Some Thoughts on Setup for the TurnoutBoss Board

Bob Jacobsen

January 18, 2025

Abstract

This note discusses using the TurnoutBoss board for basic signaling of a passing siding. It proposes a minimal set of CDI configuration fields.

1 Introduction

The TurnoutBoss is a LCC/OpenLCB board that contains:

- Four signal-head drivers for three-color signal heads
- A driver for a stall-motor turnout driver, e.g. a Tortoise or similar
- Three CT-based occupancy detectors
- Two inputs for turnout-control switches
- Two inputs for turnout position feedback

It's designed to provide a simple implementation for controlling and signaling a simple passing siding. The emphasis here is on simple, so that a new LCC/OpenLCB user can easily install, configure and operate the board.

Figure 1: Example of a railroad with simple passing sidings. Fully signaling this railroad would use four TurnoutBoss boards. The model railroad might have sidings below the main instead of above, but the basic idea is the same.

2 Usual Setup

Each TurnoutBoss operates a single turnout and the signals around it.[1]

For simplicity, by default we expect the user to wire those heads to specific output connectors on the TurnoutBoss board.

Figure 2: The four signal heads around a single turnout. Note that turnouts "c" and "d" are on the same mast.

To calculate basic signal vital logic and drive those signals, the TurnoutBoss board needs to know three things:

1. Turnout position: The board gets this from the setting of its drive output.
2. Occupancy to the next signal: The board gets this partly from its on-board occupancy detectors, and partly via events from adjacent boards.
3. Indication of the next signal, e.g. stop vs not-stop. The board gets this via events from adjacent boards.[2]

[1]Here, we're considering CTC/APB-like signal logic. ABS is another form which puts bidirectional signals at the points-end of the turnout. Although common on the prototype in certain eras, this is much less common in model railroading.

[2]Stop vs not-stop is sufficient for three aspect (Clear/Approach/Stop) signaling. Four aspect (Clear/Advance Approach/Approach/Stop) would require additional events to be exchanged.

For simplicity, we can define a standard way of wiring the occupancy detectors:

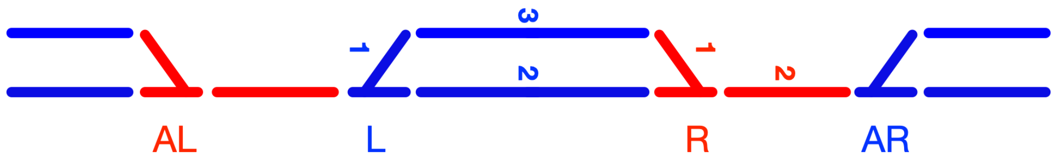

Figure 3: The expected wiring of occupancy detectors on multiple boards. Boards L (Left) and AR (Adjacent Right) detect the main between sidings, a left turnout where the board is located, and the siding. Boards AL (Adjacent Left) and R (Right) detect the right turnout where the board is located and the main between sidings.

Although this requires specific wiring of the track feeds so that they can run by the TurnoutBoss board, the alternatives end up having two boards measuring the same occupancy. This requires that power wiring go through CTs on two boards, which will inconvenient and error prone.

3 Basic Configuration Segment

The "Basic" configuration segment should start with the fields for user-provided identification of the node:

- Node Name
- Node Description

This should be followed by the minimal information needed for the signal logic:

- A binary choice of whether this board is to be configured as a "Left" board or a "Right" board.
- The Node ID of the TurnoutBoss board to the left, and of the TurnoutBoss board to the right. From this, the board can compute the standard EventIDs for itself and from the adjacent boards to indicate occupancy and signal state.

4 Basic On-Board Configuration

In addition to being configured over the LCC network by a configuration tool, the TurnoutBoss board can have its basic configuration done via buttons on the board, with no computer needed.

To do this, we recommend that the boards involved be set up on a workbench so that they're all easily accessible. To configure each board:

- First make sure that the board is at its default settings.
  - Hold down the Teach button.
  - While holding down the Teach button, press and release the Reset button.
  - Once the green, blue and yellow LEDs have come on, you can release the Teach button.
  - Push the Teach button again.
- Next configure the connection to the board to its left.
  - The yellow LED should not be blinking on any other board. If it is, press the Reset button on that board.
  - On the board to the left, press the Reset button, wait until the green LED comes on, then press the Teach button once. The blue LED should be out, and the yellow LED should be blinking once.
  - On the board being configured, press the Reset button, wait until the green LED comes on, then press the Learn button once.
  - The yellow LED on the board to the left should go out.
- Next configure the connection to the board to its right.
  - The yellow LED should not be blinking on any other board. If it is, press the Reset button on that board.
  - On the board to the right, press Reset, wait until the green LED comes on, then press the Teach button twice. The blue LED should be out, and the yellow LED should be blinking twice.
  - On the board being configured, press the Reset button, wait until the green LED comes on, then press the Learn button once.
  - The yellow LED on the board to the right should go out.
- Next, tell the board being configured whether it's at the left end or right end of the siding.
  - The yellow LED should not be blinking on any other board. If it is, press the Reset button on that board.

  - If you want to configure this board to be on the left end of the siding:
    * On the board, press the Reset button, and wait until the green LED comes on
    * Press the Teach button three times. The blue LED should be out, and the yellow LED should be blinking three times.
    * On the board, press the Learn button once. The yellow LED should go out.
  - If you want to configure this board to be on the right end of the siding:
    * On the board, press the Reset button, and wait until the green LED comes on.
    * Press the Teach button four times. The blue LED should be out, and the yellow LED should be blinking four times.
    * On the board, press the Learn button once. The yellow LED should go out.
- Finally, set the some of the hardware configuration, if needed. This only sets some of the hardware configuration information described in the next section. To configure the other values, you'll need to connect a configuration tool.
  - To configure the signal wiring:
    * Hold the Learn button down.
    * Press the Reset button.
    * When the green LED lights, release the Learn button. The blue LED should be on.
    * To set the signals to common cathode. press the Teach button. The yellow LED should be out. The blue and yellow LEDs should go out.
    * To set the signals to bidirectional, press the Teach button. The yellow LED should be blinking once. Press the Learn button. The blue and yellow LEDs should go out.
    * To set the signals to common anode (the default), press the Teach button twice. The yellow LED should be blinking twice. Press the Learn button. The blue and yellow LEDs should go out.

  Note that this configures the wiring for all of the signals. If you want to separately configure the signal head wiring, you'll have to connect a configuration tool.

- To configure the whether the signal at the points is a single-head or double-head signal:
  * Hold the Learn button down.
  * Press the Reset button.
  * When the green LED lights, release the Learn button. The blue LED should be on.
  * To set the signal at the points to double-head (the default) press the Teach button three times. The yellow light should be blinking three times. Press the Learn button. The blue and yellow LEDs should go out.
  * To set the signal at the points to single-head press the Teach button four times. The yellow light should be blinking four times. Press the Learn button. The blue and yellow LEDs should go out.

Repeat this process for each of the boards you are installing.

Although this method allows you to configure basic operation without an attached configuration tool, it doesn't provide access to the all of the Hardware Configuration information in the next section. Some items will remain at default settings.

Selection	Start	Blue	Count	Yellow	Final
Reset to Defaults	Hold Teach & Reset	Lit	(none)	Lit	Teach
Adjacent Left[3]	Reset	Dark	One Teach	One Flash	Learn
Adjacent Right	Reset	Dark	Two Teaches	Two Flashes	Learn
Set Left Board	Reset	Dark	Three Teaches	Three Flashes	Learn
Set Right Board	Reset	Dark	Four Teaches	Four Flashes	Learn
Common Cathode	Hold Learn & Reset	Lit	(none)	None	Learn
Bidirectional	Hold Learn & Reset	Lit	One Teach	One Flash	Learn
Common Anode	Hold Learn & Reset	Lit	Two Teaches	Two Flashes	Learn
Double Head	Hold Learn & Reset	Lit	Three Teaches	Three Flashes	Learn
Single Head	Hold Learn & Reset	Lit	Four Teaches	Four Flashes	Learn

Table 1: Summary of the Teach and Learn button pushes for basic on-board configuration. Note: Set Left Board and Set Right Board are done after the Teach button has been pressed once on the target board.

5 Hardware Configuration Segment

The "Hardware Configuration" segment includes basic information for setting options about the attached hardware:

- For each of the occupancy detectors, the sensitivity adjustment as an immediate slider (Default: Chosen for about 3K sensitivity)
- Is the signal at the points a single or double head? (Default: Double)
- For each of the four signa heads, does it have three outputs (individual LEDs) or two outputs (bi-directional LED with multiplexed yellow)? (Default: three output)
- For each of the four signa heads, if it has three LEDs, are they wired common cathode or common anode? (Default: common anode)
- Are there two turnout pushbuttons, or just one button that alternates the position or do the buttons not control the turnout? (Default: two buttons)

6 Advanced Configuration Segment

The advanced configuration allows the user to change the basic operation of a TurnoutBoss board. The features it enables are:

1. Remote operation and/or display of the turnout position
2. Remote use of the occupancy information for e.g. display
3. Reconnection of the occupancy information so that other, off-board detectors can be used.
4. Use of electrical feedback of the turnout position with either one or two switches.
5. Alternate uses for the button and turnout feedback inputs if they are not being used for their usual purposes
6. Remote control of the signaling logic for e.g. adding a CTC panel
7. Disabling the signal logic so that the signal lamps can be remotely controlled.

The Advanced Configuration Segment starts out hidden, so that the user is not tempted to mess with it.

To make the board completely general, this segment should:

- Expose the two turnout-set Event IDs via both producers and consumers (in addition to the turnout feedback events) so that a panel can track the position and another node can command the turnout to move.

- Expose read-only producers for the six occupancy active/inactive Event IDs so that a panel can track occupancy, and expose consumers for those six Event IDs so that they can be connected to other occupancy hardware as needed.
- Expose four producers for the button inputs so that they can be repurposed if not otherwise in use.
- Expose consumers for the Held/Cleared-leftward/Cleared-rightward Event IDs so that a CTC panel can be added. There is also a "Cleared-Both" state where the signals are just providing APB protection, without CTC control.
- Are the turnout feedback inputs in use? If so, are one or two connected? Expose the two producer EventIDs for those inputs so they can be repurposed if not otherwise in use.
- For each signal head expose both producers and consumers for the stop/not-stop Event IDs from the signaling logic.
- Provide a "don't do signaling logic on the board" option.
- Expose both producers and consumers for the four times four (including dark?) Event IDs to control the lamps in each signal head.

Exposing both producers and consumers allows the default operation to work as expected, while allowing advanced configuration to assert detailed control over that operation. As an example, consider the control of the turnout position. For simplicity, consider that PN and CN are the producers and consumers, respectively, for "Go to Normal" and PD and CD are the producers and consumers, respectively, for "Go to Diverging".

- By default, PN and CN are both set to the same Event ID, and PD and CD are both set to another Event ID. See Section 8.2 Event ID Assignments on page 12 for more information on default Event IDs.

  When the button(s) command a certain position, the relevant Event ID is produced and consumed, and the button moves.

  Any other node consuming the PN and PD Event IDs will also be notified, so e.g. a panel can display the turnout position automatically.

  Another node can also command the turnout to move by producing the correct CN or CD Event ID.
- The user can instead configure PN and CN to different Event IDs from each other, and PD and CD to different Event IDs from each other.

  They would do this if e.g. they wanted some other node to be informed that the button(s) had been pushed via the PN and PD Event IDs being produced so it could compute, including using other information, whether the turnout should be moved via the CN and CD Event IDs.

The same idea applies to the signal head's stop/not-stop producer and consumer pairs, and the signal heads' lamp control producer and consumer pairs.

The producers of occupancy are read-only to make sure that adjacent boards can locate those Event IDs when needed, without having to do initial configuration of multiple boards.

It would be useful to have "Reset to Defaults" action buttons for both the entire Advanced Configuration Segment and for individual sections of it.

7 Not Included

There are some things that an advanced user might want to do with additional logic, but that this TurnoutBoss software does not initially address. Some of these might be included in a later version or a separate set of firmware.

- Controlling the signals using different wiring from the default. The idea of the TurnoutBoss is to make the configuration simple at the cost of using a specific wiring. If that wiring is too much trouble, more complex configuration and even some external signal logic is required.
- ABS-style signaling, where the signal masts for both directions are located at the points of the turnout.
- Four-aspect signaling, e.g. Stop, Approach, Advanced-Approach, Clear
- Intermediate signals, including tumble-down
- Track direction relays
- Signals within the siding, e.g. lap sidings
- Cross-overs

Some functional limitations are due to the TurnoutBoss board's hardware configuration.

- The board only drives common-anode LED signals. Driving common-cathode signals requires some extra, external circuitry and perhaps firmware modifications.
- The board only drives low-current stall-type turnout motors. High-current and coil turnout motors will require external circuitry and perhaps firmware modifications.

8 Theory of Operation

This section discusses details of the operation of the TurnoutBoss. It is not intended as user-level documentation.

None of this is relevant to the basic user.

Advanced users may need to know about the Event IDs, producers and consumers defined in section 8.2 Event ID Assignments.

8.1 Terminology and Definitions

First, we define some terminology for definiteness, and some acronyms for brevity. This covers the entire siding area, e.g. from the main to the left of the siding through main to the right of the siding. Section 8.4.2 Calculation on page 16 will use these as variable names.

TurnoutBoss board abbreviations:

- Board Adjacent Left (BAL) - this is the TurnoutBoss board to the left of the signaled siding, This is “A” in Figure 3 on page 3.
- Board Left (BL) - this is the TurnoutBoss board at the left end of the signaled siding, This is “B” in Figure 3.
- Board Right (BR) - this is the TurnoutBoss board at the right end of the signaled siding, This is “C” in Figure 3.
- Board Adjacent Right (BAR) - this is the TurnoutBoss board to the right of the signaled siding, This is “D” in Figure 3.

Occupancy detections that will be relevant to the BL and BR board:

- Main track occupancy between BAL and BL, a.k.a Occupancy Main Left (OML)
- Turnout occupancy on BL, a.k.a Occupancy Turnout L (OTL)
- Main track occupancy between BL and BR, a.k.a Occupancy Main Center (OMC)
- Siding track occupancy between BL and BR, a.k.a Occupancy Siding Center (OSC)
- Turnout occupancy on BR, a.k.a Occupancy Turnout R (OTR)
- Main track occupancy between BR and BAR, a.k.a Occupancy Main Right (OMR)

For each of the above, “occupied” is considered True and “unoccupied” is considered False.

Turnouts are denoted by "TL" for the turnout driven by the left board (BL) and "TR" for the turnout driven by the right board (BR).

- There are two separate state variables for turnouts to implement feedback: The "Commanded" state and the "Observed" state. The corresponding variables are TLC & TRC and TLO & TRO respectively. The first represents what the turnout has been directed to do by events and/or buttons. The second represents the state of the turnout observed from the feedback contacts, or if feedback is not in use, from the Commanded state.
- The Normal position is considered True and the Diverging position is considered False. In the special cases of two-input feedback mode with neither input active or both inputs active, the Observed state of the turnout is neither True nor False; evaluation of the state will always be false whether TLO or ! TLO is being evaluated (vice TRO and ! TRO).

Signals that will be relevant to the BL and BR board are denoted by:

- Signal cd on the points of the BAL turnout (ScdBAL)
- Signal cd on the points of the BL turnout(ScdBL)
- Signal a on the diverging track of the BL (SaBL)
- Signal b on the main track of the BL (SbBL)
- Signal a on the diverging track of the BR (SaBR)
- Signal b on the main track of the BR (SbBR)
- Signal cd on the points of the BR turnout(ScdBR)
- Signal cd on the points of the BAR (ScdBAR)

Note that in these we refer to the entire mast at the points as "cd", rather than referring to the individual heads. When protecting against a next signal in three-aspect territory, all that matters is whether that signal as a whole is showing Stop or not. The individual signal head's appearance doesn't matter.

To allow dispatcher control of the signal vital logic from e.g. a CTC panel, the signaling around each turnout has four additional states:

- Held (SHD) - the signal logic will keep all signals at Stop
- Cleared-Left (SCL) - the signal logic will keep the right-bound signals at Stop, and allow left-bound signals to clear depending on the occupancy, turnout setting, etc.
- Cleared-Right (SCR) - the signal logic will keep the left-bound signals at Stop, and allow right-bound signals to clear depending on the occupancy, turnout setting, etc.

- Cleared-Both (SCB) - the signal logic will allow both left-bound and right-bound signals to clear depending on occupancy, turnout setting, etc. This is the default state so that the signals will by default allow traffic in both directions when no dispatcher is present at e.g. a CTC panel.

8.2 Event ID Assignments

From these definitions, we can define some standard Event IDs.

For occupancy detection:

Track	Producer Prefix	Occupied	Unoccupied	Consumed by
OML	BAL	00.00	00.01	BL
OTL	BL	00.02	00.03	
OMC	BL	00.04	00.05	BR
OSC	BL	00.06	00.07	BR
OTR	BR	00.08	00.09	
OMR	BR	00.00	00.01	BAR

Table 2: Standard left and right Event ID suffixes for indicating track occupancy. Note that these all have the same prefix, the Node ID of the hardware-resident node. These are both produced and consumed.

Note that the occupancy detection electrical inputs drive different EventIDs depending on whether the TurnoutBoss has been set to be a left or right board.

For turnout operation:

Operation	State	Event ID Suffix	P/C
Command Turnout	Normal	01.00	P/C
Command Turnout	Diverging	01.01	P/C
Turnout Feedback Normal	Active	01.02	P
Turnout Feedback Normal	Inactive	01.03	P
Turnout Feedback Diverging	Active	01.04	P
Turnout Feedback Diverging	Inactive	01.05	P
Normal Button	Closed	01.06	P/C
Normal Button	Open	01.07	P/C
Diverging Button	Closed	01.08	P/C
Diverging Button	Open	01.09	P/C

Table 3: Standard Event ID suffixes for turnout operations. Note that these all have the same prefix, the Node ID of the turnout-controlling node.

For signal lamp operation:

Signal	Red	Yellow	Green	Dark	Lit	Not Lit	Held	Not Held
a	02.00	02.01	02.02	02.03	02.06	02.07	02.08	02.09
b	02.10	02.11	02.12	02.13	02.16	02.17	02.18	02.19
c	02.20	02.21	02.22	02.23	02.26	02.27	02.28	02.29
d	02.30	02.31	02.32	02.33	02.36	02.37	02.38	02.39

Table 4: Standard Event ID suffixes for signal lamp operations. Note that these all have the same prefix, the Node ID of the signal-hardware node. These are both produced and consumed. Also note that with this coding, it's not possible to light two lamps in a single head. The Lit, Not Lit, Held and Not Held event IDs are for compatibility with JMRI. It's not yet clear that they are necessary.

For signal state:

Signal	Stop	Not-Stop	P/C
a	03.00	03.01	P/C
b	03.04	03.05	P/C
cd	03.08	03.09	P/C

Table 5: Standard Event ID suffixes produced for signal state. Note that these all have the same prefix, the Node ID of the signal-controlling node.

Miscellaneous events:

Operation	State	Label	Event ID Suffix	P/C
Vital Logic State	Held	SHD	05.00	C
Vital Logic State	Cleared-Left	SCL	05.01	C
Vital Logic State	Cleared-Right	SCR	05.02	C
Vital Logic State	Cleared-Both	SCB	05.03	C

Table 6: Standard Event ID suffixes for miscellaneous operations. Note that these all have the same prefix, the Node ID of the consuming node.

8.3 Event IDs and Communications for Basic Operation

BAL	BL	BR	BAR
Produces	Produces	Produces	Produces
BAL.00.00 OML	BL.03.00 Sa stop	BR.03.00 Sa stop	BAR.03.08 Scd stop
BAL.00.00 $\overline{\text{OML}}$	BL.03.01 Sa $\overline{\text{stop}}$	BR.03.01 Sa $\overline{\text{stop}}$	BAR.03.09 Scd $\overline{\text{stop}}$
BAL.03.08 Scd stop	BL.03.04 Sb stop	BR.03.04 Sb stop	
BAL.03.09 Scd $\overline{\text{stop}}$	BL.03.05 Sb $\overline{\text{stop}}$	BR.03.05 Sb $\overline{\text{stop}}$	
	BL 00.04 OMC		
	BL 00.05 $\overline{\text{OMC}}$		
	BL 00.06 OSC		
	BL 00.07 $\overline{\text{OSC}}$		
Consumes	Consumes	Consumes	Consumes
	BAL.00.00 OML	BL.03.00 Sa stop	
	BAL.00.00 $\overline{\text{OML}}$	BL.03.01 Sa $\overline{\text{stop}}$	
	BAL.03.08 Scd stop	BL.03.04 Sb stop	
	BAL.03.09 Scd $\overline{\text{stop}}$	BL.03.05 Sb $\overline{\text{stop}}$	
	BR.03.00 Sa stop	BL 00.04 OMC	
	BR.03.01 Sa $\overline{\text{stop}}$	BL 00.05 $\overline{\text{OMC}}$	
	BR.03.04 Sb stop	BL 00.06 OSC	
	BR.03.05 Sb $\overline{\text{stop}}$	BL 00.07 $\overline{\text{OSC}}$	
		BAR.03.08 Scd stop	
		BAR.03.09 Scd $\overline{\text{stop}}$	

Table 7: Events Produced and Consumed for Basic Operation. This table includes only those event IDs needed for the basic signal operation of the central siding: BL and BR.

8.4 Operating Cycle

The basic cycle is

- Input - Wait for either a consumed event or a changed electrical input; record those inputs as state variables.
- Calculation - Calculate new values for output states.
- Output - For each changed output state, produce events and/or drive electrical outputs.

The TurnoutBoss remembers its prior output values on shutdown. On startup, it enters the output phase to output those values, then starts the basic cycle. The exception to this is the Vital Logic State, which is set to "Cleared-Both" (SCB) on startup.

8.4.1 Input

In this phase, the board waits for either a consumed event or a changed electrical input. It records those inputs in the state variables.

The board then enters the calculation phase.

8.4.2 Calculation

In this phase the board records the current state of each output so that it can later tell which one(s) change during the calculation process.

It then calculates new values for the output states.

First, it calculates outputs that come directly from inputs:

- If there are changes to the electrical occupancy inputs mark the associated produced Event IDs as changed, for transmission.
- If there are changes to the electrical button inputs mark the associated produced Event IDs as changed, for transmission.
- If there are changes to the electrical turnout feedback inputs mark the associated producced Event IDs as changed, for transmission.

Then it computes the turnout and signal states.

For left boards, this calculation is:

- Turnout TL Position and Feedback
  - Handle the turnout controls
    - If in two button mode, set TLC appropriately
    - If in one button mode, and button has just become active in this cycle, toggle TLC.
    - If a turnout command Event ID has been received, set TLC appropriately.
  - Handle the turnout feedback
    - If using two input feedback, set TLO appropriately from the inputs.
    - If using one input feedback, set TLO appropriately from the inputs.
    - If not using feedback, set TLO from TLC.
- Signal SaBL
  - Set SaBL to Red and Stop

- If (SCB || SCL) && TLO && ! OML && ! OTL && ! ScdBAL at Stop:

  Set SaBL to Green, Not-Stop
- If (SCB || SCL) && TLO && ! OML && ! OTL && ScdBAL at Stop:

  Set SaBL to Yellow, Not-Stop

- Signal SbBL
  - Set SbBL at Red and Stop
  - If ! (SCB || SCL) && ! TLO && ! OML && ! OTL && ! ScdBAL at Stop:

    Set SbBL to Green, Not-Stop
  - If ! (SCB || SCL) && ! TLO && ! OML && ! OTL && ScdBAL at Stop:

    Set SbBL to Yellow, Not-Stop
- If BL are in two-head mode:
  - Signal ScBL in two-head mode
    * Set ScBL at Red and Stop
    * If (SCB || SCR) && TLO && ! OTL && ! OMC && ! SaBR at Stop:

      Set ScBL to Green, Not-Stop
    * If (SCB || SCR) && TLO && ! OTL && ! OMC && SaBR at Stop:

      Set ScBL to Yellow, Not-Stop
  - Signal SdBL in two-head mode
    * Set SdBL at Red and Stop
    * If (SCB || SCR) && ! TLO && ! OTL && ! OSC && ! SbBR at Stop:

      Set SdBL to Green, Not-Stop
    * If (SCB || SCR) && ! TLO && ! OTL && ! OSC && SbBR at Stop:

      Set SdBL to Yellow, Not-Stop
- If BL in one-head mode
  - Signal ScBL in one-head mode
    * Set ScBL at Red and Stop
    * If (SCB || SCR) && TLO && ! OTL && ! OMC && ! SaBR at Stop:

        Set ScBL to Green, Not-Stop

    - If (SCB || SCR) && TLO && ! OTL && ! OMC && SaBR at Stop:

      Set ScBL to Yellow, Not-Stop

    - If (SCB || SCR) && ! TLO && ! OTL && ! OSC && ! SbBR at Stop:

      Set ScBL to Green, Not-Stop

    - If (SCB || SCR) && ! TLO && ! OTL && ! OSC && SbBR at Stop:

      Set ScBL to Yellow, Not-Stop

  - Signal SdBL in one-head mode
    - Set SdBL to Dark and Stop

- If ScBL at Stop and SdBL at Stop, set ScdBL to Step

  Else set ScdBL to Not-Stop

For right boards, this calculation is:

- Turnout TR Position and Feedback
  - Handle the turnout controls
    - If in two button mode, set TRC appropriately
    - If in one button mode, and button has just become active in this cycle, toggle TRC.
    - If a turnout command Event ID has been received, set TRC appropriately.
  - Handle the turnout feedback
    - If using two input feedback, set TRO appropriately from the inputs.
    - If using one input feedback, set TRO appropriately from the inputs.
    - If not using feedback, set TRO from TRC.
- Signal SaBR
  - Set SaBR at Red and Stop
  - If (SCB || SCR) && TRO && ! OML && ! OTR && ! ScdBAL at Stop:

    Set SaBR to Green, Not-Stop

  - If (SCB || SCR) && TRO && ! OML && ! OTR && ScdBAL at Stop:

    Set SaBR to Yellow, Not-Stop

- Signal SbBR
  - Set SbBR at Red and Stop
  - If ! (SCB || SCR) && ! TRO && ! OML && ! OTR && ! ScdBAL at Stop:

    Set SbBR to Green, Not-Stop
  - If ! (SCB || SCR) && ! TRO && ! OML && ! OTR && ScdBAL at Stop:

    Set SbBR to Yellow, Not-Stop
- Signal ScBR in two head mode
  - Set ScBR at Red and Stop
  - If (SCB || SCL) && TRO && ! OTL && ! OMC && ! SaBR at Stop:

    Set ScBR to Green, Not-Stop
  - If (SCB || SCL) && TRO && ! OTL && ! OMC && SaBR at Stop:

    Set ScBR to Yellow, Not-Stop
- Signal ScBR in one head mode
  - Set ScBR at Red and Stop
  - If (SCB || SCL) && TRO && ! OTL && ! OMC && ! SaBR at Stop:

    Set ScBR to Green, Not-Stop
  - If (SCB || SCL) && TRO && ! OTL && ! OMC && SaBR at Stop:

    Set ScBR to Yellow, Not-Stop
  - If (SCB || SCL) && ! TRO && ! OTL && ! OSC && ! SbBR at Stop:

    Set ScBR to Green, Not-Stop
  - If (SCB || SCL) && ! TRO && ! OTL && ! OSC && SbBR at Stop:

    Set ScBR to Yellow, Not-Stop
- Signal SdBR in two head mode
  - Set SdBR at Red and Stop
  - If (SCB || SCL) && ! TRO && ! OTL && ! OSC && ! SbBR at Stop:

    Set SdBR to Green, Not-Stop
  - If (SCB || SCL) && ! TRO && ! OTL && ! OSC && SbBR at Stop:

Set SdBR to Yellow, Not-Stop

- Signal SdBR in one head mode
  - Set SdBR to Dark and Stop

At the end of the calculation, the board enters the output phase.

8.4.3 Output

In the output phase, each output state is examined to see if it changed during the calculation phase. For each one that changed, the associated electrical outputs (if any) are driven as required and any associated Event IDs are produced.

After each changed output has been processed, the board re-enters the input phase.