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Circular patch antenna with integrated arc slots

Abstract

Circular patch antenna with integrated arc slots. In one embodiment, the circular patch antenna includes a top dielectric patch and a bottom dielectric patch. The top dielectric patch includes a first plurality of apertures while the bottom dielectric patch includes a second plurality of apertures. At least a portion of the first plurality of apertures and the second plurality of apertures are aligned with one another when the top dielectric patch is positioned over the bottom dielectric patch. A flex printed circuit board (PCB) is positioned between the top dielectric patch and the bottom dielectric patch and includes a plurality of arc slots, each of the plurality of arc slots are positioned between the first and second plurality of apertures and an external periphery of the flex PCB. Methods of operating the circular patch antenna as well as systems that incorporate the circular patch antenna are also disclosed.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of, and claims the benefit of priority to, U.S. patent application Ser. No. 17/947,422 filed Sep. 19, 2022, of the same title, which claims the benefit of priority to U.S. Provisional Patent Application Ser. No. 63/246,663 filed Sep. 21, 2021, of the same title, the contents of each of the foregoing being incorporated herein by reference in its entirety.

FIELD
(1) The present disclosure relates generally to circular patch antennas, and more particularly in one exemplary aspect to circular patch antennas for use with global navigation satellite system (GNSS) frequency bands.
BACKGROUND
(2) Traditionally, antenna designs for use with GNSS frequency bands often utilize ceramic based materials to meet the performance-based requirements for these operating bands. However, these ceramic based materials are relatively heavy making there use less than desirable in applications in which mass is a design constraint. Additionally, ceramic based materials are relatively brittle which makes there use with, for example, unmanned aerial vehicles (UAVs) less than desirable. Accordingly, ongoing trends in the development of antennas for use with, for example, UAVs has required the use of non-traditional materials that: (1) are lighter in weight to, inter alia, maximize the battery life for these UAVs; and (2) have increased impact-resistance, to improve the reliability of the antenna design. As a result, new technologies that address the deficiencies of prior ceramic-

based antenna designs are now needed.

SUMMARY

(3) The present disclosure satisfies the foregoing needs by providing, inter alia, methods, apparatus and systems for the implementation of circular patch antennas that address some or all of the deficiencies recognized above.

(4) In one aspect, a circular patch antenna is disclosed. In one embodiment, the circular patch antenna includes a first dielectric patch having a first plurality of apertures; a second dielectric patch having a second plurality of apertures, at least a portion of the first plurality of apertures and the second plurality of apertures being aligned with one another when the first dielectric patch is positioned with the second dielectric patch; and a metallization that is positioned between the first dielectric patch and the second dielectric patch, the metallization including a plurality of arc slots, each of the plurality of arc slots being positioned between the first and second plurality of apertures and an external periphery of the metallization.

(5) In one variant, the metallization includes two distinct flexible printed circuit boards.

(6) In another variant, the second dielectric patch includes a plurality of slots organized into a plurality of groupings of slots.

(7) In yet another variant, a portion of the plurality of slots are positioned between one of the first plurality of apertures and one of the second plurality of apertures.

(8) In yet another variant, the plurality of groupings of slots includes a first grouping of slots and a second grouping of slots that is disposed adjacent the first grouping of slots, wherein a first arc slot of the plurality of arc slots covers a portion of the first grouping of slots and a portion of the second grouping of slots.

(9) In yet another variant, the first dielectric patch further includes an inner ring that is positioned about the first plurality of apertures.

(10) In yet another variant, the first dielectric patch further includes an intermediate ring that is positioned between the first plurality of apertures and the second plurality of apertures.

(11) In yet another variant, the first dielectric patch further includes one or more outer rings, the one or more outer rings being positioned between the second plurality of apertures and an outer periphery of the first dielectric patch.

(12) In yet another variant, the first dielectric patch and the second dielectric patch include disk-like profiles for an external periphery of the first dielectric patch and the second dielectric patch.

(13) In yet another variant, the first dielectric patch and the second dielectric patch each include one or more alignment features that provide alignment between the first dielectric patch and the second dielectric patch when mounted with one another.

(14) In yet another variant, the circular patch antenna further includes a top metallization that is disposed atop the first dielectric patch, the top metallization including a plurality of arc slots.

(15) In yet another variant, the circular patch antenna further includes a first plurality of solder pins and a second plurality of solder pins, the first plurality of solder pins being received through both the first dielectric patch and the second dielectric patch, while the second plurality of solder pins is received within the second dielectric patch, but not the first dielectric patch.

(16) In yet another variant, the circular patch antenna further includes a bottom metallization that is disposed below the second dielectric patch.

(17) In yet another variant, the two distinct flexible printed circuit boards positioned between the first dielectric patch and the second dielectric patch, the top metallization that is disposed atop the first dielectric patch and the bottom metallization that is disposed below the second dielectric patch each comprise a circular outer profile.

(18) In another embodiment, the circular patch antenna includes a first dielectric patch having a first plurality of apertures and a second plurality of apertures that are disposed between the first plurality of apertures and an external periphery for the first dielectric patch; a second dielectric patch having a third plurality of apertures and a fourth plurality of apertures, the first plurality of

apertures being aligned with the third plurality of apertures and the second plurality of apertures being aligned with the fourth plurality of apertures when the first dielectric patch is mounted on the second dielectric patch; and a metallization that is positioned between the first dielectric patch and the second dielectric patch, the metallization including a plurality of arc slots, each of the plurality of arc slots being positioned between the first and second plurality of apertures and an external periphery of the metallization.
(19) In one variant, the second dielectric patch includes a plurality of slots organized into a plurality of groupings of slots.
(20) In another variant, a portion of the plurality of slots are positioned between one of the first plurality of apertures and one of the second plurality of apertures.
(21) In yet another variant, the plurality of groupings of slots includes a first grouping of slots and a second grouping of slots that is disposed adjacent the first grouping of slots, wherein a first arc slot of the plurality of arc slots covers a portion of the first grouping of slots and a portion of the second grouping of slots.
(22) In yet another variant, the metallization comprises two distinct metallizations.
(23) In yet another variant, the circular patch antenna further includes a top metallization that is positioned atop the first dielectric patch, the top metallization including a plurality of arc slots that are aligned with the plurality of arc slots located on the two distinct metallizations positioned between the first dielectric patch and the second dielectric patch.
(24) In another aspect, systems that incorporate the aforementioned circular patch antennas are disclosed.
(25) In yet another aspect, methods of manufacturing the aforementioned circular patch antennas are disclosed.
(26) Other features and advantages of the present disclosure will immediately be recognized by persons of ordinary skill in the art with reference to the attached drawings and detailed description of exemplary implementations as given below.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) The features, objectives, and advantages of the present disclosure will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, wherein:
(2) FIG. **1**A is an exploded perspective view of a circular patch antenna, in accordance with the principles of the present disclosure.
(3) FIG. **1**B is a top plan view of the circular patch antenna of FIG. **1**A, in accordance with the principles of the present disclosure.
(4) FIG. **1**C is a front plan view of the circular patch antenna of FIG. **1**A, in accordance with the principles of the present disclosure.
(5) FIG. **1**D is an exploded top perspective view of the circular patch antenna of FIG. **1**A, in accordance with the principles of the present disclosure.
(6) FIG. **1**E is an exploded bottom perspective view of the circular patch antenna of FIG. **1**A, in accordance with the principles of the present disclosure.
(7) FIG. **1**F is an exploded bottom perspective view of the bottom dielectric patch of the circular patch antenna of FIG. **1**A, in accordance with the principles of the present disclosure.
(8) FIG. **2** are front, top, bottom, and isometric views of the circular patch antenna of FIGS. **1**A-**1**F, in accordance with the principles of the present disclosure.

DESCRIPTION

(10) Detailed descriptions of the various embodiments and variants of the apparatus and methods of the present disclosure are now provided. It is noted that wherever practicable similar or like reference numbers may be used in the figures and may indicate similar or like functionality. The figures depict embodiments of systems, circular patch antennas, or methods for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without necessarily departing from the principles described herein.

(11) Exemplary Circular Patch Antenna—

(12) Ongoing trends in the development of antennas for use with, for example, unmanned aerial vehicles (UAVs) has resulted in the development of non-traditional materials that: (1) are lighter in weight, to maximize the battery life for these UAVs; and (2) have increased impact-resistance, to improve the reliability of the antenna design. More recently, the assignee of the present disclosure has implemented a polymer dielectric substance fortified with ceramic particles that is utilized as an alternative to heavier and more brittle ceramics that have traditionally been used in these antenna designs. These polymer dielectric materials have been marketed under the name TERRABLAST® and are more than 30% lighter than traditional ceramic antenna technologies and are impact resistant to withstand drops, falls and impacts making it ideal for applications such as, for example, UAVs, where the antenna's mechanical robustness following potential impacts is critical. This polymer dielectric material also has broader utility outside of antenna designs for use with UAV applications.

(13) Referring now to FIGS. **1**A-**1**F, an exemplary circular patch antenna **100** is shown and described in detail. The circular patch antenna **100** may be utilized as a GNSS patch antenna with sufficient frequency bandwidth to cover all L-band GNSS frequencies, while remaining manufacturable and relatively small-sized. Additionally, the resonant frequency of the circular patch antenna **100** may be reduced without sacrificing its phase and polarization performance characteristics. Additionally, through its incorporation of the aforementioned polymer dielectric material, the effective dielectric constant of the patch dielectric may be altered with geometric design changes to the underlying circular patch antenna **100** design while also improving upon its manufacturability and minimizing mass.

(14) FIG. **1**A is an exploded perspective view of a circular patch antenna **100** illustrating the various components that make up one exemplary antenna design. The circular patch antenna **100** may include a top dielectric patch **102** as well as a bottom dielectric patch **104** that may be manufactured from the aforementioned polymer dielectric fortified with ceramic particles. In some implementations, the top dielectric patch **102** and/or the bottom dielectric patch **104** may be manufactured from a ceramic or may be manufactured using other types of known dielectric materials. The circular patch antenna **100** may also incorporate a plurality of distinct flexible printed circuit boards (PCBs). For example, these flexible PCBs may include a top patch flex PCB **110** that is positioned atop the top dielectric patch **102**, one or more middle patch flex PCB(s) **112**, **134** that are positioned between the top dielectric patch **102** and the bottom dielectric patch **104**, as well as a bottom ground flex PCB **114** that is positioned underneath the bottom dielectric patch **104**. These flex PCBs **110**, **112**, **134**, **114** may be manufactured from a polyimide material. The top flex PCB **110** may form the top patch metallization for the circular patch antenna **100**. One or more of the middle flex PCBs **112**, **134** may form the middle patch metallization for the circular patch antenna **100**. Additionally, the use of two distinct middle flex PCBs **112**, **134** may serve to stabilize the performance of, for example, the top dielectric patch **102** across distinct circular patch antennas **100**. The bottom flex PCB **114** may form a ground plane for the circular patch antenna **100** that may stabilize the performance of the circular patch antenna **100** when the circular patch antenna **100** is mounted on, for example, non-planar or imperfectly planar surfaces. Although, the use of flexible PCBs **110**, **112**, **134**, **114** for the circular patch antenna **100** is exemplary and may be

desirable in instances in which design constraints on the overall height of the circular patch antenna **100** dictate their usage, it would be readily appreciated by one of ordinary skill given the contents of the present disclosure that alternative implementations may utilize other types of traditional substrate materials including, for example, substrates made from FR-4, or other types of metallizations and substrate materials.

(15) The circular patch antenna **100** may also include one or more solder pins **106**, **108**. As shown in FIG. **1**A, the total number of solder pins **106**, **108** shown is four (4) to create a dual-feed circular patch antenna **100**, although it would be readily apparent to one of ordinary skill given the contents of the present disclosure that the number of solder pins **106**, **108** may be varied dependent upon specific design constraints. For example, a quad-feed circular patch antenna **100** may include eight (8) solder pins **106**, **108**. In some implementations, solder pins **106** may have a different length than solder pins **108**. For example, solder pins **106** may have a length of fifteen (15) mm, while solder pins **108** may have a length of eleven (11) mm. The difference in solder pin length may be necessary as some of these solder pins **106** may have to pass through both the top dielectric patch **102** and bottom dielectric patch **104**, while other ones of these solder pins **108** only need to pass through the bottom dielectric patch **104**.

(16) As a brief aside, and referring to FIG. **1**B, the feed apertures **120**, **122** as shown on the top of the circular patch antenna **100** are shown and described in detail. The inner feed apertures **120** are positioned about the centerline **132** of the circular patch antenna **100** at a diameter D**2**. The outer feed apertures **122** are positioned about the centerline **132** of the circular patch antenna **100** at a diameter D**1**. In some implementations, solder pins **106** may be received within respective ones of the inner feed apertures **120**, while solder pins **108** may be received within respective ones of the outer feed apertures **122**, albeit underneath the top dielectric patch **102** as shown in FIG. **1**A. However, in some implementations, this arrangement may be reversed such that solder pins **106** may be received within respective ones of the outer feed apertures **122**, while solder pins **108** may be received within respective ones of the inner feed apertures **120**. Referring now to FIG. **1**D, solder pins **106** pass through the top flex PCB **110**, the top dielectric patch **102**, through both the middle flex PCBs **112**, **134**, the bottom dielectric patch **104**, and the bottom flex PCB **114**. In some implementations, solder pins **108** are positioned atop the lower flex PCB **134** where they protrude therethrough, before passing through the bottom dielectric patch **104**, and the bottom flex PCB **114**. In some implementations, solder pins **108** do not pass through both of the middle flex PCBs **112**, **134**; rather they only pass through the lower middle flex PCB **134**. Referring again to FIG. **1**A, the circular patch antenna **100** may also be secured to an end user PCB (**200**, FIG. **1**D) via use of a threaded screw **118** and a nut **116**. The threaded screw **118** may be received in an aperture (**202**, FIG. **1**D) located on the end user PCB (**200**, FIG. **1**D). However, in some implementations the use of the screw **118** and nut **116** may be obviated in favor of other attachment means such as a solder connection made to the solder pins **106**, **108**. In some variants, an external cover (not shown), adhesive, tape or other attachment mechanism may be utilized to hold the various components of the circular patch antenna **100** together.

(17) Referring now to FIGS. **1**A and **1**F, the bottom dielectric patch **104** includes a plurality of slots **130** that are positioned between each of the feed apertures **120**, **122**. As illustrated in FIGS. **1**A and **1**F, the circular patch antenna **100** includes four (4) inner feed apertures **120** and four (4) outer feed apertures **122** and accordingly includes four (4) sets of slots **130**, although it would be appreciated that the number of sets of slots **130** could be greater than four (4) in some implementations, or less than four (4) in other implementations. Also, as shown in FIGS. **1**A and **1**F, each set of slots **130** consists of six (6) distinct slots **130** that increase in length as the slots **130** are positioned further away from the centerline **132** of the circular patch antenna **100**. The precise number of distinct slots **130** in each set of slots **130** may be more than (or less than) the number six (6) in some implementations.

(18) The middle flex PCB(s) **112**, **134** may also include a set of arc-slots **125** that may be

positioned between the outer perimeter of the respective middle flex PCB **112**, **134** and the apertures **120**, **122**. Each arc-slot **125** is defined by an arc angle ø and by increasing the arc angle ø, the resonant frequency of the circular patch antenna **100** decreases. Conversely, by decreasing the arc angle ø, the resonant frequency of the circular patch antenna **100** increases. Accordingly, the circular patch antenna **100** may be tuned to a designated frequency without necessarily requiring that the outer diameter of the circular patch antenna **100** be increased (or decreased). The sets of arc-slots **125** may be symmetrical with respect to the centerline **132** of the circular patch antenna **100** to minimize phase variations across frequency and space when the circular patch antenna **100** is driven for circular polarization. Each of the arc-slots **125** may be positioned such that the apertures **120**, **122** bisect each of the arc-slots **125**. As shown in FIG. **1**A, the arc-slots **125** are offset from the slots **130** located on the bottom dielectric patch **104**. In some implementations, the top flex PCB **110** may include arc-slots **125** in addition to, or alternatively than, the arc-slots **125** that may (or may not) exist in the middle flex PCB(s) **112**, **134**.

(19) As a brief aside, prior patch antennas typically have been manufactured to include a solid top surface to support a metallization process (typically, a sintered silver paste). However, by removing the requirement that the patch antenna have a solid top surface, as shown for the bottom dielectric patch **104**, and using regularly spaced vertical walls without a solid top or bottom surface, a dielectric loading for the bottom dielectric patch **104** can be provided that roughly corresponds to the fill ratio of the dielectric to vacuum multiplied by the dielectric constant of the underlying dielectric material. Accordingly, by using these vertical walls, the effective dielectric constant of the bottom dielectric patch **104** is higher than it otherwise would be without these vertical walls. Additionally, by removing mass from the bottom dielectric patch **104**, the dielectric loading to mass ratio is also improved. The use of these vertical walls also improves upon the manufacturability of these types of patch antennas when using composite (polymer) materials that are formed using an injection molding process. The reason for this is due to the difficulty of injection molding large flat surfaces, as the product will tend to cool unevenly after the injection molding process, resulting in random areas of sink and an uneven surface. However, by incorporating narrow even-thickness walls in the bottom dielectric patch **104**, the potential for material sink due to uneven cooling is minimized, thereby improving product yield during the manufacturing process as compared with an injection molded dielectric with large solid flat surfaces.

(20) Referring now to FIG. **1**E, the underside of the top dielectric patch **102** is best illustrated. The top dielectric patch **102** may include an inner ring **126** that is positioned symmetrically about the inner feed apertures **120**. The top dielectric patch **102** may also include an intermediate ring **128** that is positioned between the inner feed apertures **120** and the outer feed apertures **122**. The top dielectric patch **102** may also include one or more outer rings **124** that are positioned outside of the outer feed apertures **122**. As illustrated in FIG. **1**E, the number of outer rings **124** is one (1), although the number of these outer rings **124** may be greater than one (1) in some implementations. In some implementations, the top dielectric patch **102** may include a geometry that is similar to the bottom dielectric patch **104** that includes the plurality of sets of slots **130**. In another implementation, the bottom dielectric patch **104** may include the geometric features of the top dielectric patch **102** as shown in FIG. **1**E. The two dielectric patches **102**, **104** may be configured to operate in different frequency bands and accordingly, the precise geometries chosen may be varied dependent upon differing design constraints as would be readily understood by one of ordinary skill given the contents of the present disclosure.

(21) As shown in FIGS. **1**D and **1**E, the top dielectric patch **102** includes alignment features **103** and the bottom dielectric patch **104** includes alignment features **105** that facilitate the alignment of the top dielectric patch **102** with respect to the bottom dielectric patch **104**. As illustrated in FIG. **1**D, the top dielectric patch **102** alignment features **103** are protrusions while the bottom dielectric patch **104** alignment features **105** are cavities that are sized to fit these protrusions. However, it would be recognized by one of ordinary skill given the contents of the present disclosure that these

protrusions/cavities may be reversed in some implementations or may be utilized in combinations in which both the top dielectric patch **102** and bottom dielectric patch **104** each utilizes a combination of protrusions and cavities for each of the top dielectric patch **102** and the bottom dielectric patch **104**.

(22) Referring now to FIG. **1**C, exemplary dimensional attributes for one exemplary circular patch antenna **100** are shown and described in detail. For example, the top dielectric patch **102** may have a diameter D**3** and the bottom dielectric patch **104** may have a diameter D**4**. In some implementations, dimension D**3** may differ slightly from dimension D**4** although it would be appreciated that some variants may have a dimension D**3** that is equivalent to dimension D**4**. In one implementation, dimension D**3** has a diameter of 59.9 mm, while dimension D**3** has a diameter of 60.2 mm. As shown in FIG. **1**C, the circular patch antenna **100** may include a plurality of standoffs **107** which assist with the attachment of the circular patch antenna **100** to an external PCB. The circular patch antenna **100** may also include a height dimension H**1** that may be 11.8 mm in some implementations. The circular patch antenna **100** may also include a second height dimension H**2** that may be 15.7 mm in some implementations. The dimensions described above contribute to the performance characteristics of the circular patch antenna **100** in both dual-feed and quad-feed configurations as set forth in non-limiting example Appendix A.

(23) In some variations, the circular patch antenna **100** may include three (3) or more dielectric patches with an accompanying flex PCB for the circular patch antenna **100** to operate over a wider range of different frequency ranges. In some implementations, a single dielectric patch may be incorporated with an accompanying flex PCB to achieve a specific operating frequency. Such an implementation may be desirable when overall height constraints dictate a lower profile circular patch antenna **100** design. These and other variations would be readily apparent to one of ordinary skill given the contents of the present disclosure.

(24) It will be recognized that while certain aspects of the present disclosure are described in terms of specific design examples, these descriptions are only illustrative of the broader methods of the disclosure and may be modified as required by the particular design. Certain steps may be rendered unnecessary or optional under certain circumstances. Additionally, certain steps or functionality may be added to the disclosed embodiments, or the order of performance of two or more steps permuted. All such variations are considered to be encompassed within the present disclosure described and claimed herein.

(25) While the above detailed description has shown, described, and pointed out novel features of the present disclosure as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the device or process illustrated may be made by those skilled in the art without departing from the principles of the present disclosure. The foregoing description is of the best mode presently contemplated of carrying out the present disclosure. This description is in no way meant to be limiting, but rather should be taken as illustrative of the general principles of the present disclosure. The scope of the present disclosure should be determined with reference to the claims.

Claims

1. A circular patch antenna, comprising: a first dielectric patch comprising a first plurality of inner and outer feed apertures; a top metallization positioned on top of the first dielectric patch; a second dielectric patch comprising a second plurality of inner and outer feed apertures; the first dielectric patch is positioned over the second dielectric patch; wherein the first plurality of inner and outer feed apertures and the second plurality of inner and outer feed apertures are aligned with one another; a middle metallization that is positioned between the first dielectric patch and the second dielectric patch, the middle metallization comprising a plurality of arc slots, each of the plurality of arc slots being positioned between the first and second plurality of inner and outer feed apertures

and an external periphery of the middle metallization; and a bottom metallization that is disposed below the second dielectric patch, the bottom metallization comprising a ground plane for the circular patch antenna.

2. The circular patch antenna of claim 1, wherein the middle metallization comprises two distinct flexible printed circuit boards.

3. The circular patch antenna of claim 2, wherein the second dielectric patch comprises a plurality of slots organized into a plurality of groupings of slots.

4. The circular patch antenna of claim 3, wherein a portion of the plurality of slots are positioned between one of the second plurality of inner feed apertures and one of the second plurality of outer feed apertures.

5. The circular patch antenna of claim 4, wherein the plurality of groupings of slots comprises a first grouping of slots and a second grouping of slots that is disposed adjacent the first grouping of slots, wherein a first arc slot of the plurality of arc slots covers a portion of the first grouping of slots and a portion of the second grouping of slots.

6. The circular patch antenna of claim 5, wherein the first dielectric patch further comprises an inner ring that is positioned about the first plurality of inner feed apertures.

7. The circular patch antenna of claim 6, wherein the first dielectric patch further comprises an intermediate ring that is positioned between the first plurality of inner feed apertures and the first plurality of outer feed apertures.

8. The circular patch antenna of claim 7, wherein the first dielectric patch further comprises one or more outer rings, the one or more outer rings being positioned between the first plurality of inner and outer feed apertures and an outer periphery of the first dielectric patch.

9. The circular patch antenna of claim 8, wherein the first dielectric patch and the second dielectric patch comprise disk-like profiles for an external periphery of the first dielectric patch and the second dielectric patch.

10. The circular patch antenna of claim 9, wherein the first dielectric patch and the second dielectric patch each comprise one or more alignment features that provide alignment between the first dielectric patch and the second dielectric patch when mounted with one another.

11. The circular patch antenna of claim 10, wherein the top metallization comprises a plurality of arc slots.

12. The circular patch antenna of claim 11, further comprising a first plurality of solder pins and a second plurality of solder pins, the first plurality of solder pins being received through both the first dielectric patch and the second dielectric patch, while the second plurality of solder pins is received within the second dielectric patch, but not the first dielectric patch.

13. The circular patch antenna of claim 12, wherein the two distinct flexible printed circuit boards positioned between the first dielectric patch and the second dielectric patch, the top metallization that is disposed atop the first dielectric patch and the bottom metallization that is disposed below the second dielectric patch each comprise a circular outer profile.

14. The circular patch antenna of claim 1, wherein the first dielectric patch further comprises an inner ring that is positioned about the first plurality of inner feed apertures.

15. The circular patch antenna of claim 14, wherein the first dielectric patch further comprises an intermediate ring that is positioned between the first plurality of inner feed apertures and the first plurality of outer feed apertures.

16. The circular patch antenna of claim 15, wherein the first dielectric patch further comprises one or more outer rings, the one or more outer rings being positioned between the first plurality of inner and outer feed apertures and an outer periphery of the first dielectric patch.

17. The circular patch antenna of claim 1, wherein the second dielectric patch comprises a plurality of slots organized into a plurality of groupings of slots.

18. The circular patch antenna of claim 17, wherein the second plurality of inner and outer feed apertures comprises four sets of a single inner feed aperture and a single outer feed aperture.

19. The circular patch antenna of claim 18, wherein each of the plurality of groupings of slots are positioned between two of the four sets of the single inner feed aperture and the single outer feed aperture.

20. The circular patch antenna of claim 19, wherein each grouping of slots of the plurality of groupings of slots consist of six distinct slots.