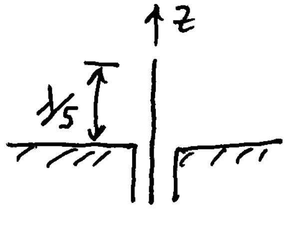
4.61 A *resonant* vertical $\lambda/\mathbf{5}$ monopole, mounted on an infinite flat Perfect Electric Conductor (PEC), is connected to a lossless transmission line. It is desired to maintain the maximum reflection coefficient inside the transmission line to 0.2. Determine the:

(a) Total far-zone electric field radiated by the $\lambda/\mathbf{5}$ monopole on and above the PEC.
(b) Input resistance of the monopole.
(c) The desired characteristic impedance of the transmission line to maintain the maximum reflection coefficient to 0.2.

- with a λ/5 monopole. For part b), check analytic answer [Hints: (4-67), (4-70), &/or (4-79)] versus NEC-2 answer [assume $a = 0.001\lambda$ and $f = 299.8$ MHz]. c) 'Resonant' implies we will assume $X_{ant} = 0$.

a) The far-zone fields of a λ/5 monopole are the same as those for a $2(\lambda/5) = 0.4\lambda$ dipole above the PEC plane.



Per (4-62a), the far-zone dipole has

$$E_\theta \simeq j\eta \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{k\ell}{2}\cos\theta\right) - \cos\left(\frac{k\ell}{2}\right)}{\sin\theta}\right]$$

Here $k\ell/2 = \frac{2\pi}{\lambda}(0.4\lambda)/2 = 0.4\pi$ and we get

$$\underline{\underline{\bar{E}_{\frac{\lambda}{5}\,monopole} = \hat{a}_\theta\, j\eta \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos(0.4\pi\cos\theta) - \cos(0.4\pi)}{\sin\theta}\right] \quad 0 \le \theta \le \pi/2}}$$

b) Per (4-106), $Z_{in,monopole} = \frac{1}{2} Z_{in,dipole}$

* Assume free space ($\eta = \eta_0 = 376.73\,\Omega$)

From notes or (4-67) & (4-70) –

$$R_{r,0.4\lambda\,dipole} = \frac{\eta_0}{2\pi}\int_{\theta=0}^{\pi}\frac{\left[\cos(0.4\pi\cos\theta) - \cos(0.4\pi)\right]^2}{\sin\theta}\,d\theta$$

$$= 36.104\,\Omega$$

MathCad

Per (4-79), this translates to an $\underline{input}$ radiation resistance of

$$R_{r,in,0.4\lambda\,dipole} = \frac{R_{r,0.4\lambda\,dipole}}{\sin^2(0.4\pi)} = 39.916\,\Omega$$

b) cont.

Therefore, for a λ/5 monopole, we get

$R_{r,in,\lambda/5\ monopole} = \frac{39.916}{2} = \underline{\underline{19.958\ \Omega}}$

NEC-2 input

```
CM EE 483 Problem 4.61b (4_61b_lambda_5.txt)
CM This file is used to determine the radiation resistance of a
CM 0.4*lambda PEC dipole antenna that is
CM center driven at 299.8 MHz lambda = 29.98 m).
CM radius = a = 0.001(lambda) = 0.001 m
CM length = l = 0.4*lambda = 0.4 m
CM Used 51 segments (del/a ~ 8).  DRIVEN SEGMENT IS #26.
CE
GW 1 51 0.0 0.0 -0.2 0.0 0.0 0.2 0.001
GE 0
EK 0          ! Use extended kernel in simulation
FR 0 1 0 0 299.8 0.0
EX 0 1 26 00 1.0 0.0
XQ 0
EN
```

NEC-2 output excerpt

```
- - - - - - FREQUENCY - - - - - -
FREQUENCY= 2.9980E+02 MHZ
WAVELENGTH= 1.0000E+00 METERS
<snip>
                    - - - ANTENNA INPUT PARAMETERS - - -
TAG SEG.  VOLTAGE (V)   CURRENT (AMPS)        IMPEDANCE (OHMS)  <snip>
NO. NO.    REAL        IMAG.       REAL        IMAG.       REAL   <snip>
1 26 1.00E+00 0.00E+00 2.14053E-03 6.73117E-03 4.29046E+01-1.34919E+02 <snip>
```

For NEC-2, $R_{\text{in},0.4\lambda,\text{dipole}} = 42.9046\ \Omega$ $\Rightarrow$ **$\underline{R_{\text{in},\lambda/5,\text{monopole}} = 21.452\ \Omega}$.**

Decent agreement w/ theory.

c) Assume $Z_{\text{in}} \sim R_{\text{in}} = 19.958\ \Omega$ for a resonant λ/5 monopole. The reflection coefficient is

$$|\Gamma| = \left|\frac{Z_{\text{in}} - Z_C}{Z_{\text{in}} + Z_C}\right| = \left|\frac{19.958 - Z_C}{19.958 + Z_C}\right| = 0.2 \quad \Rightarrow \quad \frac{(19.958 - Z_C)^2}{(19.958 + Z_C)^2} = 0.2^2 .$$

After some algebra, $19.958^2 - 39.916 Z_C + Z_C{}^2 = 0.2^2\left[19.958^2 + 39.916 Z_C + Z_C{}^2\right]$ and $(1-0.2^2)Z_C{}^2 - 39.916(1+0.2^2)Z_C + (1-0.2^2)19.958^2 = 0$.

Solving the polynomial on my calculator yields $\Rightarrow$ **$\underline{Z_C = 13.305\ \Omega \text{ or } 29.937\ \Omega}$.**