Optimizing Your GSM Network Today and Tomorrow

Using Drive-Testing to Troubleshoot Coverage, Interference, Handover Margin and Neighbor Lists

Application Note 1344

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Agilent Technologies
Innovating the HP Way

Section 1. Introduction

With the rapid growth of the wireless industry, GSM (Global System for Mobile communications) networks are rolling out and expanding at a high rate. The industry is also becoming intensely competitive. In this environment, high quality of service is a competitive advantage for a service provider. Quality of service can be characterized by such factors as contiguity of coverage, accessibility to the network, speech quality and number of dropped calls.

Service providers must continually strive to improve their quality of service if they want to keep customers. If too much time is spent simply reacting to customer complaints, there may not be enough time to improve overall service quality. Therefore, service providers need the ability to fix complaint-producing problems quickly.

The primary tool used by most service providers to solve network problems is a drive-test system. A conventional drive-test system is comprised of a test mobile phone, software to control and log data from the phone, and a Global Positioning System (GPS) receiver for position information. A test mobile gives a customer's view of the network, but can only indicate the type of problem that exists. It cannot show the cause of the problem. Several other limitations of a phone-only drive-test system are covered in this application note. These limitations are overcome if a GSM receiver is integrated with the phone. Refer to Figure 1.

Agilent provides phone-based, receiver-based, and integrated phone- and receiver-based drive-test solutions. This application note focuses on the receiver-based drive-test solution for GSM networks.

A GSM receiver provides several capabilities, including independent network analysis, faster scanning, spectrum analysis, interference management, CW and channel power measurements, and delta measurements.

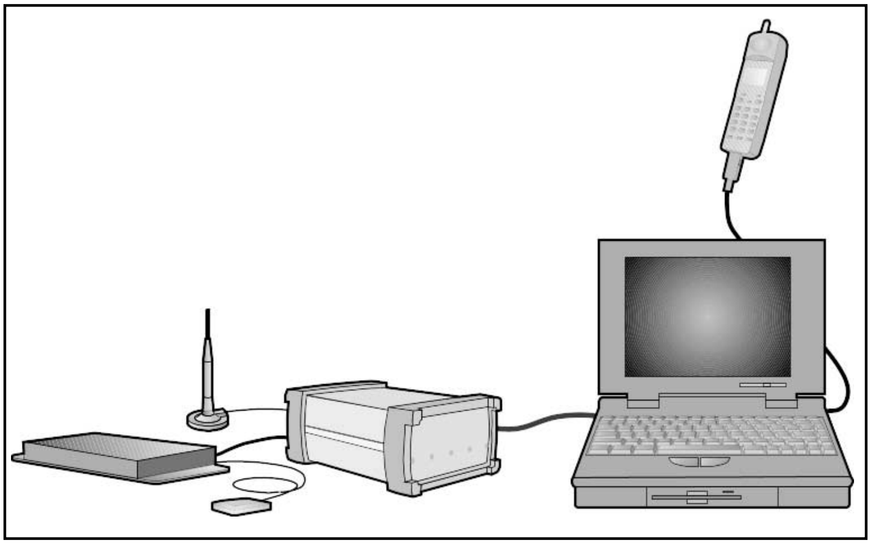


Figure 1. Integrated drive-test solution consisting of a digital receiver and phone. A GPS receiver provides location information.

Section 2. The Optimization Process

Optimization is an important step in the life cycle of a wireless network. The optimization process is illustrated in Figure 2. Drive-testing is the first step in the process, with the goal of collecting measurement data as a function of location. Once the data has been collected over the desired RF coverage area, it is output to post-processing software. Engineers can use the collection and post-processing software to identify the causes of RF coverage or interference problems and determine how these problems can be solved. When the problems, causes and solutions have been identified, steps are performed to solve the problems.

Figure 2 shows that optimization is an ongoing process. The goals are to improve quality of service, retain existing subscribers and attract new ones while continually expanding the network.

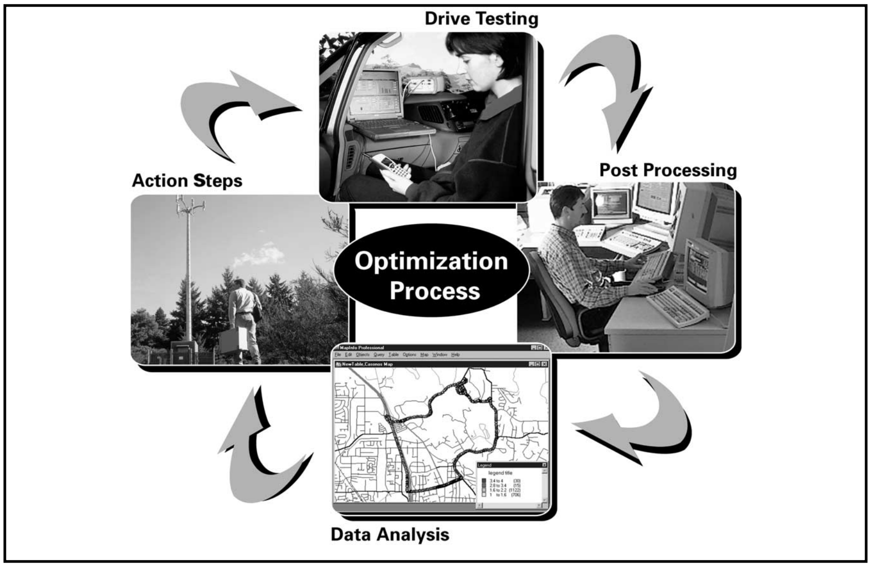


Figure 2. The optimization process. Drive-testing is performed to verify that the action steps taken to solve problems were effective.

Section 3. GSM Background

This section provides a brief description of the GSM physical channel format. Refer to reference [1] for more detailed descriptions of GSM technology.

GSM uses both TDMA (Time Division Multiple Access) and FDMA (Frequency Division Multiple Access). The available frequencies are divided into two bands. The uplink is for mobile transmission, while the downlink is for base station transmission. Each band is divided into 200 kHz slots called ARFCNs (Absolute Radio Frequency Channel Numbers). In addition to this frequency multiplexing, each ARFCN is shared among eight mobiles using time multiplexing. Each mobile uses the ARFCN for one timeslot and then waits for its turn to use the ARFCN again. Mobiles can use the ARFCN once per TDMA frame. Figure 3 depicts the TDMA and FDMA structure of the GSM system.

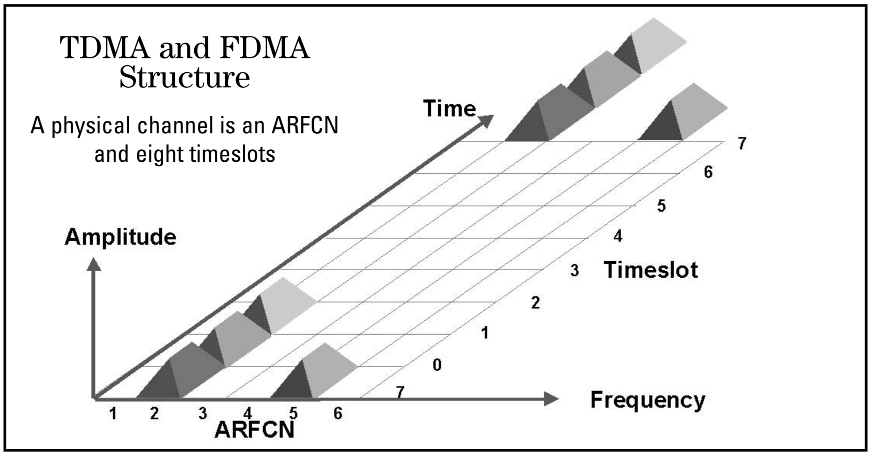


Figure 3. GSM physical channels consist of an ARFCN (frequency channel) and eight timeslots.

A GSM cell will have one or more ARFCNs depending on mobile traffic requirements. One of the ARFCNs in the cell is configured as a Broadcast Channel (BCH) ARFCN (Figure 4). Timeslot 0 of the BCH ARFCN is dedicated to several logical control channels, including the Fast Control Channel (FCCH), Synchronization Channel (SCH), Broadcast Control Channel (BCCH) and Common Control Channel (CCCH). These logical channels are used by the mobile when it camps on a cell, and also for establishing calls. A BCH ARFCN can have the remaining seven timeslots configured as traffic channels, which will be used for information (speech, data or fax) transfer to and from the mobile. All the timeslots on the BCH ARFCN in the downlink will be continuously on with the maximum power settings of the base station, and not under downlink power control. In the absence of traffic (calls) on the traffic channel timeslots, these timeslots will have dummy burst transmissions.

All other ARFCNs in the same cell are referred to as Traffic Channel (TCH) ARFCNs (or carriers). TCH ARFCNs are only activated when there is a need (that is, a call). A TCH ARFCN can have controlled power output on different timeslots in the downlink. A key difference between BCH and TCH ARFCNs is that a BCH ARFCN has continuous transmission at a constant power on all timeslots, whereas a TCH ARFCN has bursted transmission with power levels that can be different in different timeslots.

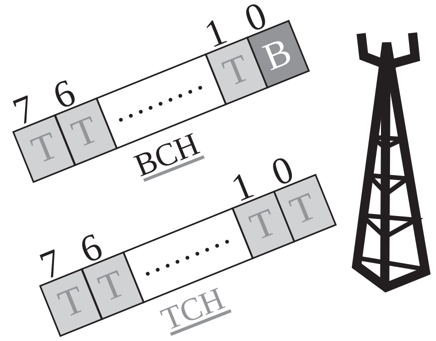


Figure 4. One ARFCN in each cell is configured as a BCH. Timeslot 0 is dedicated as a control channel. All other ARFCNs are TCHs.

Section 4. Contiguous Coverage Plot

Conventionally, a coverage plot of a service area is obtained by placing the test mobile of the drive-test system in the idle mode and driving through the service area measuring the received signal level (RXLEV). RXLEV is then plotted against GPS information to obtain a coverage plot (see Figure 5).

It is important to understand that GSM phone-based coverage measurements alone often do not show the complete picture of coverage contiguity. This is because of the way a phone operates and the rate at which measurement samples are taken. This section will show how a network-independent digital receiver, when combined with a phone-based tool, can provide more complete and accurate results.

A GSM mobile phone’s receiver is not always on in the idle mode, due to the use of Discontinuous Reception (DRX). With DRX, a mobile phone will only turn on its receiver during its paging group, and will also measure the neighbor cells’ RXLEV in the same period. It will also turn on the receiver when it is decoding the Broadcast Control Channel (BCCH), which occurs once every 30 seconds; it is optional for the mobile to measure RXLEV during this period.

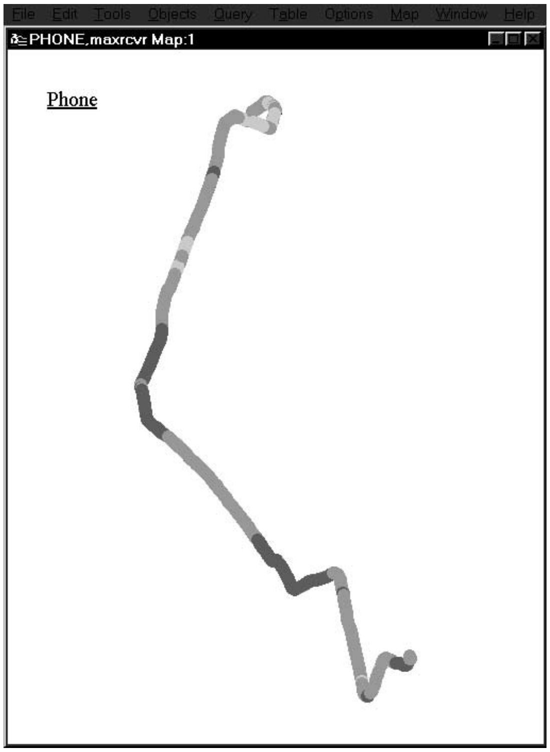


Figure 5. Coverage plot generated by MapInfo using a phone-based drive-test system.

A grasp of two important concepts, BCCH and paging groups, is required to fully understand how the phone performs measurements. We'll look first at BCCH.

As shown in Figure 4, each cell has one carrier designated as a BCH carrier. The BCH carrier has all 8 timeslots continuously on, either with traffic or dummy bursts. Timeslot 0 of the BCH carrier contains logical control channels. These control channels are used by the mobile to establish communication with the network in the idle mode and also in initiating calls to enter the dedicated mode. Timeslot 0 is grouped into structures of 51 frames referred to as Control Channel Multiframes. Each frame is 4.615 ms in length and is comprised of 8 timeslots. The control channels are grouped as follows: BCCH, CCCH and Dedicated Channels.

The BCCH occurs once in the 51-frame cycle, and contains information that is packed in a block of 4 frames. The information on the BCCH is known as System Information, and includes network identities, cell parameters, cell channels and option configurations. A GSM mobile reads the BCCH when it first camps on a cell and every 30 seconds afterwards to detect any change in parameter settings.

On the BCH carrier there are 3 or 9 blocks of the Common Control Channel. Each block is comprised of 4 TDMA frames and contains one signaling message. The Common Control Channel blocks are further subdivided into the Access Grant Channel (AGCH) and Paging Channel (PCH). To save battery power, a mobile does not monitor all the Paging Channels in a multiframe; it only monitors the Paging Channel belonging to its paging group. Each Paging Channel in a multiframe has a different group number. In the next multiframe, the same Paging Channel will have a different or identical paging group number, depending on the settings of the cell parameter BS_PA_MFRMS. This parameter informs the mobile of the number of multiframes (ranging from 1 to 9) after which the same paging group is repeated. The mobile will only turn on its receiver to decode the paging message in its paging group, which might repeat once in 1 to 9 multiframes.

With this understanding of BCCH and paging groups, let's continue with the example of coverage measurements using a phone-based tool.

According to GSM specifications for generating RXLEV measurements, a mobile should take a running average of five samples spread over a period of 5 seconds or the duration of 5 consecutive paging blocks of that mobile, whichever is larger. The duration of these 5 consecutive paging blocks is decided by the BCCH parameter BS_PA_MFRMS (described above), which informs the mobile of the number of multiframes after which the same paging block is repeated. This can range from 1 to 9 multiframes. This means a mobile's paging block can occur at intervals ranging from 470 ms to 2.1 s. Therefore, 5 consecutive paging blocks for that mobile will occur over a period ranging from 2.35 s to 10.5 s. According to GSM specifications, then, the average will be taken over a period ranging from 5 s to 10.5 s.

If we drive at a nominal speed of 40 km/h, we will cover 55 m in 5 s and 110 m in 10 s. Over any averaging period between 5 and 10 s, the mobile will take only 5 samples. If the averaging period is 5 s, then 1 sample is taken every 5.5 m. If the period is 10 s, then 1 sample is taken every 22.5 m. With this much distance between samples, there is a possibility that there will be many areas in which the mobile has not made measurements. Since coverage holes due to normal log fading at the edges of the cells can be found in the range of 5 to 50 m, a normal mobile phone's RXLEV measurement can miss these holes. So, even though the coverage plot produced by a mobile phone may indicate contiguous coverage, there may actually be many holes, resulting in patchy coverage, frequent handovers and dropped calls.

However, if we use a GSM receiver that can synchronize itself with the BCCH carrier, make carrier power measurements and perform a continuous RXLEV measurement at a specified distance of 1 to 5 m, we can get a true picture of coverage contiguity over the network's drive area (Figure 6).

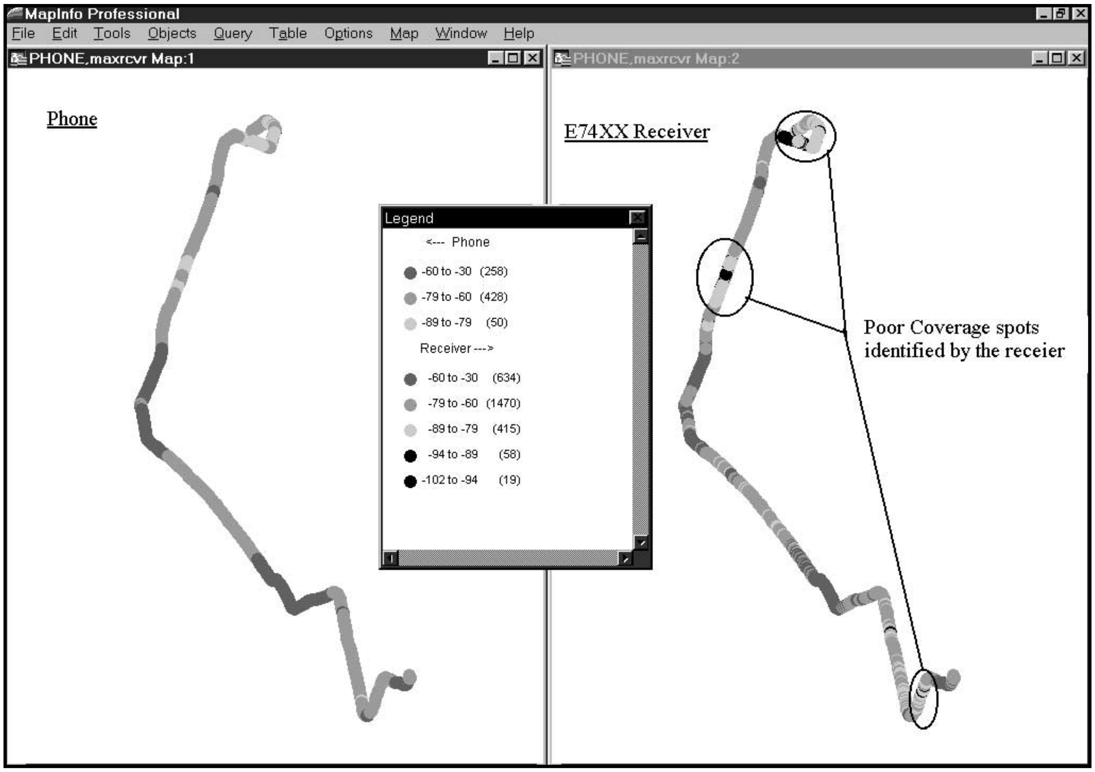


Figure 6. Coverage comparisons of phone-and receiver-based drive-test tools. Receivers are fast, accurate, and network independent. Phones provide vital call statistics.

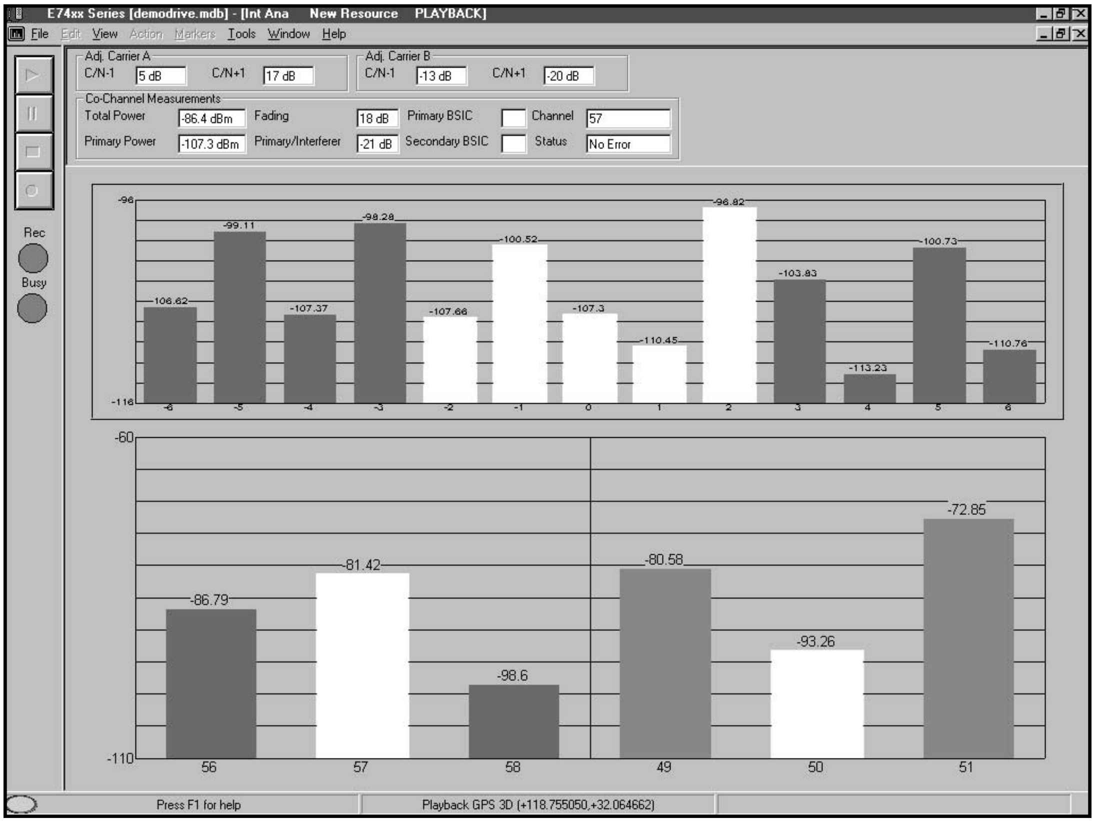
Section 5. What Causes Poor RXQUAL?

Quality of the received signal (RXQUAL) is a key parameter for evaluating network performance. RXQUAL is the Bit Error Rate (BER) derived from the 26 bits midamble on the TDMA burst. RXQUAL levels characterize speech quality and dropped calls, where 0 indicates the highest quality and 7 the worst. If we are doing a drive-test in a trouble zone with a phone, we can easily locate poor quality spots by monitoring RXQUAL. However, we may want to identify the cause of poor RXQUAL. RXQUAL can be poor because of poor RXLEV (coverage), low carrier-to-noise ratio (C/N), co-channel interference, adjacent channel interference or multipath. A phone-based system will report RXLEV, but will not provide adequate information about the other potential problems.

If RXQUAL is poor and RXLEV is good, then it is generally assumed that the cause is interference. However, interference can exist in several forms, including co-channel, adjacent channel, multipath and external. How do we determine which types of interference are present?

There are several traditional ways of isolating different forms of interference. For example, if RXQUAL improves when all the co-channel cells are switched off, then co-channel interference is present. Adjacent channel interference can be measured using a spectrum analyzer, but at present it is difficult to isolate multipath. Conventional methods are time-consuming and do not characterize interference over the entire coverage area of the network.

The Agilent Technologies GSM receiver has an interference analyzer, which can do real-time measurements of co-channel interference, adjacent channel interference and multipath (see Figure 7).



Adj. Carrier A

C/N-1 5 dB
C/N+1 17 dB

Adj. Carrier B

C/N-1 -13 dB
C/N+1 -20 dB

Co-Channel Measurements

Total Power -86.4 dBm
Fading 18 dB
Primary BSIC
Channel 57
Primary Power -107.3 dBm
Primary/Interferer -21 dB
Secondary BSIC
Status No Error

Playback GPS 3D (+118.755050,+32.064662)

Figure 7. Adjacent and co-channel interference measurements performed by GSM receiver.

This receiver has alarms that can be programmed with multiple conditions, such as “Poor RXQUAL AND C/I < 9 dB” (where C/I = carrier-to-interference ratio), and similar conditions for adjacent channel interference and multipath.

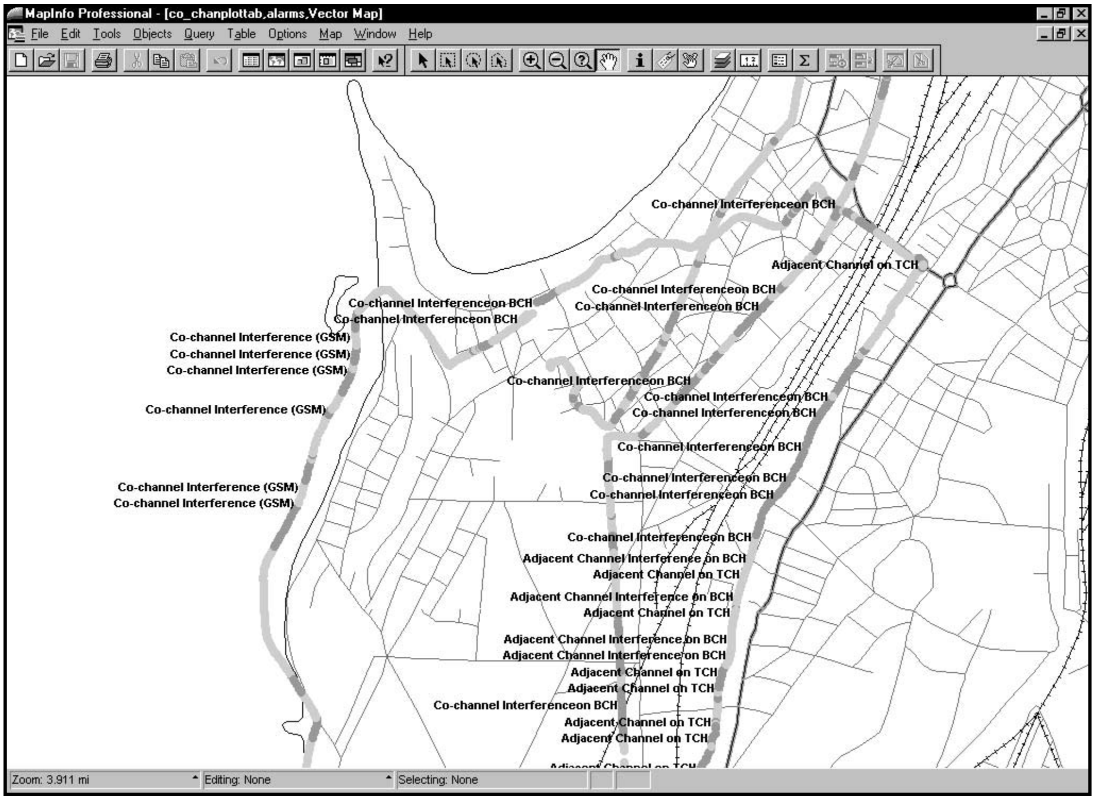


Figure 8. Adjacent and co-channel interference alarms are identified by the GSM receiver. Results are plotted in MapInfo.

A key feature of the Agilent measurement software is that it can provide a link between the test mobile phone and the measurement receiver, allowing the receiver to track the phone-reported serving cell. By integrating the receiver, a phone and a portable PC to automate measurements, we can obtain indications of poor RXQUAL *and* the related causes while performing the drive-test.

Section 6. TCH - TCH Interference

A GSM cell has more than one carrier to handle subscriber capacity requirements. Only one of the available carriers will be the BCH, which will be on continuously; the remaining TCH carriers will only turn on for specific timeslots when a call is initiated on that channel. During peak hours, the activity on the TCH carriers will be at a maximum, whereas activity may be zero during off-peak hours. TCH carriers are also reused, and hence can contribute to co-channel interference, although this interference will not always be present; it will only be present when these TCH carriers have call activity (not necessarily during peak hours). How do we measure the C/I for these reused TCH carriers?
One approach is to pick the suspected reuse interferer, set up calls on each timeslot (eight calls), and then drive around in the interfering cell measuring the C/I. This is a tedious process.

The easiest way to solve this measurement problem is to make delta (difference) measurements. As an example, consider two cells, Cell 1 and Cell 2 (see Figure 9).

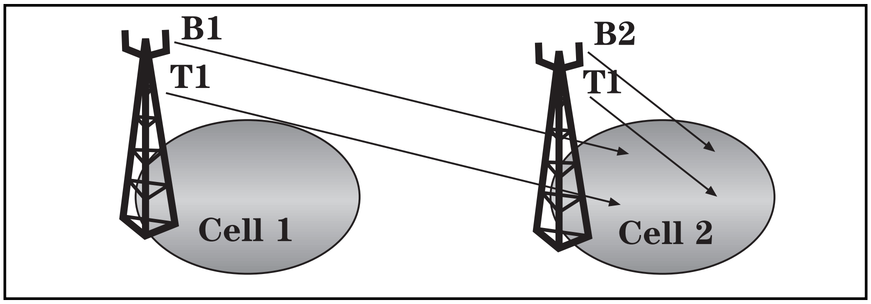


Figure 9. TCH-TCH co-channel interference.

Cell 1 has a BCH carrier on ARFCN B1 and Cell 2 has a BCH carrier on ARFCN B2, while the TCH carriers in both Cell 1 and Cell 2 are on ARFCN T1. Instead of making the C/I measurement on T1, we can make a delta measurement of B2/B1, which is near to the C/I value of T1 when both the T1 carriers are on air, since the propagation loss for B2/B1 and T1 is nearly the same. This can be easily done with the Agilent GSM receiver, which has a BCH analyzer display function (see Figure 10).

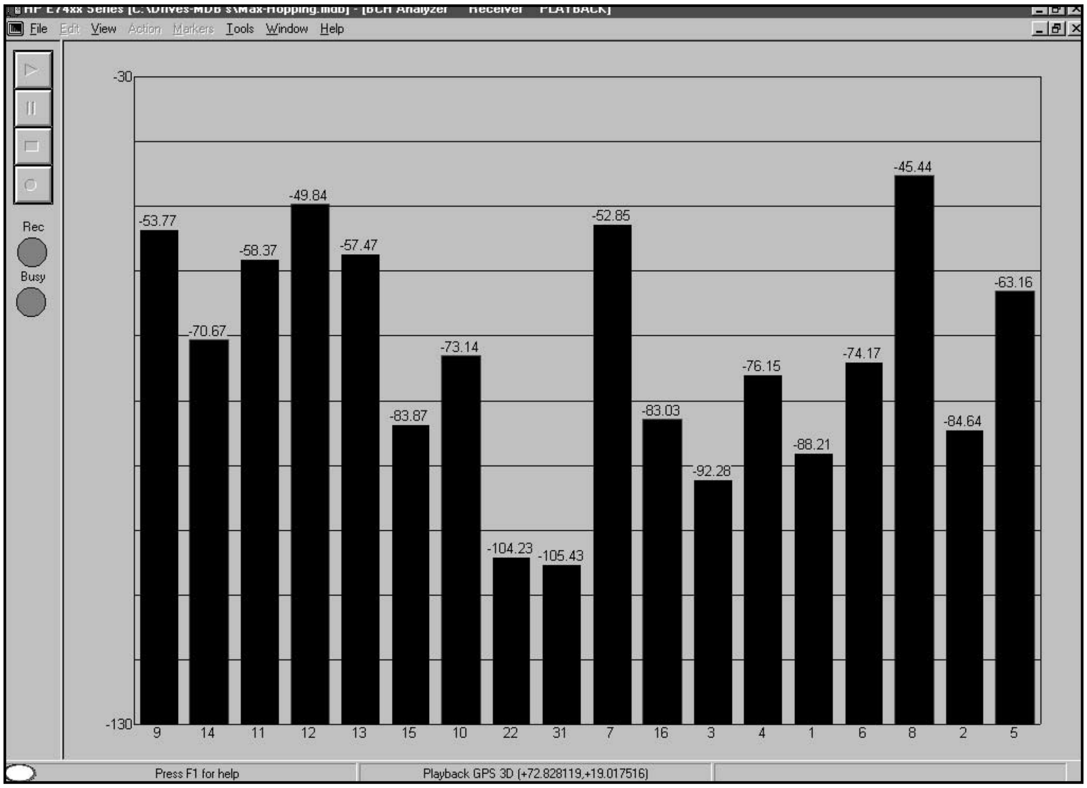


Figure 10. BCH analyzer display generated by GSM receiver. The x-axis shows ARFCNs, and the y-axis shows received power level.

The analyzer allows us to create a user list of ARFCNs for Cell 2 and Cell 1 and then, on the amplitude/time display, place a marker on B2 and a delta marker on B1. The delta measurement is the same as measuring the C/I on T1 (see Figure 11).

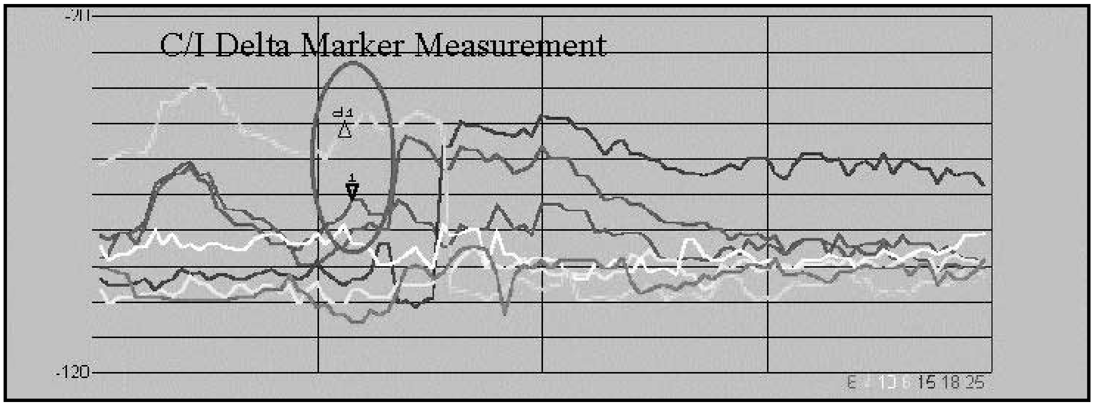


Figure 11. Amplitude versus time display showing delta amplitude difference between B1 and B2.

Using post-processing software, we can also plot the C/I map for TCH-TCH interference (Figure 12).

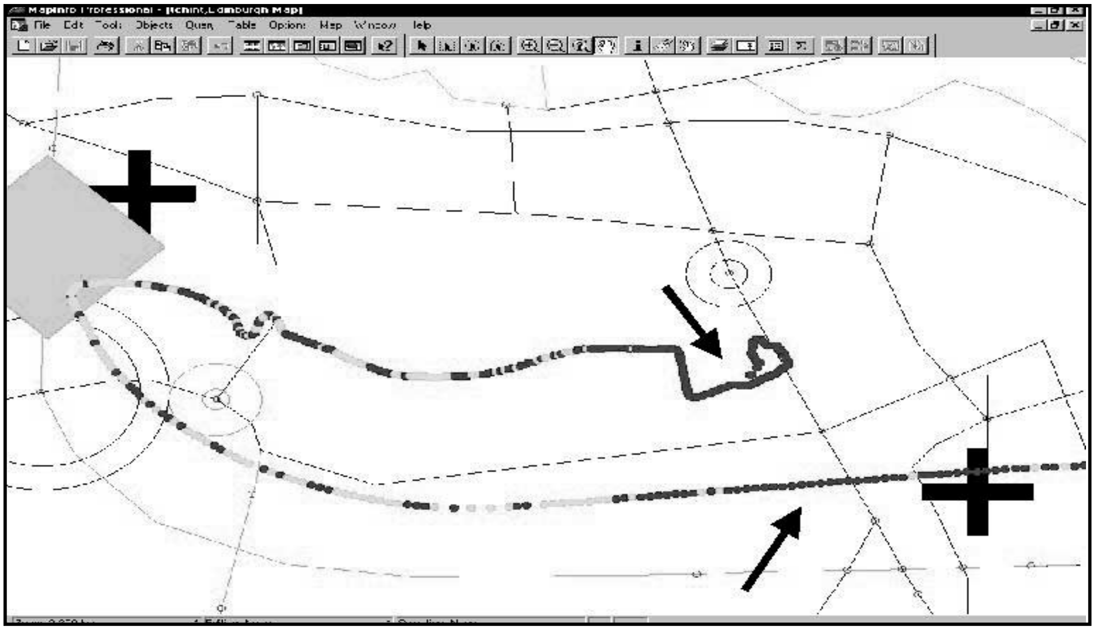
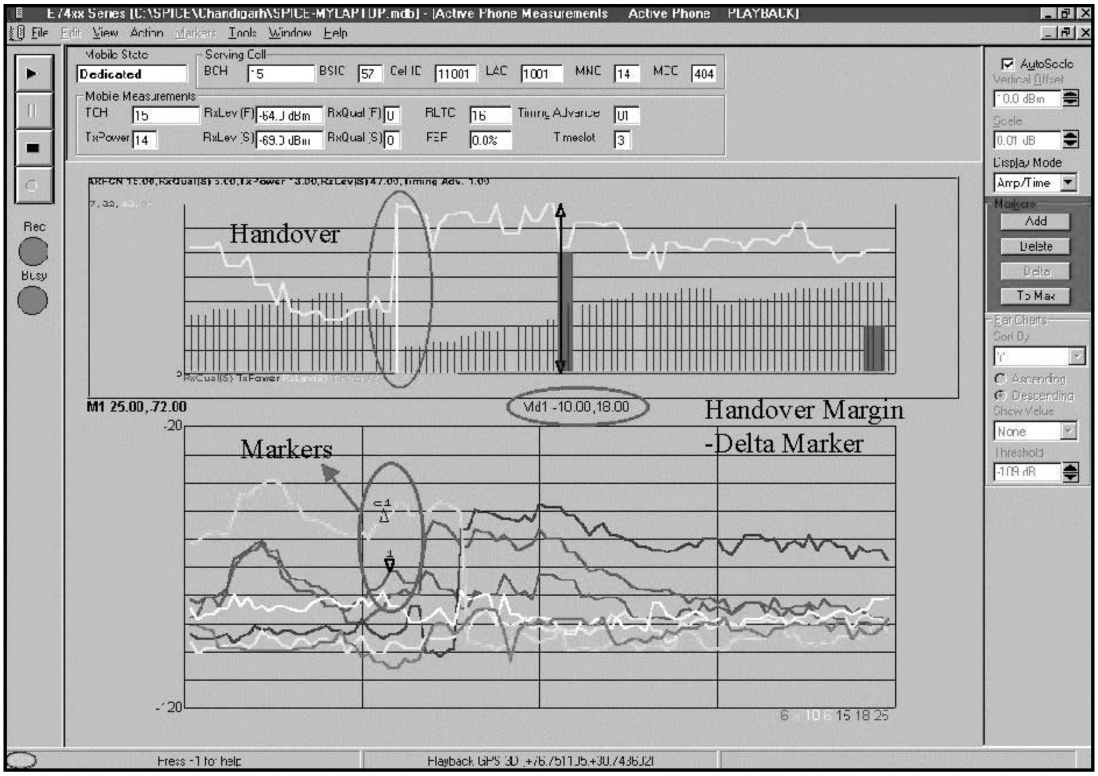


Figure 12. C/I map of TCH-TCH interference measured by the GSM receiver. Points where C/I < 9 dB are indicated by arrows.

Section 7. Optimizing Handover Margin

The same delta measurement technique can be used to verify and optimize handover margins. With a call established, and measuring on the cell edge, we can display the phone measurements of serving and neighbor cells; then, on the amplitude/time display, we can place a marker on the server and a delta marker on the dominant neighbor. The resulting delta value is the difference between the RXLEV of the server and that of the neighbor (see Figure 13). At some point on the drive-test route, the neighbor's RXLEV will become stronger than the server's signal and this delta reading will become negative; when the delta exceeds the handover margin, a handover will occur. The value of the handover margin is set in the cell, but not broadcast on the air interface. By simultaneously monitoring RXQUAL during the handover, the value of the handover margin can be determined and a decision can be made whether that value is appropriate for the quality of service desired. A handover margin on the high side will result in a handover occurring after the user has experienced some deterioration in quality. High handover margins can result in poor reception and dropped calls, while very low values of handover margin can produce "Ping-Pong" effects as a mobile switches too often between cells.



Mobile State: Dedicated

Serving Cell: BCH 15, BSIC 57, Cell ID 11001, LAC 1001, MNC 14, MCC 404

Mobile Measurements: TCH 15, RxLev (F) -64.0 dBm, RxQual (F) 0, RLTC 16, Timing Advance 01

TxPower 14, RxLev (S) -69.0 dBm, RxQual (S) 0, FEF 0.0%, Timeslot 3

☑ AutoScale

Vertical Offset: 0.0 dBm

Scale: 0.01 dB

Display Mode: Amp/Time

Sort By: Y

○ Ascending

● Descending

Show Value: None

Threshold: -109 dB

Figure 13. Handover margin delta measurement of RXLEV performed by the GSM receiver.

Delta measurements can also be used to prevent excessive cell reselections (analogous to handovers in idle mode), which can result in missing paging messages. In this case, the C2 parameters and hysteresis values can be optimized by the same delta measurement techniques described above.

Section 8. C2 Parameters, Reselection and BA Table

Before describing the handover process and the optimization of neighbor lists, we will explain three terms introduced in the previous section: C2 parameters, cell reselection and BA table.

In the idle mode, the mobile always prefers to remain with or move to the best serving cell. The best cell is decided on the basis of uplink and downlink path balance in the cells. This balance is calculated by GSM-defined C1 calculations. C1 calculations force the mobile to move to the strongest cell. In certain cases, such as macro-micro cell architecture, optimization may require that in certain areas the mobile not remain in the best cell, but instead remain in a cell depending on traffic loading. C2 parameters provide the option of adding fixed positive or negative offsets to the C1 calculation in each cell. So, although C1 might be better for a neighbor cell, the application of C2 parameters could delay reselection. C2 parameters also allow the mobile to apply temporary offsets for a period known as penalty time, which helps reduce Ping-Pong effects.

A mobile does a cell selection when it turns on or comes out of a coverage area. When the mobile has successfully camped onto a cell, it monitors the neighbor cell's ARFCN (per the BA table, described below) and does C1 and/or C2 calculations for each of the neighbor and serving cell ARFCNs at regular intervals. C1 and C2 calculations inform the mobile of the uplink and downlink path balance in the cell, allowing it to select or reject the cell. Once the mobile finds a neighbor cell's C1 and/or C2 (since C2 is optional) better than the C1 and/or C2 of the serving cell, it switches to the neighbor cell. This process of switching to another cell in the idle mode is known as cell reselection. Cell reselection is completely controlled by the mobile. The equivalent of cell reselection in the dedicated mode is handover, which is controlled by the network.

A BCCH Allocation (BA) table or list is a set of ARFCNs broadcast to the mobile in the idle and dedicated modes for monitoring as potential neighbor cells. In the idle mode, this list is broadcast on the BCCH in a System Information Type 2 message. The mobile decodes this message and monitors the ARFCNs listed in the table as idle mode neighbors. In the dedicated mode, a similarly formatted table is sent to the mobile on the Slow Associated Control Channel (SACCH) in a System Information Type 5 message. This dedicated mode table can contain the same list of ARFCNs as the idle mode table, or a different list.

Section 9. Optimizing Neighbor Lists

In GSM, we can define several neighbors for a serving cell. Usually, we want a handover to be made to the strongest neighbor, but in some cases frequent handovers to this best neighbor can result in congestion in the neighbor cell, affecting the users initiating calls from that cell. The situation can also occur in reverse, when a handover required to the best neighbor can result in a rejection due to unavailability of resources, causing the handover to be attempted to the next best neighbor, which can delay the process and deteriorate the quality further. Under certain circumstances, we may need to remove a potential neighbor from the neighbor list and provide alternatives. Usually, such decisions are made using demographic considerations. The BCH analyzer in the GSM receiver makes it easier to determine these alternative neighbors (see Figure 10).

The BCH analyzer can be used to create a list of all the possible BCH carriers in the nearby vicinity and perform the RXLEV measurement (linked to the phone's RXQUAL performance) on each of these carriers. When the RXQUAL reaches the handover decision threshold, we can determine the potential neighbors at that stage and set one of those as the optimum neighbor. This can also be done with the phone, but in this case you are limited to the BA list set in the network, which may not include good potential neighbors.

For example, a cell that is a good neighbor because of propagation over water may not be set in the BA list. Also, the number of neighbors in the BA list is usually limited, because a large number reduces the measurement samples per neighbor and hence deteriorates the authenticity of handovers. The receiver gives a complete, independent view of all the BCH carriers available at a particular location where a handover is required, and its control software capabilities (including markers, delta markers and post processing) simplify the task of making neighbor settings.

Section 10. Idle Mode BER

In the idle mode, a test mobile only reports RXLEV, so any downlink interference (which may eventually deteriorate quality) will be ignored. The mobile will be affected by a downlink interference problem in the idle mode by means of a GSM-defined process called Downlink Signaling Failure, which is based on the decoding of paging messages. The phone's Downlink Signaling Counter (DSC) is initialized to the integer that is nearest to the value of 90/BS_PA_MFRMS when the mobile camps onto a cell. This counter decrements by 4 when a mobile is not able to decode a paging message (BFI=1), and increments by 1 when a mobile successfully decodes the message (BFI=0). Once the DSC reaches a value of zero, a radio link failure is declared and the mobile does a cell reselection.

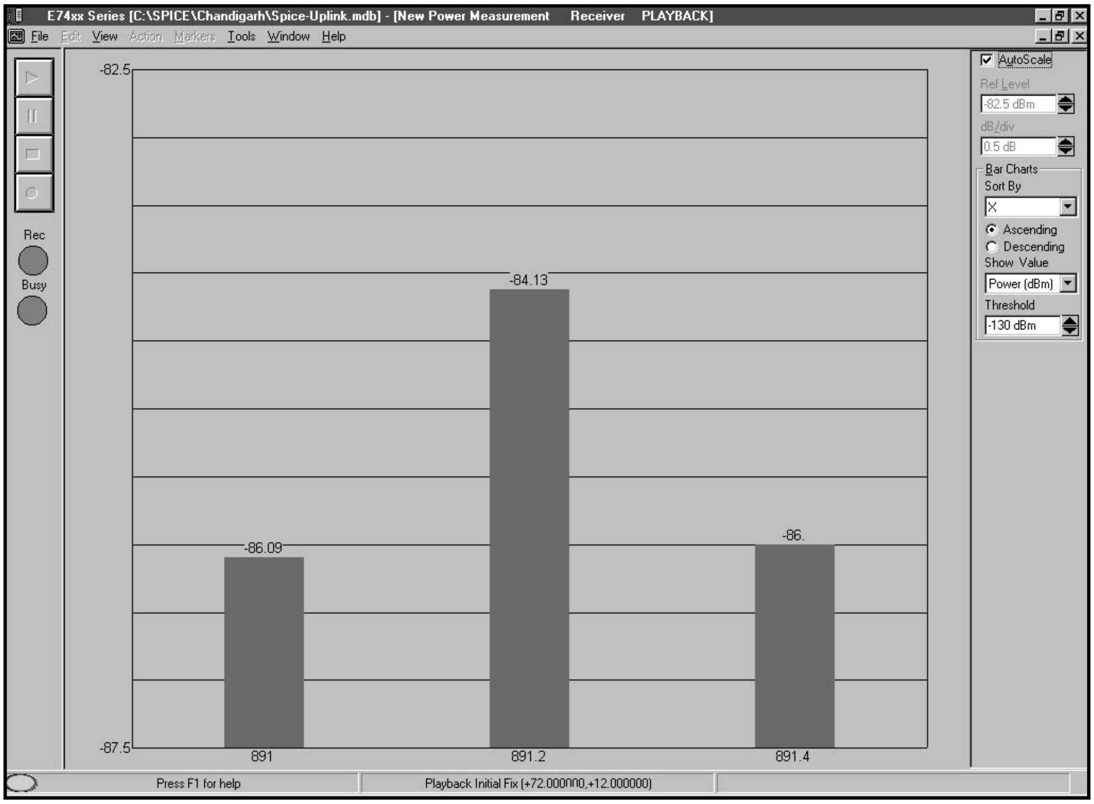
BS_PA_MFRMS can have a value in the range of 1 to 9 multiframes, so the DSC will range between 45 and 10. This means that, at a spot with particularly bad quality, for the low value of BS_PA_MFRMS, the mobile will need 45 bad messages to declare a failure. For the high value, it will need 10 bad messages to declare a failure, so in the worst case it will take 90 multiframes (21 s) to declare a failure. A phone-only drive-test system in the idle mode can only experience reselections at minimum intervals of 21 s. The only way to get a faster indication of poor quality is to set up a call and monitor the RXQUAL. If a mobile performs too many cell re-selections, it may miss paging messages.

The Agilent GSM receiver, which measures the BER on the Traffic Synch Channel (TSC) in the idle mode for the server and also any number of ARFCNs, provides a real-time continuous picture of the BER in the idle mode. This BER can be easily linked to the DSC. With this information available to us, we can also locate the cause of this BER by using the interference analyzer feature of the receiver. This will help us locate cells with interference problems in the idle mode, and then for those cells where actions cannot be taken immediately, we can adjust the C1 and C2 parameters to set prioritization of the cells for reselection.

Section 11. Uplink Interference

Uplink interference in GSM can be generated internally by mobiles in reuse and adjacent ARFCN cells, or externally by broken transmitters or illegal transmissions. Internal interference is very difficult to detect since it occurs in burst mode; there is no continuous transmission in the uplink. Even if we make a C/I measurement in the uplink, the results will vary with time because of the near-end far-end effect and the mandatory uplink power control implemented in GSM cells. Therefore, we cannot predict, estimate or measure the severity of interference in the uplink generated from internal sources.

However, there is one way of solving this measurement problem. Connect the GSM receiver in the receive path of the base station, change the ARFCN used in the cell from F1 to F2 and start measuring F1, F2, F1 + 200 kHz and F1 - 200 kHz using the channel power analyzer in the GSM receiver (see Figure 14).



☑ AutoScale
Ref Level: -82.5 dBm
dB/div: 0.5 dB
Bar Charts
Sort By: X
● Ascending
○ Descending
Show Value: Power (dBm)
Threshold: -130 dBm

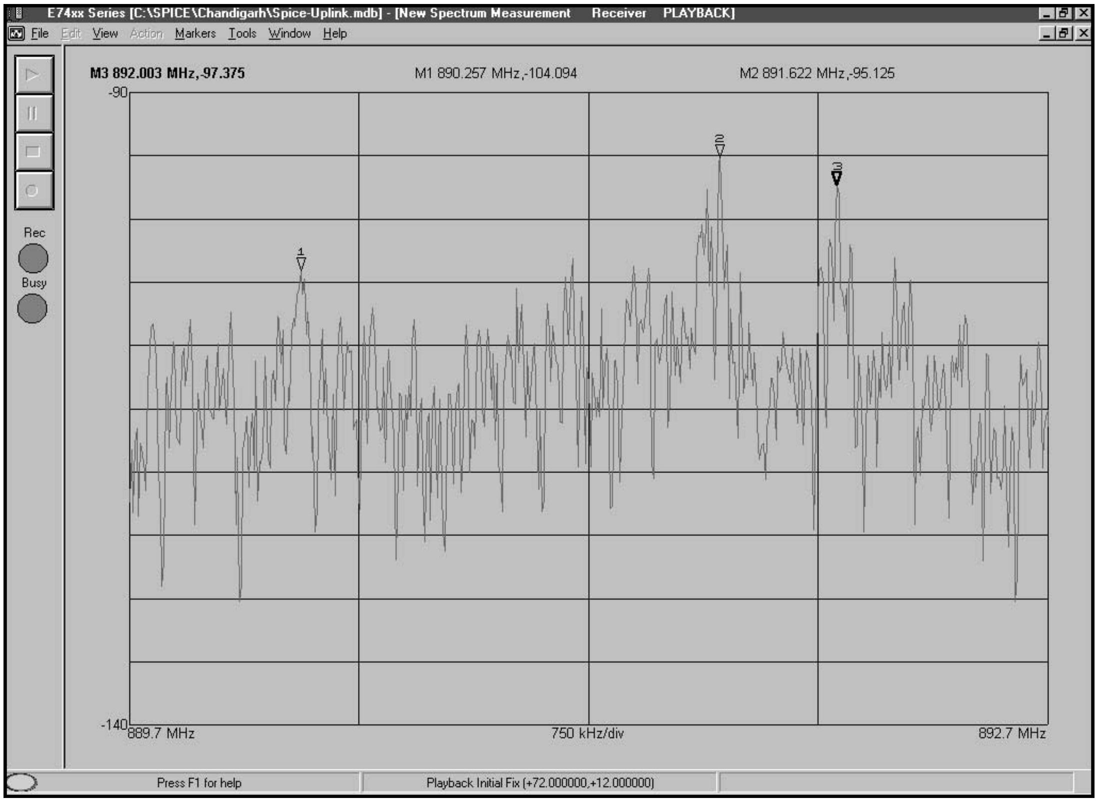
Press F1 for help
Playback Initial Fix (+72.000000,+12.000000)

Figure 14. Channel power measurements on uplink signal and adjacent channels.

Long-term monitoring is needed, so we can set up alarms to detect a signal level in the channel exceeding the threshold, and do complete, unmanned interference monitoring.

After capturing this data for a long period, such as a set of peak hours, we can export the data to post-processing software or a Microsoft® Excel® spreadsheet and generate the "probability of interference" plots for various thresholds. For example, we can plot the percentage of time co-channel interference channel power is above -110 dBm, -100 dBm, -90 dBm, and so forth. By plotting this for F1 and F2, and comparing these two graphs, we can easily estimate the severity of uplink interference. Even if the interference is not severe, we can optimize it by adjusting the cell range parameters. This technique is the most effective one, even for external interference generated by illegal transmissions (for example, by a 900 MHz cordless phone that generates continuous interference in the uplink for the duration of the call).

By monitoring the channel with alarms set for a signal occurring above a particular threshold for a period of perhaps 3 minutes, we can play back the alarm data later and use the spectrum analyzer in the receiver to observe the spectral characteristics of the signal (Figure 15). This will allow us to determine whether continuous interference for 3 minutes at a fixed level was internal or external.


E74xx Series [C:\SPICE\Chandigarh\Spice-Uplink.mdb] - [New Spectrum Measurement Receiver PLAYBACK]

M3 892.003 MHz,-97.375

M1 890.257 MHz,-104.094

M2 891.622 MHz,-95.125

Press F1 for help

Playback Initial Fix (+72.000000,+12.000000)

Figure 15. Spectrum display of uplink signals provides a troubleshooting tool for interference.

Section 12. Conclusion

This application note provides several examples that show how drive-test systems can help wireless network operators improve the quality of service of their GSM networks. The examples describe the benefits of a receiver-based solution, such as the one offered by Agilent Technologies. The network-independent receiver provides complete and accurate measurements of coverage and interference, and simplifies the optimization of handover margin and neighbor lists.

Phone-based and integrated phone-and-receiver-based solutions are also available from Agilent. For detailed information on the entire range of drive-test solutions offered by Agilent, see the product literature listed at the end of this application note. The list of references includes application and product notes that cover RF network issues and network optimization with drive-test systems.

Acronyms

AGCH	Access Grant Channel
ARFCN	Absolute Radio Frequency Channel Number
BA	BCCH Allocation
BCH	Broadcast Channel
BCCH	Broadcast Control Channel
BER	Bit Error Rate
BFI	Bad Frame Indication
CCCH	Common Control Channel
DRX	Discontinuous Reception
DSC	Downlink Signaling Counter
FCCH	Fast Control Channel
FDMA	Frequency Division Multiple Access
GPS	Global Positioning System
GSM	Global System for Mobile communications
PCH	Paging Channel
RXLEV	Receive Level
RXQUAL	Receive Quality
SACCH	Slow Associated Control Channel
SCH	Synchronization Channel
TDMA	Time Division Multiple Access
TCH	Traffic Channel
TSC	Traffic Synch Channel

References

[1] ETS-300 578, *Digital Cellular Telecommunications System (Phase 2)*, *Radio Subsystem Link Control* (GSM 05.08 version 4.22.1).

[2] *Optimizing Your CDMA Wireless Network Today and Tomorrow: Using Drive-Test Solutions*, Application Note 1345, Agilent literature number 5968-9916E.

[3] *Optimizing Your TDMA Network Today and Tomorrow: Using Drive-Testing to Identify Interference in IS-136 TDMA Wireless Networks*, Application Note 1342, Agilent literature number 5980-0219E.

[4] *Spectrum and Power Measurements Using the Agilent CDMA*, *TDMA and GSM Drive-Test System*, Product Note, Agilent literature number 5968-8598E.

[5] *CDMA Drive Test*, Product Note, Agilent literature number 5968-5554E.

[6] *N3419A Vehicle-Mounted Display System*, Product Overview, Agilent literature number 5980-0721E.

Product Literature

1. *GSM Drive-Test System*, Technical Specifications
   Agilent literature number 5968-5564E.

2. *GSM Drive-Test System*, Configuration Guide
   Agilent literature number 5968-5563E.

3. *GSM Drive-Test*, Brochure
   Agilent literature number 5968-5562E.

4. *Indoor Wireless Measurement System*, Product Overview
   Agilent literature number 5968-8691E.

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