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Microwave Radio Function, Its Traffic Routing Synchronization and Link Planning

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***Abstract* – The world's most implementable microwave transmission system is MINILINK. It is latest addition, offering compact, scalable and cost is very less. This system implemented with integrated traffic routing of E1 and its synchronization with ring protection for smooth working of media, PDH, SDH multiplexing, Ethernet transport, ATM aggregation as well as protection mechanism on link and network level. MINILINK works on the software configurable traffic routing ,minimizes the use of cable, improves network quality and facilitates control from a remote location .Space is reduced up to 70% compared to traditional solution .Configuration ranges from small end site with one single radio terminal to large hub site. Effective link estimate is very important in telecommunication industry for reliable and accurate working. This software program can be used for radio links operating in the microwave frequency range. When a link budget is prepared, many parameters are considered for calculations. Therefore this software program is very essential tool in the telecommunication industry. This paper presents a software tool that can be used to prepare link budgets by providing essential parameters. With the help of this software we can select frequency according to ITU (International Telecommunication Union) standards, graphical representation of the radio path profile between any two geographical locations on the loaded terrain and generates the Fresnel zone according to the frequency. This software can be interfaced with GPS (Global Positioning System) receiver to gather geographical locations.**

***Keywords* – ATM, MINILINK, PDH, SDH, LINK ESTIMATE.**

I. Introduction

Microwave transmission refers to the technology of transmitting information or energy by the use of radio waves whose wavelengths are conveniently measured in small numbers of centimeters; these are called microwaves. This part of the radio spectrum ranges across frequencies of roughly 1.0 gigahertz (GHz) to 30 GHz. These correspond to wavelengths from 30 centimeters down to 1.0 cm .Each Radio Terminal provides microwave transmission from 2x2 to 32x2 Mbit/s, operating within the 6 to 38 GHz frequency bands, utilizing C-QPSK and 16 QAM modulation schemes as shown in fig1. It can be configured as unprotected (1+0) or protected (1+1). 1+1 E1 SNCP 1+1 E1 Sub-Network Connection Protection (1+1 E1 SNCP) is a protection mechanism used for network protection on E1 level, between two MINI-LINK TN NEs [1]. It is based on the simple principle that E1 is transmitted on two separate E1 connections (permanently bridged).The switching is performed at the receiving end where the two connections are terminated.

Fig.1. Radio Unit, its frequency range and modulation

II. Microwave Radio Function

Some basic functions of radio is summarized below [1,2]

One radio-4 to 155Mbit/s
One radio-C-QPSK to 128 QAM
Easy upgrades and logistics
ATU-radio link in one direction. As shown in fig.2
2 modems per sub- rack in AMM 2P.
5modems per sub-rack in AMM 6P.
18modems per sub-rack in AMM 20P.
Software configurable traffic capacity.

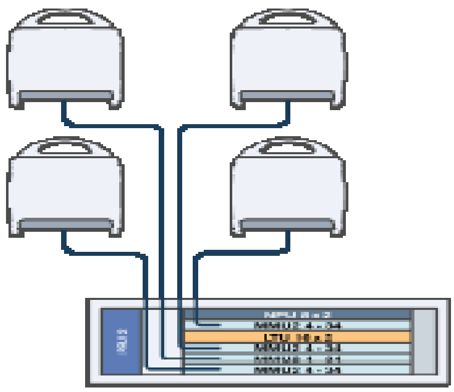

Fig.2. AMM6

A. Architecture overview

TDM Bus - The Time Division Multiplexing (TDM) bus is used for traffic routing between the plug-in units. It also used for routing of the DCN channels, used for O&M (Operation and Maintenance) data transport. The switching granularity is E1 for traffic connections and 64 Kbit/s for DCN channels. The traffic connections on the TDM bus are unstructured with independent timing. The bus has a switching capacity of 820 Mbit/s. It is redundant

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for additional protection against hardware failures Basic Node. As shown in fig.3

PCI Bus- The Peripheral Component Interconnect (PCI) bus is a high bandwidth multiplexed address/data bus used for control and supervision. Its main use is for communication between the NPU software and other plug-in units' software and functional blocks. As shown in fig.3

SPI Bus -The Serial Peripheral Interface (SPI) bus is a low speed synchronous serial interface bus used for Unit status control and LED indication Board Removal (BR) button used for unit replacement Inventory data Temperature and power supervision User I/O communication Reset of control and traffic logic. As shown in fig.3

Power Bus -The external power supply is connected to a PFU (or NPU2 for AMM 2p). The internal power supply is distributed via the Power bus to the other plug-in units. When using two PFUs in an AMM, the bus is redundant. The radio transmit power can be controlled in Remote Transmit Power Control (RTPC) or Automatic Transmit Power Control (ATPC) mode, selectable from the management system including setting of associated parameters. In ATPC mode the transmit power can be increased rapidly during fading conditions and allows the transmitter to operate at less than the maximum power during normal path conditions. The normally low transmit power allows more efficient use of the available spectrum while the high transmit power can be used as input to path reliability calculations, such as fading margin and carrier-to-interference ratio. The transmitter can be used as input to path reliability calculations, such as fading margin and carrier-to-interference ratio. The transmitter can be turned on or off from the management system.

RTPC Mode-In RTPC[1] mode the transmit power (Pout) ranges from a minimum level (Pfix min) to a Maximum level (Pmax). The desired value (Pset) can be set in 1 dB increments.

ATPC Mode-ATPC is used to automatically adjust the transmit power (Pout) in order to maintain the received input level at the far-end terminal at a target value. The received input level is compared with the target value, a deviation is calculated and sent to the near-end terminal to be used as input for possible adjustment of the transmit power. ATPC varies the transmit power, between a selected maximum level PATPC max) and a hardware specific minimum level (PATPCmin). As shown in fig.3

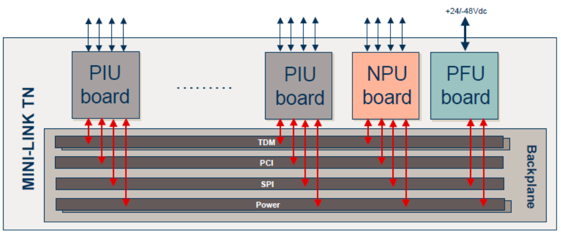

Fig.3. Architecture overview of microwave radio

III. Traffic Routing Syncronization And Protection

A. *TRAFFIC ROUTING FUNCTION*

Efficient interface between optical and microwave network[1].
Terminates full STM-1 payload.
Electrical and optical interface. MSP 1+1 for equipment and line protection. One management system to manage the complete site.
Cross connection at 2Mbit/s.
380 E1 port non blocking switching capacity, full duplex.
Hardware redundant switching function.
Up to 70% size reduction.

B. *SYNCRONIZATION.*

PDH- Unstructured E1 circuits with independent timing, Compliant to G.823 for all jitter/wander requirements[2].
SDH-E1s are mapped into VC12s at each Terminal Multiplexer using asynchronous mapping, Compliant to G.825 for all jitter/wander requirements, when building networks with MINI-LINK TN and MINI-LINK HC, local oscillator and loop timing is used. Shown below in fig. 4

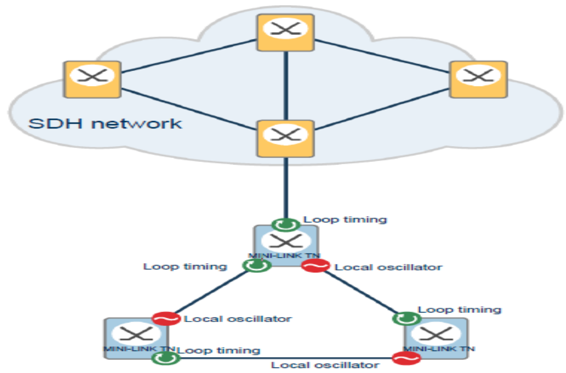

Fig.4. Synchronization between PDH and SDH.

IV. Protection

A. *1+1 Microwave radio protection – Hot Standby-*

Resulted features-[1]
Same frequency on both radios.
Only active radio is transmitting
Both receivers are active.
Rx/Tx shift independently.
Non-revertible.
Requires only one frequency.
Needs two separately located antennas.
Rx shift hitless/TX shift is non hitless. Shown all in fig.5

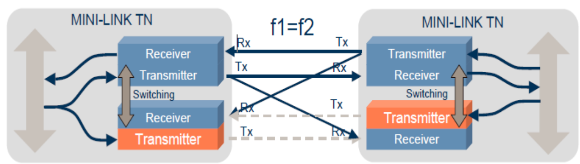

Fig.5.1+1 Microwave radio protection – Hot Standby

B. *1+1 Microwave radio protection – Working Standby*

Resulted features-[1,2]
Different frequency on both radios.

Both transmitters/receivers active.
Rx/Tx shift independently.
Non-revertible.
Requires two frequencies.
Co-located antennas for Line protection (fading).
Separately located antennas.
Both Rx and Tx hitless switching. Shown all in fig.6

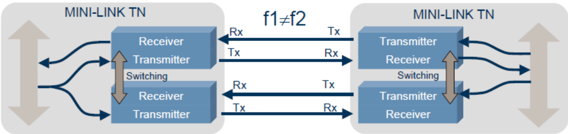

Fig.6.1+1 Microwave radio protection – Working Standby

C.1+1 E1 SNCP – Ring Application

Resulted features-[1,2]
Microwave rings, e.g. 17xE1, 32xE1 and 64xE1 capacity.
Media independent
Support for asymmetric ring capacity
Independent of MSP1+1 and 1+1 microwave protection. Shown all in fig.7

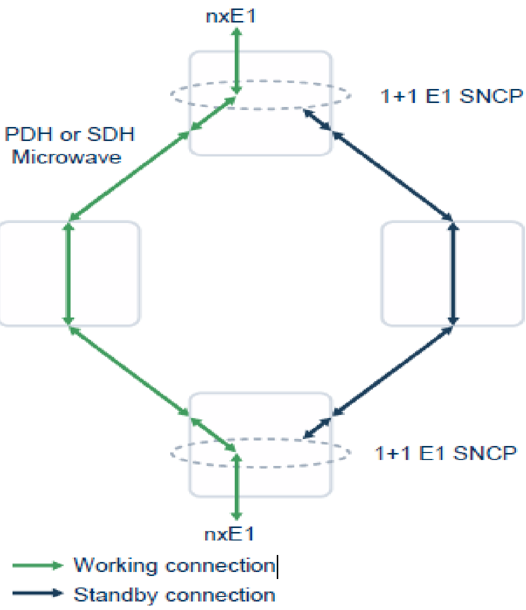

Fig.7. 1+1 E1 SNCP – Ring

IV. Operation & Maintenance

A. Equipment Handling/Temperature Monitoring.

Resulted features-[1, 2]

The temperature of all circuit boards is monitored with sensors.

Two levels of temperature violations.

High temperature threshold shuts down the circuit board's control software without disturbing the traffic Excessive temperature threshold shuts down the entire circuit board.

Alarm notification on temperature violations. Shown all in fig.8

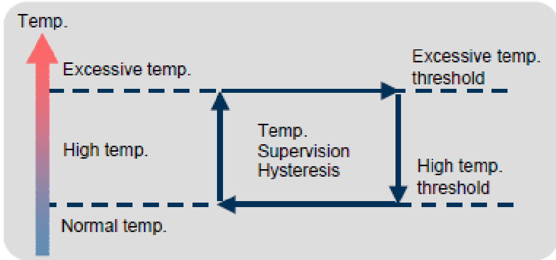

Fig.8. Equipment Temperature Monitoring

B. Loop functions-Line Loop

Resulted features-[1,2]
Line loop set locally in ingress PIU
Used to test transmission link between two nodes Can be configured remotely. Sown in fig 9

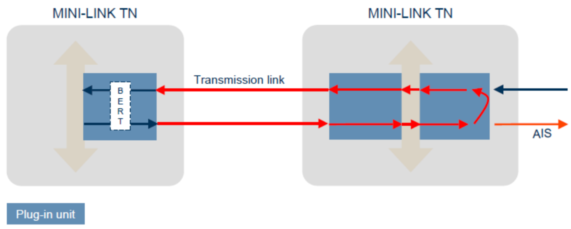

Fig.9. Line Loop

D. Loop functions-Connection Loop

Resulted features-[1]
Connection loop set in backplane.
Used to test transmission link + ingress PIU.
Can be configured remotely. Sown in fig.9

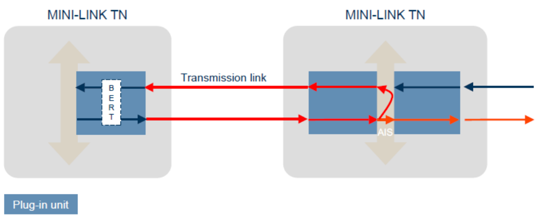

Fig.9. Connection Loop

V. Link Planning

There are two type of planning a new Microwave Radio Link with this software.
1) Two station Planning.
2) Plan one station respect to database system.

When two stations planning are considered, user has to enter data of both (NE, FE) stations. In the second method reference station data are automatically entered to the link budget. There are several steps involved in planning a new Microwave Radio Link such as Path Distance and Elevation Calculation, Frequency Planning, Link Budget calculation, Path Profile and Fresnel Zone Analysis[4].

A. Path Distance and Elevation Calculation

First step of planning a microwave link is map study and path profile preparation. Preliminary map studies help to determine the actual topography of the terrain, the height, and obstacles along the desired path for line of sight clearance. Desired stations longitude and latitude are collected for path profile preparation. Using these longitude and latitude values, path distance is calculated and it is used to select the transmit frequency and other parameters. There is a unique feature in this software to collect the longitude and latitude data from a GPS receiver module.

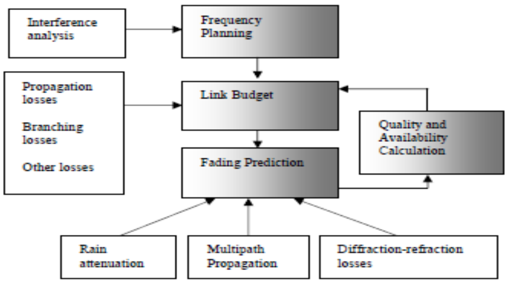

Fig.10. Link Planning Steps

By connecting the GPS receiver to a computer running this software in link planning mode at proposed station location, longitude and latitude data are automatically uploaded to the link budget calculation as shown in Fig 10. After entering the longitude and latitude values of two sites to this software, the path distance and elevations of two points are calculated automatically.

B. Frequency Planning

The second step of the link planning is Frequency Planning. The goal of frequency planning is to allocate microwave frequencies to a radio link as a few frequencies possible so that the availability and the quality of the radio link are less affected by the interference. Path length, site location, terrain topography and atmospheric effects are the basic considerations involved in the assignment of radio frequency when determining a frequency band that is suitable for the specific link . Assigning a microwave frequency channels are authorization given by an authority for an operator to use a microwave frequency channels. It is created in accordance with the series-F recommendation given by the ITU-R (International Telecommunication Union-Radio communications and wireless). The available frequency band is subdivided in to two halves, a lower/go, and an upper/return duplex half. The space between two duplex halves should sufficiently be large such that the radio transceiver can function under minimum interference full duplex operation. The bandwidth of a channel based on the capacity of the radio link and the modulation scheme used. The most important goal of frequency planning is to allocate available channels to a different link in the network without exceeding the quality and availability objectives of the individual links because of the radio frequency interferences [4]. There are two possible methods for frequency selection in this software, namely they are 'Manual' and 'ITU data'. In Manual frequency selection mode user can assign frequencies to two stations and the software will calculate the link budget for the given frequencies. In ITU data mode, the software indicates frequency sub bands / channels as shown in Fig. 10. After selecting the suitable frequency band, user can choose the site either as high or low frequency. There is a special feature in this software; it suggests the frequency band according to path distance which is issued by the spectrum governing body of a country. This automatically selects the suitable frequency band using a standard frequency vs. distance data guidelines suggested by regulatory body. This special function is useful to choose suitable frequency for a desired link which will be approved by the regulator.

C. Link Budget

The link budget is a mathematical calculation involving loss and gain factors related with the transmission lines, antennas and propagation channel, to find the maximum operating distance between a transmitter and a receiver can operate successfully. It can be seen the output power is varying in each step and finally it reduces. The final outcome is fade margin of the link. To calculate the link budget user has to enter parameters such as Transmit power of antenna, cable Losses, Transmit Gain, Receiver Sensitivity, terrain factor and Climate factor[4].

1. Transmit Power

The transmit power is the RF (Radio Frequency) power coming out of a transmitter. It is measured in 'dBm' and does not include the signal loss of the coaxial cable or the gain of the antenna.

2. Cable Losses

Usually cable losses are called as branching losses that come from the hardware used to deliver the transmitter/receiver output to/from the antenna.

3. Transmit Antenna Gain

Transmit gain is the quantity that an antenna boosters the RF signal over a specified direction. Antenna achieves 'Gain' simply by focusing RF energy.

4. Receiver Sensitivity

The minimum input signal level required to produce a specified signal-to-noise ratio at the output of the receiver to recover the transmitted signal properly.

5. Terrain Factor

The terrain factor is used to calculate the availability of a link. , it can either be calculated from terrain roughness and humidity information or be included directly.

Table. 1Parameters of link planning. (Result from site)[1]

RAU Configuration

Instance	In Service	Enable Notif.	Tx Freq. (MHz)	Rx Freq. (MHz)	Transm.	Tx Att. (dB)	Output Power Mode	Output Power (dBm)	Target Input Power Far End (dBm)	Input Power Alarm Thresh. (dBm)	Term ID
RAU2 X 23/95 1/2.1	Yes	Yes	22466.50	21234.50	On	0	RTPC	-3	-	-70	089A

Table. 2 Modulations and BER. (Result from site)[1]

Radio Terminal Configuration

ID	Far End ID	Far End ID Check	Enable Notif.	Protection Mode	Capacity (Mbit/s)	BER Alarm Threshold	Switch Mode	Modulation	Activate Traffic
089A	963D	Yes	Yes	1+0	8	1e-6	N/A	C-QPSK	Enabled

6. Climate Factor

The climate factor is used to calculate the availability of a link; it can either be computed from average annual temperature information or be entered directly.

0.500 (1/2) - gulf coast or similar hot, humid areas.
0.250 (1/4) - normal interior temperate or northern areas.
0.125 (1/8) - mountainous or very dry areas.

According to those parameters link budget is calculated including Receiver Signal Level, EIRP (Effective Isotropic Radiate Power), and Free Space Loss, Fade Margin, Outage probability and Reliability[3,4].

Free Space Loss (FSL)-Free Space loss is the theoretical attenuation of a radio signal when it propagates away from the transmitting antenna. When a radio signal radiates from the antenna with the distance it spreads out more and more. As the area covered increases, the amount of power per unit area (the power density) decreases. This effectively weakens the radio signals. FSL is calculated using following equation (1)

$$FSL = 32.44 + 20 \cdot \log(f) + 20 \cdot \log(d) \quad - (1)$$

Where,
f = frequency, MHz
d = distance between two stations, Km

7. Effective Isotropic Radiated Power (EIRP)

EIRP is the radio frequency power measured at the main focal point of the antenna. It is equal to the sum of the transmit power in the antenna (in dBm) added to the gain (dBi) of the antenna. Since it is a power level that measured in dBm, EIRP is calculated using following equation (2)

$$EIRP = P_{out} + G_t - C_t \quad - (2)$$

Pout = Output power of transmitter
Ct = Cable loss in transmitter
Gt = Antenna gain of transmitter

8. Received (Rx) Signal Level

Received signal level is the actual received signal (dBm) presented to the radio receiver at far station. It is calculated using equation (3)

$$\text{Received Signal Level} = EIRP - FSL + G_r - C_r \quad - (3)$$

Where,
Gr = Antenna gain of receiver
Cr = Cable loss in receiver

9. Fade Margin

The difference between received signal level and the receiver sensitivity threshold is called fade margin, each link must have sufficient fade margin[4] to protect against path padding's, that weakness the microwave radio signal. Fade margin is the insurance against unexpected system outage. Fade margin can be calculated by using equation (4).

Fade margin = Rx signal Level - Receiver Sensitivity- (4)

To determine the feasibility of a link, the calculated receive signal level is compared with the Receiver sensitivity threshold. The link is theoretically feasible if,
Received signal Level ≥ Receiver sensitivity.

If the receiver sensitivity threshold is smaller than or equal to the received signal level then the link might be feasible implement, because the received signal must be strong enough to be interpreted by the receiver demodulator.

10. Reliability

The reliability of a microwave link depends on the calculated fade margin. The reliability is calculated using following equation (5).

$$Reliability = a \times b \times 2.5 \times 10^{-6} \times f \times D^3 \times 10^{\frac{-F}{10}} \quad - (5)$$

Where,
a = terrain factor
b = climate factor
f = frequency, GHz
D = path length, miles
F = fade margin, dB

D. Path profile and Fresnel zone

1. Path profile

Graphical representation of the path traveled by the radio waves between the two radio stations of a link is the path profile. The path profile determines the height of the antennas and the locations at each end of the link, and it insures that the link is out of obstacles.

2. Fresnel zone

Radio frequency waves travel along a straight line. When they get away from the transmitting antenna, they spread out the farther. Fresnel zone is the area that the microwave signal spreads out. When there is an obstacle in the Fresnel zone, part of the microwave radio signal will be diffracted away from the straight-line path. The practical effect is that on a microwave radio link, is reduce the amount of energy that reaching the receive antenna [4]. The radius of the Fresnel zone depends on the frequency of the signal, when smaller the frequency, higher the Fresnel zone. Radius of the first Fresnel zone is calculated using equation .

$$R = 17.32\sqrt{\frac{x(d-x)}{f \cdot d}} \quad (6)$$

R = Radius of first Fresnel zone, m
x = distance from one point to radius point, Km
d = distance between antenna, Km
f =frequency, GHz

VI. Conclusion

Thus from this paper's initial part we can implement microwave radio in telecommunication industry to enhance data rate transmission, reduce size up to 70%, implementation of SDH,PDH ring for more number of E1and also for protection. We can detect media disconnect with the help of MINILINK.

To design this software it was required to write some additional software for handling databases of frequency bands and mean sea levels (elevations). It was compared with existing reports of several links to check whether the accuracy of this software. The results were acceptable with those existing reports which conclude that this software works properly according to the standards.

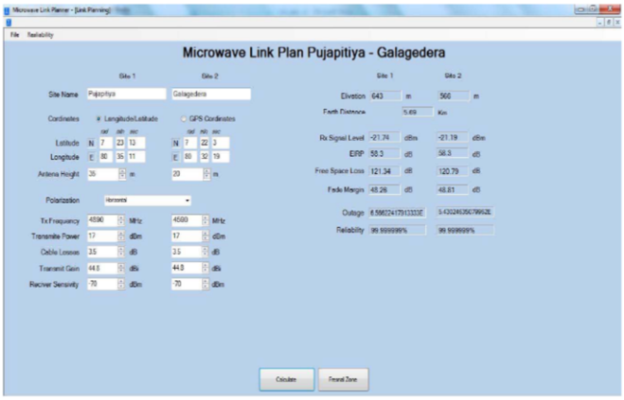

Fig.11. Link Planning Result

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