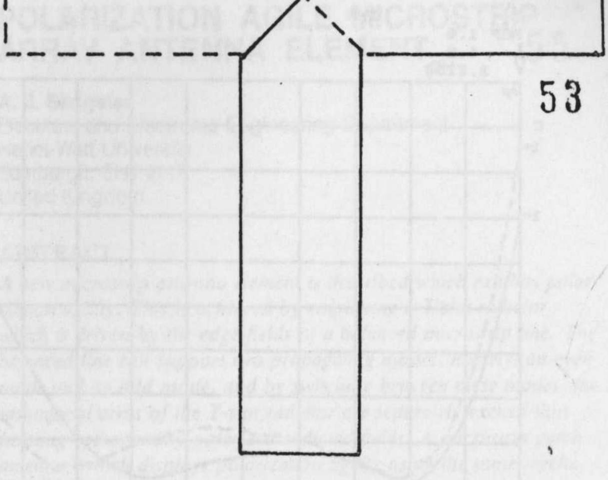

Figure 1 Schematic diagram of conventional printed dipole antenna. Dotted line shows the ground arm etched on the other side of the substrate

WIDE-BAND PRINTED DIPOLE ANTENNA

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KEY TERMS

Antennas, printed dipoles, impedance bandwidth

ABSTRACT

The design and development of an L-band printed dipole antenna, optimized for wide-band applications near first resonance, is reported. This design has achieved more than 48% impedance bandwidth (VSWR 2:1), without degrading its overall radiation efficiency.

INTRODUCTION

Microstrip antennas are fast replacing conventional antennas due to such merits as low cost, light weight, small size, and convenience for mass production. However, there is an inherent disadvantage of very narrow impedance bandwidth for these antennas. Bandwidth enhancement is reported using electromagnetically gap-coupled parasitic elements [1, 2] or by traveling-wave technique [3]. However, in both cases, bandwidth enhancement was achieved at the expense of efficiency. Bailey [4] has reported a cavity-backed printed dipole having an impedance bandwidth of 37%.

Recently the authors have developed a wideband printed dipole with an impedance bandwidth of 30% without using a cavity backup [5]. A further enhancement of radiation efficiency and impedance bandwidth of a printed dipole with no cavity backup has been reported in this article. Its design considerations and experimental details are also presented.

DESIGN APPROACH

A conventional printed dipole is shown in Figure 1. It was experimentally observed that a considerable increase in impedance bandwidth is possible by proper inductive loading. A detailed experimental investigation was carried out with various shapes and sizes. The antenna with triangular loading, having 100° apex angle, is found to be optimum for impedance bandwidth and radiation pattern. To compensate the inductive part, a stub is also used. It was also observed that antenna parameters are too sensitive to stub parameters. Incorporating these factors, the new optimum antenna design is as shown in Figure 2.

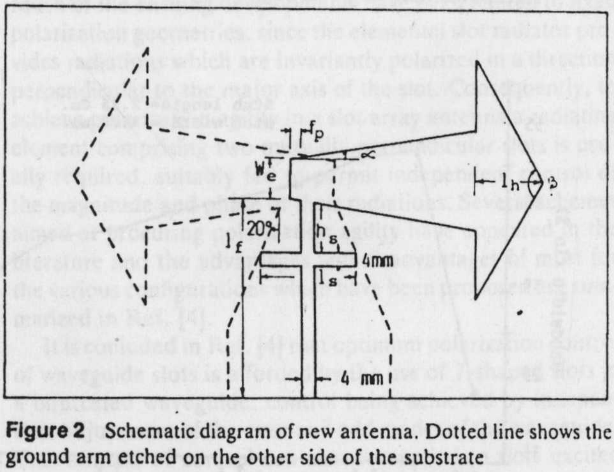

Figure 2 Schematic diagram of new antenna. Dotted line shows the ground arm etched on the other side of the substrate

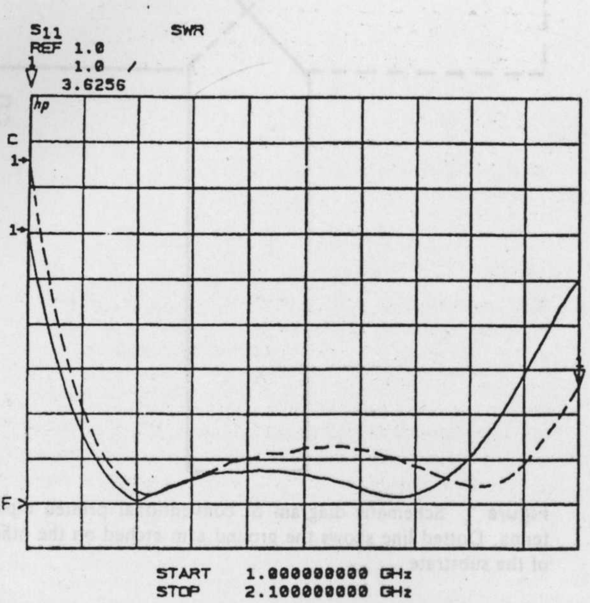

Figure 3 Variation of impedance with frequency. Solid line, h_s = 1.4 cm; dashed line, h_s = 1.2 cm

DESIGN DETAILS

The design details of the optimum antenna, as shown in Figure 2, are

Main arm length	$l_1 = 0.475\ \lambda_d$
Altitude	$l_h = 0.209\ \lambda_d$
End width	$W_e = 0.076\ \lambda_d$
Feed separation from end	$f_p = 0.021\ \lambda_d$
Stub separation from patch	$h_s = 0.119\ \lambda_d$
Stub length	$l_s = 0.307\ \lambda_d$
Feed line length	$l = 0.553\ \lambda_d$
Flare angle	$\alpha = 8°$
Apex angle	$\beta = 100°$

where $\lambda_d\ (= \lambda/\sqrt{\varepsilon_r})$ represents the wavelength in the dielectric material. Here ε_r is the dielectric constant of the substrate and λ is the free-space wavelength corresponding to the central frequency.

Except for flare angle and apex angle, all other parameters of the ground arm, which is on the other side of the main arm, are kept 1.05 times larger than those of the respective main arm parameters, for optimum bandwidth. The same flares and apex angles for both arms show better radiation patterns.

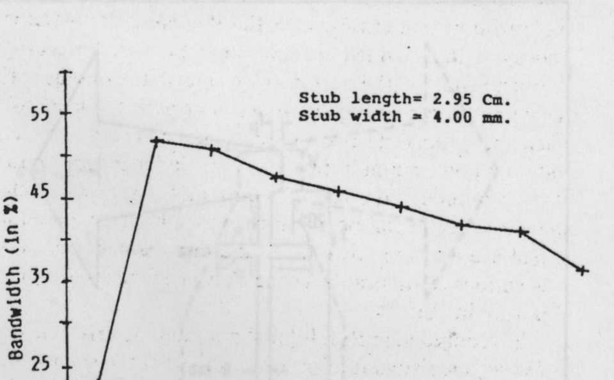

Figure 4 Variation of bandwidth with stub position (h_s)

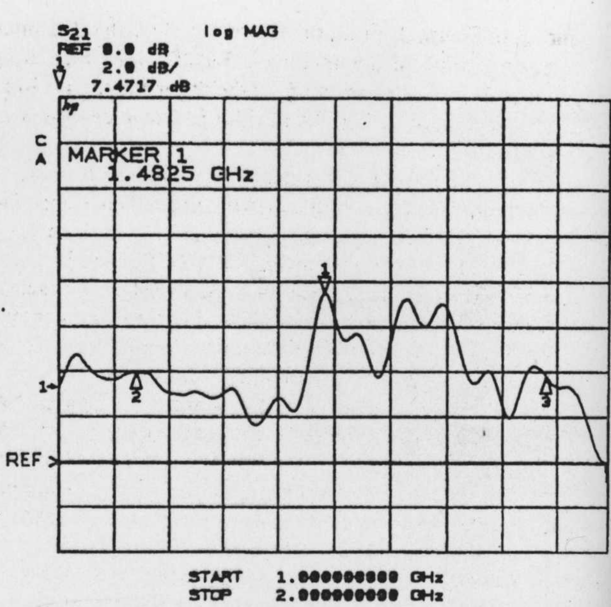

Figure 5 Variation of the S_{21} of new antenna with frequency compared to a standard dipole. REF is for conventional dipole and the trace is of the new antenna

EXPERIMENTAL RESULTS

An antenna is fabricated over a dielectric substrate ($\varepsilon_r = 4.2$) to operate at a central frequency of 1.5 GHz. Typical variations of impedance with frequency for two stub positions are

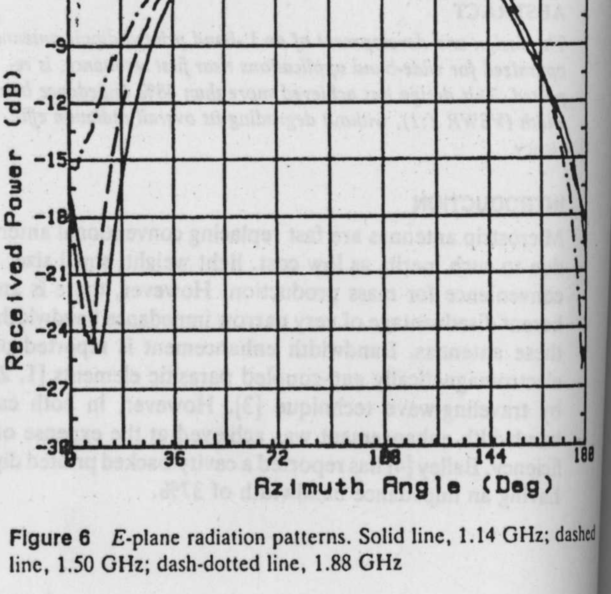

Figure 6 *E*-plane radiation patterns. Solid line, 1.14 GHz; dashed line, 1.50 GHz; dash-dotted line, 1.88 GHz

shown in Figure 3. From the figure it is clear that the impedance bandwidth of the antenna is 50.52% when the stub position is 1.4 cm. Variation of bandwidth with stub position is shown in Figure 4. The bandwidth is maximum for a stub position of 1.3 cm.

From the preceding it is clear that a slight shift in the stub position toward the antenna arm deteriorates the impedance bandwidth. When the stub position is 1.3 cm from the radiating arm, the central part of the VSWR trace just grazes the VSWR = 2 line. Hence for a safer design, h, is selected as 1.4 cm in the present study. The other two parameters of the stub, namely, stub width and stub length, are also optimized after extensive experimental iterations.

A comparison of the gain of new antenna (Figure 2) with a conventional one (Figure 1), having the same physical area and operating frequency of 1.5 GHz, is presented in Figure 5. In Figure 5, the above figure, markers 2 and 3 represent the start and end frequencies of the operating bandwidth. In this band, the gain of the new antenna is found to be greater than 2 dB and at the design frequency, the gain is 6 dB more than the conventional one. This confirms the bandwidth enhancement of the antenna without any kind of ohmic losses.

The *E*-plane radiation patterns, plotted using a time-gating technique with HP8510B-based instrumentation for three different frequencies are shown in Figure 6. The radiation patterns confirm that the antenna is not exhibiting beam squinting with frequency.

CONCLUSION

Design, development, and experimental data on a broadband printed dipole antenna are reported. It has been shown that an impedance bandwidth of more than 48% can be achieved without affecting the radiation efficiency. This antenna can be used in a wideband phased array or as a primary feed for reflectors.

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