ISA Kit 1.0

User Manual

November 2015

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www.isakit.com

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Safety and Precautions

1. Try to use the USB cable to power the ISA Kit. Power and run the ISA Kit on the 9V battery only for a short period (a few minutes), because the battery will be discharged very fast. If you have a project that requires running the ISA Kit on battery for a long period (over 30 minutes) we recommend you use a rechargeable battery or solar power bank.
2. Do not connect the USB cable and 9V battery simultaneously.

3. Do not turn on more than four sensors or actuators at the same time.
4. Do not connect the leads of the wires together because it will cause a short circuit and will damage the electronics.
5. Do not touch the sensors, microcontroller, or the jumper wires if your hands are wet.
6. Do not place the ISA Kit or any of the sensors on a wet or dirty surface.
7. If any sensor or actuator gets warm it may indicate the connection is not correct. Unplug the ISA Kit and verify all the connections.
8. The ISA Kit is not appropriate for children under 10 years old.

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ISA Kit

ISA (Intelligent Sensor and Actuator)™ is an all-in-one educational kit for students and instructors in STEM (Science, Technology, Engineering and Mathematics) programs to learn and teach about sensors (inputs) and actuators (outputs) through interactive hands-on projects.

The technology has been developed at the University of California, Irvine and Intelligent Design Technology, LLC (patent pending). It has been designed, developed, prototyped, and manufactured at Intelligent Design Technology, LLC.

ISA: Intelligent Sensor and Actuator is a registered trademark of Intelligent Design Technology, LLC.

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Key Features of the ISA Kit

- Easy to learn and use
- No soldering is required
- No wiring is required for the Basic Kit. For Pro and Premium Kits some wiring is required.
- No pre-knowledge of coding is required (automatically generates C/C++ codes for Arduino-based microcontrollers)
- Compact design to save space
- No requirements for any additional tools or parts
- Cost effective
- Interactive tutorial
- Integrates basic, intermediate, and advanced level projects
- Appropriate for middle school, high school, and college students
- Interactive communication with Windows OS and Android Apps
- Made in the USA

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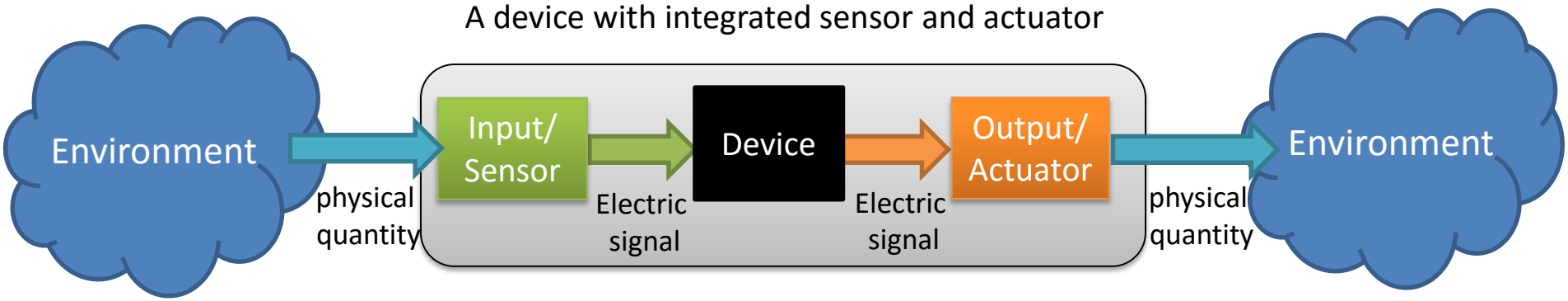
Sensor/Actuator (Input/Output)

Sensor (Input): a converter that measures a physical quantity and converts it into a signal which can be read by an electronic instrument.

Actuator (Output): a type of system (such as a motor) that moves or controls a mechanism or system. It is operated by a source of energy, typically electric current, hydraulic fluid pressure, or pneumatic pressure, and converts that energy into motion.



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ISA Kit Basic, Pro, and Premium

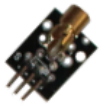
ISA Kit Basic

Actuators		Sensors							
1	2	3	4	5	6	7	8	9	10
RGB LED	Servo	Soil Moisture	Ultrasonic Rangefinder	Gas & Alcohol	Motion	Infra Red (IR)	Light	Potentiometer	Bluetooth

ISA Kit Pro

Actuators		Sensors							
11	12	13	14	15	16	17	18	19	20
2-Channel Relay	Buzzer	3-axis Accelerometer	2D Joystick	Line Track	Temperature and Humidity	Touch	Sound	Soft Pot	Pressure

ISA Kit Premium

Actuators					Sensors				
21	22	23	24	25	26	27	28	29	30
DC Motor	Laser	Pump	Valve	Fan motor	Pulse	Flame	Vibration	hall effect	Tilt
									

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Common Sensors and Actuators

Actuators		Sensors							
1	2	3	4	5	6	7	8	9	10
RGB LED	Servo	Soil Moisture	Ultrasonic Rangefinder	Gas & Alcohol	Motion	Infra Red (IR)	Light	Potentiometer	Bluetooth

1. An **RGB LED** (Light-Emitting Diode) is a four-lead light source. By changing the light intensity of red, green, and blue (RGB) components different colors can be formed.
2. A **servomotor** is a rotary actuator so it produces rotary motion and torque. It is used for control of angular position.
3. A **moisture sensor** measures the moisture level of a media such as soil
4. An **ultrasonic sensor** (range finder) determines the distance to an object
5. A **gas sensor** detects level of some common gases such as methane, alcohol, Hydrogen, and smoke.
6. A **motion sensor** detects any motion and moving objects
7. An **infrared (IR) sensor** decodes the signal sent via IR remote controller.
8. A **light sensor** measures the light intensity through a photo cell.
9. A **rotary potentiometer** functions like a knob to increase or decrease a physical quantity such as volume. For example, when used in conjunction with the servo it changes the angle of rotation.
10. A **Bluetooth** transceiver is used to communicate wirelessly with your smartphone or tablet. You can change the LED color or rotate the servo motor.

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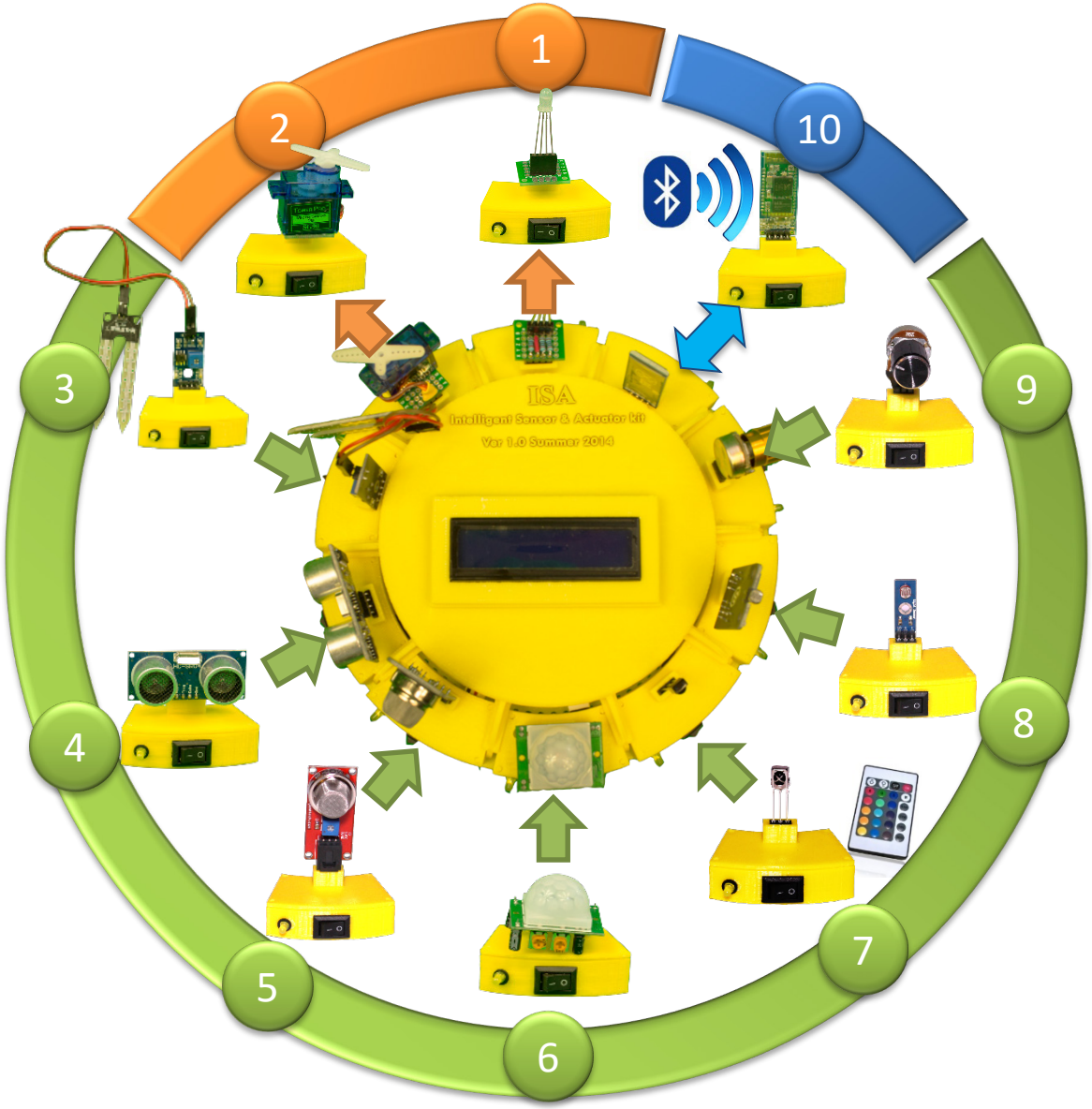
ISA™ Sensors and Actuators



Actuators

1. RGB LED
2. Servomotor

Sensors

3. Moisture
4. Ultrasonic
5. Gas/Alcohol
6. Motion
7. Infrared (IR)
8. Light
9. Potentiometer

10. Bluetooth

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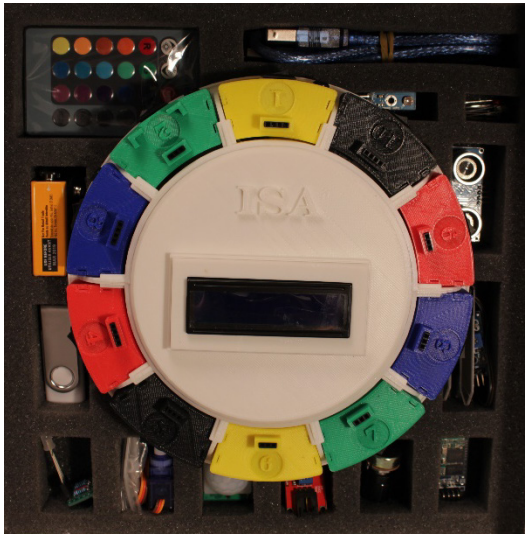
What is Included in the ISA Kit



The following parts are included in the **ISA Kit Basic**:

- One Arduino Mega compatible microcontroller
- One ISA Shield (version 3)
- 10 modules: 7 sensors, 2 actuators, and one Bluetooth
- 10 extension cables
- One infrared (IR) remote control
- LCD display
- 3D printed housing and sensor/actuator mounts
- Flash drive
- ISA dashboard (windows-based software)
- ISA kit app for Android smartphone and tablets
- USB cable (to connect ISA kit to your PC)
- 9V to Barrel Jack Adapter + 9V battery (in case you are not using the USB cable)

ISA Kit Basic comes with 10 modules (sensors and actuators),
ISA Kit Pro comes with 20 modules (sensors and actuators),
ISA Kit Premium comes with 30 modules (sensors and actuators).

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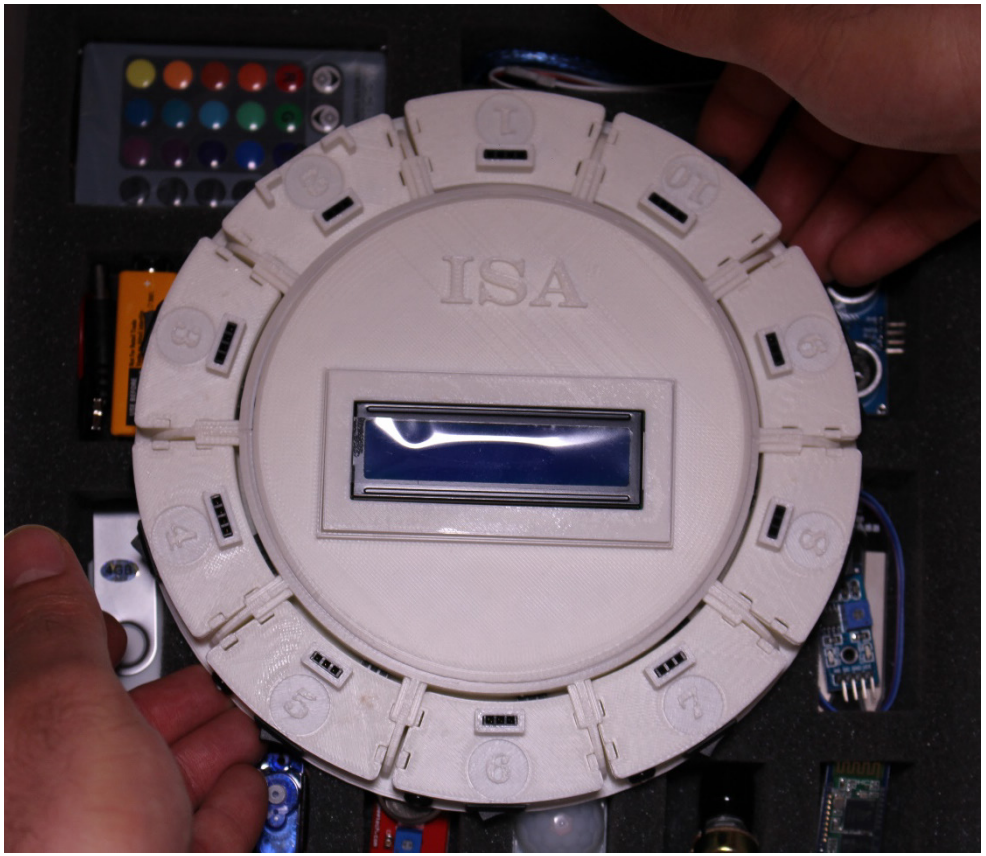
Unpacking the Box (ISA Kit Basic)



Push your fingers under the housing and lift it up

YouTube Watch the video on YouTube

ISA Kit Basic Modules

Accessories

- A Remote control
- B USB cable
- C 9V battery
- D Flash drive
- E LED's

Actuators

- 1 RGB LED
- 2 Servomotor

Sensors

- 3 Moisture
- 4 Ultrasonic
- 5 Gas/Alcohol
- 6 Motion
- 7 Infrared (IR)
- 8 Light
- 9 Potentiometer

10 Bluetooth

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ISA Kit Pro Modules

Actuators

11 Relay
12 Buzzer

Sensors

13 Accelerometer
14 Joystick
15 Line Track
16 Temperature
17 Touch
18 Sound
19 Soft Pot
20 Pressure

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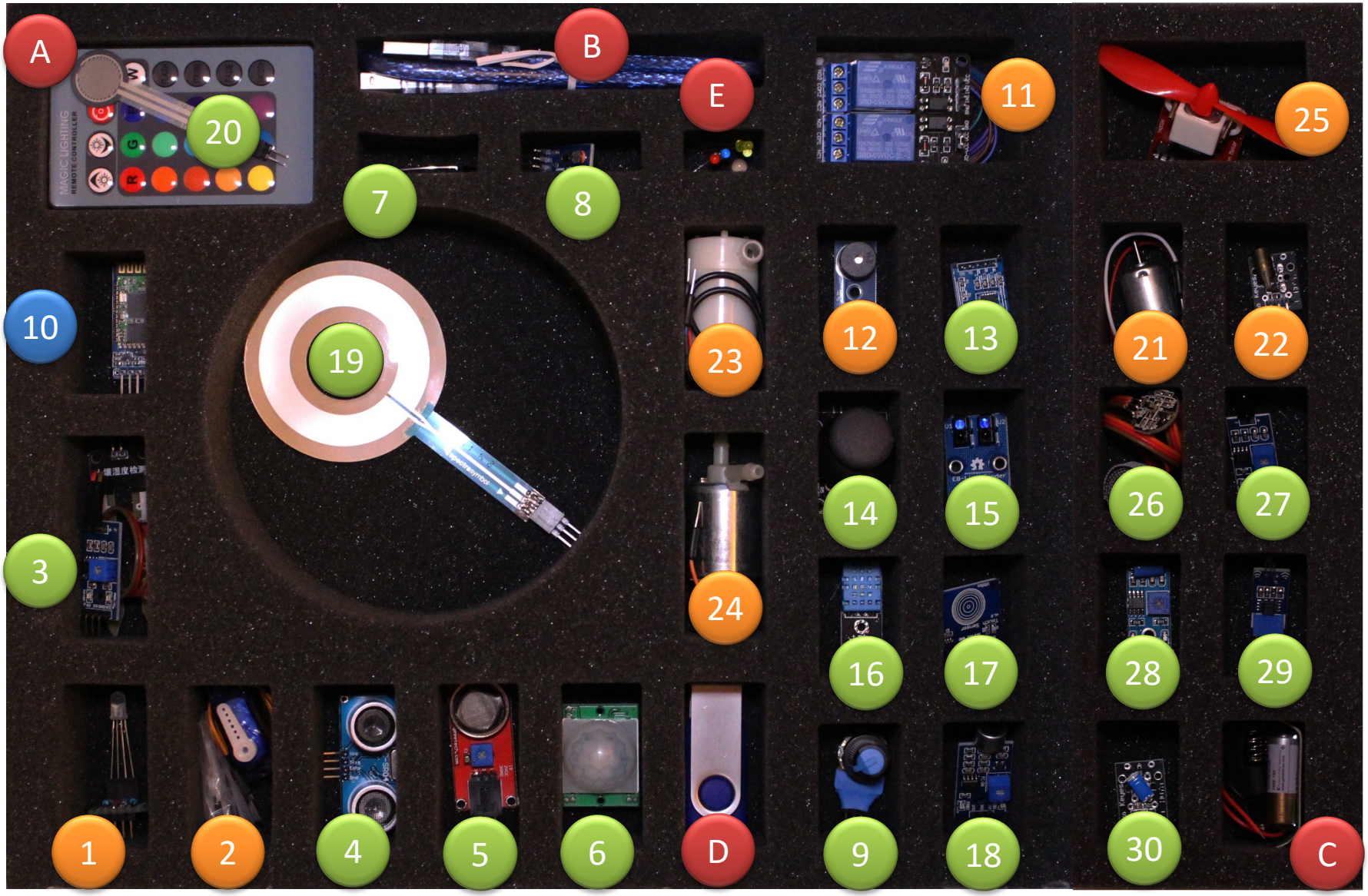
ISA Kit Premium Modules



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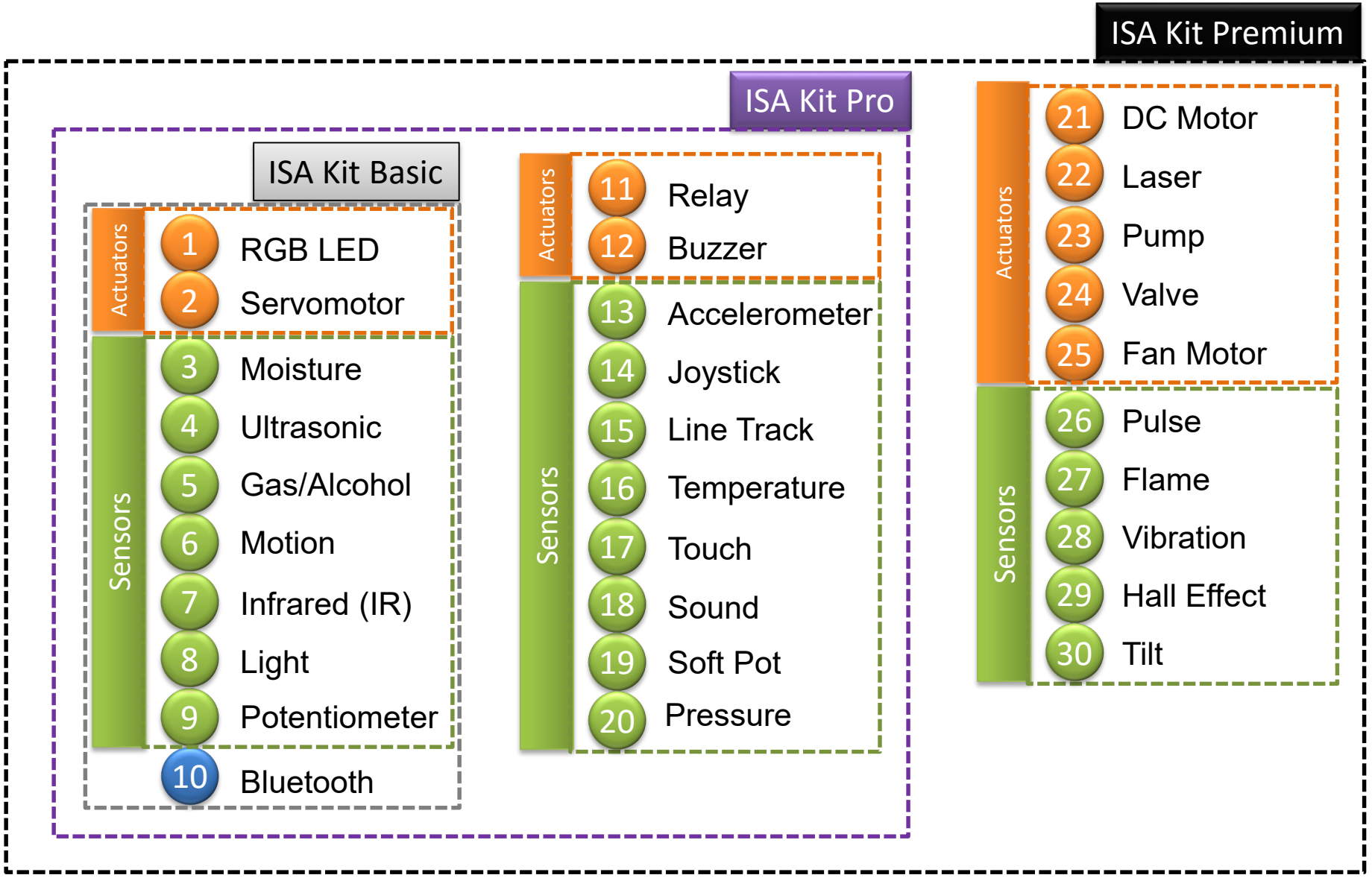
ISA Kit Basic, Pro, and Premium



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Battery

You can provide power to the ISA Kit in two ways:
1- Using the USB cable and connecting the ISA Kit to your computer.
2- Using a 9V battery
Note: Never use USB cable and 9V battery at the same time.

In **ISA Kit Pro** and **Premium**, a 2600 mAh rechargeable battery is included in the package that can be used as a source of power. You may connect it to the USB port.

In **ISA Kit Premium**, a 12 V battery is included that can be used as a power source to turn on a 12VDC solenoid valve.

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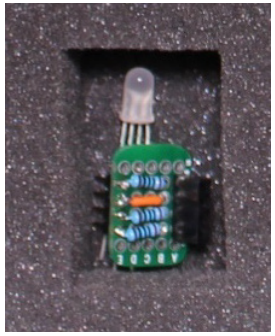
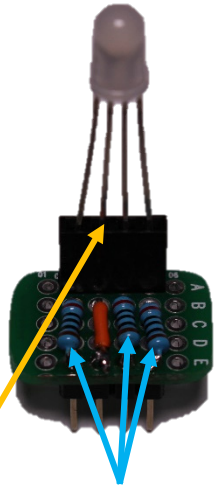
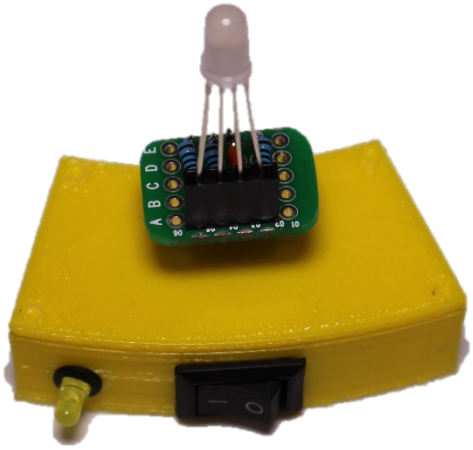
Assemble Module #1

1 **RGB LED:** Insert the RGB LED in the LED holder and then insert it in module box #1 as shown below.





resistors



The longest leg goes into the pin with no resistor connected

pin with no resistor connected

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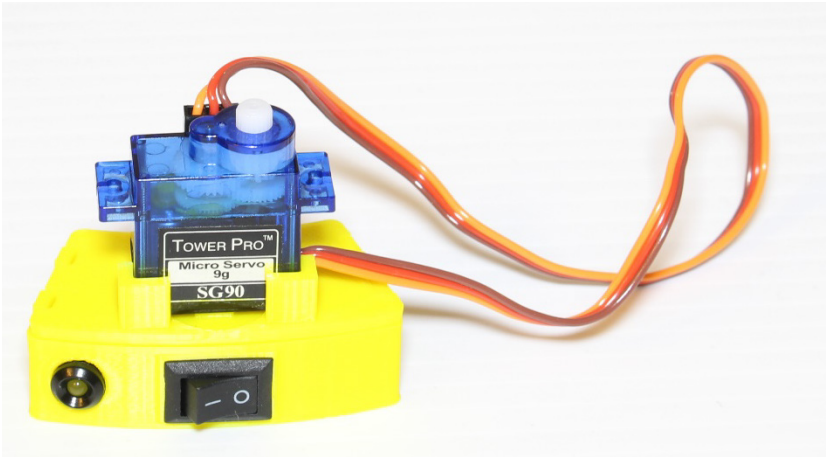
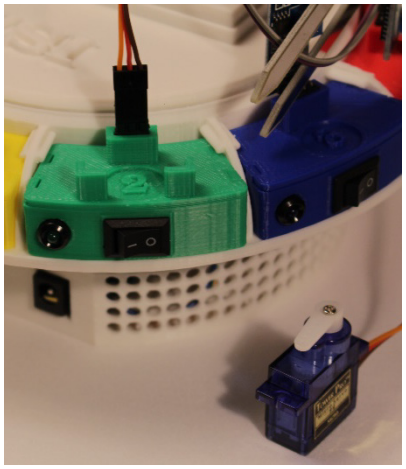
Assemble Module #2

2 **Servomotor:** Connect the wires of servomotor to module box #2 as shown in the picture (brown wire on the right, orange wire on the left). Then mount the servomotor.





Make sure the propeller of the servomotor does not touch the wires while rotating; otherwise, the propeller may damage and cut the wires.

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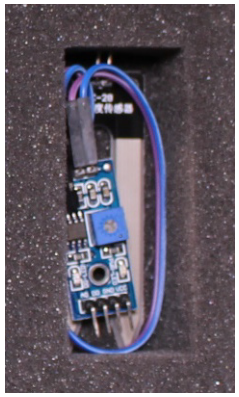
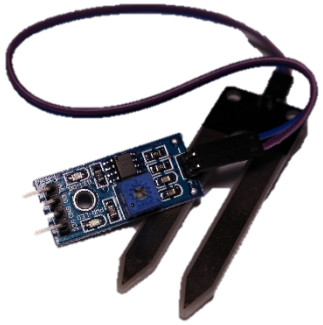
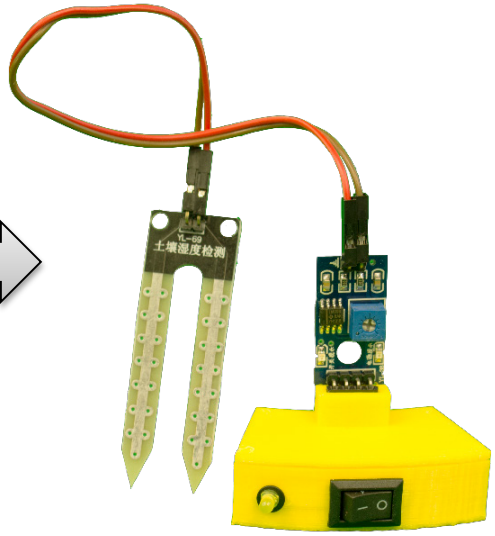
Assemble Modules #3 and #4

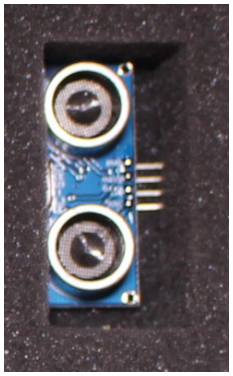
3 **Moisture sensor:** Connect the two parts of the moisture sensor and insert it in module box #3 as shown below.





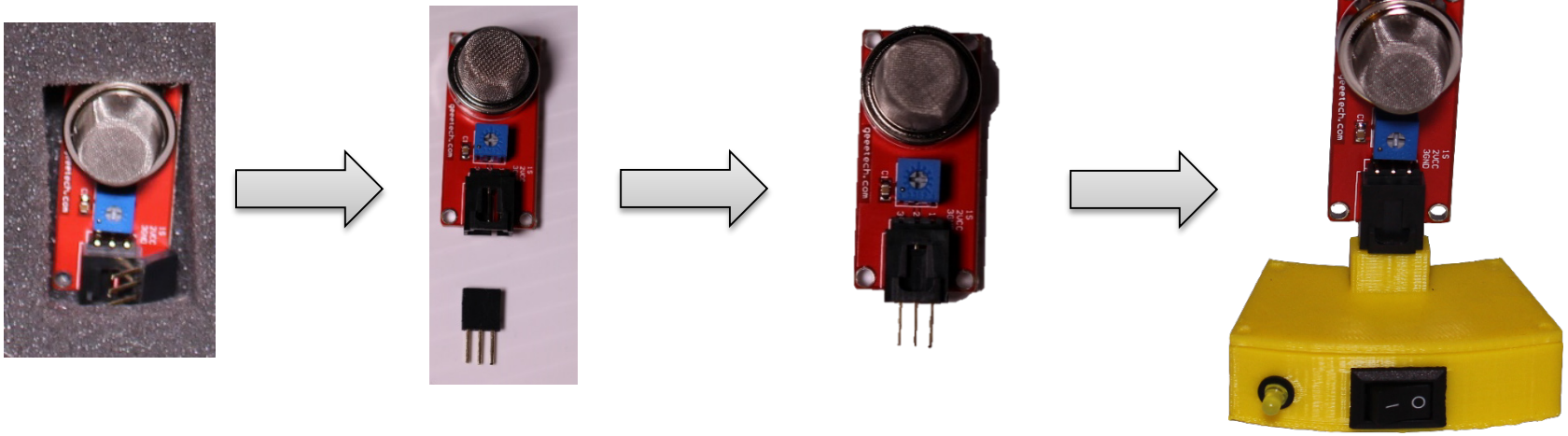


4 **Ultrasonic sensor**: Insert the ultrasonic sensor in module box #4 as shown below.

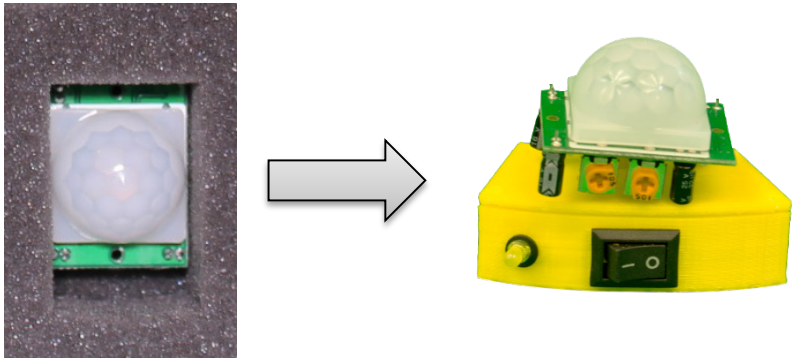


Assemble Modules #5 and #6

5 **Gas/Alcohol sensor:** Insert the female to male extension header and then mount the gas sensor on module box #5 as shown below.



6 **Motion sensor**: Insert the motion sensor in module box #6 as shown below.



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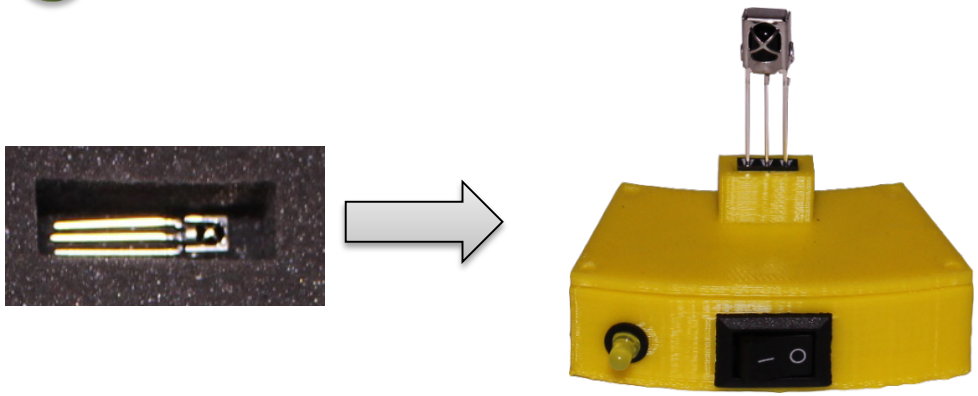
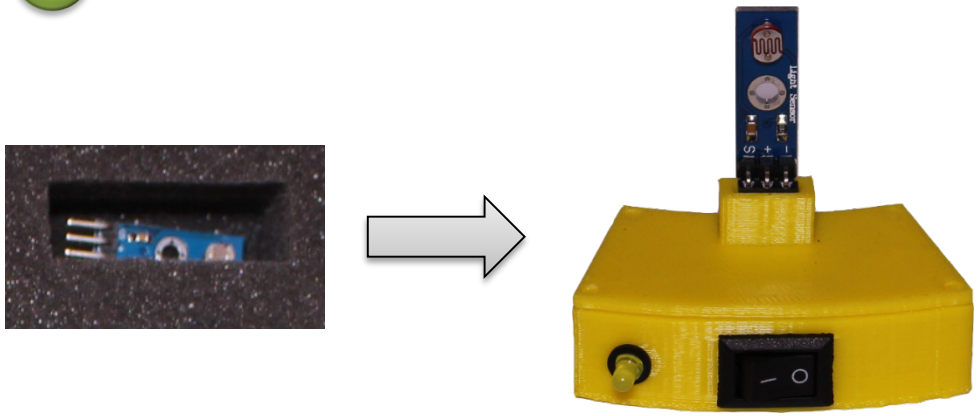
Assemble Modules #7 and #8

7 **Infrared (IR) sensor:** Insert the IR sensor in module box #7 as shown below.



8 **Light sensor**: Insert the light sensor in module box #8 as shown below.



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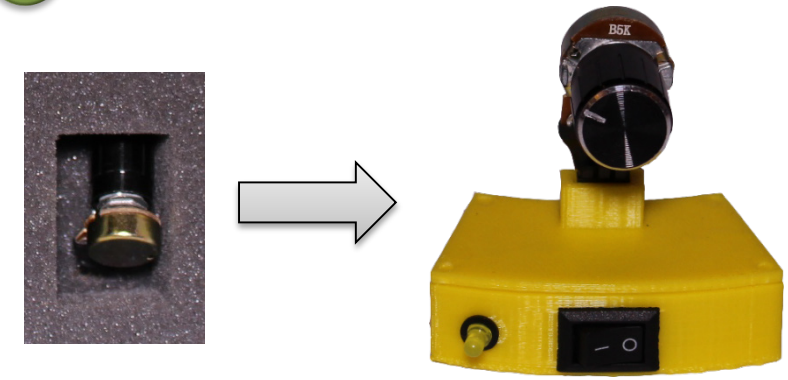
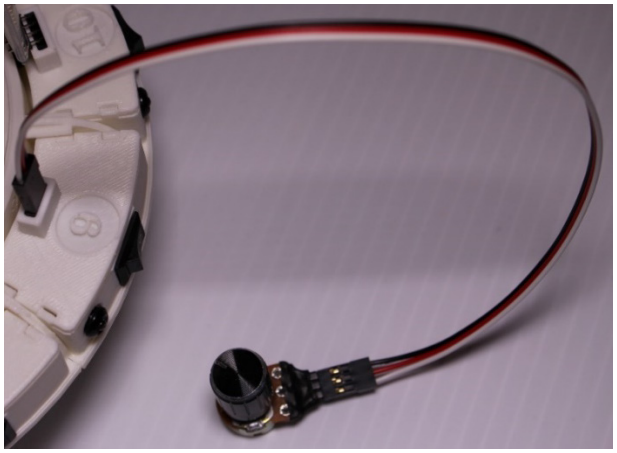
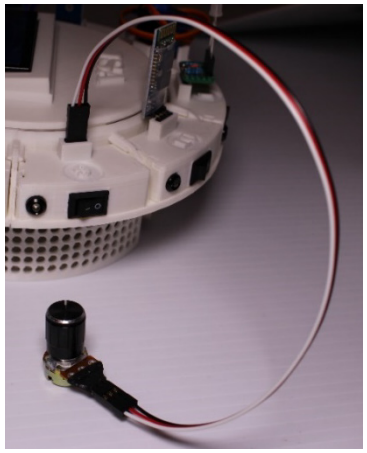
Assemble Module #9

9 **Potentiometer:** Insert the rotary potentiometer in module box #9 as shown below.



Instead of connecting the potentiometer directly to module box #9, you may use an extension cable in between. This way, it will be easier to rotate the knob on the potentiometer and signal noise will be reduced or eliminated.





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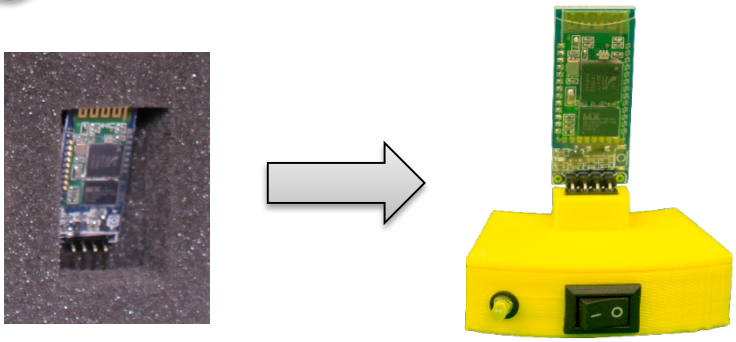
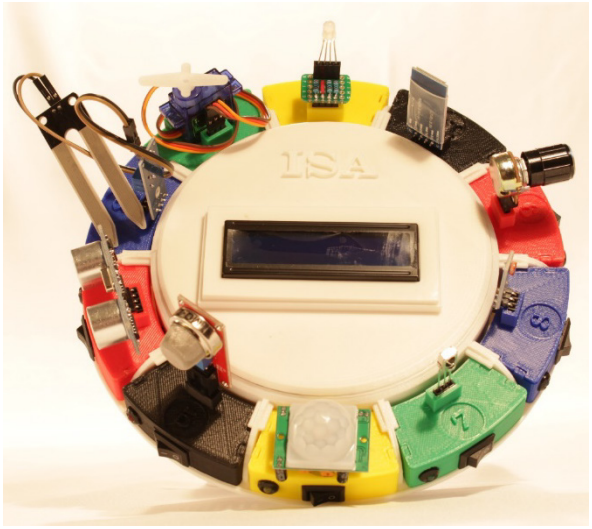
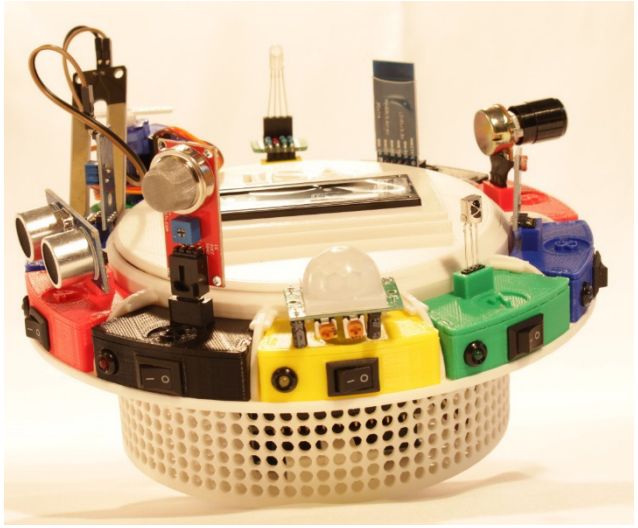
Assemble Module #10

10 **Bluetooth:** Insert the Bluetooth transceiver in module box #10 as shown below.



After connecting all the sensors and actuators, your ISA Kit should look like the following pictures.





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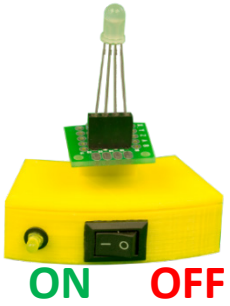
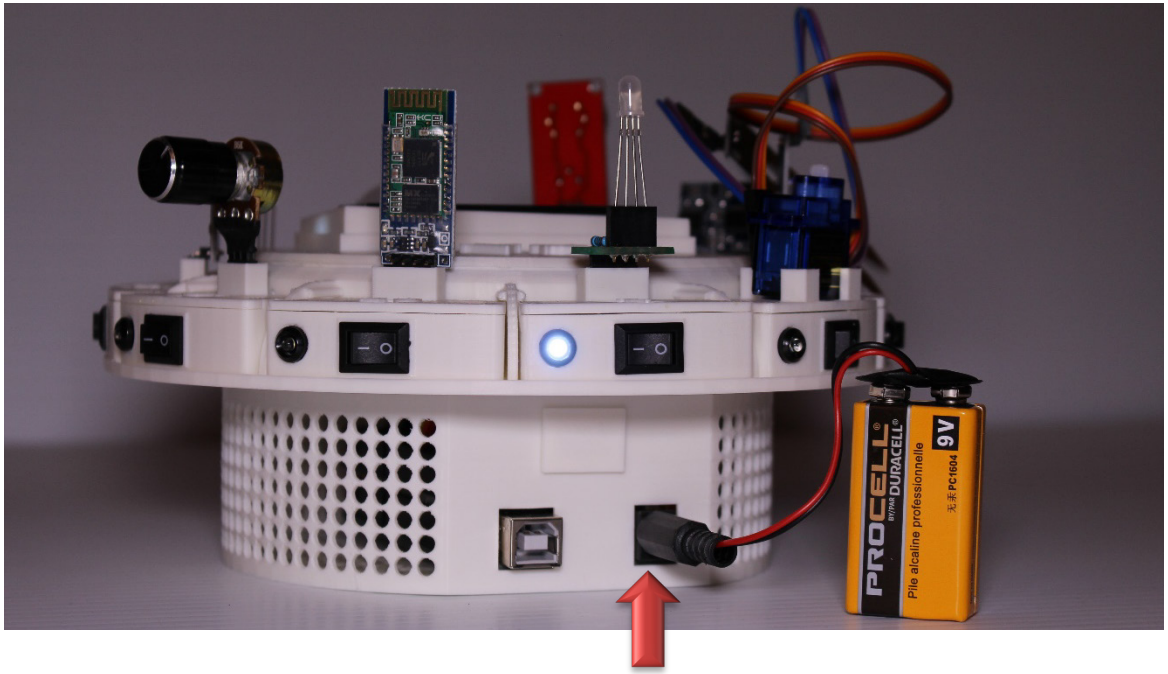
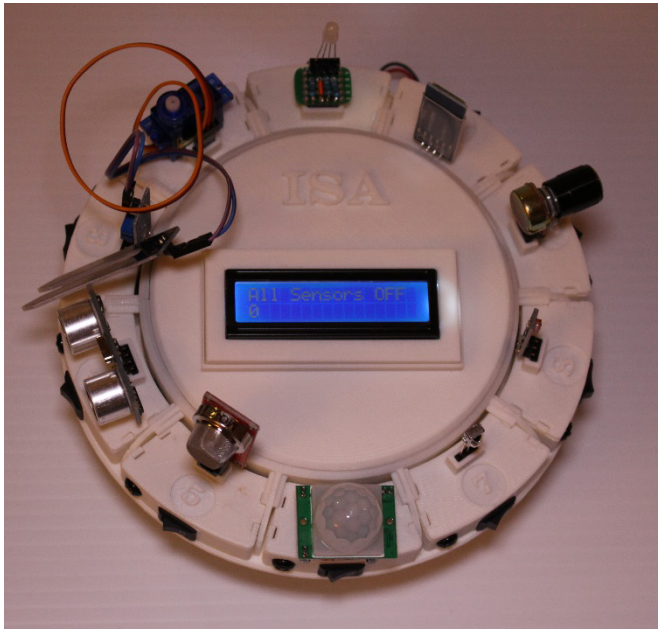
Test the ISA Kit Sensors



After connecting all the sensors and actuators, it is time to test them.
1- Make sure all the switches on the module boxes are in **off** position.
2- Turn on the RGB LED switch (module #1).
3- Connect the 9V battery to the DC power connection in the ISA Kit
4- A couple of welcome messages will be displayed on the LCD and the RGB LED should blink red, green, and blue colors with fading effects.
5- Each module box has an on/off switch. In order to test any sensor you need to turn the switch on. Make sure all the other sensors and actuators are switched off.





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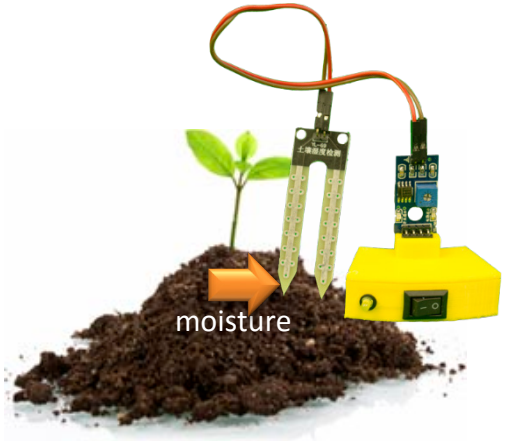
Test the ISA Kit Sensors #3 and #4

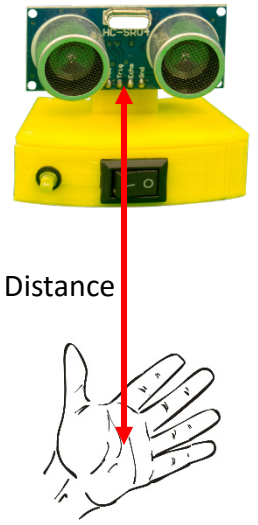
3 Moisture sensor

1. Turn all the switches off.
2. Turn on the switch for module box #3.
3. Measure the moisture of the soil or a wet napkin/cloth. You may also measure the conductivity of your skin by holding the probe of the sensor in you hand and pressing it.
4. The moisture signal will be displayed on the LCD.



4 Ultrasonic Sensor

1. Turn all the switches off.
2. Turn on the switch for module box #4.
3. Move an object backward and forward in front of the ultrasonic sensor. Moving an object with uneven surfaces, such as a hand, may cause some noise in send/receive signals. In that case, use an object with an even surface, such as a flat plate.
4. The distance from object will be displayed on the LCD (the unit of measurement is in centimeter).



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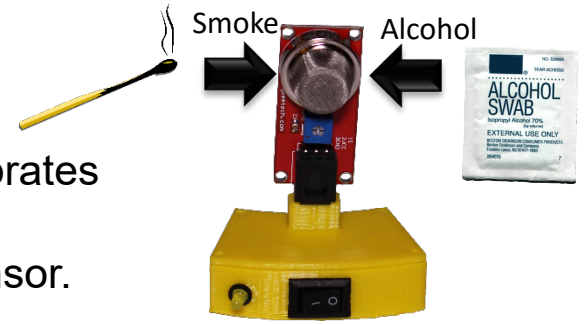
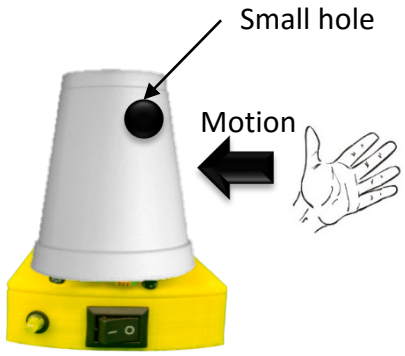
Test the ISA Kit Sensors #5 and #6

5 Alcohol sensor



1. Turn all the switches off.
2. Turn on the switch for module box #5.
3. Wait for a few seconds (~ 20 seconds) until the sensor calibrates itself.
4. Use smoke from a match or alcohol swab in front of the sensor.
5. The level of gas or alcohol will be displayed on the LCD.

6 Motion sensor



1. Turn all the switches off.
2. Turn on the switch for module box #4.
3. Wait for a few seconds then move your hand.
4. This sensor is very sensitive to motion detection so any motion in the vicinity of the sensor will be detected. One way to test the sensor is to use a Styrofoam or opaque plastic cup with a small hole in it. Cover the motion sensor with the cup. Any movement close to the hole will be detected.

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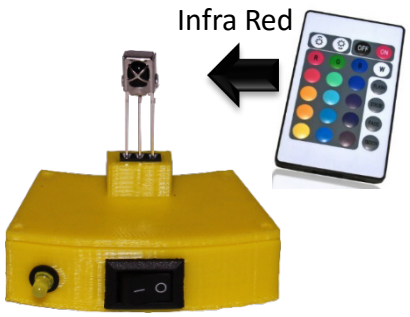
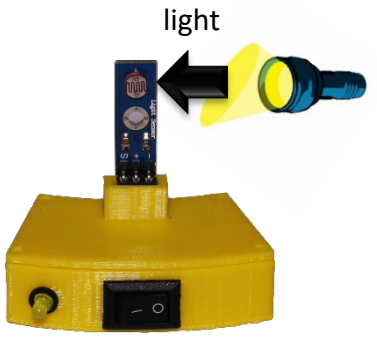
Test the ISA Kit Sensors #7 and #8

7 IR sensor



1. Turn all the switches off.
2. Turn on the switches for module box #1 (RGB LED) and #7 (IR).
3. Point the IR remote control toward the IR sensor (the same way you point a TV remote control toward a TV).
4. Push the buttons on the IR remote control to change the color of the RGB LED.
5. At the end, make sure to push the **OFF** button to turn the LED off.
6. For troubleshooting, check if the IR sensor is connected properly. Sometime, unplugging the USB cable and plugging it back may resolve the issue.

8 Light sensor



1. Turn all the switches off.
2. Turn on the switch for module box #8.
3. Change the light intensity using a flash light or by turning the room's light on and off.
4. The level of light intensity will be displayed on the LCD. This is a number between 0 to 100.

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Test the ISA Kit Sensor #9

9 Potentiometer

1. Turn all the switches off.
2. Turn on the switch for module box #9.
3. Turn the knob on the potentiometer.
4. A number between 0 to 1023 will be displayed on the LCD. When you turn the knob clockwise (CW), the value increases and when you turn it counter clockwise (CCW), the value decreased.
5. To test the servomotor (actuator), turn on the switch for module box #2. The servomotor will follow the rotation of the potentiometer.

Make sure the propeller of the servomotor does not touch the wires while rotating; otherwise, the propeller may damage and cut the wires.

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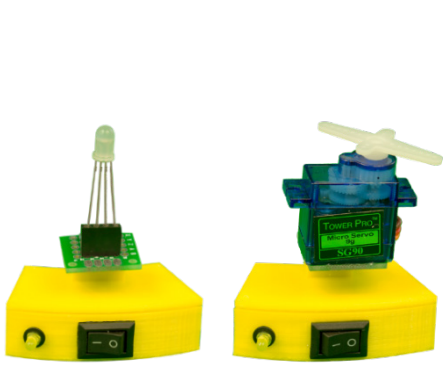
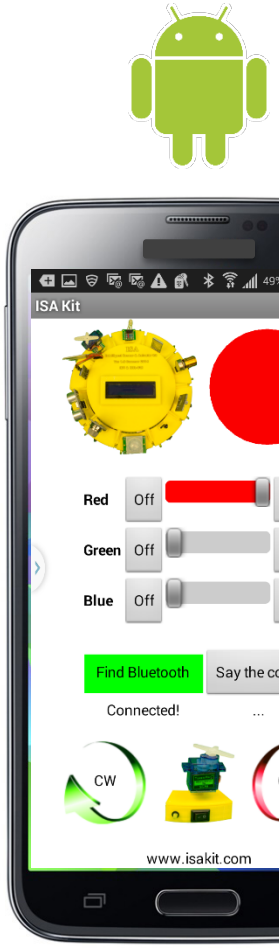
Test the ISA Kit Bluetooth

10 Bluetooth

1. Turn all the switches off.
2. Turn on the switches for module boxes #1 (RGB LED) and #10 (Bluetooth).
3. Run ISA Kit Android app on your smartphone or tablet with Android mobile operating system (OS).
4. Find the ISA Bluetooth and connect to it. The instructions on how to connect to the ISA Bluetooth will follow in the next page.
5. Change the color of RGB LED from the app.
6. You may also control the servomotor and rotate the propeller. To do so, turn on the switch for module box #2 as well.





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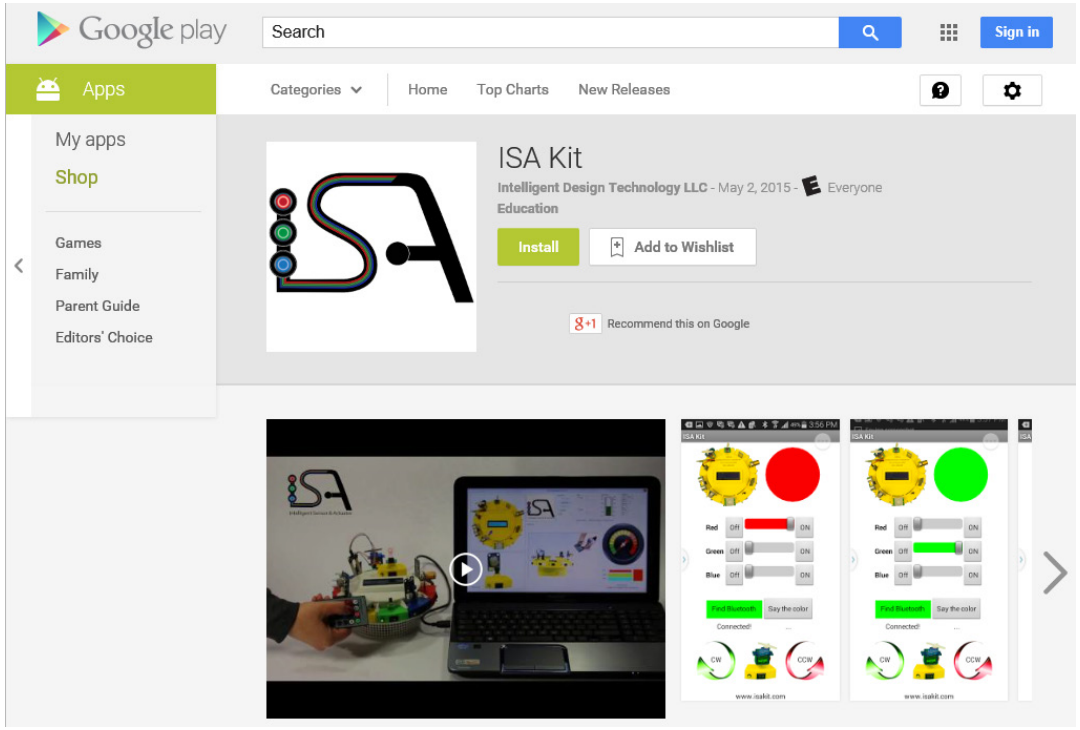
ISA Kit Application: Installing

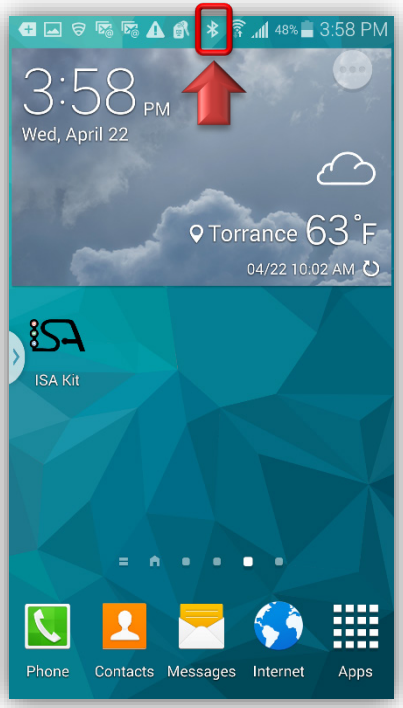
Download and install the ISA Kit Application (App) from Google Play:
Method 1: Search for “isa kit” in Google Play. Keep the quotation marks when doing the search.
Method 2: Scan the following QR code with your smart phone (Android). Then open the URL with Play Store.

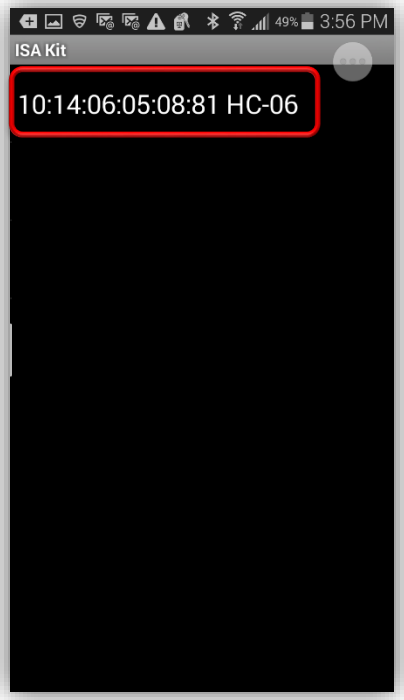


ISA Kit Application: Pairing

You need to pair your smartphone to the ISA Kit Bluetooth when connecting to it for the first time:

1. Turn on the Bluetooth on your phone or tablet. Turn on the Bluetooth (module #10) on your ISA Kit. The Bluetooth red LED should be blinking.
2. Scan (search) for Bluetooth devices. The ISA Kit Bluetooth name is “HC-06”. Select it. If asked for password, enter “1234” or “0000”.
3. If you do not see HC-06 in the list of nearby devices you may need to turn off the Bluetooth on your smartphone and ISA Kit and turn them back on then try again.





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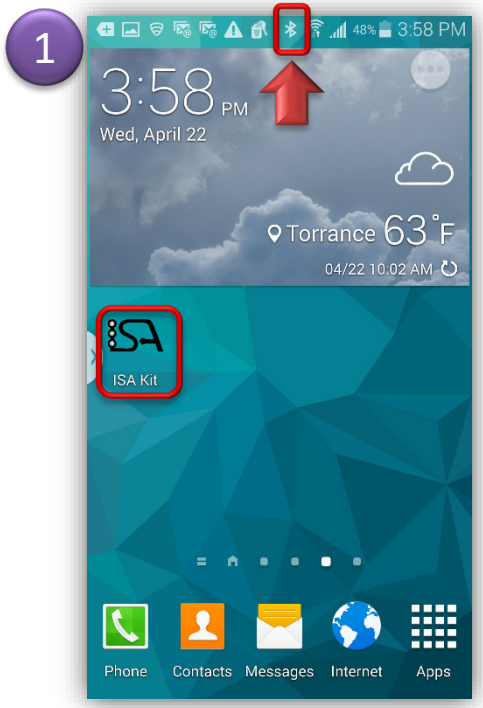
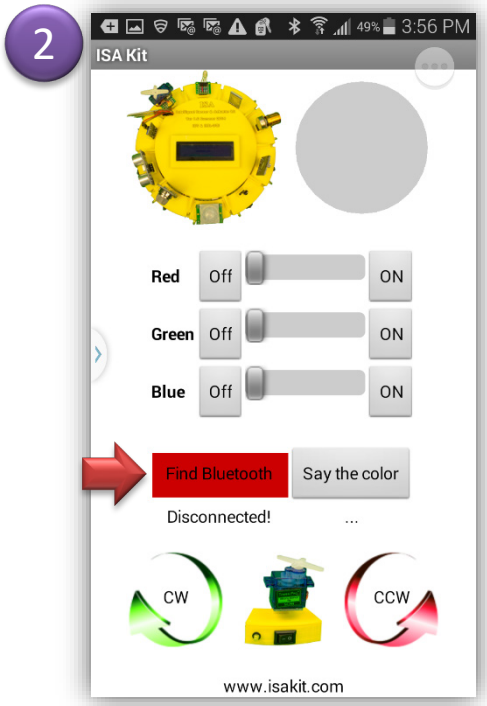
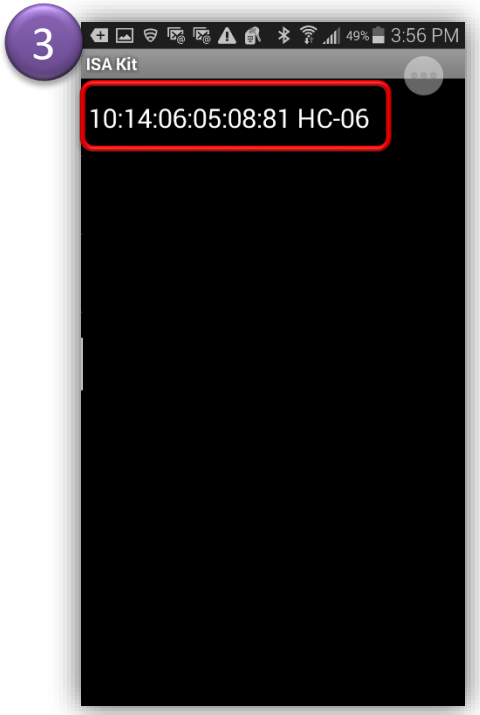
ISA Kit Application

1. Turn on the Bluetooth on your phone or tablet. Turn on the Bluetooth (module #10) on your ISA Kit. The Bluetooth red LED should be blinking. Then run the ISA Kit App.
2. Click on “Find Bluetooth” button on the App.
3. Select “HC-06”. If you do not see HC-06 you need to pair your device with the ISA Kit Bluetooth as instructed in the previous section.







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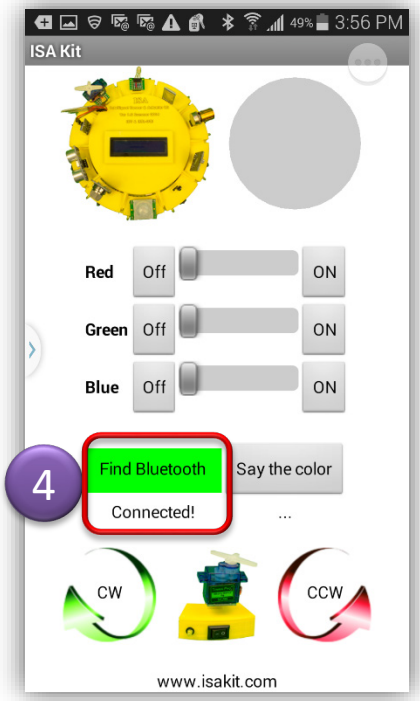
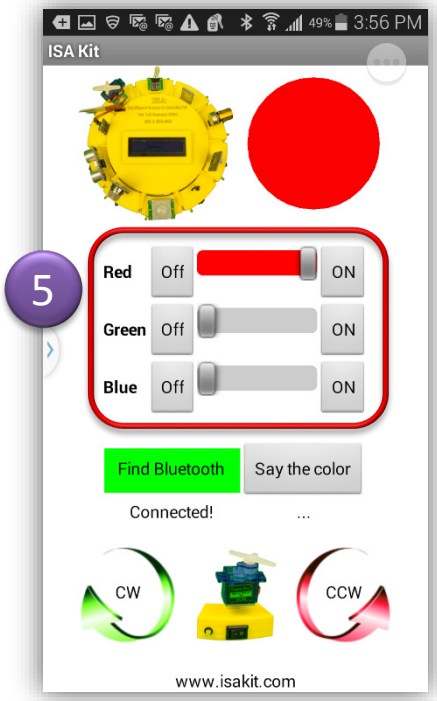
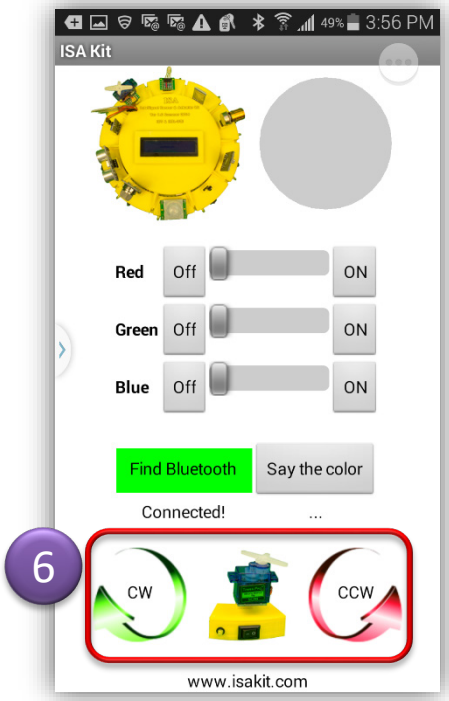
ISA Kit Application (Cont'd)

4. When successfully connected, the button color will change to green and the Bluetooth LED will be solid (not blinking).
5. Now you can change the color of RGB LED (module #1) on your ISA Kit. Simply click on "ON" or "OFF" buttons for each color (Red, Green, and Blue).
6. You can rotate the propeller of the servomotor (module #2) by clicking on CW (clockwise) and CCW (counterclockwise) buttons.







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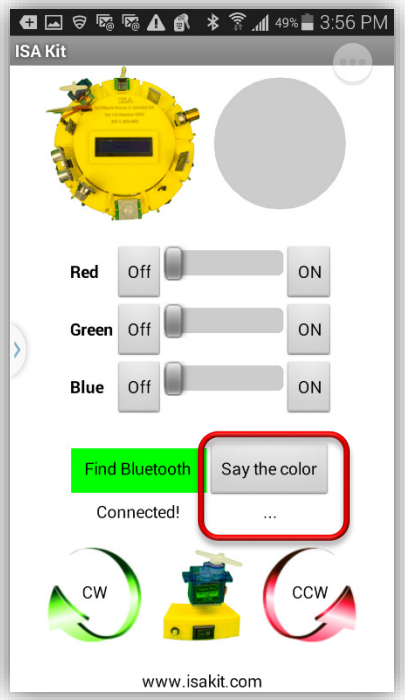
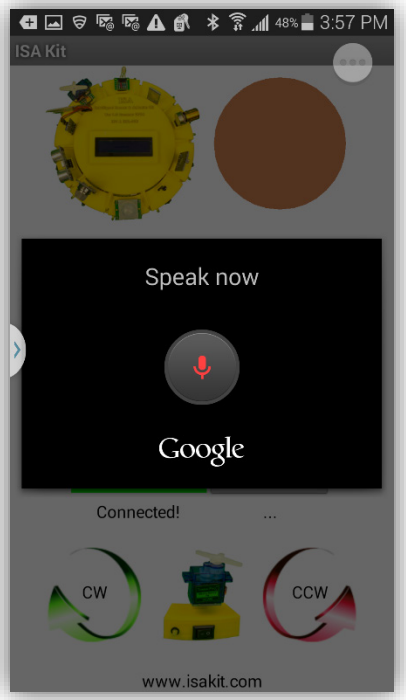
ISA Kit Application (Cont'd)

7. If you click on "Say the color" you can say the color name into the microphone. Main color names are: red, green, blue, yellow, cyan, magenta, purple, pink, orange, brown, black, and white. If you say "random" a random color will be generated. If you say "clockwise" or "counterclockwise" you can rotate the servomotor propeller.
8. If the color or command is not recognized, it will add "!?" in front of the color name.





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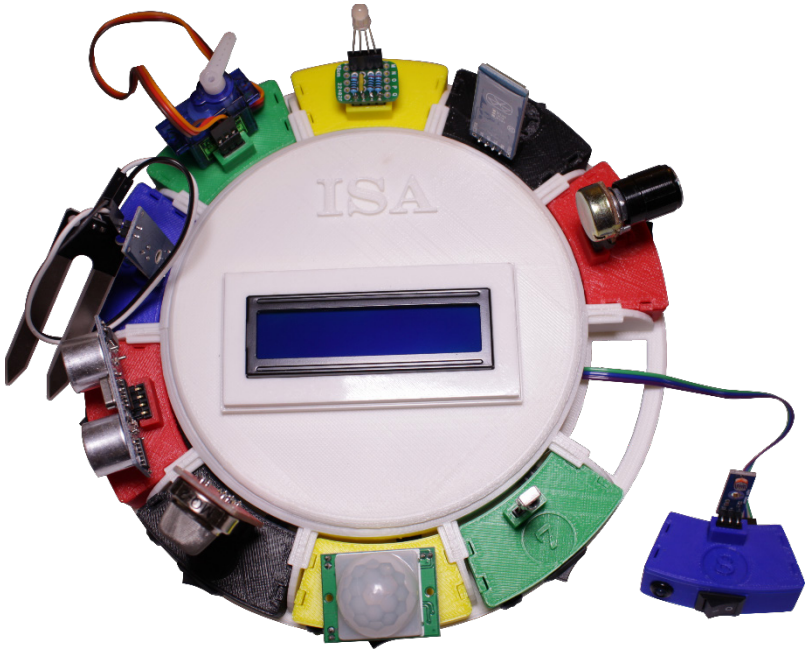
Extension Cables

Each sensor and actuator is connected to the ISA Shield through an extension cable. You can pull out the sensors and actuators from their compartments and move them according to the project requirements.



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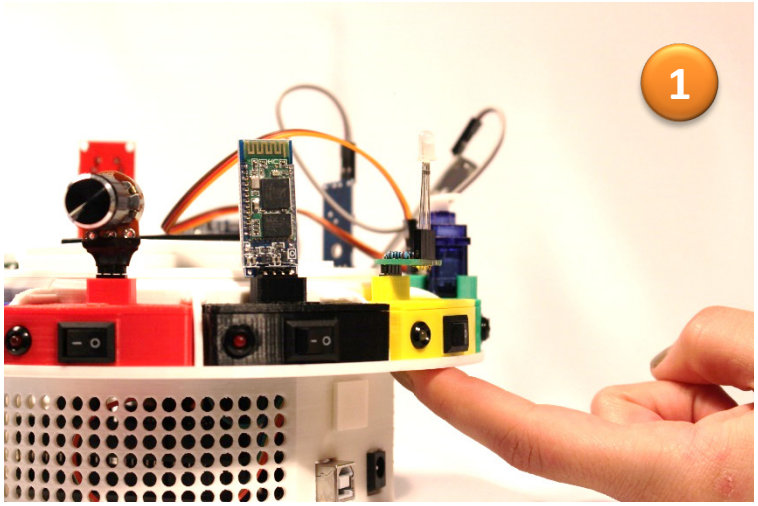
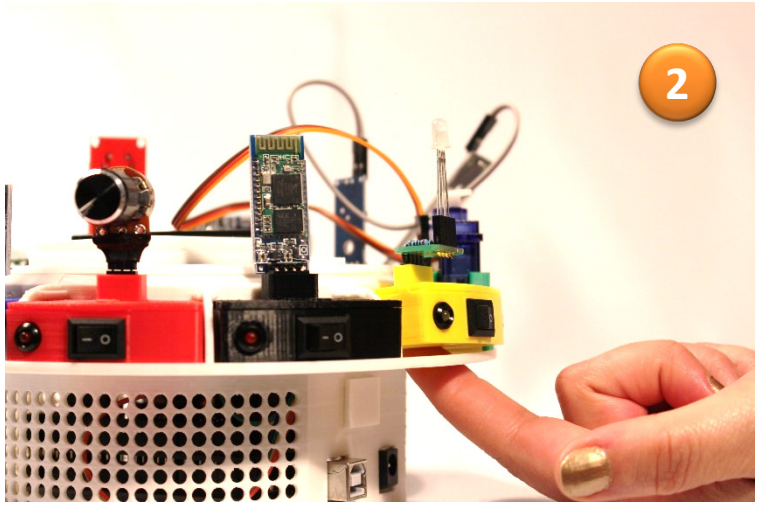
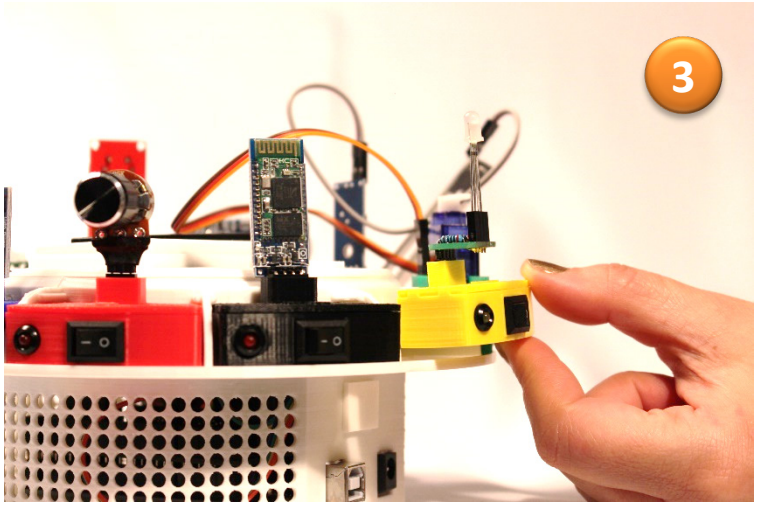
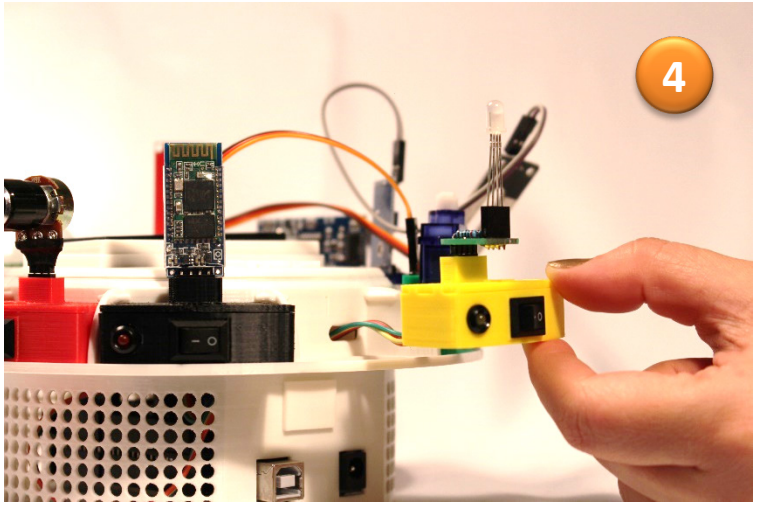
Extension Cables (Cont'd)









Push the sensor mount up then gently pull it out.

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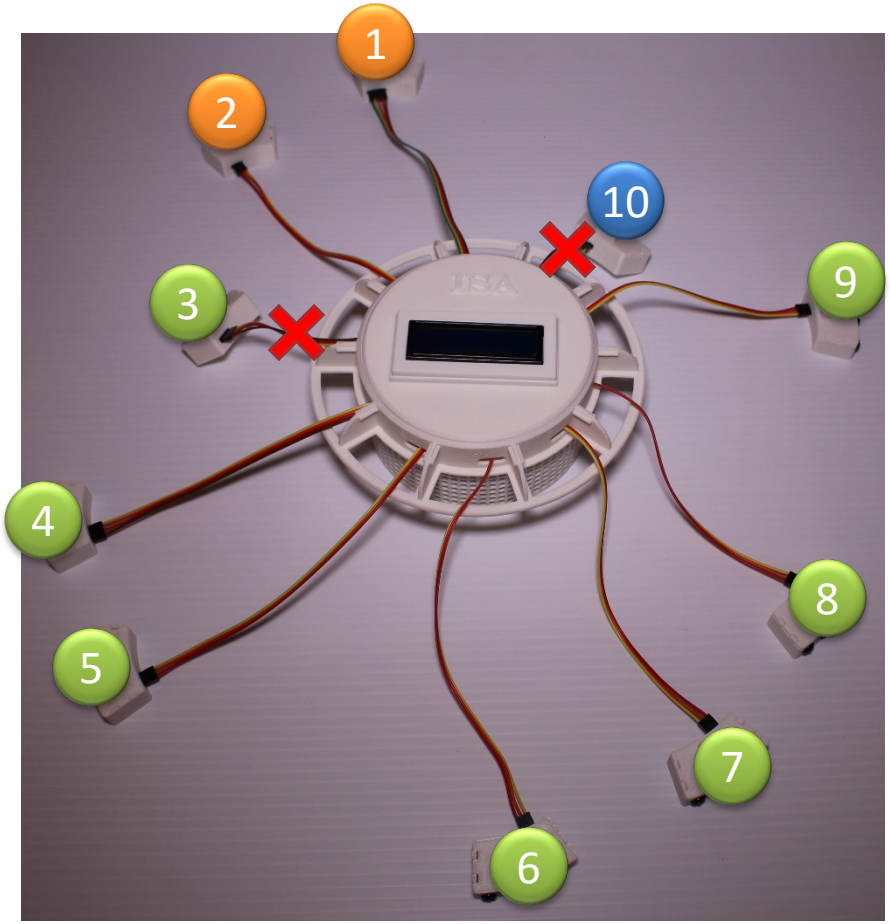
Extension Cables (Cont'd)

Warning!
Do not pull out the extension cables more than 6" (~15 cm).

A restriction in revision 1: Do not pull out the Bluetooth (#10) and moisture sensor (#3) module boxes because their extension cables are too short. This restriction has been removed in revision 2 (packages shipped after June 2015).



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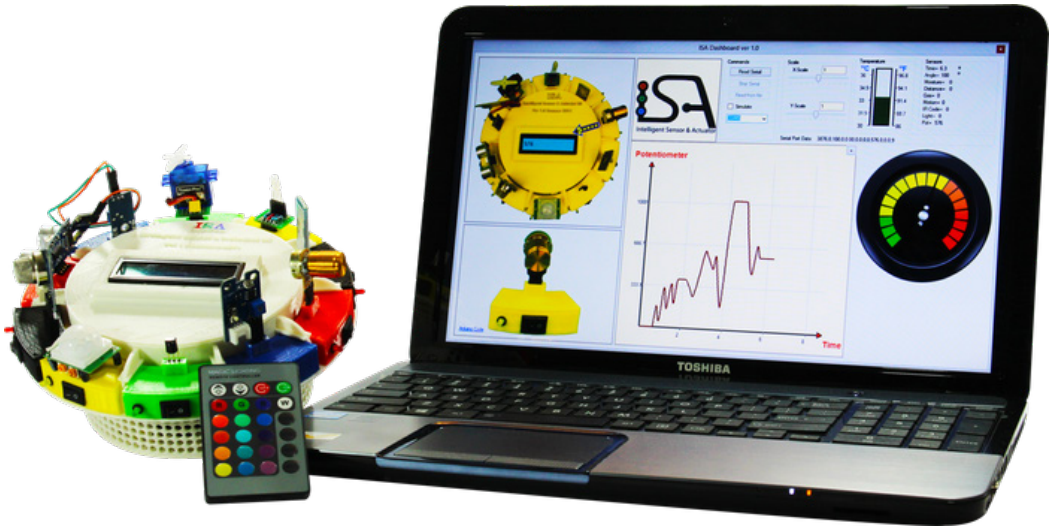
Software

The ISA Kit comes with two software packages:

1. Arduino Integrated Development Environment (IDE) to develop C code and upload it to the Arduino board.
2. ISA Dashboard is a software package developed for the ISA Kit. It provides an interface between the user and sensors/actuators on the ISA Kit. It communicates with the ISA Shield that is mounted on an Arduino microcontroller. The ISA Dashboard gets the signals and displays them on the computer screen via a Graphical User Interface (GUI). It functions similar to an oscilloscope. The ISA Dashboard is compatible with Windows 7, 8, 8.1, and 10 operating systems (OS).



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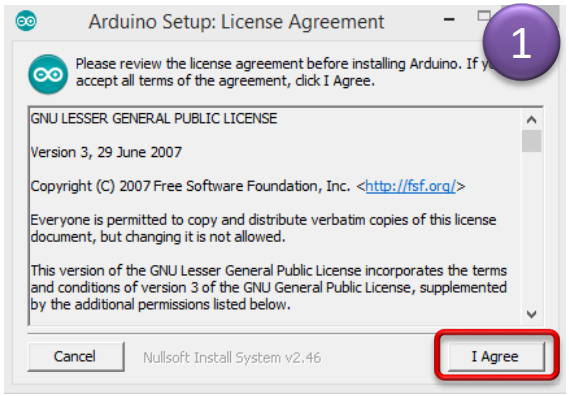
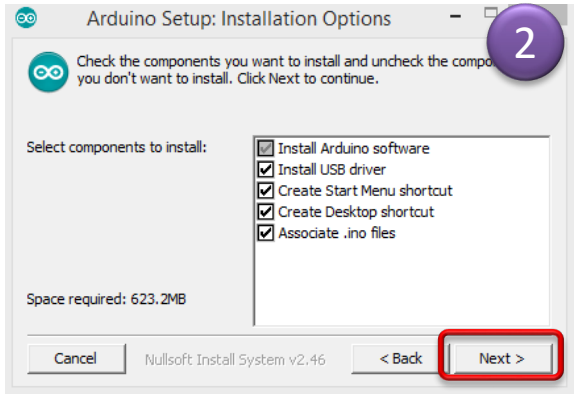
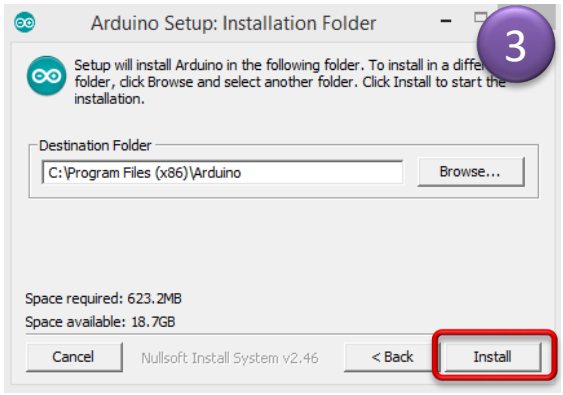
Install Arduino IDE

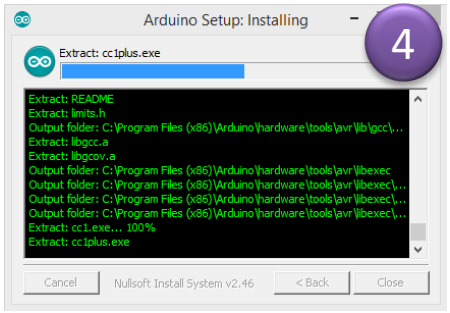
You can install the Arduino Integrated Development Environment (IDE) from the flash drive that comes with your ISA Kit. You may also download the latest version from the following link: http://arduino.cc/en/Main/Software.

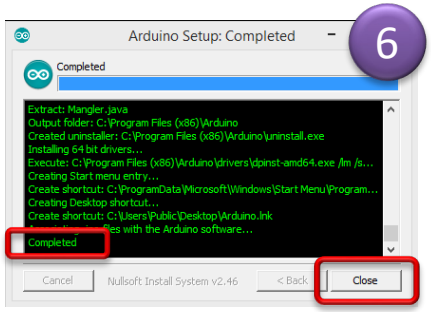
The following six steps depict the procedure to install the Arduino (IDE):







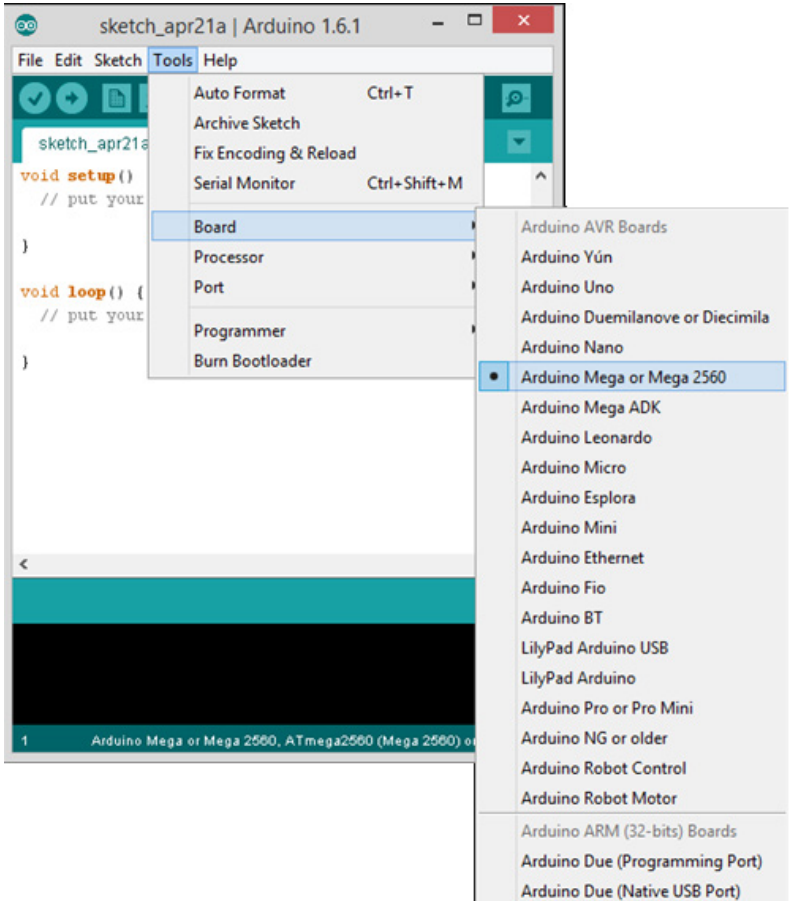




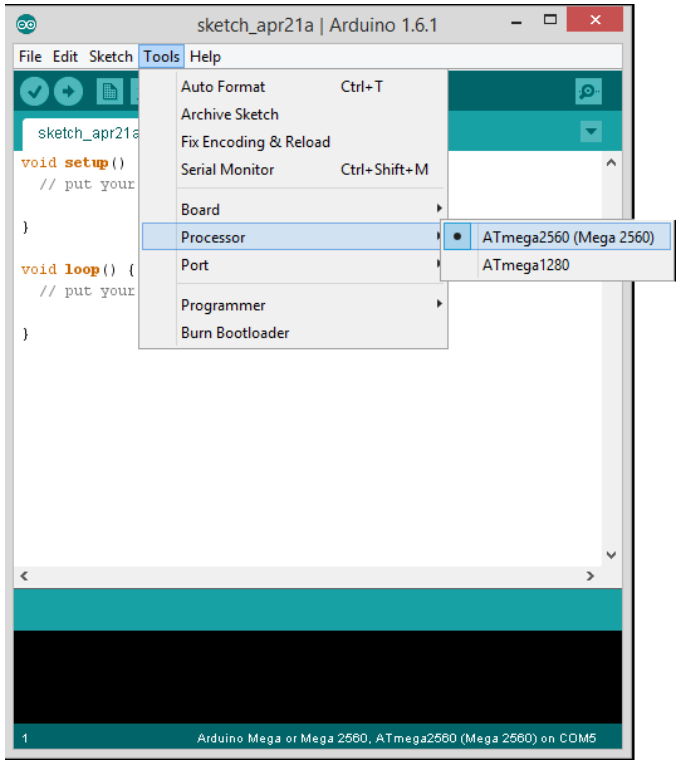
Arduino IDE

After installing the Arduino IDE, you may run it and configure the settings.

Tools→Board→ Arduino Mega or Mega 2560



Tools→Processor → ATMega 2560 (Mega 2560)



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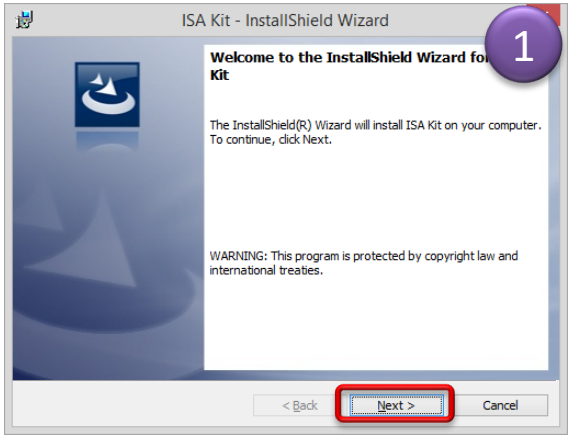
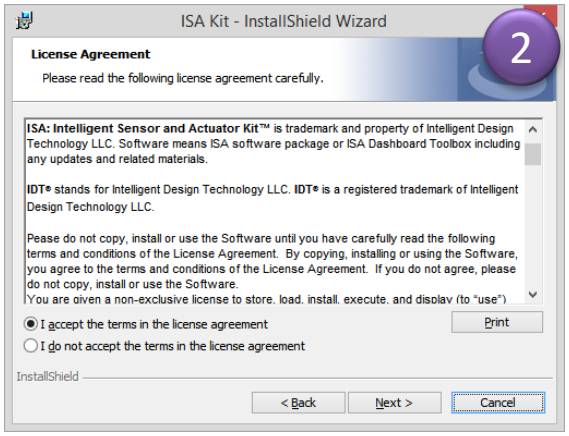
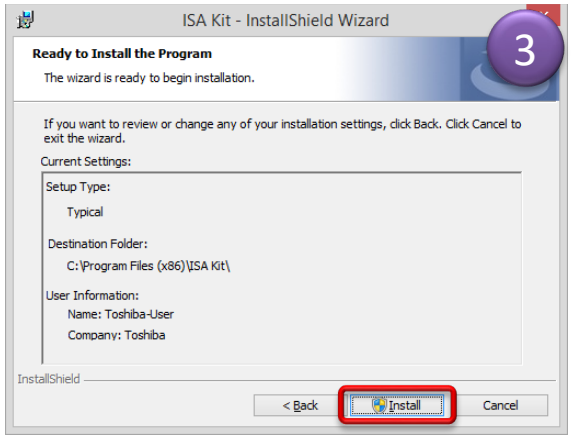
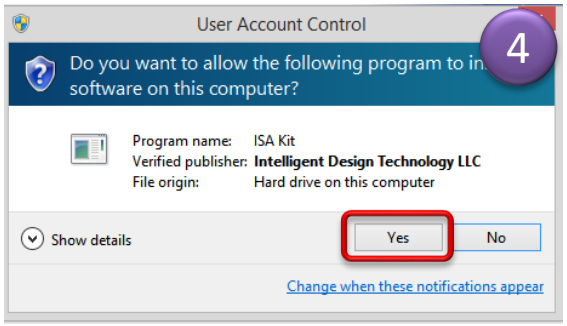
Install ISA Dashboard

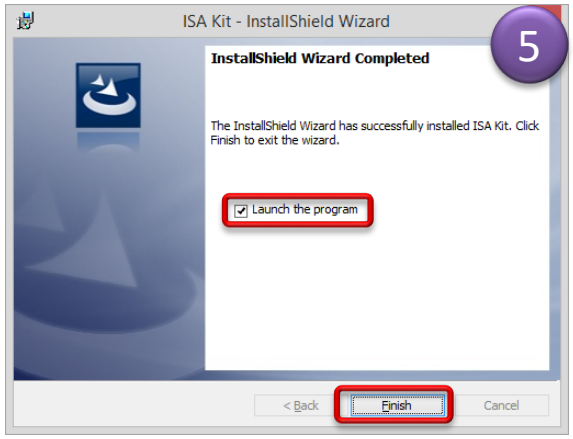
Install the ISA Dashboard Toolbox by running ISAKit_Setup.exe. Install the ISA Dashboard after installing the Arduino IDE. We highly recommend to close all other applications while installing the ISA Dashboard.
The following five steps depict the procedure to install the ISA Dashboard:





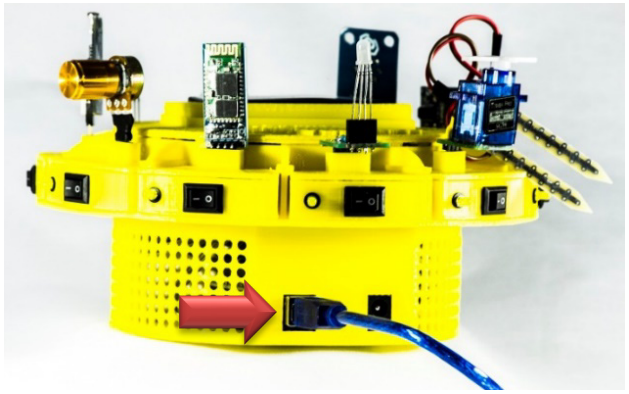




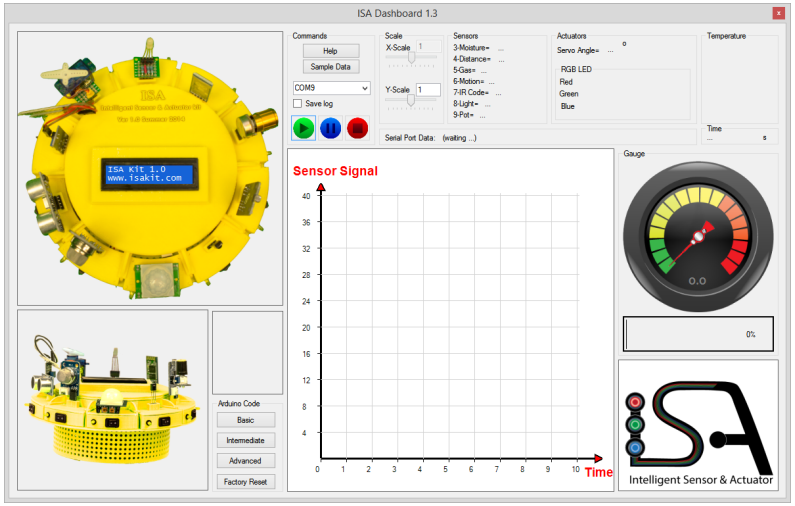


Run the ISA Dashboard

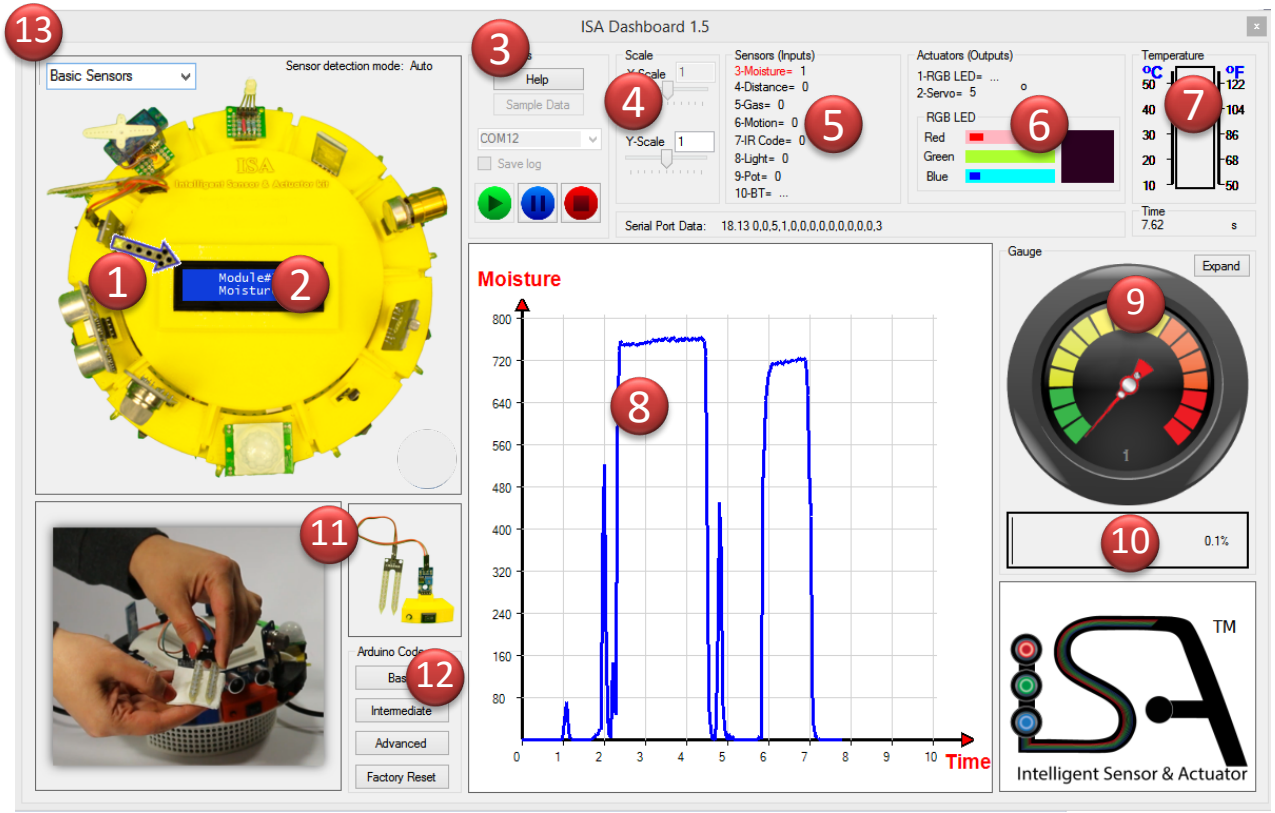
1. Connect the USB cable to the ISA Kit and the USB port of your computer. Make sure the 9V battery is NOT connected.



2. Turn on RGB LED (module #1) and servomotor (module#2). The run ISA dashboard by clicking on the ISAKit.exe shortcut ( ) on your desktop or from Windows Start menu.



ISA Dashboard



1. Animated arrow showing the signal received from sensor or the signal sent to an actuator.
2. Information of the current module being processed.
3. Command buttons:
   - Help: Opens the user manual.
   - Sample Data: Runs a sample data file
   - COM port menu: select the COM port (USB port) that is used for connecting the ISA Kit.

ISA Dashboard (Cont'd)

- Baud rate menu: sets the USB baud rate. It should match the baurd rate set in Arduino code.
- Save log: When checked, the data log will be saved.

Start: Starts receiving data from the ISA Kit via USB cable.

Pause: Pauses receiving data from the ISA Kit.

Stop: Stops receiving data from the ISA Kit.

4. Changes the scale of the y axis.
5. Date received from the sensors.
6. Date sent to the actuators.
7. Temperature data (not available in the current version).
8. Plots data signals from the sensors versus time.
9. A radial gauge.
10. A bar gauge.
11. Image of the selected module being processed.
12. Opens the corresponding Arduino code (for basic, intermediate, and advanced projects).
    When you upload an Arduino code for basic or intermediate project, the Arduino code will not communicate with the ISA Dashboard. Only for the advanced projects the communication is enabled via the USB port.
    - Factory Reset: Opens the Arduino code that was originally uploaded into the ISA Kit when the package was shipped.
13. Select from Basic (1-10), Pro (11-20), and Premium (21-30) sensors and actuators. It is used in Pro and Premium Kits with more than 10 sensors and actuators.

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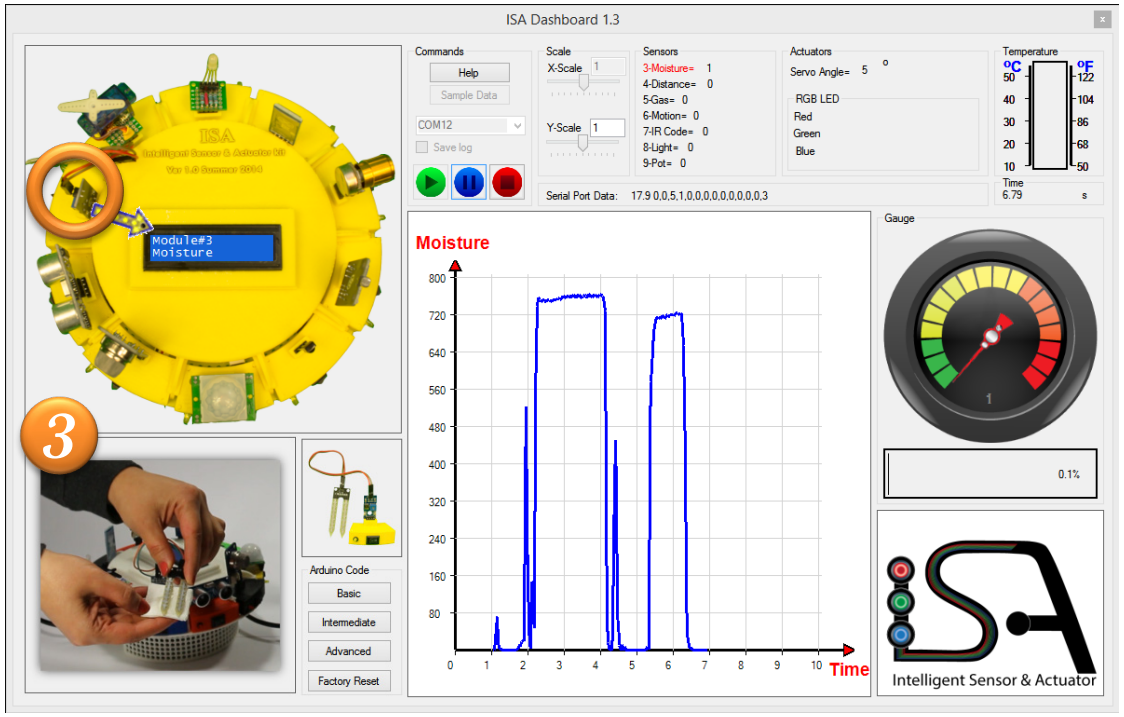
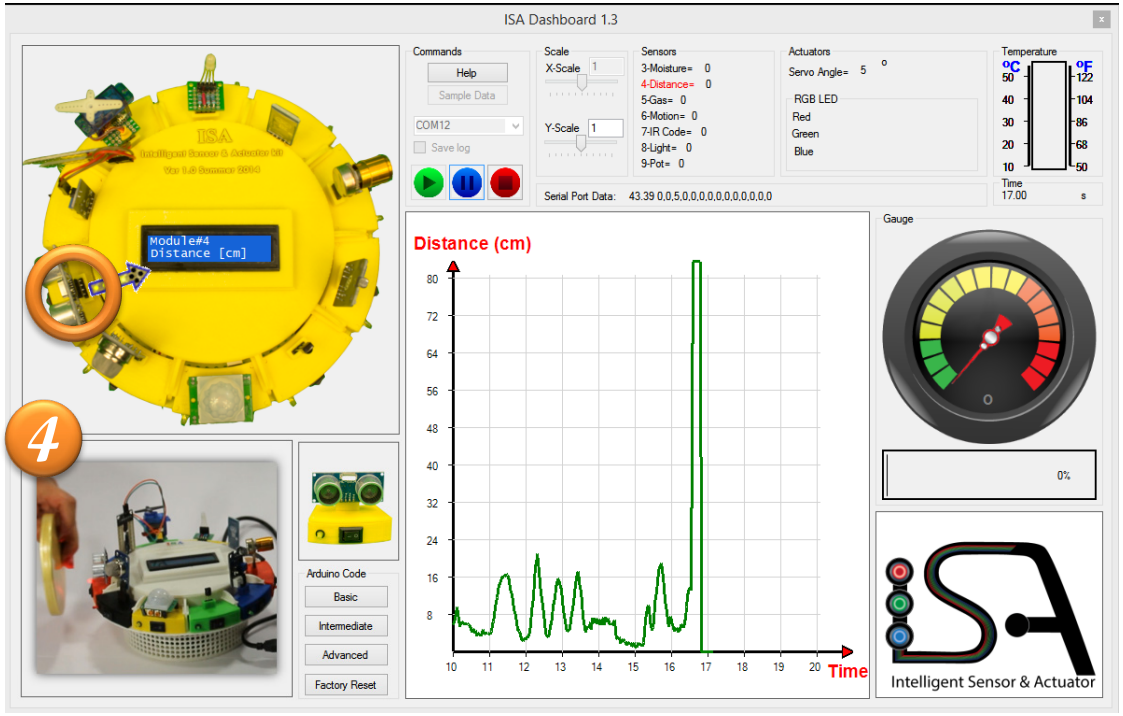
Module #3: Moisture Sensor

1. Turn all the switches off.
2. Turn on the switch for module box #3.
3. An animated arrow will show signals are being received from the moisture sensor.
4. Measure the moisture of the soil or a wet napkin/cloth. You may also measure the conductivity of your skin by holding the probe of the sensor in you hand and pressing it.
5. The data will be plotted versus time.



Module #4: Ultrasonic Sensor

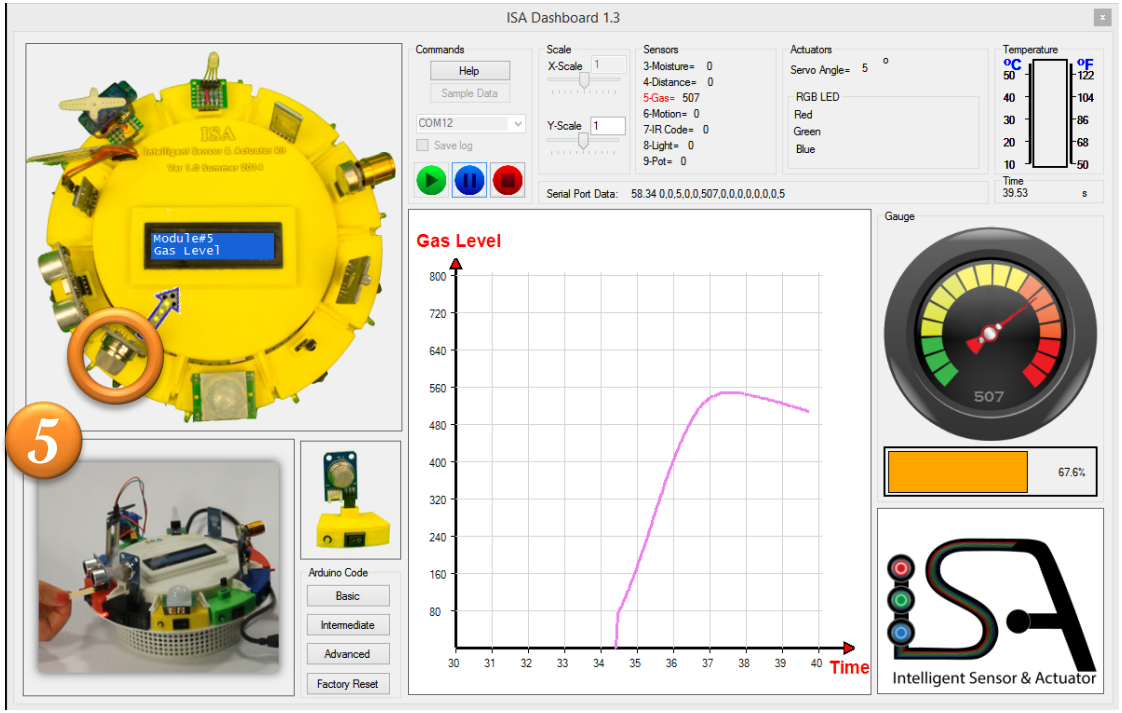
1. Turn all the switches off.
2. Turn on the switch for module box #4.
3. An animated arrow will show signals are being received from the ultrasonic sensor.
4. Move an object backward and forward in front of the ultrasonic sensor. Moving an object with uneven surfaces, such as a hand, may cause some noise in send/receive signals. In that case, use an object with an even surface, such as a flat plate.
5. The data will be plotted versus time.



Module #5: Gas/Alcohol Sensor

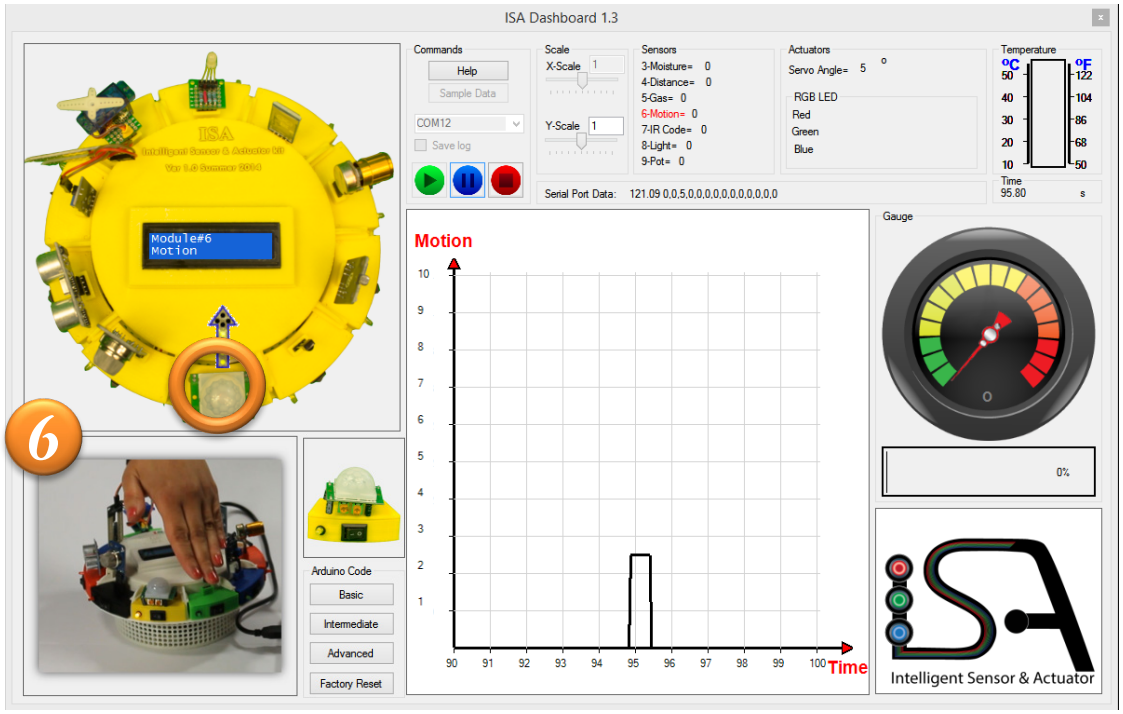
1. Turn all the switches off.
2. Turn on the switch for module box #5.
3. An animated arrow will show signals are being received from the gas/alcohol sensor. Wait for approximately 20 seconds while the sensor calibrates itself.
4. Use smoke from a match or alcohol swab in front of the sensor.
5. The data will be plotted versus time.

OR



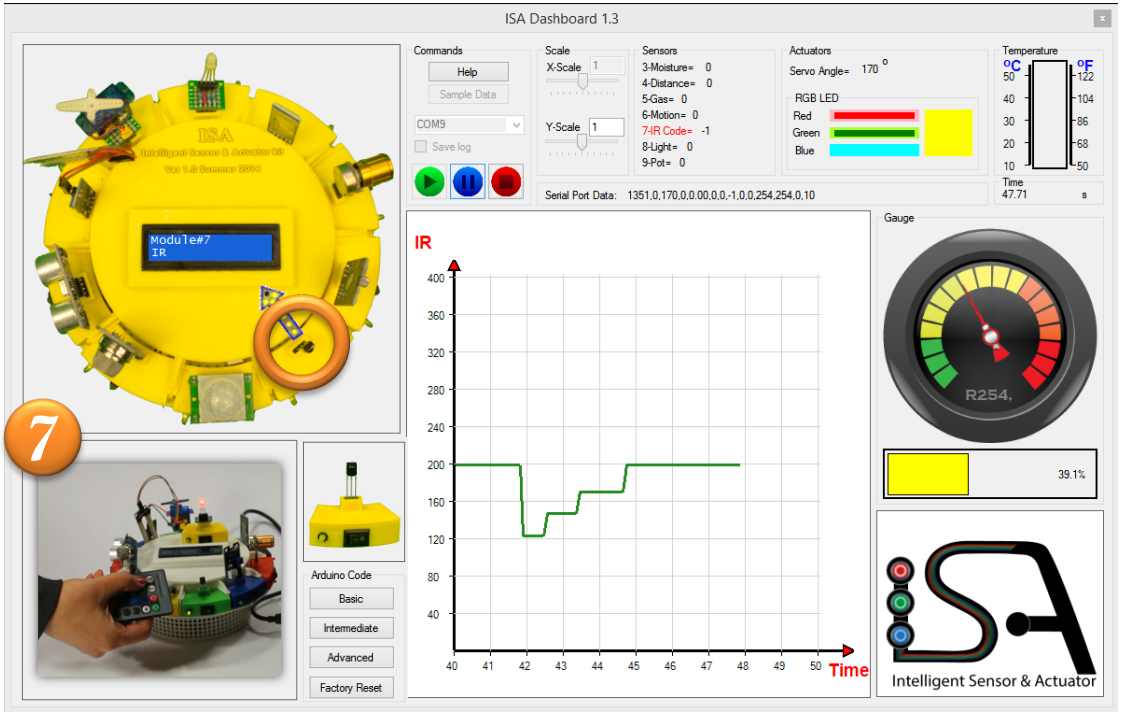
Module #6: Motion Sensor

1. Turn all the switches off.
2. Turn on the switch for module box #6.
3. An animated arrow will show signals are being received from the motion sensor.
4. Wait for a few seconds then move your hand.
5. The motion detection data will be plotted versus time (0: no motion detected, 1: motion detected).
6. One way to test the sensor is to put a Styrofoam or opaque plastic cup with a small hole in it on top of the motion sensor. Any motion close to the hole will be detected.



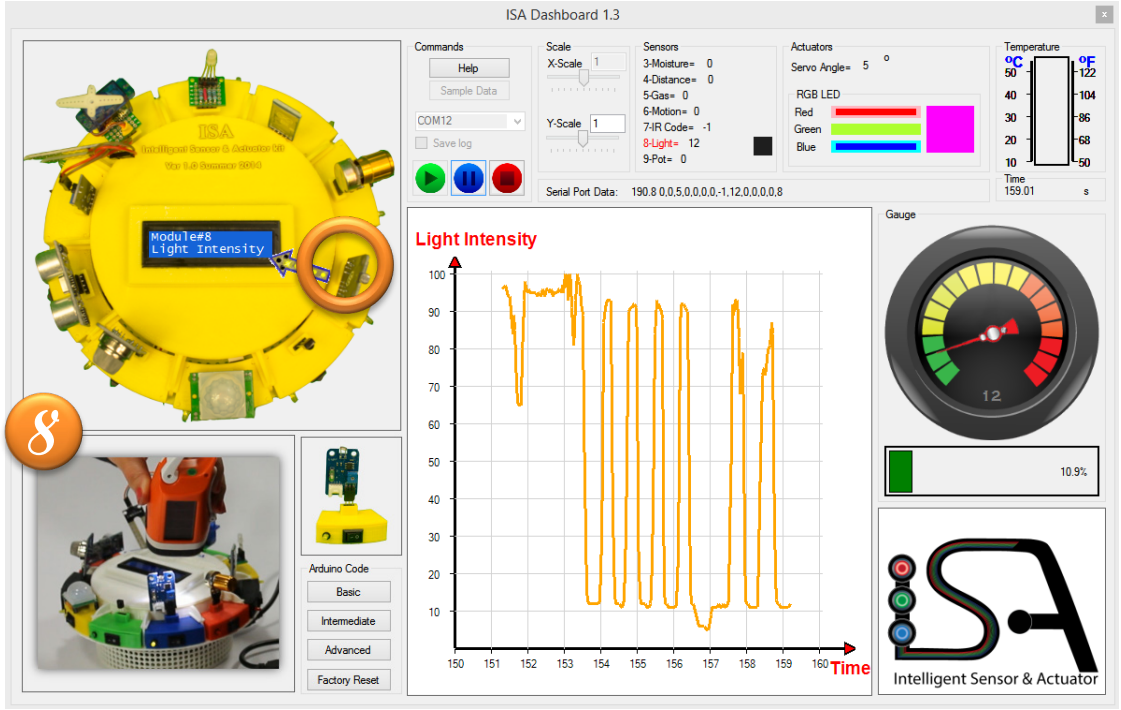
Module #7: Infrared (IR) Sensor

1. Turn all the switches off.
2. Turn on the switches for module box #7 and #1 (RGB LED).
3. An animated arrow will show signals are being received from the IR sensor.
4. Push the buttons on the IR remote control. The LED color will change accordingly.
5. The data will be plotted versus time.
6. → **Important:** At the end, make sure to push the **OFF** button to turn the LED off.
7. For troubleshooting, check if the IR sensor is connected properly. Sometime, unplugging the USB cable and plugging it back may resolve the issue.



Module #8: Light Sensor

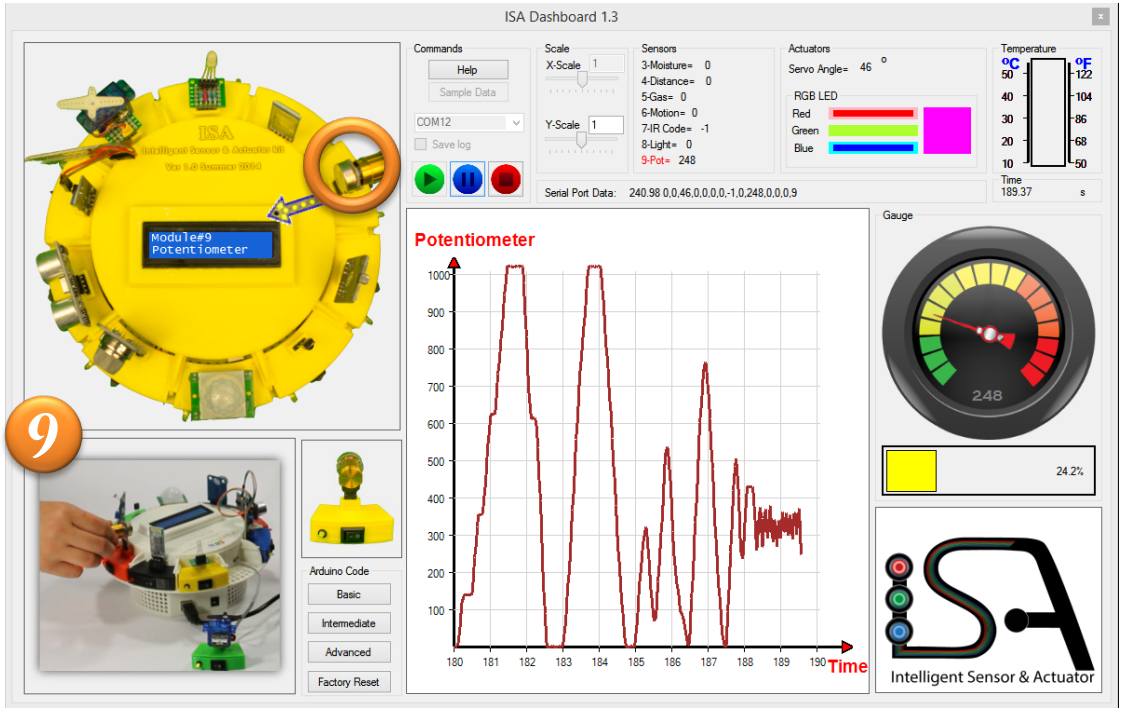
1. Turn all the switches off.
2. Turn on the switch for module box #8.
3. An animated arrow will show signals are being received from the light sensor.
4. Change the light intensity using a flash light.
5. The data will be plotted versus time.



Module #9: Potentiometer

1. Turn all the switches off.
2. Turn on the switch for module box #9.
3. An animated arrow will show signals are being received from the potentiometer.
4. Turn the knob on potentiometer.
5. The data will be plotted versus time.

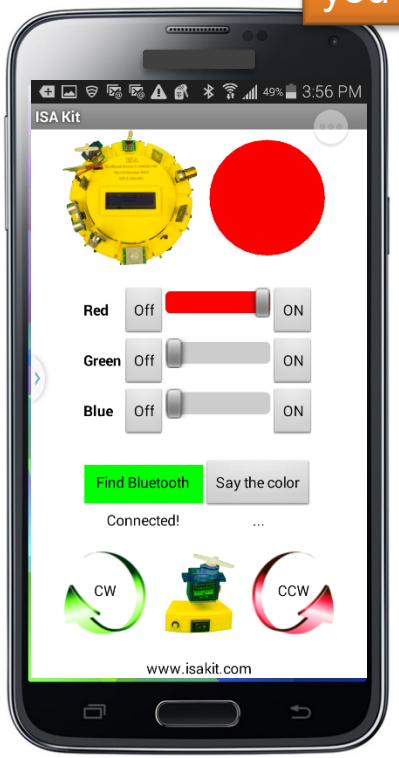
Important: If you would like to control the servomotor (module #2) you should turn it on before running the ISA Dashboard.

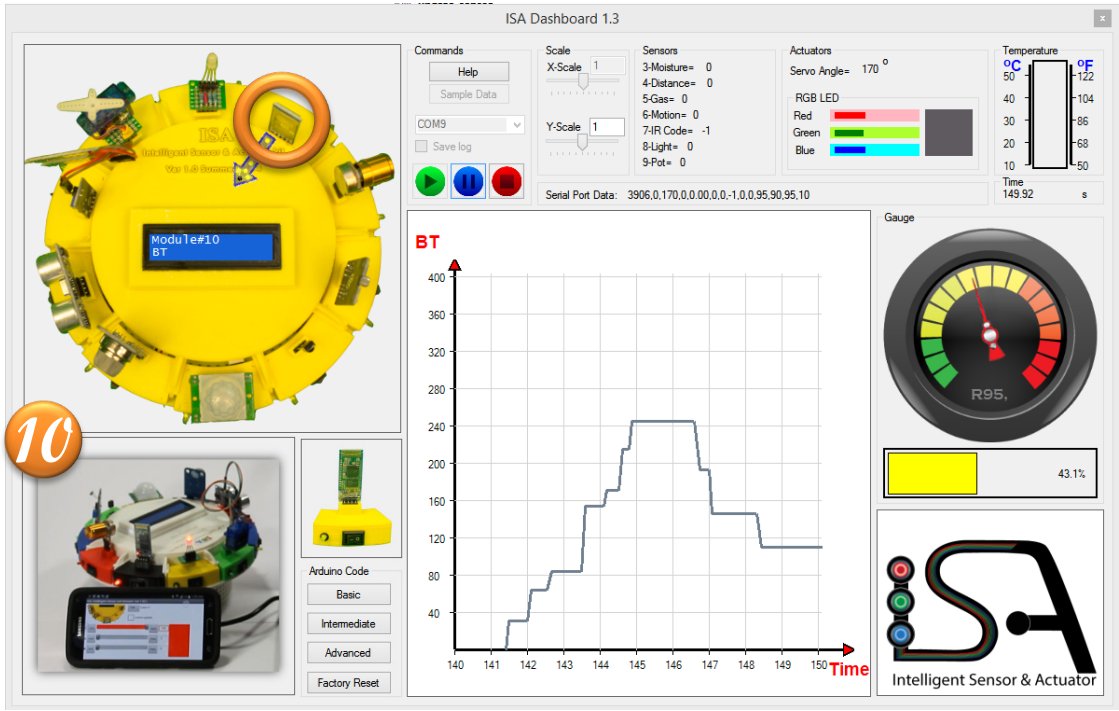


Module #10: Bluetooth

1. Turn all the switches off.
2. Turn on the switch for module box #10.
3. An animated arrow will show signals are being received from the Bluetooth.
4. Run ISA App on your smart phone or tablet.
5. The RGB color will change accordingly.

Important: If you would like to control the servomotor (module #2) you should turn it on before running the ISA Dashboard.





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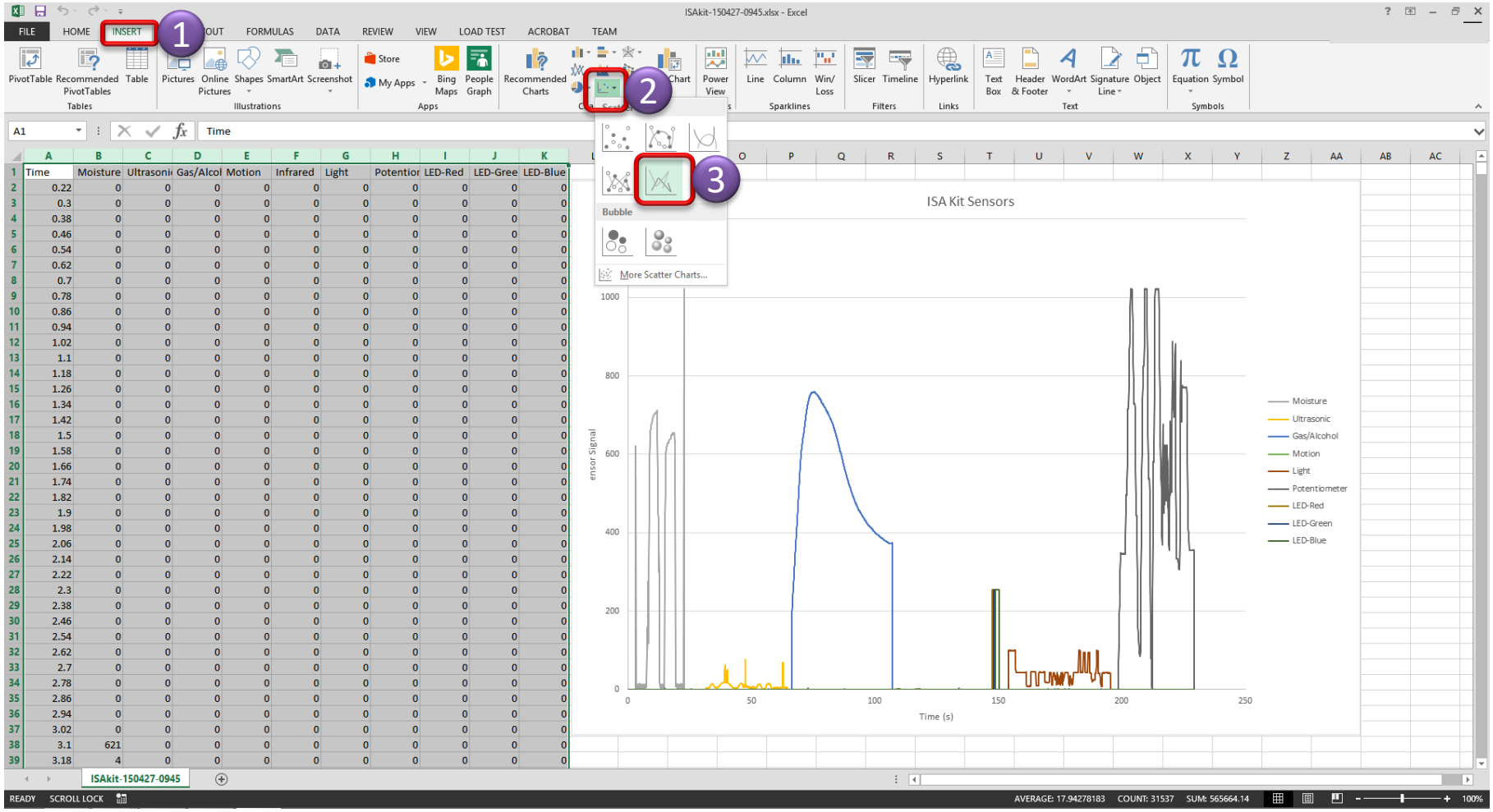
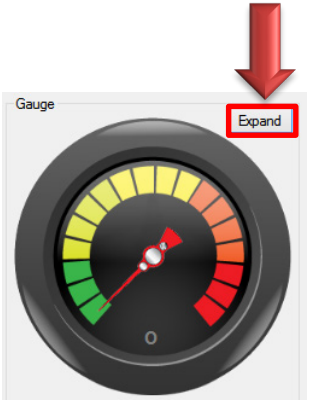
ISA Log File

When you open the saved log file in Excel, you can plot the time history of the signals received. To do so, select the data then from “INSERT” tab click on “Insert Scatter (x,y)” and finally click on your desired plot type.



Expanded Gauges

By clicking on “Expand” button on the top right of the gauge frame, a new window will pop up that included extended gauges for all the sensors connected. This tool is very useful when you are monitoring more than one sensor at a time. If any sensor is not connected, the corresponding gauge will just show noise signal.



Do not turn on more than four sensors or actuators at the same time.

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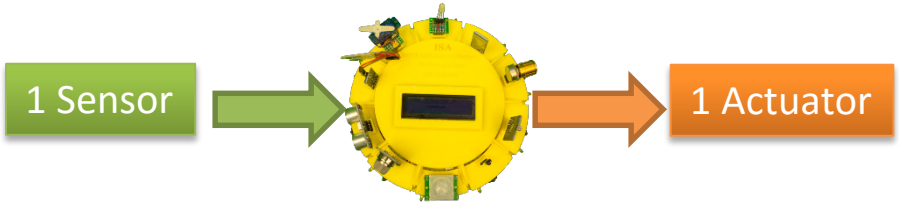
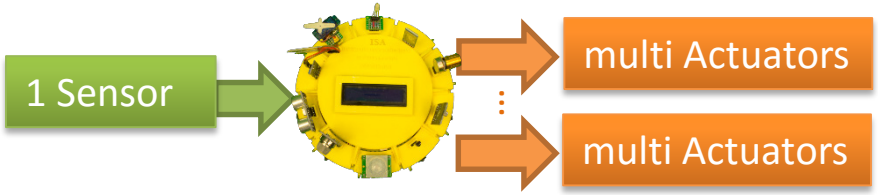
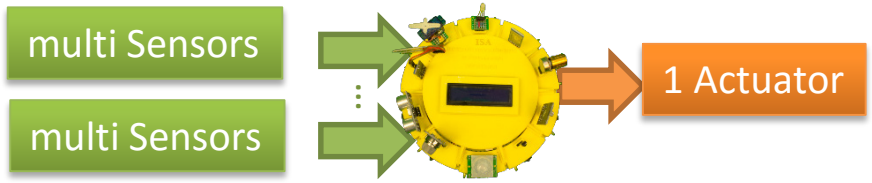
ISA Projects

Basic projects (type 1): Single-Input Single-Output (SISO)

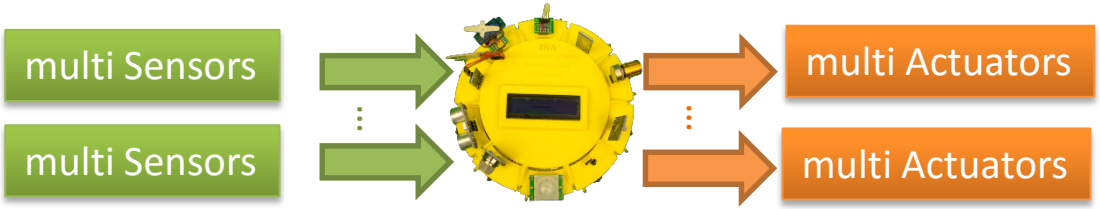


Intermediate projects (type 2): Single-Input Multi-Output (SIMO) or Multi-Input Single-Output (MISO)





Advanced projects (type 3): Multi-Input Multi-Output (MIMO)



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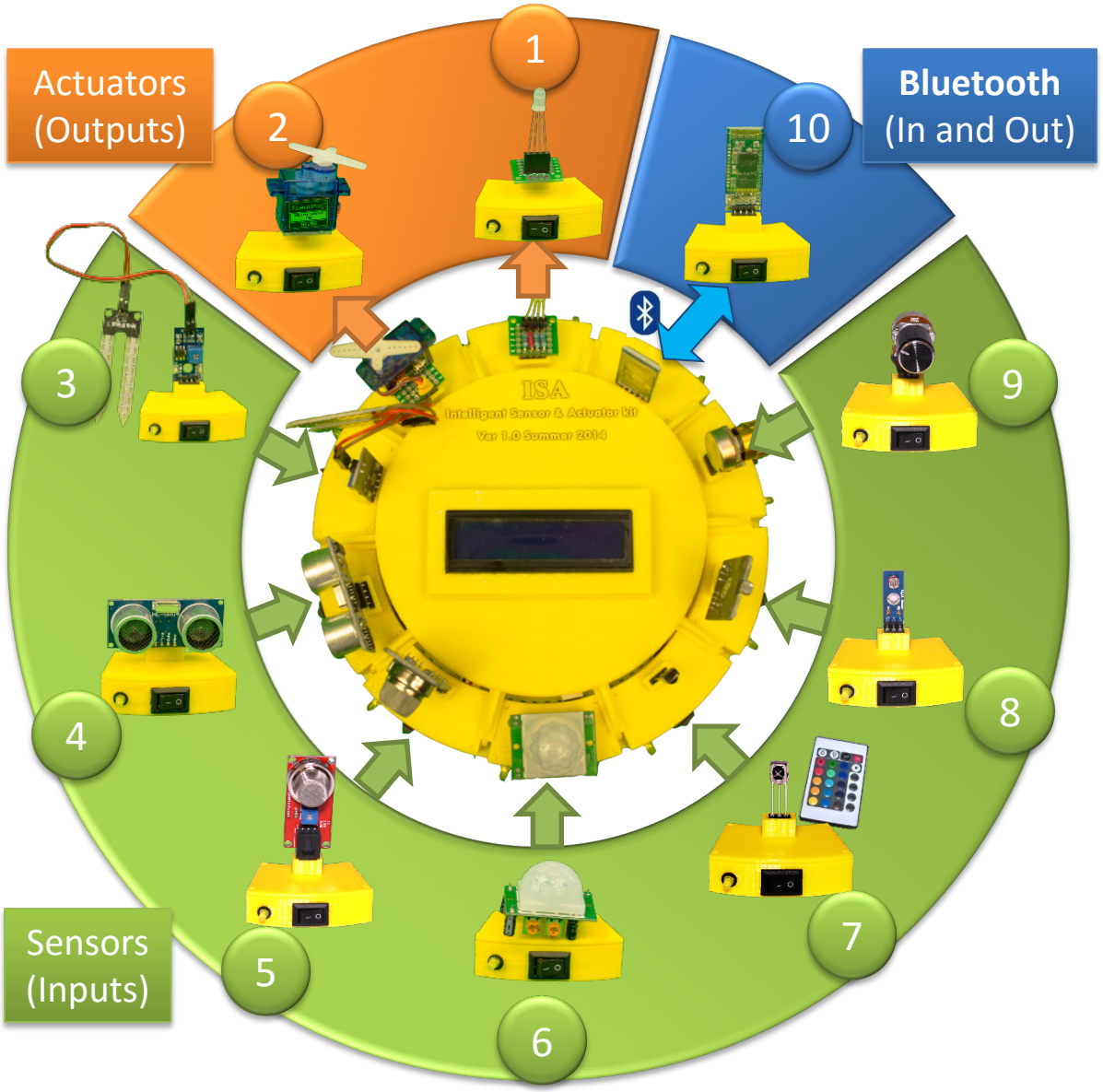
Sensors/Inputs and Actuators/Outputs



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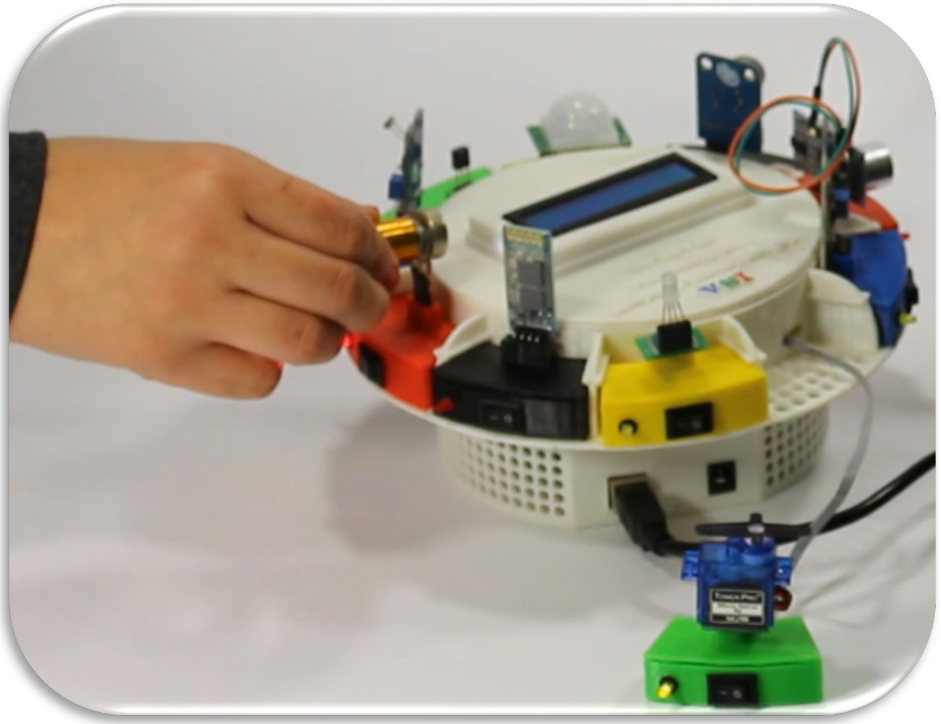
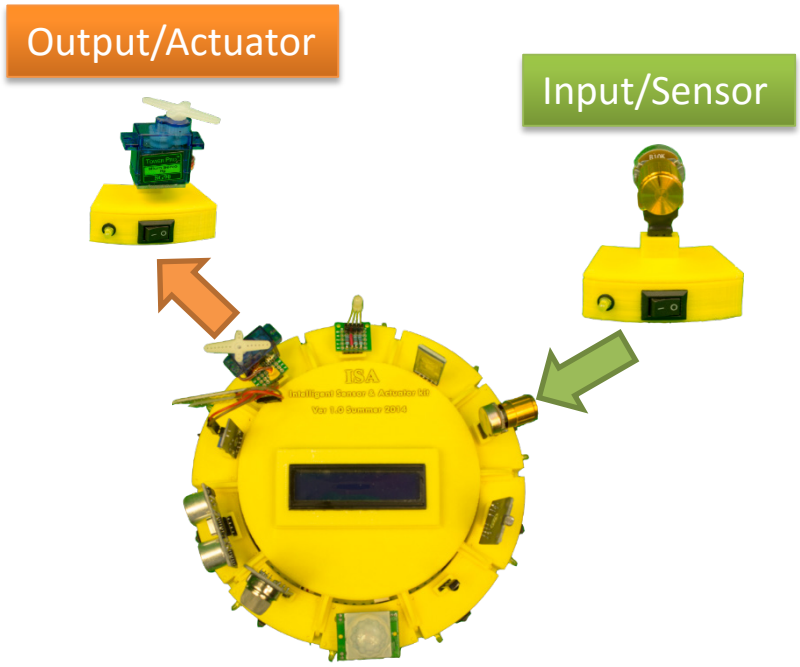
SISO Projects

ISA Kit ver 1.0 is ideal for Single Input, Single Output (SISO) projects. An example of a SISO project is a potentiometer (sensor/input) and a servo motor (actuator/output).





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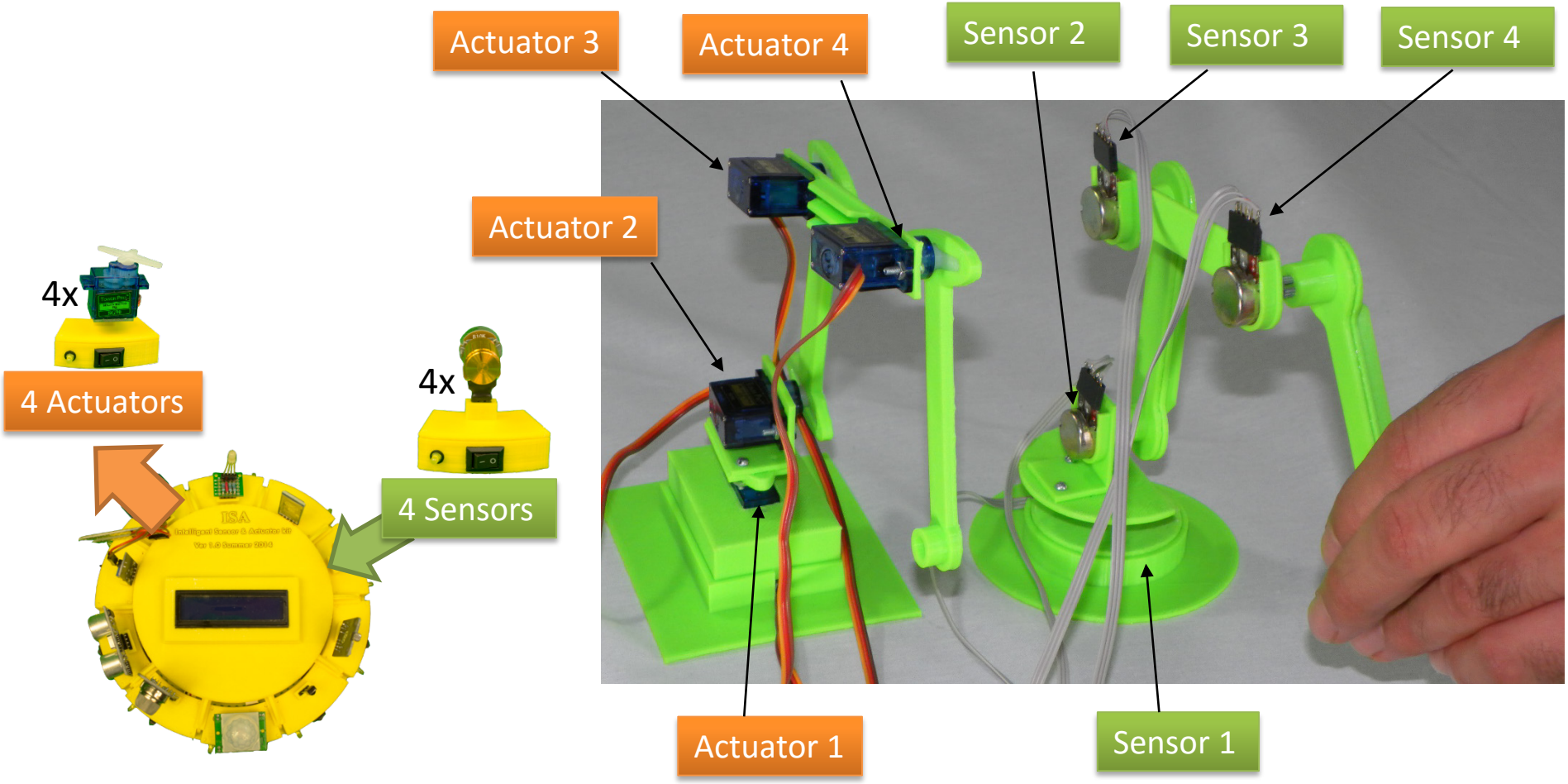
MIMO Projects

You can do Multi-Input, Multi-Output (MIMO) projects with the ISA Kit ver 1.0. An example of a MIMO project is a four degree-of-freedom (DOF) telerobotic arm. In this project, four potentiometers (sensors/inputs) and four servo motors (actuators/outputs) are used.



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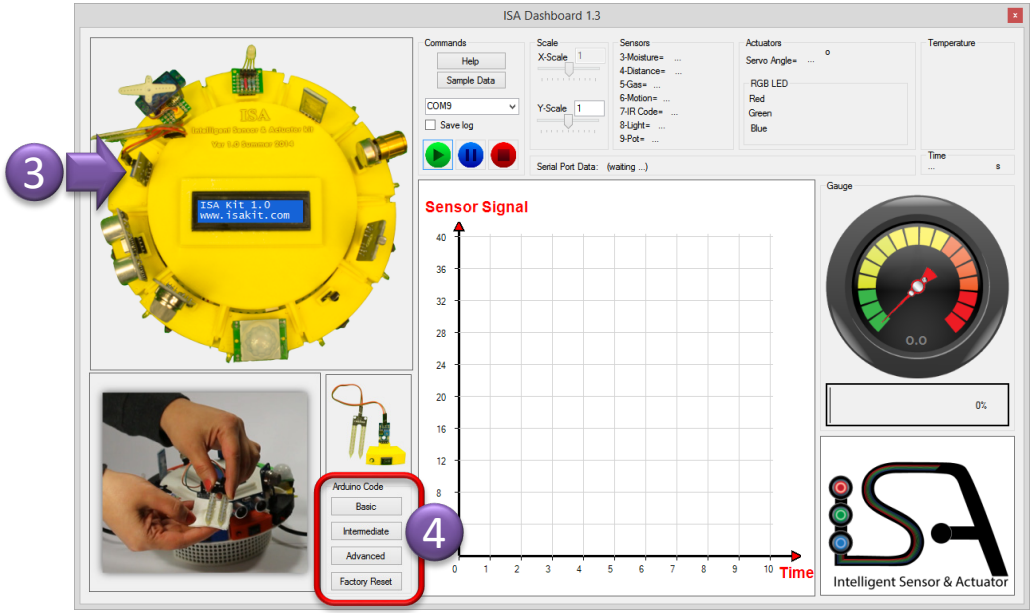
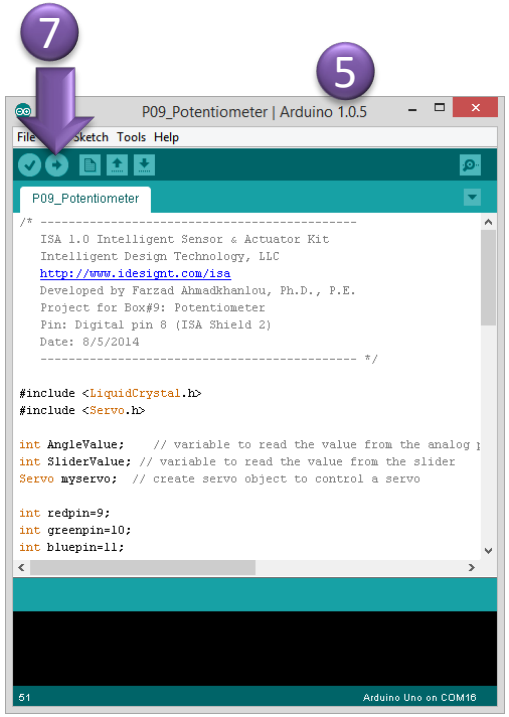
How to Run a SISO Project

1. Connect the ISA Kit to your computer through USB cable
2. Run the ISA Dashboard.
3. Pick a sensor (input) or actuator (output) by clicking on its image.
4. In the “Arduino Code” panel, select the difficulty level of the project: Basic, Intermediate, and Advanced.
5. The Arduino code for the selected project will pop up in Arduino IDE.
6. Make sure all the sensors/actuators are turned off. It is okay to leave RGB LED (module #1) on. Also make sure to stop receiving data by clicking on icon.
7. Compile and upload the code by clicking on icon.
8. Use the sensor (input) and look at the actuator (output).





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Arduino Codes

- When you compile and upload the code to Arduino it will overwrite the original file on the Arduino.
- When you upload an Arduino code for basic or intermediate project, the Arduino code will not communicate with the ISA Dashboard. Only for the advanced projects the communication is enabled via the USB port. So for basic and intermediate projects the sensor/actuator signals will not be plotted in ISA Dashboard.
- For basic projects, the LCD will be disabled. To see the sensor/actuator signals use "**Serial Monitor**" in Arduino IDE.
- After the Arduino code for a selected sensor/actuator is uploaded to the microcontroller, only the signal received/sent from/to that specific sensor/actuator will be monitored. So the signals from the rest of sensors/actuators will not be monitored. To get signals from all the sensors/actuators you need to click on "Factory Reset" button.
- "**Factory Reset**" button opens the Arduino code that was originally uploaded to the ISA Kit when the package was delivered. So to reset the configuration of the ISA Kit to its original status click on "Factory Reset" button and upload the Arduino code to the ISA Kit microcontroller.

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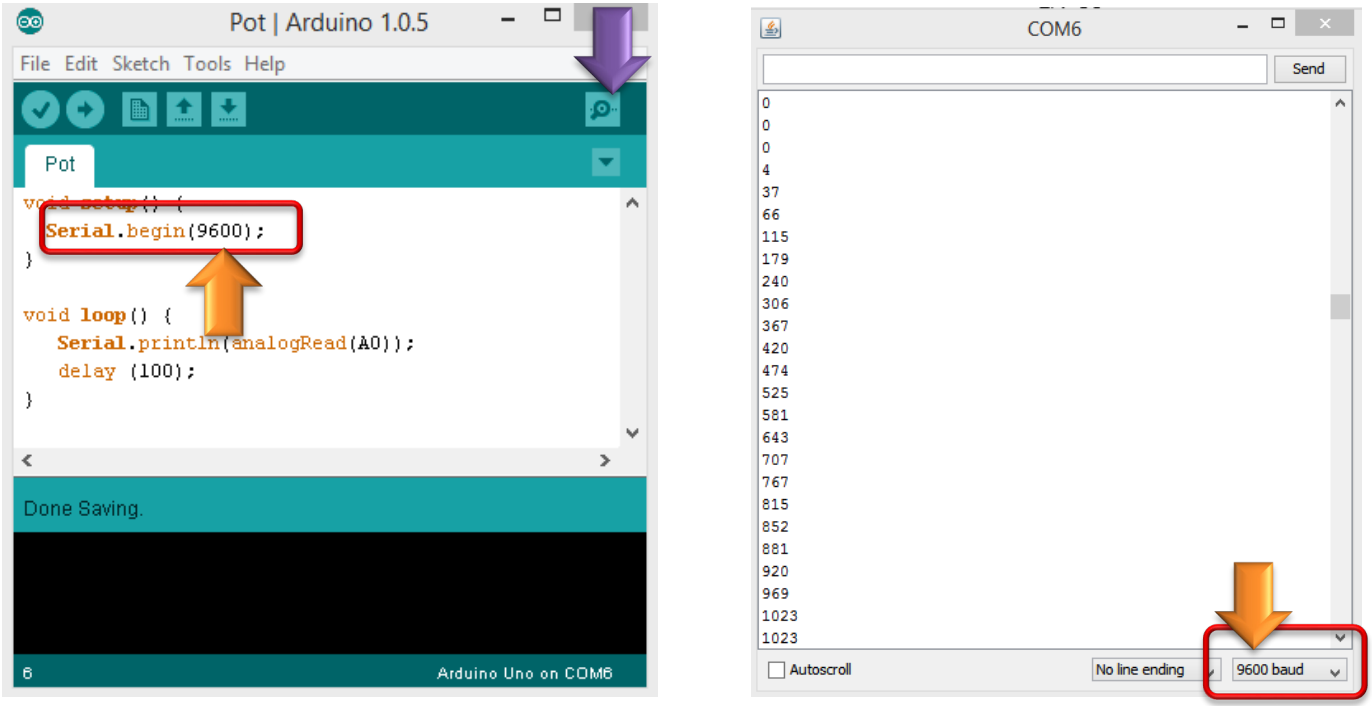
Serial Monitor

- “Serial Monitor” can be used to see the data transferred via USB port (COM or Serial port).
- After compiling the code to Arduino microcontroller, click on “Serial Monitor” to see the data.
- The baud rate value in “Serial Monitor” window should be the same as the baud rate used in the code. The default value is 9600.

Serial Monitor



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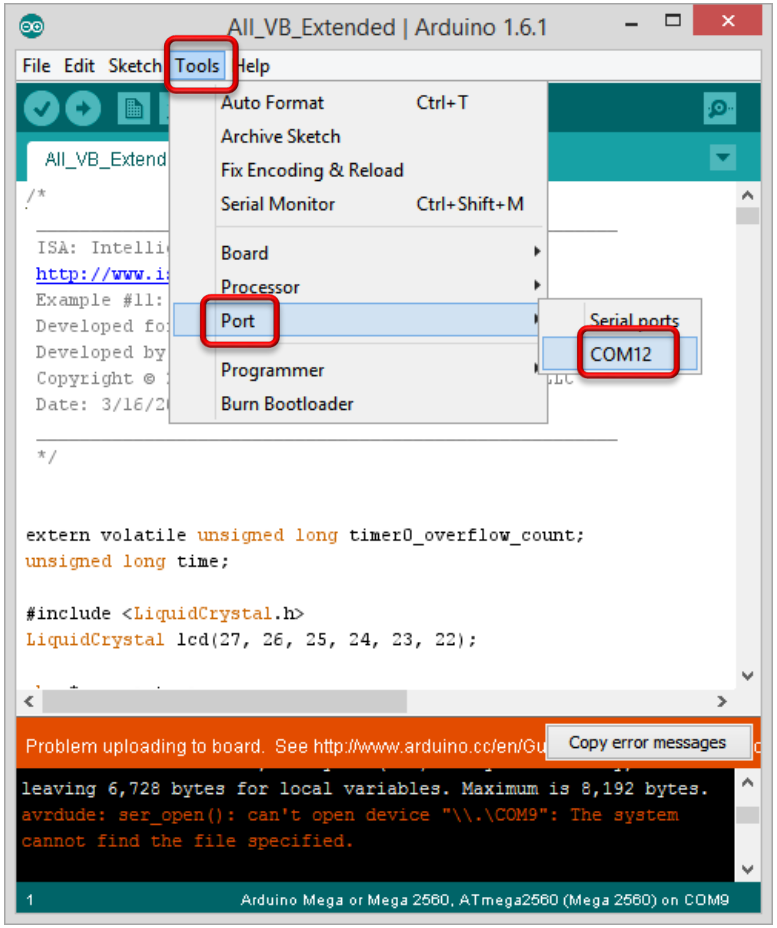
Arduino IDE Troubleshooting

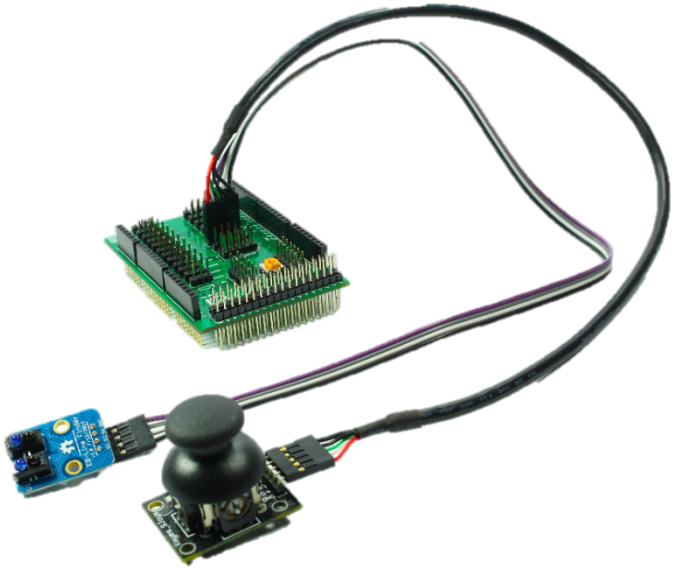
If an error message appears during uploading the code to Arduino, you may need to do one of the following actions:

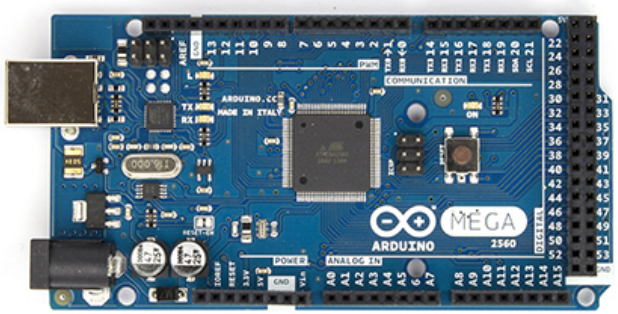
- Turn all the switches off (from module #1 to #10).
- Check the USB port connection
- Select the correct COM port number. This COM port number varies for different computers.
- Close the ISA Kit Dashboard.
- Unplug the ISA Kit from your computer and plug it back.
- Reboot your system.



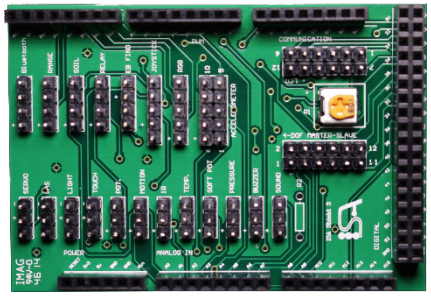
ISA Shield

ISA Shield is a Printed Circuit Board (PCB) interface between the Arduino microcontroller and sensors and actuators. ISA Shield v2 was designed for Arduino UNO and ISA Shield v3 is designed for Arduino Mega which comes with the ISA Kit 1.0. This shield is designed such that you can easily plug in your sensors and actuators.



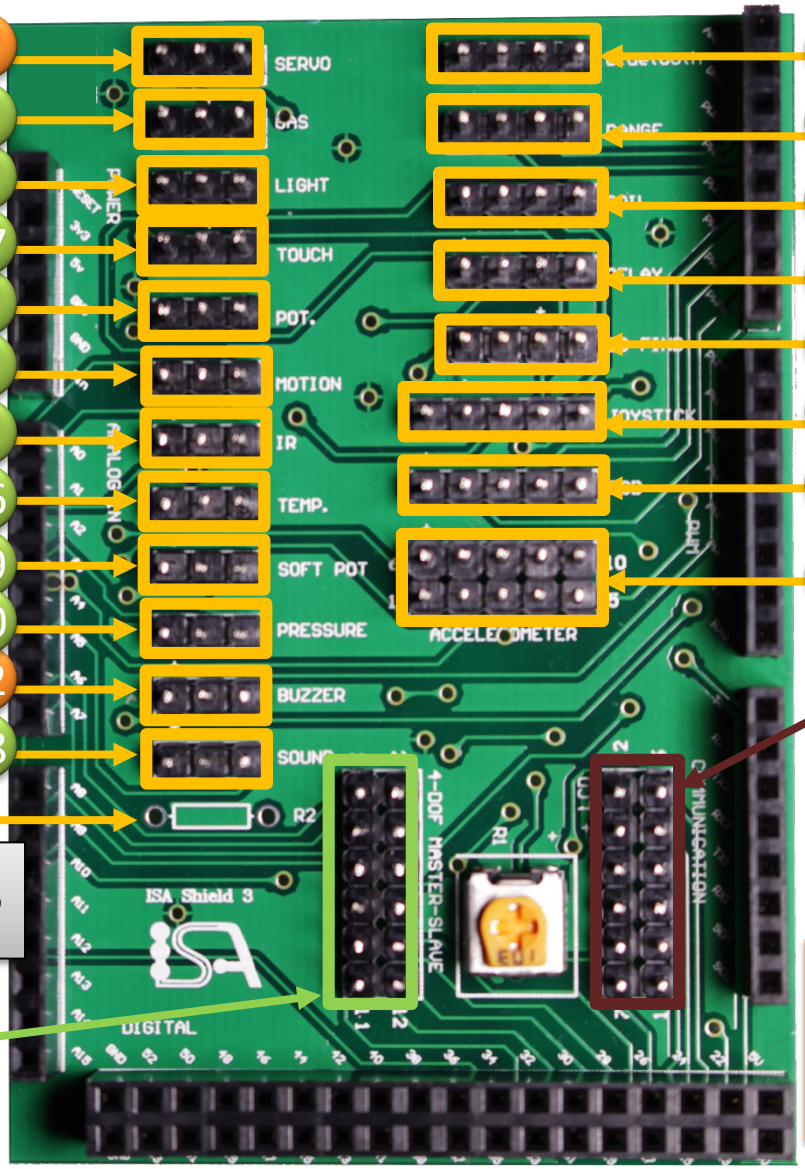


Arduino Mega



ISA Shield 3

ISA Shield v3



Servomotor 2
Gas/alcohol 5
Light 8
Touch 17
Potentiometer 9
Motion 6
Infrared (IR) 7
Temperature/humidity 16
Soft Potentiometer 19
Pressure 20
Buzzer 12
Sound 18
Pressure Resistor

For the Basic Kit, solder a resistor that is appropriate for your pressure sensor. In Pro and Premium Kits a 10 kΩ resistor is used.

4-DOF telerobotic arm (Add-on)

10 Bluetooth
4 Ultrasonic (range)
3 Moisture sensor
11 Relay
15 Find Line (Tracking)
14 Joystick
1 RGB LED
13 Accelerometer

LCD

Sensors/actuators marked in red are part of the extended features for ISA Kit 1.0 (Pro and Premium Kits).

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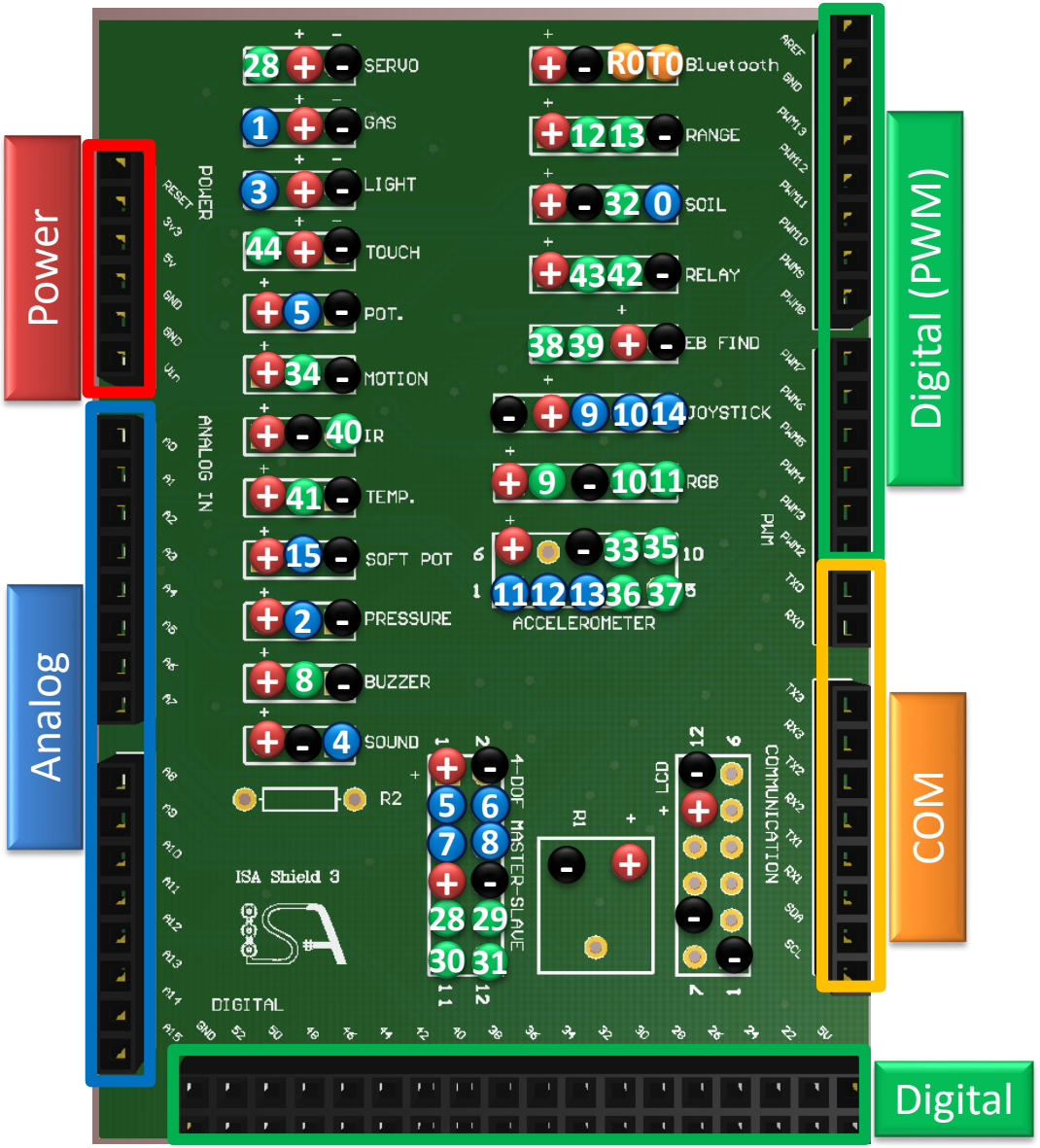
ISA Shield v3 (pins)

For intermediate and advanced projects

- + +5V
- - Ground
- D Digital pin #D
- A Analog pin #A
- C COM pin #C



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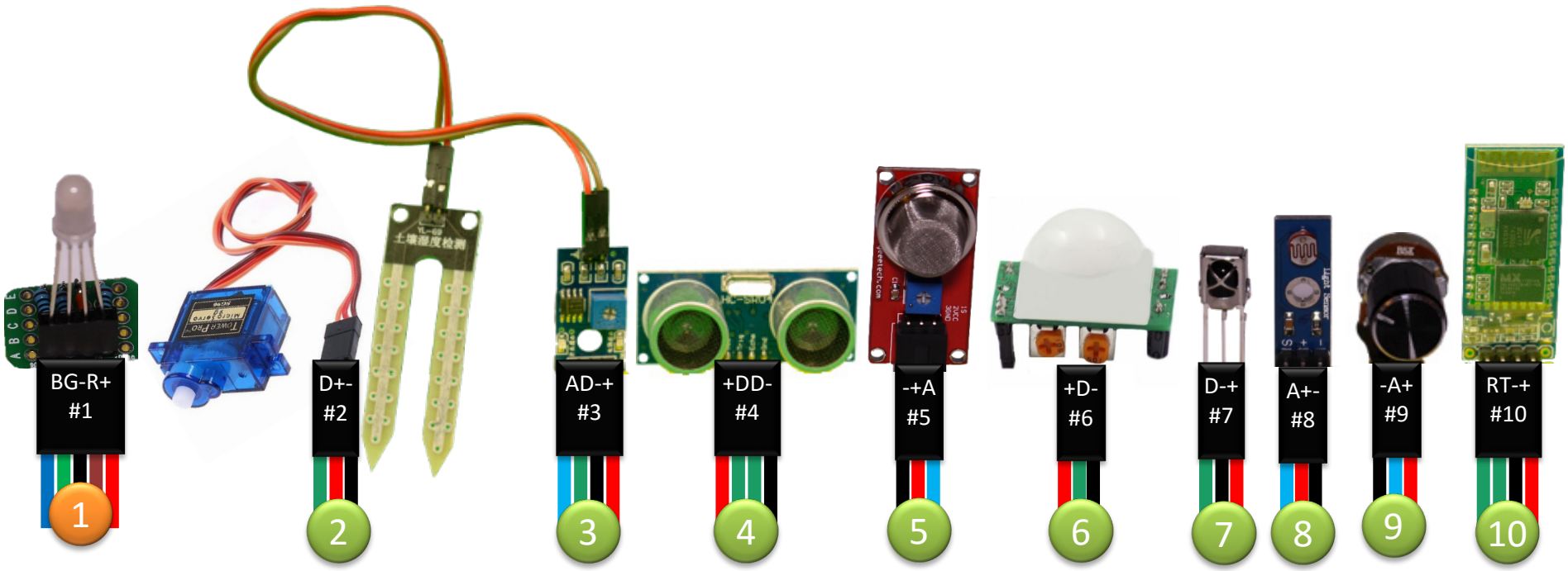
Jumper Wires #1 to #10



Sensor Lead	Pin on the ISA Shield
VCC / 5V / +	Voltage +
GND / -	Ground -
S/SIG / Out / I-O	Analog A or Digital D

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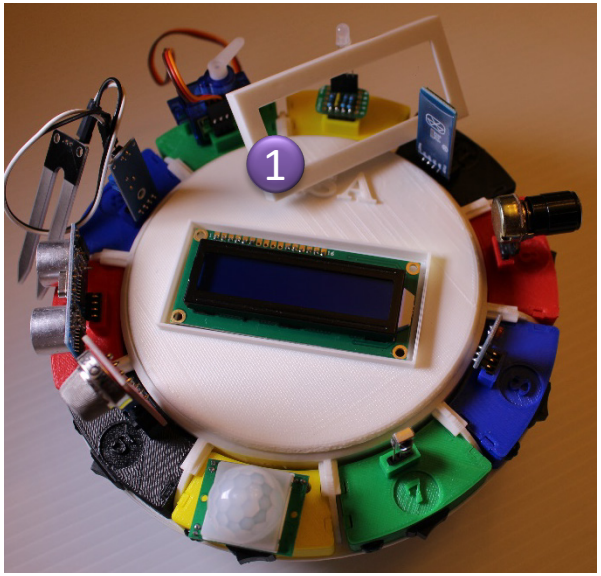
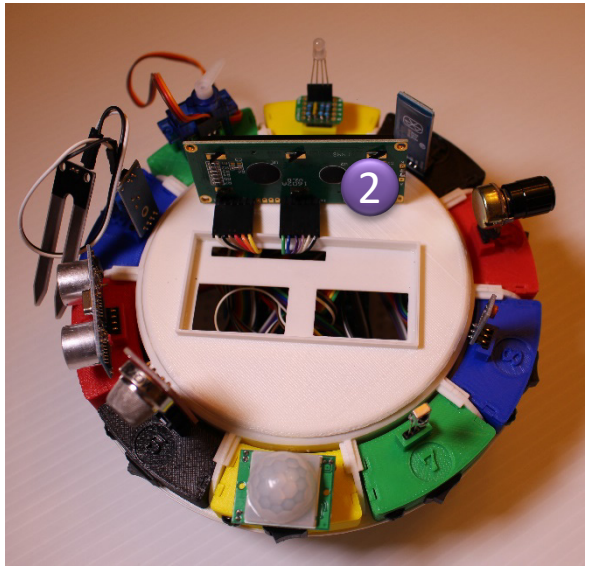
How to Access the ISA Shield

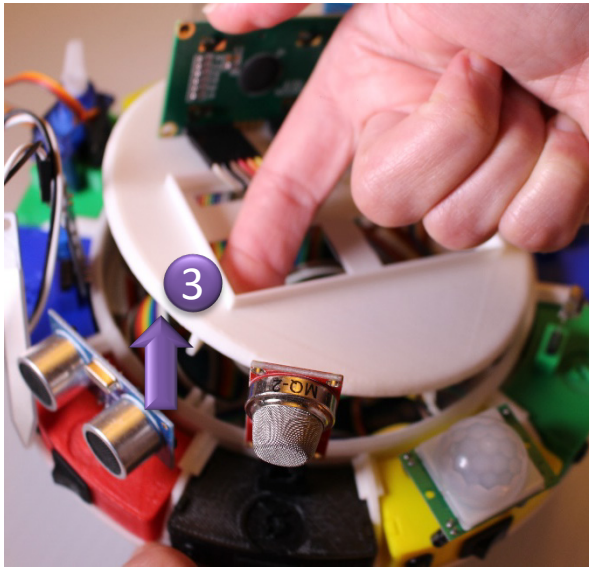
The ISA Kit is designed such that you can disassemble and reassemble it back fast.

In order to access the ISA Shield you need to follow these steps in **revision 2** (packages shipped after June 2015) :

1. Remove the LCD lid.
2. Pull up the LCD (you can unplug the LCD wires or keep them plugged-in).
3. Remove the top lid by gently pulling it upward with your fingers.







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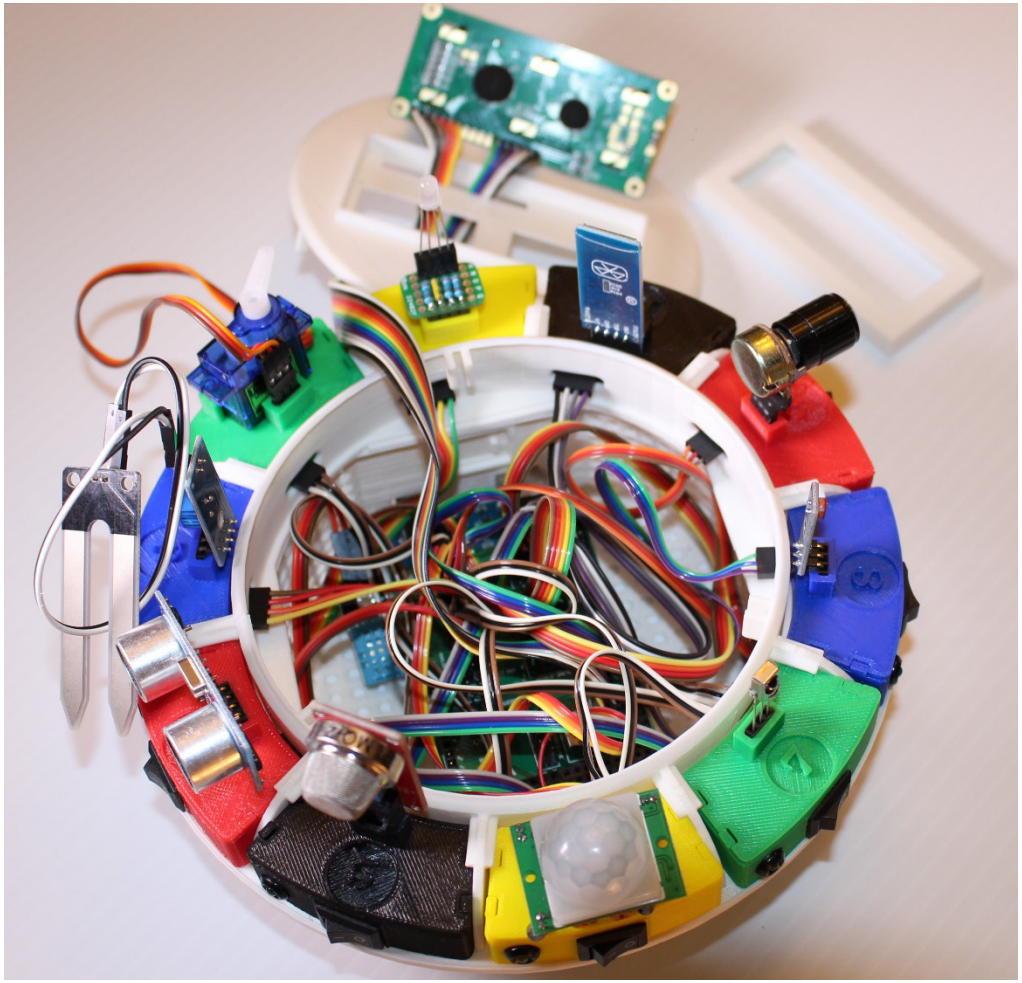
How to Access the ISA Shield (Cont'd)

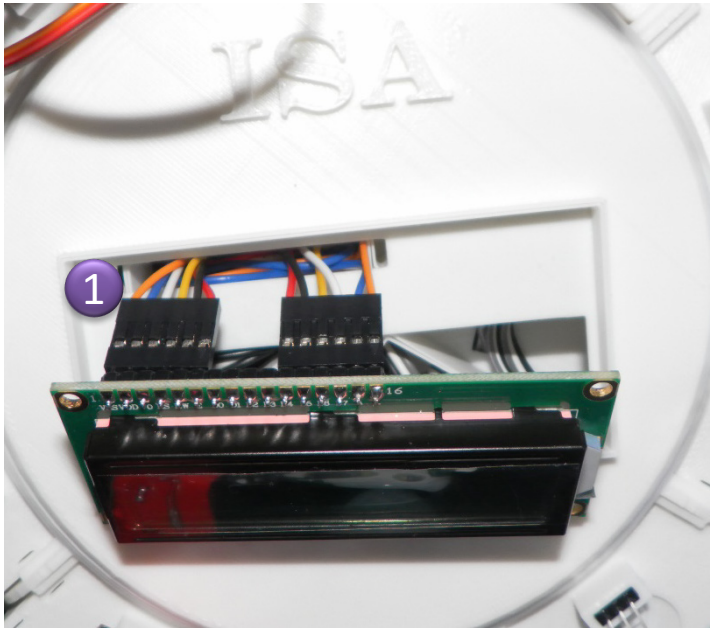
This is the view of the ISA Shield 3 inside the ISA Kit.

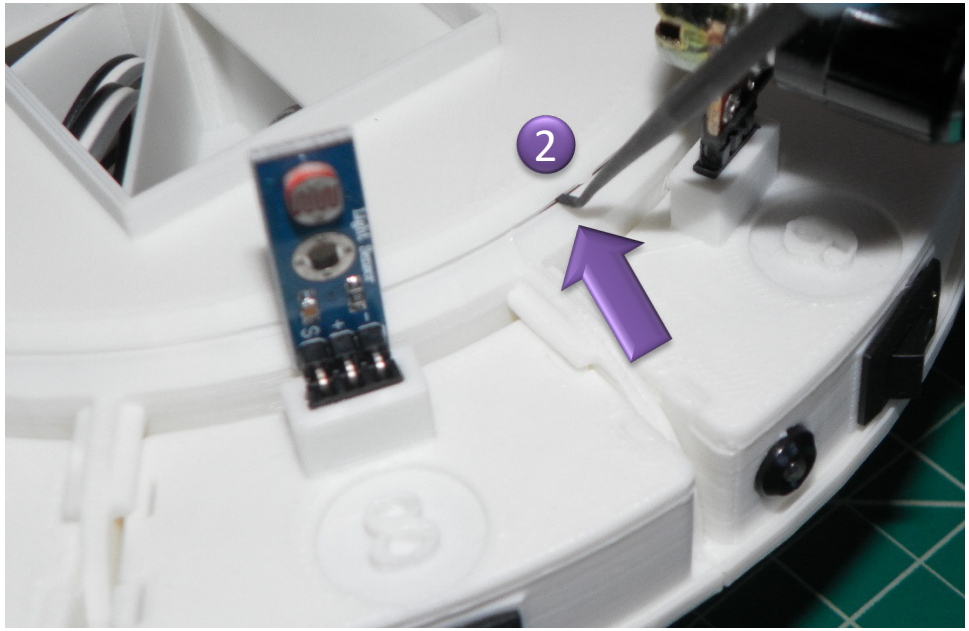


How to Access the ISA Shield (Cont'd)

In order to access the ISA Shield in **revision 1** (packages shipped before June 2015) you need to follow these steps:

1. Remove the LCD lid and then unplug the LCD
2. Remove the top lid by using a small screwdriver and gently pull it upward
3. Unplug all the wires from the sensor boxes





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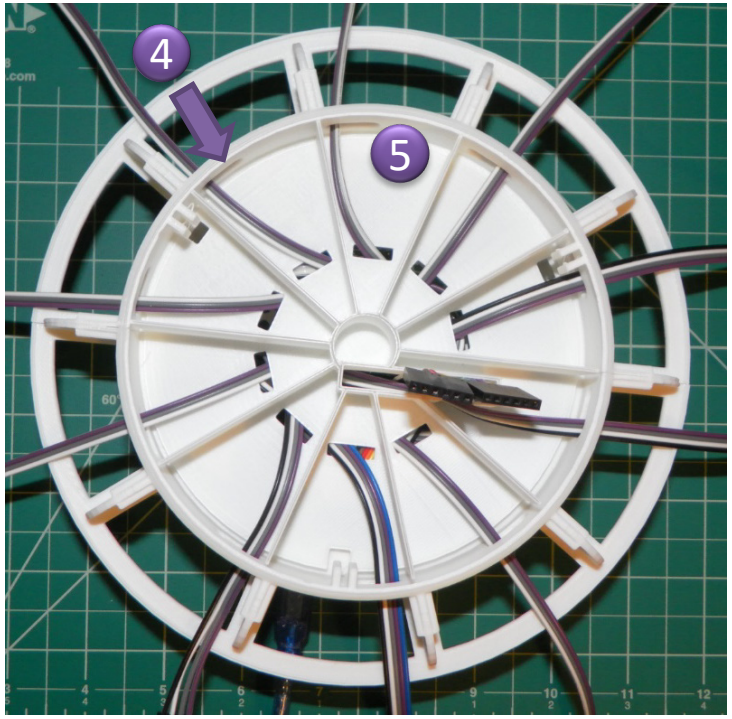
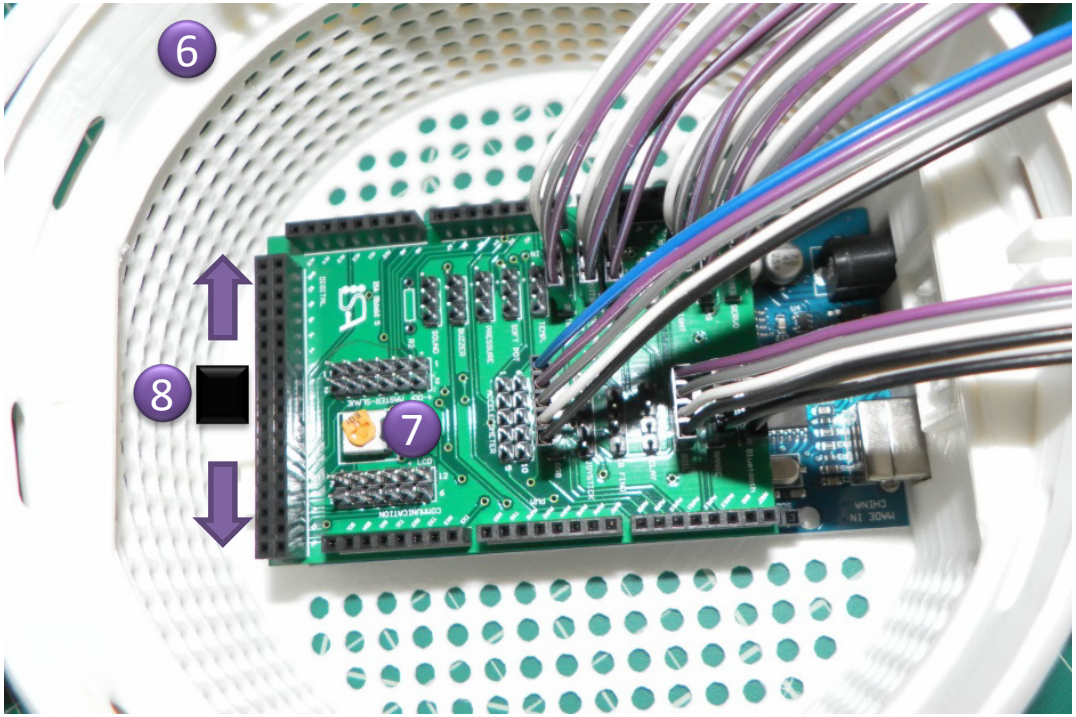
How to Access the ISA Shield (Cont'd)

4. Push all the wires inside the middle wire compartment
5. Remove the middle wire compartment. If you want to access the ISA Shield frequently, remove this part from the assembly. This part has been removed in **revision 2**.
6. This is the view of the ISA Shield 3 inside the ISA Kit
7. A potentiometer is placed on the ISA Shield that can be used to change and adjust the LCD contrast. To do so, use a screwdriver to turn it clockwise or counter-clockwise.
8. A locking mechanism key is placed on top of the ISA Shield. The key should be released before taking out the ISA Shield.





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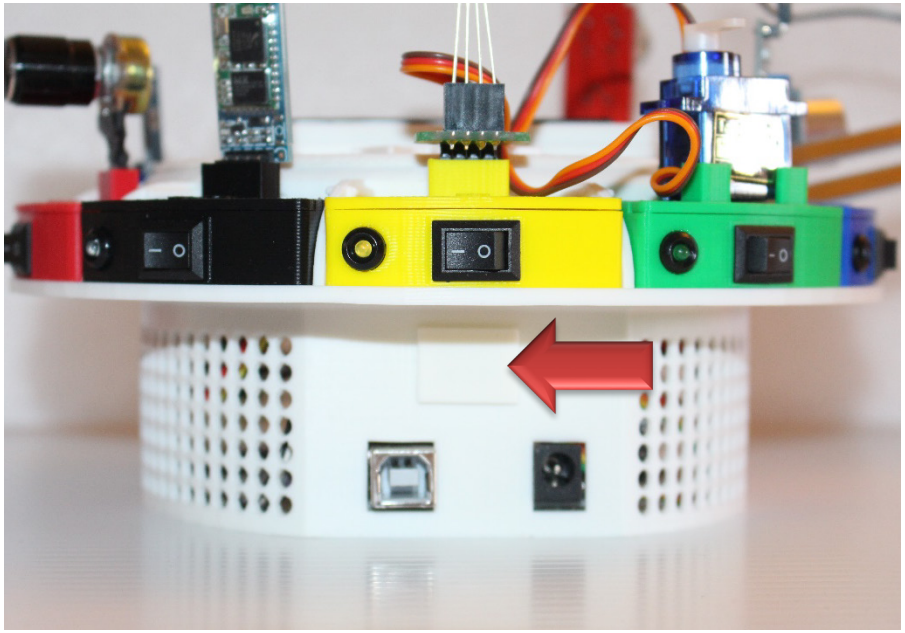
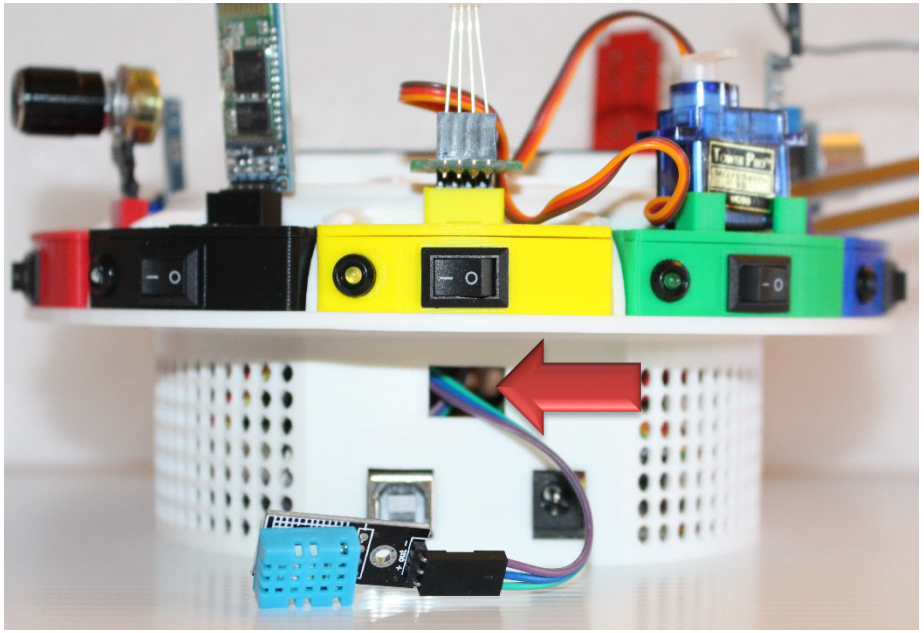
Opening for Extra Sensors

An opening is designed on the housing for the projects that require extra wiring for additional sensors/actuators. To use it, remove the LCD and top lid to access the ISA Shield as described in the previous pages, then push the rectangle cap gently from inside and the cap will pop out. Then you can connect extra sensors and actuators to the ISA Shield and bring out the wires from this opening.





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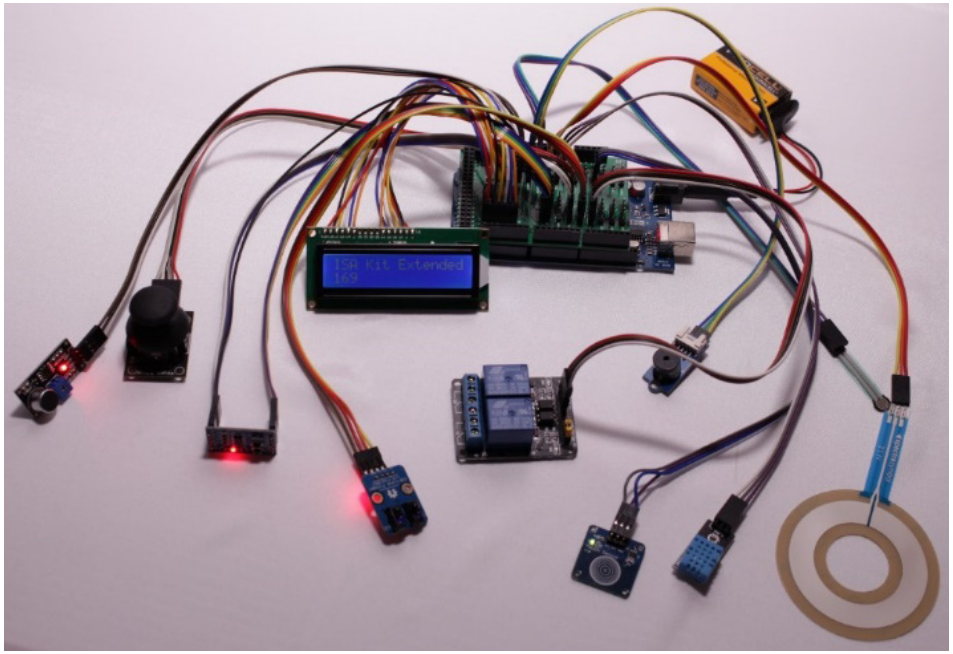
Additional Sensors/Actuators

The ISA Shield 3 is designed such that you can easily add different types of sensors and actuators and customize it based on your project requirements. These extra sensors/actuators are relay, buzzer, 3-axis accelerometer, 2-D joystick, line tracking sensor, temperature/humidity sensor, touch sensor, sound sensor, soft potentiometer, and pressure sensor. These extra sensors and actuators are included in ISA Kit Pro and Premium.



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Pro Sensors and Actuators (11-20)

Actuators		Sensors							
11	12	13	14	15	16	17	18	19	20
2-Channel Relay	Buzzer	3-axis Accelerometer	2D Joystick	Line Track	Temperature and Humidity	Touch	Sound	Soft Pot	Pressure

11. A **relay** is a switch that can be operated electronically. Each channel of a relay can be operated independently to switch on and off the connected electronic device.
12. A passive **buzzer** is an audio signaling device.
13. An **accelerometer** measures proper acceleration (g-force).
14. A **joystick** is an input device that pivots on a base. When pushed downward, it will send a click signal.
15. A **line tracking sensor** can be used in RC cars to verify if the car in on or off the track.
16. A **temperature and humidity sensor** measures temperature and humidity of the environment.
17. A **touch sensor** is a digital sensor to indicate if it has been touched or not.
18. A **sound sensor** sends a high value signal if the noise level is above some predefined threshold. The threshold can be adjusted by a potentiometer on the sensor.
19. A **soft potentiometer** functions like a rotary potentiometer. However, instead of turning a knob, you touch it with your finger and move your finger on it.
20. A **pressure sensor** measures the applied pressure.

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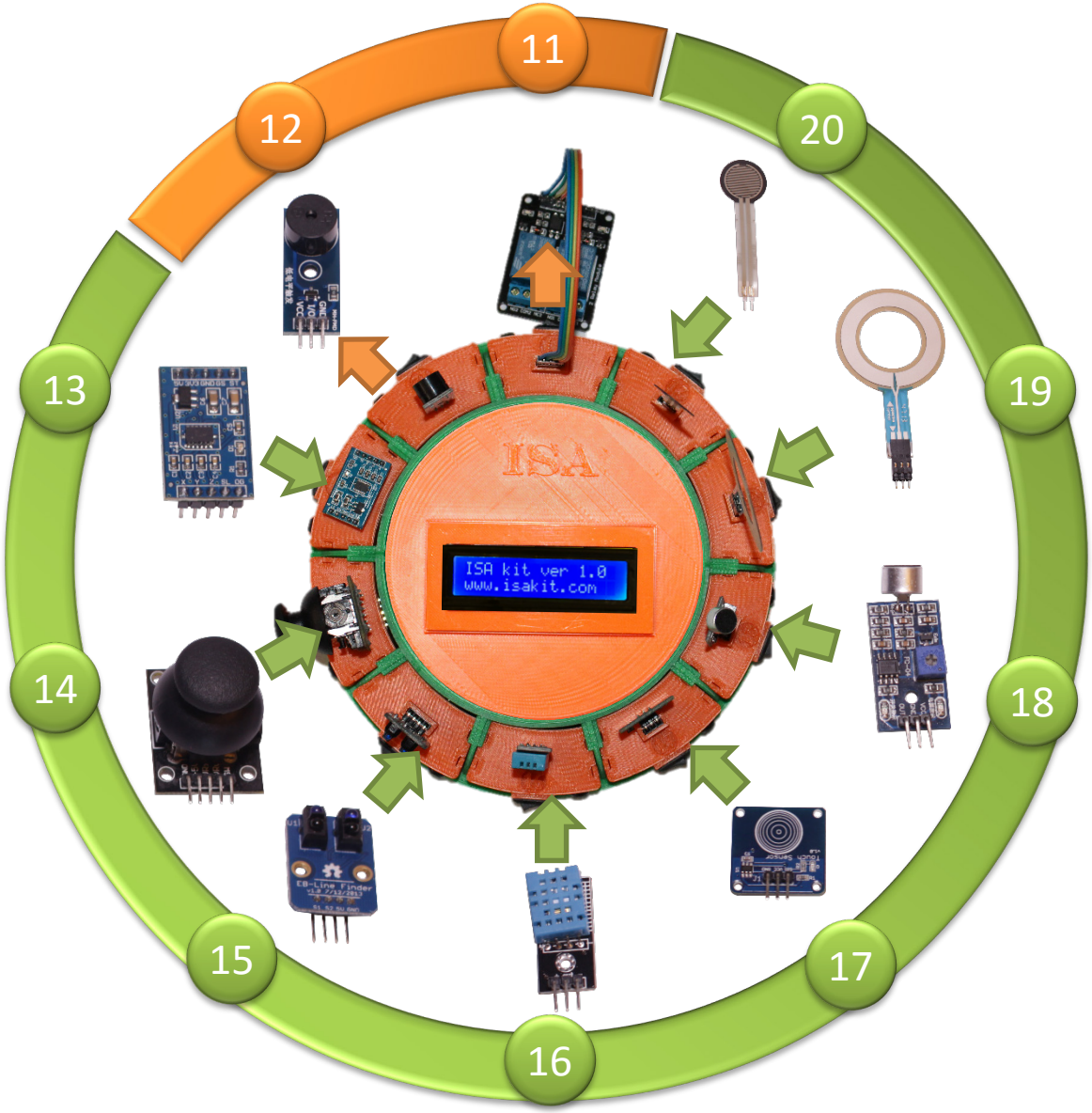
Pro Sensors and Actuators (11-20)



Actuators

- 11 Relay
- 12 Buzzer

Sensors

- 13 Accelerometer
- 14 Joystick
- 15 Line Track
- 16 Temperature
- 17 Touch
- 18 Sound
- 19 Soft Pot
- 20 Pressure

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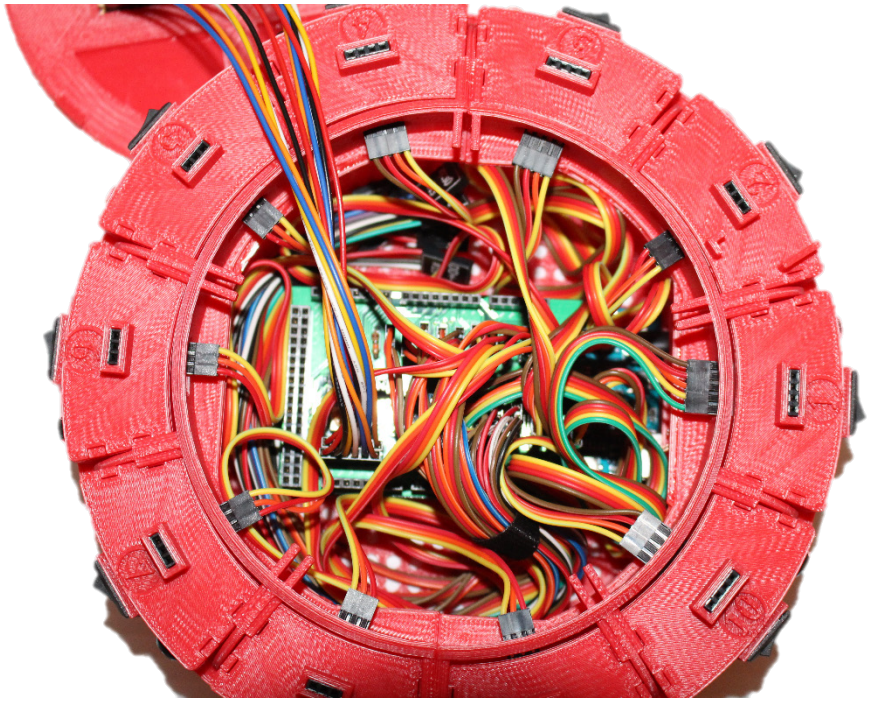
Connecting Sensors and Actuators (11-20)

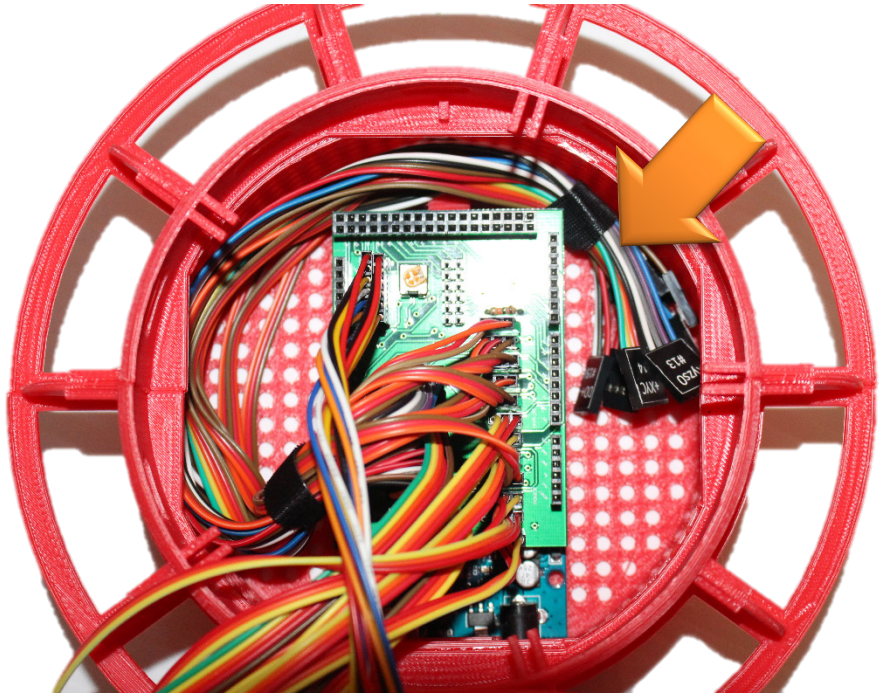
The jumper wires for module boxes #11 to #20 are connected to ISA Shield in Pro and Premium Kits. Follow these steps to have access to these wires:

1- Remove the LCD lid, pull up the LCD, and then ISA Kit lid

2- Disconnect the jumper wires of module boxes #1 to #10

3- The jumper wires for module boxes #11 to #20 are bundled together. Unbundle them and connect them to module boxes #11 to 20 that come in your ISA Kit Pro or Premium.





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Connecting Module Boxes

Jumper wires are connected to module boxes based on the following configuration:

Top View

Bottom View

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Connecting Sensors and Actuators (11-20)

In ISA Kit Pro and Premium there are four ways to connect sensors and actuators #11 to #20 to the ISA Kit:

1. Connect them to module boxes #11 to #20 correspondingly. Then connect the module boxes to the ISA Shield via jumper wires #11 to #20 accordingly.
2. Connect them to the ISA Shield directly via jumper wires.

Method 1

Accelerometer (sensor #13) does not have a box. Connect it directly to the jumper wires.

Method 2

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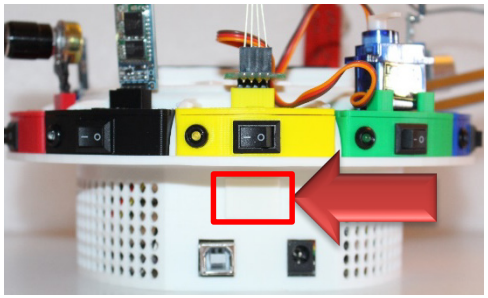
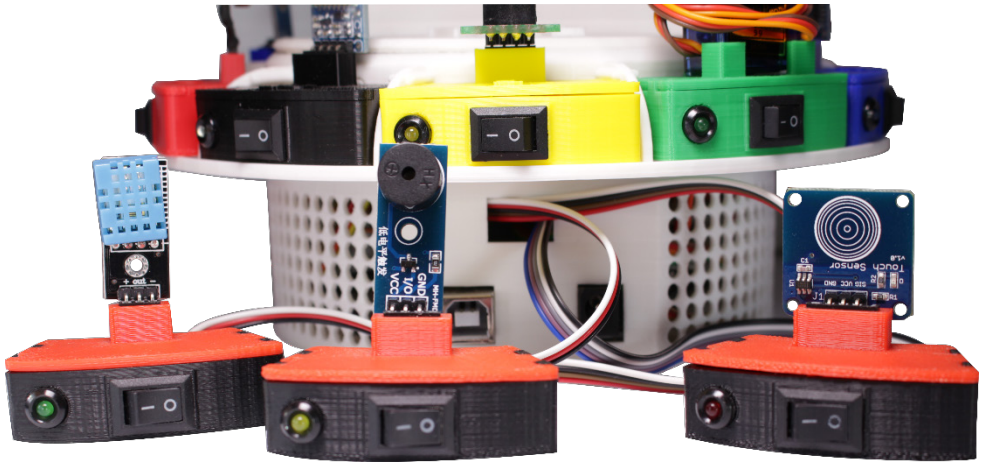
Connecting Sensors and Actuators (11-20)

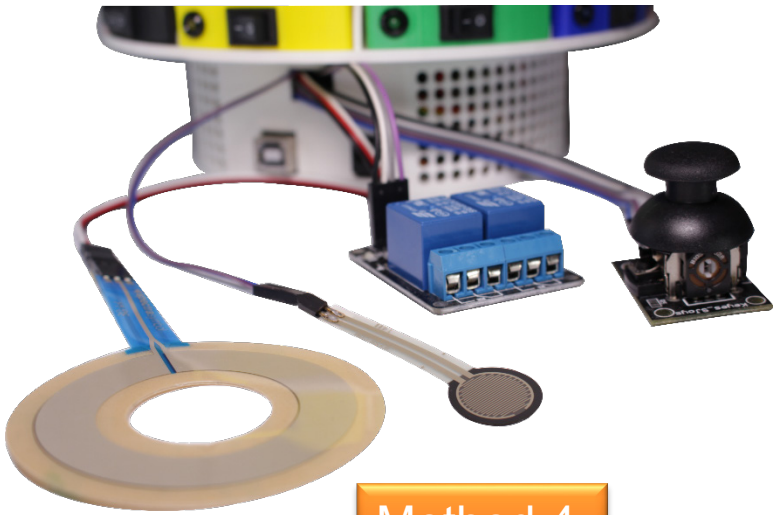
If you want to keep module boxes #1 to #10 while adding module boxes #11 to #20 you may use the opening on the housing to bring out jumper wires #11 to #20:

3. Connect sensors and actuators to module boxes #11 to #20 correspondingly. Then connect the module boxes to the ISA Shield via jumper wires #11 to #20 accordingly.
4. Connect them to the ISA Shield directly via jumper wires.



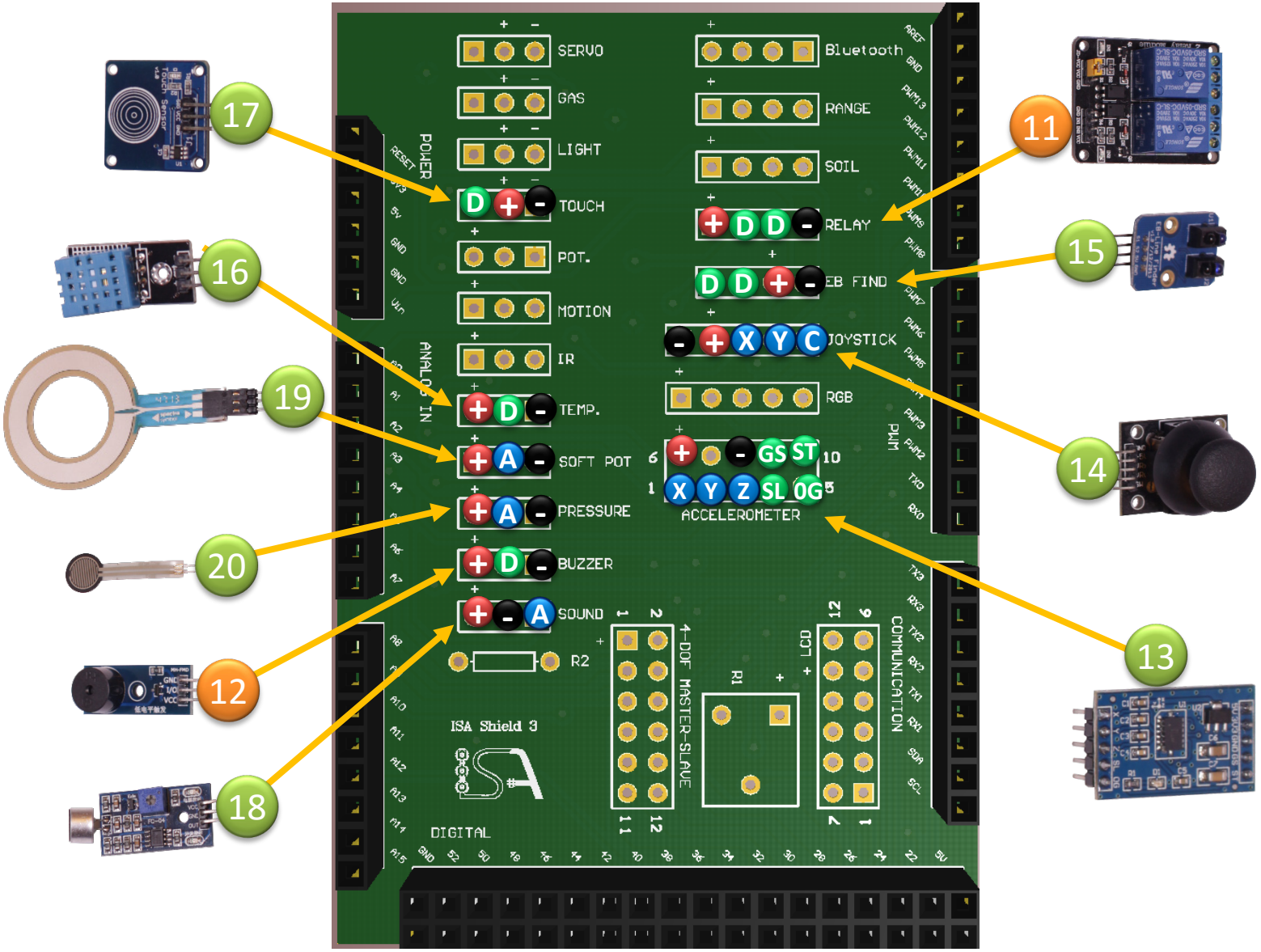


Method 3



Method 4

How to Connect Extra Sensors



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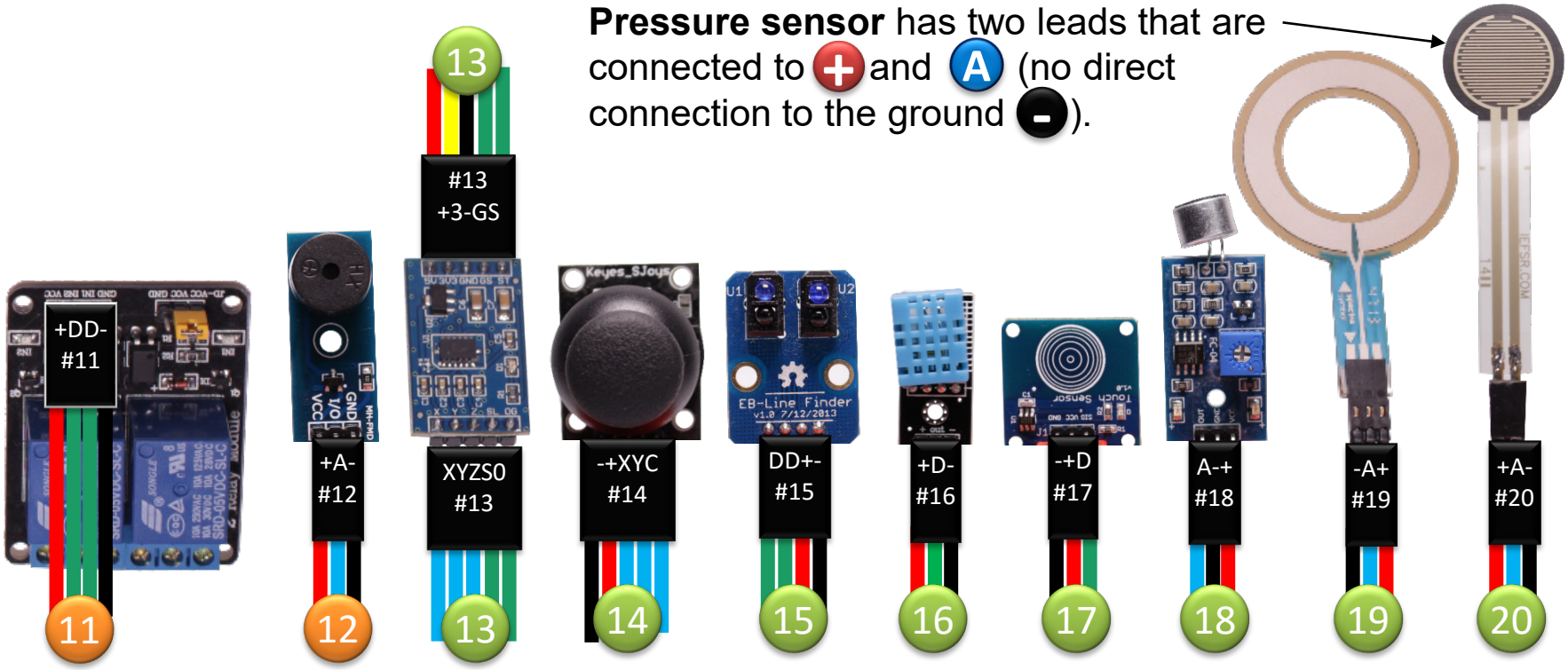
Jumper Wires #11 to #20

Instead of connecting the jumper wires to module boxes, you have the additional option of connecting the sensors directly to jumper wires based on the following configurations.

Sensor Lead	Pin on the ISA Shield
VCC / 5V / +	Voltage +
GND / -	Ground -
S/SIG / Out / I-O	Analog A or Digital D

Pressure sensor has two leads that are connected to + and A (no direct connection to the ground -).



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Module Boxes #1 to #10

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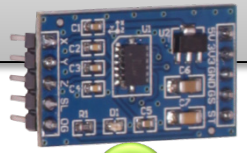
Module Boxes #11 to #20

Accelerometer (sensor #13) does not have a mounting box. Connect it directly to the jumper wires.

11

12



13

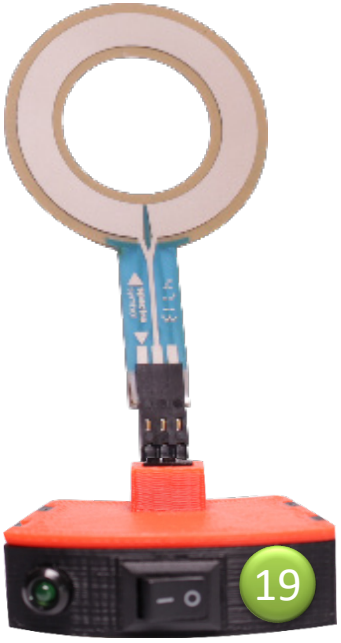
14

15

16

17

18



19

20

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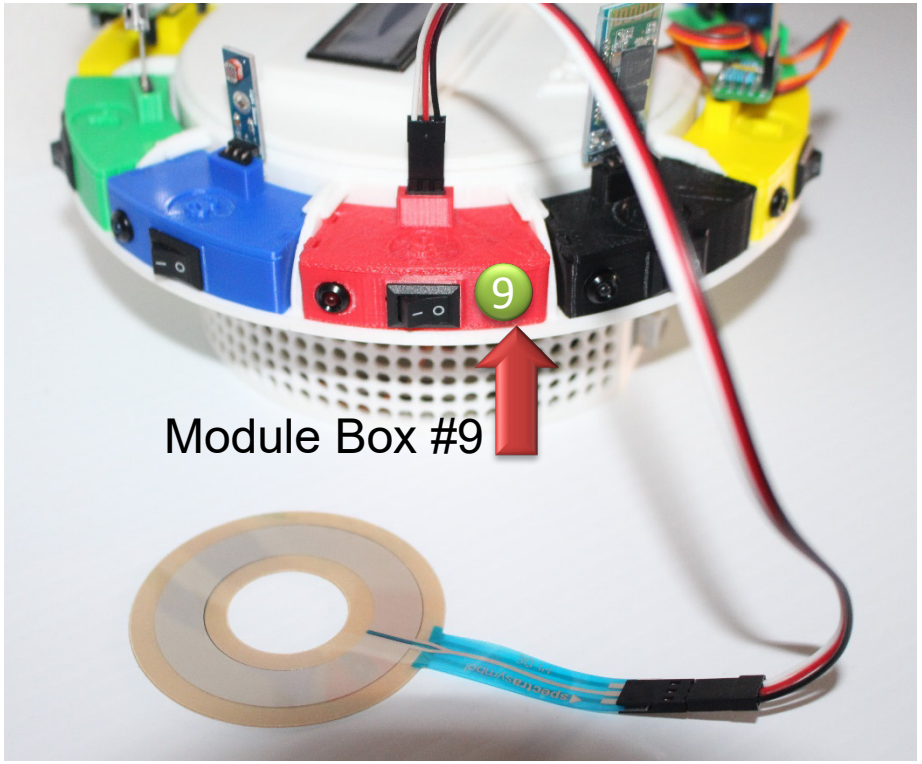
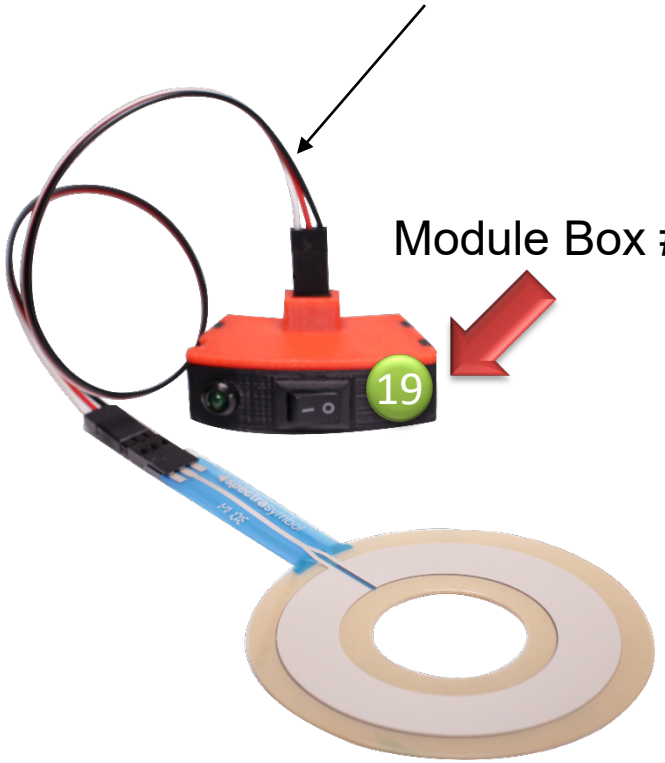
Module #19: Soft Potentiometer

Soft potentiometer can be connected either to its dedicated port on the Shield (SOFT POT) or to the rotary potentiometer (POT) port. So you can simply unplug the rotary potentiometer from module box #9 and plug in the soft potentiometer.



Like the rest of sensors and actuators, you may use an extension cable.



Make sure your fingernail does not touch the soft potentiometer because it may scratch and damage it.

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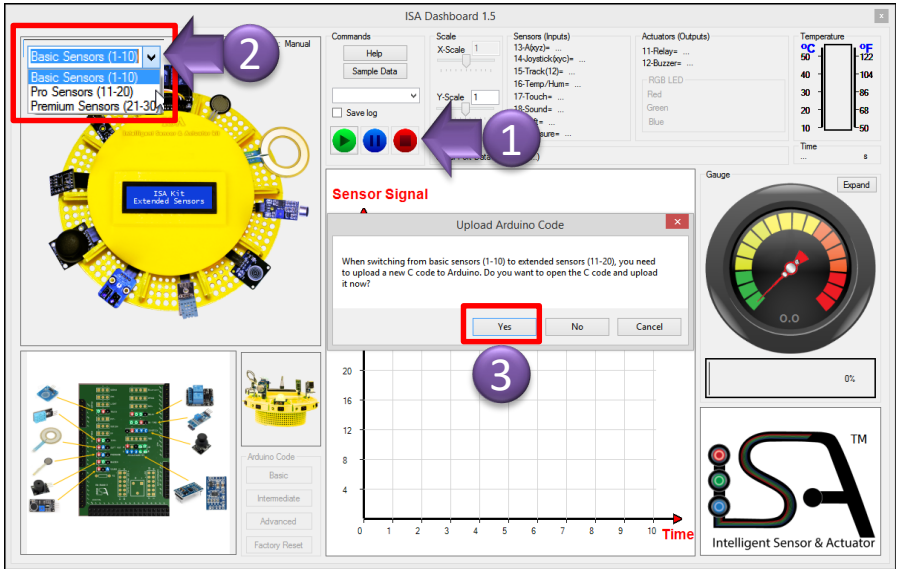
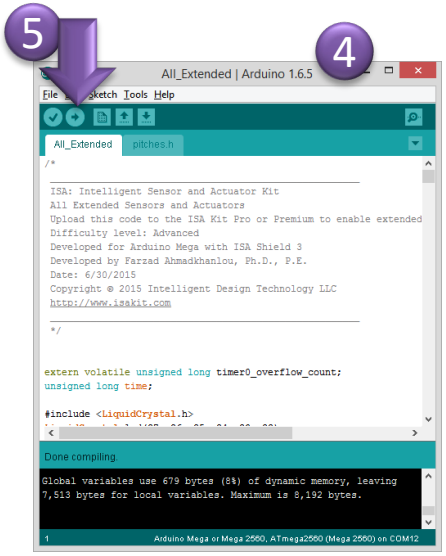
ISA Dashboard for Extended Sensors

Extended sensors and actuators (modules 11 to 20) are available in Pro and Premium Kits. You can use extended sensors/actuators by choosing **Pro Sensors (11-20)** or **Premium Sensors (21-30)** from the drop-down menu on the top left of the ISA Dashboard.



Whenever you switch from basic mode (modules 1-10) to extended mode (Pro with modules 11-20 or Premium with modules 21-30) or vice versa, you need to upload a new C code to Arduino to activate and enable receiving signals from the sensors and receiving data points in the ISA Dashboard .

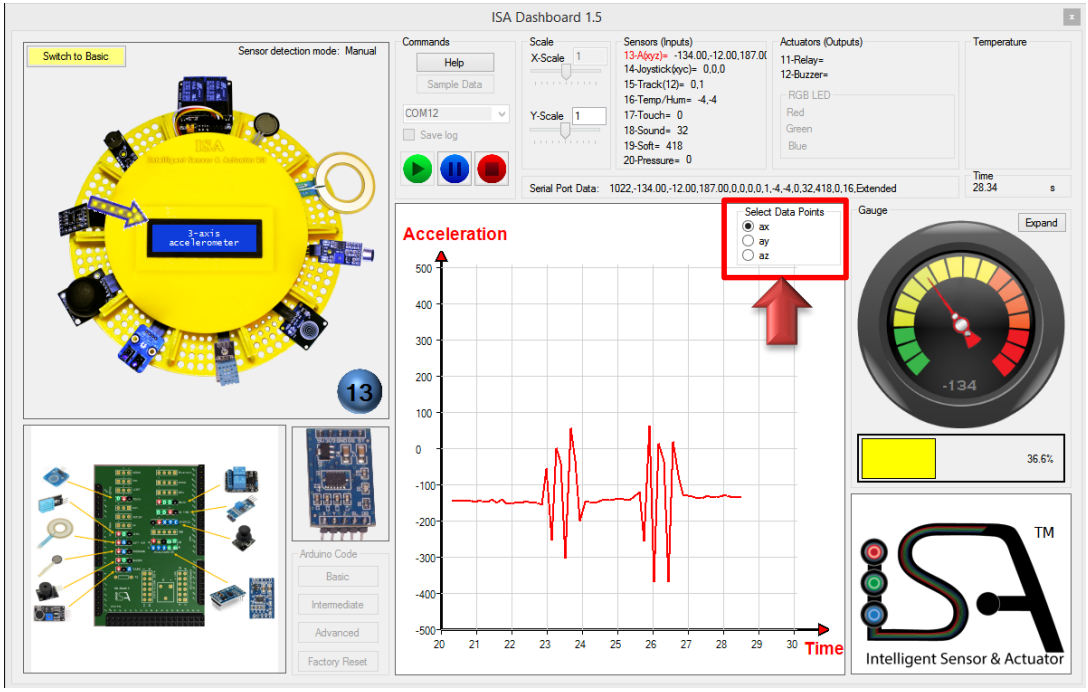


Follow these steps if you want to enable extended sensors:

1. Make sure to stop receiving data by clicking on icon.
2. Click on Pro Sensors or Premium Sensors from drop-down menu.
3. When prompted to open a new C code, click on “Yes”
4. The Arduino code for the selected project will pop up in Arduino IDE.
5. Compile and upload the code by clicking on icon.

Extended Sensors (Cont'd)

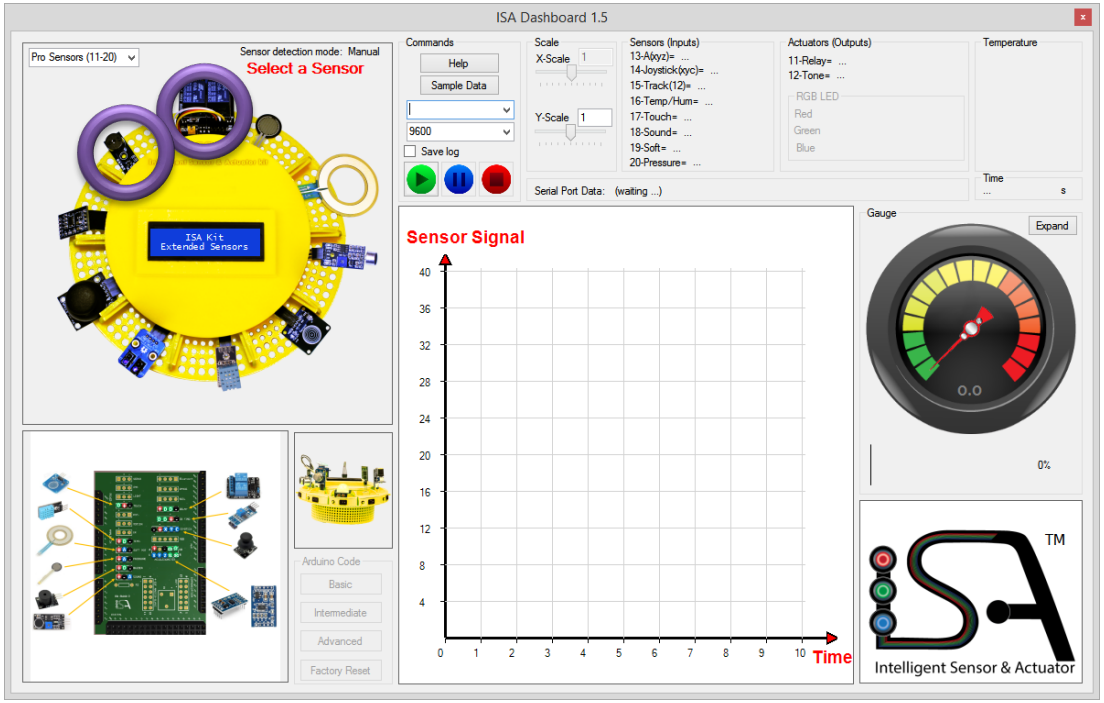
For some of the sensors in the extended mode, such as accelerometer, joystick, and temperature/humidity sensor, the transferred data is a vector (has more than one signal element). Therefore, you need to specify which signal element should be displayed by selecting that.



Modules #11 and #12: Actuators

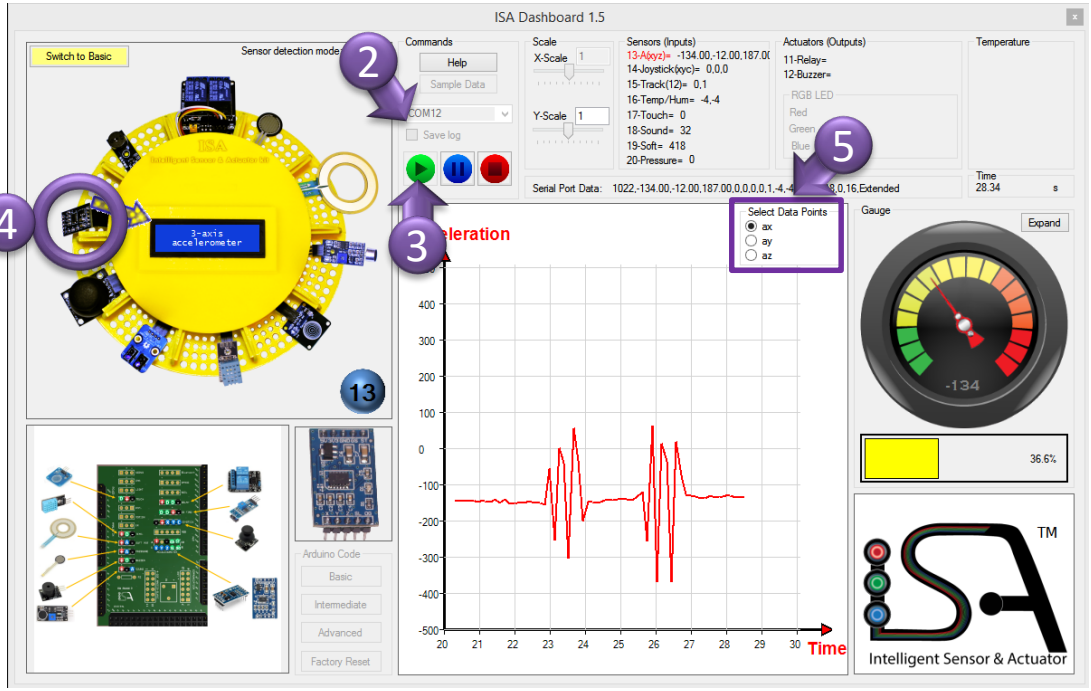
In this version of ISA Dashboard you cannot control the actuators directly from the Dashboard. In order to control the actuators, you need to use the Arduino code.

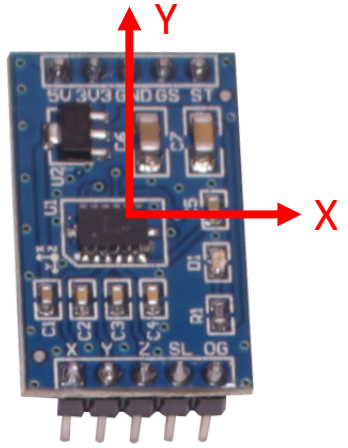
Controlling the actuators directly from the ISA Dashboard will be available in the future revisions.

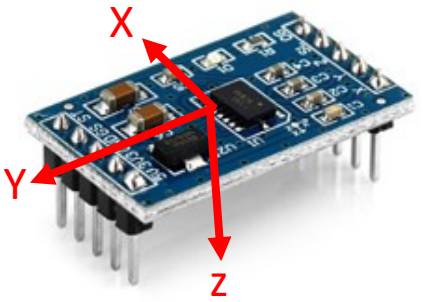


Module #13: Accelerometer

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the accelerometer by clicking on its image. An animated arrow should be displayed.
5. Select an axis x, y, or z by clicking on its corresponding radio button.
6. Move the accelerometer in x, y, or z directions.
7. The corresponding data will be plotted versus time.







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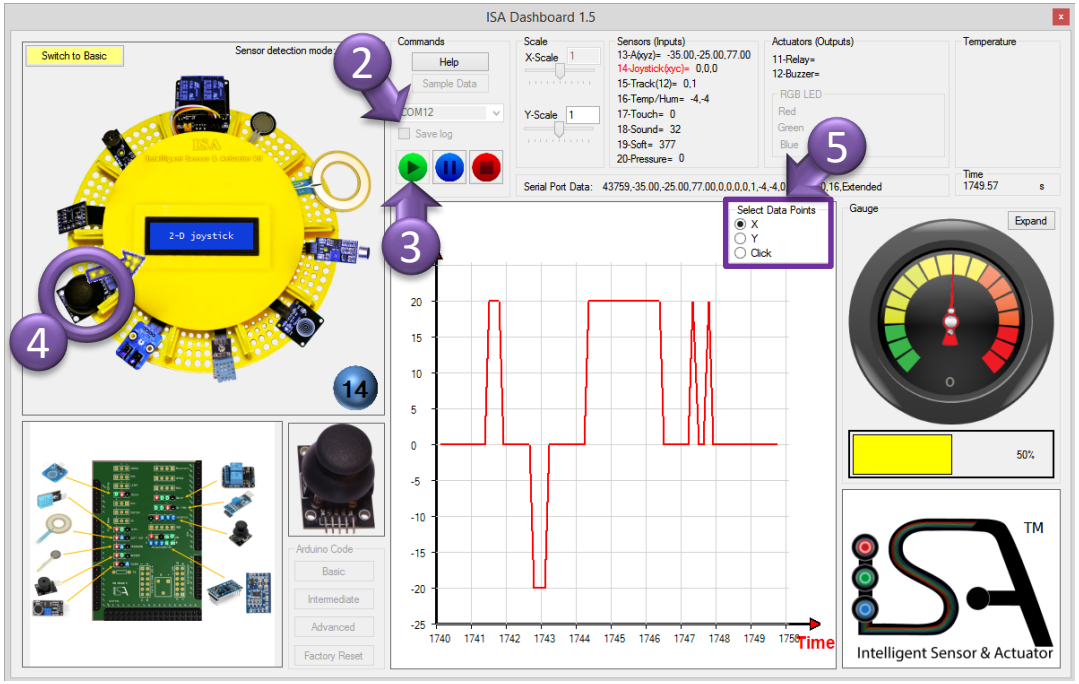
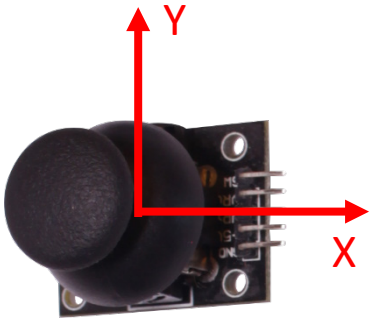
Module #14: Joystick

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Turn on joystick module. It should be turned on before connecting the ISA Kit to the USB port.
3. Select the COM port that your ISA Kit is connected to.
4. Start receiving data from the ISA Kit by clicking on icon.
5. Select the joystick by clicking on its image. An animated arrow should be displayed.
6. Select “x”, “y”, or “click” by clicking on its corresponding radio button.
7. Move the joystick in the selected direction or push it to click.
8. The corresponding data will be plotted versus time.

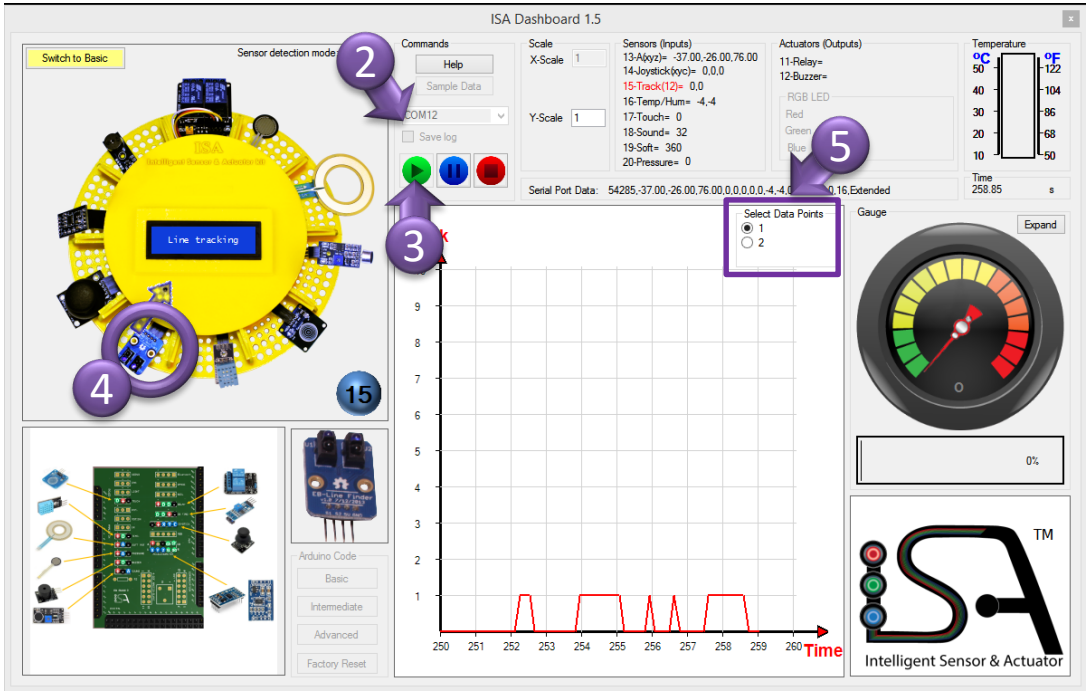




Note: Turn on joystick module before connecting the ISA Kit to the USB port. Otherwise, it will not get calibrated properly.

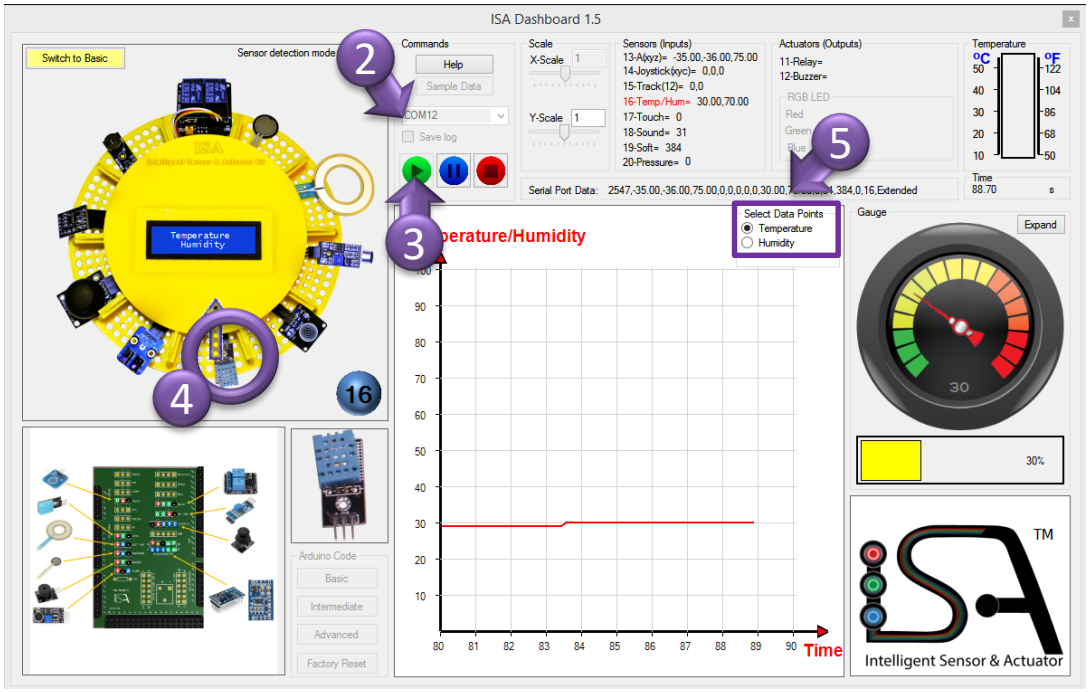
Module #15: Line Track

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the line track sensor by clicking on its image. An animated arrow should be displayed.
5. Select “1” or “2” by clicking on its corresponding radio button.
6. Move the line track sensor over a dark line.
7. The corresponding data will be plotted versus time.



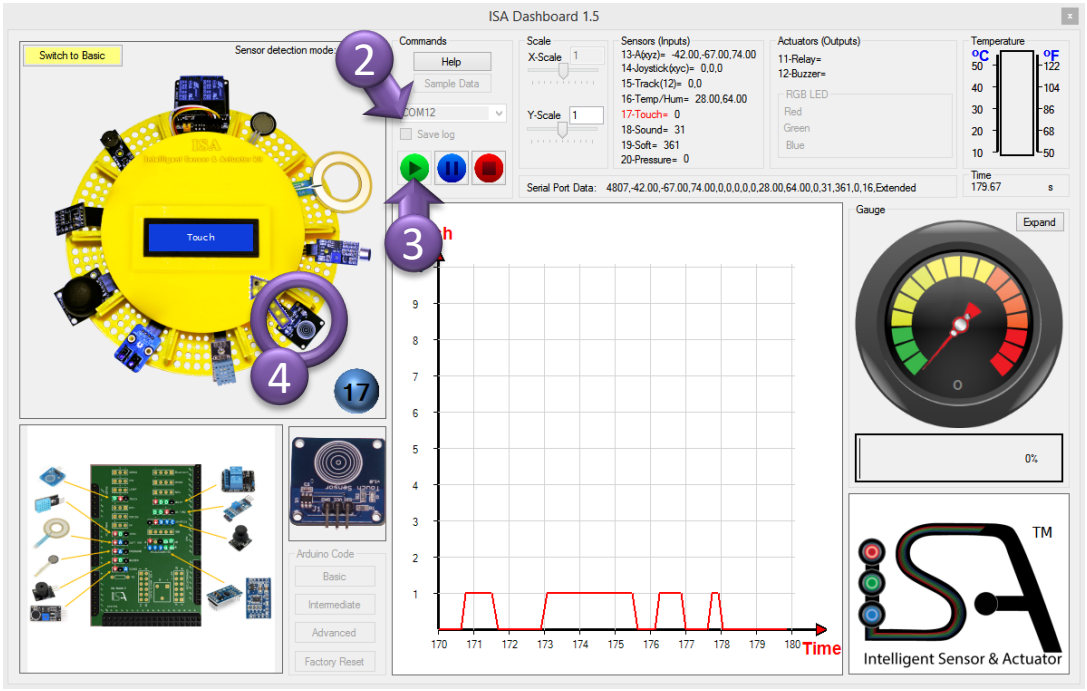
Module #16: Temperature/Humidity

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the temperature sensor by clicking on its image. An animated arrow should be displayed.
5. Select “Temperature” or “Humidity” by clicking on its corresponding radio button.
6. Change the temperature or humidity of the environment around the sensor.
7. The corresponding data will be plotted versus time.



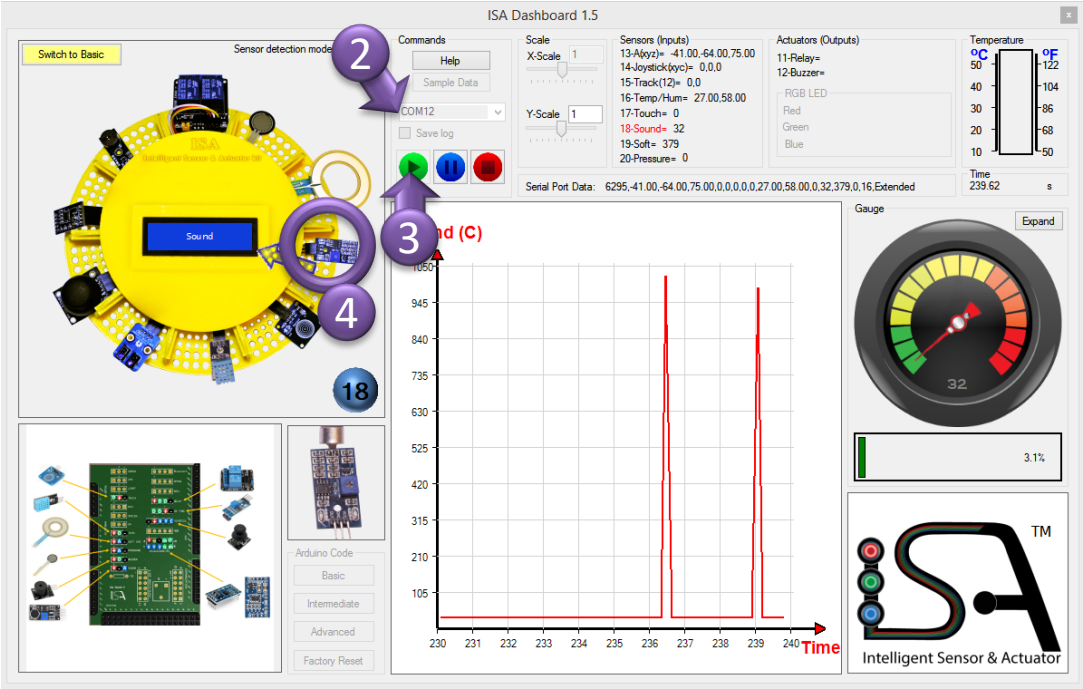
Module #17: Touch

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the touch sensor by clicking on its image. An animated arrow should be displayed.
5. Touch the sensor with your finger.
6. The corresponding data will be plotted versus time.



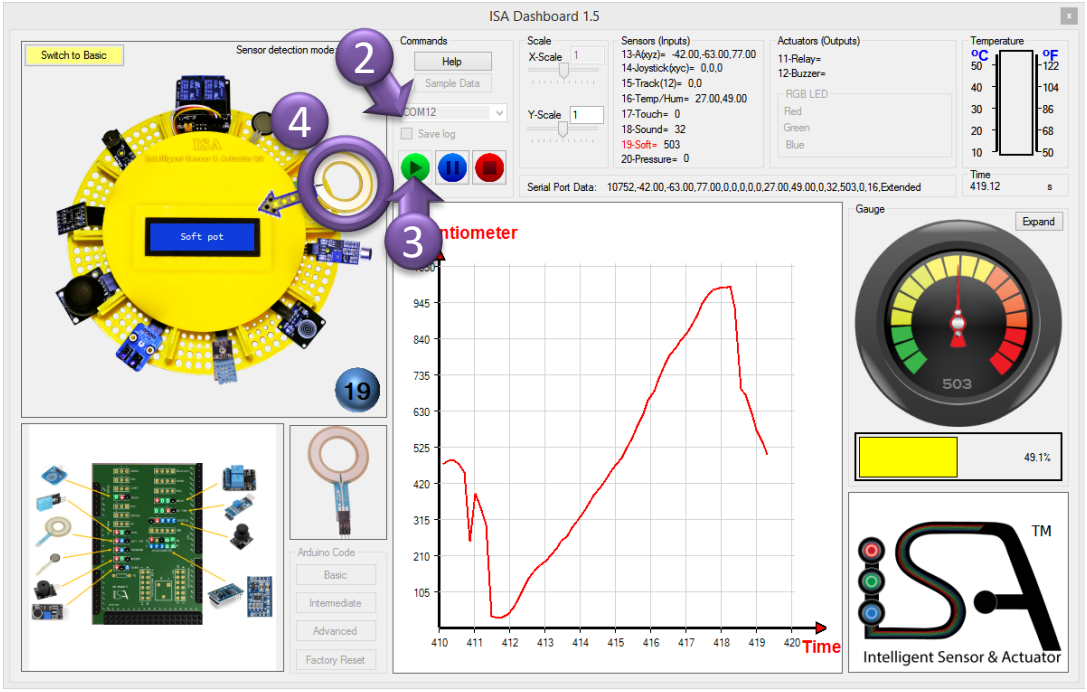
Module #18: Sound

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the sound sensor by clicking on its image. An animated arrow should be displayed.
5. When the noise level is above a threshold the sensor will send a HIGH signal. The threshold can be adjusted using a potentiometer on the sensor.
6. The corresponding data will be plotted versus time.



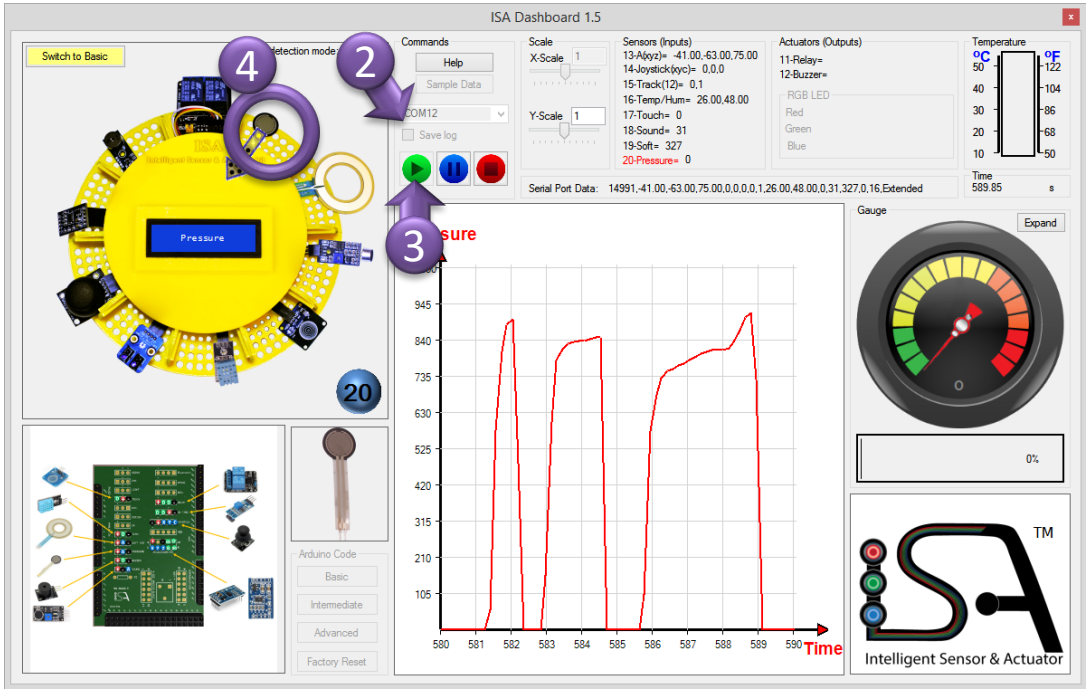
Module #19: Soft Potentiometer

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the soft pot by clicking on its image. An animated arrow should be displayed.
5. Lay the sensor on a flat surface then move your finger on it. Make sure your fingernail does not touch it because it may scratch and damage it.
6. The corresponding data will be plotted versus time.



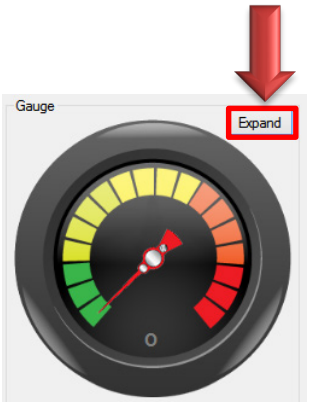
Module #20: Pressure

1. Follow the instructions on page 84 to enable Pro Sensors (11-20).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the pressure sensor by clicking on its image. An animated arrow should be displayed.
5. Apply pressure to the sensor.
6. The corresponding data will be plotted versus time.



Expanded Gauges for Extended Sensors

By clicking on “Expand” button on the top right of the gauge frame, a new window will pop up that included extended gauges for all the sensors connected. This tool is very useful when you are monitoring more than one sensor at a time. If any sensor is not connected, the corresponding gauge will just show noise signal.



Do not turn on more than four sensors or actuators at the same time.

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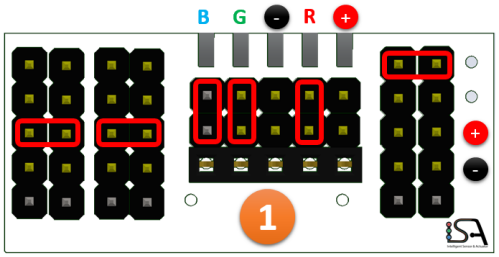
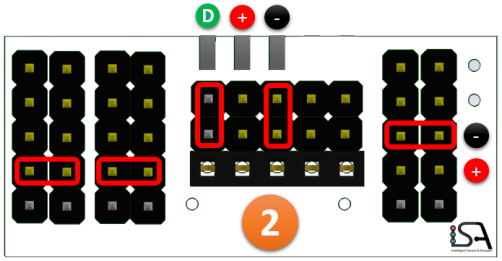
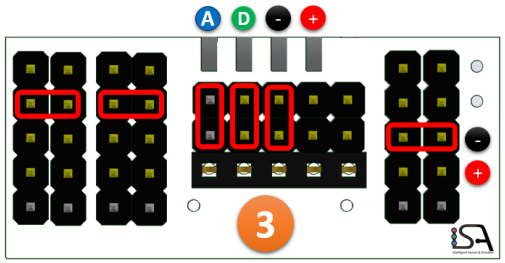
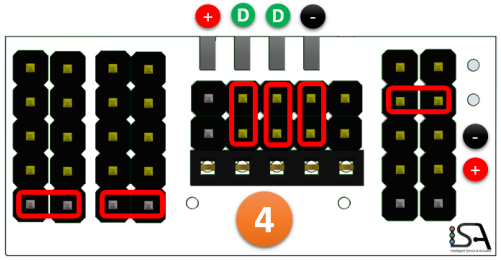
Sensor Boxes

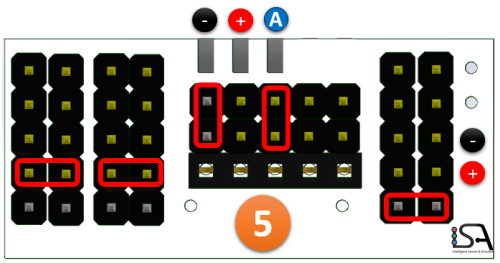
The following figures show the jumper configuration for module boxes #1 to #10.

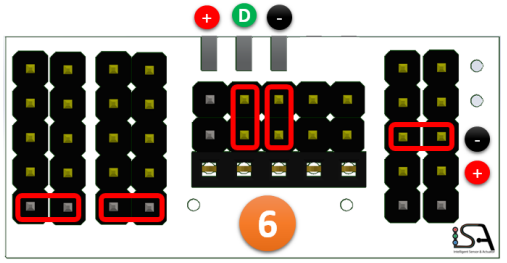


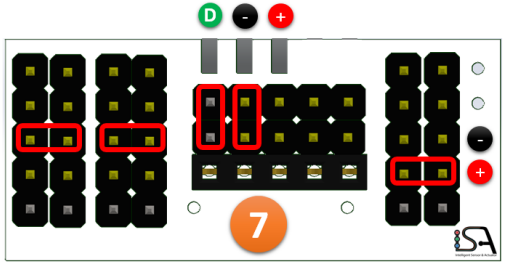


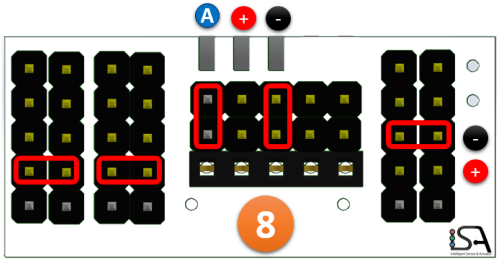


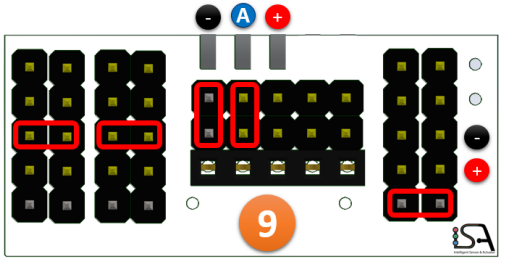


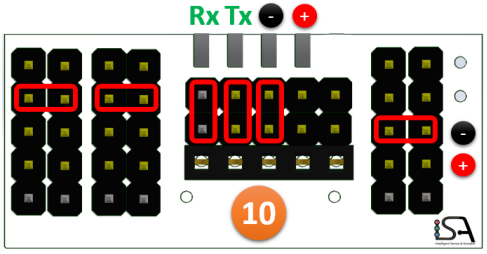












Jumper configurations are available only in Revision 2.

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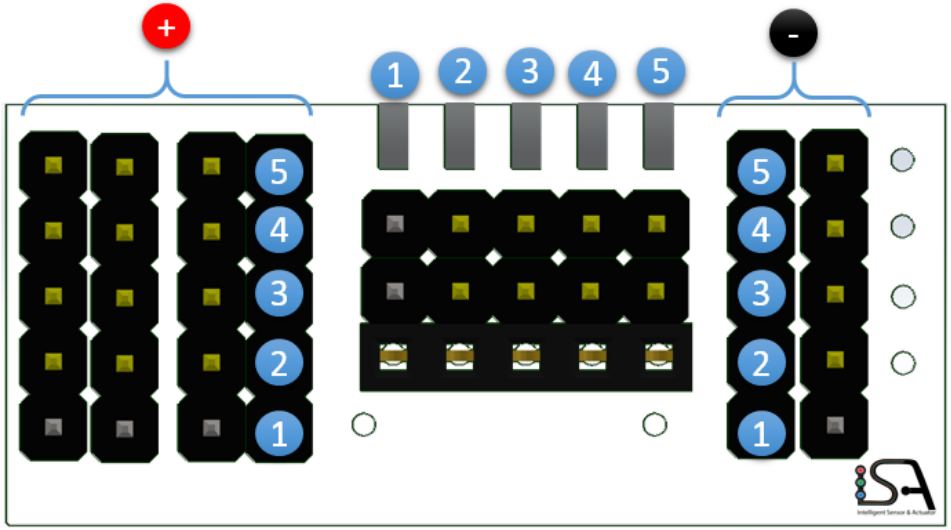
Sensor Boxes (Cont'd)

You have the option of changing the default jumper configurations to connect extra sensors and actuators (only available in Revision 2).

- Analog and digital leads: In the middle section, directly connect the right angle male header to female header for all the analog, digital, and ground leads.
- +5V: In the left section, use two jumpers to connect the corresponding pin number.
- Ground: In the right part, use a jumper to connect the corresponding pin number.



Be very careful in connecting the jumpers. If not properly connected, you can damage the microcontroller and the sensors/actuators.

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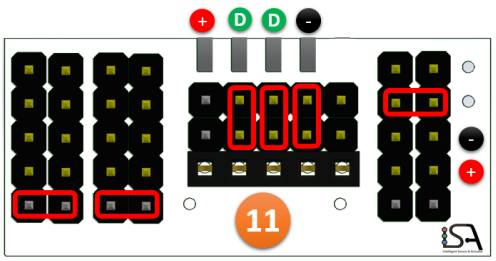
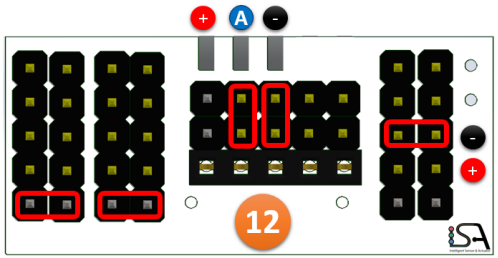
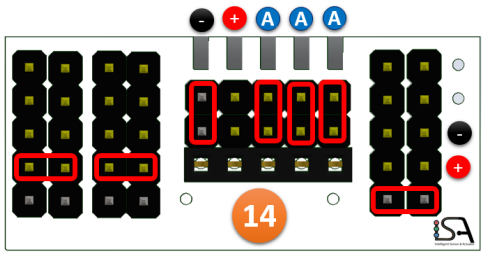
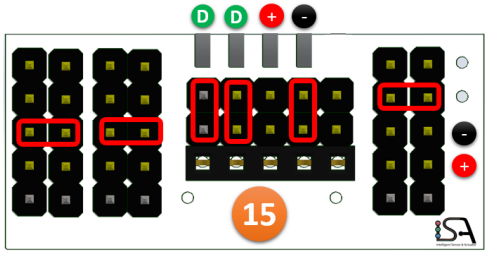
Sensor Boxes (Cont'd)

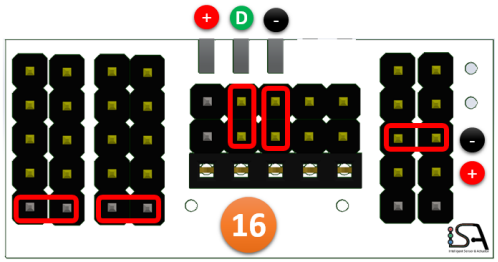
The following figures show the jumper configuration for module boxes #11 to #20 for ISA Kit Pro and Premium. Please note that module box #13 does not exist and consequently there is no module box for accelerometer. The reason is this sensor has 10 leads and the maximum number of leads in a module box is 5. Therefore, accelerometer should be connected directly to the Shield.

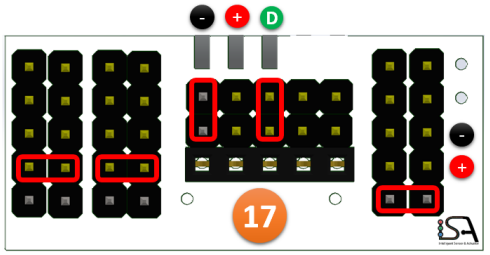


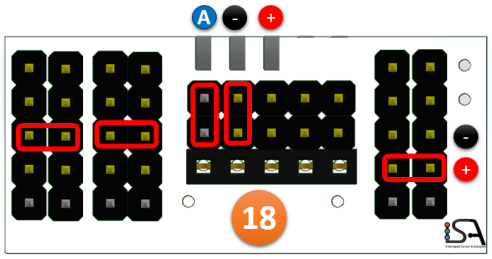


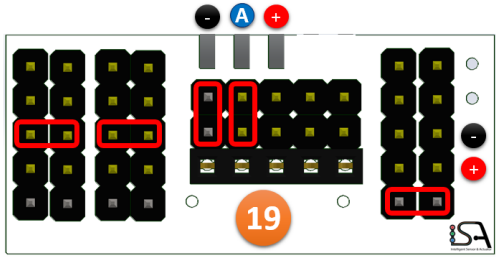


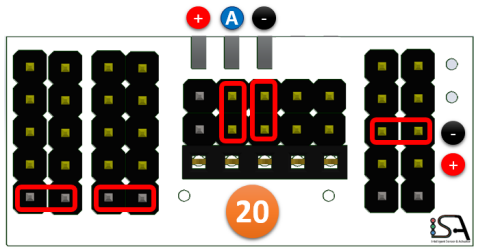












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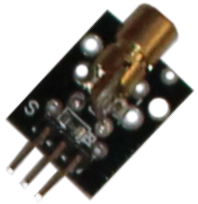
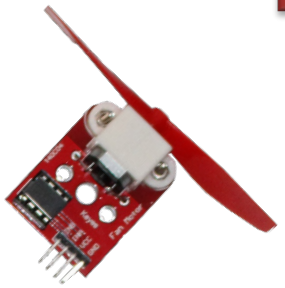
Premium Kit Sensors/Actuators

ISA Kit Premium comes with 30 sensors and actuators. The first 10 sensors/actuators (#1 to #10) are common between the Basic, Pro, and Premium Kits. The next 10 sensors/actuators (#11 to #20) are common between the Pro and Premium Kits. The last 10 sensors/actuators (#21 to #30) are available only in the Premium Kit.

Warning!
Most of the premium actuators and sensors require extra attention while being operated. Students under 16 years old should be supervised by an adult instructor.



Warning!
Do not aim the laser beam at skin, head, or eyes. It is extremely harmful!
Do not point the laser beam into the sky. It is very dangerous and illegal to point laser beam at any moving vehicle, including cars and airplanes.



Warning!
Do not touch the propeller of the fan. It is extremely harmful!

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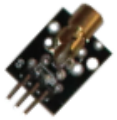
Premium Sensors and Actuators (21-30)

Actuators					Sensors				
21	22	23	24	25	26	27	28	29	30
DC Motor	Laser	Pump	Valve	Fan motor	Pulse	Flame	Vibration	hall effect	Tilt
									

21. A **DC motor** operates with 3 VDC voltage source.
22. A **laser** actuator can generate laser beam.
23. A **mini pump** is a 3-6 VDC submersible water pump. Submerge it under water and use a tube to pump the water up.
24. A **solenoid/electromagnetic valve** is an electromechanical valve operating on 12VDC. By default it is closed. When a 12 VDC voltage is applied it will be open.
25. A **fan motor** can turn clockwise or counter-clockwise to either push or draw air current.
26. A **pulse sensor** measures heart rate or pulse.
27. A **flame sensor** is a digital sensor sensitive to flame.
28. A **vibration sensor** is a digital sensor that indicates if the sensor is under movement or vibration.
29. A **hall effect** is sensitive to either north (N) or south (S) pole of permeant or inductive magnets.
30. A **tilt sensor** is a digital sensor that indicates if the sensor has been tilted.

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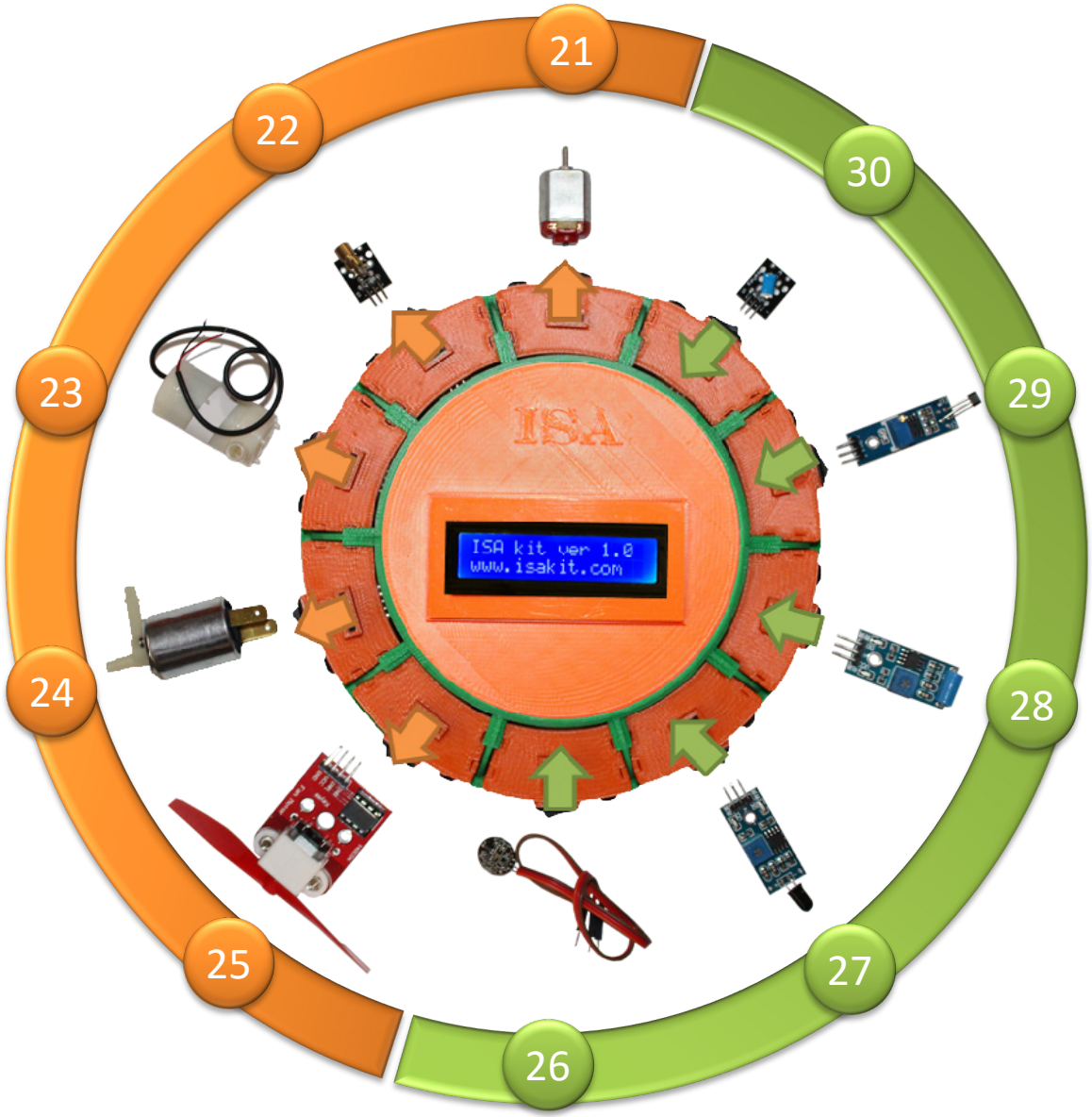
Premium Sensors and Actuators (21-30)



			Box#
Actuators	21	DC Motor	R
	22	Laser	2
	23	Pump	R
	24	Valve	R
	25	Fan Motor	15
Sensors	26	Pulse	5
	27	Flame	7
	28	Vibration	18
	29	Hall Effect	19
	30	Tilt	8

R=Relay

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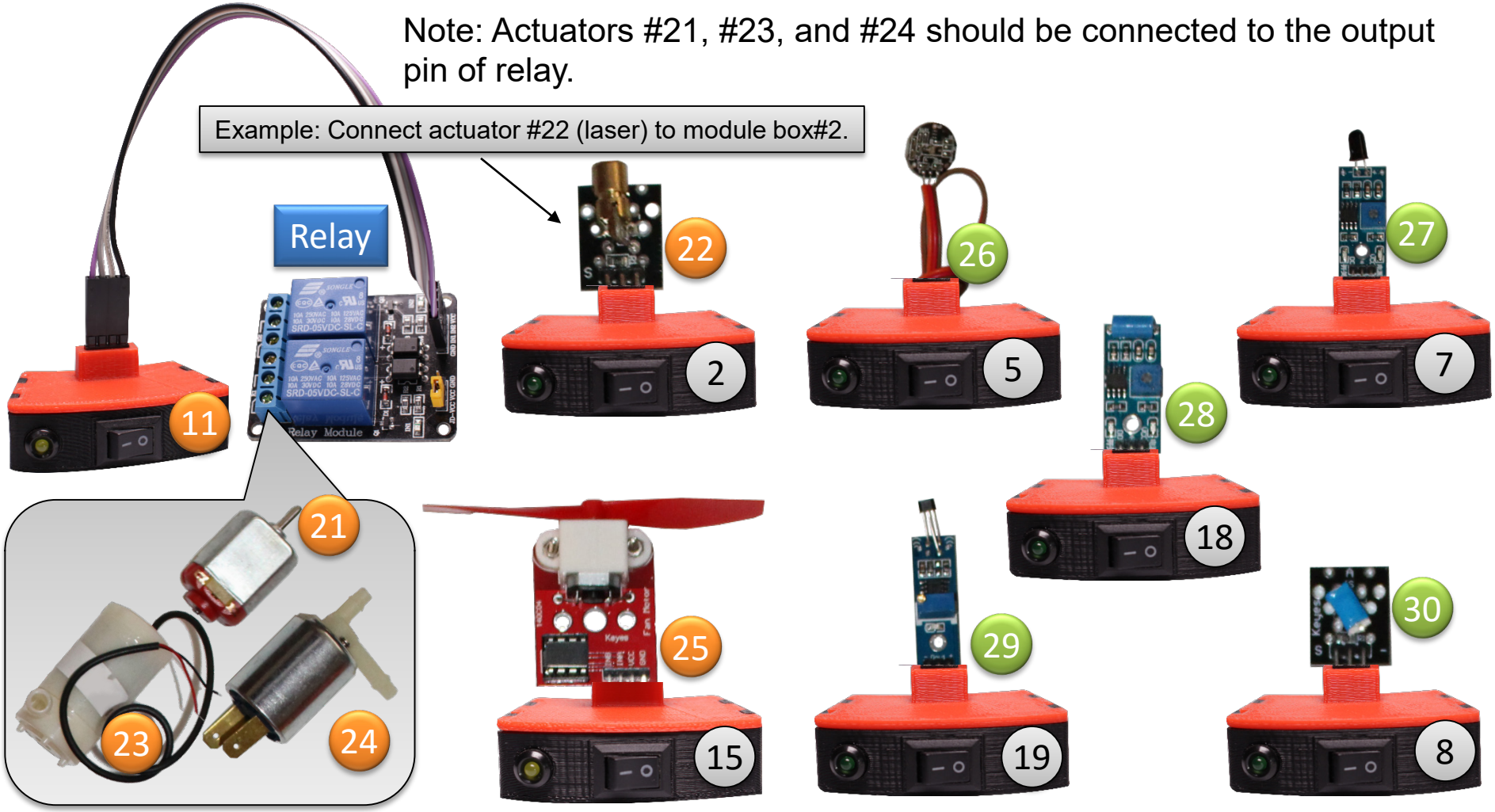
Connecting Sensors and Actuators (21-30)

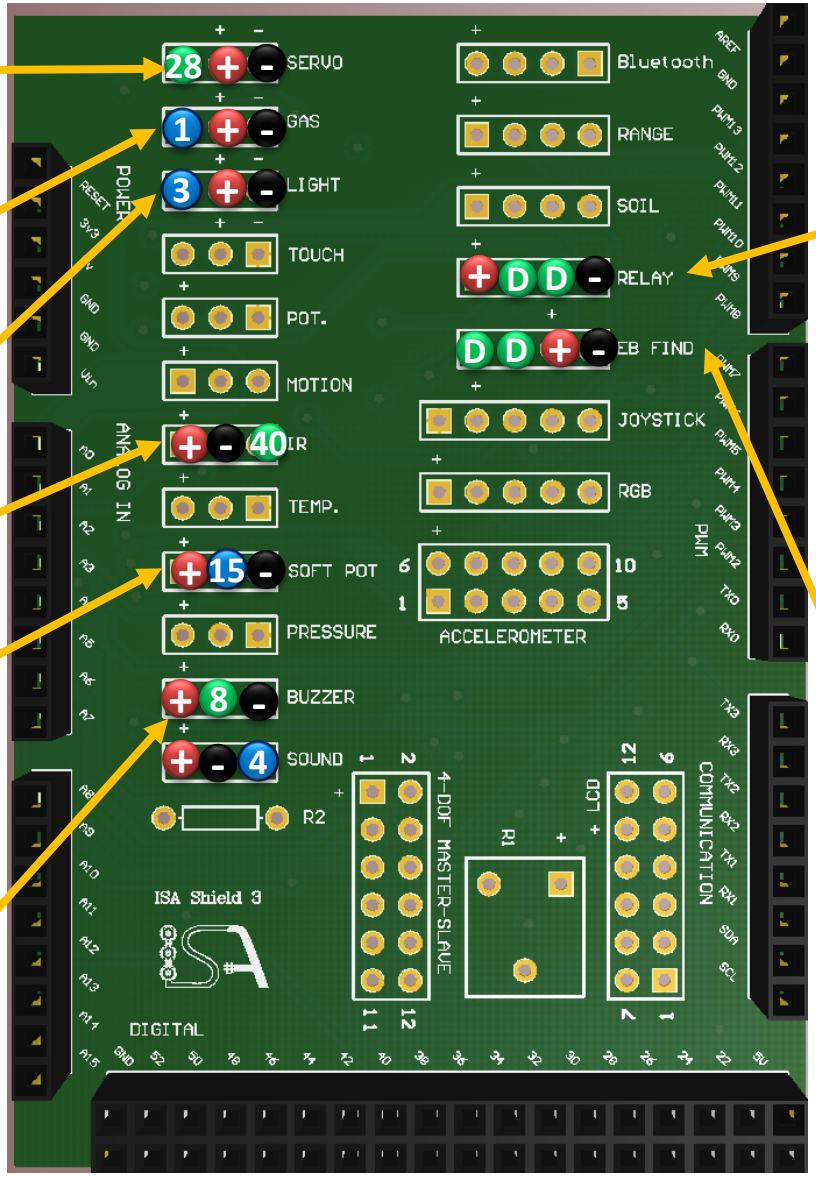
There are only 20 module boxes in ISA Kit premium. Therefore, sensors and actuators #21 to #30 should be connected to module boxes #1 to #20 based on the following configurations.

Note: Actuators #21, #23, and #24 should be connected to the output pin of relay.

Example: Connect actuator #22 (laser) to module box#2.



Connecting Sensors and Actuators (21-30)

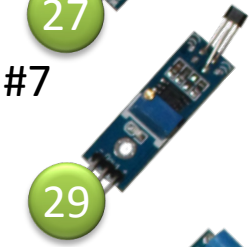


module box #2

module box #5

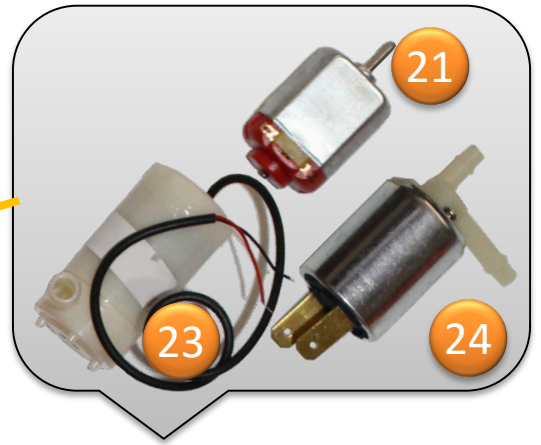
module box #8

module box #7

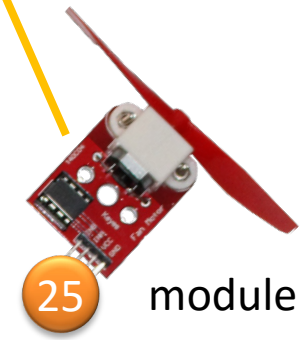


module box #19

module box #18



These actuators should be connected to the relay output pin or directly to a battery



module box #15

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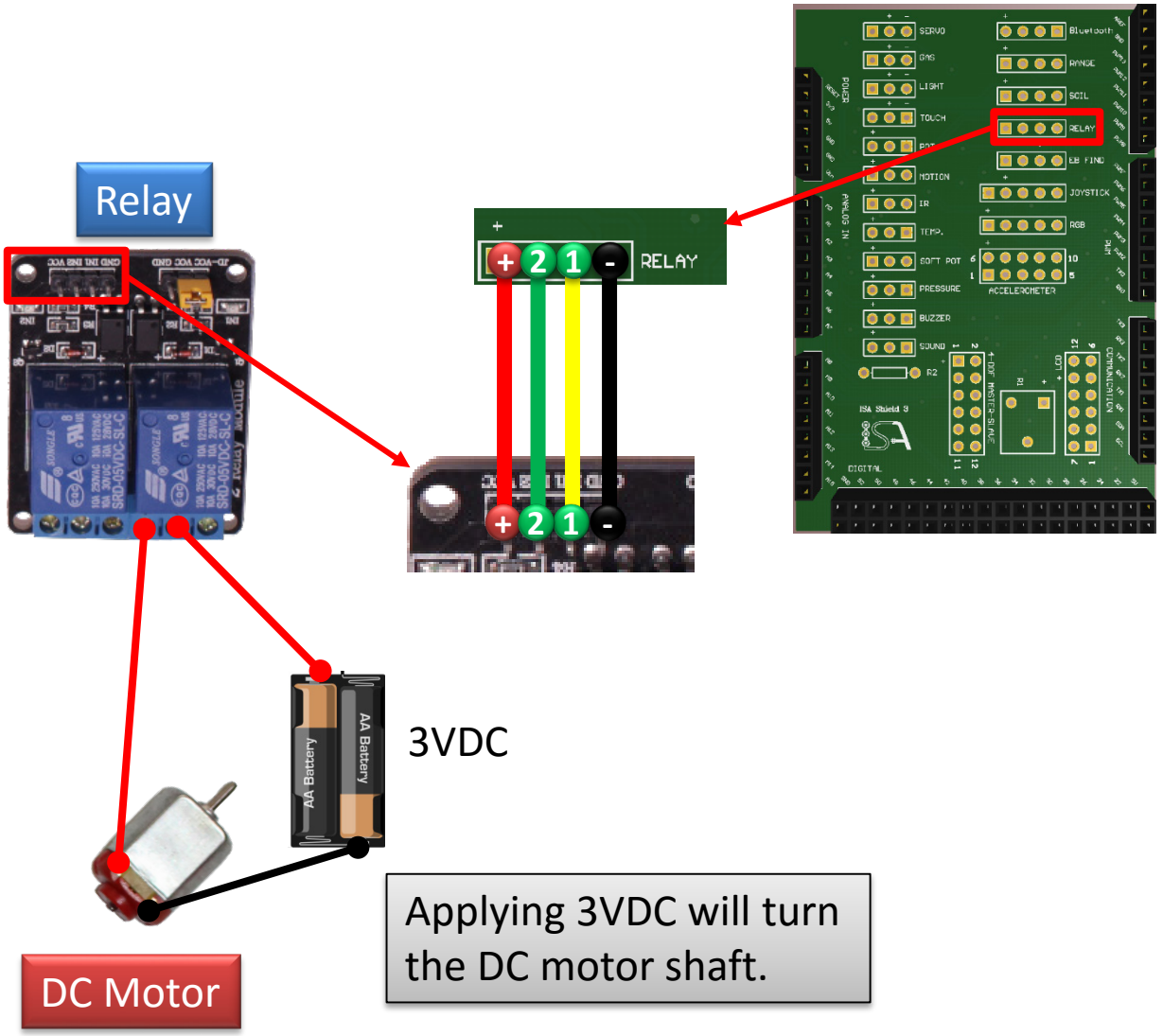
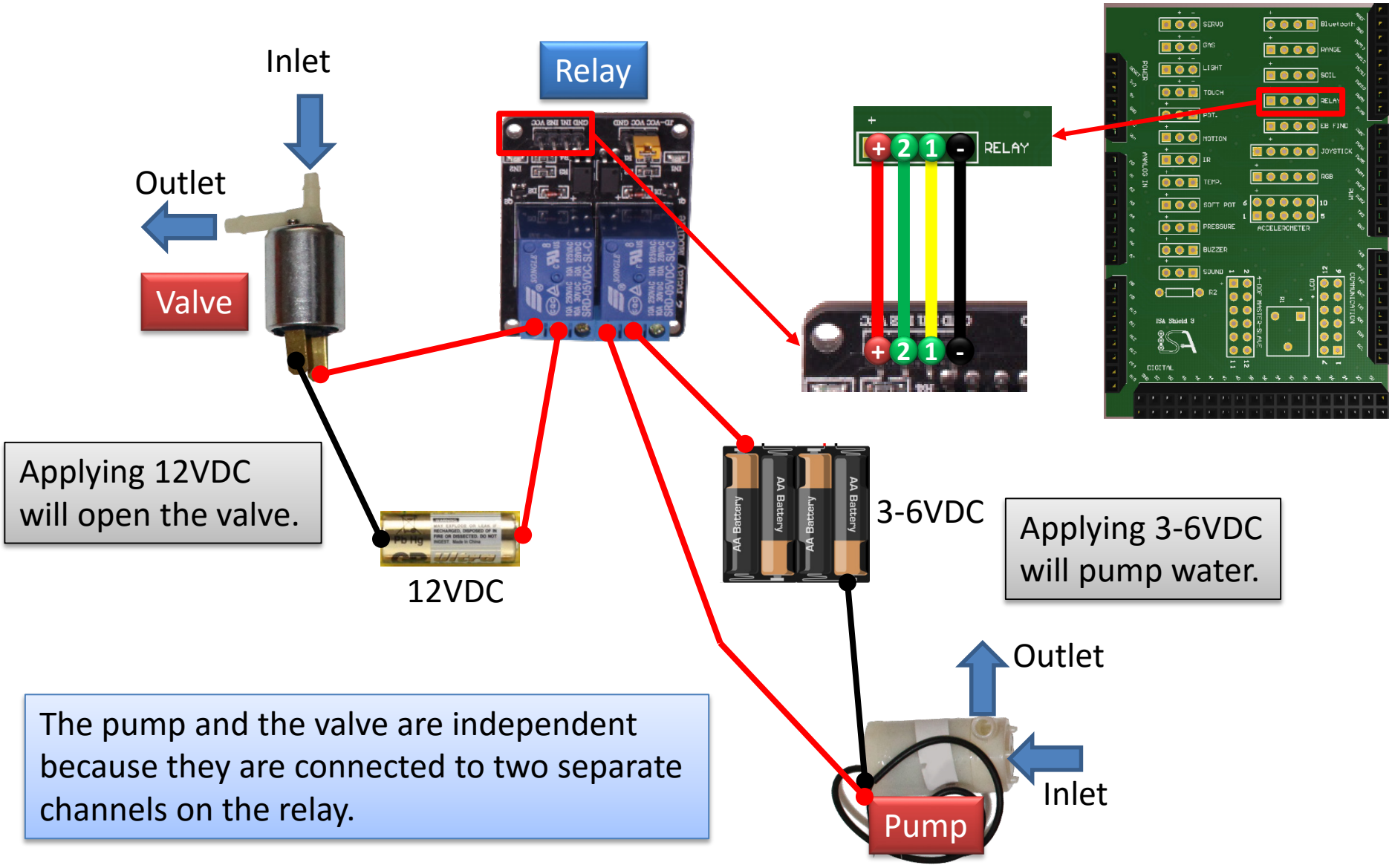
How to Use the Relay (One Channel)



How to Use the Relay (Two Channels)



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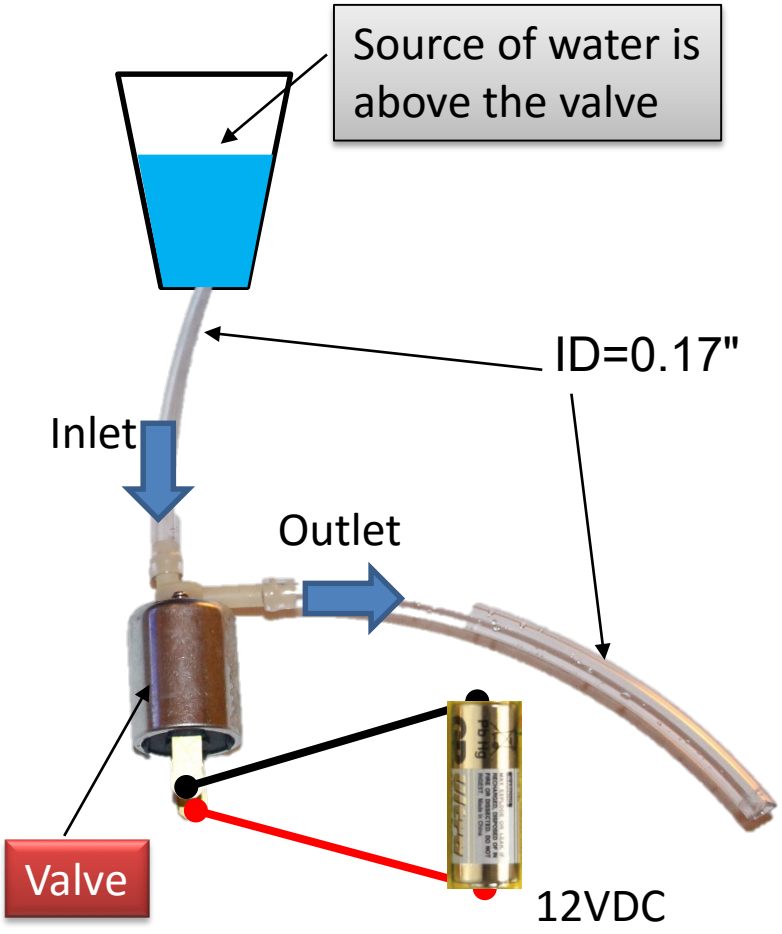
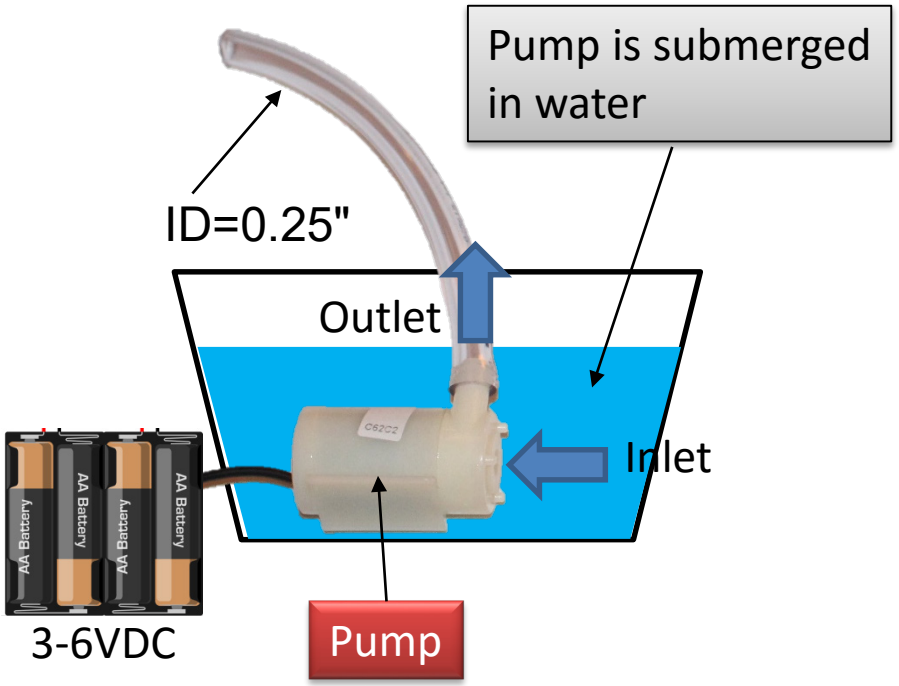
Vinyl Tubes

In **ISA Kit Premium**, three vinyl tubes are included: two with Internal Diameter (ID) of 0.17" for the electromagnetic valve (actuator #24) and one with ID=0.25" for the mini pump (actuator #23).





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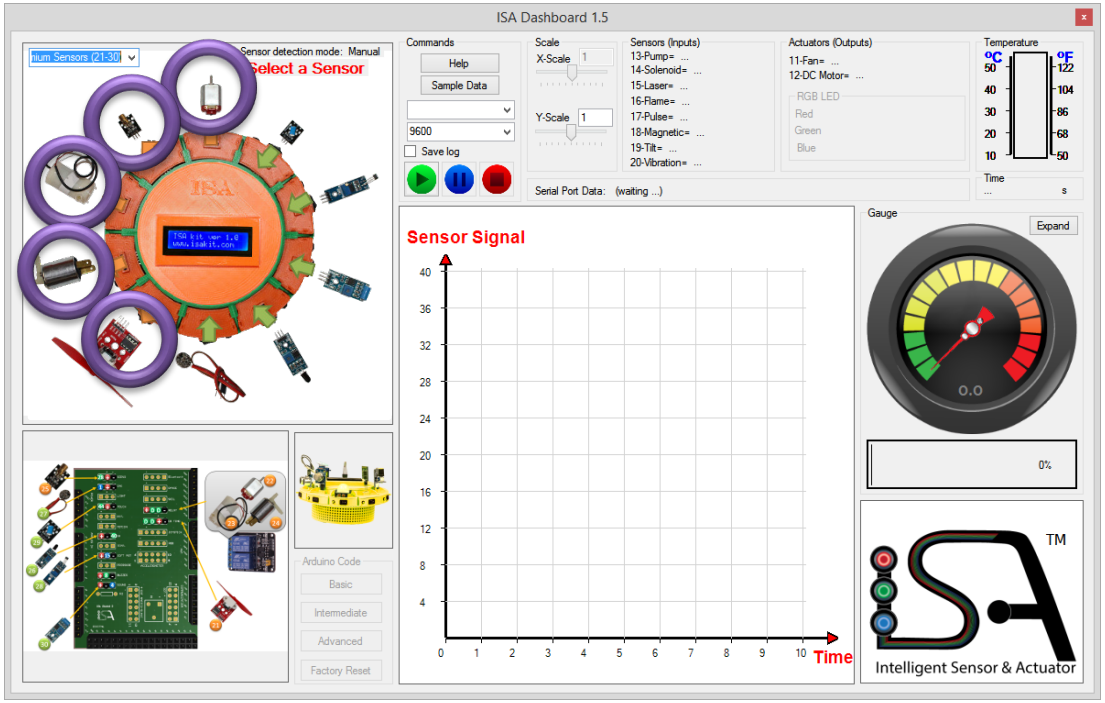
Modules #21 to #25: Actuators

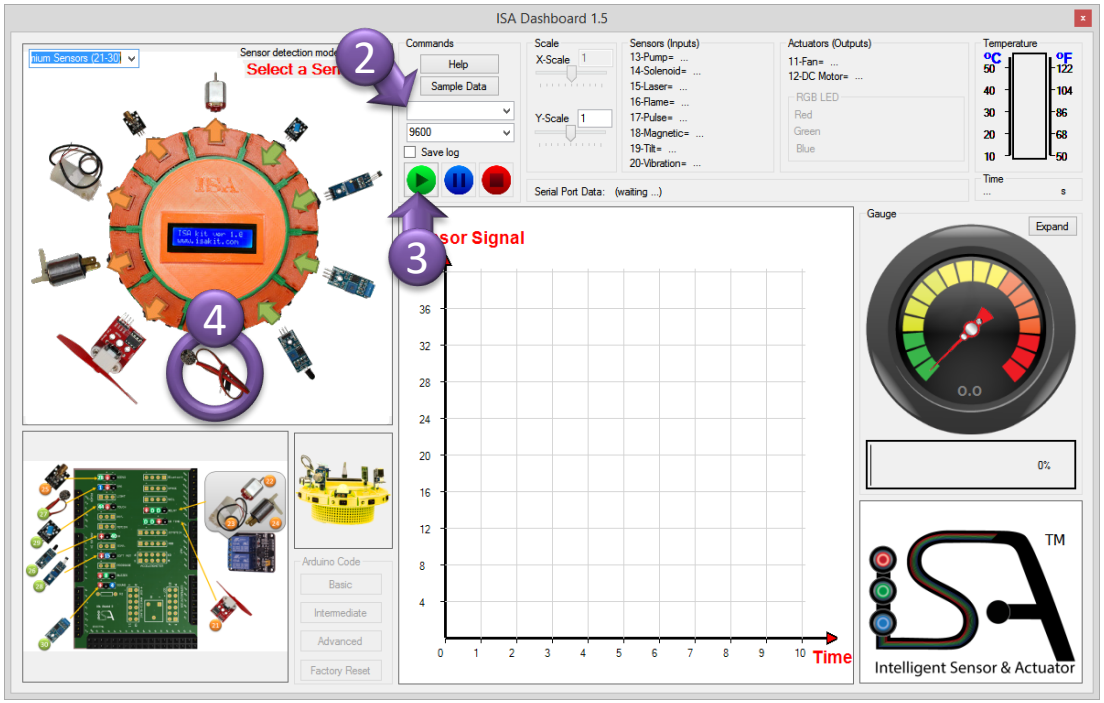
In this version of ISA Dashboard you cannot control the actuators directly from the Dashboard. In order to control the actuators, you need to use the Arduino code.

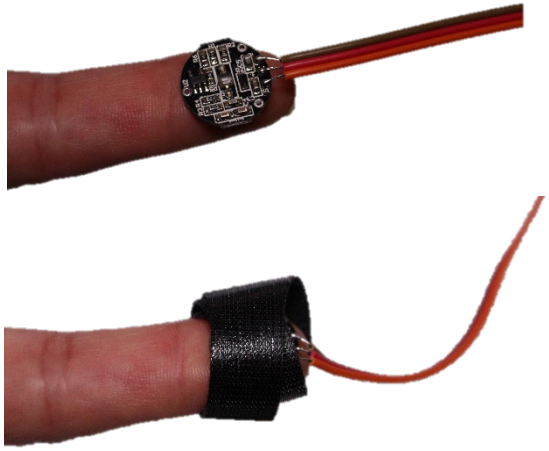
Controlling the actuators directly from the ISA Dashboard will be available in the future revisions.



Module #26: Pulse Sensor

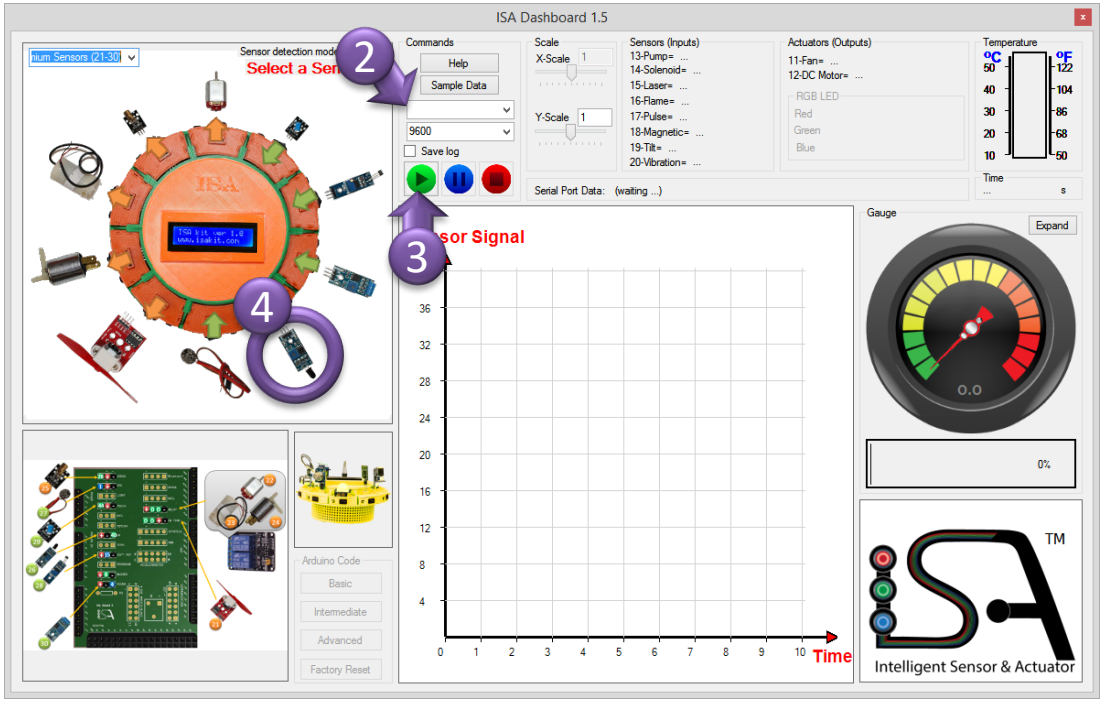
1. Follow the instructions on page 84 to enable Premium Sensors (21-30).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the Pulse Sensor by clicking on its image. An animated arrow should be displayed.
5. Use the multi-purpose fastener that comes with the pulse sensor to hold the sensor on your pointer finger. Wait for a few seconds until data is transferred and analyzed.
6. The corresponding data will be plotted versus time.

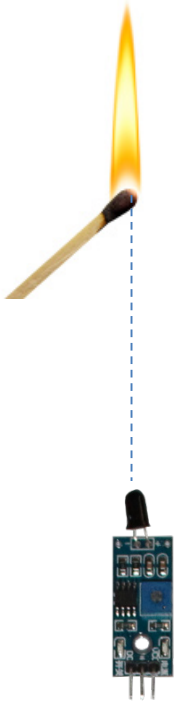




Module #27: Flame Sensor

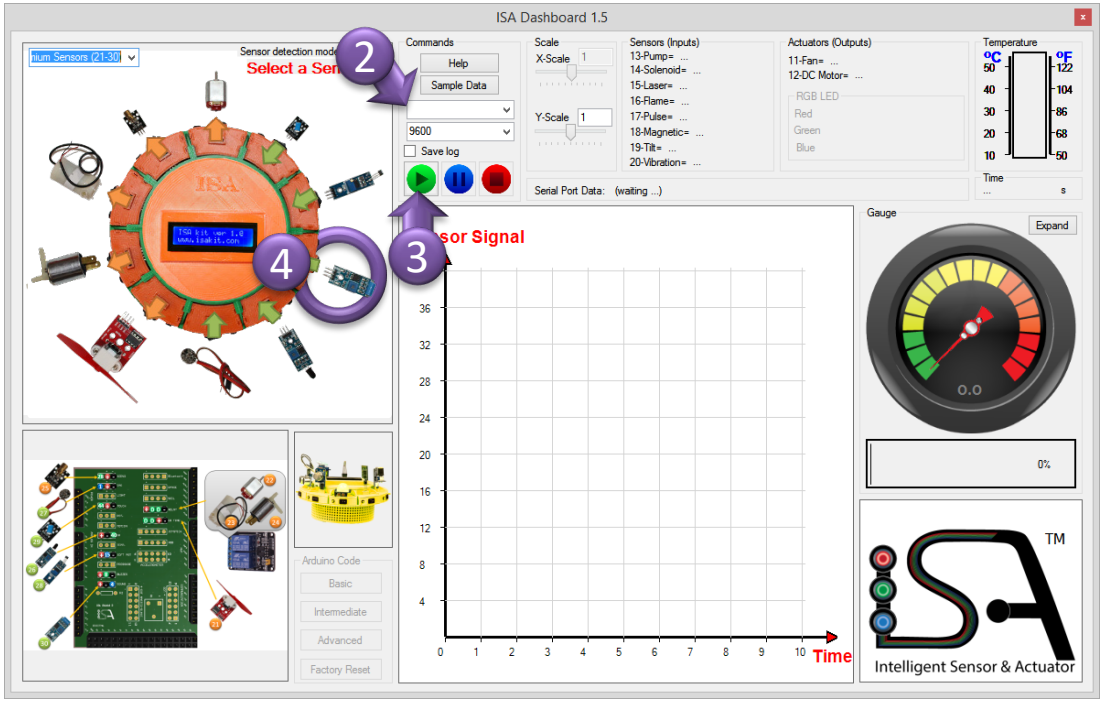
1. Follow the instructions on page 84 to enable Premium Sensors (21-30).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the Flame Sensor by clicking on its image. An animated arrow should be displayed.
5. When any flame is placed on top of the sensor it will send a “0” signal; otherwise, it will send a “1” signal.
6. The corresponding data will be plotted versus time.

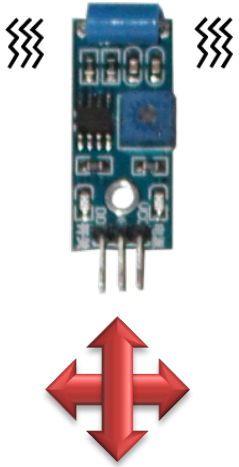




Module #28: Vibration Sensor

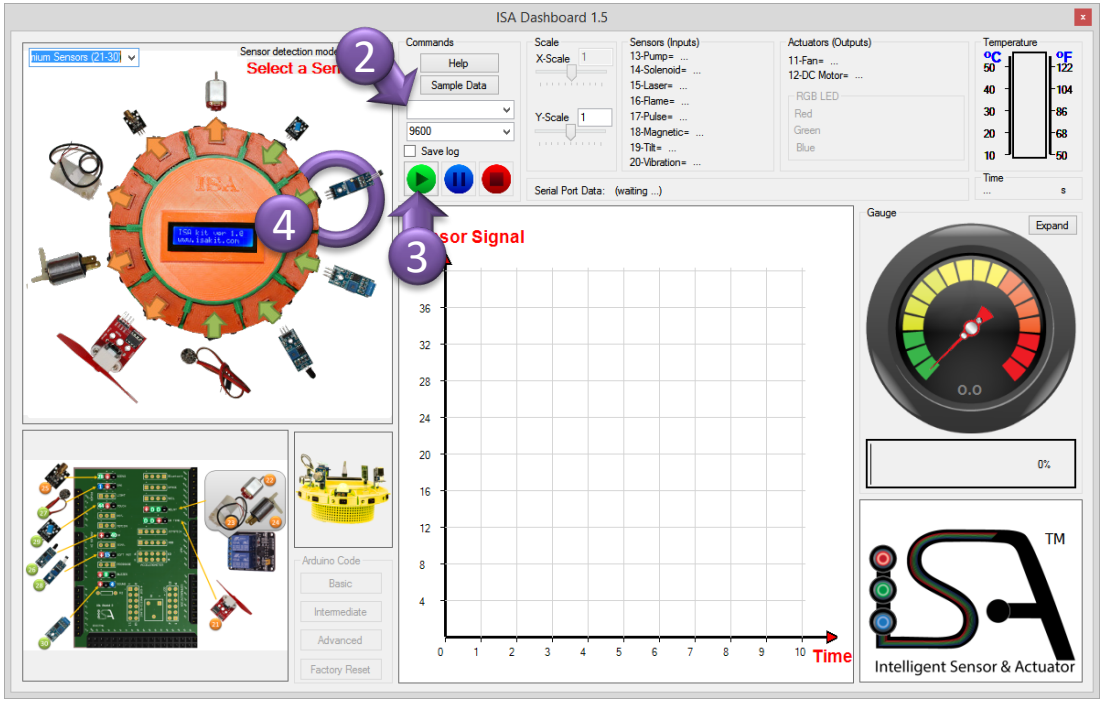
1. Follow the instructions on page 84 to enable Premium Sensors (21-30).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the Pulse Sensor by clicking on its image. An animated arrow should be displayed.
5. Rotate the sensor about x, y, and z axes. Also shake it in different directions.
6. The corresponding data will be plotted versus time.

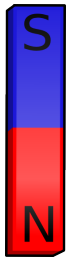


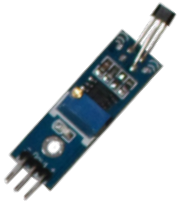


Module #29: Hall Effect Sensor

1. Follow the instructions on page 84 to enable Premium Sensors (21-30).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the Pulse Sensor by clicking on its image. An animated arrow should be displayed.
5. Use a permeant magnet and bring it close to the sensor. The hall effect sensor will respond to only one pole, either North (N) or South (S), not both.
6. The corresponding data will be plotted versus time.

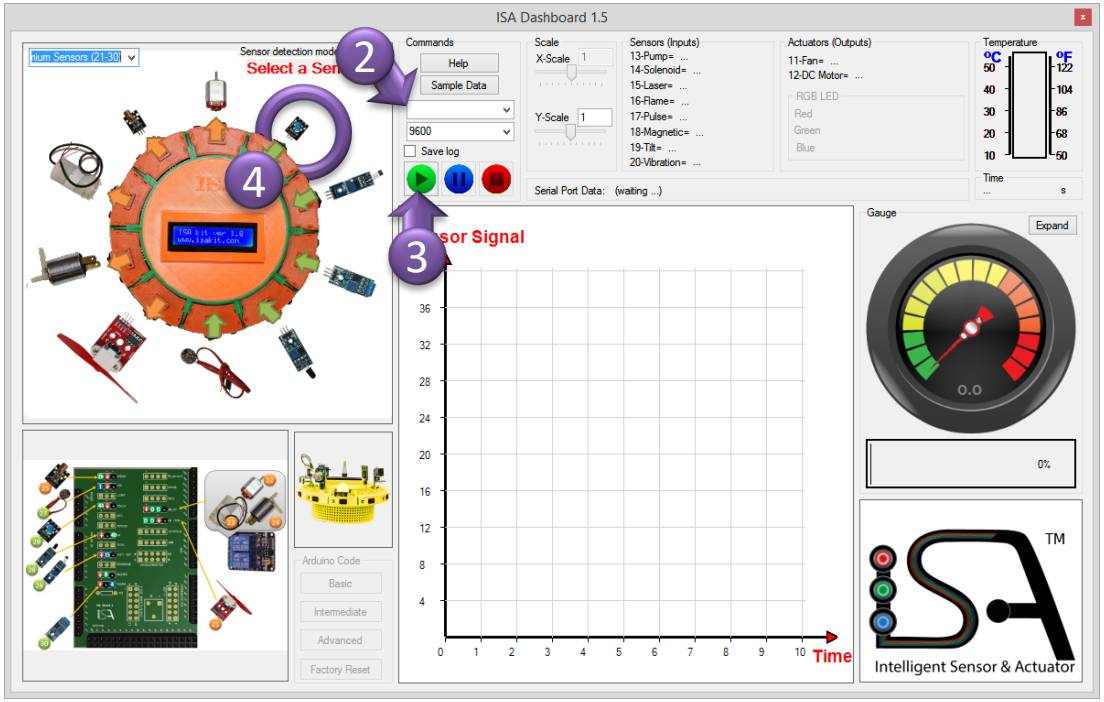


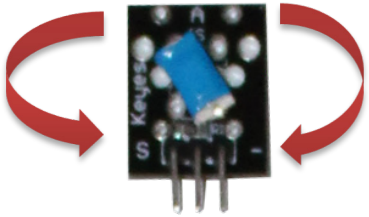




Module #30: Tilt Sensor

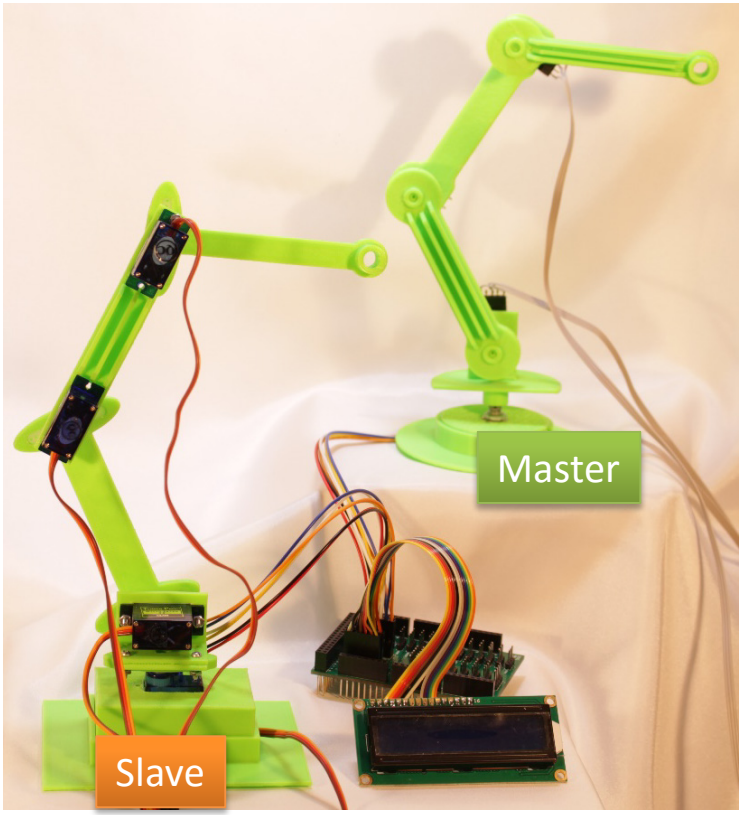
1. Follow the instructions on page 84 to enable Premium Sensors (21-30).
2. Select the COM port that your ISA Kit is connected to.
3. Start receiving data from the ISA Kit by clicking on icon.
4. Select the Pulse Sensor by clicking on its image. An animated arrow should be displayed.
5. Rotate the sensor about x, y, and z axes.
6. The corresponding data will be plotted versus time.

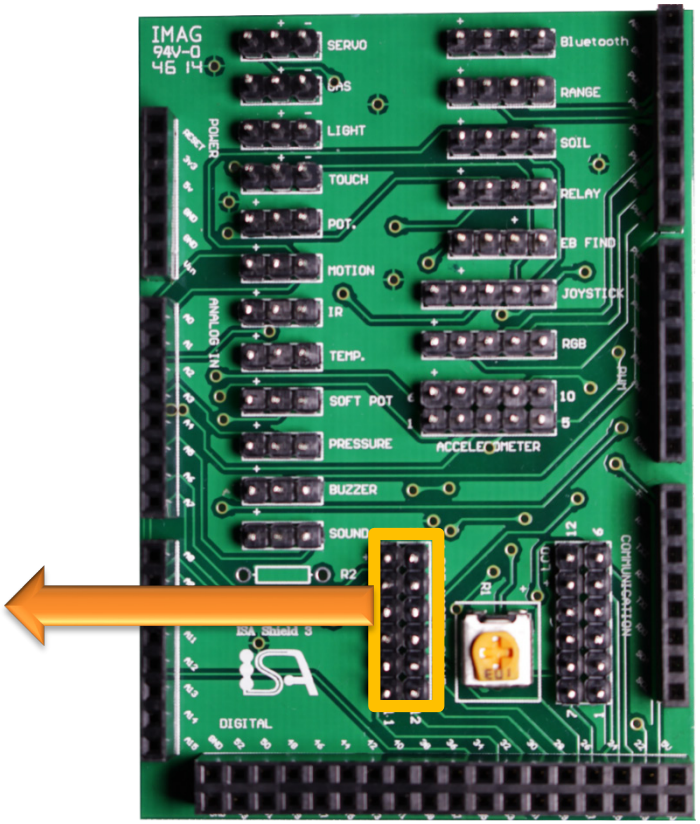




Add-On 1: 4-DOF Telerobotic Arm

In this MIMO project, four potentiometers (sensors/inputs) and four servo motors (actuators/outputs) are connected directly to the ISA Shield. The connection is already available on the ISA Shied 3. The operator moves the arm of the master (with four potentiometers) and the slave (with four actuators) will follow the command.





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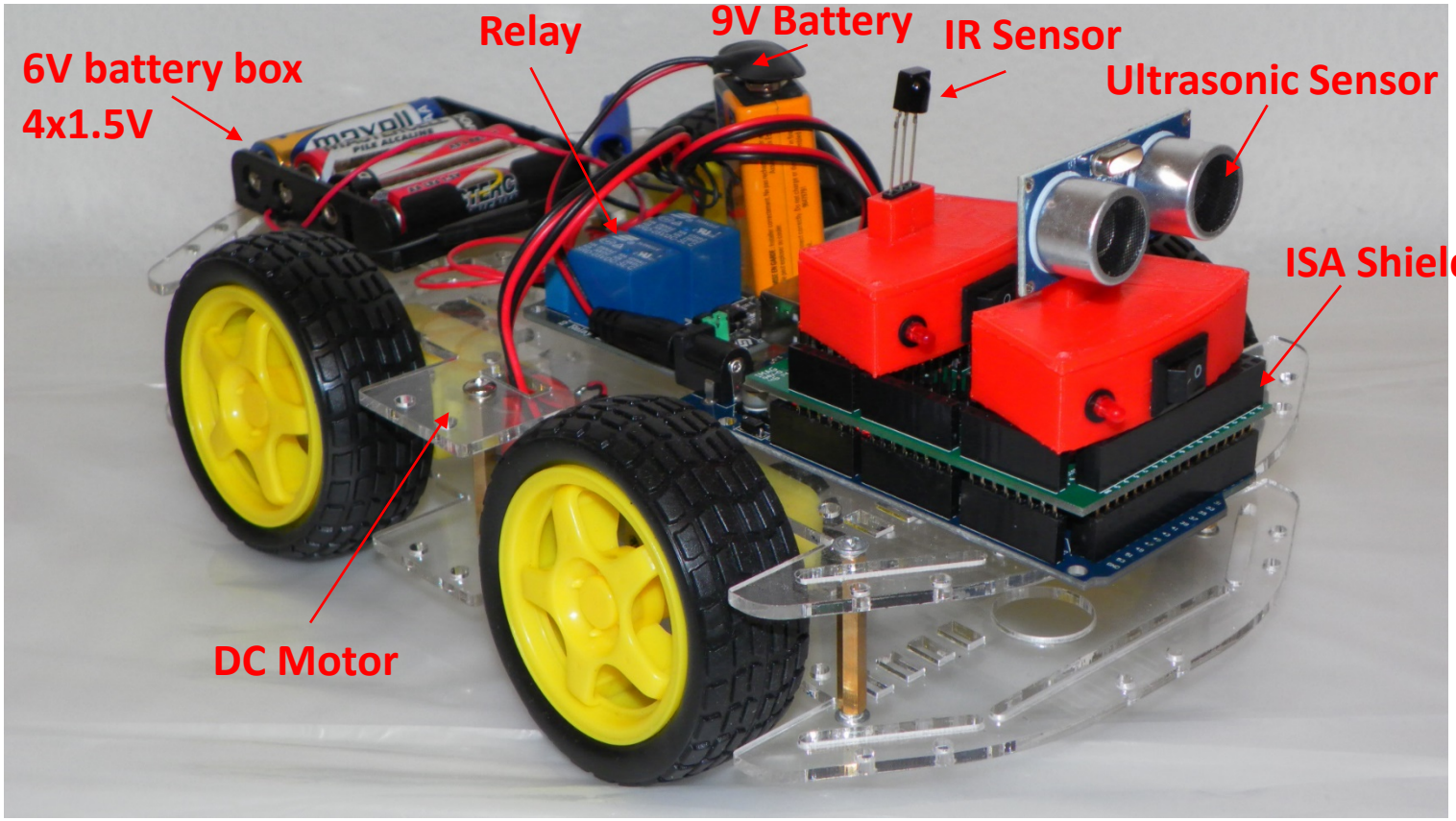
Add-On 2: Remote Control Car

In this MIMO project, four DC motors (actuator/output) are used to remotely control an RC car via IR sensor. The distance between the car and obstacles is measured via an ultrasonic sensor and it will stop automatically if it is close to hit the barrier.



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ISA Kit Projects

	# of Sensors/Inputs	# of Actuators/Outputs	# of SISO Projects	# of MIMO Projects
Basic	8	5	40	~ Eight Thousand (7,865)
Pro	15	8	120	Over Eight Million (8.3×10^6)
Premium	20	13	260	Over Eight Billion (8.6×10^9)

				Basic Sensors/Inputs								Pro Sensors								Premium Sensors				
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	16	17	18	19	20
				Moisture	Ultrasonic	Gas/Alcohol	Motion	Infra Red (IR)	Light	Potentiometer	Bluetooth	Joystick	Sound	Touch	Pressure	Soft Pot	Track	Accelerometer	Temperature	Pulse	Flame	Vibration	Hall Effect	Tilt
Basic Actuators/Outputs	A	RGB LED		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A15	A16	A17	A18	A19	A20
	B	Servo		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B15	B16	B17	B18	B19	B20
	C	LCD		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C15	C16	C17	C18	C19	C20
	D	Serial Monitor		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D15	D16	D17	D18	D19	D20
	E	Bluetooth		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E15	E16	E17	E18	E19	E20
Pro Actuators	F	LED		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F15	F16	F17	F18	F19	F20
	G	Relay		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G15	G16	G17	G18	G19	G20
	H	Buzzer		H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H15	H16	H17	H18	H19	H20
Premium Actuators	I	Motor		I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I15	I16	I17	I18	I19	I20
	J	Fan		J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J15	J16	J17	J18	J19	J20
	K	Pump		K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K15	K16	K17	K18	K19	K20
	L	Valve		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L15	L16	L17	L18	L19	L20
	M	Fan Motor		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M15	M16	M17	M18	M19	M20

Links

ISA Kit website: http://www.isakit.com

Intelligent Design Technology LLC: http://www.idesignt.com

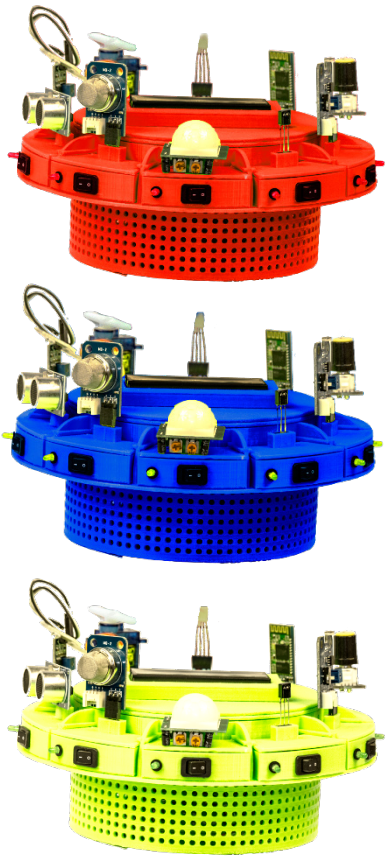
The Henry Samueli School of Engineering at the University of California, Irvine: http://www.eng.uci.edu/

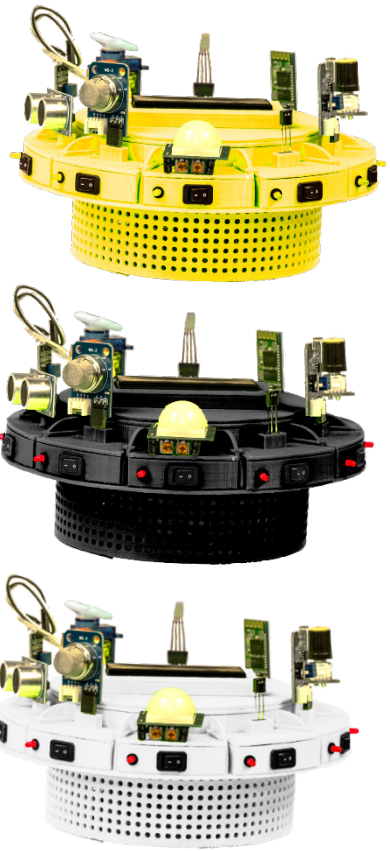
Intelligent Structures and Systems Lab (ISSL): http://issl.eng.uci.edu/

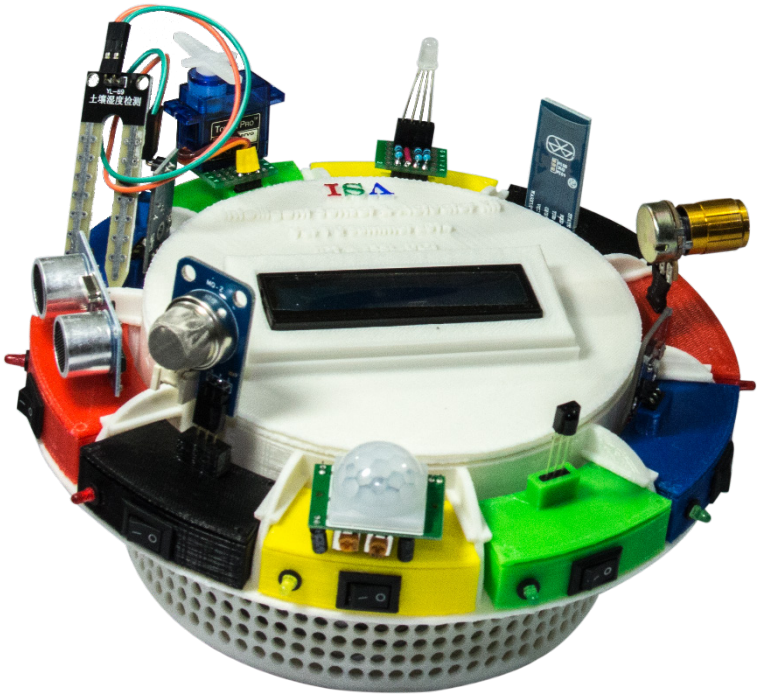
Sensors and actuators of the ISA kit (YouTube): https://www.youtube.com/watch?v=GMSeic3EwSc

Arduino: http://www.arduino.cc/

Email: info@isakit.com







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