

A Compact and Reconfigurable DVB-H Antenna for Mobile Handheld Devices

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ABSTRACT: A compact inverted F antenna which is dedicated to the Digital Video Broadcasting-Handheld(DVB-H) standard. This antenna is suitable for small mobile devices and the operating frequency is tuned with a hyperabrupt varactor diode component. Low cost, compactness, wide frequency range coverage and low frequencies are the main advantages of this antenna. The antenna dimensions are very small and it covers the entire DVB-H band going from 470MHz to 862 MHz. Moreover, efficient gain and directivity are obtained in simulations and in measurements.

KEYWORDS: HFSS software, electrically small antenna, hyperabrupt varactor diode component, inverted F antenna, Broadcasting to Handheld Receiver, Mobile integration.

I. INTRODUCTION

The reduction of the antenna size becomes an important challenge, especially if the targeted application is a low frequency standard as for the case of the Digital Video Broadcasting-Handheld (DVB-H) standard. Moreover, the latter has a 60% relative bandwidth going from 470 MHz to 862 MHz. In this project, a small frequency tunable antenna is presented. It covers the entire DVB-H band thanks to a hyperabrupt varactor diode component. Its measured S parameters will be integrated instead of the diode in the CST Microwave Studio. Antenna simulated results considering both the varactor datasheet and the measured S parameters of the diode.

Due to the fact that the hyperabrupt varactor diode datasheet is given as a rough line and does not give multiple parameters, the chosen varactor has been characterized to know its real values. Its measured S parameters will be integrated instead of the diode in the CST Microwave Studio. Antenna simulated results considering both the varactor datasheet and the measured S parameters of the diode will be compared with the measured ones. A first section will show the characterization of the varactor component. Then, the antenna design will be presented with its measured performances. This section will underscore that characterizing the varactor and integrating its data during the simulation allows, more precisely, predicting the measurements.

II. RELATED WORK

Leandro de Haro, Carlos Redondo, Manuel de la Puebla, Jose Manuel Arias. says Antenna is one of the key systems to define the feasibility of the deployment of convergent wireless system between DVB-H and e.g. UMTS. INSTINCT project within WP4 (Terminal front-end aspects) is covering this issue. This S presents the conclusions about antenna design up to now, and some results and prototypes obtained. As conclusions, passive antennas are just useful for category 1 and 2a terminals, whereas tuned antennas can be applied for category 2b and 3 terminals. Although active antennas are not the target of this study, they should be used in case it is necessary to reduce more the antenna size.

Jari Holopainen Handheld DVB and Multisystem Radio Antennas Since the volume that can be reserved for antennas is very restricted, the limits for the size of capacitive coupling element based antenna structures inside handsets of different size were studied. The results indicate that the smallest required volume of the coupling

element which ensures sufficient performance in today's typical-size monoblock mobile handsets would be about 3 - 4 cm³. Instead, for tablet-size and open clamshell-size terminals the antenna elements are shown to be significantly smaller and thinner. Direct-feed-based structures can provide very low profile antenna solutions for tablet and clamshell-type terminals.

III. HYPERABRUPT VARACTOR DIODE

CHARACTERIZATION

For a frequency tunable antenna, the S parameters of the varactor diode is necessary. The datasheet of the chosen hyperabrupt varactor diode specifies a capacity range between 0.2 pF and 2 pF for 0 to 22 Volts tuning voltage. The hyperabrupt varactor diode differs from the abrupt varactor diode in the way that the three junctions are fabricated. Hyperabrupt junctions provides a C-V curve that has an inverse square law curve over at least some of the characteristic. This provides a narrow band linear frequency variation. Two important operating conditions are the frequency at which the diode is used and mounting method. Nevertheless, these values are given as a rough line and the datasheet didn't give multiple parameters. The values for junction capacitance C_j and the quality factor Q are supplied by the manufacturer and are almost always specified at a low frequency, usually 50 MHz, and a bias voltage of -4 Volts.

**Varactor diode
on a 50 Ω
microstrip line**

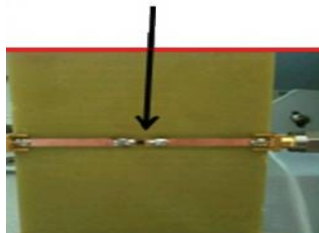


Fig 1: Hyperabrupt varactor diode

Q is defined by $Q = 1/\omega C_j R_s$. A much more accurate picture can be obtained by measuring the diode close to operating conditions and then choosing values for the lumped element model based on these measurements. Two important operating conditions are the frequency at which the diode is used and mounting method.

IV. ANTENNA DESIGN

Its structure is similar to a quarter wavelength monopole, where the top section has been bent to be parallel to the ground plane. This horizontal section involves a capacitive effect and then influences the input impedance. This effect could be compensated by adding a shorting line, that is to say a ground return. So, this shorting line allows adjusting the return loss because it involves a parallel resonance allowing setting the input impedance without adding any matching circuit. Moreover, in order to decrease the global antenna dimensions, this one has been loaded by the varactor presented previously in order to enable tunable matching at different frequencies. The simulated and measured antenna structures are respectively presented. It is printed on a FRC4 substrate ($\epsilon_r=4.9$) and studied on a 90 mm x 35 mm ground plane. The global dimensions of the radiating element are $\lambda_0/32 \times \lambda_0/14$ at 470 MHz.

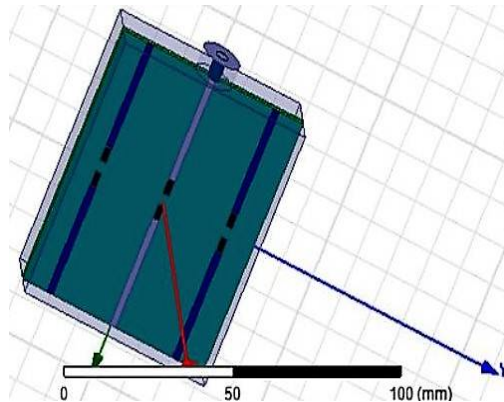


Fig 2: Antenna Design

The antenna is fed by a 50Ω coaxial cable, this one is fed by a Bias Tee. So, both the radiating element and the varactor are fed. Moreover, a DC block capacitor is needed between the radiating element and the ground as shown in Fig. 2. Indeed, it allows obtaining an open circuit for the DC voltage and a short circuit for the RF signal. The following section will deal with the simulated and the measured antenna results and the contribution of the second section, that is to say the characterization of the varactor diode component.

TECHNIQUES:

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For a frequency tunable antenna, the S parameters of the varactor diode is necessary. The datasheet of the chosen hyperabrupt varactor diode specifies a capacity range between 0.2 pF and 2 pF for 0 to 22 Volts tuning voltage. to reach an accurate antenna simulation and thus before the realization of the antenna, the hyperabrupt diode varactor component has been characterized. This one has been mounted on a 50Ω transmission microstrip line.

IV. ANTENNA PERFORMANCES AND CONTRIBUTION OF THE VARACTOR DIODE CHARACTERIZATION

This section deals with the comparison between the simulated and the measured results

S11 parameters for different polarizations of the varactor diode

The measured S11 parameters obtained for multiple polarizations of the varactor diode. Let us remind that one channel of the DVB-H band equals to 8 MHz. So, thanks to the capacity range, the antenna is matched on the entire DVB-H band going from 470 MHz to 862 MHz.

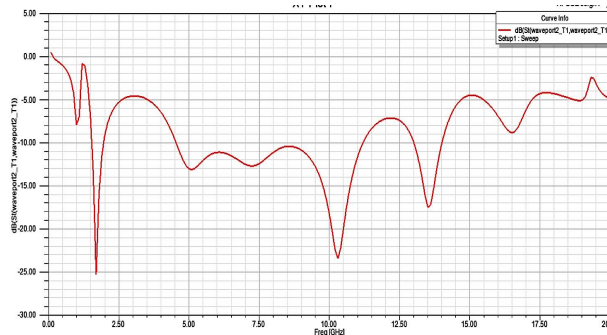


Fig 3 : Returnloss for 0.5GHz

Red curve determines the Waveport of the S parameter in dB. It will be denoted by the scattering parameter S11 and it will be calculated form:

$$S11 = \frac{Z - Z_0}{Z + Z_0}$$

Realized gain on the DVB-H band

Fig 4: the maximum realized gains and the return losses for the varactor diode polarizations respectively equal to V=2V (antenna matching at 470 MHz), V=6V (antenna matching at 673 MHz) and V=22V (antenna matching at 850 MHz). Red curve is a waveport of VSWR. VSWR is defined as the ratio b/w the maximum and minimum voltage.

$$VSWR = 1 + \frac{|e|}{1 - |e|}$$

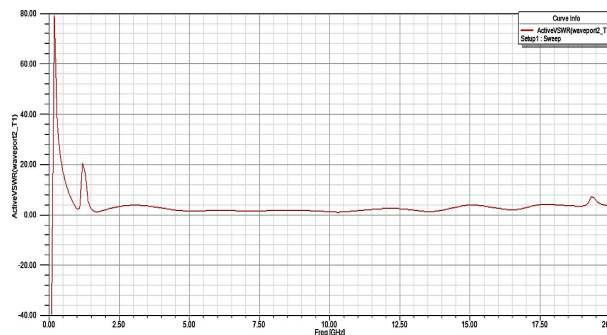


Fig 4: VSWR for 0.5GHz

Fig 5: sums up the maximum realized gain for many values of the diode polarizations. Let us notice that each value of the realized gain is identified at a given polarization when the antenna is matched. Remembering that the realized gain takes into account cable, connector and all antenna losses, it is defined as

$$Gr = (1 - |S11|^2) G_{IEEE}$$

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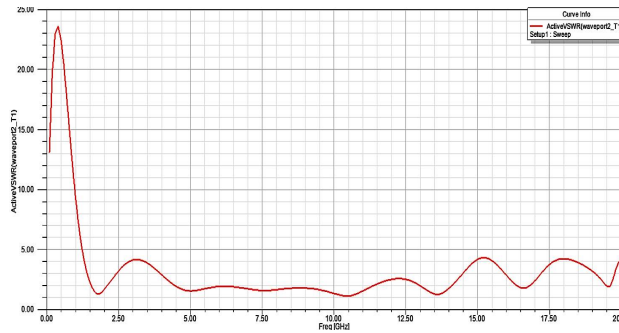


Fig 5: VSWR for 0.6GHz

Thus, the diode varactor component and the DC block capacitor losses are taken into account in the realized gain. The 0 dB reference of the realized gain is an isotropic antenna, which is a perfect omnidirectional radiator. Moreover, the total efficiency is defined as the ratio of radiated to stimulated power of the antenna or the ratio of the realized gain defined previously to the directivity of the antenna.

The directivity D and the gain G of an antenna are connected to each other by η_{rad} ,

$$G = \eta_{rad} D$$

Radiation pattern

The maximum realized gain remains always higher than the one specified by the DVB-H application. Let's notice that it is lower at low frequencies due to the varactor losses and a lower impedance matching. The shapes of these radiation patterns show omnidirectional patterns whatever the polarizations of the diode so, whatever the operating frequency of the antenna.

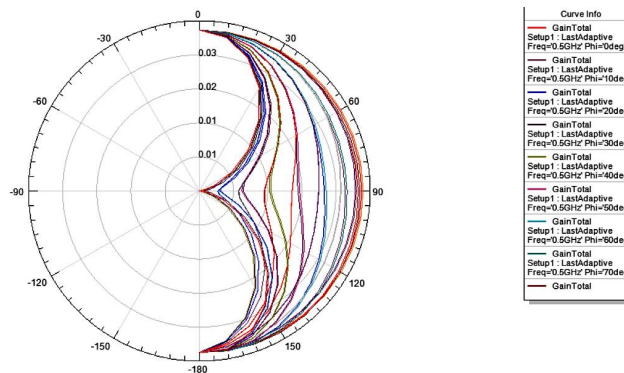


Fig 6: Radiation pattern for 0.45GHz

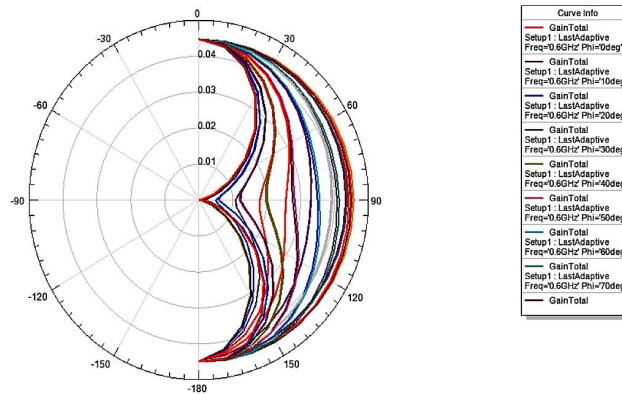


Fig 7: Radiation pattern for 0.5GHz

VI. CONCLUSION

A compact inverted F antenna which is dedicated to the Digital Video Broadcasting-Handheld (DVB-H) standard has been presented in this paper. The antenna dimensions are very small ($\lambda/32 \times \lambda/14$ at 470 MHz) and it is suitable to be integrated in all handheld devices. The characterization of the varactor diode has been done in a first time in order to predict more precisely the measurements. Finally, by changing the voltage of the hyperabrupt varactor diode, the antenna covers by a continuous shift (with a return loss lower than -6dB) the entire DVB-H band going from 470 MHz to 862 MHz. Moreover, its maximum realized gain meets the DVB-H specifications. Thus for all its efficient gain and its small size, this antenna is a very good candidate for the DVB-H application.

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