Omnidirectional Biquad Omni-Antenna for 2.4 GHz Wireless Link Application

Kalina Kalinovska[1] and Peter Z. Petkov[2]

Abstract – **In this paper a modified biquad antenna is proposed. The modified antenna has features, relatively high gain and small physicals dimensions. The directivity is omni in horizontal direction. The antenna is tuned for 2.4GHz-2.45GHz bandwidth. The antenna can be used for Wi-Fi communications and for drones communications.**

Keywords – **Biquad, biQUAD, QUAD, antenna, Omni-antenna, Wi-Fi, drone, omnidirectional**

I. Introduction

The trend in recent years shows that the number of Internet users is increasing and well as the number of devices used by every individual. The realization of user's divices full functionality requires Internet access. More and more devices are mobile and able to connect to the web via a wireless transmission environment. The development of apps that require transmission media is increasing the need of good coverage rapid speed of data transmission over Wi-Fi HotSpots. These Wi-Fi HotSpots are located in different places in our homes, shopping centers, various conference rooms, etc. These antennas should be mostly omni-directed graph with the greatest possible gain. The antennas, which are mainly used for Wi-Fi routers are omni-directed, with a gain of more than 2 dBi, with a minimum vertical width of the radiation pattern. The aim of the article is to develop an antenna for Wi-Fi access by the standards of IEEE 802.11b/g [1], for use in public places that have many users and need antennas with omni-directed radiation pattern. These antennas should provide better coverage in indoor and outdoor environments. Also the aim of article is to prove the ability to use the antenna for communication between the photo-drone and the navigator.

II. Biquad Antenna Concepts

A. IEEE 802.11 standards

IEEE 802.11 is a standard that is used for wireless local area networks (WLAN). 802.11 has several widely used protocol - 802.11a, 802.11b, 802.11g and 802.11n, which are mostly in 2.4 - 2.5 GHz range. (Table 1)

TABLE I
802.11 STANDARTS

Standard	Bandwidth	Comment
802.11b/g/n	2.4 - 2.5 GHz	For the different regions in the world the upper frequency is different.
802.11y	3.65 – 3.7 GHz	Usable mainly in USA
802.11a/ac	5.25 – 5.35 GHz и 5.47– 5.725 GHz	The new Wi-Fi range, not so common in EU

Despite advances in technology standards in 5.25 – 5.35 GHz, 2.4 - 2.5 GHz frequency band is still preferred. 802.11b/g/n [2] standards are preferred over others using higher frequencies. Greater attenuation with higher frequency in free. Development in the article can be used for all standards that are 2.4 - 2.5 GHz frequency band. Through the optimizated model of the current development can be used in different frequency standards.

B. QUAD Antenna

QUAD antennas are type of loop antenna. These antennas are specific to their closed loop which may have a specific geometric shape. An example is the square loop antenna. The length of each wire is a multiple of the wavelength λ with multiplicity λ / 4. (1.1) (Figure 1) [3]

$$l = \lambda/4 \qquad (1.1)$$

The single square loop antenna has two beams with a maximum gain about 4 dBi. (Figure 2) This antenna is powered by one of its corners. The various loop antennas are preferred for mobile communications at higher frequencies. They also have easy workmanship. Materials for these antennas can come from many places. The conductor of which can produce the antenna can be copper wire. Its thickness can vary depending on the desired bandwidth.

[1] Kalina Kalinovska is a student at Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria. kalina.kalinovska@gmail.com

[2]Peter Z. Petkov is with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria. pjpetkov@tu-sofia.bg

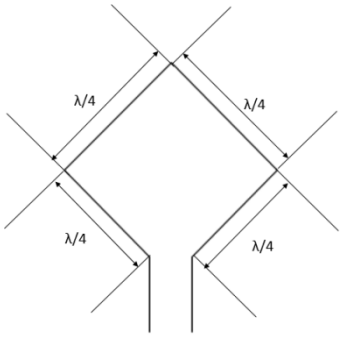

FIG. 1 – QUAD ANTENNA - PRINCIPLED SCHEME

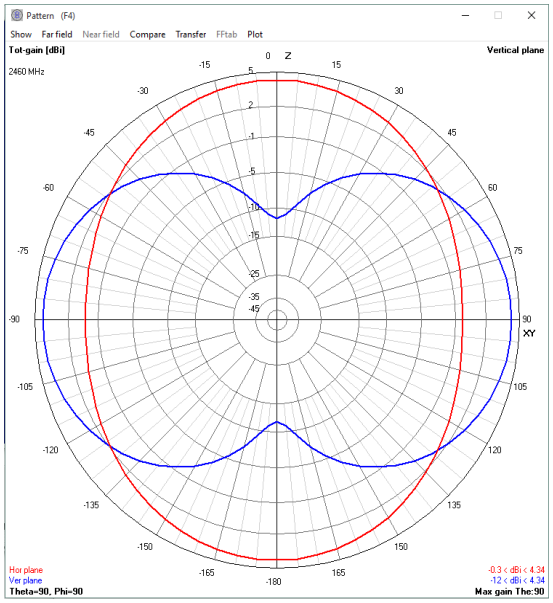

FIG. 2 – QUAD ANTENNA – DIRECTIVITY IN POLAR COORDINATE SYSTEM

C. Biquad antenna

If two square loop antennas join the indicated in (Figure 3), it gets biQUAD antenna. It is easy to construct an antenna which consists of two squares on which can be placed reflector. It provides greater amplification compared to the square loop antenna. The polarization of the emitted signal depends on the spatial location of the antenna. Horizontal - horizontal, vertical - vertical polarization. [4] The horizontal position represents when both squares are next to each other, the vertical position is when both squares are placed one above the other.

The radiation pattern is similar to square loop antenna but biQUAD antenna provides greater gain of almost 5 dBi. The width of the main sheet is approximately 70 degrees. (Figure 4) [5]

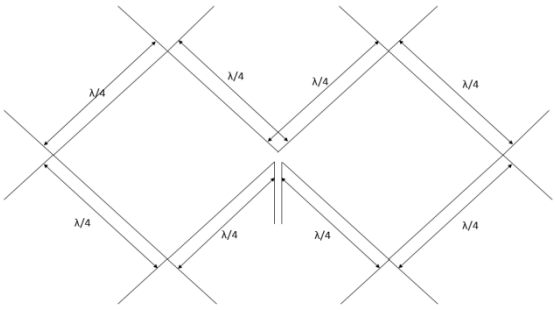

FIG. 3 – BIQUAD ANTENNA – PRINCIPLE SCHEME

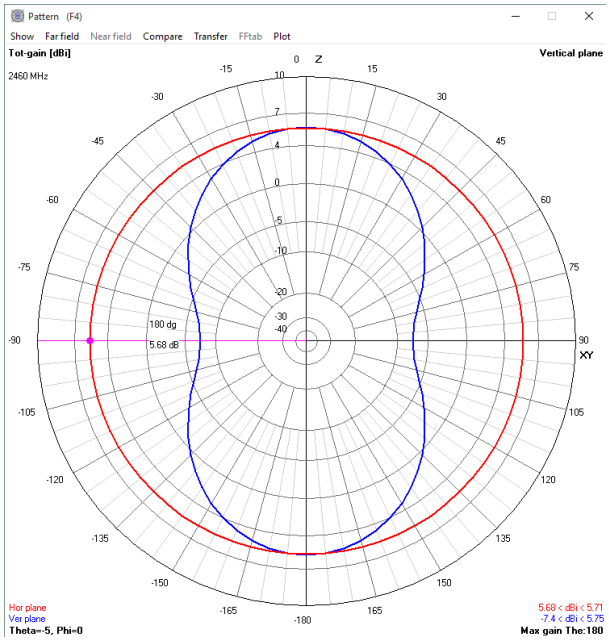

FIG. 4 – BIQUAD ANTENNA – DIRECTIVITY PATTERN IN POLAR COORDINATE SYSTEM

D. Biquad

When connecting two biQUAD antennas, as described in Figure 5 scheme gets Biquad. The antenna is with horizontal omni-directional radiation pattern. (Figure 7) This type of antennas are not widespread. In recruiting literature examination of the problem were not found formulas and previous developments. The theoretical data comparable and similar structures show that each side of it must have a length of λ/4, but the simulations and practical measurements do not match the theoretical model. When optimizing antenna simulation with 4nec2 software, there is a tendency in extending the wires. In real conditions there is an extension of the wires by ~20%. The prototype (Figure 6, Figure 7) confirmed these simulations.

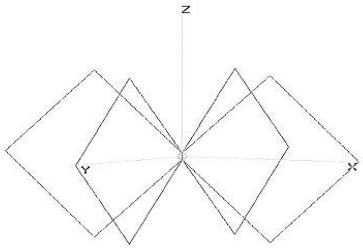

FIG. 5 – BIQUAD ANTENNA – PRINCIPLED SCHEME

This extension is due to surface currents distribution on the wires and the angle between the wires. The directivity of the antenna is omni in bough horizontal and vertical direction (Figure 7)

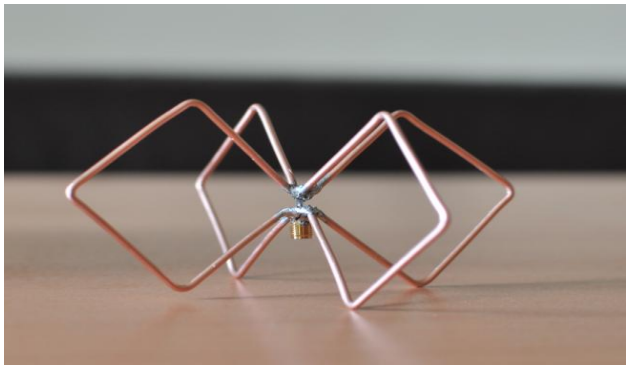

FIG.E 6 – BIQUAD ANTENNA – PROTOTYPE

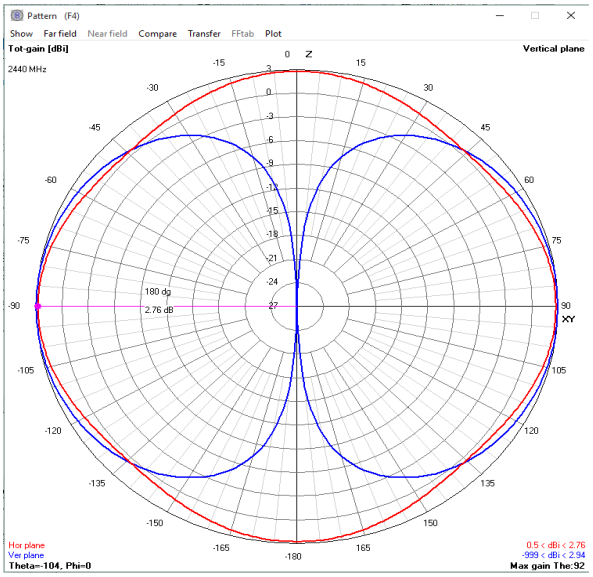

FIG. 7 – BIQUAD ANTENNA – DIRECTIVITY IN POLAR COORDINATE SYSTEM

The simulation model showed bandwidth is 2200-2700MHz (Figure 8). The prototypes bandwidth is wider than the theoretical model (Figure 9).

The prototype of the antenna was made from copper wire with thickness of 2mm and SMA female connector. The center frequency was shifted because of the complicated geometric shape.

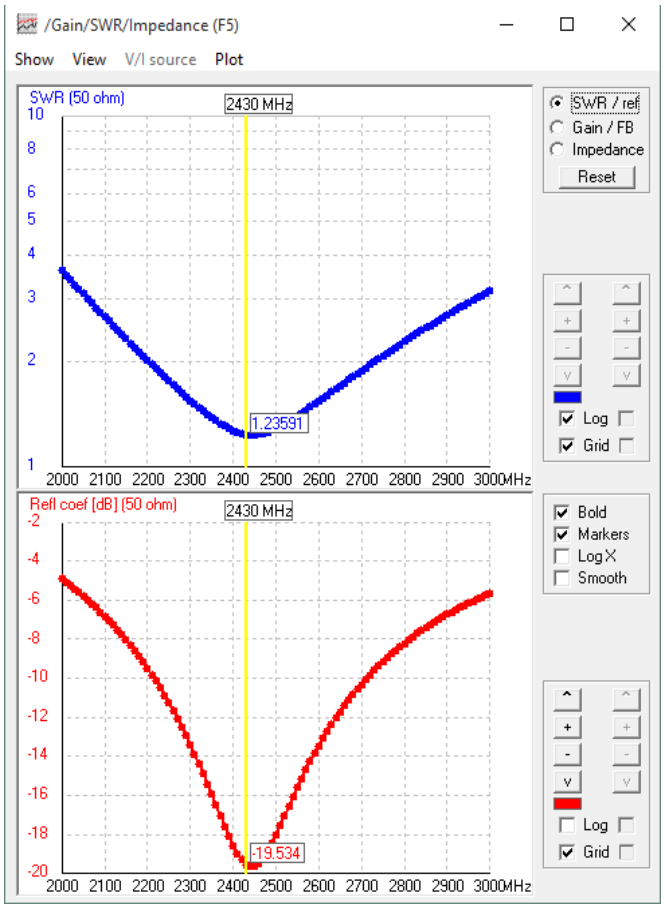

FIG. 8 – BIQUAD ANTENNA – SIMULATION BANDWIDTH, SWR

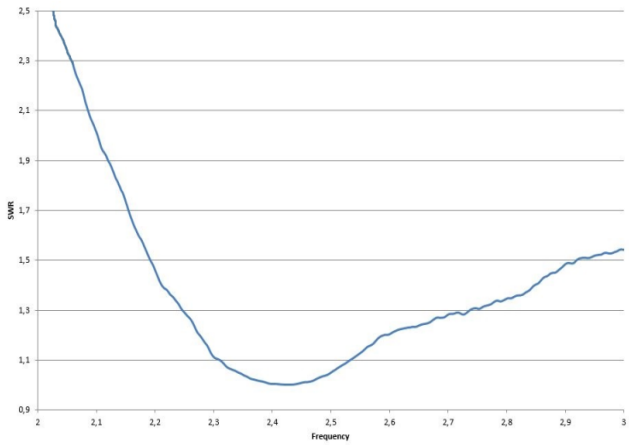

FIG. 9 – BIQUAD ANTENNA – PROTOTYPES BANDWIDTH, SWR, EXPERIMENTAL MEASUREMENTS

E. Biquad with reflector

When placing a reflector at a distance of λ/4 from the center of the structure. (Figure 10) The antenna with reflector is not omni in vertical direction, but in horizontal is. The maximum gain is 4.5dBi. (Figure 11, Figure 12) Reflector can be placed below the antenna. The best position is λ/4 from the geometrical center of the structure.

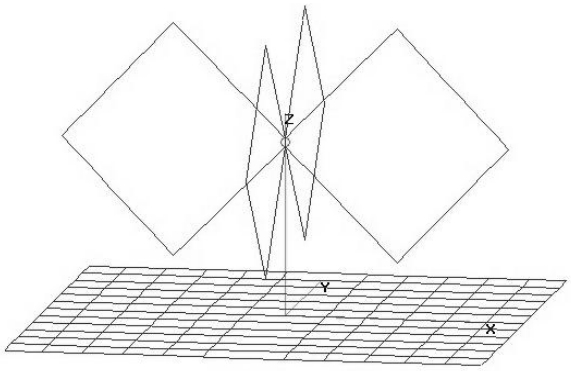

FIG. 10 – BIQUAD ANTENNA WITH REFLECTOR– PRINCIPLED SCHEME

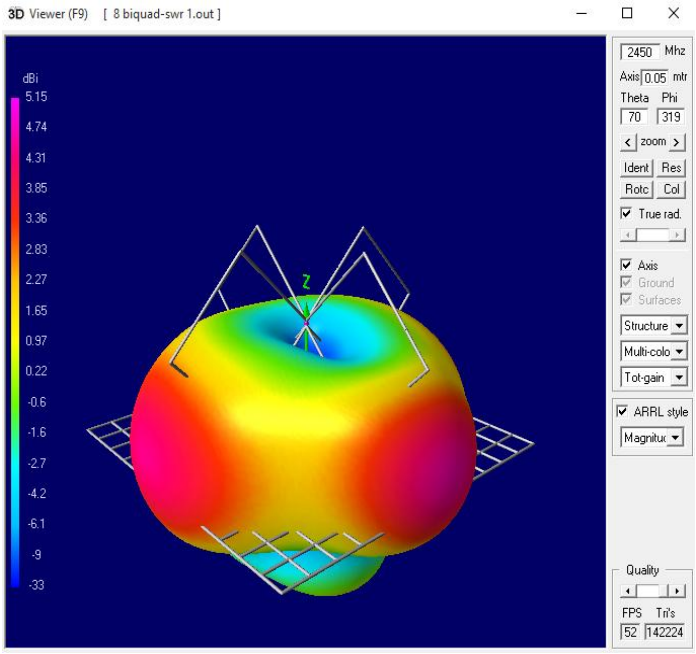

FIG. 12– BIQUAD ANTENNA WITH REFLECTOR – DIRECTIVITY IN 3D

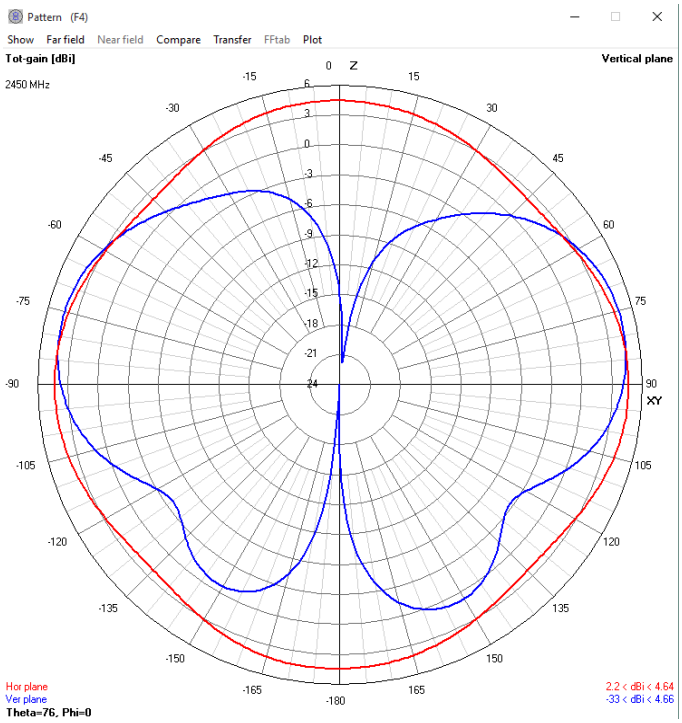

Fig 11 – Biquad antenna with reflector– directivity in polar coordinate system

FIG. 13 – BIQUAD ANTENNA WITH REFLECTOR – PROTOTYPE

The simulation model showed bandwidth is 2350-2700MHz (Figure 14). The prototypes bandwidth is wider than the theoretical model (Figure 15). That can be explained with the non-idealistic characteristics of the copper wire that was used for the prototype. The prototype has higher gain then the antennas that are used in middle and low-cost Wi-Fi routers. The antenna can be placed upside-down on a sealing for better coverage in shopping centers and conference halls.

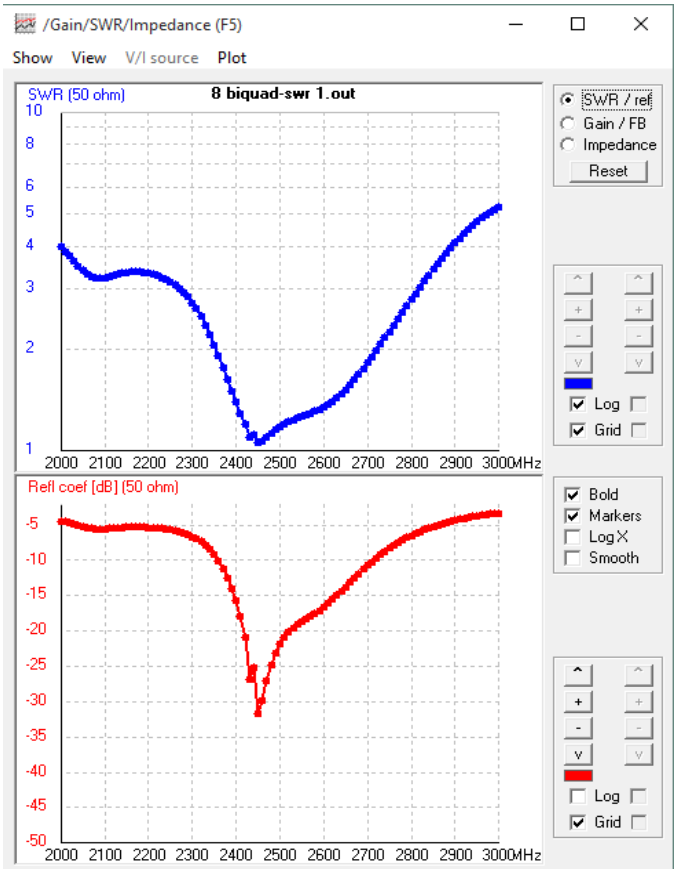

FIG. 14– BIQUAD ANTENNA WITH REFLECTOR – SIMULATION BANDWIDTH, SWR

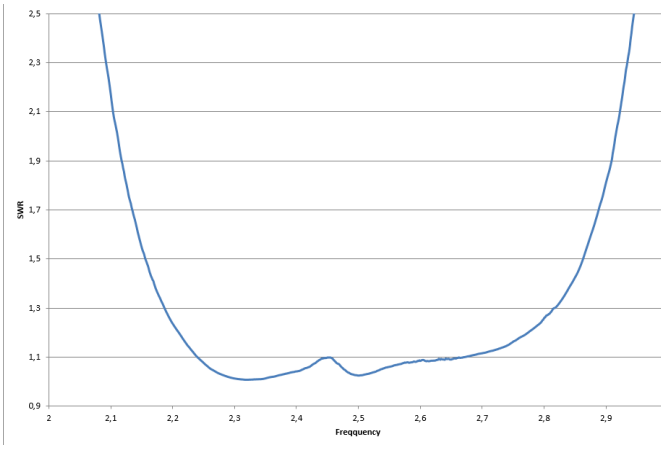

FIG. 15 – BIQUAD ANTENNA – PROTOTYPES BANDWIDTH, SWR, EXPERIMENTAL MEASUREMENTS

III. CONCLUSION

A modified Biquad antenna with reflector has been developed and examined in this study. The article shows a new type of loop antenna, modified with reflector. Biquad antenna with reflector has the highest gain from every other simulation of QUAD type antennas (Table 2). Modified Biquad antenna with reflector shows satisfactory electrical performance, compact size and easiness to manufacture, which makes it a strong candidate for practical applications. It can be used as standalone antenna and in different arrays, depending of the specifical structure of a building. The innovative approach chosen for antenna modification can lead to future developments in this still relatively undeveloped area of antenna design.

TABLE 2
COMPARATIVE ANALYSIS

Type of the	Gain	Directivity in horizontal	Conclusion
QUAD	2 dBi	Dipole type	It is not relevant to the task
biQUAD	2 dBi	Dipole type	It is not relevant to the task
Biquad	2 dBi	Omni	It is not relevant to the task
Biquad with reflector	4.5 dBi	Omni	The directivity is

REFERENCES

[1] "IEEE-SA Standards Board Operations Manual". *IEEE-SA*. Retrieved 2015-09-13.

[2] ARRLWeb: Part 97 - Amateur Radio Service". American Radio Relay League. Retrieved 2010-09-27

[3] Hall, Gerald (1991). The ARRL Antenna Book (15th edition). ARRL. p. 24. ISBN 0-87259-206-5.

[4] evelaqua, Peter J. "Types of Antennas". Antenna Theory. Antenna-theory.com Peter Bevelaqua's private website. Retrieved June 28, 2015

[5] Johnson, R, Jasik, H, ed. (1984). Antenna Engineering Handbook. McGraw Hill.