Antenna and Anti-antenna

Michael Bank, Benny Milgrom and Yuri Shalyt
The Department of Cellular Communication Engineering, Jerusalem College of Technology, Givat Mordechai 91160, Jerusalem, Israel

Abstract: One of today’s actual problems in the field of antennas is the possibility of developing a small wideband antenna, which can work without grounding. Absence of these antennas can lead to serious problems for example in case of designing small transceivers for cellular systems. In this article we show a proposed version of these antennas. Today there do not exist theoretical investigations of connections between electromagnetic fields and currents in flat metallic plates. Therefore, the basis of this work is optimization of proposed antenna construction by simulations.

Key words: Wide band, triangle antenna, quarter wave length, omni-directional, cellular satellite system.

1. Introduction

One might assume that the title of this article, which includes opposites, is illogical. In fiction, names are often unexpected: for example, “The Prince and the Pauper” by Mark Twain, “The Girl and the Death of Maxim Gorky”, “Mozart and Salieri” by Alexander Pushkin, “Snow White and the Seven Dwarfs” by the Brothers Grimm.

These titles include opposites. Many problems of science and technology are the unity synthesis of opposites. Suffice it to mention electricity, magnetism, acids and bases in chemistry and so on.

But there is another reason for this name in this article. In Refs. [1, 2] it is shown that the normal grounding system is actually an antenna. This antenna has a very low input impedance and very low radiation efficiency. In other words, even if any electric current flows into the grounding system, this system does not waste useful power energy.

Communication systems often use an unbalanced antenna, for example, a monopole. In such an antenna, the second input of the source must be at zero potential. Instead of grounding, one can use a nullifier [3]. The proposed antenna below is the combination of a normal antenna and a nullifier so actually the radiation energy of the antenna is near zero. We have named this antenna as an anti-antenna.

2. Very Wide-Band Triangular Antenna: Idea and Structure

The proposed antenna consists of a 2D triangular radiating element, as shown in Fig. 1. The triangle’s sides connecting to the lower corner have different lengths. The signal can be fed at the lower corner of the triangle.

In Fig. 1, Null denotes a nullifier for zeroing potential at the feed point in case that the use of the ground is impossible.
When a signal applied is transmitted, it excites many current lines in the radiator flowing along various paths. Each path is characterized by its impedance. And, the maximal current will flow along the path with the minimal least resistance.

This impedance is active (R) and it is approximately equal to the active resistance of a tuned monopole.

If at a given frequency the current must flow inside the triangle, but there it cannot flow. It is known, that current cannot flow along the way if there is metal on both sides of it. Numerous simulations have shown that in this case the current flows along the side of the triangle, but the length of this flow corresponds to a quarter of the wavelength of a given frequency. The short side (A) must be no longer than a quarter wavelength corresponding to the highest frequency of this frequency range.

As the frequency increases from lowest, the current path changes from long side (C) to short side (A). With a further increase in frequency, the current returns to the A side, but radiation occurs (by analogy with a monopole) at odd harmonics.

Therefore, the antenna operates at all frequencies.

3. Nullifiers Versions

Nullifiers are used in all electronic systems if it is impossible to use ground.

Small mobile transducers usually suffer from the lack of a real ground. In order to mitigate this problem, the authors have proposed to use a nullifier [1]. The main advantage of the nullifier is that it removes the need to connect the device (transducer or other) with ground. Its goal is to produce a zero-potential point. It can work at any frequency and at their harmonies, but its construction depends on the signal frequency band. This is done by connecting two signals of equal amplitude and opposite phases at the same point. For this purpose, one can use a delay line, resonance counter, strip line, or transformer with opposite windings and so on, as shown in Ref. [1]. This method is much easier and more compact than the alternative using the earth as the ground. This method provides a much easier zero-potential point (see Ref. [1] for possible explanations of what makes the earth a means of potential zeroing).

For narrow band signals, the nullifier can be implemented by a delay line, as shown in Fig. 2.

The delay line can be made by different methods. The nullifier of a wideband antenna made of a circular ring is illustrated in Fig. 3.

The nullifier can be made as a metallic plate for example PCB (Printed Circuit Board), as shown in Fig. 4.

Fig. 2  Time delay of the wide-band antenna and its length must be equal to half its wavelength.

Fig. 3  A nullifier of the wide band antenna, perimeters of the outer and inner circles are equal to half the wavelength of the lowest and highest frequencies, respectively.

Fig. 4  A further nullifier example, here its perimeter must be more than half its wavelength.
3.1 A Bifilar as Nullifier

A bifilar coil is an electromagnetic coil that contains two closely spaced, parallel windings. In engineering, the word bifilar describes wire which is made of two filaments or strands. It is commonly used to denote special types of winding wire for transformers. Wire can be purchased in bifilar form, usually as different colored enameled wire bonded together.

Some bifilars have adjacent coils in which the convolutions are arranged so that the potential difference is magnified (i.e., the current flows in the same parallel direction). The magnetic field created by one winding is therefore equal and opposite to that created by the other, resulting in a net magnetic field of zero [1]. Bifilar coils impose an inductance in the common mode, but impose no inductance in the differential mode. Coils in such a combination are widely used to eliminate ingress or egress of common mode signals from electronic signaling circuits. This arrangement is used in the transmission and reception magnetics of Ethernet cables [2] and conspicuously in the form of a ferrite bead clamped to the outside of USB, laptop power supply and HDMI (High-Definition Multimedia Interface) cables.

In case of needed grounding one can use different bifilar systems (Figs. 5 and 6).

A bifilar has non-inductive resistance, because it includes two lines in opposite directions and potential zeroing at half of the wavelength frequencies. A bifilar does not radiate at certain frequencies of half wavelengths [6-8].

A simple nullifier of any form as e.g. rectangular or circular has a large inductive reactive impedance at a certain frequencies.

The simulation results show that the antenna has very low inductive impedance at frequencies that equal half the wavelength.

4. Antenna and Anti-antenna Simulation Results

A bifilar plane is perpendicular to triangle one. The bifilar outer size is $34 \times 37$ mm.

A triangle and bifilar are in the same plane (Figs. 7 and 8).

A bifilar as nullifier has some advantages:
1) Small size in comparison with other types of nullifiers.
2) A few various size bifilar connections together can be used for wider-band antennas.
3) It can be located on different planes.
4) Various distances from radiator.
5) Different shapes (rectangular, circular, oval, etc.).
6) There is no radiation at frequencies of half its wavelengths and its odd harmonies.

Fig. 5 Non-inductive bifilar winding is wound so that the current flows in opposite directions.

Fig. 6 A proposed triangular non-flat antenna with bifilar as nullifier and bifilar only view.

Fig. 7 Triangular non-flat antenna dimensions.
Source: $R = 50$ Ohms.
Fig. 8  S11. The simulation result of the antenna in Fig. 7 shows that the antenna operates properly at frequencies 1.4-2 GHz (See Figs. 8-14).

Fig. 9  VSWR (return loss log periodic antennas). The simulation result of the antenna in Fig. 7 shows that the antenna operates properly at frequencies 1.4-2 GHz.

Fig. 10  An electric field at a distance of 1 m simulation of antenna in Fig. 7 shows that the antenna operates properly at frequencies 1.4-2 GHz.

| Type       | Farfield |
|------------|----------|
| Approximation | enabled (|\(kR \gg 1\)) |
| Monitor    | farfield \([f=1.8] [1]\) |
| Component  | Axis     |
| Output     | E Field \(r=1\mathrm{m}\) |
| Frequency  | 1.8 GHz  |
| Rad. eff.  | 0.9981   |
| Tot. eff.  | 0.8054   |
| Emax       | 7.010 \(\mathrm{V/m}\) |

Fig. 11  E-pattern for triangular antenna in Fig. 7 shows that the antenna operates properly at frequency 1.8 GHz.

Fig. 12  Triangular flat antenna dimensions (source resistance is 50 Ohms).
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Fig. 13 S11. The simulation result of the antenna in Fig. 12 shows that the antenna operates properly at frequencies 1.4-2 GHz.

Fig. 14 VSWR. The simulation result of the antenna in Fig. 12 shows that the antenna operates properly at frequencies 1.4-2 GHz.

Fig. 15 An electric field at a distance of 1 m simulation result of the antenna in Fig. 12 shows that the antenna operates properly at frequencies 1.4-2 GHz.

Fig. 16 E-pattern for triangular antenna result of the antenna in Fig. 16 shows that the antenna operates properly at frequency 1.8 GHz.

5. Triangular Antenna in Satellite Communication

A triangular antenna at high frequencies radiates upwards and can be used in satellite communication instead of a big antenna.

For certain purposes the antenna must radiate in a particular direction.

The simulation results in Figs. 17-19 show that the antenna can be used to produce circularly polarized (or nearly so) radiation.

Fig. 17 Fairfield E-pattern of triangular antenna for frequency 4 GHz simulation shows that the antenna radiates in vertical upward direction.
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6. Conclusions

This proposed antenna in-triangular shape with bifilar as nullifier enables to get ultra-wide band antennas. The main advantage of it is that it can operate at all frequencies of its frequency band. So it is possible to say that this antenna is not a resonance antenna. This combination of antenna and anti-antenna does not need ground for zeroing. This antenna has a flat shape and small dimensions for use in cellphones. This shape allows for various options in order to combine the antenna and the printed circuit board of the phone.

A folded antenna is also proposed, which is convenient for use in non-flat transceivers.

The wideband antenna can be used in systems searching for a signal source with unknown frequency but possibly known direction.

At frequencies higher than 2 GHz the triangle antenna has a vertical direction with circuit polarization. Therefore, it can be used for communication with a satellite.

References

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