From August 2010 *High Frequency Electronics*

Design Issues for Tower-Top Electronics and Remote Base Stations

By Gary Breed
Editorial Director

As tower-top installations and remote "distributed base stations" become more common, designers must accommodate new environmental and reliability performance needs

Smart antenna and MIMO (multiple-input multiple output) technologies, along with a need for flexible base station locations, are driving an increase in the use of tower-top electronics and distributed base stations. The steerable beams of smart antennas and the additional antenna hardware for MIMO require additional RF power amplifiers and antenna control equipment. If these technologies can be implemented with the electronics located adjacent to the antennas, there can be big savings in system cost. Distributed base station systems have multiple RF/antenna installations, remotely located and fed from a single baseband electronics package. These new systems are needed to improve coverage and maximize capacity of 3G and 4G networks.

Remotely located electronics present a unique set of requirements for reliability, environmental performance, maintenance and repair. These additional engineering requirements must be met in order to achieve the cost savings and performance advantages that result from the placement of electronics at the same location as the antenna.

Mechanical Advantages

A major reason for considering tower-top electronics is the elimination of the additional transmission lines that are needed for MIMO and smart antenna systems. It is easy to imagine the increased load on a tower if a MIMO system will add more antennas and double the number of large diameter (approx. one inch), heavy (0.33 lb/ft or 0.5 kg/m) and long (up to several hundred feet) coaxial feedlines. This increase is multiplied if several networks are co-located, sharing the same tower.

Tower-top electronics must be designed for maximum reliability and easy servicing by non-technical personnel.

Although the additional antennas and tower-top equipment add to the tower load, the increase is offset by replacing the original multiple coax lines with much smaller fiber optic and power cables. Although some systems feed tower-top equipment with coax carrying IF or baseband signals, these cables are also much smaller, with a similar reduction in weight and wind load.

Distributed base stations have greatest early use in urban areas, where better coverage of 3G/4G networks is demanded by the customers. In these installations, the antennas and equipment are often mounted on sides or rooftops of buildings. The ability to install base station in almost any location gives system engineers needed flexibility to fill gaps in coverage and improve system capacity during the busiest times.

Performance Advantages

Besides cost savings and flexible installation, remote electronics improve certain aspects of performance. The first is a reduction in RF losses by eliminating long feedline runs. Smaller power amplifiers are needed, requiring less DC power and producing less heat. In many cases, smaller PAs are easier to design for high linearity.

Receive performance improves with lower losses as well. Lower loss means more sensitive receivers. Even if the previous system used tower-top preamplifiers to overcome cable losses, eliminating them by placing electronics near the antenna will increase the receive system's dynamic range, improving coverage and capacity.

Shorter feedlines also reduce unwanted phase shifts in MIMO and smart antenna systems. Changes in feedline characteristics due to temperature, flexing, number of connectors, etc., can result in significant phase errors, which are multiplied by the feedline length. Reducing these errors improves the accuracy of these systems, with corresponding improvements in network performance.

Design Issues

Now that we've established the reasons for tower-top and remote electronics, let's review the key areas where such installations affect the design specifications. The two primary factors that are unique to remotely located electronics are environmental performance, and dealing with non-expert installation and maintenance personnel (tower climbers/riggers).

1. Environmental Issues

Thermal performance—Maintaining performance over a wide range of temperatures is a big design challenge. Robust design for tower-top and remote electronics must be done at the circuit and module level, since there is less supporting hardware like air conditioning systems. Every new generation of wireless transmission is more complex and requires tighter control of accuracy and drift. New design and construction techniques will be needed, including cooling with solid-state Peltier device-based systems, or dissipation of excess heat using heat pipes.

Mechanical reliability—Thermal cycles cause physical changes due to expansion/contraction. Also, there is additional vibration to deal with in tower-top installations. Internal mounting of cards or modules must account for these effects—in a poorly designed system, flexing and vibration can slowly dislodge plug-in devices, or even break individual component connections. The right construction techniques must be employed.

Enclosure requirements—The entire electronics package will be placed in some sort of enclosure. This "box" must keep out moisture and support adequate heat dissipation. It must maintain that performance with multiple cables and connectors for signals and power from below, and for connection to the antenna system. In addition, the enclosure should be no bigger or heavier than necessary to control dead weight and wind loading. Easy installation is a major design goal as well.

Lightning protection—Already in place for ground equipment shelters, the extent of lightning protection should be increased to maximize reliability. Enclosure shielding (i.e., Faraday cage) and grounding are part of the solution, as is cable routing for minimum coupling of high transient currents. Consultation with lightning control experts is recommended and should be done as the architecture is first developed—like many other aspects of design, lightning protection is best achieved when it is considered at every stage of the design process.

Environmental design for outdoor installation at a remote location has similarities to military and aerospace requirements, which are familiar to the electronics industry. Current wireless equipment is well-designed for reliability, but lessons from mil/aero design can help achieve a higher level of performance.

2. Installation and Maintenance

There are two key issues related to installation and maintenance: the work is likely to be performed by non-expert personnel, and the remote location means that performance monitoring and test functions must be integrated into the electronics.

Non-expert installation and maintenance—Although experienced tower crews are accustomed to handling technical equipment, their capabilities are physical, not electronic. Basically, tower-top and remote equipment needs to be designed to have features that account for the absence of a trained electronic technician or engineer. Foremost among these is modular design, where faulty (or suspect) modules can easily be removed and replaced to minimize down time in the event of an equipment failure.

Built-in test and monitoring—Extensive monitoring is already in place in most base stations, since they operate unattended. However, some metering or status monitors are typically used during periodic in-person maintenance. These must be converted to built-in test and, along with all the other test functions, properly interfaced for remote reporting to the operations staff. Some wireless operators may require redundancy for key elements of the system, remotely switchable to continue operating until maintenance can be performed.

Summary

Tower-top and remotely located base stations will soon become common for smart antennas, MIMO and distributed base stations. Reliable wireless network operation requires proper design that supports a new set of performance and operating requirements, achieved by including those requirements from the beginning.