Worked Example 1

A surge with the characteristics shown travels down an overhead line towards a cable that has a resistive termination. The circuit, illustrated below, has the following characteristics:

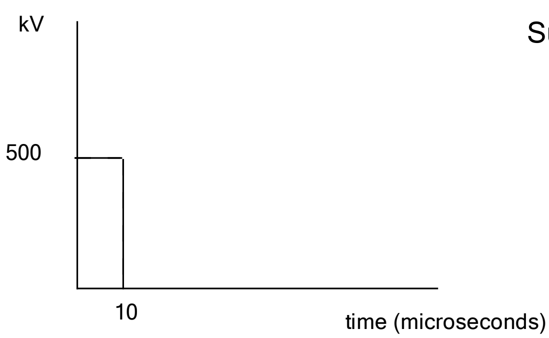
O/H line	Zo = 300 Ohms	velocity = 980 ft/microsec. (0.298704 km/microsec)
Cable	Zo = 50 Ohms	velocity = 400 ft/microsec. (0.12192 km/microsec)
Load	Z = 200 Ohms	

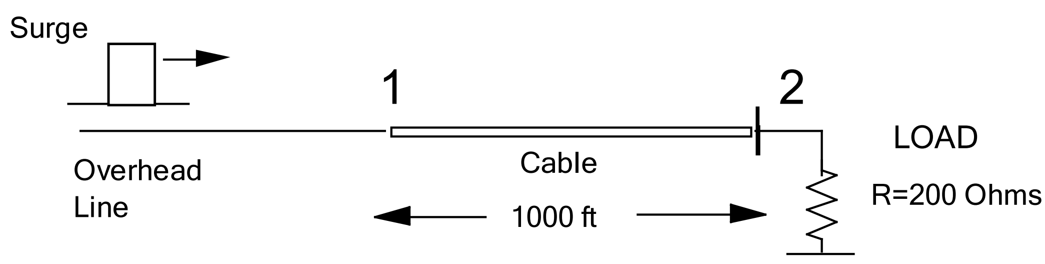
Calculate:

(a) Plot the voltage at the 200 Ohm load resistor, Point 2, as a function of time for a time period of 10 microseconds after the disturbance hits the junction between the overhead and underground cable.

(b) Plot the voltage at the junction of the overhead and underground cable, point 1, as a function of time for a time period of 10 microseconds after the disturbance hits the junction between the overhead and underground cable.

(c) Verify the results in (a) and (b) using an EMTP simulation. Include your code and plots of the voltage at Point 1 and Point 2.





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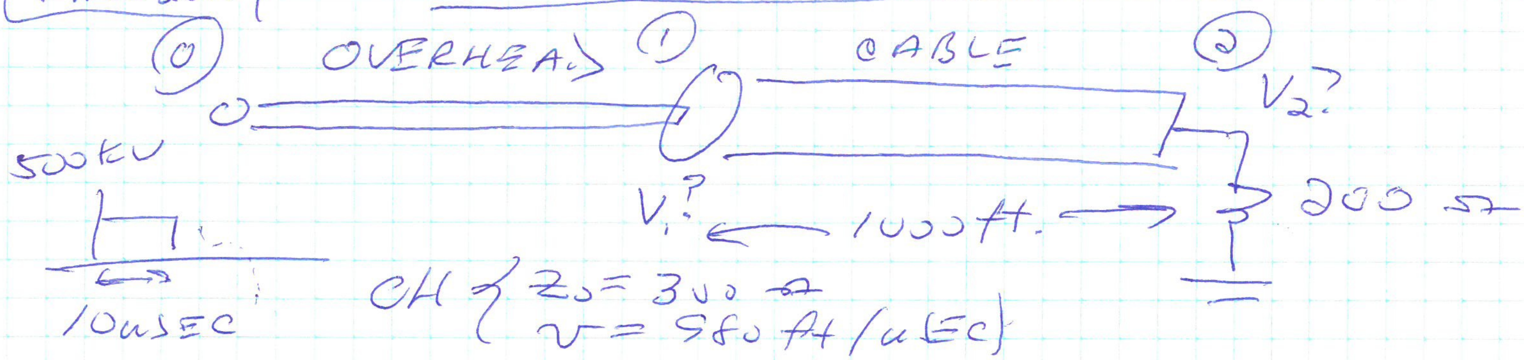
FALL 2019

EXAMPLE 1 - SQUARE WAVE 9/25/19 1/2



CH $\begin{cases} Z_0 = 300\ \Omega \\ v = 980\ \text{ft}/\mu\text{SEC} \end{cases}$

CABLE $\begin{cases} Z_0 = 50\ \Omega \\ v = 400\ \text{ft}/\mu\text{SEC} \end{cases}$

$$\tau_{CABLE} = \frac{l}{v} = \frac{1000\ \text{ft}}{400\ \text{ft}/\mu\text{SEC}} = 2.5\ \mu\text{SEC}$$

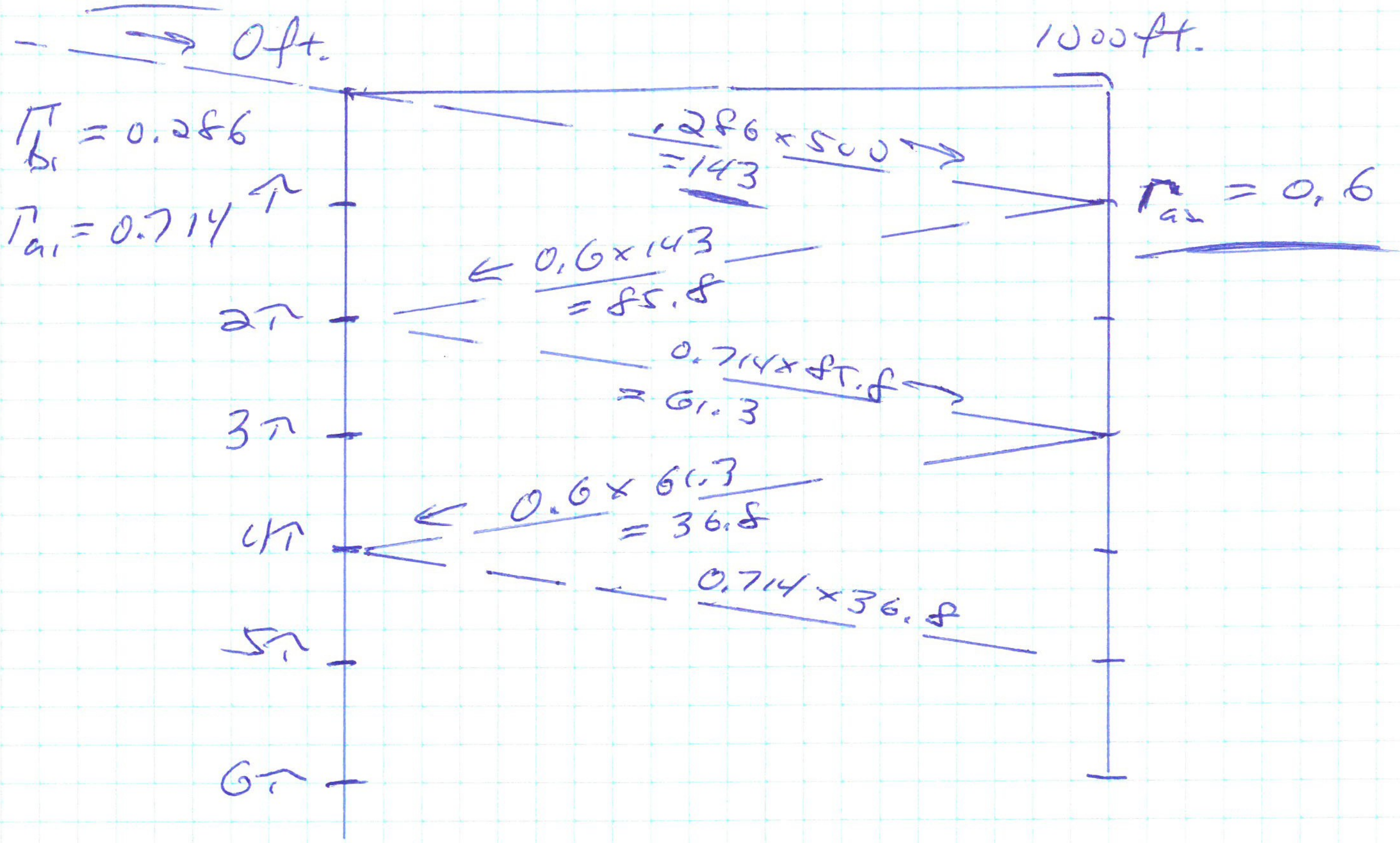
REFRACTION AT 1 $\quad \Gamma_{b1} = \frac{2 Z_B}{Z_A + Z_B} = \frac{2(50)}{300+50} = \underline{0.286}$

REFLECTION AT 2 $\quad \Gamma_{a2} = \frac{Z_B - Z_A}{Z_B + Z_A} = \frac{200-50}{200+50} = \underline{0.6}$

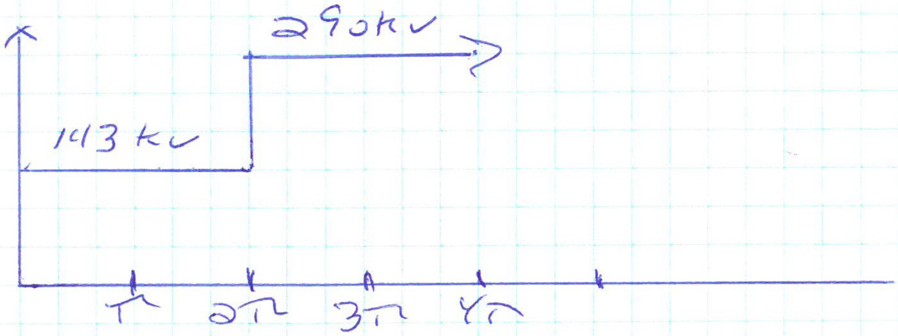
REFLECTION AT 1 $\quad \Gamma_{a1} = \frac{Z_B - Z_A}{Z_B + Z_A} = \frac{300-50}{300+50} = \underline{0.714}$

EXAMPLE 1 - SQUARE WAVE

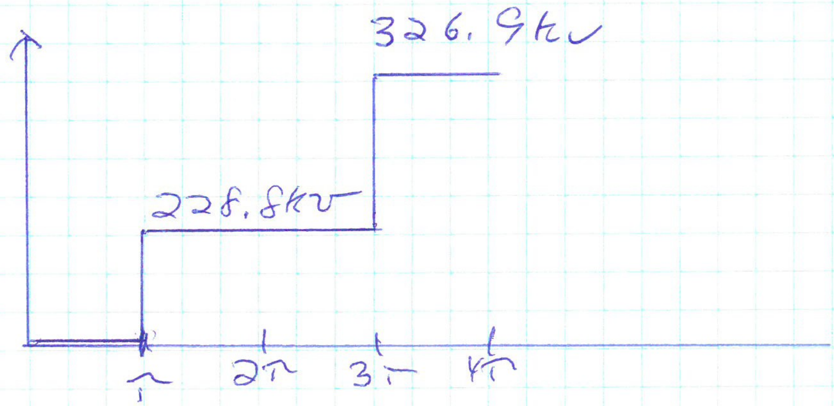
500 kV



SENDING END OF CABLE ($t = 0$ WHEN SURGE HITS CABLE)



RECEIVING END OF CABLE



Worked Example 2

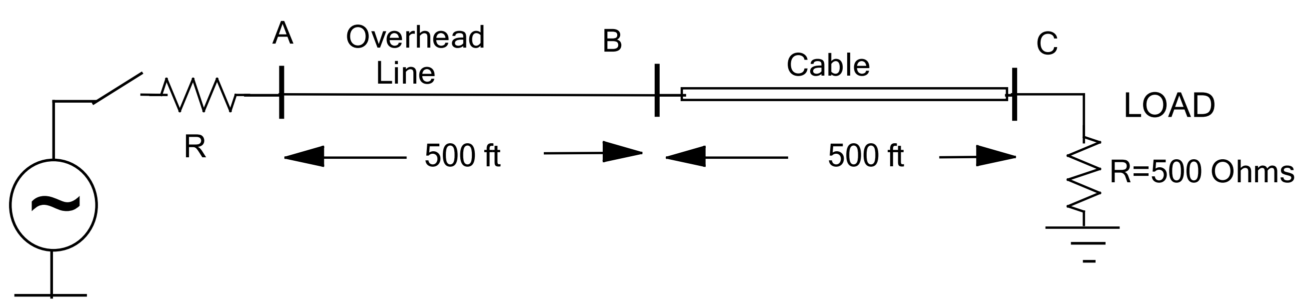
The single-phase 12.47kV (line-to-line) circuit shown below is energized at the peak of the voltage cycle. The remote end is connected to a 500 Ohm load. The pre-insertion resistor has a value of 300 Ohms. The cables have the following characteristics:

O/H line	Zo = 300 Ohms	velocity = 980 ft/microsec. (0.298704 km/microsec)
Cable	Zo = 50 Ohms	velocity = 490 ft/microsec. (0.149352 km/microsec)

Assuming that the source can be modeled as a constant DC voltage source:

(a) Plot the voltage at the 500 Ohm load resistor, Point C, as a function of time for a time period of 3.0 microseconds after the switching operation occurs. Make sure to include numerical values for the amplitude levels and transition times.

(b) Plot the voltage at the junction of the overhead and underground cable, point B, as a function of time for a time period of 3.0 microseconds after the switching operation occurs.



ONE

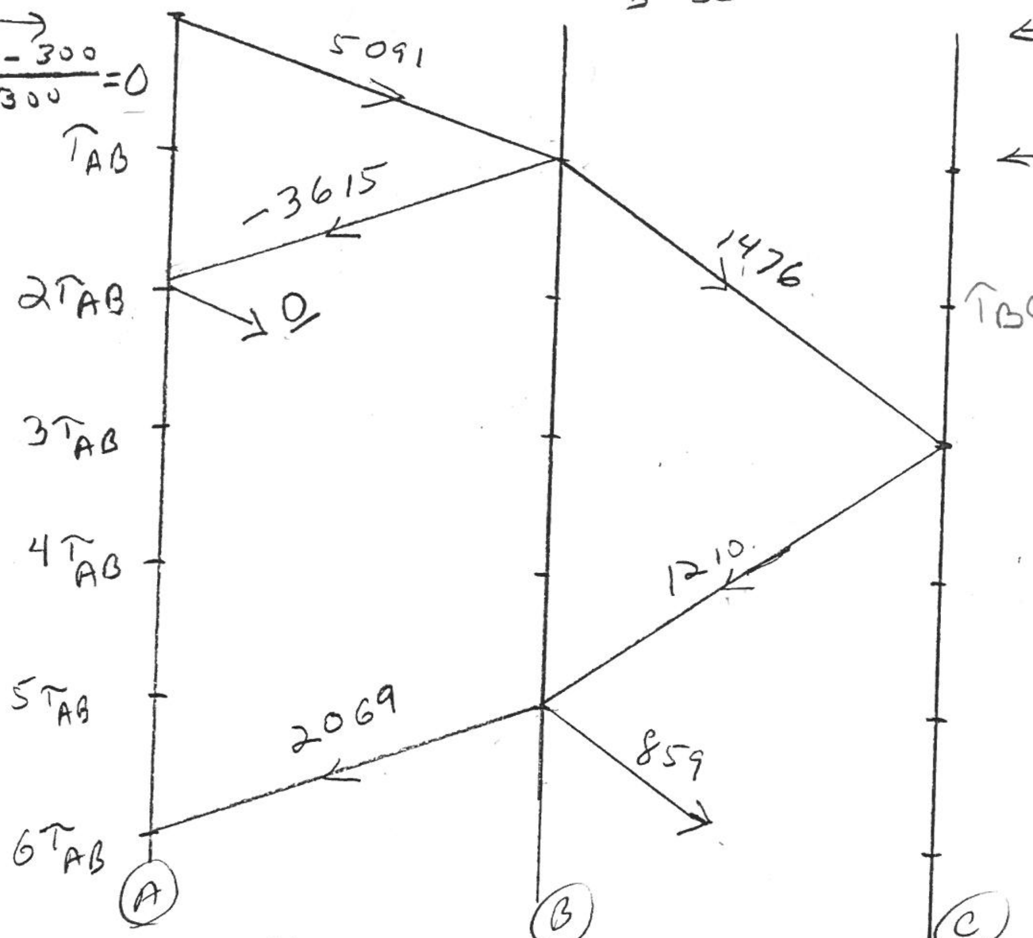
$\Gamma_b = \frac{2(300)}{350} = 1.71 \qquad \Gamma_a = \frac{300-50}{350} = .71$

$\Gamma_a = \frac{50-300}{350} = -.71 \qquad \Gamma_b = \frac{2(50)}{350} = .29$

$\Gamma_a = \frac{300-300}{300+300} = 0$

$\Gamma_a = \frac{500-50}{500+50} = .82$

$\Gamma_b = \frac{2(500)}{500+50} = 1.82$



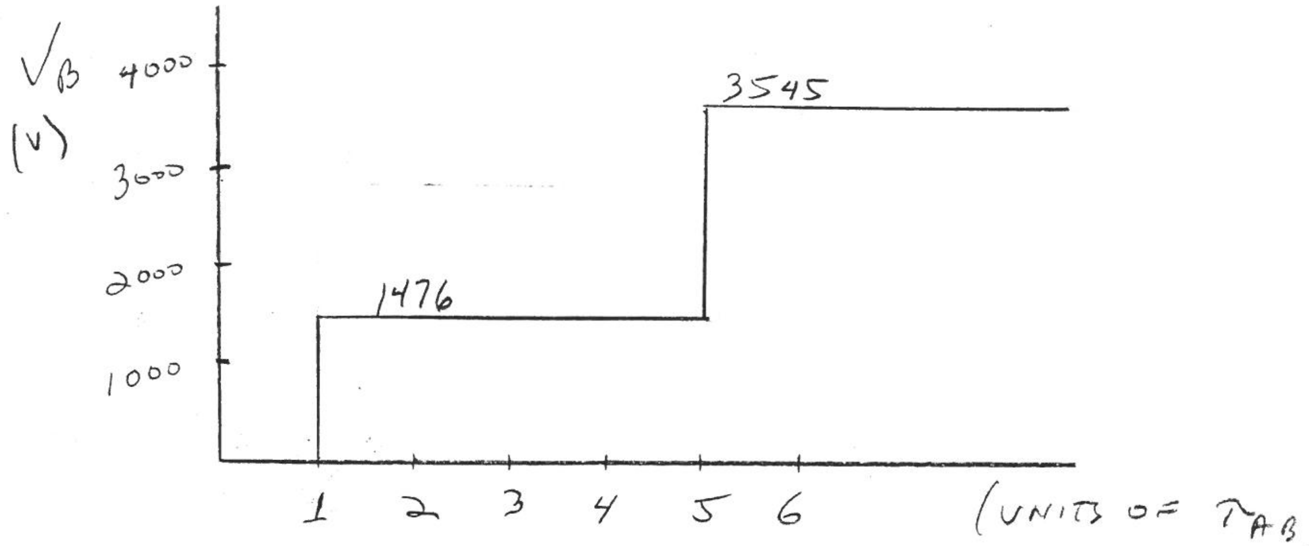
$\tau_{AB} = \frac{500\text{ ft.}}{980\text{ ft}/\mu\text{sec}} = .51\ \mu\text{sec}, \quad \tau_{BC} = \frac{500}{490\text{ ft}/\mu\text{sec}} = 1.02\ \mu\text{sec.}$

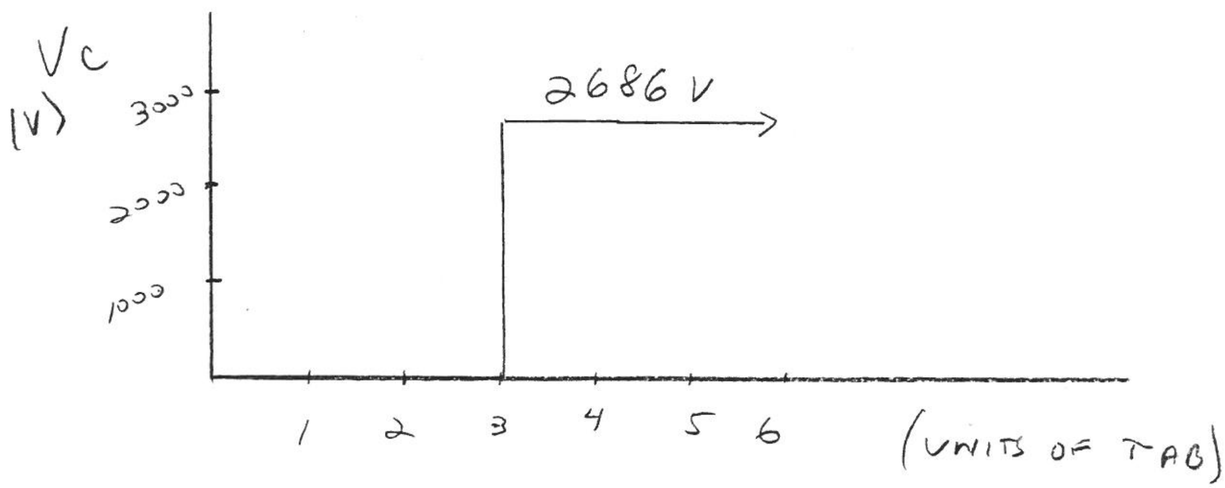
$V_{SRC} = \frac{\sqrt{2}}{\sqrt{3}}\, 12.47\times10^3 = 10,182\text{ V}$

$V_{INJ} = \frac{300}{300+300}\, 10,182 = 5091\text{ V}$

|Ex 2|

| ONE


V_B
(V)
4000
3000
2000
1000
3545
1476
1
2
3
4
5
6
(UNITS OF τ_{AB})


V_C
(V)
3000
2000
1000
2686 V
1
2
3
4
5
6
(UNITS OF τ_{AB})