Salt-Water Antenna

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Project Summary

The salt-water antenna acts as a quarter wavelength monopole. The water stream, which is produced by a pump, is set to a quarter of the wavelength of the radio signal being received. The electromagnetic field from the transmitted radio wave induces a current on the salt-water stream. The current on the stream then creates a magnetic field that is coupled with the coil and induces a voltage within the coil. That voltage is then sent through a coaxial cable into a receiver that can demodulate and display the signal.

The two theorems that govern the antenna’s functionality are:

Faraday’s Law
\[ \nabla \times E = -\frac{\partial B}{\partial t} \]

Ampere’s Law
\[ \nabla \times B = \mu_0 \mu_r \frac{\partial}{\partial t} J_f + \frac{\partial D}{\partial t} \]

Coil:
The magnetic field that is produced from the water stream generates magnetic flux in the coil which creates a voltage on the coil wire.

Purpose:
The salt-water antenna was part of a senior design project aimed at optimizing the hardware and functionality of a previous antenna design.

Network Analyzer:
Acts as a wideband receiver. It is used to receive, demodulate, and display radio signals received by the antenna.

The height of the water stream is determined by the equation:

\[ L = \frac{c}{4f} = \frac{\lambda}{4} \]

c = speed of light
f = radio frequency
\lambda = signal wavelength

Coil:
The magnetic field produced in the coil:

\[ B = \left( \mu_0 \mu_r I_1 \right) / 2\pi r_{eff} \]

\[ \mu_0 = 4\pi \times 10^{-7} ; \quad \mu_r = 12,000 \]

I_1 = current induced by the radio wave.

The magnetic flux in the coil is:

\[ \Psi_m = \left( \mu_0 \mu_r I_1 \right) A / 2\pi r_{eff} \]

The voltage in the coil:

\[ V_R = -\frac{\partial}{\partial t} \int_0^L \left( \mu_0 \mu_r J \right) A N / 2\pi r_{eff} \]

N = # of turns on the coil.

Proportional Solenoid Valve (PSV):
Controls the height of the salt-water stream by means of a voltage controlled piston.

Water Pump:
Produces the stream of salt-water that is used to receive the radio signals.