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White Paper

RF propagation measurement for UMTS networks

Summary

The roll out of UMTS Third Generation Mobile services has now begun in earnest, and whilst the availability of customer terminals has slowed deployment of some systems, most network implementation are now moving ahead.

The deployment of these networks presents some new challenges to the Operator planning departments. Traditionally, GSM networks have been planned using CW measurement techniques, and Operators are now questioning whether these techniques are still valid in the planning phase of their new network, or whether a new approach should be taken using Pilot channel measurements.

This article explains the relevant background to the technologies and by examining the measurement basics, shows that CW measurements are valid for W-CDMA systems as long as fast sampling methods are employed. And in fact modern receivers such as the Willtek Griffin series can allow valid drive-by testing as fast as 100km/h, speeding up effective network planning.

How does CDMA work?

To understand the difference between the classic way of propagation measurement with a continuous wave (CW) and the 3G W-CDMA pilot channel measurement, it is first necessary to understand CDMA and how the information or content is transmitted.

In TDMA systems like GSM each transmission or call has its own time slot and in CDMA somewhat confusingly, all carriers are transmitted continuously on the same set of frequencies with all channels active simultaneously. Each call is separated by a set of scrambling code and each receiver unscrambles the code it needs.
This can be illustrated with reference to GSM and the frequency hopping algorithms used. This technique is used to allow fast channel reuse whilst reducing potential interference. If two GSM traffic channels are on the same frequency in the same time frame, then they interfere with each other. If frequency hopping is used, the channels will not be on the same frequency in the next time frame due to the random sequence numbers used in the frequency-hopping algorithm, and there is no resulting interference. The Forward Error Correction process removes the interference (considered as additional noise in the previous time frame) and corrects the information content.

CDMA systems, each signal "hops" according to its special code within the channel bandwidth and this code is unique to the call. The very fast hopping sequence in cdmaOne is 1.3 million times a second and in W-CDMA (or 3GPP, UMTS) it is 3.8 million times a second. Each signal is a noise source for all the other signals and only if the receiver "hops" with the same code in synchronism with the transmitter, does the signal emerge from the noise and decoding can be completed.

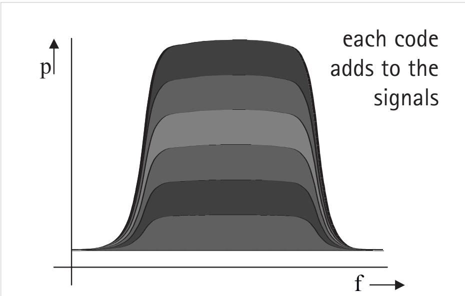
Why is the pilot channel so important?

CDMA technology uses Code channels to carry information and Pilot channels to control the hopping sequence. The Pilot channel does not contain "modulation" (i.e. does not contain information), and it remains after decoding and can be seen by all receivers. It does not change its output power and it is used as a synchronization and reference point for the mobile phones (similar to the FCCH or Frequency Correction CHannel in GSM).

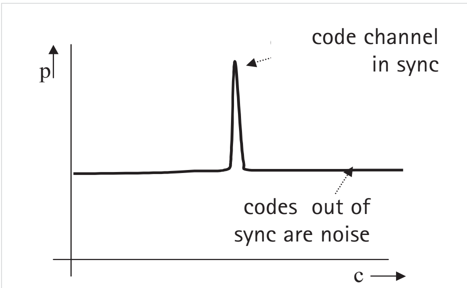
The Pilot channel allows a continuous correction of time offset in the code sequence, which is the reference for decoding all the other channels. It is also the signal level reference for the measurement reports to the serving cell and hence has been used previously for drive tests on established networks such as cdmaOne.

The signal level of the base station Pilot channels are the decision basis for handover and location updates. A CDMA network Operator has always to carefully balance the Pilot channel power between the cells and try to avoid "polluting" the channel with too many Pilots. Every carrier that is used, adds additional noise to all the other carriers in the band and this shrinks the cells' dimensions (coverage area) and reduces the network capacity.

Pilot pollution can be measured with PN scanners which scan on one frequency with all possible codes and try to detect all the Pilots within this "noisy" signal. The digital receivers used for these measurements usually contain signal processors that are able to operate on the 3GPP standard.



A W-CDMA signal in frequency



A CDMA carrier in code domain

CW or Pilot measurement, is there a difference?

A major strength of CDMA technology is its ability to protect the "modulation" (data transmission) from other in-band signals as sources of interference, and also from non-CDMA sources. However in order to plan a network in terms of geographical coverage, the propagation measurements used are of the continous Pilot channel, to provide cell dimensions and clutter characteristics. In addition, the interference due to the multi-path fading effects needs to be established by drive-by tests.
There are a number of arguments proposed which are examined below, claiming propagation measurements should be done with a CDMA Pilot transmitter and a CDMA receiver rather than a CW source and CW receiver. However a key problem with using a Pilot channel receiver is that it corrects for the very effects of RF propagation in the channel being measured.

For example a CDMA carrier with a Pilot channel is considered as a wideband signal and therefore more representative than a narrowband CW carrier. This is true as long as you look at the signal in frequency terms only. However remembering that the receiver descrambles the CDMA signal in the code domain and following decode there remains a "narrow band" carrier without information. There is no realistic difference between using an uncoded CW measurement and a coded and then decoded Pilot measurement.

The ability to perform simultaneous multicarrier drive-by tests has been used to support the argument for using Pilot channel measurements. It is true that with transmission on only one frequency, a measurement receiver does not have to scan. The decoder can measure all Pilots at the same time, if it has enough processing power. But the same result can be obtained with a fast tuning measurement receiver such as the Willtek Griffin. This measurement receiver scans up to 1,000 channels per second and delivers up to 100,000 readings per second. This is fast enough that in the W-CDMA frequency band, five carriers can be measured, driving at 120 km/h (or 75 mph) and still being compliant to the "Lee-criteria"[1]. It is a straightforward task for this type of measurement, to set up five battery powered CW transmitters within the 5 MHz channel (and probably much easier then setting up five W-CDMA test base stations). Measurements will then give comprehensive details of the propagation performance in the channel and will provide exactly the results needed by the RF planning tool.

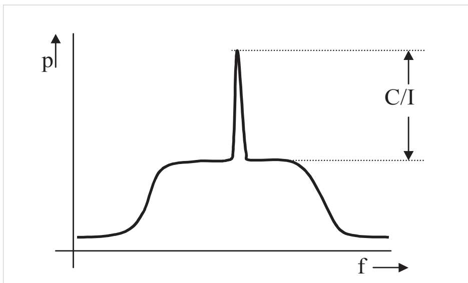
Some operators may fear that a CW test carrier could interfere with their established UMTS network. This is not a current problem as UMTS networks are still being developed, but it is true that a CW test carrier may interfere the network once deployed. However, it will do this in exactly the same way as a CDMA test carrier!

To understand the reasons for this, remember the CDMA decoder inside the mobile phone receiver descrambles the information by synchronously "hopping" with the communication signal. With this matched hopping sequence, it scrambles the CW test signal to noise and it makes no difference if noise is scrambled once (CW) or twice (CDMA test pilot). Noise is noise, independent of how often it is scrambled.
Another advantage claimed of using Pilot power measurement system is the ability to do an Ec/N measurement. This determines the energy per code symbol relative to the surrounding noise. However these Ec/N results can be computed from CW drive tests using a C/I (carrier to interference) measurement. In this case, the receiver measures two frequencies: the CW carrier and a side-by frequency. If the receiver scans quickly enough, these measurements can be done across the whole band with several CW carriers and one side-by frequency to check the coverage from several transmitter locations at once. This technique requires some post processing, but will show the same result.

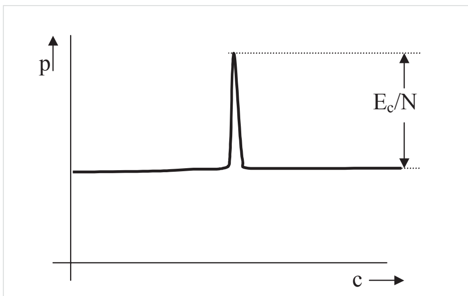
However, such measurements are really only important when networks have multiple base stations in operation which, right now is not the case for most UMTS networks.

Taking these points into account, there is no clear advantage in using a Pilot channel measurement system rather than a CW signal in the planning phase of W-CDMA.

[1] Lee-criteria is a wavelength related sampling method for valid signal strengths, widely used in the wireless industry (36 samples per 40l).
See Willtek White Paper on Lee Sampling, Publication Number LEE/WP650/0203/EN.



A CW carrier on a W-CDMA signal



A pilot channel in code domain

What are the CW measurement advantages?

The biggest advantage of CW propagation testing is the measurement speed. Whilst the PN-scanner provides only a few readings per second, the latest CW measurement receiver provides several thousands. Even the channel change speed reaches up to one thousand per second. This speed is needed to ensure reliable measurements during drive-by tests at up to 100 km/h with measurements on five frequencies (e.g. 5 CW transmitters across the band) and still being "Lee-compliant". To get the same results on PN-scanners the maximum speed is more like walking!

CW transmitters and CW measurement receivers are tried and tested following years of field operation. They are lower in price and already available. The engineers already know how to handle them as they can reuse the similar process experience gained from GSM.
The behaviour of the RF energy in the new frequency band of W-CDMA is different than in GSM, but by keeping the process the same, the number of changed parameters is reduced to one: the carrier frequency. This means that the steps towards W-CDMA for the drive test team as well as for the RF planning group, will be an evolution, rather than an revolution.

As in the case of GSM networks, in future years during network commissioning and optimization phases, the need for a UMTS decoding measurement receiver and test mobiles will arise and will overtake the importance of RF propagation measurement. In the meantime CW measurements can provide the network planning information at this initial phase of network rollout. They have provided a reliable base for GSM and as this article tried to show they can also be a reliable base for W-CDMA networks.

How can Willtek help?

Willtek's 8381 Griffin UMTS Down Converter extends the capabilities of the 8300 Griffin Fast Measurement Receiver Series extending them to carry out UMTS propagation measurement. The cost-effective combined receiver and down converter package is rugged and battery-powered. The frequency range of the Griffin is increased to cover the UMTS band up to 2.2 GHz and is able to quickly and accurately perform a wide range of measurement functions in the RF channel.

Up to five downlink channels at 100 km/h can be measured without jeopardizing the "Lee-criteria" of valid RF channel measurements. Results can be analyzed using Willtek's 8010 Hindsite RF Propagation Test Software to combine signal levels with topographical information. The results assist in providing high Quality of Service by alignment of the RF prediction model with actual channel results.

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List of abbreviations:

3GPP	= Third Generation Partnership Project
c	= code
C/I	= Carrier to Interference ratio
CDMA	= Code Division Multiple Access
cdmaOne	= Qualcomm brand name of CDMA system used e.g. in USA
CW	= Continous Wave; unmodulated carrier
Ec/N	= Energy per code (chip) to Noise ratio
f	= frequency
FCCH	= Frequency Correction Channel (GSM system)
FEC	= Forward Error Correction
GSM	= Global System for Mobile communication
p	= power; signal level
UMTS	= Universal Mobile Telecommunications System
W-CDMA	= Wideband Code Division Multiple Access

For more information , visit **www.willtek.com**, and put us to the test.

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