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SiXMEDICAL Message Timing and Duty Cycle Calculation

OVERVIEW

The SiXMEDICAL and its Access Point (AP) use an 802.15.4-compliant message protocol which is similar to Zigbee on the physical level. In the RF6 device system, there will be one AP which will serve as the coordinator among all the sensor devices in the system. The AP generates a 5ms transmit 'beacon' every 245.76ms. The spacing between beacons is called a ''superframe'.

A timing diagram of the superframe is provided on the following page. It can be referred to to locate the items described in this section. Within a superframe, the SiXMEDICAL and AP each has specific windows in which it is allowed to transmit. Outside of these windows, the device does not transmit. The SiXMEDICAL is a sensor device. Within a given superframe, a sensor device such as the SiXMEDICAL can only generate one of two response types: a *device MAC response packet*, or a *6LoWPAN response packet*. The initial *device MAC response packet* is triggered by the beacon from the AP. Each sensor has a reserved time slot (based on its address) in which it is allowed to transmit its initial *device MAC response packet*. If this transmission is not received, the sensor will try to send the same packet at its next available opportunity, as described below. A *device MAC response packet* may contain alarm, status, or supervision information.

In the same superframe, the sensor device may also generate up to 2 *device MAC transmit retry* messages. These may occur if the sensor device detects a collision upon sending its initial *device MAC response packet* (i.e. it does not receive an ACK from the AP). The response packet has two opportunities to be re-sent via a *device MAC transmit retry* message. The first opportunity is in a second time slot of the current superframe, shown in the timing diagram as *Device MAC Response Transmit Retry Window 1*. If this is not successful, the sensor will transmit the packet again in the next superframe, during the time window shown by *Device MAC Response Transmit Retry Window 2*.

There is one 6LowPAN time slot available per superframe. The 6LoWPAN time slot is designated for transmission of Internet Protocol information only. With regard to this message, only one sensor is addressed by the AP in a 6LoWPAN transmit query. Only the sensor addressed may send a 6LowPAN response. There are no retry time windows for the sensor's 6LoWPAN response; there is the initial opportunity only.

PROTOCOL AND DATA RATE

The SiXMEDICAL utilizes O-QPSK with DFSS modulation in the 2.4GHz band, with a 250kbps data rate.

TIMING DIAGRAM

A timing diagram is presented on the next page.

DUTY FACTOR

Duty factor calculations for SAR exclusion are on the pages following the timing diagram.

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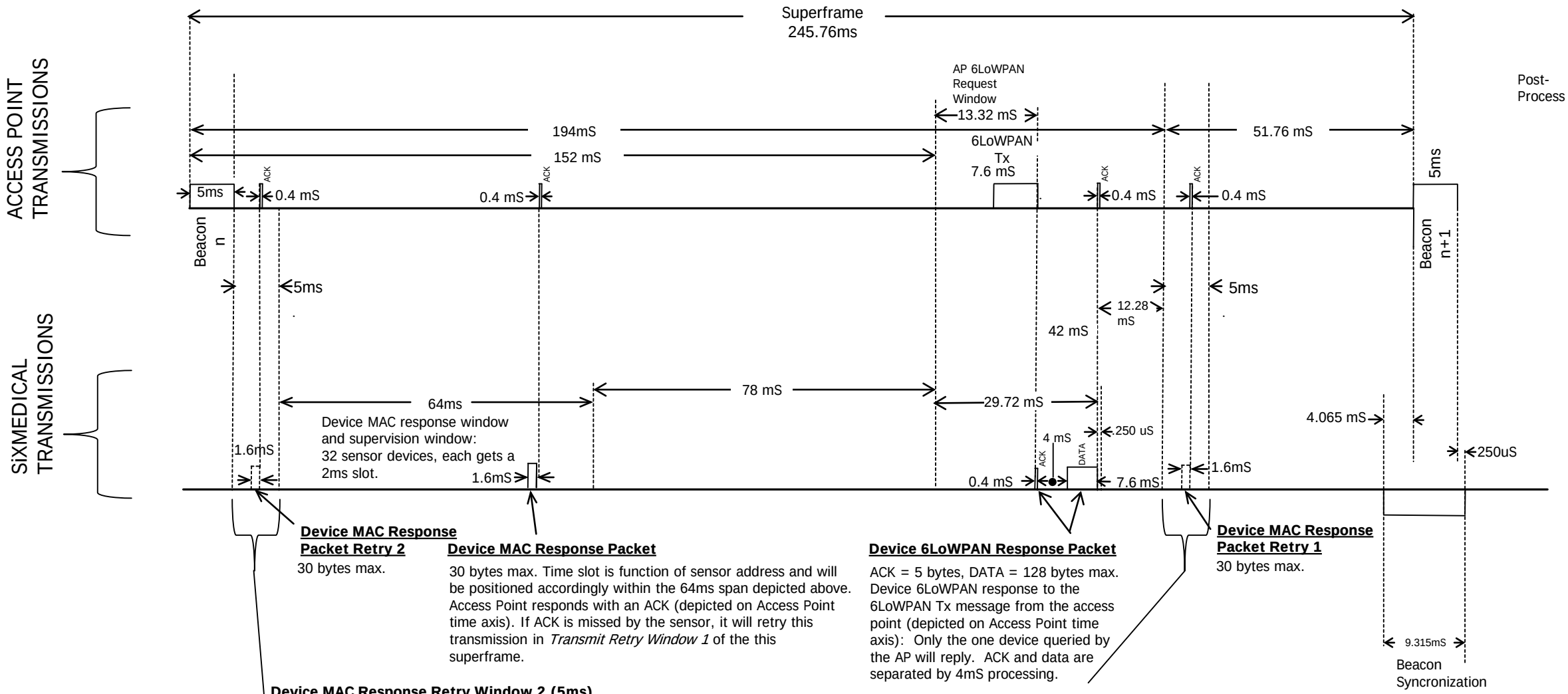
TIMING DIAGRAM

The Access Point (coordinator) generates beacon every 245.76ms (superframe). As shown in the figure, the duration of the beacon is 5ms.



Device MAC Response Packet Retry 2
30 bytes max.

Device MAC Response Packet
30 bytes max. Time slot is function of sensor address and will be positioned accordingly within the 64ms span depicted above. Access Point responds with an ACK (depicted on Access Point time axis). If ACK is missed by the sensor, it will retry this transmission in *Transmit Retry Window 1* of the this superframe.

Device 6LoWPAN Response Packet
ACK = 5 bytes, DATA = 128 bytes max. Device 6LoWPAN response to the 6LoWPAN Tx message from the access point (depicted on Access Point time axis): Only the one device queried by the AP will reply. ACK and data are separated by 4mS processing.

Device MAC Response Packet Retry 1
30 bytes max.

Device MAC Response Retry Window 2 (5ms)

This is a second retry window for a failed *Device MAC Response Packet* from the previous superframe, for which a the first retry during *Device MAC Response Transmit Retry Window 1* of that superframe failed. There is a 5ms window in which this packet is allowed to be sent. The Access Point responds with an ACK (depicted on Access Point time axis). If an ACK is not detected from the AP, there will be no more transmit retries for this packet.

Device MAC Response Retry Window 1 (5ms)

This is a retry window for a failed *Device MAC response Packet* that occurred in this superframe. There is a 5ms window in which this packet is allowed to be sent. The Access Point responds with an ACK (depicted on Access Point time axis). If an ACK is not detected from the AP, a second attempt to transmit this packet will be made in *Device MAC Response Transmit Retry Window 2* of the next superframe..

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WORST CASE AVERAGE TRANSMIT TIME AS CALCULATED FOR SAR RULE PARTS

This section shows the average SAR calculations for FCC and ISED using the transmit duty cycle. The duty cycle calculation for this purpose defines the time period as the full message cycle, as per FCC and ISED rules. The full message cycle is the same as the superframe, or 245.76ms.

Per the manual and functional description, the device usage (and therefore, on-time) is limited to button pushes by the user under emergency conditions. In reality, a user can go days/weeks/months without having to initiate a transmission. Since the device sends a regular supervision signal once per hour, we will base our worse-case on-time assuming a user would initiate a transmission once every 3 seconds for a full hour. This shows the total amount of on-time one can expect to see in a one hour period, also taking into account the regular supervision signal.

Referring to the timing diagrams on the previous pages, it is seen that all of the sensor's RF6 transmissions are captured within a superframe:

Device MAC Response Packet: 30 Bytes @ 250 kbps = (30 * 8) * (1 / [250*10^3]) = **960 uS**
Device MAC Response Packet Retry 1: 30 Bytes @ 250 kbps = (30 * 8) * (1 / [250*10^3]) = **960 uS**
Device MAC Response Packet Retry 2: 30 Bytes @ 250 kbps = (30 * 8) * (1 / [250*10^3]) = **960 uS**
6LoWPan Response Packet: 128 Bytes @ 250 kbps = (128 * 8) * (1 / [250*10^3]) = **4096 uS**
Ack Message Packet: 5 bytes / Ack @ 250 kbps = (5 * 8) * (1 / [250*10^3]) = **160 uS**

Transmit-on time per Single Button Push = [Device MAC Response Packet Retry 2] + [Device MAC Response Packet] + [ACK] + [6LoWPAN Response Packet] + [Device MAC Response Packet Retry 1]

= 960uS + 960uS + 160uS + 4096uS + 960uS = **7136uS**

Regular Supervision Signal (once per hour) = 30 Bytes @ 250 kbps = (30 * 8) * (1 / [250*10^3]) = **960 uS**

Thus, over a 1-hour period and at a rate of one button push every 3 seconds, one could expected a maximum of 1200 button pushes

So the total expected on-time over a 1-hour window would be → (7136uS * 1200) + 960uS = **8564.16mS, or 8.564s**

This makes the duty factor, for purposes of calculating the SAR correction, equal to 8.564s/3600s, or **0.238%**.

This equates to a 10log(0.238/100), or **–26.2 dB** correction to determine average output power from burst power.

The maximum rated conducted output power averaged over a 60 minute period becomes:

12.98dBm – 26.2dB = -13.3dBm, or 0.05mW

This value is far below the 5mm distance threshold value of 10mW per the table "SAR Exclusion Threshold for 100MHz – 6GHz and ≤ 50mm" of Appendix A of KDB 447498 D01 General RF Exposure Guidance v06. As such, the SAR test exclusion is claimed.