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Studies on the Directivity of Horn Antennas for Communication Links in Low Network Coverage Areas

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Abstract: Horn antennas have been observed to have excellent directive properties for transmission of microwaves. Directive communication using horn antennas can be carried out in areas with low or no network coverage through establishment of stable line-of-sight links to connect a low network coverage area to a network by using Customer Premises Equipment such as horn antennas and modems. The performances of different types of pyramidal horn antennas are therefore compared to select the best possible option among them.

Keywords: Network Coverage, Directive Communication, Line - Of - Sight, Horn Antenna, Pyramidal Horn, Customer Premises Equipment

I. INTRODUCTION

Modern technology has made communication as well as access of different types of data services much simpler in the present day. However, many semi-urban and rural areas exist where network coverage is minimal or nonexistent, and it is also not economical to conventionally connect these areas to a communication network due to factors such as low affordability of tariff as well as higher setup costs. According to the statistics of United Nations Organization, it is estimated that almost half of the global population is in rural areas. Moreover, in 2005, the majority of global population shifted from rural to urban area. Thus, development efforts made in the remote and rural areas are efforts to improve the lives of the majority of the people, and affordable internet speed access should be one of key elements which create an enabling environment in such areas. Hence techniques have been investigated for obtaining cheap solutions to the connectivity problem associated with low or no network coverage areas [1].

The current paper formulates a scheme for setting up a microwave communication link for rural areas using horn antennas, linking a high to medium network coverage area with a low network coverage area through directive horn antennas. The high-gain pyramidal horn is hence investigated for this purpose and is contrasted with sectoral horn antennas in its ability to provide high gain and directivity. The paper is organized in the following manner. Section II surveys the recent literature on wireless power transfer. Section III describes a practical scenario where network speed tests have been carried out and introduces the proposed system to mitigate the issues surfacing from the experiment. Section IV compares the experimental results obtained using sectoral and pyramidal horn antennas. Section V concludes the paper with a discussion on the scope for future research in this domain.

II. LITERATURE SURVEY

Wireless networks are the preferred path investigated for finding a solution to the problem by many researchers, using ad hoc [2] or Wi-Fi based [3] networks. The economic feasibility of these solutions has also been studied by certain researchers [3] [4] [5]. Partnership-based models have generally been proposed to lower the costs of project implementation as well as make the solution affordable for consumers [4] [5]. A general challenge faced by researchers in all the scenarios mentioned before involves the problem of signal propagation in rural areas due to lack of mobile towers or heavy attenuation due to obstacles, also referred to as shadowing [6] [7].

Researchers have also proposed certain antennas specifically for usage in rural areas to mitigate the above problems [8]. Many researchers have also been working on techniques for enhancing the directivity of antennas to implement

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line-of-sight communication effectively. Techniques such as standard beamforming [9] [10] as well as adaptive beamforming [11] have been investigated. Horn antennas have also been used for enhancement of directivity [12] [13].

In areas of low internet speed or without internet connectivity, customer premises equipment can be a valuable source of high speed internet. Considering a house in the suburban area with high speed of internet in the vicinity, we can generate high speed in the area with no facility of internet using the horn antenna as well as customer premises equipment. Hence the current paper focuses on determination of a suitable horn antenna for directive communication.

III. PROPOSED SYSTEM

The researchers faced a situation similar to consumers in a low network connectivity area, on their college premises. The variation of speed of internet often causes disruption in important time-bounded work. Thereby the researchers decided to measure the variation of internet speed with height with respect to a particular place so that the dead zones and areas of lower coverage could easily be identified. The day of the measurement was partly cloudy and the corresponding temperature was 30^{o} C. The experimental data are shown in table 1 below and the corresponding graphical variation in figure 1 that follows.

Table 1: Comparison of Upload and Download Speeds at various levels of college building

Sl.	Place	Upload Speed	Download Speed
1.	Ground Floor	1.92 Mbps	2.53 Mbps
2.	1st floor	0.94 Mbps	0.46 Mbps
3.	2nd floor	2.69 Mbps	1.28 Mbps
4.	3rd floor	2.41 Mbps	1.32 Mbps
5.	4th floor	1.63 Mbps	1.13 Mbps

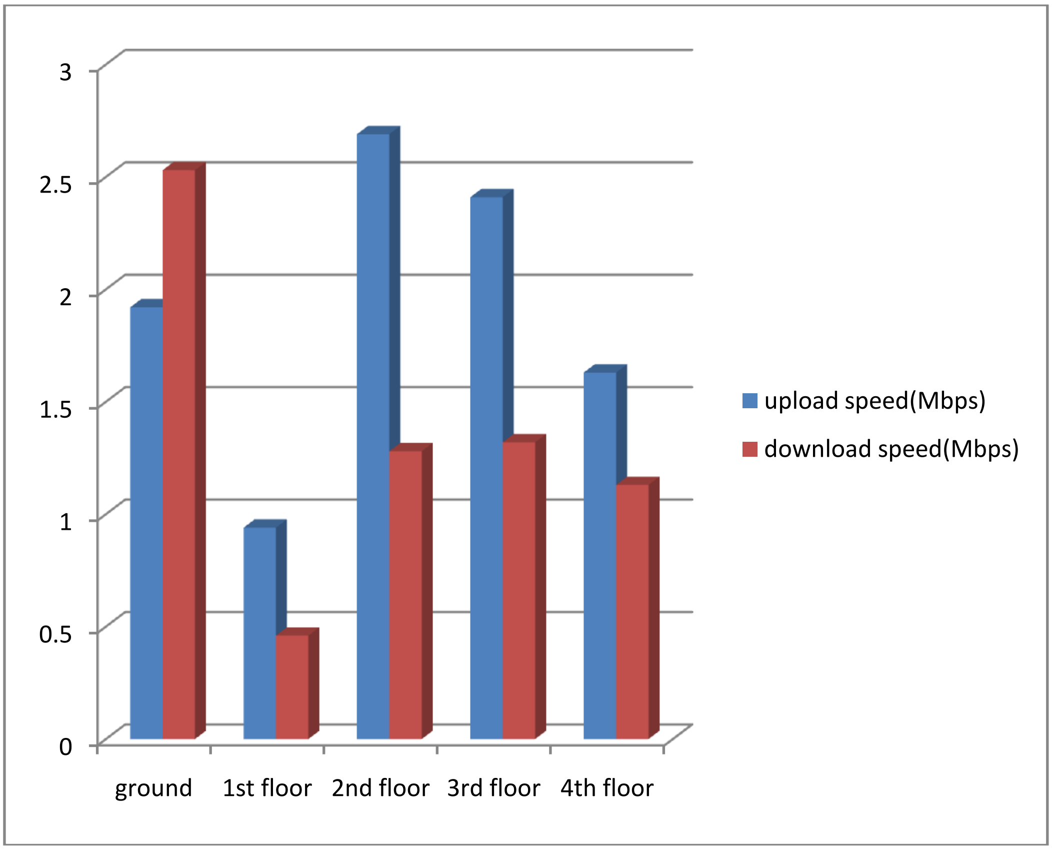

Fig. 1 Variation of internet speed on different floors

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The system proposed for mitigation of the problem of low internet connectivity is shown in figures 2a and 2b as follows.

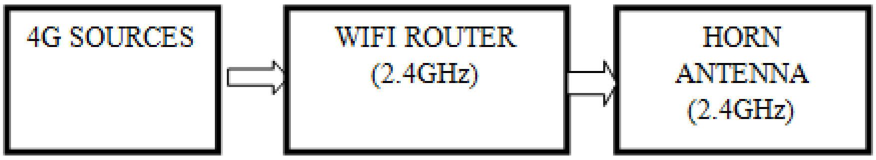

Fig. 2a Simplified Block Diagram of Transmitter Section

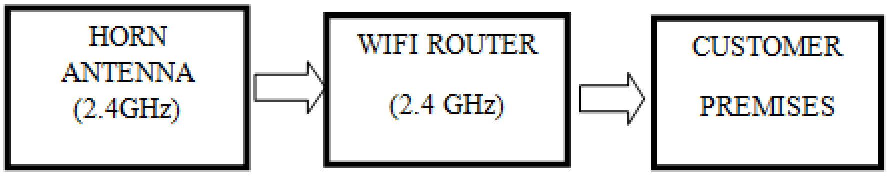

Fig. 2b Simplified Block Diagram of Receiver Section

The transmitter part consists mainly of 3 parts-source, router and antenna part. First we have to make sure that our 4G source is connected with 4G+ Base Station. This 4G source is mainly mobiles or JIO-FI which is used as a Wi-Fi hotspot. Then there will be a connection which will be established between Wi-Fi router and 4G source. This connection is a wired connection which will give us better reliability and speed. Then this Wi-Fi router gets connected with horn antenna which is a wireless connection. Then horn antenna is used to transmit signals to the customer premises. This is mainly installed in customer's premises for getting the same 4G speed which is used in urban areas. At the receiver section, horn antenna is used as a receptor of signals. These signals which are received by this antenna are transmitted to Wi-Fi router by wired connection through Ethernet Cable. Then this Wi-Fi router transmits signals in all directions and the customer can use this signals. So the customer is getting the same speed of 4G network in his home without wasting any expenditure.

IV. EXPERIMENTS ON HORN ANTENNAS AND RESULTS

In wireless signal transmission a major character is played by antennas. An antenna is the interface between radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver to transmit and receive signals wirelessly. Horn Antennas have a bandwidth of mainly 300 MHz to 30 GHz. If gain increases frequency of operation is also increased. Horn Antennas usually have very little loss and directivity of horn is roughly equal to gain. Pyramidal horns are among the simplest and most reliable microwave antennas. They find wide application due to high gain performance, mechanical simplicity, ease of excitation, versatility, and linear polarization. Pyramidal horn is most popular in microwave frequency range. Sectoral horns are also used frequently in microwave signal transmission and reception. An E-plane horn antenna is an aperture antenna that is flared in the direction of the E-field. This results in radiated fields that have a high directivity in the E-plane of the antenna. An H-plane horn is flared in the direction of the H-field, giving a better directivity in that plane.

E-plane principal pattern of the pyramidal horn is the same as the E-plane principal pattern of the E-plane sectoral horn. The power radiated by both sectoral horns as well as the pyramidal horn at 11.7 cm and 13.7 cm distances are measured and compared in tables 2 and 3 respectively.

Table 2: Polar variation of power radiated by Pyramidal horn, E-sectoral horn and H-sectoral horn at 11.7cm

Pyramidal Horn		**E-sectoral horn**		**H-sectoral Horn**	
DEGREE	POWER (dB)	DEGREE	POWER (dB)	DEGREE	POWER (dB)
0	-29.39	0	-26.96	0	-27.08
5	-29.56	5	-27.0	5	-27.19
10	-29.86	10	-27.16	10	-27.42
15	-29.92	15	-27.38	15	-29.96
20	-30.03	20	-29.97	20	-30.13
25	-30.29	25	-30.16	25	-30.50
30	-30.63	30	-30.50	30	-32.42
35	-32.63	35	-32.42	35	-32.87

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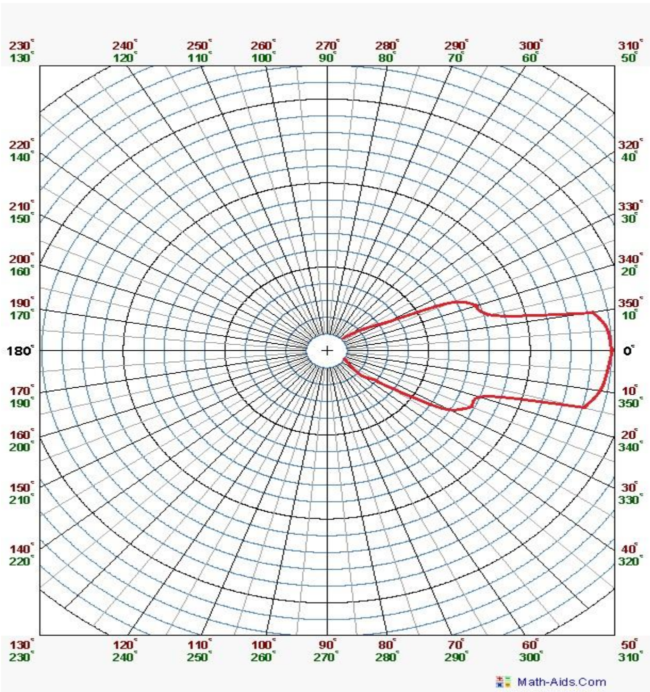
355	-29.39	355	-26.97	355	-27.08
350	-29.89	350	-27.08	350	27.1
345	-29.93	345	-27.33	345	-27.23
340	-30.08	340	-30.08	340	-27.51
335	-30.32	335	-30.37	335	-29.99
330	-30.63	330	-32.48	330	-30.16

Table 3: Polar variation of power radiated by Pyramidal horn, E-sectoral horn and H-sectoral horn at 13.7cm

Pyramidal Horn		E-sectoral horn		H-sectoral Horn	
DEGREE	POWER (dB)	DEGREE	POWER (dB)	DEGREE	POWER (dB)
0	-26.92	0	-26.93	0	-27.16
5	-26.88	5	-27.00	5	-27.31
10	-26.96	10	-27.16	10	-27.57
15	-27.08	15	-27.33	15	-29.98
20	-27.30	20	-27.60	20	-30.21
25	-29.98	25	-30.06	25	-30.63
30	-30.52	30	-30.37	30	-32.53
35	-32.30	35	-32.38	35	-34.22
355	-26.92	355	-27.00	355	-27.16
350	-27.08	350	-27.16	350	-27.23
345	-27.23	345	-27.42	345	-27.42
340	-29.95	340	-29.96	340	-29.94
335	-30.10	335	-30.13	335	-30.08
330	-30.31	330	-30.50	330	-30.49

The polar plots for the pyramidal and sectoral horn antennas at the two separations of 11.7 cm and 13.7 cm are shown in figures 3 and 4 respectively.



a) Polar Plot for Pyramidal Horn

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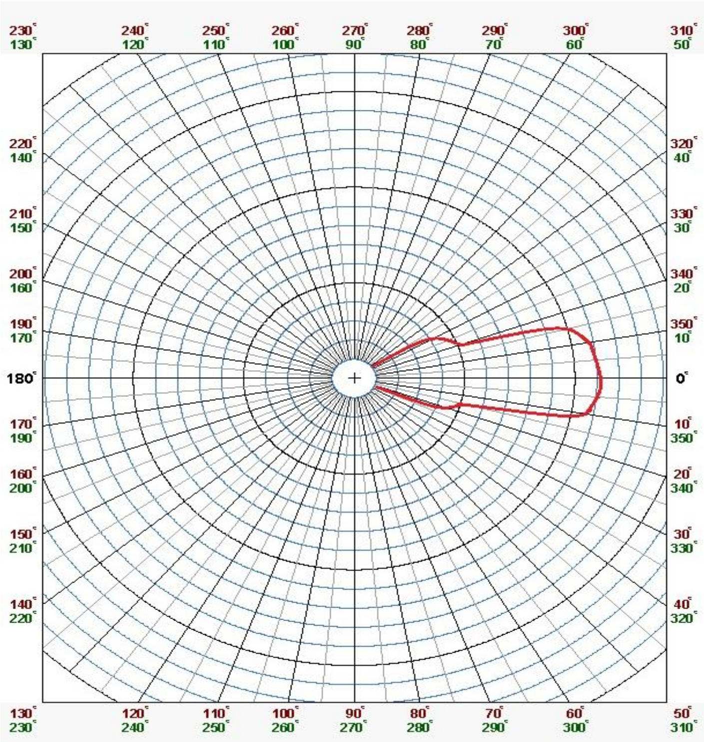
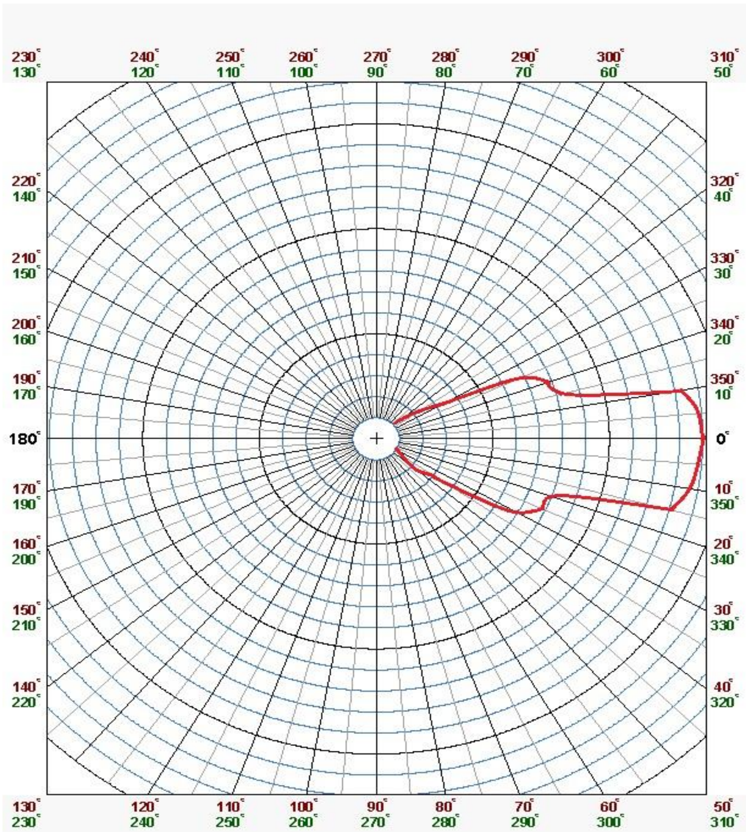


b) Polar Plot for E-sectoral Horn



c) Polar Plot for H-sectoral Horn

Fig. 3 Polar patterns of a) Pyramidal Horn b) E-sectoral Horn c) H-sectoral Horn antennas at 11.7 cm distance

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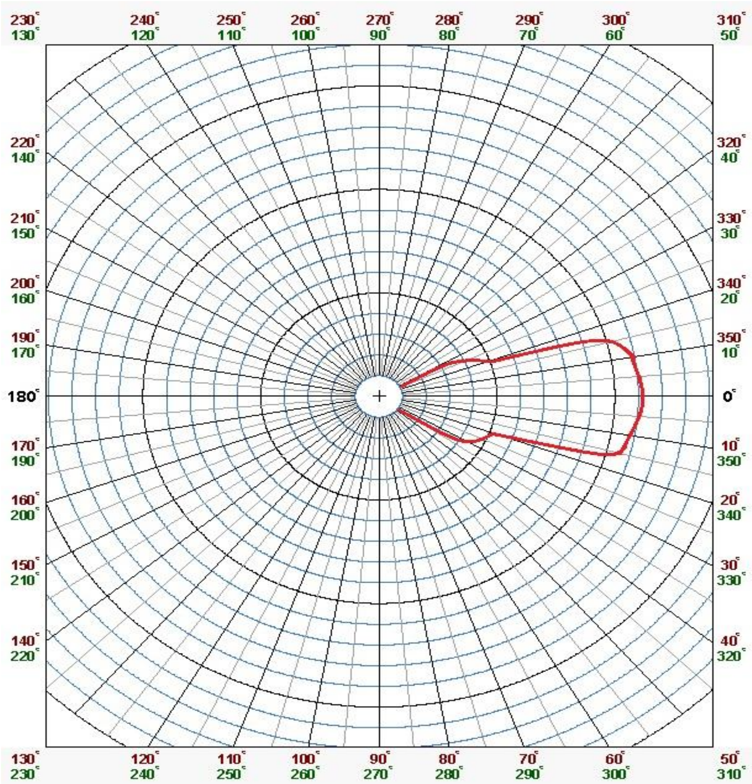
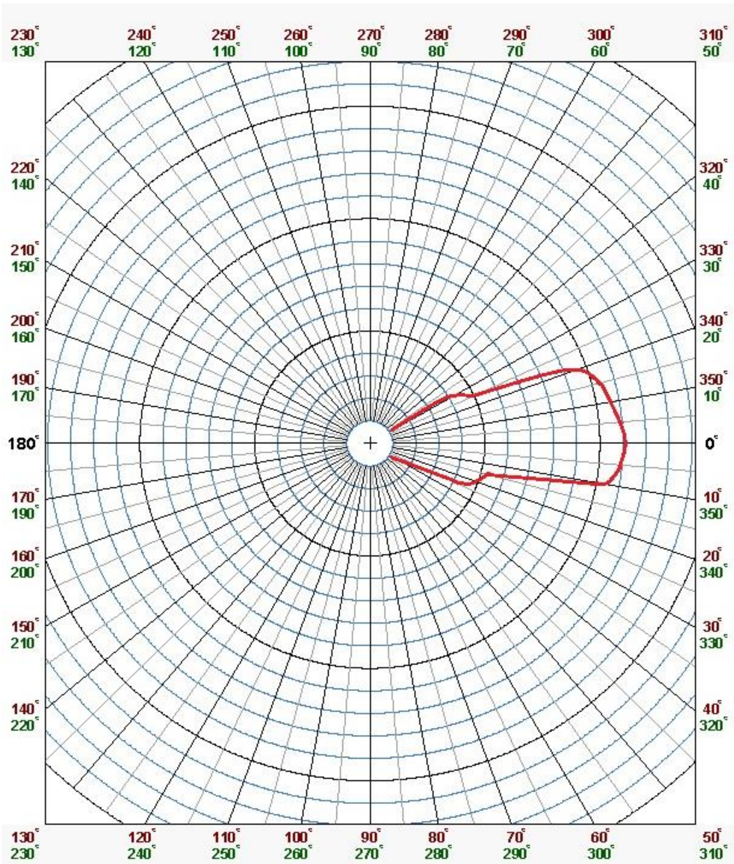
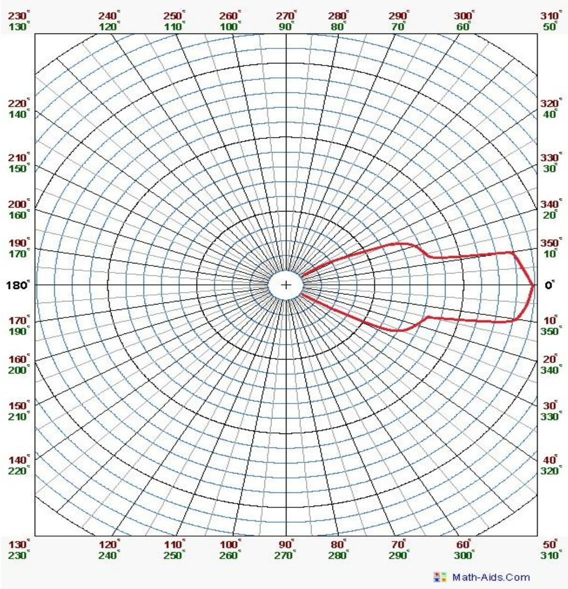


a) Polar Plot for Pyramidal Horn



b) Polar Plot for E-sectoral Horn



c) Polar Plot for H-sectoral Horn

Fig. 4 Polar patterns of a) Pyramidal Horn b) E-sectoral Horn c) H-sectoral Horn antennas at 13.7 cm distance

From the tabular data as well as the figures, it is clear that the pyramidal horn has better power gain compared to both sectoral horns, as distance between the receiver and transmitter increases. Thus, the pyramidal horn antenna can be selected as most suitable among the three types studied in this work.

CONCLUSION

The current work accomplished in this paper comprised the comparative experimental analysis of different horn antennas for their suitability in setting up a line-of-sight microwave communication link to provide access to the internet in remote areas. In future, the researchers aim to test other types of antenna such as parabolic reflectors as well as a combination of horn antennas and parabolic reflectors in a bid to further improve the gain of the system. Following this, the authors aim to implement and test the proposed system with the best antenna setup arrived at through the experiments. Array-based arrangements may also be looked at in future, for the same purpose.

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