ONBOARD ANTENNA DEVICE FOR A VEHICLE

FIELD OF INVENTION

[0001] The present disclosure generally relates to the field of telecommunication. More specifically, the present invention is related to an onboard antenna device for a vehicle.

BACKGROUND OF THE INVENTION

[0002] The subject matter discussed in the background section should not be assumed to be prior art merely as a result of its mention in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may also correspond to implementations of the claimed technology.

[0003] Generally, an automotive vehicle is considered as a mode of transportation. A person uses a vehicle to travel from one place to another or to carry goods to a designated destination. However, with the development in automotive industry, vehicles are not considered as a mere mode of transportation, but rather a mobile ecosystem that travels along with the person because an automotive vehicle is provided with various types of sensors for electronically monitoring the basic vehicle-related information along with safety information, as well.

[0004] An automotive vehicle is often provided with audio devices and/or video devices so that the driver along with occupants enjoy the unique traveling experience. In addition, the vehicles are provided with navigation-related telemetric devices to guide the person en route to a destination.

[0005] **Fig. 1** illustrates a perspective view of standalone antenna unit for Global Navigation Satellite System (GNSS) communication, in accordance with prior art. In order to navigate a user to his destination, it is essential to correctly determine the positional state of the vehicle. For example, in order to perform the navigation function, the vehicle is provided with standalone units comprising the Global Navigation Satellite Systems (GNSS). The vehicle receives a Global Positioning System (GPS) signal from the GPS/GLONASS satellite to determine the location of the vehicle. In addition, the vehicle may receive a radio broadcast signal and/or a multimedia broadcast signal which can be reproduced into audio and/or video

output by the on-board audio-visual devices. Nowadays, the vehicle is also provided with mobile communication services through on-board devices, which can communicate with the mobile base stations.

[0006] **Fig. 2a**, **Fig. 2b**, and **Fig. 2c** illustrate perspective views of the standalone antenna unit for GNSS communication placed over and within a vehicle, in accordance with prior art. In conventional set-up, the standalone antenna unit for GNSS communication are bought off-the-shelf and fixed to the external surface of the vehicle such as windscreen, dashboard, and roof of the vehicle as shown in the figure so that it can easily accessed by the driver, as and when required. Such standalone antenna unit is concerned with only one function i.e. determining correct position of the vehicle and accordingly, provide navigation route to the driver. Therefore, said standalone antenna unit are not capable of being integrated to other electronic devices of the vehicle.

[0007] Most of vehicles have navigation system being placed at the external body surface of the vehicle. The choice of having an external antenna connection has the advantages of good electromagnetic characteristics, such as good transmission and reception performance. However, on the other hand, external antennas increase integration costs (cost of cabling, connectors and operator installation time), as wiring cannot be standardized (as it varies from vehicle to vehicle). Additionally, external antennas easily suffer breakage, either due to clipping with external objects, such as the roof of a tunnel or garage, or due to other acts, such as vandalism.

[0008] Antennas have long been attached to and even embedded in certain portions of vehicles. One common approach involves to implement the antenna as a conductive wire trace deposited onto a rear window. However, window antennas have severe drawbacks, such as reduced visibility out of the window, directional sensitivity, and degradation due to sun exposure over time. So-called shark fin antennas have come into use, since the late 1990's.

[0009] **Fig. 3a** and **Fig. 3b** illustrate roof mounted shark fin antenna installed in a vehicle, in accordance with prior art. The shark fin antennas are roof mounted, approximately 6 inches or so in length, are encased in an aerodynamic or other visually pleasing housing. However, shark fins protrude from the vehicle body and their shortened length sometimes leads to compromise in the quality of signal being received. Many solutions are available for automotive car, bus,

train, heavy vehicle etc. These include applications like an internal or external antenna, multiple antenna or hybrid for GNSS applications.

[0010] Accordingly, the automotive sector majorly used external bigger size GPS antennas with active support for vehicle location tracking. In the outdoor environment, especially in the two-wheeler bike segment only limited solutions are available, which are not effective so far. Since, the two-wheeler market needs an effective solution of precise tracking using GNSS option, irrespective of environment as well as other vehicle related constraints. As an antenna case, many off-the-shelf, onboard Printed Circuit boards (PCB), low profile chip and ceramic external patch solutions are available. These devices/attachments are gaining traction in the field of providing advanced navigation since, these easily fits to the Vehicle Control Unit (VCU) of a two-wheeler vehicle.

[0011] Hence, there exist a need for developing an onboard antenna device which is compact, reliable and can be easily integrated with the two-wheeler vehicle.

SUMMARY OF THE INVENTION

[0012] This summary is provided to introduce aspects related to the present invention of an onboard antenna device for a vehicle and the aspects are further described below in the detailed description. This summary is not intended to identify essential features of the claimed subject matter nor is it intended for use in determining or limiting the scope of the claimed subject matter.

[0013] In an embodiment of the present disclosure, a microstrip antenna is disclosed. The microstrip antenna may comprises a radiator configured to receive wireless signals. Truncations are present on at least one pair of diagonally opposite corners of the radiator to generate orthogonal resonance modes to enable circular polarization reception. The microstrip antenna further comprises a ground plane positioned beneath the radiator for reflecting the wireless signals towards the radiator. The microstrip antenna further comprises a plurality of dielectric substrates sandwiched between the radiator and the ground plane to facilitate impedance matching.

[0014] In an aspect of the present disclosure, a plurality of slots is incorporated on the radiator to optimize form factor of the microstrip antenna.

[0015] In another aspect of the present disclosure, the plurality of slots has a V-shaped geometry.

[0016] In another aspect of the present disclosure, the plurality of slots is outwardly facing and symmetrically arranged along the edges of the radiator.

[0017] In another aspect of the present disclosure, the plurality of dielectric substrates is made of FR4 glass epoxy.

[0018] In another aspect of the present disclosure, a feed line coupled to the radiator to facilitate signal transmission between the radiator and one or more wireless communication modules.

[0019] In another aspect of the present disclosure, the one or more wireless communication modules are selected from a group comprising an LTE main radio device, a GPS and GLONASS radio device, a BLE radio device, a Wi-Fi radio device, and an LTE diversity radio device.

[0020] In another aspect of the present disclosure, the feed line is implemented as a microstrip or a Coplanar Waveguide (CPW).

[0021] In another aspect of the present disclosure, wherein the circular polarization is Right-Hand Circular Polarization (RHCP).

[0022] In another aspect of the present disclosure, a ground vias made of a discontinuous metallic wire around the microstrip antenna to mitigate signal interference.

OBJECT OF THE INVENTION

[0023] An objective of the present invention is to provide an onboard microstrip antenna for GPS/GLONASS tracking of two-wheeler automotive vehicle.

[0024] Another objective of the present invention is to provide an onboard microstrip antenna that is compact and can be integrated with vehicle control unit (VCU) two-wheeler automotive vehicle.

[0025] Yet another objective of the present invention in to provide a low profile onboard microstrip antenna for electric vehicle telematics connectivity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The accompanying drawings constitute a part of the description and are used to provide further understanding of the present invention. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, serve to explain the principles of the present disclosure.

[0027] **Fig. 1** illustrates a perspective view of standalone antenna unit for Global Navigation Satellite System (GNSS) communication, in accordance with prior art.

[0028] **Fig. 2a, Fig. 2b** and **Fig. 2c** illustrate perspective views of standalone antenna unit for GNSS communication installed over and within a vehicle, in accordance with prior art.

[0029] **Fig. 3a** and **Fig. 3b** illustrates roof mounted shark fin antenna for a vehicle, in accordance with prior art.

[0030] **Fig. 4** illustrates a block diagram of a system depicting a microstrip antenna for use in different applications, in accordance with an embodiment of the present invention.

[0031] **Fig. 5** illustrates a schematic diagram of the microstrip antenna for integration with a Vehicle Control Unit (VCU), in accordance with an embodiment of the present invention.

[0032] **Fig. 6** illustrates an exploded view of the microstrip antenna, in accordance with an embodiment of the present invention.

[0033] **Fig. 7a** and **Fig. 7b** cumulatively illustrate integration of V-shaped slots into the microstrip antenna, in accordance with an embodiment of the present invention.

[0034] **Fig. 8a** and **Fig. 8b** illustrate top view and bottom view of a linearly polarized microstrip antenna without corner truncations respectively, in accordance with an embodiment of the present invention.

[0035] **Fig. 9a** illustrates a side view of EBG (Electromagnetic Band Gap) structure of the microstrip antenna, in accordance with an embodiment of the present invention.

[0036] **Fig. 9b** illustrates equivalent circuit of the EBG structure of the microstrip antenna, in accordance with an embodiment of the present invention.

[0037] **Fig. 10** illustrates a graph depicting a simulated return loss of the linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention.

[0038] **Fig. 11a** illustrates Right-Hand Circular Polarization (RHCP) 3D radiation patterns of the linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention.

[0039] **Fig. 11b** illustrates Left-Hand Circular Polarization (LHCP) 3D radiation patterns of the linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention.

[0040] **Fig. 12** illustrates a simulated 2D radiation pattern of the linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention.

[0041] **Fig. 13** illustrates a graph depicting the simulated return loss of the microstrip antenna with corner truncations, in accordance with an embodiment of the present invention.

[0042] **Fig. 14a** illustrate RHCP 3D radiation patterns of the microstrip antenna with corner truncations, in accordance with an embodiment of the present invention.

[0043] **Fig. 14b** illustrate LHCP 3D radiation patterns of the microstrip antenna with corner truncations, in accordance with an embodiment of the present invention.

[0044] **Fig. 15** illustrates the simulated 2D radiation pattern of the microstrip antenna with corner truncations, in accordance with an embodiment of the present invention.

[0045] A more complete understanding of the present invention and its embodiments thereof may be acquired by referring to the following description and the accompanying drawings.

DESCRIPTION OF THE INVENTION

[0046] Exemplary embodiments now will be described with reference to the accompanying drawings. The disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. The terminology used in the detailed description of the particular

exemplary embodiments illustrated in the accompanying drawings is not intended to be limiting. In the drawings, like numbers refer to like elements.

[0047] It is to be noted, however, that the reference numerals used herein illustrate only typical embodiments of the present subject matter, and are therefore, not to be considered for limiting its scope, for the subject matter may admit to other equally effective embodiments.

[0048] The specification may refer to "an", "another", "one" or "some" embodiment(s) in several locations.

[0049] This does not necessarily imply that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

[0050] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms "include", "comprises", "including" and/or "comprising" when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. Furthermore, "connected" or "coupled" as used herein may include operatively connected or coupled. As used herein, the term "and/or" includes any and all combinations and arrangements of one or more of the associated listed items.

[0051] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure pertains. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0052] The detailed description includes specific details for the purpose of providing a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without these specific details.

[0053] Nowadays most applications require low-profile antennas (planes, trains, medical field, cell phones, vehicles. Therefore, one of the most used antenna models is the microstrip patch. These microstrip patches can be designed in linear or circular polarization. In case of satellite signals coming from space, these can be depolarized due to atmospheric propagation, and it is better to use circularly polarized radiating elements. Circular polarization and especially Right-Hand Circular Polarization (RHCP) allow maximum signal reception through the antenna when the patch surface has a clear view of the sky.

[0054] **Fig. 4** illustrates a block diagram of a system **400** depicting a microstrip antenna **502** (illustrated in **Fig. 5**) for use in different applications, in accordance with an embodiment of the present invention. The system **400** may comprise a microstrip antenna **502** integrated within a wireless System on Chip (SoC) **402**. The System on Chip (SoC) **402** may be configured to manage wireless signal processing by transmitting the wireless signals to one or more communication modules. The system **400** may further comprise a microcontroller **404** integrated with the wireless SoC **402.** The microcontroller **404** act as a control unit facilitating communication between the SoC **402** and the one or more communication modules. The one or more communication modules may include an LTE Main radio device **406** which supports cellular communication. A GPS/GLONASS radio device **408** which enables satellite-based positioning. A BLE/Wi-Fi radio device **410** which allows short-range wireless communication and an LTE diversity radio device **412** which enhances network performance by improving signal reception and reliability. The forthcoming paragraphs describe the invention with reference to GNSS signal. However, the microstrip antenna **502** is capable of receiving other wireless signals as well. The disclosure should not be construed as being limited solely to GNSS signal reception.

[0055] **Fig. 5** illustrates a schematic diagram of a microstrip antenna **502** for integration with a Vehicle Control Unit (VCU), in accordance with an embodiment of the present invention. The microstrip antenna **502** may be integrated into the wireless SoC **402** which is housed on Printed Circuit Board (PCB) of the VCU. The wireless SoC **402** serves as the primary communication interface for wireless signal processing. Further, the microcontroller **404** may be integrated to the wireless SoC **402** which is responsible for managing and facilitating various vehicle-related parameters, including speed, battery State of Charge (SOC), location, and safety alerts. Such integration facilitates real-time data exchange between the vehicle and external wireless networks, enabling advanced telematics and vehicular communication functionalities.

[0056] The microstrip antenna may **502** comprise a radiator **504**, placed on top surface of the microstrip antenna **502**. The radiator **504** is configured to receive and transmit wireless signals. Truncations **704** (illustrated in **Fig. 7**) are made on at least one pair of diagonally opposite corners of the radiator **504** to generate orthogonal resonance modes to enable Right-Hand Circular Polarization (RHCP) reception. Further a plurality of V-shaped slots may be incorporated on the radiator **504** in a symmetrical manner along the edges of the radiator **504** to optimize form factor of the microstrip antenna **502**. The microstrip antenna **502** may further comprise a feed line **506** coupled to the radiator **504** and is connected to the wireless SoC **402** to facilitate signal transmission between the radiator **504** and one or more wireless communication modules. The feed line **506** may be implemented as a microstrip or a Coplanar Waveguide (CPW). Furthermore, a series of ground vias **508** are surrounded along the periphery of the layout, which appear as small, circular, and discontinuous metallics elements. The ground vias **508** functions as electromagnetic shielding elements by mitigating interference, stabilizing the wireless signal propagation, and enhancing overall performance of the microstrip antenna **502**.

[0057] **Fig. 6** illustrates an exploded view of the microstrip antenna **502**, in accordance with an embodiment of the present invention. The microstrip antenna **502** is designed with specific structural and material considerations to ensure optimal performance in various vehicle telematics applications. The microstrip antenna **502** is integrated into the PCB of the VCU and follows a compact, rectangular form factor. The overall structure of the microstrip antenna **502** comprises multiple layers. The multiple layers may include a top metal layer where the radiator **504** is positioned in a flat and optimized manner. The multiple layers also include a bottom metal layer that represents ground plane **602**. The ground plane **602** may act as a reflector and reflect the wireless signals towards the radiator **504** to prevent signal loss. Further, the multiple layers may include a plurality of dielectric substrates **604** sandwiched between the radiator **504** and the ground plane **602** to facilitate impedance matching and enhance radiation efficiency. For example, a dielectric substrate **604-1**, dielectric substrate **604-2**, dielectric substrate **604-3,** dielectric substrate **604-4** are sandwiched between the radiator **504** and the ground plane **602**. Hereinafter, for ease of explanation, the dielectric substrates **604** from **604-1** to **604-4** are cumulatively referred as dielectric substrates **604.**

[0058] The dimensions of the microstrip antenna **502** are carefully chosen to balance size reduction and effective signal reception, measuring approximately 30 mm in length, 30 mm in

width, and 1.6 mm in thickness. Further, the dimensions of the ground plane **602** are approximately of 40 mm × 40 mm. The material selection for the microstrip antenna **502** is equally important, as the material selection influences the overall dielectric properties and efficiency. The dielectric substrate **604** is made of FR4 glass epoxy. The FR4 glass epoxy is a standard material in PCB-based antenna designs due to cost-effectiveness, mechanical stability, and dielectric properties. The chosen material provides a dielectric constant of approximately 4.5 which helps in determining operating wavelength and impedance characteristics of the microstrip antenna **502**. Furthermore, a low loss tangent of 0.005 minimizes energy dissipation, ensuring efficient transmission and reception of signals.

[0059] The current implementation of the microstrip antenna **502** follows a patch antenna structure on the PCB. Alternative design variations may be considered based on application requirements. One possible alternative is a Surface-Mount Device (SMD) antenna, which may be integrated as a bought-out component for applications requiring ultra-compact designs. Such antennas are commercially available and offer high performance, although they may not be optimized for specific vehicle architectures like custom-designed PCB antennas. Another possibility is a metal-stamped antenna, commonly used in mobile devices. The metal-stamped antennas may be designed in compact 3D structures, offering a robust and miniaturized solution suitable for space-constrained automotive applications. Additionally, alternative materials such as high-performance ceramics or flexible polymer-based substrates maybe explored to enhance durability and environmental resilience. The choice of antenna design depends on factors such as available space, required gain, integration constraints, and cost considerations.

[0060] **Fig. 7a** and **Fig. 7b** cumulatively illustrate integration of plurality of slots **702** into the microstrip antenna **502**, in accordance with an embodiment of the present invention. The integration of the plurality of slots **702** in the radiator **504** of the microstrip antenna **502** plays a dual role in enhancing bandwidth and reducing the overall antenna size. Such design modifications are crucial in optimizing antenna performance while ensuring the integration into compact vehicle telematics systems. The plurality of slots **702** has a V-shaped geometry. The plurality of slots **702** is outwardly facing and symmetrically arranged along the edges of the radiator **504.** The microstrip antenna **502** is designed on the PCB-based multilayer structure with an effective dielectric constant of approximately 4.5 and a loss tangent of 0.005, ensuring stable RF performance.

$$\lambda = \frac{c}{f\sqrt{\varepsilon_R}} \quad \ldots (1)$$

[0061] As with all PCB-based patch antennas, the initial dimensions of the original microstrip antenna **502** is determined based on the half-guided wavelength of the GPS L1 frequency (1.575 GHz). From the above equation (1), the initial configuration of the original microstrip antenna **502** is characterized by dimensions of approximately 45 mm × 45 mm × 1.6 mm, with an associated ground plane **602** measuring 50 mm × 50 mm × 1.6 mm.

[0062] To reduce physical size of the microstrip antenna **502** while maintaining the same resonant frequency, the plurality of V-shaped slots is strategically integrated in a symmetrical manner at the edges of the radiator **504** of the microstrip antenna **502**. The plurality of slots **702** effectively increases the electric length of the current flow, allowing the microstrip antenna **502** to resonate at the same frequency despite a reduced physical footprint. As a result, the microstrip antenna **502** is successfully miniaturized to 30 mm × 30 mm × 1.6 mm, with the ground plane **602** measuring 40 mm × 40 mm, achieving an approximate 33% reduction in size compared to the initial configuration. In addition to size reduction, the V-shaped slots introduce additional resonant paths, which significantly broaden the microstrip antenna's impedance bandwidth. The plurality of slots **702** has a dimension of 9mm in length. The feed line **506** has a dimension of 22.5 mm in length and 1mm in width. Further, the truncations **704** made on at least one pair of diagonally opposite corners of the radiator **504** has a dimension of 3mm in length. The dielectric substrate **604** has a dimension of 35mm ×35 mm.

[0063] **Fig. 8a** and **8b** illustrates top view and bottom view of linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention. The illustrated figure depicts the linearly polarized microstrip antenna having designed as a rectangular microstrip patch without any corner truncations. The linearly polarized microstrip antenna may have symmetrical V-shaped slots **802** integrated to the antenna. The absence of the corner truncations and the symmetrical V-shaped slots results in the antenna exhibiting linear polarization, which means it does not efficiently receive circularly polarized GNSS signals. The linearly polarized microstrip antenna without corner truncations provides a linearly polarized radiation pattern while maintaining good impedance matching within frequency range of 1570 MHz to 1602 MHz. Although the linearly polarized microstrip antenna operates effectively in terms of impedance matching, the linear polarization limits

ability of the antenna to optimally receive satellite signals which are inherently right-hand circularly polarized.

[0064] **Fig. 9a** illustrates a side view of EBG (Electromagnetic Band Gap) structure of the microstrip antenna, in accordance with an embodiment of the present invention. The EBG structure is formed by placing the ground vias **508** along the periphery of the microstrip antenna **502** in a periodic form to suppress surface waves and mitigate interference. The feed line **506** is responsible for signal transmission, while the ground plane **602** provides a reference potential.

[0065] **Fig. 9b** illustrates equivalent circuit of the EBG structure of the microstrip antenna, in accordance with an embodiment of the present invention. Capacitor C_0 **902** models the coupling capacitance between the EBG structure and the microstrip antenna **502**, influencing signal propagation and filtering high-frequency noise. Capacitor C_1 **904** accounts for the capacitance formed between the EBG structure and the ground plane **602**, playing a role in suppressing unwanted surface waves. Inductor L_1 **906** represents the inductance of the ground vias **508** connecting the EBG structure to the ground plane **602**, affecting impedance characteristics and resonance behavior. The LC network collectively enhances the microstrip antenna **502** performance by controlling electromagnetic wave propagation, reducing mutual coupling, and mitigating interference, thereby improving radiation efficiency and signal integrity.

[0066] **Fig. 10** illustrates a graph depicting simulated return loss of the linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention. As observed in the figure, the linearly polarized microstrip antenna exhibits a well-defined resonance near 1.575 GHz (GPS L1 band), with the return loss values remaining below -10 dB within operational bandwidth. Such low value confirms that the linearly polarized microstrip antenna effectively radiates and receives signals with minimal power loss. Despite achieving good impedance matching, the absence of corner truncations results in the antenna maintaining linear polarization, which restricts effectiveness in GNSS applications requiring circular polarization.

[0067] **Fig. 11a** illustrates RHCP 3D radiation patterns of the linearly polarized microstrip antenna without corner truncations and **Fig. 11b** illustrate LHCP 3D radiation patterns of the linearly polarized microstrip antenna without corner truncations respectively, in accordance with an embodiment of the present invention. The linearly polarized microstrip antenna without

corner truncations predominantly exhibits linear polarization. The linearly polarized microstrip antenna radiates electromagnetic waves along a single polarization axis. However, due to practical design constraints, small RHCP and LHCP components may be still present, as depicted in the illustrated figure. Such results establish that the linearly polarized microstrip antenna form does not effectively support GNSS signals, which require dominant RHCP performance for efficient reception.

[0068] **Fig. 12** illustrates a simulated 2D radiation pattern of the linearly polarized microstrip antenna without corner truncations, in accordance with an embodiment of the present invention. The radiation pattern illustrates how the linearly polarized microstrip antenna emits signals, displaying a broad and symmetrical main lobe. Since no corner truncations are applied, the linearly polarized microstrip antenna primarily radiates linearly polarized waves, which are not ideal for GNSS reception.

[0069] **Fig. 13** illustrates a graph depicting the simulated return loss of the microstrip antenna with corner truncations, in accordance with an embodiment of the present invention. The simulated results confirm that the microstrip antenna **502** operates effectively within the GPS L1 frequency band (1.575 GHz), with a well-matched impedance ensuring minimal signal reflection. The introduction of V-shaped symmetrical slots in the patch design contributes to maintaining stable impedance characteristics, optimizing performance for reliable GNSS signal reception.

[0070] **Fig. 14a** illustrate RHCP 3D radiation patterns of the microstrip antenna with corner truncations and **Fig. 14b** illustrates LHCP 3D radiation patterns of the microstrip antenna **502** with corner truncations respectively, in accordance with an embodiment of the present invention. **Fig. 14a** shows the RHCP gain, which is essential for receiving GNSS signals effectively. **Fig. 14b** depicts the LHCP gain, which is significantly lower, indicating that the microstrip antenna **502** successfully suppresses the undesired polarization. The microstrip antenna **502** without corner truncations primarily exhibits linear polarization, which is not ideal for wireless signals reception applications. To achieve the required RHCP characteristics, the corner truncations are introduced at the edges of the patch in an anti-clockwise orientation. Such modification ensures that the microstrip antenna **502** generates two orthogonal resonance modes with a 90-degree phase shift, thereby producing circular polarization. For optimal GNSS performance, the power level difference between the RHCP and the LHCP must be at least -10

dB, ensuring a good axial ratio and effective circular polarization, as validated in the simulated results.

[0071] **Fig. 15** illustrates the simulated 2D radiation pattern of the microstrip antenna **502** with corner truncations, in accordance with an embodiment of the present invention. The radiation pattern represents the distribution of radiated power in different directions, demonstrating performance of the microstrip antenna **502** in terms of signal propagation. The microstrip antenna **502** with corner truncations effectively generates RHCP, which is essential for GNSS signal reception. The pattern confirms that the microstrip antenna **502** radiates with a strong RHCP component while minimizing the LHCP level, ensuring efficient reception of wireless signals. Additionally, the results validate that the microstrip antenna **502** maintains a stable radiation pattern, achieving the required axial ratio for optimal circular polarization performance.

[0072] Hence, the disclosed on-board microstrip antenna architecture in the existing Vehicle Control Unit (VCU) module provides a compact navigation device along with telematics communication in two-wheeler vehicles and two-wheeler EVs.

Technical advantage of the invention

[0073] The on-board microstrip antenna architecture module proposed in the present invention, hence ensures a compact design so that the same may be installed/ integrated to the existing Vehicle Control Unit (VCU) in a two-wheeler vehicle including two-wheeler EVs. Since, the disclosed module is installed within VCU and integrated to the PCB, therefore no wiring is required for the same, which reduces the integration costs and operator's installation time. It also provides safety to the microstrip antenna from the external factors such as breakage due to vandalism or theft. The disclosed system works in an integrated manner and provide basic vehicle related information like tire pressure, fuel level in the tank, safety information i.e., integrity of vehicle frame along with navigation details to the driver. The disclosed system can also be using inter-vehicle data transfer among on road moving electric vehicle in real time, which not only increases the road safety but also leads to optimization of the distance travelled by the electric two-wheeler.

[0074] Although implementations of an onboard antenna device for a vehicle have been described in language specific to structural features and/or methods, it is to be understood that

the appended claims are not necessarily limited to the specific features or methods described. Rather, the specific features and methods are disclosed as examples of implementations of an onboard antenna device for a vehicle.

[0075] The invention has been described above with reference to numerous embodiments and specific examples. Many variations will suggest themselves to those skilled in this art in light of the above detailed description. All such obvious variations are within the full intended scope of the appended claims.

We Claim:

1. A microstrip antenna (502), comprising:

a radiator (504) for transmitting and receiving wireless signals, wherein truncations (704) are present on at least one pair of diagonally opposite corners of the radiator (504) to generate orthogonal resonance modes to enable circular polarization reception;

a ground plane (602) positioned beneath the radiator (504) for reflecting the wireless signals towards the radiator (504); and

a plurality of dielectric substrates (604) sandwiched between the radiator (504) and the ground plane (602) to facilitate impedance matching.

2. The microstrip antenna (502) as claimed in claim 1, further comprises a plurality of slots (702) is incorporated on the radiator (504) to optimize form factor of the microstrip antenna (502).

3. The microstrip antenna (502) as claimed in claim 2, wherein the plurality of slots (702) has a V-shaped geometry.

4. The microstrip antenna (502) as claimed in claim 2, wherein the plurality of slots (702) is outwardly facing and symmetrically arranged along the edges of the radiator (504).

5. The microstrip antenna (502) as claimed in claim 1, the plurality of dielectric substrates (604) is made of FR4 glass epoxy.

6. The microstrip antenna (502) as claimed in claim 1, further comprises a feed line (506) coupled to the radiator (504) to facilitate signal transmission between the radiator (504) and one or more wireless communication modules.

7. The microstrip antenna (502) as claimed in claim 6, wherein the one or more wireless communication modules are selected from a group comprising an LTE main radio device (406), a GPS and GLONASS radio device (408), a BLE/Wi-Fi radio device (410), and an LTE diversity radio device (412).

8. The microstrip antenna (502) as claimed in claim 7, wherein the feed line (506) is implemented as a microstrip or a Coplanar Waveguide (CPW).

9. The microstrip antenna (502) as claimed in claim 1, wherein the circular polarization is Right-Hand Circular Polarization (RHCP).

10. The microstrip antenna (502) as claimed in claim 1, further comprises a ground vias (508) made of a discontinuous metallic wire around the microstrip antenna (502) to mitigate signal interference.