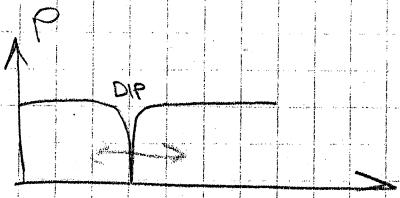
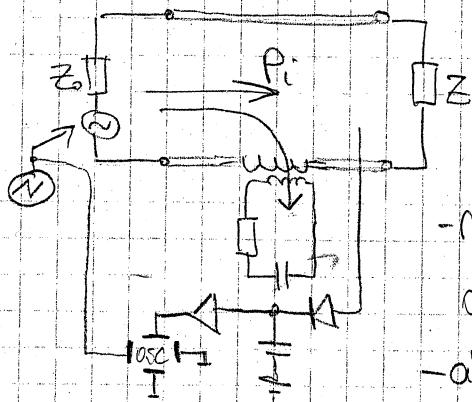


MJERENJE FREKVENCIJE

- događa se na limigu sprečnut titračni tanek velikog faktora dobrote



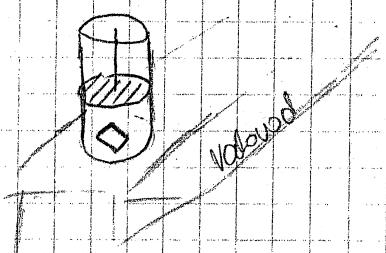
- u rezonansu je dio energije se dissipira na otpor titračnog tanka

- ako mijenjamo rezonansnu frekvenciju DIP se pomiče

- apsorbizacijski ublaživač

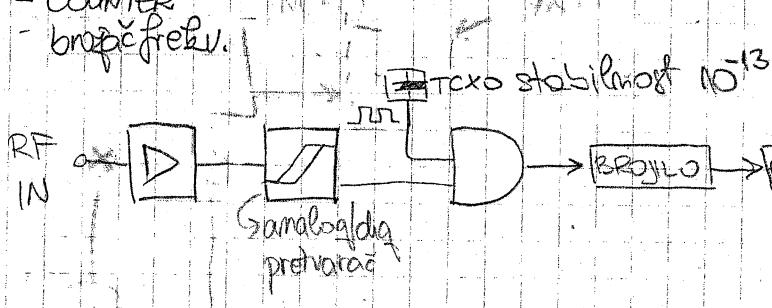
koaksijalni $\alpha \sim 1000$

valovodni $\alpha \sim 20000$



- COUNTER

- brzina frekv.



Ganaloška
prevarač

TCXO stabilnost 10^{-13}

- dana je TCXO za vrijeme
sinteza nizom za TCXO
radi na nMHZ

- Heterodimski prijamnik
dva ulaza: 10 GHz - 18 GHz

- 18 GHz - 50 GHz

↳ marge
offset frekv 2609
harmoničko
mješala

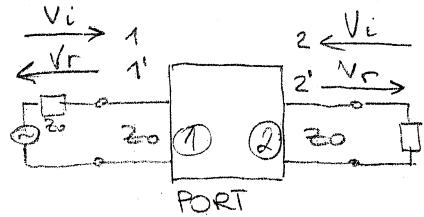
→ ne radi ako imamo modulaciju ili pravokutni

→ ogrebitost na preopterećenje $P_{IN} > -30 \text{ dBm}$

$D_L \sim 20 \text{ dBm}$ (25,30)

- točnost do 10^{-13} , u laboru 10^{-10}

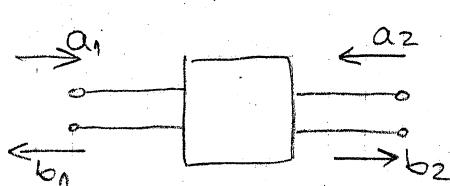
HIGERENJE RASPRŠNIH PARAMETRA I ANALIZATOR KREŽA



- na visokim frekvencijama
postoji kratki spoj ili otvoreni kraj
tako bi mogli port analizirati
preko Z/Y parametra

→ mapom ima amplitudu i
fazu ⇒ prelazak na
valove snage

$$\frac{V_i}{Z_0} \quad \text{Višina vrijednost polja} - \frac{E_i}{\sqrt{2} Z_0}$$



$$a_1 = \frac{E_i}{\sqrt{2} Z_0}$$

$$b_1 = \frac{E_r}{\sqrt{2} Z_0}$$

$$b_1 = S_{11}a_1 + S_{12}a_2$$

$$S_{11} = \frac{b_1}{a_1} \Big|_{a_2=0}$$

$$b_2 = S_{21}a_1 + S_{22}a_2$$

me znači da je četveropol
prikladnem na liniji - prikladnije
imo smo između tereta i karakterističnog imped.

$$S_{21} = \frac{b_2}{a_1} \Big|_{a_2=0}$$

$$S_{22} = \frac{b_2}{a_2} \Big|_{a_2=0}$$

- potrebno je izmjeriti odnos amplituda i odnos faza

$$\left| \frac{b_1}{a_1} \right| e^{j(\phi_b - \phi_a)}$$

- amplitude možemo dobiti preko usmjereneg spremnika i dva mjerična snaga ($|a_1|^2$, $|b_1|^2$)

- razliku u fazi dobitemo mjerom vremenskog razmaka
između 2 maksimuma

→ potrebna mjeri je razlučivost $1^\circ \rightarrow \Delta t = \frac{T}{360^\circ} = \frac{1}{f \cdot 360} \sim ps$

NA / VNA - vektorski mjereni ampl. faze
SNA - skalarno mjereni amplituda

• ANALIZATOR FREQUENCJI

- Instrument służący określaniu parametrów liniarnego mnożka zmienionego od czasu na dany pobudzenie w częstotliwości lub częstotliwości domenii

→ liniowość: $OUT = k_{\text{const.}} \cdot IN$

STIMULUS

RESPONSE

(A) NA
(automatic)

$$VANA \quad S_{12} = \frac{b_2}{a_1} \quad |a_2=0, b_2 \neq 0|$$

$$SANA \quad |S_{12}| = \frac{|b_2|}{|a_1|} \quad |a_2=0, b_2 \neq 0|$$

JEDNOSTRUKI
(SINGLE)

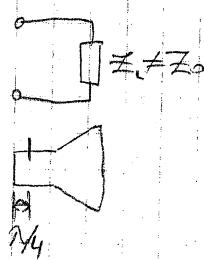
S_m, S_{22}, Γ

ANA

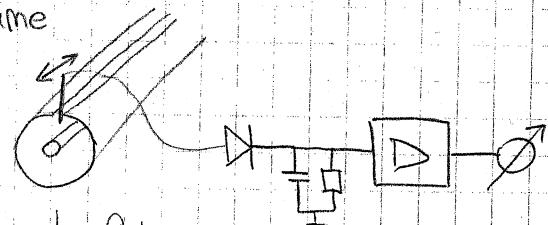
DVOOSTRUKI
(DOUBLE) $[S_m \ S_{12}]$ mlece cięgu
 $[S_{21} \ S_{22}]$ rozprzemi matricu

ANA

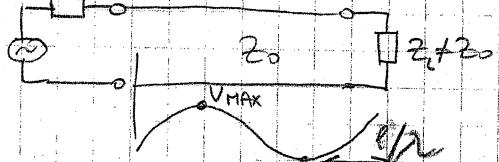
TO
FO



slot line



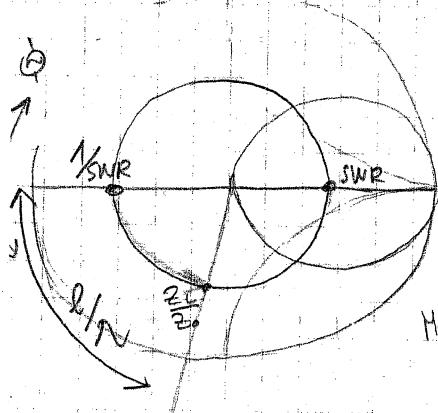
↓ słaba ochrona ~20dB



$$\text{SWR} = \frac{V_{\text{MAX}}}{V_{\text{MIN}}} \quad \text{SWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

↓ impedancja Γ

obstremiona je strogo realna



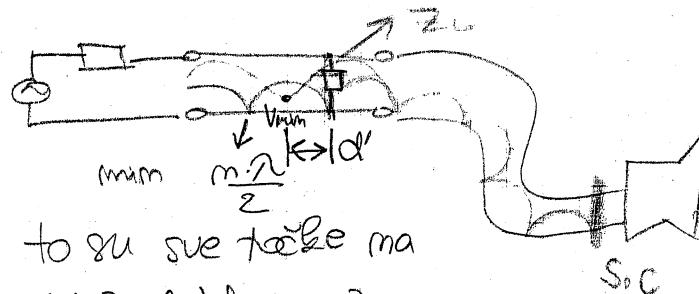
MAX

$$\text{SWR} = \frac{Z}{Z_0} \quad \text{min} = \frac{Z}{Z_0}$$

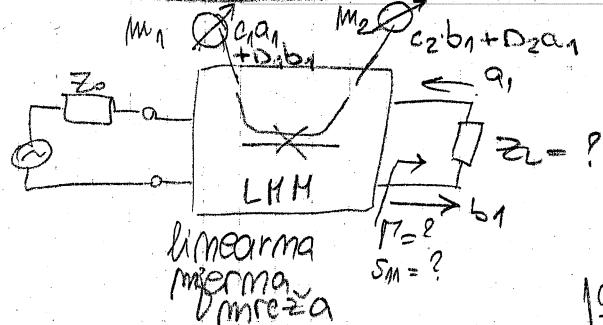
3

- problem → teret nizje ma krajne mjerne linije (između je bokelj)
ne možemo pristupiti teretu

Rješenje:



*OSNOVNA IDEJA ANALIZATORA HREŽA



$$m_1, P_1 = c_1' |b_1|^2$$

$$P_2 = c_2' |b_1|^2$$

$$\frac{P_2}{P_1} = \frac{c_2'}{c_1'} | \frac{b_1}{a_1} |^2$$

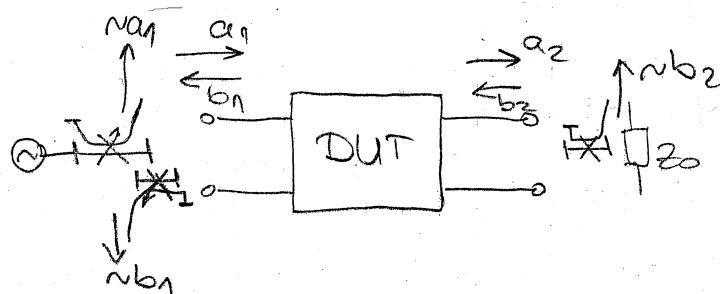
$$| \frac{a_1}{b_1} | = | S_{11} | = \sqrt{ \frac{c_1'}{c_2'} \frac{P_2}{P_1} } = B \cdot \sqrt{ \frac{P_2}{P_1} }$$

$$b_1 = S_{11} a_1 + S_{12} a_2$$

$$b_2 = S_{21} a_1 + S_{22} a_2$$

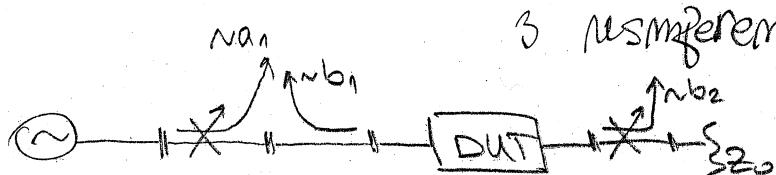
$$S_{11} = \frac{b_1}{a_1} | a_2 = 0$$

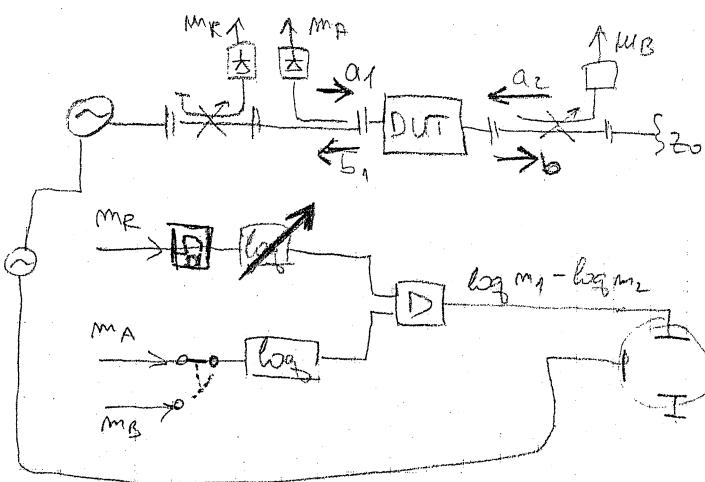
$$S_{21} = \frac{b_2}{a_1} | a_2 = 0$$



→ analizator mreža mora imati generator i

3. nezmjerena sprežnika \Rightarrow REFLEKTOMETARSKI SPOJ



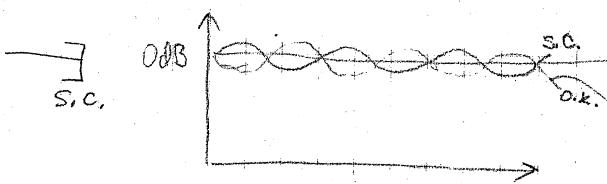


$$\frac{m_A}{m_R} = k_1 |S_{11}|$$

$$\frac{m_B}{m_R} = k_2 |S_{21}|$$

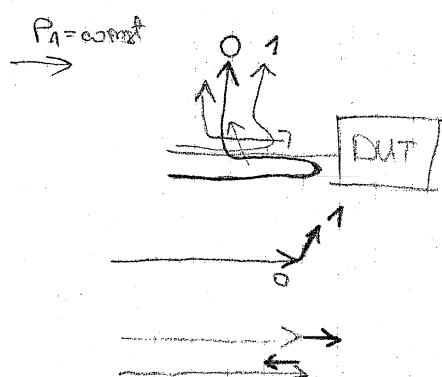
→ za měření
s₁₂ i s₂₂ obrem
DUT

• 2. Nesavršenost zdrojů mezičinnosti sprechníka

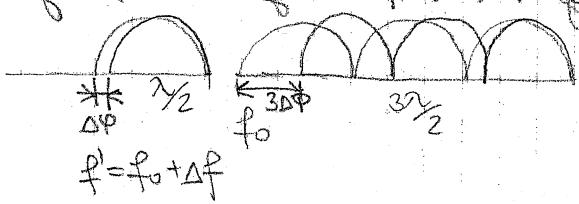


valivitost
zdrojů všeobecných
reflektorů → nesavršenost sprechníka

→ kalibrace s s.c. i o.c. da
dobjezmo rovného círu

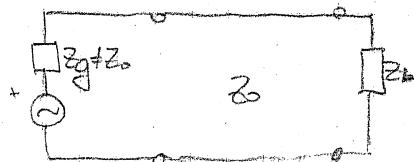


→ čo je kábel dleží bráťmu se změna frekvence



$$f' = f_0 + \Delta f$$

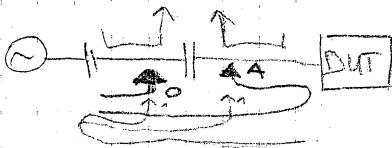
→ ale generátor mže přiladit s



→ všeobecné
reflektory

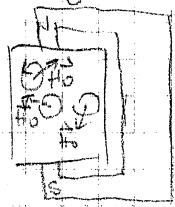
→ přepočítat po měření podél středního voleb

(5)



- rješenje ferritični isolator

- feromagnetska rezonanca → niskopojasno

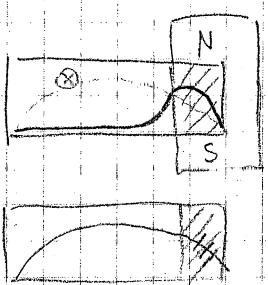
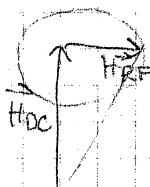


FERIT



ako delujućim magnetom

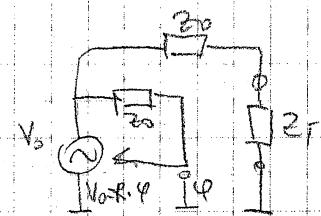
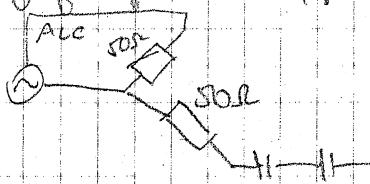
postoji magnetskim - svi spinovi
nismagnetni



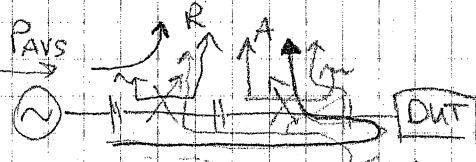
svoj energetski u ferritu → nemna propagacija

očio prelazi u akustički val RF frekvencije

- dželateli - dva otpornika



3. Nasavršenost zložog komične nismagnetnosti sprežnika



$$P_R = C_1 \cdot P_{AVS} + C_1' \cdot P_r$$

$$P_A = C_2 \cdot P_r + C_2' \cdot P_i$$

- problem je implementirati tako da ima
mali refleksiju

→ rješenje SLIDING LOAD - pomičemo
polozaj tereta na liniji

- može doći do kraja problema

- KARAKTERISTIKE SKALARNOG ANALIZATORA

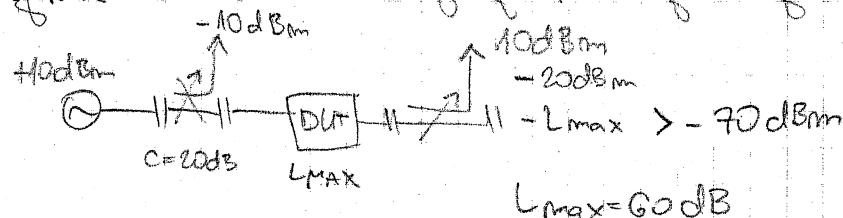
(3)

- frekvencijski opseg

ognjičava sprejnik, detektor $1\text{MHz} - 40(60\text{GHz})$

- dinamika

osjetljivost detektora - kolje je max. gubitak?

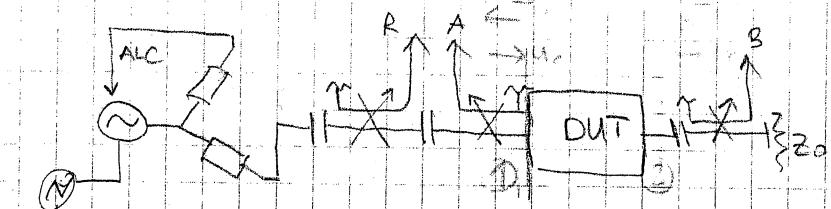


- dinamika je ograničena osjetljivosti detektor - dinamika ograničena na 60 dB

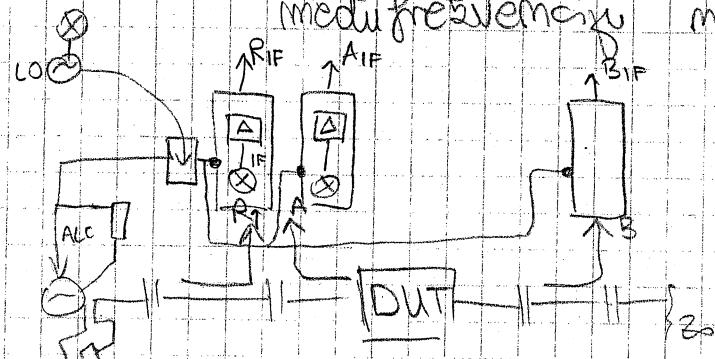
- može mijenjati fazu

(7)

• VEKTORSKI ANALIZATOR KRETA



- ideja prebaciti u drugo područje ali sačuvati odnose amplitud
 → preko heterodimeljeg programnog prebaciti sve na
 međufrekvenciju mrežala



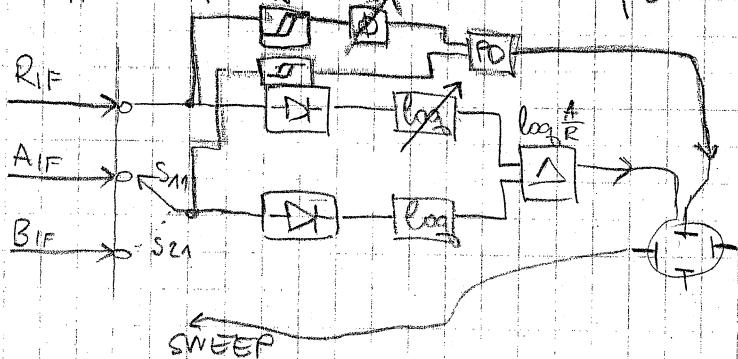
→ sva tri programna monologa
 biti identična

$$A_{IF} = S_1$$

$$V_{AIF} e^{j(\omega_{IF}t + \varphi_{AIF})} * S_1$$

$$A_{IF} = b_1 \cdot Ic_1 e^{j\varphi_{C1}}$$

$$R_{IF} = a_1 \cdot Ic_1 e^{j\varphi_{C2}}$$



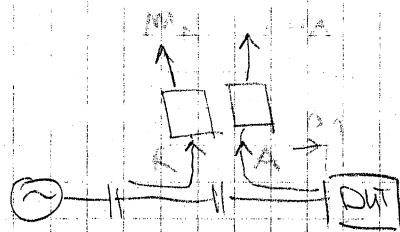
? mize jednako stoga duljine puta
 - imamo grešku u
 amplitudi i fazi

LINE
STRETCHER

mijenjati fazu da se kompenzira kašnjemje

→ dinamiku daje heterodimelji programni (180dB)

• Vektorska korekcija pogrešaka (kalibracija)



$$m_R = C_A \cdot m_1 + C'_A \cdot b_1$$

$$m_R = C'_A \cdot a_1 + C_A \cdot b_1$$

→ prelješavanje

IDEALNO

$$S_{11} = \frac{m_A}{m_R} = \frac{C_A}{C'_A} \frac{b_1}{a_1}$$

$\Delta \phi = 0$
 $\delta(\varphi_A - \varphi_R)$

$$\rightarrow |C_{AR}| = \left| \frac{C_A}{C'_A} \right| e^{-j\pi}$$

↳ ako idealno-možemo podesiti amplitudu na 1 i realnu fazu na 0
između mjerjenja i polaganja

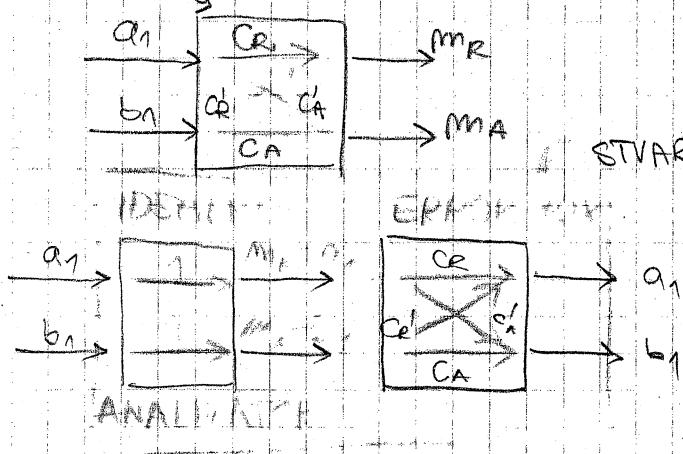
- Ideja:

$$\begin{bmatrix} m_R \\ m_A \end{bmatrix} = \begin{bmatrix} C_R & C'_R \\ C_A & C'_A \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \end{bmatrix} \quad \rightarrow \quad \begin{bmatrix} m_R \\ m_A \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} C_R & C'_R \\ C_A & C'_A \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \end{bmatrix}$$

ovo je želimo

dvojno izmjerimo

G stvarni analizator mreža



STVARNI ANALIZATOR → matematički model - nije stvarnost

$$\bar{C}' / \bar{m} = I \cdot \bar{C} \cdot \bar{m}_s$$

$$\bar{C}' / \bar{m} = \bar{C}^{-1} \cdot I \cdot \bar{C} \cdot \bar{m}_s$$

$$\bar{C}' = X \quad \bar{m}_s = (\bar{X} \cdot \bar{m}) \quad \text{kalibracijska matrica}$$

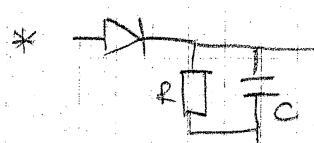
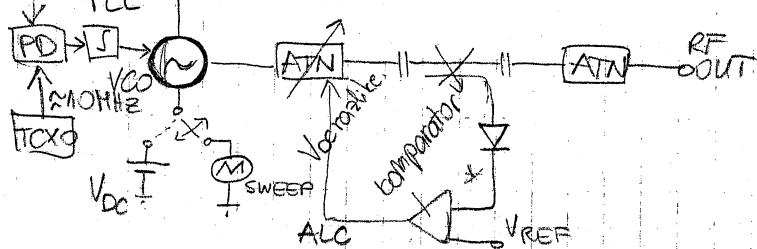
→ kako odredimo koeficijente?

stavimo pozitivni teret, analizator izmjeri tenko, ali mi znamo što trebamo dobiti

- pozmati teret \rightarrow kalibracijski teret; mjeri se amplitudi, geometrija \rightarrow odabire tabo da se može referiti Maxwell jednadžbi

1. LAB VJEŽBA

spustamo GHz na MHz



$$R \cdot C = T \quad \text{da je } C$$

nikad do koga
ne izbjegi drugi

konstantnu vršnu
vrijednost

- sam VCO ima oscilacije po amplitudi i frekvenciji
 \rightarrow potrebna nam je stabilizacija

- fazni detektor - uspoređuje fazu TCXO i VCO

TCXO - velika stabilnost

na integrator (niski propusni filter) dovodimo

razliku faza \rightarrow dobivamo mapom koji se usporjava

na bateriju / sweep

1. Njegove spretnosti \rightarrow kolika je spreča sprežnika?

TS GHz

10 dBm



2. RF OUT s tako znamo da
daje točno 10 dBm?

1) $P = -2,2 \text{ dBm}$ analogni mjerilo snage spreča 12 dB

2) $P = -2,16 \text{ dBm}$ digitalni mjerilo snage

2- direktno mjereno $P = 9,7 \text{ dBm}$ digitalni

$P_{out} = 0 \text{ dBm} \rightarrow P = -0,05 \text{ dBm}$

$P_{out} = 13 \text{ dBm}$

$P_{out} = 3 \text{ dBm} \rightarrow P = 2,98 \text{ dBm}$

$\hookrightarrow P = 12,73 \text{ dBm}$

$P_{out} = 7 \text{ dBm} \rightarrow P = 6,87 \text{ dBm}$

(11)

→ zeleno mjeriti na pravilu 10 dBm

→ gledamo kod je 10 dBm na mjeraju snage, a
(ne na generatoru (na generatoru je 10,1 dBm))

3. Koliki su quisici kabela?

GENERATOR → KABEL → VJERUŠE SNAGE

$$P_{out} = 10 \text{ dBm}$$

$$P = 8,63 \text{ dBm} \quad \text{quisici kabela } (P_{out} - P)$$

$$L = 1,37 \text{ dB}$$

4. Koliko je povećanje glavne grane sprežnika?



$$P = 7,94 \text{ dBm}$$

$$[(10 \text{ dBm} - 1,37 \text{ dB})] \cdot 0,9 = 6,57 \rightarrow 8,17 \text{ dBm}$$

$$L_s = 0,23 \text{ dB}$$

$$\Rightarrow \text{sprežnik } 12 \text{ dB} - L_s = 10,4 \text{ dB}$$

5. zamjenimo sprežnik

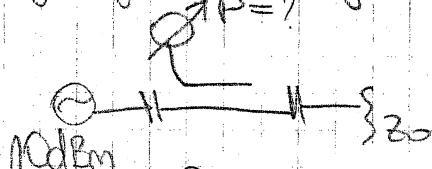
3 dB sprežnik → snaga 50:50

pretpostavka: quisici kabela isti, $P_{out} = 10 \text{ dBm}$

$$P = 5,24 \text{ dB}$$

$$\text{sprežnik } 3,41 \text{ dB}$$

6. mjerite izolacije na 3dB sprežniku



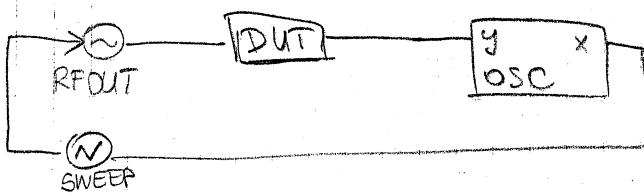
$P_1 \rightarrow$ pale ispod počnuće objektiv
zamjenimo glave - dijelme s vodom
objektivom

$$P_d = -16,48 \text{ dBm}$$

$$I = 55,1 \text{ dB}$$

• KJERENJE KARAKTERISTIKE FILTRA

$S_{21} \rightarrow$ prenese ma smaga



$$f_{\text{start}} = 3 \text{ GHz}$$

$$f_{\text{stop}} = 8 \text{ GHz}$$

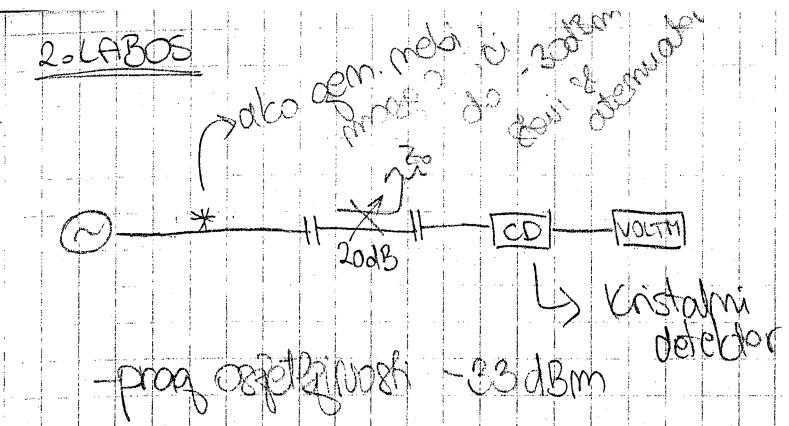
$$f_{\text{off}} = 4.3 \text{ GHz}$$

- sa eksternog maza

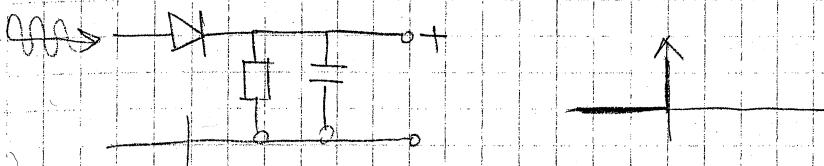
dovodimo signal na x i y placice

pratjena maza instrumenata

2. LABOS



7424A meg.



↳ dioda vodi sa poluperiodu kod je mapom izmed 0

lakos dioda

K1 - vodi da meg. ulazni mapom pa je moguim potencijal
u odnosu na referentnu

1. Hferecije karakteristike diodnog detektora u f -bandu quisici 2dB
dBm

30	-0,622 mV
-29	-0,833 mV
-28	-1 mV
-27	-1,202 mV
-26	-1,443 mV
-25	-1,84 mV
-24	-2,193 mV
-23	-2,440 mV
-22	-2,741 mV
-21	-2,910 mV
-20	-3,045 mV
-19	-3,12 mV
-18	-3,158 mV
-17	-3,287 mV
-16	-3,390 mV
-15	-3,830 mV
-14	-3,088 mV
-13	-3,904 mV
-12	-3,987 mV
-11	-4,030 mV
-10	-4,074 mV
-9	-4,116 mV
-8	-4,150 mV
-7	-4,174 mV
-6	-4,196 mV
-5	-4,212 mV
-4	-4,218 mV
-3	-4,222 mV
-2	-4,226 mV
-1	-4,228 mV
0	-4,230 mV

1	-2,10,44
2	-2,04,45
3	-2,75,49
4	-3,14,52
5	-3,56,64
6	-4,05,56
7	-4,63,00
8	-5,30,94
9	-6,00,63
10	-6,79,29
11	-7,69,72
12	-8,70,54
13	-9,82,50
14	-11,06,56
15	-12,62,1

mV
mV
mV

2dB quisica
2dB od
referentne

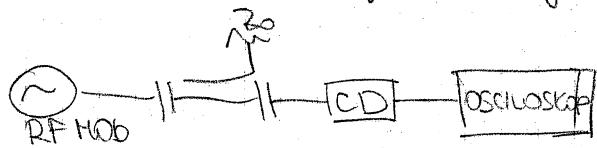
→ doduzi 2dB od
referentne vrijednosti

• Mereonje tonogeneracije i frekvencijalne oadjektivnosti detektora

- ON/OFF modulirani RF signal dajemo na x place osciloskopa

detektorom na
kristalnom detektoru

→ frekv. modulirajućeg signala $\approx 15 \text{ kHz}$



→ na DC modu ako smanjujemo RF signal na osciloskopu
& mijenja oblik norma jer imamo ali su koga proputa
signal sa negativnim poluperiodom

- između osciloskopa i detektora shvamo pojačalo da preciznije odredimo tonu oadjektivnosti

→ imamo sinusoidu a moramo dobiti opet pravokutni signal

pojačalo : DC, nivoi šum, linearna pojačanje

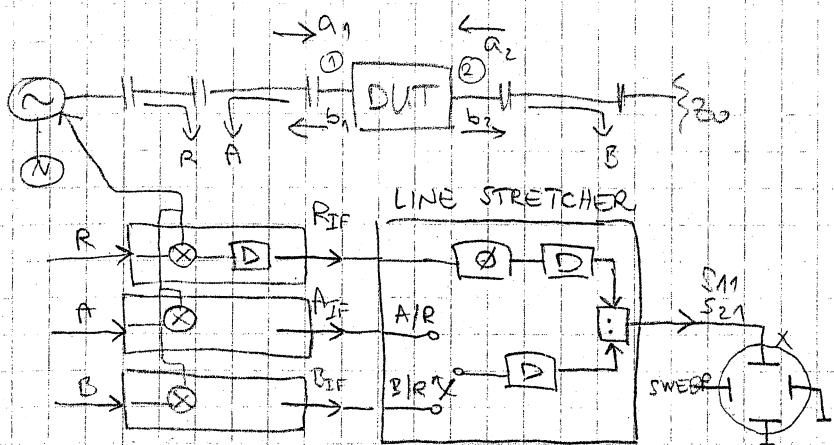
→ i bez uključenog RF signala od 0-20dB došao šum i zabilježenja

→ mora biti uključena modulacija na 1kHz da bi pojačalo radio

→ može ostati sinusoida samo pojačalo mora imati isto pogodnost za sve (njim išći za RF ; bet RF)

- treba smanjiti snagu na generatoru da se boje radi šum

Pomiarovanie + ANALYZATOR SPECTRA



$$S_M = C \cdot A_R$$

IDEALNO

b_1	x_1	$m_1 = b_1$	c_1	$m_1 = c_1 a_1 + c_2 b_1$
a_m	x_1	$m_2 = a_m$	c_2 c_3	$m_2 = c_3 a_1 + c_4 b_1$
S_M		$\frac{m_2}{m_1} = \frac{a_m}{b_1} = S_M$		

$$\begin{bmatrix} m_1 \\ m_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} c_1 & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \end{bmatrix}$$

matematický

model

$$\bar{m} = I \cdot C \cdot m_0$$

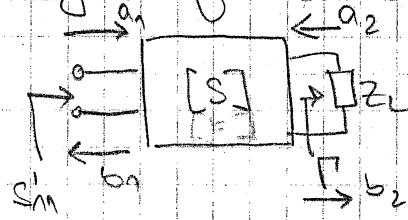
$$I \cdot C^{-1} \cdot \bar{m} = \bar{m}_0$$

+ faktorická matrica

- fázova guba:

teret lejim je so súčinnou lineárna mrežou zo zlom miernimo fac.

reflektivé - ekvivalentní problém



$$\Gamma = \frac{a_2}{b_2} \rightarrow a_2 = \Gamma \cdot b_2 \quad \text{in (1)}$$

$$(1) \quad b_m = S_{11}a_1 + S_{12}a_2$$

$$(2) \quad b_2 = S_{21}a_1 + S_{22}a_2$$

$$(1) \quad b_1 = S_{11}a_1 + S_{12}\Gamma \cdot b_2$$

$$(2) \quad b_2 = S_{21}a_1 + S_{22}\Gamma \cdot b_2 \rightarrow b_2 = \frac{S_{21}a_1}{1 - S_{22}\Gamma}$$

$$b_2 = S_{11}a_1 + S_{12}\Gamma \cdot \frac{S_{21}a_1}{1 - S_{22}\Gamma} \quad / : a_1$$

$$\frac{b_1}{a_1} = S_{11} + \Gamma \cdot \frac{S_{12} \cdot S_{21}}{1 - S_{22}\Gamma}$$

→ možemo pripojiť na matematický model + error box (d6)

$$\Rightarrow S_{11}^1 = E_{M1} + \Gamma \cdot \frac{E_{12} \cdot E_{21}}{1 - E_{22} \Gamma}$$

$\rightarrow E_M$

- treba odrediti koeficijente - odrediti gde su količnice

- stevilo poznate terete: $SOL(T) / SOM$ količica

1. Matching load $\Gamma = 0$

$$S_{11,ML}^1 = E_{M1}$$

2. S.C. $\Gamma = -1$

$$S_{11,S.C.}^1 = E_{M1} - \frac{E_M}{1 + E_{22}}$$

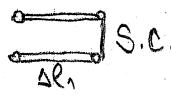
3. O.C. $\Gamma = +1$

$$S_{11,O.C.}^1 = E_{M1} + \frac{E_M}{1 - E_{22}}$$

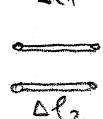
\rightarrow rješimo 3 jednadžbe s 3 nepoznаницice

rješili smo količnicu - i mamo količinu moramo dobiti, dobijemo mesto drugo \rightarrow to možemo upisati u količnicu matricu tako da je sve upisane

- moramo mapovati 3 poznata tereta koji su frekv. međusobno



S.C.



$\left[\begin{smallmatrix} z_{11} \\ z_{22} \end{smallmatrix} \right]$

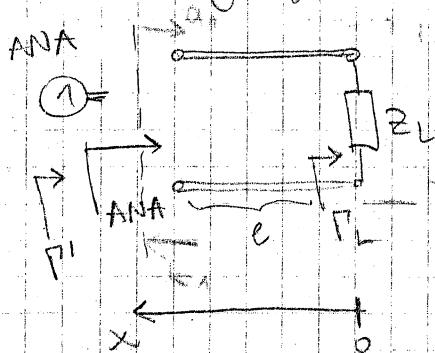
Δt_2

- tako mišljemo frekv. mjenja se počevši s drugim
mjenjuje karakterne frekvencije dulfine
 \rightarrow na nekim frekv. S.C. i O.C. padaju u istu točku

• Promjena referentne ravni

- pretpostavka - sustav je balansiran

- brzak se zove je ono što selimo mijeni ceste medostupnje

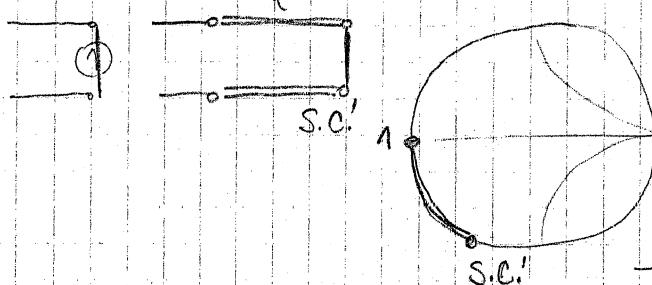


$$a_L = a_1 \cdot e^{-2\beta L}$$

$$b_L = b_1 \cdot e^{+2\beta L}$$

$$\frac{b_L}{a_L} = \frac{b_1 \cdot e^{+2\beta L}}{a_1 \cdot e^{-2\beta L}}$$

- rezultat formozimo
sai $e^{+2\beta L}$



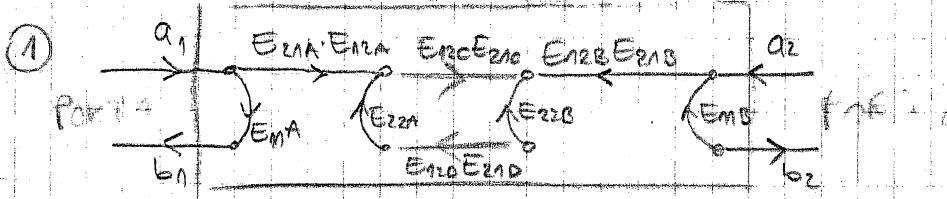
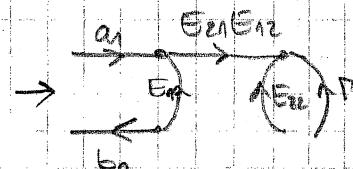
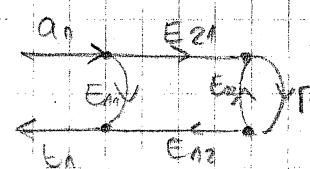
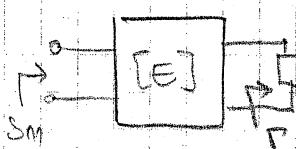
→ instrument 80sm može formoziti

i parabolističku točku

⇒ vrifedi samo da je linija bez quisaka i mesta u kojem
isti su

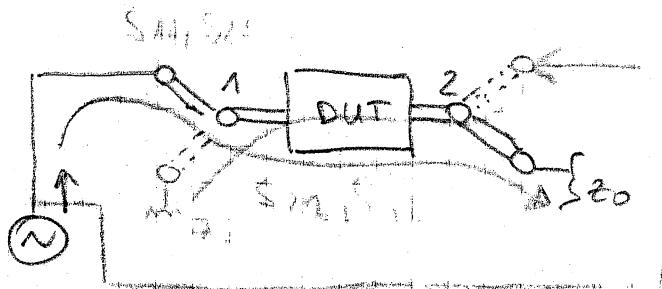
→ možemo nadograditi balansiraju prema napred, ali
NIKAD prema unatrag

+ THREE LOAD model s OSM / SOL / SOT



- puno osjetljivo na sumu

• Mjerenje S_{21} i S_{12}

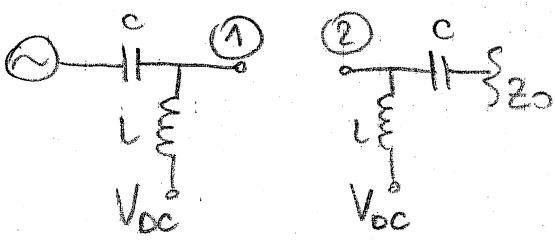


→ Instrument s am zavisnosti sklopke

Tijek pripreme sustava za mjerenje:

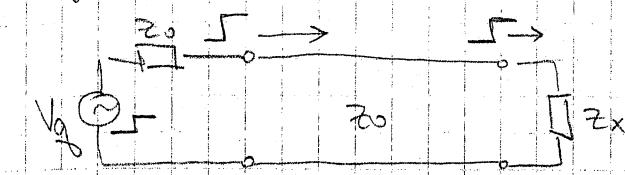
- odrediti frekv. opseg
- mjerenje bez balibracije
- ponovljati frekv. opseg
- balibracija

• Mjerenje aktivnih elemenata



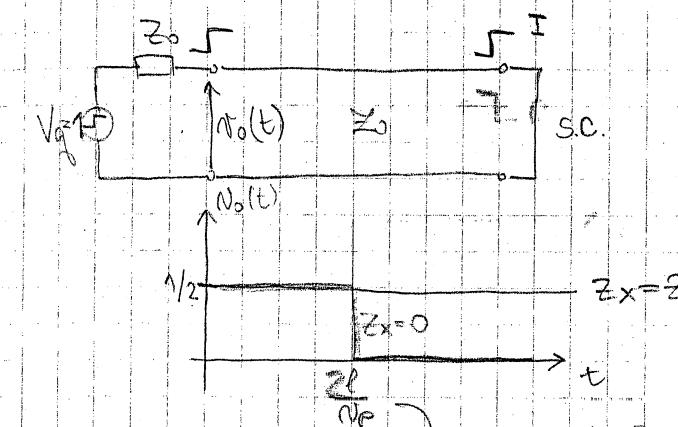
• ANALIZATOR MREŽA s Mjerenjem u VREMENSKOJ DOMENI

- ideja: (1950) Time Domain Reflectometer - TDR

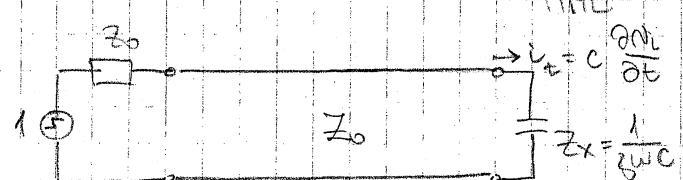


generator - STEP RECOVERY dioda

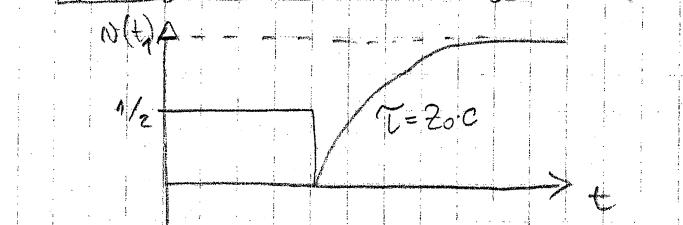
$Z_L = Z_0$ merna refleksija



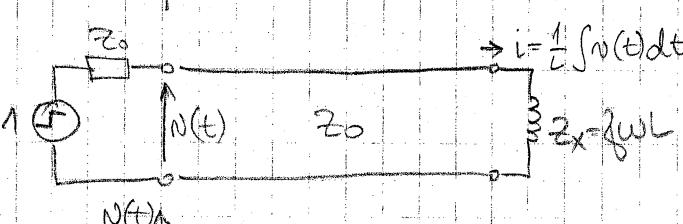
ROUND TRIP TIME



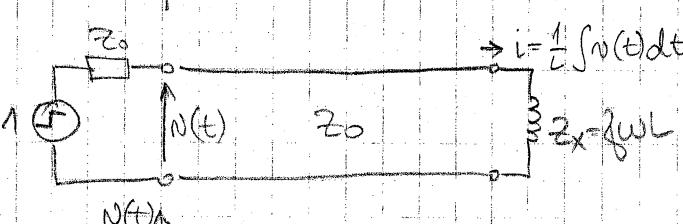
$$t_{\text{RTT}} = \frac{2Z_0}{c}$$



$$t_{\text{RTT}} = Z_0 \cdot c$$



$$i = \frac{1}{c} \int v(t) dt$$



$$z_x = \frac{1}{\omega c}$$

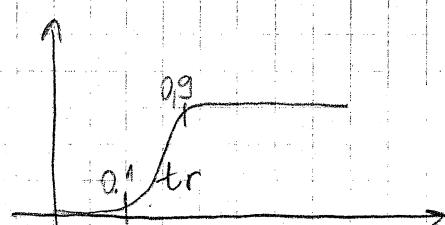
- kondenzator je za malu promjenu
kroz kraj spaj, a kad se do kraja
mali oborenje kraj

→ problem - generator impulsa nije idealan

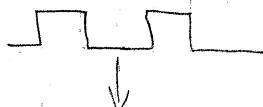
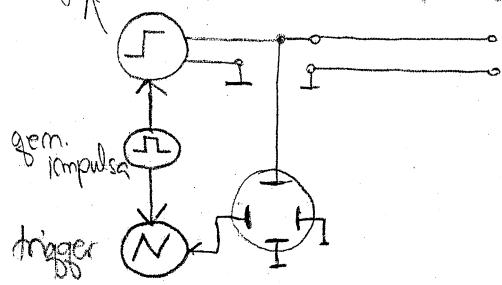
↳ mjeriti strujna ponašanje medesno modi razlučiti

duge bliske refleksije

- razlučivost $\Delta t = 2t_{\text{RTT}}$



generator pravokutnog signala

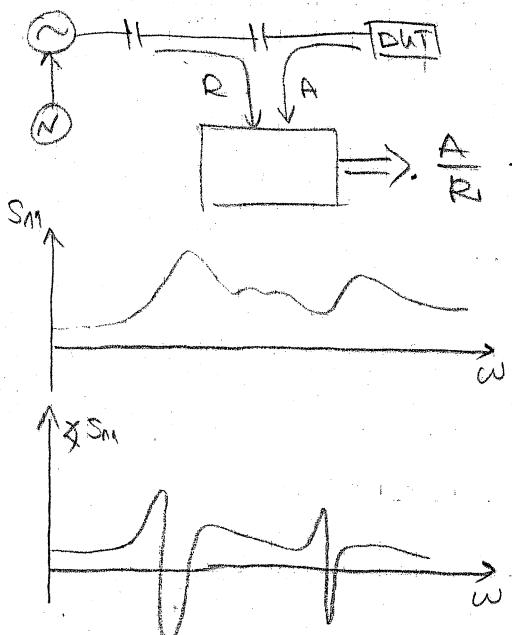


treba osigurati da ovo vrijeme bude
dulje nego sto želimo afledati što se
dosegda može liniji

- možete koristiti analizator mreža i pretvorimo u vremensku
domenu → dobijemo virtualni idealni generator impulsa

ANALIZATOR MREŽA S TRANSFORMACIJOM IZ VREMENSKOG U FREKVENCIJSKU

- analizator mreža mjeri omjer incidentnog i reflektivnog signala
svaki poselno

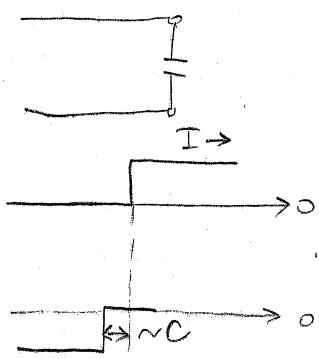


$$\frac{A}{R} \rightarrow S_{11}(w)$$

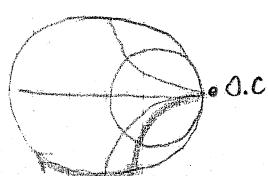
$$S_{11}(w) \Downarrow F^{-1}$$

$$S_{11}(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_{11}(w) e^{-j\omega t} dt$$

↳ Poj. refleksije postaje realan
broj sa svojom amplitudom i
predznamom



$$\begin{aligned} r &= \frac{z - z_0}{z + z_0} = \frac{\frac{1}{j\omega C} - z_0}{\frac{1}{j\omega C} + z_0} = \dots = \frac{1 - jz_0\omega C + z_0^2\omega^2 C^2}{1 + z_0^2(\omega C)^2} \\ &= \frac{1 + z_0^2\omega^2 C^2}{1 + z_0^2(\omega C)^2} - j \underbrace{\frac{z_0\omega C}{1 + z_0^2(\omega C)^2}}_{\text{predznamom}} \end{aligned}$$



sa stepom memanjemo afedat valovom, mi sa impulsom \rightarrow valovom je

- modul aceneratora:

PULSE

$\delta(t)$

STEP

$u(t)$

BURST

$u(t)$

↓ Step i direktni DC viseči propusni

LOW-PASS IMPULSE

LOW-PASS STEP

BAND-PASS

\rightarrow za valovode

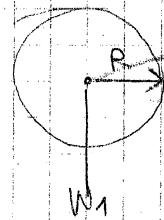
\rightarrow za Fourierova transf. bitan je omjer $\frac{f_{\text{MAX}}}{f_{\text{MIN}}}$

* Vremenski filter - GATE funkcija

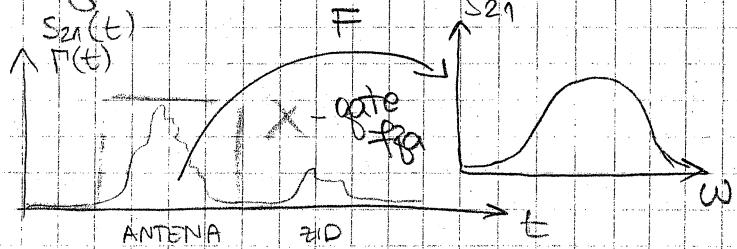


S_{21}

izotropni
radijator



$$|\vec{P}_1| = \frac{W_1}{4R^2\pi}$$



$$G = R \cdot D \quad \text{dobjitek}$$

$$\frac{\lambda^2}{4\pi} D_2$$

$$W_2 = |\vec{P}_1| \cdot A_{\text{ef}} \quad \left[\frac{W}{m^2} \right]$$

$$\frac{W_1}{4R^2\pi} \cdot G_1 \cdot \frac{\lambda^2}{4\pi} \cdot G_2 = W_2$$

$$\boxed{\frac{W_2}{W_1} = G_1 G_2 \left(\frac{\lambda}{4\pi R} \right)^2}$$

\rightarrow pogledaj vrednosti za slucej širokopasovnih antena

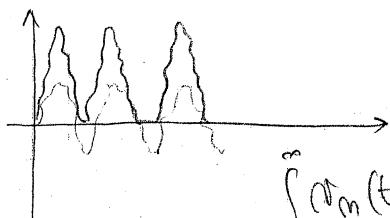
- ako imamo neširokopasnu Fourier transf. merna dvostrukno
podatoka

- u terahercnom području merna analizatore mreža u
frekv. dijelomi \rightarrow vraca se analogno

- problem generatori koji rade u terahercnom području

RTD, FEL, QCL

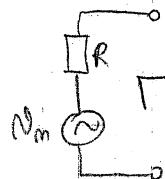
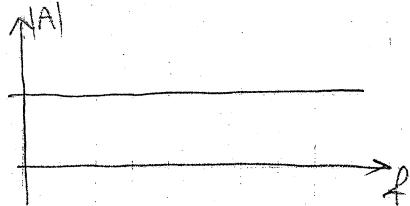
MJERENJE FAKTORA ŠUMA I TEMPERATURE ŠUMA



$$\int_{-\infty}^{\infty} N_m(t) dt = 0$$

$\overline{N_m^2}$ - srednji kvadrat snage

$$\overline{N_m^2} = kTBR \quad - \text{srednji kvadrat mjerena šuma}$$



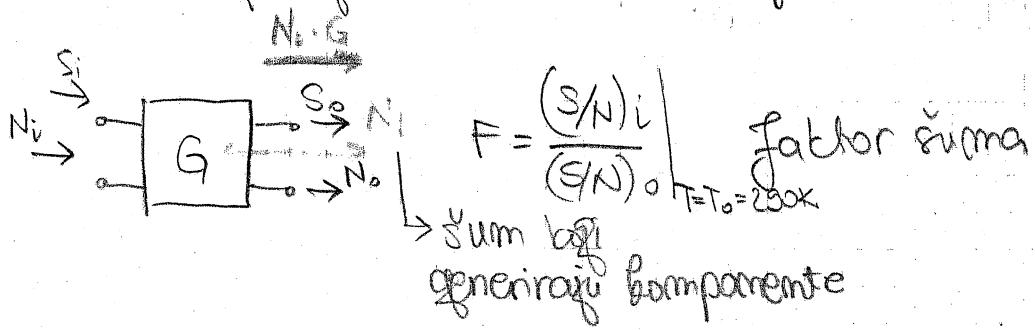
$$P_{AVS} = \frac{V^2}{4R} = \frac{N_m^2}{4R} = kTB$$

$$T = T_0 \text{ (290K)} \rightarrow N = -174 \text{ dBm/Hz}$$

$$N = kTB \quad - \text{naspodrživa snaga šuma}$$

T_e - efektivna temp. šuma \rightarrow temp na koju mjerimo

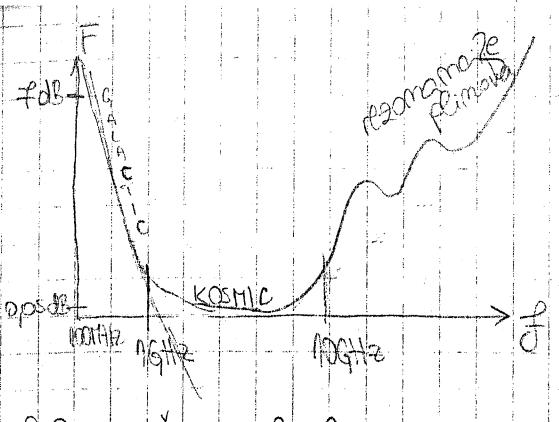
zaigrati otpornik kako bi imali istu snagu kao da je među drugim generatorom šuma - fiktivna velicina



$$N_e \cdot G = k \cdot T_e \cdot B \cdot G \quad \text{šum na ulazu pojačan pojačajem}$$

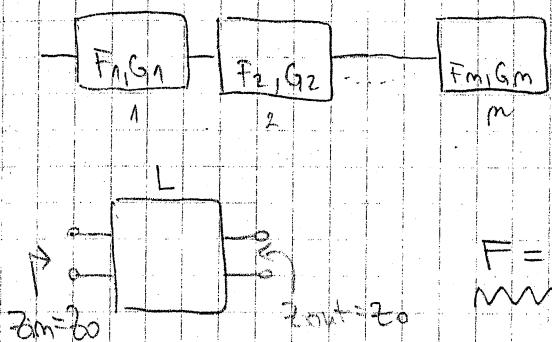
$$N_e = k \cdot T_e \cdot B \cdot G$$

$$F = \frac{\frac{S_e}{kT_0B}}{\frac{S_e \cdot G}{kG \cdot B(T_e + T_0)}} = \frac{T_0 + T_e}{T_0} \rightarrow F = 1 + \frac{T_e}{T_0}$$



$\theta = 0^\circ \rightarrow$ najmanji zutri aco $\theta = 0^\circ$
atmosfera

- faktor sivina bascoda



$$F_o = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2} + \dots$$

Smazeci doprimos od prve komponente

\rightarrow za prilagodeni attenuator

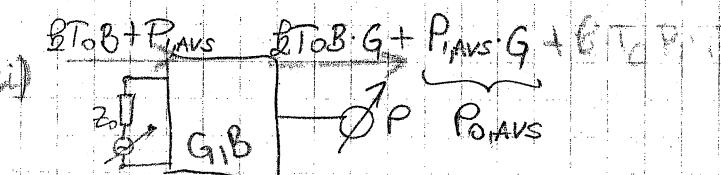
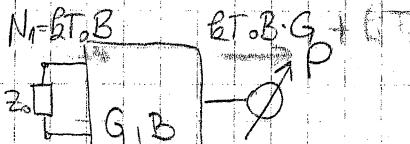
\rightarrow prva komponenta smaziva malu sum i veliko povecanje

• Kriterije

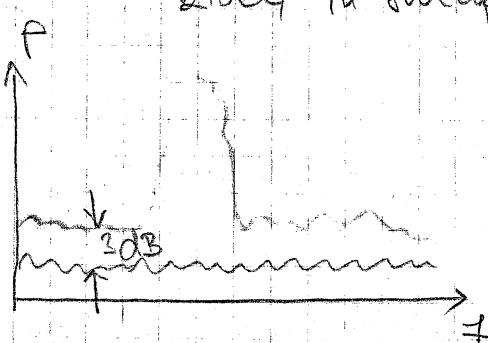
- memoanje detektori termici sum zboj medauditive obzefnosti

① METODA PRILAGOSENOG GENERATORA - 3dB METODA

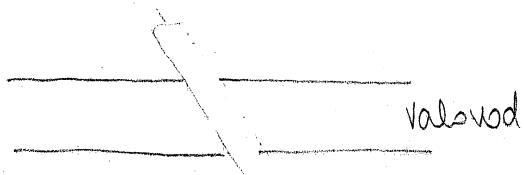
ideja:



\hookrightarrow razmazimo generator da se dobisimo $P_{0,AVS}$ 2x veci od $2T_0BG$ u slucaju ii) \rightarrow smaga gen. = smaga sume



- generator říjma - meomka lampa - MUDFORD (~1950)



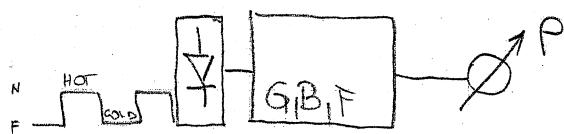
$T_e = 2000 - 4000 \text{ K} \rightarrow$ ekvivalentní temp. říjma

(2) lávingská dioda - AVALANCHE DIODE $\rightarrow Y$ metoda

\rightarrow řada bázisnáma $T_e \sim 1000 \text{ K}$

$T_{ON} \sim 1000 \text{ K} (T_H)$ hot

$T_{OFF} \sim T_0 (T_C)$ cold



\hookrightarrow repetiční frekv. $\sim 10 \text{ MHz}$

ekvivalentní diod od
stejného počátku

$$P_{COLD} = \frac{q}{2} T_C \cdot B \cdot G + \frac{q}{2} T_e \cdot B \cdot G$$

$$P_{HOT} = \frac{q}{2} \cdot T_H \cdot B \cdot G + \frac{q}{2} \cdot T_e \cdot B \cdot G$$

$$\rightarrow \frac{P_{HOT}}{P_{COLD}} = \frac{\frac{q}{2} \cdot T_H \cdot B \cdot G + \frac{q}{2} \cdot T_e \cdot B \cdot G}{\frac{q}{2} \cdot T_C \cdot B \cdot G + \frac{q}{2} \cdot T_e \cdot B \cdot G}$$

$$\boxed{\frac{P_{HOT}}{P_{COLD}} = \frac{T_H + T_e}{T_C + T_e} = Y} \quad - \text{Y-faktor}$$

$$Y = \frac{T_H + T_e}{T_C + T_e} \Rightarrow T_e = \frac{T_H - Y \cdot T_C}{Y - 1}$$

$$F = 1 + \frac{T_e}{T_0}$$

$$F = 1 + \frac{\frac{T_H}{T_0} - Y \frac{T_C}{T_0}^{1/1}}{Y - 1}$$

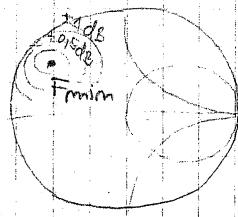
$$\boxed{F = \frac{Y}{Y - 1}}$$

- už předpostavenu da je čtvrtopol přilegoden

COI

$0.18 T_{\text{oss}}$

≈ 20



→ danas komercijalno $F \approx 0.3 \text{ dB}$ za mikrovalnu područje

KIERENJE ELEKTROMAGNETSKOG POLJA

ELEKTROMAGNETSKA KOMPATIBILNOST, ANTENSKA KIERENJA

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} \in \mathbb{R}$$

$$(x, y, z, t)$$

$$\nabla \times \vec{B} = \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t} + \nabla \times \vec{H}$$

$$\nabla \times \vec{H} = -\frac{1}{c^2} \frac{\partial \vec{B}}{\partial t} - \nabla \times \vec{E}$$

- za sinusnu promjenu

$$\vec{B} = \vec{B}_0 \sin(\omega t)$$

→ izotropno homogeno

→ mjerjenja u dalekom polju

$$\nabla \times \vec{B} = \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t}$$

$$\nabla \times \vec{E} = -\frac{1}{c^2} \frac{\partial \vec{B}}{\partial t}$$

$$\Rightarrow \nabla \times \left(-\frac{1}{c^2} \frac{\partial \vec{E}}{\partial t} \right) = \frac{1}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2}$$

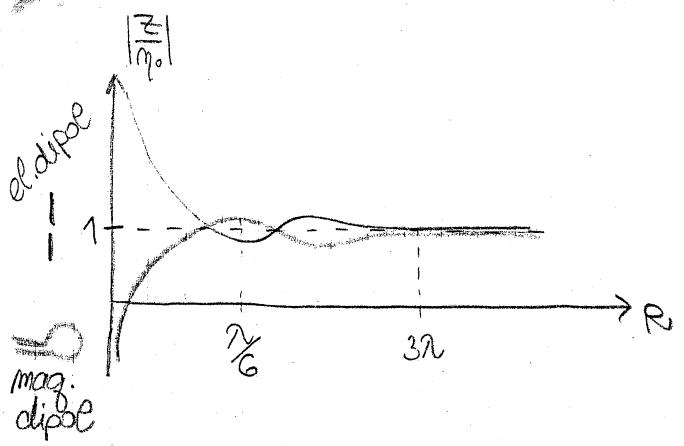
$$\nabla \times (\nabla \times \vec{E}) = \omega^2 \mu \epsilon \vec{E}$$

$$\nabla \times (\nabla \times \vec{E}) = \frac{1}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2}$$

$$\vec{E} = E_0 e^{j \omega x}$$

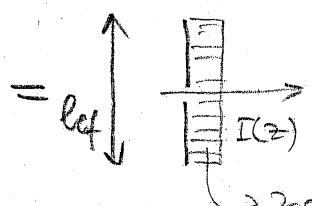
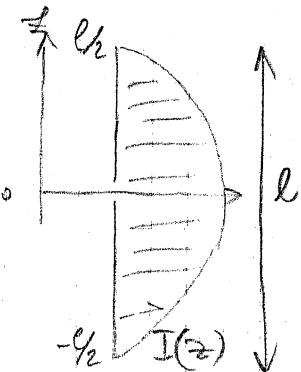
samo za realni val $\rightarrow \vec{E} = E_0 e^{j \omega x}$

→ mjez pozdrrostvarjenja - resniko u presegi imamo daleko polje i realni val



$$\lim_{Q \rightarrow 0} \frac{Z}{Q}$$

-efektivna dulžina



→ jednolike napodjedlo struktu

$$\int_{-l_h}^{l_h} I_0 f(z) dz = \int_{-l_h/2}^{l_h/2} I_0 f(z) dz$$

$$lef. I(0) = \int_{-l_h}^{l_h} I_0 f(z) dz$$

$$lef. I(0) = \frac{\int_{-l_h/2}^{l_h/2} I_0 f(z) dz}{\int_{-l_h}^{l_h} I_0 f(z) dz}$$

$$lef. I(0) = \frac{l_h}{2} \frac{\int_{-l_h/2}^{l_h/2} I_0 f(z) dz}{\int_{-l_h}^{l_h} I_0 f(z) dz}$$

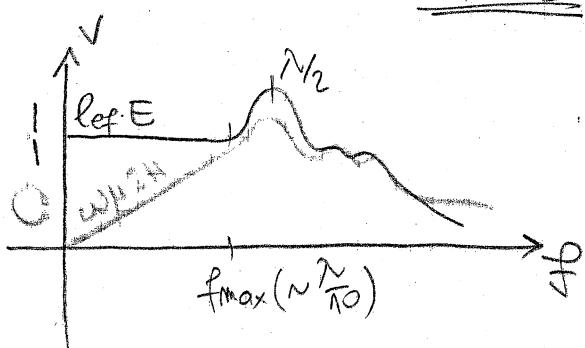
$$V = lef. I(0) \cdot E$$



$$l_h \ll \lambda \quad (< \frac{\lambda}{10}) \rightarrow \text{odzve nizko}$$

$$lef. I(0) = \frac{l_h}{2} f$$

električno polje



- kada imamo torčki dipol
možemo mijenjati bez balansirajućeg
do f_max

- magnetski dipol \rightarrow za mjerenu magnetsku polju

$$d \ll r \quad (< \frac{\lambda}{10})$$

= quis o frekvenci

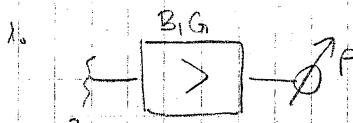
→ možemo izrediti magnetostatiku $e = -\frac{\partial \phi}{\partial t} = \int \vec{B} d\vec{s} = \vec{B} \cdot \vec{S} = \mu_0 H \cdot S$

(27)

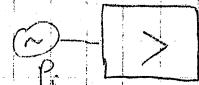
$$V = \mu_0 H \cdot S = K \cdot W \cdot H$$

* Heterodyne fázova súma

a) 3dB (metoda)

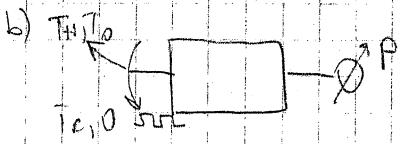


$$P_{o1} = k \cdot T_0 \cdot B \cdot G + k \cdot T_e \cdot B \cdot G = k \cdot G \cdot B \cdot (T_0 + T_e)$$



$$P_{o2} = k \cdot T_0 \cdot B \cdot G + P_n \cdot G \quad \rightarrow \text{pojavujeme dok} \\ \text{može se zájemně, me dlejme } 2x \text{ veče} \\ T_0 = 174 \text{ dBm/Hz}$$

od Pn *



$$\frac{N_H}{N_C} = Y = \frac{k \cdot G \cdot B \cdot (T_0 + T_H)}{k \cdot G \cdot B \cdot (T_0 + T_C)} \quad F = 1 + \frac{T_C}{T_0}$$

$$\text{ENR} = \frac{T_H - T_C}{T_0} = \frac{T_H}{T_0} - 1 \quad (T_C = T_0)$$

(excessive noise ratio) ~ 5 - 15 dB

T_H ~ 10000 K

$$* P_{o2} = 2P_{o1} \rightarrow k \cdot T_0 \cdot B \cdot G + P_n \cdot G = 2 \cdot k \cdot G \cdot B \cdot (T_0 + T_e)$$

$$k \cdot T_0 \cdot B \cdot G + P_n \cdot G = 2k \cdot G \cdot B \cdot T_0 + 2k \cdot G \cdot B \cdot T_e$$

$$P_n \cdot G = k \cdot G \cdot B \cdot T_0 + 2k \cdot G \cdot B \cdot T_e$$

+ NDSE FIGURE APPLICATION NOTE — H. Packard → PDF

* HIGERENCIJE UZI POLJA

$$\mathcal{E}(x, y, z, t)$$

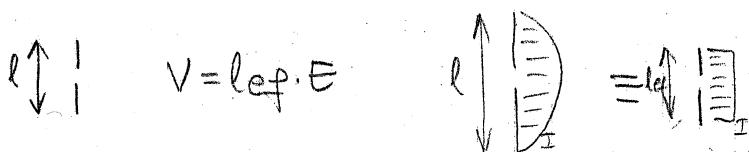
$$\mathcal{H}(x, y, z, t)$$

- Za sinusni promjenik:

$$\mathcal{E}(x, y, z)$$

$$\mathcal{H}(x, y, z)$$

$$M = \frac{\mathcal{E}}{H} = \sqrt{\frac{\mu}{\epsilon}} \rightarrow \text{mreži sastoje se od dalekog polja i ravni val}$$

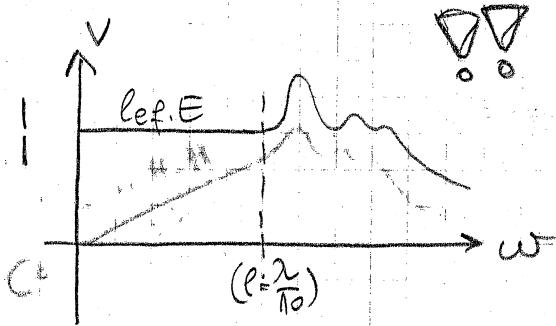


lef - dugima fletinama antene koja bi imala jednoliku raspodjelu struje

Senzori:

- kratka antena / dipol

$$l \ll \lambda \Rightarrow \text{lef.} E = \frac{l}{2}$$

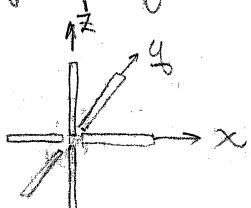


- kratki magnetski dipol

$$C: e = -\frac{\partial \phi}{\partial t} = -\omega \mu_0 H \cdot S \sim \omega t$$

↳ me mijeni mag. polje nego derivaciju?

→ za mrežne polje su zadanji tacki - 3 dipola + 3 mag. dipola



→ danas se koriste samo 3 el. dipola

SAR → dozivoferno 10 mW/cm^2

Vietnam → svetlof. polje mora izdržati 10 V/m (smartphone)

→ mini malme osjetljivost 1 V/m

$$E_{\min} = 1 \text{ V/m}$$

$$f_{\max} = 10 \text{ GHz} (40 \text{ GHz})$$

$$\lambda = 30 \text{ mm} \rightarrow \frac{\lambda}{10} = 3 \text{ mm}$$



$$V_m = \text{Iref. } E_{\min} = \frac{c}{2} \cdot E_{\min} = 1,5 \cdot 10^{-3} \text{ m} \cdot 1 \frac{\text{V}}{\text{m}} = 1,5 \text{ mV}$$

$$0 \text{ dBm} \rightarrow 1 \text{ mW} = 277 \text{ mV}$$

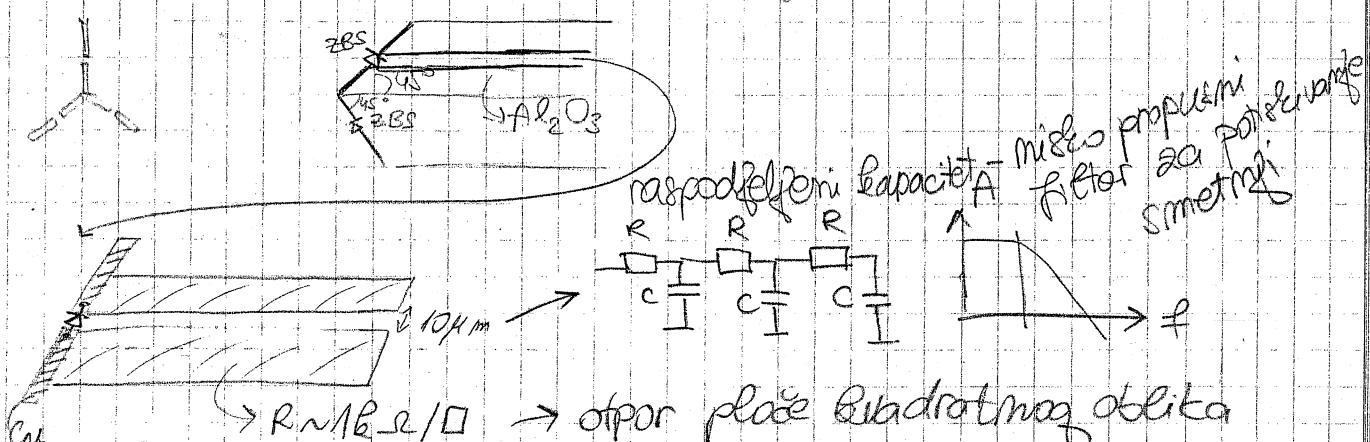
$$0 \text{ dBm} = 108 \text{ dB}\mu$$

$$\sim -74 \text{ dBm}$$

Sakz bi vodili račun da analizatora spektra kabel bi postao antena ma visokim frekvencijama

\Rightarrow moramo prijemnik staviti u sasivo možiste dipola

- u stvarnosti se 3 dipola slazu kao posebne ravnine

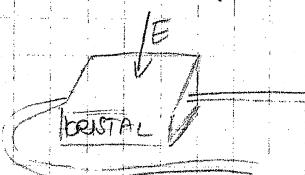


\rightarrow prototip se davao signal na elektromagnetički modulator i dalje prelazom do elektronike

- eksperimentalne faze senzora

- POKELSONOV efekt CdTe

- FARADAYEV efekt LiNb₃



\rightarrow otpor plase kvadratnog oblika

me omisao velicinu plase među sasivo

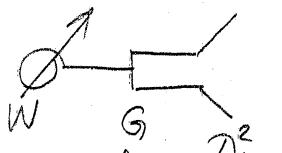
o debelim

$$R = \rho \frac{l}{S} = \rho \cdot \frac{a}{b \cdot c} = \rho \cdot \frac{a}{a \cdot c} = \frac{\rho}{c}$$

\rightarrow menj se samo amplituda, ne menjemo mjesto znati o fazu

* ANTENSKA MJEZENJA

- makroskopsko mjerjenje - Friisova formula



$$A_{ef} = \frac{\pi^2}{4\pi} \cdot G$$

$$W = P \cdot A_{ef}$$

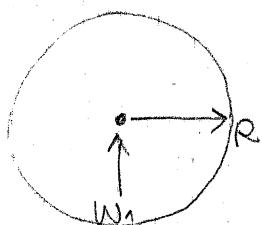
$$W = |\vec{E} \times \vec{H}| \cdot A_{ef} = \frac{E^2}{m} \cdot \frac{\pi^2}{4\pi} \cdot G$$

m daleko
20m

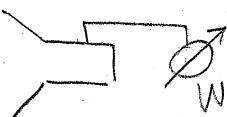
$$W = E^2 \cdot \frac{\pi^2}{4\pi} \cdot G \rightarrow E^2 = \frac{Wm}{\pi^2 G}$$

$$E = \frac{2}{\pi} \sqrt{\frac{Wm}{G}} \rightarrow m = \frac{E}{H} \quad \text{za daleko polje}$$

- dodatak



$$P = \frac{W_1}{4R^2\pi} \cdot D_1$$



$$W_2 = A_{ef} \cdot P = \frac{\pi^2}{4\pi} D_2 \cdot \frac{W_1}{4R^2\pi} \cdot D_1$$

$$\frac{W_2}{W_1} = \left(\frac{R}{2R\pi} \right)^2 \cdot q_1 \cdot q_2 \cdot [1 - |r_1|^2(1 - |r_2|^2)]$$

Mjerenja:

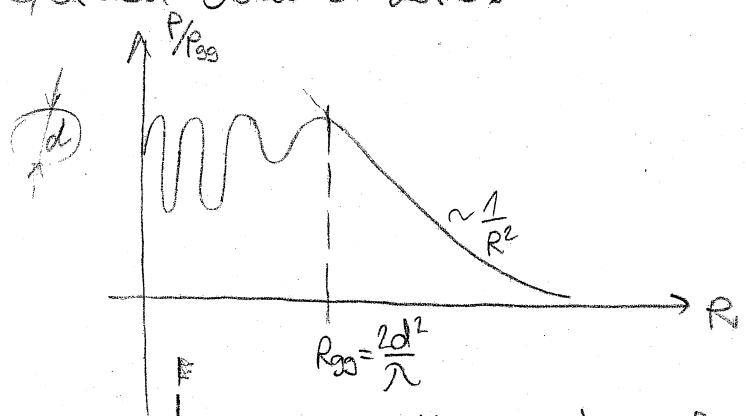
also mjeđu prilogotima

→ 2 identične antene q^2

→ 1 postrojena antena q_0

→ 3 nepoznate antene $q_1, q_2, q_3 \rightarrow q_1 q_2, q_2 q_3, q_1 q_3$ nizetko

Granica daleke zone:

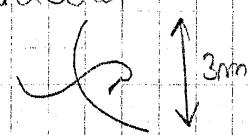


za žičane antene $R_{far} \sim 3\lambda$

-diagram sračenja

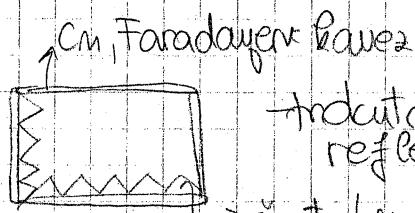
$$f = 10 \text{ GHz} \quad d = 3 \text{ cm}$$

parabola



gluha zonma

$$R_{\text{eff}} = \frac{2d^2}{\lambda} + \frac{2 \cdot 3^2}{3 \cdot 10} = 6 \cdot 10^2 = 600 \text{ m}$$

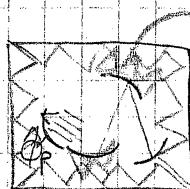


→ induktivni oddel zbroj pozitivnih i negativnih
refleksija
→ česta (najčešće)

→ nula zonma $|H| < -30 \text{ dB}$

→ problem prostora

1. Compact range - Metoda kompaktne mjerljive omjerke

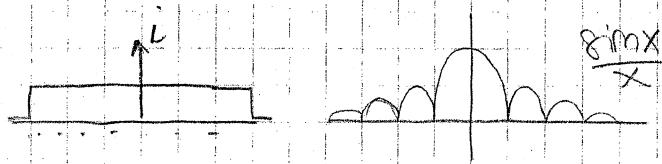


refleksion - povećavaju udaljenost

→ povećavaju mjerljiva dobitka

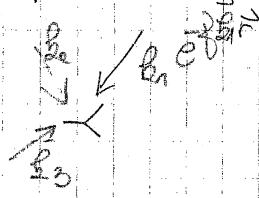
2. Near-field scanning - Mjerljivo uzorkovanjem bliskog polja

- diagram sračenja je Fourierova transf. raspodjelje struje na anteni



- blisko polje rezultirajući sa sumu ravnih valova - Fourierova transf.

PWS - plane wave spectrum

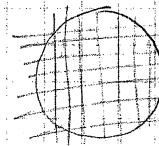


$$E(x, y, z) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} e^{j k_x x} e^{j k_y y} \cdot e^{j k_z z} dxdy$$

b-SPACE

→ prostorne harmonike

ako znamo
amp. i fazu možemo
inverznom F-transf.
izračunati što se događa
u daljem polju



1024x1024

robot mijenja amplitudu i fazu u
svakoj točci na aperturi antene

LABOS 3.

- analizator spektra i analizator mreža

→ mrežaju prema dulži, ima uvezem heterodimski prijelom

- 1. fazi osc. na sv. 3 mixera da aktivamo fazu

- uspostavljaju i oduzimaju na diferencijacijom

prijava → za amplitudu

- fazni detektor → za fazu

zero crossing dva signala i rasporedjaju se
dolješi na integrator (RC filter) - kroz
fazni detektor broj mali se pretvara u DC signal

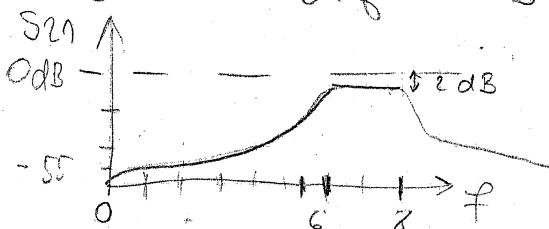
dobijemo faznu rasliku

Mjerenje S-parametara - S_{21} - analizator mreža

↳ Bandpass filter - fazni propust

6-8 GC [Giga Cycle]

$L < 2 \text{ dB}$



refleksion: DC to 5,5 GC > 50 dB

5,5 GC to 20 GC > 45 dB

- mjerenje od 6-10 GHz

- filter je pasivni dečaj i reciprocni pa je sve jedinstvo

sto je ulaz / izlaz

- aktivamo -18 dB - qubitci uči od 2 dB → nismo bališnici
pa međusobno referentnu raslinu

→ primično mreženje → spajati direkt ulaz - izlaz i

reflekti prijenos - to nam je ref rezonans OdB

3dB = 8,1268 GHz } u propustu -1,15 dB
5,92 GHz

20 S41 Anténa

$$\lambda_0 = 4,5 \text{ cm} \quad f = 2,05 \text{ GHz}$$

(short 1,8 GHz
stop 2,5 GHz)

- kalibrace - krátký způsob

→ v Smithově naměřené O.K.

změníme sa electric delay zomí n k.s.

→ můžeme dosít jednu základu

informující electric i phase delay

→ 8.0nd. kalibrace ; O.K., k.s., Z_0 na port 1-SM

$$S_{11} = 2,08 \text{ GHz} \quad -38 \text{ dB} (28\% \text{ de vrat})$$

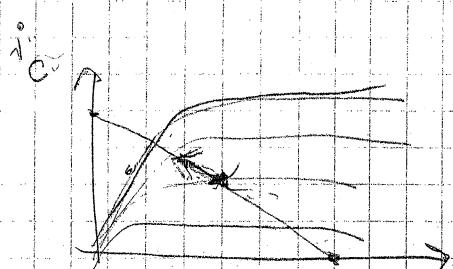
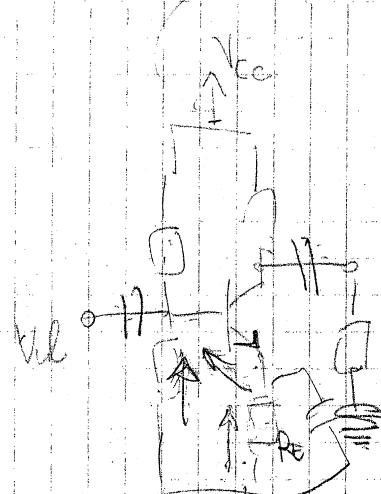
3. Pojáček - aktívni element

- na kterém frekvenci nedi? koliko pojáčení?

pojáčení 16 dB → 40 ×

cca 500 MHz do A blaze pojáček:

1 GHz



S_{11} - soubor záznamu
základní frekvence

Analizator spektra

4.0 Kriterije presečne točke 3. reda dvostrukom metodom

RBW filter - stolac centralne frekv. mjerimo snagu

Vides filter - može propust, možemo mijenjati gornji
granični frekv., usrednjavanje i dimenzija
suma

Atemuator ispred mjerela - za razlikanje intermodula,
produkator, osigurava da uvek radi u kvadratnoj fazni

- LV ma 2 redom preduči f_1 i f_2
 \rightarrow presečna točka 3. reda

Mjerena snaga - 1 točka u kojoj su snage ma ~~ako~~ i ma 3. harm
ma vise su jednake

- razlike dva signala \rightarrow bliske frekv. i iste ampe.

$$2f_1 - f_2 \rightarrow 3. \text{ harmonika}$$

- kombinacionim signalom pobudnjeno pojačalo

$$f_1 = 500,03 \text{ MHz } P = 9,8 \text{ dBm}$$

$$f_2 = 450,00 \text{ MHz } P = 9,8 \text{ dBm}$$

\rightarrow mjerena snaga na analizatoru spekta vidimo
dva zeta na f_1 i f_2 . $P = 0 \text{ dBm}$

$$P_3 = f = 550 \text{ MHz } P = -20,5 \text{ dBm}$$

$$f_1 = 500 \text{ MHz } P_1 = -16,6 \text{ dBm}$$

$$f_2 = 450 \text{ MHz } P_2 = -15,7 \text{ dBm}$$

\downarrow ampe. jednaka

bas ampl. 1. harmonike

$|P_3$ ved sadržam dati gmo
preveliku snagu

\Rightarrow stavimo manju snagu na ~~ili~~ f_2

$$P_{W1} = -10 \text{ dBm}$$

$$P_{W2} = -15 \text{ dBm}$$

$$P(f_{550}) = -8,6 \text{ dBm}$$

$$P(f_{500}) = -8,5 \text{ dBm}$$

$$\text{+ posljednja } P_3 = P = -13,4 \text{ dBm}$$

→ ISPUNTI ANKETŲ YOKISET PISMENAI - NUO NERIUSMENAI

Pitcairn ga Amerikai

Na ogranitih razliku u definiranim matematičkim veličinama i ravničevima može se izračunati

1 180 P.M. Friday

- ma visejšom frekv. memodelmo pohyblivosti, ne množstvo in konzum
tereta, izmedu zje množstva mrežia, nov licencie su nespoľahlivé
faktorom: produkčnosti, viac je možnosť po licencii

2. P, f, s, spettar, förlor pulma, E i H polje → obesenti

ZIN-70

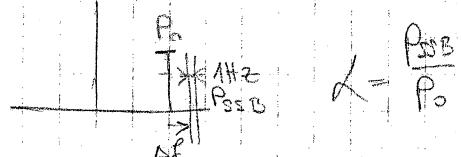
fizikalmi: fizikai algoritmusok eljárási generátor

a baki b dante b's fereto on 78 3 Γ

$$P_L + P_i = P_T$$

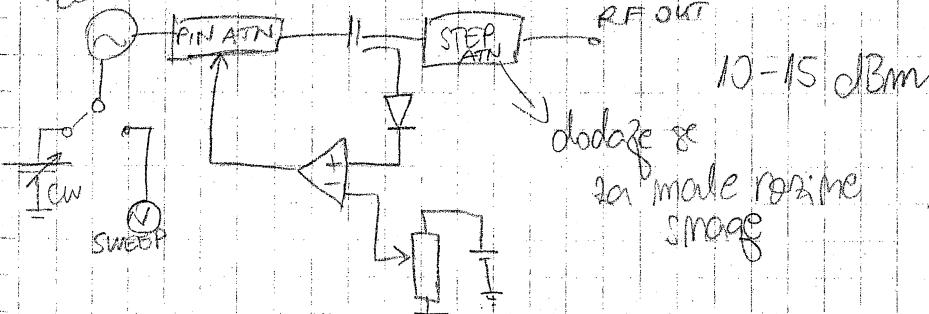
Idealistirami model boyi röd

mit Zeitdrift f. dgl. \rightarrow stochastisch: $N(t) = N_0(t) \cdot e^{(\mu t + \sigma^2 t)}$



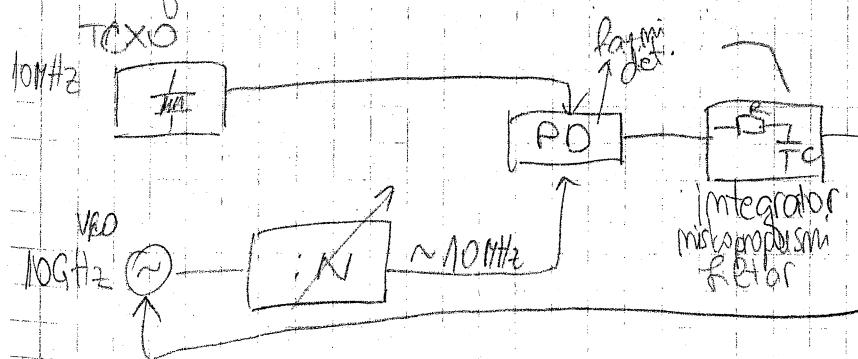
plbodmoos - gem

卷之三



Sintez. gen

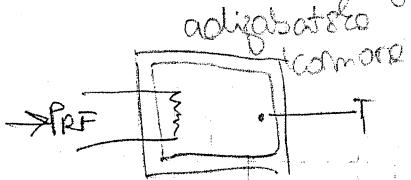
→ visoka stiskomost



infecție ampl. sporadică
a frebil de licea

me moze se brzi mijenjati
frekv fer se mijenja u
diferentim trenutcima,
neba unigme da se polzo
istekli i PC nukle boko
se nispreduje facc (36)

4. - osnovna ideja mjerjenja snage bolometar



$$Q = mc\Delta T$$

$$PRF \cdot \Delta t = mc\Delta T$$

$$PRF = mc \frac{\Delta T}{\Delta t}$$

$$P_{OC} = mc \frac{\Delta T}{\Delta t_1}$$

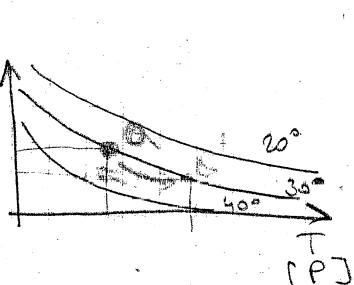
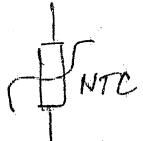
-30dBm do MW

1kHz do 40GHz frekv. opseg

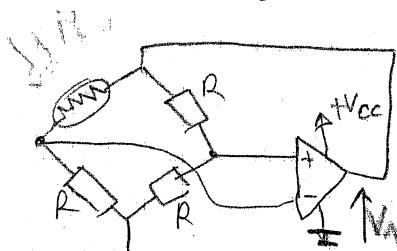
→ Mjeročnije mjerjenje - greška < 0.1%

Konst. se za mjeruvanje mora potrebno uzmjeti da se sagradi

5. Bolometar



- Vremenski most - da termistor bude stalno na istoj temp.



Kad je ustabilni $R_{TH} = R$ - redna točka

$$(V_0)^2 \cdot \frac{1}{R} \text{ snaga na svakom otporniku}$$

$$PRF = \frac{(V_{01})^2}{4R} - \frac{(V_{02})^2}{4R}$$

$$P_{TH1} \quad P_{TH2}$$

greska < 95-1%

- kompenzacija temp. okoline

pojedinačni most → ma jedan difuzije PRF na drugi T

→ termičko mjerjenje - međusi o velikom odstaku

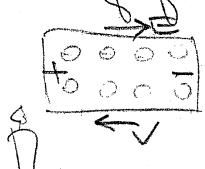
6. termopar - Thompson i Peltier efekt

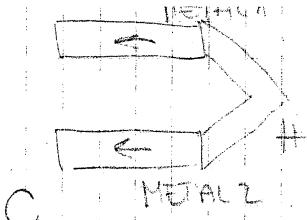
- u metalu elektromi slobodni ali zadržani nasporedeni, ako

sagradimo elektromi vibraciju - javlja se $E \propto V$

→ stabilizirati se kada obe dva kraja imaju

istu temp. - uzmu se dva različita metala
i spoje → termopar





+ 35 dBm +100 dBm

12 mW 0.2 - 1%

- mapom / stručji měří mezi nimi

- velký rozdíl v tom možném

Samo jediné diodné dílo možný senzor

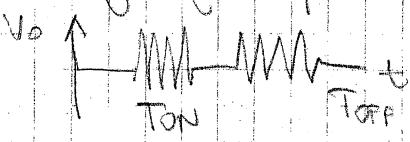
$$C = \frac{P_{SN}}{P_{RF}} \quad \text{effectivní efektivnost}^2$$

0-100 %

a počítaním f podle C

- závisí na tom početku nepřesnosti generátora

- mimořeimpulsové



$$P = P_0 \frac{T_{ON}}{T_{ON} + T_{OFF}}$$

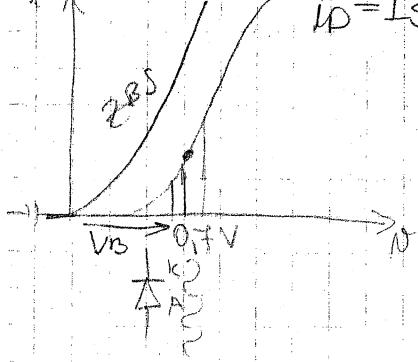
- tedy závisí termistor

ale rovněž cílbus $T_{ON} = T_{OFF}$ quasi se polohou

změny

8. Diodový detektor

$$i_D = I_S (e^{\frac{V}{nVt}} - 1)$$



- stručky může proporcionalna kadratu napětí

$$i_D \sim e^{\frac{V}{nVt}}$$

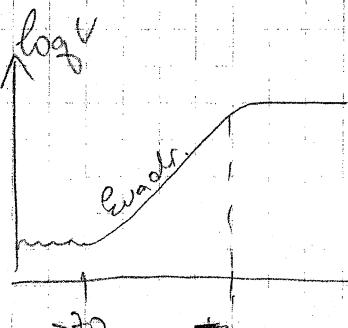
$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2}$$

za malý signál převaděvá

ali mimoře kvadratický charakter

DC + katicího tvaru když nemá charakter

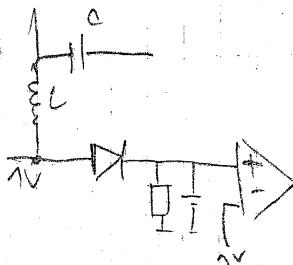
rodné funkci



P (dBm)

dioda je odstěpná na

temp - konst. se zBS



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tema: ogledljivost
 $S/N \sim 8,6 \text{ dB}$

smamuje se smaga dok se peakovi sume ne poklope

9. komedni

BNC do 1GHz

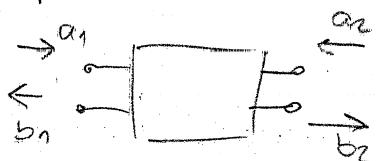
N do 18GHz

APC7 (F/M) do 26,5GHz

SMA do 26,5GHz

K više frekv (bez SMA ali mutra)

10. S-parametri

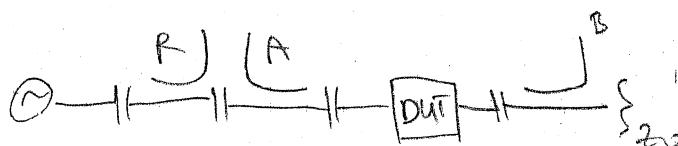


$$a_1 = \frac{V_i}{\sqrt{2}z_0}$$

$$b_1 = \frac{V_r}{\sqrt{2}z_0}$$

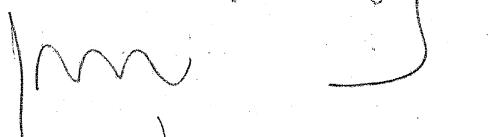
me traže O.K ili K.S kaj je teško
postići na visokim frekv.

Refleksometarski spor - polarjni analiz - mreža.



me može mijenjati fazu

→ za kratki spor dobijemo → da izravnamo dodamo O.K pa

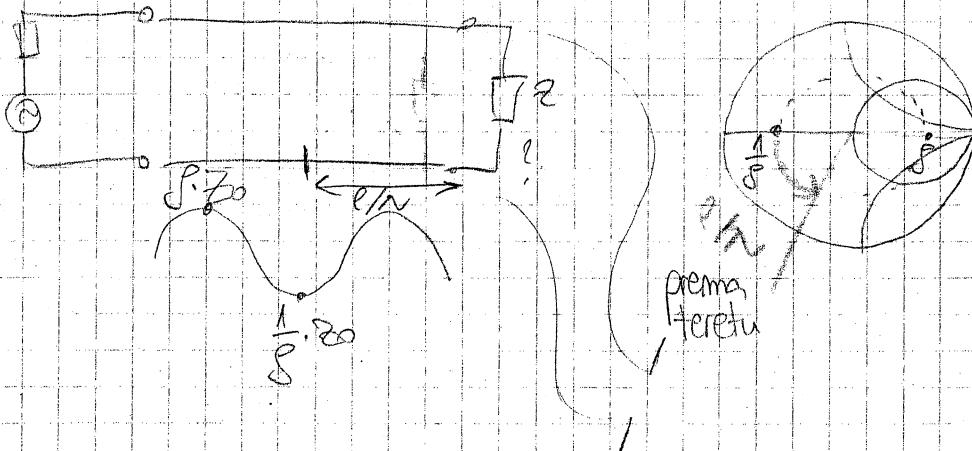


merdim smo

dobije se tako jer preko srednjice (Mjeđu) ostali signali

12. Vektorijski analizator

impedancija je max u min. dizajn u vise je realna



13. Analizator spektra

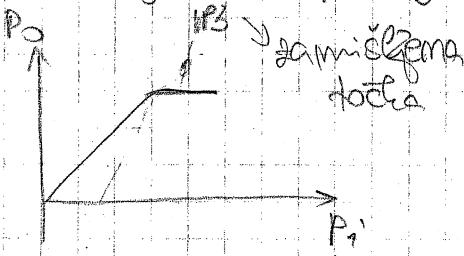
heterodimski prijemnik, LO se automatski mijenja

- dva filtera

- točku između vršnjaka Sweep Angle \rightarrow visoki filter visokog rezolucije ali dugo traje

14. Mjerenje AM signala (FM ne treba)

mjerenje precizije treće 3. reda !!!

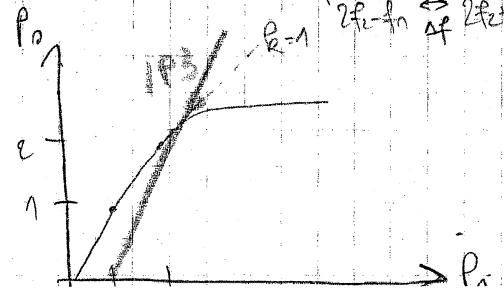
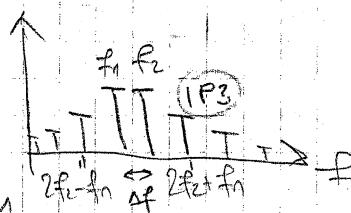
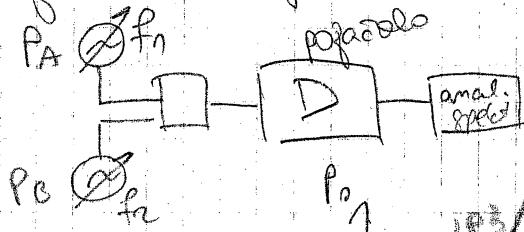


$$2f_r = f_2$$

$$f_3 = 2f_r$$

mjerenje radara - nizatko gorno \rightarrow problem može skutit

dva gen. bliskih frekv.



$$P_{A,B,1} = -10 \text{ dBm}$$

$$P_{A,B,2} = -7 \text{ dBm}$$

• 17.

$$F = \left. \frac{S/N_{im}}{S/N_{out}} \right|_{T=T_0} = 1 + \frac{T_e}{T_0}$$

$$\bar{N}_m^2 = 4\pi T B R$$

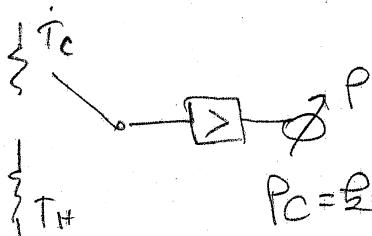
$$N = \frac{\bar{N}_m^2}{4R} = kTB$$

-17dBm/Hz

naspoloživa snaga říma

Y-metoda:

T_c i T_H izvora



$$P_C = kGB(T_c + T_e)$$

$$P_H = kGB(T_H + T_c)$$

ENR

$$\gamma = \frac{P_H}{P_C}$$

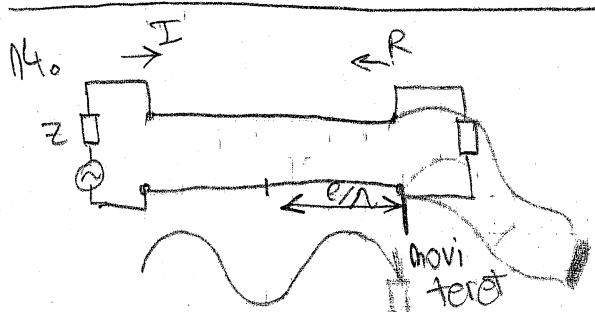
18. Hferecije EIT polja

- u bliskom polju me vředni $\eta = \frac{E}{H}$

- odzin za el. i mag. dipol
ravno \rightarrow raste s frekv.

19. Frišsova formula

nespodzela m bliskom polju preko formule nezama za daleko polje



$$\text{MAX } \frac{Z}{Z_0} = \delta \text{ (SWR)}$$

$$\text{min } \frac{Z}{Z_0} = \frac{1}{\delta}$$

- imamo kabel i onda teret \rightarrow manifesto tereta stavimo k.s

napomene
duljine

$m \cdot \frac{\lambda}{2}$ je naš teret za se možemo pomaknuti
jer je električki to iste ravnina

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