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(54) Orthogonally polarized transmission antenna and method of transmission

(57) To address the issue of adding additional RF carriers to a transmitted signal in support of subscriber growth, an antenna configuration is utilized with orthogonally polarized transmission antenna pairs. The orthogonally polarized antennas are preferably arranged in substantially a +45°/-45° relationship and substantially maintain co-phase centers. By utilizing pairs of orthogonally polarized antenna components, the number of antennas necessary to transmit carrier signals can be halved. Further, undesirable size and space limitations can be avoided without a substantial loss in output carrier signals and without substantial signal interference.

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Description

Field of the Invention

[0001] The present invention relates to an orthogonally polarized transmission antenna and to a transmission method using an orthogonally polarized antenna.

Description of the Related Art

[0002] A well recognized problem in cellular base station engineering surrounds the issue of how to add additional radio frequency (RF) carriers to a transmitted signal in support of subscriber growth. In a code division multiple access (CDMA) system, one RF carrier signal can be used by multiple subscribers, but the number of subscribers which can utilize the signal as fixed. Similarly, for time division multiple access (TDMA) systems, a fixed number of subscribers can utilize a single RF carrier, although the number of subscribers is less than that which can utilize a single carrier in a CDMA system. Finally, for a frequency division multiplex (FDM) system, only one subscriber can utilize one carrier signal. Accordingly, whether utilizing CDMA, TDMA, or FDM systems, since a carrier can only be utilized for a fixed number of subscribers, additional carriers must be added as the number of subscribers increases.

[0003] Regarding the addition of an RF carrier to transmit a signal in support of subscriber growth, three standard techniques currently exist, all with inherent limitations and undesirable aspects. A first of these techniques adds additional transmission antennas with single-carrier RF power amplifiers to amplify each carrier individually. This approach is popular in Groupe Special Mobile (GSM) and TDMA systems where each carrier supports a number of voice channels (8 voice channels in GSM, and 3 voice channels in TDMA). However, by adding one antenna for each additional carrier, the number of transmission antennas and the total physical size of the antennas can become quite substantial in a high capacity base station as will be explained in more detail as follows.

[0004] Prior art Fig. 1 illustrates a conventional configuration of a single carrier cellular base station antenna 2, using a dedicated independent carrier linear amplifier (ICLA) 4. More specifically, the ICLA 4 receives an incoming low power RF signal and boosts it to a high power signal, usually in excess of 1 watt. The RF signal is a single carrier signal, for example, a 1.95 GHz signal, with a bandwidth range of about 1 MHz, thereby ranging from 1.9495 to 1.9505 GHz. Accordingly, as the subscriber growth increases, additional carrier signals are needed and an additional antenna and ICLA must be added for each additional carrier needed.

[0005] The prior art antenna 2, as illustrated in Fig. 1, can be a single antenna, or commonly can be a vertical array of antenna elements (6). The antenna 2 receives an amplified RF signal from ICLA 4. The antenna 2 then radiates an electromagnetic wave, with a vertically polarized electric field. The electromagnetic fields radiated from antenna 2 are of a vertical polarization with respect to the electric field component and coincident with the orientation of antenna array elements shown as line(s) 6 of Fig. 1. Thus, the antenna 2 of Fig. 1 is known as a vertically polarized antenna.

[0006] As shown in prior art Fig. 2, utilizing transmission antennas with single-carrier RF power amplifiers to amplify each carrier individually, the adding of additional RF carriers to transmit signals in support of subscriber growth requires the addition of more vertically polarized antennas and, for each antenna, the addition of an ICLA. As shown in prior art Fig. 2, a first vertically polarized antenna 2a includes a corresponding ICLA 4a which is fed by a time/code multiplexed carrier "a". A second vertically polarized transmission antenna 2b can then be added along with the corresponding ICLA 4b, which is fed by a second time/code multiplexed signal carrier "b". Additionally, depending on how many carriers need to be added, "n" total vertically polarized antennas (2n) must be used, wherein n is an integer, each with additional ICLAs (4a-4n), and each fed by a single time/code multiplexed signal carrier "a" through "n". In other words, for "n" total time/code multiplexed signal carriers "n" transmission antennas are necessary.

[0007] By adding additional vertically polarized antennas for each additional carrier, with each fed by a single ICLA, which are in turn fed by a single low-power RF carrier signal, the number and total physical size of the transmission antennas becomes quite substantial. This could create space problems on a wireless base station; it could create zoning problems with the addition of several antennas; and could increase the cost of leased power space (such as the leasing of tower space).

[0008] Another known technique for adding additional RF carriers, in support of subscriber growth, is directed to the use of high-power tuned cavity RF combiners, directly after two or more single carrier amplifiers (ICLAs) . The combiners, while reducing the need for multiple transmission antennas and feed lines, carry with them significant cost, RF power loss (typically greater than 3dB), and most importantly a substantial loss of flexibility in using the assigned frequency spectrum.

[0009] Another known technique for adding RF carriers in support of subscriber growth involves the use of multicarrier linear amplifiers (MCLAs). Because of their linearity, the MCLAs can amplify a multiplicity of RF carriers fed to their input. Because the carriers are combined at low power prior to the amplifier input, RF losses become inconsequential. However, MCLAs are very costly and most newer base stations are being designed with only enough amplifier power to support the initial number of carriers. This requires the addition of more paralleled amplifiers as carriers are later added, a capability that is costly to implement.

Summary Of The Invention

[0010] The present invention addresses the problem of adding additional RF carriers to a transmitted signal in support of subscriber growth, by utilizing pairs of orthogonally polarized antennas in place of individual vertically polarized antennas. Since two orthogonally polarized antennas can be fabricated in a package that occupies virtually the same volume as a single vertically polarized antenna, the size of the overall antenna complex can be halved since half as many individual antenna packages are required to support a given number of RF carriers. Moreover, orthogonally polarized antennas can achieve appropriate levels of isolation between corresponding orthogonal feed ports as required by the transmission system and can preferably be designed with co-phased centers.

Brief Description Of The Drawings

[0011] The features, as well the advantages of the present invention, will become better understood with regard to the following description, appended claims and accompanying drawings wherein like reference numerals represent like elements and wherein:

Fig. 1 depicts a single carrier antenna/amplifier configuration of vertical polarization;

Fig. 2 depicts multiple single carrier antenna/amplifier configurations of vertical polarization; and

Fig. 3 illustrates a preferred embodiment of the present application utilizing an antenna/amplifier configuration with orthogonally polarized common aperture antennas.

Detailed Description Of The Present Invention

[0012] The present invention is directed to the design and use of dual polarized transmission antennas, preferably orthogonally polarized transmission antennas, to facilitate the addition of RF carriers. Using pairs of orthogonally polarized transmission antennas, rather than individual vertical polarized antennas, facilitates the addition of RF carriers in a way which occupies half the space as individual vertical antenna packages required to support a given number of RF carriers. The use of these orthogonally polarized antennas can be particularly useful in the United States personal communication systems (PCS) and other international bands which can transmit signals which may be arbitrarily polarized, and can further be particularly useful in connection with wireless base stations.

[0013] Fig. 3 illustrates a preferred embodiment of the present invention. Fig. 3 illustrates a first antenna configuration 10a, which can be a single antenna or an array of antenna elements. Feeding the antenna 10a, are a pair of ICLAs, 12a and 12b. The first ICLA 12a amplifies a first input RF carrier signal "a", which can be time or code multiplexed, and the second ICLA 12b amplifies a second input RF carrier signal "b" which can also be time or code multiplexed. Thus, the entire antenna configuration 10a can be used to transmit two RF carrier signals "a" and "b". Accordingly, this antenna configuration essentially takes the place of two vertically polarized antenna configurations.

[0014] Fig. 3 is a representation made to illustrate that the advantages of the present invention can occur in a single antenna configuration 10a supporting two carriers, or n/2 antenna configurations for supporting n carriers. Thus, antenna configuration 10b, and ICLAs 12c, 12d and antenna configuration 10(n/2) along with ICLAs 12(n-1) and 12n, are of identical configuration as antenna 10a, and corresponding ICLAs 12a and 12b. The number of antennas should not be considered limitative of the present invention. Further, it should be noted that the input to ICLAs 12c and 12d are respective time/code multiplexed carrier signal "c" and "d"; and the inputs to ICLAs 12(n-1) and 12n are time/code multiplexed carrier signals "n-1" and "n".

[0015] Amplifier network 20 is preferably for a wireless network, and more preferably a cellular network. The number of antennas located thereon and the type of amplifier network, whether ground-based or adjacent to the antenna, is not to be considered limitative of the present invention. Additionally, all ICLAs 12 are of essentially the same configuration as ICLAs 4. Further, regarding the ICLAs 12, they can alternatively be located adjacent to the antennas 10 or separate from the antennas 10. The ICLA/antenna configuration shown in Fig. 3, indicating the ICLAs 12 within amplifier network 20 is merely illustrative, and should not be considered limitative of the present invention.

[0016] As exemplified by Fig. 3, the antenna configuration 10a includes a pair of orthogonally polarized transmission antennas, rather than a single vertically polarized antenna. In essence, an antenna component of antenna configuration 10a, which can be an array of antennas or a single antenna, radiates an electromagnetic field whose electric field component is aligned with the first direction as illustrated by element 16 of Fig. 3. A second antenna component of antenna configuration 10a, which can also be an antenna array or a single antenna, radiates a second electromagnetic field whose electric field component is aligned with element 18, which is preferably orthogonal to the first electric field component.

[0017] The antenna configuration 10a utilizes a pair of dual polarized antenna components which are preferably orthogonal to one another to minimize signal interference during signal transmission. The two orthogonally polarized antenna components represented by 16 and 18 of Fig. 3, are arranged in a single housing as indicated by element 10a and can be implemented in a range of orientations from vertical/horizontal to +45°/-

45°. The two antenna components preferably excite orthogonally polarized electric field components and are more preferably arranged in substantially a +45°/-45° relationship. Since most wireless receivers tend to be of the hand-held type whose antennas appear to assume a near 45° orientation when held to a person's ear, utilization of the substantially +45°/-45° orientation for the first and second antenna components of a transmission antenna such as 10a, results in little or no signal degradation on average for the totality of subscribers. The small increase in base station amplifier power that might be required is offset by the advantage gained by the new antenna packaging capability. The wireless network engineer determines the system requirements in terms of modified amplifier power and antenna packaging.

[0018] Each of the first and second antenna components (producing electric field components aligned in the directions 16 and 18) of the single antenna configuration 10a are fed by discrete transmission lines, not shown. Again, it should be noted that each of the pair of antenna elements exemplified by elements 16 and 18 of Fig. 3 are typically excited as vertical antenna arrays. If so, the input transmission line is first passed through a power divider (not shown) in a known fashion, before being transmitted to the antenna array elements. A first time/code multiplexed carrier "a" is input and amplified through ICLA 12a and is transmitted through an antenna element or array exciting the electromagnetic field whose electric field component is associated with antenna element 16 of Fig. 3; and a second time/code multiplexed carrier signal "b" is amplified through ICLA 12b, and is transmitted by a separate antenna element or array exciting the electromagnetic field whose electric field component is associated with antenna element 18 of Fig. 3, which is orthogonal to the electric field component associated with antenna element 16 of Fig. 3.

[0019] Further, the antenna elements exemplified by elements 16 and 18 of Fig. 3 preferably are packaged in a single unit with co-phase centers. The co-phased center arrangement refers to the fact that the electric field components of the orthogonally arranged antennas include common centers, as shown by the intersection of elements 16 and 18 of Fig. 3. Additionally, the orthogonally polarized antennas achieve appropriate levels of isolation between corresponding orthogonal feed ports as required by the transmission systems. Due to the orthogonality of the antenna elements, a minimum amount of cross-coupling occurs which permits the use of the ICLAs (12a, 12b) in, or in conjunction with, a common antenna package (10a) with orthogonally polarized antennas (16, 18) designed and packaged with co-phase centers.

[0020] Accordingly, utilizing the antenna configurations 10a of the present invention, a plurality of signals "a" and "b", each embodied in a separate carrier wave are generated; amplified by corresponding ICLAs 12a and 12b; and transmitted from a wireless base station to a predetermined number of subscribers using an independent one of a pair of orthogonally polarized antenna components 16, 18. The orthogonally polarized antenna components are preferably arranged in substantially a +45°/-45° relationship. Each signal is transmitted using one of a TDMA, CDMA, or FDM technique. Thus, independent carrier waves are transmitted from antenna configurations occupying minimal space, thereby facilitating the use of half as many antennas.

[0021] The invention being thus described, it will be obvious that the same may be varied in many ways. For example, electromagnetic field orthogonality is not limited strictly to linearly polarized waves and associated antennas. One may establish orthogonality between opposite senses of right hand and left hand circular or elliptical polarizations, for example. These can be accomplished, for example, by either the particular radiating element design or by use of an intermediate amplitude and phase splitting network whose outputs are coupled to linearly polarized antenna elements. Such and other variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A wireless transmission method comprising the steps of:

   generating a plurality of signals, each embodied in a separate carrier wave; and

   transmitting each generated signal using an independent one of a pair of orthogonally polarized antenna components.

2. The transmission method of claim 1, further comprising the step of:
   amplifying each generated signal prior to transmission.

3. The transmission method of claim 2, wherein each generated signal is amplified by a separate independent carrier linear amplifier (ICLA).

4. The transmission method of claim 1, wherein the pair of orthogonally polarized antenna components transmitting each generated signal are arranged in substantially a +45°/-45° relationship.

5. The transmission method of claim 1, wherein each antenna component includes an antenna array.

6. The transmission method of claim 1, wherein each signal is embodied in a separate carrier wave and transmitted from a wireless base station to a prede-

termined number of subscribers.

7. The transmission method of claim 6, wherein each signal is transmitted using one of a time division multiple access (TDMA), frequency division multiplexing (FDM) or code division multiple access (CDMA) technique.

8. An antenna, comprising:

a first antenna component, exciting a first linear electric field vector, operable to transmit a first signal embodied in a carrier wave; and
a second antenna component, exciting a second linear electric field vector orthogonal to the first linear field vector, operable to transmit a second signal embodied in a second carrier wave.

9. An antenna configuration for use in signal transmission, comprising:

a plurality of amplifiers, each operable to amplify signals embodied in separate carrier waves; and
a common antenna unit, connected to the plurality of amplifiers, including a pair of orthogonally polarized antenna components operable to separately transmit amplified signals embodied in separate carrier waves.

10. The antenna of claim 8 or the antenna configuration of claim 9, wherein the first and second antenna components or common antenna are housed in a single unit, and/or the first and second antenna components are arranged in substantially a +45°/-45° relationship, or the pair of orthogonally polarized antenna components excite field vectors arranged in substantially a +45°/-45° relationship, and/or each of the first and second components include antenna array(s), and/or the said components excite orthogonal field vectors and are packaged so as to substantially maintain co-phase centers, and/or the first and second antenna components excite orthogonal field vectors and are packaged so as to substantially maintain co-phase centers.

11. The antenna configuration of claim 9, wherein the plurality of amplifiers include independent carrier linear amplifiers (ICLAs), or each of the pair of orthogonally polarized antenna components excites a field vector orthogonal to the other.

12. An antenna configuration for use in signal transmission, comprising:

signal generating means for generating a plurality of signals, each embodied in a separate carrier wave; and
transmission means for transmitting each generated signal using an independent one of a pair of orthogonally polarized antenna components.

13. The antenna configuration of claim 12, further comprising:

amplification means for amplifying each generated signal prior to transmission, or amplification means including a plurality of independent carrier linear amplifiers (ICLAs), each for amplifying a separate generated signal.

14. The antenna configuration of claim 12, wherein the pair of orthogonally polarized antenna components are arranged in substantially a +45°/-45° relationship, and/or each antenna component includes an antenna array.

15. The antenna configuration of claim 12, wherein the transmission means transmits the generated signals from a wireless base station to a predetermined number of subscribers.

16. The antenna configuration of claim 12 or 14, wherein the pair of orthogonally polarized antenna components substantially maintain co-phase centers.

FIG. 1
(PRIOR ART)

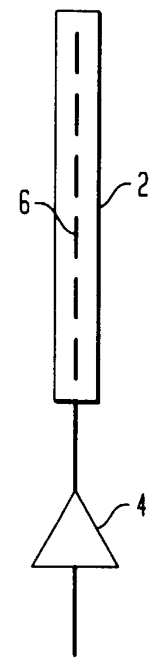

FIG. 2
(PRIOR ART)

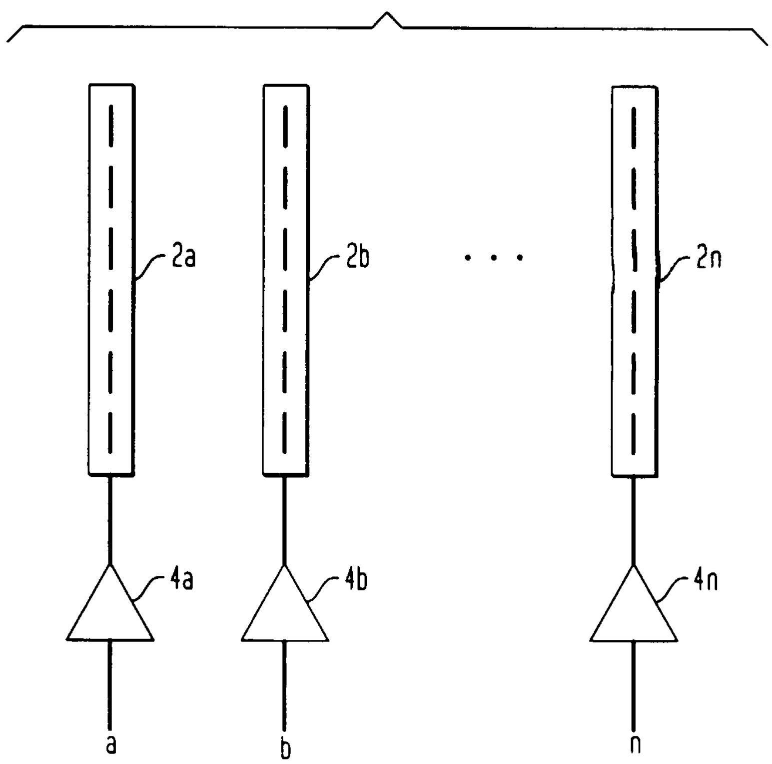

FIG. 3