A dual-band hybrid dielectric antenna for laptop computers

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Summary

The paper describes a novel antenna covering the frequency bands used for IEEE802.11a/b/g wireless LANs comprising a dual-band radiator coupled to a microstrip transmission line by means of a shaped ceramic pellet and provides a discussion of the application and the results obtained.

1. Introduction

The introduction of wireless LAN connectivity has created a demand for compact low-cost antennas covering the frequency bands 2.4 – 2.5GHz and 4.9 – 5.9GHz. These are typically fitted to laptop computers and PDAs, and they will soon be found in printers, scanners and other peripheral devices.

The essential properties for these antennas are high efficiency, and radiation patterns which are as nearly omnidirectional as possible – even when mounted on the target device. These electrical parameters must be combined with physically small dimensions and the potential for volume production at very low cost. Most antennas will be directly connected to a sub-miniature coaxial cable and the antenna design must embody a suitable means of attachment that will control the placement of the cable accurately enough to ensure good repeatability of input matching.

It has already become normal to mount several antennas on a connected device to provide some measure of polarization and spatial diversity, mitigating problems caused by the indoor propagation environment and the random orientation of the device.

The use of ceramic antenna technology has already proved effective for embedded applications where size and immunity to detuning are important (1). An antenna using an electromagnetically-coupled short-circuit quarter-wave patch has shown good potential as a single-band antenna and was taken as a starting point for a new design.

2. Description of the design

The antenna comprises three major components (see Figure 1):

Radiating element: This is a narrow quarter-wavelength grounded patch with separate resonators for each frequency band.

Microstrip feed line: The radiating elements are excited from a microstrip feedline entering the structure at the open-circuit end. The feedline incorporates a matched microstrip/coaxial transition to allow the antenna to be fed from a subminiature coaxial cable (1.2mm diameter).

Ceramic pellet: The shaped ceramic pellet loads the radiating element, reducing its physical length, and also enhances the coupling between the element and the feedline.

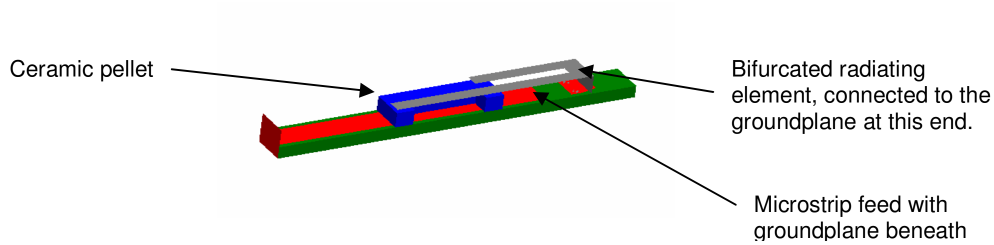


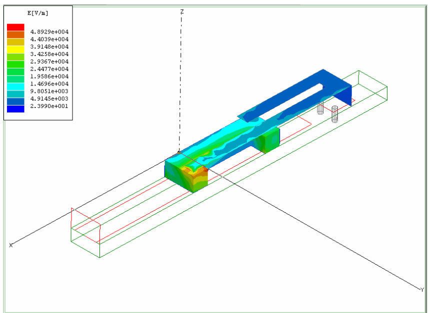
Figure 1: The hybrid antenna

The ceramic component is not functioning as a dielectric resonator antenna (DRA), yet the operation of the structure is strongly dependent upon its presence for reasons beyond simple dielectric loading; for this reason it is referred to as a hybrid ceramic antenna.

The complete antenna is very small, with overall dimensions of only 4mm x 4mm x 20mm, plus the length of any necessary additional attachment details, dependent on the application

3. Simulation

The design concept was validated and starting dimensions for a practical trial were established using HFSS. The simulation confirmed the effective and independent operation of the two sections of the radiating element and allowed the optimisation of the size, shape and permittivity of the ceramic pellet. Figures 2 and 3 show the simulated field distributions at the middle of the two operating frequency bands.



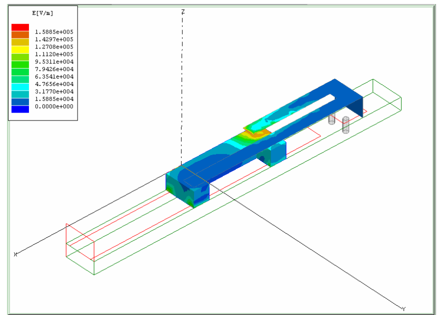


Fig 2: Field intensities at 2.5GHz (HFSS) Fig 3: Field intensities at 5.5GHz (HFSS)

4. Measurements

4.1 Input return loss The measured input return loss of the complete antenna and its feed cable is shown in Figure 4. The ripples in the measurement are caused by a mismatch at the measurement adapter, a familiar problem when working with subminiature cables at high frequencies.

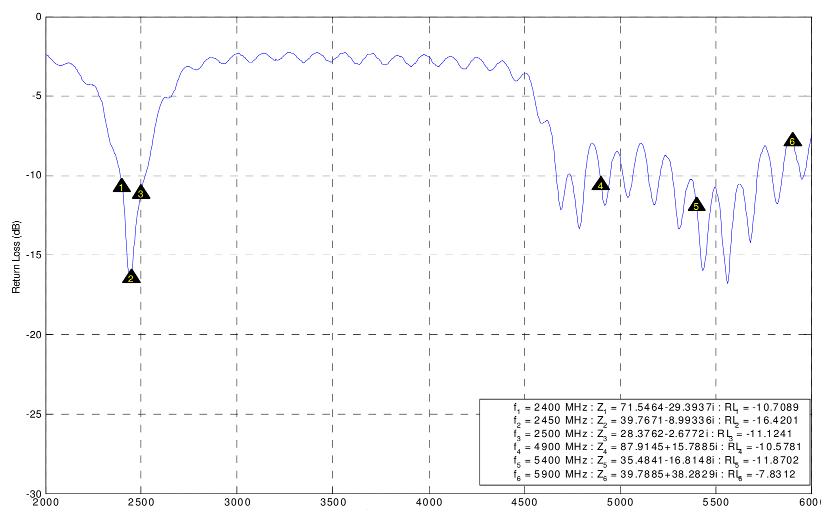


Figure 4: Input return loss at the end of a 500mm length of coaxial cable

It can be seen that the design has been optimised to provide a much wider bandwidth at 5GHz than at 2.5GHz, corresponding to the frequency assignments for each band. In a practical application, compensating the connector discontinuity within the connected device can reduce the input-end mismatch and corresponding ripple, allowing the target return loss of 10dB to be achieved across both bands.

4.2 Radiation patterns The use of antennas on laptop computers is still at an early stage of maturity. They are typically mounted round the top and sides of the display; this offers a relatively unobstructed view, and use of both top and sides provides polarization diversity. However these marginal positions fall far short of the kind of 'groundplane' which might be desired by an antenna designer. Patterns are measured in three orthogonal planes with the screen in a typical working configuration, with the screen open to make an angel of 120° with the plane of the keyboard. As the polarization of the antennas (particularly that of those on the sides of the screen) varies with the observer's direction, the usual convention is to measure patterns with orthogonal linear polarized probes and to add the results power-wise.

The radiation patterns are dominated by effects created by the shape of the laptop and the edge-mounted positions of the antennas. This is entirely normal for this application, although the resulting patterns may come as something of a surprise to those accustomed to more conventional antenna applications.

The test laptop sample had a conductive metal case and lid, so the antennas were installed with their radiating elements just proud of the edge of the lid, firing radially away from its center. In addition to some sample radiation patterns, the following results also include a simulated 3-D pattern and a cumulative distribution curve showing the probability that in any point in the surrounding space the gain of the antenna will exceed some specified value. The statistical approach is very common for this application.

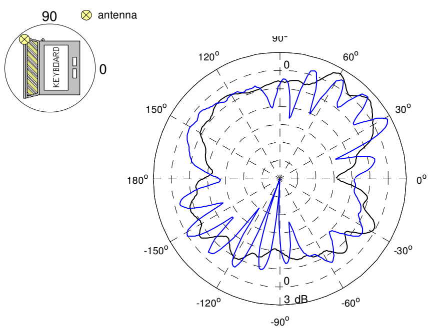


Fig 5a

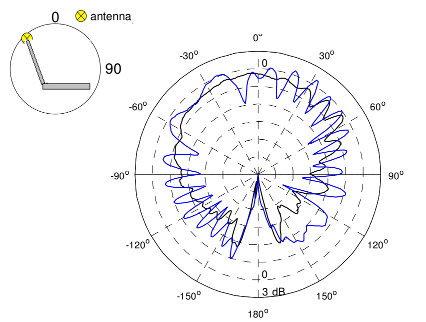


Fig 5b

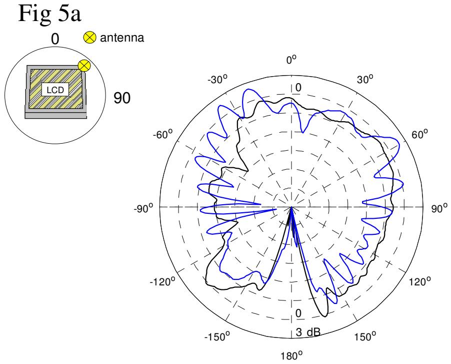


Fig 5c

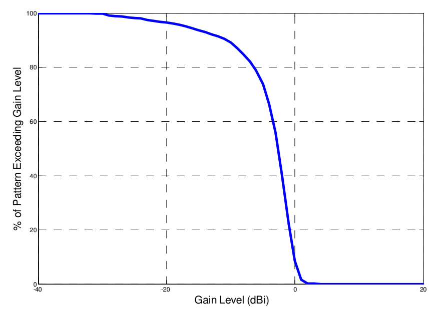


Fig 5d

Fig. 5: Principal plane radiation patterns and 3-D cumulative probability gain function in the 5GHz band. (Solid line = 4.9GHz, dashed line = 5.9GHz). Total power data in all cases.

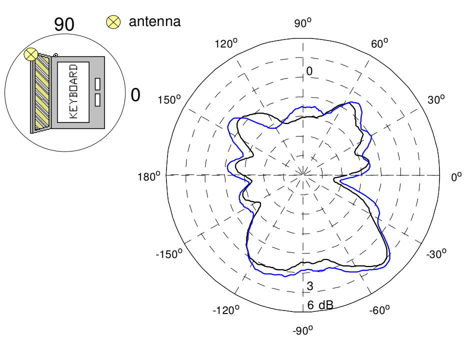


Fig 6a

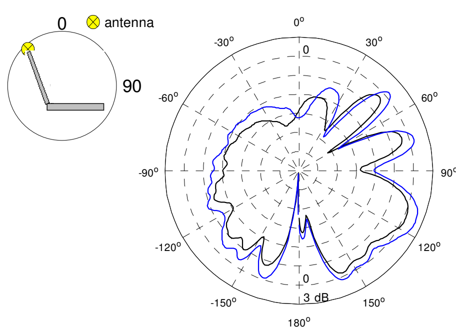
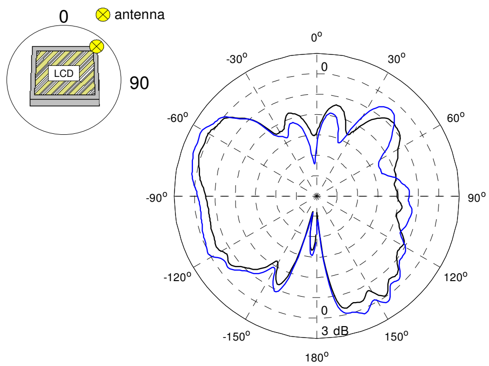


Fig 6b



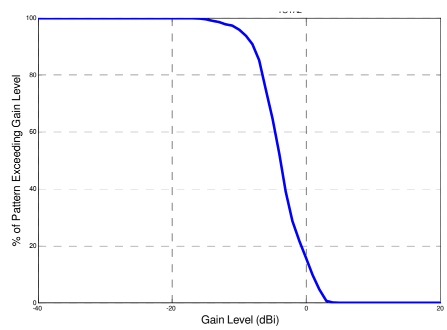


Fig 6c

Fig 6d

Fig. 6: Principal plane radiation patterns and 3-D cumulative probability gain function in the 2.5GHz band. (Solid line = 2.4GHz, dashed line = 2.5GHz). Total power data in all cases.

5. Conclusion The paper has described an unconventional antenna addressed at a specialised application. It highlights the potential advantages of the use of ceramic dielectrics in antenna designs in which the ceramic acts as a modifier of the characteristics of a more conventional structure, rather than an antenna in its own right. It is to be expected that this approach will lead to further highly-optimised designs for specific applications.

Bibliography

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Author's note:

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