IO

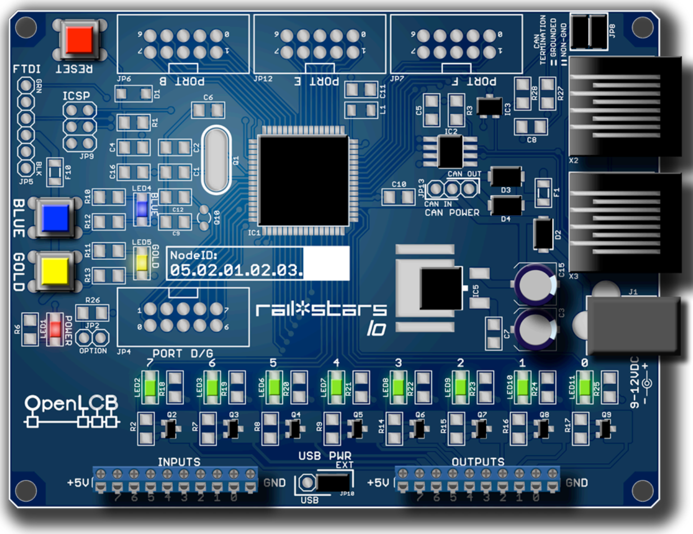
User's Manual

Table of Contents

Getting Started

Congratulations on your purchase of Railstars *Io*! You're layout will soon sit on the cutting edge of model railroading technology.

Io (named for the Jovian moon, and pronounced "EYE-oh") is easy to install on new layouts, and easy to integrate into existing layouts. This guide will help you to connect *Io*, and to understand the underlying technology so you can get the most out of your purchase.



In Chapter 1, we introduce the basic concepts of OpenLCB and the Producer-Consumer model, to help you understand how *Io* works.

In Chapter 2, we show you how to connect *Io* to you layout.

In Chapter 3, we show you how to configure your *Io* boards to control your layout.

Check the Railstars website to find updated or additional documents explaining how to connect Io to a range of layout accessories you may already have installed, such as occupancy detectors and turnout controllers.

http://railstars.com

1 / What is OpenLCB?

OpenLCB is a new networking technology for bringing all of your layout control elements together. What makes OpenLCB great is that it is open, fast, and future-proof.

Open means that anyone can look at, implement, or help to improve the standard without barriers of any kind, so that hardware from different manufacturers will work together seamlessly.

Fast means that OpenLCB can keep up with whatever is going on on your layout without bogging down under heavy loads.

Future-proof means that OpenLCB is not tied to any particular technology, and can easily expand and adapt to encompass whatever new technologies may come without leaving older technologies behind. It also means that OpenLCB isn't tied to any current technology: You don't have to be running DCC to take advantage of OpenLCB.

Working with OpenLCB requires understanding few basic concepts that guide how it works, namely: *Events*, and the *Producer-Consumer* model.

Events

Events are the fundamental building blocks of an OpenLCB network. An *Event* (with a capital ‘E’) is an electronic representation of something interesting occurring on your layout. A button-press on a fascia panel, a turnout changing position, a train entering a new block: All of these occurrences can be represented by Events on an OpenLCB network.

Importantly, Events are not only generated when something interesting happens, but also when that interesting happening ends. For example, a fascia-panel node will generate Events for button presses, and also for button releases.

Each Event has a unique identifier, called the *EventID*. An EventID permits nodes to distinguish between different Events, and hence between different occurrences on the layout.

Crucially, OpenLCB Events do not have a pre-assigned meaning. That is, there is no intrinsic difference between, *e.g.*, a button-press Event and a block-occupancy Event. This is what makes OpenLCB so powerful: *You* get to decide what each Event means, and how it is to be used by the various layout control elements on your layout.

Which brings us to the next key concept: How Events are made and used.

The Producer-Consumer Model

There are two basic kinds of OpenLCB nodes: Sensors that watch for specific occurrences on your layout, called *Producers*, and nodes that take some kind of action on your layout, called *Consumers*. Many OpenLCB nodes, such as Railstars *Io,* will combine the functions of both Producer and Consumer in one node.

The Producer-Consumer Model is a way of structuring a network. On this model, when a Producer detects an interesting occurrence, it *produces* an Event unique to that producer. Rather than being delivered to a specific other node on the network, the produced Event is broadcast to *every* node on the network, allowing each node to decide whether to act on that Event or not. A node that acts on received Events is called a *consumer.*

This is the second element that makes OpenLCB so powerful: Every Event is broadcast to every node on the network. Thus, every consumer is free to act on any Event, which allows a great deal of flexibility in how Events can be interpreted and used.

On this model, we can talk about Producers and Consumers being connected by Events. By assigning the same EventID to a Producer and a Consumer, the Consumer will respond to the Events produced by that Producer, connecting the two. Typically, each Producer and each Consumer can be assigned exactly one EventID.

To give an example, let us suppose that a train enters a new block. A block-occupancy node detects the train, and produces an Event in response. A node powering a fascia panel might interpret that Event as a command to light an occupancy indicator on the panel. A signal tower node might interpret that Event as a command to set a restrictive aspect on a signal mast. A turnout controller node might interpret that Event as a command to move a set of points. And so on. There is no end to how you can configure your layout to produce and consume events.

Railstars Io

Io combines a producer node with a consumer node. The 8 inputs are connected to 16 Producers: One Producer to produce an Event when the input goes high, and one Producer to produce an Event when the input goes low. The 8 outputs are connected to 16 Consumers: One Consumer turns the output on, and one Consumer turns the output off. By default, *Io*'s Producers are connected to its own Consumers, such that grounding input *n* low turns output *n* on, and disconnecting input *n* turns output *n* off.

Basic Terminology

Node: An individual device connected to an OpenLCB network.

NodeID: The unique identifier assigned to each OpenLCB Node.

Producer: A sensor in a Node that watches for an interesting occurrence, and generates an Event in response to that occurrence.

Consumer: An actor in a node that responds to a particular Event by generating an action or behavior.

Event: A representation of some occurrence on the layout.

EventID: The unique identifier assigned to each Event, to distinguish between different kinds of layout occurrences.

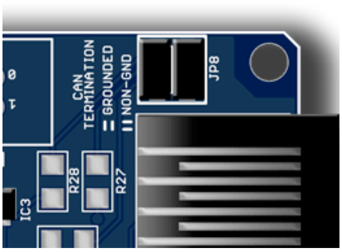
2 / Connecting Io

Io is ready to use, out of the box. Only a few connections need to be made to install *Io* on your layout.

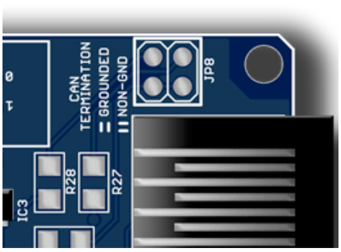
Connecting to the OpenLCB Bus

Connecting *Io* to your OpenLCB network is simple. Use a CAT5 cable to connect *Io* to another node in your network.

OpenLCB networks must be arranged as a linear string of nodes, and the two nodes at the end of the network (and only those two nodes) must be terminated. To terminate a node, set the termination jumpers on *Io*. To remove termination from a node, remove the termination jumpers.



Terminated



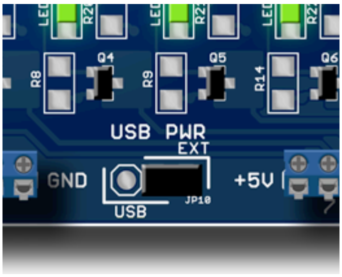
Unterminated

Connecting Power

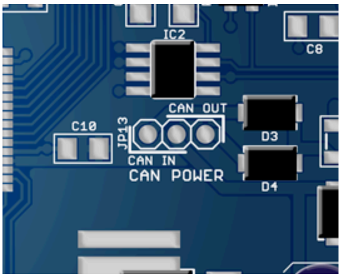
Railstars *Io* can be powered in one of two ways: From an external power supply, or via the OpenLCB bus.

Powering with an external supply

You may power Railstars *Io* using an external power supply that provides a 2.1mm center-positive plug, and between 9 and 12V DC at 500mA or more of current.



USB PWR Jumper

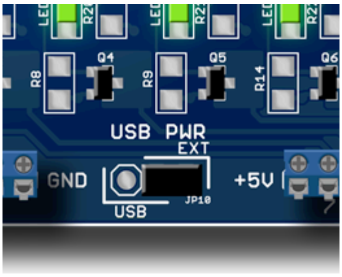


CAN POWER Jumper

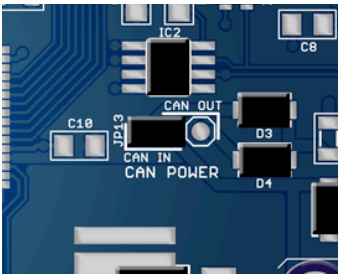
To use an external supply, ensure that the "USB PWR" jumper is set to "EXT", and that the "CAN POWER" jumper is removed.

Powering via the OpenLCB bus

The OpenLCB bus can provide a small amount of power (about 300mA) to individual boards.



USB PWR Jumper



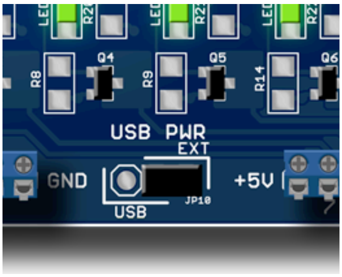
CAN POWER Jumper

To configure Railstars *Io* to draw power from the OpenLCB bus, set the "USB PWR" jumper to "EXT", and then set the "CAN POWER" jumper to "CAN IN".

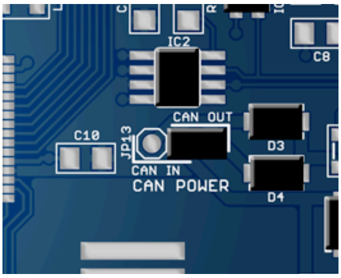
Note: Drawing power from the OpenLCB bus requires that at least one other node be configured to provide power to the OpenLCB bus.

Providing power to the OpenLCB bus

A Railstars *Io* node that is configured to use an external power supply can optionally be configured to provide some of that power to the OpenLCB bus. In this case, a power adapter capable of providing 750mA–1,000mA is suggested.



USB PWR Jumper



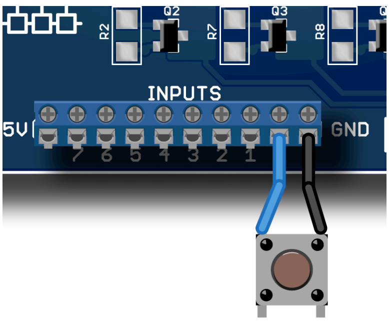
CAN POWER Jumper

Configure the board to use an external power source (above), and then set the “CAN POWER” jumper to “CAN OUT”.

Note: If you intend that your Railstars *Io* neither draw power from nor provide power to the OpenLCB bus, please remove the “CAN POWER” jumper entirely.

Io Inputs

Io's inputs are designed to be connected to what are called "open collector" outputs. Put simply, devices attached to the inputs should be designed to short to ground when active, and remain disconnected otherwise. This makes wiring momentary push-buttons and other switches, as well as logic devices, very easy. The figure below shows how to wire a momentary push-button to an *Io* input.

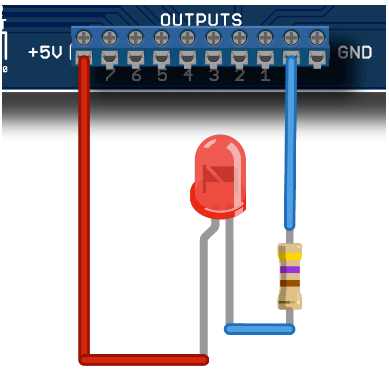


Momentary push-button on Input 0

Simply wire one leg of the push-button or switch to GND, and the other leg to one of the 8 inputs.

Io Outputs

Io's outputs are likewise open-collector. Put simply, when an output is active, *Io* shorts the output to ground. This behavior is identical to standard DCC decoders, so outputs on Io are wired in just the same way as DCC decoder function outputs. When inactive, *Io* leaves the output disconnected. This makes it very easy to connect a wide variety of devices, including indicator lamps and logic devices, to the Io outputs, because you get to decide how to power the outputs. The figure below shows how to wire an LED with current-limiting resistor to an *Io* output.



LED on Output 0

Simply wire the anode (long leg) of the LED to a power source, such as the +5V supply *Io* provides, and the cathode to one of the 8 outputs via a suitable (~150Ω) current-limiting resistor.

Connecting to Other Devices

Check the Railstars website for additional documents and videos demonstrating how to wire *Io* to a range of layout control devices you may already have installed on your layout.

http://railstars.com/hardware/io/io/

3 / Configuring Io Using the Blue/Gold Interface

Io uses the Producer-Consumer Model to communicate events both internally, and across the OpenLCB network. (See Chapter 1 for details on the Producer-Consumer model.) Each input has two associated producers, one to generate events for “input on”, and one to generate events for “input off”. Each output has two associated consumers, one to turn the output “on” and one to turn the output “off”.

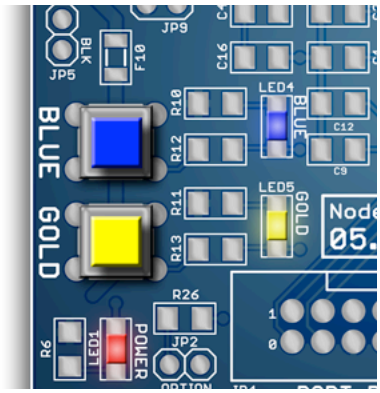
To do anything interesting, you must create associations between producers and consumers; this process of creating associations is called “configuration”, and is accomplished by a process of teaching and learning specific events.

Out of the box, *Io* both produces and consumes the same set of events, so that grounding Input 1 on any Io board will cause output 1 on all connected and unconfigured *Io* boards—including itself—to turn on.

It is easy to configure *Io* to produce more complex producer-consumer associations. There are two ways to configure *Io*: Using the on-board Blue/

Gold interface (covered in this chapter), or with a Mac or PC via a USB connection (covered in a separate manual).

The Blue/Gold Interface



Blue/Gold Interface

The Blue/Gold interface is a simple way to configure the behavior of *Io*. The interface consists of two buttons, called Blue and Gold, and two corresponding LEDs. The buttons are used to navigate the configuration options, and the LEDs are used to indicate the state of configuration.

Teaching and Learning

The basic concept behind configuring any OpenLCB is *teaching*. The process of teaching selects an event associated with one producer or consumer, and assigns it to another producer or consumer. The first consumer or producer must be set up to “teach”, and the second producer or consumer must be set up to “learn”. In this way, you can create associations between a producer and a consumer, or mirror a producer to another producer, or a consumer to another consumer.

Configuration is thus a two-step process. First, select the consumer or producer to learn. Second, select the consumer or producer to teach. And that's it!

First Time Setup, and Hard Reset

Before you begin teaching or learning with *Io*, you will probably want to perform a Hard Reset. A Hard Reset completely disconnects all producers and consumers on *Io* from all other nodes on the OpenLCB network. A Hard Reset is like a fresh start, where you can begin anew.

To perform a Hard Reset, press and hold both the Blue and the Gold buttons simultaneously for about 10 seconds; the Blue and Gold LEDs will begin to blink, warning you that you are about to perform a Hard Reset. Continue holding both buttons until the flashing stops. The Hard Reset is complete.

You can always return to a fresh state by using a Hard Reset. If you are having problems configuring your *Io*, you can use a Hard Reset to start over from scratch.

Setting up Learning

The first step in configuring a new behavior is to select the producer or consumer that will be learning. We begin by pressing the Blue button once. This tells Io to enter Learn Mode. The Blue LED begins to blink, to indicate that Learn Mode has been entered.

The next step depends on whether you want to configure an input or an output for learning.

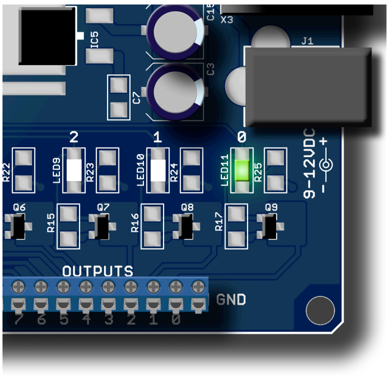
You can cancel Learn Mode at any time by pressing both Blue and Gold simultaneously. Both the Blue and Gold LEDs will extinguish to indicate that you have left Learn Mode.

You can use the flow chart at the end of this chapter to help in following the textual descriptions below.

Configuring an Output for Learning

Each output has two states: On and off. There are therefore 16 consumers, one for each possible output state. Call these states “Output 0: On”, “Output 0: Off”, and so on.

Press the Blue button to select “Output 0: On”. You will observe that the LED for Output 0 comes on (and any device attached to the output is triggered). Press the Blue button a second time to select “Output 0: Off”. The LED for Output 0 now flashes to indicate the selection. Press the Blue button a third time to move to “Output 1: On”, and a fourth time to move to “Output 1: Off”. Pressing Blue will cycle through all of the outputs/output state combinations in this way. Notice that once you have cycled through all of the output states, continuing to press Blue will then cycle through all of the possible input states as well (see the next section for configuring an input for learning).



Output 0 Selected

When you have reached the output number and state that you wish to configure for learning, press the Gold Button. The Gold LED will blink, then both Blue and Gold will go out, indicating that the selected output has been configured for learning. You are now ready to set up teaching.

Configuring an Input for Learning

Each input has two states: On and off. There are therefore 16 producers, one for each possible input state. Call these states “Input 0: On”, “Input 0: Off”, and so on.

The easiest way to configure an input is to use an input device connected to the input directly, such as a push-button or toggle switch. Press the attached push-button or toggle the toggle switch to select that input as “on”. Notice that the Blue LED lights solid, and that the Gold LED begins to flash. To select that input as “off”, press the button or toggle the switch a second time. The Blue LED begins to flash to indicate the input has been selected as “off”. To cancel the selection, press the button or toggle the switch a third time; the Gold LED will go out, and the Blue LED will return to slowly blinking.

Alternately, you can use the Blue button to select an input for learning if there is no physical device attached to the input. Press the Blue 16 times to cycle through all 16 of the possible output states. Pressing Blue a 17th time will begin to cycle through the input states. The Gold LED will begin to flash to indicate that you are cycling through the input states; the output LEDs will light to help you identify the correct input. When the LED on Output 0 in on, you have selected “Input 0: On”; when the LED on Output 0 is flashing, you have selected “Input 0: Off”, and so forth. Continue to press Blue until the desired input state is selected.

Once you have cycled through all the possible input states, pressing Blue the 33rd time will return

Io to it's normal state, canceling the learn operation.

When you have selected the input and input state that you wish to configure for learning, press the Gold Button. The Gold LED will blink once, and then both Blue and Gold will go out, indicating that the selected input has been configured for learning. You are now ready to set up teaching.

Setting up Teaching

The second step in configuring a new behavior is to select the producer or consumer that will be teaching. We begin by pressing the Gold button once. This tells Io to enter Teach Mode. The Gold LED begins to blink slowly, to indicate that Teach Mode has been entered.

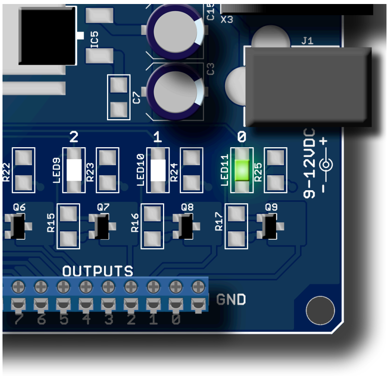
You can cancel Teach Mode at any time by pressing both Blue and Gold simultaneously. Both the Blue and Gold LEDs will extinguish to indicate that you have left Teach Mode.

Once you have entered Teach Mode, Outputs and Inputs are selected just as with Learn Mode.

Configuring an Output for Teaching

Each output has two states: On and off. There are therefore 16 consumers, one for each possible output state. Call these states "Output 0: On", "Output 0: Off", and so on.

Press the Blue button to select "Output 0: On". You will observe that the LED for Output 0 comes on (and any device attached to the output is triggered). Press the Blue button a second time to select "Output 0: Off". The LED for Output 0 now flashes to indicate the selection. Press the Blue button a third time to move to "Output 1: On", and a fourth time to move to "Output 1: Off". Pressing Blue will cycle through all of the outputs/output state combinations in this way. Notice that once you have cycled through all of the output states, continuing to press Blue will then cycle through all of the possible input states as well (see the next section for configuring an input for learning).



Output 0 Selected

When you have reached the output and output state that you wish to configure for teaching, press the Gold Button. Both LEDs will go out, indicating that the selected output has been configured for teaching. The association has been created, and you are done!

Configuring an Input for Teaching

Each input has two states: On and off. There are therefore 16 producers, one for each possible input state.

The easiest way to configure an input is to use an input device connected to the input directly, such as a push-button or toggle switch. Press the attached push-button or toggle the toggle switch to select that input as “on”. Notice that the Blue LED lights solid. To select that input as “off”, press the button or toggle the switch a second time. The Blue LED begins to flash to indicate the input has been selected as “off”. To cancel the selection, press the button or toggle the switch a third time; the Blue LED will go out, and the Blue LED will return to slowly blinking.

Alternately, you can use the Blue button to select an input for learning if there is no physical device attached to the input. Press the Blue 16 times to cycle through all 16 of the possible output states. Pressing Blue a 17th time will begin to cycle through the input states. The Gold LED will begin to flash to indicate that you are cycling through the input states; the output LEDs will light to help you identify the correct input. When the LED on Output 0 in on, you have selected “Input 0: On”; when the LED on Output 0 is flashing, you have selected “Input 0: Off”, and so forth. Continue to press Blue until the desired input state is selected.

Once you have cycled through all the possible input states, pressing Blue the 33rd time will return *Io* to it's normal state, canceling the learn operation.

When you have selected the input and input state that you wish to configure for teaching, press the Gold Button. Both LEDs will go out, indicating that the selected input has been configured for teaching. The association has been created, and you are done!

Example: Associating a Button with an LED

Scenario: You have two *Io* boards, "Io-1" and "Io-2". You wish to associate a switch on "Io-1" Input 2 with an LED on "Io-2" Output 5 such that flipping the switch up illuminates the LED, and flipping the switch down extinguishes the LED.

Step 1: Set up Learning for LED On. On "Io-2", press the Blue button to enter Learn Mode. Now, press Blue 11 times to select Output 5: On. Press Gold to mark Output 5: On for learning.

Step 2: Set up Teaching for Switch Up. On "Io-1", press the Gold button to enter Teach Mode. Now, Move the switch up (if down; if already up, move the switch down, then up) to select that switch. Press the Gold button to teach the association.

Step 3: Set up Learning for LED off. On “Io-2”, press the Blue button to enter Learn Mode. Now press Blue 12 times to select Output 5: Off. Press Gold to mark Output 5: Off for learning.

Step 4: Set up Teaching for Switch Up.} On “Io-1”, press the Gold button to enter Teach Mode. Now, Move the switch up (if down; if already up, move the switch down, then up) to select that switch, and toggle it a second time to select the “off” state. Press the Gold button to teach the association.

Now, test the association. Move the switch up and down, and observe the behavior of the LED. If the LED does not respond as expected, you have probably executed one of the above steps incorrectly, and it so you might simply try the process again. You should not have to perform a Hard Reset, unless things get very out of hand.

Example: Duplicating a Fascia Panel Button

Scenario: You have two Io boards, “Io-1” and “Io-2”. “Io-1” is already set up to control a fascia panel, and you would like “Io-2” to control an identical fascia panel on the other side of the layout. We begin by mirroring the behavior on the push-button attached to Input 0 on both boards; the process is identical for each of the remaining inputs and outputs between the boards.

Step 1: Set up Learning for Button Down. On “Io-2”, press the Blue button to enter Learn Mode. Now, press the push-button once to select it as “down”. Press the Gold button to mark that button for learning.

Step 2: Set up Teaching for Button Down. On “Io-1”, press the Gold button to enter Teach Mode. Now, press the push-button once to select it as “down”. Press the Gold button to teach the association.

Step 3: Set up Learning for Button Up. On “Io-2”, press the Blue button to enter Learn Mode. Now, press the push-button twice to select it as “up”. Press the Gold button to mark that button for learning.

Step 4: Set up Teaching for Button Down. On “Io-1”, press the Gold button to enter Teach Mode. Now, press the push-button twice to select it as “up”. Press the Gold button to teach the association.

Now, test the association. The push-button on “Io-2” should now trigger exactly the same behaviors as the push-button on “Io-1”. If the layout does not respond as expected, you have probably executed one of the above steps incorrectly, and it so you might simply try the process again. You should not have to perform a Hard Reset, unless things get very out of hand.

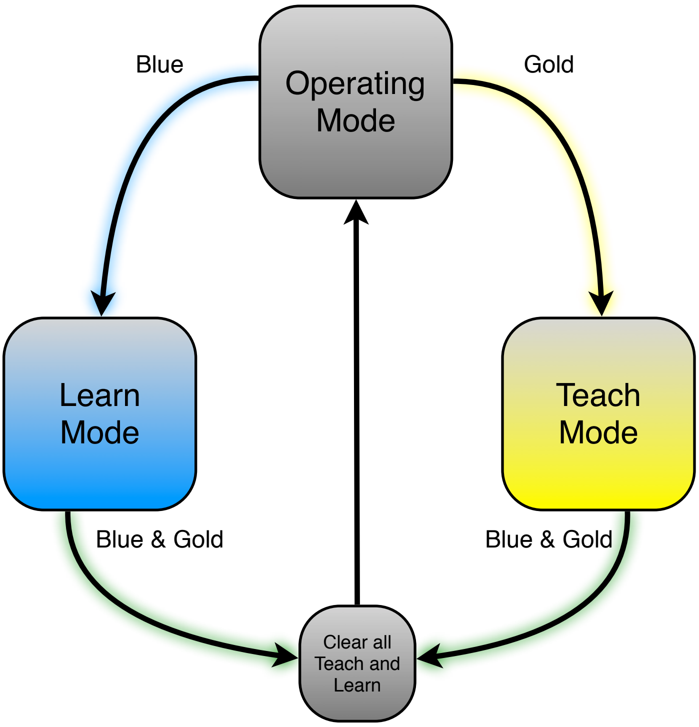
4 / Blue/Gold Flow Chart

Io has three modes: *Operating Mode*, which is when *Io* is operating normally; *Learn Mode*, which is when *Io* is being configured to learn an event; and *Teach Mode*, which is when *Io* is being configured to teach an event.

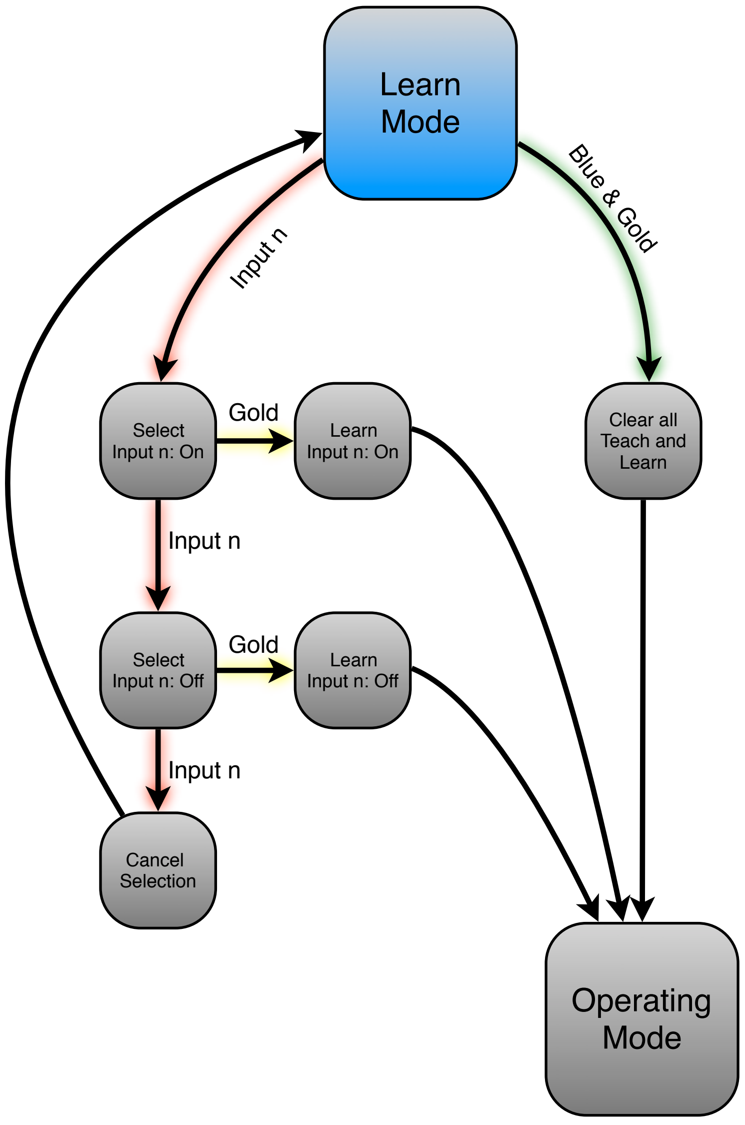
Learn Mode is reached by pressing the Blue button. *Teach Mode* is reached by pressing the Gold button.

While in *Learn Mode* or *Teach Mode*, pressing Blue and Gold simultaneously will cancel all pending Learn and Teach commands, and return *Io* to *Operating Mode*.

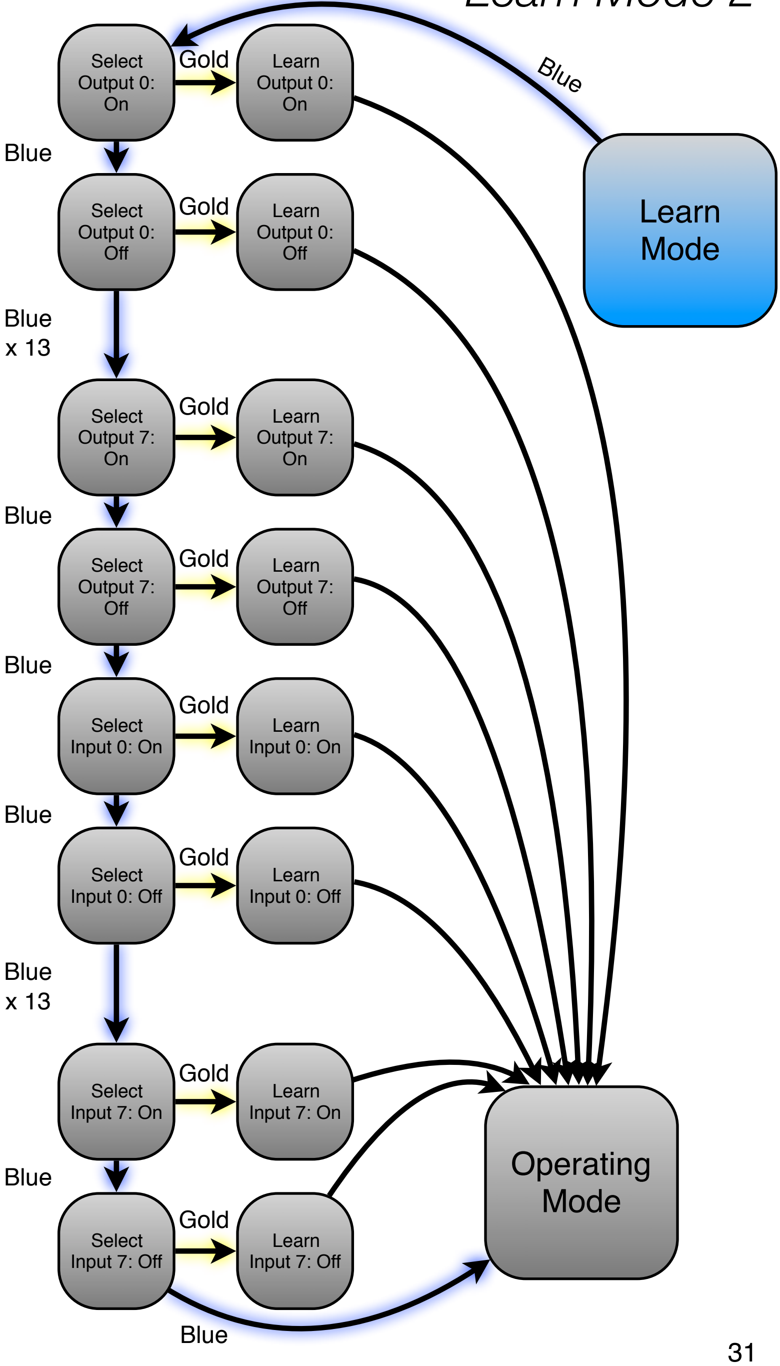
Master Flow Chart



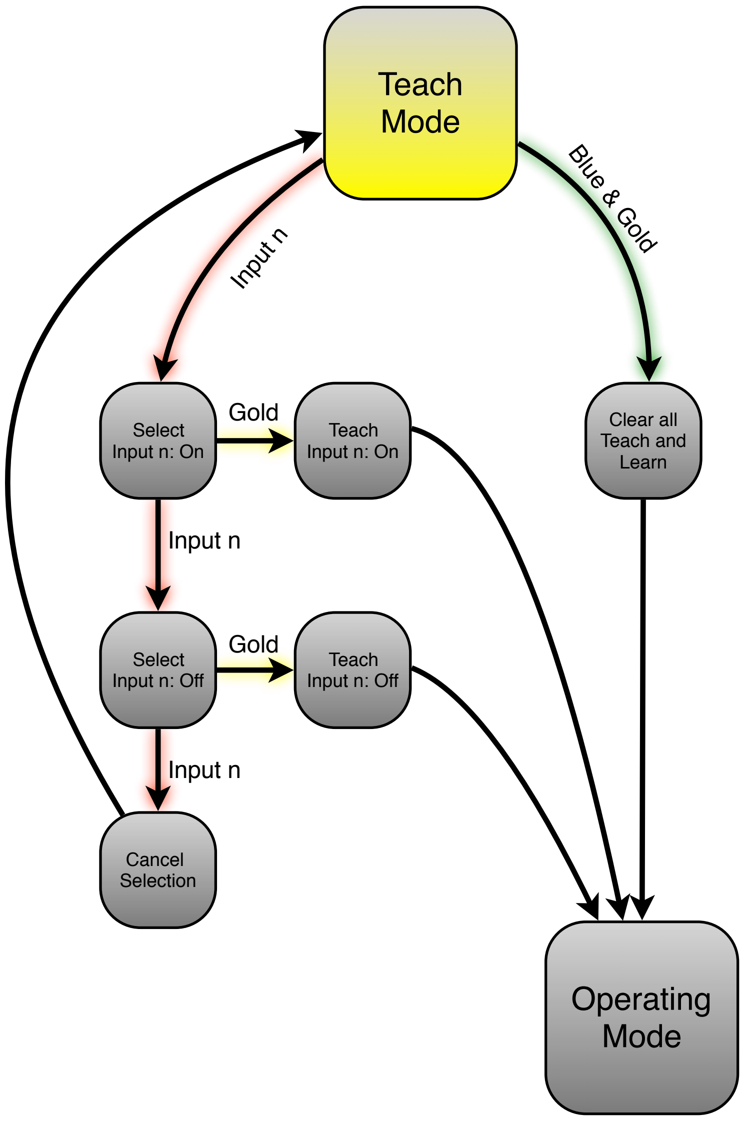
Learn Mode 1


Learn Mode
Input n
Blue & Gold
Select Input n: On
Gold
Learn Input n: On
Clear all Teach and Learn
Input n
Select Input n: Off
Gold
Learn Input n: Off
Input n
Cancel Selection
Operating Mode

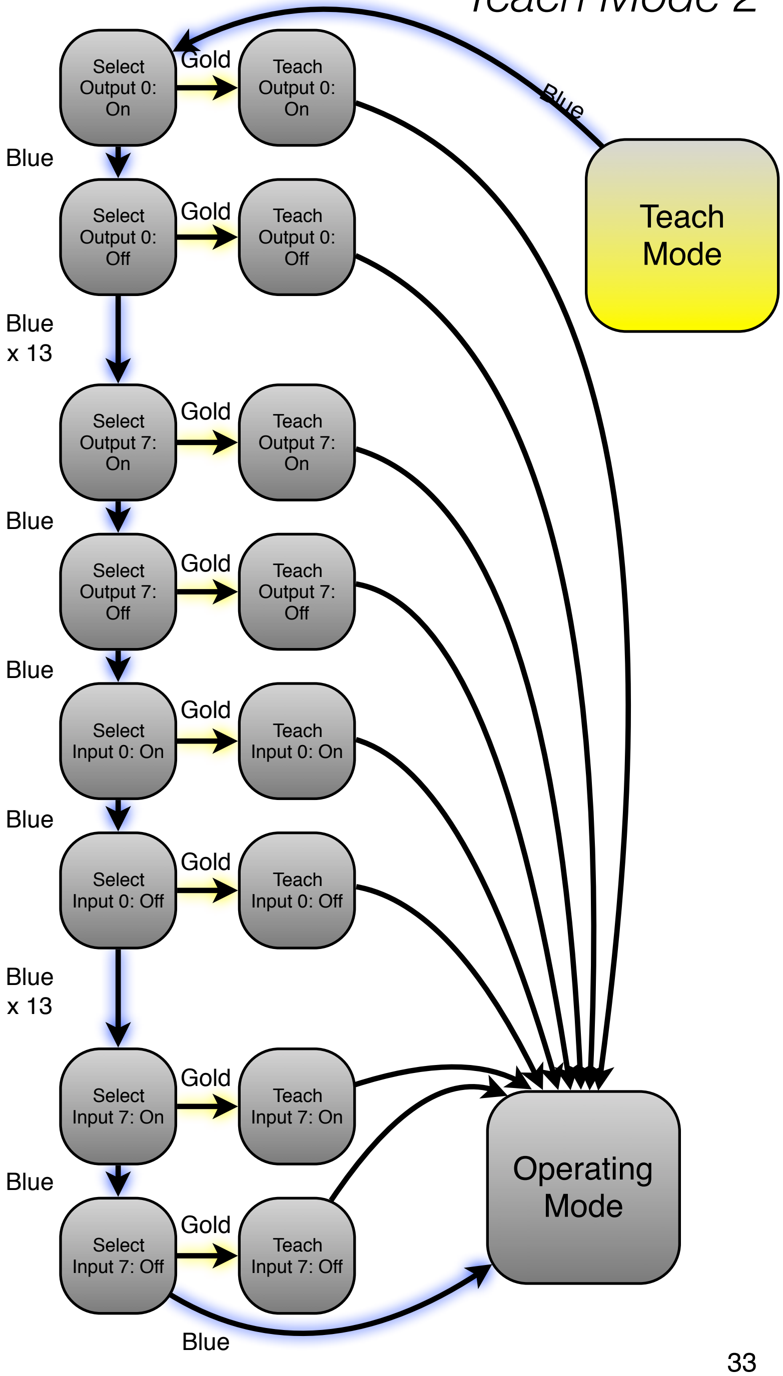
Learn Mode 2


Blue
Learn Mode
Select Output 0: On
Gold
Learn Output 0: On
Blue
Select Output 0: Off
Gold
Learn Output 0: Off
Blue x 13
Select Output 7: On
Gold
Learn Output 7: On
Blue
Select Output 7: Off
Gold
Learn Output 7: Off
Blue
Select Input 0: On
Gold
Learn Input 0: On
Blue
Select Input 0: Off
Gold
Learn Input 0: Off
Blue x 13
Select Input 7: On
Gold
Learn Input 7: On
Blue
Select Input 7: Off
Gold
Learn Input 7: Off
Blue
Operating Mode

Teach Mode 1


Teach Mode
Blue & Gold
Input n
Select Input n: On
Gold
Teach Input n: On
Clear all Teach and Learn
Input n
Select Input n: Off
Gold
Teach Input n: Off
Input n
Cancel Selection
Operating Mode

Teach Mode 2



Select Output 0: On
Gold
Teach Output 0: On
Blue
Teach Mode
Blue
Select Output 0: Off
Gold
Teach Output 0: Off
Blue x 13
Select Output 7: On
Gold
Teach Output 7: On
Blue
Select Output 7: Off
Gold
Teach Output 7: Off
Blue
Select Input 0: On
Gold
Teach Input 0: On
Blue
Select Input 0: Off
Gold
Teach Input 0: Off
Blue x 13
Select Input 7: On
Gold
Teach Input 7: On
Blue
Select Input 7: Off
Gold
Teach Input 7: Off
Operating Mode
Blue