ON METEOR SCATTER EXPERIMENT USING LOW TRANSMITTING POWER

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Abstract

Communications using meteor burst links are widely used for monitoring application. The remote stations of such systems may use the batteries as power sources. To save the energy and extend the operating life, the transmitting power should be as low as possible. This paper reports some of the observed data obtained from an experimental meteor burst link using low transmitting power. The distributions of the trail duration and the peak amplitude are presented. The number of the underdense trails exceeding the signal threshold is compared with the predicted values. The contributions of the underdense and the overdense trails to the link throughput are also investigated. This preliminary results show that to use the low power meteor burst link, the overdense trails model would provide better predictions on link characteristics and performance.

1. Introduction

One form of the meteor burst link applications is remote monitoring which has one or more master stations and many remote stations. The remote units may locate at the place where there is no other power source except their own batteries. Therefore the use of low transmitting power at the remote stations will save the energy and extend their operating life, especially when the batteries are in the unrechargeable situations. This paper provides results from the preliminary study on the use of low transmitting power meteor burst links. These results and the further studies will be used in modeling the link in the future.

Many works [1,2,3] on meteor burst communications use only the underdense trail model in predicting both the individual and statistical channel characteristics, such as the trail duration, the peak amplitude, and their distributions, due to the greater proportion of the underdense trails. The overdense trails, however, play more important role when transmitting power is decreased. This paper presents the measured results obtained from an experimental link using low transmitting power to investigate the effect of the increase of the overdense trails ratio. The receiver of this trial link is located in Chumporn province (10.4^{o}N, 99.1^{o}E). It is 400 km away from the transmitter at Chulalongkorn University, Bangkok (13.7^{o}N, 100.5^{o}E). The operating frequency is 49.1 MHz and the transmitting power (at the antenna terminal) is 60 Watts. The data obtained will be discussed in 3 perspectives. Firstly, the trail duration data will be fitted with a curve and compared with the classical model. Secondly, the peak amplitude data is also fitted with a curve and the number of the underdense trails exceeding the signal threshold will be observed to investigate the effect of the threshold level on the link's performance. Finally, the contributions of the underdense and the overdense trails to the throughput capacity are determined, based on the data captured from the link and taking into account the received power and the trail duration.

2. Distribution of the trail duration

The commonly used model for the distribution of the trail duration above an arbitary signal threshold is given by Sugar [4] as follows

$$\text{Prob}(t > t_0) = \exp\left(-\frac{a t_0}{\tau}\right) \quad (1)$$

where $\text{Prob}(t > t_0)$ is probability of the trails with duration $t > t_0$,
τ is the decay constant, and
a is an empirical constant

The curve from equation (1) is used to fit the data obtained from the experimental link. The result is shown in figure 1. The dots present the measured data while the dash line is the fitted curve. The fitted curve expressed in the exponential form shows good agreement with the measured data. The factor a obtained from the curve is 1.3 while Sugar assumes a =1 and suggests that the presence of the overdense trails increases the value of a. More measurements to establish the value of a are necessary, although this value is in the range suggested by Sugar but it seems to be less when compare with the Weitzen's data. [3]

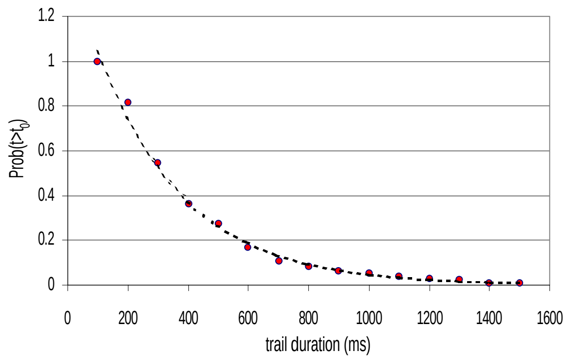


Fig.1 Distribution of trail duration

3. Distribution of the peak amplitude

The peak amplitude distribution model used to fit the data is also given by Sugar [4]. The model assumes that all parameters are constant and set equal to the average value except the electron line density (q) which varies from trail to trail. The peak amplitude distribution obtained from the approximated probability density function of q is given by

$$\text{Prob}(P > P_0) = c P_0^{-a} \quad (2)$$

where $\text{Prob}(P > P_0)$ is the probability of the trails with amplitude $P > P_0$,
c and a are constants

The fitted curve and the observed data are shown in figure 2. The value of a obtained from the curve is 1.5. This value is close to the value obtained from the duration distribution curve. When only the underdense trails are considered, the observed data shows that the number of trails decreases faster than predicted when the received signal threshold is increased. This is shown in figure 3. This result suggests that when the required signal threshold is reduced, more trails than predicted are gained and consequently leads to performance improvement [5].

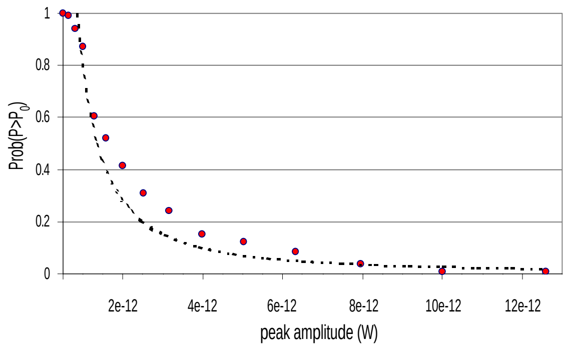


Fig.2 Distribution of the peak amplitude

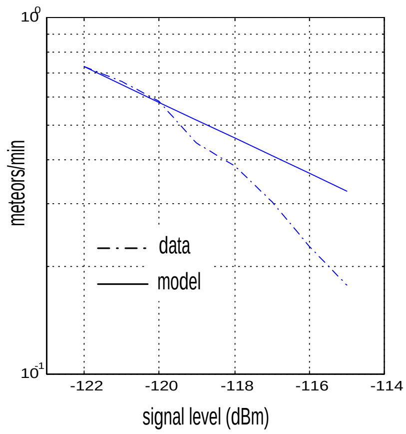


Fig.3 Number of meteor trails per minute exceeding threshold

4. Contributions of trail classes to throughput capacity.

The contributions of the meteor trails to throughput capacity are determined by dividing all trails into 2 classes, the underdense and the overdense trails. Many overdense trails are excluded in the calculation procedure especially the fading trails because their shape differences from the theory cause calculation difficulty. The contributions are determined according to the ideal cases where practical factors such as synchronization time, message length are ignored. Therefore, the received power and the trail duration are the only two factors to be considered. This analysis uses 2 communication systems, the constant data rate system and the optimum system which the data rate can be varied according to the received power and this rate can be expressed as follows [2]

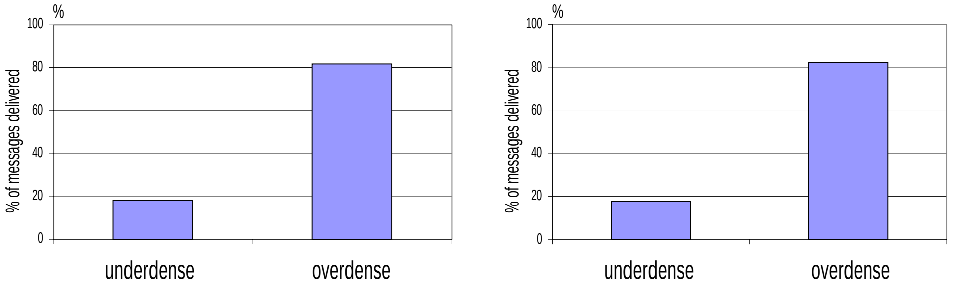
$$R(t) = \frac{P_r(t)}{N_o\left(\frac{E_b}{N_o}\right)} \qquad (3)$$

where $P_r(t)$ is the received power,

N_o is the noise power, and

$\frac{E_b}{N_o}$ is the required bit energy to noise ratio

Results from both systems are shown in figure 4. The overall contributions of the optimum system are 285% of the constant data rate system. Over 80% of the messages are delivered by overdense trails for both systems, although the low signal to noise ratio (3dB) is used. It may be resulted from the ratio of the number of overdense trails is increased when using low transmitting power. Measurements with several transmitting power levels have to be done to investigate the number of trails ratio in future works.



a) constant data rate system b) optimum data rate system

Fig.4 Underdense and overdense trail contributions

5. Conclusion

It is found that the simple trail duration distribution model based on midlink scatter from the underdense trails provides results in good agreement with the measured data. Because the assumptions used in the simple model is quite different from the experimental situation, further study is necessary in order to develop a more accurate model, although the result shows good agreement.

The number of observable underdense trails seems to decrease fast when the received signal threshold is increased. This suggests that using the methods which reduces the required signal level such as using high sensitivity receiver, low noise amplifier or using modulation and coding techniques to reduce the required signal to noise ratio, more underdense trails will be observed. But this makes the use of low transmitting power links a little improvement in performance because most of the messages are delivered by the overdense trails.

The contributions of the underdense and the overdense trails to the throughput capacity are also shown in this paper. The preliminary results indicate that the major contributors to successful meteor burst communications using low transmitting power are the overdense trails, although the required signal to noise ratio is decreased in order to increase the number of the useful underdense trails. This suggests that to use the low transmitting power links, the overdense trails should be considered first. Since many overdense trail shapes are different from the classical model, further study on modeling the overdense trails, especially dividing them into subclasses in order to predict the link characteristics and performances more accurately, is necessary.

Acknowledgements

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