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Low Cost, Electronically Steered Phased Array for General Aviation

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ABSTRACT

This paper describes a multi-faced, phased array antenna developed for general aviation satellite communications applications. The antenna design satisfies all INMARSAT Aeronautical SDM requirements. Unique features of this antenna include an integral LNA and diplexer, integral phase shifters which are shared among the array faces, a serial beam steering interface and low manufacturing cost.

INTRODUCTION

Canadian Astronautics Limited (CAL) has developed a high gain, electronically steered antenna for aeronautical satellite communications. This development is part of a larger program which is producing a low cost terminal for General Aviation applications [1]. The program is jointly sponsored by Transport Canada, Supply and Services Canada and Communications Canada.

The antenna provides coverage in the full upper hemisphere by means of a five faced phased array. all of the array faces and control electronics are enclosed in a single compact, lightweight, aero-dynamic radome. The radome also houses the low noise amplifier and diplexer. A photograph of the antenna system with its radome removed is given in Figure 1. The diplexer, controller and low noise amplifier are shown in Figure 2.

Antenna Design

An obvious advantage of housing the LNA and diplexer within the radome is that losses are minimized. This arrangement allows a system G/T of -13dB/k to be achieved with a very compact, low cost antenna. The antenna system, without radome, is 1.27m x 0.15m x 0.31m at its base. With the configuration chosen by CAL there is no need for an additional electronics unit inside the bulkhead. All cables connecting to the antenna go directly to the transceiver unit which is mounted in an avionics equipment rack.

The antenna controller receives beam steering commands from the transceiver by means of a single serial control line. On each of the three phase scanned arrays the beam position may be stepped in 0.5 degree increments. The system incorporates two modes of beam steering. In one mode steering is derived from the inertial navigation system. In the second mode a sequential lobing algorithm is implemented. This algorithm dithers the antenna beam pointing in order to maximize a signal quality estimate obtained from the modem.

The antenna system uses a total of twelve, 4-bit phase shifters. These are shared by three of the array faces (top, port and starboard). The remaining two faces are fixed beam arrays. PIN diode switches allow rapid, hot switching between the array faces. State-of-the-art, low losses have been achieved in the switches and phase shifters. The average loss is 0.3 dB per bit.

Microstrip radiating elements have been used on all array faces. The use of a thick, low dielectric constant substrate provides broad bandwidth while maintaining a very low mass. A unique microstrip patch design results in a very broad beamwidth allowing scanning to ± 70° from broadside on each of the 12 element arrays.

Typical azimuth and elevation patterns are given in Figure 3 and 4 respectively. Low sidelobes are obtained even at large scan angles through the use of a random phase added algorithm and Taylor weighting.

[1] R. Matyas et.al., "An Aircraft Earth Station for General Aviation", in these Proceedings.

Figure 1 Antenna System Without Radome

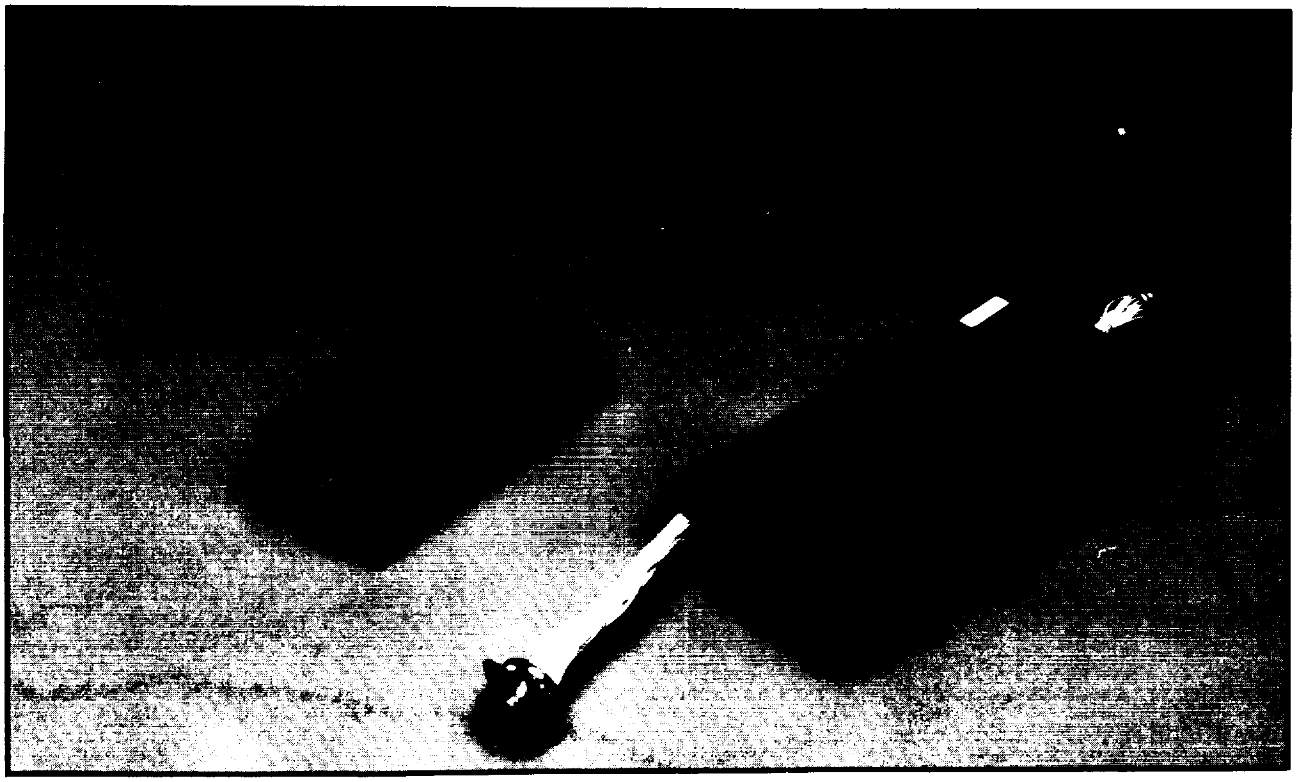

Figure 2 Diplexer, Controller
and LNA

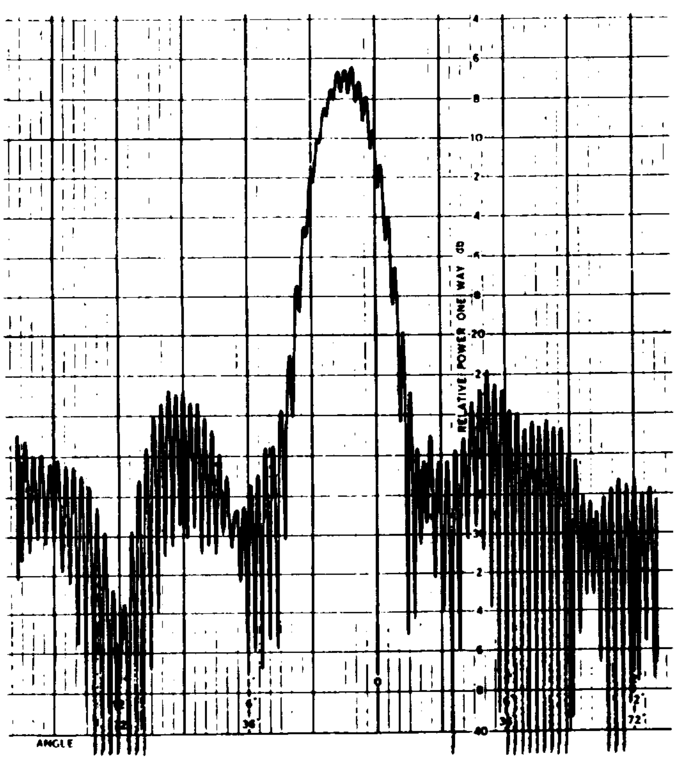

Figure 3 Azimuth Pattern of Phased Array at Broadside

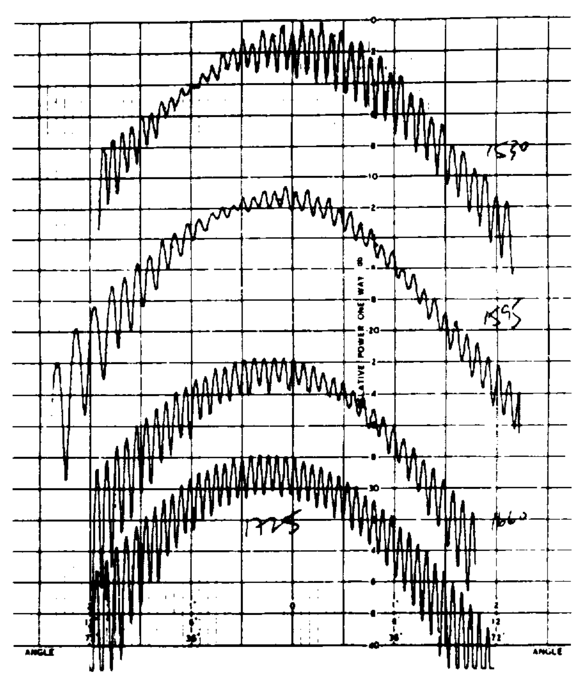

Figure 4 Elevation Pattern of Phased Array