A POINT TO POINT MICROWAVE LINK

WITH ITS SOLAR POWER SYSTEM

By

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ABSTRACT

The main aim of this system is to provide internet access for rural area using ePMP Force 180 5GHz subscriber module. The two sites are 1.45 km away from each other. Google Earth Pro is used to determine the latitude and longitude of two sites location. Google Earth Pro software is used to check for line-of-sight in choosing potential terminal site locations. In this system, system consideration, design and analysis of line-of-sight microwave link and hardware implementations are to be carried out. In the analysis, path profile, Fresnel zone, link budget and other parameters are implemented using the link planner software. For this application where electricity is required, Solar energy can be a legitimate consideration to use a solar PV system that provides Energy supply to an energy demand installation. By combination of Microwave Engineering, Software Implementation, Solar Power System Design and other factors, the impressible departmental research, "Design and Implementation of a Point to Point Microwave Link with its Solar Power System" was successfully carried out. This Research based Project is done since 2019.

SCOPE OF THE RESEARCH

The main process of this research is to design and implementation of microwave link for internet access with solar power supply system. In this process we analysis in three parts: solar power supply system, access point and subscriber module configuration, and the connection between power supply and the transmitter and the receiver. This project will provide where the electricity is not get all times places. For emergency case or rural area, this system with its own power station is very suitable to get internet access.

AIM AND OBJECTIVES

- To study point to point microwave link
- To measurement link capacity and sensitivity
- To implement hardware link design
- To analysis microwave link using Cambium network software
- To study Solar Power Systems
- To calculate and design the suitable Solar Power System for Transmission Side
- To calculate and design the suitable Solar Power System for Receiving Side

BLOCK DIAGRAM OF POINT TO POINT MICROWAVE LINK

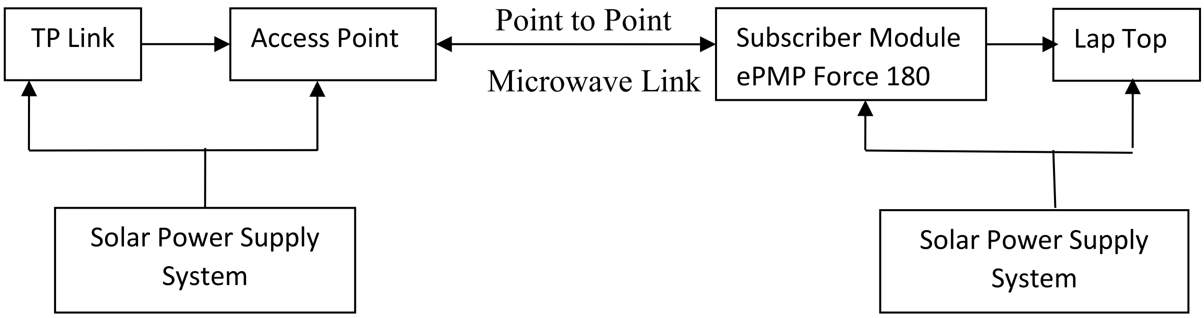


Fig 1.Block Diagram of Point to Point Microwave Link

Solar power supply system is supplied to the TP link and access point (AP). In the TP link the SIM Card has 4G Internet and it reach to the access point (AP). And then via the point to point microwave link the 4G Internet reach subscriber module ePMP force 180. In this case, we must design the location, the transmit power range, the bandwidth and the frequency which has between the AP and SM. The ePMP Force 180 is the second generation of ePMP Integrated Radio Modules. From the subscriber module the 4G Internet reach to the laptop. Both subscriber module and laptop are supplied by the solar power supply system in order to get power in 24 hours.

MICROWAVE LINK DESIGN PROCESS

To implement our own point-to-point microwave link, we have considered the first three factors in terms of required distance and capacity, desired availability target for the link and availability of Clear Line-of-Sight (LOS) between end nodes. Firstly, we select the two target sites, the first one is at the Technological University (Loikaw), and the other end is at the Taung Kwe Pagoda. These two sites are located in Loikaw, the capital of Kayah State. Moreover, for the required frequency band, the ISM (Industrial Science & Medical) 5.8 GHz band with the channel bandwidth 40 MHz has been chosen.

Site Selection

In this design, the receiver site is Taung Kwe Pagada, Loikaw (19.66750N, 097.20800E). After choosing the receiver site, the potential transmitter site is selected that are 1.45 km away from the receiver site. The transmitter is in EC department, TU loikaw (19.65450N, 097.20850E).

Antenna Height

The AP site’s elevation high (e1), peak obstruction height (e0), and the SM site’s elevation high (e2) are 934.8, 911 and 902.9 meters above sea level respectively. d1=0.95km, d2=0.39km, k=4/3, F=5.8GHz, TG=10 meters.

$$\text{Earth curvature, } E_b = \frac{d_1.d_2}{12.75k} = \frac{0.95\times0.39}{12.75\times{}^4/_3} = 0.022km \qquad \text{Equation (1)}$$

First Fresnel zone, $F_1 = 17.3\sqrt{\frac{d_1.d_2}{(d_1+d_2)F(GHz)}} = 3.76m$ Equation (2)

60% clearance of first Fresnel zone, $F_1' = 0.6 \times 3.76m = 2.256m$

$H_0 = E_b + TG + e_0 = 921.02m$ Equation (3)

Assume both AP site's antenna height and SM site's antenna height are the same, $a=a_1+a_2$.

$F_1' = [d_1(\frac{e_2-e_1}{D})] - H_0 + a + e_1$ Equation (4)

So, the antenna height, $a_1=a_2=11$m.

Fresnel Zone Clearness

Radio frequency line of sight is defined by Fresnel Zone which are ellipse shaped areas between any two radio antennas. The distance between the two antennas and the frequency of operation are required to compute the radius of the Fresnel Zone.

Radius (m) $= 17.31 \times \sqrt{\frac{D}{4f}}$ Equation (5)

r = radius of Fresnel Zone in meters

D = distance between the two antenna in kilo meter

f = operating frequency in GHz

Antenna Down Till Calculation

The Antenna Down tilt and Coverage Calculator (aka Antenna Tilt Angle Calculator) is used to determine the approximate downward angle, measured in degrees, which the transmitting antenna is to be positioned for optimal signal strength and coverage.

$\theta = \tan^{-1}\frac{h_1-h_2}{D} = 1.39°$ Equation (6)

Link Budget Calculation

The link budget is a calculation involving the gain and loss factors associated with the antennas, transmitters, transmission lines and propagation environment.

Transmitter Power=30dBm, Antenna Gain = 16dBi, Branching loss (LbR =2 dB), Radom loss (LrR=0.5dB, Miscellaneous Loss (Lmisc=2dB) and Predicted received power,

$P_{RX} = R_{TX} + G_{TX} - L_{TX} - F_{SL} + G_{RX} - L_{RX}$ Equation (7)

The Free space path loss FSPL $= 92.4 + 20\log f\,(GHz) + 20\log D\,(km)$

$= 92.4 + 20\log 5.8 + 20\log 1.335$

$= 110.27dB$ Equation (8)

TESTS AND RESULTS

Simulation Results for Coordinate's Configuration using Google Earth Pro

To design a reliable point-to-point microwave link, firstly, we consider the link implementation based on geographical site surveys. In our research, we use Google Earth Pro, is a computer program that renders a 3D representation of Earth based primarily on satellite imagery.

We consider the transmitter station is setup on the second floor of the campus building located at the 19.65450° N, 97.20850° E with the antenna height 10 meters and the receiver station on the top of the Taung Kwe Hill located at the 19.66750° N, 97.20800° E with the antenna height 10 meters from the tip of Taung Kwe hill. The range of the two ends is about 1.44 kilometers.

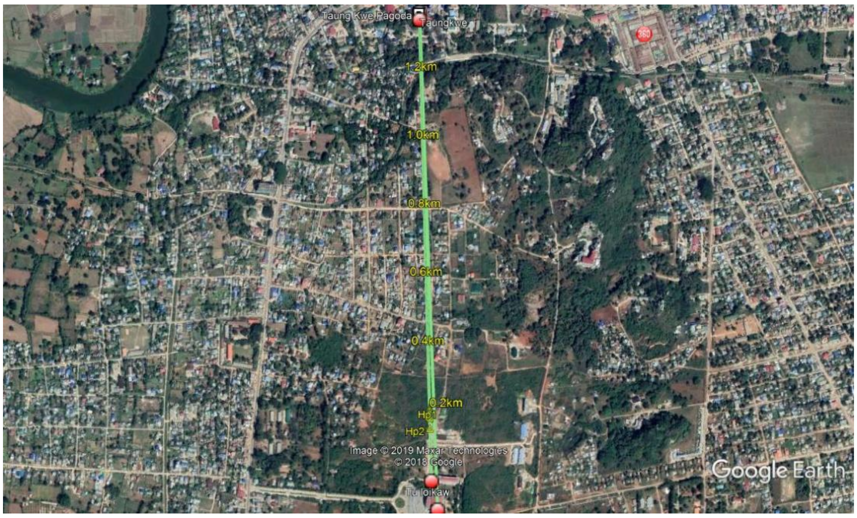


Figure 2. Geography of the specified site locations using Google Earth Pro

Simulation Results of Path Profile using Link Planner Software

The link implementation and performance summary of the proposed point-to-point microwave links are achieved by using software called RF Link Planning Tool-Link Planner Cambium Networks (4.9.1).

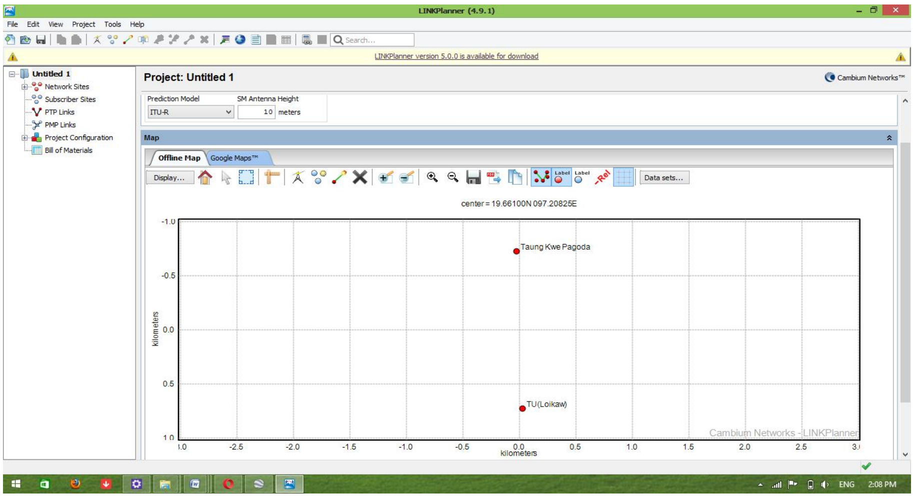


Figure 3. Sites of point 1 and 2

Network Sites in tu to tg

Name	Latitude	Longitude	Maximum Height (m)	Description	PTP Links	PMP Hub
Taung kwe Pagoda	19.66750N	097.20800E	10		1	No
TU loikaw	19.65450N	097.20850E	10		1	No

Figure 4. Network sites of two specified endpoints

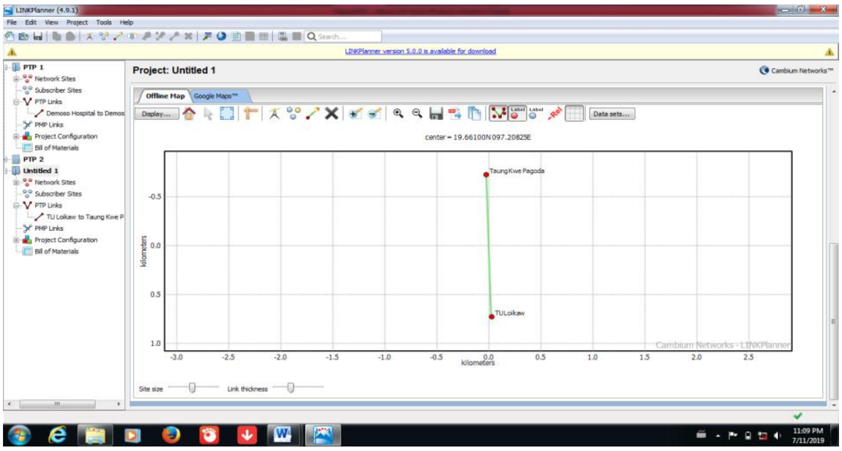


Figure 5. Microwave link between network sites 1 and 2

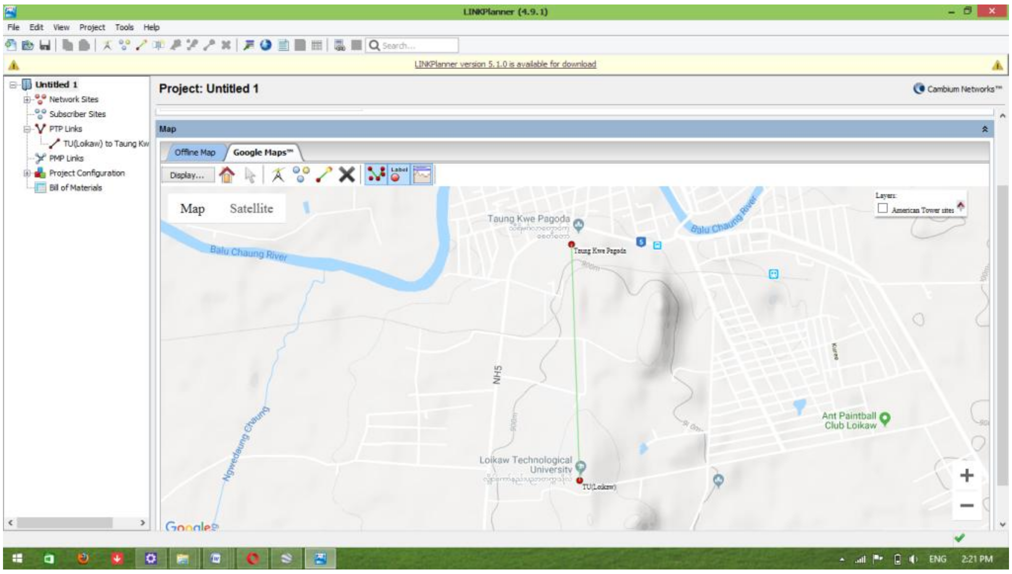


Figure 6. Online map of network sites 1 and 2

Getting Path Profile

The accuracy of the LINK Planner results depend upon obtaining accurate path data. The Link Planner software imports the path profile automatically and we can change the equipment setting and others what we wanted. The antenna height at each access of the link can be determined by creating a path profile.

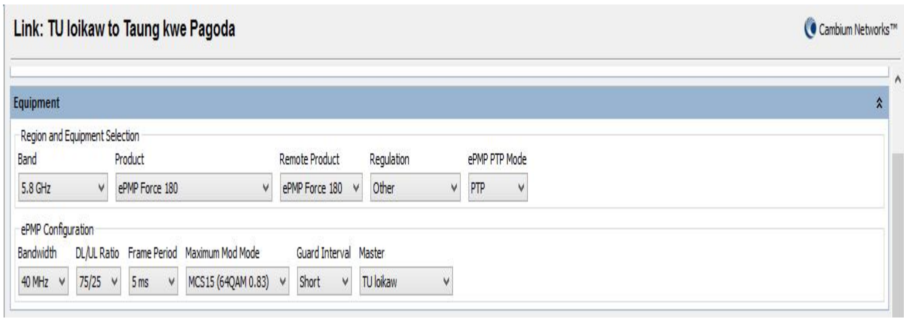


Figure 7. Equipment setting ePMP configuration

Figure 7 provides the data along the path that should be taken into account in the design process. If there are any extra obstructions, the user can add the obstruction height each one in this part. After specifying the range along the path, the terrain height at that point, and the obstruction height into the original path, the updated path profile with obstructions can be generated as in figure 8 and the line of sight is blocked there because there is obstructions within the specified Fesnel Zone.

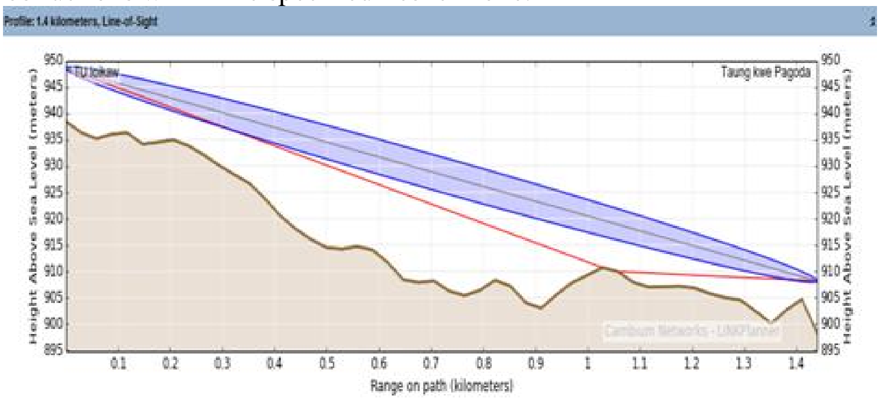


Figure 8. Orginal Path Pofile

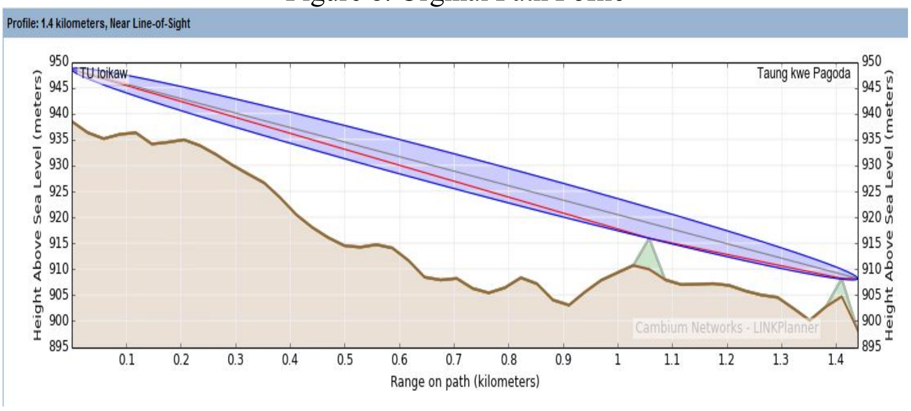


Figure 9. Path Profile updated with two obstructions at 1.058 km and 1.411 km

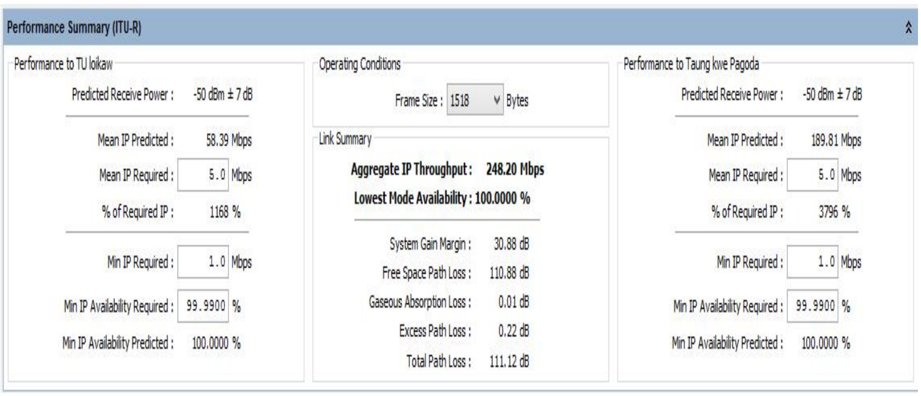


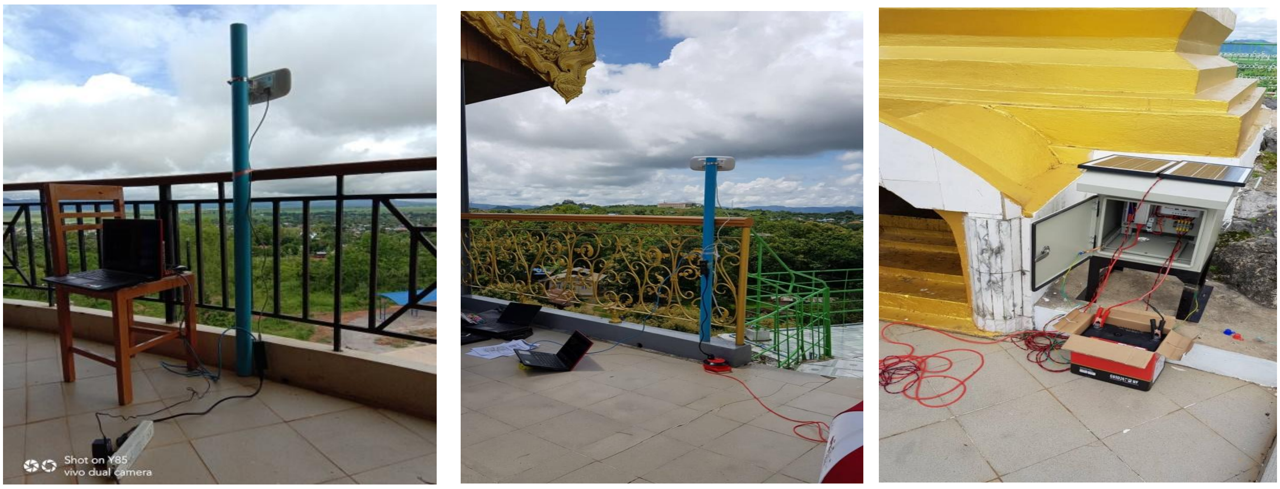
Figure 10. Performance Summary for Short guard interval

Table 1. Comparison of the link performance in terms of aggregate throughput, path loss, system gain margin and fade margin.

<table>
<tr><td colspan="2" rowspan="2">Bandwidth</td><td colspan="2">20MHz</td><td colspan="2">40MHz</td></tr>
<tr><td colspan="2">Guard Interval</td><td colspan="2">Guard Interval</td></tr>
<tr><td colspan="2">Performance to TU(loikaw)</td><td>Short</td><td>Long</td><td>Short</td><td>Long</td></tr>
<tr><td colspan="2">Mean IP Predicted(Mbps)</td><td>30.97</td><td>27.83</td><td>64.95</td><td>59.39</td></tr>
<tr><td colspan="2">Mean IP Required(Mbps)</td><td>5</td><td>5</td><td>5</td><td>5</td></tr>
<tr><td colspan="2">% of Required IP</td><td>619%</td><td>557%</td><td>1299%</td><td>1168%</td></tr>
<tr><td colspan="2">Min IP Required(Mbps)</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td colspan="2">Min IP Availability Required</td><td>99.99%</td><td>99.99%</td><td>99.99%</td><td>99.99%</td></tr>
<tr><td colspan="2">Min IP Availability Predicted</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td colspan="2">Performance to TG Pagoda</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Mean IP Predicted(Mbps)</td><td>101.28</td><td>91.06</td><td>210.97</td><td>189.81</td></tr>
<tr><td colspan="2">Mean IP Required(Mbps)</td><td>5</td><td>5</td><td>5</td><td>5</td></tr>
<tr><td colspan="2">% of Required IP</td><td>2026%</td><td>1821%</td><td>4219%</td><td>3796%</td></tr>
<tr><td colspan="2">Min IP Required(Mbps)</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td colspan="2">Min IP Availability Required</td><td>99.99%</td><td>99.99%</td><td>99.99%</td><td>99.99%</td></tr>
<tr><td colspan="2">Min IP Availability Predicted</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td colspan="2">Aggregate IP Throughput(Mbps)</td><td>132.25</td><td>118.89</td><td>275.92</td><td>248.20</td></tr>
<tr><td colspan="2">Free Space Path Loss(dB)</td><td>110.88</td><td>110.88</td><td>110.88</td><td>110.88</td></tr>
<tr><td colspan="2">System Gain Margin(dB)</td><td>35.10</td><td>35.10</td><td>30.10</td><td>30.10</td></tr>
<tr><td colspan="2">Fade Margin(dB)</td><td></td><td>8.10</td><td>6.10</td><td></td></tr>
<tr><td colspan="2">Predicted Received Power</td><td colspan="4">-50 dBm ±7 dB</td></tr>
<tr><td>IEEE 802.1p</td><td>Frame Size</td><td colspan="4">1518 bytes</td></tr>
<tr><td colspan="2">Frequency Band</td><td colspan="4">5.8GHz</td></tr>
</table>

Hardware installation of TP link Router, Access Point and Subscriber Module

A Sim card provided 4G internet is inserted in Sim card slot of TP link router. The UTP Ethernet Cat 6 cable is connected with RJ-45 socket (LAN 1) to access point module. To provide internet near the transmitter, TP link Wi-Fi antenna are implemented. The signal strength can be viewed at the top of router. The UTP Cat 6 cable from the router is connected to RJ-45 socket (Gigabit Data) of the power adapter of epmp force 180 access point module. AP module is connected to RJ-45 socket (Gigabit Data+Power) via UTP Ethernet Cat 5 cable. When the power is on, led indicators of power and ethernet on epmp force 180 must be green colour. The overall implementation are shown in figure 11.



(a) (b) (c)

Figure 11 (a). Overall Implementation of Transmitter Site
(b) Overall Implementation of Receiver site
(c) Overall solar power system at receiver site

Testing of Solar Power System

Figure 12 shows the folwchart of Implemetation of Solar Power Systems.

Testing of Point to Point Microwave Link for Internet Access

To obtain successfully internet access, we can log in Cambium Network web page with SM moduleIP address. In this page, we can configure system, monitor network and analysis data throughput.

Ethernet statistics, wireless statistics and downlink and uplink performances for different types of modulation coding rate are resulted under monitor -> performance in the page as shown in figure. The average wireless throughput is also shown in figure 13.

Ethernet Statistics - Transmitted	
Total Traffic	17477 Kbits
Total Packets	3281
Packet Errors	0
Packet Drops	0
Multicast / Broadcast Traffic	971 Kbits
Broadcast Packets	33
Multicast Packets	376

Ethernet Statistics - Received	
Total Traffic	5070 Kbits
Total Packets	3187
Packet Errors	0
Packet Drops	0
Multicast / Broadcast Traffic	1293 Kbits
Broadcast Packets	288
Multicast Packets	963

Figure 13. Performance of Ethernet

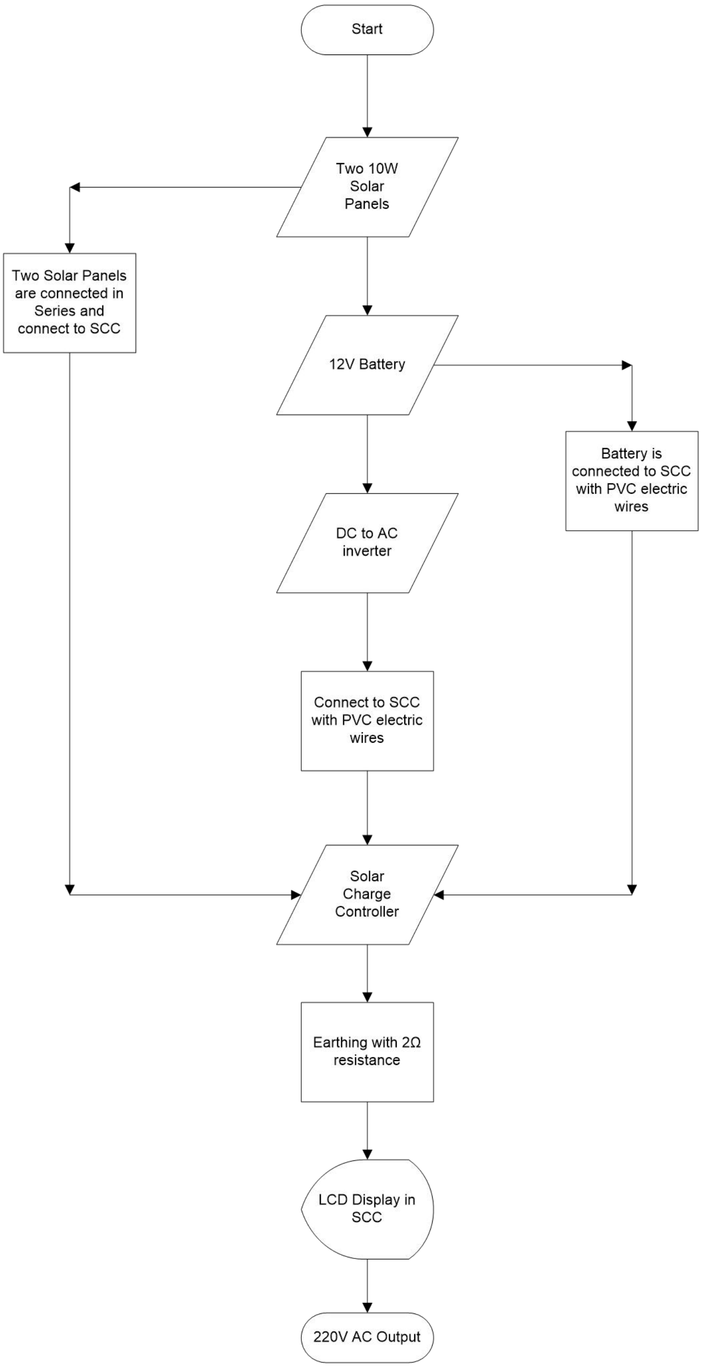


Figure 12. Flow Chart of Implementation Solar Power Supply System

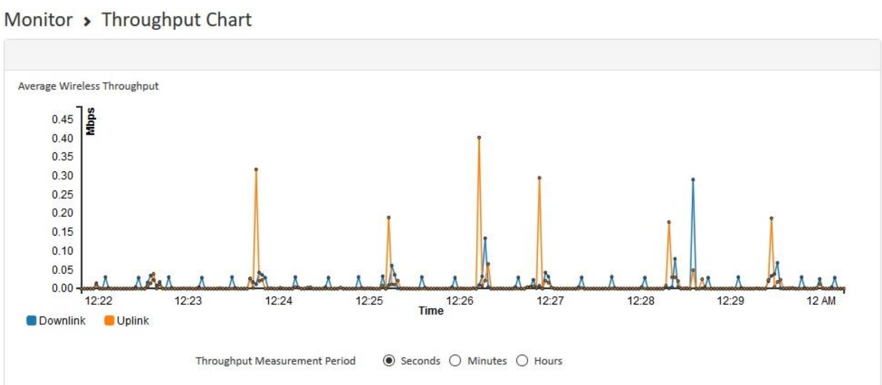


Figure 14. Throughput Chart

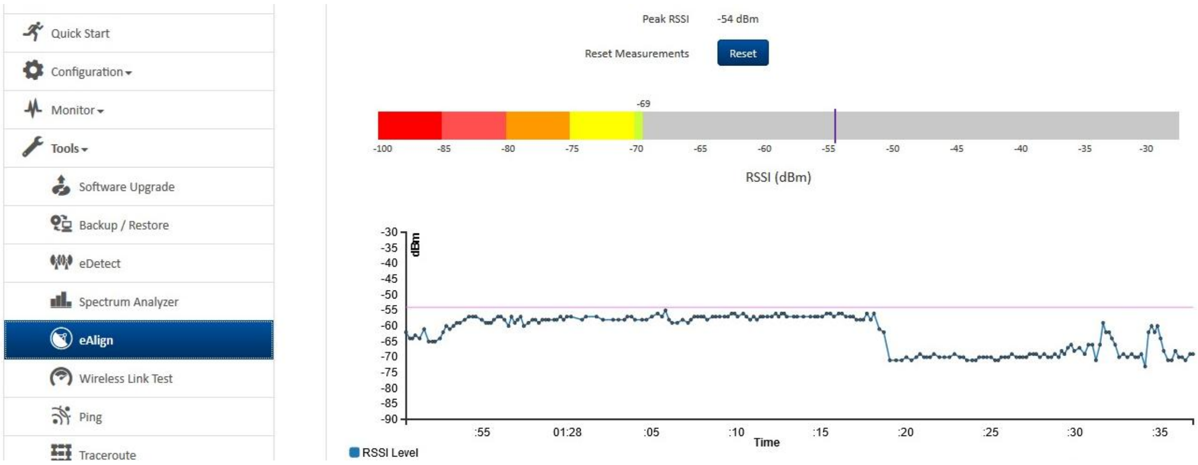


Figure 15. eAlign

CONCLUSION

Many factors are need to be considered in choosing the province where to establish a point-to-point microwave system, and after considering those factors, Technological University (Loikaw) is defined as the Access Point and Taung Gwe is defined as subscriber module. Microwave Engineering antenna and necessary parameters were deeply analyzed and determined based on the principal theories and principles about microwave propagation. Many formulas from microwave communication system principles are used to obtain all the significant parameters to be considered for the design. These parameters include the path parameters such as operating frequency, free space loss, system fixed loss, fade margin and system reliability; design parameters such as height of communication tower, Fresnel clearance, height clearance due to earth's curvature and antenna gain. These are the factors considered for determining the proper equipment to be used and ensure a line-of-sight propagation between the two selected sites.

Point to point microwave links are widely used as a cost effective alternative to fiber optic cabling for interconnecting the network of two sites with distances of few hundred meters and up to 50 km or more. In this system, the distance between two points is 1.45 km longs and two antennas must be line of sight. In microwave communication, higher frequency bands are used in shorter hops and lower frequency bands are used in longer hops. The lower frequency band is not used in urban areas. The link planner software is developed to help telecommunications engineers to design and simulate a new microwave line-of-sight radio link over varieties of terrain and paths without going into detailed mathematical equations. This system is simulated with Cambium link planner software to achieve link availability of 99.999%. However, design and implementation of a successful and reliable point to point microwave link requires good theoretical knowledge about RF design and antennas, as well as good deal of practical experience.

The design of the solar PV system for the point to point microwave link was conducted through a multi-staged criterion in order to best optimize the selection of the ratings of the main components needed by the solar PV System.The results showed promise for solar PV system. The location where the PV panel is installed in has the best solar suitability from solar designing point of view; it should be strongly considered for solar PV system as this technology becomes more affordable relative to fossil fuels.