For a matching network, a radar engineer needs a capacitive reactance of $-j40\ \Omega$ at a frequency of 4 GHz. To achieve this goal, they are required to use stubs made from 50 Ω coaxial transmission line with a phase velocity of 2.5×10^8 m/s. To allow connectors to be attached, the stubs must have a minimum length of 2 cm. Find the length of the shortest possible stubs with (a) open-circuit and (b) short-circuit terminations and sketch the resulting equivalent circuits.

(11.216) $\beta = \frac{\omega}{u} = \frac{2\pi(4\times10^9)}{2.5\times10^8} = 100.531 \frac{rad}{m}$

$\lambda = u/f = \frac{2.5\times10^8}{4\times10^9} = 0.0625\ m = 6.25\ cm$

a) open circuit (11.42a) $z_{oc} = \frac{z_o}{j\tan(\beta l_{oc})} = -j40\ \Omega$

↳ $l_{oc} = \frac{1}{100.531}\tan^{-1}\left(\frac{50}{40}\right) = 0.008913\ m = 0.8913\ cm$ Too short

add ½ ↳ $l_{oc} = 0.8913 + 0.5(6.25) = \underline{\underline{4.016\ cm}}$

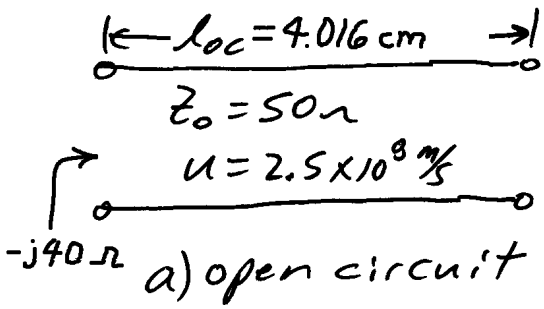
b) short circuit (11.41a) $z_{sc} = j z_o \tan(\beta l_{sc}) = -j40\ \Omega$

↳ $l_{sc} = \frac{1}{\beta}\tan^{-1}\left(\frac{-40}{z_o}\right) = \frac{1}{100.531}\tan^{-1}\left(\frac{-40}{50}\right)$

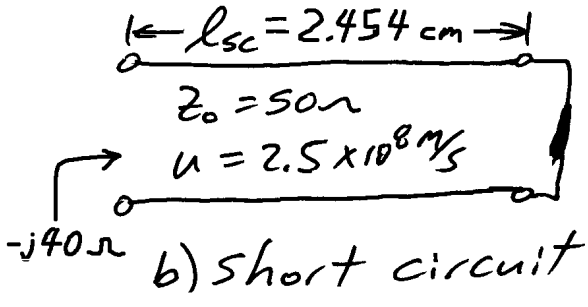
$= -0.0067118\ m = -0.67118\ cm$ ~ Not realizable

add ½ ↳ $l_{sc} = -0.67118 + 0.5(6.25) = \underline{\underline{2.454\ cm}}$

@ 4 GHz



a) open circuit



b) short circuit