF conditioning components; the new challenges faced by designers; and the latest and emerging solutions that overcome those challenges.

Components

The scope of RF conditioning includes any RF product installed in the path between radio transceiver and antenna. Most of these products fit into the following categories:

- Multiband combiners (MBCs) that combine (or separate) signals from different license bands.
- Tower-mounted amplifiers (TMAs) incorporating low-noise amplifiers (LNAs) that help improve uplink signal quality. They often also include MBC functionality in support of multiple bands.
- Same-band combiners (SBCs) that serve to combine and distribute signals from multiple radios at different frequencies within the same license band.
- Interference mitigation filters (IMFs) that protect colocated and adjacent radio systems from harmful interference.

Various other products perform specific functions in the RF path, such as surge arrestors and bias tees; power splitters and couplers; and dc blocks, among others.

Applications

In the rollout of each generation of wireless technology, the first objective has always been to establish good coverage of a geographic area. As more users adopt the new services, the strategic focus typically shifts to adding capacity—that is, improving network throughput to keep pace with traffic growth. Signal strength and quality are important to meet both goals and, therefore, we must strive to minimize signal loss, noise and interference in the RF path.

The introduction of the RRU was a significant step in that direction. RRUs allow the radio to be mounted on the tower near the antenna, eliminating feeder runs and their negative impact on the link budget. The need for RF conditioning is reduced in such installations. MBCs and SBCs are still used to facilitate antenna sharing, but, in these cases, TMAs are no longer necessary. IMFs, where needed, must be installed with the radio at the tower top.

As more spectrum is deployed, the number of RRUs at a site increases. Older tower structures cannot support the added weight and wind load, and there is often no more space to mount them. Upgrading or replacing the structure is an expensive and time-consuming option, so operators are now choosing to place more radios on the ground, introducing a need for RF conditioning that does not exist when RRUs are tower mounted.

New RF conditioning products enable sharing of existing feeders to carry the signals to the tower top, where a new generation of multiband TMAs direct them to their antennas while preserving or improving uplink performance.

Driven by social networking, cloud services and voice over LTE (VoLTE), uplink capacity and reliability are becoming increasingly important to wireless operators. TMAs at higher frequencies are already ubiquitous in locations with ground-mounted radios. While RF path loss is less pronounced in sub-1 GHz bands, TMAs for these frequencies are increasingly being considered as a means to improve uplink performance at the cell edge.

Multiple-antenna techniques, such as transmit and receive diversity and multiple input, multiple output (MIMO), can be leveraged to enhance coverage as well as capacity. When stepping up from a traditional 2-way to improved 4-way architecture, the number of required antennas is doubled. Again, this introduces tower space and load issues. Antenna sharing helps reduce the impact at the tower top, multiplying the need for RF conditioning devices.

Looking to the future, more spectrum will be made available and technology will improve. In the meantime, however, network densification offers a way ahead. Finding sites to build new cell towers is most difficult in areas where the need is greatest, so another option is to make better use of existing sites by splitting coverage into more sectors. As each sector requires its antennas and radios, tower loading would increase dramatically were it not for site sharing and cositing solutions enabled by RF conditioning.

Small cells present another densification option. Their diminutive size and unobtrusive design allow them to be located in places a full-height tower cannot go, but it follows that there is rarely space for more than a single antenna. The MBCs that double or triple the use of the antenna must be adapted to match the compact form and attractive appearance of the small cell.

Adding carriers and sharing the RF path can help us keep up with traffic demand without introducing unacceptable costs, but, as with any increase in network complexity, it also raises the risk of interference. Avoiding and controlling that threat is essential in order to fully realize the capacity benefits. In particular, the potential for passive intermodulation (PIM) must be carefully evaluated; it can largely be avoided by assigning radios to RF paths and antennas in combinations that do not produce harmful PIM. IMFs may be needed to control interference between adjacent bands.

Challenges

The list of frequency bands for mobile communications is already quite long and it keeps growing. That's a good thing, but it also presents more possibilities for multiband combining and potential for interference.

Avoiding the interference pitfall requires careful consideration of the available designs, frequencies and specifications, as well as a clear understanding of the operator's objectives and the likely operating scenarios at the site. There is a well-known tradeoff between size and performance in RF filters. In the past, the demand for wider bandwidth and sharper selectivity would normally be met with larger devices. However, constraining size is imperative in order to mitigate the effect of upgrading to a 4-way RF path, as well as to control weight and wind load on the tower. Scaling down is also necessary to fit into the small cell's form factor. The shrinking overall package eats into performance margins and, occasionally, compromise becomes inevitable.

Today, speed of delivery and production volume are keys to success, but these cannot come at the cost of performance and reliability. The RF path is now more complex, yet insertion loss and return loss must remain acceptable. The link budget must always be met.

RF power handling comes into focus with increasing radio output and more channels combined into the RF path. At the same time, controlling PIM is as critical as ever.

A secondary role of RF conditioning is to conduct and distribute dc power and AISG control signals to antennas and TMAs. Also here, complexity is growing—with multiple control points and signal routes serving different parts of the installation. Configurations will vary and flexibility is as important as simplicity in ensuring that these systems are set up correctly so they can operate reliably.

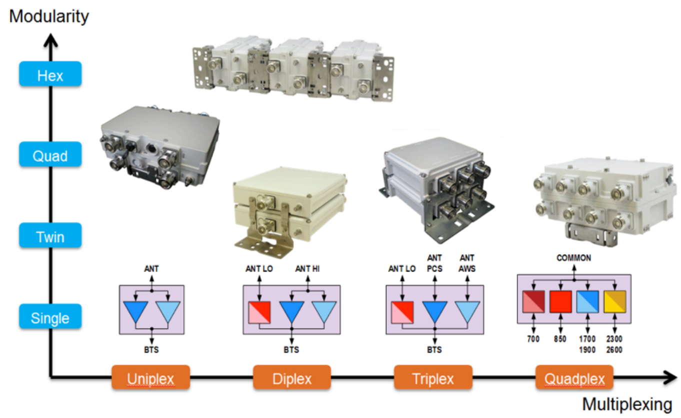
Products and solutions

When TMAs first came into use, they were singleband devices with one input (ANT port) and one output (BTS port). We now call this configuration uniplex to distinguish it from the diplex and triplex types that were introduced later. Looking at it this way, we also see the commonality with the MBC in that both are devices with multiple branches. MBC diplexers have two branches, triplexers have three, and quadplexers have four. Pentaplexers with five branches are now also entering the market. If at least one branch has an LNA, then it's a TMA.

The diplex and triplex TMAs are also examples of functional integration of a combiner and amplifier. In addition, IMF functionality can be integrated as well as AISG support. An MBC can include smart circuits for dc routing, a bias tee and AISG modem. This degree of integration reduces size and weight, simplifies installation and improves performance. Smart features can increase versatility for a greater variety of applications and help offset the flexibility reduced through integration.

Modularity offers further integration benefits. Single units can be paired into twins, then, in turn, to four-packs (quad) and even six-pack (hex) assemblies. The move from twin to quad modularity mirrors the migration from 2-way to 4-way RF path.

Integration helps reduce clutter, enhancing quality, appearance and maintainability on crowded sites. Well-conceived product packaging and mounting features address the same important goals. There is now a trend toward eliminating separate AISG cabling by combining the AISG bus with the RF path all the way to the antenna. TMAs support this method through AISG forwarding—passing the control signal through to the ANT port.



Another trend was started by the introduction of the 4.3/10 connector, which is now rapidly replacing the classic 7/16 DIN. 4.3/10 is preferred for its better PIM performance and smaller size—which are particularly helpful for small cell architectures and a vital step forward for network densification efforts.

Developing RF conditioning products today requires strength in many fields of engineering. Filter designers must master topologies and materials ranging from cavities to transmission lines and from metal alloys to ceramics. Equally important are both the electronics hardware and software we now find in all but the simplest devices. Top-class mechanical engineering is critical not only to ensure durability but also to meet the demands of the manufacturing process, where the result of all this technology and talent take its final shape.

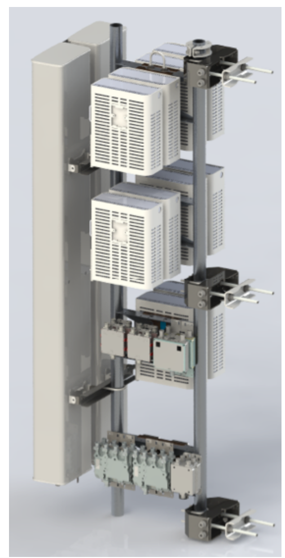
CommScope advantage

CommScope has provided RF conditioning solutions to operators and OEMs for every generation of cellular technology. Through our long-term commitment and continuing investment in this product segment, we have earned a coveted position as the leading supplier and preferred partner to operators around the globe. Innovation is a tradition embedded in our culture and a driving principle for our research and development teams. Experimentation and investigation of alternative materials, topologies and fabrication methods continue to advance our collective understanding of best design practices.

As the demand for mobile connectivity continues to accelerate, network build-out must accelerate as well. The timespan from decision to implementation is no longer years, but months; CommScope's increased flexibility in supply chain and manufacturing lets us keep pace with these contracting timelines so we can deliver with speed, quality and volume.

Even as the industry moves toward global standardization, no two wireless sites are completely alike and there is continuing demand for customized products to fit variable implementations at the local level. A broad product portfolio and adaptable design platforms—including a full line of RF conditioning solutions—help CommScope satisfy these requirements quickly and economically.

Much more could be added to the RF conditioning story. Yet it is only part of what we do as a solutions provider for the full RF path—a unique position in the industry. At CommScope, we embrace our role as independent trusted advisor, but we also recognize our duty to continue earning our customers' confidence by providing products and services of exceptional value.



WP-109955.1-EN (07/17)