

## **FCC Antenna Duty Cycle Analysis:**

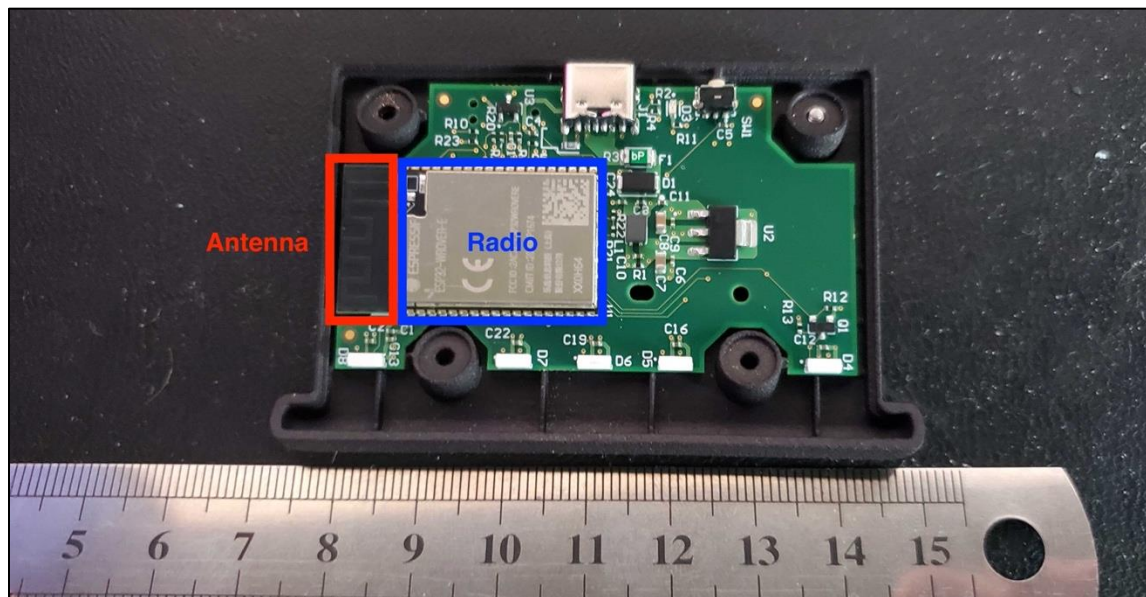
### **Device Overview:**

The DeskWizard is a desk reservation system that empowers users to easily find and reserve a place to work in an office with shared workspaces. Once reserved, the device's LED edge lighting will switch to a different color thus communicating a particular status for a workspace e.g. available for reservation, occupied, needs cleaning, etc.

The DeskWizard employs a BLE/Wi-Fi radio that operates at 2.4 GHz with one antenna embedded in the radio PCB. The radio operates only one technology i.e. only BLE or Wi-Fi will operate and not both simultaneously.

### **Location of Radio in the Device:**

The host processor (radio) employed in the DeskWizard is an Espressif Model ESP32-WROVER-E module with support for BLE v4.2 as well as 802.11b/g/n (Wi-Fi). As shown in the image below, the radio is secured to the lower half of the product enclosure with the antenna located on the left-hand side.



### **Device Location in Workspace:**

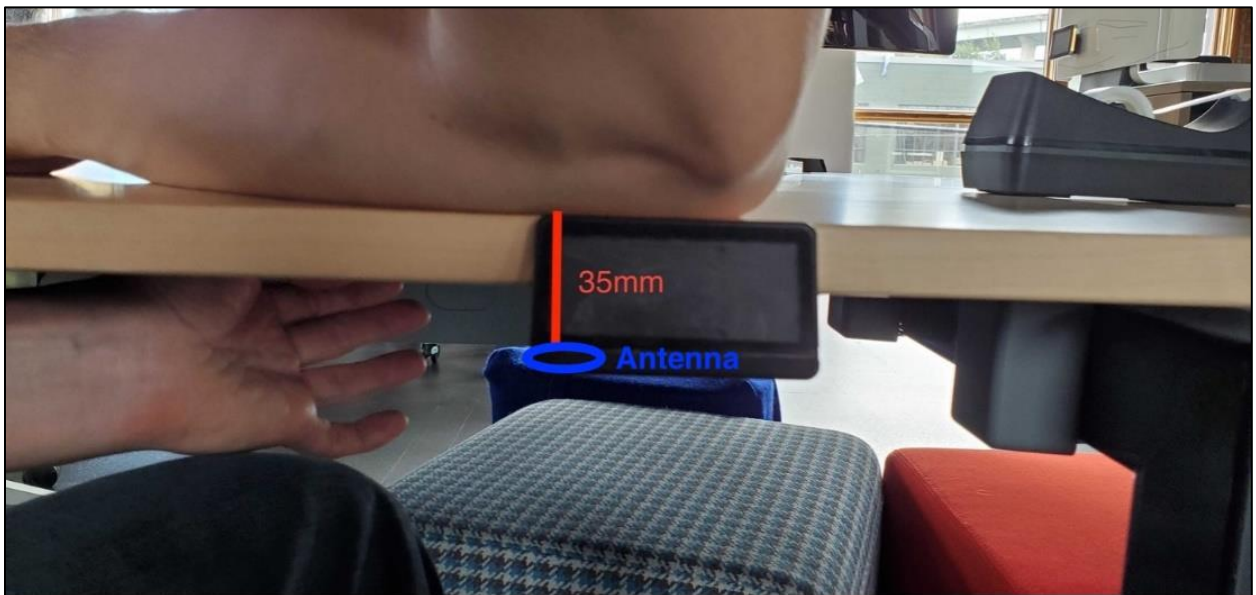
The device is attached to the front underside of a desk (default method) or may be located on top of the desk, and is located on either the far right-hand or far left-hand side of the desk.

The following image illustrates the default location of the device relative to the workspace.



**Example of Worst-Case Exposure Condition - Front View:**

In the worst-case placement (located on underside left-hand side of the desk), a human arm may be as close as 35 mm to the antenna.



**Example of Worst-Case Exposure Condition - Side View:**



### **Overview of Device Setup and General Operation/Use:**

When the device first receives power, it initializes, and the radio begins advertising via BLE. Once the installer scans the device's QR code with the setup tool via a smartphone, the device pairs with the smartphone. The installer then enters the Wi-Fi credentials to the access point, where BLE is then inactivated, and Wi-Fi is activated. The setup process from pairing to Wi-Fi activation is completed within 30 seconds. During setup the installer will be located minimum 20 cm from the DeskWizard.

In general operation (once setup is complete) the device receives status updates through the Steelcase's IoT backend (via communication with a 2.4 GHz Wi-Fi access point).

### **Duty Cycle Analysis for Device Setup (BLE):**

#### **Measurement Methodology:**

The programming session (device setup) was monitored in zero span (time domain) using a spectrum analyzer with a nearfield probe to capture transmission activity. A threshold was applied to the data set to distinguish between transmissions on channel. The threshold was determined to be a transmission measured above -50 dBm. Transmissions measured above this

threshold were captured as true transmissions and summed over the duration of the device’s programming session. Note each transmission event (pulse) lasted for 1 milli-second.

Because BLE uses 40 channels, it is assumed worst-case there are simultaneous transmissions across all channels. Therefore, the total on-time duration of a single channel during the programming session is multiplied by 40 to determine the total on-time during an observation period.

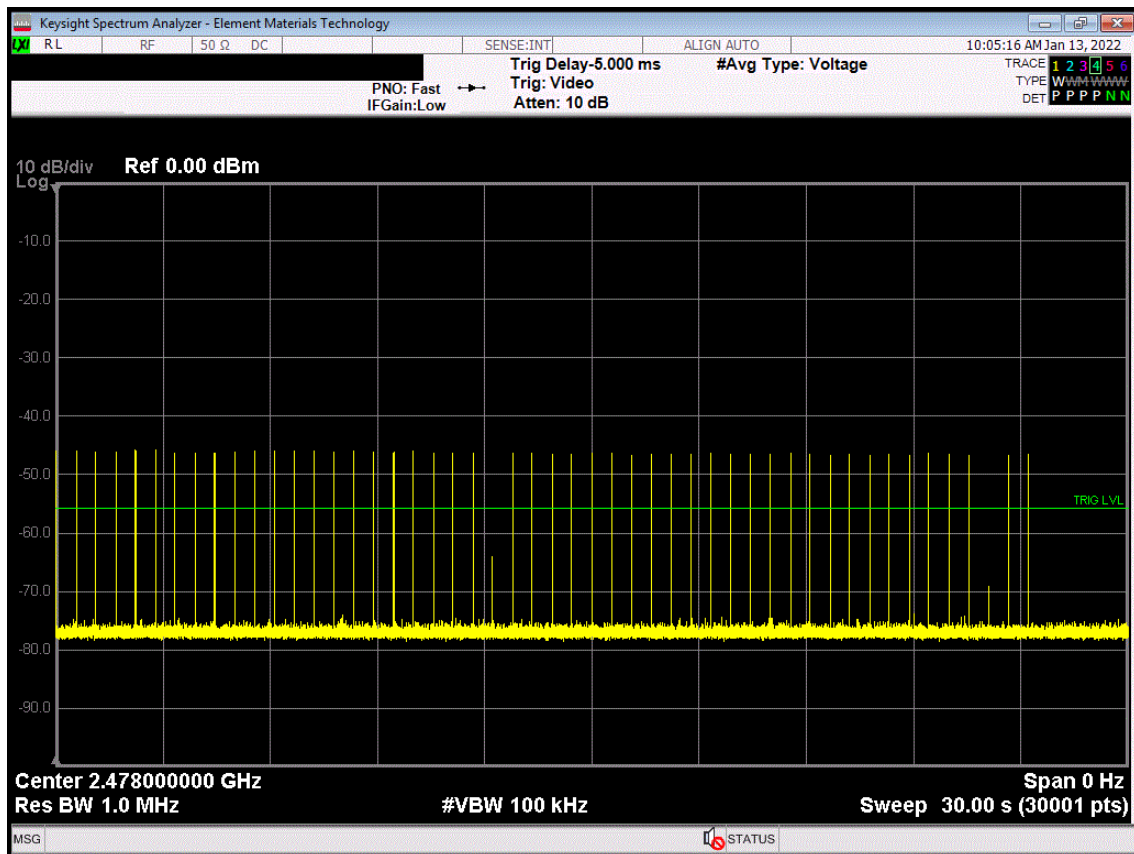
**Results:**

The total duty cycle over the observation period is calculated as follows:

$$\text{Total Duty Cycle} = \# \text{ Pulses} * \text{Pulse Duration (1 ms)} * \text{Total Number of Channels (40)} * (1 \text{ s}/1000 \text{ ms})/\text{Observation Period (s)}$$

Number of Pulses observed	Total On-time (ms)	On-time across 40 channels (ms)	Observation Period (s)	Duty Cycle (%)
65	65	2600	1800 (30 min)	<b>0.14</b>
65	65	2600	360 (6 min)	<b>0.72</b>

**Figure – Spectrum Analyzer Display Screen Capture, Illustrating Transmission Events (Pulses) During Programming Session:**



## **Duty Cycle Analysis for General Operation/Use (Wi-Fi):**

### **Measurement Methodology:**

A DeskWizard sample unit was setup and paired with a host router connected to an Internet Service Provider (ISP). The DeskWizard operated in 802.11b mode while under test due to the highest transmission duty cycle compared to the other modes 802.11g and 802.11n.

Transmission traffic was monitored with the use of the WireShark network protocol analyzer application, running on an Apple Macbook Pro 2015. Via the WireShark application, “Promiscuous mode” was enabled allowing the application to selectively isolate and capture communications between specific MAC addresses i.e. the sample unit and host router. In other words, the application filtered and discarded wireless communication traffic between other devices except for the sample unit and router.

The WireShark application analyzed the Antenna Duty Cycle under two captures that were determined as worst-case exposure conditions.

For the first capture, a DeskWizard continually performed an Over-The-Air (OTA) update over a duration of thirty (30) minutes to capture the **worst-case** Duty Cycle.

- OTA updates will be performed infrequently (less than once per month at a duration of 1-2 minutes during off-peak hours at a customer facility i.e., no user is likely present).
- For testing purposes, a simulated OTA cycle operated for 30 minutes because it represented the highest worst-case volume of radio traffic and therefore the worst-case exposure condition possible.

The second capture was of a **normally operating** DeskWizard device over a duration of sixty (60) minutes to capture the **normal** Duty Cycle.

- During normal operation, the DeskWizard sends out telemetry messages once every five minutes (duration <5ms) and otherwise maintains a ‘stand-by’ connection to the Wi-Fi Access Point.
- A few times per day, the DeskWizard device will receive status changes from a backend application and respond with updated information. This instance duration is also <5ms with comparable radio traffic.
- These status updates and responses involve very small packet sizes and will not approach the Duty Cycle observed during the OTA capture.

### **Results:**

WireShark calculated the transmission time for each packet by using the frame length and modulation. The Transmission (TX) Duty Cycle was calculated using the following formula:

$$TX \text{ Duty Cycle (\%)} = \frac{\text{Total TX Time (}\mu\text{S)}}{\text{Test Duration (}\mu\text{S)}} * 100$$

The results of the first capture of the DeskWizard continually performing OTA updates for thirty (30) minutes were summarized in the table below.

Test Duration (Microseconds)	Transmitted Packets	Average Packet Length (Bytes)	Total TX Time (Microseconds)	Calculated TX Duty Cycle (%)
1800000000	48758	140.301099	2941360	<b>0.16</b>

The results of the second capture of the DeskWizard operating normally for sixty (60) minutes was summarized in the table below.

Test Duration (Microseconds)	Transmitted Packets	Average Packet Length (Bytes)	Total TX Time (Microseconds)	Calculated TX Duty Cycle (%)
3600000000	1600	93.619375	846817	<b>0.02</b>

End of Report