Slotted Coaxial Arrays Provide Lightweight, Economical Antenna Alternatives to Panel Arrays

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***Abstract*—Antenna patterns and reliability of UHF slot array and panel array antennas are compared.**

***Index Terms*—Antenna Arrays, Antenna Patterns**

I. Introduction

How can I improve my station's transmitted and received signal? Can I boost on-air reliability? Can I add a new antenna to an existing broadcast tower?

Selecting a terrestrial television broadcast transmission system presents some difficult decisions. The slotted coaxial array antenna system is a better choice than a panel array in reliable, high-performance television broadcast. This article discusses each antenna type and compares coverage performance, tower loading effects, and reliability.

II. Antenna Configurations Explained

Television broadcast antennas consist of radiating elements assembled to produce a directive radiation pattern. The layout of the radiators and feeding network shape the pattern and focus the broadcast signal toward the viewing population. Typical antenna configurations include panel array antennas, slotted coaxial transmission line arrays, and hybrid combinations of both [1].

Antenna configuration may be understood by how the signal is distributed to the radiating elements. An array constructed of slots cut in the outer conductor of a transmission line distributes the signal to each radiating element without external power dividers or a cable network. The input signal feeds into a slot array at a single point.

In contrast, in a panel array, a network of external power dividers and transmission lines feeds each element. A large support structure holds each panel and houses the feeding network. The final power division step is often integrated into each panel, so each panel actually contains two elements. The feeding network may be simplified by integrating more power division steps into subarrays. For example, subarrays may be constructed of 4-element arrays of slotted transmission line that are then assembled into a larger array and fed by a simplified external network.

The fundamental construction of the panel and slotted coax array antennas gives insight into the particular strengths and weaknesses of each. The relative size of the two antennas may be seen in Figure 1. Panel antennas are atop the rear pylons while slotted coax arrays top the pylons in the foreground. Though the panel array is a broadband, multi-user antenna, its mechanical, electrical, and reliability characteristics are inferior to a slotted coax array antenna.

Figure 1: Panel and Slotted Coax Arrays on the Sears Tower, Chicago, IL

III. Electrical and Mechanical Comparisons

Panel antennas deliver broadband transmission, but at the expense of performance. In the design of broadband panel arrays, VSWR is optimized at the expense of radiation pattern performance. Radiation patterns in both azimuth and elevation planes do not provide the best coverage possible. In mounting the panels around the support mast, each radiator is spaced several wavelengths apart, causing interference between the panels. This interference brings rise to nulls that degrade the azimuth pattern (See Figure 2.) and the transmission of the broadcast signal to the viewer. The radiating elements are spaced less than a wavelength apart around a slotted coax array, and the troublesome interference is avoided, improving the transmitted signal by several dB in some areas.

Additionally, the positioning of panel elements around a large support mast restricts the ability to shape the azimuth pattern. A slotted coax array allows the shaping of the azimuth pattern to concentrate the signal only on the areas of significant population, areas that may differ completely from other broadcasters sharing a panel array. This feature is most useful in coastal, mountainous, or border regions where vast amounts of energy and capital may be wasted broadcasting to unpopulated areas. Because antennas are passive devices, reducing the signal transmitted to unwanted regions not only saves you money, it increases the signal transmitted to desirable areas.

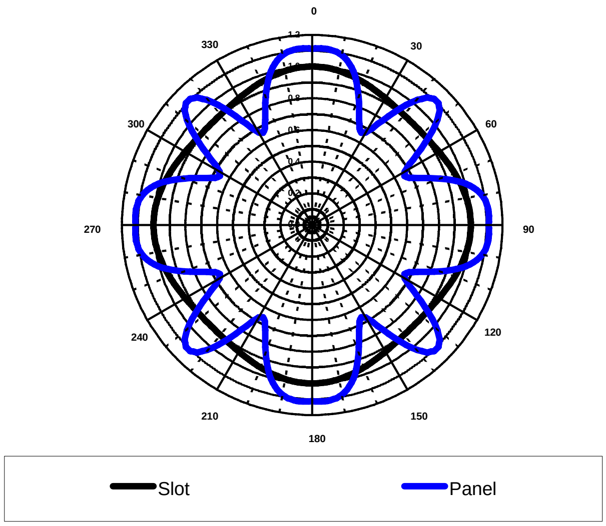

Figure 2: Azimuth Pattern Comparison

Also, radiation in the elevation plane (corresponding to the signal received on the ground traveling radially outward from the antenna) is virtually null-free in a slotted coax array [2], while the panel exhibits severe signal degradation at several points (See Figure 3.). Nulls in the elevation pattern represent an area of viewers in a ring around the transmitter tower who receive a weak or degraded signal. The nulls in the elevation pattern are affected by the spacing of the radiators along the array and the power delivered to each radiator. Panels positioned along a support mast are restricted by the size of the panel element while slots in a coax array may be individually positioned to improve the pattern. The power delivered to each radiator in a panel array is typically uniform in magnitude which increases the nulls. Again, slotted coax arrays vary the power delivered to each element to decrease the nulls and improve signal transmission to those areas.

Slotted coax arrays are electrically more efficient than panel arrays because they provide superior radiation patterns in a physically smaller area. Panel arrays exceed slot arrays by approximately three wavelengths in both directions. Thus, a panel array is about 15% longer and four times wider than a top-mounted slotted coax array, typically totaling five times greater cross-sectional area and wind load. In the case of a side-mounted, low-power slotted coax array, the panel can be up to 15 times wider with over 18 times greater cross-sectional area.

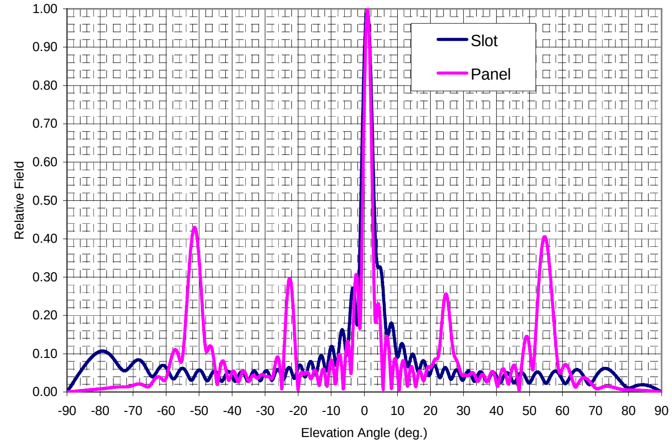

Figure 3: Elevation Pattern Comparison

The feeding transmission line must also be included in wind load computations. A multi-user panel antenna requires a large diameter rigid transmission line to handle the combined power of all contributing signals. In contrast, smaller coax cable, typically half the diameter, supplies the power to a slot antenna. The larger transmission line results in twice the cross-sectional area and wind load. For a typical 100m tower and UHF antenna, the total area of the panel antenna and transmission line is three to four times greater than the slotted antenna and coaxial cable system. Of course, a more realistic comparison would be to replace one panel array with several slotted array antennas. The cross sectional area and wind load still come out lower with the slotted coax array. The panel does become more advantageous in taller towers because of the transmission line area, though an additional run of coax may be avoided altogether with installation of a tower-top diplexer with the existing transmission line.

The smaller size of a slotted coax array and its transmission line makes it ideal for adding a transmission facility to an existing tower structure. Typically a tower will not handle the additional weight and wind-load of a large, top-mounted panel array and transmission line. A slotted coax array may be side-mounted and fed with a small diameter transmission line to avoid any expensive tower modifications and make use of prime tower space. Optimizing the mounting location through a computer analysis of the scattering minimizes the affect of the tower components on the transmitted signal.

IV. Reliability Issues

Panel array antennas contain many parts: about four power-dividers, 70 cables, and 140 connectors feeding some 48 panels is typical. In astounding contrast to the 200-plus parts in a panel antenna, a slotted coax array boasts about six: the outer conductor, inner conductor, and four radome sections (though if each radome in the panel array is counted separately, the numbers are even higher.

This component-counting exercise simply points to the superior reliability of a slotted coax array. The probability of a serial system working correctly is the product of the probabilities of each component working correctly. If each component has the same reliability, the system reliability is simply the component reliability to the power of the number of components. If each component has a 99% reliability, a system of 100 components has a total reliability of 37% and one with six, 94%. This exponential dependence on component count is why component reduction has been the fundamental axiom in decades of system reliability measures.

Each connector in a panel array is subjected to severe environmental operating conditions: the 140 connections in the signal path are subjected to corrosive coastal climates, rain, electrical storms, ice, and thermal fluctuations. A slotted coax array has only one connection in the signal path, and all other components are completely encased inside a protective, pressurized radome. Reducing the number of components exposed to the environment improves the reliability of signals transmitted to viewers.

Broadcasting with a multi-user panel antenna has the additional disadvantage of forcing all signals off the air when maintenance is performed. With individual broadcasters owning and operating completely independent transmission systems, no such wholesale interruptions occur. This is particularly important when a regional disaster means public safety information must be on the air.

IV. Conclusions

The opportunity to expand or upgrade a terrestrial television broadcast facility should be used to switch to a fully optimized, transmission system of higher reliability. A panel array antenna sacrifices optimum coverage for a broadband multi-user system that may be appealing at first, but may actually waste capital and energy. The slotted coax array system, on the other hand, transmits a tailor-made signal and minimizes size and wind load and may be added to an existing tower. Transmission system reliability dramatically improves for a slotted coax array, achieving a trouble-free facility and received signal integrity. Clearly, the slotted coax array must be seriously considered as a system option.

References

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[2] C.A. Balanis, *Antenna Theory – Analysis and Design*, Harper & Row, New York, 1982.

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