IEEE P802.11
Wireless LANs
Higher speed PHY in the 2.4 GHz band

Proposal Chirp Spread Spectrum (CHSS) PHY

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Abstract

To provide high data rate and robust communication in a multipath and interference environment, a new **80 MHz bandwidth, chirp method** is proposed. One or more linear frequency sweep chirps are used in combination with DMPSK modulation (M = 2, 4..) to realize data rates up to 16 Mbps.

The method additionally provides excellent multipath resolution, Doppler and interference tolerance, ease of synchronization and low implementation costs. The medium is accessed using the IEEE 802.11 MAC protocol. Intercell user separation is done on the MAC layer or alternatively using quasi orthogonal chirp modulation.

What is Chirp Spread Spectrum PHY(CHSS PHY)?

Chirp Spread Spectrum Modulation (CHSS) is an M-ary modulation of the data symbol combining DPSK modulation of the baseband data symbol with a **spreading modulation of the symbol using a single or a number (Multiple Quasi orthogonal Coding MOC) of quasi orthogonal chirp functions**.

A hybrid system can be designed using a set of multiple chirp functions; this is in contrast to using a single chirp.

The class of chirp functions used will be weighted linear chirps. Multiple chirp functions may be generated by using up and down chirps combined with chirps shifted in frequency and/or time.

Fig 1 shows the block diagram of a CHSS PHY. In Fig 2 CHSS is combined with MOC.

Why CHSS?

- Robust against Interference
- Robust against variable Medium (low Doppler Sensitivity)
- Robust against Multipath fading
- High data rate
- Cost effective
- Plug and play

To get maximum robustness against interference (e.g. Microwave ovens) and multipath fading, the **spreading ratio is to be maximized to achieve a high correlation gain**. Such spreading can easily be achieved by using the chirp method to spread the modulated signal. The chirp spectrum may be perfectly matched with the allowed total 2.4 GHz ISM frequency band and will therefore allow for maximum strength against interference.

To achieve robustness against a variable medium (moving reflecting objects creating multipath, and fading), a **spreading method with minimum Doppler sensitivity** should be used. Weighted linear Chirp modulation allows for a very low Doppler sensitivity compared with frequency hoppers and direct sequence systems.

To get a **high data rate, M-ary symbol** modulation should be applied. **DPSK** is suggested for symbol modulation**.** Data rate may be further increased by applying hybrid modulation: combining **DPSK** with a number of quasi orthogonal chirps.

SAW technology will allow **cost effective** implementation of high bandwidth chirp functions for modulation (Spreading) and demodulation (correlation). Such a system will allow for **large tolerances in oscillator long term stability**. Transmitters and receivers will need **only a single antenna**: Due to the large spreading bandwidth, Space Diversity as proposed for FH and DSSS will not be necessary.

Installation with channel setting will not be required. The ISM Band Resource will be shared by MOC or on a MAC layer base. The data rate will be adaptive depending on the local medium (attenuation and delay spread).

CHSS PHY vs. Regulation

CHSS is **compatible** with European Regulation ETS 300-328 and FCC 15247 (ISM-Band):

What is a Chirp Modulation?

Chirp Modulation (or Pulse Spreading) is a modulation procedure or spreading method which allows to spread a single or a chain of signal pulses (derived from data symbols) in time and bandwidth. The signal is **modulated in frequency** and therefore maintains a stationary phase. See Fig. 3 for typical characteristics of unweighted chirp function. Amplitude weighting may be applied to the chirp signal to improve time sidelobes of the correlation pulse.

Before Spreading, the time bandwidth product of each pulse is approximately one. After Spreading, the Time Bandwidth Product may be in the order of several hundreds. The length of the chirp signal produced may be designed to match the symbol time or a few symbol times; the bandwidth however may be much larger than the bandwidth of the symbol signal. Chirp Modulation is a means of achieving a much larger bandwidth than the bandwidth of the symbol signal (spreading effect).

Why Linear sweep?

Frequency modulation in the form of an amplitude weighted approximately **linear time function** frequency sweep may be designed to form a nice spectrum of the spreaded pulse: Its **spectrum** is designed to be approximately **rectangular** in shape so as to fit into the allocated frequency band. In addition this waveform has demonstrated a very **low sensitivity to Doppler shifts**. It is therefore expected to make best use of the medium and allows for excellent performance in a variable medium environment.

Frame Format

The frame format as defined in the present IEEE802.11 standard for DSSS systems shall be used.
A selectable **adaptive data rate** depending on the properties of the propagation medium is an especially useful feature. The base data rate might be 4 Mbps and might be increased to 8 and 16 Mbps.

Coping with Multipath

Bandwidth spreading is a method to cope with multipath. Generally speaking, a high bandwidth is necessary for receiver separation of signals originating from paths with a **small path difference** or from a propagation environment with a **large coherence bandwidth**. After demodulation (correlation) in the receiver the contributions of the main and the reflected signals will be short pulses with a pulse length corresponding to one divided by the spreading bandwidth. Individual delay times of the multipath signals will therefore produce a series of sharp pulses delayed according to their respective paths delays. Signal resolution is limited by the time sidelobes. **The ability to design for low sidelobes allows to minimize signal path interference.**

Correlation of the signal in the receiver will allow to discriminate between the contributions of the individual signal paths even if the path difference is small (i.e. a few meters) and the respective correlation bandwidth is high. Path contributions may therefore be resolved into individual pulses. A number of methods will allow for the decoding of the symbol. The most sophisticated being the rake receiver. But simpler schemes may be applied.

A sufficiently low symbol rate is the method of allowing the receiver to cope with a **large path difference** in the medium. The symbol rate should normally be smaller than one divided by the delay spread. It may however be further increased, if equalization is applied to the Channel medium in the receiving process.

To increase data rate with a low symbol rate, **M-ary Modulation** will be applied. This however asks for adequate signal to noise and signal to interference ratios in the receiver.

How to demodulate a Chirp?

A **filter matched** to the chirp waveform(s) is required. Such a filter will **correlate** the signal to sharp pulses originating from the contributions of each multipath response to the transmitted symbol. The bandwidth of the short pulses recovered will correspond to the chirp bandwidth and will be much higher, than the symbol bandwidth.

Resource Sharing

Due to the fact that the total frequency band is suggested to be filled by the chirp spectrum, the medium may be shared on a MAC Layer basis or by MOC. Sharing on a MAC Layer basis is compensated by the effect of an increased data rate which will allow for an efficient use of the medium. Intercell user separation may also be realized by MOC.

CHSS may even work with little deterioration when collocated with a FH PHYS or other narrowband systems. CHSS will simply increase the noise level for FH and vice versa.

CHSS Specification Summary

Data rate:	4, 8 and 16 Mbps
EIRP:	100 mW
Frequency band:	2400-2483.5 MHz

The bandwidth of the chirp spectrum will be 83.5 MHz and its approximately rectangular shape will match the frequency band.

Current status of investigations

Currently trials and simulations of the method are being undertaken by the university of Vienna (Prof. Seifert) and Siemens Switzerland.

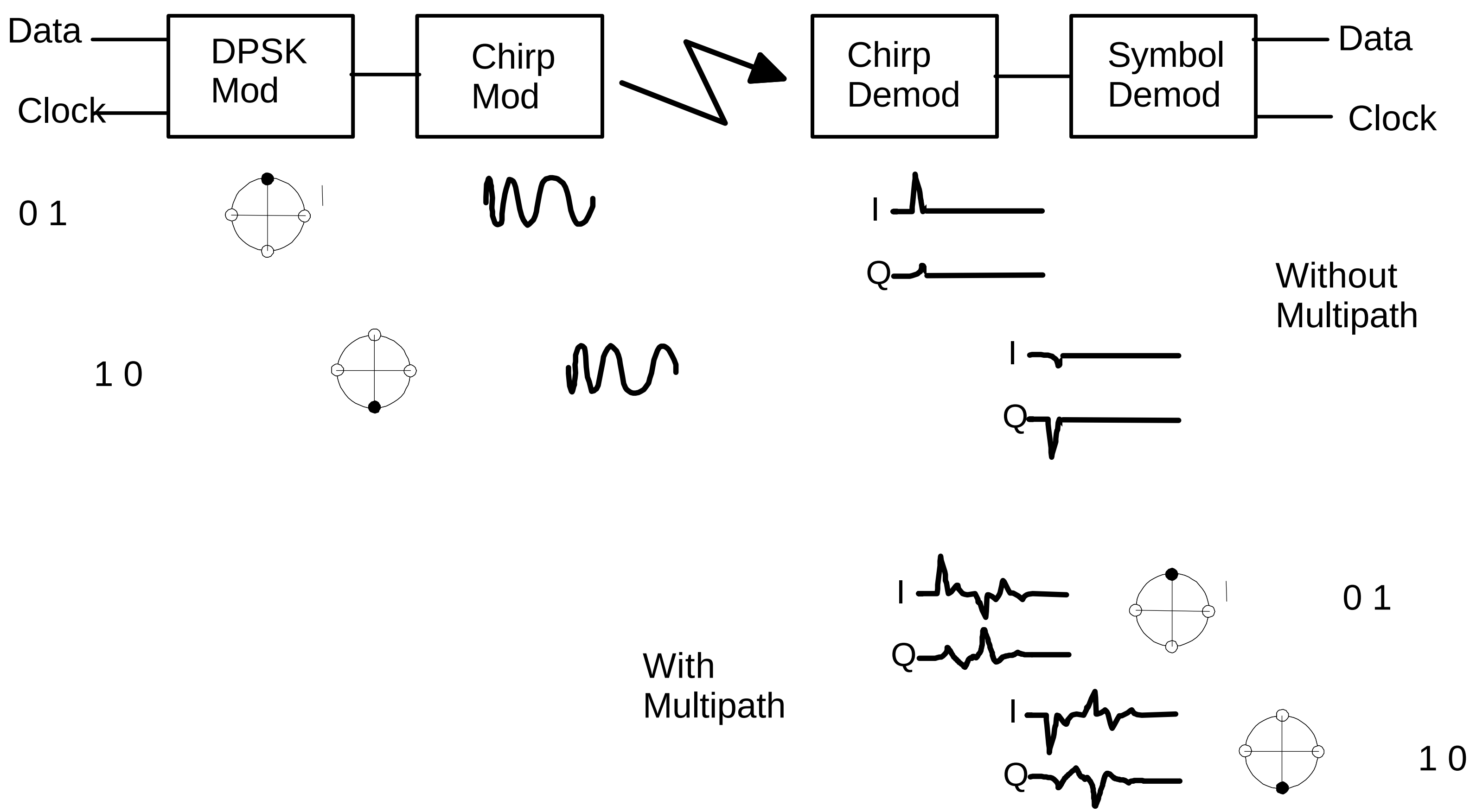

Figure 1: CHSS using a single chirp waveform

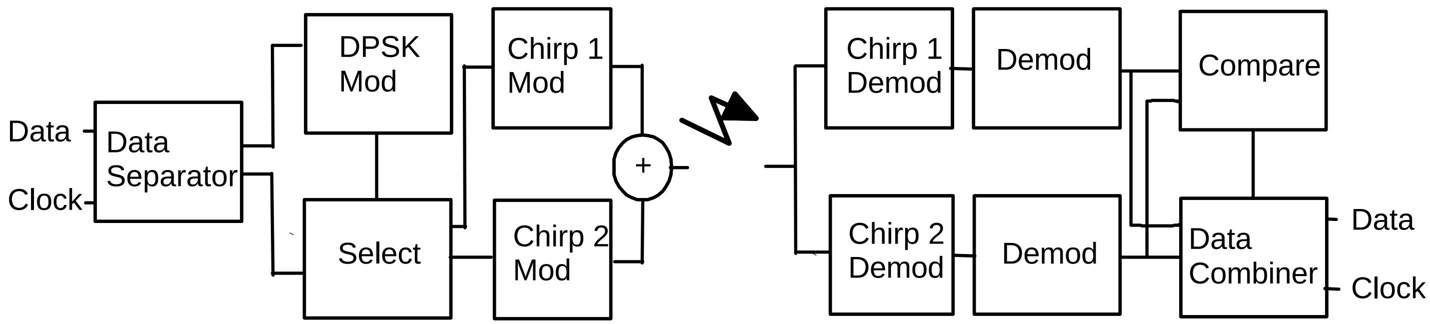

Figure 2: CHSS us ing Multiple Orthogonal Coding (MOC),
i.e. more than one chirp waveform to increase data rate.