Digitrax Transponding with BDL168 & RX4 Application Note

Transponding allows a model railroad control system to automatically identify, track and interrogate any transponder equipped device on the layout. Transponders continuously send transponder pulses when addressed in the system, so the transponder detectors installed on the layout constantly track the transponder and feeds back its transponder zone location to the system.

Transponding is not required for signaling. To set up signaling, regular occupancy detection sections are used to sense any current draw from motors, lights, decoders, transponders and resistor wheel sets. The BDL168 incorporates 16 DC occupancy detection sections that operate independently of transponding. DC occupancy detection is the basis for setting up a signal system and for occupancy display on CTC panels. BDL168's 16 occupancy detection sections will work on either DCC or DC tracks.

In the case of model railroad transponding, the interrogation "pulse" is the recognition of a command sent to a specific transponder's address resulting in encoded current pulses being sent back through the track for detection by the system. The detection of responses from a specific transponder address lets the system determine the transponder's location in a transponder detection zone and the transponder's operational state. Digitrax uses the term **zone** to describe the area of the layout instrumented for transponding. This is different from other types of detection that are employed at the same time. For example, occupancy detection sections are a different type of detection area of a layout.

Note: Throughout this document we will discuss hooking up various versions of Digitrax BDLs. The BDL16 came first, followed by the BDL162 then the BDL168. Where there are differences in operation, they are noted in the text. As a convenience, we have used BDL168 everywhere there is no difference in operation. The following table details the history of the BDL board series.

Version	Ship Date	MSRP	#RX4s supported	Supersonic Decoders	Notes
BDL16	02/2001	125.00	1	NO	
BDL16 to BDL162 Upgrade	06/2002	9.99	n/a	n/a	Customer plug in modification No Longer Available
BDL162	06/2002	125.00	1	NO	Added Operations Mode Read Back Added Timing Adjustment
BDL162 to BDL168 Exchange Program	06/2004	Working BDL162 + $20	n/a	n/a	Exchange Program No Longer Available
BDL168	06/2004	145.00	2	YES	Complete Board Re-design

Technically Speaking:

Digitrax transponding uses multiple bursts of low-current pulses that create numerous detectable voltage pulses that are sensed by transponder detectors. A transponding burst may include from 12 to 30 or more pulses. The transponder detectors, located in transponder zones on the layout, filter and measure the pulses received from the transponders as they move from zone to zone to ensure the accuracy and validity of the pulses received. The transponder detectors decode the meaning of the pulses to generate location and state information about each individual transponder. Digitrax transponder current pulses are synchronized to preset timing points of the track voltages and can be used on almost any digital command control systems including Marklin AC Digital, FMZ, DCC, etc. With DCC, the transponder system is capable of sending at least 2 data bits per track cycle for the whole data packet duration, so there is a large amount of data bandwidth available for future expansion of Digitrax transponding.

Transponder information is reported to LocoNet as follows:

1. A transponder detector, like an RX4 plugged in to a BDL168, wired to a layout reports with LocoNet <D0> six byte op codes.
2. A following value of <20> indicates positive detection and tracking of a valid transponder address.
3. A value of <00> indicates that the transponder is no longer tracked by the system.
4. The next value encodes the zone number and is followed by the transponder address value. Since the transponder detector employs digital filtering & data tracking, if a transponder appears in another zone before a release message is sent, the release message can be suppressed since a positive ID has occurred in another transponding zone. When metal wheels bridge adjacent zones, transponder detection will occur in both zones because the transponder is present in both zones at the same time.
5. Transponder detectors can track multiple transponders in each zone simultaneously. Wiring of RX4 transponder sensors is flexible and allows placement of individual RX1 sensors in the zone feed from the booster (upstream) or on the detection section outputs to the tracks (downstream). Detection sections can be removed from transponding coverage by re-threading back through the RX1 in the opposite direction and multiple wires can be detected by a single RX1 covering a zone.

What can I use Digitrax Transponding for on my layout?

Operations Mode Read-back (Mainline CV Read-back)

Transponding is most widely used on layouts to add the ability to read-back decoder CV values using Operations Mode Programming while the locomotive is on the layout. When running on a layout equipped with transponder detectors, the whole layout becomes an Ops Mode read-write programming track! Digitrax Series 3 and later decoders are able to take advantage of this feature. DT300, DT40x series & later throttles & Digitrax command stations already support this capability. Only transponders and transponder detectors need to be added to your layout for all of your Series 3 and later Digitrax decoders to have this ability.

Rolling Stock Identification and Tracking

1. Transponders continuously send transponder pulses when addressed in the system, so the transponding system constantly tracks the transponder and feeds back its transponder zone location to the system. If any unit in a train is transponder equipped, the entire train is tracked as it moves around the layout from zone to zone. If the caboose or other end-car is also transponder equipped, the system will know when the last car has exited a transponder zone. This is useful to determine if a train had become uncoupled and left some cars behind.

2. Transponder detectors, like an RX4 hosted on a BDL168, transmit the decoder identification and transponding zone information on LocoNet. This makes it visible to all devices, such as DT40x series throttles which are capable of using a FIND command to locate a transponder and display its zone location, computers displaying track plans and transponder locations and other LocoNet devices as well.

3. If all rolling stock on the layout were equipped with transponders, the system could track all rolling stock. That would be an expensive proposition. A better compromise is to equip groups of rolling stock that are usually run together with a transponder.

4. Transponding is useful for hidden staging yards and remote dispatching. With transponding installed, the dispatcher or yard-master can tell which tracks, siding or yard ladder a particular train occupies and then route it to the mainline, without actually seeing the train.

Layout Surround Sound System (SurroundTraxx)

1. Smaller scales like Z, N and HO do not have room inside the shells for the large speakers necessary for rich “sub-woofer” sounds. The rich, deep bass sounds of prototype steam and diesels are just not able to be replicated with a small speaker. Sound decoders have done a nice job with the directional high frequency sounds of locomotives but because of the limitations of physics, their realism is somewhat limited.

2. SurroundTraxx is a system built by SoundTraxx that uses a surround sound processor with multiple large under layout speakers and information from the transponding system on LocoNet to provide high quality low-frequency bass and sub-woofer sounds for more realistic sound effects for multiple locomotives on a layout. Since the surround sound processor has speed, location and other information such as bell and whistle functions for all locomotives, it can blend and spatially project the high frequency sounds for bells, whistles and other sound effects. Since each transponder is tracked by location and unique ID, it is possible for each of the blended sounds to be individually selected for the prototype you are running. For example you can choose either a 2-stroke or 4-stroke diesel and the particular type of air horn or steam whistle used by the loco you are running.

3. Automatic real time location information makes it easy to add sounds like squealing wheel flanges when the train goes through a curve or a particularly steep grade section.

Flexible Layout Automation

1. Many computer programs exist that can route and control a train on a layout automatically. This type of operation has limited flexibility for unforeseen occurrences like derailments, a person picking up and moving something on the layout, etc. Such software creates a timetable by entering information that would need to be manually edited if any physical changes occur on the layout. This type of automation can’t make changes dynamically as the operating session unfolds because it does not have a feedback mechanism to know which equipment is locate where on the layout. Any changes in synchronization or any discrepancy between the information entered in the timetable and what is actually happening on the

layout with regard to train ID or actual position can lead to unexpected results because the system can't update itself for those changes.
2. Transponding lets the system to accurately identify rolling stock and its location so software can be used to route units under positive control around occupied track sections or stop them safely if no alternate route is available. This allows fault detection, tolerance and recovery possibilities to be handled automatically by layout control software.
3. With a transponding equipped layout, fail-safe automation is possible.
4. Mixed-mode operation where a mixture of human controlled and computer controlled trains run at the same time is also possible with a transponding equipped layout because the software can dynamically adjust its operations.

Remote Layout Operation

Transponding makes remote dispatching and operation of layouts possible. Over the internet, a remote dispatcher can use transponding to have the system display the zone locations of specific transponding locomotives before changing routes and signals, and a remote engineer can move safely even if no live video feed from the train is available.

Layout Alarms
Transponding equipped decoders have a SuperFind alarm capability that can alert the system if a transponder equipped item has been placed on the layout and is not under control. The SuperFind logic automatically detects the new item's address and reports it to LocoNet. It is also possible to automatically detect a locomotive derailment when the persistent loss of transponding from the whole system is detected.

Arrival/Departure Annunciation Triggers

The identification of a particular train arriving at a pre-determined point allows actions associated with that event to be triggered. One example of this is playing a pre-recorded announcement that is matched to a particular passenger train as it approaches a particular platform. Since the system can correctly identify each train as it arrives or departs, the announcement made will match that train making the effect more realistic than simply making a generic arrival or departure announcement.

Automatic Hump/Classifying Yards
With transponding, bar coding, and Magnematic couplers or electric un-couplers hump yard operations, including the retarders and switch ladders of the classifying tracks, can be automated. Short detection sections, optical sensor or DME may be used to accurately control the position the switch engine to couple and uncouple rolling stock in the lead to the hump. The made-up trains can then be taken to staging or be moved onto the layout. This is an interesting automation possibility with large layouts since it takes a lot of effort to re-spot all the cars after an operating session, since they are often completely out of order after a real session! It also allows the cars to be sorted into a desired order for the next session to keep the yard switchers busy completing switch lists and operations. Of course this could also be set up to give an automated switch list for the next session that should match the actual layout order.

Using Transponding with Other Detection Technologies

1. Transponding, when used in combination with other detection technologies, can help achieve the goals of each individual layout. For example: DC occupancy detection sections can be used to report the presence of rolling stock without transponders and to drive a signaling system. Signaling does not require transponding and using transponding just to do simple signaling would be cost prohibitive. The addition of transponding does allow enhanced signal system capabilities such as whole-train automated stopping in front of red signals, without the "pushy-pusher" problem of many automated stopping systems.

2. Transponding is an "area" technology rather than a "point" detection technology. A sensible complement is to use more numerous short occupancy detection sections as triggers or "spotting" points while the transponder reports on a zone wide basis. For this reason it is preferable to have a ratio of more, less-expensive, detection sections per transponder zone. This is why the BDL168 supports 16 detection sections and 8 transponding zones.

3. The use of bar coding on rolling stock for specific point detection is another technology that complements transponding. The judicious placement of several bar code readers at strategic layout points allows for scanning of rolling stock as a train passes by. The advantage is that you don't need power pickups on the rolling stock for detection. You only need a simple, inexpensive bar code label on the numerous rolling stock items. Clearly, bar coding by itself is limited in that it cannot drive a signaling system, show the location of the train once it is past the detection point, feedback information about derailments, etc. These things are within the capabilities of transponding.

4. As you can see, a complete layout control system will use a variety of complementary technologies to sense, detect and report the location of equipment on the layout to make layout control more effective.

What's Next?

The following examples, based on our experience with installing detection and transponding on our own "Norcross Southern" layout, will show you some of what Digitrax Transponding has to offer for your layout. The Norcross Southern was dismantled in 2006 when Digitrax moved from Norcross, GA to Panama City, FL. The layout has not been rebuilt. Information about it is available as a Case Study on digitrax.com and in the Digitrax Big Book of DCC. The original layout was built with BDL162s but the text of this article has been changed to reflect the use of BDL168s.

All layouts, large and small, may benefit from using a combination of occupancy detection and/or Digitrax transponding depending on the operating plan for the layout.

The BDL168's wiring can support up to 16 occupancy detection sections and 8 transponding zones. It is ironic that any detection or transponding system requires so many wires, when "only 2 wires" are needed to control the trains! Any type of detection needs a lot of wiring no matter what type of control technology or sensor devices you use for your layout. At first it may seem complex, but wiring can be broken down into small steps that can be tested at each stage of installation to simplify the whole job and make it more manageable.

Digitrax Transponding Installation Tips

Introduction

1. **Planning**. Successful installation and operation of Digitrax BDL168s and RX4s requires careful **planning**. Before you begin the installation, **analyze** your railroad and determine how you want to use detection, transponding and signaling to improve your operations. BDL168 & RX4s can be used in many different ways to accomplish many different types of operation on your layout.

2. **Reserve enough physical space** around each BDL168 if you plan to add RX4 transponding receivers now or later.

3. **Clearly label** the terminal strip next to the BDL168 for the zone power, the track feeder wires and the auxiliary power. If you know where all the wires go, it is much simpler to de-bug problems that come up during the installation.

4. **Wiring.** Set up the wiring so that it is **easily accessible**. In the pictures and figures, note that the wiring connections to the BDL168, RX4, PM42, etc. have been made on drop down panels that keep the wiring **organized**, make it easy to work on, easy to see and analyze for de-bugging and easy to make changes when necessary.

5. **Terminology.** The terminology used here corresponds to the terms used in the instructions that came with your BDL168 & RX4. A glossary is provided at the end as a handy reference.

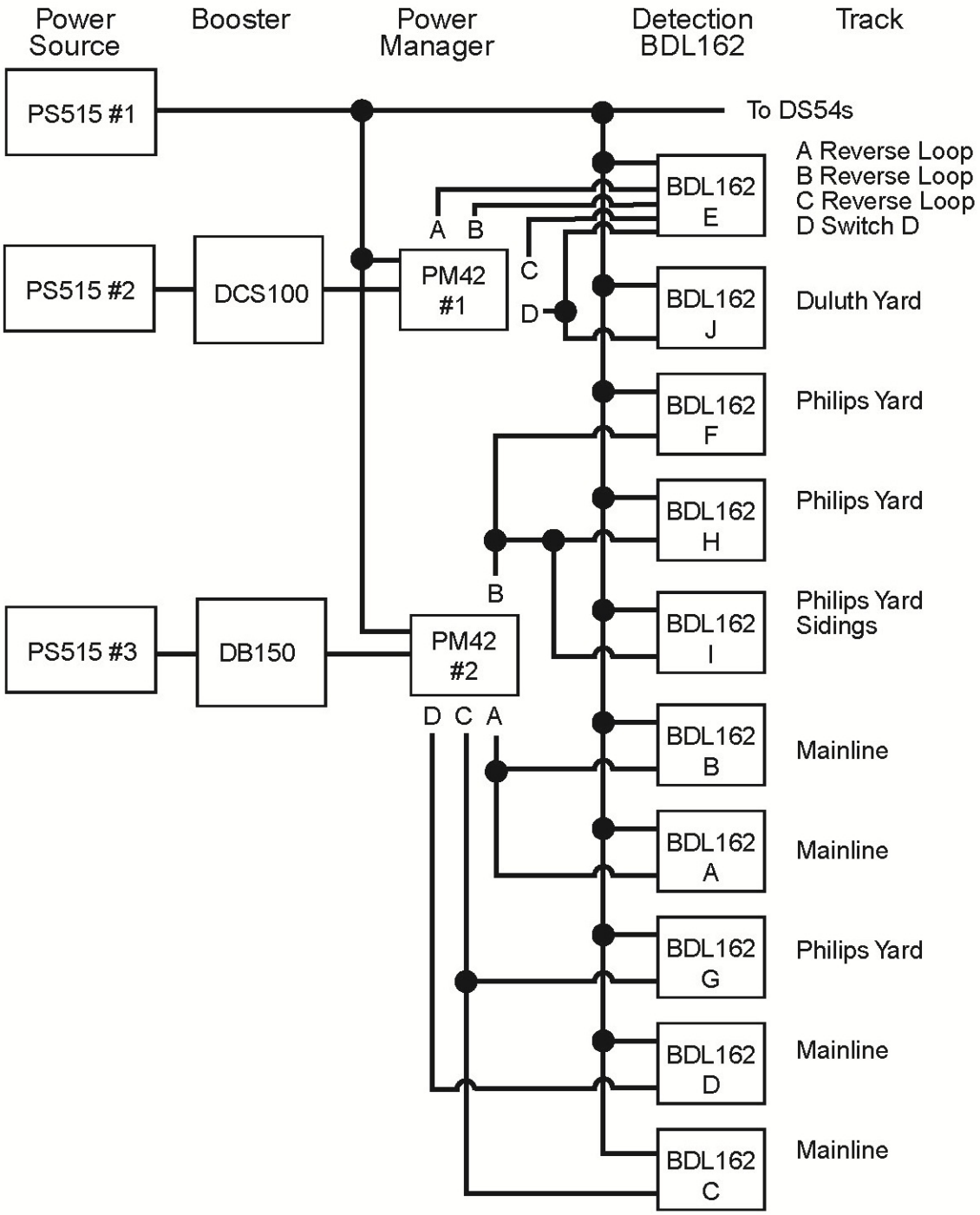
6. **Examples.** The examples below will help you understand these technologies and how to apply them to your layout.

The Norcross Southern (example layout)

The
is subdivided
into four sub-districts: three reversing sections and Duluth Yard. The other power district is run with another PS515 and a DB150 Booster. Another PM42 is used to subdivide the district into 4 sub-districts: 2 for Philips Yard and 2 for the Mainline.

Drawing Notes:
1. PS515 has been replaced by a new part number. Please use the power supply specified by the booster or command station you are using.
2. BDL162 has been replaced by BDL168.
3. DS54 has been replaced by DS64.

Figure 1: Power Distribution on the Norcross Southern



Planning is the Key

Before beginning the installation, determine exactly what you want the BDL168/RX4 installation to do for your layout. Here are some possibilities:

1. Do you want simple detection on some sidings, yard tracks or in signal blocks on the main-line? For this, you'll need basic detection section wiring, resistor wheels on rolling stock and auxiliary power to the BDL168.

2. Do you want to know which loco or piece of rolling stock is present in a section and use a computer for CTC and manual train operation? In this case, you'll need to install an RX4 with the BDL168 and transponding devices in your rolling stock. You could also include some mainline turnouts as protected detection sections, too.

3. Do you want some kind of layout automation? For this scenario, you must divide each signal block and establish short detection sections before each signal as a stop section. This will most likely double or even triple the required detection sections since "secure" turnouts must be included as protected detection sections in the areas where you plan automated operation. This type of wiring is challenging and can be very rewarding for layout operation but it is definitely not recommended for beginners. For the best chance of success with this type of installation, you'll need a detailed plan before you start, you'll need to stick to the plan until the installation is complete and you'll need to test each part of the installation before moving on to the next step.

No matter what kind of installation you decide to use, even with a good plan and careful execution, you will probably still have debugging to do before the system runs just the way you want it to. Practicing on small sections and breaking the task up into isolated sub-sections will make testing and de-bugging much simpler. Make sure each step of your plan works before moving on to the next step.

Location of Wiring Panel for BDL168 and other components

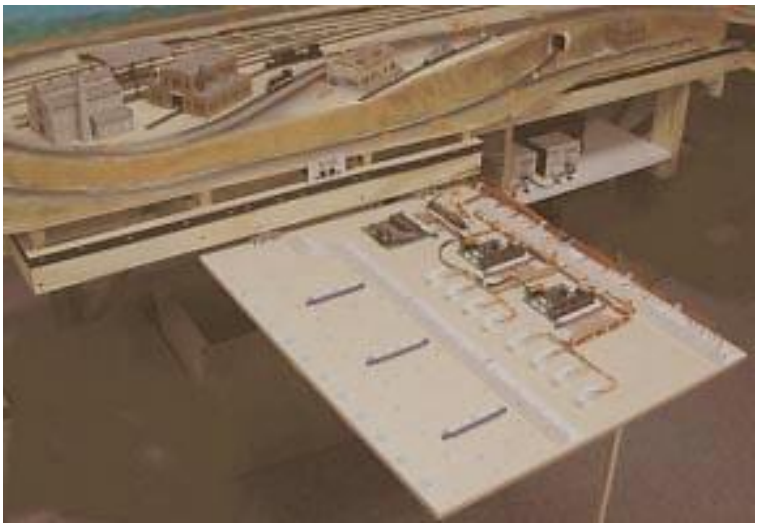
Planning the detection sections before cutting gaps in the rails is very important. We recommend that you use colored pins or other markers to mark detection sections, rail gaps and feeder locations on your layout. This lets you see your plan directly on the layout while allowing you to make changes by moving the appropriate pins while you are still in the planning phase.

The first step to determine the best location of the BDL168 & related wiring is to locate the detection sections, rail gaps & feeders needed to support the BDL168 on the layout. Do not cut gaps or install wires until you have completed the plan. On the Norcross Southern, we used a box of multicolored push pins to mark the location of each detection section as follows:

1. Mark all detection section single gaps with a yellow push pin on rail A.
2. Mark all detection section double gaps with a white push pin between the rails.
3. Mark all detection section feeder locations for the BDL168 on Rail A with 16 red push pins.
4. Mark common Rail B feeders with blue push pins.
5. Use orange dots to label the detection section.

Step back from the layout and look for the location with the highest feeder density. Locate your detection wiring panel for the BDL168, PM42, RX4s and related wiring near this area. Use a piece of plywood that is large enough to accommodate the installation of all the detection wiring for that location as a base.

On the Norcross Southern we made the detection wiring panels easily accessible as shown in the following photographs. The plywood board with all the wiring for each area of the layout is on hinges mounted just under the fascia. The wiring panels fold away under the layout during operation and they fold out like a table to make working on the wiring easy and comfortable. Your back will appreciate this approach unless of course, you feel comfortable soldering upside down while squeezed in an awkward horizontal position between the hard (cold) floor and your bench work!



Note for existing layouts:

If your layout is already wired and operational, it is important that you mark all existing gaps and feeders as explained above. Once the existing gaps are marked; then add the new ones you'll need for detection. You might need to make changes and it is very helpful to be able to see the overall configuration for the installation steps that follow.

Keep in mind that existing isolating rail joiners right at the end of the frog rail on a turnout are needed for some types of turnouts but they don't provide the clearance needed for a train if the turnout is a protected detection section. Isolating rail joiners are great if you put them at the right place but a nuisance if you have to move them later. It is much simpler to cut the gaps where needed when planning the detection sections. If you cut gaps, be sure to place non-conductive material in the cut so that the gaps cannot close up due to normal expansion and contraction of the rails during operation. Small pieces of plastic work well for making sure the gaps you cut don't close up.

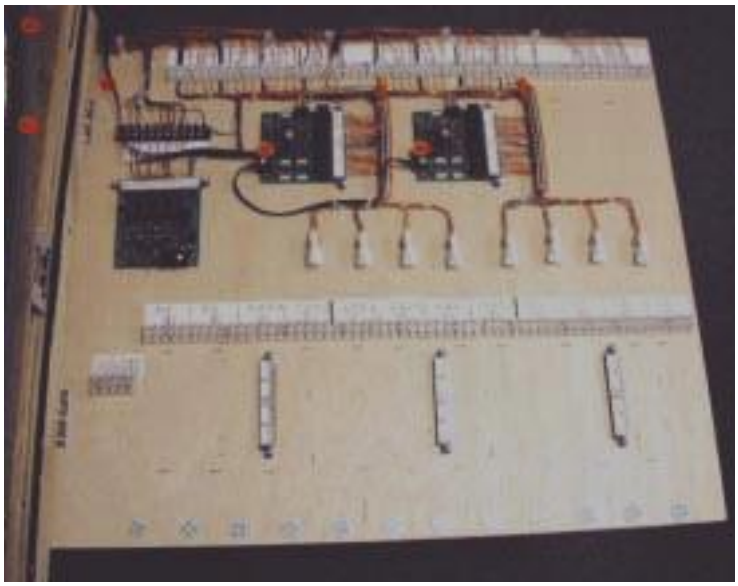
Detection Wiring Panels for PM42, BDL168 & RX4

Once you have decided where to locate the wiring panel, the next step is to plan the layout of the wiring panel itself. We strongly recommend that you use **clearly labeled** terminal strips for all electrical connections on the wiring panel as shown in the photo below. By clearly labeling all connections, you will make debug much easier.

One big advantage of this approach is that it lets you use your heavy track power bus wire from the booster (we recommend stranded 14 AWG) to terminate at the strip and use smaller (stranded or solid 18-22 AWG) to solder to the 44 pin board edge connectors that are provided with the BDL168 & PM42s.

We recommend using heavy wire for longer distances and finer wire for shorter distances. 18-22 AWG wire is good for distances up to 24 inches for example, between the terminal strips and the PM42, BDL168, RX4. Rail A (red) feeder wires (20 AWG) are good up to 16 feet for short detection sections that provide power to approximately 3 locomotives. For large detection sections and for common Rail B (black) stranded 18 AWG wires are recommended.

This photo shows the required spacing for the installation of one PM42, one BDL168 and one RX4. Each RX1 on your RX4 should be installed at least 2 inches from any other RX1. All RX1s should be installed in the same orientation relative to each other. Wires should be routed as shown to avoid interference that might cause problems with operation of detection. More information about spacing is presented later.



This photo shows an example wiring panel with one PM42, two BDL168s and two RX4s installed and labeled terminal strips on the upper half of the board.

The lower half of the board is laid out with labeled terminal strips, 3 board edge connectors for 3 additional BDL168s and three additional RX4s.

The location for each future RX1 is indicated by a double stick foam tape dots to hold the RX1 in place.

Staples indicate the planned routing of wires and will be used later to hold the wires in place with tie wraps.

By planning in advance we will have a neat and organized wiring panel that is easy to work on and troubleshoot.

If you are planning to use the RX4 transponder detectors, it is very important that you carefully follow the instructions concerning distances of components to other wires. RX1 sensors will not function properly if there is magnetic interference from any other zone wire that is too close or not properly shielded (as described later).

PM42, RX4 & BDL168 Installation on Wiring Panel

When all the feeder wires have been soldered to the appropriate place on the track and these wires are terminated at the terminal strip on the wiring panel, you can begin the installation of the PM42, BDL168 & RX4s you plan to use. First, install the PM42, then the RX4 and last the BDL168. If you are not using a particular component, then skip that step.

PM42 Installation

1. Install the 44 pin board edge connectors.
Use 90 degree angle mounting brackets or drill new holes into the mounting end of the connector as shown in this photo to attach the 44 pin board edge connectors to the plywood mounting board. Once the holes are drilled, you can screw the connector directly to the plywood wiring panel. Once the wiring installation is complete, you can add two screws with spacers to the pc-board mounting holes to keep it firmly in place. See photo at left.

For easier identification of the pins on the connector, use labels. Stick the label on top of the connector and mark all the pins according to the pin-out table in the PM42 Manual.

2. Solder the wires to the board edge connector

Note: Always remove the board from the connector when you solder wires to the connector. Do not use heavier wire than 18AWG on the board edge connector. Connect the heavy wire from the rail to the terminal strip only. For all connection shorter than 24”in lengths, 18-22 AWG wire is sufficient between the terminal strip, PM42 or BDL168.

a. Start by wiring the aux 12-16V AC or DC auxiliary power to the connector pin 3 + C.
b. Route the wires neatly along the staples to the auxiliary power terminal on the terminal strip.
c. Connect the booster track wires to the PM42 power sub-district. Please refer to the PM42 manual for the correct pins, ground connection and reversing loop setup.

There are example wire diagrams in the PM42 Manual that will help you to configure your PM42.

3. Plug the PM42 in to the edge connector.

RX4 Installation

1. Install the RX4.
Use double stick foam tape to secure the RX1s spaced 2 inches apart from each other. It is important that the RX1s are installed all in the same orientation with wires and imprint on the shrink-wrap facing the same direction.

2. Route the wires to avoid interference
Lay the ribbon wire along the staples to see that the connector reaches the plug on the BDL168; then fold the ribbon wire out of your way for now.

BDL168 Installation

1. Mount the board edge connectors you did for installing the PM42 above.
2. Label the connector for easy identification of the pins.
3. Route the ground and the AC aux power wires from the terminal strip to the pins on the board connector.
4. Solder each wire to the designated pin. Then connect the other end of the wire to the appropriate connector on the terminal strip.
5. Plug the BDL168 into the edge connector.
6. Plug the RX4 in to the BDL16’s AUX 2 pins.

If you are not using transponding, all instructions in regards to the RX4 can be omitted. You can use ***Figure 7a*** as an example. This figure shows the wiring for our **Example 1**.

BDL168 Hookup Worksheet

This is an example of an RX4/BDL168 Hookup Worksheet. Use this worksheet to organize your installation plans. Label the detection sections on the track and on the terminal strips. Download a blank copy of this worksheet from the BDL168 or RX4 product page on our web site www.digitrax.com.

RX4 / BDL168 Hookup Worksheet

BDL168 #_____Address:_____ Description:_____ Aux Power:_____

Standard BDL168 Configuration

Advanced Detection Section Wiring:

Transponding method_____

	Section	Pin #	Named Detection Section	Description	In	Out	Alternate Zone	Comments
ZONE A	Power In	1						
	1	2						
Power	2	3						
District	3	4						
	4	5						
ZONE B	Power In	6						
	5	7						
Power	6	8						
District	7	9						
	8	10						
ZONE C	Power In	13						
	9	14						
Power	10	15						
District	11	16						
	12	17						
ZONE D	Power In	18						
	13	19						
Power	14	20						
District	15	21						
	16	22						

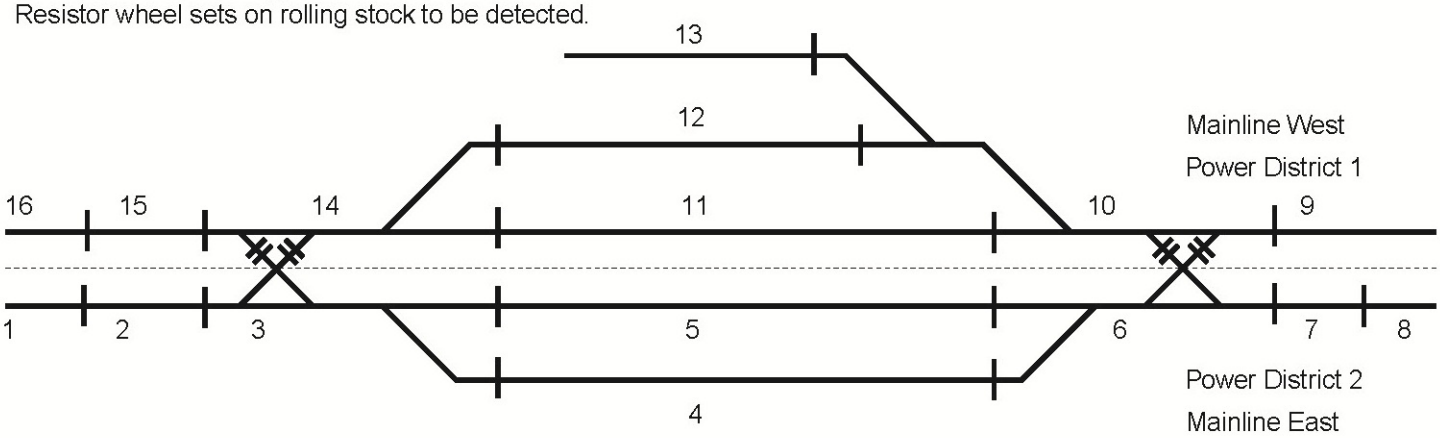
Example 1 covers basic occupancy detection. You'll just need to wire the detection sections you want to use to a BDL168 and add resistor wheel sets to any rolling stock you want to detect. In this case, the system will detect that something is in the detection sections. This occupancy detection can be used as the basis for a signaling system.

Example 1: Basic occupancy detection

When a detection section is occupied by a powered locomotive or any piece of rolling stock with resistor wheels the system will detect occupancy.

Components needed:

BDL162
Detection section wiring
Resistor wheel sets on rolling stock to be detected.



Single Gap Rail A within the Detection Section

Double Gap Rail A & Rail B only at Power District Boundaries

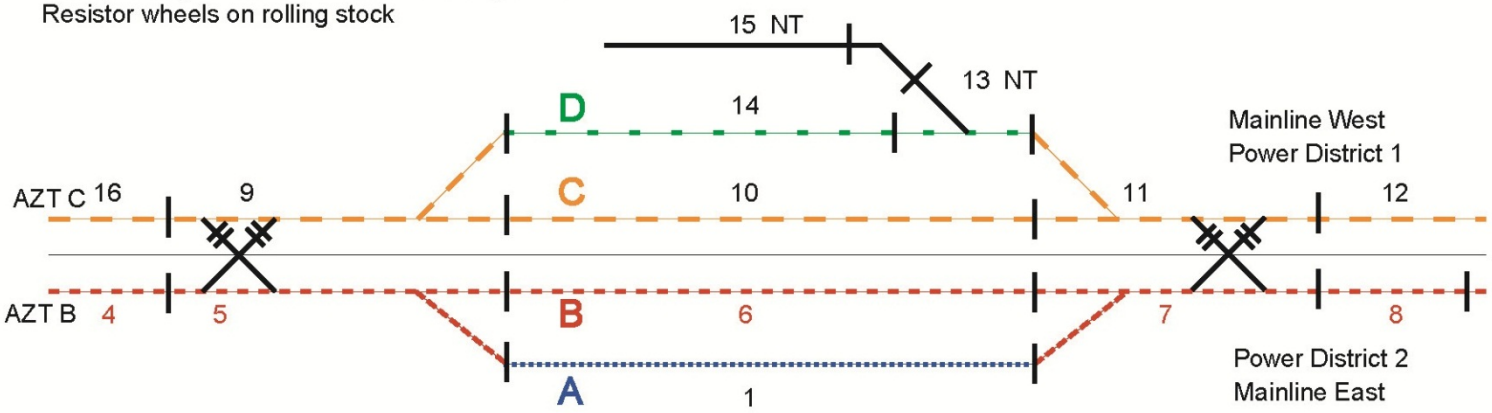
In this example, there are two power districts double gapped at the crossovers only.
All other gaps are single gaps on Rail A only.

Example 2 includes basic occupancy detection and 3 different types of transponding to give you occupancy detection and transponding for CTC with manual occupancy detection. Automated signals and limited automated train operation would be possible using this example.

Example 2: Zone, Sectional, & Alternate Sectional Transponding with Basic Occupancy Detection

Occupancy detection & transponding for CTC with manual occupancy detection
Automated signals & limited automated train operation possible.

Components Needed:
1 BDL162
1 RX4
Sectional, Zone and Alternate Zone Wiring & Set up
Transponding devices in locos &/or rolling stock
Resistor wheels on rolling stock



A = Sectional Transponding 1 = Sectional, 4 = Alternate Zone B, 2 & 3 Not Wired
B = Zone Transponding
C = Zone Transponding
D = Sectional Transponding 14 = Sectional, 13 & 15 Non Transponding. 16 = Alternate Zone C

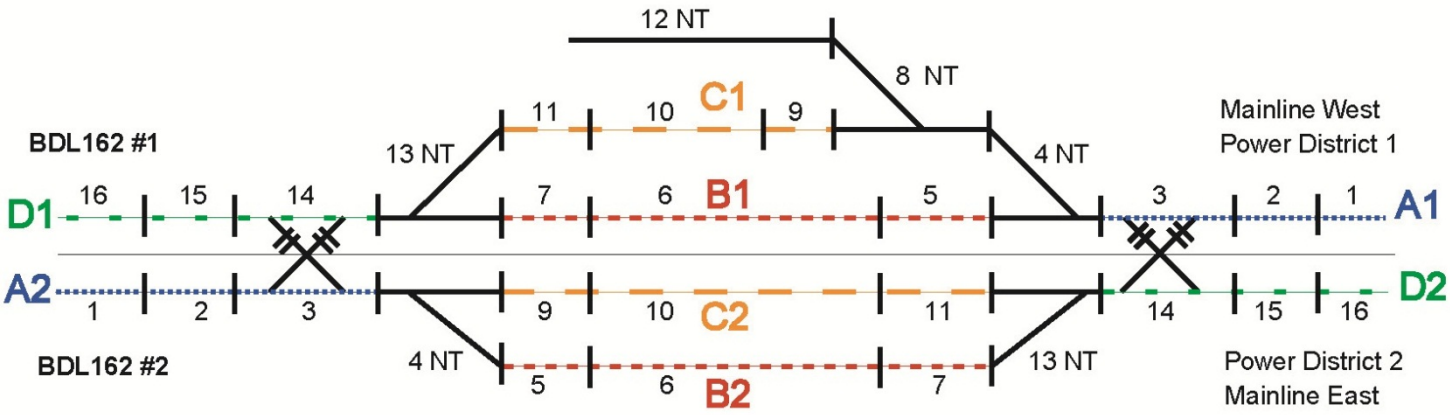
	Single Gap Rail A = Detection Section
//	Double Gap = Power District Separation
NT	Non Transponding Section
AZT	Alternate Zone Transponding

Example 3 shows how to set up detection & transponding for CTC and secure automated train operation. This example uses 2 BDL168s and 2 RX4s to do.

Example 3: Detection & Transponding for CTC and Secure Automated Train Operation

Components needed:
2 BDL162s
2 RX4s
Advanced wiring

Note: If the crossovers are right at the yard entrances, the crossover protection could be combined with the turnout protection section adjacent to it. This would add another detection section on each side of the yard and on both mainlines.



BDL162 #1 Power District I (Mainline West)
A1 = Sectional Transponding 1,2 & 3, Section 4 Non Transponding (Turnout Protection)
B1 = Sectional Transponding 5, 6 & 7, Section 8 Non Transponding (Turnout Protection)
C1 = Sectional Transponding 9, 10 & 11, Section 12 Non Transponding Siding
D1 = Sectional Transponding 14, 15, & 16, Section 13 Non Transponding (Turnout Protection)

BDL162 #2 Power District 2 (Mainline East)
A2 = Sectional Transponding 1,2 & 3, Section 4 Non Transponding (Turnout Protection)
B2 = Zone Transponding Section 8 Not Used
C2 = Zone Transponding Section 12 Not Used
D2 = Sectional Transponding 14, 15, & 16, Section 13 Non Transponding (Turnout Protection)

	Single Gap Rail A = Detection Section	NT	Non Transponding Section
//	Double Gap = Power District Separation	AZT	Alternate Zone Transponding

Standard BDL168 Occupancy Detection

To use the BDL168 for occupancy detection only (standard BDL168 configuration), you simply have to organize the power distribution for the zones. Group the detection sections on the layout for the desired BDL168 zone and update the gaps (remember the yellow pins) to white pins at the end of your detection section where another power district begins.

Advanced Transponding Configurations

For transponding, the BDL168 plus one RX4 can be wired in several different configurations depending on your goals. However it is important that you use the individual detection section from one zone in sequence as shown in Example 2.

A transponding message from a transponding device in one detection section will also show in another occupied detection section in the same zone even if it is just a boxcar with resistor wheels. So, be careful how you plan your detection sections when you use transponding so you don't detect a train in a siding that transponds to the same zone as a train on the mainline on another section but the same detection zone.

Figure 6 illustrates an one way you might use the BDL168/RX4 combination. This example is configured with flexibility to operate CTC with manual operated trains common during operating sessions as well as for completely automated train operation.
This is accomplished by using the following components: 1 PM42, two BDL168 and 2 RX4s totaling 32 detection sections

Upstream-Zone Transponding

Zone transponding means that all four detection sections within a zone are configured for transponding detection. In this case, the RX1 sensor is placed between the booster, or PM42 if there is one, and the BDL168. That means that the rail A track power for that zone on the BDL168 is feed through the RX1 sensor. See zone A in ***Figure 6***.

Downstream-Sectional Transponding

Sectional transponding means that only selected detection sections in each zone are used for transponding. This is accomplished by running only the track A feeder wires for the selected transponding detection section through the RX1. The remaining detection sections in that zone will only show occupancy. This is useful in yards and/or passenger stations where you want to know which train occupies a given track and all other detection sections are used to protect turnouts, which are important in a CTC environment. In this case, the RX1 sensor is placed between the BDL168 and the track. See zone B in ***Figure 6*** below.

Mixed-Alternate Zone Transponding

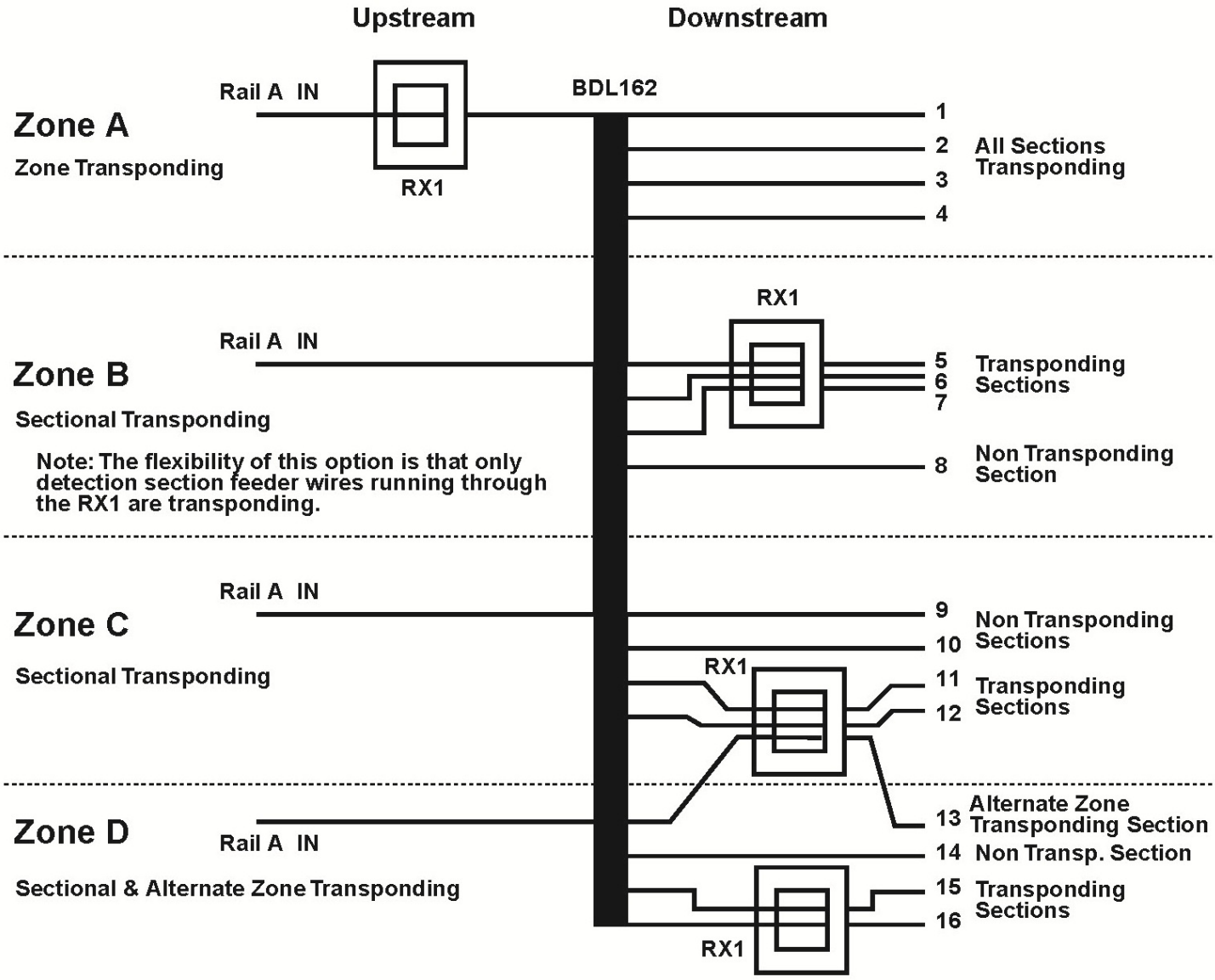
As shown in ***Figure 6*** below, there are extra detection sections in zone D and not enough in zone C.
In this case we can use the available detection section from another zone, providing that zone is configured as sectional transponding and the feeder wire has not been run through the RX1 of that zone.
Instead, use that feeder wire and run it through the alternate zone RX1 that could be configured as either zone transponding or sectional transponding.

Independent Transponding (transponding detection independent from occupancy detection)

Something must be there if it transponds! This is how a computer will see it. A computer can easily make use of all 16 detection sections plus the 4 transponding zones. This means that a BDL168 can actually detect 20 sections for a computer if wired this way. However, the drawback is that only a transponding device will trigger the transponding section. As a transponding train travels over a very short (4") independent transponding detection section at the throat of the yard, the computer will read the address and then track the assigned train name or number (if supported by software) to its final staging track and keep it in memory when the address is released from the throttle and the layout is turned off. A transponding device that is NOT selected (active) does not transpond.

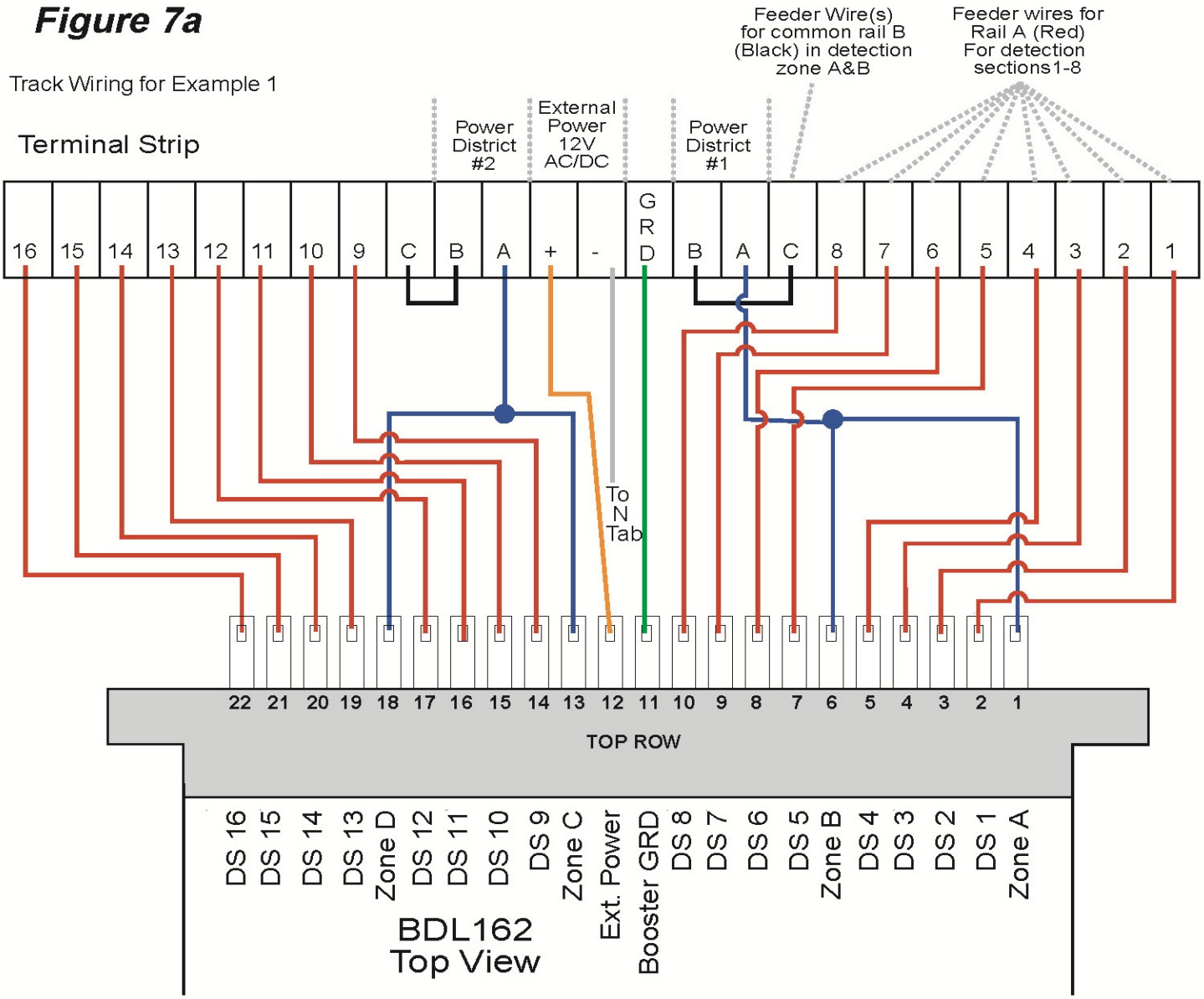
As shown in ***Figure 6***, sectional, zone and alternate zone transponding can be used on the same BDL168. Sectional and alternate zone transponding can be used in the same zone.

Figure 6
BDL162 & RX4 Wiring Options



Detection Section Wiring Following is the same track configuration as **Example 1** with the single gaps marked yellow (yellow push pins) and double gaps marked purple (white push-pins), as well as the color coded feeder wires for Rail A and Rail B from the terminal strip and for both power districts. For your layout, remember to use the colored pins for easy identification of all the necessary feeder-wires and gaps.

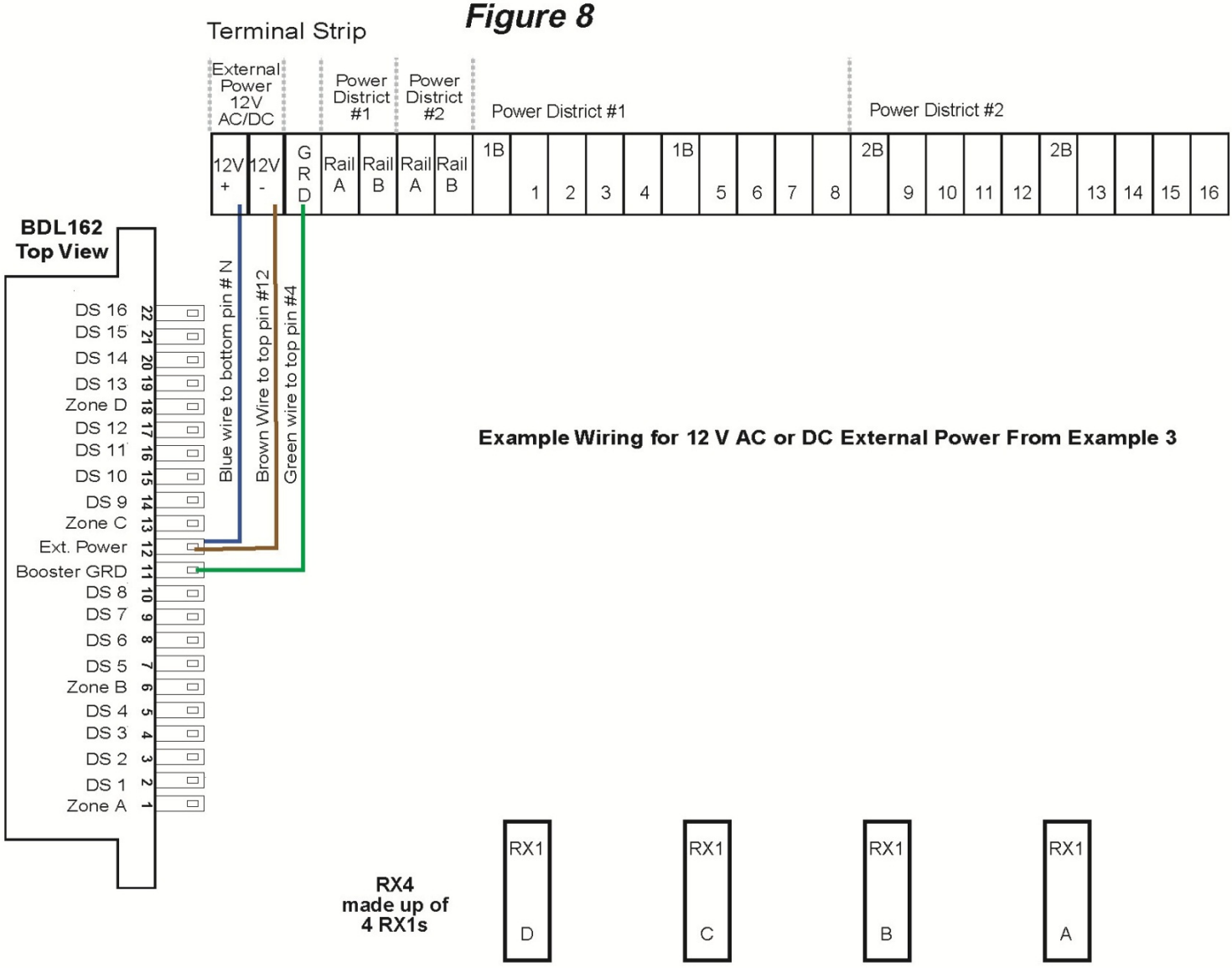
Figure 7a



Note:

All wires except for ground and auxiliary power input, should be soldered to **both** the upper & lower pins. This will increase the current rating of the input/output & provide stress relief for the pins versus individual pin solder connection. 18 - 22 AWG wire will fit through both solder tabs. Strip the wire about 1/4 inch & twist the leads, then insert it through both solder ears. This will hold the wire in place while you apply the solder. When soldering, make sure the solder flows on both solder tabs for a solid connection. To use BDL168's transponding capabilities, see Figure 8 below to add the necessary wiring and an RX4 Transponding sensor.

Figure 8


Terminal Strip
External Power 12V AC/DC
Power District #1
Power District #2
Power District #1
Power District #2
12V +
12V -
G R D
Rail A
Rail B
Rail A
Rail B
1B
1
2
3
4
1B
5
6
7
8
2B
9
10
11
12
2B
13
14
15
16
BDL162 Top View
DS 16
DS 15
DS 14
DS 13
Zone D
DS 12
DS 11
DS 10
DS 9
Zone C
Ext. Power
Booster GRD
DS 8
DS 7
DS 6
DS 5
Zone B
DS 4
DS 3
DS 2
DS 1
Zone A
22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
Blue wire to bottom pin # N
Brown Wire to top pin #12
Green wire to top pin #4
Example Wiring for 12 V AC or DC External Power From Example 3
RX4 made up of 4 RX1s
RX1 D
RX1 C
RX1 B
RX1 A

Install zone power wires

If you are using transponding, check your worksheet to determine the routing of the rail A track power wire for zone A.

If you configured zone A as zone detection

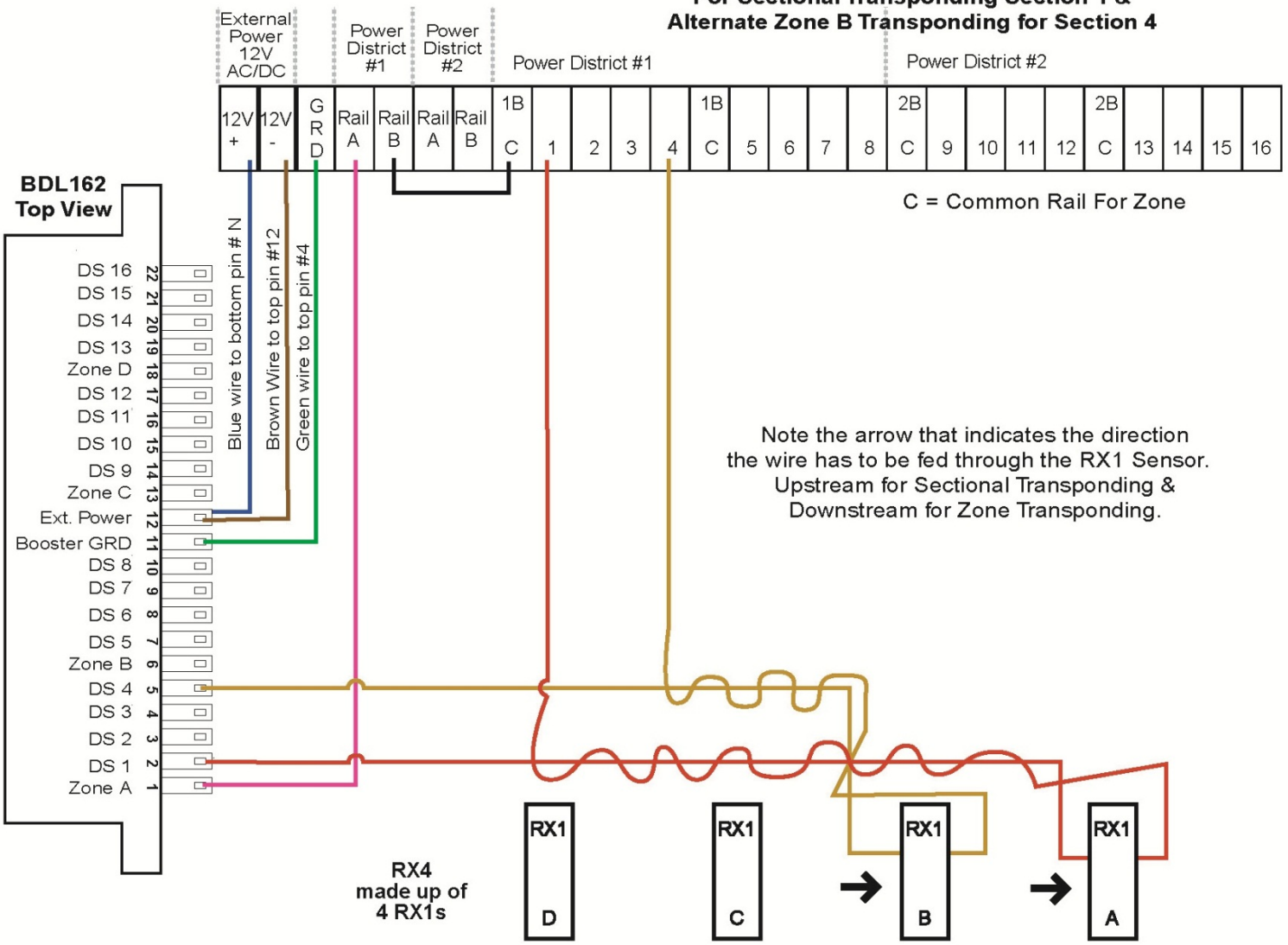
1. Mark the path you will use for routing the wire from the board edge connector through the hole in the RX1 and back to the terminal strip.
2. Solder the wire to the zone power pin on the board edge connector.
3. Pre-measure the wire by routing it along the path you will use to pass through the RX1 hole and back to the terminal strip. Add 1 or 2 inches and cut the wire. This will give you a manageable length of wire to work with.
4. Route the wire along the predetermined path and insert it through the hole in the RX1 going from the printed side of the RX1 to the blank side of the RX1.
5. Pull the wire through the RX1 loop it back.
6. As you route the wire back to the terminal strip , twist it loosely around itself as shown in Photo 8. This will help to avoid interference with other RX1 sensors.
7. Secure the wire to the board along the predetermined path with staples.
8. Attach the wire to the terminal strip.

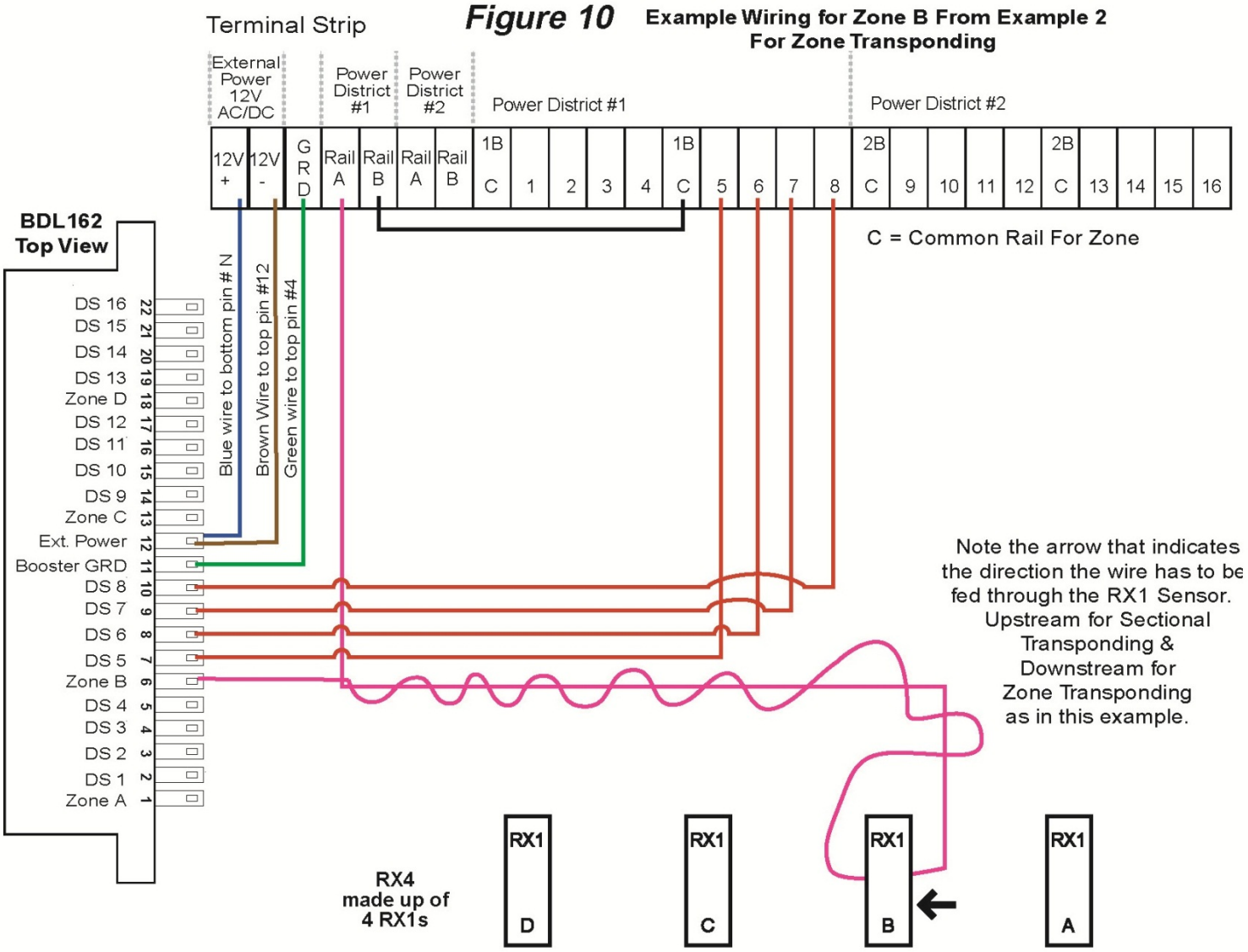
Install detection section wires

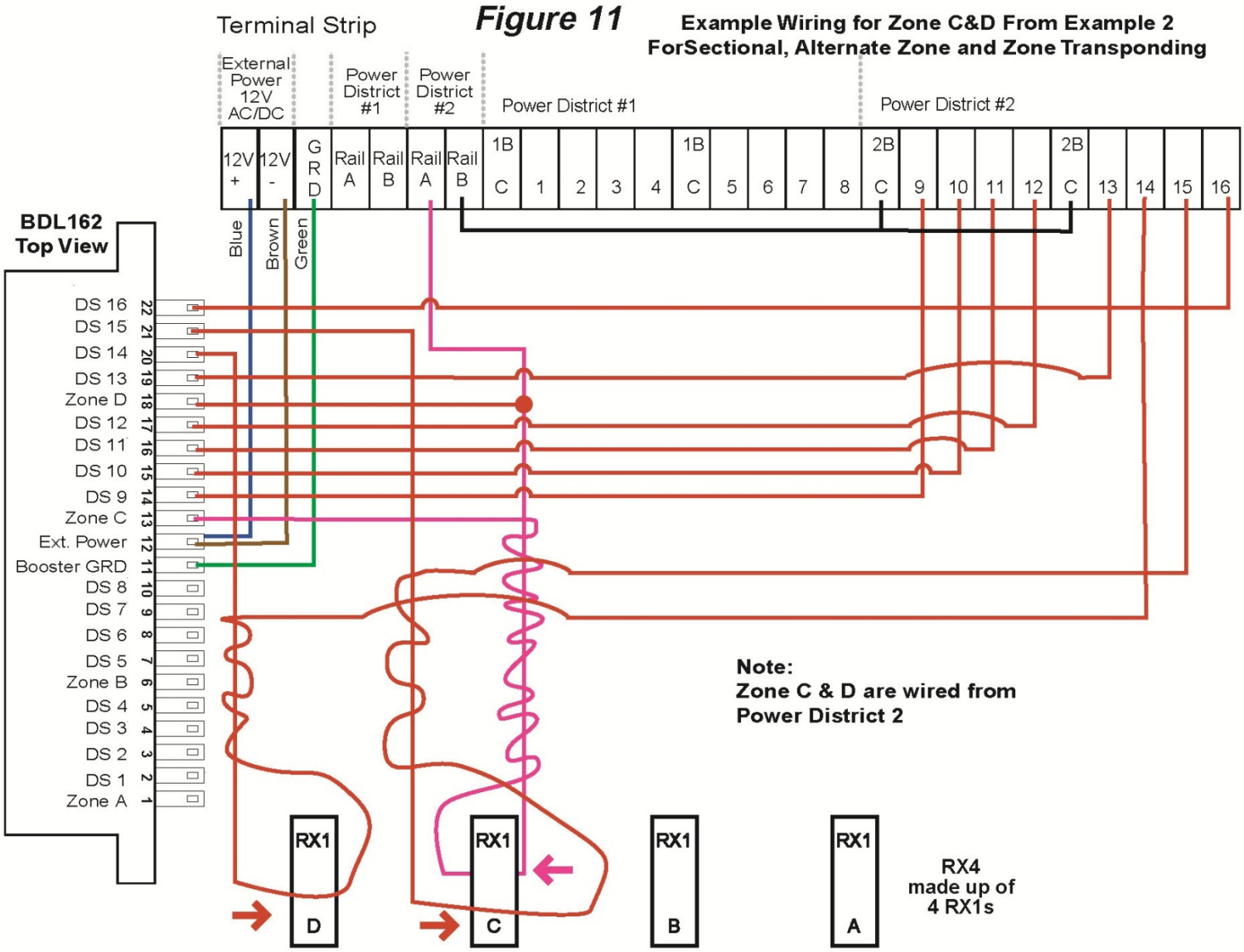
Depending on your requirements, use one of the following examples to wire zone in power wires and detection sections feeder wires.

Figure 9

Example Wiring for Zone A From Example 2 For Sectional Transponding Section 1 & Alternate Zone B Transponding for Section 4




Terminal Strip
Figure 10
Example Wiring for Zone B From Example 2
For Zone Transponding
External Power 12V AC/DC
Power District #1
Power District #2
Power District #1
Power District #2
12V +
12V -
G R D
Rail A
Rail B
Rail A
Rail B
1B C
1
2
3
4
1B C
5
6
7
8
2B C
9
10
11
12
2B C
13
14
15
16
C = Common Rail For Zone
BDL162
Top View
DS 16
DS 15
DS 14
DS 13
Zone D
DS 12
DS 11
DS 10
DS 9
Zone C
Ext. Power
Booster GRD
DS 8
DS 7
DS 6
DS 5
Zone B
DS 4
DS 3
DS 2
DS 1
Zone A
Blue wire to bottom pin # N
Brown Wire to top pin #12
Green wire to top pin #4
Note the arrow that indicates the direction the wire has to be fed through the RX1 Sensor. Upstream for Sectional Transponding & Downstream for Zone Transponding as in this example.
RX4
made up of
4 RX1s
RX1
D
RX1
C
RX1
B
RX1
A


Terminal Strip
Figure 11
Example Wiring for Zone C&D From Example 2
ForSectional, Alternate Zone and Zone Transponding
External Power 12V AC/DC
Power District #1
Power District #2
Power District #1
Power District #2
12V +
12V -
G R D
Rail A
Rail B
Rail A
Rail B
1B C
1
2
3
4
1B C
5
6
7
8
2B C
9
10
11
12
2B C
13
14
15
16
BDL162 Top View
Blue
Brown
Green
DS 16 22
DS 15 21
DS 14 20
DS 13 19
Zone D 18
DS 12 17
DS 11 16
DS 10 15
DS 9 14
Zone C 13
Ext. Power 12
Booster GRD 11
DS 8 10
DS 7 9
DS 6 8
DS 5 7
Zone B 6
DS 4 5
DS 3 4
DS 2 3
DS 1 2
Zone A 1
RX1
D
RX1
C
RX1
B
RX1
A
RX4
made up of
4 RX1s
Note:
Zone C & D are wired from
Power District 2

LocoNet Connection

Connect all components to LocoNet with **tested** LocoNet cables.
Note: To insure good LocoNet cables and trouble free operation, test every LocoNet cable with an LT1. Testing should always be done by plugging in to the command station's LocoNet port A with a throttle connected to port B. All 4 LEDs on the LT1should light up if the LocoNet cable is good. Also check to be sure that the white wire is on the same side of the plug on both ends of the cable. Bad cables or incorrect cable polarity are often found to be the culprit when problems arise.

BDL168 Setup

Once the layout wiring is done and the wiring panel is complete, it's time to power up the BDL168 and set it up.

Confirm LocoNet Connection

When power is applied to the BDL168, the green and red LEDs will come on for a short time. The red LED will go off and the green LED will "wink off" every 2 seconds.

Connect a throttle, select any address that is not programmed into any locomotive on the layout and change its speed, the red LocoNet indicator LED should blink with every LocoNet message sent. In normal operations the red "option" LED will blink ON briefly when valid LocoNet messages are seen confirming a good LocoNet network connection.

Set BDL16, BDL162 & BDL168 Option Switch (OpSw) Settings

OpSw11 & 12 should be closed on all LocoNet layouts. If you are using a new BDL16, this is already taken care of. If you are using a BL16 with a LocoNet Command Control System such as Digitrax or Uhlenbrock Intellibox, you must close OpSw 11 + 12 on all BDL16s to disable the extra master feature and LocoNet termination.

If you use a BDL with a non-LocoNet layout, OpSw 11 & 12 must be set to "thrown" on the "first" BDL. This provides the LocoNet termination necessary for proper operation. All other BDLs on the layout should have OpSw 11 & 12 set to closed.

Factory Settings Note:

The factory settings for the BDL168 & BDL162 are OpSws 11 & 12 closed. This means that a new from the factory BDL168 or 162 will be ready to add to any LocoNet layout. If you are using them on a non-LocoNet layout, the first BDL you install will need to have OpSw 11 & 12 reprogrammed to be thrown to provide the single LocoNet termination that is needed. This change was made to make BDL168 & BDL162 easier to use for LocoNet customers.

The factory setting for the first generation BDL16 is for the unit to be a LocoNet Master with OpSws 11 & 12 thrown. The original thinking was that it would be easier for non-LocoNet layouts to use and in the BDL16 only, it was not possible for these users to reprogram the variables.

See your BDL168, BDL162 or BDL16 Manual for information about setting up the specific model BDLs you are using.

Program the BDL168 s Board Address

The BDL168 can be programmed to any address from 1- 255.
Example: BDL168 with an address of 1 would be detection sections 1,1 to 1,16, while BDL168 with an address of 8 would be detection sections 8,1 to 8,16.

Note: If you have DS64 or DS54 stationary decoders installed on your layout or are planning to use them for your turnouts, make sure that they do not share the same board address as any BDLs. Also, a DS54 address is for only half of the available bits. Address 1 is for 1,1 to 1,8 while address 2 is for 1,9 to 1,16. Hence section 1,1 to 8,16 would be addresses 1 to 16 with the DS4.

Once you are sure that all configurations are set correctly, you can begin testing your installation. Turn on the track status and follow the applicable detection and transponding testing procedures below.

Power Up & Testing

Detection Testing

The BDL168 is shipped with an LT5. This little device is an excellent tool for testing the occupancy & transponding status for each individual zone.

1. Plug the LT5 in to the A socket with LEDs facing the nearest edge of the BDL168.
2. The single LED in the center of the LT5 indicates track status. “ON” means track power is on.
3. The row of 4 LEDs indicates the occupancy status of each detection section. An “ON” LED indicates that the BDL168 detects something on the track. Any locomotive or car with resistor wheels will trigger the input.
4. With track status on, run a locomotive through all four detection sections of zone A to test for its proper detection. Two LEDs will be on while the locomotive travels over the gaps.
5. If the LEDs respond and indicate each detection section’s occupancy, you wired everything correctly.
6. Repeat the procedure above for zones B, C and D by moving the LT5 to the other sockets to test each zone and its detection sections that you wired to the BDL168.

Note: If there is no occupancy detection, check “Occupancy /Detection Debug” in the troubleshooting section below.

Transponding Testing

1. Plug the LT5 into the A socket with LEDs facing the nearest edge of the BDL168.
2. The single LED in the center of the LT5 that indicates track status “ON” if lit is also used to indicate if the source of occupancy is a transponding device such as a transponding decoder or stand alone transponder. If the BDL168 detects transponding in one of the zones, the track status LED for that zone will blink.
3. With track status on, run a locomotive through all four detection sections of zone A to test for transponding.
4. If the test is successful for Zone A, proceed to test zones B, C, & D.

Note: If detection worked properly in the detection test above but there is no transponding message, check “Transponding Debug” in the troubleshoot section below.

Testing transponding messages with a computer

If you are planning to use a computer and CTC for your layout, you need a Digitrax or other LocoNet computer interface. We urge you to use a LocoNet monitor program such as DigiMon available in the LocoNet section of the Digitrax website. Following is a simple table that explains the meaning of some of the numbers that the monitor displays when LocoNet messages are present. This example shows a BDL168 with board address 01triggered by a loco with address 03 in zone C.

Message MSEN:	1st 2 digits D0	2nd 2 digits 20	3rd 2 digits 04	4th 2 digits 7D	5th 2 digits 03	6th 2 digits 75
		20=Transpond on 00=Transpond off	Zone Indicator X0=A X2=B X4=C X6=D	7D=short address	Address	check sum

Transponding: The 2nd 2 digits show if transponding is turned ON or OFF.

Detection Section/Zone Indicator: The 3rd set of 2 digits indicates the If a BDL168 with an address higher than F (15) is used, the second digit of the 2nd. Set of numbers will show the first digit in hex.

Address: The 4th and the 5th set of two digits show the address of the transponding source. If the source is a two digit address, the 4th. 2 digits will show 7D and the 5th. 2 digits will show the address in hex.

Troubleshooting

LocoNet Troubleshooting

The green LED on the BDL168 is not lit.	1. Make sure the system is powered up & track status is ON. 2. Check external power connections. 12 -16V AC or DC. 3. Make sure the BDL168 is connected to LocoNet.
The green LED on the BDL168 is winking "ON" every 2 seconds.	Connect the BDL168 to LocoNet.
The green LED is "ON" but does not wink "OFF" every 2 seconds.	This means that no DCC packets are being decoded from the left most (RailSync) pin of the RJ12 LocoNet socket. 1. Connect BDL168 setup directly to booster with the rest of the LocoNet network disconnected. 2. Check and test every LocoNet Cable used on your network.
The red option LED on the BDL168 is not lit and/or does not blink when LocoNet messages are sent.	This means that no LocoNet messages are present from the center two pins of the RJ12 LocoNet socket. 1. Connect BDL168 setup directly to booster with the rest of the LocoNet network disconnected. 2. Check and test every LocoNet Cable used on your network. 3. Be sure that the configuration of your BDL's Option Switches are correct for your usage. Check OpSw 11 & 12 settings.
LocoNet goes down when the BDL168 is connected.	The BDL might be in Master Mode. When the BDLs are used with a LocoNet compatible command station OpSw 11 & 12 must be closed. Check for all problems above.

Occupancy Detection Troubleshooting

Did you complete the LocoNet Troubleshooting above?	If not, please troubleshoot LocoNet first before continuing.
No detection, the LEDs on the LT5 are not "ON"?	Make sure the LT5 is connected in the right orientation and to the correct zone occupancy LED header hat you are testing on the BDL168. (LEDs facing the nearest edge of BDL168)
The zone status LED on the LT5 is "OFF" and all 4 sections LEDs are "ON"? Note: *If the zone power is OFF or there is a "short", by default the occupancy LEDs of that zone will be ON to be sure that signaling systems or a CTC/dispatcher will see the detection in its most restricted aspect.*	Turn the track power ON or remove "short" on track or in wiring. If the track power is ON at the booster, check that there is power on the terminal strip for that zone by shorting rail A and B. If you can't short the power district, there is no power or insufficient current to operate the BDL168. Check your power bus wires. Make sure your individual detection sections and zones are correctly gapped on rail A (isolated) and gapped on rail B to adjoining power districts.
The zone status LED on the LT5 is ON, indicating track power but there is no occupancy detection?	Check that there is power on the track in that section (Quarter Test). Use a locomotive or a resistance of 22kohms between the rails for testing.
Section detection is working but there are two LEDs ON for the same section?	Two sections will be ON if the locomotive sits over the gap of the two sections or if the gap has closed and the rail makes contact with the adjoining detection section. A drop of glue on the gap will prevent the rails from closing completely when there is expansion due to temperature changes.

Transponding Troubleshooting

Did you troubleshoot Occupancy Detection?	If not, please troubleshoot occupancy detection before continuing.
Section detection works fine but there is no indication of transponding. The status LED does not blink.	Check that the decoder address is selected and active on a throttle. Make sure the transponding option on the decoder is enabled. CV61 must be set to 02 on the mobile decoders with transponding. Make sure OpSw 11 & 12 are closed to disable the LocoNet Master Mode option on the BDL16 or BDL168. Check that the wires through the RX1 are run in the correct direction for the zone. See Upstream and Downstream detection. Close OPSW 3 on the BDL168. This will switch Railsync polarity for the entire BDL168 in case you feed the wires through the RX1 sensors in the wrong direction. If this does not help, reset OpSw 02 to thrown. This will only help if all 4 zones are wrong. I one or two zones are wrong, you must correct the wiring direction through the affected RX1s.
The status LED blinks in another zone than the detection section zone?	This is normal if you wired that section for alternative zone transponding. However this may also indicate that the BDL168 is in Master Mode. Make sure that OPSW 11 & 12 are set to closed! On BDL 16 the factory setting is closed. On BDL162 & BDL168 the factory setting is thrown.
If all of the above checked OK and it just won't transpond?	Check OpSw 05, make sure it is thrown. Closed means disable transponding. On BDL16 the factory setting is closed (transponding disabled). On BDL168 & BDL162 the factory setting is thrown
Still NO Luck?	Use a loco with another transponding decoder to see if the problem is your transponding device. If it is indeed the BDL168, connect the LocoNet cable directly to the command station's LocoNet port, unplug the rest of your LocoNet network and check all "ALL" OpSw settings to make sure that all are set correctly.

Downloads Available

DigiMon LocoNet Monitor program download

http://www.digitrax.com/support/loconet/home/ click on the DigiMon link on the right side of the page

The DigiMon LocoNet Monitor lets you see and save LocoNet messages. A Digitrax or other LocoNet computer interface is required to use with this application.

BDL168 Hookup Worksheet Download See the BDL168 & RX4 Product pages at www.digitrax.com

This worksheet is a PDF document that you can print and fill out to help organize your installation plan.

Digitrax Transponding Terminology

Following are some terms you might find useful as you work with the BDL168.

Direct home wiring is a layout wiring method where each power district and its booster is electrically isolated. The track within each power district uses a "common return" wiring method for occupancy detection and/or power management. Direct home wiring is the wiring method recommended by Digitrax for safety reasons & also because it makes detection work more prototypically.

Power district is the power wiring, components and equipment attached to that wiring, driven by a single properly isolated booster. BDL168 is used to set up detection sections within one or more power districts.

Power sub-district is the wiring, components and equipment that are controlled from both power bus wires by their own power management device, for example a reversing section controlled by an automated reversing device like the PM42.

Detection common is the common return used within a properly electrically isolated power district for implementing occupancy detection.

Security element is the plant, including track, associated with any reporting, interlocking and/or signaling for that track section.

Whole layout common rail is a method of wiring layouts where power districts and their boosters are connected electrically by a common rail or common power bus return wire. This method is traditionally used for conventionally controlled layouts. The track feeds for one rail are connected together to one output of the power pack. The other rail is gapped and the track feeds are connected to the power pack through block control switches. Whole layout common rail wiring has a disadvantage when it comes to detection systems because detectors are not able to independently monitor whether zone power is on or off. There is no way to tell whether occupancy detection is actually working in any given detection section.

Detection Section is a section of track gapped on one or both rails and connected to an occupancy detector so that the detector can sense the presence of a loco (or other specially equipped cars) in that section of track.

Occupancy detector is a device that senses the presence of a locomotive (or other specially equipped cars) in a section of track that is set up for occupancy detection. Occupancy detectors also provide feedback to indicate occupancy. This feedback may be in the form
of a lamp on a control panel or it may be a feedback message sent to the system that can be used by other layout devices. Also called a block occupancy detector on conventional layouts. Detectors are not covered by the DCC Standards or Recommended Practices.

Transponder is an electronic device with a transponder address that is installed in rolling stock. Transponders provide information to transponder detectors installed on the layout. This lets the system determine in which detection section the transponder is currently located. Transponders are included in all series 3 and subsequent Digitrax decoders. TL1 (transponder with 1 function output) & TL4 (transponder with 4 function outputs) are available as separate units that can be added to locos with existing decoders or to other rolling stock without decoders if you want to use them for transponding only and don't need motor control.

Transponder detector is an electronic device installed in a detection section on the layout that receives the information broadcast from a transponder. The transponder detector sends feedback to the system that lets it determine the detection section location of any given transponder at any time. RX4 Transponder detectors are hosted by the BDL168 and upgrade 4 detection zones of the BDL168 to be transponder detection zones. In this case, each transponding zone encompasses 4 detection zones.

The BDL168 is divided into four **Zones.** Each Zone supports 4 detection sections and each zone can be run from a different boosters.