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BROADBAND Andy Singer

High-performance antenna design

Choice of materials critical to operation

In the February issue of MRT, a previous article discussed the basics of microwave antenna design and specifically feed design and selection for parabolic microwave antennas. In this article, we will discuss design and performance basics of high performance parabolic microwave antennas. These high performance microwave antennas are a key element in high capacity point-to-point microwave links.

Microwave antenna basics

Modern microwave links are quite prevalent due to the cost effective nature of utilizing microwave point-to-point links to relay traffic compared to wire-line rental rates and fiber usage. Wireless microwave links also can serve as an excellent backup to fiber-optic links. With such a high demand for implementation of links, but limited frequency spectrum, governments have had to provide guidelines that assure pattern performance is such that interference is not caused by two links that are geographically close.

In the United States, the Federal Communications Commission has developed two categories of standards for microwave antenna performance. These are category A and category B, with A being the more stringent standard. For certain licensed links, the license holder must assure that the microwave antennas utilized meet these pattern standards.

Category A standards apply to all stations operating in areas where certain microwave frequency bands are congested, or where there is a predictable risk of interference to other stations. Stations operating in other areas may utilize category B antennas. If interference problems arise in the future, these stations may require changing to a category A standard. The standard is defined by a mask or radiation pattern envelope (RPE) that defines the specific allowable level of signal at a specific angle from bore-sight. Figure 1 is typical high performance antenna pattern with a category A mask overlay. High performance microwave antennas are required to meet these more stringent pattern requirements.

A basic schematic for a microwave antenna can be seen in Figure 2. A feed system is placed with its phase center at the focus of the parabola. Ideally, all the energy radiated by the feed will be intercepted by the parabola and reflected in the desired direction. To achieve maximum gain, this energy would be distributed such that the field distribution over the aperture is uniform. Because the feed is small, however, such control over the feed radiation is unattainable in practice. Some of the energy actually misses the reflecting area and is lost; this is commonly referred to as "spillover."

Also, the field is generally not uniform over the aperture, but is tapered: maximum signal at the center of the reflector, less signal at the edges. This" taper loss" reduces gain, but the field taper provides improved sidelobe levels. Optimum performance is generally considered to be achieved with a -10 dB edge illumination taper.

In 1988, Radio Waves introduced one of the first hybrid-Cassegrain (US Patent # 5,943,024 "Feed Assembly Waveguide Interface") sub-reflector type feeds for high frequency commercial microwave antennas. This design is a modification of the classical Cassegrain feed system. In a Cassegrain system a feed is mounted in the dish and energy is radiated towards a sub-reflector. A back-fire feed does not incorporate the dielectric lens and suffers from poor side lobe performance relative to the Hybrid-Cassegrain style feed. This hybrid-Cassegrain design has several benefits over the button-hook design, including higher antenna efficiency, a lower antenna profile and lower wind loading. A high performance microwave antenna will also utilize a shroud, absorber and a radome in addition to the components utilized in a basic standard performance microwave antenna.

High-performance antennas

Shrouds are added to parabolic microwave antennas to reduce the sidelobe level being radiated. They appear to look like "drums" or a "tunnel" that has a diameter about the same as the parabolic antenna and is bolted on to the surface.

A picture of a high performance antenna utilizing a shroud can be seen in Figure 3.

The shroud is also lined with flat absorber material to enhance pattern performance. Absorber material can be utilized for a number of applications, including reducing reflections in anechoic

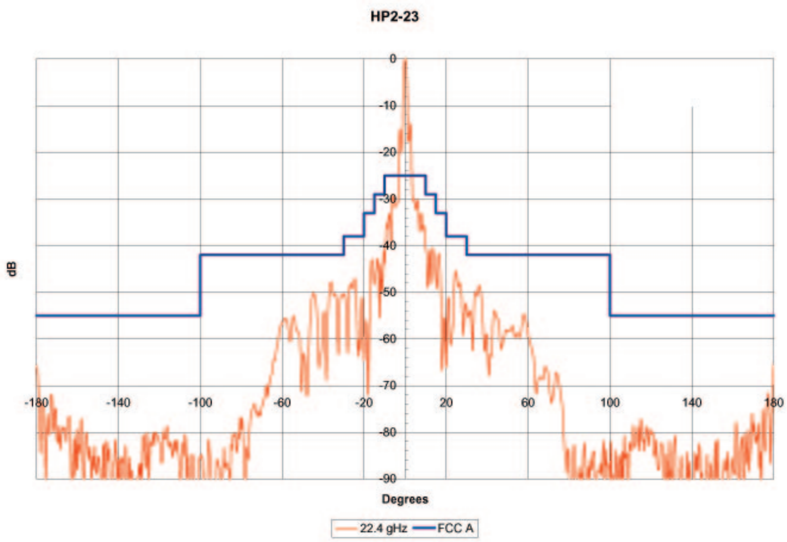

Fig.1. Typical high-performance antenna pattern with a category A mask overlay.

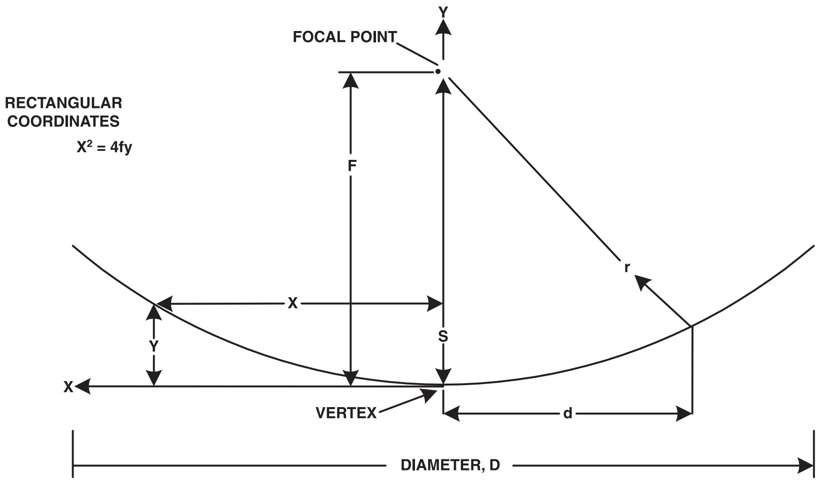

Fig.2. Basic schematic of microwave antenna.

Fig.3. High-performance antenna with a shroud.

chambers, reducing the radar cross section of objects, shielding improvement of enclosures and for improving microwave antenna patterns. Absorber material is generally manufactured from a carbon loaded foam material. By lining the inside of the shroud with absorber material side lobe and back lobe radiation can be dramatically decreased. Typical reduction in back lobe radiation can be on the order of 12 dB.

Most manufacturers of high performance microwave antennas also offer an ultra high performance version of these antennas. A high performance antenna may have a typical front-to-back ratio of say 64 dB, where the ultra high performance version would have a front-to-back ratio of 70 dB.

The final additional component that is added to create a high performance microwave antenna is the radome. The radome serves two purposes. One is to protect the inside of the antenna from the elements. The second purpose is to reduce what would otherwise be significant wind loading on the antenna due to the shroud "catching" wind if not for the radome. Radomes for high performance microwave antennas are generally made from either nylon or Teflon coated fiberglass. Manufacturers normally ship nylon radomes with the antenna and the customer can upgrade for an extra charge to a Teflon radome. The standard nylon radomes are suitable for lower frequencies and areas with minimal rain rates. At higher microwave frequencies (10 GHz and above) rain can sheet on a nylon radome and cause significant attenuation of the signal level. In heavy rain situations values of 15 dB or more attenuation have been reported with nylon radomes. At a rain rate of 10mm/hr several dB of attenuation at 10 GHz has been observed with materials that do not exhibit good levels of hydrophobicity. By using Teflon or other specialized coatings that provide a high contact angle between the surface and water droplets on the radome, a hydrophobic surface is provided that prevents water from filming on the radome.

The extra cost for the Teflon coated radome material is a wise investment at higher microwave frequencies in areas where heavy rain can be expected.

Ultra high performance

Most manufacturers of high performance microwave antennas also offer an ultra high performance version of these antennas. Generally the difference from the high performance antenna is that the ultra high performance version utilizes a specially designed feed system that improves the side lobe radiation and in particular improves the front-to-back ratio by several dB. A high performance antenna may have a typical front-to-back ratio of say 64 dB, where the ultra high performance version would have a front-to-back ratio of 70 dB. The ultra high performance antenna is required on paths that require the maximum possible interference reduction off the main beam to minimize frequency congestion.

Another specific feature that some manufacturers offer is a high cross polarization discrimination version. These antennas utilize a specially designed and tuned feed system that provides for cross polarization discrimination of about 40 dB. This level of cross polarization discrimination is only achieved near the boresight of the antenna. These antennas are utilized on specific high capacity digital links that require very high isolation between polarizations. If this high level of cross polarization discrimination is not required, the added cost provides no system benefit.

When selecting high performance microwave antennas one should consider the company's reputation, the length of the warranty provided on the product and a review of the antenna's patterns. An antenna needs to be chosen which assures that interference is minimized on a particular link.

Clearly high performance versions of microwave antennas assure that stringent pattern requirements are met for microwave system links. The choice of materials utilized is critical and the investment in a high quality antenna will provide superior link performance for years to come. ■

Andy Singer is executive vice president and general manager of Radio Waves Inc.