Mala antenca za 1-10 GHz

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A SMALL ANTENNA FOR 1-10 GHz

Marko Čebokli - S57UUU

1. UVOD

Log-periodično antenico sem si zamislil predvsem kot primarni vir za parabolično zrcalo. Antenca pa je uporabna tudi samostojno, brez zrcala in ima v tem primeru dobitek 8 do 9 dBi, kar je zelo priročno za razna eksperimentiranje 'na dvorišču'. HI - dvorišče je lahko precej veliko, pri 100mW in 5dB šuma je teoretični doseg v praznem prostoru z dvema takšnima antencama brez zrcal še vedno več kot 100 km na 10 GHz in več kot 1000 km na 1296MHz.

2. IZDELAVA CIK-CAK LOG-PERIODIČNE ANTENE

Za frekvenčno področje 1-10 GHz je antena velika od vrha do repa 167mm.

Anteno izdelamo v tehniki tiskanih vezij, na enostransko kaširanem vitronitu debeline 0.8mm. Naredimo dve enaki ploščici in ju sestavimo, kot je narisano na sliki 2, tako da sta bakrena vzorca na zunanji strani. Preden ploščici sestavimo, lahko odvečen (prazen) vitronit poševno odrežemo kak centimeter nad konicami zobcev. Na zgornjem robu obe ploščici malo odbrusimo, tako da bakrena vršička prideta čim bliže skupaj, na milimeter ali manj. Ploščici zlepimo z aralditom (epoksi, donipox itd) pod kotom kakih 15 stopinj, tako da sta zadnja dela približno 45mm narazen. Zadnji del ojačimo z dvema ploščicama vitronita velikosti 20x60 mm, ki ju prav tako prilepimo z aralditom. Za lepljenje vitronita je daleč najboljše epoksi lepilo, ker je tudi vitronit samo steklena cunja, namočena v epoksi smolo. Če pred lepljenjem površino malo obrusimo, da postane hrapava, bo spoj postal neločljiva celota. Preden pa anteno zlepimo, je treba narediti balun za napajanje. Napajanje izvedemo s poltrdim (semi-rigid) kablom debeline 2.2 mm (UT 86). Na kos kabla dolžine približno 20cm monitramo konektor (SMA ženski), in kabel po vsej dolžini prispajkamo po sredini bakrenega vzorca na eni od ploščic, tako da konektor gleda kakih 5mm preko repa antene, prosti konec pa kak cm čez vrh. Prosti konec potem ukrivimo za približno 70 stopinj preko roba ploščice ter odrežemo bakreni plašč in teflon tik ob robu ploščice. Srednjo žilo skrajšamo na en milimeter. Kabel naj bo čim ostreje zakrivljen, vendar pa moramo biti pri krivljenju zelo nežni, da bakreni plašč ne poči. Zaradi simetrije moramo tudi na drugo stran antene prispajkati podoben kos kabla, ki pa je 'slep', brez konektorja. Zadostuje tudi samo zunanji plašč kabla ali pa bakrena žica premera 2.2 mm. Pri vrhu ga prav tako zakrivimo in odrežemo. Srednjo žilo popolnoma odrežemo, ker je ne bomo potrebovali. Zdaj lahko zlepimo obe polovici antene. V sredini, približno po 5mm na vsako stran od vrha, kjer prideta skupaj oba kabla, ne nanesemo lepila, da preveč ne spremenimo impedance. Srednjo žilo

1. INTRODUCTION

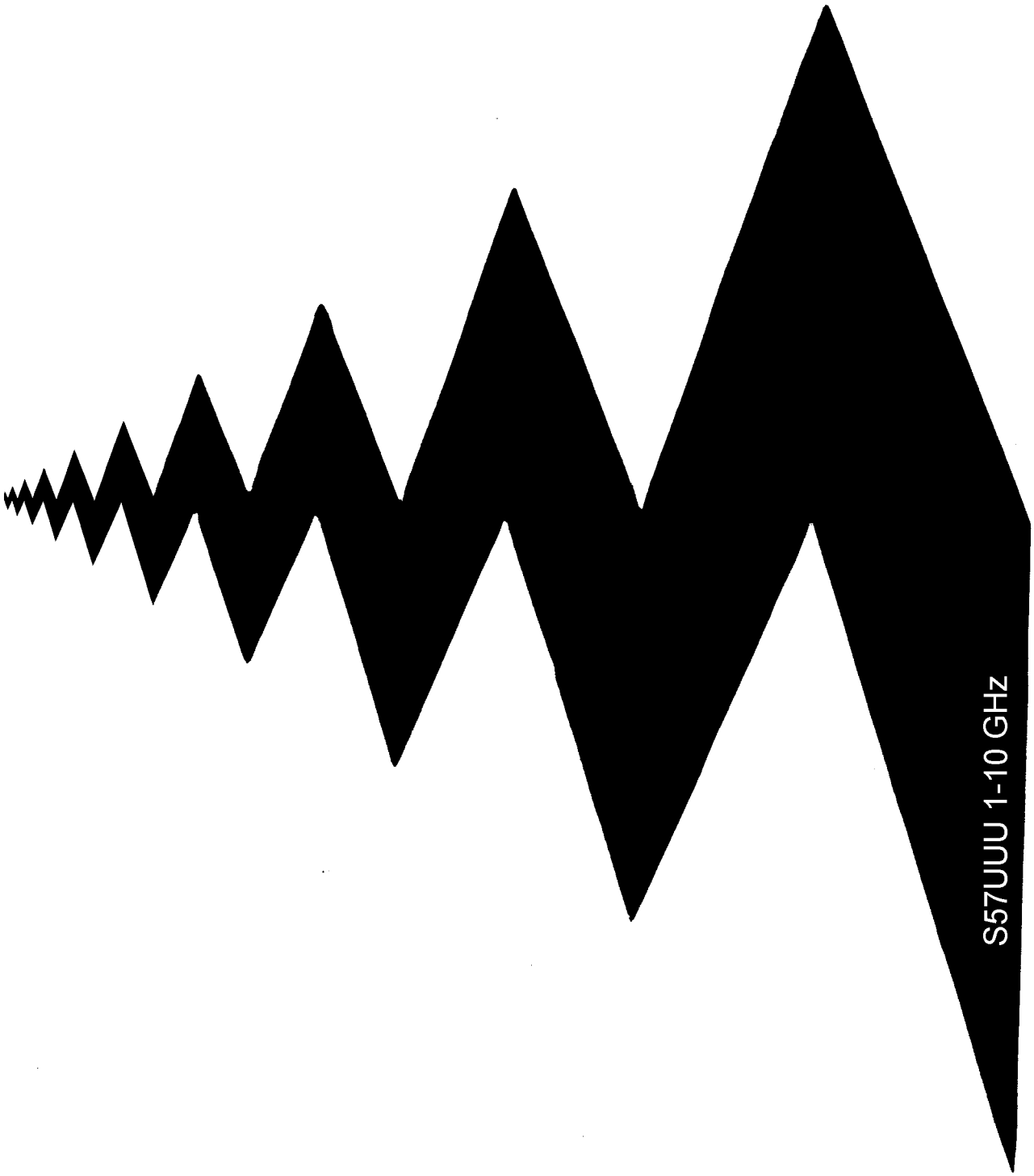
This log-periodic antenna was designed as a feed for a parabolic dish, but it can also be used alone. With 8..9 dBi gain, it is very convenient as an universal antenna for backyard experiments. HI - the backyard can be pretty big: the theoretical free-space range for 100mW and 5dB NF is more than 100km on 3cm and more than 1000km on 23cm.

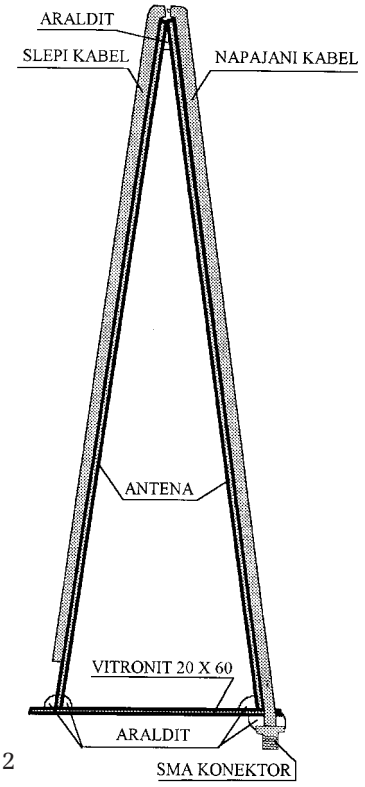
2. CONSTRUCTION

For the 1..10 GHz range, the size of this antenna tip to tail is 167mm. It is etched on 0.8mm thick epoxi PCB board material. Two identical boards are combined as shovn on fig 2, with the copper pattern on the outside. Before assembly, surplus PC board can be cut off diagonally about 1cm above the copper teeth. The inner edge of the boards at the tip should be filed away, so that the copper tips come within 1mm of each other. The two boards are glued together with epoxi glue at an angle of approx 15 degrees, so that the tails are about 45mm apart. The rear end is strengthened with two 20x60mm pieces of PCB material, also glued with epoxi. The PC boards themselves are mostly epoxi, and if the surfaces are made rough before applynig the glue, the bonds will be very strong.

The feeding balun must be made before the antenna is glued together. It is made of UT-86 (2.2mm diameter) semi-rigid cable. A piece about 20cm long with an SMA female connector at one end is soldered along the center of the copper pattern on one of the boards. The connector should reach about 5mm over the tail end, the other end about 1cm over the tip. The bare end should be bent about 70 degrees over the edge and the copper mantle cut tightly by the edge. The bend should be as sharp as possible, however care is needed to avoid breakage of the copper mantle. The center conductor is then shortened to 1mm or less. To achieve symetry, a similar piece of 'blind' cable (without a connector), must be soldered to the other PC board. A piece of solid wire with the appropriate diameter can be used instead, since the center conductor is not needed. This cable is also bent and cut at the top. The antenna can now be glued together. No glue is applied about 5mm to each side of the tip, to avoid changing the impedance. The center conductor of the feed cable must now be soldered to the mantle of the 'blind' cable. (fig 3)

The tip must be made very carefully, since the performance of the antenna at the upper end of the frequency range depends on this. The distance between the mantles of the feed and 'blind' cables should not surpass 1mm. With a precisely made tip, this antenna is usable up to 13 GHz. After the antenna is assembled, the


S57UUU 1-10 GHz



Slika 2 / Fig. 2

napajalnega kabla pri vrhu prispajkamo na plašč slepega kabla, kot je narisano na sliki 3. Pri izdelavi vrha moramo biti zelo pazljivi, ker je od tega odvisno delovanje antene v zgornjem delu frekvenčnega področja. Med koncema plaščev napajalnega in slepega kabla naj ne bo več kot en milimeter, srednjo žilo napajalnega kabla pa je treba prispajkati čim bolj na kratko. Če je vrh lepo izdelan, je antena uporabna vsaj do 13 GHz.

Ko je antena sestavljena, z dodatno ploščico vitronita velikosti 20x60 mm, v katero naredimo zarezo za prehod kabla, mehansko ojačimo še konektor. Ploščico prilepimo na zadnjem koncu antene, v sredini pri konektorju. Konektor obilno 'pripacamo' na ploščico z aralditom. Paziti je treba, da araldit ne pride na navoje konektorja. V sredini te ploščice lahko izvrtamo tudi luknjo za pritrditev antene. Ker je antena zelo lahka, za pritrditev zadošča en sam vijak v osi antene, kar omogoča preprosto menjavo polarizacije. Repa antene v sredini lahko povežemo s kosom navadne žice, da zaščitimo vhod postaje pred statično elektriko.

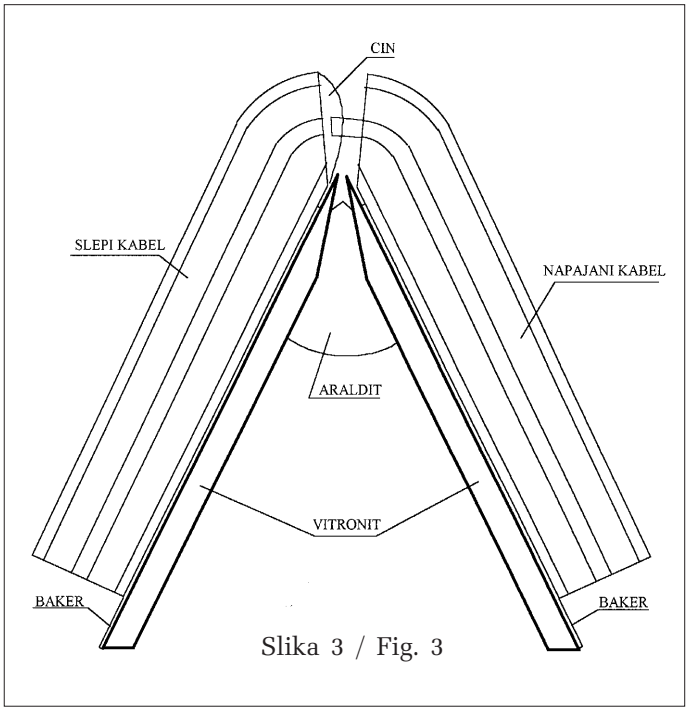
Izgled gotove antene prikazuje slika 5.

3. *ELEKTRIČNE LASTNOSTI CIK-CAK LOG-PERIODIČNE ANTENE*

Sevalni diagram te antene je v načrtovanem frekvenčnem pasu skoraj neodvisen od frekvence. V E ravnini (če vodoravno polarizirano anteno vrtim po azimutu) sta 3 in 10 dB širina diagrama približno 60 in 110 stopinj, v H ravnini (če navpično polarizirano anteno vrtim po azimutu) pa okrog 80 in 160 stopinj. Stranski snopi in razmerje naprej/nazaj so okrog -15 do -20 dB.

Tipičen smerni diagram v obeh ravninah je na sliki 4.

Razlika med obema ravninama bi bila manjša, če bi obe polovici montiral pod enakim kotom kot se širijo 'zobje', to je okrog 32 stopinj. V tem primeru bi lahko tudi



Slika 3 / Fig. 3

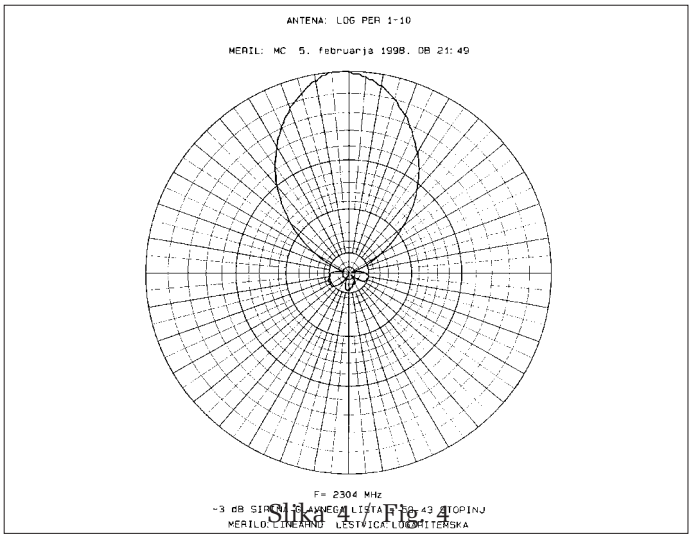
connector should be mechanically fixed using another 20x60mm piece of PCB material and epoxi glue. Keep epoxi away from the connector's threads! The antenna is very light, and can be supported by a single screw along its axis, so the polarisation can be easily adjusted. The tail ends should be connected with a piece of ordinary wire, to protect the transceiver against electrostatic discharges.

Fig 5 shows the finished antenna.

5. *ELECTRICAL PERFORMANCE OF THE ZIG-ZAG LOG-PERIODIC ANTENNA*

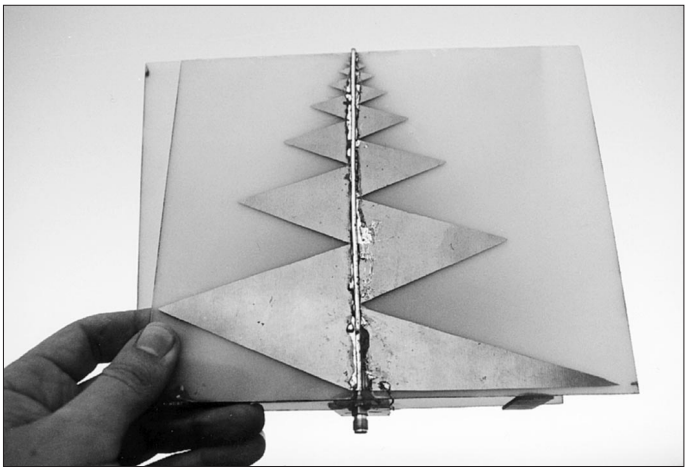
The directional pattern is almost independef of frequency in the planned band. In the E-plane (when a horizontally polarised antenna is rotated in azimuth) the 3 and 10dB beamwidths are approx. 60 and 110 degrees respectively, in the H plane (vertically polarised antenna rotated in azimuth) they are approx. 80 and 160 degrees. Sidelobes and front to back are about -15 to -20 dB. Fig 4 shows a typical pattern in both planes. One could reduce the difference between both planes by mounting the two halves at approx. 32 degrees, i.e. the angle at which the copper teeth 'grow'. In this case, one could also indent two such antennas at right angles and have acces to both polarisations simultaneously. The problem is that in this case the impedance of the antenna increases to about 100 ohm, requiring a broadband impedance transformation. It would be easy to make such a impedance transformer in microstrip form on the underside of the antenna board, but even on a real microwave substrate, the losses would be bigger than 2dB on 10GHz. Therefore, I decided to 'squeeze' the antenna a little, to get the impedance closer to 50 ohm. At the tip, where a bigger part of the space between the copper patterns is filled with dielectric, the impedance is lower. The chosen angle between the antenna halves (45mm between the tails) was chosen as a compromise between the match at higher and lower frequencies. From this point of view, it would make sense to etch the antenna on even thinner substrates, and put the halves closer together. Return loss

'uzobil' dve takšni anteni pod pravim kotom, tako da bi imel istočasno dostopni obe polarizaciji. Vendar pa pri takem kotu impedanca naraste preko 100 ohmov, in bi za prilagoditev potreboval širokopasoven impedančni transformator. Tega v mikrotrakasti tehniki sicer ne bi bilo težko narediti, n. pr. kar na spodnji strani antene, problem pa bi bile izgube, ki bi tudi na teflonskem laminatu presegale 2 dB na 10 GHz. Zato sem anteno raje malo 'stisnil', da se je impedanca približala 50 ohmom. Pri vrhu, kjer je večji del prostora med cik-cak linijama izpolnjen z vitronitom, je impedanca že zaradi tega nekoliko manjša, zato je izbrani kot (približno 45mm med repoma) kompromis med prilagoditvijo na višjih in nižjih frekvencah. S tega stališča bi bilo anteno bolje narediti na še tanjšem laminatu, in jo še malo 'stisniti'. Prilagoditev niha med 6 in 15 dB, tipično pa znaša okrog 10 dB. Dobitek znaša 8 do 9 dBi. Dobitek takšne antene sicer lahko povečamo tako, da jo naredimo 'položnejšo'. Ker pa sem to anteno načrtoval predvsem kot primarni vir za parabolično zrcalo, sem jo naredil precej 'strmo', da ima dovolj širok diagram za pokrivanje tipičnega simetričnega zrcala globine 0.3 do 0.4. Na strmejši anteni je manjše tudi seljenje sevajočega dela antene. Aktivni del antene se s frekvenco seli, kar je rahlo neprijetno pri napajanju zrcala, saj bi teoretično morali za vsako frekvenco malo spremeniti fokusiranje. Ker pa se na srečo kritičnost fokusiranja z rastočo valovno dolžino zmanjšuje, lahko anteno postavimo fiksno, tako da je približno v gorišču del, ki seva pri najvišji frekvenci. Pri tej anteni na 10 GHz sevajo zobci, ki so približno 1 cm od vrha. Zaradi nepopolnega fokusiranja in nesimetričnega diagrama je izkoristek zrcala seveda nekoliko manjši (1-2 dB manjši dobitek), kot če bi uporabili optimalne ozkopasovne sevalce, kar pa po mojem ni previsoka cena za univerzalnost takšne antene, še posebej če upoštevamo nizko ceno in enostavnost izdelave.



Slika 4 / Fig. 4

varies between 6 and 15 dB, typically around 10 dB. Gain is 8 to 9 dBi. It could be increased by making the antenna less steep. Because this antenna was primarily intended as a feed for a parabolic reflector, it was made quite steep, so that the beamwidths are suitable for a f/d 0.3 to 0.4 reflector. On a steep log-periodic antenna, the active region moves less with frequency. Theoretically, such an antenna when used as a reflector feed, should be refocused for each frequency because of this movement. Luckily, the sensitvity of focusing decreases for lower frequencies. Therefore, the antenna should be mounted so, that the part that radiates at the highest frequecy is in focus. On this antenna, on 10Ghz these are the copper teeth about 1cm from the tip. Because of non-ideal focusing and non-symetry the gain of the reflector will be somewhat (1-2dB) less than with an narrowband feed, but I think that is not too high a price to pay for versatility of such an antenna, especially considering the low price and ease of manufacture.



Slika 5 / Fig. 5