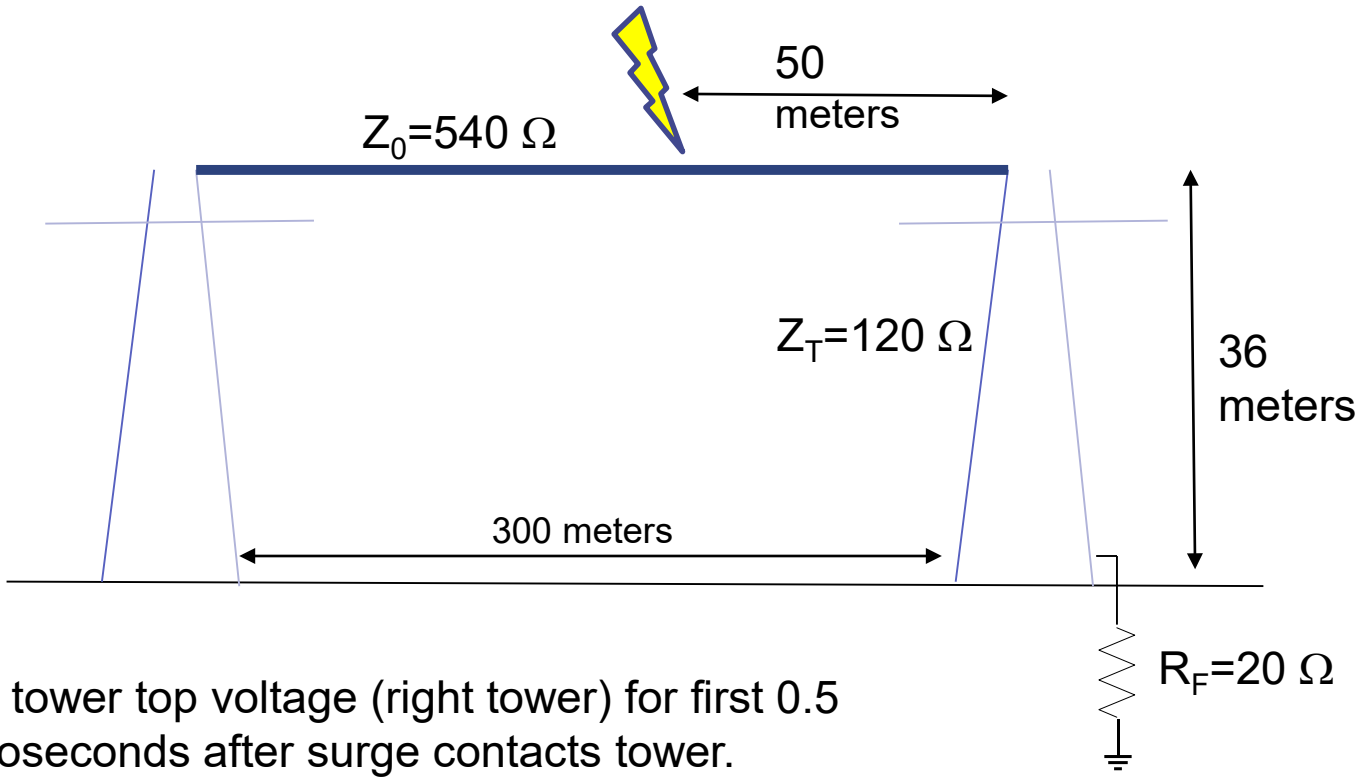
Worked Example

The towers of a transmission line circuit are 36 meters tall and spaced 300 meters apart. They are joined at their tops by a ground wire with surge impedance of 540 Ohms. The tower footing resistance is 20 Ohms. A ground wire is struck by lightning 50 meters from the last tower on the circuit as shown below. The lightning current rises linearly to a peak of 100 kA in 2 microseconds before commencing to decline. The tower surge impedance is 120 Ohms. Assume all disturbance waves travel at 2.9×10^8 meters/second.

a. Sketch the tower top potential as a function of time for the first 0.5 microseconds after the surge makes contact at the tower, making sure to give explicit values a 0τ, 2τ and 4τ.

b. Verify your results by using an EMTP simulation. What difference does having a poor ground impedance of 200 Ohms make?

Worked Example Schematic

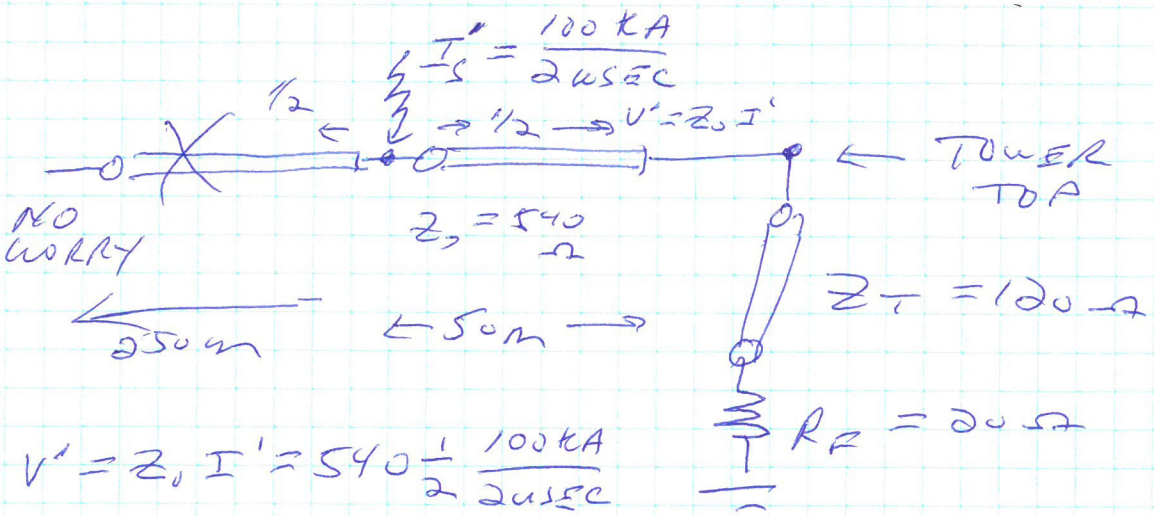


Find tower top voltage (right tower) for first 0.5 microseconds after surge contacts tower.

ECE 541
OCT. 2, 2018

LIGHTNING STRIKE EXAMPLE

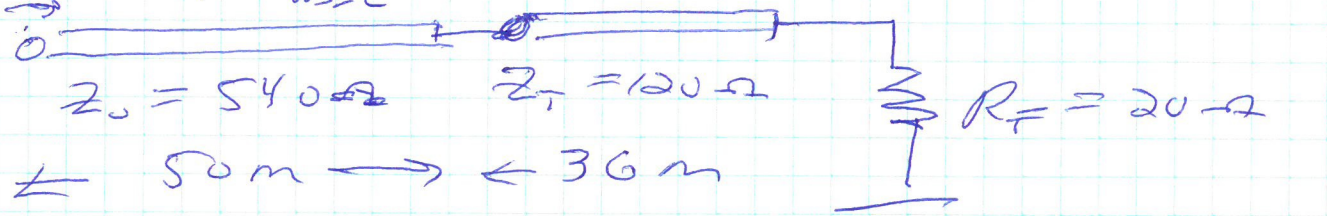
STROKE MODEL: PEAK 100 KA IN 2 μSEC
WITH SPEED = 2.9×10^8 m/SEC



$$V' = Z_0 I' = 540 \cdot \frac{1}{2} \cdot \frac{100\text{ kA}}{2\ \mu\text{SEC}}$$

$$= 13{,}500\ \text{kV}/\mu\text{SEC}$$

$$\tau = \frac{36}{2.9 \times 10^8} = 0.124\ \mu\text{SEC}$$

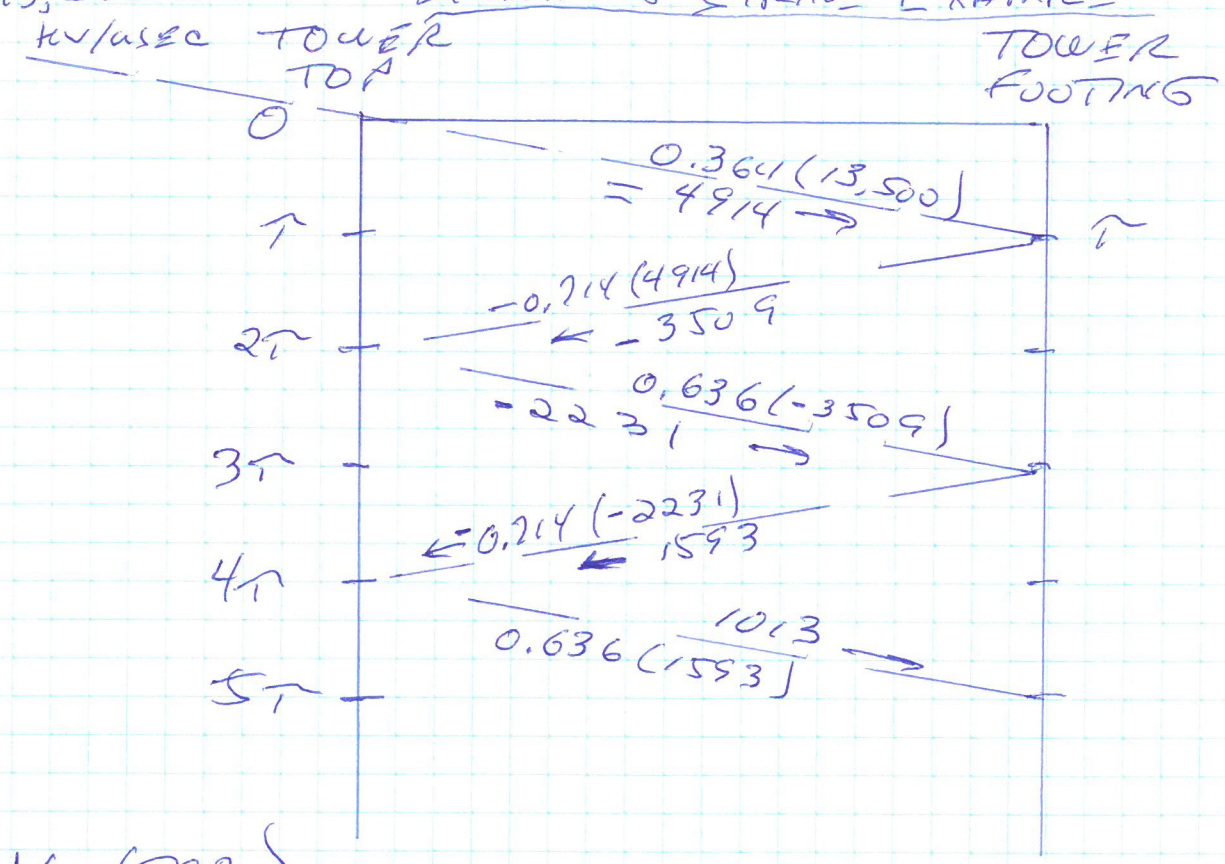


AT TOWER TOP
$$\Gamma_b = \frac{2 Z_T}{Z_0 + Z_T} = \frac{2(120)}{540 + 120} = 0.364$$

AT TOWER BOTTOM
$$\Gamma_a = \frac{Z_F - Z_T}{Z_F + Z_T} = \frac{20 - 120}{20 + 120} = -0.714$$

AT TOWER TOP
$$\Gamma_a = \frac{Z_0 - Z_T}{Z_0 + Z_T} = \frac{540 - 120}{540 + 120} = 0.636$$

LIGHTNING STRIKE EXAMPLE



V_T (TOP)

$0 \rightarrow 2\tau$ $\quad V_T = 4914\,t$ $\quad (t$ IN μsec)

APPROACHING 2τ $\quad V_T = 1219$ kV

($2\tau = 2 \times 0.124$ μsec)

$2\tau - 4\tau$ $\quad V_T = 1219\text{ kV} + (4914 - 3509 - 2231)(t - 2\tau)$

$= 1219 - 826(t - 2\tau)$

AT 4τ BEFORE NEXT REFLECTIONS $\quad V_T = 1014$ kV