Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**Proposal on modulation methods for PHY of FWA**
Date Submitted	**1999-10-29**
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Re:	802.16 Physical Layer Task Group Call for Contributions – Session #4, Document 80216p-99/01
Abstract	In this document we propose a modulation scheme for variable data rate broadband wireless access services.
Purpose	Adoption of this document as basis for broadband wireless access PHY
Notice	
Release	
IEEE Patent Policy	

Proposal on modulation methods for PHY of FWA

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Introduction

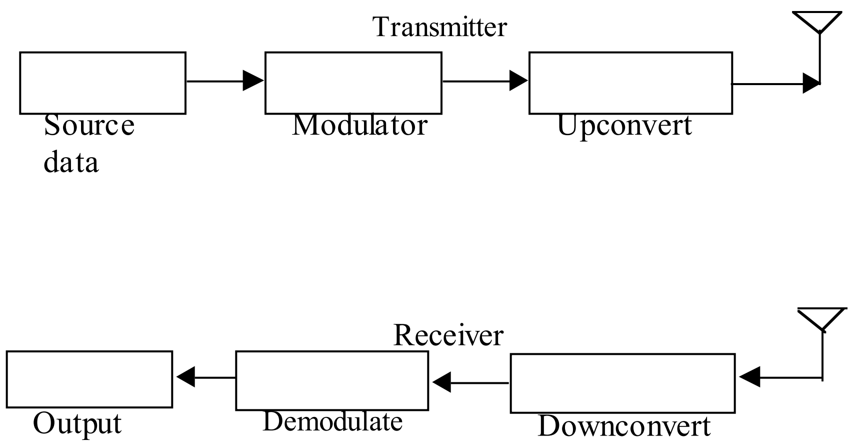
This document provides a draft specification for an adaptive modulation scheme for the physical layer of fixed wireless access service standards IEEE802.16. The main focus of this document is modulation of data, including rate-adaptive signal mapping and modulation to produce a digital carrier suitable for FWA. The modulation types include QPSK, 8PSK, and 16-256QAM. The initial data rates range from 10Mbps to 70Mbps, transmitted in the carrier frequency bands of 10 to 66GHz.

Reference model

System overview

A high-level block diagram of the transmitter and receiver model is shown in figure 1.

Figure 1. Transmitter and receiver systems



Source data are processed by forward error correction (FEC), interleaving and mapping to QPSK, 8PSK, or 16-256 QAM constellation, frequency conversion and bandpass filtered to generate the IF carrier. The IF signal bandwidth is determined by the selection of the modulation type, with successively less bandwidth as modulation type changes from QPSK to 256QAM. Finally, the IF signal is upconverted to the channel and transmitted via the antenna. At the receiver, the RF signal is downconverted to IF first, then demodulated and decoded to recover the information data. In addition, a receiver demodulator also contains timing and carrier recovery. Adaptive equalizers are needed for certain operation modes, including high data rate and high modulation constellations, as well as channels with severe impairments due to multipath and fading.

Two types of coding are applied in the FEC. An outer Reed Solomon code is concatenated with an inner trellis code. The RS coding rate is fixed (204,188), whereas the inner coding rate is variable, depending on bandwidth and data rate requirements. For QPSK mode, supported rates are _, 2/3, _, 5/6, and 7/8, with an inner code constraint length of 7.

Relationship to MAC

The PHY is one layer below the MAC. A downstream PHY contains a transmitter, an upstream PHY contains a receiver. The MAC layer controls the PHY.

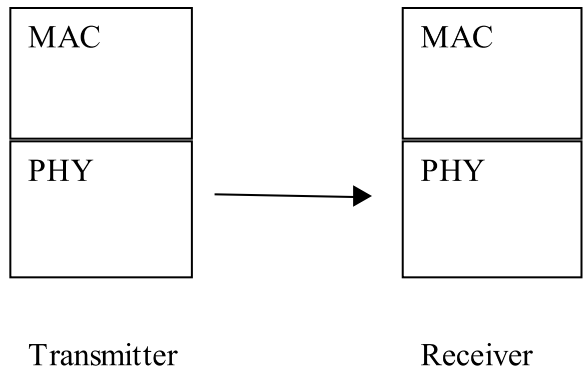


Figure 2. MAC-PHY relationship

Proposed modulation scheme

Baseband and modulator

A block diagram of the modulator is shown in figure 3.

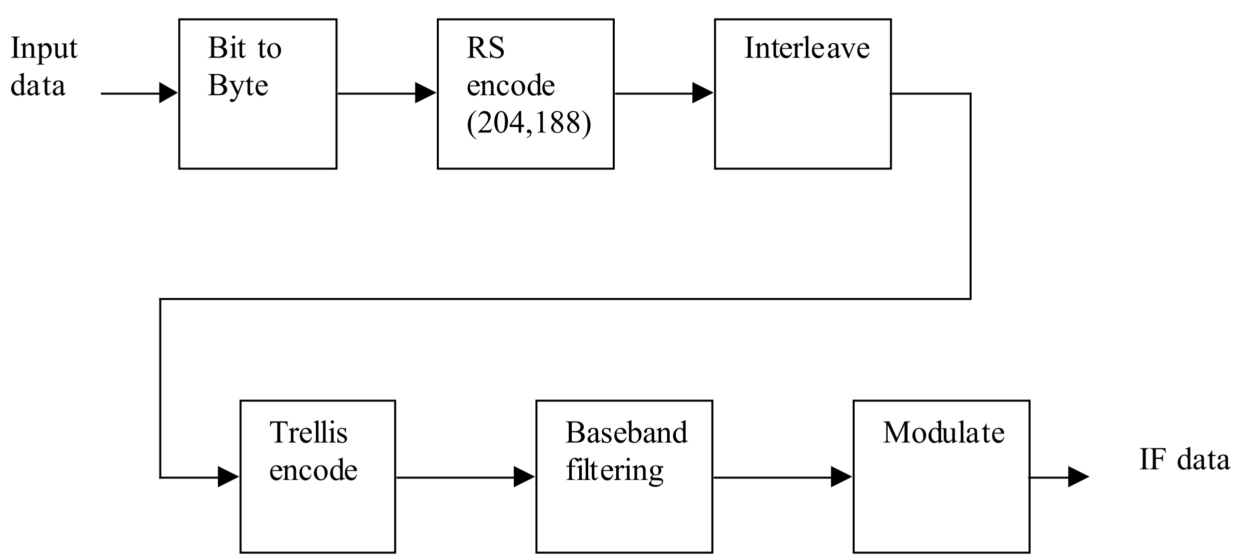


Figure 3. Upstream block diagram

The modulation type is determined based on channel bandwidth, information data rate, FEC inner coding rate, and required E_b/N_0.

For QPSK mode, possible inner code rates are _, 2/3, _, 5/6, and 7/8. A modem implementation margin of 1dB is required.

For 8PSK mode, inner code rates are 2/3, 5/6, and 7/8. Modem implementation margin is 1.5.

Layered modulation, where more than one modulation mode is used to modulate the same data stream is an optional operation mode.

Burst signal for carrier recovery: to ensure stable carrier recovery at low carrier to noise ratio, burst signals are inserted every 203 symbols of main signals, and the duration of each burst signal is 4 symbols. The burst signals are scrambled with PN sequence for energy dispersion.

Carrier frequency offset: maximum carrier frequency offset from to manufacture device is +/- 5ppm (ppm = part per million).

Demodulator

A block diagram of the modulator is shown in figure 4.

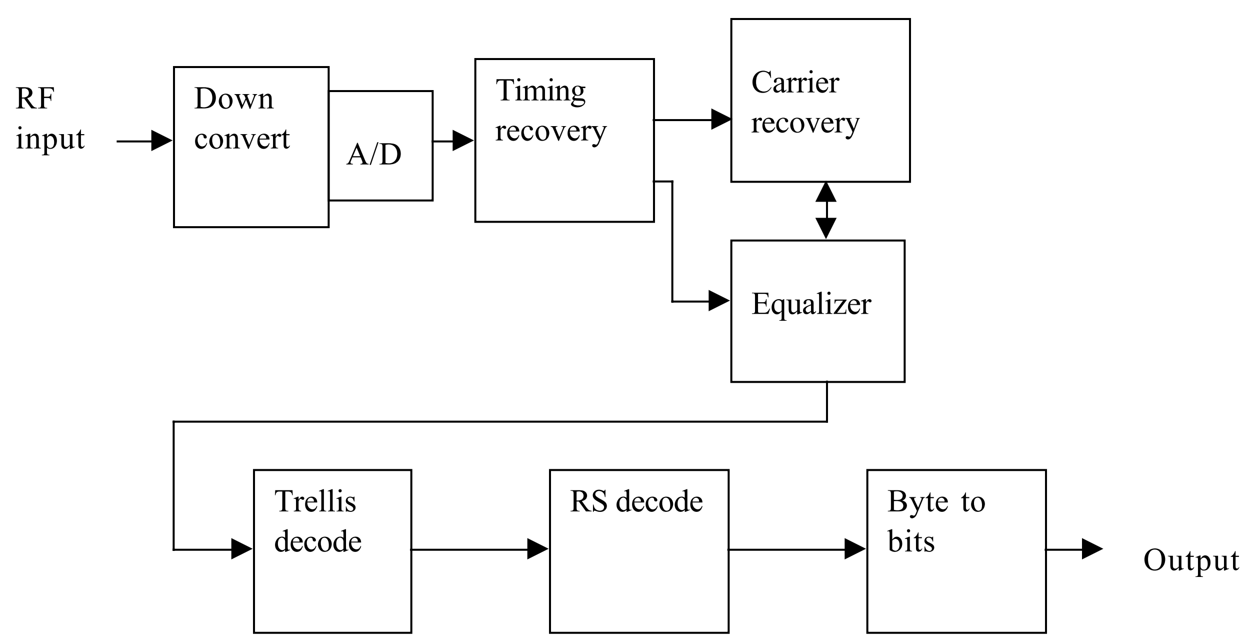


Figure 4. Downstream block diagram

The receiver uses synchronous detection. Adaptive equalizer is used to improve performance against multipath impairments. Modulation type detection, constellation search and estimation are performed inside the carrier recovery block.

A BER of $<10^{-6}$ is required after FEC, at <7dB of carrier to noise ratio for QPSK with coding rate of _ and information rate of 35Mbps; or <30dB for 256QAM.

In the case of MPEG audio and video data, the output will be demultiplexed and decoded by appropriate functional blocks, which are out of the scope of this document. The output data are also accessed by MAC layer.

Compliance

The modulation modes defined in this document have mandatory and optional portions. QPSK is a mandatory transmission mode. All other modes are optional.

RF channel

The target carrier frequency bands are 10 to 66GHz. Nominal channel spacing (bandwidth) will be on the order of 10MHz, with the exact number to be determined.

Baseband filter shaping

Root raised cosine filter is used. The roll off factor depends on modulation type. For QPSK, a roll off of 0.35 is used. For 64QAM, the roll off is 0.18, and for 256QAM, it is 0.12.

Benefits of proposed scheme

The proposed the modulation scheme for PHY meets all system requirements by IEEE802.16. The main benefits of the proposed scheme are as follows.

Improved spectrum efficiency

For given bandwidth, higher data throughputs are achieved by using higher orders of modulation, whereas for given data rate, bandwidth can be optimized by choosing of appropriate modulation. This ensures very high spectrum resource flexibility.

In addition, the proposed modulation scheme allows spectral reuse between sectors.

Power efficient

With the proposed scheme, transmission power, available bandwidth, and modulation modes can be considered together to provide a power efficient operation mode.

Robust against interference and fading

The proposed adaptive modulation scheme operates under large variation of interference conditions. In addition to having the flexibility of choosing modulation type based on channel condition, source data can also be modulated in different modulation types and transmitted simultaneously, allowing a smooth transition of service quality under severe channel conditions. For example, under rain fading and atmospheric conditions, QPSK can be used for its low E_b/N_0 threshold; and for less channel impairments, 8PSK or 16QAM will be used for higher data throughputs.

Scalable for various data types

The proposed scheme is capable of carrying various data types such as IP, ATM, and MPEG. It is capable of handling variable packet sizes as well as burst traffic.

Flexible for standards updates

The proposed the scheme allows future increase of data rates at higher bandwidth. It is not limited to any specific type of applications.

Simple to implementation

The modulation techniques described in the proposed scheme are fairly mature and tested. The proposed PHY with adaptive modulation can be implemented using recent technologies in VLSI signal processing, in particularly run-time reconfigurable DSP.

Relationship to existing standards

The proposed adaptive modulation scheme uses the following system standard for satellite and cable digital broadcasting standards:

1. Advanced Television Systems Committee, Doc. 13/S14-061, Modulation and Coding Requirements for Digital TV Applications Over Satellite
2. Advanced Television Systems Committee, Standards for Terrestrial Digital Television Broadcasting, September, 1995
3. Society of Cable Television Engineering, Digital Video Transmission Standard for Cable Television