COMPACT DUAL-BAND ANTENNA FOR SYMULTANEOUS MONOPULSE TRACKING AND IFF FUNCTIONING

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SUMMARY

The paper describes a dual-band antenna for symultaneous monopulse tracking and IFF functioning. The technique uses a partially filled L-Band circular waveguide, Fig 1a. The Centre dielectric rod is excited by a X-band conical horn (1,4) at 9.5 GHz and is used for monopulse tracking by exciting error signals in elevation and azimuthal planes from TM_{01} and TE_{01} modes, respectively and reference signal from hybrid HE_{11} mode. IFF Signal can be obtained from Hybrid HE_{11} mode excited at 1.65 GHz in the partially filled circular waveguide. High launching efficiency for exciting surface waves on dielectric rod is attempted and experimentally determined following Deschamp's method(2,3). Radiation patterns of the compact antenna for tracking and IFF signals are also determined experimentally.

The design characteristics for the composite structure are the following:-

a. The diameter 2a, length l and the free end linear tapering of the dielectric rod are chosen to obtain optimum error signal mode illuminations (TM_{01} and TE_{01}) for which the propagation phase constants β's along the length of the rod are nearly equal (5).

b. The sum mode HE_{11} in the dielectric rod is converted into TE_{11} mode and difference modes into TM_{01} and TE_{01} modes in the X-band circular waveguide at the feed end. Two longitudinal slots cut diametrically opposite in the exciter couple the TE_{11} and the TE_{01} modes into the connecting rectangular X-band waveguide whose broader dimension is parallel to the slots, Fig 1b. These two signals are applied to the two isolated straight arms 1,2 of a magic-T so that the azimuthal error signal and sum signal are obtained separately from the E and H arms of the matched magic-T, respectively. Elevation error signal mode TM_{01} is coupled to an axial probe at the back end, Fig 1a.

c. Diameter of the L-band waveguide is selected to support dominant HE_{11} mode such that metal walls does not affect the X-band surface wave propagation along the dielectric rod. Length of the L-band waveguide is truncated before tapering of the dielectric rod starts. L band wave guide is excited with the help of a radial probe placed at a distance of quarter wave length from the back end.

d. Junction radiation at the feed end of the dielectric rod is reduced by flaring the X-band circular waveguide which increases the launching efficiency.

The junction between the exciter and the dielectric rod can be considered as two port network. Launching efficiency can then be defined in terms of S-Parametersof the junction:

$$\eta\% = \frac{\text{Surface wave power x 100}}{\text{Input power - Reflected power}} = \frac{100\,|S_{12}|^2}{1-|S_{11}|^2} \qquad ....(1)$$

η can be determined by measuring S-Parameters following Deschamps method (2,3) which utilises measured values of complex input reflection coefficients for eight different lengths of the uniform dielectric rod changing in steps of 1/8th guided wavelength with free end of the rod short circuited by a shorting plate of dimensions much larger than free space wavelength. When the attenuation coefficient α in the rod is small and also the change of total length of the rod is less than one wavelength, points P's of reflection coefficients for different lengths of the rod describe a circle on the polar chart with Centre OC and radius CP, Figs, 2,3. It can be shown that

$$|S_{11}| = |OS_{11}| \qquad |S_{12}| = \frac{|S_{11}E|}{\sqrt{\rho R}} \qquad ....(2)$$

where R is the radius of the circle and $\rho = \exp(-2\alpha l)$, the magnitude of input reflection coefficient with output end of the rod short circuited. Attenuation coefficient can be determined from the following equation when experiment is performed using two widely different lengths l & l' of the rod:

$$\alpha = \frac{1}{2(l-l')} \ln\left(\frac{R\,|S_{11}E'|^2}{R'\,|S_{11}E|^2}\right) \qquad ....(3)$$

Two different lengths 47.5 cms and 51.5 cms of perspex rod($\epsilon_r = 2.56$) are used to find attenuation constant α and S-Parameters of the junction at 9.5 GHz. Radiation patterns are determined by using former rod with linear tapering at the free-end.

The attenuation constant α of the rod is found to be 5db/m in hybrid HE_{11} mode. It is found that points of complex reflection coefficients in Deschamp's method almost lie in a circle for a total change of length of the rod of one guided wavelength, Figs 2-3. Tuning screws are provided at the coupling apertures between the X-band circular waveguide and the connecting rectangular X-band waveguide. S-Parameters are determined with the help of HP network analyser and reflection bridge set up.

Typical value of η is 79.3% for the hybrid HE_{11} mode without the launching horn and L-band waveguide. Value becomes 88.3%

with the composite structure. Thus an increase in launching efficiency is observed for the dielectric rod with composite structure compared to that for simple excitation by circular X-band waveguide. The experimental results of radiation patterns are shown in Figs 4 and 5. Sum and difference patterns at 9.5 GHz show an excellent symmetry, a low cross polarisation level of 35 db over 3 db main beam-width, low side lobe levels and high tracking slope. Phase centres at the two bands are seen to be located near the physical aperture of the L-band guide. Exact coincidence of these phase centres and optimum monopulse patterns are dependent on the diameter and tapering of the dielectric rod which are under further investigation.

The compact dual-band feed requires a single paraboloid reflector and therefore reduces the cost and complexities of the system. Because of large separation between the two frequency bands for tracking and IFF operations effects of interference to tracking signals due to harmonics of IFF signals would be avoided. Power handling capability can be increased by using suitable dielectric material for the rod such as teflon. L-band circular waveguide may be properly dimensioned for conventional IFF frequencies.

Acknowledgement

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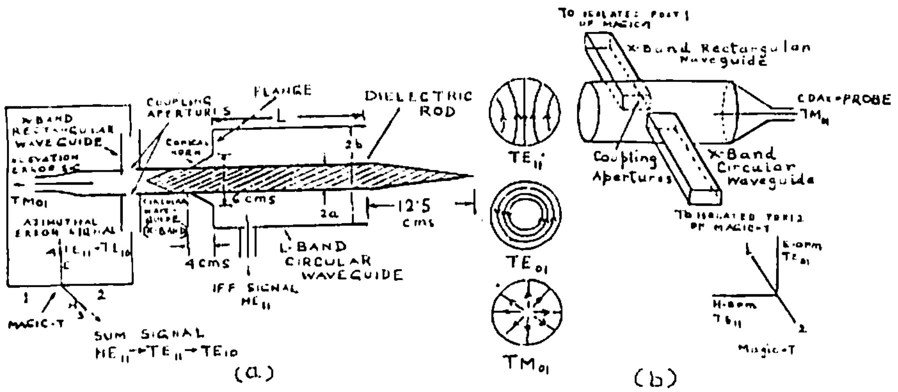

Fig.1 DUAL-BAND COMPOSITE ANTENNA
(2a = 2.9 cms, 2b = 11 cms, L= 35 cms)

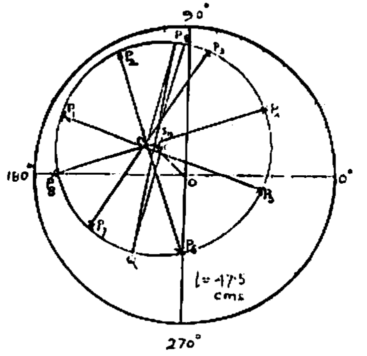

Fig.3 S-PARAMETER MEASUREMENTS OF FEED END OF DIELECTRIC ROD WITH COMPOSITE STRUCTURE (x EXPERIMENTAL POINTS)

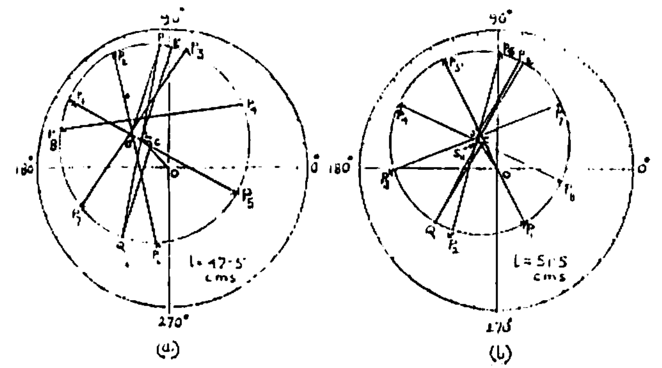

Fig.2 S-PARAMETER MEASUREMENTS OF FEED END OF DIELECTRIC ROD WITHOUT LAUNCHING HORN AND L - BAND WAVEGUIDE (x EXPERIMENTAL POINTS)

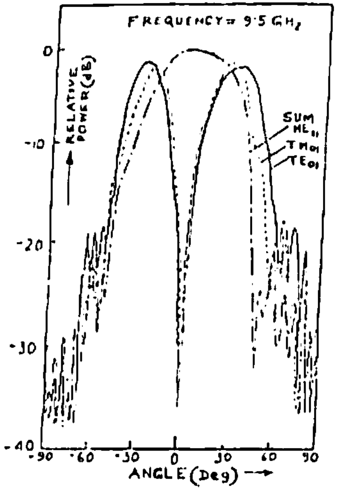

Fig.4 SUM AND DIFFERENCE PATTERNS AT X-BAND (Frequency = 9.5 GHz)

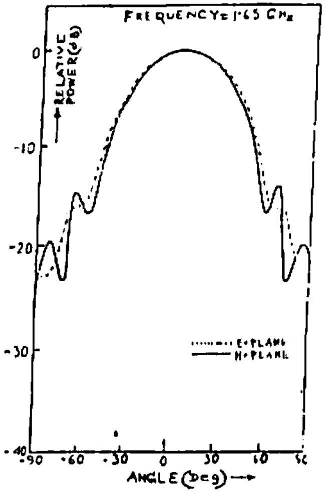

Fig.5 L-BAND PATTERNS (Frequency = 1.65 GHz)