Article : Challenges of testing UMTS basestations

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Comprehensive on-site testing of UMTS basestations using real-world scenarios, both at initial installation and then during ongoing maintenance, plays a vital role in preventing performance problems before they impact subscribers. Poorly performing basestations will significantly impact the quality of service (QoS) experienced by users, particularly the higher data rate services available on 3G networks. Whether poor network performance is caused by incorrect installation, hardware/software incompatibility, gradual degradation or complete failure of a particular module, the end result is that the subscriber experience will be less than satisfactory and network operator revenues adversely affected. Making sure a cell site works from day one ensures that problems are isolated before the network goes "live". This is also the most cost effective testing solution as it is harder to trouble shoot when a cell site is active and some performance issues may not actually become visible until network capacity limits get tested.

So, it is important that basestations are maintained correctly to identify faulty components and avoid no-fault found return penalty charges at the same time as minimising site visit costs. In this respect, it is essential to understand what test capabilities are required to correctly confirm that actual basestation performance matches planned performance. As a consequence, basestation test equipment needs to be chosen using three key performance criteria - test coverage, test speed and ease of use. Compromising on any of these key performance criteria is really a false economy as it will inevitably impact QoS and maintenance costs, which will have a knock-on effect for revenues.

What effects do problems have?

A poorly operating cell can result in an increase in dropped calls, poor quality calls, poor data throughput, interference and actual network coverage not matching what was planned. Add to this the cell-breathing effect common to all CDMA systems, and it makes it all the more important that there are no differences between actual and planned cell site coverage. Unlike TDMA systems, the size of a W-CDMA cell is not fixed. With cell breathing, as more and more calls are set up, it becomes harder to separate weaker signals from the combined spread spectrum signal. As a result, a weak signal can be demodulated more easily when traffic levels are low and there are fewer interfering signals than when traffic levels are high. This means that the cell size shrinks as traffic levels increase and then grows again as they fall off.

Challenges in performing UMTS measurements?

At a simplistic level, GSM and UMTS are essentially two technologies that attempt to achieve the same goal: to provide wireless communications between a network and a mobile. However, the method in which this is achieved and the capabilities of each system are very different. GSM uses Time Division Multiple Access (TDMA) technology in which channels are separated over frequency and time allowing multiple channels in a single frequency band. Each channel is 200 kHz wide and split into eight timeslots. In UMTS, however, channels are separated by frequency and coding allowing multiple channels in a single frequency band; this is known as Code Divided Multiple Access (CDMA). The frequency bands are much wider than those used for GSM, approximately 5 MHz.

Nevertheless, the requirements for testing a GSM or UMTS basestation are much the same, in that what is wanted is the ability to make transmitter and receiver RF measurements. However, the methodology for undertaking these RF performance measurements is completely different. The whole nature of UMTS makes performance testing of basestations in the field a challenge; as propagation and cell loading conditions change dynamically so measurements recorded using purely on-air monitoring tools, or test mobiles, are inconclusive when trying to establish if a basestation is operating to specification. These UMTS testing issues can be addressed by providing comprehensive on-site testing of basestations using repeatable scenarios, as defined by the 3GPP TS25.141 test specification. These test scenarios can be used both at initial installation and for ongoing site maintenance; ensuring comparable performance measurements are taken.

The Aeroflex 6413A (see figure 1) is a UMTS basestation test system with a built-in RNC emulator designed to control a basestation over the Iub interface. This enables the signalling and traffic channels required by the 3GPP TS25.141 test scenarios to be set up on the basestation, in order for meaningful transmitter and receiver RF measurements to be performed to quantify its performance.

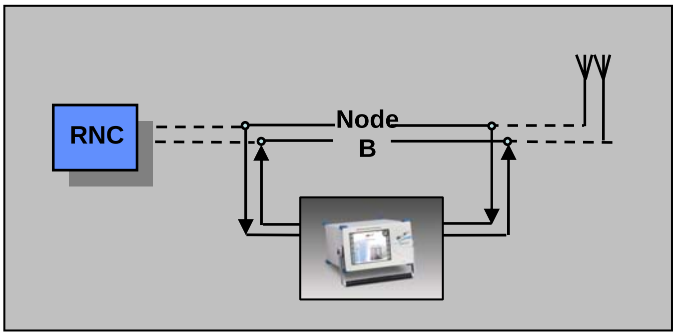

Figure 1: The Aeroflex 6413A RNC emulator mode

The importance of receiver testing

We tend to forget that, of the two basestation RF paths, the uplink path is the weaker. Basestation transmitters are very powerful and in effect the mobile does not have to do much to "hear" it. Conversely, a mobile's transmission power is very low. This means that the basestation receiver has to be exceptionally good.

Degradation in receiver performance can impact subscribers in several ways. For example, it can result in an increase in dropped calls at the limits of a cell due to lower sensitivity and throughout the cell because of lower signal quality. Also, the number of calls an affected cell can support will be reduced. This will not only adversely impact network performance as cell planning is based upon a basestation performing to specification but it will also be harder to use revenue generating higher data rate services. Furthermore, mobiles will be required to transmit at higher power resulting in reduced battery life and increasing cell interference.

The latter point is amply illustrated by a particular case where customers in the area surrounding a cell site complained that their mobile batteries were being drained in a day or so. The problem was eventually found to be that the basestation receiver on one specific sector was failing to decode the access burst from the customers' mobiles when trying to register with the basestation. This caused the customers' mobiles to continuously and unsuccessfully try to establish a service whilst increasing the transmit power, which consequently drained the mobiles' batteries at an accelerated rate. It is a fact of life that radio performance will degrade over time, and test equipment is needed to detect even the smallest of changes in performance before subscribers are affected.

With UMTS, the operation of the transmitter and the receiver are closely linked. Any problem with the receiver is likely to have an impact on the operational performance of the transmitter. If the basestation's receiver is insensitive, for example, the power control loop will instruct each mobile to increase its output power to maintain the target Bit Error Rate (BER) for the uplink path. As each mobile is a source of interference to all the other mobiles, and the multiple access system works by sharing power across the code domain, the result is a reduction in uplink capacity, and a degradation of network performance for everyone.

The most appropriate way to quantify full receiver path performance of a basestation is by controlling it via the Iub interface. The Aeroflex 6413A test set, for example, configures the basestation into the required operational state and then transmits a known signal pattern on the uplink RF path. The data is then demodulated by the basestation and sent back to the test set via the Iub interface. The test set can then compare the transmitted test pattern with the pattern received from the basestation and produce an accurate BER measurement (see Figure 2).

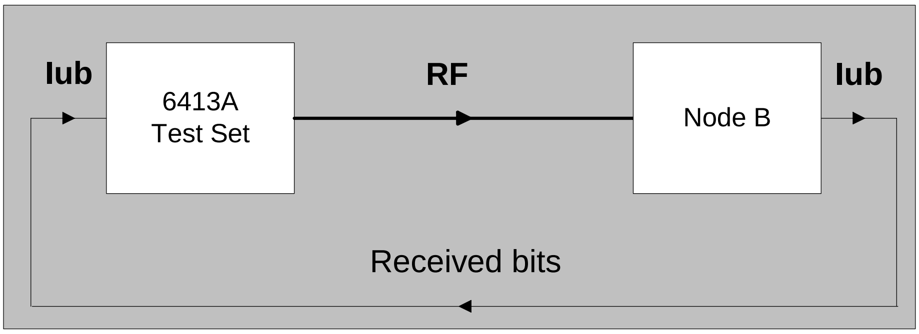

Figure 2: Equipment configuration for receiver testing

The key receiver measurement tests include:

- Reference Sensitivity Level
- Absolute Sensitivity Level
- Uplink Wideband Power
- Dynamic Range.

Sensitivity is defined as the level of received signal power required to meet specified criteria, for example a BER of less than 0.001. The Reference Sensitivity Level test measures the amount of signal power required to achieve a BER of less than 0.001 on a 12.2 kbps Reference Measurement Channel (RMC) with a mobile power of -120 dBm specified at the basestation antenna input.

The Absolute Sensitivity Level is a measure of the optimum performance of the basestation receiver. The higher the absolute sensitivity level of the receiver, the greater the cell coverage. The measurement starts at a pre-defined signal level on a single uplink channel, and progressively decreases and increases the power depending on the BER measurement results, until the definitive receiver sensitivity can be identified. For a UMTS basestation this is typically -125 dBm, measured at the TMA input.

The Uplink Wideband Power measurement checks the integrity of the receiver system. A given signal level is transmitted to the basestation, where the power at its receiver input is measured by the basestation and reported back to the test set via the Iub interface. The test set can then compare the transmitted signal level with the level measured by the basestation

The Dynamic Range measures the ability of the receiver to receive the desired signal in the presence of interference – essentially testing the performance of the receiver in a fully loaded cell. The target signal level of -91 dBm should give a BER measurement of 0.001 or better, with -73 dBm of interference (generated white noise).

Transmitter testing

The transmitter conformance standards for basestations are defined in the 3GPP TS25.141 specification, with different UMTS transmitter measurements requiring different RF test scenarios to be used. These test scenarios are referred to as Test Models (TM), and are pre-defined RF channel configurations, consisting of both signalling and traffic channels. The Test Models are designed to cater for specific test requirements as detailed below:

- TM1: Simulates a live network cell.
- TM2: A simple cell used to measure power dynamics.
- TM3: Designed to emphasise code domain errors.
- TM4: A very simple test model to allow frequency measurement.
- TM5: Simulates a live cell with HSDPA.

A series of in-channel measurements such as MOP (Maximum Output Power), EVM (Error Vector Magnitude) and FE (Frequency Error) are used to test the quality of the wanted transmitter W-CDMA signal. A further series of wideband measurements including ACLR (Adjacent Channel Leakage Ratio) are used to test the interference to other radio users.

The transmitter tests from TS25.141 include:

- **MOP (Maximum Output Power):** This test uses TM1 to simulate a live network and tests the basestation against the manufacturer's claimed specification and the conformance limit is ±2.7 dB relative to specification.
- **CPICH power accuracy:** The CPICH power defines cell size. It is defined as a relative power test with a conformance limit of ±2.9 dB, and is measured with TM2.
- **FE (Frequency Error):** The test employs test model 1 and verifies that the transmitted RF is on the correct channel with a conformance limit of ±0.05 ppm. A high frequency error on a basestation could impact mobile access to the corresponding cell.
- **Power Control Steps and Power Control Dynamic Range:** These test the power control of a single code channel using TM2. The power control steps test verifies the size of the power steps to be 1 dB, and the dynamic range test ensures that the power can be adjusted by at least 25 dB. A basestation transmitting too low or too high at specified power levels will impact performance of the corresponding cell.
- **Total Power Dynamic Range:** As power control is used to optimise the signal power, the goal is to get an acceptable SNR, with the lowest power, as excess power causes interference to other UEs and neighbour cells. Using TM4 with a conformance limit of 17.7 dB or greater, this test ensures a basestation can control output power over a wide range.
- **OB (Occupied Bandwidth):** This test measures the bandwidth that contains 99% of the transmitted energy using TM1, producing a simple measure of how much radio spectrum the basestation is using. The conformance limit is 5 MHz.
- **ACLR (Adjacent Channel Leakage Ratio):** Using TM1 at maximum output power, this test measures the power transmitted by the basestation in adjacent and next channels. The conformance limits are 44.2 dB and 49.2 dB. ACLR affects other network operators in the same band and is caused by spectral re-growth, which is often a Power amplifier problem.
- **EVM (Error Vector Magnitude):** EVM is a measure of modulation quality using TM1. Poor EVM affects mobile SNR, restricts cell size and therefore impacts data throughput.
- **PCDE (Peak Code Domain Error):** This is tested using TM3 with a conformance limit of 32 dB and measures noise and spurious signals in the code domain.

Please visit the Aeroflex 6413 product home page which contains Application Notes with more detailed trouble shooting information: www.aeroflex.com/products/commtest/cellparametric/6413a.cfm.

Summary

It is essential, therefore, to thoroughly test UMTS basestations both at initial installation and as part of an on going preventative maintenance policy, in order to ensure that they are performing to specification and potential QoS problems are caught before they impact users. Typically, it takes two to three days to install a basestation site and the majority of sites have issues that vendor site manager equipment and test mobiles cannot isolate. Without appropriate trouble shooting equipment these issues can often require multiple site visits to resolve, so, thorough, independent testing will give operators greater confidence in the quality of the deployed network. The Aeroflex 6413A basestation test set is designed to undertake a complete set of transmitter and receiver measurements that give technicians and RF performance engineers confidence that the basestation under test is performing according to specification and will meet network demands. If the basestation is performing below specification there is sufficient information to enable faulty modules to be quickly and correctly identified.

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Sidebar

The following table highlights the key UMTS RF parametric tests for confirming a basestation is performing to specification. The table has been produced based on Aeroflex's extensive experience of dealing with GSM manufacturers and operators and also from discussions with UMTS basestation manufacturers and operators.

Test Node B Transmitter Tests	Why Test
Maximum Output Power	Checks Transmitter of Node B complies to 3GPP & vendor specification.
Error Vector Magnitude	Checks distortion of Transmitter RF signal.
Relative CPICH Power Accuracy	Checks CPICH power complies to required performance
Frequency Error Test	Checks accuracy of transmitted frequency
Power Control Steps	Checks TX configuration. Closed loop power control critical to capacity.
Spectrum Emmission Mask	Checks Power/Feq against Conformance Mask within 3GPP
Adjacent channel Leakage Radio Test	Checks TX channel leakage into neighbouring channels. ACLR problems impact traffic throughput on these neighbouring channels.
Peak Code Domain Error	Checks Noise and Spurious signals in Code Channels
Code Domain Analyser	Qualitative indication of cell usage. Verify scrambling code and CPICH power.
Node B Receiver Tests	
Absolute Sesitivity Level	Checks the optimum performance of Node B receiver. Higher sensitivity means higher cell coverage.
Dynamic Range	Checks receiver performance in a fully loaded cell.
Uplink Wideband Power	Check receiver system integrity

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