NOVEL PRINTED SLOT RADIATORS WITH PATTERN SHAPING CAPABILITY FOR ARRAY APPLICATIONS

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ABSTRACT

In this thesis several new configurations of strip-line fed printed slot radiators are proposed. In these, the parallel plate mode/waveguide mode generated at the slot-strip junction, instead of being confined by the usual mode suppressing pins, is allowed to radiate to achieve certain useful pattern characteristics. The newly proposed configurations are characterised by experimental investigations. Equivalent circuits and equivalent array models are provided which are useful in designing such antennas.

The first antenna considered is a strip-fed printed slot which is backed by a large cavity. An equivalent circuit for this is proposed in which empirical equations to the slot-strip and slot-cavity couplings are derived from theoretical simulation and experimental results. Based upon this study, a strip-fed printed slot antenna having two adjacent waveguide coupled parasitic slots is proposed. In this antenna, one of the parasitic slots can be switched 'ON' or 'OFF' by a simple switch so as to get two distinct E-plane patterns. This property has been utilized to achieve pattern synthesis in active array environment. Equivalent circuit and equivalent array model for the antenna are given. Two more similar antennas are reported in which the coupling to parasitic slots is via

parallel plate mode, but in one the printed slot is strip-fed while in the other it is fed by a strip-resonator.

A 2 x 2 printed slot array fed by strip-resonators and etched on a circular stripline package, for use as a primary feed in reflector antennas is reported. The fabrication is simple since no mode suppressing pins are utilised. The energy coupled from slots to the stripline parallel plates, and escaping from stripline package edge is redirected to broadside by a simple conical edge reflector. The use of this feed in a trans-twist cassegrain antenna is demonstrated. Lastly, a strip-fed dual slot antenna, with slots in the same transverse plane to the strip but on opposite ground planes is proposed. By utilising unequal slot lengths it is shown that the main lobe can be switched from one side to the other by varying the frequency.

NOMENCLATURE

c	velocity of light in free space
f	frequency of operation
$\lambda_o = \frac{c}{f}$	free space wavelength
$\beta = \frac{2\pi}{\lambda_o}$	free space propagation constant
ε_r	relative dielectric constant of strip transmission line dielectric substrates.
$\lambda_s = \frac{\lambda_o}{(\varepsilon_r)^{\frac{1}{2}}}$	wavelength of TEM mode in strip transmission line
$\beta_s = \frac{2\pi}{\lambda_s}$	propagation constant of TEM mode in strip transmission line
Z_s	characteristic impedance of the stripline
$Y_s = \frac{1}{Z_s}$	characteristic admittance of the stripline
W	width of the strip conductor
L	length of printed slot
t	width of printed slot

A x D x B — dimensions of the rectangular stripline package containing the printed slot

A: dimension of the package parallel to the printed slot

D: Dimension of the package perpendicular to the printed slot

B: ground plane spacing of the stripline

For the propagating TE_{mo} modes, the cavity is considered as a section of rectangular waveguide of cross-section A x B and length D. With this notation the various parameters for the waveguide are defined as follows:

$$f_{mc} = \frac{mc}{2A(\varepsilon_r)^{\frac{1}{2}}}$$

cut-off frequency of the TE_{mo} mode of the rectangular waveguide.

$$\lambda_w = \frac{\lambda_s}{\left[1 - (f_{1c}/f)^2\right]^{\frac{1}{2}}}$$

wavelength of TE_{10} mode in rectangular waveguide.

$$\beta_w = \frac{2\pi}{\lambda_w}$$

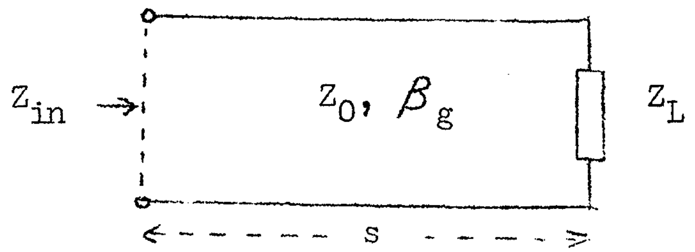
propagation constant of TE_{10} mode in rectangular waveguide

$$Z_w = \frac{120\pi}{(\varepsilon_r)^{\frac{1}{2}}} \frac{\lambda_w}{\lambda_s}$$

characteristics impedance of TE_{10} mode in rectangular waveguide

Input impedance of a section of lossless transmission line of length 's' terminated in a load Z_L (Z_0 = characteristic impedance and β_g = propagation constant):

$$Z_{in} = f(\beta_g, Z_0, Z_L, s) = Z_0 \frac{Z_L + jZ_0 \tan(\beta_g s)}{Z_0 + jZ_L \tan(\beta_g s)}$$



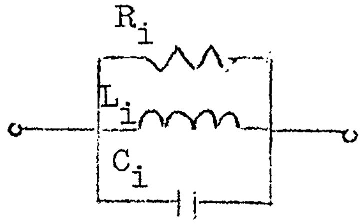
Parameters of the parallel resonant circuit representing the impedance Z_i of the i^{th} slot.

$$Z_i = \frac{R_i}{1 + jQ_i\,(f/f_i - f_i/f)}$$

where

$$f_i = \frac{1}{2\pi(L_i\, C_i)^{\frac{1}{2}}}$$ the resonant frequency of the parallel resonant circuit

$$Q_i = \frac{R_i}{2\pi f_i\, L_i}$$ the quality factor of the parallel resonant circuit



$\left\{Z_x \| Z_y\right\} = \frac{Z_x Z_y}{Z_x + Z_y}$	is the notation for parallel combination of impedances Z_x and Z_y.
$Re[Z] =$	real part of Z
$Im[Z] =$	imaginary part of Z.
$\angle I$	phase of current I
Γ	reflection coefficient
T	transmission coefficient
S_{ij}	magnitude of transmission S-parameter between ports i and j
ϕ_{ij}	phase of transmission S-parameters between ports i and j.
δ	distance between plane of electric slot and plane of physical slot.
SLC	abbreviation for surface launch connector

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