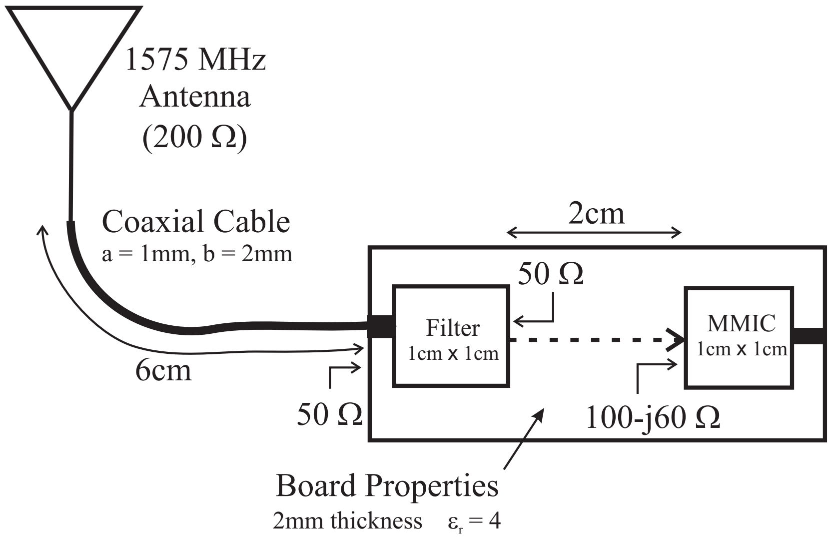
ECE 3065 Homework 2: Matching Lines

1. You have been asked to design the RF front end for a Global Positioning System (GPS) receiver. This RF front end consists of a board with two chips and a coaxial cable. The cable is meant to attach to a monopole receiver antenna that behaves as an independent sinusoidal source at 1575 MHz with a 200Ω impedance. This cable then connects to the board, where it feeds a band-pass filter with 200 MHz bandwidth and a 50Ω input impedance. Once the out-of-band signals have been filtered, the signal passes to the next device on the board, an RF amplifier that is made from a microwave monolithic integrated circuit (MMIC). This stage has an input impedance of 100-j60 at 1575 MHz. Both devices are soldered to a board that has relative permittivity of $\epsilon_R = 4$ and a dielectric thickness of 2mm. The entire set-up is sketched in the diagram below. Answer the following questions (10 points each) based on this situation.



   (a) Design the 6cm coaxial cable to match the output of the antenna to the input of the filter using a quarter-wavelength transmission line section. The initial impedance of the coaxial cable on the antenna side should be 200Ω and the quarter-wavelength section of line should be smaller so as to match the line with the 50Ω filter input. The inner and outer radii of the coaxial cable are preset to 1 mm and 2 mm, respectively. Since you only have control of the ϵ_r of the cable, choose two values (one for the antenna side, one for the load side) and calculate the position of the dielectric medium change in cm along the cable length.

   (b) Design a microstrip line with a stub open-circuit tuner that connects the output of the filter (50Ω) with the input of the MMIC amplifier ($100 - j60\Omega$). Since the permittivity and board thickness are set, all transmission line impedances are controlled by the designer through the trace width of the microstrip line. Your answer should include a to-scale engineering drawing of the microstrip lines to be etched onto the surface of the board. Label all dimensions.

Keep in mind that there is more than 1 right answer for this problem. Attach all computations, any Smith Chart work, and graphs or computer codes you use to solve this problem.

Electrical Properties of Common Transmission Lines

	L	C	Z_0	v_p
Coaxial Cable	$\frac{\mu}{2\pi}\ln\left(\frac{b}{a}\right)$	$\frac{2\pi\epsilon}{\ln\left(\frac{b}{a}\right)}$	$\frac{1}{2\pi}\ln\left(\frac{b}{a}\right)\sqrt{\frac{\mu}{\epsilon}}$	$\frac{1}{\sqrt{\mu\epsilon}}$
Microstrip	$\frac{1}{Z_0 v_p}$	$\frac{Z_0}{v_p}$	$\frac{1}{2\pi}\sqrt{\frac{\mu}{\epsilon_{\text{eff}}}}\ln\left(\frac{8b}{a}+\frac{a}{4b}\right)$ for $a < 2b$ $\sqrt{\frac{\mu}{\epsilon_{\text{eff}}}}\frac{1}{1.393+\frac{a}{b}+\frac{2}{3}\ln\left(\frac{a}{b}+\frac{13}{9}\right)}$ for $a > 2b$	$\frac{1}{\sqrt{\mu\epsilon_{\text{eff}}}}$

$$*\epsilon_{\text{eff}} = \epsilon_0\left[\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}\frac{1}{\sqrt{1+12b/a}}\right]$$