

Detector Building

1. **DESCRIPTION:** Teams must design, build, program, and a test an *instrument that will measure changes in a single environmental condition (e.g., temperature, light, humidity, sound) and display the measurement using the appropriate units.*

A TEAM OF UP TO: 2 **EYE PROTECTION:** None **IMPOUND:** Yes **APPROX. TIME:** 10 min.

2. **EVENT PARAMETERS:**

- a. Teams need to bring their *device*, design & testing log, any tools required, and whatever *resources* (e.g. laptop) *needed to program their device to respond to the changing environmental conditions.*
- b. Event Supervisors will provide the necessary equipment to test each *device's* ability to detect and signal changes in the designated environmental condition for that competition year *at a set standard as well as across two different ranges.*

3. **CONSTRUCTION PARAMETERS:**

- a. *Each year, the environmental condition* (e.g. Light Level, Sound Level, Motion, pH, CO₂ concentration, O₂ concentration) *to be measured will be identified in the Event Rules.* The environmental condition to be measured will be the same for all teams *and at all tournaments. At each tournament, the event supervisor will inform the teams which ranges the device should be programmed to detect. These ranges will be the same for all teams at that tournament.*
- b. *Devices should be built using a microcontroller* (e.g. TI Innovator, Raspberry Pi, Arduino), *a display, LED lights, an alarm, and a sensor/probe that produces a voltage dependent on the physical stimulus provided. The device maybe connected to a laptop, or other handheld device, powered by battery without built-in/internal environmental sensors/probes that functions as a display or programming interface device. The sensor/probe should be made water proof for total immersion.* Sensor/probe may not be constructed using *pre-calibrated, preassembled* sensors/probes (e.g. Vernier, PASCO).
- c. *The device, and any associated elements, must function on an independent power supply. No element can be plugged into an electrical outlet at any time during the competition.*
- d. *The device must be calibrated to detect the selected environmental condition for that year. In addition, the device must respond differently to two different ranges of the designated environmental condition through the use of LED lights and/or an alarm.* The exact *ranges* of the environmental condition detected will be provided to the competitors at the start of their 10-minute time.
- e. Teams will also need to submit a Design Log with their device at Check-In. This Design Log should contain:
 - i. A detail drawing or illustration of the device identifying all the components and their function.
 - ii. An explanation of the programing language used, a written copy of the programing code that is used to operate the device, and an indication of, as well as a source for, any programing code that was not originally written or developed by the competitors.
 - iii. *The mathematical modeling function and the calculations used to convert the sensor/probe output voltage into the calibrated output shown on the device display.*
 - iv. A written practice log that details at least 10 trails of the device for *2 different ranges* of the environmental condition indicating the *range* of the environmental condition detected, the time it took to detect that condition, and the responses, or alarms, produced.
- f. Each *device, and associated impounded items*, must be labeled so the Event Supervisor can easily identify to which team *they* belong.
- g. Competitors must be able to answer questions regarding the design, construction, programing, and operation of the device per the Building Policy found at www.soinc.org.

4. **THE COMPETITION:**

- a. The *device*, power supply, spare parts, design log, and *other materials* must be impounded before the start of the competition. Tools need not be impounded.
- b. Only competitors and event supervisors are allowed in the impound and competition areas. Once competitors enter the event area, they must not leave or receive outside assistance, materials, or communications.

- c. Teams are given 10 minutes to set up their *device* and complete 3 trials: **1) detection of an environmental constant, 2) detection of a broad-range of environmental condition, and 3) detection of a narrow-range of environmental condition.** Devices activated for any trial before the end of the 10-minute time period will be able to complete the trial.
- d. At no point during a trial may the *device* be connected to a power supply.
- e. Teams may adjust their *device* before each trial (e.g. adjust the program, reset an alarm, clean a detector, charge the device) within their 10 minutes providing the device continues to meet specifications.
- f. A trial will begin when the Team activates their device and continue until the *device* detects the identified environmental *measurement or range* (i.e. the specified noise level). **At that point, the event supervisor will stop the 10-minute timer and record the measurement value displayed on the device as well as the value measured by an appropriate device provided by the event supervisor.** The values will be recorded to the precision of the *device*.
- g. **The Event Supervisor will then reset conditions to allow for a second trial.** Once the environment is ready the 10-minute timer will restart and competitors will be able to make any adjustments or reset their *device*. **Upon completion of the second trial, the 10-minute timer will be stopped and preparations made for a third trial.**
- h. At any point where the specified environmental *value or range* have been exceeded without the sensor performing the indicated alarm the team can notify the Event Supervisor that they would like to declare a Failed Run. The competitors can then deactivate their device and make adjustments through the 10-minute timer still continues.
- i. The Event Supervisor must *share* with the team the correct recording of data on the team scoresheet.
- j. Teams who wish to file an appeal must leave their design log and sensor with the event supervisor.

5. SAMPLE TASKS/STATIONS/QUESTIONS:

An example of one possible iteration of this event would be to have the students design a *device* to detect different *temperature ranges* in a solution. The students could build this device using a TI Innovator hub as the *microcontroller*, a *TI NSPIRE calculator as the display device*, and a *LM19 Analog Temperature Sensor*. **The Event Supervisor would start the competitors' trials by having them use their device to measure the temperature of an unknown solution. After recording the data from this trial, the Event Supervisor tells the competitors that the device needs to identify when the solution has a temperature between 5 °C and 10 °C. The timer begins and the participants would program their device to flash a green LED when the solution has a temperature between 5 °C and 10 °C. Once the run is completed and data recorded, the timer stops and the Event Supervisor would then tell the participants that the device now needs to detect when the temperature exceeds 70 °C. The timer begins and the participants would program their device to flash a red LED when 70 °C is exceeded. Once the run is completed, the timer stops and the Event Supervisor would then record the data and share results with the participants.**

6. SCORING:

- a. *Devices determined to be in violation of construction rules 3.b or 3.c will not be tested.*
- b. *A total score for each team will be determined as follows:*
 - (1) *Standard Score: The percent error during the standard measurement trial x 30 points*
 - (2) *Board-Range Score: The percent error during the broad-range trial x 20 points*
 - (3) *Narrow-Range Score: The percent error during the narrow-range trial x 50 points*
- c. Team with the lowest **Total Score** wins.
- d. If there is a tie, **the lowest average percent error across all three trials should be used to break it.** If a second tie-breaker is needed **the time remaining on the 10-minute event timer** should be used.
- e. Teams that do not successfully complete **the three** trials will be ranked behind teams that do complete **the three** trials.

7. RECOMMENDED RESOURCES:

TI-Innovator Hub:

<https://education.ti.com/en/products/micro-controller/ti-innovator>

Raspberry Pi:

https://en.wikipedia.org/wiki/Raspberry_Pi

<https://www.raspberrypi.org/help/videos/>