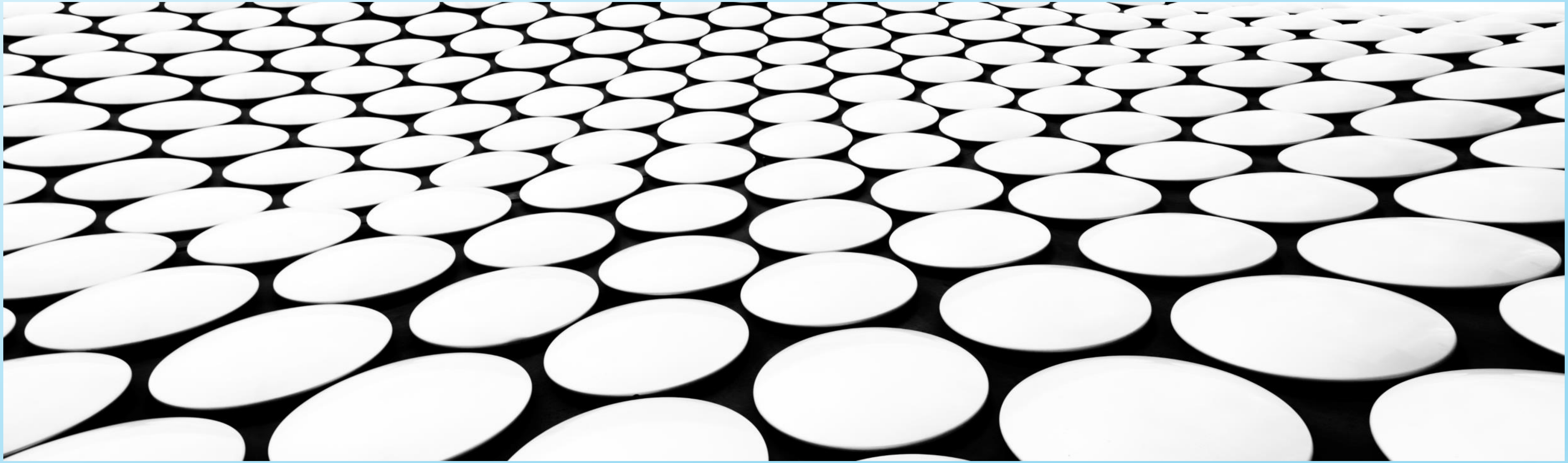
ARHITECTURA SISTEMELOR DE CALCUL

UB, FMI, CTI, ANUL III, 2022-2023



Linii de transmisie

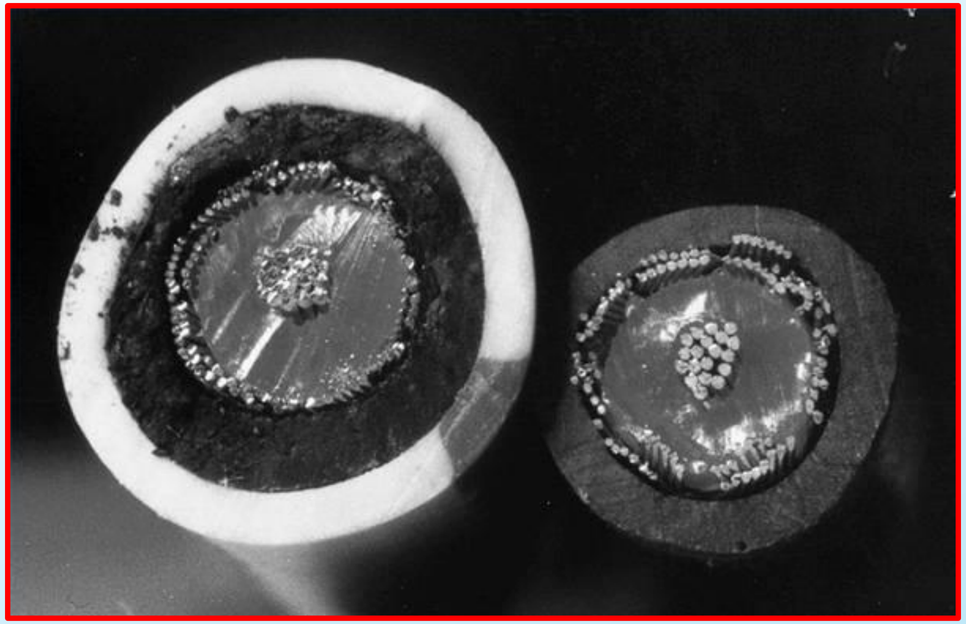
- Caracteristicile si aplicatiile liniilor de transmisie
- Fizica liniilor de transmisie
  - Reflexii si alte distorsiuni in liniile de transmisie si metode de a le reduce efectele.

exemple

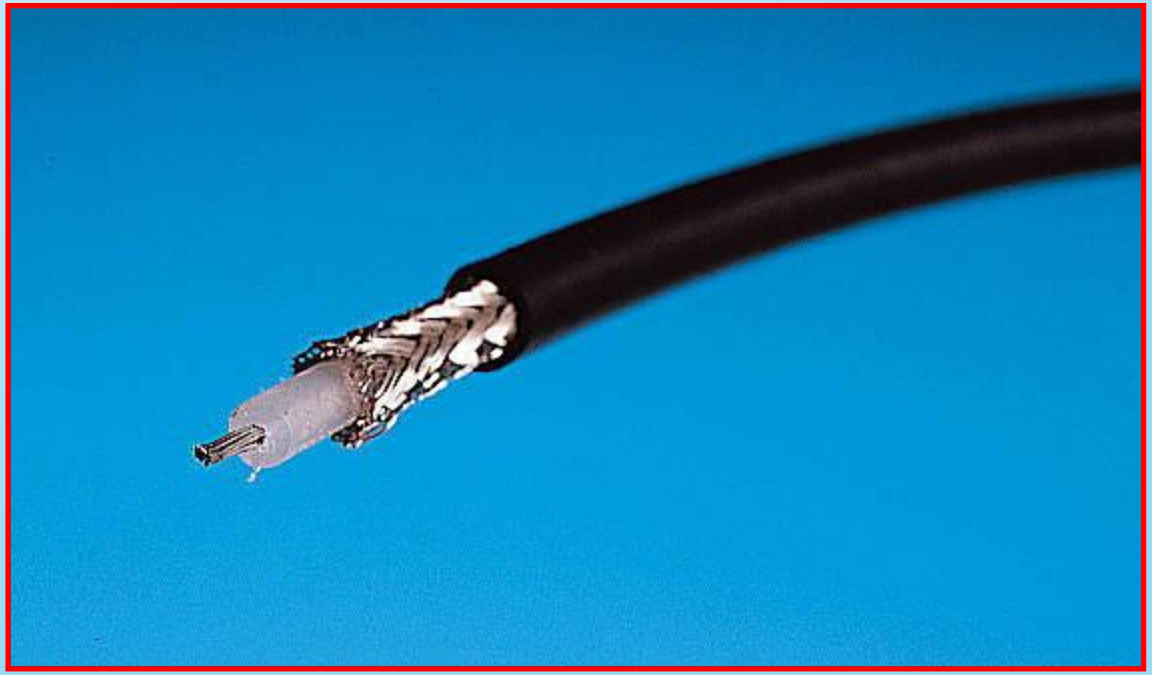
LINIE DE TRANSMISIE COAXIALA

CONECTORI

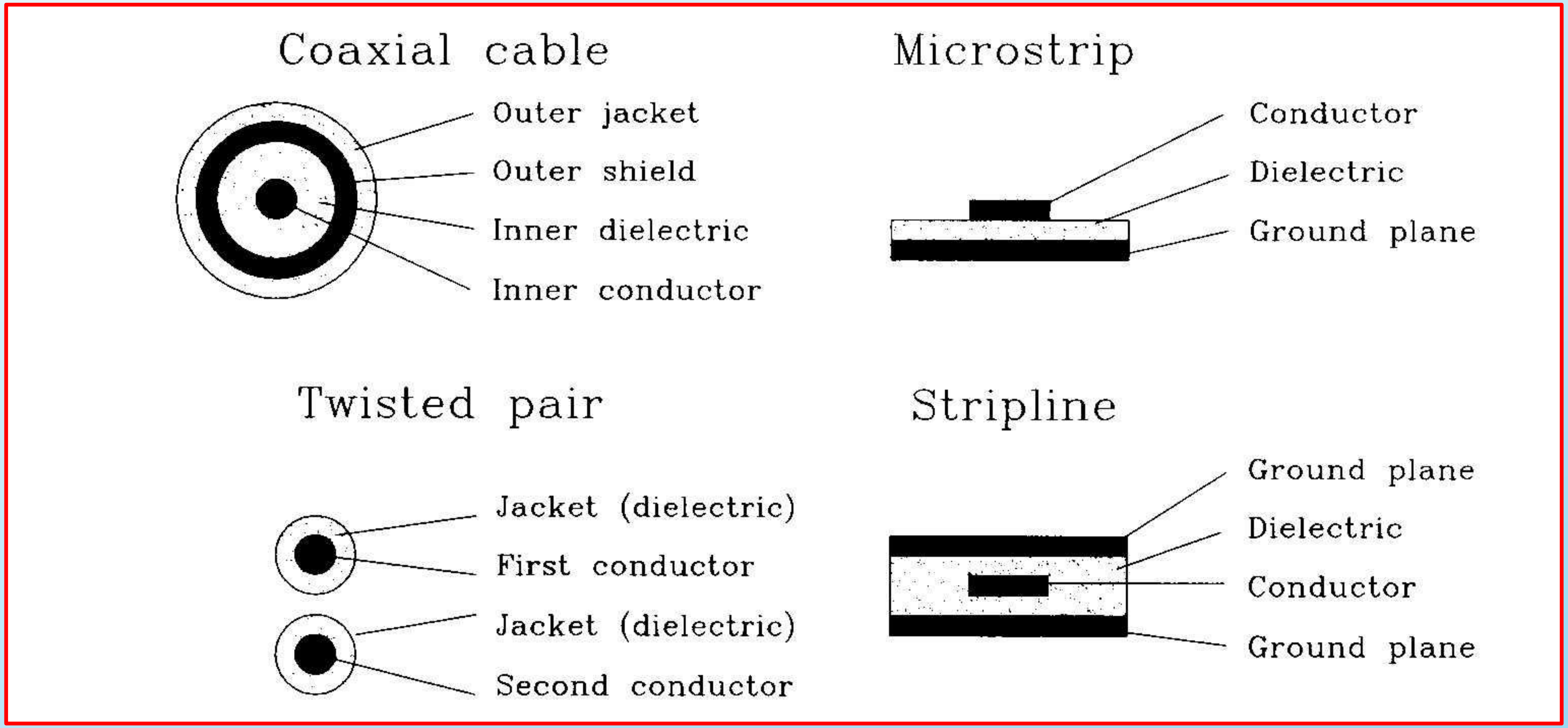
TERMINATOR DE 50 Ω



SECTIUNE IN CABLUL COAXIAL



Principalele tipuri de linii de transmisie

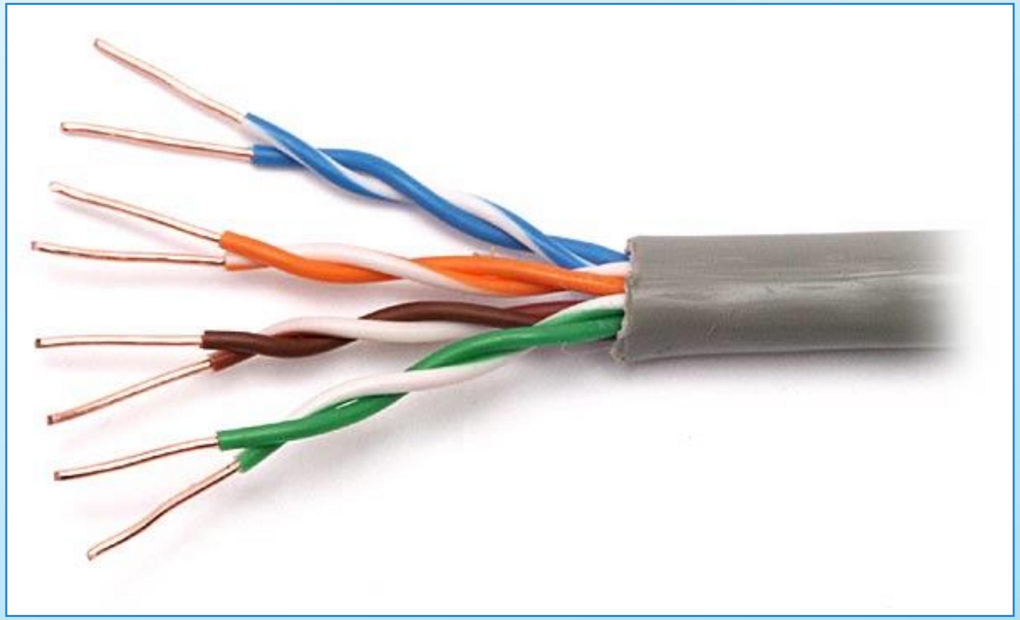


CABLU COAXIAL;

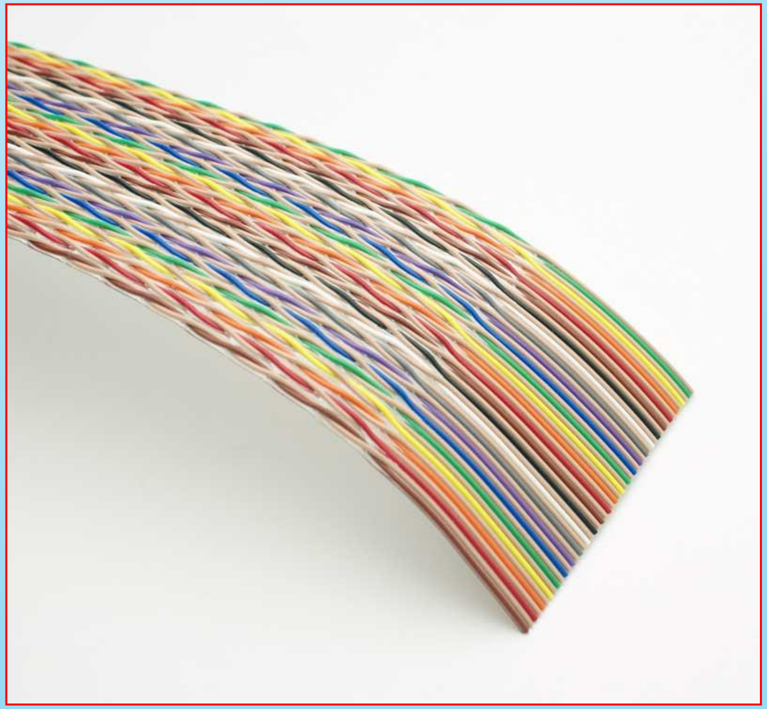
MICROBANDA

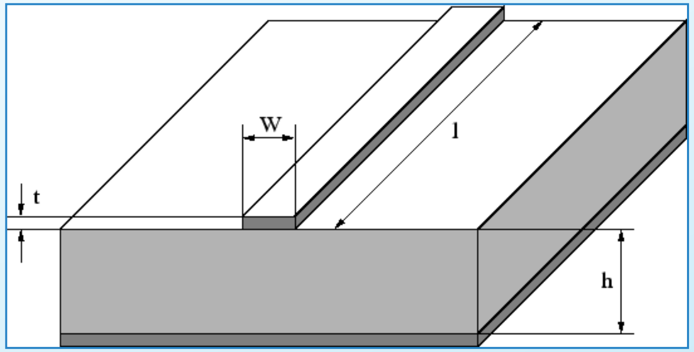
CABLU TORSADAT

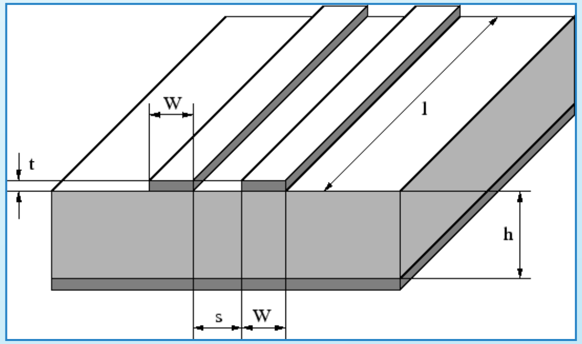
BANDA

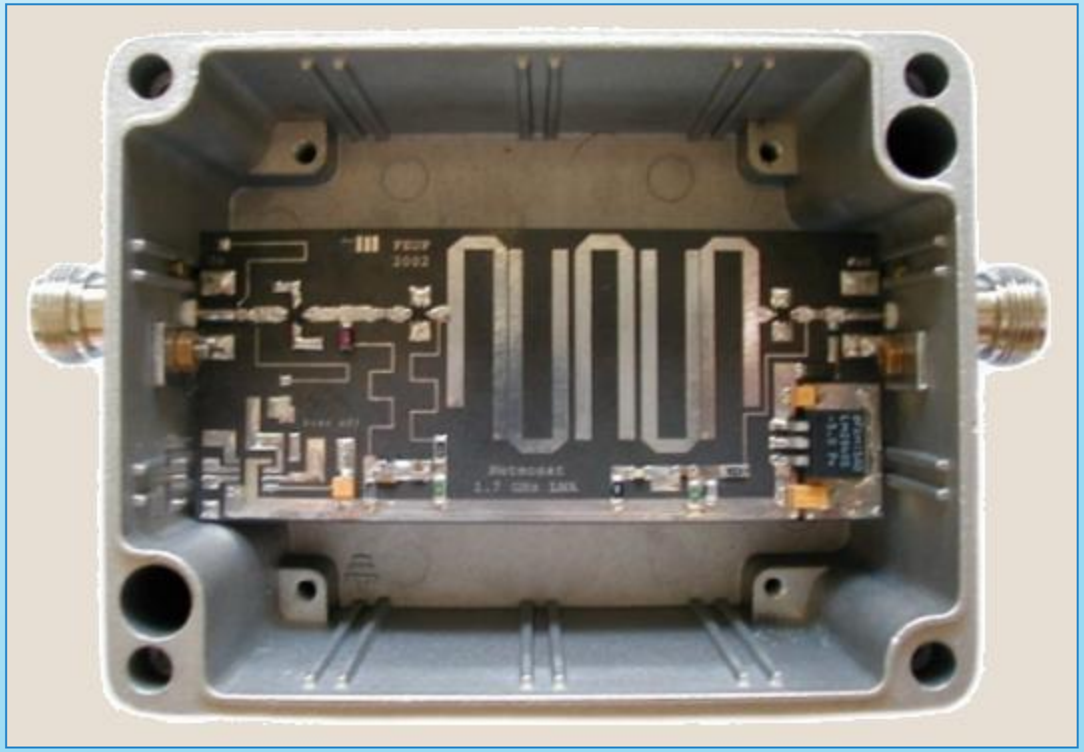



CABLURI TORSADATE

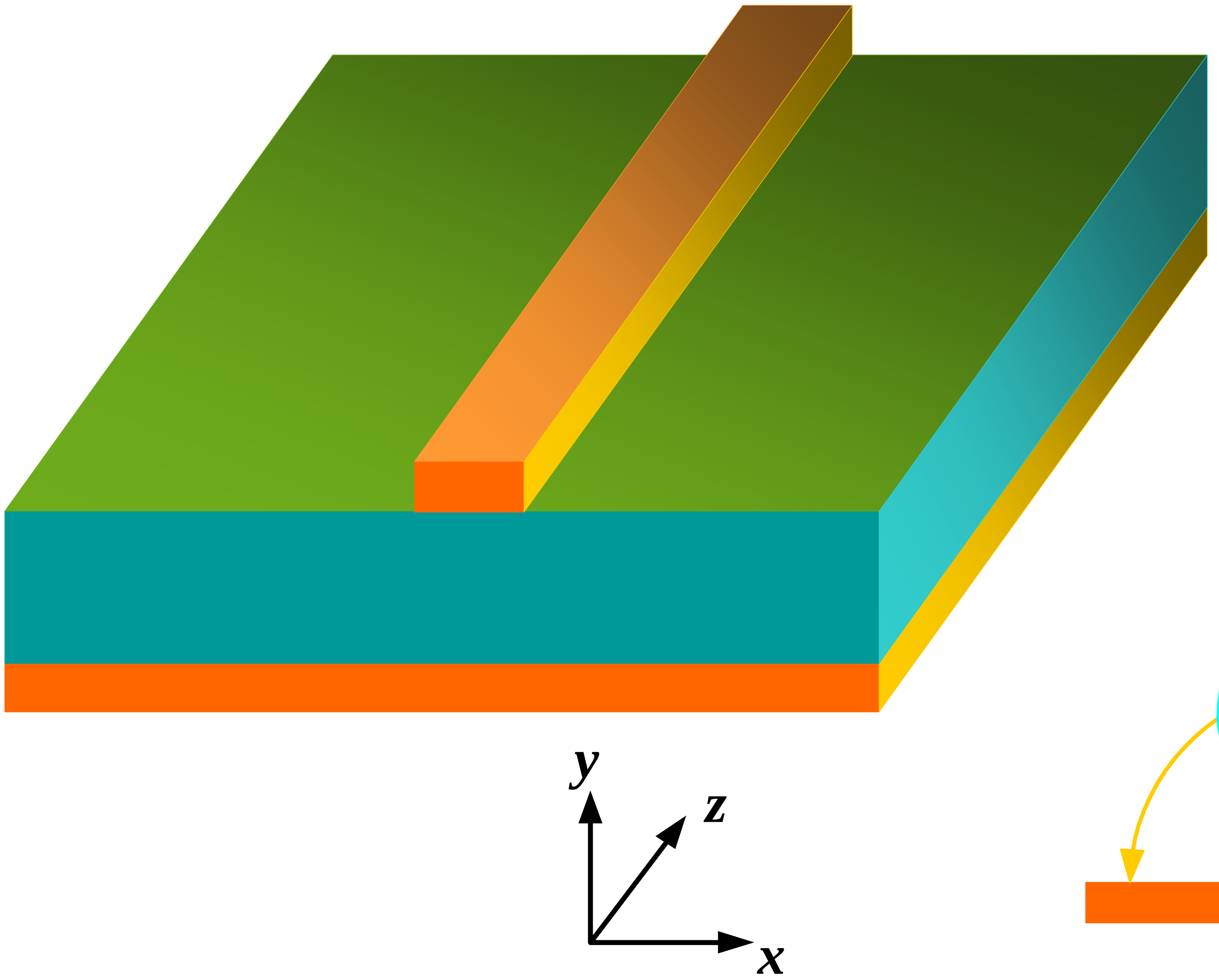


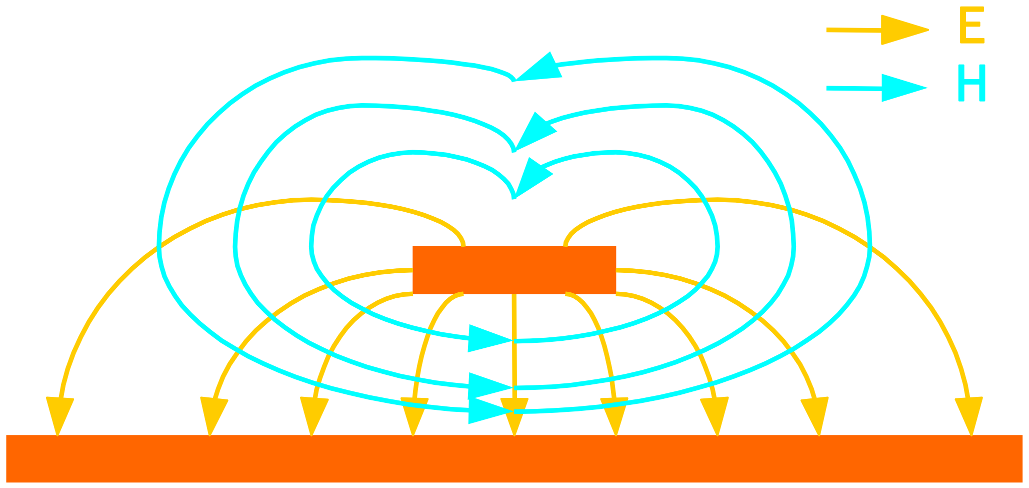


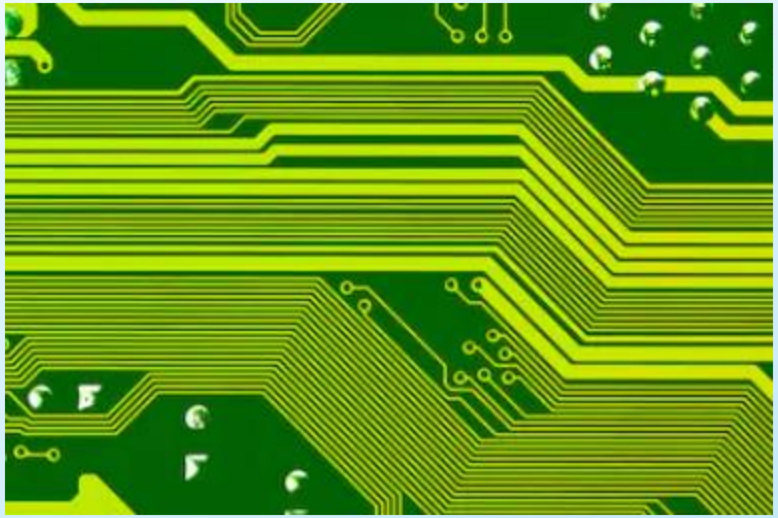


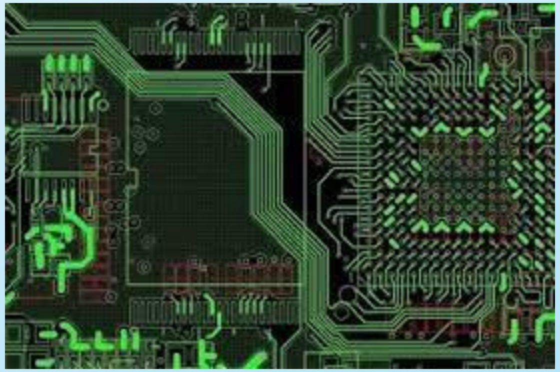


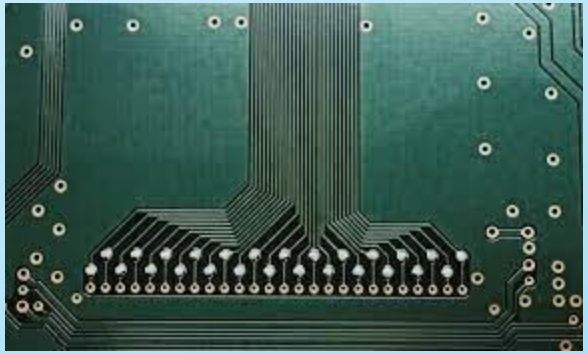
MICROBANDA (MICROSTRIP)


y
z
x

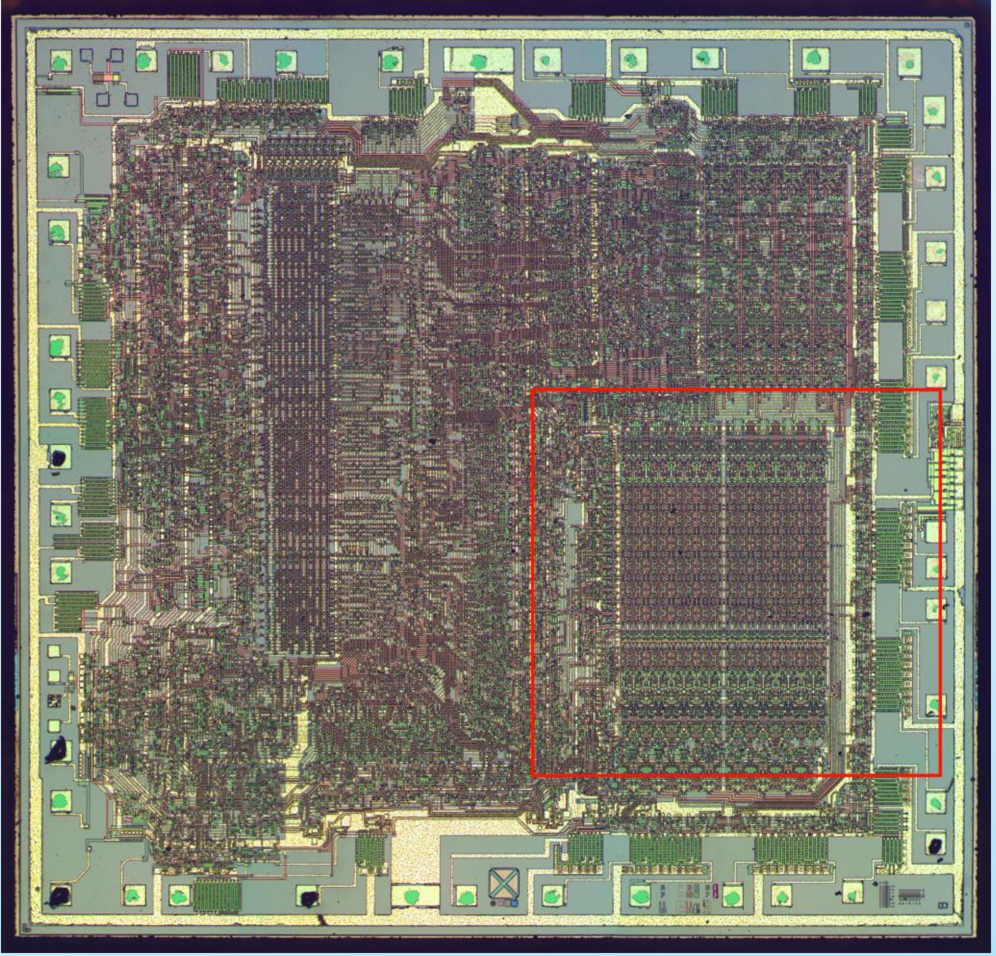

E
H

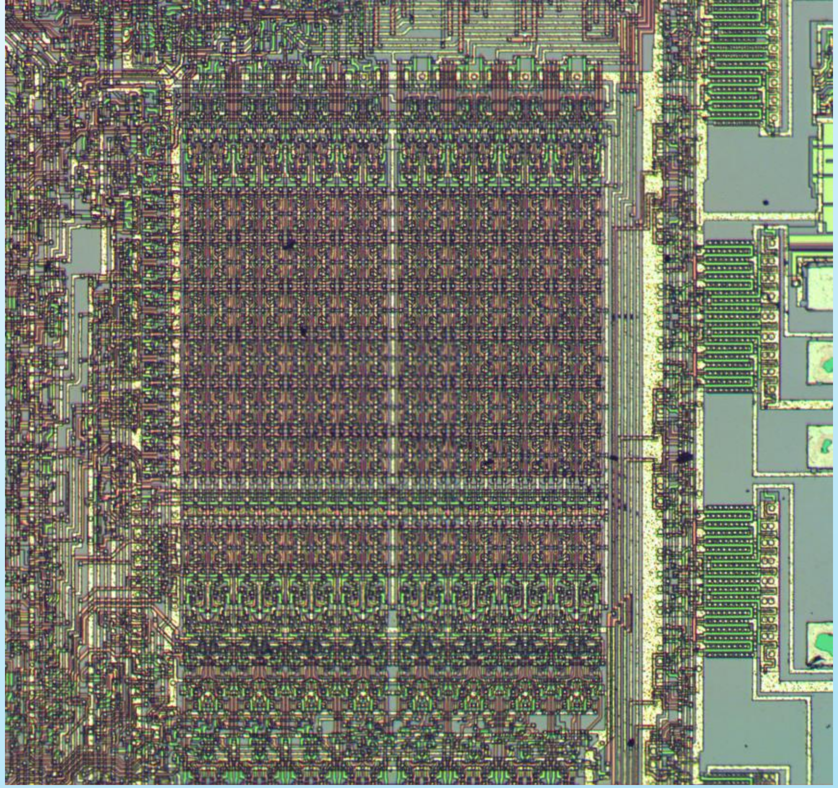


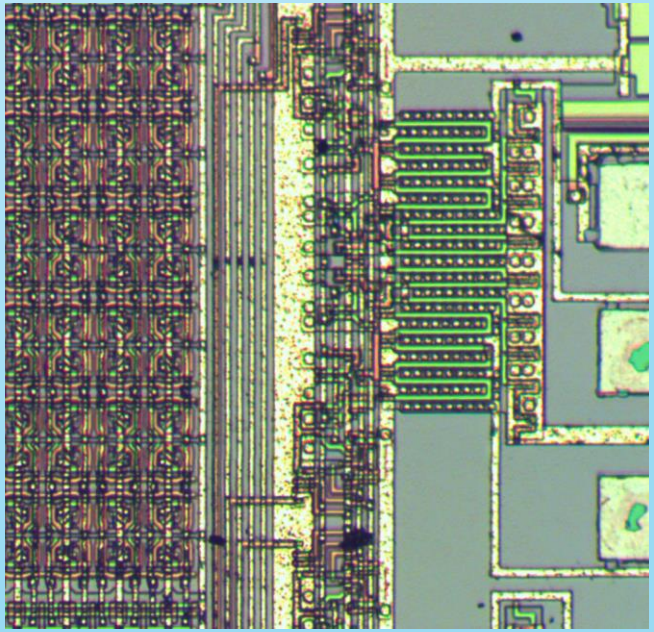


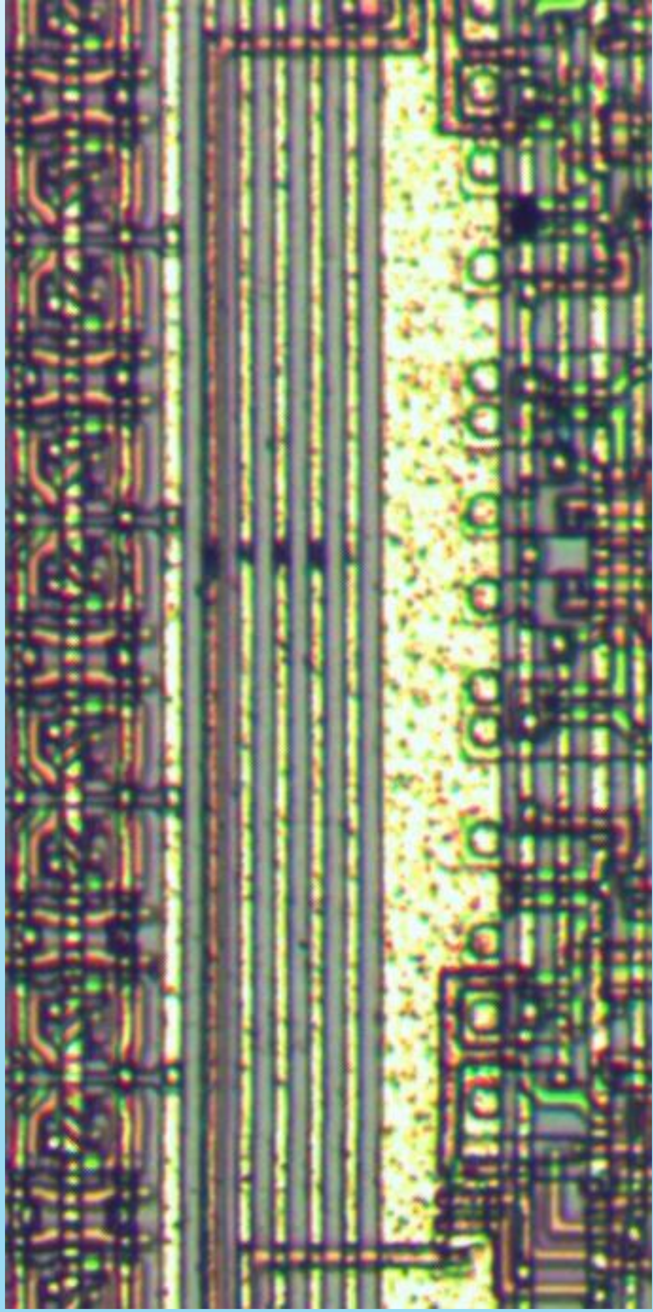


Diverse arhitecturi microstrip pe placi de baza in calculatoare sau in alte dispositive de calcul.







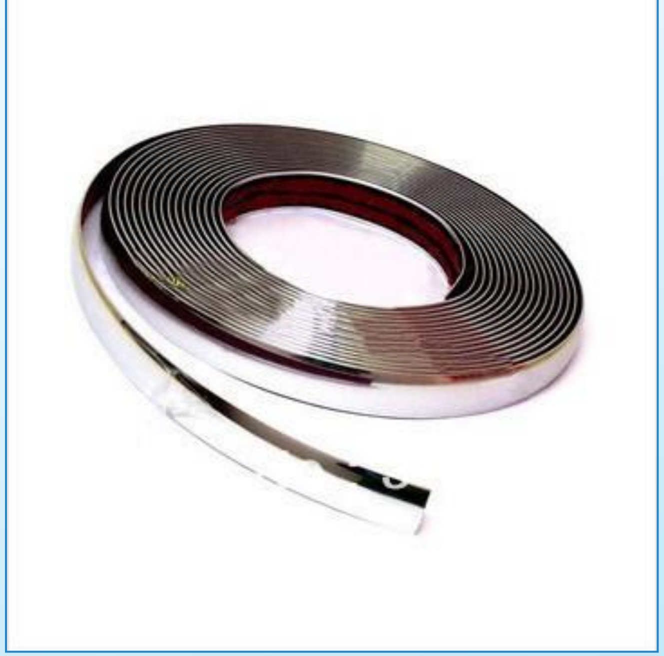


microstrip

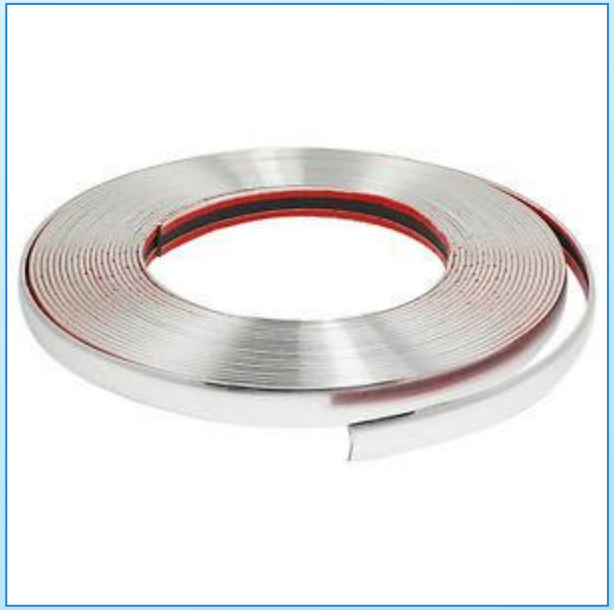
Microprocesor Z80A

Tehnologie 5µm (1976)

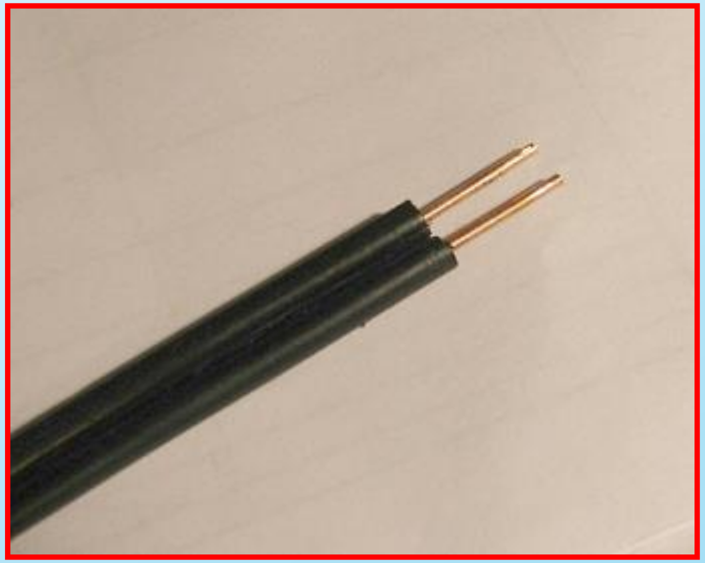
Dimensiune cip 4 950 × 4 720 µm

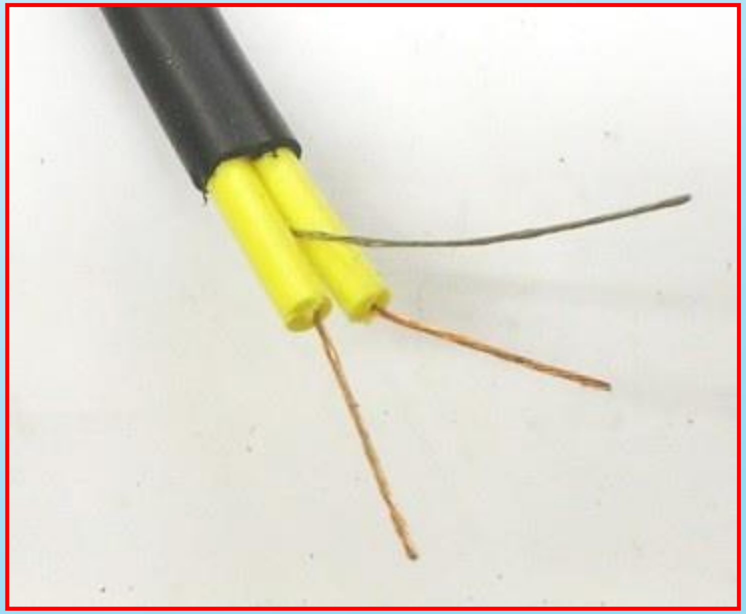


STRIPLINE



LINIE PARALELA (TWIN LEAD)





CABLURI TORSADATE

AVANTAJE

Distorsiuni mici

Inter-influente mici

Radiatie redusa

DEZAVANTAJE

Consum de energie

APLICATII

Cabluri de retea

Cabluri usb

Conexiuni cablate lungi (circuite imprimate)

Caracteristicile liniei ideale

Fara pierderi (de energie);

Lungime infinita;

Transmisie nedistorsionata a semnalelor;

Semnale transmise cu intarziere. Timpul de intarziere este proportional cu distanta parcursa.

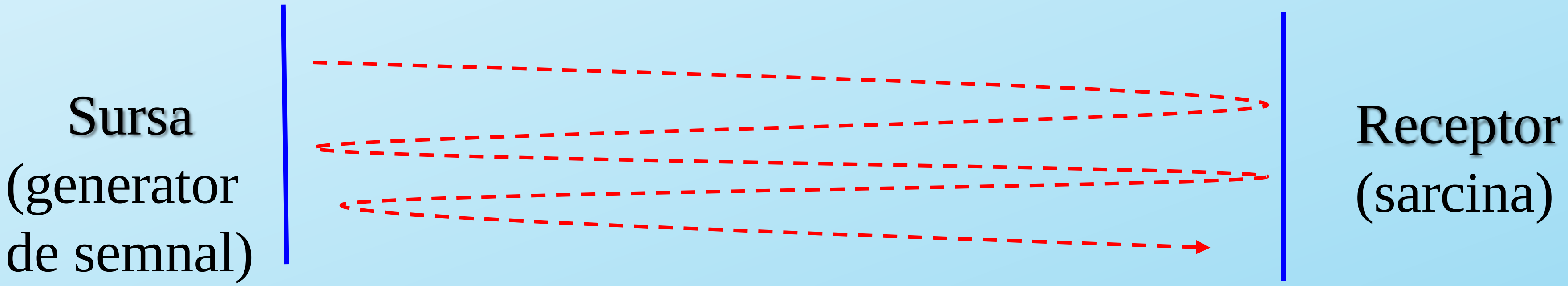
$$\tau_l = \sqrt{L_l \cdot C_l}$$

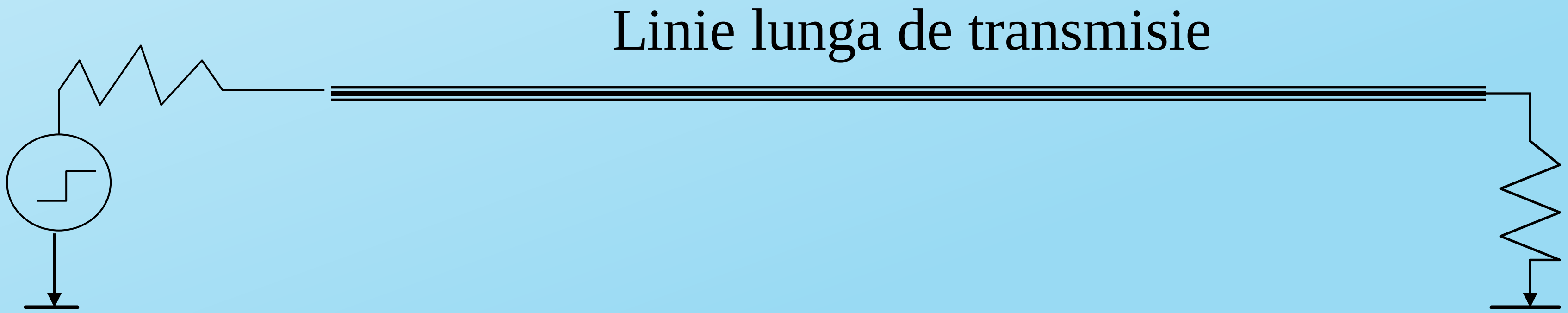
τ_l este timpul de intarziere (s/m) L_l inductanta pe unitatea de lungime (H/m), iar C_l capacitatea pe unitatea de lungime (F/m)

Problema liniei de transmisie (țiuitul)

SEMNALUL NU SE TRANSMITE INSTANTANEU. SE TRANSMITE SUB FORMA DE UNDE.

APARE FENOMENUL DE ***REFLEXIE MULTIPLA***.

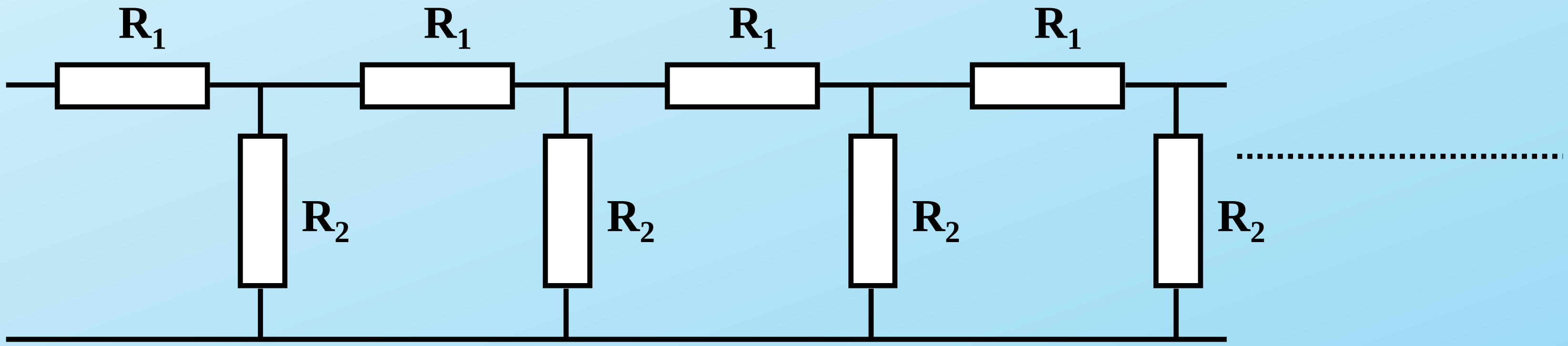




Linia cu pierderi

LINIA OHMICA

Doua fire metalice echidistante, separate de un izolator, la frecventa f.joasa.

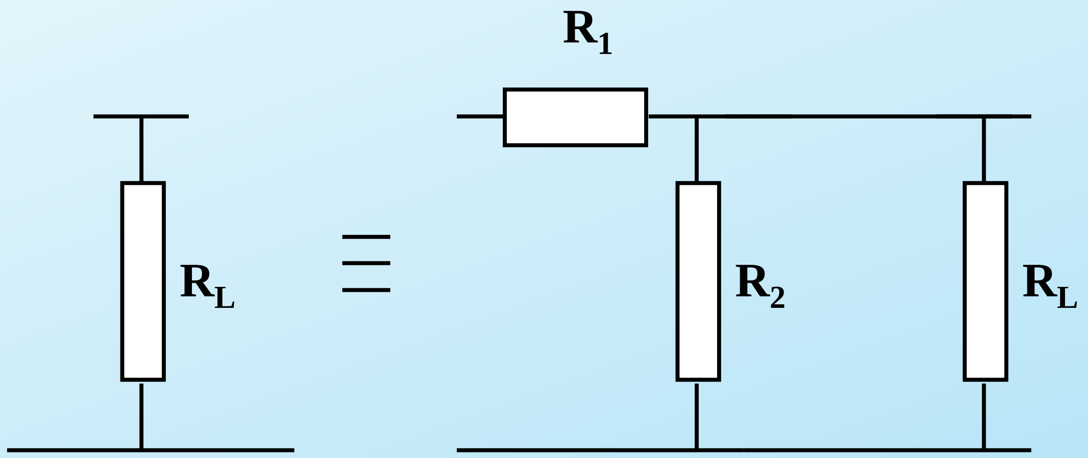


Semnificatii

R_1 rezistenta firelor pe unitatea de lungime

R_2 rezistenta de izolatie pe unitatea de lungime

LINIA ESTE ECHIVALENTA CU O REZISTENTA R_L



Daca adaugam un grup suplimentare R_1, R_2, rezistenta liniei nu se schimba, deoarece linia este infinita (R_L)

$$R_1 + \frac{R_2 \cdot R_L}{R_2 + R_L} = R_L$$

$$R_L = \frac{R_1}{2}\left[1 + \sqrt{1 + 4\frac{R_2}{R_1}}\right]$$

In cazul unei linii reale R →Z (complex), iar formula se pastreaza.

In cazul liniei ideale (fara pierderi)

R_1 → ωL (bobina ideala), iar R_2 → 1/ωC (condensator ideal)

$$Z_L = \frac{Z_1}{2}\left[1+\sqrt{1+4\frac{Z_2}{Z_1}}\right]$$

$$Z_L = \frac{\omega L_1}{2}\left[1+\sqrt{1+4\frac{1}{\omega C_2 \omega L_1}}\right] \quad \frac{1}{C_2 L_1} = \omega_r^2$$

$$\omega << \omega_r \quad Z_L \cong \frac{\omega L_1}{2}\left[\sqrt{4\frac{1}{\omega C_2 \omega L_1}}\right] = \sqrt{\frac{L_1}{C_2}}$$

ω_r este frecventa de rezonanta a liniei

Impedanta liniei de transmisie nu depinde de frecventa la frecvente mult mai mici decat frecventa de rezonanta.

Cazul general: linie reala, cu pierderi: bobina reala (inductanta in serie cu rezistenta) si condensator real (capacitate in paralel cu o rezistenta)

$$R_1 \to R_1 + j\omega L_1 \quad 1/R_2 \to 1/R_2 + j\omega C_2 = G_2 + j\omega C_2$$

$$Z_L = \sqrt{(R_1 + j\omega L_1)/(G_2 + j\omega C_2)}$$

$$v(z,t) = V(x)e^{j\omega t} \quad V(x) = V_0 e^{-\gamma z} + V_1 e^{+\gamma z}$$

$$\gamma = \sqrt{(R_1 + j\omega L_1)\cdot(G_2 + j\omega C_2)}$$

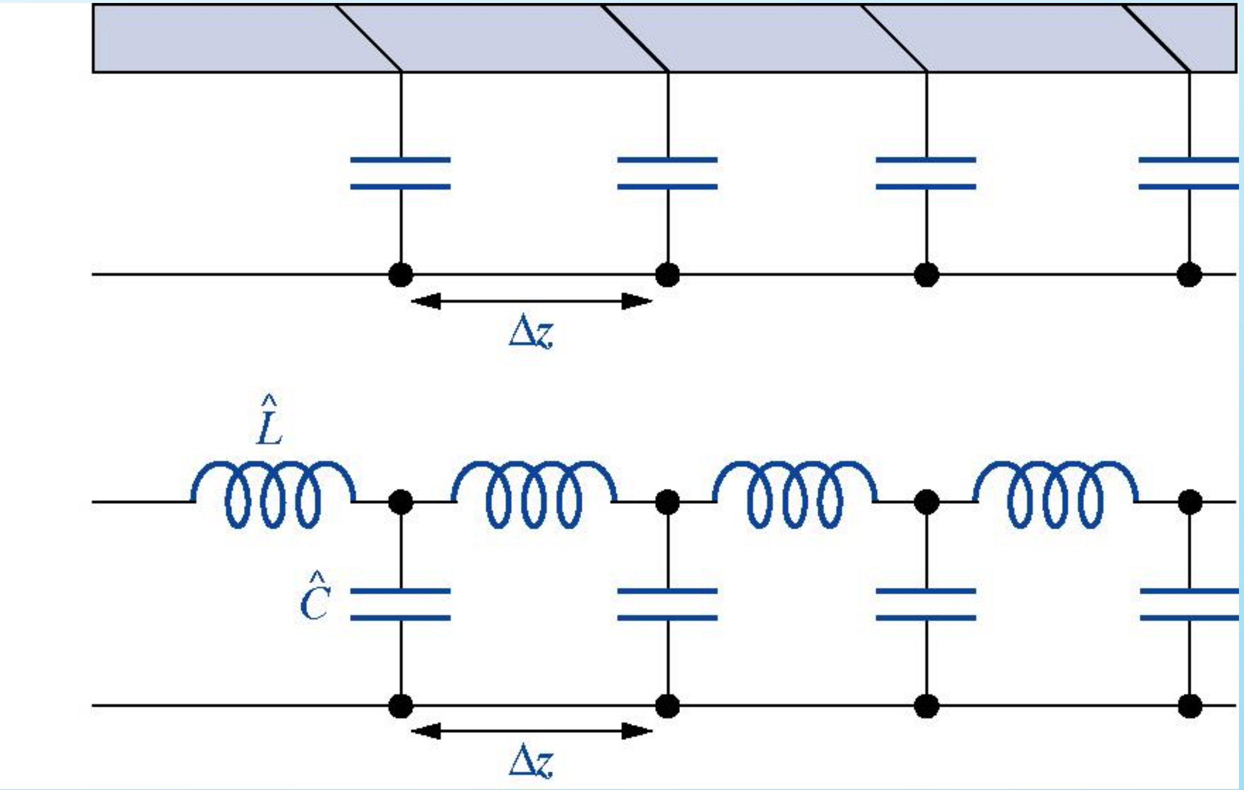
In cazul liniei ideale $\boldsymbol{Z_L}$ este de natura rezistiva.
(partea imaginara este nula)

Conditia de reflexie 0 la capetele liniei:

$Z_{sursa}=Z_{linie}=Z_{sarcina}$ (toate 3 rezistive)

In caz contrar apare o unda inversa

care preia o parte din energia transmisa prin linie.



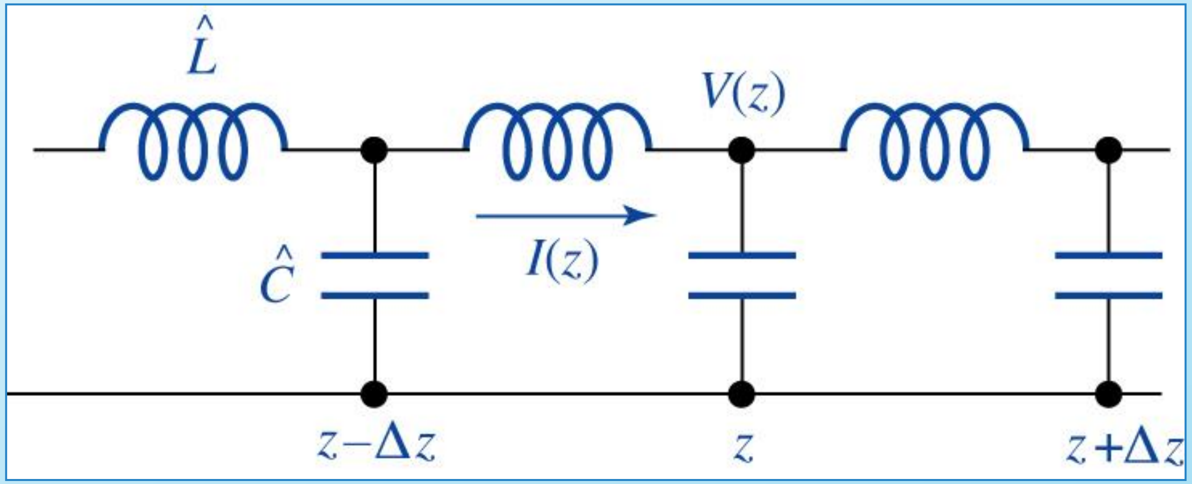
$$L = \hat{L} \cdot \Delta z$$

$$C = \hat{C} \cdot \Delta z$$

Line	Inductance	Capacitance
Coaxial cable	$L = \frac{\mu}{2\pi} \ln\left(\frac{b}{a}\right)\Delta z$	$C = \frac{2\pi\varepsilon}{\ln(b/a)}\Delta z$
Microstrip line	$L = \frac{\mu d}{w}\Delta z$	$C = \frac{\varepsilon w}{d}\Delta z$
Twin lead	$L = \frac{\mu}{\pi} \cosh^{-1}\left(\frac{D}{2a}\right)\Delta z$	$C = \frac{\pi\varepsilon}{\cosh^{-1}(D/2a)}\Delta z$

μ permeabilitatea magnetica
ε permitivitatea electrica
A, b, d, D caracteristici de dimensiune (in sectiune)
Δz lungime linie

Ecuatiile telegrafistului (ec. Heaviside)



Cazul liniei fara pierderi

$$\frac{\partial I(z,t)}{\partial z} = -\hat{C}\frac{\partial V(z,t)}{\partial t}$$

$$\frac{\partial V(z,t)}{\partial z} = -\hat{L}\frac{\partial I(z,t)}{\partial t}$$

Ecuatiile anterioare se pot rescrie astfel:

$$\frac{\partial^2 I(z,t)}{\partial z^2} - \hat{L}\hat{C}\frac{\partial^2 I(z,t)}{\partial t^2} = 0$$

Ecuatia undei de curent

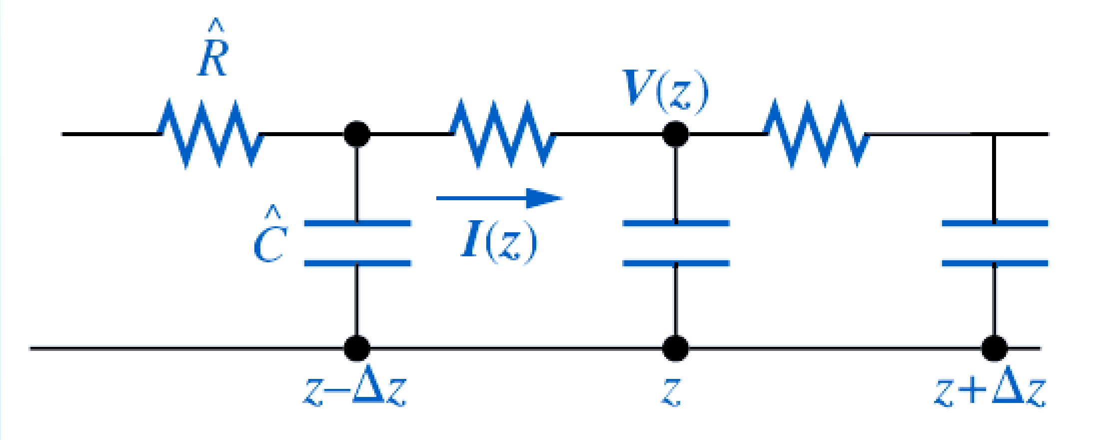
$$\frac{\partial^2 V(z,t)}{\partial z^2} - \hat{L}\hat{C}\frac{\partial^2 V(z,t)}{\partial t^2} = 0$$

Ecuatia undei de potential

$$v = \frac{1}{\sqrt{\hat{L}\hat{C}}}$$

Viteza de propagare undelor

Linie cu pierderi



$$\Rightarrow \quad \frac{\partial V(z,t)}{\partial z} = I(z,t)\hat{R}$$

$$\frac{\partial I(z,t)}{\partial z} = \hat{C}\frac{\partial V(z,t)}{\partial t}$$

Aceste ecuatii se pot recombina astfel:

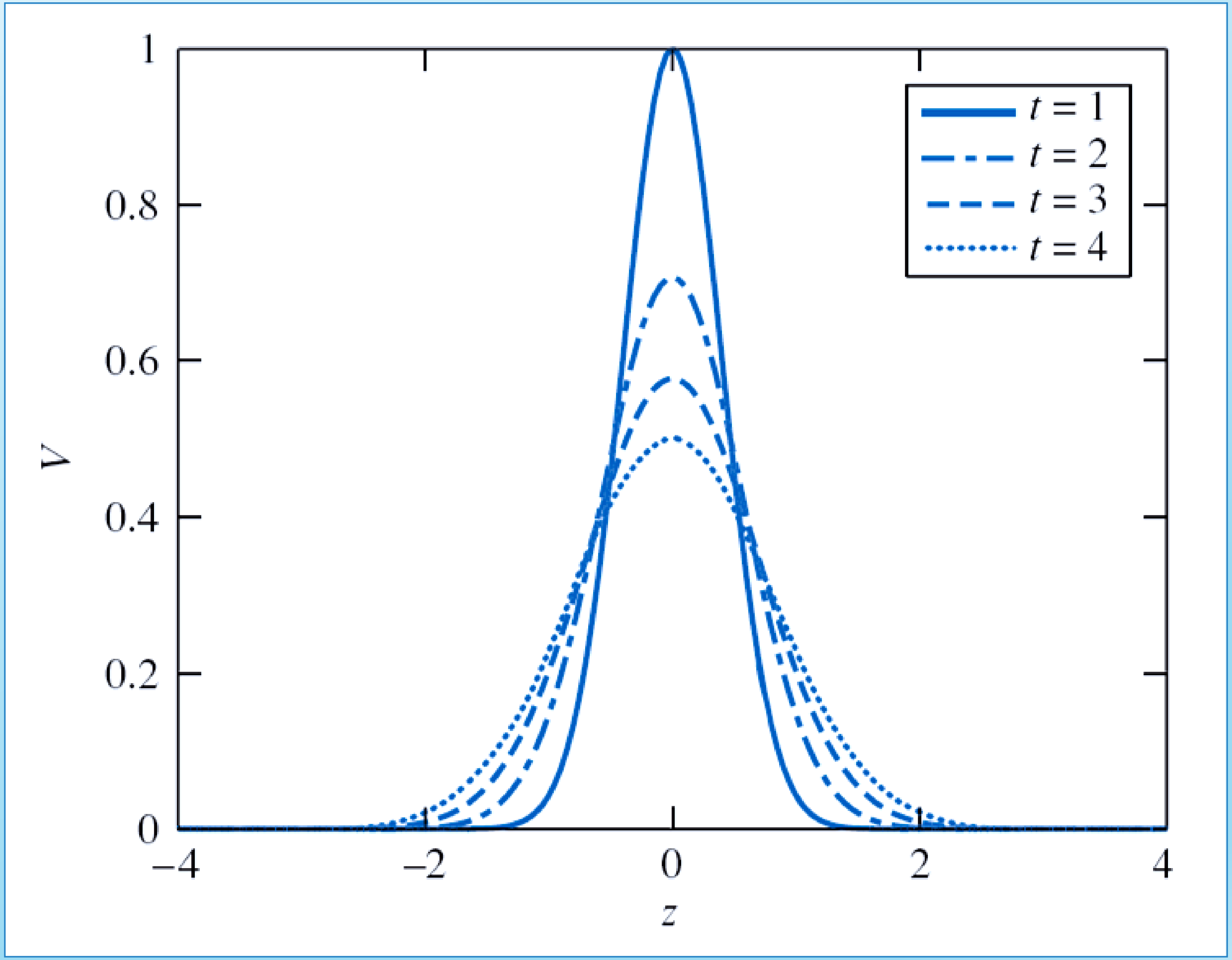
$$\frac{\partial^2 V(z,t)}{\partial z^2} = \hat{R}\frac{\partial I(z,t)}{\partial z} = \hat{R}\left(\hat{C}\frac{\partial V(z,t)}{\partial t}\right) = \hat{R}\hat{C}\frac{\partial V(z,t)}{\partial t}$$

$$D = \frac{1}{\hat{R}\hat{C}}$$

PROPAGAREA UNUI PULS DE TENSIUNE (GAUSS)

$$\boxed{V(z,t) = \frac{1}{2\sqrt{D\pi t}} e^{-\frac{z^2}{4Dt}}}$$

De-a lungul unei linii disipative, un puls de tensiune se lateste.



Unde sinusoidale intr-o linie ideala

Apar daca la capatul liniei cuplam o sursa sinusoidala de tensiune

$$k = \frac{\omega}{v} = \frac{2\pi}{\lambda}$$

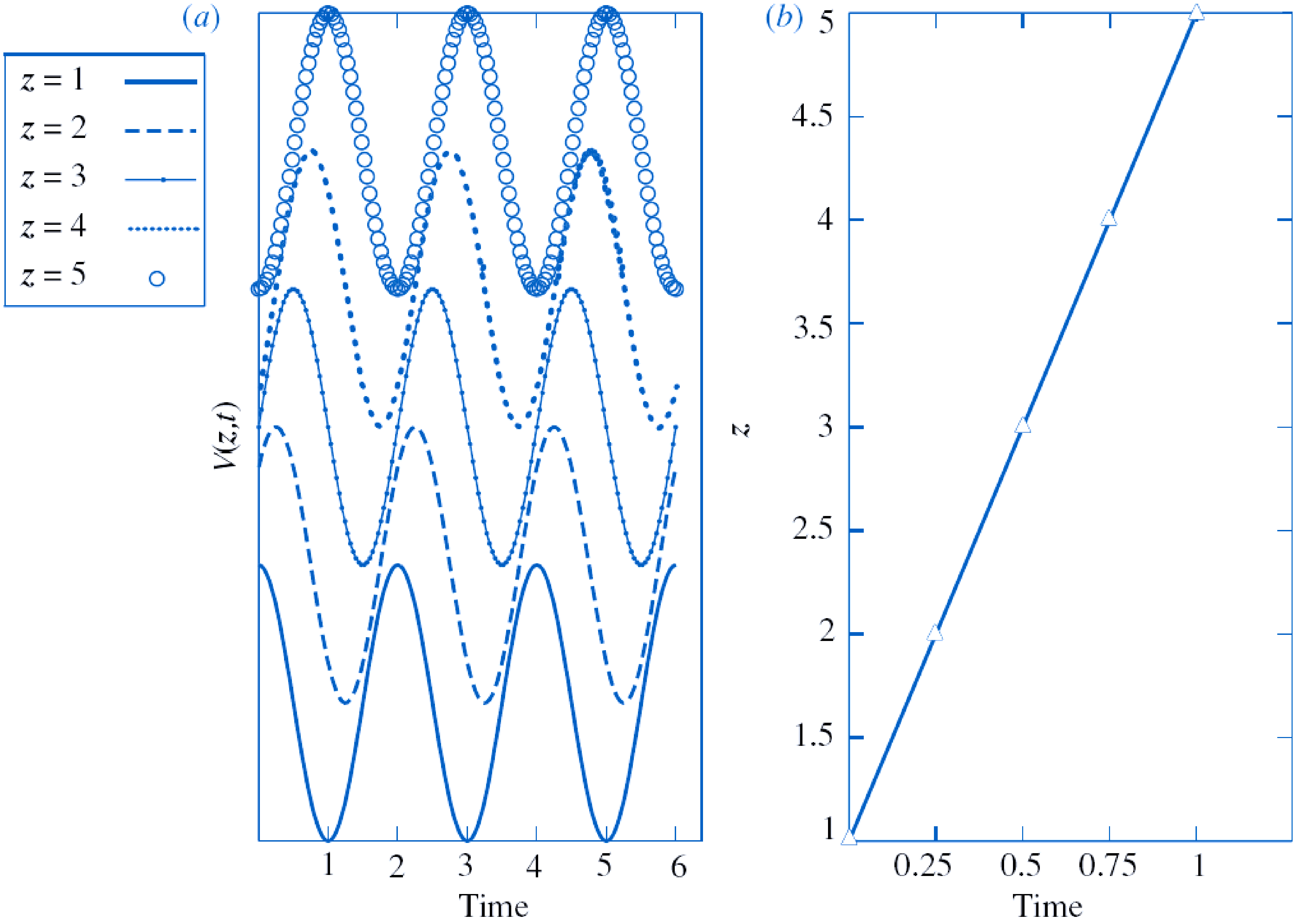
$$V(z,t) = \mathrm{Re}\left\{V(z)e^{j\omega t}\right\}; \quad I(z,t) = \mathrm{Re}\left\{I(z)e^{j\omega t}\right\}$$

$$\frac{d^2V(z)}{dz^2} + k^2V(z) = 0$$

$$\frac{d^2I(z)}{dz^2} + k^2I(z) = 0$$

$$V(z) = A_1 \cos kz + B_1 \sin kz$$

$$V(z) = A_2 e^{-jkz} + B_2 e^{+jkz}$$



(a)
z = 1
z = 2
z = 3
z = 4
z = 5
V(z,t)
1
2
3
4
5
6
Time
(b)
z
5
4.5
4
3.5
3
2.5
2
1.5
1
0.25
0.5
0.75
1
Time

Stabilirea impedantei liniei

$$V(z)=V_0e^{-jkz}$$

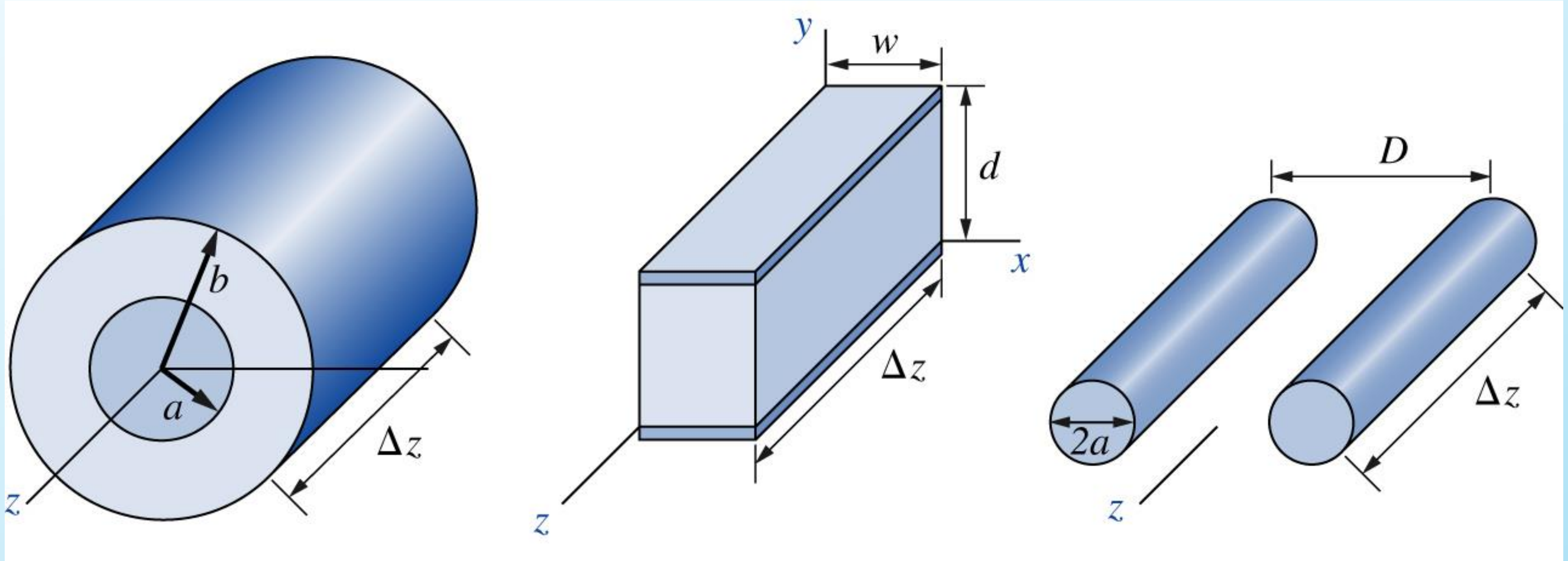
$$\frac{dV(z)}{dz}=-jkV(z)=-j\omega\hat{L}I(z)$$

$$I(z)=\frac{k}{\omega\hat{L}}V(z)=\frac{k}{\omega\hat{L}}V_0e^{-jkz}$$

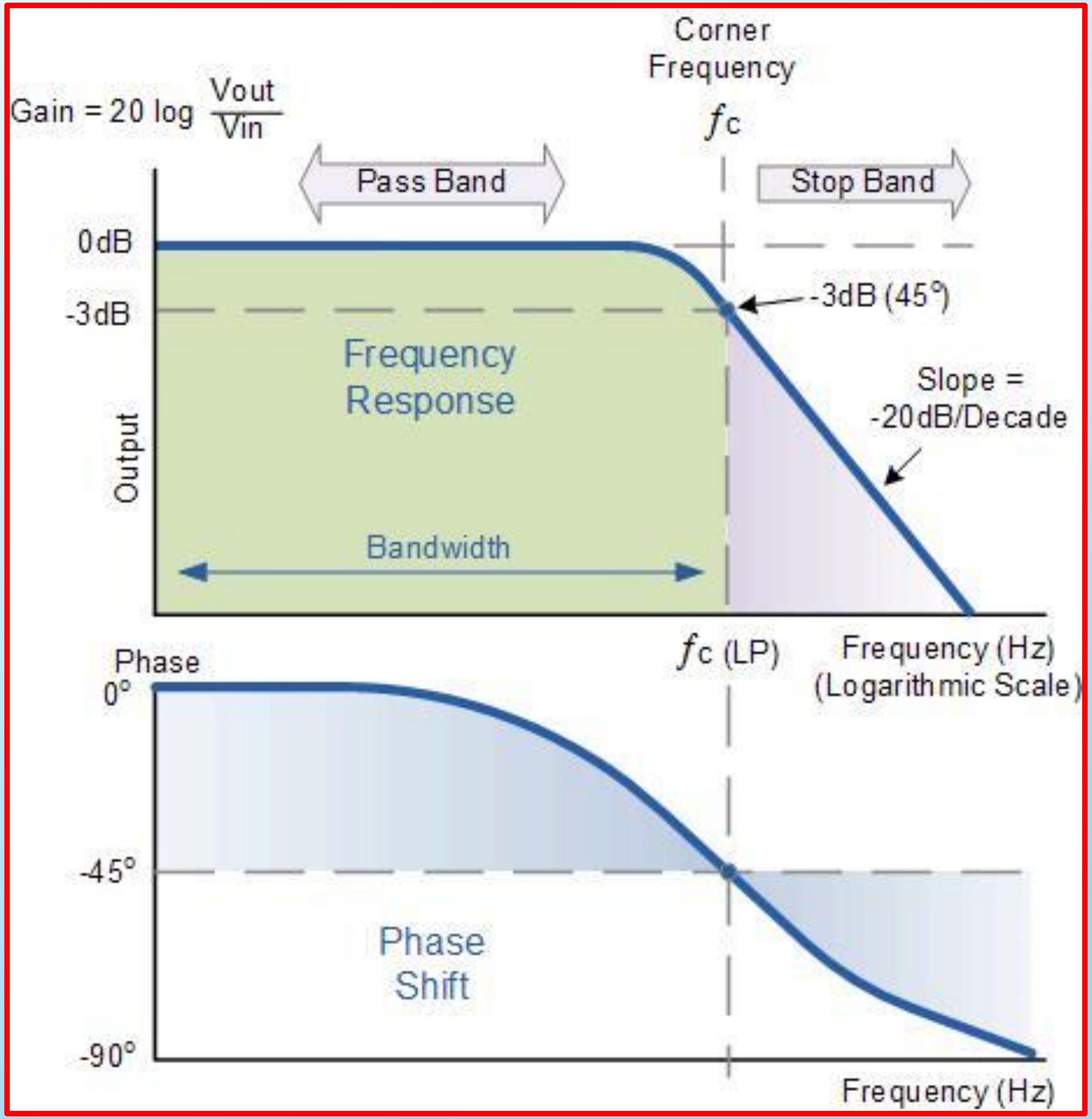
$$Z_c=\frac{V(z)}{I(z)}=\frac{\omega\hat{L}}{k}$$

$$k=\frac{\omega}{v} \qquad v=\frac{1}{\sqrt{\hat{L}\hat{C}}}$$

$$Z_c=\sqrt{\frac{\hat{L}}{\hat{C}}}\ [\Omega]$$

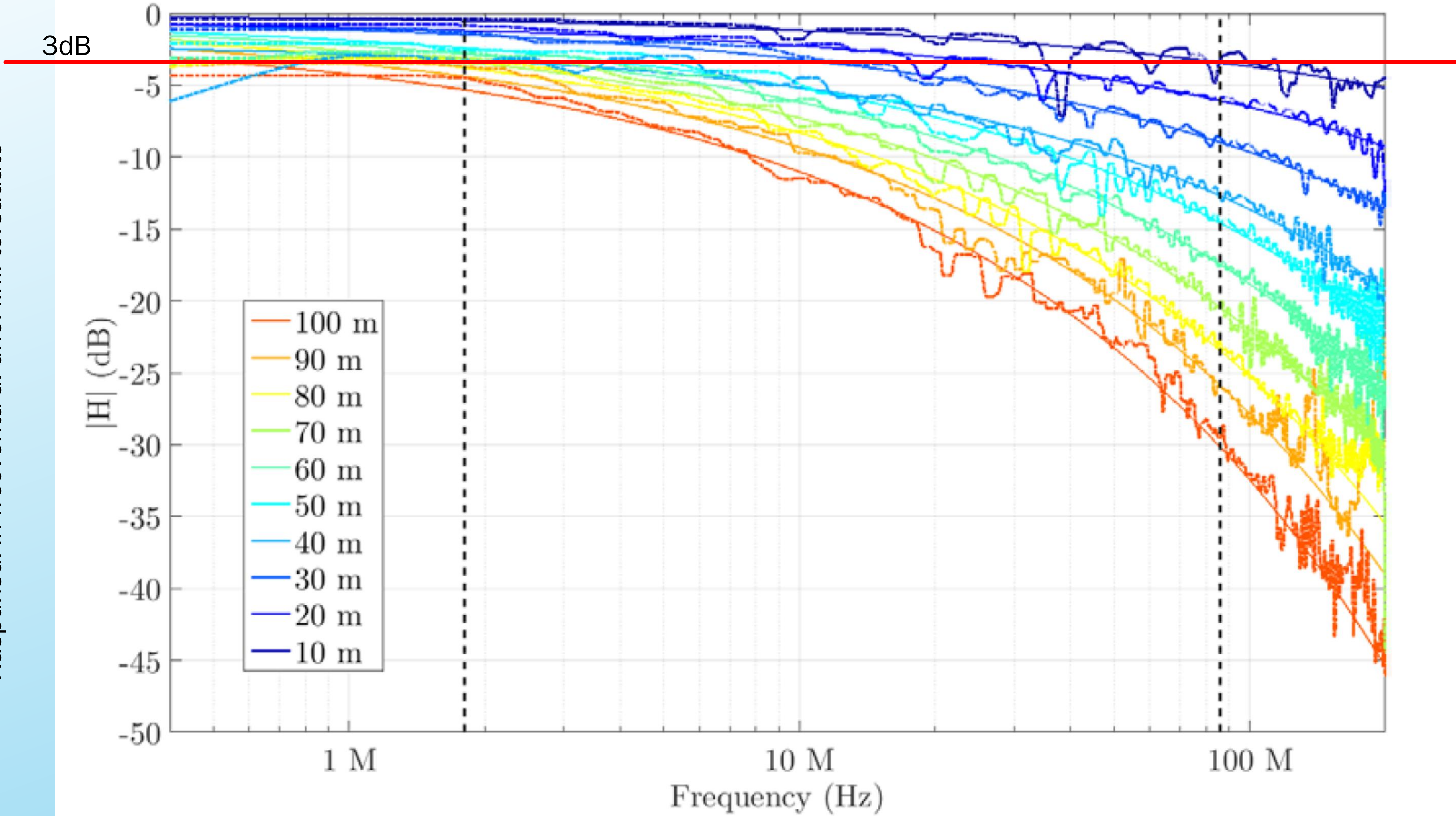


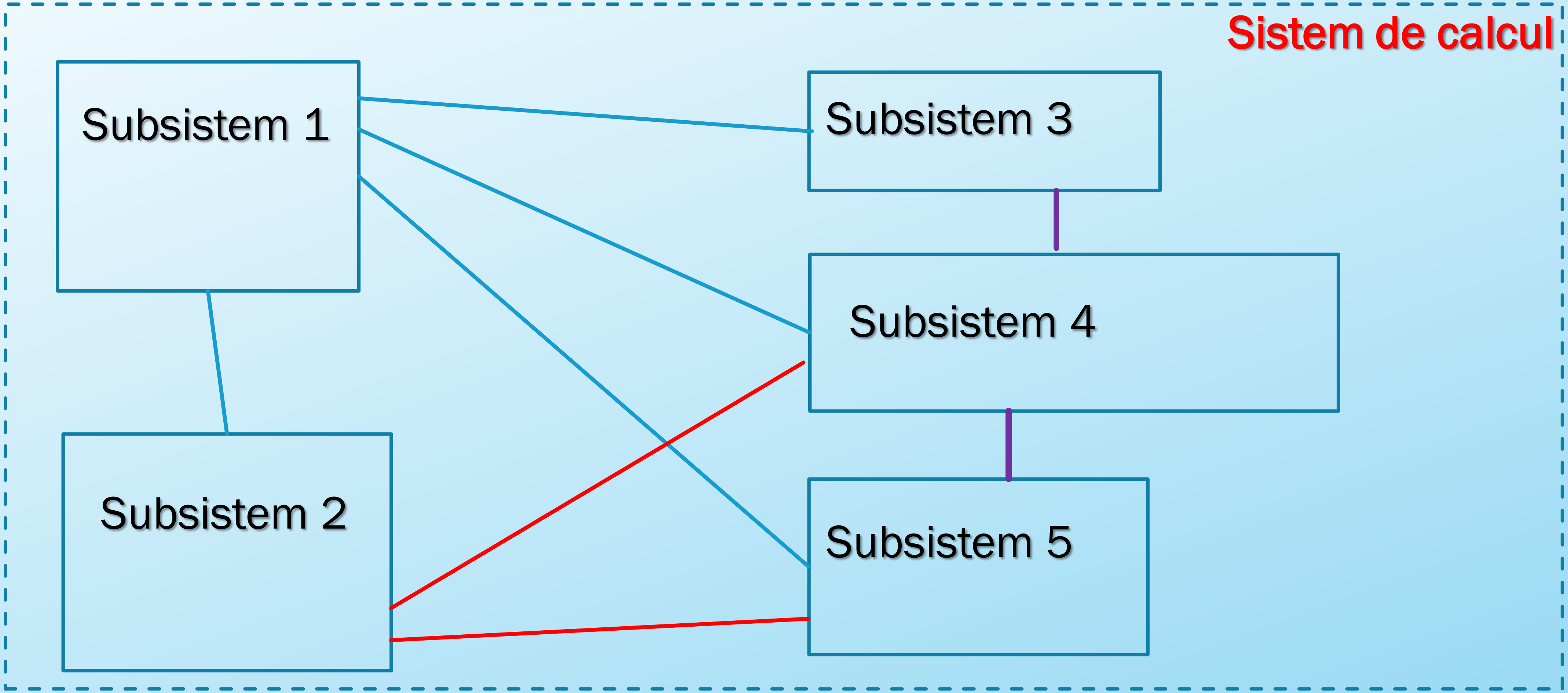
Line	Velocity of propagation	Characteristic impedance
Coaxial cable	$v = \dfrac{1}{\sqrt{\hat{L}\hat{C}}} = \dfrac{1}{\sqrt{\mu\varepsilon}}$	$Z_c = \sqrt{\dfrac{\hat{L}}{\hat{C}}} = \sqrt{\dfrac{\mu}{\varepsilon}}\left(\dfrac{\ln(b/a)}{2\pi}\right)$
Microstrip line	$v = \dfrac{1}{\sqrt{\hat{L}\hat{C}}} = \dfrac{1}{\sqrt{\mu\varepsilon}}$	$Z_c = \sqrt{\dfrac{\hat{L}}{\hat{C}}} = \sqrt{\dfrac{\mu}{\varepsilon}}\left(\dfrac{d}{w}\right)$
Twin lead	$v = \dfrac{1}{\sqrt{\hat{L}\hat{C}}} = \dfrac{1}{\sqrt{\mu\varepsilon}}$	$Z_c = \sqrt{\dfrac{\hat{L}}{\hat{C}}} = \sqrt{\dfrac{\mu}{\varepsilon}}\left(\dfrac{\cosh^{-1}(D/2a)}{\pi}\right)$



Corner Frequency
f_c
Gain = 20 log $\frac{Vout}{Vin}$
Pass Band
Stop Band
0dB
-3dB
-3dB (45°)
Frequency Response
Slope = -20dB/Decade
Output
Bandwidth
f_c (LP)
Frequency (Hz) (Logarithmic Scale)
Phase
0°
-45°
Phase Shift
-90°
Frequency (Hz)

Raspunsul in frecventa al unei linii torsadate





Subsistemele ce compun un sistem de calcul comunica prin intermediul liniilor de transmisie

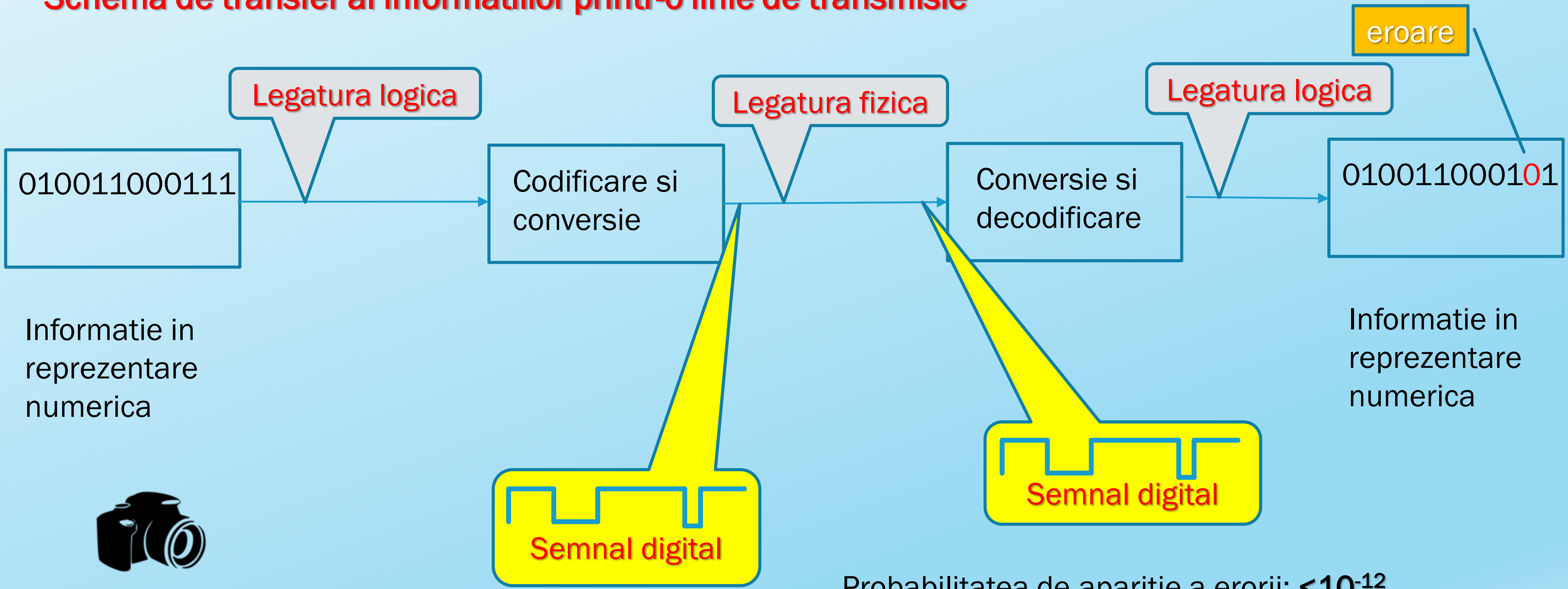
Subsistem: dispozitiv, unitate, bloc, modul, etc

In aceasta reprezentare liniile de transmisie au o largime de banda sufficient de mare incat sa nu franeze transmisia de date intre subsisteme

Caracteristici importante ale liniilor de transmisie

- Viteza finita de transmitere a semnalelor
- Transmitere distorsionata a semnalelor analogice
- Banda de frecvente finita pentru semnale analogice (existenta unei frecvente maxime)
- Capacitate limitata de transmitere a informatiei prin semnale digitale

Schema de transfer al informatiilor printr-o linie de transmisie



Probabilitatea de aparitie a erorii: **<10^{-12}**

Caracteristici digitale ale liniilor de transmisie

Rata de transfer: numarul de biti transferati in unitatea de timp; unitatea de masura: bps

Largimea de banda: rata maxima de transfer; unitatea de masura: bps (cate o data se utilizeaza Hz)

Uzual se utilizeaza multiplii unitatilor de masura:
Kbps; kHz
Mbps; MHz
Gbps; GHz

Observatii:
Unitatea de masura Hz se foloseste numai pentru largimea de banda!
In unele situatii se foloseste si definitia:
Rata de transfer: numarul de bytes transferati in unitatea de timp; unitatea de masura: Bps

Exemple de transformare de unitati:

1 Bps = 8 bps

1 MBps = 8 MHz

O linie de transmisie poate fi formata din unul sau mai multe canale.
Pot fi canale fizice si/sau logice.
In cel de al doilea caz se utilizeaza frecvent denumirea de culoar (lane).

Linia de transmisie cu mai multe canale fizice consta din mai multe fire (electrice) de-a lungul carora se transmite in paralel informatia (se transmit simultan biti diferiti pe fire diferite)

In cazul mai multor canale logice se partajeaza acelasi canal fizic intre mai multe canale logice (multiplexare)

Cabluri telefonice

Cablu PATA

Daca o linie de comunicatie este formata din **N** canale fizice atunci

(*Largimea de banda totala*) < **N** x (*largimea de banda a unui canal izolat*).

Aceasta limitare apare datorita interferentelor intre canale.

Este una din explicatiile tranzitiei de la PATA la SATA.