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### Antenna system for vehicles

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#### Abstract

A communication system and method for vehicles, particularly trains, are described with the vehicle having antenna sets. Each antenna set includes a plurality of antennas mounted onto a convex-shaped vehicle roof in which an axis of one antenna set is approximately perpendicular to an axis of another antenna set and in which the antenna sets are mounted below roof level of the convex-shaped vehicle roof. A switching device is operable to switch between a first antenna configuration and a second antenna configuration based on a difference in measured signal power received at the antenna sets. The first antenna configuration is associated with a first stationary communication system of the plurality of stationary communication systems and a second antenna configuration is associated with a second stationary communication system of the plurality of stationary communication systems.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
5548835	12/1995	Sasaki	455/66.1	H04B 7/0805
6380910	12/2001	Moustakas	N/A	N/A
7372911	12/2007	Lindskog	375/267	H04B 7/0617
7515051	12/2008	Wagner	N/A	N/A
7768952	12/2009	Lee	N/A	N/A
10305198	12/2018	Schleef	N/A	H01Q 1/007
10601109	12/2019	Jamaly	N/A	H01Q 1/3275
11362414	12/2021	Jamaly	N/A	H04B 5/28
12027756	12/2023	Jamaly	N/A	H01Q 21/24
2005/0113038	12/2004	Kasami	455/101	H04B 7/0814
2007/0013593	12/2006	Zafar	343/700MS	H01Q 1/3275
2011/0298669	12/2010	Rao	343/893	H01Q 1/243
2013/0064151	12/2012	Mujtaba	N/A	N/A
2014/0198715	12/2013	Zasowski	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
203279089	12/2012	CN	N/A
0658013	12/1994	EP	N/A
1830485	12/2006	EP	N/A
2755440	12/2013	EP	N/A
2010-288057	12/2009	JP	N/A

OTHER PUBLICATIONS

Suzuki et al, “Design of Tunnel Relay System with a Leaky Coaxial Cable in an 800-MHz band land mobile telephone system”, IEEE Transactions of vehicular technology, IEEE Service Center, Piscataway, NJ, US vol. 29, No. 3, Aug. 1980 (Aug. 1, 1980), pp. 305-316, XPO011486786. (Year: 1980). cited by examiner

Plattner et al., "A Millimetrewave Communication System for Maglev Application", Vortrag AUF DEM IEEE German Chapter Workshop, XX, XX, Jan. 1, 1982 (Jan. 1, 1982), pp. 1-8, XP002043527. Design (Year: 1982). cited by examiner  
European Patent Office, Communication with extended European search report in Application No. 15165768.1-1812, dated Nov. 4, 2015 (7 pages). cited by applicant  
Plattner A: "A Millimetrewave Communication System for Maglev Application", Vortrag AUF DEM IEEE German Chapter Workshop, XX, XX, Jan. 1, 1982 (Jan. 1, 1982), pp. 1-08, XP002043527. cited by applicant  
Suzuki T et al: "Design of a tunnel relay system with a leaky coaxial cable in an 800-MHz band land mobile telephone system", IEEE Transactions on Vehicular Technology, IEEE Service Center, Piscataway, NJ, US, vol. 29, No. 3, Aug. 1, 1980 (Aug. 1, 1980), pp. 305-316, XPO11486786, ISSN: 0018-9545, DOI : 10.1109/T-VT.1980.23858. cited by applicant

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## **Background/Summary**

### **CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE**

(1) This patent application is a continuation of U.S. application Ser. No. 17/743,055, filed May 12, 2022, which is a continuation of U.S. application Ser. No. 16/827,889, filed Mar. 24, 2020 (U.S. Pat. No. 11,362,414), which is a continuation of U.S. application Ser. No. 15/142,412, filed Apr. 29, 2016 (U.S. Pat. No. 10,601,109), which claims the benefit from and priority to European Patent Application No. EP15165768, filed on Apr. 29, 2015. The aforementioned documents are hereby incorporated herein by reference in their entirety.

### **TECHNICAL FIELD**

(1) The present disclosure generally relates to the field of communications and, in particular, to a system and a method that establishes wireless communication between a moving vehicle following a predefined path or track and base stations located along such a track.

### **BACKGROUND**

(2) The widespread use of mobile communication devices for wireless data communication has made it a great challenge for manufacturers and operators of telecommunications networks to provide wireless data communication with sufficient bandwidth and broadband capacity. In particular, communication related issues can arise in transportation related use scenarios. For example, on a train where typically a large number of users attempt to simultaneously use broadband data communication services through the same limited number of base stations in range of the train, it can be very difficult to provide sufficient data communication capacity for a passing train. Moreover, the tremendous increase of the speed of trains has accentuated this problem since data communication resources need to be provided very quickly, with great bandwidth and broadband capacity, and for very short periods of time.

(3) Considering that modern high-speed trains or cars can travel at approximately 200 km/h or more, a customer's connection can be transferred to a new mobile network cell every 20 seconds, for example. Such rapid cell changes with many mobile communication users in a train pose a major technical challenge and call for different communication systems to cover an entire track. In such circumstances, it is desirable to provide a fast and reliable switching system and method.

### **BRIEF SUMMARY**

(4) A system and/or method is provided for improved antenna switching in mobile communications

for vehicles, substantially as shown in and/or described in connection with at least one of the figures, and as set forth more completely in the claims.

(5) These and other advantages, aspects, and novel features of the present disclosure, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and the attached drawings as listed below.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1A shows a train in the vicinity of a first stationary communication system according to an embodiment of the present disclosure.

(2) FIG. 1B shows a schematic cross-section of the train in FIG. 1A according to an embodiment of the present disclosure.

(3) FIG. 2A shows a train in the vicinity of a second stationary communication system according to an embodiment of the present disclosure.

(4) FIG. 2B shows a schematic cross-section of the train in FIG. 2A according to an embodiment of the present disclosure.

(5) FIG. 3 illustrates a switching and control scheme for a vehicle-based antenna system according to an embodiment of the present disclosure.

### DETAILED DESCRIPTION

(6) FIG. 1A is a diagram illustrating schematically a top view of a moving train moving in the vicinity of a transceiver station. Referring to FIG. 1A, there is shown a train **10** comprising a locomotive **15** and a number of coaches, of which coaches **C1** and **C2** are illustrated. The train **10** is on railroad tracks **19**. There is further shown a transceiver station **11** comprising a transceiver **11B** communicatively coupled to an antenna system **11A**. The antenna system **11A** can generate an illustrative radiation pattern, referred to as an RF antenna corridor **17**. A coach **C1**, **C2** can comprise an interior antenna **13**, a signal repeater **12**, a set of antennas **A1**, and a set of antennas **A2**. The set of antenna **A1** can comprise a plurality of antennas, of which two, **A11** and **A12**, are illustrated as black dots. The set of antennas **A2** similarly comprises a plurality of antennas, of which two, **A21** and **A22**, are illustrated as black dots. The antennas **A11** and **A12** are separated by a distance **d1**. Similarly, the antennas **A21** and **A22** are separated by the distance **d1**. The sets of antennas **A1** and **A2** are separated by a distance **d2**, as illustrated by the distance **d2** between antennas **A12** and **A22**. Generally, the antennas of one set are mounted on opposite sides of the vehicle with respect to those of the other set. In FIG. 1A, the antennas **A11** and **A12** of the set **A1** are mounted on the right side (in direction of travel) while the antennas **A21** and **A22** of the set **A2** are mounted on the left side. The signal repeater **12** is communicatively coupled to the interior antenna **13** and to the sets of antennas **A1** and **A2**.

(7) The train **10** is powered by the locomotive **15** which is mechanically coupled to the coaches **C1**, **C2** as illustrated and moves the train **10** towards (as shown) or away from the transceiver station **11** along the railroad track **19**.

(8) The transceiver station **11** can be operable to transmit and/or receive radio frequency signal in accordance with one or more RF technologies, for example, mobile communication standards such as GSM, UMTS, WCDMA, 4G, LTE, HSDPA, HSUPA, 5G, and WiMAX 802.16. The transceiver station **11** can also be referred to as a base station or Node B in accordance with various embodiments of the present disclosure. The transceiver station **11** comprises a transceiver **11B**, which comprises suitable logic, circuitry, and/or code to generate and process radio and/or baseband signals in accordance with mobile communication standards. The signals received and/or generated at the transceiver **11B**, respectively, are then transmitted/received through the antenna system **11A**. The antenna system **11A** can comprise one or more antennas in general, but can

typically comprise a plurality of antennas to allow various protocols of multiple-input multiple-output (MIMO) communication such as 2×2 communication with a mobile transceiver system such as those installed in the train coaches C1, C2, for example. For example, antenna system 11A can be configured to receive and transmit a cross-polarized signal, i.e., receive and transmit two signals concurrently that are polarized differently, for example, horizontally and vertically. The antenna system 11A can also be suitably configured to support other MIMO schemes in accordance with various embodiments of the present disclosure. The antenna system 11A can be configured such that it receives and transmits favorably along the railroad tracks 19. Such a favorable reception/transmission area is illustrated by the exemplary RF antenna corridor 17.

(9) The coaches C1, C2 can be adapted to any purpose including, but not limited to, the carriage of persons and/or goods. The interior antenna 13 can comprise suitable logic, circuitry, and/or code to receive and transmit radio frequency signals to mobile transceivers typically located inside the carriage (not shown), for example, inside the carriages C1, C2, in which interior antennas 13 are located. The mobile transceivers receiving from or transmitting to the interior antennas 13 can be mobile handsets or computers operated by train passengers, or can be machine-operated mobile communication transceiver such as those used for machine-to-machine communications, for example. The interior antenna 13 is typically placed in the interior of a carriage and can comprise any type of RF antenna type suitable for its operating frequencies. This can include printed antennas, leaky feeders, or any other antenna technology adapted to a mobile communications technology.

(10) The signal repeater 12 can comprise suitable logic, circuitry, and/or code to process radio signals received from the interior antenna 13 or the sets of antennas A1, A2. Moreover, the signal repeater 12 can be operable to control, configure, and adapt the configuration of the sets of antennas A1 and A2. Similarly, the signal repeater 12 is operable to process radio signals for transmission over the interior antenna 13 or the sets of antennas A1, A2. Typically, in a downlink scenario, a signal repeater 12 can receive radio signals transmitted from the transceiver station 11 via one or more of the antenna sets A1, A2. The signals can then be processed for retransmission over the interior antenna 13. The reprocessing can comprise, but is not limited to, amplifying, decoding, and/or re-encoding of the radio signal and can be at radio frequency, intermediate frequencies, or baseband frequencies in accordance with various embodiments of the present disclosure. Similarly, in an uplink scenario, the signal repeater 12 can receive radio signals on the interior antenna 13 and process these suitably for transmission via the sets of antennas A1, A2 to a receiver, for example, transceiver station 11.

(11) The set of antennas A1, A2 can comprise suitable logic, circuitry, and/or code to receive and transmit radio signals in accordance with a radio communications protocol suitable for reception from and transmission to a transceiver station 11. This can, as described above for transceiver station 11, typically comprise one or more mobile communications protocols/standards. The set of antennas A1, A2 can be operable to utilize multiple antenna protocols, for example, MIMO, using the exemplary plurality of antennas A11, A12 and A21, A22, respectively. The antennas A11, A12, A21, A22 can comprise suitable logic, circuitry, and/or code to receive and transmit radio frequency signals at their respective operating radio frequency.

(12) In many instances, the transceiver antenna system 11A can be located approximately along the railroad track 19, typically at a height greater than that of the train 10. Choosing a height of the antenna system 11A greater than the train can improve an effective transmission and reception range of the transceiver station 11 and, furthermore, often result in a line-of-sight (LOS) signal reception/transmission between the sets of antennas A1, A2 and the transceiver antenna system 11A.

(13) FIG. 1B shows an exemplary schematic cross-section of the train in FIG. 1A. Referring to FIG. 1B, there is shown a coach C1 of a train 10 on a railway track 19 and an illustrative transceiver antenna system 11A. The cross-section of the coach C1 further shows an antenna A11

and an antenna **A21**. The antenna **A11** is, for example, part of the antenna set **A1** as shown in FIG. **1A**. The antenna **A21** is, for example, part of the antenna set **A2** as shown in FIG. **1A**. There is further shown a train roof **101**, which is typically made of an electrically conducting material, e.g., metal. There is also shown an angle  $y$  between some axis of antennas **A11** and antenna **A21**, due primarily to the location and orientation of the antennas **A11** and **A21** on the roof **101**. The orientations of the antennas of a set can also be regarded as the orientation of the set itself. The reference numbers used in FIG. **1B** correspond to the respective elements shown and described for FIG. **1A**. As illustrated, a transceiver antenna system **11A** of the stationary communication system can be located at a height greater than height of the train **10**.

(14) The train roof **101** can typically be curved (or arched) or otherwise be of a convex shape as seen in the exemplary cross-section of FIG. **1B**. For example, the roof **101** can be convex, but approach a curved roof **101** as illustrated through a plurality of straight segments. The angle  $y$  can advantageously be chosen to be close to 90 degrees and can, in practice, be approximately 75-100 degrees. In this exemplary configuration with an angle  $y$  of approximately 90 degrees, the antennas **A11** and **A21** can be operable to receive and transmit RF fields that can be cross-polarized. For example, antenna **A11** can receive primarily a vertically polarized signal component of a transmitted cross-polarized RF signal from the transceiver antenna system **11A**, and antenna **A21** can receive primarily a horizontally polarized signal component of a transmitted cross-polarized RF signal from the transceiver antenna system **11A**. The conductive roof can act as ground plate of the antennas. Such an arrangement can similarly be used to transmit a cross-polarized signal via antennas **A11** and **A21**.

(15) As mentioned above, in a scenario as illustrated in FIG. **1A** and FIG. **1B**, a strong LOS signal path can often exist between the transceiver antenna system **11A** and the sets of antennas **A1** and **A2**. The antennas **A11** and **A12** can receive a substantially same signal slightly phase-shifted (e.g., delayed) due to the separation  $d1$  of the antennas **A11** and **A12**. The phase shift between the signals received at **A11** and **A12** can depend on the separation distance  $d1$  between **A11** and **A12**, as well as the geometric position of the set of antennas **A1** with regard to the transceiver antenna system **11A**. The received signals at **A11** and **A12** can be coherently combined to constructively add both received signals. In some cases, a delay line, possibly adaptive, can be used to compensate the phase-shift incurred between the received signals at antennas **A11** and **A12**. In other cases, it can suffice to simply connect the antennas **A11** and **A12** and, in particular, when the delays between the received signals can be relatively small. Similarly, the received signals at antennas **A21** and **A22** can be combined.

(16) The distance  $d2$  between the sets of antennas **A1** and **A2** can typically exceed  $d1$  and can depend on the particular shape of the coach roof **101** and the specific antenna arrangement chosen. For this reason and the angular positioning of antennas (as illustrated by angle  $y$ ), the received signals at the set of antennas **A1** and **A2** can be approximately uncorrelated and can be used in a variety of multiple antenna protocols, including MIMO. For example, by coherently combining the antennas signals within each set as described above, there will be two effective antennas, one each for the set of antennas **A1** and **A2**. If, for example, the transceiver antenna system **11A** employs two cross-polarized antennas, an effective  $2 \times 2$  MIMO channel can be created between a coach (e.g., coach **C1**) and the transceiver antenna system **11A**.

(17) FIG. **2A** shows an example of a train in the vicinity of a second stationary communication system. Referring to FIG. **1B**, there is shown a train **10**, railroad tracks **19**, and a transceiver station **11**. The transceiver station **11** can comprise a transceiver **11B** communicatively coupled to an antenna system **11C**. The antenna system **11C** can comprise a plurality of leaky feeder cables, sometimes also referred to as cable antennas, illustrated by the dot-dashed double line. The reference numbers in FIG. **2A** can refer to substantially similar elements with the same numbers as described for FIG. **1A**.

(18) The leaky feeders in antenna system **11C** can be operable to transmit and/or receive radio

frequency signal in accordance with one or more RF technologies, for example, mobile communication standards such as GSM, UMTS, WCDMA, 4G, LTE, HSDPA, HSUPA, 5G, and WiMAX 802.16. The leaky feeder cables of antenna system **11C** can run approximately parallel to the railroad track **19**.

(19) FIG. 2B shows an exemplary schematic cross-section of the train in FIG. 2A. Referring to FIG. 2B, there is shown a train **10** and a transceiver antenna system **11C**. The transceiver antenna system **11C** can comprise a plurality of leaky feeder cables, of which two are illustrated as dots, mounted on a mount **18**. There is also shown a leaky feeder separation distance  $d_3$ . The reference numbers in FIG. 2B can refer to substantially similar elements with the same numbers as described for FIG. 1A, FIG. 1B, and FIG. 2A.

(20) The mount **18** can be enabled to mount the leaky feeder cables of transceiver antenna system **11C** in a desirable position with respect to the railroad track **19**. For example, as illustrated in FIG. 2B, the mount **18** can mount the plurality of leaky feeder cables at a certain height above the ground and/or relative to the coach **C1**, and substantially parallel to the railroad track **19**. Furthermore, the mount **18** can allow the single leaky feeder cables to be mounted at a desirable separation distance  $d_3$  to each other.

(21) As illustrated in FIG. 2B, when the transceiver station **11** is transmitting to the coach **C1** (or any other coach of train **10**), the leaky feeder cables of antenna system **11C** can typically be mounted lower than the height of the train coach roof **101**, i.e., below roof level. In this scenario, there can often be line of sight from the antenna system **11C** to the set of antennas mounted on the side of the train that is physically closer to the antenna system **11C**. In the illustrated example in FIG. 2B, this is the set of antennas **A2**. In such a scenario, the antennas **A21** and **A22** can receive most of the energy transmitted from the transceiver antenna system **11C**. On the other hand, the antennas on the side of the coach farther away from the leaky feeder cables will receive significantly weaker signals. In this example, the antennas **A11** and **A12** will receive less signal power than the antennas **A21** and **A22**. Because of the radiation characteristics of the leaky feeder cables of antenna system **11C**, the signals received at antennas **A21** and **A22** can be uncorrelated and hence allow a variety of MIMO schemes to be applied. A suitable MIMO scheme can, for example, be a  $2 \times 2$  MIMO scheme as proposed in the LTE mobile communication standard. The above scenario is also applicable to the scenario in which the antenna systems **A1**, **A2** from the coach are transmitting to the transceiver system antennas **11C**, as well as to the case in which the leaky feeder cables are located on the other side of the railroad track **19**.

(22) The transceiver antenna system **11C**, specifically, the leaky feeder cables, can be installed on either side of the railroad track **19**. From the above-described reception characteristics, it can be advantageous to communicatively couple the antennas **A11** and **A21** and **A12** and **A22**, respectively. In this case, two effective antennas can be formed, a first one from the coupled antennas **A11** and **A21**, and a second one from the coupled antennas **A12** and **A22**. These two effective antennas based on the physical antennas **A11**, **A12**, **A21** and **A22** can be used to receive and/or transmit from leaky feeder cables of the transceiver antenna system **11C** installed on either side of the railroad track **19**. In other words, such a configuration can be operated without regard to the side of the track **19** on which the leaky feeders are located.

(23) FIG. 3 illustrates a switching and control scheme for a vehicle-based antenna system in accordance with an embodiment of the present disclosure. Referring to FIG. 3, there is shown a switching device **20** which can be integrated within the signal repeater **12** as shown in FIG. 1A, FIG. 1B, FIG. 2A, and/or FIG. 2B, an antenna configuration MODE **1**, and an antenna configuration MODE **2**. The switching device **20** can comprise a comparator **21** and the switch **22**. The antenna configuration MODE **1** can comprise antennas **A11**, **A12**, **A21** and **A22**, whereby antennas **A11** and **A12**, and antennas **A21** and **A22** can be communicatively coupled, respectively, with each pair of coupled antennas forming a single effective antenna. The antenna configuration MODE **2** can comprise antennas **A11**, **A12**, **A21** and **A22**, whereby antennas **A11** and **A21**, and

antennas **A12** and **A22** can be communicatively coupled, respectively, with each pair of coupled antennas forming a single effective antenna. There is also shown a signal power of the set of antennas **A1** and **A2**, denoted by **P1** and **P2**, respectively. The reference numbers in FIG. 3 can refer to substantially similar elements with the same numbers as described in FIG. 1A, FIG. 1B, FIG. 2A, and FIG. 2B.

(24) The switching device **20** or the signal repeater **12** can, in addition to the functionality already described above, comprise suitable logic, circuitry, and/or code to compare a plurality of signal powers and control a plurality of possible antenna configuration modes, for example, **MODE 1** and **MODE 2**. The comparator **21** can comprise suitable logic, circuitry, and/or code to compare the signal power of a plurality of input signals and to operate the switch **22**. The switch **22** can comprise suitable logic, circuitry, and/or code to be operable to switch between a plurality of configurations and/or signal paths between one or more inputs and one or more outputs.

(25) Along a railroad track **19**, both scenarios of a transceiver station **11** with a transceiver station antenna system **11B**, as described in FIG. 1A and FIG. 1B, or with a transceiver station antenna system **11C**, as described in FIG. 2A and FIG. 2B can be employed on different segments of the railroad track **19**. The selection of an antenna system can depend on, among other factors, terrain, cost, ease of installation, and/or required throughput. Accordingly, it can be desirable to adapt the vehicle-based configuration to be operable with both transceiver station antenna systems **11B** and **11C**.

(26) As described with respect to FIG. 1A and FIG. 1B, in a scenario using a transceiver antenna system **11B**, it can be advantageous to communicatively couple the antenna pairs **A11**, **A12** and **A21**, **A22**, respectively, to form two effective antennas. In some cases, the antenna pairs can, as described above, be communicatively coupled such that a phase-delay between the coupled antennas can be approximately compensated to form a single effective antenna. This is referred to as antenna configuration **MODE 1**. Similarly, in a scenario using a transceiver antenna system **11C**, it can be advantageous to communicatively couple the antenna pairs **A11**, **A21** and **A12**, **A22**, respectively. This is referred to as antenna configuration **MODE 2**.

(27) When a transceiver antenna system **11B** is used for a particular segment of the railroad track **19**, the received signal power from the transceiver **11** of the set of antennas **A1** and the set of antennas **A2** is similar in antenna configuration **MODE 1**. Hence, the antenna configuration **MODE 1** can remain active and can be advantageous, as described for FIG. 1A and FIG. 1B. On the other hand, in antenna configuration **MODE 1**, when a transceiver antenna system **11C** is used for a particular segment of the railroad track **19**, the received signal power from the transceiver **11** by the set of antennas **A1** and the set of antennas **A2** is significantly different. In particular, as described for FIG. 2A and FIG. 2B, the set of antennas on the side of the coach that is closer to the antenna system **11C** can receive significantly higher signal power than the other set of antennas. For example, as illustrated in FIG. 2B, the set of antennas **A2** would receive significantly higher signal power than the set of antennas **A1** because the set of antennas **A2** is physically closer to the transceiver antenna system **11C**, whereas the set of antennas **A1** might be out of sight of the transceiver antenna system **11B** and electromagnetically shielded partially by the presence of the train roof **101**. Thus, in a scenario where a transceiver antenna **11C** is active, it can be advantageous to switch from antenna configuration **MODE 1** to antenna configuration **MODE 2**, as described above with reference to FIG. 2A and FIG. 2B. The comparison of the respective signal powers can be performed in the comparator **21** and be a basis by which the switch **22** is operated. In accordance with various embodiments of the present disclosure, the comparison of the signal powers and the switching between antenna configuration modes can be integrated into the signal repeater **12**, or performed in another equipment, for example, a dedicated hardware switching device **21** not integrated into the signal repeater **12**.

(28) Thus, the signal powers of the sets of antenna **A1** (signal power **P1**), and **A2** (signal power **P2**) can be compared in antenna configuration **MODE 1**. If the signal power **P1** is substantially similar



to the signal power **P2**, the antenna configuration **MODE 1** might be desirable and hence no antenna configuration change is necessary. On the other hand, if the signal power **P1** is substantially different from the signal power **P2**, the antenna configuration **MODE 2** might be desirable and the vehicle-based antenna system can switch from antenna configuration **MODE 1** to antenna configuration **MODE 2**. In a typical train system, an exemplary threshold to change antenna configuration mode from **MODE 1** to **MODE 2** can be a power difference of approximately 6 dB. As will be known to a person skilled in the art, the threshold value is exemplary and can depend on a wide variety of factors in a particular communication system. Moreover, the threshold value can be adaptively changed in some scenarios. In the present example, if the difference in signal power **P1** to **P2** is less than or equal to 6 dB, the antenna configuration remains or changes back to **MODE 1**. On the other hand, if the difference in signal power **P1** to **P2** exceeds 6 dB, the antenna configuration changes from **MODE 1** to **MODE 2** or remains in **MODE 2** depending on the prior status.

(29) In accordance with various embodiments of the present disclosure, it is also possible in the above switching scheme to compare the signal power of one antenna each from the sets of antennas **A1** and **A2**, instead of the set powers as described above. For example, the power at antenna **A11**, **P(A11)**, and the power at antenna **A21**, **P(A21)**, can be used to determine a switching condition. Similarly, the pair **P(A11)**, **P(A22)**, the pair **P(A12)**, **P(A21)**, and the pair **P(A12)**, **P(A22)** can be used to determine a switching condition, for example. It is also possible to further refine the comparison, for example, by taking into account which of the powers **P1** and **P2** are larger to determine the side of track on which the leaky feeder is located. In such a case, the switching can be adapted to establish the communication link only through antennas located on the respective side of the vehicle.

(30) The above-described compare and switch scheme can be applicable to a comparison of any measure related to signal power or amplitudes, mean amplitudes, etc. reasonably related to the signal power at the relevant antennas or sets of antennas. This includes, but is not limited to, averaged values, correlated values, and/or peak/trough analysis of such measures.

(31) Though described using a train **10** as an example, the systems and methods described above can be applied in any communication system using fast switching of in-vehicle equipment between two or more different stationary communications systems along the trajectory of the vehicle. The vehicle can be a coach of a train, the train itself, or a different type of vehicle such as guided bus, a car, etc.

(32) The distance **d1** between the two antennas of each set **A1**, **A2** can be the order of half the wavelength of the center frequency of the communication link or larger. The same applies to the distance **d3** between the signal cables of the leaky feeder **11C** antennas.

## Claims

1. A method, comprising: determining between a first kind of wireless communication system and a second kind of wireless communication system according to a first signal power received at a first antenna device, comprising a first plurality of antennas, and a second signal power received at a second antenna device, comprising a second plurality of antennas, wherein a first plurality of cables, associated with the first type of wireless communication system, is configured to be installed in areas that are different from areas where a second plurality of cables, associated with the second type of wireless communication system, is configured to be installed; for the first kind of wireless communication system, physically connecting the first antenna device, via a switch, to the second antenna device; and for the second kind of wireless communication system, decoupling the first antenna device from the second antenna device.

2. The method according to claim 1, wherein: the first antenna device comprises a first plurality of antennas, and the second antenna device comprises a second plurality of antennas.

3. The method according to claim 1, wherein the first antenna device is mounted to a vehicle.
  4. The method according to claim 3, wherein the vehicle is one of a train, a bus, and a car.
  5. The method according to claim 1, comprising: establishing, via the first antenna device and the second antenna device, a 2×2 communication link with a stationary transceiver system.
  6. The method according to claim 1, comprising: for the first kind of wireless communication system, forming a single effective antenna by communicatively coupling antennas from the first antenna device and antennas from the second antenna device.
  7. The method according to claim 1, wherein two or more antennas of the first antenna device and the second antenna device are separated by a half wavelength of a communication frequency.
  8. The method according to claim 1, wherein the switch is operable to switch between the first antenna device and the second antenna device.
  9. The method according to claim 1, wherein an axis of the first antenna device is perpendicular to an axis of the second antenna device.
  10. The method according to claim 1, comprising: in the second kind of wireless communication system, forming a plurality of effective antennas.
  11. The method according to claim 1, comprising: in the first kind of wireless communication system, coherently combining signals received via the first antenna device.
  12. The method according to claim 1, wherein signals received via the first antenna device and the second antenna device are uncorrelated.
  13. The method according to claim 1, wherein the switch is part of a repeater.
  14. The method according to claim 1, wherein the method is performed in a vehicle.
  15. The method according to claim 14, wherein the vehicle is one of a train, a bus, and a car.
  16. The method according to claim 1, comprising: providing cross-polarized communication in the first kind of wireless communication system.
  17. The method according to claim 1, wherein the second kind of wireless communication system comprises two or more leaky feeders.
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