Cellular mobile communications antenna.

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Description

Field of the Invention

The present invention relates to communications antennas and more particularly to mobile communications antennas for frequencies in the area of the 800 MHz frequency band of the type adapted to be mounted on a non-conductive surface such as a vehicle windshield.

Background of the Invention

The recent introduction of cellular telephone service which utilize frequencies in the 800 MHz frequency band and above, has increased interest in the efficient mobile antenna systems for those frequencies. Such services typically utilize a fairly wide band width. For example, existing and/or proposed systems operate over frequency bands of about 800-870 MHz, 820-900 MHz and 860-940 MHz. As can be seen by the above figures, the band width of such operating systems ranges from between about 60 to about 80 MHz. Thus, any antenna designed for use with such systems should provide efficient radiation characteristics and low VSWR over these band widths.

In addition, mobile antennas for such communications systems are designed to be mounted on vehicles. Some type of permanent installation is often necessary. For preferred locations, those which provide the most uniform radiation patterns, such as roof tops, this requires mounting to the vehicle such as automobiles by cutting holes into the body and permanently mounting the antennas in place. This is not always a satisfactory arrangement for vehicle owners.

Alternate mounting locations, such as fenders or trunk lids, which may allow for different mounting techniques, result in deterioration in the desired uniformity in the radiation pattern. It would be desirable, therefore to have an antenna which could operate at these UHF frequencies and which at the same time could provide the desired operating characteristics without requiring the mounting arrangements that permanently mar a vehicle and require body repair when the antenna system is removed from the vehicle.

The mounting of a communications antenna on insulated surfaces such as the windshield of an automotive vehicle is known for much lower frequencies. One such antenna system is disclosed in commonly assigned U.S. Patent No. 4,238,799 which issued on December 9, 1980.

The antenna there specifically disclosed is particularly adapted for operation at frequencies well below the frequencies used for cellular phone communication systems. Thus, the antenna there disclosed was designed for operation in the CB and related bands of about 28-29 MHz.

Antennas similar to and adapted from the antenna disclosed in the aforesaid U.S. Patent No. 4,238,799 have been designed and operate at somewhat higher frequencies than those disclosed in that patent. However, although the electrical schematic representation of the circuit remains the same as that shown in Fig. 4 of that patent, as frequencies increase and reach the frequencies utilized in cellular phone systems, those at and above the 800 MHz band, the structure utilized for lower frequencies is no longer appropriate.

Furthermore, the antenna disclosed in the aforesaid patent is a relatively narrow band antenna which does not operate satisfactorily over the wide frequency bands which are required for cellular phone systems. An antenna system including the features of the preamble of Claim 1 is known from U.S-A-4238 799. However this known system is not operable in a frequency range in excess of 800 MHz and does not comprise a counterpoise separate from the vehicle body.

Summary of the Invention

In accordance with the present invention, there is provided a communications antenna adapted to operate at and above the 800 MHz frequency band which is designed for mounting on an insulated surface such as the windshield of an automotive vehicle and which provides excellent efficiency and gain as well as the desirable band width to allow for efficient use at the cellular communications frequencies under consideration.

In accordance with the present invention, a vehicle window, e.g., the windshield is utilized to efficiently couple RF energy to a two-element collinear radiator mounted on the external surface of the windshield. In order to couple the RF energy between the antenna and a transceiver, a specially designed coupler configuration is mounted on the inner surface of the window in proximity to the antenna mount. The coupler reactively couples the radiator element to a transmission line while providing the desired 50 ohm input impedance.

The coupler in accordance with the present invention together with the radiator designed for use therewith provides desired VSWR characteristics over the operating band width ranges of 60 to 80 MHz such as contemplated for use in cellular telephone systems.

In accordance with the present invention, specially designed tuning circuit elements are utilized and are disposed in a conductive coupler box which acts as a counterpoise for the antenna radiator. The window mounted antenna incorporating the present invention is capable of providing radiation
characteristics comparable to antennas mounted on the roof tops of vehicles, provides desired omni-directional coverage and satisfactory gain without the distortion which may arise from mounting antennas on trunk lids and other less satisfactory locations on a vehicle.

More specifically, the communications antenna system incorporating the present invention utilizes a collinear radiator having a 5/8 wave-length upper radiator and a lower radiator having an electrical length of between about 1/4 and 1/2 wave-length separated by an air-wound phasing coil.

One advantage of the glass mounted antenna system as set forth in the above-mentioned patent is the elimination of the ground plane and the resultant uniformity of radiation pattern independent of vehicle configuration. At the frequencies at which the assembly incorporating the present invention is used, however, one problem that arises is that the transmission line connecting the antenna assembly to the transceiver becomes "hot".

In order to eliminate this problem, the coupling or feed assembly is incorporated in a conductive housing which acts as a counterpoise. Disposed within the conductive housing are the components defining a coupling capacitor plate, and the tuned circuit utilized to tune the antenna and couple the radiator mounted on the external surface of the glass to the transmission line.

The configuration of the components disposed within the coupling or feed housing are significantly different than those that were suitable for use in the antenna disclosed in the aforesaid patent. Thus, the coupling capacitor plate forming a part of the feed housing is a printed circuit foil embedded in a dielectric sheet forming one side of the housing. The plate of the coupling capacitor also acts as the plate of the adjustable tuning capacitor. The other plate of the tuning capacitor is a generally U-shaped member. The base of the U is affixed to and in contact with the metallic housing forming the counterpoise. One leg of the U shaped plate, oriented at substantially 90° to the base, provides the ground or shield connection to a transmission line connector. The second leg forms the other plate of the tuning capacitor. The second leg extends over at least a portion of the coupling plate or embedded foil element to define the adjustable coupling capacitor.

The adjustment of the capacitor is achieved by adjusting the position of the free end return and thereby adjusting the amount of overlap between that plate of the tuning capacitor and the foil coupling plate. The dielectric member in which the coupling plate is embedded forms the closure for the conductive housing or counterpoise.

The inductor is defined by a straight wire having a dimension suitable to the frequencies at which the antenna is to be tuned. The wire extends between and is electrically connected to the base of the generally U-shaped conductor and the foil coupling plate. The center conductor of the transmission line connector is electrically connected to the inductor at an appropriate tap point along its length whereby the impedance of the tuning circuit is matched to the 50 ohm impedance of the transmission line.

By utilizing a through-the-glass antenna assembly in accordance with the present invention, there is provided an antenna system capable of producing omni-directional radiation at and above the 800MHz band having a band width defined by a VSWR less than 1.5 over a range of about 60-80 MHz rendering the antenna suitable for use as a cellular phone system antenna providing desired gain and band width capabilities. At the same time, by use of the antenna system incorporating the present invention, the transmission line connecting the antenna to the transceiver is not hot, thereby eliminating one safety concern.

Numerous other advantages and features of the present invention will become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings in which the details of the invention are fully and completely disclosed as a part of this specification.

Brief Description of the Drawings

Fig. 1 is a perspective view showing installation of an antenna on a windshield;
Fig. 2 is an enlarged cross-section taken along lines 2-2 of Fig. 1;
Fig. 3 is a perspective view, partially broken away of a feed or coupling assembly in accordance with the present invention;
Fig. 4 is an elevation of the coupling housing;
Fig. 5 is an elevation showing a suitable antenna radiator; and
Figs. 6 and 7 are VSWR plots for the antenna incorporating the present invention.

Detailed Description of a Preferred Embodiment

Referring to the drawings there is shown an antenna system incorporating the present invention. The antenna system includes an elongated collinear radiator 10 comprising an upper section 10a having an electrical length of approximately 5/8 wavelength, and lower section 10b having an electrical length in excess of 1/4 wavelength separated by an air wound phasing coil 10c having a length
suitable for proper phasing at the frequency at which the antenna is to be used.

The radiator terminates in a base or foot 12 such as one shown in U.S. Patent No. 4,266,227 having a generally flat surface adapted to be suitably affixed to the outer surface of a dielectric member such as a windshield 14 of a vehicle 16. A coupling or feed assembly 20 is affixed to the inner surface of the windshield 14 juxtaposed to the antenna base member 12.

The feed assembly 20 includes a conductive housing 22 having a front wall 24 and four side walls 26 with an open back 28. The conductive housing acts as a counterpoise for the antenna system and thereby results in the feed or transmission line between the antenna system and the transceiver remaining "cold". The open back 28 is closed by a dielectric circuit board 30 having formed therein a conductive foil plate 33 which defines the second plate of a coupling capacitor on opposite sides of the windshield 14.

The inner coupling plate 33 also forms one plate of an adjustable tuning capacitor. The other plate of capacitor is defined by a generally U-shaped bent member 38 having a generally planar base portion 38a lying along and affixed to the inner surface of front wall 24 of the conductive housing 22. A standard transmission line coaxial connector 42 is disposed in one side wall 26a of the housing 22. The shield connection of the connector 42 is electrically connected to the housing 22 and to one leg 38b of the second tuning capacitor plate or U-shaped member 38 disposed generally perpendicular to the base 38a of the capacitor plate.

The other free leg 38c of the bent member 38 extends at a generally obtuse angle from the base 38 with the free end bent back to form a return 38d which overlaps and is spaced from the foil coupling plate 33. Adjustment of the capacitor is achieved by utilizing a non-conductive member 44 which passes through the side wall 26b and engages the free end or leg 38c of the tuning capacitor plate 38 to displace the leg 38c inwardly and outwardly. This adjusts the amount of overlap between the capacitor plate return 38d and the coupling plate 33 to adjust the amount of capacitance thereof as is well known.

An inductor 46 in the form of a straight wire having a diameter to produce an inductance appropriate to the frequency to which the system is to be tuned is electrically connected to the base 38a of the adjustable capacitor plate 38 and to the foil 33 formed in the PC board dielectric. The center conductor of the transmission line connector 42 is electrically connected to the inductor/wire 46 at a point between its ends to match the impedance of the transmission line itself of about 50 ohms.

A system so constructed is capable of providing significant band width over the desired range of at least about 60 to 80 MHz. For example, in one embodiment of the antenna system incorporating the present invention an antenna was tuned at 806 MHz and maintained a VSWR below 1.5 between frequencies of about 800 MHz and about 860 MHz as shown at A in Fig. 6. An antenna tuned to 820 MHz maintained VSWR equal or less than 1.5 between a frequency of about 802 MHz to excess of 865 MHz as shown in B in Fig. 6. Another antenna that was designed for use in the 821-896 MHz band maintained a VSWR at or below 1.5 between the frequencies of 820 MHz and 895 MHz, as shown in Fig. 7.

Such an antenna system was able to provide a uniform radiation pattern as a function of radiation angle with a uniformity substantially similar to a roof mounted antenna and substantially better than trunk and cowl mounted antennas. Such uniformity is especially important for cellular phone type systems since communications using such systems occur in all directions and any reduction of gain in any particular direction would adversely affect the quality and ability of the mobile system to maintain communications.

Thus there has been disclosed a mobile communications antenna system capable of use in the 800 MHz frequency band and above which does not require affixing to the metallic or conductive surface of a vehicle with the resulting damage thereto, which provides desired uniformity of transmission as a function of horizontal angle which provides satisfactory gain in all direction and which eliminates any concern or problem of having a hot cable disposed within the passenger compartment of such vehicles.

Claims

1. A mobile communications antenna system comprising:
- an elongated radiating member (10) attached to one end to a conductive antenna base member (12) affixed to the outer surface of a non-conductive dielectric means (14) of a vehicle (18); and
- a feed assembly (20) disposed on the inner surface of said dielectric means (14) and juxtaposed with said antenna base member (12), said feed assembly including a coupling member (33) juxtaposed with said antenna base member (12) to define therewith a coupling capacitor for RF energy, a tuned circuit connected to said coupling member (33) and a connector member (42) for a coaxial transmission line electrically con-
nected to said tuned circuit at a point at which the impedance of the transmission line connected to said connector member (42) and said tuned circuit is substantially the same, characterised in that said antenna system is adapted for use in the UHF frequency range in excess of 800 MHz; that said feed assembly (20) includes a conductive housing (22) defining a counterpoise for said antenna system; that said coupling member (33) is electrically insulated from said conductive housing (22); and that said tuned circuit is disposed within said conductive housing (22) for tuning said antenna system to a desired frequency within said 800 MHz band, and in order to achieve a wide bandwidth.

2. An antenna system as claimed in claim 1 wherein said coupling member (33) is a printed foil circuit formed in a non-conductive dielectric member (30), said dielectric member (30) closing one side of said housing (22); and wherein means are provided for affixing said non-conductive dielectric member (30) to the inner surface of said vehicle dielectric means (14) with the foil generally juxtaposed with said antenna base (12).

3. An antenna system as claimed in claim 2 wherein said tuned circuit comprises an adjustable capacitor and an inductor (46) connected in parallel therewith, said coupling member (33) being one plate of said tuning capacitor, and the other plate comprising a generally U-shaped conductive plate (38) having a base portion (38a) affixed to a conductive wall (24) of said housing (22), a first leg (38b) connected to said connector (42) and a second adjustable leg (38c) having a free portion (38d) juxtaposed and spaced from said coupling member (33).

4. An antenna systems as claimed in claim 3 including means (44) for adjusting the degree of overlap between the plates (33, 38d) of said adjustable capacitor.

5. An antenna system as claimed in claim 3 or 4 wherein said inductor (46) is a straight wire extending between and connected to said coupling member (33) and said U-shaped plate (38).

6. An antenna system as claimed in claim 5 wherein said connector member (42) is a coaxial connector having a shield contact con-

7. An antenna as claimed in any of the preceding claims wherein said elongated radiating member is a collinear radiator (10) having a first portion (10a) having a length about equal to 3/4 wavelength, a second portion (10b) including said base having a length between about 1/4 and 1/2 wavelength, and a phasing coil (10c) therebetween.

Patentansprüche

1. Mobiles Kommunikations-Antennensystem mit - einem ländlichen abstrahlenden Element (10), das mit einem Ende an einem linkenden Antennen-Basiselement (12) angeschlossen ist, das an der Außenfläche einer nichtleitenden dielektrischen Einrichtung (14) eines Fahrzeugs (16) befestigt ist; und mit - einer Zuführanordnung (20), die an der Innenfläche der dielektrischen Einrichtung (14) angeordnet ist und dem Antennen-Basiselement (12) gegenüberliegt, wobei die Zuführanordnung ein Koppel element (33), das dem Antennen-Basiselement (12) gegenüberliegt, um damit einen Koppel kondensator für HF-Energie zu bilden, einen mit dem Koppellement (33) verbundenen abgestimmten Kreis und ein Verbindungselement (42) zu einer Koaxialübertragungsleitung aufweist, das mit dem abgestimmten Kreis an einer Stelle elektrisch verbunden ist, an der die Impedanz der mit dem Verbindungselement (42) verbundenen Übertragungsleitung im wesentlichen gleich der des abgestimmten Kreises ist, dadurch gekennzeichnet, daß das Antennensystem zur Verwendung im UHF-Frequenzbereich über 800 MHz vorgesehen ist; daß die Zuführanordnung (20) ein leitendes Gehäuse (22) beinhaltet, das eine künstliche Antennenerde für das Antennensystem bildet; daß das Koppellement (33) elektrisch vom leitenden Gehäuse (22) isoliert ist; und daß der abgestimmte Kreis innerhalb des leitenden Gehäuses (22) angeordnet ist, um das Antennensystem auf eine gewünschte Frequenz innerhalb des 800-MHz-Bandes abzustimmen und um eine große Bandbreite zu erreichen.

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2. Antennensystem nach Anspruch 1, wobei das Koppelelement (33) eine gedruckte Folien- schaltung ist, die in einem nichtleitenden dielektrischen Element (30) ausgebildet ist, wobei das dielektrische Element (30) eine Seite des Gehäuses (22) verschließt; und wobei eine Einrichtung zur Befestigung des nichtleitenden dielektrischen Elementes (30) an der Innenfläche der dielektrischen Einrichtung (14) des Fahrzeugs vorgesehen ist, wobei die Folie im wesentlichen der Antennenbasis (12) gegenüberliegt.

3. Antennensystem nach Anspruch 2, wobei der abgestimmte Kreis einen einstellbaren Kondensator und eine Induktionsspule (46) aufweist, die parallel dazu angeschlossen ist, wobei das Koppelelement (33) eine Platte des Abstimmkondensators und die andere Platte eine im wesentlichen U-förmige leitende Platte (38) ist mit einem Basisabschnitt (38a), der an einer leitenden Wand (24) des Gehäuses (22) befestigt ist, mit einem ersten Schenkel (38b), der mit dem Verbindungselement (42) verbunden ist, und mit einem zweiten verstellbaren Schenkel (38c) mit einem freien Abschnitt (38d), der dem Koppelelement (33) gegenüberliegt und davon beabstandet ist.


5. Antennensystem nach Anspruch 3 oder 4, wobei die Induktionsspule (46) ein gerades Drahtstück ist, das sich zwischen dem Koppelelement (33) und der U-förmigen Platte (38) erstreckt und damit verbunden ist.

6. Antennensystem nach Anspruch 5, wobei das Verbindungselement (42) ein Koaxial-Verbindungstecker ist, dessen Abschirmkontakt mit dem ersten Schenkel (38b) und dem leitenden Gehäuse (22) verbunden ist und dessen Mit- tenkontakt (48) an den Induktionsspulendraht (46) zwischen dessen Enden angeschlossen ist.

7. Antenne nach einem der vorstehenden Ansprüche, wobei das längliche abstrahlende Element ein kollinerer Strahler (10) ist mit einem ersten Abschnitt (10a) mit einer Länge, die etwa gleich 3/4 der Wellenlänge ist, einem zweiten Abschnitt (10b), der die Basis einschließt und eine Länge zwischen etwa 1/4 und 1/2 der Wellenlänge hat, und mit einer Phasenabschlußspule (10c) dazwischen.

Revendications

1. Système d’antenne de communication mobile comprenant :
   un élément rayonnant allongé (10) monté au niveau d’une extrémité sur un élément de base d’antenne conducteur (12) fixé à la surface externe d’un moyen diélectrique non conducteur (14) d’un véhicule (16) ; et
   un assemblage d’alimentation (20) disposé sur la surface interne dudit moyen diélectrique (14) et juxtaposé audit élément de base d’antenne (12), ledit assemblage d’alimentation incluant un élément de couplage (33) juxtaposé audit élément de base d’antenne (12) pour définir avec une capacité de couplage pour une énergie radio-fréquence (RF), un circuit accordé connecté audit élément de couplage (33) et un élément de connecteur (42) prévu pour une ligne de transmission coaxiale connecté électriquement audit circuit accordé en un point auquel les valeurs d’impédance de la ligne de transmission connectée audit élément de connecteur (42) et dudit circuit accordé sont sensiblement les mêmes,
   caractérisé en ce que :
   ledit système d’antenne est conçu pour une utilisation dans la plage de fréquences UHF excédant 800 MHz ;
   ledit assemblage d’alimentation (20) inclut un boîtier conducteur (22) qui définit un équilibre pour ledit système d’antenne ;
   ledit élément de couplage (33) est isolé électriquement dudit boîtier conducteur (22) ; et
   ledit circuit accordé est disposé à l’intérieur dudit boîtier conducteur (22) pour accorder ledit système d’antenne à une fréquence souhaitée contenue dans ladite bande à 800 MHz et pour obtenir une largeur de bande importante.

2. Système d’antenne selon la revendication 1, caractérisé en ce que ledit élément de couplage (33) est un circuit en feuille imprimé formé dans un élément diélectrique non conducteur (30), ledit élément diélectrique (30) fermant un côté dudit boîtier (22) ; et dans lequel un moyen est prévu pour fixer ledit élément diélectrique non conducteur (30) à la surface interne dudit moyen diélectrique de véhicule (14), la feuille étant de façon générale juxtaposée à ladite base d’antenne (12).

3. Système d’antenne selon la revendication 2, caractérisé en ce que le circuit accordé comporte une capacité réglable et un inducteur (46) connecté parallèlement à celle-ci, ledit élé-
ment de couplage (33) étant une plaque de ladite capacité d’accord et l’autre plaque comprenant une plaque conductrice de forme générale en U (38) comportant une partie de base (38a) fixée à une paroi conductrice (24) dudit boîtier (22), un premier jambage (38b) connecté audit élément de connecteur (42) et un second jambage réglable (38c) comportant une partie libre (38d) juxtaposée audit élément de couplage (33) et espacée de celui-ci.

4. Système d’antenne selon la revendication 3, caractérisé en ce qu’il inclut un moyen (44) pour régler le degré de chevauchement entre les plaques (33, 38d) de ladite capacité réglable.

5. Système d’antenne selon la revendication 3 ou 4, dans lequel ledit inducteur (46) est un fil rectiligne qui s’étend entre ledit élément de couplage (33) et ladite plaque en forme de U (38) et qui leur est connecté.

6. Système d’antenne selon la revendication 5, caractérisé en ce que ledit élément de connecteur (42) est un connecteur coaxial comportant un contact de blindage connecté audit premier jambage (38b) et audit boîtier conducteur (22) et un connecteur central (48) connecté audit fil inducteur (46) en une position intermédiaire par rapport à ses extrémités.

7. Antenne selon l’une quelconque des revendications précédentes, caractérisé en ce que ledit élément rayonnant allongé est un élément rayonnant colinéaire (10) comportant une première partie (10a) présentant une longueur égale à environ 3/4 de longueur d’onde, une seconde partie (10b) incluant ladite base présentant une longueur qui se situe entre environ 1/4 et 1/2 de longueur d’onde, et une bobine de mise en phase (10c) située entre.
FIG. 6

FIG. 7