seaperch

BEACON CIRCUIT BUILD GUIDE

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ROBOTICS COMMUNITY

Office of Naval Research
Science & Technology

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Beacon Introduction

The Beacon is a magnetically activated underwater light that is used in tasks used in the International SeaPerch Challenge.

The Beacon construction is intended to serve as a teaching project that teachers may use to help broaden their students' knowledge of electronic circuit theory and construction.

It may seem intimidating if you have never built a device similar to the Beacon, however if you can build a SeaPerch ROV then we are confident that you can build the Beacon. We are here to support your efforts and we hope you enjoy this project. Please connect with us on the SeaPerch Challenge Forum if you need help or have suggestions.

There are many ways to design and build this circuit and mechanical housing; and we are merely presenting one way to accomplish this along with a few options. If you would like to share a different design or tips, please post them on the forum.

Fully constructed Beacon *(left);* CAD drawing of Beacon from Fusion 360 *(right)*

Section 1: Beacon Circuit Construction

Tools and Equipment

Must haves:

- Safety glasses *(worn at all times during the project)*
- Soldering iron
- Soldering iron stand *(the type with a brass wool tip cleaner is ideal)*
- Desoldering tool *(only if solder needs to be removed)*
- Diagonal cutting pliers
- Needle nose pliers
- Wire strippers *(with appropriate size for the wire used)*
- Heat gun *(or other source of heat)*
- Scissors
- Ruler or tape measure
- Marker or pencil

Helpful to have:

- Helping hand gripper with magnifying glass
- Soldering mat *(the one shown throughout the guide is a Heat Insulation Silicone Repair Mat available online for under $10)*
- Crimpers *(if using connectors on the wiring harness)*

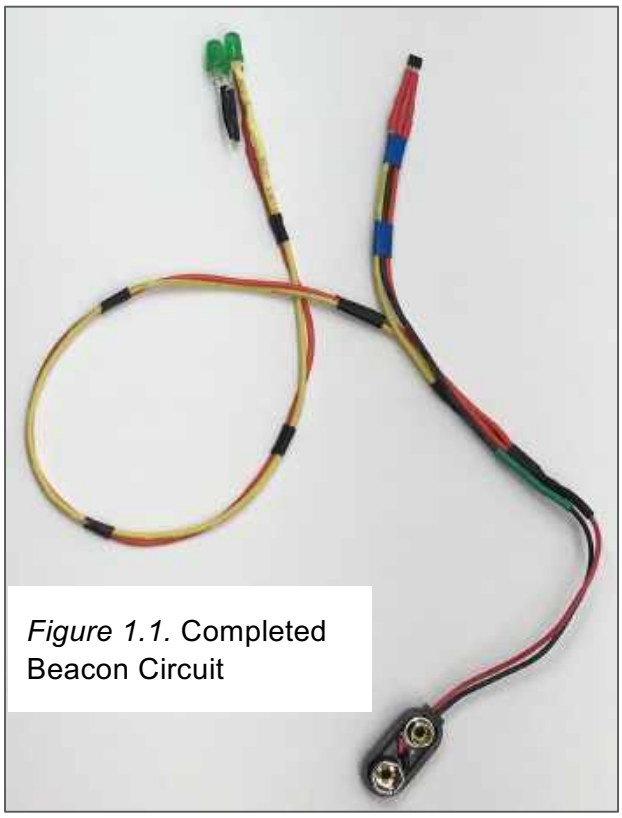


Figure 1.1. Completed Beacon Circuit

Materials and Supplies

- Solder
- Heat shrink tubing (1mm through 5mm diameters)
- Wire – 24 AWG *(other sizes will work; smaller gauge wire is easier to solder to the small terminals on the Hall Effect Sensor, but is easier to break)*
- Clear Tape (*Optional: Used to hold components when soldering*
- *Electrical tape*
- Connectors and crimp terminals *(Optional)*

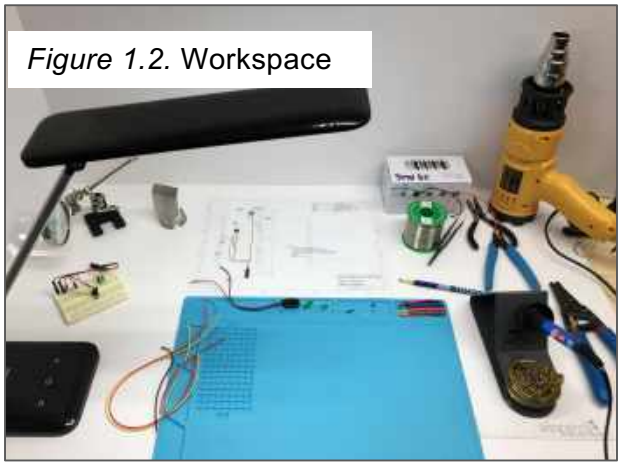


Figure 1.2. Workspace

Circuit Components

- LEDs, Three 5mm Green, 2.8 – 3.2 volt, 20 mA. The circuit will work with 1 LED.
- 10k Ohm 1/4 watt resistor (1/8 watt will work also)
- 10 Ohm 1/4 watt resistor (1/8 watt will work also). Use a 330 ohm resistor if you are only using 1 LED
- Hall Effect Sensor, P/N A3144 or A1104EUA-T.
- 9 Volt Clip-on Battery Connector with wires

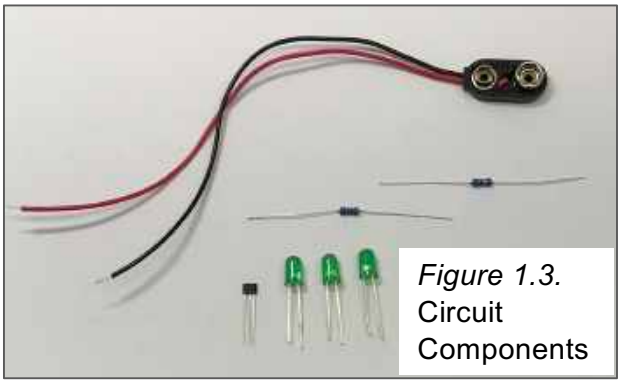


Figure 1.3. Circuit Components

Helpful References

Hall Effect Sensor (Switch)

Hall Effect Theory: Hall-Effect Application Guide
Datasheets
Allegro A3144 Hall Effect Switch (Sensor) Datasheet
Allegro A1104 Hall Effect Switch (Sensor) Datasheet

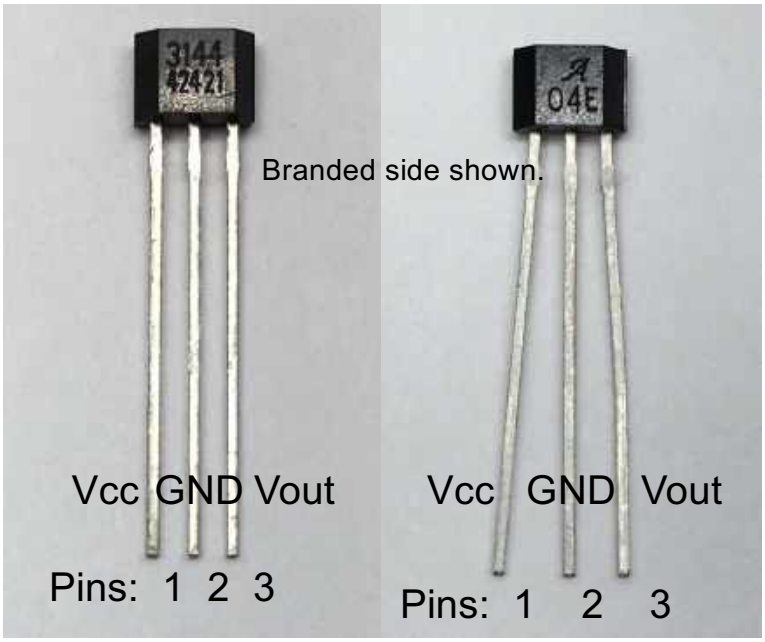
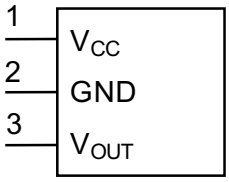


Figure 1.4. A3144 Hall Effect Sensor

Figure 1.5. A1104 Hall Effect Sensor



V_{cc} = Supply voltage
GND = Ground
V_{OUT} = Output voltage

Figure 1.6. HES Electronic Circuit Schematic Representation

LED – Light Emitting Diode

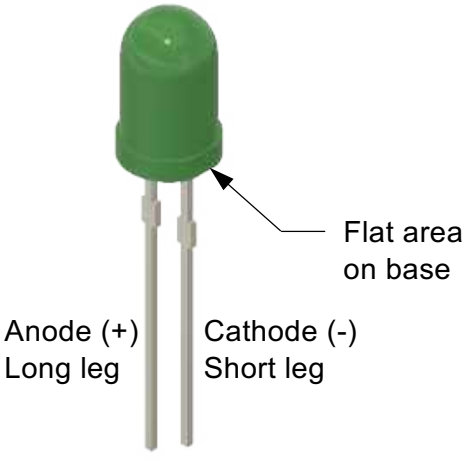


Figure 1.7. LED

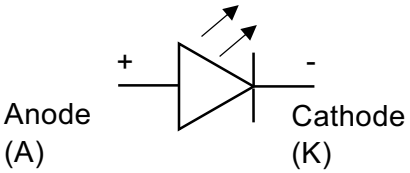


Figure 1.8. LED Electronic Circuit Schematic Representation

Notes:
The green color LED was chosen because it is the most visible color LED to people with color blindness. Since LEDs are diodes they only allow current flow in one direction. They will not work if they are reversed in a circuit.

Tutorials

- LED Tutorial
- How to Read a Schematic Tutorial
- How to Use a Breadboard
- Working with Wire Tutorial
- Resistors

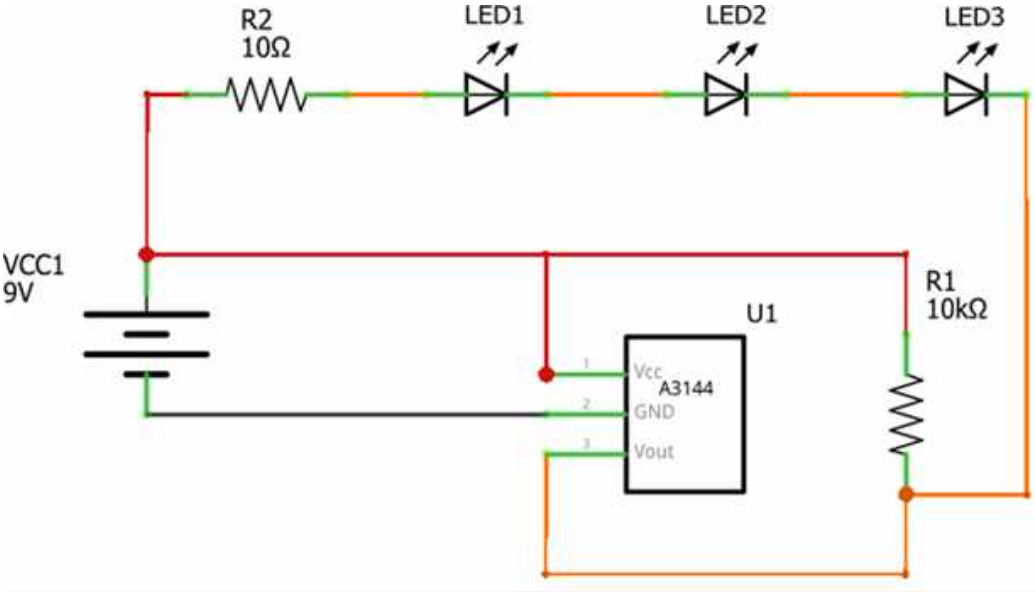


Figure 1.9. 3 LED Beacon Schematic

We recommend building the circuit on a breadboard to verify the components and for the educational value.

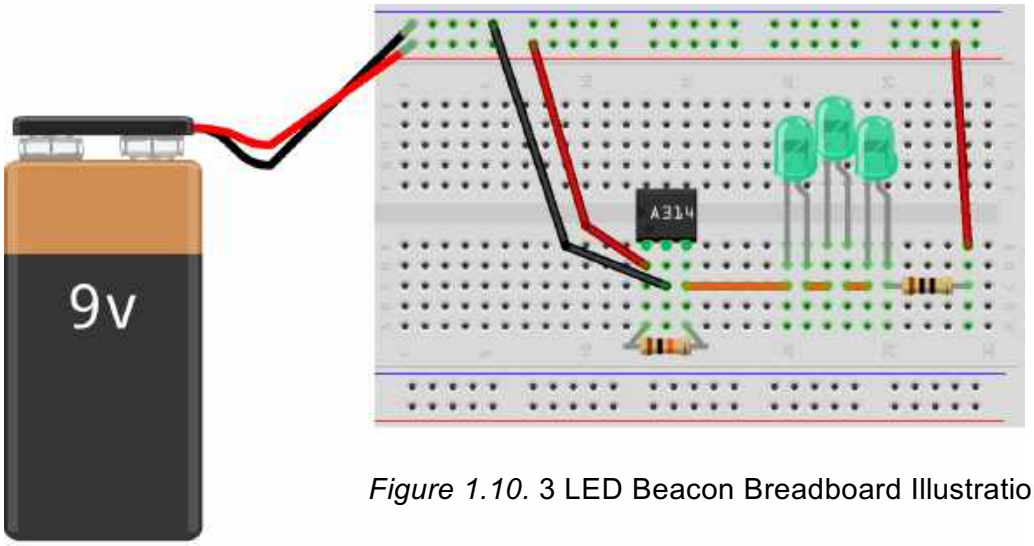


Figure 1.10. 3 LED Beacon Breadboard Illustration

Wiring Overview

The Beacon circuit has 3 LEDs connected in series for better visibility as shown in *Figure 1.11*. You may use a single LED and replace the 10 Ohm resistor (R2) with a 330 Ohm resistor. A 330 Ohm resistor will also work with 3 LEDs, but the LEDs will be slightly dimmer.

Figure 1.11 shows one possible way to wire the circuit. Throughout this guide we use 24 gauge wire. While smaller gauge may make it easier to solder to the small terminals on the Hall Effect Sensor, we choose 24 gauge to ensure durability.

Connectors could be used in the circuit and an example is shown in *Figure 1.12.*

Recommended wire lengths are given in the step-by-step section of this guide.

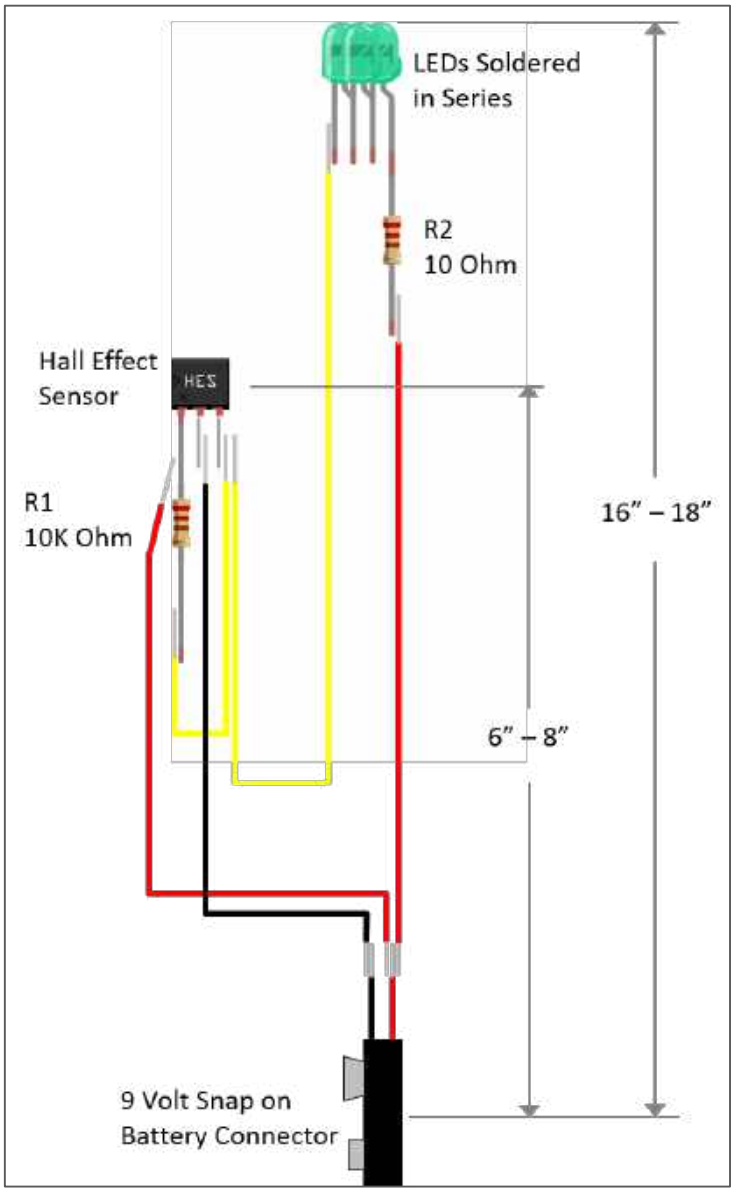


Figure 1.11. Wiring Illustration

Figure 1.12. Example Using JST Connectors

Wire Bundles Tips

- Pay attention to wire lengths and cut lengths as required to ensure wire bundles are tight. The wire lengths listed throughout this guide are recommended starting lengths. Some wires will need to be cut shorter in order to keep a tight wire bundle as shown in *Figure 1.13.*
- The required length of the wires depend on how connections are made up and need to be determined as you build the circuit.
- Notes are given through the build steps when a wire needs to be cut shorter than the listed starting length. **This is optional and will not effect the operation of the Beacon.**

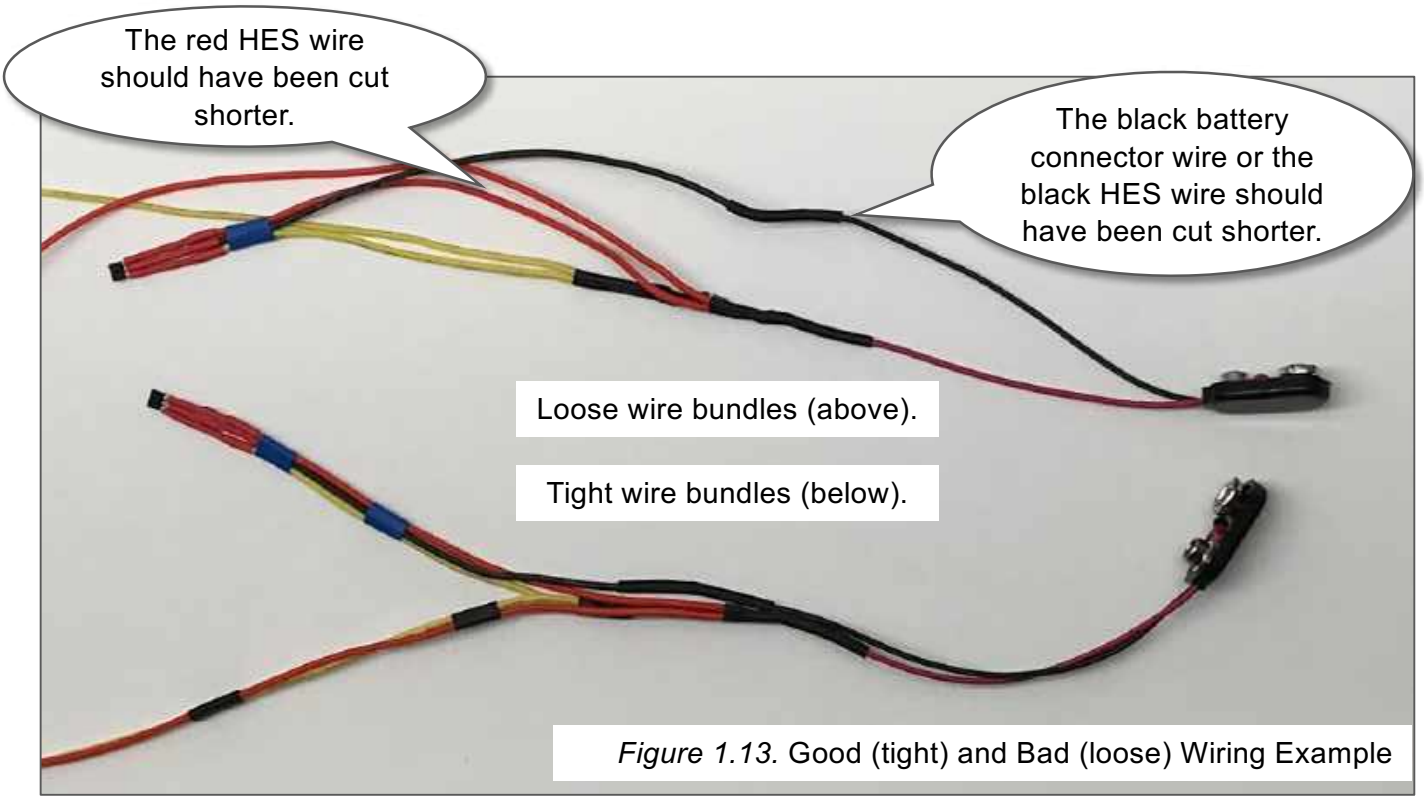


Figure 1.13. Good (tight) and Bad (loose) Wiring Example

Safety Tips

- Wear safety glasses
- Be careful and observe safe practices when soldering, using hot air gun, glue gun, sharp tools.
- Do not touch wire or components until you know they have cooled down when soldering.
- Heat guns produce extremely hot air. If using a heat gun do not put your fingers, hands, or other body parts in the hot air flow. Do not hold components that are close to the hot air flow since they will become very hot. Do not point the hot air flow from a heat gun at yourself or anyone else.
- Do not tough hot glue.

Pre Build Tips

- Build the circuit on a breadboard to assure your components function properly and that you understand the circuit.
- Secure parts when soldering. See *Figures 1.14* and *1.15.*
- Test each part of the circuit after soldering and installing the heat shrink tubing. You can use the breadboard circuit to help in testing.
- Remember to place heat shrink tubing on the wires before soldering. Make sure the heat shrink tubing is large enough to fit over the soldered connection and components.
- Inspect solder connections using a magnifying glass or macro lens on a camera.
- Use a shield to protect components when heating the heat shrink tubing.
- Use a solder mat if available to protect worksurfaces.

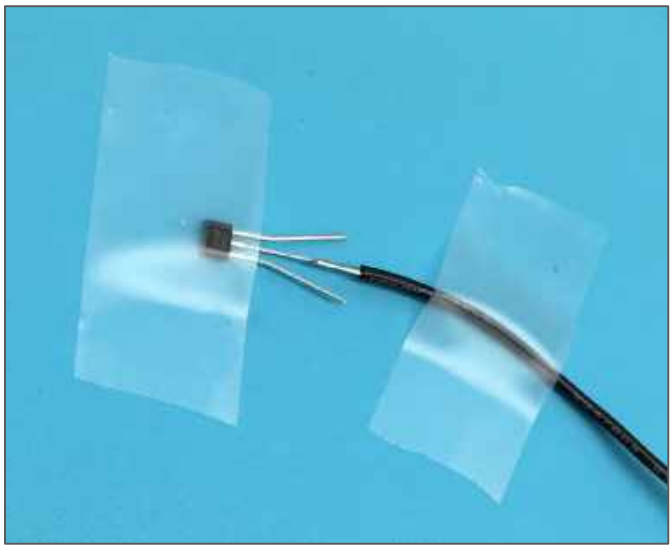


Figure 1.14. Example of securing components using tape.

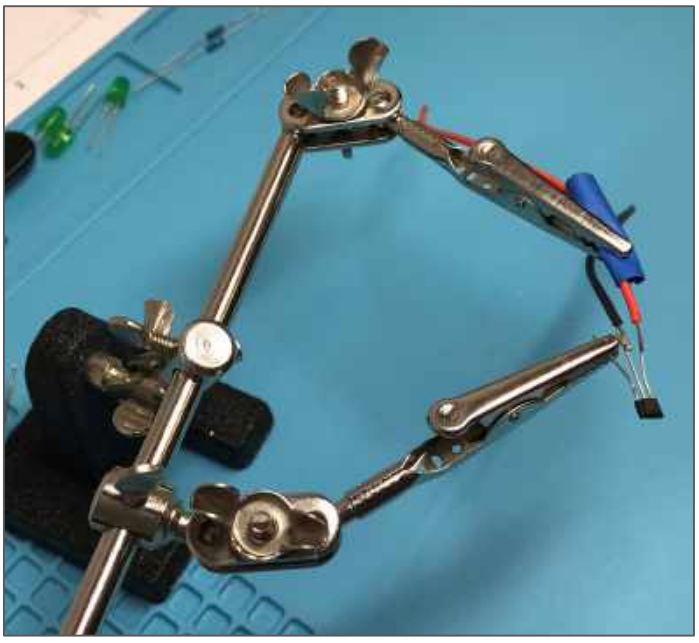


Figure 1.15. Example of securing components using grippers.

Section 2: Beacon Circuit Step-by-Step Instructions

1. Gather materials and supplies and setup your workspace.

2. Review the Beacon circuit, this guide, and decide on options such as: 1) using a single LED verses 3 LEDs and 2) hard wiring verses using connectors,

Figure 2.1. Project Workspace Example

Part 1 – Wire the Hall Effect Sensor

3. Solder the wires (6” long) to the Hall Effect Sensor (HES). Recommended color scheme:
    - Pin 1: **Red** Pin 2: **Black** Pin 3: **Yellow**
    - *Note*: The 10k Ohm resistor may be connected directly to pins 1 and 3 of the Hall Effect Sensor, however the guide shows connecting the resistor to the wires.
3. Inspect the solder connections. Since it is difficult to wrap the wire around the Hall Effect Sensor terminals to form a mechanical bond it is important to achieve good solder flow around the wire and the terminal.

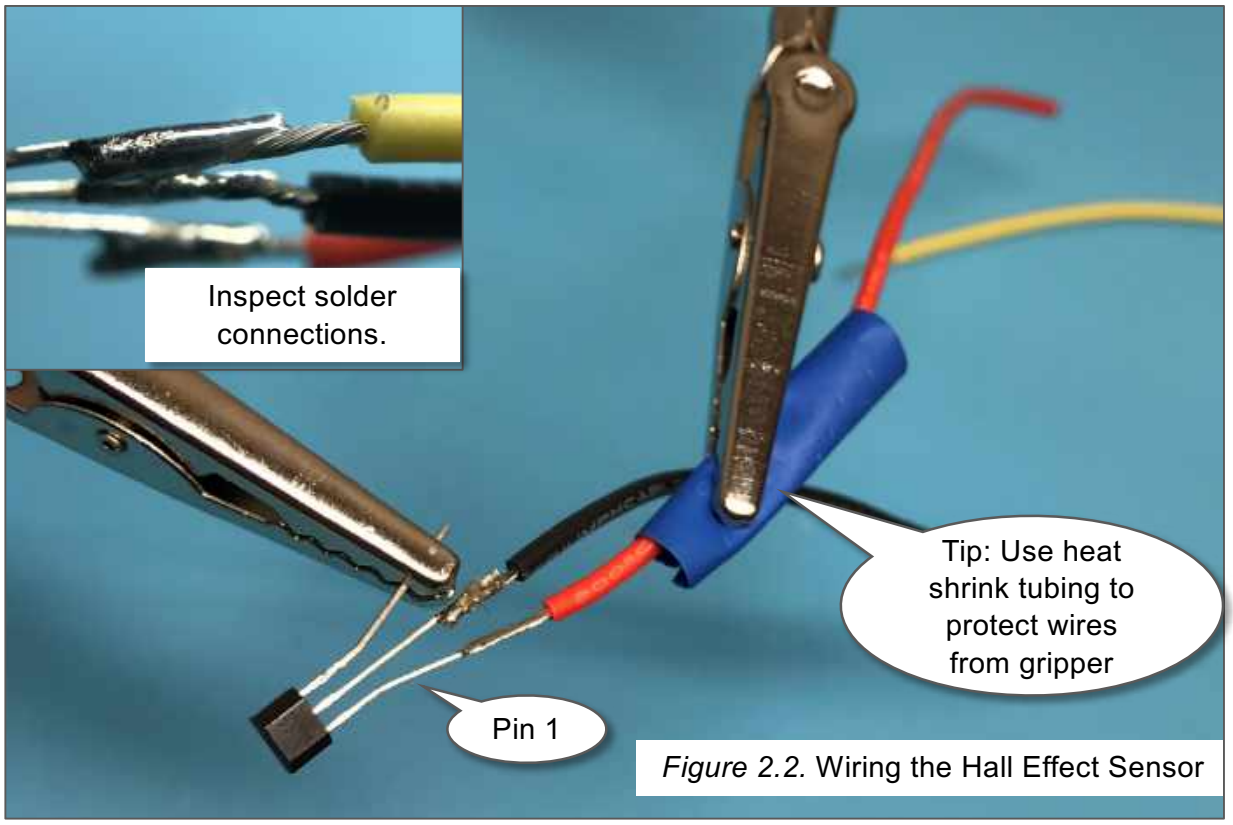


Figure 2.2. Wiring the Hall Effect Sensor

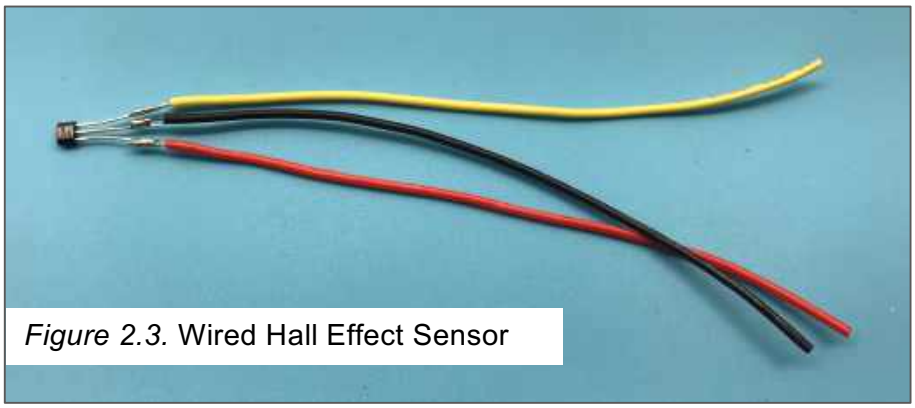


Figure 2.3. Wired Hall Effect Sensor

7. Install heat shrink tubing and test Hall Effect Sensor. See *Figure 2.5.* Standard Procedure for Heating Heat Shrink Tubing.

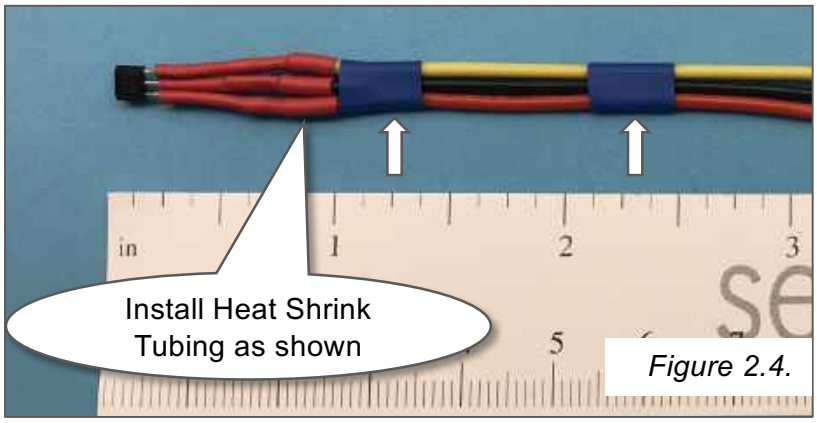


Figure 2.4.

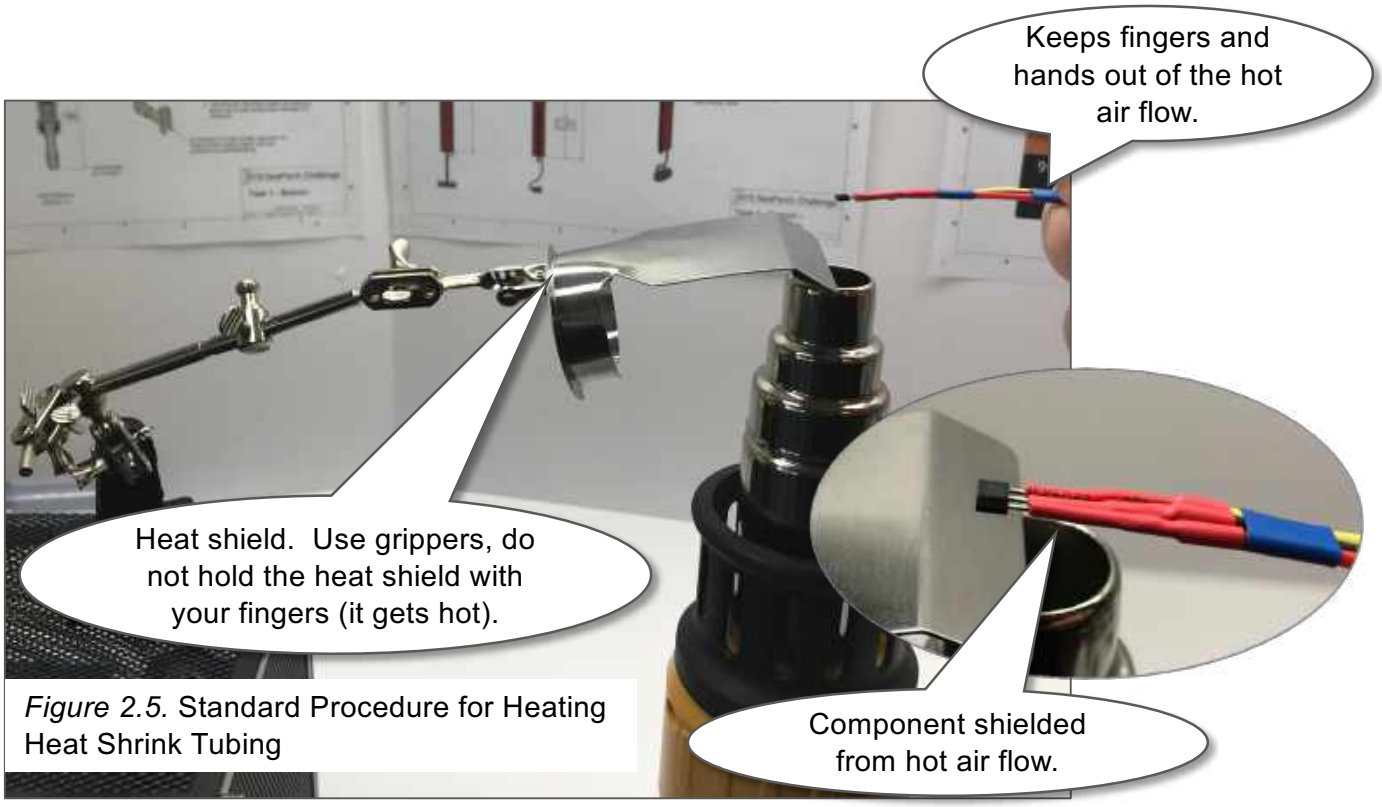


Figure 2.5. Standard Procedure for Heating Heat Shrink Tubing

8. *OPTIONAL Step:* Test Soldered Hall Effect Sensor using a breadboard (*Figure 2.6.).*

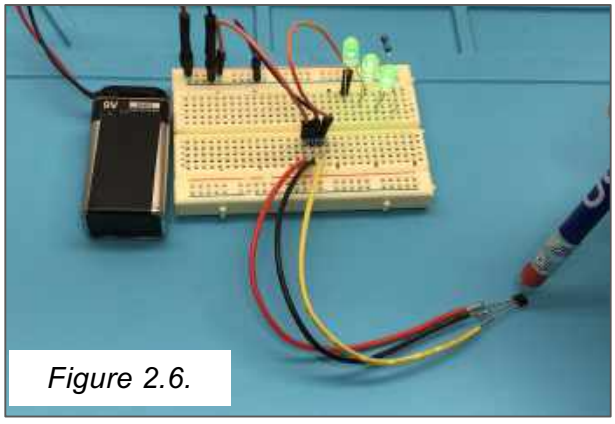
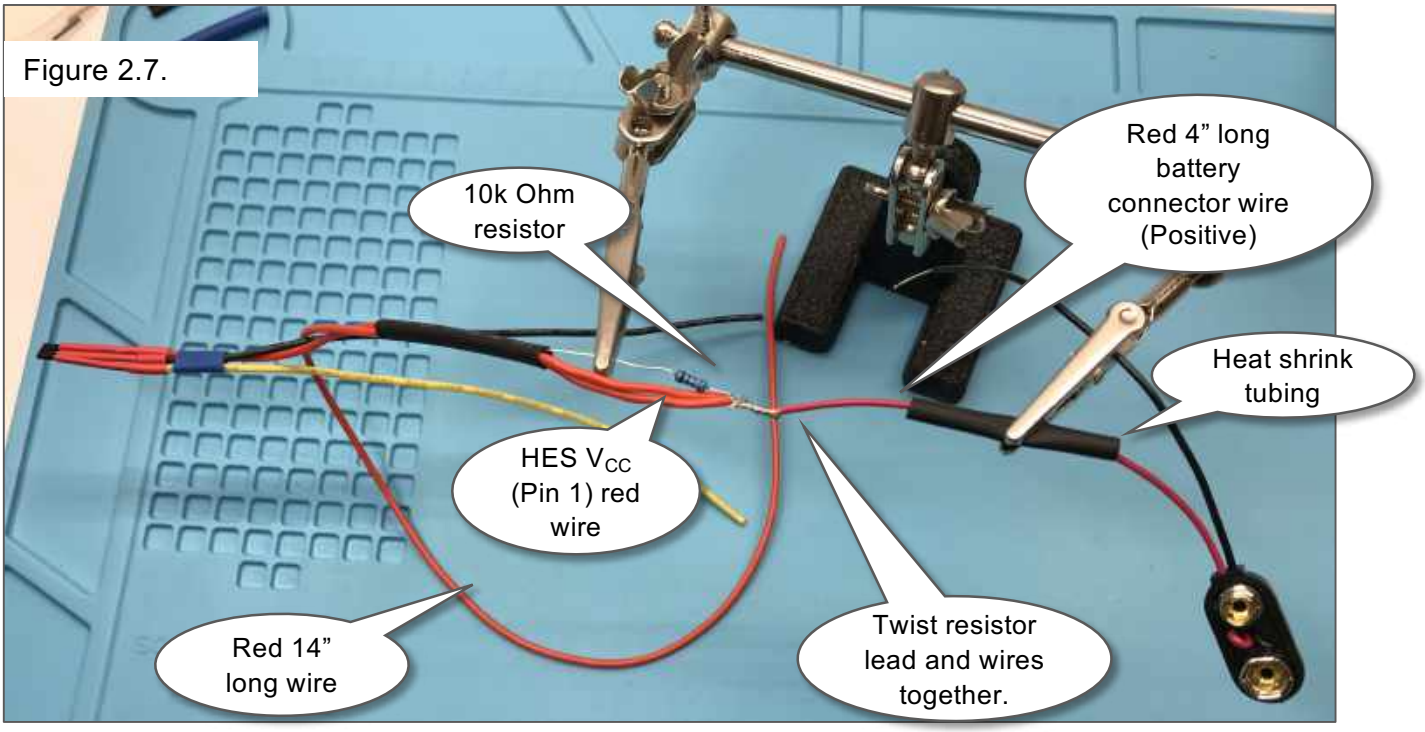


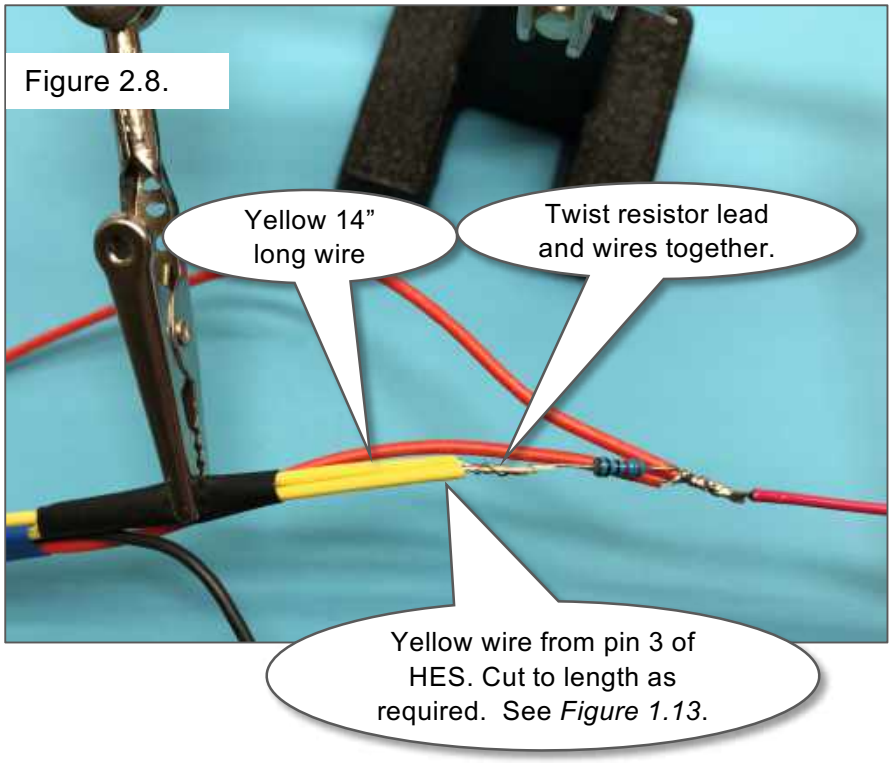
Figure 2.6.

Part 2 - Solder Wires and the 10k Ohm Resistor

(as shown in figures 2.7 – 2.9)



9. Place heat shrink tubing on wires **prior** to soldering.
10. Twist resistor lead and wires together:
    - Connect **red** 4” long battery connector wire to the HES V_{CC} (**Pin 1**) **red** wire AND 10k Ohm resistor (*See Figure 2.8).*
    - Connect **yellow** 14” long wire to the **yellow** wire from **Pin 3** AND other end of the 10k Ohm resistor (See *Figure 2.8).*
    - Connect **black** wire from **Pin 2** and black battery connector wire *(*See *Figure 2.10* on next page*).*
11. Solder wires and inspect prior to installing heat shrink tubing.



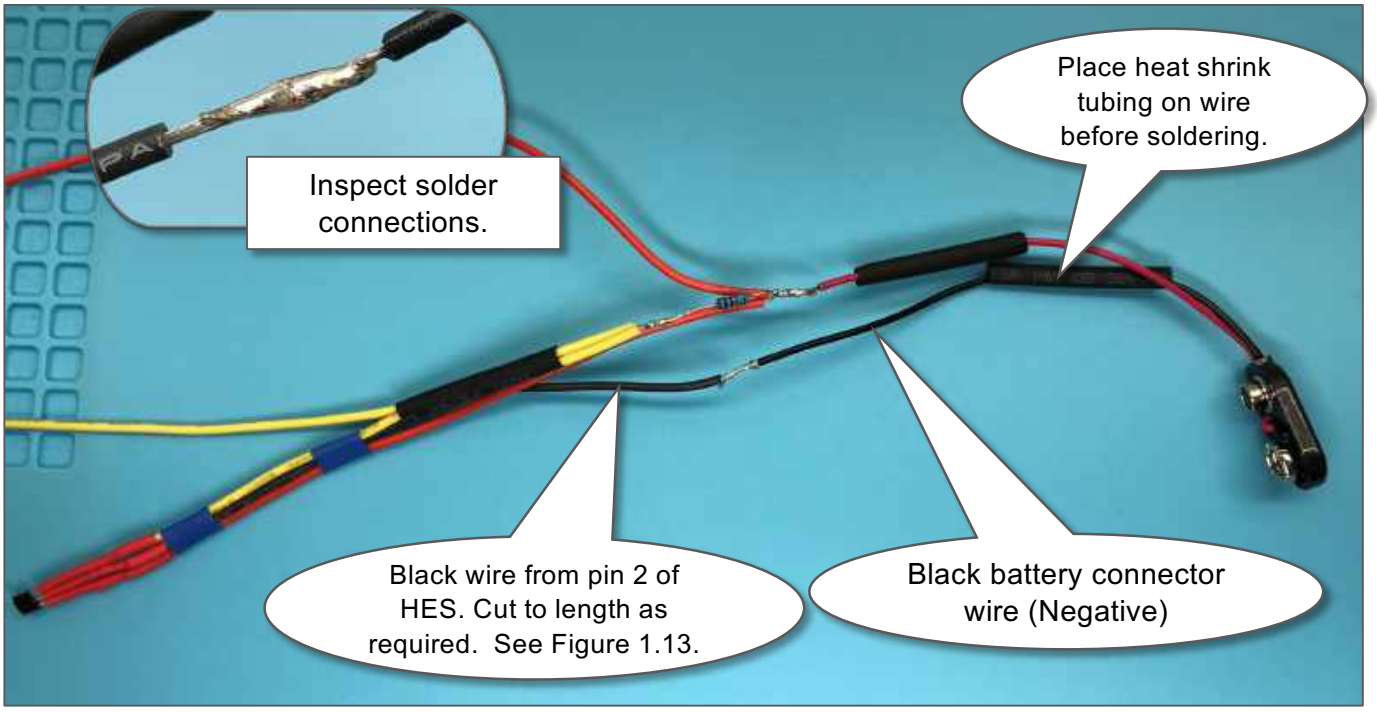


Figure 2.9.

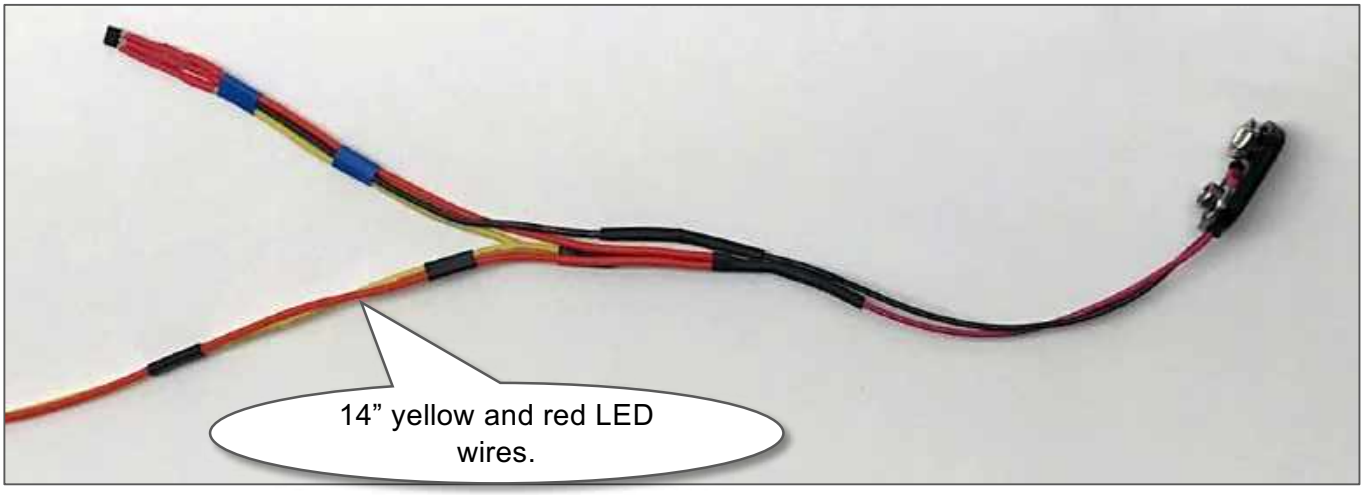


Figure 2.10. Completed Hall Effect Sensor/Power Cable with LED Wires

Part 3 - LED Array Assembly (3 LED Option)

The LED array consists of 3 LEDs connected together in series. See *Figure 2.12* and follow the instructions on the following pages to prepare the LEDs for inclusion in the Beacon circuit.

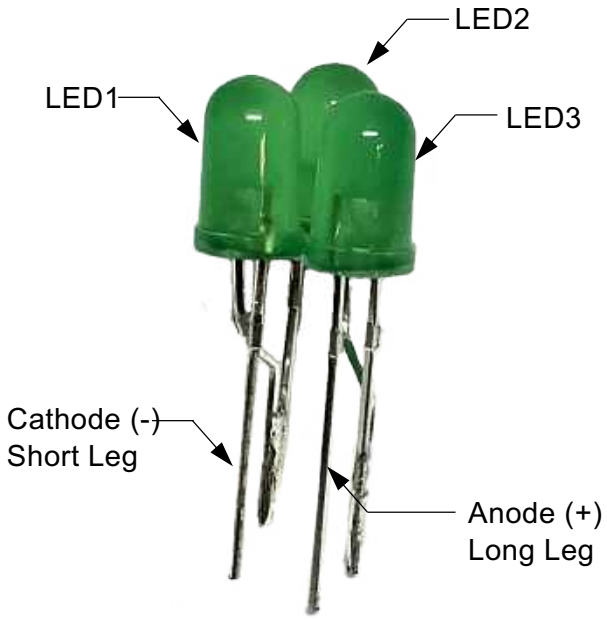


Figure 2.11 Completed LED Array

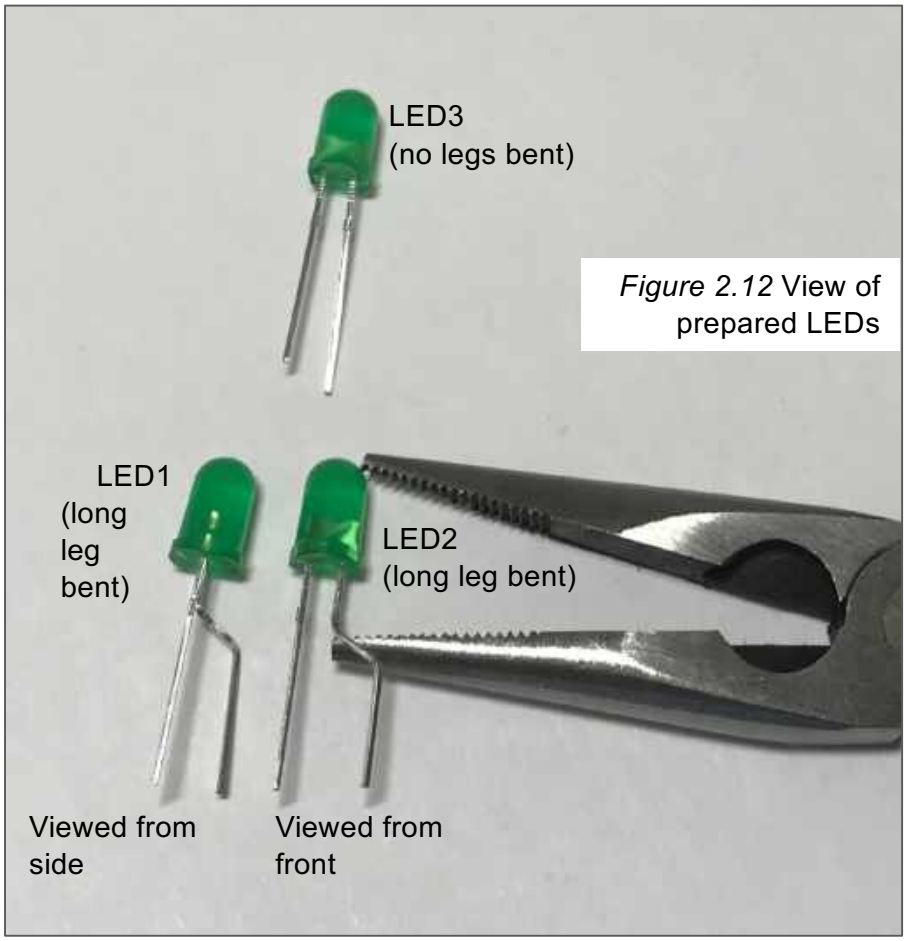


Figure 2.12 View of prepared LEDs

1. Bend the long leg of two (2) LEDs as shown using needle nose pliers to grip the LED leg. The long LED leg should be bent approximately 45° outward and 45° forward. **Note**: Do not grip the LED by the bulb when bending the legs.

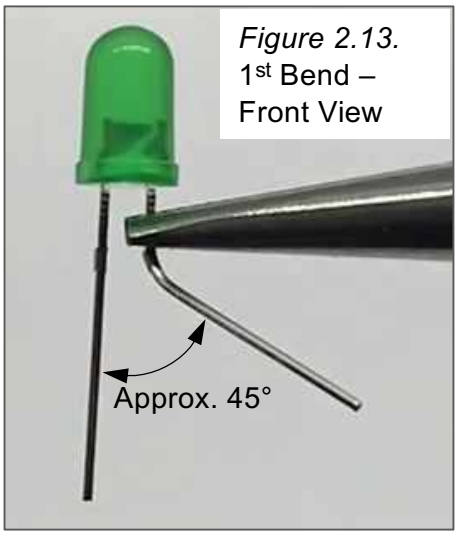


Figure 2.13. 1st Bend – Front View

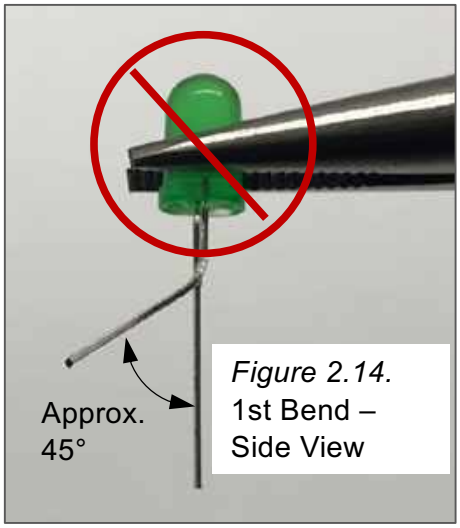


Figure 2.14. 1st Bend – Side View

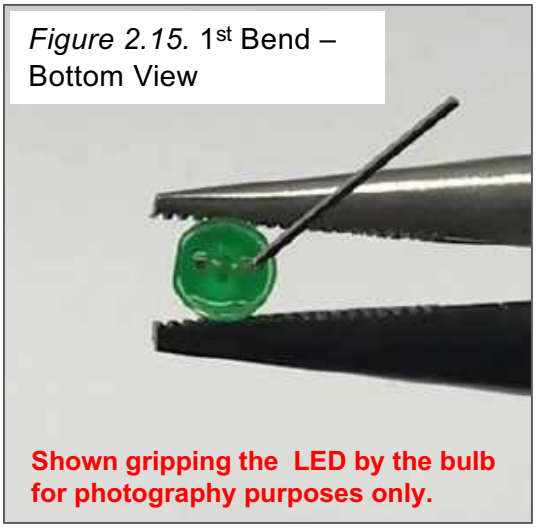


Figure 2.15. 1st Bend – Bottom View

Shown gripping the LED by the bulb for photography purposes only.

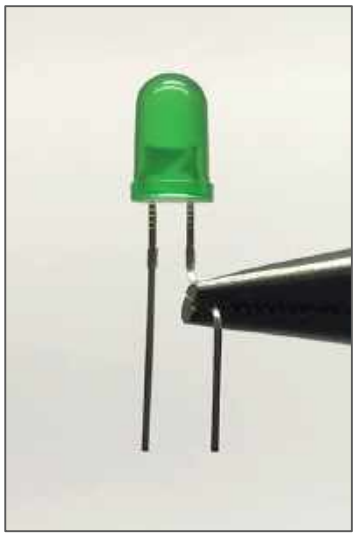


Figure 2.16. 2nd Bend – Front View

Figure 2.17. 2nd Bend – Side View

2. Solder the bent leg of LED1 and the straight leg of LED2 together.

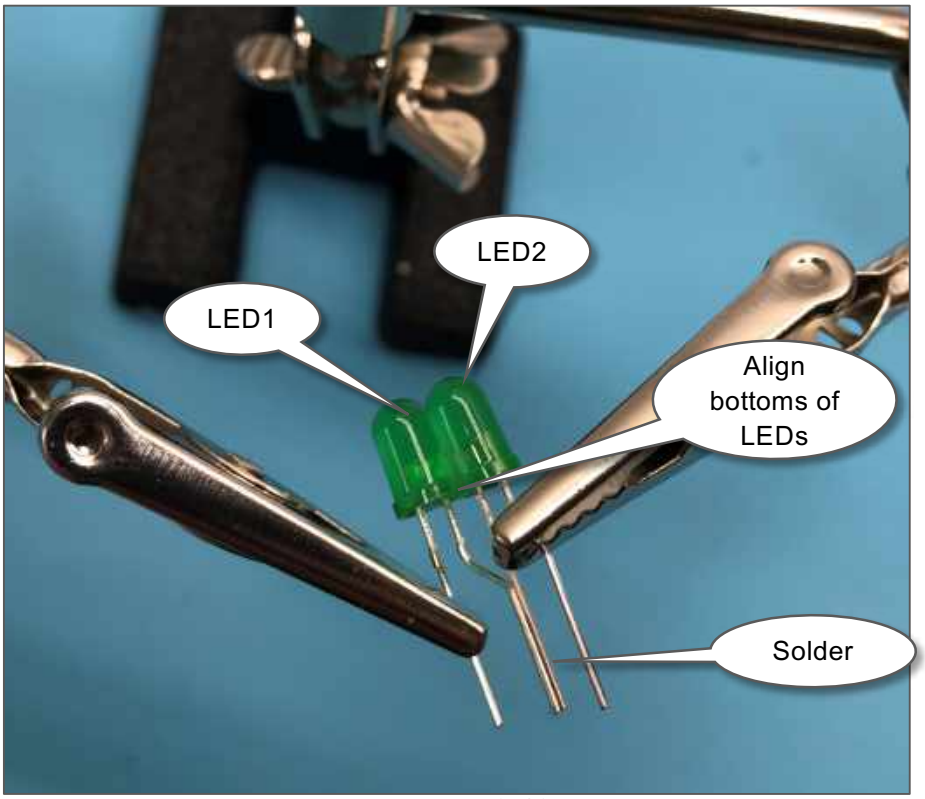


Figure 2.18

3. Solder the short leg of LED3 and the bent leg of LED2 together.

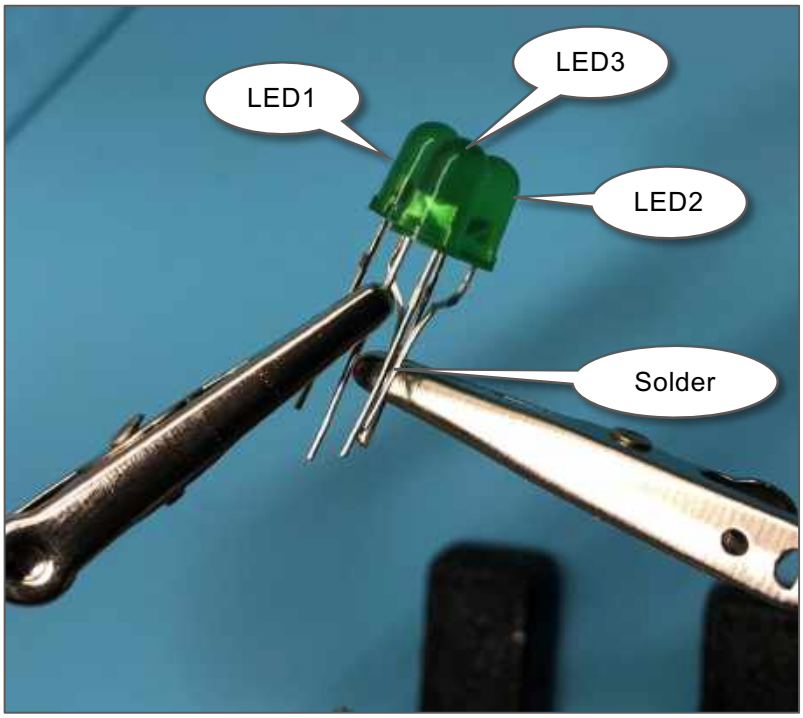


Figure 2.19

4. Solder the 10 Ohm resistor to the long leg of LED3.

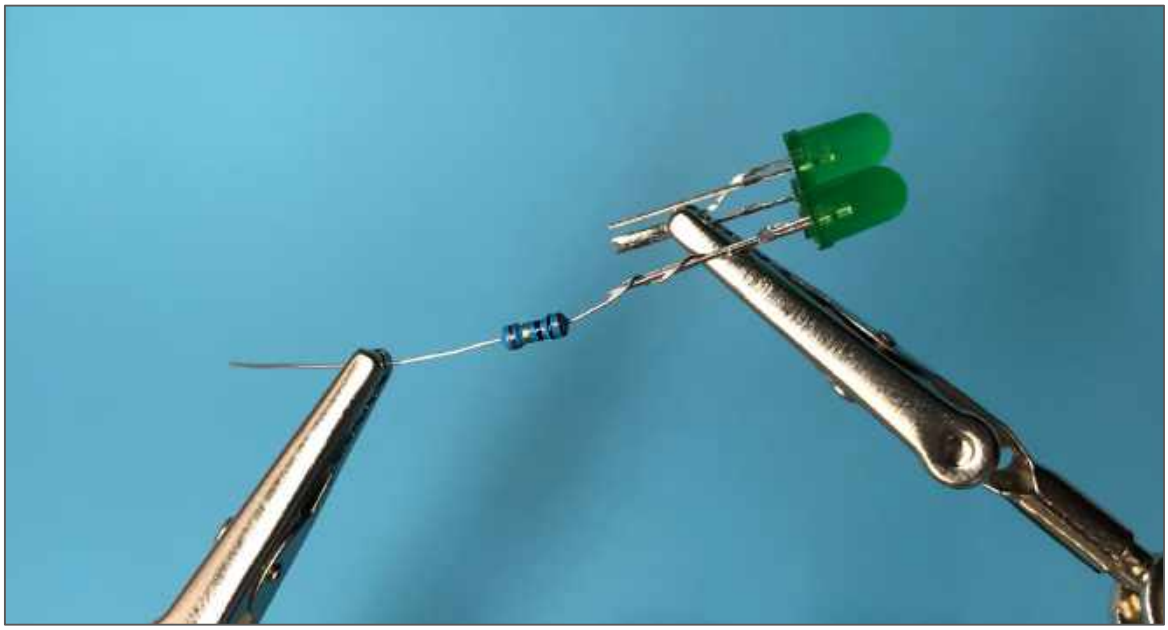


Figure 2.20

5. Install heat shrink tubing as shown in *Figure 2.21*. Do not shrink until soldering is complete.

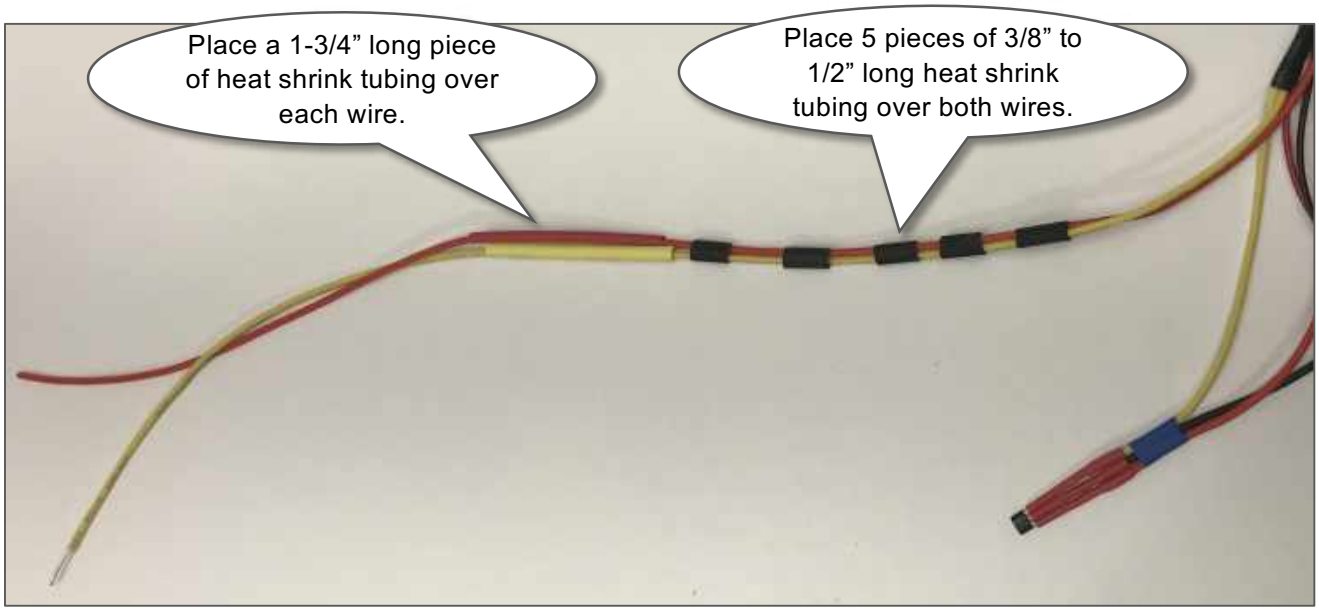


Figure 2.21

6. Solder the yellow wire to the short leg of LED1.
7. Cut the red wire as required to create a tight wire bundle then solder to the resistor.

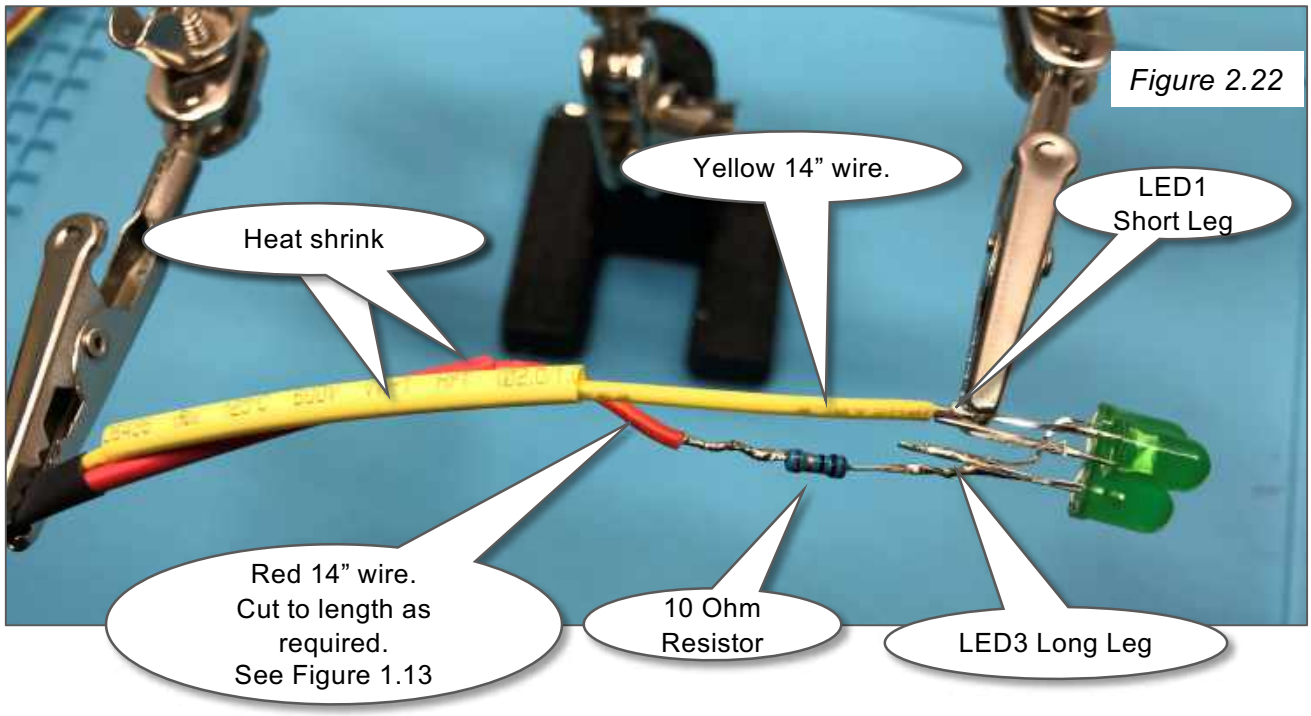


Figure 2.22

8. Shrink the heat shrink tubing.

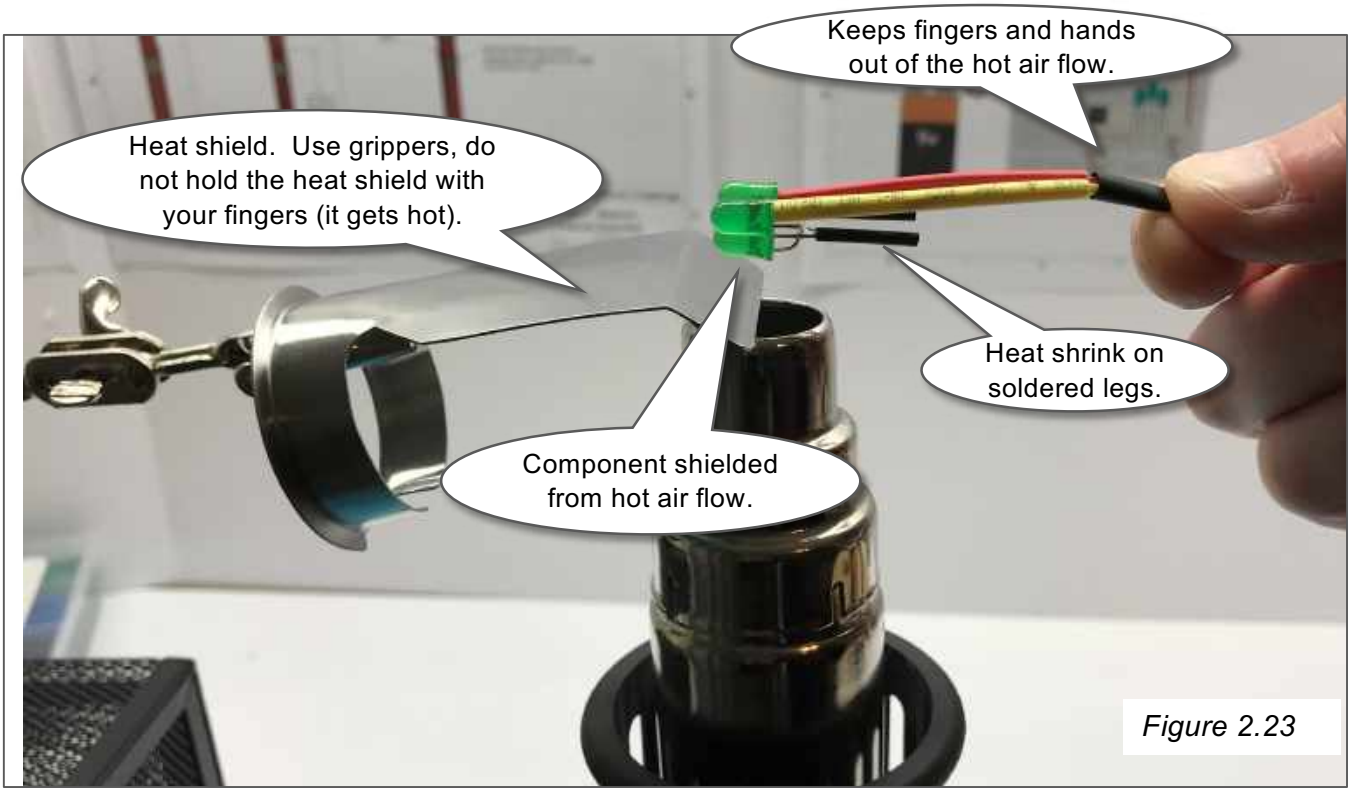


Figure 2.23

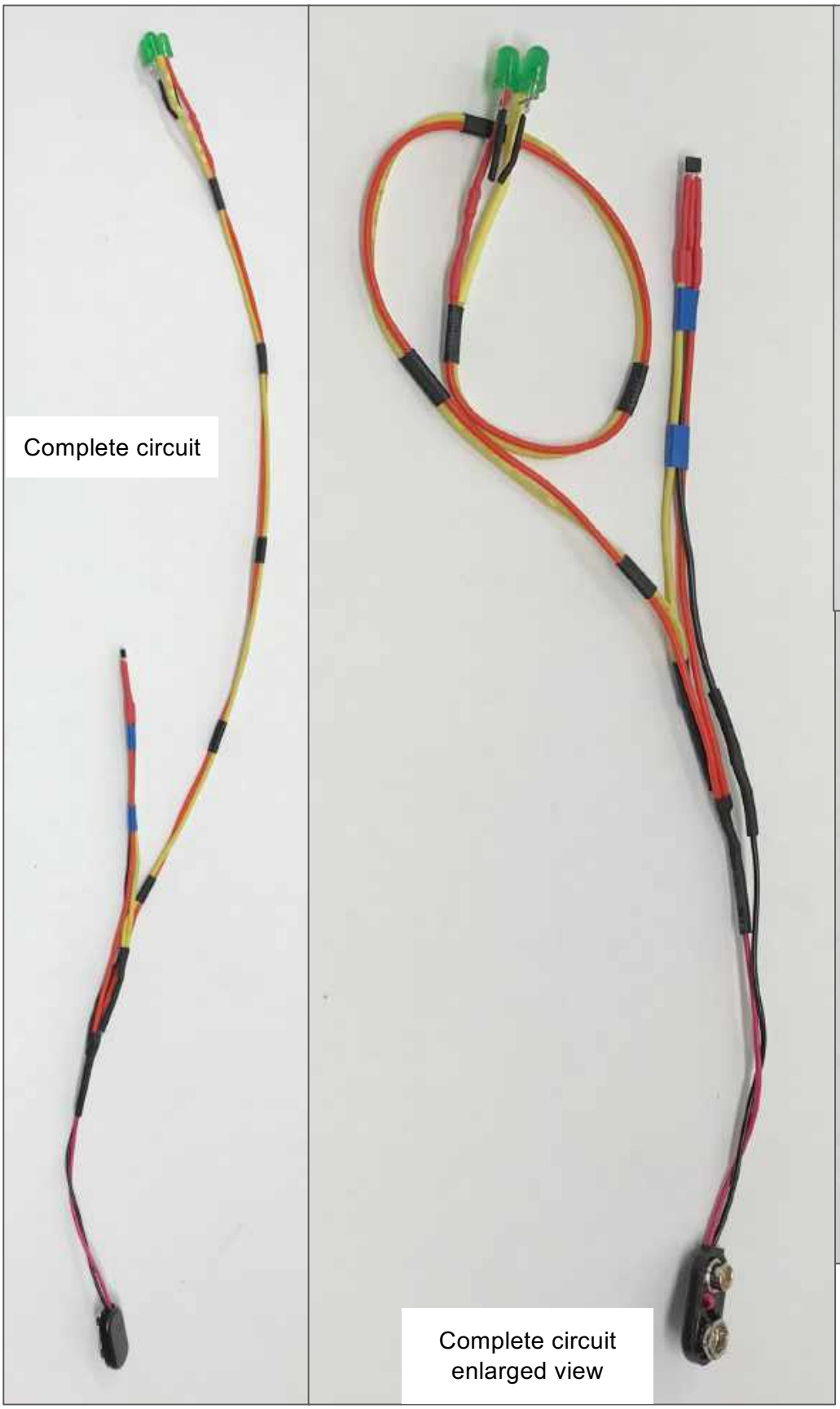


Figure 2.24. Completed Beacon Circuit (various views)

Tools and Equipment

- Safety glasses (worn at all times during the project)
- Scissors
- Ruler or tape measure
- Marker
- Pipe cutters or other appropriate tool for cutting PEX pipe
- Hot glue gun

Materials and Supplies

- Electrical tape

Parts

- ½” PEX pipe, 10” long
- Beacon Circuit Assembly

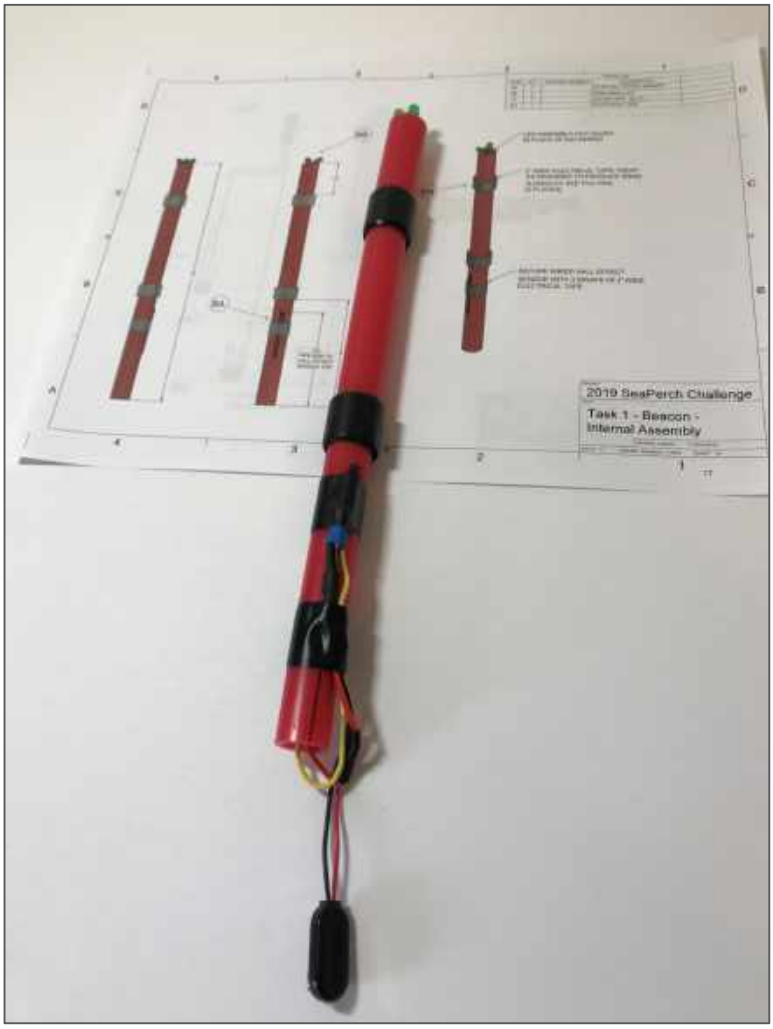


Figure 3.1. Completed Beacon Internal Assembly

1. Mark pipe at 1-1/2”, 6”, and 6-1/2”

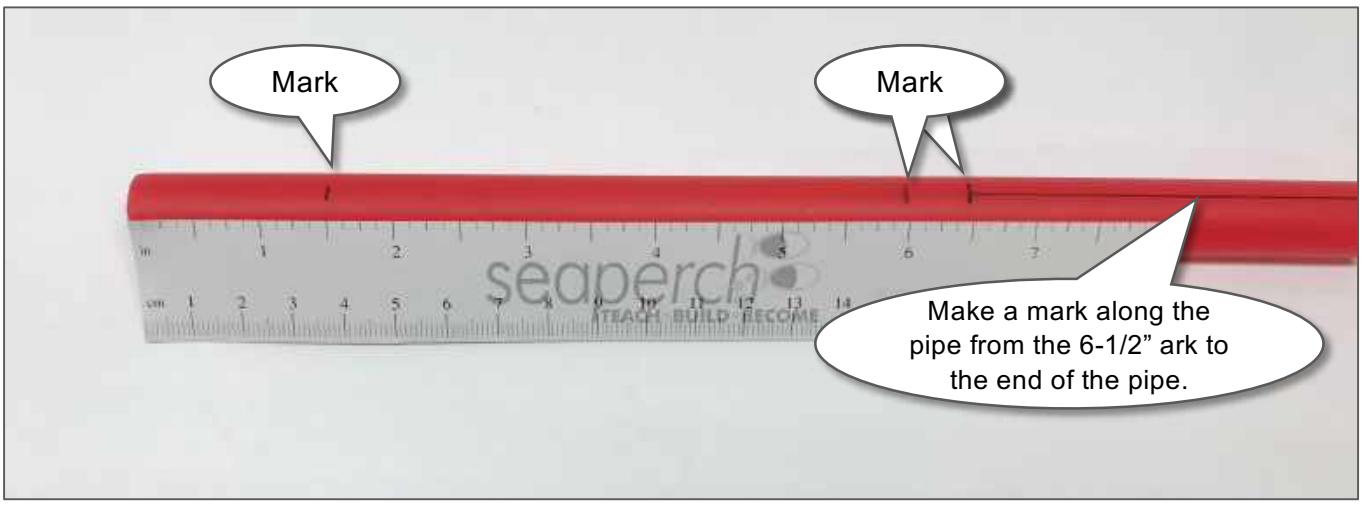


Figure 3.2

2. Wrap electrical tape around the pipe at positions shown (See *Figures 3.3* and *3.4)*.The number of wraps required will depend on the thickness of the tape and the inside diameter of the ¾” PVC pipe being used.

Figure 3.3

Figure 3.4

3. Push the LED end of the Beacon circuit through the PEX pipe (See *Figure 3.5)*.

4. Align the Hall Effect Sensor top with the cross mark centered on the long mark (See *Figure 3.6).*

5. Tape the Hall Effect Sensor to the PEX pipe with 2 wraps of tape.

6. Tape the wires to the PEX pipe with 2 wraps of tape (location is not critical)

Figure 3.5

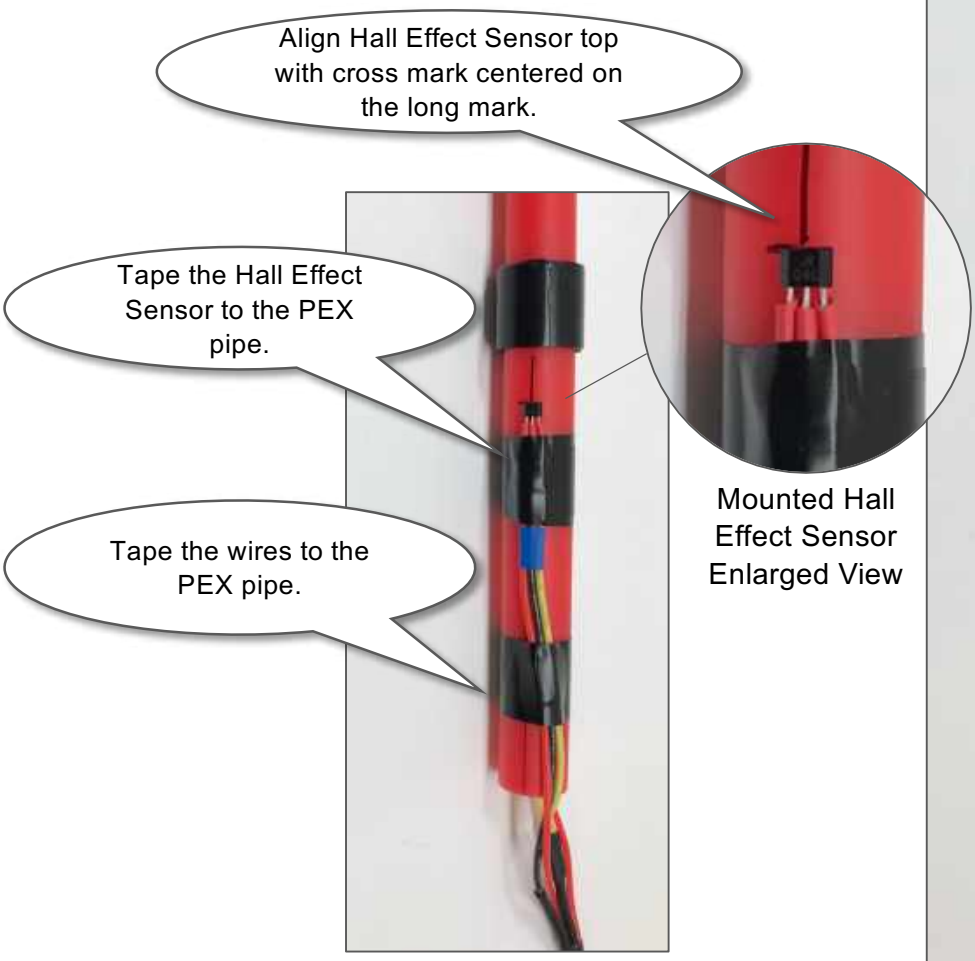


Figure 3.6

7. Carefully bend each LED away from the center of the pipe so the LEDs will not fit back into the pipe.

8. Position the LEDs about ½" from the end of the pipe and apply hot glue inside the pipe and around the LED wires. **Note: Observe safety practices when working with the hot glue gun and do not tough the hot glue until it cools.**

9. Push the LEDs toward the pipe until they rest on the edge of the pipe. Hold the LEDs in place until the hot glue cools.

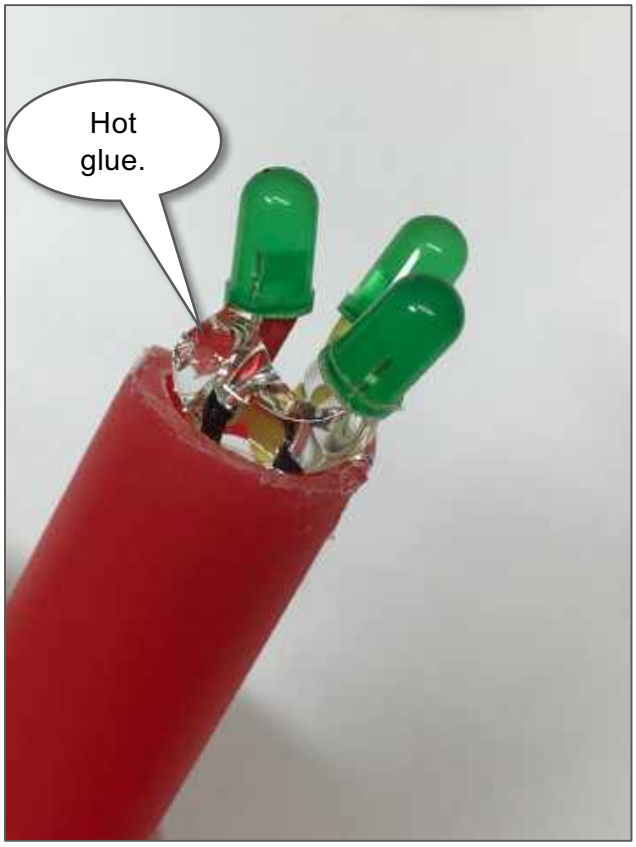


Figure 3.7

Figure 3.8

11. Glue items BN, BI, BO, and BJ with PVC solvent cement. Follow manufacturer's recommended procedures and safety practices for gluing pipes and fittings. Items BK, A3, D, A2, and I (seen in Figure 3.9 lower section Front View) are also glued, but are not part of the Beacon Internal Assembly.

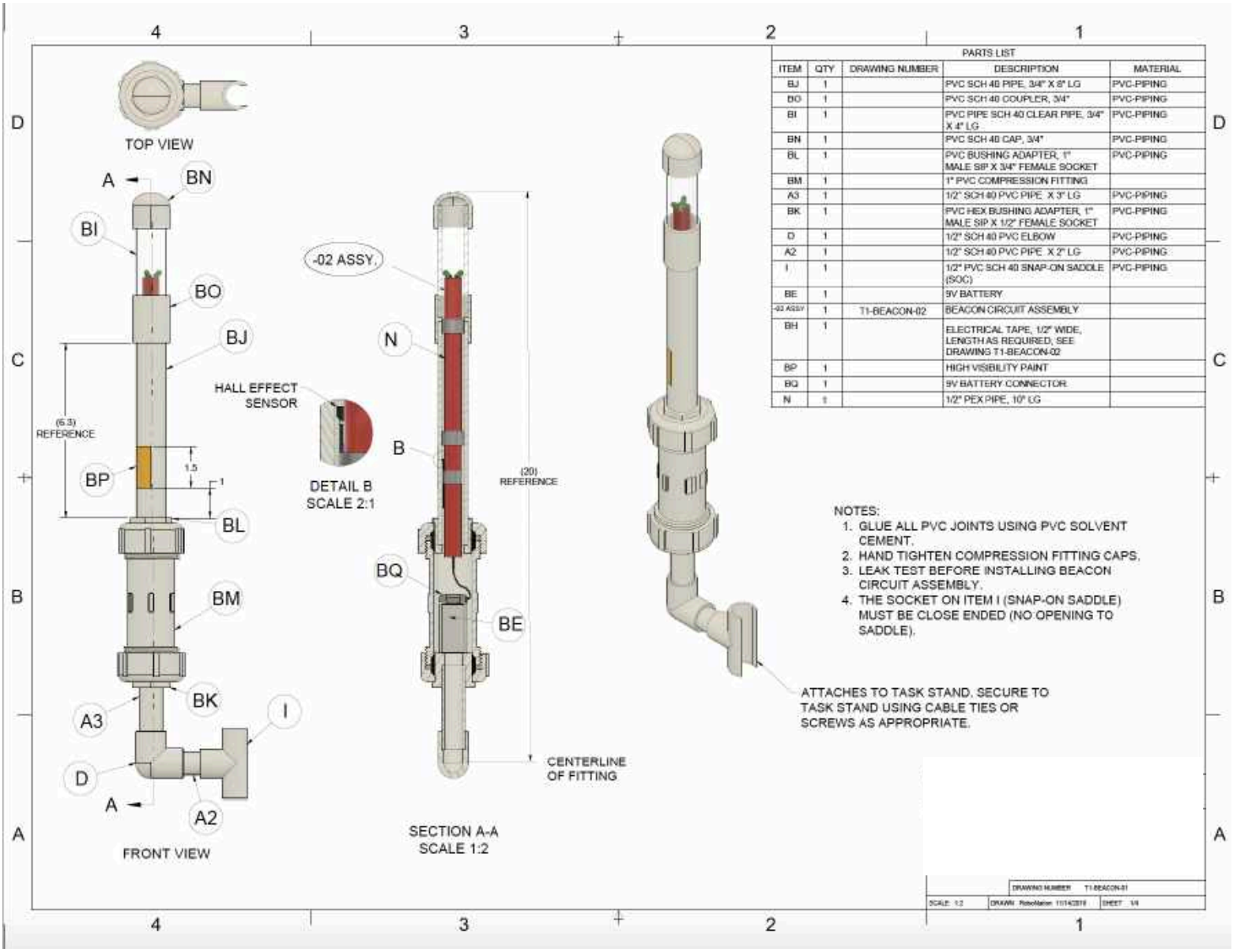


Figure 3.9 Drawing T1-Beacon-01

13. Mark the pipe and busing adapter (the glued assembly from step 11) as shown in Figure 3.10.

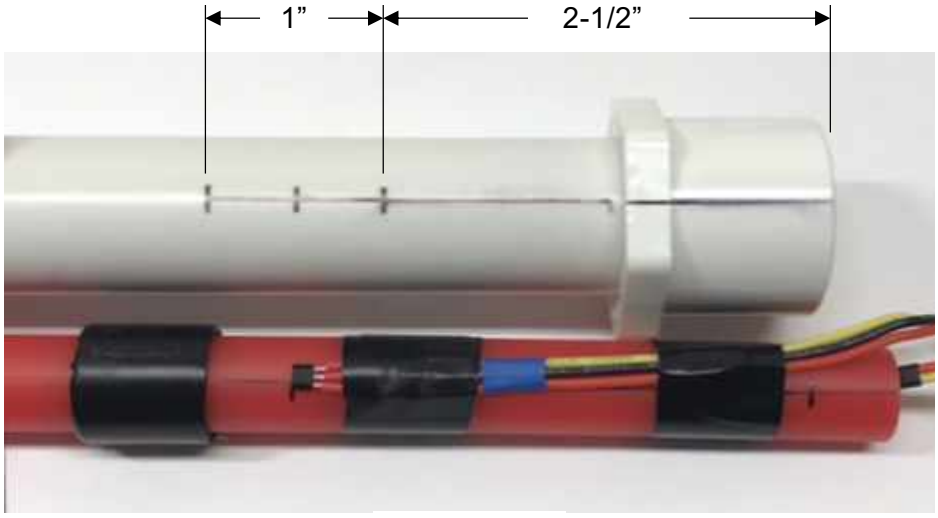


Figure 3.10

14. Slide the internal assembly into the 8” long ¾” PVC pipe leaving ½” of the PEX pipe exposed. Align the marks on the PEX and ¾” pipe.
15. Apply colored electrical or duct tape or paint.

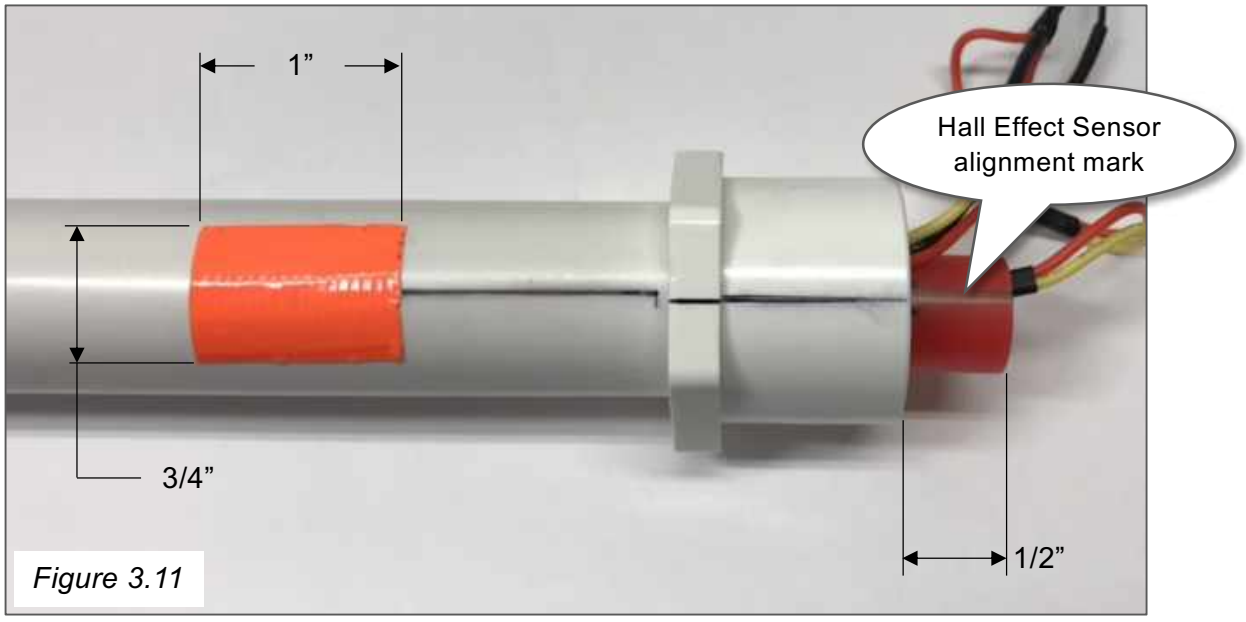


Figure 3.11

Section 4 – Magnet Recommendations

Figure	Type	Size	Max Distance To Activate HES	Store Link
4.1	Rare Earth	6 mm Dia. X 3 mm Thk.	1/16”	Amazon - Neodymium Magnets (5-Sizes, 80 Magnets), $11.20
4.2	Rare Earth	15 mm Dia. X 3 mm Thk.	1/4”	Part of set in above link
4.3	Rare Earth	15 mm Dia. X 3 mm Thk. (Stack of 5)	1/2”	Part of set in above link
4.4	Ceramic (Craft Magnet)	.68” Dia. .16” Thk. (tested)	1/16”	Home Depot 1" Dia. (Pack of 6), $1.98

Many types of magnets will work to activate the Hall Effect Sensor, however stronger magnets will activate the Hall Effect Sensor from a greater distance.

Figure 4.1

Figure 4.2

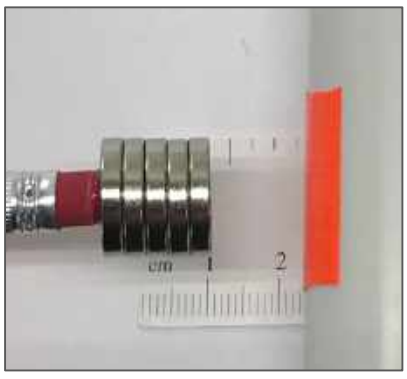


Figure 4.3

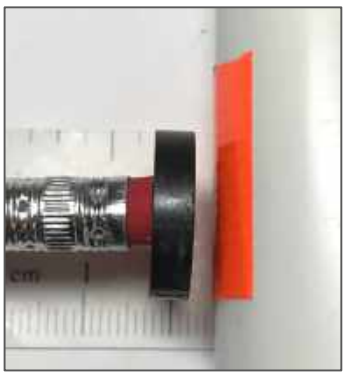


Figure 4.4

IMPORTANT NOTE: For successful activation the magnet’s South pole must be facing the Hall Effect Sensor.