Ground Decoupled J-pole Antenna

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Abstract – **In this paper a J-pole antenna with an additional J shaped quarter-wave short stub is proposed. This additional component is introduced in order to decrease the currents in the lower section of the antenna mast and in respect, to minimize the antenna noise temperature, unwanted sidelobes and the coupling with the ground plane. The antenna performances (radiation patterns and gain) are simulated and optimized for LoRaWAN in the 433Mhz band. The proposed antenna has relatively small size, frequency stable radiation pattern and high gain.**

Keywords – **Ground Decoupling, J-pole, second 'J' element, reduced currents, ground interference, LoRaWAN antenna, noise temperature**

I. Introduction

One of the problems with wireless communication is the design of the antennas. They should work in wide frequency bands while consuming low energy and have small physical size. Especially with the LoRa technology that depends on a wide range and because of that weak signal received, signals can be lost because of the noise. In this paper is proposed and analyzed ground decoupled J-pole antenna based on easily accessible copper tubing. This approach represents a wide band performance, acceptable total gain, return loss and relatively small size. The main antenna parameters – radiation pattern, return loss and antenna gain were simulated and analyzed.

II. Theoretical Analysis

The J-pole antenna on Fig. 1 is an omnidirectional antenna, so called because of its similarity with the letter "J". It is formed by a vertical half-wavelength radiator end-fed by a quarter-wavelength matching stub. One of the advantages of this antenna comes from the fact that the lower end of the matching stub can be used for direct grounding.[2,3,4].The radiation in J-pole antennas occurs due to the acceleration and deceleration of electrons along the antenna's length. Current distribution is maximum at the feed point located along the matching stub. This behavior is due to the antenna being a half-wavelength element, where the voltage node is at the feed point. The placement of the feed point along the stub is crucial because the impedance needs to match with the impedance of most transmission line standards for maximum transmission efficiency.

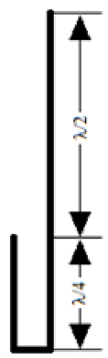

Fig. 1 J-pole antenna.

The ground decoupled antenna proposed can be a critical solution to a common problem with the J-pole antenna. The currents flowing at the base of the antenna make reflections from the ground and interfere with the main signal of the antenna which can be a problem, especially with low power signals. This problem can be solved by adding another quarter-wave length matching stub on the main half-wave tube beneath the first one and with an offset along the Z axis 180 degrees as shown on Fig. 2.

III. Design and Simulations

As an initial step, a J-pole antenna is designed using a known calculation approach. The elements of the antenna are two J shaped copper conductors placed opposites on the main frame (line shaped copper conductor). The length of the J shaped elements has been changed to provide the proper parameters for the antenna and its specific uses. The optimization and simulations of the antenna parameters (SWR, reflectivity coefficient and antenna gain) are performed with 4nec2 software (www.qsl.net/4nec2) for the frequency of 433 MHz.

The currents' simulations shown on Fig. 9 and 10 are performed using Ansys HFSS software [6].

When designing a J-pole antenna there are several specifics that should be taken into account [1]. The input matching is obtained through optimisation of the design parameters below. Since the antenna input is balanced, the balancing to coaxial line is obtained by so-called "infinite balun" technique, where the coaxial cable is passed through the center conductor tubing. The imbalance currents flow on the surface of the boom as they should in regular mode of operation.

The optimized and simulated antenna model is presented on Fig. 2 and the element length (in mm) is given in Table I. The antenna's elements are round copper wires with a radius 5 mm.

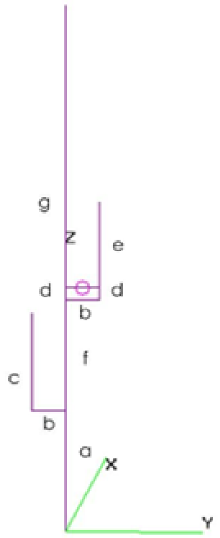

Fig. 2 Proposed design of Ground Decoupled J-pole Antenna

TABLE I
ANTENNA ELEMENT LENGTH

a	200 mm
b	28 mm
c	163 mm
d	20 mm
e	143 mm
f	185 mm
g	490 mm

In simulations up to 50 segments are used, which provides the accuracy of the simulations.

In Fig. 3 is shown SWR for 433Mhz frequency and the simulation resulted that the SWR for the frequency is 1.0765. The results from the second simulation for reflect coefficient Fig. 4 shows that the reflect from a standard 50 ohm input is -28.66 dB.

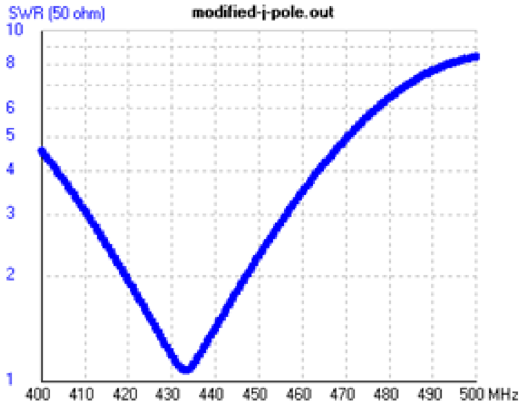

Fig. 3 Simulated SWR for 433MHz frequency

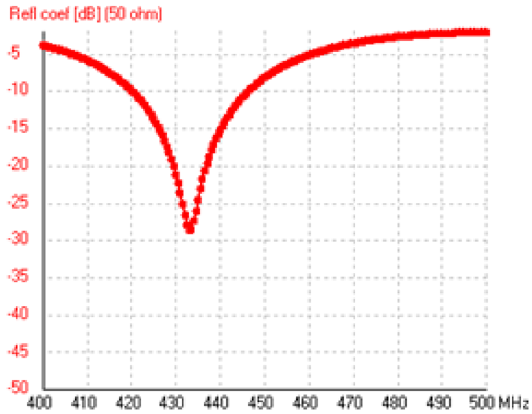

Fig. 4 Simulated reflection coefficient in dB for 433Mhz frequency

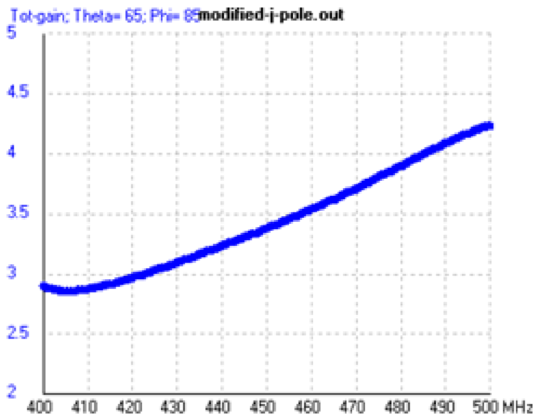

Fig. 5 Simulated antenna gain for 433MHz frequency

The antenna simulations displayed in Fig. 5 showed a gain for our frequency (433MHz) around 3.14 dBi which is acceptable for the purpose for which it will be used. Because of the specific current distribution, the antenna has an almost omnidirectional horizontal radiation pattern and directional vertical pattern, which is shown in Fig. 6.

The antenna simulated with the Ansys HFSS software on Fig. 7 has the same dimensions as the one shown on Fig. 2 and lengths that are shown in Table I.

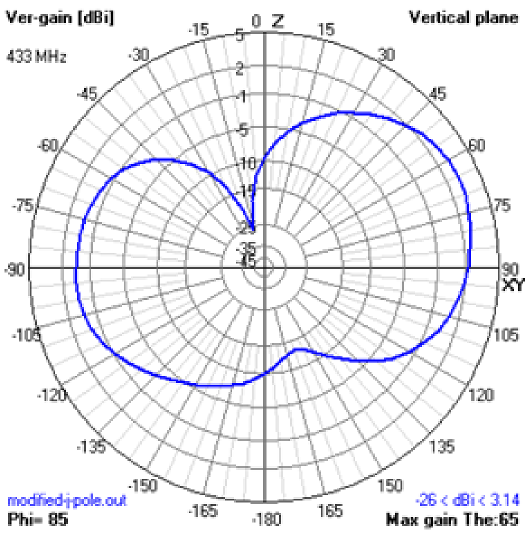

Fig. 6 Simulated radiation pattern for 433MHz
(XY-axis is aligned with 90;-90 deg. line)

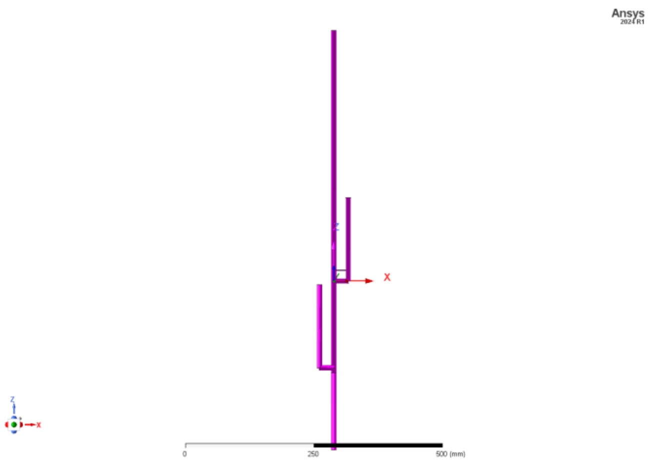

Fig. 7 Simulated antenna with Ansys HFSS

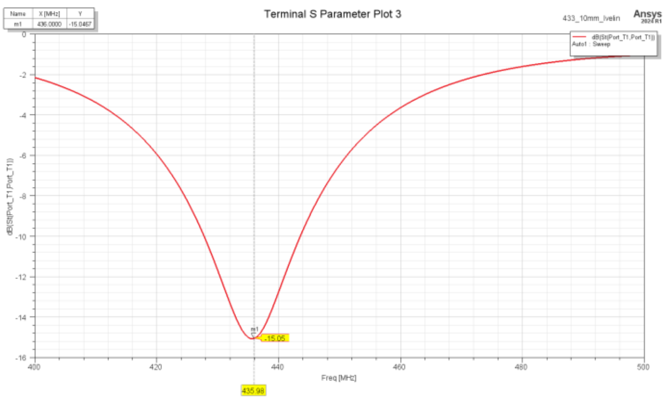

Fig. 8 Return loss (S_{11},dB) of the proposed antenna

On Fig. 8 the return loss of the proposed antenna is displayed. It is evident that the antenna possess excellent matching to 50 Ohm coaxial cable.

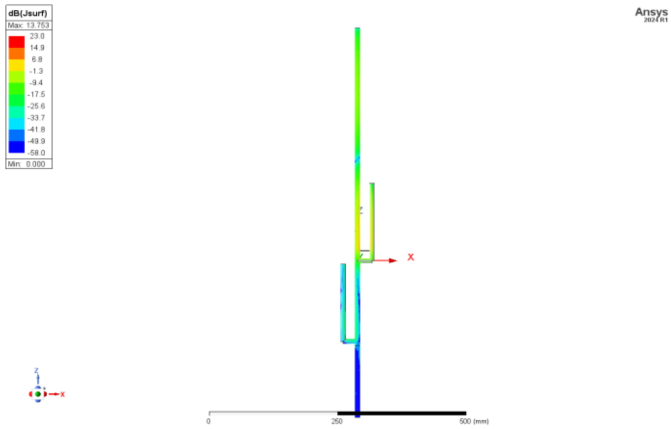

Fig. 9 Current distribution in ground decoupled J-pole antenna

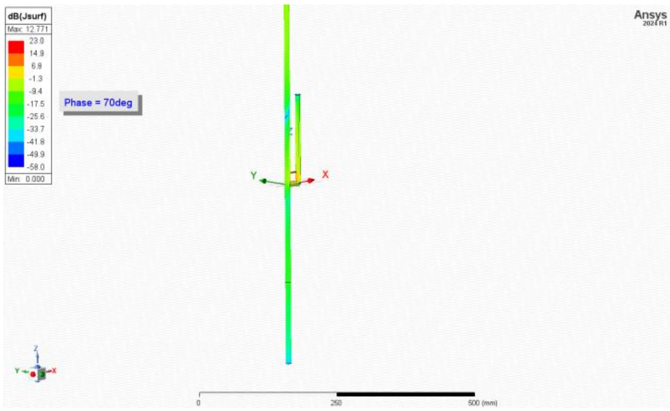

Fig. 10 Currents in J-pole antenna

Decibels are relative to amps/meter and the logarithmic measure is used to emphasize low current levels on Figs. 9 and 10. In the base of Fig. 10 when there is no slip, a significant part of the current flows through the base and passes into the ground under the antenna, which creates two problems: parasitic radiation is created and the radiation pattern depends on the presence of ground.

With the solution we offer, these parasitic currents are reduced by about 20 dB, which can be seen on Figs. 9 and 10.

IV. Conclusion

In this paper a Ground Decoupled J-pole antenna with a second J quarter-wave decoupling element is introduced. This design helps to reduce the currents in the lower sections of the antenna and therefore lowers the effect of the imperfect ground, the extra side lobes and the potential increase of the noise temperature. The proposed solution makes the antenna versatile for installation on arbitrary platforms - cars, UAV's, standalone poles, etc., while keeping the fundamental specs unaffected by the installation location and method.

ACKNOWLEDGEMENT

This study is financed by the European Union – NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0005

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