# Wideband Monofilar Helical Antenna for Wireless Communication In Remote Area

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***Abstract*—This paper presents the wideband monofilar helical antenna which is aimed to increase low level signal reception commonly occurs in the remote area such as highlands, ridge, and borderlands. The use of helical antenna type is due to its ability in producing circularly polarized wave useful to support wireless communication frequently surrounded by some obstructions. The proposed antenna is expected to operate at wideband frequency range including cellular communication and connectable to the GSM modem associated with a laptop or PC device. The antenna is designed by using thin copper wire with spiral turn number of 8 and fed through a 50Ω female N-connector type. The proposed monofilar helical antenna is then realized based on the optimum design for experimental characterization. The measurement result shows that the realized antenna has working frequency from 1200 MHz to 2250 MHz and has the gain up to 14.5 dBi.**

***Keywords*—Helical monofilar antenna; remote area; wideband; wireless communications.***

## I. Introduction

Commonly the wireless transmission used in cellular communications require a reliable continuous data stream [1]. This is to ensure that the data from base transceiver station (BTS) to cellular device, or vice versa, can be well-transferred. However, in the remote area such as highlands, ridge, and borderlands, the reliability of data transmission is becoming a serious problem. The level of signal might be relatively low which cannot process data stream continuously. While the reliability of data stream is very important in wireless communications to ensure the communication from one point to another one can be maintained properly.

In recent years, cellular communications have grown up rapidly which are initiated with 1G to 4G [2]–[3]. Long Term Evolution (LTE) frequently called as forth-generation (4G) is developed through Universal Mobile Telecommunications System (UMTS) or third-generation (3G) and High-Speed Downlink Packet Access (HSDPA) which has a downlink speed of 7.2 Mbps to 14.4 Mbps [4]. Meanwhile, LTE has uplink speed of 50 Mbps and downlink speed of 100 Mbps. Cellular communications commonly used for mobile devices need an access to the nearest BTS [5]. However, at the remote area with low quality of signal, an optional apparatus connectable to a Global System for Mobile Communications (GSM) modem associated with a laptop or PC device is required to increase the signal level reception in order to the client data can stream continuously.

According to the case above, this paper presents a monofilar helical antenna which is developed by using thin copper wire. The proposed antenna is expected to have high gain useful to increase the quality of receiving signal. Some features of antenna concerned in the design process are its ability and reliability to support wireless communication in the remote area frequently surrounded by high mountains and other obstructions [6]–[7]. Furthermore, the proposed helical antenna type which has circular polarization is expected to be more effective reducing multi-path interferences caused by some objects [8]– [10]. Based on the optimum design, the proposed monofilar helical antenna is realized for characteristic measurement in which the measured results are applied to evaluate the performance of realized antenna.

## II. Design of Monofilar Helical Antenna

It is known that a monofilar helical antenna consists of a single conductor wound into a helical shape. Although a helix can radiate in many modes, the normal mode and the axial mode are the ones of general interest [11]. The normal mode referred as lowest transmission mode, the length of one turn of the helix is small compared to the wavelength affecting to geometrical size of antenna. Meanwhile, the axial mode as the most commonly used mode has the helix circumference of the order of one wavelength. This mode can provide maximum radiation along the helix axis.

In this paper, the monofilar helical antenna is designed to produce axial mode of radiation. Since the analysis of helical shape is rather complicated, the methods to analyze radiation characteristics of helical antenna such as input impedance, gain, and far-field pattern are investigated by combining experimental technique, approximate analytical method, and numerical analysis [12]. Here, the numerical analysis is usually carried out based on a uniform current distribution over the length of helix with a constant phase [13]–[14].

The far-field pattern which is independent of the number of turns may be approached by modeling the helical antenna as a series of small loop and short dipole elements as illustrated in Fig. 1 with its parameters detailed in Table I. It shows that the length of short dipole element is the same as the spacing between turns of the helix, whilst the diameter of helical loop is the same as the diameter of helix. The helical antenna can be obtained by accomplishing the condition of helix circumference.

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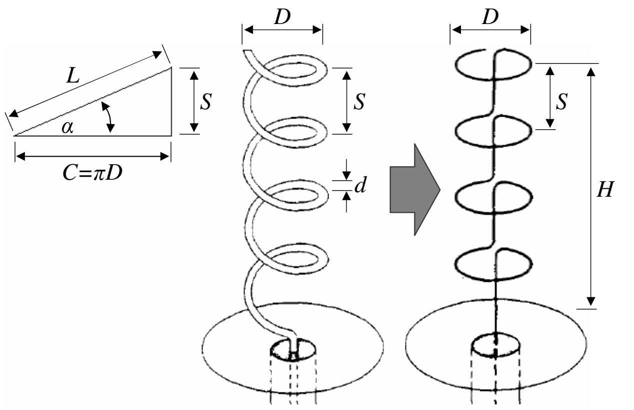


Fig. 1. Helical antenna modeled as a series of small loop and short dipole elements [13].

TABLE I. PARAMETERS OF NORMAL MODE HELICAL ANTENNA.

| Parameter | Symbol | Design value |
|---|---|---|
| Height of helix $(mm)$ | $H$ | 343.78 |
| Diameter of helix $(mm)$ | $D$ | 54.74 |
| Spacing between turn of helix $(mm)$ | $S$ | 42.97 |
| Circumference of helix $(mm)$ | $C$ | 171.98 |
| Length of wire per turn $(mm)$ | $L$ | 177.26 |
| Pitch angle of helix $(^o)$ | $\alpha$ | 14.03 |
| Diameter of wire conductor $(mm)$ | $d$ | 1.67 |
| Number of turns | $N$ | 8 |

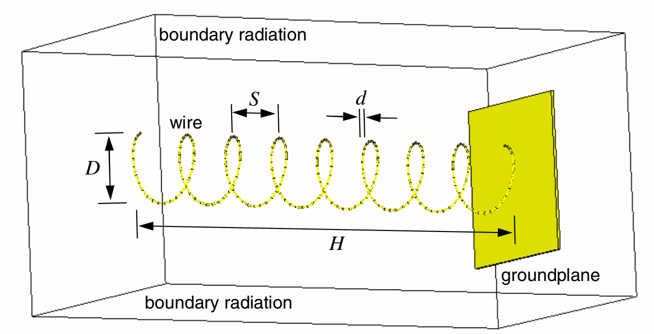


Fig. 2. Design of proposed monofilar helical antenna

Fig. 2 illustrates the design of proposed monofilar helical antenna for increasing the signal level by improving the characteristic radiation. The proposed antenna is constructed with helical wire stand on an aluminium metal with the size of 125 mm × 125 mm as a groundplane. The aluminium metal is also used to improve the radiation characteristic of antenna especially in radiation pattern. As tabulated in Table I, the antenna which is fed through a coaxial connector type is designed by using thin copper wire the number of spiral turn number is 8 to achieve the desired working frequency with wide bandwidth response.

## III. Hardware Realization and Characterization

### A. Hardware Realization

The proposed monofilar helial antenna which is designed by using simulation software to obtain the radiation characteristics is then prototyped to be verified by measurement. In the design process, the monofilar helical antenna is implemented by use of copper conductor wire. In order to achieve the required specification, the diameter of copper conductor wire is chosen as 1.67 mm with 8 turns of spiral wire winding and 54.74 mm spacing between each turn. Then, based on this values, the total height of monofiral helical antenna 343.78 mm. Fig. 3 shows the picture of realized antenna which is standing on an aluminium metal as a groundplane.

Fig. 3. Realized monofilar helical antenna standing on an aluminium metal.

It shows that a 50Ω female N-connector type is soldered at the feeding port of realized antenna for experimental characterization. To support the spiral wire winding, an acrylic is used to hold the wire to make a helical shape. Here, the experimental characterization which is carried out using vector network analyzer (VNA) is applied to analyse the antenna parameters focused on its impedance bandwidth and gain. The results of experimental characterization are plotted in Figs. 4 and 5 for reflection coefficient ($S_{11}$) and gain, respectively.

### B. Experimental Characterization

The measured reflection coefficient ($S_{11}$) of realized monofilar helical antenna depicted in Fig. 4 shows that the proposed antenna operates at wideband frequency satisfying the required specification. The value of $S_{11}$ is up to -23 dB for the frequency of 1860 MHz; -34.5 dB for the frequency of 2040 MHz; and -31 dB for the frequency of 2190 MHz. From the result, it can be observed that the measured impedance bandwidth of realized antenna for $S_{11} \leq$ -10dB is about 1050 MHz ranges from the frequency of 1200 MHz to 2250 MHz. Other than GSM application, the measured antenna bandwidth can also cover Global Positioning System (GPS) and UMTS (3G) applications.

Moreover, the measurement result of realized monofilar helical antenna gain is depicted in Fig. 5. It is seen that the gain of antenna is up to 13.5 dBi at the frequency of 1860 MHz, and 14.5 dBi at the frequencies of 2040 MHz and 2190 MHz. In overall, the measured gain is sufficiently high to strengthen the low level signal which frequently occurs in the remote area. However, the stability of antenna gain should be improved since the value is fluctuated especially in the frequency range less than 1600 MHz.

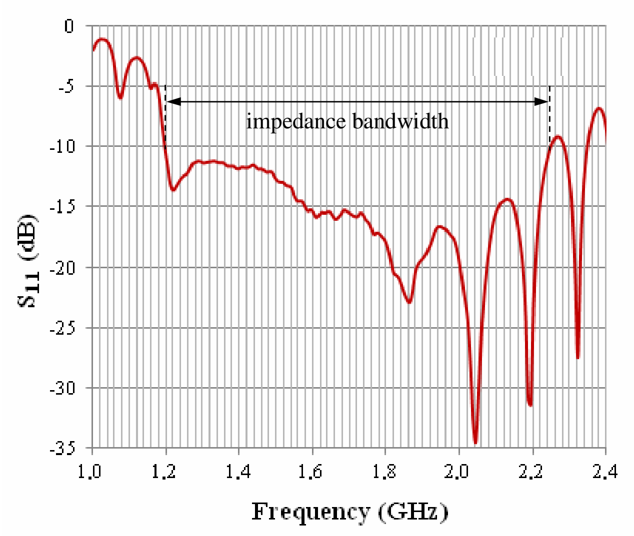


Fig. 4. Reflection coefficient of realized monofilar helical antenna.

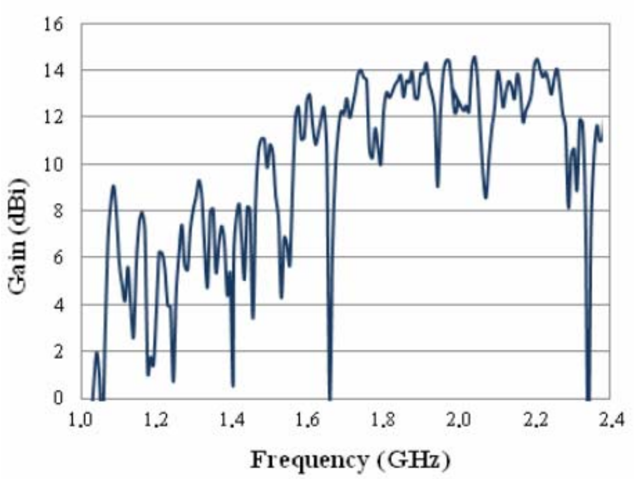


Fig. 5. Gain of realized monofilar helical antenna.

## IV. Conclusion

The design and characterization of wideband monofilar helical antenna has been presented. The proposed antenna has been developed using helical shape with spiral turn number of 8. It has been demonstrated that the proposed antenna has wide bandwidth response of 1050 MHz in the frequency range of 1200 MHz to 2250 MHz useful for wireless communication applications. The realized monofilar helical antenna has also sufficient gain achievement up to 14.5 dBi beneficial for increasing the signal level in the remote area. In addition, some attempts to improve the radiation characteristics of antenna are still in progress where the result will be reported later.

## Acknowledgment

The authors would like to thank Mr. Zenal Aripin from the Radio Telecommunication and Microwave Laboratory, School of Electrical Engineering and Informatics, Institut Teknologi Bandung, Indonesia, for technical assistance and discussion in the experimentation.

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