Mitigating interference in USATs by using different illumination distributions on the antenna.

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In light of new developments in modulation and coding such as the ones supported by DVB-S2 and the use of Ka band which uses spot beams where more energy can be concentrated, smaller antennas can be used.

Ultra Small Aperture Terminals consist of antennas with apertures below 1 m. radius, SSPAs up to 4 Watts and Rf equipment for the conversion to and from intermediate frequency (IF) normally in the range of 70 MHz

USATs can be used in fixed services where real state is an issue, not mentioning that sub one meter antennas require minimum regulation for their installation. Another great advantage for USATs is on mobile platforms where real state is inherently limited; such is the case for military applications for field vehicles, aircraft and vessels. Similar applications can be extended to the commercial realm like in recreational vehicles (RVs) and commercial vessels.

The trend for the development of new spacecraft points to a greater use of Ka-band and more powerful satellites which will allow for the use and growth of the USATs base.

However this brings up an inherent problem in satellite communications and specially when using small aperture antennas. That is interference to and from adjacent satellites. All links must comply to limitations set in FCC Title 47 §25 where specific spectral densities and power flux densities must be met.

In this paper we will discuss one of the techniques that can be used to help mitigate such interference. Antenna radiation patterns behave in specific ways depending on the antenna geometry and how the reflector is illuminated by the feed. The electric field change, transversal to the area of the antenna is called the taper.

For a theoretically uniform illumination, the electric field is constant and the aperture taper efficiency is 1. If the feed is designed to cause the electric field to decrease with distance from the center, then the aperture taper efficiency decreases but the proportion of power in the main lobe increases. In general, maximum aperture taper efficiency occurs for a uniform distribution, but maximum beam efficiency occurs for a highly tapered distribution.

For uniform illumination, the half power beamwidth is 58.4° l /*D* and the first side lobe is 17.6 dB below the peak intensity in the boresight direction. In this case, the main lobe contains about 84 percent of the total radiated power and the first side lobe contains about 7 percent.

If the electric field amplitude has a simple parabolic distribution, falling to zero at the reflector edge, then the aperture taper efficiency becomes 0.75 but the fraction of power in the main lobe increases to 98 percent. The half power beamwidth is now 72.8° l /*D* and the first side lobe is 24.6 dB below peak intensity. Thus, although the aperture taper efficiency is less, more power is contained in the main lobe, as indicated by the larger half power beamwidth and lower side lobe intensity.

The normalized antenna pattern with taper “tpr” is given by,

$$f(\phi) = \left| 2^{tpr+1}(tpr+1)! \frac{J^{1}_{tpr+1}(\phi)}{(\phi)^{tpr+1}} \right|$$

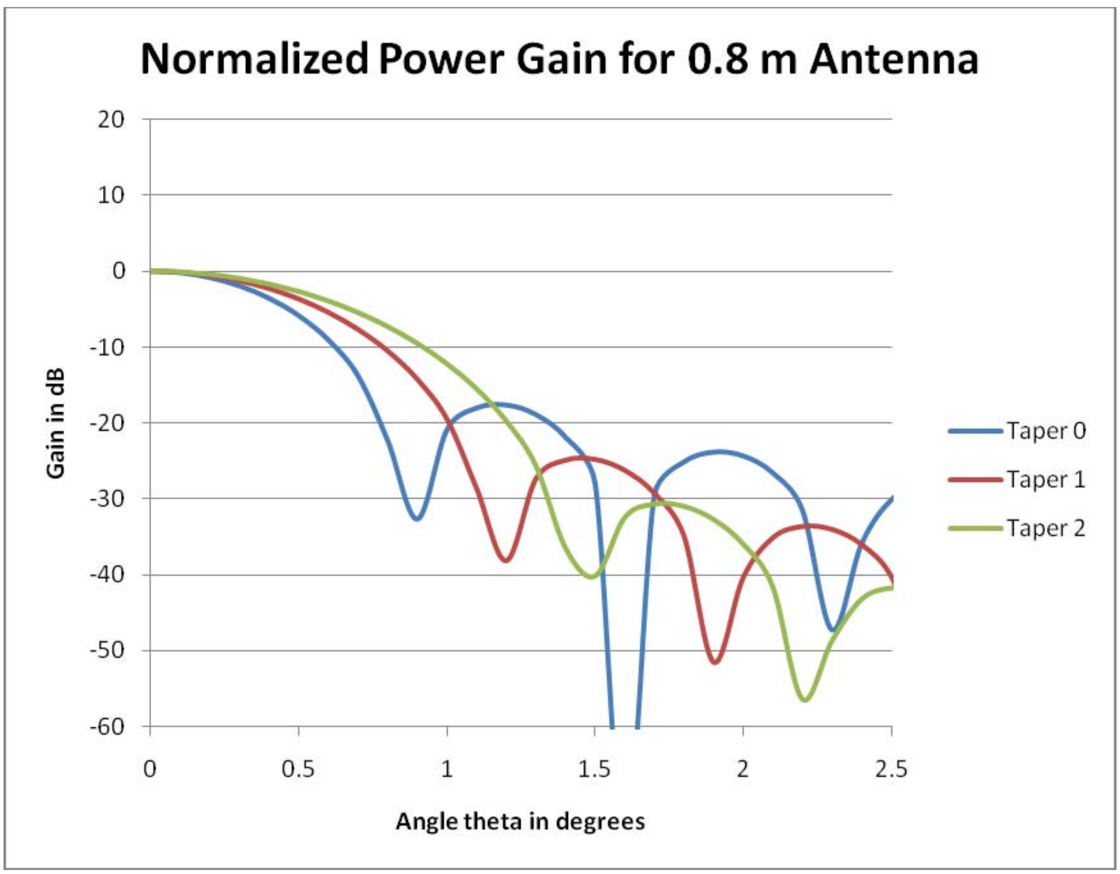
This implies that the gain of the antenna is given by,

$$G(\phi) = G_{\max}\left[f(\phi)\right]^2 = G_{\max} \cdot \left| 2^{tpr+1}(tpr+1)! \frac{J^{1}_{tpr+1}(\phi)}{(\phi)^{tpr+1}} \right|^2$$

This in dB is given by,

$$G^{dB}(\phi) = G^{dB}_{\max} + 10.\log_{10}\left[f(\phi)\right]^2 = G^{dB}_{\max} + 20.\log_{10}\left|2^{tpr+1}(tpr+1)!\frac{J^{1}_{tpr+1}(\phi)}{(\phi)^{tpr+1}}\right|$$

We can see that by using different tapers for illuminating the antenna, the side lobes can be reduced, but we concentrate more energy on the main lobe therefore generating a wider beam, as we can see in the next picture.



Taper Value	Sidelobe Level	Illumination Distribution
0	-17.6 dB	Uniform
1	-24.6 dB	Parabolic
2	-30.6 dB	Parabolic Squared

By using a taper that uses a Parabolic Squared distribution the side lobe can be reduced by almost 13 dB from a uniform illuminated antenna; on the other hand more energy is concentrated in the main lobe, generating a wider main lobe.

Current satellites are spaced at 2 degrees from each other; in our example we are using a 0.8 m aperture antenna, which can be used to bring down the energy on the side lobes allowing for more interference margin under the mask specified by the FCC. We can see how the first null of this antenna falls at 1.5 degrees off axis, clearing the first adjacent satellite. For this specific antenna we accomplish to reduce the side lobes and clear the adjacent satellite mitigating this way potential interference due to the small aperture of the terminal.