

# TrainBoss™ Defect Detector

## Displaying Detector Model No. TB-21D

### Hotbox & Equipment Defect Detector for model railroads

- Displays 6 types of defect alarms for passing trains: hotbox, dragging equipment, high car, wide or shifted load, sliding wheel
- **User defined** alarm probability for each defect type, 1/30 to 1/8000 cars
- Reports train axle count, speed and length, and cumulative axle count per session
- Visual display options to match your railroad's operations:
  1. **Trackside** and/or **Remote Operator** alert on a defect
  2. **Trackside or Remote Operator** display of defect type and axle
- Infrared Axle Sensors support day and night operation in all scales
- 200 mA alerting outputs drive LEDs, motors, relays, or other railroad electronics
- Inputs to 1) Repeat last display, 2) Force alarm on next train, 3) Clear alerts

### Simple installation

- One-piece Axle Sensors slip under installed track and simplify correct alignment
- Screw terminals for all circuit board connections
- Factory configured for immediate use
- Polarity-independent DC (9-12 V) or AC (7-9 V), 250 mA **required**

### Parts List

- Defect Detector Circuit Board
- Infrared Axle Sensors (2)
- Repeat Push Button Switch
- Display Bezel
- Fascia Template
- Vinyl Tubing for Standoffs

**Notice: This product simulates defect detection for model railroads and does not sense the true condition of rail cars.**

### Before You Install

- Your **TrainBoss™ Defect Detector** can be damaged by static electricity. Before removing the circuit board from its packaging, discharge static electricity by touching a bare metal surface.
- Do not make connections when circuits are powered.
- Insulate all exposed connections, preferably with heat shrink tubing.
- Prevent contact between your Defect Detector and track wiring.
- Read through the rest of these instructions before beginning.
- Visit [www.bouldercreekengineering.com](http://www.bouldercreekengineering.com) for additional information.

## 1. Installing Axle Sensors

Only one Axle Sensor is needed for your **TrainBoss™ Defect Detector** to produce alarms. Add the second sensor for train speed and length reports.

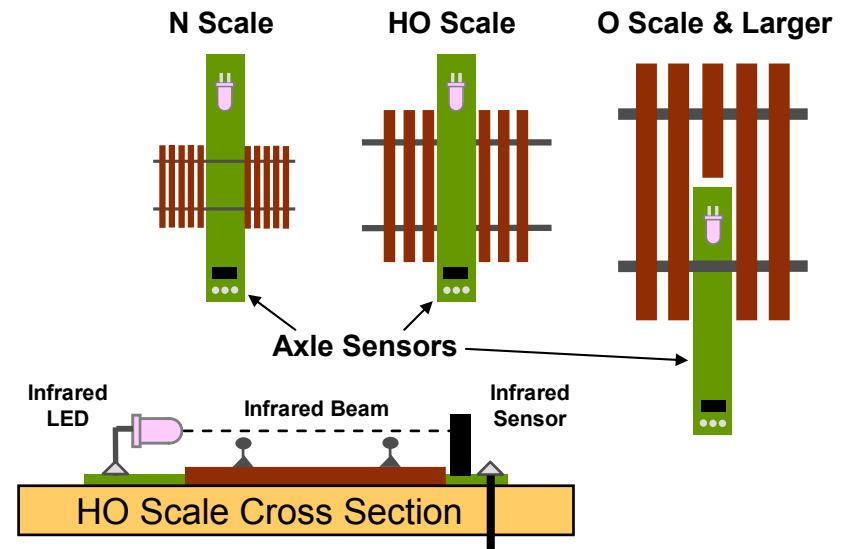
1. Select the location for your Axle Sensors. A straight section of avoids rail car interference problems that long equipment may have on curves.

Close incandescent lighting will interfere with proper Axle Sensor operation. **40 W bulbs within 12 inches will block proper detection.**

2. If you are installing two Axle Sensors, you can install them from 4 to 235 scale feet apart. Over 20 feet is recommended. (The factory setting is 44 feet; change the separation in SV 7 if you choose another spacing.)

**You can install Axle Sensors before or after installing your track. Refer to either Step 3 or Step 4 to match your situation.**

3. Installing the Axle Sensor before installing the track:
    - a. Refer to **Figure 1** for correct Axle Sensor positioning for your scale.
    - b. Carefully bend the Axle Sensor's LED to face the Infrared Sensor.
- Warning: Bending the LED more than once can break the LED.**
- c. Position the Axle Sensor, mark and drill a 3/16" hole for the wires through the roadbed.
  - d. Thread the wires through the hole.
  - e. Remove ties as necessary and lay the track over the Axle Sensor.
  - f. Go to Step 5.



**Figure 1: Axle Sensor Alignment**

4. Installing the Axle Sensor after installing the track:
  - a. Power down your track.
  - b. Refer to **Figure 1** for correct Axle Sensor positioning for your scale.
  - c. Remove ties from the track as necessary.
  - d. Drill a 1/4" hole in the roadbed beneath the track and partially or completely across the rails as in **Figure 1**.
  - e. Cutting with a knife, extend the roadbed hole to the roadbed surface.
  - f. Position the Axle Sensor, mark and drill a 3/16" hole for the wires through the roadbed.
  - g. With the LED leading, slide the Axle Sensor under the rail(s).
  - h. Thread the wires through the 3/16" hole.
  - i. Carefully bend the Axle Sensor's LED to face the Infrared Sensor.

**Warning: Bending the LED more than once can break the LED.**

5. Align the LED to just clear the top of the rail as in the "HO Scale Cross Section" of **Figure 1**. Check that rail cars clear the Axle Sensor.
6. We will test the Axle Sensor(s) later in the installation. Do not glue Axle Sensors in place until your installation is complete and tested.

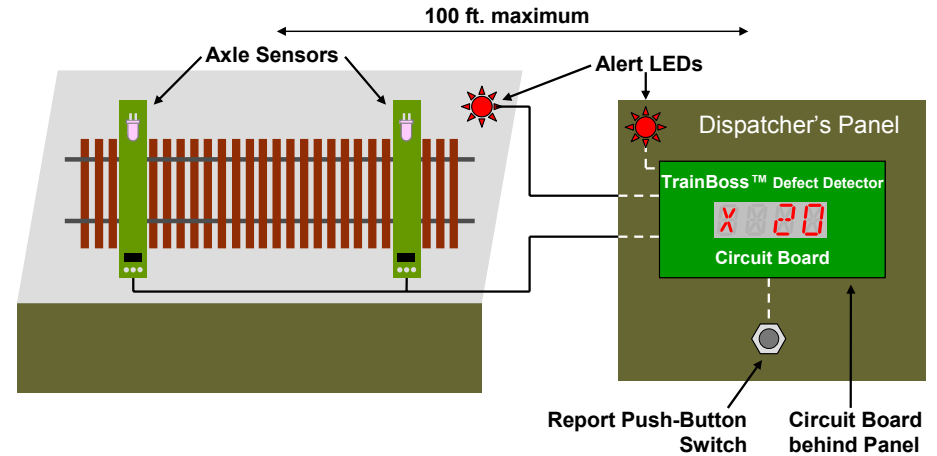
## 2. Choosing an Installation Option

Starting in the 1940s, railroads began to automate train defect detection. A trackside detector either alerted a remote operator (who alerted the train crew) or alerted the train crew directly, typically with a flashing light.

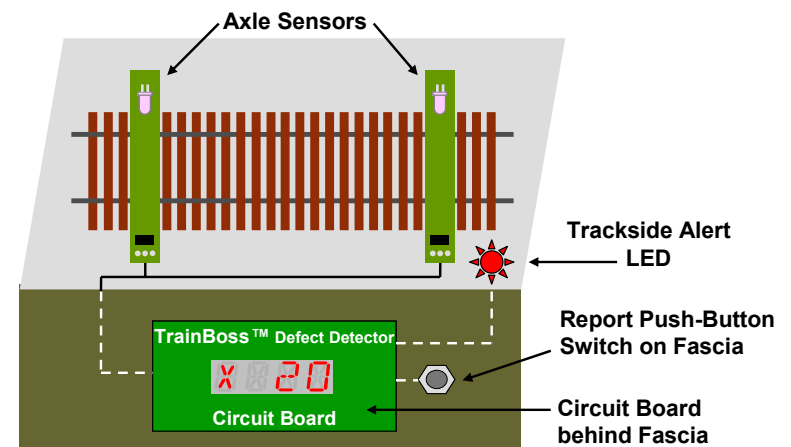
Once the train stopped, either: 1) the remote operator identified the defective car/axle to the train crew, 2) the train crew checked the detector for the identified car/axle, or 3) the train crew walked the train to find the defect.

Your **TrainBoss™ Defect Detector** can be configured to directly notify train crews of a defect, or to signal a remote operator. With two independent outputs, the **TrainBoss™ Defect Detector** can drive a variety of signals, including trackside or remote LEDs, semaphore motors, or railroad electronics such as C/MRI. Visit [www.bouldercreekengineering.com](http://www.bouldercreekengineering.com) for more information on how to interface other electronics to these two outputs.

The Defect Detector's LED display identifies the defect type and location. **Figures 2 and 3** show two options for locating the Defect Detector's circuit board and Alerting LEDs. The circuit board can be up to 100 feet away from the Axle Sensors for remote operators as shown in **Figure 2**. In **Figure 3**, train crews directly read car/axle information from the Defect Detector. Pressing the **Report** push button displays/repeats the message.



**Figure 2: Remote Display Installation**



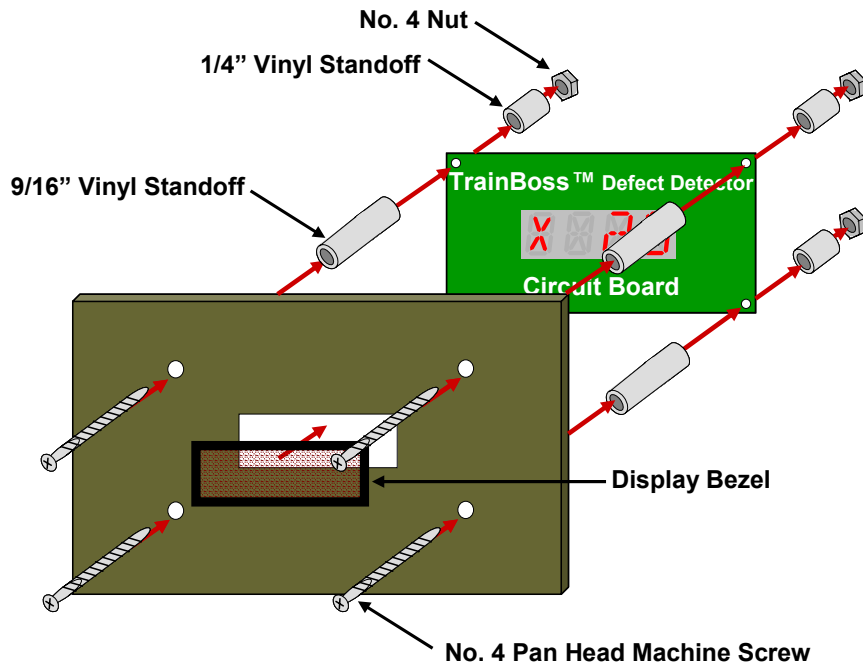
**Figure 3: Trackside Display Installation**

### 3. Installing the Circuit Board

1. You will need 3" clearance behind your panel or fascia.
2. Use the Fascia Template (included) to mark the screw and Display holes on your panel or fascia.
3. Cut out the Display hole; drill the screw holes. Check Display Bezel fit.
4. Install the Defect Detector circuit board as shown in **Figure 4**. Slice 9/16" and 1/4" standoffs from the vinyl tubing provided. The screw holes in the circuit board are for No. 4 pan-head screws (not included).

**Warning: Do not enlarge the circuit board holes or over-tighten the mounting screws as this will damage the circuit board.**

5. Snap the Display Bezel into the Display hole.
6. Trim the 9/16" standoffs to move the Display close to the Bezel if necessary.



**Figure 4: Circuit Board Installation**

### 4. Wiring Instructions

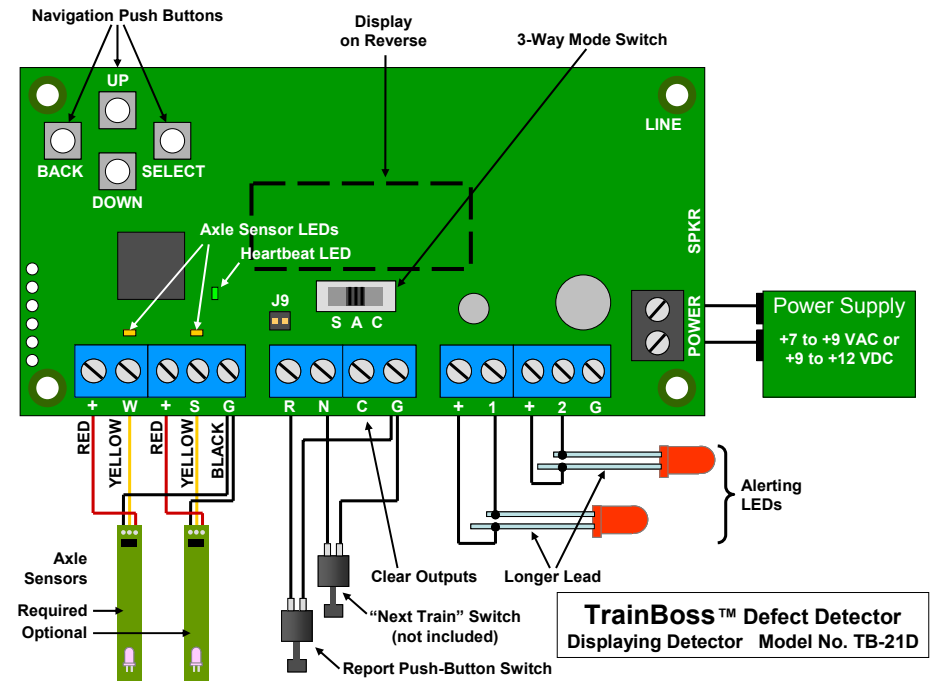
**Figure 5** shows how to wire your **TrainBoss™ Defect Detector** for visual display reporting, along with key features on the circuit board.

1. Connect two wires from your power supply to the Defect Detector power **gray** terminals as shown in **Figure 5**. Polarity does not matter. The power supply must be 7 to 9 Volts AC or 9 to 12 Volts DC, with 250 mA capacity. Radio Shack sells an AC adapter (#273-314) that works well.

**Warning: Do not exceed 9 Volts AC or 12 Volts DC as this will damage the circuit board.**

2. Connect the RED, BLACK and YELLOW wires from the Axle Sensors as shown in **Figure 4**.
3. If you are installing the speed/length Axle Sensor, **remove Jumper J9**.
4. You can wire Alerting LEDs as in **Figure 5**. LEDs are polarity sensitive – connect the long and short leads as shown. Visit [www.bouldercreekengineering.com/manuals.php](http://www.bouldercreekengineering.com/manuals.php) for information on how to interface other electronics to these two outputs. (LEDs not included.)

**Warning: Do not exceed 200 mA on either output as this will damage the circuit board.**



**Figure 5: Circuit Board & Wiring Diagram**

- The **Report** Switch triggers or repeats a defect report. Connect the push button **Report** Switch (included) as shown in **Figure 5** and mount on your fascia.
- The **Next Train** Switch forces a defect report on the next train when pressed, which is nice for testing. If desired, connect a push button **Next Train** Switch (n. o. type – not included) as shown in **Figure 5**.
- Grounding **Clear Outputs** will clear LED Outputs 1 and 2. Visit our website ([www.bouldercreekengineering.com/manuals.php](http://www.bouldercreekengineering.com/manuals.php)) for information on how to interface other electronics to this input.

## 5. Testing Your Installation

- Apply power to your **TrainBoss™ Defect Detector**. The Heartbeat LED should blink once every second. Check your power wiring if it does not.
- Axle Sensor LEDs should be off. Check Axle Sensor alignment if not.
- Set the 3-Way Mode Switch to “A”.
- Break the infrared beam(s) by passing your finger along the track. The Axle Sensor LEDs should flicker. Check your wiring if they do not.

You will see a visual report on the LED Display.

- Repeat Step 4 by running a train. If axle count is correct, glue your “W” sensor in place. **Allow 48 hours for water-based glue to thoroughly dry before connecting to your Defect Detector.**

If axle count is not correct, check the alignment of the “W” Axle Sensor. The infrared beam should just clear the railhead as in **Figure 1**.

If you receive a speed and length report, glue your “S” sensor in place. (Axle count, train speed, and train length are flashed – in that order – on the Display.) Be sure to program SV 7 (see **Section 8**).

If you do not receive a speed or length report, check the alignment of the “S” Axle Sensor. The infrared beam should just clear the railhead as in **Figure 1**. Also check your wiring.

- Congratulations**, your Defect Detector is now operational!

## 6. Basic Operation

### Operating Modes and Mode Switch Positions

The 3-way Mode Switch positions are labeled S, A, and C. See **Figure 5**. Changing the switch position immediately puts the Defect Detector into a new mode:

**S = SETTINGS** – Settings Mode

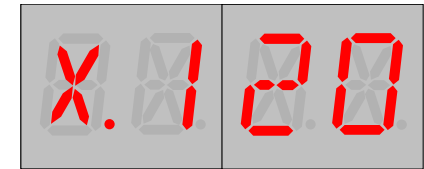
**A or C = RUN** – Run Mode, either **A** or **C** may be selected for operation.

The Defect Detector Circuit Board has a green “Heartbeat LED” that blinks every second while waiting for a train in **A** or **C**. It is steadily on other times.

### Visual Display Operation

Set the 3-Way Mode Switch to **either** the **A** or **C** position. Five seconds after a train passes, the Defect Detector will briefly display axle count, train speed, and train length – in that order – if there are no defects. In case of a defect, a one letter defect code is given as shown in the following table, along with the axle location. **Figure 6** shows a Hotbox on axle 120, north or east.

Letter	Defect Type
X	Hot box
D	Dragging Equipment
S	Sliding Wheel
H	High Car
W	Wide Load
L	Shifted Load



**Figure 6: Axle 120 Hotbox, with north or east rail indicated by decimal point**

### Error Messages

Display	Meaning
<b>*ERR</b>	Starting/stopping/reversing trains close to the Axle Sensors has reset the Detector
<b>*DET</b>	The “W” Axle Sensor is blocked by a railcar upon power up or reset

## 7. Settings Mode Operation

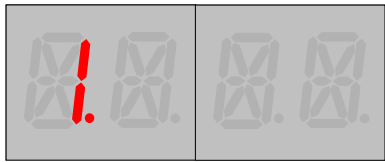
### Settings Mode Basics

While your **TrainBoss™ Defect Detector** works right out of the box, you can customize its performance by changing the values of its Setting Variables (SVs). SVs are similar to Configuration Variables (CVs) for DCC decoders. SVs are stored by the Defect Detector when power is off. Section 8 describes the SVs available for your Defect Detector.

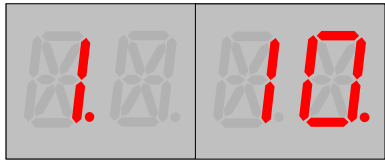
Upon selecting **S** with the 3-way Mode Switch, the Defect Detector enters Settings Mode and will show SV 1, but not a value, on the Display. See **Figure 7a**. Axle Sensors are ignored while in Settings Mode.

While in Settings Mode, the Display shows the number of the current SV, followed by a decimal point. (See **Figure 7a**.) A value for an SV is shown to the right of this decimal point. (See **Figure 7c**.) If this value is the currently stored value for the SV, there is another decimal point to the right of the value. (See **Figures 7b** and **7d**.)

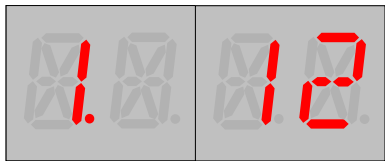
Selecting either the **A** or **C** position on the 3-way Mode Switch will exit Settings Mode. The Defect Detector will immediately begin operation.



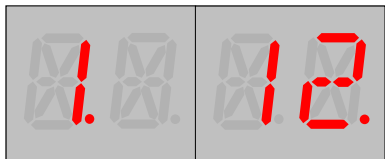
**Figure 7a: Entering Settings Mode.** SV 1 is displayed with decimal point to the right. No value shown while navigating among SVs.



**Figure 7b: SV with its stored value.** SV 1 has a stored value of 10. Stored value is indicated with decimal point to the right of the value.



**Figure 7c: SV with unstored value.** Pressing UP jumps the value from 10 to 12 as 11 is not a valid value for this SV. (See Section 7 Setting Variable Descriptions.) No decimal point to right of 12 indicates it is not a stored value.



**Figure 7d: SV with new stored value.** Selecting this unstored value will store it, and a decimal point appears to its right indicating it is the stored value.

### Navigating SVs

1. Use the Navigation pushbuttons (UP, DOWN, SELECT, BACK – see **Figure 4**) and the Display to move among SVs. A light touch is best.
2. Use UP and DOWN to move forward and backward among SVs.
3. Holding down the UP and DOWN pushbuttons will move rapidly through SVs in the direction indicated.
4. UP and DOWN pushbuttons “wrap around” between the highest and lowest SV. Unused SVs are skipped.
5. Pressing the SELECT pushbutton stops navigation among SVs and displays the stored value of the displayed SV. SV value can now be changed as described in “Changing SV Values” below. See **Figure 7b**.
6. Returning the 3-way Mode Switch to **A** or **C** position exits Settings Mode.

### Changing SV Values

1. When the SV value is displayed, use the four pushbuttons (UP, DOWN, SELECT, BACK) and the Display to select a value for the current SV.
2. Use UP and DOWN to increase or decrease the displayed SV value. See **Figures 7b** and **7c**.
3. Holding down UP and DOWN pushbuttons will move rapidly through values in the direction indicated.
4. UP and DOWN pushbuttons “wrap around” between the highest and lowest value. Unused SV values are skipped.
5. Pressing the SELECT pushbutton will store the displayed value for this SV. A decimal point appears to the right of the value to indicate it is the new stored value. See **Figure 7d**.
6. Pressing the BACK pushbutton will stop display of values and return to navigating SVs as described above. See **Figure 7a**.
7. Returning the 3-way Mode Switch to **A** or **C** position exits Settings Mode.

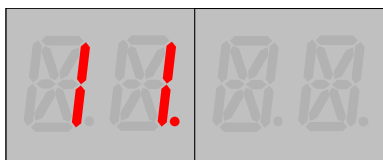
### Bit-Wise SV Values

SVs 11 through 15 turn features on or off by storing a one or zero in a particular bit position. See SV 11 for a good example.

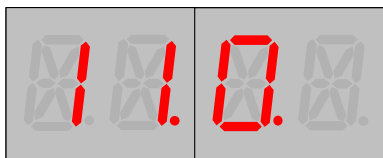
To avoid fancy arithmetic, these bit-wise SVs have an additional level of navigation. See **Figure 8**. Here it is step by step:

1. Navigate to the desired SV with UP and DOWN. See **Figure 8a**.
2. Press SELECT. The Bit Number is displayed. See **Figure 8b**.

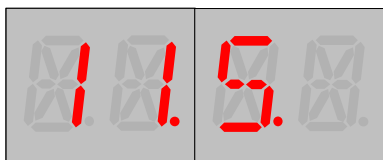
3. Navigate to the desired Bit Number (UP, DOWN). See **Figure 8c**.
4. Press SELECT. The Bit value is displayed. See **Figure 8d**.
5. UP and DOWN will move the Bit value between 0 and 1. Press SELECT to store the displayed value. See **Figure 8e**.
6. BACK will stop display of Bit values and return to navigating Bit Numbers. See **Figures 8b** and **8c**.
7. Returning the 3-way Mode Switch to **A** or **C** position exits Settings Mode.



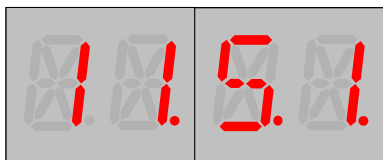
**Figure 8a: Navigate to desired SV.**  
SV 11, our target, is displayed. Compare to **Figure 7a**.



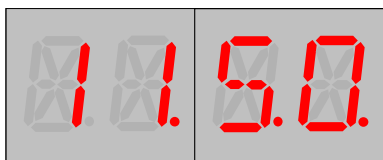
**Figure 8b: Bit Number displayed.**  
SELECT causes Bit Number to display with decimal point to its right. Bit 0 is the first Bit Number displayed.



**Figure 8c: Navigate to desired Bit.**  
UP and DOWN are used to navigate to our target, Bit 5. This bit will cause Output 1 to turn off after 30 seconds if it is set to "1".



**Figure 8d: Current Bit value.**  
SELECT causes Bit value to display. "1" is the current stored value.



**Figure 8e: New stored Bit value.**  
UP/DOWN move back and forth between "0" and "1" Bit values. SELECT stores new value of "0" – Output 1 is now held on indefinitely.

## Returning to Factory Default

While in Settings Mode, you can return your Defect Detector SVs to their original values:

1. While navigating SVs, depress and hold the BACK pushbutton.

2. While holding down BACK, depress and hold down both the UP and DOWN pushbuttons at the same time.
3. After 4 seconds, the Defect Detector will show \*RST.
4. Release all three pushbuttons. All SVs are now reset to original values.

## Viewing Session Axle Count

While in Settings Mode, you can view total axles counted since power on:

1. While navigating SVs, depress and hold the BACK pushbutton.
2. While holding down BACK, depress and hold down the SELECT pushbutton at the same time.
3. After 4 seconds, the Defect Detector will show the total axles since power up. The Detector will count up to 4095, then roll over to 0.
4. Release both pushbuttons to return to navigating SVs.

## 8. Setting Variable (SV) Descriptions

Visit our website ([www.bouldercreekengineering.com/manuals.php](http://www.bouldercreekengineering.com/manuals.php)) for worksheets to record your SV settings.

### SV 1 – 6: Defect Probabilities

**Description:** The average number of 4-axle cars per defect. The value stored and displayed is 1/10 of the actual rate, so multiply by 10 for the true value.

If more than one defect is active, the rates add. For example, if both Hotbox and Dragging Equipment are set to 100 (10 stored), you could expect one of each defect every 100 cars, or some type of defect roughly every 50 cars.

**Valid Values:** 0 (defect disabled), 3, 4, 5, 6, 8, 10, 12, 15, 20, 25, 30, 40, 50, 60, 80, 100, 120, 150, 200, 270, 400, 800

**Examples:** 3 = 30; 10 = 100; 800 = 8000 cars per defect

SV	Defect	Default
1	Hotbox	10 (=100)
2	Dragging Equipment	0 (disabled)
3	Sliding Wheel	0 (disabled)
4	High Car	0 (disabled)
5	Wide Load	0 (disabled)
6	Shifted Load	0 (disabled)

**Note:** This probability is an average. For example, with the default setting and after 5000 cars have passed, you would expect to have seen about 50 hotboxes. But just as in real life, you can't predict when stuff will happen!

### SV 7: Axle Sensor Separation

**Description:** The distance in scale feet between the two Axle Sensors.

**Valid Values:** 4 – 235, minimum of 20 suggested

**Default Value:** 44 scale feet

**Examples:** 20 scale ft. between sensors; 44 scale ft. between sensors

### SV 8: Engine Axles

**Description:** Engine axles on front of train. Defects will not be assigned to these axles during normal operation – and avoided if possible for a “Next Train” event – if SV 15, Bit 4 is active.

**Valid Values:** 4- 235

**Default Value:** 8 axles                      **Examples:** 4 axles, 12 axles, 18 axles

### SV 11,12: Output Behavior

**Description:** Defines Output 1 and Output 2 behavior with individual bits.

Outputs are **on** or **off**. Outputs are either pulled to ground or open circuit when **on** and **off** as set by Bit 2.

- SV 11 controls Output 1
- SV 12 controls Output 2

**Default Value:** 01000010

Bit 7	6	5	4	3	2	1	Bit 0
<b>Opp 1<sup>a</sup></b>	<b>Clr Rpt</b>	<b>ClrTime</b>	<b>DbITime<sup>b</sup></b>	<b>Reserved</b>	<b>Invert</b>	<b>Output Action</b>	

#### Bit 7 **Opposite Output 1**

<sup>a</sup>Valid for SV 12 Output 2 only, ignored for SV 11 Output 1

1 = Output 2 puts out opposite value of Output 1, **off** if Output 1 is **on** and vice versa. The rest of this SV is ignored.

0 = Output 2 is independent of Output 1 and the rest of this SV determines Output 2 behavior (**default**)

#### Bit 6 **Clear on Report**

1 = Output is cleared when **Report** input activated (**default**)

0 = Output is not cleared when **Report** input activated

#### Bit 5 **Clear on Time**

1 = Output is cleared after time set by Bit 4

0 = Output is not cleared after time set by Bit 4 (**default**)

#### Bit 4 **Double Time**

<sup>b</sup>Value in SV 11 applies to both Output 1 and Output 2.  
 Bit 4 in SV 12 is ignored.  
 1 = Output is cleared after 60 seconds  
 0 = Output is cleared after 30 seconds (**default**)

#### Bit 3 **Reserved** (ignored)

#### Bit 2 **Invert**

1 = Output pulled to ground when **off**, open circuit when **on**  
 0 = Output open circuit when **off**, pulled to ground when **on** (**def**)

#### Bits 1, 0 **Output Action**

11 = Flash **on/off** when train has defects, patterned by SV 13/14  
 10 = **On** steady only when train has defects (**default**)  
 01 = **On** steady only when train has no defects  
 00 = **On** steady when train has no defects or output is cleared

### SV 13,14: Output Flash Pattern

**Description:** Defines **Output 1** and **Output 2** flash patterns.

Corresponding Output Behavior SV must be set to Flash.  
 Each bit turns the output **on** or **off** for 1/8 of a second, with 1 = **on** and 0 = **off**. Bit 0 controls the first 1/8 sec, Bit 1 the second 1/8 sec, etc. Pattern repeats every second.

- SV 13 controls Output 1
- SV 14 controls Output 2

**Default Value:** 00001111 (on ½ sec, off ½ sec)

**Examples:** 00001111 is **on** for ½ sec., then **off** for ½ sec.  
 01010101 is **on/off** 4 times per second

### SV 15: Control

**Description:** Defines miscellaneous control values with individual bits.

**Default Value:** 00111011

Bit 7	6	5	4	3	2	1	Bit 0
<b>Reserved</b>	<b>Max Defects</b>	<b>No Eng</b>	<b>Display</b>	<b>Reserved</b>			

#### Bit 7 **Reserved** (ignored)

#### Bits 6, 5 **Maximum Defects per Train**

11 = 3 max def/train                      01 = 1 max def/train (**default**)  
 10 = 2 max def/train                      00 = defects will not be reported

Bit 4 **No Engine**

1 = Engine axles will not receive defects per SV 8 (**default**)

0 = Engine axles can receive defects

Bit 3 **Visual Display Enable**

1 = Messages always visually displayed (**default**)

0 = Message displayed only when **Report** push button depressed

Bits 2 - 0 **Reserved** (ignored)

## **Support & Service**

If you have problems with your **TrainBoss™ Defect Detector**, please consult our website [www.bouldercreekengineering.com](http://www.bouldercreekengineering.com). If you need additional help, please contact us at [support@bouldercreekengineering.com](mailto:support@bouldercreekengineering.com).

Your Defect Detector can be repaired with a charge for parts and labor. Please contact [support@bouldercreekengineering.com](mailto:support@bouldercreekengineering.com) for a cost estimate on non-warranty repairs before sending product to us.

## **Limited Warranty**

Boulder Creek Engineering, LLC warrants its products to be free of defects in materials and workmanship for a period of **one (1) year** from the purchase date. Defective product received by Boulder Creek Engineering during the warranty period will be repaired or replaced at our option. You must pay shipping to and from Boulder Creek Engineering.

This warranty does not cover damage resulting from negligent installation, improper operation, or unauthorized repair or modification. Removal of the heat shrink voids this warranty. Boulder Creek Engineering makes no other warranty of any kind, expressed or implied. In no event shall Boulder Creek Engineering be liable for incidental or consequential damages.

For warranty service, please contact Boulder Creek Engineering for a Return Merchandise Authorization (RMA) number. Product must be shipped to Boulder Creek Engineering with dated proof of purchase (your receipt).



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