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IMPROVED GAIN MICROSTRIP PATCH ANTENNA

STATEMENT OF GOVERNMENT INTEREST

[0001] The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

CROSS REFERENCE TO OTHER PATENT APPLICATIONS

[0002] None.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0003] The present invention provides a microstrip patch antenna having increased gain, and an apparatus for increasing the gain and bandwidth of an existing microstrip patch antenna.

(2) Description of the Prior Art

[0004] Microstrip patch antennas are widely used in many applications in the microwave frequency regime, ranging from GPS reception to line of sight communications to arrays for radar and satellite communications. They are simple, lightweight, and can be made to be conformal to a given structure as long as the radius of curvature is not too small. They are known to have

limited bandwidth and modest realized gain values on the order of 0 to +3 dBi. Given the increasing need to use these antennas in higher data rate communications systems, a way of improving the gain of the antenna, while also increasing its bandwidth, is desired.

[0005] A patch antenna, also referred to as a rectangular microstrip antenna, is a type of radio antenna with a low profile that can be mounted on a flat surface. The patch antenna includes a flat conductor mounted on a dielectric substrate over a larger conductor, typically referred to as a ground plane. The substrate can be round or rectangular but its thickness is always much smaller than the shortest wavelength of operation of the antenna. The patch is designed to have a length of approximately one-half wavelength of the radio waves being transmitted or received. This is done to prevent the formation of higher order surface wave modes. A patch antenna can be constructed using the same technology as that used to make a printed circuit board.

[0006] It is known to make a patch antenna from a copper foil deposited or otherwise provided on a dielectric substrate. The antenna can be fed from beneath with a standard coaxial connector. An ordinary patch antenna exhibits resonant behavior characterized by a high Q-factor and a relatively narrow

impedance bandwidth on the order of 2-6 percent, depending on the losses in the antenna.

[0007] It is known to provide a frequency selective structure (FSS) as a layer above a microstrip patch antenna. This is done to filter undesirable frequencies. For this purpose the FSS is positioned about one-tenth wavelength away from the patch. This results in attenuation of the frequency reflected by the FSS. This technique is used for isolating the antenna from the filtered frequency, not improving the gain of the antenna.

[0008] Thus, there is a need for microstrip patch antennas having improved gain. There is a further need for enhancing existing patch antennas to improve gain.

SUMMARY OF THE INVENTION

[0009] Accordingly, it is an object of the present invention to provide a microstrip patch antenna having improved gain.

[0010] Another object is to provide method for retrofitting an existing microstrip patch antenna to make an antenna having an improved bandwidth.

[0011] Yet another object is to provide a kit that can be used to retrofit an existing microstrip patch antenna.

[0012] In view of these objects, there is provided an antenna for mounting on a ground plane that includes a dielectric substrate for mounting on the ground plane. A conductive patch

dimensioned to a design frequency is positioned on the substrate. A frequency selective surface is mounted at a specific spacing above the conductive patch creating a Fabry-Perot cavity effect between the surface and the patch at the design frequency. A spacer can be included for maintaining the spacing between the patch and the frequency selective surface. A kit for enhancing an existing patch antenna including a spacer and a frequency selective surface, and a method for enhancing existing patch antennas are further provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Other objects, features and advantages of the present invention will become apparent upon reference to the following description of the preferred embodiments and to the drawings, wherein corresponding reference characters indicate corresponding parts throughout the several views of the drawings and wherein:

[0014] FIG. 1 is an exploded perspective view of a patch antenna having a resonating frequency selective surface;

[0015] FIG. 2 is a graph of the standing wave ratio of a prior art patch antenna and an embodiment of current invention; and

[0016] FIG. 3 is a graph of the power level received at an embodiment compared to a patch antenna not having this enhancement.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Referring now to FIG. 1, an exploded perspective view of an antenna 10 is provided for mounting on a conductive ground plane 12. Antenna 10 includes a dielectric substrate 14 for mounting directly on the ground plane 12. A conductive patch 16 is provided on the opposite side of dielectric substrate 14. Conductive patch 16 can be made from a copper foil or some other thin conductive material. While a rectangular substrate 14 and patch 16 are shown, substrate 14 and patch 16 can be any shape. The average major dimension, W , of the patch 16 should be about the same as one half wavelength, λ , of a design frequency for reception or transmission by the antenna 10. Patch 16 can be joined to a coaxial feed 18. A foam spacer 20 is also positioned on the side of the dielectric substrate 14 away from ground plane 12. Foam spacer 20 can be made from polystyrene foam or another dielectric material. Spacer 20 should be effectively transparent to radio waves at the design frequency. Many different materials can be used. Spacer 20 does not need to be a contiguous material as long as it supports the spacing and maintains this transparency.

[0018] A frequency selective surface 22 is provided on the side of the spacer 20 away from the ground plane 12. Surface 22 should extend sufficiently beyond the patch 16 to pick up radiation from the patch. Frequency selective surface 22 is used as a reflective layer at the frequency of interest. In one embodiment, surface 22 is made from a multiplicity of copper rings 24 deposited on a Kapton™ backing. Rings 24 should have a dimension and spacing calculated to be reflective at the frequency of interest. Typically, this means that the periodicity, P , of the conductive pattern on surface 22 should be one-half wavelength of the frequency of interest. Frequency selective surface 22 is designed to be reflective at a single frequency, and nearly transparent at others.

[0019] Patch 16 and surface 22 must be positioned at the distance at which a Fabry-Perot cavity effect forms at the reflective frequency of surface 22. If this frequency is near the resonant frequency of patch 16, a resonant cavity forms between the ground plane 12 of the patch and surface 22. Typically, this results in the thickness, T , of the spacer 20 being calculated to provide a one-half wavelength separation between ground plane 12 and surface 22. (Theoretically, T could be any T such that $T=n(\lambda/2)$ where n is an integer.) This causes an increase in the effective aperture of the antenna 10, resulting in an increase in antenna directivity and an

improvement in gain. Furthermore, the biaxial tensor property of surface 22 electrically loads antenna 12 in such a manner that an improvement in bandwidth occurs.

[0020] Surface 22 also acts as an artificial dielectric in its plane. This requires that the surface's dielectric tensor be biaxial of the form:

$$\bar{\epsilon}_r = \begin{bmatrix} \epsilon_{xx} & 0 & 0 \\ 0 & \epsilon_{xx} & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad (1)$$

where ϵ_r is the dielectric tensor, ϵ_{xx} is the permittivity along the xx axis, and the surface is presumed to lie in the x-y plane. There is no requirement that the frequency selective surface be a metamaterial or anything other than a conventional frequency selective surface. Any such frequency selective surface material including metamaterials could be used.

[0021] FIG. 2 provides a graph of voltage standing wave ratio (VSWR) obtained by testing a prior art patch antenna and an embodiment of the invention. Curve 30 shows the VSWR of the prior art patch antenna. Curve 32 shows the VSWR of a patch antenna having a spacer and frequency selective surface applied. The passband is generally indicated as the region where the curve passes below a VSWR of 3. These results indicate a bandwidth of about 20% versus the bandwidth of 8.4% obtained from the standard patch without the surface. FIG. 3 provides a graph 34 obtained from actual test results showing the relative

power level gain of the patch, spacer and surface versus the patch alone. This shows that the power increased by over 8 dB at 8.37 GHz. It is noted that the modified patch antenna has lower gain above the passband of the antenna. This may be considered an advantage because lack of out of band performance reduces undesirable frequencies.

[0022] Other embodiments of the invention could feature different frequency selective surface designs that maintain the required biaxial dielectric tensor.

[0023] It will be understood that many additional changes in the details, materials, steps and arrangement of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

[0024] The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive nor to limit the invention to the precise form disclosed; and obviously many modifications and variations are possible in light of the above teaching. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

IMPROVED GAIN MICROSTRIP PATCH ANTENNA

ABSTRACT OF THE DISCLOSURE

An antenna for mounting on a ground plane includes a dielectric substrate for mounting on the ground plane. A conductive patch dimensioned to a design frequency is positioned on the substrate. A frequency selective surface is mounted at a specific spacing above the conductive patch creating a Fabry-Perot cavity effect between the surface and the patch at the design frequency. A spacer can be included for maintaining the spacing between the patch and the frequency selective surface.

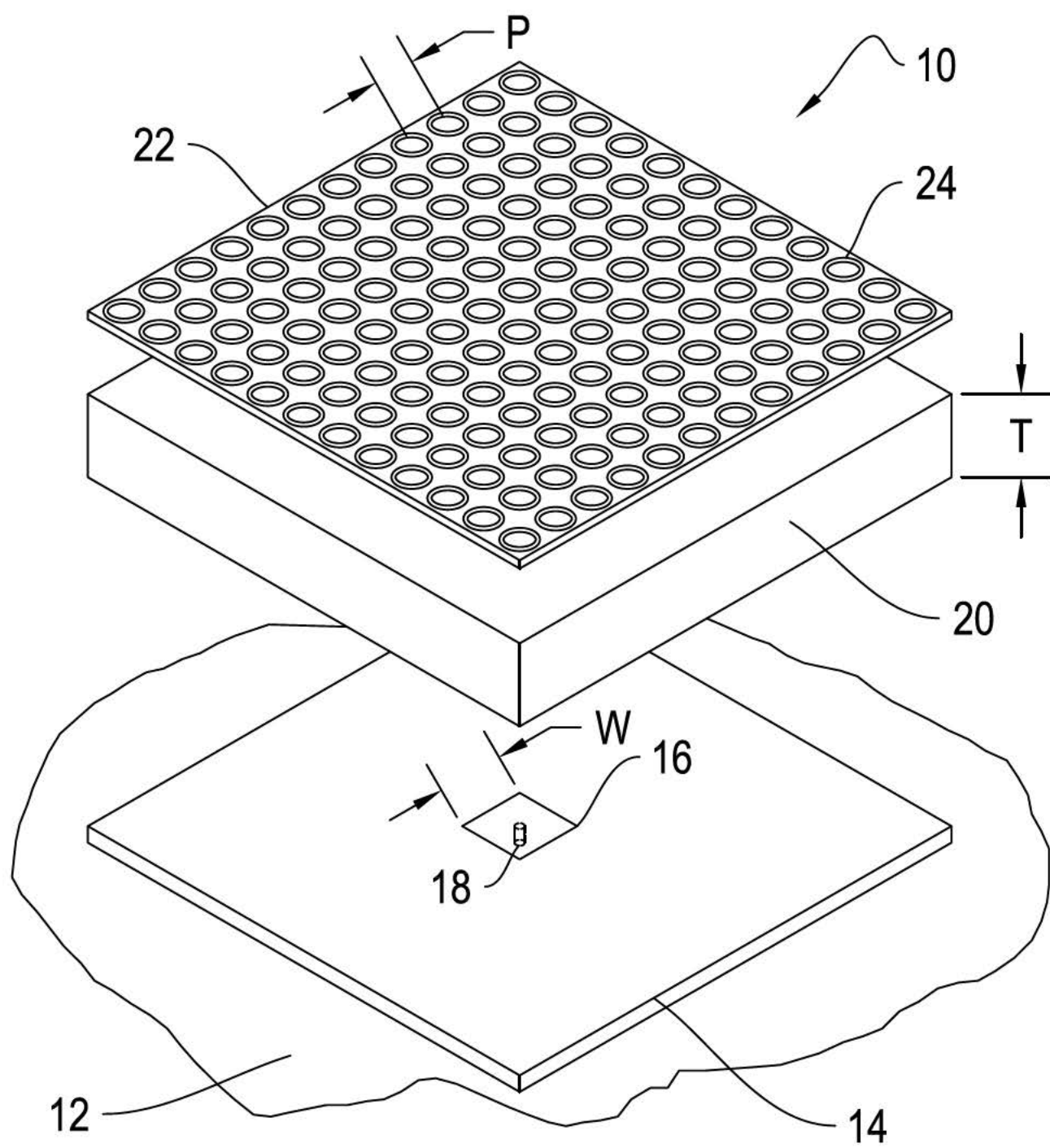


FIG. 1

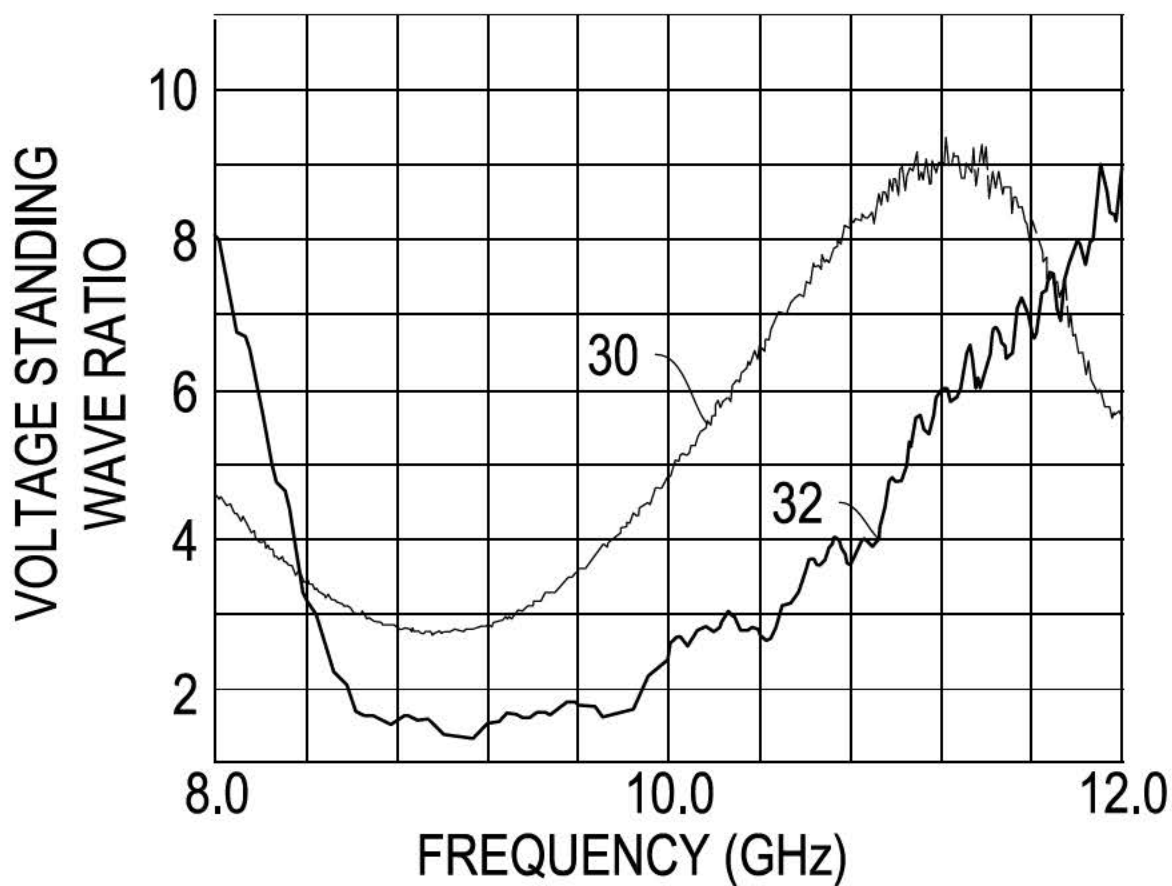


FIG. 2

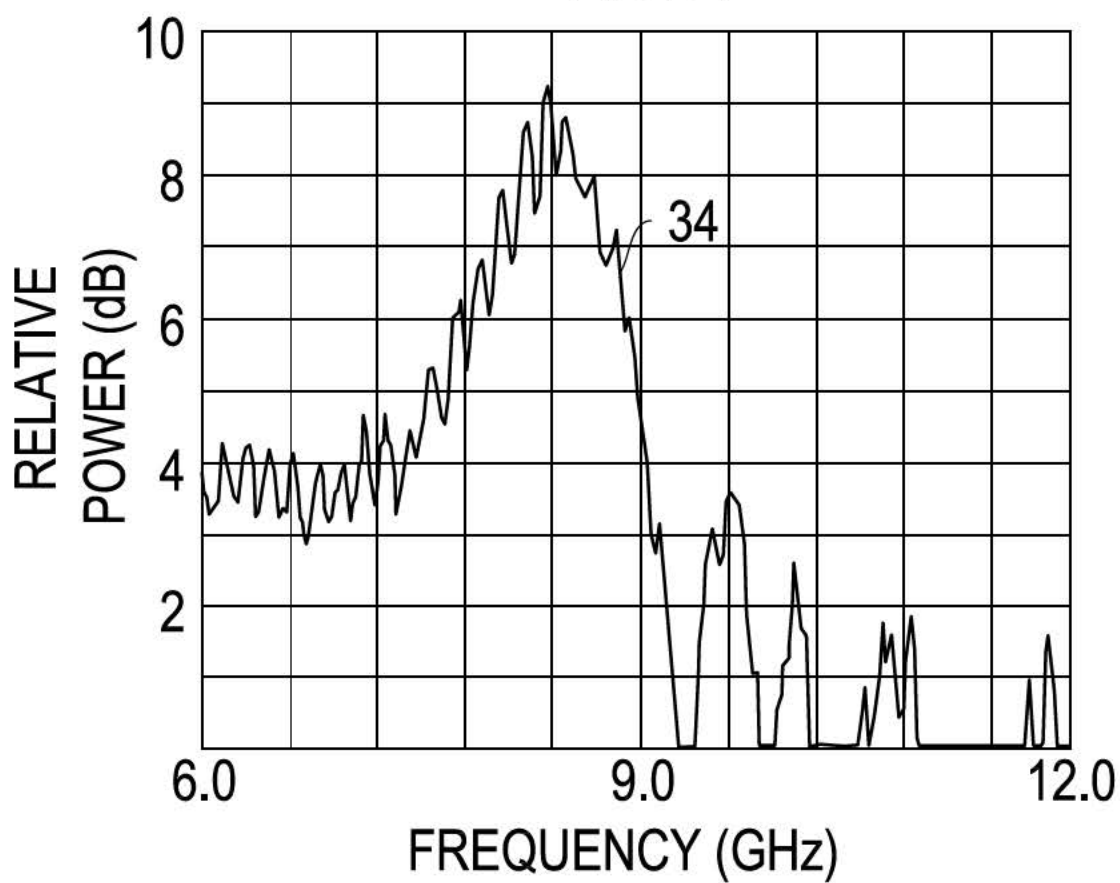


FIG. 3