

Progress in Design Of Extremely Short Transmitting Antennas *Short and still efficient, how is that possible?*



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There may be some environments where the dreaded antenna policy is so strict that you not dare put any short-wave antenna of usual dimensions outside.

Other hams like me living in a high-rise condominium where antennas are not welcome or where only very restricted space is available. The only solution is to employ an antenna small enough which does not attract the unwanted attention of the neighbourhood.



Photo 1:

A 40m DL7PE-MicroVert Monopole of the length of only 32 inches fixed on a balcony during vacation. Shown here in almost horizontal position. It is more than it appears to be!

On the way to the marvellous DL7PE-MicroVert

It took me many years to test the various common designs of short antennas such as magnetic loops, mobile radiators, helical-wound wires on fibreglass tubes, wire simply hanging on a fishing rod and tuned by a coupler or the dipole-shaped Isotron type with its capacitive plates. Some types with new ideas were published in German Magazines [6-10]. During this phase many more typical and non-typical aerials were thoroughly tested. All antennas managed to radiate, however did not deliver great signals at my location. Only the Isotron came very near to my expectations and attracted my attention. So I started to study the principles behind it and tried to improve this design. The attempt to find a more efficient solution resulted finally in a different concept of a Monopole.

The DL7PE-MicroVert introduced here is an extremely short and hardly visible short-wave antenna with outstanding radiation properties

Fig.1 shows the evolution from a closed resonant circuit to the concept described.

There are no wonder antennas!

...although it may seem so to some of those radio amateurs having tested this tiny little radiator and were surprised by its efficiency. However, all antennas will have to follow the laws of physics, as also does the DL7PE-MicroVert. Its operational capability is based on theoretical principles discovered by the German scientists Prof. F.Landstorfer and Prof. H.H.Meinke [1] published as early as 1973 in the communications magazine "NTZ" (Nachrichtentechnische Zeitschrift). Unfortunately not much attention has been given so far by anyone in the ham radio community. A high radiation resistance of about 30 Ohms was discovered at this time for small size monopoles being the sole secret of its efficiency. Still there was a lot of effort necessary to convert the theory into a practicable solution and matching certain conditions for their use as a radiating antenna. In spite of its very small dimensions the DL7PE-MicroVert has a high overall efficiency, which will according to my knowledge not be achieved by any other antenna of a similar small size.

Werner, DL6NDJ, has written about the very interesting discoveries of the Stuttgart University Professors to you in a separate article in this month's issue of *antenneX*.

Evolution from a resonance circuit to the DL7PE-MicroVert

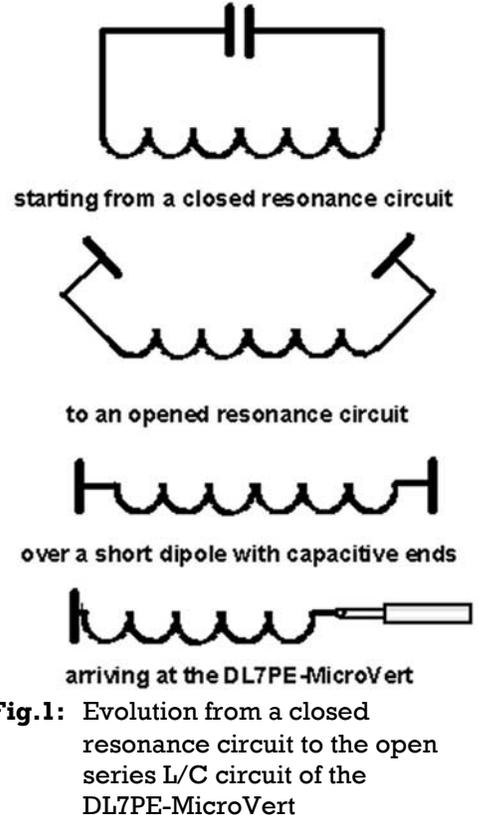


Fig.1: Evolution from a closed resonance circuit to the open series L/C circuit of the DL7PE-MicroVert

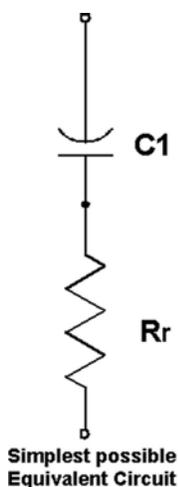


Fig. 2: Simplest schematic

The Monopole at a first glance:

It was the aim to develop a radiator with the primary objective of high efficiency at stealth size. The dimensions of the DL7PE-MicroVert (**Photo1**) are extremely short in comparison to the wavelength, i.e., $0,02\lambda$. No special counterpoise will be required apart from the coaxial-feeder cable. The simplest possible Circuit Diagram is depicted in **Fig. 2**.

It is only the capacitor in form of an Aluminium tube that radiates in the near field, an almost pure electrical field evenly distributed along the rod. Capacitance in general does not lead to as much electrical losses as it is the case with inductive components.

At resonance, the feeding-point resistance is real at around 50 Ohms. Thus, no antenna tuner will be required. Shifting of frequency (QSY) within the working range can be done on many bands without any adjustments.

For whom is this antenna useful?

As mentioned above, this antenna is especially for those people with antenna restrictions. Also for those on the road, on camping sites or for amateurs with a second QTH where it is difficult to build something permanent.

Although it is not a mobile antenna for cars it has been used as mobile antenna on non-metallic Mobile Homes/Caravans as well as on non-metallic Ships.

However, if you can install a full-size antenna you normally are better off.

The principle of radiation

The principle is based on an open L/C series resonance circuit.

For an antenna to function, it should be electrically resonant. The DL7PE-MicroVert consists of 4 components

- the capacitive radiator,
- the reactance coil,
- the resonant coaxial cable-counterpoise and
- the electrical insulator (RF-Choke).
-

A proper match is automatically achieved with the right combination of those four components.

Any antenna needs also a sufficient area to couple the radiation into the atmosphere. By stretching the capacitive plates to a greater physical length, as well as by the implementation of the feeding coaxial cable as a low-radiating counterpoise, this area has thus been considerably enlarged and contributes to high efficiency.

The antenna emits in the near by field mainly an electrical field (E-field) which is >30dB higher than the still existing small magnetic field which may be neglected. So we can consider the DL7PE-MicroVert aerial as an electrical radiator. The principle is opposite of that we know from the small magnetic loop with a predominantly magnetic field in the near distance (H-field).

However, both antennas will form a homogeneous electromagnetic field at some distance.

Comparison with the small magnetic loop antenna

According to Kraus [2], the electrical area of a small magnetical-loop with its evenly distributed current I is comparable with the equivalent to the area of a short Monopole.

Thus, a direct comparison between the two complementary systems is offered to us.

The efficiency of the *~1 foot long 20m DL7PE-MicroVert* is also comparable with a *~ 5 foot* diameter small circular magnetic loop antenna.

Evolution toward the DL7PE-MicroVert

Often it turns out that ideas, which seem to be new are not so new at all. This is also true with this antenna. Already during the 1980s Ralf Bilal [3] came out with his Isotron antenna (**Photo 2**), which is since commercially produced in the USA. Before that a similar design was used by the CIA. Also, many other amateurs did create such types, e.g., Douglas E. Person, W4DXV [4] with his variant of MicroVert. However, supporting literature was not found.

Many experiments followed according to the principle of trial and error to improve the efficiency and a great deal of developing and optimisation work was still necessary to arrive at the DL7PE-MicroVert in its present stage. During the course of evolution, also the appearance changed. The following steps were taken:

1. Converting the Top capacity plate from a flat sheet to a tubular capacitor of a greater physical length. This gives the advantage of a slim, less visible shape as well as a greater electrical "area".
2. By implementation of a counterpoise, the RF-"area" was again considerably enlarged. But instead of using a second tubular capacitor, the available coaxial feeder is used for this purpose. However, also dipoles have been built with 2 radiator tubes, which shall not be discussed here.



Photo 2:
The Isotron with the vast capacity plates

According to Landsdorfer/Meinke there is an additional capacity $C1$ apart from the radiating capacity $C2$ that they called "dead-capacity". This capacity forms a closed rf-field to the near environment, similar to that of a conventional capacitor.

$C1$ does not exist if the radiator is of $\frac{1}{4} \lambda$ length, while its capacity increases steadily with the decreasing of the radiator's physical length. Hence, the capacitance $C1$ becomes part of the antenna capacity and results in a new radiating resistance R_{r0} of almost constant 30 Ohms regardless of the frequency used. This phenomenon actually is the key to success (**Fig. 3**).

In the next paragraph we will discuss the four components used.

Equivalent Circuit of the DL7PE-MicroVert

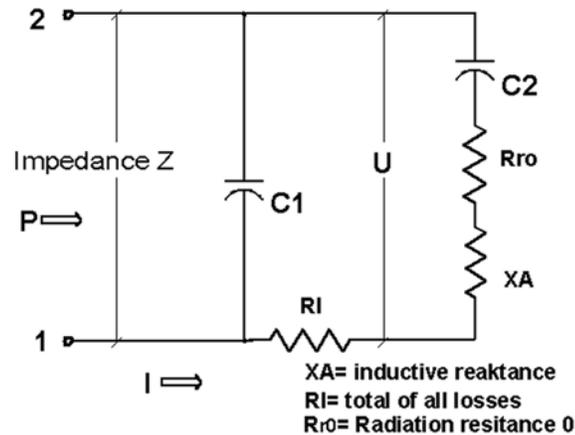


Fig. 3: Equivalent circuit including $C1$ ("dead" Capacity). X_A stands for the reactance Coil, while R_I is the summary of all losses.

Principle design of the DL7PE-MicroVert

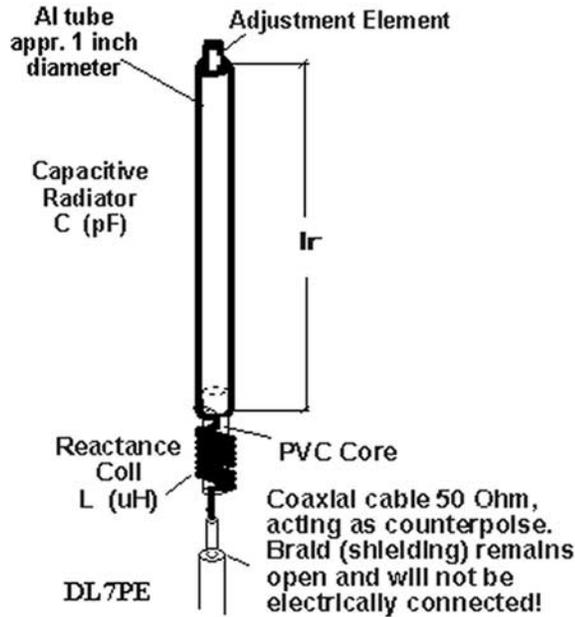


Fig.4 Principle design of a DL7PE-MicroVert Monopole

Component 1: The radiator:

The dimensions of the radiator used have been designed in such a way and optimised that with the shortest possible physical length a reasonable operational result is achieved. Any further reduction of length would immediately reduce the efficiency dramatically as well as reduce the bandwidth. With **Formula 1** this length can be calculated for any frequency.

$$l_s \text{ (mm)} = \frac{4700}{f \text{ (MHz)}}$$

Formula 1: Radiator Length

The capacity of the radiator is dependent on the length of the tube as well as on the diameter used. Should an attempt be made to reduce the length and increase its diameter so that it would result in an equal capacity, the effectiveness would considerably suffer as the following example shows.

Effects on changes observed:

- Signal strength of a full-size Dipole: S9 + 10 dB
- Signal strength of a DL7PE-MicroVert: S9
- Signal strength of 50% reduced Radiator: S7

In comparison to the Dipole we have already -22 dB reduction of signal strength if a radiator is only 50% of the proposed size and with greater diameter.

If the length would be increased it will result in a greater bandwidth without noticeable change of efficiency.

Formula 2 allows the theoretical calculation of the capacity:

$$C_{pF} = 19,1 \times l_s \times \frac{1}{\log 0,575 \times (l_s/d)}$$

Formula 2: Calculation of the capacity of a tubular radiator

To obtain proper results it will be necessary to give the length l and diameter d in meters!

On top of the radiator rod is a movable adjustment element, of non-galvanic alloy, connected to the radiator (**Photo 3**). It is coupled only on capacitive basis. Frequency adjustments to compensate the environmental influence will be possible with the help of this element.

Component 2: The reactance Coil:

The capacitive reactance of the radiator has to be compensated by an adequate Inductance X_A as shown in **Fig. 3**. For this purpose a suitable Coil has to be made.

We all remember having seen some mobile antennas with water bucket size coils, using up to finger-thick wires at large spacing between the windings. This is essential for those whip antennas in order to keep the electrical losses as low as possible and to achieve suitable radiation efficiency. Those types of antenna have only a very low radiation resistance in the range of a few Ohms where any small loss would have an immediate effect on the efficiency.



Photo 3: Adjustment Element

Not so for the DL7PE-MicroVert having a much higher radiation resistance where only a reactive inductance with small dimensions and small wire-sizes will be necessary just to transport the emitted RF-power without getting warm. Also, high demands on the Q of the coil will not be required. This leads us to a rather slim coil design with a diameter of around one inch and small wire diameters, e.g., #18 for 150 watts pep!

The inductive value can now easily be calculated with the help of the well-known **Formula 3** after the capacity of the radiator is computed.

$$L_{\mu H} = \frac{(159/f)^2}{C_{pF}}$$

Formula 3: calculation of the required Inductivity of the reactance Coil

Component 3: The Counterpoise:

A Monopole is always used in conjunction with a ground plane, which acts as a sort of electrical mirror. As for any other non-symmetrical antenna system, it also becomes necessary for the DL7PE-MicroVert to have a counterpoise. But not in the manner that you think of a balcony railing or a metal-post or a separate wire that would have to be employed for this task. No extra Radial in any form is required with the exception of the available coaxial-feeder cable! It is the outer braid (shielding) of the RG 58 U, which will work for this purpose. It therefore should have a dense shielding.

Under specified condition it will provide a perfect matching of 50 Ohms. Therefore, the physical length has to be below $\frac{1}{4}$ lambda irrespective of the fact that a further coaxial cable of random length will be connected to the transceiver behind (in series) the RF-Choke. **Formula 4** is used to calculate the length of the counterpoise.

$$l_r (m) = \frac{\sim 58}{f (MHz)}$$

Formula 4: Defined Length of the coaxial cable part acting as counterpoise.

It seems that a part of the energy of the radiator tends to bounce back from the counterpoise. So far I could not find any clue that the counterpoise is radiating as might be expected. Only a very low electromagnetic field was found if compared with the Monopole. Thus all measurements point to the fact that radiation takes mainly place on the capacitive radiator.

This explains also why it makes no difference to the signal strength if the bulk length of the counterpoise is laid hidden behind a steel enforced concrete wall.

To insulate this part of counterpoise from the next part of coaxial cable up to the transceiver an efficient RF-choke, e.g., (Fig. 5) has to be placed between those 2 coaxial cables.

Usually two opposite windings of 4 to 5 turns can be accommodated giving sufficient inductivity.

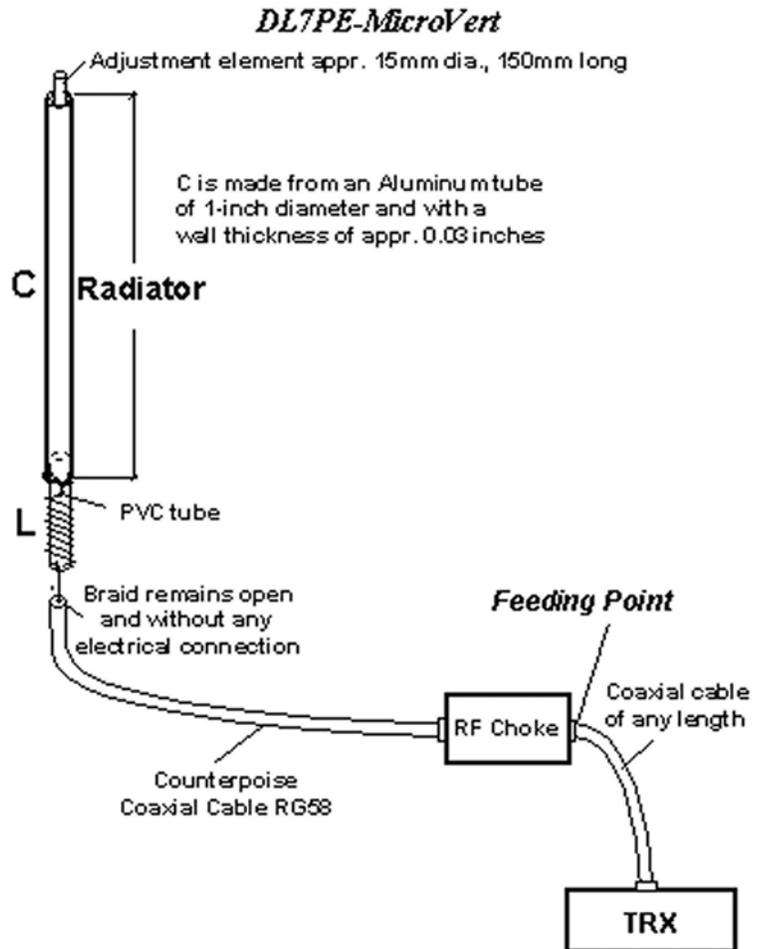


Fig. 5 Choke according To W1JR

Tuning the antenna-system:

Final tuning to the desired frequency is possible by:

- a) Adjusting the Coil inductance by reducing or increasing turns.
- b) Adjusting the radiator rod length.
- c) Shortening or extent the Counterpoise

A VSWR of 1.3:1 or better should be achieved after tuning.

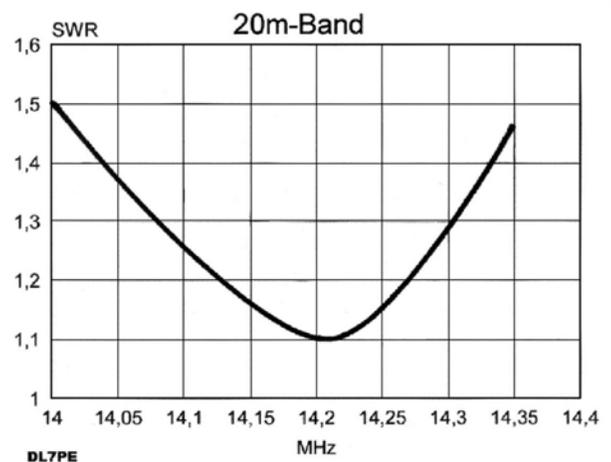


Fig.6: Typical SWR-diagram for the 20m band

Fig. 6 shows the typical SWR-diagram for 20m after tuning. The impedance has been measured with an RF-1 Analyst-Instrument after the antenna resonance was adjusted

approximately in the middle of the band. In this case the complete band can be conveniently worked without an antenna-tuner. The impedance at resonance is 50 Ohms behind the RF-Choke at the end of the Counterpoise.

Directivity and Radiation pattern:

For this kind of short antenna a radiation characteristic near to that of an isotropic antenna can be assumed. In vertical position it favours practically no direction and it radiates under all elevation angles. It therefore can be well compared with the small magnetic Loop

There will also be a little directivity at horizontal polarized operation. Then it may show approx. 3 dB as depicted in **Fig.7**. Because of the characteristics as explained above no antenna rotator is required.

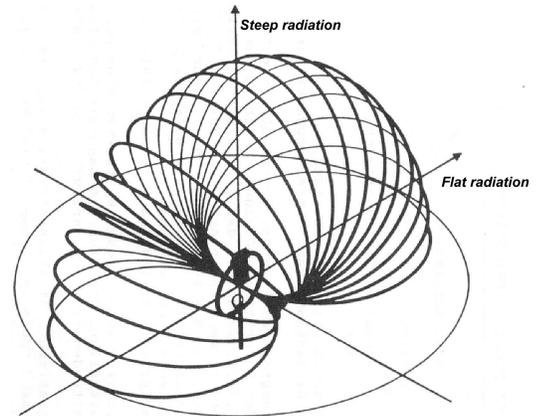


Fig. 7 Radiation pattern of a vertical small magnetic Loop more or less identical with that of the DL7PE-MicroVert

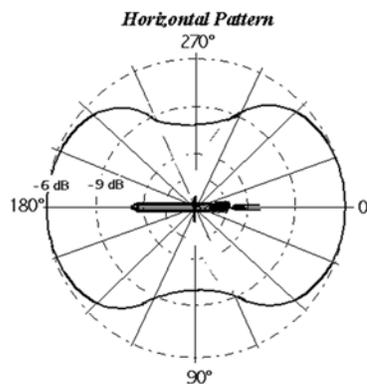


Fig. 8 Horizontal-Plane Radiation Pattern of the DL7PE-MicroVert

Interference: BCI or TVI

How will the DL7PE-MicroVert behave?

Due to its rather sharp resonance-circuit there will be no harmonics or sub-harmonics generated and interference is hardly possible. This is advantageous in particular in apartment buildings where TV/Stereo sets as well as the common TV/BC set-ups have only a relatively short distance to your antenna. No interference can be expected except direct irradiation at very close distance to the appliance.

It may also be known to you that the magnetic field of a small loop easily penetrates the walls of a building even if made out of steel enforced concrete. Not so with the electrical field of the DL7PE-MicroVert which provides a far greater security in this regard. In the environment of my apartment there are many flats around me, above and below me in rather near distance. However, none of the neighbours have ever complained about having interference in spite of running at times 500 to 600 Watts of radiation power!

Operating experience

My antenna was first set up in 1997 and is since in use as the only antenna for short-wave operation. Eight Monopoles are available for all bands, which proved to be successful during the course of time. Reports of 5/7 to 5/9 and even 5/9+10 dB or more are frequently received from my QSO Partners. Also DX operation is possible during favourable propagation conditions, e.g., Australia, USA and other Continents could be worked from Germany. QRP contacts were made on 20 and 40m with only 1-watt output power. When I describe the antenna, I often have to deal with a mini-pileup as one station after another wants to know more about this short antenna. Willy, DM3WSO, reported that he has recorded 1030 QSOs in his computer log and worked 16 Countries within 7 months with his DL7PE-MicroVert on the 15 and 20m bands. Like this I receive frequent letters from many OMs expressing their thanks for this antenna design, which gives them an opportunity to be on air again. Some of those letters can be found on my homepage:

www.t-online.de/home/dl7pe/afu.htm

In my homepage you will find also parts of my logbook.

Another feature of this antenna is the excellent low noise reception quality which you will surely enjoy.

Technical Data

Feeding-point Resistance:	50 Ohm real
Gain:	-6 to -12 dBd (below full size dipole)
Max. Power:	150 to 1000 Watts pep, depending on the design
Polarization:	Vertical or Horizontal, depending on Installation
Counterpoise:	None, except Coaxial Feeder cable
Typical SWR:	1.3 :1 or better

Antenna lengths (m)

80m Band:	≈ 1.60 m (<6 ft)
40m Band:	≈ 0.80m (<3 ft)
20m Band:	≈ 0.40m (< 1.5 ft)
10m Band:	≈ 0.25m (< 1 ft)

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