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Research Article

DESIGN OF TUNABLE DUAL-BAND ANTENNAS FOR CARRIER AGGREGATION SYSTEMS

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ABSTRACT

Single and Dual feed Antennas with dual frequencies have been demonstrated. Varactor diodes are used for independent tuning. The PIFA (Planar Inverted F-Antenna) has two frequencies from 0.7 to 1.1 GHz and from 1.7 to 2.3GHz. Impedance match as much as -10dB an isolation greater than 13dB is assumed. The single feed antenna can be tuned from 1.2 to 1.6GHz and 1.6 to 2.3 GHz. The antenna volumes are 63x100x3.15 mm^3 with relative permittivity is 3.55 substrates. The efficiency varies from 25% to 50% over tuning range. The application areas are in 4G wireless systems.

INTRODUCTION

An antenna is an electrical device which adopts electrical energy into electromagnetic waves, and vice versa. It is Usually rundown with a radio transmitter or radioreceiver. In transmission, a radio transmitter supplies an electric current oscillating at a high frequency alternating current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves. In receipt, an antenna intercepts some of the power of an radio wave benecfiial to produce a tiny voltage at its terminals, which is useful to a receiver to be amplified. Antennas are for most components of whole equipment that uses radio. They are used in systems such s radio broadcasting, broadcaste television, two way radio communication receiver radar, cell phones, and satellite communications as well as other devices such as garage door openers, wireless microphones, Bluetooth-allowed devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

In wireless communications, various systems used apathetic geographical regions have unmoved frequency bandwidths. Hence, for the portable cellular phones to be suitable with the various systems, dual-band antennas are needed. Previous dual-band designs have been normally rooted on the dual-feed approach where the lower band and upper band antennas are put together into a compact structure. However, all these antennas will interfere with each other while transmitting or receiving the signals. Another procedure combined a *LC* resonator on a PIFA antenna to realize the dual-band characteristic. This approach only has single signal feed. since, there is no interference between the radiation elements. The *L*C resonator used is poised of a fixed capacitor and a settled inductor. So the PIFA antenna only has static lower band and static upper band.

This paper describes a tunable dual-band Inverted-F antenna (IFA) which can cover a broader bandwidth distinguished to other dual-band antennas. The dual-band characteristic is realized by employing a *LC* resonator approach like in. However, the capacitor beneficial in the resonator is a tunable capacitor based on the thin-film BST technology. The BST capacitors value can be varied by an external DC voltage. By varying the capacitance, both the lower band and the high band of the IFA antenna can be varied to cover a broader bandwidth. Experiments show that maximum six systems like GSM-850, GSM-900, GPS, DCS, PCS and UMTS, can be covered by using a 3.3:1 tunable capacitor. furthermore, the planar structure of the IFA antenna creates it easy to incorporate it into cell phones or other wireless devices.

Proposed Scheme

The proposed system includes Dual-feed Planar inverted F-antenna (PIFA) antennas with coaxial feed by using HFSS Ansoft. Directivity, return loss, antenna gain and radiation pattern of the dual band antenna is obtained. Two antennas

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with single feed and dual feed are optimized and their parameters are obtained. Dual band antenna gives better performance with efficiency from 25% to 50% while tuning. The range of the return loss is below -10dB for single feed,-13dB for double feed and VSWR is less than 3dB.Radiation pattern, Gain, Return loss, Directivity and VSWR of the proposed antenna is obtained. Since tuning cannot be done in varactor diode, values are changed till constant biasing is achieved. The substrate used is ROGERS R04003, which is the material that acts as an insulator. Since tuning cannot be done manually, biasing is done till a constant value is achieved.

System architecture

Single feed dual band antenna

The antenna is printed on the $63 \times 100 \times 3.15mm^3$ substrate with permittivity = 3.55 similar to the dual feed dual-band antenna, and same varactor diodes (Skyworks SMV1232-040LF) are used tune the antenna. Ten-kΩ resistors are used to bias the varactor diodes at points *B*1 and *B*2. The same substrate and biasing pad configuration as the dual-feed dual-band antenna are used. Similar to the dual-feed dual-band antenna, the single feed antenna has two branches: 1) one resonating at the low-band and 2) the other resonating at the high-band.

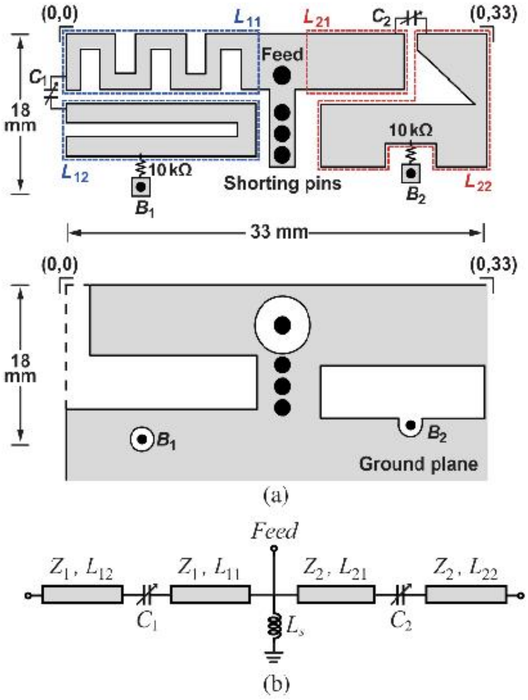

Fig.1 Single feed Dual Band Antenna Geometry

1. Top view and bottom view. All dimensions are in mm.
2. Transmission line model

The varactor diode capacitances *C*1 and *C*2 are used to tune the two different antenna resonant frequencies. The lower resonance frequency can be tuned from 1.2 to 1.6 GHz and the higher resonance frequency can be tuned from 1.6 to 2.3 GHz. These frequencies do not coincide with the traditional LB, MB, and HB regions for CA standards, and were chosen to demonstrate a dual-tuned antenna with near contiguous tuning, covering a 1.2–2.3-GHz range.

Dualfeed Dual Band Antenna

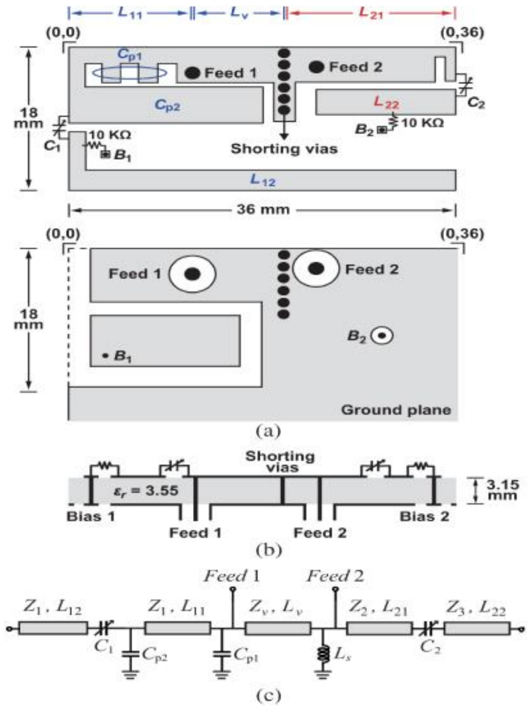

Fig.2 Dual-feed dual-band antenna geometry

1. Top metal plate and ground plate
2. Cross section. All dimensions are in mm.
3. Transmission-line model

The dual-feed dual-band antenna is shown in Fig. 3.3. The antenna resonance frequency is controlled using two varactor diodes *C*tot= 0.8–3.8 pF, *V*bias = 0–20 V). The antenna is printed on a 63 × 100 ×3.15mm3 substrate stack which is formed by two 1.524 mm thick Rogers RO4003 C substrates (permittivity= 3.55, tan δ = 0.0027 at 2.5 GHz) joined by a 0.101-mm Rogers RO4450B bond ply (permittivity = 3.54, tan δ = 0.004 at 10 GHz). In several other implementations, the antenna is made of sheet copper and suspended in air or printed on a low permittivity plastic carrier. The choice of the substrate here is only for research/demonstration purposes since it is low cost and provides mechanical robustness for soldering.

The PIFA has two feeds that are used for low-band (feed 1) and high-band (feed 2) operations. All frequencies above 1.7 GHz are referred to as high-band (that is the mid-band and high-band are lumped together into one band). Shorting vias of the LB and high-band (HB) PIFAs are combined together and placed between the feeds. The inductance of the six shorting vias is simulated using ANSYS HFSS to be 0.17 nH, and results in a high isolation between the LB and HB PIFA arms. This makes it possible to independently tune the two resonance frequencies. Fig. 3.4 (c) presents the transmission-line model.

Two tunable PIFAs are merged together at their short circuit sections and the inductive effects of the shorting vias are captured as *Ls* in the transmission-line model. The LB and HB resonances are controlled by varactor diodes *C*1 and *C*2, respectively. To reduce the antenna size, short sections of open-ended transmission lines are added to the LB PIFA. The tuning characteristics were simulated with surface impedance boundary conditions at the tuning device ports using ANSYS HFSS. The low-band operation, using feed 1, covers the 0.7–1.1 GHz band, whereas the high-band operation, using feed 2, covers the 1.7–2.3 GHz band.

RESULT ANALYSIS

Return loss

The simulated return losses are shown in Fig.5.1. Generally, the return loss of the antenna should be designed so as to have less than -10dB. The proposed antenna has both lower frequency and higher frequency bands. In the lower frequency band, the simulated -15.25dB bandwidth is from 0.7 to 1.1 GHz,. In the higher band, the simulated bandwidth is -13.48dB between 1.7 and 2.3 GHz. A slight frequency shift may occur in the higher frequency region which might be caused by feeding method.

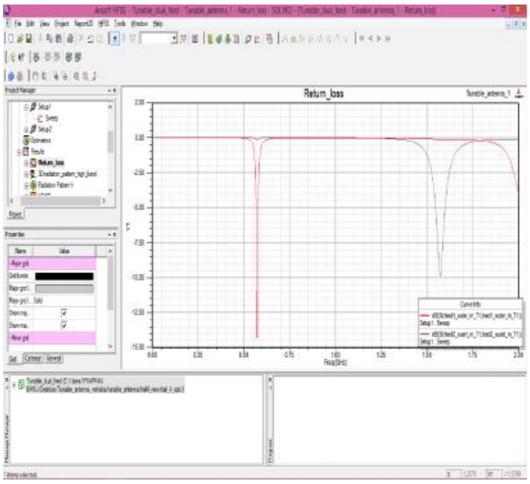

Fig 4.1 Return loss of tunable dual band antenna

Radiation Pattern

The radiation patterns of the antenna were measured using a Satimo SG32 spherical near-field chamber. The measured and simulated radiation efficiency is plotted in fig 5.12. The efficiency increases as the antenna is tuned to higher frequencies.

This is because the antenna radiation Q decreases with frequency and the varactor diode Q increases as the capacitance decreases (i.e., with frequency). Radiation patterns are mostly isotropic for all of the tuning cases and as expected from PIFAs. The radiation pattern of the higher and lower band antenna is as shown below.

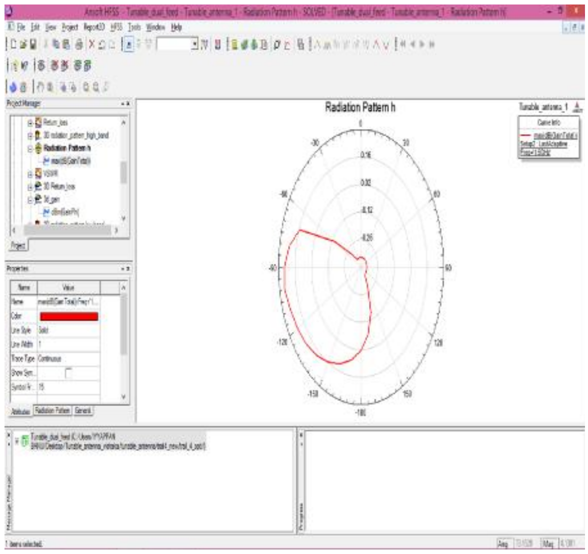

Fig.4.2.1. Radiation pattern of high band antenna

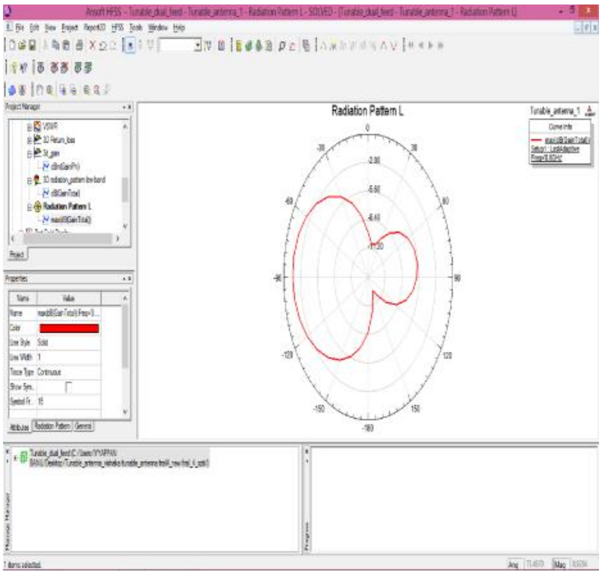

Fig.4.2.2. Radiation pattern of low band antenna

VSWR

The Voltage Standing Wave Ratio of the antenna is usually less than 3dB and less than 1dB for a best antenna. The proposed antenna is so designed to have +0.57dB as shown in fig.5.14.

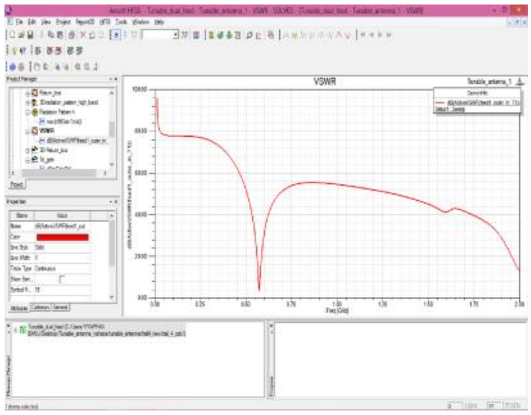

Fig.4.3VSWR of the tunable dual band antenna

D plots of the parameters of tunable dual band antenna

Gain

The gain is obtained as 2.4dBi for tunable dual band antenna as shown in fig.4.4.1.

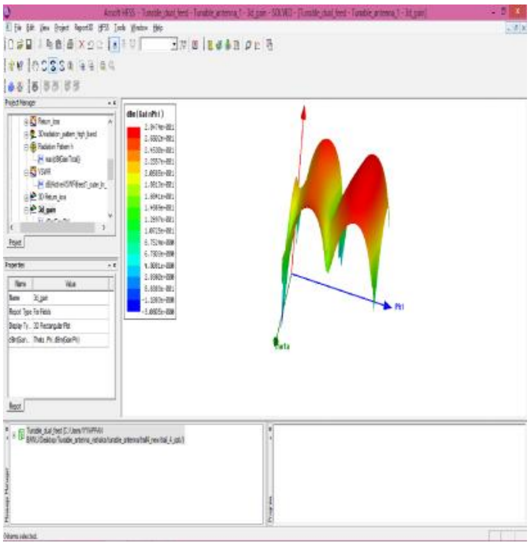

Fig.4.4.1 Gain of the antenna in 3d plot

Return loss

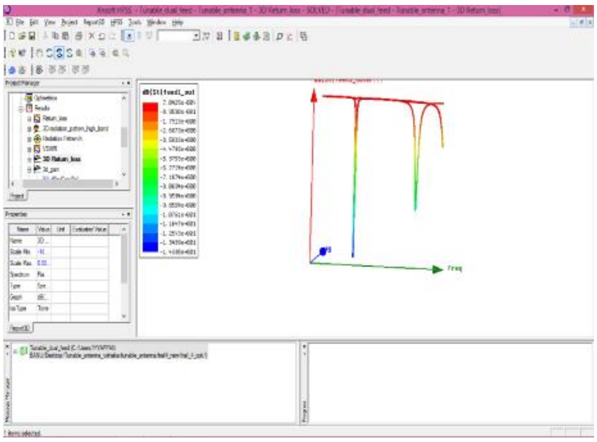

Fig.4.4.2 Return loss in 3d plot

Radiation pattern

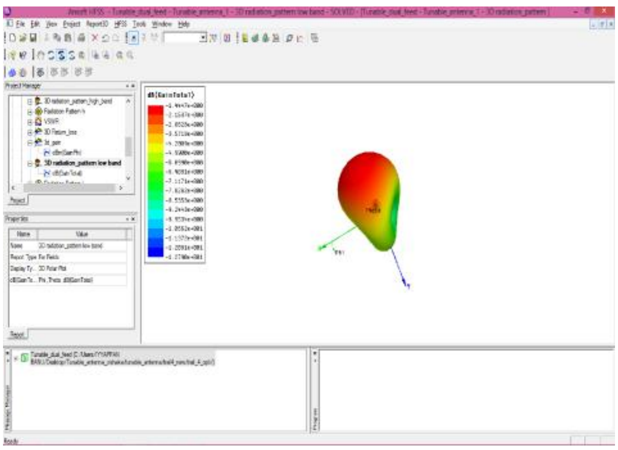

Fig.4.4.3 Radiation pattern of Lower Band Antenna

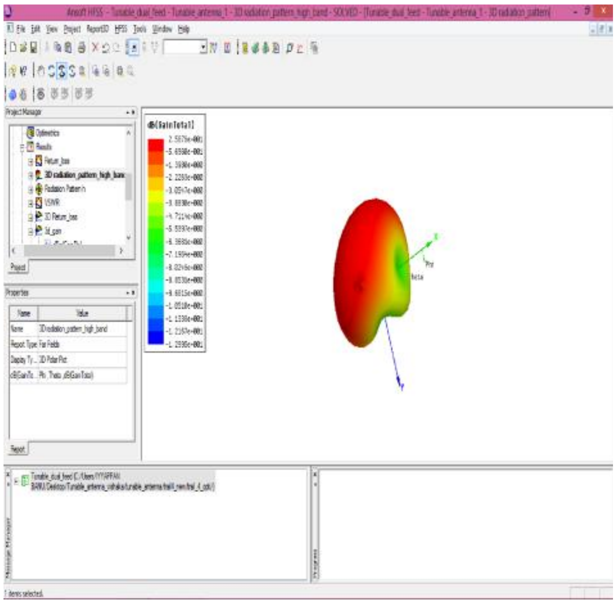

Fig.4.4.4 Radiation pattern of Higher Band Antenna

CONCLUSION

A dual-feed dual-band PIFA going underground the 0.7–1.1 GHz and 1.7–2.3 GHz bands has been demonstrated using varactor diodes. There exists a high isolation between the bands; hence the two resonance frequencies can be tuned independently without affecting each other. Additionally, a single-feed antenna with two independently tunable resonant frequencies is demonstrated at 1.1–2.3 GHz using varactor diodes. The efficiencies of the both antennas can be increased significantly by using RF MEMS varactors. In practice, and when these antennas are used in cell phones and with hand and body loading effects, the antennas will become more wideband and less efficient ,and a lot of additional effort is needed to build a true working dual-band antenna on actual platform. The goal of this work is to show that dual-tuned PIFAs are a promising candidate for increasing the performance of communications systems using the 3GPP LTE CA standard.

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