Dual_Band_Patch_Antenna

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Design Notes

Dual-Band Patch Antenna

This project analyzes a dual-band patch antenna, designed for mobile phones to be used as an internal antenna. The design is published in Proceedings of the AP2000 Millennium Conference on Antennas & Propagation, Davos, Switzerland, 9-14 April 2000, titled "Internal Dual-Band Patch Antenna for Mobile Phones", by Jani Ollikainen, Outi Kiveks, Anssi Toropainen, and Pertti Vainikainen.

Overview

Patch antennas are standard antennas used in handsets today, because they are inexpensive, easy to manufacture and integrate in the handset cover. The article referenced above discusses details of the design, and in fact this simple antenna was one of the first internal handset antennas covering E-GSM, GSM1800, DECT, PCS1900 and UMTS frequency bands (880 - 960MHz and 1710 - 2170MHz) at S11<-6dB level without any discrete matching circuit.

The AXIEM document is rather straightforwardly constructed from the dimensions given in the article. The capacitive load and coaxial probe feed are discussed separately. The patches are supported by a piece of Styrofoam in the prototype. It has only mechanical supporting role, and no attempt is made to model it in AXIEM. All dielectrics in the problem are air. The ground plane is finite, and it roughly represents a handset ground plane in size and shape.
In this project, all the same measurements given in the article are performed: reflection coefficient, radiation patterns at selected frequencies, and radiation efficiency. In addition, to highlight the ground plane role in handset antenna performance, a parametric study of the reflection coefficient as a function of ground plane size is carried out.

**Capacitive load**

The load is formed by folding the last 5mm of the other end of the low-band patch to point downwards. In AXIEM, this is easily accomplished by splitting the total vertical distance between the patches and the ground plane (7mm) into two parts (2mm + 5mm). The load is then drawn as a via through the 5mm layer. To guarantee sufficient resolution in z-dimension, right-click EM document > Options > Mesh click the Show Secondary button and uncheck Minim al Z Meshing.

**Coaxial probe feed**

Two alternative probe feed models are used here, with little difference in the response. First version (used in EM document "Dual_band_patch_feed_v1") has a hole in the ground plane, and a rectangular patch on the bottom of the circular via post, representing the extension of the inner conductor of the coax cable. The positive terminal of the port has been defined parallel on each four sides of the patch, and the negative terminal likewise parallel on the edges of the rectangular hole.

The other alternative probe feed model is used in EM document "Dual_band_patch_feed_v1". Here a small vertical gap is introduced by splitting the air layer on top of the ground plane into two (2mm => 0.1mm + 1.9mm). Small patch is defined to the bottom of the probe such that the patch edge is in the middle of the probe, and then a differential port is defined between bottom of the probe and ground plane.

**Frequency response**

Frequency response of the antenna is shown in graph "S11", due to both feed strategies described above. The reflection coefficient is shown also on Smith chart in graph "Smith", showing the characteristic dual resonance shape for the high-band.
Radiation patterns

The graphs "Pattern XY", "Pattern XZ" and "Pattern YZ" represent the radiation patterns of Etheta- and Ephi-components at XY, XZ and YZ planes, respectively.
Radiation efficiency

Radiation efficiency is calculated as a ratio of radiated power with and without resistive losses. The ratio is calculated under Output Equations, and the measurement used is Electromagnetic > Antenna > Sweep Frequency > SF_TPwr where one can select whether or not resistive and/or mismatch losses are taken into account. The efficiency is given in graph "Radiation eff" and it does not include mismatch loss.

Note that Advanced Frequency Sweep (AFS) cannot be used with this measurement, therefore the data is calculated using document "Dual_band_patch_no_AFS" frequency by frequency.

Ground plane size study

EM documents "Dual_band_patch_short_GND" and "Dual_band_patch_long_GND" represent variants of the original design in which the ground plane patch is 20mm shorter or longer. Graph "Ground size study" shows S11 for each case. We can see that the shorter ground provides actually better matching for the high-band, but the low-band resonance is almost lost. The longer ground performs uniformly better on both low- and high-bands, but the ground plane size may become impractically large.

The message of this study is that the ground plane has a significant contribution to the antenna performance - in good and bad - and should be considered as a design parameter together with the actual antenna element.
The graph illustrates the ground size study with several curves labeled as follows:

- **m1**: 880 MHz, -8.55 dB
- **m2**: 960 MHz, -15.07 dB
- **m3**: 1710 MHz, -5.519 dB
- **m4**: 2170 MHz, -8.554 dB

The graph plots **S11 (dB)** against **Frequency (MHz)**, where the curves represent different configurations labeled as:

- Dual_band_patch_feed_v1
- Dual_band_patch_short_GND
- Dual_band_patch_long_GND

The graph shows the performance comparison across different frequencies and configurations, indicating the impact of ground size on the S11 parameter.