Doc: IEEE 802.4L/89-04

NCR Systems Engineering B.V.
SUBMISSION TO IEEE 802.4L
THROUGH-the-air Token Bus Physical Layer

Bruce Tuch March 1989
NCR SYSTEMS ENGINEERING
ZADELSTEDE 1-10
3431 JL NIEUWEGEIN-HOLLAND
(0)3402-76468

SUBJECT: Review of Report: UHF Fading in Factories
by
THEODORE S. RAPPAPORT & CLARE D. McGILLEM

IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS VOL. 7. NO. 1. JAN. 1989

UHF FADING IN FACTORIES

1. INTRODUCTION

A report has come to my attention which is of interest to our 802.4L work, especially those involved within the MAP environment. While quite a lot of information has recently become available concerning indoor propagation, around the 1GHz Frequency band, it has been limited to indoor office and store like environments. Therefore justifiable concern has been expressed upon the extrapolation of this data to the factory floor.

2. THE MEASUREMENTS

In the article by Rappaport & McGillem, narrow band propagation loss measurements have been reported together with small scale fading characteristics within five different factories. Within any one factory four different topologies have been defined which behave in a similar way in terms of propagation loss:

Class

1. Line of Sight Path with Light Surrounding Clutter
2. Line of Sight Path with Heavy Surrounding Clutter
3. Obstructed Path with Light Surrounding Clutter
4. Obstructed Path with Heavy Surrounding Clutter

2.1. PATH LOSS EXPONENT (LARGE SCALE PROPERTY)

When all the data from all the measurements (over 20,000 power measurements) are put into one pool the linear minimum mean square estimate of the propagation exponent and standard deviation is found to be:

$$n = 2.18 \quad \sigma = 7.92 \text{ dB}$$

It is noted that the deviation of the signal power with respect to the mean (calculated from the regression line) can be quite accurately modeled as a gaussian distribution.

The fact the propagation loss within the factory is close to free space is quite different what has been found within the indoor office environments (exponent between 3 and 6). To give a direct comparison:

Within our NCR office (Topology of the class 3)	Factory with same Topology
n= 3.9 σ = 2.2 dB	n = 2.38 σ = 4.67 dB.

This difference can be attributed to the type of material in which a factory is built. With large ceiling expanses, metal walls and objects the power is reflected within the building.

It would be expected with such an environment that antenna spacing, using some distribution system, would not necessarily be limited by signal attenuation but by multipath delay. Multipath delay measurements have been done by the same authors but I have not yet seen the results.

2.2. SMALL-SCALE FADING CHARACTERISTICS

2.2.1. Receiver Motion

As in the office environment fading with dynamic ranges of around 30dB has been found. Rayleigh distributions seemed to model the fading for some of the measured topologies, but also log-normal. For a pool of all the data the log-normal distribution fits the best. It is noted though that the Rayleigh distribution gives worst case small-scale fading predictions.

2.2.2. Temporal Fading

Measurements of temporal fading, measured with stationary Transmit and Receiver Antennas, while people and factory equipment was in motion, assembly lines, large ceiling mounted fan, was done. The dynamic range of the signal variations was found to be about 20dB, about 10dB less than an office type of environment! Excellent agreement was found using a Rican probability distribution with a K = 10dB. The fact that the factory floor has a better behaved temporal fading, compared with office environments, can be traced to more illumination opportunities, due to more reflective surfaces, within the factory area.

3. SUMMARY

In short the report by Rappaport and McGillem gives very promising information concerning the attenuation characteristics within the factory floor. As far as attenuation and fading effects are concerned the factory environment seems to give less of a problem than office and retail topologies. The next step, in terms of data gathering, is getting information concerning the Multipath Delay response, which is expected to be much higher in the factory.