**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title | **PHY/MAC for Offset Variable Pulse Width Modulation used for Smart Device Flash Light** | |
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| Re: |  | |
| Abstract | Offset Variable Pulse Width Modulation for Smart Device Flash Light is proposed. | |
| Purpose | Discussion and approval. | |
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# **PHY Layer Operating Mode(s)**

SNUST is introducing the following classification with three new PHY modes for IEEE802.15.7r1.

* PHY 7r1\_1 – Singular Point Source /Surface Light Source
* PHY 7r1\_2 – 2 Dimensional Source / Multi Point Source

PHY 7r1\_3 - LiFi

The SNUST Offset Variable Pulse Width Modulation for Smart Device Flash Light uses the PHY 7r1\_1 – Singular Point Source /Surface Light Source.

The IEEE802.15.7r1 PHY 7r1\_1 Operating Modes system specifications are given in Table 1-1.

|  |  |  |  |
| --- | --- | --- | --- |
| **PHY 7r1\_1 Operating Modes** | | | |
| **Modulation** | **Optical Clock Rate** | **FEC** | **Data Rate** |
| OffsetVPWM | 100HZ | RS/CRC | 12bps |
|  |  |  |  |
|  |  |  |  |

**Table 1-1 - IEEE802.15.7r1 PHY Operating Mode for Offset Variable Pulse Width Modulation for Smart Device Flash Light**

# **PHY Specifications**

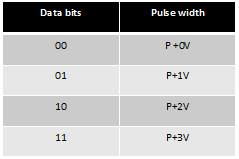
The IEEE802.15.7r1 PHY 7r1\_1 with supported data rates and operating conditions is shown in Table 1-1 for Offset Variable Pulse Width Modulation for Smart Device Flash Light data transmission.

**2.1 OFFSET-VPWM**

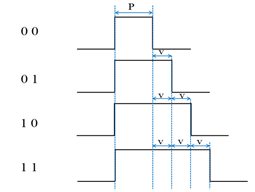
The proposed Offset-VPWM (Variable Pulse Width Modulation) designed with following characteristics,

* Modulation methods includes line coding
* Defining the sum (P + nV) of the unit to be added to the minimum pulse (P) which is a reference pulse width (V) as a Symbol ( P>>V, V>time error(jitter) )
* Can specify a 2bit data symbol, 4bit data symbol according to number of added pulse
* Data is expressed with offset pulse width, 2bits data(for example) were mapped into 4 Offset-VPWM symbols

The data symbol map for two bits symbol with pulse width and respective symbol blinking waveform are shown in Table 2-1 and Figure 2-1 respectively.

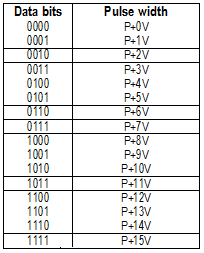


**Table 2-1 – Two Bits Symbol Mapping Truth Table**

****

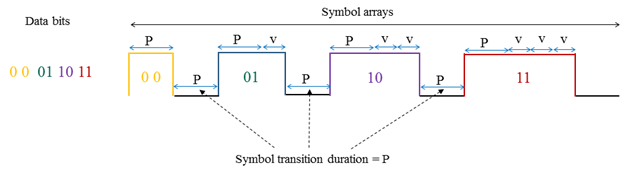
**Figure 2-1 – Two Bit Symbol Data Diagram**

In offset-VPWM, the data is expressed with offset pulse width, 4bits data (for example) were mapped into 16 Offset-VPWM symbols. The 4 bits symbol mapping truth table is shown in Table 2-2.



**Table 2-2 – Four Bits Symbol Mapping Truth Table**

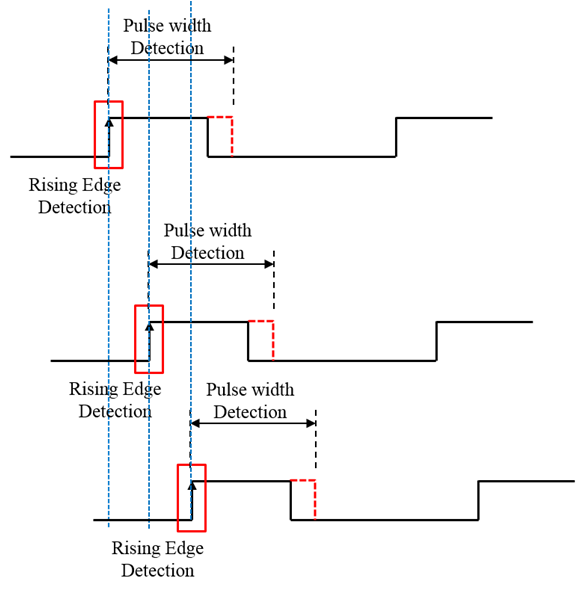
The symbol arrays mapping is described in waveform pattern as shown in Figure 2-2.



**Figure 2-2 – Symbol Array Mapping Timing Diagram**

**2.2 Receiver Detection Method**

Receiver can synchronize rising edge and check pulse width length using Rolling-shutter method. The receiver detection process in the wave formatted approach is show in Figure 2-3.



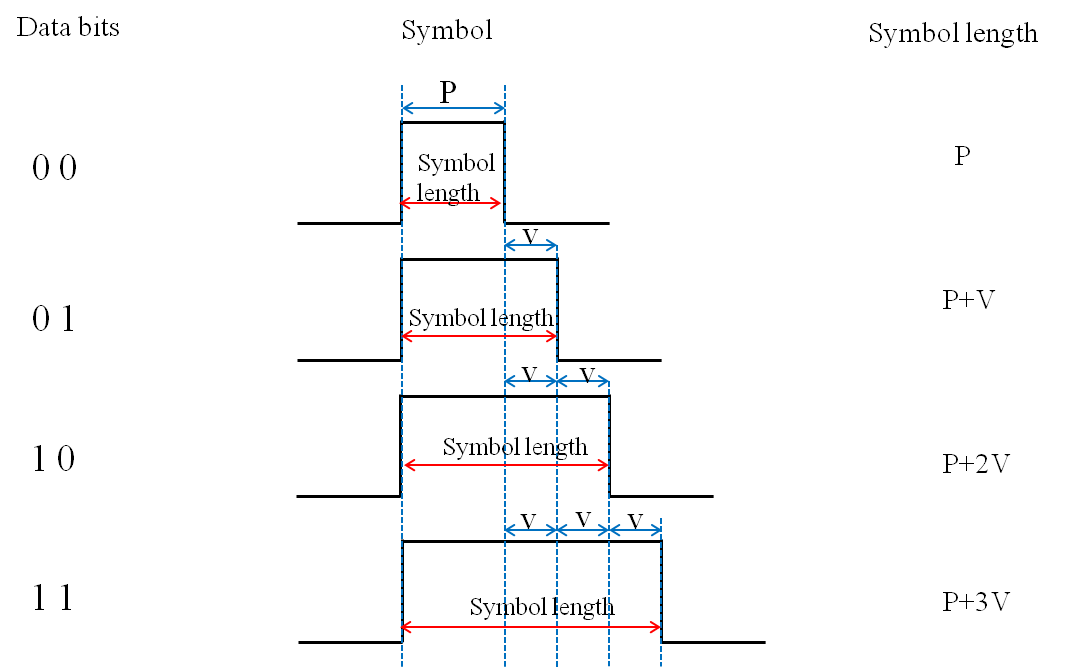
**Figure 2-3 – Receiver Detection Process**

# **PHY Layer Dimming Method**

In the Offset Variable Pulse Width Modulation for Smart Device Flash Light PHY uses the Smartphone Camera LED Flash light sources, no need concerning dimming. The Camera LED Flash light is no using for illumination and blinking speed is very low, then can't control dim.

* Symbol Length : P, P+V, P+2V, P+3V

The Figure 3-1 shows the 2bit symbol map dimming control for Offset Variable Pulse Width Modulation for Smart Device Flash Light.

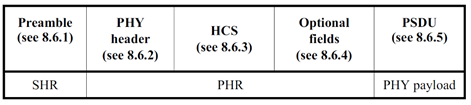


**Figure 3-1 – 2 Bit Symbol Map Dimming Control**

In accordance with the provisions of the symbol, depending on the data bit transmission because the High Pulse interval being determined brightness is adjustable (P >> V, V>time error (jitter)).

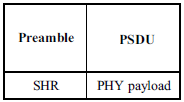
# **PPDU Format**

The PPDU frame structure presented in IEEE802.15.7-2011 (Figure 118 – Format of the PPDU) is shown in Figure 4-1.



**Figure 4-1 – Format of the IEEE802.15.7-2011 PPDU**

The IEEE802.15.7r1 PPDU frame structure is formatted as illustrated in Figure 4-2 for PHY-IV Rolling/Global Shutter Cameras and Low Rate PD.

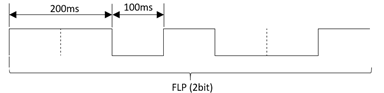


**Figure 4-2 – Format of the IEEE802.15.7r1 PPDU**

**SHR Field:**

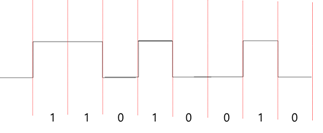
The preamble field is used by the transceiver to obtain optical clock synchronization with an incoming message. The standard defines one fast locking pattern (FLP). The MAC shall select the optical clock rate for communication during the clock rate selection process. The preamble shall be sent at a clock rate chosen by the TX and supported by the RX. The preamble is a time domain sequence and does not have any channel coding or line coding.

The preamble first starts with a FLP. The FLP is fixed as a pattern “11010010”. The fast locking pattern length shall not exceed the maximum. The timing information for preamble is shown in Figure 4-3.



**Figure 4-3 – Preamble Timing Diagram**

In the Offset Variable Pulse Width Modulation for Smart Device Flash Light PHY uses OOK modulation for preamble transmission using flash light. The Preamble Bit Mapping shown in Figure 4-4.



**Figure 4-4 – Preamble Transmission – OOK BIT MAPPING**

**PSDU Field:**

The PSDU field has a variable length and carries the data of the IEEE802.15.7r1 PHY frame. The FCS is appended if the PSDU has a non-zero byte payload. The structure of the PSDU field is as shown in Figure 4-5.



**Figure 4-5 – IEEE802.15.7r1 PHY PSDU Field Structure**

# **PHY PIB Attributes**

The PHY PIB comprises the attributes required to manage the PHY sublayer of a device. The attributes contained in the IEEE802.15.7-2011 PHY PIB are presented in Table 100 - PHY PIB Attributes.

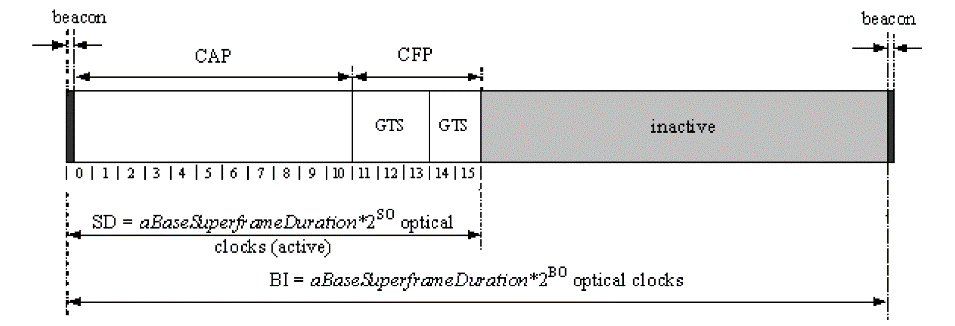
The additional PHY PIB attributes added on IEEE802.15.7r1 for Offset Variable Pulse Width Modulation for Smart Device Flash Light PHY is presented the Table 5-1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PHY PIB Table 100 Additions** | | | | |
| **Attribute** | **Identifier** | **Type** | **Range** | **Description** |
| phySMFlashLIGHTApplicationSpecificMode | 0x10 | Unsigned | 0~255 | This attribute specifies the application specific PHY mode.  0 : Normal Data (Media Content, Information Content based on the Application used for)  1 : ID Data  2 : Authentication Data |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Table** **5-1 - IEEE802.15.7r1 PHY PIB Attributes Additions**

# **Superframe Structure**

The Super frame structure presented in IEEE802.15.7-2011 is shown in Figure 6-1.



**Figure 6-1 – Superframe Structure**

The Offset Variable Pulse Width Modulation for Smart Device Flash Light PHY uses the unslotted ALOHA; that is, when the Smart Device flash light transmitter has a packet to send, it just transmit the data. This support with beacon and without beacon support and the transmitter does not do a listen before talk channel activity check.

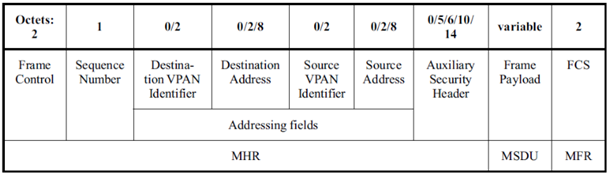
The super frame structure for IEEE802.15.7r1 without beacon is shown in Figure 6-2.



**Figure 6-2 – IEEE802.15.7r1** **Superframe Structure without Beacon**

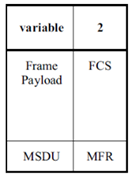
# **MAC Frame Formats**

The MAC frame structure presented in IEEE802.15.7-2011 (Figure 44 – General MAC Frame Format) is shown in Figure 7-1.



**Figure 7-1 – General MAC Frame Format**

The IEEE802.15.7r1 MAC frame structure is formatted as illustrated in Figure 7-2 for Offset Variable Pulse Width Modulation for Smart Device Flash Light.



**Figure 7-2 – IEEE802.15.7r1 MAC Frame Format**

**Frame Payload Field:**

The Frame Payload field has a variable length and contains information specific to individual frame types. If the Security Enabled subfield is set to one in the frame control field, the frame payload is protected as defined by the security suite selected for that frame.

**FCS Field:**

The FCS field is 2 octets in length and the FCS is calculated over the MHR and MSDU parts of the frame. The FCS shall be only generated for payloads greater than zero bytes.

The FCS is option is given as an optional option, it is adaptive to RS/CRC/NONE.

# **MAC Frame Formats**

The MAC PIB comprises the attributes required to manage the MAC sublayer of a device. The attributes contained in the IEEE802.15.7-2011 MAC PIB are presented in Table 60 - MAC PIB Attributes.

The additional MAC PIB attributes added on IEEE802.15.7r1 for Offset Variable Pulse Width Modulation for Smart Device Flash Light is presented the Table 8-1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **MAC PIB Attributes Table 60 Additions** | | | | | |
| **Attribute** | **Identifier** | **Type** | **Range** | **Description** | **Default** |
| macLEDIDusage | 0x81 | Unsigned | 0-255 | This attribute indicates the type of data transmitted using Flash Light Transmitter.  0 : LED IT  1 : With or Without LED ID and IP address | 0 |

**Table** **8-1 - IEEE802.15.7r1 MAC PIB Attributes Additions**