Northern California Free-mo

HO Scale Free-Form Modular Model Railroading

Module Standards and Construction Guidelines

Updated December, 2008

1.0 Overview

The main purpose of this modular group is to provide a place to operate finely detailed HO scale standard gauge models in a realistic fashion. Operating trains is the important aspect of meets, so the layout setup does not follow the traditional "endless circle" format of modular layouts that follow the NMRA modular standard. Instead it follows a "free-form" configuration that does not readily lend itself to continuous running: trains originate from one point on the layout, traverse it, and then terminate at the other end (or back at the starting point). This format results in modules that are viewed from both sides, and that are designed to be reversible (rotated 180 degrees).

This type of operation requires end points, typically in the form of stub end yards or reverse loops. A layout may then take on the form of an "out-and-back" or a "point-to-point" configuration. Other more complex formats are possible if "junction" modules are built; for example a wye module could allow a branch line operation.

Between the end points of the layout are modules which carry the single track main line from one end to the other. Large modules may be assembled from small, easily transportable "sections" to create a large layout feature; for example a passing siding long enough for a full-length freight train could be created as a multi-section module.

2.0 Definitions

NORCALF or NORCAL FREE-MO
An informal group of like-minded modelers experienced in the various model railroading disciplines. We aspire to a high standard of modeling ranging from cabinetry skills for module framing, to preparation and operation of highly detailed engines and rolling stock. There is no organizational structure, meetings or dues. All decisions about setups and group recommendations are made by consensus. Setups occur as space and time are available, typically 2 to 4 times per year.

MODULE
Any layout component (or group of "sections") meant to be operated as a single unit in a fixed configuration. A module can have any number of sections. Both ends of a module must comply with the Free-mo physical and electrical standards defined within this document.

SECTION
A part of a larger module, complete with bench work, track, scenery, etc. Except where otherwise noted, standards for module end interfaces do not apply to inter-section interfaces, as these are considered to be internal to the module.

ENDPLATE
The standardized end surface of a module that mates to an adjacent module in a Free-mo layout. The physical aspects of the endplate are defined in the Frame Work description, below.

FITTER RAILS:
The 2" long removable rails and joiners used to bridge the joints between adjacent modules or sections. Must be Code 83.

TRACK (POWER) BUS
The continuous two wire bus feeding power and DCC commands to the track.

ACCESSORY (POWER) BUS
The continuous two wire bus powering electrical accessories such as turnout motors, structure lighting, signals, etc.

LOCONET (DCC) BUS
The continuous six-wire bus carrying DCC information among the Digitrax system components such as throttles, boosters, radio receivers, etc.

OCCUPANCY BUS
The continuous eight-wire bus carrying main track occupancy status among modules. While not required by the Free-mo standard, NorCalF expects this bus to be installed on the modules of group participants.

PIGTAIL
Common name of any of the connector/wire assemblies used to connect the electrical busses together between modules.

3.0 Frame Work

"Frame work" refers to a module's structural frame including endplates, sides, interior supports, legs, and braces. There are no requirements to use specific materials or construction methods; however, the basic trade-off is sturdiness versus weight. To date, frames have been built from high-quality plywood such as birch, dimensional lumber, and medium-density fiberboard (MDF). Other more exotic materials are possible but have not yet been used by NorCalF (wood/foam sandwich, aluminum, honeycomb structures, etc.).

Based on this experience it is recommended to use high ply-count, void-free birch plywood (Baltic birch, Finn birch, multi-ply birch plywood) for at least the endplates. Dimensional lumber is strongly discouraged due to warping issues. MDF is also strongly discouraged due to weight and breakage issues.

HEIGHT FROM FLOOR

The nominal module height measured from **floor to top of main track rail** is **50"**, adjustable from 49" to 51" above floor.

Suggestion: the height adjustment range of 2" is a minimum; a larger range is acceptable and recommended.

WIDTH, LENGTH, SHAPE

Only the width at the endplates is specified (see Endplate specifications below); otherwise free.

Suggestion: modules over 6 feet long are difficult to transport and store.

ENDPLATES, GENERAL

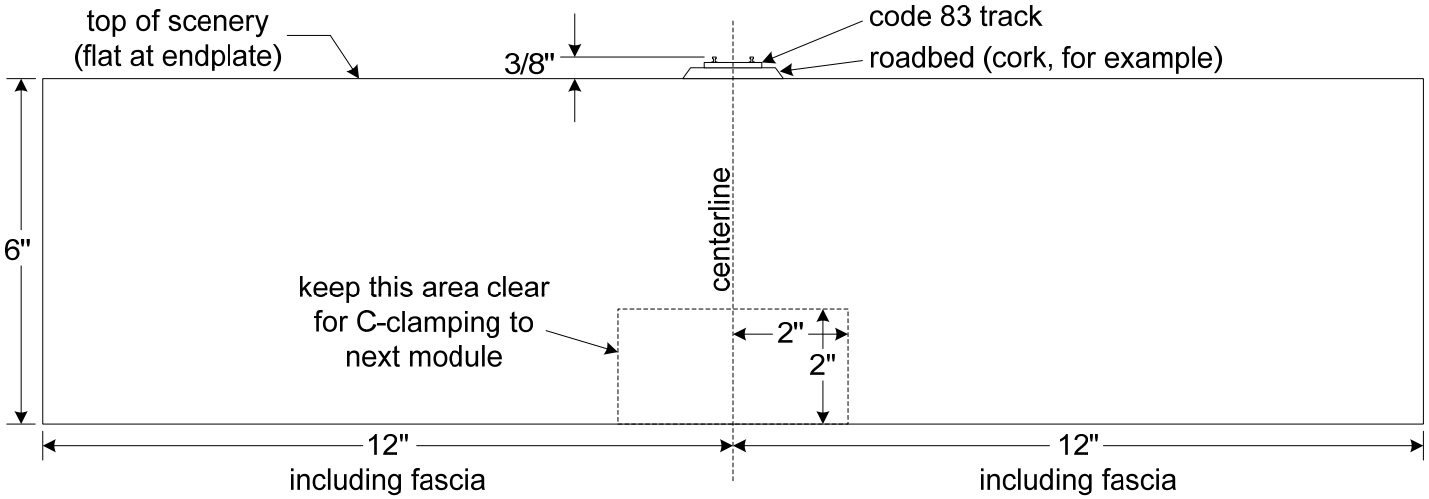
Endplates MUST be parallel to each other vertically, and perpendicular to track both vertically and horizontally. They must be flat (e.g. not bowed, twisted, etc.). Material must be solid and sturdy for C-clamping to adjoining modules.

Suggestions:

- Make endplates from 3/4" high-quality plywood or equivalent stable material to maintain flatness. High ply-count, void-free birch plywood (Baltic birch, Finn birch, multi-ply birch plywood) is recommended. Dimensional pine lumber and MDF are not recommended.
- To allow room for C-clamps, keep inner surface of endplate clear of obstructions (electrical terminal blocks, LocoNet connectors, etc.). Recommended clearance area is 2" high by 4" wide, centered at bottom edge of endplate inner surface.
- Cut handholds into endplates to assist transporting and positioning the module.
- Paint endplates Glidden "Great Desert" beige. Use "flat" to prevent modules sticking together.

Tops of rails are a total of 3/8" above the scenery top surface.
Scenery profile along top of endplate must be flat; scenery profile within module is free.

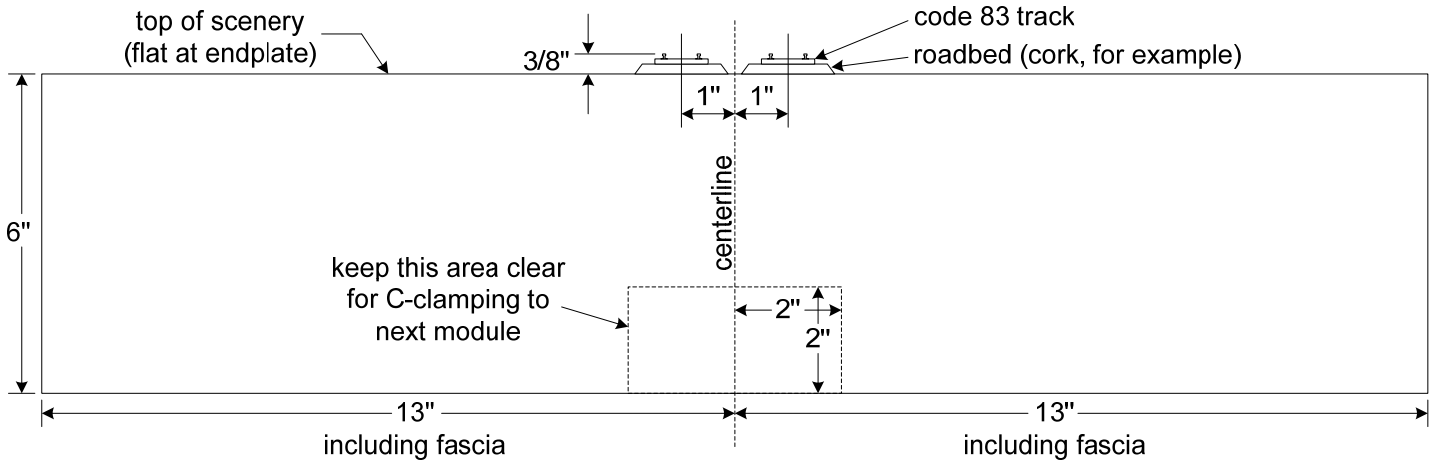
ENDPLATES, SINGLE TRACK



Single Track Endplate

Single track endplates are 24" wide, 6" tall from bottom to scenery top surface.

ENDPLATES, DOUBLE TRACK



Double Track Endplate

Double track endplates are 26” wide, 6” tall from bottom to scenery top surface. The two tracks are centered 2” apart, each centered 1” from endplate centerline. Rail tops of both tracks are at same height, 3/8” above scenery top surface.

Notes:

- Track spacing may deviate from 2” centers within a module (e.g., broader through curves). See NMRA standards for spacing specifications.
- Some legacy modules have more than one track at a 24”-wide endplate. Mating them with 26”-wide double track modules results in small fascia offsets.
- Mating 24”-wide single track and 26”-wide double track modules results in small fascia offsets.

SIDES AND FASCIA

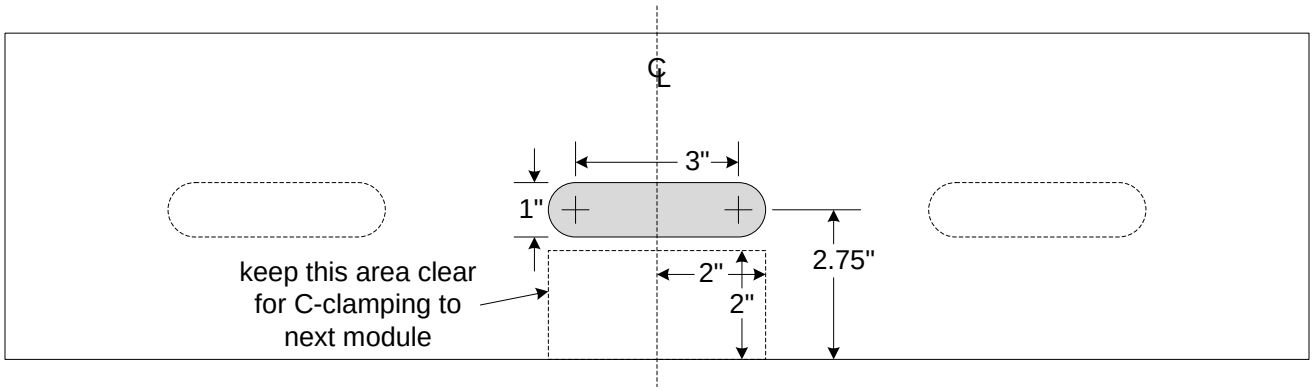
Fascias must be smooth and made of a solid, sturdy material (plywood, hard board, Masonite, etc.). The 24” or 26” width of the module must include fascia thickness on both sides of the module. Color must be Glidden "Great Desert" beige.

Suggestions:

- Use “semi-gloss” Great Desert to permit easier clean up of fingerprints and the like.
- Back thin fascia materials (hard board, Masonite, etc.) with solid frame material (plywood, etc.) all the way to the bottom edge of the frame, to prevent damage to fascia when module is lifted by its sides.
- Recess items like turnout controls and throttle panels to prevent accidental damage or injury to operators; avoid protruding items that could be damaged when module is set on its fascia.
- Label electrical switches and other operational items when their function is not obvious. Use black lettering at least 3/8” tall.

HANDHOLDS

Handholds are not required, but are suggested to ease handling modules during transport and setup. On endplates, many NorCalF modules use one centered handhold, or two side-by-side, per the sketch below.



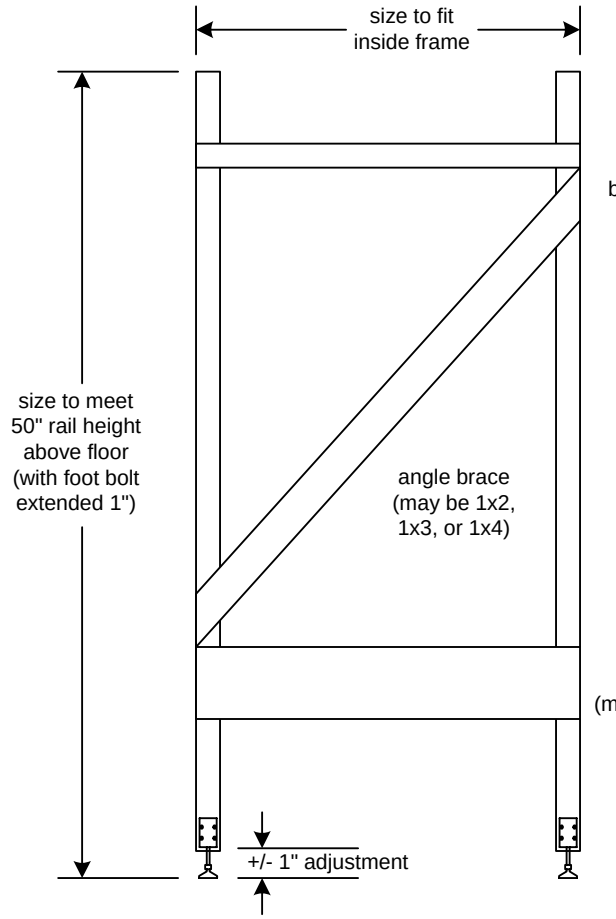
Endplate Handhold Suggestions

LEGS AND LONGITUDINAL BRACING

Each module must have legs that support the module free-standing. A module must stand secure and level independent of other modules. Each leg must include vertical adjustment of plus and minus 1" minimum to compensate for uneven floors (e.g. rail top height above floor must be adjustable minimum of 49” to 51”). Painting legs is optional.

Suggestions:

- Design and construct legs as part of the frame, making them an integral part of a module structure.
- Install cross- and angle-bracing on legs for added stability.
- Permanently attach legs to module frame and have them fold up for transport, if module size allows. This method allows speedy setup/teardown, simplifies transport and storage, and eliminates loose hardware.
- Add angled longitudinal braces to prevent module from swaying parallel to the track. This stabilizes the module for fine adjustments during setups, and when working on the module during construction.
- Use Lee Valley 4” leveler feet (see below) to prevent damaging floor surfaces.



One possible leg design using dimensional lumber. Lee Valley leveler feet and brackets mounted at the bottom for height-adjustment.

1x2 top horizontal (place to support bottom of end plate)

Visit Lee Valley Hardware at www.leevalley.com/hardware/

Folding brackets like these from Lee Valley (#00T16.01) can be used to build permanently attached fold-up legs. They lock into position both open and closed.

2x2 verticals

T-nuts like these may be used in the bottom of legs to hold height-adjustment bolts. Lee Valley #00N23.01 (item H above) are 1/4" Propell Nuts designed for end-grain installment.

bottom horizontal (may be 1x2, 1x3, or 1x4)

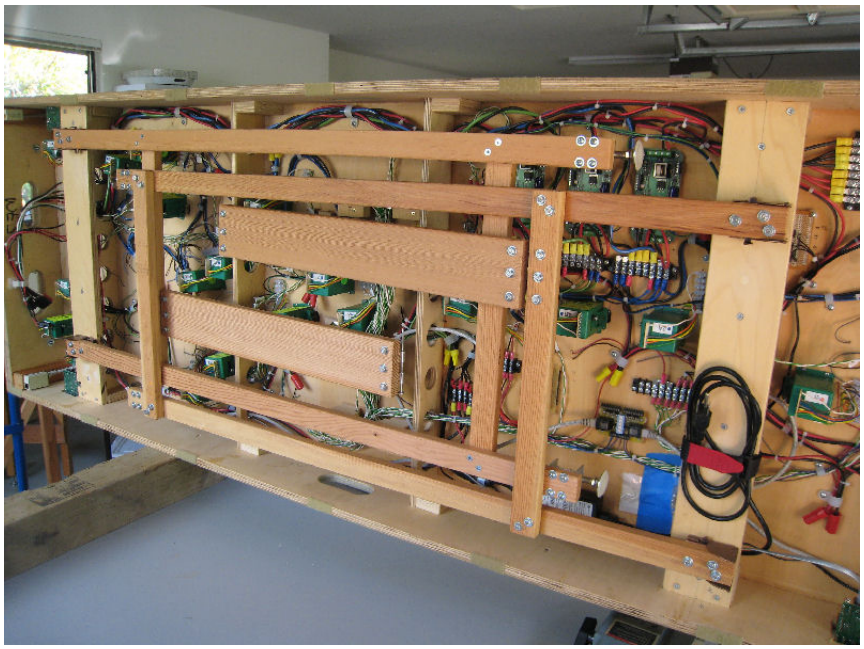
Another option for height-adjustment hardware. Lee Valley #01S04.05 bracket and #01S06.03 (3" tall) or #01S06.04 (4" tall) leveler feet. These can be adjusted with a screwdriver from above, avoiding crawling around on the floor during setups.

Because many setup locations have very uneven floors, 3/8” T-nuts or brackets and 4” leveler feet are recommended. Most NorCalF modules now use the Lee Valley products.

For folding legs, verticals can be 1x2 and the angle brace omitted in order to permit nesting of the folded legs. The resulting legs will not be as sturdy without the brace, but experience has shown that stability is adequate.

These views of the NorCalF Mojave yard illustrate the use of folding legs.

Stored for transportation:



Deployed, ready to be stood up on the legs:

MODULE-TO-MODULE ATTACHMENT

C-clamps are used at the endplates, positioned near the endplate center (directly below the tracks).

Suggestions:

- Use “deep-throat” C-clamps to apply pressure closer to module top and draw track ends together
- Wide modules with multiple tracks (e.g., yard modules) may be secured with two clamps, one toward each side of the module.

4.0 Track Work

GENERAL

All NMRA standards must be met. All track and turnouts must pass all tests using the NMRA Mark IV track gauge (track gauge, flange ways, etc.).

Track MUST be perpendicular to the endplate both horizontally and vertically!

SUB-ROADBED

Sub-roadbed construction and materials are free, but must be built to prevent sagging or flexing, and must be installed to comply with the endplate requirements (see section **3.0 Frame Work**).

Suggestions:

- To date NorCalF modules have used plywood or foam insulation board. The main trade-off is rigidity/stability versus weight.
- If foam board is used, provide supports either parallel or perpendicular to the track to provide maximum support for the foam, resulting in a flat track profile. Consider locations where access to the track from underneath the module (e.g., for a switch machine) will be required. Note that foam board has been unstable over time and hard to glue permanently in place.
- Unless it is sealed thoroughly on all surfaces before installation, Homasote is susceptible to humidity changes.
- Consider use of 5/8" to 3/4" plywood sub-roadbed under track locations, well supported from the sides of the module to prevent sagging or bowing.

ROADBED

Material is free, but must comply with standard 3/8" dimension for top-of-scenery to rail-top (see section **3.0 Frame Work**).

Suggestion: Standard HO scale cork roadbed used under flex track meets the 3/8" requirement.

MAINLINE LOCATION

Single track mainline centers must cross the module's 24" endplate centerline precisely.

Double track mainline centers must cross the module's 26" endplate precisely at 1" to either side of the centerline.

Mainline track(s) MUST run precisely perpendicular both horizontally and vertically to the endplates, for a minimum of 6" from each endplate. Otherwise track location is free within limits of standards for curves and turnouts. This guideline ensures there is at least 12" of straight mainline track between reverse curves.

> Note: Failure to meet the requirement that track be perpendicular vertically to the endplate without a twist of any kind is the most common issue when aligning modules at setups and the most common cause of derailments during operations.

MULTIPLE TRACKS CROSSING ENDPLATES

All additional tracks crossing a Free-mo endplate must be centered at 2" increments from the mainline track(s).

Rail tops of all tracks must be at the same height at the endplate, and extending a minimum of 6" from the endplate.

RAIL

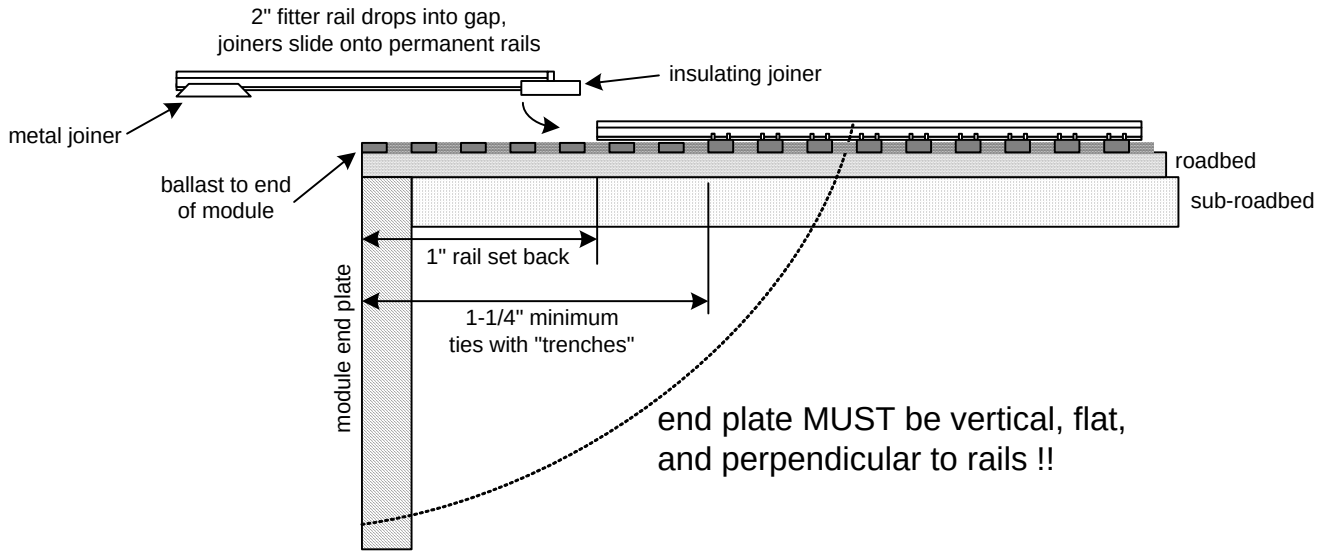
Code 83 nickel-silver rail must be used for all mainline track(s) throughout the module, and for all additional tracks crossing a Free-mo endplate for a minimum of 6" into the module from the endplate.

Smaller code (e.g. 70 or 55) nickel-silver rail may be used for non-mainline tracks within the module as long as the previous paragraph standard is met, but must permit reliable travel by rolling stock with NMRA RP25 flanges.

Larger code (e.g. 100) rail is not permitted.

All active rails have clear flangeways, and must be easily cleanable using an abrasive track cleaner block.

JOINING TRACK BETWEEN MODULES



Rails end 1" from end of module (outer surface of the endplates). Ties and ballast continue to end of module. The ties within 1.25” (minimum) must accommodate installation of fitter rails with accompanying rail joiners, which are slid onto the module’s fixed rail ends - typically these ties have a small “trench” where the spikes normally are found. These tie trenches must accommodate plastic insulating track joiners.

Tracks crossing Free-mo module joints are connected with two 2"-long Code 83 nickel-silver fitter rails with rail joiners, which are dropped into the rail gaps and joined to the module’s fixed rail ends.

All modules or sections that include a current sensing occupancy detector must be isolated from other modules or sections that include a current sensing occupancy detector by using an insulating rail joiner on one end of each of the fitter rails. The other end of each fitter rail must have a metal conducting joiner to carry track power onto the fitter rail from the module’s fixed rail.

Suggestions:

- Use Atlas code 83 joiners on fitter rails (their profile provides a surface for pushing into place).
- If code-100 insulating joiners are used, trim down the center insulating divider so it does not project above the rail top.
- To help visually blend in the fitter rails, use weathered rail stock or paint them, including joiners.
- Make sure that the trench for fitter rails will accommodate rail joiners before they are slid into place.
- The various manufacturer’s Code 83 rail has different cross sections. Wherever possible, user fitter rails that match the rails used on the adjoining module.

CURVES

42” is the minimum radius for mainline and through tracks such as passing sidings (however, 48” is strongly preferred).

30" is the minimum radius for branchlines, industry spurs, and similar non-through trackage.

There must be at least 12" of straight track between reverse curves.

All mainline curves should include easements; an article for creating easements can be found on the Internet at

http://www.trains.com/mrr/default.aspx?c=a&id=290.

Suggestions:

- Use 48" radius or more whenever possible. The 42" radius is the mainline minimum but larger radius looks and operates better!
- For spurs, service tracks, and the like, consider what type equipment will potentially attempt to operate over the trackage during a typical Free-mo setup. For example - if a large steam engine tries to use an engine servicing track, it may require a larger curve radius than the 30” minimum.

SUPER-ELEVATION AND GRADES

Super-elevation of mainline curves, vertical track curves, and grades are permitted, appropriate for mainline operation of contemporary long cars (90' cars must be able to negotiate these track profiles without derailing or uncoupling from adjacent cars). The maximum mainline grade is two percent (1/4" rise per foot of run). Track must be flat and level for at least six inches from each end of module.

Suggestion: when constructing track that includes vertical curves as described above, use a straight edge of at least 12" laid on top of the rail to measure the rate of change of the rail height. Measure each rail separately. The space between rail top and straight edge should not exceed 1/16" within 12" of horizontal run.

Note: grades are possible within a large module, as long as nominal rail-top height is 50" from floor at both endplates of the module. US Free-mo standards have a provision for grades across multiple modules, but for simplicity NorCalF presently does not allow this until further notice.

Suggestions:

- To super-elevate track, the outside rail is raised.
- The transition from flat to super-elevated track must be very long in order to prevent derailments of long cars and engines. A good guideline is to make the transition twice the length of the longest cars to be operated on the track (20-24” long for 85’ cars).
- The transition should run from the start of the fixed radius curve through the easement and onto the tangent (straight) track as required. Super-elevation should be constant through the fixed radius curve.
- Super-elevation is often modeled at an overly extreme height. Elevation of the outside rail by just 1/32” would be quite prototypical.

TURNOUTS

Minimum #6 for mainline, minimum #5 for branch and industrial trackage. All turnouts are controlled locally or through DCC. Point throw must reliably and completely close the point rails against the stock rails.

While the method of throw (powered or manual) is free, controls for all turnouts must be located on all operator-accessible sides of the module. Frogs must be power-routed from stock rails (avoid reliance of the contact between point and stock rails to conduct power through points into the frog). Turnout controls must not require reaching into a module (e.g., Caboose Industries throws).

Note: DCC accessory decoders are allowed for turnout control as long as there is at least one other method available to throw the turnout (fascia buttons, hand throw levers, etc.). To avoid duplications, DCC decoder addresses must be registered in the *DCC Address and Loco Roster* file on the NorCalF Yahoo group.

Note: The diverging track of turnouts may be located within the 6” straight at the module end so long as the mainline is on the straight track.

SIDING AND SPUR TRACKS

Both rails to all siding and spur tracks must be gapped from the main track rails, for full electrical isolation to ensure main track current detectors are not affected by trains on side tracks.

CASCADE MODULES (MODULAR SIGNAL SYSTEM)

A Cascade module in the Modular Signal System is used to define the ends of two signal blocks; i.e. it is where one signal block stops and the next one begins. Both rails must be gapped at the signal block separation point, to fully electrically isolate the current detectors on the two blocks. Refer to section **5.4 OCCUPANCY BUS** for more information.

CLEARANCES

All clearances (curves, tunnels, structures, etc.) must meet NMRA standards.

Note: potentially every type of rolling stock will run over all modules; clearances must accommodate the tallest double stack, longest piggyback flat, prototypically articulated steam engine, etc.

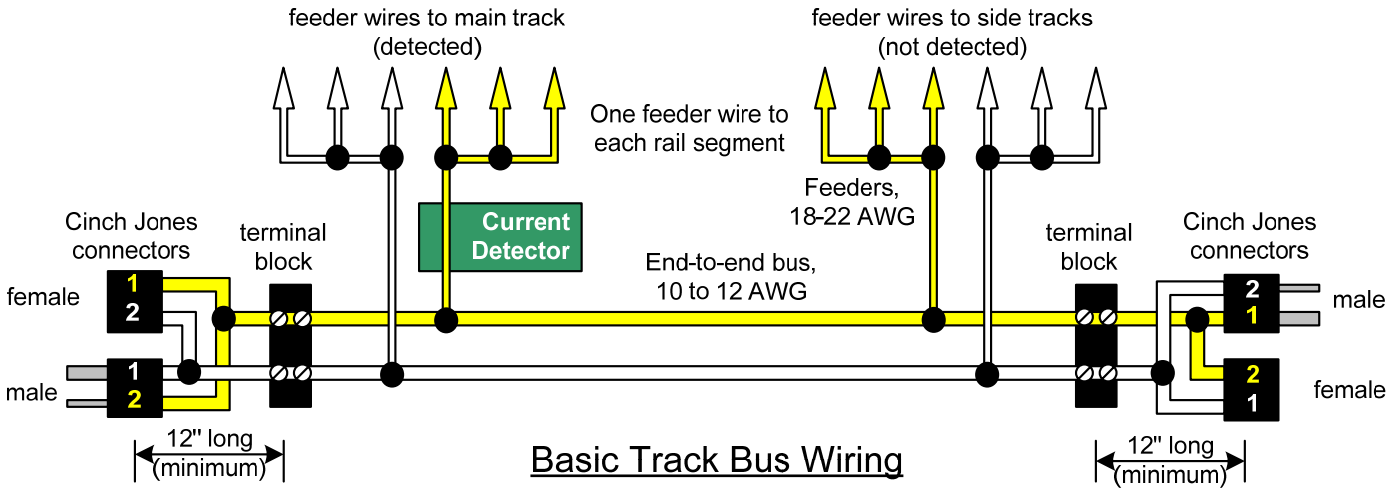
5.0 Electrical

Four simple electrical "busses" run through each module and connect them together. Power to the track is routed over the Track Power bus, layout control is routed over the DCC LocoNet bus, power for accessories is routed over the Accessory bus, and track occupancy information is routed over the Occupancy bus. Each bus uses a unique connector style to prevent accidental misconnection from one module to the next.

Suggestions:

- Tie all wiring to module frame to prevent damage during transport and setup, especially near endplates where C-clamping occurs.
- Construct wiring to be "modular" for easy debugging and repair; i.e. use terminal blocks, connectors, etc. wherever possible.

5.1 TRACK POWER BUS



Basic Track Bus Wiring

The track bus is a two-wire track power daisy chain bus that jumpers the mainline track power from one module to the next. It has two Cinch "jones" connectors at each end of each module. The two connectors form a male and female pair, cross-wired to allow a module to be rotated (reversed) and still maintain correct track polarity; these pairs are commonly called "pigtails".

The "pigtails" must be 12" long minimum and terminate within 6" of module endplates. Use 12-16 AWG stranded wire.

These connectors are available at several large electronic supply companies (but not Digikey or Radio Shack). For example, one source is Mouser Electronics (www.mouser.com), where the two contact connectors can be found by searching on **JONES PLUGS / SOCKETS SERIES 300**.

These connectors are left disconnected where an electrical gap between DCC power districts is desired (insulated rail joiners must also be used at one end of the 2" fitter rails to avoid shorting one power district to the next).

See the sketch above. Note the male and female connectors are wired differently at either end of the module. It is recommended to define "directions" for a module, i.e. North/East/South/West, to use as orientation keys during wiring.

> NOTE: One good way to verify the pigtails are correct is: when facing the module endplate the male connector's pin 1 (the large blade) and the female connector's pin 2 (small receptacle) must both connect to the left-hand rail.

It is good practice to install a terminal block at each end of the module; tie the internal track bus wires to one side and the connector pigtails to the other side.

It is required to install a continuous, 10-12 AWG "end-to-end" track bus wire pair between the two connector pigtails. Use 18-22 AWG feeder wires to supply power to the rails, with one feeder to each segment of rail. This method allows the bus to carry high currents throughout the layout with minimal voltage drop, and avoids relying on rail joiners to carry power from one rail segment to the next.

Track Wiring to Support Current Detection

Refer to section **5.4 OCCUPANCY BUS** for more information.

As part of the Modular Signal System adopted by NorCalF, all modules must have current detection on their main track(s) and no detection on siding or spur tracks. This requirement affects Track Bus and rail feeder wiring as follows:

Only one rail of each main track must have current detection. Do not place current detectors on both rails.

Structure rail feeder taps from the Track Bus so that all current to the main track rail passes through a current detector, and no current to side track rails passes through the current detector.

When multiple feeders to the main track rail are necessary, create a separate internal bus wire that is first passed through the current detector from the Track Bus, and then fans out to the multiple connections to the main track rail.

Cross-over modules require at least one current detector, for detecting the full length of the main track on the module. Cascade modules require at least two current detectors, one on each side of the signal block boundary (where both main rails are gapped).

For double main track modules, provide a way to easily select which track is detected. Possible solutions include a heavy-duty DPDT switch, or internal swappable connectors that select which rail feeders pass through the detector(s).

5.2 DIGITRAX DCC AND LOCONET BUS

NMRA compatible digital command control (DCC) is used for layout control providing maximum operational flexibility and realism with a minimum of inter-module wiring. The Digitrax system has been chosen due to its relatively low cost, rich feature set and simple, robust LocoNet system. NorCalF has developed a robust method to configure Digitrax DCC systems in Free-mo layouts, detailed in a separate document “NorCalF DCC Standard”.

The Digitrax LocoNet is required in all modules. The LocoNet is a 6-wire network that carries control commands among the various Digitrax DCC system components (command station, radio receivers, tethered throttles, remote boosters).

Each module must have a single 6-wire "RJ12" jack mounted on the underside, within 6" of each endplate, for connection of LocoNet jumper cables between modules forming a continuous network throughout the Free-mo layout.

> Suggestion: mount a female-female straight-through-wired RJ12 coupler inside each endplate of the module, attached with either glue or Velcro.

Modules four feet or longer must have at least one LocoNet throttle panel on each operator-accessible side of the module for operators to plug in walk around DCC throttles. DCC throttles use the RJ12 phone clip-plug style connector. Experience at many setups has shown there can never be too many panels.

> NOTE: While NorCalF has used commercially available wall-mount style phone panels in the past, DCC-specific throttle panels are now recommended for robustness and ease of system debugging. Digitrax and Tony’s Train Exchange make DCC-specific throttle panels; these allow fully modular LocoNet wiring (e.g. clip-plugs crimped on RJ12 cable).

Wire all RJ12 jacks in a series "daisy-chain" fashion to minimize branches in the LocoNet network. Make sure all LocoNet cables are wired “straight through”.

> WARNING: commercially available prefabricated telephone cables or cords cannot be used because they are not wired straight through!

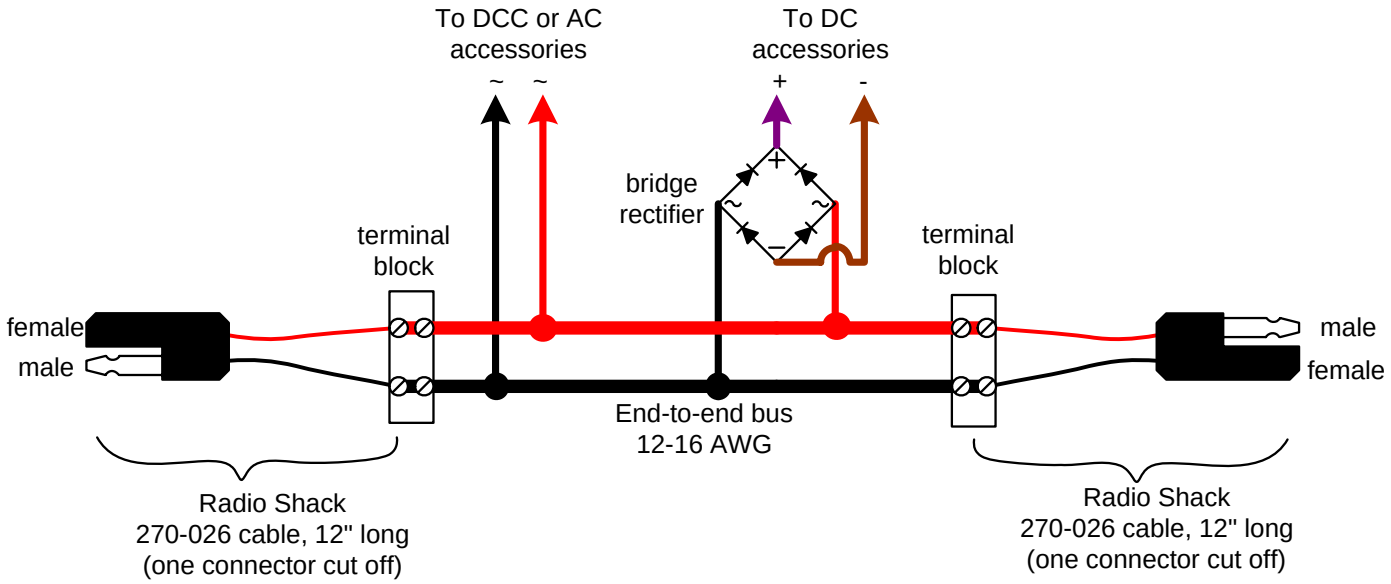
Do not rob track power for throttle panel lighting or supplementing LocoNet power. Use the Accessory Bus with the appropriate AC to DC rectifier (described in section **5.3 ACCESSORY BUS** below) or a stand-alone power source.

Suggestions:

- Add strain relief and service loops to the wires near their connections to the throttle panels and barrier strips.
- Spend a bit more money and make everything modular for easier debug and repair.

Interconnection of modules is made with 24" lengths of RJ12 6-conductor jacketed phone cable with 6-position clip-plugs installed at both ends. Install the clip-plugs so all wires run "straight through", i.e. pin 1 to pin 1, pin 2 to pin 2, etc.

5.3 ACCESSORY BUS



This two-wire bus is used to power turnout motors that control track switches (i.e. Circuitron Tortoises), and other accessories on modules such as signal circuits, structure lighting, animation, and so forth.

The Accessory Bus normally carries DCC, similar to that found on the Track Power bus, and usually powered by a dedicated DCC booster. The booster may be synced to the Track Power DCC boosters as needed by the specific Free-mo layout. Alternately, the Accessory Bus may carry 14-16V AC.

Electrical accessories within modules may use the DCC power directly (e.g. to control and power stationary decoders), or rectify and regulate it to DC (e.g. to power lights or electronics). If 14-16V AC is on this bus it may be used directly or may be rectified and regulated to DC as well.

> Suggestion: Use a bridge rectifier such as Radio Shack's 276-1146.

Accessory Bus is required in all modules. Use a 12-16 AWG two-wire bus running the length the module, and connector pigtails on each end to connect to adjacent modules.

The pigtail connectors are "automotive DC accessory cable" connectors (sometimes called “trailer plugs”). These connectors are available as pre-assembled cables from Radio Shack, part number 270-026 (2-conductor automotive DC accessory cable). This cable has two wires, one red and one black, with connectors at both ends, each of which has one male pin and one female pin. The "pigtails" must be 12" long minimum and terminate within 6" of module endplates. Therefore two 270-026 cables are required for each module, one at each end. Cut off one connector from each cable; attach the loose wires to the module’s internal bus.

> Suggestion: Use terminal blocks at the module ends; connect the internal 2-wire bus on one side and the pigtail connector on the other side. One 4-position terminal block may be used for both Accessory and Track bus pigtails (see above).

The red wires on the two pigtails must be connected together, and the black wires must be connected together. There must not be a "cross wire" that shorts the red and black wires between the two pigtails on a module. This arrangement allows modules to be reversed without concern about shorting out the Accessory bus.

A typical pigtail for Track and Accessory busses.

5.4 OCCUPANCY BUS

This bus is part of the Modular Signal System developed and adopted as standard practice by NorCalF. Additional documentation for this system is available outside of this document.

The Occupancy Bus carries main track occupancy status among modules for the purpose of animating trackside signals in a realistic sequence as trains move over the layout. Though it is not required by Free-mo standards, it is a required feature of NorCalF modules and is strongly encouraged in "visiting" modules included in NorCalF-organized layouts.

The bus is constructed from commercially available 8-conductor CAT5 "Ethernet" cables and 8-position RJ45 straight-through couplers. Two types of cables are used, depending on a module's role in the signal system and the specific implementation of the bus wiring within a module:

- **Cross-over cable** has a built-in wire pattern in which two wire pairs change pin positions from one end to the other, and the other two wire pairs connect straight through. NorCalF standard is yellow cable jacket.

- **Patch cable** wire pattern connects all 8 wires straight through from one end to the other. NorCalF standard is blue cable jacket.

All modules require two RJ45 straight through female-female couplers, one mounted inside each endplate (typically attached with either glue or Velcro). The module's internal bus cabling is plugged into one side of each coupler, while the other side of each coupler is left open (this is very similar to the DCC LocoNet is implemented).

The bus is connected across each module joint using a cross-over cable, minimum 2 feet long, plugged into the open side of each module's endplate RJ45 coupler. Therefore each module must provide one of these cables at NorCalF setups.

The internal implementation of this bus within a module depends on that module's role in the signal system, as follows:

- **Cross-over module** does not have trackside signals, and is part of the central portion of a signal block; this is the most common type. Its Occupancy Bus must have an odd number of cross-over wire patterns between its endplate RJ45 couplers (most cross-over modules have just one cross-over, implemented as a cross-over cable).

- **Cascade module** usually has trackside signals (though it is not absolutely required) and acts as the dividing point between two signal blocks (i.e. these modules define the ends of signal blocks). Its Occupancy Bus must have a special wire pattern called a "cascade", which requires custom wiring to implement (i.e. this wire pattern is not available in commercial CAT5 cables). The specific details of this wire pattern are described in separate documentation for the Modular Signal System. Cascade modules must not have any cross-over wire patterns between endplates; this implies the wiring is straight through between the "cascade" pattern and each endplate RJ45 coupler (patch cables are typically used).

  Suggestion: NorCalF's "Occupancy Bus Utility Board" implements the cascade pattern in a PC board.

All modules are required to have train detection circuits, which send the module's "local" main track occupancy status into the Occupancy Bus. Two types of detectors are used – current detectors and infrared (sometimes called 'optical') detectors. In general, current detectors are required in all modules, infrared detectors are required in Cascade modules and are optional in Cross-over modules.

> Suggestion: NorCalF has successfully used NCE BD20 current detectors in mainline modules, and CVP DCCOD current detectors in endpoint modules (e.g. yards, loops). For infrared/optical detectors, use Micromark IRDOT-1D board with an Optek OPB704W track-mounted sensor.

Refer to section **5.1 TRACK POWER BUS** regarding track wiring to support current detection.

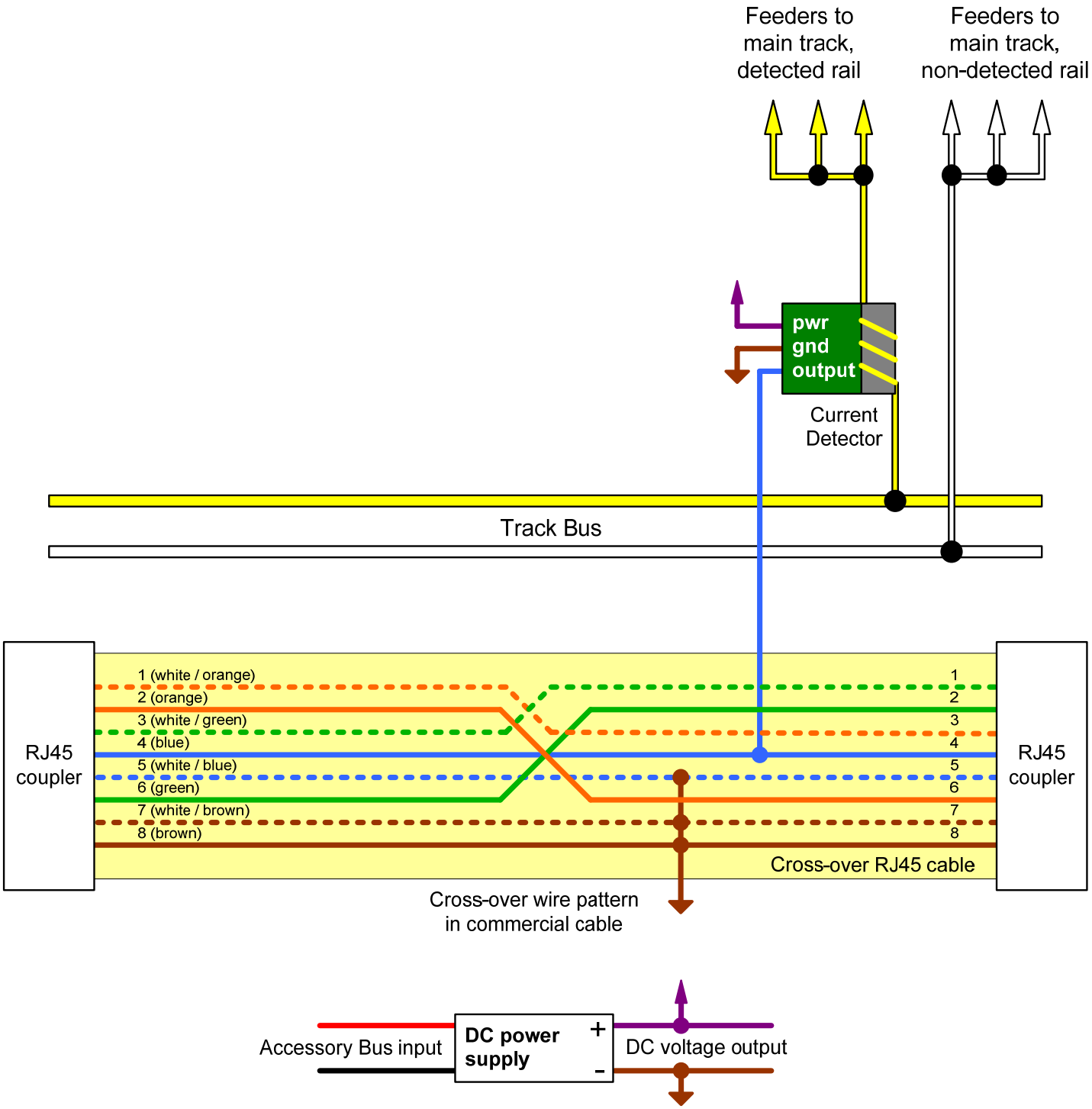
All detectors regardless of type must have open-collector, active low outputs. Each detector's output must connect to the blue wire (pin 4) in the Occupancy Bus within the module (the blue wire carries "local" occupancy status).

Each detector's ground reference must connect to the white/blue (pin 5), white/brown (pin 7), and brown wires (pin 8) in the Occupancy Bus within the module (these three wires carry a common ground reference throughout the signal system). The DC voltage source that powers any signal system electronics must also be grounded to these three wires.

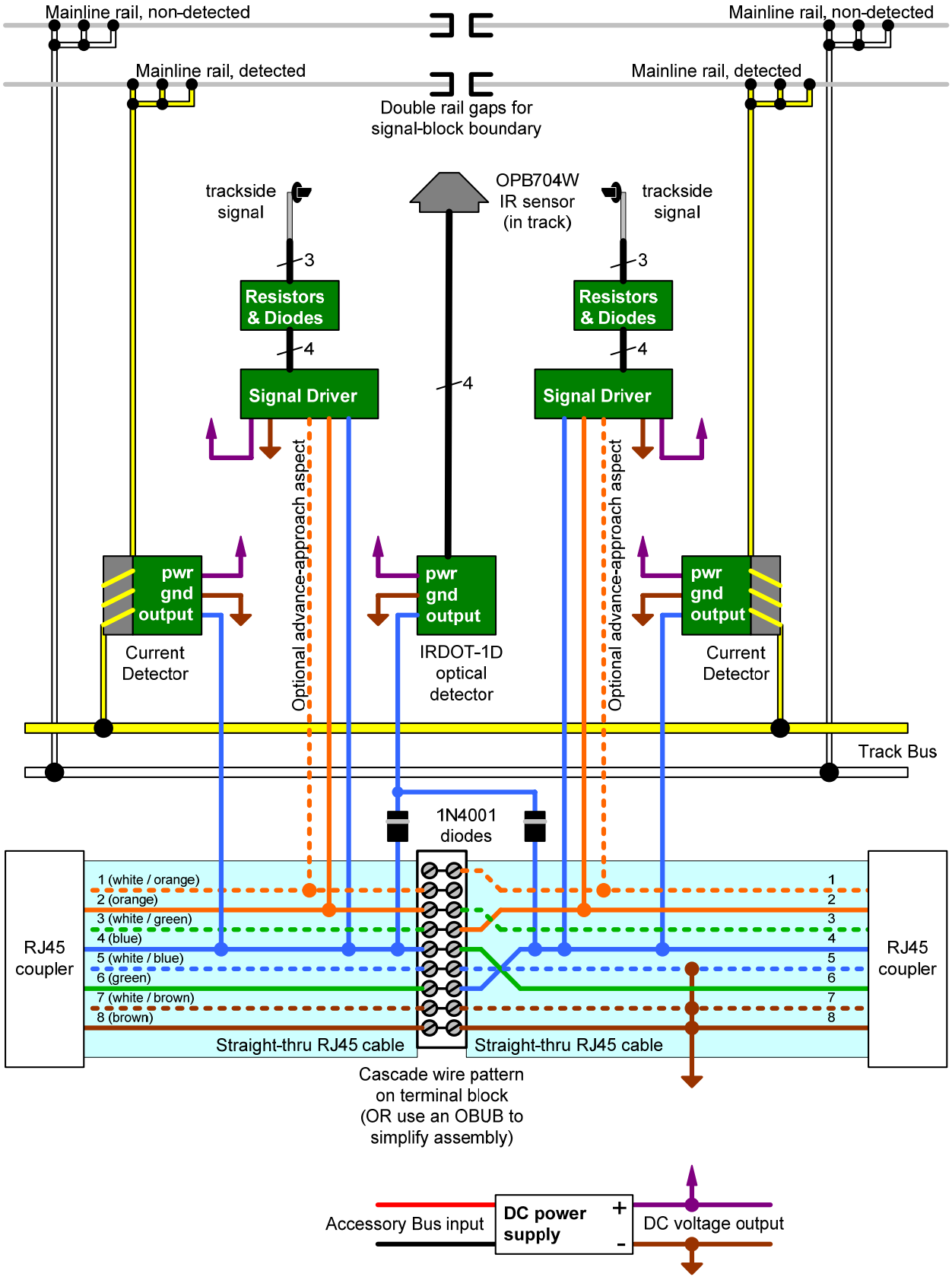
In Cascade modules, note there are two "blue" wires, one on either side of the cascade wire pattern. Take care to properly connect detector outputs to affect the appropriate signal block.

The following diagrams show generic Occupancy Bus implementations for both types of modules.

Modular Signal System
Generic Cross-over Module
Electronics and Wiring



Modular Signal System
Generic Cascade Module
Electronics and Wiring



6.0 Scenery

SCENERY STYLE, MATERIALS, TECHNIQUES

Scenery must depict realistic, commonly found rail-oriented scenes, with prototype locations preferred. Materials and techniques are free.

Scenery must allow hand-cleaning of all tracks using an abrasive block type cleaner.

Suggestion: use a generic "Northern California" scenic theme so NorCalF layouts look continuous and integrated.

MAINLINE BALLAST

Ballast size must be "fine" – use Arizona Rock & Mineral 130-2 “Northern Pacific Medium Gray Granite HO Fine”, or Woodland Scenics B1393 “Gray Blend Fine” (shaker bottle). Modules 12 feet or longer may use other ballast colors (to match a prototype locale, for example), but must gradually transition to the standard ballast at module ends.

END PROFILE AND LANDSCAPE

A flat horizontal scenery profile is used at module ends with scenic "ground level" at module ends nominally 3/8" below top of rails (see endplate sketches in section **3.0 Frame Work**). Landscaping along the module ends must be designed to smoothly flow into adjacent modules - avoid features such as roads, lakes, and so forth terminating along the module endplates (see INTER-MODULE JOINT TREATMENT, below). Rather, terminate such features along the module sides.

Suggestion: Using HO cork roadbed under mainline track to meet the 3/8" ground level guideline.

Note: scenic contours within a module are free between the flat end profiles (i.e. entire module does not have to be flat; in fact table-top flat modules are discouraged).

INTER-MODULE JOINT TREATMENT

Polyfiber covered with fine ground foam (i.e. Woodland Scenics "turf" material) to simulate undergrowth "thickets" may be temporarily placed over joints during a NorCalF setup, in random patterns, shapes, and colors. This technique hides the joints and transitions scenery from module to module. Polyfiber thickets must be placed clear of the track right-of-way.

BACKDROP

No backdrop is allowed as modules are viewed from either side and are also meant to be reversible.

7.0 Public Displays

SKIRTING

Both sides of all modules must have a skirt for use at public displays. Embossed vinyl sheeting, 54” size, brown color, treated with Antimony Oxide to meet NFPA 701 (Rev. 1989) and California Fire Marshall flammability test. Each end of skirt extends 2” past the module endplate to ensure adequate coverage and no “gaps” at module joints. Bottom edge of skirt is even with bottom of leg vertical member to prevent dragging on the floor regardless of the module height setting. Skirt attaches to inside of fascia or to underside edge of fascia (the extra height of the 54” skirting material is folded inward at top of skirt to be hidden behind skirt face). It is not permitted to simply thumbtack skirting to the outside surface of the fascia as this method has a sloppy appearance and defaces the fascia with pinholes.

A tutorial on making skirting with Velcro attachment is available on the NorCalF website.

Note: NorCalF has a limited supply of vinyl skirting material for general distribution to module owners.

CROWD CONTROL BARRIER SYSTEM

Each module that is 5’ or longer must provide two barrier stands for every 5’ of length. Barrier stands consist of bases and uprights designed for simple assembly and setup, and which may be disassembled for more efficient storage and transport. ¼” yellow nylon style ropes (available at any hardware store) are threaded through the stands as a barrier.

Stand bases are 12” square made from either 1” or 1.5” plywood (or equivalent multiple plywood layers). Painting is optional. A hole is centered in the base to accommodate a ½” white PVC pipe end cap, firmly wedged into the hole and used to receive the stand upright.

Stand uprights press-fit into the base and are 36” tall ½” white PVC pipe with a PVC “T-junction” mounted on top, through which the nylon rope is threaded. Painting is not allowed – leave uprights white.

PLEXIGLAS SHIELDS

Free, but must be easily removable for access to track for cleaning, uncoupling cars, etc.

8.0 Locomotives and Rolling Stock

WHEELS

- ❑ Metal
- ❑ Clean
- ❑ Back-to-back spacing meets NMRA gauge
- ❑ Gauge meets NMRA gauge
- ❑ Flange contours are RP-25 or have equivalent flange depth
- ❑ Semi-scale (.088") wheel treads are allowed

ROLLING QUALITY

- ❑ Cars roll freely down a 3% grade

TRUCKS

- ❑ Pivot freely
- ❑ Slight lateral rock on at least one end (three-point mount)
- ❑ Able to negotiate a #5 turnout
- ❑ Able to negotiate a 30" radius curve
- ❑ Able to negotiate vertical rail curves as specified in section **4.0 Track Work**

COUPLERS

- ❑ Kadee #5 or #58; no substitute brands allowed as they all have one problem or another
- ❑ Match to center of Kadee coupler height gauge or NMRA Standards Gauge, plus or minus 1/32"
- ❑ Knuckle and centering springs work freely
- ❑ Free of flash
- ❑ Metal couplers are insulated from the rail
- ❑ Trip pins clear Kadee coupler height gauge or equivalent
  OPTIONAL: coupler trip pins may be cut off at the bottom of the coupler body

WEIGHT

- ❑ Weighted to within +10%, -5% of NMRA specification (1 oz + ½ oz for each inch of car length:

car length (scale ft)	NMRA weight (oz)
30	3.1
35	3.4
40	3.8
45	4.1
50	4.4
55	4.8
60	5.1
65	5.5
70	5.8
75	6.2
80	6.5
85	6.9
90	7.2

NOTE: Cars operated only in unit trains may be weighted less or more than specified.
Such cars may not be operated in other trains.

ELECTRONICS

- ❑ Locomotives equipped with DCC decoders compatible with NMRA DCC compliant systems.
- ❑ Locomotives use 4-digit address—address is locomotive road number.
- ❑ Analog conversion (DC operation) must be disabled to prevent runaways.
- ❑ Register decoder addresses (rolling stock and stationary) on the NorCalF Address List to avoid duplications.

9.0 Setup Checklist

REQUIRED ITEMS

In addition to the obvious items to bring to a Free-mo setup such as modules, legs, and rolling stock, the following items are required for each module:

- ❑ Minimum of two 2" fitter rails with one metal joiner and one insulating joiner, for each track crossing module joints. Additional fitter rails are always welcome. Bring additional fitter rails and joiners to connect any additional tracks that cross module joints (i.e. yard extension modules). Atlas makes a metal joiner that fits both code 83 and code 100 rail; these seem to work well for fitter rails as they can be pushed easily onto the module's permanent rail ends with a small screwdriver. Atlas also makes code 83 insulated clear-plastic joiners, which are recommended.
- ❑ Minimum of one large C clamp to hold module ends together. Deep-throated clamps are best.
- ❑ Minimum of one 24" six conductor phone cable with RJ12 clip plugs on both ends, wired straight through, to connect the Digitrax DCC LocoNet across module joints.
- ❑ Minimum of one 24-36” CAT5 ”Ethernet” cross-over cable to connect the Occupancy bus across module joints.
- ❑ Minimum of one set of polyfiber/ground foam "thickets" to cover one inter-module joint on both sides of main line.
- ❑ Skirting for all viewable module sides, when required by the Run Chief.
- ❑ Barrier stands and nylon ropes, when required by the Run Chief (two stands for every 5 feet of module length).

SUGGESTED ITEMS

Other items suggested to bring, but not required:

- ❑ AC power extension cords and outlet expanders or strips to extend wall power throughout the layout.
- ❑ Digitrax DCC throttles - the more throttles available, the more people can run trains at once.
- ❑ Digitrax DCC boosters – for multiple power blocks or emergency backup should one fail.
- ❑ FRS 14-channel radios – handy for operations in noisy show environments.
- ❑ Spare batteries and/or rechargers for throttles, radios, tools.
- ❑ Tools including rail cutters, files, wood glue, levels, wrenches, screwdrivers, tape measures, pliers, wire cutters and strippers, multi-meter, soldering iron, track gauge, track cleaner, etc. These help resolve problems that may crop up, and to repair minor damage that may occur while transporting modules.
- ❑ Model tools including coupler height gauge, wheel gauge, small screwdrivers, ACC and styrene glues, tweezers, files, etc. These help repair or adjust rolling stock and track to keep things running smoothly.
- ❑ Spare parts and scenic supplies for repairing trains and modules.
- ❑ Lamps or flashlights to inspect module undersides.
- ❑ Folding chair or stool.

10.0 Revision History

Revised 12/08: general update; added detection and occupancy information.

Revised 6/02: added double track standards, general update reflecting current construction methods.

Revised 12/00: added skirting and barrier requirements, general update, converted to PDF for web viewing/printing

Revised 8/29/00: added rolling stock section; clarified vertical curves, general update

Revised 8/7/00: updated sketches, tightened up spec of endplates, leg heights, track; added more suggestions for reliability

Revised 7/7/00: changed group name to Northern California Free-mo, minor text improvements

Revised 6/7/00: Added fascia labeling guidelines, revised Accessory bus to allow DCC, corrected fonts

Revised 11/10/99: improved sketches, minor text changes

Revised 5/2/99: added Accessory Power bus; updated DCC info; enlarged min radius to 42"; replaced Timescape paint with Great Desert

Revised 10/6/98: added DCC and setup guidelines

Revised 9/30/98: general update; added scenery guidelines; changed sketches to Visio

Revised 5/4/98: general update