About the MiniWhip and the CMMA

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We are going to talk about two special antenna concepts, which at first glance seem to have nothing in common with each other, but on closer inspection turn out to be surprisingly related, and even have almost the same equivalent circuit diagram.

In 2017, the undersigned, Hans Van Bruggen (PA3AZA), owner of ElegAnt Solutions Antenna & RF Design, published a new concept for an electrically short monopole antenna with internal matching, the **HighAnt© 'Compact Matched Monopole Antenna'**, or **CMMA** for short, in the magazine High Frequency Electronics (link*). In appearance, this antenna resembles the classic monopole with topload, yet with two plates instead of one (see Fig. 1).

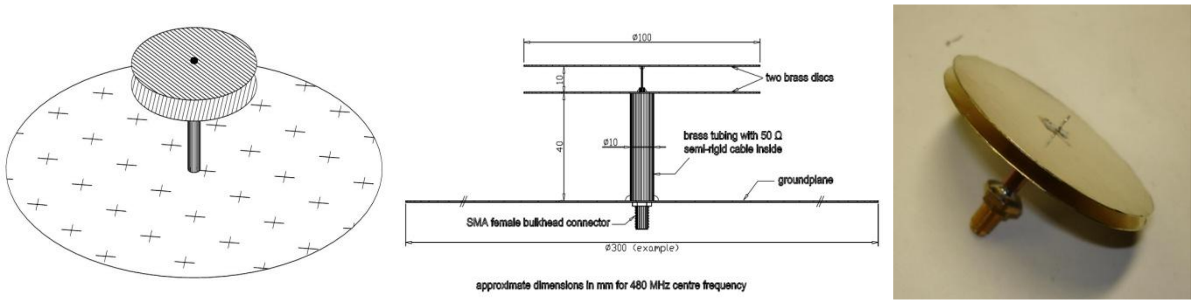

Fig. 1 Example of a HighAnt© CMMA, for 480 MHz.

Ten years earlier, Roelof Bakker (PA0RDT) introduced a new concept for an active antenna for reception in the LG-MG-KG bands: the **'MiniWhip'**. In fact, the MiniWhip is not an antenna, but merely the 'coupling' to a monopole antenna formed by the mantle (shield) of the coaxial cable with which the MiniWhip is connected to the receiver. The MiniWhip simply consists of a small conductive patch, the RF voltage of which is 'sensed' and passed on to the receiver via the coaxial cable (see Fig. 2).

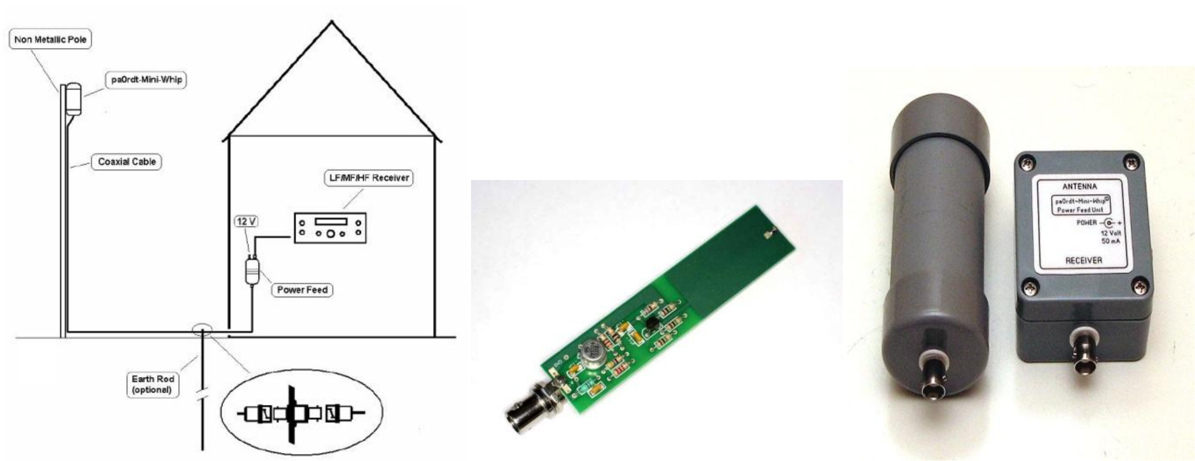

Fig. 2 Basic idea and example of the PA0RDT MiniWhip.

Interestingly enough, the monopole-with-MiniWhip (in short: MiniWhip) and the CMMA now appear to be related. In this article we discuss the similarities and differences between the two and try to remove misunderstandings about the deservedly popular MiniWhip. Disclaimer in advance: the author himself has no practical experience with the MiniWhip!

In principle, the MiniWhip and CMMA are vertically polarized antennas above a ground plane. First of all, it is important to dispel the misunderstanding that the conductive patch of the MiniWhip is the antenna. That patch is nothing more than a single capacitor plate, which capacitively couples to the actual antenna beneath the MiniWhip. The RF voltage of the patch is 'sensed' and sent to the receiver.

The most important similarity between MiniWhip and CMMA is that the coaxial feed line is not only used for transporting the RF signal. Its mantle (the shield) functions as a monopole antenna (the 'radiator') from a certain ground point at the bottom, to the top end of the coax. The radiator of the CMMA, i.e. the vertical part under the plates, is also a coaxial line, even though you cannot see it.

An important difference between the two, however, is that the *active* MiniWhip is only intended and suitable for receiving, while the *passive* CMMA is suitable for both transmitting and receiving. In addition, the MiniWhip configuration is *broadband* and *unmatched*, while the CMMA is *narrowband* (resonant) and *matched*.

The CMMA and MiniWhip are not fed at the base, as is usually the case with a monopole, but - via the coaxial feed line - at the top, by means of applying a capacitive tap to the RF voltage over the length of the mantle of the coax, being the radiator. If we forget the active part of the MiniWhip for a moment, the equivalent circuit diagram valid for both antennas is shown in Fig. 3.

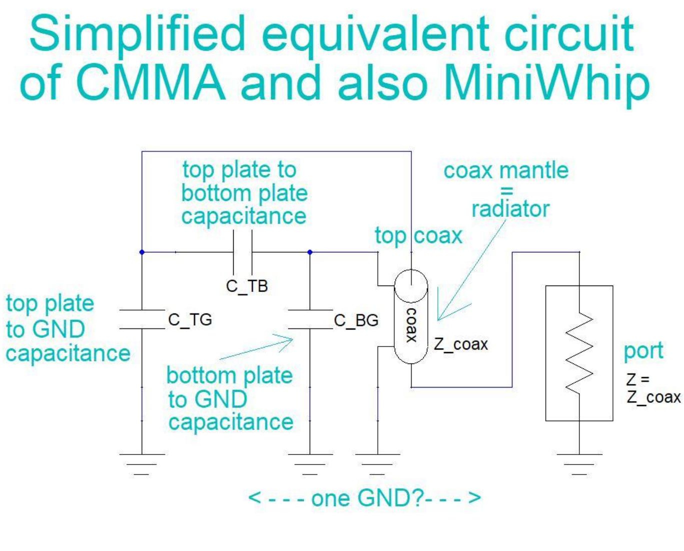

Fig. 3 Simplified equivalent circuit diagram for both CMMA and MiniWhip.

The remark “One GND?” with a question mark, at the bottom of Fig. 3, refers to the important question of what actually is ‘antenna ground’ (GND) in these antennas. Is it, as for example with a CMMA for VHF and higher frequencies, usually a well-defined conductive ground plane, or as in many cases with the MiniWhip precisely the unclear, less conductive ‘real’ earth, with or without an earth pin? We will come back to this.

In the case of the CMMA, the capacitive tap is formed using two parallel capacitor plates, connected across the factual feed point at the top end of the coaxial radiator. Due to the ‘top load’ formed in this way, the CMMA can be made shorter and more compact than the standard quarter-wave monopole. The plates do not have to be the same size. Fig. 4 shows the RF model for the CMMA with values for the 480 MHz version from Fig. 1.

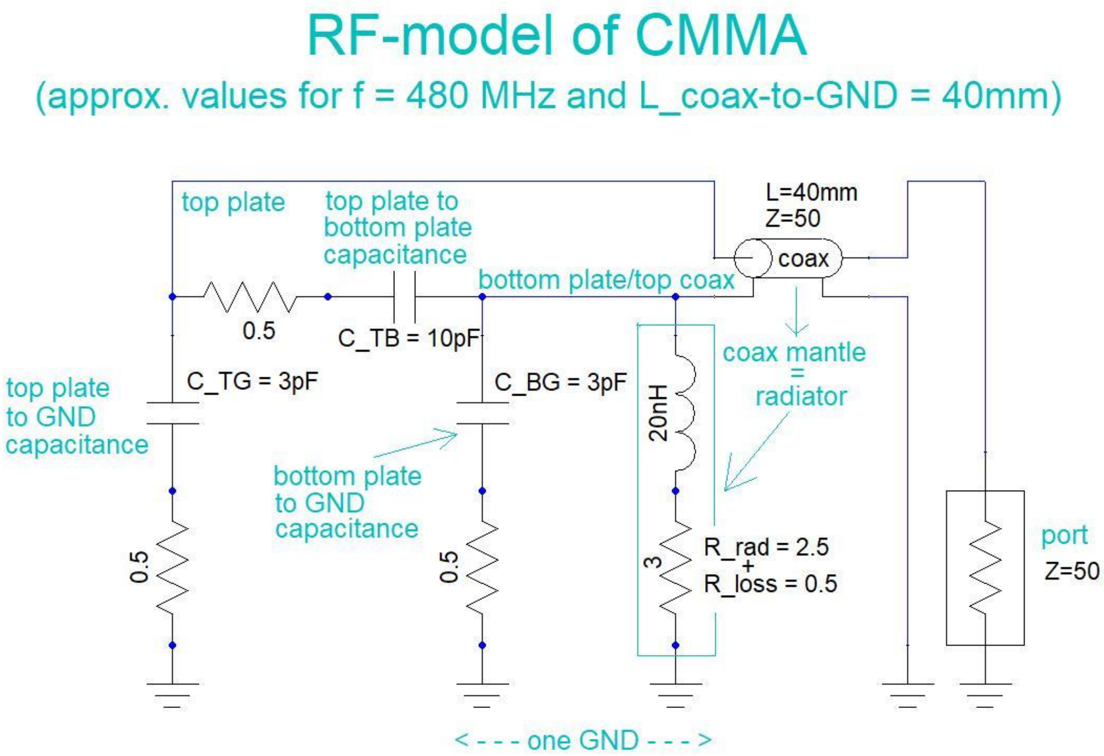

Fig. 4 RF model for the CMMA of Fig. 1.

Given a certain chosen radiator length, the plates, their dimensions and distance, can be dimensioned in such a way that a 50 Ohm impedance is created both for the factual feed point at the top, and the relocated connection point at the bottom of the CMMA. Fig. 5 shows results of matching measurements to the physical model. The -10dB S11 bandwidth in this example is 25 MHz, at 480 MHz, which shows that the CMMA is a narrowband antenna.

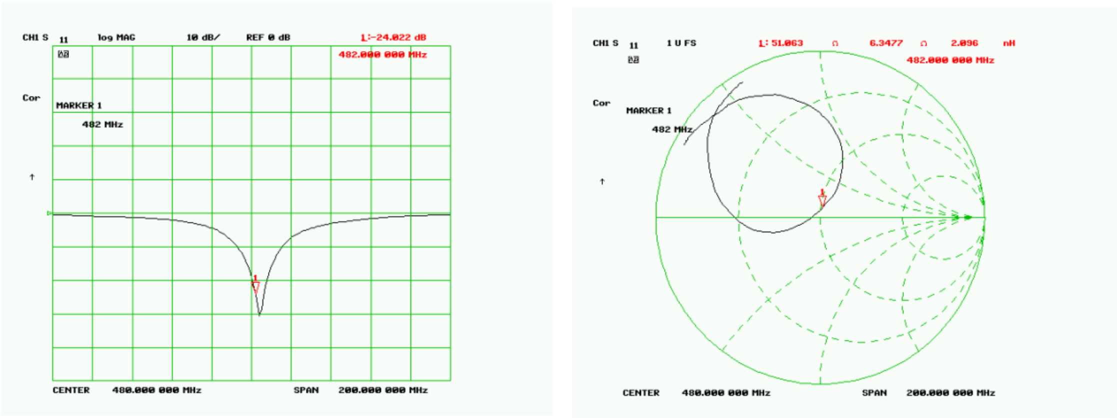

Fig. 5 Measured LOGMAG S11 and Smith Chart for the CMMA of Fig.1.

In the case of the MiniWhip, the capacitive tap is formed with only a single plate, a very small conducting patch, as compared to the wavelength, at the top of the antenna as a whole, which on the one hand couples capacitively to the top of the radiator just below it (being the top end of the mantle of the coax, also the GND-connection of the active part) and on the other hand down to 'antenna ground' somewhere at the very bottom of the whole. The two capacitances to earth C_TG and C_BG are minuscule in comparison with the CMMA, which is why the RF voltage on the patch, generated by capacitive voltage division, should not be loaded and is fed to the very high-impedance input of an active impedance converter, which 'senses' the signal and then sends it via the coax connection to the receiver. Fig. 6 shows the RF model for a MiniWhip with a radiator length of 2 meters, when receiving at 10 MHz. The given capacitance values are only estimates.

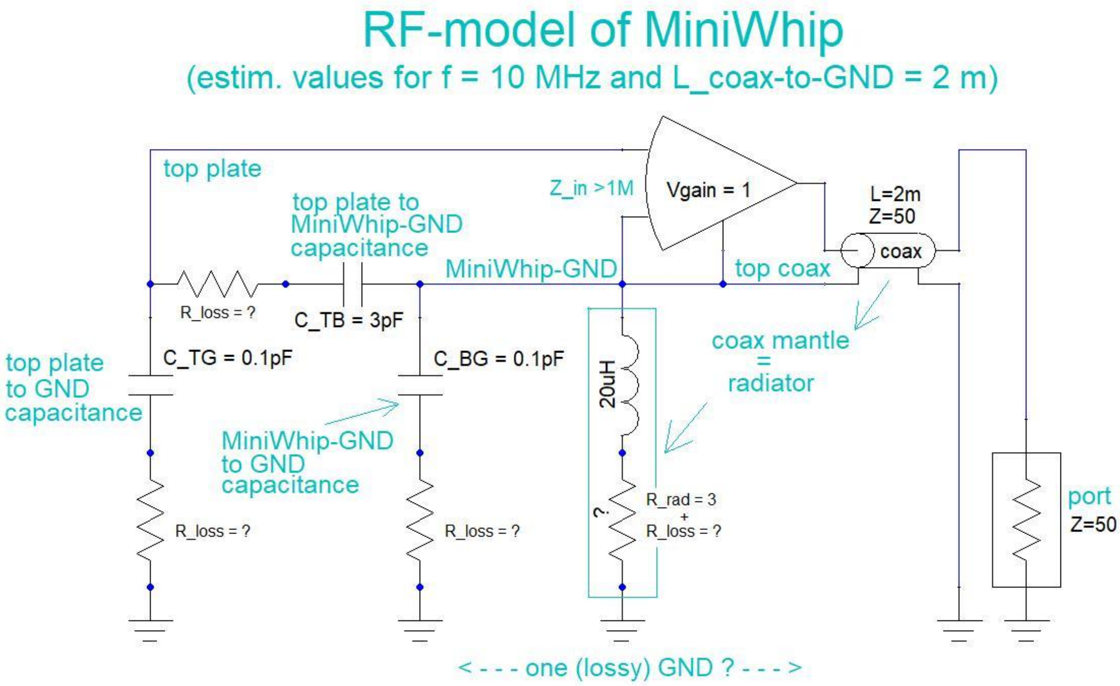

Fig. 6 RF model for the MiniWhip.

It should be noted, in the case of the MiniWhip, that an increase in the value of C_TB, i.e. the capacitance between the conductive patch and the top of the radiator (being the top end of the mantle of the coax, also the GND-connection of the active part), *reduces* the strength of the received signal, while an increase in the value of C_TG, i.e. the capacitance of the patch to antenna earth, *increases* the signal strength.

This may explain why the signal strength can improve if the top of the antenna is bent back to ground and the patch of the MiniWhip is held closer to antenna ground. What happens then, is that C_TG increases and the capacitive tap changes in a favourable way. It is assumed here that the radiating part of the antenna (the mantle of the bent back coax) still picks up signal in that situation. It may also be a matter of a better S/N, due to a 'cleaner' earth ground locally. If the entire antenna (i.e. coax + MiniWhip) is laid flat on the ground, there will be no reception at all.

It is also interesting to note that the RF voltage on the MiniWhip patch, so at the very top of the antenna as a whole, just like the voltage on the top capacitor plate of the CMMA, is not (still) *higher* but slightly *lower* than the voltage at the top of the radiator just below it (the top end of the mantle of the coax, also the GND-connection of the active part).

If there were no coax cable with the MiniWhip to function as a radiator, for example if it were replaced by an alternative non-electrically conductive connection, then no reception would be possible. In that case, however, a conductive mast, with the MiniWhip mounted on top, *its GND-connection connected to the top of the mast*, can take over the radiator function.

If there *is* a coaxial cable, it will make little difference to reception whether the coaxial cable is routed along a conductive or insulating mast. What *can* make a difference is an earth pin. Either at the bottom of a conductive mast, or on the coax mantle somewhere at ground level, as in Fig. 2. The choice of its location determines where the radiator ends ('antenna ground') and can help to reduce the influence of local interference signals on reception.

Replacing the patch of the MiniWhip with, for example, a whip will only have an effect (either positive or negative) if the capacitive tap on the radiator changes in some way. The bottom line is that for maximum signal, the aim is to minimize C_TB and maximize C_TG (see Fig. 6).

The MiniWhip and the CMMA are not necessarily vertically polarized. A connection to the real earth is also not necessary, a substantial counterpoise is sufficient for 'antenna ground'. A MiniWhip should also be able to work on the balcony of an apartment building, by making an antenna as long as possible, with the MiniWhip at the top, and sticking the whole thing out at an angle, with a metal balustrade or other large counterpoise *connected to the coax* *mantle and/or mast at the lower end point of what is the actual antenna*, thereby defining the ‘antenne earth’ point.

And then the ‘near field’ of the antennas, and the antenna currents. Simulations give an impression. We have to distinguish between self-generated fields for transmitting (CMMA only) and the interaction with incoming waves from the ‘far field’ for receiving (MiniWhip and CMMA). *We look at the fields in a plane that vertically intersects the antennas.*

Fig. 7 (L) shows the generated field of the CMMA from Fig. 1, on a well-conducting circular ground plane. The field strength is highest at the edge of the plates, up to 200 V/m (pk) when driving the antenna with 1V (pk), corresponding to 10 dBm in the 50 Ohm antenna (scale 200V pk). On the right (R) is an image of the currents on the antenna, up to 1A (pk).

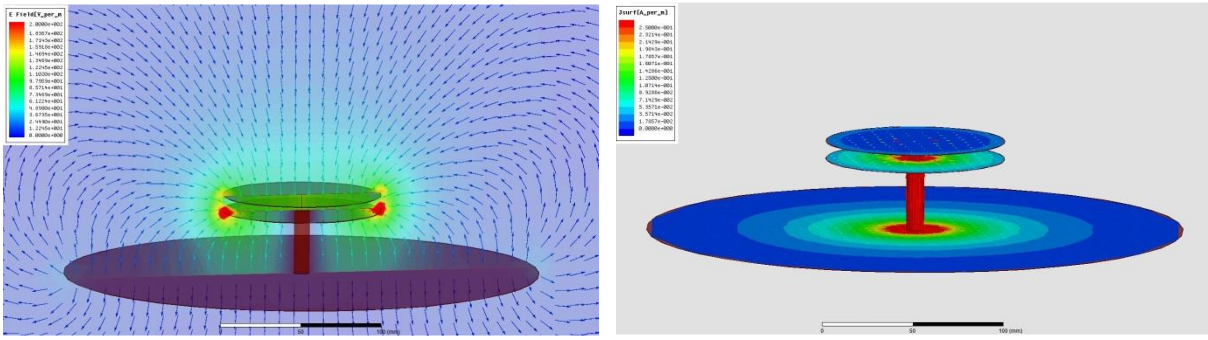

Fig. 7 (L) Generated field around a CMMA, (R) surface currents.

In Fig. 8 we see the response of the CMMA to an incoming plane wave with field strength 1V/m (pk) propagating horizontally from left to right, above an infinitely large perfectly conducting ground plane. On the left an image of the isolated incoming field (scale 1V pk), on the right the resulting total field (scale 2.5V pk). Note that these are *snapshots*, at the moment when the incoming wave has a maximum exactly at the antenna centre position.

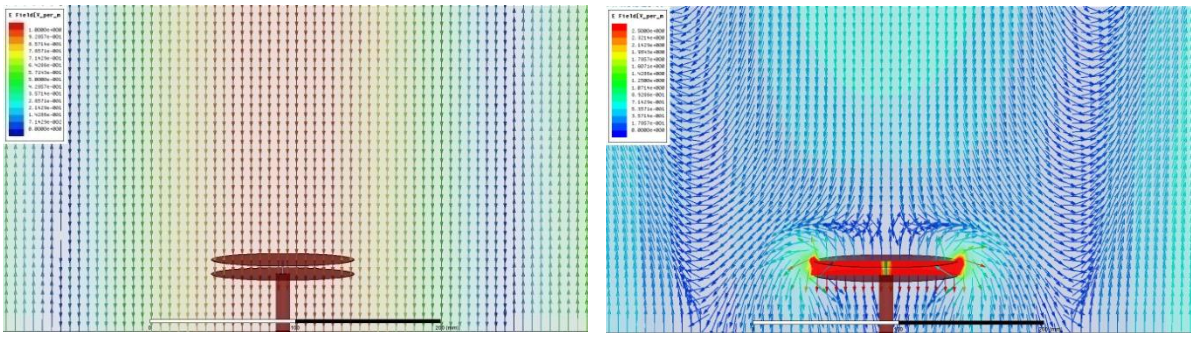

Fig. 8 (L) the isolated incoming wave, (R) the resulting field around the CMMA.

It is difficult to say anything about the image of the resulting field, and you should actually see an animation over a whole period of the wave. On the scale of Fig. 8 (R) you also miss details, such as the fields close to the radiator that do not seem to be perpendicular to the conductor (yet visible when zooming in). The max field strength is more than 4V/m (pk) between the plates and at their edges, with an incoming field of 1V/m (pk) and 50 Ohm load.

If we do the same for a MiniWhip on top of a radiator of 2 meters height and at a frequency of 10 MHz, we get a completely different image (Fig. 9). Remember that these are also *snapshots*, just like in Fig. 8 also at the time that the incoming wave has a maximum at the location of the antenna. Despite an equally strong incoming field (1 V/m pk), the scale of the resulting field is quite different from Fig. 8.

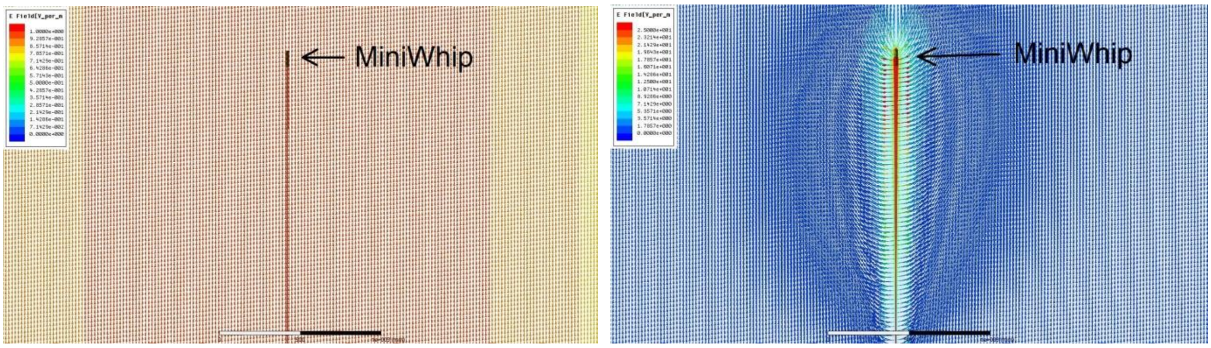

Fig. 9 (L) the isolated incoming wave, and (R) the resulting field around the MiniWhip.

Compared to Fig. 8 (L), the phase of the field of the incoming wave in Fig. 9 (L) changes relatively slowly at 10 MHz despite the larger physical size of the antenna (as can be seen by almost one red color from left to right, scale 1V pk). The resulting field (R) around the antenna is even more difficult to image well than with the CMMA (scale is 25V pk). See Fig. 10 for a close-up of the MiniWhip at the top of the radiator.

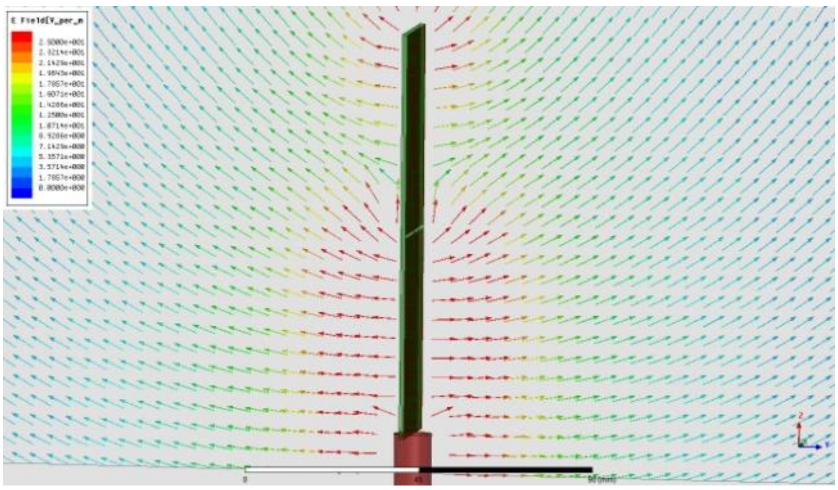

Fig. 10 Close-up of the resulting field around the MiniWhip.

The MiniWhip in this simulation is modeled as two copper patches of 30 X 50 mm with 1 mm spacing, on a standard single-sided FR4 printed circuit board (green), at the top end of the radiator, modeled as a copper cylinder of 2 meters in length and 10 mm in diameter (brown). The upper patch is loaded here with an impedance (resistance) of 1 megaohm to the lower patch, which models the active part of the MiniWhip, with an (assumed) ohmic input impedance of 1 megaohm.

It may not be very realistic to assume an infinitely large perfectly conducting earth in these simulations of the MiniWhip. But under such conditions, the field strength around the top of the radiator (i.e. at the MiniWhip) increases according to the simulation to as much as 50 V/m (pk) with 1V/m (pk) incoming field.

Also not so realistic is perhaps that the incoming wave in these simulations would arrive exactly horizontally (a real 'ground wave'). After all, at shortwave frequencies or even lower, we more often have 'grazing incidence' (obliquely from above) after reflection of waves against the ionosphere, sometimes even almost perpendicularly from above.

Despite these reservations, the simulations do at least give an idea how things may look like.

This concludes this article on the remarkable similarities but also differences between two special antennas, the CMMA and the MiniWhip, and an explanation of how they work. The MiniWhip has been successfully used for the WebSDR at Twente University (http://websdr.ewi.utwente.nl:8901/).

The reader is encouraged to send the author any comments or remarks, and questions are also welcome. It is quite possible that a revised version of the article will appear if new insights become available. Please address your comments to Hans Van Bruggen (PA3AZA) at info@elegantsolutions.nl.

A Dutch version is also available. Publication only via ElegAnt Solutions' website: http://www.elegantsolutions.nl/News.htm

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