Modular Signal System User Guide

Part 2 - Planning

Contents

2 MSS Planning

This Part 2 of the MSS User Guide describes how to incorporate the MSS into the planning and design of your module or layout from the very beginning, before any construction has begun. It is common knowledge that a project of any complexity turns out better by investing time up front in planning and design. The more detailed and comprehensive the planning, the smoother the project will go and the better the result will be.

If you are retrofitting the MSS into an existing module or layout, the information presented here can be helpful in recognizing which aspects of your railroad may need to be modified and what equipment you'll need to acquire for a successful retrofit.

This document uses many MSS-specific terms and assumes the reader is familiar with the basic structure and requirements of the MSS. If you are unfamiliar with these, refer to the MSS User Guide Part 1 where terms are defined and MSS requirements are described.

2.1 Before Construction

Planning for the MSS to be part of your module or layout starts at the very beginning, with the model railroad track plan drawing. Use a computer automated design (CAD) tool if possible as it makes brainstorming and design changes much easier. However, the old fashioned tools of paper, pencil, and eraser are still a viable way to plan and design.

2.1.1 Signal Blocking

Use your finished track plan to decide where you want trackside signals. These locations will become signal block boundaries in the MSS, which always have an optical sensor on the signaled track. It's important to identify the exact positions of optical sensors and trackside signals so that the underlying framework can be designed to clear the wiring (and mechanisms when semaphore signals are used) passing down through the layout surface. With this in mind, mark the following on your track plan:

- The positions of optical sensors on the signaled track, one located at each signal block boundary. Also mark any additional optical sensors you may want within the length of signal blocks (e.g. to detect non-powered trains parked between block boundaries on the signaled track).
- The positions of each trackside signal, with a notation of the signal type (e.g. target, tri-light, semaphore, etc.). Draw each signal's footprint onto the plan at its exact placement relative to the track. It may be necessary to first acquire the signals you wish to use and measure their footprints and wire configurations.

2.1.2 MSS Device List

Now that you know the number of signal blocks, block boundaries, and the types and quantities of trackside signals, you can make a list of the MSS devices you'll need. If you're planning a small module with just a single MSS Node (Cascade or Crossover), this step will be rather straight-forward. However if you're planning a larger module or a complete fixed layout with multiple MSS Nodes, follow this process:

- **MSS Cascades and Crossovers:** The number of signal block boundaries tells you directly how many MSS Cascade Nodes you'll have, which in turn tells you how many MSS Crossover elements you'll need between each pair of MSS Cascades. Recall that the MSS requires an odd number of MSS Crossover elements between any two MSS Cascade Nodes. Remember to account for any MSS Complex Cascade Nodes where two or more signaled tracks interconnect at a junction. Also remember to account for multiple parallel signaled tracks – each signaled track requires its own independent MSS Cascades and Crossovers linked by an MSS Occupancy Bus.

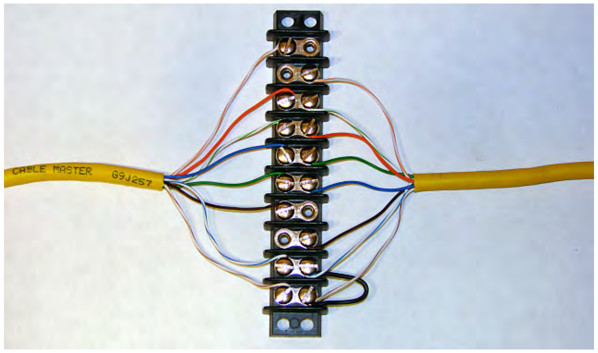
- **CAT5 Cables and RJ45 Connectors:** Use the numbers of MSS Cascades and MSS Crossovers to determine the types and quantities of CAT5 network cables and RJ45 connectors needed to build your MSS Occupancy Bus. Remember to account for multiple parallel signaled tracks – each signaled track requires its own independent MSS Occupancy Bus.
  - For a module: It is common practice to install one RJ45 straight-through coupler at each endplate, and then use two CAT5 cables to connect the couplers to the RJ45 jacks on the MSS Node located within the module. In other words, the intra-module CAT5 cabling extends the MSS Node out the module endplates. The type of intra-module CAT5 cables (crossover or straight-through) depends on the type of MSS Node: extending an MSS Cascade Node to the endplates requires two straight-through cables; extending an MSS Crossover Node can use either two crossover or two straight-through cables, <u>but both cables must be the same type</u>. Additionally, you will need CAT5 crossover cables for linking the module to adjacent modules in a modular layout (i.e. connecting between the RJ45 couplers installed at the module endplates).
  - For a fixed layout: At a minimum, one CAT5 crossover cable is needed for connecting between MSS Cascade Nodes and will plug directly into the RJ45 jack on each MSS Cascade Node. However if additional MSS Crossover elements exist in the layout (between the MSS Cascade Nodes), then additional CAT5 crossover cables will be needed to link the intermediate MSS Crossover elements to the adjacent MSS Cascades.
- **Current Detectors:** The number of MSS Cascades and signal blocks gives you a sense of how many current detectors you'll need. The exact number depends on the layout format and how the track power wiring is structured. Remember to account for multiple parallel signaled tracks – each signaled track requires its own independent current detection.
  - For a module: Every module, regardless of the type of MSS Node it contains, requires current detection. This is because every module has its own track power feeder wires to the detected/signaled track, and all of those feeders must be fitted with current detection for the MSS to work correctly. For an MSS Crossover Node module, at least one current detector is required. For an MSS Cascade Node module, at least two current detectors are required. For an MSS Complex Cascade Node module (where the MSS Occupancy Bus splits at a railroad junction), at least three current detectors are required (a more complex junction will likely require more current detectors).
  - For a fixed layout: This is a good time to begin thinking about how the track power wiring will be structured to support the MSS – more on this later in this document. At a minimum, one current detector is required for each signal block of each signaled track.
- **Optical Detectors:** The number of MSS Cascade Nodes (i.e. signal block boundaries) tells you directly the minimum number of optical detectors you'll need – one at each MSS Cascade Node. Add to this any additional detectors you plan to place within the length of a signal block (e.g. to detect non-powered trains parked between optical sensors at block boundaries of the signaled track). Remember to mark the locations of these additional optical detectors on your track plan. Again, remember to account for multiple parallel signaled tracks and junctions that will need additional optical detectors.
- **Turnout Mechanisms:** The track plan tells you how many turnouts are on the signaled track. Each turnout requires a mechanism that incorporates an electrical switch used to force the appropriate MSS Occupancy Bus wires to active low.
- **Signal Drivers:** The numbers and types of trackside signals marked on your track plan tells you the quantities and types of signal driver logic elements you will need (and mechanisms when semaphores are used). Remember, each individual signal head requires its own dedicated signal driver - for example, a double-headed signal will need two signal drivers.
- **Occupancy Bus Routing:** At each junction where the MSS Occupancy Bus splits, you'll need some type of routing element, e.g. a multi-contact relay or a logic circuit.

2.1.3 MSS Device Selection

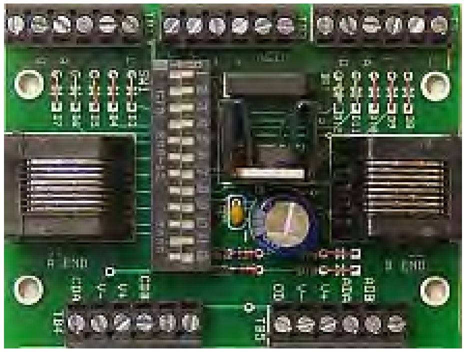
Now that you have a list of required MSS devices, the next step is to select which commercially available products (if any) will fulfill your needs, and acquire them.

This will involve some research on your part to learn what products are available, confirm they are MSS compatible, and determine if they have the specific features you want. One place to start is the MSS website's "MSS Resources" page that lists several products known to be MSS compatible. Be aware the MSS website can't provide a comprehensive list, as new products are entering the marketplace all the time. Ask fellow model railroaders who have experience with the MSS which products they like and why. Here are some factors and sample products to consider:

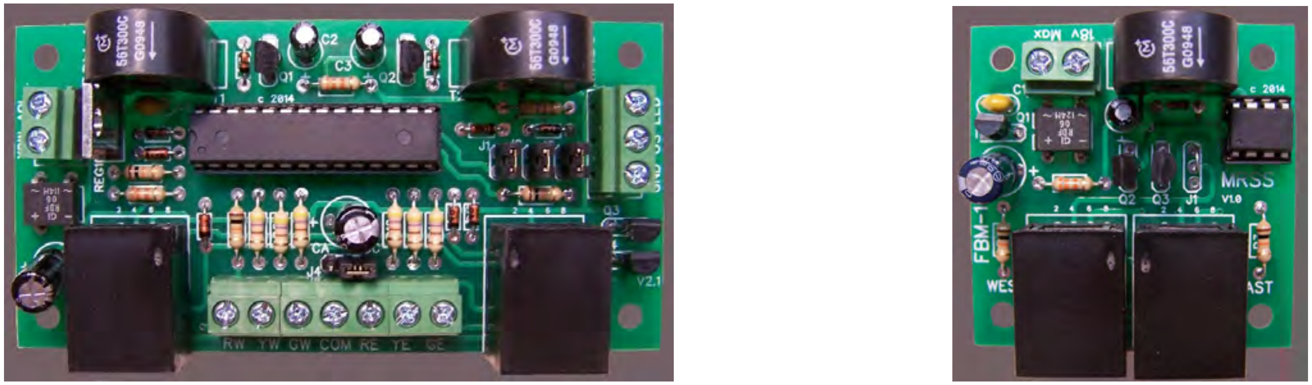
- **MSS Cascades and Crossovers:** These MSS-specific wire patterns can be hand-built from CAT5 cable broken out onto terminal strips (Figure 2-1) where detectors and signal drivers would be connected. There are also commercial products with the MSS wire patterns built-in. The Scale Nature Company OBUB-3 (Figure 2-2) has RJ45 jacks for simple connection of CAT5 cables, DIP switches for configuring as either an MSS Cascade element or an MSS Crossover element, and wire terminals for connecting separate detectors and signal drivers. Also, a line of fully-integrated MSS Nodes is offered by Model Railroad Signal Systems, which have MSS Cascade or Crossover elements integrated with current and optical detectors as well as signal drivers (Figure 2-3).



2-1: A hand-wired V2.0 compliant MSS Cascade element.



2-2: Scale Nature Company OBUB-3.



2-3: Model Railroad Signal Systems FCM-1 integrated MSS Cascade Node and FBM-1 integrated Crossover Node.

- **CAT5 Cables and RJ45 Connectors:** There are dozens, if not hundreds, of sources for CAT5 network cables, both brick-and-mortar stores and on-line. But be aware that not all CAT5 cables follow the TIA/EIA 568A/568B wiring standard! Be certain to acquire only cables with all four wire pairs. For crossover network cables, be sure that only pin pairs 1/3 and 2/6 cross over within the cable; pin pairs 4/5 and 7/8 must pass straight-through from end to end. You can check this by looking at the RK45 plugs at each end and carefully comparing the pattern of wires visible through the clear plastic housing. Also, CAT5 cables can be found with almost any color of outer jacket – the jack color is not at all important for the functionality of the MSS. However, consider always using the same color for crossover cables and a different color for straight-through (patch) cables, if you use them. Finally, there is no reason to spend a lot of money on CAT5 cables for MSS, since the data speed is essentially DC. Cables come ready-made in a variety of standardized lengths, but it is not difficult to make your own custom-length cables by attaching RJ45 plugs using a crimping tool specifically designed for this purpose. For RJ45 couplers (with a jack on each end, Figure 2-4), the only important thing is to be certain to use straight-through wired couplers. Do not use crossover couplers. RJ45 couplers can be found in various colors, which does not matter for the MSS. Choose whatever color you like. Again, don't spend a lot of money on fancy couplers with shielding, etc. that the MSS does not need.

2-4: RJ45 straight-through coupler.

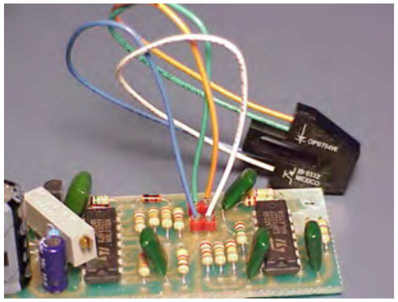
- **Current Detectors:** When choosing current detectors, the type of train power/control system matters – DCC versus DC – because most commercial current detectors only work with one or the other. Be certain to select current detectors designed to work with your type of train power/control system. Current detectors are available with an assortment of features. In general, the more features the higher the cost and the larger the footprint. One such feature is adjustable sensitivity, allowing you to set the lower limit of current that the detector will sense. This feature can help to detect high-efficiency can motor equipped locomotives idling with their lights off (i.e. they draw very little current). Also, such detectors can be set to ignore small leakage currents that could flow between the rails through the scenery should it consist of materials that are slightly conductive. Another feature to look for "delay off" – this means the detector waits a short period of time (either a fixed period or adjustable) before turning off. For current detectors, this is a terrific feature because it prevents signal flicker due to intermittent current flow caused by dirty track. Finally, look for detectors with a status light that illuminates when the unit is active, which can be quite helpful during troubleshooting (this applies to optical detectors too). There is even a dual DCC current detector on the market (Figure 2-5), which is handy for modules incorporating an MSS Cascade Node that requires at least two current detectors and will reduce the number of devices you'll need to acquire.

2-5: Team Digital's DBD22 dual DCC current detector.

- **Optical Detectors:** Some features found in current detectors also appear in optical detectors. The “delay off” feature is good to have as it prevents signal flicker when the gaps between train cars pass over the sensor (e.g. couplers). There are two broad categories of optical detectors to consider. The first type uses a sensor that detects ambient light and activates when a train blocks the ambient light (Figure 2-6, right). The downside of this type is it could preclude night operations when the room lighting is too low for the sensor to detect. The second type uses a sensor that emits infrared (IR) light and activates when it receives that IR light after bouncing off a train (Figure 2-6, left). This is the type preferred for the MSS, as it works regardless of room lighting conditions. Even so, there is a variety of infrared sensor technology to explore. Some sensors have two separate parts, the IR emitter and the IR receiver, which you must install into the track separately and manually align to ensure the emitted IR light bounces off the underside of trains at the correct angle to strike the receiver (Figure 2-7). Other sensors have the emitter and receiver integrated into a single unit, simplifying installation and eliminating the manual alignment task. Even within this niche there are many styles - some integrated IR sensors are larger, others are smaller, some have odd shapes, they’re tuned to a variety of sensing distances, many have specialized filtering windows to prevent interference from dust or ambient lighting, and so forth. To help narrow things down, to date the Free-mo modular community has used Optek brand OPB704WZ one-piece IR sensors attached to Heathcote brand IRDOT-1D detector electronics (Figure 2-8), though certain ambient lighting conditions can interfere with this combination. However, recent tests of the Iowa Scaled Engineering (ISE) CKT-IRSENSE one-piece IR detector (Figure 2-9) show promise – the sensor is small enough for N-scale track and the unit seems impervious to a wide variety of ambient lighting conditions. Iowa Scaled Engineering is also developing a unit with a separate sensor wire-connected to the detection electronics for a more flexible and serviceable installation.

2-6: Optical sensors: IR integrated (left) and ambient (right).

2-7: Two-piece IR sensor.



2-8: Optek IR sensor and IRDOT-1D.

2-9: ISE CKT-IRSENSE.

- **Turnout Mechanisms:** There are a few options for turnout mechanisms with built-in auxiliary electrical switches and contacts. One popular choice is the Circuitron Tortoise (Figure 2-10), which has a double-pole-double-throw (DPDT) set of built-in auxiliary switches. Typically, one auxiliary switch is used for the MSS to connect MSS Ground to the Local In-Out occupancy wire when the turnout is set against the signaled track, or to power the coil of a relay used for MSS Occupancy Bus routing at a junction. The second auxiliary switch is used for power routing of the turnout frog. If you prefer a different type of turnout mechanism, be certain to consider how it can be used to both power-route the turnout frog and also meet the needs of the MSS.

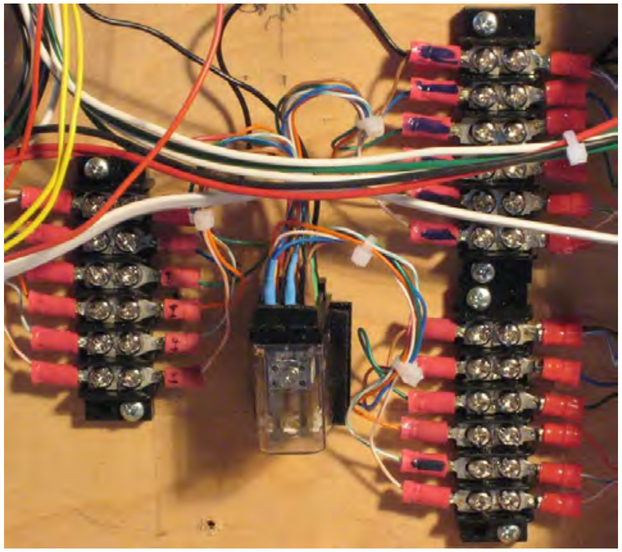
2-10: Circuitron Tortoise turnout mechanism.

- **Signal Drivers:** The options you'll have for signal drivers (which, as a reminder, must have active-low inputs with pull-up resistors) depends on the type of trackside signals to be driven. For signals with only lights, you'll need a driver having just an electronic circuit (Figure 2-12). However for semaphore signals, the signal driver solution will also need a mechanism for moving the blade (note: some semaphore servo driver boards, e.g. the Tam Valley Depot Dual 3-Way shown in Figure 2-11, require a signal logic circuit to decode the MSS occupancy wires and to drive their inputs, e.g. a Circuitron SD-1 signal driver. Be certain to check this detail when selecting semaphore driver devices and account for this potential additional hardware). To select a signal driver with the appropriate output circuit, you'll need to know what type of light is in your chosen signal. It can get complicated quickly - is the signal's light incandescent or LED? If LED, does it have separate one-color LEDs or is it a single multi-color LED? If multi-color, does it have a common lead? If so, is the common lead the anode or the cathode? Then, you'll need to decide what other MSS features you want the signal driver to support, such as flashing for Advance Approach, the ability to go dark for Approach Lighting, and displaying Approach Diverging indication.

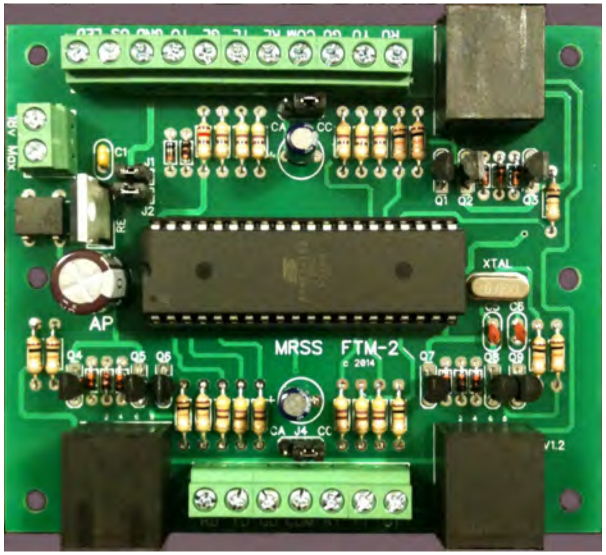
2-11: Circuitron basic signal driver.

2-12: Tam Valley Depot's Dual 3-Way semaphore driver and typical servo mechanisms.

- **Occupancy Bus Routing:** Routing elements required at junctions can be hand-built using a multi-contact relay (Figure 2-13. More about this in a later Part of this User Guide). Another possible choice is the FTM-2 Complex Cascade Node available from Model Railroad Signal Systems (Figure 2-14), which includes circuitry for signal drivers and optical detection.



2-13: Hand-wired TE Connectivity brand relay for an MSS Occupancy Bus routing element. Courtesy Gary Green.



2-14: Model Railroad Signal Systems FTM-2 Complex Cascade Node board.

In the end, it's possible your specific MSS may need a custom device that simply isn't available off the shelf. In that case you'll need to design and construct it yourself, work with a friend who has the necessary skills, or engage a manufacturer to produce what you need.

Once you have all your MSS equipment on hand, take the time to read through the product literature that came with each device. Familiarize yourself with each one's functions, connections, and power requirements. Try testing each device on your workbench to make sure you understand how to connect things and that the device is in working order. It's important to know what power input voltages the equipment can use, as this will influence the next planning phase.

2.1.4 MSS Power Planning

Establishing how to power all the MSS equipment is crucial. If power supplies with inadequate current ratings are used, the MSS will suffer sporadic faults when a power supply overloads and shuts down (or fails due to damage). A rule of thumb is to choose power supplies with higher current ratings than you think you'll need – this is called "overhead margin".

The standard power voltage for MSS is 12 volts DC (12VDC), chosen because most model railroad signal products will accept this as an input power voltage. The MSS Occupancy Bus does not have accommodations for power voltages, thereby requiring local power sources for the various MSS devices (e.g. detectors and signal drivers). This means modelers must plan how to provide the 12VDC power required by their MSS installation.

It's important to note that **the MSS requires power supplies to be <u>regulated</u>**, meaning the output voltage remains relatively constant regardless how much current is being delivered. Not all power supplies are regulated, so make certain to look for this feature when selecting a supply.

Be aware that some commercial signal products might require power input voltages other than 12VDC (e.g. 5 volts DC). Make certain to check for this limitation when selecting MSS devices and planning your MSS power system. If you have this situation, you'll need to add (regulated) power supplies to provide these additional power voltages. The selection process is the same regardless of voltage – determine the current needs of each required power voltage and select an appropriately rated regulated power supply.

There are two possible methods for selecting a power supply. The first might be called the "brute force method": choose a power supply with a high current rating so that, no matter how much current the MSS devices actually use, the power supply will have plenty of overhead margin. If you're impatient to get going on your MSS installation and don't mind spending more money than necessary, this might be the method for you. However, it is recommended you read through the rest of this section as it might save you some money on power supplies, or at least inform you a bit about this important aspect of your MSS.

The second method might be called the "analytical method", which is described below.

The first step in the "analytical method" is to determine how many local 12VDC supplies you will need. This decision is based on two factors: the architecture of the MSS installation, and the total current needs of the MSS equipment. For example, if you are installing the MSS into a module (i.e. the architecture is intended to be modular), a single regulated 12VDC supply in the module should be adequate because there will be fewer MSS devices to power and the overall 12VDC current load will be relatively small. On the other hand, if you are installing the MSS into a complete fixed layout with multiple MSS Cascade Nodes (i.e. the architecture is fixed), you may need to use multiple regulated 12VDC supplies to provide enough current. Each supply would be assigned to power some portion of the MSS (or a single high-current supply could power the entire system).

The second step is to estimate how much current each 12VDC supply must provide to the MSS devices and any other devices it is responsible for powering. To calculate this, use your MSS device literature to determine how much 12VDC current each device will draw (this will be listed in Amps or milli-Amps). If current draw is not specified, you can contact the manufacturer and ask, or you can use a digital multi-meter to measure the current draw of an MSS device on your workbench. Once the individual device current needs are known, add up the current draws of all the devices to be powered by the 12VDC supply including any non-MSS devices it is powering (e.g. turnout mechanisms, structure lighting, etc.). Now multiply the total by 1.25. The resulting number, in Amps, is used to select an appropriately rated 12VDC supply and includes a 25% overhead margin so that the selected supply will not be overstressed. If you prefer having a larger overhead margin, there is no harm in selecting a supply with a higher current rating. The tradeoff is cost and physical size.

Now that you know the current requirement of your 12VDC supply, the third step is deciding what type of supply to acquire. The choice falls into two broad categories: wall-powered supplies versus step-down supplies.

Wall-powered supplies plug into a 120VAC outlet and include “wall-wart” styles (Figure 2-15) and “brick” styles (Figure 2-16, like a laptop computer uses), and obviously require a nearby 120VAC source (e.g. a wall outlet, power strip, or extension cord). Be aware that some wall-wart and brick style power supplies, though labeled as providing 12VDC, actually provide unregulated voltages as high as 18VDC.

2-15: Wall-wart style AC power supply.

2-16: Brick style AC power supply.

2-17: Circuitron PS-2 step-down power supply.

Step-down supplies derive their 12VDC from some other higher voltage source other than wall power. There are many commercial step-down supplies available in a wide variety of configurations, including some produced by model railroad electronics vendors (Figure 2-17). An example application is using the Free-mo Accessory Bus that carries 16VAC or DCC power throughout a modular Free-mo layout to power a 12VDC step-down supply. This power supply solution has the advantage of being more self-contained, which can be an advantage especially for modules (i.e. there is no need for a 120VAC outlet). However, if this is the solution you’re choosing, make certain the voltage source can provide adequate current input to your step-down 12VDC supply. For example, the Free-mo Accessory Bus is often limited to 5 Amps – it would not be practical to connect a 5 Amp 12VDC step-down supply to it. Also, check your step-down power supply’s specifications to be certain it can function properly at the available input voltage. The Free-mo Accessory Bus, for example, is typically around 14.5VAC when DCC power is on it (for HO scale). This means that a 12VDC step-down supply must be able to operate at a relatively low voltage differential to its input, in this case 2.5 volts. Such supplies are often called “low drop out” or LDO supplies.

When power voltages other than 12VDC are required by an MSS device, one solution to consider is using a step-down power supply that is powered from your 12VDC supply. For example a 5VDC step-down type supply could be powered from your 12VDC source, as long as the added current load of the 5VDC supply has been accounted for in the selection of the 12VDC power supply.

Again, for emphasis, **the MSS requires <u>regulated</u> power supplies.**

2.1.5 Wiring Planning

At this point you should know, and have acquired, all the MSS devices you'll need.

The next phase of planning is to make a complete, detailed wiring diagram (schematic) as a roadmap to follow during installation and to assist troubleshooting later. The diagram should include all wiring in the module or layout, not just the MSS wiring, because there are some important relationships among the various electrical subsystems of your model railroad. For example, the MSS interfaces with the track power wiring via the current detectors.

Don't forget to document the connections to MSS Ground, which are pins 5 and 7 in the MSS Occupancy Bus. **All MSS devices and power supplies must be referenced (grounded) to MSS Ground**. This means that all ground connections on power supplies, MSS elements and the appropriate pins of the MSS Occupancy bus must be connected together.

Another recommended practice is to establish a wire color code for your module or layout, including the MSS. The color code is entirely up to you, but make sure to document it for reference while installing, troubleshooting, or modifying your wiring. One good place to list your wire color code scheme is on your wiring diagram schematic.

Once you've decided the colors of wire you'll be using, consider the wire gauges that will be appropriate for each connection. In general, the more current the wire will carry, the larger gauge it should be. Be aware the American Wire Gauge (AWG) system is "backwards" – the higher the AWG number, the smaller the wire size. For example, the wires in a CAT5 network cable are typically 26 AWG, which is quite small because they never need to carry a lot of current – usually in the micro-Amp to milli-Amp range. On the other hand, the track power bus wires in a model railroad are typically 14 AWG to 10 AWG, which is relatively large because they must carry the full current capacity of the track power supply, often 5 Amps or more. Another factor that will influence your choices of wire gauge is the types of connectors, terminal strips, crimp-on lugs, etc. you will be selecting to make the installation modular and serviceable (discussed below). These items are designed to accept only a certain range of wire gauges, such that their selection must happen concurrently with selecting wire gauges to ensure everything will fit together properly. Also consider what type of wire, solid core versus stranded. Stranded wire is usually the best choice for model railroad applications because it is more flexible and is often required for use with certain types of crimp-on lugs, etc.

Now that you know what colors, gauges, and types of wire you'll need, go ahead and acquire it. And while you're spending money, purchase things like wiring tie-downs, tie wraps, and labels to keep things neat, organized, and secure inside you module or layout (Figure 2-18).

2-18: A variety of wiring tie-downs and tie wraps to keep wiring neat and secure. Tie wraps with label flags are handy for identifying wires.

2.1.6 Servicing and Expansion

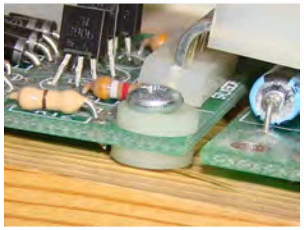
Plan for servicing and expansion of your MSS.

Whenever possible, avoid soldering wires in place. Instead, use electrical connectors, terminal strips, barrier blocks, and crimp-on lugs to make the wiring easy to repair or revise (Figure 2-19). One way to determine what is needed for this is to include such connection hardware on your wiring diagram. Remember, choose connection hardware that is compatible with the gauge and type of wire to be attached to it.

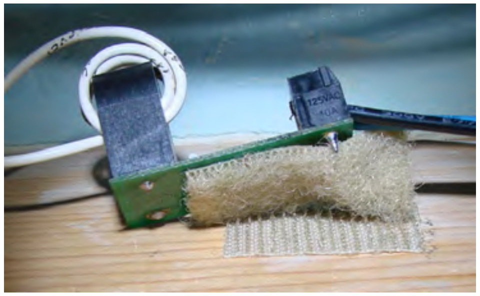
Whenever possible, avoid gluing MSS devices in place. Instead, use mounting methods that allow easy removal in case a device must be replaced due to damage or failure. For circuit boards that have mounting holes, it's usually necessary to use non-conductive hollow standoffs to raise the board off the framework a short distance to prevent damaging the board's bottom side (Figure 2-20). Wood screws are then driven through the board mounting holes and stand-offs to secure it in place. When a board does not have mounting holes, consider using sticky-back Velcro to attach the board to the framework (Figure 2-21).

Acquire all the connection and mounting hardware you'll need before you begin installation so it will be on hand when it's needed. Also be sure to acquire any required specialized tools such as contact crimpers.

2-19: A variety of wire-to-wire connectors, terminal strips, and barrier blocks.



2-20: Board standoffs.



2-21: Velcro-mounted NCE BD20 detector.

2.1.7 Framework Design

The next phase in MSS planning is to design the MSS hardware and wiring to fit within the module or layout framework. Obviously the framework must be tailored to your specific track plan, but it must also accommodate all the MSS devices, wiring connection hardware, and paths for the routing the wiring.

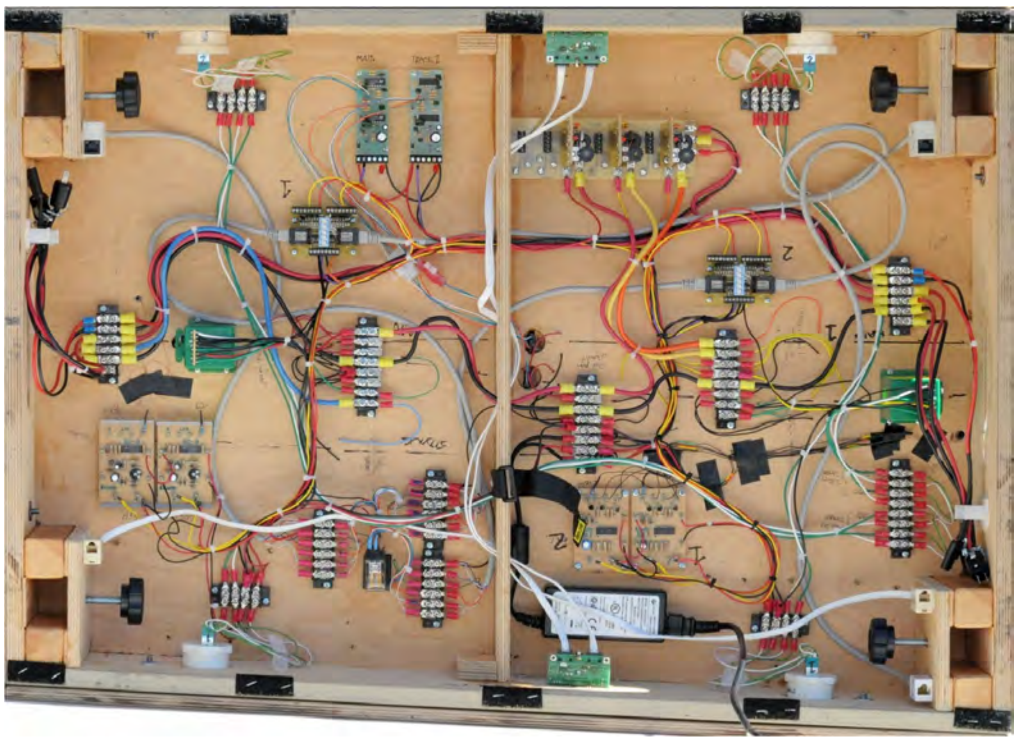
First, measure all the MSS hardware you've acquired including power supplies, connection items like connectors, terminal strips, and barrier blocks. Also measure devices like mechanisms for track turnouts and semaphore signals. Try to account for anything and everything that will need to be mounted and will consume space within the framework. Keep notes about the sizes and shapes of all these items so you can draw them into your frame design.

At the beginning of this planning process you marked on your track plan the positions and sizes of MSS devices having fixed locations relative to the track and wiring paths that pass through the module surface, including optical sensors and trackside signals. Now as you develop the framework design, be certain to avoid blocking these wire paths. Also ensure there are no mechanical conflicts between the framework and mechanisms for track turnouts and semaphore type signals.

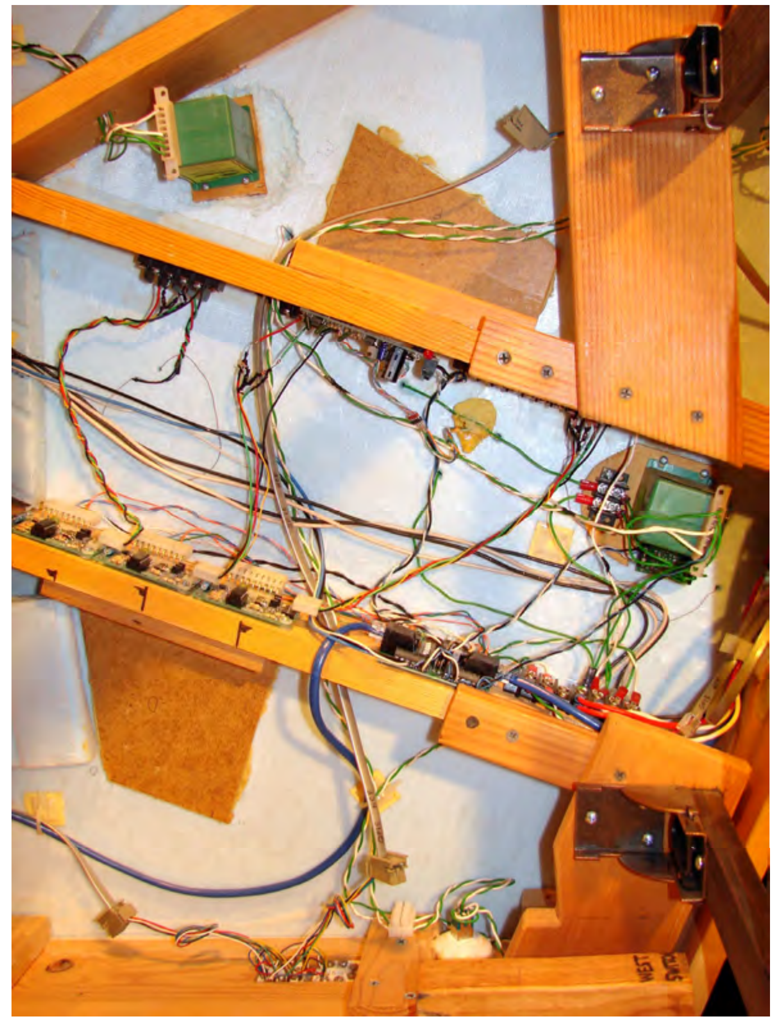
As you refine the framework design, draw in the remaining MSS hardware items to scale so you can see how much space they consume. Tweak the framework design as needed to allow for ease of installation, removal, and service access of the MSS hardware. Arrange and place the MSS devices in the framework to allow easy connection of their wiring (i.e. provide adequate space for tool access, e.g. screwdrivers for tightening terminal screws, etc.). Consider how the wiring will flow, how long the wiring runs will be, and so forth as you choose where to place MSS hardware within the framework.

Figure 2-22 shows an example of the desired result of all this up-front design and planning. This Free-mo module with an MSS Complex Cascade Node for a one-to-two track transition benefited greatly from thorough design planning. The solid plywood top requires minimal internal framing, thereby freeing up space to fit in all the electrical gear. The wiring is neatly modularized using multiple barrier blocks.

Figure 2-23 shows how lack of good planning can result in a rather messy MSS implementation. In this Free-mo module where an MSS Cascade Node was retrofitted in after construction, the foam-on-lattice frame structure provided few locations for mounting electrical hardware, which was “shoe-horned” in wherever it could fit. The wiring is a crisscrossing rat’s nest, making debugging and repairs a real chore.



2-22: A well-planned MSS Complex Cascade Node module. Courtesy Gary Green.



2-23: A retrofitted MSS Cascade Node is messy due to lack of planning.

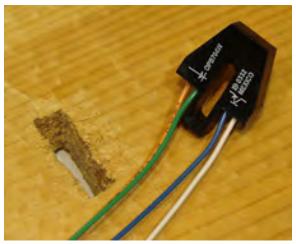
2.2 Roadbed and Track Installation

The MSS requires some forethought and accommodations before and during installation of the roadbed and track.

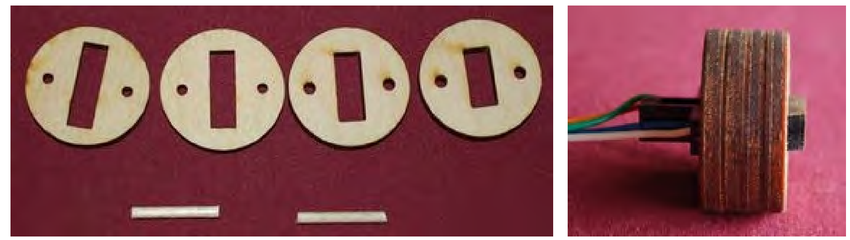
2.2.1 Optical Sensor Mounting Holes

Because MSS optical sensors are often embedded in the track, it is easier to cut holes for them into the subroadbed before the roadbed and track are installed.

After the track centerlines are drawn on the subroadbed, mark where optical sensors will be located at the signal block boundaries and any other locations where optical sensors are desired (recall these locations were previously marked on your track plan drawing). Cut mounting holes into the subroadbed to fit the specific optical sensors you have chosen and acquired. Figure 2-24 is an example of a cut-to-fit hole for the Optek sensor. Figure 2-25 shows the Optek sensor mounting kit available from Prawn Designs, which must be installed before track or roadbed.

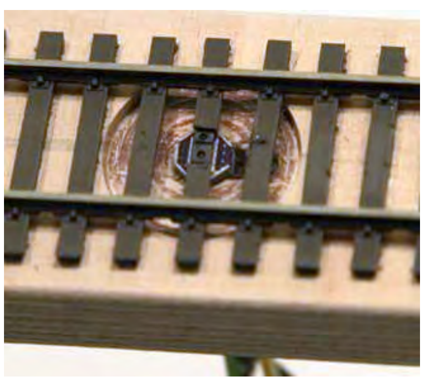


2-24: A cutout for the Optek OPB704W optical sensor before laying roadbed.



2-25: Prawn Designs laser-cut wood mount set for the Optek sensor.

When optical sensors must be installed before roadbed and/or track, cover the sensor's working element with a removable material such as painter's tape to prevent fouling it with glue and paint during installation of roadbed, track, ballast, and scenery. If you're concerned about glue or paint seeping down onto the detector electronics below, seal the installation with liquid electrical tape or another non-conductive sealant. As the roadbed is laid (for example, cork), cut holes into the roadbed to fit around the optical sensors. When the track itself is laid and ballasted, take care to not damage or block the optical sensor's working elements. Often, the sensor can be disguised as a track tie (Figure 2-26). Remember to remove the optical sensor's protective cover after all track, ballast, and scenic work is complete and dry.

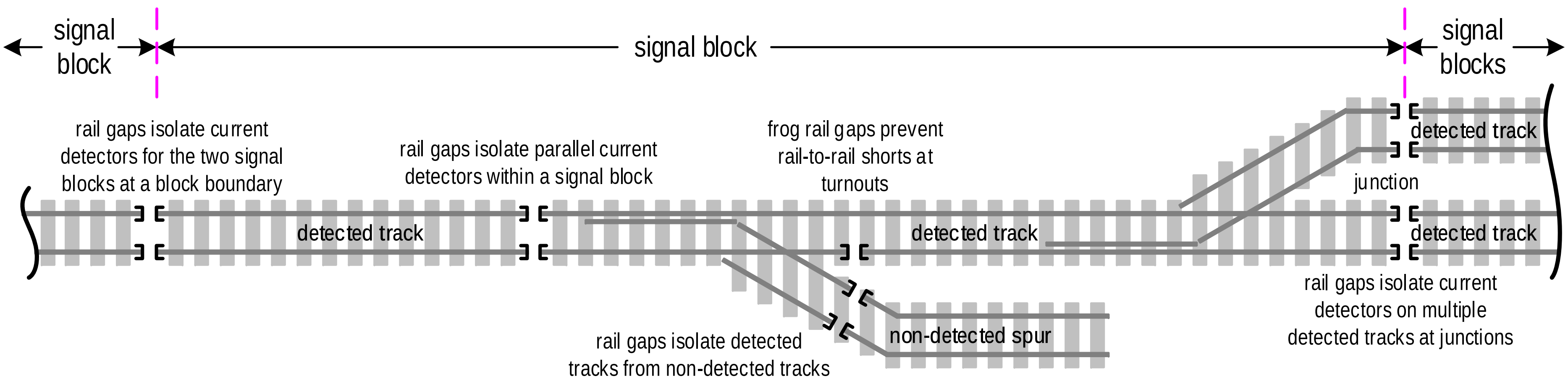


2-26: An ISE CKT-IRSENSE optical detector disguised as a track tie.

2.2.2 Rail Gaps

The MSS requires track rail gaps at the locations described below to ensure current detectors are electrically isolated and trains on non-detected tracks do not influence the MSS (Figure 2-27). Make certain to include these rail gaps as you install the track. Rail gaps can be implemented using insulated rail joiners as the track is installed, or by cutting gaps into the rails after they're in place. It is recommended to fill the cut gaps with epoxy or other plastic material to prevent them from closing up due to rail expansion. Here are the locations where rail gaps are required for the MSS:

- Both rails of a detected track at signal block boundaries (e.g. at MSS Cascade Nodes);
- Both rails of a detected track between parallel current detectors (e.g. at the ends of MSS Crossover Node modules);
- The frog rails at track turnouts (standard practice to prevent rail-to-rail shorts).
- Both rails of a non-detected track where it joins a detected track (e.g. sidings and spurs);
- Both rails where multiple detected tracks join (e.g. junctions, track crossovers, etc.);



2-27: Rail gap locations for the MSS.

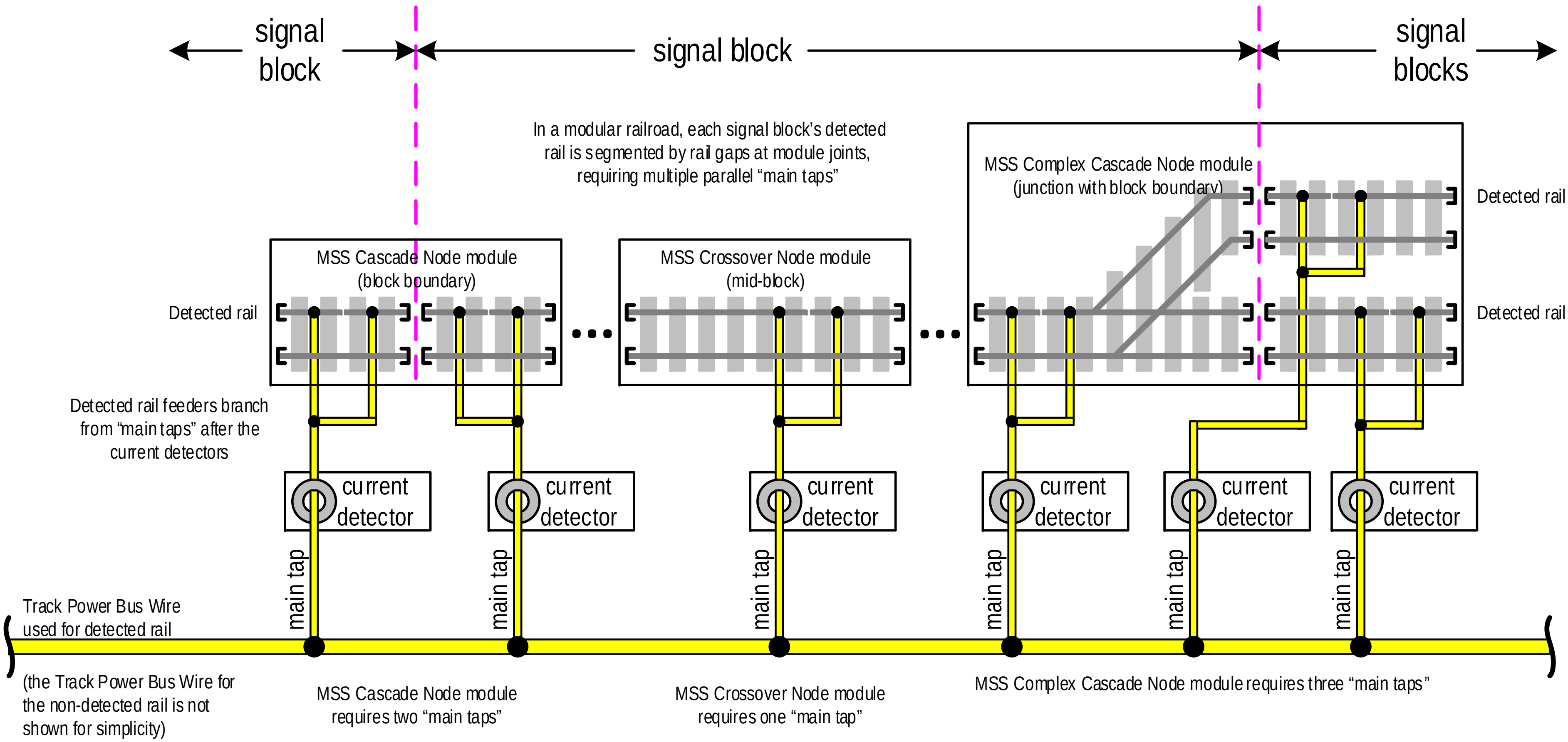
2.3 Track Power Wiring Installation

Every DCC or DC powered model railroad, whether it consists of a group of modules or it's a fixed layout, uses two wires to carry power to the track. One wire connects to one track rail everywhere, and the second wire connects to the second rail everywhere. We'll refer to these "global" wires as "track power bus wires".

When planning and installing the track power feeder wires for your MSS-equipped modular or layout, make certain to **separate the feeders for detected rails from the feeders for non-detected rails**. This is typically done using **"main tap" wires** branching from one track power bus wire. Each signal block requires at least one "main tap" wire, which is passed through a current detector before connecting to all the individual feeder wires on the detected rail of the signal block.

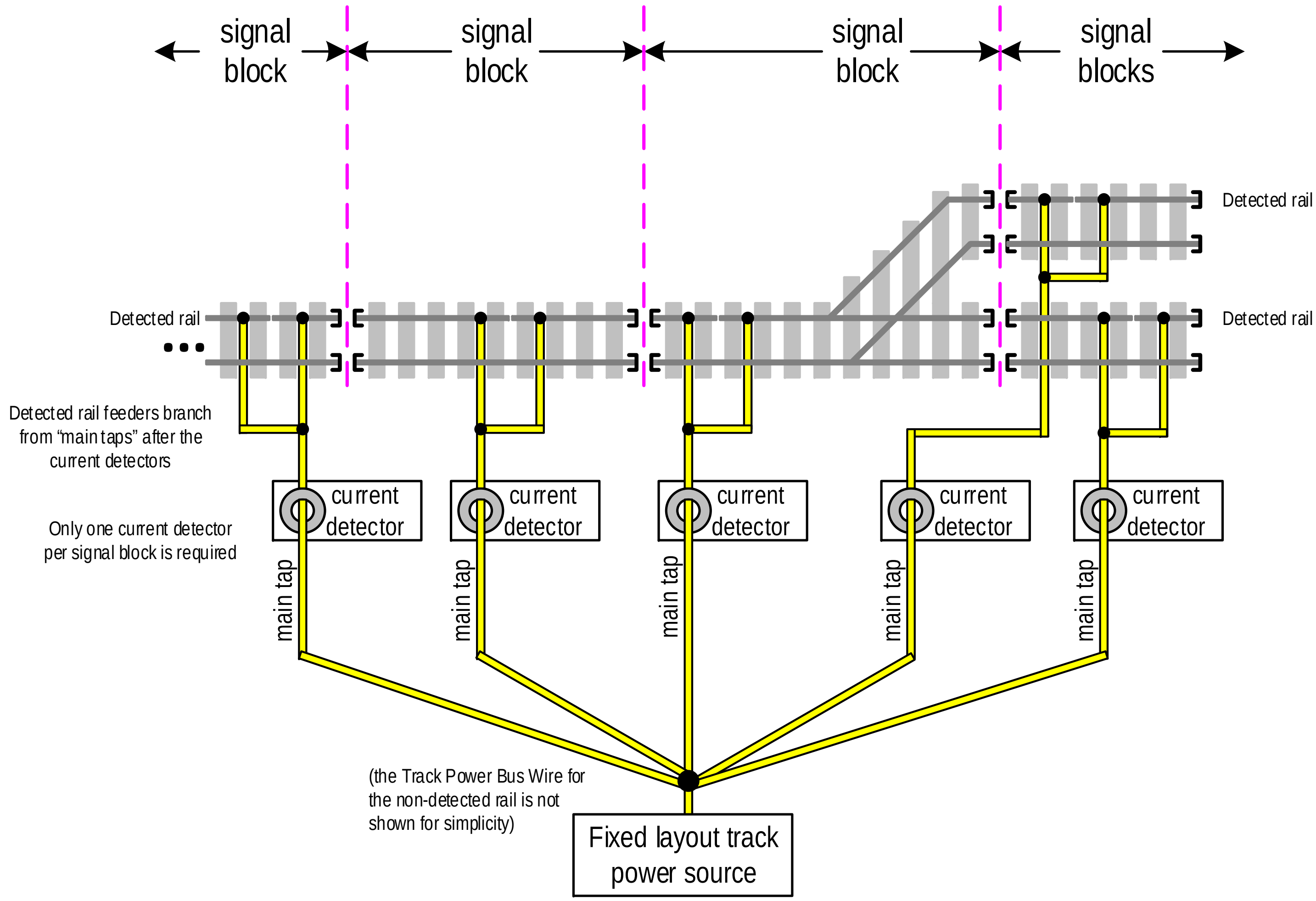
In modular model railroads where a signal block (usually) spans several individual modules, each signal block will have multiple "main taps" in parallel because the track power wire feeders are replicated in each module (Figure 2-28). Therefore, plan as follows for the track power wiring in your module:

- A module incorporating an MSS Crossover Node will require a minimum of one "main tap" wire (and one current detector) for each signaled/detected track present on the module. For example when there is just one signaled/detected track on the module, you'll need just one "main tap" wire. When there are two parallel signaled/detected tracks, you'll need two "main tap" wires, etc.
- A module incorporating an MSS Cascade Node at a signal block boundary will require a minimum of two "main tap" wires for each signaled/detected track. One “main tap” feeds the detected rail on one side of the rail gaps at the block boundary, while the second “main tap” feeds the detected rail on the other side of the block boundary rail gaps (through a second, independent current detector). Note that while it’s not necessary for both “main taps” to branch from the same track power bus wire, it’s less confusing to always use the same track power bus wire for detected rail “main taps”.
- Modules incorporating an MSS Complex Cascade Node at a track junction will require a minimum of three "main tap" wires, one for each branch of the junction. As the complexity of the junction increases, additional "main tap" wires (and associated current detectors) may be necessary.



2-28: Modular layouts have multiple parallel "main tap" wires for each signal block because the detected rail is segmented by rail gaps at module joints. The number of "main tap" wires required in a module depends on the type of MSS Node it contains (Crossover, Cascade, or Complex Cascade).

For a fixed layout, plan for at least one "main tap" wire for each signal block. If planned carefully it's possible to reduce the current detector requirements to just one per signal block - the "main tap" wires can be structured as a "star" pattern that fans out from the track power source to various destinations in the layout (Figure 2-29). Such a layout will have only MSS Cascade Nodes connected by MSS Crossover elements (CAT5 network crossover cables). There is no need for the MSS Crossover Nodes (MSS Crossover elements fitted with current detectors) that are necessary in a modular layout.



2-29: Fixed layouts can be planned to have a single "main tap" wire for each signal block, forming a star pattern from the track power source.

As for the track power feeder wires to non-detected rails (the non-detected rail of signaled tracks, and both rails of non-signaled tracks), their structure really does not matter for the MSS as long as they do not pass through current detectors.

This concludes Part 2 of the MSS User Guide. Part 3 will describe how to build MSS Crossover Nodes, which are typically needed for modular model railroads.

Document History

Date	Author	Notes
December 24, 2015	Gregg Fuhriman	General update. Added more sample products. Improved section 2.1.3
December 19, 2015	Gregg Fuhriman	First publication.