[3.1] INTRODUCTION:
Microwave communications are coming in a big way in the north-eastern region of the Indian subcontinent. The terrains are covered by widely different topographic and botanical features. So, to examine the association of microwave fading/attenuation with these environments, it is essential to have a comprehensive picture of terrain features at different weather or tropospheric and meteorological situations. With that aim in mind, a number of microwave links over this region are selected. The selection is so made that propagation aspects can be addressed to different terrain conditions. The selected links are as follows:

1. Milmilia - Durgasarovar (Indian P&T Link, Marshy)
2. Maopet - Durgasarovar (Indian P&T Link, Hilly)
3. Motapahar - Durgasarovar (Indian P&T Link, Built up)
4. Laopani - Habaiapur (Indian Railway Link, Plain, wet)

The sites of microwave links for the proposed study are shown in the figure (3.1). This shows that the P&T microwave links are in the Kamrup district while the Railway link falls in the Nagaon district of Assam valley.

[3.2] TERRAIN FEATURES AND FRENSNEL ZONE CLEARANCE:
The terrain features of microwave links have been collected from various data sources. The basic path height have been obtained from the survey data made at the time of establishing the links. The data on vegetations and their changes with seasons have been obtained from the botanical and satellite imagery survey data. From these data, characteristic features of each terrain are summarised as follows. It is to be noted...
that here all the heights are measured with respect to sea level unless the base level is specified.

(1) Milmilia - Durgasarovar Link:
The terrain profile over this link is shown in the fig. (3.2a). The main receiving station Durgasarovar is at a height of 228 meters and Milmilia is at height of 105 meters. This link falls in Guwahati- Calcutta LOS Microwave communication path and is basically covered with marshy agricultural land (10km) and forested plain land (20 km). A small hill of height 220 meters at 5-6 km from Durgasarovar also falls at this link path. The link passes over the major swamps of Deepor Bill and as well as over Kukurmara Bill system which lies further south to the link. Also it runs along the river Brahmaputra towards the north as well as along river Kulsi to the south. The reserved forest is populated with sal and sagoon trees. In summer, most of he belt is covered with paddy fields.

The fresnel zone ellipsoid for this link is calculated by using the equation (1.5) as described in the chapter 1. The clearance of Fresnal zone over this link is examined for different conditions of K viz. 4/3 and 2/3. The fresnel ellipsoids for both the values of K are plotted and are shown in figs. (3.2a) and (3.2b). Fig. (3.2a) shows that fresnel ellipsoid is cleared from the highest peak of the hill by 24 meters for K = 4/3 condition, and even for the extreme situation of K, the fresnel zone clearance is 22 meters fig. (3.2b).

(2) Maopet - Durgasarovar Link: Fig. (3.3a) shows the terrain profile over this link. This link runs to the south from Durgasarovar. This terrain is hilly. The heighest point of this link is at 1660 meters and antenna height is about 70 meters above that peak. The path covers two plateaues forming a step like structure. The first step is 30
km long and average height of it is 550 meters. At the 32 km point, there is a steep rise to the next plateau which is situated at an average height of 900 meters and runs to a distance of 50 km. Beyond that point, there is a steady steep increase in height up to Maopet. This link is covered with evergreen forest as well as with desidious forests. Over this link, the major trees are SAL, SHAGUN and the PINE and abundant foliage like bamboo.

Fresnel zone ellipsoid over this link for $K = \frac{4}{3}$ and $\frac{2}{3}$ are plotted as shown in figs.(3.3a) and (3.3b). Fig. (3.3a) shows fresnel zone clearance for $K = \frac{4}{3}$ value. Fresnel zone clearance is 195 meters for $K = \frac{4}{3}$ (at the hill point) while for the extreme $K$ situation the clearance is reduced to 120 meters fig.(3.3b). The clearance is adequate for an uninterrupted LOS communication even for worst atmospheric situation.

(3) Motapahar - Durgasarovar Link:
This link goes towards east of Durgasarovar and its west part is hilly, covered with built up area and shurbs. There are two peaks in the path, one is of height 200 meters at 10 km and another of 180 meters at 13 km from Durgasarovar. The terrain between these two peaks is a plateau with average height of 160 meters. The eastern end of the lane extending 5 km is a plain covered by cultivated land. The hill and the plateau are mainly covered by planted forest of Sagoon, Sal, and Sisso trees.

Plot for fresnel ellipsoid is shown in figs.(3.4a) and (3.4b) for values of $K = \frac{4}{3}$ and $\frac{2}{3}$ respectively. The fresnel zone clearance is 40 and 23 meters for $K =\frac{4}{3}$ and $\frac{2}{3}$ situations over this link.

(4) Laopani - Habaipur Link:
The Laopani Habaipur link lies in Nagaon district and covers a
LOCATION OF THE MICROWAVE LINKS AND THE OTHER FIELD STATIONS USED FOR RECENT STUDY

Fig. (3.1) : Sites Of The Microwave Links And Other Field Stations Used For Present Study.
MILMILIA-DURGASAROVAR MICROWAVE LINK 6GHz

PATH DISTANCE 41.2 Km
ANTENNA HT TX: 50 METER
RX: 50 METER

Fig.(3.2a): Path Profile Of Milmilia - Durgasarовар Link
For $K = 4/3$, Earth's Radius Factor.
$K = \frac{2}{3}$

MILMILIA - DURGASAROVAR MICROWAVE LINK 6GH₂

PATH DISTANCE 41.2 Km
ANTENNA HT TX: 50 METER
RX: 50 METER

Fig.(3.2b): Path Profile Of Milmilia - Durgasarовар Link
For $K = \frac{2}{3}$, Earth's Radius Factor.
FIG. (3.3A): PATH PROFILE OF MAOPET - DURGASAROVAR LINK
FOR $k = 4/3$, EARTH'S RADIUS FACTOR.
Fig. (3.3b): Path Profile of MAOPET - DURGASAROVAR Link For $K = 2/3$, Earth's Radius Factor
FOR $k = 4/3$

MOTAPAHAR DURGASAROVAR MICROWAVE LINK

PATH DISTANCE 335 Km

ANTENNA HEIGHT TX: 100 METERS
RX: 80 METERS

Fig.(3.4A) : Path Profile Of Motapahar - Durgasarovar Link
For $k = 4/3$, Earth's Radius Factor.
K = 2/3

MOTAPAHAR - DURGASAROVAR LINK

PATH DISTANCE 33.5 Km.

ANTENNA HEIGHT
TX: 100 METER
RX: 80 METER

Fig. (3.4b) : Path Profile Of Motapahar - Durgasarovar Link
For K = 2/3, Earth's Radius Factor.
LAOPANI HABAIPUR MICROWAVE LINK 7GH2

FOR $K = \frac{3}{2}$
PATH DISTANCE 55 KM
ANTENNA HEIGHT:
TX: 80 METERS
RX: 90 METERS

Fig.(3.5a) : Path Profile of Laopani - Habaipur Link
For $K = \frac{4}{3}$, Earth's Radius Factor.
FOR $K = \frac{2}{3}$

LAOPANI HABAIPUR MICROWAVE LINK $7GH_2$

PATH DISTANCE 55 KM

ANTENNA HEIGHT

TX: 85 METERS
RX: 80 METERS

Fig. (3.5b): Path Profile of Laopani - Habaipur Link
For $K = 2/3$, Earth’s Radius Factor.
The path of 55 km. This link runs over a plain terrain along the river Kopili which is crossing this link path at three points. The altitude of Laopani is 54 meters and that of Habapipur is 91 meters. The terrain over this link is covered with cultivated land and forests.

The fresnel ellipsoids over this link for $K = \frac{4}{3}$ and $\frac{2}{3}$ are shown in fig. (3.5a) and (3.5b) respectively. For $K = \frac{4}{3}$ situation of the atmosphere, fresnel ellipsoid is fully clear from obstruction by 44 meters. But interestingly, for $\frac{2}{3}$ condition of the atmosphere, fresnel ellipsoid is obstructed at the mid path of the link by earth's bulging. This leads to obstruction type of fading resulting in a complete fade out of signals Fig. (3.5b).

**[3.3] MICROWAVE LINK INFORMATION**

The information on the various link parameters of the above mentioned link is given in the table 3.1.

**Table-3.1**

<table>
<thead>
<tr>
<th>Link Parameter</th>
<th>Milimilia D.sarovar</th>
<th>Maopet D.sarovar</th>
<th>Motapahar D.sarovar</th>
<th>Laopani Hab.Pur</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Distance</td>
<td>40.2 Km</td>
<td>64.4 Km</td>
<td>33.5 Km</td>
<td>55.8 Km</td>
</tr>
<tr>
<td>2. Frequency</td>
<td>6.4 GHz</td>
<td>6.0 GHz</td>
<td>6.0 GHz</td>
<td>7.13 GHz</td>
</tr>
<tr>
<td>3. Antenna Tx</td>
<td>50 mtrs.</td>
<td>70 mtrs.</td>
<td>100 mtrs.</td>
<td>80 mtrs.</td>
</tr>
<tr>
<td>Height Rx</td>
<td>50 mtrs.</td>
<td>70 mtrs.</td>
<td>80 mtrs.</td>
<td>80 mtrs.</td>
</tr>
<tr>
<td>4. Antenna Tx</td>
<td>43.3 db</td>
<td>44.8 db</td>
<td>45.5 db</td>
<td>39.5 db</td>
</tr>
<tr>
<td>GainRx</td>
<td>43.2 db</td>
<td>44.8 db</td>
<td>45.5 db</td>
<td>35.5 db</td>
</tr>
<tr>
<td>5. HASL Tx</td>
<td>105 mtrs</td>
<td>1660 mtrs</td>
<td>54 mtrs</td>
<td>91 mtrs</td>
</tr>
<tr>
<td>Rx</td>
<td>228 mtrs</td>
<td>228 mtrs</td>
<td>228 mtrs</td>
<td>91 mtrs</td>
</tr>
<tr>
<td>6. Power*</td>
<td>40 db</td>
<td>40 db</td>
<td>40 db</td>
<td>30 dbm</td>
</tr>
</tbody>
</table>

* With respect to 1μW signal level.
FADE MEASUREMENT & CALIBRATION OF THE FADE RECORDING SYSTEM:

Schematic diagram for recording fade character is shown in fig. (3.6). The setup consists of RF, IF, AGC and detector stage along with differential amplifier and chart recorder.

To study fade character of the above mentioned links, the AGC outputs of the receivers are fed to recorders through a differential amplifier or voltage to current converter system depending on the type of the recorder fig. (3.7). The normal signal level is placed at zero volt. Fluctuations over this level are measured with the help of calibration chart.

Fig. (3.8) describes the technique adopted for calibration of the system used in the Indian railway link. Here, the RF sections consisting of antenna and amplifier are disconnected from the rest of the circuit and a standard signal generator is used as a calibration source. As the IF of the receiver is 70 MHz, a 70 MHz signal from this generator is fed to the IF section. Its output goes to the recorder after proper processing through detector and amplifier. The dynamical range is then calibrated. The calibration of the system is done on a regular basis.

However, for calibrating dynamical range of the setup for the P&T links, the above procedure as adopted for Laopani Habaipur link has been followed. Further, the calibration is also made where the antenna itself is allowed to act as a source and RF section is then kept intact with the rest of the system. An attenuator pad is inserted between the RF and IF section. The schematic diagram for this arrangement is shown in the fig. (3.9). The corresponding variation is then detected in the recorder. Here the dynamical range is adjusted for suitably registering the fade depth information.
Fig. (3.): Block Diagram Of Microwave Signal Receiving Set Up
Fig (3.7) : Circuit Diagram Of Differential Amplifier
Fig. (3.8) : Block Diagram Of Signal Calibration Technique Adopted At The N.F Railway Receivers
Fig. (3.9) : Block Diagram Of Signal Calibration Set Up Adopted At P&T Link.
3.53 MEASUREMENT OF ASSOCIATED WEATHER PARAMETERS:

To realise the effect of medium on microwave propagation the following tropospheric parameters have been measured:

(a) Ground based temperature, humidity, pressure and wind speed
(b) Dry and wet temperatures at different heights by a tower of 25 meters height from the ground.
(c) Dry temperature, humidity, pressure, wind speed and direction at different heights (up to 2 km) with the help of radiosonde.
(d) Elevated structure, thermal plumes, cold and hot fronts by sodar.

The data on temperature and humidity have been collected with the help of conventional thermohygrograph. But sensitivity of the system is poor and fluctuations of temperature only up to 0.5°C could be measured with limited accuracy. Moreover, the time resolution which is 15 minutes, is also not acceptable for a meaningful study in relation to microwave fades where a change of 30 dB signal level is detected within 2-3 minutes of observation. To overcome this limitation, four sets of electronic dry and wet temperature systems along with recorder have been developed. Details of the circuits are described in section 3.6.

The data on wind speed are also collected by a conventional type of anemometer. But limitation of this anemometer is the necessity of making a physical connection of the recorder and sensor. This limits the placing of the sensor to a close proximity of receiving stations. To overcome this drawback a telemetric optoelectronically controlled anemometer powered by solar cell is developed. This system transmits wind parameters through frequency modulated radio signals. The details of the circuits is given in section 3.6.
For monitoring troposphere, both direct or insitu and remote sensing techniques are used. The radiosonde is one of the insitu techniques where the associated data at different heights can be received through a baloon equipped with sensors. By this technique, we receive the temperature, dew point, wind speed and wind direction information. But the major disadvantage of the radiosonde technique is height resolution. Furthermore, the measurements are available only for a limited period of time. However, radiosonde technique gives information on temperature inversion, subrefraction, super refraction and ducting conditions very effectively during the flight time. So this information can be correlated with fading of microwave signals observed during the period.

[3.6] SYSTEM AND CIRCUITS DEVELOPED DURING THE RESEARCH PERIOD:

(1) Sodar-
Among the remote sensing techniques, the sonic detection and ranging techniques (SODAR) can very effectively be used for continuously monitoring of the tropospheric conditions.

In an effort to identify the cause of fadings in microwaves, two SODAR units are installed. One in the midpath between Milmilia-Durgasarvar microwave link and the other at the Gauhati university, (Barbara et.al.1991 TR-1). The block diagram of the device is shown in fig(3.10). The system consists of following units
1. Antenna
2. Transmitter
3. Receiver
4. Recorder and monitor
The photograph of antenna and sodar are shown in fig.3.11a, b.
System Description
The antenna is a parabolic dish of 6 feet in diameter. The focus is at the height of 160 cm. The dish system is mounted on a suitable base for damping unwanted vibrations while
transmitting high power acoustic pulses. The same dish also serves as a receiver of the echoes. It is therefore surrounded by a carefully designed acoustic shield of double wall hexagonal structure. Shield height is 8 feet and is internally lined with thick foam to prevent reverberation and the space between the walls is filled with saw dust, which keeps out the external noise. The transducer is a high power (80 Watt) PA unit with flat response in the frequency range 1.5 - 2.2 KHz. This unit is filled with a specially designed exponential horn, and is mounted at the focus of the dish. The unit is activated by the tone burst generator. The frequency of the tone burst is adjustable from 1.2 KHz to 4 KHz and 2 KHz is the frequency selected by us for probing the atmosphere. The tone signal is then sufficiently amplified by the power amplifier to generate an electrical output power of 140 watt. The duration of the tone burst is also adjustable from 20 to 100 m sec. The triggering control pulse is generated by an external circuit and is fed to the transmitting as well as receiving system to maintain the proper synchronisation.

The same transducer is used for receiving the backscattered signal from atmosphere and is routed to the receiver system through a preamplifier. A T/R switch is introduced between the preamplifier and transducer unit to isolate and protect the highly sensitive preamplifier from the burst of high power probing signal sent from the transmitter. The T/R switch and the preamplifier circuits which are assembled in a single setup is placed at the antenna site. The output is brought to the receiver through a good quality thick shielded cable to avoid losses and pick up of noise. The received signal is then passed through a biquad narrow bandpass active filter with optoelectronic control device specially designed for this purpose. An optoelectronic switch is further used to blank the receiver input for a period of 200 m sec, so that the strong echoes from the nearby
Fig. 3.10: Block Diagram Of The Sodar Unit
Fig. (3.11a) : Photograph Of The Antenna Unit
Fig. (3.11b) : Photograph Of The Sodar Unit.
structure do not interfere with the received backscattered signal. The echo signal is then detected and amplified to an adequate output level. The detected output is then fed to the log amplifier such that the slope of the logarithmic transfer function is controlled by the gain of the amplifier. The output of the log amplifier is then suitably boosted for recording in a recorder.

Some sample records of the sodar echogram are shown in fig.(3.12 a,b,c,). Where fig.(3.12a) represents the ground based inversion layer which is generally developed after a couple of hours of sun set due to radiative cooling of earth., fig.(3.12b) shows the elevated layer recorded on Sodar echogram. This type of structure also occurs during night hours. Fig.(3.12c) shows a representative Sodar echogram of not so well developed thermal plumes characterising poor convective state of the atmosphere.

Table-3.2
Characteristic Of Gauhati University Sodar System

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitting Frequency</td>
<td>2 KHz</td>
</tr>
<tr>
<td>Pulse Width</td>
<td>50 msec</td>
</tr>
<tr>
<td>Transmitted Power</td>
<td>140W</td>
</tr>
<tr>
<td>Antenna System</td>
<td>parabolic dish</td>
</tr>
<tr>
<td>Pre Amplifier Sensitivity</td>
<td>1 uV</td>
</tr>
<tr>
<td>Pre Amplifier Gain</td>
<td>80 dB</td>
</tr>
<tr>
<td>Band Width Of Filter</td>
<td>20 Hz</td>
</tr>
<tr>
<td>Display</td>
<td>Facsimile</td>
</tr>
</tbody>
</table>

Modification Incorporated In The System -
In the basic design of the unit there is not much of a
Fig. (3.12 a,b,c) : Photograph of Sample Record of Sodar Echogram
difference from the generally built up unit. But some modifications introduced in the present system has increased its reliability. The modifications are:

Replacement of the high gain transformer at the front end of the pre amplifier switch system by an optoelectronic attenuator cum amplifier which amplifies the weak back scattered signal by more than 60 dB during receiving periods and attenuating the strong transmitting signal during transmissions, so that the receiver is protected from the high power transmitted signal. The sodar echogram shown in the fig.(3.12a, b, c) are received on a facsimile recorder developed as a part of the project and a brief description is given in the following section.

(2) Facsimile Recorder:
The basic aim of using a facsimile recorder is to have a three dimensional picture (x,y,t) of any signal so that a comprehensive view of the signal variation in the three parameters can be received. In sodar system, such a recorder is necessary to study variations of height of structures and their intensity as a function of time.

Basic Principle -
The received backscatter signal is properly filtered and processed through optoelectronic devices, is converted to frequency. The signal is allowed to pass through a buffer before being fed to the voltage to frequency converter (VFC) to avoid loading. The converted frequency is amplified for power, the output of which is fed to the stylus through a conducting bar. The stylus is allowed to move over a heat sensitive paper so that the paper burns to a degree depending on the frequency ie on the intensity of the received signal. As with the increase of frequency, the burning gets deeper, the echogram is received as a varying shades of grey. The
Fig.(3.13): Photograph Of Facsimile Recorder.

1. Paper feeder spindle
2. High voltage aluminium bar
3. Chart roll
4. Writing stylus
5. Belt
6. Paper advancing stylus
7. Paper intake spindle
8. Aluminium base
recorder that generate a triggering pulse at the beginning of each scan, synchronises the receiver for receiving the backscattered echoes. The blanking of the receiver from the high power transmitting pulse is also synchronised with this master trigger pulse. The photograph of the facsimile recorder is shown in the fig(3.13). The system basically consists of the following units:

1. System synchronising unit.
2. Electronic unit consisting of VFC, amplifier and associated circuits like system protecting device, matching unit.
3. Mechanical unit consisting of paper intake and driving system.
4. Writing unit.

Merits of The System -
1. The system has been developed with all indigenous materials and know how, its parts are easily available and repairable.
2. The echogram can be received on ordinary wax coated paper.

(3) Electronic Dry And Wet Temperature Sensing System:
The conventional thermohygrograph used for routine temperature/humidity measurement is found to be not fast and sensitive enough to record the quick changes in temperature and humidity. There are cases when inadequate response of the temperature recorder results to loss of information. To overcome this limitations a fast response electronic dry and wet temperature sensing system is designed (Barbara et al. 1992 TR-2). The circuit diagram is shown in fig.(3.14). The circuit is based on LM 335 and associated amplifier circuit. The output of the temperature sensor ($V_o = R_{sat}$) is fed to a summing amplifier to get an amplified output of the temperature controlled signal. This output is fed to the chart recorder. The output voltage is calibrated to the corresponding
Fig. (3.14): Circuit Diagram Of The Fast Response Temperature Sensing Unit.
Fig.(3.15a) : Photograph Of The Temperature Sensing Circuit.
Fig.(3.15b) : Photograph Of Tower To Measure The Temperature At Different heights.
Fig.(3.16) : Calibration Curve For Dry And Wet Temperature Measurement.
Fig.(3.17 a&b) : Sample Record Of Wet And Dry Temperature Fluctuations
temperature. For wet temperature measurements the same circuit is used. The photograph of the circuit and the tower to measure the temperature at different heights are shown in fig. (3.15 a & b).

The calibration curve are drawn for both dry and wet bulb systems and are shown in fig. (3.16). The sample records of wet and dry temperature variations during afternoon period are shown in fig. (3.16 a,b). Fig. (3.17a) shows temperature variation of the wet sensor, where temperature shows variation from 19°C to 24°C. Fig. (3.17b) shows the temperature variation of dry bulb from 25°C to 30°C, during this period. From the temperature records it can be clearly seen that the temperature fluctuations up to 0.1°C can be detected with a time resolution of less than a minutes. This is a convenient resolution for the micro structure study of the temperature parameter.

(4) Telemtric Anemometer:
The design philosophy of the system is based on the conversion of mechanical rotations of a wind vane to a corresponding train of electrical pulses through an optoelectronic device (Barbara et.al. 1992 TR-3). The pulses that are frequency-modulated on a 92 MHz carrier, are transmitted by a small transmitter. The number of pulses so obtained are calibrated to give the wind velocity at that instant. The block diagram of the system is presented in fig.(3.16). It consists of
1. Cup and cone wind vane
2. Transmitter
3. Receiver with recording system.

The cup and cone wind vane has three conical cups and cones of diameter 10 cm and arm length of 22 cm each which are
placed at the corner of an equilateral triangle. This vane system rotates with speed in proportion to that of wind. It gives one electrical pulse at each rotation. These pulses are then transmitted by a FM transmitter of range 150-200 meters operating at 92 MHz. The transmitted signal is received by a FM receiver. Output pulses are detected, amplified for power and then recorded on a heat sensitive paper. So, for ten rotation of cup and cone system we will get one dot mark on the the thermal sensitive paper. So in a very strong wind condition we get a continuous line with small gap in between two ten marks. Here the transmitter remains on for the duration of two pulses and remains quiescent for the next eight sequence of pulses. This system requires a power unit of 12 volts which can be provided by a solar cell. Thus the complete setup can be arranged over a tower or at any place near the recording setup, without the necessity of battery charger or long connecting wires. The photograph of transmitter unit and the recorder unit of this system is shown in the figs. (3,19a & b)

The wind speed is calibrated in terms of speed in miles/hour. The wind speed can be calculated from the fig.(3.20) both in terms of length of dot marks and in terms of gap between two marks.

Figs (3.21a, b) shows the sample records of wind speed on 10th Nov. 1992 and 31st Oct. 1992 respectively. From sample records it can be seen that on 10th Nov., wind speed is changing from 0-15 miles/hour, while on 31st Oct. the wind is moderate and it is blowing with a
Fig. (3.18) : Block Diagram Of The Telematic Anemometer.
Fig.(3.19a) : Photograph of Anemometer Transmitter Unit.
Fig.(3.19b) : Photograph of Recorder Unit.
wind calibration chart
1-mark length ; 2-time interval

Fig.(3.20) : CALIBRATION CURVE FOR WIND SPEED MEASUREMENT.
Fig. (3.21 A & B) : Sample Record Of Wind Speed.
variable speed of 0-10 miles/hour. The output of the system has not been used for the present study but would effectively be used for further analysis that is going on in association with sodar echogram.

5. FAST RESPONSE RAIN GAUGE:
Accurate data on total rainfall and rainfall intensity are very essential to understand the rain attenuation of microwave signal generally above 10 GHz. The conventional rain gauges such as syphon type, tilting bucket or tripping buckets have inherent limitations in recording fast changes of rainfall intensity, because of their large integration time. But it has been observed that heavy rain rates of 200 to 250 mm/hr generally last for few seconds and appreciable attenuation leading to link cutoff may be expected during that period. So, it is a very essential to have an instrument capable of responding to fast changes in rain rate. The basic principle of this rain gauge is to count the number of the rain drops (Barbara et al. 1993 TR -4). The rain water is allowed to pass through a funnel and is fed to a nozzle so that the drops falling out of it are of equal size. Each rain drop then produces a pulse which is fed to the recorder through a VFC and power amplifier unit. We then receive a signature of a rain drop in the form of a black dot on heat sensitive paper used in the recorder. When the rain is very heavy a blanking pulse is applied after each eight drops. Thus, when the rain is very heavy and marks on the paper are too close for individual identification, we get a blank space between two traces signifying a set of ten drops. So in between a set of ten drops, we get a eight black dot marks and two blanks. For the economic use of chart paper an automatic speed control device is also incorporated. During no rain conditions the chart move at a very slow speed of 1mm/minute and each 90 sec is marked on the chart paper by a timer. The rain collected through the system may not normally be very essential for correlating the microwave fading
Fig (3.22) Block diagram of fast response raingauge
Fig. (3.23) : Photograph of Circuit Diagram of Fast Response Rain Gauge System.
Fig.(3.24) : Calibration Curve For Measuring The Rain Fall Intensity
Fig.(3.25 a & b) : Sample records of rain fall intensity measurement.
at 6/7 GHz. However this is developed to examine the effect of fast changes in rain rate on microwave fades because of large rainfall rate situation over this region.

The block diagram of the system is shown in the fig (3.22). The system consists of the following units:
1. Collector and sensor
2. Counter
3. Recorder
4. Marker
5. Automatic speed control
(The photograph of the system is shown in fig. 3.23)

To find out the rainfall rate, a calibration chart is drawn associating the number of drops in ten seconds with rainfall rate mm/hr and is shown in fig.(3.24). This chart is drawn to find the rainfall rate up to 250 mm/hour.

The sample records of different rainfall intensity are shown in the figs(3.25a,b). Fig. (a) represents the rainfall rate of moderate intensity varying from 14 mm/hour to 28 mm/hour and fig.(b) shows variation of rainfall rate up to 65 mm/hr. It is seen from the plot, that any changes in rainfall rate within seconds (or even in milli-second) can be easily resolved.

[3.7] CONCLUSION:
This chapter describes the different terrain features over the four links used for observation of 6/7 GHz microwave fadings. The path profile analyses point to the fact that the Fresnel zone clearance is though well maintained over Maopet and Milmilia links, the first Fresnel zone is obstructed in Laopani- Habaipur link for $K = 2/3$ condition. Relatively small clearance is noted over Jorhat link for both, $K = 4/3$ and $K = 2/3$ conditions. The microwave setup and calibration...
procedure is described. The system and circuits like Sodar, Facsimile recorder, Fast response dry and wet temperature recorder, Telemetric anemometer, and Fast response rain gauge etc. that have been developed are discussed and sample records are presented for each case. The merits of the developed systems over the commercially available ones are highlighted. The system calibration curves are shown along with the circuit blocks.