

Do It Yourself: Stern Klingon Bird of Prey WingLEDs

The following document will attempt to walk you through the installation of the WingLED boards necessary to update the typical [Hot Wheels JJAbrams' Star Trek Klingon Bird of Prey](#) (herein referred to as KBOP) so it can be easily installed in a Stern Star Trek pinball machine. *Please note:* the Author of this document is not responsible for any damage you do to yourself or your property. Following document blindly is no excuse for lack of common sense. ;) **Duplication of this document is *not* permitted without written consent.**

Tools/Materials Needed:

- [2010 Hot Wheels KBOP](#)
- Soldering Iron & Solder
- [Dremel](#) or Drill
- [1/16" drill bit](#) or two or three ... seriously; get more than one
- 5/16" Dremel [#114 High Speed Cutter](#) Bit
- xacto knife
- small gauge [rework wire](#)
- Blue Painters or Masking Tape
- White and/or Silver Plastic-adhering spray paint

This set of WingLEDs provide all the necessary circuits to directly power your KBOP from the Pinball machine's GI circuit. A simplified wiring diagram is provided in Figure 1 below.

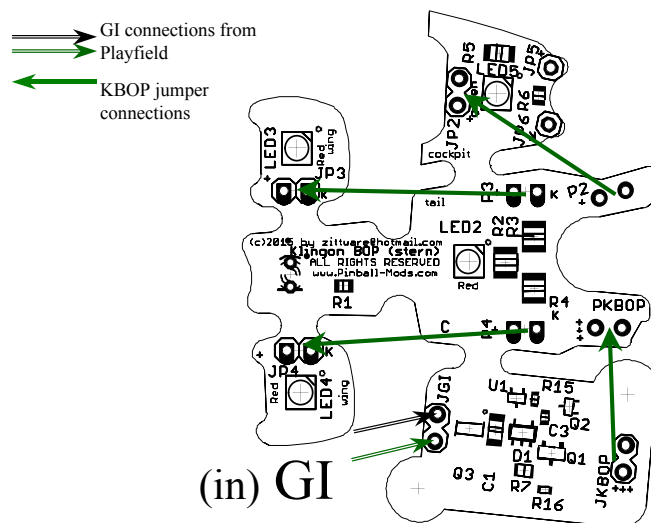


Figure 1. simplified KBOP Wiring

Here is how your board should look fresh out of the package:

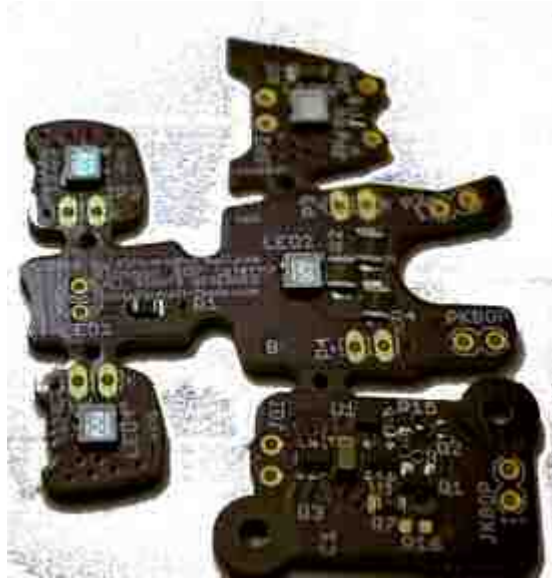


Figure 2. virgin WingLED set

Please Note: Your boards may be white; please do not be alarmed if they are not purple.

1) Begin by snapping the boards apart. They should easily snap along the holes in the center of the FR4 material. Once the boards are snapped; clean the "[mouse bites](#)" off the PCBs using a dremel or belt sander. This will make the boards look clean when attached to the KBOP and is critical to ensuring the boards will fit inside the ship.

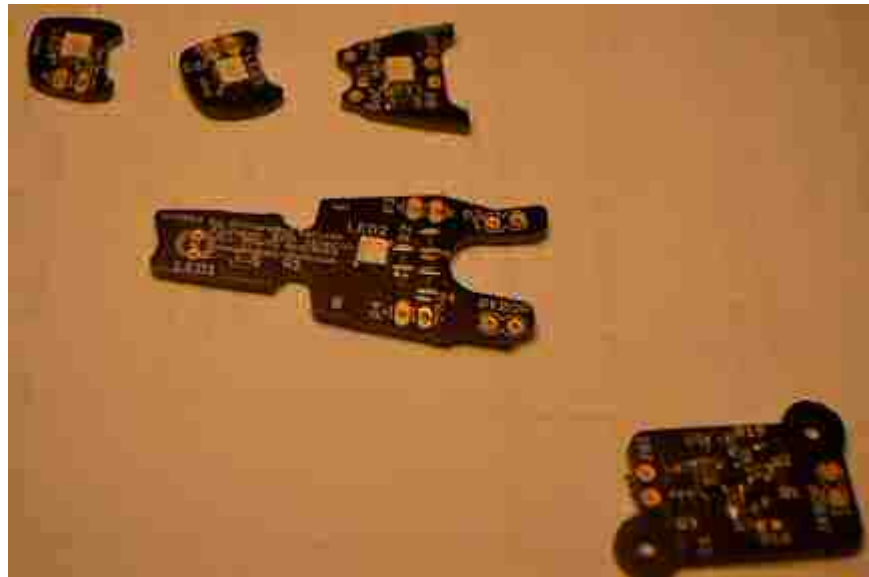


Figure 3. Separated Boards

2) Start by removing the plugs hiding the screws which keep the ship together. You can see the plugs clearly in the following picture:



Figure 4. remove screw hiding plugs

Removing these plugs can be super simple or a PITA... really depends on who assembled the ship. Sometimes the plugs are just press fitted in place; and sometimes they put huge amount of glue on them. Try to use the tip of an xacto knife to pry on the plugs, if they don't have glue; they'll come free. Else; be prepared to have to drill out the plugs with a dremel bit. Once you have the plastic plugs removed; you'll see the Philips head of the screws. Remove the screws and the ship will come apart.

NOTE: Be *VERY* careful when separating the ship halves. The wings are held in place with a simple ratcheting mechanism. If the wings push up on the ratcheting mech; the mech will pop out of it's home and fly across the room never to be seen again. For best results; put the ship top down on a desk so the wings don't sag when you're separating the halves.

Save the screws, plugs (if salvageable), ratcheting mech and spring, and the nubbie thing in a safe place... like a ziplock bag.

3) With top and bottom fuselage separated; we need to drill some holes for the engine manifold effect. This is best done by removing the horseshoe shaped implement on the top of the ship. To do this use a SHARP xacto knife to cut away one side of each of the 3 shafts until you can work these press fittings out of the holes. Remove just enough material so you can pry the decorative piece off of the top of the ship. You want to leave enough of the press fitting so you can re-install the decorative piece back on the ship and have it stay in-place with little fuss:

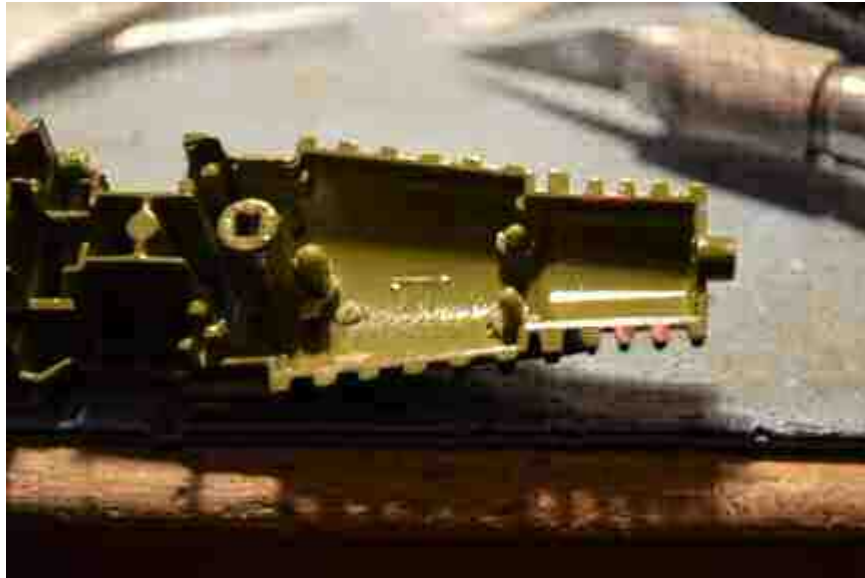


Figure 5. Remove decorative engine piece



Figure 6. Engine piece removed

4) From the top of the ship half; use a 1/16" bit to drill out light holes for the engine manifold. The ship is casted from aluminum so should be easy to drill using a dremel. Drill as close to the interior fin as you can; above the first line on the red part. Snapping a drill bit is easy if you rush it... so take your time. You'll need to save your bit for the pain on the cockpit. Once you've drilled 4 holes per side; your done. :D



Figure 7. Drill light holes for the engine

5) This is the step where you will probably begin to hate 1/16" drill bits. They like to snap when drilling the body light holes. Have a couple of spares ready and take your time. It's quiet a trick to keep the ship steady and drill these holes. If you can find a way to clamp the ship to a vise; that would ideal to minimize bit flex which leads to the bit snapping off. Anyway; You want to drill about 5 holes per side of the body in between the fins as pictured. You can use a smaller bit... but they tend to break easier. These holes is where the green body light exits the ship. Do this on both sides of the body.

Figure 8. Drill body light holes



6) Congrats if you didn't break a bit. At this point; you need to drill out the cockpit rubber nose piece. For this I tend to use a [#114 High Speed Cutter](#) in my dremel to quickly remove the rubber. I've also used a [Carbide Cutter](#) to do the job but it's slower. You want to remove enough of the rubber material so you can fit the 5mm Red LED in the cockpit.



Figure 9. Remove some cockpit rubber

You may also want to trim the flanges off of the 5mm red LED to aid in inserting it in the cockpit hole. Basically you want the LED to fit snugly in the cockpit; but not be sticking out of it on any side.

7) Using the 1/16 drill bit; drill a hole in the top engine plug. This hole will house the 3mm candle flicker LED; so make sure it's big enough to allow the 3mm LED to fit snugly.



Figure 10. Drill an Engine LED hole

8) Now we get to install the cockpit LED board (JP2). Install the 5mm LED in the rubber cockpit and install the rubber cockpit in place. You'll want to bend the LEDs leads around the screw hole and bend them at a right angle so you can push them into JP5 and JP6 from the bottom of the cockpit board. Push the cockpit board with the SMT LED facing you. Once you've got the PCB wedged behind the screw post and below the cockpit ledge you're ready to solder the 5mm Red LED's leads to the PCB. Make sure the Cathode of the 5mm Diode installs in JP6 (K).



Figure 11. Position Cockpit PCB



Figure 12. Another Cockpit view

10) Drill the bottom half plastic for the engine LED using a 1/16" drill bit.



Figure 13. Final Engine hole drilled

9) Now install the body board. This board should be installed in the top half of the ship body with the LED facing the holes you drilled in step#4 above. It should fit snugly as pictured. Note my prototype boards were missing bottom silkscreen which is present in your production boards so there should be no question which is the Cathode pad.

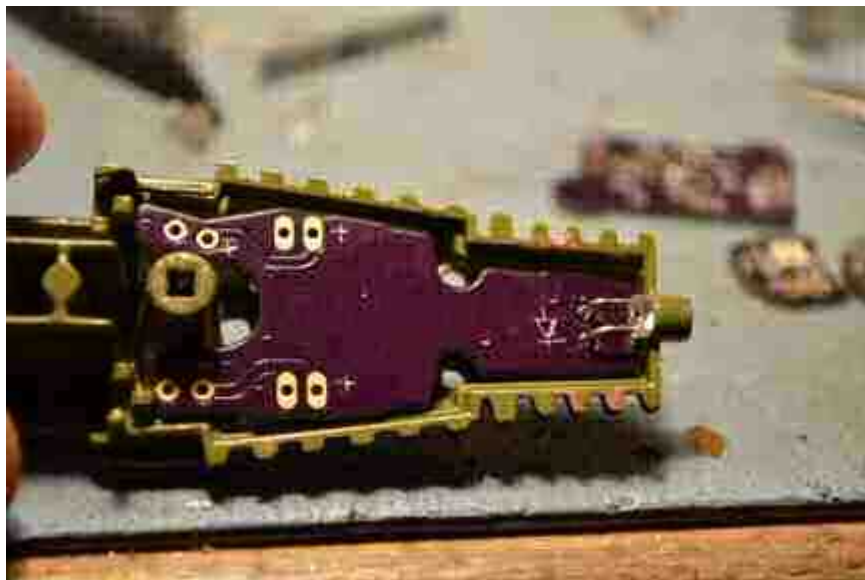


Figure 14. Secure jumper wires

Bend the leads of the candle flicker 3mm LED at a 90 degree angle; and solder it in place on the back of the PCB after inserting it in the engine hole you created in step #7. Make sure the Cathode of the 3mm Diode installs in lower hole of the LED locations. This would be the pin on the P4 side of the PCB.

10) Using some rework wire; Connect P2 on the Body board to JP2 on the cockpit board. Both boards will have a + near the positive terminal; make sure you connect + to +. You want to run the wire along the inside of the body as shown.



Figure 15. Connect P2 to JP2

Note: The Author uses a heat activated adhesive rework wire which has a meltable jacket used to secure it to PCBs and other surfaces. This adhesive rework wire is nice; but not required.

11) Time to move to the wings. Start by using the tip of a xacto knife or a small screwdriver to pry off the panel which hides the screw:



Figure 16. Pry off screw cover

12) With the cover removed; you have access to the screws. Remove them and take apart the wing assembly. Note that the LONGER screw goes in the fatter part of the wing body: This will be important when reassembling. Using your 1/16" drill bit; bore a hole wing bar assembly and "carve" out a channel in the bottom cover of the wing:



Figure 17. Drill wire holes in the wing and lower cover

13) On the wing side; bore two holes in the corner of the plastic for the wires:



Figure 18. more Wire holes

14) Now, solder some rework wire to the terminals on the wing PCB. Note the polarity of the wires is important. The Cathode of the SMT LED is marked with a "K". It will need to be attached properly to the Body board later in the instructions. You can do this any number of ways... One is by keeping the cathode wire shorter than the anode; so you can ID it when needed; or you can use a multimeter to find the proper terminals when soldering to the body board. I've done both - implementer's choice.



Figure 19. Solder Wire to the Wing LED board

Run the wire thru the two holes you created in Step#13. The Wing PCBs should be the right size to Press/Friction fit in the cavity of the ships wing. If necessary; you can use Hot Glue or Epoxy to secure it if necessary.

15) Reassemble the arm to the wing, running the wires out the hole you created in Step#12.



Figure 20. more wire Routes

16) Reattach the bottom cover; **remembering the longer screw goes in the fatter part** of the wing. Before tightening the screws; put enough slack in the wire so it will allow the wings to rotate to your intended position.



Figure 21. Reattach bottom cover

17) Repeat Steps 11-16 for the Left wing.



Figure 22. Repeat/Rinse Left Wing

18) Time to reattach the wings. This will be a struggle. In this picture; I had lost the ratcheting mech I warned you about in Step#2. I actually heard it hit the ceiling then the wall behind my Star Trek Captains chair. Never found it again. As a result I used hot glue to secure the wings in place. This actually works well to help keep the wings in place while soldering the jumper between the wing PCBs and the body pcb. Remember; the Polarity of the Wing boards matter; Make sure the Kathode of the LED connects to the non-+ side of the P3 or P4 connections. If in doubt; [verify with a multimeter](#).



Figure 23. Wire WingLEDs to Body board

19) Now for the arts and crafts portion of the instructions; wrap the lower ship body in blue painters or some other kind of tape. Your goal here is to paint the cockpit area with several layers of paint to prevent light from escaping from the plastic on the bottom. IE the body shouldn't glow green; just green exits from the holes you drilled. I spray the cockpit with white plastic paint first; then after it dries - hit it with a coat of silver spray. My thinking is silver would reflect the green and block the light bleed. YMMV.



Figure 24. A White Cockpit



Figure 25. Silver Light Block

Remove the Plainters tape after it dries:

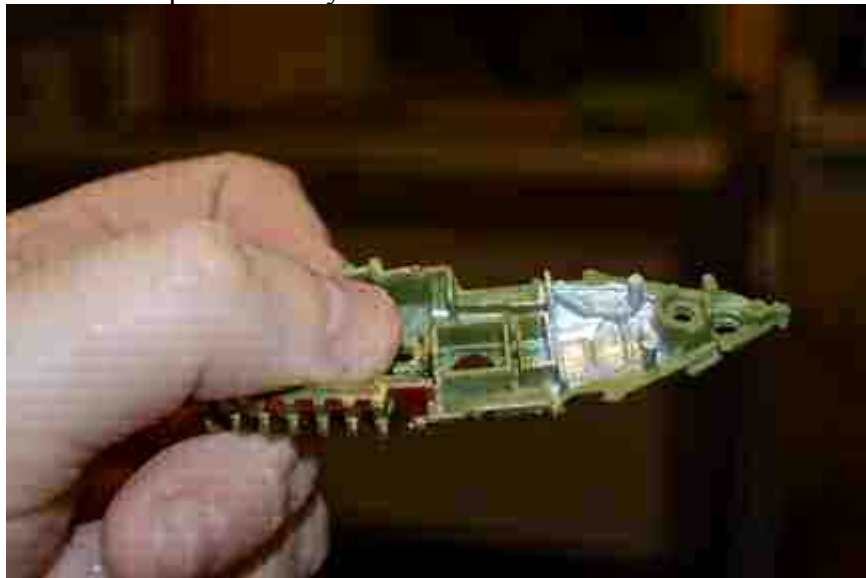


Figure 26. Examine handy work

20) Solder wires to the **PKBOP** pads. I use two colors so I can determine the polarity coming out of the ship. **PKBOP** is polarized; you need to make sure you have a + color and a - color. In this picture I went with Yellow for the positive and Green for the negative.



Figure 27. Add Wire to PKBOP

At this point; you can test the ship assembly before buttoning it up. If you have a +5V bench supply; connect the positive to the +wire (yellow) and ground to the -wire(green). All the LEDs should light. Both Wings, the Rubber cockpit Red, Cockpit Green, Candle Yellow on the Engine, and Red for the manifold. If one or more do not lite; check polarity/wiring.

21) At this point reassemble the ship. Run the ship wires out the large hole in the bottom of the ship. Do not re-install the rubber ball joint. It won't be used with the MezelMods bracket. Reinstall the wing ratcheting mech, and the little nubbie thing. Tighten down the screws and reinstall the wing screw covers. If you were able to save the body screw covers; re-install them. Install the engine manifold horseshoe piece from Step#3.



Figure 28. Bracket in original mounting hole

22) At this point you can install the bird of prey bracket on you machine. The Author installed it over the LOCK plastic on his STLE using an existing screw for the plastic. You may choose to install it at a different location.



Figure 29. Mount Location for bracket on STLE

23) The Author hard-wired his KBOP to a GI bulb socket which lights the same LOCK plastic. Do this running the KBOP polarized wires below the Playfield; then solder the positive (yellow in this picture) to the positive terminal of the **JKBOP** connection in the polarizer board. The polarizer board is the only one you haven't installed in the ship and has screw hole ears on opposite corners. The jumper the JGI connection to the lamp socket base or some other suitable GI connection. Do not exceed 6.3V as an input to this polarizer board. IF you choose to hardwire the connection; skip to Step #30 below.

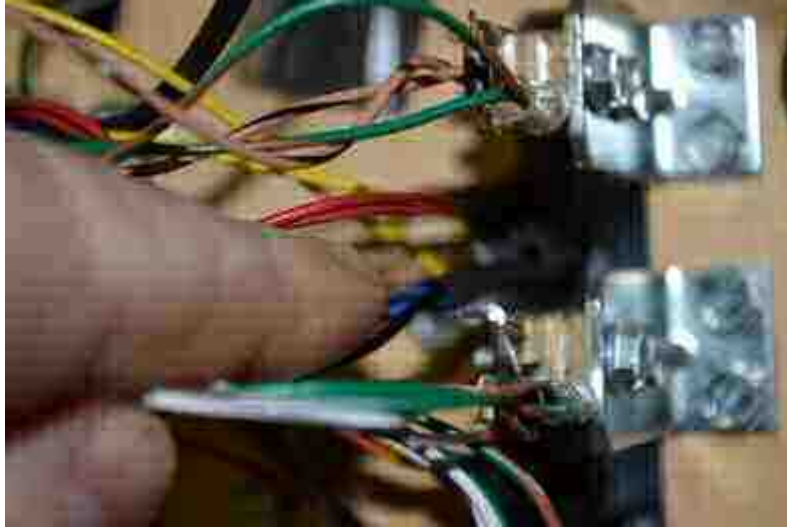


Figure 30. Direct Wired to Lamp Base

24) If you desire a more "bolt-on" method to powering your KBOP; then start by taking a 2SMD natural white #555 base LED lamp such as: [Twin 2835 from Comet Pinball](#) and removing the Lens so you can take apart the LED. This LED will replace one of the LEDs under the LOCK Plastic and power the KBOP. To remove the lens; I find I can usually do it using my thumb and fingers in a prying movement:



Figure 31. Remove LED lens

25) Then straighten the LEDs leads and the white PCB should come out of the base freely. It may be glued in place; but I haven't seen that to be the case.



Figure 32. Straighten LED leads to remove base

26) Using the 1/16" drill bit; drill two small holes in the base right next to each other. This will serve as an outlet for the wires you are going to solder in the next step.



Figure 33. Drill Wire holes in base

27) Using some 26AWG wire; solder one wire to each of the two 15ohm resistors which make up the leads for the LED. Run the other end of the wire out of the holes you drilled in Step#26.



Figure 34. Solder GI wires to LED leads

28) Reassemble the LED. thread the resistor LEDs back out the base so they continue to make up the leads of the Lamp. The author used a dab of 5minute Epoxy to secure the lamp lens on top of the base and puts it in a clamp. You may want to use some of that epoxy to secure the wires to the holes of the base to add a kind of strain relief.



Figure 35. Epoxy Lens to LED base

29) Once the Epoxy dries; solder the other end of the green wires to the **JGI** connection on the polarizer board. The author finds it's easier to install the LED in it's final lamp socket then feed the wires thru to the underside of the PF where you solder it to the JGI connection.

30) Once you have the **JKBOP** and **JGI** connections made to the polarizer board; you simply need to secure the board to a easy place under your machine (so it doesn't short to something). The Author used a zip-tie to secure it to the wire harness anchor near the ship.

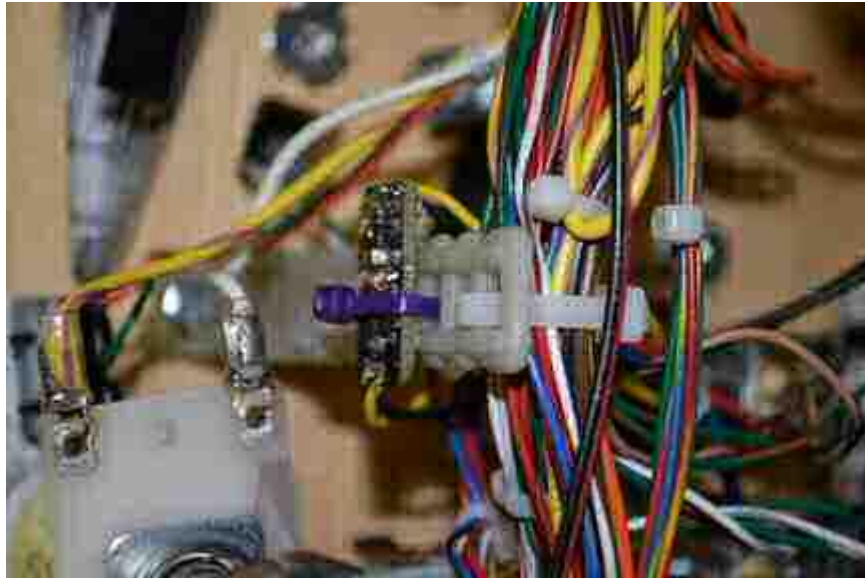


Figure 36. Secure Polarizer board to Harness mount

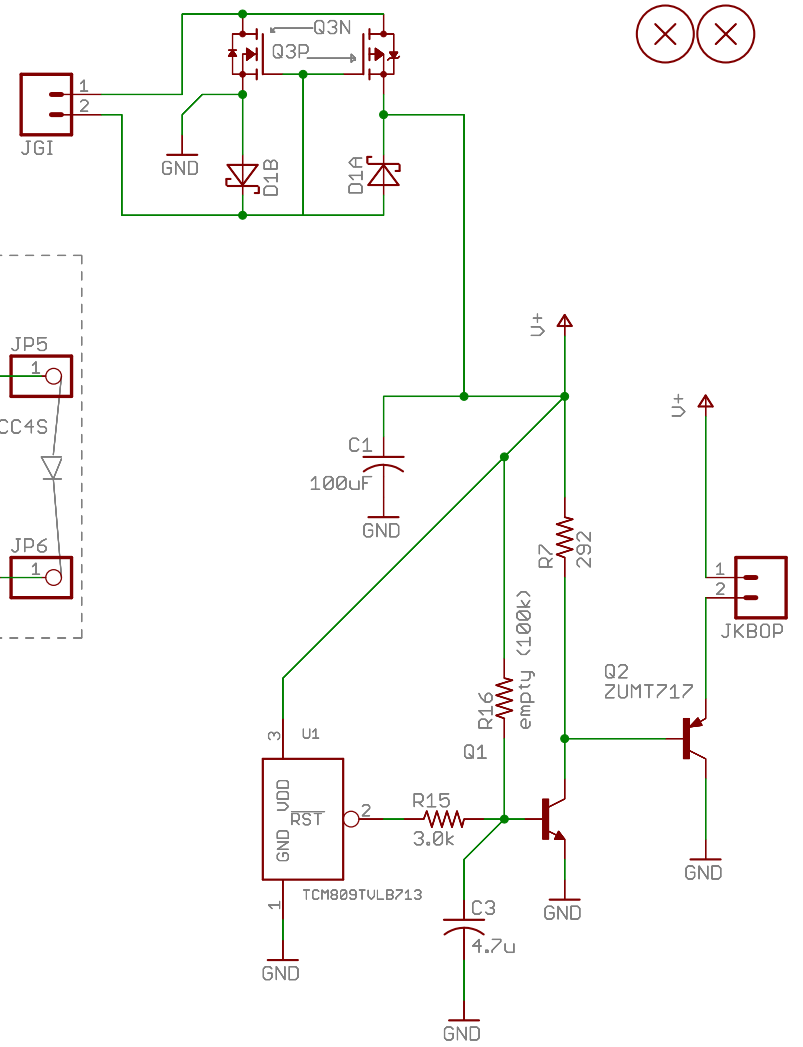
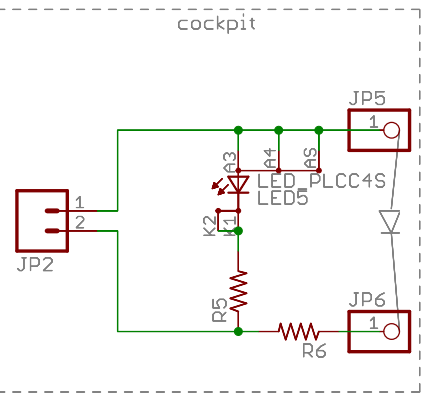
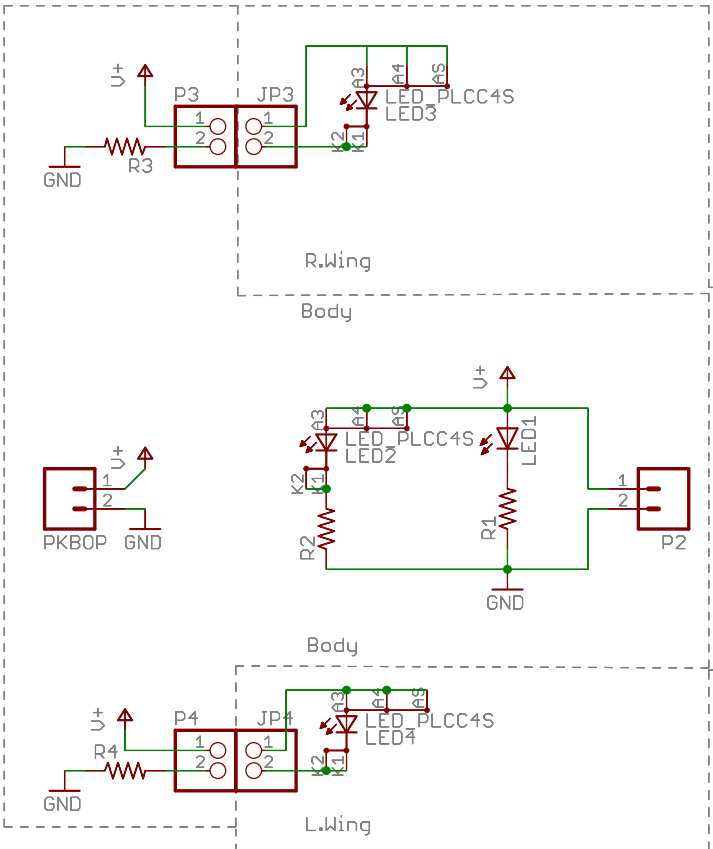
Congrats; you've completed the modification for the HotWheels Bird of Prey w/ WingLEDs.



Figure 37. Final Installation

Appendix A: WingLED Schematics

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