COMMON ANTENNA APERTURE HAVING POLARIZATION DIVERSITY

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ABSTRACT

A common aperture including beamwidth compensating septums or fins in conjunction with a double sidelobe suppression choke for a slotted antenna system which is adapted to illuminate a single cylindrical reflector with both horizontally and vertically polarized primary patterns which are substantially identical due to the subject aperture to provide secondary patterns reflected from the reflector which are polarization insensitive.

11 Claims, 8 Drawing Figures
COMMON ANTENNA APERTURE HAVING POLARIZATION DIVERSITY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to microwave apparatus of the type generally employed for radiating electromagnetic energy in cooperation with a reflecting surface for the purpose of forming a shaped beam such as a csc$^2$ cos$^{1/2}$ pattern utilized for ground mapping applications. More particularly the present invention relates to a common aperture for two slotted waveguide antenna arrays respectively radiating vertically polarized and horizontally polarized energy to a common reflector in order to obtain a transmitted secondary csc$^2$ cos$^{1/2}$ beam which is polarization insensitive.

2. Description of the Prior Art

Antennas comprised of slotted sections of waveguide placed at the throat of a radiating horn are generally well known to those skilled in the art. An example of this is disclosed in U.S. Pat. No. 2,730,717, issued to M. Katchky, et al. Additionally a dual polarized antenna comprised of two slotted waveguide arrays feeding a common horn is disclosed in a publication entitled "A Dual-Polarized Line Source for Use at S-band," W. A. Cumming, appearing in The Microwave Journal on Jan., 1963, at pages 61-67, inclusive. The vertically polarized array employed consisted of slots in the broad wall of a waveguide radiating into the TEM parallel-plate region. The horizontally polarized array employed inclined edge slots, radiating into a parallel plate region sufficiently wide to support the dominant waveguide mode. The spacing of these regions is made below the cutoff for the next highest mode in order to suppress the second order beams otherwise associated with an array of staggered slots. A reflecting grid or grating is placed at the intersection of these regions and is essentially opaque to the horizontally polarized waves but is transparent to the vertically polarized component from the other array. In the portion of the parallel-plate region common to both polarizations, a series of vertical polarizing fins are employed to prevent signals from the vertically polarized array from reaching the horizontally polarized array and suppressing the cross-polarized component generated by the inclined slots.


While the noted prior art presumably operates as intended, beamwidth compensating fins alone are not sufficient to produce truly equal primary patterns of horizontally and vertically polarized energy. It is the primary objective of the subject invention therefore to provide aperture means for generating such equal primary radiation patterns and obtaining secondary radiation patterns transmitted from a reflector which are independent of polarization.

SUMMARY

In accordance with the objectives mentioned above, the subject invention comprises a common aperture for a horizontally polarized slotted waveguide array and a vertically polarized slotted waveguide array wherein the common aperture extends substantially the entire length of the arrays and includes beamwidth compensating means in the form of regularly spaced triangular fins and a double choke comprising linearly rectangularly shaped slots running lengthwise along the outer surface of the aperture which faces a common reflector. The arrays additionally include means for directing horizontally polarized energy into the aperture section as well as means for preventing vertically polarized energy from getting into the horizontally polarized feed. By utilizing the beamwidth compensating means in conjunction with the double choke for vertically polarized sidelobe suppression equal radiation patterns of both horizontal and vertical polarization energy are directed to and reflected from a single cylindrical reflector thereby obtaining polarization diversity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a dual slotted waveguide array illustrating the preferred embodiment of the subject invention;

FIG. 2 is a cross-sectional view of the embodiment shown in FIG. 1 taken along the lines 2--2;

FIG. 3 is a fragmentary sectional view of the embodiment shown in FIG. 1 taken along the lines 3--3 of FIG. 2;

FIG. 4 is a fragmentary front elevational view of the embodiment shown in FIG. 1 as viewed from the lines 4--4 of FIG. 2;

FIG. 5 is illustrative of the horizontally polarized radiation pattern provided by the common aperture shown in FIG. 1;

FIG. 6 is illustrative of the vertically polarized radiation pattern provided by the common aperture shown in FIG. 1;

FIG. 7 is illustrative of the horizontally polarized antenna pattern reflected from a common reflector; and

FIG. 8 is illustrative of a vertically polarized antenna pattern reflected from the same common reflector as utilized with respect to the pattern shown in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

To achieve extremely well matched secondary antenna patterns in elevation the elevation primary pattern of vertically polarized energy must be extremely well matched to the horizontally polarized energy. The aperture distribution for a simple horizontally polarized flared horn is approximately a cosine distribution and this distribution gives a far field pattern of the form:

$$E(\mu) = \frac{\pi}{2} \cos \mu$$

where

$$\mu = \frac{\pi l \sin \phi}{\lambda}$$

where $\phi$ is the angle of the flared horn and $\lambda$ is the wavelength.

The aperture distribution for a simple vertically polarized flared horn is also a uniform distribution; however, this distribution gives a far field pattern of the form:

$$E(\mu) = \frac{l \sin \mu}{\mu}$$

Upon close examination, it can be seen that these two forms of $E(\mu)$ deviate significantly over a large range of $\phi$. It is to this deviation that the present invention is directed.

Referring now to the drawings and more particularly to FIG.

1 wherein the embodiment of a dual polarized array and a common aperture is shown in perspective, reference numeral 10 refers to a vertically polarized slotted waveguide section comprising a first slotted antenna array and including a plurality of radiating slots 12 alternating in inclination fabricated into one broad wall 14 of the waveguide section 10.

The vertically polarized waveguide section 10 is adapted to be coupled to a source of vertically polarized waveguide energy, not shown, by means of the waveguide flange 16. The waveguide section 10 is located in and held in a lengthwise orientation by means of a mounting block 18 which contacts a substantial portion of the waveguide section 10. A second mounting block 20 coextensive with the block 18 abuts one surface thereof and is adapted to partially engage the broad wall 14. Additionally the mounting block 20 is adapted to engage a horizontally polarized slotted waveguide section 22 which forms a second antenna array in combination with the vertically polarized array comprised of the waveguide section 10. The waveguide section 22 is additionally held in place by a third mounting block 24 which abuts the lower portion of the mounting block 20 so that the two engage the lower narrow wall 26 and a portion of the broad wall 28 and 30 such as shown in FIG. 2. The other narrow wall 32 of the waveguide section contains a plurality of alternately inclined radiating slots 34 such as shown in FIG. 3. A source of horizontally polarized energy, not shown, is adapted to be coupled to the
waveguide flange 35. It is well known to those skilled in the art of slotted waveguide antenna arrays that the narrow wall is used for radiating horizontally polarized electromagnetic energy whereas the broadwall is utilized for radiating vertically polarized energy. Accordingly, vertically and horizontally polarized energy is adapted to be radiated from the slots 12 and 34, respectively, in the waveguide sections 10 and 22.

Vertical and horizontally polarized energy radiated from the slots 12 and 34 is coupled to a common aperture comprised of two identical aperture sections 36 and 38 respectively secured to the front surfaces 40 and 42 of the mounting blocks 20 and 24. The inner faces of the mounting blocks 20 and 24 are configured to provide a first and a second interior throat section 40 and 42 for respectively coupling the vertically polarized energy emitted from the slots 12 and the horizontally polarized energy emitted from the slots 34 to the aperture sections 36 and 38. Additionally, a first set of regularly spaced polarizing fins 44 shown in FIGS. 2 and 4 are arranged in a row on the underside of the mounting block 20 in the forward portion of the throat section 40 which couples into the aperture sections 36 and 38. The purpose of the polarizing fins 44 is to direct the horizontally polarized energy emitted from the waveguide section 22 into the aperture sections. A second set of regularly spaced fins 46 positioned on the mounting blocks 23 and 24 as shown by FIGS. 2 and 3 lie above and across the inclined slots 34 in the narrow wall 32 of the waveguide section 22 to prevent the vertically polarized energy emitted from the waveguide section 10 from being coupled into the horizontally polarized feed as well as suppressing any cross-polarized component generated by the inclined slots. It should be observed that the dimensions of the slots 12 and 34 as well as the spacing of the respective fins 44 and 46 are determined by the operating frequency intended. The details of the specific design is within the purview of one skilled in the art.

Attention is now directed to the common aperture comprising sections 36 and 38 for both the vertically and horizontally polarized energy emitted from the waveguide sections 10 and 22, respectively. Each section 36 and 38 includes an inclined surface 48 and 50, respectively, which is in a plane defined by the front portions or leading edges of the fins 44 and 46. As noted earlier, the sections 36 and 38 extend along the surfaces 41 and 43. The length of these sections is determined by the number of slots 12 and 34. The inclined surfaces 48 and 50 in combination with the leading edges of the fins 44 and 46 define a divergent feed of both vertically and horizontally polarized energy.

Two identical sets of right triangular shaped beamwidth compensating septums or fins 52 and 54 shown in FIGS. 1 and 2 are located on the inclined surfaces 48 and 50, respectively, forward of the fins 44 and 46. The edges 70 and 72, 74 and 76 of the fins 52 and 54, respectively, which intersect at right angles define the outer edges of the fins. These beamwidths compensating fins are located along the entire length of the aperture sections 36 and 38 and are selectively spaced at regular intervals such as shown in FIG. 1. Moreover, FIGS. 3 and 4 indicate that the spacing of a beamwidth compensating fins 52 and 54 are not the same as the polarizing fins 44 and 46, but are spaced relatively farther apart, such as twice the spacing between the fins 44 and 46. It should also be pointed out that the dimensions of the fins 52 and 54 are such that they do not extend over the entire width of the respective inclined surfaces 48 and 50 and therefore do not extend to the tips of the fins 44 and 46.

In conjunction with the beamwidth compensating fins 52 and 54, the aperture sections 36 and 38 additionally include sidelobe suppression chokes 62 and 64 on the respective front surfaces 56 and 58 thereof. The choke for the aperture section 36 comprises a double choke configuration entailing a pair of equally spaced rectangular slots 60 and 62 running the entire length of the front surface 56. Moreover, the width of the rectangular slots 60 and 62 is substantially equal to the spacing between the slots and the distance from the respective outer edges of the section 36. Similarly, the choke for the aperture section 38 comprises a double choke configuration including the rectangular slots 64 and 66.

It should also be pointed out that the edges 70 and 74 of the fins 52 and 54 are aligned or coplanar with the front surfaces 56 and 58, respectively, while the edges 72 and 76 face each other in a substantially parallel alignment.

In operation, the aperture sections 36 and 38 cause both the vertically and horizontally polarized energy to have polarization insensitive primary radiation patterns which when reflected from a common cylindrical reflector shown schematically by reference numeral 68 in FIG. 2 results in a polarization insensitive $csc^2 \cos^{1/2}$ secondary pattern. Reference to FIGS. 5 and 6 illustrate experimentally obtained antenna patterns utilizing the aperture configuration shown in FIGS. 1 through 4. FIG. 5 is illustrative of the primary radiation pattern for horizontally polarized energy whereas FIG. 6 is the primary radiation pattern of vertically polarized energy. It can be seen that the patterns are substantially the same between the relative power levels of 20db. Next reference to FIGS. 7 and 8 illustrates the secondary radiation patterns for horizontally polarized and vertically polarized energy respectively produced from the patterns respectively shown by FIGS. 5 and 6 as radiated from a common reflector.

Whereas apparatus for such applications as ground mapping normally utilize horizontally polarized energy only and having a $csc^2 \cos^{1/2}$ radiation pattern, it has become desirable to utilize both vertically and horizontally polarized energy, but prior art apparatus necessitated completely separate antennas to achieve the desired operation. However the subject invention provides a means for obtaining both horizontally and vertically polarized $csc^2 \cos^{1/2}$ patterns which are substantially identical to provide secondary patterns reflected from a common antenna which is polarization insensitive. Having thus described the present invention with respect to the preferred embodiment thereof,

I claim as my invention:

1. A common aperture for a dual polarized microwave antenna system having a common reflector and a first slotted waveguide section emitting electromagnetic energy of a first type polarization and a second slotted waveguide section emitting electromagnetic energy of a second type polarization, said aperture comprising in combination:

a. a first and a second microwave aperture section located in mutually spaced apart relationship in relatively close proximity to said first and second waveguide sections and wherein energy of said first and second type polarization is adapted to be directed in a common path therebetween to said reflector;

b. each said first and second aperture section being further characterized by,

a. a body portion having an outer surface directed toward said reflector and an inclined surface adjacent said outer surface, said inclined surface diverging outwardly from said common path,

b. a plurality of beamwidth compensating means located on said inclined surface, each said means having a first and a second intersecting surface, said first surface being substantially coplanar with said outer surface of said body portion, and said second surface being directed along the direction of said common path, and
c. sidelobe suppression choke means located on said outer surface, whereby substantially identical $csc^2 \cos^{1/2}$ primary radiation patterns of first and second type polarization which when reflected from said reflector produce substantially identical primary radiation patterns of said first and second type polarization and a polarization insensitive secondary pattern.

2. The invention as defined by claim 1 wherein said body portion is characterized by an elongated member of electrically conductive material and having a predetermined length with respect to the length of said first and second slotted waveguide sections.
3. The invention as defined by claim 1 wherein said beamwidth compensating means comprises triangular shaped fin means.

4. The invention as defined by claim 2 and wherein said plurality of beamwidth compensating means comprises a plurality of fins being selectively spaced in substantially parallel relationship on said inclined surface.

5. The invention as defined by claim 2 and wherein said plurality of beamwidth compensating means comprises a plurality of substantially equally spaced fins located on said inclined surface and being in substantially mutually perpendicular alignment therewith.

6. The invention as defined by claim 5 wherein said first and second surfaces of said plurality of fins are substantially orthogonal.

7. The invention as defined by claim 2 and wherein said sidelobe suppression choke means comprises at least one recess in said outer surface of said body portion running coextensively with said length thereof and having a mutual separation therebetween substantially equal to the distance from the respective outer edge of said outer surface.

8. The invention as defined by claim 2 and wherein said sidelobe suppression choke means comprises a pair of linear recesses located in said outer surface of said body portion running coextensively with said length thereof and having a mutual separation therebetween substantially equal to the distance from the respective outer edge of said outer surface.

9. The invention as defined by claim 8 wherein said pair of recesses comprise substantially rectangularly shaped slots.

10. The invention as defined by claim 2 wherein said plurality of beamwidth compensating means comprises a plurality of regularly spaced right triangular shaped fins located on said inclined surface and wherein said second surface intersects said inclined surface at a predetermined point intermediate the extremities of said inclined surface, and said sidelobe suppression choke means comprises at least a pair of substantially parallel rectangular slots fabricated in said outer surface of said body portion and being substantially coextensive with its length and extending substantially orthogonal to said common path of said electromagnetic energy.

11. The invention as defined by claim 10 wherein said substantially rectangular slots have a width dimension substantially equal to their mutual separation and wherein the separation from a respective outer edge of said outer surface is substantially equal to said mutual separation.