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Analysis and Development of Components of Dipole Linear Antenna Array

Lei Wang
University of Birmingham
Beijing, China
e-mail: leiw0920@outlook.com

***Abstract*—The paper will discuss the wide usage of dipole antenna and the associated problems of the construction dipole in a towing system. Focusing on ways to improve and develop components of dipole linear antenna. Dipole antenna parameter values will be designed and calculated before creating model on software. The properties of dipole antenna will be discussed and analyzed in the paper; the principal two being S parameters and antenna patterns. I will then focus on the single half-wavelength dipole antenna. Creating two elements of dipole linear antenna array models and simulations will be produced with CST software. In the papers final phase, simulation results of S11 parameter and antenna pattern will be compared and analysed according to different cases.**

Keywords-dipole antenna; towing system; half-wavelength; antenna array; conductor; CST

I. Introduction

Wire antenna is one type of antenna that are omnipresent, virtually seen everywhere, such as in buildings, military communications, satellite, and mobile communications. Antenna array is a set of two or more antennas working together [1] which is designed with high directivity and low side lobes to achieve a given antenna pattern [2], [3]. A number of dipole antennas that are arranged along a straight line is called a dipole linear antenna array. Dipole antenna is one of the simplest and most popular wire antenna used in telecommunication, while it is also one of commonly used antenna type in RF [4], which is shown in Fig. 1 a. The dipole has two halves which are on each side of the centre as shown in Fig 1.b. As a balanced antenna, dipole antenna has two symmetrical poles in equal length but extend in opposite directions from feed point. Simply, a dipole is an antenna made of wire and a feed at its centre [5].

As the most useful antenna used in telecommunication, it is both important and meaningful to analyse and improve the property of dipole antenna. Dipole antennas are commonly constructed alongside some conductors like coaxial cable or wire conductors, which will cause the change of antenna parameters and interfere with its property. And usually dipole is not constructed singly but in couple. Therefore, in practice such antennas, like a dipole antenna array, makes the case more complicated.

Towed Antenna System (TAS) [6], [7]are used in military, for example, a towed antenna can be applied in aircraft and submarine. Like submarine which is underwater that can't use a global positioning system (GPS) signal and or radio frequency (RF) communication [8]. In the case, a towed antenna that is deployable and retrievable from an underwater vehicle can do communications or act as an intermediary for communications between a submerged underwater vehicle and the one or more remote communication systems [10]. For aircraft, to get desirable smooth omnidirectional antenna patterns, a towing antenna system in vehicle is designed to eliminate interference from the aircraft, making antenna patterns ideal for power measurements [11]. But it will increase complexity of the system, for example, the towed vehicle is always entwined with a couple of wire conductors like cables that can cause the interference to radiators which need development of components of dipole.

a b

Figure 1. Dipole Antenna.
a dipole antenna in reality [9]
b dipole antenna model [5]

Since the demand for flexible antennas with higher efficiency has increased in the recent years, the development and analysis of dipole is of great significance in RF and communication field. Therefore, to analyse and develop the dipole antenna, there are many fundamental parameters of antenna to be considered when analyse the property of antenna like radiation pattern, gain, beamwidth, S parameters, input impedance and so on [12]. Radiation pattern and S parameters, especially S11 are two of the most salient parameters of antenna that will be discussed in the paper.

II. Fundamental Parameters of Half Wavelength Dipole Antenna

A. Model of Half Wavelength Dipole Antenna

As a very common antenna in practice, there are several types of dipole antennas like half-wave dipole, small dipole, folded dipole and so on [13]. Half wavelength dipole antenna means its length is half wavelength according to operation frequency, each 1/4 wavelength long at a certain frequency which is the basic unit that many complex antennas are constructed from [14]. But, normally its length is a little bit smaller than the half wavelength in free space considering alot of elements like ratio of the thickness or diameter of the conductor to the length, dielectric constant of the medium around the radiating element and so forth [15]. Fig.2 is a model of half wavelength dipole antenna.

In Fig. 2, half-wavelength dipole is constructed with two arms and a feeding gap. The feeding gap is always the centre position of the antenna and the input of power or signal of radiator. The inductive and capacitive reactance levels cancel each other out which make the load become purely resistive and feed the half wave dipole antenna much easier, that the impedance is 73 ohm of dipole in free space [15]. L is the length of dipole antenna which is near to half of wavelength but usually smaller than it. D is the diameter or thickness of dipole arms, and g represents the gap of the antenna.

The half wavelength dipole antenna is operated on the frequency of 435MHZ in the case, so the frequency

f = 435 MHz

Wavelength

$$\lambda = \frac{c}{f} = 3 \times 10^{11} \div (435 \times 10^{6}) = 689.655\, mm$$

The math formula of dipole length is L=143/f [16],

So Length of dipole antenna is

$$\mathrm{L} = \frac{143}{f} = 143 \div (435 \times 10^{-3}) = 328\, mm$$

The math formula of dipole diameter is D=λ/500 [16]

Diameter of dipole antenna is

$$\mathrm{D} = \frac{\lambda}{500} = \frac{689.655}{500} = 1.379 mm$$

So radius R of dipole antenna is

$$\mathrm{R} = 0.5 \times \mathrm{D} = 0.5 \times 1.379 = 0.68965\mathrm{mm}$$

Feeding gap of antenna is

$$\mathrm{g} = \frac{L}{200} = 328 \div 200 = 1.64 mm$$

All the parameters of dipole antenna can be shown in the Table I.

B. S11 and Antenna Pattern

An antenna radiation pattern is defined as "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates.' [2] S parameter characterizes the relationship between ports of antennas. S 11 will represent the power reflected to port 1, which always represents the coefficient or return loss of antennas.

S-parameters describe the input-output relationship between ports in an electrical system [17]. S11 represents how much power is reflected from the antenna which is defined as reflection coefficient or return loss. Return loss is specified in decibels (dB) that is the ratio of reflected power and received power which is normally negative value and represents how well the transmission devices are matched [18].

Radiation pattern or antenna pattern is the graphical representation of the radiation properties of the antenna as a function of space [19]. Antenna pattern property include radiation intensity, field strength phase or polarization [2]

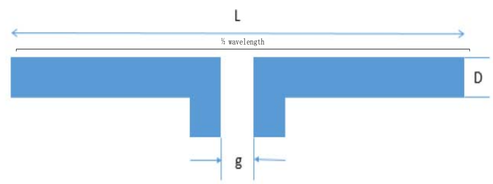

Figure 2. Half-wave Dipole Antenna [20].

TABLE I

Parameter	Value	Unite
Antenna Length (L)	328	mm
Impedance	73	Ω
Radius of Antenna	0.68965	mm
Frequency	435	MHz
Wavelength	689.655	mm

which can be divided to isotropic, directional and omnidirectional three patterns.

III. SIMULATION RESULTS

A. Simulation and Results of Single Dipole Antenna

In this paper, dipole antenna is operated in frequency 435 MHz and simulated in simulation tool CST Microwave Studio (MWS). Single Half wavelength dipole antenna model is created in CST according to the parameter calculated before in Fig. 3 below. In this figure, two halves are designed with 0.68965 mm radius and 328mm length in yellow colour. Copper material is used in the case for dipole. The vacuum part in centre is gap of dipole.

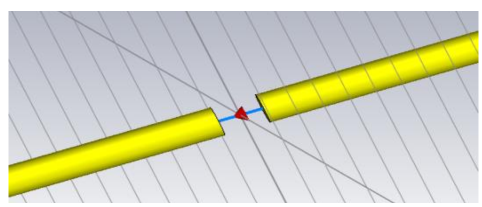

Figure 3. Dipole Antenna in CST.

After simulation, the S11 result which represents return loss from simulation is show in Fig. 4

In Fig. 4, the frequency range is from 360 MHz to 500MHz, the minimum mark is 428.5 MHz which is near to the radiation frequency 435 MHz, and the return loss is -42.25431dB.

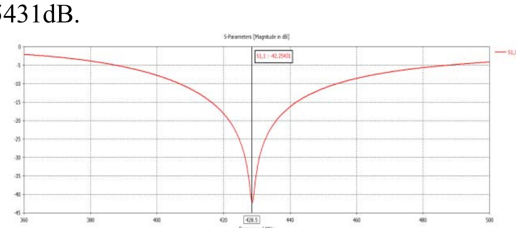

Figure 4. S11 of Half wavelength Dipole Antenna.