RF Testing During the Installation and Maintenance of Wireless Base Stations

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This article describes key installation, maintenance and troubleshooting issues for wireless base stations, supported by Agilent Technologies' FieldFox Handheld RF Analyzer

For today's Wireless Service Provider (WSP), deploying wireless networks is no easy task. The network deployment process involves network design, site construction, base station configuration, equipment installation, optimization and troubleshooting. At each step in the process problems can occur that threaten the WSPs ability to deliver continuous and stable service at a high level of Quality of Service (QoS). Once deployed, problems can arise requiring ongoing network maintenance and troubleshooting.

Today's increasingly complex wireless networks and wide range of operating frequencies, from sub-GHz levels up to 5.8 GHz, complicate this task, forcing the WSP to deploy and maintain more cell sites to serve the same coverage area in the same amount of time. In addition the growing demand for wireless multimedia services, coupled with the increased complexity caused by the digital wireless evolution, has placed even more pressure on the WSP. Much of this pressure comes from the fact that operating frequencies are getting higher, while base stations are getting more complex, supporting multiple technologies and incorporating such new technologies as Multiple Input Multiple Output (MIMO). At the same time, base stations are migrating to a smaller, faster, cheaper design—all of which means that more functional tests are required to ensure optimal network operation.

Faulty cables, connectors and antennas can cause 50% to 60% of base station problems. Interference can be another major cause of performance degradation. The routine testing of a base station's cables, filters, antennas, amplifiers and the troubleshooting of any internal or external interference is therefore absolutely critical. Effective installation routines are essential to ensure the rapid deployment of new cell sites. Effective preventive maintenance routines are essential to ensure the ongoing optimal performance of a base station following deployment. Effective remedial maintenance routines are essential to ensure that when a fault occurs, the base station is up and running as soon as possible in order to minimize customer disruption and degradation of QoS.

Cell Site Test Requirements

Figure 1 shows a typical cell site configuration. Any transmission system is made up of a transmitter, the transmission cables, the antenna and all of the connectors in between. In an ideal transmission system all of the signal power that is sent out of the transmitter is completely broadcast into the air. In reality the signal encounters disruptions so that reflections and losses occur and signal power is lost. There are four separate areas where RF issues have to be addressed:

- Cables and antenna system
- Interference (external or internal)
- Filters and amplifiers
- Transmitter power

These issues relate directly to the potential sources of disruption that can occur within the cell site. At the top of the list are RF issues related to cable and antenna degrada-

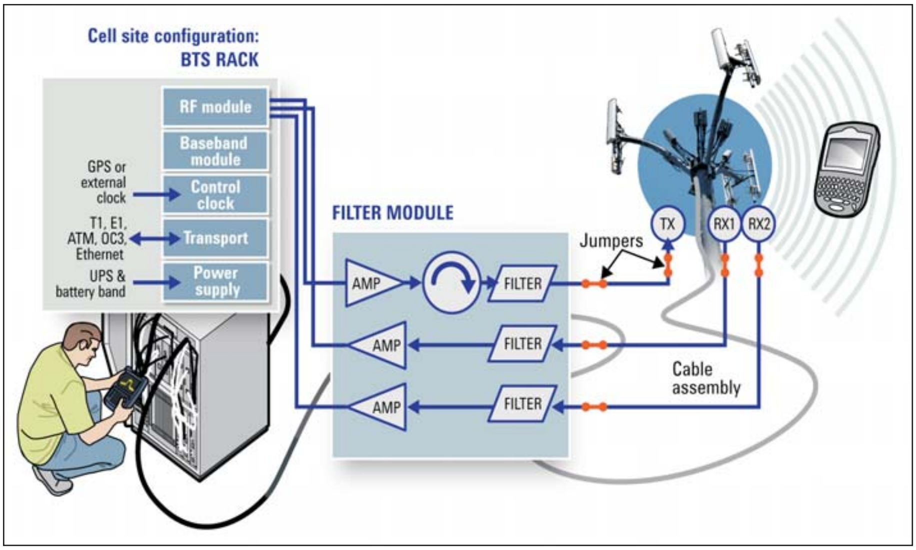

Figure 1 · Equipment configuration at a typical wireless base station.

tion and antenna performance. Degraded feedlines cause poor coverage, unnecessary handovers, paging failures and access failures on the uplink. Interference—whether co-channel, adjacent channel or intermodulation (external or internal)—is another common culprit. Downlink (radiated) interference reduces coverage and results in dropped calls, while uplink interference causes access failure. Interference has a direct impact on the QoS of wireless communication services.

Other common causes of failures in cell sites stem from damage to filters and tower-mounted amplifiers (TMAs), errors in radio settings and configurations, transmitter performance degradation and receiver sensitivity degradation. Problems can also occur when the reference clock is out of sync, resulting in "island cells" and hand-over failures. Backhaul transmission is another source of faults, with T1/E1 breakdowns being the most common defect in a cell.

For effective installation and maintenance routines, each of these areas have to be tested. The challenge is to make the testing of these issues efficient and reliable.

Traditionally, the testing toolkit carried by the RF installation and maintenance engineer comprised a wide range of test instruments, including dedicated cable testers, spectrum analyzers, power meters, etc. The engineer was faced with the task of carrying multiple boxes, learning how to use each one individually and ensuring that each was up to date with their calibration. Simply keeping track of the multiple instruments was a challenge in itself with the result that the RF field engineer's speed, productivity and flexibility were severely compromised.

Dealing with this mounting list of potential problems, along with a lack of skilled RF field engineers and technicians, requires an integrated test solution that minimizes the number of separate test instruments required in the field, and is able to quickly, accurately and easily conduct a number of key measurements.

The Agilent Technologies FieldFox Handheld RF Analyzer (Figure 2) has been developed to address this need for an integrated solution for installation and maintenance of wireless networks.

Cable and Antenna Testing

Cable testing is required to detect the imperfections or disturbances that cause reflection of incident energy throughout the cable length. The detection also must include Distance-to-Fault (DTF) measurements to accurately determine the location of the fault. Disturbances along a cable length can take the form of a small dent or a change in the diameter of the cable due to damage or faulty installation. Periodic effects on the cable can often be caused during the manufacturing process, for example by a drive wheel with a rough spot on a bearing. Cables may also contain one or more discrete faults, for example, due to a bent or damaged cable, contaminated dielectric, a poor cut or a bad connector.

Whatever the cause of the fault or imperfection, the resulting mismatch will cause reflections to occur. The reflections from the individual imperfections sum up to the point that that they can be measured as cable loss or return loss. With periodic faults the energy reflected can appear in the loss measurement as a reflection spike at a frequency corresponding to the spacing of the imperfections, where the spacing between the periodic imperfections is one half wavelength at the frequency of the reflection spike.

Cable testing techniques include loss measurements (return loss, insertion loss) and transmission measurements (e.g., VSWR). Return loss measurements are expressed in dB with 0 dB being recorded when measuring an open or short circuit, and typically 40 to 60 dB being displayed when measuring a load condition with proper impedance matching. With transmission tests, the transmitted and reflected signal combine to create a standing wave. The voltages of the peaks and troughs of the standing wave are measured and expressed in terms of the voltage standing wave ratio (VSWR). With no reflections, i.e., a perfect transmission system, the VSWR is unity. With higher reflections the VSWR will increase to the point where the reflections become unacceptable.

The Agilent FieldFox RF Analyzer includes comprehensive cable testing capabilities. The instrument can be used to test antennas, cables, filters and amplifiers for the purpose of making return loss, VSWR, insertion loss/transmission, one-port cable loss and DTF measurements. Both return loss and DTF measurements can be made at the same time, which helps correlate overall system degradation with specific faults in the cable and antenna system.

A key feature of FieldFox is QuickCal, a built-in calibration system, which allows the user to calibrate the cable/antenna tester without having to carry a calibration kit into the field. This simplifies cable and antenna test, ensures accuracy and repeatability at the point of measurement and improves productivity. QuickCal also corrects drift error caused by temperature changes during instrument operation. FieldFox is also calibration-ready at the cable and antenna test port immediately following power up.

RF Measurements

To identify the causes of potential RF problems within a cell site, an arsenal of RF test capabilities must be available. By integrating all of the key RF test tools into one device, the Agilent FieldFox RF Analyzer provides an integrated toolkit for the RF field engineer. These measurement tools include:

Spectrum analyzer—FieldFox features an optional built-in spectrum analyzer that covers frequency ranges from 100 kHz to 6 GHz. A fast spectrum scan detects interference and RF burst capture to measure intermittent signals. It displays four traces at the same time and allows the user to choose different detector modes.

Power meter with USB power sensor—FieldFox can connect with the Agilent U2000 Series USB power sensor to make RF/microwave power measurements up to 24 GHz. It provides true-average power measurements with high dynamic range from –60 dBm to +20 dBm (sensor dependent). The sensor has an internal zeroing function with no external calibration needed.

Figure 2 · The Agilent Technologies FieldFox Handheld RF Analyzer addresses the needs of Wireless Service Providers for an integrated solution for the installation and maintenance wireless networks.

Network analyzer—FieldFox has an optional network analyzer mode that provides standard vector network analyzer measurements such as S_{11} magnitude and phase, S_{21} magnitude, and a Smith chart display.

FieldFox's sweep speed reduces time-to-problem resolution with test times over 50 percent faster. This enables RF engineers to tackle increasingly complex wireless networks in less time, radically improving productivity. Fast distance-to-fault location is further enabled by its 1001-point resolution and excellent dynamic range.

Conclusion

Testing a cell site's antennas, cables, filters, and amplifiers, plus troubleshooting interference, is critical to ensuring good QoS in a wireless network. Although traditional handheld installation and maintenance test solutions may address these measurement tasks, they fail to offer the speed, productivity and flexibility required to meet the needs of today's RF field engineers and technicians.

The FieldFox RF analyzer, with its high level of integration, calibration-ready measurements and fast test times, not only provides the measurement functionality today's Wireless Service Provider's demand, but offers a dramatic productivity improvement as well. For the Wireless Service Provider, the result is the ability to more effectively deploy and maintain today's complex wireless networks in less time.

For more information on the FieldFox Handheld RF Analyzer, go to www.agilent.com/find/fieldfox

Author Information

Giovanni D'Amore joined Agilent Technologies (then Hewlett-Packard) in 1999, as Application Engineer providing technical support for RF and microwave instruments such as network and spectrum analyzers. He has been part of the marketing organization since 2005, being responsible for parametric test instruments, and since 2007 responsible for marketing development of the network analyzer business. Giovanni holds a Masters Degree in Electronic Engineering with specialization in Microwave and Telecommunications from Palermo University (Italy).