BlockMaster™

Installation Guide

Revision 1.7b
5/28/08

LOGIC RAIL™
TECHNOLOGIES

PMB #287   21175 Tomball Parkway   Houston, TX 77070
Voice/Fax: (281) 251-5813
email: info@logicrailtech.com
http://www.logicrailtech.com

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1.0 INTRODUCTION

Thank you for purchasing a ***Logic Rail Technologies*** product! Please read all instructions prior to installing this board. **CAUTION:** The *BlockMaster* contains circuits which can be sensitive to electrostatic discharge. Store the *BlockMaster* board in its static protective bag until you are ready to install it. Avoid a build-up of static electricity and handle the board by its edges to minimize potential damage.

1.1. Package Contents

The following items should be found in the *BlockMaster* packing box:

- *BlockMaster* board
- Detection Diodes (quantity of 4)
- 30-pin card edge connector with solder terminals
- flat, ribbon cable assembly for connection to trackside signal heads
- installation guide (what you're reading!)

1.2. Electrical & Mechanical Data

The *BlockMaster* has the following electrical and mechanical specifications:

Board size:	3.9" x 5" including gold fingers
Board height:	1"
Mounting holes:	0.125" (quantity 4)
Input Voltage:	12.6VAC - 16VAC or 14VDC - 18VDC
Output Voltage:	DC, value depends upon input voltage
Detector Current Capacity:	6 amps per block, easily expanded
Power Consumption:	≤ 450mA when searchlight signals are used ≤ 250mA when standard 3-color signals are used
Signal Head Cable Length:	4'

1.3. Locating the *BlockMaster*

The *BlockMaster* board is best located underneath your layout near the blocks that it is signaling. You can use the holes in the card edge connector or on the *BlockMaster* board to mount it. Do **NOT** enlarge the holes. Irreparable damage may occur and you will certainly void the warranty! You should locate the *BlockMaster* board in area where there is some ventilation. **CAUTION:** The voltage regulators on-board the *BlockMaster* can get hot so it is best to have some airflow around it. These are located near the power jack near the lower lefthand corner of the board. Try not to touch them - burnt fingers are not covered under the warranty!

1.4. Edge Connector Pinout

The 30 pin edge connector has the pin numbers as described in the table below. The front of the *BlockMaster* board has pins 1 - 15 starting from the lefthand side. The back of the board has pins 16-30 with pin 16 being located behind pin 1, pin 30 behind pin 15. The card edge connector has the pin numbers molded into it near the solder terminals. When locating the connector for mounting orient it so that the numbers match the numbers on the *BlockMaster* board. The edge connector is referred to as “J1” and so pin 7 of the edge connector would be listed as “J1-7”.

Edge Connector Pinout

Pin #	Description	Pin #	Description
1	+V	16	+V
2	Ground	17	Ground
3	N rail, block 2	18	N rail, block 1
4	Block Occupied Output 2	19	Block Occupied Output 1
5	Block Occupied Output 2	20	Block Occupied Output 1
6	Reserved	21	Reserved
7	Status Input	22	Status Input
8	Status Input	23	Status Input
9	Status Input	24	Status Input
10	Status Input	25	Status Input
11	Reserved	26	Reserved
12	Status Input	27	Status Input
13	Status Input	28	Status Input
14	Status Input	29	Status Input
15	Status Input	30	Status Input

2.0 BACKGROUND ON SIGNALING

2.1. Description of Signal Head Types

There are many different types of signal heads on the prototype railroads. There is no right or wrong choice of signal head! A wide variety of signal types can be found on many railroads. In other words, few railroads standardized on a single type. However, most railroads had/have a favorite. For example, the Pennsylvania Railroad favored the Position Light signal. Signal heads can be found mounted on masts (often called vertical signals), on the “ground” (known as a dwarf signal) or on a signal bridge. In addition, multiple heads are used in areas where there are diverging routes. In general, one head is used per route. Figure 1 illustrates the more commonly used signal heads. Keep in mind that there are many variances on these alone which goes beyond the scope of this document.

Signal Head Types

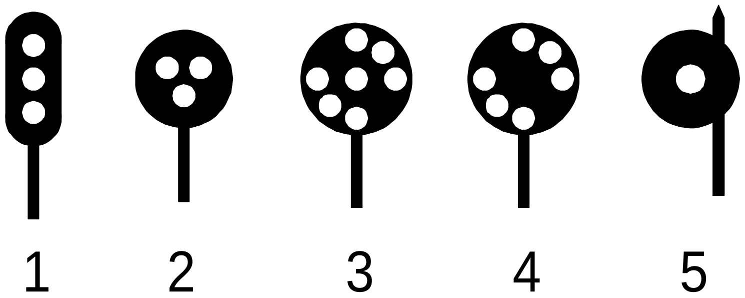


Figure 1

#1 : Type D color light
- 3-color illustrated, from top to bottom Green-Yellow-Red

#2 : Type G tri-color
- Green and Yellow on top, either order, Red on bottom

#3 : Position light
- Attempts to duplicate “blade position” of old semaphore signal type

- All indicators are Yellow for a signal which displays a *permissive stop*; outside horizontal indicators are Red for a signal which displays an *absolute stop*
- Two perimeter indicators (180° opposites) are illuminated and center is always illuminated if it is a permissive signal
    - Vertical indicates Clear
    - Diagonal indicates Caution
    - Horizontal indicates Stop

#4 : Color position light (vertical are Green, diagonal are Yellow, horizontal are Red)
#5 : Type SA Searchlight (3-colors from one indicator)

2.2. Signal Operating Rules

There are several categories of signaling protocols. The most familiar ones are Automatic Block Signaling (ABS), Absolute-Permissive Block signaling (APB) and Centralized Traffic Control (CTC). Whichever signaling protocol is used there is a basic set of signal indications and meanings. Most North American railroads have standardized on the General Code of Operating Rules. The *BlockMaster* supports ABS with the following rules.

Rule 9.50 (230) - Clear. Proceed with at least two clear blocks ahead. Green indication.
Rule 9.54 (234) - Approach Medium. Proceed prepared to pass next signal not exceeding 40 MPH. This indication basically means that the next signal indication to be encountered is Approach. Flashing Yellow indication.
Rule 9.56 (236) - Approach. Proceed prepared to stop before any part of train or engine passes the next signal. Reduce speed to 40 MPH or less. This indication means that the next signal indication to be encountered is Stop or Stop and Proceed. Yellow indication.
Rule 9.57 (237) - Diverging Clear. Proceed on diverging route not exceeding prescribed speed through turnout. Red over Green indication.
Rule 9.58 (238) - Diverging Approach Medium. Proceed on diverging route not

exceeding prescribed speed through turnout prepared to pass next signal not exceeding 40 MPH. This indication means that the next signal indication to be encountered on the diverging route is Approach. Red over Flashing Yellow indication.

Rule 9.59 (239) - Diverging Approach. Proceed on diverging route not exceeding prescribed speed through turnout prepared to stop at next signal, reduce speed to 40 MPH or less. This indication means that the next signal indication to be encountered on the diverging route is Stop or Stop and Proceed. Red over Yellow indication.

Rule 9.61 (241) - Stop and Proceed. Stop, then proceed at restricted speed. This is known as a permissive stop. Red indication with mileage marker on signal mast.

Rule 9.62 (242) - Stop. Stop before any part of train or engine passes the signal. This is known as an absolute stop. Red indication.

The diagrams in Figure 2 illustrate these rules (assumes flashing yellow is enabled). Each of the signal heads is numbered. For simplicity we've labeled each signal at the entrance to a block with the number of the block. Although it may seem odd, most railroads do not label their signals "East" and "West." We've followed their convention here and used "L" for leftbound (meaning traffic flowing from the right to the left) and "R" for rightbound. The lower case "m" or "s" simply denotes mainline or siding.

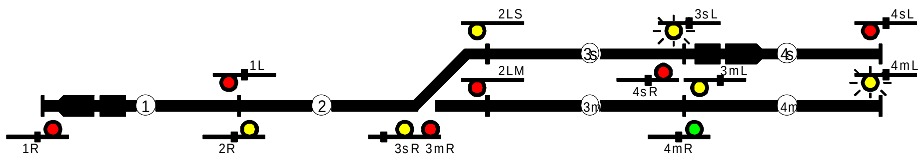


Figure 2a

The signal aspects in Figure 2a are:

Signal Head 1R: Stop & Proceed (the black bar on the mast indicates a mileage marker)
Signal Head 1L: Stop & Proceed
Signal Head 2R: Approach
Signal Head 2mL: Stop (no mileage marker ⇒ Absolute Stop)
Signal Head 2sL: Approach
Signal Heads 3mR/3sR: Diverging Approach
Signal Head 3mL: Approach
Signal Head 3sL: Approach Medium
Signal Head 4mR: Clear
Signal Head 4sR: Stop & Proceed
Signal Head 4mL: Approach Medium
Signal Head 4sL: Stop & Proceed

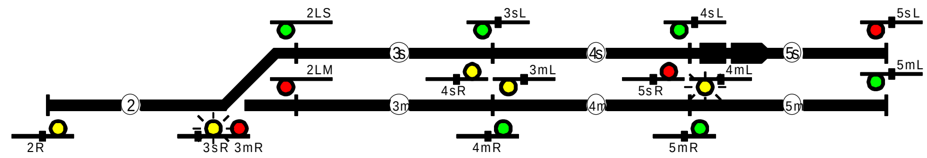


Figure 2b

The signal aspects in Figure 2b are:

Signal Head 2R: Approach
Signal Head 2mL: Stop
Signal Head 2sL: Clear
Signal Heads 3mR/3sR: Diverging Approach Medium
Signal Head 3mL: Approach
Signal Head 3sL: Clear
Signal Head 4mR: Clear
Signal Head 4sR: Approach
Signal Head 4mL: Approach Medium
Signal Head 4sL: Clear
Signal Head 5mR: Clear
Signal Head 5sR: Stop & Proceed
Signal Head 5mL: Clear
Signal Head 5sL: Stop & Proceed

2.3. Approach Lighting

The concept of Approach Lighting is quite simple. A signal remains dark (not illuminated) until a train approaches it (i.e. the block in advance of the signal is occupied). This has been primarily used in the western U.S. in remote locations where signal equipment operates on battery power. Having the signals unlit most of the time saves battery power as well as prolongs the life of the bulbs. The “rule” for illumination is simple: the signal shall be illuminated when the preceding block is occupied. Figure 3 contains a sequence of events which illustrates approach lighting.

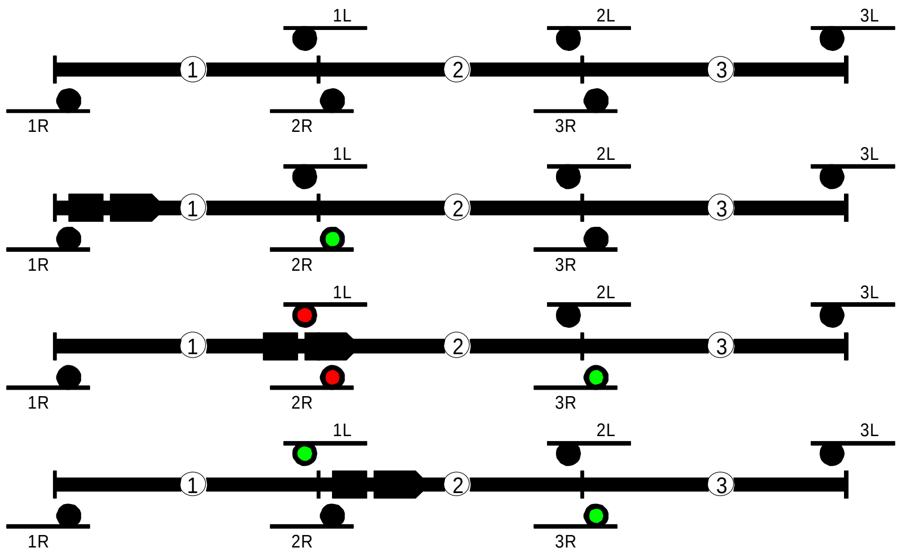


Figure 3

3.0 *BlockMaster* FEATURES

The *BlockMaster* has many different modes of operation. These modes and features are selected by a set of six configuration switches. These switches are summarized below.

Switch #	Description
1,2	Track arrangement/configuration
3	Searchlight Signal Select (ON/CLOSED = searchlights, OFF/OPEN = regular 3-color)
4	Common Anode LED signals (ON/CLOSED = Common Anode, OFF/OPEN = Common Cathode) OR Yellow Hue Select in Searchlight Signal mode (see text below)
5	Flashing Yellow for Approach Medium (ON/CLOSED = Enabled, OFF/OPEN = Disabled)
6	Approach Lighting (ON/CLOSED = Enabled, OFF/OPEN = Disabled)

Note that all combinations of switch selections are not supported. Most importantly switches 3, 5, and 6 are dependent upon the settings of Switch 1 & 2. If searchlight signals are selected (Switch 3 ON/CLOSED) then the position of Switch 4 determines the yellow hue. ON/CLOSED gives less red and more green. OFF/OPEN gives more red and less green. Choose the switch position that gives the best yellow hue for the searchlight signals you're using. The following table shows the valid combinations of features/settings for these switches.

Track Configuration Selected	Switch 1	Switch 2	Switch 3	Switch 5	Switch 6
1	OFF	OFF	X	X	X
2a	OFF	ON	OFF	X	OFF
2b	OFF	ON	X	X*	X*
2c	OFF	ON	X	X	X
3	ON	OFF	X	X	X
4	ON	ON	X	X	X

"X" denotes that the switch can either be ON or OFF (i.e. the feature is supported). "X*" denotes that either Switch 5 or 6 can be ON but not both at the same time. In other words, Configuration 2b supports either Flashing Yellow or Approach Lighting, but not both simultaneously. Obviously, you can choose to have both switches OFF.

3.1. Track Arrangements

The first step in setting up the *BlockMaster* is to select the track arrangement. The various track arrangements that are supported are illustrated below in Figure 4. You should choose the configuration that best matches the track arrangement you have on your layout. Remember that some configurations do not support all features. For minimal wiring and maximum features choose configuration 1, 3 or 4. Since those configurations have the two blocks interconnected there is less wiring for you to do. Please note that in the drawings below that there are several sub-configurations for each major configuration (1, 2a-c) supported. For each major configuration the first track arrangement shown is the one that has maximum utilization of signals. If you match up configuration 3 and 4 you'll notice that you have a passing siding! Obviously this requires two *BlockMaster* boards.

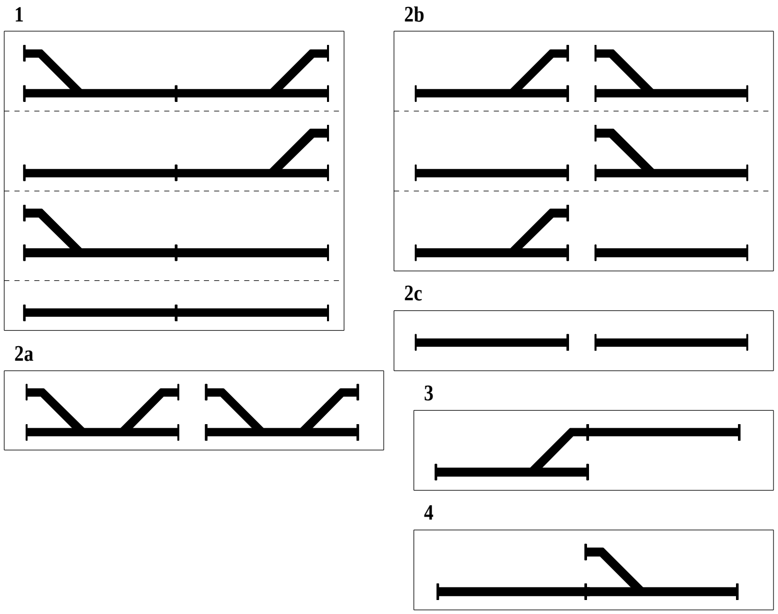


Figure 4

3.2. LED Signal Types

Before connecting the *BlockMaster* to your signal heads you must first select the type of LEDs used and how they are wired. **NOTE:** All signal heads connected to a given *BlockMaster* board **MUST** use the same LED type and wiring. In other words, you **CANNOT** mix searchlight signals and standard 3-color signals on a given *BlockMaster* board. You **CANNOT** mix signal heads wired as common cathode with those wired as common anode on a given *BlockMaster* board. However, it is perfectly acceptable to have different LED types and/or wiring on separate *BlockMaster* boards.

If you're using searchlight signals then you should put switch #3 in the ON/CLOSED position. In this mode the *BlockMaster* directly drives the searchlight signal's bipolar LED without any external circuitry! Note that you should always use current limiting resistors with LEDs to prevent overvoltage damage. The *BlockMaster* is capable of driving up to six individual searchlight signals. The bipolar LED contains both red and green elements so obviously two-color signaling is possible. Three-color signaling is supported by simply switching on the red and green LEDs alternately at a very high frequency. The human eye cannot detect this switching and thus just sees the blend of the two colors ⇒ yellow!!! Figure 5 below illustrates the two different types of bipolar LEDs that you may encounter. The *BlockMaster* can control both types.

Bipolar LEDs

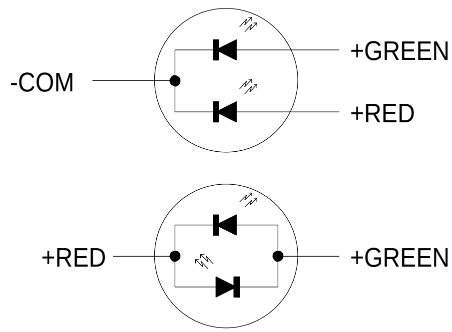


Figure 5

If you're not using searchlight signals then switch #3 should be OFF/OPEN. You must now determine whether your signals are wired for common anode (+) or common cathode (-). Refer to Figure 6 below for an illustration. The following manufacturers of signals use common anode wiring: Tomar, Shiloh Signals, NJ International, Jay's Engineering and Oregon Rail Supply (all signal units except position light). The following manufacturers use common cathode wiring: Integrated Signal Systems and Oregon Rail Supply (position light only). The Oregon Rail Supply position light signals can be handled in a special way. If you haven't already assembled the signal kit AND you want to use it with their other common anode signal units then you can simply build it backwards! Just reverse the orientation of the LEDs (+ and -) from the instructions. In any case you do not necessarily have to purchase their diode logic board to control the signal (see Section 8.2). If you're using signals wired for common anode then switch #4 should be ON/CLOSED. If your signals are wired for common cathode then switch #4 should be OFF/OPEN. Remember, for a given *BlockMaster* board **ALL** signals must be of the same type and wiring scheme.

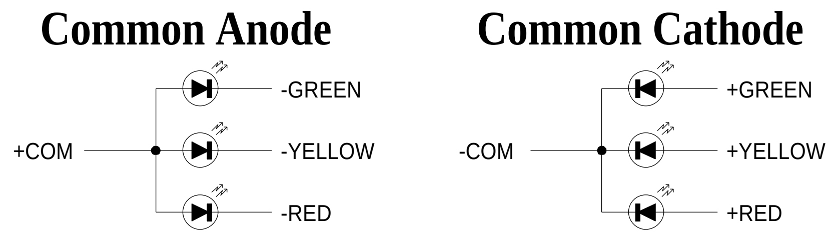


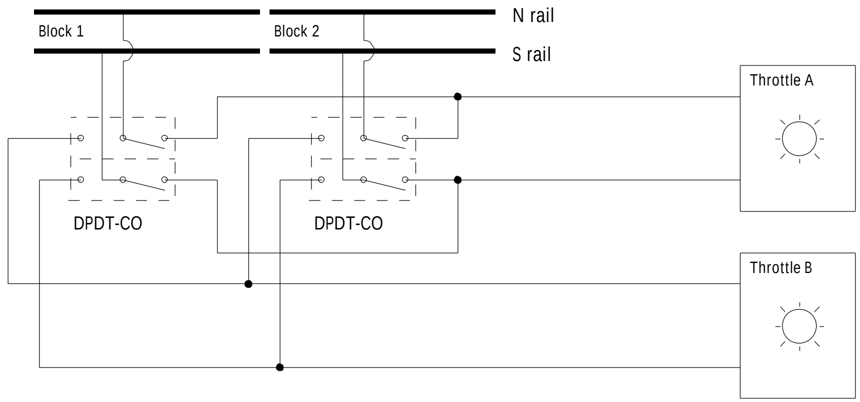
Figure 6

4.0 THROTTLES/CONTROL SYSTEMS

4.1. Conventional Throttles

In order to signal your model railroad you must electrically gap sections of your track. Believe it or not the rails on real railroads are gapped for this reason! Each section is referred to as a **block**. If you're using conventional throttles then presumably you're already gapping your track in order to run multiple trains independently, each with its own throttle/power pack. In a common rail wiring scheme only one rail, call it the **S** rail, is gapped. The *BlockMaster* detection circuitry needs to be spliced into the common rail, call it the **N** rail. As such both rails will need to be gapped. The drawing in Figure 7 illustrates a two-throttle wiring scheme before and after installing the *BlockMaster*. This wiring scheme is easily expanded using more throttles and block power switches. You may notice that you no longer need DPDT switches since you're now only switching one rail; you can use SPDT switches instead! Notice how the detection diodes are wired back-to-back (or anti-parallel). The diodes have a white band on them with signifies their cathode (negative side). It's best to locate the diodes under your layout near the block they're used in. As you can see one side of each throttle is connected to ground. Don't worry this is not a problem! You can always connect one side (lead) of individual power systems together as long as the other leads can never be directly connected together. You should make this common or *single point ground* at a central location, preferably where your throttles are located. This will minimize the effects of potential ground loops.

"Before"



"After"

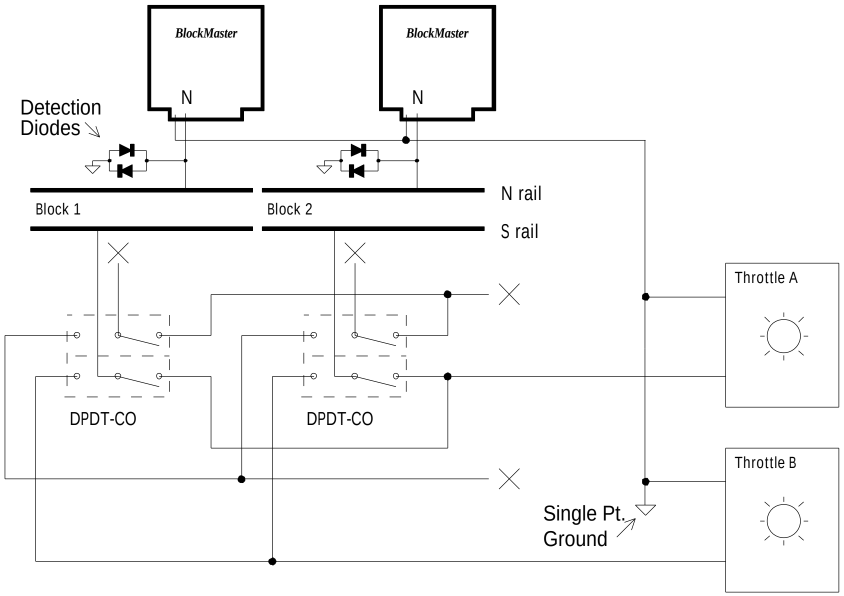


Figure 7

Even though power can be removed from the **S** rail (i.e. all block power switches off or throttle turned all the way down) it is still desirable to detect a train sitting in the block. This is easily accomplished by providing a small amount of current (also referred to as bias voltage) to the **S** rail. There are two types of bias circuits: AC and DC. The DC circuit is easily generated from the **+V** output on the *BlockMaster* edge connector. Simply connect a 2.2KΩ resistor (1/4 watt will do) between the **+V** output and the **S** rail as shown in Figure 8. You'll need one resistor for each signalled block.

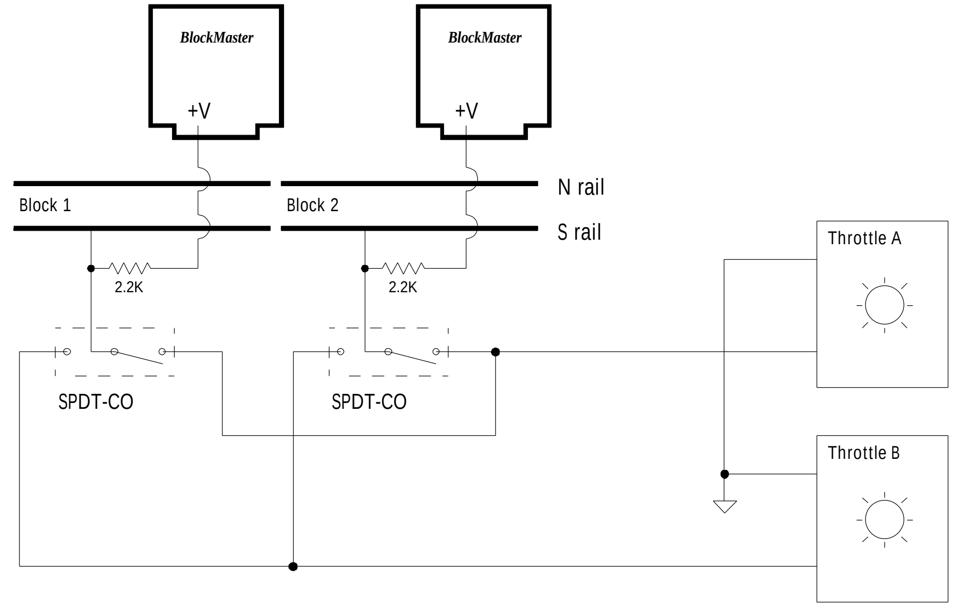


Figure 8

The DC bias circuit has a potential downside. Some commerical throttles output a non-zero voltage when they're turned all the way down. Depending upon its polarity (the position of the throttle's direction switch!) this non-zero voltage can actually cancel out the DC bias voltage! The simplest solution is to use an AC bias circuit. Since the AC voltage spends half its time below zero volts and half its time above the net effect is that no cancellation occurs. You **MUST** use a separate AC transformer to supply the bias voltage; you cannot use the same transformer that powers the *BlockMaster*. You should connect one lead from the transformer to the single point ground as shown in Figure 9. We suggest Radio Shack #273-1365 (ignore the center lead on the transformer's secondary). **WARNING! This transformer requires wiring to a 120VAC outlet. If you don't know how to do this let an expert do it!** Alternatively, you can use a wall transformer such as Radio Shack #273-1610 or our WT1A. Simply clip off the connector and strip the insulation off the ends of the wires.

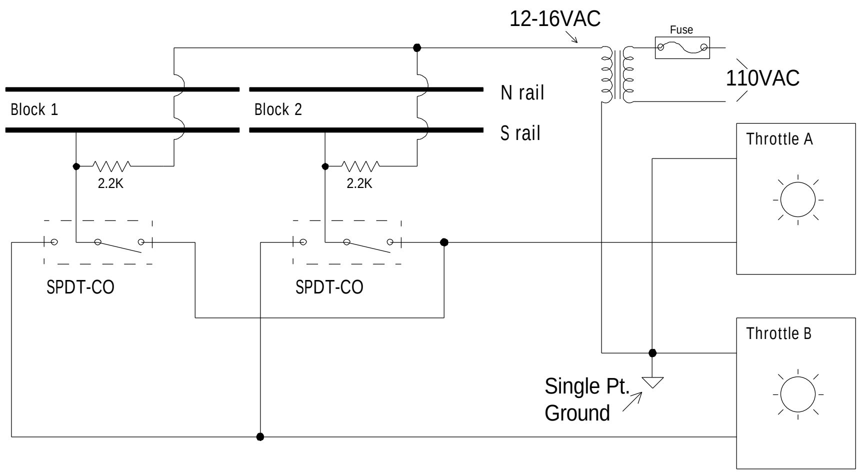


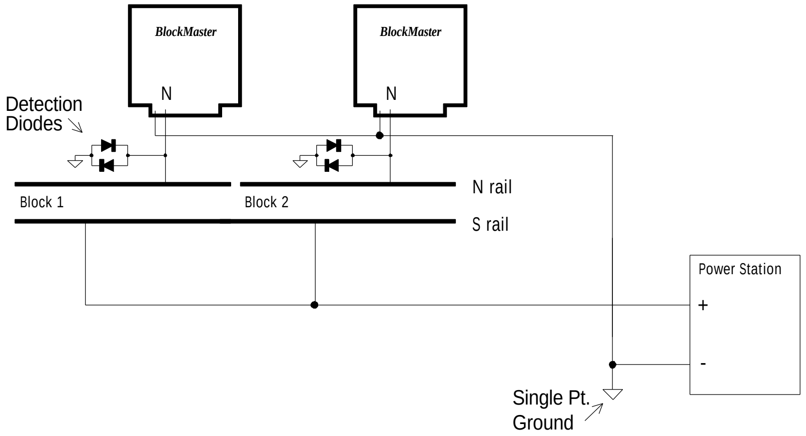
Figure 9

4.2. Command Control

A common misconception about command control is that it doesn't require you to gap your track. Untrue! There are several reasons to still gap your track with command control.

1. Reverse loops. You still need to gap both rails when you encounter a reverse loop!
2. Multiple power stations. If your layout has more than one power district (See section 7.2) then you'll need to gap both rails at the district boundaries.
3. Troubleshooting. If you wire your layout as one big block you'll have a hard time locating shorts if they occur.
4. Signaling!

Obviously if you're reading this manual the most important reason is #4!!! Rail gapping is simplified with command control however. Since it is not necessary to switch power on and off to each block it is only necessary to gap the **N** rail. In addition, since power is always present on the **S** rail it is not necessary to supply any bias voltage to it. See the figure below and also read section 7.1 to understand power blocks vs. signal blocks. Note: some Power Stations do have a polarity (e.g. Railcommand ®) and some do not (e.g. DCC).



5.0 *BlockMaster* POWER

The *BlockMaster* requires power that is separate from your track power. Although it is tempting to use the spare/auxiliary AC or DC output on your throttle - DON'T!!! Since the *BlockMaster* accepts AC or DC power at a minimum of 12VAC or 14VDC you can use a variety of power sources. The *BlockMaster* accepts AC or DC power through its power jack or DC power through its edge connector. Wall transformers (available from places such as Radio Shack) provide a convenient and inexpensive means of providing power. The mating connector on the wall transformer should be a 2.1mm (I.D.) x 5.5mm (O.D.) female type. If you choose to use DC power via the edge connector take great care in matching the polarity. Severe damage to the *BlockMaster* could result if power is applied incorrectly. The *BlockMaster's* current requirements vary based on the type of LED signals used and the number of signal heads connected. Your power source can be shared among multiple *BlockMaster* boards if it can provide sufficient current for each *BlockMaster*. For example, a single AC power source can be connected to one *BlockMaster.* The DC connections on that *BlockMaster's* edge connector can then be connected to the DC connections on other *BlockMaster* boards. See the illustration in Figure 10. Do NOT "daisy-chain" the AC power between *BlockMaster* boards.

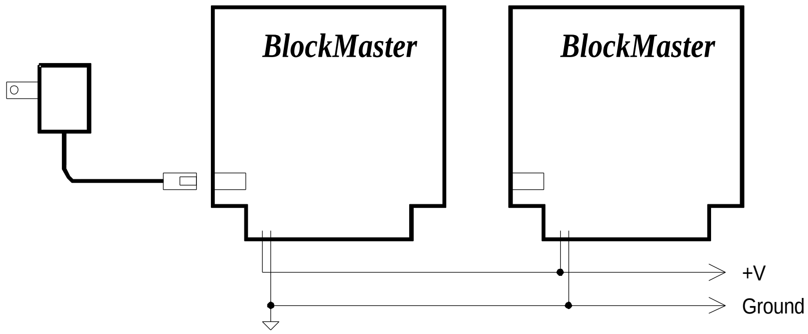


Figure 10

Alternatively, you can use a DC power source and daisy-chain it among *BlockMaster* boards as illustrated in Figure 11.

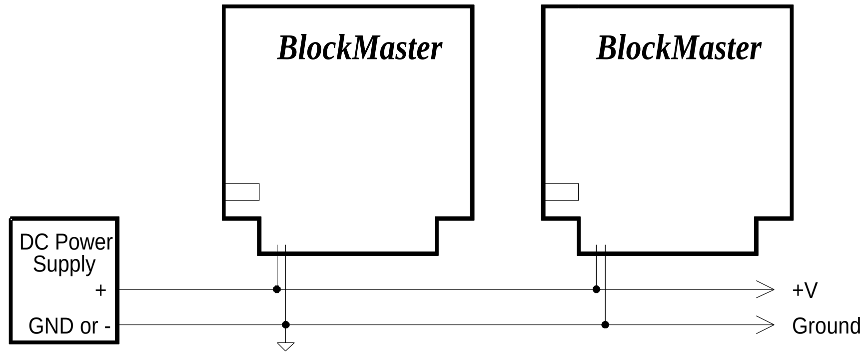


Figure 11

NOTE: ALL *BlockMaster* boards within a Power District MUST have their grounds connected together as shown in Figure 12.

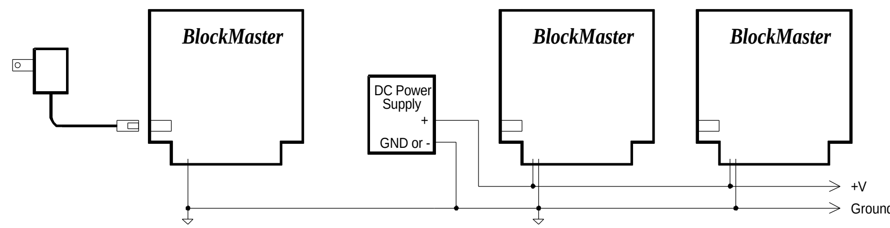


Figure 12

6.0 STATUS INPUTS

6.1. Diode & Transistor Logic

In order to implement 3-color signaling and approach lighting it is necessary for the *BlockMaster* to know the occupancy status of adjacent blocks. In other words, it has to "talk" with the *BlockMaster* boards around it. For the interlocking functions needed for diverging route signaling or CTC arrangements it is necessary to inform the *BlockMaster* of certain layout conditions (e.g. turnout position). This is accomplished using active low digital logic. That means that an electrical signal will be at approximately 0 volts when it's considered "active" or "on." It is important to note that in this implementation an electrical signal which is "inactive" or "off" does NOT have a valid voltage level associated with it; the signal is said to be "floating." The simplest way to activate one of the *BlockMaster* status inputs is to connect it to ground. However, that input will thus always be considered active (i.e. it is a static signal). The more common way to control the status inputs are with active components (diodes, transistors, relays). The block occupied outputs from the *BlockMaster* are simply open-collector transistor outputs. When one of these transistors is active its output is at ≈0.3V. In many cases you will simply connect the block occupied output from one *BlockMaster* board to the status input of others. However, there are some instances where you'll need to connect a block occupied output AND some other status signal (such as turnout position). In this case you'll need to handle the inputs a little differently. In these cases you want the input to be active if either status signal is active. In order to do this "OR" function you'll need to use *diode logic*. The symbol for a diode and its terminals are shown in Figure 13. The concept used here is *negative logic*. Consider the circuit in Figure 14. If either line B or C are at a low voltage then line A will be at a low voltage. B and C are considered *terms* in the equation for A.

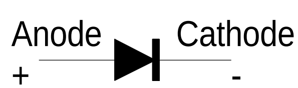


Figure 13

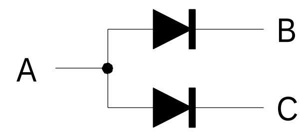


Figure 14

There is one some simple rule to determine when you need to use diode logic. If the status signal is used for more than one status input AND this status input has additional terms then you'll need diode logic. Consider the circuit in Figure 15. Status input A is active if either -BOn is active or Turnout Status A is active. Status input B is active if either -BOn is active or Turnout Status B is active. Status input C is active if -BOn is active. Following the rule above you can see that status inputs A & B require diode logic where status input C does not. The diodes used are the popular 1N4001 (Radio Shack #276-1101). As mentioned previously the band on the diode is the cathode.

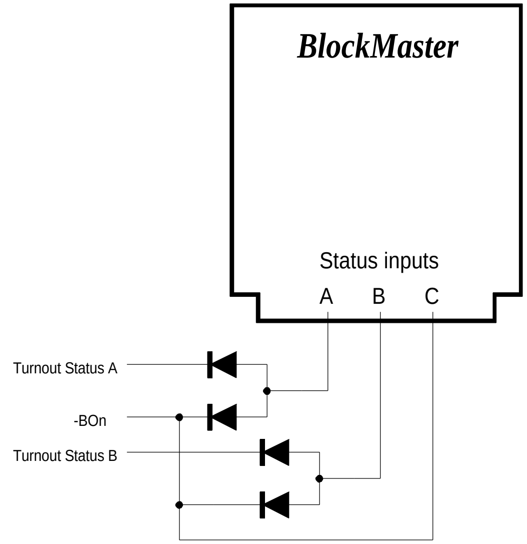


Figure 15

6.2. Configuration-Specific Inputs

There are four different types of external status inputs for each signal head. These are:

1. Next Block occupancy status. This determines whether or not the Approach aspect (yellow) should be generated.
2. Interlocking status. This determines whether the Stop aspect (red) should be generated for conditions other than block occupancy. For example, if a turnout is thrown against a route then the signal associated with that route should indicate Stop.
3. Previous Block occupancy status. When Approach Lighting is chosen (configuration switch #6 ON/CLOSED) this input determines when the signal should be illuminated.
4. Second Next Block occupancy status. This determines whether or not the Approach Medium aspect (flashing yellow) should be generated. This input is only used when configuration switch #5 is ON/CLOSED.

You do not need to understand how these inputs exactly determine the signal indications in order to use the *BlockMaster* but it will be described here for those who are interested. The signal indication "equations" are:

RED: If block is occupied *or* if Interlocking input is active.
YELLOW: If not RED *and* Next Block is occupied
GREEN: If not RED *and* not YELLOW *and* not FLASHING YELLOW
FL. YELLOW: If not RED *and* not YELLOW *and* 2nd Next Block is occupied *and* Cfg Switch #5 ON/CLOSED
SIGNAL LIT: If Cfg Switch #6 OFF/OPEN *or* Previous Block is occupied

For each track configuration the status inputs are defined differently. The following tables illustrate the definitions. For each track configuration there are two tables. The first table lists the actual status signals needed for each status input. The second table lists which pin on the edge connector is used for each status input. In that table you may see the same pin number listed more than once. That doesn't mean you need to make more than one connection! To remind you of this we've put parenthesis around the redundant connections. The wire size for these connections is not critical. We recommend 24 gauge wire.

Some explanation of the notation is required. -BO*n* is the block occupied output from block *n*. -INT*xyz* is the interlocking input for signal head *xyz*. For example, -INT1LM is the interlocking input for the Left Mainline signal in block 1. There are some status inputs which require a connection to two status signals. In this case an ampersand (&) is used to denote that you should use diode or transistor logic as described in the previous section. In some cases you do not actually have to make an external connection. For example, in Track Configuration 1 the Previous Block input for signal head 1L is -BO2. Since the two blocks are interconnected in this configuration, the signal controller already knows the state of block 2 from the on-board train detection circuitry. Therefore, this entry is marked "internal" and the associated terms are shown in square brackets for reference only. It may not be obvious why the Next Block input for signal heads 1RM and 1RS is the same as the Interlocking input for signal head 2R. In this situation we want those two signals to indicate Approach if signal 2R is indicating Stop. The latter can happen two ways: Block 2 is occupied or signal 2R's Interlocking input is active. It is not necessary in this case to externally connect -BO2 to the Next Block input for signal heads 1RM and 1RS as this is done internal to the signal controller.

The most common use of the interlocking input is with turnout position. In the case of a diverging route it is only possible to travel on one leg of the turnout or the other. As such the signal for the "non-aligned" route needs to be red! The simplest way to incorporate the turnout position into your signaling system is to utilize the auxiliary contacts found on most switch machine or switch motors. Most all twin-coil switch machines (e.g. NJ International) have such contacts. Some switch motors offer them standard as well (e.g. Circuitron's Tortoise™). In their simplest form these contacts are just SPDT (Single Pole Double Throw) switches. Simply connect the center pole or common terminal to ground. The normally closed (N.C.) contact is defined as the one that is connected to the center pole when the turnout is aligned for the straight route. The normally open (N.O.) contact is defined as the one that is connected to the center pole when the turnout is aligned for the diverging route. In this application the N.C. contact will be at ground when the turnout is aligned for the straight route and the N.O. will be at ground when the turnout is aligned for the diverging route. Only one terminal can possibly be at ground at any given time; the other terminal will be an open-circuit. This application is depicted below.

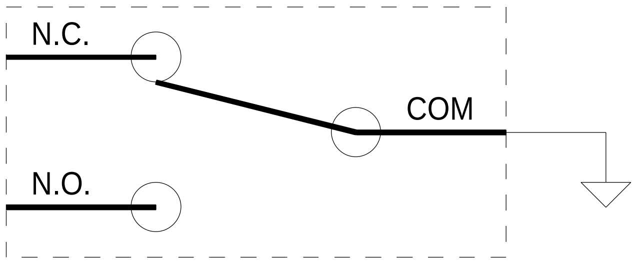


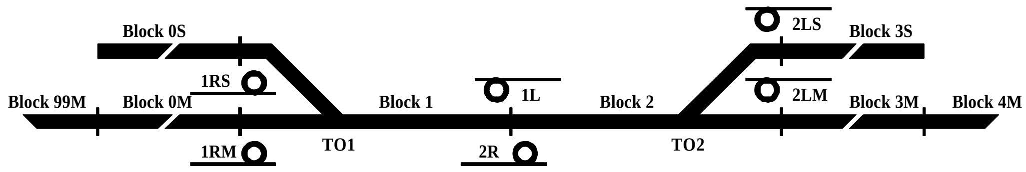
Figure 16

Track Configuration 1

Status signal connections

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1RM		-INT1RM	-INT2R	-BO0M	-BO3M & -INT3RM
1RS		-INT1RS	-INT2R	-BO0S	-BO3M & -INT3RM
1L		-INT1L	-BO0M & -INT0LM	internal [-BO2]	-BO99M & -INT99LM
2R		-INT2R	-BO3M & -INT3RM	internal [-BO1]	-BO4M & -INT4RM
2LM		-INT2LM	-INT1L	-BO3M	-BO0M & -INT0LM
2LS		-INT2LS	-INT1L	-BO3S	-BO0M & -INT0LM

The configuration and its surrounding blocks are depicted below:



The interlocking inputs should be tied into the turnout position. For example, -INT1RM should be connected to the N.O. contact of TO1's switch machine while -INT1RS should be connected to the N.C. contact of the same switch machine. Thus, when the turnout is thrown for the mainline the N.C. contact will be grounded which in turn activates -INT1RS and causes signal head 1RS to display Red.

Edge connector assignments

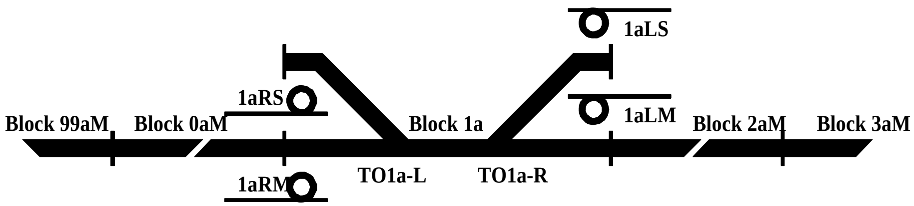
Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1RM		J1-23	(J1-9)	J1-15	(J1-7)
1RS		J1-24	(J1-9)	J1-27	(J1-7)
1L		J1-22	J1-8	n/a	J1-29
2R		J1-9	J1-7	n/a	J1-30
2LM		J1-25	(J1-22)	J1-14	(J1-8)
2LS		J1-10	(J1-22)	J1-28	(J1-8)

Track Configuration 2a

Status signal connections

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1aRM		-INT1aRM	-BO2aM		-BO3aM
1aRS		-INT1aRS	-BO2aM		-BO3aM
1aLM		-INT1aLM	-BO0aM		-BO99aM
1aLS		-INT1aLS	-BO0aM		-BO99aM
1bRM		-INT1bRM	-BO2bM		-BO3bM
1bRS		-INT1bRS	-BO2bM		-BO3bM
1bLM		-INT1bLM	-BO0bM		-BO99bM
1bLS		-INT1bLS	-BO0bM		-BO99bM

The configuration and its surrounding blocks are depicted below. Only block 1a is illustrated for the sake of space. Simply replace every instance of "a" with "b" to obtain the diagram for block 1b.



The interlocking inputs should be tied into the turnout position. For example, -INT1aRM should be connected to the N.O. contact of TO1a-L's switch machine while -INT1aRS should be connected to the N.C. contact of the same switch machine. Thus, when the turnout is thrown for the mainline the N.C. contact will be grounded which in turn activates -INT1aRS and causes signal head 1aRS to display Red.

Edge connector assignments

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1aRM		J1-24	J1-28		J1-14
1aRS		J1-25	(J1-28)		(J1-14)
1aLM		J1-22	J1-27		J1-15
1aLS		J1-23	(J1-27)		(J1-15)
1bRM		J1-8	J1-30		J1-12
1bRS		J1-7	(J1-30)		(J1-12)
1bLM		J1-10	J1-29		J1-13
1bLS		J1-9	(J1-29)		(J1-13)

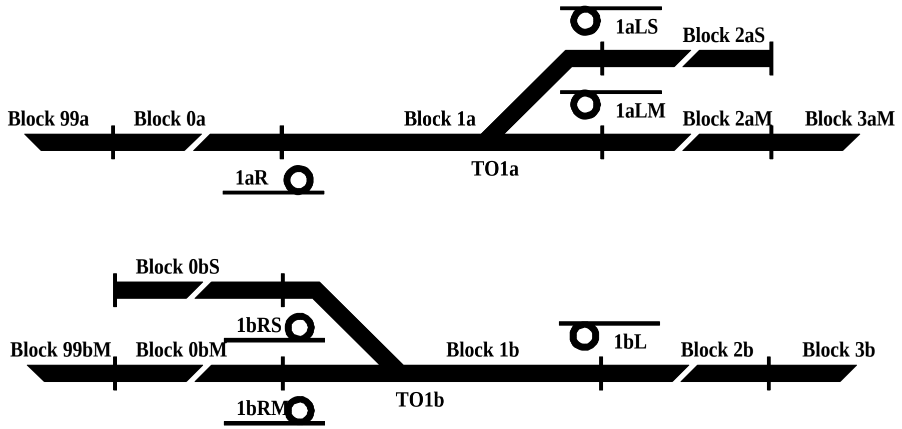
Track Configuration 2b

Status signal connections

Signal Head		Interlocking	Next Block	Previous Block[1]	2nd Next Block[2]
1aR		-INT1aR	-BO2aM & -INT2aRM	-BO0a	-BO3aM & -INT3aRM
1aLM		-INT1aLM	-BO0aM & -INT0aL	-BO2aM	-BO99aM & -INT99aL
1aLS		-INT1aLS	-BO0aM & -INT0aL	-BO2aS	-BO99aM & -INT99aL
1bRM		-INT1bRM	-BO2b & -INT2bR	-BO0bM	-BO3b & -INT3bR
1bRS		-INT1bRS	-BO2b & -INT2bR	-BO0bS	-BO3b & -INT3bR
1bL		-INT1bL	-BO0bM & -INT0bLM	-BO2b	-BO99bM & -INT99bLM

1) If Approach Lighting is enabled and Flashing Yellow is disabled
2) If Flashing Yellow is enabled and Approach Lighting is disabled

The configuration and its surrounding blocks are depicted below:



The interlocking inputs should be tied into the turnout position. For example, -INT1aLM should be connected to the N.O. contact of TO1a's switch machine while -INT1aLS should be connected to the N.C. contact of the same switch machine. Thus, when the turnout is thrown for the mainline the N.C. contact will be grounded which in turn activates -INT1aLS and causes signal head 1aLS to display Red.

Edge connector assignments

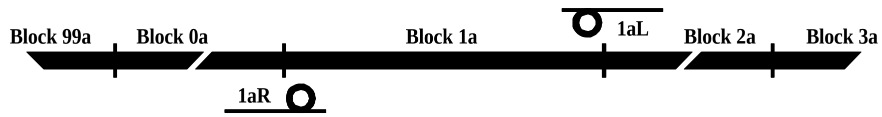
Signal Head		Interlocking	Next Block	Previous Block[1]	2nd Next Block[2]
1aR		J1-24	J1-28	J1-7	J1-7
1aLM		J1-22	J1-27	J1-8	J1-8
1aLS		J1-23	(J1-27)	J1-15	(J1-8)
1bRM		J1-10	J1-30	J1-12	J1-14
1bRS		J1-9	(J1-30)	J1-14	(J1-14)
1bL		J1-25	J1-29	J1-13	J1-15

Track Configuration 2c

Status signal connections

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1aR		-INT1aR	-BO2a & -INT2aR	-BO0a	-BO3a & -INT3aR
1aL		-INT1aL	-BO0a & -INT0aL	-B02a	-BO99a & -INT99aL
1bR		-INT1bR	-BO2b & -INT2bR	-BO0b	-BO3b & -INT3bR
1bL		-INT1bL	-BO0b & -INT0bL	-B02b	-BO99b & -INT99bL

The configuration and its surrounding blocks are depicted below. Only block 1a is illustrated for the sake of space. Simply replace every instance of "a" with "b" to obtain the diagram for block 1b.



Edge connector assignments

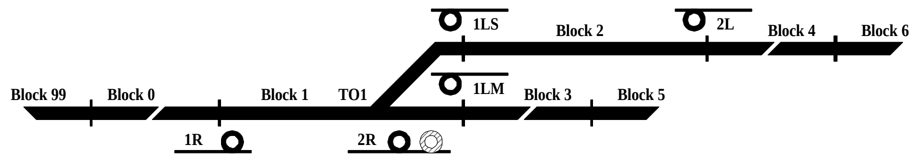
Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1aR		J1-24	J1-28	J1-7	J1-9
1aL		J1-22	J1-27	J1-8	J1-23
1bR		J1-10	J1-30	J1-12	J1-14
1bL		J1-25	J1-29	J1-13	J1-15

Track Configuration 3

Status signal connections

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1R		-INT1R	-BO3 & -INT3R	-BO0	-BO5 & -INT5R
1LM		-INT1LM	-BO0 & -INT0L	-BO3	-BO99 & -INT99L
1LS		-INT1LS	-BO0 & -INT0L	internal [-BO2]	-BO99 & -INT99L
2R		-INT2R	-BO4 & -INT4R	internal [-BO1]	-BO6 & -INT6R
2L		-INT2L	-INT1LS	-BO4	-BO0 & -INT0L

The configuration and its surrounding blocks are depicted below:



The interlocking inputs should be tied into the turnout position. For example, -INT1LM should be connected to the N.O. contact of TO1's switch machine while -INT1LS should be connected to the N.C. contact of the same switch machine. Thus, when the turnout is thrown for the mainline the N.C. contact will be grounded which in turn activates -INT1LS and causes signal head 1LS to display Red.

Edge connector assignments

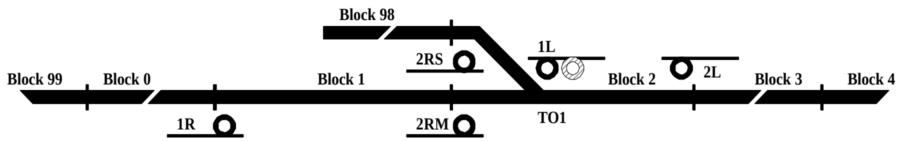
Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1R		J1-24	J1-28	J1-7	J1-15
1LM		J1-22	J1-27	J1-8	J1-30
1LS		J1-23	(J1-27)	n/a	(J1-30)
2R		J1-10	J1-29	n/a	J1-14
2L		J1-25	(J1-23)	J1-9	(J1-27)

Track Configuration 4

Status signal connections

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1R		-INT1R	-INT2RM	-BO0	-BO3 & -INT3R
1L		-INT1L	-BO0 & -INT0L	internal [-BO2]	-BO99 & -INT99L
2RM		-INT2RM	-BO3 & -INT3R	internal [-BO1]	-BO4 & -INT4R
2RS		-INT2RS	-BO3 & -INT3R	-BO98	-BO4 & -INT4R
2L		-INT2L	-INT1L	-BO3	-BO0 & -INT0L

The configuration and its surrounding blocks are depicted below:



The interlocking inputs should be tied into the turnout position. For example, -INT2RM should be connected to the N.O. contact of TO1's switch machine while -INT2RS should be connected to the N.C. contact of the same switch machine. Thus, when the turnout is thrown for the mainline the N.C. contact will be grounded which in turn activates -INT2RS and causes signal head 2RS to display Red.

Edge connector assignments

Signal Head		Interlocking	Next Block	Previous Block	2nd Next Block
1R		J1-23	(J1-24)	J1-7	(J1-28)
1L		J1-22	J1-27	n/a	J1-29
2RM		J1-24	J1-28	n/a	J1-30
2RS		J1-10	(J1-28)	J1-8	(J1-30)
2L		J1-25	(J1-22)	J1-9	(J1-27)

6.3. Boundary Situations

It is unlikely that you will signal every block on your layout. Likewise, you will have blocks that aren't connected to other blocks on both ends (e.g. a spur). What should you do with the status inputs on the *BlockMaster* when you reach the end of signaled territory? Well, there obviously is no "Next Block" status to be had so you can't have three color signaling! The recommended thing to do is nothing! If you do not connect anything to a "Next Block" status input it will simply be treated as being permanently inactive! You might then choose to use a two-color signal head (if using a Type D head) in that situation since the Approach indication will never be generated.

7.0 TRACK CONNECTIONS

7.1. Power Blocks vs. Signal Blocks

It is not a requirement to have the gaps in the **N** rail match the locations of the gaps in the **S** rail. This is the concept of a signal block vs. a power block. The gaps in the **S** rail define the power blocks whereas the gaps in the **N** rail define the signal blocks. There are two exceptions to this statement: power districts and reverse loops. In both cases the gaps for both rails MUST be located directly across from one another as shown in Figure 17 below. When using conventional throttles you are likely have the gaps located directly across from each other anyway since the nature of a conventional throttle prevents you from running two trains independently in the same power block. Therefore, it doesn't make much sense to have multiple signal blocks within a single power block under conventional control.

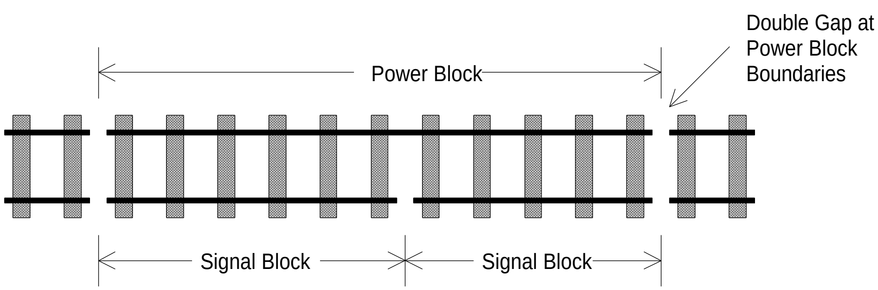


Figure 17

7.2. Power Districts

The concept of a power district primarily applies to command control systems. In simple terms a power district is defined to have one power station. One of the primary benefits of command control is multi-train operation from a single power station. As such the power draw from that device tends to be much larger than from a conventional throttle. On large layouts it is easily possible to exceed the current ratings of a single power station. As a result the layout may be divided up among multiple power stations. For example, if a single power station has a maximum output of 4 amps but the number of trains running simultaneously demands 6 amps then a second power station must be added. A good analogy is the electrical power coming into your house. There is no transformer in the world big enough to support every house. Therefore, your electric company divides their territory into grids each with a dedicated transformer(s). What does all have to do with your new signaling system?

Some command control systems (e.g. NMRA DCC) do not allow common connections of power stations across power districts. Since the *BlockMaster* establishes a common ground with one lead from the power station you cannot directly connect any inputs or outputs from the *BlockMaster* in one power district to those of a *BlockMaster* in another power district. In other words, you MUST keep their ground reference points separate. As a result there will be multiple ground points on your layout that must remain isolated. For example, if you have two power districts and want signaling in both then you will have a separate power supply(ies) for the *BlockMaster* board(s) in power district #1 versus those boards in power district #2. The status inputs for the *BlockMaster* boards at the power district boundaries must be electrically isolated using a small device called an optoisolator or optocoupler. The recommended part is a 4N35 available from many electronic parts distributors (e.g. Digikey Corporation, call 1-800-DIGI-KEY for a catalog). Observe the pinout carefully! There will be a notch or dot denoting pin 1; the pins are numbered counterclockwise (i.e. pin 1 is opposite to pin 6). No modifications are necessary for the signal head outputs since they derive all of their power from the *BlockMaster* itself. Figure 18 illustrates how the optoisolator should be wired to a *BlockMaster* input.

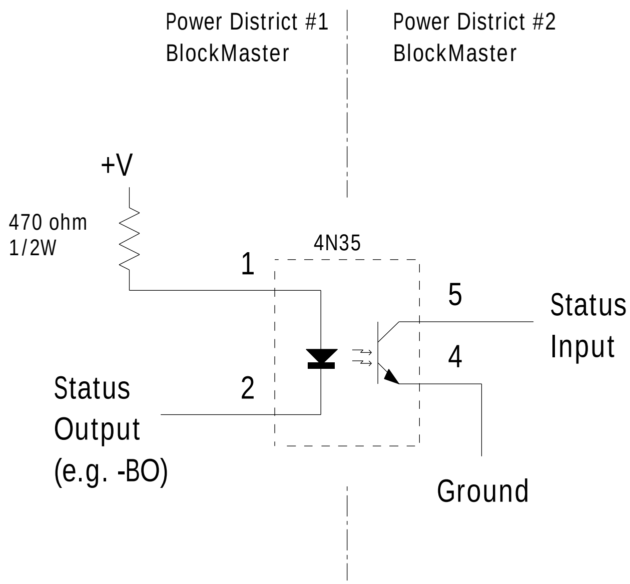


Figure 18

If you're using command control you should contact the manufacturer of the system and find out if it's acceptable to establish a common ground connection between power stations. If the answer is yes, then you don't have to worry about the isolation techniques described above.

7.3. Reverse Loops

Due to the nature of reverse loops, a *BlockMaster* installed in a reverse loop must be electrically isolated from mainline *BlockMaster* boards. This requirement is similiar to the one described in the previous section on power districts. **Failure to adhere to the following instructions could cause severe damage to your circuits!** The *BlockMaster* used in a reverse loop requires a separate power supply from the one used on non-reverse loop *BlockMaster* boards. A separate power supply is required for **EACH** reverse loop that uses a *BlockMaster*. Do **NOT** connect the ground of the reverse loop *BlockMaster* to the mainline *BlockMaster* power supply ground. Figure 19 illustrates how the *BlockMaster* is wired in a reverse loop. Remember to use optoisolators for the status inputs used between the mainline and reverse loop *BlockMaster* boards. Figure 20 shows how the optoisolators are used. Pay attention to the power supply connections (i.e. the **+V** is from the *BlockMaster* driving **-BO** whereas **Ground** is from the *BlockMaster* receiving the status input).

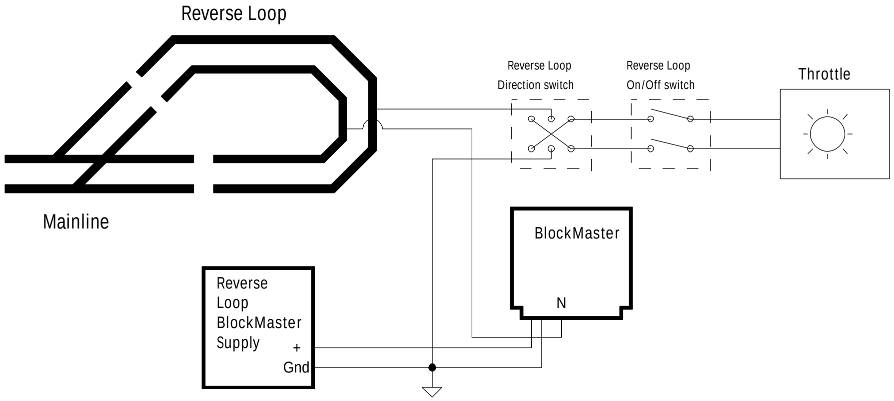
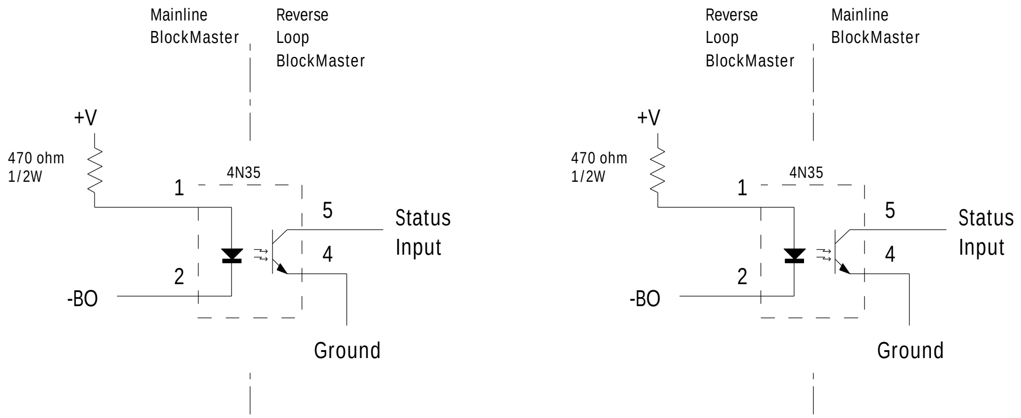


Figure 19



Mainline
BlockMaster
Reverse
Loop
BlockMaster
+V
470 ohm
1/2W
4N35
1
2
5
4
Status
Input
-BO
Ground
Reverse
Loop
BlockMaster
Mainline
BlockMaster
+V
470 ohm
1/2W
4N35
1
2
5
4
Status
Input
-BO
Ground

Figure 20

7.4. Unsignalled Blocks

Your layout will most likely have some unsignalled blocks. Each signalled block incurs a slight voltage drop (≈0.7V) between the throttle and the engine due to the diodes in the detection circuit. As such it is recommended that you installed similiar diodes in the unsignalled blocks. This should eliminate any changes in locomotive speed when crossing between a signaled block and an unsignaled block. These diodes should have a current rating which meets or exceeds your throttle's output capability. There's nothing wrong with a little overkill here! We recommend 6 amp diodes (50V minimum voltage rating). These are available from us (part number DD6A) or from most electronic supply stores (again, try Digikey). You can also parallel diodes with lower rating to increase the overall current handling capability. Figure 21 illustrates how to do this.

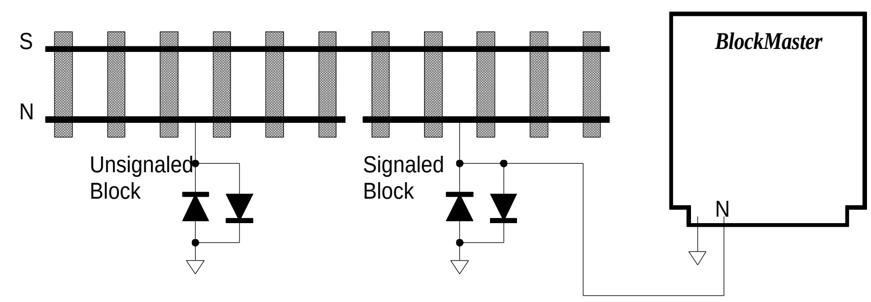


Figure 21

8.0 SIGNAL HEAD CONNECTIONS

8.1. Direct Drive vs. Multiplexed Drive

There are two ways to illuminate an LED. The more conventional method will be referred to as Direct Drive. This basically means that one side of the LED is connected to power or ground through a current limiting resistor (R_L). The other side of the LED is then connected to a signal output driver (typically an open-collector transistor). If the LED should be illuminated then the corresponding signal output driver is turned on and left on until the signal indication is changed. Refer to the lefthand side of Figure 22 below. Although common anode wiring or common cathode wiring is possible we have only shown one for the sake of space. The other method is referred to as Multiplexed. In this method no LED is constantly turned on. Instead, multiple LEDs are "ganged" together on the signal output driver side. In addition, the "common" side is NOT tied to power or ground but rather to a different signal control driver. The latter will be referred to as the signal select or mast select. Reference the righthand side of Figure 22 below. The multiplexed method operates as follows:

1. The signal controller puts the signal information on the Green, Yellow, and Red outputs (only one output is turned on) for signal head #1.
2. The signal controller will turn on signal select #1 while keeping signal select #2 off. Therefore, one of the indicators for signal head #1 will illuminate.
3. The signal controller will turn off ALL signal selects.
4. The signal controller puts the signal information on the Green, Yellow, and Red outputs for signal head #2.
5. The signal controller will turn on signal select #2 while keeping signal select #1 off. Therefore, one of the indicators for signal head #2 will illuminate.
6. The signal controller will turn off ALL signal selects.

This procedure will be repeated hundreds of times per second. The effect is that to the human eye the signals are constantly illuminated. In fact, this method is used in the majority of digital clocks like the ones on your VCR, microwave, car, etc. This method has the benefit of reduced wiring and is best utilized when there are many outputs to control. In the case of the *BlockMaster* it only takes 10 wires to control eight signal heads (2 sets of G,Y,R and 4 signal selects). If the Direct Drive method were used, then it would have taken 24 wires (8 sets of G,Y,R). One effect of multiplexing is that lower valued current limiting resistors should be used. Since a given LED is not turned on 100% of the time it will appear dimmer than if it were on constantly. Therefore, lowering the value of R_L will allow more current to get to the LED during the time it is turned on. This will gain back the brightness.

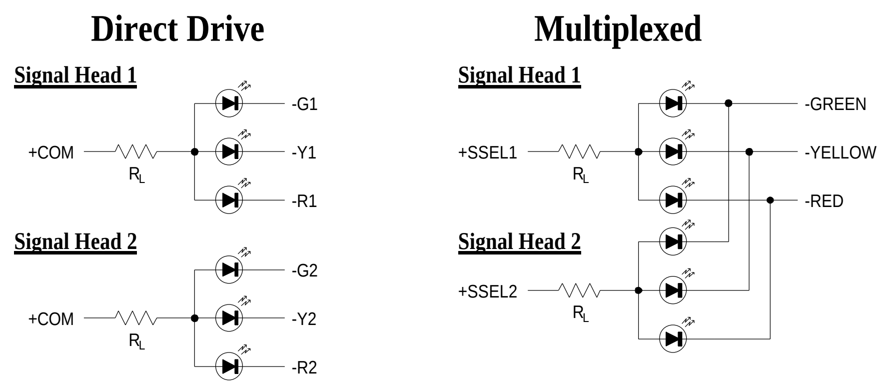


Figure 22

8.2. Standard 3-color Signals

As indicated above the *BlockMaster* uses multiplexing to control the LEDs found in standard 3-color signals (includes everything that doesn't use a bipolar LED). There are two sets of Green, Yellow and Red signal control outputs. These are denoted as GRN-M, YEL-M, RED-M, GRN-S, YEL-S, and RED-S. The "M" stands for "mainline" and the "S" stands for "siding". There are four signal select outputs denoted as SSEL1L, SSEL1R, SSEL2L, SSEL2R. We do not indicate a polarity on these signals since the *BlockMaster* supports common anode and common cathode wiring. The signal selects should be connected to the common side of the LEDs. If the signal was wired for common anode, then the appropriate signal select output would be at a high voltage when the signal was selected and would be at a low voltage (i.e. off) when the signal was deselected. We recommend a value of 68Ω for R_L. We have shown a single current limiting resistor for each signal head. Alternatively you could have a current limiting resistor in each of the G,Y,R paths. In this way you could adjust the relative brightness of the individual LEDs; the choice is yours! The signal head cable has a stripe on one side. Carefully plug the black connector onto the mating gold pins on the *BlockMaster* board with stripe along the lefthand side and near the large white dot on the board. The following table shows the signal head cable pinout for each track configuration (pin 1 on the cable has the stripe):

Pin #	Track Cfg 1	Track Cfg 2a	Track Cfg 2b	Track Cfg 2c	Track Cfg 3	Track Cfg 4
1	SSEL1L	SSEL1L	SSEL1L	SSEL1L	SSEL1L	SSEL1L
2	SSEL1R	SSEL1R	SSEL1R	SSEL1R	SSEL1R	SSEL1R
3	SSEL2L	SSEL2L	SSEL2L	SSEL2L	SSEL2L	SSEL2L
4	SSEL2R	SSEL2R	SSEL2R	SSEL2R	SSEL2R	SSEL2R
5	not used	not used	not used	not used	not used	not used
6	not used	not used	not used	not used	not used	not used
7	not used	not used	not used	not used	not used	not used
8	not used	not used	not used	not used	not used	not used
9	GRN-M	GRN-M	GRN-M	GRN-M	GRN-M	GRN-M
10	YEL-M	YEL-M	YEL-M	YEL-M	YEL-M	YEL-M
11	RED-M	RED-M	RED-M	RED-M	RED-M	RED-M
12	not used	not used	not used	not used	not used	not used
13	GRN-S	GRN-S	GRN-S	not used	GRN-S	GRN-S
14	YEL-S	YEL-S	YEL-S	not used	YEL-S	YEL-S
15	RED-S	RED-S	RED-S	not used	RED-S	RED-S
16	not used	not used	not used	not used	not used	not used

As an example the following illustration shows how your signal heads should be wired for track configuration #1. The current limiting resistors were left out so as not to clutter the diagram.

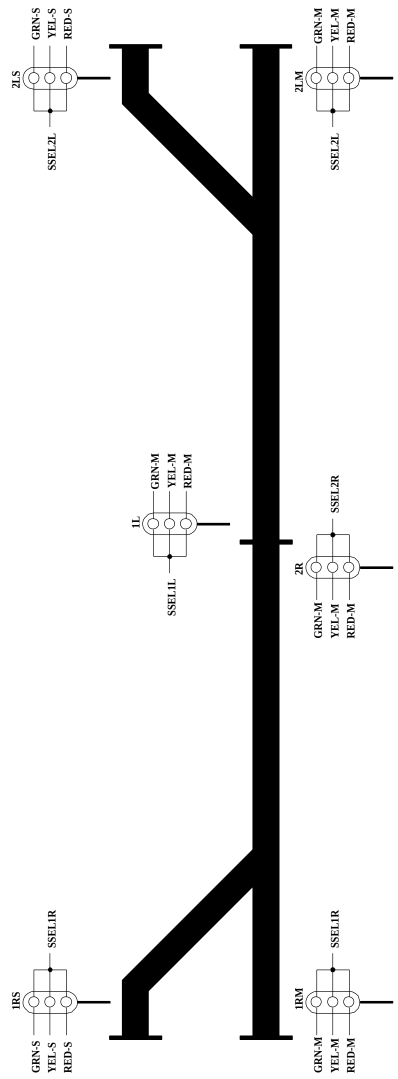

GRN-S
YEL-S
RED-S
2LS
SSEL2L
GRN-M
YEL-M
RED-M
2LM
SSEL2L
GRN-M
YEL-M
RED-M
1L
SSEL1L
SSEL2R
2R
GRN-M
YEL-M
RED-M
SSEL1R
1RS
GRN-S
YEL-S
RED-S
SSEL1R
1RM
GRN-M
YEL-M
RED-M

Figure 23

8.3. Searchlight Signals

The *BlockMaster* uses the direct drive method to control the bipolar LEDs found in searchlight signals. Remember to always use a current limiting resistor; we recommend a value of 150Ω (available from Radio Shack). Higher values will limit the current more and cause the LED to be dimmer. Figure 24 below illustrates the wiring for the two different types of bipolar LEDs. Figure 25 illustrates a different way to use current limiting resistors with a three-lead bipolar LED. In this case you can use a different resistor value for the two colors. In this way you can slightly adjust the brightness of each LED if necessary.

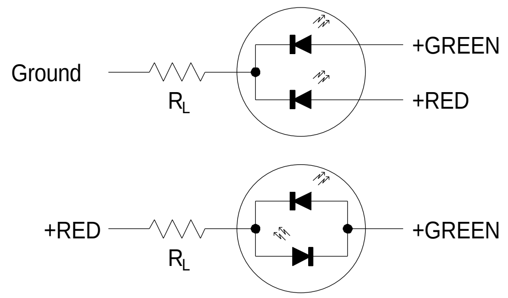


Figure 24

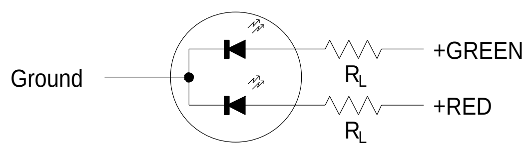


Figure 25

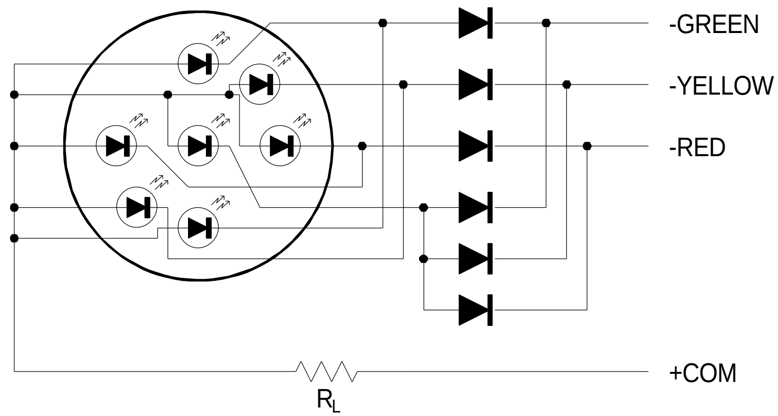
The signal head cable has a stripe on one side. Carefully plug the black connector onto the mating gold pins on the *BlockMaster* board with stripe along the lefthand side and near the large white dot on the board. The following table shows the signal head cable pinout for each track configuration when using searchlight signals (pin 1 on the cable has the stripe):

Pin #	Track Cfg 1	Track Cfg 2b	Track Cfg 2c	Track Cfg 3	Track Cfg 4
1	Red, signal 1RS	Red, signal 1aR	Red, signal 1R	Red, signal 1R	Red, signal 1R
2	Grn, signal 1RS	Grn, signal 1aR	Grn, signal 1R	Grn, signal 1R	Grn, signal 1R
3	Red, signal 1RM	Red, signal 1aLS	not used	Red, signal 1LS	not used
4	Grn, signal 1RM	Grn, signal 1aLS	not used	Grn, signal 1LS	not used
5	not used	not used	not used	not used	not used
6	not used	not used	not used	not used	not used
7	not used	not used	not used	not used	not used
8	not used	not used	not used	not used	not used
9	Red, signal 1L	Red, signal 1aLM	Red, signal 1L	Red, signal 1LM	Red, signal 1L
10	Grn, signal 1L	Grn, signal 1aLM	Grn, signal 1L	Grn, signal 1LM	Grn, signal 1L
11	Red, signal 2R	Red, signal 1bRS	not used	not used	Red, signal 2RS
12	Grn, signal 2R	Grn, signal 1bRS	not used	not used	Grn, signal 2RS
13	Red, signal 2LS	Red, signal 1bRM	Red, signal 2R	Red, signal 2R	Red, signal 2RM
14	Grn, signal 2LS	Grn, signal 1bRM	Grn, signal 2R	Grn, signal 2R	Grn, signal 2RM
15	Red, signal 2LM	Red, signal 1bL	Red, signal 2L	Red, signal 2L	Red, signal 2L
16	Grn, signal 2LM	Grn, signal 1bL	Grn, signal 2L	Grn, signal 2L	Grn, signal 2L

8.4. Position Light Signals

As previously mentioned there are several ways you can wire a position light signal with the *BlockMaster*. These signals can be wired in a common cathode or a common anode configuration. If you are building this type of signal from a kit then you should choose the common to be the same as the rest of your signals. For example, if you're mixing Type D and position light signals from Oregon Rail Supply then you should assemble the position light signal(s) *backwards* from what their directions instruct you to do. In other words, reverse the polarity of the LEDs when you install them in the little circular PCB. If you're building a Pennsy-type position light signal then you will have four control wires (green position LEDs, yellow position LEDs, red position LEDs and center position LED) coming from the signal. You will need to add some inexpensive external diodes (such as the popular 1N914; Radio Shack #276-1122) to properly control the signal. This is shown in Figure 26 below assuming common anode wiring. If you're using common cathode wiring then simply reverse the polarity of the LEDs AND the external diodes. In the case of the absolute signal (two red LEDs) the center LED should only illuminate if the indication is clear or approach. In the case of the permissive signal (all yellow LEDs) the center LED should illuminate under all of the indications. You may want to slightly lower the value of the current limiting resistor since two or three LEDs are lit up simultaneously.

Permissive Position Light



Absolute Position Light

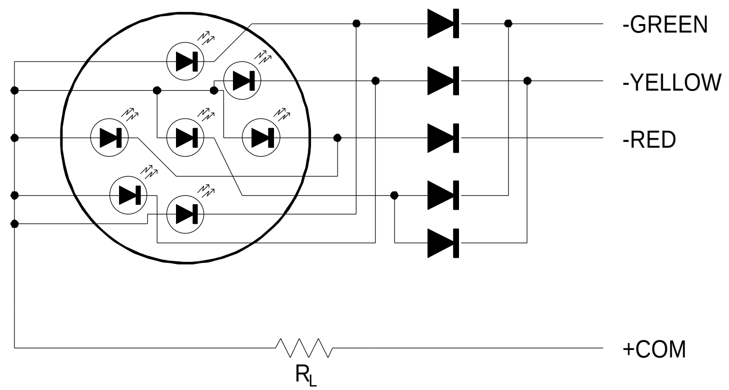


Figure 26

If you're using the B&O/N&W color position light signals then you'll have three control wires corresponding to the three standard colors (green , yellow, and red). The only difference in using this type vs. a Type D signal is that you may want to slightly lower the value of the current limiting resistor since two LEDs (of the same color!) are lit up simultaneously.

9.0 TRAIN DETECTION

9.1. Sensitivity Adjustment

Once the *BlockMaster* is installed on your layout you must adjust the sensitivity of its train detectors. This is easily accomplished by clipping a 100KΩ resistor across the track for each of the two blocks. Rotate the sensitivity adjustment potentiometer (square component marked VR1 for block #1 and VR2 for block #2) fully clockwise using a small slotted screwdriver. Slowly rotate in the counterclockwise direction until the corresponding red LED on the *BlockMaster* turns on. The sensitivity should only need future adjusting if the environment changes drastically (e.g. more humidity). The *BlockMaster* has a built-in delay to eliminate false indications from dirty track. The delay circuitry does not affect the sensitivity adjustment/LED circuitry. When properly adjusted the *BlockMaster* will be able to detect any piece of rolling stock with a resistance of approximately 100KΩ or less (most engines have very low resistances).

9.2. Unpowered Rolling Stock

In order to detect unpowered/unlit rolling stock, a minor modification will have to be made to one or both of the trucks. A 15KΩ resistor (1/4 or 1/8 watt) must be connected across a wheelset. The easiest method is to use a metal wheelset with one end insulated. Remove one of the wheelsets from a truck. Carefully drill a #68 (0.031") hole in each wheel. Insert one end of the resistor into one of the holes keeping the resistor parallel to the axle. Insert the other end into the opposite hole. Center the resistor on the axle without letting the resistor leads touch the metal axle on the insulated side! Clip the resistor leads approximately 1/8" past the outside of each wheel. Bend each lead against the wheel so that it fits securely to maintain connection with the wheel. Alternatively, you may wish to solder the resistor leads to the inside of each wheel. Insert the modified wheelset back into the truck and insure that the truck rolls freely. Adjust if necessary. We also offer ready-to-use detectable wheelsets for HO & N. We use resistors so small you can hardly see them!

9.3 Block Occupied Outputs

The block occupied outputs, **-BO1** and **-BO2**, use an open-collector type driver. This provides the most flexibility for connecting external circuits such as a relay, panel lamp, or digital logic. The output will be ≈0.3V when the block is occupied; it is not affected by the interlocking inputs. It can sink up to 125mA with a +15VDC load supply. Figure 27 shows several possible uses for the block occupied outputs; $+V_L$ is the load voltage supply. The formula in the previous section can be used for determining dropping resistor values for panel lamps. A protection diode (1A/50V such as the popular 1N4001) **MUST** be used in the relay circuit as shown; the voltage supply should match the rating for the relay. Do not mix different load types - in other words, do not connect a relay and a logic circuit to a block occupied output. You may connect up to 10 TTL **or** CMOS logic loads on each block occupied output. A separate power supply may be used for any of these circuits. A +5VDC supply is required for TTL logic circuits; a +3 to +15VDC supply can be used for CMOS circuits. If a separate supply is used you **MUST** connect its ground to the single point ground as described in previous sections.

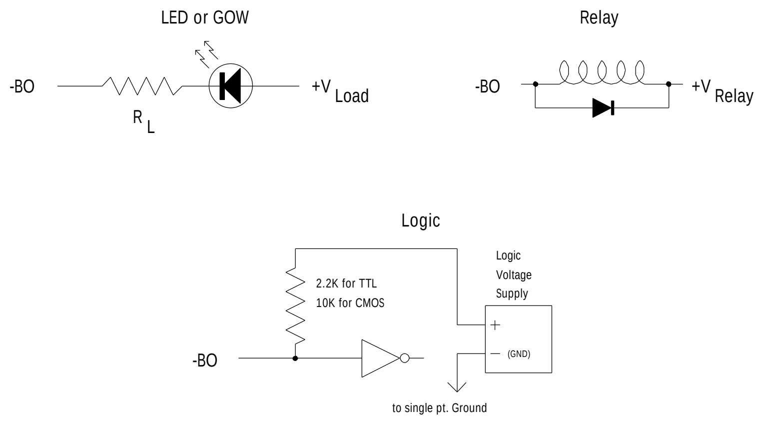


Figure 27

10.0 TECHNICAL SUPPORT

Please direct any questions about the use of this product to ***Logic Rail Technologies.*** You can contact us as follows:

email: info@logicrailtech.com
phone/fax: (281) 251-5813
mail: PMB #287
21175 Tomball Parkway
Houston, TX 77070

Include as much detail as possible about your usage (e.g. voltage supply rating, throttle type, block wiring, signal indicator type, etc.). Comments and suggestions are always welcome.

11.0 WARRANTY

This product is warranted to be free from defects in materials or workmanship for a period of one year from the date of purchase. ***Logic Rail Technologies*** reserves the right to repair or replace a defective product. The product must be returned to ***Logic Rail Technologies*** in satisfactory condition. This warranty covers all defects incurred during normal use of this product. This warranty is void under the following conditions:

1) If damage to the product results from mishandling or abuse.
2) If the product has been altered in any way (e.g. soldering).
3) If the current or voltage limitations of the product have been exceeded.

Requests for warranty service must include a dated proof of purchase, a written description of the problem, and return shipping and handling ($6.00 inside U.S./$8.00 outside U.S. - U.S. funds only). Except as written above, no other warranty or guarantee, either expressed or implied by any other person, firm or corporation, applies to this product.