# The Array Fractal Graphene Antenna Used for Mobile Digital Television

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Keywords: Mobile digital television, Growth tree fractal dipole antenna, Rectangular antenna array, Polyethylene Terephthalate (PET) thin film substrate, Graphene conductive ink.

Abstract: According to the requirements of the mobile digital television system, the present paper creatively combines growth tree fractal dipole antenna, rectangular antenna array, Polyethylene Terephthalate (PET) thin film substrate, and graphene conductive ink, designed an array fractal graphene antenna used for mobile digital television, fabricated the antenna sample and tested the radiation characteristics of the antenna. The result of test indicate that the antenna's working frequency range is 10.841-14.136 GHz, the antenna's working bandwidth is 3.295 GHz, the antenna's relative bandwidth is 26.38%, the minimum value of return loss is -32.45 dB. This antenna completely covered the working frequency band of the mobile digital television system, it is a mobile digital television antenna that have small size, broadband, highly integrated, and can meet the requirements of mobile digital television system, such as stable signal, wide coverage, fast receiving, clear picture, strong mobility.

## 1 INTRODUCTION

Mobile digital television is a new technology in the era of mobile internet, it can realize watching digital television in various fast moving vehicles, and through the digital television channels to carry out video on demand, TV shopping, propaganda and promotion, remote consultation, interactive games and other services. Mobile digital televisionhas covered a number of major cities in China, has been widely used in public transport and private cars, has become recognized as a new media of great influence (Wang, 2016; Carey J., 2016; Silva V.J., 2015; Punt M., 2015; Chang, 2015).

Antenna design and manufacturing technology is one of the key technologies of mobile digital television system. The performance of antenna greatly affects the performance and application field of mobile digital television system. According to the frequency division of ITU, the mobile digital television band based on satellite transmission is 11.700~12.200 GHz. Mobile digital television antenna must completely covered the 11.700~ 12.200 GHz working frequency band, and can meet the requirements of mobile digital television system, such as stable signal, wide coverage, fast receiving, clear picture, strong mobility (Yeo, 2017; Liao, 2017; Osklang P., 2016).

## 2 BRIEF INTRODUCTION OF GROWTH TREE FRACTAL DIPOLE ANTENNA

The growth tree fractal dipole antenna is a dipole antenna based on growth tree fractal structure. The iterative process of growth tree fractal structure is shown in Figure 1, its original structure is dipole antenna, and two dipole arms are used as "trunk". At the top of "trunk", two "branches" grow out, they perpendicular to the dipole arm and the length is half of the dipole arm, which constitutes the 1st-order growth tree fractal structure. At the top of each "branches" of 1st-order growth tree fractal structure, two "small branches" grow out, they perpendicular to the "branches" and the length is half of the "branches", which constitutes the 2nd-order growth tree fractal structure. Followed this iteration, can get high-order growth tree fractal structure.



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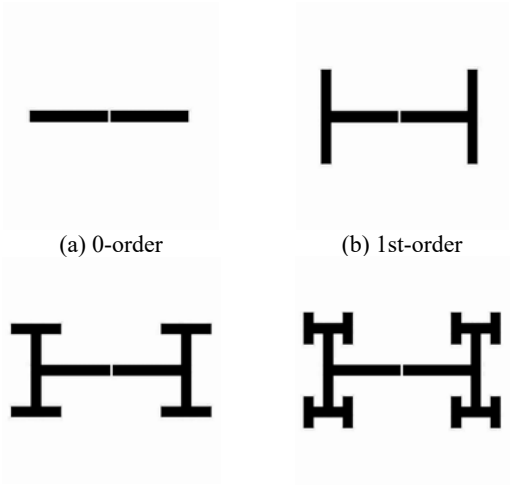

(a) 0-order (b) 1st-order

(c) 2nd-order (d) 3rd-order

Figure 1: The iteration process of growth tree fractal structure.

## 3 BRIEF INTRODUCTION OF POLYETHYLENE TEREPHTHALATE (PET) THIN FILM SUBSTRATE

Mobile digital television system is mainly used in all kinds of vehicles, its working environment is complex, may work in a variety of unpredictable environment, which requires the mobile digital television antenna has excellent mechanical properties, good corrosion resistance, good high and low temperature performance. Polyethylene Terephthalate (PET) thin film substrate is a very stable antenna substrate material, can be resistant to oil, dilute acid, dilute alkali, resistant to most solvents, can be in the temperature range of -70 to 150 degrees of normal work, and high and low temperature has little impact on its mechanical properties. Using PET thin film as antenna substrate material can ensure the antenna has stable working performance in all kinds of harsh environments.

## 4 BRIEF INTRODUCTION OF GRAPHENE CONDUCTIVE INK

Graphene conductive ink is a high performance conductive ink composed of graphene conductive fillers, adhesives and solvents. Graphene is a single layer of graphite composed of carbon atoms, it has very good thermal conductivity, conductivity, light transmittance, and has high strength, ultra light, large surface area and other characteristics. Graphene has high electron mobility, which can accommodate high intensity radio frequency current. Conductive ink made from graphene as conductive filler has lighter quality, lower cost, higher conductivity and better heat resistance than traditional metal conductive filler ink. The printed antenna made of graphene conductive ink has no metal in the radiation patch, and is not easy to be corroded in the open working environment, and has high working stability.

## 5 STRUCTURE DESIGN OF ARRAY FRACTAL GRAPHENE ANTENNA

The antenna substrate used in the design is PET film substrate, the shape is rectangle, the size is 8.8 mm x 8.8 mm, the thickness is 0.2 mm. PET thin film substrate consists of 8 rows and 8 columns were 64 regions, the relative dielectric constant of each film substrate region gradual change along the length and width direction ; the region that has minimum relative dielectric constant is located in the upper left corner of the film substrate, the relative dielectric constant is 3.5; the region that has maximum relative dielectric constant is located in the lower right corner of the film substrate, the relative dielectric constant is 4.9; the relative dielectric constant of each film substrate region increases gradually from left to right, from top to bottom, the difference of relative dielectric constant between the two adjacent regions is 0.1. The structure of the PET film substrate is shown in Figure 2, the number in the figure represents the relative dielectric constant of a region. After using this new thin film substrate, the relative dielectric constant of each element antenna of the array antenna is different, so the frequency of each element antenna is different. When the working frequencies of different element antennas are close, their radiation and operating frequency bands overlap each other, forming a working band with large radiation intensity and working bandwidth, which can improve the radiation performance and bandwidth performance of the array antenna.

The growth tree fractal dipole antenna is used as the element antenna in the design, and its structure is shown in Figure 3. The size of the growth tree fractal dipole antenna is 1.1 mm x 1.1 mm, which

consists of a pair of symmetric dipole arms, and each dipole arm uses a 3rd-order growth tree fractal structure. The opening gap is arranged on the symmetrical central line of two dipole arms, and the antenna feed point is arranged on both sides of the opening gap.

The structure of array fractal graphene antenna is shown in Figure 4, it use the rectangular array structure as the basic array arrangement structure, 64 growth tree fractal dipole element antennas are arranged in accordance with the rectangular array structure, form the antenna array. Although the working bandwidth of the single growth tree fractal dipole antenna is large, but its radiation intensity is weak. Multiple element antennas are arranged in rectangular array structure to form an antenna array, can let their radiation overlap, and further enhance the radiation intensity of the antenna. The radiation structure of the array fractal graphene antenna is all printed by graphene conductive ink.

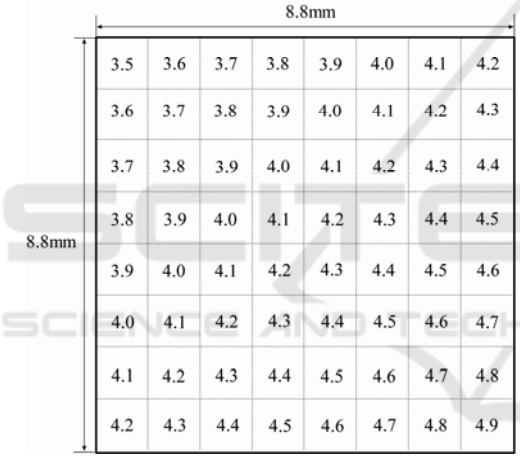


Figure 2: The structure schematic diagram of PET film substrate.

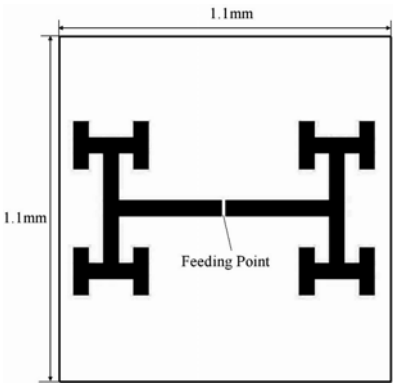


Figure 3: The structure schematic diagram of growth tree fractal dipole element antenna.

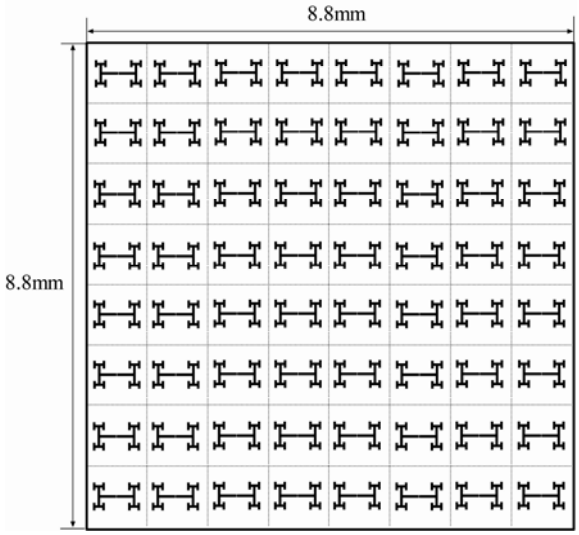


Figure 4: The structure schematic diagram of array fractal graphene antenna.

## 6 FABRICATION AND TEST OF ANTENNA SAMPLE

According to the design scheme mentioned above, we use the conductive ink printing process to produce the antenna sample. The radiation performance and directional performance of the antenna sample are tested, and the results are shown in Figure 5 and Figure 6.

The tested results show that this antenna's working center frequency is 12.000 GHz, the antenna's working frequency range is 10.841-14.136 GHz, the antenna's working bandwidth is 3.295 GHz, the antenna's relative bandwidth is 26.38%, the minimum value of return loss is -32.45 dB. This antenna completely covered the working frequency band of the mobile digital television system. The E and H plane patterns of the antenna have good omnidirectional coverage characteristics.

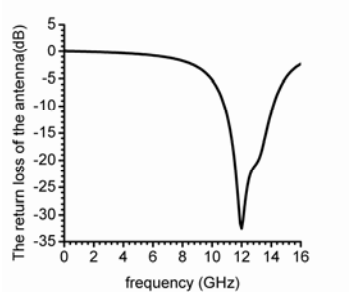


Figure 5: The tested radiation characteristics of antenna.

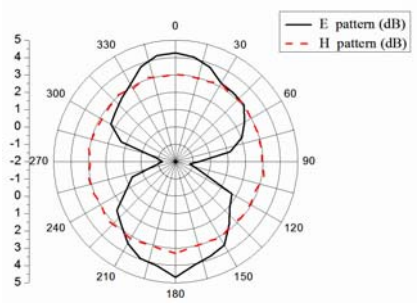


Figure 6: The measured directional pattern of antenna.

## 7 CONCLUSIONS

In this paper, according to the performance requirements of the mobile digital television system based on satellite transmission, we use the gradient dielectric constant PET film substrate as the antenna substrate material, and use the graphene conductive ink to make the antenna radiation structure, combines growth tree fractal dipole antenna and rectangular antenna array, designed a array fractal graphene antenna used for mobile digital television, fabricated the antenna sample and tested the radiation characteristics of the antenna. In the case of having 64 element antennas, the size of the antenna is only 8.8 mm×8.8 mm×0.2 mm, it is a miniature ultra thin antenna, which can be put into all kinds of mobile digital television equipment. This antenna has excellent physical and mechanical properties, and can work normally in the temperature range from -70 to 150. It has the advantages of oil resistance, acid resistance, alkali resistance and corrosion resistance. It has stable and reliable working performance in outdoor environment. This antenna completely covered the working frequency band of the mobile digital television system, and it has large performance redundancy, it can guarantee the transmission quality of mobile digital television signal in a variety of unpredictable harsh environment. This antenna is expected to be widely used in mobile digital television equipment.

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