

**WiFi Lab 2019 Trial Event Rule**  
(A.K.A Radio Lab)  
(Physics Committee; revised October 2017)

1. **DESCRIPTION:** Teams construct an antenna prior to the tournament that is designed to transmit a signal at 2.4 GHz and complete a written test on the principles of electromagnetic wave propagation.

**A TEAM OF UP TO:** 2

**EYE PROTECTION:** No

**IMPOUND:** Yes

**APPROXIMATE TIME:** 50 Minutes

2. **EVENT PARAMETERS:**

- a. Each team may bring one three-ring binder of any size containing information in any form and from any source, attached using the available rings. The information may be removed during the written test portion of the event.
- b. Participants may bring writing utensils and two calculators of any type dedicated to computation for use during any part of the event
- c. The antenna, as well as any graphs/tables submitted, must be labeled with the team name and tournament specific team number and must be impounded. Bonus points are given for antennas impounded in a box. Tools, supplies, and three-ring binders do not need to be impounded.
- d. Prior to competition, teams must calibrate their devices by preparing graphs and/or tables showing the relationship between power and distance for various device configurations. A labeled device picture or diagram should be included.
  - i. Any number of graphs and/or data tables may be submitted but the team must indicate up to four to be used for the Chart Score, otherwise the first four provided are scored.
  - ii. Graphs and/or tables may be computer generated or drawn by hand on graph paper. Each must be on a separate sheet of paper. A template is available at [www.soinc.org](http://www.soinc.org).
  - iii. Teams are encouraged to have a duplicate set to use, as those submitted may not be returned
- e. Participants must be able to answer questions regarding the design, construction, and operation of the antenna per the Building Policy found on [www.soinc.org](http://www.soinc.org).

3. **CONSTRUCTION:**

- a. Each team brings one pre-constructed antenna.
- b. The antenna must fit within a 15.0 cm x 15.0 cm x 15.0 cm cube during all parts of the competition and must be supported solely by the backplane and the SMA-Female connector mounted in the backplane.
- c. The antenna must include an SMA-Male connector that can be connected to the backplane connector.
- d. The antenna may be constructed of any materials except for commercial antenna parts or magnets.
- e. The antenna must be entirely passive; no batteries, AC power or other energy sources are permitted.
- f. Event supervisors may prohibit antennas from being tested if they will damage the testing setup (e.g. due to excessive weight/torque, residue on the metal sheet, etc.)

4. **THE COMPETITION:**

**Part I: Written Test**

- a. Teams will be given a minimum of 20 minutes to complete a written test consisting of multiple choice, true-false, completion, or calculation questions/problems.
- b. The written test will consist of at least five questions from each of the following areas:
  - i. The Electromagnetic Spectrum, radio waves, and EM wave propagation
  - ii. Relating velocity, wavelength, and frequency for waves, with emphasis on radio waves
  - iii. Common antenna designs, compare/contrast different types of antennas
  - iv. Gain patterns, the radar equation, impedance, bandwidth, noise, and information
- c. Unless otherwise requested, answers must be in metric units with appropriate significant figures.

**Part II: Device Testing**

- d. Teams have a total of 5 minutes to adjust and repair their antenna, and make 3 connection attempts. Event supervisors will give teams a warning at 4 minutes.
- e. Supervisors will check antenna specifications during impound or right before a team's testing period. Teams must be notified as soon as possible if an antenna is out of spec. Teams may modify the antenna to bring it into compliance during impound or their 5-minute testing period, if time is available.
- f. Once the 5 minutes testing period begins, teams may select a starting distance (measured to the nearest 50.0 cm) at which to have the event supervisor place the receiver unit.
- g. Prior to each connection attempt, teams may connect, disconnect, modify or adjust the antenna and the position of the antenna and metal sheet relative to the transmitter. Teams must not move the transmitter.
- h. Once a team is ready for testing, they must step at least 5 feet away from the antenna, and notify the event supervisor.

- i. The event supervisor will then measure the average dBm reading over a 10 second period using the receiver unit. Antennas not meeting construction specifications at the beginning of the measurement period must be judged as failing the connection attempt. Modifications are not allowed during the measurement period.
- j. Connection with the receiver is defined by an average (over 10 seconds) measured dBm reading equal to or higher than the threshold dBm reading obtained by the supervisor's 3.1 cm monopole antenna.
- k. If connection was achieved, the team may elect to move the receiver to a farther distance for their next attempt. If connection was not achieved, they may elect to move the receiver to a closer distance for their next attempt but must not be allowed to move to a farther distance for their next attempt.
- l. Event supervisors must record the distance of all attempts and whether the connection was successful.
- m. Teams that achieve connection at the longest possible distance (as determined by the competition venue) must have their average dBm reading recorded as a bonus.
- n. **The supervisor will review with the team the Part II data recorded on their scoresheet.**
- o. A team filing an appeal regarding Part II must leave their antenna in the competition area.

#### 5. **THE TEST SETUP:**

- a. Example setups are provided on the event page at [www.soinc.org](http://www.soinc.org)
- b. The event supervisor will provide the testing materials listed below, which will be the same for all teams:
  - i. A transmitter that supplies a 2 mW, 2.4 GHz, 802.15.4 encoded signal (e.g. a standard WiFi access point / router with external antennas)
  - ii. A **~30.0 cm x ~30.0 cm x ~0.05 cm** metal sheet attached to a tripod with an SMA-F connector in the middle (backplane)
  - iii. Adapters and an antenna cable to connect the transmitter to the metal sheet
  - iv. A receiver that can display the received power in dBm with at least -80 dBm sensitivity. (**Acrylic WiFi Home is recommended for PC machines. KisMac is recommended for Mac machines.**)
  - v. A 3.1 cm monopole antenna for setting the connection threshold dBm value
- c. Tournament personnel are encouraged to provide a long space for antenna testing and share room specifications with all participants at least two weeks before the competition.
- d. The event supervisor will set up the transmitter and receiver on surfaces that are of equal height that are at least 50.0 cm above the floor. Once positioned, the setup must stay the same for all teams.
- e. Prior to the start of competition, the event supervisor will test their provided 3.1 cm monopole antenna at a distance of 3.0 m to determine the connection threshold dBm reading.

#### 6. **SCORING:**

- a. A scoring rubric is available on the event page on [www.soinc.org](http://www.soinc.org)
- b. Final Score (FS) = ES + AS + CS + IB + MB. High score wins.
- c. Antenna Score (AS) = (greatest successful distance / greatest successful distance of all teams) x **38** points
- d. Exam Score (ES) = (Part II score / highest Part II score of all teams) x **45** points
- e. **One of the submitted graphs and/or tables, selected by the event supervisor, must be scored as follows for the Chart Score (CS, max of 10 points). Partial credit may be given.**
  - i. **2 points for including data spanning at least 5m distance**
  - ii. **2 points for including at least 10 data points**
  - iii. **2 points for proper labeling (e.g. title, team name, units)**
  - iv. **0.5 points for each graph or table turned in (up to 2 points total as long as they are not the same)**
  - v. **2 points for a labeled device picture or diagram**
- f. **Impound Bonus (IB) = 3 points if antenna impounded in a box labeled with team name & number**
- g. **Max Bonus (MB) =** If multiple teams achieve connection at the maximum distance, the team with the highest dBm reading at the maximum distance will receive a bonus of **four** points.
- h. AS must be zero if a team has no successful connection attempts, is disqualified for unsafe operation, or fails to bring an antenna. Teams must still be allowed to compete in Part I.
- i. The connection distance must be multiplied by 0.7 when calculating AS if any construction violation(s) are corrected during Part II or if the team misses impound.
- j. **A team violating any COMPETITION rules during a successful attempt will have their connection distance for that attempt multiplied by 0.9 when calculating AS.**
- k. **Tie breakers:** 1st - Best AS; 2nd - Best dBm at Max Distance; 3rd – # successful connections; 4th - specific test questions

**Recommended Resources:** Reference and training resources are available on the Science Olympiad Website at [www.soinc.org](http://www.soinc.org).