Grandpa’s Railroad Control Panel User’s Manual

Dec 18, 2023

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1 Introduction

Grandpa's Railroad is a collection of hardware and software that provides a **computerized control panel** for model trains. The system is ***centralized*** in that all data is sent to one Windows 11 Mini PC that performs all computations for the control panel. The advantage of such a centralized system is that sophisticated algorithms can be used to process the data without the user ever being aware of them. For example, IR proximity locators which are normally plagued by varying lighting conditions can be continuously calibrated virtually eliminating these sensitivities. Also in a centralized system, each element of the system can be independent of all other elements (not dedicated to a specific function). Objects like proximity locators can be used for multiple purposes to implement multiple objectives. For example, a single proximity locator can be used for a crossing flasher, for train traffic control signals, for collision avoidance, for animation, etc.

1.1 Trading Wires for WIFI

Most ***centralized*** systems have the disadvantages of requiring many wires to bring the data back to the central processing unit and require a large amount of space inside or outside the processing unit for boards to digitize and handle the data. The large number of wires makes the use of centralized control on modular layouts nearly impossible. Grandpa's Railroad has solved these problems by digitizing and handling the data locally (near the source) and then sending the data to and from the centralized system using WIFI. Depending on the router used, data can be sent reliably over several hundred feet thus accommodating even very large layouts. Currently Grandpa's Railroad software can handle up to 32 WIFI modules. Each WIFI module can process up to 16 digital I/O elements and 16 proximity locators. Since a turnout only requires one digital I/O connection, this means that up to 512 turnouts and 512 proximity locators could be used on one control panel.

1.2 Dedicated Processor and Router for Reliable Operation

Grandpa's Railroad software comes preinstalled on a Windows 11 Mini PC with a WIFI router also connected. We have chosen to take this approach to eliminate installation problems. Everyone who has used a Windows PC has experienced a new software package you have purchased asking you if it can change your system. These packages are actually changing your system. In some cases, they may change dynamic link libraries or drivers that are not compatible with our software. Games are particularly notorious for this. Instead of dealing endlessly with customers trying to install our software on their older computers and in some cases possibly claiming it doesn't work, we have chosen to provide customers with a preinstalled pretested system. This does not mean that you can't later install reliable software packages like Windows Office, etc. on your own. The Mini PC we provide is adequate for these applications. While we do not guarantee a particular brand of PC, we will ship one containing two 4K display ports. This is done so that if you desire you can use multiple displays for your layout and so that we have room for enhanced model train control features without requiring our customers to buy a new Mini PC.

We have supplied a WIFI router for similar reasons. Most people have a WIFI router in their homes, however these are typically used for applications such as TV or video streaming, gaming, etc. These can quickly use up the bandwidth of a router. Since we do not want complaints about our control panel not working because others are steaming or gaming on your home router, we have supplied a dedicated router. This does not mean that you cannot use your home router or a more powerful one than we supply, it just means that the system as we deliver it works. For very large layouts you may need a more powerful router than we supply and thus we have provided a software application preinstalled to program our WIFI modules for a different router or module number.

1.3 Ease of Use

From the beginning we have designed Grandpa's Railroad for ease of use. Our goal was to provide a system that our customers could use if they can count, add, use a screwdriver, use pliers, and operate a PC. We think we have accomplished that goal. **Absolutely no software programming** is necessary to use the system. Setup is done through conventional dialog boxes, many with illustrations to aid in filling in the data. We also have extensive error checking to detect problems and missing data entries.

Ease of use does not mean that the system is not flexible or sophisticated. Complex algorithms are used for various features, but they require no knowledge or interaction by the user.

1.4 Educational Benefits

One of the goals of Grandpa's Railroad is to spur interest in science and engineering among young people. It is our belief young people are interested in model trains and computers. Therefore, we have combined the two. Scientific and engineering creativity is just as rewarding as art or music. We are creating a video course on electricity which is very basic (*meant for people with zero knowledge of electricity*). The course is not meant for children but as an aid for parents, grandpas, group leaders, mentors, etc. to learn and help younger people understand the basics. Normally, most beginners' courses are labeled as 101. For example, cooking 101, sewing 101, etc. We have labeled our course Electricity 99 because it is even more basic than the 101 level courses. We start with the atom and expand from there. Since we believe that hands on use is very important to learning, we hope you reproduce the experiments in these videos. The videos can be accessed either through our website GrandpasRR.com or our YouTube channel Grandpas Railroad.

Grandpa's Railroad software also includes various features that allow you to visually learn from its data. One example is a plot of the data that the IR proximity locators are seeing.

We are also hopeful that our users will share the creative animations or uses they have implemented with Grandpa's Railroad.

1.5 User Manual Outline

Grandpa's Railroad Control Panel Software has three modes. These are:

1. Layout Setup
2. Control Panel Setup
3. Control Panel

The first step (***Layout Setup***) in using the Grandpa's Railroad Control Panel is to define your layout. This involves defining the position of the track, turnouts, etc.

The second step (***Control Panel Setup***) is to define how the layout elements defined during ***Layout Setup*** interact or connect with the hardware.

The third mode (***Control Panel***) is used to operate the control panel to control your model railroad. The first two steps only need to be done once or when you make additions or changes to your layout. The fact that the control panel is software based allows expansion of a layout to be easily accomplished.

Chapter 2 covers the first steps to building a control panel. These are defining the layout size and type and defining custom turnouts if needed.

Each element in the layout may have different hardware requirements and functions that need to be performed during each of the modes. This manual has been written in a manner so that each element of the layout is addressed separately but completely in Chapter 3. These include all hardware and software setup as well as simple examples.

Chapter 4 presents software features that will aid in the building of a control panel. These include tools such as axes, grids, viewing and printing of connections, possible problem checking, and many more handy features for development and documentation. Some features allow you to customize the look of your control panel to get just the look you want.

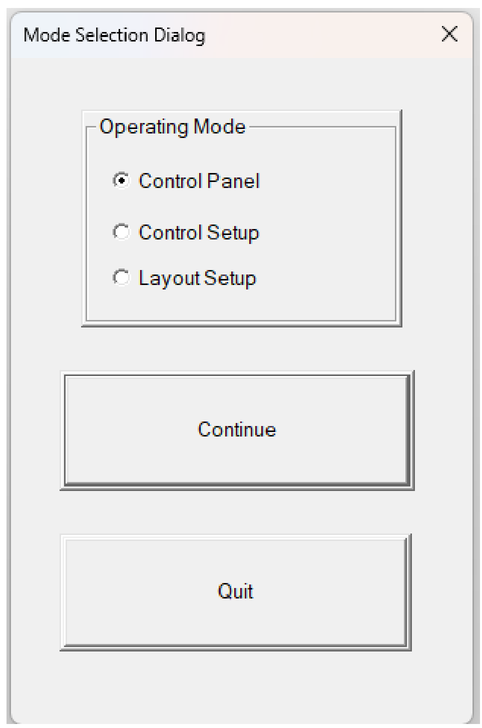
Chapter 5 covers special topics for Grandpa's Railroad construction. Hints we have learned will be presented as well as very specific details on connecting certain features to your layout.

2 Layout Basics

The first step to defining a layout is to define its size and type. In addition, this chapter covers defining custom turnouts which you may need to do before starting layout construction if you have hand-built turnouts or turnouts not currently on our list.

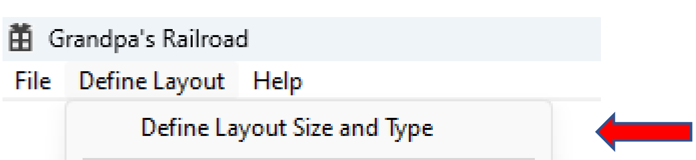
2.1 Defining the Layout Size and Type

When you start the software, a dialog box will appear allowing you to select the basic mode.



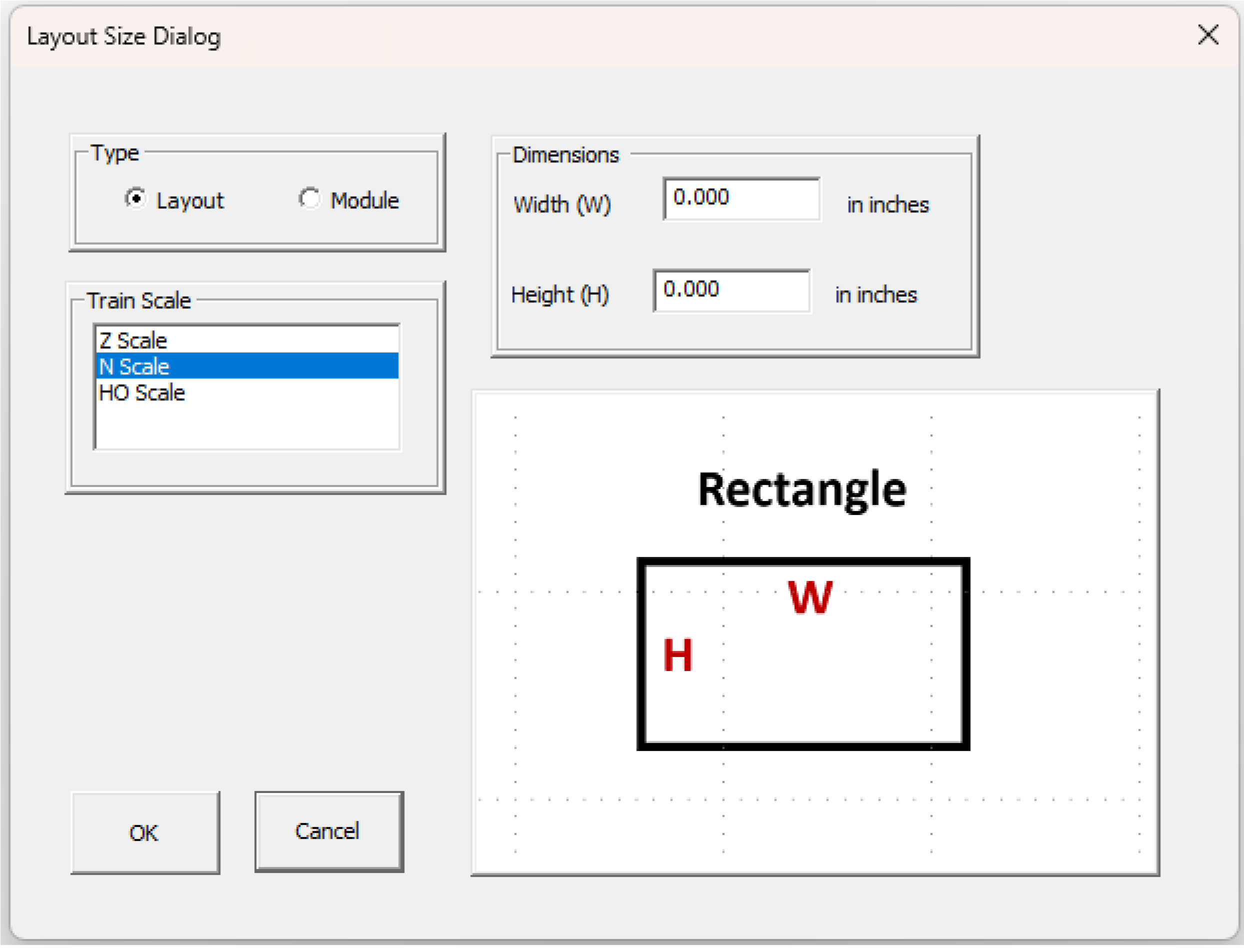
Select Layout Setup.

From the main menu at the top select



Define Layout/Define Layout Size and Type

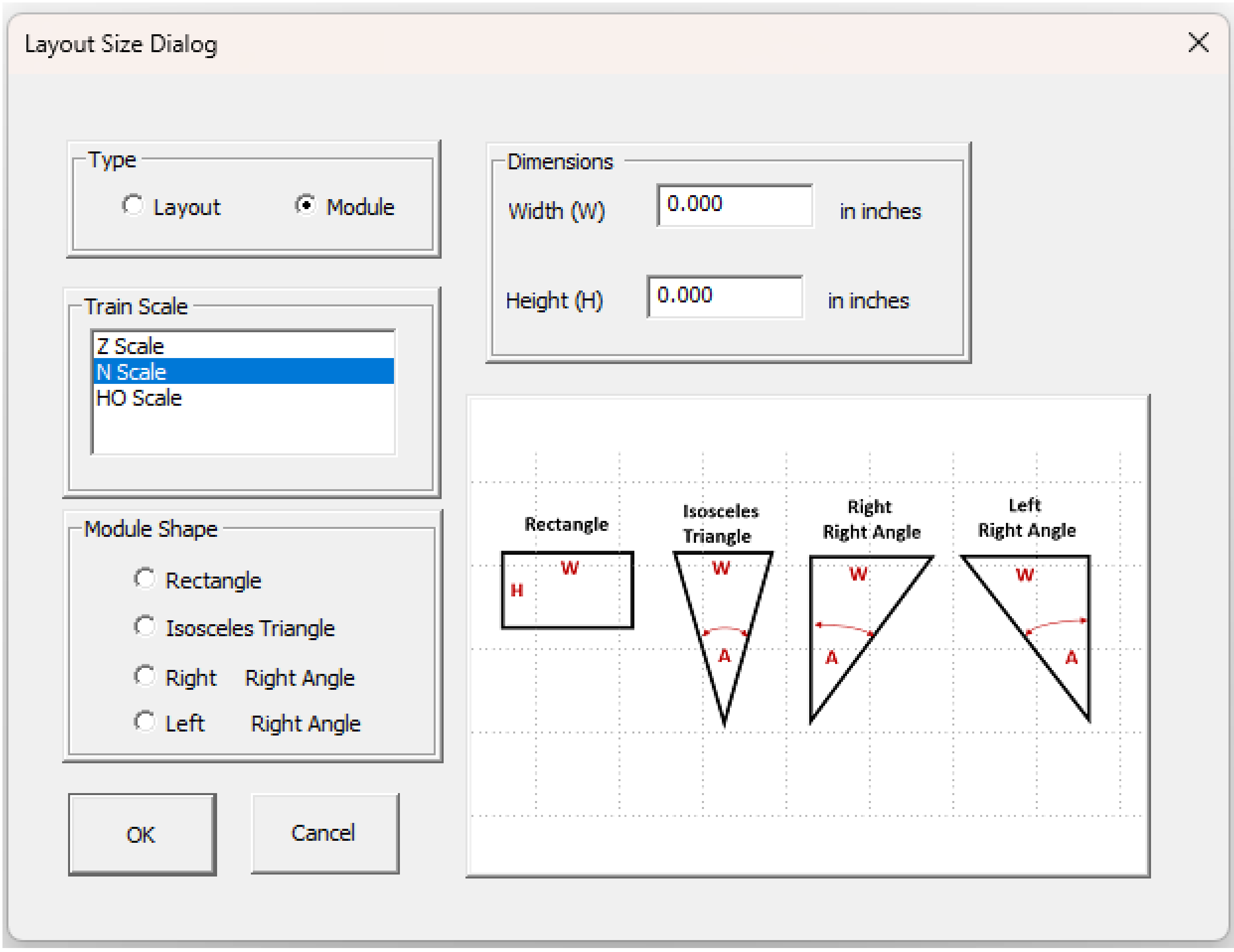
The following dialog will appear.



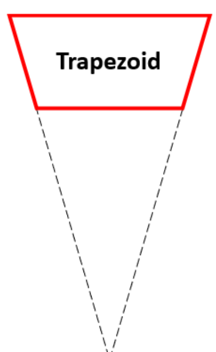
There are two basic methods for defining the layout:

1) Define the entire layout as one component.
2) Defining modules and then importing them into a layout.

The second method is best for layouts that are physically modular and can be separated and reconstructed with elements in different locations. Using this method greatly reduces the time to recreate the layout. Select whether you wish to define a ***Layout*** or a ***Module***. If you choose **Layout** enter the width and height of the smallest rectangle that will encapsulate your entire layout even if it is not rectangular. If you choose **Module,** the dialog will change as follows allowing you to define the shape and size of the module.



At first glance some of these shapes seem somewhat strange but they are the most basic shapes. For example, a trapezoidal module could be generated from an isosceles triangle.



The orientation of a module may not be what you desire in your layout, but <u>the orientation is assigned as you import the module</u> into a layout.

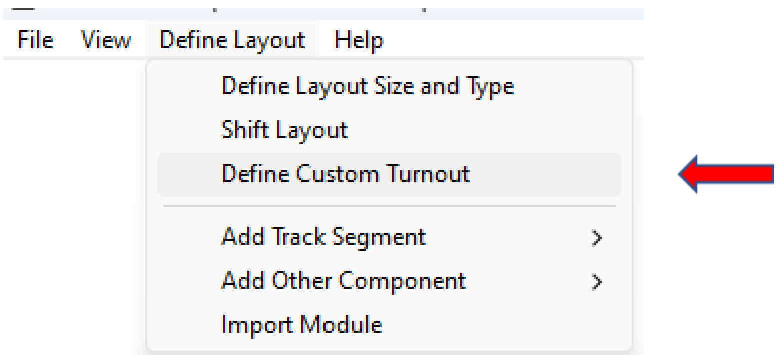
Before exiting the dialog select the train scale. Only N and HO are currently supported. Even though it is listed in the dialog, Z scale is not supported.

Once you have defined the layout size and type, additional menu items will appear allowing the definition and addition of various elements to the layout or module. These include track segments, borders, buildings/buttons, proximity locators, etc.

2.2 Defining Custom Turnout

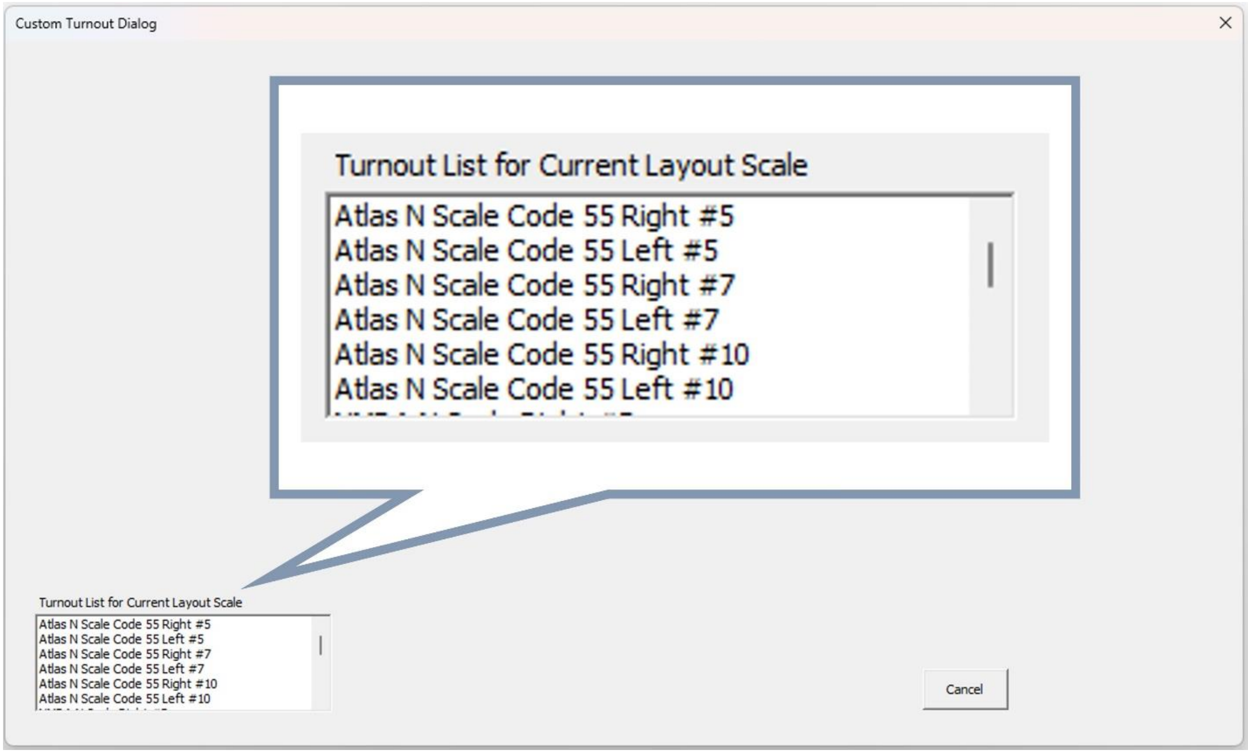
You may have turnouts from a company that is not currently on our list or that you custom made. These can be added to the turnout list using the **Define Custom Turnout** item which will appear after the train scale has been defined.

From the main menu select



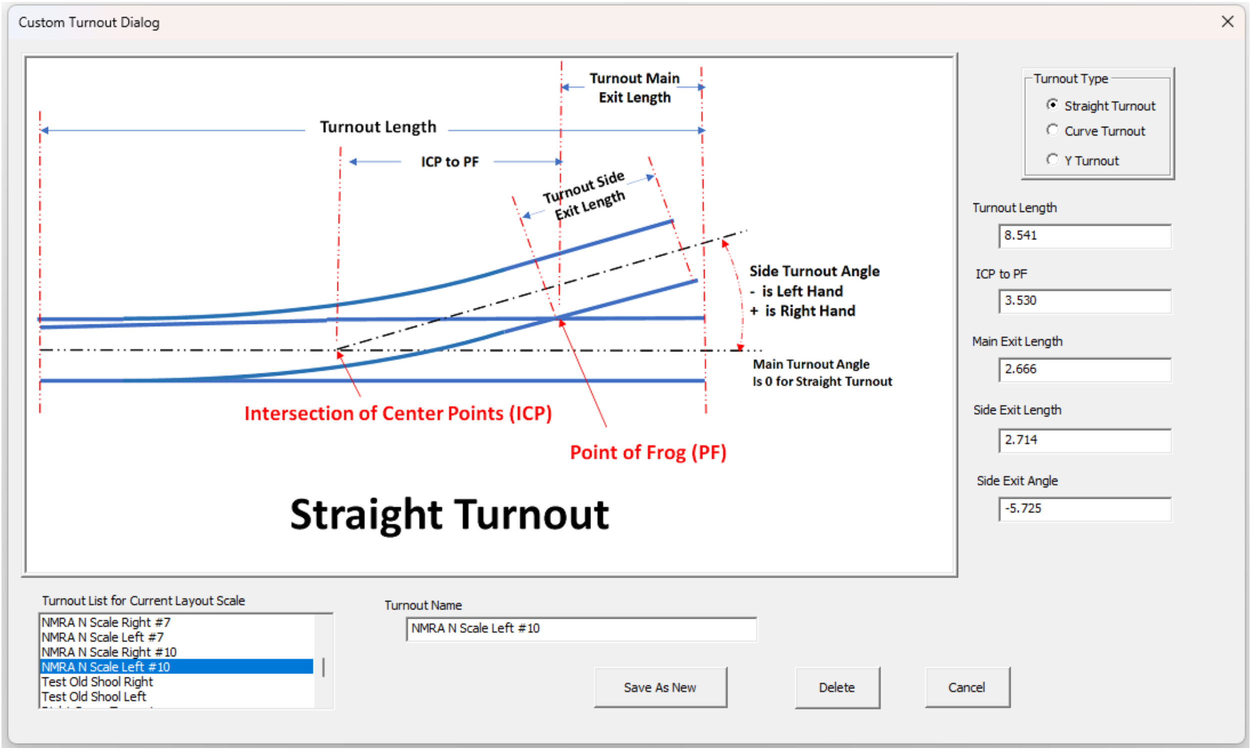
Define Layout/Define Custom Turnout

Upon selecting this menu item, the following dialog will appear.



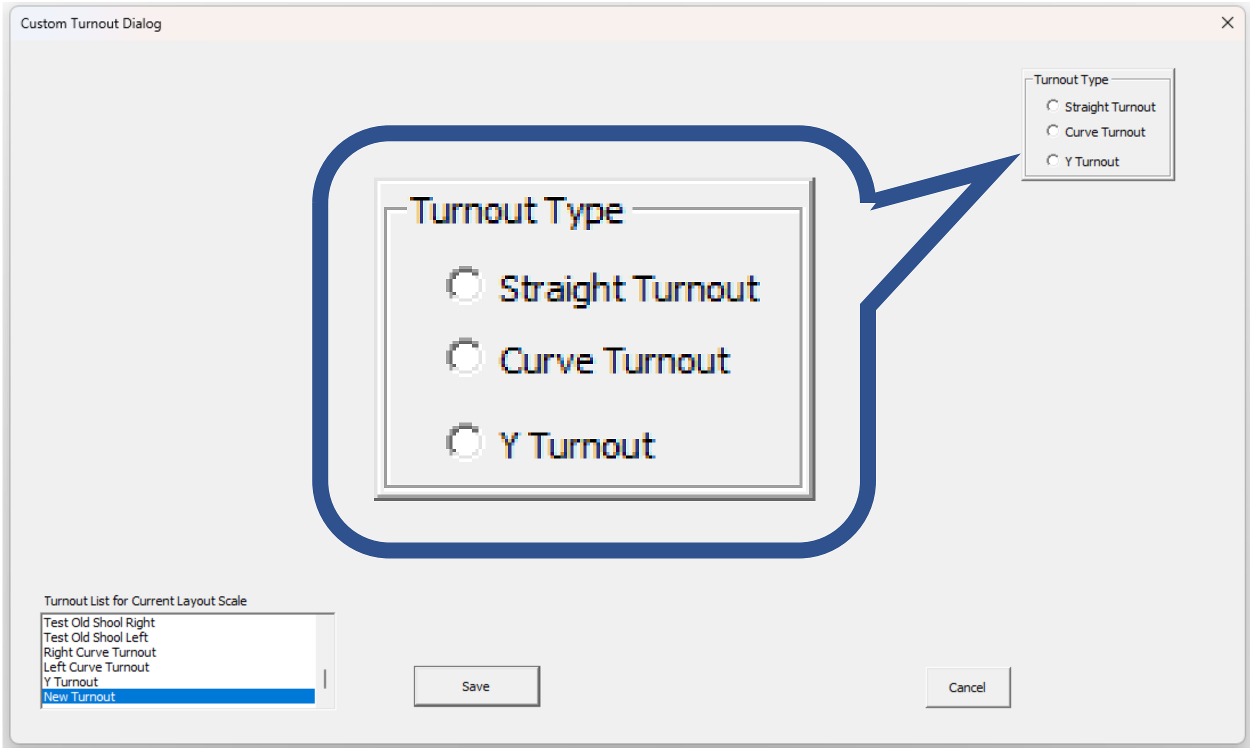
In the lower corner is the list of currently defined turnouts for the layout scale. You can either select a current one and edit it or create a totally new one by selecting **New Turnout** at the bottom of the list.

If a current turnout definition is selected, the dialog will be filled with the parameters for that definition and an image that visually illustrates those parameters.

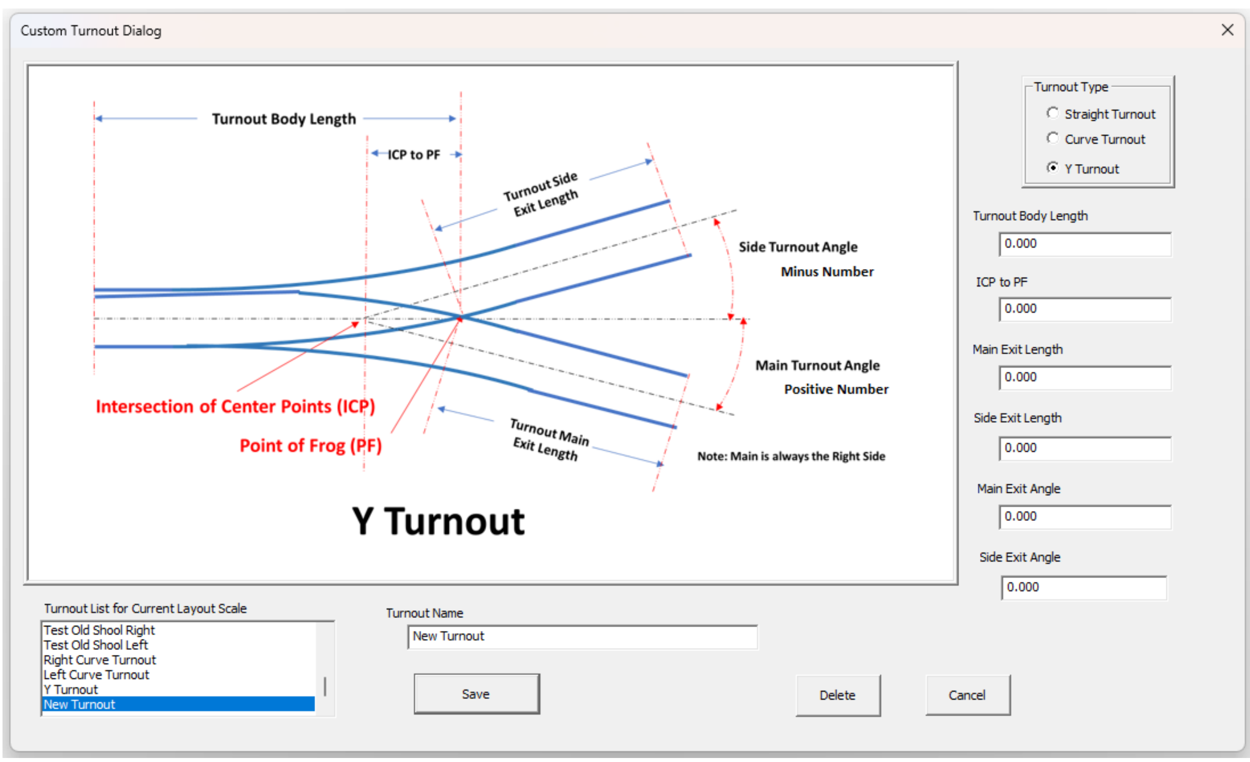


You can then edit the parameters and save the definition or save it under a new name.

If **New Turnout** is selected, then the dialog will change to give you a choice of **Turnout Type**.



Once you select a type, the parameters you need to define and an image to visually illustrate them will appear. An example of a Y Turnout is shown below.



After entering all the appropriate data, select **Save** and the definition will be saved under the **Turnout Name** specified. If the data has not been added correctly a detailed error message will appear explaining what is incorrect.

3 Adding an Element to Your Layout

Each element in a layout may have different hardware requirements and functions that need to be performed during each of the software modes. All aspects of the addition of an element to your layout will be covered including:

1. Hardware Required
2. Adding to Layout
3. Control Panel Setup
4. Control Panel Operation
5. Special Considerations
6. Practical example

if applicable.

The following table shows each of the elements and provides quick links to sections.

Element	Section
Adding Straight Track	3.1
Adding Curved Track	3.2
Adding Turnout	3.3
Adding Border Line	3.4
Adding Button	3.5
Adding Proximity Locator	3.6
Adding Gate, Signal, or Animation	3.7
Adding Collision Avoidance	3.8
Adding External Input Object	3.9
Adding WIFI Module	3.10
Import Layout Module	3.11

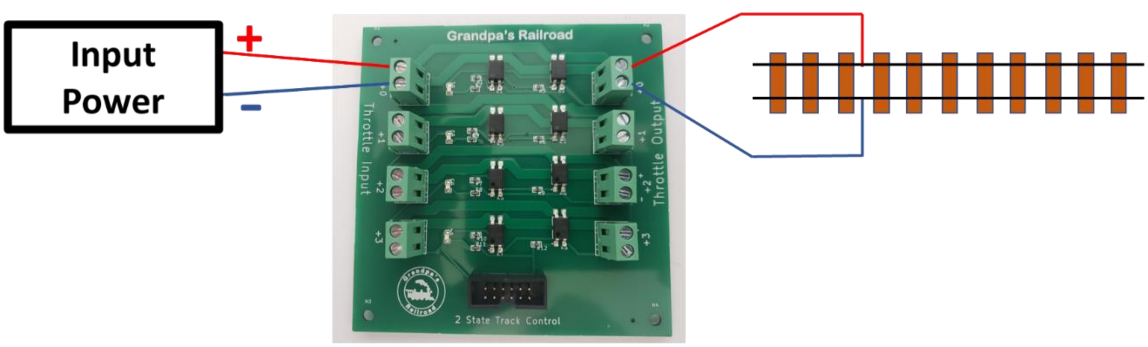
3.1 Adding Straight Track

A straight track section is not associated with a particular length of track but can be an entire straight length which is composed of many individual pieces.

3.1.1 Hardware Required

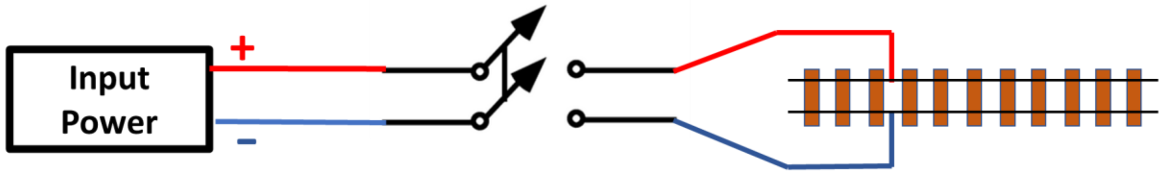
Hardware is only required if you are setting up this section to control power for the entire block. A **Block** represents all track elements which are electrically connected. That is, all elements which are between track insulators. Definition of Blocks in a layout is important to isolate segments allowing collision avoidance and in non DCC layouts to be able to park locomotives on sidings. Two options are available. Using a **2-state Track Control** card, you can power *Off* a block or connect it to one power source such as Cab (Throttle Power Pack) or another track section. For DCC systems there is only one power source so this card would either turn it *On or Off.* Using a **3-state Track Control** card, you can power *Off* a block or connect one of two other power sources such as Cabs or other blocks. This option is now used with DDC. It is not the intention of this manual to demonstrate various block configuration methods for specific layout types. These will be covered in separate videos. In this document we will only cover the operation of basic elements.

The **2-state Track Control** card is equivalent to a solid-state double pull single through switch. The wiring is:



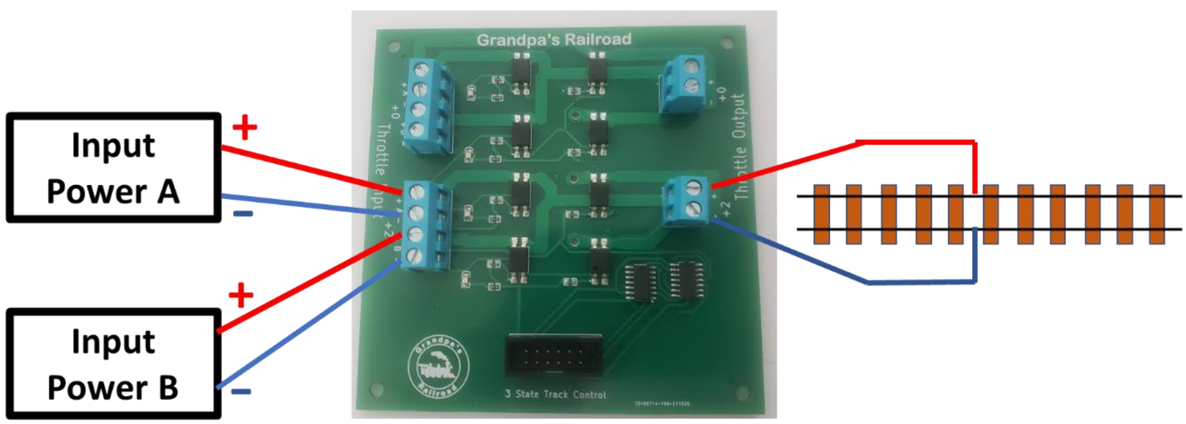
Note: Input power could be a DC Controller, power currently being supplied to another block, or in the case of DCC a DCC power supply.

A simplified diagram for this Configuration is:

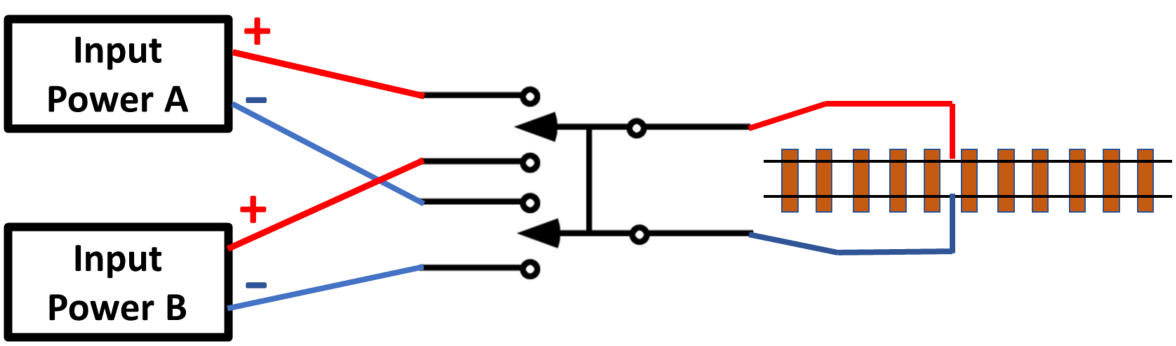


Note: Input power could be a DC Controller, power currently being supplied to another block, or in the case of DCC a DCC power supply.

The **3-state Track Control** card is equivalent to a solid-state double pull double through center off switch. The wiring is:



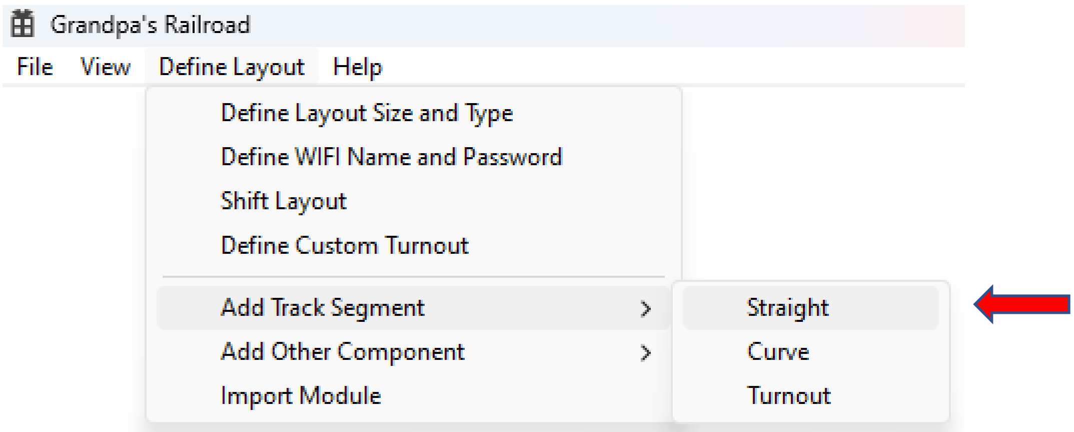
A simplified diagram for this Configuration is:



Note: Input power could be a DC Controller or power currently being supplied to another block.

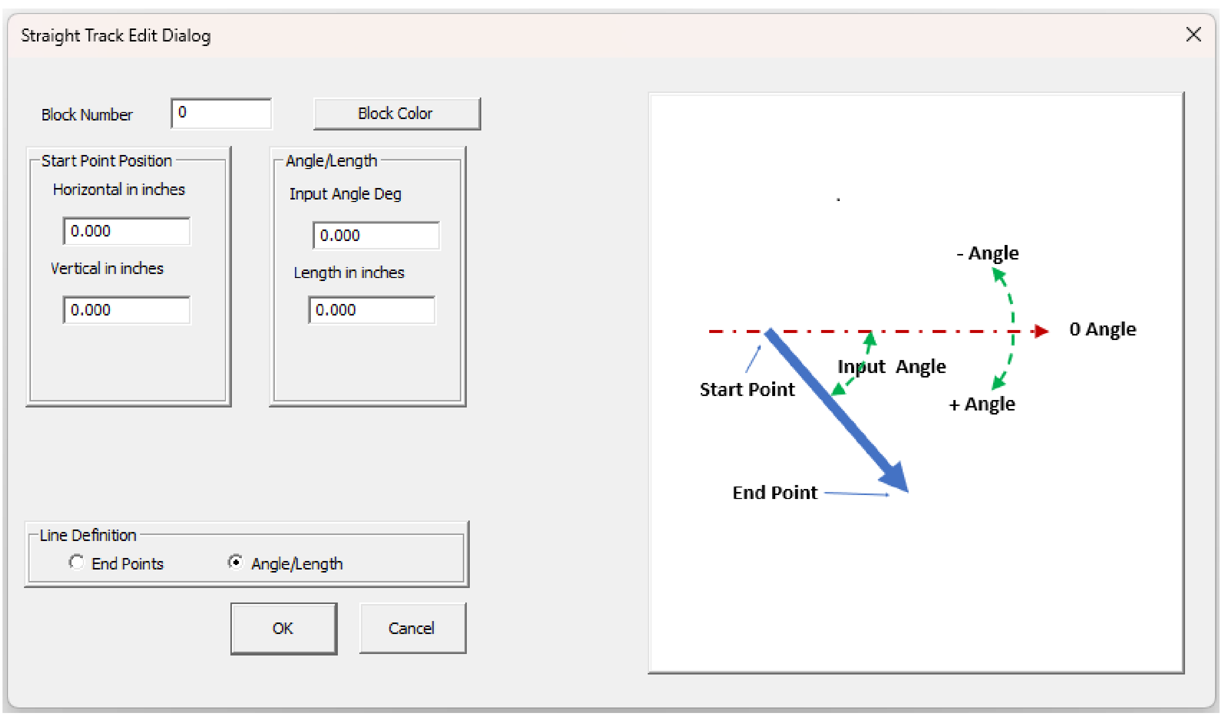
3.1.2 Adding a Straight Track Section to Your Layout

From the main menu select



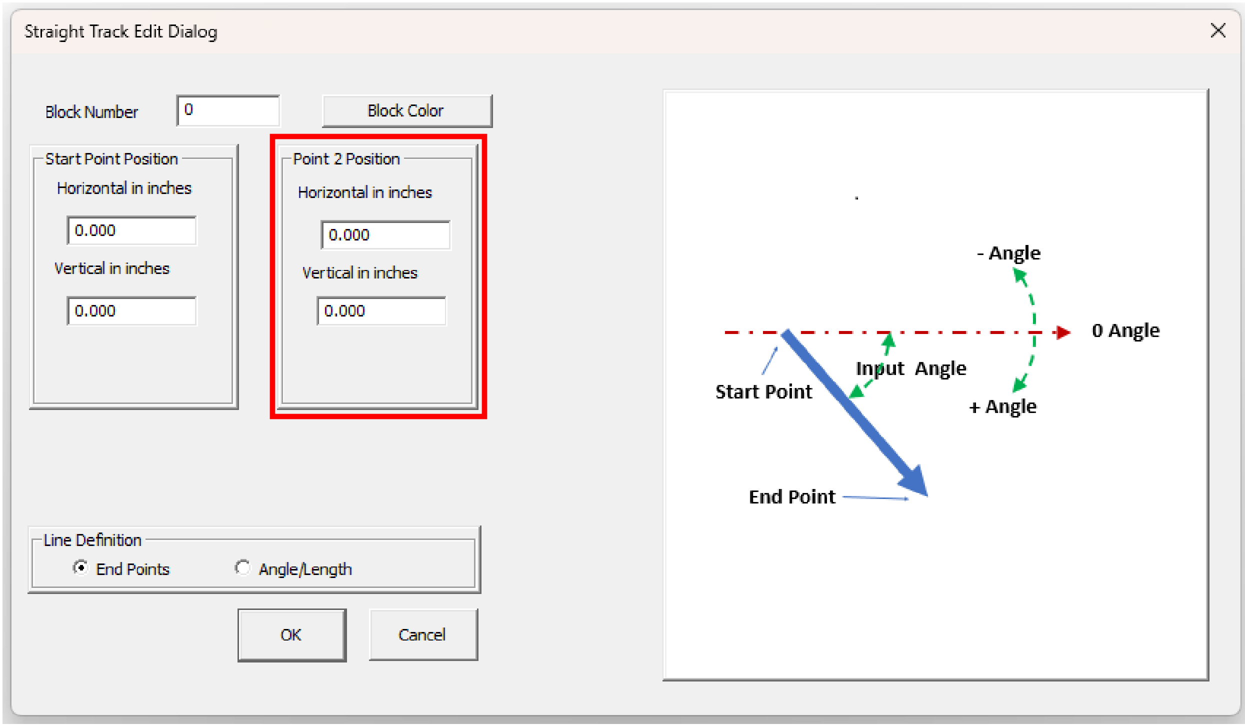
Define Layout/Add Track Segment/Straight

Upon selecting this menu item, the following dialog will appear.



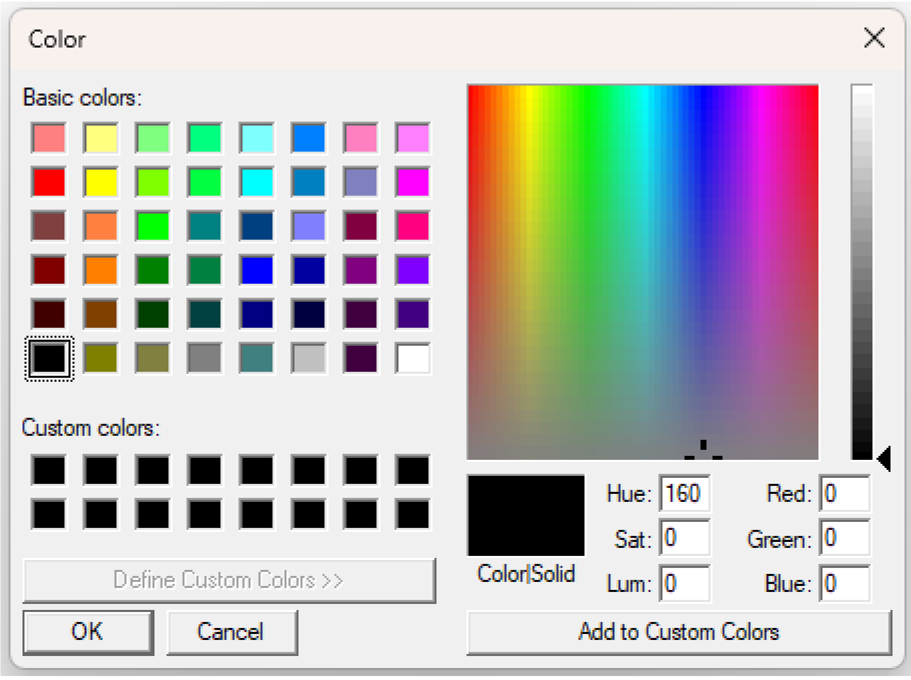
In this form the dialog allows you to enter the straight track segment as a starting point, input angle, and length.

If you wish to enter the two end points for the line, you can select ***Line Definition/End Points*** and the dialog will be changed as follows:



Along with the actual segment definition, you must enter the **Block Number**. This is a number between 1 and 100. A **Block Number** represents all track elements which are electrically connected. That is, all elements which are between track insulators. Definition of Blocks in a layout is important to isolate segments allowing collision avoidance and in non DCC layouts to be able to park locomotives on sidings.

Once you have input the block number, if the block number has been previously used for another segment, the selected color for the **Block Number** will be displayed. If it has not been previously used, you will be required to use the **Block Color** button to define a color. Using this button will cause the following dialog to appear.



If the color has been previously defined and you select the **Block Color** button, the color you select from the dialog that appears will be applied to all track segments with that **Block Number**.

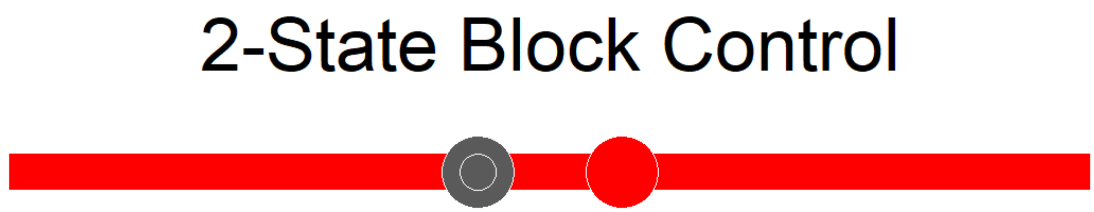
Once you select **OK** from the Straight Track Editing dialog and if you have entered all required data, the track segment will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

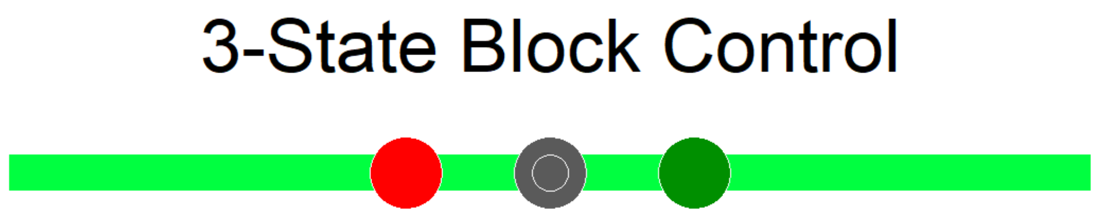
If you need to edit a track segment, you can left click with your mouse on the track segment **Edit Location** and this dialog will reappear. (See **Show Edit Locations**)

3.1.3 Setting Up a Straight Track Section for your Control Panel as a Block Control

Note: This section is only applicable if you are setting up a Block Control on this track section. A section can only be used as Block Control if it is long enough to display the control image.

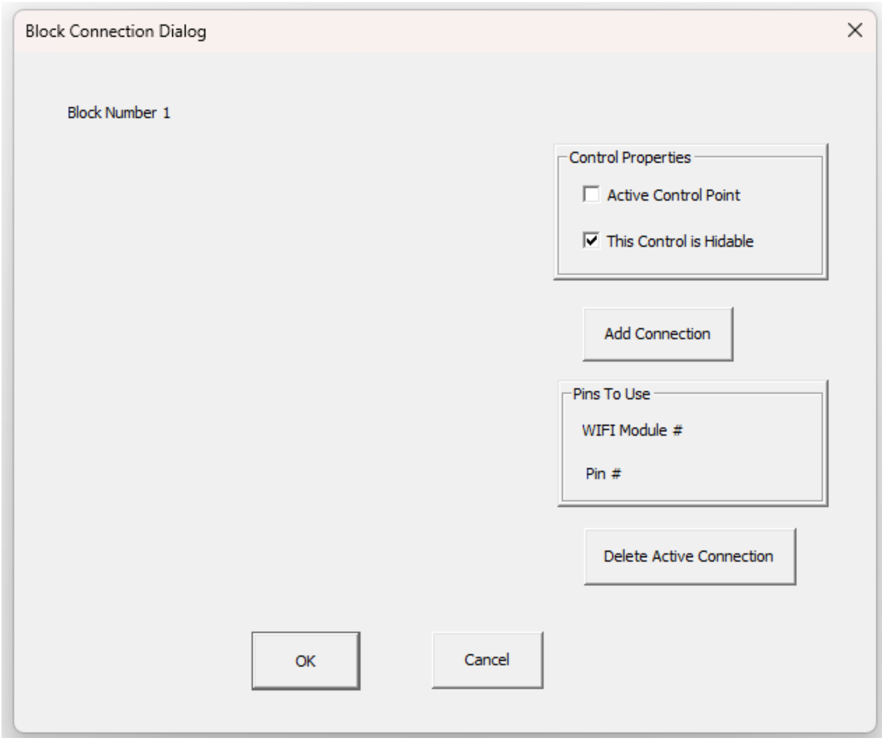
When you set up a Block Control on a track segment, either a 2-state or 3-state control will appear depending on how you defined it. These images are shown below.



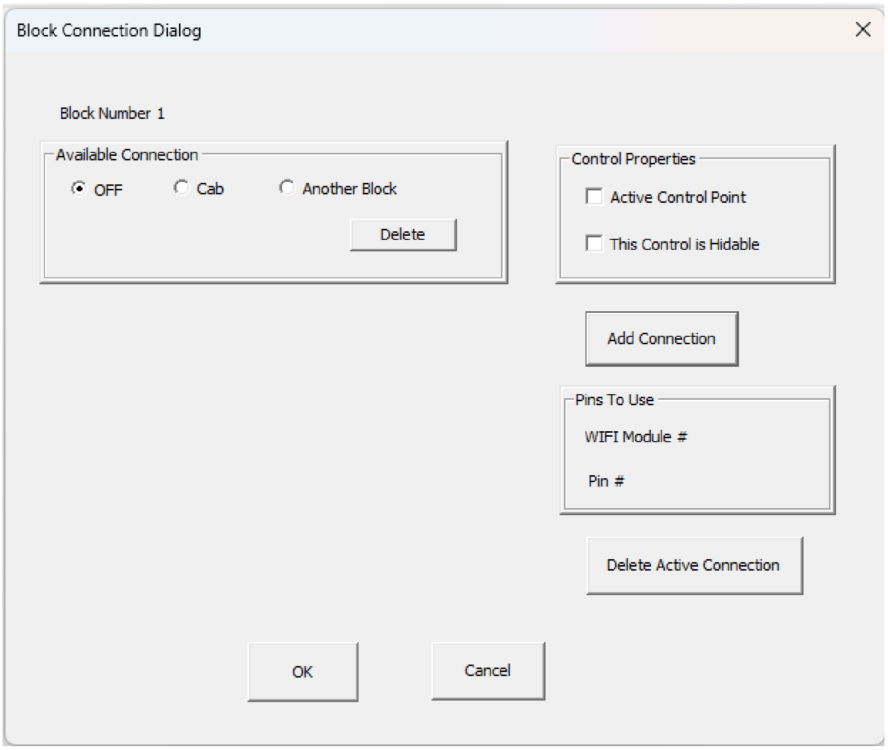


As the name implies, a 2-State Block Control allows you to either cut power to the block or connect to one power source. For DCC operation this would be the DCC power and for DC operation this could be either a throttle cab or another track block. 3-State Block Control is only useful for DC operation. It allows connection to two other power sources, either block or cab. In both cases, ***OFF*** is one of the required states.

To set up a straight track section for your layout as a Block Control you must be in the **Control Setup** mode. Using the *Left Mouse Button*, click the **Control Box** (See **Show Control Boxes**) for the section on the layout and the following dialog will appear.



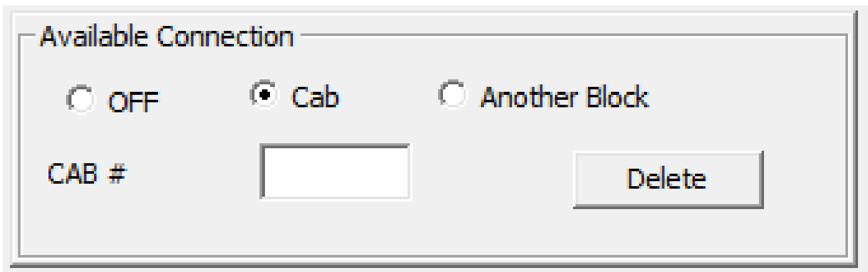
By pressing the **Add Connection** button you will be able to add two or three connections. After you push the button, the display will change as follows:



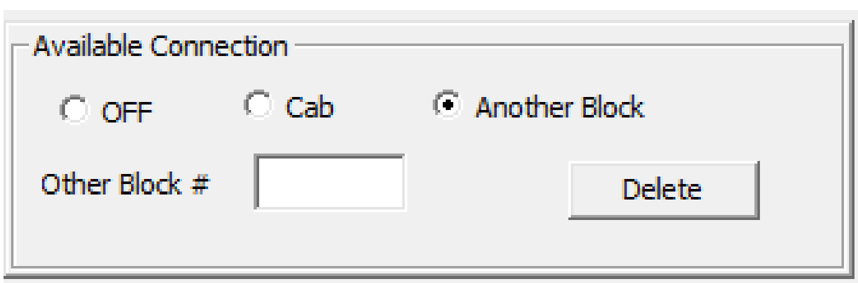
Note: An OFF connection is required for all configurations.

Pressing the button a second time will add the second connection.

If you select a cab connection a window will appear to allow you to select the cab number.

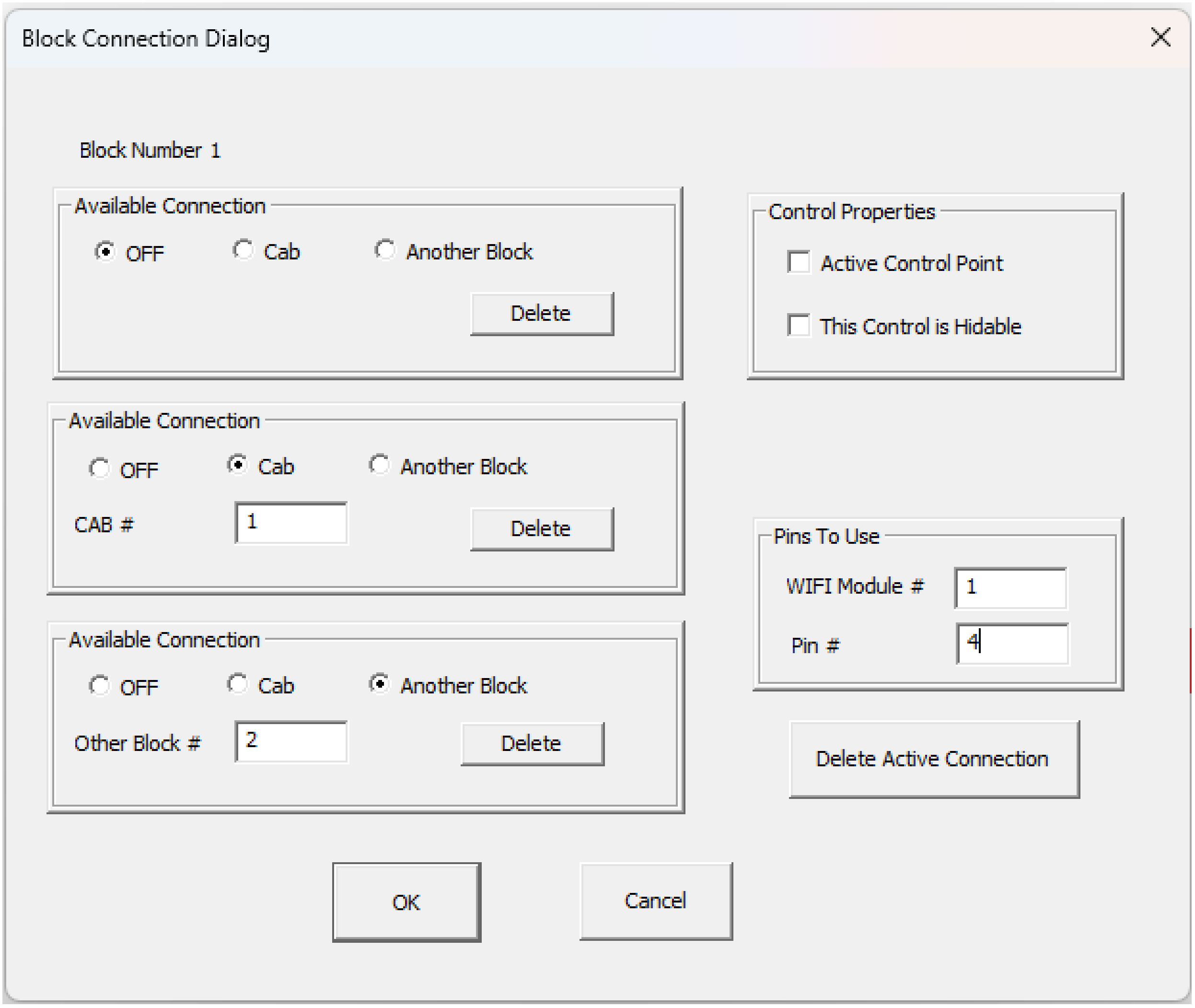


If you select a Block connection, a window will appear to allow you to select the Block number.



In both cases the delete button will delete the connection.

After you have added three connections, the dialog box will appear as below:



Note that the **Add Connection** button has disappeared since 3 is the maximum number.

The right side of the dialog box gives you options for the Block Control.

<u>**Active Control Point:**</u> This option defines whether the image will be displayed on the control panel so that the user can select the state with a mouse. For very large blocks you may wish to have more than one active control point. Clicking on a second track segment control point will cause this dialog to appear allowing the **Active Control Point** checkbox to be checked, but the characteristics cannot change.

Note: If you do make changes on another control point on a block other than Active Control Point and This Control is Hidable, they will apply to all control points for the block.

This Control is Hidable: When operating in the control panel mode, several options are available to simplify the display. One of these is to hide active Block Control Points. These may only be hidden if the control has been designated as hidable by checking this box.

You must enter the **WIFI Module** number that the Throttle Control card is connected to. That number is the actual number that is programmed into the **WIFI Module**. Note: All modules are shipped with a **Module Number** of 1. You can use the WIFI Module Programmer software to change that number if your layout has more than one module. (Put Link into User's Manual)

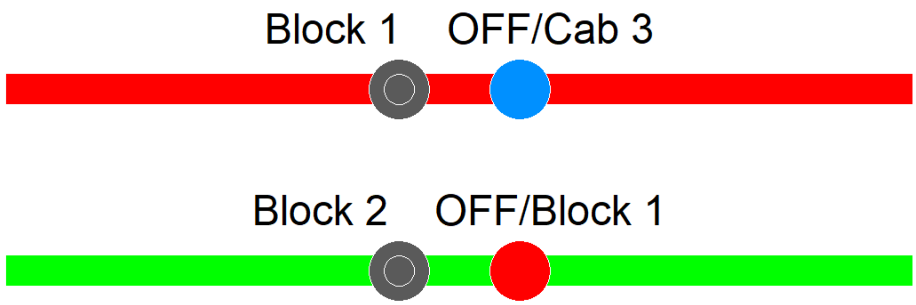
The Pin # is calculated by adding the number of the connector on the WIFI Module where the ribbon cable is connected and the Input Pin number on the card used.

The **Delete Active Connection** deletes all connections from the current block.

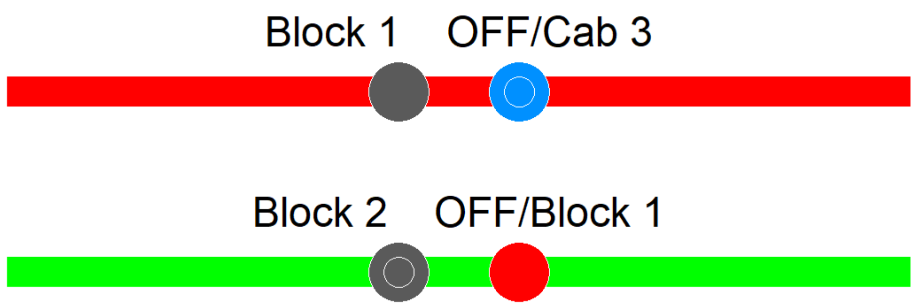
3.1.4 Control Panel Operation of a Block Control

On the control Panel, the circles on the Block Control will show the power source the block is connected to. For DCC operation there is only one power source so only a two connection Block Control is needed. In this case the Block Control simply indicates block on or off.

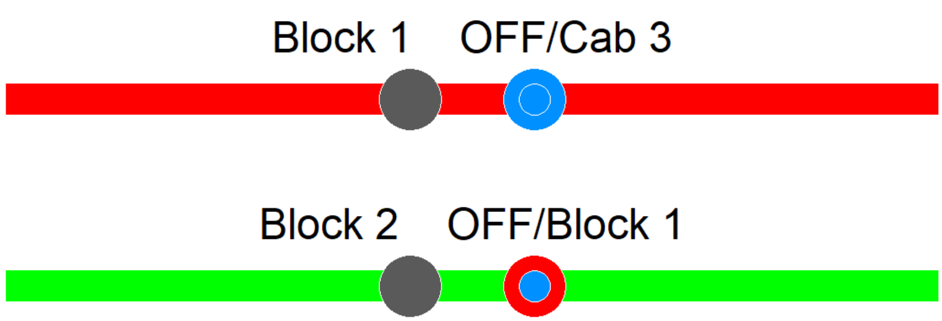
For DC operation the circles on the Block Control indicate power source, either Cab or connection to the source of another Block. To illustrate, assume we have a two-block layout as shown below.



In this example, Block1 can either be OFF or connected to the Cab 3 power source. Block 2 can either be OFF or connected to the same power source as Block 1. Note that in the above diagram both blocks are OFF indicated by the inner circle on the black circle. If we would click on the blue circle of block 1 so that it is powered by cab3 the following diagram would appear.

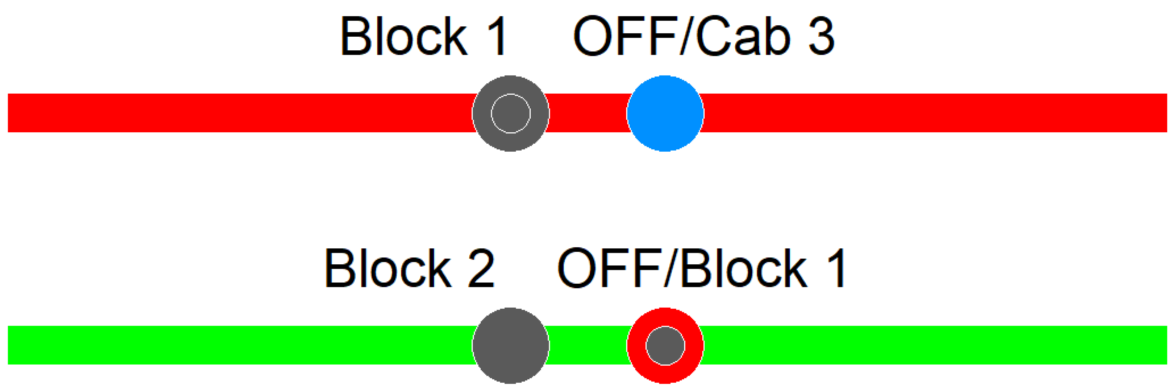


Now the inner circle for Block 1 is on the blue circle indicating that Block 1 is connected to Cab 3. Block 2 is still OFF. Left clicking on the Block 2 red circle, produces the following diagram.



Note that the inner circle of the red circle turns blue indicating that block 2 is connected to the same source as block 1 which is Cab 3. Thus, the outer circle of a

Block Control indicates the source of a possible connection, and the inner circle the current state of that connection. In the above example if we turn OFF Block 1 we get the following:



Since Block 1 was turned OFF, Block 2 will also be OFF since it is connected to the source of Block 1 which is OFF.

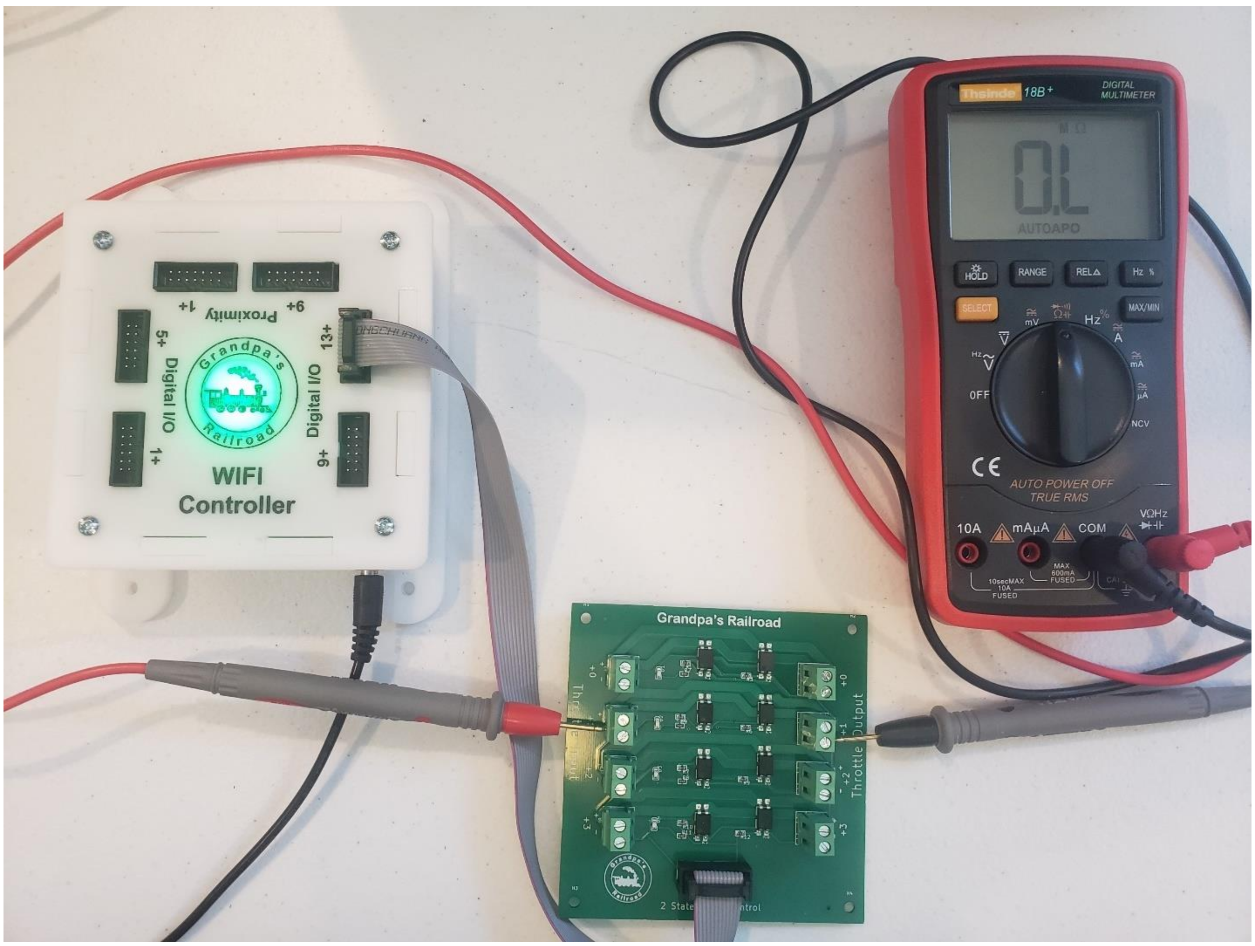
While there is currently no known use of a three connection Block Control for DCC, the DC mode operation is the same as the two connection with one more possible power source.

Note: Changing the power source for a Block Control in the Control Panel Setup mode must be accompanied by changing the wiring suppling the input. For example, if you have defined the input as Cab 1 and you decide to make the input Cab 2, you must switch the wires from Cab 1 to Cab 2 at the card input.

3.1.5 Practical Example 2 State Block Control

A simple example of a 2-state Active Block Control is illustrated below. In this example we will use a multimeter to demonstrate power source connection. High resistance indicates that the input is not connected to the output. Low resistance indicates that the power source is connected, and power will be available on the output connector.

Step 1: Connect a 2-State Track Control Card to the WIFI a module. Note that in the photo below, the card is connected to the +13 connection and the multimeter is connected to the +1 connection on the card.

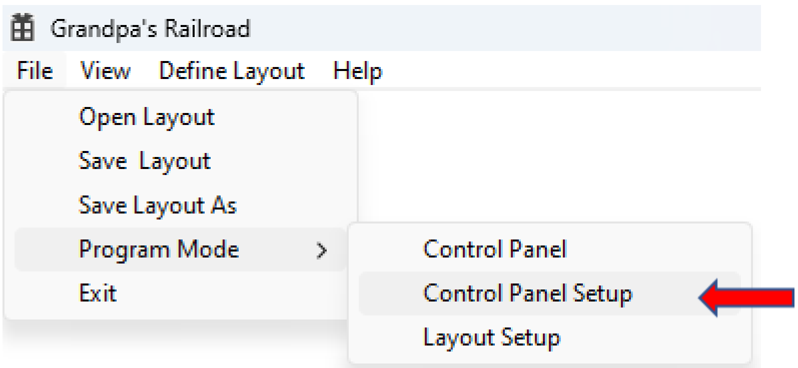


Step 2: Start the Grandpa's Railroad Application, select the **Layout Setup** mode, and create a 30-inch by 30-inch layout in any scale.

Step 3: Add a WIFI Module to your layout as described in the [Adding a WIFI Module](). The module number should be that number assigned to the module you are using. Note that the base Grandpa's Railroad system is always shipped with the module #1. If you are unsure of the module number use the *WIFI Module Programmer* software to determine it.

Step 4: Add a straight track section at location x = 0, y = 15, length = 30, and angle = 0.

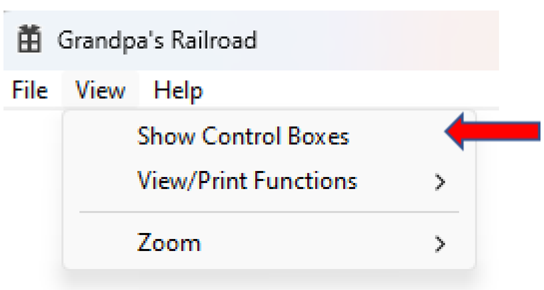
Step 5: From the File Menu item select:



File/Program Mode/Control Panel Setup

This will change to the Control Panel Setup mode.

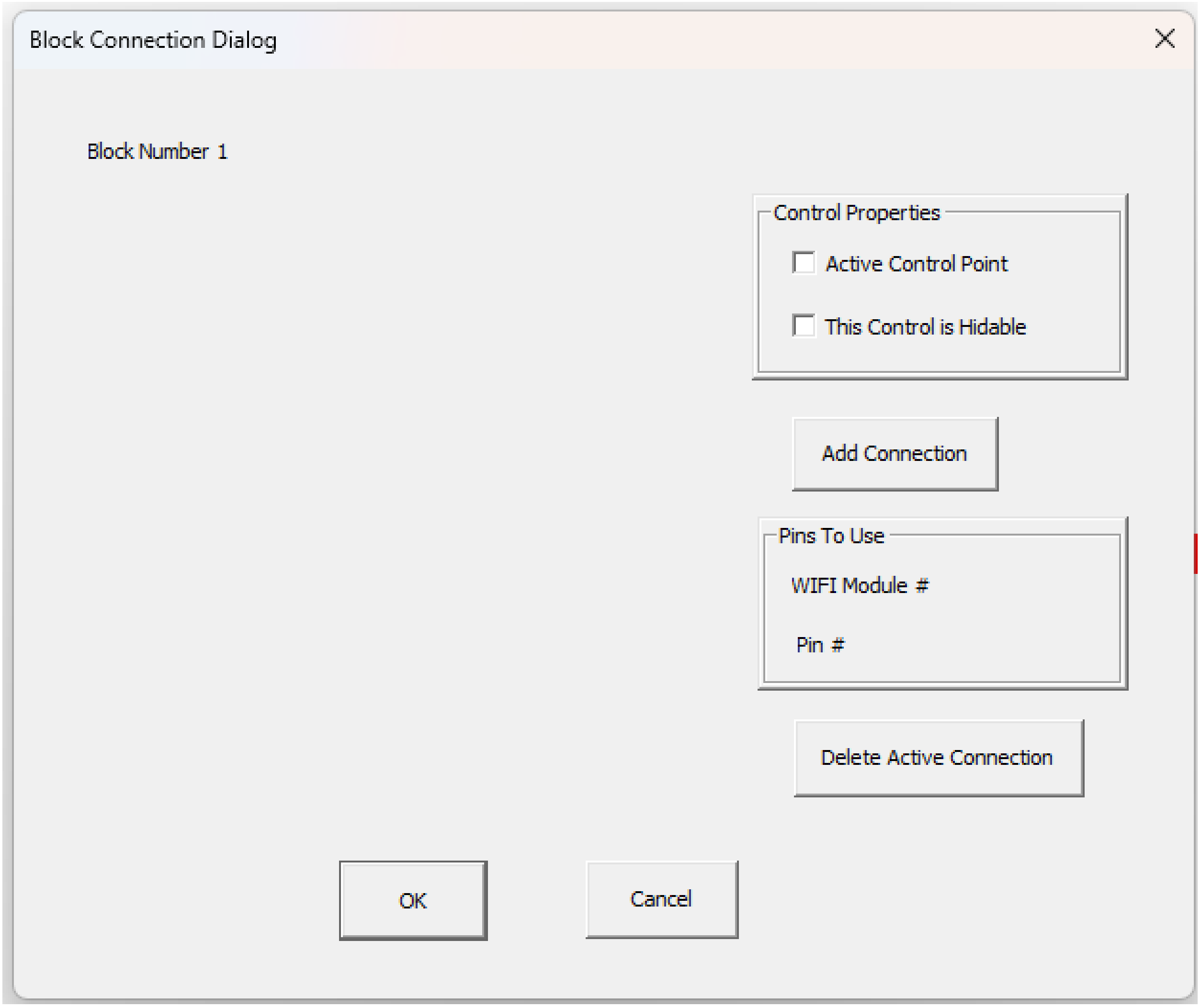
Step 6: From the View Menu item select:



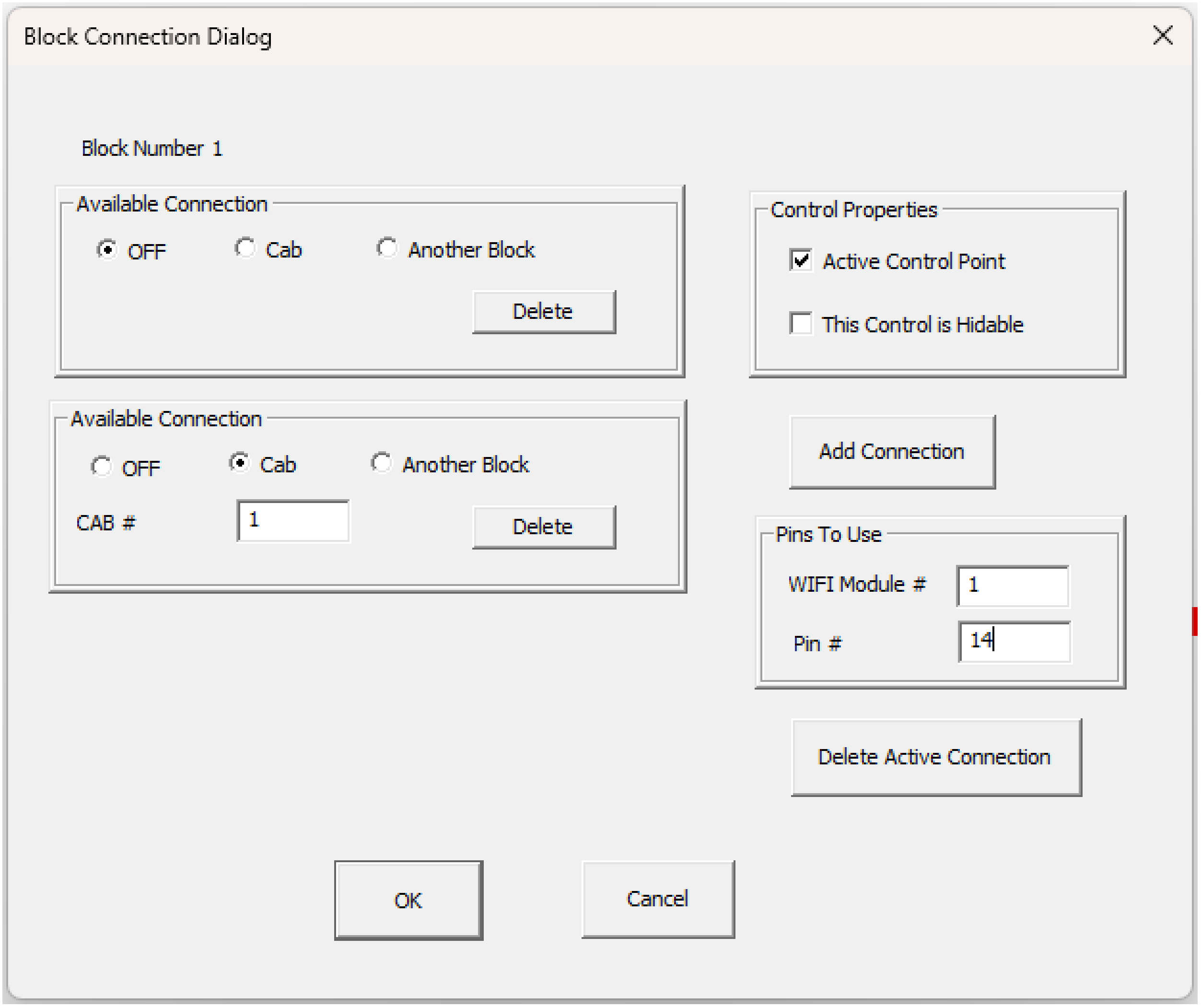
View/Show Control Boxes

This will cause a circle to appear at the center of the straight track segment.

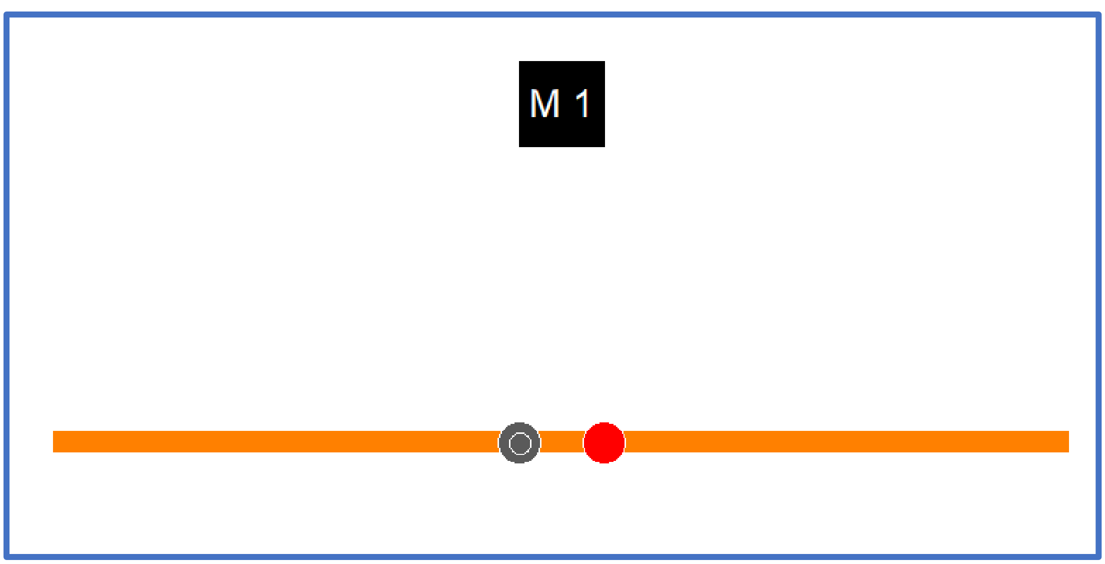
Step 7: Using the *Left Mouse Button*, click the above-described circle on the straight track segment and the following dialog will appear.



Add two connections by pushing the *Add Connection* button twice. Leave the first connection as *OFF* and change the second connection to Cab 1. Set this as an Active Control Point. Also enter the WIFI Module # and Pin #. Since we used the +13 connector on the WIFI module and the +1 connection on the card the pin # would be 14 for our example. At this point the dialog box should be as follows:

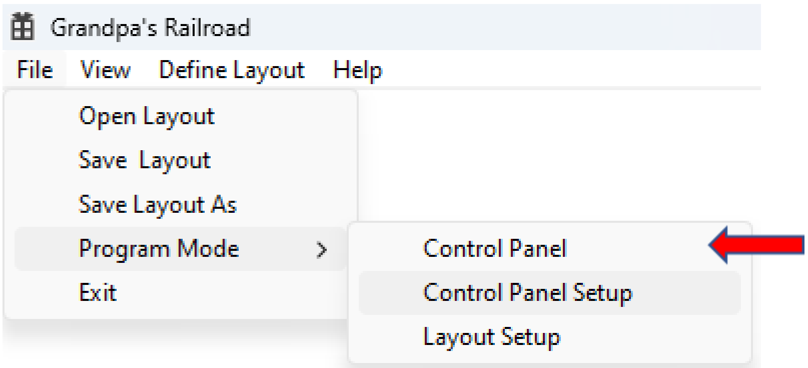


Next press *OK* and our layout should look as follows.



Step 8: Make sure the WIFI Module is powered on.

From the File Menu item select:



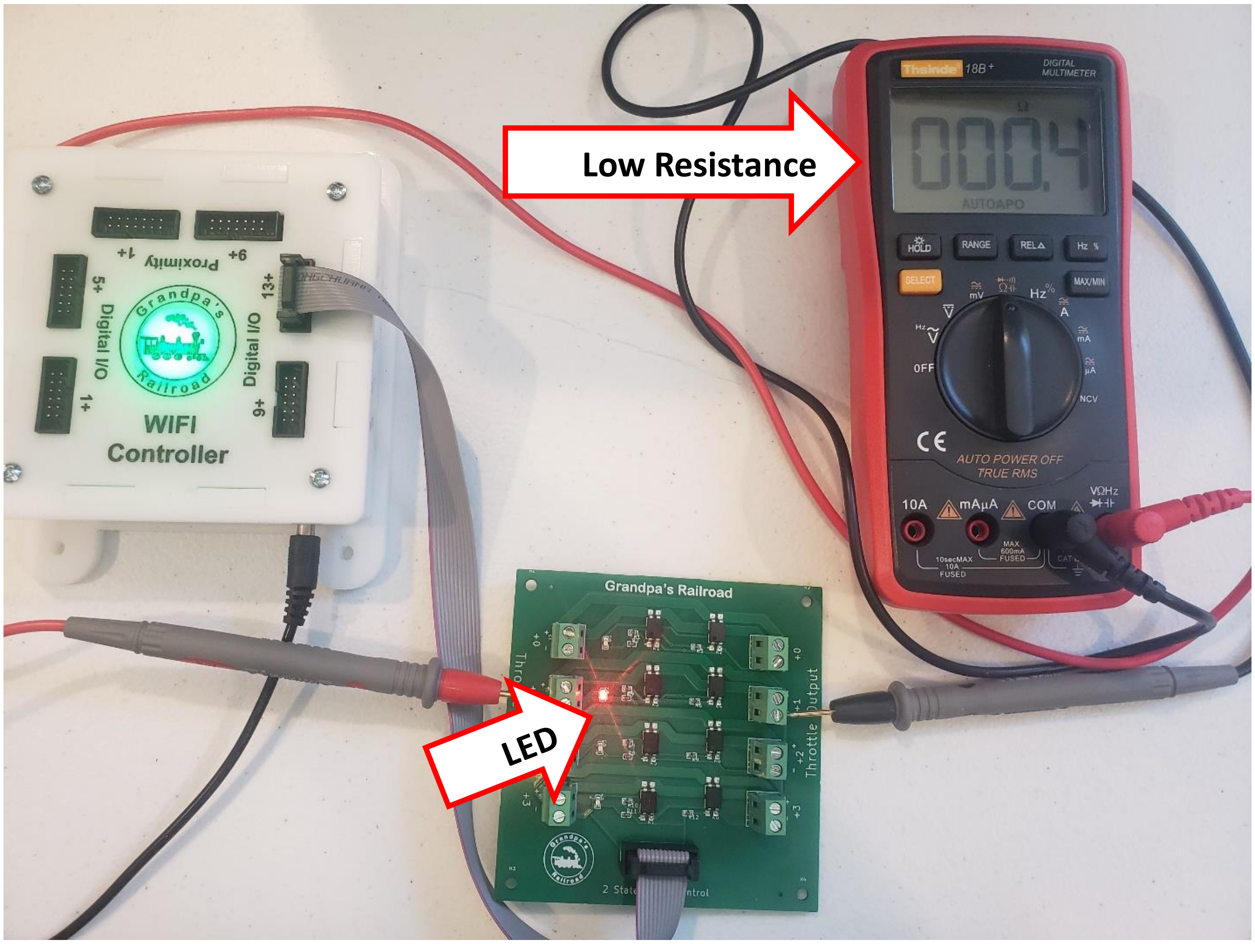
File/Program Mode/Control Panel

This will change to the Control Panel mode.

Step 9: The WIFI Module should now connect to the network and change to the connected color. The Control Point should indicate the OFF condition and the

multimeter should read a high resistance. Pressing the *__red dot__* will connect the input throttle connection to the output. The layout should be:

The multimeter should show a very low resistance and a red LED should light next to the +1 connection on the card. This indicates that the throttle is now connected to the output.



Note that when ***ON,*** the Throttle Input to Throttle Output + to + and -- to – connections will have low resistance, but the – to + and + to – terminals will always have high resistance.

3.1.6 Practical Example 3 State Block Control Coming Soon

3.2 Adding Curved Track

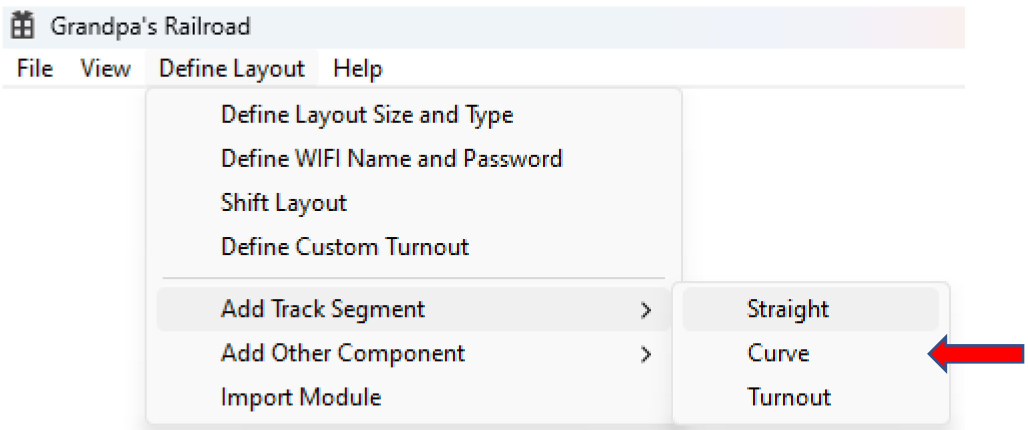
A curved track section is not associated with a particular length of track but can be an entire curved length which is composed of many individual pieces. The only requirement is that all sections of the curve must have the same radius.

3.2.1 Hardware Required

Hardware is only required if you are setting up this section to control power for the entire block. If you are, refer to 3.1.1 Adding Hardware for Straight Track since the processes are identical.

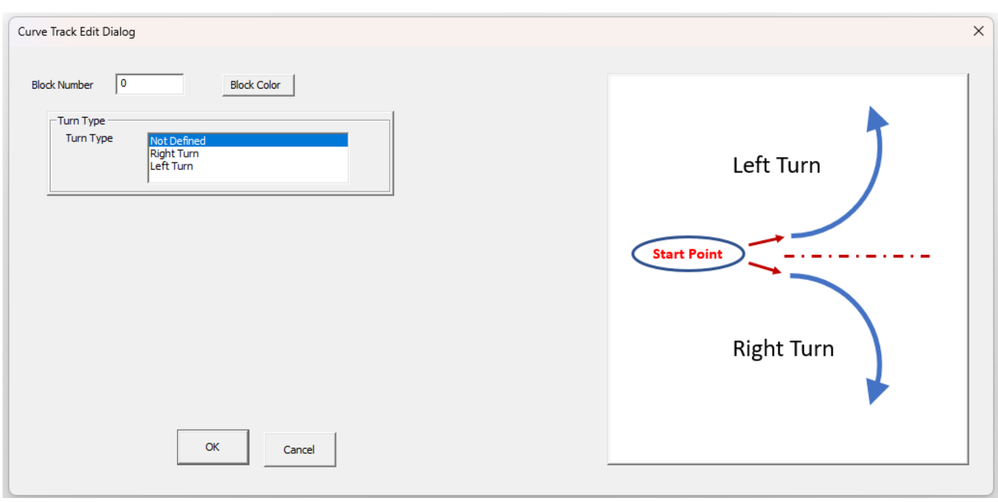
3.2.2 Adding a Curved Track Section to Your Layout

From the main menu select

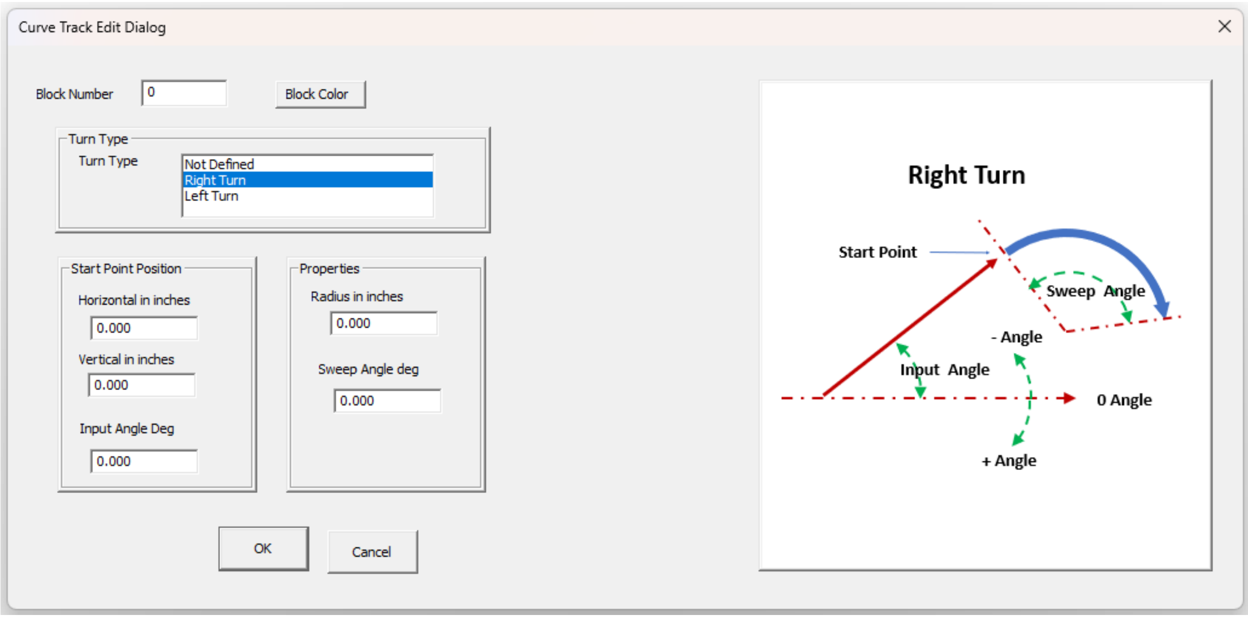


Define Layout/Add Track Segment/Curve

Upon selecting this menu item, the following dialog will appear.



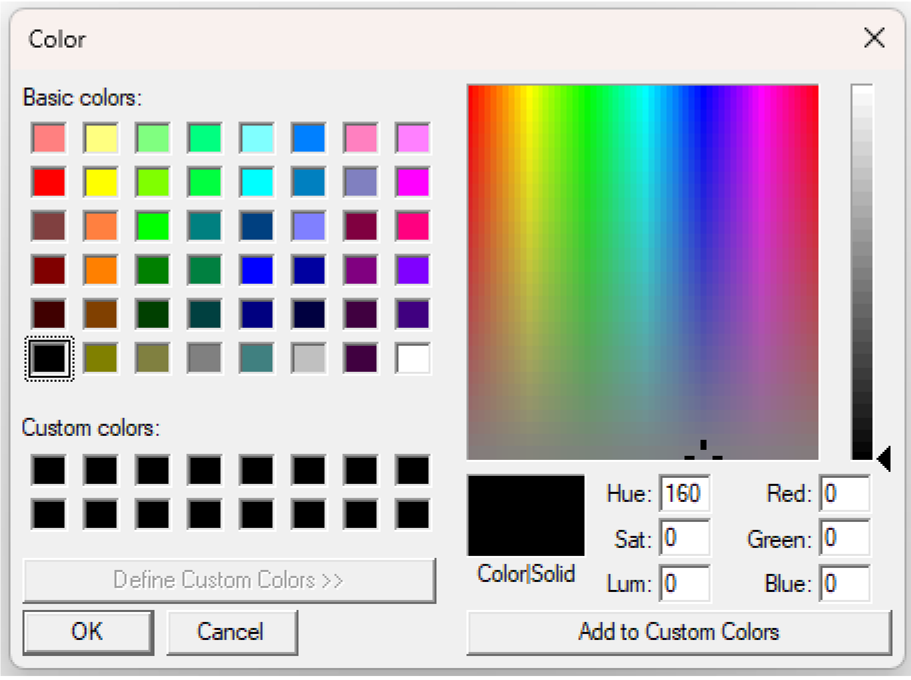
Once you have selected whether you want a right or left turn, the dialog will change as follows for a right turn.



This allows you to define the turn based on its start point horizontal and vertical position, input angle at start point, radius of the turn, and the angle that is swept by the turn. These parameters are all illustrated in the picture that accompanies the dialog.

Along with the actual segment definition, you must enter the **Block Number**. This is a number between 1 and 100. A **Block Number** represents all track elements which are electrically connected. That is, all elements which are between track insulators. Definition of Blocks in a layout is important to isolate segments allowing collision avoidance and in non DCC layouts to be able to park locomotives on sidings.

Once you have input the block number, if the block number has been previously used for another segment, the selected color for the **Block Number** will be displayed. If it has not been previously used, you will be required to use the **Block Color** button to define a color. Using this button will cause the following dialog to appear.



If the color has been previously defined and you select the **Block Color** button, the color you select from the dialog that appears will be applied to all track segments with that **Block Number**.

Once you select **OK** from the Curved Track Editing dialog and if you have entered all required data, the track segment will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

If you need to edit a track segment, you can left click with your mouse on the track segment **Edit Location** and this dialog will reappear. (See **Show Edit Locations**)

3.2.3 Setting Up a Curved Track Section for your Control Panel as a Block Control

Note: This section is only applicable if you are setting up a Block Control on this track section. A section can only be used as Block Control if it is long enough to display the control image.

The method for setting up a curved section as a block control is exactly like that of a straight track. Refer to 3.1.3 Setting UP a Straight Track Section for your Control Panel as a Block Control.

3.2.4 Control Panel Operation of a Block Control The operation of a Block Control for a curved section is exactly like that for a straight section refer to section 3.1.4 Control Panel Operation of a Block Control.

3.2.5 Practical Example Refer to straight track examples.

3.3 Adding A Turnout

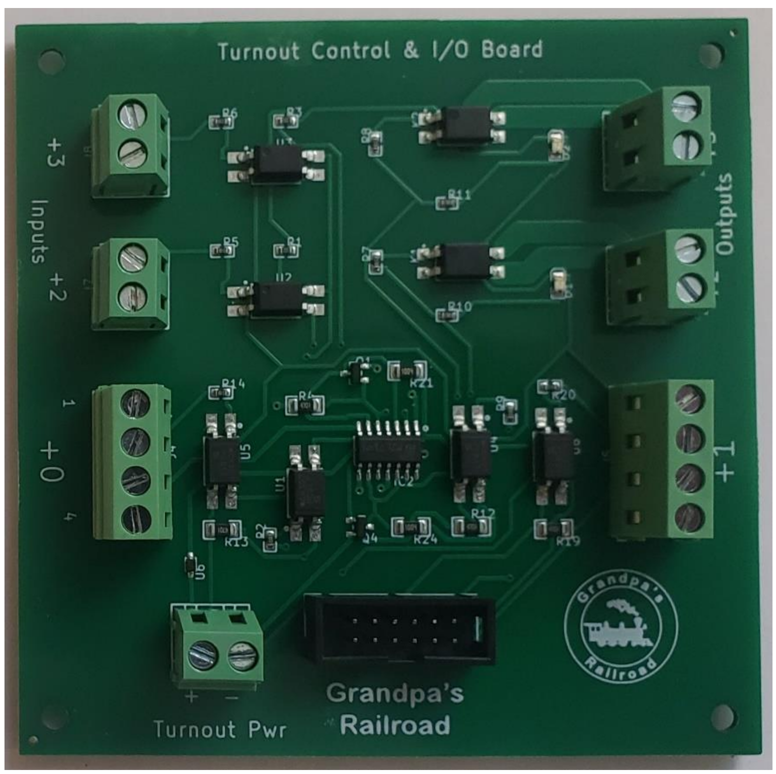
A turnout may be added to the layout from a predefined list. You can also add to this list by using the *Define Custom Layout* feature. You will be able to add right or left, straight or curved turnouts, as well as Y turnouts.

3.3.1 Hardware Required

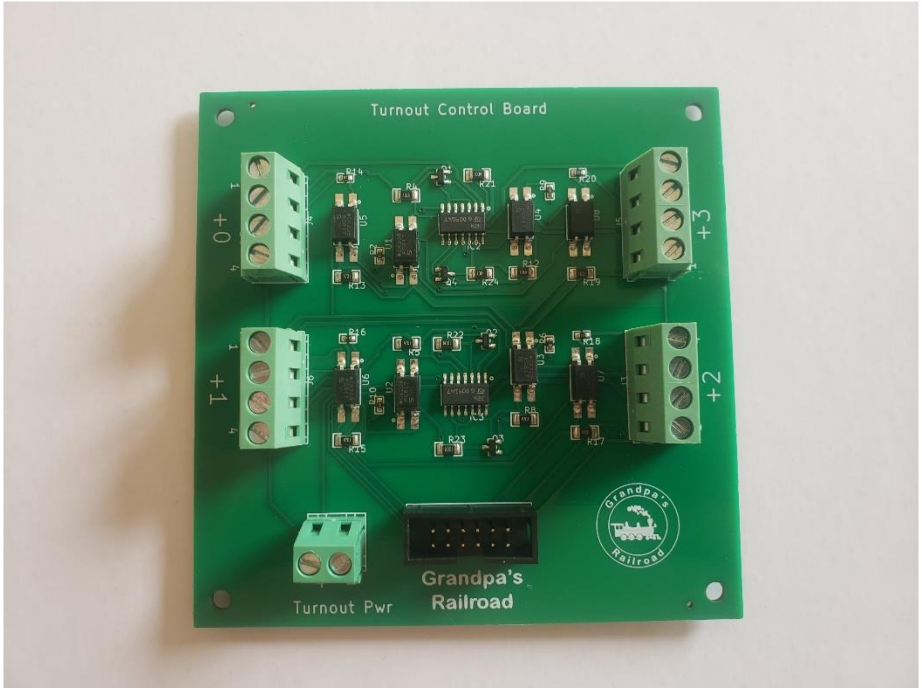
Note: Currently only servo type turnout machines like the Tortoise Slow Motion Switch Machine are supported. Use of a relay type machine with the currently available cards will cause them to fail.

There are three card types for connecting servo type turnout machines:

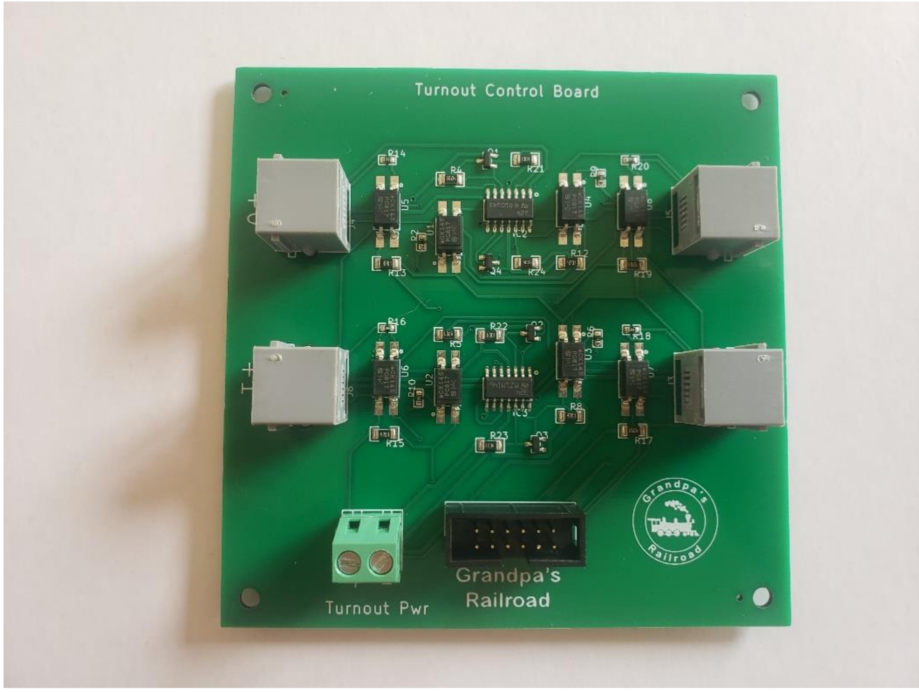
The *Turnout & I/O Board* has two screw connections for turnout machines.



The *Turnout Control Board* has four screw connections for turnout machines.



A similar board to the above uses RJ11 connectors.



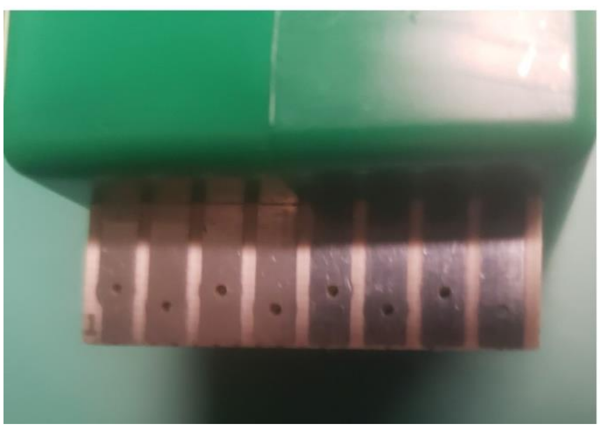
One advantage of using Grandpa’s Railroad Control Panel software is that the turnouts are wired in exactly the same manner independent of turnout machine mounting (or connector mounting). This occurs since the direction of the switch machine can be changed in the setup dialog box.

Note: Turnout machines must be wired in exactly the same manner, or the software will not work correctly.

3.3.1.1 Connection to a Tortoise Switch Machine

The Tortoise Switch Machine has an old and new version that differs mainly in their connector. These are pictured below:

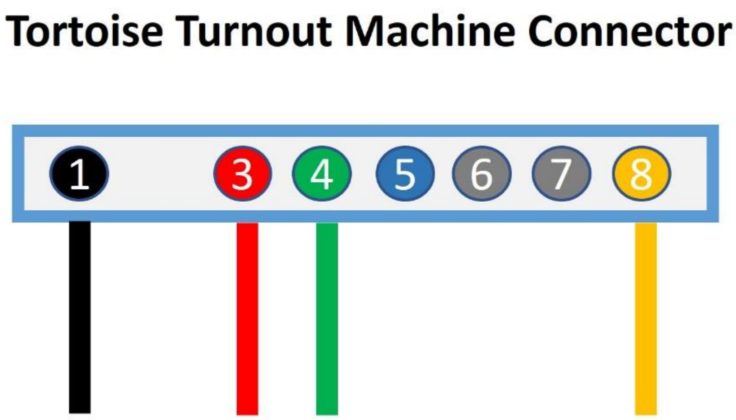
Old Design **New Design**

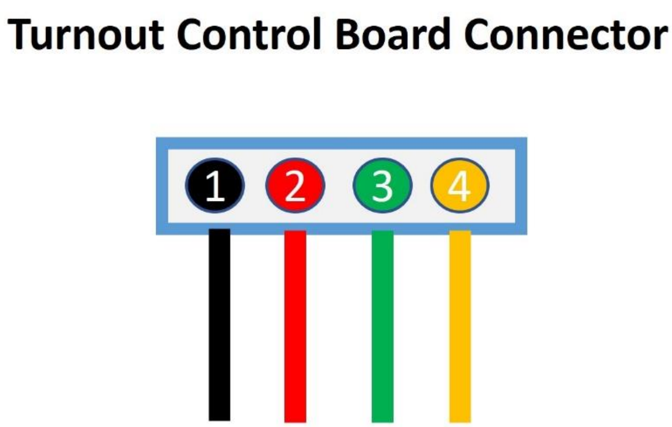


The new boards have an industry standard edge connector, while the old boards were undersized connectors. What this means is that the old boards should not be used with our optional edge connector. These old boards should be connected by soldering.

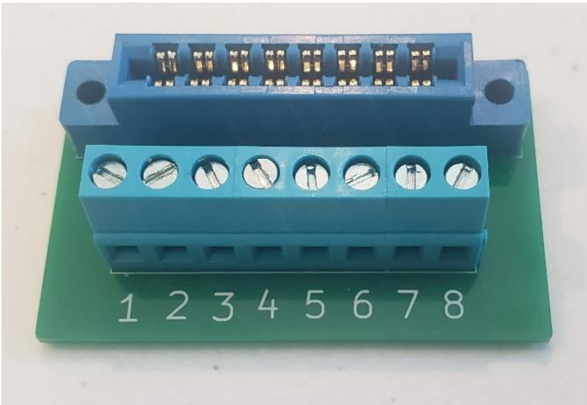
On Grandpa’s Railroad we use 26 AWG telephone cable to wire our turnouts (solid or stranded is fine). The advantage is that the cable wires are color coded, and the cable is readily available.

The wires for the Tortoise Switch Machine, should always be connected as follows.



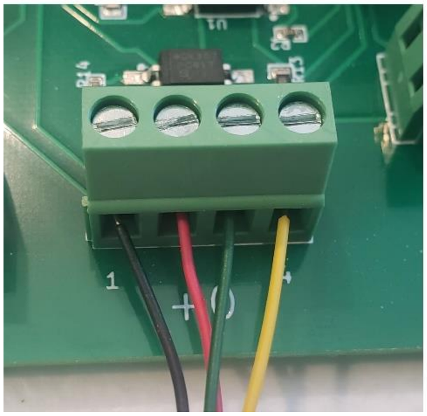


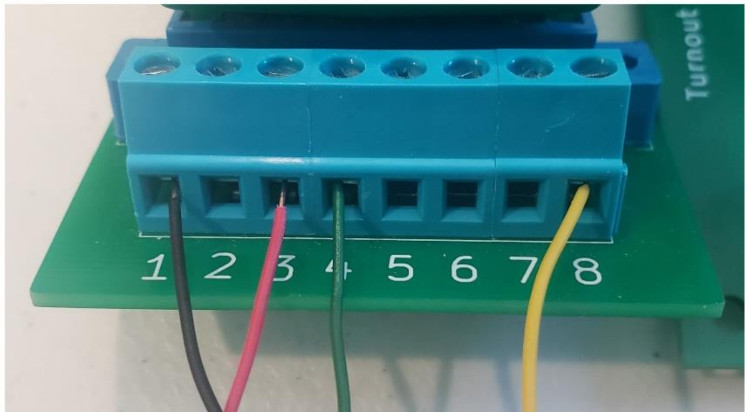
While soldering to the switch machine connector is fine, you could also use this optional Grandpa's Railroad connector that slips over the switch machine connector.



The final wiring should appear something like the picture below:

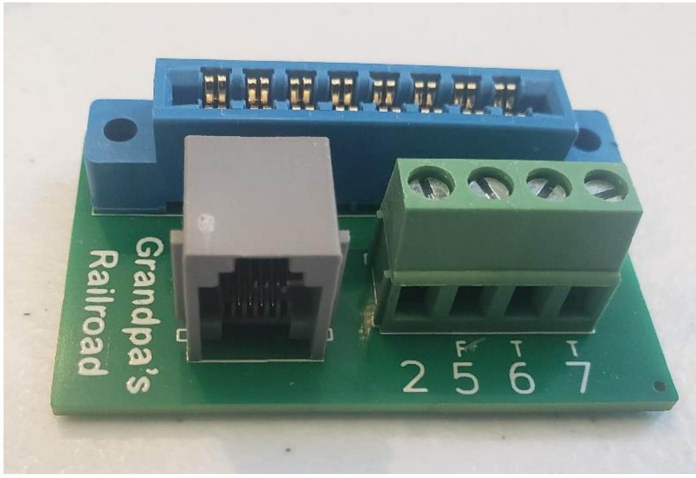
Turnout Card **Switch Machine**





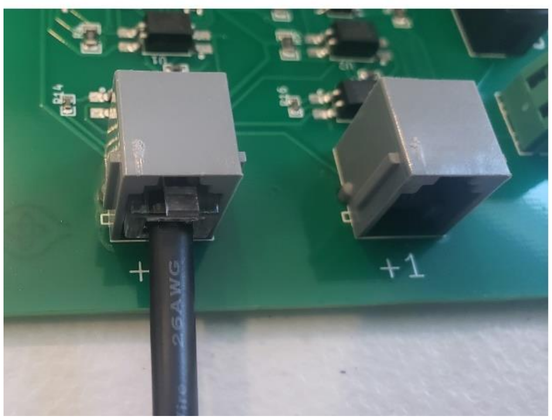
There is a second method of wiring a turnout using the Turnout Control board with RJ11 connectors. The advantage is that connections are easy to make. Cables of various lengths can be premade which is useful when you need to crawl under a layout. The disadvantage is that extra tools are required to make the cables. An example of this tool is:

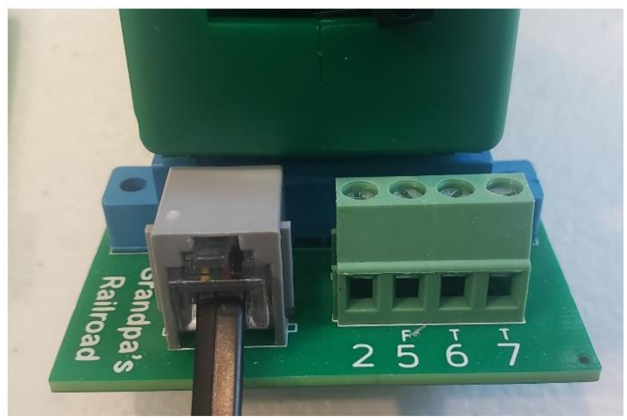
To do this you must use a Grandpa's Railroad RJ11 connector.



If you properly make a RJ11 telephone cable, the connections are as follows:

Turnout Card **Switch Machine**



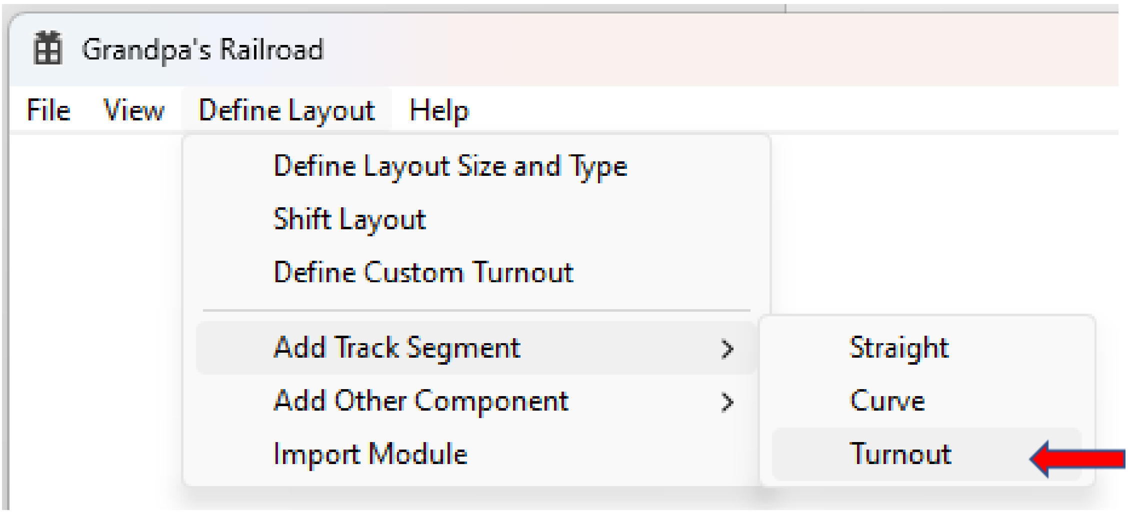


These connections are simple, clean, and easy to install or change. Also note that the unused connections on the switch machine are still available through a screw connector.

3.3.1.2 Connection to Other Switch Machines Future Addition

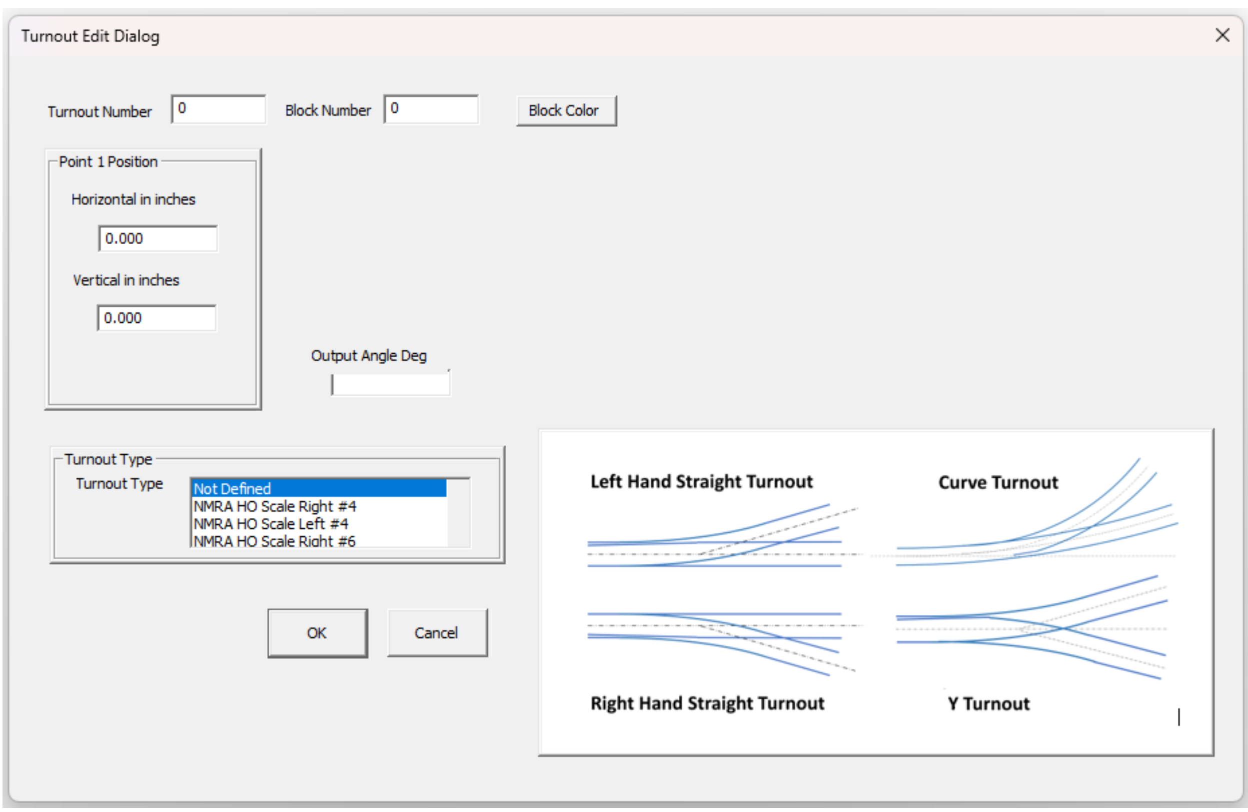
3.3.2 Adding a Turnout to your Layout

From the main menu select



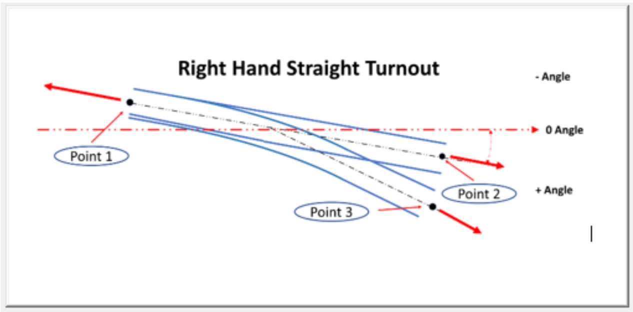
Define Layout/Add Track Segment/Turnout

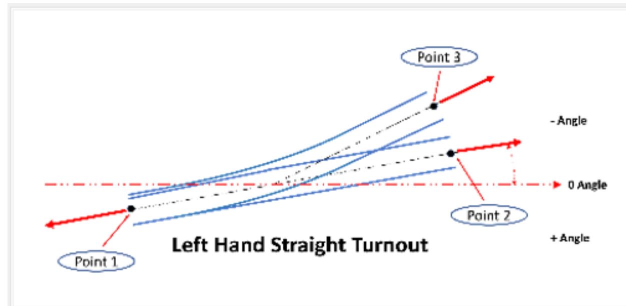
Upon selecting this menu item, the following dialog will appear.

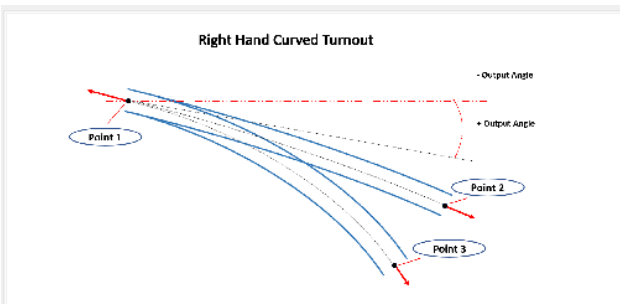


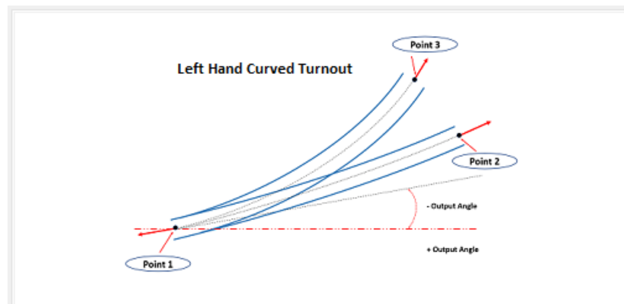
From the **Turnout Type** list, select the type of turnout you want to add. If the turnout you want is currently not in the list, you can exit the dialog using the cancel button and then define a custom turnout and add it to the list. (see **Defining a Custom Turnout**).

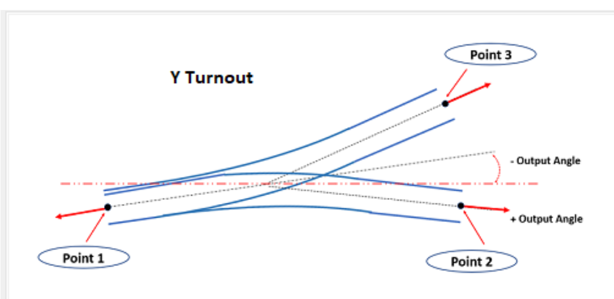
After selecting a turnout Type the image in the dialog will change depending on the type as follows:







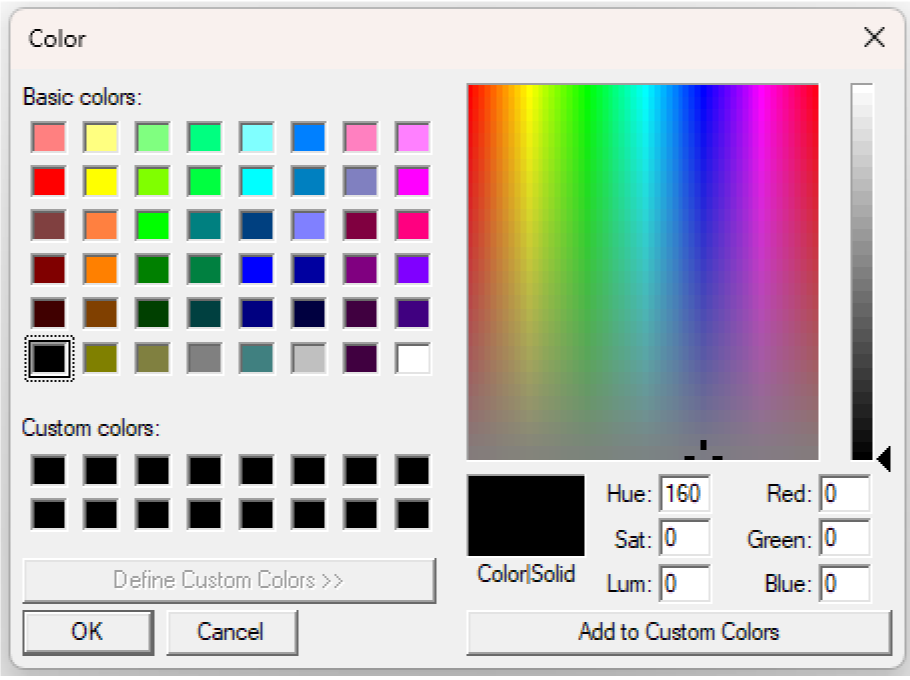




These images provide a visual definition of the parameters which must be entered in the dialog. These include the **Point 1** position and the **Output Angle**.

Along with these parameters, you must enter the **Block Number**. This is a number between 1 and 100. A **Block Number** represents all track elements which are electrically connected. That is, all elements which are between track insulators. Definition of Blocks in a layout is important to isolate segments allowing collision avoidance and in non DCC layouts to be able to park locomotives on sidings.

Once you have input the block number, if the block number has been previously used for another segment, the selected color for the **Block Number** will be displayed. If it has not been previously used, you will be required to use the **Block Color** button to define a color. Using this button will cause the following dialog to appear.



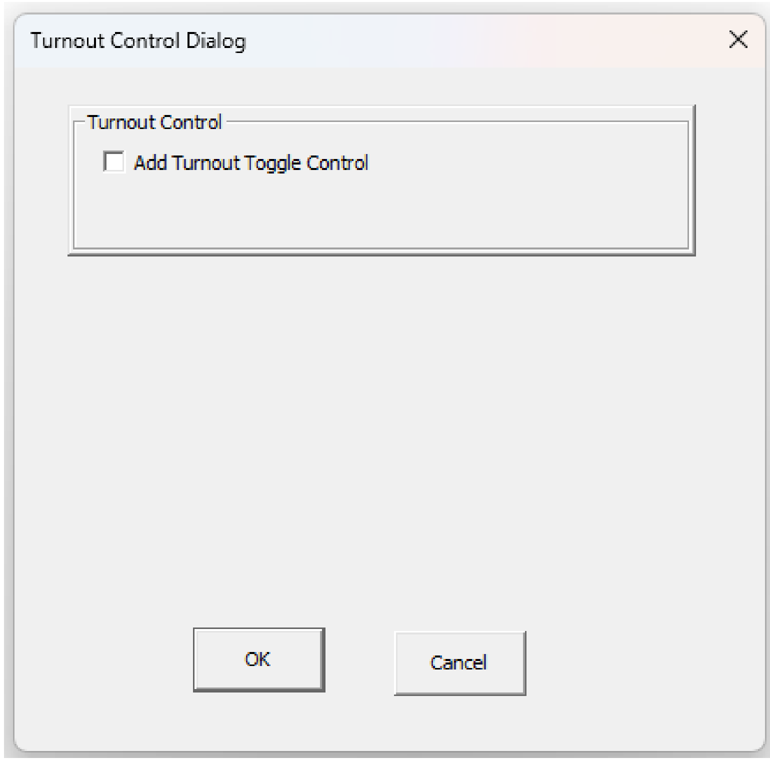
If the color has been previously defined and you select the **Block Color** button, the color you select from the dialog that appears will be applied to all track segments with that **Block Number**.

Once you select **OK** from the Turnout Edit dialog and if you have entered all required data, the turnout segment will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

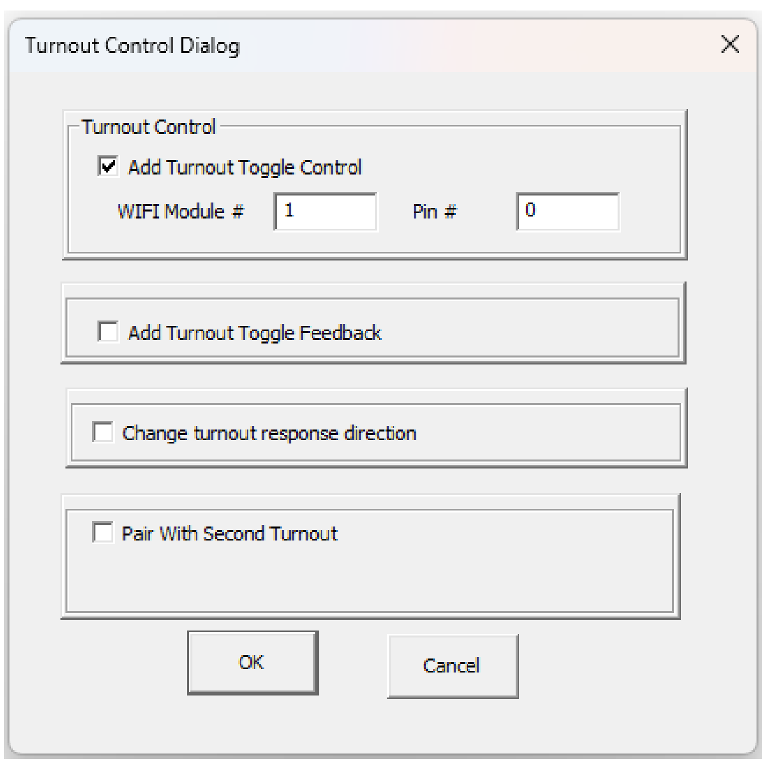
If you need to edit a turnout, you can left click with your mouse on the turnout element **Edit Location** and this dialog will reappear. (See **Show Edit Locations**)

3.3.3 Control Panel Setup for a Turnout

To set up a turnout you must be in the **Control Setup** mode. Using the *Left Mouse Button*, click the **Control Box** (See **Show Control Boxes**) for the turnout which is near the center of the turnout and the following dialog will appear:



If you check the box ***Add Turnout Toggle Control,*** additional items will be displayed allowing setup.

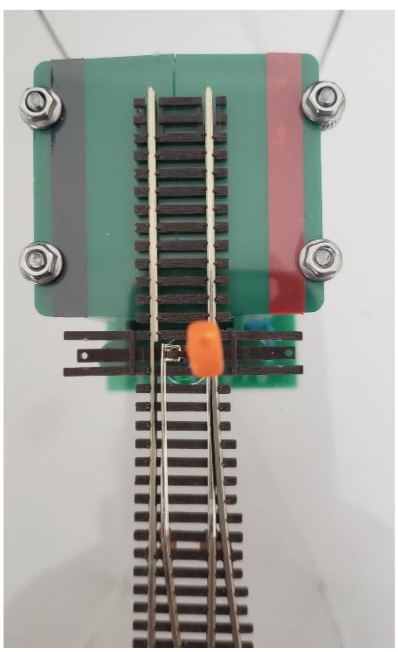


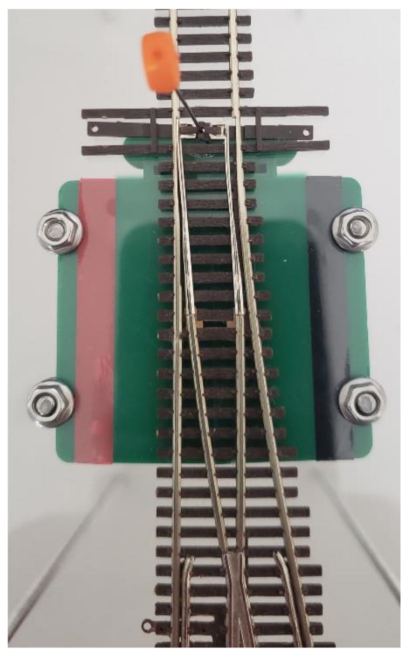
You must enter the ***WIFI Module #*** that the Throttle Control card is connected to. That number is the actual number that is programmed into the WIFI Module. Note: All modules are shipped with a Module Number of 1. You can use the WIFI Module Programmer software to change that number if your layout has more than one module. (Put Link into User's Manual)

The Pin # is calculated by adding the number of the connector on the WIFI Module where the ribbon cable is connected and the Input Pin number on the card used.

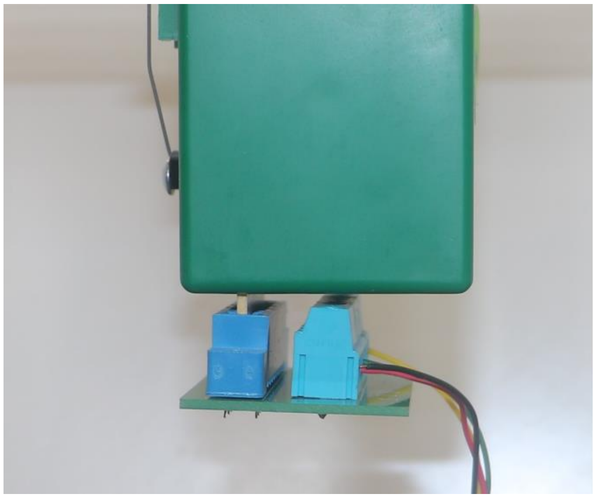
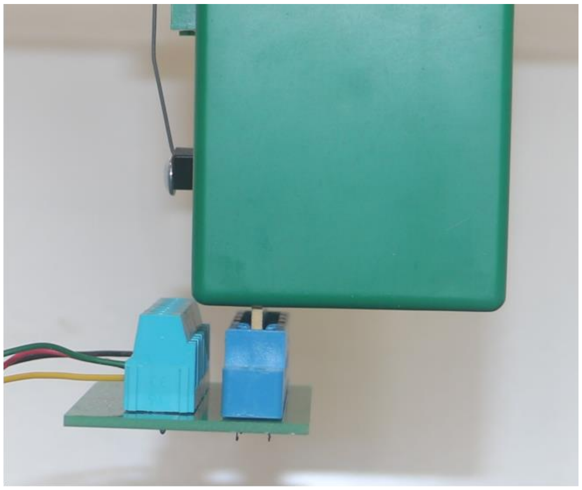
Add Turnout Toggle Feedback can be added if there is a return signal from the turnout connection that indicates the actual turnout position. We have implemented this feature with the Tortoise switch machine connection that we have showed earlier. This will cause an indicator on the display to change when the turnout is in the desired position. This will be described in the control panel mode.

Change Turnout Response Direction is an adjustment that allows you to connect the switch machine motor and connector in any orientation. The picture below shows a switch machine mounted on a clear surface below a turnout. Red and



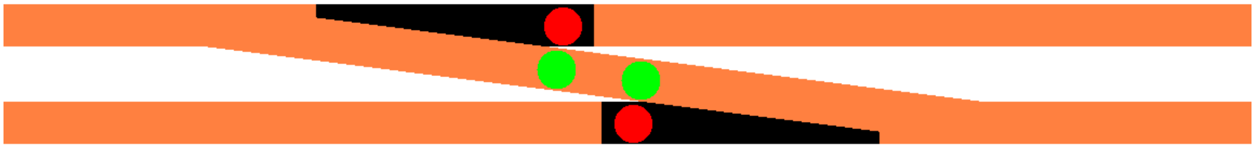


black tape has been placed on top of the turnout. Note that when the turnout machine is oriented toward the red tape the turnout changes from straight to siding depending on the mounting. Likewise, if you change the orientation of the connector on the switch machine as shown below, the direction of the motor will change.

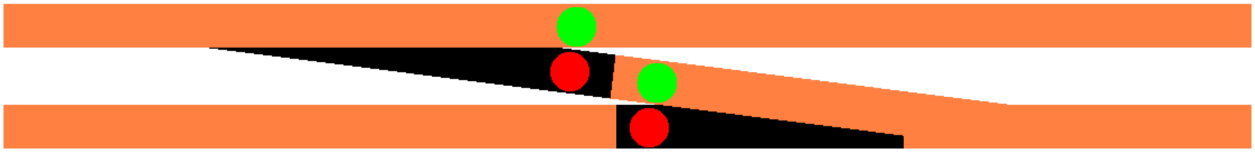



By checking the ***Change Turnout Response Direction*** box, the direction of switch machine output will change. _The easiest way to determine the correct setting for this box is to do all your hardware and software setup and then try it. If the indicator on the control panel does not match the turnout direction, checking this box will fix it._ Therefore, you do not have to worry about orientation when mounting your switch machines.

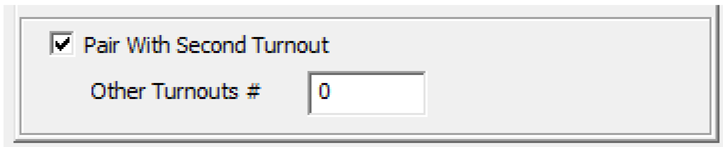
In some cases, on a layout two turnouts should always work together. For example



It would make no sense to allow the following configuration.



To allow the turnouts to operate together you can pair them. By checking the ***Pair with Second Turnout*** box, the dialog will change allowing you to enter the number of the turnout you wish to pair with.



Note: The second turnout must also have the pairing button activated with the appropriate turnout number.

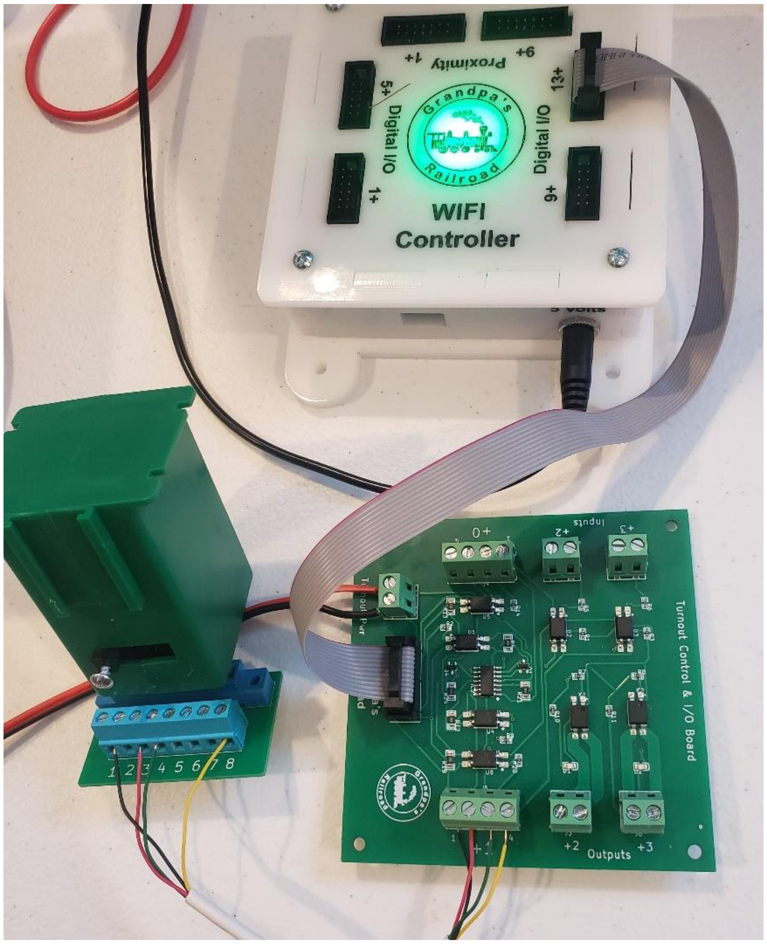
3.3.4 Control Panel Operation for a Turnout

To change the direction of a turnout in the control panel mode, simply place the mouse cursor over the circle indicating direction you wish the turnout to be and press the *Left Mouse Button*. If you are not using ***Turnout Toggle Feedback*** the circle will be black and white. Placing the mouse over the black circle and pressing the *Left Mouse Button* will cause the circle colors to toggle as well as the color of the active turnout direction. These changes will happen immediately. When using ***Turnout Toggle Feedback,*** the colors will be green for the current direction and red for the other direction. Placing the mouse over the red circle and pressing the *Left Mouse Button* will cause the active track direction color to change immediately. However, the red and green circles will not change colors until the feedback from the turnout connection indicates that the turnout has changed direction. This positive feedback assures the turnout direction corresponds to the actual direction.

3.3.5 Practical Example

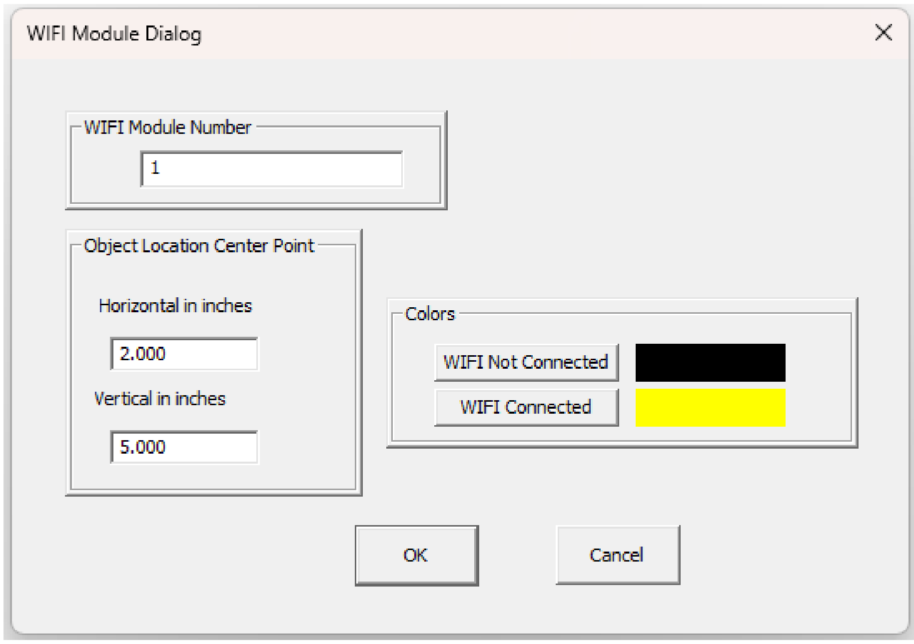
A simple example adding a turnout is illustrated below. In this example we will show that the direction of the Tortoise servo motor changes as we toggle the turnout.

Step 1: Connect a Turnout Control and I/O Card to the WIFI module. Note that in the photo below, the card is connected to the +13 connection and the turnout is connected to the +1 connection on the card. Also 12 volts DC should be connected to the *Turnout PWR* connector of the card. Make sure that you have the polarity of the 12 correct.

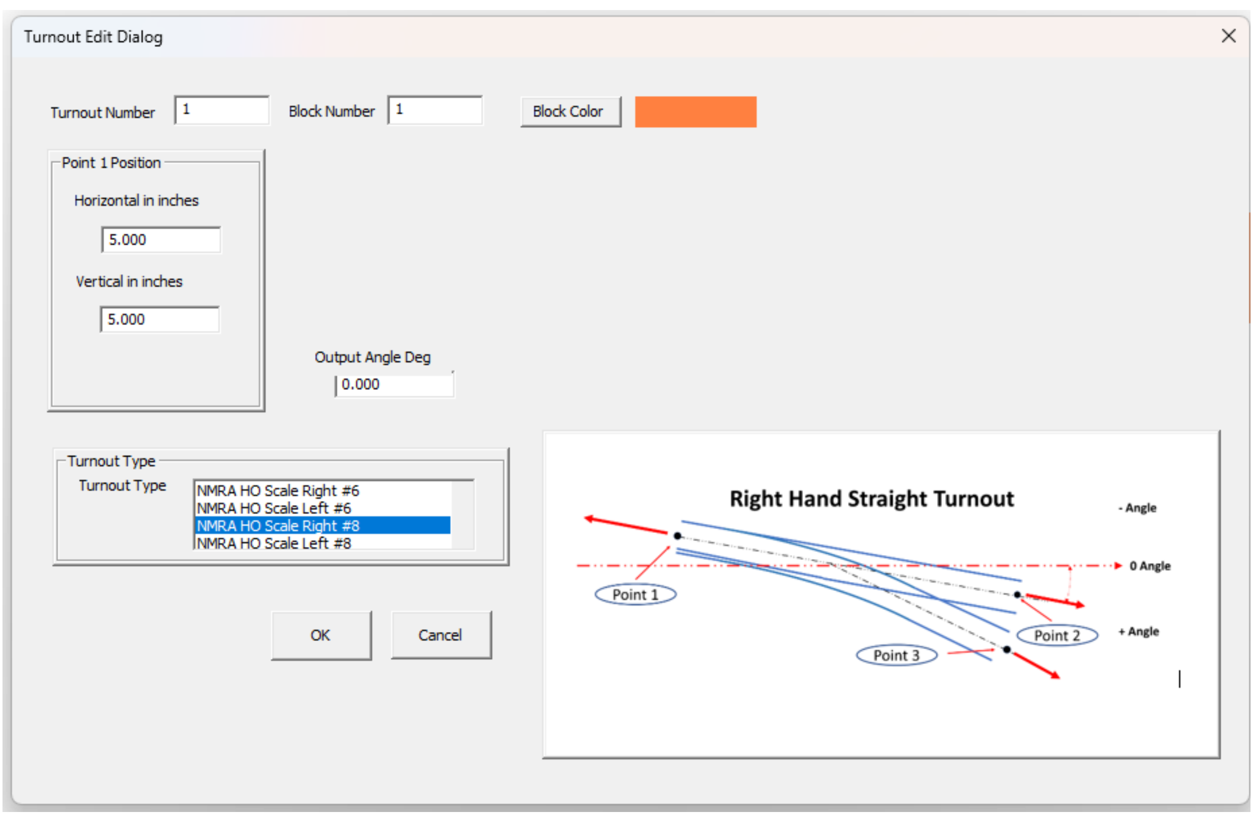


Step 2: Start the Grandpa's Railroad Application, select the **Layout Setup** mode, and create a 20-inch by 20-inch layout in HO scale. (Note: A layout does not need to be complete. In this example we are only adding a turnout.)

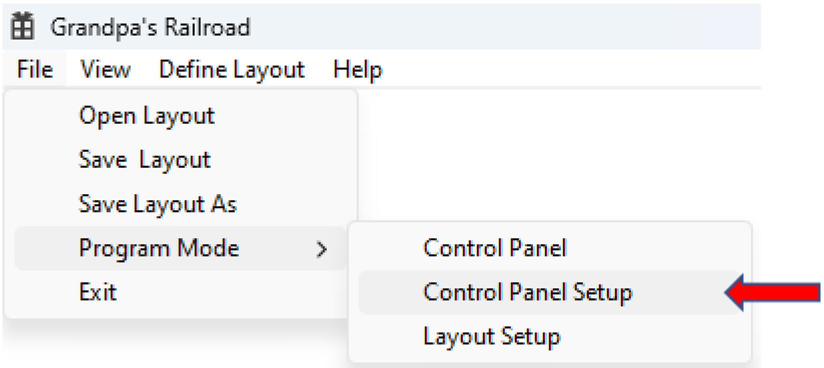
Step 3: Add a WIFI module to the layout at 2 inches Horizontal and 5 inches Vertical with the desired <u>Connected</u> and <u>Not Connected</u> colors. If you are using the supplied WIFI Module and have not changed the number, enter a 1 for the Module Number.



Step 4: Add a turnout to the layout. Place a NMRA HO Scale Right #8 at 5 inches horizontal and vertical with a zero output angle.



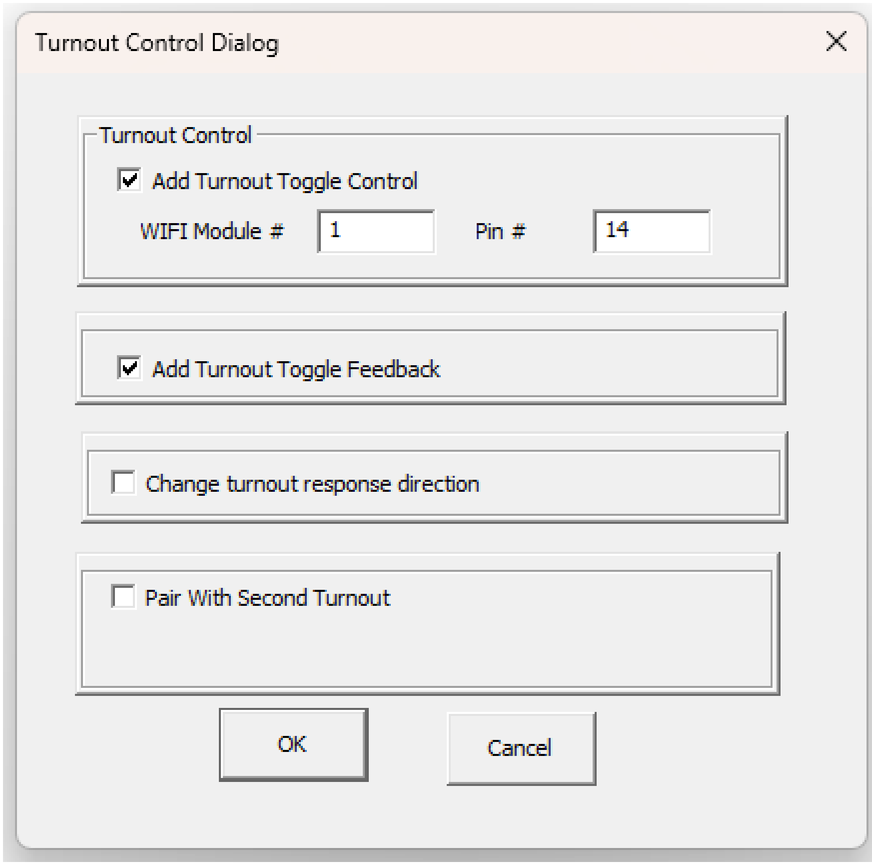
Step 5: From the File Menu item select:



File/Program Mode/Control Panel Setup

This will change to the Control Panel Setup mode.

Step 6: Left click with your mouse on the turnout element **Control Box** and the following dialog will appear. (See **Show Control Boxes**)



Enter the WIFI module # and Pin #. Select Turnout Toggle Feedback.

At this point your layout should look as follows:

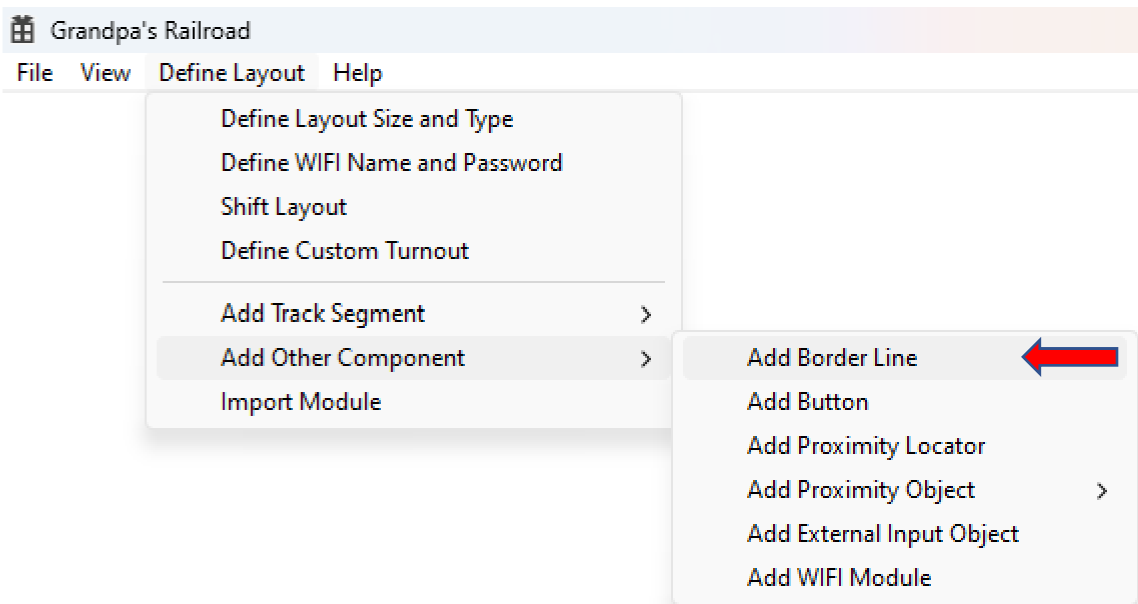
Step 7: Change to the Control Panel mode. As you toggle the turnout by clicking on the red circle with the left mouse button the motor should travel from one side to the other.

<u>If there is a problem, it is always wise to first check that you have wired it correctly. Secondly, check that the wires are properly fit and secured into the connectors.</u>

3.4 Adding Border Line

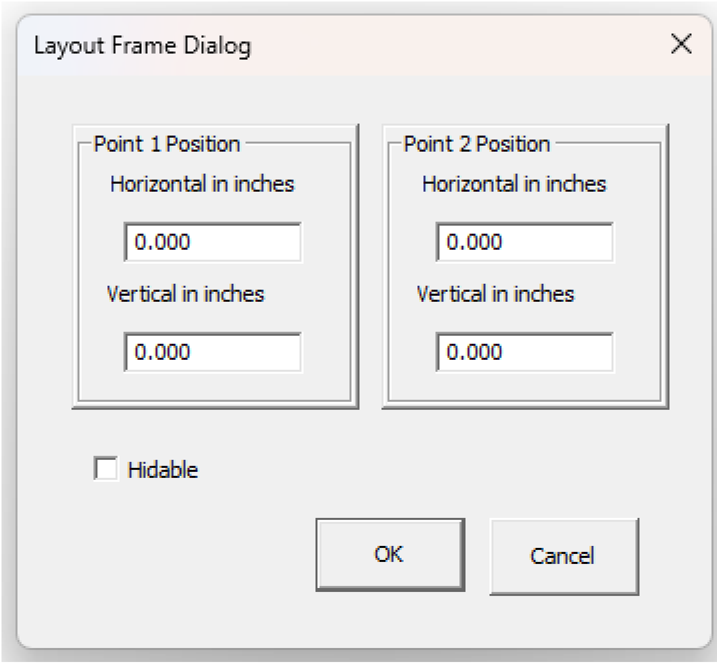
A border line is a boundary on your layout that you wish to show. For example, this could be your actual table outline.

From the main menu select



Define Layout/Add Other Component/Add Border Line

Upon selecting this menu item, the following dialog will appear.



This dialog allows you to enter the two end points of a border line. It also allows you to make the line hidable in the **Control Panel** mode. This is useful for defining the internal or side borders of a module, but later hiding them once you have built the final layout. Once you select **OK** and if you have entered all required data, the border line will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

If you need to edit a border element, you can left click with your mouse on the border element **Edit Location** and this dialog will reappear. (See **Show Edit Locations**)

3.5 Adding Button

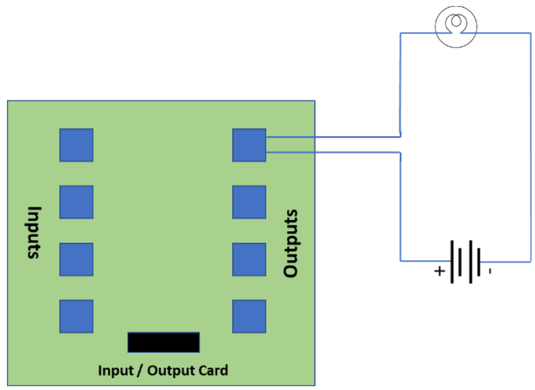
A **Button** is a switch used to turn a digital pin ***On*** or ***Off***. As such, it can control whatever is connected to that pin.

3.5.1 Hardware Required

The most basic application of a button is to control a light or some other external electric device. To accomplish this, you will need at least one **Output Pin** on an *Input/Output Card* or a *Turnout Control & I/O Board*. (Put in link to card

Specifications) The output pins on these boards act as a switch for AC or DC current. (Note: Refer to the card specifications for voltage and amperage limits.)

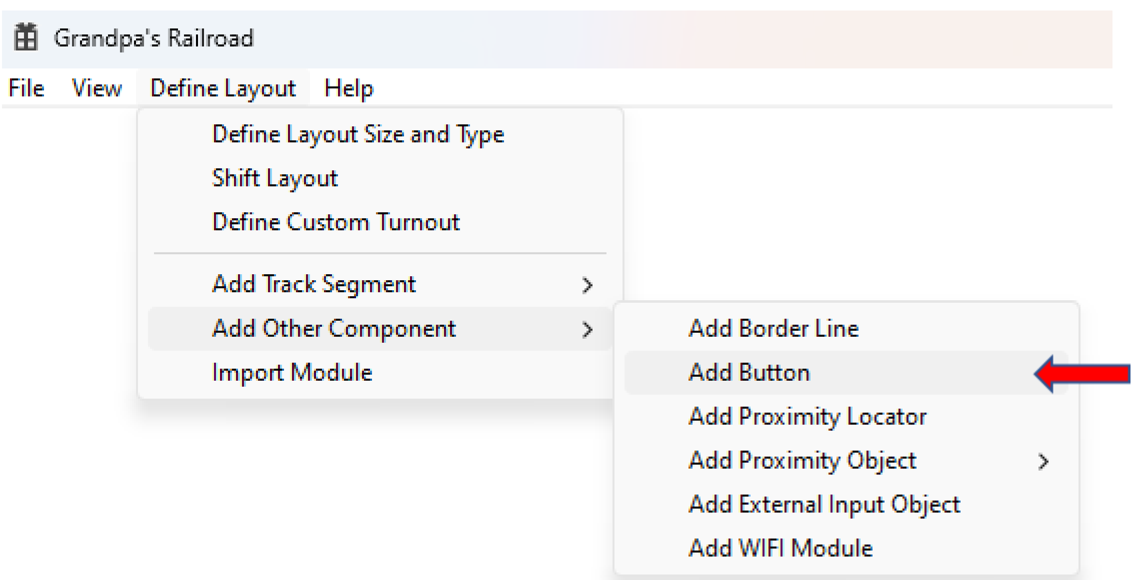
A simple schematic of connecting a light to the Output Pin is shown below:



To learn more about electricity, voltage, and current watch Educational Tutorials "Electricity 99".

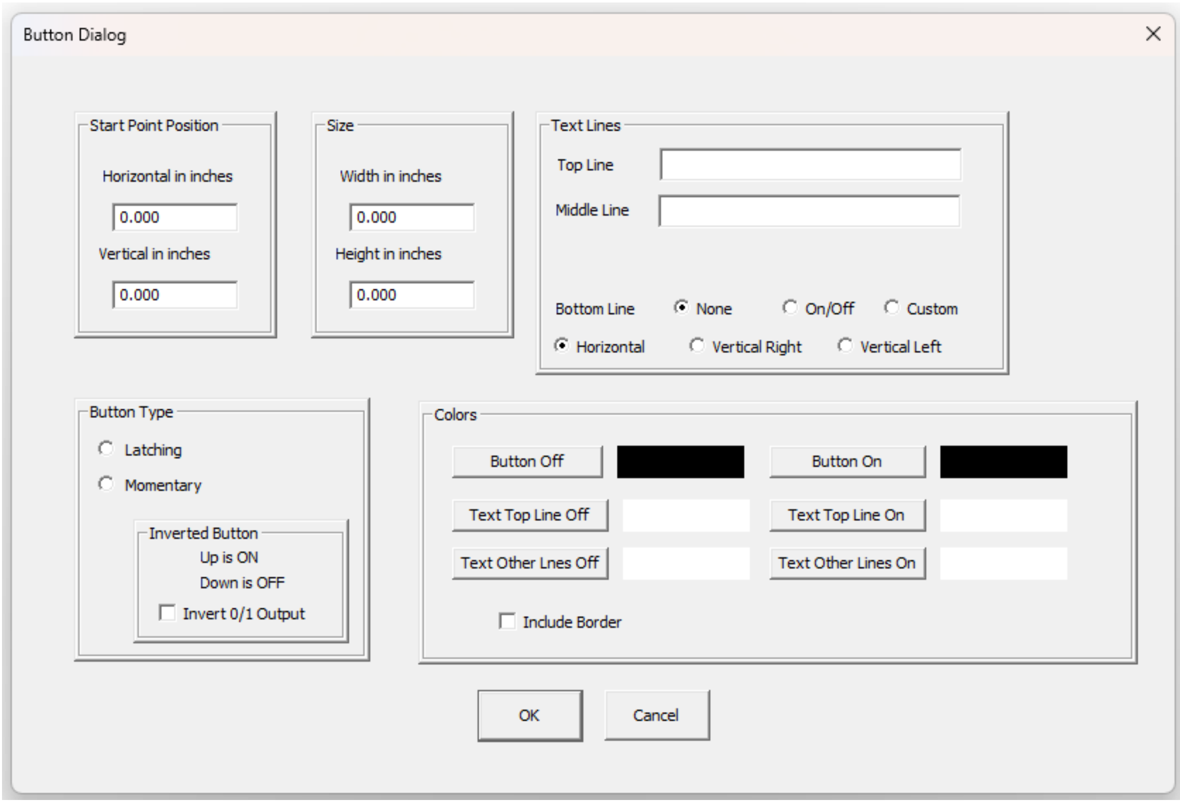
3.5.2 Adding a Button to your Layout

To add a Button to your layout you must be in the **Layout Setup** mode. From the main menu select



Define Layout/Add Other Component/Add Button

Upon selecting this menu item, the following dialog will appear.



This dialog allows you to customize each button by size, color, text, etc. You must enter the following parameters:

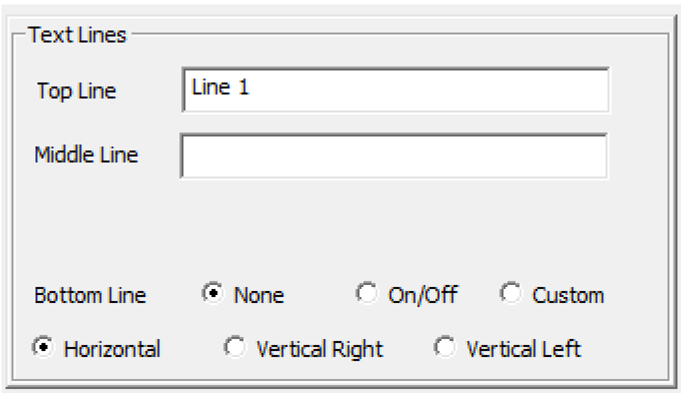
<u>Start Point Position</u> is the location of the upper left corner of the button. If the button is associated with a particular item on your layout such as a building, it is advantageous to place the button where that item is located.

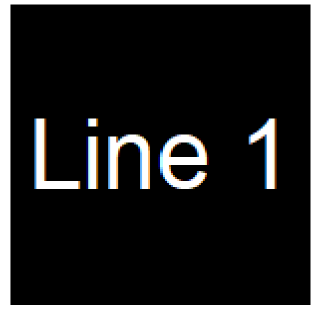
<u>Size</u> defines the dimensions of the button. As with the position, if the button is associated with a particular item on your layout such as a building, it is advantageous to size the button to that items size.

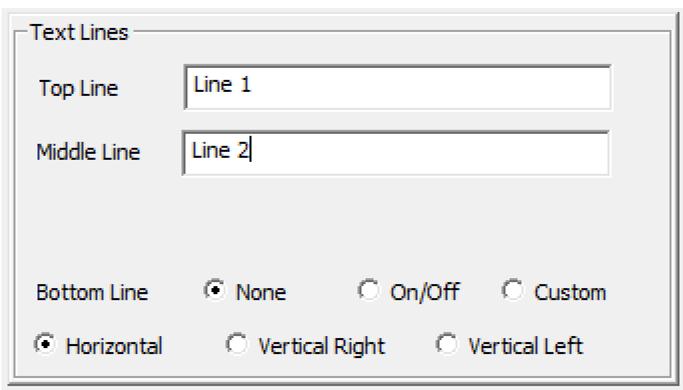
<u>Button Type</u> allows you to specify whether the button is **Latched** or **Momentary**. A latched button is turned *On* with the first left mouse click and turned *Off* with the second left mouse click. A momentary button is on only while the left mouse button is held down.

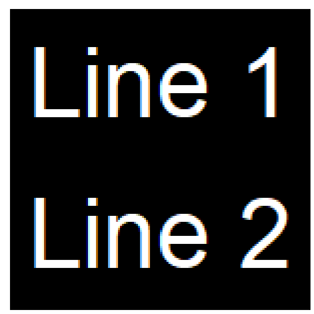
Invert I/O Output reverses the state of the button. That is a momentary button will normally be *On* and will be turned *Off* while the left mouse button is held down.

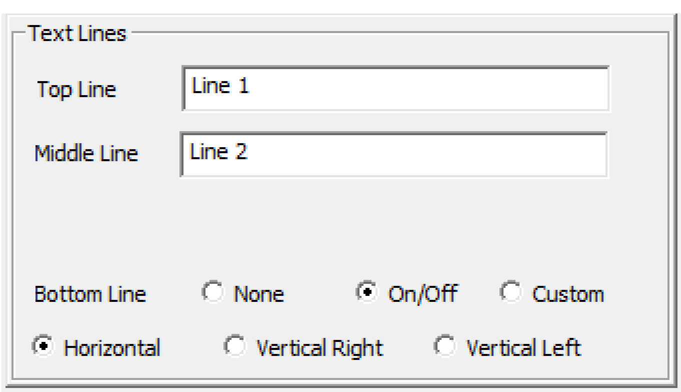
The **Text Lines** group allows the addition of one, two, or three lines of text to the button as shown below:

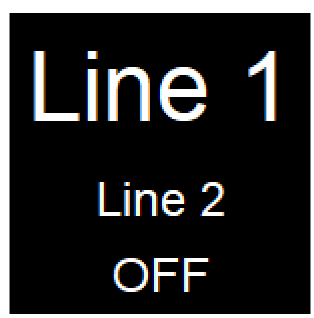




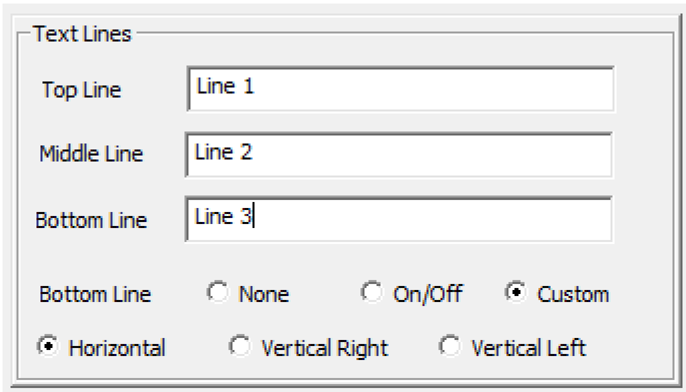


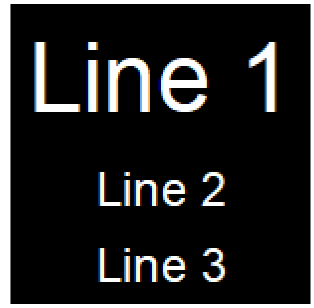


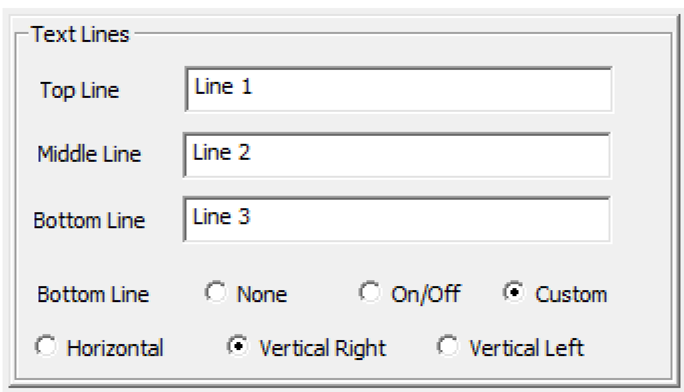


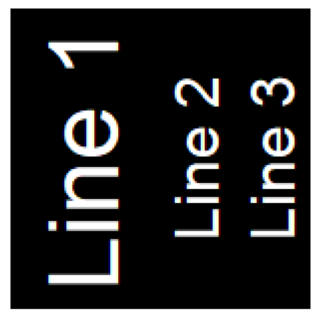


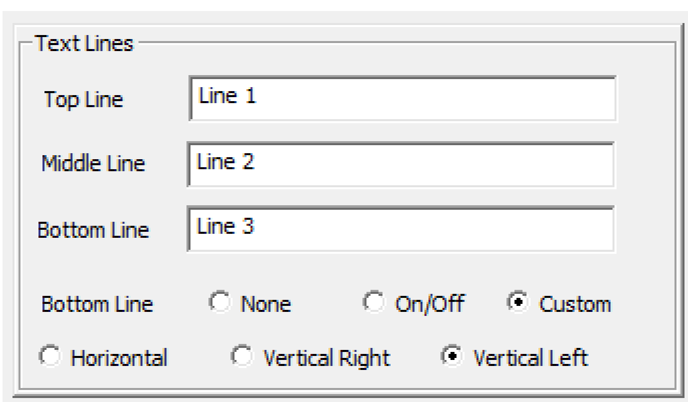
For the above case, selecting **Bottom Line On/Off** will cause *Off* to be displayed on the bottom line when the button is off and *On* when the button is on.

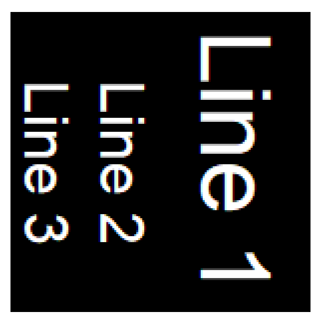




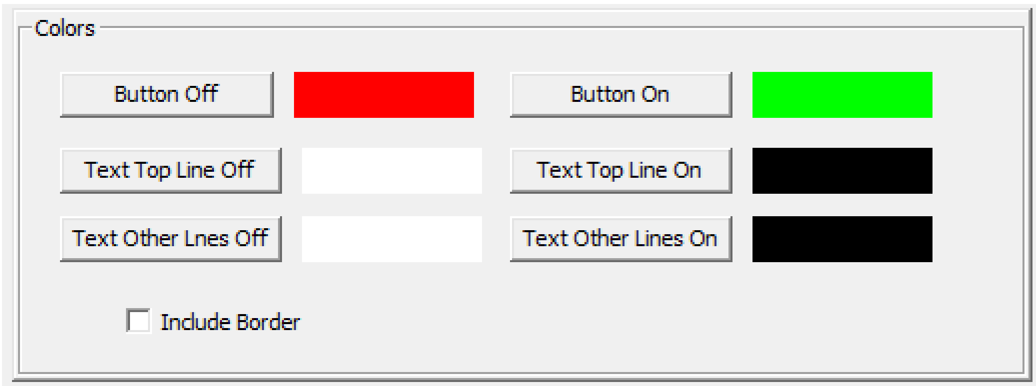


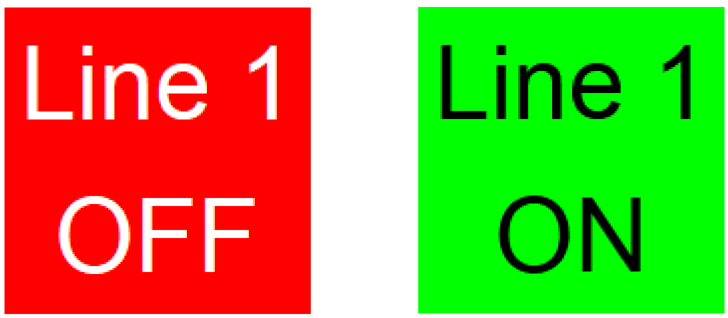




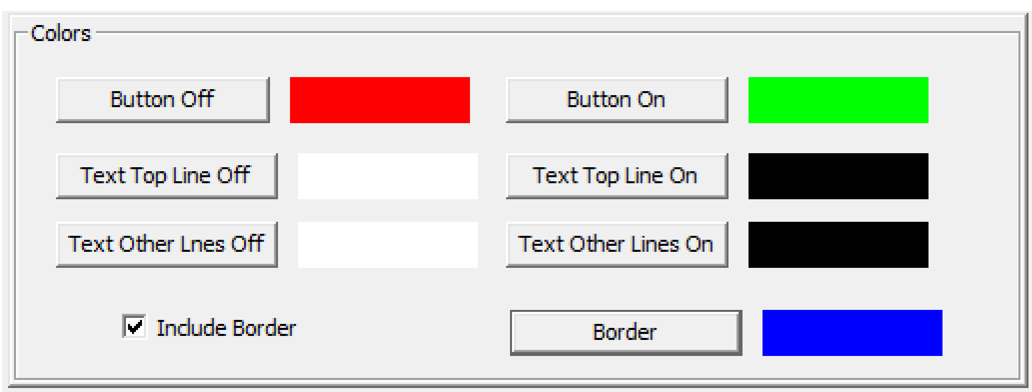


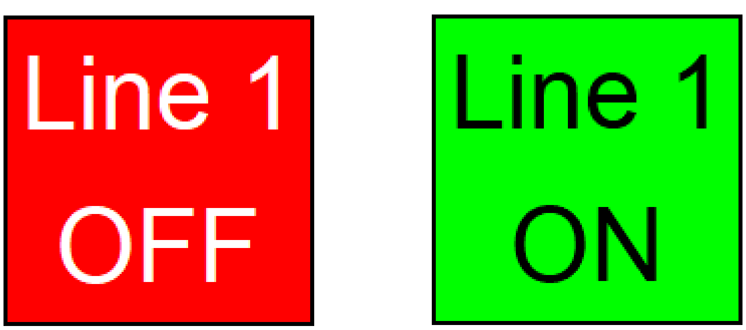
The **Colors** group is used to customize the *On* and *Off* colors of not only the button but also the text.





The **Include Border** check box allows a border color to be selected for the button.



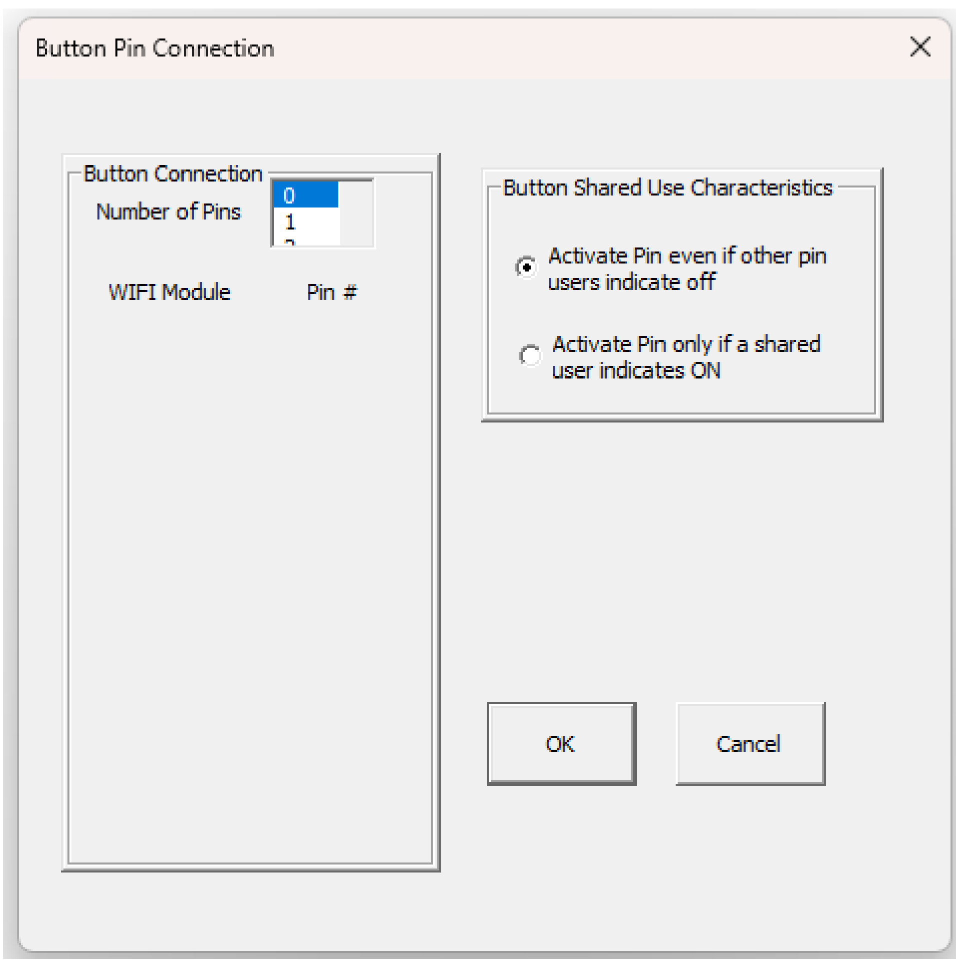


A button may also be used as a line of text or a non active layout element, simply by not associating it with a output pin in the Control Panel Setup mode. For a text line or lines simply specify the button color as white.

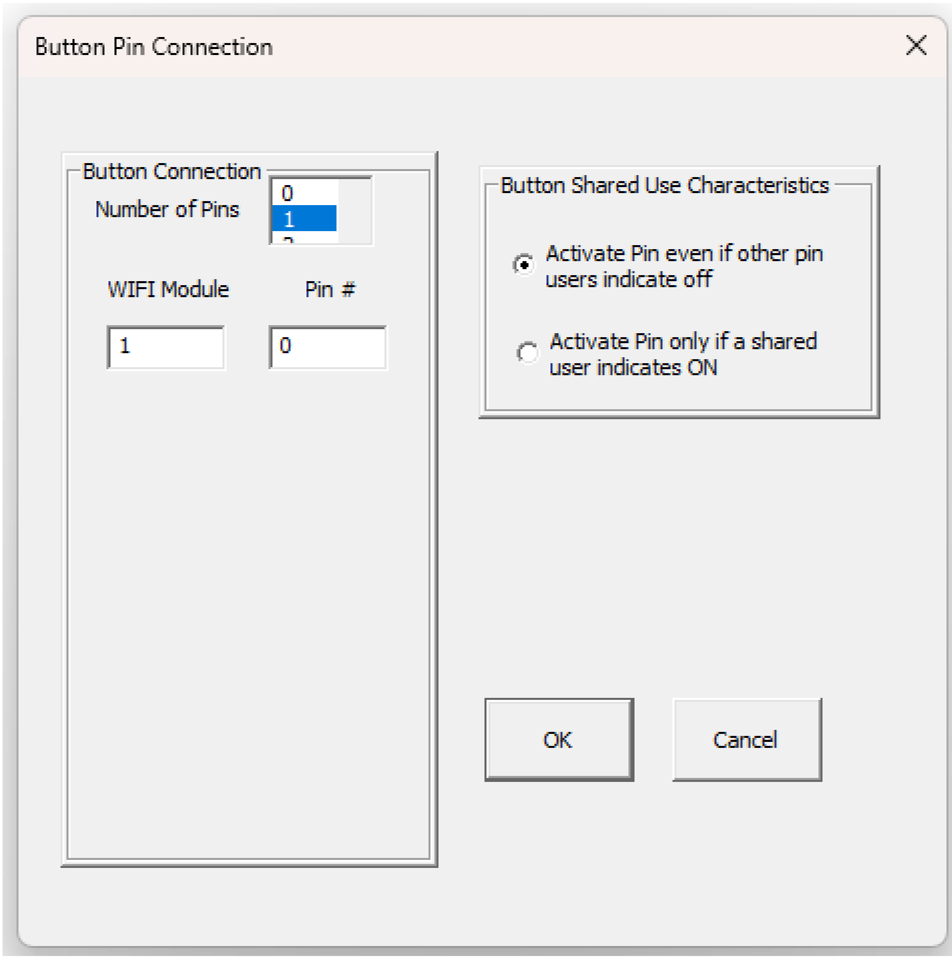
Text Line 1

3.5.3 Setting Up a Button for your Control Panel

To set up a Button for your layout you must be in the **Control Setup** mode. Using the *Left Mouse Button*, click the **Button** image on the layout and the following dialog will appear.

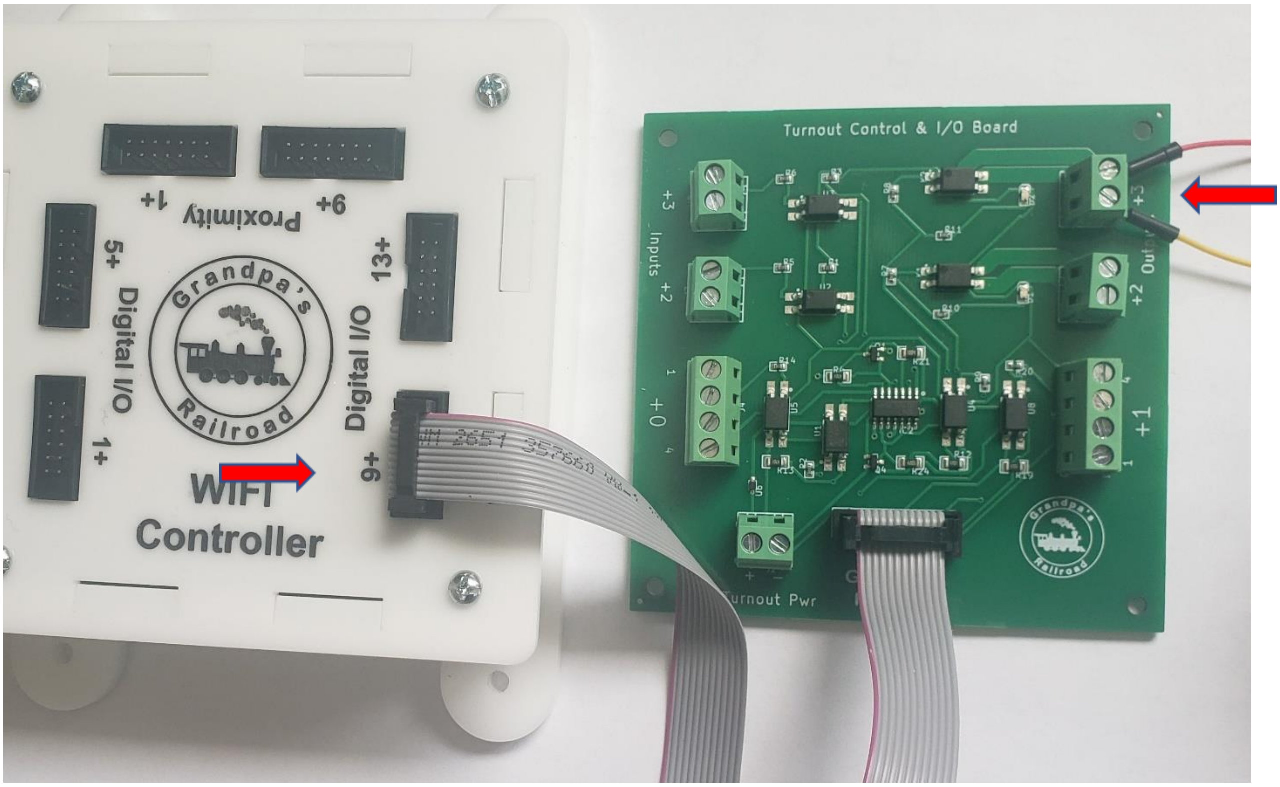


You must now select the number of **Output Pins** this button will activate. Zero is the special case of using the button as a line of text. You can activate up to 8 pins with one button. If a non-zero value is selected, the dialog will change allowing you to enter the **Output Pin** to be controlled. For example, selecting one will result in the following change.



For each Output Pin that is to be activated, you must enter the **WIFI Module** number that the I/O card is connected to. That number is the actual number that is programmed into the **WIFI Module**. Note: All modules are shipped with a **Module Number** of 1. You can use the WIFI Module Programmer software to change that number if your layout has more than one module.

The Pin # is calculated by adding the number of the connector on the WIFI Module where the ribbon cable is connected and the Output connector number on the card used.

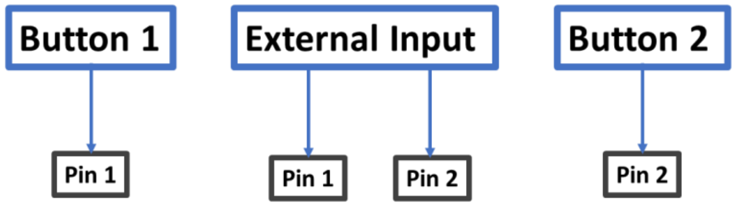


Using the image above, we would calculate the Pin # as 9+ from the WIFI Module plus +3 from the board for a total of 13. Thus, we would enter 13 for the Pin #.

The final item which we must specify is whether the button is shared. Sharing is a concept where the button may be paired with a second button, an external input, or some Proximity Objects. For example, this feature allows external inputs to be easily turned off or switched to an alternate pin. If your layout has an external button to allow visitors to control an animation, sharing the external input with a button allows you to turn off the external input. The button sharing is of two types:

1) The button activates the designated pin even if other pin users indicate *Off.*
2) The button only activates the designated pin if other pin users indicate *On,* and this button indicates *On.*

To illustrate the above, assume we have an external input that controls two pins and it is of type 2 sharing as described above. Also assume there is a button of type 2 associated with each of these pins.



Then Pin 1 and the animation associated with it will only be *On* If both Button 1 and the external input are *On.* Likewise, Pin 2 and the animation associated with it will only be *On* If both Button 2 and the external input are *On*. Therefore, by simply manipulating Buttons 1 & 2 you can determine what the External Input controls in real time without changing the Control Panel Setup.

3.5.4 Button Control Panel Operation

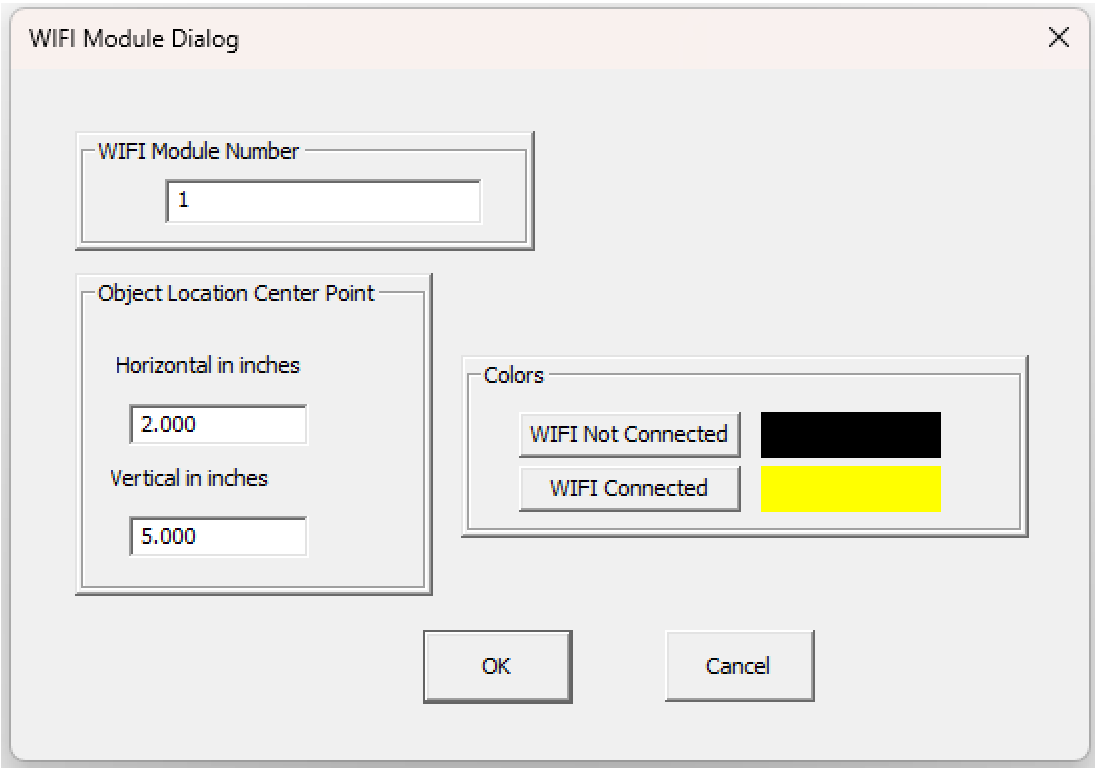
To activate a **Button** in the control panel mode, simply place the mouse cursor over it and press the *Left Mouse Button*. If the button type is **Momentary**, the button will be active as long as the *Left Mouse Button* is held down. If the button type is **Latched**, the button will remain *On* until the mouse cursor is over it and the *Left Mouse Button* is pressed a second time.

3.5.5 Practical Example

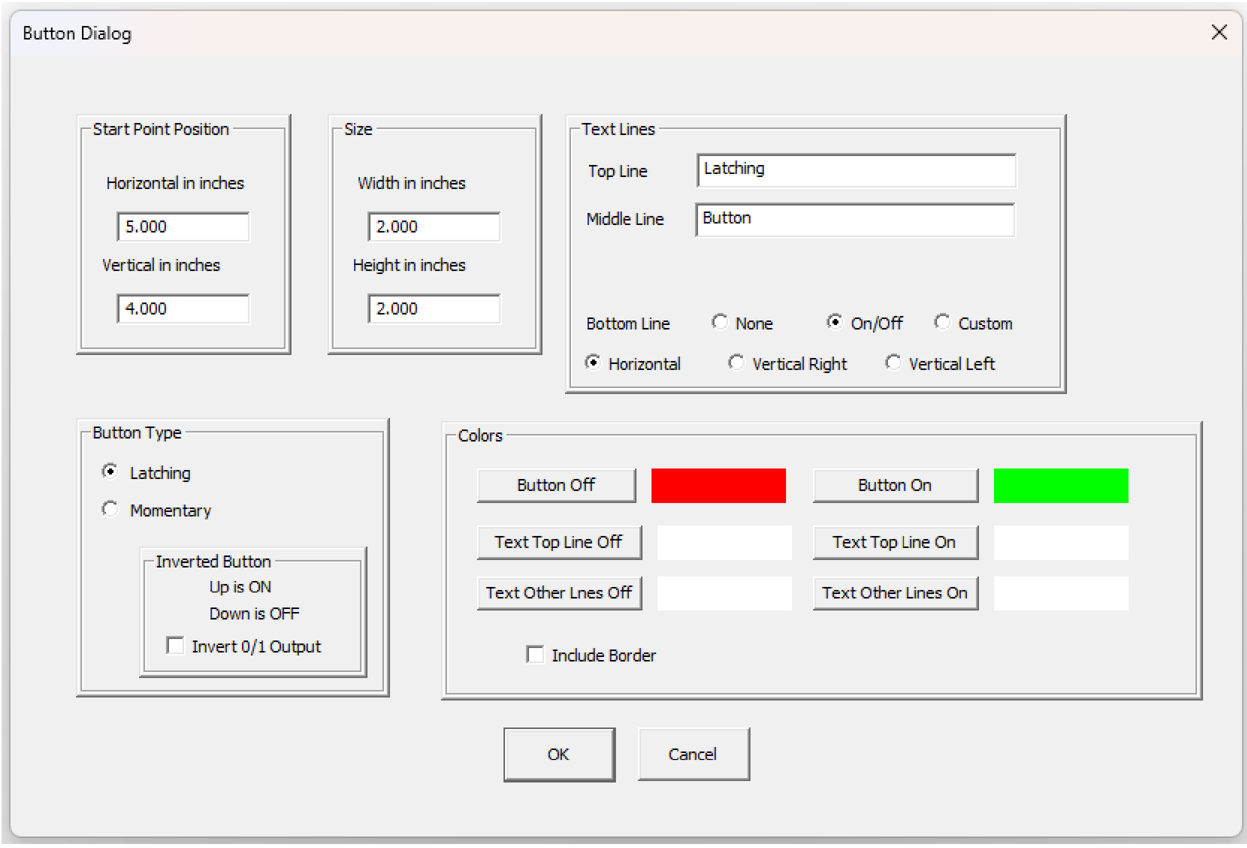
A simple example using a **Button** is illustrated below. In this example we are using a multimeter to demonstrate that the output connection is a switch. In the Off state the switch is open so the resistance is unmeasurably high and in the on state the resistance is very low. We will also connect a simple LED circuit to light the LED.

Step 1: Start the Grandpa's Railroad Application, select the **Layout Setup** mode, and create a 10-inch by 10-inch layout in any scale. (Note: A layout does not need to contain track. In this example we are only adding a button.)

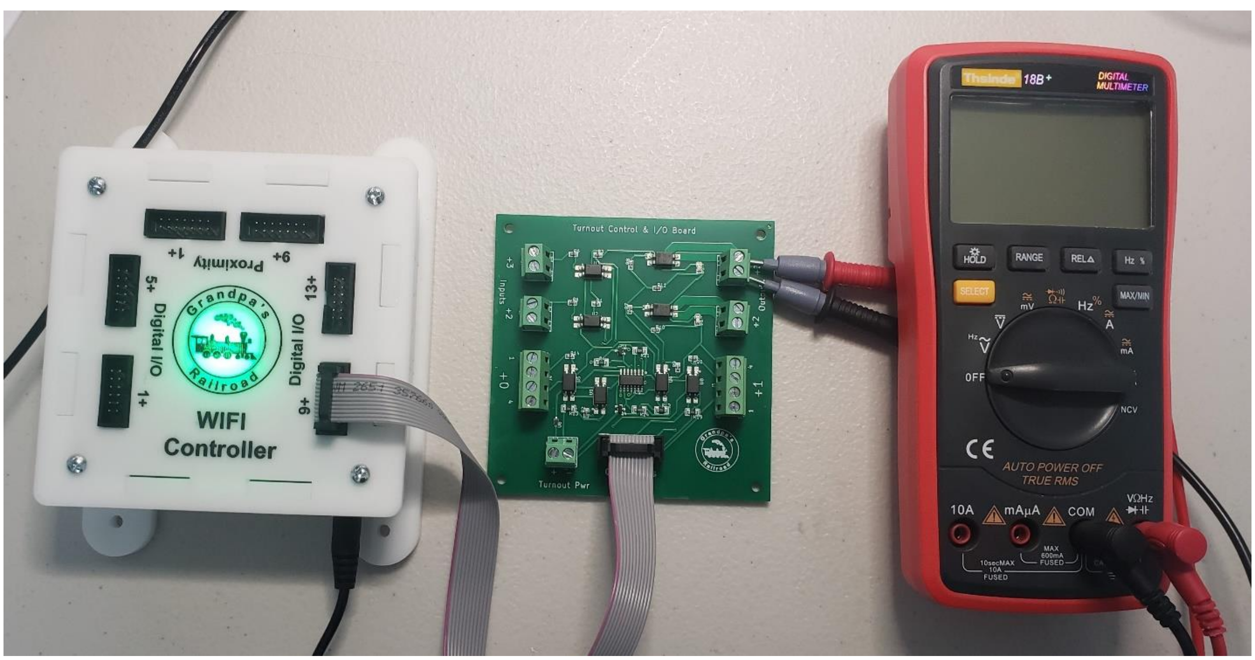
Step 2: Add a WIFI module to the layout at 2 inches Horizontal and 5 inches Vertical with the desired Connected and Not Connected colors. If you are using the supplied WIFI Module and have not changed the number enter, a 1 for the Module Number



Step 3: Add a **Latching** Button to the layout at 5 inches Horizontal and 4 inches Vertical with a width and height of 2 inches. Add text for the button. For this example I have selected a bottom line of *On/Off*. Also select colors for the *On* and *Off* states.

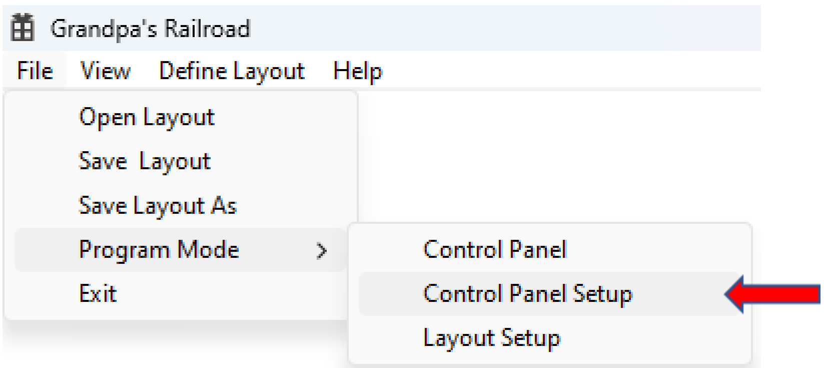


Step 4: Connect the hardware as pictured below:



We have connected power to the WIFI Module, the card to the 9+ port on the WIFI Module, and a multimeter to the +3 connector on the card. These connections will provide a Pin # of 12 for the multimeter. The card we are using is the *Turnout Control & I/O Board* provided with the basic system.

Step 5: From the File Menu item select:

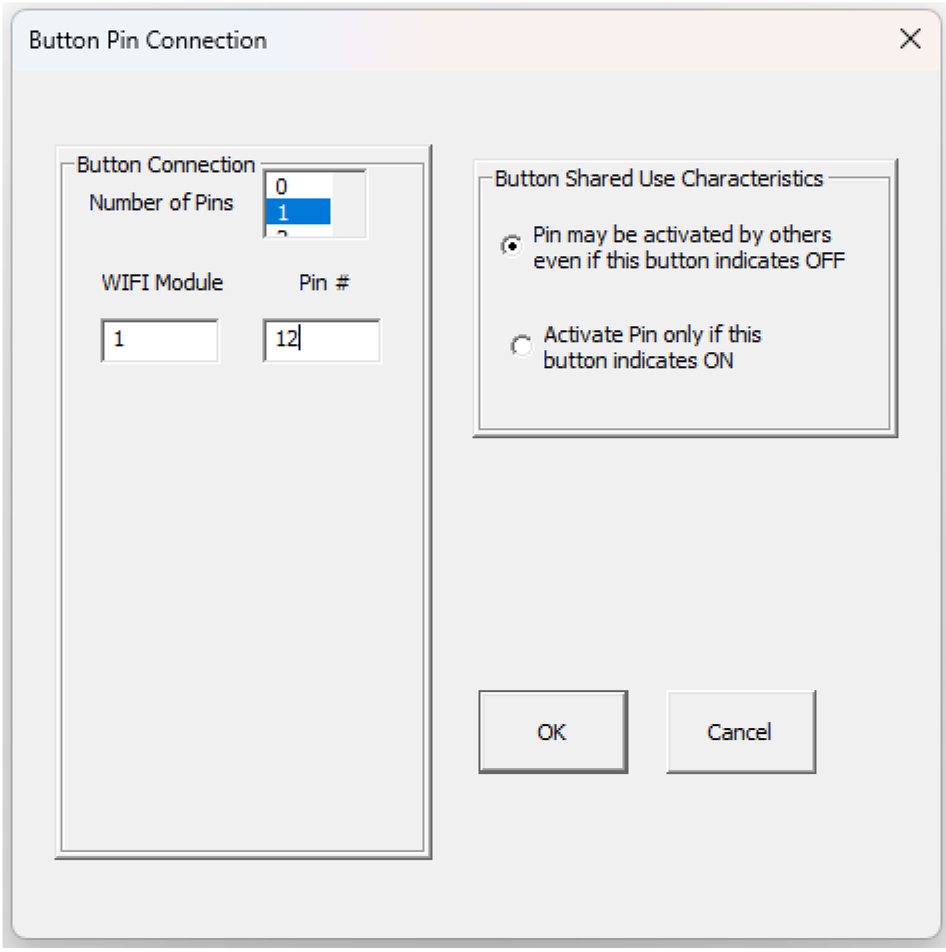


File/Program Mode/Control Panel Setup

This will change to the Control Panel Setup mode.

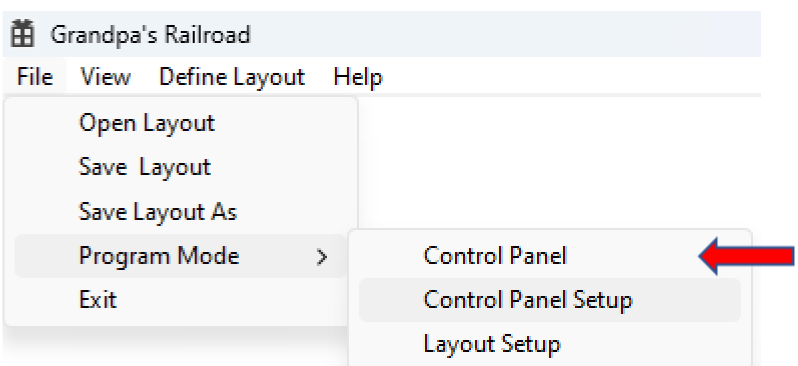
Step 6: Place the mouse cursor over the button and press the left mouse button.

The following dialog will appear.



Based on the connections we made in step 4, the module # is 1 and the Pin # is 12. Since only one button has been defined, the sharing type is not important.

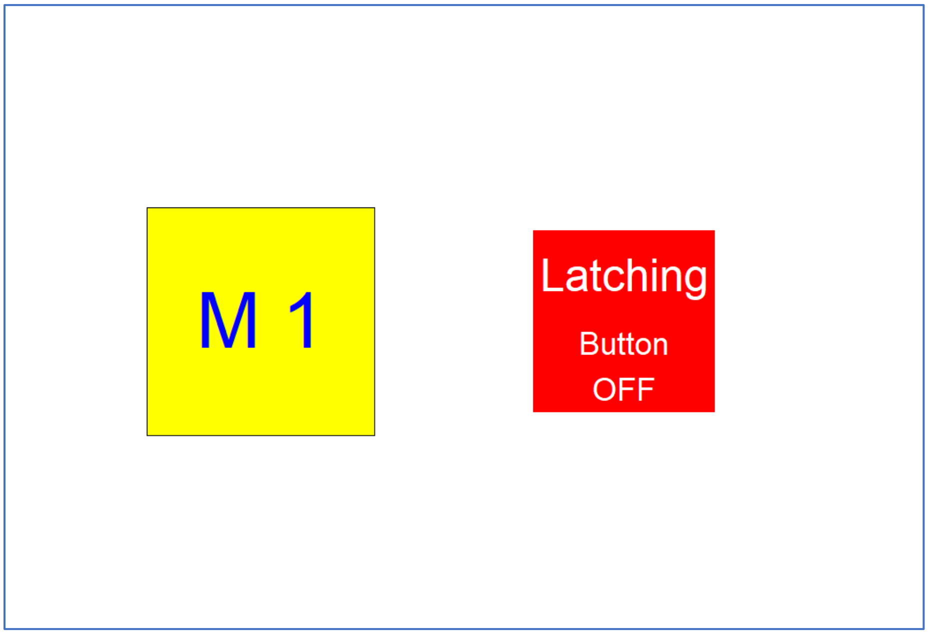
Step 7: From the File Menu item select:



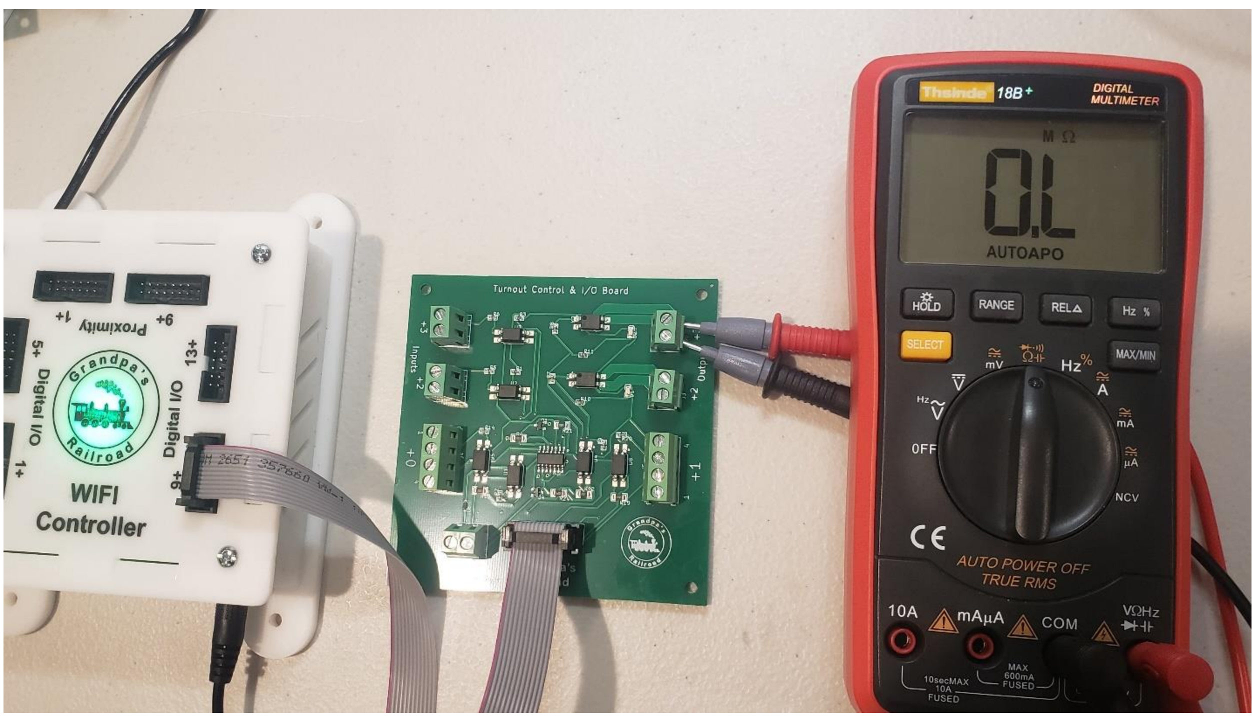
File/Program Mode/Control Panel

This will change to the Control Panel mode.

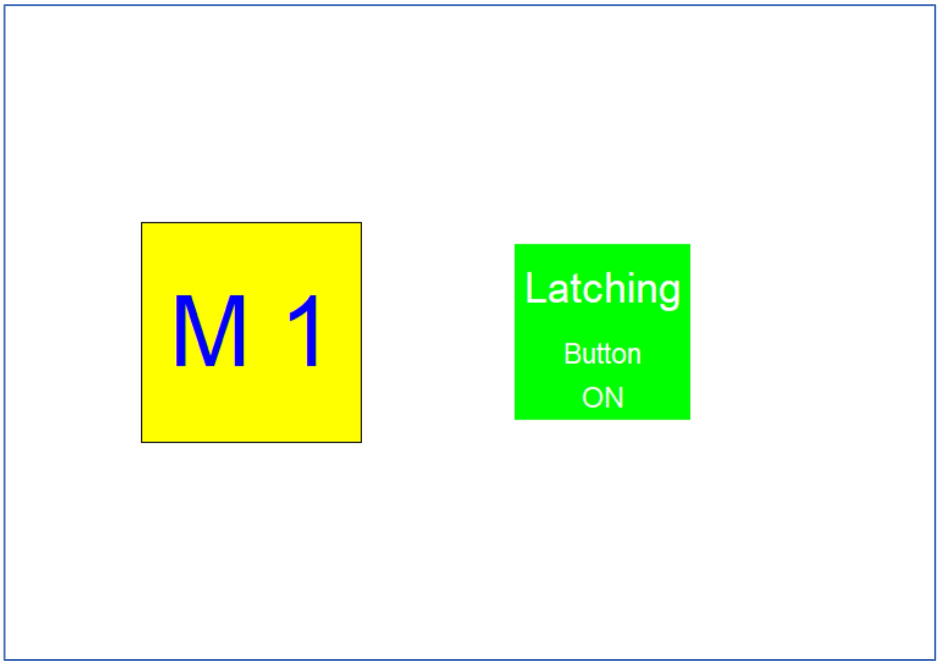
Step 8: If you have used our setup parameters and colors, after the WIFI Module connects, the screen should resemble the following.



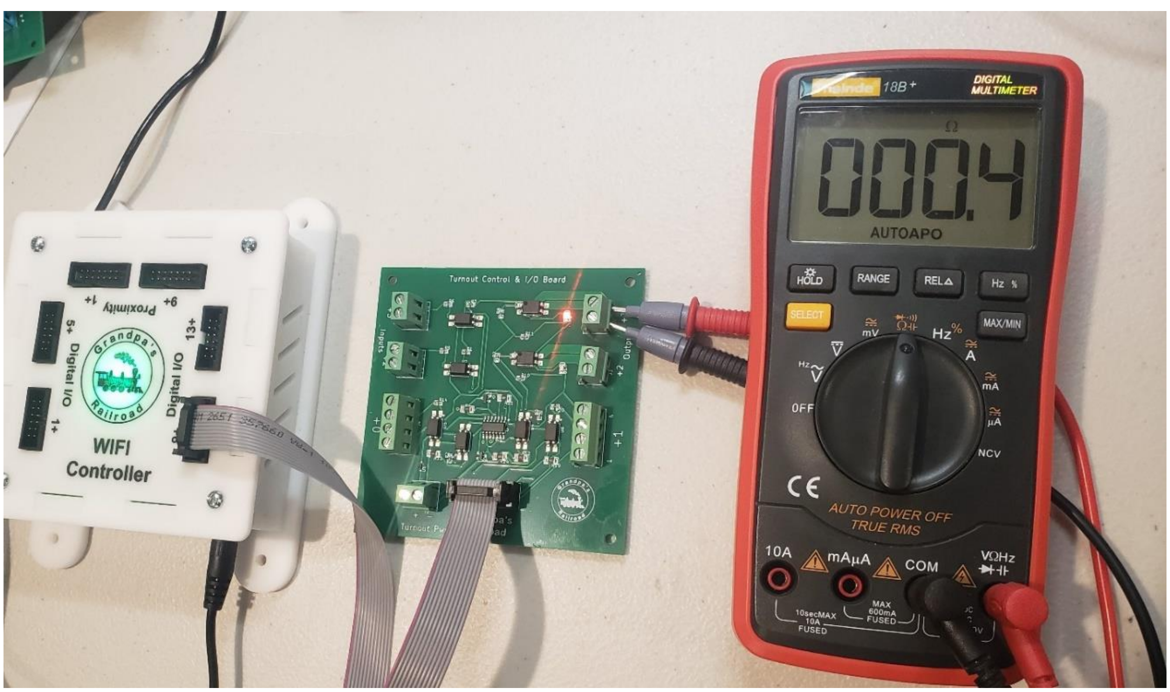
Your multimeter 0.L which means no connection or open.



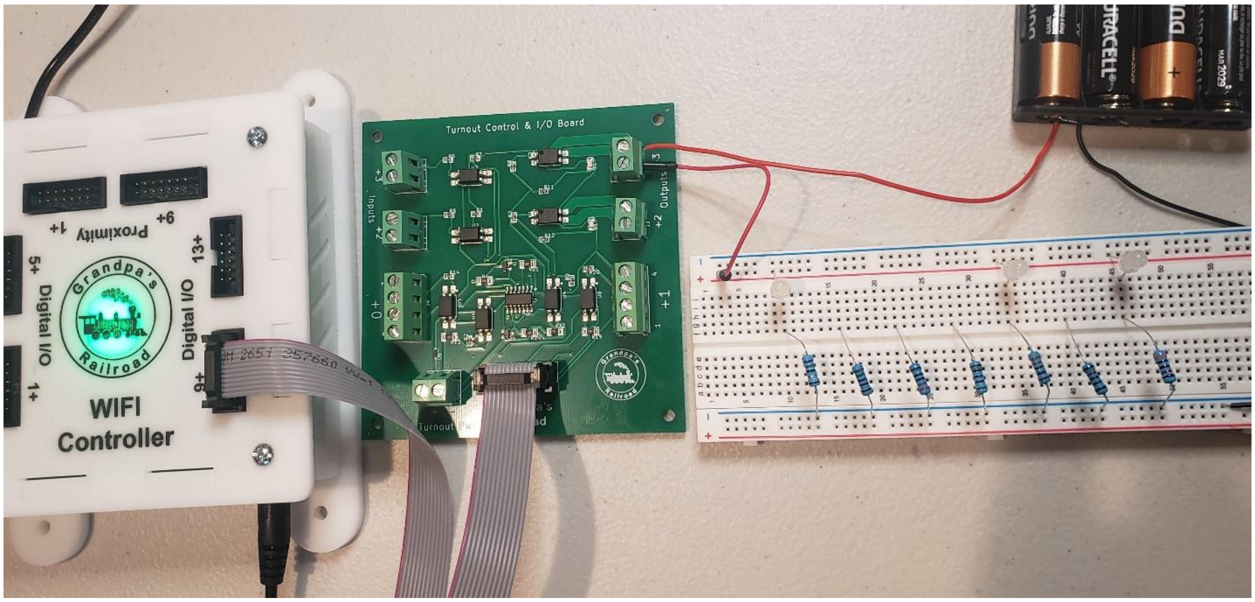
Pressing the Left Mouse Button over the button symbol will produce the following screen.

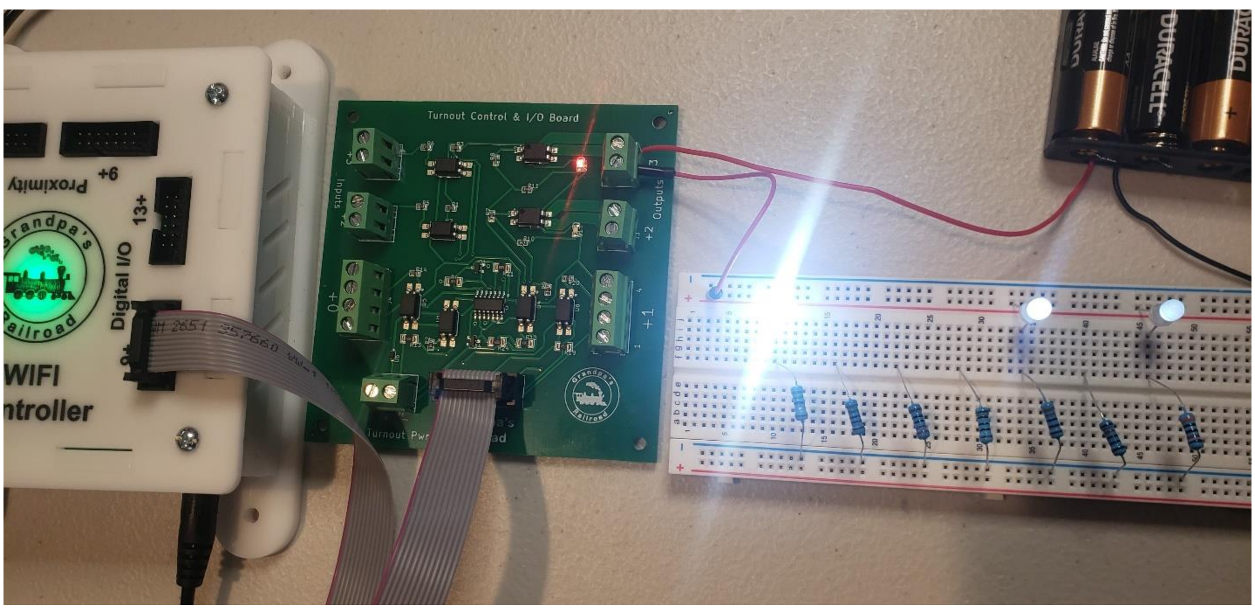


The corresponding multimeter reading is 0.4 ohms, which is typical of a closed switch. Also note a red LED next to the connector lights indicating the switch is *On*.



If you have been following our Educational Tutorials <u>"Electricity 99"</u> a more practical application for model trains would be to turn on and off lighting. Connecting a circuit from those videos we can see how we can use a **Button** to turn *On* and *Off* lighting on the layout. Obviously, the battery pack would be replaced with your accessory power.

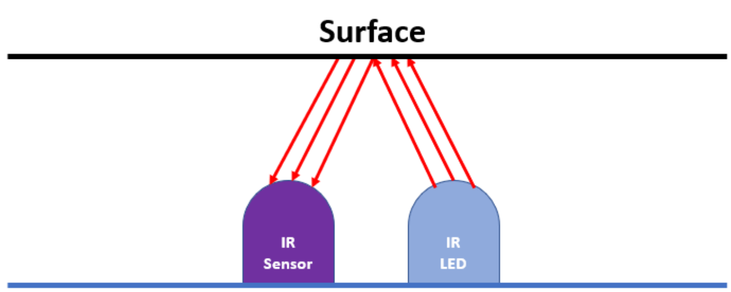




3.6 Adding a Proximity Locator

A proximity locator on Grandpa's Railroad is an IR device that is used to determine train position or to indicate that an object is near the device. IR device refers to an infrared device that emits and senses light at a wavelength from about 800 nanometers to 1 millimeter. This light is invisible to humans and is generally emitted by heated objects. Main contributors to IR radiation are the sun, heat lamps, and conventional light bulbs. These sources sometimes make the use of IR devices on model railroads erratic. Since Grandpa's Railroad is a centralized system, sophisticated algorithms can be used to combine and continuously calibrate these devices making their use simple and stable.

There are two ways to use these devices. The first, which we refer to as **Reflective** is typically used for devices placed inside the train tracks. An IR LED transmits light which is reflected off to an object in the vicinity and is detected by an IR sensor. It is the presence of IR light at the sensor that indicates an object is present.



Reflective Proximity Sensor

The second is **Direct** which refers to a device where the IR LED transmits directly to the IR sensor. It is the breaking on the beam that indicates an object.

Direct Proximity Sensor

On a model railroad this may be used on opposite sides of a track to detect trains.

3.6.1 Hardware Required

The hardware required to use proximity locators is a WIFI Module and either:

1) Screw type *IR Proximity Locator* card
    a. IR Proximity Locator (These are supplied with the card)[1]
    b. Shrink tubbing (Supplied with the card)
    c. 4 wire telephone cable (solid wire)
    d. Wire strippers
    e. Soldering iron
    f. Solder
    g. Hair dryer or heat gun
    h. Screwdriver

or

2) RJ11 type *IR Proximity Locator* card
    a. IR Proximity Locator (These are supplied with the card)[1]
    b. Shrink tubbing (Supplied with the card)
    c. 4 wire flat stranded 26 AWG telephone cord
    d. RJ11 6P4C male connector (Make sure they are 6P4C)
    e. Wire strippers
    f. Soldering iron
    g. Solder
    h. Hair dryer or heat gun
    i. RJ11 Crimp tool

The first step in preparing the hardware is to attach the wire to the IR LED and sensor. The following steps cover the wire and methods we use. Other methods maybe easier for you but it should be remembered that the final goal is to have a method that does not apply too much heat to the IR LED or sensor and produces

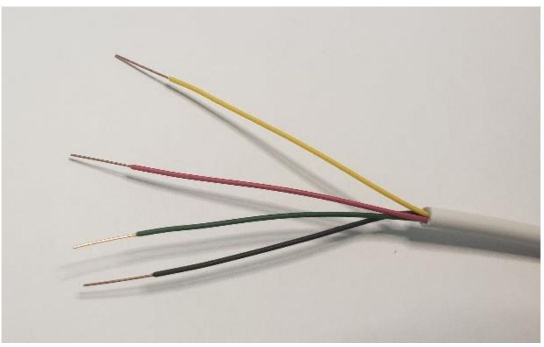
[1] The IR Proximity Locators are TCRT5000. If you need more because you ruined one during soldering, wiring, etc. they are available relatively inexpensively on Amazon.

small diameter units that can be slid into a 9/64-inch hole (See Installing the Proximity Locator under Special Considerations)

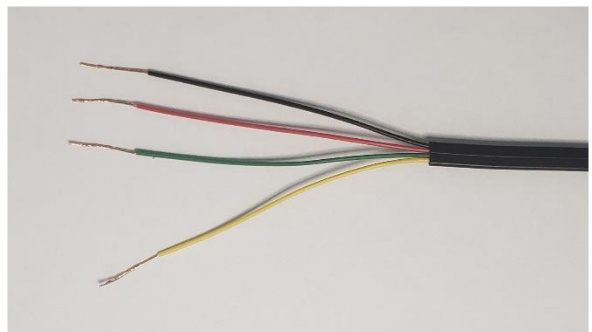
3.6.2.1 Soldering Method of Wiring IR LED and Sensor

Step 1: Cut the appropriate cord to a length that will go from the proximity locator location on your layout to the desired pin on *IR Proximity Locator* card. It is best to cut the cord a little long and leave some slack.

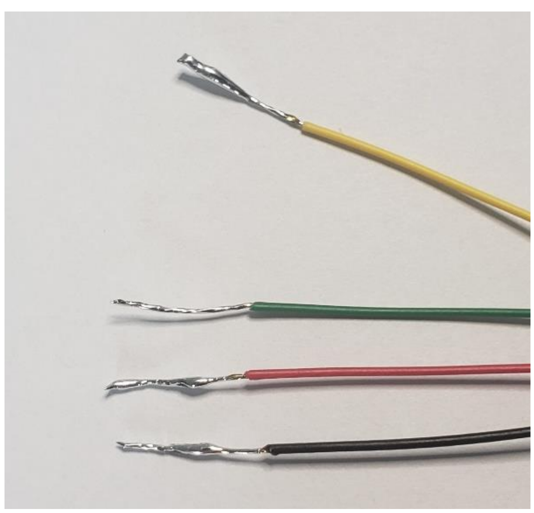
Step 2: Strip 2.5 inches of the cable jacket from the appropriate cord and then strip ½ inch of insulation from each wire. Twist the end of each stranded wire so that the strands stay together.



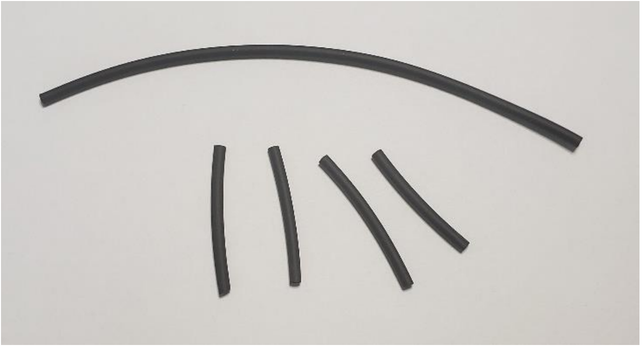
or



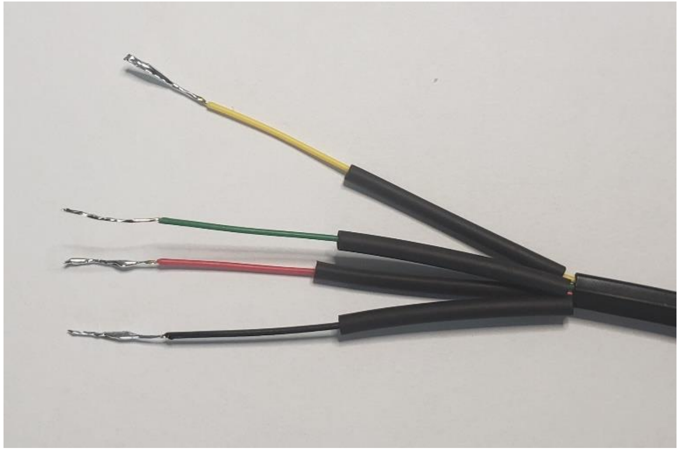
Step 3: Tin each bare wire end with solder. Apply a generous amount. Do this even on the solid wire.



<u>Step 4</u>: Cut a piece of 5” shrink tube into 4 equal pieces.

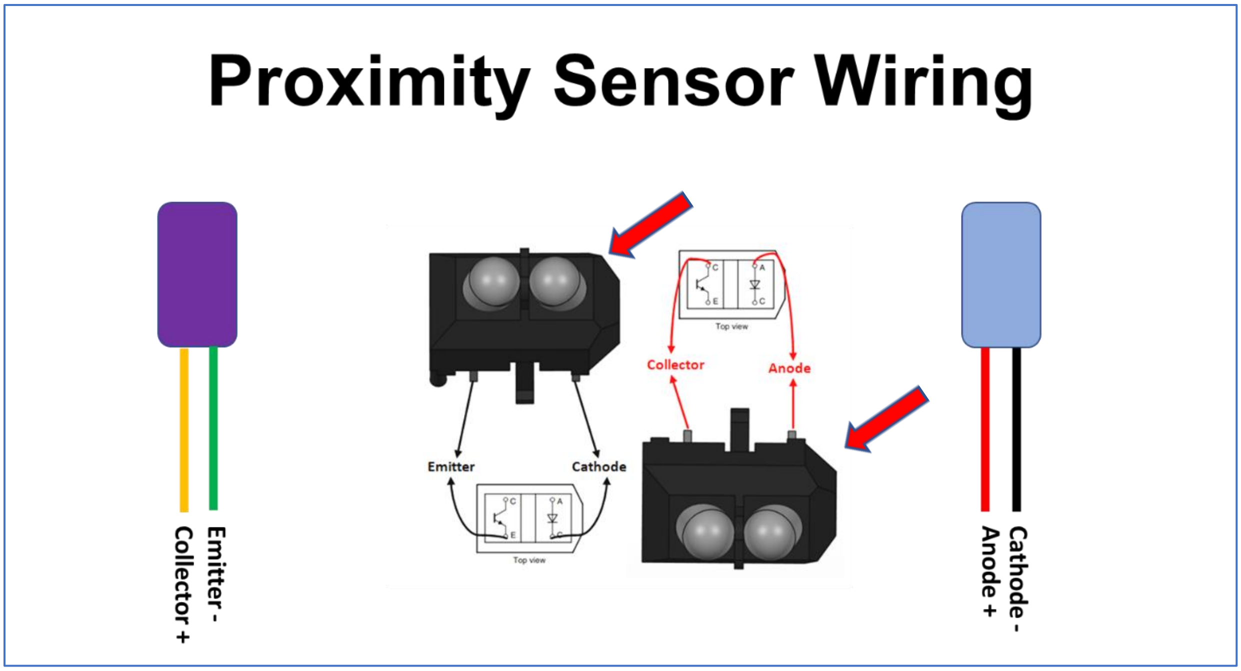


<u>Step 5</u>: After the solder has cooled slide the shrink tube over each wire all the way to the cable jacket. We <u>do not</u> want heat to get near these tubes during soldering.



<u>Step 5</u>: Using the diagram below solder the wire of the proper color to the IR device. Normally you would heat the leg of the device to attach the wire but in this case, we will barely heat the leg while heating the wire and solder as we touch it. Make sure to keep the shrink tube away from the soldering area.

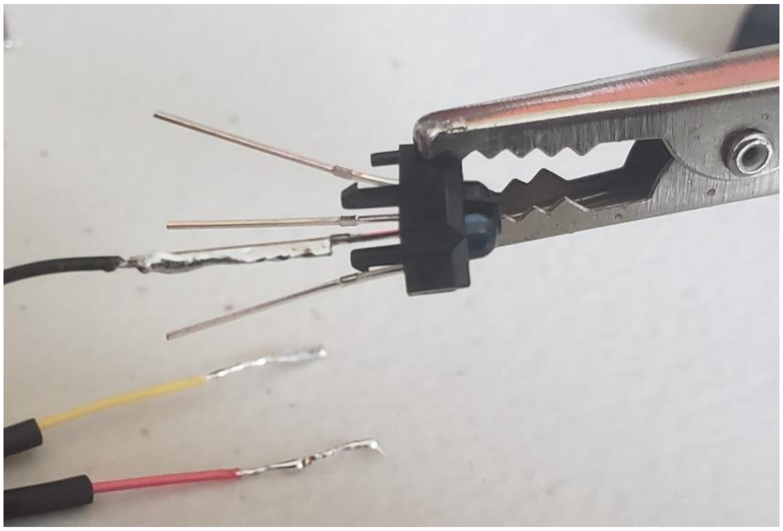
Do not remove the LED or sensor from the plastic case before soldering. Doing so may cause you to lose track of how the colored wires are to be connected. If you do lose track of the leads, see determining IR leads under special considerations.



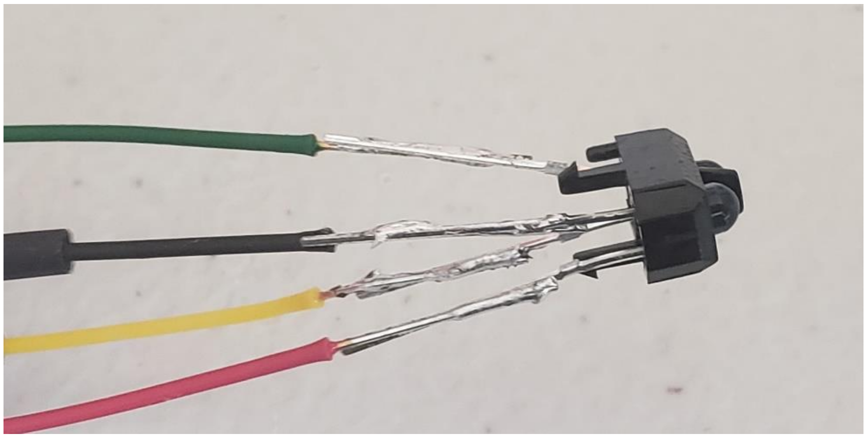
Note the 45-degree corners on the case that indicate the LED side of the case which we will call the front. Therefore, wiring is as follows:

1) Front left – LED Anode (Red wire)
2) Front right – LED Cathode (Black wire)
3) Back left – Sensor Collector (Yellow wire)
4) Back right – Sensor Emitter (Green wire)

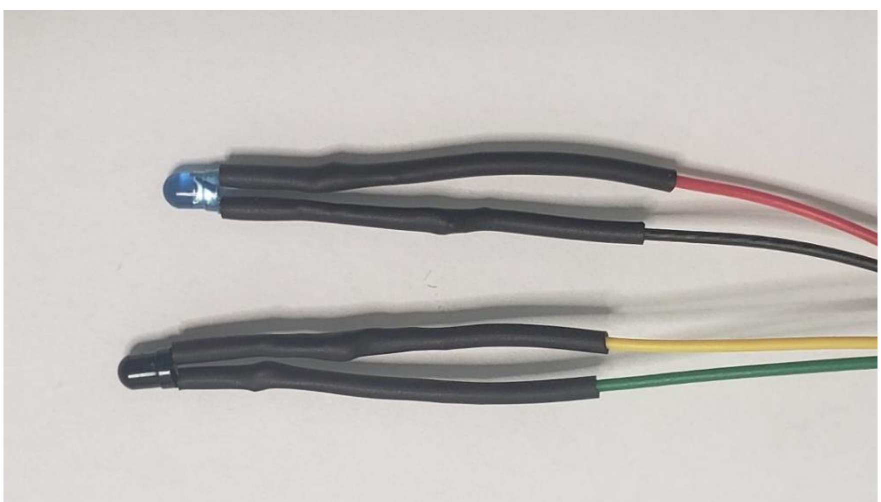
To solder bend the legs out some and use a stand if available.



The final product should look something like this:

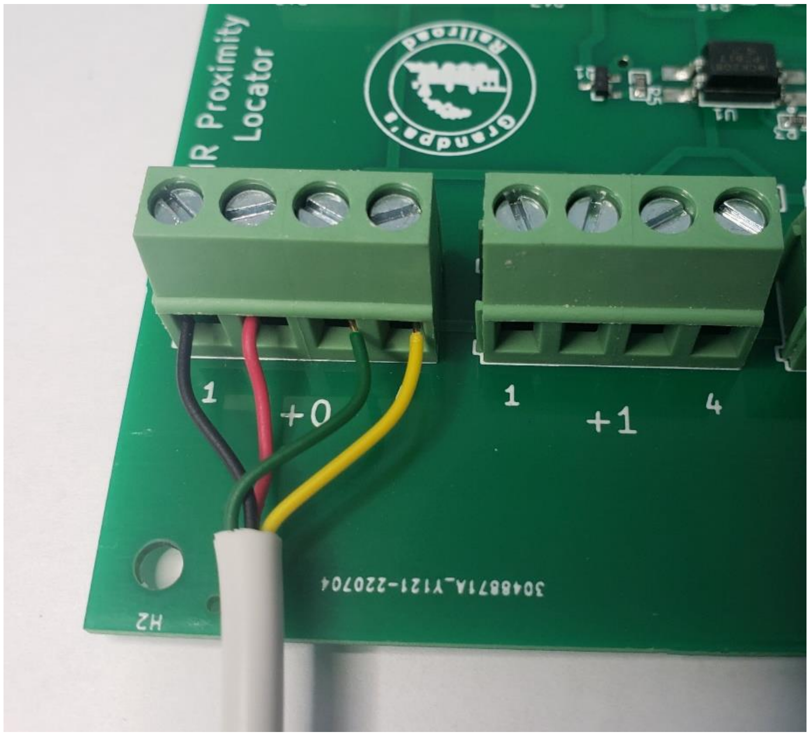


Step 6: Once the solder has cooled, remove the LED and sensor from the case and slide the shrink tubing all the way up. (Save the case for later testing.) (The LED and sensor easily pop out if you hold the case and press on the top with a soft plastic or padded item so that you don't scratch the lens.) Use a hair dryer or heat gun to shrink the tubing. Make sure it is all the way to the top. While a hair dryer takes quite a bit longer than a heat gun, there is less chance of hurting the LED or sensor. A heat gun can actually melt the plastic case.



Step 7: The connection of the IR Proximity Locator to the card depends on the card type. For a screw type connection, strip 1 inch of the cable jacket from

the 4-wire telephone cable (<u>solid wire</u>) and then strip ¼ inch of insulation from each wire. The connection to the card is as follows: where the colors represent the wire colors, and the numbers are the connection numbers. On the card the 1 and 4 positions are printed to show the two ends.



Make sure when making the screw connection that the wire is not under the connector. Open the connector fully, insert the wire, tighten the connectors, check the connection. These steps will save you time because it is easy to get the wire under the connector and either not make a connection or an intermittent connection.

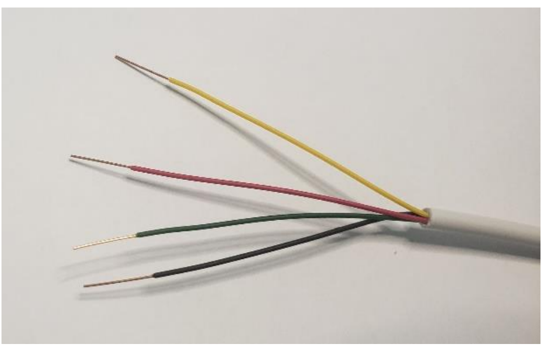
For a RJ11 type connection, strip ¼ inch of the cable jacket. Next using the crimping tool crimp the RJ11 6P4C connector with the wires as shown. The crimp tool has the proper orientation. Finally, simply insert the connector into the appropriate slot of the card.

<u>Step 8</u>: Reinstall the plastic case for the IR LED and sensor. Next, test using the example in a later section of this topic. Best practice is to keep a known working setup for this or other items and test all items including cables before installation. Using this method, you can save a lot of time and trouble later.

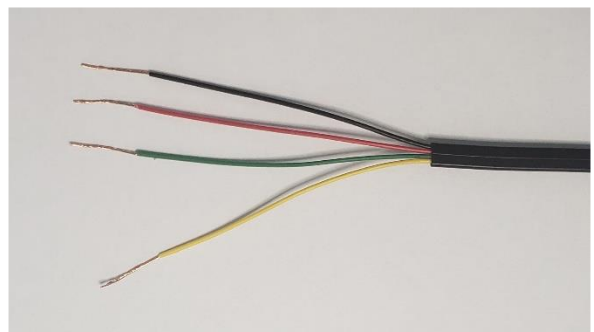
3.6.2.2 Butt Connector Method of Wiring IR LED and Sensor

Step 1: Cut the appropriate cord to a length that will go from the proximity locator location on your layout to the desired pin on *IR Proximity Locator* card. It is best to cut the cord a little long and leave some slack.

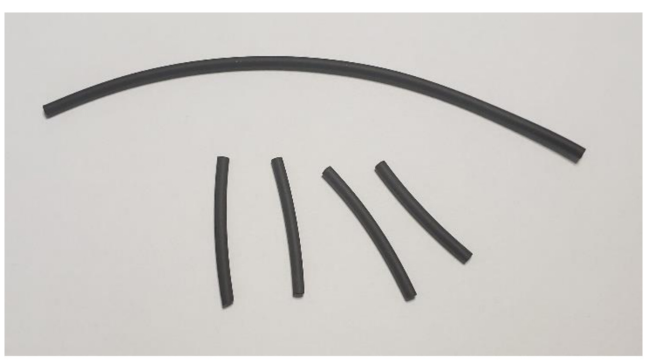
Step 2: Strip 2.5 inches of the cable jacket from the appropriate cord and then strip ½ inch of insulation from each wire. Twist the end of each stranded wire so that the strands stay together.



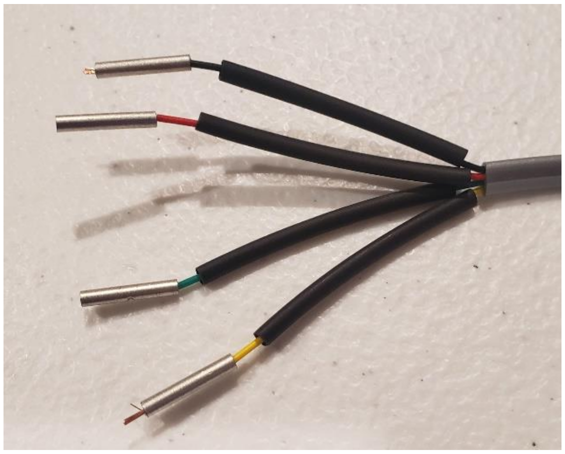
or



Step 3: Cut a piece of 5” shrink tube into 4 equal pieces.



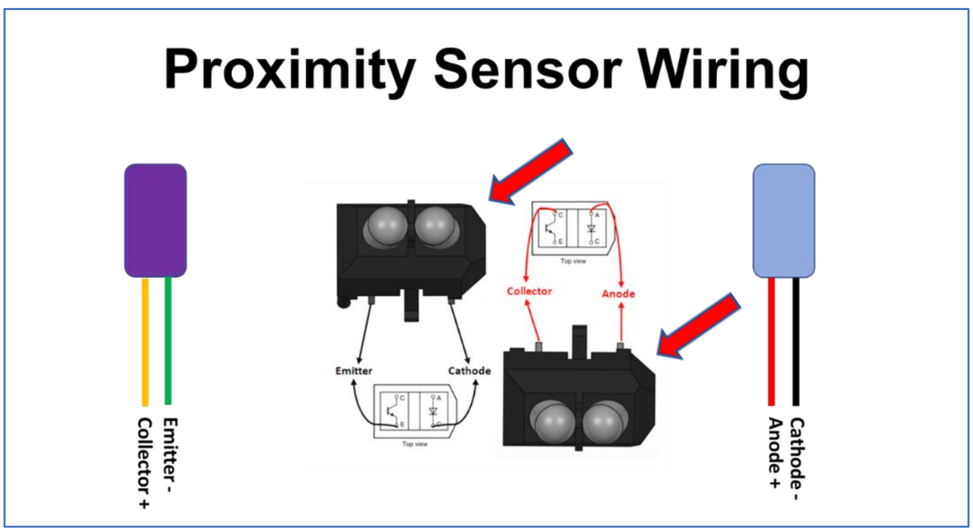
Step 4: Slide the shrink tube over each wire all the way to the cable jacket. Slide a BN0.5 butt connector over the end of the wire.



Step 5: Using the diagram below crimp the wire of the proper color to the IR device.

Do not remove the LED or sensor from the plastic case before soldering. Doing so may cause you to lose track of how the colored wires are to be connected. If you do lose track of the leads, see determining IR leads under special considerations.

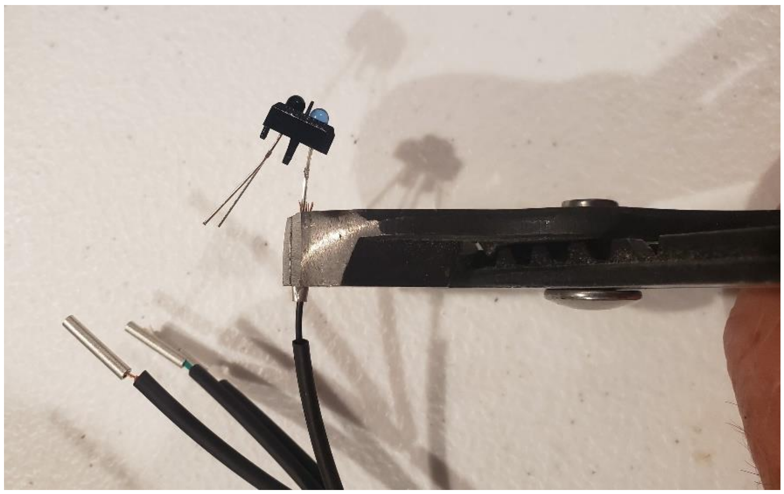
Note the 45-degree corners on the case that indicate the LED side of the case



which we will call the front. Therefore, wiring is as follows:

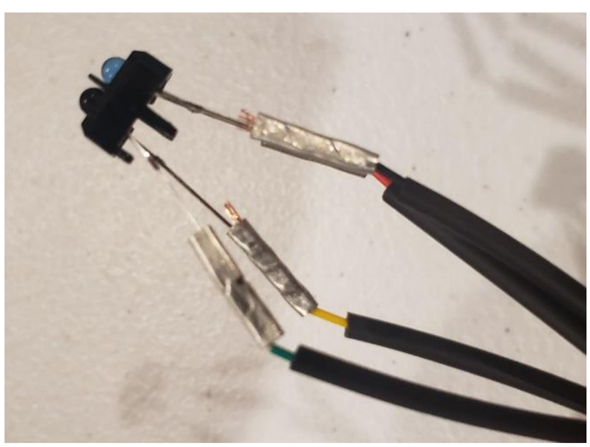
1) Front left – LED Anode (Red wire)
2) Front right – LED Cathode (Black wire)
3) Back left – Sensor Collector (Yellow wire)
4) Back right – Sensor Emitter (Green wire)

To crimp, blend the legs out some.

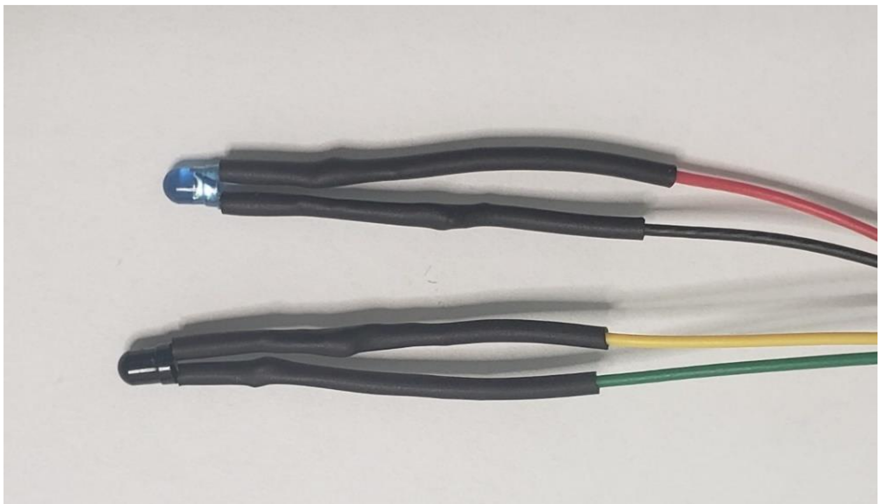


Crimp the legs to the wire using a large set of pliers to put a high force on the crimp. Also crimp (flatten the butt connector) so that the flat part is perpendicular to the axis of the wires on the LED or IR Sensor. This will make the finished connector wires when trying to slide them through the hole under the track by making the flat sides face each other.

The final product should look something like this:

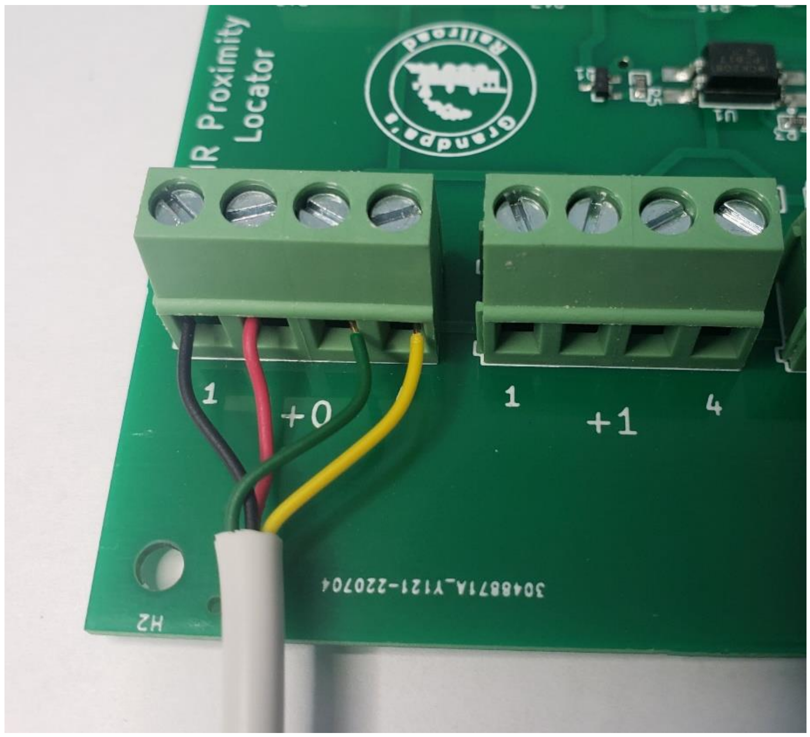


<u>Step 6</u>: Remove the LED and sensor from the case and slide the shrink tubing all the way up. (Save the case for later testing.) (The LED and sensor easily pop out if you hold the case and press on the top with a soft plastic or padded item so that you don't scratch the lens.) Use a hair dryer or heat gun to shrink the tubing. Make sure it is all the way to the top. While a hair dryer takes quite a bit longer than a heat gun, there is less chance of hurting the LED or sensor. A heat gun can melt the plastic case.



<u>Step 7</u>: The connection of the IR Proximity Locator to the card depends on the card type. For a screw type connection, strip 1 inch of the cable jacket from the 4-wire telephone cable (<u>solid wire</u>) and then strip ¼ inch of insulation from each wire. The connection to the card is as follows where: the colors represent the wire colors, and the numbers are the connection numbers. On the card the 1 and 4 positions are printed to show the two ends.

Make sure when making the screw connection that the wire is not under the connector. Open the connector fully, insert the wire, tighten the connectors, check



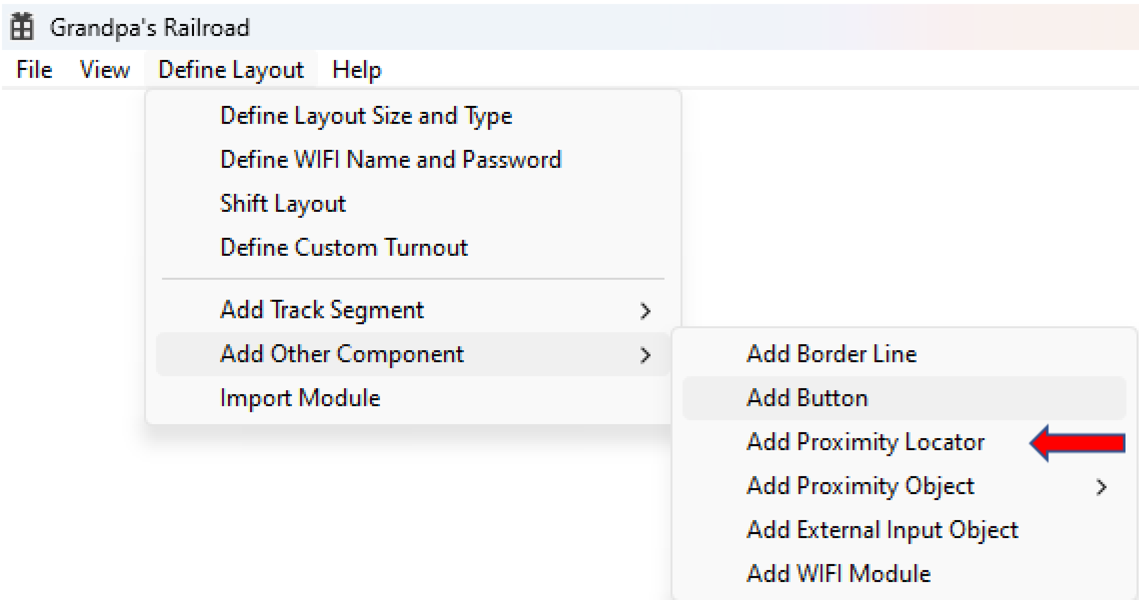
the connection. These steps will save you time because it is easy to get the wire under the connector and either not make a connection or an intermittent connection.

For a RJ11 type connection, strip ¼ inch of the cable jacket. Next using the crimping tool crimp the RJ11 6P4C connector with the wires as shown. The crimp tool has the proper orientation. Finally, simply insert the connector into the appropriate slot of the card.

Step 8: Reinstall the plastic case for the IR LED and sensor. Next test using the example in a later section of this topic. Best practice is to keep a known working setup for this or other items and test all items including cables before installation. Using this method, you can save a lot of time and trouble later.

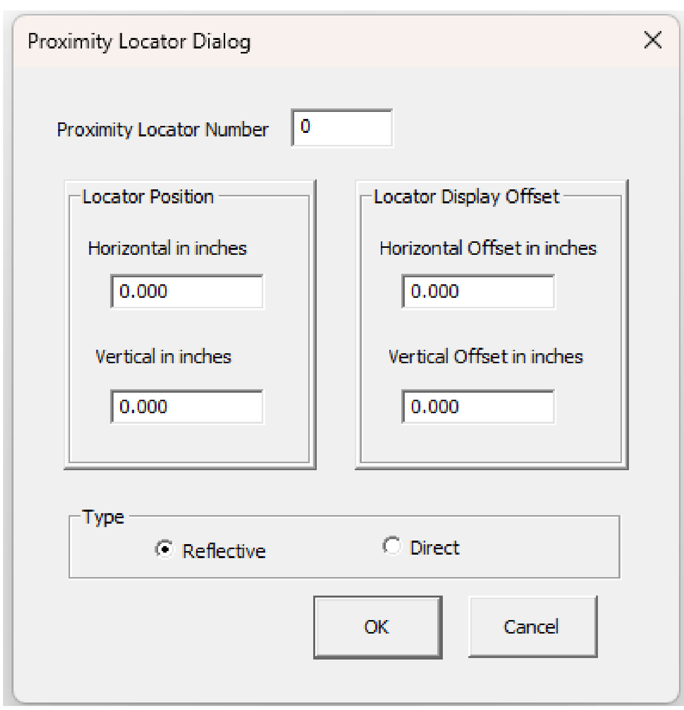
3.6.2 Adding a Proximity Locator to your Layout

From the main menu select



Define Layout/Add Other Component/Add Proximity Locator

Upon selecting this menu item, the following dialog will appear.



Using this dialog, the following data must be entered.

Proximity Locator Number is a number between 1 and 999 that you assign to this device. This number must be unique for the device since it will be used to identify the device for use with **Proximity Objects**.

Locator Position is the point on your layout that the locator is installed. This is the trigger point for the device.

Locator Display Offset is an offset in the locator position used solely to change the displayed location of the device on the screen. In a few rare instances the actual device location may coincide with another layout display element and therefore you may wish to move it for display purposes only.

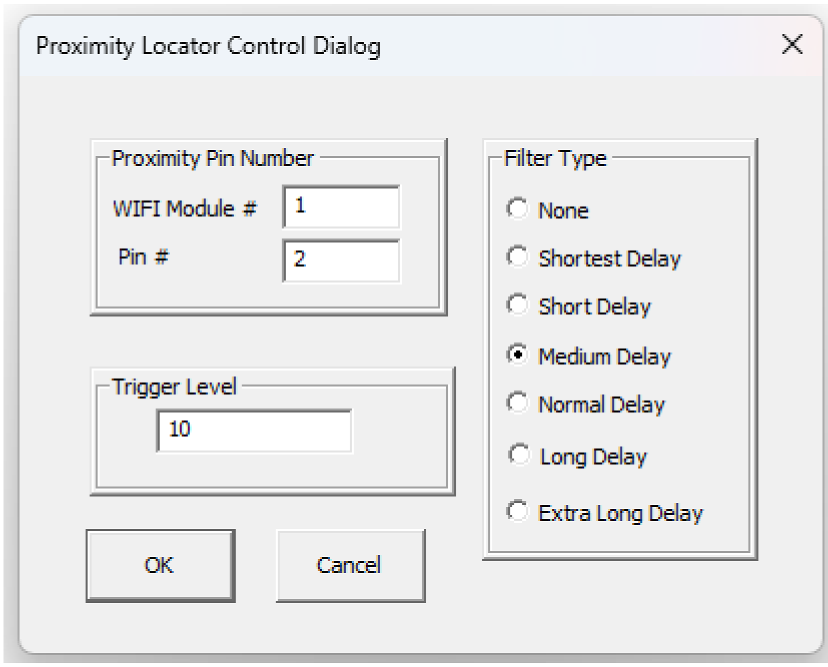
Type refers to the actual implementation of the device. Reflective is typically used for devices placed inside the train tracks. Direct refers to a device where the IR LED transmits directly to the IR sensor, and it is the breaking on the beam that indicates an object. On a model railroad this may be used on opposite sides of a track to detect trains.

Once you select **OK** from the Proximity Locator dialog and if you have entered all required data, a circle will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

If you need to edit a proximity locator, you can left click with your mouse on the proximity locator element **Edit Location** and this dialog will reappear. (See **Show Edit Locations**)

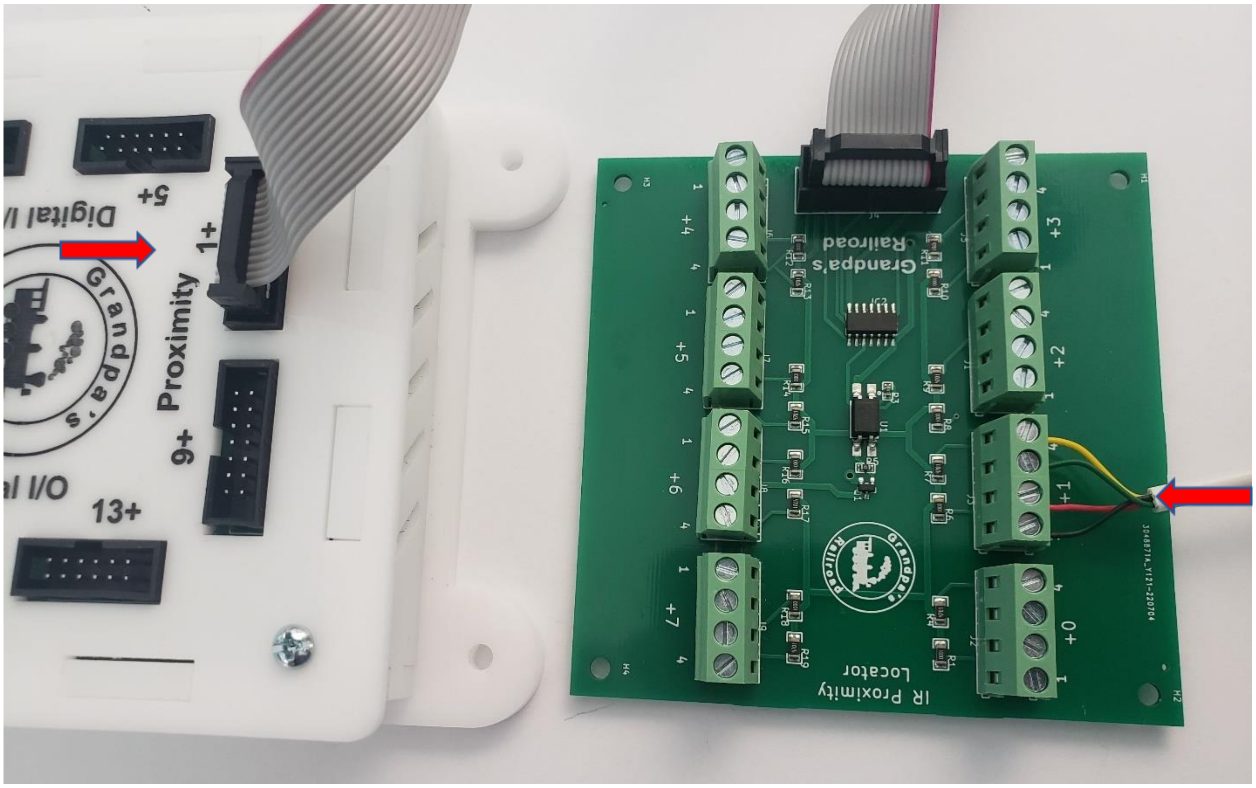
3.6.3 Setting Up a Proximity Locator for your Control Panel

To set up a Proximity Locator for your layout you must be in **Control Setup** mode. Using the *Left Mouse Button*, click the **Proximity Locator** image on the layout and the following dialog will appear.



You must enter the **WIFI Module** number that the Proximity Locator card is connected to. That number is the actual number that is programmed into the **WIFI Module**. Note: All modules are shipped with a **Module Number** of 1. You can use the WIFI Module Programmer software to change that number if your layout has more than one module. (Put Link into User's Manual)

The Pin # is calculated by adding the number of the connector on the WIFI Module where the ribbon cable is connected and the Proximity Locator connector number on the card used.



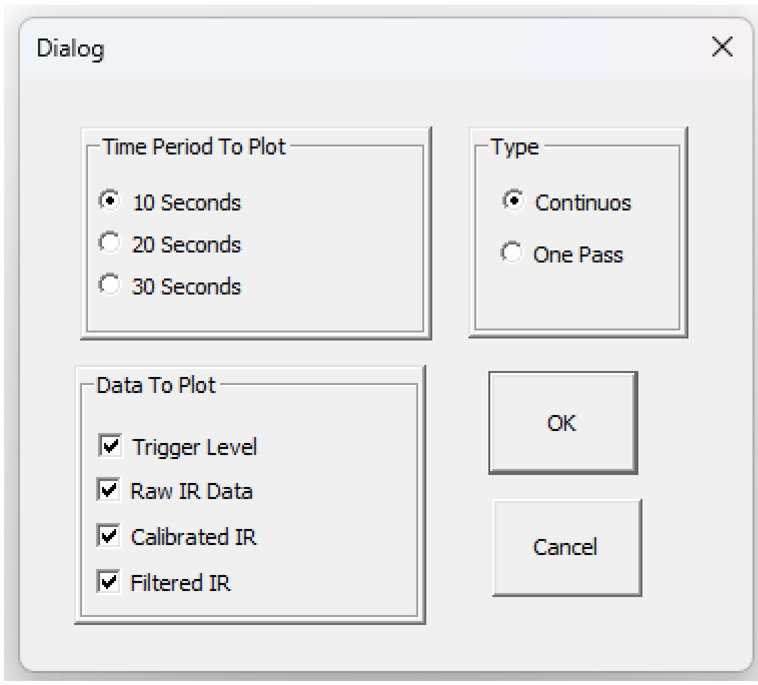
Using the image above, we would calculate the Pin # as 1+ from the WIFI Module plus +1 from the board for a total of 2. Thus, we would enter 2 for Pin #.

The **Trigger Level** is the level at which the proximity locator indicates there is an object (like a train) present. Each locator and each installation vary significantly, so this number should be set by observing results and then adjusting it. As a starting value, 10 is typical.

The **Filter Type** allows you to use one of several predefined filters instead of just the calibrated value to set the object present decision. The filters smooth out the transition from an *On* stay to and *Off* state. For example, the gap between train cars which may produce a temporary Off position. Using a filter can keep this from happening, providing a smooth result. The delay length is an arbitrary indication of how much smoothing occurs. For the typical user, it is best to experiment visually to see what each of these filters does and then set the type. The best filter you should use depends on installation, scale, car type, speed etc. This can be done in the **Control Panel** mode by viewing the plot of the actual data using various filters versus the Trigger Level.

3.6.4 Proximity Locator Control Panel Operation

The proximity locator will turn *On/Off* depending on the calibrated (or filtered) value of the trigger level. The locator will normally be white but will become black when an object is present. To gain much more insight into the operation, you can use the *Left Mouse Button* and click the **Proximity Locator** image to open the following dialog to set up a plot of what the sensor sees.

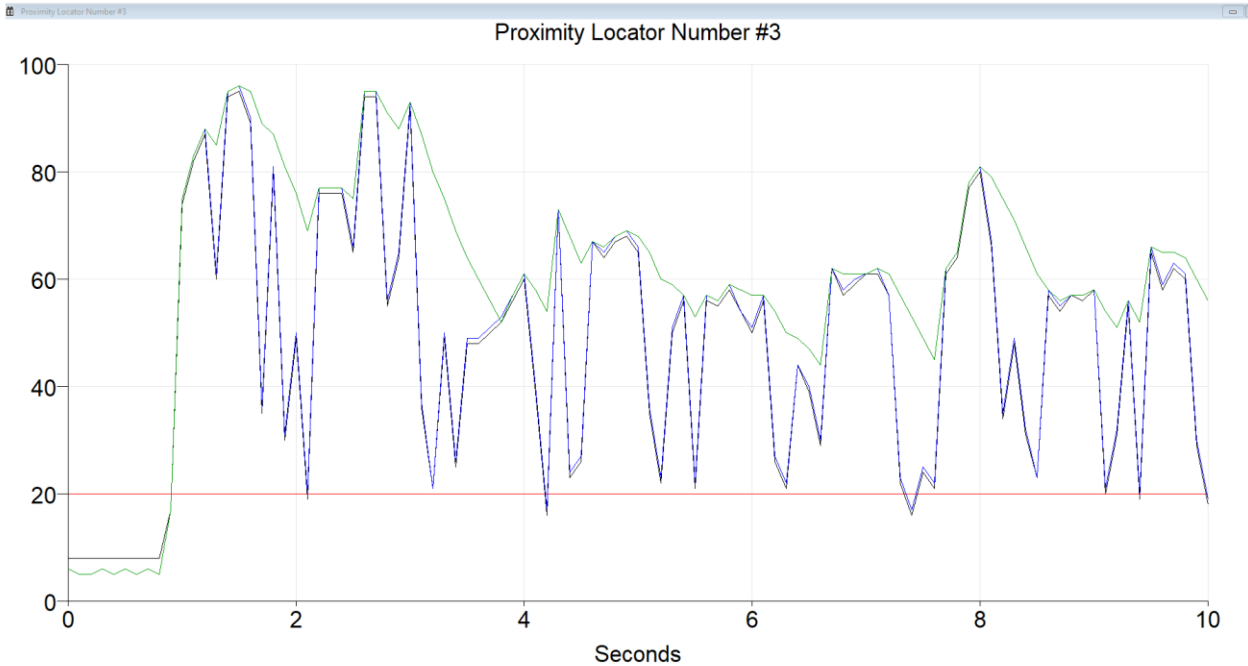


Time Period To Plot is used to adjust the time axis of the plot.

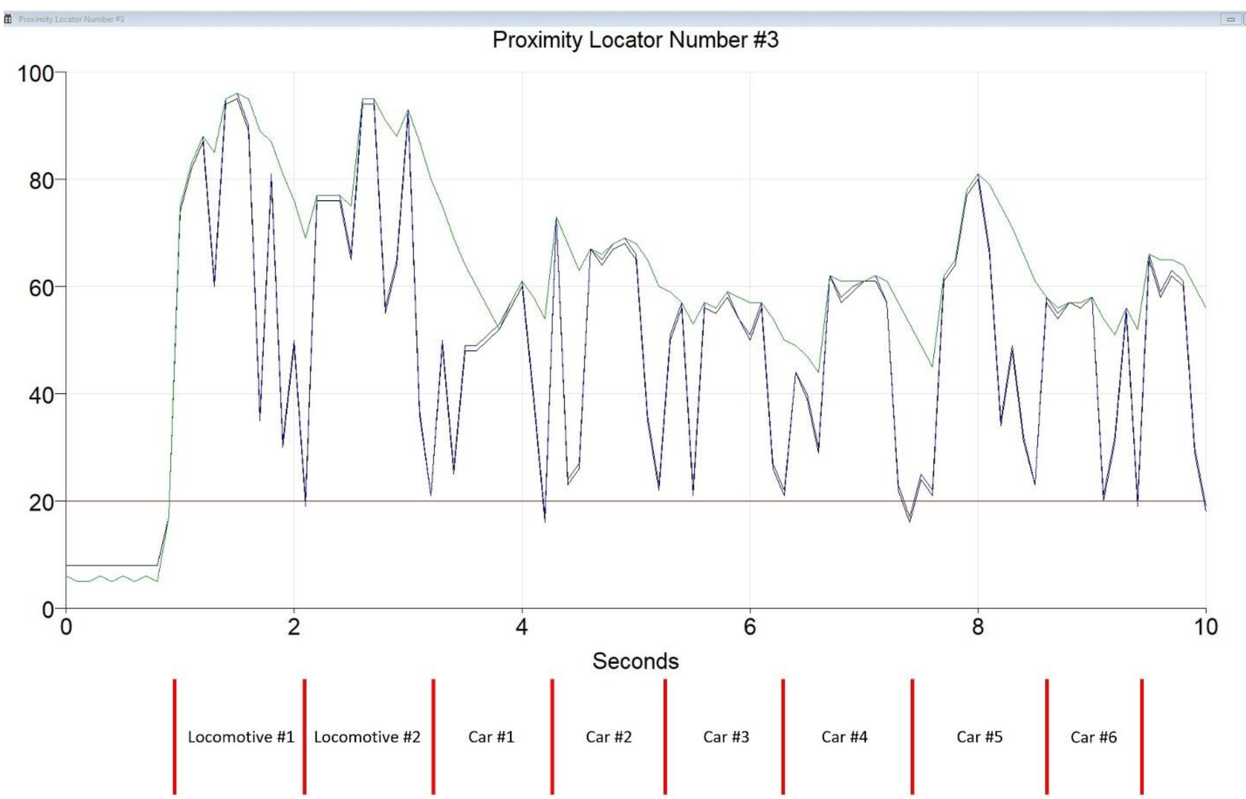
Type is used to provide either a continuously scrolling plot or a single time segment pass which stops at completion.

Data To Plot allows the plotting of the raw IR data that the sensor records (black), the calibrated version of this data (blue), and the filtered version of this data (green). The filter represented is the one selected in the Control Setup mode. The object present trigger level (red) can also be shown.

A sample plot of a train passing over a proximity locator is shown below.



The proximity locator system is a digitally sampled system. At each pass the bottom of a train car is sampled at different locations so the plots will appear different. Since the bottom of train cars has a different reflectivity due to color,



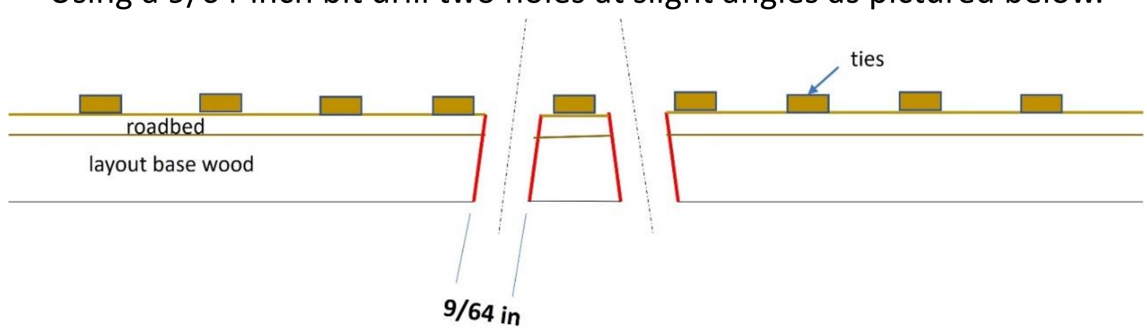
shape, and height, the car to car the pattern will change. To help clarify this I have repeated the above plot with annotations.

Note that you can see the spaces between cars. In a few cases the calibrated signal reflectivity from the coupler drops below the trigger level. If we did not use a filter, the proximity locator would flicker from _On to Off to On_ not only affecting the display but possibly also one of the Proximity objects that use this display. In all those cases the green line (filtered value) does not drop below the trigger line eliminating the problem. The shorter the filter delay that you select, the quicker the green line drops. The longer the delay, the slower the drop allowing you to customize your set up. While you don't need to know the exact inner workings of the algorithms, by changing filters, observing reflectivity from different cars, etc. you can learn a lot about IR sensors through visual observations.

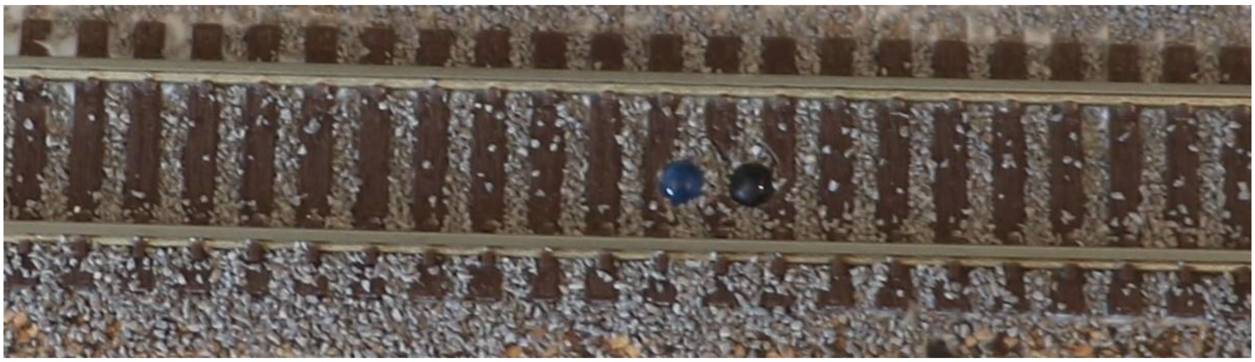
3.6.5 Special Considerations

3.5.5.1 Mounting IR Proximity Locator in Your Track An important thing to remember when mounting your locator is that there must be a barrier between the IR LED and Sensor. If you look at the plastic holder that came with the unit, you will see a small barrier between the two. This is to prevent the IR from going directly from the LED to the sensor giving a false reading. When mounting in N scale track, the units must be parallel to the rails because of width restraints. It is then best to use a railroad tie as the barrier. For HO scale track the unit could be mounted either parallel or perpendicular to the track. Mounting parallel allows you to use a tie as the barrier. If you do mount perpendicular to the rails, ballast can be used as a barrier. Make sure in all cases you allow sufficient space between the rails and units, and the units themselves.

Using a 9/64-inch bit drill two holes at slight angles as pictured below.



The angle of the holes is not that critical, but they should be such that they intersect about ½ to ¾ inch up depending on scale. For N scale you may have to remove part of a tie to drill the holes. If you run the drill up and down several times to clean out the hole, the units should slide in with a smug fit. Next test each unit and adjust the height of the LED and sensor for best performance. After ballast is in and you are happy with the performance, you can put a little glue from a hot glue gun underneath to secure it.



We suggest that you build a short section of track and roadbed on a test board to practice and experiment.

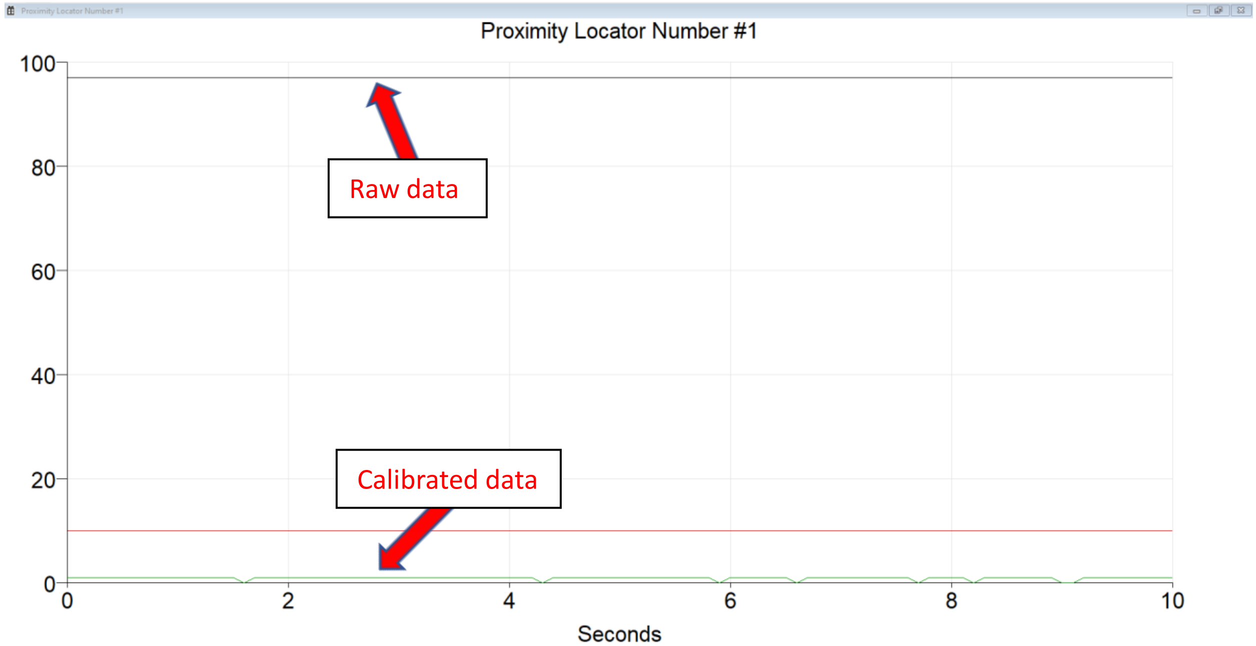
3.5.5.2 Determining the leads of the IR LED and Sensor Sometimes the LED, sensor, or both in the proximity locator will come loose from the case before you can wire it. To determine the proper wiring in this case you can do the following:

For the LED (the light blue element), set your multimeter to the diode setting.  For the multimeter presented in our Equipment Episode of the “Electricity 99” series, move the level to the Ω position and press the select button until  appears. Now connect the two leads to the LED. If you get a .0L reading, switch the leads. In one of the two lead connections you should get a reading slightly over 1 volt. In this position, the red lead will be connected to the LED anode and the black to the cathode. These two leads should be wired exactly in the same manner to the black and red wires of the phone cord.

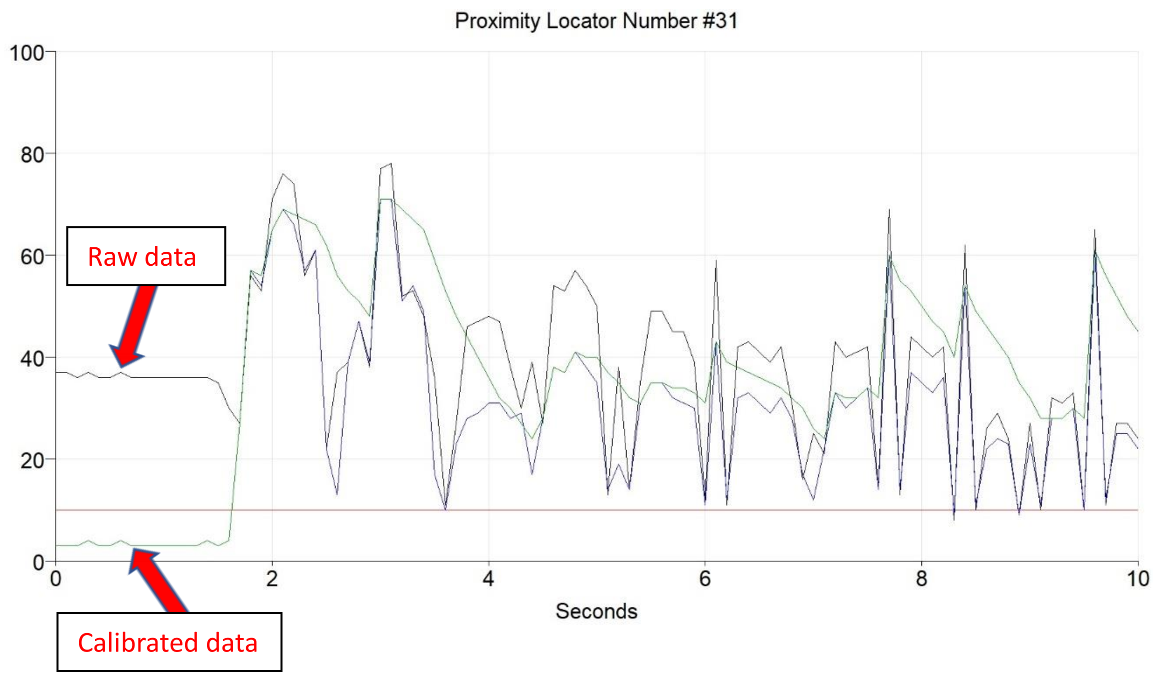
For the Sensor (the dark purple element), set your multimeter to Ω to measure ohms. Connect the leads to the sensor. If the reading is erratic and jumping around or reading .0L when you hold your finger over the top of the sensor switch the leads. In one of the two lead connections you should get a reading of about 150 kΩ with your finger over the sensor, about 15 kΩ in normal room light, and 250Ω to 1 kΩ in direct sunlight. When these readings are achieved, the red lead will be connected to the sensor collector and the black lead to the sensor emitter.

Connect the green phone cord wire to the emitter and the yellow to the collector.

3.5.5.3 Effect of sun on IR Proximity Locator The sun is a very significant source of IR light. As would be expected it will have a significant impact on the reading you get from your proximity locator. If we do a plot of the IR Proximity Locator as we have implemented it in direct sunlight, we see the following:



Note that the raw data line is at about 98 well above the trigger line. However, the calibrated data is only at about 2, well below the trigger line. The raw data visually shows why many people do not like IR sensors. By centralizing our process in a main computer, we can use algorithms to calibrate the sensors. Shown below is a plot from an N scale layout where part of the layout was in the



sun and a train passed by.

The raw data would have constantly triggered the reflective locator, but the calibrated filtered data shows perfect operation as the train passes by.

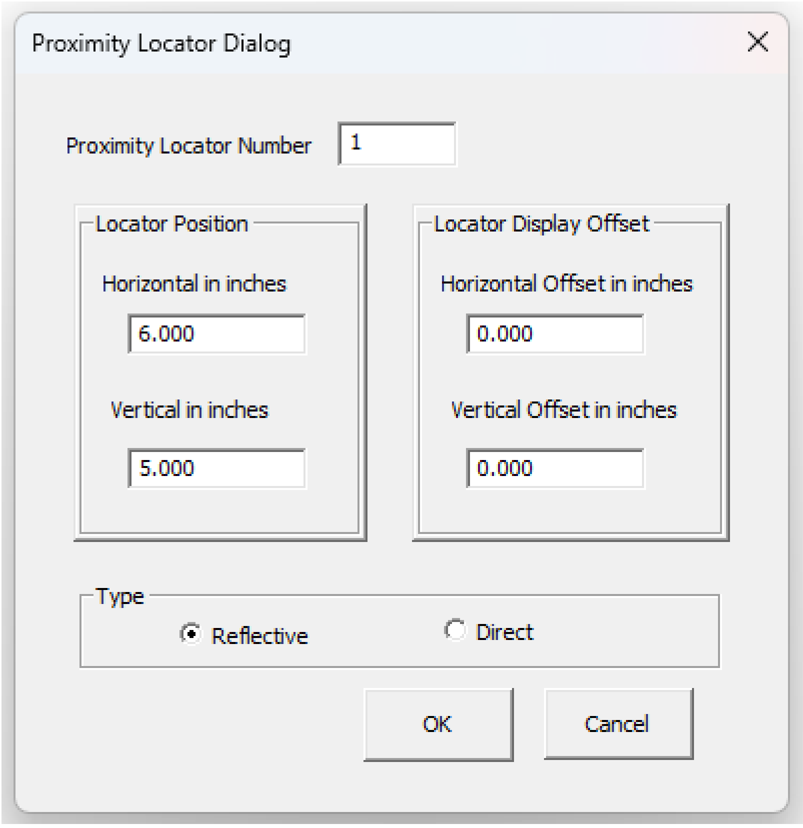
3.5.6 Practical Example

A simple example using an **IR Proximity Locator** is illustrated below. In this example we add only a WIFI Module and one Proximity Locator.

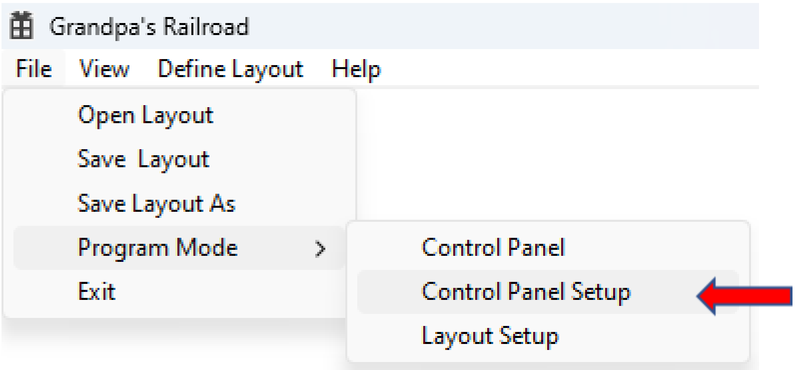
Step 1: Prepare the hardware as described in the Hardware Required Section above. Make sure to reinstall the plastic case.

Step 2: Add a WIFI Module to your layout as described in the Adding a WIFI Module Practical Example Section.

Step 3: Add a proximity locator to the layout at 6 inches Horizontal and 5 inches Vertical. Define the Type as **Reflective**.



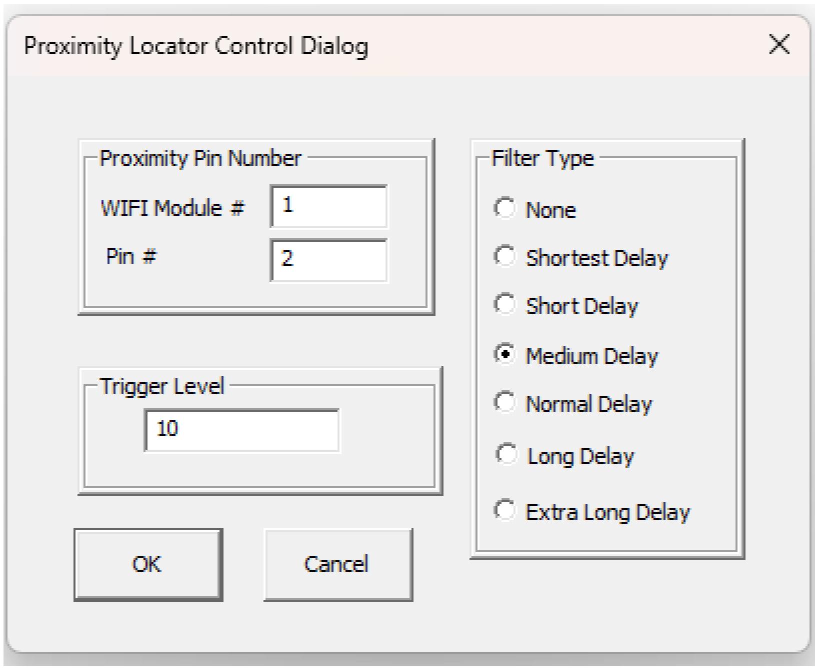
Step 4: From the File Menu item select:



File/Program Mode/Control Panel Setup

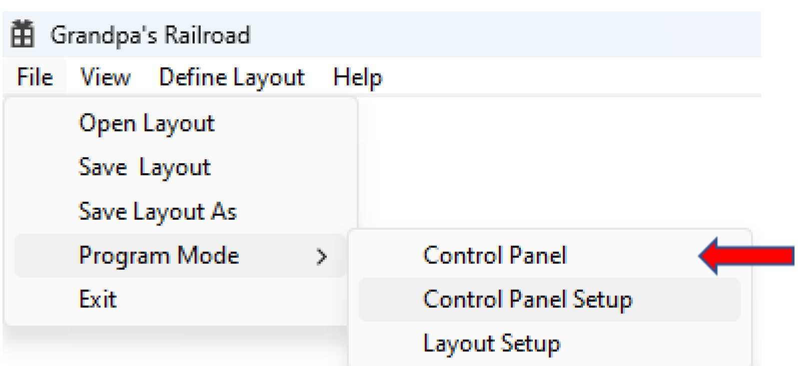
This will change to the Control Panel Setup mode.

Step 5: Using the *Left Mouse Button*, click the **Proximity Locator** image on the layout and the following dialog will appear.



Enter the data in the dialog.

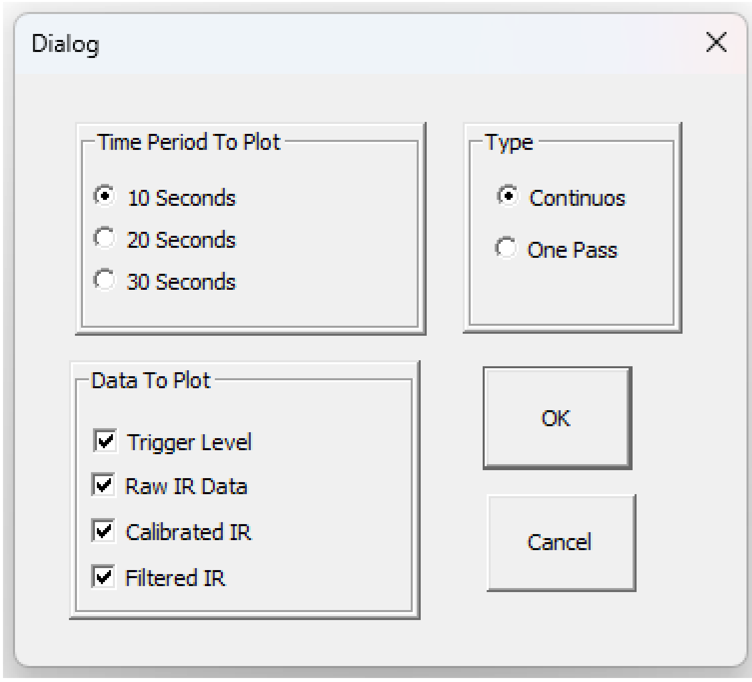
Step 6: From the File Menu item select:



File/Program Mode/Control Panel

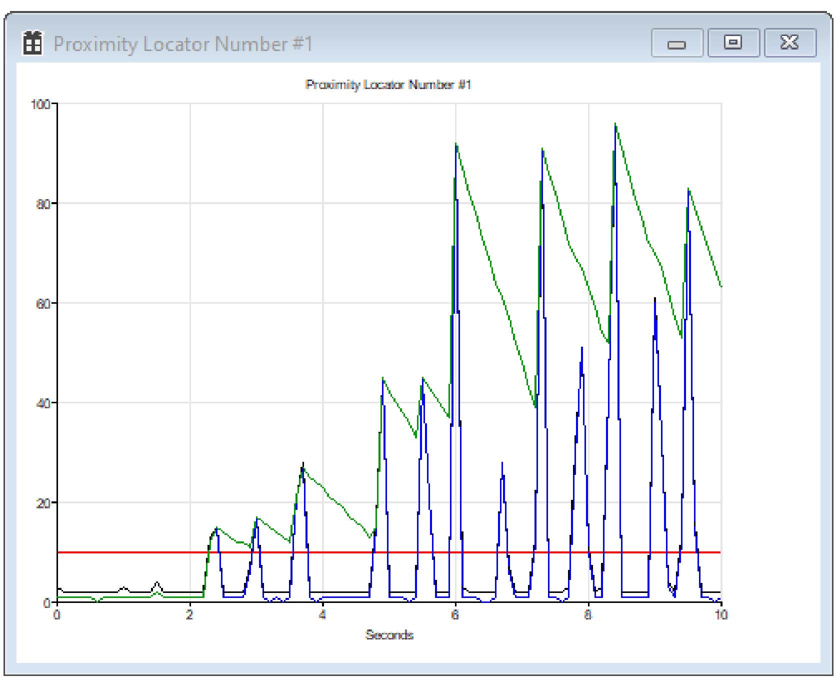
This will change to the Control Panel mode. The WIFI Module should connect.

Step 7: Using the *Left Mouse Button*, click the **Proximity Locator** image on the layout. A dialog will appear to define the proximity Locator Plot.



Fill in the above data and press ok.

Step 8: Wave your hand in front of the sensor at about 1 inch. The screen should look as follows:



Experiment with changing filters, different light conditions, etc.

3.7 Adding Gate, Signal, or Animation Coming Soon

3.8 Adding Collision Avoidance

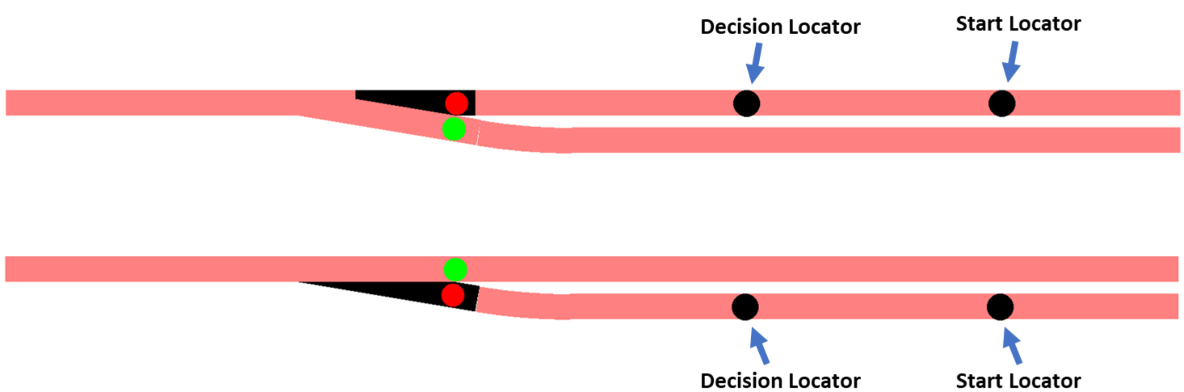
Collision Avoidance on Grandpa's Railroad is used to prevent a train from colliding with something on the tracks or derailing from entering a switch that is in the wrong direction. In both cases this is done by automatically cutting power to the section of track, **Block**, that the train is on. (See Section 3.1 for a discussion of **Blocks**.)

3.8.1 Hardware Required

The track must be wired to a block control card to use collision avoidance. The installation and setup of this card is discussed in Section 3.1. In addition, there must be two proximity locators per leg for a turnout for turnout collision avoidance and three or more per track segment for track occupied collision avoidance. Before moving on to setting up these features, the relationship between the proximity locators and the track will be discussed.

3.8.1.1 Turnout Collision Avoidance Hardware Location Three scenarios of proximity locators to turnout positioning will be discussed.

The first is a simple turnout as pictured below:

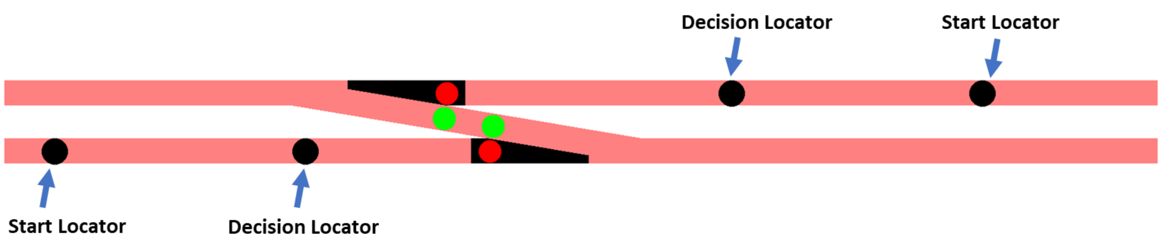


To fully cover this situation, we would need two collision avoidance proximity objects defined, one for each leg. Each would need a start locator and a decision locator. The decision locator must always be closer to the turnout. This is so that direction of travel can be determined as well as motion. If the train is traveling away from the turnout, you would not want to cut power to the track. Likewise, if the train is just sitting in one spot, power should not be cut.

It is important to position the decision locator far enough from the switch, so that the train will coast to a stop before reaching the switch when power is cut. On a high speed mainline this distance may be different than on a siding. If you have multiple control blocks as depicted below, you will want to set the decision locator

far enough from the end of the block so that the train would not coast into the next powered block. In this example, the decision locator would need to be far enough from the end of the green control block so that the train could stop before reaching the powered red block.

A second scenario is with paired turnouts. For the example below, there are only two derailment situations, even though there are two turnouts. This occurs since



the turnouts have been paired. The turnouts will change together so that the crossover situation will always be correct. We would still need to define two collision avoidance proximity objects to cover the two legs. The location of the proximity locators would need to follow the same rules as with the first scenario.

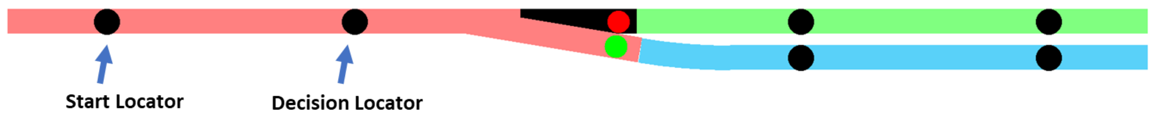
The third scenario is the case where a turnout is directly in front of a second turnout as pictured below. If the turnouts were as shown, we would obviously

have a derailment situation and want to cut power. However, if the turnouts were as pictured below, we would not have a derailment situation and not want to cut power. To address this situation, we have included the possible use of a second turnout during control panel setup, which will be discussed later.

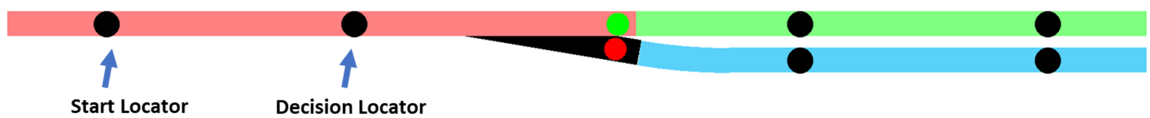
3.8.1.2 Track Occupied Collision Avoidance Hardware Location Two scenarios of proximity locators to track block positioning will be discussed. The first is the simple case of going from one track block to another as pictured below. As with

turnout collision avoidance, direction of travel and motion are both important. We do not want power to be cut if the train is traveling away from the green block or just stationary on the red block. However, if the green block is occupied, we do want the train to stop. One or more proximity locators can be used on the green block to determine green block occupancy. Obviously, the more sensors you use (the higher the density) the smaller the obstruction that can be detected. If you are trying to determine if a long train is on the segment versus a single car, the density would need to be less. As with turnout collision avoidance, the decision locator should be closer than the start locator to the end of the block but far enough away so that the train has enough distance to coast to a stop before reaching the powered green block. The drawing above only depicts protecting for occupancy on the green block. If we want to protect the opposite direction of a train going from the green block to the red block, we will have to define a second track occupied collision object. This object may not require any additional resources or wiring since Grandpa's Railroad proximity locators are not dedicated to a particular function. That is, the locators that are used in the green block to determine occupancy could be the same locators that are used for the start and decision locators when going in the opposite direction.

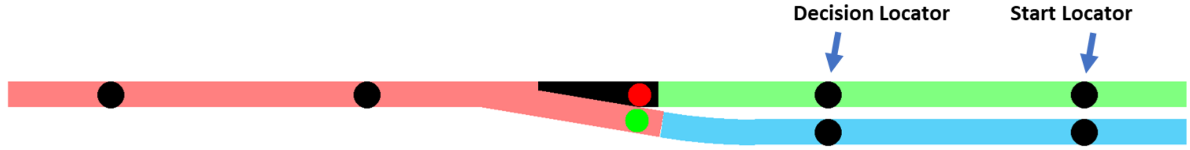
The second scenario occurs when there is a turnout before the occupied block. A drawing of this is shown below. In this scenario we only care about the green

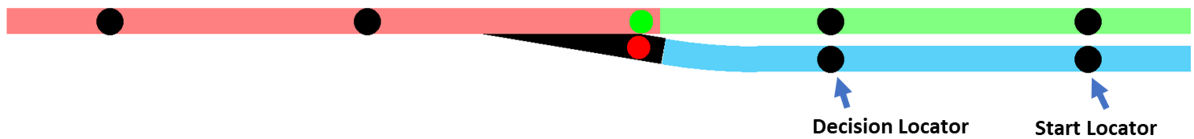


block being occupied if the turnout is in the mainline position. However, in this case we would care about blue block occupancy. If we change the switch position as follows, we now must consider green block occupancy not blue. During control



panel setup the turnout direction can be specified thus dealing with this situation. To cover the above two possible switch positions, you would need to define two track occupied proximity objects since the locators used would be different. If you wanted to provide track occupancy collision avoidance in the opposite direction, you would need to define two more track occupied collision avoidance objects for the two scenarios below. Again, no more resources or wiring may be necessary

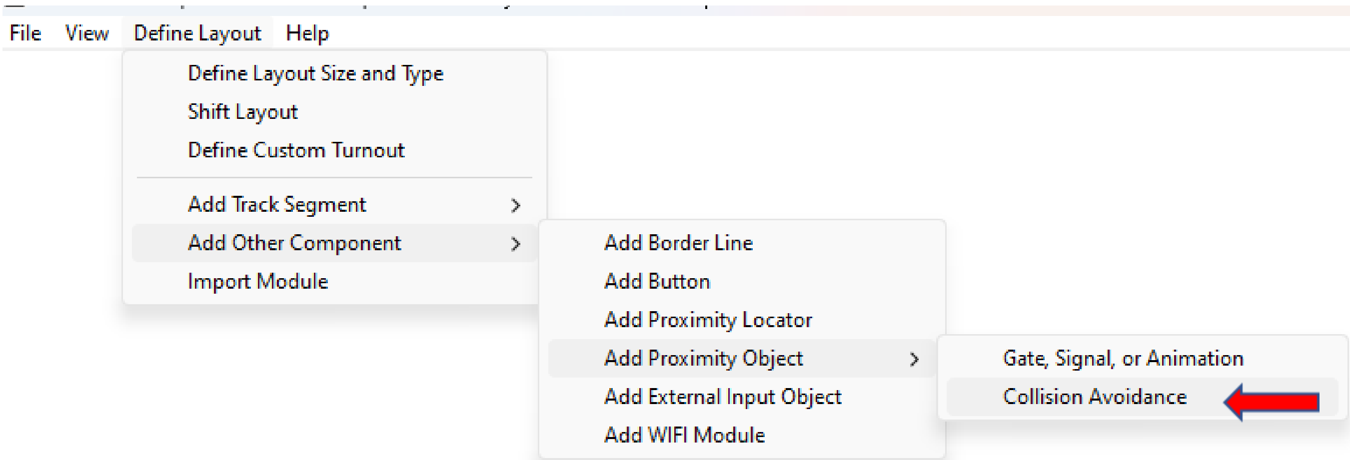




since Grandpa's Railroad proximity locators are not dedicated to a particular function.

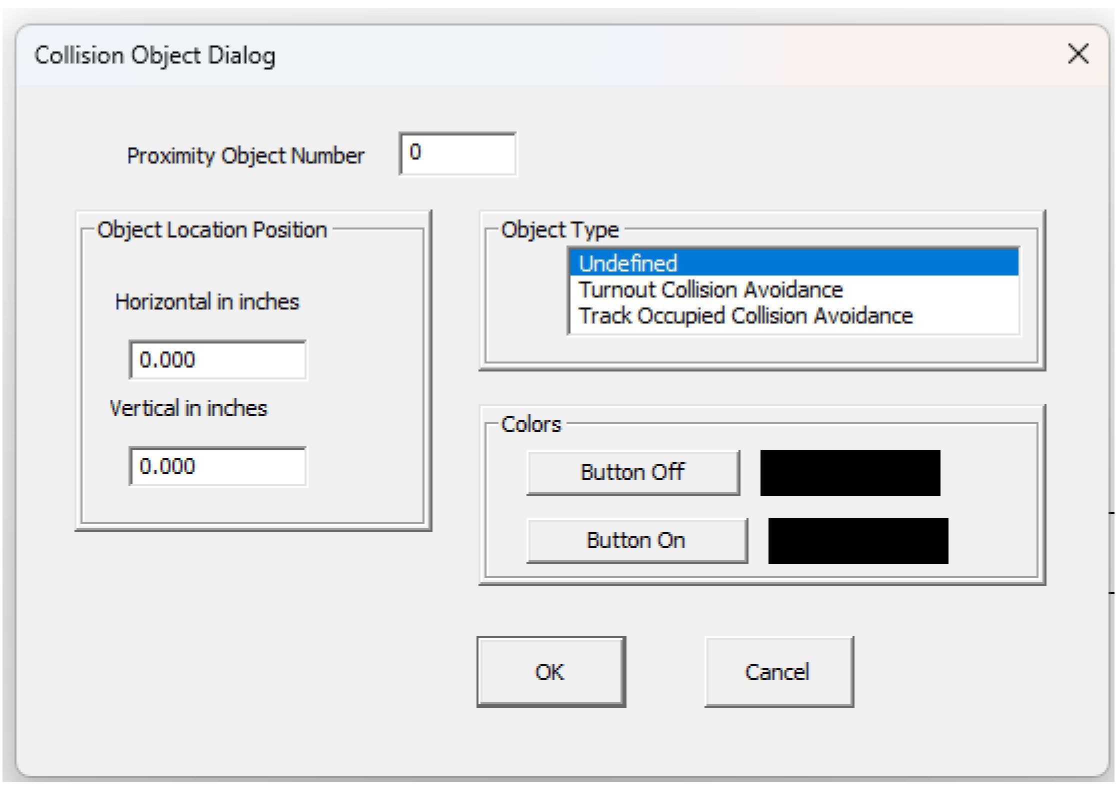
3.8.2 Adding a Collision Avoidance Object to your Layout

From the main menu select



Define Layout/Add Other Component/Add Proximity Object/Collision Avoidance

Upon selecting this menu item, the following dialog will appear.



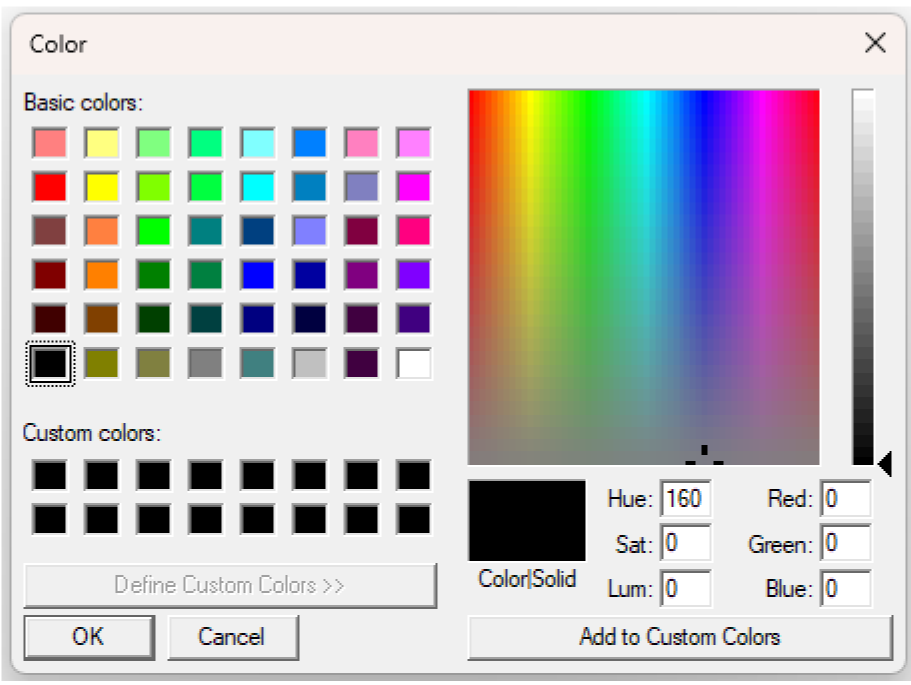
Using this dialog, the following data must be entered.

Proximity Object Number is a number between 1 and 999 that you assign to this object. This number will be used to identify the object.

Object Location Position is the point on your layout where the object symbol (a square) will be placed. It is best to place the symbol near the location where the avoidance is utilized. For example, if it is a turnout collision avoidance object, place it next to the turnout it is utilizing. In this way, if an avoidance situation occurs, the symbol which will flash will give you an indication of the location of the problem.

Object Type is either turnout collision avoidance or track occupied collision avoidance.

Colors The Colors group is used to customize the *On* and *Off* colors of collision avoidance signal. Collision avoidance can be manually disabled and the off color will be displayed. When on, the on color will be displayed. You may chose to use a different color for both *On* and *Off* for the two types of avoidance. This will allow you to easily distinguish between the two types on the display. Pushing either button will cause the following dialog to appear.



Using this dialog, you can select the color of the object.

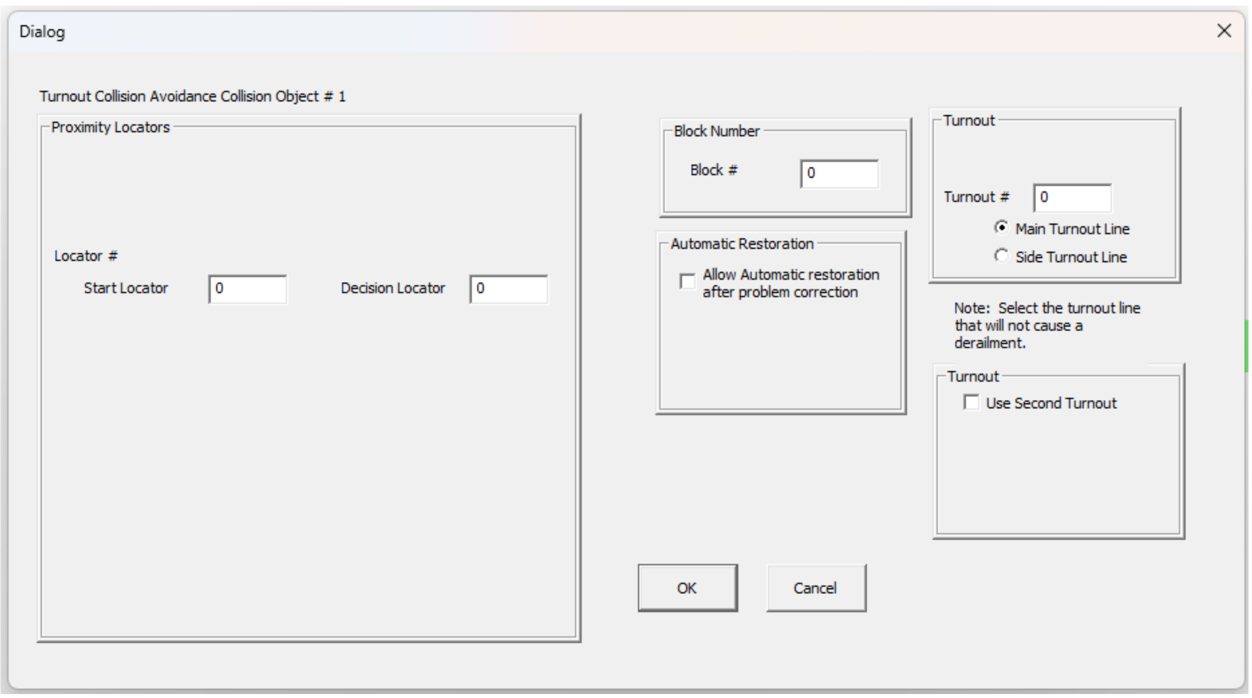
Once you select **OK** from the Collision Object dialog and if you have entered all required data, a square will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

If you need to edit a Collision Avoidance Object Input, you can left click with your mouse on the Collision Avoidance Object and this dialog will reappear.

3.8.3 Setting Up a Collision Avoidance Object for your Control Panel

To set up a Collision Avoidance Object for your layout, you must be in **Control Setup** mode. Using the *Left Mouse Button*, click the Collision Avoidance Object image on the layout. The dialog that appears depends on the avoidance type. Each will be discussed separately.

3.8.3.1 Turnout Collision Avoidance Control Panel Setup The dialog that appears for Turnout Collision Avoidance is as follows:



Using this dialog, you must enter the following:

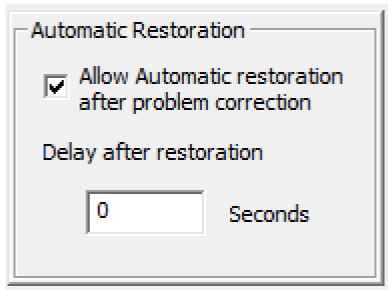
Start Proximity Locator Number The start proximity locator number is the number of the locator which is first encountered when approaching the turnout. This locator starts the testing sequence for train direction.

Decision Proximity Locator Number The decision proximity locator number is the number of the locator which is nearest the turnout. This locator is the decision point for train direction and the time at which the turnout position is tested to see if there will be a derailment.

Block Number The block number is the number of the control block which will have power cut if a derailment is indicated.

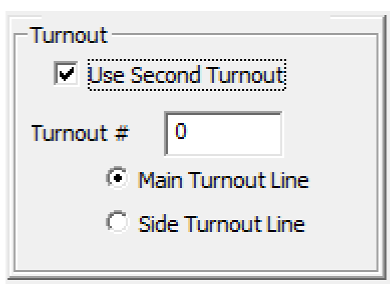
Turnout # The turnout number is the number of the turnout being tested. You must also select the direction that the turnout should be in **to not cause** a derailment. This will either be the mainline or siding positions.

Automatic Restoration If you check the automatic restoration box, the dialog changes as follows:

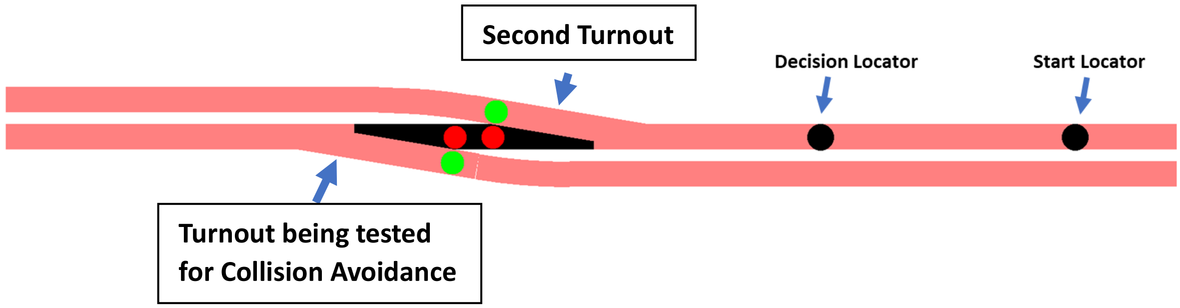


You must now enter a time delay between the time you click the mouse to correct the turnout position and the time that power is restored. This delay is typically 4-6 seconds to account for the time for the switch machine to fully change the direction of the turnout. Depending on the distance the train stopped from the turnout, it could reach the turnout before the repositioning has fully occurred. The number entered must be in 1 second increments (an integer). Even if you select automatic restoration, you can take manual control after the train has stopped as will be discussed under control panel operation.

Use Second Turnout If you the Use Second Turnout box, the dialog changes as follows:



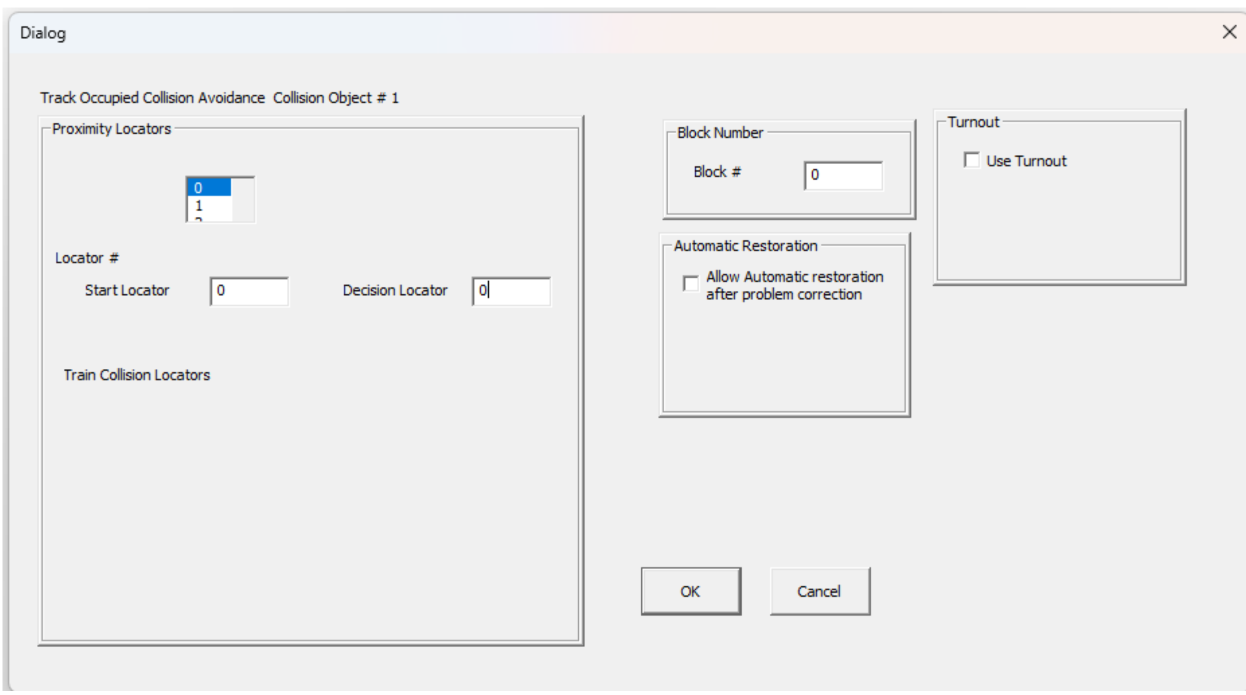
This feature allows you to address the third scenario described in section 3.8.1.1 where a turnout is directly in front of a second turnout as pictured below.



Using this dialog, enter the turnout number of the second turnout and the direction that **will not reach** the turnout being tested for collision avoidance.

Once you have entered all the required data, select **OK**. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

3.8.3.2 Track Occupied Collision Avoidance Control Panel Setup The dialog that appears for Track Occupied Collision Avoidance is as follows:

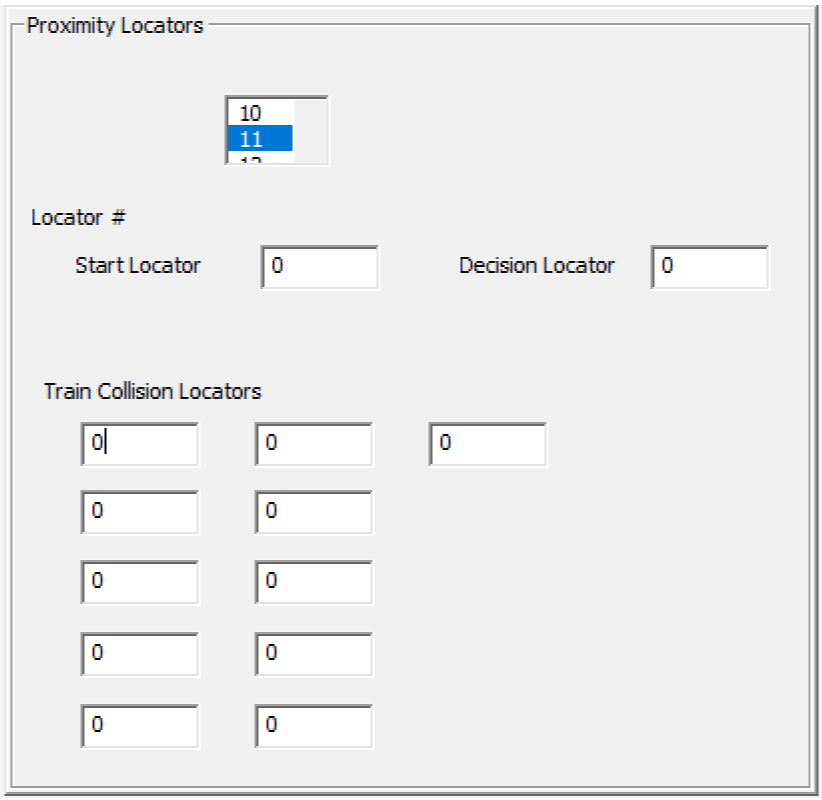


Using this dialog, you must enter the following:

Start Proximity Locator Number The start proximity locator number is the number of the locator which is first encountered when approaching the block that may be occupied. This locator starts the testing sequence for train direction.

Decision Proximity Locator Number The decision proximity locator number is the number of the locator which is nearest the block that may be occupied. This locator is the decision point for train direction and the time at which the proximity locators defined as the Train Collision Locators are tested.

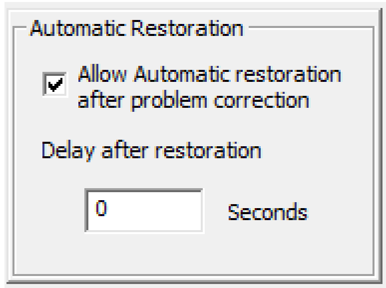
Number of Proximity Locators The number of proximity locators to be tested in the occupied track is set in the scrolling box at the top of the dialog. At least one locator must be defined and up to 20 are allowed. These should not include the start and decision locators. When a number is selected the dialog box changes allowing the entry of those numbers as shown below:



These are the locators that will be tested to determine occupancy.

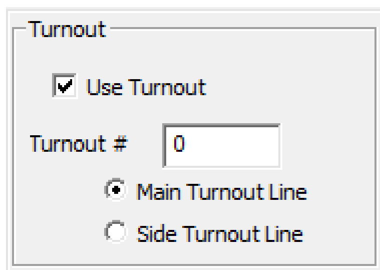
Block Number The block number is the number of the control block which will have power cut if a collision is indicated.

Automatic Restoration If you check the automatic restoration box, the dialog changes as follows:

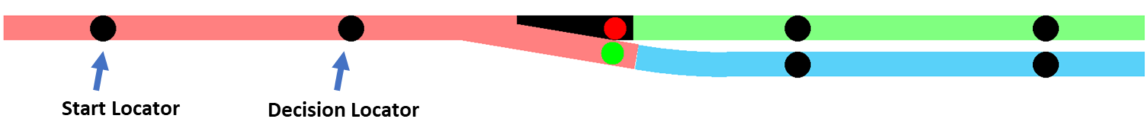


You must now enter a time delay between the time you click the mouse to correct the turnout position and the time that power is restored. This delay is typically 1 second. The number entered must be in 1 second increments (an integer). Even if you select automatic restoration, you can take manual control after the train has stopped as will be discussed under control panel operation.

Turnout If you the Turnout box, the dialog changes as follows:



This feature allows you to address the second scenario described in section 3.8.1.2 where a turnout is directly in front of a track block to be tested for track occupancy as pictured below:



In this scenario the turnout position will determine whether the green or blue block is important for occupancy. You should select either the main or side turnout line. To provide a test for both the green and blue blocks you would need to define 2 track occupied collision objects one for each track. We will clarify this using the example above. The train occupied collision avoidance object testing the green line should have the main turnout line set. When the train reached the decision point since the turnout is pointed to the side turnout track, even if the green or mainline is occupied, the power would not be cut.

3.8.4 Control Panel Operation for a Turnout

Before you can use the collision avoidance feature you must make sure the individual collision avoidance objects are turned on. This is done by simply clicking on their symbol with the left mouse button. By defining different colors for *ON* and *OFF* it is easy to determine the status.

When a collision avoidance condition arises, power will be cut to the designated block, it's symbol will start flashing, and a window will appear with the following symbol. If you have specified automatic restoration during setup, operation can

continue simply by clearing the condition that caused the even. You may choose to use manual restoration to continue operation. To do this, should first correct the condition causing the event or take other action such as reversing train direction, correcting turnout position, etc. Next, close the collision avoidance window (stop sign) by right mouse button clicking on the X in the upper right corner. Finally restore the power to the block using the Block Control feature for that block (see 3.4.1 Control Panel Operation of a Block Control). Note that if you continually manually without correcting the condition, the collision avoidance event will still occur.

Multiply collision avoidance conditions can occur at once. Since power is only cut to one block, operation on the rest of the layout continues allowing other events to occur.

3.8.5 Practical Example

Due to the complexity of the collision avoidance feature, we have no simple example to test it. However, we suggest that you become familiar with Proximity Locators and Track Block Controls on your layout and test these before implementing this feature.

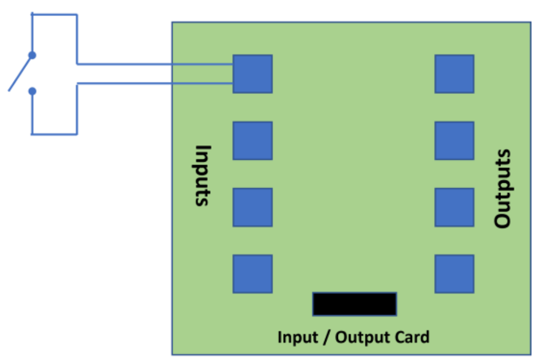
3.9 Adding External Input Object

The External Input object is a method of getting a physical external switch or button position into Grandpa's Railroad Control Panel. One of the main uses of this is to allow an observer (a grandchild) to trigger a feature or animation.

3.9.1 Hardware Required

You will need at least one **Input Connection** on an *Input/Output Card* or a *Turnout Control & I/O Board*.

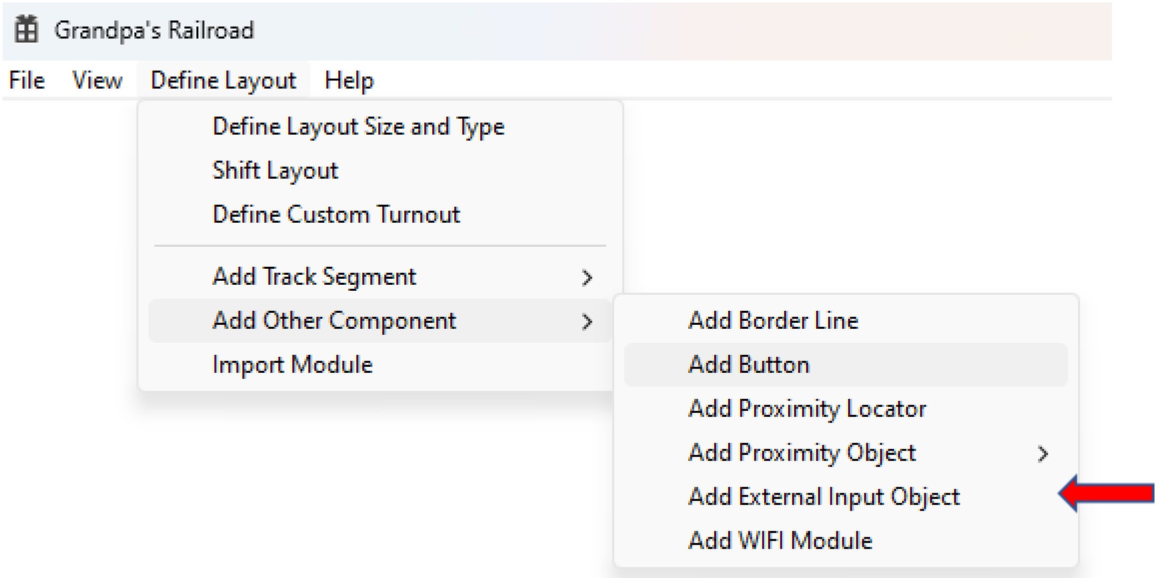
A simple schematic of connecting a switch to the Input connector is shown below:



To learn more about electricity, voltage, and current watch Educational Tutorials "Electricity 99".

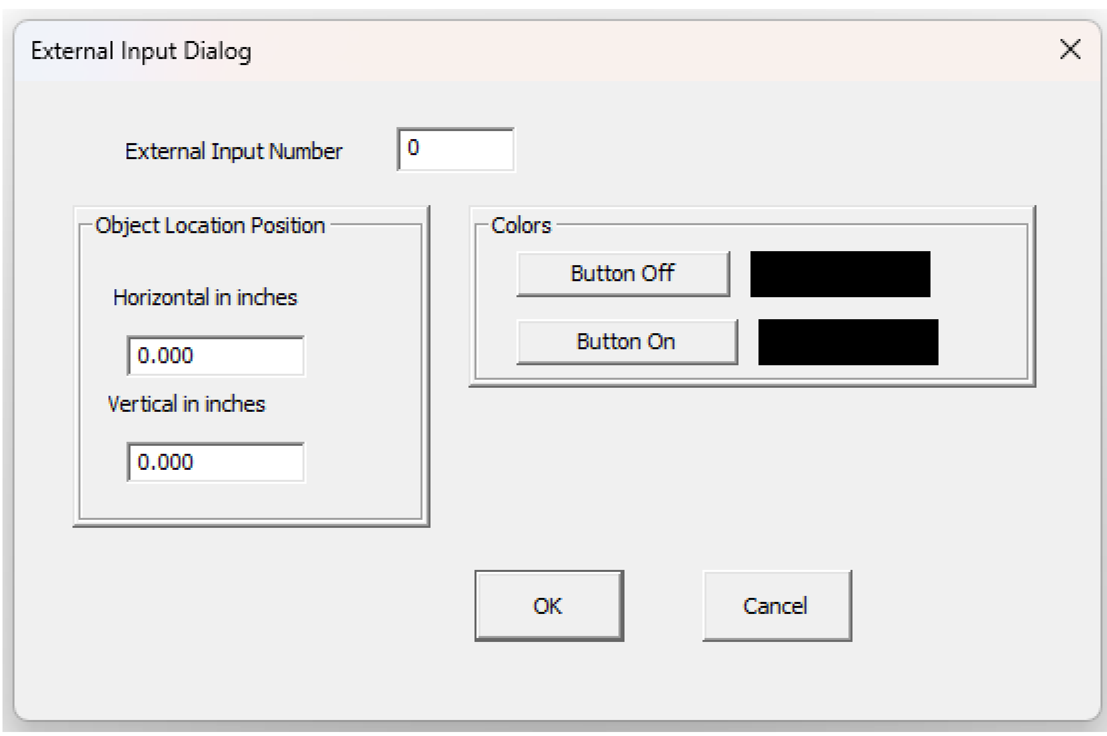
3.9.2 Adding a External Input to your Layout

To add an External Input to your layout you must be in the **Layout Setup** mode. From the main menu select



Define Layout/Add Other Component/Add External Input Object

Upon selecting this menu item, the following dialog will appear.

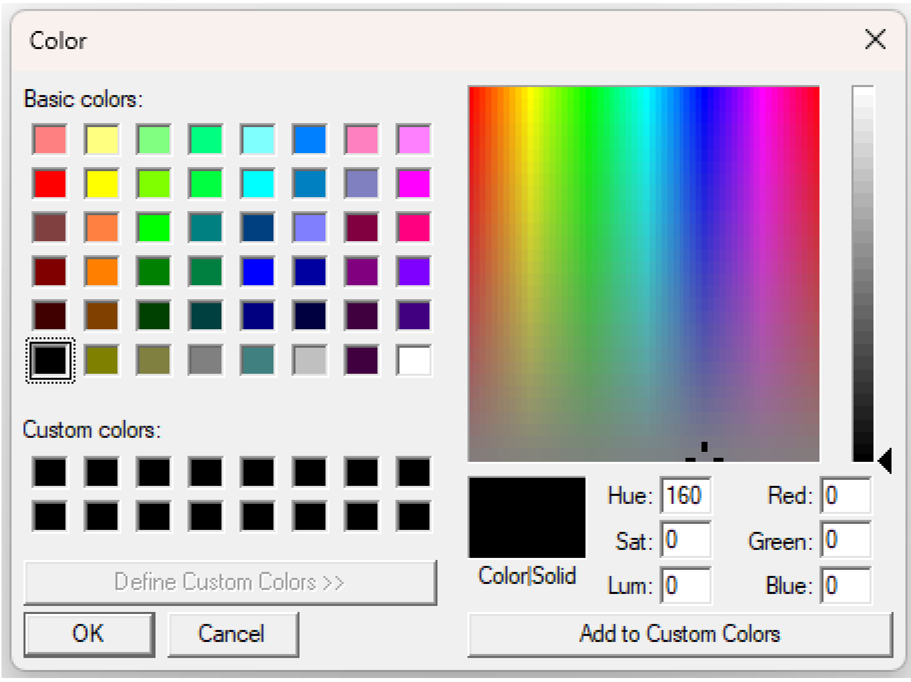


This dialog allows you to enter the External Object number, position, and ***ON/OFF*** colors of the object.

<u>External Object Number</u> is a number between 1 and 999 that you assign to this object. This number must be unique for the object.

<u>Object Location Position</u> is the location of the center of the square indicator that will be placed on layout.

The **Colors** group is used to customize the *On* and *Off* colors of not only the button but also the text. Pushing either button will cause the following dialog to appear.



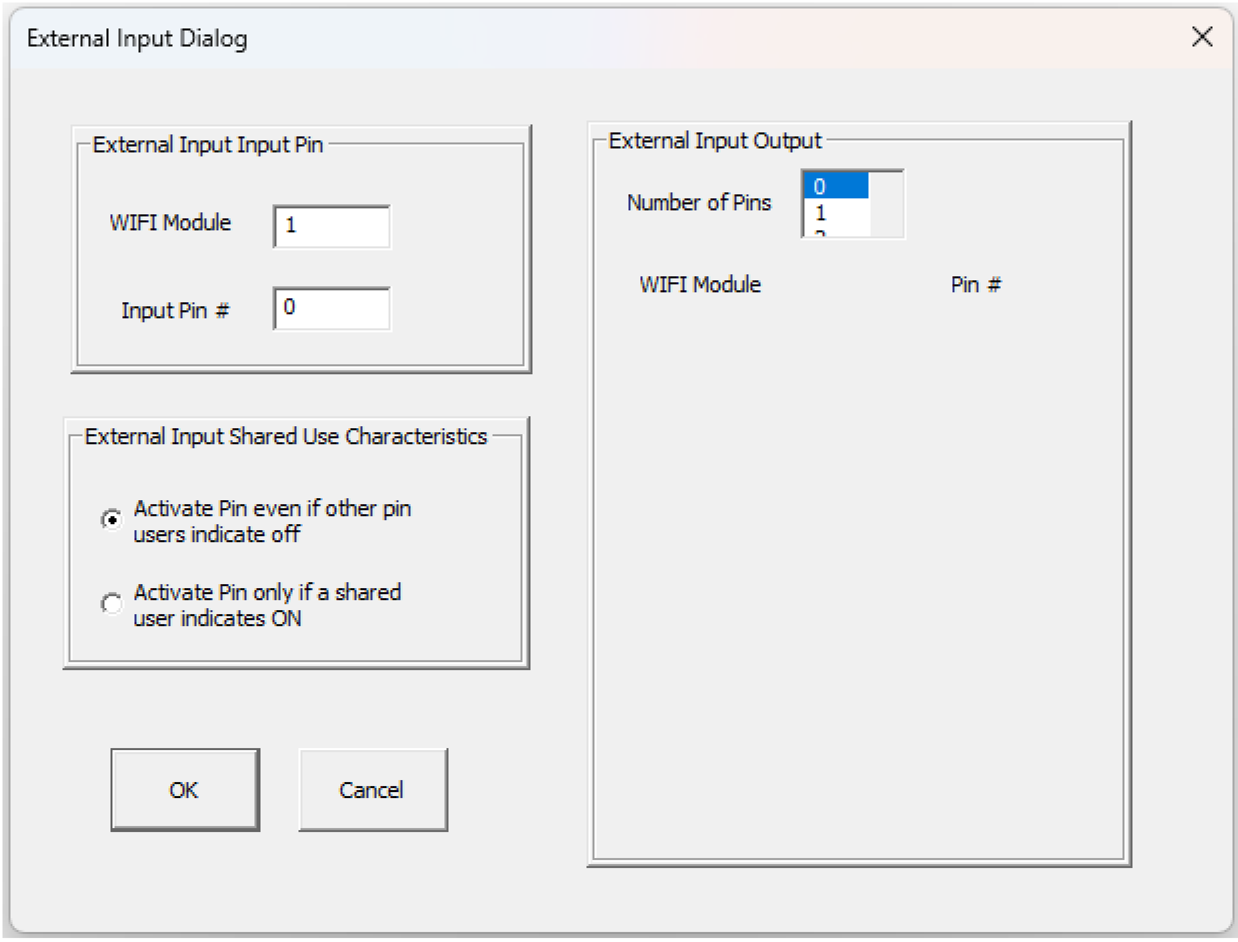
Using this dialog, you can select the color of the object.

Once you select **OK** from the External Input dialog and if you have entered all required data, a square will be placed on the layout. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

If you need to edit an External Input, you can left click with your mouse on the External Input Object and this dialog will reappear.

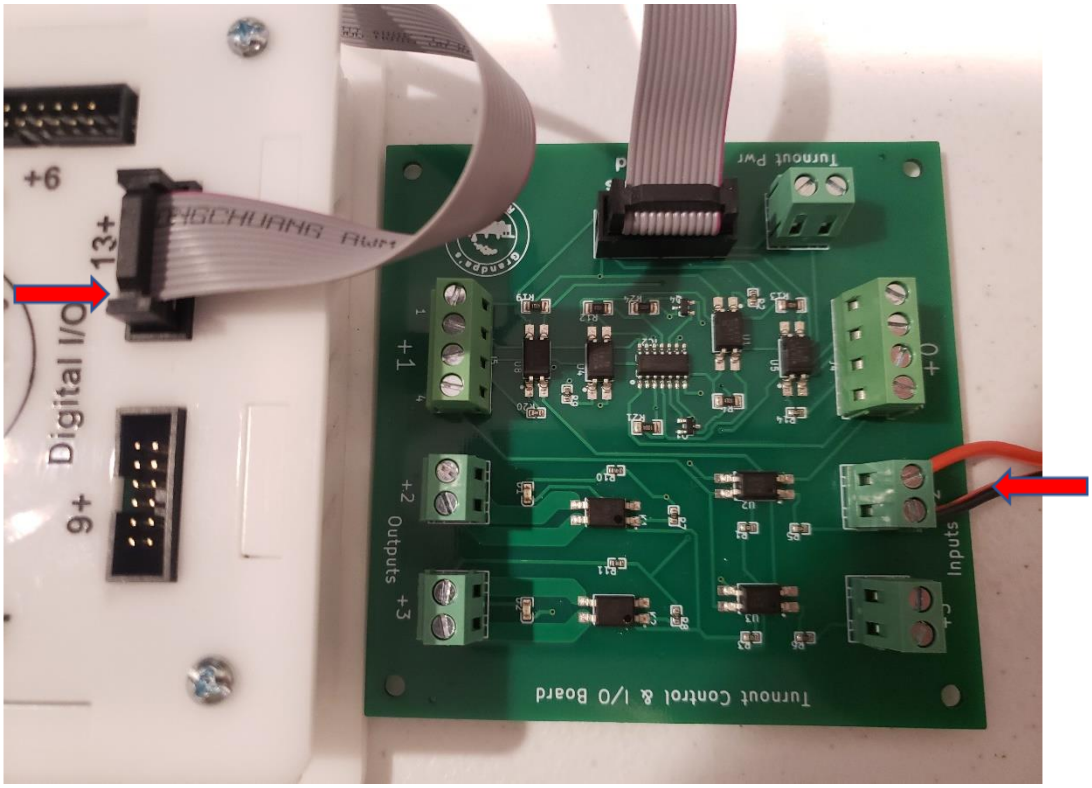
3.9.3 Setting Up an External Input for your Control Panel

To set up an External Input for your layout you must be in **Control Setup** mode. Using the *<u>Left Mouse Button</u>*, click the **External Input** image on the layout and the following dialog will appear.



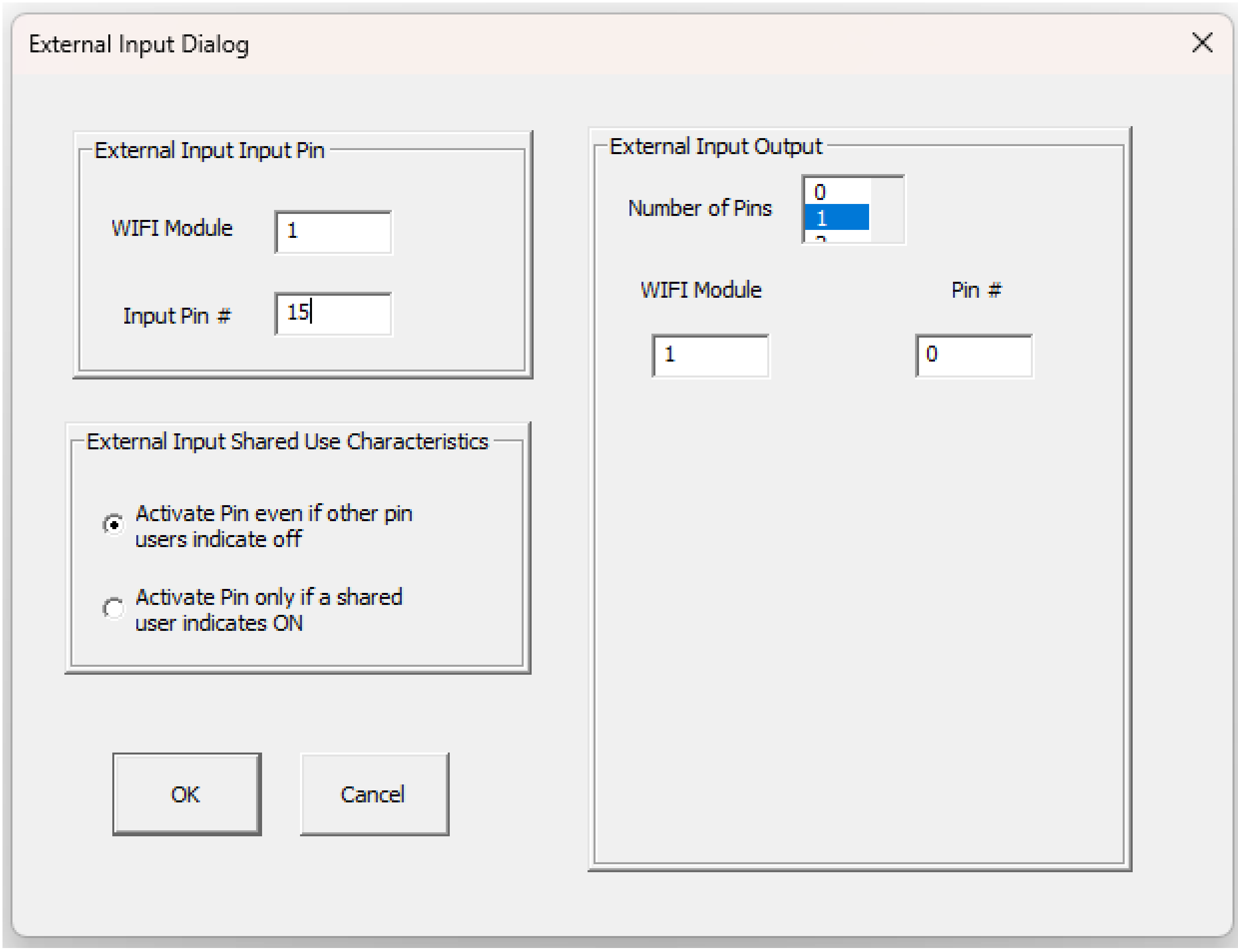
You must enter the **WIFI Module** number that the *Input/Output Card* or a *Turnout Control & I/O Board* card is connected to. That number is the actual number that is programmed into the **WIFI Module**. Note: All modules are shipped with a **Module Number** of 1. You can use the WIFI Module Programmer software to change that number if your layout has more than one module.

The Pin # is calculated by adding the number of the connector on the WIFI Module where the ribbon cable is connected and the *Input/Output Card* or a *Turnout Control & I/O Board* connector number on the card used.



Using the image above, we would calculate the Pin # as 13+ from the WIFI Module plus +2 from the board for a total of 15. Thus, we would enter 15 for Pin #.

You must now select the number of **Output Pins** this External Input will activate. Zero is the special case where the external input is disconnected. You can activate up to 8 pins with one button. If a non-zero value is selected, the dialog will change allowing you to enter the **Output Pin** to be controlled. For example, selecting one will result in the following change.



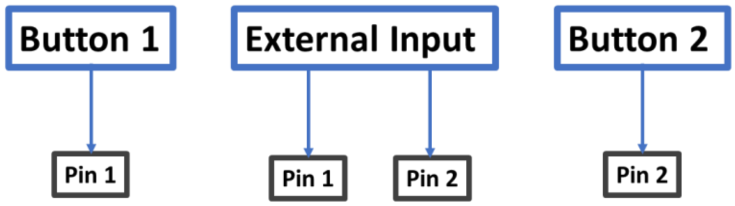
For each Output Pin that is to be activated, you must enter the **WIFI Module** number that the I/O card is connected to. That number is the actual number that is programmed into the **WIFI Module**. Note: All modules are shipped with a **Module Number** of 1.

The final item which we must specify is whether the external input is shared. Sharing is a concept where the external input may be paired with a button or some Proximity Objects. For example, this feature allows external inputs to be easily turned off or switched to an alternate pin. If your layout has an external input to allow visitors to control an animation, sharing the external input with a button allows you to turn off the external input. The button sharing is of two types:

1) The button activates the designated pin even if other pin users indicate *Off.*

2) The button only activates the designated pin if other pin users indicate *On,* and this button indicates *On.*

To illustrate the above, assume we have an external input that controls two pins and it is of type 2 sharing as described above. Also assume there is a button of type 2 associated with each of these pins.



Then Pin 1 and the animation associated with it will only be *On* If both Button 1 and the external input are *On.* Likewise, Pin 2 and the animation associated with it will only be *On* If both Button 2 and the external input are *On*. Therefore, by simply manipulating Buttons 1 & 2 you can determine what the External Input controls in real time without changing the Control Panel Setup.

3.9.4 External Input Control Panel Operation

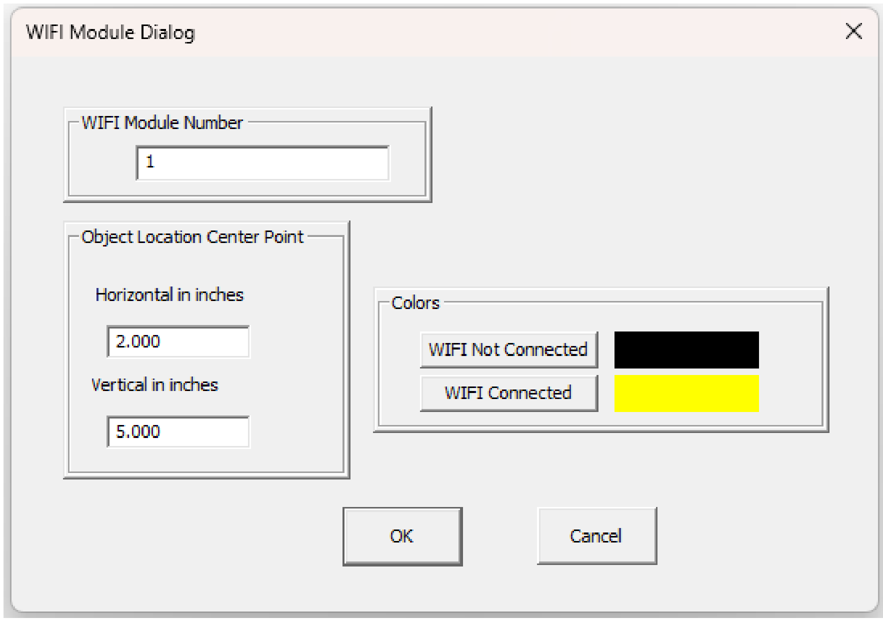
The External Input Object is activated by pressing an external button or switch. The color on the control panel will change from the ***OFF*** color to the ***ON*** color. In addition, the pin or pins associated with the object are activated.

3.9.5 Practical Example

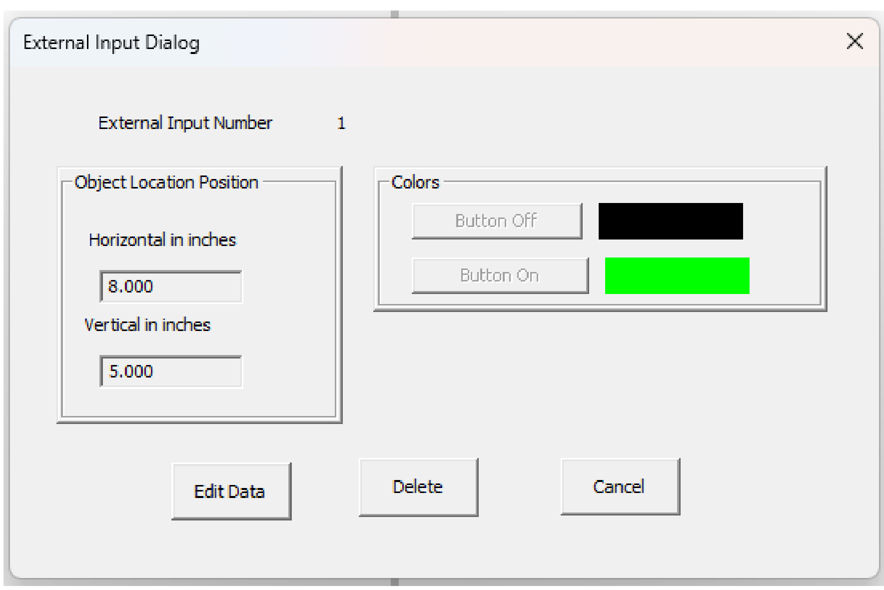
As a practical example, we will reproduce the example used for a **Button**. In this example we are using a multimeter to demonstrate that the output connection is switched when the external button is activated. In the Off state the switch is open, so the resistance is unmeasurably high and in the on state the resistance is very low. We will also connect a simple LED circuit to light the LED.

Step 1: Start the Grandpa's Railroad Application, select the **Layout Setup** mode, and create a 10-inch by 10-inch layout in any scale. (Note: A layout does not need to contain track. In this example we are only adding a button.)

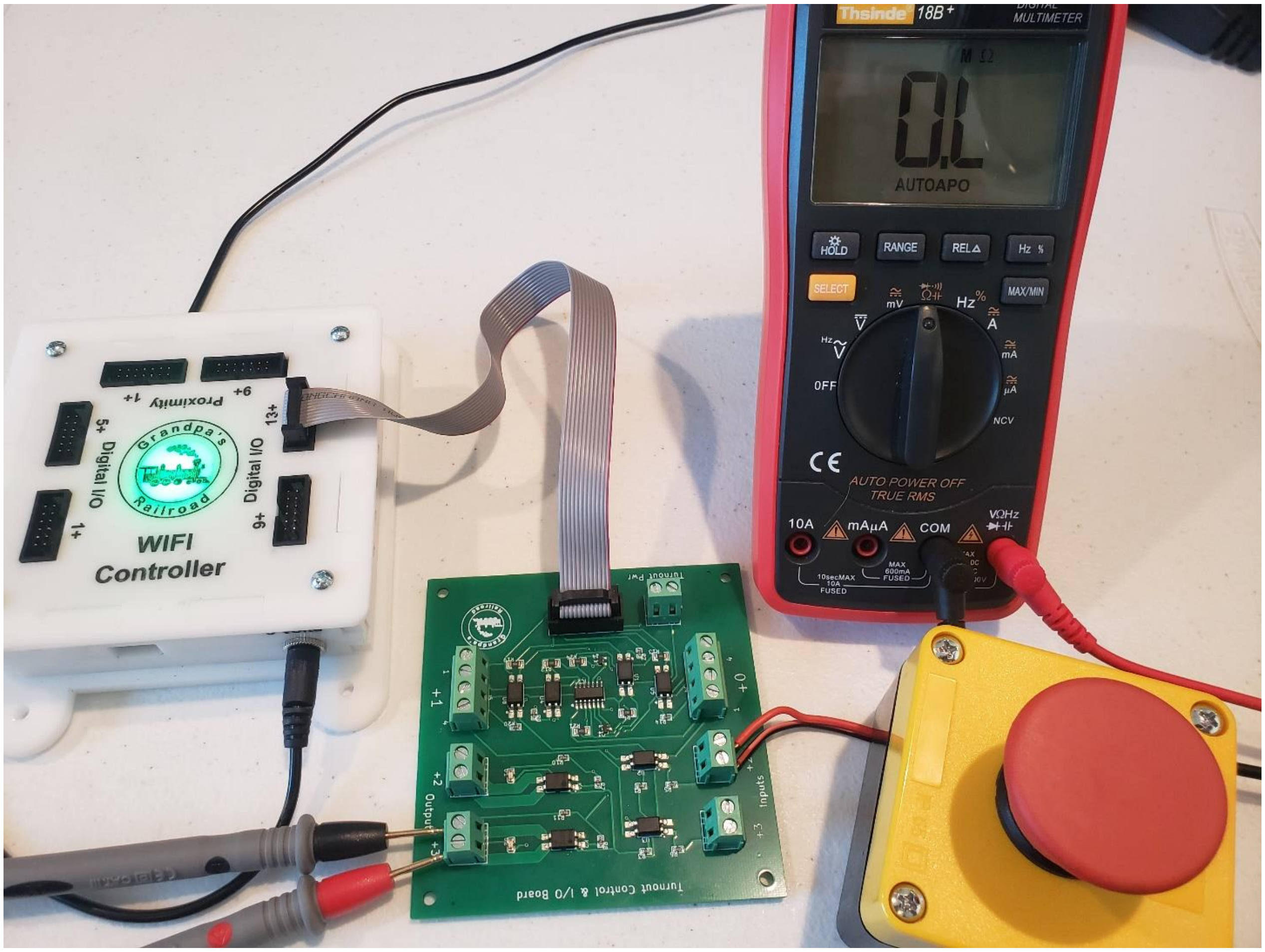
Step 2: Add a WIFI module to the layout at 2 inches Horizontal and 5 inches Vertical with the desired Connected and Not Connected colors. If you are using the supplied WIFI Module and have not changed the number, enter a 1 for the Module Number



Step 3: Add an **External Input** to the layout at 8 inches Horizontal and 5 inches Vertical.

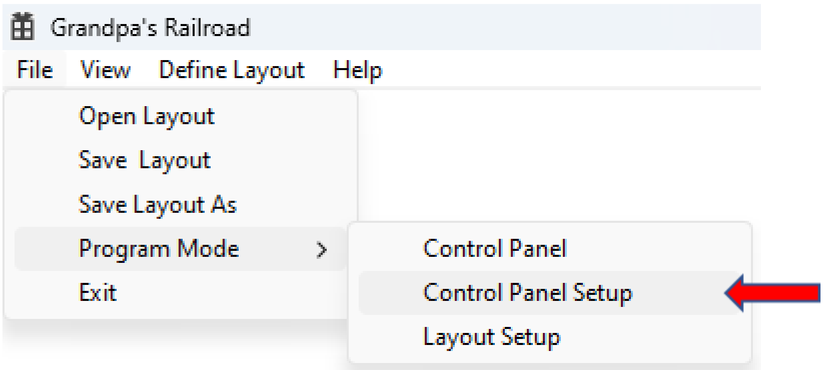


Step 4: Connect the hardware as pictured below:



We have connected power to the WIFI Module, the card to the 13+ port on the WIFI Module, the switch to the +2 connector on the input side, and a multimeter to the +3 connector on output side of the card. These connections will provide a Pin # 15 for the switch and a Pin # 16 for the multimeter. The card we are using is the *Turnout Control & I/O Board* provided with the basic system.

Step 5: From the File Menu item select:

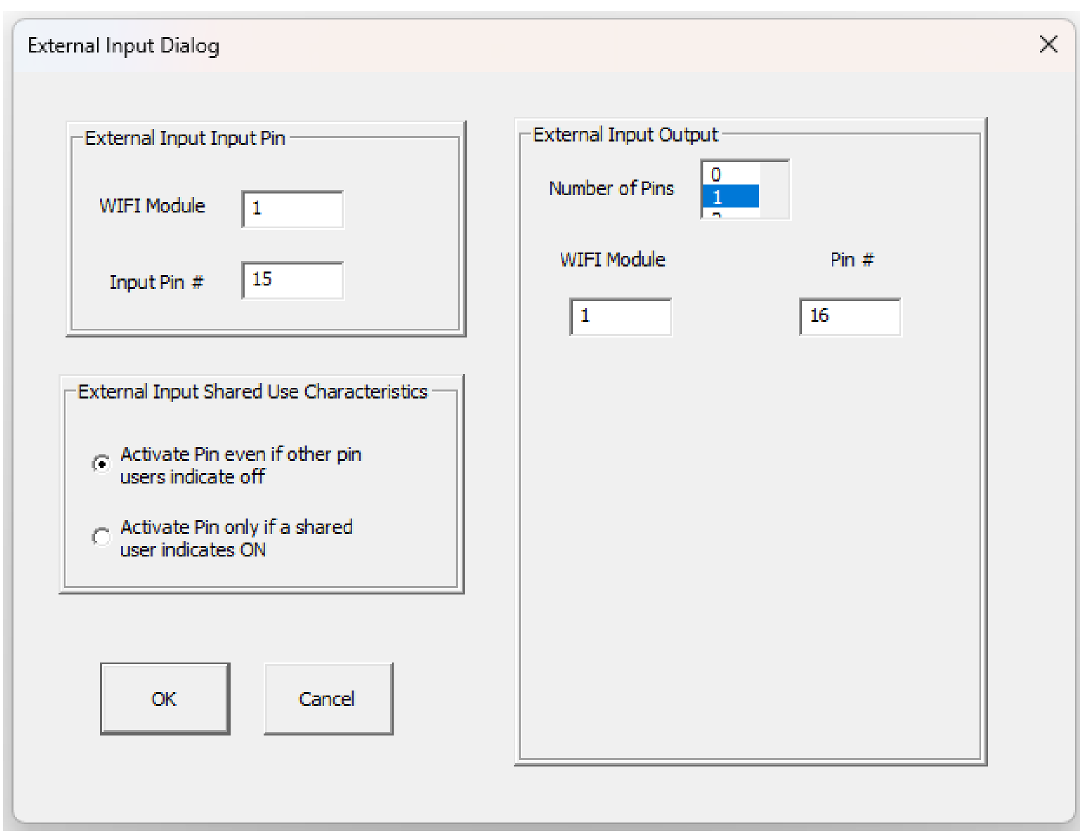


File/Program Mode/Control Panel Setup

This will change to the Control Panel Setup mode.

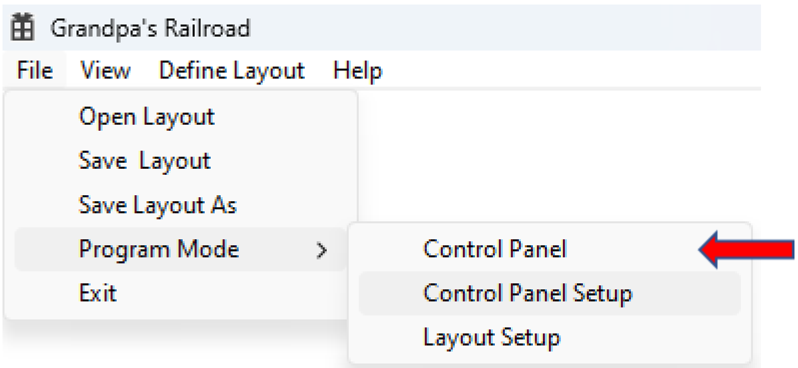
Step 6: Place the mouse cursor over the external input and press the left mouse button.

The following dialog will appear.



Based on the connections we made in step 4, the module # is 1 and the Pin # is 15 for the input switch and 16 for the output. Since only one external input and no buttons have been defined, the sharing type is not important.

Step 7: From the File Menu item select:

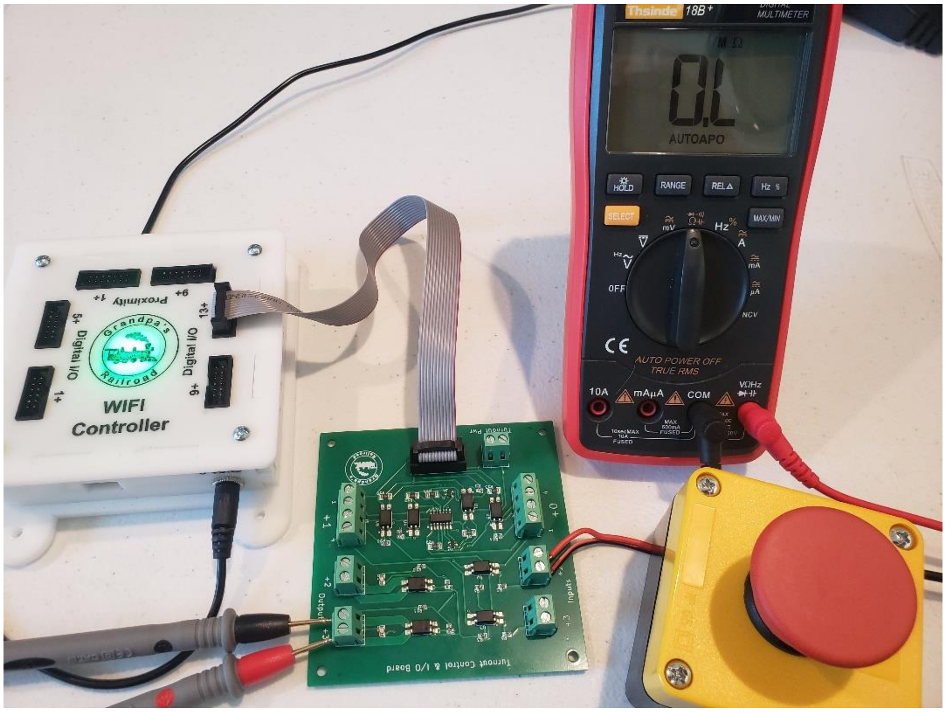


File/Program Mode/Control Panel

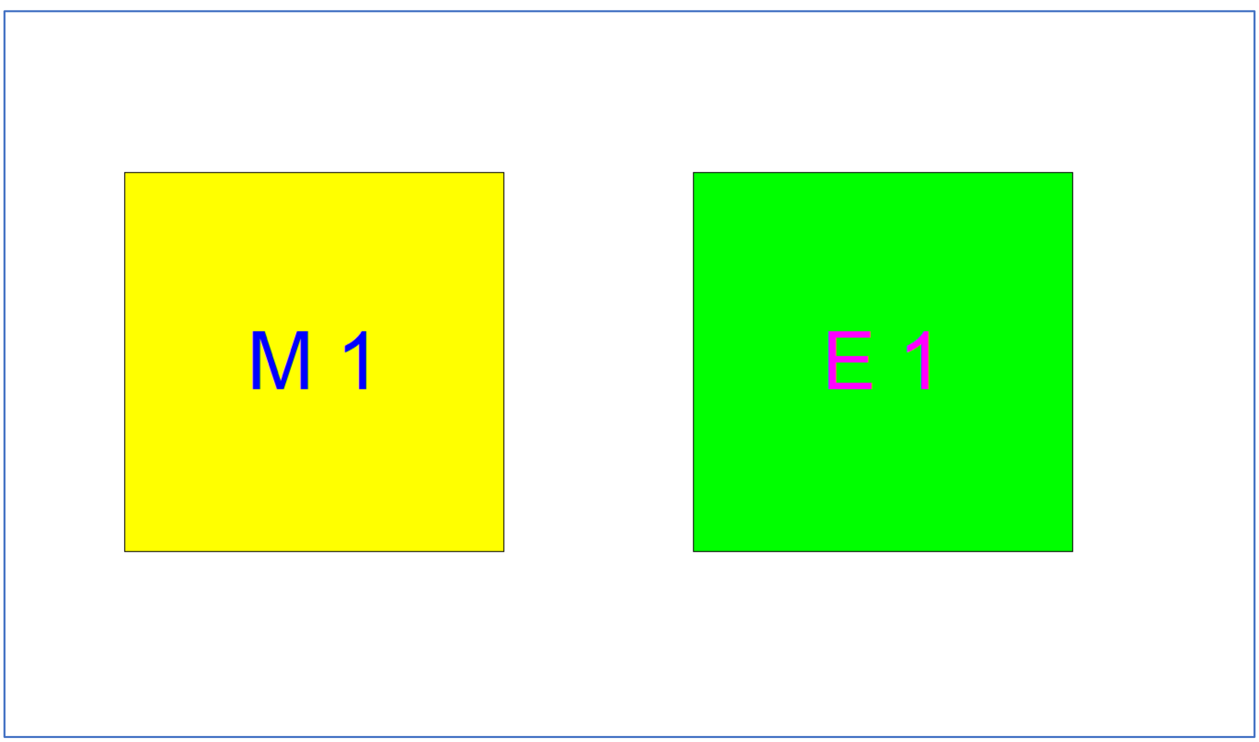
This will change to the Control Panel mode.

Step 8: If you have used our setup parameters and colors, after the WIFI Module connects, the screen should resemble the following.

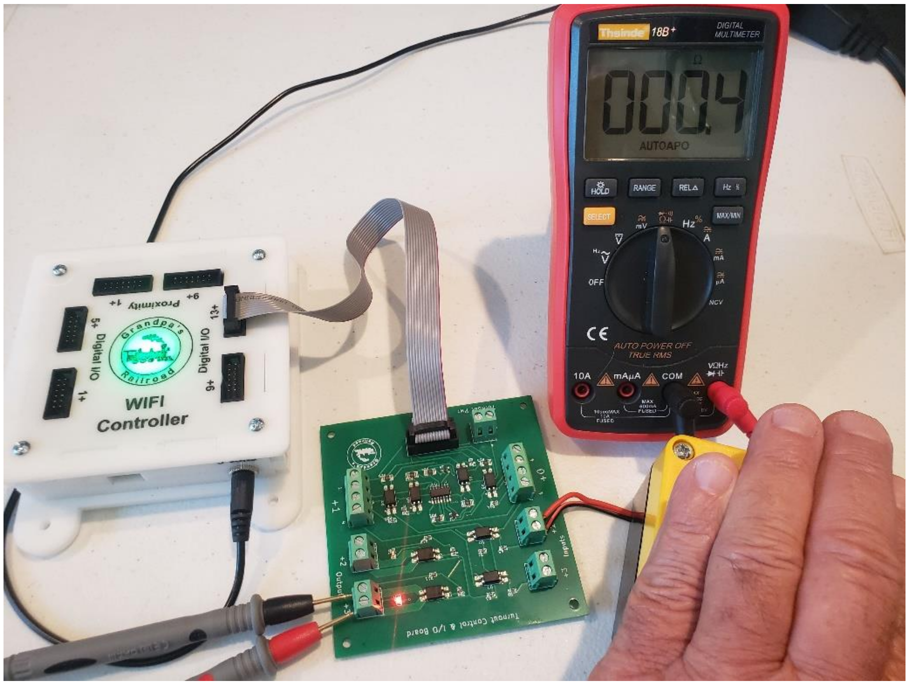
Your multimeter 0.L which means no connection or open.



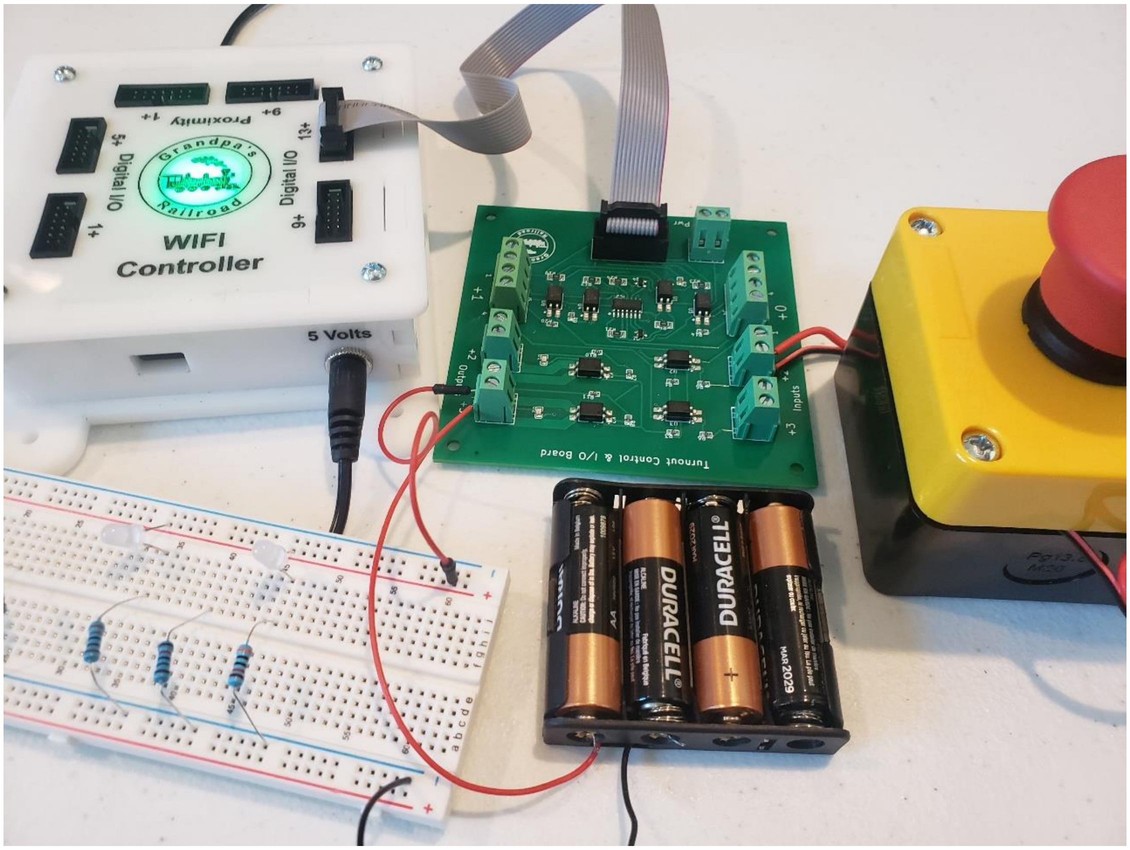
Pressing the External Input switch that you wired will produce the following screen.

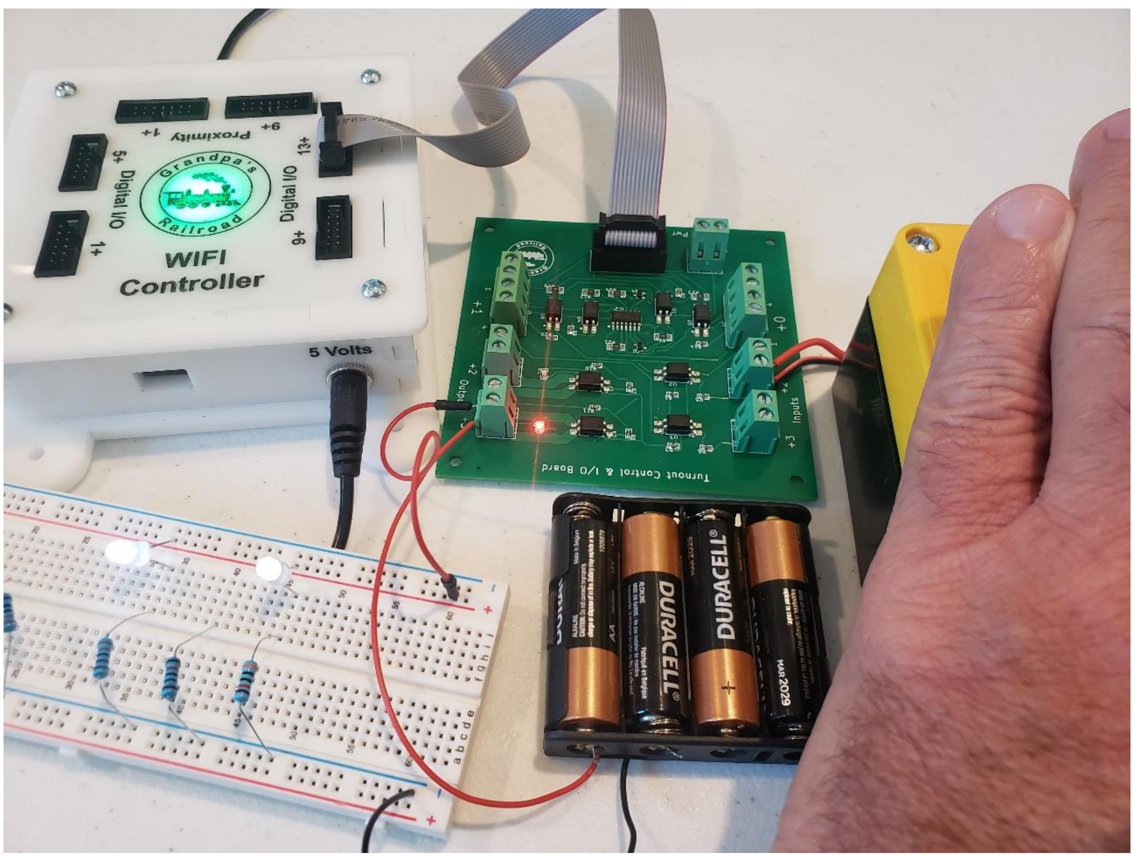


The corresponding multimeter reading is 0.4 ohms, which is typical of a closed switch. Also note a red LED next to the connector lights indicating the switch is *On*.



If you have been following our Educational Tutorials "Electricity 99", a more practical application for model trains would be to turn on and off lighting or an animation that children may like. Connecting a circuit from those videos we can see how we can use a **External Input** to turn *On* and *Off* lighting on the layout. Obviously, the battery pack would be replaced with your accessory power.


WIFI
Controller
5 Volts
Turnout Control & I/O Board
DURACELL


WIFI
Controller
5 Volts
Turnout Control & I/O Board
DURACELL

3.10 Adding WIFI Module

The WIFI Module is the basic controller for Grandpa's Railroad Control Panel. All other cards are connected to this controller. Each controller allows for connection of up to 16 digital inputs and outputs and 16 proximity locators. The controller passes information to the main centralized computer via WIFI for processing. Up to 32 controllers can be used on one layout allowing for 512 I/O and 512 proximity connections. Each WIFI controller that is added must have a unique number from 1 to 32. All controllers are shipped with the number 1. Controllers shipped as part of a basic package have already been programmed for the WIFI router contained with the package. Any additional controllers must first be programmed to set the number, WIFI name, and WIFI password for your system. This is easily accomplished by using the WIFI Module Programmer App supplied with your basic system and preloaded on the Windows PC. (See the WIFI Module Programmer User's Manual.)

3.10.1 Hardware Required

The following hardware is used:

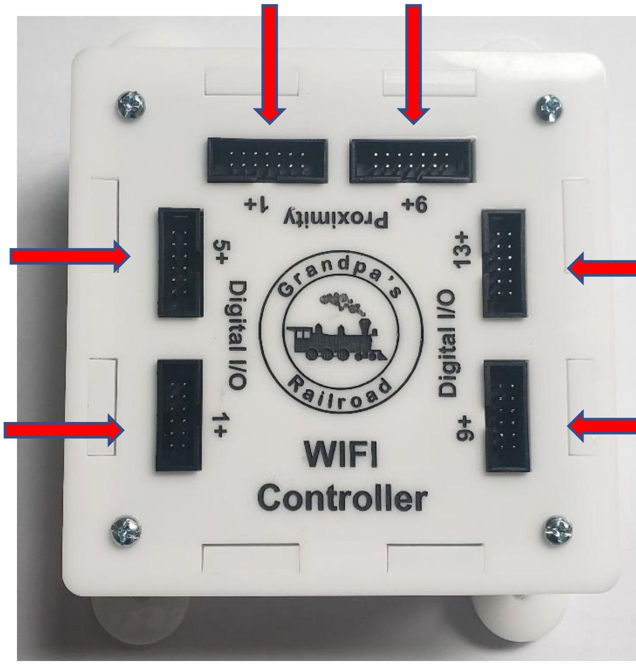
WIFI Module

Proximity Connector
for pins 1-8

Proximity Connector
for pins 9-16

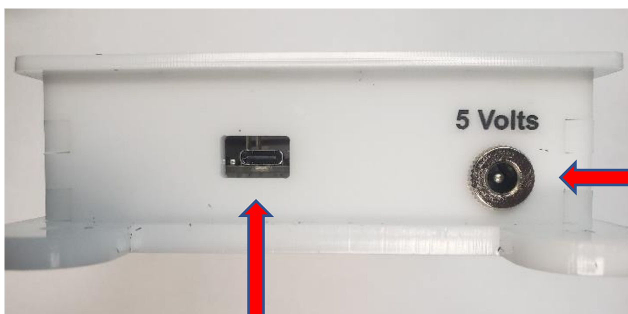
Digital I/O Connector
for pins 5-8

Digital I/O Connector
for pins 1-4



Digital I/O Connector
for pins 13-16

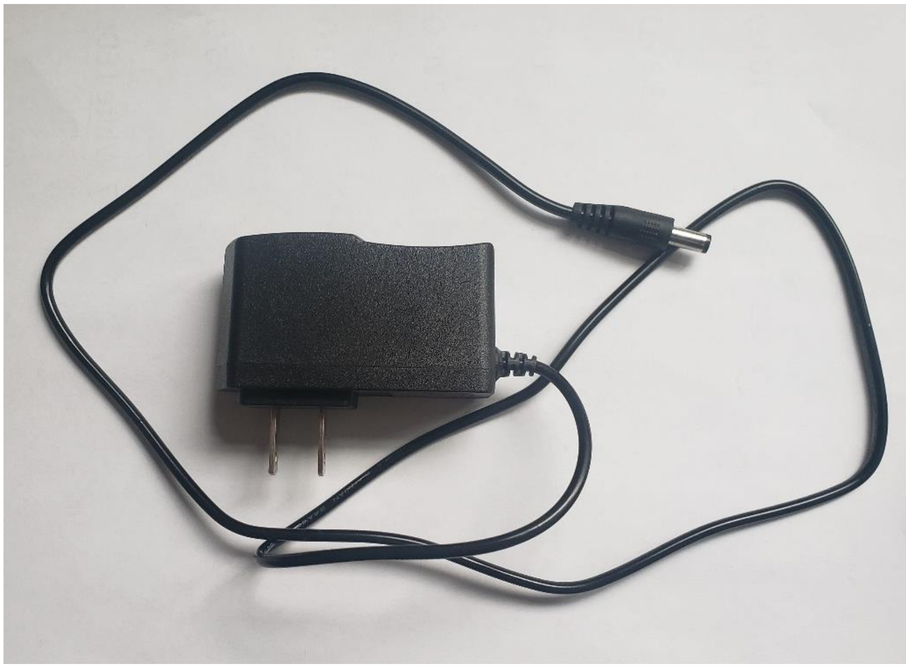
Digital I/O Connector
for pins 9-12



5 Volt Input

USB Port
Used only with WIFI Module Programmer

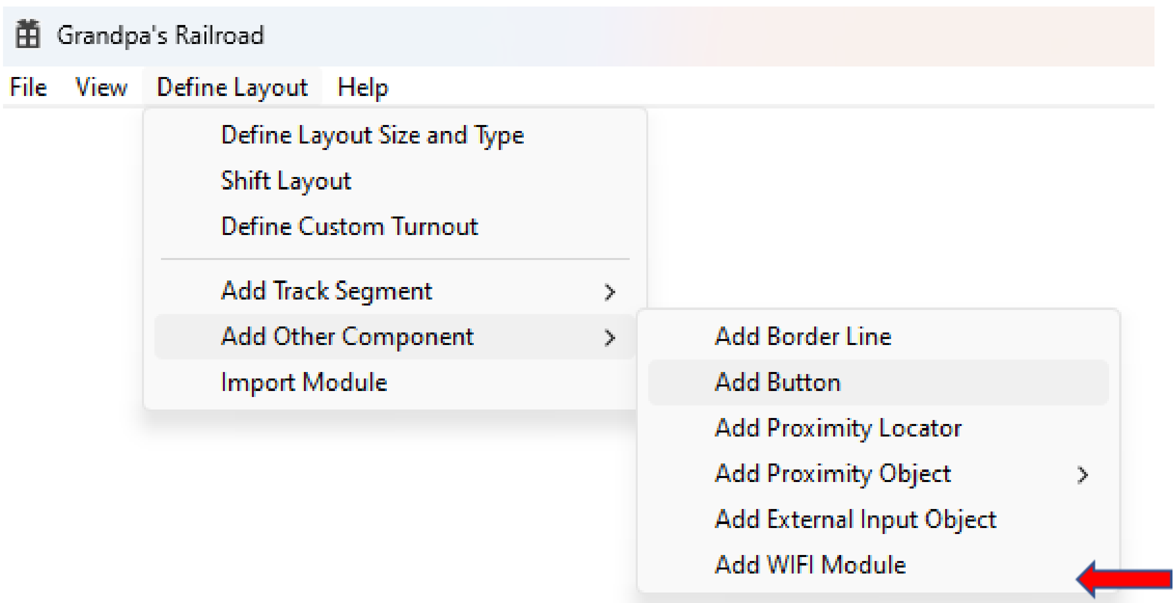
5 Volt Power Supply   Pictured is the supply provided with the base unit. It is



capable of powering 2 WIFI Modules. If you use more than 2 modules, you should use a larger supply.

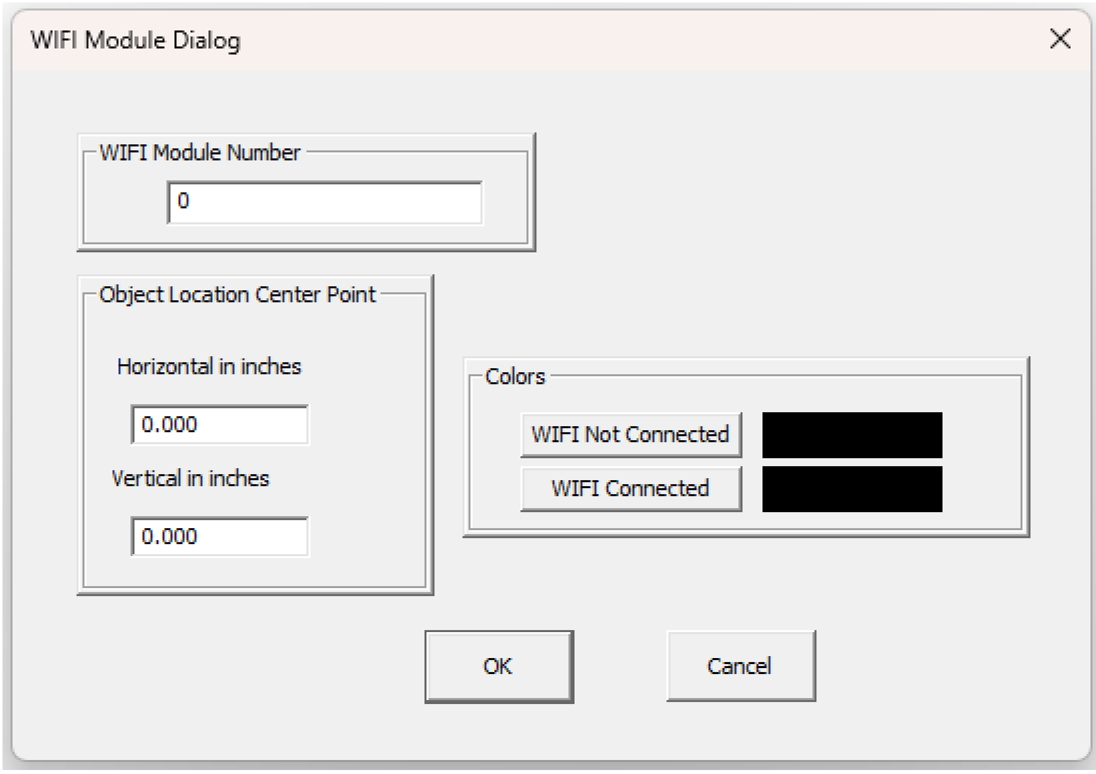
3.10.2 Adding a WIFI Module to your Layout

A WIFI Module is the remote data collector and controller of the Grandpa's Railroad system. You must add each module you use to identify it for identifying connections in the **Control Panel Setup** mode. To add a WIFI Module to your layout, you must be in the **Layout Setup** mode. From the main menu select



Define Layout/Add Other Component/Add WIFI Module

Upon selecting this menu item, the following dialog will appear.



WIFI Module Number is the number from 1 to 32 that has been programmed into the module. There must be only one number per layout using this number. If you reprogram the module with a different number, you must edit this value.

Object Location Center Point is the point on your layout that the Module is displayed. Typically, this should be at the location of the module or in the near vicinity so it can be easily associated with the module. Its location is for display only so you can place it anywhere.

Colors allow you to enter a unique color for the connected and not connected so that problems connecting can be analyzed if they occur.

Once you select **OK** from the dialog and you have entered all required data, a Rectangle will be placed on the layout with the appropriate color and the text M# where # is the module number. If the data has not been added correctly, a detailed error message will appear explaining what is incorrect.

If you need to edit the Module data, you can left click with your mouse on the Module element while in Layout Setup Mode and this dialog will reappear.

3.5.3 Setting Up a WIFI Module for your Control Panel

No setup is needed in Control Panel Setup. The Module number was specified in the Layout Setup mode.

3.5.4 WIFI Module Control Panel Operation

When power is applied to a WIFI Module the top will light with a green, red combination.

This indicates that the module has not yet connected to the WIFI network. In less than 10 seconds the module light should turn totally green indicating a connection.

If the Module does not connect, it could possibly be for one of the following reasons:

1) The WIFI router network name is incorrect in the module.
2) The WIFI router network password is incorrect in the module.
3) The WIFI router is not On.
4) The WIFI router is too far from the module, therefore its signal is too weak.

The power should be applied to the WIFI Modules in a layout at least 10 sec before opening a file in the Control Panel Mode. This allows time for the modules to connect to the network before the Grandpa's Railroad software tries to connect to them.

After the Modules are connected, and when you open a layout file in the Control Panel mode, the Grandpa's Railroad software will connect to the modules. If you have selected different colors for the Connected and Not Connected states for the modules, the color of the modules should change. After several seconds if all modules in your layout file have not been connected, an error message will appear. Possible reasons connection does not occur are:

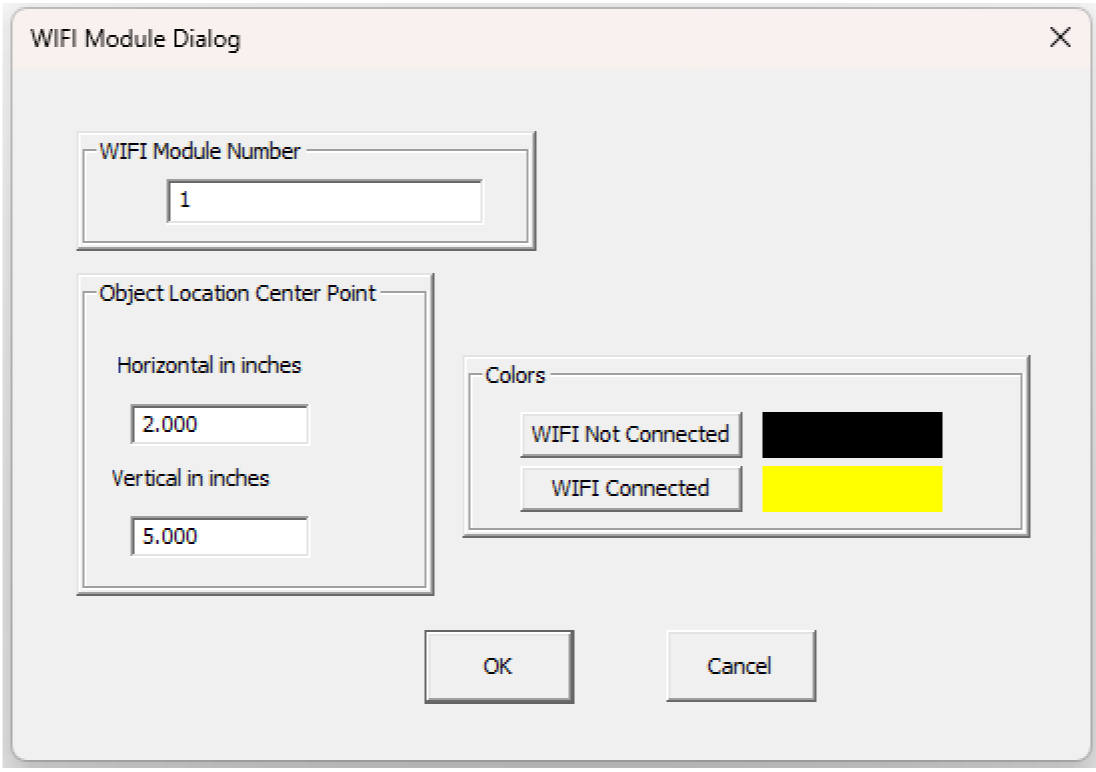
1) The Grandpa's Railroad Mini PC is not connected to the network.
2) The Mini PC and modules are connected to different networks. This can occur if you have used your Mini PC on your home network and have not changed it back to the Grandpa's Railroad router network.

3.5.5 Practical Example

A simple example using a **WIFI Module** is to create a layout that only contains the module.

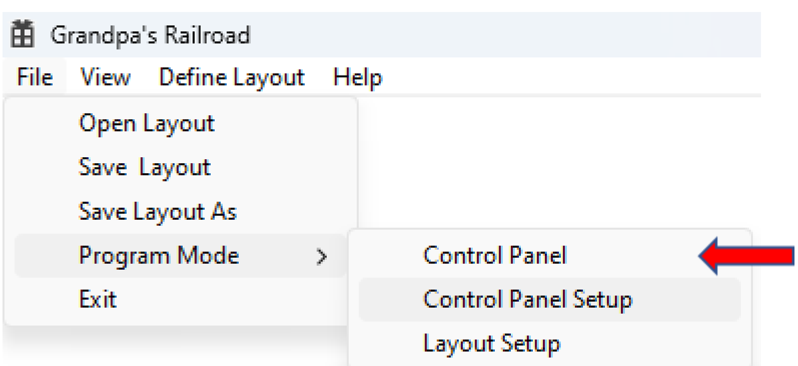
Step 1: Start the Grandpa's Railroad Application, select the **Layout Setup** mode, and create a 10-inch by 10-inch layout in any scale. (Note: A layout does not need to contain track. In this example we are only adding a WIFI Module.)

Step 2: Add a WIFI moule to the layout at 2 inches Horizontal and 5 inches Vertical with the desired Connected and Not Connected colors. If you are using the supplied WIFI Module and have not changed the number, enter a 1 for the Module Number



Step 3: Connect power to the WIFI Module and make sure the module light turns fully green indicating it has connected to the network.

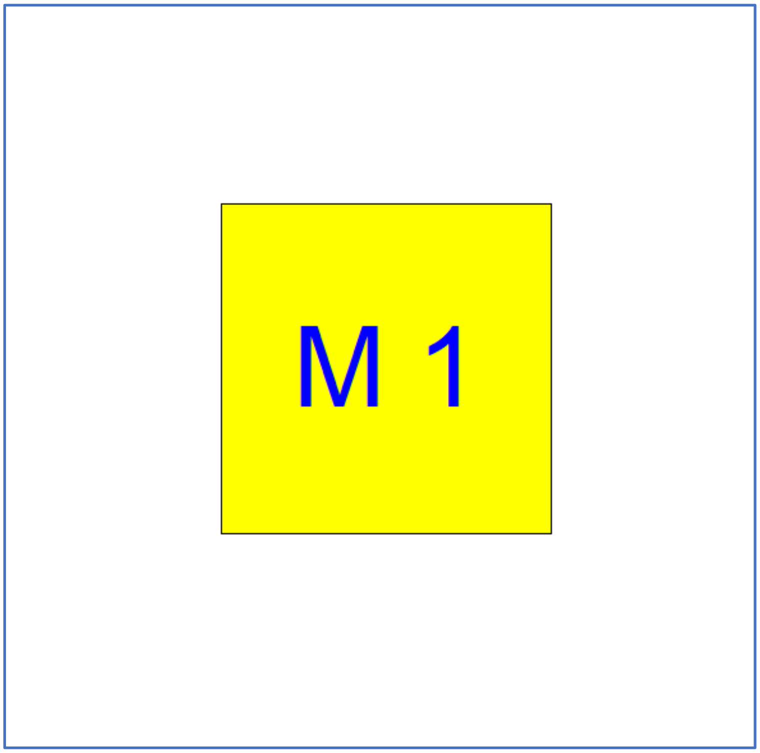
Step 4: From the File Menu item select:



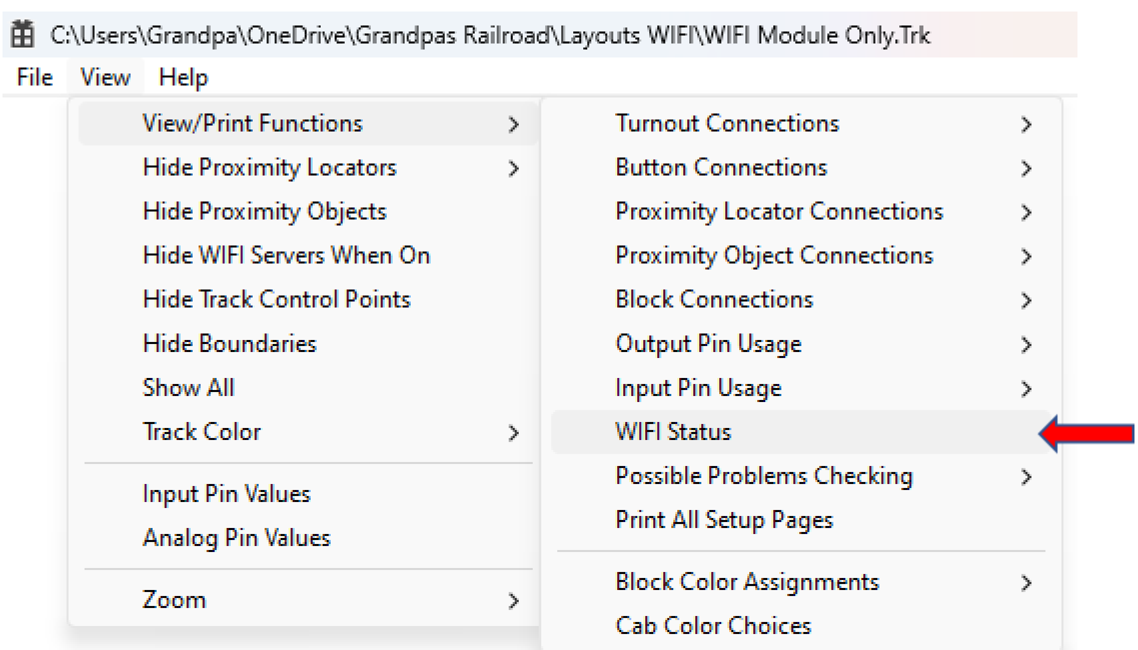
File/Program Mode/Control Panel

This will change to the Control Panel mode.

Step 5: If you have used our setup parameters and colors, after the WIFI Module connects, the screen should resemble the following.

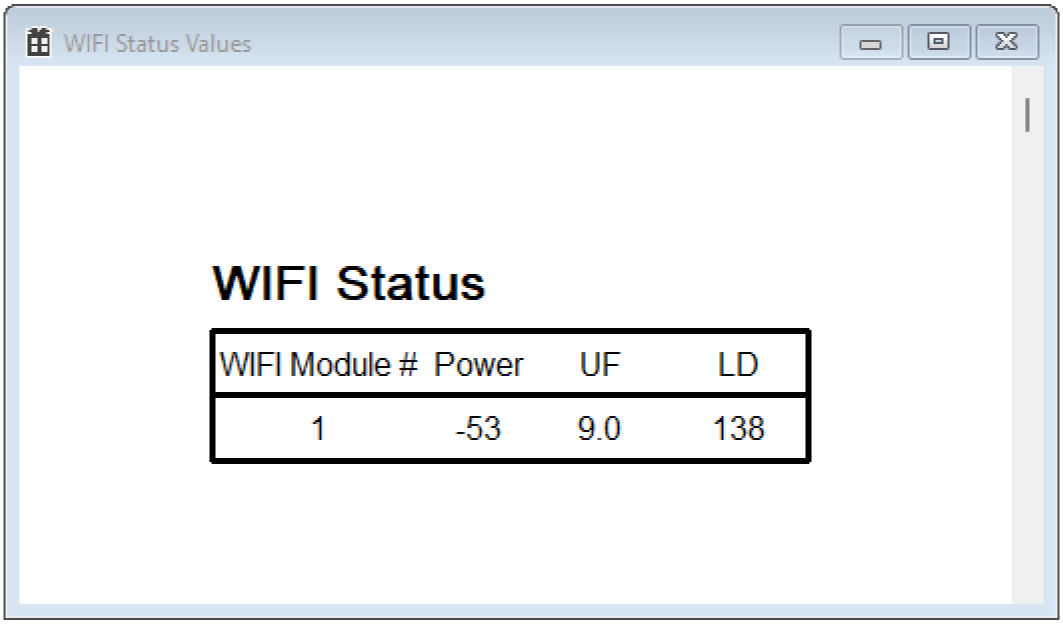


Step 6: To determine the strength of the connection, from the View Menu item select:



View / View/Print Functions / WIFI Status

This will provide a window containing the status of all WIFI modules in the layout.



WIFI Module #	Power	UF	LD
1	-53	9.0	138

The most important number for users in this window is the Power number. This number has units of dbm or decibel milliwatts. Basically, the smaller the number the worse the signal strength. To make this perfectly clear since there can be some confusion as to what smaller means with negative numbers, a strength of -40 dbm is stronger than -60 dbm. In general, we would like to see strengths of -70 dbm or greater. These numbers may bounce around since they are single samples, but it is the mean value over time that is important. Re-locating your WIFI router may improve signal strength. If your layout is too large you may have to use a more powerful router. The router provided should be adequate for layouts up to 30 ft if centrally located.

3.11 Import Layout Module Coming Soon

4 Aids for Building, Troubleshooting, and Documenting a Control Panel

This Chapter presents software features that will aid in the building of a control panel. These include tools such as axes, grids, viewing and printing of connections, possible problem checking, and many more handy features for development and documentation. Some features allow you to customize the look of your control panel to get just the look you want. Not all features are available in all operational modes. All these features will be found under the **View** menu item in all modes. The following table presents the features and the modes in which they apply.

Feature	Applicable Mode			Section
	Layout	Setup	Panel	
Show Edit Location	√	NA	NA	4.1
Show Axis Scales	√	NA	NA	4.2
Show Grid Lines	√	NA	NA	4.3
Show Module and Layout Boundary	√	NA	NA	4.4
Block Color Assignments (View or Print)	√	√	√	4.5
Cab Color Choices	√	√	√	4.6
Zoom	√	√	√	4.7
Mouse Thumbwheel Zoom	√	√	√	4.8
Dragging a Zoomed Layout to Change Position	√	√	√	4.9
Using the Mouse to Get Precise Coordinates	√	NA	NA	4.10
Show Control Boxes	NA	√	NA	4.11
Turnout Connections (View or Print)	NA	√	√	4.12
Button Connections (View or Print)	NA	√	√	4.13
Proximity Locator Connections (View or Print)	NA	√	√	4.14
Proximity Object Connections (View or Print)	NA	√	√	4.15
Block Connections (View or Print)	NA	√	√	4.16
Output Pin Usage (View or Print)	NA	√	√	4.17
Input Pin Usage (View or Print)	NA	√	√	4.18
Possible Problem Checking (View or Print)	NA	√	√	4.19
Print All Setup Pages	NA	√	√	4.20
Hide Proximity Locators	NA	NA	√	4.21
Hide Proximity Objects	NA	NA	√	4.22
Hide WIFI Modules When Connected	NA	NA	√	4.23
Hide Track Block Controls	NA	NA	√	4.24
Hide Border Lines	NA	NA	√	4.25
Show All	NA	NA	√	4.26
Track Color	NA	NA	√	4.27
WIFI Status	NA	NA	√	4.28

4.1 Show Edit Locations

From the main menu item **View** select:

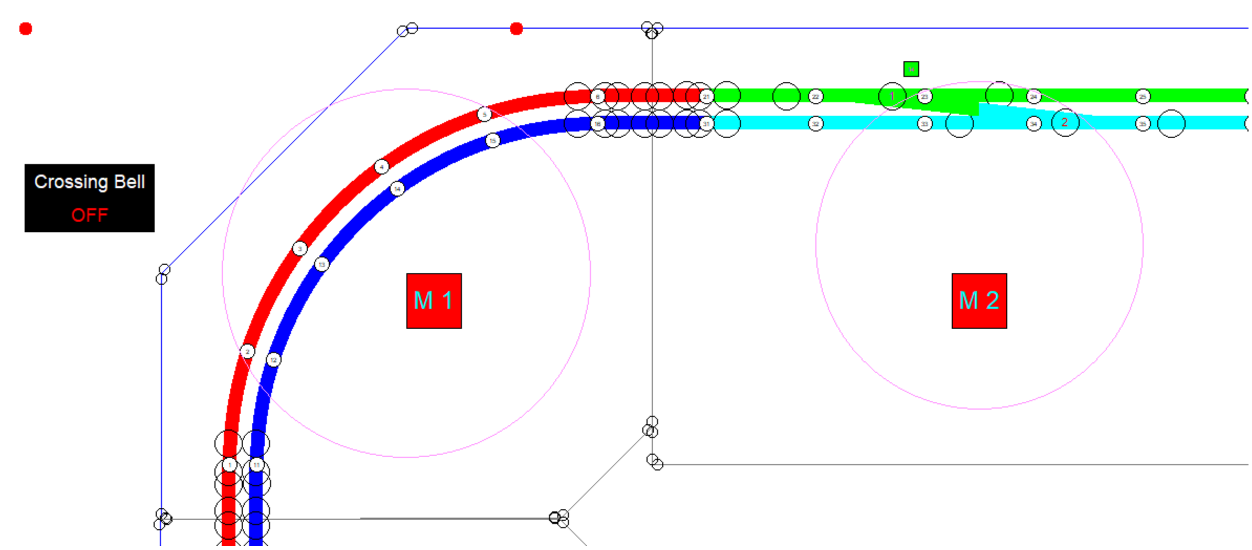
View/Show Edit Locations

The layout diagram will be annotated as follows:

- Circles on the ends of the straight and curved track sections
- A circle at the center of turnouts with the turnout number
- Small circles on the ends of border lines
- Large circles at the center of each module
- The Proximity Locator Number on proximity locators
- The Proximity Object Number on proximity objects
- Buttons and WIFI objects are unannotated (they are the edit point)

These above points are the edit locations. By clicking the left mouse button over these points, the dialog box originally used to define the object appears so that its parameters can be edited.

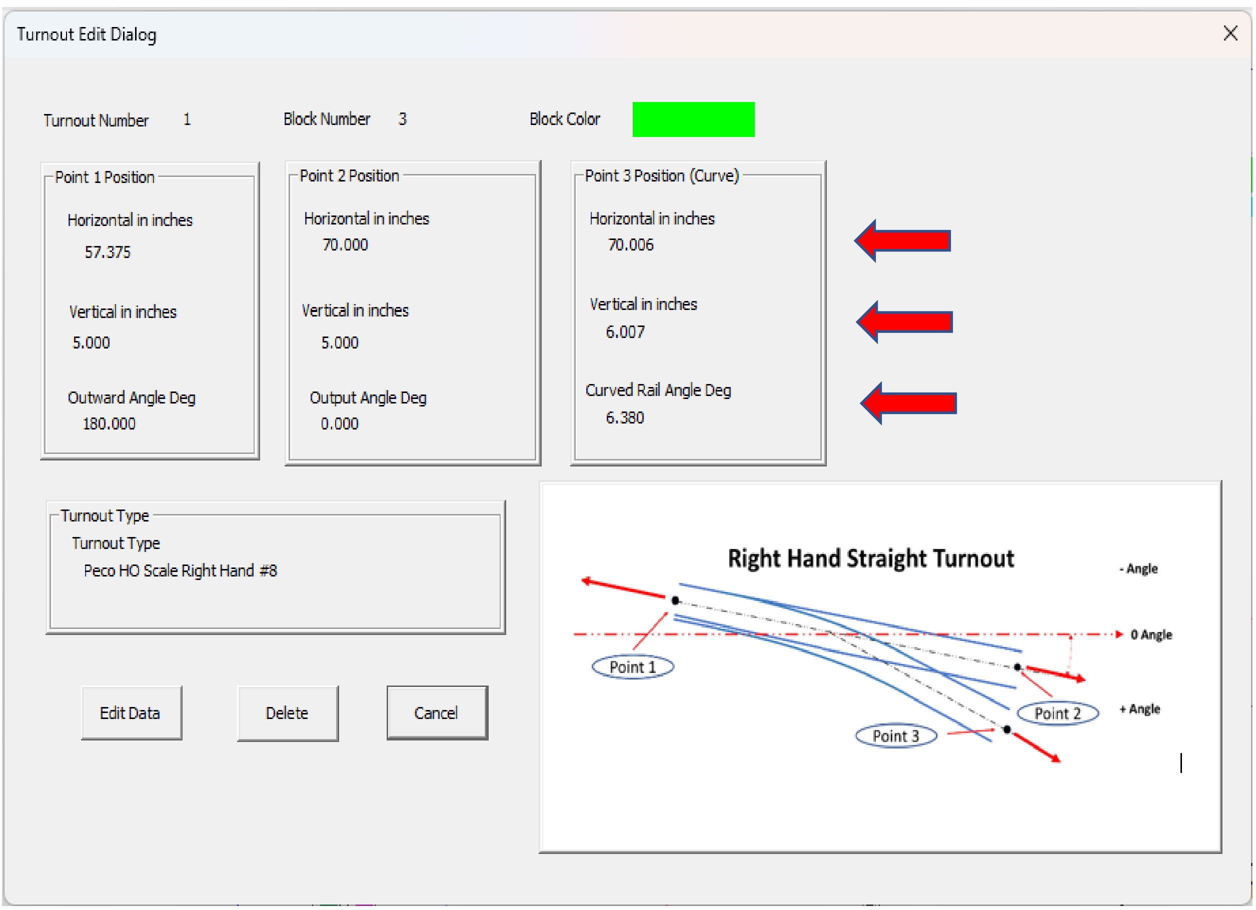
An example of an annotated layout is shown below:



In some cases, the edit locations will overlap. For this situation, the edit dialogs will appear one after another. You can cancel the dialogs for the objects you do not wish to edit.

Note: This is a very useful way of determining the end points and angles of track sections and turnouts when building your layout to get track sections that butt to each other with smooth connections.

For example, we can learn the end points of a turnout simply by opening the edit dialog as follows:

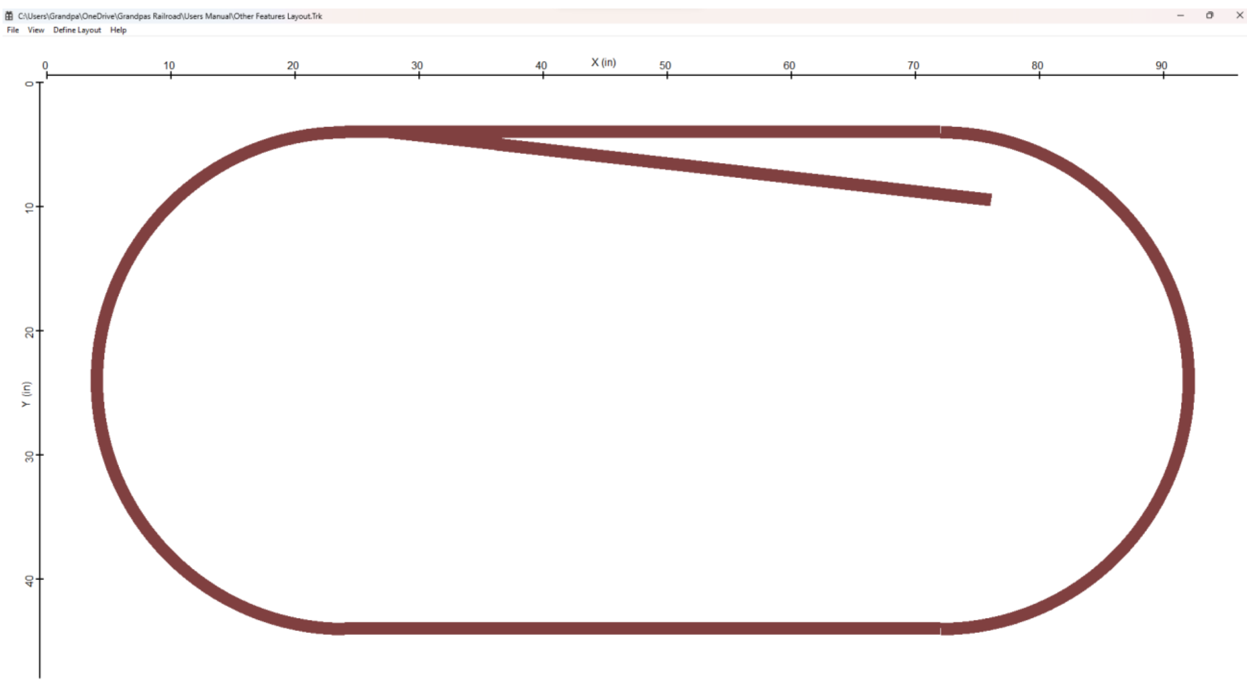


4.2 Show Axis Scales

From the main menu item **View** select:

View/Show Axis Scales

An x and y scale will appear on the diagram to aid in placing components on your layout. The scales will be the size of your defined layout as shown below for a 4x8 foot layout. The numbers on the scales are in inches.

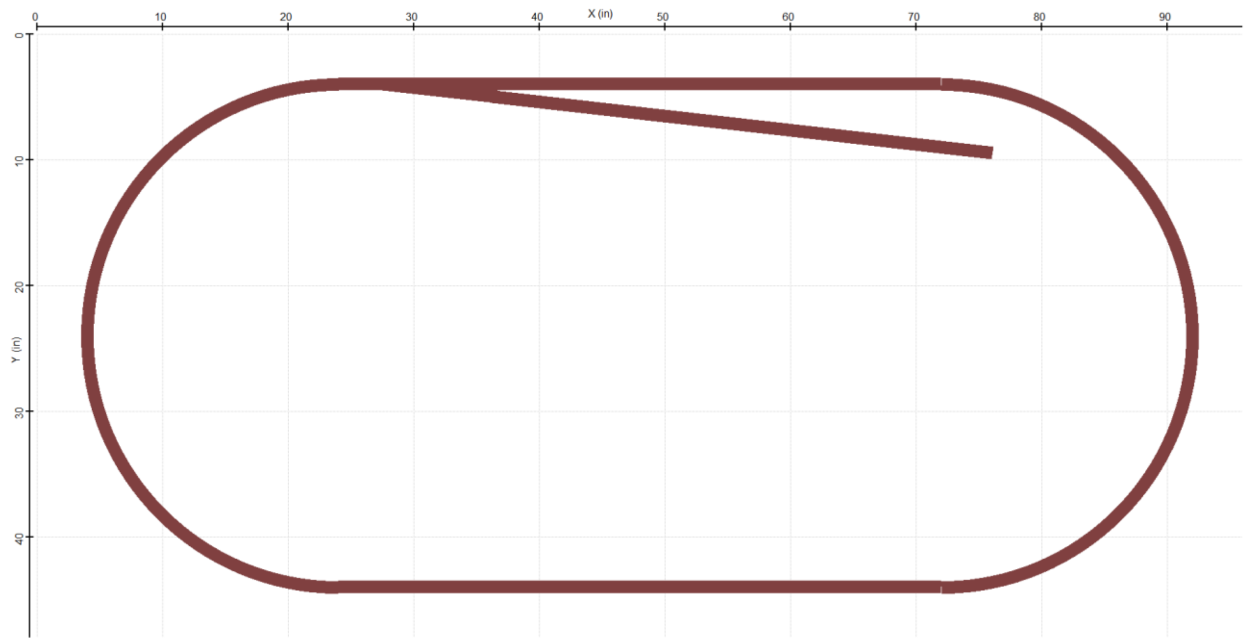


4.3 Show Grid Lines

From the main menu item **View** Menu select:

View/Show Grib Lines

Equally spaced x and y grid lines will appear on the diagram to aid in placing components on your layout. The lines are especially useful when placing layout components when used in conjunction with the **Axis Scales** described above. Note that in the illustration below the grid lines are very light and hard to see.



4.4 Show Module and Layout Boundary

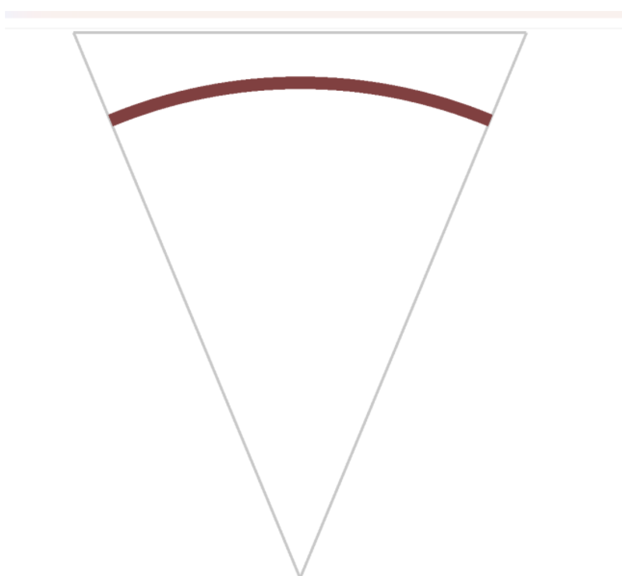
From the main menu item **View** select:

View/Show Module and Layout Boundary

A light gray frame will appear which defines the boundaries of the layout or module.

Layout Example:

Module Example:

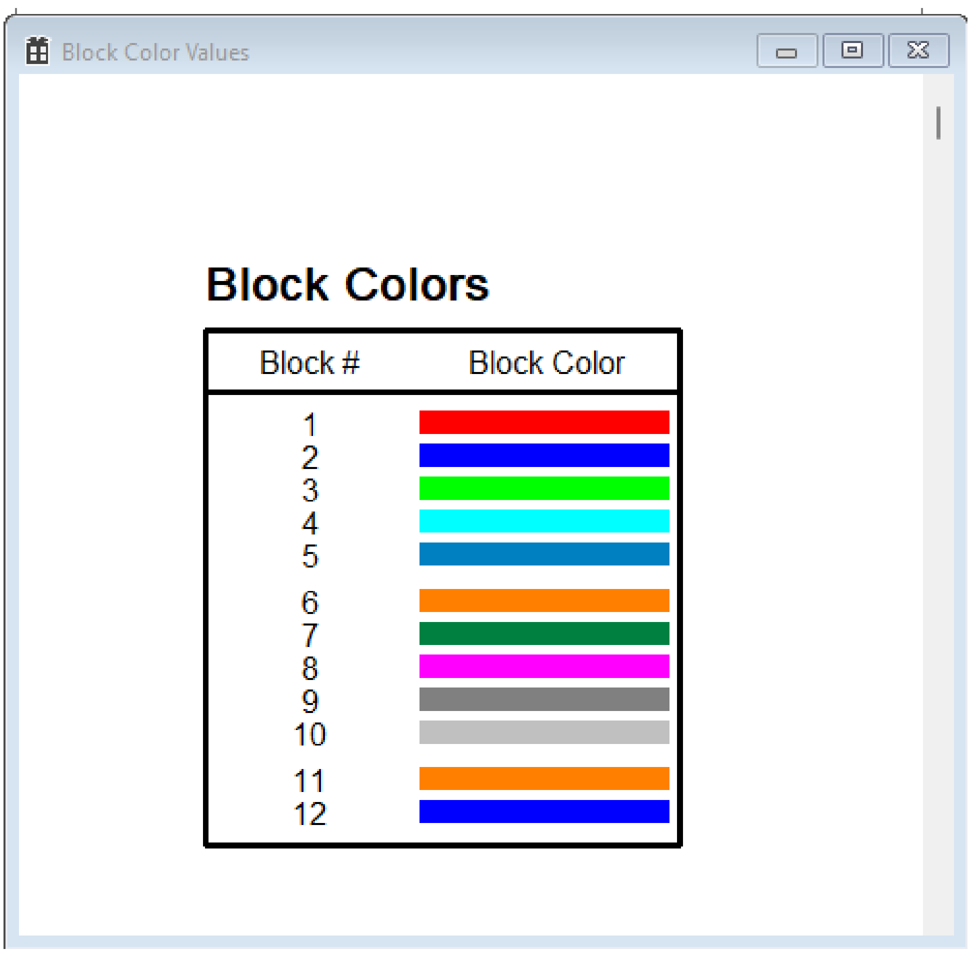


4.5 Block Color Assignments (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Block Color Assignments

Activating the **view** option opens a window that gives the colors you have assigned to all blocks you have defined for your layout. In the example below 12 blocks were defined. If you wish to change a color for a block, select any track segment in that block and edit the color for that segment. This will also change that color of all other segments of that block.



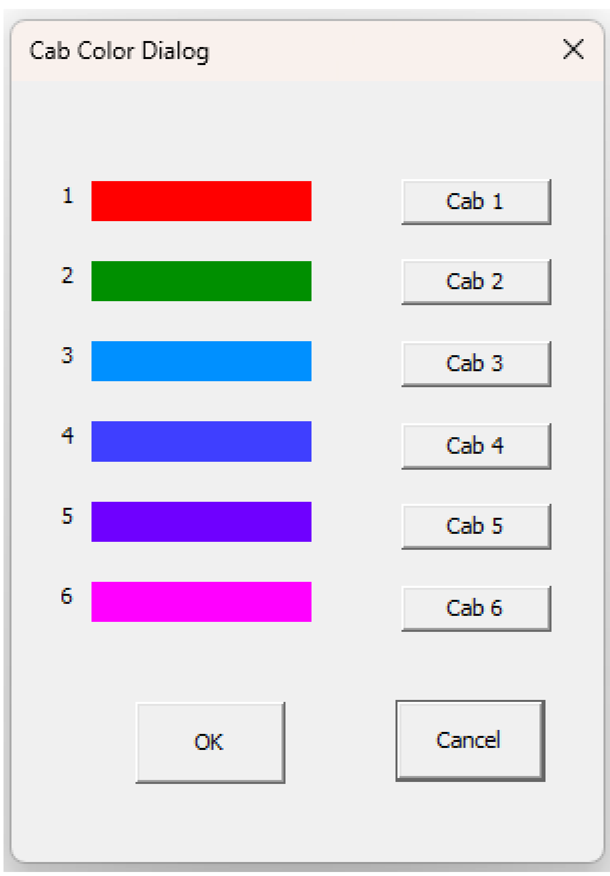
4.6 Cab Color Choices

From the main menu item **View** select:

View/Cab Color Choices

A cab is a throttle control in a DC system. Grandpa's Railroad software currently allows up to 6 cabs for DC operation. (For a DCC system there is only one power source for the entire system so only one Cab is used for the entire layout.) A window opens which shows the colors that are currently assigned to each cab. Clicking on the Cab # button allows you to select a different color for a given Cab.

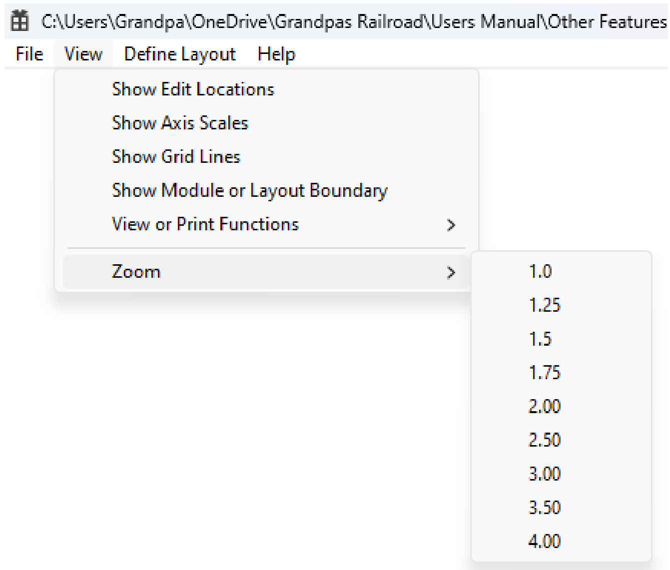
These colors are used during operation to either represent a Cab power source in an Active Block Control or as the track color if Power Source Color is selected. (See **Track Color** for Control Panel Additional Features).



4.7 Zoom

From the main menu item **View** select:

View/Zoom



As shown, a menu will appear that allows the Control Panel Display to be magnified from 1 to 4 times. At 1 times magnification the entire control panel is presented in the display. Any magnification higher than 1, magnifies relative to the base window display size. The full control panel cannot be displayed in the window so both horizontal (on right) and vertical (on bottom) scrollbars will appear to view other parts of the display. (See also Dragging a Zoomed Layout to Change Position below)

4.8 Mouse Thumbwheel Zoom

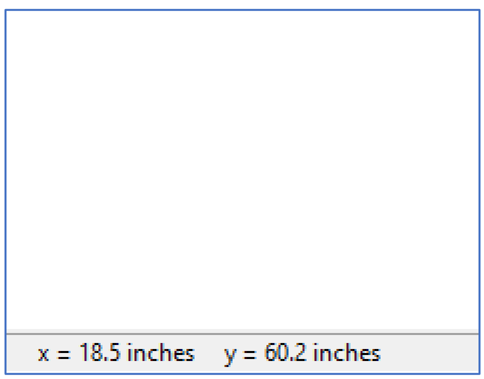
A second method for zooming the display is to roll the mouse wheel. The magnification occurs about the mouse cursor point when the zoom starts. Rolling the wheel upward increases magnification. Rolling the wheel downward reduces magnification. The magnification goes from 1 to 4. This is a very useful approach for very large layouts to enhance a portion of the panel to make it easier to click on turnouts, etc.

4.9 Dragging a Zoomed Layout to Change Position

A second method of repositioning a zoomed display is to place the mouse cursor on the display, hold down the right mouse button, and drag the display right or left, up or down.

4.10 Using the Mouse to Get Precise Coordinates

If you desire to place a component at a particular position, a simple method to determine the coordinates of that location is to place the cursor at the point and hold down the right mouse button. In the lower left corner of the window, the x and y coordinates of the point will appear in inches. This method also works when the window is zoomed.



4.11 Show Control Boxes

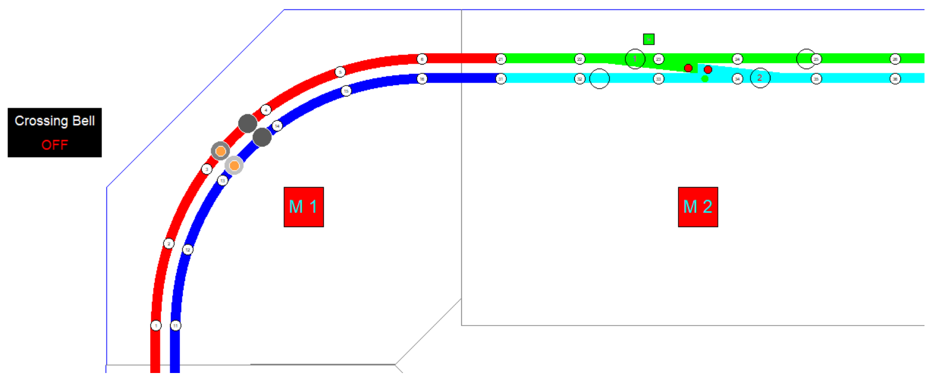
From the main menu item **View** select:

View/Show Control Boxes

The layout diagram will be annotated as follows:

- Circles at the center of the straight and curved track sections if no block control exists.
- A circle at the center of turnouts with the turnout number
- The Proximity Locator Number on proximity locators
- The Proximity Object Number on proximity objects
- Buttons and WIFI objects are unannotated (they are the control point)

These above points are the Control Box locations. By clicking the left mouse button over these points, a dialog box allowing the definition or editing of the control parameters for the object appears. For details on these dialogs go to the sections on adding specific components to the layout in Chapter 3. An example of an annotated layout is shown below:

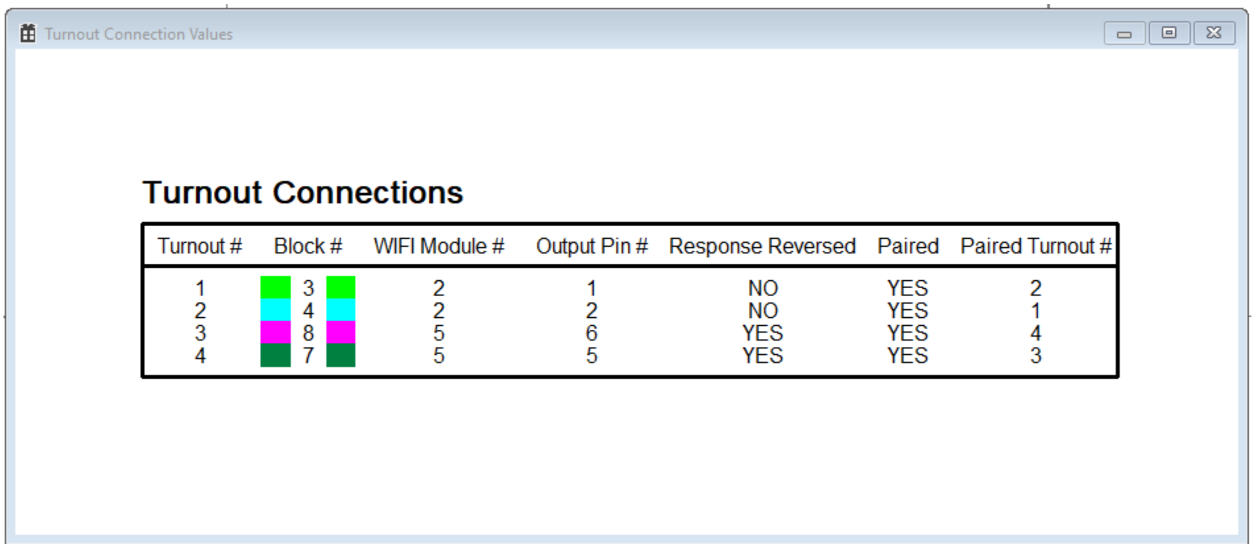


4.12 Turnout Connections (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Turnout Connections

Selecting the **View** option causes a window to appear that describes the parameters for all turnout connections. This is helpful for not only documenting your configuration but also checking to make sure all parameters are defined. A sample window follows:



Turnout Connection Values

Turnout Connections

Turnout #	Block #	WIFI Module #	Output Pin #	Response Reversed	Paired	Paired Turnout #
1	3	2	1	NO	YES	2
2	4	2	2	NO	YES	1
3	8	5	6	YES	YES	4
4	7	5	5	YES	YES	3

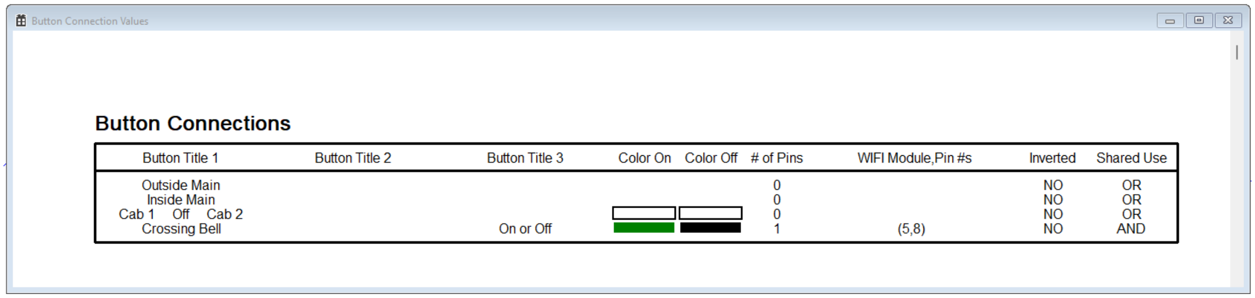
Selecting the **print** option prints a similar table.

4.13 Button Connections (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Button Connections

Selecting the **View** option causes a window to appear that describes the parameters for all buttons connections. This is helpful for not only documenting your configuration but also checking to make sure all parameters are defined. A sample window follows:



Button Connection Values

Button Connections

Button Title 1	Button Title 2	Button Title 3	Color On	Color Off	# of Pins	WIFI Module,Pin #s	Inverted	Shared Use
Outside Main					0		NO	OR
Inside Main					0		NO	OR
Cab 1 Off Cab 2					0		NO	OR
Crossing Bell		On or Off			1	(5,8)	NO	AND

Selecting the **print** option prints a similar table.

In this example, buttons that have no WIFI connections are used as labels instead of operating buttons. For a definition of the parameters see **Adding a Button.**

4.14 Proximity Locator Connections (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Proximity Locator Connections

Selecting the **View** option causes a window to appear that describes the parameters for all proximity locator connections. This is helpful for not only documenting your configuration but also checking to make sure all parameters are defined. A sample window follows:

Proximity Locator Connection Values

Proximity Locator Connections

Proximity Locator #	Type	On Level	Filter Type	WIFI Module,Pin #
1	Reflective	10	Medium Delay	1,13
2	Reflective	10	Small Delay	1,15
3	Reflective	10	Small Delay	1,9
4	Reflective	10	Small Delay	1,7
5	Reflective	10	Small Delay	1,1
6	Reflective	10	Small Delay	1,3
11	Reflective	10	Small Delay	1,14
12	Reflective	10	Small Delay	1,16
13	Reflective	10	Small Delay	1,10
14	Reflective	10	Small Delay	1,8
15	Reflective	10	Small Delay	1,2
16	Reflective	10	Small Delay	1,4
21	Reflective	10	Medium Delay	2,13
22	Reflective	10	Medium Delay	2,15
23	Reflective	10	Medium Delay	2,9
24	Reflective	10	Medium Delay	2,7
25	Reflective	10	Medium Delay	2,1
26	Reflective	10	Medium Delay	2,3
31	Reflective	10	Medium Delay	2,14
32	Reflective	10	Medium Delay	2,16
33	Reflective	10	Medium Delay	2,10
34	Reflective	10	Medium Delay	2,8
35	Reflective	10	Medium Delay	2,2
36	Reflective	10	Medium Delay	2,4
41	Reflective	10	Medium Delay	3,13
42	Reflective	10	Medium Delay	3,15
43	Reflective	10	Medium Delay	3,9
44	Reflective	10	Medium Delay	3,7
45	Reflective	10	Medium Delay	3,1
46	Reflective	10	Medium Delay	3,3

Selecting the **print** option prints a similar table. For a definition of the parameters see **Adding a Proximity Locator.**

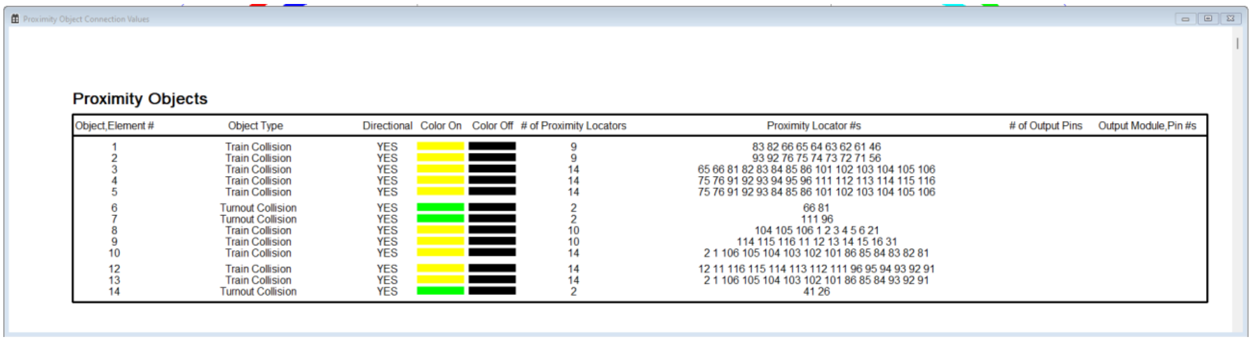
4.15 Proximity Object Connections (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Proximity Object Connections

Selecting the **View** option causes a window to appear that describes the parameters for all proximity object connections. This is helpful for not only documenting your configuration but also checking to make sure all parameters are defined. A sample window follows:

Selecting the **print** option prints a similar table.


Proximity Object Connection Values

Proximity Objects

Object,Element #	Object Type	Directional	Color On	Color Off	# of Proximity Locators	Proximity Locator #s	# of Output Pins	Output Module,Pin #s
1	Train Collision	YES			9	83 82 66 65 64 63 62 61 46		
2	Train Collision	YES			9	93 92 76 75 74 73 72 71 56		
3	Train Collision	YES			14	65 66 81 82 83 84 85 86 101 102 103 104 105 106		
4	Train Collision	YES			14	75 76 91 92 93 94 95 96 111 112 113 114 115 116		
5	Train Collision	YES			14	75 76 91 92 93 84 85 86 101 102 103 104 105 106		
6	Turnout Collision	YES			2	66 81		
7	Turnout Collision	YES			2	111 96		
8	Train Collision	YES			10	104 105 106 1 2 3 4 5 6 21		
9	Train Collision	YES			10	114 115 116 11 12 13 14 15 16 31		
10	Train Collision	YES			14	2 1 106 105 104 103 102 101 86 85 84 83 82 81		
12	Train Collision	YES			14	12 11 116 115 114 113 112 111 96 95 94 93 92 91		
13	Train Collision	YES			14	2 1 106 105 104 103 102 101 86 85 84 93 92 91		
14	Turnout Collision	YES			2	41 26		

For a definition of the parameters see **Adding a Proximity Object.**

4.16 Block Connections (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Block Connections

Selecting the **View** option causes a window to appear that describes the parameters for all Block connections. This is helpful for not only documenting your configuration but also checking to make sure all parameters are defined. A sample window follows:

Block Connection Values

Block Connections

Block	Connection Type	Output Module,Pin #
1	Another Block	1,3
2	Another Block	1,4
3	Another Block	1,1
4	Another Block	1,2
5	Another Block	4,3
6	Another Block	4,4
7	Another Block	4,1
8	Another Block	4,2
9	Cab	4,9
9	Cab	4,10
10	Cab	4,11
10	Cab	4,12

Selecting the **print** option prints a similar table.

For a definition of the parameters see **Adding a Straight Track Section.**

4.17 Output Pin Usage (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Output Pin Usage

Selecting the **View** option causes a window to appear that describes the usage of all connected output pins. This is helpful for not only documenting your configuration but also checking to make sure all parameters are defined, and the actual connections are correct. A sample window follows:

Pin Usage Values

Output Pin Usage

WIFI Module #	Pin #	Connection Type	Object or Block #	Shared Use
1	1	Track Block	3	NA
1	2	Track Block	4	NA
1	3	Track Block	1	NA
1	4	Track Block	2	NA
2	1	Turnout	1	NA
2	2	Turnout	2	NA
4	1	Track Block	7	NA
4	2	Track Block	8	NA
4	3	Track Block	5	NA
4	4	Track Block	6	NA
4	9	Track Block	9	NA
4	10	Track Block	9	NA
4	11	Track Block	10	NA
4	12	Track Block	10	NA
5	5	Turnout	4	NA
5	6	Turnout	3	NA
5	8	Button	4	AND

Selecting the **print** option prints a similar table.

4.18 Input Pin Usage (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Input Pin Usage

Selecting the **View** option causes a window to appear that describes the usage of all connected input pins. This is helpful for not only documenting your

Input Pin Usage Values

Input Pin Usage

WIFI Module #	Pin #	Connection Type	Object or Block #	Shared Use
2	1	Turnout	1	NA
2	2	Turnout	2	NA
5	5	Turnout	4	NA
5	6	Turnout	3	NA

configuration but also checking to make sure all parameters are defined, and the actual connections are correct. A sample window follows:

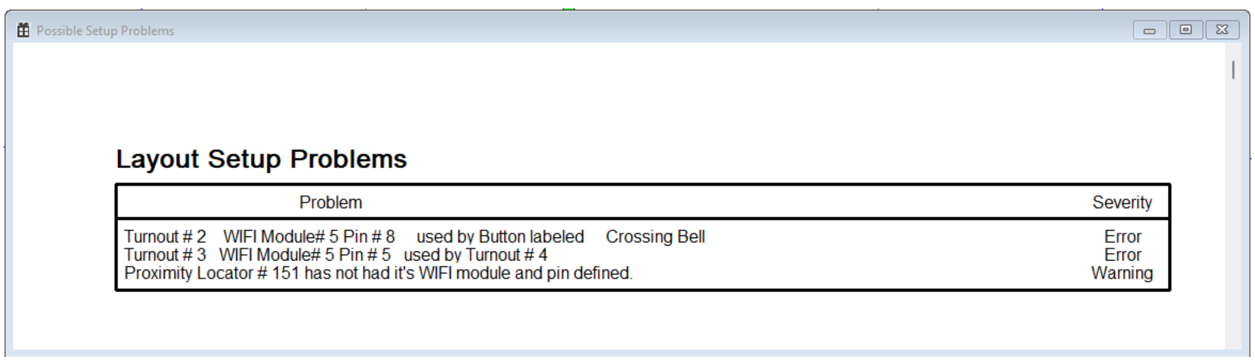
Selecting the **print** option prints a similar table.

4.19 Possible Problem Checking (View or Print)

From the main menu item **View** select:

View/View or Print Functions/Possible Problem Checking

Selecting the **View** option causes a window to appear that displays possible problems with the control panel setup. These problems are divided into errors and warnings. Errors must be resolved for proper operation. If not, errors could cause erratic operations. Warnings are less severe and may simply be because you are testing without fully completing the layout. A sample window which was produced by intentionally creating errors follows:


Possible Setup Problems

Layout Setup Problems

Problem	Severity
Turnout # 2 WIFI Module# 5 Pin # 8 used by Button labeled Crossing Bell	Error
Turnout # 3 WIFI Module# 5 Pin # 5 used by Turnout # 4	Error
Proximity Locator # 151 has not had it's WIFI module and pin defined.	Warning

Selecting the **print** option prints a similar table.

4.20 Print All Setup Pages

From the main menu item **View** select:

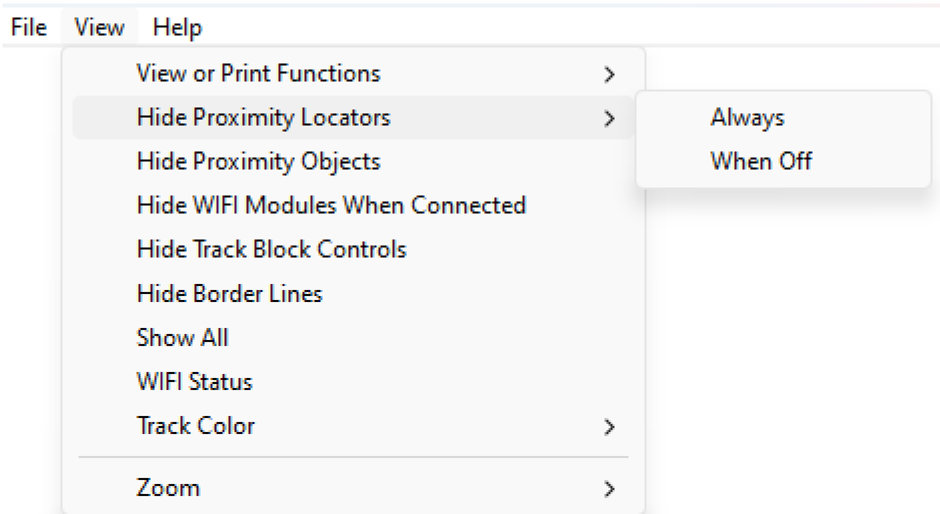
View/View or Print Functions/Print All Setup Pages

Selecting this item prints a document containing all the information contained in sections 4.12 – 4.19 providing a detailed description of the control panel setup.

4.21 Hide Proximity Locators

From the main menu item **View** select:

View/Hide Proximity Locators



This item allows you to customize your control panel during operation. Selecting this item presents options of hiding the proximity locators always or hiding them only when they are off. If you have previously selected one of these two options, when you return to that option it will be checked. Simply click on it again to turn off the option.

4.22 Hide Proximity Objects

From the main menu item **View** select:

View/Hide Proximity Objects

This item allows you to customize your control panel during operation. Selecting this item will hide all proximity objects that are off. The object will appear however if it is activated. Activating this item can significantly simplify your display during operation. If you have previously selected this option, when you return to the option it will be checked. Simply click on it again to turn off the option.

4.23 Hide WIFI Modules When Connected

From the main menu item **View** select:

View/ Hide WIFI Modules When Connected

This item allows you to customize your control panel during operation. Selecting this item will hide all WIFI modules if they are connected properly. The module will appear, however, if it loses its connection to the router. Activating this item can significantly simplify your display during operation. If you have previously selected this option, when you return to the option it will be checked. Simply click on it again to turn off the option.

4.24 Hide Track Block Controls

From the main menu item **View** select:

View/ Hide Track Block Controls

This item allows you to customize your control panel during operation. When **Active Block Controls** are added to a track segment you have the option to make them hidable. (See Adding Straight Track) Selecting this item will hide all Active Block Controls which were labeled as hidable. If you have previously selected this option, when you return to the option it will be checked. Simply click on it again to turn off the option.

4.25 Hide Border Lines

From the main menu item **View** select:

View/ Hide Boundaries

This item allows you to customize your control panel during operation. When **Border Lines** are added to the layout, you have the option to make them hidable. (See Adding Border Lines) Selecting this item will hide all Border Lines which were labeled as hidable. If you have previously selected this option, when you return to the option will be checked. Simply click on it again to turn off the option.

4.26 Show All

From the main menu item **View** select:

View/ Show All

Selecting this item will show all control panel elements which had been previously hidden.

4.25 Hide Border Lines

From the main menu item **View** select:

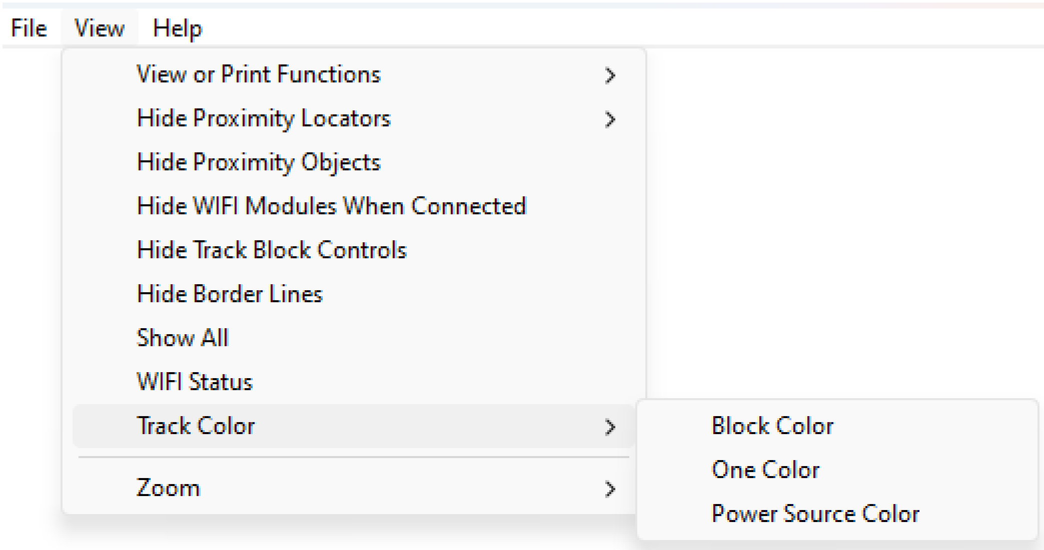
View/ Hide Boundaries

This item allows you to customize your control panel during operation. When **Border Lines** are added to the layout, you have the option to make them hidable. (See Adding Border Lines) Selecting this item will hide all Border Lines which were labeled as hidable. If you have previously selected this option, when you return to the option it will be checked. Simply click on it again to turn off the option.

4.27 Track Color

From the main menu item **View** select:

View/ Track Color



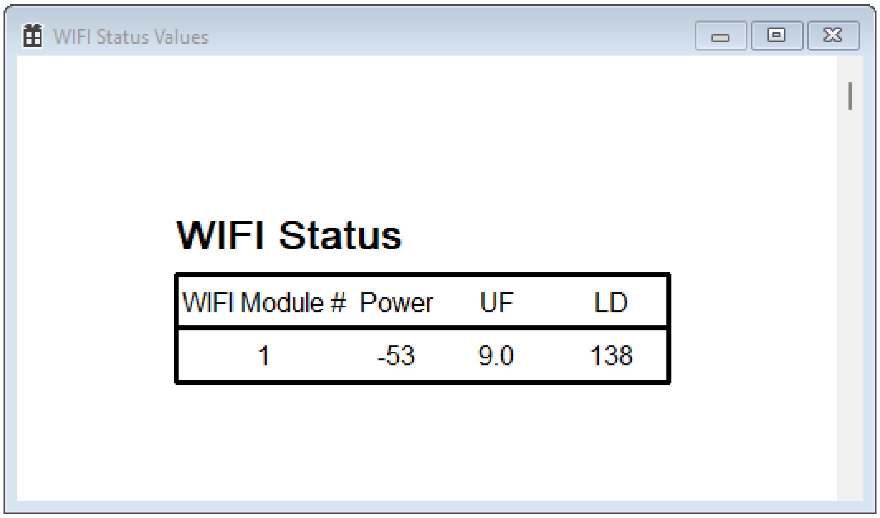
This item allows you to customize your control panel during operation. Selecting this item presents options for how the track on the layout will be displayed. The first option, **Block Color**, shows the track in the color previously assigned to it's block when the layout is defined. The second option, **One Color**, allows you to assign one color for all track elements. The final choice, **Power Source Color**, is very useful for DC operation. With this option each track block displays the color of the cab (throttle) that it is connected to. If the block is off, the color will be black.

4.28 WIFI Status

From the main menu item **View** Menu select:

View/WIFI Status

Selecting this item causes a window to appear that displays the current power setting of each WIFI module. This is helpful locating your router unit with respect to the modules.



The most important number for users in this window is the Power number. This number has units of dbm or decibel milliwatts. Basically, the smaller the number the worse the signal strength. To make this perfectly clear since there can be some confusion as to what smaller means with negative numbers, a strength of -40 dbm is stronger than -60 dbm. In general, we would like to see strengths of -70 dbm or greater. These numbers may bounce around since they are single samples, but it is the mean value over time that is important. Re-locating your WIFI router may improve signal strength. If your layout is too large, you may have to use a more powerful router. The router provided should be adequate for layouts up to 30 ft if centrally located.

5 Special Topics for Grandpa's Railroad Construction

This Chapter presents special topics and hints we have learned. Very specific details on connecting certain features to your layout will be presented. We are not saying these methods are the only way of implementing items, but they are the way we do it. We hope that our users will send in their suggestions so that we can learn as well and share them with other users.

5.1 Selecting the Right Wire Gauge

Selecting the right wire gauge for your model railroad and accessories can lead to hours of uninterrupted operation. Selecting the wrong gauge could lead to unnecessary expense, poor operation, or even wires overheating. For your understanding we are going to go into further detail as to why this occurs and how to choose the proper wire gauge. You do not have to understand everything we will present because we also present an easy way to calculate your wire size with some examples.

5.1.1 Background and Theory   In Episode 2 of our "Electricity 99" video tutorial series, Grandpa shows an analogy between current flow and water flow. Let's use that analogy to demonstrate our point. If firemen arrived at a house fire with only garden hoses, I'm sure the house would burn down before they could put the fire out. That is because the garden hose can't deliver the amount of water needed. Likewise, I'm sure you could water your garden with a fire hose, but since you don't need the volume of water it could deliver, you would just be wasting money on purchasing such a hose. The same holds true for electrical wire. Why purchase an oversized wire if a smaller one would suffice. It would be a waste of money and space under your layout. The converse of this is even more important. If you use too small a wire for an application, two very important things happen, voltage drop, and the wire will heat. In extreme cases the heat could cause the insulation to melt or even catch fire. Let's look a little closer as to why these two things happen.

We learned from "Electricity 99", that electricity is electrons in motion and current is a measure of the movement of electrons in a wire over time. Wire has a resistance based on its material and diameter. This resistance results in a voltage drop in the wire and causes heating of the wire. If we have too large of a voltage drop your model train may run at different speeds depending on where you are on your layout. The voltage drop may also cause accessories to function slowly or improperly.

For model railroading there are only three types of wire we will consider:

1. Copper
2. Aluminum
3. Copper clad aluminum

The last type, copper clad aluminum, for simplicity we will consider as having the same conductivity as the aluminum wire. This wire is basically aluminum with a copper coating to aid in making connections.

A materials resistivity (ρ) is a measure of that material's ability to conduct electricity and is given by its resistance (R) times it's cross-sectional area (A) divided by a unit length (L).

$$\rho = \frac{RA}{L}$$

The resistivity of copper is 1.72x10-8 Ωm or 5.6429x10-8 Ωft.

For aluminum wire the resistivity is 2.82e-8 Ωm or 9.2519x10-8 Ωft.

Rearranging the above equation, we can solve for the resistance (R) of a single strand of wire.

$$R = \frac{\rho L}{A}$$

The area of a round wire is $A = \pi r^2$ where r the radius is the wire diameter divided by 2.

For a particular wire gauge **n** AWG, the diameter can be calculated as

$$\mathbf{d_n = 0.005\ inches\ x\ 92^{(36-n)/39}}$$

For example, if we consider a single strand of gauge 22 AWG wire, the diameter in inches is

$$\mathbf{d_{22} = 0.005\ inches\ x\ 92^{(36\text{-}22)/39} = 0.005\ inches\ x\ 92^{(14)/39} = 0.0253\ inches}$$

Therefore, the area A is

$$A = \pi\ (0.0253/2)^2 = 0.0005027\ in^2 = 0.0005027\ in^2$$

Converting to ft^2 by dividing by 144 in^2 / ft^2

$$A = 3.4911x10^{-6}\ ft^2$$

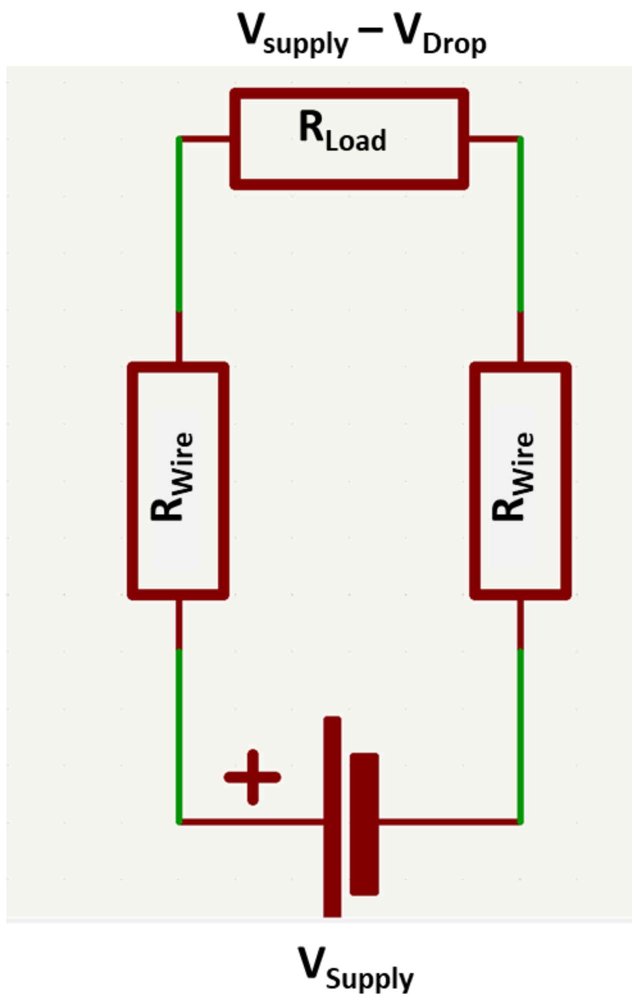
The resistance for a 10 ft length of 22 AWG copper wire would be

$$R = 5.6429x10\text{-}8\ \Omega ft\ X\ 10\ ft\ /\ 3.4911x10^{-6}\ ft^2 = 0.1616\ \Omega$$

Episode 3 of our "Electricity 99" video tutorial series, presented Ohm's Law which shows the relationship between current voltage and resistance in a circuit.

$$\mathbf{V_{(Volts)} = I_{(Amps)} * R_{(Ohms)}}$$

Now consider a simple circuit where the wires in the circuit have resistance as follows:



Assume the two wires are of equal length with a resistance of R_{Wire}. Since there is only one path in this circuit, the current (I) flows through the entire circuit. Applying Ohms Law

$$V_{Supply} - V_{Drop} = I \times R_{Load}$$

$$R_{Load} = V_{Supply} - V_{Drop} / I$$

$$V_{Supply} = I \times R_{Wire} + V_{Supply} - V_{Drop} + I \times R_{Wire;}$$

$$V_{Drop} = 2 \times I \times R_{Wire;}$$

$$\text{Voltage Drop \%} = 2 \times I \times R_{Wire;} / V_{Supply} \times 100$$

Using the 10 ft 22 AWG wire we calculated above, for a 12 V supply and a 0.25 amp load current, the voltage drop is

$$\mathbf{V_{Drop} = 2 \times 0.25\ amp \times 0.1616\ \Omega = 0.0808\ volts}$$

Voltage Drop % = 0.0808 volts / 12 volts x 100 = 0.6733%

The above discussion is the way the voltage loss is calculated. Doing this for every wire would be more complex than necessary. The following section shows a much easier way.

5.1.2 Solid vs Stranded Wire   Stranded wire is more flexible than solid wire and if this is a consideration, it should be used. However, stranded wire of the same gauge (AWG) has a higher DC resistance than solid wire since the wire has air gaps between strands. This can be 20% to 50%. This should be taken into consideration if you choose to use stranded wire in the following discussion of wire size. On Grandpa's Railroad we use solid wire in all cases except if we use RJ11 connectors or for very low amperage application such as IR sensors.

5.1.3 Calculating Wire Size with Examples (The Easy Way)

There are many Voltage Drop Calculators online. One that I use is:

https://www.rapidtables.com/calc/wire/voltage-drop-calculator.html

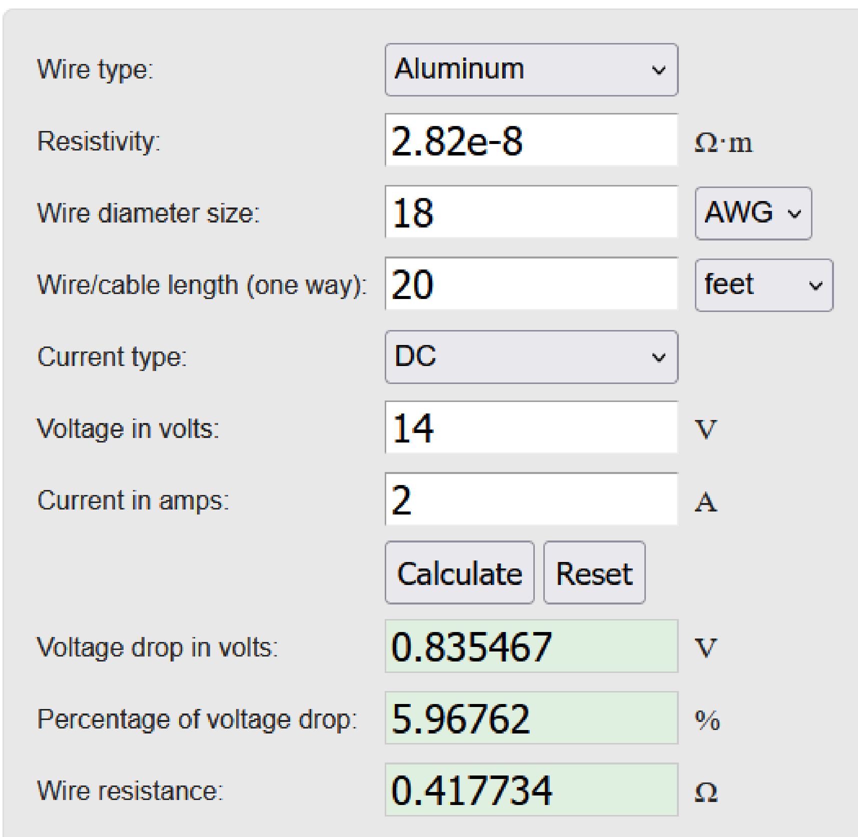
For the low voltages used in model trains, a voltage drop of 2% to 3% is fine. These low levels cause no temperature problems and even on track power wires show no slowing of trains. Likewise, accessories do not seem to be affected. These voltage drop levels also do not seem to place an undue burden on wire size. On Grandpa's Railroad we use telephone wire for many applications. This type of wire is cheap, easy to get, and easy to work with.

5.1.3.1 Calculating Wire Size for Track Power There are many opinions on power requirements for N or HO scale engines since these vary based on manufacture and age of equipment. To calculate wire size, we don't need to know specific values only a general idea of the requirements. For planning purposes, I use 12V 0.25 amp for N scale and 14V 0.5 amp for HO scale.

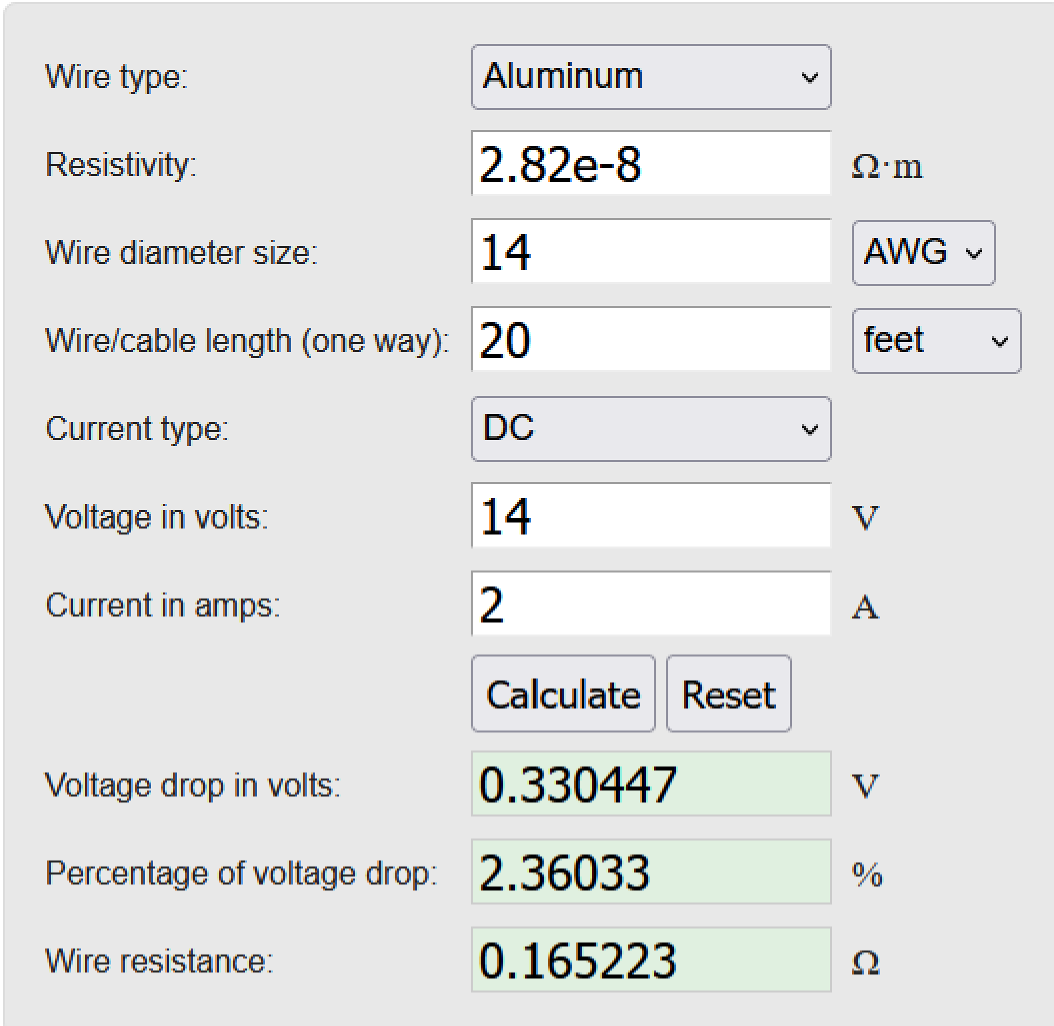
Assume we have a block in our layout that we wish to wire that will run up to 4 HO locomotives. This would need wiring to support 14V at 2 amps. Also assume the supply line (main bus) will need to be 20 ft long to travel from the transformer to the block.

To calculate wire size, we must first choose a preferred wire type. I find that 18 and 14 gauge copper clad aluminum wire is cheap and comes in many colors since it is commonly used in cars. It has many connector types that can be used with it and most of these can be used on both gauges requiring the need for stocking fewer types. (Connectors will be covered in Section 5.3)

Using the calculator given above and these values, we see that an 18 gauge produces a voltage drop of 5.97% which is well above our desired 3%.



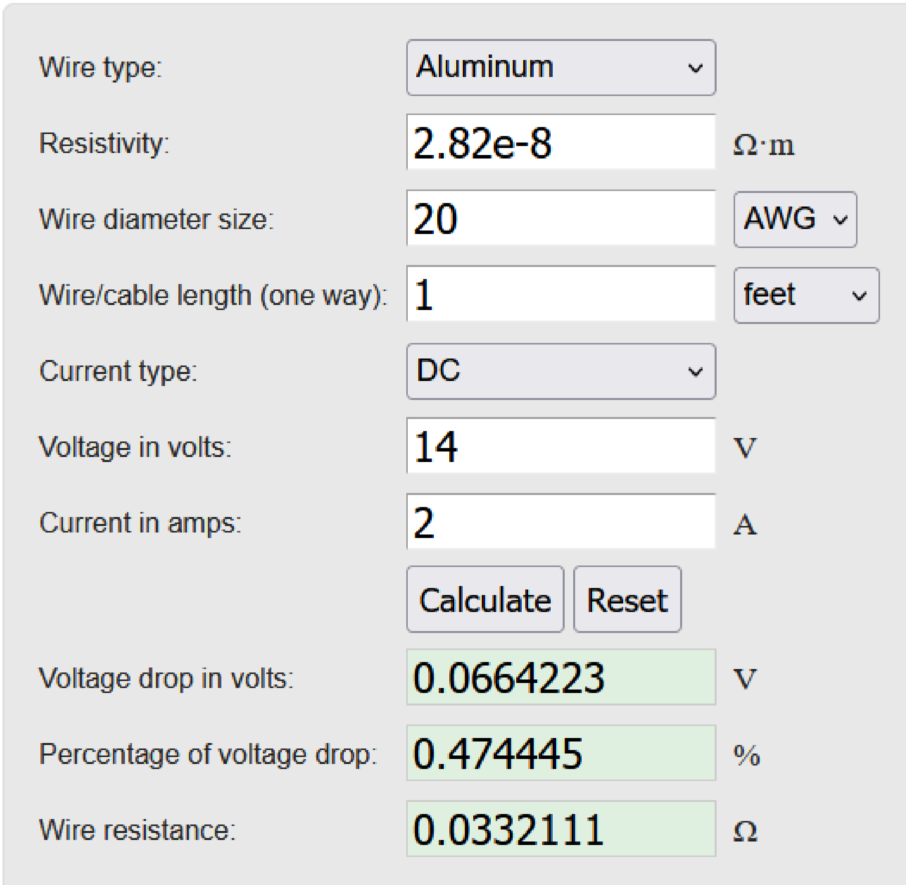
Using a 14 gauge wire the results produce a 2.36% drop which is not only



Wire type:	Aluminum	
Resistivity:	2.82e-8	Ω·m
Wire diameter size:	14	AWG
Wire/cable length (one way):	20	feet
Current type:	DC	
Voltage in volts:	14	V
Current in amps:	2	A
	Calculate Reset	
Voltage drop in volts:	0.330447	V
Percentage of voltage drop:	2.36033	%
Wire resistance:	0.165223	Ω

acceptable but also provides some room for loss from feeder wires to the track.

Let's assume we use a 1 ft 20 gauge feeder wire from the main bus 14 gauge wire to the track. The voltage drop is 0.47% which when added to the 2.36% main bus



the loss is still below 3%. Although model train track is conductive, it is still a good idea to connect from the main bus wire to the track in multiple places. Let's assume 3 for this example. From the above figure, we see that one wire has a resistance of about 0.033 Ω. We are now effectively connecting three wires with a 0.033 Ω resistance in parallel. In Episode 5 of our "Electricity 99" video tutorial series, we saw that resisters in parallel have an equivalent resistance of

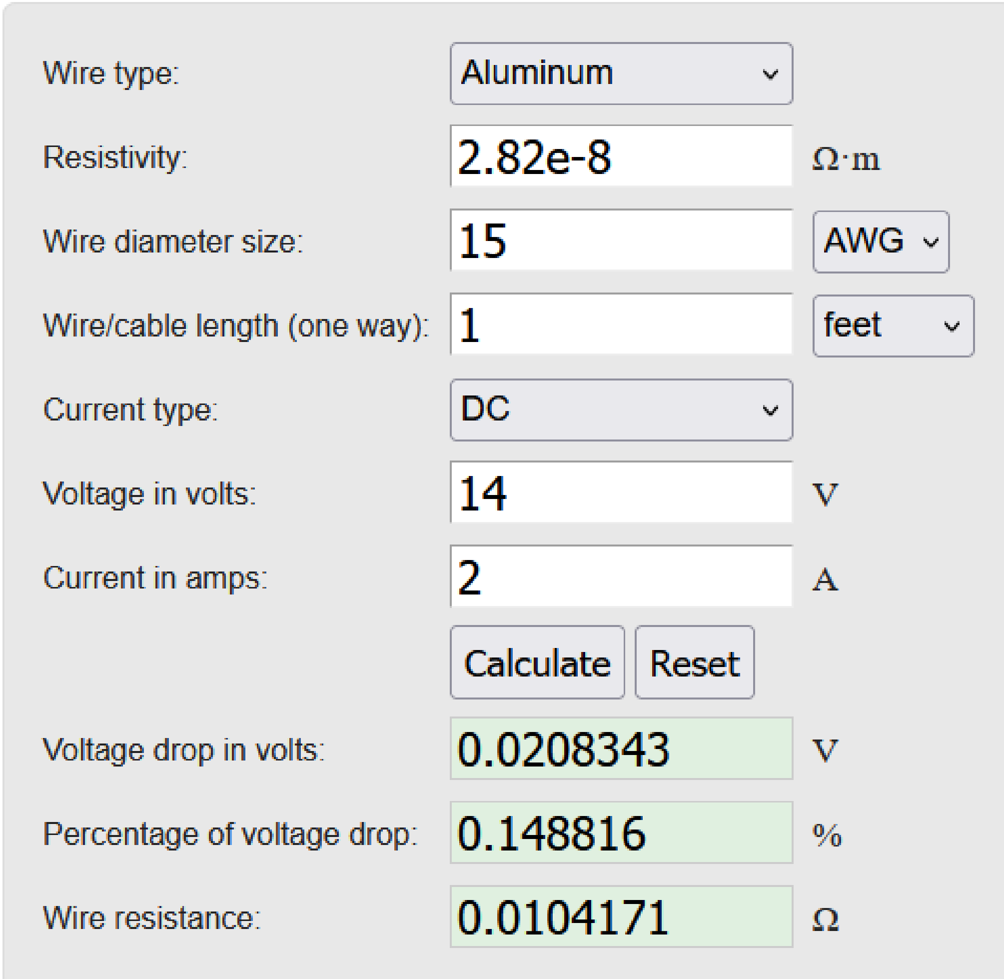
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Therefore, the three wires are equivalent to

$$\frac{1}{R_T} = \frac{1}{0.033} + \frac{1}{0.033} + \frac{1}{0.033}$$

or R_T = 0.011 Ω.

Using the calculator to determine a near equivalent wire gauge, we find that a

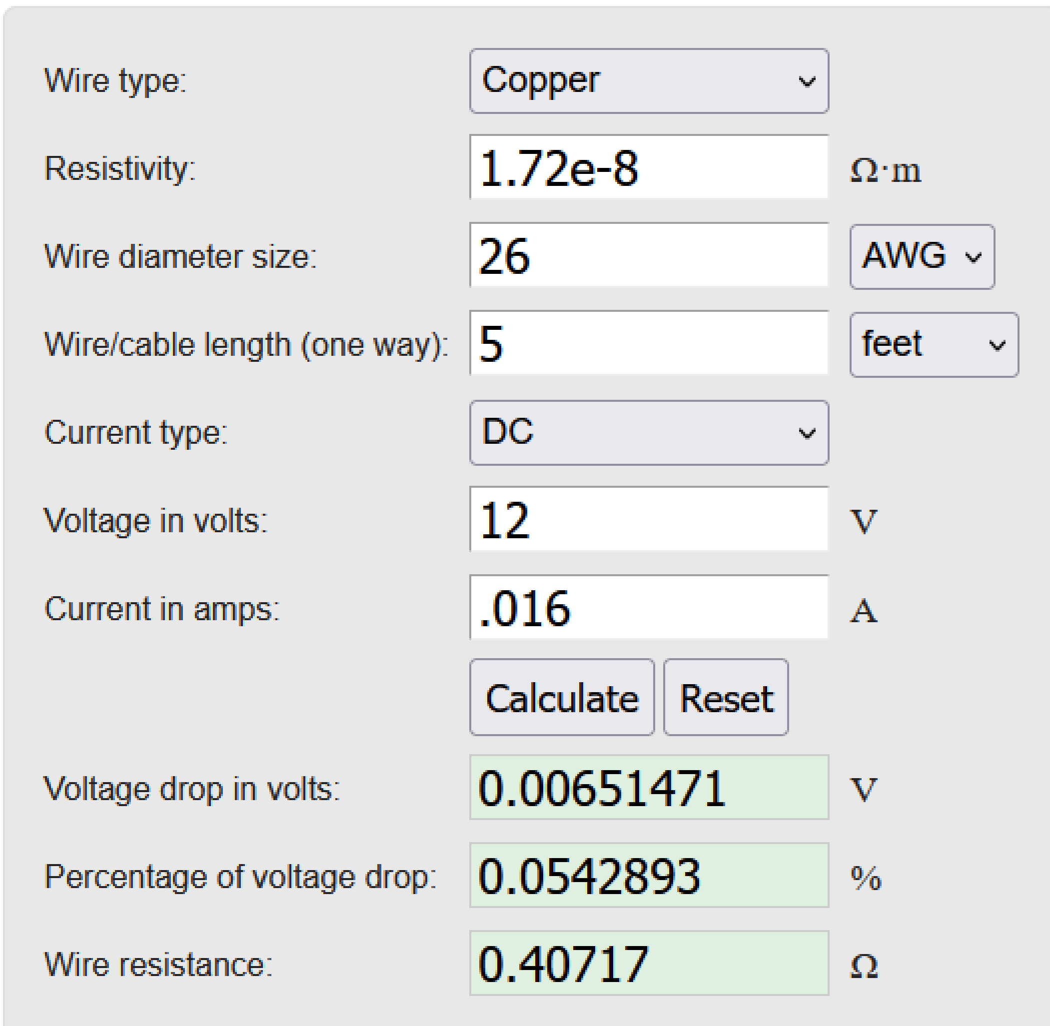


gauge of 15 provides a nearly equivalent resistance. The percentage of voltage drop is only 0.149%. Thus, multiple connections will not only cause less dependency on the track as a conductor, but also reduces the voltage drop for the equivalent feeder wire.

For this example, we can use a use a 20 ft 14 gauge aluminum main supply wire and three 1 ft aluminum feeder wires to the track and achieve a 2.51% voltage drop.

5.1.3.2 Calculating Wire Size for Accessories On Grandpa's Railroad we chose to use 12 V as our main accessory power supply. We convert this to 5 V when necessary to power WIFI modules, servos, etc. Since most accessories are near their controller (WIFI card) very short wire lengths can be used. This results in small gauge wires being possible with low voltage drops. Where possible we use telephone wire in these situations because it is cheap with various connector options. Typically, these wires are copper which has lower resistance.

A Tortoise Switch Machine is said to use only 16 milliamps. If we drive it at 12 volts, (using the above voltage drop calculator) we see that a 26 gauge copper wire has a voltage drop of only 0.05% over 5 ft and 0.22% over 20 ft. Therefore 26



gauge telephone wire is totally acceptable for this application.

LED lights typically draw 20 ma. If we use a 12 volt supply (with resistor) and 25 LEDs connected for a small scene, this would be 0.4 amps. Using the calculator this is a 2.71% drop over 10 ft. (Note: In the case of LEDs lowering the voltage drop would be of no significance. We showed in Episode 6 of our "Electricity 99" video tutorial series that LED lights required a large voltage drop before becoming noticeably dimmer. Again, a good place to use 26 gauge phone wire.

Small servo motors can draw 0.25 amps during operation typically at 5 volts. If we apply these parameters to the calculator, we see a 2.04% drop at 5 ft. Since accessories are typically close to their controller (WIFI card), 26 gauge phone wire is appropriate.

Note: In some cases (where WIFI has not been used to replace long wire runs), larger gauge wire may need to be used for accessories.

5.2 Making your own Cables

Many times on a model railroad you would like to run a cable containing many wires to keep the wiring clean looking. For example, we have wired Grandpa's Railroad traveling layout to be able to run on two DC throttles for the two parallel main lines. This requires two sets of wires to bring track power down the mainline. Running a four-wire cable sounds great but it has many disadvantages. Four-wire 14-gauge cables are expensive and it is hard to get to and separate the wires where you wish to add feeder wires to power the track. It is much easier and cheaper to make your own cable (wire bundle) using heat shrink tubing. Individual wire strands come in many colors making each wire in the bundle easy to identify. (It is a good idea to reserve certain colors on your layout for specific uses. For example, we use red for our positive 12-volt DC accessory supply wire and black for the ground.)

The following table shows the shrink tubing we use.

Wire Type		Heat Shrink Tube
Gauge	Number of wires	
14	4	1/4 inch (6mm) 2:1 shrink ratio
14	2	3/16 inch (5mm) 2:1 shrink ratio
18	4	3/16 inch (5mm) 2:1 shrink ratio
18	2	1/8 inch (3mm) 2:1 shrink ratio

Using the above sizes, before shrinking the wire is held in place and it is easy to slide on. After shrinking the wire is held tightly together. We typically use 1 inch pieces spaced 6 to 8 inches apart. This leaves plenty of room for adding connectors between tubing. Below are pictures of a cable before and after shrinking.

For more details on creating a cable see our video on Grandpa's Railroad YouTube Channel.

5.3 Wire Connectors Coming Soon

5.4 Adding Lighting Coming Soon

5.5 Adding Sound Coming Soon

5.6 Adding a Road Crossing Flasher Coming Soon

5.6 Adding a Track Traffic Signal Coming Soon