USER'S MANUAL

RibEye™ Multi-Point Deflection Measurement System

3-Axis Version for 50th Male Hybrid III ATD

Hardware Manual for Model 7800B-3

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Boxboro Systems, LLC
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1.0 Overview

The RibEye measurement system is made up of several hardware components, described in this manual. Detailed specifications appear in **Appendix A**. This manual does not cover the RibEye control software.[1]

The components of the 3-axis RibEye for the 50th Male ATD are identified in **Figures 1–7**. (Not all of the components appear in every figure.) The components are –

- The RibEye controller("A"), located in the ATD spine.
- A sensor bar ("B"), which contains three optical sensors. The bar is mounted to the spine and is permanently wired to the controller.
- Six light-emitting diodes (LEDs), two sets of 3 each ("C"), which are mounted on the rib stiffener bars on the sides of the sternum. Some of the LEDs have an angled mounting surface that aims the LEDs toward the sensors to minimize power requirements. **DANGER:** *The LEDs are very bright when driven at full power. Do not look directly at the LEDs.*
- Two LED connector blocks ("D"), which are mounted on the sides of the spine box.
- The interface box ("E"), also called the trunk box because it is typically placed in the trunk of the vehicle.
- A power cable and a communication cable that are bundled together ("F"). The cables connect the RibEye controller to the trunk box.
- A power input cable ("G"), which connects the trunk box to the customer's power supply.
- A data acquisition system (DAS) interface cable ("H"), which connects the trunk box to the customer's DAS for trigger and control signals. **Appendix B** contains the DAS/trigger connector pinouts and trigger circuits.
- Modified Hybrid III 50th spine (I) that the RibEye components mount to.
- Controller cable removal tool (J) that allows removal of the power and control cables without unbolting the controller from the spine

Figures 8 and 9 show how the components are interconnected and mounted.

[1] The RibEye Software User's Manual describes the installation and operation of the RibEye software. The software manual can be found on the disk shipped with the RibEye, or it can be downloaded from the Boxboro Systems website at http://www.boxborosystems.com/servicepage.html. RibEye Software Release Notes provide updates in-between revisions to the software manual and can also can be downloaded from the same link. If you want to write your own software to control the RibEye, you can download the RibEye Communications Protocol from this link.

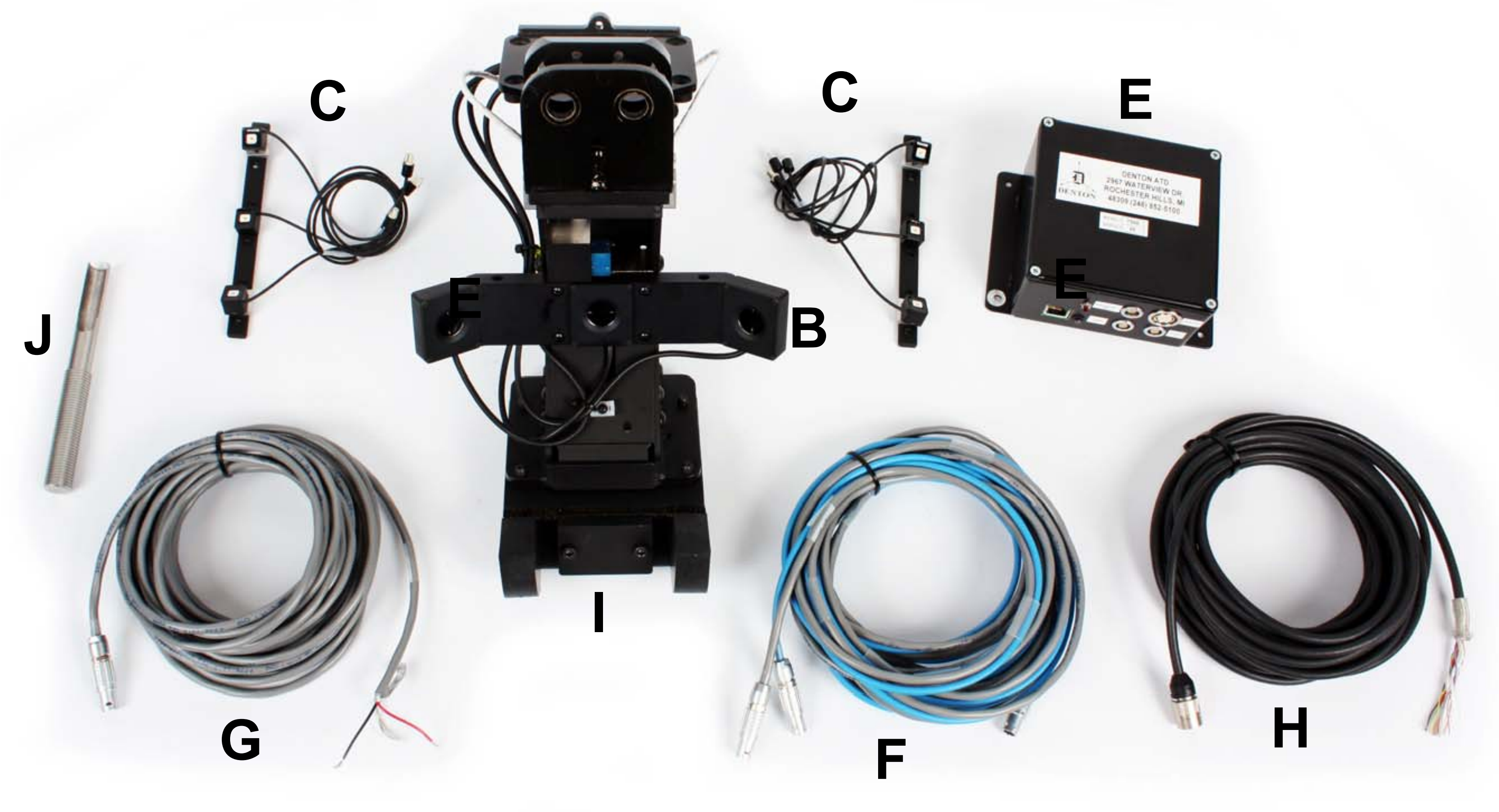

Figure 1. RibEye components

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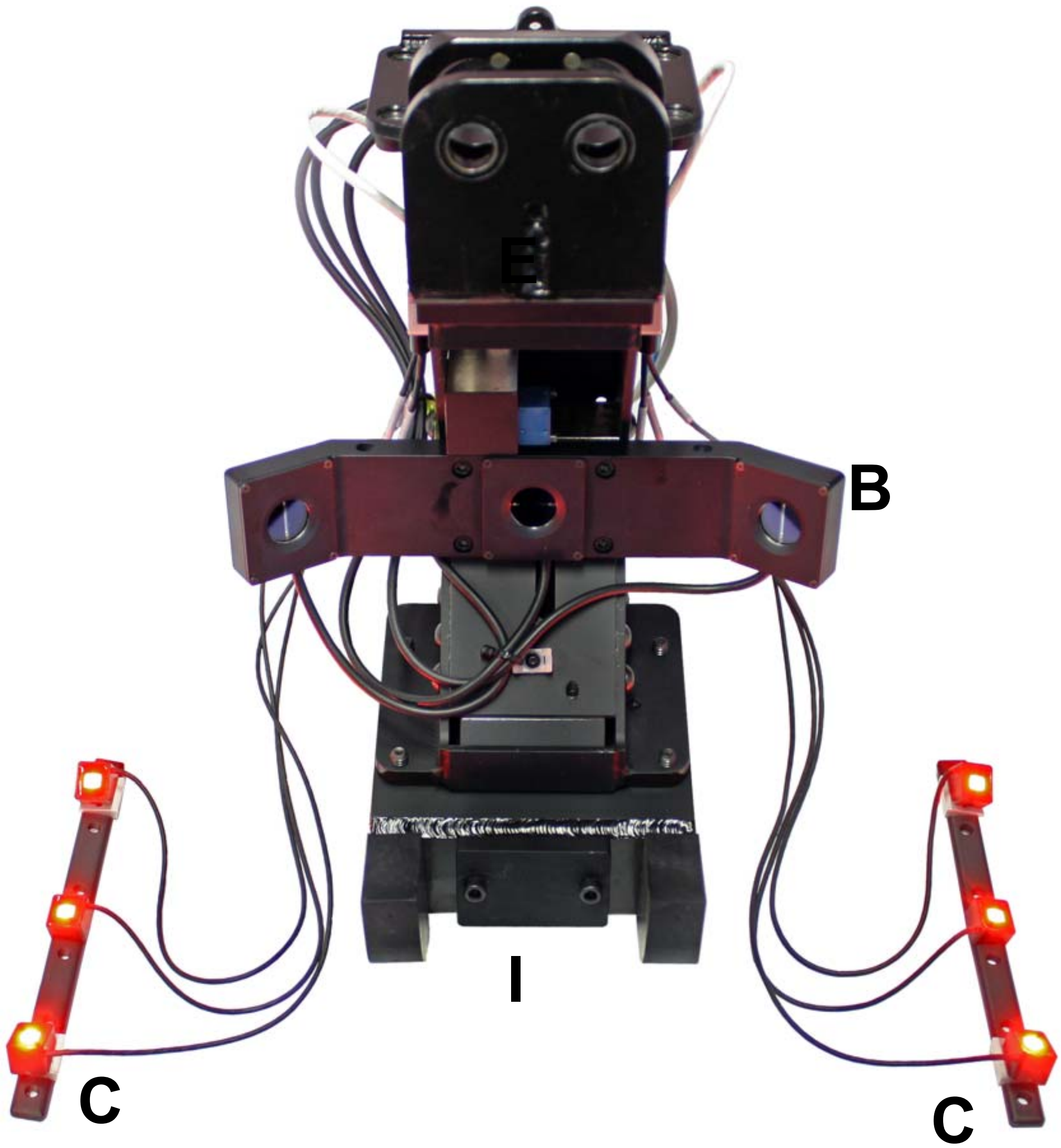


Figure 2. RibEye components mounted on spine box – front view

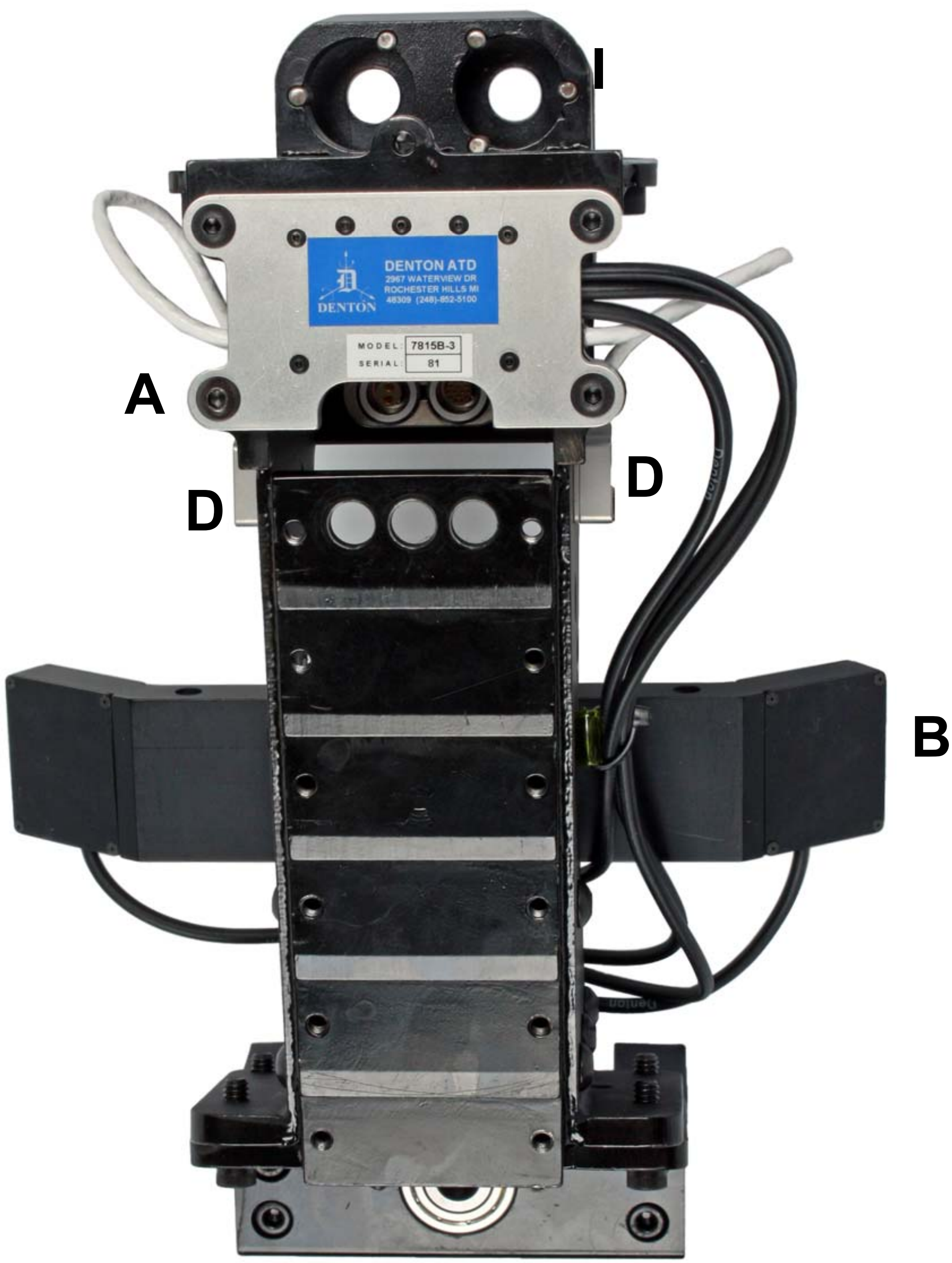


Figure 3. RibEye components mounted on spine box – rear view

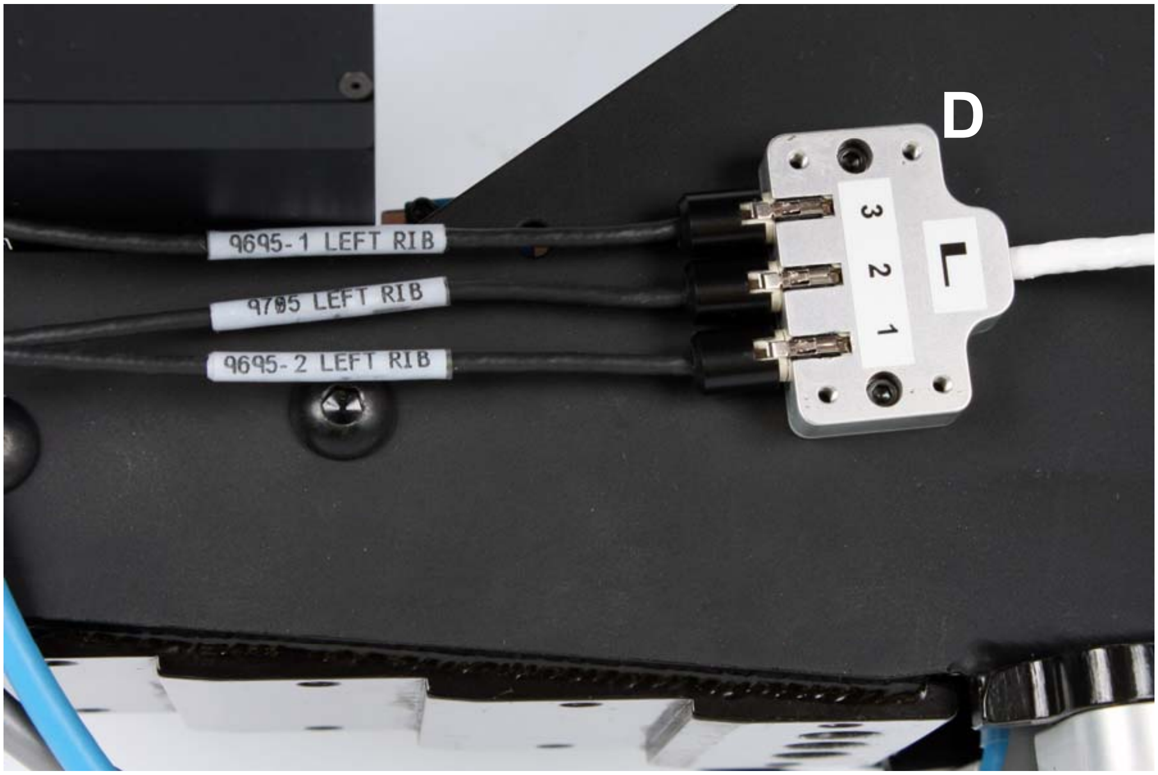


Figure 4. LED connectors on left side of spine box

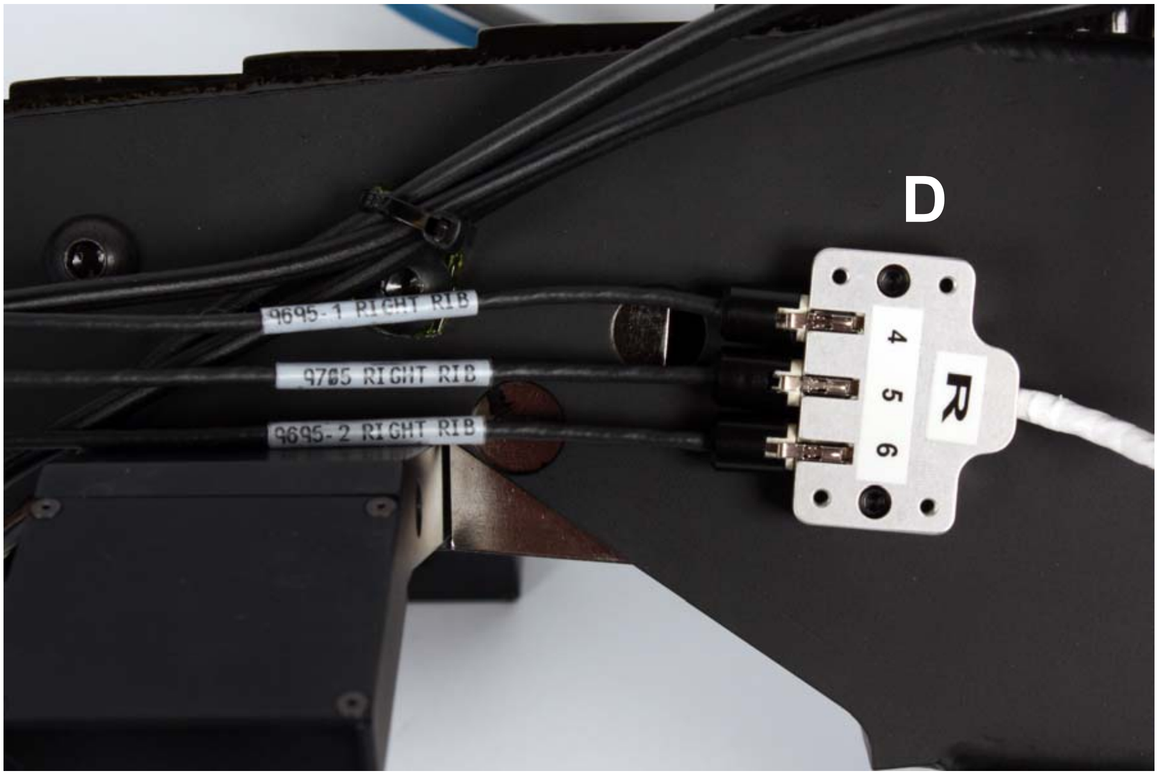


Figure 5. LED connectors on right side of spine box

Figure 6. LEDs mounted on rib stiffeners

Figure 7. Trunk box (interface box)

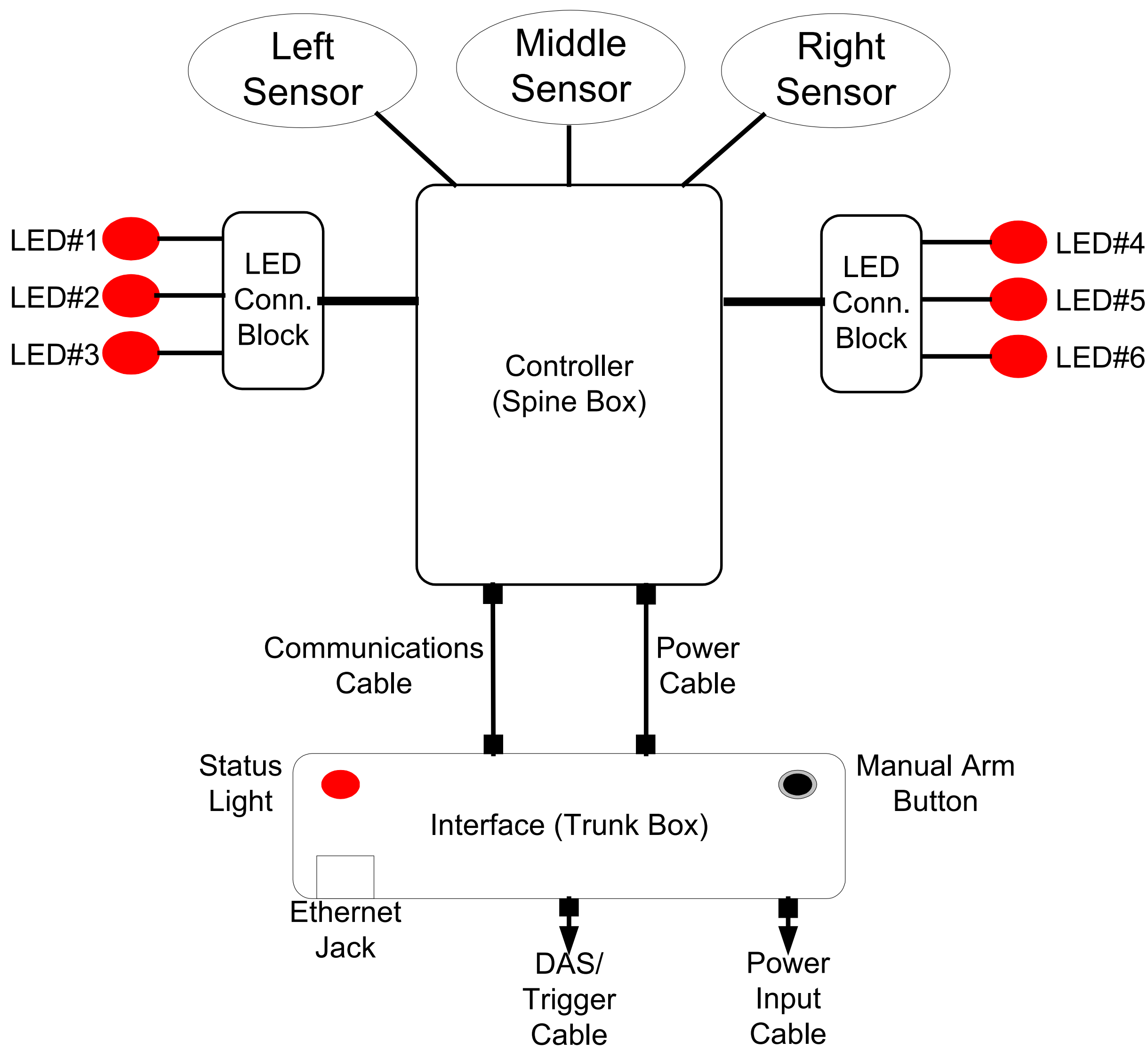
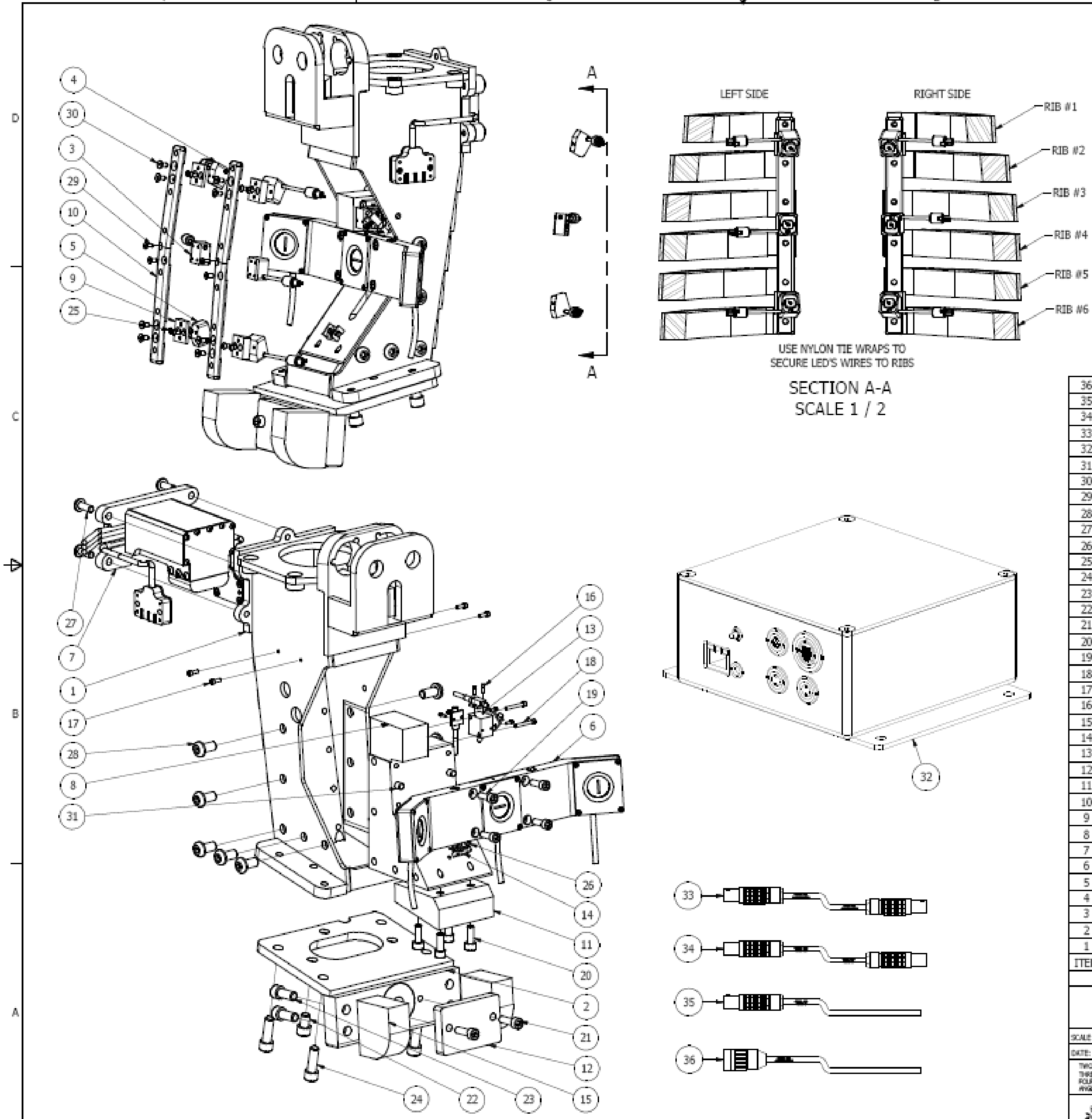


Figure 8. RibEye connections



ITEM	QTY	PART NUMBER	DESCRIPTION
36	1	FL-48	24 PIN COMMUNICATION CABLE
35	1	7594	2 PIN POWER SUPPLY CABLE
34	1	7593	2 PIN POWER CABLE
33	1	7592	14 PIN COMMUNICATION CABLE
32	1	7590	TRUNK BOX
31	2	98381A505	.1875 DIA. X 1/2 LG. DOWEL
30	8	91253A106	#4-40 X 1/4 LG. FHCS
29	4	91253A077	#2-56 X 1/4 LG. FHCS
28	10	91255A537	1/4-20 X 1/2 LG. BHCS
27	4	91255A265	#10-32 X 1/2 LG. BHCS
26	1	91255A106	#4-40 X 1/4 LG. BHCS
25	8	91255A076	#2-56 X 3/16 LG. BHCS
24	4	91251A540	1/4-20 X 3/4 LG. SHCS
23	4	91251A539	1/4-20 X 5/8 LG. SHCS
22	2	91251A535	1/4-20 X 3/8 LG. SHCS
21	2	91251A344	#10-32 X 5/8 LG. SHCS
20	4	91251A342	#10-32 X 1/2 LG. SHCS
19	4	91251A194	#8-32 x 1/2 LG. SHCS
18	2	91251A102	#2-56 X 5/8 LG. SHCS
17	4	91251A077	#2-56 X 1/4 LG. SHCS
16	6	91251A054	#0-80 X 3/16 LG. SHCS
15	2	78051-85	MOLDED STOP
14	1	7566k12	CABLE ANCHOR
13	1	5039	ACCEL MOUNT
12	1	9703	FRONT BALLAST WEIGHT
11	1	9701	BALLAST WEIGHT
10	2	9694	RIB BAR
9	4	9697	ADAPTOR PLATE
8	1	9681	CENTER MOUNTING BLOCK
7	1	78158-3	RIBEYE PROCESSOR/POWER BOARD HOUSING
6	1	9645	SENSOR HEAD ASSEMBLY
5	2	9695-2	22 DEGREE LED ASSEMBLY
4	2	9695-1	22 DEGREE LED ASSEMBLY
3	2	9705	FLAT LED ASSEMBLY
2	1	9699	ALTERED ADAPTOR ASSEMBLY
1	1	9641	ALTERED HIII-50TH SPINE BOX

Parts List

HIII-50th RIBEYE ASSEMBLY 3 AXIS
HIII-50th MALE DUMMY

SCALE: 1 : 2	SHEET 1 OF 1	DRAWN BY: ctorchala
DATE: 3/9/10	DO NOT SCALE DRAWING	MODEL: 7800B-3

ROBERT A. DENTON INC.
2967 WATERVIEW DR. ROCHESTER HILLS, MICHIGAN 48309

DRAWING NUMBER: C-7800B-3-D

Figure 9. Diagrams for mounting RibEye components

2.0 Mounting the RibEye

Diagrams for mounting the RibEye controller, sensor heads, and LED connector blocks are shown in **Figure 9**. The controller, sensor head assembly, and connector blocks should be mounted to the dummy's spine prior to assembling the ribs onto the spine. The following mounting instructions are for application in the 50^{th} Male Hybrid III ATD, Model 7800B-3.

2.1 Controller mounting

The RibEye controller is mounted inside the top of the dummy spine in the rectangular opening. The power and communication cables can be connected to the controller before or after the controller is mounted in the spine. The controller slides into the spine and is attached with four screws (shown at the top of **Figure 3**). The power and communication cables come out from the back of the spine and then down under the skin to exit at the bottom of the jacket. These cables are then routed to the interface box.

2.2 Sensor head assembly mounting

The sensor head assembly is mounted to the spine weight inset with four screws and two dowel pins as shown in **Figure 9**. Note that the sensor assembly is oriented such that the cables are pointed downwards. The sensor head assembly is also shown in **Figures 1–3.**

2.3 LED connector block mounting

The two LED connector blocks mount on the sides of the spine box with two screws for each. **Figures 4 and 5** show the connector block mounted on the left and right sides of the spine. Note that the LED connectors have a locking tab that must be pressed to remove them from the connector block.

2.4 LED mounting

After the controller, sensor heads, and connector block are mounted, the ribs can be assembled onto the spine and sternum. The LEDs are mounted to the rib stiffeners as shown in **Figures 6 and 9,** using two #4-40 screws for each LED. Some of the LEDs have an angled mounting surface that aims the LEDs toward the sensors to minimize power requirements.

The LED cables should be securely fastened to the ribs using black nylon cable ties. The LEDs are plugged into the LED connector blocks as follows:

Left Side	Right Side
Top LED = #1	Top LED = #4
Middle LED = #2	Middle LED = #5
Bottom LED = #3	Bottom LED = #6

The RibEye uses different calibration curves to process the LED data, depending on which Z-axis location that the LED is mounted on. To obtain the guaranteed accuracy, the LEDs must be mounted on the rib stiffeners at the locations specified above and must be plugged into the correct specified LED connector. See the specifications (Appendix A) for more information on the calibrated range for each LED location.

Figure 10 shows the radiation pattern of the LEDs. Note that the brightest light is directly in front of the LED (on axis), and the brightness gets lower at larger angles. The RibEye controller continuously adjusts how hard it drives the LEDs to get a good signal from the sensors.

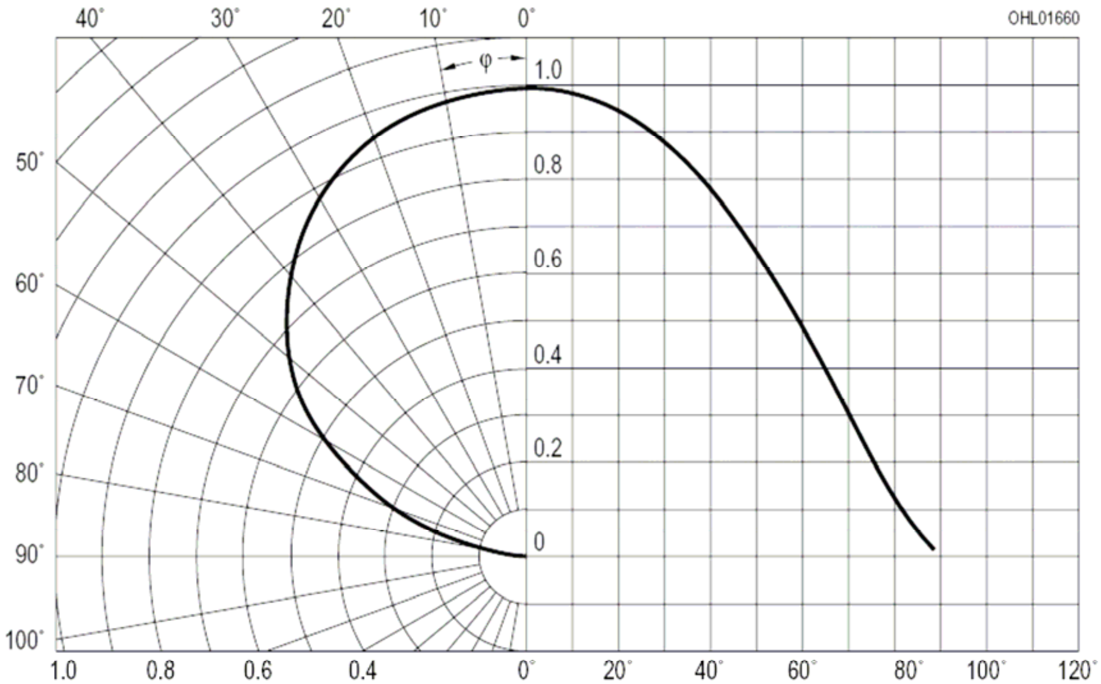


Figure 10. LED radiation pattern

2.5 Interface box mounting

The interface box, or trunk box, is intended to be mounted in the trunk of the vehicle, near the DAS and the power source. Four holes are provided in the base of the box for mounting. The interface box can be mounted in any orientation, but we recommend that it be mounted such that the side of the box with all of the connectors is easily accessible.

The communications and power cables from the spine box are connected to jacks on the interface box. An Ethernet cable is used to connect the interface box to a router/hub or directly to a laptop PC. Jacks are provided for incoming power and DAS/trigger connections.

3.0 Operating the RibEye

The RibEye operates as a stand-alone smart sensor that collects and stores data. In this stand-alone mode, a PC program is used to control the RibEye and to download data. In addition to controlling the RibEye with the PC program, the interface box has a status light and a manual "Arm" button. The status light blinks at different rates depending on the state of the RibEye:

- 0.5 Hz = idle with data in memory
- 1.0 Hz = idle with memory erased
- 2.0 Hz = acquiring data
- 5.0 Hz = storing data in flash memory
- 10 Hz = erasing flash memory.

The "Arm" button can be used to manually arm the RibEye when it is idle and the memory is erased. You must press the "Arm" button for at least 3 seconds to arm the RibEye.

3.1 RibEye IP address

The RibEye ships from the factory with its IP address set to 192.168.0.240. This IP address can be changed to work with your local area network (LAN). You can also communicate with the RibEye directly using a PC, without connecting to a LAN. To directly connect a PC to the RibEye, your PC must be set up with a fixed IP address on the same subnet as the RibEye. Please refer to the RibEye Software Manual for instructions on how to change the RibEye IP address.

3.2 LED flashing on power up

When the RibEye is powered on, it will flash each of the LEDs for about 1 second. The LEDs will flash in the following order:

1. Upper Left
2. Middle Left
3. Lower Left
4. Upper Right
5. Middle Right
6. Lower Right

4.0 RibEye software

As footnoted earlier, instructions for installing and operating the RibEye PC software can be found in the RibEye Software User's Manual. The software manual can be found on the disk shipped with the RibEye, or it can be downloaded from the Boxboro Systems website at http://www.boxborosystems.com/servicepage.html. Updates to the RibEye PC software can be downloaded from the website as they become available.

5.0 RibEye maintenance

The RibEye lenses must be kept clean for accurate measurements. Dust and smudges from fingers will affect the instrument's accuracy.

To clean the lenses:

1. Blow the lenses off with canned compressed air (not shop air) to remove any grit
2. Wipe the lenses with lens-cleaning solution or alcohol, using a clean, lint-free cloth
3. Dry the lenses with another clean, lint-free cloth.

Never remove the lenses from the case or loosen the lens cover screws. If the lens are loosened, the calibration will be invalid.

There are no user-serviceable parts in the RibEye.

Appendix A. RibEye specifications

RibEye coordinate system

The coordinate system for the 3-axis 50th Male RibEye is shown in **Figure A1**.

The Y axis is on the line between the center of the two outer (left and right) sensors. The origin of the X axis is where the X line crosses the Y axis, 10.34 mm in front of the center sensor. The Z axis is positive downward to match the standard dummy coordinate system.

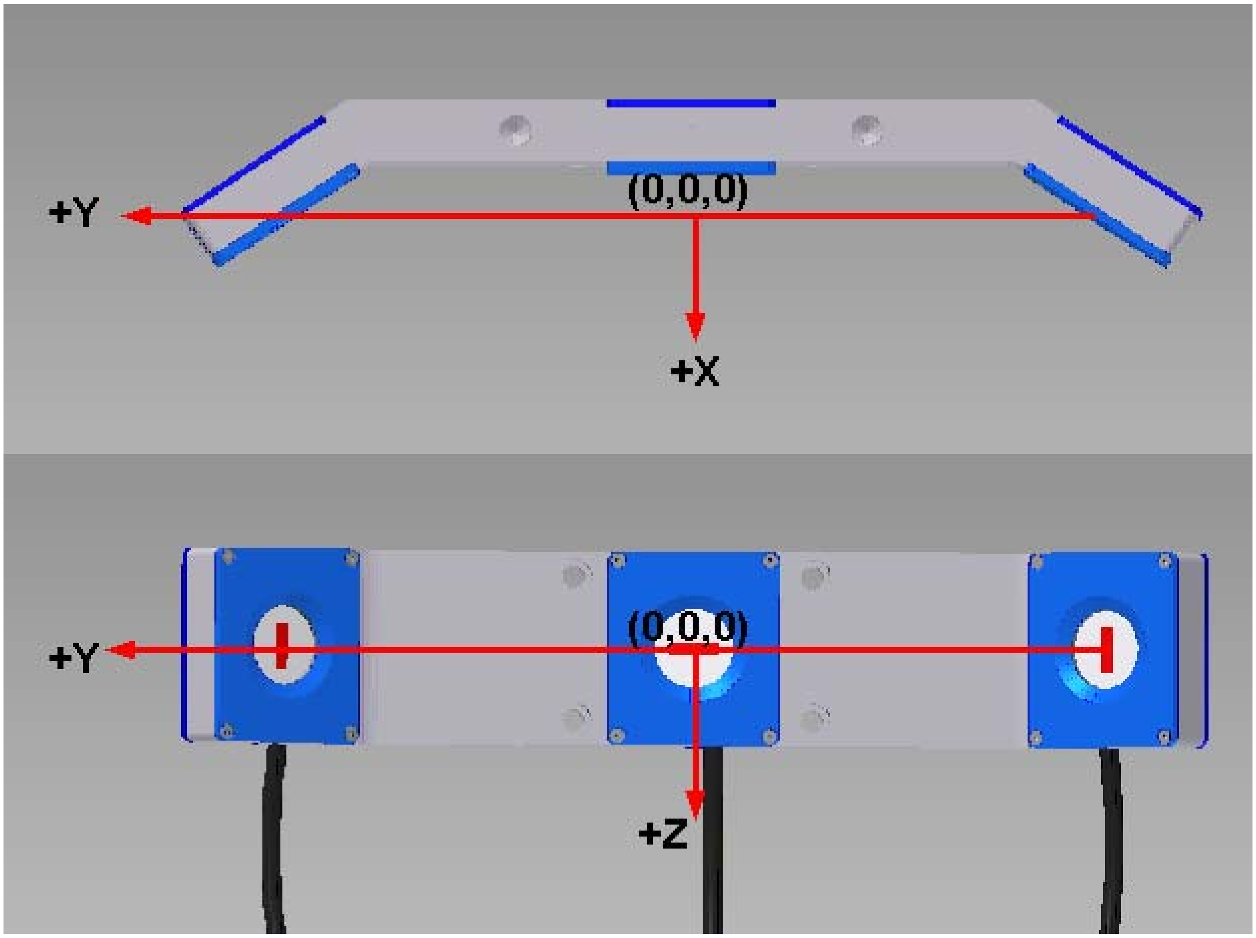


Figure A1. RibEye coordinate system definition

Measurement accuracy and range

The RibEye uses one set of calibration curves for each of the nominal Z positions of each LED. Therefore, there is a specified Z range of motion for each LED. **Figure A2** shows the XZ range for each LED. The nominal unloaded LED positions are also shown, overlaid on the range. **Figure A3** shows the XY range for each LED. The nominal unloaded positions of the LEDS are also shown, overlaid on the XY range. The nominal unloaded LED positions are shown in **Table A1**.

From the range graphs, you can see that the RibEye can measure 70–80 mm of X compression, +/–40 mm of Z motion, and 60–130 mm of Y motion.

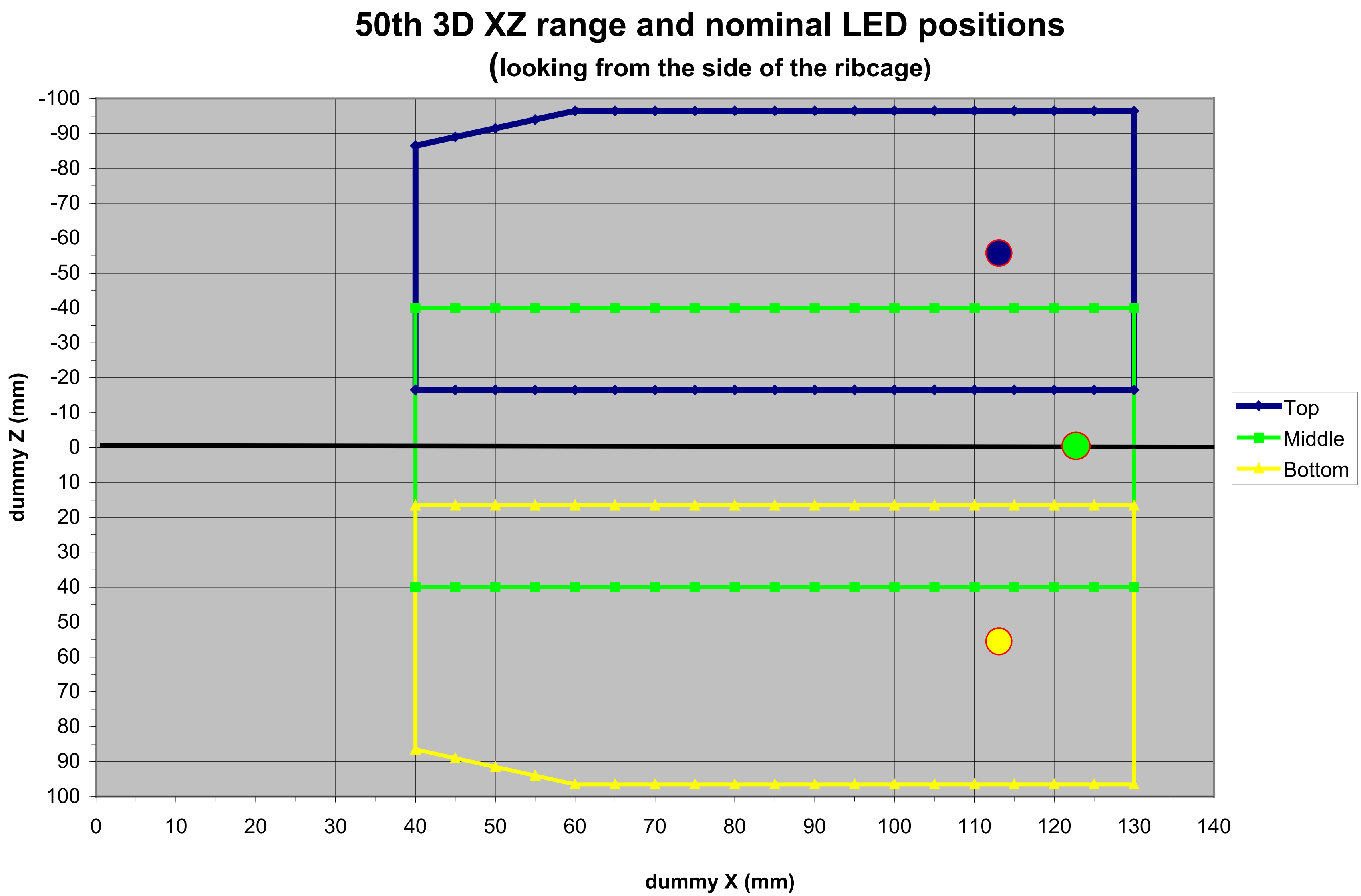


Figure A2. RibEye XZ range

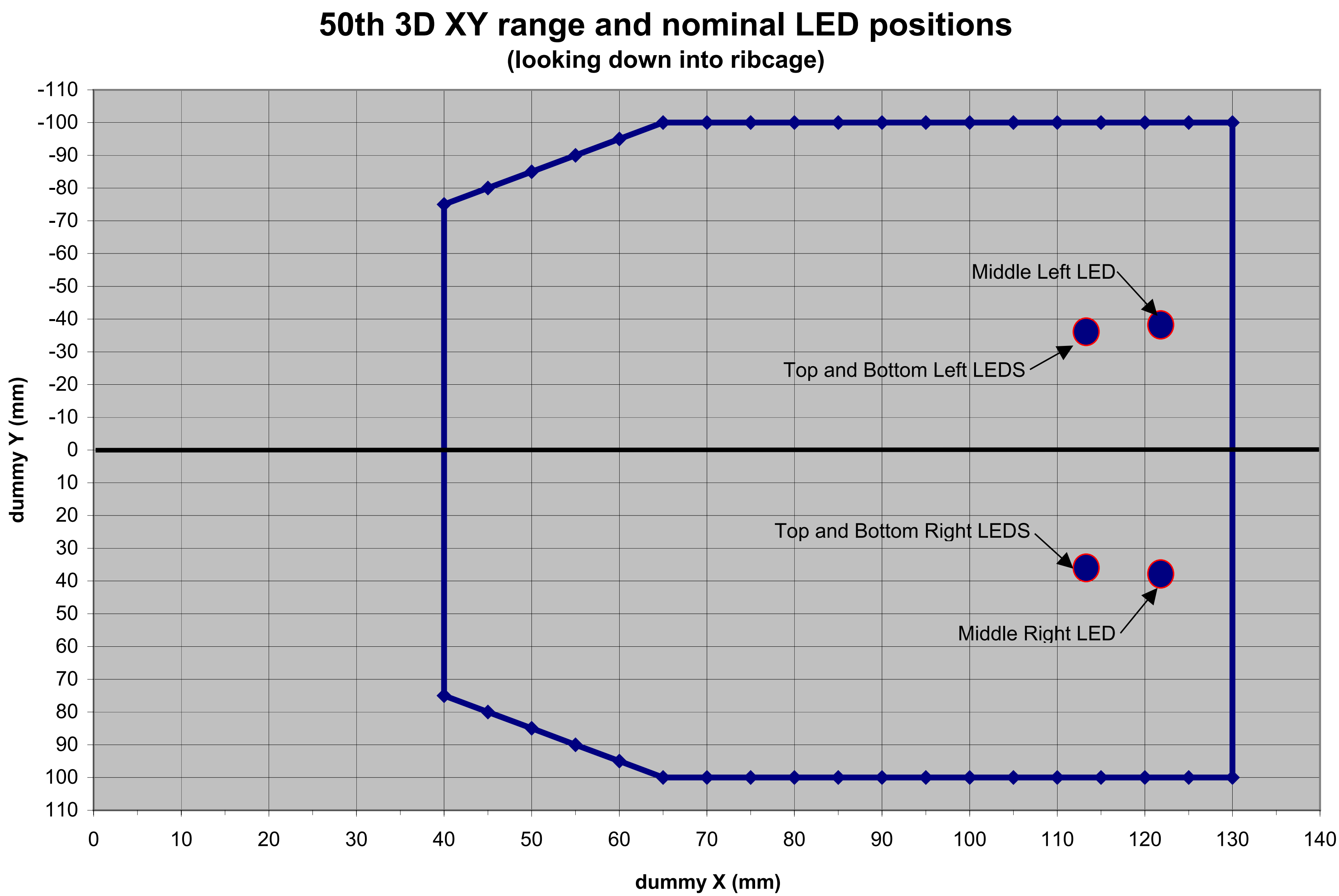


Figure A3. RibEye XY range

Table A1. Nominal Unloaded LED Positions

LED Number	Position	X (mm)	Y (mm)	Z (mm)
1	Upper Left	112.8	–35.6	–56.4
2	Middle Left	121.9	–37.3	0.0
3	Lower Left	117.1	–35.6	56.6
4	Upper Right	112.8	35.6	–56.4
5	Middle Right	121.9	37.3	0.0
6	Lower Right	117.1	35.6	56.6

The guaranteed measurement accuracy for all LEDs for all axes is better than 1 mm for the worst-case error. The average error over the whole range for each axis is less than 0.2 mm.

The first model was tested by taking data points for each LED over the whole range at 5-mm increments in X, Y ,and Z, resulting in 11,905 measurements per LED for the upper and lower LEDs, and 12,035 points for the center LEDs. The maximum and average errors are shown in **Table A2**.

Table A2. Measured Accuracy for Model 7800B-3 s/n 81

	X Errors (mm)		Y Errors (mm)		Z Errors (mm)	
LED Number	Maximum	Average	Maximum	Average	Maximum	Average
1/4	0.42	0.06	0.38	0.05	0.6	0.04
2/5	0.38	0.06	0.38	0.05	0.37	0.02
3/6	0.32	0.05	0.41	0.06	0.56	0.05

Power requirements

The RibEye can be powered by any DC voltage source from 12 to 36 Volts. The power cable from the RibEye's interface (trunk) box to the power source has two conductors: the red wire is positive, and the black wire is negative. The interface box has an internal self-resetting polymer fuse. It can take up to ½ hour to reset after an overload.

The power draw depends on the RibEye's operating conditions, as shown in **Table A3**.

Table A3. RibEye power requirements

Operating Conditions	Interface Box	Controller + LEDs	Total
	Watts		
On/idling	3.3	2	5.3
Collecting data (typical)	3.3	5	8.3
Maximum*	3.3	9	12.3

* When all LEDs are out of view of both sensors and driven to full power.

Data acquisition and storage

Sample rate: 10,000 samples per second per LED

Acquisition time: 30,000 ms (30 seconds) in D-RAM, 2 Seconds in Flash

Data is collected to RAM memory and stored post-test in flash memory.

Control signals

The DAS/trigger interface cable has 20 conductors used for trigger inputs and control/hand-shaking signals to an external data acquisition system. At this time, only the trigger and armed output signals are programmed. The other control wires are not used, but are connected to internal circuitry and should not be connected. All unused control wires should be individually insulated and protected.

The active trigger and control signals are listed in **Table A4**.

Table A4. RibEye active trigger and control signals

Pin Number	Color Code	Function
10	white	switch trigger in
20	tan	5V through 1k resistor for pull-up
7	blue	ground
6	green	differential trigger in +
11	black/stripe	differential trigger in –
8	violet	+5V (50 milli-amp maximum)
1	black	armed output

Differential trigger inputs (pins 6, 11)

- Maximum differential input voltage: +/– 12 VDC
- Minimum differential input voltage: +/– 0.2 VDC
- Common mode input voltage +/– 12 VDC

Switch trigger input (pin 10 with respect to pin 7, ground)

- Maximum input voltage = 5.0 VDC
- Minimum “on” voltage = 3.3 VDC
- Maximum “off” voltage = 0.4 VDC
- Current limited by 1k resistor

Additional 5V for external power (pin 8)

- Output voltage 4.75 to 5.25 volts
- Limit external loads to 50 milli-amp maximum
- Short circuit will cause resettable fuse to trip

Armed output (pin 1)

- Output voltage 4.75 to 5.25 volts at 0.5 ma max when armed
- Output voltage 0.5 volts when disarmed
- See Appendix B for a schematic of the armed output circuit (Figure B5)

<u>Communication and power cables</u>

These cables connect the interface box in the vehicle trunk to the RibEye's controller. The communication and power cables are internal to the RibEye system and should not be modified in any way. No user connections are available on these cables.

Note that the input power cable is terminated at the user end in pigtails. The red wire is connected to the DC power supply positive power connection. The black wire is for the DC power supply negative (ground) connection. The power cable shield should be tied to either the vehicle common ground point or the DC power supply negative (ground) connection, or both, depending on the configuration of your DC power grounding scheme. We recommend that you try the various shield connection options and see which option provides the lowest noise on the RibEye data.

Appendix B. DAS/trigger connector pinouts and trigger circuits

The DAS/trigger interface connector on the RibEye's interface box is a 24-pin connector. A mating cable, terminated in a pigtail, is supplied with the RibEye. At this time, 6 of the connector's 24 pins can be used for triggering and status. **Table B1** lists the pinouts, pigtail color code, and signal function for these 6 pins. The remaining pins are for future control and communications connections to DAS systems. The unused signals pins are internally connected to active signals and should not be connected externally.

Table B1. Trigger signals

Pin #	Color Code	Function
10	white	switch trigger in
20	tan	5V through 1k resistor for pull-up
7	blue	ground
6	green	differential trigger in +
11	black/stripe	differential trigger in –
8	violet	+5V (50 milli-amp maximum)
1	black	armed output

Figures B1–B4 show how to connect trigger switches, active TTL level trigger sources, and differential trigger sources. Where a trigger switch is shown, you can use the same configuration for open collector transistor output trigger sources. If you want to use a photo-interrupter type trigger source, you can power it from the 5-Volt supply on pin 8.

Figures B1–B4 also show the input circuitry in the interface box. Note that the differential receiver connected to pins 6 and 11 is enabled when a differential trigger is selected. The output of the receiver is internally connected to pin 10, the "SWITCH OR TTL" trigger input.

WARNING: *DO NOT DRIVE PIN 10 WHEN DIFFERENTIAL TRIGGERING IS SELECTED. THIS MAY CAUSE THE INPUT CIRCUITS TO BE DAMAGED.*

WARNING: *DO NOT EXCEED THE MAXIMUM INPUT RATING GIVEN IN THE SPECIFICATIONS SECTION (Appendix A).*

Figure B5 shows the armed output circuitry that you can use to monitor the state of the RibEye.

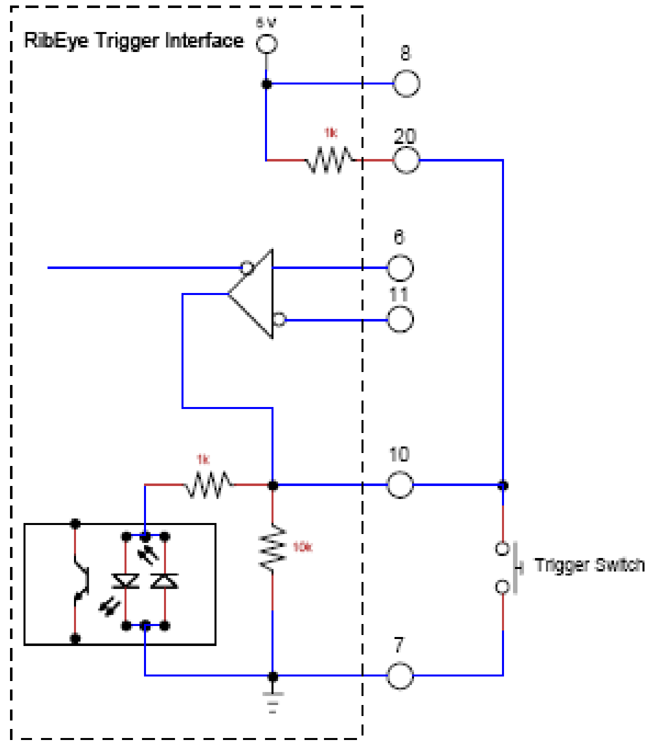


Figure B1. Trigger switch connection

For this connection, if the switch closes at the start of the event, select—

SWITCH OR TTL, FALLING EDGE TRIGGER

If the switch opens at the start of the event, select—

SWITCH OR TTL, RISING EDGE TRIGGER

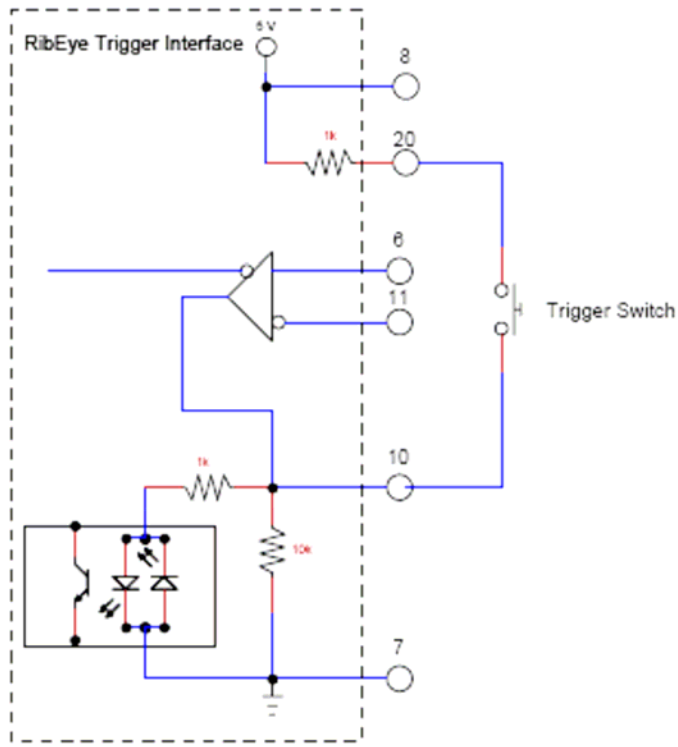


Figure B2. Alternate trigger switch connection

For this connection, if the switch closes at the start of the event, select—

SWITCH OR TTL, RISING EDGE TRIGGER

If the switch opens at the start of the event, select—

SWITCH OR TTL, FALLING EDGE TRIGGER

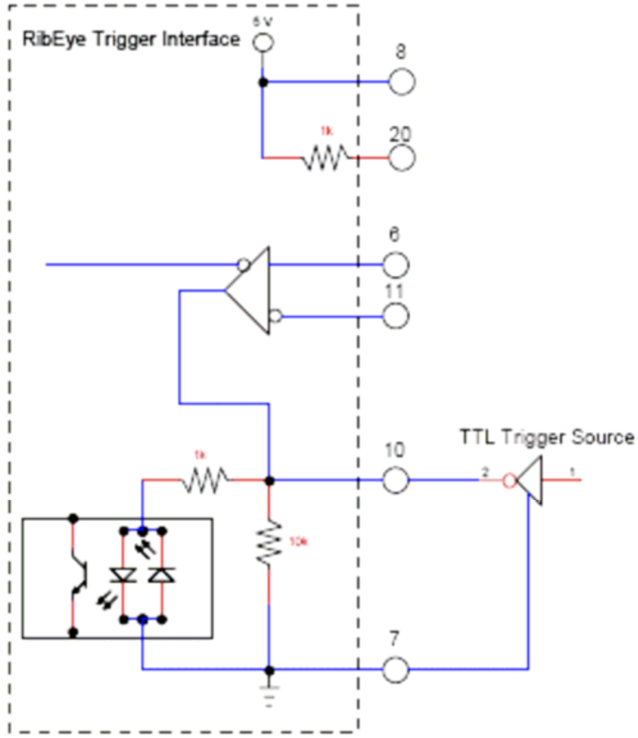


Figure B3. TTL trigger source connection

For this connection, if the input at pin 10 goes from 0V to 5V at the start of the event, select—

SWITCH OR TTL, RISING EDGE TRIGGER

If the input at pin 10 goes from 5V to 0V at the start of the event, select—

SWITCH OR TTL, FALLING EDGE TRIGGER

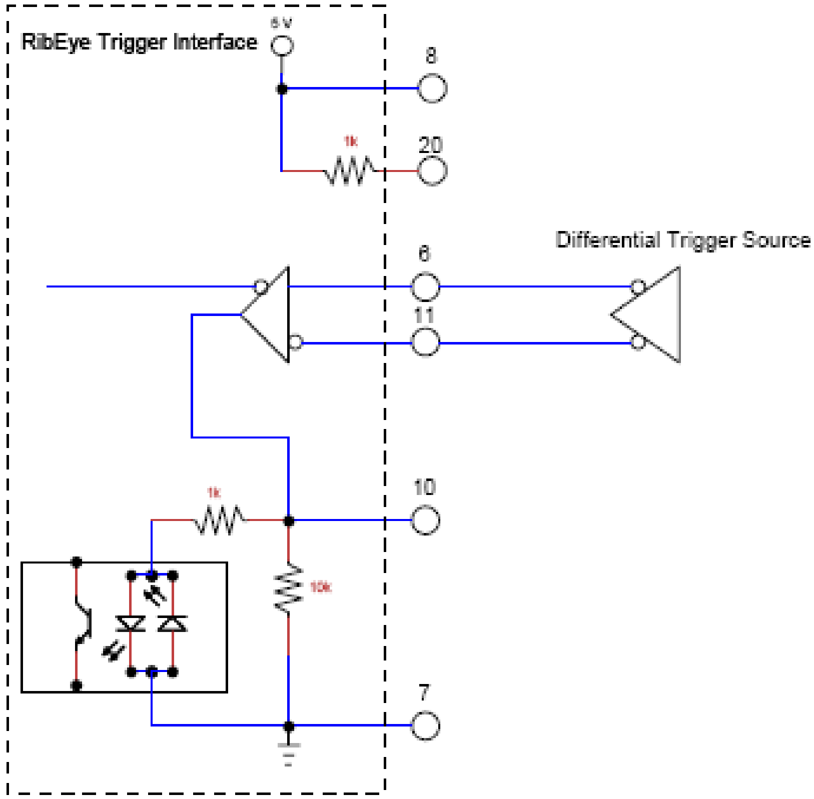


Figure B4. Differential trigger source connection

In this configuration, if the differential driver transitions from HIGH (pin 6 voltage > pin 11 voltage) to LOW (pin 6 voltage < pin 11 voltage) at the start of the event, select—

DIFFERENTIAL, FALLING EDGE TRIGGER

If the differential driver transitions from LOW (pin 6 voltage < pin 11 voltage) to HIGH (pin 6 voltage > pin 11 voltage) at the start of the event, select—

DIFFERENTIAL, RISING EDGE TRIGGER

Note that when differential triggering is selected, the output of the differential receiver can be monitored at pin 10.

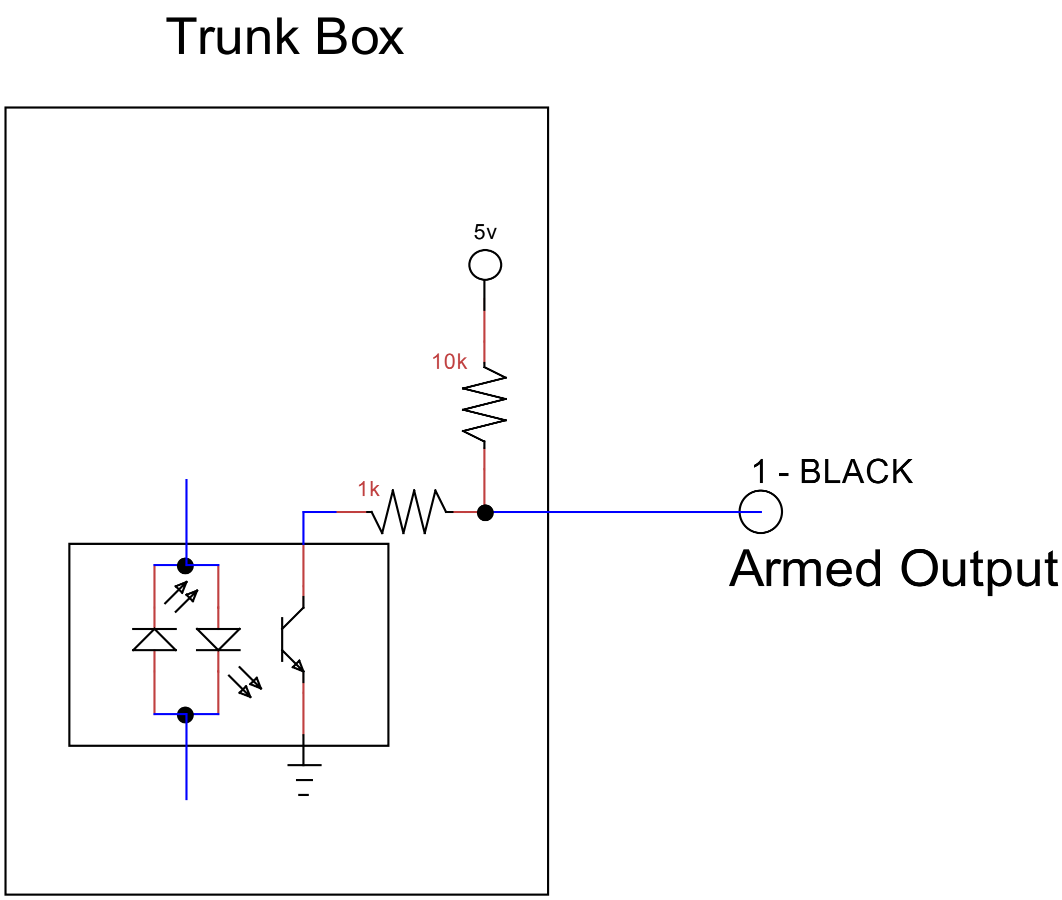


Figure B5. Armed output circuit