

**IEEE P802.15**  
**Wireless Personal Area Networks**

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Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)
Title	TVWS-FSK Merged Proposal to TG4m
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Re:	Submission in response to TG4m CFP for PHY amendment to IEEE 802.15.4
Abstract	Text for the TVWS-FSK merged proposal to TG4m
Purpose	TVWS-FSK merged proposal submission
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*Insert after Clause 19 the following new clause (Clause 20):*

## 20. TVWS PHYs

Three PHYs are specified: a FSK PHY (TVWS-FSK), as described in 20.1, an orthogonal frequency division multiplexing PHY (TVWS-OFDM) as described in 20.2 and a narrow-band orthogonal frequency division multiplexing PHY (TVWS-NB-OFDM) as described in 20.3.

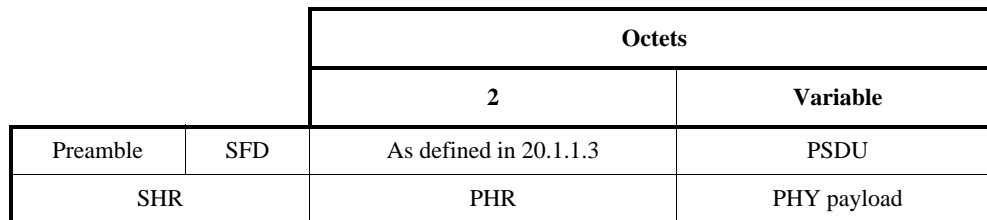
### 20.1 TVWS-FSK

#### 20.1.1 PPDU format for TVWS-FSK

The TVWS-FSK PPDU shall support the format shown in Figure 112.

The synchronization header (SHR), PHY header (PHR), and PHY payload components are treated as bit strings of length  $n$ , numbered  $b_0$  on the left and  $b_{n-1}$  on the right. When transmitted, they are processed  $b_0$  first to  $b_{n-1}$  last, without regard to their content or structure.

All reserved fields shall be set to zero upon transmission and shall be ignored upon reception.



**Figure 112—Format of the TVWS-FSK PPDU**

##### 20.1.1.1 Preamble field

The Preamble field shall contain *phyFSKPreableLength* (as defined in 9.3) multiples of the 8-bit sequence “01010101”.

##### 20.1.1.2 SFD

The SFD shall be a 16-bit sequence or, optionally, a 24-bit sequence selected from the list of values shown in Table 131. The SFD length is controlled by the PIB attribute *phyTVWSSFDLength*, as defined in 9.3.

Devices that do not support the FEC (see 20.1.2.4) shall support the SFD associated with uncoded (PHR + PSDU). Devices that support FEC (see 20.1.2.4) shall support both SFD values shown in Table 131.

##### 20.1.1.3 PHR

The format of the PHR is shown in Figure 113. All multi-bit fields are unsigned integers and shall be processed MSB first.

The Parity Check (PC) field provides error detection. Its value is the modulo-2 addition of all bits in the PHR other than the Parity Check.

**Table 131—TVWS-FSK SFD values**

<i>phyTVWSSFDLength</i>	SFD value for coded (PHR + PSDU)	SFD value for uncoded (PHR + PSDU)
16 bits	0110 1111 0100 1110	1001 0000 0100 1110
24 bits	1100 0001 1000 1000 1101 0110	1000 0101 1111 1100 1011 0011

Bit string index	0-1	2	3	4	5-15
Bit mapping	$R_1-R_0$	PC	FCS	DW	$L_{10}-L_0$
Field name	Reserved	Parity Check	FCS Type	Data Whitening	Frame Length

**Figure 113—Format of the PHR for TVWS-FSK**

The FCS Type field (FCS) indicates the length of the FCS field described in 5.2.1.9 that is included in the MPDU. Table 132 shows the relationship between the contents of the FCS Type field and the length of the transmitted FCS.

**Table 132—Relationship between FCS Type field and transmitted FCS length**

FCS Type field value	Transmitted FCS length
0	4-octets
1	2-octets

The Data Whitening field (DW) indicates whether data whitening of the PSDU is used upon transmission. When data whitening is used, the Data Whitening field shall be set to one. It shall be set to zero otherwise. Data whitening shall not be applied to the SHR or PHR.

The Frame Length field ( $L_{10}-L_0$ ) specifies the total number of octets contained in the PSDU (prior to FEC encoding, if enabled). The most significant bit (leftmost) shall be transmitted first.

#### 20.1.1.4 PSDU field

The PSDU field carries the data of the PPDU.

#### 20.1.2 Modulation and Coding for TVWS-FSK

The modulation for the TVWS-FSK PHY is 2-level Filtered FSK or 4-level Filtered FSK, depending on the operating mode. The Filtering method is as needed to meet regulatory requirements in the band of operation. Table 133 shows the modulation and channel parameters for the operating modes of the TVWS-FSK PHY.

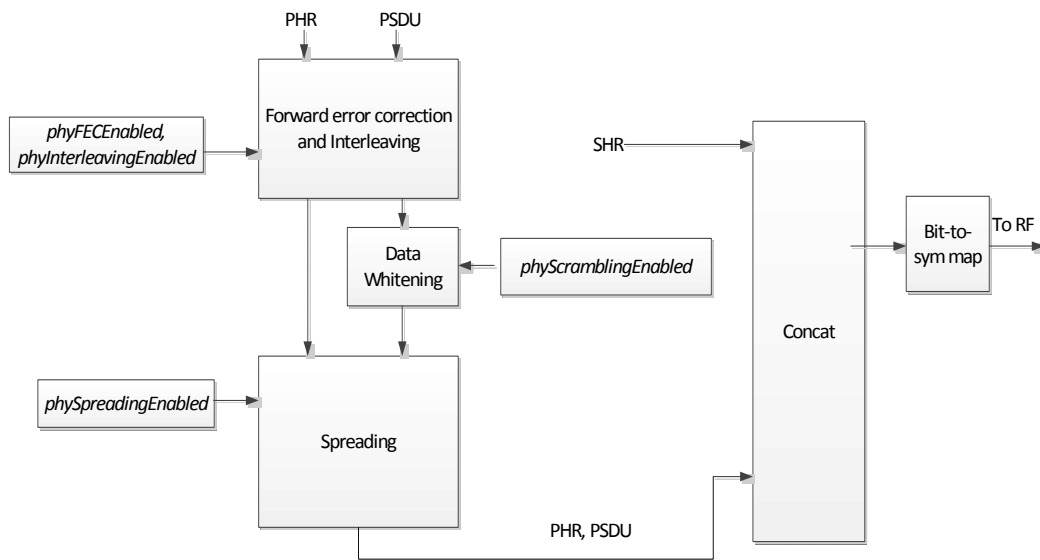
##### 20.1.2.1 Reference modulator diagram

**Table 133—TVWS-FSK modulation and channel parameters<sup>a</sup>**

Freq. Band (MHz)	Param	Mode #1	Mode #2	Mode #3	Mode #4	Mode #5
All available TVWS bands	Data rate (kb/s)	50	100	200	300	400
	Modulation level	2-level	2-level	2-level	2-level	4-level
	Modulation index h	0.5 or 1.0	0.5 or 1.0	0.5 or 1.0	0.5	0.33
	Channel spacing (kHz)	100 if h=0.5 200 if h=1.0	200 if h=0.5 400 if h=1.0	400 if h=0.5 600 if h=1.0	600	600

<sup>a</sup>Data rates shown are over-the-air data rates (the data rate transmitted over the air regardless of whether the FEC is enabled).

The functional block diagram in Figure 114 is provided as a reference for specifying the TVWS-FSK data flow processing functions.



**Figure 114—Reference modulator diagram**

**20.1.2.2 Bit-to-symbol mapping**

The symbol encoding is shown in Table 134, where the frequency deviation,  $f_{dev}$ , is equal to (symbol rate x modulation index)/2 for 2-level Filtered FSK and is equal to (3 x symbol rate x modulation index) / 2 for 4-level Filtered FSK. For 4-level Filtered FSK modulation, two bits shall be mapped to four frequency

deviation levels for the PHR and PSDU. The SHR shall be encoded in the lowest ( $-f_{\text{dev}}$ ) and the highest ( $+f_{\text{dev}}$ ) frequency deviations.

**Table 134—TVWS-FSK symbol encoding**

2-level	
Symbol (binary)	Frequency deviation
0	$-f_{\text{dev}}$
1	$+f_{\text{dev}}$
4-level	
Symbol (binary)	Frequency deviation
01	$-f_{\text{dev}}$
00	$-f_{\text{dev}} / 3$
10	$+f_{\text{dev}} / 3$
11	$+f_{\text{dev}}$
Symbol (binary)	Frequency deviation

### 20.1.2.3 Modulation quality

The modulation quality shall be as given in 18.1.2.3.

### 20.1.2.4 Forward error correction (FEC)

FEC support is optional. The use of FEC is controlled by the PIB attribute *phyFECEnabled*, as defined in 9.3. The FEC scheme shall be according to sub-clause 19.2.2.4 for the case when the PHR is 2-octet long.

### 20.1.2.5 Code-symbol interleaving

Interleaving support is optional. The use of interleaving is controlled by the PIB attribute *phyInterleavingEnabled*, as defined in 9.3. Interleaving shall be according to sub-clause 19.2.2.5 for the case when the PHR is 2-octet long.

### 20.1.2.6 Spreading

Spreading support is optional. The use of spreading is controlled by the PIB attribute *phySpreadingEnabled*, as defined in 9.3. The spreading method shall be as defined in 19.2.2.6.

### 20.1.3 Data whitening

Data whitening is optional. The use of data whitening is controlled by the PIB attribute *phyScramblingEnabled*, as defined in 9.3. The data whitening algorithm shall be as defined in 19.2.3.

### 20.1.4 RF requirements for TVWS-FSK

#### 20.1.4.1 Clock accuracy

The clock frequency and time accuracy shall be better than  $\pm 20$  ppm.

**20.1.4.2 Channel switch time**

The channel switch time shall be as given in 19.2.4.4.

**20.1.4.3 Receiver sensitivity**

The receiver sensitivity shall be as given in 18.1.5.7.

**20.1.4.4 Tx-to-Rx turnaround time**

The TX-to-RX turnaround time shall be as given in 18.1.5.9.

**20.1.4.5 Rx-to-Tx turnaround time**

The RX-to-TX turnaround time shall be as given in 18.1.5.10.