Proceedings

IST MOBILE COMMUNICATIONS SUMMIT 2001

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MOBILITY antenna for Ku-band satellite terminal on board ships

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The paper presents a two-dimensional wide-band printed antenna array operating at Ku-band and to be mounted on a ship. The terminal is able to receive both polarisation components in the entire frequency range. The antenna relies on a fast tracking system capable to track the HISPASAT-satellite independently on the ship motion..

I. Introduction

In the next years terrestrial infrastructures will be implemented in many European areas to provide live TV service using DVB-T. But there will be many other areas uncovered due to the lack of economical interest. One example is the maritime areas. Consequently there will be a very important traveller segment that will be out of the reach of these services.

The option to provide real time DVB-S services to ships by satellite means (some sort of DTH services) appears as an attractive option given the wide coverage capability of satellites. Actually there are already a number of GEO satellite broadcasting covering the European maritime regions.

The basic goal of the MOBILITY project is to provide live TV satellite services in ships by using these satellite services. This project will have a demonstration phase by means of trials in the real maritime scenario. Several routes have been selected along the Mediterranean Sea. HISPASAT will be used as satellite system providing a good coverage in along the selected trial routes. The strong interest in this TV service from several European ferries line operators have recommended the selection of ferries along their maritime route as the mobile platforms for the demonstration phase. Ferries from Compañía Transmediterranea and Strintzis Lines Shipping will be used in the trials.

II. Concept of design

One of the key issues of the project is the design and development of suitable antenna systems for on board terminals. Basically there are two main technical challenges that must be overcome in the design and development of the antenna system. One is the fast tracking system capable to track a geo-satellite independently on the ship motion. This tracking has to be complete, in the sense that, apart from the beam pointing, a full matching between the antenna and polarisation plane of the wave has to be maintained during the ships movements. The second challenge is to aim reaching the same performances (radiation pattern characteristics, cross polarisation isolation, etc.) than a conventional fixed antenna with low cost and reduced physical dimensions.

In an initial stage of the project a detailed analysis of the required antenna subsystem specifications has been carried out. As figure 1 shows, the requirements and specifications come from the characteristics of the satellite, the ships and the service provision.

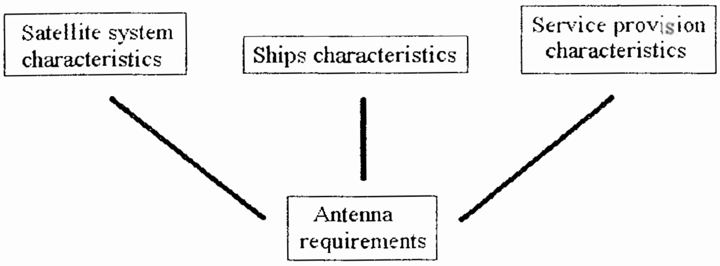

Figure 1. Dependence of the antenna requirements

The majority of the commercial satellite systems that offer this kind of services operates at Ku frequency bands (10.70-11.70 and 11.70-12.75 GHz). Therefore this frequency range has been adopted for the terminals. Also, these satellite systems typically re-use frequencies over both linear polarisations (vertical and horizontal) so the terminals must be able to receive both polarisation components in the entire frequency range. In the case of terminals for ferries or big ships, collective service provision is desired so the terminals must be able to provide simultaneously all the channel combinations between frequency and polarisation. The satellite systems also imposes the required G/T in the ships operational areas. Obviously this specifications have an important impact in the antenna design.

To state the specifications of the tracking systems, a number of experiments are carrying out in different type of ships and in different sea conditions. These specifications deal with the ships movements (roll, pitch and yaw) in terms of angular ranges, rates and accelerations. The movement behaviour of the ships determines the required ranges and agility of the tracking system in elevation and azimuth co-ordinates. Each type of ship has a particular movement characteristics so different designs must be made for in each case. Usually smaller ships usually pose higher requirements than large ships, although there may be exceptions like for military vessels. Also the ships operational area influences the elevation range of the antenna tracking system.

Apart from the mentioned requirements, low cost and reduced dimensions (especially in height) are necessary specifications to reach a competitive terminal.

II.I Antenna System

Although at this stage of the project there is not a definitive and detailed baseline design for the antenna system, at this moment there are a number of basic guidelines. To achieve the low-size requirement, a planar phase array antenna concept have been adopted. To fulfil the wide-band requirements (more than 17 %), SSFIP elements have been adopted as elementary antennas in the array figure 2 shows a model of this element.

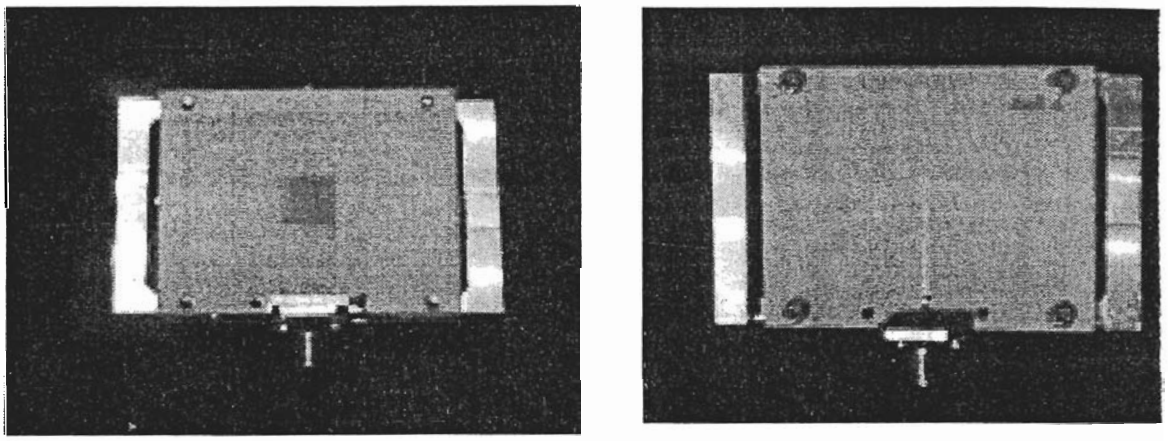

Figure 2: Top and bottom view of model for SSFIP patch

The SSFIP antennas are developed based on the utilisation of thicker dielectric substrates with very low permitivity and losses. The SSFIP patches are arranged in a sub-array scheme. Each sub-array comprises a number of printed patches (typically 4 or 8) in a serial or corporate configuration.

Each sub array is directly connected to a LNA (low-noise amplifier) to maximise the antenna efficiency. Antenna efficiencies of about 70% can be reached with this type of configuration. The sub-arrays are combined with a corporate power distribution network. as figure 3 shows.

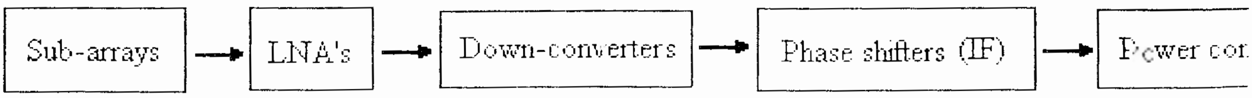

Figure 3. Proposed general arrangement of the phase array

Regarding the feeding network some combiners have been anlysed. The first one is a symmetric Wilkinson combiner printed in TMM 6 (ROGERS) substrate. This can be used to achieve non-uniform amplitude distribution in the array.

The antenna beam steering is performed by a set of phase shifters based on delay lines (one for each row of sub-arrays) controlled by a control board which follows the instructions from the tracking system.

Given the fact that the antenna must be able to receive simultaneously both linear polarisation components, there must be two independent arrays (see figure 4).

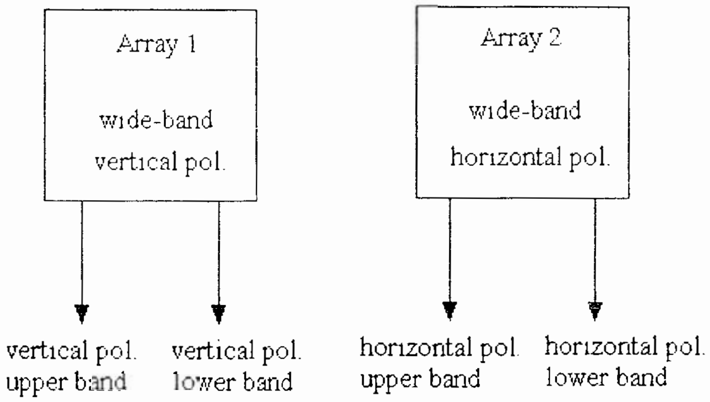

Figure 4. Arrays arrangement in the antenna system

II.II. Tracking System

For the satellite tracking system a hybrid electronic-mechanical system is proposed (see figure 5). This is combined with an open-loop PAT (pointing acquisition and tracking) algorithm.

The mechanical system comprises two mechanical rotation capabilities plus the array scanning capability. The system is able to achieve satellite pointing and polarisation matching regardless the ship motion and the geographic position of the ship.

In this system the vertical polarized array and the horizontal polarized array share a unique mechanical pointing system. The switching between vertical polarized channels and horizontal polarized channels is achieved by a simple 180° mechanical azimuth rotation.

The inclination of the arrays panels is such that the normal vector to the arrays planes are at the middle value of the elevation range along the route. In this way the scanning losses are minimized.

An open-loop system seems the most appropriate because of the availability of the ships navigation systems (fiber-optic gyro, GPS, etc.). In order to compensate the roll and pitch movements of the ships, the antenna is mounted on an X-Y stabilised pedestal that provides a horizontal platform. The yaw movement and the intentional variations of course are compensated by a 360°-azimuth mechanical system. In contrast with the above movements, the routes followed by the ships are large-scale translation movements, which determine the maximum and minimum elevation range for the antennas. This movement is compensated by the electronic steerable capability of the phase array.

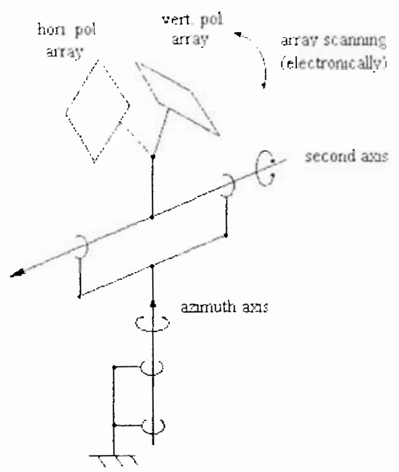

Figure 5. Scheme of the antenna tracking system

This tracking system is meaningfully reduced in height with respect the conventional systems that are based on a fully mechanical tracking system combined with a reflector antenna.

II.III Radome

The radome is an important element of the antenna system, specially is maritime environment where the external conditions may be hard because of the sea and weather conditions. They must cover the radiating device (antenna) the RF-unit and the mechanics of the tracking systems. A trade-off among insertion losses (which have to be compensated by increased terminal G/T), wind resistance and cost must be found. A solution based on a sandwich structure combining low dielectric caps seems to be and adequate selection for the Ku-band.

III. Performance of the terminal

Next table summarises the targeted performance of the proposed terminal of the trial to be allocated in a big ship sailing on the West of the Mediterranean Ship for individual reception.

Parameter	Value
Frequency band	10.7-12.75 GHz
Polarisation	LV and LH

G/T	13.4 dBk
RX Gain	35 dB a 12 GHz
Beam pointing angles	± 20°
Cross polarisation suppression	Better than 25 dB
Aperture Size	3500 cm^2
Max. pointing error	0.8°
Max. polarisation mismatching	2°
Beam width	2.8°

Table 1: Performance of the terminal

The target of the features of the antenna is to fulfil the HISPASAT specifications for fixed terminals. In this way the size of the terminal is reduced compared to the existing maritime antenna systems such as the D SAT 2000 platform of Eutelsat. This concept also pretends to be applied for small ships like yachts.

IV. Conclusion

Printed antennas for mobile reception in ships have been considered and studied. The proposed terminal is able to receive both polarisation components in the Ku-band. The terminal is going to be tested in a trial along the Mediterranean Sea.

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