Surge Arrestor Example

A surge with the characteristics shown below travels down an overhead line towards a cable that has an unloaded transformer connected to it. The circuit has the following characteristics:

Overhead Line	Z_0 = 400 Ohms	velocity=980 feet/microsecond
Cable	Z_0 = 50 Ohms	velocity=400 feet/microsecond
Load	Z = ∞ Ohms (Open Circuit)	

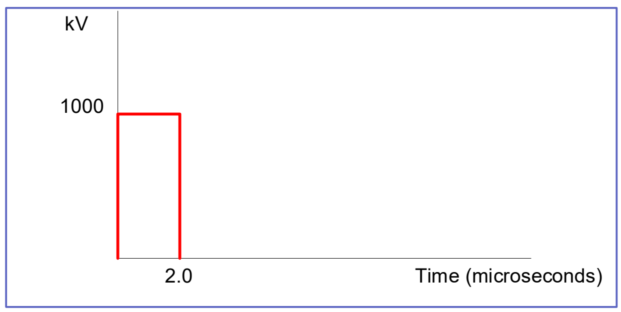
a) Plot the voltage at the load end of the circuit, Point 2, as a function of time for a time period of 3.5 microseconds after the disturbance hits the junction between the overhead and underground cable. Assume that reflections from the far left side of the circuit can be neglected.

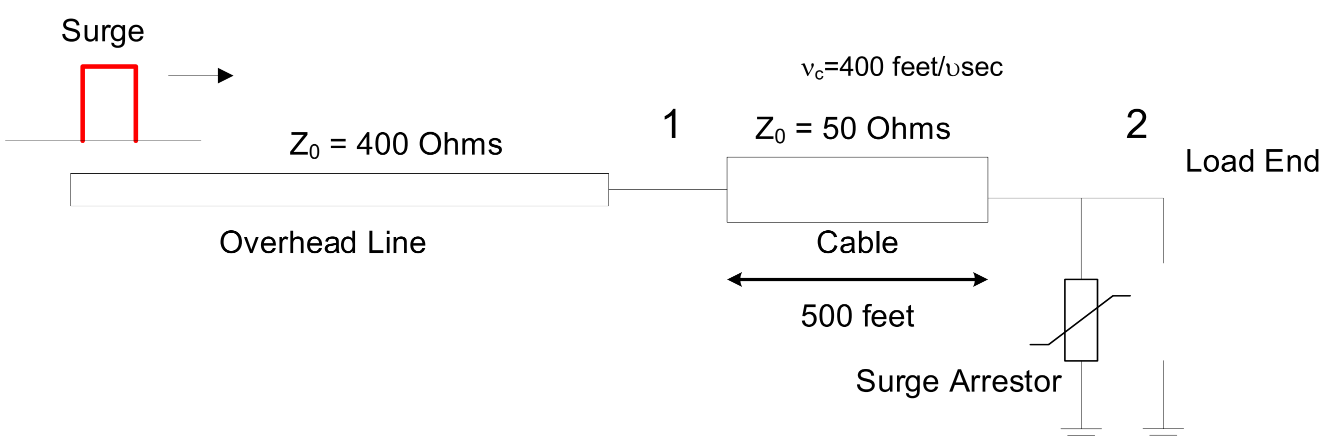
b) A metal oxide arrestor is inserted at Point 2 in order to protect the transformer from transient overvoltages. The MCOV's characteristics are given by:

$$I = 500 \times \left(V \,/\, 20{,}000\right)^{30}$$

Determine the peak voltage at the load end after the MCOV has been placed into the circuit. Use either a graphical technique or a nonlinear solution technique to get the numerical results.

Surge Arrestor Diagrams





SURGE ARRESTOR EXAMPLE

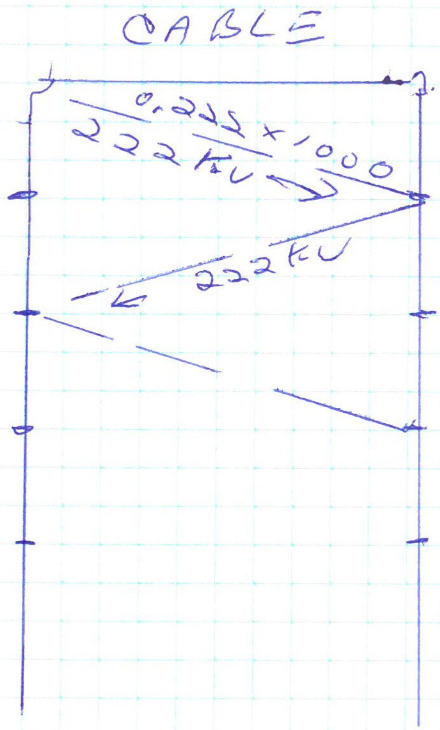
(a.) $\tau_{CABLE} = \frac{l}{v} = \frac{500 \text{ FOOT}}{400 \text{ FT}/\mu\text{SEC}} = \underline{1.25 \mu\text{SEC}}$

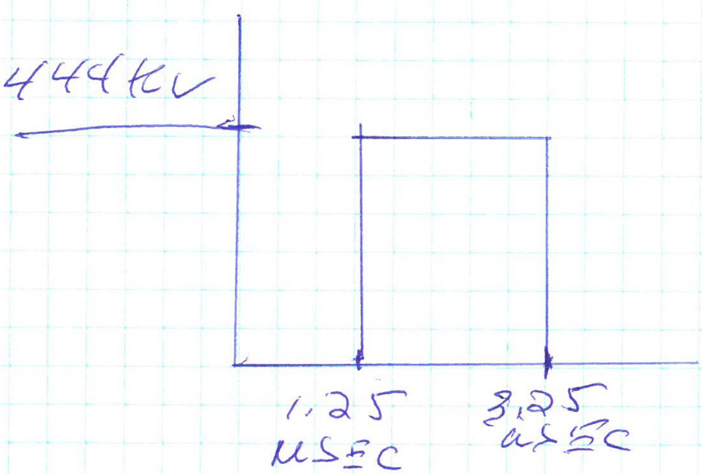
1000 KV INCOMING

$\Gamma_1 = \frac{2(50)}{400+50}$

$= 0.222$

$\Gamma_a = \frac{\infty - 50}{\infty + 50} = 1$





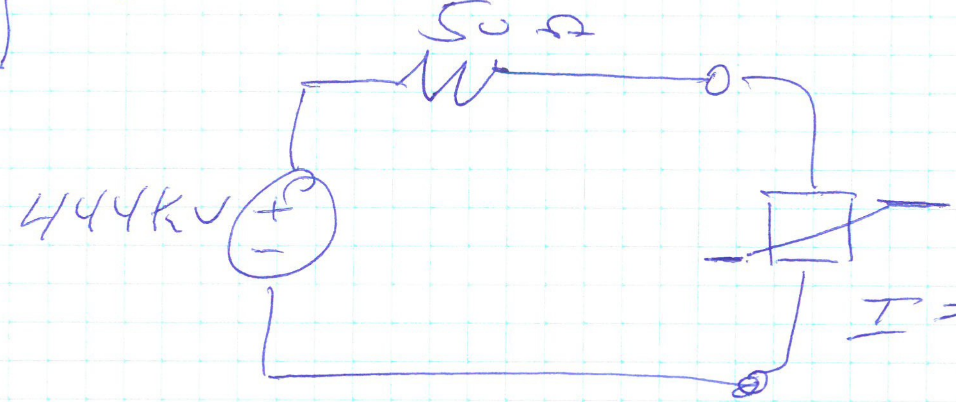
NO SURGE ARRESTOR

ECE 557
FALL 2019

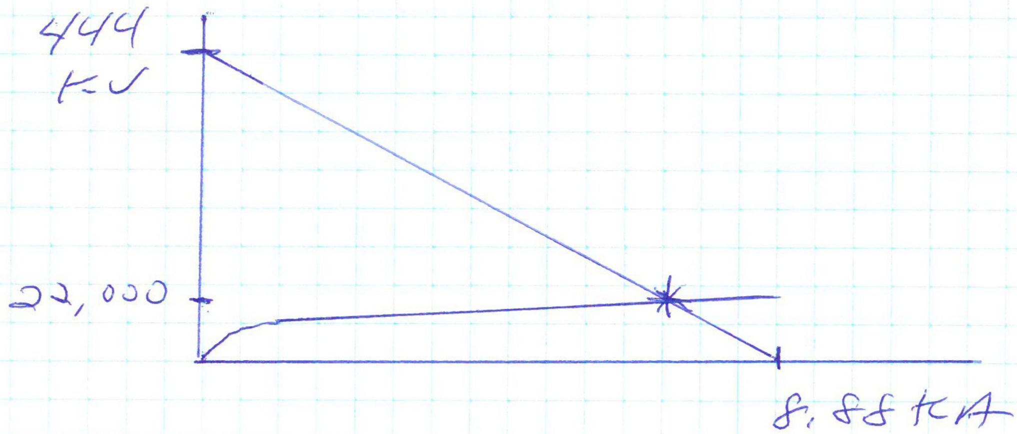
SURGE ARRESTOR EXAMPLE

OCT-7, 2019

(b.)



$$I = 500\left(\frac{V}{20000}\right)^{30}$$



INTERSECTION AT $\underline{22,000V}$ W/ SURGE ARRESTOR

NUMERICAL TECHNIQUE

$$500\left(\frac{V}{20000}\right)^{30} = \frac{444,000 - V}{50}$$

$$f(V) = 500\left(\frac{V}{20,000}\right)^{30} - \left(\frac{444,000 - V}{50}\right) = 0$$

NEWTON-RAPHSON TECHNIQUE

$$V_{n+1} = V_n - \frac{f(V_n)}{f'(V_n)}$$

Newton-Raphson Numerical Solution

```
                                   surgevoltage
# Solve for intersection of circuit load line and surge arrestor current curves

# Intial estimate for voltge
voltage =21000.0
converge = False
iteration = 1
while converge == False:
    fx=500.0*(voltage/20000.0)**30 - ((444000.0-voltage)/50.0)
    dfx=(15000.0/20000.0)*(voltage/20000.0)**29
    voltage = voltage - fx/dfx
    if abs(fx) < 1.0:
        converge = True
    print 'Iteration=',iteration,'Estimated Voltage=',voltage
    iteration = iteration + 1
print 'Converged Voltage=', voltage

Program Output:
Iteration= 1 Estimated Voltage= 23040.4345019
Iteration= 2 Estimated Voltage= 22457.7090487
Iteration= 3 Estimated Voltage= 22099.1340775
Iteration= 4 Estimated Voltage= 21985.0352918
Iteration= 5 Estimated Voltage= 21975.7675488
Iteration= 6 Estimated Voltage= 21975.7265139
Converged Voltage= 21975.7265139
```