A method and apparatus for testing a mobile communication device comprising receiving signals emitted by the device during a test period while the device is in an off call state, measuring the strength of the received signals, determining when the strength of the received signals corresponds to the device attempting to access a communications network, and measuring the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network.
A Method and Apparatus for Testing Mobile Communication Devices

Field of the Invention

This invention relates to a method and apparatus for testing mobile communication devices, and in particular to a method and apparatus for testing smartphones.

Description of the Related Art

A known problem which can occur in mobile communication devices is unexpectedly rapid battery drain. That is, the battery powering the device being discharged faster than would be expected based on the usage being made of the device by a user. Recently, as smartphones have entered into common usage, this has been found to be a particular problem. Some surveys indicate that as many as 50% of smartphone users report problems to smartphone vendors, the main problem reported relating to the battery life.

In some cases, the unexpectedly rapid battery drain may just be an annoyance for users, necessitating inconveniently frequent recharging. However, in some cases, the unexpectedly rapid battery drain may be so rapid that the battery is discharged and the mobile communication device rendered unable to operate, that the user is seriously inconvenienced and the utility of the device is impaired.

There are a number of possible problems which can result in unexpectedly rapid battery drain, and it can be difficult for users, or advisers such as retail staff, to correctly identify what problem is affecting any specific device. Further, it can be difficult to correctly identify the problem without the use of intrusive diagnostic tools. Although the problem of unexpectedly rapid battery drain can be investigated and the fault diagnosed by technical personnel with suitable diagnostic tools, it can be costly and time consuming to forward a device to such specialist personnel and return it to the user after diagnosis.

Further, the use of intrusive diagnostic tools by users or retail staff may affect operation of the device, or device warranties.
It is an object of the present method and apparatus to address at least the aforementioned problems.

**Summary of the Invention**

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

In a first aspect, the invention provides a method of testing a mobile communication device, the method comprising: receiving signals emitted by the device during a test period while the device is in an off call state; measuring the strength of the received signals; determining when the strength of the received signals corresponds to the device attempting to access a communications network; and measuring the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network.

Preferably, the method further comprises locating the device adjacent an antenna, wherein the signals emitted by the device are sensed using the antenna.

Preferably, determining when the strength of the received signals corresponds to the device attempting to access a communications network comprises comparing the strength of the received signals to a predetermined threshold.

Preferably, measuring the strength of the received signals comprises measuring the power of the received signals.

Preferably, the test period is divided into a plurality of time intervals and the measuring comprises determining whether the strength of the received signals corresponds to the device attempting to access a communications network during each time interval; and
accumulating a count of the number of the time intervals in which the strength of the
received signals corresponds to the device attempting to access a communications network.

Preferably, the time intervals have equal lengths.

Preferably, the time intervals have a length of about 1 second.

Preferably, the time intervals have a length of 1.05 seconds.

Preferably, the test period has a predetermined length.

Preferably, the test period has a length of 10 minutes or less.

Preferably, the test period has a length of 5 minutes or less.

Preferably, the test period has a length of 1 minute.

Preferably, the method may further comprise comparing the proportion of the test period
during which the strength of the received signals is determined to correspond to the
device attempting to access a communications network to one or more thresholds, and
more preferably providing advice regarding possible action based on the comparison results.

Preferably, the method may further comprise calculating the proportion of the test period
during which the strength of the received signals is determined to correspond to the
device attempting to access a communications network as a percentage.

Preferably, if the device is using GPRS and the proportion of the test period during which
the strength of the received signals is determined to correspond to the device attempting
to access a communications network is 25% or higher, the method may further comprise,
identifying the device network activity as too high.
Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is between 10% and 25%, the method may further comprise, identifying the device network activity as too high.

Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 10%, the method may further comprise, identifying the device network activity as acceptable.

Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 5%, the method may further comprise, identifying the device network activity as good.

Preferably, the mobile communication device is a smartphone.

In a second aspect, the invention provides apparatus for testing a mobile communication device, the apparatus comprising; receiving means arranged to receive signals emitted by the device during a test period while the device is in an off call state; measuring means arranged to measure the strength of the received signals; determining means arranged to determine when the strength of the received signals corresponds to the device attempting to access a communications network; and measuring means arranged to measure the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network.

Preferably, the receiving means comprises an antenna.

Preferably, the receiving means comprises a radio frequency (RF) power detector.

Preferably, the RF power detector has a frequency range of 600MHz to 7GHz.
Preferably, the determining means is arranged to determine when the strength of the received signals corresponds to the device attempting to access a communications network by comparing the strength of the received signals to a predetermined threshold.

Preferably, the measuring means measures the power of the received signals.

Preferably, the test period is divided into a plurality of time intervals and the measuring means is arranged to determine whether the strength of the received signals corresponds to the device attempting to access a communications network during each time interval; and more preferably the measuring means comprises a counter arranged to accumulate a count of the number of the time intervals in which the strength of the received signals corresponds to the device attempting to access a communications network.

Preferably, the time intervals have equal lengths.

Preferably, the time intervals have a length of about 1 second.

Preferably, the time intervals have a length of 1.05 seconds.

Preferably, the test period has a predetermined length.

Preferably, the test period has a length of 10 minutes or less.

Preferably, the test period has a length of 5 minutes or less.

Preferably, the test period has a length of 1 minute.

Preferably, the apparatus may further comprise a processor adapted to compare the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network
to one or more thresholds, and to provide advice regarding possible action based on the comparison results.

Preferably, the apparatus may further comprise means arranged to calculate the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network as a percentage.

Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is 25% or higher, the apparatus may further comprise a processor adapted to, identify the device network activity as too high.

Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is between 10% and 25%, the apparatus may further comprise a processor adapted to, identify the device network activity as too high.

Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 10%, the apparatus may further comprise a processor adapted to identify the device network activity as acceptable.

Preferably, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 5%, the apparatus may further comprise, a processor adapted to identify the device network activity as good.

Preferably, the mobile communication device is a smartphone.

The invention further provides systems, devices and articles of manufacture for implementing any of the aforementioned aspects of the invention.
The preferred and/or optional features may be combined as appropriate, as would be apparent to a skilled person, and may be combined with any of the aspects of the invention.

Description of Figures

The invention will now be described in detail with reference to the following figures in which:

Figure 1 is a diagram of an example of a testing apparatus according to an aspect of the present invention; and

Figure 2 is a more detailed circuit diagram of an example of the testing apparatus of Figure 1.

It will be appreciated that although features from each of the embodiments may be identified by difference reference numerals in the figures and throughout the description, similar features including the properties and functionality attributed thereto, from one embodiment may be interchangeable with those of another embodiment.

Detailed Description of the Invention

There are a number of possible reasons why smartphones may suffer unexpectedly rapid battery drain, which can result in an unacceptable smartphone operating life between charging operations. For example, there may be a fault with the battery cell so that it is not properly retaining charge, the smartphone may be incorrectly set to power unused radio features or to light up a screen unnecessarily, or may contain malfunctioning software, such as an application, commonly referred to as an App, which may be causing continuous, unnecessary CPU operations, among others.
Further, there may be a fault in the charger or connections to the charger so that the smartphone battery is not properly charging. Although such a failure to charge the battery does not in fact result in rapid battery drain, in practice, it may be misidentified by users as a rapid battery drain problem.

In principle, many of these possible reasons for unexpectedly rapid battery drain can be identified and remedied by users or advisers. For example, the smartphone settings can be checked and incorrect or inappropriate settings changed, CPU loading can be checked, charge indicators can be checked to confirm that charging operations are successful, and in some cases, batteries can readily be exchanged to see if there is a change in performance.

It has been realized by the present inventors that another common cause of rapid battery drain in smartphones is unexpectedly high levels of network activity. That is, unexpectedly high levels of wireless access to a communications network through an over-the-air interface. The communications network may be a mobile telephone network and/or mobile data network. Such unexpectedly high levels of network activity may be caused by malfunctioning software, such as an App. However, there is no straightforward way for a user or advisers to identify that this is happening.

In general for mobile devices, network activity requires accessing a communications network wirelessly through an over-the-air interface, which significantly increases the amount of power consumed by the mobile device compared to a standby mode, or a mode where user operations are carried out on board the mobile device without over-the-air network access. In practice, the usage patterns for users of mobile devices such as smartphones are that most users are only intentionally carrying out operations on their mobile devices which require over-the-air network access for a relatively small proportion of the time. As a result, it is possible for unexpectedly high levels of network activity to greatly increase the average power consumption of a mobile device, resulting in rapid battery drain.
Figure 1 illustrates an overview of an example of a testing apparatus 1 according to an aspect of the present invention.

The testing apparatus 1 in this example comprises an antenna 2, a radio frequency (RF) power detector 3 and a signal conditioning module 4. The testing apparatus 1 further comprises in this example a counter module 5, a counter display 6 and a computer 7.

In operation of the testing apparatus 1, a mobile communication device, such as a smartphone 8, to be tested so that possible problems affecting the smartphone 8 can be diagnosed, is placed in local proximity to the antenna 2. In order to allow testing and diagnosis, the smartphone 8 is placed in local proximity to the antenna 2 while switched on but without any voice call being carried out, in other words the smartphone is in what is commonly referred to as an off-call operating state.

Any radio signals transmitted from the smartphone 8 are received by the antenna 2 and detected by the radio frequency (RF) power detector 3 which is connectable to the antenna 2. Accordingly, the antenna 2 and RF power detector 3, when connected, act to sense the RF signals emitted by the smartphone 8. In the illustrated example, the RF power detector 3 has a frequency range of at least 600MHz to 4GHz. It will be appreciated that other frequency range's may be set and that these frequency ranges may be dependent on the type of device being tested.

The frequency range of the RF power detector 3 of 600MHz to 4GHz covers the operating frequency ranges of the different radio access technologies most commonly used by smartphones, such as General Packet Radio Services (GPRS), Wideband Code-Division Multiple Access (WCDMA), Long-Term Evolution (LTE) and Wi-Fi. This may allow the diagnostic apparatus to be used for smartphones 8 using any of these radio technologies. In other examples, different frequency ranges may be used as appropriate to the operating frequencies of the mobile devices to be tested and their radio access technologies.
The RF power detector 3 converts the received RF signals into a DC voltage level output signal having a DC voltage level corresponding to the RF power received by the antenna 2.

The DC output signal from the RF power detector 3 is supplied to the signal conditioning module 4. The signal conditioning module 4 converts the DC signal received from the RF power detector 3 into a logic level voltage output signal suitable for subsequent digital analysis.

The antenna 2, RF power detector 3 and signal conditioning module 4 are preferably arranged so that the logic level signal output from the signal conditioning module 4 depends upon the amount of RF power being received by the antenna 2. The logic level signal has a first voltage corresponding to a first logic level when the received RF power is below a predetermined threshold value and the logic level signal has a second voltage corresponding to a second logic level when the received RF power is equal to or above the predetermined threshold value. The antenna 2, RF power detector 3, and signal conditioning module 4 are preferably arranged so that the received RF power threshold value is between the anticipated received RF power value when a smartphone 8 is making over-the-air network access and the received RF power value due to ambient signals.

In some examples, the first logic level indicating that the received RF power is below the predetermined threshold value may 0V, and the second logic level, indicating that the received RF power is equal to or above the predetermined threshold value, may have a positive voltage value. In one example the second logic level may have a value of 5V.

In the illustrated example, the comparison of the received RF power to a predetermined threshold value is carried out by the signal conditioning module 4. In other examples, this comparison may be carried out elsewhere. In some examples, this comparison may be carried out by the RF power detector 3. In one example, this comparison may be carried out by the RF power detector 3 only detecting, or responding to, received power levels over a predetermined threshold value.
Thus, the logic level signal is at the first logic level when the smartphone 8 or other mobile communication device is not making over-the-air network access and is at the second logic level when the smartphone 8 is making over-the-air access.

The logic level signal is provided to the counter module 5, which counts, over a predetermined period, the number of time intervals in which the logic signal is at the second logic level, indicating that the smartphone 8 is making over-the-air access. The counter unit 5 in this example provides the cumulative value of this count to the counter display 6, which displays the count value.

Thus, the numerical count value displayed by the counter display 6 indicates the amount of over-the-air network access carried out by the smartphone 8 during the predetermined period, with higher displayed count values indicating higher amounts of over-the-air network access.

In one example, the counter module 5 may operate to count the number of 1 second intervals during which the logic signal is at the second logic level over a 1 minute testing period. In this example, the displayed count value will indicate the amount or proportion of time during which the smartphone 8 was conducting over-the-air network access during the testing period.

In other examples, the testing period may be 5 minutes or 10 minutes. In general, a longer testing period may be expected to provide more statistically reliable results, while a shorter testing period may be preferred for user convenience. The testing period may additionally or alternatively be selected based on the properties of the particular model of smartphone 8 being tested.

In some examples, the length of the intervals and the testing period may be arranged so that the displayed count value is the percentage of the time for which the smartphone 8 was conducting over-the-air-network access during the testing period.
The logic level signal may also be provided to the computer 7. The computer 7 comprises at least one processor, and in one example may be a personal computer (PC). In other examples, the computer 7 may be a microprocessor or other programmable computing device.

The computer 7 can carry out analysis of the logic level signal and preferably may output the results of the analysis to users. The computer 7 may, for example, output results using a visual display unit (VDU).

In one example, the computer 7 may calculate and display the percentage of the time for which the smartphone 8 was conducting over-the-air network access during the testing period. In some examples, the computer 7 may display the proportion of the time for which the smartphone 8 was conducting over-the-air network access during the testing period as a graphical output, such as an activity bar, additionally or alternatively to a numerical value. Displaying the test results in these forms may assist user comprehension.

The illustrated example of the testing apparatus 1 comprises both the counter module 5 and counter display 6, and also the computer 7. Other examples, may comprise only one of these.

In some examples the testing apparatus 1 may comprise the counter module 5 and counter display 6, and not the computer 7. In some examples, the testing apparatus 1 may comprise the computer 7, and not the counter module 5 and counter display 6.

In some examples where the testing apparatus 1 does comprise the computer 7, the computer 7 may be integrated with the other parts of the testing apparatus 1. In other examples, the computer 7 may be separate from the remainder of the testing apparatus 1, and may, for example, be connected by a cable.

In some examples comprising both the computer 7 and the counter module 5, the results from the computer 7 or the counter module may be used to cross check the results of the
other. In this example, a combined or modified result may be displayed on the computer
7 and/or the counter display 6.

As described above, the testing apparatus 1 provides a user with a measurement value of
5 the amount of over-the-air network access by the smartphone 8 during the testing period.

This measured value can then be used to assess whether or not the smartphone 8 is
operating correctly.

As mentioned above, one possible common cause of rapid battery drain in smartphones
or other mobile device is unexpectedly high levels of network activity when off-call. Such unexpectedly high levels of off-call network activity may be caused by malfunctioning software, such as an App.

A correctly operating smartphone running a range of typical communications Apps, such
as an email client, will generally spend a relatively low proportion of the time conducting
over-the-air network access when off-call. The precise amount of time spent conducting
network access will vary from case to case for different models of smartphone, different
operating systems and different software, such as Apps running on the smartphone. For
example, in general, the off-call network activity rate will be less than 8% for a correctly
operating smartphone using GPRS. In one typical example of a correctly operating
smartphone using GPRS, the off-call network activity rate was around 5%.

Many game Apps are made available for free but display advertising to the user while the
game is being played. Typically for smartphones using GPRS, such free game Apps may
increase the off-call network activity rate to around 20% while the game App is running
as a result of the App using the smartphone network connection to download advertising
material and exchange positioning and game data, even when the game is not actually
being played.

Malfunctioning Apps may result in a very high off-call network activity rate. It has been
determined that in practice, for smartphones using GPRS, malfunctioning Apps may
result in an increase in the off-call network activity rate to 80% or more, and in practice, one malfunctioning App was found to increase the off-call network activity rate for smartphones using GPRS to just under 90%.

In many cases, malfunctioning Apps which generate very high off-call network activity rates are communication Apps, such as email or messaging services; particularly where these Apps attempt to contact a communication server to synchronize and/or check for new communications, have the attempt fail for some reason and immediately repeat the attempt. Where the reason for the failure persists or is permanent, this can result in a continuous cycle of repeated attempts to contact the server. In a properly functioning App, this cycle should be stopped before the number of attempts is sufficient to significantly affect battery life, but a malfunctioning App may fail to do this.

A smartphone being used to make a voice call will generally have a network activity rate of 100%. High network activity rates may also occur when a smartphone is downloading large amounts of data. However, most smartphones are only actually in use making voice calls or downloading data for a relatively small proportion of the time, so that for most users the off call network activity rate will dominate the average rate of power consumption and battery life.

For smartphones using different radio technologies to access a network, the off call network activity rate may be different. For example, smartphones using radio access technologies with a faster data transmission rate such as WCDMA and LTE may have lower rates of off-call network activity because the required data transmissions, for example to download advertising material, require a shorter time.

As described above, the testing apparatus 1 can provide a measurement indicating the amount of network access activity carried out being carried out by an off-call smartphone. By comparing this measured amount to the expected ranges of values of off-call network access activity, improper operation of the smartphone 8, and preferably likely causes, may be deduced.
Before testing the smartphone 8, and/or after identifying that the measured amount of network access activity was high enough to indicate that corrective action or further investigation should be carried out, it should preferably be checked that the smartphone 8 was not connected for a voice call or engaged in a data download. If this is the case, the test should be delayed or repeated when the voice call has been disconnected or the download completed or cancelled.

In one example, if the measured amount of network access activity corresponded to a network activity rate of 5% or less, the smartphone off-call activity could be regarded as good, and it could be concluded that any problem of unexpectedly fast battery drain was not caused by excessive network activity.

If the measured amount of network access activity corresponded to a network activity rate of between 5% and 10%, the smartphone off-call activity could be regarded as acceptable, and it could be concluded that any problem of unexpectedly fast battery drain was not caused by excessive network activity.

If the measured amount of network access activity corresponded to a network activity rate of between 10% and 25%, the smartphone off call activity could be regarded as too high and undesirable, and it could be concluded that any problem of fast battery drain might be caused by excessive network activity. The identities of live Apps running on the smartphone 8 should be checked to see if any of them are causing excessive network activity.

If the measured amount of network access activity corresponded to a network activity rate of over 25%, the smartphone off call activity could be regarded as too high and unacceptable, and it could be concluded that any problem of unexpectedly fast battery drain is likely to be caused by excessive network activity. The identities of live Apps running on the smartphone 8 should be checked to see if any of them have issues or faults which are causing the excessive network activity.
In other examples, different thresholds and/or a different number of categories may be used.

The comparison of the amount of network access activity to expected values and the resulting classification of the amount of network activity and any possible remedial action may be determined by the tester, for example, based on written operating instructions.

Alternatively, in examples where the computer 7 is present, the computer 7 may compare the measured amount of network activity to predetermined threshold values and, based on this comparison, provide an output categorizing the smartphone off-call network access activity and proposing possible corrective or investigative action to be carried out.

As is explained above, the testing apparatus and method according to the present invention provides a non-intrusive means of testing a smartphone and identifying excessive off-call network activity which may cause problems of rapid battery drain and short operating life between charging operations. The testing is based on measuring sensed RF transmission power from the smartphone while the smartphone is operating normally in its standard mode with its usual Apps running, and there is no need to access the smartphone battery, or to physically connect the smartphone to test equipment. Accordingly, the tests are quick and simple to set up, the testing may be quickly and easily carried out, and is non-intrusive. The test results are straightforward and easy to understand.

It should be noted that it is not necessary for the testing apparatus to be able to use, or even identify, the communication protocol used by the smartphone for network access, or for the testing apparatus to be able to receive or understand any data sent by the smartphone 8 or other mobile devices to the network.

In some examples, the apparatus 1 may have the location of the antenna 2 marked to indicate where the smartphone 8 should be placed for testing in order to ensure good coupling of RF signals transmitted by the smartphone 8 to the antenna 2.
In some examples shielding, such as a Faraday cage, may be placed around at least the antenna 2 of the testing apparatus 1 in order to exclude extraneous RF signals and noise, which could otherwise affect the test results.

As discussed above, smartphones may use a number of different radio access technologies. Some of these technologies transmit a constant radio signal, one example being WCDMA, while some other technologies transmit a non-constant signal, one example being GPRS, which transmits at a time slot frame rate of 217Hz.

Preferably, in order to allow both of these types of radio access technologies to be measured, the signal conditioning module 6 is arranged to respond to a constant signal from the RF power detector 3 by generating a constant logic level signal, and to respond to a pulsed signal from the RF power detector 3 by generating a constant logic level signal for a predetermined response time when a pulse is received. After the predetermined response time, the signal conditioning module then waits to receive and respond to the next subsequent pulse, or a constant signal.

Although it would be possible to respond to each pulse of a pulsed signal, for example a 217Hz pulsed signal for GPRS, there will not generally be any improvement in results sufficient to justify the added difficulty and complexity of doing this.

In the illustrated example where the counter module 5 counts, over a predetermined period, the number of time intervals in which the logic signal is at the second logic level, indicating that the smartphone 8 is making over-the-air access, the predetermined response time of the signal conditioning module 4 should be the same as the time interval.

In one example where the counter 5 operates to count the number of 1 second intervals during which the logic signal is at the second logic level over a 1 minute testing period, the predetermined response time of the signal conditioning module 6 should be 1 second.
Figures 2a to 2c illustrate circuit diagrams of parts of an example of the testing apparatus 1 of Figure 1.

In Figure 2a, the RF power detector 3 comprises an SMA-RF connector 20 connected through a 33 pF coupling capacitor 21 to input of an amplifier 22. The SMA-RF connector connects the antenna 2 (not shown in Figure 2a) to the RF power detector 3. The amplifier 22 may be an LTC5535, produced by Linear Technology, a temperature compensated Schottky diode peak detector and output amplifier with a frequency range of 600MHz to 7GHz. The gain, detection bandwidth and starting DC voltage of the amplifier 22 are set by two external resistors 22a and 22b. The resistor 22a has value of 470Ω and the resistor 22b has a value of 100Ω so that the amplifier 22 has a gain of 5.7 (15.1 dB), detection bandwidth of 7MHz and starting DC voltage of 0.57V. The amplifier 22 is connected to a power supply line and decoupled by two capacitors 23 with respective values of 470nF and 33pF.

The output signal from the amplifier 22 is output from the RF power detector 3 to the signal conditioning module 4. The signal conditioning module 4 comprises a transistor switch 24 connected to a Schmitt trigger 25, and the signal received from the RF power detector 3 passes through the transistor switch 24 and the Schmitt trigger 25 to convert it into a clean signal compatible with 5V logic levels.

The signal conditioning module 4 further comprises first and second circuit branches 26 and 27 which each connect the Schmitt trigger 25 to a respective input of a 7432 OR gate 28.

The first circuit branch 26 is a conductive line, and when the logic compatible signal is a constant signal this passes along the circuit branch 26 to the OR gate 28.

The second circuit branch 27 is more complicated. The second circuit branch 27 comprises a mono-stable 74221 logic device 29 set to a time value of approximately 1 second. The monostable device 28 has a time set by the values of resistors and capacitors 30 according to the equation:
Using a resistor value of 150K and a capacitor value of 10uF gives a time of approximately 1.05 seconds.

When the logic compatible signal is a pulsed signal this passes along the circuit branch 27 to the mono-stable logic device 29, triggering the logic device 29 to send an approximately 1 second (as explained above 1.05 second) output pulse to the OR gate 28 before resetting.

The OR gate 28 combines the signal it receives along the first and second circuit branches 26 and 27 and outputs the OR combined signal. The output signal from the OR gate 28 is the output signal of the signal conditioning module 4.

The output signal from the signal conditioning module 4 may be supplied to the computer 7 through an output socket 30 of the testing apparatus 1.

The output signal from the signal conditioning module 4 may also or alternatively be supplied to the counter module 5. The counter module 5 comprises an 7408 AMD gate 31, a timer 32, and a counter unit 33. The AND gate 31 is supplied with the output signal from the signal conditioning module 4 as one input and a timing signal from the timer 32 as another input. The timer 32 comprises an NE555N timer/oscillator set to generate a 10Hz clock signal.

The output of the AND gate 31 is supplied to the counter unit 33 and increments the counter. The counter unit 33 is an ME-SP430 counter unit produced by Sure Electronics, and incorporates the counter display 6.

Figure 2b illustrates a power supply unit 34 used to provide power to the components of the testing apparatus 1 from a 12V DC source. The power supply unit 34 comprises a 12V input socket 35, and a 7805 voltage regulator 36, and produces a +5V output power
supply. The power supply unit 34 also comprises an LED 37 to indicate that the testing apparatus 1 is powered.

Figure 2c illustrates a chip decoupling circuit 38 used in testing apparatus 1 to reduce noise on the +5V power supply.

In the examples described above, it is specified that the smartphone 8 to be tested should be in an off-call operating state. This is because a smartphone using currently available radio access technologies to make a voice call would generally be expected to be maintaining over-the-air network access throughout the call, making any measurement of the amount of over-the-air network access useless for fault diagnosis.

In the examples described above, the testing period is predetermined. This is not essential, and in other examples, the length of the testing period may not be predetermined. In principle, the proportion of the time for which a smartphone or other mobile device is conducting over-the-air network access during a testing period can be determined for any length of testing period. In some examples, the length of the testing period may be timed to assist in this determination. In some examples, the test may be stopped at any time by the test operator.

In the examples described above, the apparatus may comprise a computer. In some examples, a discrete computer may not be required and the apparatus may comprise a processor to carry out the functions of the described computer.

In the examples described above, the application of the present invention to a testing a smartphone is described. The method and apparatus according to the present invention can also be used to test other mobile communication devices having a wireless communication capability.

The systems and apparatus described above may be implemented at least in part in software. Those skilled in the art will appreciate that the apparatus described above may be implemented using general purpose computer equipment or using bespoke equipment.
The different components of the systems may be provided by software modules executing on a computer.

The hardware elements, operating systems and programming languages of such computers are conventional in nature, and it is presumed that those skilled in the art are adequately familiar therewith. Of course, the server functions may be implemented in a distributed fashion on a number of similar platforms, to distribute the processing load.

Here, aspects of the methods and apparatuses described herein can be executed on a computing device such as a server. Program aspects of the technology can be thought of as "products" or "articles of manufacture" typically in the form of executable code and/or associated data that is carried on or embodied in a type of machine readable medium. "Storage" type media include any or all of the memory of the computers, processors or the like, or associated modules thereof, such as various semiconductor memories, tape drives, disk drives, and the like, which may provide storage at any time for the software programming. All or portions of the software may at times be communicated through the Internet or various other telecommunications networks. Such communications, for example, may enable loading of the software from one computer or processor into another computer or processor. Thus, another type of media that may bear the software elements includes optical, electrical and electromagnetic waves, such as used across physical interfaces between local devices, through wired and optical landline networks and over various air-links. The physical elements that carry such waves, such as wired or wireless links, optical links or the like, also may be considered as media bearing the software. As used herein, unless restricted to tangible non-transitory "storage" media, terms such as computer or machine "readable medium" refer to any medium that participates in providing instructions to a processor for execution.

Hence, a machine readable medium may take many forms, including but not limited to, a tangible storage carrier, a carrier wave medium or physical transaction medium. Non-volatile storage media include, for example, optical or magnetic disks, such as any of the storage devices in computer(s) or the like, such as may be used to implement the encoder, the decoder, etc. shown in the drawings. Volatile storage media include dynamic
memory, such as the main memory of a computer platform. Tangible transmission media include coaxial cables; copper wire and fiber optics, including the wires that comprise the bus within a computer system. Carrier-wave transmission media can take the form of electric or electromagnetic signals, or acoustic or light waves such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of computer-readable media therefore include for example: a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD or DVD-ROM, any other optical medium, punch cards, paper tape, any other physical storage medium with patterns of holes, a RAM, a PROM and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave transporting data or instructions, cables or links transporting such a carrier wave, or any other medium from which a computer can read programming code and/or data. Many of these forms of computer readable media may be involved in carrying one or more sequences of one or more instructions to a processor for execution.

Those skilled in the art will appreciate that while the foregoing has described what are considered to be the best mode and, where appropriate, other modes of performing the invention, the invention should not be limited to specific apparatus configurations or method steps disclosed in this description of the preferred embodiment. It is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that the teachings may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all applications, modifications and variations that fall within the true scope of the present teachings. Those skilled in the art will recognize that the invention has a broad range of applications, and that the embodiments may take a wide range of modifications without departing from the inventive concept as defined in the appended claims.

Although the present invention has been described in terms of specific exemplary embodiments, it will be appreciated that various modifications, alterations and/or combinations of features disclosed herein will be apparent to those skilled in the art
without departing from the spirit and scope of the invention as set forth in the following claims.
Claims:

1. A method of testing a mobile communication device, the method comprising:
   receiving signals emitted by the device during a test period while the device is in an off call state;
   measuring the strength of the received signals;
   determining when the strength of the received signals corresponds to the device attempting to access a communications network; and
   measuring the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network.

2. The method of claim 1, wherein the method further comprises locating the device adjacent an antenna, wherein the signals emitted by the device are sensed using the antenna.

3. The method of claim 1 or claim 2, wherein determining when the strength of the received signals corresponds to the device attempting to access a communications network comprises comparing the strength of the received signals to a predetermined threshold.

4. The method of any preceding claim, wherein measuring the strength of the received signals comprises measuring the power of the received signals.

5. The method of any preceding claim, wherein the test period is divided into a plurality of time intervals and the measuring comprises determining whether the strength of the received signals corresponds to the device attempting to access a communications network during each time interval; and
   accumulating a count of the number of the time intervals in which the strength of the received signals corresponds to the device attempting to access a communications network.
6. The method of claim 5, wherein the time intervals have equal lengths.

7. The method of claim 6, wherein the time intervals have a length of about 1 second.

8. The method of claim 7, wherein the time intervals have a length of 1.05 seconds.

9. The method of any preceding claim, wherein the test period has a predetermined length.

10. The method of claim 9, wherein the test period has a length of 10 minutes or less.

11. The method of claim 10, wherein the test period has a length of 5 minutes or less.

12. The method of claim 11, wherein the test period has a length of 1 minute.

13. The method of any preceding claim, the method further comprising comparing the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network to one or more thresholds, and providing advice regarding possible action based on the comparison results.

14. The method of any preceding claim, the method further comprising calculating the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network as a percentage.

15. The method of claim 14, the method further comprising, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is 25% or higher, identifying the device network activity as too high.
16. The method of claim 14 or claim 15, the method further comprising, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is between 10% and 25%, identifying the device network activity as too high.

17. The method of any of claims 14 to 16, the method further comprising, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 10%, identifying the device network activity as acceptable.

18. The method of any of claims 14 to 17, the method further comprising, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 5%, identifying the device network activity as good.

19. The method of any preceding claim, wherein the mobile communication device is a smartphone.

20. Apparatus for testing a mobile communication device, the apparatus comprising;
    receiving means arranged to receive signals emitted by the device during a test period while the device is in an off call state;
    measuring means arranged to measure the strength of the received signals;
    determining means arranged to determine when the strength of the received signals corresponds to the device attempting to access a communications network; and
    measuring means arranged to measure the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network.

21. The apparatus of claim 20, wherein the receiving means comprises an antenna.
22. The apparatus of claim 20 or claim 21, wherein the receiving means comprises a radio frequency (RF) power detector.

23. The apparatus of claim 22, wherein the RF power detector has a frequency range of 600MHz to 7GHz.

24. The apparatus of any one of claims 20 to 23, wherein the determining means is arranged to determine when the strength of the received signals corresponds to the device attempting to access a communications network by comparing the strength of the received signals to a predetermined threshold.

25. The apparatus of any one of claims 20 to 24, wherein the measuring means measures the power of the received signals.

26. The apparatus of any one of claims 20 to 25, wherein the test period is divided into a plurality of time intervals and the measuring means is arranged to determine whether the strength of the received signals corresponds to the device attempting to access a communications network during each time interval; and

   the measuring means comprising a counter arranged to accumulate a count of the number of the time intervals in which the strength of the received signals corresponds to the device attempting to access a communications network.

27. The apparatus of claim 26, wherein the time intervals have equal lengths.

28. The apparatus of claim 27, wherein the time intervals have a length of about 1 second.

29. The apparatus of claim 28, wherein the time intervals have a length of 1.05 seconds.

30. The apparatus of any one of claims 20 to 29, wherein the test period has a predetermined length.
31. The apparatus of claim 30, wherein the test period has a length of 10 minutes or less.

32. The apparatus of claim 31, wherein the test period has a length of 5 minutes or less.

33. The apparatus of claim 32, wherein the test period has a length of 1 minute.

34. The apparatus of any one of claims 20 to 33, the apparatus further comprising a processor adapted to compare the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network to one or more thresholds, and to provide advice regarding possible action based on the comparison 10 results.

35. The apparatus of any one of claims 20 to 34, the apparatus further comprising means arranged to calculate the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network as a percentage.

36. The apparatus of claim 35, the apparatus further comprising a processor adapted to, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is 25% or higher, identify the device network activity as too high.

37. The apparatus of claim 35 or claim 36, the apparatus further comprising a processor adapted to, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is between 10% and 25%, identify the device network activity as too high.
38. The apparatus of any of claims 35 to 37, the apparatus further comprising a processor adapted to, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 10%, identify the device network activity as acceptable.

39. The apparatus of any of claims 35 to 38, the apparatus further comprising, if the device is using GPRS and the proportion of the test period during which the strength of the received signals is determined to correspond to the device attempting to access a communications network is below 5%, identify the device network activity as good.

40. The apparatus of any one of claims 20 to 39, wherein the mobile communication device is a smartphone.

41. Apparatus and/or method for testing a mobile communication device substantially as shown in or as described with reference to the accompanying figures.
A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC:

INV. H04B17/00 H04W52/22

ADD.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols):

H04B H04W

Electronic data base consulted during the international search (name of date base and, where practicable, search terms used):

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>WO 2012/074451 AI (ERICSSON TELEF0N AB L M [SE]; HELLANDER B0 [SE]) 7 June 2012 (2012-06-07) the whole document</td>
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X Further documents are listed in the continuation of Box C. X See patent family annex.

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Date of the actual completion of the international search: 28 February 2014

Date of mailing of the international search report: 10/03/2014

Name and mailing address of the ISA:

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Authorized officer: Boetzel, Ulrich
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