Use of Shaped Lens to Control Spillover in Reflector Antennas

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Abstract - In the design of Reflector antenna systems, the control of sidelobes caused from spillover of the primary pattern presents a major design challenge. The design of the illumination pattern of the reflector system is key to designing a reflector system that optimizes gain while minimizing the level of the sidelobes. The reduction of spillover sidelobes requires the use of large aperture feeds that provide a highly tapered illumination pattern. One of the traditional methods for accomplishing this design is the use of large aperture conical or corrugated horns for the feed. These designs are extremely effective for single band feeds but present problems when needed to operate over an extended frequency band. The approach presented in this paper attempts to illustrate a broadband solution to the feed pattern shaping design. The use of a doubly shaped lens placed at the aperture of a multi-band feed is investigated. The investigation is performed on a parabolic antenna system. The first surface of the lens transforms the radiation pattern into a plain wave exiting the feed aperture. The second surface then refocuses the radiation to the focal point of the reflector's parabolic surface. This approach allows greater control of the primary pattern and allows the illumination pattern to be optimized for the antenna system design.

INTRODUCTION

Current SATCOM antenna systems operate in only one frequency band at a time. Most systems provide the capability of operation in the three main frequency bands, C, X, and Ku. These systems require the exchange of feed components and system electronics to operate in the different bands. A feed has been developed that allows operation in all three bands through a single feed. Basically, the feed design consists of a formation of coaxial concentric waveguide cavities operating in the $TE_{1,1}$ mode. This mode, normally used in circular waveguide feed design, is also amenable for use in coaxial waveguide. The frequency of operation of this mode, in coaxial waveguide, is dependent on the dimensions of the inner and outer radius of the waveguide, the cutoff wavelength being roughly equal to the mean circumference of the inner and outer cylinders. [1]

The coaxial cavity feed is ideal for SATCOM applications because the feed produces high efficiency, nice symmetrical illumination patterns and coincident phase centers in all bands. Based on experience with this type of antenna, the feed has proven to be an ideal multi-band illuminator for parabolic reflectors and therefore could be used in many applications, civilian as well as military, which require multi-band operation. The feed was developed under an Army Small Business Innovative Research Phase I Program. [1]

The main disadvantage of the current feed design is the broad beam patterns that it produces. This broad feed limits the number of antenna systems that can utilize the feed. The broad pattern produces high edge illumination of some reflector systems, which produces high sidelobes particularly in the spillover regions. Several techniques were investigated to attempt to taper the illumination pattern for various antenna systems. Many of the techniques involved varying the aperture diameter, and using different styles and sizes of conical horn structures on the aperture. Many of these designs tended to make the feed illumination pattern frequency dependent. So the illumination may be ideal at Ku-Band but may not be ideal for C-Band.

The investigation migrated toward the use of a lens on the aperture of the feed to shape the pattern to any desired illumination angle. The fact that by changing the lens we could achieve any illumination pattern is a highly desirable property. With this property we could essentially adapt the feed to be used by any currently available antenna system. This paper describes the design process used to develop the lens.

Some work has been completed in this area including [3]. The techniques described in [3] were very similar to the philosophy that we followed in our design. However as is stated later in this paper we were concerned with the theory of feeding a reflector with a single lens and proceeded to design a two surface lens for our application.