IEEE 802.11
Wireless Access Method and Physical Layer Specification

Title: **Response to the document P802.11-94/151**

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Summary

At the 802.11 Orlando meeting, July 12, 1994, F. J. Lopez-Hernandez et al. - Spain, submitted a document that compares FQPSK and PPM modulation techniques [4].
The data and conclusions presented in that document are very confusing, but are, accordingly to the authors, based on their own studies and supported by several other institutions. One of the references used in the document is a recent paper form J. M. Kahn, et al., University of California, Berkeley [1], where an extensive discussion of IR transmission techniques is presented.
In the present document it is shown that the conclusions in [1] are in complete disagreement with those presented in document 94/151.

Comments on Table 2 (doc 94/151)

The conclusions achieved in document 94/151 seem to be based on the data arranged in Table 2. We found it almost impossible to interpret Table 2. We believe most of the entries have no meaning in face of a comparison between modulation schemes. Where the entries are meaningful, the numbers were not identified in the quoted references, even after extensive research.
From the above we are going to concentrate only on the conclusions achieved in doc. 94/151.

Illusion or mistake ?

The major conclusions presented in document 94/151 are:

a) carrier based modulation schemes require less energy to work than PPM;
b) and that is true even for higher bit rates for FQPSK than for PPM,

and, accordingly to the authors of doc. 94/151, this is supported by the Berkeley paper [1]. The authors of doc. 94/151 also claim that their data is based on "experimental results of IBM, DEC and AT&T supported programs". However, no references were supplied for that "support" which we found quite strange.

We were also surprised for the lack of reference to the work already presented by the University of Aveiro to the 802.11 working group [2, 3] and the lack of explanation on the disagreement between our results and those presented on doc. 94/151.

The results and conclusions presented in the Berkeley paper are in close agreement with the work done by the University of Aveiro and **are in contradiction with the conclusions of doc. 94/151**. Indeed, from [1] it is clear that PPM is the most power efficient modulation technique even at bit rates as high as 30 Mbps and under multipath distortion.
The following are transcriptions from [1] that clearly show the advantages of PPM over other modulation techniques:

a) "L-PPM is a transmission technique that offers an improvement in average-power efficiency over OOK, at the expense of an increased bandwidth requirement..."

b) "The excellent average-power efficiency of L-PPM can result in a significant decrease in transmitter power consumption..."

c) "...This makes L-PPM an excellent choice in the presence of near-d.c. interference from fluorescent lighting."

d) "A single BPSK or QPSK subcarrier requires 1.5 dB more optical power than OOK;"

Figure 9 in [1] presents a comparison between several modulation methods. From that figure it is clear that, **for the same bit rate**, QPSK requires about 4.5 dB more average optical power than 4-PPM and about 9 dB more average optical power than 16-PPM. We must note that these results already take into account the different receiver bandwidth requirements of each modulation method.

From the above, it is at least enigmatic how the authors of document 94/151 achieved their conclusions based on reference [1]. Even more strange is the conclusion (Table 2, entry 6) that the same modulation method at 4 and 10 Mp/s have the same performance!

Methodology

In previous submissions to the 802.11 working group, the Univ. of Aveiro presented a comparison between modulation methods, and absolute values for the receiver sensitivity were then supplied for particular sets of conditions. Others have done the same. We invite every people submitting documents on modulation techniques to do the same. This way it becomes easier to evaluate the power requirements and compare different modulation methods on a solid basis.

References

[1] Joseph M Kahn, et al.,
"Non-Directed Infrared Links for High-Capacity Wireless LANs"
IEEE Personal Communications, Second Quarter, 1994

[2] Adriano J. C. Moreira et al. - Univ. of Aveiro - Portugal, "Modulation / Encoding Techniques for Wireless Infrared Transmission", doc: P802.11-93/79

[3] Adriano J. C. Moreira et al. - Univ. of Aveiro - Portugal, "Performance Evaluation of the IR PHY Proposal", doc: P802.11-94/97

[4] F. J. Lopez-Hernandez, M. J. Betancor, W. Just and H. Kindl, "Low Power IR-4 Mb/s and 10 Mb/s FQPSK and 1 Mb/s and 2 Mb/s PPM Components and Systems", doc: P802.11-94/151