



# **TI-Innovator™ Hub with TI LaunchPad™ Board Getting Started Guide**

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### **Learning More with the TI-Innovator™ Technology eGuide**

Parts of this document refer you to the TI-Innovator™ Technology eGuide for more details. The eGuide is a Web-based source of TI-Innovator™ information, including:

- Programming with the TI CE Family of Graphing Calculators and TI-Nspire™ Technology, including sample programs.
- Available I/O Modules and their commands.
- Available breadboard components and their commands.
- Available TI-RGB Array and its commands.
- Available TI-Innovator™ Rover and its commands.
- Link to update the TI-Innovator™ Sketch software.
- Free classroom activities for TI-Innovator™ Hub.

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## **TI-Innovator™ Hub Overview**

The TI-Innovator™ Hub lets you use your compatible TI graphing calculator or TI-Nspire™ CX computer software to control components, read sensors, and create powerful learning experiences.

- You communicate with the Hub through TI Basic programming commands.
- Hosts that are compatible with TI-Innovator™ Hub include:
  - TI CE Family of Graphing Calculators (TI-83 Premium CE, TI-84 Plus CE, and TI-84 Plus CE-T) with operating system version 5.3 or later installed. You also need to install or update the Hub App, which contains the Hub menu.
  - TI Nspire™ CX or TI Nspire™ CX CAS handheld with operating system version 4.5 or later installed
  - TI Nspire™ computer software version 4.5 or later
- **TI-Innovator™ Hub.** Communicates with the host, the Hub on-board components, and connected external components. It also distributes power to external components.
- **TI-Innovator™ Components.** These components, sold separately, include sensors, motors, and LEDs that connect to the Hub through its I/O ports and breadboard connector.

### **Learn More**

For a list of precautions to take while using the Hub and its components, refer to *General Precautions* (page 38).

To find information on accessories, external modules, and breadboard components, visit [education.ti.com/go/innovator](http://education.ti.com/go/innovator).

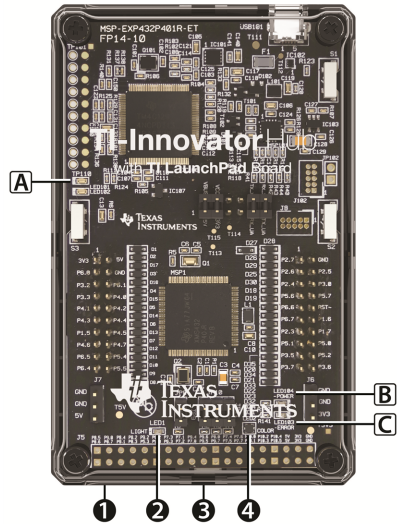
## What's in the Box

### TI-Innovator™ Hub with On-Board Components

- 1 A Light Brightness Sensor at the bottom of the Hub can be read as "BRIGHTNESS" in Hub command strings.
- 2 Red LED is addressable as "LIGHT" in Hub command strings.
- 3 Speaker (at back of Hub, not shown) is addressable as "SOUND" in Hub command strings.
- 4 Red-Green-Blue LED is addressable as "COLOR" in Hub command strings.

Also visible on the face of the Hub are:

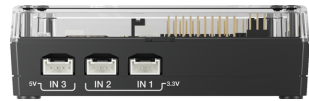
- A Green auxiliary power LED
- B Green power LED,
- C Red error LED.



### Built-in Ports

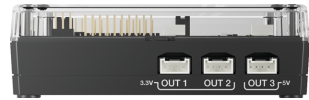
Left side - Three ports for collecting data or status from input modules:

- **IN 1** and **IN 2** provide 3.3V power.
- **IN 3** provides 5V power.



Right side - Three ports for controlling output modules:

- **OUT 1** and **OUT 2** provide 3.3V power.
- **OUT 3** provides 5V power.



Bottom - Light Brightness Sensor (described earlier) and two ports:

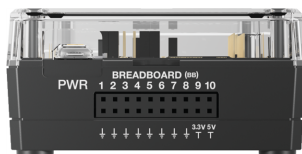
- **I<sup>2</sup>C** port connects to peripherals that use the I<sup>2</sup>C communication protocol.
- **DATA** Mini-B port, used with the appropriate cable, connects to a compatible graphing calculator or computer for data and power.



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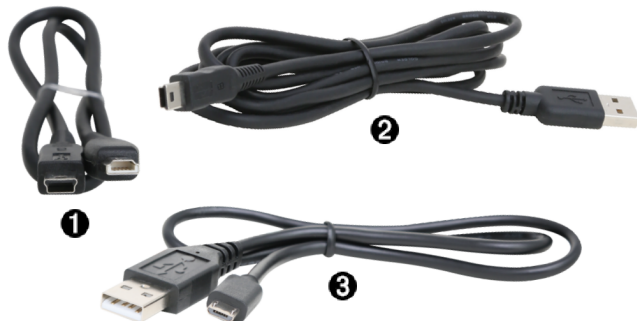
Top - Two connectors:

- USB-Micro connector (**PWR**) for auxiliary power required by some components. Also used for updating the Hub internal software.
- Breadboard Connector with 20 labeled pins for communication with connected components. A breadboard and jumper cables are included with the TI-Innovator™ Breadboard Pack, sold separately.



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## USB Cables



- ① USB Unit-to-Unit (Mini-A to Mini-B) - Connects the Hub to a TI CE Graphing Calculator or a TI-Nspire™ CX Handheld.
- ② USB Standard A to Mini-B - Connects the Hub to a computer running TI-Nspire™ CX Software.
- ③ USB Standard A to Micro - Connects the **PWR** port of the Hub to a TI approved power source required by some peripherals.

## Auxiliary Power

TI Wall Charger - Supplies power through the TI-Innovator™ Hub for components, such as motors, that require additional power.

The optional External Battery Pack can also provide auxiliary power.

**Note:** An auxiliary power LED on the Hub indicates when the Hub is receiving auxiliary power.



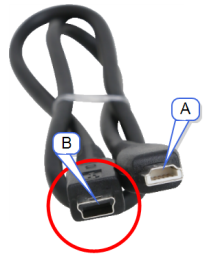
## Connecting TI-Innovator™ Hub

The TI-Innovator™ Hub connects by a USB cable to a graphing calculator or computer. The connection lets the Hub receive power and exchange data with the host.

**Note:** Some peripherals, such as motors, may require auxiliary power. For more information, see Using an Auxiliary Power Source (page 27).

### Connecting to a Graphing Calculator

1. Identify the "B" connector on the USB Unit-to-Unit (Mini-A to Mini-B) cable. Each end of this cable is embossed with a letter.
2. Insert the "B" connector into the **DATA** port at the bottom of the TI-Innovator™ Hub.



3. Insert the free end of the cable (the "A" connector) into the USB port on the calculator.



*Hub connected to  
TI CE Graphing Calculator*

*Hub connected to  
TI-Nspire™ CX Handheld*

4. Turn on the calculator if it is not already on.

The power LED on the Hub glows green to show that it is receiving power.



## Connecting to a Computer Running TI-Nspire™ CX Software

1. Identify the "B" connector on the USB Standard A to Mini-B cable for Windows®/Mac®. Each end of this cable is embossed with a letter.
2. Insert the "B" connector into the **DATA** port at the bottom of the TI-Innovator™ Hub.
3. Insert the free end of the cable (the "A" connector) into a USB port on the computer.



The power LED on the Hub glows green to show that it is receiving power.



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## Updating the Hub Software

The TI-Innovator™ Hub contains software, TI-Innovator™ Sketch, that interprets Hub commands and communicates with on-board devices and connected modules. A Web-based tool lets you update the Sketch. Updated versions contain bug fixes and ensure that your TI-Innovator™ Hub can communicate with the latest components.

To obtain the latest version of the TI-Innovator™ Sketch go to the following site:

<https://education.ti.com/go/innovator>

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## Questions About the Hub Software

### What is the TI-Innovator™ sketch?

The 'sketch' is the software on the TI-Innovator™ Hub that communicates with the graphing calculator, processes the commands, and controls the external components.

### Do I need to update the sketch on the TI-Innovator™ Hub?

For best results always use the latest version of TI-Innovator™ sketch. To stay informed on any updates to the TI-Innovator™ Hub, make sure you register your product at [education.ti.com/register](https://education.ti.com/register) or check the TI-Innovator™ website at [education.ti.com/go/innovator](https://education.ti.com/go/innovator).

## **What is the latest version of the sketch?**

For best results always use the latest version of TI-Innovator sketch. You can always find the latest version of the sketch at [education.ti.com/go/innovator](http://education.ti.com/go/innovator).

## **Why would I update the sketch?**

There are a couple of different reasons to upgrade the sketch.

1. To get the latest version from TI that may include new functionality.
2. To restore the TI sketch after loading a custom sketch – This is only needed by advanced users who use an alternative sketch.

## **How do I load the sketch on the TI-Innovator™ Hub?**

The sketch can be updated through the TI-Innovator Hub Update Software. This software is a free download on the TI website.

## **Can I update multiple TI-Innovator Hubs at the same time?**

The TI-Innovator Hub Update Software only allows updating a single Hub at a time. However, the application is designed to allow you to update multiple Hubs without having to re-launch the software.

## **Can the sketch that comes on the TI-Innovator™ Hub be edited to add functionality but still work with the TI calculator? Is the sketch open source?**

The code for sketch that is loaded on the TI-Innovator™ has not been published for others to modify or edit. To maintain compatibility between the TI-Innovator™ Hub and TI calculator products, only use the officially published sketch for TI-Innovator™ Hub.

## Hub Programming on TI CE Graphing Calculator

**Note:** These instructions apply to TI CE graphing calculator. For similar instructions for TI-Nspire™ CX technology, refer to Hub Programming on TI-Nspire™ CX Technology (page 15).

The TI-Innovator™ Hub responds to TI Basic programming commands such as **Send** and **Get**.

- **Send** - Sends command strings to the Hub to control devices or request information.
- **Get** - Retrieves information requested from the Hub.
- **eval** - Supplies the result of an expression as a character string. Especially useful within the Hub command string in **Send** commands.
- **Wait** - Pauses program execution for a specified number of seconds.

### Code Examples: TI CE Graphing Calculator

Desired Action	Program Code
Turn on the on-board Red LED ("LIGHT").	<code>Send("SET LIGHT ON")</code>
Play a 440Hz tone on the on-board speaker ("SOUND") for 2 seconds.	<code>Send("SET SOUND 440 TIME 2")</code>
Turn on blue element of on-board RGB LED ("COLOR") at 100% brightness.	<code>Send("SET COLOR.BLUE 255")</code>
Read and display the current value of the on-board light sensor ("BRIGHTNESS"). Range is 0% to 100%.	<code>Send("READ BRIGHTNESS")</code> <code>Get(A):Disp A</code>

### Sample Program to Blink an On-Board LED

The following TI CE graphing calculator program uses the **Send** and **Wait** commands to blink the on-board red LED in the Hub. The commands are contained in a "For...End" loop that repeats the ON/OFF blink cycle for 10 iterations.

```

PRGM: BLINK
For(N,1,10)
Send("SET LIGHT ON")
Wait 1
Send("SET LIGHT OFF")
Wait 1
End

```



## How to Create and Execute a Program

**Note:** These are abbreviated instructions. For detailed instructions on creating and executing programs, refer to *TI-Basic Programming for the TI CE Graphing Calculator*. The guide is available through the TI-Innovator™ Technology eGuide (page ii).

### Before You Begin

- ▶ Refer to System Requirements (page 1), and update your calculator's OS (Operating System) and Hub App, as needed. You can update from TI Connect™ CE software or from another updated calculator.

**Note:** The TI-Innovator™ Hub App is available for download from the TI website at [education.ti.com/latest](http://education.ti.com/latest).

### To Create a New Program on TI CE Graphing Calculator:

1. On the Home Screen, press **[prgm]**, select **New**, and press **[enter]**.
2. Type a name for your program, such as "SOUNDTEST," and then press **[enter]**.  
The Program Editor opens, displaying a template for your program code.
3. Enter the lines of code that make up your program.
  - You must use the Hub Menu to enter TI-Basic commands, such as **Send** and **Get**. (Press **[prgm]** and select **Hub**.)
  - You can enter Hub command strings and parameters such as "**SET LIGHT ON**" by using the menu or by typing. If you type the strings, make sure to use the correct case.
  - At the end of each line, press **[enter]**. Each new line is automatically preceded by a colon (:).
  - Use the arrow keys to move through a program. Press **[del]** to delete, or press **[2nd] [ins]** to insert.

### To Close the Program Editor

- ▶ Press **[2nd]** **[quit]** to return to the Home Screen.

The program remains available through the **[prgm]** key.

### To Run the Program:

1. Ensure that the TI-Innovator™ Hub is connected to your calculator.
2. Ensure that any needed I/O Modules or Breadboard components are connected to the Hub.
3. From the Home Screen, press **[prgm]**, select your program name from the displayed list, and press **[enter]**.

The program name is pasted to the Home Screen.

4. Press **[enter]** again to run the program.

### To Edit an Existing Program:

1. On the Home Screen, press **[prgm]**, select **Edit**.
2. Select the program name from the displayed list, and press **[enter]**.

The program opens in the Program Editor.

### Using the Hub Menu to Build Commands

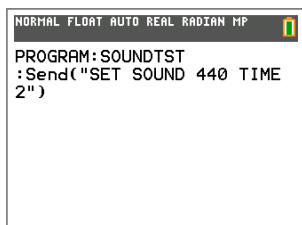
The Hub menu is available on the TI CE graphing calculator anytime you are creating or editing a program. It can save you time building commands and help you with correct command spelling and syntax.

**Note:** To build a command from the Hub menu, you need to know:

- The unique name of the component that you are addressing, such as "SOUND" for the on-board speaker.
- The command parameters that apply to the component, such as sound frequency and duration. Some parameters are optional, and you might need to know the value range of a parameter.

### Example of Using the Hub Menu:

This TI CE graphing calculator example builds the command **Send** ("**SET SOUND 440 TIME 2**") to sound a 440Hz tone for 2 seconds on the on-board speaker.



1. Open (or create) the program that you will use to communicate with the Hub.
2. Position the cursor where you want to place the command.

3. Press **[prgm]** and select **Hub**.

The Hub menu appears.

```
NORMAL FLOAT AUTO REAL RADIAN MP
CTL I/O COLOR EXEC HUB
1:Send("SET...
2:Send("READ...
3:Settings...
4:Wait
5:Get(
6:eval(
7:Send("CONNECT-Output...
8:Send("CONNECT-Input...
9↓Ports...
```

4. Select **Send "SET** and press **[enter]**, and then select **SOUND** and press **[enter]**.

```
PROGRAM: SOUNDST
:Send("SET SOUND █
```

5. Type **440** as the sound frequency.

```
PROGRAM: SOUNDST
:Send("SET SOUND 440█
```

6. On the Hub menu, select **Settings > TIME**.

```
PROGRAM: SOUNDST
:Send("SET SOUND 440 TIME
█
```

7. Type **2** as the TIME value.

```
PROGRAM: SOUNDST
:Send("SET SOUND 440 TIME
2█
```

8. To complete the command, type closing quotes (press **[alpha]** **[+]**), and then press **[ ]**.

```
PROGRAM: SOUNDST
:Send("SET SOUND 440 TIME
2")█
```

9. To return to the Home Screen and test the command, press **[2nd]** **[quit]** and then follow the previous instructions for running a program.

### Tips for Coding with TI CE Graphing Calculator

- Make sure your code is free of unnecessary spaces that can cause syntax errors. This includes repeated spaces within the line and one or more spaces at the end of a line.
- Code from an external source might show "curly" quotation marks ("...") in places that require straight quotes ("..."). To type straight quotes, press **[alpha]** and then **[+]**.
- To clear the current line of code, press **[clear]**.
- To type relational operators such as =, <, and ≤, press **[2nd]** **[test]**.
- To type a space, press **[alpha]** and then **[0]**.
- If your program becomes unresponsive while running, press the **[on]** key.
- **Note:** If a command syntax does not include an opening left parenthesis, such as "Wait", using a pair of parentheses in an argument may be interpreted as the full argument and give an unexpected syntax error. When entering long expressions with parentheses, enclose the entire expression with paired parentheses to avoid syntax errors of this nature.

Valid: Wait ((X+4)\*5)

Valid: Wait X+4\*5

Syntax Error: Wait (X+4)\*5

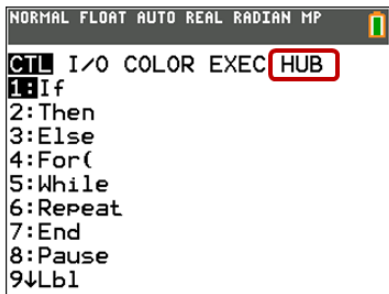
### **Learn More**

To find sample programs and details about programming the TI-Innovator™ Hub, see the TI-Innovator™ Technology eGuide (page ii).

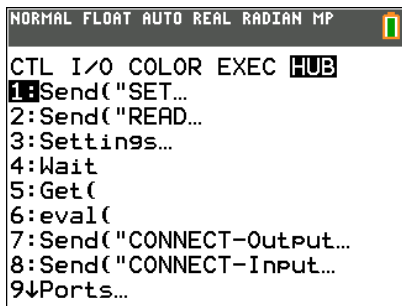
## TI-Innovator™ Hub App for the TI CE Graphing Calculator(s)

### What is the TI-Innovator™ Hub App?

The TI-Innovator™ Hub App adds the HUB menu to the programming menu on a TI CE graphing calculator.



This menu option makes it easy to select commands that are commonly used when creating programs to use with the TI-Innovator™ Hub.

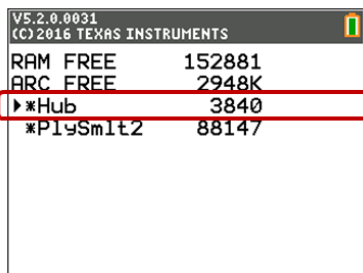


### How do I know whether I have the TI-Innovator™ Hub App?

To determine if the Hub app is loaded on your TI CE graphing calculator, follow these steps.

1. Press 2nd [mem]
2. Select option "2: Mem Management/Delete..."
3. Select option "A: Apps"
4. The TI-Innovator™ Hub App is listed as "Hub" in the list of apps. Confirm that the Hub is listed.





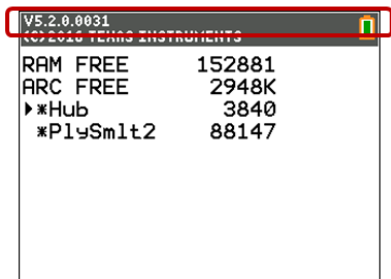
### What version of the TI-Innovator™ Hub App do I need?

For best results always use the latest version of the TI-Innovator™ Hub App and TI CE Family of Graphing Calculators. Visit [education.ti.com/en/product-resources/whats-new-84-ce](http://education.ti.com/en/product-resources/whats-new-84-ce) to get the latest.

### How do I know what the version number of my TI-Innovator™ Hub App is?

To determine the version of the Hub App that is loaded on your TI CE Graphing Calculator, follow these steps.

1. Press 2nd [mem]
2. Select option "2: Mem Management/Delete..."
3. Select option "A: Apps"
4. Press the down arrow until the Hub app is selected.
5. Look at the title bar to view the version number of the Hub app.



### How do I get the TI-Innovator™ Hub App?

The TI-Innovator™ Hub App is available for download from the TI website at [education.ti.com/latest](http://education.ti.com/latest).

**Will I need to update the TI-Innovator™ Hub app every time I update the calculator OS?**

The TI-Innovator™ Hub app would only need to be updated when new functionality is added to the app. However, it is strongly recommended that you always keep your TI products up to date with the latest OS and versions. When updating your OS always check to see if any apps have updates as well.

**Do I need an app to use the TI-Innovator™ Hub with TI-Nspire™ CX technology?**

No. TI-Nspire™ CX technology has all the commands to communicate with the TI-Innovator™ Hub built in. For best results always use the latest version of TI-Nspire™.

## Hub Programming on TI-Nspire™ CX Technology

**Note:** These instructions apply to TI-Nspire™ CX technology. For similar instructions for TI CE graphing calculator, refer to Hub Programming on TI CE Graphing Calculator (page 7).

The TI-Innovator™ Hub responds to TI Basic programming commands such as **Send** and **Get**.

- **Send** - Sends command strings to the Hub to control devices or request information.
- **Get** and **GetStr** - Retrieve information requested from the Hub.
- **eval()** - Supplies the result of an expression as a character string. Valid only within **Send**, **Get**, and **GetStr** commands.
- **Wait** - Pauses program execution for a specified number of seconds.

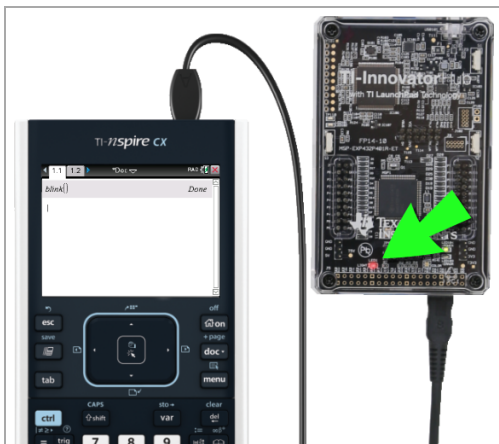
### Code Examples: TI-Nspire™ CX Technology

Desired Action	Program Code
Turn on the on-board Red LED ("LIGHT").	Send "SET LIGHT ON"
Play a 440Hz tone on the on-board speaker ("SOUND") for 2 seconds.	Send "SET SOUND 440 TIME 2"
Turn on blue element of on-board RGB LED ("COLOR") at 100% brightness.	Send "SET COLOR.BLUE 255"
Read and display the current value of the on-board light sensor ("BRIGHTNESS"). Range is 0% to 100%.	Send "READ BRIGHTNESS" Get a: Disp a

### Sample Program to Blink an On-Board LED

The following TI-Nspire™ CX program uses the **Send** and **Wait** commands to blink the on-board red LED in the Hub. The commands are contained in a "For...EndFor" loop that repeats the ON/OFF blink cycle for 10 iterations.

```
Define blink()=  
Prgm  
For n,1,10  
  Send "SET LIGHT ON"  
  Wait 1  
  Send "SET LIGHT OFF"  
  Wait 1  
EndFor  
EndPrgm
```



## How to Create and Execute a Program

**Note:** These are abbreviated instructions. For detailed instructions, refer to the *TI-Nspire™ CX Program Editor*, accessible through the TI-Innovator™ Technology eGuide (page ii).

### Before You Begin:

- ▶ Refer to System Requirements (page 1), and update your software as needed.
  - On TI-Nspire™ CX handhelds, use TI-Nspire™ computer software to update the Operating System.
  - On computers running TI-Nspire™ CX software, use the Help menu to update the software.

### To Create a New Program in a TI-Nspire CX Document:

1. On the handheld, press **doc** and select **Insert > Program Editor > New**. From the computer software, click **Insert > Program Editor > New**.
2. Type a name for your program, such as "soundtst," select **Program** as the Type, and then click **OK**.

The Program Editor opens, displaying a template for your program code.

3. Between the **Prgm** and **EndPrgm** lines, type the lines of code that make up your program.
  - You can either type command names or insert them from the Program Editor menu.
  - After typing each line, press **Enter** to type additional code.
  - Use the arrow keys to scroll through the program.

### **To Store the Program:**

You must store your program before you can run it.

- ▶ On the handheld, press **menu** and select **Check Syntax & Store > Check Syntax & Store**.  
On the Program Editor menu, click **Check Syntax & Store > Check Syntax & Store**.

### **To Close the Program Editor**

- ▶ On the handheld, press **menu** and select **Actions > Close**.  
On the Program Editor menu, click **Actions > Close**.

If you have made changes since storing the program, you are prompted to Check Syntax & Store.

### **To Run the Program:**

1. Ensure that the TI-Innovator™ Hub is connected to your handheld or computer.
2. Ensure that any needed I/O Modules or Breadboard components are connected to the Hub.
3. Open the document that contains the program.
4. On a Calculator page, type the program name and parentheses. If the program requires arguments, enclose them in the parentheses, separated by commas.

The program runs.

### **To Edit an Existing Program:**

1. If necessary, open the document that contains the program.
2. Go to a Calculator page.
3. On the handheld, press **menu** and select **Functions & Programs > Program Editor > Open**.  
On the Calculator menu, click **Functions & Programs > Program Editor > Open**.
4. Select the program name from the displayed list.

The program appears in a Program Editor page.

### **Using the Hub Menu to Build Commands**

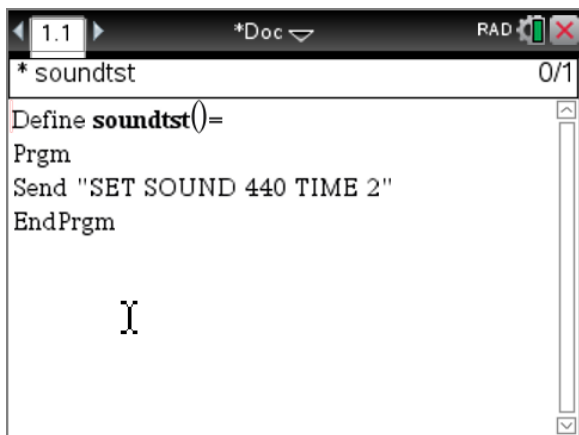
The Hub menu is available on the TI-Nspire™ CX technology anytime you are creating or editing a program. It can save you time building commands and help you with correct command spelling and syntax.

**Note:** To build a command from the Hub menu, you need to know:

- The unique name of the component that you are addressing, such as "SOUND" for the on-board speaker.
- The command parameters that apply to the component, such as sound frequency and duration. Some parameters are optional, and you might need to know the value range of a parameter.

### Example of Using the Hub Menu:

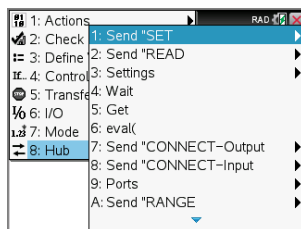
This TI-Nspire™ CX example builds the command **Send "SET SOUND 440 TIME 2"** to sound a 440Hz tone for 2 seconds on the on-board speaker.



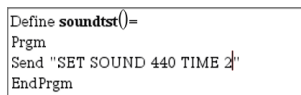
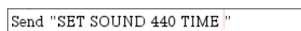
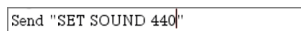
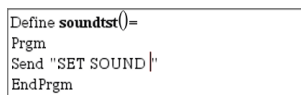
1. Open (or create) the program that you will use to communicate with the Hub.
2. Position the cursor where you want to place the command.

3. On the handheld, press **menu** and select **Hub**.  
In the Program Editor menu, select **Hub**.

The Hub menu appears.












4. Select **Send "SET**, and then select **SOUND** to insert the first part of the command.
5. Type **440** as the frequency value.
6. On the Hub menu, select **Settings > TIME**.
7. To complete the command, Type **2** as the TIME value.



8. To test the command, follow the previous instructions for running a program.

## Tips for Coding with TI-Nspire™ CX Technology

- Code from an external source might contain "curly" quotation marks ("...") in places that require straight quotes ("..."). To type straight quotes, press  .
- To clear the current line of code, press  .
- To type relational operators such as =, <, and ≤, press  .
- To type a space, press .
- If your program becomes unresponsive while running:

TI-Nspire™ CX Handheld: Hold down the  key and press  repeatedly.

Windows®: Hold down the **F12** key and press **Enter** repeatedly.







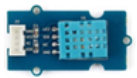
Mac®: Hold down the **F5** key and press **Enter** repeatedly.

## Learn More





To find sample programs and details about programming the TI-Innovator™ Hub, see the TI-Innovator™ Technology eGuide (page ii).

## TI-Innovator™ I/O Modules

TEST These Input/Output modules (purchased separately) include cables for connecting the modules to the TI-Innovator™ Hub.

Module	Ports	Image	Sample code for TI CE Graphing Calculator
White LED *	OUT 1 OUT 2 OUT 3		Turn on the White LED module connected to <b>OUT 1</b> : <pre>Send("CONNECT LED 1 TO OUT 1") Send("SET LED 1 ON")</pre>
Servo Motor **	OUT 3		Rotate the shaft of the Servo Motor connected to <b>OUT 3</b> counter clockwise by 90°: <pre>Send("CONNECT SERVO 1 TO OUT 3") Send("SET SERVO 1 TO -90")</pre> Equivalent code using a variable with <b>eval()</b> : <pre>angdeg:=-90 Send("CONNECT SERVO 1 TO OUT 3") Send("SET SERVO 1 TO eval(angdeg)")</pre>
Analog Light Sensor	IN 1 IN 2 IN 3		Read and display ambient light level from the sensor connected to <b>IN 2</b> : <pre>Send("CONNECT LIGHTLEVEL 1 TO IN2") Send("READ LIGHTLEVEL 1") Get(L):Disp(L)</pre>
Ultrasonic Ranger	IN 1 IN 2		Read and display measured distance from the ranger connected to <b>IN 2</b> : <pre>Send("CONNECT RANGER 1 TO IN2") Send("READ RANGER 1") Get(R):Disp(R)</pre>
Vibration Motor	OUT 1 OUT 2 OUT 3		Turn on the Vibration Motor connected to <b>OUT 1</b> : <pre>Send("CONNECT VIB.MOTOR 1 TO OUT 1") Send("SET VIB.MOTOR 1 TO ON")</pre>
Temperature Sensor	IN 1 IN 2 IN 3		Read and display the ambient temperature from the sensor connected to <b>IN 3</b> : <pre>Send("CONNECT TEMPERATURE 3 TO IN3") Send("READ TEMPERATURE 3") Get(T):Disp(T)</pre>
Temperature and Humidity Sensor	IN 1 IN 2 IN 3		Connect the <b>DHT</b> sensor to port <b>IN 2</b> <pre>Send("CONNECT DHT 1 TO IN2")</pre> Read the temperature from the <b>DHT</b> sensor connected to <b>IN 2</b> :



Module	Ports	Image	Sample code for TI CE Graphing Calculator
			<pre>Send( "READ DHT 1 TEMPERATURE") Get temperature Read the humidity from the DHT sensor: Send "READ DHT 1 HUMIDITY" Get humidity</pre>
Hall Sensor	IN 1 IN 2 IN 3		<p>Connect the Hall effect sensor to <b>IN3</b> port:</p> <pre>Send "CONNECT ANALOG.IN 1 TO IN 3"</pre> <p>Read the value of the magnetic field reported by the sensor:</p> <pre>Send "READ ANALOG.IN 1" Get m</pre>
Moisture Sensor	IN 1 IN 2 IN 3		<p>Connect moisture sensor to <b>IN 1</b>:</p> <pre>Send "CONNECT MOISTURE 1 IN 1"</pre> <p>Configure the measurement range to be between 0 and 100. The range is an index and has no units.</p> <pre>Send "RANGE MOISTURE 1 0 100"</pre> <p>Read the sensor:</p> <pre>Send "READ MOISTURE 1" Get moisture</pre>
MOSFET	OUT 1 OUT 2		<p>Connect the <b>MOSFET</b> to the <b>OUT 1</b> port:</p> <pre>Send "CONNECT ANALOG.OUT 1 TO OUT 1"</pre> <p>Control the connected motor/pump at 50% speed for 3 seconds:</p> <pre>Send "SET ANALOG.OUT 1 128 TIME 3"</pre>
Water Pump			It is controlled through a MOSFET module.

\*The White Led module requires some assembly.

\*\*The Servo Motor requires auxiliary power and some assembly.

**Note:** For details, refer to the TI-Innovator™ Technology eGuide (page ii).

## Connecting an I/O Module

You use the I/O cable included with the module to connect it to a Hub Input or Output port.

1. Check the above table to ensure that you know which I/O ports support the module that you are connecting.
2. Connect either end of the I/O cable to the white connector on the module.
3. Connect the free end of the I/O cable to the Hub port you have decided to use.
4. If the module requires auxiliary power, connect the power source (page 27),

### Sample Program to Blink an LED Module

The following TI CE graphing calculator program uses **Send** and **Wait** commands to blink an LED module connected to an I/O port.

**Note:** This program operates correctly only if the calculator is connected to the Hub and an LED module is physically connected to port **OUT 1**.

```
PRGM: BLINKIO
Send("CONNECT LED 1 TO
OUT1")
For(N,1,10)
Send("SET LED 1 ON")
Wait 1
Send("SET LED 1 OFF")
Wait 1
End
Send("DISCONNECT LED 1")
```

**Note:** If you are using TI-Nspire™ CX technology, omit the parentheses, and change **End** to **EndFor**.



The Hub command string "CONNECT LED 1 TO OUT1" tells the Hub that an LED module is connected to port **OUT 1** on the Hub. After sending this command, the code can address the LED as "LED 1." The CONNECT command is required only for I/O Modules and Breadboard components. It is not necessary with the on-board components such as the built-in speaker.

### Learn More

For a list of precautions to take while using the I/O Modules, refer to *General Precautions* (page 38).

To find sample programs, a list of additional I/O Modules, and details about programming I/O Modules, see the TI-Innovator™ Technology eGuide (page ii).







## TI-Innovator™ Breadboard Pack






The breadboard and its components (purchased separately) let you build breadboard projects and connect them to the TI-Innovator™ Hub through its Breadboard Connector pins.

The breadboard components include:

- A breadboard and jumper cables for creating electrical connections.
- Addressable components, such as LEDs and sensors, that respond to Hub commands. These are listed in the table below.
- Passive components, such as resistors, capacitors, and manual switches that are not directly addressable by the Hub but are required in many breadboard projects.
- A Battery Holder that holds four AA batteries. Batteries are not included.

### Addressable Components

Component	Image	Used with pins	Description
Red LEDs		BB 1-10	Light-emitting diode that emits light when current passes through it.
Green LEDs		BB 1-10	Light-emitting diode that emits light when current passes through it.
RGB (Red-Green-Blue) LEDs		BB 8-10	Light-emitting diode with independently adjustable red, green and blue elements. Can produce a wide variety of colors.
Thermistor		BB 5,6,7 (analog input required)	Resistor whose resistance changes based on temperature. Used for measurement and control.
7-segment Display		BB 1-10	Array of LEDs arranged to display numbers and some alphabetic characters. Also has an LED for a decimal point.
Small DC Motor		BB 1-10 (uses digital to)	Motor that converts direct current electrical power into mechanical

		generate software PWM)	power.
TTL Power MOSFET		BB 1-10	Transistor used for amplifying or switching electronic signals.
TI Analog Temperature Sensor		BB 5,6,7 (analog input required)	Sensor that reports a voltage proportional to the ambient temperature within a range of -55°C to 130°C.
Visible Light Sensor		BB 5,6,7 (analog input required)	Sensor that reports the level of ambient light.
Infrared Transmitter LTE-302, yellow dot		BB 1-10 (digital output)	Side emitting Infrared LED, designed to be paired with the LTR-301 Photo-Transistor.
Infrared Receiver LTR-301, red dot		BB 1-10 (digital input)	Side sensing Infrared photo transistor, designed to be paired with the LTE-302 Infrared Emitter.

### Sample Code to Blink a Breadboard LED

The following TI CE graphing calculator(s) program uses **Send** and **Wait** commands to blink a specific LED on the breadboard.

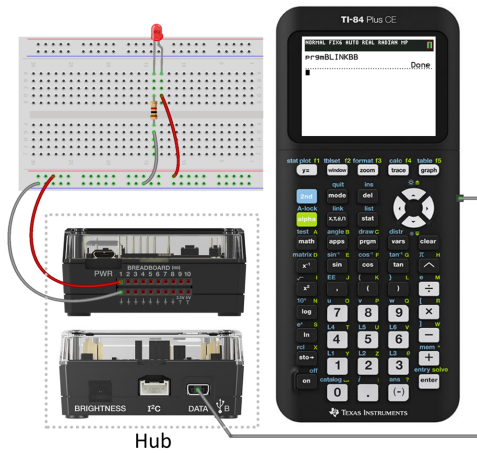
**Note:** This program operates correctly only if the calculator is connected to the Hub and the LED is physically connected to **BB1** (breadboard pin 1) on the Hub.

```

PRGM: BLINKBB
Send("CONNECT LED 1 TO BB1")
For(N,1,10)
Send("SET LED 1 ON")
Wait 1
Send("SET LED 1 OFF")
Wait 1
End
Send("DISCONNECT LED 1")

```

**Note:** If you are using TI-Nspire™ CX technology, omit the parentheses, and change **End** to **EndFor**.



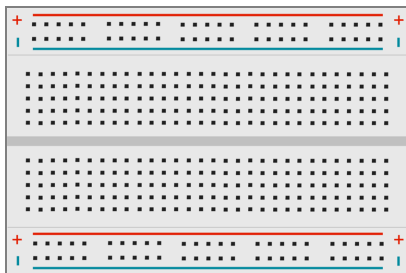
The Hub command string "CONNECT LED 1 TO BB1" tells the Hub that an LED on the breadboard is connected to pin 1 on the Hub. After sending this command, your code can address the LED as "LED 1." The CONNECT command is required only for I/O Modules and breadboard components. It does not apply to on-board components such as the built-in speaker.

### Breadboard Basics

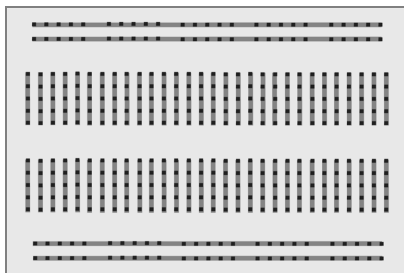
The breadboard makes it easy to connect the electronic components of a project by inserting component leads and jumper cables into pins on the breadboard.

The pins are arranged in groups of 5. The 5 pins in each group are electrically connected to each other at the back of the board. You connect leads and cables together by inserting them into pins within the same group.

- Power rails at the top and bottom are marked with red (+) and blue (–) stripes. The groups in each rail are electrically connected along the entire length of the stripe.
- The remaining 5-pin groups on the board are labeled with numbers and letters. Each group is electrically isolated from the others.



Front of board showing power rails and connection pins



Interconnections at back of board (normally hidden). The 5-pin groups in each power rail are interconnected. All other 5-pin groups are isolated.

The gap at the center of the breadboard allows easy connection of electronic components provided as dual-inline packages.

You use jumper cables between the Hub and the breadboard to power breadboard components and to control or monitor them through program code. The Hub has 20 labeled pins, including 10 signal pins, 8 ground pins, one 3.3V power pin, and one 5.0V power pin.

### Learn More

For a list of precautions to take while using the breadboard and its components, refer to *General Precautions* (page 38).

To find sample programs and details about programming breadboard components on the TI-Innovator™ Hub, see the TI-Innovator™ Technology eGuide (page ii).

## Using an Auxiliary Power Source

Normally, the TI-Innovator™ Hub and its connected components draw power from the host calculator or computer, through the **DATA** connector. Certain components, such as the optional Servo Motor, require more power than a calculator can provide reliably.

The **PWR** connector on the Hub lets you connect an auxiliary power source. You can use the TI Wall Charger or the External Battery Pack.

### TI Wall Charger (included with the Hub)

- Plugs into a wall outlet.
- Does not use batteries.



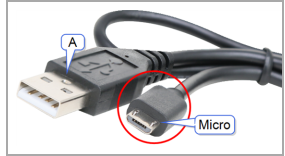
### External Battery Pack (sold separately)

- Rechargeable.
- Has On/Off button with a row of LEDs that momentarily indicate the battery charge when you turn the battery on.
- Turns itself off after being disconnected from the Hub for about 3 minutes.



**Note:** To recharge the External Battery Pack, disconnect it from the Hub and then connect it to the TI Wall Charger using the USB Standard A to Micro cable. Do not use the External Battery Pack as an auxiliary power source while it is being charged.

### Connecting the Power Source

1. Identify the Micro connector on the USB Standard A to Micro auxiliary power cable.
  2. Insert the Micro connector into the **PWR** connector at the top of the Hub.
- 
- The image shows a black USB Standard A to Micro auxiliary power cable. The USB Standard A connector is labeled 'A' and the Micro connector is labeled 'Micro'. A red circle highlights the Micro connector.
3. Insert the free end of the cable (the "A" connector) into the USB port on the power source.
  4. Turn on the power source:
    - If using the TI Wall Charger, plug it into a wall socket.
    - If using the External Battery Pack, press the power button.

An auxiliary power LED on the Hub glows to show that the Hub is receiving auxiliary power.

5. Connect the TI-Innovator™ Hub to the host calculator, using the USB Standard A to Mini-B cable.
6. Connect the I/O Module or breadboard component to the Hub.



## ***TI-Innovator™ Hub Troubleshooting***

### ***I don't see the green LED when I connect TI-Innovator™ Hub.***

- Make sure that the calculator is turned on.
- If you are using a USB Unit-to-Unit (Mini-A to Mini-B) cable to connect to a calculator, make sure to connect the "B" end of the cable to the **DATA** connector at the bottom of the Hub. Reversing this cable prevents the Hub from receiving power.
- Make sure your calculator or computer meets the System Requirements (page 1).
- Make sure the end of the USB cable connected to the calculator is inserted completely.

### ***How do I turn the Hub off?***

1. Turn off the host calculator or computer.
  - OR –
  - Disconnect the USB cable.
2. Disconnect any auxiliary power source connected to the **PWR** port on the Hub.

### ***Why does my program give me a syntax error?***

- If you have pasted code from an external source or text editor, it might contain "curly" quotation marks ("...") in places that require straight quotes ("..."). You may need to replace some or all of the curly quotes.
- The syntax rules are slightly different between the TI CE graphing calculator and TI-Nspire™ CX technology. Code originally created for one platform may need to be modified to work on the other.
- On the TI CE graphing calculator, make sure you don't have a space character at the end of a line of code. To find these trailing spaces in a line, move the cursor to the line and press **[2nd]** **[ ]**. Adjacent spaces in code can also cause a syntax error.

### ***How do I stop a program that becomes unresponsive?***

- TI CE graphing calculator: Press the **[on]** key.
- TI-Nspire™ CX Handheld: Hold down the **[on]** key and press **[enter]** repeatedly.
- Windows®: Hold down the **F12** key and press **Enter** repeatedly.
- Mac®: Hold down the **F5** key and press **Enter** repeatedly.

### ***Why do I get an error when I try to update the TI-Innovator™ Sketch?***

- For sketch updating, make sure you are using the USB Standard A to Micro cable, not the USB Standard A to Mini-B cable. Connect the micro end of the cable to the **PWR** connector at the top of the Hub.
- Make sure you are using one of the Web browsers required for updating. See Updating the Hub Software (page 5).

***Learn More***

To find more troubleshooting information, see the TI-Innovator™ Technology eGuide (page ii).

# TI-RGB Array

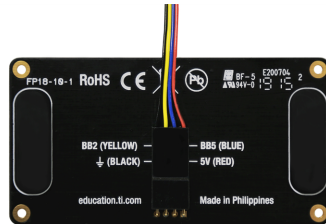
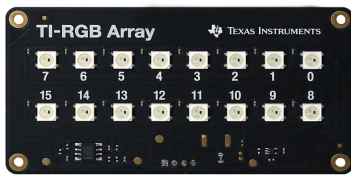
## What is TI-RGB Array?

TI-RGB Array is an accessory to TI-Innovator™ Hub.

TI-RGB Array has 16 programmable RGB LEDs.

Multiple applications

- Smart greenhouse
- Binary counter
- STEAM projects
- Coding lessons



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## TI-RGB Array – Industrial design and markings

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Top view of TI-RGB Array.



Bottom view - identifying label.



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## Requirements for TI-RGB Array:

### Hardware:

Add-on TI-RGB Array to TI-Innovator™ Hub

Use Hub Sketch v1.4 or later

---

# Connecting the TI-RGB Array

Follow these set of steps in this order to connect and use the TI-RGB Array.

## Connect the TI-RGB Array to the TI-Innovator™ Hub

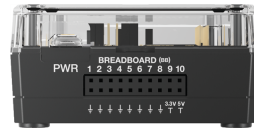
TI-RGB Array



Provided Cable



TI-Innovator™ Hub



### STEPS

1. Connect one end of the provided cable to the TI-RGB Array port labeled:



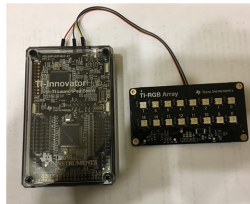
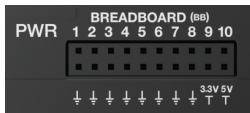
2. Connect the corresponding wires to the usable pins on the Hub labeled:

Red: 5V - power

Blue : BB5 - analog out

Yellow: BB2 - SPI signal

Black: GND - ground



---

## Connect the TI-Innovator™ Hub to a Graphing Calculator

The TI-Innovator™ Hub connects by a USB cable to a graphing calculator or computer. The connection lets the Hub receive power and exchange data with the host.

See complete details (page 33).

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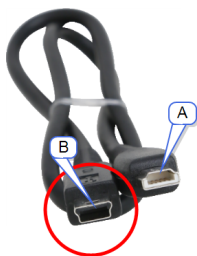
## Connecting TI-Innovator™ Hub

The TI-Innovator™ Hub connects by a USB cable to a graphing calculator or computer. The connection lets the Hub receive power and exchange data with the host.

**Note:** Some peripherals, such as motors, may require auxiliary power. For more information, see Using an Auxiliary Power Source (page 27).

### Connecting to a Graphing Calculator

1. Identify the "B" connector on the USB Unit-to-Unit (Mini-A to Mini-B) cable. Each end of this cable is embossed with a letter.
2. Insert the "B" connector into the **DATA** port at the bottom of the TI-Innovator™ Hub.
3. Insert the free end of the cable (the "A" connector) into the USB port on the calculator.



*Hub connected to  
TI CE Graphing Calculator*

*Hub connected to  
TI-Nspire™ CX Handheld*

4. Turn on the calculator if it is not already on.

The power LED on the Hub glows green to show that it is receiving power.

## Connecting to a Computer Running TI-Nspire™ CX Software

1. Identify the "B" connector on the USB Standard A to Mini-B cable for Windows®/Mac®. Each end of this cable is embossed with a letter.
2. Insert the "B" connector into the **DATA** port at the bottom of the TI-Innovator™ Hub.
3. Insert the free end of the cable (the "A" connector) into a USB port on the computer.



The power LED on the Hub glows green to show that it is receiving power.



---

## TI-RGB Array Commands

### ***Prerequisite: Use the Send "Connect RGB" Command First***

The "CONNECT RGB" command needs to be used first when using the TI-RGB Array. The "CONNECT RGB" command configures the TI-Innovator™ Hub software to work with the TI-RGB Array.

It establishes the connections to the various led binary slots on the TI-RGB Array – 0 through 15 RGB LED. It also clears the various counters and sensor values.

For additional commands see: [education.ti.com/eguide](http://education.ti.com/eguide)

### **CONNECT RGB**

<b>Command:</b>	<b>CONNECT RGB</b>
Command Syntax:	<b>CONNECT RGB</b>
<b>Code Sample:</b>	Send "CONNECT RGB"
Range:	N/A

<b>Command:</b>	<b>CONNECT RGB</b>
Describe:	The "CONNECT RGB" command configures the TI-Innovator™ Hub software to work with the TI-RGB Array.
Result:	Connects the TI-RGB Array to the TI-Innovator™ Hub. The TI-RGB Array is now ready to be programmed
Type or Addressable Component:	All components of the TI-RGB Array. <b>See Also:</b> Commands to use with TI-RGB Array

<b>Command:</b>	<b>CONNECT RGB AS LAMP</b>
Command Syntax:	<b>CONNECT RGB AS LAMP</b>
<b>Code Sample:</b>	Send "CONNECT RGB AS LAMP"
Range:	N/A
Describe:	This command will enable the "high brightness" mode of the TI-RGB Array as long as an external power source (like the USB battery) is connected to the <b>PWR</b> port. <b>Note:</b> "AS LAMP" will need to be typed in.
Result:	The TI-RGB Array is now configured to be in high-brightness mode. If the external power is not connected, the "AS LAMP" has no effect – i.e. the brightness will be at the default level. Also note, an error will be indicated by a beep tone.
Type or Addressable Component:	All components of the TI-RGB Array. <b>See Also:</b> Commands to use with TI-RGB Array

## SET RGB

<b>Command:</b>	<b>SET RGB n r g b</b>
Command Syntax:	<b>SET RGB n r g b</b> <b>SET RGB eval(n) r g b</b>
<b>Code Sample:</b>	Send "SET RGB 1 255 0 255"
Range:	0-15 for 'n', 0-255 for r,g,b

<b>Command:</b>	<b>SET RGB n r g b</b>
Describe:	The SET RGB command controls the brightness and color of each RGB LED in the TI-RGB Array
Result:	The specific LED lights up with the specified color
Type or Addressable Component:	All components of the TI-RGB Array <b>See Also:</b> Commands to use with TI-RGB Array <b>See Also:</b> SET RGB ALL

### SET RGB [n1 n2 n3...] r g b

<b>Command:</b>	<b>SET RGB [n1 n2 n3...] r g b</b>
Command Syntax:	<b>SET RGB [n1 n2 n3...] r g b</b>
Range:	A max of 16 LEDs can be specified.
<b>Code Sample:</b>	<pre>SET RGB [1 3 5 7] 200 0 200</pre> <p>Sets LEDs #1, 3, 5 &amp; 7 to purple (red + blue).</p> <p><b>Note:</b> If using eval() with a variable for the LED number, make sure there's a preceding space before the 'eval()'.</p> <pre>SET RGB [ eval(i) eval(i+1) ] 255 0 255</pre>
Describe:	Set the LEDs specified by their numbers to the specified color.
Result:	
Type or Addressable Component:	All components of the TI-RGB Array.

### SET RGB PATTERN nnnn r g b

<b>Command:</b>	<b>SET RGB PATTERN nnnn r g b</b>
Command Syntax:	<b>SET RGB PATTERN nnnn r g b</b> nnnn – can be a decimal or a hexadecimal number.
Range:	nnnn – 0 to 65535
<b>Code Sample:</b>	<pre>SET RGB PATTERN 100 255 0 255</pre> <p>Display the number 100 in binary form on the RGB array and set the color of the LEDs to purple.</p> <pre>SET RGB PATTERN 0X100 255 0 0</pre>



<b>Command:</b>	<b>SET RGB PATTERN nnnn r g b</b>
	Display the hexadecimal number 100 (equal to 256 in decimal) in binary form on the RGB array and set the color of the LEDs to red.
Describe:	Display the pattern indicated by the number using the specified color.
Result:	
Type or Addressable Component:	All components of the TI-RGB Array.

## SET RGB ALL

<b>Command:</b>	<b>SET RGB ALL r g b</b>
Command Syntax:	<b>SET RGB ALL r g b</b>
<b>Code Sample:</b>	SET RGB ALL 255 0 255
	SET RGB ALL 255 0 0
	SET RGB ALL eval(R) eval(G) eval(B)
	SET RGB ALL 0 0 0
Range:	
Describe:	To control all the LEDs in a single command use: SET RGB ALL r g b
Result:	Control all LEDs in a single command
Type or Addressable Component:	All components of the TI-RGB Array

## READ RGB

<b>Command:</b>	<b>READ RGB</b>
Command Syntax:	<b>Send "READ RGB"</b>
<b>Code Sample:</b>	Send "READ RGB" Get c

<b>Command:</b>	<b>READ RGB</b>
Range:	
Describe:	Returns the value of the current consumed by the TI-RGB Array in mA
Result:	
Type or Addressable Component:	All components of the TI-RGB Array <b>See Also:</b> New Commands to use with TI-RGB Array

## General Precautions

### *TI-RGB Array*

- Do not expose the TI-RGB Array to temperatures above 140°F (60°C).
- Use only the Ribbon cable provided with the TI-RGB Array.
- When inserting the Ribbon cable into the TI-RGB Array connectors, make sure the red (dark) wire pin is inserted into the 5v hole.
- Use the TI-RGB Array no closer than 8 inches to your eyes.
- Rest your eyes periodically by focusing on an object at least 5 feet away.

### *General Precautions for the TI-Innovator™ Hub*

#### **TI-Innovator™ Hub**

- Do not expose the Hub to temperatures above 140°F (60°C).
- Do not disassemble or mistreat the Hub.
- Do not chain together multiple Hubs through the I/O ports or the Breadboard Connector.
- Use only the USB cables provided with the Hub.
- Use only the TI provided power supplies:
  - TI Wall Charger included with the TI-Innovator™ Hub
  - Optional External Battery Pack
  - 4AA battery holder included in the TI-Innovator™ Breadboard Pack
- Ensure that the components receiving power from the Hub do not exceed the Hub's 1-amp power limit.
- Avoid using the Hub to control AC electricity.

## Breadboard Connector on the Hub

- Do not insert the leads of LEDs and other components directly into the Hub's Breadboard Connector. Assemble the components on the breadboard and use the provided jumper cables to connect the breadboard to the Hub.
- Do not connect the 5V receptacle pin on the Hub's Breadboard Connector to any of the other pins, especially the ground pins. Doing so could damage the Hub.
- Connecting the top row of receptacle pins (BB1-10) to the bottom row (grounding and power pins) is not recommended.
- No pin on the Hub's Breadboard Connector can sink or source greater than 4 mA.

## Breadboard

- Do not connect the positive and negative leads of a power source to the same group of 5 pins on the breadboard. Doing so could damage the breadboard and the power source.
- Observe the correct polarity:
  - When connecting the breadboard to the Hub.
  - When connecting components that are sensitive to polarity, such as LEDs and the TTL Power MOSFET.

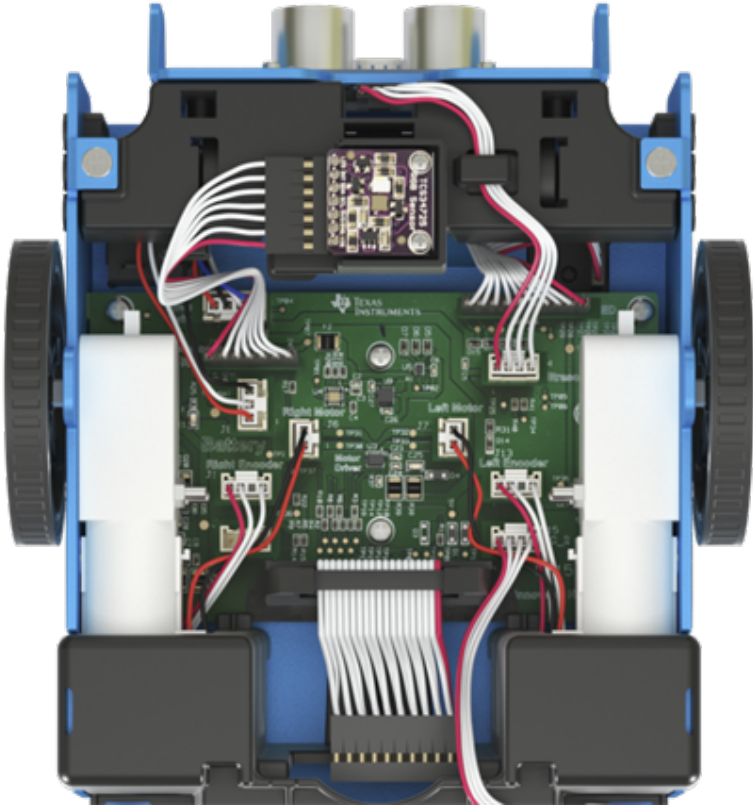
## I/O Modules

- Use the correct Input or Output port as required for each module.
  - Vibration Motor – supported on **OUT 1**, **OUT 2**, and **OUT 3**.
  - Servo Motor – use **OUT 3** only.
  - White LED – supported on **OUT 1**, **OUT 2**, and **OUT 3**.
  - Analog Light Sensor – supported on **IN 1**, **IN 2**, and **IN 3**.
  - Ultrasonic Ranger – supported on **IN 1**, **IN 2**.
- Use an Auxiliary Power Source for modules that require more than 50 mA, including:
  - Vibration Motor
  - Servo Motor
- Do not hold the Servo Motor's shaft while it is rotating. Also, do not rotate the Servo Motor by hand.
- White LED:
  - Do not bend the leads repeatedly; this will weaken the wires and may cause them to break.
  - The LED requires the correct polarity when inserted into its socket. For details, refer to the instructions for assembling the LED in the TI-Innovator™ Technology eGuide (page ii).
  - The LED requires the correct polarity when inserted into its socket. For details, refer to the instructions for assembling the LED (here).
- No I/O module can sink or source greater than 4 mA.

## **TI-Innovator™ Rover**

- Do not expose the Rover to temperatures above 140°F (60°C).
- Do not disassemble or mistreat the Rover.
- Do not put anything heavier than 1 Kg or 2.2 lbs on the Rover platform.
- Use only the USB cables provided with the TI-Innovator™ Hub.
- Use only the Ribbon cables provided with the Rover.
- Use only the TI provided wall charger included with the Hub.
- The front-mounted Ultrasonic Ranger will detect objects within 4 meters of the Rover. For best results make sure the object's surface is bigger than a folder. If used to detect small objects, such as a cup, place the Rover within 1 meter of the object.
- For best results, leave the Slide Case off of your graphing calculator.
- For best performance, use Rover on the floor, not on tables. Damage may occur from Rover falling off a table.
- For best performance, use Rover on a hard surface. Carpet may cause the Rover wheels to catch or drag.
- Do not turn the Holder pegs on the Calculator Platform without lifting them first. They could break.
- Do not use the marker as a lever to pull or push the Rover.
- Do not unscrew the case enclosure on the bottom of the Rover. Encoders have sharp edges that should not be exposed.
- Do not move Rover after executing a program. The internal gyroscope may unintentionally try to get the Rover back on track using the initial location.
- When inserting the Breadboard Ribbon Cable into the Hub Breadboard Connector, it is critical that you insert the cable correctly. Make sure the red (dark) wire pin is inserted into the 5v hole on the Hub's Breadboard Connector.

**Caution:** If you dislodge or disconnect any of the cables, use this image as a reference for correct hookups. Reference to Bottom View



# General Information

## ***Online Help***

[education.ti.com/eguide](http://education.ti.com/eguide)

Select your country for more product information.

## ***Contact TI Support***

[education.ti.com/ti-cares](http://education.ti.com/ti-cares)

Select your country for technical and other support resources.

## ***Service and Warranty***

[education.ti.com/warranty](http://education.ti.com/warranty)

Select your country for information about the length and terms of the warranty or about product service.

Limited Warranty. This warranty does not affect your statutory rights.