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Link Budget Site Planning in Kuranji Region-Andalas University Mount Sarik

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***Abstract*— A link budget is a way to calculate all parameters in signal transmission, ranging from gain and loss from the transmitter to the receiver via transmission media. This design is motivated by planning at PT. Alita Praya Mitra for site development in Kuranji region–Andalas University (UNAND)–Mount Sarik with the reason to provide improved operator services, especially XL operator. In this final project to design using Pathloss 4.0 software as a tool that can facilitate a planner in calculating link budget. In this design the parameters used are propagation distance between sites, Effective Isotropic Received Power (EIRP), Free Space Loss (FSL), Isotropic Received Level (IRL), Received Signal Level (RSL), and Fade Margin (FM). On the calculation of the microwave transmission line of the Kuranji region- Andalas University with a propagation distance of 1.17 km, EIRP of 57.88 dBm, FSL of 121.049 dB, IRL of -64.489 dBm, RSL of -25.189 dBm, and FM of 48.311 dB. Andalas University - Mount Sarik with a propagation distance of 1.01 km, EIRP of 57.88 dBm, FSL of 119.771 dB, IRL of -63.211 dBm, RSL of -24.331 dBm, and FM of 49.169 dB. While Mount Sarik–Kuranji with a propagation distance of 1.19 km, EIRP of 57.88 dBm, FSL of 121.196 dB, IRL of -64.636 dBm, RSL of -25.756 dBm, and FM of 47.744 dB.**

***Keywords*— Link Budget, Pathloss 4.0, Propagation distance between sites.**

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I. Introduction

The rapid development of telecommunications technology in recent years, has been one of the factors of the ever-increasing human need to communicate quickly, efficiently, and reliably[1]. The same is true of the development of microwave radio communication systems that have been widely used. This is due to the function of the microwave radio communication system as one of the transmission media that has important roles and advantages compared to other transmission mediums such as cables and fiber optics [2]. As for its advantages, it has the cost of cheap and easy installation, large area coverage, and construction can be done gradually. Creating a transmission link requires a barrier-free propagation path condition (LOS) with a high definition and a good antenna position at each point. In calculating the link budget can use the Pathloss 4.0 software, with the use of Pathloss 4.0 work will be easier, faster, and more time-efficient. This plan is in the background of planning at PT. Alita Praya Partner for the construction of the site in the region of Kuranji– Andalas University (UNAND)-Mount Sarik with the reason to provide improved services to operators in particular operator XL.

II. MATERIAL AND METHOD

Planning is a very important thing to do in the process of determining the location of the site as well as a good positioning of the transmitter and receiver to the propagation of the line of sight. Properly planned and careful will give a good work result and fit what is desired. To facilitate the planning can be used some software and in this design, everything is done based on the data obtained as a coordinate point, and the condition of Line of Sight (LOS) on the site. Devices used during the planning are a Global Positioning System (GPS) and Camera w to process the data taken using the Software Map Source, the devices used for data processing are Google Earth Pro, Pathloss 4.0, and laptop.

A. Link Budget Planning

A Link budget is a way to calculate all the parameters in signal transmission, ranging from gains and losses from Tx to Rx through the transmission media[3]. The link budget is calculated based on the distance between the transmitter (Tx) and the receiver (Rx). The link budget is also calculated by looking at the specifications of the antenna. Steps in link budget planning can be described as follows

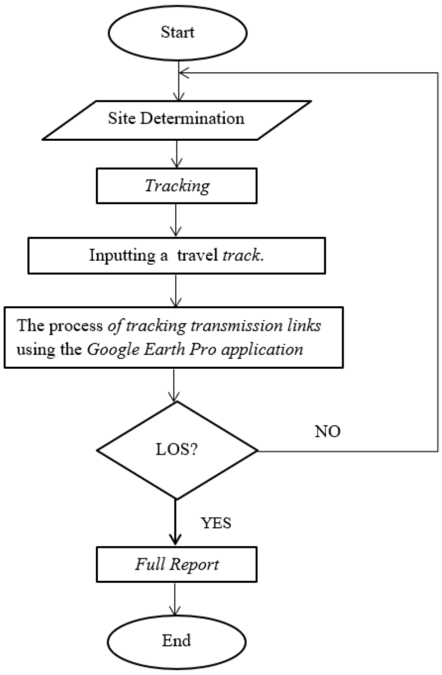

Figure 1. Flow Chart Link Budget Design.

B. Site Determination

Selected Site Region Kuranji – Andalas University– Mount Sarik. The three areas are data taken from PT. Alita Praya Mitra. In the process of planning the link budget, data such as longitude, latitude, antenna height, antenna diameter, azimuth, and frequency are needed, as shown in Table 1 below.

Table 1. Data Site.

Site Name	Long	Lat	Height	Diameter	Azimuth	Frequency (GHz)
Kuranji	100.45633	-0.93149	32	0.6	347.17	23
UNAND	100.454	-0.92125	32	0.6	167.59	23
Mount Sarik	100.46287	-0.92309	25	0.6	281.64	23

C. Tracking using GPS

The Global Positioning System (GPS) is a satellite-based radio navigation system that can accurately and quickly locate an object on the surface of the Earth and provide information about the time and speed of movement throughout the world.

D. Travel Track Input Using Map Source

Map Source is a software that is used to view maps of Indonesia, and even the world. Map Source is an offline navigation application that can browse a map, starting from roads, hotels, ATMs, banks, SPBU, and many more. Some of the things that can be done between the GPS and the computer are to transfer maps, and track waypoints from the computer to the GPS or vice versa to transfer track and waypoint from the GPS to the computer. [3]

E. Tracking Transmission Links Using Google Earth Pro

Google Earth Pro is a virtual globe program called the Earth Viewer created by Keyhole, Inc. Google Earth Pro is used to find out all the morphological conditions and the contours of the Earth's surface in real life. [3].

F. Link Budget Using Pathloss 4.0

Pathloss 4.0 is an internationally recognized software for calculating the budget links of radio and UHF communication lines. It is used to process the topographic information of the area, which can be processed from digital maps and contour maps.

G. Line Of Sight

Line of Sight propagation is also referred to as direct wave propagation used in terrestrial communication because the waves emitted from the transmitter antenna propagate directly to the receiver antenna and do not sink above the surface of the ground. [1].

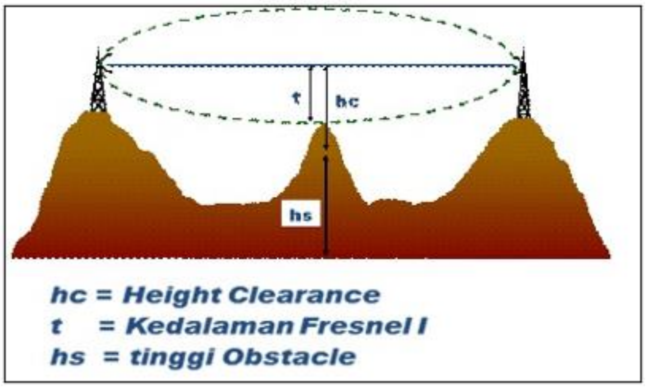

Figure 2. Line of Sight.

Line-of-sight propagation is the mainstay of radio communications, as it can provide greater information channels and higher reliability and is not affected by natural change phenomena, as in general sky wave propagation. [1]

H. Full Report

After all the parameters are inserted in the design process, a full report can then be displayed which represents the values of the required parameters in the transmission process.

III. RESULTS AND DISCUSSION

A. Radio Link Distance

After performing the link budget planning process using Pathloss 4.0 software than can be described the topography of the radio distance of the link as seen in Figure 3. below

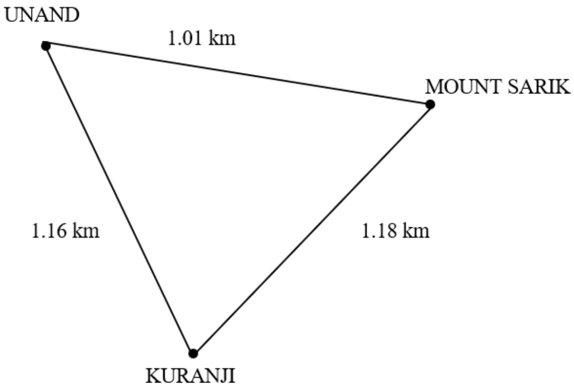

Figure 3. Topography of Radio Link Distance.

After determining the route by connecting the points already in then obtained the radio distance of the link that connects the site Kuranji – UNAND, UNAND – Mount Sarik, Mountain Sarik – Kuranji. The radio distance of such a link can be seen in Table 2.

Table 2. Distance Radio Link

Site Name	Distance (km)	Information
Kuranji-UNAND	1.16	LOS
UNAND-Mount Sarik	1.01	LOS
Mount Sarik-Kuranji	1.18	LOS

The diameter of the antenna and the frequency usage used depends on the distance between the transmitter and the receiver site, as frequencies are influenced by the distance.

The use of the frequency and diameter of the antenna can be seen in Table 3.

Table 3. Usage: Antenna frequency and diameter.

Distance (km)	Frequency (GHz)	Kuranji Site Antenna Diameter	UNAND Site Antenna Diameter	Mount Sarik Site Antenna Diameter
1.16	23	0.6		
1.01	23		0.6	
1.18	23			0.6

On the Kuranji-UNAND site with a distance of 1.16 km using the frequency of 23 GHz, on the UNAND-Mount Sarik site with a distance of 1.01 km using 23GHz frequencies, on Mount Sarik-Kuranji site with 1.18 km using 23. It refers to the Ministry of Communications regulation No. 33 of 2015 on the planning of the use of microwave point-to-point radio frequency bands.

B. Line Of Sight (LOS) Conditions

The Line of Sight (LOS) condition can be seen using the Pathloss 4.0 application as shown in Figures 4, 5, and 6 below:

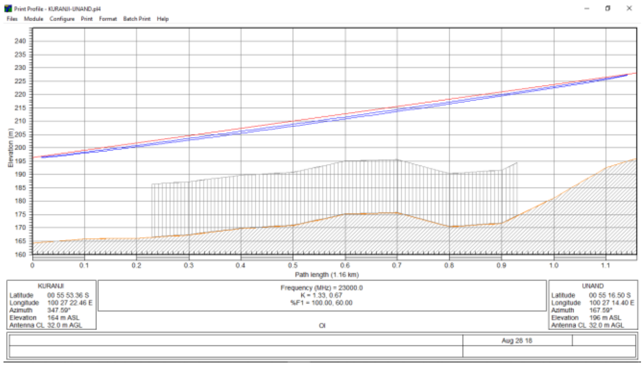
Figure 4. Print Profile Kuranji – UNAND.

At the design site Kuranji – UNAND suffered LOS with the height of the antenna on Kuranji being 32.0 m whereas the height of the antenna on UNAND is 32.0 m.

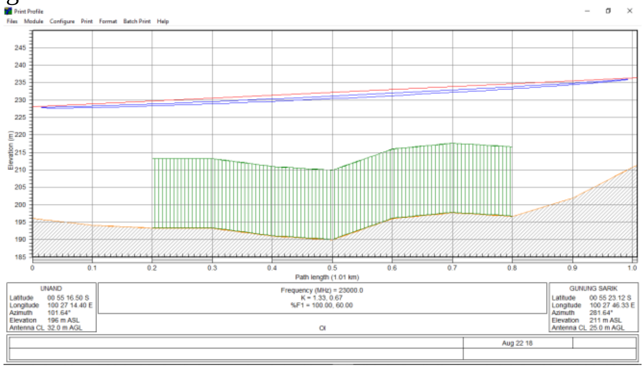
Figure 5. Print Profile UNAND – Mount Sarik.

At the design site, UNAND-Mount Sarik suffered LOS with the height of the antenna on UNAND being 32.0 m while the elevation of the antenna on Mount Sarik is 25.0 m.

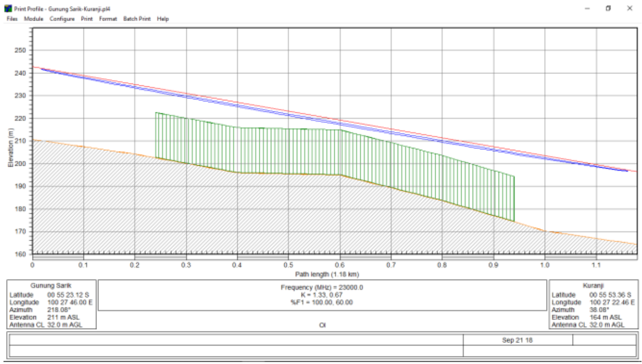
Figure 6. Print Profile of Mount Sarik – Kuranji.

At the site planning Mount Sarik-Kuranji suffered LOS with the height of the antenna on Mount Sarik is 32.0 m while the height of the antenna on Kuranji is 32.0 m.

C. Full Report

The link design and distance measurement of the link have been done as well and the input of the terrain data on the Pathloss 4.0 software yields the following data:

	Kuranji	UNAND
Elevation (m)	164.30	196.10
Latitude	00 55 53.36 S	00 55 16.50 S
Longitude	100 27 22.46 E	100 27 14.40 E
True Azimuth (°)	347.59	167.59
Vertical Angel (°)	1.57	-1.58
Antenna Model	ASL2-212DS-0.6m	ASL2-212DS-0.6m
Antenna height (m)	32.00	32.00
Antenna gain (dBi)	40.20	40.20
Connector loss (dB)	0.60	0.60
Circ. branching loss (dB)	0.50	0.50
Frequency (MHz)	23000.00	
Polarization	*Vertical*	
Path length (km)	1.16	
Free space loss (dB)	120.99	
Atmospheric absorption loss (dB)	0.22	
Net path loss (dB)	43.01	43.01
Radio model	iPASO 23G 90M	iPASO 23G 90M
TX power (watts)	0.08	0.08
TX power (dBm)	19.00	19.00
EIRP (dBm)	58.10	58.10
RX threshold criteria	BER 10-6	BER 10-6
RX threshold level (dBm)	-73.50	-73.50
Maximum receive signal (dBm)	-21.00	-21.00
RX signal (dBm)	-24.01	-24.01
Thermal fade margin (dB)	49.49	49.49

Figure 7. Kuranji Data Transmission – UNAND.

	UNAND	Gunung Sarik
Elevation (m)	196.10	211.40
Latitude	00 55 16.50 S	00 55 23.12 S
Longitude	100 27 14.40 E	100 27 46.33 E
True azimuth (°)	101.64	281.64
Vertical angle (°)	0.47	-0.48
Antenna model	ASL2-212DS-0.6m	ASL2-212DS-0.6m
Antenna height (m)	32.00	25.00
Antenna gain (dBi)	40.20	40.20
Connector loss (dB)	0.60	0.60
Circ. branching loss (dB)	0.50	0.50
Frequency (MHz)	23000.00	
Polarization	*Vertical*	
Path length (km)	1.01	
Free space loss (dB)	119.77	
Atmospheric absorption loss (dB)	0.22	
Net path loss (dB)	41.76	41.76
Radio model	iPASO 23G 90M	iPASO 23G 90M
TX power (watts)	0.08	0.08
TX power (dBm)	19.00	19.00
EIRP (dBm)	58.10	58.10
RX threshold criteria	BER 10-6	BER 10-6
RX threshold level (dBm)	-73.50	-73.50
Maximum receive signal (dBm)	-21.00	-21.00
RX signal (dBm)	-22.76	-22.76
Thermal fade margin (dB)	50.74	50.74

Figure 8. UNAND Data Transmission - Mount Sarik.

	Gunung Sarik	Kuranji
Elevation (m)	210.69	164.30
Latitude	00 55 23.12 S	00 55 53.36 S
Longitude	100 27 46.00 E	100 27 22.46E
True azimuth (°)	218.08	38.08
Vertical angle (°)	-2.26	2.25
Antenna model	ASL2-212DS-0.6m	ASL2-212DS-0.6m
Antenna height (m)	32.00	32.00
Antenna gain (dBi)	40.20	40.20
Connector loss (dB)	0.60	0.60
Circ. branching loss (dB)	0.50	0.50
Frequency (MHz)	23000.00	
Polarization	Vertical	
Path length (km)	1.18	
Free space loss (dB)	121.14	
Atmospheric absorption loss (dB)	0.23	
Net path loss (dB)	43.17	43.17
Radio model	iPASO 23G 90M	iPASO 23G 90M
TX power (watts)	0.08	0.08
TX power (dBm)	19.00	19.00
EIRP (dBm)	58.10	58.10
RX threshold criteria	BER 10-6	BER 10-6
RX threshold level (dBm)	-73.50	-73.50
Maximum receive signal (dBm)	-21.00	-21.00
RX signal (dBm)	-24.17	-24.17
Thermal fade margin (dB)	49.33	49.33

Figure 9. Mount Sarik – Kuranji Transmission Data

D. Line of Sight Propagation Conditions

Line of sight propagation conditions are performed using the Google Earth Pro application. The propagation condition on Kuranji against Andalas University with the azimuth of the transmitting antenna on Kuranji is 347.59^o and the receiver at the Andalas University site is 167.59^o against the transmitter. Propagation conditions at Andalas University against Mount Sarik with azimuth transmitting antenna at Andalas University amounting to 101.64^o and receiver at Mount Sarik site amounting to 281.64^o against transmitters. The area of Mount Sarik to Kuranji with azimuth transmitting antenna on Mount Sarik amounting to 218.08^o and receiver at Kuranji site amounting to 38.08^o to transmitters.

Figure 10. Azimuth Site.

E. Manual Calculation

1) *Distance of propagation:* Data of coordinates of sites obtained, used to determine path lengths between sites.

Table 4. Coordinate Site.

Stasiun Name	Kuranji	UNAND	Mount Sarik
Latitude	-0.93149	-0.92125	-0.92309
Longitude	100.45624	100.45400	100.46287

Table 4. shows the latitude and longitude of each site, so that the propagation distance can be calculated using the equation 2.2 – 2.3 as follows:

Latitude Distance: |Latitude A- Latitude B| x 110.33 km

Longitude Distance: |Longitude A- Longitude B| x 111.32 km

Distance A and B: $\sqrt{\text{Latitude Distance}^2 + \text{Longitude Distance}^2}$

1. Propagation Distance from Kuranji- UNAND
   Latitude Distance =|0.93149 - 0.92125| x 110.33
   = 1.129 km
   Longitude Distance =|100.45624-100.454000| x 111.32 km
   = 0.249 km
   Distance A and B = $\sqrt{1.129^2 + 0.249^2}$
   = 1.17 km

2. Propagation Distance from UNAND – Mount Sarik
   Latitude Distance =|0.92125 - 0.92309| x 110.33

= 0.202 km

Longitude Distance =|100.454000-100.46287| x 111.32 km

= 0.987 km

Distance A and B = $\sqrt{0.202^2 + 0.987^2}$

= 1.01 km

3. Propagation Distance from Mount Sarik- Kuranji
Latitude Distance =|0.93149 - 0.92309| x 110.33
= 0.927 km
Longitude Distance =|100.45624-100.454000| x 111.32 km
= 0.738 km
Distance A and B $\sqrt{0.927^2 + 0.738^2}$
= 1.19 km

The calculation of the propagation distance between sites that has been done using the manual formula produces a path length with values that are close to the propagating value (path length) using the Pathloss 4.0 software. The comparison can be seen in Table 5. As follows:

Table 5. Comparison of Propagation Distance with Manual Formula and Pathloss Software 4.0.

Link Name	Propagation Distance with Manual Formula (km)	Distance Propagation with Software Pathloss 4.0 (km)
Kuranji – UNAND	1.17	1.16
UNAND – Mount Sarik	1.01	1.01
Mount Sarik - Kuranji	1.19	1.18

2) *EIRP Calculation:* The power of the EIRP is influenced by the transmission power generated from the transmitter, the reinforcement of the antenna of the emitter, and the length of the feeder used[5]. The following table 6. shows the power wasted on transmission using Pathloss Software 4.0.

Table 6. Transmission line losses.

Connector Loss (dB)	Circ. Branching Loss (dB)	Atmospheric Absorption Loss (dB)
0.60	0.50	0.22

Total losses = -1.32 dB

The transmit power of EIRP can be calculated using the formula according to equation 2.5 as follows:

$EIRP_{dBM}$ = Pt + Lt + Gx
= 19 dBM + (-1.32 dB) + 40.20 dB
= 57.88 dBM

The calculation of the EIRP that has been done using the manual formula produces EIRPs whose values are close to the EIRP values using Pathloss 4.0 software. Such comparisons can be seen in Table 7 as follows:

Table 7. Comparison of EIRP with Manual Formula and Pathloss Software 4.0

Link Name	EIRP with Manual Formula (dBm)	EIRP with Software Pathloss 4.0 (dBm)
Kuranji UNAND Mount Sarik	57.88	58.10

3) *FSL calculation:* FSL that occurs at microwave propagation is influenced by the distance and frequency used by radio communication[4]. The design was carried out using the frequency 23 GHz with the distance link Kuranji – UNAND 1.17 km distance link UNAND – Mount Sarik 1.01 km, the distance connection Kuranji – Mount Sarik 1.19 km. Loss–free space loss on each link is assumed using equation 2.6.a based on working frequencies and propagation distance, so the design can be described as follows:

$$FSLdB = 32.45 + 20 \text{ Log } D_{km} + 20 \text{ Log } F_{MHz}$$

1. Kuranji – UNAND
$FSL_{dB} = 32.45 + 20 \text{ Log } D_{km} + 20 \text{ Log } F_{MHz}$
= 32.45 + 20 Log 1.17 + 20 Log 23000
= 32.45 + 1.364 + 87.235
= 121.049 dB

2. UNAND – Mount Sarik
$FSL_{dB} = 32.45 + 20 \text{ Log } D_{km} + 20 \text{ Log } F_{MHz}$
= 32.45 + 20 Log 1.01 + 20 Log 23000
= 32.45 + 0.086 + 87.235
= 119.771 dB

3. Mount Sarik – Kuranji
$FSL_{dB} = 32.45 + 20 \text{ Log } D_{km} + 20 \text{ Log } F_{MHz}$
= 32.45 + 20 Log 1.19 + 20 Log 23000
= 32.45 + 1.511 + 87.235
= 121.196 dB

FSL calculations that have been performed using manual formulae produce FSL values that are close to the FSL value using Pathloss 4.0 software. The comparison can be seen in Table 8.

Table 8. Comparison of FSL with Manual Formula and Pathloss Software 4.0.

Link Name	FSL with Manual Summary (dB)	FSL with Software Pathloss 4.0 (dB)
Kuranji-UNAND	121.049	120.99
UNAND-Mount Sarik	119.771	119.77
Mount Sarik-Kuranji	121.196	121.14

4) The receiving power of the receiver's isotropic antenna is influenced by the transmission power on the transmitters and the loss of space based on the frequency and propagation distance used[6][9]. The calculation of the IRL of each link can be calculated using equation 2.7 as follows:

$$IRL_{dBW} = EIRP_{dBm} + FSL_{dB} + Lg_{dB}$$

1. Kuranji
$IRL_{dBW} = EIRP_{dBm} + FSL_{dB} + Lg_{dB}$
= 57.88 dBm + (-121.049 dB) + (-1.32 dB)

$= -64.489$ dBm

2. UNAND
$IRL_{dBW} = EIRP_{dBm} + FSL_{dB} + Lg_{dB}$
$= 57.88$ dBm + (-119.771 dB) + (-1.32 dB)
$= -63.211$ dBm

3. Mount Sarik
$IRL_{dBW} = EIRP_{dBm} + FSL_{dB} + Lg_{dB}$
$= 57.88$ dBm + (-121.196 dB) + (-1.32 dB)
$= -64.636$ dBm

Table 9. IRL with Manual Formula.

Link Name	IRL with Manual Formula (dBm)
Kuranji	-64.489
UNAND	-63.211
Mount Sarik	-64.636

5) *RSL calculation:* The receiving power on the receiver is influenced by the receiving capacity on the isotropic, receiver antenna gain, and the loss-loss value of the transmission channel used[7]. Based on the equation below, the design can be described as follows:

$$RSLdBm = IRL + GRx + LRx$$

1. Kuranji
RSLdBm = IRL + GRx + LRx
= (-64.489 dBm) + 40.20 dB + (-1.32 dB)
= -25.189 dBm

2. UNAND
RSLdBm = IRL + GRx + LRx
= (-63.211 dBm) + 40.20 dB + (-1.32 dB)
= -24.331 dBm

3. Mount Sarik
RSLdBm = IRL + GRx + LRx
= (-64.636 dBm) + 40.20 dB + (-1.32 dB)
= -25.756 dBm

The RSL calculations that have been performed using manual formulae produce RSL with values close to RSL values using Pathloss 4.0 software. The comparison can be seen in Table 10. As follows:

Table 10. Comparison of RSL with Manual Formula and Pathloss Software 4.0.

Link Name	RSL with Formula (dBm)	RSL with Software Pathloss 4.0 (dBm)
Kuranji	-25.189	-24.01
UNAND	-24.331	-22.76
Mount Sarik	-25.756	-24.17

6) Fade Margin Calculation: In designing a transmission link should bear in mind that the link designed can last in the worst of conditions, where the signal received by the receiver antenna must always be above the threshold value[8][10]. Based on the equation below, the design can be described as follows:

$$FM_{(dB)} = RSL_{(dBm)} - P_{t(dB)}$$

1. Kuranji
$FM_{(dB)} = RSL_{(dBm)} - P_{t(dB)}$
= (-25.189 dBm) – (-73.50 dB)
= 48.311 dB

2. UNAND
$FM_{(dB)} = RSL_{(dBm)} - P_{t(dB)}$
= (-24.331 dBm) – (-73.50 dB)
= 49.169 dB

3. Mount Sarik
$FM_{(dB)} = RSL_{(dBm)} - P_{t(dB)}$
= (-25.756 dBm) – (-73.50 dB)
= 47.744 dB

The FM calculations that have been done using manual formulas produce FM whose value is close to the FM value using Pathloss 4.0 software. The comparison can be seen in Table 11. As follows:

Table 11. Comparison of FM with Manual Formula and Pathloss Software 4.0.

Link Name	FM Manual Formula (dB)	FM with Software Pathloss 4.0 (dB)
Kuranji	48.311	49.49
UNAND	49.169	50.74
Mount Sarik	47.744	49.33

Link Budget reference for 23 GHz Frequency, a good fade margin value is >40 dB, so the fade margin value in this design can be said to be good.

IV. Conclusion

Link Budget design using Pathloss 4.0 Software can already be used to see the condition of LOS from the Kuranji site to Andalas University with the addition of obstacles experiencing LOS with the antenna height at Kuranji is 32 m while the antenna height at Andalas University is 32 m. The design at the Andalas University site to Mount Sarik with the addition of obstacles experienced LOS with the height of the antenna at Andalas University was 32 m while the height of the antenna at Mount Sarik was 25 m. The design at the site of Mount Sarik to Kuranji with the addition of obstacles experienced LOS with the height of the antenna on Mount Sarik is 32 m while the height of the antenna on Kuranji is 32 m. The propagation distance between the Kuranji site to Andalas University obtained was 1.17 km, EIRP of 57.88 dBm, FSL of 121,049 dB, IRL of -64,489 dBm, RSL of -25,189 dBm, FM of 48,311 dB. The propagation distance between Andalas University sites to Mount Sarik obtained was 1.01 km, EIRP of 57.88 dBm, FSL of 119,771 dB, IRL of -63,211 dBm, RSL of -24,331 dBm, FM of 49,169 dB. The propagation distance between Mount Sarik sites to Kuranji obtained is 1.19 km, EIRP is 57.88 dBm, FSL is 121,196 dB, IRL is -64,636 dBm, RSL is -25,756 dBm, and FM is 47,744 dB.

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