

Comparative Spectral Study of the Performance of Two LTE Networks Using a N9342C Spectrum Analyzer and User Equipment

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Abstract— *There are three fundamental indicators used to evaluate the coverage quality and physical performance of a Long-Term Evolution (LTE) network: Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), and the Channel Power received within the LTE bandwidth. This article analyzes several practical measurement results obtained from two different LTE networks in Honduras. The analysis presents useful information, such as the RSRP and RSRQ levels for each network, with measurements taken under the same procedure to ensure comparability. Channel Power measurements were also collected using an Agilent/Keysight N9342C spectrum analyzer, employing a monopole antenna and a directional Horn antenna, while maintaining the same measurement methodology for both networks.*

Keywords—*Directional antennas, Horn antennas, Power measurements, Spectrum analysis, Wireless communication.*

I. INTRODUCTION

The demand for high-speed mobile applications has increased significantly in recent years [1]. As a result, the expansion of fourth-generation networks, commonly known as 4G/LTE, has been driven forward, offering higher data transfer rates and better spectral efficiency than their predecessors. [2]. In Honduras, the operators Telefónica Celular S.A. (Tigo) and Servicio de Comunicaciones de Honduras S.A. de C.V. (Claro) are responsible for providing LTE services, with an increase in users and traffic according to reports from the Comisión Nacional de Telecomunicaciones (CONATEL). [3].

The evaluation of LTE signal coverage quality is based on physical parameters measured at the user level, especially RSRP, which represents the average received power, and RSRQ, which measures signal quality by considering noise and interference. [1]. These indicators are key to analyzing signal strength and link performance under real operating conditions. [4]. Experimental studies confirm that high RSRP values reflect good signal strength, while decreases in RSRQ are often associated with interference or higher cell load. [5], [6].

For an even broader comparison, it is also necessary to measure the total channel power using a spectrum analyzer, which allows quantifying the power within the carrier. [7]. By combining RSRP and RSRQ measurements with channel power measurements, a broader view of the signal behavior is obtained. This makes it possible to identify variations associated with attenuation, interference, or network activity, providing useful information that allows for a more accurate description of the signal performance in the evaluated area.

Within the campus of the Universidad Nacional Autónoma de Honduras (UNAH), it is useful to understand how the LTE signal from both operators behaves in the areas frequently used by students and staff. A specific section inside the university will be evaluated, and this section will be divided into several points to measure RSRP, RSRQ, and channel power for both operators, with the aim of enabling a comparison of both signals under the same environment. The purpose is to objectively describe how the signal from both operators behaves along this route, to provide a clearer view of the actual performance of the LTE networks within this university area.

II. LONG TERM EVOLUTION (LTE)

Long Term Evolution is a radio access system designed to provide high data rates, low latency, and efficient spectrum usage through Orthogonal Frequency-Division Multiple Access (OFDMA) in the downlink. Its structure generates resource blocks within a continuous bandwidth, which appear on a spectrum analyzer as rectangular power blocks corresponding to the active LTE carrier in the measured band. [8]. In LTE, the reference signals included within the carrier make it possible to obtain indicators such as RSRP and RSRQ, which are essential parameters for evaluating the power and quality of the signal received by the user. These signals coexist with data and control channels, forming a single spectral block that the spectrum analyzer detects as the total channel power within the assigned bandwidth. The frequency blocks shown in Fig. 1 were obtained using a monopole antenna with the spectrum analyzer.

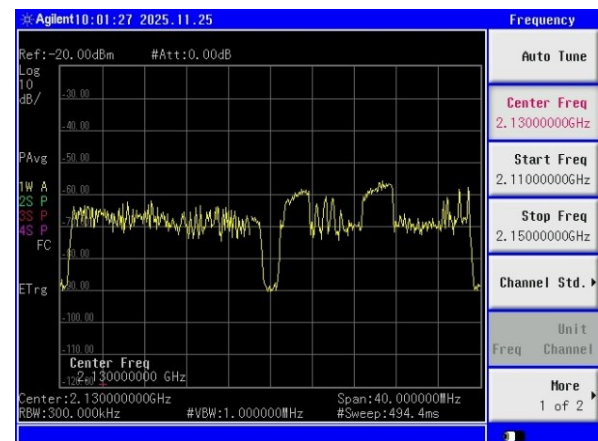


Fig. 1 Clearly defined frequency blocks corresponding to the downlink carriers of two different LTE operators.

Each elevated block in the spectrum reflects the total energy transmitted by an LTE carrier, where the reference signals responsible for the RSRP and RSRQ values are located. The average ranges of RSRP and RSRQ are shown in TABLE I.

A. Reference Signal Received Power (RSRP)

The reference signal received power is one of the most important indicators in LTE data measurements. It represents the average power received from the serving cell in the reference signal element and does not include interference power or noise. [9], it can be expressed as:

$$RSRP = \left(\frac{1}{N} \right) \sum_{i=1}^N P_{RSi} \quad (1)$$

Where P_{RSi} is the power of the reference signal i and N is the total number of reference signals considered. The typical RSRP range in LTE networks varies between -60 dBm (excellent) and below -100 dBm (very poor), with this value serving as a direct indicator of the serving cell's signal strength. Low RSRP levels are often associated with shadowed areas, attenuation caused by obstacles, or excessive distance from the base station. [9].

TABLE I
RSRP AND RSRQ INTERVALS AND THEIR INTERPRETATION

RSRP Range (dBm)	RSRQ Range (dB)	Interpretation	Color
> -80	> -10	Excellent	Green
-80 to -90	-10 to -15	Good	Yellow
-90 to -100	-15 to -20	Marginal	Orange
< -100	< -20	Poor	Red

B. Reference Signal Received Quality (RSRQ)

The Reference Signal Received Quality is a fundamental parameter within the key performance indicators of LTE data. It indicates the quality of the signal received in the resource elements, which includes the reference signals. Its calculation is performed through:

$$RSRQ = N \times \left(\frac{RSRP}{RSRI} \right) \quad (2)$$

Where N represents the number of resource blocks within the measurement bandwidth. [9]. This parameter is particularly sensitive to co-channel interference and to the traffic load in the cell. Typical RSRQ values range between -3 dB (excellent) and -19.5 dB (poor). A degradation in RSRQ, even when RSRP is acceptable, may indicate intercell interference, channel congestion, or poor frequency planning.

C. Channel Power in the Spectrum Analyzer.

In LTE systems, channel power corresponds to the total energy received within the bandwidth assigned to the LTE carrier, including reference signals, control signals, user data, and interference. This power is typically measured using spectrum analyzers configured to the carrier's center frequency and bandwidth, allowing the complete spectral behavior of the downlink to be visualized.

The direct observation of the total power in the spectrum is an essential tool for the physical analysis of the LTE radio layer, as it instantly reflects the real condition of the channel and the spectral occupancy. [9].

III. METHODOLOGY

Two drive tests were carried out using Cell Network Info Pro (CNIP) application (Version 7.3.2) installed on the user equipment (UE) Samsung Galaxy A21S (SM-A217M/DM) along the selected section (see Fig. 2) inside UNAH-CU to obtain multiple RSRP and RSRQ measurements for each operator. This data provided us with an initial baseline and insight into the spatial distribution of RSRP and RSRQ, enabling the strategic selection of measurement points for subsequent detailed assessments. Operator 1 corresponds to Tigo, which is assigned the downlink frequency block centered at $2120 \text{ MHz} \pm 10 \text{ MHz}$, and Operator 2 corresponds to Claro, which is assigned the downlink frequency block centered at $2140 \text{ MHz} \pm 10 \text{ MHz}$. These frequencies were also used in the spectrum analyzer to record the channel power measurements within the corresponding frequency ranges.

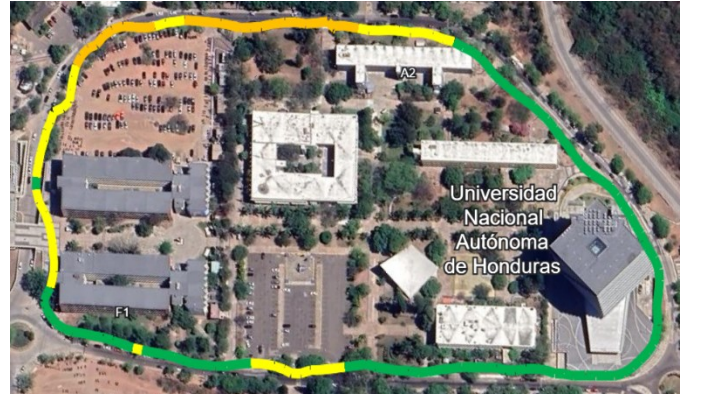


Fig. 2 Continuous RSRP measurements for Operator 1 along the selected area, using the color palette from TABLE I.

The route was then divided into 14 points, as shown in Fig. 3 where the RSRP, RSRQ and channel power measurements were recorded. These measurements were taken on different dates between 9 A.M. and 1 P.M. when pedestrian traffic increases and may contribute to increased LTE network activity. The CNIP app also provided the geographic coordinates for each measurement point where the antennas were used simultaneously. These coordinates are shown in TABLE II. On another two dates we measured only RSRP and RSRQ for both operators along the selected area, same schedule (see Fig. 17 through Fig. 20).

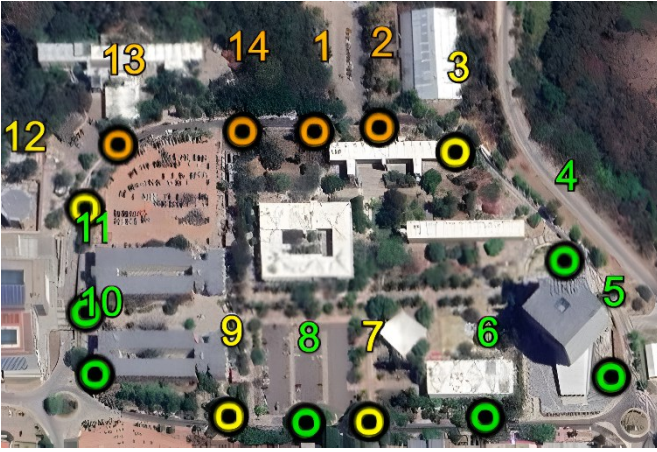


Fig. 3 View of the 14 points where the measurements were taken for the two LTE networks. Colors refer to values shown in TABLE I.

TABLE II
GEOGRAPHIC COORDINATES OF THE 14 MEASUREMENT POINTS

Point	Latitude	Longitude
1	14.08598810	-87.16266050
2	14.08585670	-87.16225367
3	14.08552780	-87.16185235
4	14.08462188	-87.16146088
5	14.08382377	-87.16146897
6	14.08387900	-87.16233224
7	14.08412442	-87.16304918
8	14.08426958	-87.16343808
9	14.08449002	-87.16389577
10	14.08505998	-87.16461315
11	14.08545159	-87.16451734
12	14.08607884	-87.16426190
13	14.08638225	-87.16390006
14	14.08616102	-87.16310293

For channel power measurement, an Agilent/Keysight N9342C spectrum analyzer was used along with two different antennas, and we used two different sweeps. On the first two dates 68.5 ms (measurements were averaged) and then on the third date 494.4 ms. A 20 MHz bandwidth was used on each measurement. First, a monopole antenna that can operate in the 900 MHz, 1800 MHz, and 2100 MHz bands, with a gain of 3 dBi was used to capture the overall received power in the LTE downlink frequency for each operator.

Following these measurements it was replaced with a directional Horn antenna (SAS-571) with an approximate gain of 11 dBi for frequencies near 2100 through 2200 MHz [10]. This was mounted on a tripod at a height of 1.09 m and positioned with an inclination of 45° for the 68.5 ms sweep and 30° for the 494.4 ms sweep. The inclination was set using the application *Digital Compass: Smart Compass* (Version 3.1.3), installed on the UE OnePlus 9 5G (LE2117). Using the same application, the Horn antenna was oriented toward the South,

East, North, and West directions, and the channel power measurements were recorded for each one of them. Vertical polarization was always used. A total of 10 measurements were taken at each point, corresponding to 5 measurements per operator, over the course of 3 days, resulting in 30 measurements per point.

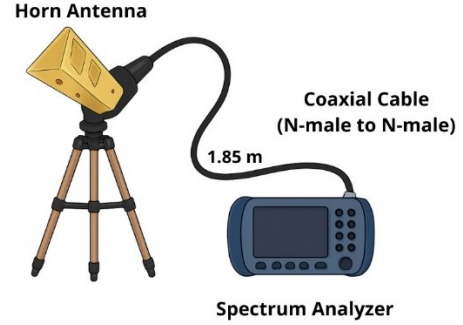


Fig. 4 Diagram of the setup using the Horn antenna, cable with a length of 1.85 m and the spectrum analyzer.

IV. DATA MEASUREMENT AND ANALYSIS

In this section, the data recorded during the channel power measurements using the monopole antenna, the Horn antenna, and the RSRP/RSRQ measurements collected with the UE are analyzed. The analysis begins with the static measurements taken at the 14 points using the monopole antenna.

Based on the recorded measurements, the corresponding statistical distributions are generated. The average, maximum, minimum, median, and interquartile range (IQR) values are presented in TABLE III, and the box-and-whisker plots are shown in Fig. 5 and Fig. 6.

In general, Operator 2 shows higher power levels in most measurements. Although a longer sweep increases the average values for both operators, Operator 2 maintains a clear advantage, while Operator 1 exhibits lower power but greater stability since its IQR is lower. These results show that, although both operators provide acceptable channel power levels at most points, the average conditions offered by Operator 2 in the downlink frequency are better compared to those of Operator 1, which exhibits lower power levels, suggesting less favorable coverage.

TABLE III
CHANNEL POWER FOR MONOPOLE ANTENNA

Metrics	Channel Power with a 68.5 ms sweep (dBm)		Channel Power with a 494.4 ms sweep (dBm)	
	2120 MHz	2140 MHz	2120 MHz	2140 MHz
Average	-52.39	-48.64	-51.40	-49.03
Maximum	-38.90	-36.60	-39.37	-31.55
Minimum	-65.50	-62.61	-64.45	-65.76
Median	-51.57	-50.28	-50	-47.88
IQR	14.99	11.93	13.95	15.19

The measurements taken with the Horn antenna show that Operator 1 has a lower IQR on directions North and East, while Operator 2 has it on directions South and West. For both, their median and average values didn't change more than 2 dB when sweep was changed from 68.5 ms to 494.4 ms. TABLE IV presents a general comparison of the power levels obtained in the four directions for the two different sweep durations.

TABLE IV
CHANNEL POWER FOR HORN ANTENNA

Direction	Metrics	Channel Power with a 68.5 ms sweep (dBm)		Channel Power with a 494.4 ms sweep (dBm)	
		2120 MHz	2140 MHz	2120 MHz	2140 MHz
North	Average	-43.81	-39.94	-43.81	-39.05
	Maximum	-33.58	-21.35	-35.54	-21.67
	Minimum	-52.42	-54.87	-52.86	-55.83
	Median	-42.84	-41.76	-41.51	-40.12
	IQR	12.49	14.48	12.12	16.62
East	Average	-41.59	-40.03	-40.54	-38.59
	Maximum	-30.58	-26.97	-28.33	-22.63
	Minimum	-54.48	-53.13	-54.65	-52.09
	Median	-39.06	-41.07	-39.17	-39.85
	IQR	13.74	14.03	12.25	14.47
South	Average	-39.83	-37.00	-38.60	-37.30
	Maximum	-26.43	-20.43	-25.43	-24.27
	Minimum	-53.32	-53.02	-52.46	-52.27
	Median	-37.79	-38.37	-35.89	-36.55
	IQR	15.46	10.97	15.76	11.57
West	Average	-41.07	-38.71	-40.27	-38.13
	Maximum	-29.98	-24.45	-29.74	-25.51
	Minimum	-54.12	-53.58	-52.68	-53.97
	Median	-38.82	-39.06	-39.33	-37.37
	IQR	15.00	11.68	16.27	14.51

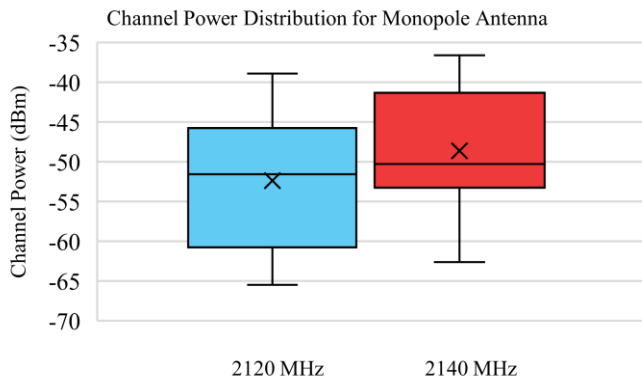


Fig. 5 Channel power distribution with a 20 MHz bandwidth, captured with a monopole antenna, using a 68.5 ms sweep.

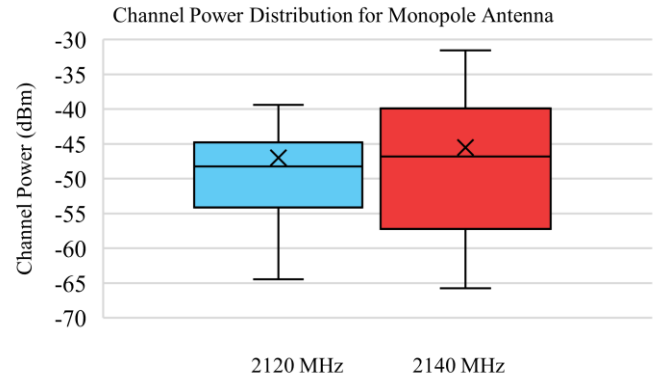


Fig. 6 Channel power distribution with a 20 MHz bandwidth, captured with a monopole antenna, using a 494.5 ms sweep.

Fig. 7 and Fig. 8 show the channel power distribution obtained with the Horn antenna in four directions for Operator 1 under both sweep durations. The South direction consistently yielded the highest received power across all sweeps, whereas the East direction produced the lowest power values.

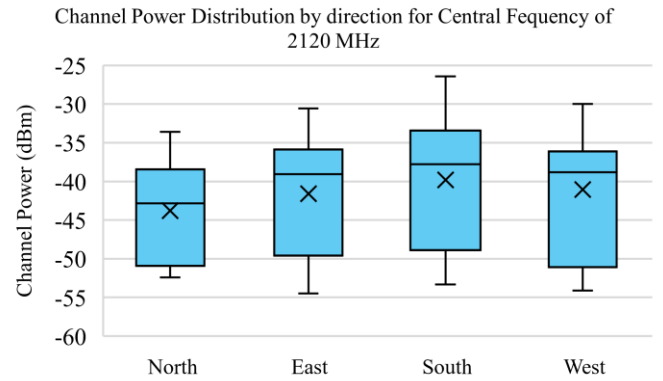


Fig. 7 Channel Power Distribution by Direction with 20 MHz Bandwidth, Captured with Horn Antenna, with 68.5 ms Sweep and 45° Angle.

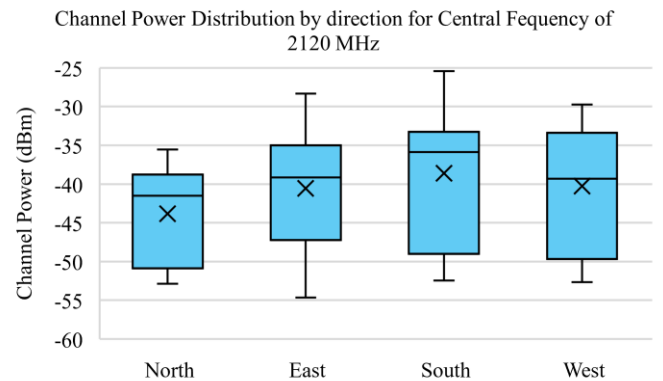


Fig. 8 Channel Power Distribution by Direction with 20 MHz Bandwidth, Captured with Horn Antenna, with 494.5 ms Sweep and 30° Angle.

Fig. 9 and Fig. 10 show the two channel power distributions obtained with the Horn antenna for the central frequency of 2140 MHz. The North direction consistently yielded the highest received power across all sweeps. The IQR also increased for each direction, meaning more variable power values obtained with a bigger sweep.

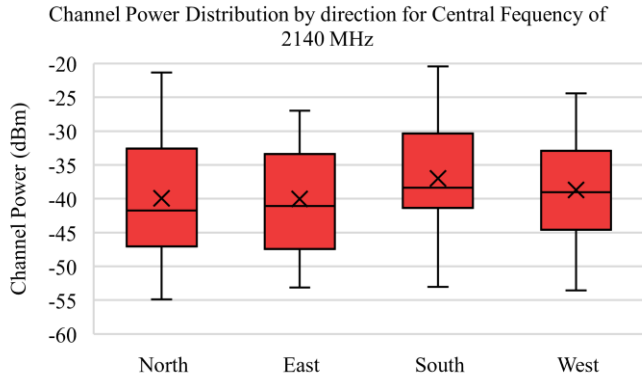


Fig. 9 Channel Power Distribution by Direction with 20 MHz Bandwidth, Captured with Horn Antenna, with 68.5 ms Sweep and 45° Angle.

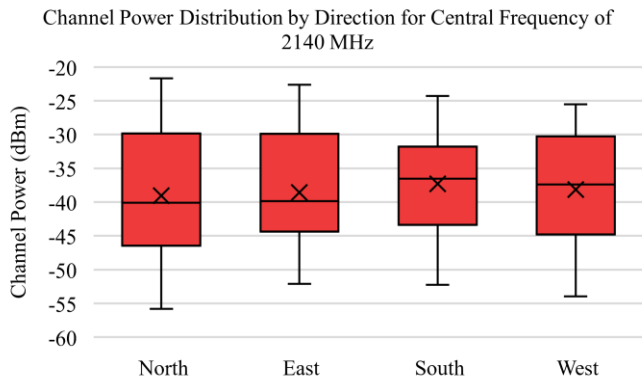


Fig. 10 Channel Power Distribution by Direction with 20 MHz Bandwidth, Captured with Horn Antenna, with 494.5 ms Sweep and 30° Angle.

When a 68.5 ms sweep was performed, Operator 1 showed better results in 55.36 % of the points, while Operator 2 did so in 44.64 %. With a 494.5 ms sweep, Operator 1 showed better results in 51.79 % of the points, whereas Operator 2 did so in 48.21 %. Operator 1 predominates mainly in points 3 through 9, while Operator 2 predominates in points 1, 2, and 10 through 14.

For Operator 1, as shown in Fig. 11 and Fig. 12 the horn antenna generally exhibits a clear advantage over the monopolar antenna, typically providing a gain in the range of 10 to 20 dB across most measurement points when evaluated using the 68.5 ms sweep. This consistent difference highlights the strong directional characteristics of the received signal and suggests the presence of dominant propagation paths that are effectively captured by the horn's narrower beam pattern. When the longer 494.4 ms sweep is considered, the overall trend

remains similar, although the extended integration time tends to smooth out rapid fluctuations and slightly increases the measured channel power at several points, reinforcing the predominance of these directional components. Best directions are towards the South and West.

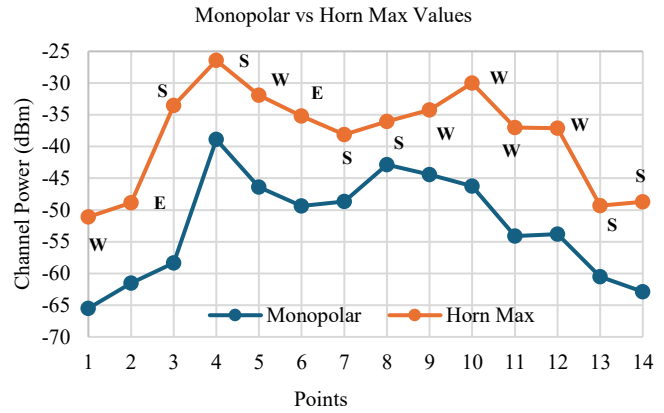


Fig. 11 Comparison between Monopolar and Horn maximum values on each point. Sweep 68.5 ms. Center Frequency 2120 MHz.

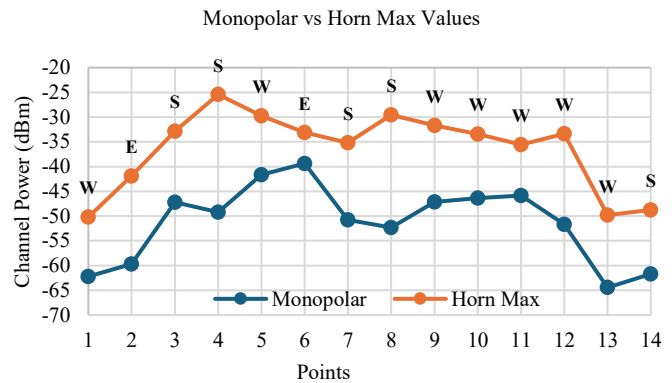


Fig. 12 Comparison between Monopolar and Horn maximum values on each point. Sweep 494.4 ms. Center Frequency 2120 MHz.

Fig. 11 at point 3, the horn antenna reaches nearly 24 dB of gain, which is the highest improvement observed, and in Fig. 12 it shows a similar behavior at point 4. In contrast, the more moderate differences observed in Fig. 11 at points 7 through 9 and in Fig. 12 at points 6 and 9 through 11 suggest a propagation environment with greater multipath dispersion or weaker line of sight influence, where the energy received arrives from several comparable directions.

For Operator 2, as shown in Fig. 13 and Fig. 14, the horn antenna clearly outperforms the monopolar antenna for both sweep times of 68.5 ms and 494.4 ms. In almost all points the horn provides a gain of roughly 10 to 20 dB with respect to the monopolar value, which indicates that the channel power arrives highly concentrated from a dominant direction that is effectively captured by the horn pattern.

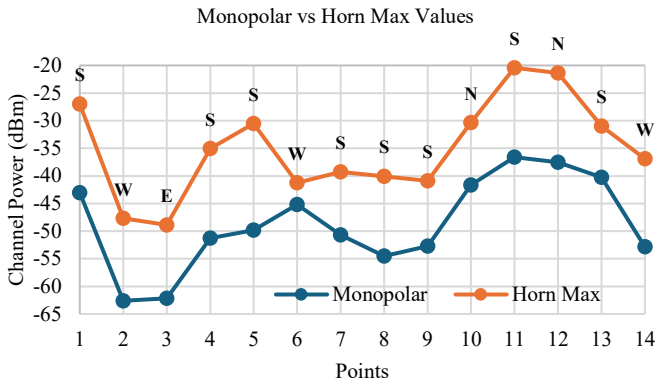


Fig. 13 Comparison between Monopolar and Horn maximum values on each point. Sweep 68.5 ms. Center Frequency 2140 MHz.

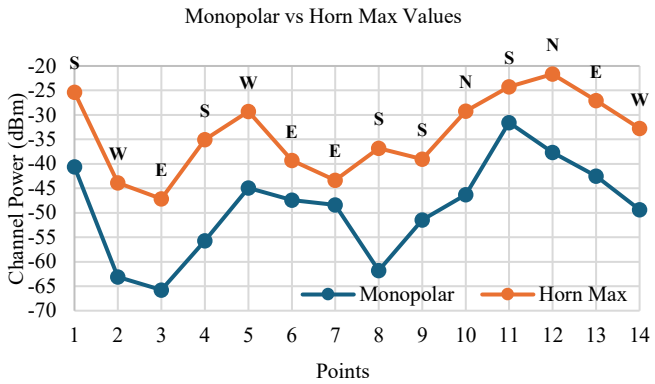


Fig. 14 Comparison between Monopolar and Horn maximum values on each point. Sweep 494.4 ms. Center Frequency 2140 MHz.

The directions associated with the maximum horn values are mainly towards the South, with some cases towards the West, East or North, suggesting that the strongest components of the field come from a well-defined sector of the cell rather than from an isotropic environment. Only at point 6, and to a lesser extent at points 7 and 11 in the longer sweep, the difference between antennas becomes moderate, which points to a more diffuse or multipath-rich propagation.

The longer sweep of 494.4 ms preserves the same tendency and even increases the separation between horn and monopolar at some locations, confirming that Operator's 2 downlink around the measurement route is strongly directional and that the monopolar antenna systematically underestimates the available channel power in comparison with the horn.

It should be noted that part of this margin comes from their different radiation characteristics previously described in the methodology indicating that directional effects and propagation selectivity contributed beyond the nominal gain difference.

The average RSRP and RSRQ measurements recorded at each of the 14 evaluation points are shown in Fig. 15 for Operator 1 in and in Fig. 16 for Operator 2. It can be observed that lower RSRP values also coincide with a decline in RSRQ. This indicates that the signal arrives highly attenuated and is additionally affected by interference.

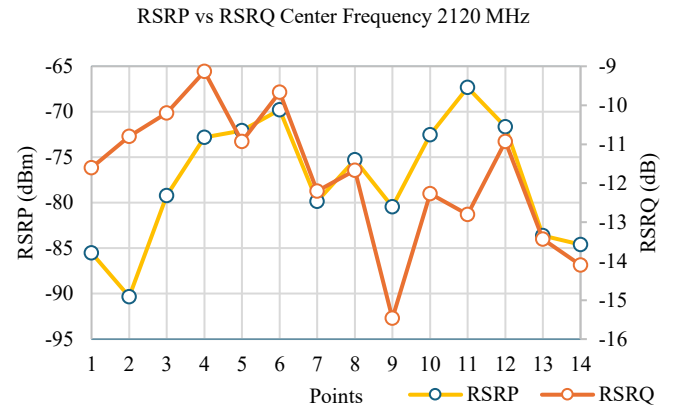


Fig. 15 RSRP vs RSRQ for operator 1

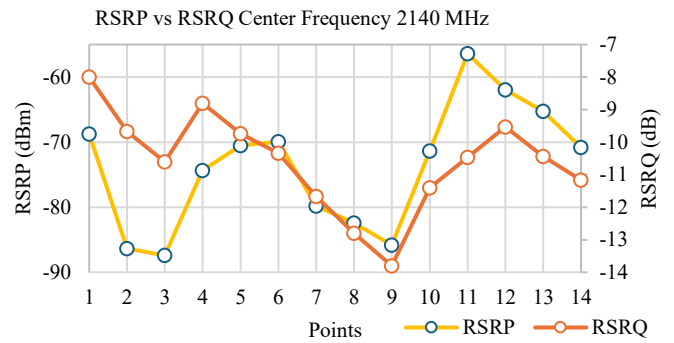


Fig. 16 RSRP vs RSRQ for operator 2.

Operator 2 exhibits more favorable behavior, with higher RSRP levels in most points and more stable RSRQ values. Operator 1 shows weaker RSRP levels and stable but lower RSRQ values. This suggests that Operator 2's network provides better quality and performance than Operator 1's network in the evaluated locations.

Fig. 17 to Fig. 20 shows the pathways with averaged RSRQ and RSRP. Operator 2 clearly outperforms in the route from Point 10 to 14, which is a zone with elevated pedestrian traffic.



Fig. 17 Pathway for RSRP distribution in Operator 1.



Fig. 18 Pathway for RSRQ distribution in Operator 1.



Fig. 19 Pathway for RSRP distribution in Operator 2.



Fig. 20 Pathway for RSRQ distribution in Operator 2

Fig. 21 to Fig. 24 shows an empiric probability density function (PDF) over a normalized histogram for the RSRP and RSRQ for each operator, considering 377 data measurements for each. To estimate the coverage probabilities based on TABLE I, we used the Kernel Density Estimation (KDE) and integrated using the trapezoidal rule. Operator 2 has a better probability to get “Excellent” RSRP and RSRQ. Results are shown on TABLE V.

TABLE V
RSRP AND RSRQ LEVEL PROBABILITIES BY COVERAGE

Interpretation	Operator 1 (2120 MHz)		Operator 2 (2140 MHz)	
	RSRP	RSRQ	RSRP	RSRQ
Excellent	54.19	29.69	65.01	49.79
Good	27.22	53.90	25.59	42.65
Marginal	15.54	15.32	7.38	6.77
Poor	1.31	0.92	0.19	0.18

RSRP Probability Density Function Center Frequency 2120 MHz

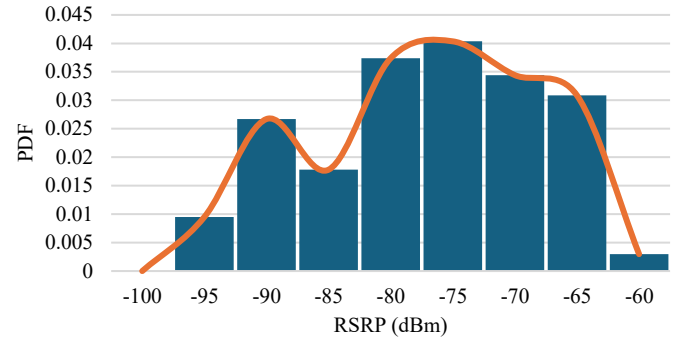


Fig. 21 PDF for RSRP with Central Frequency of 2120 MHz for Operator 1.

RSRQ Probability Density Function Center Frequency 2120 MHz

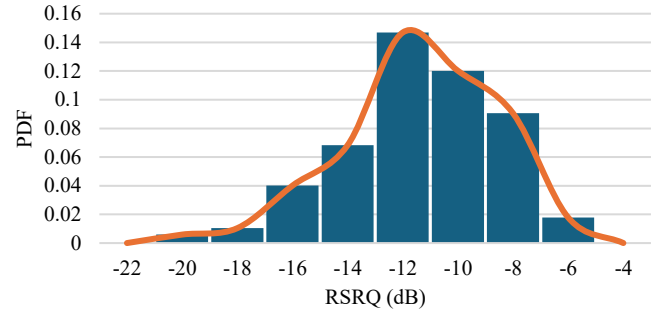


Fig. 22 PDF for RSRQ with Central Frequency of 2120 MHz for Operator 1

RSRP Probability Density Function Center Frequency 2140 MHz

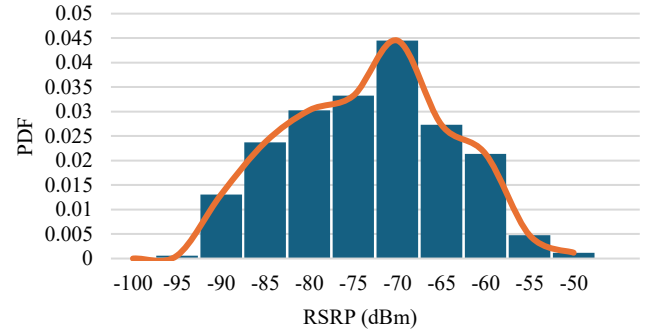


Fig. 23 PDF for RSRP with Central Frequency of 2140 MHz for Operator 2

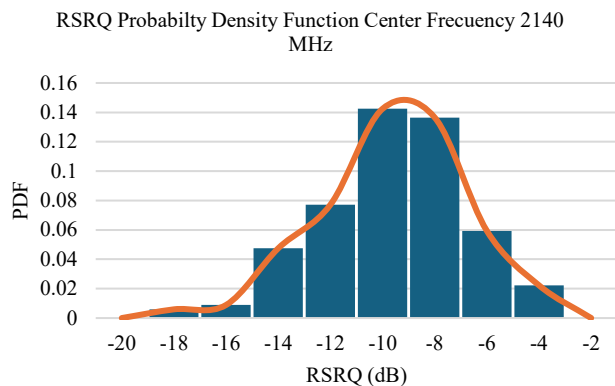


Fig. 24 Probability Density Function for RSRQ with Central Frequency of 2140 MHz for Operator 2.

V. CONCLUSIONS

The comparative analysis shows that Operator 2 provides better performance in the evaluated area. It exhibits higher RSRP values with stable RSRQ levels, as well as greater channel power at most points measured with the monopole antenna. This objectively reflects higher propagation efficiency and better link quality. Operator 1, although showing stable RSRQ measurements, presents lower RSRP and channel-power values, which translates into less efficient coverage across the evaluated points. Even so, the measured values indicate that both operators provide adequate connectivity; however, Operator 2 offers better overall quality and performance in the measured locations.

The measurements obtained with the Horn antenna provide a more physical and directional perspective of the link, as they show how the channel power varies according to the orientation of the main beam. The comparison between the channel power measured with the Horn antenna and the RSRP and RSRQ values recorded by the user equipment reveals a clear consistency in the LTE link behavior. The directions and points where the Horn antenna reports higher power coincide with more favorable RSRP and RSRQ values, whereas areas with lower spectral energy show a decline in both indicators. This adds greater robustness to the comparison between both operators, with Operator 2 presenting the highest channel-power values.

The comparison between horn and monopolar antennas for both operators shows that the horn consistently records higher channel power across most measurement points. These results indicate that the propagation environment is largely directional, with well-defined dominant paths that the horn antenna captures more effectively than the monopolar antenna.

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