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Analysis of Signal Quality Performance on Telkomsel Providers in Simpang Alahan Mati District, Pasaman Regency

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***Abstract*— The emergence of complaints about the quality of the Telkomsel operator signal such as the received signal is not stable, data access is difficult to connect, and connection failures, so in this study to determine the cause of poor signal quality. Analysis of signal quality was carried out in Simpang Alahan Mati Kabupaten Pasaman.analysis was carried out by means of a drive test at the LSK120, LSK174, and LSK030 sites using TEMS Pocket on 3G and 4G networks, by analyzing parameter RSRP, SINR for 4G networks as well as the parameters RSCP and Ec/No to the 3G network. Then the propagation calculation is carried out to compare the value of the received power level measured with the coverage site obtained from the propagation calculation. The signal quality of Telkomsel operators in Simpang Alahan Mati From the measurement results for the 4G network with the average parameter value of RSRP - 102 dBm, and SINR 8 dB. The measurement results on the 3G network with an average value of RSCP parameters -98 dBm and Ec/No -11 dB. From the measurement results based on KPI, it can be seen that the signal quality on the 3G and 4G networks is included in the bad category caused by obstacles in the form of hills and trees from the comparison results of the RSRP and RSCP values measured by the range. site with propagation calculations.**

***Keywords*— Drive test; RSRP; SINR; RSCP; Propagation.**

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I. Introduction

The emergence of complaints from Telkomsel operator users in Simpang Alahan Mati District who complained about network quality including unstable signals received, data access that is difficult to connect, connection failures, handover failures, and throughput service interruptions when uploading and downloading data also called low throughput cells. Low throughput cell is a condition where the cell experiences excessive load due to the large number of users so that it will reduce throughput.

Handover is a mechanism that allows users to move services from one sector to another within and between BTSs without disconnection, with frequency/channel transfer performed automatically by the system. The handover process is affected by receiver power factors, receiver signal quality, distance between UE and BTS, and interference, each of which has a threshold above which handover must occur to prevent a downlink or dropped call. The handover process does not always run smoothly, even though the threshold value has been passed but still no handover occurs, which causes handover failure or handover failure.[5]

Simpang Alahan Mati District is one of the sub-districts in Pasaman Regency, this sub-district is located at 00°04ˈLU-00°04ˈ S and 100°08'-100°112' E with an area of ±69.56 km2. Simpang Alahan Mati sub-district consists of two Nagari namely Nagari Simpang and Nagari Alahan Mati, which have a population of 12384 people consisting of 6266 males and 6118 females [3]. Simpang Alahan Mati District has many trees that can inhibit signal emission also called obstacles. This results in the EU (User Equipment) experiencing a weakening of the received signal allowing the EU to fail to communicate.

The signal quality in Simpang Alahan Mati district is found to be -105 dBm for the RSRP parameter and -12 dBm for the RSRQ parameter in tests conducted on one of the networks, namely the 4G network using G-Nettrack. Based on the standard value of the Key Performance Indicator (KPI), the RSRP value of the Telkomsel operator is considered good at a value of -85 dBm. A good RSRQ value is -10 dBm. From the tests performed, we see that the signal quality in the Simpang Alang Mati district is weak and is called a bad spot area, a bad spot area is where the parameters are not optimal and may affect the performance of the network. There are two solutions to overcome the problem of bad spot areas, namely antenna configuration and site addition.

At the LSK120_Mudik Simpati, LKS174_Kenagarian Simpati, and LSK030_Simpang Alahan Mati sites, a drive test is carried out to find out which areas are covered by the network using TEMS Pocket, which aims to collect real network information in the field. The measured drive test data will be viewed and analyzed concerning the parameters measured using TEMS Discovery.

II. MATERIALS AND METHOD

To ensure optimal signal quality, several stages must be carried out during the checking process. To assess the areas that have not been covered by the 4G LTE network, a survey was conducted at a location in Simpang Alahan Mati Pasaman District, as shown in Figure 1. Subsequently, a drive test was performed using the TEMS Pocket application to identify areas that require optimization and to locate bad spot points within the area. The drive test data was collected at the Simpati LSK120_Mudik, Simpati LSK174_Kanagarian, and LSK030_Simpang Alahan Mati sites. After completing the drive test, the data was processed using the TEMS Discovery application, and an analysis was carried out on the results.

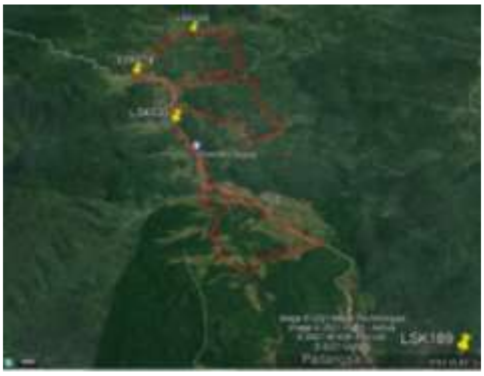

Fig. 1 A drive test track planning on Google Earth

A. *Third Generation (3G)*

Universal Mobile Telephone Standard (UMTS) is the 3G standard system used in Indonesia. It uses WCDMA (Wideband Code Division Multiple Access) technology that allows data rates of up to 384 kbps. In 3G networks, the voice quality is better, and the data rate is higher (up to 10 Mbps using High-Speed Downlink Packet Access (HSDPA)), therefore a bandwidth of 5 MHz is required in the WCDMA system[9].

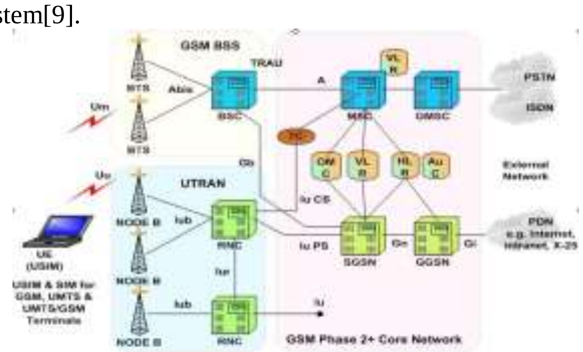

Fig. 2 3G Architecture

B. *Fourth Generation Technology (4G)*

4G LTE stands for Fourth Generation Long Term Evolution which is a long-term evolution radio access network produced by The Third Generation Partnership Project (GPP). LTE is a continuation of the third-generation (3G) WCDMA-UMTS technology. LTE technology has a data transfer rate on the Downlink side reaches 100 Mbps and the Uplink side maximum access speed of 50 Mbps with access technology used is Orthogonal Frequency Division Multiplexing Access (OFDMA) in the downlink direction and Single Carrier Frequency Division Multiplex Access (SCFDMA) in the uplink direction, which is combined with the use of Multiple Input Multiple Output (MIMO).

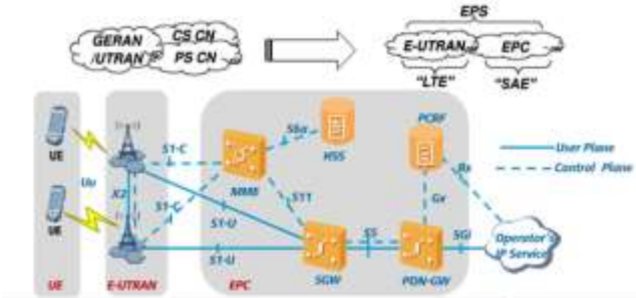

Fig. 3 4G LTE Architecture

C. *Drive Test*

Drive Test is a data collection conducted to observe the performance of coverage area conditions. This is done to observe and is a stage to determine network conditions and signal strength measurements. Drive tests aim to collect real network information in the field. The information collected is the actual condition of Radio Frequency (RF) in an eNodeB.[4]

D. *Drive Test Parameters on 4G*

The parameters contained in the 4G network are as follows.

1) *Reference Signal Received Power (RSRP)*

RSRP is the LTE signal power received by the user in a certain frequency range. If the distance between the site and the user is getting farther, it can cause the RSRP value to be smaller when received by the user. RS (Reference Signal) or RSRP is at every point of coverage. When the user is out of coverage, it will not get LTE service. As shown in Figure 2.4. The following.

2) *Reference Signal Received Quality (RSRQ)*

RSRQ is a measurement parameter used in LTE technology to assess the quality of the received signal. It is calculated as the ratio between RSRP (Reference Signal Received Power) and the wideband power. The RSRQ value is influenced by multiple factors such as the strength of the signal, the presence of noise, and interference experienced by the User Equipment (UE).

3) *Signal to Interference and Noise Ratio (SINR)*

SINR is the ratio of the power of the reference signal to the power of the interference (I) and noise (N) on the same subcarrier shown in equation 1.

$$\text{SINR} = \frac{RSRPserv}{\sum RSRPother+1+N}) \quad (1)$$

4) *Throughput*

Throughput in the LTE drive test is the value of data rate (Kbit/s) from UE to eNodeB. Throughput can be calculated with two types, namely download and upload.

E. *Drive Test Parameters on 3G*

The parameters contained in the 3G network are as follows.

1) *Receive Signal Code Power (RSCP)*

Receive Signal Code Power (RSCP) is a value that indicates the level of signal strength, which is shown in the minus dBm range.

2) *Energy Carrier Per Noise (Ec/No)*

Ec/No is the ratio of the energy of each information signal chip to the accompanying interference signal or noise signal. Ec/No indicates the quality of the signal received by the UE.

F. *Key Performance Indicator (KPI) of 3G*

Key Performance Indicators are tools for evaluating the quality and effectiveness of mobile network services. The following are the KPI parameter values on 3G networks :

1) *Receive Signal Code Power (RSCP)*

Table 1 Range of RSCP Value

Category	Strength (dBm)
Excellent	-75= < RSCP
Very Good	-85 ≤ RSCP < -75
Good	-100 ≤ RSCP < -85
Fair	-110 ≤ RSCP < -100
Poor	RSCP < -110

2) *Energy Carrier Per Noise (Ec/No)*

Table 2 Range of Ec/No Value

Category	Strength (dBm)
Excellent	0>Ec/No>=-8
Good	-8 >Ec/No>=-12
Fair	-12>Ec/No>=-16
Poor	Ec/No < -16

G. *Key Performance Indicator (KPI) of 4G LTE*

The following are the KPI parameter values on 4G LTE networks :

1) *Reference Signal Received Power (RSRP)*

Table 3 Range of RSRP Value

Category	Strength (dBm)
Very Good	-80= < RSRP
Good	-95 ≤ RSRP < -80
Fair	-110 ≤ RSRP < -95
Poor	RSRP < -110

2) *Reference Signal Received Quality (RSRQ)*

Table 4 Range of RSRQ Value

Category	Strength (dBm)
Very Good	-9
Good	-10, ≤ -9
Fair	-15, ≤ -10
Poor	< -15

3) *Signal to Interference and Noise Ratio (SINR)*

Table 5 Range of SINR

Category	Strength (dBm)
Excellent	20 =< SINR
Good	13 ≤ SINR < 20
Fair	0 ≤ SINR <13
Poor	SINR < 0

H. *Propagation Model*

Propagation models aim to predict the received signal strength in the form of an average value at a certain distance from the transmitter, as well as changes in the signal strength. There are several propagation models to predict the attenuation of a path in areas with irregular surfaces. Propagation models are based on the interpretation and measurement of data in an operator's territory.

propagation used in the writing of this final project, namely Okumura-Hatta, Cost-231, and SUI.

1) *Okumura-Hatta*

The validity range of the model is frequency fc between 150 MHz to 1500 MHz, transmitter height between 3m to 200 m, receiver height between 1m to 10 m, and distance between sender and receiver between 1 m and 10 km [1]. The following is the Okumura-Hatta propagation formula :

For Urban areas:

$$Lu(dB) = 69{,}55 + 26{,}16 \log f_c + (44{,}9 - 6{,}55 \log h_b) \log d - 13{,}82 \log h_b - a(h_m) \quad (2)$$

For Sub Urban areas:

$$Lsu(dB) = Lu - 2\{\log(fc/28)\}^2 + 18{,}33 \log f_c - 40{,}94 \quad (3)$$

For Rural areas:

$$Lr(dB) = Lu - 4{,}78 (\log f_c)^2 + 18{,}33 \log f_c - 40{,}94 \quad (4)$$

Where:

Lu : pathloss for urban areas

Lsu : pathloss for sub urban area

Lr : pathloss for rural areas

fc : carrier frequency in MHz

d: distance from base station (km)

hte : base station height (m)

hre : mobile station height (m)
a(hre): correction factor for

2) *SUI*

The Stanford University Interim (SUI) model was derived from AT&T wireless service experiments in several areas in the United States. This model includes the path loss calculation which is influenced by the factors of distance between transmitter and receiver, antenna height, carrier frequency, and terrain type. The SUI formula is listed in Equation 5 below.

$$Lp = 109{,}78 + 47{,}9 \log (d/100) \quad (5)$$

Where d is the site to UE distance

3) *COST 321*

COST 231 is a propagation model developed from the Okumura-Hata propagation model. This propagation model will be valid if used for the frequency range between 1500 - 2000 MHz. Coverage of the COST-231 model is:

1. Frequency is 1500 - 2000 MHz
2. The effective height of the transmitter antenna is ht: 30 - 200 m
3. The effective height of the receiver antenna is hre: 1-10 m
4. Link distance (d): 1 - 20 km

The path loss formula in this COST 231 propagation model is as follows:

$$Lp(dB) = 46{,}33 + 33{,}9 (\log f) - 13{,}82 \log (ht) - a(hre) + (44{,}9 - 6{,}55 \log ht) \log d + cm \quad (6)$$

Where:

fc : frequency in MHz
ht : base station height (m)
hr : mobile station height (m)
cm : 0 dB for medium-sized cities and suburbs
3 dB for metropolitan city centers

III. RESULT AND DISCUSSION

A. Measurement result

1) Reference Signal Received Power (RSRP)

After performing a drive test with TEMS Pocket, the log file data is processed using the TEMS Discovery software, which displays a plot of the RSRP parameters based on the KPI color indicator set in the legend. As shown in Figure 4.

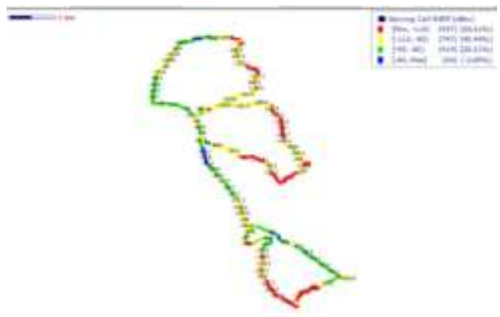

Fig. 4 RSRP parameter on Tems Discovery

2) Signal to Interference and Noise Ratio (SINR)

Figure 5 is a plotting that shows the SINR parameter in Tems Discovery based on the standard KPI color indicator set in the legend.

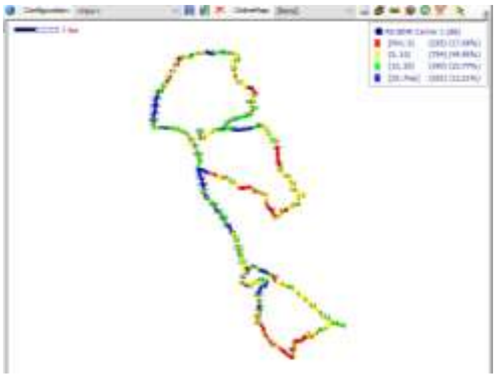

Fig. 5 SINR parameter on Tems Discovery

3) Band Spot Areas

The measurement of the length of the bad spot area has been carried out on google earth software, where the bad spot area is seen based on RSRP and SINR with a bad category with a range of RSRP values ≤ -100 dBm and SINR < 10 dB. The measured area is shown in Figure 6. The length of the bad spot area can be seen in Table 6.

Fig. 6 Band Spot Area

Table 6 Band spot areas

Area	Lenght
A	0,92 km
B	2.65 km
C	2,84 km

D	2,65 km
E	0,52 km
F	0,97 km
G	3,52 km

4) Receive Signal Code Power (RSCP)

Figure 7 is a plotting that shows the RSCP parameter at Tems Discovery on a 3G WCDMA network.

Fig. 7 Plotting RSCP

5) Energy Carrier Per Noise (Ec/No)

Figure 8 is a plotting that shows the Ec/No parameter at Tems Discovery on a 3G WCDMA network

Fig. 8 Plotting Ec/No

B. Measurement Analysis

After processing the data from the drive test measurements on Tems Discovery, the measurement data will be analyzed for signal quality based on the network parameters RSRP, SINR, RSCP, and Ec/No.

1) Analysis of RSRP Parameter Measurement

Based on the measurement results in Figure 4, it can be seen that there are 1642 reference signal receive power (RSRP) sample points, very strong and strong category signal reception with blue and green indicators totaling 458 sample points, and for weak and very weak categories marked with yellow and red indicators as many as 1184 sample points, from the data it can be seen that the signal quality in Alahan Mati Simpang District is said to be very weak, where 72.1% of the sample points fall into the bad and very bad categories. Of the 1642 sample points totaling -167856.7998 dBm has an average value of -102 dBm.

To see the value of RSRP, the calculation of site coverage distance based on frequency and propagation model is as follows.

a. Okumura-Hatta Propagation Calculation

In the 4G Network propagation calculation is carried out using Okumura-Hatta propagation of 900 MHz frequency at site LSK174.

MAPL (*downlink*) = 157,7

$$Lp = 69{,}55 + 26{,}16 \log f_c - 13{,}82 \log hte - a(h_{re}) + (44{,}9 - 6{,}55 \log h_{te}) \log d$$

$$157{,}7 = 69{,}55 + 26{,}16 \log f_c - 13{,}82 \log hte - a(h_{re}) + (44{,}9 - 6{,}55 \log h_{te}) \log d$$

$$157{,}7 = 69{,}55 + 26{,}16 \log (900) - 13{,}82 \log 71 - (-1{,}26) + (44{,}9 - 6{,}55 \log 71) \log d$$

$$157{,}7 = 69{,}55 + 77{,}28 - 25{,}58 + 1{,}26 + (44{,}9 - 12{,}1) \log d$$
$$157{,}7 = 122{,}51 + (32{,}8) \log d$$
$$157{,}7 - 122{,}51 = 32{,}8 \log d$$
$$32{,}8 \log d = 35{,}19$$
$$\text{Log } d = 1{,}07$$
$$d = \log^{-1} 1{,}07$$
$$d = 11{,}8 \text{ km}$$

(5)

From the calculations carried out for the LSK174 site, the farthest site distance is 11.8 km. In field measurements for site LSK174 at bad spot point E which is still included in the coverage site with a distance of 1.4 km has an RSRP value of -107.6 dBm, the small RSRP value obtained is due to obstacles or obstacles in its form of high hills that hinder signal transmission as seen in Figure 9 where the antenna height is 375 +71 = 446 m while the barrier height is 455 m including the height of the trees.

Fig. 9 LSK174 4G with 1.4 km Distance to UE

b. COST-231 Propagation Calculation

In the 4G Network propagation calculation is carried out using Cost-231 propagation of 1800 MHz frequency at site LSK030.

MAPL = 157,7 dB

$157{,}7 = 46{,}3 + 33{,}82 \log f - 13{,}82 \log hte - a(h_{re}) + (44{,}9 - 6{,}55 \log h_{te}) \log d + CM$

$157{,}7 = 46{,}3 + 33{,}82 \log 1800 - 13{,}82 \log 72 - (-1{,}47) + (44{,}9 - 6{,}55 \log 72) \log d + 0$

$157{,}7 = 46{,}3 + 33{,}82 (3{,}25) - 25{,}6 + 1{,}47 + (32{,}7) \log d$

$157{,}7 = 46{,}3 + 110 - 25{,}6 + 1{,}47 + 32{,}8 \log d$

$32{,}7 \log d = 157{,}7 - 132{,}17$

$\text{Log } d = 0{,}78$

$d = \log^{-1}(0{,}78)$

$d = 6 \text{ km}$ (6)

In calculations using Cost-231 propagation, the farthest site coverage distance of 6 km is obtained. from the measurement data obtained when the UE distance, namely bad spot D to the site as far as 1 km, obtained an RSRP value of -114.7 dBm. Where on the path there are hills and tall trees that inhibit signal transmission so that a poor RSRP value is obtained. This can be seen in Figure 10.

Fig. 10 LSK030 4G site distance to UE 1 km

c. SUI Propagation Model

In the 4G Network propagation calculations were carried out using SUI propagation frequency of 2100 MHz at site LSK120 and for 3G also using a frequency of 2100 MHz.

MAPL = 157,7 dB

$Lp = 109{,}78 + 47{,}9 \log (d/100)$

$157{,}7 \text{ dB} = 109{,}78 + 47{,}9 \log (d/100)$

$157{,}7 \text{ dB} - 109{,}78 = 47{,}9 \log (d/100)$

$47{,}9 \log (d/100) = 47{,}92$

$\text{Log } (d/100) = 1$

$d/100 = \log^{-1} 1$

$d = 1000 \text{ meters}$ (7)

In SUI 4G propagation for the farthest site range is 1 km, from the measurement results obtained at bad spot B at a distance of 0.75 km the RSRP value has passed the KPI threshold of -113.6 dBm, this is due to the track path in the form of hills so that attenuation occurs as shown in Figure 11.

Fig. 11 LSK120 4G with 0.75 km Distance to UE

2) SINR Parameter Measurement Analysis

Based on the results of measurements taken, 1642 sample points of Signal Interference to Noise Ratio (SINR) values were obtained. The results of processing the SINR value on TEMS Discovery can be seen in Figure 5. In the SINR parameter, the better the signal strength is characterized by a larger positive number value. For data with excellent and good categories, there are 592 sample points with blue and green indicators, and as many as 1049 sample points categorized as bad and very bad with red and yellow indicators. From the measurements that have been taken, it can be seen that the signal quality in the Alahan Mati Simpang District with a total value of 12457.4 dB contained in Appendix 1 has an average value of 8 dB, and the signal quality in the Alahan Mati Simpang District is said to be weak. Weak SINR is caused by interference caused by poor RSRP values or passing the KPI standard value so that it will cause handover failure the data in Figure 12 obtained 93 handover failure points.

Fig. 12 Handover Failure

3) Bad Spot Area Analysis

Based on the processing of drive test results on TEMS Discovery in Figure 6, it can be seen that areas that have poor signal quality are marked with yellow and red sample points, in bad spot areas there are problems with poor RSRP and SINR values, from Table 1 is known the length of the bad spot area points, it can be seen that the area with the longest bad spot area is area g, b, c, and d which has an RSRP range value

<-100 dBm which is categorized as a weak network, the cause of the length of the bad spot in area g, b, c, d is that the area is the farthest area from the existing site in Simpang alahan Mati District. One of the bad spot areas, namely in area d, is the government center of the Simpang Alahan Mati Subdistrict, where there is a sub-district head office, Religious Affairs Office (KUA), Population and Family Disaster Agency (BKKBN) office, Health Center (Pustu), and Bulakan Simpang tourist attraction. Bad spot areas for SINR parameters have the same location points as bad spot areas for RSRP parameters, bad spot areas in SINR parameters occur due to interference caused by poor RSRP values.

4) RSCP Parameter Analysis

Figure 7 is the result of data processing with a total of 1801 sample points from the received signal code power (RSCP) parameter. A total of 895 sample points from 1801 existing sample points, fall into the category of very good and good with blue, green, and yellow indicators. 906 sample points are said to be bad and very bad with orange and red indicators. From the results of the drive test conducted, it can be seen that the strength of the 3G network signal in the Alahan Mati Simpang District is very weak because 50.3% of the 3G coverage area is included in the bad and very bad categories. The RSCP value contained in Appendix 2 is known with the total RSCP value of -175684.7 dBm from 1801 sample points obtained an average value of -98 dBm.

To see the coverage value/level of receiving power of the 3G network can be done by looking at the RSCP parameter. The frequency used is 2100 MHz so the farthest distance from the site is 1 km using the SUI equation. The following is the *RSCP* value at sites LSK120, LSK174, and LSK030 with several predetermined UE distances.

a. Site LSK120 distance 0.75 km to UE

In Figure 13 below, it is known that at a distance of 0.75 km at the point of bad spot B, the RSCP value is -100.1 dBm, this value is included in the bad category because of the hills and tall trees that block the signal beam so that the signal received is bad while the distance of 0.75 km is still included in the site coverage distance.

Fig. 13 LSK120 to RSCP Distance of 0.75 km

b. Site LSK030 distance 1 km to UE

Figure 14 shows the RSCP value at site LSK030 with a distance of 1 km. obtained RSCP value of -113 dBm. This is due to the UE / bad spot D area is a hilly area, to overcome this it is recommended to increase the antenna height value from 50 meters to 70 meters for rural areas.

Fig. 14 LSK030 Distance to RSCP 1 km

c. Site LSK174 distance 1 km to UE

In Figure 15 it is known that the RSCP value at site LSK174 with a distance of 1 km. the RSCP value is obtained at -111.8 dBm, the RSCP value is categorized as poor, this is due to the distance from the UE to the site being the maximum distance from the site which is 1 km so a poor RSCP value is obtained.

Fig. 15 LSK174 Distance to RSCP 1 km

5) Measurement Analysis of Ec/No Parameters

Figure 8 is the result of the data processing drive test Ec/No parameters using TEMS Discovery, Ec/No is a parameter that shows the quality of the signal received by the UE and is used to analyze signal quality. From the processing results, 1801 sample points were obtained. The total measurement results of the sample points are categorized into several categories following the standard key performance indicator of the source of Communication and Information Technology. Of the 1801 sample points, 1290 sample points are said to be good and very good with blue and green color indicators, and as many as 511 sample points are said to be bad and very bad with yellow and red color indicators. It can be seen that the signal quality value in the Alahan Mati Simpang District is included in the good category, with a total Ec / No value of -19009 dB contained in Appendix 2 obtained an average value of -11 dB. From the RSCP and Ec/No measurements, it is known that the 3G network is included in the weak coverage problem where the RSCP parameter is weak while the Ec/No value is good.

IV. CONCLUSION

From the results of writing this final project, it can be concluded that the signal quality of Telkomsel operator in Simpang Alahan Mati District From the measurement results for the 4G network with an average value of RSRP parameters -102 dBm, and SINR 8 dB. Measurement results on 3G networks with an average value of RSCP parameters of -98 dBm and Ec/No -11 dB. The value of RSRP and SINR parameters respectively based on the KPI value of 1642 sample points, 458 and 592 sample points are categorized as good with blue and green indicators while 1184 and 1049 sample points are categorized as bad with red and yellow indicators. RSCP parameter values based on KPI values from 1801 sample points, 895 sample points are categorized as good with blue, green, and yellow indicators while 906 sample points are categorized as bad with orange and red indicators and for Ec/No parameters 1290 sample points are categorized as good with blue and green indicators while 511 sample points are categorized as bad with red and yellow indicators. From the measurements taken, several bad spot areas were obtained which were caused by obstacles or barriers in the form of hills and tall trees that cause poor signal reception. To overcome these problems, it is recommended to increase the antenna height from 50 m to 70 m for 3G networks and build new sites for 4G networks at several bad spot points.

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