DVB-T and DAB-T Transmitter Antenna Design by Using Stacked Suspended Plates

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Abstract: *In this paper, design of transmitter antenna for Digital Video Broadcast-Terrestial (DVB-T) and Terrestial Digital Audio Broadcast (T-DAB) is presented with Stacked Suspended Plate Antenna (SSPA) method. Considering the similar products in the world, antenna has been designed in (174-230)Mhz for both DVB-T and DAB-T with horizontal polarization, 65°±6° half power beam width (HPBW) and return loss of S_{11} < -10dB. Contrary to conventional dipole structures, we have employed SSPA with two plates for wide band matching and design flexibility. Radiating primary plate has been excited by novel wideband inverted L-type probe in a capacitively coupled manner. Ungrounded vertical wall soldered to primary plate also provides wideband matching and adjustmest of beamwidth properly. Parasitic secondary plate has been used for further matching and tuning. Together with equivalent circuit model of designed antennas, simulation and measurement results for S_{11}, gain and radiation patterns are presented..*

1. Introduction

Microstrip antenna is one of the important type of planar antennas, in which researchers are trying to improve its bandwidth and radiation performance. For example, four port capacitive probe feeding is applied in [2] to get broad bandwidth and radiation performance, but the coupling between input ports degrades the return loss. Dual L-shaped strips or single modified L-shaped strip that employs electromagnetic coupling have been presented in [1]-[3].

Furthermore, in [5]-[6], the impedance bandwidth is improved by means of non planar radiating plate and making the middle portion of probe feed plate antenna concaved to form a V like structure to get a bandwidth of about 60%. However, the method suffers from bad radiation pattern performance, which is further improved in [5] by using tapered down feeding strip mechanism. It gives dipole like radiation pattern.

In this paper, we have used a novel wideband modified inverted L-probe feeding mechanism to excite the primary radiating plate in a capacitively coupled manner. Wideband matching is achieved by determining the best suitable positions of suspended plates. Ungrounded vertical plate soldered to the primary plate is used for further matching and beamwidth adjustment. The antenna is designed to work for both DVB-T and DAB-T applications with frequency band of 174-230 MHz. After the simulation results the antenna has been manufactured to verify the simulation results. In the entire band the return loss (S_{11}) is below -10dB with average Gain of 8.5 dBi. In the next section the antenna geometry with equivalent circuit representation is presented, and followed by simulation and some measurement results.

2. Antenna Design and Geometry

The antenna is designed at center frequency f_c = 202MHz (λ_c = 1485mm). The dimensions of antenna are determined after in-depth parametric studies in terms of return loss, gain, bandwidth and radiation patterns etc. The structure of antenna, which includes top view, side view and front view are depicted in Figure 1. The dimensions of modified inverted L-probe feed are (h_f = 0.07166λ_c,W_f = 0.1433λ_c, L_f = 0.1075λ_c). The ungrounded vertical plate is at 0.493λ_c from origin or feed point. The position of feed point on ground plane is also important [3] and it is not exactly in the center. In xy-plane the position of feed point is (0.459λ_c , 0.197λ_c).

It must be noted that the modified inverted L-probe consist of triangular leg and rectangular tap regions, where, the triangular sheet connects the rectangular sheet after a gap of L_e = 6mm (0.0043λ_c). Table I summarizes the dimensions of the complete SSPA.

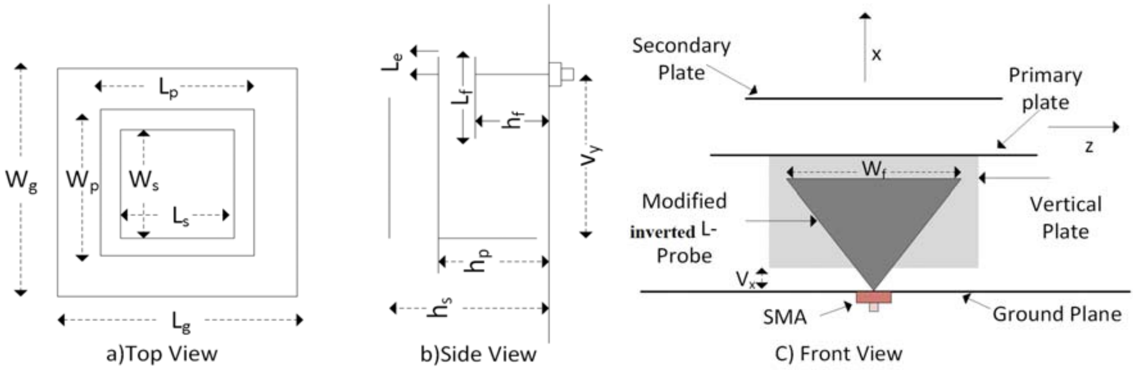

Figure-1. Geometry of proposed SSPA.

Table I: SSPA Dimensions

Structure Type	*Length*	*Width*	*Height*
Ground Plane	$L_g = 0.896\lambda_c$	$W_g = 0.753\lambda_c$	$h_g = 0$
Primary Plate	$L_p = 0.394\lambda_c$	$W_P = 0.394\lambda_c$	$h_g = 0.1125\lambda_c$
Secondary Plate	$L_s = 0.337\lambda_c$	$W_S = 0.337\lambda_c$	$h_g = 0.1899\lambda_c$
Vertical Plate	$L_v = 0.218\lambda_c$	$W_V = 0.111\lambda_c$	$h_g = 0.1125\lambda_c$

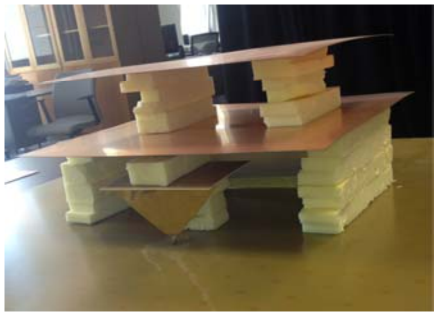

Figure-2. Manufactured proposed SSPA.

As shown in Figure-2, the antenna is manufactured by using 0.1 mm thick copper foil [3] and supported by foam with permitivity of 1.05. Primary plate is the main radiator, which is excited through electromagnetic coupling by modified inverted L-probe section of SSPA. To get better results for return loss, gain and bandwidth, a secondary plate is introduced. Further tunning is obtained through insertion of ungrounded vertical plate, 1 mm above ground plane. Figure-3 depicts the approximate equivalent circuit model of the SSPA. In the model L_p represents the inductance of L-section probe. In the plot, the subscripts represent self or mutual reactance and/or capacitances. For instance, C_1 and L_1 are the self capacitance and inductance of rectangular patch of inverted L-probe feed, while C_{12} give the mutual capacitance of rectangular patch of inverted L-probe feed and primary plate.

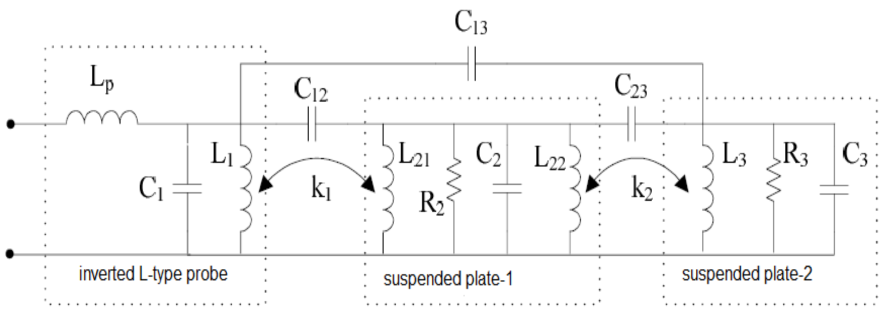

Figure-3. Equivalent Circuit of SSPA

3. Simulations and Measurement Results

A. Input Matching and Return Loss: The return loss ,when the SMA connector of 50Ω is matched to input impedance of SSPA, is shown in Figure-4-a. Both of the curves shows that the antenna has return loss below -10dB in the bandwidth of operation. It has -10dB fractional bandwidth of about 42.14%. At the center frequency, the return loss is about -10dB.

B. Gain and Radiation Patterns: The gain of the antenna is found from simulation and plotted in Figure-4-b. The antenna gives average gain of about 8.5dB in the desired frequency band of 174-230Mhz. However, due to higher mode excitation the antenna gain drops to 7dB beyond 250MHz at higher band. Desired gain can be obtained from the detailed parametric study of the antenna.

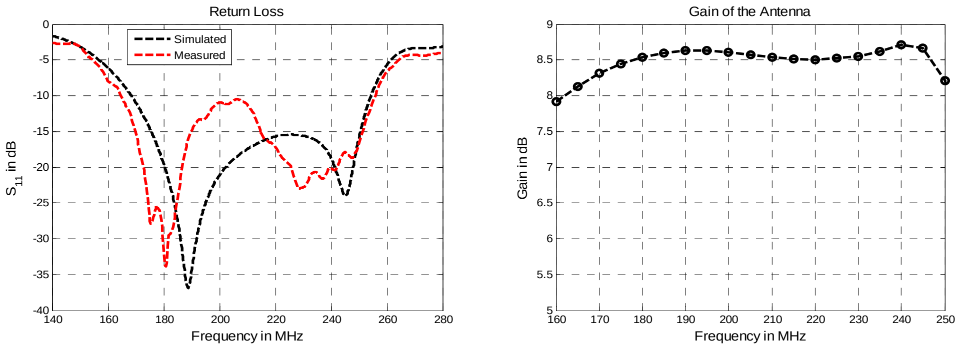

Figure-4. a) Retun Loss of SSPA b) Gain of SSPA

The horizontal and vertical plane power patterns are depicted in Figure-5. The HPBW in horizontal plane is 71^{o} while in vertical plane it is 59^{o}. The null in horizontal pattern occurs due to higher order modes distorting the co-polarized field [4]. The side lobe level is found to be -14 dB. It can further be reduced if we use ground plane of large size.

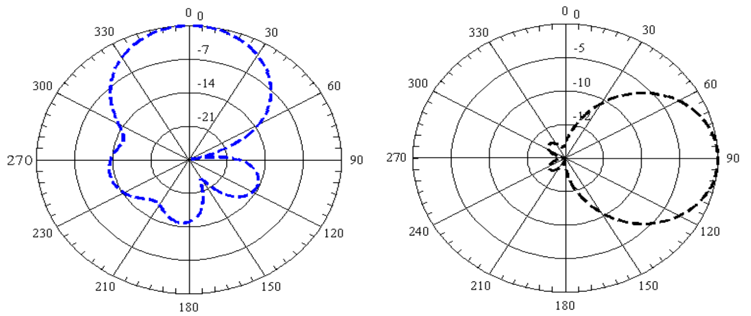

Figure-5. Radiation patterns: a) Horizontal Pattern b) Vertical Pattern

4. Conclusion and Future Study

A wideband SSPA antenna is designed for DVB-T and DAB-T transmission. The antenna gives fractional bandwidth of about 42.14% for S_{11} <-10dB and cross polarization level of about -25dB in H-Plane. The antenna gives stable average gain of 8.5dB in the operating bandwidth. The half power beamwidth of about 71^{o} is achieved in horizontal plane while 59^{o} in vertical plane. Future study will include the adaptation of proposed technique to (470-790)MHz band for DVB-T only.

5. Acknowledgement

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