

RADIO TERMINAL TESTING DEVICE AND ELECTRICAL WAVE
ENVIRONMENT TESTING APPARATUS FOR THE RADIO TERMINAL
TESTING DEVICE

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BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a testing device used for testing a radio communication terminal (radio terminal). More specifically, the invention relates to an improved radio terminal testing device for establishing and controlling the electrical wave environment, and to an electrical wave environment testing apparatus for the radio terminal testing device.

Description of the Prior Art

FIG. 17 illustrates a conventional radio terminal testing device disclosed in a preliminary technical report of The Institute of Electronics, Information and Communication Engineers, 1997, B-1-6, "The Method for Constructing a Field Simulator for Evaluating Mobile Radio Terminals". In FIG. 17, a signalling tester 401 simulates a base station, an electrical wave absorber 409 covers one side of the inside surface of a measuring box 408, a distributor 402 is connected to the signalling tester 401 and distributes an output of the signaling tester 401 to phase-shifters 403. The phase-shifters 403 shift the phases of the signals output from the distributor 402. Each amplifier 406 amplifies the output signal from the respective phase-shifter 403. Transmitting antennas 407 are respectively connected to the amplifiers 406 and transmit the signal amplified in the amplifiers 406. A digital-to-analog (D/A) converter 405 generates a signal for switching the phase-shifters 403. A personal computer 404 control the D/A converter 405 to output timing signals for controlling the phase-shifter

403 and outputs digital data to control the operation of the signalling tester 401. A radio terminal 410 is an object of this test and placed inside the measuring box 408, and a receiving antenna 411 receives radio signal output from the radio terminal 410. Solid lines in FIG. 17 illustrate the flow of signals, and dotted lines illustrate the flow of the control signals.

The operation of the conventional terminal testing device is explained. The distributor 402 distributes the output signal received from the signalling tester 401, which is the source of the transmission signal having a single frequency, into plural signals. Each of the distributed signals randomly changes the phase of the output from the respective phase-shifters 403, based on the different random numbers generated by the personal computer 404 for the respective signals, using the signals output from the D/A converter 405. After the respective amplifiers 406 amplify the respective signals, the amplified signals are transmitted from the respective transmitting antennas 407, and the electrical waves are actually interfered in the measuring box 408 to generate fading. By placing the electrical wave absorber on one side of the inner surface of the measuring box 408 facing the transmitting antennas 407, the actual environment is simulated. That is, because the reflected electrical waves do not attenuate quickly, the electrical wave absorber 409 facilitates the attenuation of the electrical waves, to create similar environment to the actual environment. The fading generated in the radio terminal testing device has different distribution characteristics depending on the location where the radio terminal is placed inside the measuring box 408. The fading follows the Rayleigh distribution in one area of the measuring box 408, and follows the Rice distribution in the other area.

FIG. 18 shows a general fading simulator, which was disclosed in the laid-open Japanese Patent Publication 6-132865 as a prior art. This fading simulator simulates the variation of receiving signals caused by fading or multi-pass, by setting the moving speed. In FIG. 18, an input terminal 412 receives input signal, a

distributor 413 distributes the input signal into two lines. Gaussian noise generators 417 and 718 generate Gaussian noise, a 90-degree phase-shifter 414 shifts the phase of the input signal. A multiplier 415 multiplies the signal generated in the Gaussian noise generator 417 and the signal output from the distributor 413. Another multiplier 416 multiplies the signal generated in the Gaussian noise generator 418 and the signal output from the 90-degree phase-shifter 414. A synthesizer 419 synthesizes the signals on the two lines, one from the multiplier 415 and the other from the multiplier 416. An amplifier 420 amplifies the signal synthesized in the synthesizer 419. A delay time generator 421 generates delay, an amplifier 422 amplifies the signal output from the delay time generator 421, and the terminal 423 outputs the output signal.

The operation of the fading simulator illustrated in FIG. 18 is described below. A signal is input in the input terminal, and distributed into two lines by the distributor 413. The 90-degree phase-shifter 414, which is connected to the distributor 413, phase-shifts the distributed signal on one line so as to become orthogonal to the distributed signal on the other line. The multiplier 416, which is connected to the 90-degree phase-shifter 414, multiplies the signal output from the 90-degree phase-shifter 414 with a random noise generated in the Gaussian noise generator 418 to produce a random amplitude. The multiplier 415 multiplies the distributed signal on the other line with a random noise generated in the Gaussian noise generator 417 to produce a random amplitude. The synthesizer 419, which is connected to the multipliers 415 and 416, synthesizes the signals on the two lines whose phases are orthogonal and whose random amplitudes have no correlation, to output a signal having a random phase and random amplitude. This random signal is amplified in the amplifier 420, which is connected to the synthesizer 419, and is added with a delay time in the delay time generator 421, which is connected to the amplifier 420. The output from the delay time generator 421 is amplified again in the amplifier 422, and output to the output terminal 423. This output signal is radiated from the

transmitting antennas provided inside the measuring box 408, which is illustrated in FIG. 17.

5 The conventional radio terminal testing device simply simulates statistical fading distribution, and could not faithfully simulate the fading of a specific environment. This is because the characteristics of the measuring box limit conditions to be simulated. Moreover, even when testing takes place under the statistical fading distribution, it has been necessary to precisely control the position of the radio terminal which is the object of testing. In addition, the conventional device could not simulate the environment where radio waves arrive from plural base stations, just as in the
10 actual field.

Alternatively, a general fading simulator could simulate only signals of the statistical fading distribution, and could only test how the fading statistically behaves by the moving speed of the radio terminal.

15 SUMMARY OF THE INVENTION

It is an object of the present invention to solve the problems described above, and to provide a radio terminal testing device, which can simulate an actual specific environment and change the environment, and can carry out an operation test including
20 communication protocols with high reproducibility.

According to a first aspect of the invention, a radio terminal testing device comprises a base station for simulatively generating a base station signal; a phase-shifter for changing the phase of the base station signal; a transmission gain controller for changing the amplitude of the base station signal; a control information storage for
25 storing time variation information of the phase and amplitude of a radio signal which is received or pre-calculated at a radio terminal; and a controller for controlling the phase-shifter and the transmission gain controller based on the time variation information of

the phase and the amplitude stored in the control information storage; wherein the controller creates a fading state at the output terminal of a transmission gain controller by controlling phase and amplitude of the base station signal based on the time variation information of the phase and amplitude stored in the control information storage.

According to a second aspect of the invention, the radio terminal testing device further comprises a first separator for separating the upward and the downward signals at the input / output terminal of the base station; and a second separator for separating the upward and the downward signals at the input / output terminal of the radio terminal.

According to a third aspect of the invention, the radio terminal testing device further comprises: a reception gain controller for amplifying the signal received from the radio terminal and transmitting the amplified signal to the base station; wherein the first separator are placed between the base station and the phase-shifter and the reception controller, to output the transmission signal from the base station to the phase-shifter, and to input the receiving signal from the reception gain controller to the base station; the second separator are placed between the radio terminal and the reception gain controller and the transmission gain controller, to output the transmission signal from the transmission gain controller to the radio terminal, and to input the receiving signal from the radio terminal to the reception gain controller; the controller controls the phase-shifter, the transmission gain controller and the reception gain controller based on the information stored in the control information storage.

According to a fourth aspect of the invention, the radio terminal testing device further comprises a plurality of sets of the base station, the first separator, the reception gain controller, the phase-shifter and the transmission gain controller; a signal distributor, which are placed between the second separator and the plurality of the reception gain controller, for distributing the receiving signal from the radio

terminal to the respective reception gain controllers; and a mixer, which are placed between respective transmission gain controllers and the second separator, for mixing and outputting the transmitting signals sent from the respective transmission gain controller.

5 According to a fifth aspect of the invention, the radio terminal testing device wherein TDMA system is used for a radio communication system, the phase and amplitude information for each slot are used as time variation information of the phase and amplitude, which is stored in the control information storage, and the phase and the amplitude are varied for each slot.

10 According to a sixth aspect of the invention, the radio terminal testing device wherein said base station comprises base station signal transmitting / receiving terminal for transmitting and receiving the base station signal, and a plurality of delay signal output terminals for transmitting delayed base station signal, said plurality of delay signal output terminals are connected to respective phase-shifters for phase-
15 shifting the delayed signals, respectively, and the phase-shifters are connected to the respective transmission gain controllers for amplifying the delayed signal; a mixer is provided between the respective gain controllers and the second separator for mixing the transmission signals received from the respective transmission gain controllers to output the mixed signal to the second separator.

20 According to a seventh aspect of the invention, the radio terminal testing device wherein said plurality of the base stations comprise a plurality of synchronous type base stations each for simulatively generating base station signal based on the synchronization timing signal, and said radio terminal testing device further comprises a synchronization timing signal generator for generating the synchronous timing signal
25 which controls the synchronous type base stations; said control information storage controls the plurality of phase-shifters and the plurality of gain controllers, and controls the synchronization timing signal generator.

According to an eighth aspect of the invention, the radio terminal testing device further comprises a background base station signal generator comprising a pattern generator for generating background base station signal data and a modulator for modulating the generated background base station signal data to generate background base station signal based on the synchronization timing signal, which is generated by the synchronization timing signal generator.

According to a ninth aspect of the invention, the radio terminal testing device further comprises one or more noise generator for generating noise; and one or more transmitting gain controllers, which correspond to respective noise generators, for changing the amplitudes of the noise signals generated by the respective noise generators.

According to a tenth aspect of the invention, the radio terminal testing device controls the transmitting/ receiving timing according to the synchronization timing signal input from the outside of the radio terminal testing device.

According to an eleventh aspect of the invention, the radio terminal testing device further comprises an antenna for connecting the radio terminal of test object to the second separator, and a radio wave dark room for housing the radio terminal and the antenna inside.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing a radio terminal testing device according to a first embodiment of the present invention.

FIGS. 2A - 2C illustrate the amplitude and phase of the radio terminal device on the time axis according to the first embodiment of the present invention.

FIG. 3 is a block diagram showing a radio terminal testing device according to a second embodiment of the present invention.

FIG. 4 is a block diagram showing a radio terminal testing device according to a third embodiment of the present invention.

FIGS. 5A - 5C illustrate the amplitude and phase of the radio terminal device on the time axis according to a fourth embodiment of the present invention.

5 FIG. 6 is a block diagram showing a radio terminal testing device according to a fifth embodiment of the present invention.

FIG. 7 is a block diagram showing a radio terminal testing device according to a sixth embodiment of the present invention.

10 FIG. 8 is a block diagram showing a radio terminal testing device according to a seventh embodiment of the present invention.

FIG. 9 is a block diagram showing a radio terminal testing device according to an eighth embodiment of the present invention.

FIG. 10 is a block diagram showing a radio terminal testing device according to a ninth embodiment of the present invention.

15 FIG. 11 is a block diagram showing a radio terminal testing device according to a ninth embodiment of the present invention.

FIG. 12 is a block diagram showing another radio terminal testing device according to the ninth embodiment of the present invention.

20 FIG. 13 is a block diagram showing a radio terminal testing device according to the ninth embodiment.

FIG. 14 is a block diagram showing a radio terminal testing device according to the ninth embodiment.

FIG. 15 is a block diagram showing a radio terminal testing device according to the ninth embodiment.

25 FIG. 16 is a block diagram showing a radio terminal testing device according to the ninth embodiment.

FIG. 17 is a block diagram showing a conventional radio terminal testing

device.

FIG. 18 is a block diagram showing a conventional fading simulator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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Embodiment 1.

FIG. 1 is a block diagram showing a radio terminal testing device according to a first embodiment of the present invention. In FIG. 1, a base station 1 generates a base station signal simulatively, a phase-shifter 2 is connected to the base station 1 and shifts the phase of the base station signal output from the base station 1. A transmission gain controller 3 changes the amplitude of the waveform output from the phase-shifter 2. A controller 4 controls the base station, phase-shifter 2 and the transmission gain controller 3. A control information storage 5 stores control data, which is received or pre-calculated in the radio terminal, to control the phase-shifter 2 and the transmission gain controller 3. An output terminal 21 outputs signal from the transmission gain controller 3, and the radio terminal 6, which is an object for testing, is connected to the output terminal 21. In FIG. 1, the solid lines illustrate flows of signals, and the dotted lines illustrate flows of control signals.

The operation of the radio terminal testing device according to the first embodiment of the present invention is explained. Phase data and amplitude data, stored in the control information storage 5, are information obtained by delay profile measurement in an actual field and actual reception level measurement, or information calculated using rate racing method in a calculator. These information consists of values which are obtained by calculating phases and amplitudes at the position where signals are received from a base station at an arbitrary coordinate and at an arbitrary time, based on information affected by electrical wave transmission of buildings or roads in an urban area. Thus, this information corresponds to time change at a

specific point, or to a change caused by transportation moving on an arbitrary path in an arbitrary speed. The controller 4 controls the start and stop of transmission at a base station signal in the base station 1, and controls sequences. The controller 4 also controls the phase-shifter 2 and the transmission gain controller 3 using the above-mentioned phase and amplitude data which are stored in the control data storage 5. By changing the phase and amplitude of the signal output to the radio terminal 6, an arbitrary electrical wave environment such as fading can be simulated.

FIGS. 2A - 2C illustrate the process for controlling the phase and amplitude of a base station signal (testing signal) output from the radio terminal testing device according to the first embodiment of the present invention, on the time axis. In FIGS. 2A - 2C, the horizontal axis shows the time, which passes from the left hand side to the right hand side. FIG. 2A illustrates the amplitude information for controlling the transmission gain controller 3, and FIG. 2B illustrates the phase information for controlling the phase-shifter 2. These signals are both stored in the control information storage 5, read by the controller 4, and control the phase-shifter 2 and the transmission gain controller 3, respectively. FIG. 2C shows the phase and amplitude of a testing signal measured in a constant interval at the output terminal 2 when the radio terminal testing device of the present invention is controlled by the respective values illustrated in FIG. 2A and FIG. 2B. The length of the arrows shows the amplitude, and the rotation angle of the arrows from the y axis shows the phase. From FIG. 2C, it can be observed that the testing signal with arbitrary phase and amplitude is output at the output terminal 21, which is connected to the transmission gain controller 3, when the phase-shifter 2 and the transmission gain controller 3 are controlled based on the information stored in the control information storage 5.

As explained above, the radio terminal testing device according to the first embodiment of the present invention is constructed so that it can output signals having arbitrary state. Especially, by changing phase and amplitude based on the information

stored in the control information storage 5, it is possible for the radio terminal 6 to receive substantially the same signals transmitted from the base stations under particular environment by synthesizing the direct signal and other signals passing via various paths from the base station. Therefore, the radio terminal 6 can receive
5 substantially the same testing signal as one in an actual environment, which can achieve a test with high reproducibility.

Embodiment 2.

The invention according to the first embodiment explained above simulates a
10 base station transmission signal. In a second invention, however, the base station 1 further comprises a receiving function and a communication procedure, makes it possible to simulate a testing environment which is closer to the actual field.

FIG. 3 is a block diagram showing a radio terminal testing device according to the second embodiment of the present invention. In FIG. 3, a circulator 7 is
15 connected to a base station 1 to separate bidirectional signal into the upward and downward directions. A circulator 8 is connected to a radio terminal 6 to separate bidirectional signal into the upward and downward directions. A reception gain controller 9 changes the amplitude of the signal separated in the circulator 8. An output terminal 21 receives output from the second circulator 8. In FIG. 3, the
20 elements with the same numerals as in FIG. 1 are identical elements, or elements with identical functions, therefore, their explanation is omitted. Also, the duplicated explanation which is the same as that in the first embodiment is omitted.

The operation of the radio terminal testing device according to the second embodiment is explained. The (downward) transmission is output from the base
25 station 1 to the radio terminal 6 via the circulator 7, phase-shifter 2, transmission gain controller 3, circulator 8 and output terminal 21. The path in which the transmission signal passes is the same as that in the first embodiment, except for the circulators 7

and 8. On the contrary, the (upward) transmission, which is output from the radio terminal 6, is separated in the circulator 8 without passing through the transmission gain controller 3, and passes through the reception gain controller 9. The amplitude of the upward signal is adjusted in the reception gain controller 9 under the control of the controller 4, and the upward signal reaches the base station 1 via the circulator 7.

In this manner, the base station receives the signal from the radio terminal 6, and it is possible for the base station 1 to simulate a test which is performed by a base station in an actual field. Therefore, it is possible to perform a test with high reproducibility under substantially the same environment as in the actual field, not only for reception-transmission testing at the radio terminals, but also for a test which needs communication procedures such operations as originating and receiving calls and making conversation.

Embodiment 3.

The invention according to the second embodiment of the present invention simulates an electrical wave environment having one base station. In a third embodiment, however, the invention is characterized in that the electrical wave environments having plural base stations are simulated.

FIG. 4 is a block diagram illustrating a radio terminal testing device according to the third embodiment of the present invention. In FIG. 4, a mixer 10 mixes plural downward signals, and a distributor 11 distributes the upward signal which is output from the radio terminal 6 and separated in the circulator 8 into plural lines. In addition, the radio terminal testing device according to the third embodiment further includes plural sets comprising a base stations 1, a phase-shifter 2, a transmission gain controller 3 and a reception gain controller 9. In FIG. 4, the elements with the same numerals as in FIGS. 1 and 3 are identical elements, or elements with identical functions, therefore, their explanation is omitted. Also, the duplicated explanation

which is the same as that in the first and second embodiments is omitted.

The operation of the radio terminal testing device according to the third embodiment is explained. Phase and amplitude data of testing signals are stored in the control information storage 5 corresponding to the plural base stations 1, respectively.

5 The controller 4 controls the phase-shifter 2 and the transmission gain controller 3 to simulate electrical wave environment which varies for each base station 1. The base station signals, each of which is controlled independently, are mixed in the mixer 10, and transmitted to the radio terminal 6, which is the object of the test, via circulator 8. Output signals such as response signals from the radio terminal 6 are transmitted to the
10 distributor 11 via the circulator 8, and distributed into plural (upward) receiving signals, which correspond to the number of the base stations 1. Respective distributed (upward) receiving signals pass through respective reception gain controller 9, where their signal amplitudes are adjusted, respectively, and reach respective base station 1 via respective circulator 7.

15 Since the respective base stations can independently perform the communication procedures with the radio terminal 6, it is possible for the base station 1 to execute a test with a high reproducibility under an equivalent environment as in the actual field for the tests requiring plural base stations necessary for hand-over operations to switch the communicating mate base station, and for retry operations to
20 another base station, after failure or rejection in establishing a radio channel with a base station.

Embodiment 4.

A radio terminal testing device in a fourth embodiment, uses the radio terminal
25 testing devices according to the first to the third embodiment, and also uses TDMA system as the radio communication system, and controls phase and amplitude of a signal for each transmission slot. FIGS. 5A -5C illustrate the process for controlling

the phase and amplitude in the radio terminal testing device, according to the fourth embodiment of the present invention, on the time axis. The explanation below refers to an example of radio terminal testing device of FIG. 1 which uses the testing signal of TDMA system.

5 The darkened portions in FIG. 5A show the transmission slot timings in TDMA system generated by the base station 1. FIG. 5B illustrates one example of the gain control from the controller 4 to the transmission gain controller 3, based on the information stored in the control information storage 5. FIG. 5C illustrates one example of the phase control from the controller 4 to the phase-shifter 2, based on the information stored in the control information storage 5. The base station 1 generates and transmits the transmission signal only in the transmission slot timing periods, which are illustrated in FIG. 5A. Therefore, by controlling the phase and amplitude only when the transmission slot timings are generated, it is possible to change the phase control of the phase-shifter 2 and the gain control of the transmission gain controller 3 during the period between the transmission slot timings, where there is no transmission signal. In this manner, the constructions of the phase-shifter 2 and the transmission gain controller 3 can be simplified.

As explained above, by controlling the phase and amplitude only during the transmission slot timings, it is possible to reduce the response performance of the phase-shifter 2 and the transmission gain controller 3, and to greatly reduce the circuit scale and the amount of information stored, since the switching speed can be decreased.

Embodiment 5.

25 FIG. 6 shows a radio terminal testing device according to the fifth embodiment of the present invention. In FIG. 6, the base station 20 has delay output terminals, and outputs a base station signal and plural delayed base station signals. In FIG. 6,

the elements with the same numerals as in FIGS. 1, 3 and 4 are identical elements, or elements with identical functions, therefore, their explanation is omitted. Also, the duplicated explanation which is the same as that in the first to the fourth embodiments is omitted.

5 In FIG. 6, the base station 20 (with delay outputs) not only has an input-output terminal for simulating a base station, but also has plural outputs for outputting base station signals which have been delayed for predetermined time based on the delay information stored in the control information storage 5. Each of the delayed
10 signal are output from the base station 20 with delay and its phase and amplitude are controlled in the phase-shifter 2 and transmission gain controller 3, respectively, and then mixed in the mixer 10, and reaches the radio terminal 6 through the circulator 8.

Generally, a small delay can be reproduced by controlling the phase of the carrier. However, when the delay is closer to, or exceed 10% of symbol rate, where it is said that the error rate deteriorates in QPSK modulation, the delay cannot be
15 reproduced by simply controlling the phase. In order to deal with such situations, the base station is provided with a plurality of delay outputs, as illustrated in FIG. 6. The signals with different carrier delay time via a plurality of paths are synthesized or switched. In this manner, it is possible to simulate an arbitrary multipass electrical wave environment in a laboratory with high reproducibility.

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Embodiment 6.

The radio terminal testing device according to a sixth embodiment simulates electrical wave environment including relative operation timings between the plural base stations. FIG. 7 is a block diagram showing a radio terminal testing device
25 according to the sixth embodiment of the present invention. In FIG. 7, synchronous type base stations 12 synchronize transmission timing and reception timing based on the synchronization timing signal input from outside. A synchronization timing signal

generator 13 generates synchronization timing signal which controls the synchronous type base stations 12. The synchronization timing signal generator 13 is controlled by the controller 4 to generate synchronization timing signals for controlling the respective synchronous type base stations 12, and to control the relative operation timing of the respective synchronous type base stations 12, for realizing operation timing corresponding to actual environment.

PHS is used in the explanation below as an example of the synchronous type base station 12. The communication system of the PHS is usually TDMA (Time Division Multiple Access) or TDD (Time Division Duplex). In this system, eight slots are multiplexed in one frame, and four continuous slots are respectively assigned to the upward and downward channels. Furthermore, the control signals are broadcasted for every n frames (the number " n " is decided depending on system) so that the respective base stations can transmit control signals on the same frequency. The control information, broadcasted by the respective base stations, is repeated in a predetermined unit, and this unit is called "super frame." The synchronous type base station 12 for simulating PHS base station controls the synchronization between signals input or output from the synchronous type base station 12 by giving the start timing of the slots, the start timing of the frames, the start timing of the super frame, or combination of these timings.

It is also possible to control the relative operation timing of the respective synchronous type base station 12 based on the synchronization timing signal provided from the outside of the radio terminal testing device, without providing the synchronization timing generator 13, and to realize operation timing corresponding to the actual environment.

In this method, it is also possible to realize, for example, an environment where two base stations transmit signals on the adjacent slots, and the transmission timings of the two base stations drift gradually and finally cause a collision. Also, it

is possible to simulate significant variation of the electrical wave reaching path in case when the radio terminal 6 moves, by simulating the two base stations 12 in a same state by selecting one of the transmission gain controller 3.

5 Embodiment 7.

In the above-explained sixth embodiment, in order to simulate plural base stations, the same number of the synchronous type base stations 12, phase-shifters 2 and the transmission gain controllers 3 as that of the base stations is necessary. The invention according to a seventh embodiment, however, can omit the paths for
10 receiving the receiving signals for the base stations which do not perform communication procedure, and transmit plural transmission signals together.

FIG. 8 is a block diagram showing the radio terminal testing device according to the seventh embodiment. In FIG. 8, a background base station signal generator 14 simulates the transmission signals from plural base stations. A pattern generator 15
15 generates data transmitted by the background base station. A modulator 16 modulates the data generated by the pattern generator 15. In FIG. 8, the elements with the same numerals as in FIGS. 1, 3, 4 and 7 are identical elements, or elements with identical functions, therefore, their explanation is omitted. Also, the duplicated explanation which is the same as that in the first to the sixth embodiments is omitted.

20 The radio terminal testing device according to the seventh embodiment is characterized in the background base station signal generator 14, which is added to the radio terminal testing device as illustrated in FIG. 7 according to the sixth embodiment of the present invention. In this embodiment, "not performing communication procedure" means that the upward signal is not received at the base station side.
25 Therefore, it is not always necessary to provide phase-shifters 2 and the transmission gain controllers 3 corresponding to the base stations in the radio terminal testing device. In the background base station signal generator 14, the pattern generator 15

generates plural transmission signals all at once, then the modulator 16 modulates these signals, and transmits modulated signals via a pair of the phase-shifter 2 and the transmission gain controller 3. The controller 4 controls the respective phase-shifters 2 and the respective transmission gain controller 3 in the timings corresponding to the
 5 respective base stations. The background base station signals, generated in the background base station signal generator 14, are mixed with other signals transmitted from the plural synchronous type base stations 12, which simulate the base stations actually performing the communication procedure, then the mixed signals finally reach the radio terminal 6.

10 As explained above, for the radio terminal testing device according to the seventh embodiment, it is possible to simulate actual electrical wave environment using less device scale and appropriate signal combination by generating a desired number of base station signals together.

15 Embodiment 8.

In the above-explained embodiment 7, plural base stations are simulated. The invention according to the eighth embodiment is characterized in that noise signals in actual field can be also simulated.

FIG. 9 is a block diagram showing a radio terminal testing device according to
 20 the eighth embodiment of the present invention. In FIG. 9, a noise generator 17 generates noise. In FIG. 9, the elements with the same numerals as in FIGS. 1, 3, 4, 7 and 8 are identical elements, or elements with identical functions, therefore, their explanation is omitted. Also, the duplicated explanation which is the same as that in the first to the seventh embodiments shown in FIG. 8 is omitted.

25 The noise generator 17, which is controlled by the controller 4, generates noise signals of arbitrary frequencies. The transmission gain controller 3 adjusts the amplitude of the noise signals, which are generated in the noise generator 17, under

the control of the controller 4. The noise signals output from the respective transmission gain controllers 3 are mixed with the base station signals output from the respective synchronous type base stations 12 and from the respective background base stations 14 in the mixer 10, and finally reach the radio terminal 6.

5 In the radio terminal testing device according to the eighth embodiment, the controller 4 controls the transmission gain controllers 3 which control noises generated in the noise generators so as to actually realize electrical wave environment where random noise and burst noise occur. In addition, it is possible to generate random noise or burst noise by providing plural pairs of the noise generator 17 and the
10 transmission gain controller 3, and to realize more complex electrical wave environment.

Embodiment 9.

In the above-explained first to eighth embodiments, the radio terminal 6,
15 which is the object of the test, is directly connected to the input / output terminal 21 for receiving and transmitting the base station simulation signals. In the ninth embodiment, however, it is not necessary to directly connect the radio terminal to the input / output terminal 21, and it is possible to test the radio terminal 6 via antennas.

FIGS. 10 - 16 are block diagrams showing a radio testing terminal device
20 according to the ninth embodiment. The radio testing terminal devices according to FIGS. 10 - 16 respectively include a radio terminal 6, an antenna 18 to be connected to the radio terminal testing device and a radio wave dark room 19 for housing the antenna 18 and the radio terminal 6. In FIGS. 10 - 16, the elements with the same numerals as in FIGS. 1, 3, 4, and 6 - 9 are identical elements, or elements with
25 identical functions, therefore, their explanation is omitted. Also, the duplicated explanation which is the same as that in the first to the eighth embodiments is omitted.

Simulation base station electrical wave output from the radio terminal testing

device is already effected by fading or noise when being transmitted by the antenna 18. Therefore, in order to remove the effect caused by reflective wave after emission, the antenna 18 and the radio terminal 6 are housed in the radio wave dark room 19. The simulation base station electrical wave, which is output from the base station 1, is
5 transmitted from the antenna to the radio terminal 6, which makes it possible to perform the same tests as those explained for the first to eighth embodiments of the present invention.

In such construction as explained above, where the antenna 18 and the radio terminal 6 are housed in the radio wave dark room 19, the location of the radio
10 terminal can be determined by simply considering the attenuation caused by the distance from the antenna 18. Therefore, it is possible to realize the variation of the electrical wave environment under the moving condition of the radio terminal, without actually moving the location of the radio terminal 6. Accordingly, it is possible to perform various tests by simply placing the antenna 18 and the radio terminal 6 in the
15 radio wave dark room 19.



What is claimed is :

1. A radio terminal testing device comprising:
 - a base station for simulatngly generating a base station signal;
 - 5 a phase-shifter for changing the phase of the base station signal;
 - a transmission gain controller for changing the amplitude of the base station signal;
 - a control information storage for storing time variation information of the phase and amplitude of a radio signal which is received or pre-calculated at a radio
 - 10 terminal; and
 - a controller for controlling the phase-shifter and the transmission gain controller based on the time variation information of the phase and the amplitude stored in the control information storage;
 - wherein the controller creates a fading state at the output terminal of a
 - 15 transmission gain controller by controlling phase and amplitude of the base station signal based on the time variation information of the phase and amplitude stored in the control information storage.
2. The radio terminal testing device of claim 1 further comprising:
 - 20 a first separator for separating the upward and the downward signals at the input / output terminal of the base station; and
 - a second separator for separating the upward and the downward signals at the input / output terminal of the radio terminal,
 - wherein the base station realizes the communication procedure by not only
 - 25 outputting the base station signal generated in the base station to the radio terminal, but also by receiving the signal from the radio terminal.



3. The radio terminal testing device of claim 2 further comprises:

a reception gain controller for amplifying the signal received from the radio terminal and transmitting the amplified signal to the base station;

5 wherein the first separator are placed between the base station and the phase-shifter and the reception controller, to output the transmission signal from the base station to the phase-shifter, and to input the receiving signal from the reception gain controller to the base station;

10 the second separator are placed between the radio terminal and the reception gain controller and the transmission gain controller, to output the transmission signal from the transmission gain controller to the radio terminal, and to input the receiving signal from the radio terminal to the reception gain controller;

the controller controls the phase-shifter, the transmission gain controller and the reception gain controller based on the information stored in the control information storage; and

15 the base station realizes the communication procedure by not only outputting the base station signal generated in the base station to the radio terminal, but also by receiving the signal from the radio terminal.

4. The radio terminal testing device of claim 3 further comprising:

20 a plurality of sets of the base station, the first separator, the reception gain controller, the phase-shifter and the transmission gain controller;

a signal distributor, which are placed between the second separator and the plurality of the reception gain controller, for distributing the receiving signal from the radio terminal to the respective reception gain controllers; and

25 a mixer, which are placed between respective transmission gain controllers and the second separator, for mixing and outputting the transmitting signals sent from the respective transmission gain controller;



wherein the plurality of base stations realize a plurality of communication procedures by not only outputting the base station signals generated in the plurality of base stations to the radio terminal, but also by receiving the signal from the radio terminal.

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5. The radio terminal testing device of any one of claims 1 to 4, wherein TDMA system is used for a radio communication system, the phase and amplitude information for each slot are used as time variation information of the phase and amplitude, which is stored in the control information storage, and the phase and the amplitude are varied for each slot.

10

6. The radio terminal testing device of claim 3 wherein said base station comprises base station signal transmitting / receiving terminal for transmitting and receiving the base station signal, and a plurality of delay signal output terminals for transmitting delayed base station signal, said plurality of delay signal output terminals are connected to respective phase-shifters for phase-shifting the delayed signals, respectively, and the phase-shifters are connected to the respective transmission gain controllers for amplifying the delayed signal; and

15

a mixer is provided between the respective gain controllers and the second separator for mixing the transmission signals received from the respective transmission gain controllers to output the mixed signal to the second separator;

20

wherein the controller creates a fading state at the signal output terminal by controlling the phase of the phase-shifter and the amplitudes of the transmission gain controller, the base station realizes the communication procedure by receiving the signal from the radio terminal, thereby the radio terminal testing device simulates an environment where the signals, which passed through a plurality of propagation paths, reach the radio terminal with arbitrary delay.

25



7. The radio terminal testing device of claim 4 wherein
said plurality of the base stations comprise a plurality of synchronous type
base stations each for simulatngly generating base station signal based on the
5 synchronization timing signal;
said radio terminal testing device further comprises a synchronization timing
signal generator for generating the synchronous timing signal which controls the
synchronous type base stations; and
said control information storage controls the plurality of phase-shifters and the
10 plurality of gain controllers, and controls the synchronization timing signal generator;
wherein the controller creates a fading state at the signal output terminal by
controlling the phase of the phase-shifter and the amplitudes of the transmission gain
controller, the synchronous type base station realizes the communication procedure by
receiving the signal from the radio terminal, thereby the radio terminal testing device
15 simulates an environment where a plurality of signals, which passed through a
plurality of propagation paths from the plurality of synchronous type base stations,
reach the radio terminal with arbitrary delay.

8. The radio terminal testing device of claim 7 further comprising:
20 a background base station signal generator comprising
a pattern generator for generating background base station signal data
and
a modulator for modulating the generated background base station
signal data to generate background base station signal based on the
25 synchronization timing signal, which is generated by the synchronization
timing signal generator;
wherein the controller creates a fading state at the signal output terminal by



controlling the phase and the amplitudes of the background base station signal in the phase-shifter and the transmission gain controller, respectively, the synchronous type base station realizes the communication procedure by receiving the signal from the radio terminal, thereby the radio terminal testing device simulates an environment
5 where a plurality of signals from the synchronous type base stations reach the radio terminal with an arbitrary timing, and a plurality of the transmission signals from the base stations which do not perform the communication procedure are sent from one background base station signal generator.

10 9. The radio terminal testing device of claim 8 further comprising:
one or more noise generator for generating noise; and
one or more transmitting gain controllers, which correspond to respective noise generators, for changing the amplitudes of the noise signals generated by the respective noise generators;
15 wherein the mixer mixes the noise signals, which are amplified by the transmission gain controllers, with the base station transmission signals from the base stations.

20 10. The radio terminal testing device of any one of claims 7, 8 or 9
wherein the base station signals, which are output from the plurality of base stations, are controlled according to the synchronization timing signal input from the outside of the radio terminal testing device, thereby the radio terminal testing device simulates an environment where a plurality of signals from the plurality of base stations reach the radio terminal with an arbitrary timing.

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11. An electrical wave environment testing apparatus comprising the radio terminal testing device of any one of claims 1, 2, 3, 4, 6, 7, 8 or 9 further comprising:



an antenna for connecting the radio terminal of test object to the second separator, and a radio wave dark room for housing the radio terminal and the antenna inside;

5 wherein the radio terminal and the second separator are connected by radio signal to enable the radio terminal testing.