10.22 Design a nine-turn helical antenna operating in the axial mode so that the input impedance is about 110 ohms. The required directivity is 10 dB (above isotropic). For the helix, determine the approximate:

(a) circumference (*in* λ_0). (b) spacing between the turns (*in* λ_0).

(c) half-power beamwidth (*in degrees*).

Assuming a symmetrical azimuthal pattern:

(d) determine the directivity (*in dB*) using *Kraus' formula*. Compare with the desired.

- Assume axial feed. Hint: Use Kraus' directivity formula.

a) Per (10-30), $R \simeq 140\left(\frac{C}{\lambda_0}\right)$ for axial feed.

letting $Z_{in} = R = 110 = 140\left(\frac{C}{\lambda_0}\right)$

$$\hookrightarrow \underline{\underline{C = \frac{110}{140}\lambda_0 = 0.7857\lambda_0}}$$

b) Use the directivity equation and specification to find spacing.

Per (10-33), $D_0 \simeq 15N\frac{C^2 S}{\lambda_0^3}$

$D_0 = 10\,dB = 10\log_{10} D_0 \Rightarrow D_0 = 10^{10/10} = 10$

$$10 = 15(9)\frac{\left(\frac{110}{140}\lambda_0\right)^2 S}{\lambda_0^3}$$

$$\hookrightarrow S = 0.11998776\,\lambda_0$$

$$\underline{S = 0.12\,\lambda_0}$$

$\underline{\underline{\text{But}}}$, per Kraus, $D_0 \simeq 12N\frac{C^2 S}{\lambda_0^3}$ which yields

$$\underline{\underline{S_{Krause} = 0.15\,\lambda_0}}$$

c) Per (10-31), $HPBW(\text{deg}) = \dfrac{52\,\lambda_0^{3/2}}{C\sqrt{NS}}$

Using $S = 0.12\lambda_0$, $HPBW = \dfrac{52\,\lambda_0^{3/2}}{\frac{110}{140}\lambda_0\sqrt{9(0.12\lambda_0)}}$

$$\underline{\underline{HPBW = 63.6835^\circ}}$$

Using $S_{Krause} = 0.15\lambda_0$, $HPBW_K = \dfrac{52\,\lambda_0^{3/2}}{\frac{110}{140}\lambda_0\sqrt{9(0.15\lambda_0)}}$

$$\underline{\underline{HPBW_{K_{rause}} = 56.9602^\circ}}$$

d) Per Kraus (2-27), the directivity is

$$D_0 = \frac{4\pi(180/\pi)^2}{\theta_{1d}\,\theta_{2d}} = \frac{4\pi(180/\pi)^2}{(63.6835^\circ)^2}$$

$\underline{\underline{D_0 = 10.17188 = 10.074\ dB_i}}$ for $S = 0.12\lambda_0$ <u>very close</u>

If we use $S = 0.15\lambda_0$, we get

$$D_0 = \frac{4\pi(180/\pi)^2}{(56.9602^\circ)^2}$$

$\underline{\underline{D_0 = 12.715 = 11.04\ dB_i}}$ about a dB higher