

# EduForce™ Module & Remote User's Guide

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This User's Guide is written to provide basic information about the operation of the BioForce Analytics EduForce™ Module ("Module") and EduForce™ Remote ("Remote"). Information contained in this document will guide the user on the physical characteristics of the equipment, technical specifications, and maintenance required to operate the equipment. Information on using the Module / Remote to collect motion data is contained in the *EduForce Dashboard User's Guide*. Users should use the *SINC™ Technology User's Guide* for information on using the Module to capture motion and video data simultaneously.

# Module Operation

## The Module

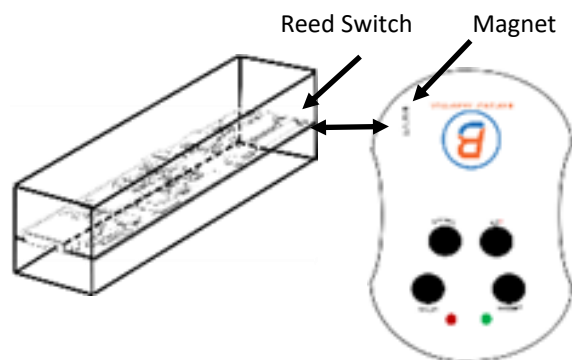
The EduForce Module is designed for use in the classroom, providing state-of-the-art motion data previously unobtainable through the use of stopwatches, photogates, and sonic rangers. Each of these devices has inherent limitations, by which, students are then limited in the exploration of physics concepts during their own personal experimentation.

The Module's electronics are encased in a silicon epoxy to resist high impacts, such as being dropped on the floor accidentally. The lightweight, compact design allows students the ability to mount Modules on a variety of existing classroom equipment. Instructors can also use a wide range of BFA designed holders, mounts, and equipment to more securely attach modules for use in, *and out of*, the classroom.

There are two (2) primary electronic components to the Module; the Inertial Measurement Unit (IMU) and the Processor. The IMU contains the sensor hardware which collects, then transfers, the motion data to the Module's volatile ("erasable") memory. The Processor contains the firmware (operating commands) for the Module. These two components, along with the on-board non-volatile (permanent) memory, allow the Module to detect, transfer, and store motion data for analysis through the Dashboard (and supporting software).

The Module is connected to the EduForce Dashboard ("Dashboard") via a USB-C style connector ("USB"). The USB allows for two-way communication between the Dashboard and the Module. When connecting and disconnecting the USB it is important to hold the connector ends between your fingers and push/pull the connector firmly into the Module/Computer USB ports. DO NOT PULL THE USB OUT OF A PORT FROM THE CABLE, DOING SO COULD WEAKEN OR DAMAGE THE CONNECTOR ENDS OR THE PORT.

The Module can be powered on ("turned on") in two ways. When the Module is connected to the Dashboard via the USB, the Module automatically powers on and remains on until disconnected from the USB. The Module will then automatically time out (power down) in five (5) minutes. To turn the Module on without connecting it to the USB, simply place the marked corner of the Remote near the Reed Switch of the Module for a few seconds. The Module will power on as indicated by the flashing PCB LEDs.



The Module can be begin communicating with the Dashboard in two ways. When connecting the Module to the computer via the USB *BEFORE* launching the Dashboard, the Module then automatically begins communicating with the Dashboard. The Module can also be connected once the Dashboard has been launched (such as when you are switching between two or more Modules). In the **Education mode** of the Dashboard, simply click “Connect Module” on the appropriate tab. The Dashboard will display a message confirming the connections. ***(It is important to wait until the message displays prior to performing another operation or clicking another button.)*** In the **Advanced mode**, click “Disconnect” (Port Closed will display), then “Refresh Port List” (COM list populates), then select the Module from the COM list (“Current Module Configurations Received and Displayed” will display).

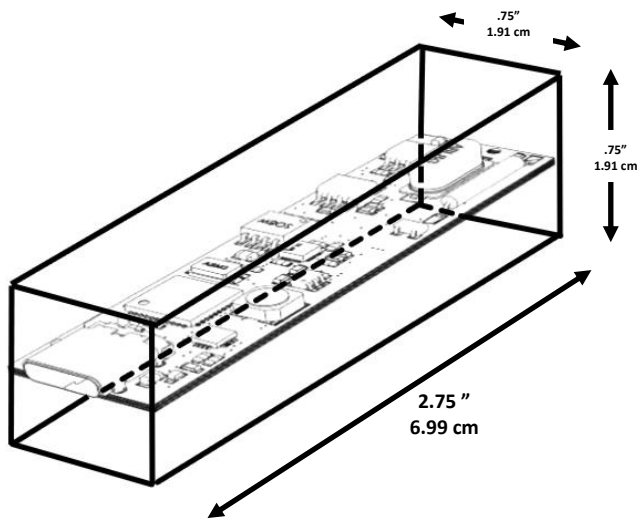
The Module has three basic modes; Off, Stand-By, and Operating (i.e. conducting a trial)

**Off** – The Module is powered down. No LEDs are illuminated. No data is being collected. Power on the Module by connecting to the Dashboard, or manually via the Remote.

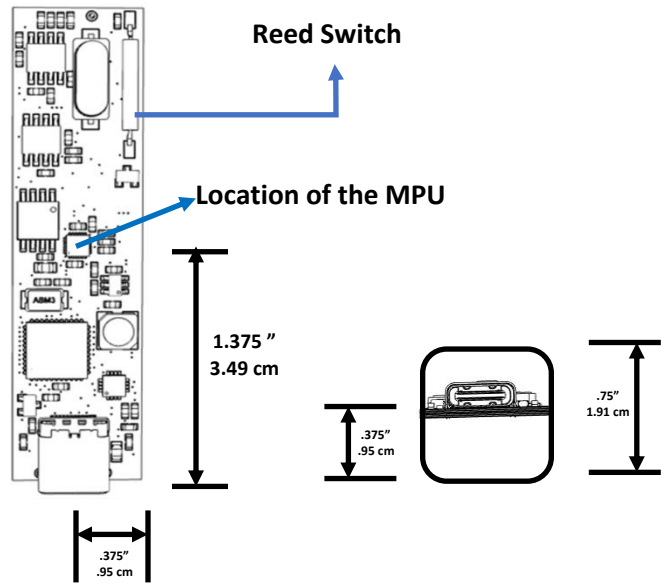
**Stand-By** – The Module is powered up but is not currently performing any functions. The PCB LEDs are flashing, while the Charging and/or Status LEDs may be illuminated. The Module can be in Stand-by while connected to the Dashboard or disconnected from it. Typically the Module is in Stand-By mode while the user is working with the Module through the Dashboard without any current operations being performed, or when the Module has been programmed for a trial, disconnected from the Dashboard and is awaiting the start of a trial. Should the Module power down while waiting for a trial to begin, simply hold the Remote’s magnet (marked on the face of the Remote) near the Reed Switch until the Module powers up (PCB LEDs will begin to flash).

**Operating** – The Module is conducting a trial and collecting data according to the parameters set by the user. The PCB LEDs are flashing, the Status LED will be illuminated (see Appendix A for details). Refer to the *EduForce Dashboard User’s Guide* for more information on programming the Module for use in a trial.

Module Measurements (*nominal*)

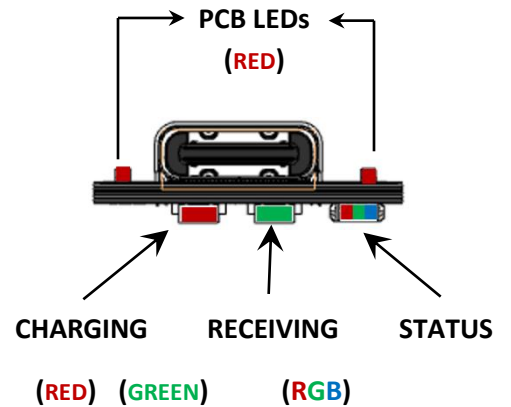
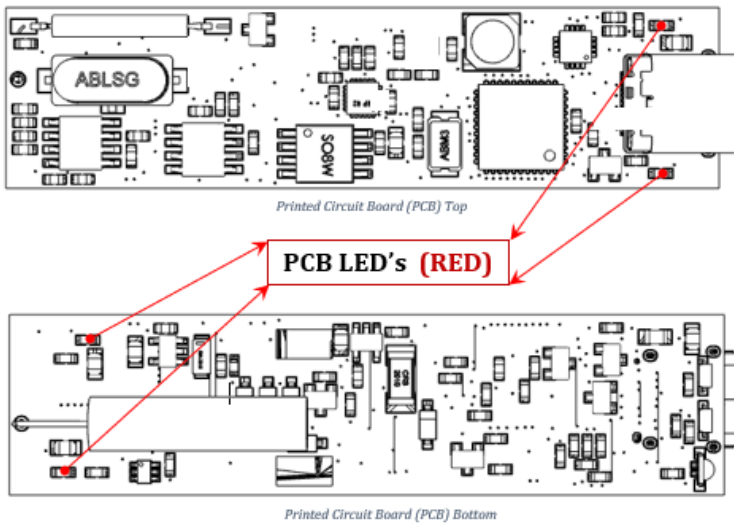


**1.3 Ounces**  
**36.85 g**



LED Locations

The Module has two sets of LEDs, one set on the Printed Circuit Board (PCB) and one set on the USB end-face of the Module. ( Refer to Appendix A: Module LEDs for the specific LED indications. ) The Diagrams below show the relative location of the LEDs on the Module for reference.



## Sensor Axes

The Module is equipped with three sensors – Accelerometer, Gyroscope, and Magnetometer- each measuring along three axes, providing the user with measurements in nine degrees of freedom (9 DOF). The user can select either a timed or untimed test. User-selected inputs are available for Accelerometer and Gyroscope for sample rate, sensitivity, and filtering. (see *Technical Specifications below for details*).

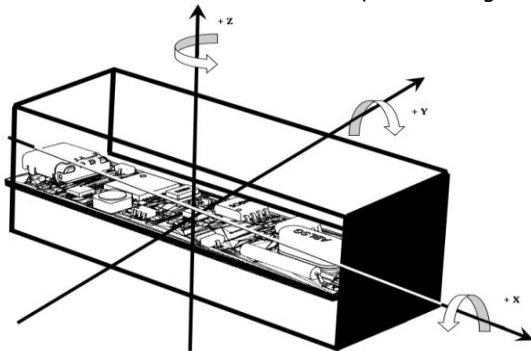
The Education Dashboard uses a proprietary Java-based graph to display data.

- Accelerometer data displayed is Acceleration in  $m/s^2$  for each axis
- Gyroscope data displayed is Rotational Velocity in degrees per second ( $^{\circ}/s$ ) for each axis
- Magnetometer data displayed is Field Strength for each axis

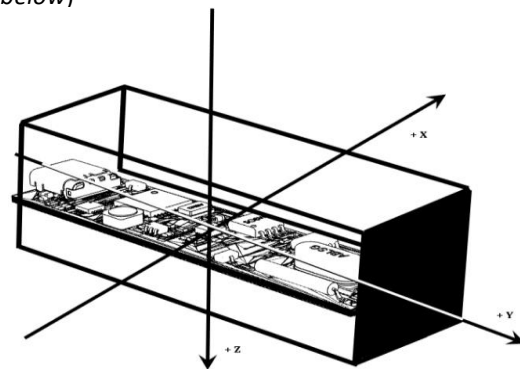
The Advanced Dashboard allows the user to work with either the Java-based graph or an Excel-based graph. The Excel-based graph displays:

- Accelerometer data (3-Axis)
  - Linear Acceleration in  $m/s^2$  (from the module, converted from bit count to data)
  - Linear Velocity in  $m/s$  (integrated from Acceleration)
  - Linear Displacement in  $m$  (integrated from Velocity)
- Gyroscope data (3-Axis)
  - Angular Acceleration in  $^{\circ}/s^2$  (differentiated from Velocity)
  - Angular Velocity in  $^{\circ}/s$  (from the module, converted from bit count to data)
  - Angular Displacement in degrees (integrated from Velocity)
- Magnetometer (3-Axis)
  - Field Intensity (from the module, converted from bit count to data)

The Module's "Positive" X, Y, Z Axis orientation, as determined by the IMU's manufacturer, is marked directly on the Module for the Accelerometer and Gyroscope. The Magnetometer Axis orientation is different from the Accelerometer and Gyroscope. The X and Y Axes of the Magnetometer are  $90^{\circ}$  relative to the other sensors while the Z Axis is  $180^{\circ}$  to the other sensors. (see the diagrams below)



Accelerometer & Gyroscope

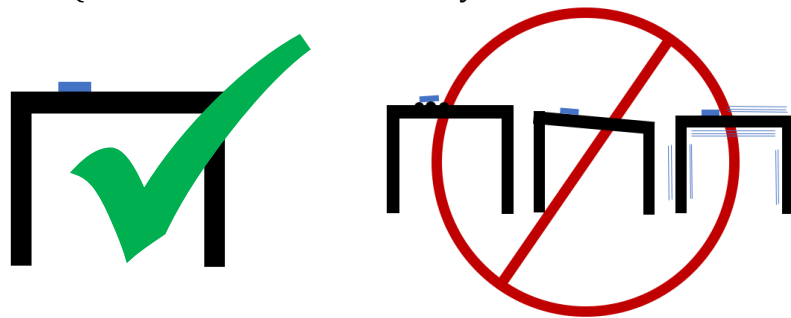


Magnetometer

## Calibration

Though the Module's IMU is manufactured to "ideal" specifications, due to inherent manufacturing processes it is best to calculate any difference from this ideal to the Module's actual performance. This difference (or offset) can be calculated and stored to the Module's non-volatile memory. The offset is then applied automatically when trial data is read from the Module and imported and analyzed by the Dashboard. The Module is initially calibrated during manufacturing however, users may wish to recalibrate their Module periodically, particularly if it received a significant shock. (a short fall from a tabletop is not considered a "significant shock".) We do recommend the Module be calibrated annually. In the education field this can be performed at the beginning of the school year.

To perform a calibration the Module must be placed on a flat, level, stable (non-vibrating) surface during the entire calibration test. Take care to ensure there are no external vibrations, sudden shocks, or movement of the Module (other than what is necessary to rotate the Module through the process).



## IMU Calibration Process

*(Note: Detailed instructions for programming the Module, and the calibration process can be found in the EduForce Dashboard User's Guide. The calibration function is conducted only through the Advanced Dashboard.)*

- 1) Using default configurations, program the Module to conduct a test
- 2) Disconnect the Module, place it on the surface, then start the trial
  - a. Rotate the Module placing it on each of the six (6) Module faces for 3-4 seconds
- 3) Stop the trial
- 4) Reconnect the module, read the test, make a note of the file location and name
- 5) On the MPU Calibration tab, click Browse
  - a. In the pop-up window locate your file, and click Open
  - b. Then click "Calibrate"
- 6) The Dashboard will automatically write the offsets into the module system memory and populate the data fields on the tab

## Technical Specifications

### Physical Specifications (nominal)

	Customary	Metric
Dimensions (L X W X H)	2.75" X .75" X .75"	7 cm X 2 cm X 2 cm
Mass	1.3 oz	37 gm

### Power Supply Specifications<sup>†</sup>

	Supercapacitor	LiPo Battery
Maximum Test Length per Charge	4 minutes	1 hour
Recharge Time	30 seconds	1 minute
Maximum Charge Cycles	Unlimited	Over 1,000 <sup>‡</sup>

<sup>†</sup>All values are approximate.

<sup>‡</sup> The Module's LiPo battery is similar to other rechargeable batteries such as those used in smartphones, laptop computers, and other portable devices. The number of charge cycles is an indication of the battery's ability to accept and retain a *full* charge. This ability, like all rechargeable batteries, declines slowly over the life of the battery. This estimate is *not* an indication of the battery's ability to accept *any* charge.

### Memory Specifications

Volatile Memory Storage	128 MB
Max Test Length @ Default Settings	~2 hours*
<small>*[A (960 sps x 3 Axis) + G(960sps x 3 Axis)+M(96sps x 3 Axis)] = 18,144 bytes/second 128 MB/18,144 bytes/second = 7054 seconds or 1.96 hours</small>	

### Sensor Specifications (*Default Settings in BOLD*)

Accelerometer and Gyroscope Sampling Rates (Hz)60, 120, 240, 480, 500, **960**

Magnetometer Sampling Rate (Hz)**96**

Accelerometer Sensitivities (g)± 2, 4, **8**, 16

Gyroscope Sensitivities (°/s)± 250, 500, **1000**, 2000

Magnetometer Sensitivity (µT)± **4800**

Accelerometer Filter (Hz)5, 10,20,41,**92**,184,460, 1130 (OFF)

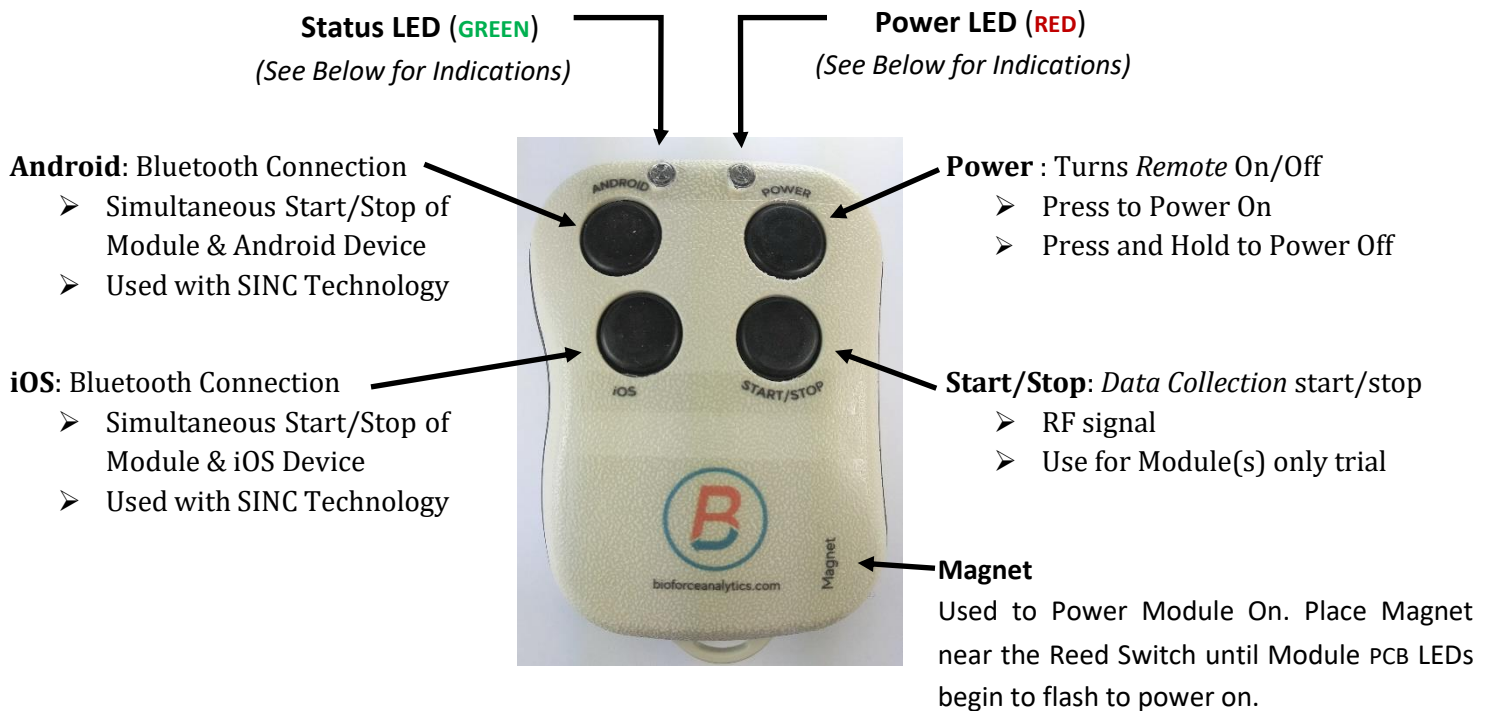
Gyroscope Filter (Hz) 10,20,41,**92**,184,250,3600,8800 (OFF)

# Remote Operation

## The Remote

The Module pairs with the EduForce Remote to provide the user the ability to remotely start/stop data collection without physical contact with the module, reducing the amount of spurious motion imparted on the module during a trial. The Remote is equipped with an automatic time-out circuit (two (2) minutes from the last button activation) to prevent unnecessary battery drain. The Remote can also pair with iOS and Android video recording devices to simultaneously start/stop video and data recording to analyze trial data through SINC™ Technology. (See the SINC Technology User's Guide for details)

## Overview





## LED Indications

### To Power On

- Press “Power”
  - Status & Power LEDs turn on, then Power LED turns off.
  - Status LED remains on to indicate Remote is ON
  - Unit will time-out automatically after two (2) minutes

### To Power Off

- Press *and* Hold “Power” Button
  - Status *and* Power LEDs turn on
  - When Power LED turns off (Status LED will remain lit), release “Power” Button
  - Remote turns off, Status and Power LEDs are off

### Status LED

- Remains lit anytime Remote is on

### Power LED

- Will illuminate anytime Start/Stop, Android, or iOS button is pressed to indicate signal is being transmitted to the Module / Video Recording Device.
- Trial will begin when Start/Stop, Android, or iOS button is pressed or “upon release” depending upon the parameters written for the trial. (*See EduForce Dashboard User’s Guide, Advanced Dashboard, Configure Test Parameters tab for details.*)

## Bluetooth & Pairing

To operate a Module, it must be paired with a Remote. (*Refer to the EduForce Dashboard User's Guide for instruction how to pair a Remote/Module.*) The operational range of a Remote is approximately 2-5 feet. The Remote communicates with the Module via an RF signal. Although the most common pairing is one-to-one, other configurations are possible to meet the needs of the user in light of the physical set-up of the trial.

### Remote / Module Pairing Configurations

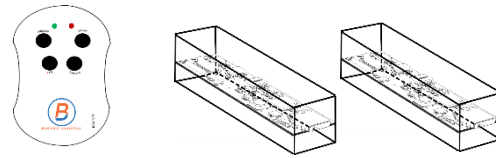
#### One (1) Remote + One (1) Module

- Most Common Pairing
- Ex: Inclined Plane or Pendulum Lab



#### One (1) Remote + Two (2) or more Modules

- Modules in close proximity to Remote during trial
- Ex: Conservation of Momentum Lab



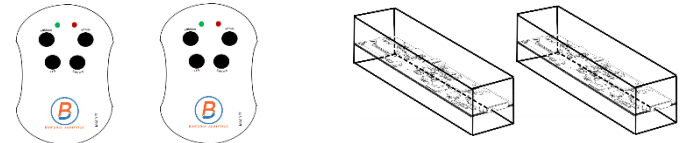
#### Two (2) Remotes + One (1) Module

- Physical Start/Stop location is 5+ Feet
- Ex: Foot Race Trial



#### Two (2) Remotes + Two (2) or more Modules

- Multiple Modules used where Start/Stop location is 5+ Feet
- Ex: User is getting creative in using the Modules



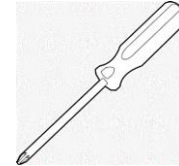
### Bluetooth and SINC™ Technology (*Refer to the SINC Technology User's Guide for more details.*)

The Remote is capable of generating both an RF signal (for use with Module's) and Bluetooth signal (for use with video devices). In order to record both motion and video data the user must start/stop the numerical and video data recording simultaneously and synchronize the two data formats during analysis. SINC Technology does this for the user automatically. However, the video recording device (Android or iOS) must be paired with the Remote. This operation is conducted through the Device's Settings procedures; therefore, user's will need to be familiar with their own device's process. When pairing the Device with the Remote through Bluetooth, the Remote's name is "AB Shutter 3".

## Battery Replacement

- The Remote is powered by a CR 2477 Battery, which is replaceable by the user
- The Remote features a “Low Battery” Alert to make the user aware when to change the battery
- To conserve battery life there is an automatic “time-out” feature
  - Remote turns off after two (2) minutes of inactivity

To replace the battery, you will need a CR 2477 Battery and a small Phillips screwdriver.



- 1) Turn the Remote over and remove the three screws (be careful not to drop or lose the screws).



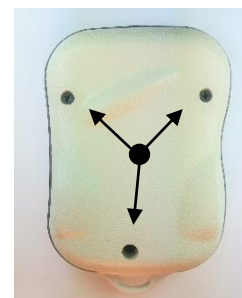
- 2) Push the battery out of the holder, with a **NON-METALLIC OBJECT**, from the top of the battery holder.



- 3) Slide the new battery into holder.



- 4) Close the cover and replace the screws.



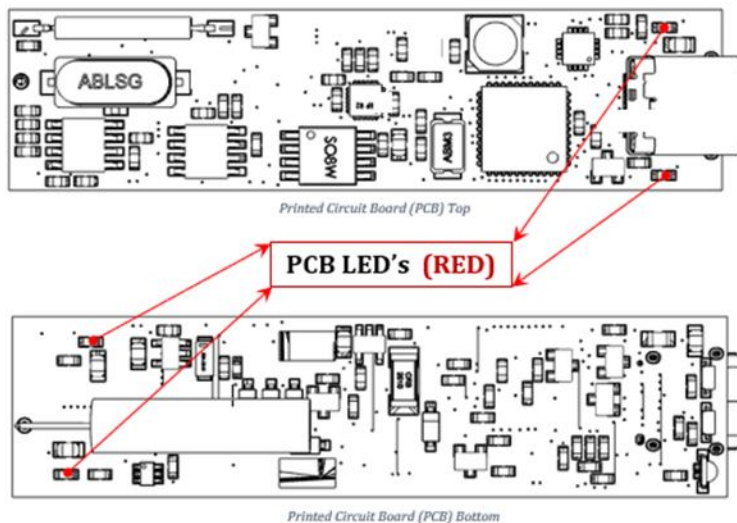
# Appendix A: Module LEDs

## LEDs by Location ( with function )

### LEDs on the PCB

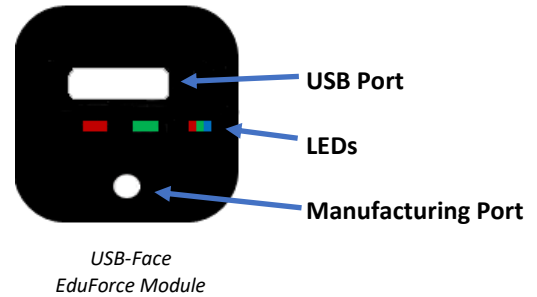
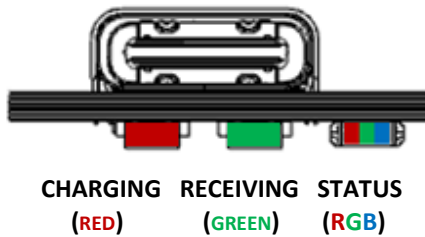
There are four (4) LEDs on the PCB, two (2) each located on the top and bottom of the PCB as indicated in the diagram. All four LEDs are **RED**.

- LEDs **FLASH** when the Module is:
  - In “Standby” Mode
  - While the Module is collecting data
- LEDs are **OFF** while the unit is performing a process
  - For example; Erase, Writing Configurations, Remote Pairing, etc.
- LEDs are **ON** during the SINC Calibration process



## LEDs on the USB-face of the Module

There are three (3) LEDs on the USB-Face of the Module, located directly below the USB Port as shown below.



### The Charging LED

There is one (1) Charging LED, located *below* the USB Port, in the *Left position*. The LED is **RED** only. This LED indicates when the Module's battery is charging.

- LED is ON (**RED**) when the Module is plugged in and charging
- LED is OFF all other times

### The Receiving LED

There is one (1) Receiving LED, located *below* the USB Port, in the *Center position*. The LED is **GREEN** only. This LED indicates when the Module is receiving an RF signal from the EduForce Remote during the Pairing/Unpairing/Test process or when starting/stopping a trial.

- LED is ON (**GREEN**) indicating when any button on the Remote is being pressed/held
- LED is OFF all other times

## The Status LED

There is one (1) Status LED, located *below* the USB Port, in the *Right position*. The LED is **RED** / **GREEN** / **BLUE**. The LED can flash any of the individual colors, or flash 2 or 3 in combination to create an alternate color. Depending on the angle the LED is viewed you may see a “single color”, e.g. **YELLOW**, or be able to distinguish when two colors are lit to make up the **YELLOW** (**BLUE** + **GREEN**). The Status LED can operate independently or in combination with other LEDs dependent on the current operation/task the Module is undergoing. Full details of the color/combination used is covered under the “LED by Function” section below.

- During Operation of a trial,
  - **GREEN** indicates the Module is currently on and in a “stand-by” mode and is not collecting data.
  - **RED** indicates the Module is collecting data.
  - When the user stops a trial the Status LED will transition from **RED** to flashing the LEDs in a **GREEN** - **BLUE** - **RED** sequence once then hold on **GREEN**.

## LEDs by Function

(Note: for Dashboard instructions and messages, please refer to the EduForce Dashboard User's Guide)

### Module is Off

- All LEDs are dark
- When the Module is turned on,
  - The Status LED will flash **RED**, **GREEN**, then **BLUE** in sequence, then hold on **GREEN**
  - The PCB LEDs will begin to flash

### Stand-by

- USB Connected – PCB LEDs flashing **RED**; Status LED Solid **GREEN**; Charging LED may or may not be lit (**RED**) depending on if the module is charging
- USB Not Connected – PCB LEDs flashing **RED**; Status LED Solid **GREEN**;

### Charging

- Charging LED on (**RED**)
- Status LED on (**GREEN**)
- PCB LEDs flashing (**RED**)

(Note: The Charging LED is independent of all other functions, therefore if the unit is **not charging**, the Charging LED will be off, all other LEDs are controlled by the function being executed.)

### Erase Module

- Status LED on (**YELLOW**)
  - Upon completion, Status LED is **GREEN**
- PCB LEDs off *during* ERASE, will *flash* when ERASE is completed

### Unpair with Remote

- Status LED alternates between **YELLOW** and **GREEN**
  - Upon completion, Status LED is **GREEN**
- PCB LEDs off *during* UNPAIR, will *flash* when UNPAIR is completed

## Pair with Remote

- Status LED alternates between **BLUE** paired with **GREEN** and **GREEN**
  - Upon completion of pairing, Status LED is **GREEN**
- Receiving LED flashes **GREEN** *while a button is being pressed*, otherwise it is OFF
- PCB LEDs will be OFF once the “Pair New Remote” Button is clicked on the Dashboard, and *while a Remote button is pressed*
  - *Once pairing is complete and the button is released*, LEDs will flash

## Test Pairing

- Status LED is off
  - *When Remote button is pressed*, Status LED turns **RED**
  - *When Test Pairing is exited*, Status LED turns **GREEN**
- Receiving LED is off
  - *When Remote button is pressed*, turns **GREEN**
  - *When Test Pairing is exited*; LED remains off
- PCB LEDs
  - *During the entire Testing function*, LEDs are off
  - *When Test Pairing is exited*, LEDs begin to flash

*(Note: Upon exiting the Test Function, the Module will switch into OPERATING MODE, pressing a Remote button will start a trial)*



## Operating a Trial

- Status LED
  - **GREEN** - Module is currently on, in “stand-by” mode, and *is not collecting data*.
  - **RED** - Module *is collecting data*.
    - When the user stops the trial, the Status LED will transition from **RED** to flashing the LED in a **GREEN – BLUE - RED** sequence once, then hold on **GREEN**
- Receiving LED
  - Will flash while a Remote button is being pressed or held, otherwise LED is off
- PCB LEDS
  - Will flash throughout the trial
  - LEDS will stop flashing
    - when a Remote button is held (starting/stopping a trial)
    - momentarily while the Remote is ending the trial and switching to stand-by Mode
  - If the PCB LEDS are not flashing the unit has powered off
    - Restart the Module placing the Remote’s magnet near the Module’s Reed switch
    - Unit will begin to flash the PCB LEDS to indicate it is powered on, start the trial by pressing the appropriate Remote button

## SINC™ Calibration

Preparing the Module (writing the test parameters to the Module from the Dashboard)

- Status LED turns **YELLOW** briefly while parameters are written to the Module
  - Returns to **GREEN** when completed
- PCB LEDS
  - Off during while parameters are written to the Module
  - Will flash before and after parameters are written

### Calibration Test

- Status and PCB LEDS
  - Turn solid **RED** during entire Calibration process (approximately 2 minutes)
  - At the end of the test,
    - Status LED – **GREEN**
    - PCB LED – flashes **RED**