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Frequency selective lens antenna.

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A variant of the hemispherical microwave lens antenna is reported where the ground plane region is modified through use of a frequency selective surface. This allows discrimination of frequencies by two closely spaced primary feeds. A scale model is reported operating at 12 GHz and 30 GHz.

Introduction: In satellite communications, antenna ground terminals may be required to operate at various frequencies, for example a Ku band downlink (in region 10-12 GHz) and two-way communications at Ka band (30 GHz uplink, 20 GHz downlink). In general it is difficult to realise a single primary feed which can operate over these three bands, and a typical solution would entail use of two primary feeds and a frequency selective surface (FSS) in the focal region of a reflector. However, where a scanning antenna is required, e.g. on a moving vehicle, or for tracking multiple satellites, a hemispherical lens antenna offers advantages, in which case a Luneburg-type antenna might be used. Here the primary feed is placed close to the lens edge and this renders the use of a FSS problematic due to lack of space. In our proposed solution we show that the ground plane region of the hemispherical lens can be modified so that different frequency bands emerge from the lens at slightly different angles - the difference needs only be sufficiently large so as to accommodate separation of the primary feeds.

Experimental model. While the Luneburg lens is a well known technology for multi-beam and scanning antennas [1] its primary disadvantage is the complexity of fabrication, and this has often been a stumbling block which has held back a more widespread acceptance. In an attempt to simplify the lens fabrication [2] and [3] reported a two-layer lens, which comprised inner and outer layers respectively of Rexolite (ε_r = 2.53) and polyethylene (ε_r = 2.28) and outer diameter 236 mm. This lens was then used with a modified ground plane region as illustrated in Fig. 1 so as to investigate the feasibility of the concept. The FSS was a hexagonal aperture loop type, printed on a Taconic 'TLC30' substrate (ε_r = 3.0, thickness = 0.79 mm) and a mean value of dielectric constant value of 2.6 was estimated after [4] when deriving the FSS loop dimensions (inset in Fig. 1). The FSS was chosen to be transmissive at 11.5 GHz; the lower frequency of interest.

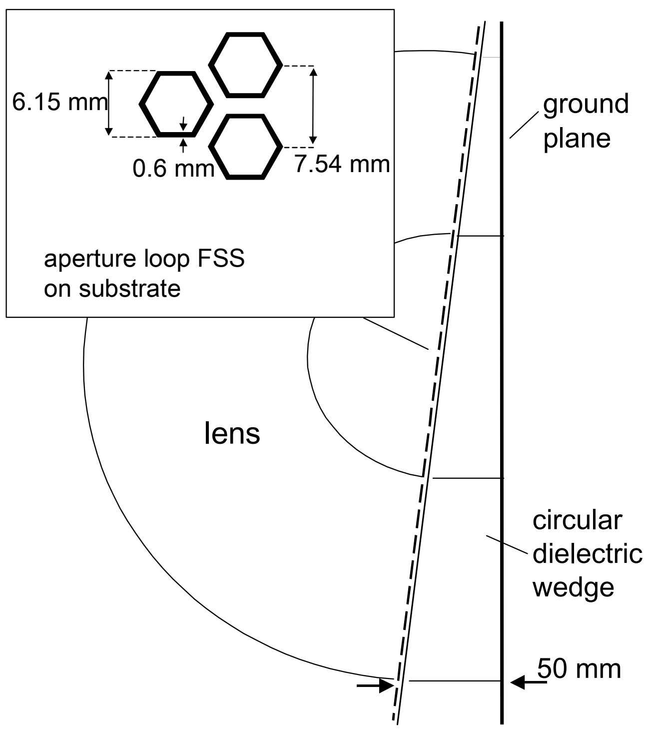

Fig. 1 Simple FSS ground plane geometry (inset: FSS pattern).

Experimental Results. The experimental arrangement is shown in Fig. 2 where the radiation patterns were measured in an anechoic chamber for two representative frequencies i.e. 11.5 GHz and 30 GHz (see Fig. 3). Maximum gain was respectively 28 dBi and 31 dBi. These figures are somewhat degraded, respectively by 2 dB and 4 dB, compared to the lens when used without the FSS. Hence, while this configuration is not optimal, it serves to demonstrate the principle of using two primary feeds with the FSS to discriminate the two frequency bands. Thus a tri-band feed may not need to be developed.

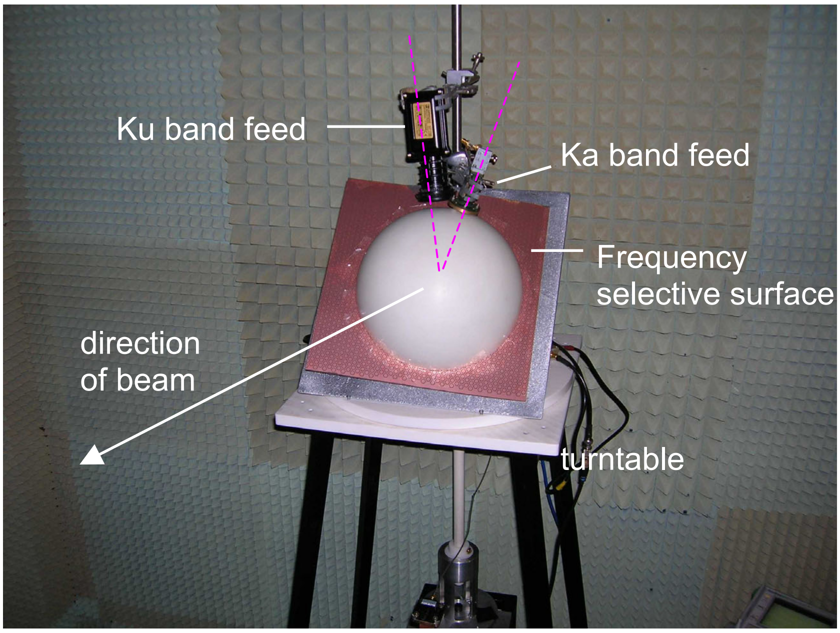

Fig. 2 Experimental arrangement.

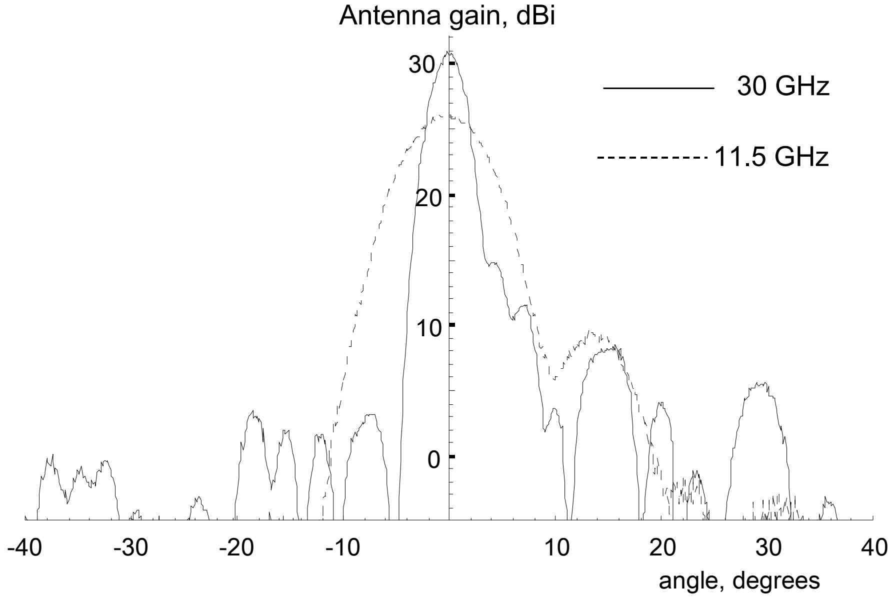

Fig. 3. Measured H-plane radiation patterns.

Alternative geometries. The simple ground plane and dielectric wedge arrangement used for the experiment is by no means the only type which might be used: an alternative approach is illustrated in Fig. 4 where surface FFS1 is a 'negative' of surface FSS2, i.e. frequencies reflected by FSS2 are transmitted through FSS1 and vice versa. For a single beam at direction *a*, the two feeds are separated by angle 2θ. The advantage here is that each frequency band is focussed by a full hemisphere, in contrast to our experiment where the lensing action on lower frequency band is by a quasi-hemisphere due to the additional layer of dielectric material. Numerous variants are suggested: the ground plane region could be exploited to manipulate polarisation response, or absorbing layers could be added to control radar cross section so as to yield a narrow band, stealth antenna where a frequency selective radome might not then be needed.

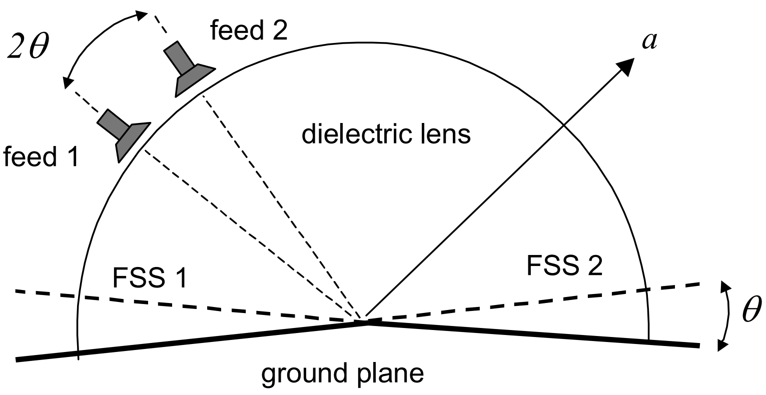

Fig. 4 An alternative geometry.

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