

# A Printed Monopole Antenna for TV White Space Applications

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## Abstract

In this paper a printed monopole antenna is presented for TV white spaces applications. The shape of the antenna is based on the shape of a wine glass. The overall dimension of the antenna is 170mm x 120 mm x 1.6 mm. It is designed using FR4 substrate which makes it low cost and light weight. The antenna shows wider bandwidth coverage from 495 MHz to 1540 MHz (1045 MHz). Simulated results are presented and discussed in this paper. The proposed antenna is suitable candidate for its use for TV white space communication devices.

## Keywords

Cognitive Radio (CR); Digital Switch over (DSO); Federal Communication Commission (FCC); FR4; Global System for Mobile (GSM); Long Term Evolution (LTE); TV Band; TV White Space (TVWS).

## I. Introduction

Several antennas structures have been designed for handheld devices. These antennas were developed to meet the demand of increasing the cellular market. The use of these antennas was focused on major communication standard worldwide such as GSM, DCS, PCS, UMTS, and Long Term Evolution (LTE). On the other hand, some designs were also used for UHF, WLAN, Bluetooth, GPS, UWB and WiMax. Microstrip Antennas (MSA), Inverted F Antennas (IFA), Planar Inverted F Antennas (PIFA) and Printed Monopole Antennas are used for these applications. Different frequencies to different wireless standards have been assigned by National and International bodies which can communicate within these standards. In order to avoid interferences between these bands, the frequency allocation process is assigned and it creates a band plan. The White Space is assigned in between them. The assigned White Space reduces the problem of destructive interference which would have occurred if assignment of immediate channel is done. Moreover this White Space also consists of a radio spectrum which has ever been used earlier [1]. White space Radio link can be considered as an alternative for different infrastructures such as wireless cellular or wired medium. White Space frequencies occupy the range which is used by analog TV in UHF frequency band [2]. Now-a-days a wide variety of wireless systems are available that require different wireless standards. In order to process this flexibility, cognitive radio (CR) is the best candidate. Cognitive Radio can change its transmitter parameters according to the environment in which it is operating, defined by Federal Communication Commission (FCC) [3]. It works as spectrum sensing unit and can adopt different structures according to the interaction with the space. The radio spectrum is ranges from 3 KHz to 3000 GHz but only 50 GHz have been used till now. The unusable spectrum is allocated to 41 radio communication services worldwide. Different radio communication services have been allocated a spectrum below 3 GHz; hence no wireless standard can be accumulated below 3 GHz. As radio spectrum is a natural resource hence its efficient use is very necessary. The white space or spectrum hoe can be defined

as the unutilized part of the spectrum at any given location or time. In terrestrial TV networks there are channels which are not used in a particular location and therefore in order to avoid interference caused due to adjacent channels, these channels are left vacant. These vacant channels are known as TV White Spaces (TVWS) with respect to that particular location. From the coverage point of view, the TV band is the most precious band and is allocated for TV broadcasting [4]. The Cognitive access of TV White Space is an important regulatory trend in the context of Dynamic Spectrum Access (DSA). Various countries have developed a regulatory framework in TV white space for unlicensed applications [5].

In this paper, a printed monopole antenna is proposed for TV White Space communication. The proposed antenna has compact structure and covers wide frequency band. The antenna is well suited for TV White Space devices.

In Section II, the antenna structure and its dimensions are presented. Section III, presents the simulated results such as the return loss, gain, radiation pattern and VSWR of the proposed antenna. The paper is concluded in Section IV.

## II. Structure of Proposed Antenna

Various types of techniques and antenna designs have been used so far for TVWS systems such as printed antennas for UHF, UWB & EWB bands. The popular antenna types are printed monopoles, patch, PIFA, meander shaped etc [6]-[12].

The proposed design of printed monopole antenna is shown in fig. 1. The proposed antenna consists of wine glass shaped patch and a defected ground structure.

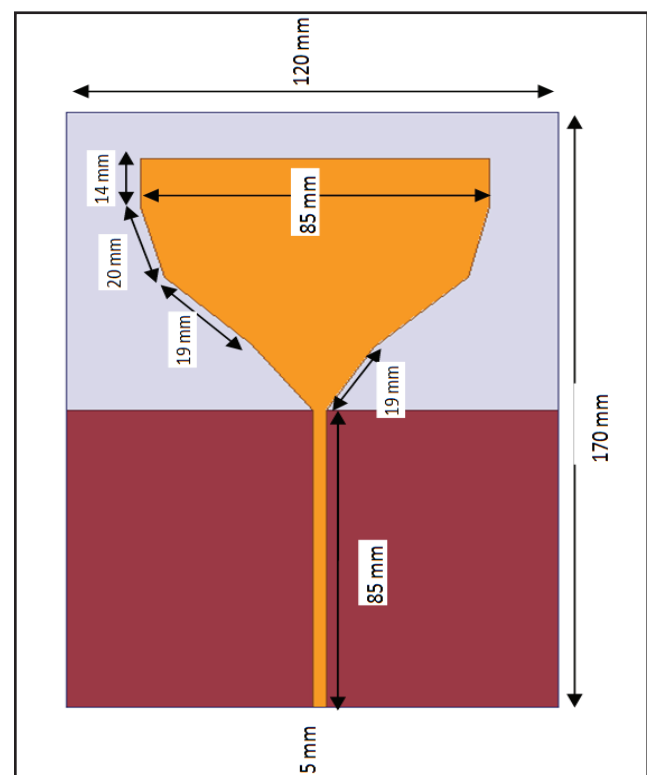


Fig. 1: Detailed Dimensions of Proposed Antenna

Here FR4 material is used for fabrication of the antenna which is cost effective. The overall dimension of the antenna including the ground plane is 170 mm × 120 mm × 1.6 mm. The size of the antenna is very compact and hence is well suited for TV white space devices.

Various parameters such as dielectric constant ( $\epsilon_r = 4.4$ ), resonant frequency ( $f_r = 703$  MHz) and thickness of substrate ( $h = 1.6$  mm) are considered while designing the proposed antenna. As compared with the conventional microstrip patch antenna designs, the ground plane of the antenna is on the half portion on one side of the substrate leaving the rest of the substrate vacant.

### III. Simulation Results of Proposed Antenna

The proposed antenna is simulated and optimized using the simulation tool called High Frequency Structure Simulator (HFSS) software. The design parameters include scatter parameter (return loss), Voltage Standing Wave Ratio (VSWR), electric gain and radiation pattern. Return loss and VSWR parameters relate to bandwidth. Gain and radiation pattern relate the radiation performance and directivity of the proposed antenna.

#### A. Return Loss Plot

S11 represents how much power is reflected from the antenna and hence it is known as reflection coefficient. Fig. 2 shows the return loss plot of the proposed antenna. Using wave port configuration, S11 (return loss) plot is obtained taking the level as -6 dB which is considered good for frequencies in UHF range.

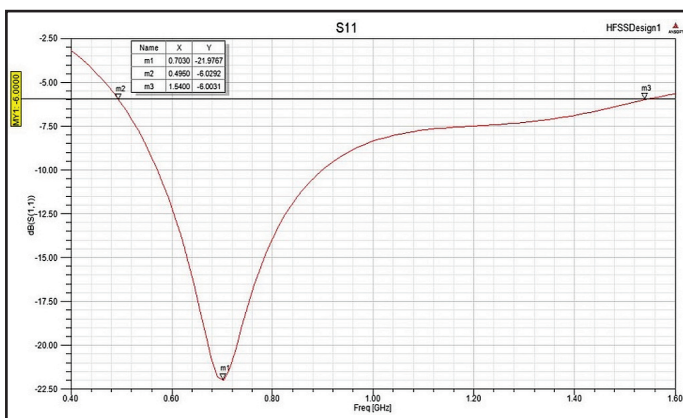


Fig. 2: Simulated Return Loss Plot of Proposed Antenna

The proposed antenna resonates at 703 MHz with a return loss of -21.97 and covering a bandwidth from 495 MHz to 1540 MHz. The overall bandwidth coverage is 1045 MHz which is considered as wideband coverage. So the proposed antenna is wideband antenna.

#### B. Voltage Standing Wave Ratio Plot

The Voltage Standing Wave Ratio (VSWR) is a measure that numerically described how well the antenna is impedance matched to the transmitter or receiver or the transmission line it is connected to. If VSWR is minimum, then the better the antenna is matched and more power can be delivered to the antenna. The VSWR of the proposed antenna is shown in fig. 3. The value of VSWR should not exceed 3 dB and ideally it should be 1 dB. As seen in fig. 3, the value of VSWR is less than 3 dB which can be considered good in case of an antenna operating in UHF range. VSWR obtained at 703 MHz is 1.38 dB.

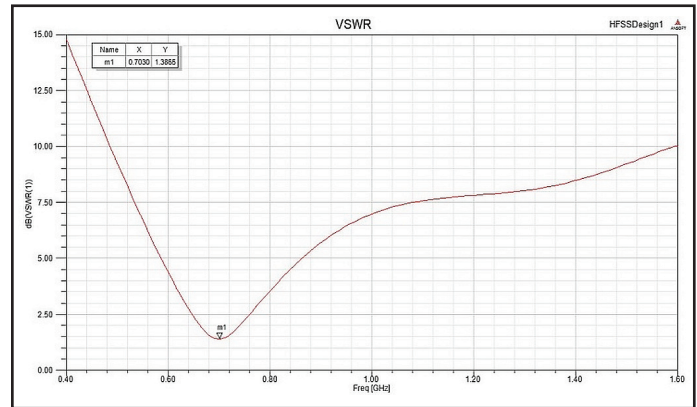


Fig. 3: Simulated VSWR Plot of Proposed Antenna

#### C. Gain Plot

Fig. 4 shows the 3D gain plot of the proposed printed monopole antenna. It describes how much power is transmitted in the direction of peak radiation to that of an isotropic. The proposed antenna shows average peak gain of 2.32 dB which is considered excellent in terms of a compact antenna design for UHF range of frequencies.

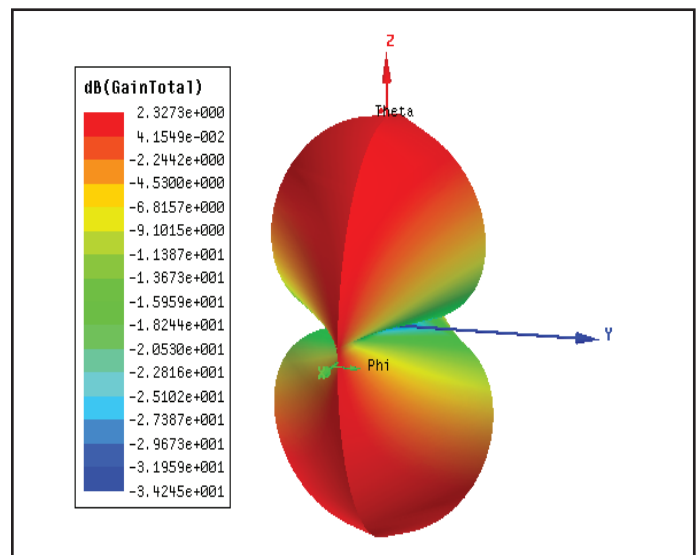


Fig. 4: 3 D Gain Plot of Proposed Antenna

#### D. Radiation Pattern

The radiation pattern of the antenna is shown in fig. 5. The antenna shows an omni directional pattern. Good omnidirectional radiation characteristics making the antenna suitable for the TV white space applications.

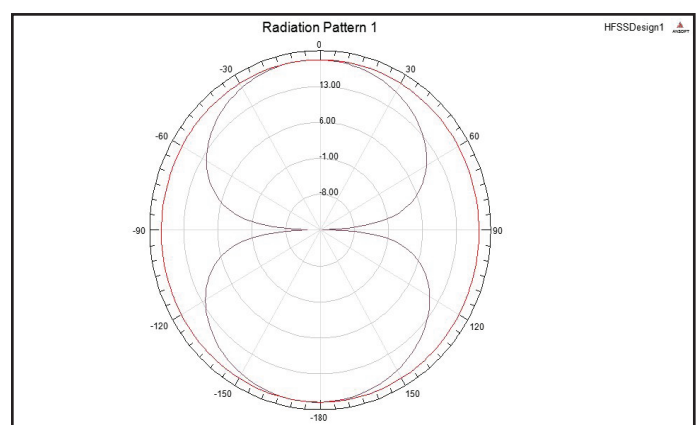


Fig. 5: 2D Radiation Pattern of Proposed Antenna

The antenna shows a good radiation pattern with excellent gain. The radiation characteristics shown in the above figure is for  $\phi = 0^\circ$  and  $90^\circ$ . Pattern obtained is similar to conventional pattern of monopole antenna with more radiation on top and bottom sides of the antenna.

#### IV. Conclusion

A compact printed monopole antenna is presented in the paper. The antenna shows wideband coverage with over 1GHz of bandwidth covering almost complete band for TV UHF range. Proposed antenna shows good gain and radiation pattern characteristics as well as good matching with low VSWR. It is suitable candidate for its use in TV white space communication devices in near future.

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