Lick ports

Lick Ports are used both for lick detection and reward delivery. Regarding the former, lick ports include a LED and a photo sensor positioned in parallel. Close vicinity of an object (e.g. the tongue of a mouse) reflects the infrared light and activates the photosensor. This signal is connected to the control circuit board that links them with the computational node (Raspberry Pi or PC). Regarding the latter, a tube for water delivery for correct responses is coupled to a computerized valve that controls the liquid delivery that can deliver liquid volumes with 1μL resolution. The water is channeled through a liquid delivery device when the correct electrical signal is transmitted from the port to the electric control panel leading to the opening of the respective valve. Both the LED and photo sensor wires and the reward tubes are enclosed and glued in a metal cylinder at their end point in order to prevent possible damages that could be caused by chewing or other mice activities.

Hardware parts list

Electronics

#	Item	Qty	Part #	Vendor	Ind. Price	Notes
1	Shielded cable	25-28 cm	1804A	Belden		To protect the signal from electrical noise and interference
2	Optical switch, Phototransistor	1	QRE1113	Onsemi	0.88€	
3	Wirewound Resistors - Through Hole EP 2W (SS) 330R 5%	1	EP2WSS330RJ	TE Connectivity / Neohm	0.38 €	To control the current flow
4	Metal Film Resistors - Through Hole 0.6W 47Kohms 1% 50ppm CECC	1	MBB0207VC4702FCT00	Vishay / Beyschlag	0.35 €	To control the signal output voltage

Other Hardware

#	Item	Qty	Part #	Vendor	Ind. Price	Notes
1	Heat shrink set	6	05-00017098	Cyg, Grobotronics	9.90€	4x1/16” - for the individual wires 1x3/16” - for the sensor’s side 1x1/4” or 1x3/8” - for the phototransistor’s side
2	Welded Stainless Steel Tubing 6 mm OD, 0.25 mm Wall Thickness	3-4 cm	50415K25	Mc Master Carr	22€	
3	Unolok Disposable Needles 18G	1		https://www.medi-shop.gr/en/needles/unolok	5.02€	For reward delivery
4	Pin Header 1x40 Male 2.54 mm	3 pins	19-00011916	Grobotronics https://grobotronics.com/pin-header-1x40-male-2.54-mm-black.html	0.10€	
5	Soldering Wire Cynel 100g 0.5mm - Lead Free	-	05-00605630	Grobotronics https://grobotronics.com/cynel-100g-0.5mm-lead-free.html	10.90€	
6	Bison 5 minutes epoxy glue	-	6305448	https://tapshop.eu/store/home-and-garden/bison/bison-glue-epoxy-5-min-(24ml)-1586025?srsltid=AfmBOopn1n0Sk1DUIYxXs0nLBW0gYJDcW8TKiw47t9EIVCd--mV-pzhR	8.51€	

Step-by-step assembly instructions

Connecting the cable to the sensor

Step 1. Cut the ends of the phototransistor (Electronics parts list, item #2) pin connectors to shorten them to a few millimeters.

Step 2. Strip the outer insulation from the cable (Electronics parts list, item #1) to expose the individual wires, then strip each wire to reveal the inner conductors.

Step 3. Slide a small piece of heat shrink tube (1/16'') onto each wire (Other Hardware parts list, item #1). Make sure it covers both the pins of the sensor and the exposed wire (do not heat the heat shrink tube yet, just move it to the base of each wire).

Step 4. Each of the 4 pins of the phototransistor corresponds to a specific wire. The pin positions start from the trimmed edge of the rectangle (Pin 1), and the rest follow in an anticlockwise direction (Fig. 3).

Pin 1: anode of the LED (connects to the power supply)
Pin 2: cathode of the LED (connects to the ground)
Pin 3: collector of the sensor (current flow after light reflection)
Pin 4: emitter of the sensor (connects to the signal output)

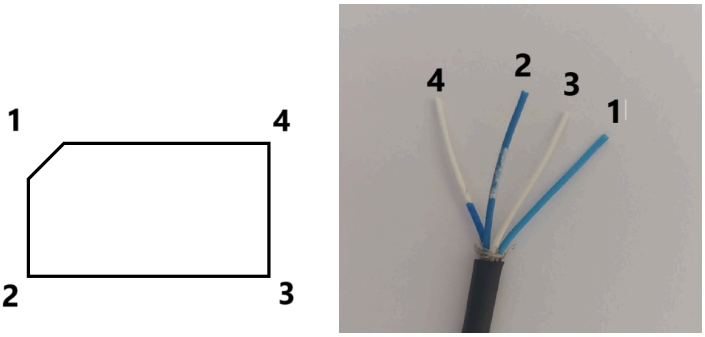

Figure 3. *Positions of the phototransistor's pins and their corresponding wires.*

Step 5. Use the soldering station to connect the pins vertically to their corresponding wires as described below (Figure 4).

Step 6. Use a hot air gun to heat the heat shrink tubes you have added to each wire to cover the wire and the phototransistor's pins.

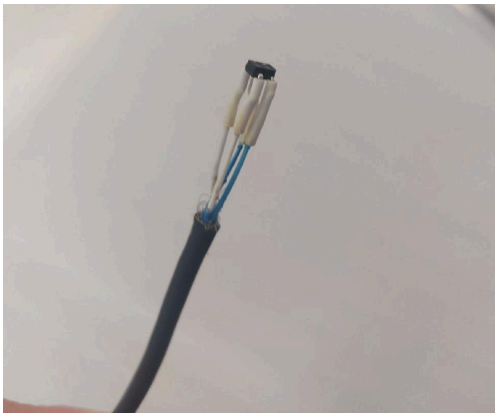

Figure 4. *Heat shrink tubes covering the exposed wires and the phototransistor's pins.*

Step 7. Cut a piece of heat shrink tube (3/16'') long enough to cover the exposed cable and the pins of the phototransistor, and pass it down the cable. Apply the epoxy glue (Other Hardware parts list, item #6) to the exposed section of the cable and cover it up to the edge. Cover the exposed cable with the heat shrink tube and use the hot air gun to heat it. Ensure that the phototransistor's pins and the wires are well covered.
Note: As the hot air gun shrinks the tube, ensure that the epoxy glue will not cover the phototransistor.

Figure 5. *Heat shrink tube covering the phototransistor side of the lick port.*

Step 8. Cut a steel cylinder (Other Hardware parts list, item #2) long enough to cover the heat shrink tube that covers the exposed wires (Fig. 6). Carefully smooth both edges of the cylinder with sandpaper to ensure the mouse is not injured while licking it.

Step 9. Cut the pointy edge of the 18G needle (Other Hardware parts list, item #3) and smooth it with sandpaper. Remove the plastic hub from the needle. Ensure that the needle is long enough to extend beyond the bottom end of the steel cylinder so that it can be properly connected to the water tube (Fig. 6).

*Note: The needle is required **only if** you will use the lick port for reward delivery.*

Figure 6. *Indicative lengths of the steel cylinder and the needle relative to the lick port.*

Step 10. Pass the phototransistor cable and the needle through the steel cylinder. Apply epoxy glue around the heat shrink tube insulation of the phototransistor (Fig. 5) and the needle, ensuring that the phototransistor's and the needle's tops are not covered with glue. Pull the cable and the needle so that they are on the same level and a few millimeters below the top of the steel cylinder to prevent possible damage. Fill all the empty spaces between the phototransistor and the cylinder with epoxy glue.

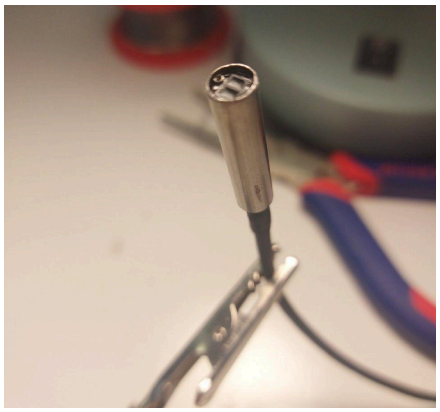

Figure 7. *Phototransistor end of the lick port.*

Connecting the cable to the resistors

You will need two resistors:

- 330Ω: The anode of the LED is connected to the power through the 330Ω resistor to control the current flowing through the LED.
- 47kΩ: The resistor is placed between the emitter of the phototransistor and the ground to help define the signal output voltage.

Step 11. Shorten the wire connected to the anode and expose the conductor. Cut both ends of the 330Ω resistor (Electronics parts list, item # 3) and use soldering to connect the 330Ω resistor to the wires connected to the anode and the collector. Solder the resistor horizontally across the cable, connecting the distal pin to the collector wire and the proximal pin to the anode wire (Fig. 8).

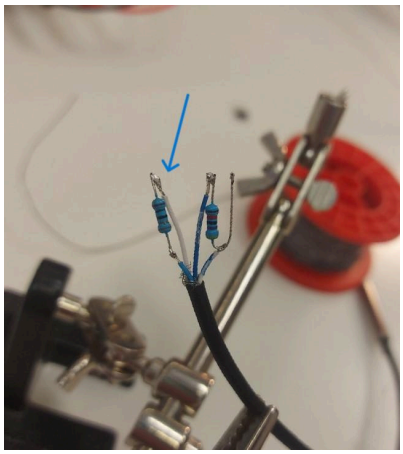

Figure 8. *Connections of the 330Ω resistor.*

Step 12. Shorten the wire connected to the emitter and expose the conductor. Bend one of the pins of the 47KΩ resistor (Electronics parts list, item #4). Use soldering to connect the cathode wire to the straight pin and the emitter wire to the other pin (Fig. 9).

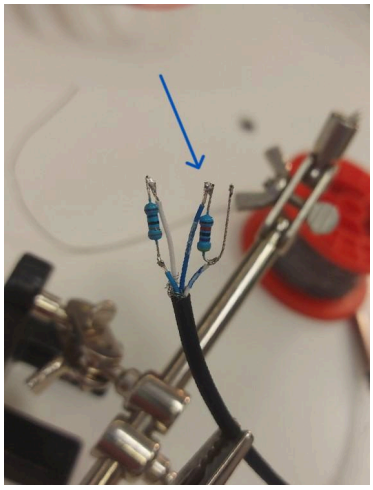

Figure 9. *Connections of the 47kΩ resistor.*

Step 13. Use a male pin header (Other Hardware parts list, item #4) with 3 pins and connect it to the cable (Fig. 10). Mark the tip that is connected to the bent pin of the 47kΩ resistor so you can distinguish it (it corresponds to the signal).

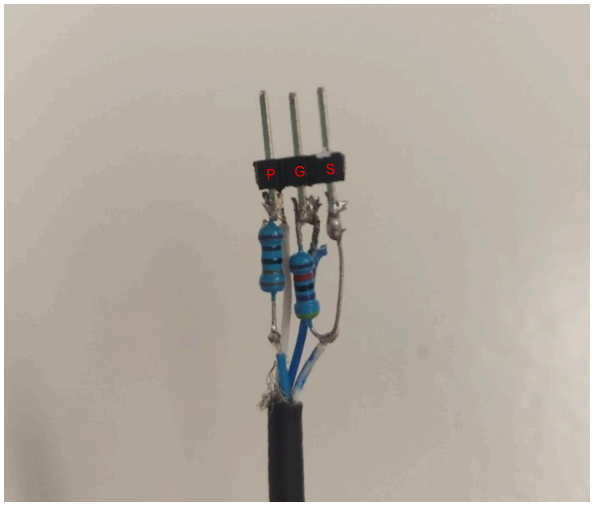

Figure 10. *Connections of the signal cable (P: power, G: ground, S: signal).*

Step 14. Cover the exposed cable and the proximal part of the male pin header with heat shrink tube (1/4'' or 3/8''), and heat it with the hot air gun.

Testing the lick ports

Step 1. Provide a DC power supply (~3.5V). Connect the positive terminal to the power input and the negative terminal to the ground in the pins shown in Fig. 10.

Step 2. Use an oscilloscope and connect it to the signal cable (Fig. 10).

Step 3. Use your finger to simulate the lick of a mouse and observe the activation of the phototransistor (Fig. 11)

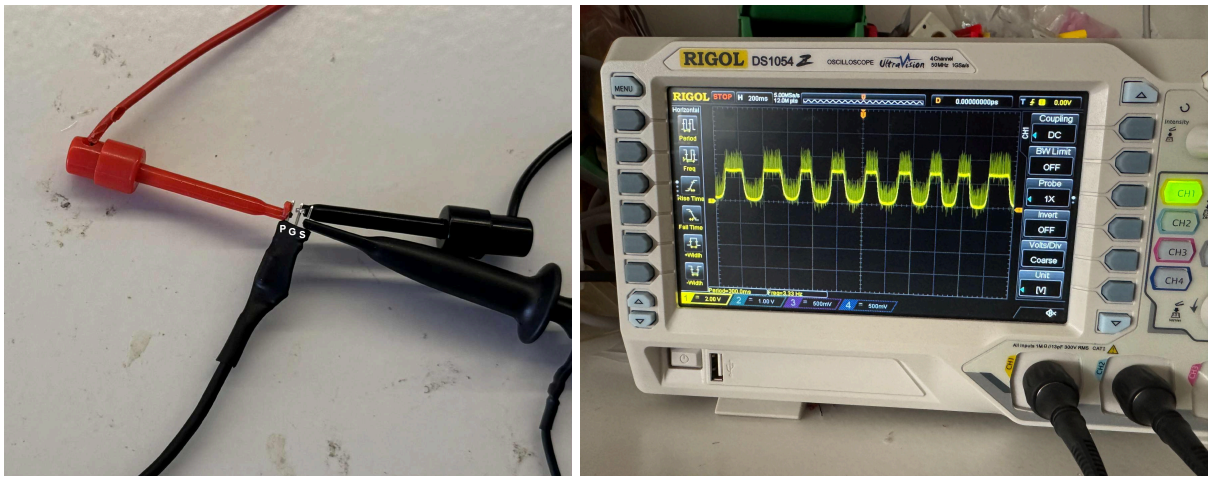

Figure 11. *Sensor voltage output (left: connections of the power supply and the oscilloscope, right: activation of the phototransistor).*