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Comparative Analysis Of 4G LTE Network Quality At 900 Mhz And 2100 Mhz Frequencies

Ditto Putra Wenadri [a], *Afrizal Yuhanef[b], Dikky Chandra[c]

[a,c,b] *Politeknik Negeri Padang, Padang, Indonesia*

**afrizal@pnp.ac.id,*

***Abstract*— 4G networks were created to provide excellent service and fast data transmission. The goal is to promote better reception, maintain smooth data flow, and speed up information exchange. Indonesia has six mobile operators, each of which has the right to use the radio frequency spectrum to deploy mobile network services. The radio frequencies used are divided into 450 MHz, 850 MHz, 900 MHz, 1,800 MHz, 2,100 MHz, and 2,300 MHz. This research focuses on the comparison of 4G LTE network quality at 900 MHz and 2100 MHz frequencies.Data collection is done by conducting a drive test and using the dedicated mode method. The software that is utilized for data processing are TEMS Pocket and TEMS Discovery Device. The network quality of both frequencies is measured based on RSRP, SINR, and Throughput parameters. The results of network quality measurements were obtained for the 900 MHz frequency, namely, RSRP worth 79.54%, SINR worth 65.69%, and Throughput worth 37.65%. While the frequency of 2100 MHz, namely, RSRP is worth 82.1%, SINR is worth 76.84%, and Throughput is worth 72.18%. Of the two frequencies, the 2100 MHz frequency has a better value than the 900 MHz frequency.**

***Keywords*— 4G LTE, Radio Frequency, Comparison, RSRP, SINR**

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I. INTRODUCTION

4G networks are an extension of 3G technology, officially known as 3G. HSDPA (High Speed Downlink Packet Access) technology, also known as 3.5G technology, had previously been devel- oped based on WCDMA and has similarities to EVDO, which was developed based on CDMA in 2000. HSDPA is a cellular protocol that evolved from UMTS (Universal Mobile Telecommunica- tions System)[1].

Indonesia has six mobile operators registered with the Ministry of Communication and Infor- mation Technology (Kominfo). Each operator has the right to use the radio frequency spectrum to deploy cellular network services. The radio frequencies used are divided into 450 MHz, 850 MHz, 900 MHz, 1,800 MHz, 2,100 MHz, and 2,300 MHz. Of the six operators, Telkomsel has the longest frequency band. Telkomsel operator has a total frequency capacity of 105 Mhz[2]. Some of the frequency bands used by Telkomsel operators include; 850, 900, 1800, 2100 and 2300 Mhz. All Telkomsel 4G LTE networks have spread throughout Indonesia, including in the Korong Gadang Village area.

Korong Gadang Village is included in the administrative area of Kuranji Subdistrict, Padang City, West Sumatra. The population in 2021 was 20,125 people and has an area of 7.05 square kilometers[3]. The geographical location on the north is bordered by Gunung Sarik Village, the south is bordered by Pasar Ambacang Village, the west is bordered by Kalumbuk Village, the east is bordered by Kuranji Village.

Source from Telkomsel site data in 2022, there are 2 sites included in the Korong Gadang village area. The first site is SITEID PAD020 with the type of frequency band used is LTE1800, LTE900, LTE2300 and LTE2100. As for the second site with SITEID PAD145 with the type of frequency band LTE2300, LTE1800, LTE900 and LTE2100. Both sites have different antenna azimuths that allow coverage areas for the Korong Gadang area to be poorly met. In addition, each frequency band has different coverage limits and signal quality due to differences in antenna height at the site.

II. MATERIALS AND METHOD

In this research, checking the network quality of Telkomsel provider using the Drive Test method, which aims to see how the quality of the existing network in the area that has been taken real data and determine the influence and causes of problems in each 4G LTE parameter. The drive test measurement method used in this research is dedicated mode. Path planning is done to determine which areas will be taken network data later, as shown in Fig. 1.

Fig. 1. Drive Test Route

Drive test data collection is carried out using software TEMS Pocket that is already installed on a Samsung Galaxy S5 smartphone. The devices used when conducting the drive test are Smartphone and Global Positioning System (GPS). As for processing the data that has been taken using TEMS Discovery Device, the devices used for data processing are Laptop and Dongle.

A. Fourth Generation Technology (4G)

Fourth-generation technology stands for 4G, which describes the fourth generation standard of cell phone technology. 4G is a development of 3G and 2G technology. Worldwide, 4G has two standards, WiMAX and Long Term Evolution (LTE)[4]. Long Term Evolution (LTE) is a name given to a project of the Third Generation Partnership Project (3GPP) to improve the 3rd generation mobile phone standard or (3G), namely UMTS WCDMA. LTE is a development of the previous UMTS or (3G) and HSPA (3.5G) which LTE is referred to as the 4th generation or (4G)[5].

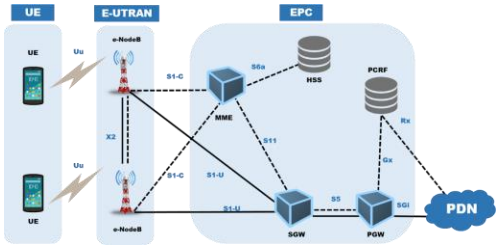

Fig. 2. 4G LTE Architecture[6]

B. 4G LTE Frequency Bands in Indonesia

Indonesia has several types of 4G frequency bands available including Band 1 (2100 MHz), Band 3 (1800 MHz), Band 5 (850 MHz), Band 7 (2600 MHz), Band 8 (900 MHz), and Band 28 (700 MHz)[7]. In addition, the use of LTE frequencies is different in each city. Telkomsel has the largest 4G frequency band in Indonesia with a total frequency capacity of 105 Mhz. After the merger between Indosat Ooreedoo and Hutchison Tri, both have large frequency band allocations[8]. XL Axiata has a total frequency band allocation of 90 MHz, while Smartfren has a total of 62 MHz.

C. Drive Test

Drive Test is one part of the work in radio network optimization that aims to measure and collect real network information in the field. The information collected is the actual radio frequency (RF) conditions in an eNodeB[9]. The drive test measurement method is divided into two, with the following explanation[10]:

a. Idle Mode : It is a measurement of the quality of the signal received by the MS in download or connection activities. This mode aims to determine the network signal in areas that experience low signal.

b. Dedicated Mode: This is a signal quality measurement followed by channel occupation during the download process to a specific server address. This mode aims to measure and iden- tify the data transfer speed.

C. Drive Test Data Collection

The way drive test data is collected is divided into four processes, including[11]:

a. Single Site Verification (SSV) : Single Site Verification is a method that is carried out for one site only. This method is performed on problematic sites or newly constructed sites to determine how far away the site is and whether it interferes with nearby sites. SSV is done to ensure the site is in an optimal and proportional state.

b. Cluster : Cluster is a drive test method that measures the network of each cluster or area consisting of several sites but only for one network operator.

c. Benchmark : The benchmark method is a drive test method to compare the network of an operator with the network of another operator in a cluster.

d. Optimization : Optimization is part of the analysis of interference or lack of service quality at the finished site.

D. Drive Test Parameter

Drive test is an activity to take data

(collecting) a network network using certain software and hardware. The following below are the majority of parameters used in drive tests on LTE tech- nology[12]. To measure the quality of a 4G LTE network, there are several parameters that are most important, namely :,

a. Reference Signal Received Power (RSRP)

RSRP (Reference Signal Received Power) is LTE power signal received by the user in a certain frequency. The farther the distance between the site and user, the smaller the RSRP received by the user[13].

b. Reference Signal Received Quality (RSRQ)

RSRQ is the quality of the signal received by the UE. It is the ratio between RSRP and wideband power. RSRQ is also affected by the signal, noise and interference received by the UE. The unit of RSRQ is dB and the value is always negative[14].

c. Signal to Interference Noise Ratio (SINR)
SINR is the ratio of signal strength to background noise[15].

d. Throughput

Throughput is the effective data transfer rate, measured in bps. Headers in data packets re- duce this value. Throughput is related to the available bandwidth on the network. The band- width provided is not all used by applications on the network[16].

E. Test Mobile System (TEMS)

TEMS Investigation is short for test mobile system which is one of the software used to conduct drive tests[17]. While TEMS Pocket is one of the devices that can be used to observe cel- lular networks. TEMS is also useful for verification, maintenance, and troubleshooting of cellular networks as well as for basic cell planning tasks.

F. Google Earth

Google Earth, originally called Earth Viewer, is a virtual globe, map, and geographic infor- mation program developed by Keyhole.Inc, a company acquired by Google. Google Earth displays satellite images of the Earth's surface in a variety of resolutions, giving you visual access to a variety of information about cities, homes, roads, rivers, and more[18].

G. Key Performance Indicator (KPI)

Table 1. KPI Targets[19][20]

No	Parameter	KPI Targets
1	RSRP	90% ≥ -100 dBm
2	SINR	80% ≥ 0 dB
3	THROUGHPUT	≥ 7200kbps

Key performance indicators are tools for evaluating the quality and effectiveness of mobile net- work services. Some KPIs used to measure LTE network quality are:.

a. Reference Signal Received Power (RSRP)

Table 2. Range of RSRP Value[20]

RSRP	Color	Strength (dBm)
Excellent		-75 ≤ RSRP < 0
Very Good		-85 ≤ RSRP < -75
Good		-100 ≤ RSRP < -85
Fair		-110 ≤ RSRP < -100
Poor		RSRP < -110

b. Signal to Interference Noice Ratio (SINR)

Table 3. Range of SINR Value[20]

SINR	Color	Srength (dB)
Excellent		SINR ≥ 20
Good		13 ≤ SINR < 20
Fair		0 ≤ SINR < 13
Poor		SINR < 0

c. Throughput

Table 4. Range of Throughput Value[19]

Throughput	Color	Strength (Kbit/s)
Excellent		Throughput ≥ 12000
Very Good		7200 ≤ Throughput < 12000
Good		1500 ≤ Throughput < 7200
Fair		324 ≤ Throughput < 1500
Poor		0 ≤ Throughput < 324

III. RESULTS AND DISCUSSION

A. RSRP Parameter Result

RSRP is a power received by a user or MS (Mobile Station) from BTS (Base Transceiver Station). The closer the MS position is to the BTS, the better the signal will be received and the greater the RSRP value.

B. RSRP of 900 MHz Frequency

The following Fig.3. is a display of the results RSRP parameter drive test at a frequency of 900 MHz.

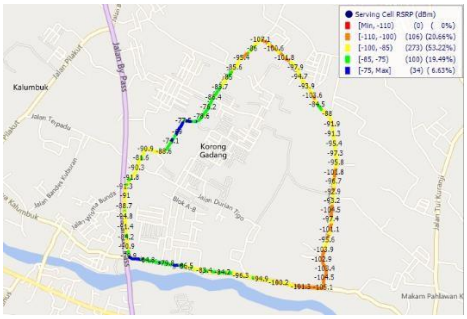

Fig. 3. Result display of RSRP at 900 MHz

Table 5. RSRP Value 900 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	-75 ≤ RSRP < 0	34	6.63
Very Good	-85 ≤ RSRP < -75	100	19.49
Good	-100 ≤ RSRP < -85	273	53.22
Fair	-110 ≤ RSRP < -100	106	20.66
Poor	RSRP < -110	0	0.00
TOTAL		513	100,00

From the drive test data obtained for the results of the RSRP parameters of Telkomsel operators at a frequency of 900 Mhz, it can be seen in Fig.3. In this figure it can be seen that there are 513 samples obtained during the record process around the route. Signal reception in the very strong/ex- cellent category is marked with a blue indicator with a receiving power of >-75 dBm, which has 34 samples with a percentage value of 6.63%. As for the Very Good category in the -85 to -75 dBm value range, there are 100 samples with a percentage of 19.49% marked with a green indicator. Normal signal reception is marked with a yellow indicator, which has a receiving power of -100 dBm to -85 dBm from 273 samples with a percentage of 53.22%. Signal reception with a weak category is characterized by a red indicator, which has a receiving power of <-110 dBm from 0 samples at 0%. Signal reception with orange color with values at -100 to -110 has 106 samples with 20.66%.

C. RSRP of 2100 MHz Frequency

The following Fig.4. is a display of the results of the RSRP parameter drive test at a frequency of 2100 MHz.

Fig. 4. Result display of RSRP at 2100 MHz

Table 6. RSRP Value 2100 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	-75 ≤ RSRP < 0	58	11.28
Very Good	-85 ≤ RSRP < -75	105	20.43
Good	-100 ≤ RSRP < -85	259	50.39
Fair	-110 ≤ RSRP < -100	91	17.7
Poor	RSRP < -110	1	0.19
TOTAL		514	100

For the results of the Telkomsel operator drive test at a frequency of 2100 MHz can be seen in Fig.4. In table 6 it can be seen that there are 514 samples obtained during the data collection process. For the excellent signal reception category, there are 58 samples with a percentage of 11.28%, which are marked with blue indicators. In the Very Good/excellent category there are 105 samples with a percentage of 20.43%, marked with a green indicator. As for signal reception in the good category, there were 259 samples with a percentage of 50.39%, marked with a yellow indicator. For the mod- erate category, there are 91 samples and only 1 sample in the bad category, both have a percentage of 17.7% and 0.19% which are marked with orange indicators for the moderate category and red indicators for the bad category.

D. Comparison of RSRP Parameters at 900 MHz and 2100 MHz Frequencies

The following Fig.5. below is a graph of the percentage comparison of RSRP parameter values of Telkomsel providers at frequencies of 900 MHz and 2100 MHz.

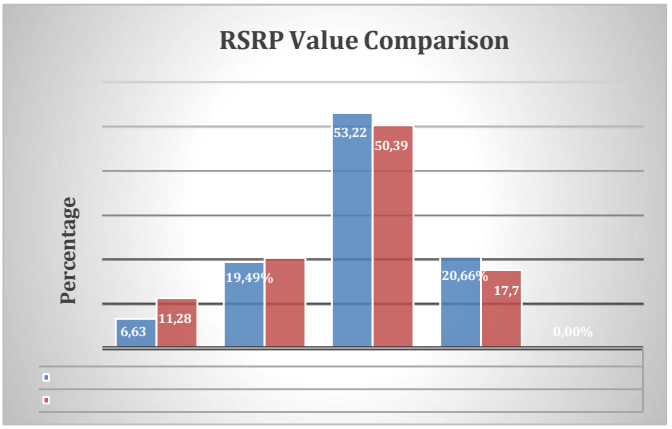

Fig. 5. Comparison of RSRP at 900 MHz and 2100 MHz

E. SINR Parameter Result

SINR which is the ratio of the signal strength between the main signal transmitted with in- terference compared to the background noise that arises (mixed with the main signal). In other words, the ratio between the average received power and the average interference and noise.

SINR of 900 MHz Frequency

The following Fig.6. is a display of the results of the SINR parameter drive test at a fre- quency of 900 MHz.

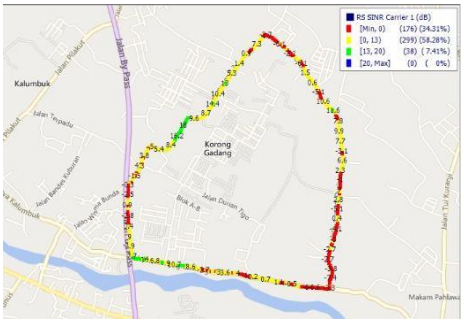

Fig. 6. Result display of SINR at 900 MHz

Table 7. SINR Value 900 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	SINR ≥ 20	0	0.0
Good	13 ≤ SINR < 20	38	7.41
Fair	0 ≤ SINR < 13	299	58.28
Poor	SINR < 0	176	34.31
TOTAL		513	100

From the drive test data obtained for the results of the Telkomsel provider SINR parameters at a frequency of 900 Mhz can be seen in Fig.6. In table 7, it can be seen that during the record process, 513 samples were obtained. For the excellent SINR value category, not a single sample was obtained with a percentage of 0.0%. In the good/good category signal reception there are 38 samples with a percentage of 7.41% marked with a green indicator. For the moderate/fair category there are 299 samples with a percentage of 58.28%, having a receiving power of 0 dB to 13 dB marked with a yellow indicator. Signal reception with a weak category with a red indicator is 176 samples with a percentage of 34.31. It can be concluded that the SINR parameter of Telkomsel operator at a fre- quency of 900 MHz in the Korong Gadang area has very poor quality, because the largest number of samples is in the yellow and red indicators.

SINR of 2100 MHz Frequency

The following figure 7 is a display of the results of the SINR parameter drive test at a frequency of 2100 MHz.

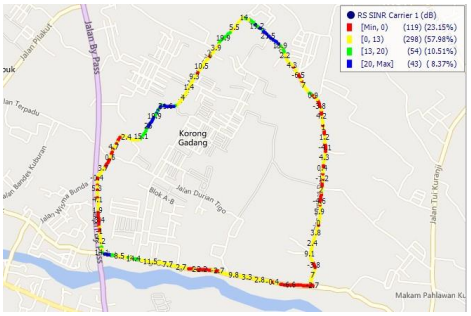

Fig. 7. Result display of SINR at 2100 MHz

Table 8. SINR Value 2100 MHz Frequency

Legend	Range (dBm)	Sample	Percentage (%)
Excellent	SINR ≥ 20	43	8.37
Good	13 ≤ SINR < 20	54	10.51
Fair	0 ≤ SINR < 13	298	57.98
Poor	SINR < 0	119	23.15
TOTAL		514	100

For Telkomsel provider drive test data at a frequency of 2100 MHz can be seen in Fig.7. During the record process there are 514 samples shown in table 4, where the signal reception in the excellent category is 43 samples with a percentage value of 8.37% which is marked with a blue indicator. For signal reception in the good category there are 54 samples marked with green indicators, having a percentage value of 10.51%. For the most samples there are moderate/fair category SINR values with 298 samples with a percentage value of 57.98%. As for the weak category, there are 119 sam- ples with a percentage value of 23.15% which is marked with a red indicator in Figure 4.5. The equation below shows the KPI value of the SINR parameter at a frequency of 2100 MHz.

Comparison of SINR Parameters at Frequencies of 900 MHz and 2100 MHz

The following figure 8 below is a percentage comparison graph of the SINR parameter value of Telkomsel operators at frequencies of 900 MHz and 2100 MHz.

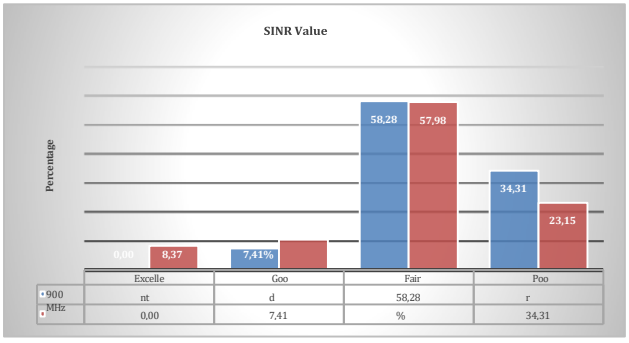

Fig. 8. Comparison of SINR at 900 MHz and 2100 MHz

F. Throughput Parameter Result

Throughput is a 4G parameter that shows the actual bandwidth measured at a certain size of time in a day using a specific internet when downloading a file or more commonly known as the download / upload speed. Throughput data only takes download data.

Throughput of 900 MHz Frequency

The following Fig.9. displays the results of the throughput parameter drive test at a fre- quency of 900 MHz.

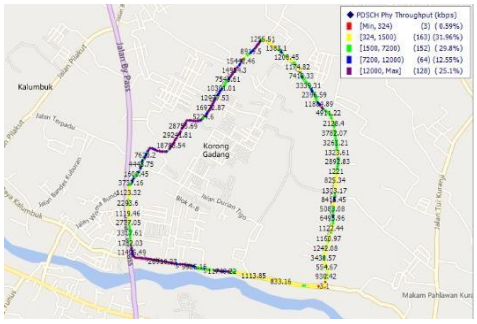

Fig. 9. Result display of Throughput at 900 MHz

Table 9. Throughput Value 900 MHz Frequency

Legend	Range (Kbit/s)	Sample	Percentage (%)
Excellent	Throughput ≥ 12000	128	25.1
Very Good	7200 ≤ Throughput < 12000	64	12.55
Good	1500 ≤ Throughput < 7200	152	29.8
Fair	324 ≤ Throughput < 1500	163	31.96
Poor	0 ≤ Throughput < 324	3	0.59
TOTAL		510	100,00

Figure 9 is the result of the drive test of throughput parameters of Telkomsel provider at a frequency of 900 MHz. From the data obtained for the throughput value of the very good category there are 128 samples with a percentage value of 25.1%. For the very good category there are 64 data samples with a percentage value of 12.55%. For the good category, the data obtained were 152 samples with a percentage value of 29.8%. As for the moderate category, the data obtained amounted to 163 samples with a percentage of 31.96%. Finally for the bad category there are only 3 samples with a percentage of 0.59%. In the measurement of throughput data that has been obtained, there are a total of 192 samples that exceed the value ≥ 7200 Kbps with a total percentage value of 37.65%.

Throughput of 2100 MHz Frequency

The following Fig.10. displays the results of the throughput parameter drive test at a fre- quency of 2100 MHz.

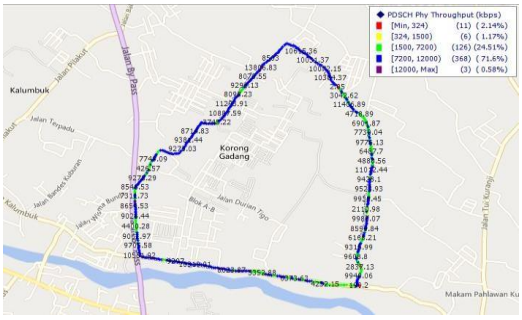

Fig. 10. Result display of Throughput at 900 MHz

Table 10. Throughput Value 2100 MHz Frequency

Legend	Range (Kbit/s)	Sample	Percentage (%)
Excellent	Throughput ≥ 12000	3	0.58
Very Good	7200 ≤ Throughput < 12000	368	71.6
Good	1500 ≤ Throughput < 7200	126	24.51
Fair	324 ≤ Throughput < 1500	6	1.17
Poor	0 ≤ Throughput < 324	11	2.14
TOTAL		514	100,00

Figure 10 is the result of the drive test of Telkomsel provider throughput parameters at a frequency of 2100 MHz. For the data that has been obtained, the most samples are obtained in the excellent/very good category with 368 samples with a percentage of 71.6%. In the excellent category there are only 3 samples with a percentage of 0.58%. For the good category there are 126 samples with a percentage of 24.51%, while for the medium and bad categories there are 6 and 11 samples with a percentage value of 1.17% and 2.14%.

Comparison of Throughput Parameters at Frequencies 900 MHz and 2100 MHz

The following Fig.11. below is a percentage comparison graph of Telkomsel provider throughput parameter values at frequencies of 900 MHz and 2100 MHz.

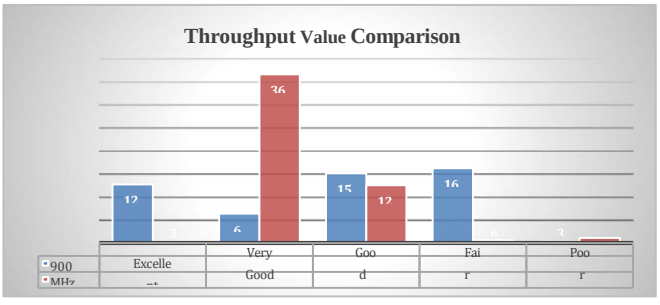

Fig. 11. Comparison of Throughput at 900 MHz and 2100 MHz

To see the comparison of the results of the throughput parameter drive test at frequencies of 900 MHz and 2100 Mhz can be seen in Figure 11. At a frequency of 900 MHz there are 192 data samples that

reach the throughput parameter standard. For the 2100 MHz frequency, there are 371 data sam- ples that reach the throughput parameter standard. In the throughput parameter of Telkomsel opera- tor, 2100 MHz frequency has a good and stable value in the verygood category with a range of values ≥ 7200 Kbps to < 12000 Kbps. The advantage of 2100 MHz frequency lies in the speed of data transmission, therefore the throughput value of 2100 MHz frequency is much better and stable than 900 MHz frequency. In addition, the 2100 MHz frequency is a capacity band, which is a fre- quency that provides more bandwidth, which means it has a higher speed, but has a coverage area that is not so wide. While the 900 MHz frequency is a type of coverage band frequency, which is a frequency that has a very wide coverage area and propagates further, but has shortcomings in the speed of data transmission.

IV. CONCLUSION

Based on the results of the drive test that has been done and the results of data that has been processed through TEMS Discovery, the calculation of the percentage value of 4G LTE parameters are RSRP, SINR and Throughput. RSRP parameter has a target value ≥ 100 dBm is 90%, SINR parameter has a target value ≥ 0 dB is 80%, and throughput parameter has a target value ≥ 7200 Kbps. For the 900 MHz frequency results, the RSRP parameter obtained a value of 79.54%, the SINR parameter obtained a value of 65.69% and the throughput parameter obtained a value ≥ 7200 Kbps as many as 192 data samples. For the frequency of 2100 MHz, the SINR parameter obtained a value of 82.1%, the RSRP parameter obtained a value of 76.86% and the throughput parameter obtained a value ≥ 7200 as many as 371 data samples. Based on the drive test results, the quality of 2100 MHz frequency is better than 900 MHz frequency in Korong Gadang area.

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