Curs 2

2025/2026

Dispozitive şi circuite de microunde pentru radiocomunicații

Disciplina 2025/2026

- 2C/1L (+1), **DCMR (CDM)**

- **Minim 7 prezente (curs+laborator)**

- Curs - **conf. Radu Damian**
  - Vineri 10-12/**Video (istoric)**, C1, corp C
  - E – **50%** din nota
  - **probleme** + (2p prez. curs) + (3 teste) + (bonus activitate)
    - primul test L1: ~01.10.2025 (t2 si t3 neanuntate la **curs**)
    - 3pz (C) ≈ +0.5p (**2p** max)
  - **toate materialele permise**

Disciplina 2025/2026

- 2C/1L, **DCMR (CDM)**
- Laborator – **conf. Radu Damian**
  - Miercuri 08-12, par/impar, **II.13**
  - L – **25%** din nota
    - ADS, 4 sedinte aplicatii
    - prezenta + **rezultate personale!**
  - P – **25%** din nota
    - ADS, 3 sedinte aplicatii (-1? 21-22.12.2022)
    - tema personala

Documentatie

- https://rf-opto.etti.tuiasi.ro

Microwave and Optoelectronics Laboratory
Faculty of Electronics, Telecommunications and Information Technology
Gheorghe Asachi Technical University of Iaşi

Main | Courses | Master | Staff | Research | Students

English
Romana

Microwave Devices and Circuits for Radiocommunicati

Course: DCMR (2024-2025)

Course Coordinator: Assoc.P. Dr. Radu-Florin Damian
Code: DOS412T
Discipline Type: DOS; Alternative, Specialty
Credits: 4
Enrollment Year: 4, **Sem.** 7

Activities

Course: Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:
Laboratory: Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, Timetable:

Evaluation

Type: **Exam**

A: 50%, (Test/Colloquium)
B: 25%, (Seminary/Laboratory/Project Activity)
D: 25%, (Homework/Specialty papers)

Grades

Aggregate Results

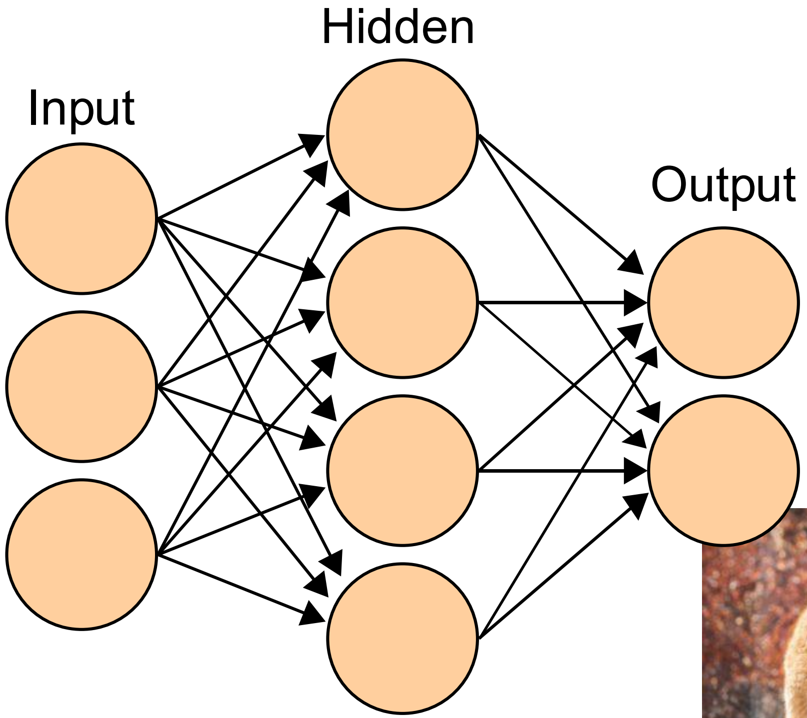
Documentatie

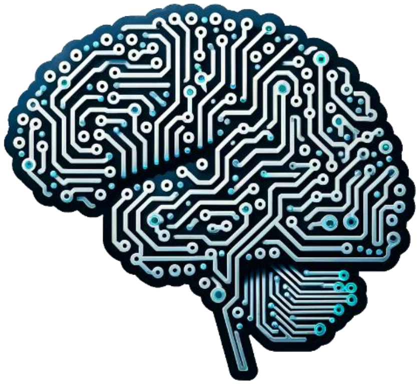
- RF-OPTO
  - https://rf-opto.etti.tuiasi.ro ~~Moodle~~
- Fotografie
  - de trimis pe rf-opto
  - necesara la laborator/curs
  - bonus activitate 0.5p/1p (**C4/C6**)

Scop curs 4

Sinapse
“inginerești”

IA/AI



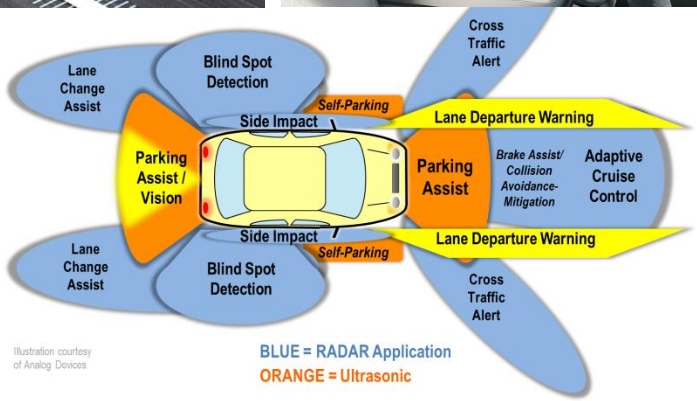


Bibliografie

- https://rf-opto.etti.tuiasi.ro
- Irinel Casian-Botez: "Microunde vol. 1: Proiectarea de circuit", Ed. TEHNOPRES, 2008
- David Pozar, Microwave Engineering, Wiley; 4th edition , 2011, ISBN : 978-1-118-29813-8 (E), ISBN : 978-0-470-63155-3 (P)

Tehnologie

> 2010



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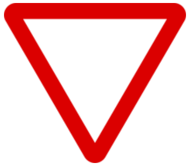


Examen: Reprezentare logaritmică

- $\boldsymbol{X[dB] = 10 \cdot log_{10}(X[lin])}$
- $X[B] = log_{10}(X[lin])$
- X[lin] – adimensional
- $log(A \cdot B) = log(A) + log(B)$

- $\boldsymbol{X[lin] = 10^{X[dB]/10}}$

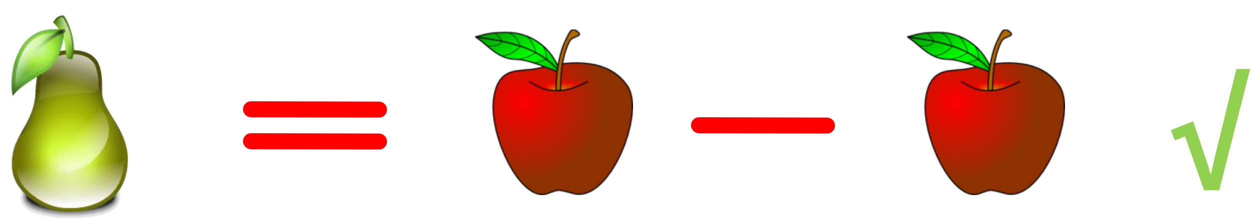
Calculul atenuarii/amplificarii

$$\text{Pierderi/Castig} = \frac{P_{out}}{P_{in}}$$

$$\text{Pierderi}[\text{dB}] = [-]10 \cdot \log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

$$\text{Pierderi}[\text{dB}] = [-]10 \cdot \log_{10}\left(\frac{P_{out}}{P_0} \cdot \frac{P_0}{P_{in}}\right) = [-]10 \cdot \left[\log_{10}\left(\frac{P_{out}}{P_0}\right) - \log_{10}\left(\frac{P_{in}}{P_0}\right)\right]$$

$$\text{Pierderi}[\text{dB}] = [-]\left(P_{out}[\text{dBm}] - P_{in}[\text{dBm}]\right)$$



Examen: Reprezentare logaritmică

$\text{dB} = 10 \cdot \log_{10} (P_2 / P_1)$

0 dB	= 1
+ 0.1 dB	= 1.023 (+2.3%)
+ 3 dB	= 2
+ 5 dB	= 3
+ 10 dB	= 10
-3 dB	= 0.5
-10 dB	= 0.1
-20 dB	= 0.01
-30 dB	= 0.001

$\text{dBm} = 10 \cdot \log_{10} (P / 1\ \text{mW})$

0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
-3 dBm	= 0.5 mW
-10 dBm	= 100 μW
-30 dBm	= 1 μW
-60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

[dBm/Hz] + [dB] = [dBm/Hz]

[x] + [dB] = [x]

Calculul atenuarii/amplificarii

$$\text{Atenuare} = \frac{P_{out}}{P_{in}} < 1 \qquad \text{Pierderi[dB]} = 10 \cdot \log_{10}\left(\frac{P_{out}}{P_{in}}\right) < 0$$

$$\text{Pierderi/Atenuare[dB]} = [-]\ 10 \cdot \log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

$$\text{Castig} = \frac{P_{out}}{P_{in}} > 1$$

$$\text{Castig/Amplificare[dB]} = 10 \cdot \log_{10}\left(\frac{P_{out}}{P_{in}}\right) > 0$$

$$\text{Atenuare[dB/km]} = \frac{\text{Pierderi[dB]}}{\text{Lungime[km]}}$$

Calcului atenuarii/amplificarii

$$\text{Pierderi/Atenuare} \rightarrow P_{out} < P_{in} \rightarrow P_{out}[\text{dBm}] < P_{in}[\text{dBm}]$$

$$P_{out}[\text{dBm}] = P_{in}[\text{dBm}] - \text{Pierderi/Atenuare}[\text{dB}]$$

$$\text{Castig/Amplificare} \rightarrow P_{out} > P_{in} \rightarrow P_{out}[\text{dBm}] > P_{in}[\text{dBm}]$$

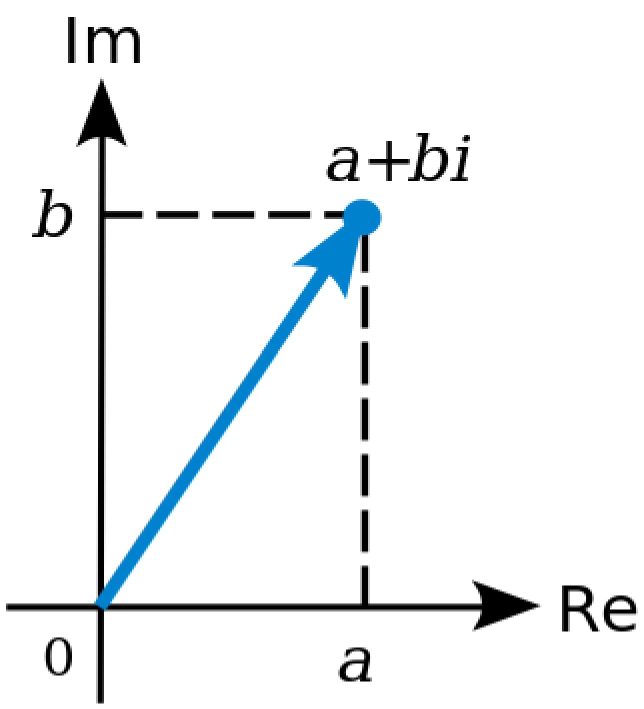
$$P_{out}[\text{dBm}] = P_{in}[\text{dBm}] + \text{Castig/Amplificare}[\text{dB}]$$

Examen

- Operatii cu numere complexe!
- $z = a + j \cdot b$; **$j^2 = -1$**

Plan complex

- abscisa – partea reala
- ordonata – partea imaginara
- oricare poate fi negativa, intregul plan, 4 cadrane



Operatii

- Adunare

$$z+w=(a+j\cdot b)+(c+j\cdot d)=(a+c)+j\cdot(b+d)$$

- Scadere

$$z-w=(a+j\cdot b)-(c+j\cdot d)=(a-c)+j\cdot(b-d)$$

- Inmultire

$$z\cdot w=(a+j\cdot b)\cdot(c+j\cdot d)=(a\cdot c-b\cdot d)+j\cdot(b\cdot c+a\cdot d)$$

- Impartire

$$z/w=\frac{a+j\cdot b}{c+j\cdot d}^{(c-j\cdot d}=\frac{(a+j\cdot b)\cdot(c-j\cdot d)}{(c+j\cdot d)\cdot(c-j\cdot d)}=\left(\frac{a\cdot c+b\cdot d}{c^2+d^2}\right)+j\cdot\left(\frac{b\cdot c-a\cdot d}{c^2+d^2}\right)$$

Complex Conjugat

- z $z = a + j \cdot b$
- z^* $z^* = a - j \cdot b$
- Simetric fata de axa **reala**

$$\mathrm{Re}(z) = a = \frac{1}{2} \cdot \left(z + z^*\right)$$

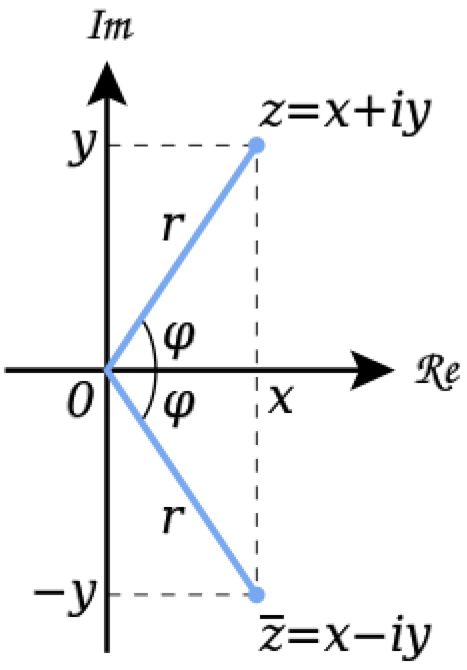
$$\mathrm{Im}(z) = b = \frac{1}{2 \cdot j} \cdot \left(z - z^*\right) = \frac{j}{2} \cdot \left(z^* - z\right)$$

$$(z + w)^* = z^* + w^*$$

$$(z - w)^* = z^* - w^*$$

$$(z \cdot w)^* = z^* \cdot w^*$$

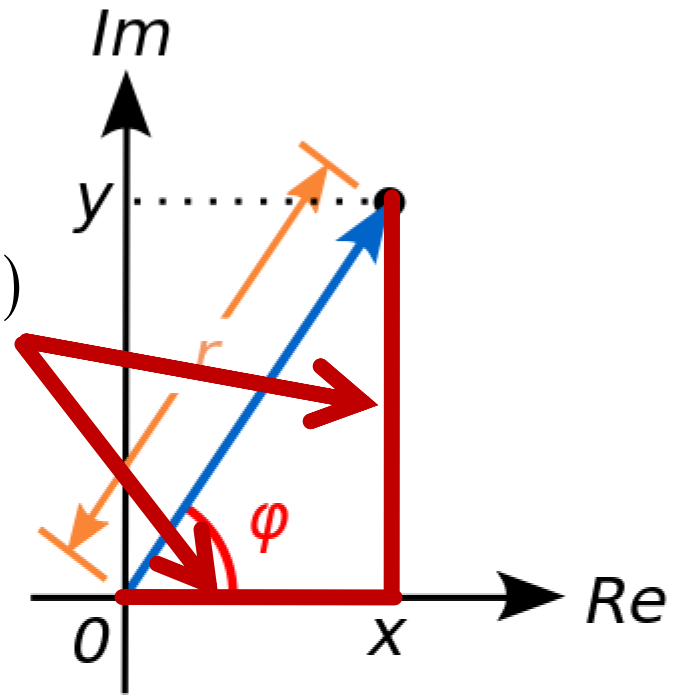
$$(z / w)^* = z^* / w^*$$



Reprezentare polara

- Reprezentare polara
  - modul
  - faza

$$z = a + j \cdot b = |z| \cdot (\cos\varphi + j \cdot \sin\varphi)$$



$$|z| = \sqrt{a^2 + b^2}$$

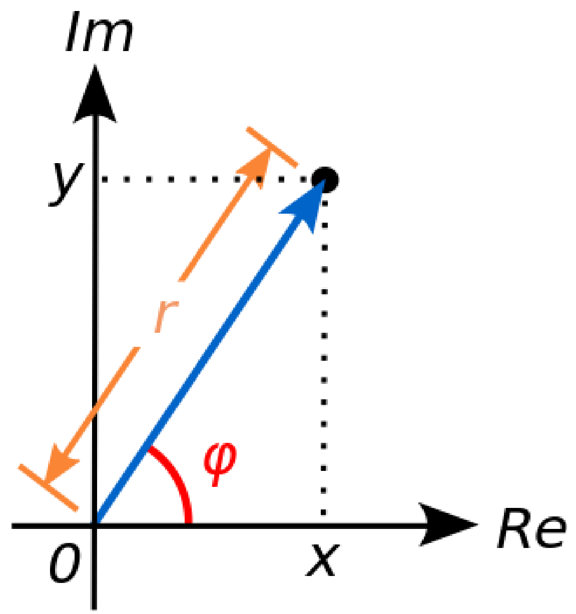
$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, nedefinit & a = 0 \end{cases}$$

Reprezentare polara

- Formula lui Euler

$$e^{j\cdot x} = \cos x + j\cdot \sin x; \forall x \in R$$

- Reprezentare polara



$$z = a + j\cdot b = |z|\cdot e^{j\cdot\varphi}$$

$$z = a + j\cdot b = |z|\cdot(\cos\varphi + j\cdot\sin\varphi)$$

$$z^n = \left(|z|\cdot e^{j\cdot\varphi}\right)^n = |z|^n\cdot e^{j\cdot n\cdot\varphi} = |z|^n\cdot[\cos(n\cdot\varphi) + j\cdot\sin(n\cdot\varphi)]$$

$$\sqrt{z} = \left(|z|\cdot e^{j\cdot\varphi}\right)^{1/2} = \sqrt{|z|}\cdot e^{j\cdot\frac{\varphi}{2}} = \sqrt{|z|}\cdot\left(\cos\frac{\varphi}{2} + j\cdot\sin\frac{\varphi}{2}\right)$$

$$z\cdot w = |z|\cdot e^{j\cdot\varphi}\cdot|w|\cdot e^{j\cdot\theta} = |z|\cdot|w|\cdot e^{j\cdot(\varphi+\theta)} = |z|\cdot|w|\cdot[\cos(\varphi+\theta) + j\cdot\sin(\varphi+\theta)]$$

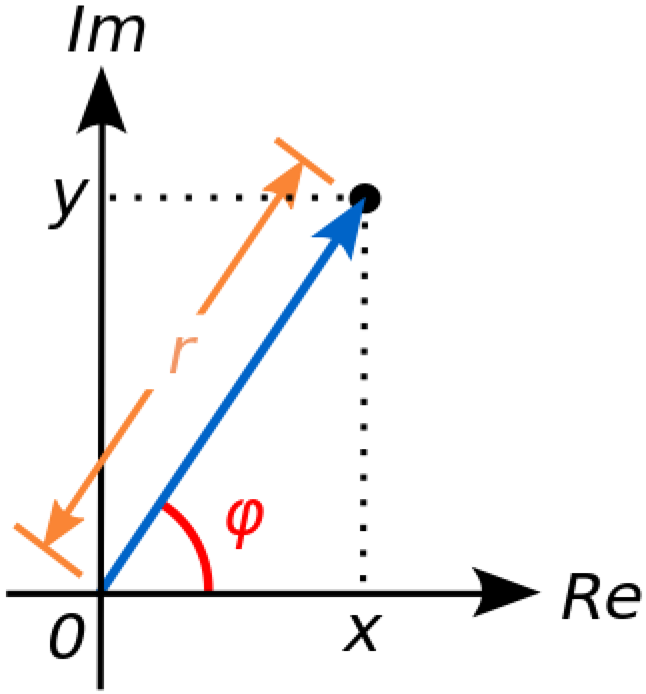
$$z/w = \frac{|z|\cdot e^{j\cdot\varphi}}{|w|\cdot e^{j\cdot\theta}} = \frac{|z|}{|w|}\cdot e^{j\cdot\varphi}\cdot e^{-j\cdot\theta} = \frac{|z|}{|w|}\cdot e^{j\cdot(\varphi-\theta)} = \frac{|z|}{|w|}\cdot[\cos(\varphi-\theta) + j\cdot\sin(\varphi-\theta)]$$

Reprezentare polara

- Reprezentare polara

$$|z| = \sqrt{a^2 + b^2}$$

$$|z|^2 = z \cdot z^*$$



$$\left|e^{j\cdot x}\right| = \left|\cos x + j \cdot \sin x\right| = \sqrt{\cos^2 x + \sin^2 x} = 1$$

$$\left|e^{j\cdot x}\right| = 1; \quad \forall x \in R$$

$$z^* = \left(|z| \cdot e^{j\cdot\varphi}\right)^* = |z| \cdot (\cos\varphi + j \cdot \sin\varphi)^* = |z| \cdot (\cos\varphi - j \cdot \sin\varphi) =$$

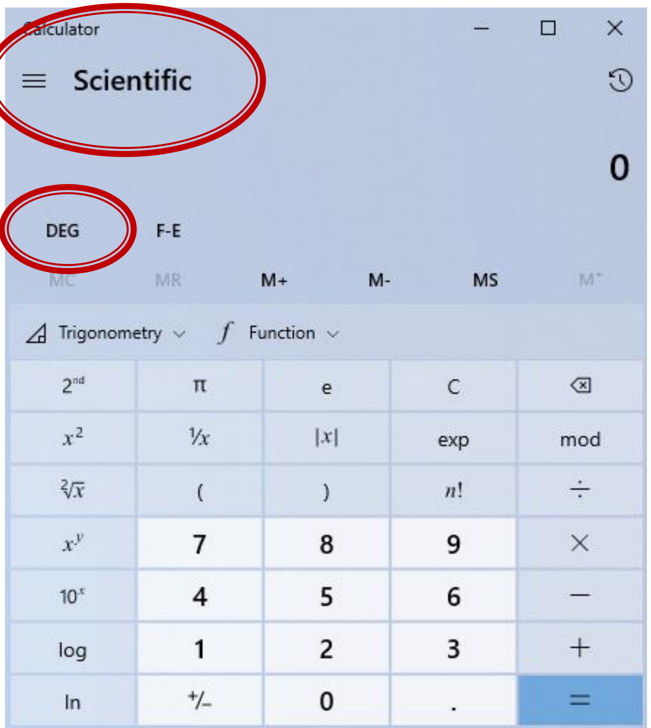
$$= |z| \cdot [\cos(-\varphi) + j \cdot \sin(-\varphi)] = |z| \cdot e^{-j\cdot\varphi}$$

Reprezentare polara

- unitate de masura standard – radiani
- unitate de masura traditionala in microunde – **grade format zecimal** (55.89°)

$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, nedefinit & a = 0 \end{cases}$$

$$\varphi[°] = 180° \cdot \frac{\varphi[rad]}{\pi} \qquad \varphi[rad] = \pi \cdot \frac{\varphi[°]}{180°}$$

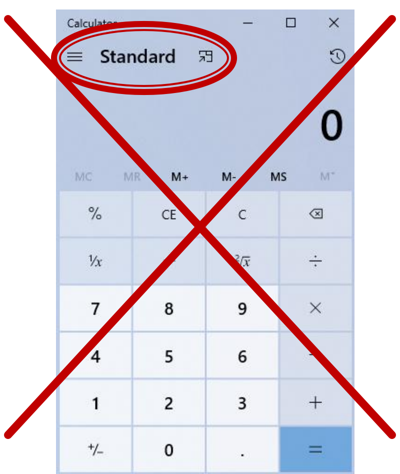


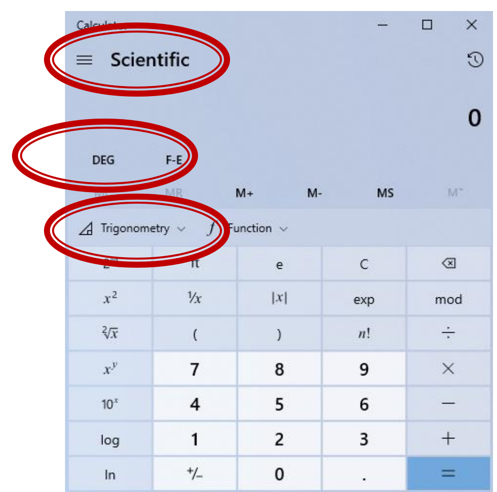
Reprezentare polara

- **Atentie la reprezentarea unghiurilor!!**
  - programele matematice – lucreaza standard in radiani
    - e necesara o **conversie** inainte si una dupa aplicarea unei functii trigonometrice
  - calculatoarele (stiintifice) au posibilitatea (de obicei) de a stabili unitatea de masura pentru unghiuri
    - e necesara **verificarea** unitatii de masura curente

$$\varphi[°] = 180° \cdot \frac{\varphi[rad]}{\pi}$$

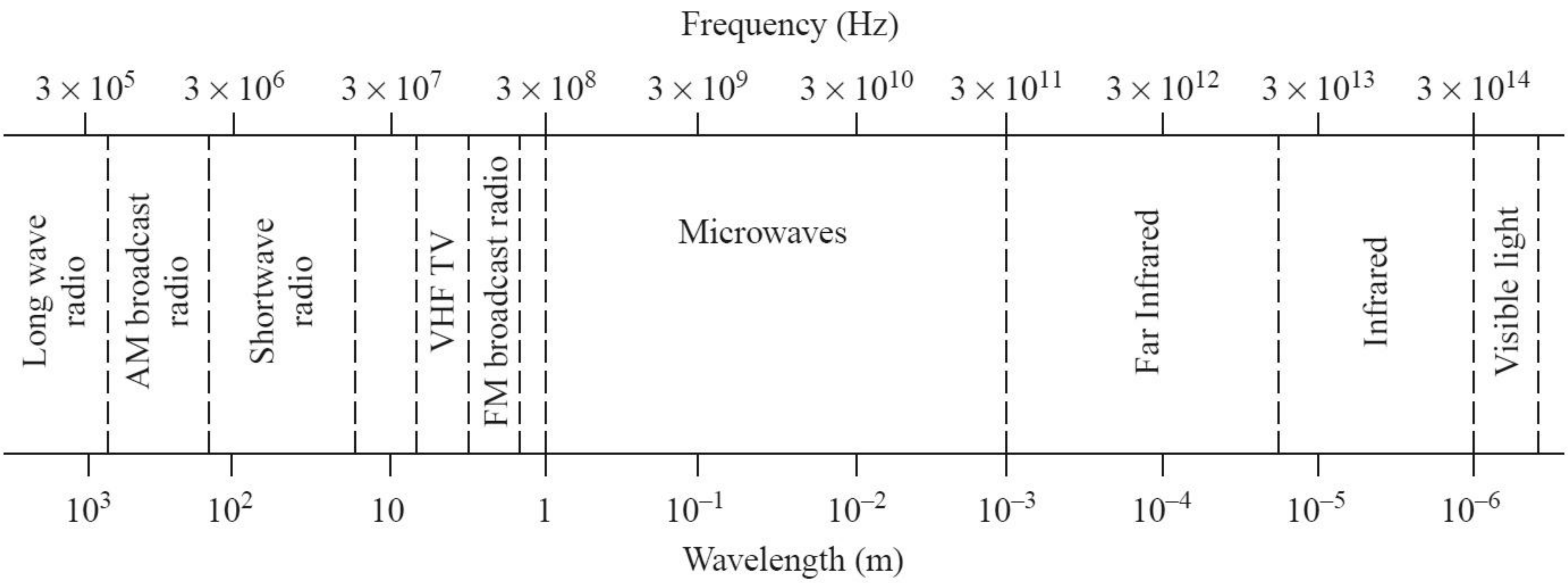
$$\varphi[rad] = \pi \cdot \frac{\varphi[°]}{180°}$$





Introducere

Microunde

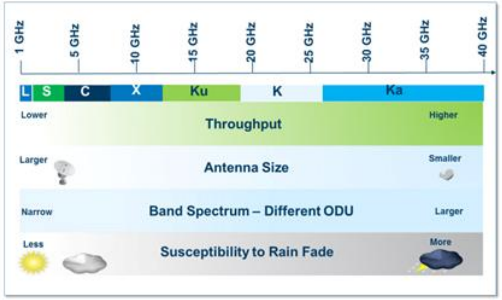


- tipic
  - f ≈ 1÷3GHz – 300GHz
  - λ ≈ 1mm – 10cm

Microunde

Typical Frequencies	
AM broadcast band	535–1605 kHz
Short wave radio band	3–30 MHz
FM broadcast band	88–108 MHz
VHF TV (2–4)	54–72 MHz
VHF TV (5–6)	76–88 MHz
UHF TV (7–13)	174–216 MHz
UHF TV (14–83)	470–890 MHz
US cellular telephone	824–849 MHz
	869–894 MHz
European GSM cellular	880–915 MHz
	925–960 MHz
GPS	1575.42 MHz
	1227.60 MHz
Microwave ovens	2.45 GHz
US DBS	11.7–12.5 GHz
US ISM bands	902–928 MHz
	2.400–2.484 GHz
	5.725–5.850 GHz
US UWB radio	3.1–10.6 GHz

Approximate Band Designations	
Medium frequency	300 kHz–3 MHz
High frequency (HF)	3 MHz–30 MHz
Very high frequency (VHF)	30 MHz–300 MHz
Ultra high frequency (UHF)	300 MHz–3 GHz
L band	1–2 GHz
S band	2–4 GHz
C band	4–8 GHz
X band	8–12 GHz
Ku band	12–18 GHz
K band	18–26 GHz
Ka band	26–40 GHz
U band	40–60 GHz
V band	50–75 GHz
E band	60–90 GHz
W band	75–110 GHz
F band	90–140 GHz

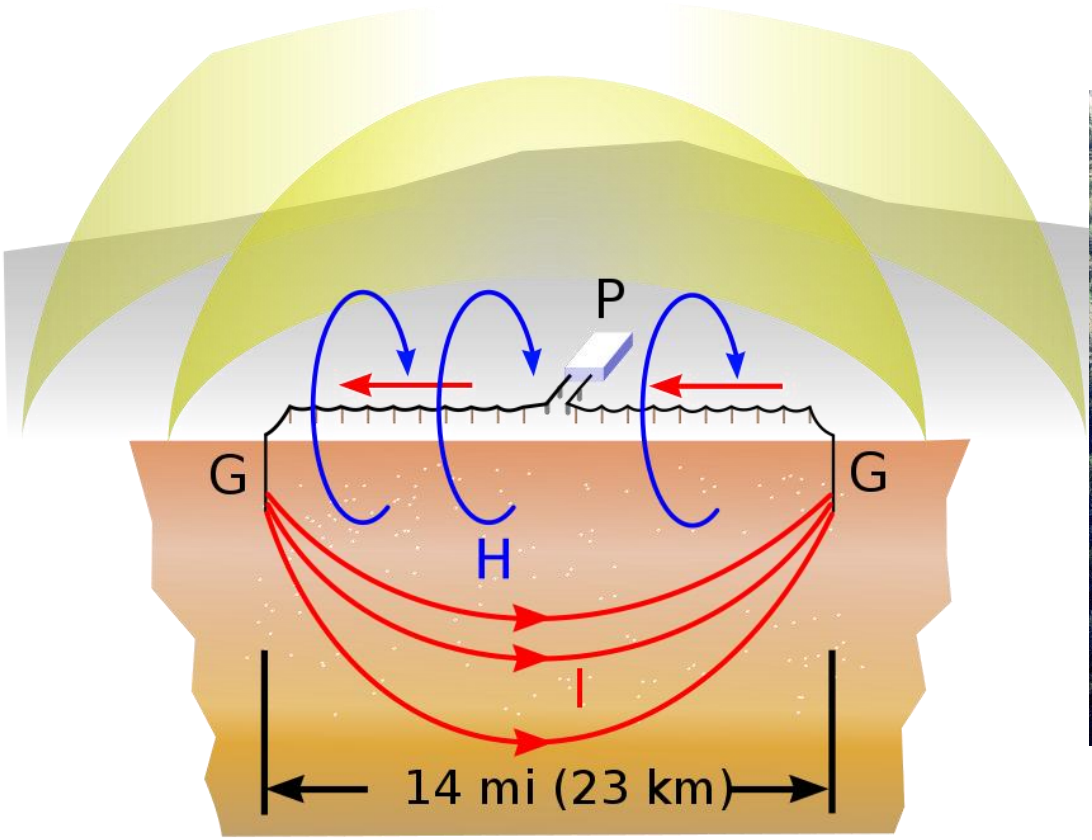


CPU

- Intel® Core™ 14th Gen i9-14900KS
- 6.2 GHz
- overclock 9.043 GHz

ELF, VLF

- Extremely low frequency, 3 - 30 Hz
- Very low frequency, 3 - 30 kHz



~ Microunde

- Lungimea electrica a unui circuit
  - l – lungimea fizica
  - E = β·l – lungimea electrica

$$E = \beta \cdot l = \frac{2\pi}{\lambda} \cdot l = 2\pi \cdot \left(\frac{l}{\lambda} \right)$$

$$E = \beta \cdot l = \frac{2\pi}{c_0} \cdot \left(l \cdot f \cdot \sqrt{\varepsilon_r} \right)$$

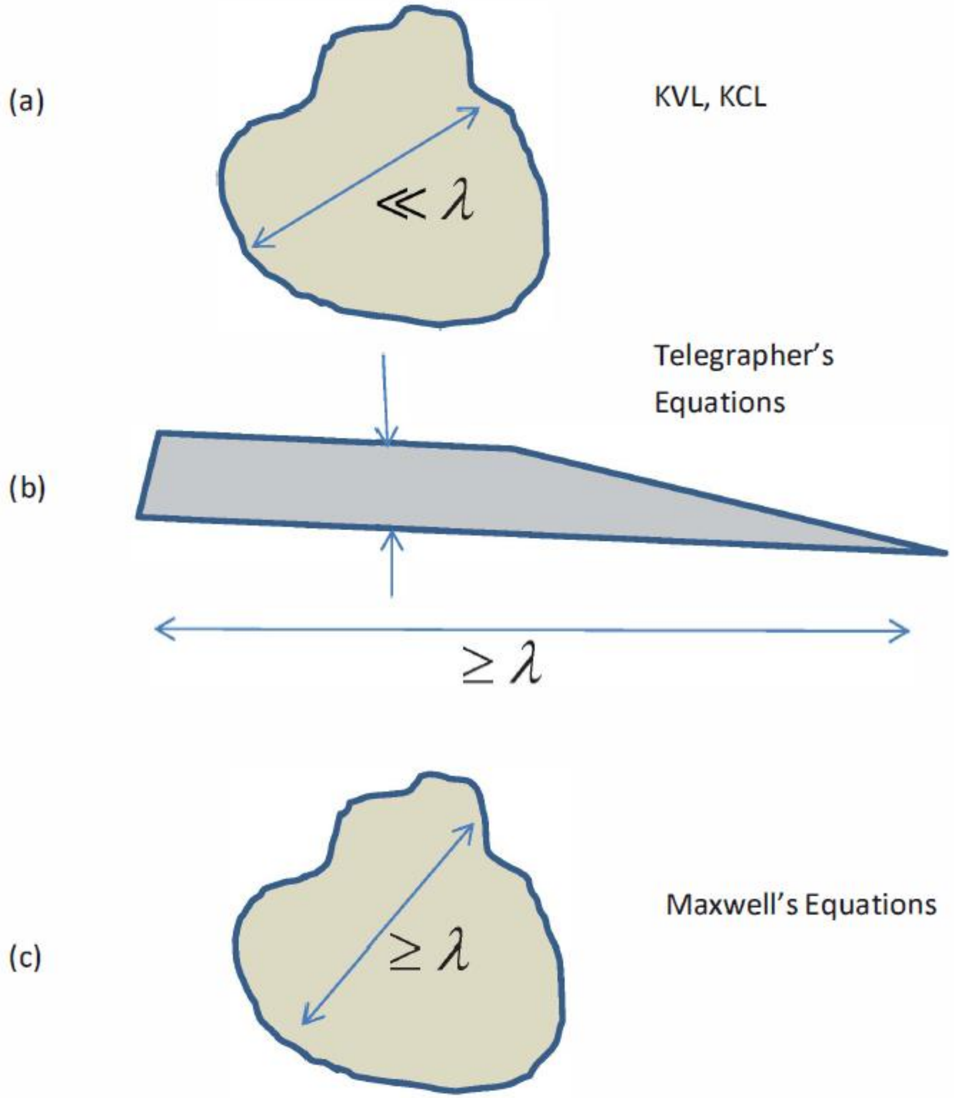
V, I variabile
~ inutile

- Dependenta
  - castigul antenei
  - imaginea unui obiect pe radar

Lungime electrica

- Comportarea (descrierea) unui circuit depinde de lungimea sa electrica la frecventele de interes
  - E≈0 → Kirchhoff
  - E>0 → Maxwell

$$E = \beta \cdot l = \frac{2\pi}{\lambda} \cdot l = 2\pi \cdot \left(\frac{l}{\lambda} \right)$$



Ecuatiile lui Maxwell

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$\nabla \times H = \frac{\partial D}{\partial t} + J$$

$$\nabla \cdot D = \rho$$

$$\nabla \cdot B = 0$$

$$\nabla \cdot J = -\frac{\partial \rho}{\partial t}$$

- Ecuatii constitutive

$$D = \varepsilon \cdot E$$

$$B = \mu \cdot H$$

$$J = \sigma \cdot E$$

- In vid

$$\mu_0 = 4\pi \times 10^{-7}\ H/m$$

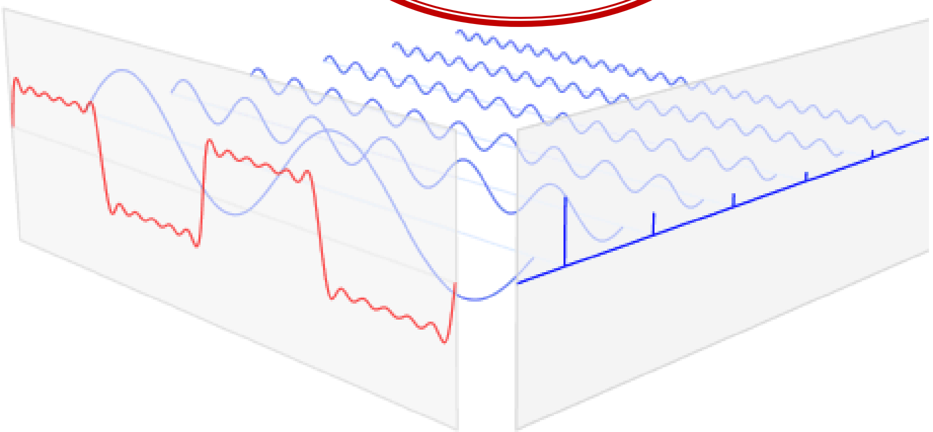
$$\varepsilon_0 = 8{,}854 \times 10^{-12}\ F/m$$

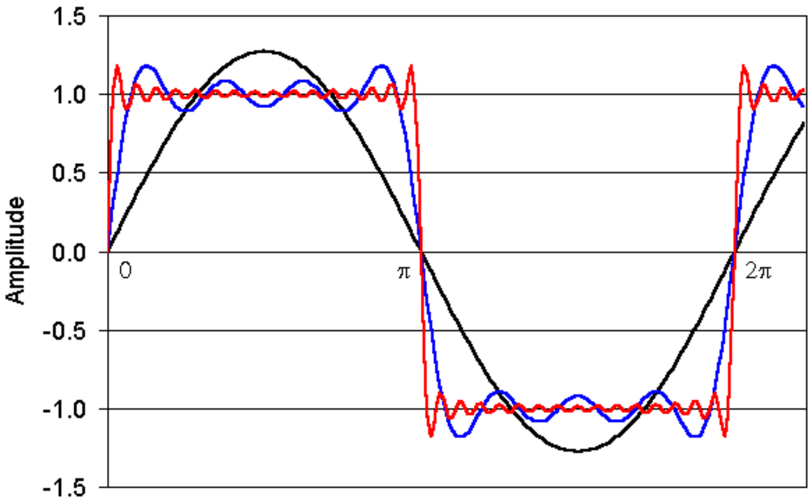
$$c_0 = \frac{1}{\sqrt{\varepsilon_0 \cdot \mu_0}} = 2{,}99790 \cdot 10^8\ m/s$$

Modele matematice

- cazuri particulare in care exista rezolvare analitica
  - semnale cu variație armonică în timp, transformata Fourier, spectru

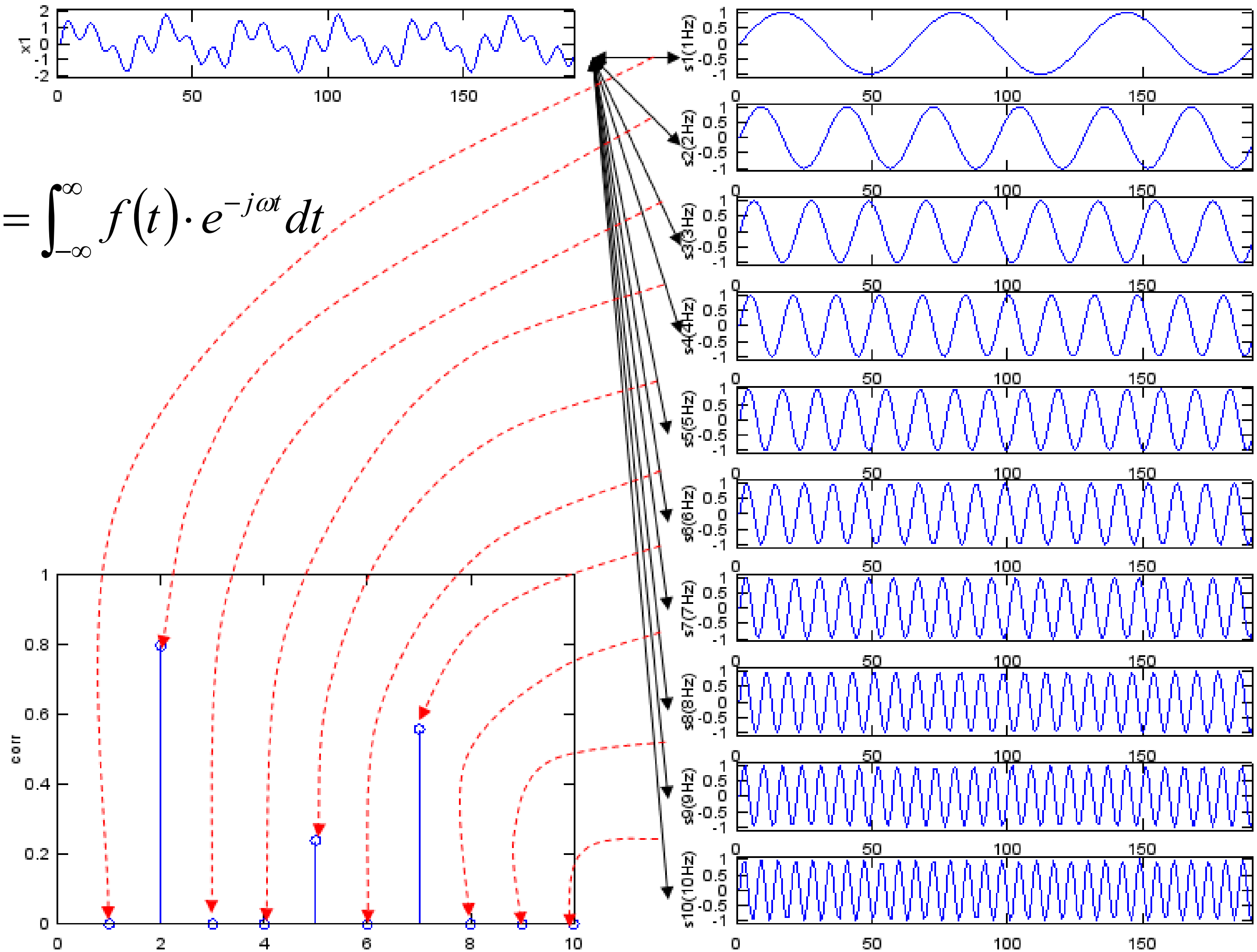
$$X = X_0 e^{j\cdot\omega\cdot t} \qquad \frac{\partial X}{\partial t} = j\cdot\omega\cdot X \qquad g(\omega) = \int_{-\infty}^{\infty} f(t)\cdot e^{-j\omega t}dt \qquad f(t) = \int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}d\omega$$



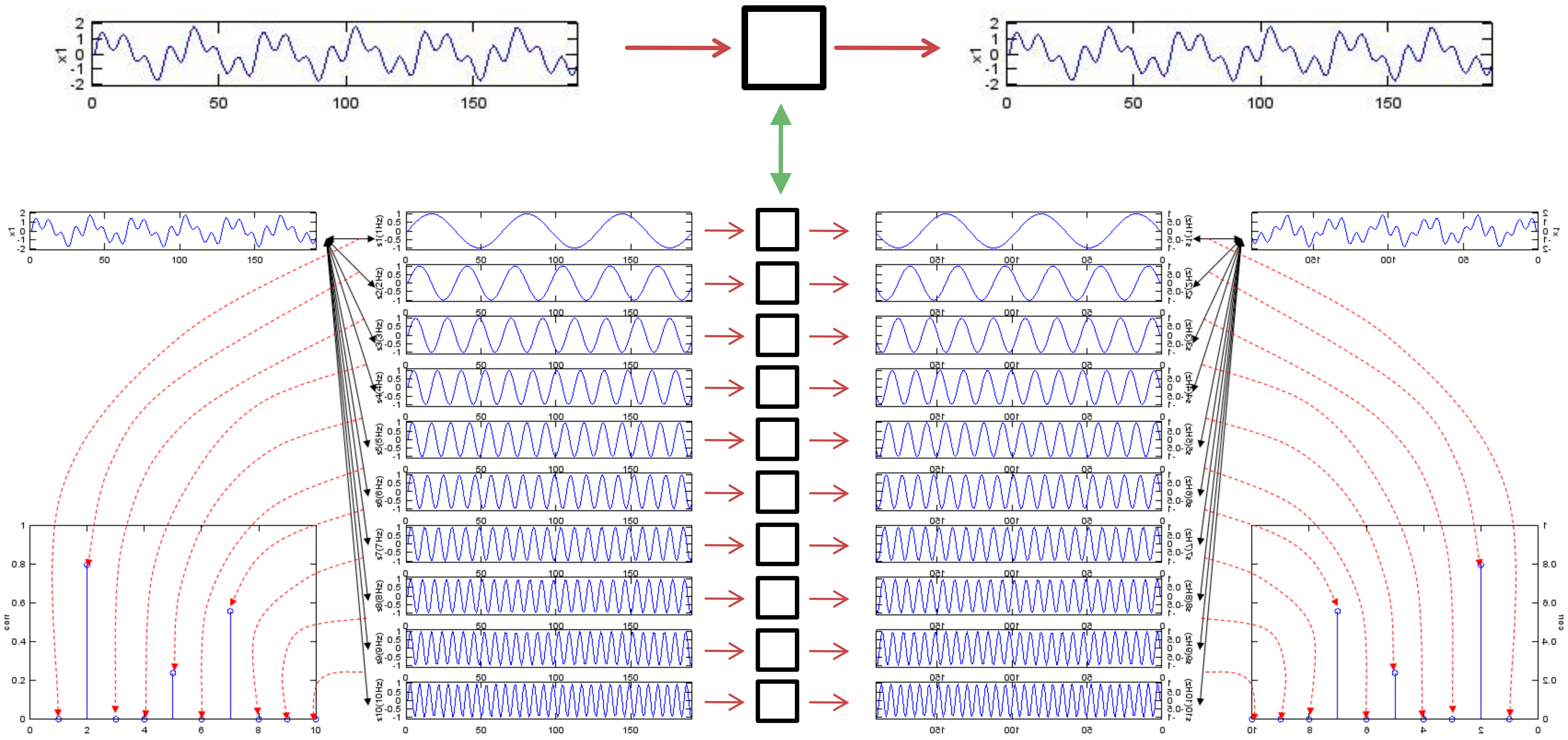


Modele matematice

$$g(\omega) = \int_{-\infty}^{\infty} f(t) \cdot e^{-j\omega t} dt$$



Modele matematice



$$F(\omega)=\int_{-\infty}^{\infty} f(t)\cdot e^{-j\omega t}dt$$

$$G(\omega)[F(\omega)]$$

$$g(t)=\int_{-\infty}^{\infty} G(\omega)\cdot e^{j\omega t}d\omega$$

Câmpuri electromagnetice cu variație armonică în timp

$$X = X_0 e^{j\cdot\omega\cdot t} \qquad \frac{\partial X}{\partial t} = j\cdot\omega\cdot X$$

$$g(\omega) = \int_{-\infty}^{\infty} f(t)\cdot e^{-j\omega t}\,dt \qquad f(t) = \int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}\,d\omega$$

- Simplificarea ecuatiilor lui Maxwell

$$\nabla^2 E + \omega^2 \varepsilon\mu E = j\omega\mu J + \frac{1}{\varepsilon}\nabla\rho$$

$$\nabla^2 H + \omega^2 \varepsilon\mu H = -\nabla\times J$$

$$\nabla\cdot E = \frac{\rho}{\varepsilon}$$

$$\nabla\cdot H = 0$$

Ecuațiile de propagare

- Ecuațiile Helmoltz sau ecuațiile de propagare

Mediu lipsit de sarcini electrice

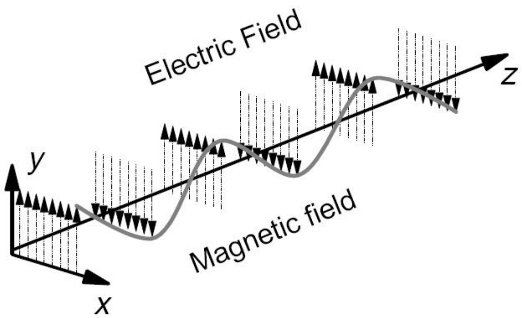
$$\nabla^2 E - \gamma^2 E = 0$$

$$\nabla^2 H - \gamma^2 H = 0$$

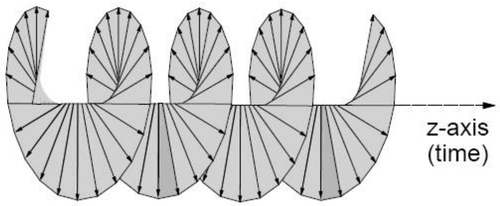
$$\gamma^2 = -\omega^2 \varepsilon\mu + j\omega\mu\sigma$$

γ – Constanta de propagare

Solutia ecuatiilor de propagare



Propagare



Polarizare circulara

Camp electric dupa directia Oy, ← **prin alegerea judicioasa**
propagare dupa directia Oz ← **a sistemului de referinta**

$$E_y = E_+ e^{-\gamma \cdot z} + E_- e^{\gamma \cdot z}$$

$$\gamma = \sqrt{-\omega^2 \varepsilon\mu + j\omega\mu\sigma} = \alpha + j \cdot \beta$$

Exista numai unda progresiva E_+=> A

$$E_y = A e^{-(\alpha + j \cdot \beta) \cdot z}$$

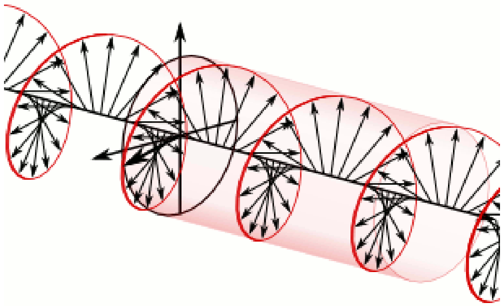
Camp armonic

$$E_y = A \cdot e^{-\alpha \cdot z} \cdot e^{j(\omega \cdot t - \beta \cdot z)}$$

Amplitudine

Atenuare

Propagare
(variatie in timp si spatiu)



Modele matematice

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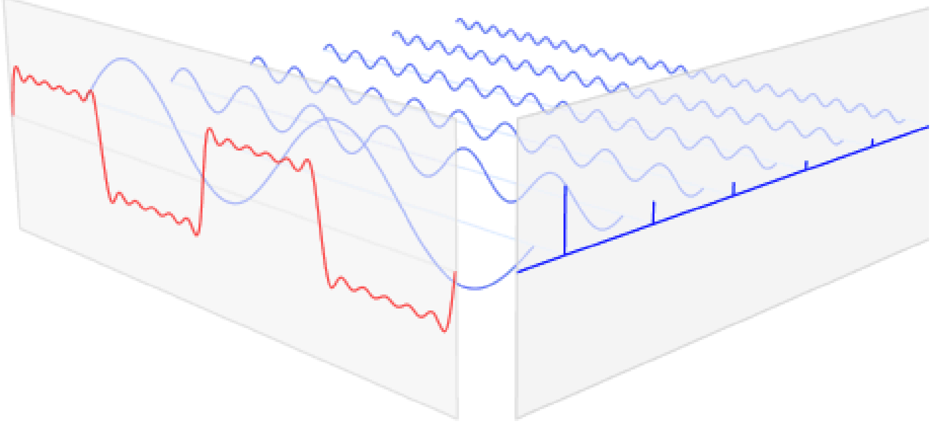
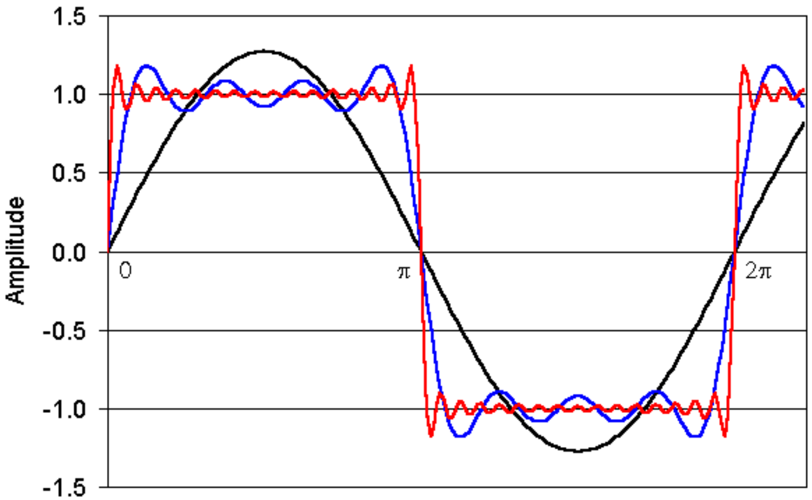
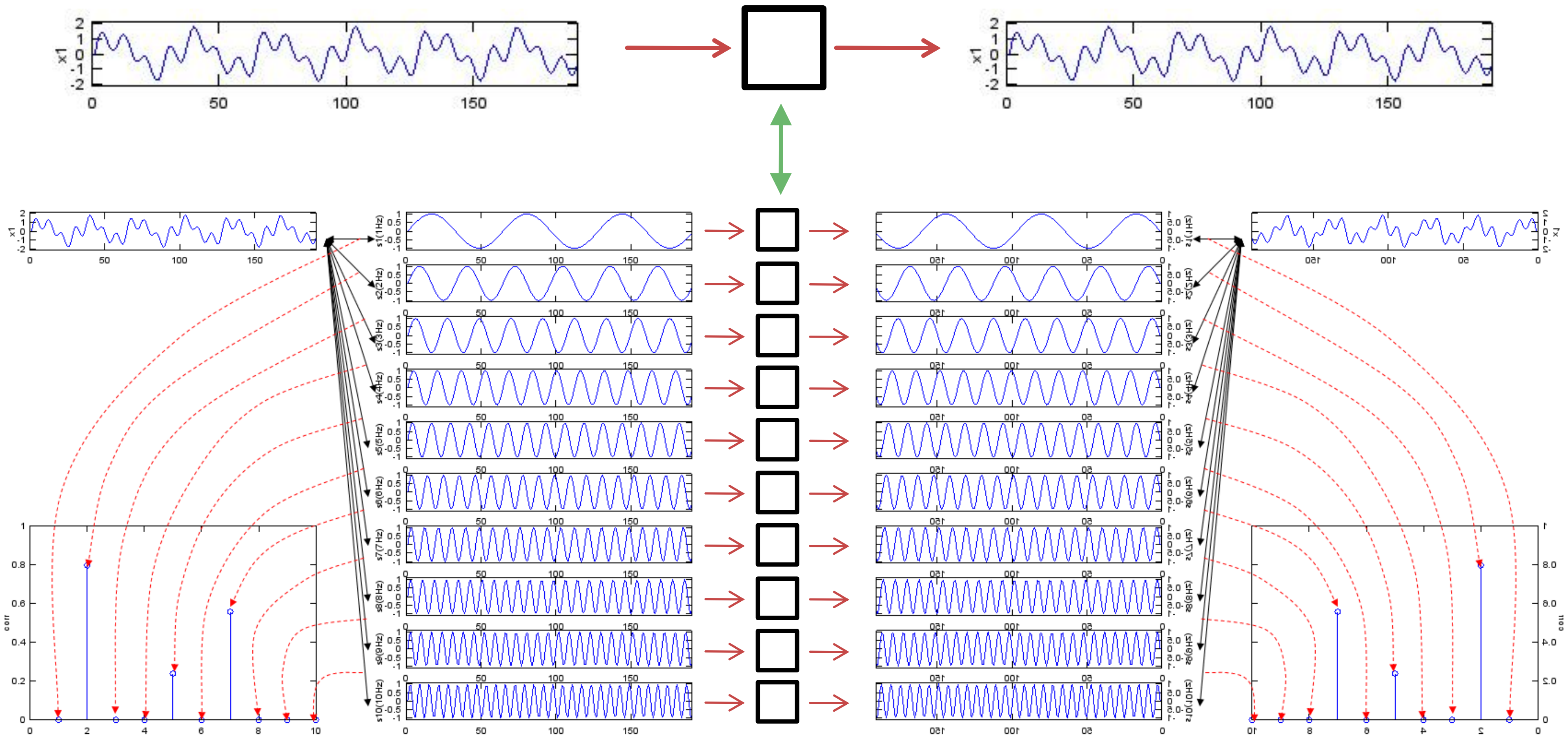
  - semnale cu variație armonică în timp, transformata Fourier, spectru

$$X = X_0 e^{j\cdot\omega\cdot t} \qquad \frac{\partial X}{\partial t} = j\cdot\omega\cdot X \qquad g(\omega) = \int_{-\infty}^{\infty} f(t)\cdot e^{-j\omega t}\,dt \qquad f(t) = \int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}\,d\omega$$





Modele matematice



$$F(\omega)=\int_{-\infty}^{\infty} f(t)\cdot e^{-j\omega t}\,dt$$

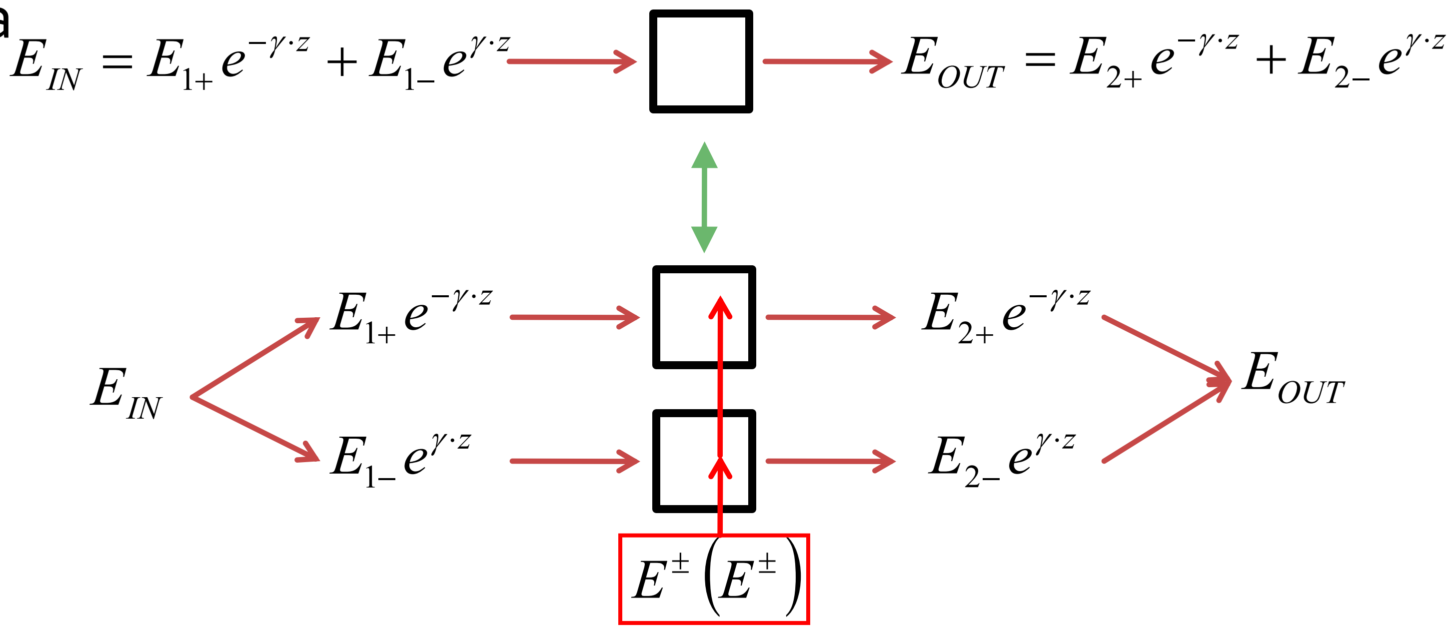
$$G(\omega)\left[F(\omega)\right]$$

$$g(t)=\int_{-\infty}^{\infty} G(\omega)\cdot e^{j\omega t}\,d\omega$$

Modele matematice

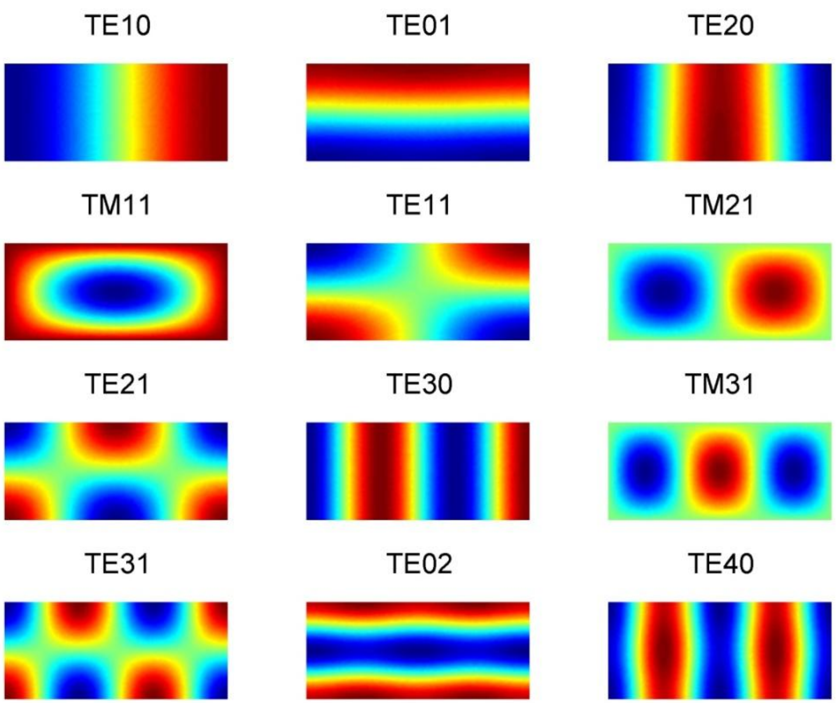
- cazuri particulare in care exista rezolvare analitica
  - Exista unda in o singura directie $\quad E^{+}\left(E^{+}\right), \quad E^{-}\left(E^{-}\right)$
  - unda
    - incidenta
    - reflectata
  - unda
    - directa
    - inversa

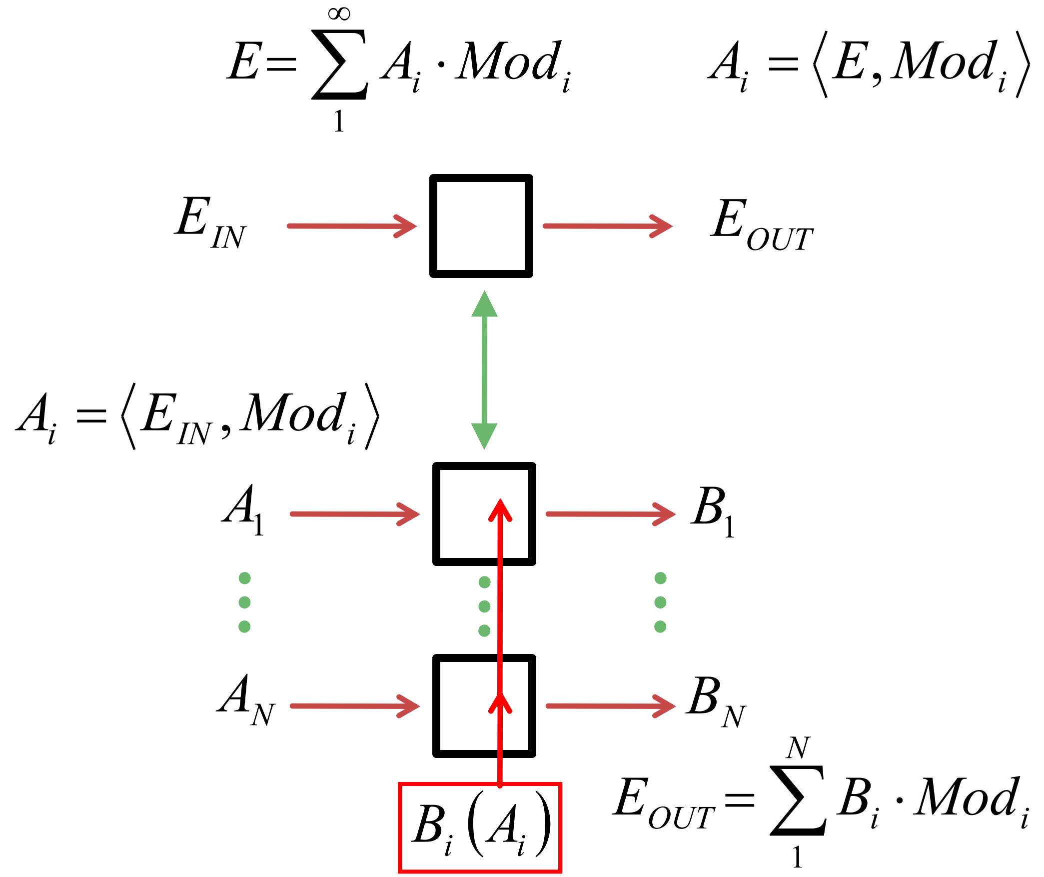
$$E_y = E^{+} \cdot e^{-\alpha \cdot z} \cdot e^{j(\omega \cdot t - \beta \cdot z)} + E^{-} \cdot e^{-\alpha \cdot z} \cdot e^{j(\omega \cdot t + \beta \cdot z)}$$



Modele matematice

- cazuri particulare in care exista rezolvare analitica
  - moduri in medii delimitate $B_i(A_i)$





Transfer de putere

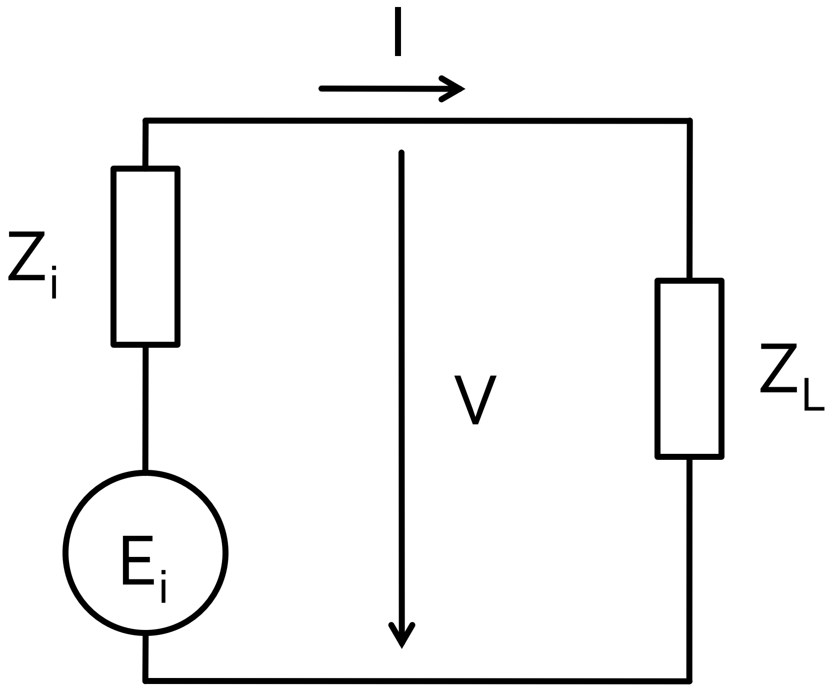
Adaptarea de impedanța

Cuprins

- Linii de transmisie
- Adaptarea de impedanța
- Cuploare direcționale
- Divizoare de putere
- Amplificatoare de microunde
- Filtre de microunde
- Oscilatoare de microunde ?

Adaptare

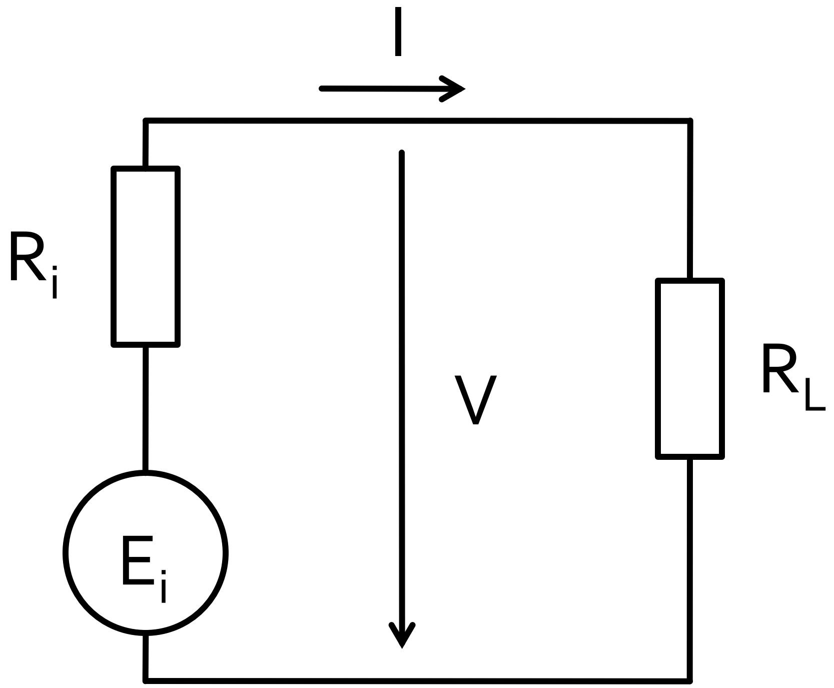
- Generator **adaptat** la sarcina ?



- valori impedanta ?
- reflexii ?

Adaptare, impedante reale

- Generator adaptat la sarcina



$$I = \frac{E_i}{R_i + R_L}$$

$$V = \frac{E_i \cdot R_L}{R_i + R_L}$$

$$P_L = R_L \cdot I^2$$

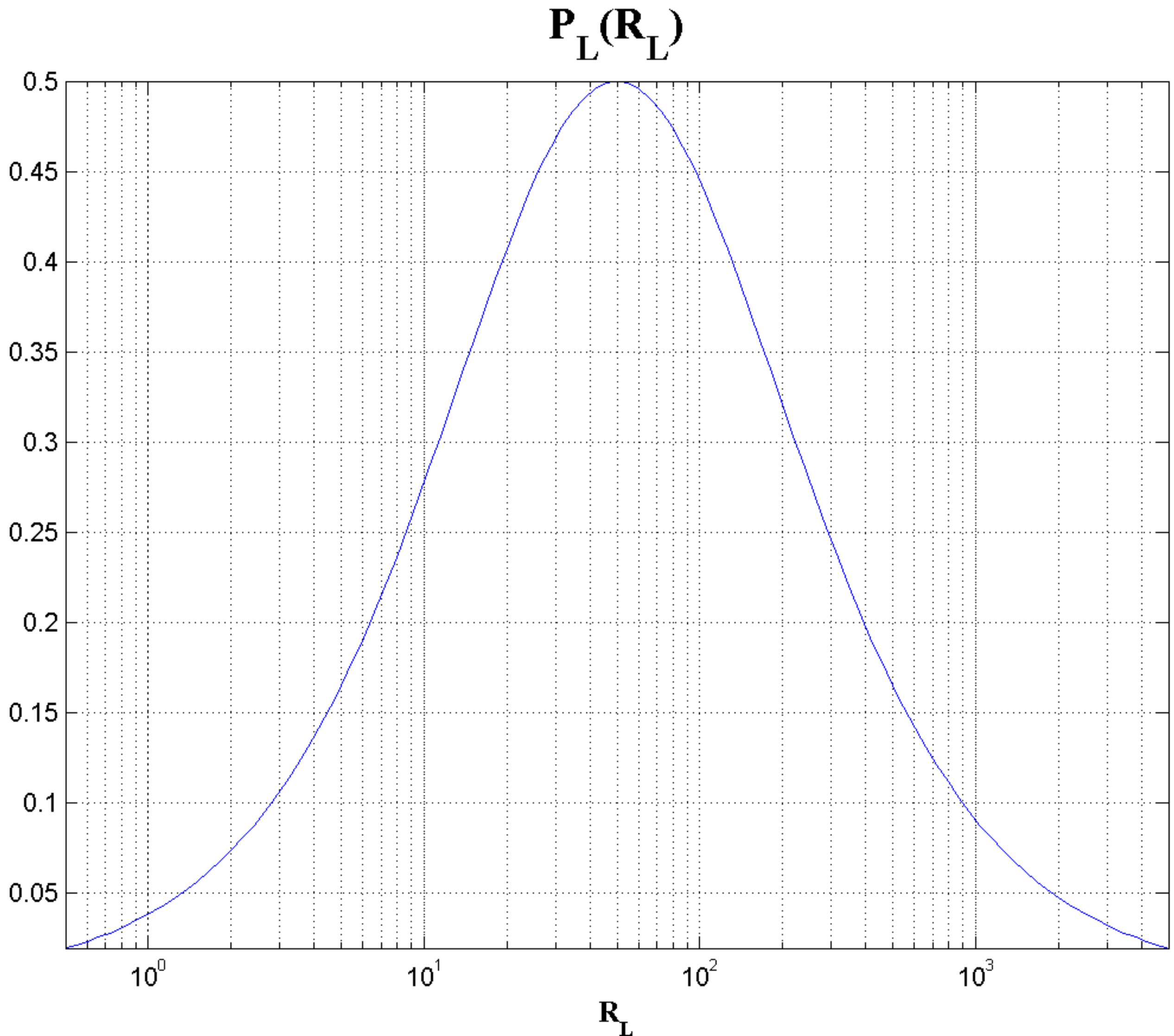
$$P_L = \frac{R_L \cdot E_i^2}{(R_i + R_L)^2}$$

Adaptare , impedante reale

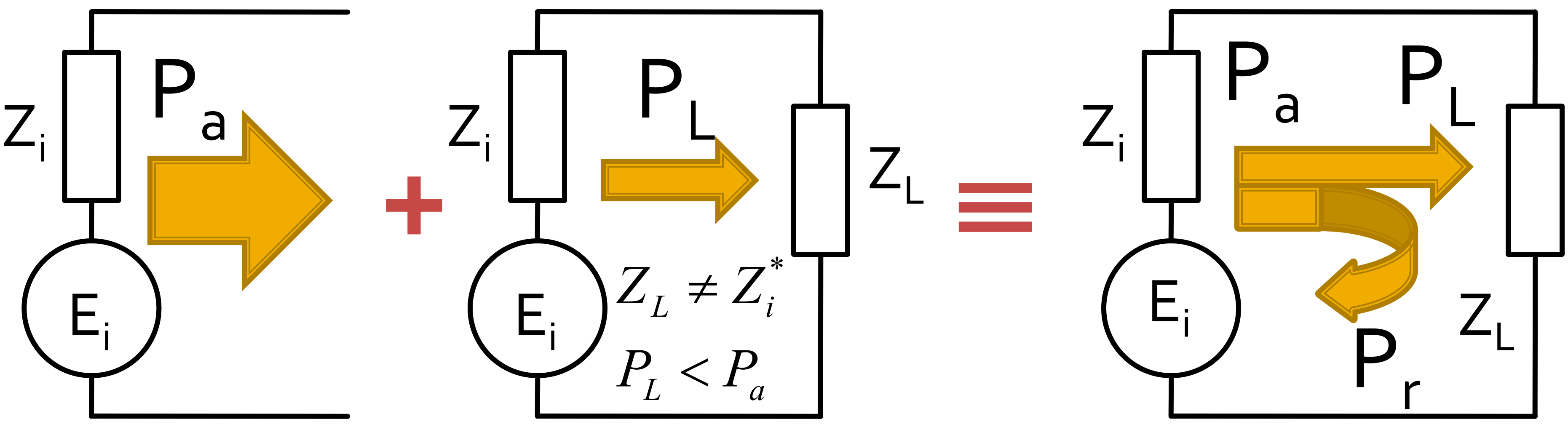
$$P_L = R_L \cdot I^2 \qquad P_L = \frac{R_L \cdot E_i^2}{(R_i + R_L)^2}$$

- Putere pe sarcina
  - $R_i = 50\Omega$
  - $R_L = 0 \rightarrow P_L = 0$
  - $R_L = \infty \rightarrow P_L = 0$

Adaptare , impedante reale



Reflexie de putere / Model



- Generatorul are posibilitatea de a oferi o anumita putere maxima de semnal P_a
- Pentru o sarcina oarecare, acesteia i se ofera o putere de semnal mai mica $P_L < P_a$
- Se intampla **"ca si cum"** (model) o parte din putere se reflecta $P_r = P_a - P_L$
- Puterea este o marime **scalara!**

Laborator 1

2025/2026

Dispozitive şi circuite de microunde pentru radiocomunicații

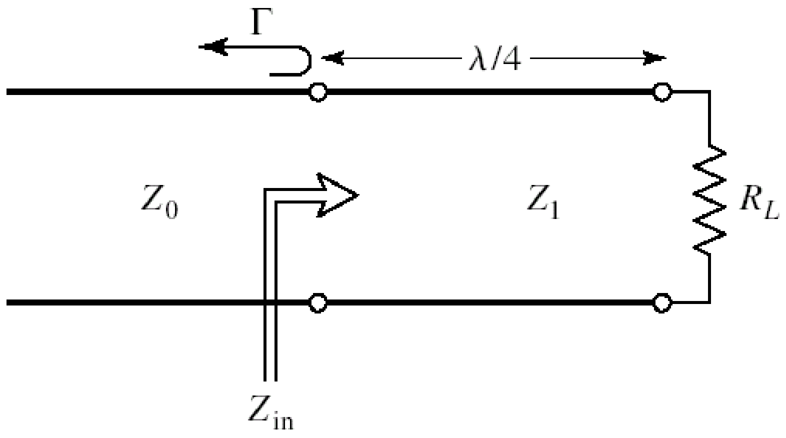
Scurta teorie

Adaptare de impedanta

- Adaptarea de impedanta este necesara atunci cand are loc o variatie in salt a impedantei/impedantei caracteristice
- Se caracterizeaza prin valoarea coeficientului de reflexie (Γ)
  - $|\Gamma|=0$ adaptare perfecta
  - $|\Gamma|\approx 0$, $|\Gamma|<\Gamma_{max}$ adaptare "suficienta"
- in simulare $|\Gamma|==|S_{11}|$

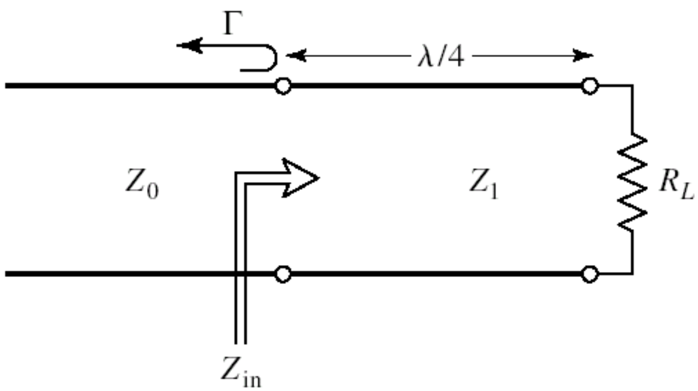
Transformatorul in sfert de lungime de unda

- Feed line – linie de intrare cu impedanta caracteristica Z_o
- Sarcina cu impedanta (**rezistiva!**) R_L
- Dorim adaptarea sarcinei la fider cu o linie de lungime **λ/4** si impedanta caracteristica Z_1



$$\Gamma_{in} = 0 \quad \Rightarrow \quad Z_1 = \sqrt{Z_0 R_L}$$

Transformatorul in sfert de lungime de unda



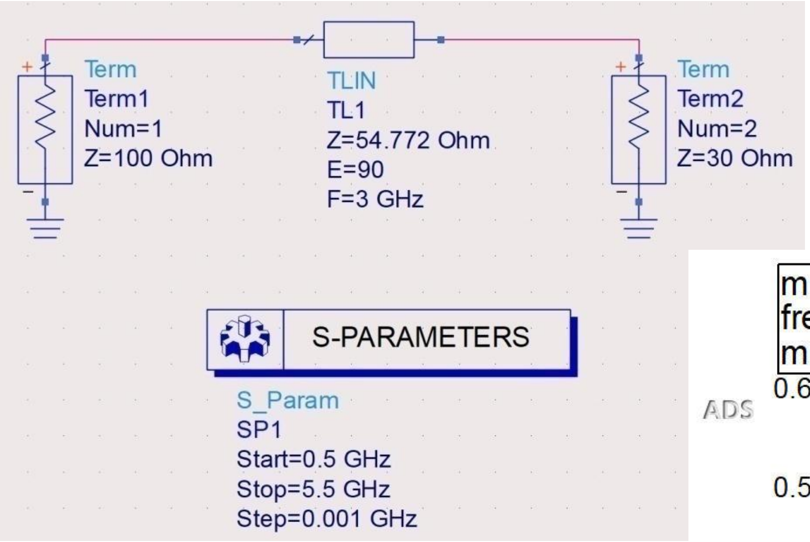
$$\Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

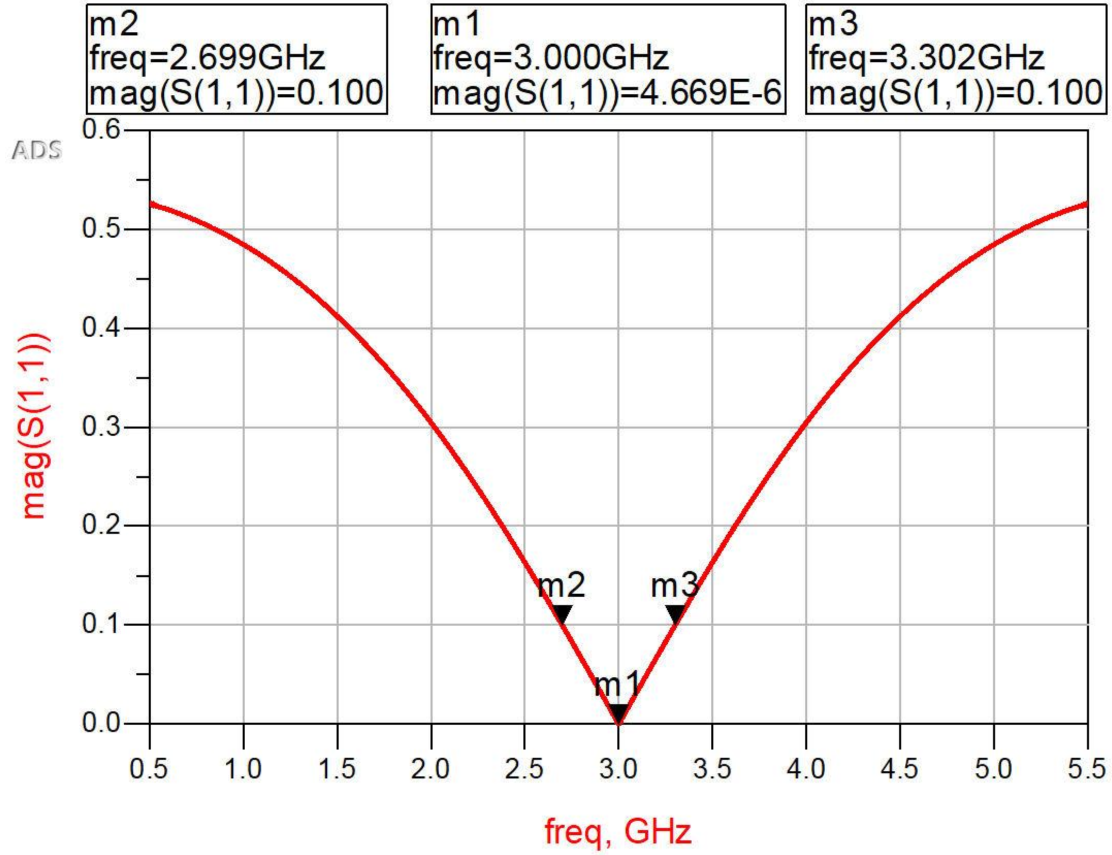
$$\beta \cdot l = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} = \frac{\pi}{2} \qquad Z_{in} = \frac{Z_1^2}{R_L}$$

$$\Gamma_{in} = \frac{Z_1^2 - Z_0 \cdot R_L}{Z_1^2 + Z_0 \cdot R_L} \qquad \Gamma_{in} = 0 \quad \Rightarrow \quad Z_1 = \sqrt{Z_0 R_L}$$

- Pe fider (Z_0) avem doar unda progresiva
- Pe linia in sfert de lungime de unda (Z_1) avem unda stationara

Sfert de lungime de unda



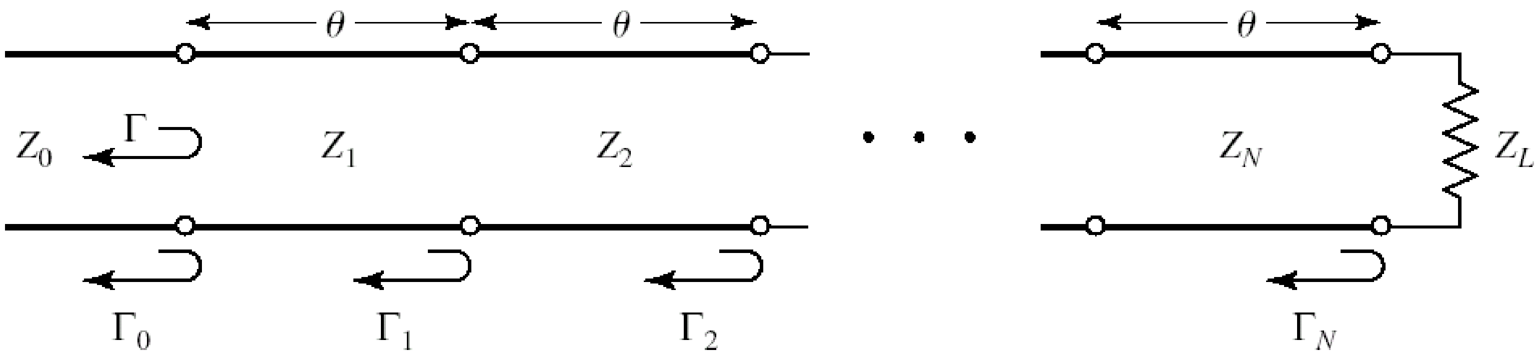


$$P_{avg} = \frac{1}{2} \cdot \frac{\left|V_0^+\right|^2}{Z_0} \cdot \left(1 - \left|\Gamma\right|^2\right)$$

Transformatoare de impedanta multisectiune

- Transformatorul in sfert de lungime de unda permite adaptarea oricarei impedante reale cu orice impedanta a fiderului (liniei).
- Daca banda necesara este mai mare decat cea oferita de transformatorul in sfert de lungime de unda se folosesc transformatoare multisectiune
  - caracteristica binomiala
  - tip Cebîşev

Transformatoare cu mai multe sectiuni



- Presupunem ca toate impedantele **cresc sau descresc uniform**
- Toti coeficientii de reflexie vor fi reali si de acelasi semn
- Anterior $\Gamma \cong \Gamma_1 + \Gamma_3 \cdot e^{-2j\theta} \Rightarrow$

$$\Gamma(\theta) = \Gamma_0 + \Gamma_1 \cdot e^{-2j\theta} + \Gamma_2 \cdot e^{-4j\theta} + \cdots + \Gamma_N \cdot e^{-2jN\theta}$$

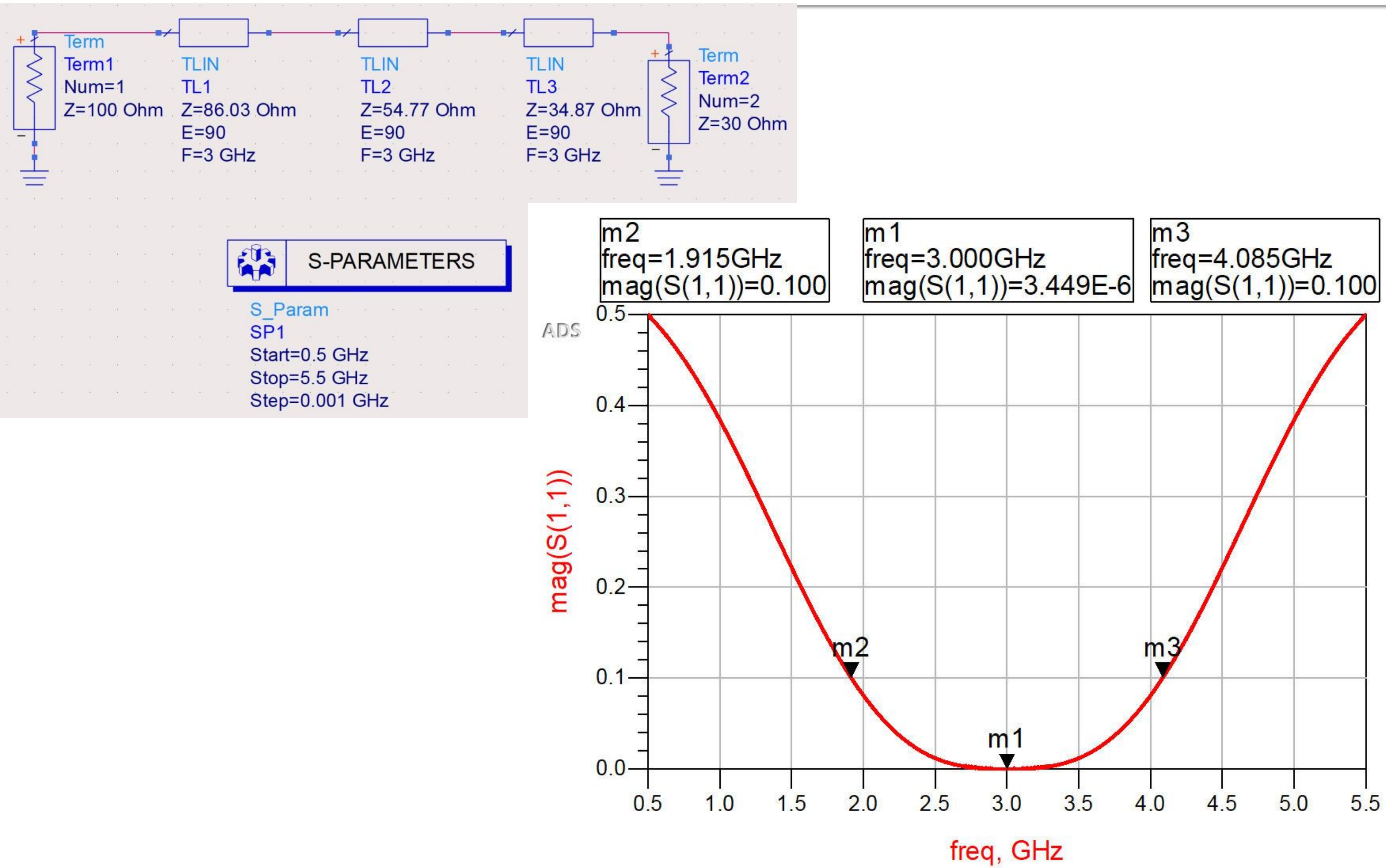
$$\Gamma_1 = \frac{Z_1 - Z_0}{Z_1 + Z_0}$$

$$\Gamma_n = \frac{Z_{n+1} - Z_n}{Z_{n+1} + Z_n}$$

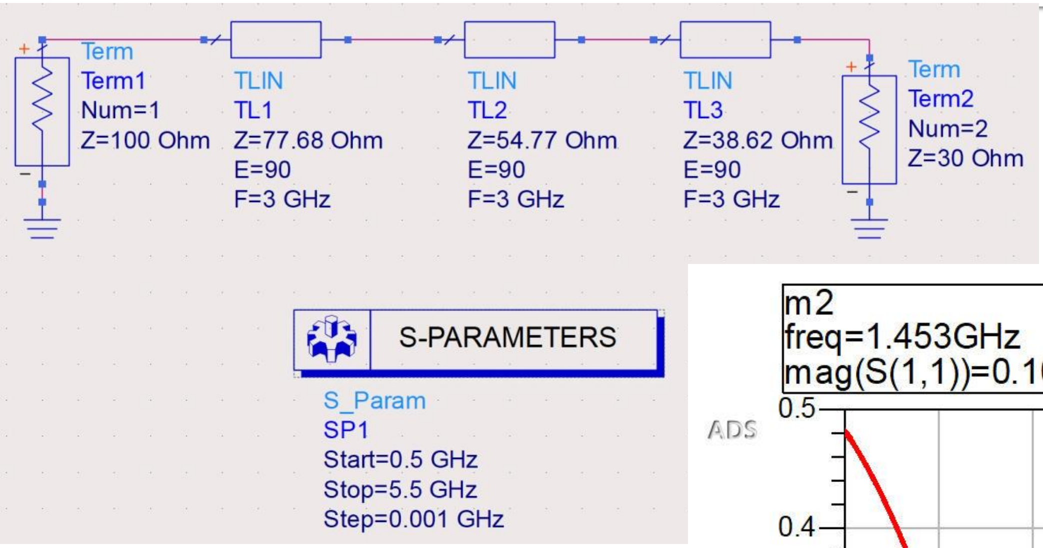
$$n = \overline{1, N-1}$$

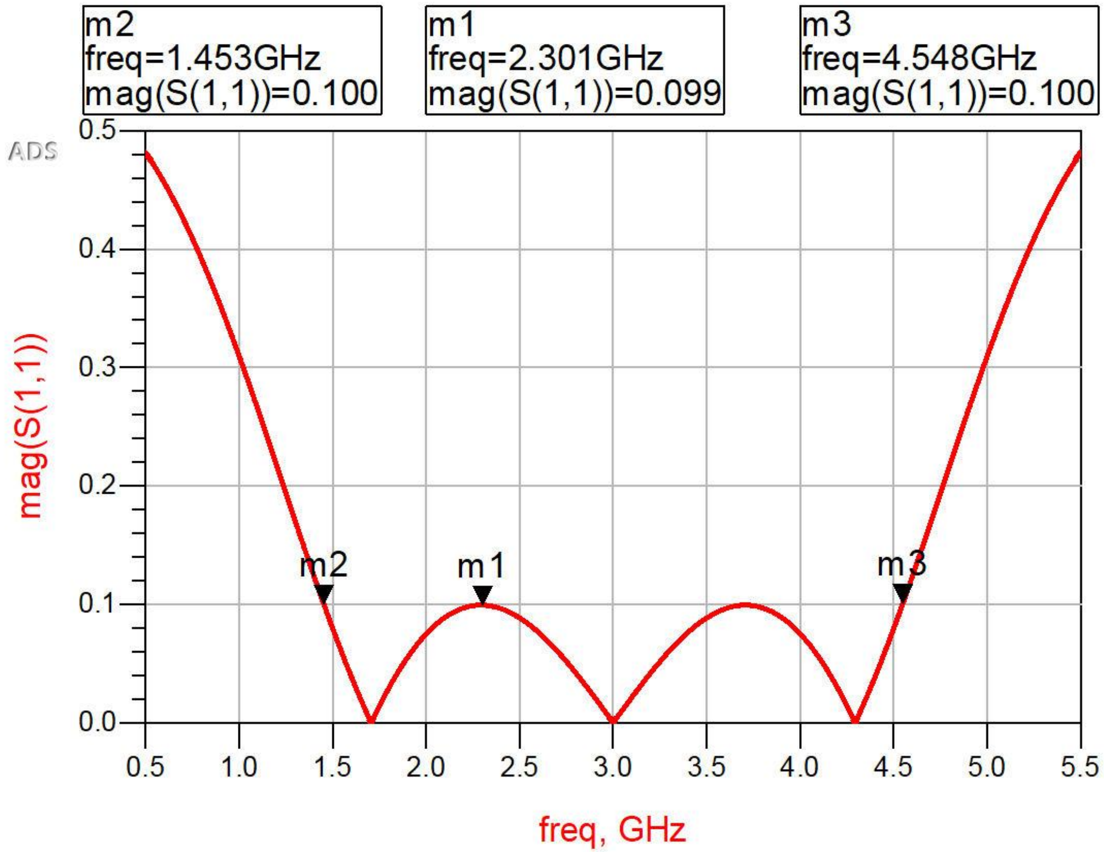
$$\Gamma_N = \frac{Z_L - Z_N}{Z_L + Z_N}$$

Binomial


Term
Term1
Num=1
Z=100 Ohm
TLIN
TL1
Z=86.03 Ohm
E=90
F=3 GHz
TLIN
TL2
Z=54.77 Ohm
E=90
F=3 GHz
TLIN
TL3
Z=34.87 Ohm
E=90
F=3 GHz
Term
Term2
Num=2
Z=30 Ohm
S-PARAMETERS
S_Param
SP1
Start=0.5 GHz
Stop=5.5 GHz
Step=0.001 GHz
m2
freq=1.915GHz
mag(S(1,1))=0.100
m1
freq=3.000GHz
mag(S(1,1))=3.449E-6
m3
freq=4.085GHz
mag(S(1,1))=0.100
ADS
mag(S(1,1))
0.5
0.4
0.3
0.2
0.1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
freq, GHz

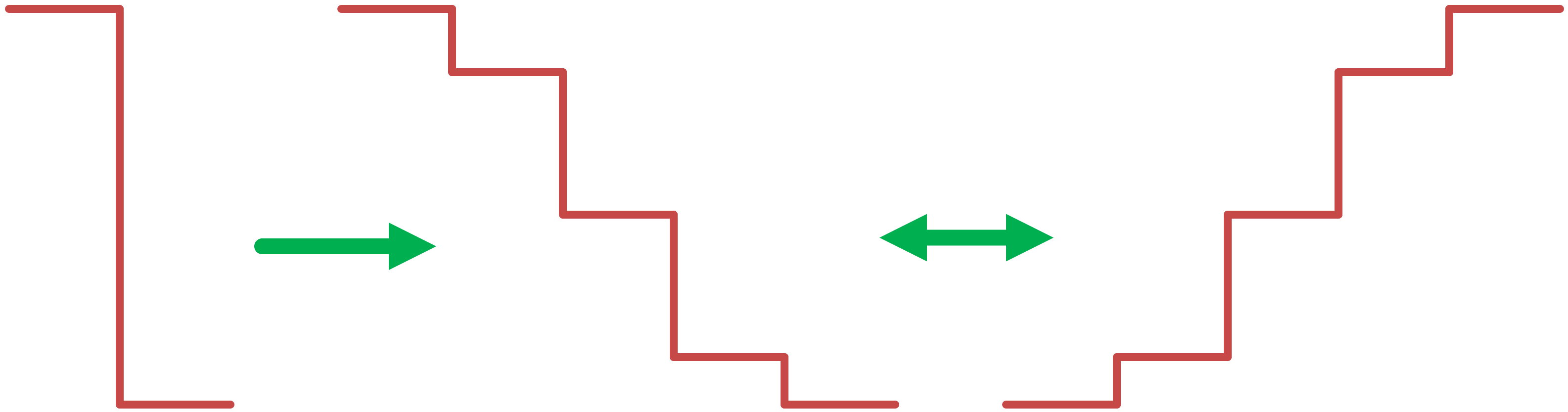
Cebâşev


Term
Term1
Num=1
Z=100 Ohm
TLIN
TL1
Z=77.68 Ohm
E=90
F=3 GHz
TLIN
TL2
Z=54.77 Ohm
E=90
F=3 GHz
TLIN
TL3
Z=38.62 Ohm
E=90
F=3 GHz
Term
Term2
Num=2
Z=30 Ohm
S-PARAMETERS
S_Param
SP1
Start=0.5 GHz
Stop=5.5 GHz
Step=0.001 GHz


m2
freq=1.453GHz
mag(S(1,1))=0.100
m1
freq=2.301GHz
mag(S(1,1))=0.099
m3
freq=4.548GHz
mag(S(1,1))=0.100
ADS
mag(S(1,1))
0.5
0.4
0.3
0.2
0.1
0.0
m2
m1
m3
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
freq, GHz

Adaptare de impedanta

- Principial se inlocuieste o **variatie in salt** a impedantei cu o **crestere/descrestere graduala** a impedantei
- Pasii de crestere/descrestere graduala a impedantei trebuiesc atent calculati



Contact

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