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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 two pages.

DUTY FACTOR

Duty factor calculations for average radiated emissions are on the pages following the timing diagram.

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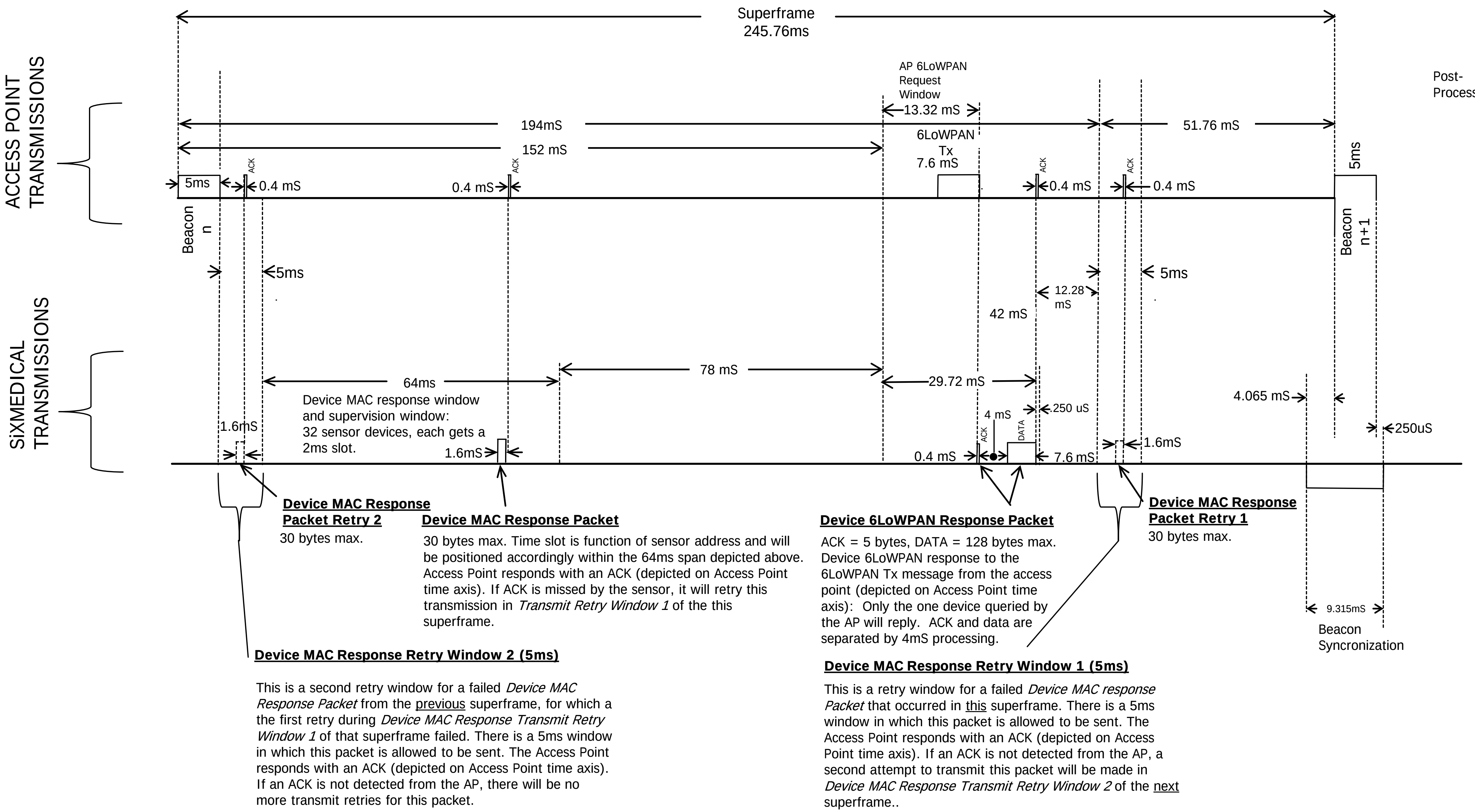
TIMING DIAGRAM

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



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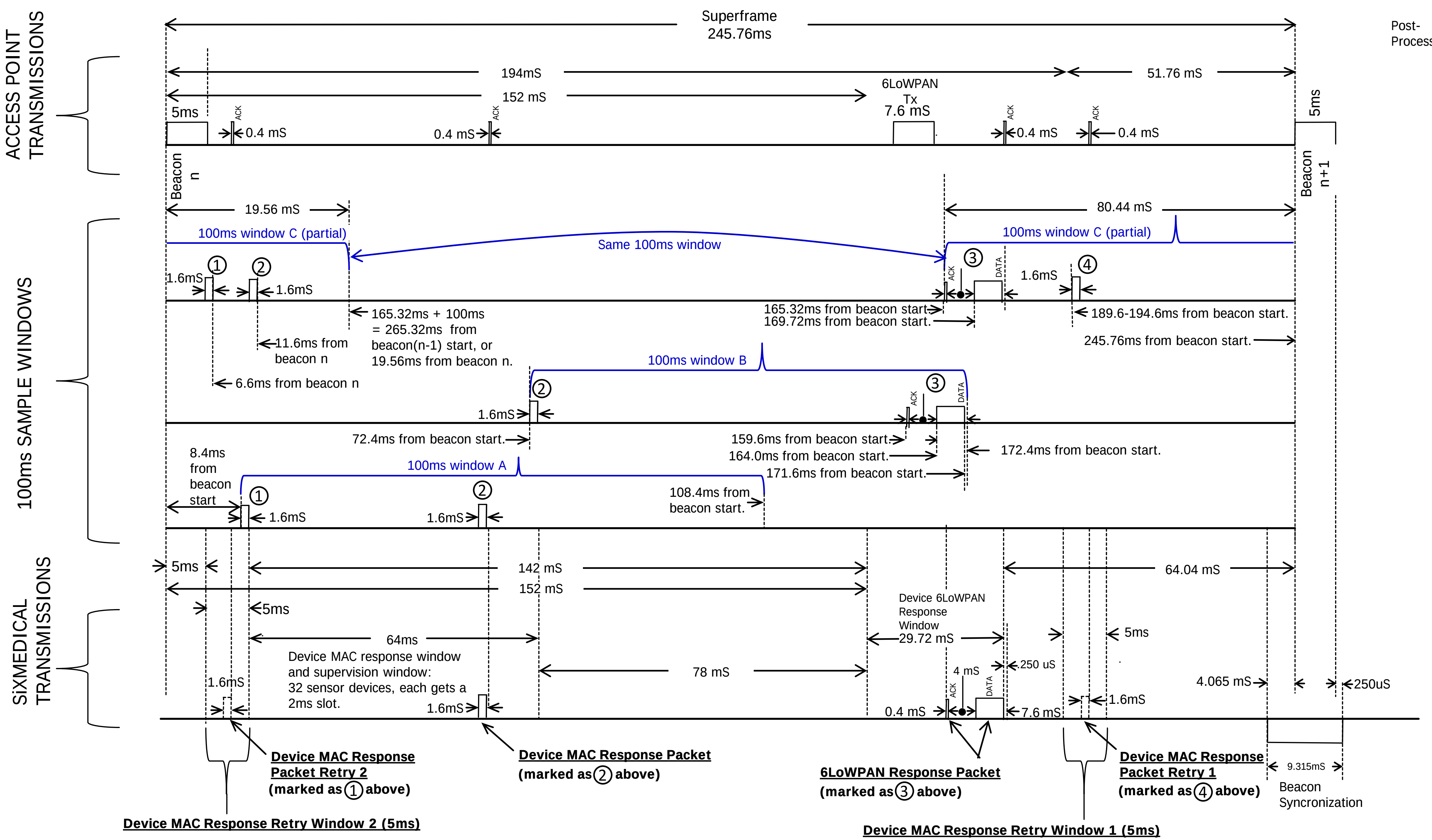
CFS8DL6MED / 573F-6MED

TIMING DIAGRAM WITH 100ms WINDOWS SUPERIMPOSED

Three 100mS windows are drawn to find max Tx-on time, which will be used to determine the duty factor for average power calculations.



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WORST CASE TRANSMIT TIME FOR DETERMINED FOR AVERAGE RADIATED EMISSIONS

This section shows the average radiated emissions calculations for FCC and ISED using a duty cycle. The duty cycle calculation uses a 100ms window as per the FCC and ISED rules.

Referring to the timing diagrams on page 3, it is apparent that the following RF6 transmissions may be captured within a 100ms window, depending on where the window is placed:

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**

To find the worst case, three 100ms windows were applied to the timing diagram. These are shown in blue. For each 100ms window, the starting edge was justified to the starting edge of one of the different packet transmissions listed above, and the transmit time in the 100ms window was summed. Each transmission has a variable start time. So, for each 100ms window, the transmit packets were time-adjusted such that the largest possible segment of each transmission fell inside the 100ms window. The total transmit time for each transmit window is given below.

100ms window A
Transmit time = [Device MAC Response Packet Retry 2] + [ACK for 6LoWPAN Response Packet]
= 960uS + 960uS = **1920uS**

100ms window B
Transmit time = [Device MAC Response Packet Retry 2] + [ACK] + [6LoWPAN Response Packet]
= 960uS + 160uS + 4096uS = **5216uS**

100ms window C
Transmit time = [ACK] + [6LoWPAN Response Packet] + [Device MAC Response Packet Retry 1]
+ [Device MAC Response Packet Retry 2] + [Device MAC Response Packet]
= 960uS + 160uS + 4096uS + 960uS + 960uS = **7136uS**

The worst case transmit time out of the three above 100ms windows is 7136uS.

This makes the duty factor for purposes of calculating average radiated emissions equal to 7.136ms /100ms, or 7.136%. This equates to -22.9 dB:

Duty factor = 7.136% or -22.9 dB.