TIME DOMAIN REFLECTOMETRY

PROBLEMA MISURA IMPEDENZA DI UNA LINEA.

Metodo tradizionale → $\Gamma(\omega) \Rightarrow Z$

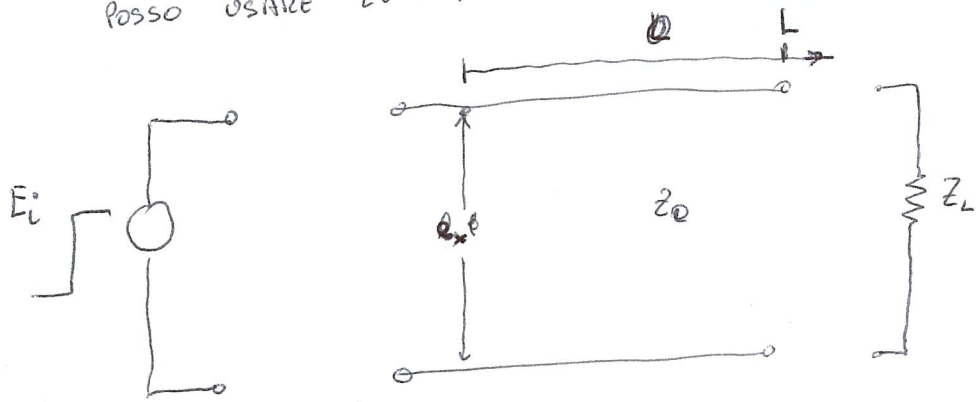
CHE SUCCEDE SE HO DISCONTINUITA' O TRATTI DI IMPEDENZA DIVERSA ?

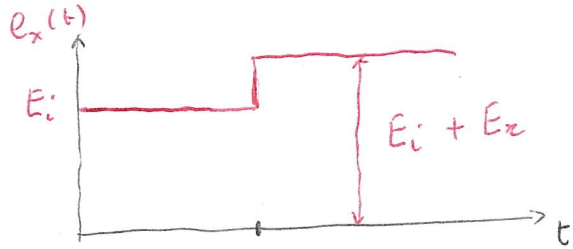
LE MISURE IN FREQUENZA NON POSSONO RISOLVERE LE POSIZIONI

L'INFORMAZIONE È COMUNQUE contenuta nella risposta in frequenza.

SOLUZIONE: MISURE DI ECO (COME RADAR)

POSSO USARE LE MISURE IN TEMPO ($\neq$ ISTANTI $\Rightarrow \neq$ POSIZIONI)





$$T = \frac{2L}{v}$$

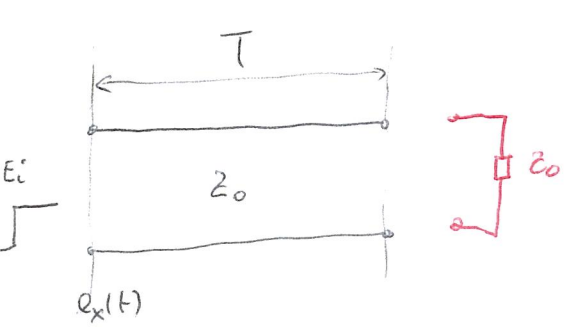
$$\frac{E_R}{E_i} = \Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

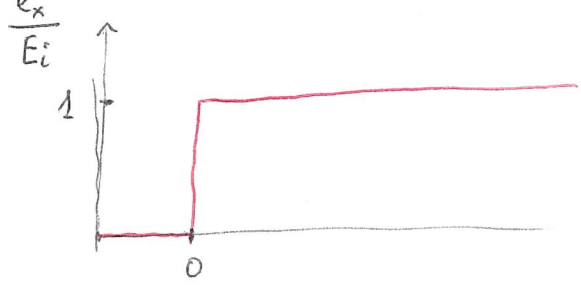
I APPLICAZIONE ⇝ POSSO LOCALIZZARE DISACCOPPIAMENTI $\boxed{L = \frac{vT}{2}}$

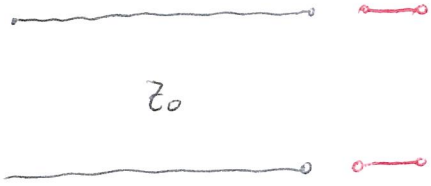
II APPLICAZIONE ⇝ POSSO CAPIRE LA NATURA E LA QUANTITA' DEL DISACCOPPIAMENTO

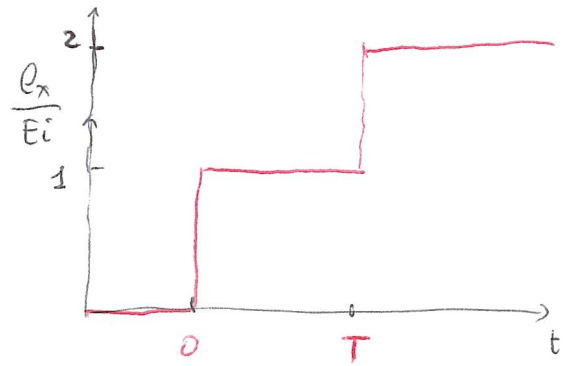
→ A RIGORE USO LA TRASFORMATA DI LAPLACE

MA NOI POSSIAMO FARE INTUITIVAMENTE - (CASI SEMPLICI)

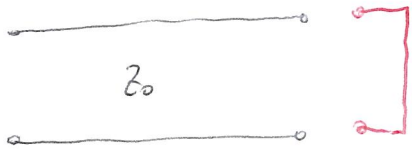


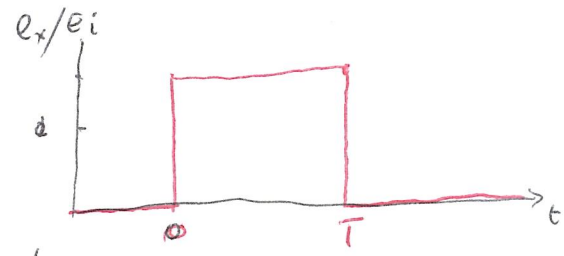




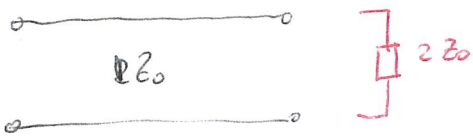


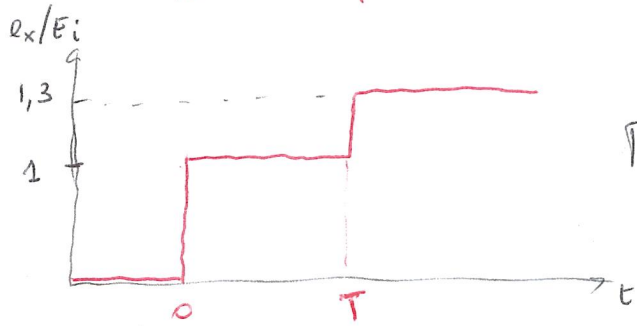
$\Gamma = 1$



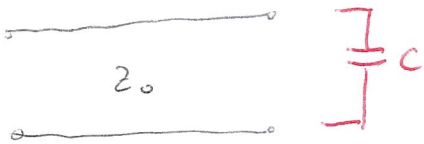


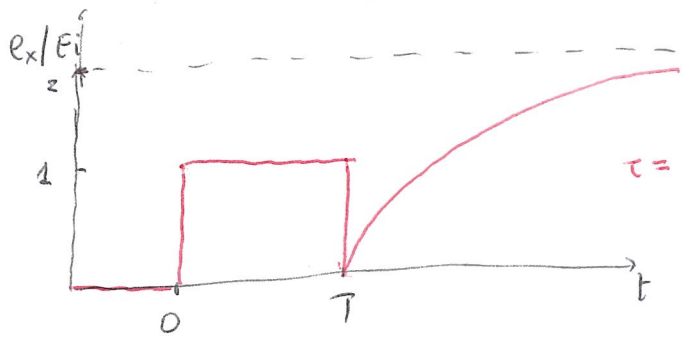
$\Gamma = -1$



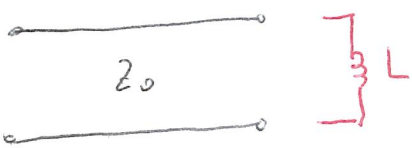


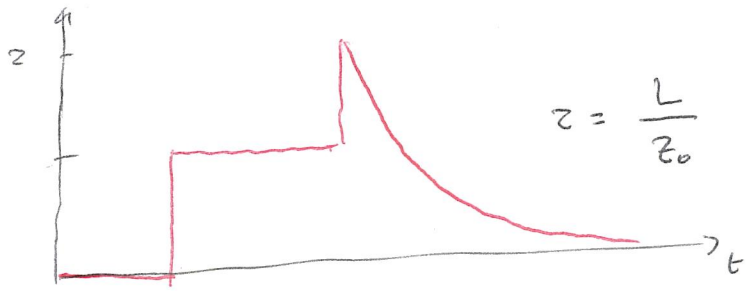
$\Gamma = \frac{1}{3}$





$\tau = Z_0 C$





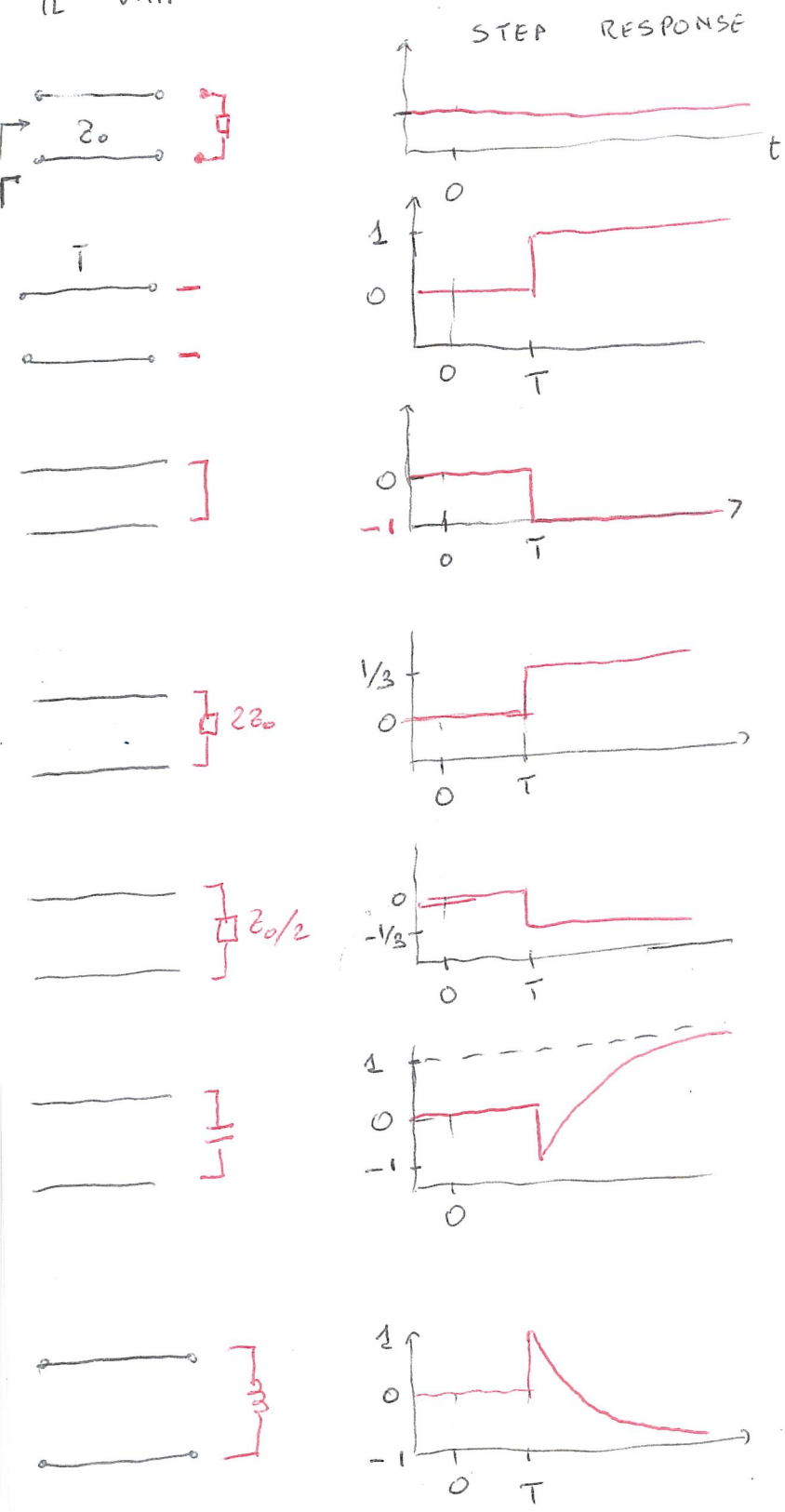
$\tau = \frac{L}{Z_0}$

IMPULSO SINTETICO CON VNA (TIME DOMAIN)

VANTAGGIO RISPETTO ALLA TDR TRADIZIONALE: VNA HA UN ELEVATO RANGE DINAMICO

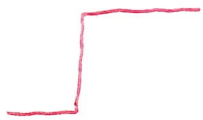
SISTEMI LINEARI: RISPOSTA IN TEMPO $\overset{\text{FOURIER}}{\longleftrightarrow}$ FUNZIONE DI TRASFERIMENTO

IL VNA FA LA FFT DELLA ~~[illegible]~~ RISPOSTA



LA TDR nel VNA è un'operazione matematica

I^A CONSEGUENZA

RISPOSTA A  ⇒ RISPOSTA A $\frac{d}{dt}$ 

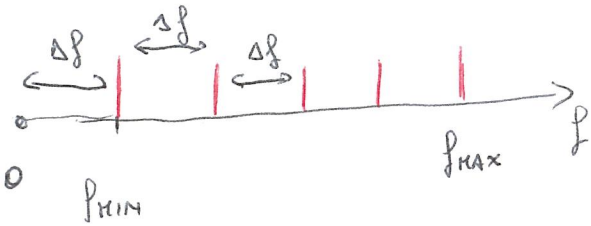
STEP RESPONSE PULSE RESPONSE

II^a CONSEGUENZA

L'ALGORITMO DI FFT RICHIEDE CHE I CAMPIONI DI FREQUENZE SIANO SIMMETRICI RISPETTO ALL'ORIGINE ⇒ $f_{min} = \Delta f$

(NON SI PUÒ AVERE $f_{MIN} = 0$!!)

VA ESTRAPOLATA



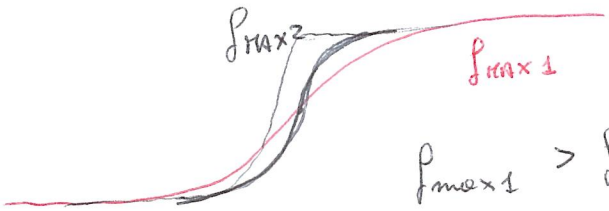
⇒ f_{MIN} dipende da f_{MAX} e del #di campioni (# di PUNTI)

⇒ SET LOW FREQUENCY PASS (prima di calibrare!)

RISPOSTA ~~ERRATA~~ LE FREQUENZE GIUSTE

III^A Conseguenza

LA RAPIDITÀ DEL SEGNALE SIMULATO DIPENDE DA f_{MAX}



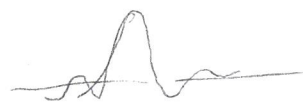
RISE TIME $\propto \frac{1}{f_{max}}$

$f_{max1} > f_{max2}$

LA RISOLUZIONE SPAZIALE È LEGATA A f_{MAX}

f_{MAX} = MAX FREQUENZA DI MISURA (È FINITA!!)

IL PULSE RESPONSE NON È UNA  MA PIUTTOSTO sinc(f)

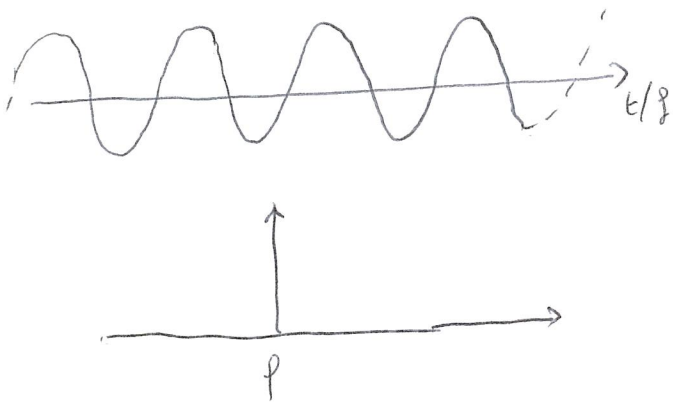


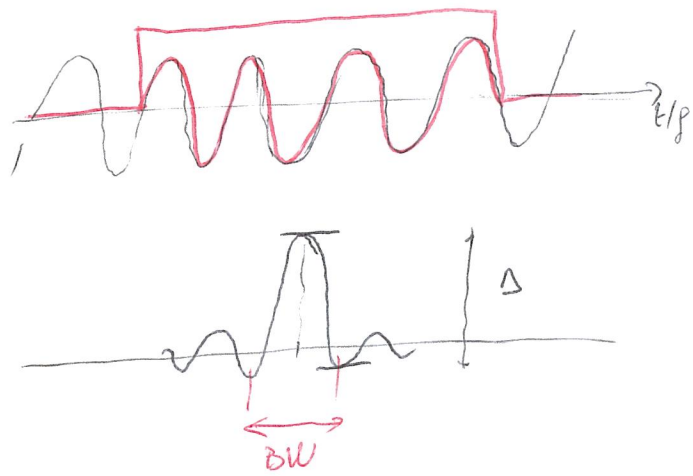
IV CONSEGUENZA

TIME DOMAIN ← FFT — FREQUENCY DOMAIN

(sintetico) (minuscolo)

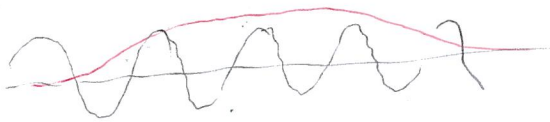
DALLA TEORIA DELLA FFT SI SA CHE IL NUMERO LIMITATO DI CAMPIONI HA DEGLI EFFETTI

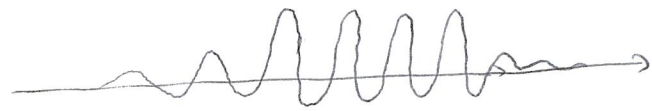




FINESTRA RETTANGOLARE $\Delta = -13dB$, $BW = \dots$

LA FINESTRA RETTANGOLARE NON È L'UNICA POSSIBILE, MA SI PUÒ FARE UN "PROFILO" DIVERSO





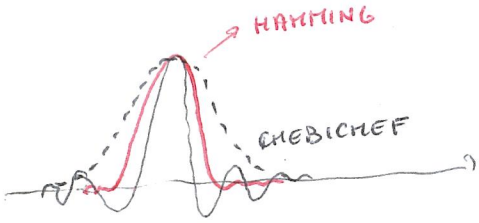
LE VARIE FINESTRE RIDUCONO Δ MA AUMENTANO BW

WINDOW MINIMUM — FINESTRA RETTANGOLARE — $\Delta = -13dB$

NORMAL — FINESTRA HAMMING — $\Delta = -44\ dB$

MAXIMUM — FINESTRA TCHEBICHEF — $\Delta = -75\ dB$

COSENO RIALZATO



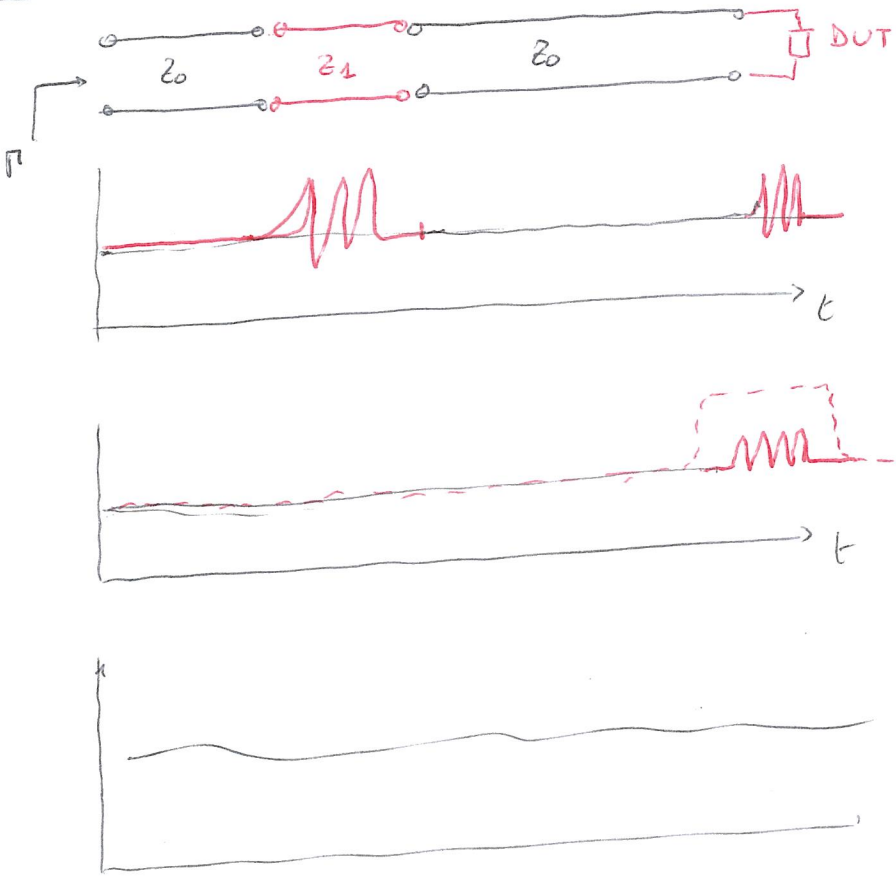
→ ESERCIZIO APERTO — PULSE RESPONSE

SI VEDONO LE FINESTRE

V CONSEGUENZA :

POSSO DISCRIMINARE IN TEMPO
LA PARTE DI RISPOSTA
CHE MI INTERESSA
$\Rightarrow$ GATING

ESEMPIO



TIME DOMAIN
(PULSE RESPONSE

GATING
(ancora problemi di "finestra")

FREQUENCY DOMAIN

PROBLEMA IL GATING TOGLIE POTENZA AL SEGNALE
$\Rightarrow$ SNR + ~~ALTO~~ BASSO
$\Rightarrow$ ATTENUATORE ATTENUA DI PIÙ ---

—o —o —o —o

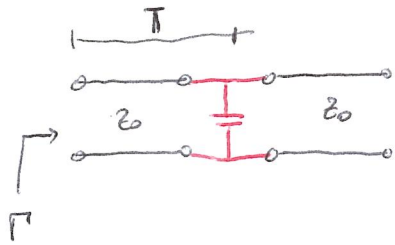
LOW PASS STEP

LOW PASS ~~IMPULSE~~ PULSE

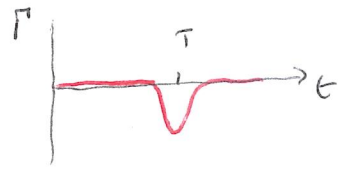
BAND PASS
$\rightarrow$ USATO PER DISPOSITIVI PASSA BANDA
$\rightarrow$ SEGNO E AMPIEZZA DI ρ NON SEMPRE DI FACILE INTERPRETAZIONE
$\rightarrow$ USATO PER IL GATING

FAULT LOCATION

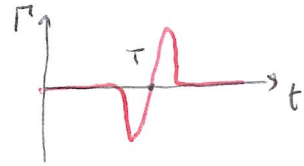
VARIAZIONE C
(CAVO PIEGATO)



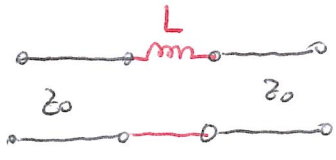
STEP RESPONSE

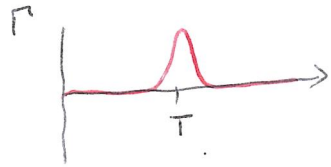


LOW PASS PULSE



VARIAZIONE DI L
(CAVO SFILACCIATO)

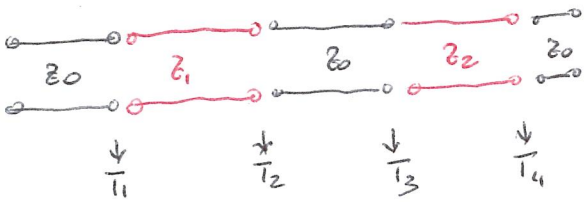


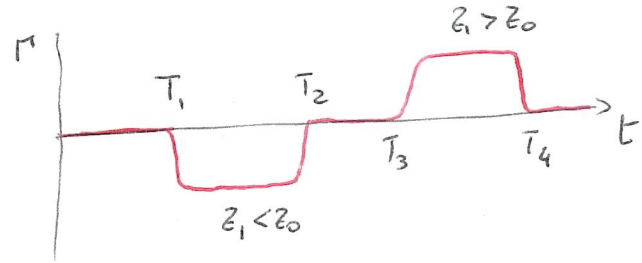


OCCHIO ALL'INIZIO GUIDA

MISURA DI IMPEDENZA IN FUNZIONE DI Z

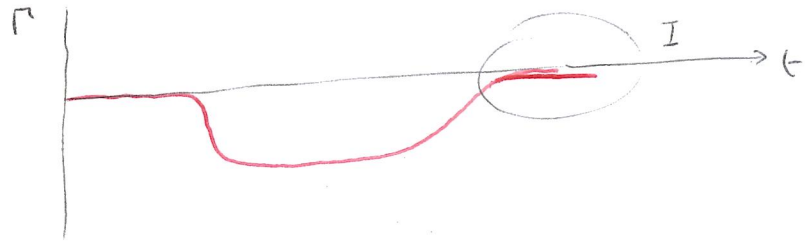
MICROSTRISCE





$$Z(t) = Z(x) = Z_0 \frac{1+\Gamma}{1-\Gamma}$$

ESEMPIO



NON IDEALITÀ

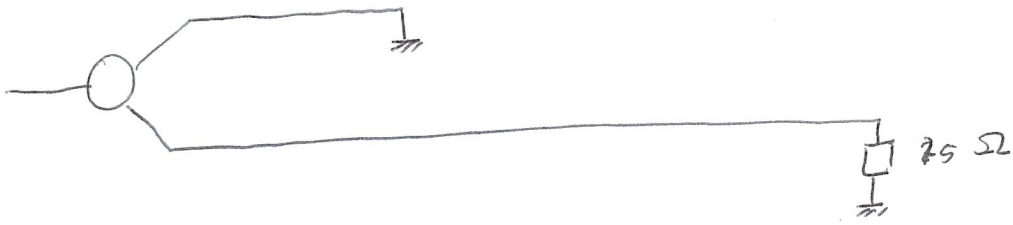
(I) NON TORNA A ZERO ⇝ (ATTENUAZIONE, PERDITA ENERGIA & RIFLESSIONI)

(II) IL SECONDO TEMPO DI SALITA È PIÙ LENTO

⇒ DISPERSIONE

PER FARE $Z(x)$ BISOGNA CALCOLARSI U !!

GATING



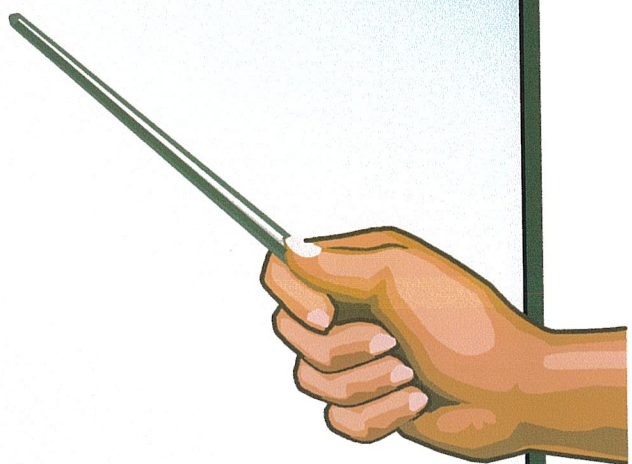
- MISURA DI CAVO già misurato

- EFFETTO DELLE FINESTRE E DI f_{MAX}

Γ di un aperto con + finestre (LOW PASS PULSE)

Ten Steps for Performing TDR (Low Pass Step)

1. Set up desired frequency range (need wide span for good spatial resolution)
2. Under SYSTEM, transform menu, press "set freq low pass“
3. Perform one- or two-port calibration
4. Select S11 measurement *
5. Turn on transform (low pass step) *
6. Set format to real *
7. Adjust transform window to trade off rise time with ringing and overshoot *
8. Adjust start and stop times if desired
9. For gating:
   - set start and stop frequencies for gate
   - turn gating on *
   - adjust gate shape to trade off resolution with ripple *
10. To display gated response in frequency domain
    - turn transform off (leave gating on) *
    - change format to log-magnitude *



* *If using two channels (even if coupled), these parameters must be set independently for second channel*