**IEEE P802.11**
**Wireless Access Methods and Physical Layer Specifications**

# Revised version of the Combined Baseband and Modulated Multi-Channel IR-PHY EXIRLAN

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## 1. General

Since the 1st presentation of the EXIRLAN (**EX**pandable **I**nfra**R**ed **L**ocal **A**rea **N**etwork) - concept in on the 802.11-meeting at West Palm Beach in November 1993, essential technical and strategical progress has been achieved:

- The specified features have been enhanced, and the complexity of the circuitry required for the implementation could be reduced drastically at the same time. The enhancement in performance became possible by choosing FQPSK-modulation. This modulation scheme provides an extremely high efficiency concerning bund rate per bandwidth, which is, in turn, economically very important for IR-communication due to the limited speed of low-cost IR-transmission-LED's

- A laboratory device has been implemented using existing commodity components

- A major semiconductor manufacuturer - SIEMENS AG - joined the EXIRLAN community, delivering the necessary components for implementation today with the option for higher performance and integration components shortly after approval of the standard.

- Three US-and three European computer companies have stated their intention to support the EXIRLAN activity so far. A worldwide EXIRLAN users group will be founded soon formally. Every company is invited to contribute to the further development. The results will be made available to IEEE 802.11.

- The EXIRLAN-structure has been tuned technically to existing IEC/CENELEC/DKE IR-standardization drafts.

## 2. EXIRLAN structure

Many equipment manufacturers are issuing new devices using IR data communication.

Such IR devices from different manufacturers will have to work independently from each other in the same room, and are not supposed to use the same environment in terms of common infrastructure, application programs and so on.

Having only ONE channel in the IR-PHY available for all these applications and manufacturers, heavily limits the size of the available market and prevents worldwide standardization due to the lack of acceptance of baseband solutions by the several standardization committees.

To avoid this situation, an IR-PHY concept has been developed, that

- allows several applications to run in parallel in the same room independently from each other
- may operate in the same room, where a baseband system non-compliant to the 802.11-standard is running, given that its electrical spectrum does not exceed 6 MHz
- provides also a very power-efficient, low cost baseband standard, that complies with the IEC/CENELEC draft and can be operated independently from the "modulated" applications.
- allows segmentation of a room into subareas in a way, that each subarea is handled by 1 server - thus, in most cases a virtually unlimited number of terminals can be operated in 1 room and/or in 1 application [1], [2] in spite of the limited bandwidth available.
- gives a very high total available data throughput (30 Mb/s in a first step, more than 100 Mb/s in a second step).
- uses very low cost IR transmitter - and receiver-components also for the narrow band part.
- can be implemented with existing IC's at a component cost of 23 US $ for the multichannel transmitter and 21 US $ for the multichannel receiver on quite small PCB-area.
- will be brought down by the factor 2...3 in cost and size, when specific components are available.

EXIRLAN uses narrow-band technique with 8 different carriers. The 8 communication channels occupy the high end of the available bandwidth; in the demodulator, the modulated signal is mixed down to 0 MHz and demodulated in the baseband.
The low end of the total bandwidth is reserved for lowest cost, non carriered baseband transmission at reduced data rate; as in this band also most IR-devices can communicate that do not follow the EXIRLAN-standard, this band is refered to as "Coexistence Band".

### 2.1. Narrow Band Part of EXIRLAN

The entire frequency scheme used by EXIRLAN is shown in figure 1. The baseband upper-limit frequency has been moved to 6 MHz, providing compatibility to the IEC/CENELEC standard proposal.
Data will be modulated on one of 8 different carriers. These carriers are transmitted only while data should be sent out.
To achieve maximum possible transmission speed for the narrow band channels, FQPSK-modulation is being used.

FQPSK is the only spectral / power efficient modulation technique which is simple and robust, constant envelope suitable for NLA (Nonlinear Amplification) and coherent as well as noncoherent detection. This technique invented by Feher & Associates has been extensively described in the IEEE 802.11 documentation. FQPSK is equivalent in structure to MSK and GMSK except it is much more spectrally and power efficient and has simpler baseband processors. Thus FQPSK is at the same time equivalent and compatible with FM modulated digital systems with a modulation index of m = 0.5 and is equivalent with OQPSK (Offset QPSK). The simple and powerfull baseband processor of the transmit FQPSK leads to the numerous NLA spectral advantages-making it ideally suitable for Infrared standardization and multi user applications.

For more detailed information, please see references [3]....[12].

The specification of the Narrow Band Part of EXIRLAN looks as follows:

- Frequency range — 6 MHz to 30 MHz
- Bandwidth per channel — 3 MHz
- Data rate per channel (1st generation) — 1 Mb/s to 4.2 Mb/s selectable rates
- Eb/No for BER = 10exp-5 — 15 dB to 23 db
- Spectral suppression (PSD) — -20 dB at edge of band

Due to the high data rate per bandwidth efficiency of FQPSK, the following data rates can be achieved:

1 Mb/s
1.4 Mb/s
2 Mb/s
2.8 Mb/s
4.2 Mb/s

Where, apparently, the 1.4, 2.8 and 4.2 Mb/s are compatible with the proposed HS-FH standard.

In as second generation using improved linearized diodes even datarates as high as 12.6 Mb/s could be achieved - to be precise, 5.6 Mb/s, 8.4 Mb/s and 12.6 Mb/s.

This will include ETHERNET with 10 Mb/s, but providing 8 independent channels giving a total throughput capacity of 80 Mb/s (or 100.8 Mb/s at 12.6 Mb/s per channel)!

The second generation will include the real high speed WLAN applications. For the second generation the same modulation structure/synchropnization clock recovery etc. hardware could be maintained as for the first generation. Bit rate speed up/down gear shift could be accomodated simply by vendor bits in the preamble (a similar solution to the HS FH and DS gear shift issues).

It should be pointed out, that all these features are achieved using low cost IR-transmitting and receiving components, i.e. IRLED's for about 0,5 US $ and photodiodes for about 0,7 US $ each.

### 2.2. Baseband Part of EXIRLAN (= "Coexistence Band")

The baseband part of EXIRLAN follows two purposes:

- allow manufacturer-independent baseband communication, yielding its lowest cost and lowest power consumption opportunities, while at the same time EXIRLAN narrowband communication takes place.

- allow the operation of non-standardized IR-communication without conflicting with EXIRLAN narrow band communication. This protects the former investment of equipment manufacturers and users; the user of a non-standardized IR-product is aware, that it is not compatible with standardized products, but he can continue to use it and add additional solutions using EXIRLAN narrow band installations.

Because of the facts described above, the baseband part of EXIRLAN is called "Coexistence Channel".

For this band, we suggest the following specification (see also figure 1):

| | |
|---|---|
| • Data transmission rate | 19.2 kb/s and/or 115.2 (PPM)<br>1MB/s (16PPM) |
| • Baseband modulation | PPM/ 16PPM |
| • Pulse width | 100ns |
| • No of baseband channels | 1 |
| • Eb/No required for BER = 10 exp-5 | normalized to bit rate bandwidth |
| • Communication distance: | 30...80 meters |

## 3. Conclusion

EXIRLAN covers all essential needs of a standard for both parties, the manufacturing industry and the computer- and network-users, at very modest cost.

It opens the door for widespread use of IR datacommunication as well as it protects the investment that has been done in the past.

## 4. References

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[3] K. Feher: "Filter," U.S. Patent No. 4.339,724. Issued July 13, 1982. Canada No. 1130871, August 31, 1982

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[10] K. Feher: "Flexible Higher (and Lower) Multiple Data Rate PHY/MAC Proposed Standard," Doc.IEEE P802.11-93/186, November, 1993

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EXIRLAN

# Frequency Scheme

(revised Feb. 94)

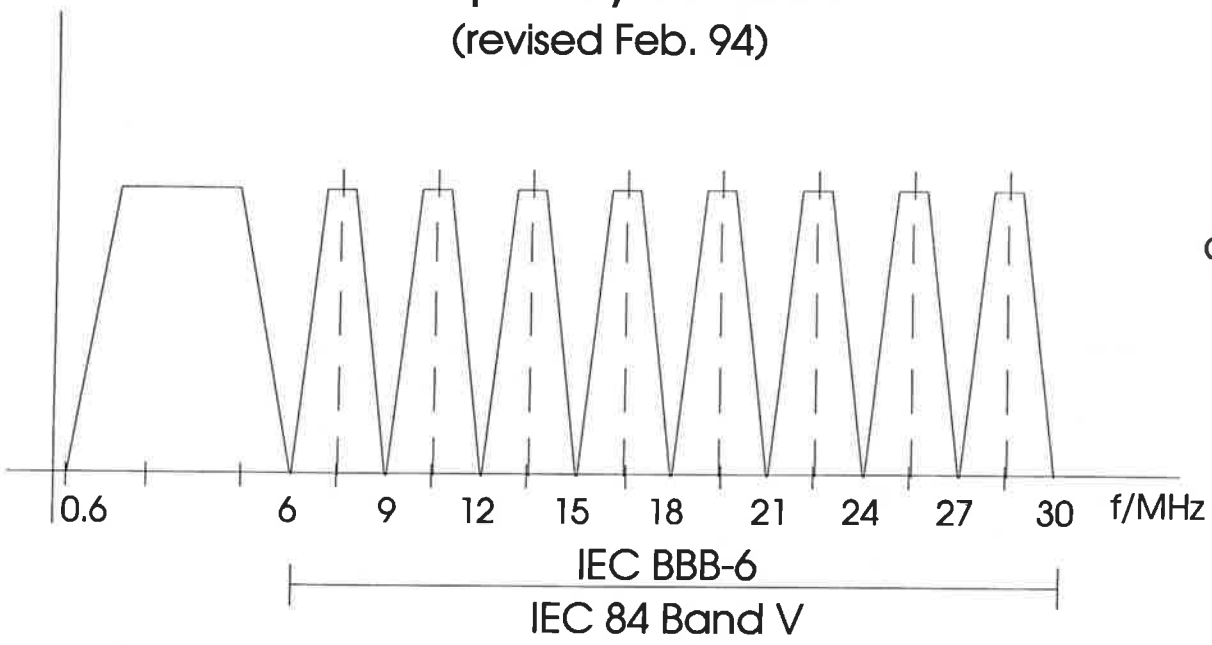


Fig. 1