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Memo 11

The Electric-Dipole-Fed Reflector

In [4] we describe the general concept of a dispatcher, involving a switched oscillator [3] driving some kind of antenna (e.g. a TEM horn or such a horn feeding a reflector). In this memo we describe another antenna concept.

Figure 1 shows a special kind of dipole-fed reflector. The quarter-wave (in the dielectric medium) oscillator is connected to an antenna of approximately a half-wave long (in air or SF_6). The half wavelength makes the antenna element resonant at the same frequency as the oscillator. Figure 2 shows the approximate voltage and current distribution. In a simple (but approximate) transmission-line model the characteristic impedance $Z_c^{(0)}$ of the oscillator section is much less than $Z_c^{(a)}$ of the antenna section.

The oscillating antenna element might be of circular cylindrical shape, from the oscillator might be better to avoid electrical breakdown. So this might look like an equivalent asymptotic conical dipole (ACD) [1, 2]. In addition near the connection to the source there might be some special insulating dielectric medium (e. g. oil, polyethylene) to handle the high electric fields there.

For greater fields at a distance one needs some significant antenna gain. This is efficiently accomplished by a paraboloidal reflector with focus at the dipole-like element. Noting the polarization of electric-dipole fields the reflector should not extend to the left of the xy plane (or $z = 0$ plane), at least above the dipole (near the $+y$ axis). So one might choose

$$\begin{aligned} \frac{\text{focal length}}{\text{diameter}} &\equiv \frac{F}{D} = 0.25 \\ \frac{\text{focal length}}{\text{radius}} &\equiv \frac{F}{a} = 0.5 \end{aligned} \qquad (1)$$

Larger values intercept less of the power radiated by the dipole, so the above may be a reasonable choice. One could extend the reflector to $+z$ values near the ground plane, and truncate top portions of the reflector (near the $+y$ axis) which do not intercept much power.

Consider now the size of the reflector as parameterized by the focal length F. Near the ground plane we can imagine an image dipole near $z = -2F$ with opposite

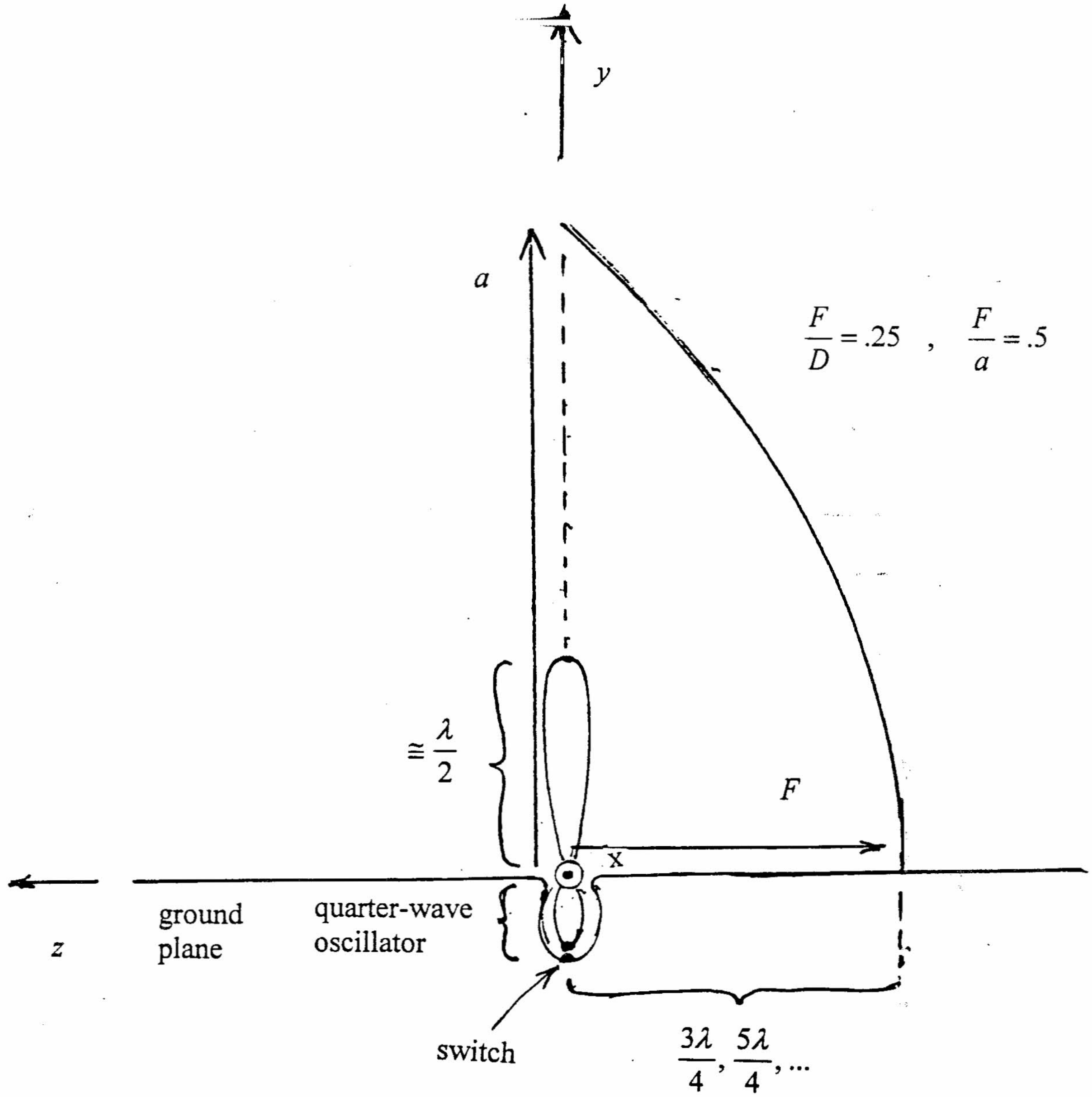

Fig. 1 Electric –Dipole-Fed Reflector

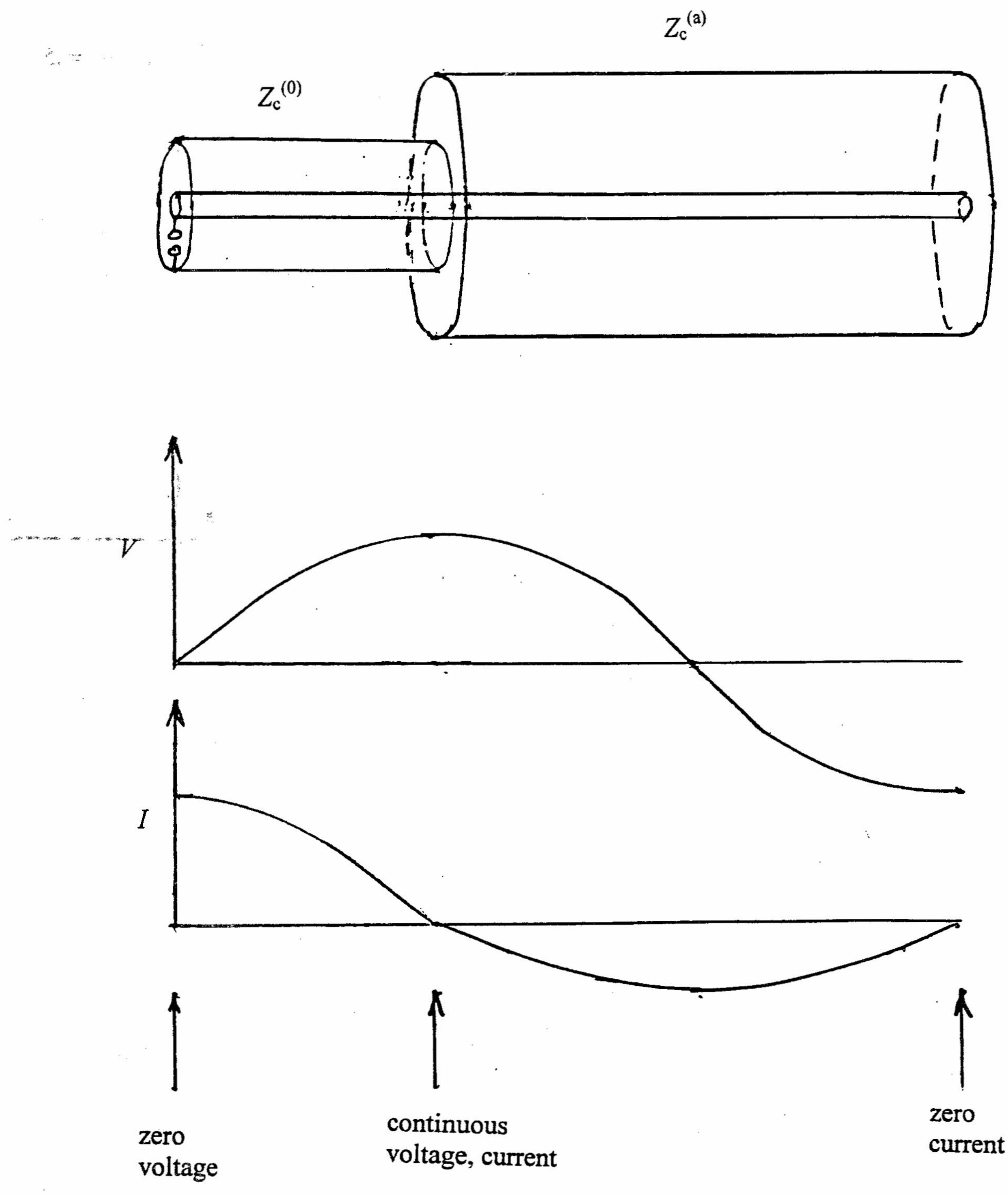

Fig. 2 Approximate Transmission-Line Model

current (due to negative reflection at the conducting reflector). In the forward direction ($+z$) of the reflector beam the forward radiation from the dipole will add to the reflector beam by judicious choice for F. To make the two waves add in phase we need

$$
\begin{aligned}
&F = \frac{2n+1}{4}\lambda \\
&\lambda = \frac{c}{f} = \text{wavelength} \\
&f = \text{frequency} \\
&c = \left[\mu_0 \varepsilon_0\right]^{-1/2} = \text{speed of light} \\
&n = \text{integer} \geq 0
\end{aligned}
\qquad (2)
$$

Next, what is the optimal choice for n? Since $n = 0$ implies $a \cong \lambda/2$ the touching the top of the dipole element (and giving only low gain). So let as constrain

$$
\begin{aligned}
&n \geq 1 \\
&F = \frac{3\lambda}{4}, \frac{5\lambda}{4}, \ldots
\end{aligned}
\qquad (3)
$$

This gives only a rough description. The details of the switched oscillator and dipole element need to be considered for accurately matched resonant frequencies. This in turn will affect the reflector design. Then there are the high voltage and switching considerations.

References

1. C. E. Baum, "An Equivalent-Charge Method for Defining Geometries of Dipole Antennas", Sensor and Simulation Note 72, January 1969.

2. G. D. Sower, "Optimization of the Asymptotic Conical Dipole EMP Sensors", Sensor and Simulation Note 295, October 1986.

3. C. E. Baum, "Switched Oscillators", Circuit and Electromagnetic System Design Note 45, September 2000.

4. C. E. Baum, "The Dispatcher", Microwave Memo 10, July 2000.