Effective Test Procedures for Cellular Telephones

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TABLE OF CONTENTS

Introduction

Cellular phone testing plays a critical role in product development, manufacturing, and repair. Ideally, testing should be as simple as connecting the phone to the tester, running the test, and documenting the results. This level of simplicity is achievable, but requires a considerable amount of up-front preparation. It's important to select a tester that is easy to program, accurate and fast. Each type of phone to be tested needs to be characterized to understand the losses produced in transmitting signals between tester and phone. A test suite also needs to be defined for each phone that will identify potential defects in the least possible amount of time.

Various cellular phone testing applications

Testing of cellular telephones is critical at several stages in its lifecycle. During the development process, prototypes need to be tested to verify their performance against design specifications. On the manufacturing line, finished phones must be tested to ensure they will deliver customer satisfaction. Finally, when a customer brings a phone in for repair, tests are performed first to diagnose the problem and later to ensure the repair has been properly performed.

Testing of cell phones in repair depots is a particularly demanding application. About 7 million phones are returned for repair each year and about half of these are fixed by the service provider or manufacturer. The remaining volume of returned phones are typically repaired by service contractors that are in the business of repairing multiples types of phones from different manufacturers. For the service provider, signing repair contracts with these cellular phone repair facilities provides a cost-effective solution to handset repair.

Testing of cellular telephones seems like it should be easy yet there are a number of factors that make it more complicated than it appears at first glance. Testing at the repair depot is perhaps the most challenging application because of the need for the facility to deal with many different types of phones. The repair facility needs to characterize all of the different types of phones it will be testing. This can normally be accomplished by performing

radio frequency (RF) testing on a group of each type of phone that the facility will be responsible for testing.

Characterizing phones prior to testing

Sensitivity and transmitter measurements are performed by using the tester to generate a signal or powering up the phone's transmitter. But test definitions revolve around the power that is injected at the receiver or received by the tester. In each case, the measurements are affected by losses incurred in moving the signal between the phone and tester. These losses include RF power loss due to egress and heating of the cable from the RF port to the antenna coupler as well as the RF power loss between the coupler and the phone receiver. Different phones have different antenna characteristics and geometries so they will have different losses. Up-front effort is required to define the losses for each model of phone to be tested.

Phones that are capable of reporting their received power, such as GSM phones, are easier to characterize. Connect the phone to the tester with a direct connection and measure the loss of the cable externally on another piece of equipment. Then, set the power to a known level and read the report from the phone. A second measurement is then done with the antenna coupler by setting the RF power to the same level and reading the report from the phone. The difference in the reports with the direction connection and the antenna coupler is the loss of the system. This loss can be compensated at the tester by increasing the output power by this loss amount.

The phone also needs to be characterized in the opposite direction, with the phone transmitting and the tester receiving. Instruct the phone to transmit at a particular level through both a direct connection and radiated signal. The difference between the signal received in these two cases is the loss which is added back to the test measurement during the maximum power test. Since these tests are not iterative, they can both be performed in less than a minute.

In phones that are not capable of reporting the received power, such as CDMA phones, a more complex method is needed to determine this loss. Start by connecting the direct connection cable to the phone. Then starting with a relatively high power level, the RF power is slowly decreased until the phone starts to report receive errors. This is the baseline level. Next, connect the phone to the tester using the antenna coupler. Starting with a relatively high RF power level, slowly decrease the RF power until the phone again starts to report receive errors. At the level where the errors occur, the phone is receiving the same power as the baseline level measured earlier. The difference between the two transmission levels is the loss of the system. This loss can be compensated by increasing the tester power by this amount. This compensation should be made for each test channel that is used. This test must be performed manually because it requires an iterative process of checking the frame error rate each time the transmit power is reduced.

The phone also needs to be characterized in the opposite direction. Start by setting the tester to instruct the phone to transmit at a low level such as -90 dB in the direct connection mode. Set the closed loop power control of the tester to "all up" which means it will increase power by 1 dB every 1.25 milliseconds until it reaches the phone's maximum power limit. Compare the results on this test against the phone's rated maximum power limit which can be obtained from www.3gpp2.org for CDMA phones. The iterative nature of these tests means they typically take about 20 minutes.

Losses can be very different at different frequencies. Most cellular communications systems employ a frequency separation between the uplink and downlink so losses need to be measured at both frequencies using similar methods. First a measurement must be made with a direct connection, setting the phone ouput power to a known level. Then a second measurement is made with the antenna coupler. The difference in the measurements is the system loss value and this must be added to the antenna coupler measurement to compensate for this loss.

Preparing the phone for testing

It's important to test the phone in the same condition in which it is intended to be used. Phones are not intended to

be used with a cable connecting them to a base station antenna. So the phone should be tested through an antenna coupler inside an RF enclosure. The connection between the antenna coupler in the enclosure and test equipment should be made with a high quality shielded cable to prevent any external noise from entering the system. In situations where a direct connection is used for testing, at last some of the testing should be performed with a radiated RF connection in order to ensure that the antenna circuitry is working properly. Since the type of connector used for direct connection varies widely among phones, using the antenna coupler also avoids the need for the repair depot to keep a large inventory of connectors. The potential disadvantages of using a radiated connection, such as difficulties in testing the low end of the power range and possible interference, can be addressed with a good RF shielding enclosure.

In today's environment consumers often make modifications to their phones. They may change the front plates or back plates, add third party batteries or antennas, or add jewels or other decorations. These and other modifications may affect the RF performance of the phone. So the phone should be returned to its original condition by removing any add-ons. The phone should be fully assembled because any missing parts might affect the RF characteristics. The proper phone battery should be used because the battery shape, size and materials can affect the phone's RF characteristics. The battery should be fully charged to ensure that poor battery performance does not cause the phone to fail tests where it is asked to transmit at high power levels.

The phone should be configured in a manner that is consistent with the way it is intended to be used. Flip and clam-shell phones should be in the open position and extendable antennas should be extended. One exception to this rule relates to the fact that some flip and clam-shell phones can be opened at different angles. The angle to which they are opened often affects their RF performance. When tested in an RF shielding enclosure, the angle of opening determines the orientation of the antenna to the antenna coupler. The angle of opening may also affect the way in which RF energy is reflected within the RF shielding enclosure. In this situation, it may be necessary to test phones closed in order to get consistent results.

Level 1 testing

Parameter	Importance
Mobile Origination	Needed to establish and maintain call. This will also test the keypad if all of the keys are used in making the call.
Mobile Origination	Needed to establish and maintain call.

Level 2 testing

Parameter	Importance
Proper Transmitter Frequency	Needed to establish and maintain call
Receiver Sensitivity of low power signals	Needed to establish and maintain call at a larger distances from the base station transmitter
Receiver Sensitivity of high power signals	Needed to establish and maintain call at short distances from the base station transmitter without saturating or overdriving the receiver.
Maximum Transmitter Power	Needed to establish and maintain call at a larger distances from the base station transmitter
Handover	Needed to maintain a call while traveling

Level 3 testing

Parameter	Importance
Modulation analysis	Needed to identify digital modulation and waveform quality errors
Timing analysis	Needed to identify timing errors

Categories of phone testing

Phone testing is generally divided into three categories. Level 1 is the simplest level of testing and usually involves mobile origination and mobile page tests. Passing level 1 tests is necessary but not sufficient to determine that a phone will work on a live system. Level 2 testing adds transmitter frequency, receiver sensitivity, maximum power, and handover testing to evaluate the usability of the phone under various conditions. Yet a phone could still pass of these tests but not work properly under certain conditions. For example, digital modulation errors, timing errors, and waveform quality problems could prevent the phone from meeting its performance specifications. Level 3 testing addresses this concern by adding modulation and timing analysis.

In the real world, time is a factor and it may be necessary to eliminate some tests in order to save time. Either the mobile page or the mobile origination is frequently removed. This is because these tests are considered to be essentially identical from an RF point of view. If a mobile origination is performed, the keypad will also be tested. In phones that take a long time to attach to the system and register, a mobile origination will be faster than a mobile page. However, when an RF enclosure is being used for testing, the enclosure needs to be opened to replace the call. When this happens, the tests need to be paused not only for the call to be placed but also for the enclosure to be closed. A phone that can be placed in automatic answer can be paged without opening the RF enclosure. The disadvantage of using a page in automatic answer mode is that the keypad does not get tested.

In some cases, trade-offs may be made due to the time that is required to perform a particular test. For example, in some technologies receiver sensitivity tests take a considerable amount of time. In this case, a test suite may perform this test just once or twice per phone while the other tests in the suite are performed in multiple channels per band. Patterns discovered in previous rounds of testing may also help eliminate tests. For example, you may note in historical data that a phone that passes the sensitivity test will always pass the frequency test. This may make it possible to eliminate the frequency test.

Automating cellular phone testing

While any tester can be operated manually, the latest generation of test automation tools removes the need to manually conduct testing. This greatly reduces the amount of training required by operators, reduces test time, and reduces the risk of errors. Anritsu's Cellular Repair Center Application (CRCA) software simplifies the process of creating a test program. You select a particular test by clicking on it and the program then prompts you for any parameters that may be required to further define the test. Normally, the specified default values work perfectly. Multiple test sequences can be set up for different phones and customized to execute a variety of tests. Once the test sequences have been defined and saved, they can be downloaded to multiple test stations. The operator then needs only to select the type of phone to be tested and the corresponding service provider and execute the test. The user interface consists only of one screen that operators can easily learn to navigate. They can typically become productive in a very short period of time even without any cellular phone test experience. The software provides security by requiring users to log in and only giving administrators access to the test sequences defined for a particular phone.

The software automatically recalls the defined test sequence and completes the set of tests via remote control of the radio communications analyzer. A data file of test results is automatically generated. This data file is saved in

tab delimited format so it can easily be extract to run reports. If the phone fails, it is sent to another department for repair. The test sequence ensures that the tester runs the right tests in the proper sequence and also verifies that the test is based on the correct losses determined during the characterization process.

The latest generation of testers, called radio communications analyzers, can support a variety of formats and test many different types of handsets. Radio communications analyzers combine the capabilities of multiple instruments such as a digital modulation generator, audio analyzer and generator, analog modulation analyzer, and digital modulation analyzer. A built-in power meter and sensor provide accurate power measurements. A spectrum analyzer may be offered for checking for out-of-band spurious signals.

Anritsu offers a line of testers optimized for virtually any cell phone testing application. The MT8510B is a low cost tester designed for Level 1 and 2 testing of WCDMA and GSM phones. It can run test programs under the control of a separate PC or be operated manually. The MT8815B is a full-featured tester designed for Level 1, 2 and 3 testing at a high rate of speed. It supports WCDMA, GSM/GPRS/EGPRS, cdma2000 1xRTT, cdma2000 1xEV-DO, AMPS voice channel and PHS. The MT8820B essentially combines the functionality of two MT8815B units into one mainframe. When used in combination with the Parallel Phone measurement option, the MT8820B can test two phones at the same time, enabling substantial increases in throughput at a minimal increase in cost.

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