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IN REPLY REFER TO:

Attorney Docket No. 83309
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Attorney Docket No. 83309

MICROSTRIP PATCH ANTENNA WITH PROGRESSIVE SLOT LOADING

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT DAVID A. TONN, citizen of the United States of America, employee of the United States Government and resident of Charlestown, County of Washington, State of Rhode Island has invented certain new and useful improvements entitled as set forth above of which the following is a specification:

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Attorney Docket No. 83309

MICROSTRIP PATCH ANTENNA WITH PROGRESSIVE SLOT LOADING

STATEMENT OF GOVERNMENT INTEREST

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.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates generally to patch antennas, and more particularly to a microstrip patch antenna having a plurality of parallel slots formed therein to increase the bandwidth performance of the antenna.

(2) Description of the Prior Art

An ordinary microstrip patch antenna consists of a rectangular metallic "patch" that is printed on top of a grounded slab of dielectric material. It is a very useful antenna, but suffers from limited bandwidth as a result of its resonant properties. Bandwidth of these antennas is typically limited to 2-4% of the antenna's center frequency.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a patch antenna having improved bandwidth characteristics.

Another object of the present invention is to provide a rectangular microstrip patch antenna having improved bandwidth characteristics for a variety of antenna applications.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, a patch antenna with progressive slot loading is based on a rectangular patch of electrically conductive material with long and short dimensions. A centerline of the patch is defined along the long dimension. The patch has a feedpoint located at one end of the patch at its centerline. A plurality of slots are formed in the patch with each slot having its center aligned with the centerline of the patch. Further, each slot has its longitudinal axis perpendicular to the centerline of the patch. Each slot has a unique length L_n and width W_n. The slots are arranged in an order starting at a position n=1 that is furthest from the patch's feedpoint so that, for an n-th slot, the inequalities $L_n > L_{n+1}$ and $W_n < W_{n+1}$ are always satisfied. In general, the length decreases linearly with each successive slot while the width increases exponentially with each successive slot.

BRIEF DESCRIPTION OF THE DRAWINGS

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:

FIG. 1 is a schematic view of a patch antenna having progressive slot loading in accordance with the present invention; and

FIG. 2 is a graph comparing bandwidth performance of a conventional rectangular patch antenna with that of an embodiment of the progressive slot loaded patch antenna of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to the drawings, and more particularly to FIG. 1, a schematic view of a microstrip patch antenna in accordance with the present invention is shown and is referenced generally by numeral 10. Typically, a rectangular patch 12 of electrically conductive material is provided (e.g., deposited, printed, etc.) on a base 14 of grounded dielectric material as is well known in the art. Rectangular patch 12 is defined by a long dimension referenced by arrow 16 and a short dimension referenced by arrow 18. As is known in the art, the rectangular nature of patch 12 defines a dominant mode of current distribution that runs along long dimension 16. To take advantage of this fact, patch 12 is fed with an electrical input at one end thereof along short

dimension 18. More specifically, for an even current distribution, patch 12 is fed with its electrical input at a feedpoint 20 that is centered at one end 12A of patch 12 along short dimension 18. In other words, feedpoint 20 is located along a centerline 22 of patch 12 that extends along long dimension 16. Feedpoint 20 can be fed by any known feedline structure such as a conductive strip, a coaxial line, etc., the choice of which is not a limitation of the present invention.

In accordance with the present invention, patch 12 has a plurality of slots 30 (i.e., slots 30_1, 30_2, ..., 30_n, ..., 30_N) cut or otherwise formed therein. Each of slots 30 is a hole formed all the way through patch 12, but does not extend into dielectric base 14. Slots 30 can be formed when patch 12 is formed or after in accordance with any of a variety of well known fabrication techniques. In general, each of slots 30 has a length L that is substantially greater than its width W where length L is perpendicular to centerline 22 and width W is parallel to center line 22. Typically, each of slots 30 will be rectangular or approximately rectangular depending on the precision of the particular fabrication technique. However, in all cases, each of slots 30 is centered on centerline 22 with its longitudinal axis A (i.e., the axis extending along length L) of each slot 30 being perpendicular to centerline 22. For clarity of illustration, the slot's longitudinal axis A_n is only illustrated for slot 30_n.

For the present invention, each of slots 30 has a unique length L_n and width W_n where the index n is referenced to a

starting position (i.e., n=1) that is furthest from feedpoint 20. In general, as slots get closer to feedpoint 20, their length decreases while their width increases so that the inequalities $L_n > L_{n+1}$ and $W_n < W_{n+1}$ will always be satisfied. On-center spacing between adjacent slots is approximately equal and can be used to fine tune antenna performance.

Testing of the present invention yielded good bandwidth performance when adjacent lengths L_n decreased linearly from n=1 to N while widths W_n increased exponentially from n=1 to N. By way of illustrative example, an exponential width relationship that yields good bandwidth performance is

$$W_{n+1} = e^{1/4} W_n \qquad (1)$$

where the starting position of n=1 generally has its width W_1 defined by the user.

A tested example of the present invention was based on a 31 millimeter (mm) by 19mm rectangular patch having a first slot (i.e., slot 30_1) that was 0.5mm wide by 15mm long. Four additional slots were formed with adjacent slots being decreased by 2mm in length and increased in width predicated on equation (1). Bandwidth performance of this progressive slot loaded antenna is illustrated by curve 40 in FIG. 2. This graph represents the magnitude of the reflection coefficient looking into the input port of the antenna. Dashed-line curve 42 represents the bandwidth performance of a conventional 31mm by 19mm patch with no slots. A lower value on this graph means more energy is getting into the antenna. From this, it is clear that

bandwidth performance is substantially improved by the progressive slot loading of the present invention.

The advantages of the present invention are numerous. Bandwidth performance is greatly improved simply by forming slots in a patch antenna. The principles set forth herein can be adapted/scaled to a variety of specific applications and bandwidth requirements simply by scaling the dimensions of the slots, changing the number of slots used, and/or changing the dimensions of the patch.

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.

CLAIMS NOT INCLUDED

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MICROSTRIP PATCH ANTENNA WITH PROGRESSIVE SLOT LOADING

ABSTRACT OF THE DISCLOSURE

A microstrip patch antenna with progressive slot loading is provided. A rectangular patch of electrically conductive material has a plurality of slots formed therein with each slot having its center aligned with the centerline of the patch's long dimension. Each slot further has its longitudinal axis perpendicular to the centerline. The slots are arranged in an order starting at a position n=1 that is furthest from the patch's feedpoint so that, for an n-th slot, the inequalities $L_n > L_{n+1}$ and $W_n < W_{n+1}$ are always satisfied. In general, the length decreases linearly with each successive slot while the width increases exponentially with each successive slot.

FIG. 1

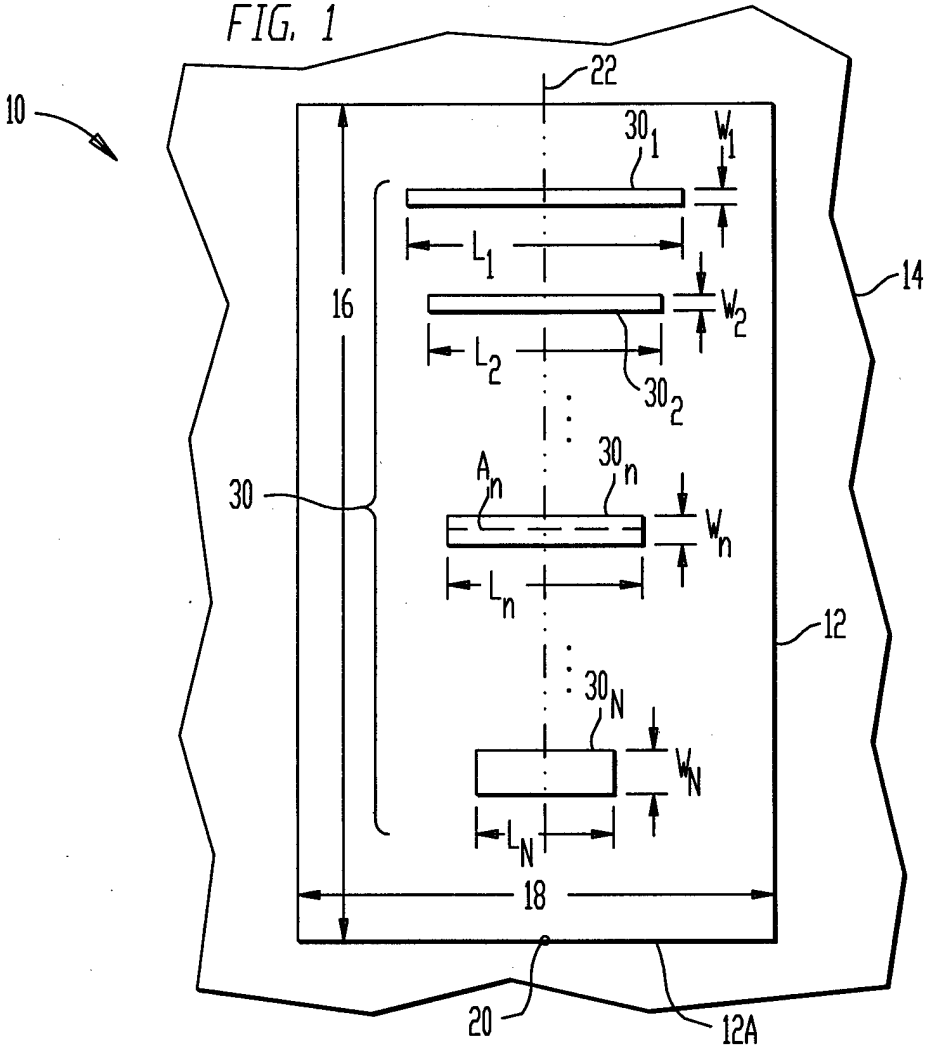
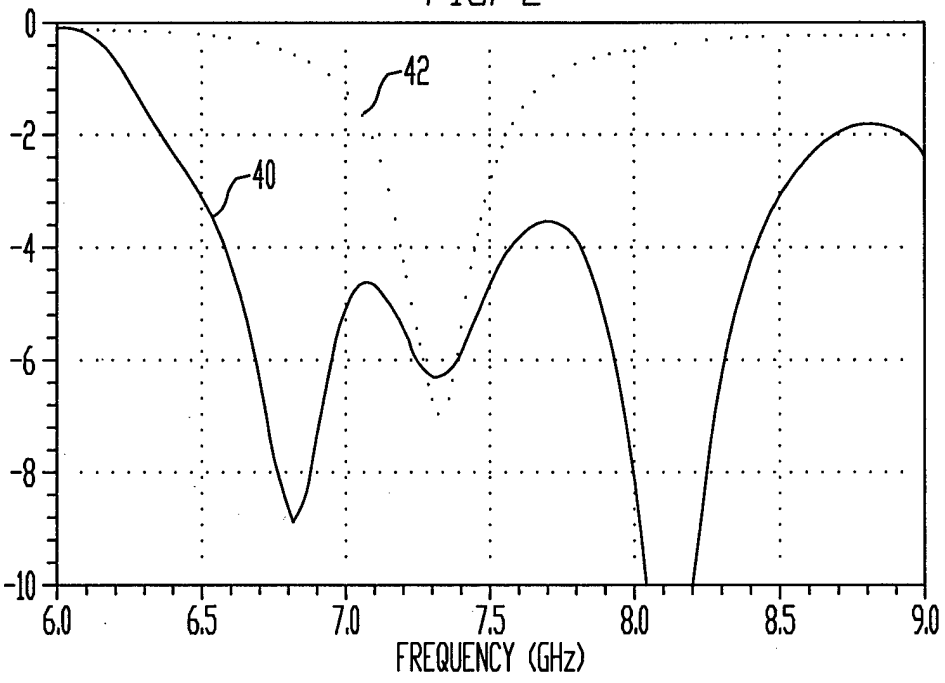

10
22
30_1
W_1
L_1
16
14
W_2
L_2
30_2
A_n
30_n
30
W_n
L_n
12
30_N
W_N
L_N
18
20
12A

FIG. 2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7.0
7.5
8.0
8.5
9.0
FREQUENCY (GHz)