Earth station antenna technology

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1 Introduction

Norwegian Telecom Research (NTR) has for many years been engaged in developing different earth station antennas, in co-operation with other research institutes and Norwegian industry.

The applications are business communications (VSAT), satellite TV up-link and receive only, and mobile satellite communications.

In the early 1980s a synthesis method for offset dual-reflector antennas was developed, and 3.3 m and 1.8 m antennas were produced. Later smaller antennas of the same type have been used for satellite TV reception. These antennas have been successfully produced and marketed by the Norwegian company Fibo-Støp.

In the last 3 years NTR has developed flat plate antennas for mobile satellite communications. Some of these antennas will be manufactured by ABB NERA.

2 Shaped offset dual-reflector antennas

2.1 Introduction

Since 1980 Norwegian Telecom Research (NTR) has constructed and built many different shaped offset dual-reflector antennas (1). The unique synthesis method developed at NTR for construction of such antennas, was presented at the ICAP conference in 1981 by G. Bjøntegaard and T. Pettersen (2) and later published in (3) and (4).

2.2 Synthesis and analysis method

A good description of the synthesis method can be found in (2), (3) and (4), and we will therefore not describe it in detail. The goal of the method is to obtain a prescribed aperture distribution, giving the wanted radiation pattern with high gain, low sidelobes, or a combination with rather high gain and quite low sidelobes. This goal can be obtained by shaping the sub- and main-reflectors, and in this way let them have small deviations from the original confocal system (with parabolic and elliptical or hyperbolic surfaces of revolution). The method also gives a low cross polarisation.

The synthesis is based upon Geometrical Optics (GO), and when using this method the diffraction effects are not included. The radiation pattern including these effects can be found by a Physical Optics (PO) analysis.

Figure 1 shows the GO rays in a 3.3 m antenna. It is possible to see the shaping of the aperture distribution by the varying distances between the rays.

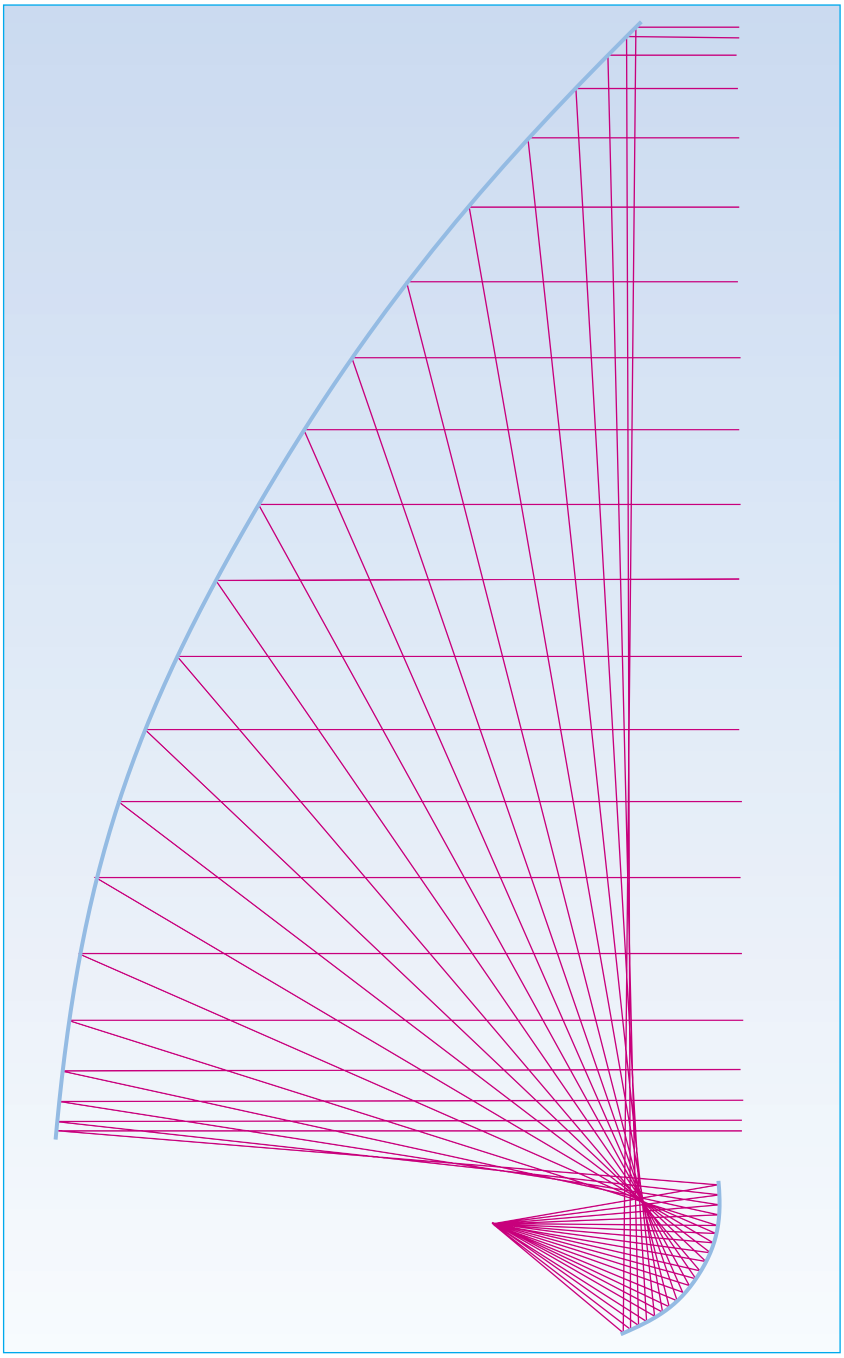

Figure 1 3.3 m antenna with GO ray-path

2.3 Production of earth station antennas

The first offset dual-reflector antenna was built in 1981, and a few years later production started at Raufoss. Their production technique was based on composite materials on an aluminium honeycomb structure. The technique fulfilled the requirements and Raufoss produced several 3.3 m and 1.8 m antennas up to 1987, but the production method was too expensive to produce antennas in large numbers. Figure 2 shows a 1.8 m antenna on a transportable earth station.

In 1988 the production was transferred to EB-NERA (now ABB-NERA). The reflectors are produced at Ticon in Drammen. They use polyester with glass fibre as material, and are able to produce the antennas cheaper. At the moment, they only produce 3.3 m antennas.

These antennas are intended for Ku-band (11/14 GHz), but with a modification of the feed horn they can be used at other frequency bands (12/18 GHz or 4/6 GHz). With a modified sub reflector, the 1.8 m antennas are also used at Ka-band (20/30 GHz).

The large antennas (D > 1.5 m), are only produced in a limited number, but smaller antennas are mass-produced for the consumer and professional market at Fibo-Støp, Holmestrand. At the moment they are producing three different types of antennas in large numbers (55 cm, 90 cm and 1.2 m antennas).

The 55 cm and 90 cm antennas have been produced for some years now, and they have obtained a good reputation both in Norway and in other European countries. They are shaped for high gain, and their efficiencies are higher than 80 %. The 55 cm antenna has also obtained a price for good design. Figure 3 shows this antenna. The antenna is sold through several large and small companies selling equipment for the satellite-TV receive market.

Last year, the production of a new 1.2 m antenna started. This antenna is intended for both the receive-only consumer market and for the business communication market in the 11/14 GHz band. It is shaped to have rather low sidelobes and still having high gain. Like the other antennas produced at Fibo-Støp, this antenna will be sold at a low price.

3 Microstrip array antennas

3.1 Introduction

In 1989 Norwegian Telecom Research (NTR) performed a study of array antennas in communication systems. The study report (5)concludes that antennas for mobile satellite terminals

Figure 2 1.8 m antenna on transportable earth station

Figure 3 Fibo-støp 55 cm antenna

are one of the most promising applications for array antennas.

As a consequence of the results from this study, we started construction of antenna elements for L band (1.5 - 1.6 GHz)(6). The elements are modified square patches. As can be seen from figure 5, two of the corners of the elements are cut off. The goal is to obtain circular polarisation with only one feed point. In order to improve the axial ratio, the elements are sequentially rotated and phase shifted when used in arrays (7). This technique gives almost perfect circular polarisation in the boresight direction of the antenna, and very good circular polarisation in an angular area around the boresight. In addition, reflections to the input port cancel each other, improving the VSWR performance of the antenna.

3.2 INMARSAT-C

The first antenna which was developed was an antenna with higher gain for INMARSAT-C terminals. The ordinary C antenna is “nearly” omnidirectional. NTR developed a new antenna with approximately 11 dBi gain. This antenna is now being manufactured by ABB NERA, and is used in the Saturn-C Portable terminal. A short description of the performance of the C antenna is given in table 1. A photo of the antenna is shown in figure 4.

3.3 INMARSAT-M

NTR is now developing antennas for INMARSAT-M, a system which will be operational in 1993. This system will use terminals with antenna gains in the region 13-16 dBi. Array antennas with a small number of elements are a natural choice for these terminals. The small size of the antennas gives only small losses, and the antennas may be manufactured with low cost and low weight. Table 2 gives an overview of the main specifications for the INMARSAT-M system (8).

Table 3 gives the most important performance parameters for the first prototype antenna for a portable INMARSAT-M terminal. A photo of the antenna is shown in figure 5. This antenna will be used in ABB-NERA`s Saturn-M Portable terminal.

NTR has also developed an experimental INMARSAT-M antenna for land mobile applications. This antenna has been used for experiments with different tracking systems, both mechanical and electronic A photo of the prototype is shown in figure 6. The electronic system is based on digital phase shifters, making it possible to shift the antenna beam in discrete steps. This work is aimed at developing low cost antenna systems for land mobile applications. Using mechanical steering is a costly way of realizing tracking systems, while the electronic steering has the potential for reducing the cost of the outdoor unit.

Figure 4 Antenna for a portable INMARSAT-C terminal

Figure 5 Antenna for a portable INMARSAT-M terminal

	Receive band	Transmit band
Axial ratio, asimuth ($\pm 10^{o}$)	1.8 dB	5.8 dB
Axial ratio, elevation ($\pm 30^{o}$)	3.5 dB	4.5 dB
Gain	≈ 11.5 dBi	≈ 11.5 dBi
Return loss	< -17.5 dB	< -14.0 dB

Table 1 Antenna for a portable INMARSAT-C terminal. Measurements

	Specifications
Minimum G/T	Landmobile -12 dBK Maritime -10 dBK
Max EIRP	Landmobile 25 dBW Maritime 27 dBW
Channel bit rate	8 kbit/s
Bandwidth	1525 - 1559 MHz (RX) 1626.5 - 1660.5 MHz (TX)
Polarization	Right hand circularly polarized, axial ratio less than 2 dB on-axis

Table 2 INMARSAT-M specifications

	Receive band	Transmit band
Axial ratio, asimuth ($\pm 10^{o}$)	< 0.5 dB	< 1.0 dB
Axial ratio, elevation ($\pm 30^{o}$)	< 0.5 dB	< 1.0 dB
Gain	≈ 14 dBi	≈ 14 dBi
Return loss	< -27 dB	< -28 dB
Side lobe level	< -17 dB	< -17 dB

Table 3 Antenna for a portable INMARSAT-M terminal. Measurements

Figure 6 Experimental antenna system for land mobile INMARSAT-M terminal

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