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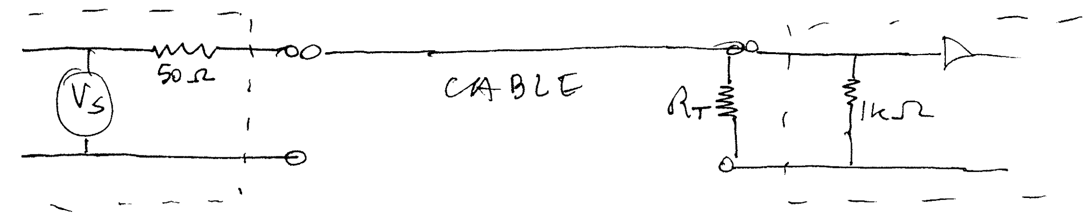
ch 16.

16.4 -



a) Since we're dealing with fast pulses, we have to choose a cable and a termination that would match the input and output impedances, and thus eliminate signal reflections.

To obtain 50Ω impedance we need a shunt resistor R_T of:

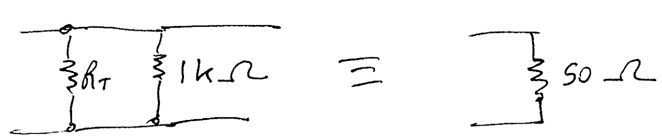
$$\frac{1}{50\Omega} = \frac{1}{R_T} + \frac{1}{1000\ \Omega} \Rightarrow R_T = \frac{50000}{950}\ \Omega = 52.6\ \Omega$$

The attenuation in decibels is:

$$A(dB) = 10 \log_{10}\left(\frac{P_{out}}{P_{in}}\right) \Rightarrow P_{out} = P_{in} \cdot 10^{\frac{A(dB)}{10}}$$

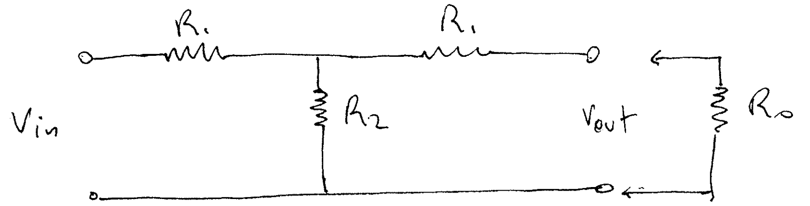
Thus a good cable is RG-178/U, which has 50Ω characteristic impedance, and the larges attenuation value for the fast frequencies (400 MHz).

b)



$$\Rightarrow V_{out} = V_{in} = 5V$$

$\boxed{16.5}$



R_o - input and output impedances

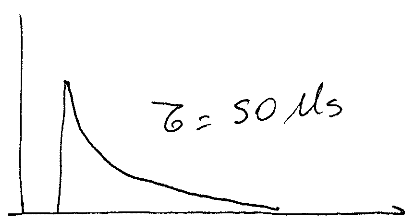
$$R_1 = R_o \frac{\alpha - 1}{\alpha + 1} \quad ; \quad R_2 = R_o \frac{2\alpha}{\alpha^2 - 1}$$

α = gain = 10 ; R_o = 50 Ω

$$R_1 = 50\,\Omega \left(\frac{9}{11}\right) = \boxed{40.9\,\Omega = R_1}$$

$$R_2 = 50\,\Omega \left(\frac{20}{99}\right) = \boxed{10.1\,\Omega = R_2}$$

$\boxed{16.7}$



$$V(t) = V_0 \, e^{-t/\tau}$$

$$\frac{V(t)}{V(0)} = 0.01 = \frac{e^{-t/\tau}}{e^0} = e^{-t/\tau}$$

$$t = -\tau \ln(0.01) = 50\,\mu s\,(4.60517) \simeq \boxed{230\,\mu s}$$

$\boxed{16.8}$

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In[2]:= Assuming[τ > 0 && A > 0 && k > 0, DSolve[τ * x'[t] + x[t] == A * (1 - e^(-t/k)), x[t], t]]
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$$Out[2]= \left\{\left\{x[t] \to A e^{t\left(-\frac{1}{k}+\frac{1}{\tau}\right)-\frac{t}{\tau}}\left(e^{\frac{t}{k}}+\frac{k}{-k+\tau}\right)+e^{-\frac{t}{\tau}}C[1]\right\}\right\} \quad V_{out}(t) = E\left(1+\frac{k}{\tau-k}e^{-t/k}\right)+Ce^{-t/\tau}$$

initial conditions:

$$V_{in}(0) = 0 = V_{out}(0) = E\left(1+\frac{k}{\tau-k}\right)+C$$

$$\Rightarrow C = -E\left(\frac{\tau-k+k}{\tau-k}\right) = \frac{\tau E}{k-\tau}$$

$$\Rightarrow V_{out}(t) = E\left(1+\frac{k}{\tau-k}e^{-t/k}+\frac{\tau}{k-\tau}e^{-t/\tau}\right)$$

$$\frac{dV_{out}(t)}{dt} = E\left(\left(\frac{-1}{k}\right)\frac{k}{\tau-k}e^{-t/k}+\left(\frac{-1}{\tau}\right)\frac{\tau}{k-\tau}e^{-t/\tau}\right)$$

$$= \frac{E}{\tau-k}\left(e^{-t/\tau}-e^{-t/k}\right)$$

Plugging the results back into the diff. equation 16.17:

$$\tau\frac{dV_{out}}{dt}+V_{out} = \frac{E\tau}{\tau-k}\left(e^{-t/\tau}-e^{-t/k}\right)+E\left(1+\frac{k}{\tau-k}e^{-t/k}+\frac{\tau}{k-\tau}e^{-t/\tau}\right)$$

$$= E\,e^{-t/k}\left(e^{t/k}+\frac{k}{\tau-k}-\frac{\tau}{\tau-k}\right)$$

$$= E\,e^{-t/k}\left(e^{t/k}+\frac{k-\tau}{\tau-k}\right) = E\left(1-e^{-t/k}\right) = V_{in} \quad \checkmark$$

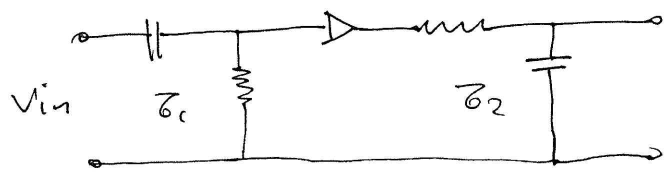
Limits $\to$ $k \gg \tau$ low frequency signal

$$\Rightarrow \frac{\tau}{k-\tau} \sim 0 \Rightarrow V_{out}(t) = E\left(1-e^{-t/k}\right) \approx V_{in}(t) \checkmark$$

$$\to \tau \gg k \Rightarrow \frac{k}{\tau-k} \sim 0$$

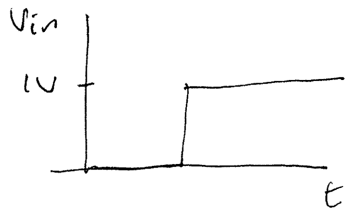
$V_{out}(t) = E\left(1-e^{-t/\tau}\right)$ - response to a step function (16.21) $\checkmark$

$\boxed{16.10}$



CR-RC

$\tau_1 = \tau_2 = \tau$



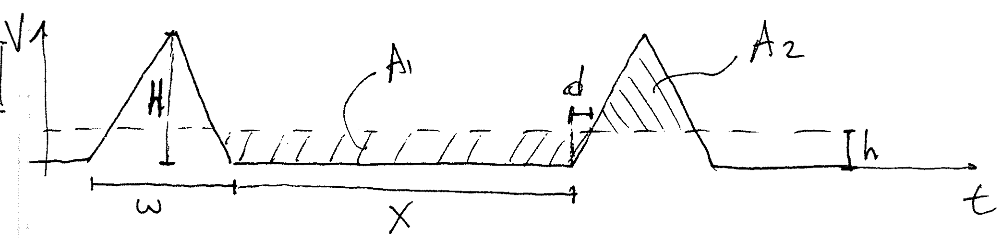
$$V_{out} = V_{in} \frac{t}{\tau} e^{-t/\tau}$$

$$\frac{dV_{out}}{dt} = V_{in} \left(\frac{e^{-t/\tau}}{\tau} - \frac{t}{\tau^2} e^{-t/\tau} \right) = \frac{V_{in}\, e^{-t/\tau}}{\tau} \left(1 - \frac{t}{\tau}\right)$$

$\frac{dV_{out}}{dt} = 0 \Rightarrow 1 - \frac{t}{\tau} = 0 \Rightarrow t = \tau$ is a maximum for V_{out}.

$$\frac{V_{out\,max}}{V_{in}} = \frac{V_{out\,max}}{1V} = \frac{\tau}{\tau} e^{-\tau/\tau} \Rightarrow V_{out\,max} = \frac{1}{e} V \cong \boxed{0.368\,V}$$

$\boxed{16.14}$



In steady state $A_1 = A_2$ (equal areas)

$$A_1 = (X + d)\,h =$$

$$A_2 = \frac{1}{2}(H - h)(w - 2d) \qquad H = 10V;\ w = 5\mu s.$$

and we also have $\frac{d}{h} = \frac{1}{2}\frac{w}{H} = \frac{1}{4}\frac{\mu s}{V}$

$$\Rightarrow \left(X + \frac{h}{4}\right) h = \frac{1}{2}(10 - h)\left(5 - \frac{h}{2}\right)$$

$$Xh + \cancel{\frac{h^2}{4}} = 25 - 5h + \cancel{\frac{h^2}{4}}$$

$\Rightarrow (X + 5\mu s)\, h = 25\ V\cdot\mu s$

$$\text{rate} = 100\ s^{-1} \Rightarrow T = \text{rate}^{-1} = 10000\ \mu s = X + 5\mu s$$

$$\text{baseline shift} = h = \frac{25\ V\mu s}{10000\mu s} = \boxed{2.5\ mV}$$

$$\text{rate} = 50000\ s^{-1} \Rightarrow X + 5\mu s = \text{rate}^{-1} = 20\ \mu s$$

$$\text{baseline shift} = \frac{25\ \mu s\cdot V}{20\ \mu s} = \boxed{1.25\ V}$$

16.15 The result of single delay line shaping is the superposition of the input pulse with a signal generated by its reflection in the coaxial cable. The reflection is inverted and delayed by twice the cable lenght.

signal velocity in RG-59/U cable = $0.659\, c$

$$\Rightarrow \text{delay} = \frac{2 \times 10 m}{3\times10^8 m/s \cdot 0.659} \simeq 101\ ns$$

input pulse:

reflected pulse:

output pulse: