Abstract—A wideband omnidirectional antenna, designed for mounting on vehicles and other mobile devices, covers the 1700–2700 MHz band, i.e. 45% impedance bandwidth of 1000 MHz. It has an array of two in-phase planar λ/2 dipoles that are arranged side by side and fed by a coplanar waveguide. The dipole microstrip patches are printed on a 66 mm by 28 mm, 1.6 mm thick FR-4 PCB. The in-band antenna gain is about 2.6 dBi with nearly doughnut shape radiation patterns.

Index Terms — Coplanar waveguide, λ/2 dipole array, omnidirectional, sleeve dipole, wideband antenna.

I. INTRODUCTION

Microstrip patch antennas are intrinsically narrow bandwidth devices, i.e. less than 10 %. Special techniques are always applied in order to increase their bandwidths. These include complicated wideband balun impedance transformers and parasitic elements.

Abdelaziz reported a 10 GHz dual-element microstrip patch antenna design which was printed on a 1.6 mm thick Duroid substrate [1]. The two elements resonate at 9.64 and 10.74 GHz, respectively. Enhanced by two rectangular parasitic patches, the omnidirectional antenna covers 9.3–10.5 GHz, i.e. a bandwidth of 1.2 GHz (12 %).

Vasiliadis et al proposed a double-sided printed dipole antenna on Taconic-TLY5 substrate (εr = 2.21) which is fed by a tapered balun [2]. It covers 2.19–3.97 GHz obtaining a bandwidth of 1.78 GHz (60 %) with gains of 2.9 to 5.5 dBi, for a dimension of 50 mm×30 mm×1.6 mm.

Lindberg et al presented a dual wideband printed dipole antenna on 0.8 mm thick double-sided 133 mm×70 mm FR-4 PCB which covers 824–960 MHz (15 % bandwidth of 136 MHz with gain <2.0 dBi) and 1.65–2.35 GHz (36 % bandwidth of 700 MHz with gain <2.5 dBi) [3]. The key component of this antenna is a wideband transition from unbalanced microstrip line to balanced coplanar slotline.

Pan printed a coplanar waveguide (CPW) collinear array on a 30 cm×3 cm 1.6 mm thick FR-4 substrate [4]. This pseudo-omnidirectional antenna consists of multiple CPW radiating elements resonating at several frequencies. It covers two commonly used wide bands: 750–1050 MHz (33 %) and 1.7–2.9 GHz (54 %).

II. SLEEVE DIPOLE

Feeding a balanced dipole with an unbalanced coaxial launcher requires a balanced-to-unbalanced impedance matching transformer (balun). A balun takes space and is complicated when antenna size is an issue. A sleeve dipole, which has the characteristic of a balun by itself, can be connected to a coaxial cable directly.

Taguchi and Rohadi analysed a multi-sleeve UWB planar antenna which covered from 2.7 to 5.1 GHz [5]. It is essentially a multiple half-wave dipole antenna fed by a CPW.

III. MUTUAL IMPEDANCE

Mutual impedance (positive and negative) occurs when two in-phase λ/2 dipoles are placed side-by-side forming an array [6]. The individual dipole element’s driving-point impedance will be its self-impedance minus the mutual impedance which depends on the spacing of the two dipoles. Impedance matching between the driving-point of the array (50 Ω) and the driving-points of the two dipoles (<50 Ω for spacing <0.3 λ) is required critically.

Two identical impedance transformers are required to match 100 Ω dipole driving-point impedance with 50 Ω transmission line impedance (two 100 Ω in parallel equals 50 Ω). Wider separation increases the element impedance and the gain of the array, but reduces the degree of omnidirectionality.

IV. DESIGN SIMULATION

The initial PCB layout of a two λ/2 dipole array is shown in Fig. 1. It is basically a 50 Ω CPW asymmetrical sleeve dipole. The patches are printed on a 1.6 mm thick FR-4 substrate. The CPW strip width is 4 mm and its gap width is 0.5 mm. The width of the dipole arms is 5.5 mm. The right (61 mm) λ/2 dipole element resonates at 1.7 GHz while the left (55 mm) one at 1.9 GHz. The gap width between the upper and lower arm is 1 mm. The gap width between the outer sleeve and the CPW is also 1 mm. The outer dimensions of the antenna are 66 mm by 28 mm.

This configuration was analysed and simulated by CST Microwave Studio. Figs. 2 and 3 show its return loss and VSWR plot, respectively from 1.4 to 3 GHz. Resonances at 1.7 and 1.9 GHz are clearly seen. The 10 dB return loss bandwidth is 800 MHz (1.7–2.5 GHz) which is 39 %.

An uneven U shape parasitic element is inserted between the upper arms of the two dipoles as shown in Fig. 4. It has a patch width of 6 mm and is placed 0.5 mm above the impedance transformer. The corresponding simulated return loss and VSWR shown in Figs. 5 and 6 depict two extra resonant frequencies, 2.05 and 2.8 GHz, resulting in an enhanced bandwidth of 1 GHz (1.7–2.7 GHz, 45 %).
Fig. 1. Two λ/2 dipole array PCB antenna layout

Fig. 2. Return loss of two λ/2 dipole array PCB antenna

Fig. 3. VSWR of two λ/2 dipole array PCB antenna

Fig. 4. Two λ/2 dipole array with parasitic element

Fig. 5. Return loss of two λ/2 dipole array with parasitic patch

Fig. 6. VSWR of two λ/2 dipole array with parasitic patch
Simulated 2.2 GHz H-plane and E-plane radiation field pattern of the array with parasitic element are shown in Figs. 7 and 8, respectively. They show that the antenna is fairly omnidirectional on H-plane with a gain of 2.6 dBi. From 1.7 to 2.7 GHz the doughnut shape patterns are very similar with the gain varying between 2 and 3 dBi.

V. Prototype

Fig. 9 depicts the two $\lambda/2$ dipole array with a U-shape parasitic element omnidirectional wideband PCB antenna prototype. The SMA launcher is soldered directly onto the coplanar waveguide. Measurements were made by using an Agilent E8364A network analyser together with an H&S HE300CE directional antenna inside an anechoic chamber. The separation between the reference antenna and the antenna under test is 3 m. The measured results of return loss, VSWR, and radiation pattern over the 1.0 GHz bandwidth are very similar to those simulated ones obtained by using CST Microwave Studio.

VI. Conclusion

Using a very simple coplanar waveguide instead of a complicated balun, the planar array antenna consists of two different resonant frequency (1.7 GHz and 1.9 GHz) $\lambda/2$ dipoles printed on a common low cost FR-4 PCB. With the aid of a U-shape parasitic strip (resonant frequencies at 2.05 GHz and 2.8 GHz), it achieves a 45% impedance bandwidth of 1 GHz from 1.7 to 2.7 GHz with a doughnut shape radiation pattern. It covers the upper five bands out of eight IMT bands plus the wideband data transmission band. Since the two narrowly spaced side-by-side $\lambda/2$ dipoles and the parasitic element do not resonate at the same frequency simultaneously, the array antenna has a small but sufficient gain of 2.0 to 3.0 dBi in the bandwidth of 1 GHz. This omnidirectional antenna is designed for mounting on a vehicle and can also be used in a femtocell repeater.

REFERENCES