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OF TELEVISION, SOUND PROGRAMME AND OTHER  
MULTIMEDIA SIGNALS

Cable modems and home networking

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### Physical layer specification of second generation HiNoC

Recommendation ITU-T J.196.2



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# Recommendation ITU-T J.196.2

## Physical layer specification of second generation HiNoC

### Summary

Recommendation ITU-T J.196.2 specifies the physical (PHY) layer specification of second generation high performance networks over coax (HiNoC) which provides 1 Gbit/s data transmission over coaxial networks in the cable industry. The HiNoC architecture consists of a HiNoC bridge (HB) and HiNoC modems (HMs) and the HiNoC protocol stack includes the media access control (MAC) layer and PHY layer. This Recommendation contains descriptions for the signal transmission mode of the PHY layer, including frame structure, channel coding and modulation techniques.

### History

| Edition | Recommendation | Approval   | Study Group | Unique ID*                                                                |
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# Recommendation ITU-T J.196.2

## Physical layer specification of second generation HiNoC

### 1 Scope

This Recommendation specifies the physical (PHY) layer protocol and is part of a series of second generation HiNoC Recommendations for high-speed data transmission over coaxial cable.

This Recommendation applies to bidirectional high-performance wideband access digital systems that use coaxial cable connected between fibre-to-the-building (FTTB) and HiNoC modems (HMs).

Frequency planning, safety and electromagnetic compatibility (EMC) requirements are a national matter and are not covered by this Recommendation. Compliance remains the operators' responsibility.

### 2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T G.972] Recommendation ITU-T G.972 (2016), *Definition of terms relevant to optical fibre submarine cable systems*.
- [ITU-T J.112] Recommendation ITU-T J.112 (1998), *Transmission systems for interactive cable television services*.
- [ITU-T J.195.1] Recommendation ITU-T J.195.1 (2016), *Functional requirements for high speed transmission over coaxial networks connected with fibre to the building*.
- [ITU-T J.195.2] Recommendation ITU-T J.195.2 (2014), *Physical layer specification for high speed transmission over coaxial networks*.
- [ITU-T J.195.3] Recommendation ITU-T J.195.3 (2014), *Medium Access Control layer specification for high speed transmission over coaxial networks*.
- [ITU-T J.196.1] Recommendation ITU-T J.196.1 (2016), *Functional Requirements for second generation HiNoC*.

### 3 Definitions

#### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

- 3.1.1 available sub-carrier** [ITU-T J.195.2]: Sub-carriers of OFDM symbol for data bearing.
- 3.1.2 constellation mapping** [ITU-T J.195.1]: The process of mapping the data bits to the constellation symbol.
- 3.1.3 control frame** [ITU-T J.195.2]: Frame of the MAC layer used for access control and channel allocation.

- 3.1.4 cyclic prefix** [ITU-T J.195.2]: Data located at the front of an OFDM symbol, which is a copy of the data from the end of the OFDM symbol.
- 3.1.5 cyclic redundancy check** [ITU-T J.112]: A method of error detection using cyclic code.
- 3.1.6 data frame** [ITU-T J.195.2]: Frame of the MAC layer used to carry data of the upper layer.
- 3.1.7 downlink** [ITU-T J.195.2]: Link from HiNoC bridge (HB) to HiNoC modem (HM).
- 3.1.8 forward error correction** [ITU-T G.972]: A technique which consists of transmitting the data in an encoded form such that the redundancy added by the coding allows the decoding to detect and correct errors.
- 3.1.9 frame check sequence** [ITU-T J.195.2]: A redundant sequence that is used for verifying the correctness of the received data.
- 3.1.10 Pd cycle** [ITU-T J.195.2]: A time interval between two adjacent downlink probe frames.
- 3.1.11 probe frame** [ITU-T J.195.2]: Frame of the physical layer used for carrying signalling frames of the MAC layer.
- 3.1.12 scrambler** [ITU-T J.195.2]: Process that randomizes data using a pseudo-random binary sequence.
- 3.1.13 signalling frame** [ITU-T J.195.2]: Frame of the MAC layer used for node admission, node quitting/deletion and link maintenance.
- 3.1.14 unavailable sub-carrier** [ITU-T J.195.2]: Sub-carriers of OFDM symbol for adjacent channel protection and zero frequency sub-carrier.
- 3.1.15 uplink** [ITU-T J.195.2]: Link from HiNoC modem (HM) to HiNoC bridge (HB).

## 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

- 3.2.1 pilot sub-carrier:** Sub-carriers for transmission of specific symbols in an orthogonal frequency division multiplexing (OFDM) symbol.
- 3.2.2 constellation scrambler:** The process that takes phase rotation of the constellation symbols in 4 quadrants by using binary pseudo random sequence.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

|       |                                            |
|-------|--------------------------------------------|
| BCH   | Bose-Chaudhuri-Hocquenghem (code)          |
| Cd    | Control down                               |
| CP    | Cyclic Prefix                              |
| Dd    | downlink Data                              |
| DQPSK | Differential Quadrature Phase-Shift Keying |
| Du    | uplink Data                                |
| EMC   | Electromagnetic Compatibility              |
| FEC   | Forward Error Correction                   |
| FTTB  | Fibre-To-The-Building                      |
| GSM   | Global System for Mobile communications    |
| HB    | HiNoC Bridge                               |

|        |                                               |
|--------|-----------------------------------------------|
| HiNoC  | High performance Network over Coax            |
| HM     | HiNoC Modem                                   |
| IFFT   | Inverse Fast Fourier Transform                |
| LDPC   | Low Density Parity Check Code                 |
| MAC    | Media Access Control                          |
| MAP    | Media Access Plan                             |
| MSO    | Multiple Systems Operator                     |
| OFDM   | Orthogonal Frequency Division Multiplexing    |
| OFDMA  | Orthogonal Frequency Division Multiple Access |
| Pd     | downlink Probe                                |
| PSD    | Power Spectral Density                        |
| Pu     | uplink Probe                                  |
| QAM    | Quadrature Amplitude Modulation               |
| QPSK   | Quadrature Phase-Shift Keying                 |
| RF     | Radio Frequency                               |
| Ru     | Report up                                     |
| SC     | Sub-Channel                                   |
| SCG_Ru | Sub-Carrier Group for Ru frame                |
| SSC    | Symbol Sub-Cell                               |
| TDMA   | Time Division Multiple Access                 |

## 5 Conventions

The keywords "is/are required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this Recommendation and its annexes, the words *shall*, *shall not*, *should* and *may* sometimes appear, in which case they are to be interpreted, respectively, as *is required to*, *is prohibited from*, *is recommended* and *can optionally*. The appearance of such phrases or keywords in an appendix or in material explicitly marked as *informative* are to be interpreted as having no normative intent.

The keywords "HiNoC 1.0" indicate the HiNoC system defined by the ITU-T J.195 series.

The keywords "HiNoC 2.0" indicate the second generation HiNoC.

## 6 PHY layer structure

### 6.1 Overview

The functional blocks of the transmitter include scrambler, forward error correction (FEC) coding, constellation mapping, constellation scrambler, orthogonal frequency division multiplexing (OFDM) modulation, cyclic prefix (CP) insertion, framing (into different types of PHY packets) and up conversion to radio frequency (RF) signals. The sequence of the blocks is shown in Figure 1, in which scrambler, FEC coding, constellation scrambler and framing can be optionally closed or opened according to different types of data stream.

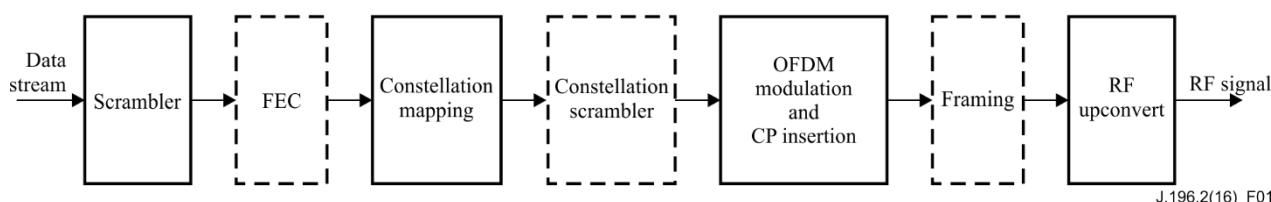


Figure 1 – Functional block diagram of the transmitter

### 6.2 Scrambler

The procedure of scrambler is required to conform to clause 6.2 of [ITU-T J.195.2].

### 6.3 FEC coding

#### 6.3.1 Overview

The FEC encoder is required to support Bose-Chaudhuri-Hocquenghem (BCH) codes and can optionally support the low density parity check (LDPC) codes specified in clause 6.3.3.

#### 6.3.2 BCH code

##### 6.3.2.1 Overview

The BCH encoder is required to support three truncated BCH codes with the following code parameters: (392, 248), (1920, 1040) and (1920, 1744).

##### 6.3.2.2 (392, 248) truncated BCH code

The (392, 248) BCH code is truncated from (511, 367) BCH code, a systematic code with the octal representation for the generator polynomial shown as follows:

(1126657202505666323017001652245562614435511600655)<sub>8</sub>.

##### 6.3.2.3 (1920, 1040) truncated BCH code

The (1920, 1040) BCH code is truncated from (2047, 1167) BCH code, a systematic code with the octal representation for the generator polynomial shown as follows:

(2607213617224645406577025220731152106357217602413642657023052056326613650555607  
46124155122706374565474720414262325513114121607751671240010170277341021754016552  
31230342573577525607211634376436714210307434573616501027347554213212451363043514  
3515626347123264462606121045647652066606334120024047475)<sub>8</sub>.

##### 6.3.2.4 (1920, 1744) truncated BCH code

The (1920, 1744) BCH code is truncated from (2047, 1871) BCH code, a systematic code with the octal representation for the generator polynomial shown as follows:

(64372013435571223560747633451755373433074714007120505460007)<sub>8</sub>.

### 6.3.2.5 Encoding procedure

The truncated BCH encoding procedure is required to conform to clause 6.3.5 of [ITU-T J.195.2].

### 6.3.3 LDPC code

#### 6.3.3.1 Overview

The LDPC encoder is required to support two LDPC codes with the following code parameters: (1920, 1728) and (3840, 3456).

#### 6.3.3.2 (1920, 1728) LDPC code

The parity check matrix of (1920, 1728) LDPC code is composed of the information bits part and the parity bits part, which correspond to information bits and parity bits respectively and is restricted to the form that the information part is located in the first half of the matrix and the parity part is located in the second half of the matrix.

The information part of (1920, 1728) LDPC parity matrix can be divided into 8\*72 sub-matrices with a size of 24\*24. Each sub-matrix is a null matrix or cyclic shift of unit matrix. The code table of the information part is shown in Table 1, where I represents the abscissa of the non-zero sub-matrix in mother matrix, J represents the ordinate of the non-zeros sub-matrix in mother matrix, R represents the cyclic right shift amount of the non-zero sub-matrix with respect to the unit matrix. For example, (I,J,R)=(2,1,23), represents that there is a non-zero sub-matrix in the first column and the second row of the mother matrix and it is obtained from cyclic right shifting a unit matrix by 23 bits.

**Table 1 – Information part code table of (1920, 1728) LDPC code**

| I | J | R  | I | J  | R  | I | J  | R  | I | J  | R  |
|---|---|----|---|----|----|---|----|----|---|----|----|
| 2 | 1 | 23 | 1 | 17 | 4  | 7 | 33 | 3  | 2 | 52 | 19 |
| 1 | 1 | 5  | 3 | 17 | 10 | 6 | 33 | 7  | 8 | 53 | 4  |
| 8 | 1 | 8  | 8 | 17 | 16 | 1 | 33 | 17 | 3 | 53 | 10 |
| 4 | 1 | 19 | 6 | 17 | 20 | 5 | 33 | 19 | 5 | 53 | 18 |
| 5 | 2 | 0  | 6 | 18 | 3  | 4 | 34 | 9  | 6 | 54 | 6  |
| 3 | 2 | 5  | 3 | 18 | 5  | 7 | 34 | 11 | 4 | 54 | 11 |
| 6 | 2 | 18 | 2 | 18 | 19 | 8 | 34 | 18 | 1 | 54 | 20 |
| 4 | 2 | 21 | 4 | 18 | 22 | 2 | 34 | 20 | 1 | 55 | 2  |
| 4 | 3 | 2  | 8 | 19 | 23 | 1 | 35 | 3  | 3 | 55 | 19 |
| 6 | 3 | 4  | 7 | 19 | 3  | 6 | 35 | 6  | 2 | 55 | 22 |
| 8 | 3 | 10 | 2 | 19 | 13 | 5 | 35 | 11 | 6 | 56 | 3  |
| 7 | 3 | 22 | 3 | 19 | 15 | 8 | 35 | 17 | 3 | 56 | 9  |
| 5 | 4 | 3  | 4 | 20 | 3  | 8 | 36 | 8  | 1 | 56 | 14 |
| 3 | 4 | 6  | 3 | 20 | 5  | 2 | 36 | 9  | 7 | 57 | 6  |
| 2 | 4 | 17 | 6 | 20 | 7  | 4 | 36 | 11 | 5 | 57 | 10 |
| 7 | 4 | 21 | 8 | 20 | 21 | 3 | 36 | 12 | 6 | 57 | 11 |
| 3 | 5 | 0  | 4 | 21 | 3  | 7 | 37 | 8  | 6 | 58 | 2  |