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DESIGN, CONSTRUCTION AND IMPLEMENTATION OF A 3 METER SATELLITE DISH ANTENNA (PARABOLOID REFLECTORS)

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ABSTRACT,
The objective of this work is to design, construct and implement a 3m diameter paraboloid reflector with a frequency allocation of 3GHZ and above. The design was achieved with the help of wire mesh, aluminum span, mild steel, aluminum foil and glass fiber. The designed model was able to pick up signal from Arabian Satellite CNN, Adamawa Broadcasting television station and other channels with the help of low noise amplification block (LNB)

KEYWORDS: Signal, frequency allocation, background noise, frequency spectrum and efficient transmission.

INTRODUCTION

Antennas are fundamental components of radio systems and use free space as the carrying medium. They are used to interface the transmitter or receiver to free space, antenna have quite number of important parameters, and those of most interest include the gain, radiation pattern, polarization, beamwidth, bandwidth, directivity, voltage standing wave ratio (VSWR), efficiency and impedance matching (Haykin, 2001 & Website, 2002a).

In some years ago, developments in broadcast technology have caused demand for more frequency allocation since the present frequency in used is inadequate for efficient transmission. (Green, 2000). Also there is the need to use frequencies where background noise is less effective that is why use of frequency of radio spectrum of above 1-2GHZ is being made (Saunders, 1999) At these frequencies, the use of parabolic reflector type antenna is a must for transmission and reception, therefore only practical form of antenna for receiving these frequency is the parabolic dish reflector antenna. This now prompted the emergency of this design.

DESIGN METHODOLOGY

Brief Description of the parabolic reflectors

The dish is 3m diameter wide of depth 0.6m, the LNB is attached to the feed horn which has provision for the supply of power through a radio frequency (RF) cable (coxial cable) by the R.F connector.

COMPONENT DESIGN

The basic parabolic antenna generally has a define formula given by

$$F = \frac{D^2}{16d} \quad (1)$$

And general equation of a parabola is also given by

$$k^2 = 4Fr \quad (2)$$

Combining Equations (1) and (2), we have

$$k^2 = \frac{D^2}{4d} r \quad (3)$$

Table 1: Cost Estimate for the manufacture

Items	Quantity	Price (N)
Wire mesh	2x1m	₦10,000
Aluminum span	1span	₦11,000
Mild steel	1m	₦ 4,200
Aluminum foil	2m	₦340
Fiber glass		₦2,000
Pipes	2/4" x 1 and ¾"x3	₦6000
Total		₦33,540

Table 2: Design Results

r	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
k	1.99	2.81	3.45	3.98	4.45	4.87	5.27	5.63	5.97	6.29

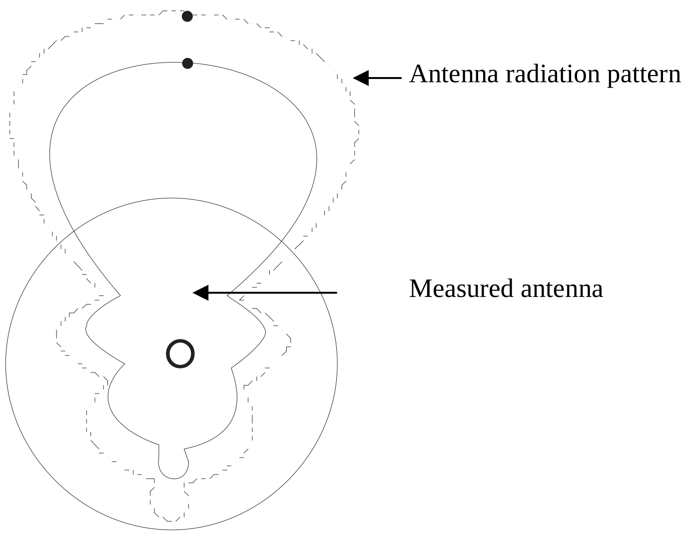

Fig1: Parabolic antenna with radiation pattern

Where F is the focal focus of the dish measured in meters; D is the diameter of the dish in meters; d is the depth of the dish and r,k are chosen variable for the parabolic antenna design. (Bajpai *et al*, 1981and Erwin, 1989)

If D = 3m, the ratio of F/D is equal to 0.33, from equation (3) d becomes 0.6m. Assume r = 1 to 10 the corresponding values of k were determined as shown in Table 2.

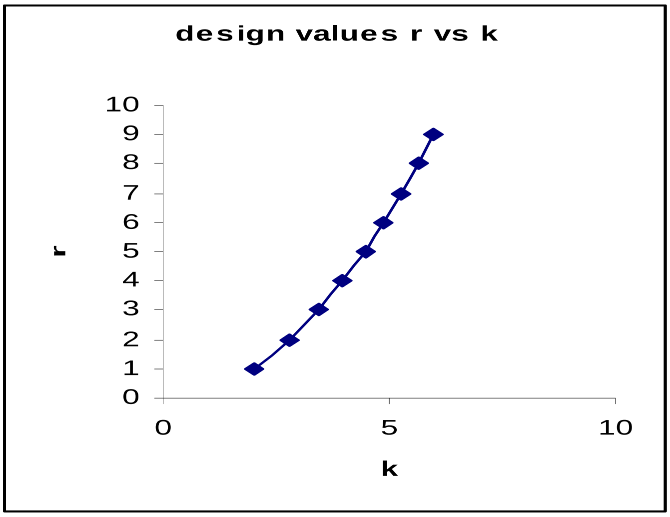

Fig 2: Interpretation of the chosen variable r and k.

Antennas have some important parameters parameters as stated before, this work took into consideration all parameters.

Voltage Standing Wave Ratio (VSWR) Determination

The VSWR used in this design define the radio of voltage standing at maximum wave per voltage standing at minimum wave given by

$$\text{VSWR} = \frac{1 + /\rho/}{1 - /\rho/} \quad \text{and} \qquad (4)$$

$$\rho = \frac{Z_L - Z_o}{Z_L + Z_o} \qquad (5)$$

Where ρ is the reflection coefficient, Z_o and Z_L are the characteristics impedance and load impedances respectively (Pozar, 1997). In this design VSWR = 1, ρ = o for proper matching and maximum power transfer.

Efficiency Determination

Efficiency (β) is determine by the total radiated power per total input power given by

$$\beta = \frac{\mathrm{Pr}}{Pi} \qquad (6)$$

Where Pr is the total power radiated and P_I is the total input power (Website, 2002b).

$\beta =$ 67%. In this design, but in real situation 75% is very good although 50% is acceptable in most antenna design. (Website, 2002a)

Antenna gain/3D pattern Determination
Antenna gain is directly related to frequency and antenna capture area. The number of wavelength in its signal – capture area determines the gain of an parabolic antenna given by

$$G = 7.5 + 20 \log (f) + 20 \log (D) \qquad (7)$$

Where f is the frequency and G is the antenna gain (Frank, 2001) in this design the antenna gain of the parabolic antenna was determined as G = 30.66dBi because of the wideness of the dish, although in smaller diameter antenna the gain may be between 2dBi – 3dBi (Website, 2002b)

Directivity Determination
This is similar to gain, but heat losses (i.e. the affectivity) are disregarded. We will then get a pattern as a dotted line shown in Fig 1; the value of directivity is obtained using

$$D = \frac{c}{a} \qquad (8)$$

Where c represent total power and a represents average power which can also be written as (Website, 2002a)

$$D = \frac{P}{p_{av}} \qquad (9)$$

Beamwidth Determination
This is the directiveness of a directional antenna used in this design as the angle between half – power points either side of the main lobe of radiation. -3dB was obtained as the angle between two half powers. (Website, 2002a).

Bandwidth Determination
Is the region where there is no losses given by

$$B = f_{H_i} - f_{L_i} \qquad (10)$$

Where f_{H_i} is the highest frequency attended while f_{L_i} is the losses of the amplifier at that frequency (Edeko,2004). The larger the bandwidth the higher the signal transmitted.

Impedence Matching
An ideal situation antenna has an impedence of 50Ω (Ludwig 1997) all the way from the transceiver to the antenna. So to get the best possible matching impendence between transceiver, transmission line and antenna as used is this design, since the ideal condition do not exist in reality, this design used impedence matching in the antenna interface, often must be compensated by the means of matching network, i.e. a net build with inductive or capacitive components. The VSWR was optimized by choosing the proper layout and components values for the matching net and maximum potential of the antenna shown in Fig 1.

CONSTRUCTION DETAILS
All measurements were done accurately in engineering Laboratory federal polytechnic Mubi, before the materials were assembled to form a parabolic dish of 3m wide and 0.6m depth. Little adjustment was made to determine the approximate principle focus where most of the signals concentrate that is both wanted and unwanted signals before amplification by LNB, for transmission in to the reception. The parabolic shape was cut – out to specification from
the cardboard paper and then transferred to the metal pipe. Several of these metals pipes were joined together by welding to the parabolic frame. The Ohmic resistance of joints was given serious attention by ensuring professional welding

COST ESTIMATE

One of the major aims of this paper is to show how a 3m diameter parabolic antenna can be designed and constructed using locally available materials at a cheaper price compared to the current price in market today. A typical 3m diameter antenna will cost about N50, 000.00 in the market depending on the manufactures product name for example DSTV, STRONG and so on. The designed and the constructed parabolic antenna cost far less than the imported parabolic antenna as shown in Table 1.

PERFORMANCE TEST AND RESULTS

The testing of the disc was done when the antenna and accessories including the feed horn, LNB receiver and television/monitor were placed in order. The LNB was attached to the feed horn which has provision for the supply of power through a radio frequency cable by RF connector, this passed directly to a TV set for monitoring the signal. The output of the receiver was monitored, the dish was pointed to the exact sport of orbital satellite we wished to get the signal, and Arabian satellite was trapped with clear reception and many others like CNN, ATV and so on.

CONCLUSION

A 3m parabolic antenna has been designed, constructed and implemented using engineering experimental technique locally reliable and readily available materials were used in the construction of the 3m parabolic antenna. The design ensures that the system delivers up to 3GHz and above. This designed antenna can be used in a very verse communication areas including global system for mobile communication (GSM)

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