MPE Calculations for Skylinks Unit

For calculations shown below, the case of **General population/uncontrolled** exposure limits for Mobile equipment is assumed.

Effective Isotropically Radiated Power (EIRP) = Pout (mWatts) * antenna's numeric gain, which yields

EIRP = 4 W x 2 = 8 Watts = 39 dBm

This is above the 1.5 -watt limit stated in paragraph 3 of page 41, which requires that this case be examined for compliance with the MPE limits, and for determination of the minimum safe distance from the antenna.

In above calculation the numeric gain of the antenna was inserted. The antenna's gain has been listed, by the manufacturer, to be 3 dB; and converts to a **numeric gain** of **2** using the equation $\mathbf{G = 10^{(dB/10)}}$ in page 20 of the OET 65.

From Table 1 in Appendix A of the OET bulletin 65;

MPE = f/1500 = 450/1500 = 0.3 (mW/cm^2).

For the worst-case calculation, the lower frequency in the operating band 450 – 470 MHz has been used.

From Equation 3 in page 19 we have:

$$S\ (mW/cm^2) = P\ (mW) * G\ (\text{numeric gain}) / 4\pi R^2.$$

Where R is the separation distance from the center of the radiating structure, and is measured in centimeters. Plugging in for the variables results in:

$$\mathbf{0.3 = 4000 * 2 / 4pR^2}$$

Which then yields a separation distance of:

$$\boxed{R = 46.1\ cm}$$

Source-Based Time-averaging Method:

It should be noted that the unit transmits for controlled duration of 50 ms once every 3.85 seconds. If the source-based time-averaging method is used, as permitted under §2.1091 (d) (2), the following should apply.

The worst-case duty factor method is used for the following calculations:

The base station transmits a message to all cart units. The cart units (here on referred to as the head units) take turn to respond with the requested information in the predetermined allowed period (60 ms = 50 ms transmit + 10 ms silent period).

An example is shown below. The worst-case scenario, where the minimum number of golf carts may have been deployed in a golf course with the maximum time of transmission allowed for each unit, has been considered for these calculations.

Period = T,
Each cart transmits once during T,
50 ms transmit time every 6 seconds (typical) + 10 ms silent time
50 ms transmit time every 3.85 seconds (worst-case) + 10 ms silent time

The total time allowed for all 40 carts to each have their turn to transmit is then,
60 ms x 40 cart units = 2400 ms.

Then the total period for the case of 40 cart units is:

$$T = 1000 + 150 + (60 \times 40) + 300 = 3850 \text{ ms} = 3.85 \text{ sec},$$

and the process repeats itself.

The following calculations are provided here considering the duty-cycle method by using the following equation.

$$\mathbf{S\ (mW/\ cm^2) = (D) * P\ (mW) * G\ (numeric\ gain) / 4p\ R^2}$$

The duty cycle **(D)** of transmission by each unit is included in this equation, and is calculated below.

$$D = t_{on} / (t_{on} + t_{off}) = t_{on} / T$$

D = 50 ms / 3.85 s = 0.013 or 1.3%

Plugging in the numbers and solving for R yields:

R = 5.25 cm.

This distance is less than the recommended minimum distance for MPE calculations for mobile devices (i.e., the 20-cm minimum separation distance). Therefore, it is proposed that the labeling requirements are withdrawn/waved, since the current antenna mounting location guarantees the required separation distance.

The above calculation is based on the source-based time-averaging. This is the case for this product, since the transmission from the unit is under software control. The look-up table in the software determines the total amount of time a given unit/cart is allowed to transmit. There could be as many as 40 to 60 golf carts deployed in a given course.

The Software Routine:

Shown here is the routine (as a part of skycomm.ini program) that applies the source-based control.

```
[TimingMaps]
MapName = "Normal"

                    Blk Type        Slot    Freq    First   Last
TimingBlock = Base                  1000    0
TimingBlock = correction            150     0
TimingBlock = slave                 60      0       1       40
```

TimingBlock = padding	250	0		
MapName = "Transfer"				

Blk Type	Slot	Freq	First	Last
TimingBlock = Base	2000	0		
TimingBlock = correction	150	0		
TimingBlock = slave	60	0	1	40
TimingBlock = padding	250	0		

Glossary of terms used in the above code:

Timing Map: A set of timing blocks that define a transmission cycle for the radio network. The cycle repeats itself.

Timing Block: One portion of a timing map that defines which node(s) are active and for how much time.

Normal: The timing map used during normal operation of SkyLinks.

Transfer: The timing map used during the installation of SkyLinks. This timing map functions similarly to the normal map, but allows for greater outgoing (base to cart) bandwidth.

Base: A type of timing block allowing for base (pro-shop) transmission.

Slave: A type of timing block allowing for slave (vehicle) transmission. Each slave defined in this block is allowed to transmit in turn for the specified slot duration. Example: Cart 1 gets 60ms, cart 2 gets 60 ms, etc.

Padding: A timing block during which no transmissions are allowed.

Slot: The duration of timing blocks in milliseconds. For the slave timing block, the total duration is the "slot" multiplied by the number of vehicles.

Freq: Defines the radio frequency to be used during a particular TimingBlock. This value is an index into a defined array of possible radio frequencies available for use at a course.

First: Defines the first of a range of vehicle numbers to be scheduled into a Slave TimingBlock

Last: Defines the last of a range of vehicle numbers to be scheduled into a Slave TimingBlock

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