

Improvement Proposal for Cell Phone Signal Reception in Tabatinga- Amazonas

Anne Valéria da Silva Grandes Reis

anne_sgrandes@hotmail.com

Centro Universitário FAMETRO – Manaus, Amazonas - Brasil

Livia da Silva Oliveira

oliveira.livia@gmail.com

Centro Universitário FAMETRO – Manaus, Amazonas - Brasil

Aristeu Souza da Fonseca

aristeu.eng@gmail.com

Centro Universitário FAMETRO – Manaus, Amazonas - Brasil

David Barbosa de Alencar (Corresponding author)

david002870@hotmail.com

Instituto de Tecnologia e Educação Galileo da Amazônia – ITEGAM - Brasil

Abstract

This article will explain the signal difficulties that the city of Tabatinga in Amazonas and will propose a possible analysis of signal repetition improvement and signal regeneration in relation to the demographic issue of the city. It will show that the use of cell phone repeaters with regenerators is a possible technical application that would improve the city's signal issue and its difficulties that lead to a financial and social economic backwardness for the municipality.

Keywords: amplifier; modulator; cell phone.

1. Introduction

A survey conducted by the Getulio Vargas Foundation in June 2016 points out that there were 168 million smartphones in Brazil, a data that shows today many mobile phones are much more than to receive call, today it is possible by mobile to perform many tasks and shows the trace of development of the country and that is not just a matter of luxury today cell phone is a necessity [1].

The municipality of Tabatinga, in the state of Amazonas, is one of the reference municipalities in the interior, being a point of entry for other municipalities, as it is the only one in Alto Solimões that has an airport. The municipality has 3,239.3 km², with 64,448 inhabitants (IBGE) with a demographic density of 16,2 inhabitants per km². Situated at 73 meters altitude, Tabatinga has the following geographical coordinates:

Latitude: 4 ° 15 '12' 'South, Longitude: 69 ° 56' 19 " West[2].

Tabatinga is one of the municipalities of Alto Solimões with the highest rate of problems both using mobile telephony and internet, the population suffers a quality service and is at the mercy of the service offered precariously to its consumer [2].

Mobile communication in the Alto Solimões region is one of the most precarious in the northern region with a high rate of processes related to signal failure and non-use of services, the declared services are not fulfilled or poorly done, and this hinders the development of the region. , since most people have cell phones, not landlines [3].

One of the main reasons for poor signal quality is because of the satellite link. As Tabatinga is a municipality that does not have fiber, mainly due to its geographical location, the signal goes out via satellite internet link, as the cost is very high, the operators do not hire the necessary capacity to support the basic consumption of the population.

The cellular mobile phone system is a wireless, wireless communication system consisting of mobile radios, user terminals, ERBs, fixed base radio stations. The system allows consumptions by voice, video, alphanumeric messages, etc. [4].

Nowadays we live in the age of internet communication, you have the possibility of being connected in real time with the happenings around the world, but in a municipality like Tabatinga that the internet connection happens only via radio, it is an expensive cost to the consumer that often does not work, which often hinders not only personal communication, but the economic development of the municipality, which makes it not develop, making the city not seen as a tourist spot, making economic transactions and even emergency care difficult. Today with the technology we have and in the development process that mobile telephony has undergone over the years it is unacceptable that a municipality does not have the minimum connection services.

The analysis of the project given by the problem lived within the municipality that lives in a growing economic and social moment of the population, within the project seeks to study the propagation of data traffic signal and voice to understand the current functioning in environments with dense vegetation. and in micro cellular systems through prediction methods. Point out a possible basic concept that may show an improvement in relation to the signal used within the municipality. Show that the use of signal repeaters can be an economical alternative to the existing mobile phone service in the municipality, enabling the basic concept of signal amplification and regeneration.

2. Theoretical Reference

2.1 How the Mobile Phone Framework Works

It is a system that has coverage areas to be serviced by a mobile service that are divided into hexagonal cells, which are illuminated by base stations (ERB) located in the center of the same, usually on top of towers or masts in the areas of. among other factors, the output power of the radio transmitter and the frequency band used. This mobility is only possible thanks to wireless communication between the terminal and a Base Station (ERB) that is connected to a Control Center and which has an interconnection with the switched fixed telephone service and other centrals. This is why calls between cellular terminals and

landlines are possible[4].

The ERB communicates between the mobile terminal (TM), which can be cell phones, tablets, etc., with the CCC (Switching and Control Center), which in turn makes the calls. Some factors are analyzed and define the extent of coverage of an ERB such as: the output power applied to the antenna; the frequency band to be used; antenna height and location; antenna type; area topography and receiver sensitivity.

The waves propagate in a straight line, called the line of sight, from the ERB. There are cases where the user has no direct sight with the ERB, due to major obstacles. These areas without coverage are called the shadow area. The shading effect caused by these uncovered areas is minimized by buildings in large cities, due to the refractive and reflective capacity of transmitted radio waves, and by the large amount of small cells in these regions.

Basically we have two types of ERB, commonly called:

- Greenfield - those that are installed on land, i.e. on the ground.
- Roof Top - those installed on building roofs.
 - Both can use indoor telecommunication equipment, whose manufacturing characteristics determine the need for a climate infrastructure, such as outdoor equipment, which are stand alone unit previously designed for exposure to air. Free and dimensioned for proper ventilation.

All mobile operators have different frequencies, and even the same carrier can operate in different bands in certain cities and states, and it is also possible for different carriers to use the same frequency [4].

In Brazil we currently have 3 types of technologies:

- **2G:** In Brazil since the 90's, GSM (Global System for Mobile Communications) is used which is mainly used for telephone calls. When it comes to the internet, this technology leaves a lot to be desired. Their frequencies are 900 and 1800 Mhz.
- **3G:** Uses the technologies WCDMA or CDMA, is the most popular in Brazil. It has speed from 200 kbps and is in the frequencies 850 and 2100 Mhz.
- **4G:** Is very popular in Brazil using the LTE (Long Term Evolution) standard. Delivers superior speed and performance superior to 2G and 3G Technologies with 700, 1800 and 2500 MHz having availability in the frequencies [5].

2.2 Types of Cells

There are two most common cell types, omnidirectional cells and sectorized cells. Omnidirectional cells consist of an ERB with an omnidirectional antenna that will radiate in all directions, thus making the ERB the center of a circular transmission area. In the sectorized cells, there are in ERB several directive antennas, which together will cover an entire area.

The area of a cell is defined by the density of telephone traffic, such that the higher the traffic, the smaller the cell projected for this region. Thus, suburban or rural areas will have larger cells than urban centers. Regardless of cell size, care should be taken to reuse frequencies in cells.

There are two solutions when traffic in a cell grows, the addition of new cells or the sectorization of a cell. In cell sectorization the omnidirectional antennas are replaced by directional antennas sectorizing the old cell. This method is more economical and more used by operators as it uses existing structures [4].

Cells in any method overlap, but without co-channel interference.

There are other processes used within the telephony is the so-called handoff and must be unnoticeable to the user when he moves across from one cell to another, the CCC should automatically transfer the user to a new channel with a different frequency.

The CCC must make sure that the user's signal drop comes from a signal shift rather than a momentary signal drop before making the handoff. The other roaming process is given when a user enters a cell belonging to a CCC other than their home exchange. The visited switch (CCC-V) must inform the user switch that it is no longer about your domain. Thus, the user's home CCC should record the fact and release the user to use the visited home exchange normally as if it were his home exchange.

When you switch from a cell belonging to one CCC to a cell belonging to another CCC, during a call, you have the handoff between switches. This handoff must also be imperceptible to the user.

A fast moving user is a problem for CCC, as in the same cell there are also pedestrian users or even slow moving users. For this particular case, there is a technique called umbrella cell, which provides a large coverage area for fast moving users and small areas for slow moving or non-moving users.

Signal propagation environments can be classified as:

- Urban: When they are in large cities, metropolitan regions with a predominance of high buildings;
- Suburban: Low-rise residential environments;
- Rural: Characterized by regions with low demographic densities, where the population is dispersed in large areas such as farms, farms and farms;
- of houses and buildings (indoor): Treated differently from the environments described above, because they are external and the waves are easier to travel through them. These places are the subject of much study today, as it is the place where mobile phones are most used, however the large amount of obstacles such as walls and slabs attenuate the signal strongly and the service works inefficiently on many occasions [6].

In a large environment all these users will get the signal from mobile networks. And because carrier antennas are often unable to reach the intensity levels needed to reach those locations with poor coverage (blind spots or no signal) and large numbers of subscribers, there are reasons to use existing technologies that can remedy the absence of the signal, or amplify them. In the area and market of telecommunication technology there are several possible technologies that can solve the absence of mobile signal, some require end customer investment and others are the responsibility of the local operator [4].

As shown in table 1, the frequencies used in Brazil are:

Table 1. Signal Frequencies

Transmission of		Blocks(MHz)	Operators / Area
Mobile Station (MHz)	ERB (MHz)		
708-718	763-773	10+10	Algar/ Sectorsof PGO (3,22,25 e 33) ;RestofVacantBrazil
718-728	773-883	10+10	TIM BRASIL
728-738	783-793	10+10	VIVO BRASIL
738-748	793-803	10+10	CLARO BRASIL

Fonte: teleco.com

2.3 Introduction to Cell Repeaters

Within cities, it is often the case, at small points within an ERB's coverage area, that the signal level is very low, unable to provide the quality of service needed for good communication, such as tunnels, subways, stadiums and even the forest among others. These points, called shadow zones or silence zones, are mainly motivated by topographic factors (hills, valleys, etc.) and artificial constructions. This is also common in areas not far from the coverage area contemplated in the original design of a cell due to its large geographical size and the low demand potential generated.

A return on investment in these areas, even in the long run, is difficult to achieve. To remedy this problem, deploying a new ERB would in principle be a good option.

However, the high cost and the need for a new set of frequencies make this alternative subject to careful studies to verify its technical and economic viability, often against its implementation. The use of Cellular Repeaters is a good alternative to the case presented, since it represents advantages in most of the verified points, including in the attendance of rural areas adjacent to cities served by only one ERB and that have sufficient traffic capacity to meet the demand generated [5].

2.4 Basic Concept of Signal Repeater and Amplifier

A repeater is an electronic device that works only on the physical layer of the OSI model. When data is transmitted over the network, it is carried by signals from one host to another. Signals carrying information may travel a fixed distance on the network because as the signal travels it experiences a loss or attenuation that may result in loss of information and some information, thus causing loss of signal in voice transmission and data.

Attenuation is generated because the medium through which the signal is traveling produces some resistance, such as building in urban areas and forest in rural areas. Thus, to overcome the attenuation problem, a repeater is installed on a link that receives the signal before the signal reaches its limits or becomes extremely weak. The repeater listens for the input signal and regenerates the original bit pattern, not the noise, and relays the updated signal to the network correcting some errors that occur during the transmission process. The only problem is the noise, especially the demodulation of QAM systems, which added to the signal will also suffer the same filtering. [10]

A repeater provides only a means to extend the physical length of the network. It does not change any network functionality and is not smart enough to interrupt the input frame or redirect the input frame in another direction. It receives the signal, corrects and redirects again. The use of an amplifier which is also an electronic device whose purpose is to increase the amplitude of the signal waveform without changing the other parameters such as frequency or waveform. It is one of the most widespread circuits in electronics and can be used for various functions. Amplifiers are generally used in wireless communication.

Unlike the repeater, an amplifier is not capable of generating an original bit pattern, it only amplifies whatever is fed because it cannot discriminate between the intended signal and noise i.e. other words even if an input signal is corrupted and contains some noise, the amplifier only increases the signal amplitude despite correcting the corrupted signal. The differences between repeater and amplifier are generally simple from a technical point of view.

The repeater is used to regenerate the original signal with the help of the received signal pattern and relay

the regenerated signal. On the other hand, the amplifier amplifies the signal increasing its amplitude. Since the amplifier cannot differentiate between the desired signal and the noise, the signal strength increases with the built-in noise. In contrast, the repeater removes signal noise while regenerating the signal bit by bit. The repeater has high gain power and low output power. On the other hand, the amplifiers have low power gain and high output power. Repeaters are used in a stationary environment where the radio frequency signal is stable, as in buildings. In contrast, amplifiers are used in the mobile environment, where the radio signal is weak and constantly changing, for example, remote areas. The implication of the amplifiers results in a minimized signal to noise ratio and increased noise. On the other hand, repeaters increase the signal to the noise rate, which decreases the error associated with the signal. An amplifier is part of a repeater. Amplifier increases signal amplitude, regardless of the noise contained in this signal. Inverse Repeater regenerates the signal, gradually using the input signal and removes the display of noise in the signal [5].

2.5 Covering and Capacity Concept

Coverage is the geographical area (also called lighted area) reached by the signal emitted by a BTS or a set of BTSs within which the cellular mobile service operates. In this cover, the emergence of shadow zones, which indicate voids that must be filled.

Capacity is the expression of the number of calls that occur within the coverage area over a set period of time or, in other words, the number of talking subscribers that a given system can handle simultaneously. Capacity may also be associated with the availability of carrier-purchased radio channels for the region under consideration.

Current techniques for capacity enhancement are narrowband radios (lower bandwidth per channel), microcells, sectorized cells, and the use of enhanced digital techniques. This often involves acquiring new frequencies [7].

In the current landscape of mobile telephony, there is a considerable increase in capacity, mainly through the use of sophisticated digital techniques. The adoption of smaller and smaller cells, tending towards the concept of micro cells, causes the range of each of these cells to become smaller and smaller. Cell sectorization, a common practice in any system, also leads to capacity increases.

The concepts of coverage and capacity are to some extent associated, despite the antagonistic condition between them. Indeed, the activation of a new BTS implies the expansion of both. However, it is often the case that the above capacity building techniques end up in overcapacity geographical areas which, despite this, continue to lack coverage due to shadow zones.

The deployment of BTSs in these shaded areas is neither a practical nor an economical alternative due to the cost of a BTS and an even greater increase in capacity, which is not necessary in this case. The solution is to increase coverage considering the same capacity already installed. This is exactly the proposal of cellular repeaters. A very important factor when using cellular repeaters is the isolation between the antennas. Without it, the signals transmitted by the subscriber antenna can be picked up by the collecting antenna and vice versa, since most repeaters do not perform frequency translation, causing a signal resorption by the system [5].

3. Methodology

This research is done through a technical study of equipment feasibility, being carried out a study of the city of Tabatinga that has a signal deficiency. In this case study was done research between sites, telecommunication books about what is the mobile phone system and prediction methods, which is the use of basic signal amplifiers and regenerators that can be used, more economically, taking into account Considering that an analysis of a public-private partnership can even be done to encourage the acquisition, installation and maintenance of the equipment.

Before installation it needs to be checked whether or not the use of amplifiers will be compatible with all frequencies, so there must be a compatibility check between the signal donor operators, the telephone plan technology and the frequency delivered by the amplifier to be used. . The range and signal distribution capability of the amplifiers. In this case “the more the merrier”.

It is essential that in the installation process there is a minimum of signal in the area where it will be installed as it needs to pick up the frequency of the signal to be able to amplify and deliver a satisfactory quality, it is also essential that there are not many physical barriers in the environment, since This is a factor that impairs the distribution of signal, ie it can be installed in squares, where there is a greater circulation of people. It is also important to analyze the environment where the signal amplifier will be installed, as barriers such as walls and plumbing negatively influence the signal distribution. Amplifiers are indispensable for remote areas or even in locations in large centers where the telephone signal is low. The most important thing in the case of antennas is dBi, isotropic decibel, which is important for measuring antenna gain, which is what evaluates signal strength, so you should look for amplifiers with higher antenna ratings. dBi to get a better frequency. The amplifier model that can be used by the problem will expose the value and brand of the amplifier, the analysis and measurement of antenna db search, frequency and range, but it is necessary an analysis of the locations and sizing. of the spaces to be implemented, so that there is a better result of the study [7].

The project allows communication correction between users and signal failures within the municipality, as the signal in the region is weak (poor quality) and cable service is not available. The user interface is via the handset's own antenna (the user's mobile station, the handset itself) and on the other side the base station's antenna. Any signal received on one antenna should be amplified and transmitted to another antenna. The system will have a symmetrical shape. Antenna “A” receives signals from the base station and transmits back to the base station in amplified and corrected versions of the signal originating from the mobile phone. Symmetrically, antenna “B” receives signals from the cellular mobile phone and transmits amplified versions of the signal originating from the base station back to the telephone. The upper amplifier amplifies the signals received from the base station, while the lower amplifier amplifies the signals received from the user's handset. This system requires the use of duplexing devices that act as a filter that prevents the transmitting radio from interfering with the receiving radio, but must be adjusted to the frequency to be used to prevent coupling of an amplifier's input signals and output signals. from the other. The biggest design question will be to project the repeater gain over the chosen frequency range. The system must be able to amplify all received signals that fall within the frequency bands. For simplicity, the aim was to project a signal gain from the lower band limit lower than the upper band upper limit, that is, from 700 to

850 MHz. The system must satisfy the frequency conditions of the base station as well as , from handset's. The biggest challenge lies in calculating and designing repeater amplifier gain [5].

4. Results Analysis and Discussion

According to modulation frequency translation calculations and digital analog calculations, frequency range dBs can be obtained by modulation calculation.

$$V_t = N \cdot V_m$$

Where:

- ✓ V_t - baud rate
- ✓ N - Number of bits
- ✓ V_m - ModulationSpeed [9].

4.1 Amplifier

The choice of amplifier that was made for repeater design application will be developed with an electronic circuit for signal amplification that is captured by the external antenna. This circuit will use the RP-760S signal amplifier as its main component, which has a 60 dB gain and typical frequency range of 700-750 MHz and can be used to work in CDMA technology only.

4.2 Antennas

The choice of antennas is designed to meet three objectives: operating frequency range, 700 - 750 MHz; low standing wave ratio (SWR) over this frequency range; and radiation in all directions except in the direction of the repeater output. The third item ensures that a radiated signal is not received by another antenna, amplified again and retransmitted (infinite loop), causing amplifier saturation and repeater performance degradation. The choice of antenna for this project was made technically, will be used two fixed antennas one directional type and the other satellite dish 1.70 M hollow for transmission and reception, working as server and donor antennas. Feedback does not depend on system performance, the repeater must be mounted to achieve minimal isolation between the servo antenna and the collector The duplexers will work so that both antennas will be receiving and transmitting signal at the same time, causing a signal to enter without interfering with the output, the duplexers will act as bandpass filters. The duplexer will be configured in the desired signal will have the function of filtering and differentiating the signals, for the project to work will need two separate amplifiers with filters for the handset transmission frequency and base station reception frequency bands. Then the upper amplifier will work by amplifying the signals captured from the base station, while the lower amplifier will amplify the signals captured from the user's handset [5].

The installation process will be very simple, as antenna installation, a technician can do all installations, because the amplifier and duplexer programming will be done before the installation in the frequency selection process.

4.3 Cost estimates for project implementation

The chosen components were analyzed via frequency range, range and db, in order to make the choice and estimate values. Remembering that the values of infrastructure, installation and maintenance were not analyzed, the values are only of the components that can be used within the applied system. Table 2 shows the description of each component.

Table 2. Components Used for Installation

Description	Amount	Component Value
AntennaPanelSector - 806-960/1710-2170 - 15.0dBi/17.5dBi	1	R\$ 1.828,90
Jumper AntennaPanel Sector - 2 Meters - N Male / DIN Male	1	R\$ 152,90
AntennaLeakedSatelliteDish 1,70 M	1	R\$ 353,30
Parable Illuminator 850 MHz	1	R\$ 326,90
Cellular Drop Cable RGC-213 15 meters	1	R\$ 312,14
Connector N Male RGC-213	2	R\$ 28,00
Signal AmplifierRP-760S	1	R\$ 1.259,32
Directional Grid Satellite Dish - CF-2620	1	R\$ 82,37
FrequencyDuplexer 70W MTDPLX160A	1	-
AMOUNT	10	R\$ 4.343,83

*Values of the components to be used.

Distributed Antenna System (DAS) technology is highly visible from the moment it enables support for all technologies (2G, 3G, 4G) under a shared infrastructure model among operators, a feature that is part of the suite of solutions for Indoor coverage and environments with high concentration of public, it is also possible to suggest for future studies the facilities and applications that any technology to be presented that may bring to the city, because for any solution that is chosen, a condition that brings a series benefits and a range of possibilities for the municipality [8].

The operator most used within the municipality can be analyzed, so that the installation can be made so that the research is conducted within the municipality for use evaluation. The objectives were partially achieved by the method of research techniques and analysis so that studies prove that the use of repeaters can improve the signal within certain locations and areas, and because it is the small developing municipality, and there may be partnerships, so that no installation and application not applied due to lack of financial resources [7].

5. Conclusion

This work showed the operation of telephony, its technical processes and its possible failures, so that the use of repeaters, amplifiers and signal regenerators can promote the improvement. Being that if there are partnerships and mainly political will of the municipal government to not only take this idea to the operators, because it is known that within the municipality signal failures and lack of it often interfere not only so much the media, but also the economic process within the municipality, proposing and encouraging them so that what was analyzed within this project can be applied.

As a suggestion for future work, it should be considered that the model presented using repeaters, amplifiers as well as the methods, and making the study of propagation loss calculations and coverage prediction form, can serve as a basis for improving the telephone signal. mobile phone, with physical characteristics similar to the case studied, making the appropriate adaptations and, if possible, using professional equipment to obtain more faithful the theoretical results.

6. Thanks

I thank my advisors, MSc. Teacher Livia da Silva Oliveira – Fametro

Teacher Aristeu Fonseca de Souza – Fametro

Teacher Lauro Rosas - Fametro

Teacher Claudio Henrique Albuquerque Rodrigues – Fametro

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