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Estimation of P_0 Multipath Occurrence Factor in Latvia

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Multipath fading invents

Multipath events are observed with daily and seasonal cycles, when atmospheric stratification is more likely to happen. They are more frequent with strong evaporation (high temperature and humidity), absence of wind, and flat terrain. During multipath propagation events, the Rx signal level varies very fast (See Drawing 1). It may be almost cancelled, for short periods (fraction of a second, or few seconds). A multipath activity period can last some minutes or even one hour or more (Fig. 1).

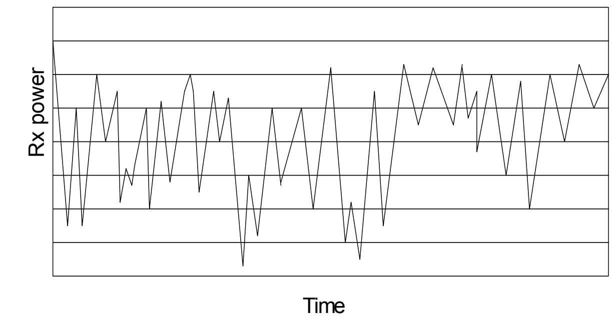

Fig. 1. Radio link

Multipath activity depends on: environmental conditions and on environmental conditions and radio link parameters. Particularly in tropical climates, long multipath events can be observed.

Multipath fading statistic

When the Rx signal is produced by a large number of components (vectors with random phases), then the Rx power level is variable, with Rayleigh statistics (Fig. 2).

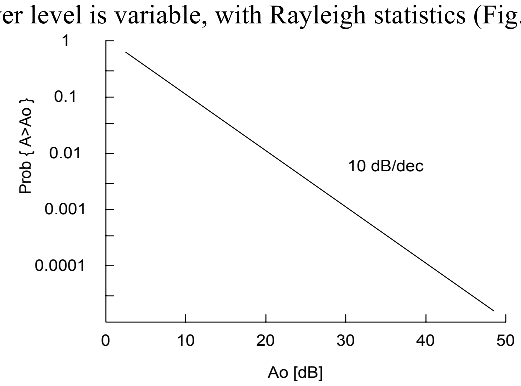

Fig. 2. Power level

The **Probability** of having a fade depth A (dB) greater than a given depth A_0 is (Rayleigh formula):

$$P_{prob}\{A > A_0\} = P_0 \times 10^{A_0/10}; \qquad (1)$$

where $\mathbf{P_0}$ **= Multipath Occurrence Factor.** It is a measure of the multipath activity in a radio hop.

How to know P_0?

Operating Hop: P_0 is estimated by **monitoring the Rx Power** and by processing the measured data.

Hop under Design : P_0 is predicted by **empirical propagation models.**

Multipath occurrence factor

The Multipath Occurrence Factor $\mathbf{P_0}$ **depends on:**

1. **Frequency;**
2. **Hop length;**
3. **Climatic conditions;**
4. **Terrain.**

Po can be predicted using empirical formulas, proposed by ITU-R and by operating companies or research labs. A general formula is :

$$P_0 = K \times Q \times F^a \times L^b \ ; \qquad (2)$$

where : **F** = Frequency; **L** = Hop Length; **K** = Geo-climatic Coefficient; **Q** = Terrain Coefficient; **a** and **b** –factors to account for regional effect based on empirical data

The **Frequency Exponent is close to unity.** This means that the fading activity [1] in a given hop is proportional to the frequency (at 11 GHz is approximately twice than at 5.5 GHz).

The **Distance Exponent is in the range 3 - 3.6.** This means that the fading activity , for a given frequency, climate, and terrain, is increased about ten times if the hop length is doubled.

Multipath occurrence factor examples

6 GHz hop: According to the prediction models, $\mathbf{P_0}$ **expected in the ranges:** Linear scaling to other frequencies: **3 GHz - divide by 2** the Po values computed for the 6 GHz hop.

12 GHz - multiply for 2 Po values computed for the 6 GHz hop

Table 1. Range of P_0 multipath activity factor in

	30 km	50 km	65 km
Dry climate, mountains	0,01- 0,05	0,05 – 0,2	0,12 – 0,5
Temperate clim., average terrain	0,05 – 0,12	0,2 – 0,6	0,5 – 1,5
Tropical, humid clim., average terrain	0,15 – 0,4	0,8 – 2,0	1,8 – 4,5
Tropical, humid clim., wet terrain	0,4 – 2,0	2,0 - 10	5,0 - 20

How to use P_0 predictions, for examp.: $P_0 = 1$ **>Fade Depth > 30 dB** for **2600 seconds** / one month.

Any Fade Depth : **divide seconds by ten for 10 dB** deeper fade (e.g. P_0 = 1 -► Fade Depth > 40 dB for 260 seconds / one month). **Other Po values** : **linear scaling** (number of seconds proportional to Po).

New prediction methods

ITU-R recommendation P.530 gives a new method for calculating the fading occurrence factor for the worst month. No path profile is required for this method, but a general classification of the path type gives a more accurate prediction.

The methods are derived from fading data on paths with lengths in the range 7-95 km, frequency range 2 – 37 GHz, path inclinations for the range 0 – 24 mrad, and grazing angles in range 1 – 12 mrad.

Checks using several other sets of data for paths up to 237 km in length and frequencies as low as 500 MHz, suggest however, that it is valid for larger ranges of path length and frequency.

The results of semi-empirical analysis indicate that the lower frequency limit of validity is inversely proportional to path length. A rough estimation of this lower frequency limit, f_{min} can be obtained from. f_{min}=15/d[GHz].

The outage probability (in percent) for the worst month is given by: $P_{flat} = P_0 \times 10^{-F/10}$ and the fading occurrence factor is:

$$P_0 = K \times d^{3,6} \times f^{0,89} \times (1+E_p)^{-1,4}; \qquad (3)$$

where K – geoclimatic factor; d – path length (km); f – frequency (GHz); $E_p=[h_1 - h_2]/d$ – path inclination [milirad]; h_1; h_2 – antenna heights above mean sea level

The geoclimatic factor may be estimated for the average worst month from fading data. In absence of such data empirical relations must be used based on the type of path.

Practical observations and conclusion

As was mentioned above research was done for the twenty microwave hops during the year. All hops have working frequency 7/8 GHz and length between 40 and 60 km. In result we got 0,03% percent of time when fading value was more than microwave link feed margin.

There are two-conclusion outcome from that result.

1) Space diversity technique shall be used building 7/8 GHz hops which lengths is more than 40 km.

2) The feed margin on existing hops shall be increased up to 45 dB or radial network topology shall be used.

3) In case of microwave links upgrade for capacity extension the microwave systems with modern equalization technique shall be used.

During the observation period we notice that there is significant increase in the hourly standard deviation of fade in the morning hours during the summer season. This is clear indication of high multipath activity.

Table 2. The time interwals when receiving signal was below threshold (-80 dBm) see in:

HOP name	PCM	Jun	July	August	September	October	November	December	January	February
Baltel_Olaine	18			0:00:24	-				0:06:07	
Olaine_Apsupe	14	0:43:23		0:01:33	0:00:58					
Apsupe_Biksti	21	0:23:34		2:02:11	0:16:40	1:23:21		0:00:44		0:01:30
Biksti_Saldus	13	0:12:43		0:04:23	0:00:58				0:42:36	
Saldus_Kalvene	13	0:23:54		0:04:23	0:00:58				0:42:36	
Kalvene_Liepaja	22		0:29:11	3:04:02	0:02:10	0:00:25	0:06:20	0:02:08		
Baltel_Sloka	19		0:24:56		0:00:47					
Sloka_Tukums	20		0:17:19		0:00:32					
Tukums_Kamparkalns	21		0:12:32			0:00:57				
Kamparkalns_Ugale	18					0:00:22				
Ugale_Ventspils	1				0:00:01	0:01:52				
Ugale_Ventspils	23		0:08:32							
Skirotava_Kegums	8		0:07:56			0:03:38	1:00:42			
Kegums_Skriveri	9		0:13:25					0:05:47		
Skriveri_Selpils	2	0:02:32								
Selpils_Jersika	4							0:01:35		
Jersika_Svente	13					0:22:15		0:05:00	0:00:23	
Svente_Kraslava	21						0:01:18			

As expected, the multipath activity is highest during summer and lowest during wintertime.

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D. Serdega, G. Ivanovs. „Multipath“ faktoriaus P_0 atsiradimo Latvijoje įvertinimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2005. – Nr.3(59). – P. 90–92.

Kaip žinoma, mikrobangų perdavimo linijose signalas gali smarkiai nykti, dėl to gali padaugėti klaidų ar net visai nutrūkti duomenų perdavimas. Tai atsitinka tada, kai priimamas signalas susideda iš didelio skaičiaus komponentų (skirtingos fazės vektorių), kai Rx signalo galias kinta pagal Relėjaus statistikos dėsnį. Tikimybė, kad nykimo dydis A (dB) bus didesnis už nustatytąjį A_0 (pagal Relėjaus formulę) yra $P_{prob}\{A>A_0\}=P_0 10^{-A_0/10}$. Tai yra „multipath" aktyvumo matas radijo perdavimo linijoje. Yra dvi P_o įvertinimo galimybės: matuojant ir apdorojant Rx galią bei panaudojant empirinį bangų sklidimo modelį. Analizuojamas pirmasis būdas. Tam tikslui per vienerius metus buvo surinkti ir apdoroti matavimo duomenys iš 20 mikrobangų linijų. Apskaičiuotas Po dydis Latvijai. Jis gali būti panaudotas mikrobangėms linijoms planuoti ir leis gerokai padidinti šių linijų pateikiamumą. Il. 2, bibl. 9 (anglų kalba, santraukos lietuvių, anglų ir rusų k.).

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As we know microwave transmission can be affected by deep fading, which can cause bit errors or even transmission loss. It happened when the Rx (receiving) signal is produced by a large number of components (vectors with random phases), then the Rx power level is variable with Rayleigh statistics. The Probability of having a fade depth A (dB) greater than a given depth A_0 is (Rayleight formula) $P_{prob}\{A>A_0\}=P_0 10^{-A_0/10}$; P_0- Multipath Occurrence factor. It is measure of multipath activity in radio hop. How to know P_0? There are two possibilities: P_0 can be estimated by monitoring the Rx Power and by processing measured data and P_0 can be predicted by empirical propagation model. We had chosen first possibility. We collected data from twenty microwave hops during the year. As a result we practically find P_0 value for Latvia, which can be taken into account during microwave hop planning and will let engineers to decrease microwave transmission interruption time. Ill. 2, bibl. 9 (in English, summaries in Lithuanian, English, Russian).

Д. Сердега, Г. Ивановс. Оценка появления “Multipath” P_o фактора в Латвии // Электроника и электротехника. – Каунас: Технология, 2005. – № 3(59). – С. 90–92.

Как мы знаем, передача информации по радиорелейной линии может быть нарушена в связи с глубокими замираниями сигнала, которые могут вызывать ошибки или даже перерывы передачи информации. Это происходит когда приёмный сигнал складывается из множества компонентов (т.е. векторов с различной фазой и амплитудой), поэтому приёмный сигнал варьирует в соответствии со статистической моделью распределения Релея. Вероятность появления замирания глубиной A (дБ) большей чем данная величина A_0 (дБ) определяется по формуле $P_{prob}\{A>A_0\}=P_0 10^{-A_0/10}$; где P_0 – вероятность появления многолучевого распространения. Он определяет вероятность возникновения затухания определённой величины. Как определить величину P_0? Существуют две возможности: P_0 можно определить путём наблюдения уровня приёмного сигнала и обработки результатов измерения или P_0 может быть подсчитан используя эмпирическую модель распространения. Мы выбрали первый метод. Мы собирали данные с двадцати радиорелейных пролётов в течении года. В результате мы практически нашли значение P_0 для Латвии, данная величина может быть использована при проектировании радиорелейных линий и позволит снизить время прерывания передачи. Ил. 2, библ. 9 (на английском языке; рефераты на литовском, английском и русском яз.).