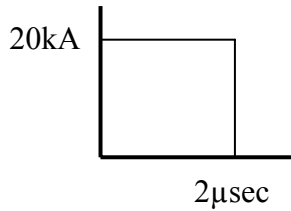


Homework #11, Due Monday, April 24.

A lightning strike hits the top of a very tall (24m) tall flag pole. The Z_0 of the flagpole is 100Ω , and the velocity of propagation along the flagpole is 0.8vel_0 , where vel_0 (velocity of light in free space) = $300\text{m}/\mu\text{sec}$. The resistance of the flagpole ground is zero.

The characteristics of the lightning current strike are constant 20kA for $2\mu\text{sec}$. Treat the lightning current as a current source with infinite impedance.



Compute and plot voltages at the top $v_{\text{top}}(t)$ and bottom $v_{\text{bot}}(t)$ of the flagpole for $0 \leq t \leq 1\mu\text{sec}$.

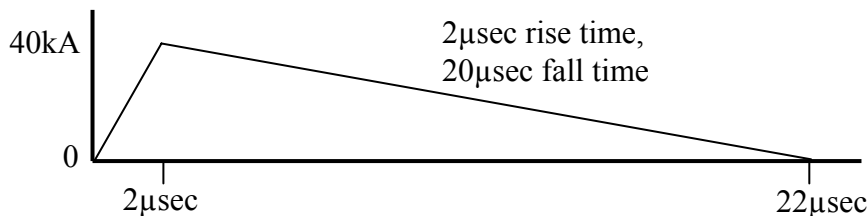
Homework #12, Due Wednesday, April 26.

The top of the flagpole in Homework #11 has a ground wire attached – the ground wire comes in from one direction, and continues in the opposite direction to adjacent flagpoles. The spacing between flagpoles is 1000m. The Z_0 of the ground wire is 500Ω . The resistance of the flagpole ground is 10Ω .

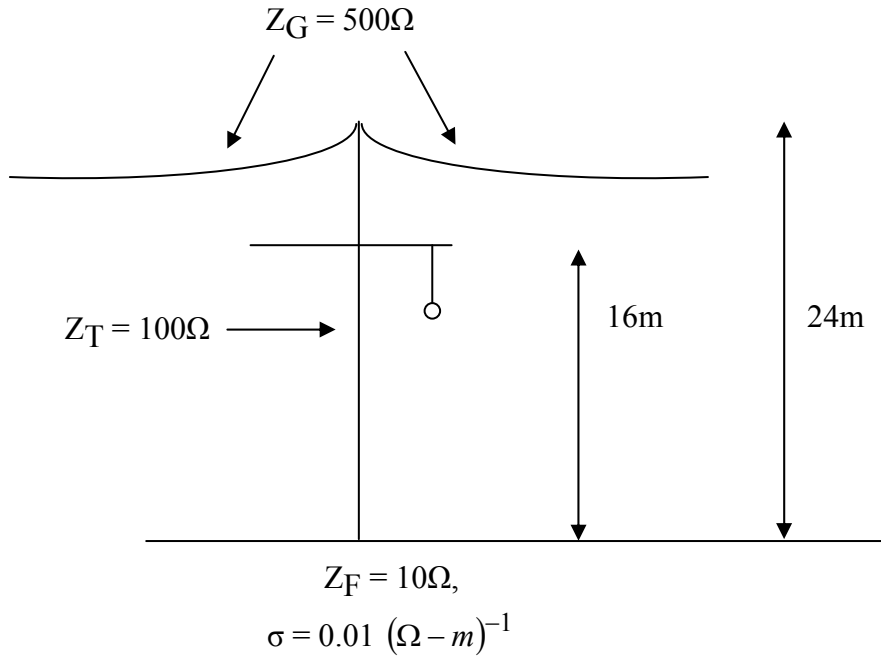
Compute and plot voltages at the top $v_{\text{top}}(t)$ and bottom $v_{\text{bot}}(t)$ of the flagpole for $0 \leq t \leq 1\mu\text{sec}$. You are encouraged to use an Excel spreadsheet.

Homework #13, Due Friday, April 28.

Repeat Homework #12, using a 40kA , $2\mu\text{sec} \times 20\mu\text{sec}$ lightning current waveshape. Compute and plot voltages at the top $v_{\text{top}}(t)$ and bottom $v_{\text{bot}}(t)$ of the flagpole for $0 \leq t \leq 4\mu\text{sec}$. Allow for variable inputs for tower Z_0 , ground wire Z_0 , and flagpole ground resistance.



Homework #14, Due Wednesday, May 3.



Continuing with Homework #13, let the “flagpole” become a 345kV transmission line. The cross arm is 2/3 the way up the tower. Determine and plot the voltage across the insulator string for $0 \leq t \leq 4\mu\text{sec}$, for both $Z_F = 10\Omega$ and $Z_F = 40\Omega$ cases. Make the following assumptions:

1. To find voltage $V_{crossarm}$, it is adequate to use linear voltage division with distance as follows:

$$V_{crossarm} = V_{bottom} + \frac{20}{30}(V_{top} - V_{bottom}),$$

ignoring the slight time shift between V_{top} and V_{bottom} .

2. To find the voltage across the insulator string, assume the worst-case (i.e., phase voltage wrt ground is at its negative peak)
3. Due to coupling, 30% of the ground wire voltage is induced on the phase wire (this adds to the negative peak 60Hz voltage)

Homework #15, Due Friday, May 5.

A person stands with one foot R_1 meters from the base of the tower, and the other foot R_2 meters from the base of the tower. Each shoe has resistance $1\text{k}\Omega$, and the body resistance is $1\text{k}\Omega$. Assuming that

- the Earth has uniform conductivity, so that the current density decreases according to $\frac{1}{R^2}$,

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- the person does not significantly affect the voltages at the Earth's surface when a lightning strike occurs,
- $(R_2 - R_1) = 1\text{m}$,
- Lethal shock energy is 50J,

determine the maximum lethal R_1 for average soil ($\sigma = 0.01$), and for very dry soil ($\sigma = 0.001$). Consider the entire $22\mu\text{sec}$ in this computation.