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(71) Applicant: **THE SECRETARY OF STATE FOR DEFENCE** [GB/GB]; DSTL, Porton Down, Salisbury, Wiltshire SP4 0JQ (GB).

(72) Inventor: **BOYES, Stephen John**; DSTL IP Group, G02 Building 005, DSTL Porton Down, Salisbury, Wiltshire SP4 0JQ (GB).

(74) Agent: **FARNSWORTH, Alastair Graham**; DIPR Formalities Section, Poplar 2#2214, MOD Abbey Wood (South), Bristol BS34 8JH (GB).

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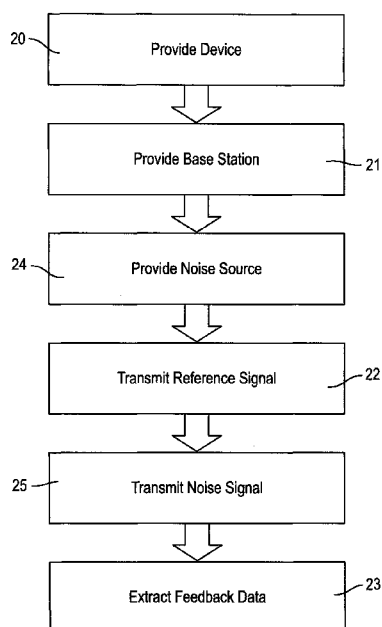
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(54) Title: OVER THE AIR TEST CONFIGURATION AND METHOD

Fig. 2B



(57) Abstract: A method of testing wireless devices (optionally mobile phone handsets) having means for generating feedback data in response to received signals. A wireless device is located in a reverberation chamber (20) with a provided base station antenna (21) and optionally a noise antenna (24). A reference signal (22) and optionally a noise signal (25) are transmitted to the wireless device from the respective base station and noise antennas. Feedback data from the wireless device (optionally reference signal received power 'RSRP' and quality 'RSRQ') is extracted (23), enabling the performance of the wireless device in the given signal environment to be measured. Particularly suited to laboratory testing of mobile phone handsets in representative signal environments. Also relates to a test configuration for performing the same.

OVER THE AIR TEST CONFIGURATION AND METHOD

Technical Field of the Invention

This invention relates to the field of over the air testing (OTA) of wireless devices, in particular to test configurations and methods that utilise reverberation chambers.

Background to the Invention

Reverberation chambers can be used to emulate a variety of different multipath environments within which non-line-of-sight wireless communication systems typically operate. The chambers were originally proposed for laboratory based electromagnetic compatibility testing of wireless devices but are now gaining widespread acceptance for over the air (OTA) performance testing of wireless devices and networks.

A reverberation chamber (RC) can be described as a shielded metallic cavity that is typically operated in an over-mode condition (i.e. many resonant modes). The electromagnetic fields inside the cavity are formed as a result of standing waves which have a sine and cosine dependence. The electromagnetic fields are typically 'mode stirred' to render the field distribution within the chamber statistically homogenous, such that a wireless device will receive substantially the same time-averaged signal environment at different locations within the chamber. Through use of mode stirring and channel emulation techniques, the electromagnetic environment (K factors, delay spreads, coherence bandwidths and coherence times) within the chamber can also be tuned which emulates various propagation scenarios.

In conventional testing using reverberation chambers, passive antennas are often used and direct access to raw measurement data will exist (via use of test equipment such as vector network analysers) which can be processed to determine the performance of a wireless device and/or system under test. This conventional approach however does not readily extend to active wireless devices and wider systems.

Therefore it is an aim of the present invention to provide an alternative test method and configuration for over the air testing of active wireless devices.

Summary of the Invention

According to a first aspect of the invention there is provided a method of testing a wireless device, the method comprising the steps of: locating a wireless device in a reverberation chamber, the wireless device comprising means for generating feedback data in response to a received signal; locating a base station antenna in the reverberation chamber; transmitting at least one reference signal to the wireless device from the base station antenna; and then extracting feedback data from the wireless device; such that the performance of the wireless device in receiving the at least one reference signal can be measured.

Modern day communication networks utilise multiple input multiple output (MIMO) channels to increase channel capacity and throughput and also to mitigate multipath fading. Therefore when testing modern wireless devices -, it is essential to replicate the MIMO environment and the various channel conditions. For instance statistical behaviour (owing to the time varying signals associated with modern non-line-of-sight communications), delay spreads, coherence bandwidths, coherence time and Doppler, will have a direct influence on the performance of a wireless device. Whilst a reverberation chamber can be used to emulate these conditions with appropriate measurement setup, prior art test configurations and methodologies have not adequately provided for the testing of active wireless devices (such as mobile phone handsets).

A reverberation chamber may support many resonant modes (electromagnetic fields formed as result of standing waves). Naturally this generates variations in electromagnetic field distribution with position in the chamber. This is undesirable from a measurement perspective as deviations in position of a device under test will result in different experimental conditions. Furthermore such an environment must be time varying to be representative of real non-line-of-sight communications scenarios. To mitigate these effects, the electromagnetic environment within the reverberation chamber may be 'mode stirred'

to render the electromagnetic fields statistically homogenous when averaged over time. Field measurements within the reverberation chamber are usually made using passive devices under test, or 'sense antennas', that provide direct access to raw signal measurements, that can be subsequently processed.

The inventor has identified that when seeking to test the receive performance of an active wireless device (such as a mobile phone handset), prior art test methodologies are not suitable. This is because active wireless devices do not typically provide access to raw received signal measurements from which to perform a statistical average (such as can be achieved using passive devices and vector network analysers, for example). This issue is further compounded when testing the ability of an active wireless device to receive a reference signal (for instance from a mobile phone base station) in the presence of noise source, as there is no means within the active device of separating the two raw received signals to correlate the signal to noise with receiver performance. Employing separate passive antennas to measure the electromagnetic field within the reverberation chamber (to obtain signal and noise measurements) is not effective either, as the active wireless devices will be relying on instantaneous field value measurements and performing their own processing, and the passive antennas would be positioned at different locations to the active wireless device, and therefore would experience different instantaneous electromagnetic fields, or indeed process the received signals differently. In addition, any surrogate 'sense antenna' would have different antenna performance characteristics to the - performance of the active wireless device, and therefore would not be a true representation of what is 'observed' by the wireless device at any instance in time. Furthermore direct instrumentation of an active wireless device to obtain raw received signal measurements is undesirable, as such instrumentation can affect the performance of the active device.

In response to these issues the inventor has implemented the method of the invention that enables representative testing of active wireless devices. Active wireless devices such as mobile phone handsets, when in communication with a mobile telecommunications base station, generate feedback data when receiving base station reference signals. These feedback signals are communicated wirelessly back to the base station to indicate the

receipt, power and quality of the received signals. The inventor has shown that when testing an active wireless device in a reverberation chamber, this feedback data can be used to directly indicate the performance of the active device, in a variety of emulated electromagnetic environments and differing channel conditions. Such a method offers the ability to use a representative wireless device (the actual mobile phone handset, for instance) in experiments as both the device under test, but also as a 'sense antenna' for determining received signal power and quality. This avoids the requirement to instrument the device and potentially influence the behaviour of the device when under test.

In preferred embodiments of the invention the step of transmitting at least a first reference signal comprises the steps of: establishing a network connection between the base station antenna and the wireless device; and then transmitting a plurality of reference signals to the wireless device using the base station antenna. The ability to transmit a plurality of reference signals means a wide range of different MIMO performance scenarios can be evaluated. For instance the long term evolution (LTE) telecommunication standard comprises a plurality of transmission modes exploiting single transmit antennas; multiple antennas; or open and closed loop spatial multiplexing. Reference signals can be transmitted to stimulate one or more of these communication channels to evaluate device response.

Preferably the feedback data generated by the wireless device comprises received signal indications. This may be a binary flag generated within the wireless device when a reference signal is received through a corresponding MIMO channel. The binary flag being wirelessly communicated back to the base station antenna to indicate reference signal receipt in the respective channel. Even more preferable is that the feedback data comprises reference signal received power (RSRP). RSRP is the average power received from a reference signal. A reference signal may be transmitted at a constant power, and therefore RSRP provides a reliable means of measuring the receive performance of a wireless device. Furthermore because RSRP is an average value, it can be used as a statistical measurement of the time varying electromagnetic environment within a reverberation chamber, which in turn means that physical position of the active device within the chamber has less of an effect performance measurements. Even more preferable is that the feedback data comprises

reference signal received quality (RSRQ). The RSRQ provides an indication of the quality of a received reference signal, and therefore can provide further evidence of how a given wireless device performs in different simulated electromagnetic environments.

Some embodiments further comprise the step of providing a means for processing data, the means for processing data being operable to control a base station emulator connected to the base station antenna and thereby to request feedback data from the wireless device. The means for processing data may comprise computer code and enables automated transmission of reference signals and storing of feedback data, in synchronisation with the control of other hardware of the reverberation chamber (which may also be controlled using software).

In some embodiments the step of providing a base station antenna comprises positioning the base station antenna at least half an operational wavelength away from the walls, ceiling and floor of the reverberation chamber, and the wireless device. This helps to ensure the antenna experiences a substantially uniform field distribution that is less affected by the boundaries of the chamber. The operational wavelength is intended to be the wavelength corresponding to the chambers lowest usable frequency.

Certain embodiments of the method further comprise the steps of: locating a noise antenna into the reverberation chamber, the noise antenna being connected to a noise generator; and transmitting a noise signal to the wireless device using the noise generator. The noise signal can be used to subject the wireless device to background noise in the electromagnetic environment whilst it attempts to acquire and receive the reference signals. Therefore the ability of the wireless device to receive signals at various signal to noise ratios can be examined. Preferably the noise signal has a predetermined power level and bandwidth. The noise signal may for instance be pre-programmed into an arbitrary waveform generator for triggered playback. The power level and bandwidth may be predetermined for each test, such that the noise signal can be varied in a known manner.

Some embodiments of the method further comprise the step of measuring a signal to noise ratio between the reference and noise signals, the signal to noise ratio being measured prior

to transmission through the respective base station and noise antennas. When subjecting a wireless device to both reference signals (which it is seeking to receive) and noise signals -, the aim of the measurement may be to determine the particular signal to noise at which point a reference signal cannot be acquired by the wireless device. Or moreover the effect of different signal to noise ratios on reference signal received power (RSRP) and reference signal received quality (RSRQ) may be being examined. The wireless receiver may not provide a power value for the reference signal and noise signal separately, and so a different means for obtaining a signal to noise ratio is required. The inventor has chosen to measure the reference signal power and noise signal power prior to transmission through the respective base station and noise antennas. This measurement is performed outside of the reverberation chamber by using a power divider to channel either a portion of the reference signal or noise signal to a signal/spectrum analyser. The inventor has shown that using the same power divider and cabling (same cable length) whether measuring the reference signal or noise signal, ensures the signal to noise ratios are measured precisely at the same 'point' in the measurement system and under the same conditions.

In some embodiments of the method the step of providing a noise antenna comprises positioning the noise antenna at least half an operational wavelength away from the walls, ceiling or floor of the reverberation chamber, the base station antenna, and the wireless device. This positioning avoids any mutual coupling effects between antennas.

In preferred embodiments of the method the reverberation chamber comprises a means for mode stirring. The means for mode stirring is used to render the electromagnetic field distribution within the reverberation chamber, statistically uniform and isotropic when averaged over time. The means for mode stirring may comprise mechanical stirrers, polarisation stirrers, platform and position stirrers or frequency stirrers. Preferably the means for stirring comprises vertical and horizontal paddles for mechanical stirring. The paddles may be configured to rotate or move in a step wise or continuous manner, with each rotation or movement altering the boundary conditions for the electromagnetic field inside the reverberation chamber. The vertical paddle may comprise a set of planar elements on a rotational shaft mounted from the floor to the ceiling of the chamber that are ideally configured to provide for an asymmetric rotational profile. The horizontal paddle

may comprise a set of planar elements on a rotational shaft mounted onto one of the inside walls of the chamber. Vertical and horizontal paddles are required owing to changes in polarisation of reflected waves inside the chamber, regardless of the polarisation of radiation emitted from an antenna inside the chamber. The paddles should be electrically large at the chamber's / particular test's frequency of operation.

In preferred embodiments of the method the wireless device is a mobile phone. The inventor has shown the method can be used effectively to assess the receive performance of active wireless devices such as mobile phones, which are expected to operate in non-line-of-sight environments and under different channel conditions. Furthermore the inventor has shown that feedback data generated within a mobile phone can be extracted in an emulated environment and used to monitor receive performance.

According to a second aspect of the invention there is provided a test configuration in a reverberation chamber, the test configuration comprising a base station antenna and a wireless device to be tested, the wireless device comprising means for generating feedback data in response to a received signal, wherein the base station antenna is connected to a base station emulator located external to the reverberation chamber, the base station emulator being configured to transmit through the base station antenna at least one reference signal and to receive respective feedback data from the wireless device. Using the feedback data generated by a wireless device to monitor the receive performance of the device mitigates the limitations associated with prior art test configurations when testing active wireless devices.

Preferred embodiments of the second aspect of the invention further comprise a noise antenna located inside the reverberation chamber and connected to a noise generator for transmitting a noise signal. This provision - enables the receive signal performance of a wireless device to be examined whilst also subject to noise or interference clutter. Even more preferred embodiments comprise means for measuring a signal to noise ratio of the reference and noise signals. The signal to noise ratio is the ratio of the reference signal power and the noise signal power. The means for measuring the signal to noise ratio may be a signal or spectrum analyser receiving the input signals to the base station and noise

antennas. These preferred embodiments enable wireless device performance to be evaluated against different signal to noise ratios.

Preferably the base station and noise antennas, and the wireless device, are positioned at least half an operational wavelength away from each other and the walls, floor and ceiling of the reverberation chamber, to mitigate mutual coupling effects or degradation of antenna performance.

Some embodiments of the second aspect of the invention comprise means for mode stirring. The means for mode stirring acts to render the electromagnetic field variation in the reverberation chamber statistically uniform and isotropic when averaged over time. The means for mode stirring may comprise vertical and horizontal paddles for mechanical stirring inside the chamber. Even more preferably the paddles have an asymmetric rotational profile.

Brief Description of the Drawings

Embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 provides an illustration of an embodiment of a test configuration of the invention;

Figure 2A illustrates the steps of an embodiment of the method; and

Figure 2B illustrates the steps of a different embodiment of the method.

Detailed Description

Figure 1 shows an illustration of a test configuration in a reverberation chamber. Inside a reverberation chamber 10 there are three individual sets of antennas: a base station antenna 13; a noise antenna 14; and a wireless device under test 15. The wireless device 15 is an active mobile phone handset. The antennas 13 and 14 are configured such that they are not radiating directly towards device 15 (i.e. configured with non-line of sight). The base station antenna 13 and noise antenna 14 are positioned at least half an operational wavelength apart from each other inside the chamber 10. They are also positioned at least

half an operational wavelength away from the walls, floor and ceiling of the chamber 10. Antennas 13 and 14 are directional antennas and are orientated to radiate towards mechanical stirring paddles 11 and 12 to ensure effective scattering of radiation within chamber 10. Active wireless device 15 is also positioned at least half a wavelength away from the walls, floor and ceiling of chamber 10. All antenna sets 13, 14, and 15, are mounted on non-metallic stands to mitigate coupling effects.

The base station antenna 13 is a dual-port, dual polarised antenna suitable for setting up dedicated network channels with active wireless device 15. Both ports of base station antenna 13 are fed with separate RF cables connected to a base station emulator CMW 16. The base station emulator CMW 16 is controlled by a means for processing data in the form of a personal computer 'PC' 9. The PC 9 is connected to the base station emulator CMW 16 through an Ethernet switch 17 shown as 'SWITCH' in the figure. The PC 9 is configured to select and request a transmission mode for the base station emulator CMW 16. The transmission mode is one of the Long Term Evolution (LTE) transmission modes. The noise antenna 14 is connected to a noise generator in the form of a vector signal generator SMU 18 also controlled by the PC 9. For timing synchronisation there are BNC cables connecting the base station emulator CMW 16 and the vector signal generator SMU 18. For triggering synchronisation, a separate BNC cable connects the base station emulator CMW 16 to the vector signal generator SMU 18. RF cables from the vector signal generator SMU connect into a power divider 8 to allow a sampling of output power for determining signal to noise ratios. This cable can be switched over to the base station emulator CMW 16 to also determining a power measurement. By using the same cabling the signal to noise ratio determined between the base station emulator CMW 16 and the vector signal generator SMU 18 is based on power measurements taken at the same 'point' in the signal generation simulation. The vector signal generator SMU 18 is also connected to the PC through the SWITCH 17. A signal analyser (FSL) 19 is also connected to the power divider 8 and to the host PC 9 through the SWITCH 17. For direct communication between the PC 9 and the active wireless device 15 a USB cable is provided. This enables device 15 to be reset if needed. All of the signal generation and measurement equipment interfaces with SWITCH 17 to enable PC control.

The reverberation chamber 10 also contains a horizontal paddle 11 and a vertical paddle 12 for mechanical stirring. Each paddle 11 and 12 is driven with a motor controlled by the PC 9. The motors are connected to the PC through an RS232 connection.

In use, antennas 13, 14, and 15 are setup inside the chamber 10. The base station emulator CMW 16 is configured for a particular test. The signal analyser FSL 19 is configured with exact corresponding centre frequency and bandwidth settings as the base station emulator CMW 16. The vector signal generator SMU 18 is configured with a noise signal file to playback upon being triggered through noise antenna 14. The PC 9 is configured to specify the mechanical stirring sequences for paddles 11 and 12. Signal measurements are taken on signal lines from the base station emulator CMW 16 and the vector signal generator SMU 18 to determine a signal to noise ratio for the given test. The base station emulator CMW 16 then configures and requests a dedicated wireless network connection with the active wireless device 15. The vector signal generator SMU 18 then transmits a noise signal, according to the noise file, at a predefined bandwidth and power level. The base station emulator CMW 16 attempts to send 10 reference signals to the device 15. The device 15 reports back to the base station emulator CMW 16 how many of the reference signals were successfully received, in addition to reference signal received power (RSRP) and reference signal received quality (RSRQ). This information is stored in memory of PC 9. The vector signal generator SMU 18 is then stopped from transmitting. The paddles 11 and 12 are adjusted for the next test, and the method can be repeated for subsequent test scenarios.

The configuration presented may additionally be used with a passive wireless device that generates feedback data on received signals if the feedback data can be extracted through other means (such as the USB connection). The device 15 may be orientated in different directions, particular if the device 15 is providing feedback data based on an instant in time (such that the electromagnetic field distribution inside the chamber is not perceived as homogenous, and therefore different positions/orientations of the device 15 may result in different feedback data). The reference signals transmitted from the CMW 16 through base station antenna 13 may be based on the Long Term Evolution (LTE) protocol. A plurality of said reference signals may be transmitted to evaluate device 15 performance across a number of MIMO channels. All operations performed using the equipment of the

configuration shown may be controlled by software in the PC 9. The software may for instance comprise MATLAB code.

Figure 2A provides an illustration of an embodiment of a method of testing a wireless device. The method comprises the step of providing a device 20, the device may be an active wireless device such as a mobile phone, or a passive wireless device. The device comprises a means for generating feedback data, such as reference signal received power (RSRP). The device is provided into a reverberation chamber. The method further comprises the step of providing a base station 21. The base station comprises an antenna inside the reverberation chamber and a base station emulator connected to the antenna, but positioned outside the reverberation chamber. The step of transmitting a reference signal 22 is also provided. One or more reference signals may be transmitted from the base station to the wireless device under test. A reference signal being a signal that the wireless device can generate feedback data for (for instance a Long Term Evolution (LTE) mobile phone reference signal). As part of transmitting a reference signal 22, the base station establishes a network connection with the wireless device under test. The step of extracting feedback data 23 is also provided, wherein feedback data such as RSRP relating to a reference signal received by the wireless device under test is extracted. Using this method the receive performance of an active wireless device can be evaluated in the laboratory.

Figure 2B provides an illustration of an alternative embodiment of a method of testing a wireless device. The method comprises the same steps in Figure 2A of providing a device 20; providing a base station 21; transmitting a reference signal 22; and extracting feedback data 23. The method further comprises the step of providing an noise source 24. The noise source comprising a noise antenna connected to a noise generator. The noise antenna is positioned within the reverberation chamber, the noise generator being positioned outside of the reverberation chamber. This embodiment of the method further comprises the step of transmitting a noise signal 25 within the chamber. The noise signal 25 affects the ability of the wireless device to detect and register the reference signal. The step of extracting feedback data 23 reflects the effect of the noise signal. For instance RSRP may be reduced, or reference signal received quality (RSRQ) may evidence a reduction in reference signal

quality. This embodiment of the method allows active wireless device receive performance to be evaluated in the presence of different forms of background noise.

CLAIMS

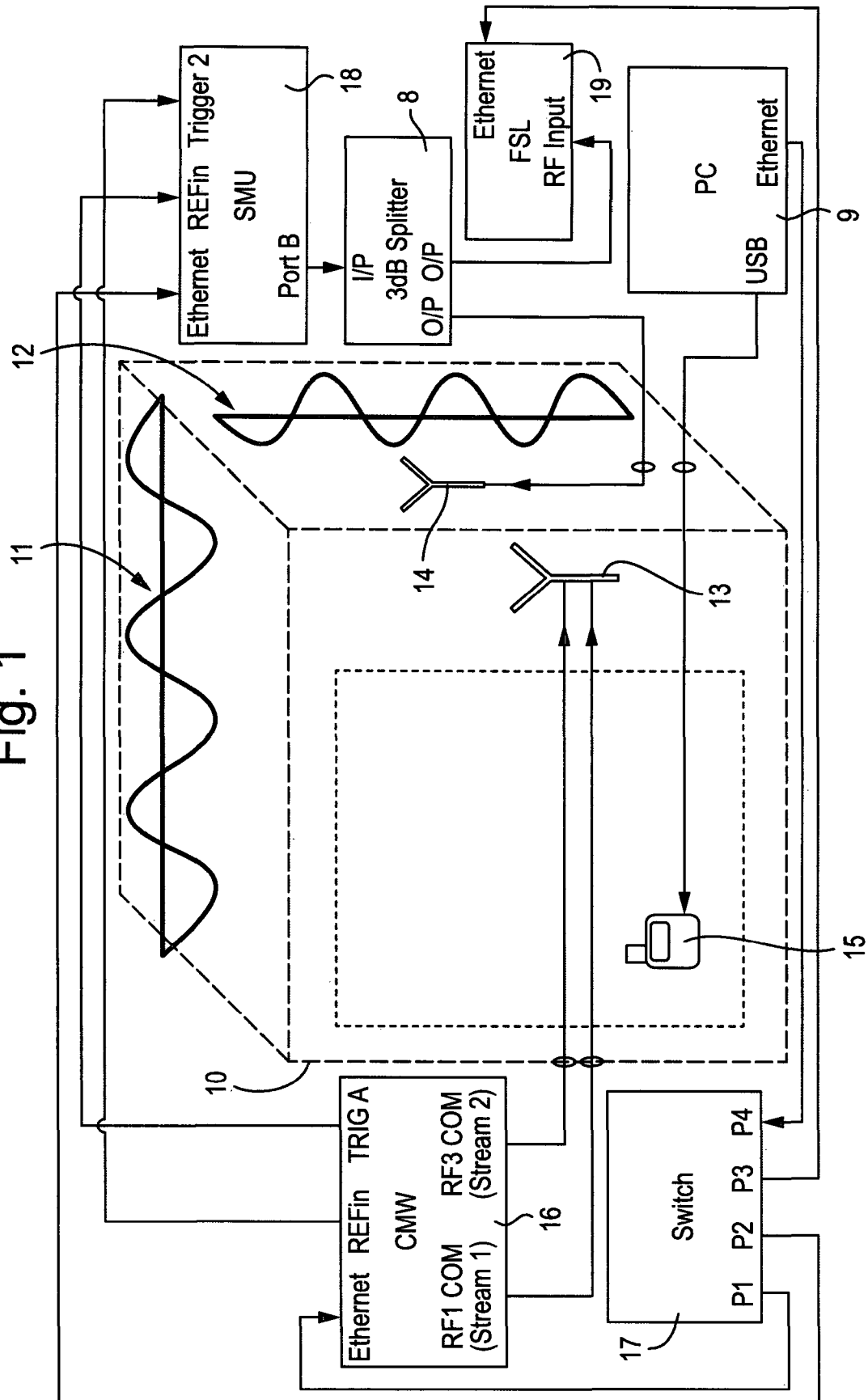
1. A method of testing a wireless device, the method comprising the steps of:
 - a) locating a wireless device in a reverberation chamber, the wireless device comprising means for generating feedback data in response to a received signal;
 - b) locating a base station antenna in the reverberation chamber;
 - c) transmitting at least one reference signal to the wireless device from the base station antenna; and then
 - d) extracting feedback data from the wireless device;such that the performance of the wireless device in receiving the at least one reference signal can be measured.
2. The method of claim 1 wherein the step of transmitting at least a first reference signal comprises the steps of:
 - e) Establishing a network connection between the base station antenna and the wireless device; and then
 - f) Transmitting a plurality of reference signals to the wireless device using the base station antenna.
3. The method of any one of claims 1-2 wherein the feedback data comprises received signal indications.
4. The method of claim 3 wherein the feedback data comprises reference signal received power (RSRP).
5. The method of claim 4 wherein the feedback data further comprises reference signal received quality (RSRQ).
6. The method of any preceding claim further comprising the step of providing a means for processing data, the means for processing data being operable to control a base

station emulator connected to the base station antenna and thereby to request the feedback data from the wireless device.

7. The method of any preceding claim wherein the step of locating a base station antenna comprises positioning the base station antenna at least half an operational wavelength away from the walls, ceiling and floor of the reverberation chamber, and the wireless device.
8. The method of any preceding claim further comprising the steps of:
 - g) locating a noise antenna in the reverberation chamber, the noise antenna being connected to a noise generator; and
 - h) transmitting a noise signal to the wireless device using the noise generator.
9. The method of claim 8 wherein the interference signal has a predetermined power level and bandwidth.
10. The method of any one of claims 8-9 further comprising the step of measuring a signal to noise ratio between the reference and noise signals, the signal to noise ratio being measured prior to transmission through the respective base station and noise antennas.
11. The method of any one of claims 8-10 wherein the step of locating a noise antenna comprises positioning the noise antenna at least half an operational wavelength away from the walls, ceiling and floor of the reverberation chamber, the base station antenna, and the wireless device.
12. The method of any preceding claim further comprising the step of providing a means for mode stirring.
13. The method of claim 12 wherein the means for mode stirring comprises horizontal and vertical paddles located inside the reverberation chamber.
14. The method of any preceding claim wherein the wireless device is a mobile phone.

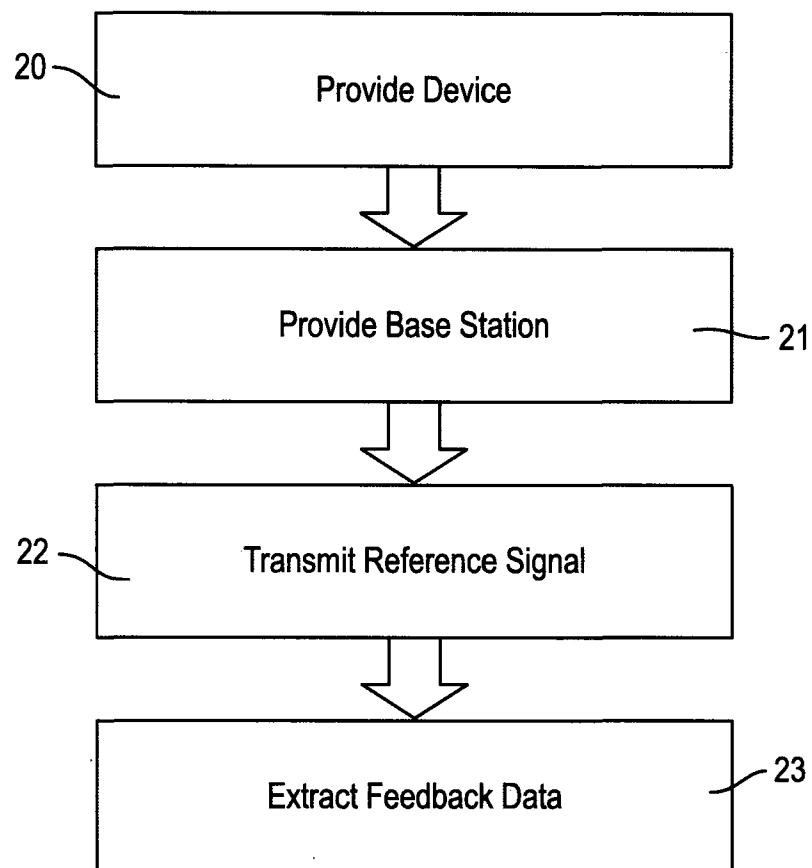
15. A test configuration in a reverberation chamber, the test configuration comprising a base station antenna and a wireless device to be tested, the wireless device comprising means for generating feedback data in response to a received signal, wherein the base station antenna is connected to a base station emulator located external to the reverberation chamber, the base station emulator being configured to transmit through the base station antenna at least one reference signal and to receive respective feedback data from the wireless device.
16. The test configuration of claim 15 further comprising a noise antenna inside the reverberation chamber and connected to a noise generator for transmitting a noise signal.
17. The test configuration of claim 16 further comprising means for measuring a signal to noise ratio between the reference and noise signals.
18. The test configuration of any one of claims 16-17 wherein the base station and noise antennas, and the wireless device, are positioned at least half an operational wavelength away from each other and the walls, floor and ceiling of the reverberation chamber.
19. The test configuration of any one of claims 15-18 further comprising means for mode stirring.
20. The test configuration of claim 19 wherein the means for mode stirring comprises a rotationally asymmetric paddle.

Fig. 1



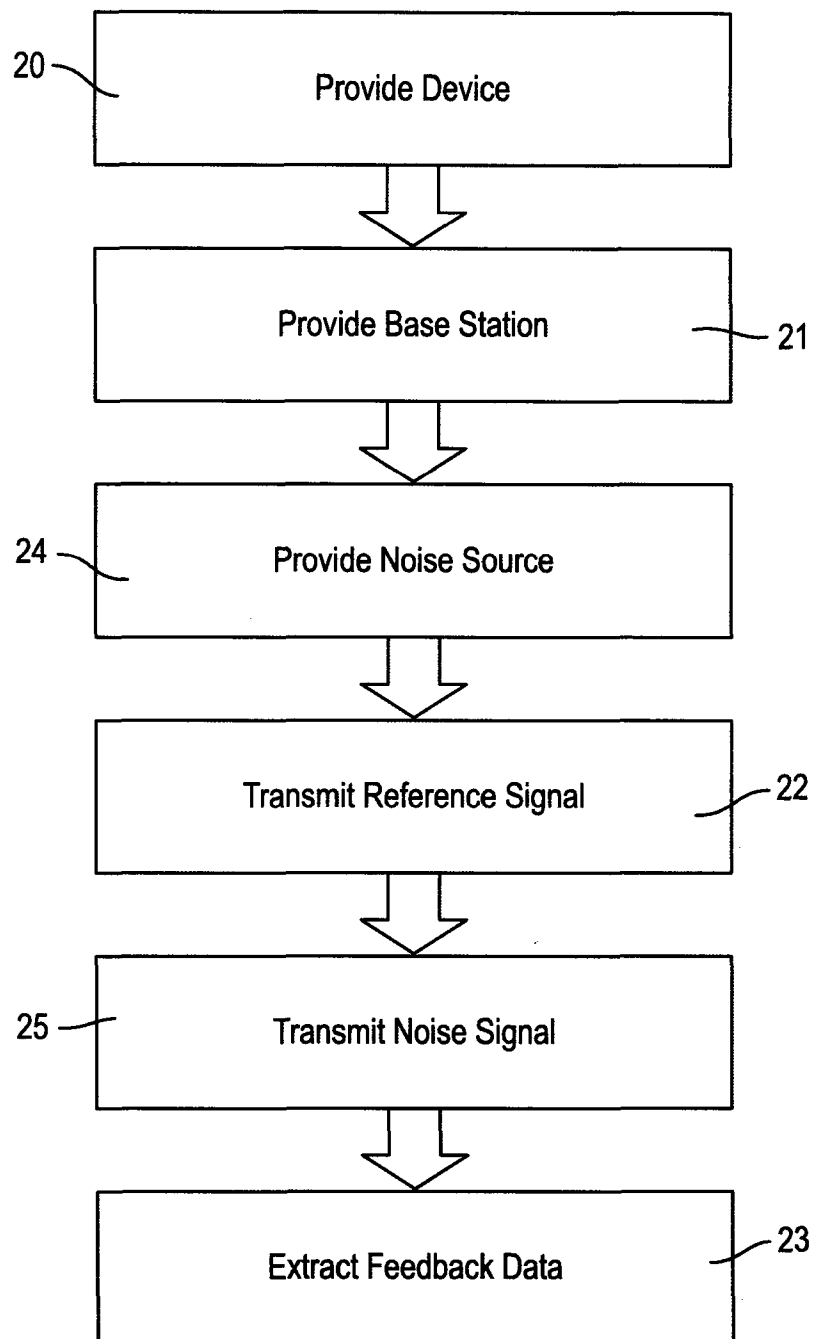
2/3

Fig. 2A



3/3

Fig. 2B



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/000125

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B17/29
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2013/303089 A1 (WANG XIAOWEN [US] ET AL) 14 November 2013 (2013-11-14) paragraph [0044] - paragraph [0050] paragraph [0089] - paragraph [0105] paragraph [0116] - paragraph [0119] paragraph [0136] - paragraph [0142] paragraph [0036] - paragraph [0043] paragraph [0052] - paragraph [0060] paragraph [0065] - paragraph [0000] ----- -/-	1-9, 11-20 10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

19 November 2019

Date of mailing of the international search report

26/11/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

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INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2019/000125

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 2 770 771 A1 (HUAWEI TECH CO LTD [CN]) 27 August 2014 (2014-08-27) paragraph [0032] - paragraph [0034] paragraph [0044] - paragraph [0054] paragraph [0062] - paragraph [0067] paragraph [0070] - paragraph [0079] paragraph [0081] - paragraph [0093] paragraph [0105] - paragraph [0114] paragraph [0124] - paragraph [0140] -----	1-9, 11-20
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