Currents on Sinusoidal Surfaces of Small Period

Gary S. Brown & Thaddeus H. Black
Bradley Department of Electrical & Computer Engineering
Virginia Tech, Blacksburg, VA 24061

In studying the scattering from rough surfaces, it is normal practice to ignore the effects of surface roughness components whose periods are less than one-half the electromagnetic wavelength. This practice is based on the prediction provided by perturbation theory that such surfaces are essentially specular in their scattering. However, when the surface roughness is comparable to the electromagnetic wavelength in height but less than one-half the electromagnetic wavelength in period, perturbation theory no longer applies. In this situation, two questions arise; (1) how does the current behave under such circumstances and (2) is the scattered field specular? The purpose of this paper is to provide insight into these questions by studying the current and scattering produced by a perfectly conducting sinusoidal surface of moderate height ($0.637\,\lambda_o$) and small period ($< 0.5\lambda_o$).

When the surface is perfectly flat, the current is $2\hat{n}\times\vec{H}^i$ where $\hat{n}$ is the normal to the surface and $\vec{H}^i$ is the incident magnetic field. The Fourier transform of this current is an exact replica of the incident but redirected into the specular reflection direction. For a sinusoidal rough surface with a period less than one-half the electromagnetic wavelength, the scattered field should be approximately equal to the flat-surface reflected specular field independent of the amplitude of the roughness. As the period of the surface becomes smaller than $0.5\lambda_o$, the scattered should approach the flat-surface specular field but the current cannot be the same as the flat surface current. We have verified this fact for both TE and TM polarizations for one-dimensional, sinusoidal, perfectly conducting surfaces of $0.637\,\lambda_o$ peak amplitude and periods varying from $\Lambda_S = 0.5\,\lambda_o$ to $0.2\,\lambda_o$.

For TE polarization, we found the current to be nonzero only on the crests of the sinusoidal surface. The support of the current is $\approx 0.5\Lambda_S$ for $\Lambda_S = 0.5\lambda_o$ and decreases as the surface period becomes smaller. Conversely, the amplitude of the current on the crests of the surface increases as the surface period decreases. While it appears that the current is behaving much like a delta-function, i.e., the product of the support and the amplitude of the current is a constant, such is not the case. What is constant is the product of the current support, its amplitude, and the number of current spikes per electromagnetic wavelength. In addition, the current for the TE case is such that the scattering from the surface appears to be coming from the surface crests; this is consistent with the failure of the current to penetrate the troughs of the surface.

For the TM polarization the current appears to be distributed over both the crests and troughs of the sinusoidal surface. However, the current in the trough region seems to be responsible for the visible scattered field while the current on the crests appears to be too oscillatory to contribute to the visible scattered field.