Feedback — Channel Exercises

You submitted this homework on **Wed 3 Apr 2013 2:12 PM CDT -0500**. You got a score of **0.00** out of **7.00**. You can attempt again, if you'd like.

Question 1

RG-6 is a very common type of coaxial cable. One manufacturer's specifications state that the cable's characteristic impedance is $75\ \Omega$ and that its capacitance/unit length is 52 pF/m. What do these parameter values predict for the speed of propagation?

Express your answer as a fraction of the speed of light in free space c_0. If your answer is $0.5c_0$, type `0.5`. Please round your answers to two decimal places.

You entered:

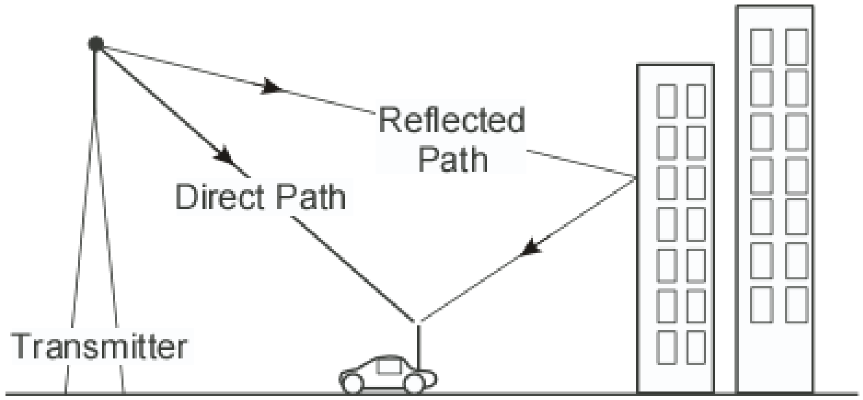
Your Answer		Score	Explanation
	✘	0.00	
Total		0.00 / 1.00	

Question Explanation

The characteristic impedance is $Z_0 = \sqrt{\frac{\widetilde{L}}{\widetilde{C}}}$. Therefore, $\widetilde{L} = Z_0^2\widetilde{C}$. The speed of propagation c equals $\frac{1}{\sqrt{\widetilde{L}\widetilde{C}}}$ that, upon sustituting for $\widetilde{L}$ we obtain $c = \frac{1}{Z_0\widetilde{C}}$. Numerically, we have $c = \frac{1}{75 \cdot 52 \times 10^{-12}}\ \text{m/s} = 2.564 \times 10^8\ \text{m/s}$. As the speed of light in free space is $3 \times 10^8\ \text{m/s}$, we have $c = 0.8547c_0$.

Question 2

In addition to white, Gaussian noise, metropolitan cellular telephone channels also contain **multipath**: in addition to a direct, line-of-sight path, reflections from buildings cause secondary paths to reach the receiving antenna.



Note that the reflected path is always longer than the direct path, which means more attenuation and a greater delay occurs along the reflected path.

Assume the direct path is 100 m long and that the secondary path is 1.5 times longer. What are the attenuations and delays along each path? Assume here that the attenuation constant is one.

Type your answer as four numbers separated by spaces: α_{direct} , τ_{direct} , $\alpha_{\text{reflected}}$, $\tau_{\text{reflected}}$. Express the delay answers in units of microseconds (μs). For example, if your answers are .5, 1 μs, .25, 31 μs, you would type `.5 1 .25 31`.

You entered:

Your Answer		Score	Explanation
	✘	0.00	
Total		0.00 / 1.00	

Question Explanation

Attenuation equals $\frac{k}{d}$. Since k in this problem is taken to be one, $\alpha_{\text{direct}} = 0.01$ and $\alpha_{\text{reflected}} = 0.0067$. Delay τ equals d/c, c being the speed of light in free space. We find that $\tau_{\text{direct}} = \dfrac{100}{3 \times 10^8} = 0.33\ \mu\text{s}$ and that $\tau_{\text{reflected}} = \dfrac{150}{3 \times 10^8} = 0.5\ \mu\text{s}$.

Question 3

What is the transfer function between the transmitter and the receiving antenna?

Your answer should an expression involving complex values. For α_1 and τ_1, the attenuation and delay along the direct path, type `a1` and `tau1`. For α_2 and τ_2, the attenuation and delay along the reflected path, type `a2` and `tau2`.

You entered:

Preview Help

Your Answer		Score	Explanation
	✘	0.00	Could not parse student submission
Total		0.00 / 1.00	

Question Explanation

Since $r(t) = \alpha_1 x(t - \tau_1) + \alpha_2 x(t - \tau_2)$, the transfer function is $H(f) = \alpha_1 e^{-j2\pi f \tau_1} + \alpha_2 e^{-j2\pi f \tau_2}$, which can be simplified to $\alpha_1 e^{-j2\pi f \tau_1} \cdot \left(1 + \dfrac{\alpha_2}{\alpha_1} e^{-j2\pi f(\tau_2 - \tau_1)}\right)$.

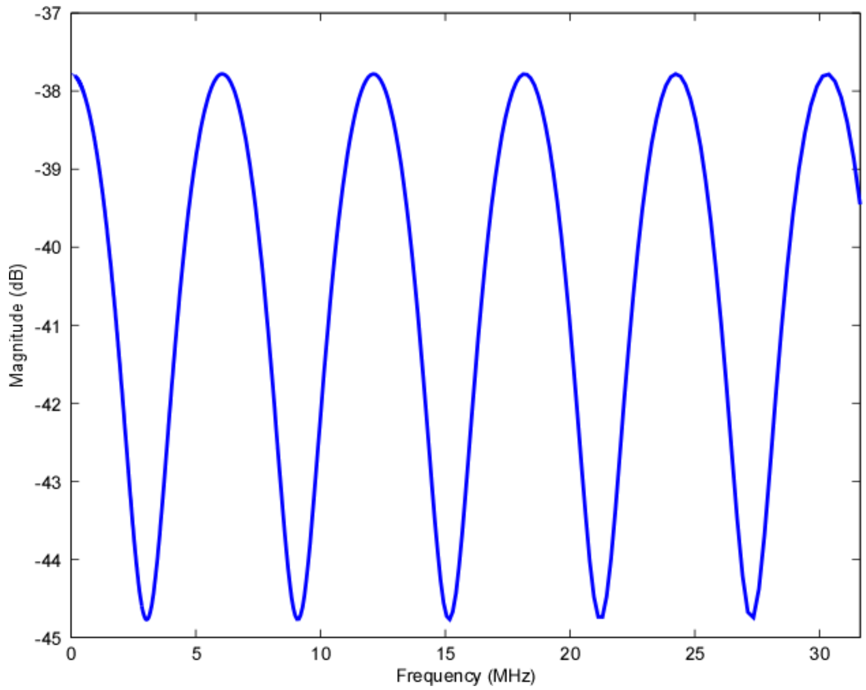
Question 4

For the parameter values for the path lengths given above, how would you characterize the transfer function between the transmitter and the receiver?

Your Answer	Score	Explanation
Bandpass		
Multiband		
Lowpass		
Highpass		
Total	0.00 / 1.00	

Question Explanation

The magnitude of the transfer function is $\alpha_1\sqrt{1+\left(\frac{\alpha_2}{\alpha_1}\right)^2+2\frac{\alpha_2}{\alpha_1}\cos 2\pi f(\tau_2-\tau_1)}$. This expression says we have a multiband filter.



Question 5

You should have found that the transfer function between the transmitter and receiver is small at certain frequencies. What are the first three “bad” frequencies?

Type your answers in units of MHz as numbers separated by spaces.

You entered:

Your Answer		Score	Explanation
	✘	0.00	
Total		0.00 / 1.00	

Question Explanation

Since the magnitude of the transfer function is proportional to $\sqrt{1+\left(\frac{\alpha_2}{\alpha_1}\right)^2+2\,\frac{\alpha_2}{\alpha_1}\cos 2\pi f(\tau_2-\tau_1)}$, this expression will be small when the argument of the cosine equals an odd multiple of π. In other words, the transfer function is small when $2\pi f(\tau_2-\tau_1)=(2n+1)\pi$, $n=0,1,\ldots$. Solving, we find the "bad" frequencies are given by $\left(n+\frac{1}{2}\right)(\tau_2-\tau_1)$, which equals $\left(n+\frac{1}{2}\right)\cdot 6\ \mathrm{MHz}$. The first three frequencies are 3, 9, 15 MHz. You would not want the transmitter's carrier frequencies to coincide with the "bad" values.

Question 6

If the signal-to-noise ratio (SNR) measured 100 m from the transmitter's antenna is 30 dB, what is the SNR 10 km from the transmitter? Express your answer in decibels.

You entered:

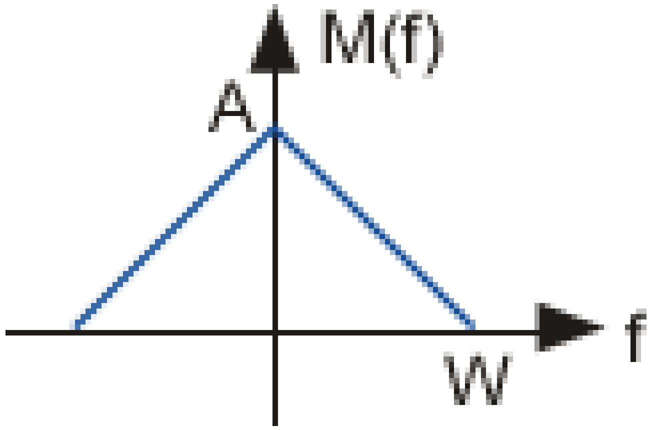
Your Answer		Score	Explanation
	✘	0.00	
Total		0.00 / 1.00	

Question Explanation

The ratio of distances is $\frac{100}{10,000} = 10^{-2}$. Since the power loss is proportional to the square of the distance, the loss, in decibels, is $10 \log_{10} 10^{-4} = -40\text{ dB}$. So the SNR 10 km from the transmitter is -10 dB.

Question 7

Suppose the message has the now-familiar triangle-shaped spectrum.



This signal is sent at baseband to a receiver. The intervening wireless channel attenuates the signal (gain α) and adds white noise of spectral height $\frac{N_0}{2}$. What is an expression for the signal-to-noise ratio of the received signal?

For the amplitude A, type `A`; for the attenuation gain α, type `a`; for the noise spectral height parameter, type `N0`; and for the bandwidth W,type `W`.

You entered:

Preview Help

Your Answer		Score	Explanation
	✘	0.00	Could not parse student submission
Total		0.00 / 1.00	

Question Explanation

The formula for the message spectrum is $A\left(1-\frac{|f|}{W}\right)$ for $|f|<W$. The message power at the receiver is
$2\alpha^2 A^2 \int_0^W \left(1-\frac{|f|}{W}\right)^2 df = 2\alpha^2 A^2 \int_0^W \left(1-2\frac{|f|}{W}+\frac{f^2}{W^2}\right) df = 2\alpha^2 A^2 \cdot \frac{W}{3}$. The noise power is $2 \cdot \frac{N_0}{2} \cdot W = N_0 W$. The signal-to-noise ratio is

$$\frac{2\alpha^2 A^2 \cdot \frac{W}{3}}{N_0 W} = \frac{2\alpha^2 A^2}{3N_0}$$

Note how the answer does not depend on the bandwidth W.