Claims

1. A system for calibration of a phased array antenna having a network of auxiliary channels internally injecting internal signals to the antenna, to be used in an environment including at least one interfering member affecting a calibration ratio of the antenna, the antenna comprising a plurality of mutually electro-magnetically coupled antenna elements, the system comprising:

an RF source external to the antenna, operative to project external signals toward the antenna when disposed at a near-by distance therefrom;

an RF simulation unit operative to generate simulated first electro-magnetic coupling -zero far-zone external fields projected toward the antenna from an RF source located at a far-zone distance from the antenna, assuming that first electro-magnetic coupling between the mutually electro-magnetically coupled antenna elements to be zero, and also operative to generate simulated first electro-magnetic coupling -zero near zone external fields projected toward the antenna from an RF source located at said near-by distance from the antenna were the first electro-magnetic coupling between said mutually electro-magnetically coupled antenna elements to be zero; and

a electro-magnetically coupled structure-accommodating calibration ratio computer operative to compute a Modified Calibration ratio by combining an indication of said internal signals and said external signals as received by the antenna, with a correction factor based on an output of said RF simulation unit.

2. A system according to claim 1 wherein said RF source comprises an RF point source.

3. A system according to claim 1 wherein said RF source is spherical.

4. A system according to claim 1 wherein said RF source is non-spherical.

5. A system according to claim 1 wherein said antenna calibrator is operative to combine said calibration ratio and said correction factor by adding the phases of the calibration ratio and said correction factor to obtain a phase value of the Modified

Calibration ratio and adding decibel representations of the amplitudes of the calibration ratio and said correction factor to obtain a decibel representation of an amplitude of the Modified Calibration ratio.

6. A system according to claim 1 wherein said RF simulation tool computes the correction factor by computing electromagnetic fields generated in and propagating within a non-continuous medium.

7. A system according to claim 1 wherein said antenna comprises a cellular antenna.

8. A system according to claim 1 and also comprising a platform upon which the antenna is mounted and wherein said interfering member is part of said platform.

9. A system according to claim 1 wherein said signal measurement and recording device measures amplitude and phase of the samples of said internal and external signals.

10. A method for calibrating an antenna comprising a phased array of antenna elements connected to plurality of transceivers, the method comprising:

providing an RF source of externally injected signals operative when located close to the antenna to be synchronized with the transceivers;

determining, per antenna element, a calibration ratio adapted to accommodate for presence of at least one interfering structure electromagnetically interfering with a signal transmitted from said RF source and received by the antenna; and

calibrating the antenna using the per-antenna element calibration ratios adapted to accommodate for presence of at least one interfering structure.

11. A method according to claim 10 wherein said determining includes:

generating simulated far field and near field signals so as to simulate a signal transmitted by an RF source located at infinity and located near the RF source respectively;

internally injecting an internal signal into the antenna via an internal injection network synchronized with the transceivers, wherein said interfering structure interferes with said internal signal;

using said RF source to externally inject an external signal into the antenna; and

for each individual antenna element, computing said calibration ratio by combining information characterizing said internal and external signals as received by said individual antenna element with a correction factor characterizing said simulated far field and near field signals and representing, per antenna element, the ratio of said simulated far field and near field signals.

12. A method according to claim 10 wherein at least one physical object which is electromagnetically coupled to radiation emitted by the RF source thereby to define unwanted radiation in context of said calibration, is present in the course of said determining and calibrating and is absent in a subsequent operational stage, the method also comprising screening said unwanted radiation.

13. A method according to claim 12 wherein said screening comprises covering said at least one physical object with RF-radiation absorbing material.

14. A method according to claim 13 wherein said determining and calibrating occurs on the ground, said operational stage is airborne and said physical object is fixed to the ground.

15. A method according to claim 10 wherein said determining comprises determining the calibration ratio a plurality of times thereby to obtain a plurality of interim calibration ratio results and averaging said plurality of interim calibration ratio results to obtain said calibration ratio adapted to accommodate for presence of at least one interfering structure.

16. A method according to claim 15 wherein said determining the calibration ratio a plurality of times includes re-positioning said RF source a plurality of times, thereby to compensate for artifactual noise generated by said at least one interfering structure during calibration ratio measurement.

~~17. A method according to claim 15 wherein said calibration ratio is determined a~~ plurality of times for a single position of said RF source, thereby to compensate for white noise during calibration ratio measurement.

18. A method according to claim 10 wherein said correction factor includes a phase and an amplitude and wherein said at least one interfering structure comprises a plurality of interfering structures and wherein generating at least one simulated signal comprises performing the following operations for a near field configuration and for a far field configuration:

a. computing a plurality of simulated first electromagnetic fields generated at the plurality of interfering structures respectively due to radiation emitted by the RF source;

b. computing a plurality of simulated induced currents generated at the plurality of interfering structures respectively due to radiation emitted by the RF source;

c. for each antenna element in the phased array of antenna elements:

1. simulating a second electromagnetic field generated at the antenna element due to radiation emitted by the RF source;

2. computing a plurality of simulated third electromagnetic fields generated at the antenna element due to said plurality of simulated induced currents respectively; and

3. generating a total field by summing said plurality of simulated third electromagnetic fields and said second electromagnetic field;

d. for each antenna element in the phased array of antenna elements:

1. computing a correction factor by computing a ratio of the total field as computed for the far field configuration divided by the total field as computed for the near field configuration; and

2. computing said phase and amplitude of said calibration ratio by measuring phase and amplitude for each of said internal and external signals as received by each of said antenna elements; and

e. for each individual antenna element, computing said calibration ratio adapted to accommodate for presence of at least one interfering structure by

computing a difference between said phases of said external and internal signals as received by said individual antenna element, and adding the phase of the correction factor.

19. A method according to claim 18 wherein said antenna is installed on an aircraft and said plurality of interfering structures include a fuselage, a first wing, a second wing, an engine, a stabilizer and a rudder.

20. A method according to claim 18 wherein said antenna is installed on an ship and said plurality of interfering structures include a hull, at least one mast and a bridge.

21. A method according to claim 18 wherein said antenna is installed on a tank and said plurality of interfering structures include a hull, a turret and a cannon.

22. A computer program product, comprising a computer usable medium having a computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method for calibrating an antenna comprising a phased array of antenna elements connected to plurality of transceivers, the method comprising:

providing an RF source located operative when located close to the antenna to be synchronized with the transceivers;

determining, per antenna element, a calibration ratio adapted to accommodate for presence of at least one interfering structure electromagnetically interfering with a signal transmitted from an RF source, which is located close to the antenna and synchronized with the transceivers, the signal being received by the antenna, wherein said determining includes:

generating simulated far field and near field signals so as to simulate a signal transmitted by an RF source located at infinity and located near the RF source respectively;

internally injecting an internal signal into the antenna via an internal injection network;

using said RF source to externally inject an external signal into the antenna; and

for each individual antenna element, computing said calibration ratio by combining information characterizing said internal and external signals as received by said individual antenna element with a correction factor characterizing said simulated far field and near field signals; and

calibrating the antenna using the per-antenna element calibration ratios adapted to accommodate for presence of at least one interfering structure.

23. A method according to claim 10 wherein said method is carried out in field conditions in which no anechoic chamber is available.

24. A system according to claim 1 wherein the external signals are affected by first electro-magnetic coupling between the plurality of mutually electro-magnetically coupled antenna elements and by second electro-magnetic coupling between the source and the interfering member,

the system also comprising:

a signal measuring and recording device measuring and recording samples of the internal signals and said external signals; and

a correction factor computation unit operative to compute a correction factor for the calibration ratio which factor corrects for presence of the interfering member and has a phase and an amplitude, by comparing said simulated first electro-magnetic coupling-zero far-zone external electromagnetic fields and said simulated first electro-magnetic coupling-zero near zone external electromagnetic fields,

and wherein said electro-magnetically coupled structure-accommodating calibration ratio computer is operative to compute the modified Calibration ratio by combining the ratio of said internal and external signals as received by the antenna with said correction factor.

25. A method according to claim 18 and also comprising computing (in dB) a difference between said amplitudes of said external and internal signals as received by said individual antenna element, and adding the amplitude (in DB) of the correction factor.

~~26. A system according to claim 1 and also comprising an internal injection network synchronized with the transceivers and operative for internally injecting internal signals to the antenna.~~

CLAIMS

1. A system for calibration of a phased array antenna having a network of auxiliary channels internally injecting internal signals to the antenna, to be used in an environment including at least one interfering member affecting a calibration ratio of the antenna, the antenna comprising a plurality of mutually electro-magnetically coupled antenna elements, the system comprising:

an RF source external to the antenna, operative to project external signals toward the antenna when disposed at a near-by distance therefrom;

an RF simulation unit operative to generate simulated first electro-magnetic coupling-zero far-zone external fields projected toward the antenna from an RF source located at a far-zone distance from the antenna, assuming that first electro-magnetic coupling between the mutually electro-magnetically coupled antenna elements to be zero, and also operative to generate simulated first electro-magnetic coupling-zero near zone external fields projected toward the antenna from an RF source located at said near-by distance from the antenna were the first electro-magnetic coupling between said mutually electro-magnetically coupled antenna elements to be zero; and

a electro-magnetically coupled structure-accommodating calibration ratio computer operative to compute a Modified Calibration ratio by combining an indication of said internal signals and said external signals as received by the antenna, with a correction factor based on an output of said RF simulation unit.

2. A system according to claim 1 wherein said RF source comprises an RF point source.

3. A system according to claim 1 wherein said RF source is spherical.

4. A system according to claim 1 wherein said RF source is non-spherical.

5. A system according to claim 1 wherein said antenna calibrator is operative to combine said calibration ratio and said correction factor by adding the phases

of the calibration ratio and said correction factor to obtain a phase value of the Modified Calibration ratio and adding decibel representations of the amplitudes of the calibration ratio and said correction factor to obtain a decibel representation of an amplitude of the Modified Calibration ratio.

6. A system according to claim 1 wherein said RF simulation tool computes the correction factor by computing electromagnetic fields generated in and propagating within a non-continuous medium.

7. A system according to claim 1 wherein said antenna comprises a cellular antenna.

8. A system according to claim 1 and also comprising a platform upon which the antenna is mounted and wherein said interfering member is part of said platform.

9. A system according to claim 1 wherein said signal measurement and recording device measures amplitude and phase of the samples of said internal and external signals.

10. A system according to claim 1 wherein the external signals are affected by first electro-magnetic coupling between the plurality of mutually electro-magnetically coupled antenna elements and by second electro-magnetic coupling between the source and the interfering member,
the system also comprising:

a signal measuring and recording device measuring and recording samples of the internal signals and said external signals; and

a correction factor computation unit operative to compute a correction factor for the calibration ratio which factor corrects for presence of the interfering member and has a phase and an amplitude, by comparing said simulated first electro-magnetic coupling-zero far-zone external electromagnetic fields and said

simulated first electro-magnetic coupling-zero near zone external electromagnetic fields,

and wherein said electro-magnetically coupled structure-accommodating calibration ratio computer is operative to compute the modified Calibration ratio by combining the ratio of said internal and external signals as received by the antenna with said correction factor.

11. A system according to claim 1 and also comprising an internal injection network synchronized with the transceivers and operative for internally injecting internal signals to the antenna.

12. A method for calibrating an antenna comprising a phased array of antenna elements connected to plurality of transceivers, the method comprising:

providing an RF source of externally injected signals operative when located close to the antenna to be synchronized with the transceivers;

determining, per antenna element, a calibration ratio adapted to accommodate for presence of at least one interfering structure electromagnetically interfering with a signal transmitted from said RF source and received by the antenna; and

calibrating the antenna using the per-antenna element calibration ratios adapted to accommodate for presence of at least one interfering structure.

13. A method according to claim 12 wherein said determining includes:

generating simulated far field and near field signals so as to simulate a signal transmitted by an RF source located at infinity and located near the RF source respectively;

internally injecting an internal signal into the antenna via an internal injection network synchronized with the transceivers, wherein said interfering structure interferes with said internal signal;

using said RF source to externally inject an external signal into the antenna; and

for each individual antenna element, computing said calibration ratio by combining information characterizing said internal and external signals as received by said individual antenna element with a correction factor characterizing said simulated far field and near field signals and representing, per antenna element, the ratio of said simulated far field and near field signals.

14. A method according to claim 12 wherein at least one physical object which is electromagnetically coupled to radiation emitted by the RF source thereby to define unwanted radiation in context of said calibration, is present in the course of said determining and calibrating and is absent in a subsequent operational stage, the method also comprising screening said unwanted radiation.

15. A method according to claim 14 wherein said screening comprises covering said at least one physical object with RF-radiation absorbing material.

16. A method according to claim 15 wherein said determining and calibrating occurs on the ground, said operational stage is airborne and said physical object is fixed to the ground.

17. A method according to claim 12 wherein said determining comprises determining the calibration ratio a plurality of times thereby to obtain a plurality of interim calibration ratio results and averaging said plurality of interim calibration ratio results to obtain said calibration ratio adapted to accommodate for presence of at least one interfering structure.

18. A method according to claim 17 wherein said determining the calibration ratio a plurality of times includes re-positioning said RF source a plurality of times, thereby to compensate for artifactual noise generated by said at least one interfering structure during calibration ratio measurement.

19. A method according to claim 17 wherein said calibration ratio is determined a plurality of times for a single position of said RF source, thereby to compensate for white noise during calibration ratio measurement.

20. A method according to claim 12 wherein said correction factor includes a phase and an amplitude and wherein said at least one interfering structure comprises a plurality of interfering structures and wherein generating at least one simulated signal comprises performing the following operations for a near field configuration and for a far field configuration:

a. computing a plurality of simulated first electromagnetic fields generated at the plurality of interfering structures respectively due to radiation emitted by the RF source;

b. computing a plurality of simulated induced currents generated at the plurality of interfering structures respectively due to radiation emitted by the RF source;

c. for each antenna element in the phased array of antenna elements:

1. simulating a second electromagnetic field generated at the antenna element due to radiation emitted by the RF source;

2. computing a plurality of simulated third electromagnetic fields generated at the antenna element due to said plurality of simulated induced currents respectively; and

3. generating a total field by summing said plurality of simulated third electromagnetic fields and said second electromagnetic field;

d. for each antenna element in the phased array of antenna elements:

1. computing a correction factor by computing a ratio of the total field as computed for the far field configuration divided by the total field as computed for the near field configuration; and

2. computing said phase and amplitude of said calibration ratio by measuring phase and amplitude for each of said internal and external signals as received by each of said antenna elements; and

e. for each individual antenna element, computing said calibration ratio adapted to accommodate for presence of at least one interfering structure by computing a difference between said phases of said external and internal signals as received by said individual antenna element, and adding the phase of the correction factor.

21. A method according to claim 20 wherein said antenna is installed on an aircraft and said plurality of interfering structures include a fuselage, a first wing, a second wing, an engine, a stabilizer and a rudder.

22. A method according to claim 20 wherein said antenna is installed on an ship and said plurality of interfering structures include a hull, at least one mast and a bridge.

23. A method according to claim 20 wherein said antenna is installed on a tank and said plurality of interfering structures include a hull, a turret and a cannon.

24. A method according to claim 20 and also comprising computing (in dB) a difference between said amplitudes of said external and internal signals as received by said individual antenna element, and adding the amplitude (in DB) of the correction factor.

25. A method according to claim 12 wherein said method is carried out in field conditions in which no anechoic chamber is available.

26. A computer program product, comprising a computer readable storage medium having a computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method for calibrating an antenna comprising a phased array of antenna elements connected to plurality of transceivers, the method comprising:

providing an RF source located operative when located close to the antenna to be synchronized with the transceivers;

determining, per antenna element, a calibration ratio adapted to accommodate for presence of at least one interfering structure electromagnetically interfering with a signal transmitted from an RF source, which is located close to the antenna and synchronized with the transceivers, the signal being received by the antenna, wherein said determining includes:

generating simulated far field and near field signals so as to simulate a signal transmitted by an RF source located at infinity and located near the RF source respectively;

internally injecting an internal signal into the antenna via an internal injection network;

using said RF source to externally inject an external signal into the antenna; and

for each individual antenna element, computing said calibration ratio by combining information characterizing said internal and external signals as received by said individual antenna element with a correction factor characterizing said simulated far field and near field signals; and

calibrating the antenna using the per-antenna element calibration ratios adapted to accommodate for presence of at least one interfering structure.