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Minimization of Monotonous Examination and Design Contemplation of Cassegrain for Satellite Communication

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Abstract:

This paper describes aspects of a simple methodology for evaluating satellite link quality (particularly in the downlink segment) using readily available technologies and satellite. A communication system's quality of service is defined by the performance of its antenna. Reflector antennas such as Cassegrain and Garegorian are the most commonly used narrow beam antennas in satellite communication systems. This paper presents a design and analysis for achieving high performance of an antenna specific to a Cassegrain antenna while accounting for system losses. The antenna system's efficiency is discussed, and parametric curves displaying losses as a function of the Cassegrain design parameters are presented. The performance of the designed antenna system yields useful relationships for selecting design parameters for maximum gain performance.

***Keywords* — Cassegrain, satellite, Satellite Communication, Cassegrain antenna, Contemplation of Cassegrain.**

INTRODUCTION

A "passive" satellite transponder is a broadband RF channel used to amplify one or more carriers on a geostationary communications satellite's downlink side. It is a component of the onboard microwave repeater and antenna system. For Europe, examples of these satellites include the ASTRA fleet and the Hotbird fleet, which are located at 19.2- and 13-degrees east longitude, respectively. These satellites, along with the majority of their companions, have geostationary orbits and Ku band repeaters; a repeater is simply a block that receives all signals in the uplink beam, translates them to the downlink band, and separates them into individual transponders of a fixed bandwidth. [1]

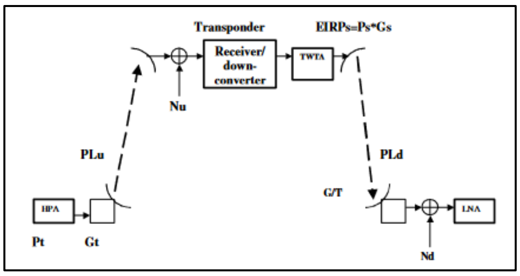

Figure 1: Satellite link model

Figure 1 depicts the fundamental concept. A travelling wave tube amplifier (TWTA) or a solid-state power amplifier (SSPA) amplifies each transponder (SSPA). This type of satellite is used to transmit TV channels to broadcast stations, cable TV systems, or directly to the home (DTH). Other applications include data communications networks with very small aperture terminals (VSAT), international high bit rate pipes, and rural telephony. Integration of these data types is becoming more common as satellite transponders can deliver data rates ranging from 50 to 150 Mbps. Achieving these high data rates necessitates careful consideration of the repeater's design and performance.

SATELLITE LINK EVALUATION PROCEDURE:

DOWNSTREAM LINK ANALYSIS:

Many applications involving RO (receive only) systems benefit from downstream link analysis. DTH (Direct to Home) television is the most common example.

a). Pass Loss (Free Space Attenuation)

$$PL = 20\log\left(\frac{4\pi d}{\lambda}\right)$$

If f = 12GHz, PL = 206dB. If f = 4GHz, PL = 196dB.

This is a rough estimate. To fully assess the true losses, the following factors must be considered:

• loss of coupling (wave guide, filter, coupler)

• alignment errors (alignment of antenna to satellite, alignment to direction of polarised wave)

• Rain attenuation is dependent on the frequency used.

b). Gain(G) of Satellite Dish Antenna

$$G = 10\log\left(\eta(\pi D\, f / c)^2\right)$$

η= antenna efficiency (55% - 70%)

c). Input Power at Earth Station

The Input Power (Pin) for the LNA/LNB positioned at the receiving antenna's focal point is determined by the EIRP, the Gain (G) of the satellite receiving antenna, and the Pass Loss.

$$P_{in} = EIRP + G - PL$$

e). Noise N at input of the system

$$N = K + T_{sys} + B_n\ [dBW]$$

K = -228dBWs/K (Boltzmann Constant)
T = Temperature of antenna system
Bn = noise bandwidth of receiver

T_{sys} All system noise sources, expressed in K, are as follows:

- T_a, The noise temperature of the antenna is affected by elevation, frequency, and efficiency.
- T_{LNB} , LNA/LNB noise temperature, see data sheet
- T_{amb} , ambient temperature
- T_{feed} , feed system attenuation losses

f). Figure of Merit (G/T)

G/T denotes the antenna and LNB system quality.

$$G/T = G - T\ [dB]$$

Instead of specifying the required antenna diameter for satellite reception, the G/T figure is more precise because it includes system noise. T_{sys}.

g). Power Ratio of RF-carrier and noise (C/N)

$$C/N = EIRP + G/T - PL + 228dBWs/K - B_n\ [dB]$$

Each satellite network has a unique Bn (noise bandwidth). SES Astra, for example, uses 27MHz transponders, whereas Eutelsat's transponder bandwidth is 36MHz. A spectrum analyzer can be used to calculate and measure the C/N value. For an error-free signal, a receiving system requires a low C/N (threshold value). This last formula is the main issue and the starting point for the described procedure. The test procedure described in this paper is based on the evaluation of C/N realised and delivered in the DVB board's front-end. As previously stated in paragraph II, the channel decoder includes the ability to deliver the C/N and BER of the received signal. The BER is the foundation of a so-called "Quality" evaluation, but no producer (DVB cards or STB) provides detailed information on the exact "Quality" definition or evaluation. In fact, different receiver brands display different values for this parameter on the same channel. Fortunately, the C/N ratio is a well-defined value that is delivered "as is" in the driver for the channel decoder. [2]

The Cassegrain antenna is a double reflector system with many interesting characteristics such as high efficiency, low noise temperature performance, and easy access to electronic equipment. Cassegrain systems are not appealing for small antennas (D/100) due to large blockage and inefficient scattering mechanisms. Feed, feed support beams, and subreflectors, in particular, cause distribution losses and large blockings in antenna apertures in dual reflector antennas. The radiation pattern from the sub reflector is then calculated at a large number of points on the main reflector and used to establish the main reflector's current distribution. By incorporating edge effects, geometric theory of diffraction is used to improve the accuracy of far field patterns. [3]

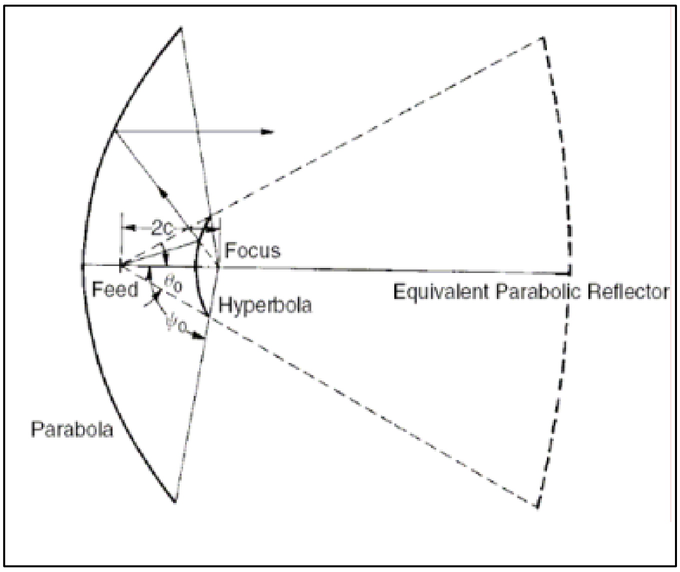

Figure 2: Cassegrain Antenna

DESIGN CONSIDERATION:

The optimal design of an entire antenna system is complicated, but some published descriptions use mathematics, making it appear even more complicated. Figure 2 depicts the notations used in the proposed antenna. A Cassegrain antenna was used in the analysis.

Table I: Geometrical parameters for selected Cassegrain antenna

Geometry Configuration	
Type	Casse grain
Focal length	f_m=1.5meter
Aperture size X	D_x=2meter
Aperture size Y	D_y=2meter
Magnification	M=5
Interfocal length	f_s=1.3meter

Table I contains a description of the geometric values. Circular horn feed is used. The design frequency chosen is 6GHz. Diffractions caused by the finite sub reflector size result in main reflector spillover, cross-polarized sub reflector reflections, phase error losses, and additional amplitude taper losses. The loss is proportional to the effective focal length and sub reflector diameter. [4]

Objectives:

1. Satellite communication design and implementation
2. Geometrical parameter analysis for a selected Cassegrain antenna.
3. To assess the satellite communication procedure.

Review Of Literature:

Because of their high gain, reflector antennas are commonly used in satellite ground stations (above 20dB). The shorter transmission line connecting the feed point and transmitter or receiver equipment provides low loss for reflector type antennas. This can be accomplished by employing a dual reflector antenna (Cassegrain antenna). Cassegrain antennas outperform parabolic reflectors in terms of noise temperature, pointing accuracy, and feed design flexibility. Furthermore, placing the feed near the vertex of the primary reflector reduces transmission losses [5].

Cassegrain antennas are dual reflector antennas with a paraboloid main reflector, hyperboloid sub-reflector, and feed. The paraboloid's focal point and the hyperboloid's virtual focal point converge on the same point. The phase centre of the feed is located on the true focal point of the sub-reflector. A horn antenna is typically used as a feed for high-frequency applications, while a dipole antenna is used for low-frequency applications. The feed energy illuminates the sub-reflector, which reflects the signal energy to the main reflector. The reflected energy is then reflected by the main reflector, forming the desired beam.

The physical optics (PO) principle can be used to analyse a double reflector system. First, the current on the Subreflector surface is determined using rays from the feed. Following that, the Subreflector illuminates the main reflector, allowing induced currents to be calculated. Finally, by integrating all of these currents, the total field can be calculated [6].

RESEARCH METHODOLOGY:

Books, educational and development journals, government papers, and print and online reference resources were among the secondary sources we used to learn about the composition, use, and consequences of Minimization of Monotonous Examination and Design Contemplation of Cassegrain for Satellite Communication.

RESULT AND DISCUSSION:

Table 1 contains the results. The final column contains the calculated value for transponder EIRP based on the link model described.

Table 2: EIRP -Effective Isotropic Radiated Power

Sat.	Program	Transp	Pol	SR	FEC	C/N	Q	EIRP (est)
Astra2C	Taquilla	10788	V	22000	5/6	11.5	80%	46.6
	TVVint	10818	V	22000	5/6	9.6	66%	44.7
	BibelTV	10832	H	22000	5/6	7.3	54%	42.4
	TVPolonia	10862	H	22000	5/6	6.5	49%	41.6
Astra1G	CNN	11778	V	27500	3/4	8.9	67%	44
	Canal+	11856	V	27500	3/4	6.1	50%	41.2
	Bloomberg	12552	V	22000	5/6	2.6	28%	37.7
	BVN	12574	H	22000	5/6	8.2	60%	43.3
	France4	12581	V	22000	5/6	6.9	53%	42
	STB	12604	H	22000	5/6	2.5	26%	37.6
	Disney FR.	12640	V	22000	5/6	7.3	54%	42.4
	MTV Germ.	11739	V	27500	3/4	9.4	70%	44.5
Astra1F	Premiere	11720	V	27500	3/4	7.3	57%	42.4
	Premiere1	11798	H	27500	3/4	6.1	50%	41.2

The following columns are significant: Sat.-satellite, Pol.-polarity, SR-Symbol rate, C/N -carrier to noise, EIRP -Effective Isotropic Radiated Power, Q - Quality (a measure of the error rate BER delivered in the demodulator part - not fully explained in the board's documentation). [7]

The simulations were carried out by the Antenna Group at the University of Virgo using ICARA (Induced Current Analysis of Reflector Antenna) software and physical optics (PO) and, in some cases, physical theory of diffraction (PTD).

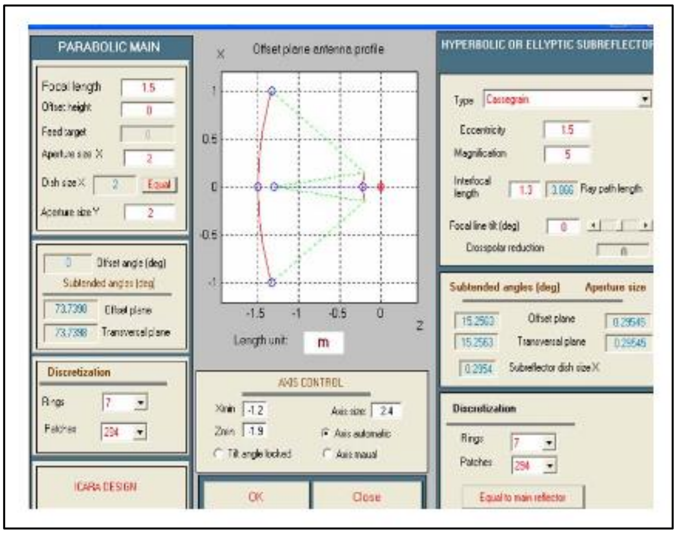

Figure 3.a: geometric values of the Cassegrain antenna

The geometric values of the Cassegrain antenna are depicted in the figure. The following demonstration shows how the field from this geometry is analysed using ICARA.

The radiation pattern in figure 3.b was simulated for a 5 metre diameter with no other parameters changed. The simulation demonstrates that the gain is proportional to the size of the antennas, which reduces cross-polarization. [8]

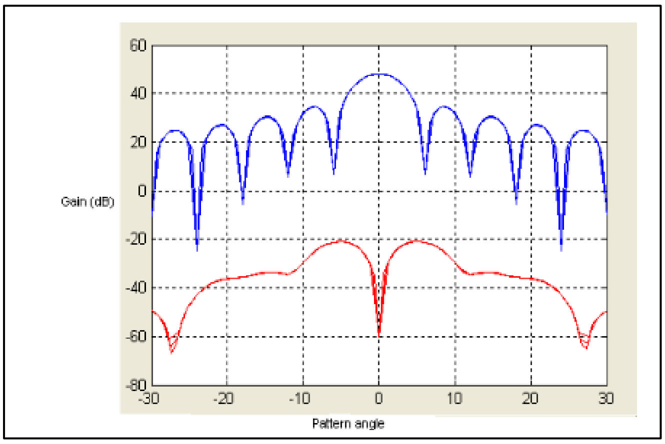

Figure 3.b: Nominal Radiation pattern (PO+PTD) for 5meter C band antenna

CONCLUSION:

The total network latency is the sum of propagation and processing delays. If switching from a geosynchronous satellite to a low- or medium-Earth orbit satellite is not an option, the only other way to reduce latency is to reduce processing delay. Create a detailed network diagram and calculate the processing delay for each device. Keep in mind that there are options that could significantly reduce your latency, thereby improving network performance. The total network latency is the sum of propagation and processing delays. If switching from a geosynchronous satellite to a low- or medium-Earth orbit satellite is not an option, the only other way to reduce latency is to reduce processing delay. Create a detailed network diagram and calculate the processing delay for each device. Keep in mind that there are options that could significantly reduce your latency, thereby improving network performance. Most symmetric dual reflector antennas in use today are based on the traditional Cassegrain reflector system. To avoid distribution losses and large blockings, the limitation ratio f/D in the design used is generally 0.75 or greater. If the main reflector diameter is between 10λ and 20λ, the sub reflector diameter should be between 1λ and 2λ. Shaped reflectors and corrugated horn techniques have been developed for high efficiency and low noise performance, increasing aperture efficiency from 60% to 80%.

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