Novel Wide Band Printed Dipole Antenna

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Design, development and experimental observations of a L-band printed dipole antenna is presented. Bandwidth enhancement is achieved by end-loading of the dipole arms. Using the present technique impedance bandwidth can be enhanced up to 50% without degrading the efficiency of the antenna.

A simple dipole is of great interest not only historically but also as a feed for reflector antennas with low aperture blockage. Dipoles are also commonly used as building blocks in phased array technology.

This is an era of microstrip antennas because of their excellent properties like low profile, light weight and smallness in size. They can be made conformal to the nozzle of the missiles and rockets and can be easily mass produced with very high precession at a low cost with photo-etching techniques.

In the past few years, dipoles etched on the same side or on either side of a dielectric substrate, with or without reflector has drawn the attention of many researchers [1,2]. Printed dipoles provide minimum aperture blockage and due to their light weight nature, they can be used as an ideal radiating element in electronically scanned phased arrays. Bailey [3] has reported a cavity backed printed dipole antenna having 37% impedance bandwidth. The rigid requirement of the cavity restrict the use of this antenna in certain applications. Recently, the authors have reported a new printed dipole antenna offering an impedance bandwidth of 42% without any cavity backup [4]. This paper is the extension of the above work for further enhancement of the impedance bandwidth.

DESIGN APPROACH

As reported in [4], considerable enhancement in impedance bandwidth is possible by end-loading the dipole arms using triangular shape at the end of the dipole arms. Experimental investigation shows that a rectangular end-loading instead of a triangular one gives better impedance bandwidth. Further enhancement is achieved by keeping the main arm slightly shorter than the ground arm.

Figure 1 shows the schematic of the antenna structure, with solid line as main arm and dotted line as ground arm, etched on either side of a dielectric substrate. The low input impedance of the dipole is matched with 50 Ω feedline using an impedance transformer. To compensate the inductive part, due to endloading, a stub is also used. The antenna can be placed over a reflector plate, acting as cavity, to produce unidirectional pattern.

DESIGN DETAILS

For clarity the main arm and the ground arm are shown

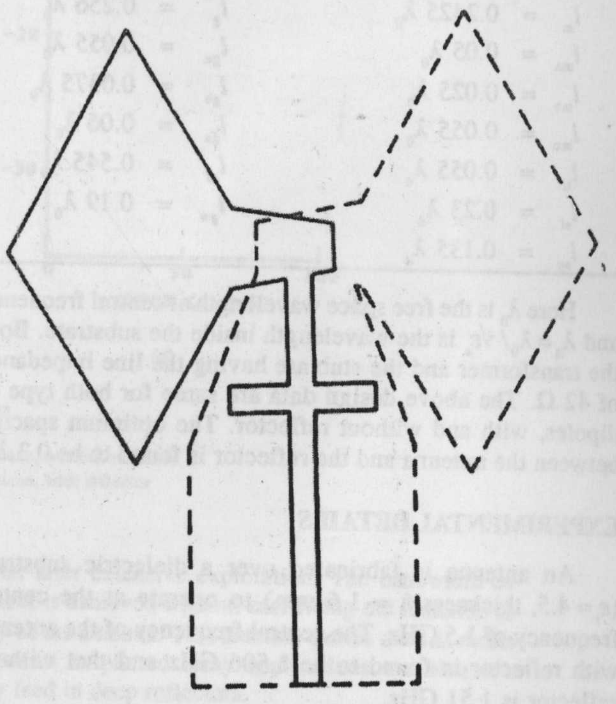

Fig 1 Schematic of the dipole (dotted line shows the ground arm etched on the other side of the substrate)

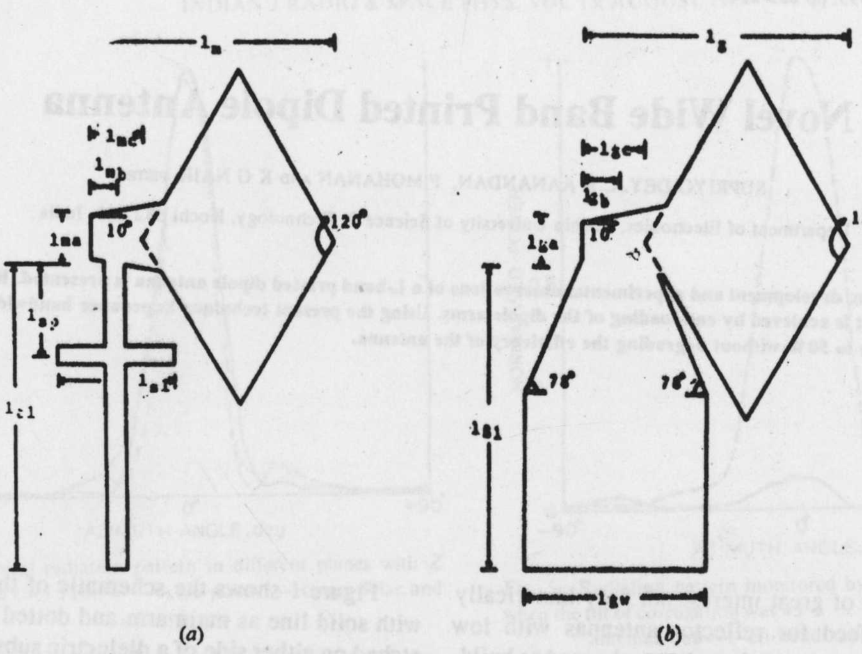

Fig 2 Schematic of the dipole (*a*) main arm (*b*) ground arm

separately in Fig 2*a* and 2*b*. The experimentally optimized design data are given in Table 1.

TABLE 1 Design data for a dipole antenna

Main arm			Ground arm		
l_m	=	$0.2425\ \lambda_0$	l_g	=	$0.256\ \lambda_0$
l_{ma}	=	$0.05\ \lambda_0$	l_{ga}	=	$0.055\ \lambda_0$
l_{mb}	=	$0.025\ \lambda_0$	l_{gb}	=	$0.0375\ \lambda_0$
l_{mc}	=	$0.055\ \lambda_0$	l_{gc}	=	$0.06\ \lambda_0$
l_{tl}	=	$0.055\ \lambda_d$	l_{gl}	=	$0.545\ \lambda_d$
l_{sl}	=	$0.23\ \lambda_d$	l_{gw}	=	$0.19\ \lambda_0$
l_{sp}	=	$0.135\ \lambda_d$			

Here λ_0 is the free space wavelength at central frequency and $\lambda_d = \lambda_0 / \sqrt{\varepsilon_r}$ is the wavelength inside the substrate. Both the transformer and the stub are having the line impedance of 42 Ω. The above design data are same for both type of dipoles, with and without reflector. The optimum spacing between the antenna and the reflector is found to be 0.3 λ_0.

EXPERIMENTAL DETAILS

An antenna is fabricated over a dielectric substrate ($\varepsilon_r = 4.5$, thickness h = 1.6 mm) to operate at the central frequency of 1.5 GHz. The central frequency of the antenna with reflector is found to be 1.506 GHz and that without reflector is 1.51 GHz.

Figure 3 shows the input VSWR variation of the antenna with and without reflector. The 2:1 VSWR bandwidth of the antenna with and without reflector are 51% and 48% respectively.

The E and H-plane radiation patterns of the antenna with and without reflector are given in Fig 4*a*, 4*b*, 4*c* and 4*d*. The deviation of the H-plane radiation patterns of the antenna from conventional half-wave dipole may be due to the radiation from feed structure. As evident from Fig 4*c* and 4*d*, there is a slight depression in the patterns at bore-sight at higher frequencies in the case of antenna with reflector. This is due to increase in the effective separation between the antenna and the reflector with increase in frequency.

The gain of the antenna with reflector is compared with a rectangular microstrip patch of same physical area and etched on same dielectric substrate. The microstrip patch antenna is matched at 1.5 GHz. The gain of the dipole is

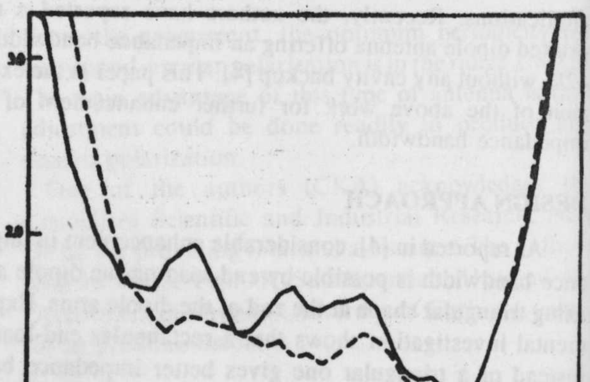

Fig 3 Variation of VSWR with frequency
—— with reflector, ---- without reflector

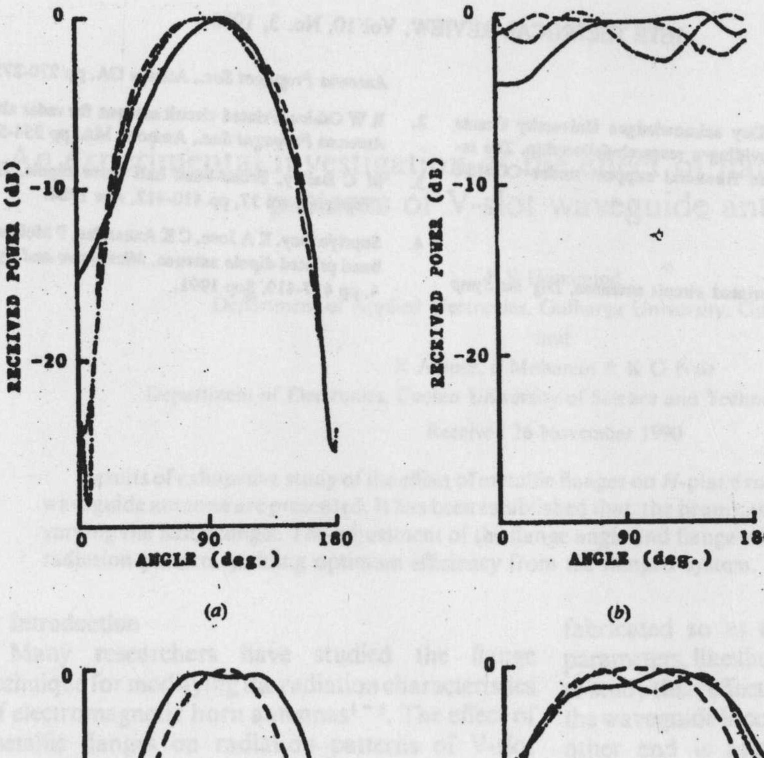

Fig 4 Radiation patterns of the antenna at different frequencies
------1.15 GHz, ——— 1.5 GHz, — · — 1.8 GHz.
(*a*) E-plane, without reflector (*b*) H-plane, without reflector
(*c*) E-plane, with reflector (*d*) H-plane, with reflector

found to be 1 dB more than that of microstrip patch.

CONCLUSION

The design and experimental details of an L-band printed dipole antenna with more than 48% impedance bandwidth are given after extensive exploration. The bandwidth enhancement is achieved without sacrificing the radiation efficiency of the antenna. This antenna can be used as radiating elements in phased array applications and also as a primary feed in deep reflectors.

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