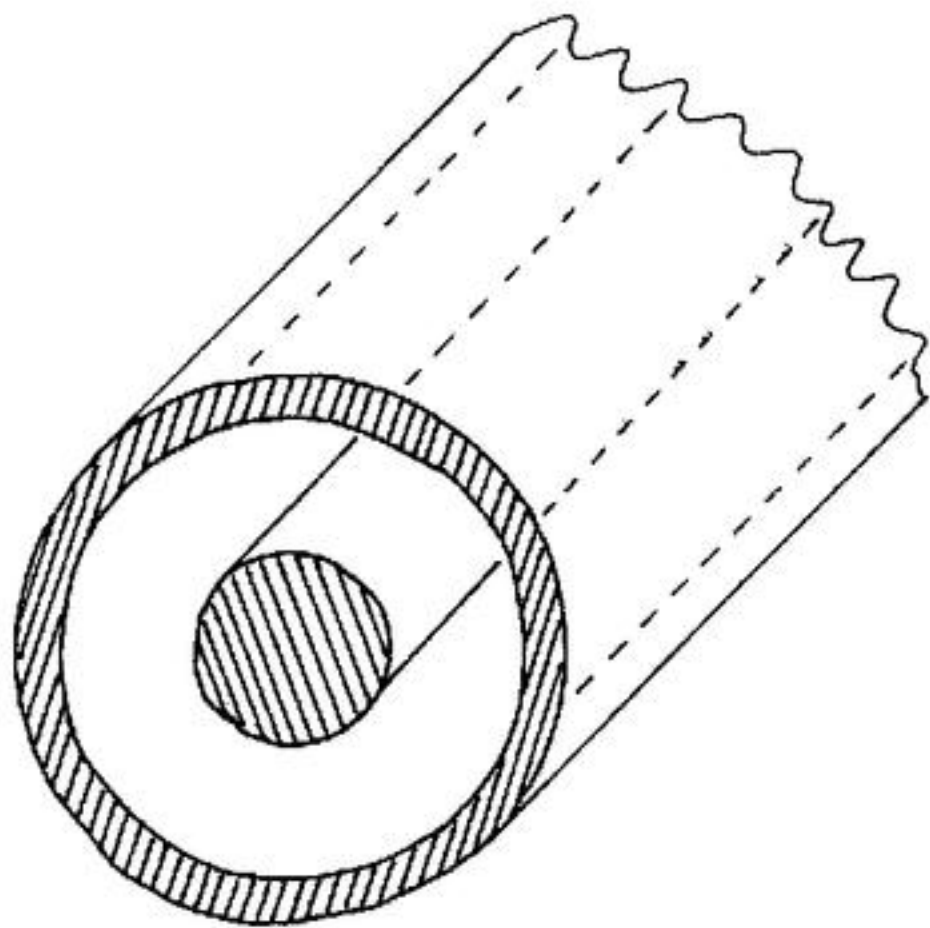


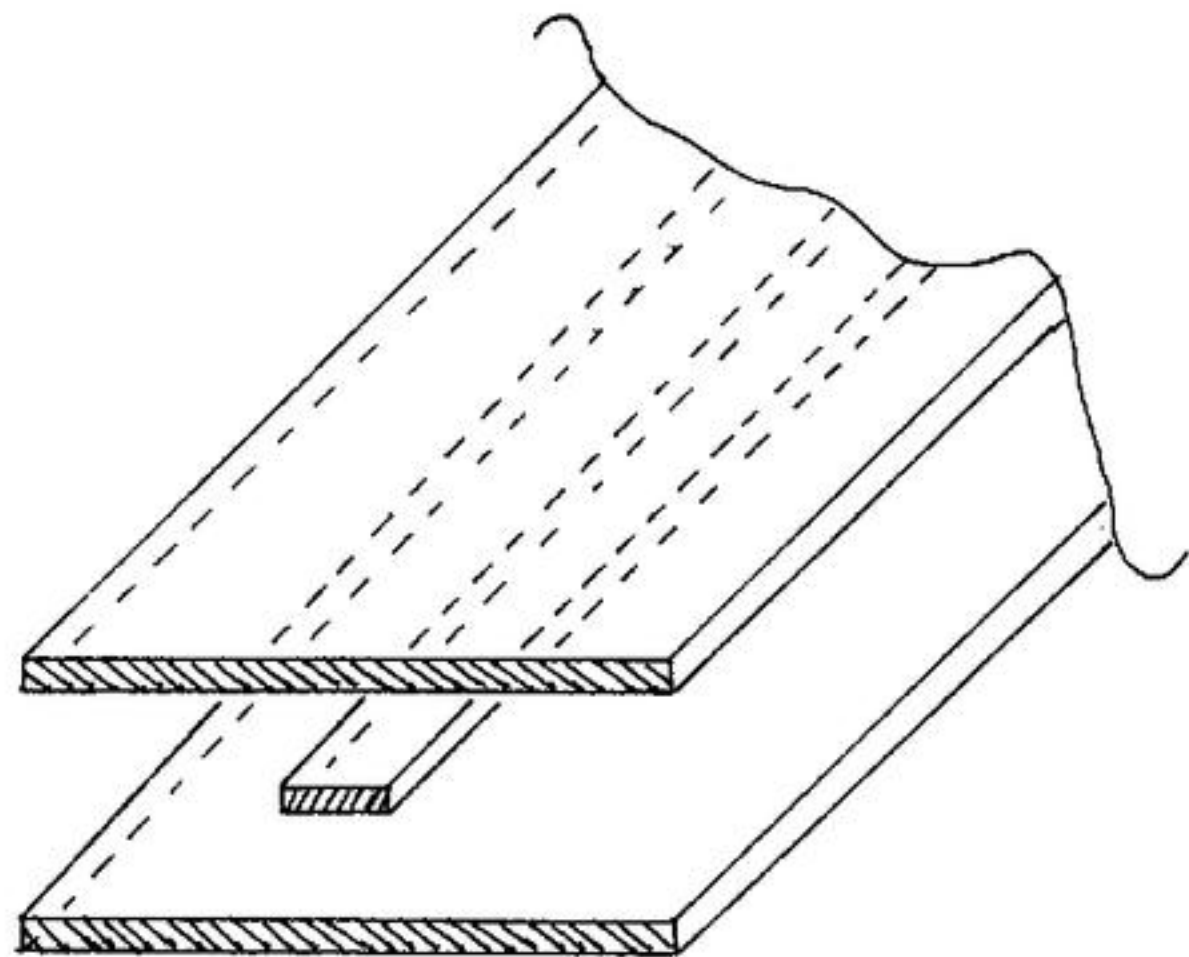
VISOKOFREKVENČNA TISKANA VEZJA

Matjaž Vidmar, S53MV

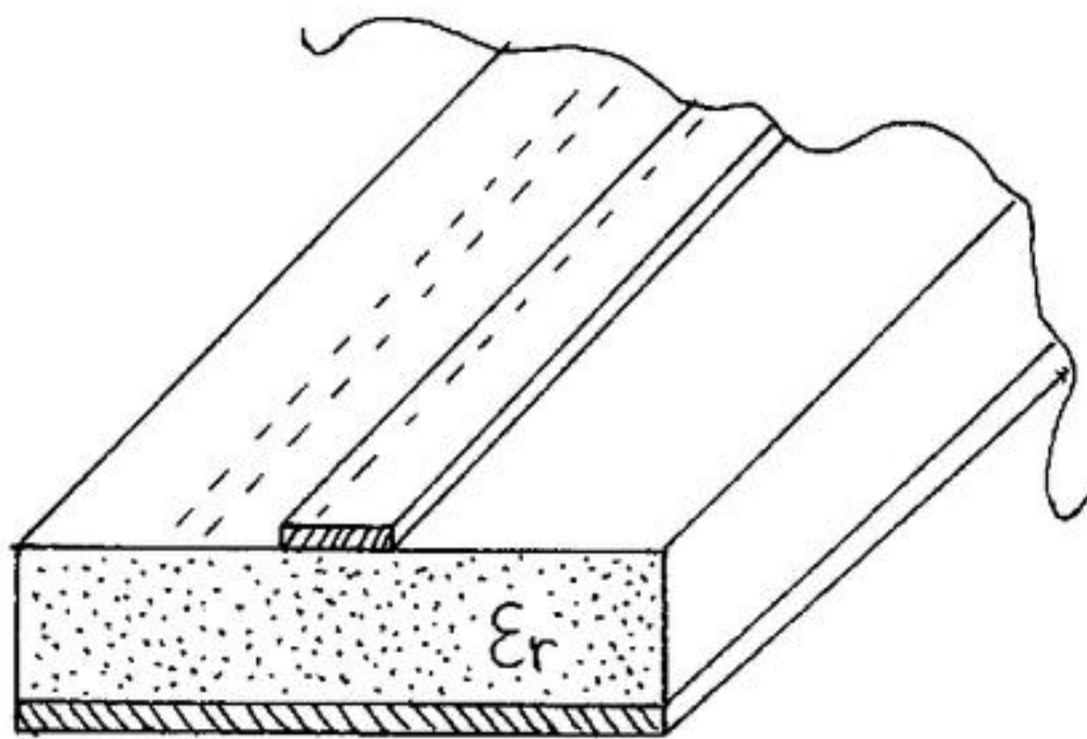
FE, Ljubljana, 06.07.2013



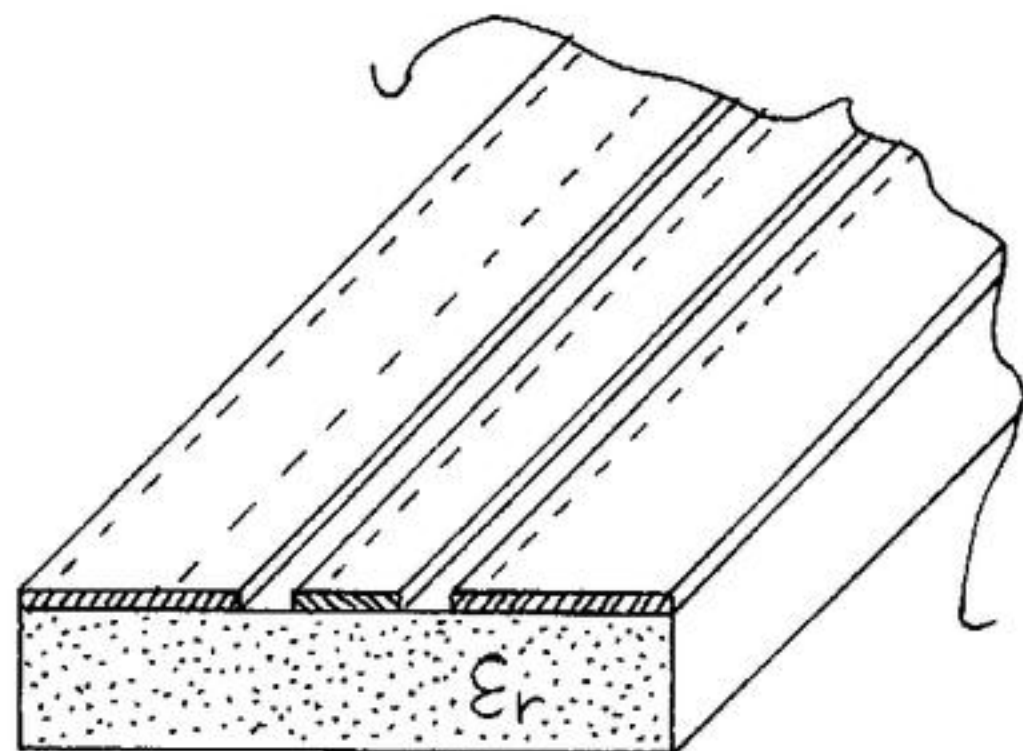
(A) Koaksialni kabel



(B) Trakasti vod (strip line)



(C) Mikrotrakasti vod (microstrip)



(D) Koplanarni vod

Običajni visokofrekvenčni TEM vodi

Karakteristična impedanca:

$$Z_k = \sqrt{\frac{L/l}{C/l}}$$

$L/l \equiv$ induktivnost na enoto dolžine

$C/l \equiv$ kapacitivnost na enoto dolžine

Hitrost valovanja:

$$v = \sqrt{\frac{1}{L/l \cdot C/l}} = \frac{c_0}{\sqrt{\epsilon_r'}}$$

$$c_0 \approx 3 \cdot 10^8 \text{ m/s}$$

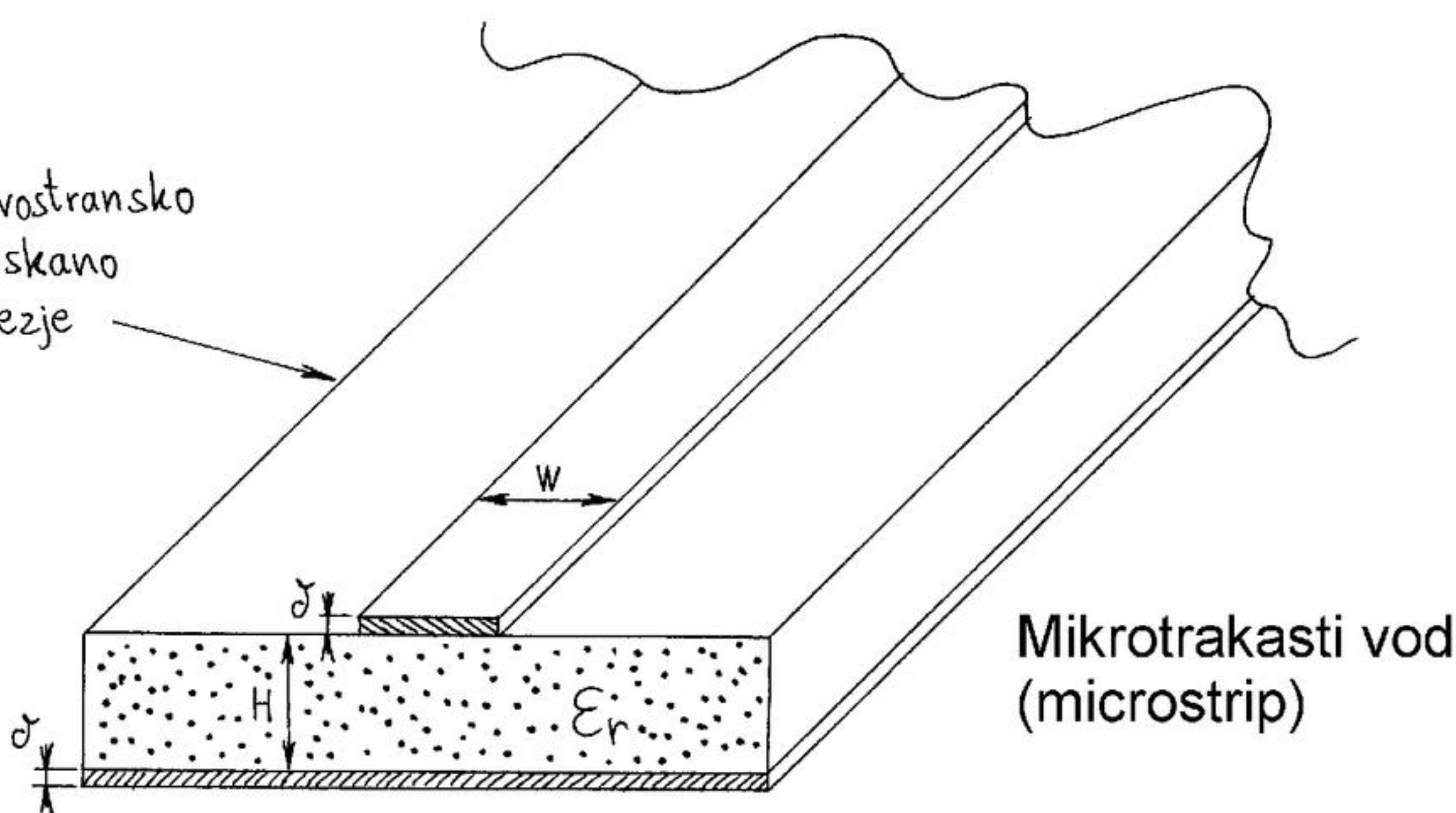
Mnogokratnik skrajšanja:

$$\frac{\lambda_0}{\lambda} = \frac{c_0}{v} = \sqrt{\epsilon_r'}$$

$\epsilon_r' \equiv$ povprečna dielektrična konstanta

Karakteristična impedanca, hitrost valovanja in mnogokratnik skrajšanja v TEM vodih

Dvostransko
tiskano
vezje



Mikrotrakasti vod
(microstrip)

$H \equiv$ debelina dielektrika (običajno 0.8mm ali 1.6mm)

$\delta \equiv$ debelina bakrene folije ($17.5\mu\text{m}$ ali $35\mu\text{m}$, običajno zanemarljiva)

$W \equiv$ širina trakastega vodnika

Teflonski laminat : $\epsilon_r = 2.2 \div 2.5$ } odvisno od vsebine
Vitroplast : $\epsilon_r = 4 \div 5$ } steklenih vlaken

Al_2O_3 keramika : $\epsilon_r = 10$

Približki pri $W \gg H$:

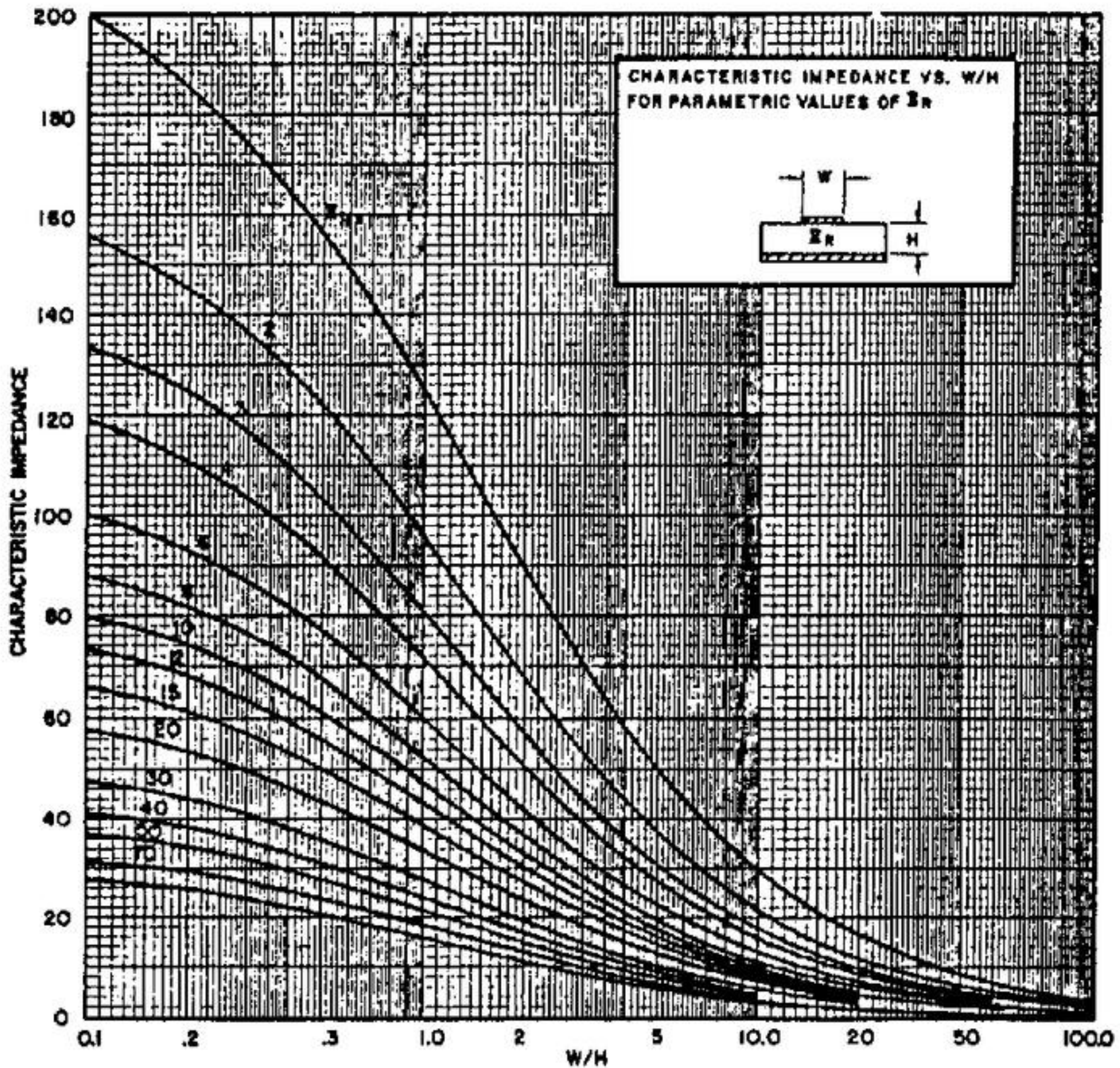
$$C/l \approx \epsilon_r \epsilon_0 \frac{W}{H} \quad ; \quad L/l \approx \mu_0 \frac{H}{W}$$

$$Z_k \approx \frac{H}{W} \sqrt{\frac{\mu_0}{\epsilon_r \epsilon_0}} \approx \frac{H}{W} \cdot \frac{377 \Omega}{\sqrt{\epsilon_r}}$$

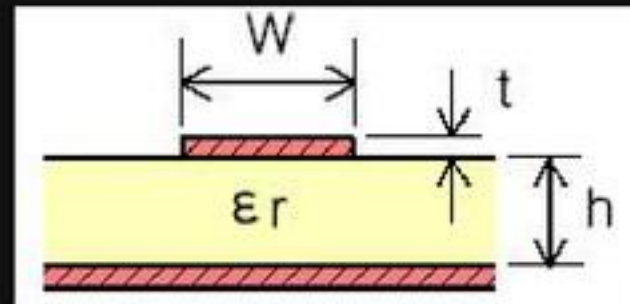
$$\epsilon_r' \approx \epsilon_r \quad ; \quad n \approx \frac{\kappa_0}{\sqrt{\epsilon_r}} \quad ; \quad \frac{\lambda_0}{\lambda} \approx \sqrt{\epsilon_r}$$

MICROSTRIP CHARACTERISTIC IMPEDANCE CALCULATED FROM WORK OF WHEELER

WIDE STRIP APPROXIMATION ($W/H > .1$)



Microstrip Line Calculator



er 4.5
h 0.6 [mm]
t 18 [um]
f 2000 [MHz]

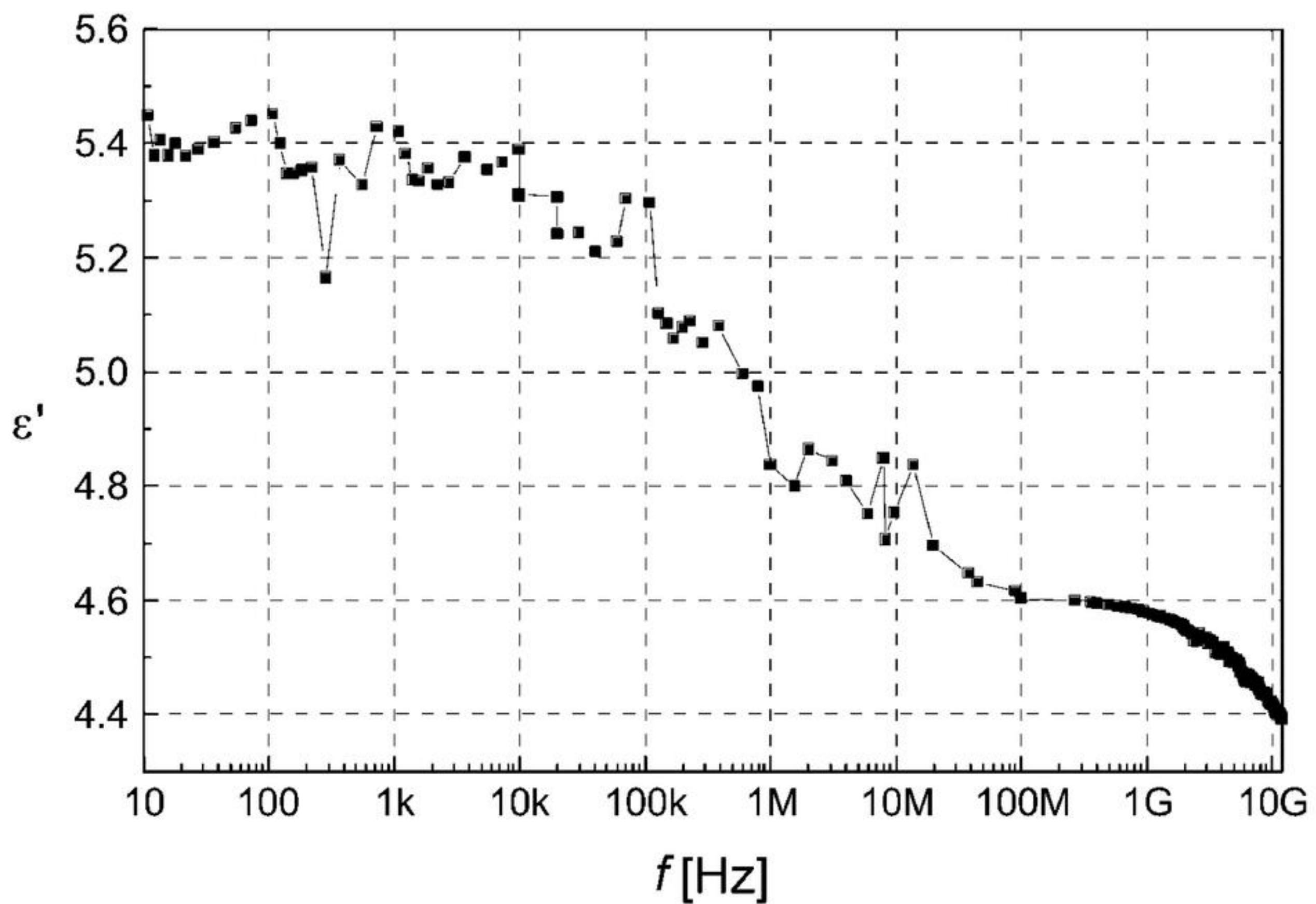
W 1.2 [mm] Analyze >>> Zo 47.5479 [ohm]

Zo 50 [ohm] Synthesis >>> W 1.10357 [mm]

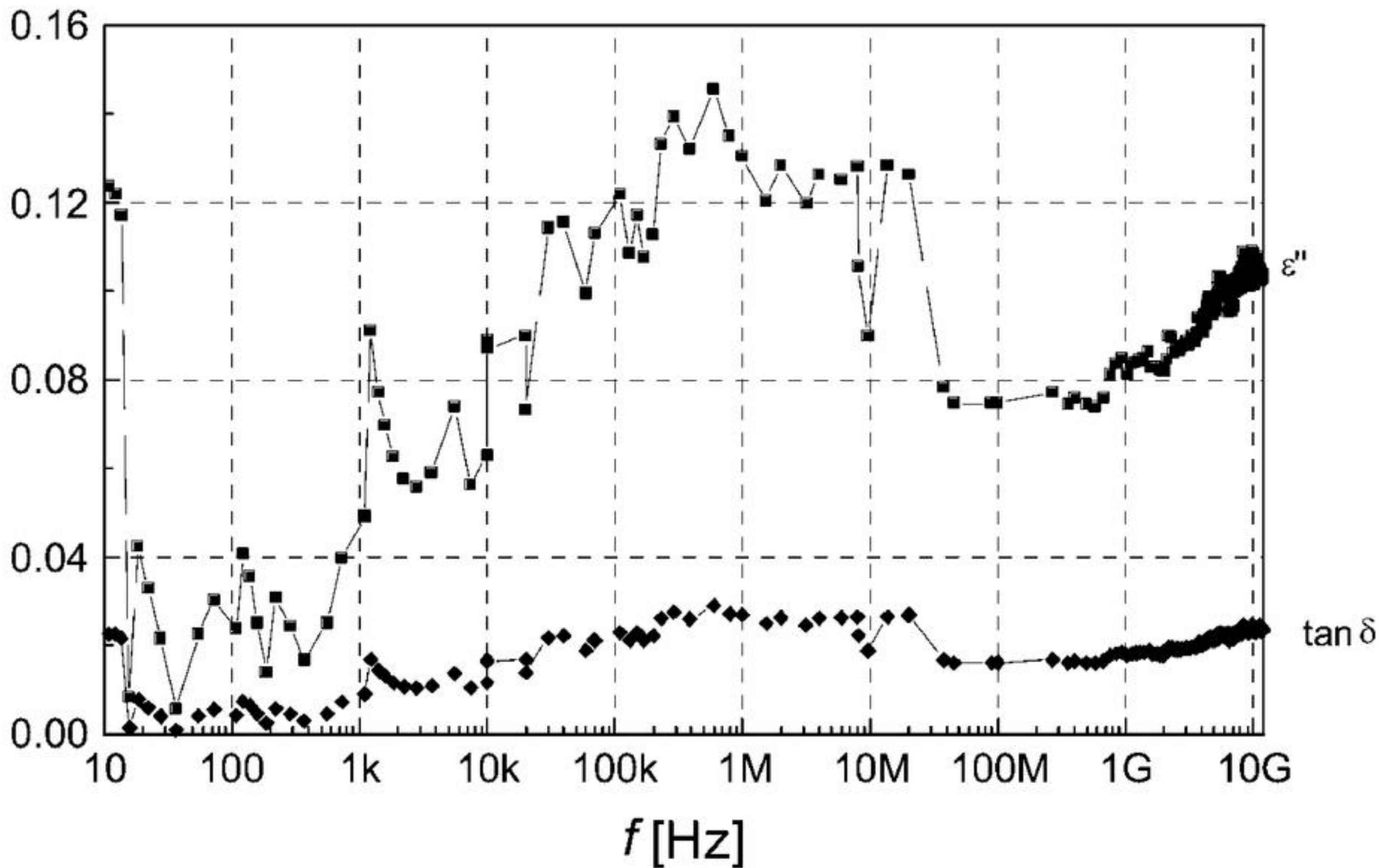
er eff 3.33377 k 0.54768 lambda/4 20.5382 [mm]

[How to use]

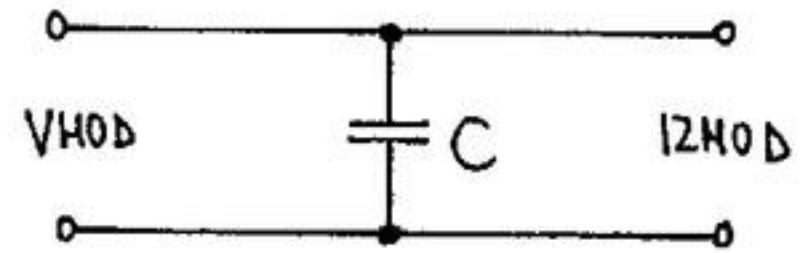
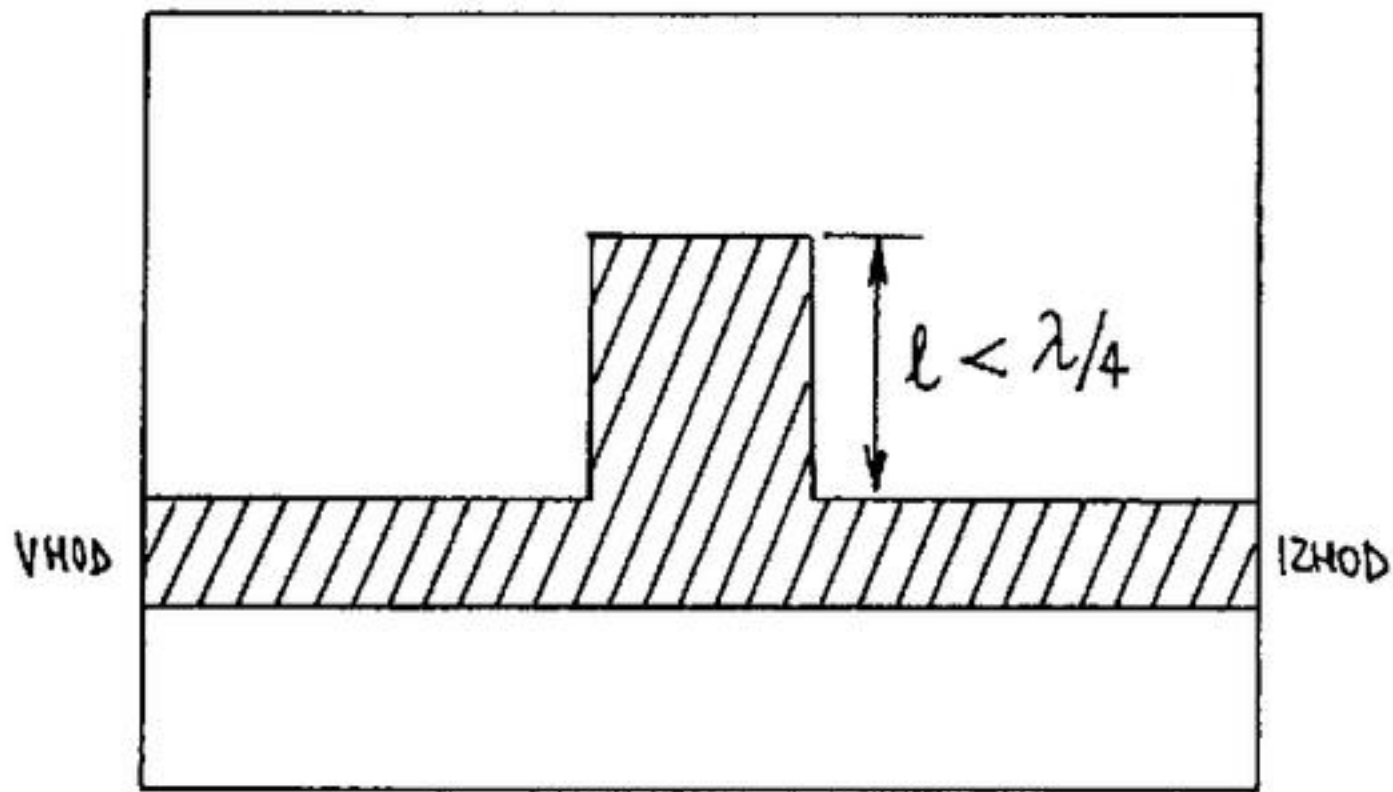
1. Input the parameter of the circuit board and center frequency.
2.
 - (1) When the characteristic impedance (Z_o) of the line width (w) is calculated. Input w , and click on [**Analyze**] button.
 - (2) When the line width (w) of the characteristic impedance (Z_o) is calculated. Input Z_o , and click on [**Synthesis**] button.
3. A calculation result is indicated.



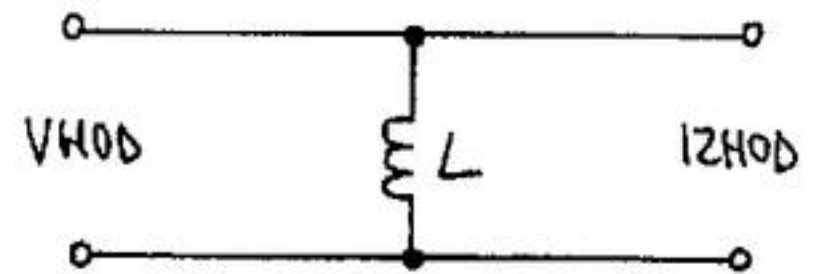
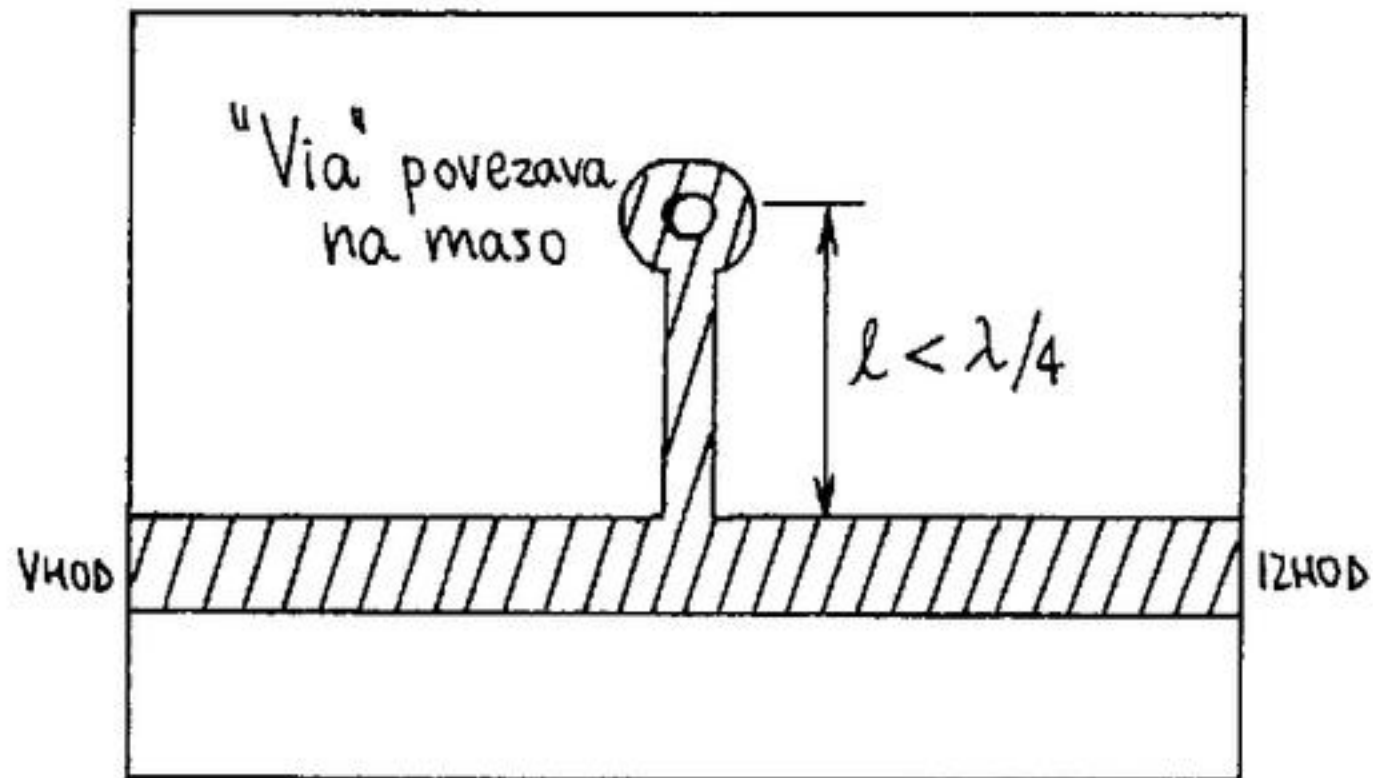
Izmerjena relativna dielektričnost vitroplasta



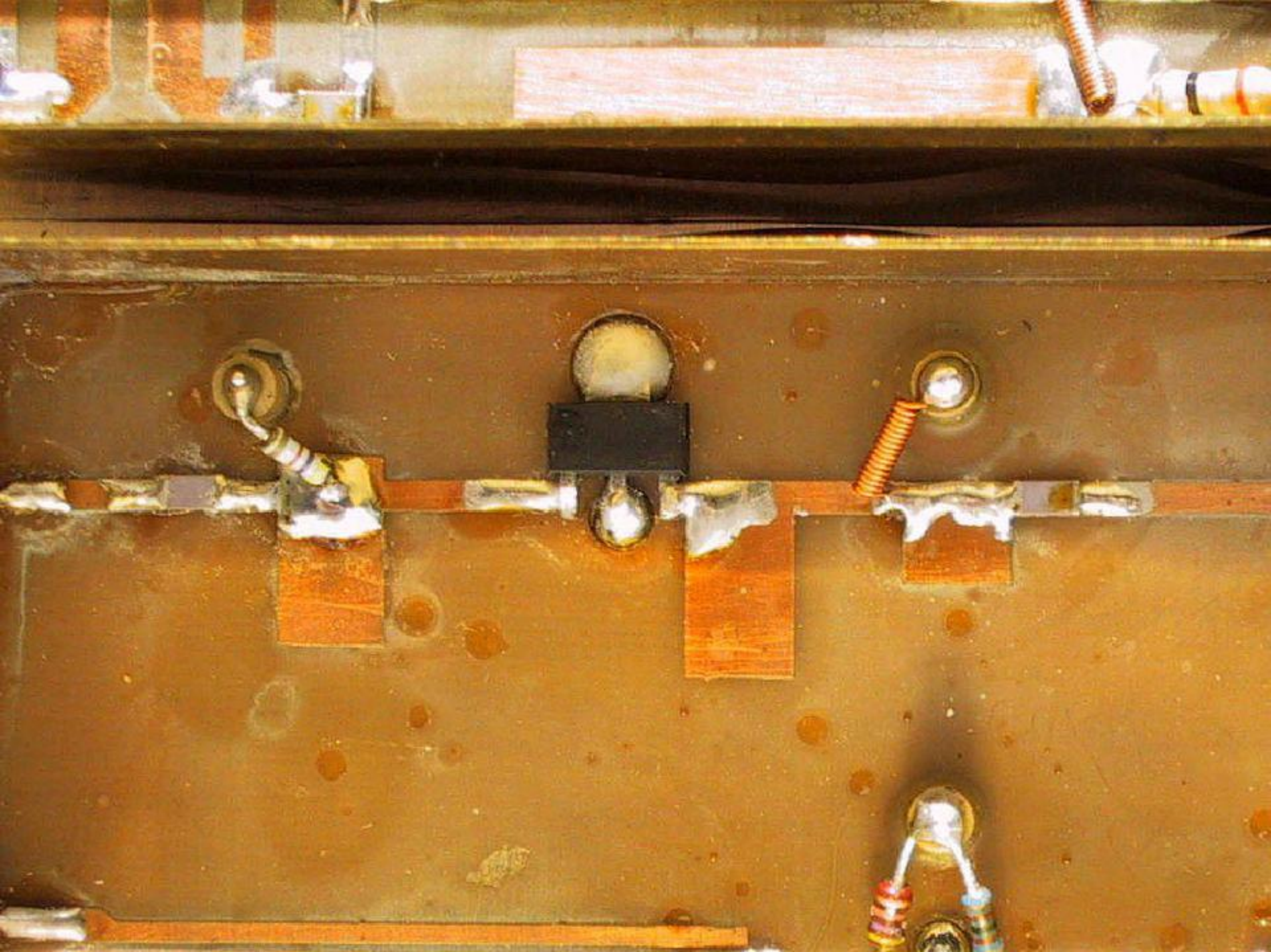
Izmerjene dielektrične izgube vitroplasta

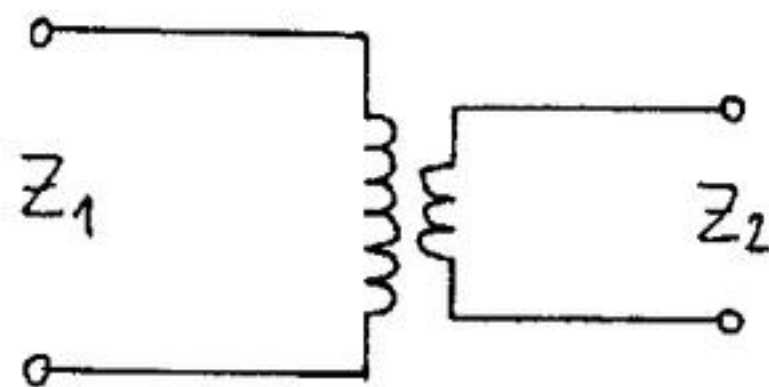
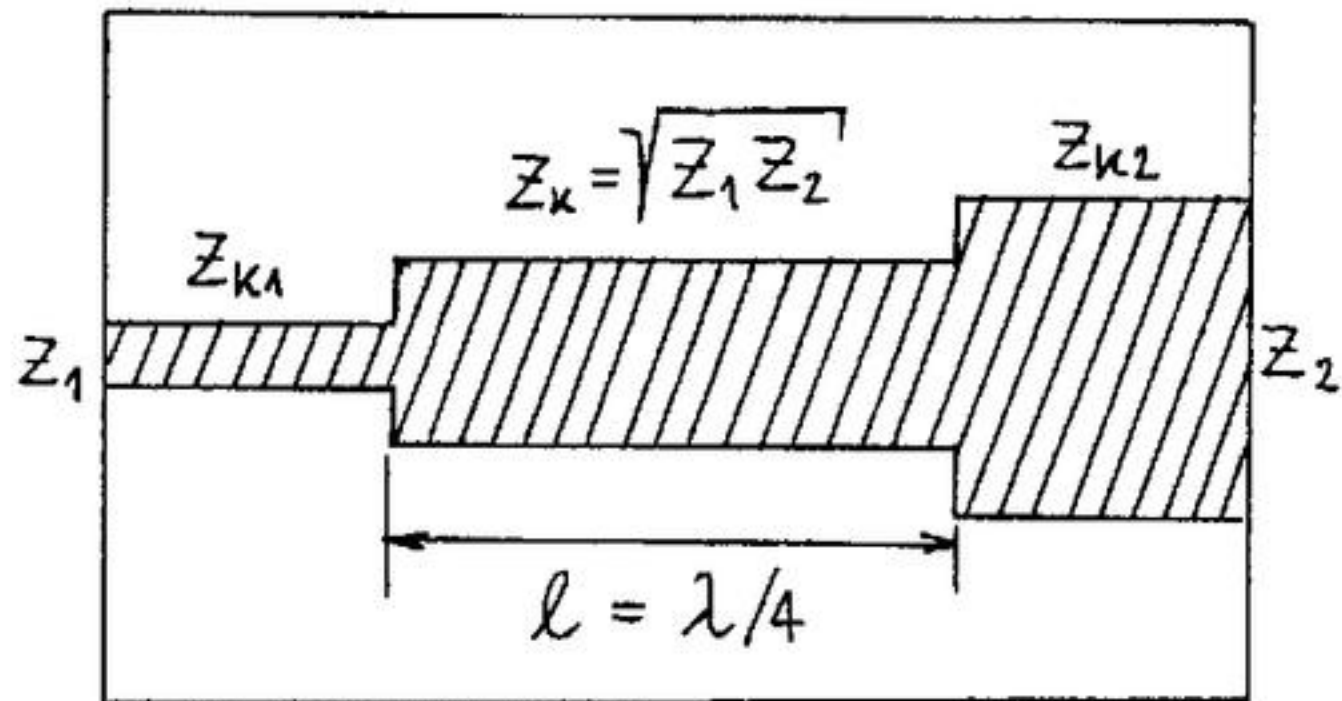


Kapacitivni štrcelj

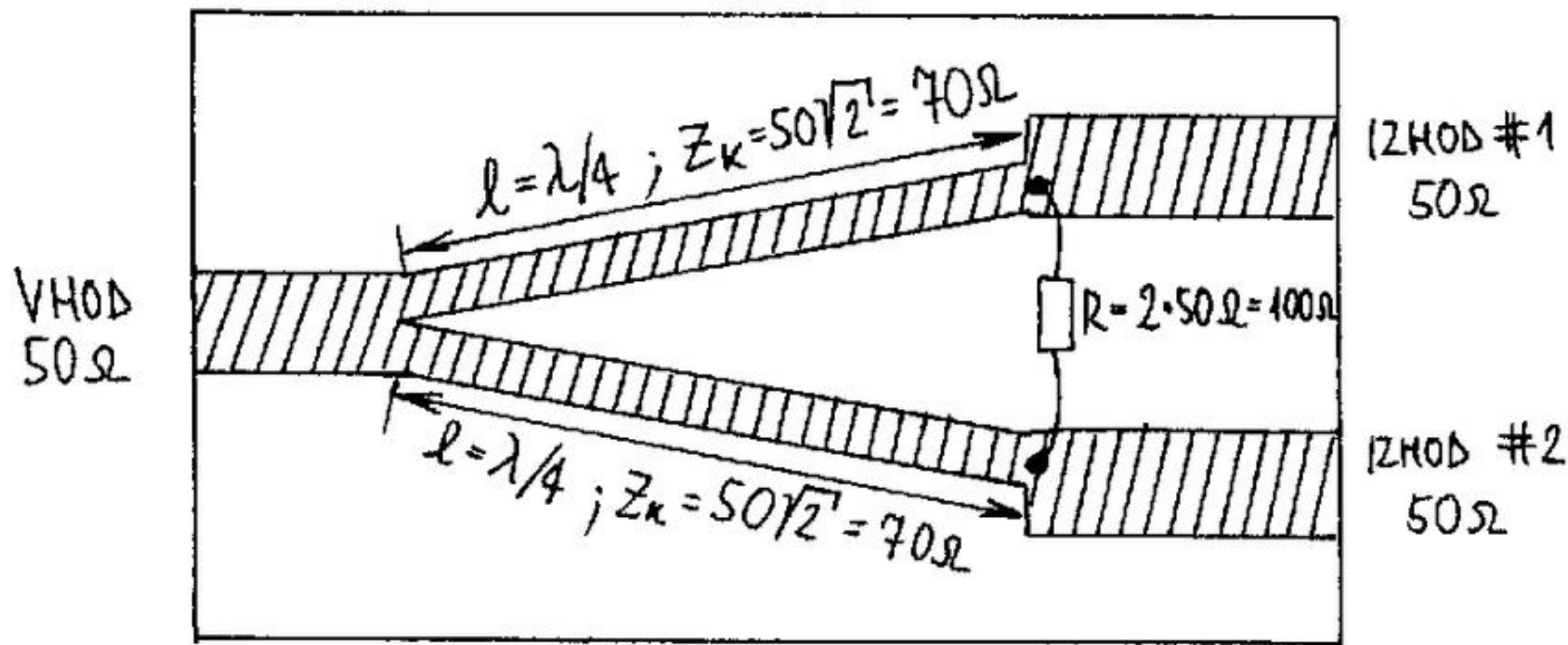


Induktivni štrcelj

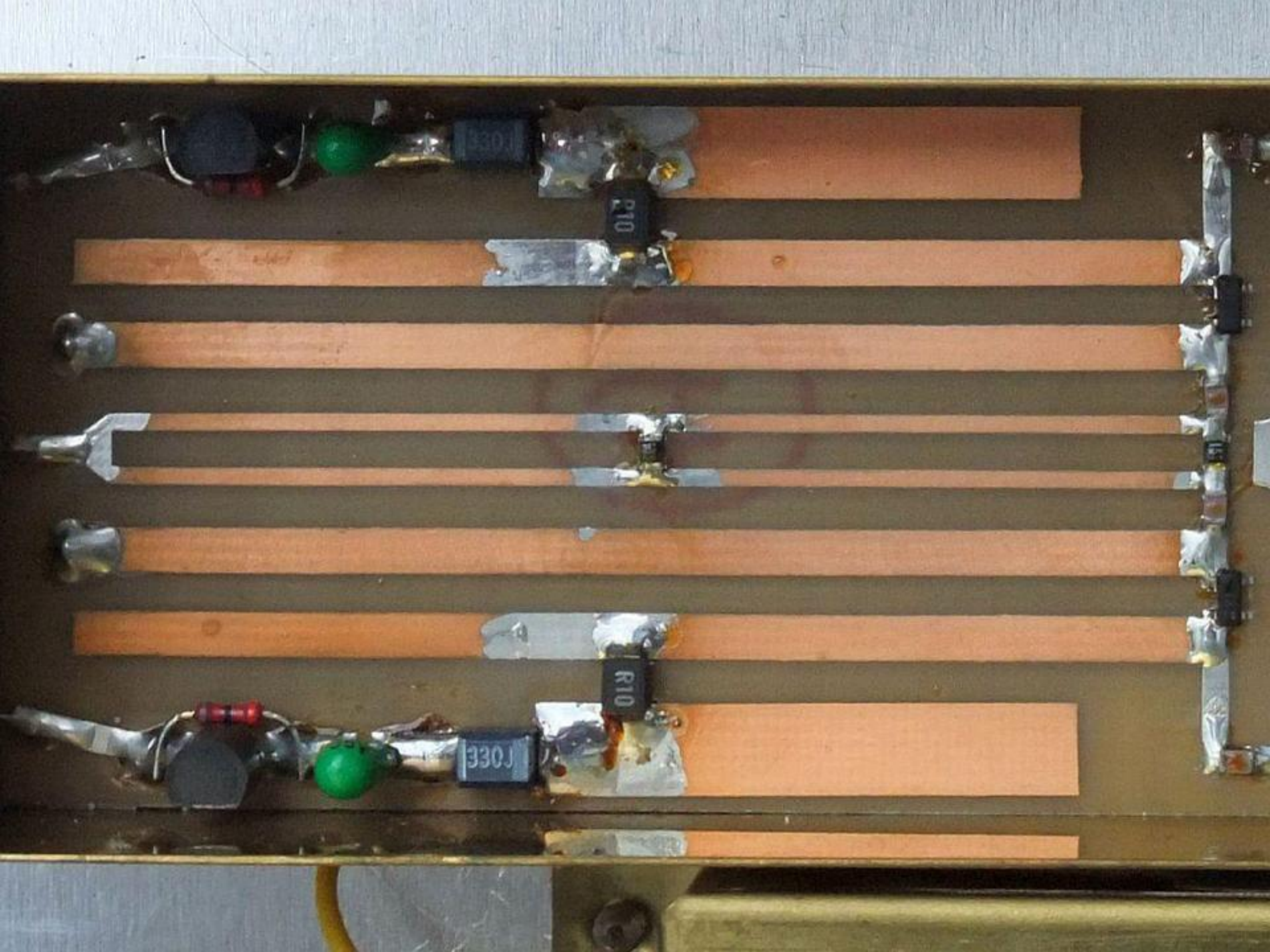




Četrt valovni transformator



Sofazni (Wilkinson-ov) delilnik moči

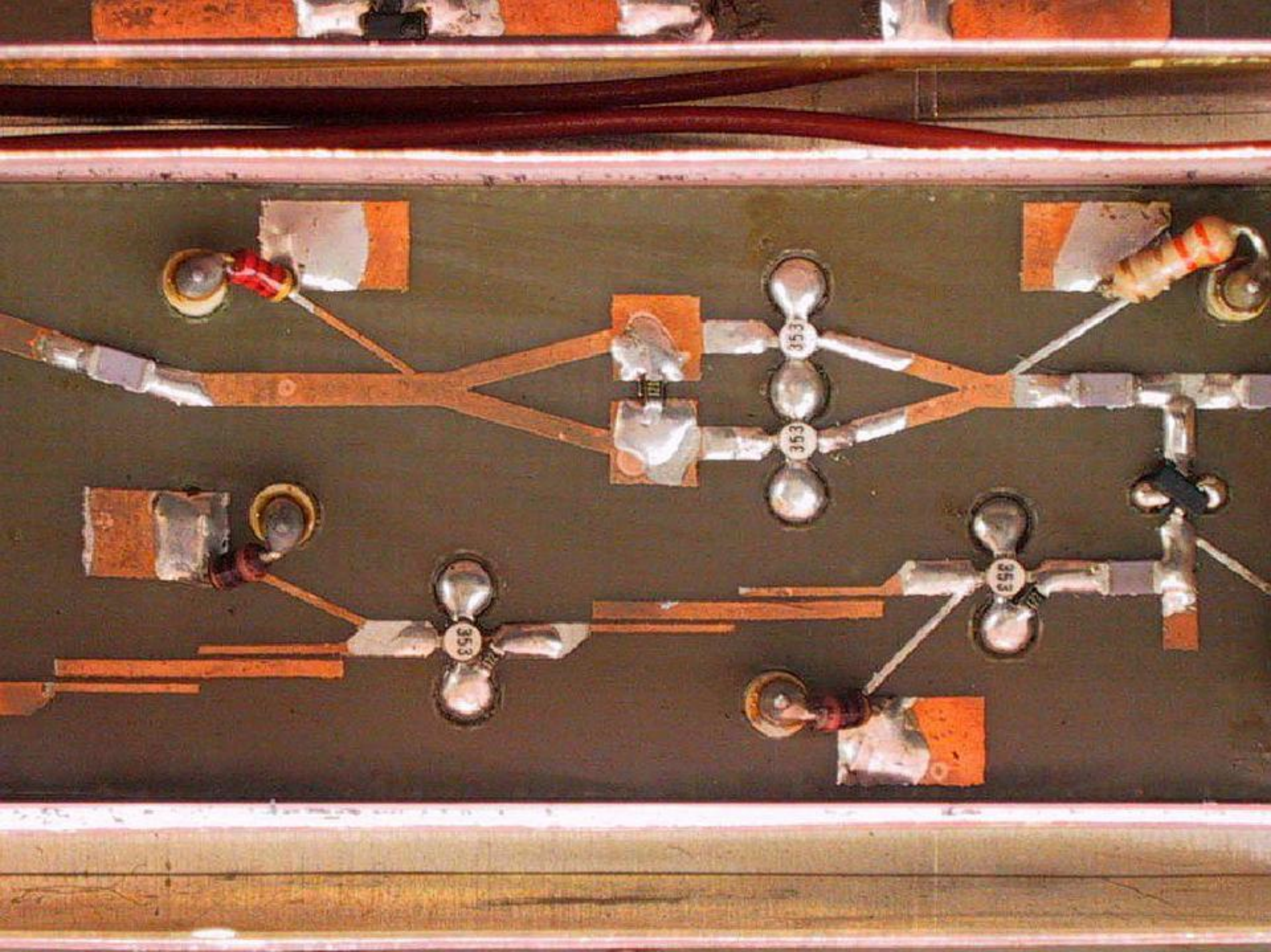


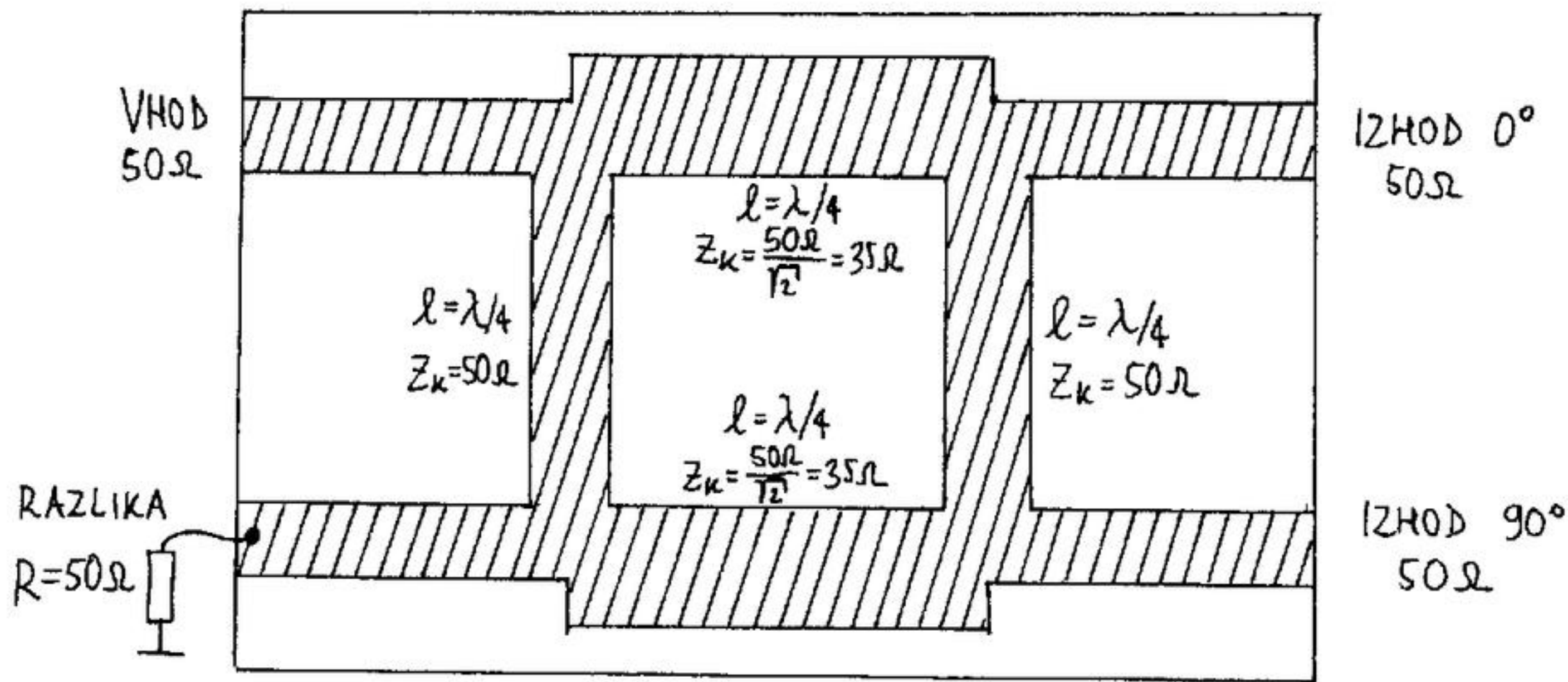
R10

R10

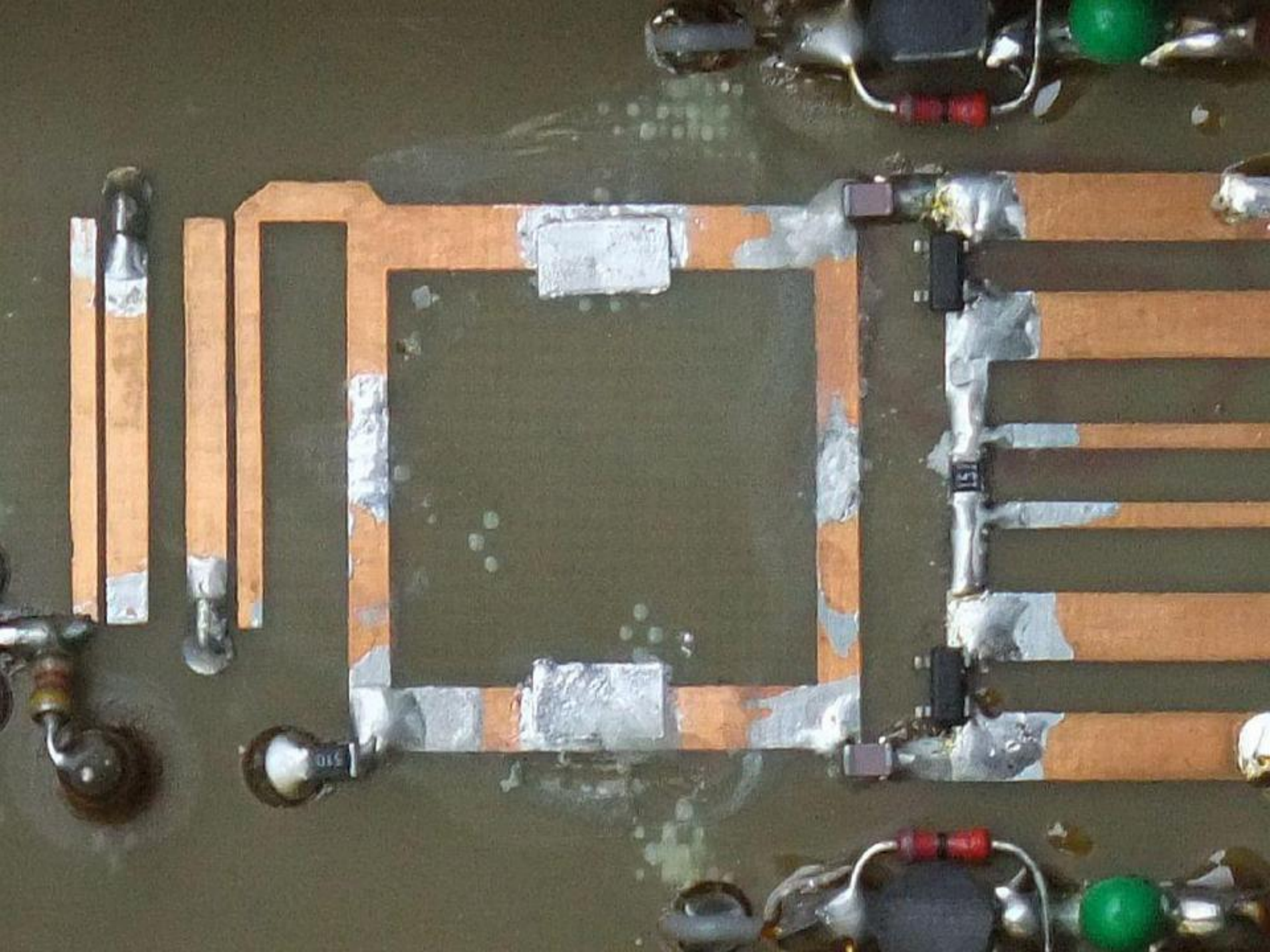
330J

330J

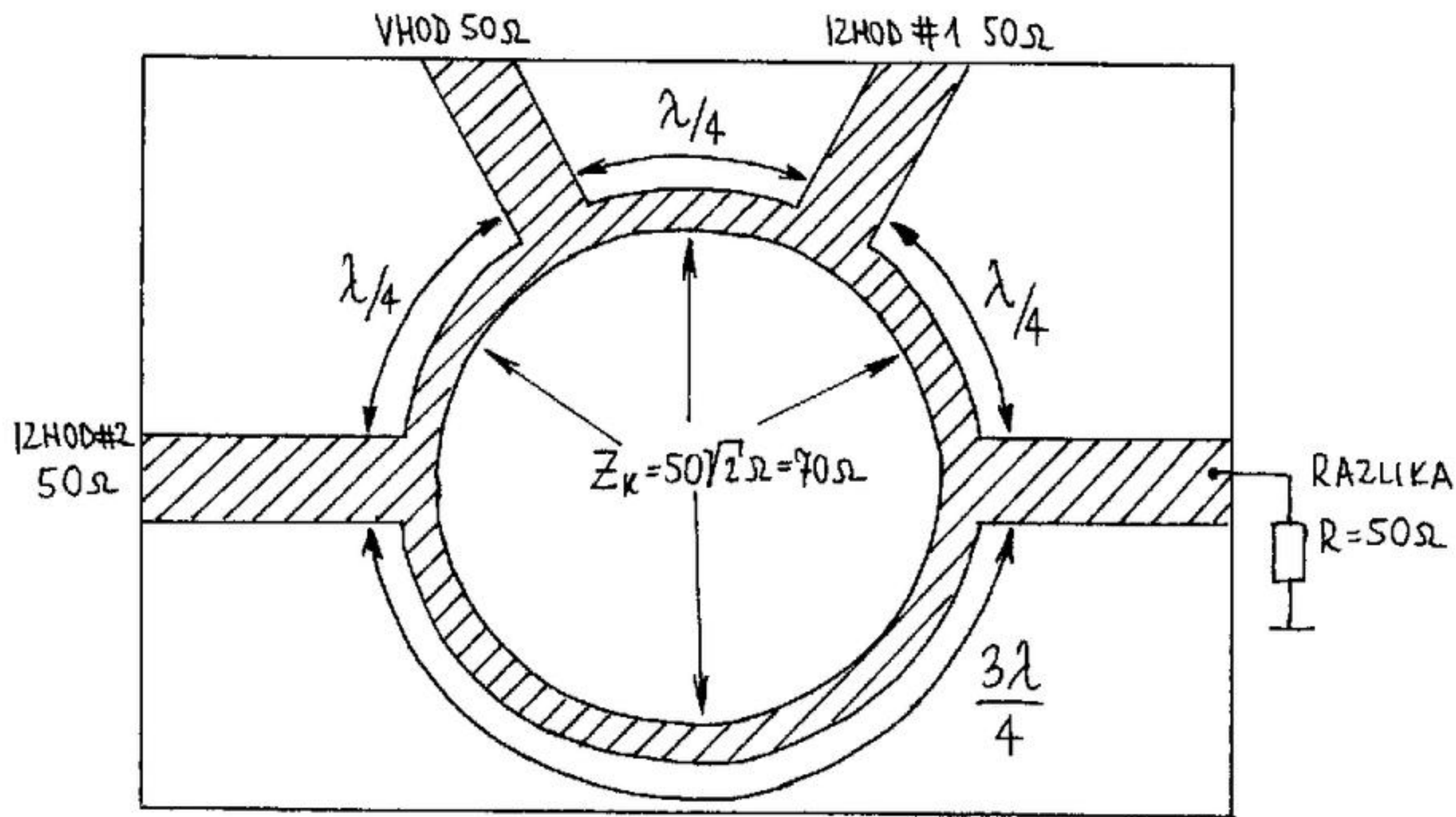




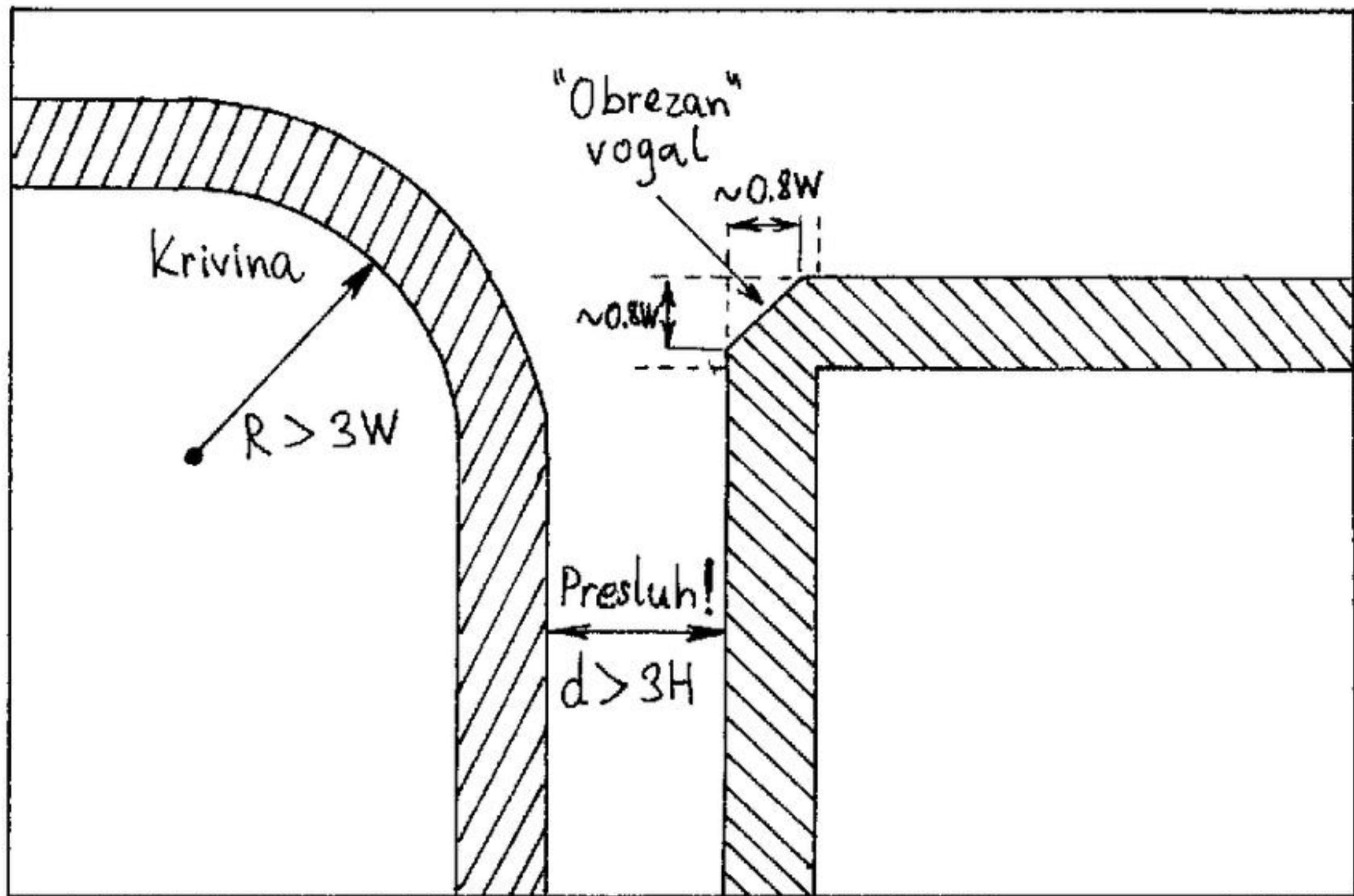
90 - stopinjski (kvadraturni) delilnik moči



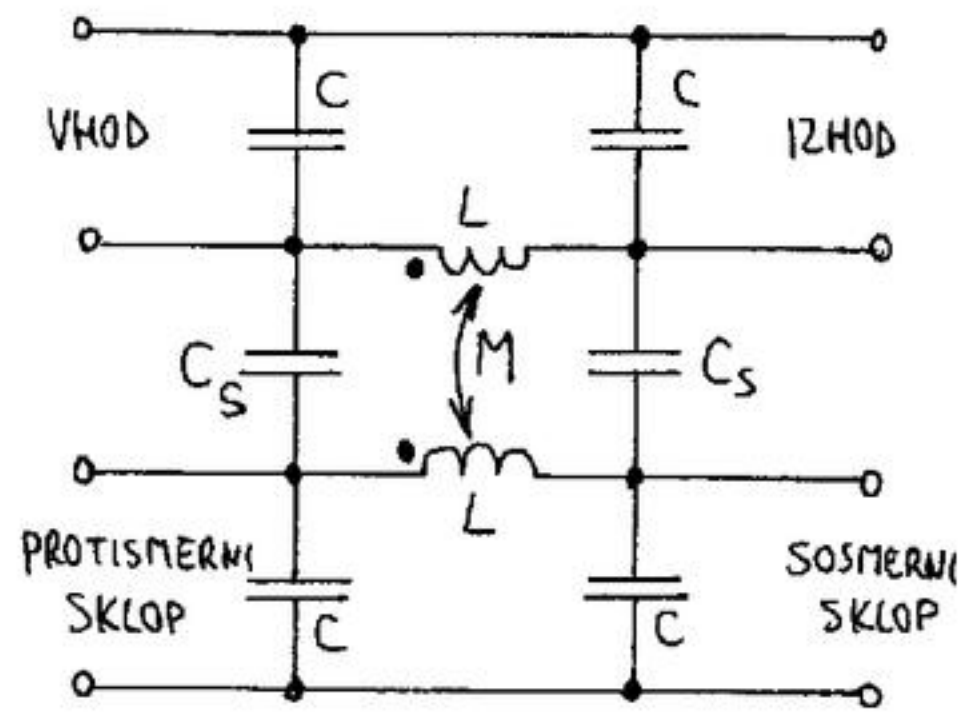
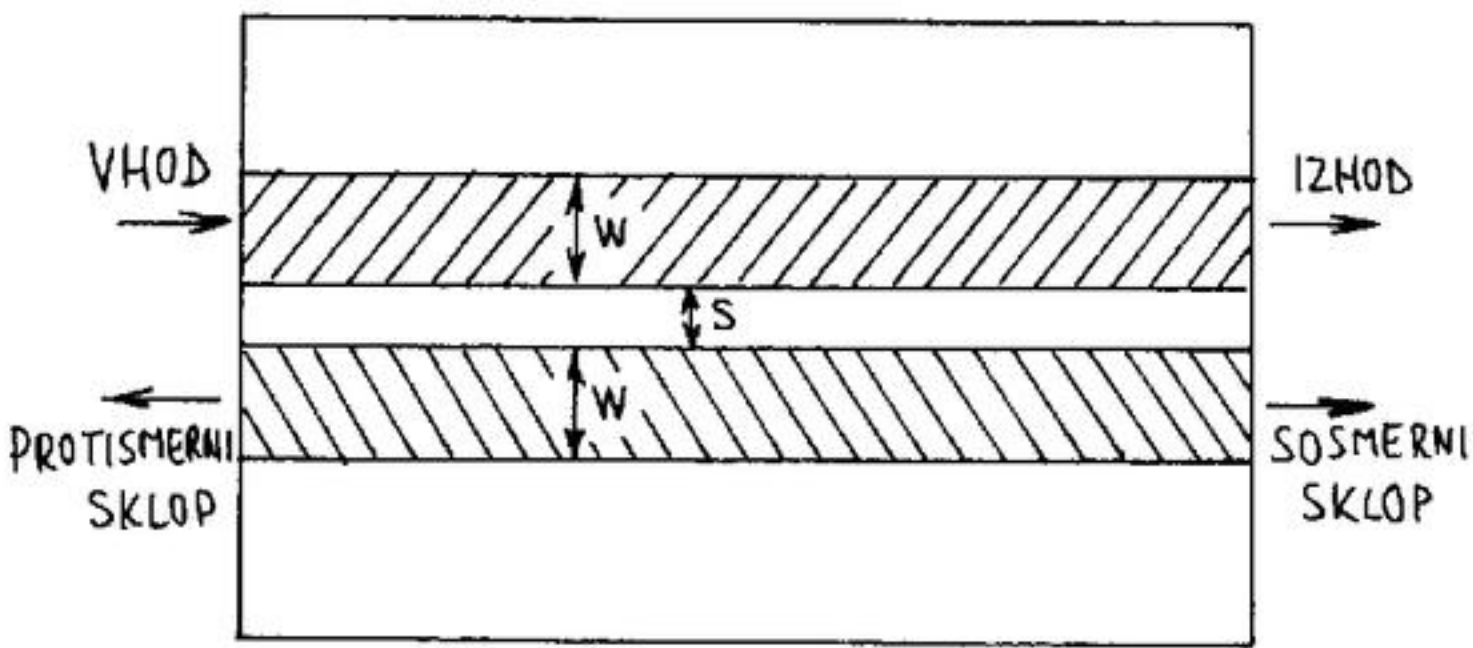
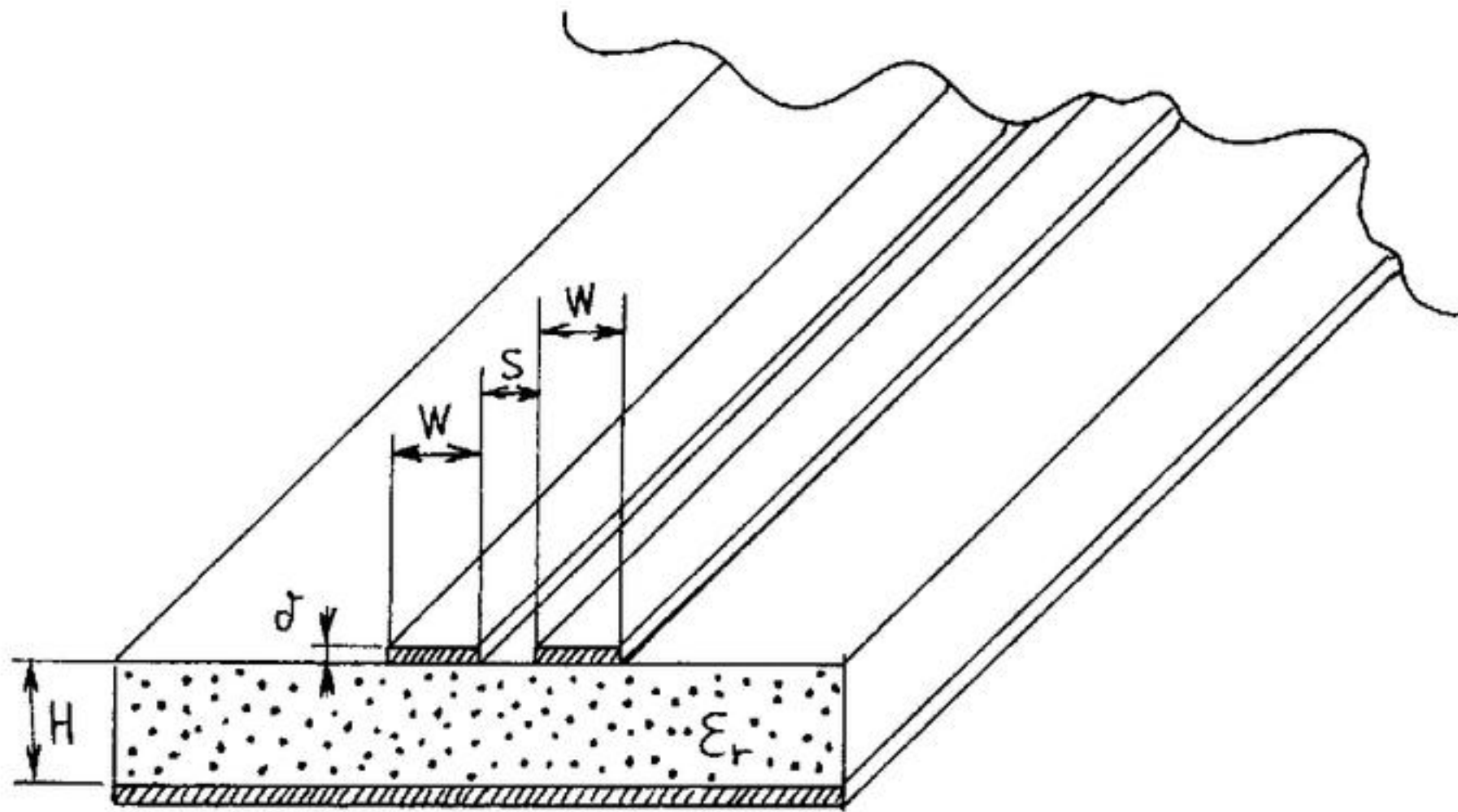




Podganji hibrid (rat-race hybrid)

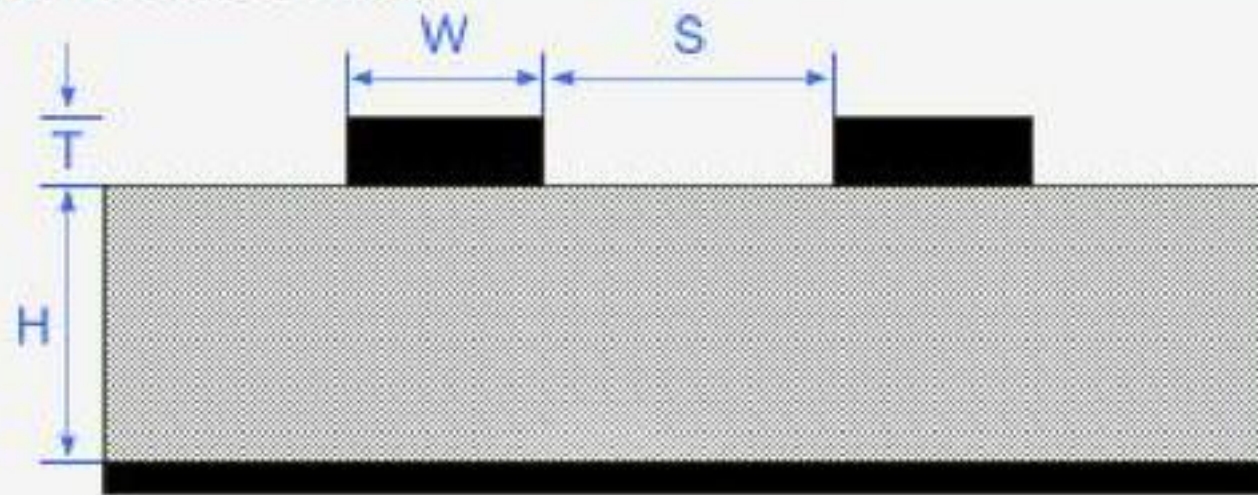


Preprečevanje presluha in odbojev na krivinah



Mikrotraka sti sklopnik

Edge Coupled Microstrip



Edge Coupled Microstrip Impedance Calculator Inputs

Trace Thickness	T	<input type="text" value="1.2"/>	<input type="text" value="mil"/>	<input type="button" value="v"/>
Substrate Height	H1	<input type="text" value="63"/>	<input type="text" value="mil"/>	<input type="button" value="v"/>
Trace Width	W	<input type="text" value="10"/>	<input type="text" value="mil"/>	<input type="button" value="v"/>
Trace Spacing	S	<input type="text" value="63"/>	<input type="text" value="mil"/>	<input type="button" value="v"/>
Substrate Dielectric	Er	<input type="text" value="4"/>		

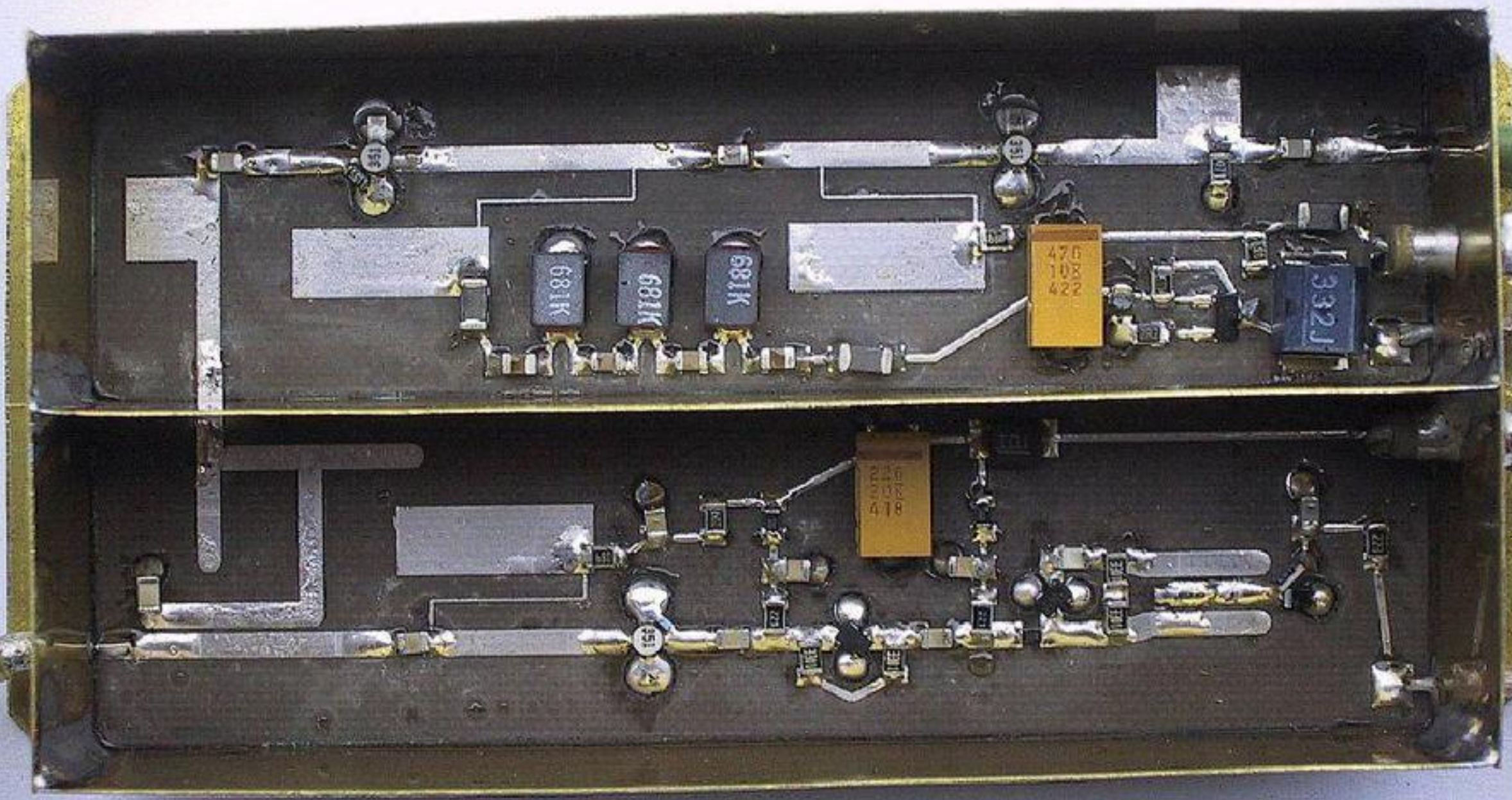
Edge Coupled Microstrip Impedance Calculator Outputs

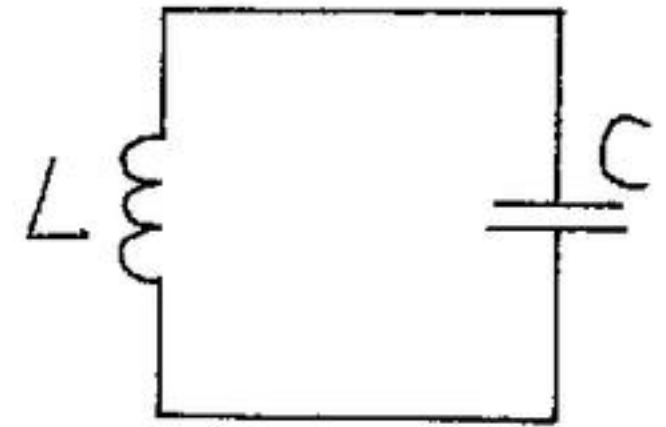
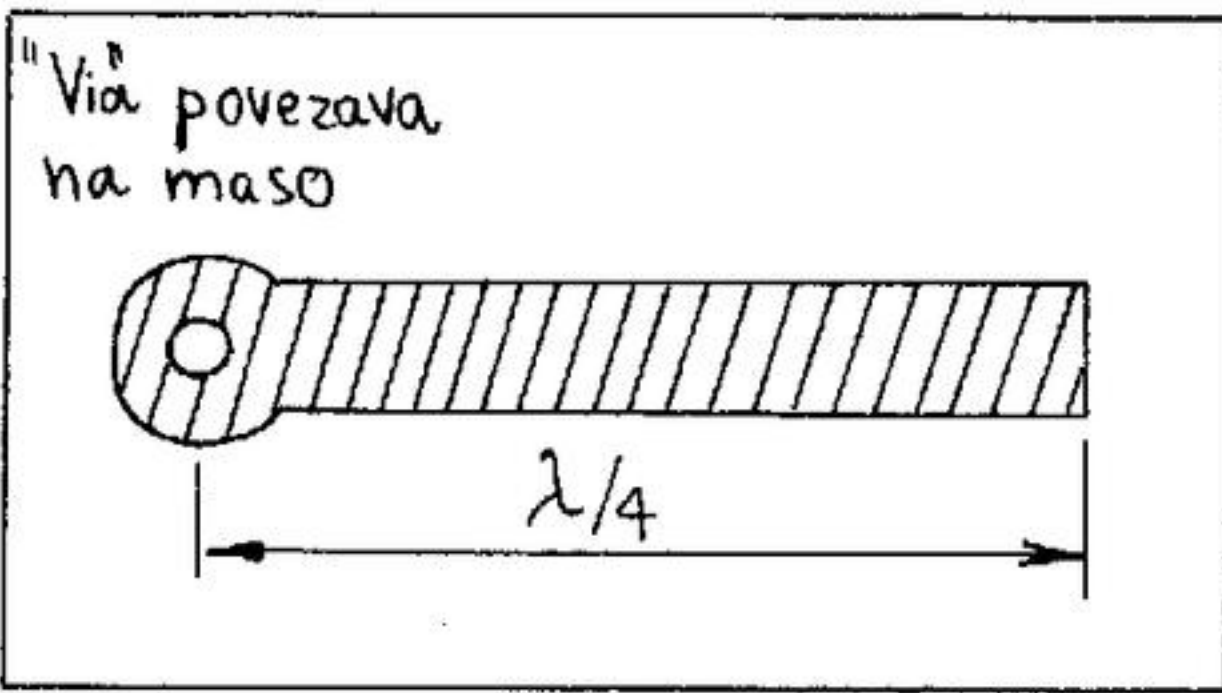
Odd (Z): 133 ohms

Even (Z): 152 ohms

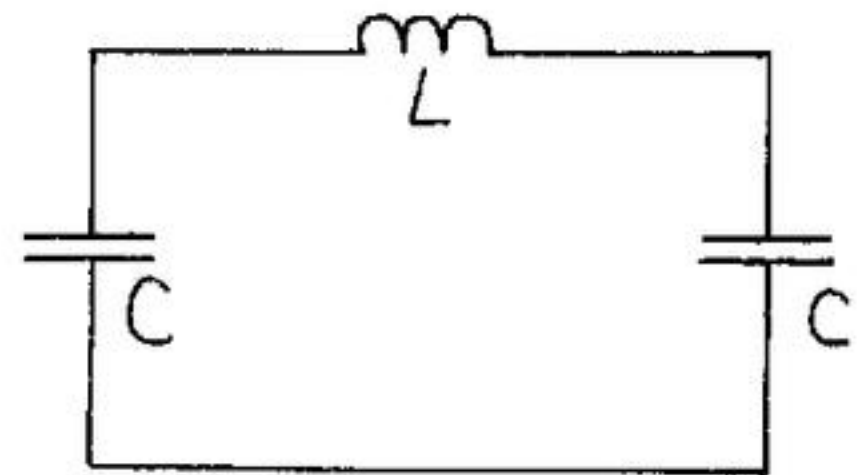
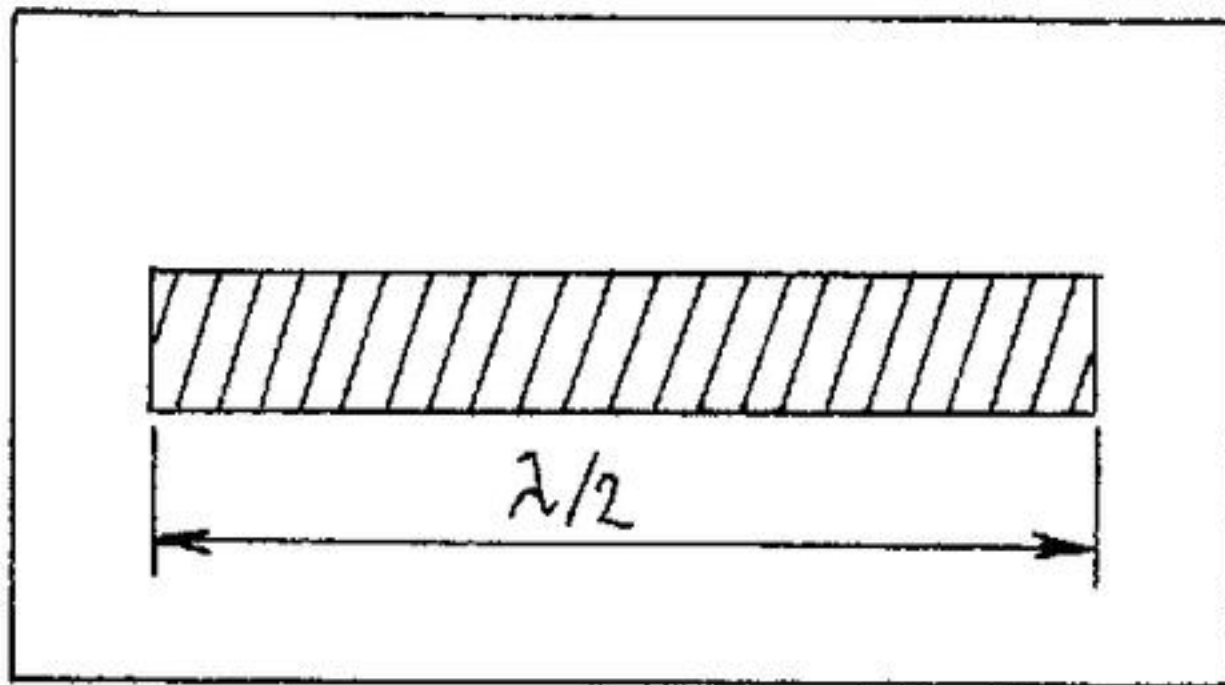
Common (Z): 76.2 ohms

Differential (Z): 267 ohms

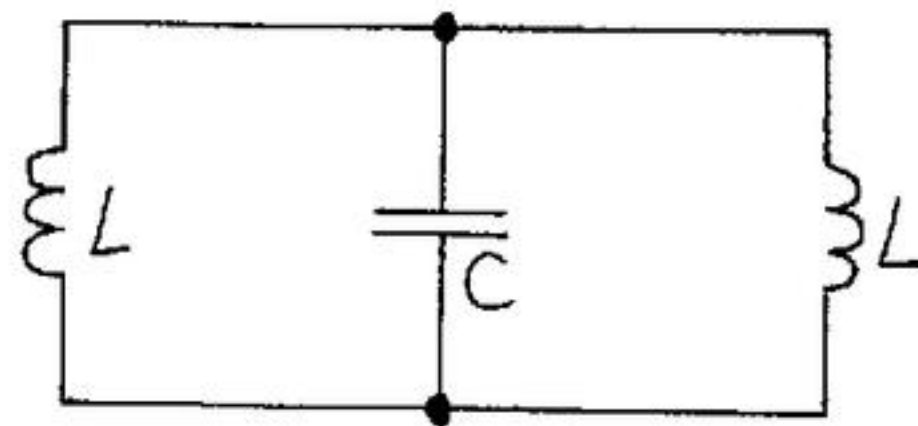
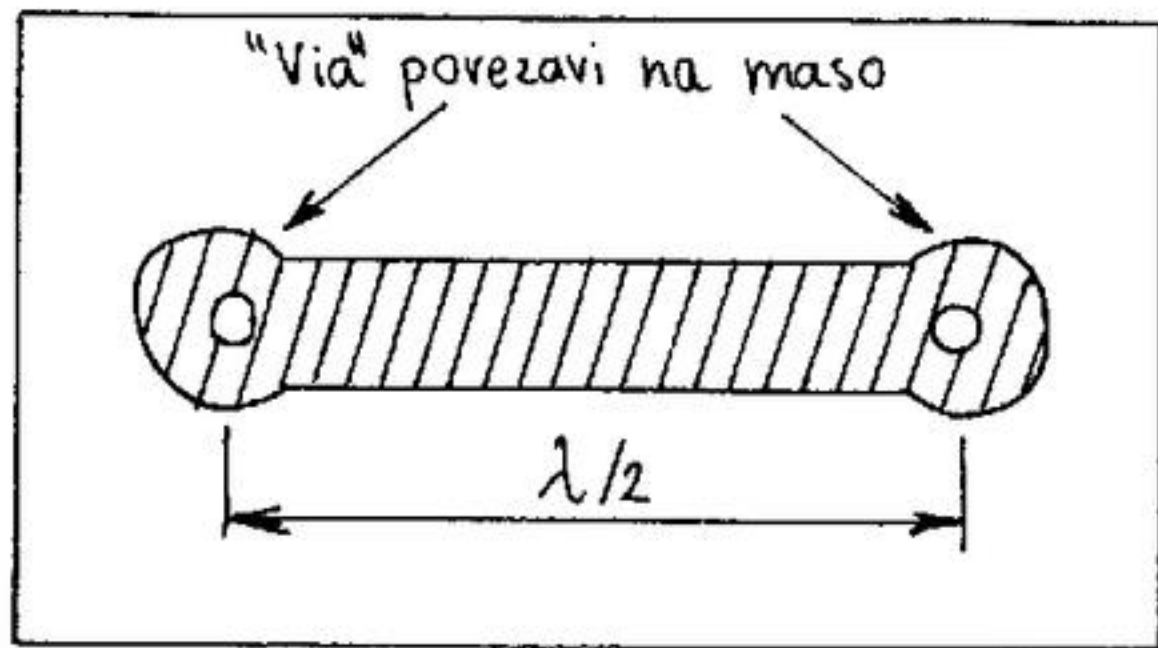




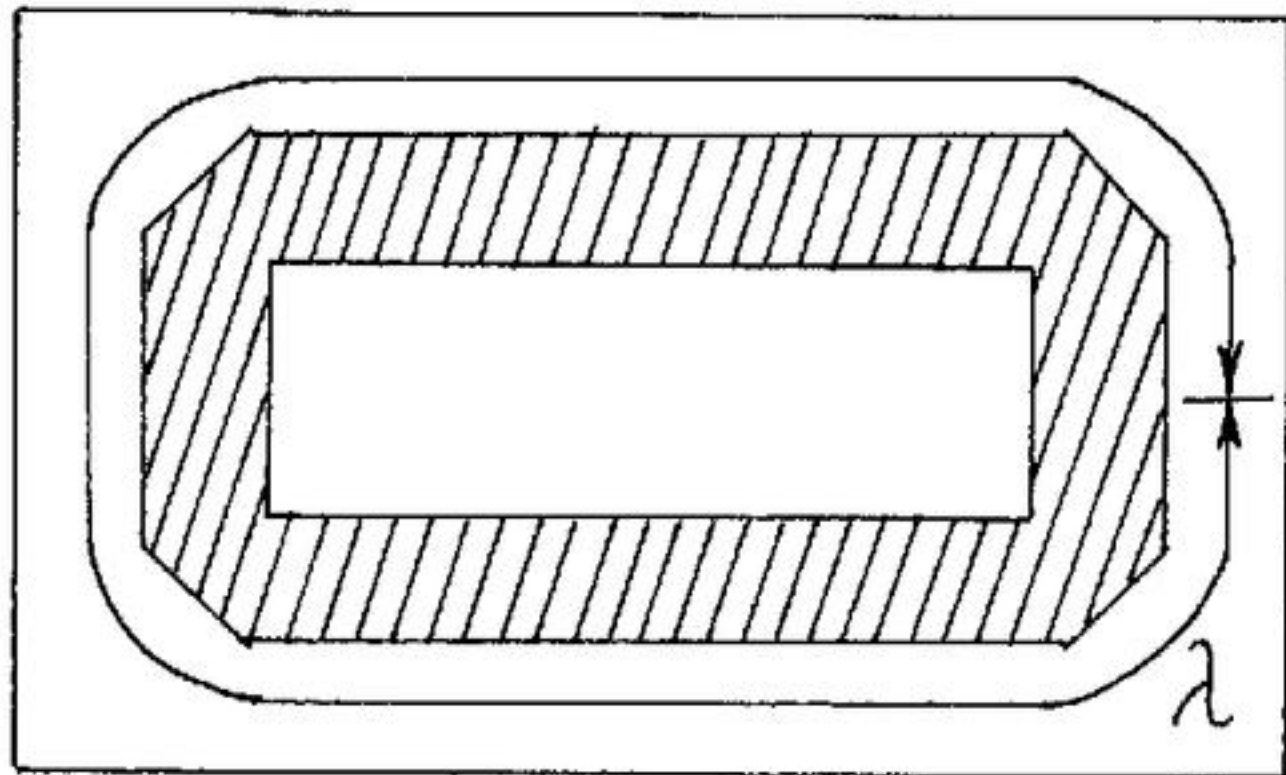
Četrť valovni mikrotrakasti rezonator



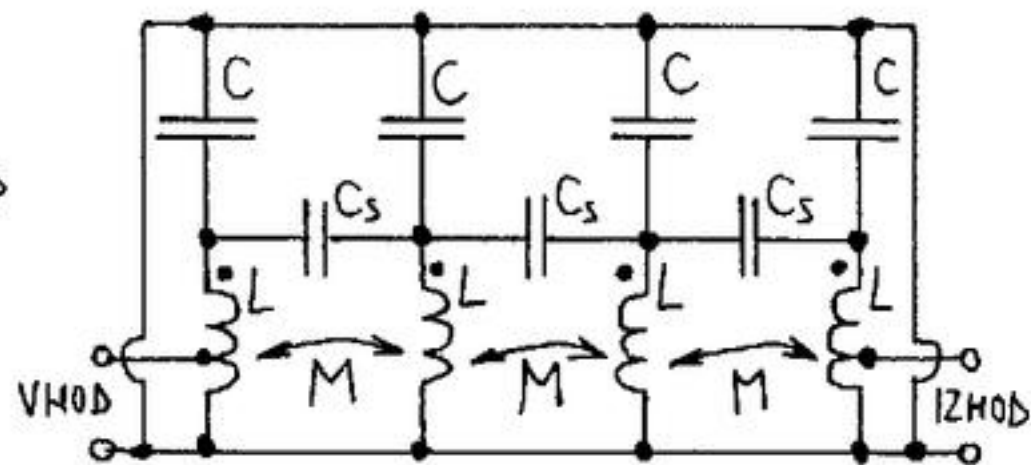
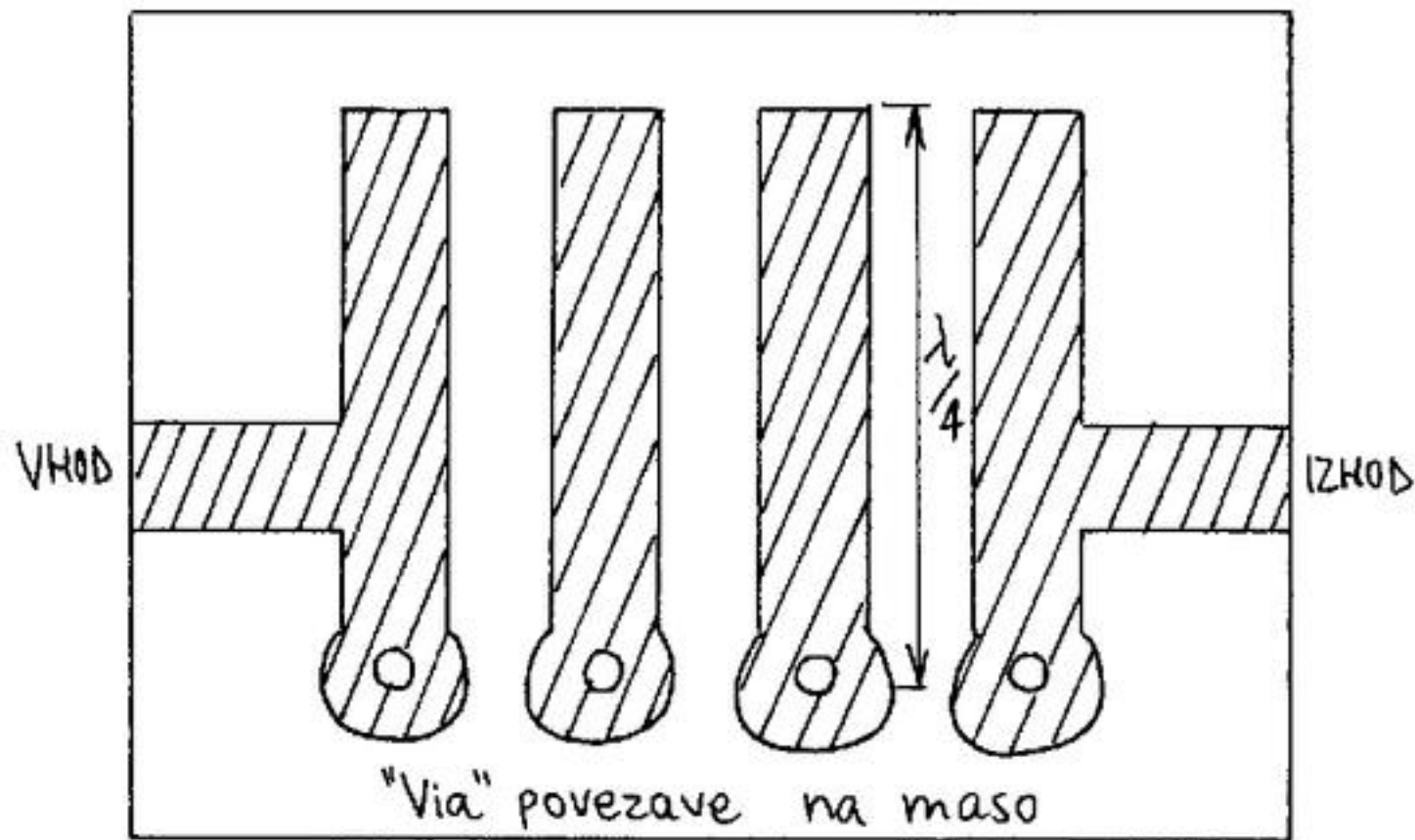
Polvalovni odprti rezonator



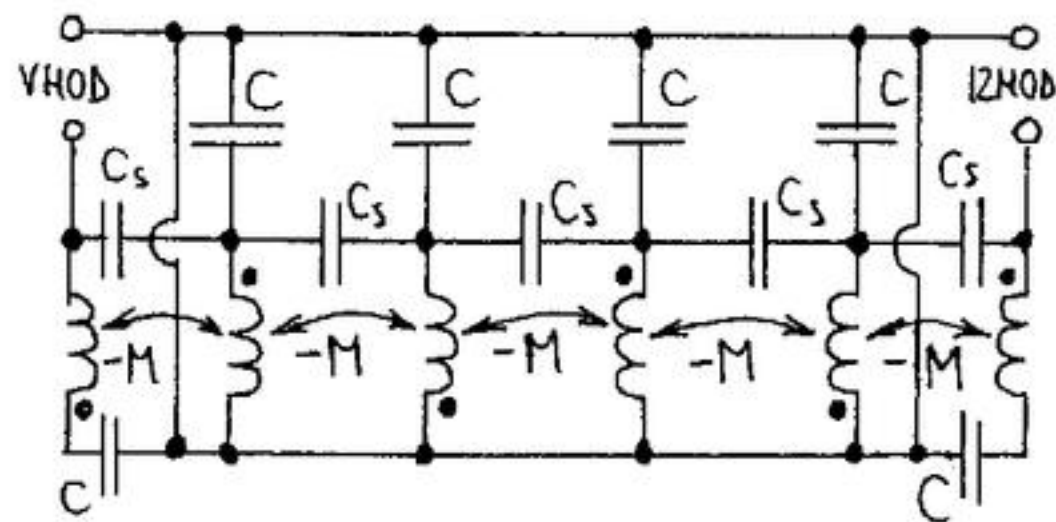
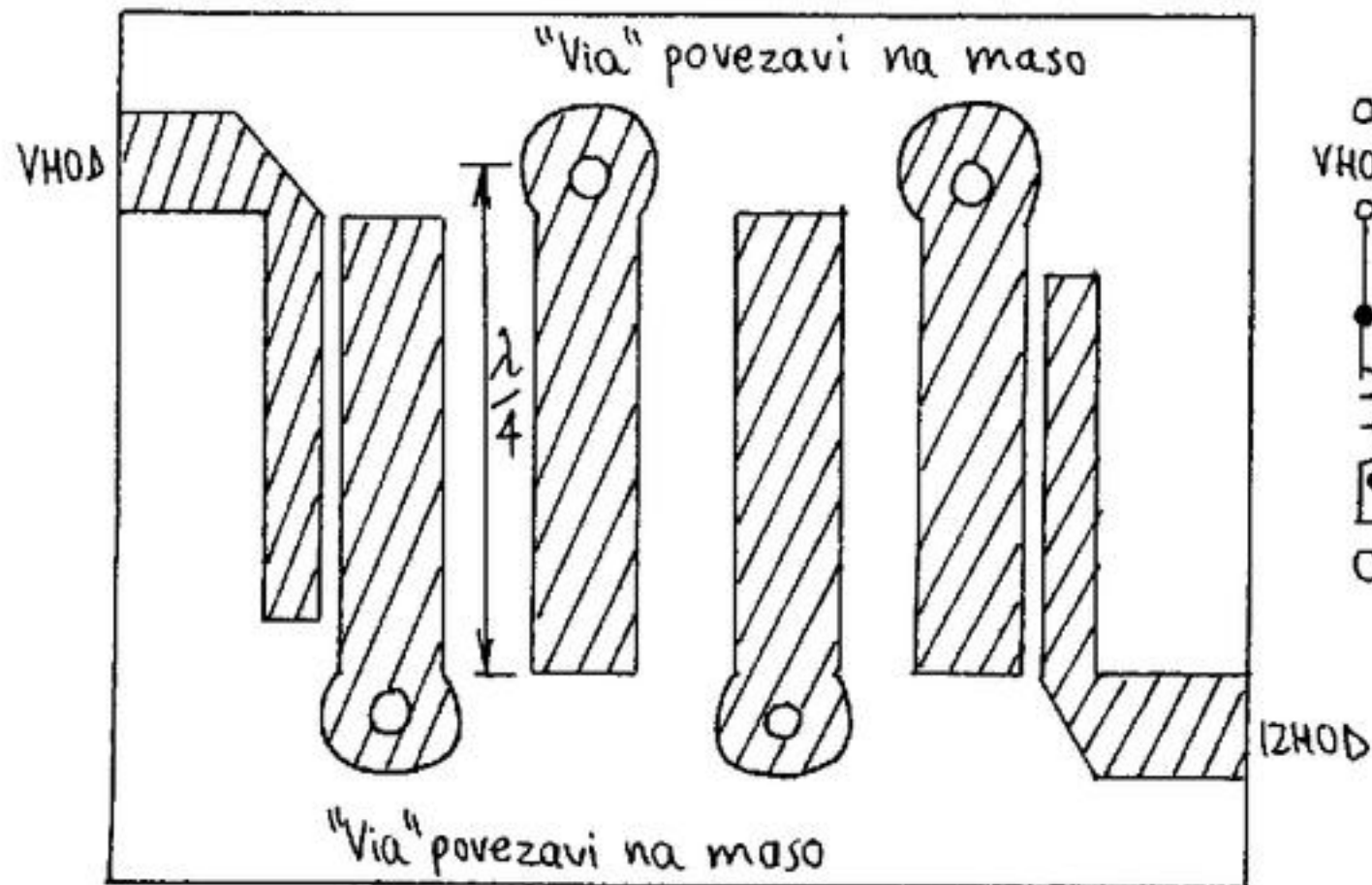
Polvalovni kratkosklenjeni rezonator



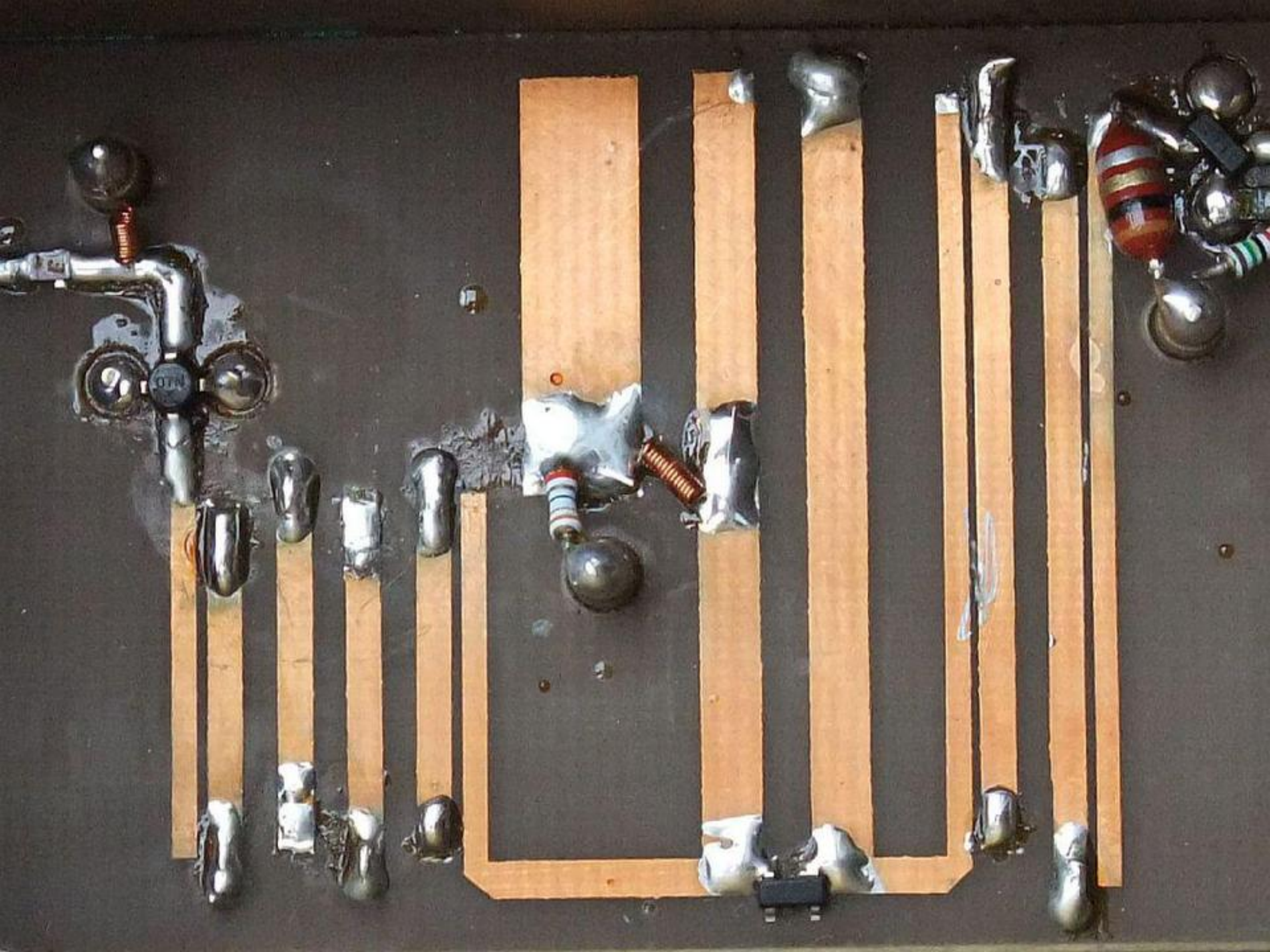
Celovalovni krožni rezonator

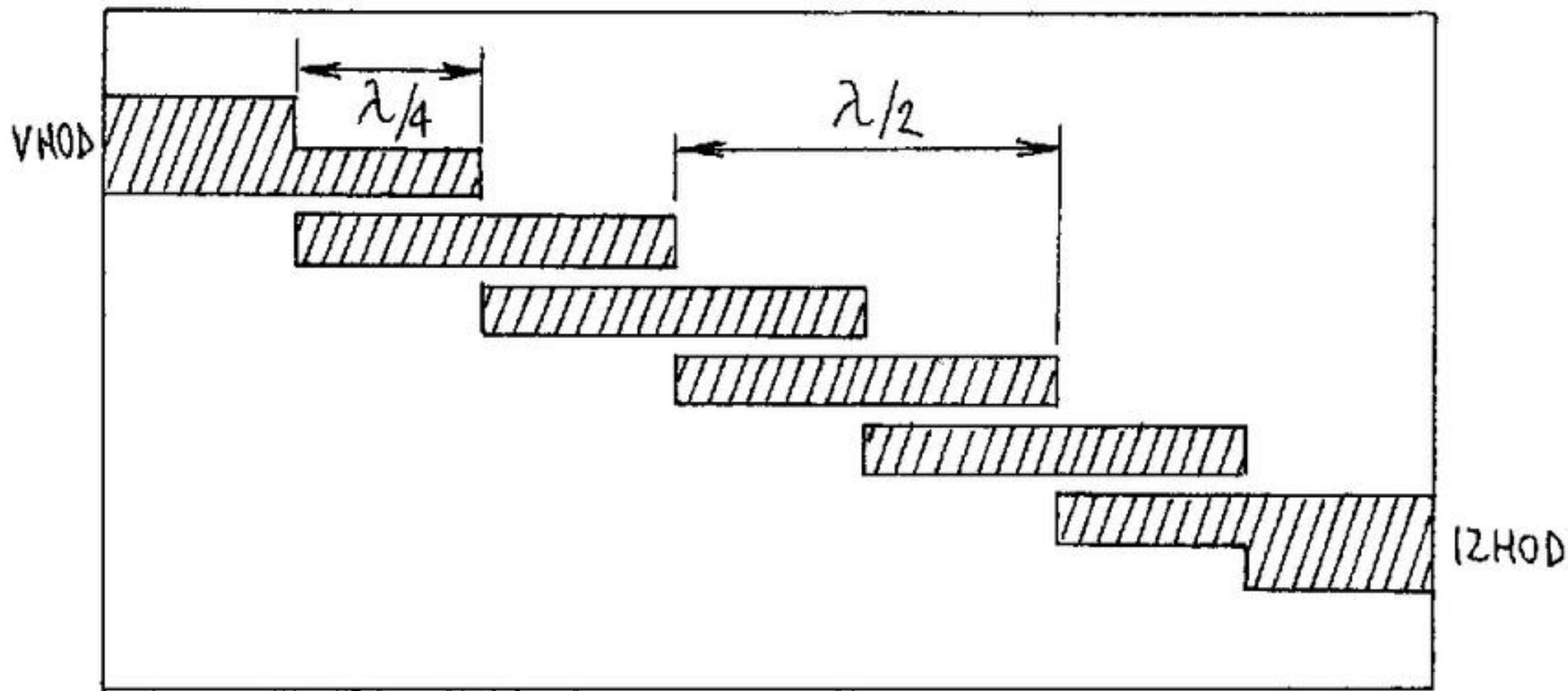


Sito "glavnik" (comb filter), vhod in izhod sklopljena z odcepom

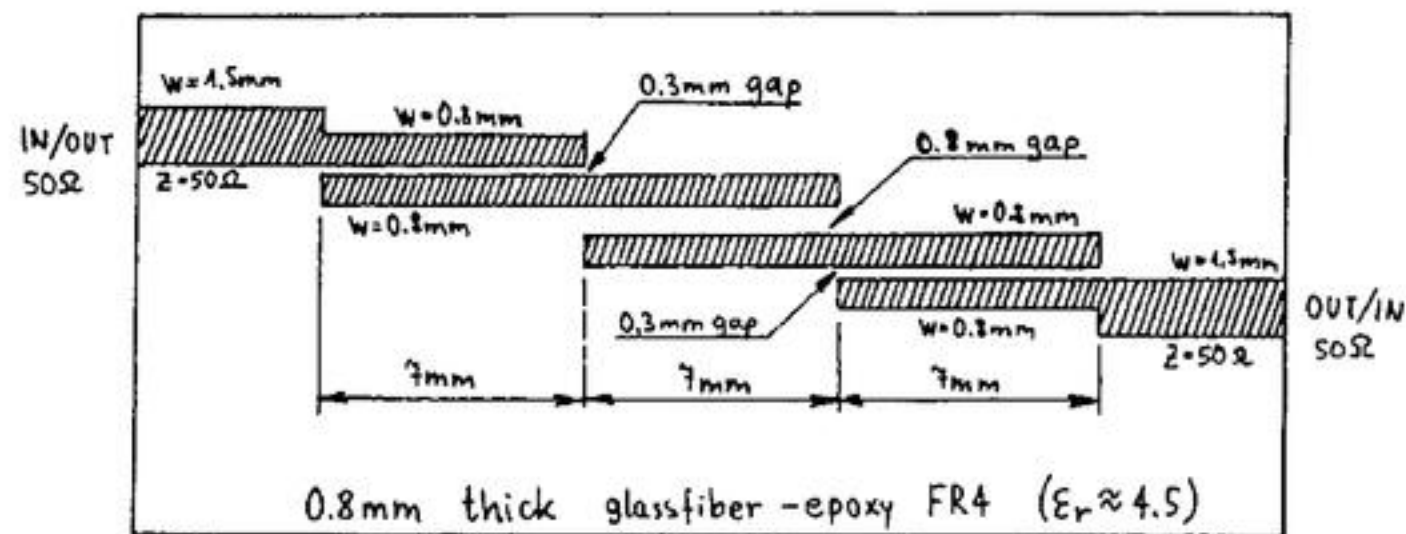


Interdigitalno sito, vhod in izhod sklopljena z mikrotrakastim sklopom

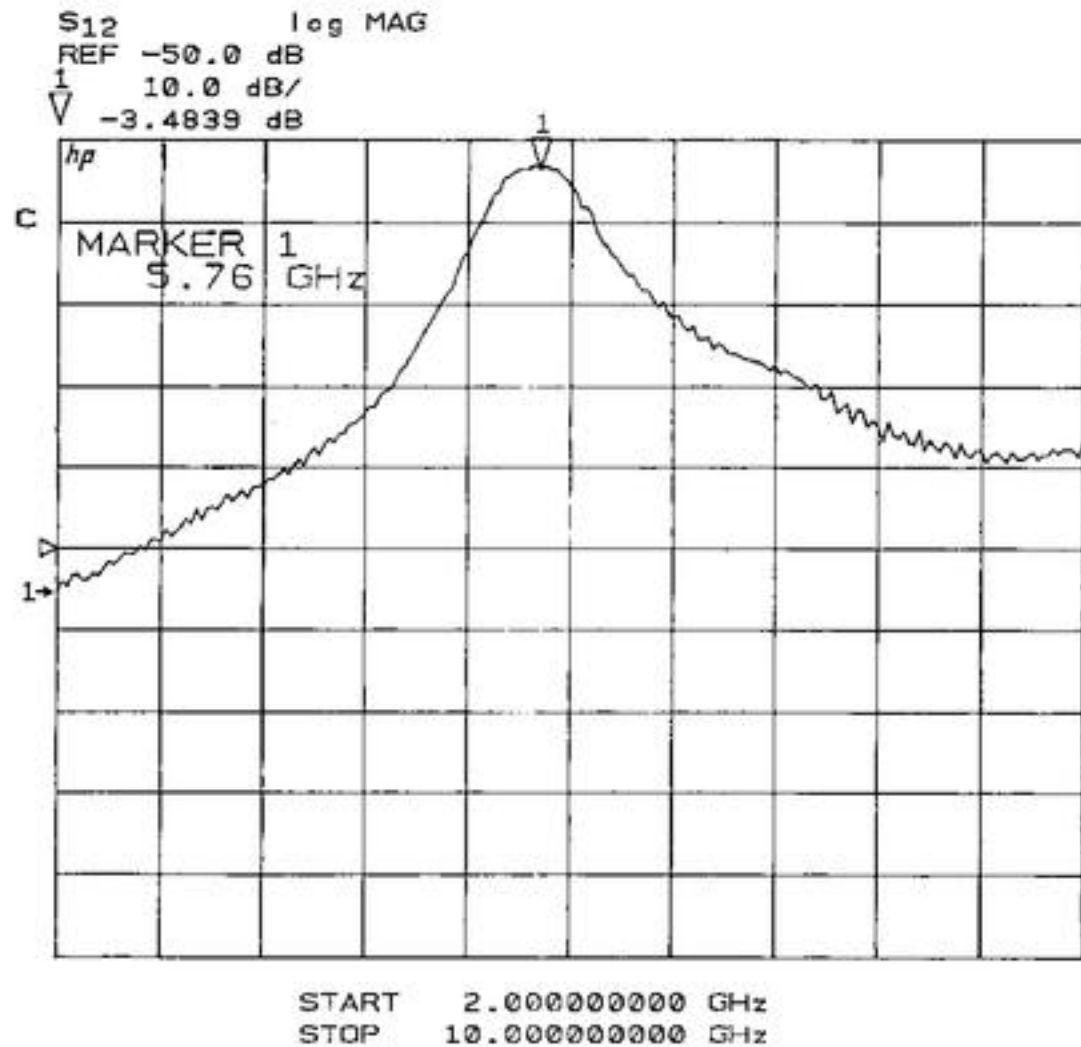


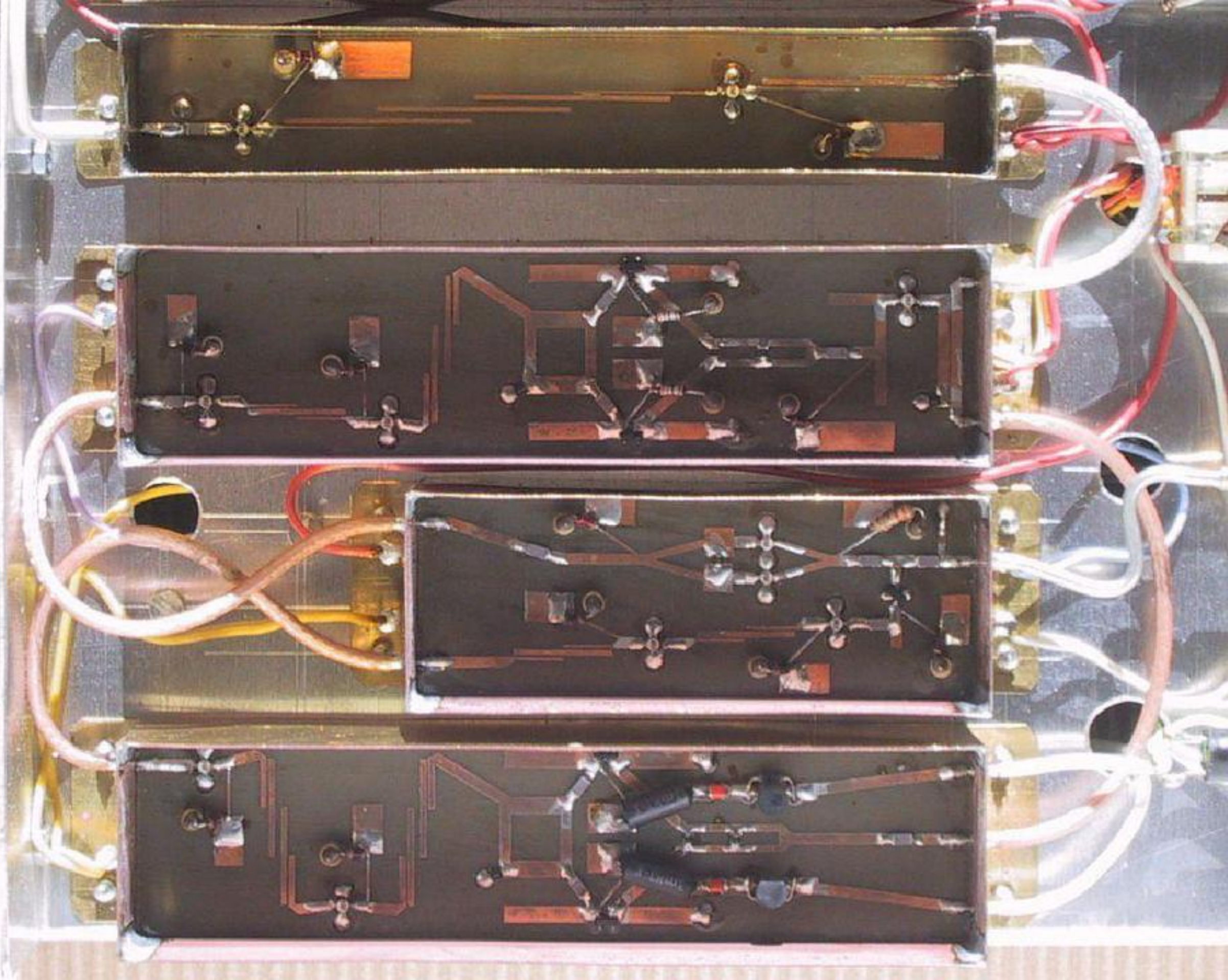


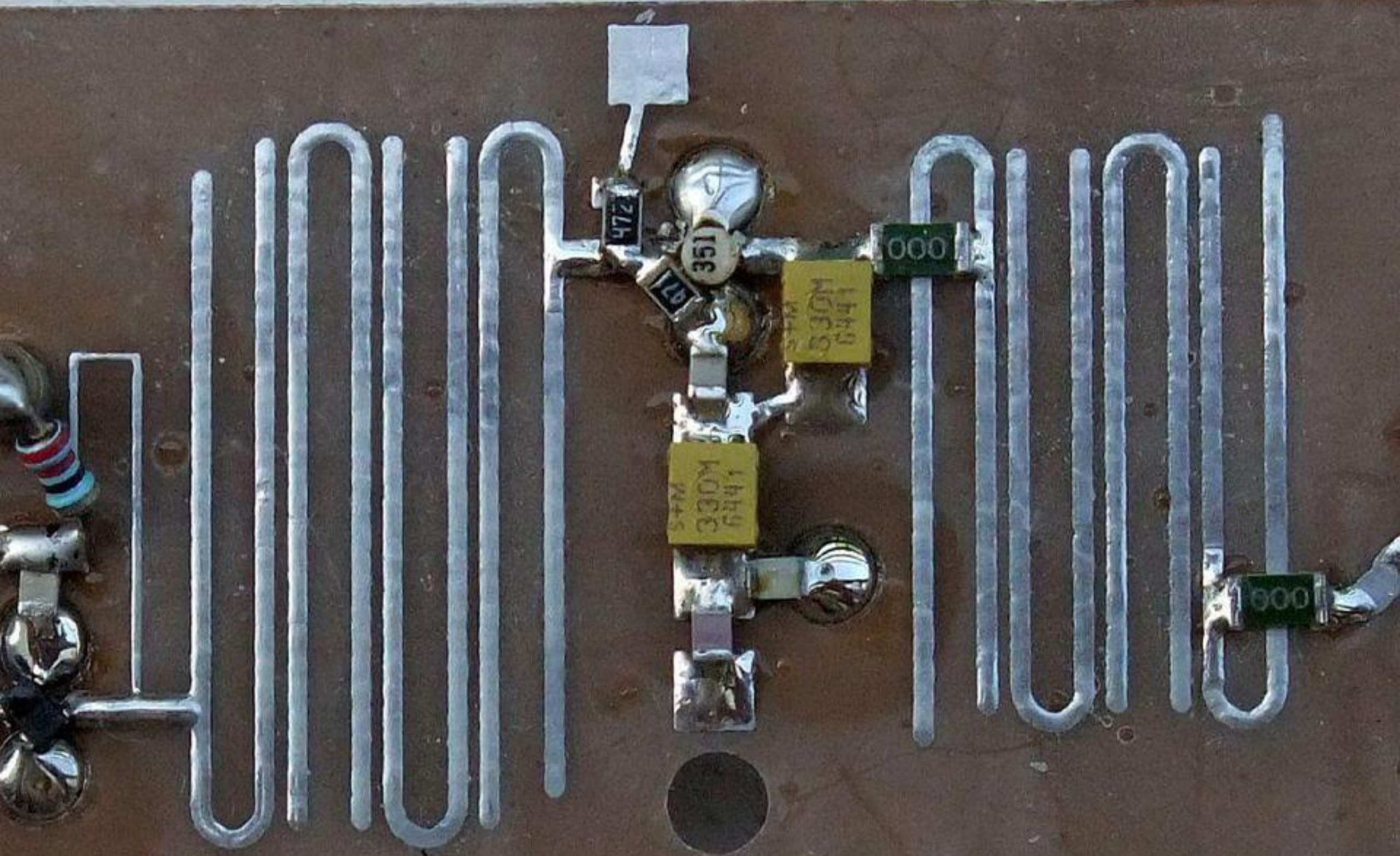
Sito s polvalovnimi odprtimi rezonatorji

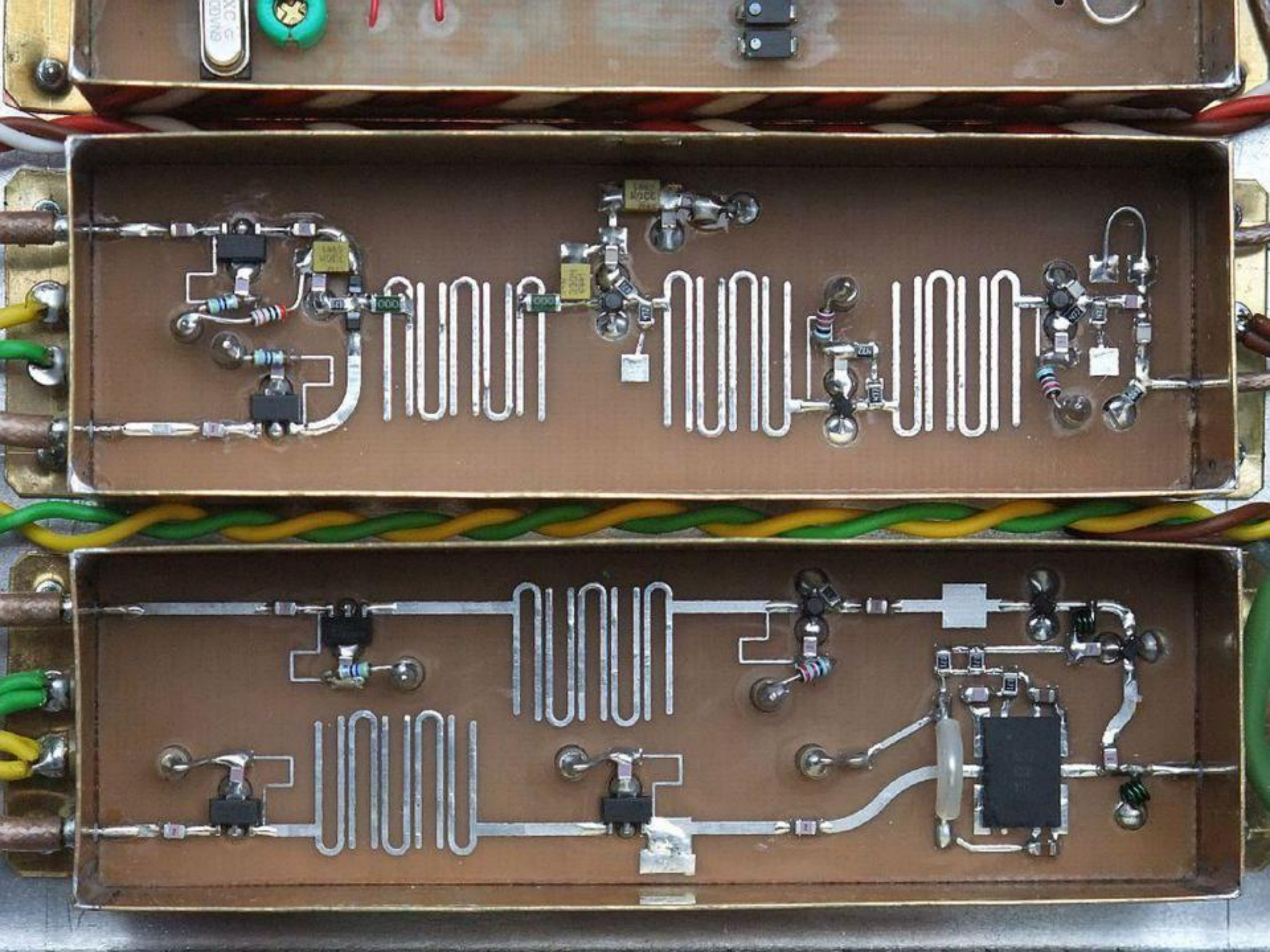


Uporabno sito na vitroplastu





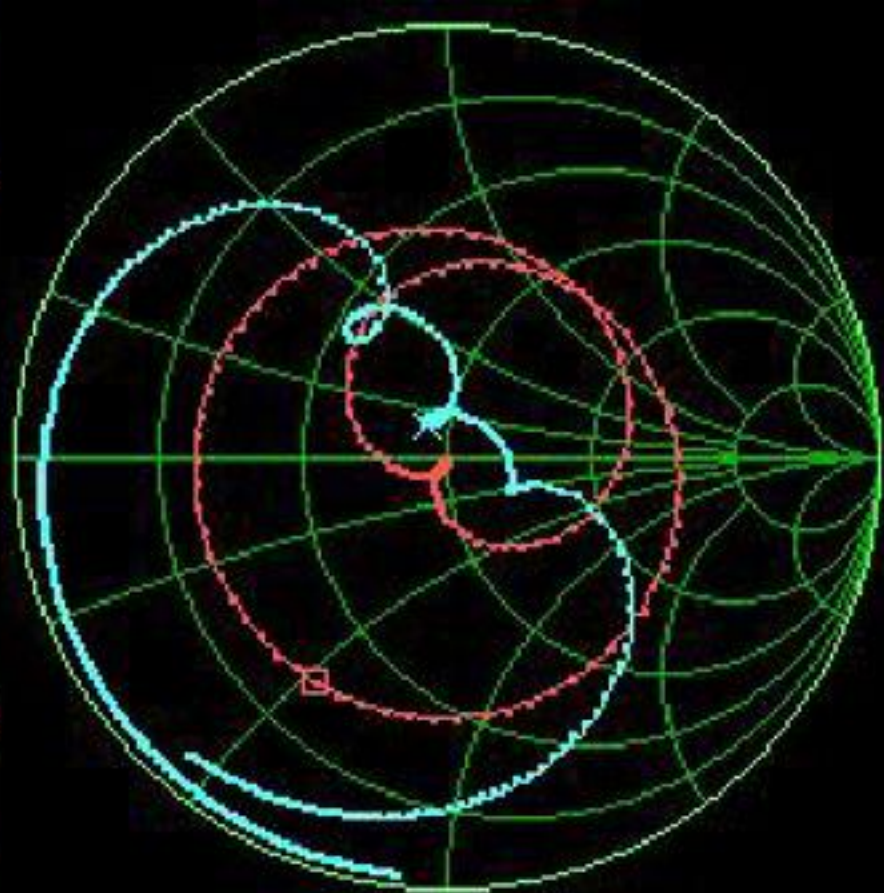
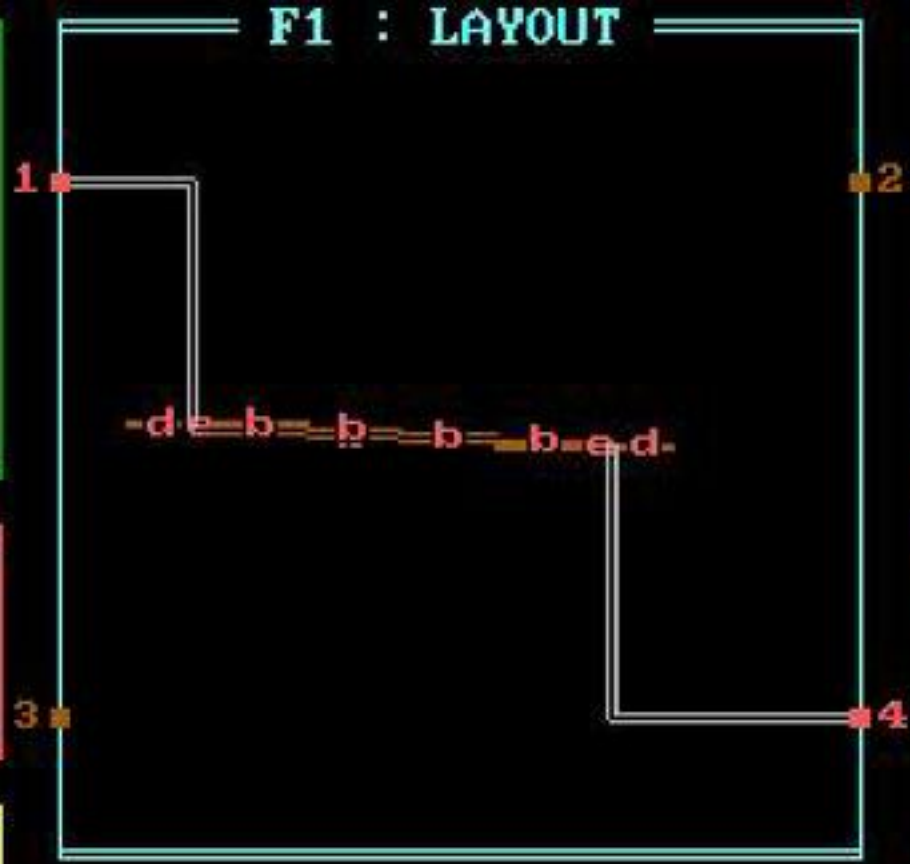




F2 : PLOT

Points 333
 Smith radius 1
 f 2.3614 GHz
 □ S41 -4.42dB -120.6°
 × S11 -21.19dB 122.7°

F1 : LAYOUT



Time 26.3 secs

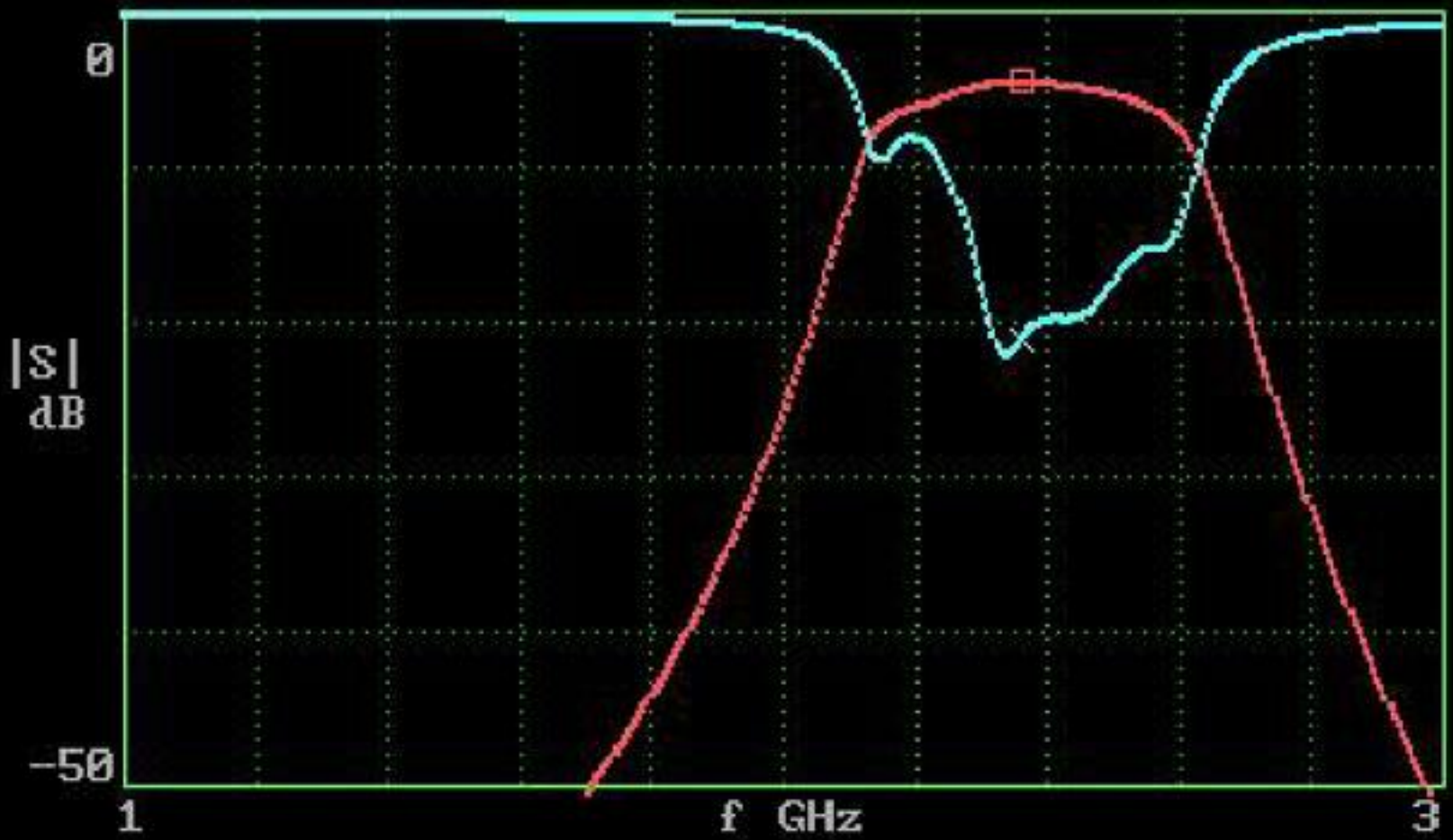
F3 : PARTS

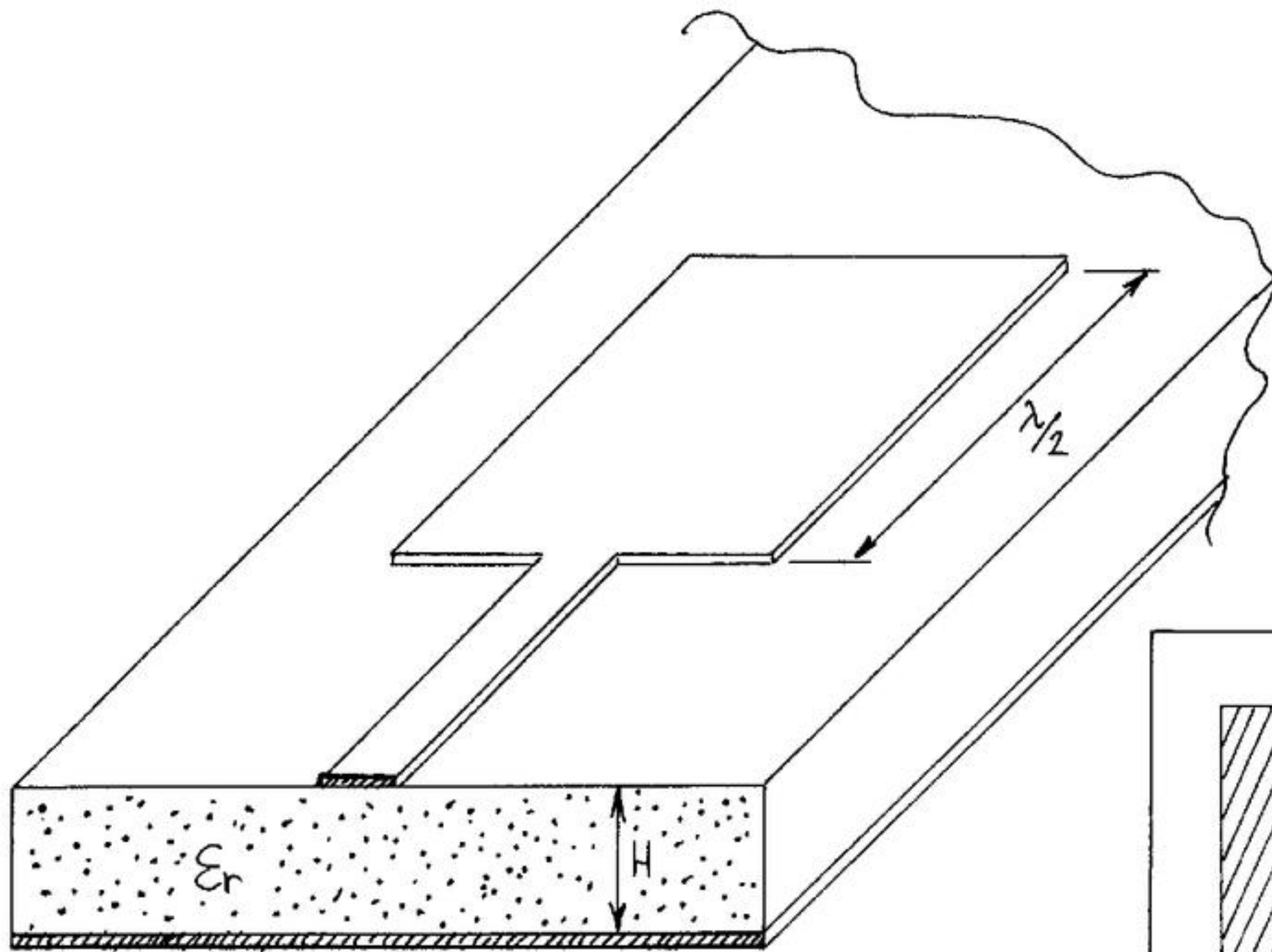
a cl! 83Ω 58Ω 70°
 b cl! 83Ω 58Ω 90°
 c cl! 83Ω 58Ω 20°
 d tl! 70Ω 60°
 e tl! 70Ω 20°
 f cl 81Ω 60Ω 90°
 g cl 80Ω 62Ω 90°
 h tl 50Ω 30°
 i cl 83Ω 58Ω 90°

file : bpf2360e

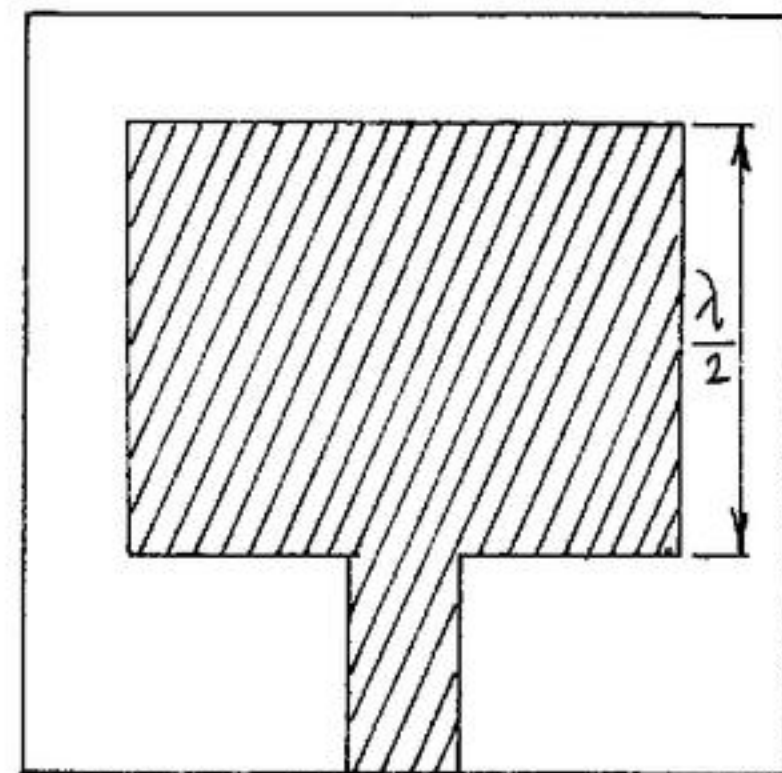
F4 : BOARD

zd 50.000 Ω
 fd 2.360 GHz
 er 4.500
 h 0.600 mm
 s 150.000 mm
 c 100.000 mm
 Tab microstrip





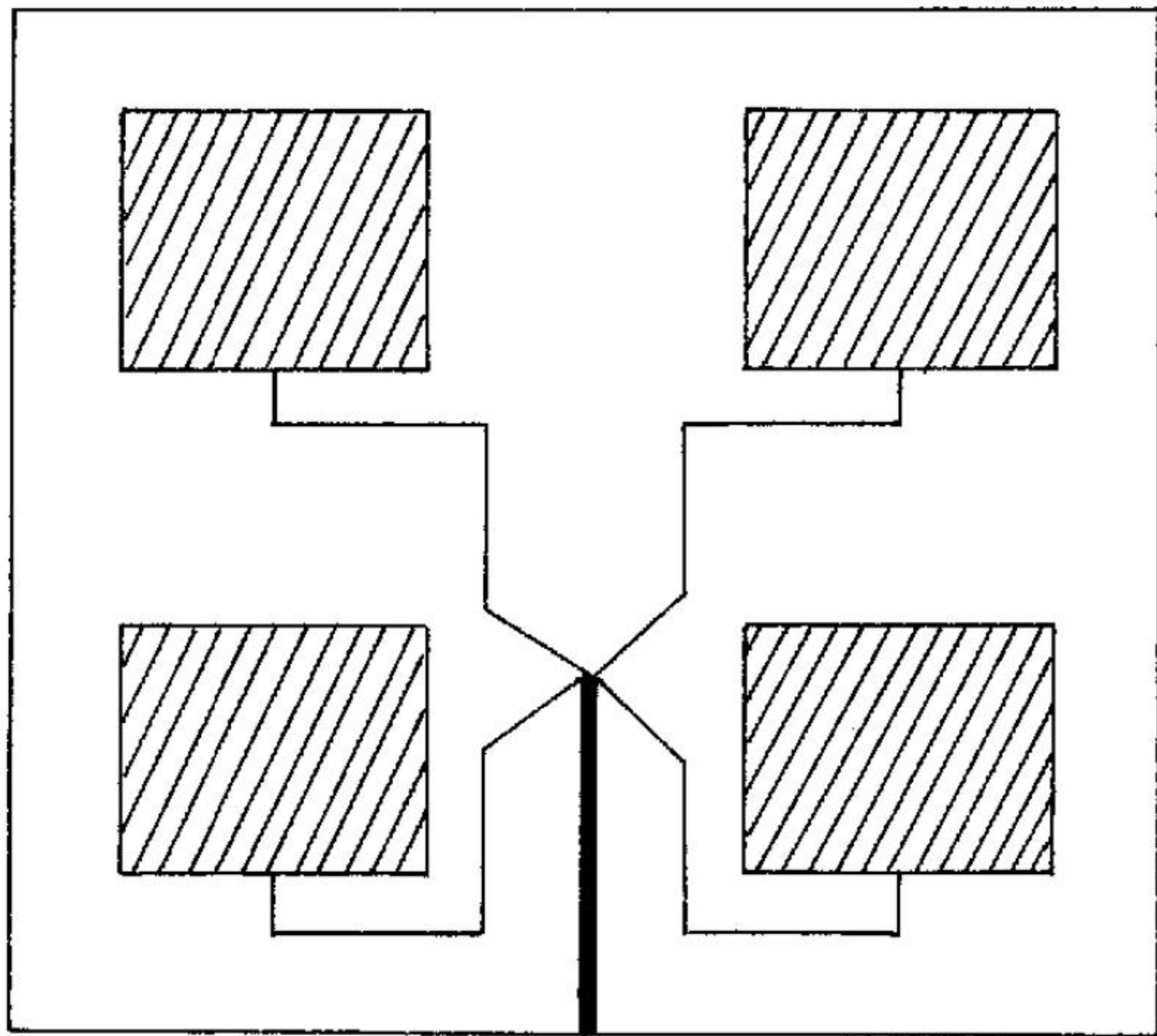
Mikrotrakasti rezonator kot antena



VF PRIKLJUČEK

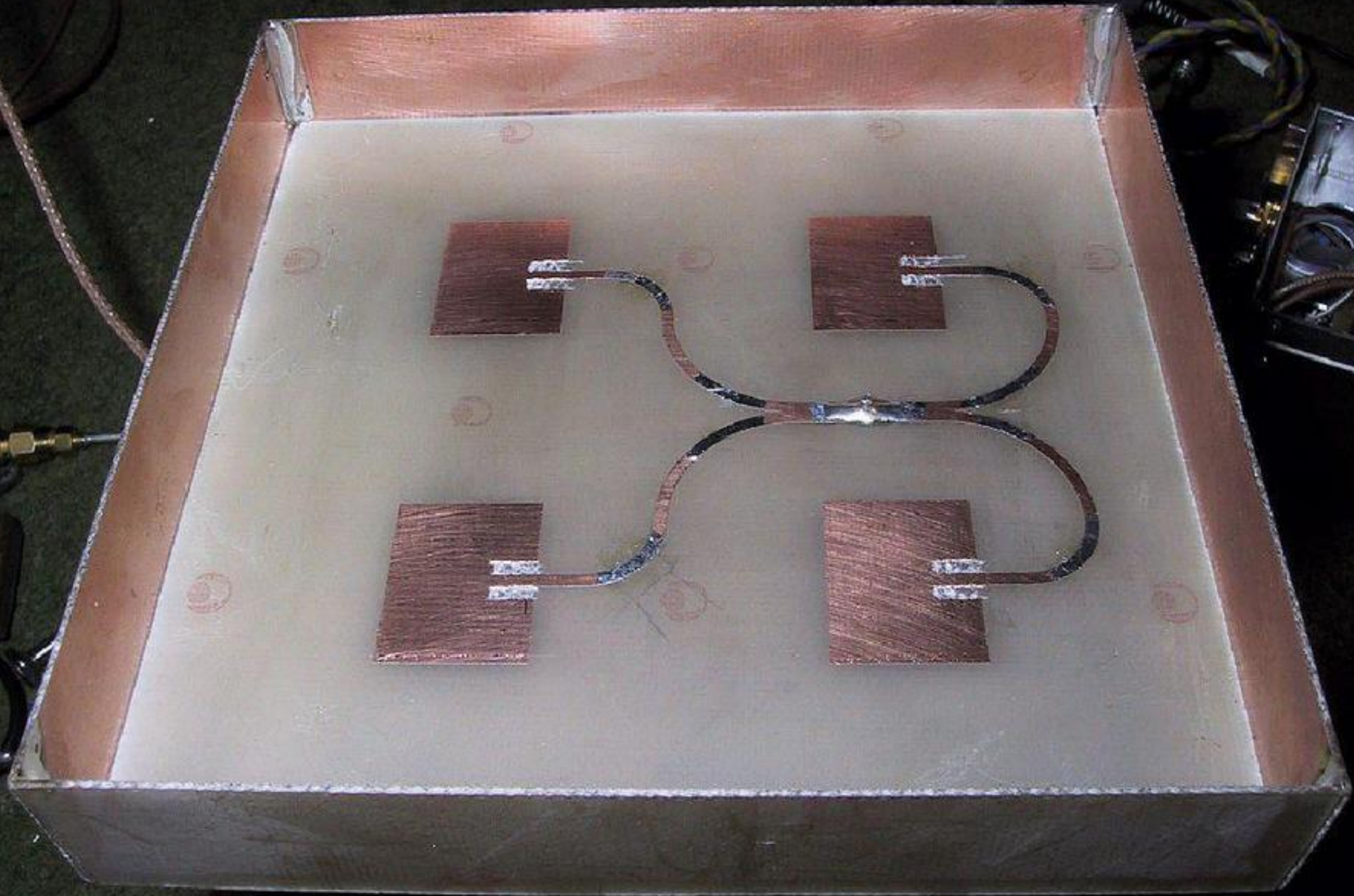


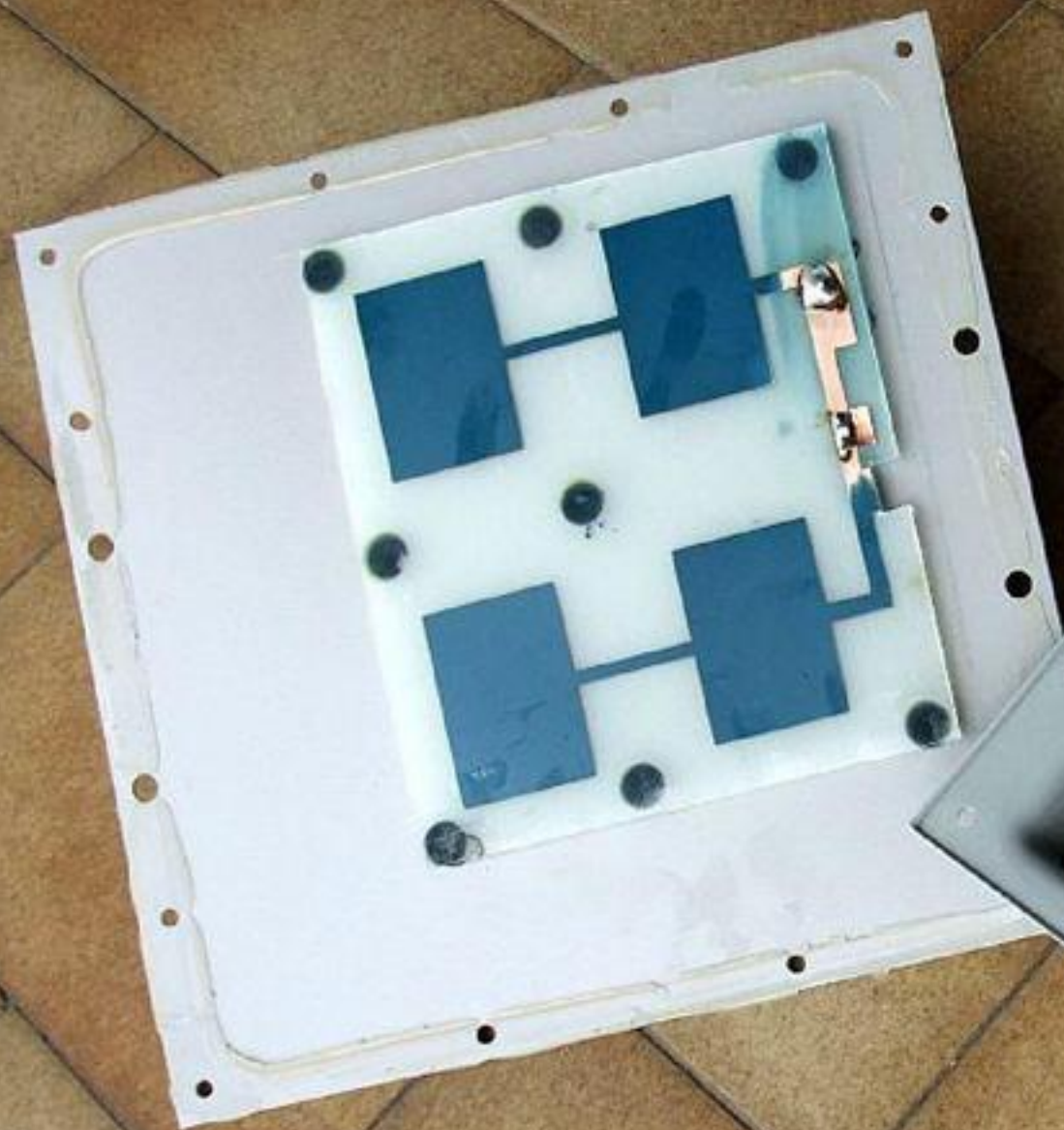




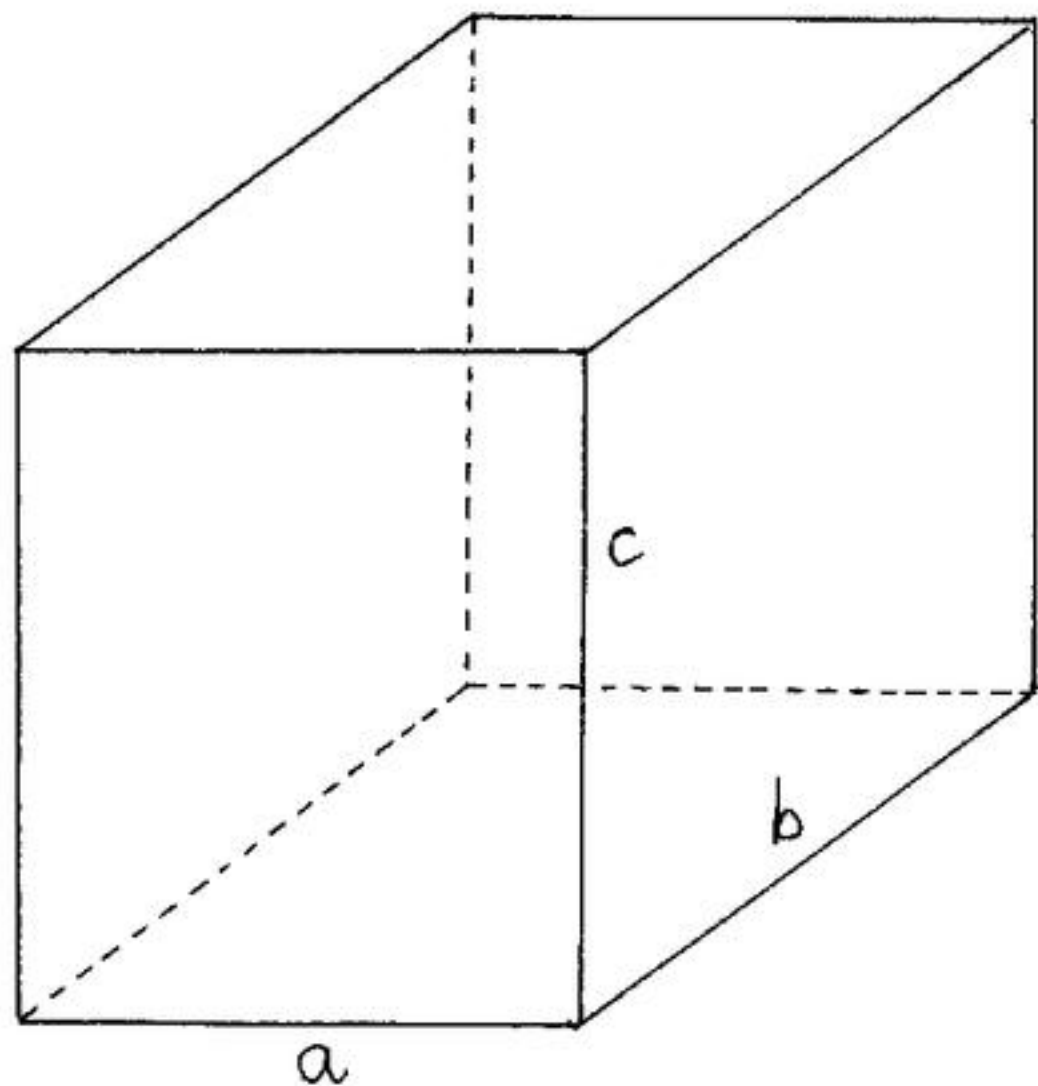
VF PRIKLJUČEK

Mikrotrakasta antenska skupina







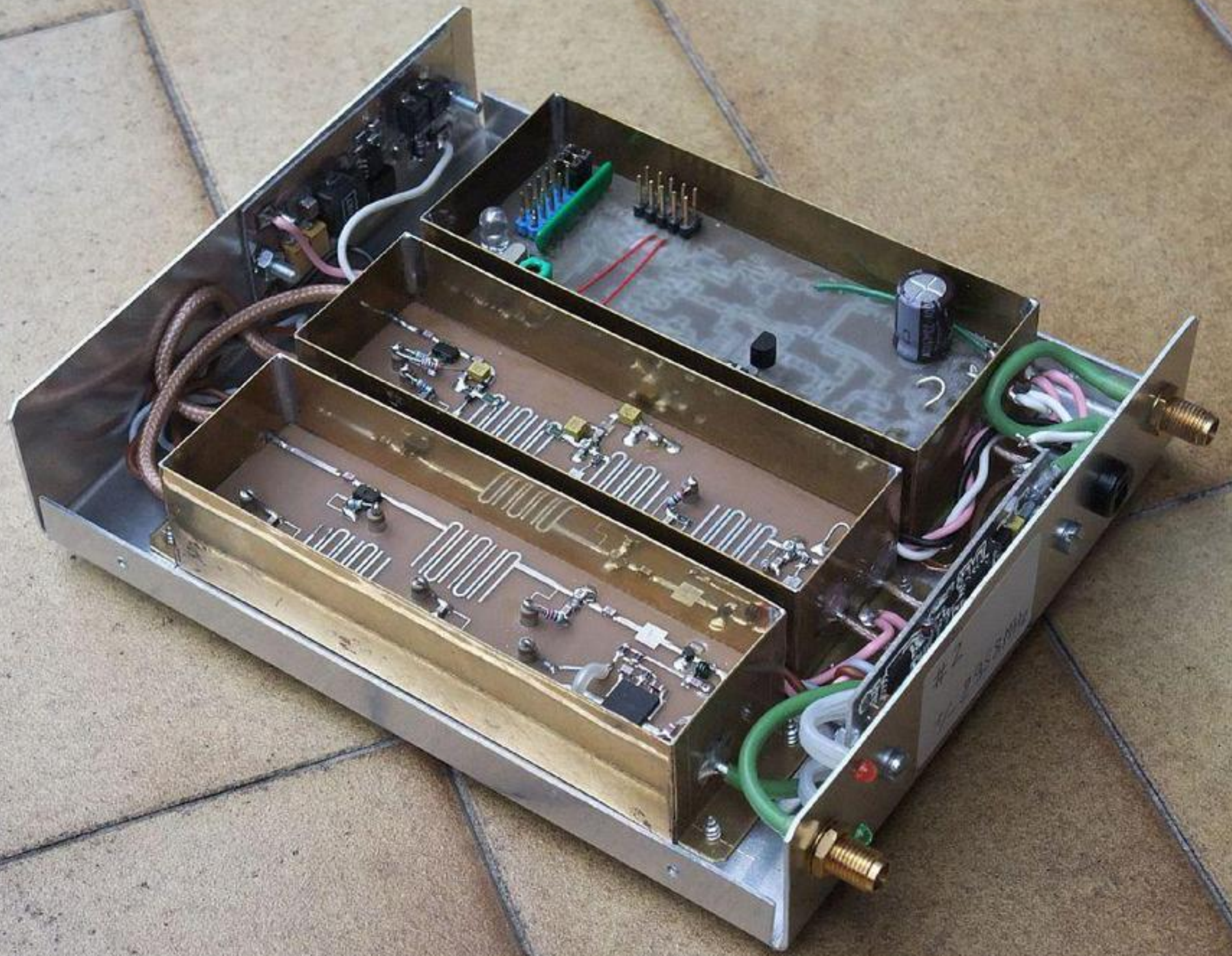


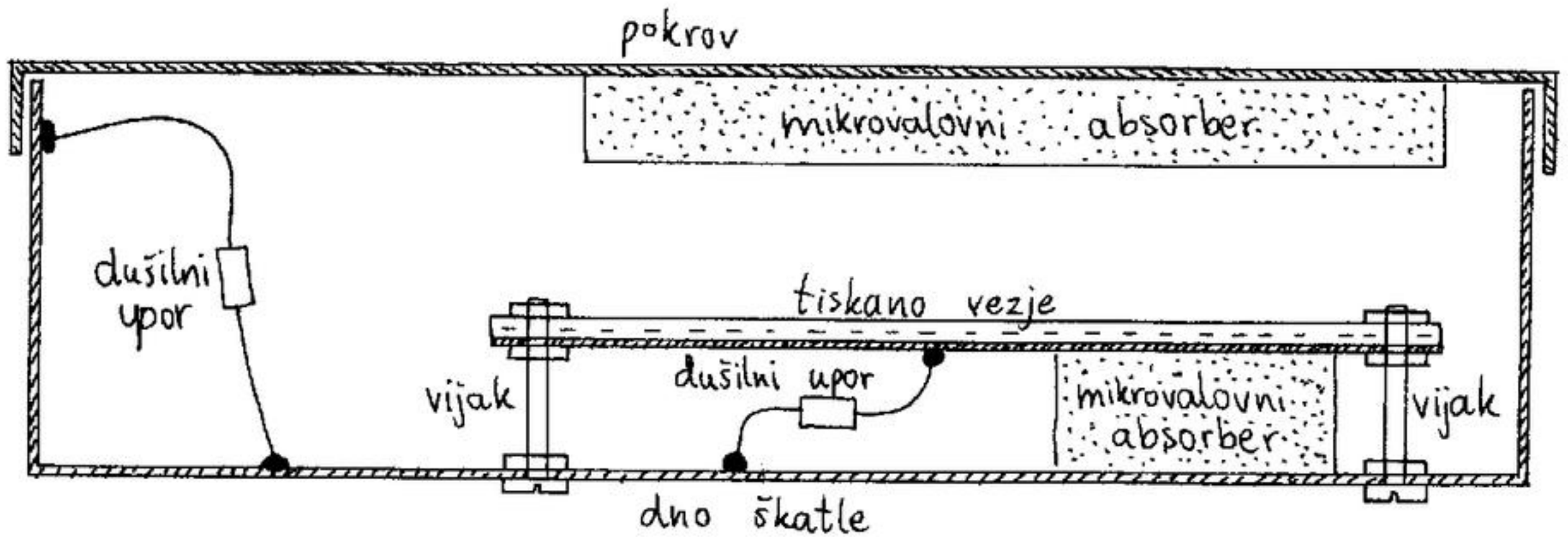
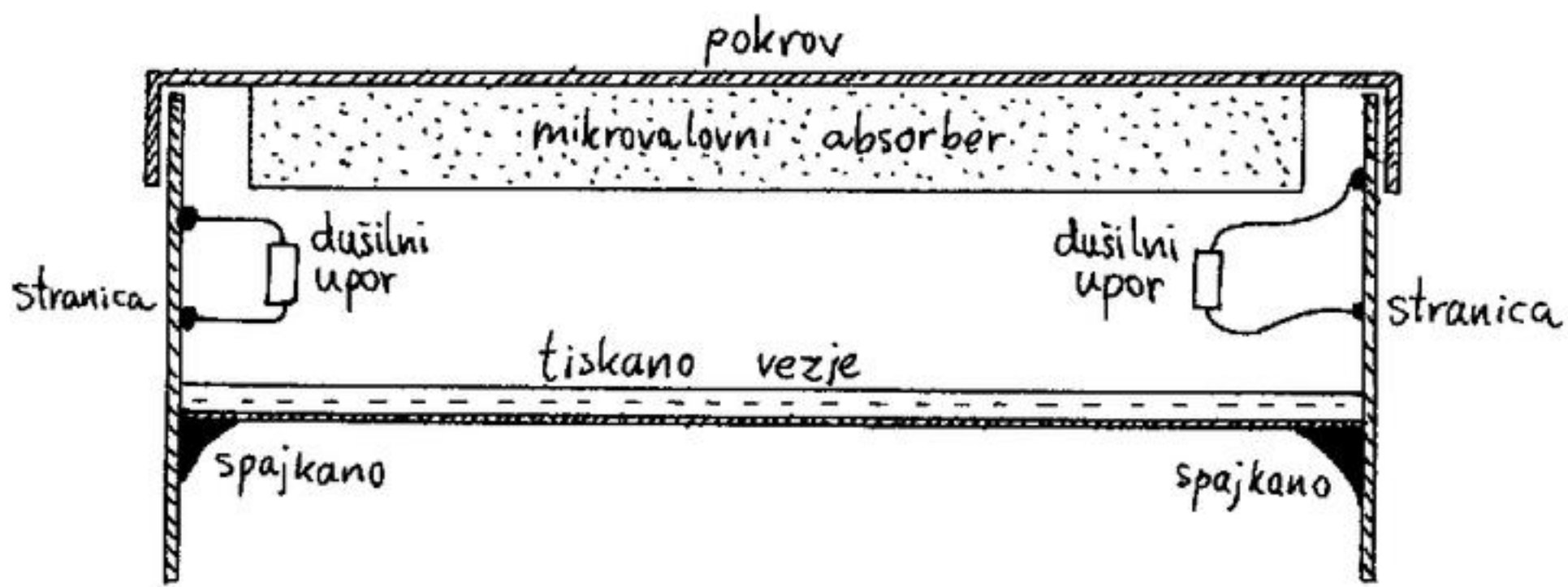
$$f_{lmn} = \frac{c_0}{2} \sqrt{\left(\frac{l}{a}\right)^2 + \left(\frac{m}{b}\right)^2 + \left(\frac{n}{c}\right)^2}$$

$$c_0 = 3 \cdot 10^8 \text{ m/s}$$

$l, m, n \equiv$ cela števila (pozitivna)
vsaj dve različni od 0!

Rezonančne frekvence votle pravokotne
kovinske škatle





Dušenje rezonanc ohišja z upori in absorberjem

