Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	DOCSIS based PHY layer proposal for BWA
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Re:	This contribution is submitted in response to call for contributions from the IEEE 802.16 chair on Sept.22nd, 1999 for submission of PHY proposals for BWA
Abstract	The PHY proposal based on DOCSIS (Data over Cable Systems Interface Specifications) is submitted for consideration by the group to be accepted as PHY standards for BWA.
Purpose	This proposal should be accepted as PHY standard for BWA
Notice	
Release	
IEEE Patent Policy	

PHY proposal based on DOCSIS

Introduction

This contribution proposes that PHY standards be developed for BWA based on DOCSIS standards as specified in ITU-T draft Recommendation J.116 [1] and draft Recommendation ITU-R F.BWA [2]. These draft Recommendations use ITU-T Recommendations J.112 [3] and J.83 [4] for cable modems as the **basis** for **wireless** access systems in order to achieve **economies of scale**. The technical parameters have been adapted to the wireless environment rather than for a cable environment in order to support bidirectional data over broadband **wireless** access systems for interactive services.

Physical Layer

The Physical (PHY) layer is comprised of two sublayers:

- Transmission Convergence (TC) sublayer (present in the downstream direction only);
- Physical Media Dependent (PMD) sublayer.

Physical Media Dependent (PMD) Sublayer Specification

This specification defines the electrical characteristics and protocol for a BWA CPE modem and BWA BTS modem. It is the intent of this specification to define an interoperable BWA CPE Modem and BWA BTS Modem such that any implementation of a BWA CPE Modem can work with any BWA BTS Modem. It is not the intent of this specification to imply any specific implementation.

The broadband wireless access (BWA) system uses time division multiple access (TDMA). The key functional characteristics are the following:

- two-way wireless transmission based on FDD
- downstream uses TDM (time division multiplex);
- upstream uses TDMA (time division multiple access);
- One or more upstream carriers may be supported for a single downstream carrier;
- frequency bands between *10 to 40 GHz* will be used;
- a BTS service area is called a cell, with a cell radius typically <15 km, depending on rain regions and the availability requirement;
- a cell may be divided into multiple sectors and sector may have multiple downstream RF carriers;
- the system must be able to combat rain fades of 30 dB and a fade rate of 5 dB / sec.
- configurable downstream channel equalization and upstream burst pre-equalization

Transmission Convergence Sublayer (Downstream only)

The Downstream Transmission Convergence sublayer exists in the downstream direction only. It provides an opportunity for additional services over the physical-layer bitstream. These additional services might include, for example, digital video. Definition of any such additional services is beyond the scope of this document.

This sublayer is defined as a continuous series of 188-byte MPEG [ITU-T H.222.0] packets, each consisting of a 4-byte header followed by 184 bytes of payload. The header identifies the payload as belonging to the data-over-BWA MAC. Other values of the header may indicate other payloads. The mixture of payloads is arbitrary and controlled by the BWA BTS Modem.
The Downstream Transmission Convergence sublayer is defined in the downstream section of this document..

Upstream (contains only PMD sublayer)

Overview

The upstream Physical Media Dependent (PMD) sublayer uses a FDMA/TDMA burst modulation format, which provides variable symbol rates and two modulation formats (QPSK and 16 QAM). The modulation format includes pulse shaping for spectral efficiency, is carrier-frequency agile, and has selectable output power level. The PMD sublayer format includes a variable-length modulated burst with precise timing beginning at boundaries spaced at integer multiples of 6.25 µsec apart. The burst size is defined by number of minislots. The minislot consists of one or integer multiples of 6.25 µsec timing tick. Each burst supports a flexible modulation, symbol rate, preamble, randomization of the payload, and programmable FEC encoding. All of the upstream transmission parameters associated with burst transmission outputs from the BWA CPE Modem are configurable by the BWA BTS Modem via MAC messaging. Many of the parameters are programmable on a burst-by-burst basis.

Modulation Formats

The upstream modulator MUST provide both QPSK and 16 QAM and/or optionally 64 QAM modulation formats. The upstream demodulator MUST support QPSK, and 16 QAM and/or optionally 64 QAM.

Modulation Rates

The upstream modulator should provide the symbol rate from the following range***: 1 280 to 20 480 ksym/sec.***

Symbol Mapping

The modulation mode (QPSK or 16 QAM or 64 QAM) should be programmable.

Spectral Shaping

The upstream PMD sublayer should support ***a minimum*** of 25% Nyquist square root raised cosine shaping.

Upstream Frequency Agility and Range

The upstream PMD sublayer MUST support operation over the frequency range of 10 – 40 GHz edge to edge. Offset frequency resolution MUST be supported having a range of ±350 kHz.

Spectrum Format

The upstream modulator MUST provide operation with the format $s(t) = I(t)*\cos(\omega t) \pm Q(t)*\sin(\omega t)$, where t denotes time and ω denotes angular frequency.

FEC Encode

The upstream modulator MUST be able to provide the following selections: Reed-Solomon codes over GF(256) with T = 1 to 10 or no FEC coding.
The Reed-Solomon generator polynomial MUST be supported:

$$g(x) = (x + \alpha^0)\ (x + \alpha^1)\ (x + \alpha^{2T-1})$$

The Reed-Solomon primitive polynomial MUST be supported:

$$p(x) = x^8 + x^4 + x^3 + x^2 + 1$$

The upstream modulator MUST provide codewords from 3 to 255 bytes in size. The uncoded word size (k bytes) can have a minimum of one byte. In Shortened Last Codeword mode, the BWA CPE Modem MUST provide the last codeword of a burst shortened from the assigned length of k data bytes per codeword. The number of the FEC coding bytes (T) MUST be configured in response to the Upstream Channel Descriptor from the BWA BTS Modem.

Scrambler (Randomizer)

The upstream modulator MUST implement a scrambler where the 15-bit seed value MUST be arbitrarily programmable. At the beginning of each burst, the register is cleared and the seed value is loaded. The seed value MUST be used to calculate the scrambler bit which is combined in an XOR with the first bit of data of each burst (which is the MSB of the first symbol following the last symbol of the preamble).
The scrambler seed value MUST be configured in response to the Upstream Channel Descriptor from the BWA BTS modem. The polynomial MUST be $x^{15} + x^{14} + 1$.

Preamble Prepend

The upstream PMD sublayer MUST support a variable-length preamble field that is prepended to the data after they have been randomized and Reed-Solomon encoded.
The value of the preamble that is prepended MUST be programmable and the length MUST be 0, 2, 4, ..., or 1 024 bits for QPSK and 0, 4, 8, ..., or 1 024 bits for 16 QAM. Thus, the maximum length of the preamble is 512 symbols for QPSK or 256 symbols for 16 QAM. The preamble length and value MUST be configured in response to the Upstream Channel Descriptor message transmitted by the BWA BTS Modem.

Burst Profiles

The burst profiles are separated into two portions: a) Channel Burst Parameters, which are common to all users assigned to a given channel using that burst type, and b) User Unique Parameters, which vary for each user even when using the same burst type on the same channel as another user (for example, Power Level). In addition to these parameters, the assigned center frequencies and mini-slot grants MUST also be provided by the BWA BTS Modem.
The upstream PMD sublayer MUST support a minimum of four distinct burst profiles to be stored within the BWA CPE Modem, with variable parameters as defined in Table 1. User Unique parameters are defined in Table 2.

TABLE 1

Channel Burst Parameters

Parameter	Configuration Settings
Modulation	QPSK, 16 QAM (optionally 64 QAM)
Diff Enc	On/Off
Symbol Rate	***1 280 to 20 480 ksym/sec***
Preamble Length	0-1 024 bits
Preamble Values	***configurable***
FEC On/Off	On/Off
FEC Codeword Information Bytes (k)	***Fixed: 1 to 255 (assuming FEC on)*** ***Shortened: 16 to 255 (assuming FEC on)***
FEC Error Correction (T bytes)	0 to 10
Scrambler Seed	15 bits
Burst Length m mini-slots[1)]	0 to 255
Last Codeword Length	Fixed, shortened
Guard Time	5 to 255 symbols

[1)] A burst length of 0 mini-slots in the Channel Profile means that the burst length is variable on that channel for that burst type. The burst length, while not fixed, is granted explicitly by the BWA BTS Modem to the BWA CPE Modem in the MAP.

TABLE 2

User Unique Burst Parameters

Parameter	Configuration Settings
Transmit Power Level[1)] (minimum range) (at antenna flange)	-30 dBm to +20 dBm (QPSK), -27 dBm to +17 dBm (16 QAM), 1-dB steps
Offset Frequency[1)]	Range = ±350 kHz
Spectrum Inversion	Normal, Inverted
Ranging Offset in time	0 to (2^{16} - 1), increments of 6.25 µsec/64
Burst Length (mini-slots) if variable on this channel (changes burst-to-burst)	1 to 255 mini-slots
Transmit Equalizer Coefficients[1)] (advanced modems only)	Up to 64 coefficients; 4 bytes per coefficient: 2 real and 2 complex
[1)] Values in table apply for this given channel and symbol rate.	

Ranging Offset ***in time*** is the delay correction applied by the BWA CPE Modem to the BWA BTS Modem Upstream Frame Time derived at the BWA CPE modem, in order to synchronize the upstream transmissions in the TDMA scheme. The Ranging Offset is ***a time*** advancement equal to roughly the round-trip delay of the BWA CPE Modem from the BWA BTS modem. The BWA BTS Modem MUST provide feedback correction for this offset to the BWA CPE modem, based on reception of one or more successfully received bursts (i.e. satisfactory result from each technique employed: error correction and/or CRC), with accuracy within 1/2 symbol and resolution of 1/64 of the frame tick increment (6.25 µsec/64 = 0.09765625 µsec).

Burst Timing Convention

At a symbol rate of Rs, symbols occur at a rate of one each Ts = 1/Rs seconds. Ramp Up and Ramp Down are the spread of a symbol in the time domain beyond Ts duration owing to the symbol-shaping filter. If only one symbol were transmitted, its duration would be longer than Ts due to the shaping filter impulse response being longer than Ts. The spread of the first and last symbols of a burst transmission effectively extends the duration of the burst to longer than N * Ts, where N is the number of symbols in the burst.

Transmit Power Requirements

The upstream PMD sublayer MUST support varying the amount of transmit power. Requirements are presented for 1) the range of commanded transmit power; 2) the step size of the power commands; and 3) the accuracy (actual output power compared to the commanded amount) of the response to the command.

Output Power Agility and Range

The output transmit power in the design bandwidth MUST be variable over the minimum range of -27 dBm to +17 dBm (16 QAM), -30 dBm to +20 dBm (QPSK), in 1-dB steps.

The absolute accuracy of the transmitted power MUST be ±2 dB, and step size accuracy ±0.4 dB. For example, the actual power increase resulting from a command to increase the power level by 1 dB in a BWA CPE modems next transmitted burst MUST be between 0.6 dB and 1.4 dB.

Fidelity Requirements

Spurious Emissions

The noise and spurious power MUST NOT exceed the levels given in Table 3. The measurement bandwidth is equal to the symbol rate (e.g. 1280 kHz for 1280 ksymbols/sec) for the requirements. In addition to Table 3, the spurious emissions MUST meet local national and/or regional limits.

TABLE 3

Spurious Emissions

Parameter	Transmitting Burst	Between Bursts
Inband	-40 dBc	The greater of -72 dBc or -97 dBm
Adjacent Band	-45 dBc	The greater of -72 dBc or -97 dBm

Spurious Emissions During Burst On/Off Transients

Each transmitter MUST control spurious emissions, prior to and during ramp up and during and following ramp down, before and after a burst in the TDMA scheme. On/off spurious emissions, such as the change in voltage at the upstream transmitter output due to enabling or disabling transmission, MUST be no more than 100 mV, and such a step MUST be dissipated no faster than 2 µs of constant slewing. This requirement applies when the BWA CPE is transmitting at +20 dBm or more; at backed-off transmit levels, the maximum change in voltage MUST decrease by a factor of 2 for each 6-dB decrease of power level from +20 dBm, down to a maximum change of 7 mV at -4 dBm and below. This requirement does not apply to BWA CPE Modem power-on and power-off transients.

Bit Error Rate (BER)

Overall modem performance MUST be within 1.5 dB of theoretical uncoded BER vs C/N, at BER = 10^{-6}, for QPSK and 16 QAM.

Filter Distortion

The following requirements assume that any pre-equalization is disabled.

Amplitude

The spectral mask should be the ideal square root raised cosine spectrum with ***minimum*** alpha = 0.25, within the ranges given below:

f_c - R_s/4 Hz to f_c + R_s/4 Hz: -0.3 dB to +0.3 dB

f_c - 3R_s/8 Hz to f_c - R_s/4 Hz, and f_c + Rs/4 Hz to f_c + 3R_s/8 Hz: -0.5 dB to 0.3 dB

f_c - R_s/2 Hz and f_c + R_s/2 Hz: -3.5 dB to -2.5 dB

f_c - 5R_s/8 Hz and f_c + 5R_s/8 Hz: no greater than -30 dB

where f_c is the center frequency and R_s is the symbol rate.

Phase

f_c - 5R_s/8 Hz to f_c + 5R_s/8 Hz: Group Delay Variation MUST NOT be greater than 100 nsec.

Carrier Phase Noise

The upstream transmitter total integrated phase noise (including discrete spurious noise) MUST be less than or equal to -43 dBc summed over the spectral regions spanning 1 kHz to 1.6 MHz above and below the carrier.

Channel Frequency Accuracy

The BWA CPE MUST implement the assigned channel frequency within ± 5 parts per million over a temperature range of -40 to 75 degrees C up to five years from date of manufacture.

Symbol Rate Accuracy

The upstream modulator MUST provide an absolute accuracy of symbol rates ± 50 parts per million over a temperature range of 0 to 40 degrees C up to five years from date of manufacture.

Symbol Timing Jitter

Peak-to-peak symbol jitter, referenced to the previous symbol zero-crossing, of the transmitted waveform, MUST be less than 0.02 of the nominal symbol duration over a 2-sec period. In other words, the difference between the maximum and the minimum symbol duration during the 2-sec period shall be less than 0.02 of the nominal symbol duration for each of the eight upstream symbol rates.

The peak-to-peak cumulative phase error, referenced to the first symbol time and with any fixed symbol frequency offset factored out, MUST be less than 0.04 of the nominal symbol duration over a 0.1-sec period. In other words, the difference between the maximum and the minimum cumulative phase error during the 0.1-sec period shall be less than 0.04 of the nominal symbol duration for each of the eight upstream symbol rates. Factoring out a fixed symbol frequency offset is to be done by using the computed mean symbol duration during the 0.1 sec.

Frame Structure

Figure 1 shows two examples of the frame structure: one where the packet length equals the number of information bytes in a codeword, and another where the packet length is longer than the number of information bytes in one codeword, but less than in two codewords. Example 1 illustrates the fixed codeword-length mode, and Example 2 illustrates the shortened last codeword mode.

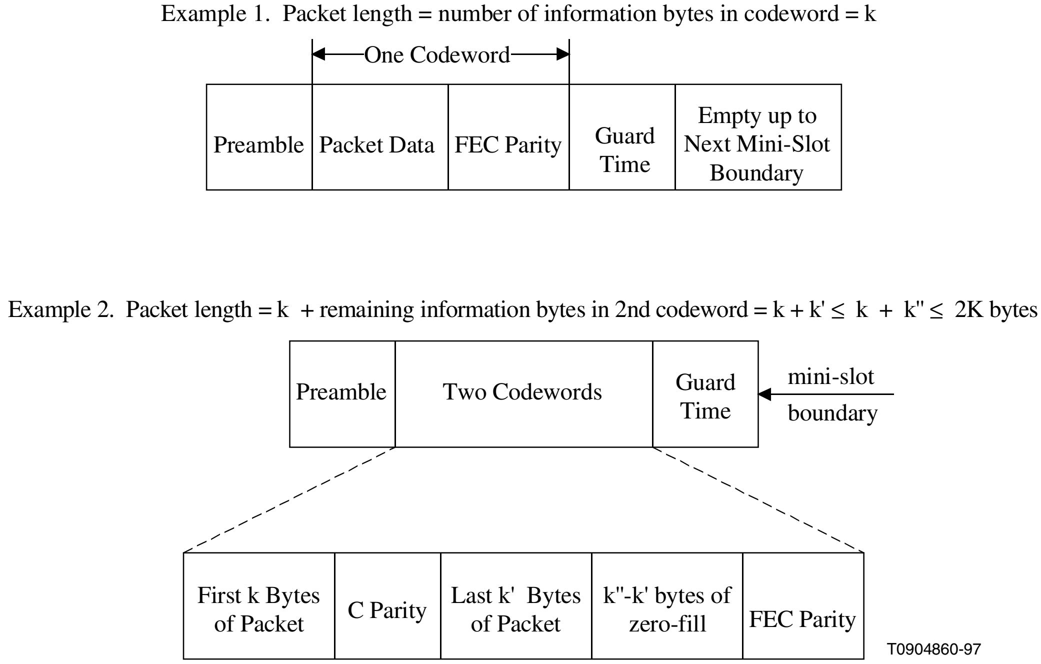

FIGURE 1

Example Frame Structures with Flexible Burst Length Mode

Codeword Length

The BWA CPE Modem operates in fixed-length codeword mode or with shortened codeword capability enabled. Shortened codeword capability is available with k >= 16 bytes, where k is the number of information bytes in a codeword. With k < 16, shortened codeword capability is not available.

The following descriptions apply to an allocated grant of mini-slots in both contention and non-contention regions. (Allocation of mini-slots is discussed in Section 6 of this document.) The intent of the description is to define rules and conventions such that BWA CPE Modems request the proper number of mini-slots and the BWA BTS Modem PHY knows what to expect regarding the FEC framing in both fixed codeword length and shortened last codeword modes.

Fixed Codeword Length

With the fixed-length codewords, after all the data are encoded, zero-fill will occur in this codeword if necessary to reach the assigned k data bytes per codeword, and zero-fill MUST continue up to the point when no additional fixed-length codewords can be inserted before the end of the last allocated min-slot in the grant, accounting for FEC parity and guard-time symbols.

Shortened Last Codeword

As shown in Figure 4-7, let k' = the number of information bytes that remain after partitioning the information bytes of the burst into full-length (k burst data bytes) codewords. The value of k' is less than k. Given operation in a shortened last codeword mode, let k" = the number of burst data bytes plus zero-fill bytes in the shortened last codeword. In shortened codeword mode, the BWA CPE Modem will encode the data bytes of the burst (including MAC Header) using the assigned codeword size (k information bytes per codeword) until 1) all the data are encoded, or 2) a remainder of data bytes is left over which is less than k. Shortened last codewords shall not have less than 16 information bytes, and this is to be considered when BWA CPE Modems make requests of mini-slots. In shortened last codeword mode, the BWA CPE Modem will zero-fill data if necessary

until the end of the mini-slot allocation, which in most cases will be the next mini-slot boundary, accounting for FEC parity and guard-time symbols. In many cases, only k" - k' zero-fill bytes are necessary to fill out a mini-slot allocation with 16 <= k" <= k and k' <= k". However, note the following.
More generally, the BWA CPE Modem is required to zero-fill data until the point when no additional fixed-length codewords can be inserted before the end of the last allocated mini-slot in the grant (accounting for FEC parity and guard-time symbols), and then, if possible, a shortened last codeword of zero-fill shall be inserted to fit into the mini-slot allocation. If, after zero-fill of additional codewords with k information bytes, there are less than 16 bytes remaining in the allocated grant of mini-slots, accounting for parity and guard-time symbols, then the BWA CPE Modem shall not create this last shortened codeword.

Signal Processing Requirements

The signal processing order for each burst packet type MUST be compatible with the sequence shown in Figure 2 below and MUST follow the order of steps in Figure 3.

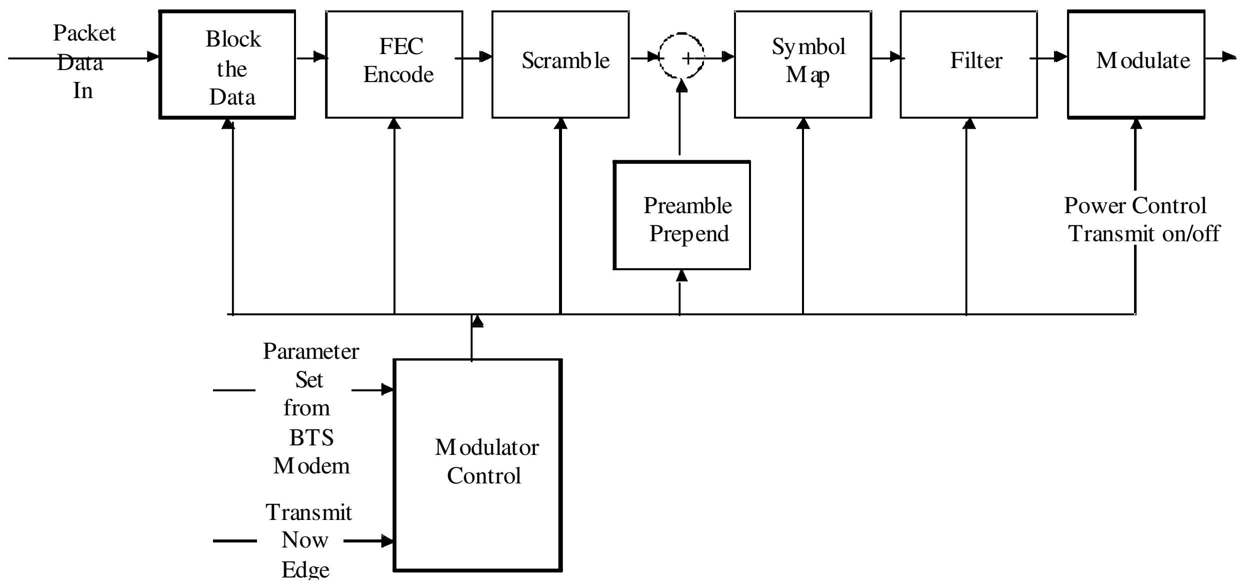

FIGURE 2

Signal-Processing Sequence

	Packet Stream Input
	⇓
Block the Data	Separate Packet into Information Blocks(=data bytes in one codeword)
	⇓
FEC Encode	FEC Encode (Reed-Solomon)each Information Block, using shortened codeword for last block if needed. FEC can be turned off
	⇓
Scramble	Scramble (see paragraph 0)
	⇓
Preamble Prepend	Preamble prepend Symbols
	⇓
Symbol Map	Symbol Map the Data Stream into Modulator Symbols
	⇓
Filter	Filter Symbol Stream for Spectral Shaping
	⇓
Modulate	Modulate at Precise Times(QPSK; 16 QAM)
	⇓
	Output RF Waveform Bursts

Fig. 3 TDMA Upstream Transmission Processing

Upstream Receiver Input Power Characteristics

All CPEs MUST implement upstream power control so that the various bursts from different CPEs arrive at the BWA BTS with more or less the same power level. The objective receive signal at the BTS receiver depends upon the specific power control algorithm implemented. Once the objective receive signal level is defined, the demodulator MUST operate within its defined performance specifications with received bursts within ±6 dB of the nominal commanded received power.

Upstream Electrical Output from the BWA CPE Modem

The BWA CPE Modem MUST output an RF modulated signal with the characteristics delineated in Table 4.

TABLE 4

Electrical RF Output from BWA CPE

Parameter	Value

Frequency	10 to 40 GHz
Minimum Level range (one channel)	-27 to +17 dBm (16 QAM) -30 to +20 dBm (QPSK)
Modulation Type	QPSK and optionally 16 QAM and/or 64 QAM
Symbol Rate range (nominal)	1 280 to 20 480 ksym/sec
Bandwidth	1 600 to 26 000 kHz
Output impedance	50 ohms

Downstream (contains PMD and TC sublayer)

Downstream Protocol

The downstream PMD sublayer MUST conform to ITU-T Recommendations J.83, with the exceptions of 256 QAM. The downstream PMD sublayer MUST support QPSK, 16 QAM and optionally 64 QAM modulations and symbol rates and bandwidth defined in Table 5.

Scalable Interleaving to Support Low Latency

The downstream PMD sublayer MUST support a variable-depth interleaver with the characteristics defined in [ITU-T J.83], except those with latencies greater than 4 msec.
The interleaver depth, which is coded in a 4-bit control word contained in the FEC frame synchronization trailer, always reflects the interleaving in the immediately-following frame. In addition, errors are allowed while the interleaver memory is flushed after a change in interleaving is indicated.
Refer to [ITU-T J.83] for the control bit specifications required to specify which interleaving mode is used.

Downstream Frequency Plan

The downstream frequency should be in the range 10 to 40 GHz with channel bandwidth up to 40 MHz.

BWA BTS Output Electrical

The BWA BTS MUST output an RF modulated signal with the following characteristics defined in Table 5.

TABLE 5

BWA BTS RF Output

Parameter	Value

Center Frequency (fc)	10 to 40 GHz ± 5 ppm
Transmit Power Level (at tx antenna flange)	>10 dBm
Modulation Type	QPSK, 16QAM and optionally 64 QAM
Symbol Rate (R_s)	up to 34.78 Msym/sec
Nominal Channel Spacing	up to 40 MHz
Frequency response	12%~18% Square Root Raised Cosine shaping
Spurious and Noise	
Inband (fc ± R_s/2)	< -50 dBc in symbol rate bandwidth (R_s)
Adjacent channel (fc ± R_s/2) to (fc ± 1.25 * R_s/2)	< -51 dBc in a bandwidth of R_s/8
Adjacent channel (fc ± 1.25 * R_s/2) to (fc ± 3 * R_s/2)	< -55 dBc, in 1.75 * R_s, excluding up to 3 spurs, each of which must be <-53 dBc when measured in a 10 kHz band
Next adjacent channel (fc ± 3 * R_s/2) to (fc ± 5 * R_s/2)	< -58 dBc in symbol rate bandwidth (R_s)
Output Impedance	50 ohms
Output Return Loss	> 14 dB

Downstream RF Input to BWA CPE

The BWA CPE MUST accept an RF modulated signal with the following characteristics (Table 6).

TABLE 6

RF Input to BWA CPE

Parameter	Value
Center Frequency	10 to 40 GHz ± 5 ppm
Level Range (one channel)	-87 dBm to -32 dBm
Modulation Type	QPSK, 16QAM and optionally 64 QAM
Symbol Rate (nominal)	up to 34.78 Msym / sec
Bandwidth	up to 40 MHz with 12%~18% Square Root Raised Cosine shaping
Input (load) Impedance	50 ohms
Input Return Loss	> 14 dB

BWA CPE Modem BER Performance

The bit-error-rate performance of a BWA CPE Modem MUST be as described in this section.

QPSK

QPSK BWA CPE Modem BER Performance

Implementation loss of the BWA CPE Modem MUST be such that the BWA CPE Modem achieves a post-FEC BER less than or equal to 10^{-8} when operating at a carrier to noise ratio (C/N) of 10.8 dB or greater.

QPSK Adjacent Channel Performance

Performance as described in Section above MUST be met with digital signal at 0 dBc in the adjacent channels. Performance as described in Section above, with an additional 0.2-dB allowance, MUST be met with digital signal at +10 dBc in the adjacent channels.

16 QAM

16 QAM BWA CPE Modem BER Performance

Implementation loss of the BWA CPE Modem MUST be such that the BWA CPE Modem achieves a post-FEC BER less than or equal to 10^{-8} when operating at a carrier to noise ratio (C/N) of 17.8 dB or greater.

16 QAM Adjacent Channel Performance

Performance as described in Section above MUST be met with digital signal at 0 dBc in the adjacent channels. Performance as described in Section above, with an additional 0.2-dB allowance, MUST be met with digital signal at +10 dBc in the adjacent channels.

64 QAM

64 QAM BWA CPE Modem BER Performance

Implementation loss of the BWA CPE Modem MUST be such that the BWA CPE Modem achieves a post-FEC BER less than or equal to 10^{-8} when operating at a carrier to noise ratio (C/N) of 24.5 dB or greater.

64 QAM Adjacent Channel Performance

Performance as described above MUST be met with digital signal at 0 dBc in the adjacent channels. Performance as described above, with an additional 0.2-dB allowance, MUST be met with digital signal at +10 dBc in the adjacent channels.

Downstream Transmission Convergence Sublayer

In order to improve demodulation robustness, facilitate common receiving hardware for both video and data, and provide an opportunity for the possible future multiplexing of video and data over the PMD sublayer bitstream. A sublayer is interposed between the downstream PMD sublayer and the Data-Over-BWA MAC sublayer.

The downstream bitstream is defined as a continuous series of 188-byte MPEG [5] packets. These packets consist of a 4-byte header followed by 184 bytes of payload. The header identifies the payload as belonging to the Data-Over-BWA MAC. Other values of the header may indicate other payloads. The mixture of MAC payloads and those of other services is optional and is controlled by the BWA BTS Modem.

Figure 4 illustrates the interleaving of Data-Over-BWA (DOC) MAC bytes with other digital information (digital video in the example shown).

header=DOC	DOC MAC payload
header=video	digital video payload
header=video	digital video payload
header=DOC	DOC MAC payload
header=video	digital video payload
header=DOC	DOC MAC payload
header=video	digital video payload
header=video	digital video payload
header=video	digital video payload

FIGURE 4

Example of Interleaving MPEG Packets in Downstream

MPEG Packet Format

The format of an MPEG Packet carrying BWA data is shown in Figure 5. The packet consists of a 4-byte MPEG Header, a pointer_field (not present in all packets) and the BWA Payload.

MPEG Header (4 bytes)	pointer_field (1 byte)	BWA Payload (183 or 184 bytes)

FIGURE 5

Format of an MPEG Packet

MPEG Header for BWA Data-Over-the-Air

The format of the MPEG Transport Stream header is defined in Section 2.4 of [ITU-T H.222.0]. The particular field values that distinguish Data-Over-BWA MAC streams are defined in Table 7. Field names are from the ITU specification.The MPEG Header consists of 4 bytes that begin the 188-byte MPEG Packet. The format of the header for use on an BWA Data-Over-BWA PID is restricted to that shown in Table 7. The header format conforms to the MPEG standard, but its use is restricted in this specification to NOT ALLOW inclusion of an adaptation_field in the MPEG packets.

TABLE 7

MPEG Header Format for BWA Data-Over-BWA Packets

Field	Length (bits)	Description
sync_byte	8	0x47; MPEG Packet Sync byte
transport_error_indicator	1	Indicates an error has occurred in the reception of the packet. This bit is reset to zero by the sender, and set to one whenever an error occurs in transmission of the packet
payload_unit_start_indicator	1	A value of one indicates the presence of a pointer_field as the first byte of the payload (fifth byte of the packet)
transport_priority	1	Reserved; set to zero
PID (see NOTE)	13	Data-Over-BWA well-known PID (0x1FFE)
transport_scrambling_control	2	Reserved, set to "00"
adaptation_field_control	2	"01"; use of the adaptation_field is NOT ALLOWED on the BWA PID
continuity_counter	4	cyclic counter within this PID
NOTE - In the future, additional PIDs MAY be assigned to a BWA CPE Modem.		

MPEG Payload for BWA Data-Over-the-Air

The MPEG payload portion of the MPEG packet will carry the BWA MAC frames.

Interaction with the MAC Sublayer

MAC frames may begin anywhere within an MPEG packet, MAC frames may span MPEG packets, and several MAC frames may exist within an MPEG packet.

Interaction with the Physical Layer

The MPEG-2 packet stream MUST be encoded according to [ITU-T J.83], including MPEG-2 transport framing using a parity checksum as described in [ITU-T J.83].

MPEG Header Synchronization and Recovery

The MPEG-2 packet stream SHOULD be declared "in frame" (i.e. correct packet alignment has been achieved) when five consecutive correct parity checksums, each 188 bytes from the previous one, have been received. The MPEG-2 packet stream SHOULD be declared "out of frame", and a search for correct packet alignment started, when nine consecutive incorrect parity checksums are received.

REFERENCES

[1] ITU-T Draft Recommendation J.116: Interaction channel for Local Multipoint Distribution Services, Sept. 1999

[2] Draft Recommendation ITU-R F.BWA: Radio Transmission systems for Fixed Broadband Wireless Access (BWA) based on cable modem standards (Annex B of J.112)

[3] ITU-T Recommendation J.112 “Transmission systems for interactive cable television services"

[4] ITU-T Recommendation J.83 "Digital multiprogramme systems for television, sound and data services for cable distribution”

[5] ITU-T Recommendation H.222 “Information technology – generic coding of moving pictures and associated audio information systems