A Study of Environmental Effects on a Seasonal Fading of 7 GHz Frequency Band in a Microwave Transmission Network

Kapugedara S.M.K.O.S.[1]
Vidanapathirana K.P. [2]

ABSTRACT

In microwave transmission, free space point to point communication is used. Therefore it is affected by the conditions of the free space between two ends of the link. The frequency of a microwave link is selected according to the hop length. The 7 GHz frequency band is used for links with hop length more than 20 km. In the western coastal area, these 7 GHz links have severe interferences during the period of November to February. Normally these disturbances are occurring around 22:00 hrs to 8:00 hrs. The reason for these disturbances is changes in weather condition. This study was focused to identify the factors affecting for the seasonal fading of microwave transmission links. The receiving signal levels were analyzed with some variations of climatic characteristics such as Temperature, Humidity, Wind Speed and Rain Fall.

The data related to receiving signals were observed from the link histories and the weather data were collected from the Department of Meteorology. It was found that some of the weather conditions have a special change in their behavior during the time periods when the microwave links were subjected to fading. Out of all weather factors, only Temperature and Humidity had a direct impact to the seasonal fading of microwave transmission links.

KEY WORDS: Fading, Frequency, Hop Length, Interference, Microwave Transmission

INTRODUCTION

The Telecommunication Regulatory Commission (TRC) holds the total control and authority of the frequency spectrum. All the operators who use the frequency spectrum should get the formal approval from the TRC to use frequencies. As there are many numbers of operators who use the spectrum for their operations, the allocation of frequencies is a very difficult and challenging task. Therefore the frequency spectrum is a scare resource and should be utilized carefully.

Normally these links are high capacity backbone links.
Therefore the traffic from several coverage areas may be connected to a 7 GHz link. So the continuous operation of these links is the continuous operation of these links is very critical. Long haul high capacity links are protected using several link protection techniques such as space diversity and hot standby equipment protection.

The 7 GHz microwave links in the western coastal area have a special link fading problem during the season from November to February. This problem only occurs within 20:00 hrs to 8:00 hrs in some days. Due to this problem sometimes these links are totally failed.

Although this affects to the microwave transmission network very much, this cannot be overcome with the available link protection techniques

In microwave transmission, diversity techniques are used to protect links from fading. But above problem was not occurred in rainy days. So this problem is not because of the rain fading. Also this is not because of the multipath fading because these links are protected by using space diversity technique. Therefore this seasonal fading should be due

[1]Graduate, Department of Electronics, Faculty of Applied Sciences, Wayamba University of Sri Lanka.

[2]Senior Lecturer, Department of Electronics, Faculty of Applied Sciences, Wayamba University of Sri Lanka.

to some other atmospheric changes within that period.

Normally within this period of the year, there is a slight change in the climate. So this fading occurs due to some critical changes of weather characteristics such as temperature and humidity. An analysis was carried out to find out the real causes of this problem.

LITERATURE REVIEW

An experimental study on atmospheric multipath on a 23 km link at 9.6 and 28.8 GHz near Boulder, Colorado , was reported (Ott, 1979). The preliminary observations were made for three days in July 1979 when strong inversion layer was present, creating an elevated tropospheric duct. The possible influence of antenna aperture size on atmospheric multipath was investigated by observing fades and enhancement on the 28.8 GHz carrier using 10^0 horn and a 1.2^0 parabolic dish. Continuous height – gain observations were obtained using the 300 m. Tower at Erie, Colorado was used, as one end of the link. Meteorological data at the tower were also recorded during observation periods of the radio signal. (Ott, 1979)

Multipath fading is a common phenomenon in wireless signal transmission. When a signal is transmitted over a radio channel, it is subjected to reflection, refraction and diffraction. The communication environment changes quickly and thus introduces more complexities and uncertainties to the channel response. In order to observe the effects of multipath fading channel on the transmitted signal, a whole digital communication system simulator was developed. Three kinds of digital communication systems: baseband transmission via additive white Gaussian noise (AWGN) channel, pass band transmission via single AWGN channel, and pass band transmission via multipath fading channel, were simulated. (Zeng, 2000)

The records from line-of-sight paths have been processed to display variations of the occurrence of selected fade depths with local time (Zygielszyper, 2003). The results showed that even the occurrence of shallow fading can vary with local time. However, the variations can be more impressive for deep fading. Data from one space-diversity path have also been processed to show the distributions of the number of events and the exceedance time as functions of the fade depth and the duration. The results indicated that space diversity has only effectively decreased the number and the duration of deep fade events. (Zygielszyper, 2003)

METHODOLOGY

The problem selected is a very critical issue when the business operations of the organization are considered. But this problem only occurs in a limited period of time in a year. So for the present study, this specific time period was considered. Therefore study period from 1st of October 2008 to 31st March 2009 was selected. This was the period where the fadings were recorded for the last year. The next important point to consider was that this effect was only occurred in a specific geographic area. Most of the fading links are situated around western coastal area. Therefore the 7 GHz microwave links which were located around Puttlam and Kadawatha were selected for the study.

First, the geographical data such as hop length, antenna heights and terrain patterns which were related to the selected links were studied. With this study it was found that most of the links have a flat terrain pattern and almost same antenna heights and hop lengths. After that the fading times were found from the link histories. It was found that the fadings started around 20.00 hrs and ended around 08.00 hrs.

The weather data such as temperature, humidity and rain fall within the selected area at the selected time period were collected from the Department of Meteorology. These data were studied with the receiving signal levels of the links at the fading times and non fading times. With that the behavior of each factor within those periods were observed and compared with the normal average values of those factors. By that, it was found which characteristic affects to the fading of the links and the way they affect.

After the factors were identified, each factor was studied with the behavior of microwave signals to find possible solutions for this problem. The solutions were proposed to minimize the effect to improve the performance of the microwave transmission network of the organization.

DATA COLLECTION AND ANALYSIS

All the links that were selected for the study are located in the western coastal area of Sri Lanka.

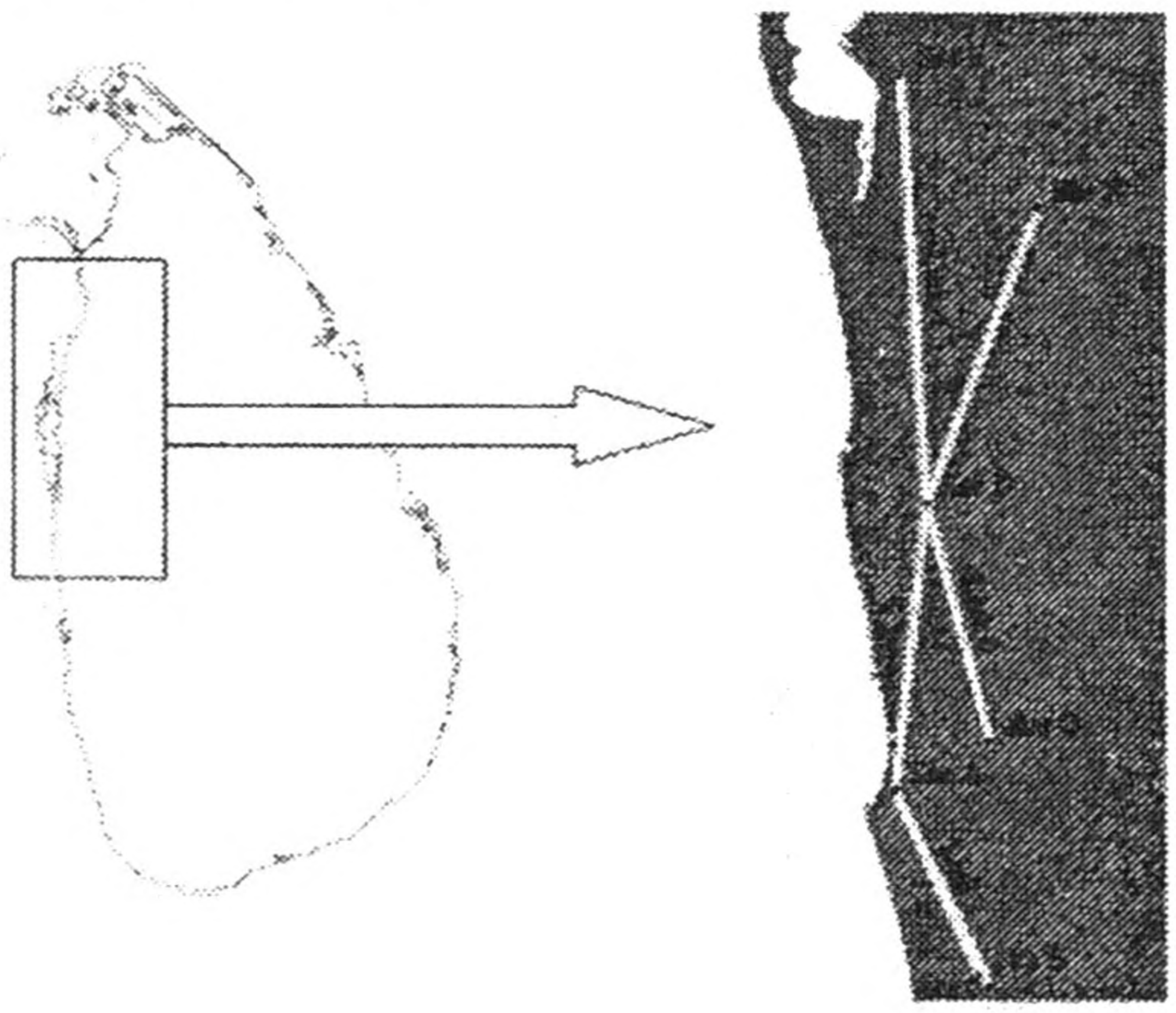

Figure 1.Map of selected links

Following table 1 shows the details of each link. It consists of frequency channel used, the number of E1s used to transmit traffic, diameters of the used antennas, polarization of the microwave signals, distance between the two towers of the links and the observed Receive Signal Levels (RSL) of each link. The RSL values are the practical values that were observed when accepting the link performances after they were installed and implanted. These values depend on the equipments used in each link.

Table 1. Detail of selected links

Link Name	Link 01	Link 02	Link 03	Link 04	Link 05
Tx Frequency (MHz)	7149	7261	7000	7233	7368
Rx Frequency (MHz)	7310	7422	6660	7394	7172
Capacity	75 E1	75 E1	150 E1	75 E1	75 E1
Polarization	V	V	V & H	V	V
Antenna Diameter (m)	1.8	1.8	2.4	1.8	1.8
Hop Length (km)	26	43.6	48.4	32	37.6
RSL Nominal (dB)	-45	-42	-36	-43	-41

The terrain pattern of a link means the pattern of the height profile of the cross section of a link. It shows the height at different points in the line which connects the two towers of a link. By this profile the line of sight clearance and the Fresenel zone of each link can be determined.

The following figure shows some terrain patterns of the selected links. This figure was obtained from a special software tool called Global Mapper.

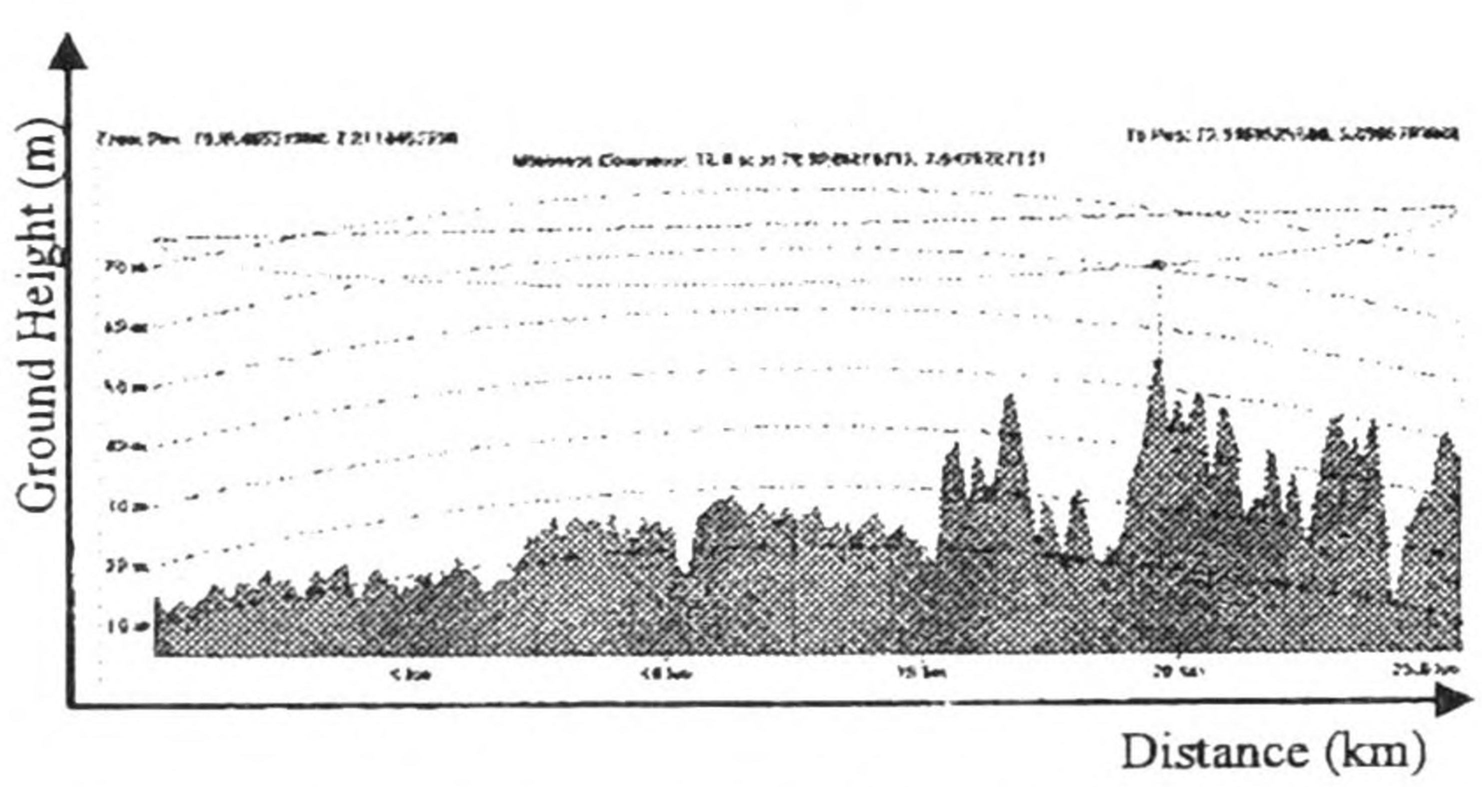

Figure 2. Graph of Terrain Pattern of Link 01

The RSL values of the links when they were subjected to seasonal fading were observed from the link history of the monitoring system.

Table 2 includes the details of the fading times of some selected links which were taken from the link history of the monitoring system.

Three hourly weather data of the relevant selected weather stations were collected from 01st of October 2008 to 31st of March 2009. Some of the collected weather data are shown in Table 3.

The theoretical RSL value for each link was calculated using the RSL equation

$$RSL = P_{Tx} + G_{Tx} - L_{Tx} - FSL + G_{Rx} - L_{Rx}.$$

Where,

P_{Tx} = Transmitting Power in dB
G_{Tx} = Transmitting Antenna Gain in dB
L_{Tx} = Feeder, Coupler and Waveguide losses at Transmitter in dB
FSL = Free Space Loss in dB
G_{Rx} = Receiving Antenna Gain in dB
L_{Rx} = Feeder, Coupler and Waveguide losses at Receiver in dB

To study the behavior of weather characteristics at fading times, the average of the three hourly weather data was calculated. Then the nominal average values were plotted with the instant temperature, humidity, wind speed and rainfall values.

Table 2. Fading times for different links with respect to dates

Link Name	Date	Fading Time	
		Start Time	End Time
Link 01	1/11/2008-1/11/2008	2:45	7:15
	2/11/2008-2/11/2008	4:00	7:30
	14/11/2008-15 /11/2008	21:45	7:15
	15/11/2008-16/11/2008	22:45	7:00
	30/11/2008-30/11/2008	0:45	6:30
	15/02/2009-15/02/2009	0:00	3:00

Table 3. Three hourly weather data at Puttlam

Weather Station		Puttlam				
Date	Time	Temperature (°C)	Humidity	Wind		Rain Fall (mm)
				Wind Direction	Wind Speed (km/h)	
01st of November 2008	2:30	22.1	97	CALM	0	0
	5:30	21.2	99	CALM	0	0
	8:30	26.3	84	S	2.4	0
	17:30	39	68	CALM	0	0
	20:30	24.4	94	CALM	0	0
	23:30	23	98	CALM	0	0

RESULTS AND DISCUSSION

According to the study carried out it was found that some of the weather conditions have a special change in their behavior at the times when the microwave links were subjected to fading. But some characteristics do not have a clear change in their behavior.

According to the data collected, during the link fading times no rain fall was recorded at those areas. So it can be concluded that this seasonal fading do not have an effect from rain.

The effect of wind speed was also considered in this study. But with the available data there was no clear indication of an effect of wind speed for the fading. So effect of wind speed can also be neglected.
When the nominal values and the average values of the temperature and humidity were studied, a considerable change in the behavior during the fading times can be observed. Therefore it can be considered that there is an effect on seasonal fading due to change in temperature and humidity.

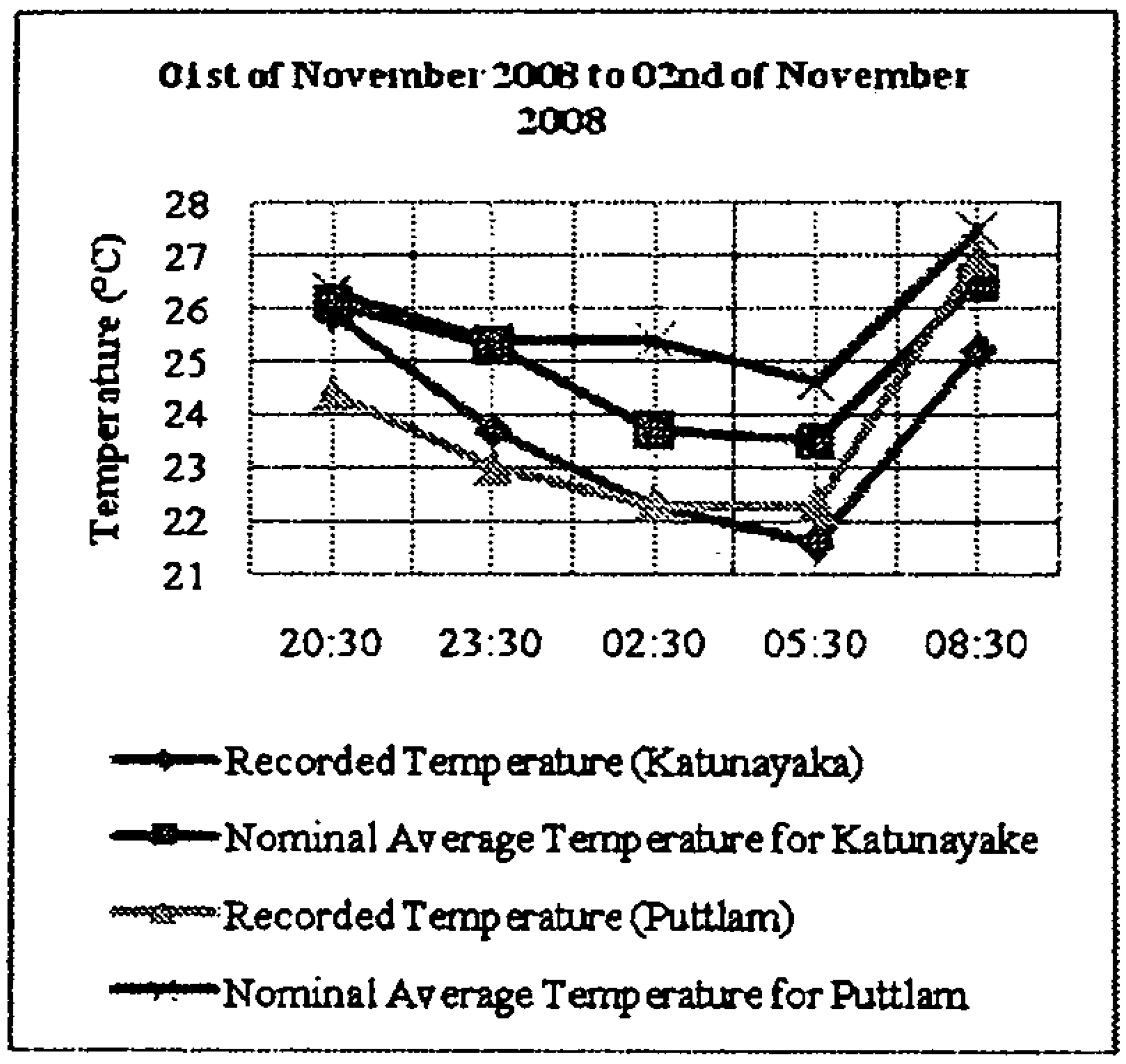

Figure 3. The Graph of Temperature Against Time

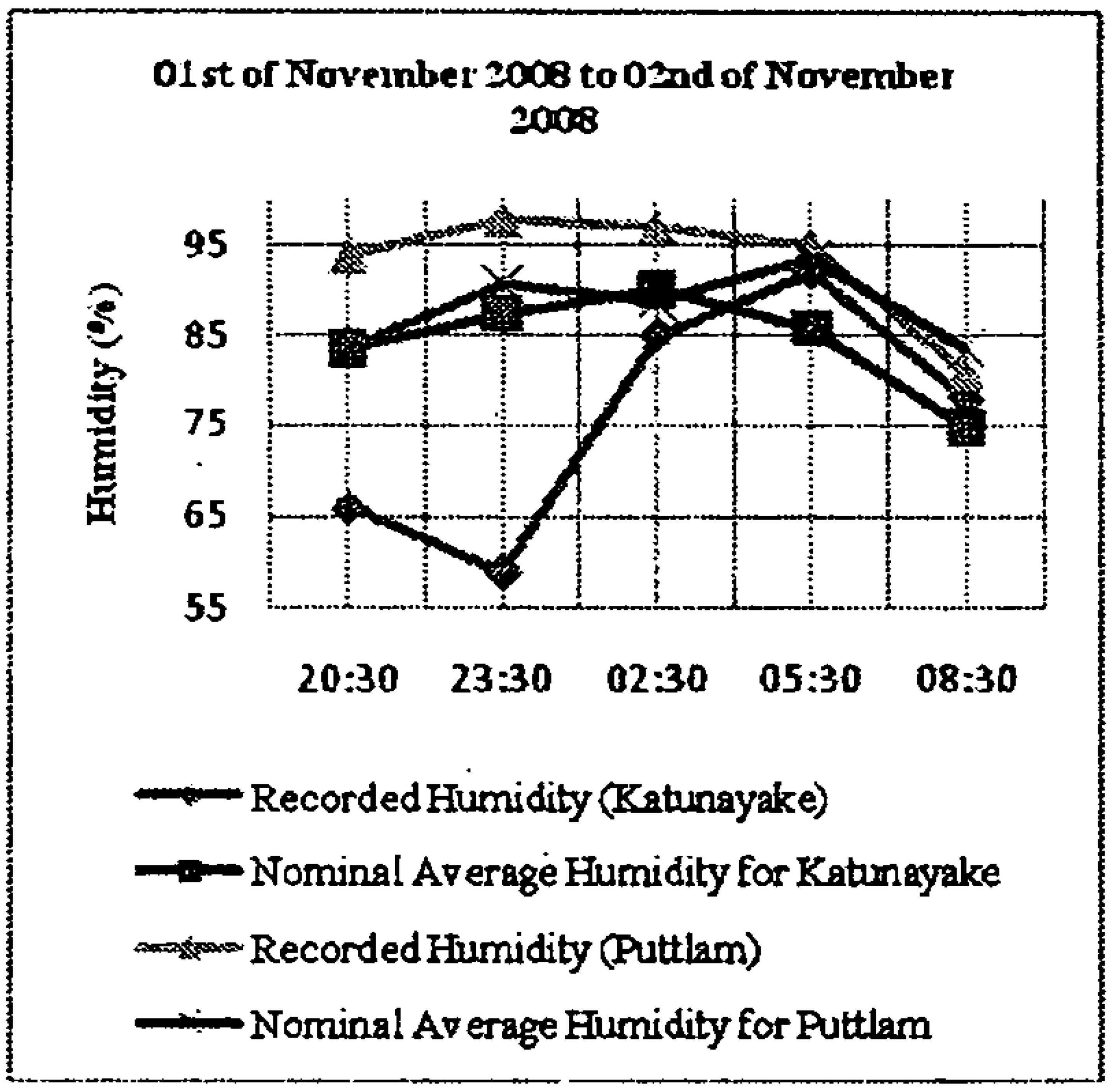

Figure 4. The Graph of Humidity against Time

When the behavior of temperature was considered, according to Figure 3, the recorded temperatures during the fading times were lower than the nominal average temperature at that time. When all the selected links and their fading time periods were studied, it was found that this temperature change was present in most of the cases.

On the other hand when the behavior of humidity was considered, according to Figure 4 the humidity was higher than the calculated nominal humidity at the time of fading. This behavior was almost present in all the fading situations in all the links considered.

Therefore it can be considered that, the seasonal fading of 7 GHz microwave links occurs due to this special change of behavior in temperature and humidity.

According to the root causes found, this problem occurs due to a special change in the climate of those areas. Therefore this is an effect of weather characteristics.

Since this is an effect of weather, the problem of fading of microwave links is difficult to solve. But the alternative solutions were proposed to minimize the effect of this problem to the operations of the organization

- Change the hop length

When the hop lengths of the links are changed, the frequency band can be changed. Since this problem only occurs in the 7 GHz band, the fading problem can be solved.

- Reduce the height of the antennas

The layering effect is higher when the height from the ground level increases due to the higher difference in temperature. So if the antenna heights are reduced the layering effect can be lowered compared to the higher levels.

- Implement redundancy paths

Implement alternative stand by paths for the links which have a risk of fading. The alternative paths should have a different frequency band so that they wouldn't subject to seasonal fading.

- Implement the ring protection for the microwave network

By connecting the links in a ring network, if one link is fading, the traffic can be transferred to the other side of the ring.

- Use a lower modulation scheme

The lower modulation schemes are subjected to less fading than the higher modulation schemes. But when the modulation is reduced, the capacity of the link is also reduced.

- Introduce adaptive modulation technique to the network

  Adaptive modulation can reduce the level of modulation according to the condition of the transmission path. Therefore if the path is fading, the link will use a lower modulation scheme and if the path condition is good it will use a higher modulation scheme.

- Use fiber optic transmission links

  Use of fiber is the most suitable and the long term solution. But the cost is higher.

In this study, only the weather data observed from Department of Meteorology were considered. As weather conditions, only Temperature, Humidity, Wind Speed and Rain Fall data were selected. Out of those factors only Temperature and Humidity seem to affect the seasonal fading. These results were obtained by using the available secondary data. Since the secondary data were not 100% accurate, the results obtained here depend on the accuracy of data.

When conducting this study the only available data were secondary data of Department of Meteorology.The available climatic data had been taken for every 3 hours. This format is not the best format for this study. If the interval between the spot data can be decreased, the results will be more accurate.

In this study the weather factors were considered as the only reason for this problem. But the weather factors will not be the only reason for fading of 7 GHz links in the western coastal area. Terrain Pattern, Hop length also affect to the fading of 7 GHz links. Therefore all those factors that might have an impact on this problem should be considered for a complete research study.

A deep study should be carried out by considering 7 GHz links in all geographical areas in order to identify the real causes of this problem. This study can be extended to study about all frequency bands in order to find out why this problem only occurs for 7 GHz band.

CONCLUSION

Fading of 7 GHz link depends on the change in temperature and humidity of the atmosphere. Fading occurs when the temperature is lower than the average and the humidity is higher than the average.

It can be concluded that the company should consider the outcome of this study when planning new microwave transmission links, in order to minimize the effects to the transmission network. Also company can use this information when requesting frequency bands from TRC.

It is recommended that TRC and other official bodies should conduct a proper study to resolve this problem since they are the governing bodies of the frequency spectrum usage in Sri Lanka.

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