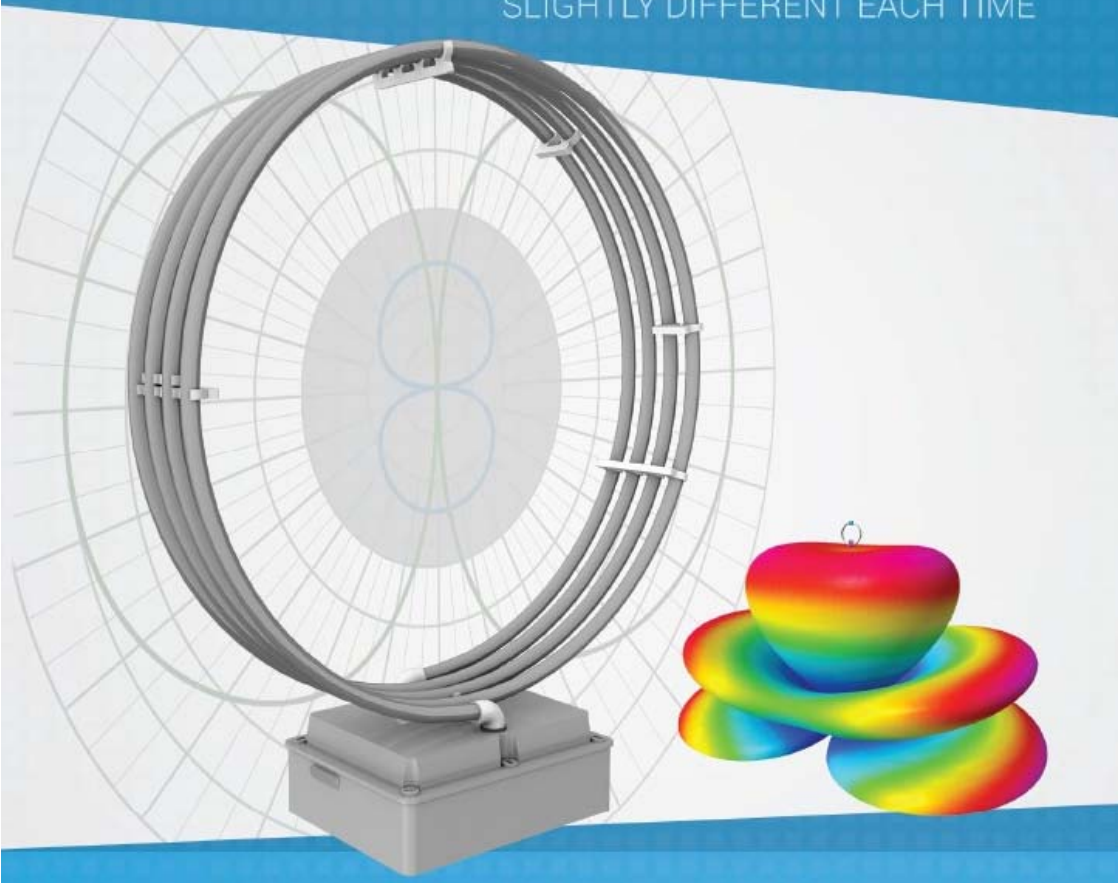
MAGNETIC LOOP ANTENNA

SLIGHTLY DIFFERENT EACH TIME



OLDŘICH BURGER | MAREK DVORSKÝ

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LaTeX

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M L A

Magnetic Loop Antenna

after 90 years

Montain Recruer 1924

Motto:

Compare the Comparable

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Preface

The book Magnetic Loop Antenna with the subtitle Slightly Different Each Time, was firstly published in Czech language in January 2015. The writing style of the book is a good example of an effective teamwork between academic theory and practice, where both of the authors examine the subject from their own points of view.

Ing. Marek Dvorský, Ph.D., assistant professor at VŠB – TU Ostrava, has been focusing since a number of years on antenna design.

Oldřich Burger, a former Army SigComm specialist with a HAM license since 1967 and a shareholder of the company BTV, is busy in the field of telecommunications. Marek's work inspired him. Since then he has been engaged in MLA development for commercial purposes. The result of his enthusiastic work are several unique types of MLA.

The first chapter of this book deals with a theoretical description of the MLA (including an MLA calculation example). The second part describes several types of unique MLAs. The third chapter is devoted to the independent evaluation of MLAs by HAM (radio operators who had the opportunity to use MLAs from BTV production). The last chapter provides a reprint of the in-house technical MLA documentation produced by BTV.

Finally, and with great pleasure, we would like to say thank you to Jiří Polívka and Dewayne Holden for translation and proofreading. Last but not the least we express gratitude to our families for continuously supporting us all the way from the beginning to the completion of this book.

Oldřich Burger and Marek Dvorský

2

Magnetic Loop Antennas in Practice

"Trying to compare comparable things, let us not consider an `MLA` only as a replacement of a long-wire TX antenna. `MLAs` function as RX antennas nicely even under QRM and 'radio smog' that prevent a 'large antenna' from picking up any useful signal. `MLAs` deserve much wider attention than that the OK ham community gives them."

– Oldřich Burger

DURING the last several years, I have devoted a lot of time to technical experiments with `MLAs`, and also in-band operation with `MLAs`, to compare `MLAs` with other antenna types. The experience brought more questions. When Mark (coauthor) presented me his computer simulation results, with 3D models of `MLA` radiation at various heights above ground, we were surprised enough to raise a series of more questions.

It is useful to know that the practical advantage of an `MLA` (`MLA` size related to a wavelength) is logically higher with longer wave lengths. Naturally, one has to consider the optimum loop size $2a/\lambda$, and an achievable efficiency. It is also useful to know that good magnetic loop antennas may exhibit Q values exceeding 1 000, sometimes even more than 3 000. Such antennas then function really well and their 'loss' against a much larger dipole may be insignificant.

It is often observed that due to a simpler pointing of a small MLA, the MLA output signal can be larger if the MLA is pointed to the minimum of the dipole radiation pattern. If in an actual QTH it is impossible to build a classical long-wire antenna for the lowest SW bands, then good MLAs can be used as 'not-ersatz' antennas. The theoretical model of MLA radiation (a freely available 4NEC2 program) indicates that in certain directions and elevation angles, an MLA can have a real gain higher than that of a normalized dipole.

It is still important to say that not all MLAs are really good, with the Q higher than 1 000 (here named as 'royal' MLAs). A number of practical design hints can be used for the high Q [10].

The authors of this monograph did not intend to present a detailed instruction on how to build MLAs. The documentation in the form of pictures taken over several years is instructive for new creations, also in directions not pursued by BTV (due to economical reasons). Our intention was to offer important expertise not generally known. Such details are included also in MLA radiation patterns which are not generally known among HAM community.

We were quite surprised by the fact that the generally accepted (and included in textbooks) information about the basic MLA radiation patterns are different from experimentally observed data but also from the computer simulations presented in the theoretical chapter of this book. Popular publications repeat that this type of antenna (MLA) can be used at any height above ground, that its radiation pattern has a form of flat number eight with a strong minimum in loop plane, and that its vertical radiation pattern above a planar ground is a half-circle (a circle in free space), as in Fig. 1.5a, etc. Also an erroneous suggestion is propagated, that an MLA positioned vertically is suitable as a NVIS antenna. As one can see from figures and graphs in this book, some such points may hold but not all and under all circumstances (Fig. 1.8c).

From the graphs presented in the first chapters of this book it can be theoretically concluded that by locating an MLA at various heights above ground, its radiation pattern can be modified, mainly its vertical radiation angle (maximum). With larger wire antennas, a similar effect can be achieved by much more complex means. This knowledge can be utilized for an effective use of the transmission chan-

nel, or transmission distance, with respect to the ionosphere state.[3] The results of computer simulations clearly indicate that the radiation of magnetic loop antennas is different from the simplified image maintained so far. The misunderstood specificity of the MLA, observed in practical operations on short-wave bands (while momentary switching with several other antennas), acquires a new dimension in the light of new computer simulations.

It seems to me that the basic specificity of MLAs compared to a classical wire dipoles stems from the fact that MLAs generate a strong magnetic field component while a dipole generates both, electrical as well as magnetic component. With the classical dipole a clearly defined wave polarization exists due to dipole orientation above ground plane, so defining the balanced electrical and magnetic field components. In terrestrial communication we speak about vertical or horizontal polarization, and the separation of V/H polarization typically is up to 20 dB (receiving by an orthogonally-polarized antenna). The MLA evidently behaves otherwise. As can be seen from experiments and computer simulations, the MLA generates in free space both wave polarizations at the same time while the vertical polarization tends to be dominant. Paradoxically this is not dependent on loop position against the ground plane (vertical/horizontal).

A specific behaviour of a magnetic loop antenna as transmitting or receiving a space wave reflected from an unstable ionosphere is observed in a temporal and qualitative different fading effect (QSB), and can be explained probably by that the wave propagates in both polarizations. When the signal propagates as a space wave (reflected from the ionosphere) it is in practice difficult to say if an MLA at a given instant is better or worse than a dipole. Ionosphere varies quite fast, so the MLA to dipole comparison is often difficult.

A short conclusion: the MLA behaves differently than a wire antenna. For a practical use for a radio amateur, this fact can be transformed into the following recommendation: As a minimum, for improving reception, it is advisable to get an MLA as another RX antenna.[4] An MLA is not equal to a set of long beverages, but try to extend a beverage across a town square protected by con-

[3] This assumption was already empirically confirmed by experiment with two identical MLA-C located at a height of 1 m and 10 m above the ground.

[4] Multiband MLA-M is may be as another RX antenna an ideal solution.

servationists! There is a noticeable difference between a classical antenna and an MLA as mentioned in all independent references, page 99. The preference and difference of an MLA you will notice during the first T-storm and during summer QRN – you will have a significant advantage against other stations using classical antennas. For reception, the preference is quite impressive.

We are aware that any verbal arguments cannot convince curious amateurs; this is why we included graphics and colour 3D simulations in the chapter on Theory. For the wide HAM public there are four points of summary and comments as follows:

1. The Magnetic Loop Antenna behaves otherwise than a dipole antenna.

2. It is important at what height the MLA is located.

3. A vertically positioned MLA exhibits approximately equal sensitivity to H and V polarized wave (V is a bit stronger), while with a horizontally polarized MLA the sensitivity to H-wave prevails while V-wave is significantly rejected. This holds mostly for one-turn loop. On the other hand, if locating a multi-turn MLA close to ground (under one-meter height), then V-wave is stronger than H-wave! So far we cannot explain why there is such a difference between one- and multi-turn MLAs; maybe some error in simulation software can be the cause.

4. A widely held view that MLA equals to a NVIS antenna does not hold always, see Fig. 1.8a. By locating an MLA higher in a free space, we get more upward lobes. By locating an MLA above a conductive plane (house floor), a lower height above it will result in an upward lobe. The amplitude of this upward lobe increases with the size of the conductive plane while other lobes are reduced. Signal level varies with the MLA height while it does not depend directly on the radiation pattern variations due to the plane.

During the time I devoted to MLA development and testing I have re-discovered and possibly even invented an original know-how. I have measured and tested in operation tens of models and varieties of MLAs. From small VHF loops to large short-wave antennas,

fixed-tuned to tunable, I have tested all known or less-known loop-matching methods. The MLA-M (Multi-Band) antenna [UM(VI), page 159] is one of a few commercial MLAs that can operate over a wide frequency band at short-wave, although it virtually resists the physics. Some knowledge acquired in this narrow field of antenna techniques may be original and not published elsewhere.

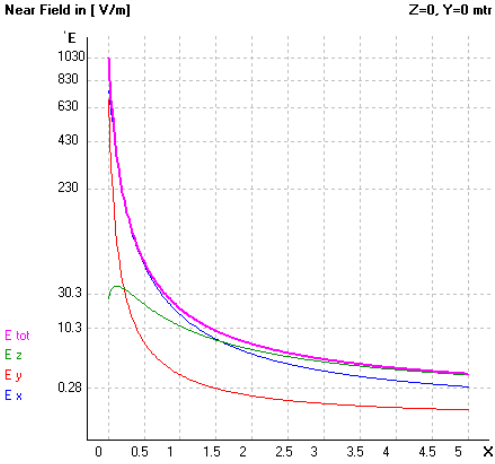
Magnetic Loop Antennas differ from the common 'classical' ones mainly in that like an optical lens concentrates light, an MLA concentrates mostly the magnetic field in its vicinity. This field, due to the physical properties of space and matter (Maxwell equation theory) then converts into a wave propagating through space by a speed of light. Close to the magnetic loop, the magnetic field component prevails. Although it is logical and mathematically proven, it is not generally known that this RF magnetic field close to an MLA has extremely high intensity.

An example of the pattern of magnetic and electric field intensity for 14.1 MHz and 10 W RF input power, for the distance from 0 to 5 meters from the MLA loop is shown in Figs. 2.1 and 2.2.

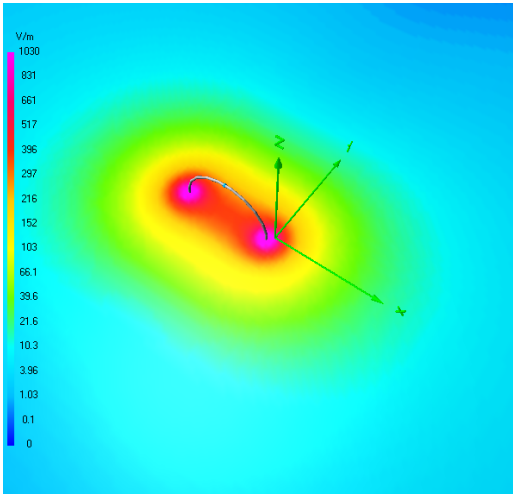
As can be seen, the peak intensities occur only very close to the loop. With a growing distance the intensity decays exponentially. Computer models (also those presented by Aki Kogure JG1UNE), page 73, indicate that the generally enforced recommendations on the close vicinity of an MLA are valid in the same extent as with other TX antennas. Several wave lengths from an MLA, the intensities of electric and magnetic field decrease under the standard limits.

Magnetic Loop Antennas differ from 'classical' antennas also by the fact that their radiation resistance R_r usually is by several orders smaller than in 'classical' antennas. As the antenna efficiency can be expressed by the ratio of radiation and loss resistances, see the formula (1.8), it is clear that due to this ratio a well–functioning MLA would rather be an exception, not a rule. Before I came to understand this fact, I fought for months by unsuccessful experiments.

Any (almost) manufactured loop antenna brings an unpleasant surprise for an inexperienced designer. By tuning the loop into resonance by turning the capacitor, the effect is clear and nice. Only time will show if the antenna is really good. An exact way to characterize the antenna is more difficult. The best way but not the simplest is to try the antenna in operation, and evaluate the reports statistically.

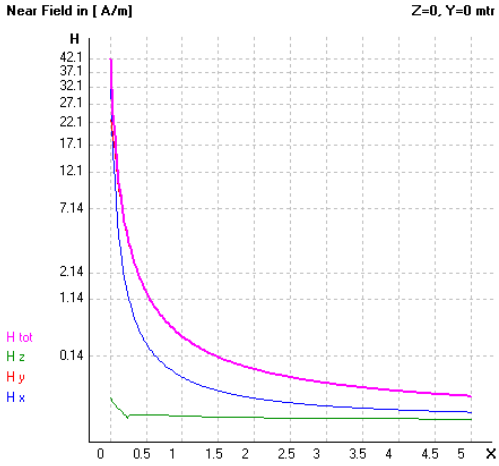


(a) Electric field, 1 mm to 5 m from loop conductor

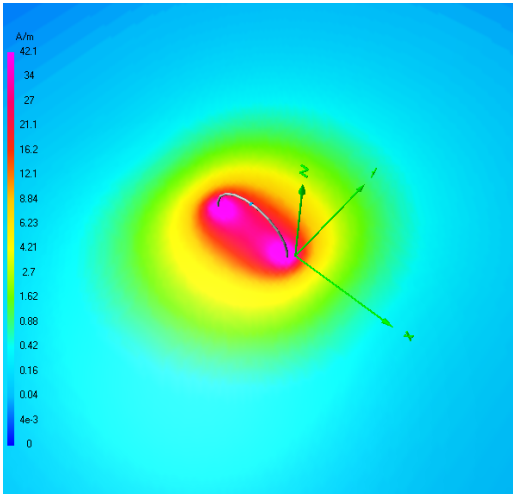


(b) 3D pattern – E component

Figure 2.1: Simulation of the near field (E component) for an `MLA` with 10 W input



(a) Magnetic field, 1 mm to 5 m from loop conductor



(b) 3D pattern – H component

Figure 2.2: Simulation of the near field (H component) for an `MLA` with 10 W input

Nowadays it is possible to use the useful tools RBN, the skimmers (page 127). Such approaches, however, require to collect hundreds of reports, and the variation of the ionosphere introduces more distortion, and larger by an order or two. So it is quite difficult to tell what `MLA` is good and what is not (Fig. 3.15). As I did not want to spend my time on reducing the loss resistance R_l by evaluating my `MLAs` as worse–equal–better, I gradually developed another approach by substitution. The progress evaluation is based on the Q value of the basic LC loop circuit. The Q factor can be read from the SWR plot. I assumed that Q in a LC circuit is a linear multiplication constant that increases the voltage across the capacitor in resonance. As the LC circuit of an `MLA` is also a radiator, then the ratio of the radiated power (ERP) between an etalon (MLA_1) and a tested unit (MLA_2) is proportional to the square of Q_1/Q_2 ratio. By putting the bandwidth and frequency in the formula for Q, then after some reduction (2.1) we have relative gain:

$$G_{\mathrm{MLA}_{1,2}} = 10 \cdot \log \frac{b_1}{b_2}, \tag{2.1}$$

Fig. 2.3 shows how b_1 and b_2 are read from `MLA` SWR plots, at $SWR + 2.414$ [11, 12]. Formula (2.1) has the limitations that the measurement must be related to the same frequency f_0, and the same antenna design (the loop diameters must be roughly equal). By using the described approach, all complex calculations may be avoided. In practice, I found that just the minor insignificant points become important that affect the loop Q (and can be easily evaluated by the SWR plot). The plot can be easily evaluated on PC monitor, and the result is straightforward (2.1). The relative `MLA` 'gain' helps any time one tries to improve the tested `MLA`. In practice, a glimpse on the screen gives the needed result even without calculation. The condition is to keep the same frequency sweep on the admittance analyzer, and to keep the same vertical scale on screen. For those not having an impedance analyser: you can take the SWR plot by using your TRX and SWR meter.

An important caution: the calculated `MLA` 'gain' from eq. (2.1) represents only a difference of MLA_1 to MLA_2 Q-factors, not the antenna gain like $\mathrm{G_{dBd}}$, or $\mathrm{G_{dBi}}$. With any `MLA`, the $\mathrm{G_{dBi}}$ will rather be negative.

Figure 2.46: Example of MLA-BMIS

Figure 2.47: Example of a 'Polystyrene foam' `MLA`

The conception of `MLA-ER` is not an universal design for a magnetic loop antenna. It is clear that there are many other designs and concepts of `MLA`s. Any simpler, cheaper and a smaller antenna for one use could barely be imagined. I have started with an aluminium foil like in Fig. 2.45; later I found a good replacement of copper pipes in PEXAL aluminium pipes for floor heaters (Al pipe alone is 0.3 mm thick), Fig. 2.50. More varieties of `MLA-ER` are shown in Fig. 2.50.

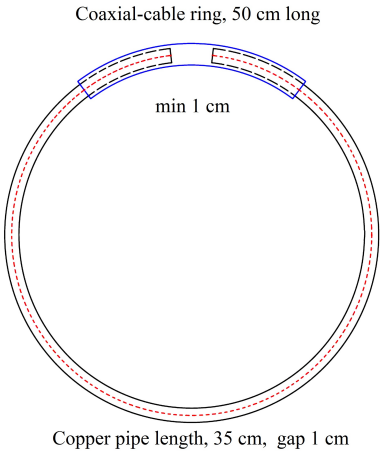


Figure 2.48: Example of `MLA-A`, detail [29–31]

`MLA-ER: Description and Operation`

The `MLA-ER` magnetic loop antenna is the final development result of five year's work at BTV company, and it can be said it breaks some traditional 'rules' of magnetic loop antenna design. It still holds that low-cost magnetic loop antennas can be manufactured only for less than 10 W RF power, and in their circuits only surplus variable capacitors can be used. To achieve a higher RF input, an objective cost exceeds several times the cost of a QRP `MLA`, and possibly 10 times more than a low-gain long-wire antenna. We have observed by trials that `MLAs` for 100 W RF input are commercially inaccessible for most of ham community.

The cost difference is objectively determined by the physical `MLA` principle. A correctly designed `MLA` has a very high Q, therefore a high RF voltage is generated between loop ends where the resonating capacitor is connected. For RF power input higher than 10 W, the voltage can rise to 1 kV, such capacitors must be large, heavy and costly. As in resonance the loop current is also high, all components of `MLA` resonant circuits must be rated for high voltages and currents. This directly affects `MLA` design. `MLA` resonant circuit

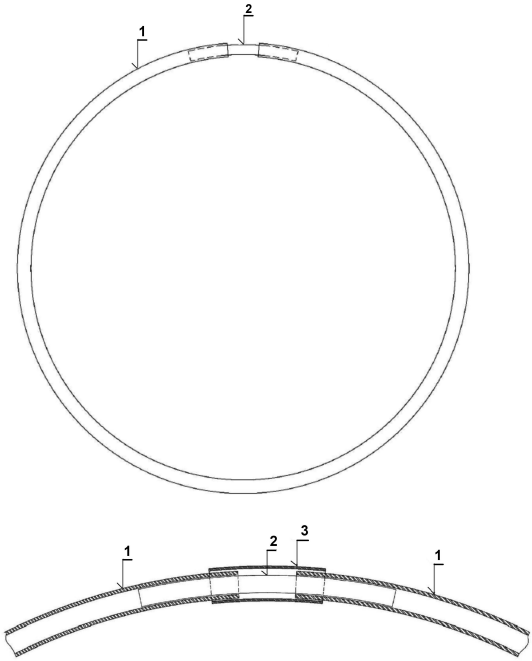


Figure 2.49: A schematic of `MLA-ER`

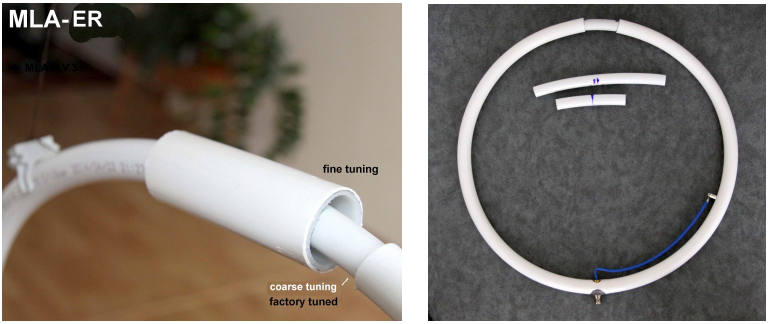
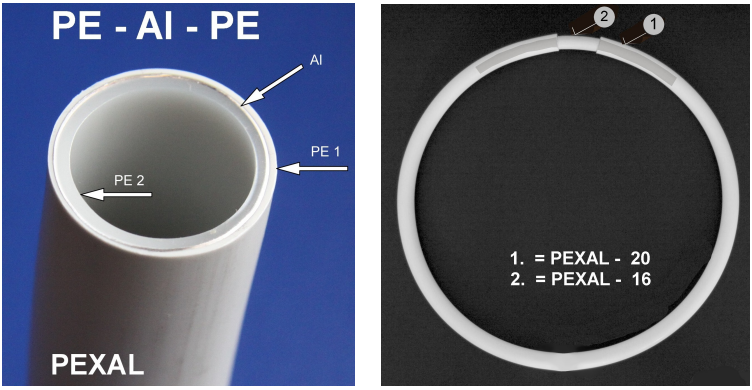


Figure 2.50: Simple philosophy behind `MLA-ER`

capable of operating under 100 W input must be designed along high-power electronics rules, and the cost rises correspondingly.

MLA-ER Principles

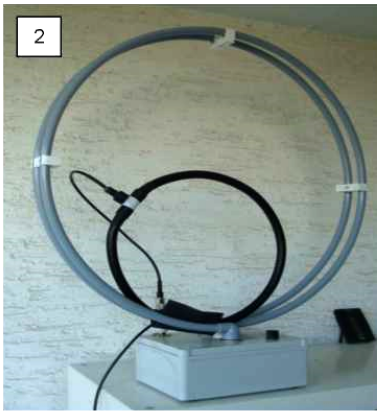
The base of MLA-ER design is a special resonant circuit, made of a single turn of PEXAL 20 three-layer tube. These tubes are used in floor heating systems. It has a conductive layer of 0.3 mm thick aluminium tube sandwiched between two polyethylene layers (Fig. 2.51a). A speciality of MLA-ER design is that there is no discrete capacitor to resonate with the loop. It is virtually created by an inserted tube of a smaller diameter (e.g. PEXAL 16), Fig. 2.51b, into the ends of the loop tube, PEXAL 20 (numbers are tube outer diameters in mm). Capacitance of this virtual capacitor is determined by insertion length of the thinner tube in the thicker one.

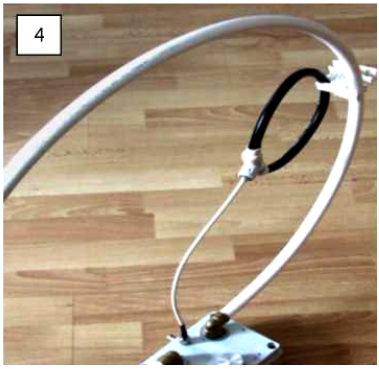


(a) PE-AL-PE tube **(b)** PEXAL's mail loop

Figure 2.51: MLA-ER; mail loop

While in the older model MLA-ER the resonant frequency was done by adjusting loop diameter and by inserting one internal section of the tube (Fig. 2.52), the new MLA-ER design has one common loop diameter, and insertion tubes are pre-cut in length for each individual frequency band. In other words, for each band frequency there are special insertion tube sections cut for each band. Those





References OK1DVA and OK1PFM

We had an opportunity to test `MLA-M` *magnetic loop antenna from September to November 2014 and test it in a practical operation on all bands specified by the manufacturer. This is 3.5 to 28 MHz including WARC bands.*

Our QTH: Loděnice u Berouna, QRA JN 79BX. Our equipment: Kenwood TS-850TS transceiver, 10 W output, `MLA-M` *antenna in a window, to the North or West. During three months we made several hundred QSOs in an ordinary traffic or in several contests.*

We operate our system as a leisure. We sleep in the night and are active during days. For our life style, `MLA-M` *is a very good antenna.*

On Sunday 5 October in KV PA contest I made 10 QSOs over 40 minutes which looks nothing special. But the KV PA contest only runs one hour and hundreds of stations take part with QRO equipment. The way MLA-.M operates a good experience was gained in OK/OM DX Contest, 2014. As the foreign stations search for OK/OM stations including weak QRP ones, we can sit on a top end of the band and call CQ. In that contest we made 150 QSOs, usually with responders to our CQ calls. Mostly we communicated with European stations.

On 14 MHz we achieved 10 QSO each ten minutes and were called also by stations from Asian part of Russia, Kazakhstan, Azerbaijan and the U.S.A. When you look at the small ring in the window (Fig. 23 PE-AR No.12/2014), it is quite impressive. I1ATL ended our QSO by saying: My compliments to your QRP!

OK1DVA and OK1PFM Petr Havliš ok1rar@seznam.cz

Magnetic Antenna, First Impressions
With author's permission taken from OK1CJB website

The antenna appears professionally made, has two turns and a plastic case attached to the loop. I opened the case and saw the printed-board circuit with various jumpers made of a copper wire, 3 mm in diameter. Also the manufacturer is indicated, OK2ER. Jumpers were set for 80 m.

The best time for experiments on 80 m is an evening. I connected `MLA-M` *in place of my wire antenna, and started listening. After a light tuning by the two knobs I heard several stations , all with S 8-9. I was surprised, I expected weaker signals. My FT857 had regime I set, it means the preamplifier was OFF. I could read CW and noise was very low. I turned the loop to see how directive it was. I found two maxima, one larger than the other. Also minima were two, one deeper.*

If I wanted to use antenna directivity, I would need a 360-degree rotator. 90 degrees would not suffice like it would if the pattern were like figure eight.

As I turned the loop, I noticed that I could reduce local interference down to S 1. I listened to UR5MSF some time as he called CQ DX, and as he made some US stations. I was able to hear them, too, S 1 to 2, but clearly. I knew about more DX stations. All that was a giant progress against my long-wire antenna as it generates a lot of interference on 80 meters at night. It cannot be reduced and stays at S7—8. I would never think about any DX listening. Receiving dynamic range with `MLA-M` *was fantastic, I heard cracking from far storms like S3–5, neighbor's elevator chirped S 6, noise S1–2, stations S1–9. Stations from EU, mostly German , generally S8–9. I have not seen more than S9 over entire evening. I am very happy to write this first report the magnetic antenna not only works but offers a wonderful listening!*

Vláda OK1SVB ok1svb@seznam.cz

`MLA-M` *Magnetic Antenna, A Bit Different*

I have participated again in this year's OK QRP Contest on 80 meters, just on my birthday. While I gained 15th place last year, I achieved 7th now, and was happy. The Contest is evaluated and results published as always during the QRP meeting in Chrudim but my health prevented me to attend.

Contest participants are also awarded by prizes from a lottery. I was lucky and won an `MLA-M`*, the Top Prize. This multiband magnetic antenna was made by B plus TV in Klimkovice, and made a nice gift to my 64th birthday. In the past I have only noticed* `MLA` *existence but was not interested.*

My friends Laco OM5LD, Marian OM3THX, Alex OM3TY and Milan OM3TBG were so kind o bring my `MLA-M` *prize to me in Trnava. It excited me to new experiments. Having read the Manual, I assembled the antenna, tightened screws, connected a cable, and started testing it.*

I put the antenna next to me, on a chair. After a while turning knobs I discovered how to tune my antenna, without a SWR meter. Later I tested the antenna with SWR meter but the result was identical and made me happy. I noticed no change in function after I put the antenna on my balcony.

After calling I detected that my `MLA-M` *is a genial invention. I do not like theories but prefer being convinced by myself (though I am an engineer and teacher of electrical engineering). I want to test everything, then I can decide. I started on 21 MHz, later on 18, 14 and 10 MHz, and using gradually 5 W, 4 W and 2.5 W I made interesting QSOs. I was nicely surprised to make WX and K stations from U.S.A., EA9 from North Africa, OD5, UA9, U0, over 4 900 km, with wonderful reports, from 339 to 599. I was extremely excited, I would have never expected such success. I continue testing the antenna having not much free time. I became convinced that* `MLA-M` *is the right antenna for all those amateurs who cannot build big antennas, in apartment houses, etc. I plan to test my* `MLA-M` *also on 7 and 3.5 MHz, and promise to write about my experience. In May 2013 QRP meeting in Vrutky I presented this antenna before the public, and gave a detailed information to all interested amateurs.*

Jozef Štefík - OM6TC stefik@stonline.sk

Several years since MLA-160 tests were published [15], I had an opportunity to test a new BTV company product, the MLA-T antenna. I was very surprised by that a normal operation on 80 m was possible with an almost invisible antenna (from outside the house), set on a chair on the seond floor on my family house. I made EM7 and G3 after a first call, with reports 579 and 599, respectively. My CQs were also responded by several reverse beacons. Such report is unbelievable for such indoor antenna. All QSOs and skimmer tests I did with the power limited to 50 W. This means there is a 3 dB spare power (LP 100 W) for the case MLA-T is located outdoors.

The only conclusion I could make now is that MLA-T is a really wonderful solution for those who cannot extend a really good wire antenna.

Jirka - OK2RZ kral@printo.cz

My experience with `MLA-M` in several sentences. Perfect matching. On all bands it definitely sucked all TX power to the air, no tuner needed. Perfect in storms, best used indoors. Good reference antenna. My property does not allow to build more antennas side-by-side, to switch them and compare by skimmers. Thanks to `MLA` I can compare various antennas during building and testing. There is no other affordable antenna perfectly matched on all bands.

Milan - OK2BYW ok2byw@centrum.cz

First tests I made in my QTH Žilina, from an eight-story concrete building apartment located at fourth floor. First nice surprise was that `MLA-M` can be perfectly matched by the built-in tuner on all bands, from 3.5 to 28 MHz. I have also a OM license for 60 m operation. I tuned the antenna from 5 258 to 5 405 kHz. Therefore it may be used on NINE amateur bands. With some patience the antenna can be matched to SWR 1.1:1. I used a FT817 with an output power of 5 W, and a resistive SWR meter of my own design.

I made a number of QSOs in EU on 17 and 20 meters. It i shocking that this tiny loop, 60 cm in diameter, located in an iron-concrete cage of a panel house can generate a readable signal with QRP 5 W input.

More tests and operation I have done in my other QTH, Žilina-Budatín. I have a LW antenna there, 9 meters to 5 meters above ground. The building is built of brick combined with concrete. The roof is aluminium sheet. I located my `MLA-M` on a camera tripod next to a window. I compared the two antennas by RBN, skimmer network. With 5W input the radiated field is low and no health problems were observed. (reference by OK2ER). On 12 m I succeeded to make J28NC and W1AW/4, the longest distances. All required is time and patience. The antenna is best for QRP. I can keep it in hand's reach and retuning takes a minute. When no outdoor antenna can be built, the `MLA-M` is a perfect possibility how to operate on short-wave bands.

Igor - OM3CUG om3cug@pobox.sk OK QRP Club 21G

I purchased my MLA-M in 2012. I live in a concrete-panel house, so I wondered how it will work. The first use and tuning was disappointing. I could tune the antenna but I saw no success. I could not achieve any response to my calls. I tried 80 meters, then 30 meters, still nothing. I started to try various locations, and the best results came when I put the MLA-M in the apartment hall. As my ham-shack is built in a closet, I put the antenna on a chair before door. Here the good results started to come. I tested all bands, 30 meters was best. After testing the MLA-M in Pilsen, I relocated the antenna to my son's weekend cottage in Highlands. There a big surprise came: with MLA-M and 5 W input I achieved a QSO with a U.S. station! First in Arizona, then to Florida. Both reports were 559! If you follow the Manual, MLA-M is easy to tune. I can notice a good rejection of various noises and interference around us. Although BTV now developed a high-power version for 100 W, I continue with MLA-M. Why? I enjoy to operate with low power, by CW. I never used SSB.

73! Vláďa OK1IVU ok1ivu@email.cz

I am using both MLA-M and MLA-T at a complex housing of a city. It is well known that most dwellers live in a restricted area here in overoccupied Tokyo.However, we do not want to give up operating with HF antennas at our veranda. So we must beg for small but efficient antennas, MLA-M and MLA-T. Feel very happy to use MLA-T especially on top bands [34].

Aki Kogure, JG1UNE kogure@kcejp.com

I just tested the MLA-M on 80 m send and receive for the past two days. I was very happy with the results. My JT65 signal was received up to 2 500 km on a regular base with only 0.5 Watt power and the antenna in my living room. Bandwidth is very small of course but for digi-mode no problem. For CW or SSB the antenna need to be close to the operator to readjust or we need a remote control for the C. This is the first time I had the chance to work on 80 m and this is new for me.

Gerard DL8SEL - gerardf@web.de

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Studied at High School of Electrical Engneering, Prague, later at Military Special Communications School, Nove Mesto nad Váhom, PF Ostrava. In 1970s worked as an electronic technician at Institute of Physical Metallurgy, Ostrava, Since 1989 he established a telecom company B Plus TV, acted as a CEO of one of the first private local TV networks. Published many technical papers. Since 2009 studied agnetic loop antennas, MLA.

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