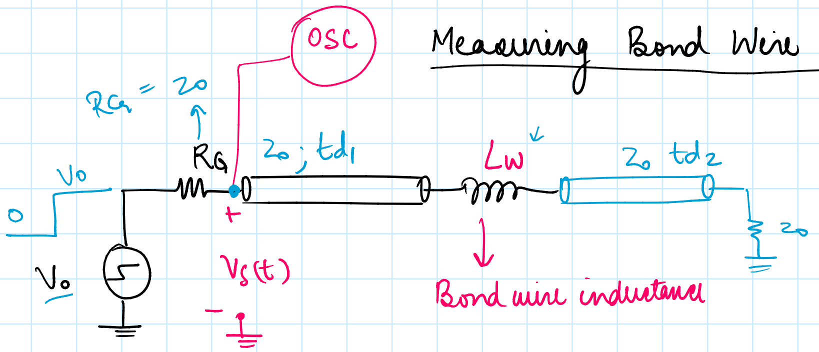
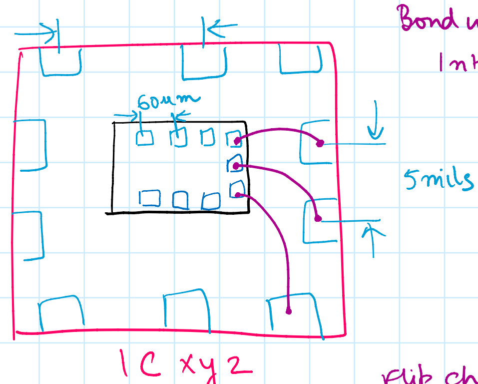
Lec-15

Monday, May 4, 2020 8:42 AM

Measuring Bond Wire Inductance

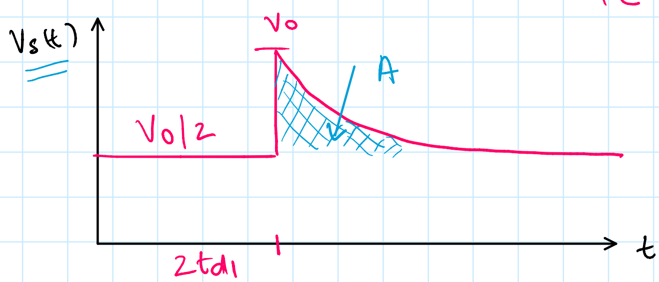




Bond wire inductance 1nH/mm

Flip chip.

BGA →



$$V_s(t) = \frac{V_0}{2} \qquad 0 < t < 2td_1$$

$$= \frac{V_0}{2}\left[1 + e^{-(2Z_0/L_w)(t-2td_1)}\right] \qquad t \geq 2td_1$$

Area → Integrate $\left(V_s(t) - \frac{V_0}{2}\right)$ from $t = 2td_1$ to $t = \infty$

$$A = \int_{2t_1}^{\infty} \frac{V_0}{2} e^{-(2Z_0/L_w)(t-2td_1)} dt$$

$$t - 2td_1 = t'$$

$$A = \int_{0}^{\infty} \frac{V_0}{2} e^{-(2Z_0/L_w)t'} dt'$$

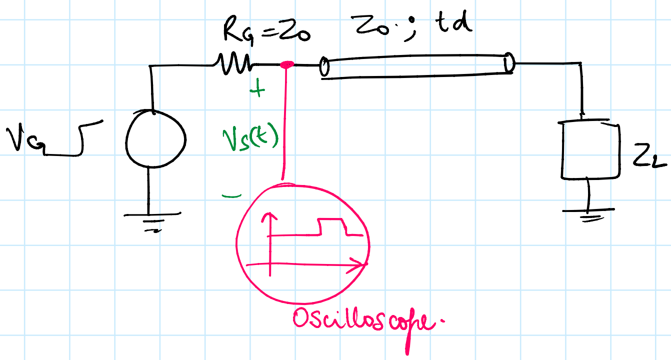
$$A = L_w \cdot \frac{V_0}{4Z_0}$$

$$L_w = \frac{A \cdot 4Z_0}{V_0}$$

Time Domain Reflectometry (TDR)

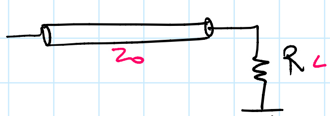
1. Measure unknown characteristic impedance.
2. Understand the nature of termination load.
3. Detect the presence of discontinuity on a transmission line.

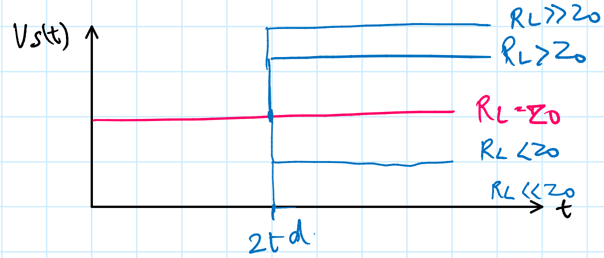
TDR instrument :
- Step pulse source with sharp rise time $t_r < 50ps$
- Oscilloscope.



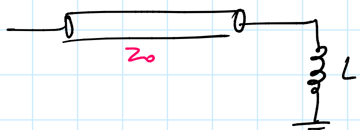
Termination Types :

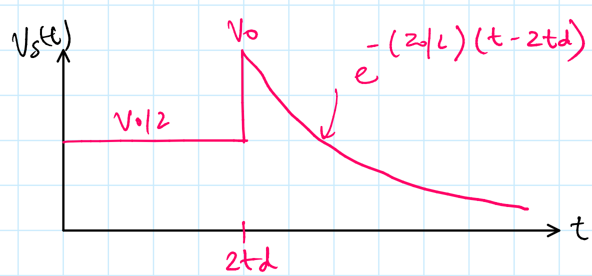
1. Resistive Termination

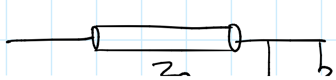


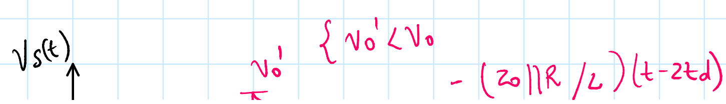


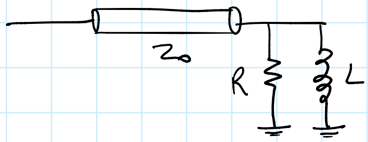
2. Inductive Termination.

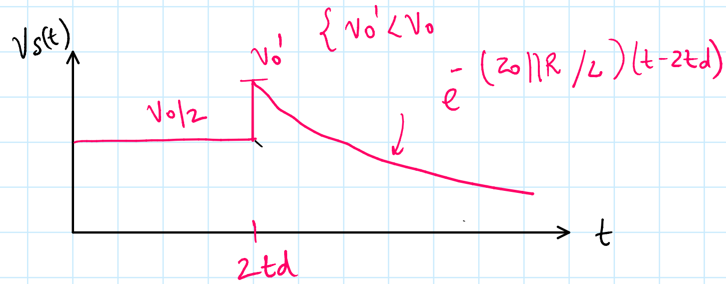










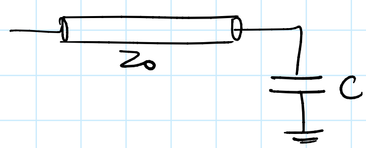


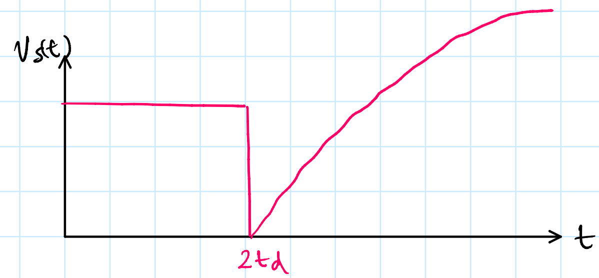
$V_0' > \frac{V_0}{2}$ if $R > Z_0$

$V_0' < \frac{V_0}{2}$ if $R < Z_0$

$V_0' = \frac{V_0}{2}$ if $R = Z_0$

3. Capacitive Termination





Waveforms are TDR signatures

(Fig 2.34 in the text book)

Transmission Lines with Sinusoidal Excitation

Loss-Less Transmission Line → $\alpha = 0$
$\gamma = j\beta$

Voltage : $V(\ell) = V^+ e^{j\beta\ell} + V^- e^{-j\beta\ell}$

$V(\ell) = V^+ e^{j\beta\ell}\left[1 + \frac{V^-}{V^+} e^{-2j\beta\ell}\right]$

$V(\ell) = V^+ e^{j\beta\ell}\left[1 + \Gamma_L e^{-j2\beta\ell}\right]$ → Standing voltage expression

Notice!

Current : $I(\ell) = \frac{V^+}{} e^{j\beta\ell} - \frac{V^-}{} e^{-j\beta\ell}$

Current :

$$I(\ell) = \frac{V^+}{Z_0} e^{j\beta\ell} - \frac{V^-}{Z_0} e^{-j\beta\ell}$$

$$I(\ell) = \frac{V^+ e^{j\beta\ell}}{Z_0} \left\{ 1 - \Gamma e^{-2j\beta\ell} \right\}$$

Notice!

$$\frac{Z_L - Z_0}{Z_L + Z_0}$$

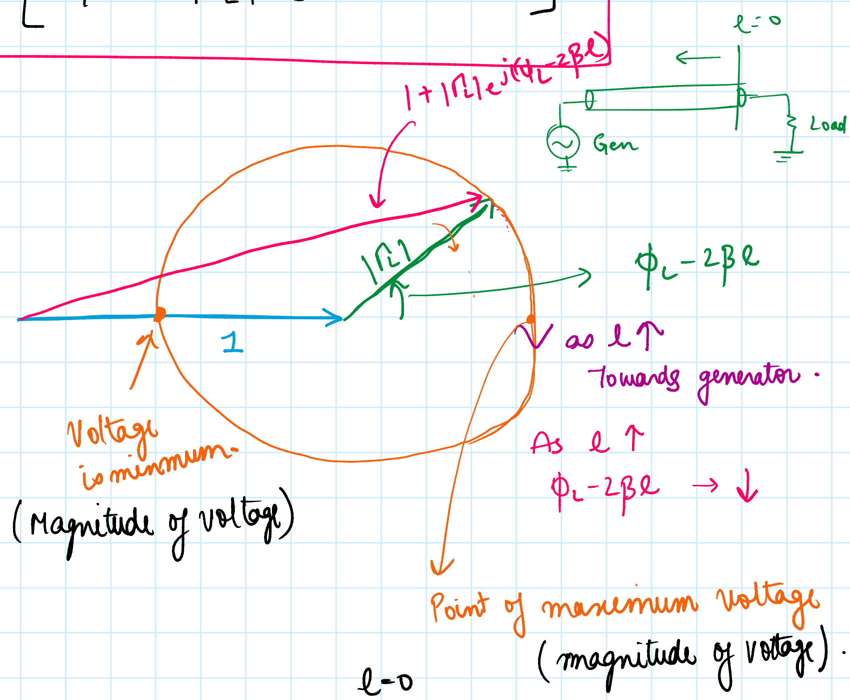
$$\Gamma_L = |\Gamma_L| e^{j\phi_L}$$

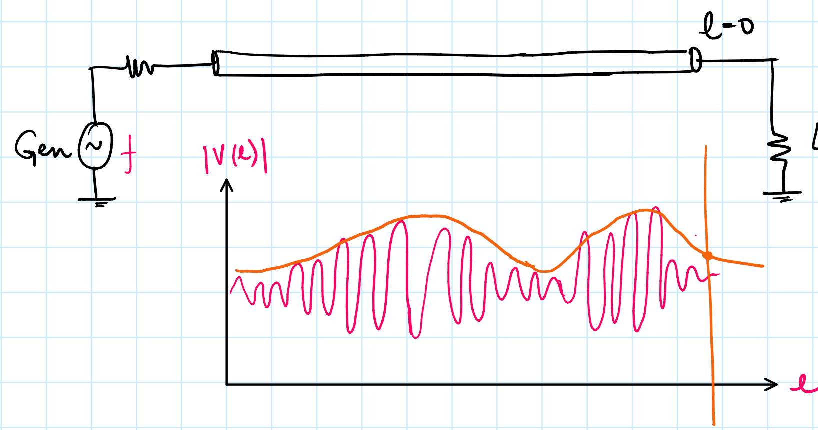
↓ complex quantity

$$V(\ell) = V^+ e^{j\beta\ell} \left[1 + |\Gamma_L| e^{j(\phi_L - 2\beta\ell)} \right]$$

$$I(\ell) = \frac{V^+}{Z_0} e^{j\beta\ell} \left[1 - |\Gamma_L| e^{j(\phi_L - 2\beta\ell)} \right]$$

Phasor Notation





Observations :

1. Maximum of voltage & current do not happen at the same point in a Transmission line.

2. Point of max V(l) is the point of min I(l) & vice-versa.