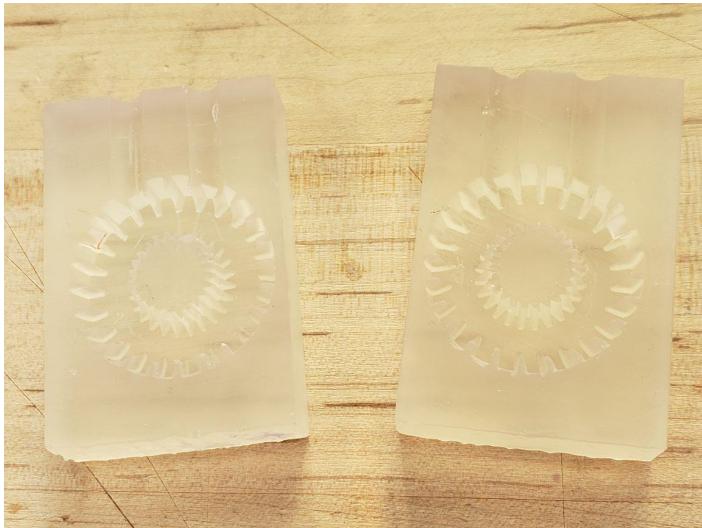


## Twisted Pair Toroid Fabrication Steps

The following are instructions for fabricating caterpillar traps with ID = 11.5, OD = 28.5 and d=9mm and N=24 for 3T (127.7MHz). Different sizes will need adaptation of wire length, number of turns and tuning cuts.

### Materials:

1. 3D Printed Toroidal Mold

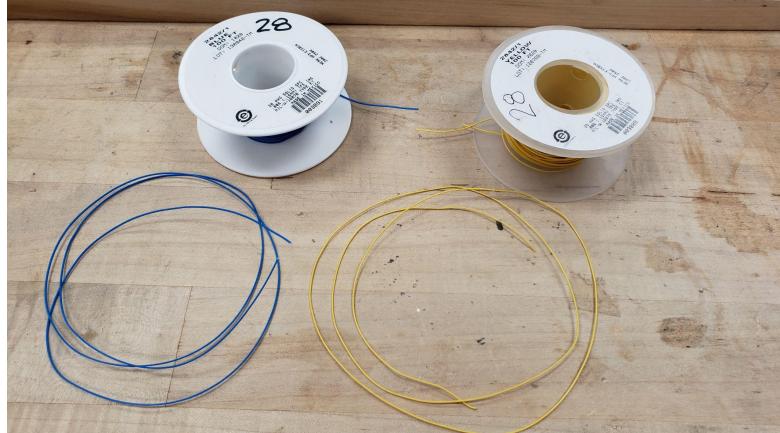


The stl files for the two parts of the mold can be found here: ([pt1](#), [pt2](#)).

2. Smooth-Sil 945 Silicone Rubber Compound  
(<https://www.smooth-on.com/products/smooth-sil-945/>)
3. 28 AWG, Polytetrafluoroethylene (PTFE) insulated wires in two colors (yellow and blue)
  - o <https://www.digikey.com/en/products/detail/alpha-wire/2842-1-YL001/3708259>
  - o <https://www.digikey.com/en/products/detail/alpha-wire/2842-1-BL001/3708253>
4. (only for the clamp-on design) Low-Profile/In-line Cable ties  
(<https://www.cabletiesunlimited.com/4-18lb-natural-low-profile-in-line-cable-ties-100-bag-part-lp4-18-9c.html>). We picked low-profile cable ties so that they occupy minimal space within the toroid.

## Fabrication Instructions:

1. Preparation of the Twisted Pair
  - a. Cut 80cm of both of the yellow and blue PTFE insulated wires



- b. Clamp one end of the two wires to a wooden board using vice grips. Secure the other ends to a drill. Slowly press the switch. As the wires twist the overall length should decrease.



- c. Continue twisting until the length is 72cm.



2. (only for the clamp-on design) Preparation of the Cable Tie

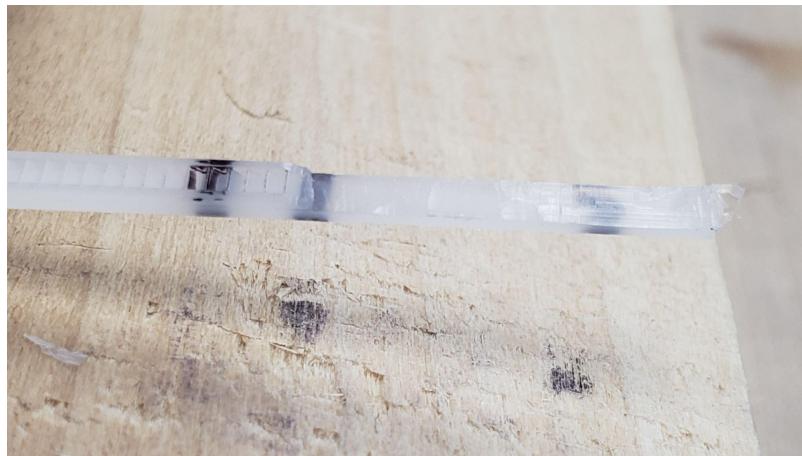
- a. Before molding the cable tie inside of the toroid, we would like to prepare it. Make three marks on the cable tie using a permanent marker at 5.4cm, 5.8cm and 7cm from the left end of the cable tie.



- b. Cut the cable tie 4-5mm right of the third marking. Then clamp the tie (near the head) to wood or other base, with the ridged side facing up. Using a utility knife or scalpel, carefully shave off plastic ridges from the middle marking until the end marking. Shaving off these markings will allow you to unlock the cable tie easier once it is inside the toroid.



- c. In the end there should be 3-4 ridges left between the first and second markings.



- d. Finally, cut the tie at the marking closest to the end, making a "^\wedge" tip.



- e. Bend the entire tie into a loop and feed the cut end into the head, making sure to continue to the inside of the loop. Push through until 1 or 2 clicks are heard/felt.



- f. Cut 12 cm of the 28 AWG blue wire. Wrap wire around the cable tie and twist excess ends down so that the wire is in a tight loop surrounding the cable tie. The base of the twist needs to be as close as possible to the locking entrance of the head.



### 3. Creating the Toroid Mold

- a. Prepare PDMS mixture according to product directions, 1:1 ratio of parts A & B.  
Stir until uniform color and consistency is achieved.



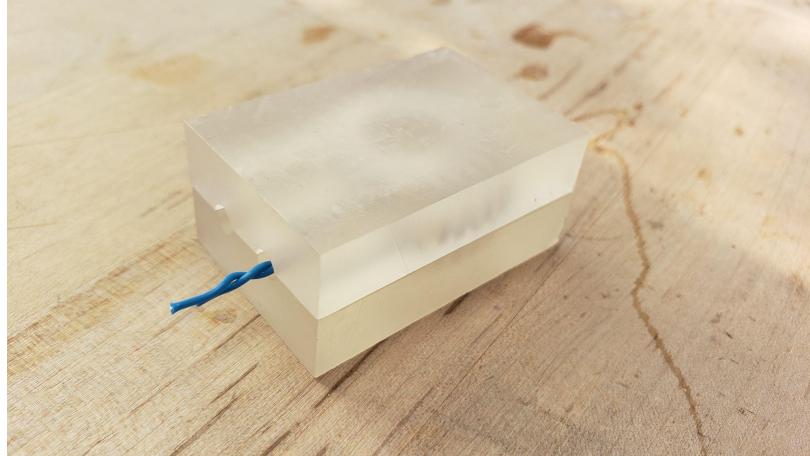
- b. Use a syringe with an opening that fits into the mold. Retract plunger to fill with silicone, or remove plunger and pour silicone mixture into the syringe.



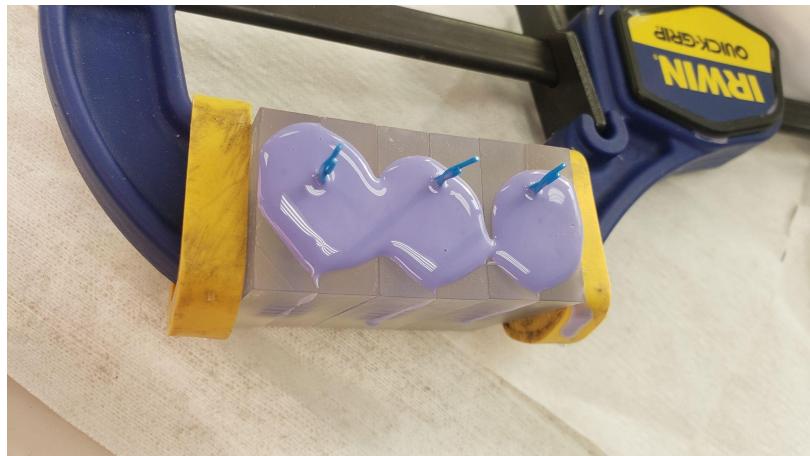
- c. **(only for the clamp-on design)** Place one cable tie and wire into the mold, with the tie's locking tab centered under the tab built into the mold (marked in orange below)



- d. Close with the matching piece, the wire should be sticking out of one of the injection holes.

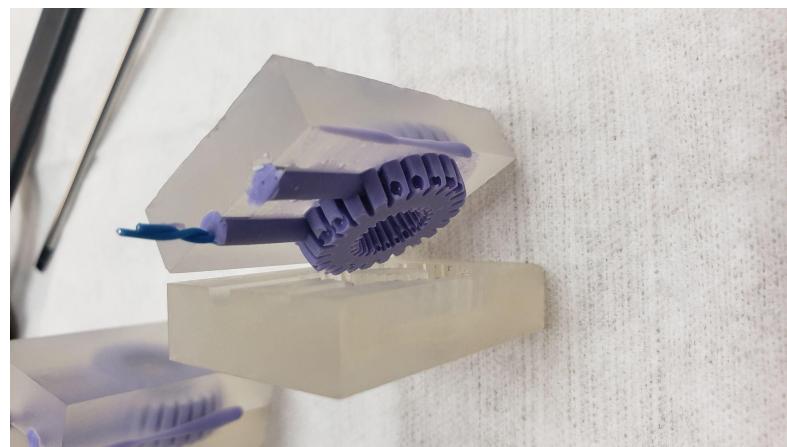


- e. Clamp the two parts of the mold together. Inject the PDMS mixture in the syringe into one of the holes until the mixture comes out of the other hole. Initially the mixture that comes out may have significant air bubbles. Continue injecting until no more air bubbles are seen. Multiple molds can be clamped together as seen below.

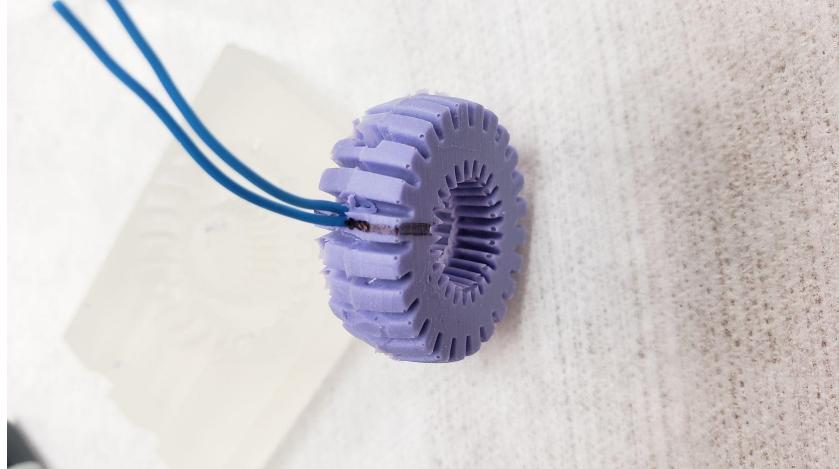


- f. Excess PDMS can be left on top, it will peel away easily when set. Leave the molds to set at least 6 hours before opening.

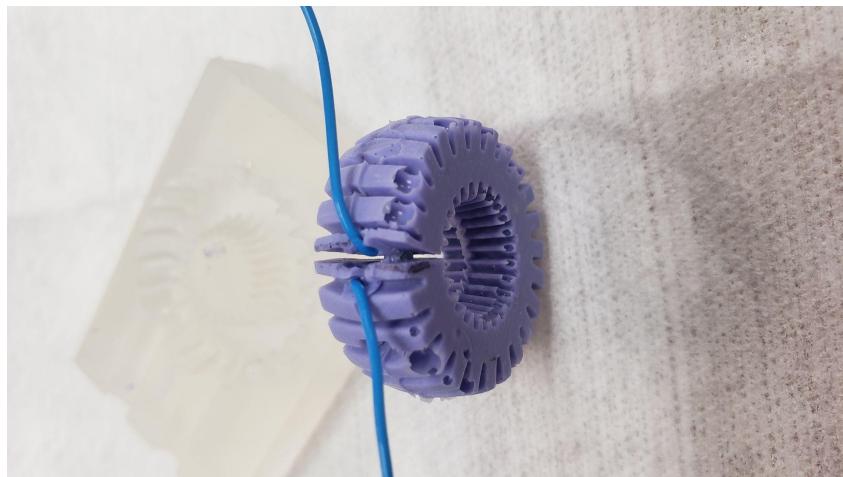
- g. Once the molds are set, remove them from the clamp. Peel away the excess PDMS and open the two halves and remove the toroid from the mold. The excess silicone due to the injection tubes (used to insert the syringe).



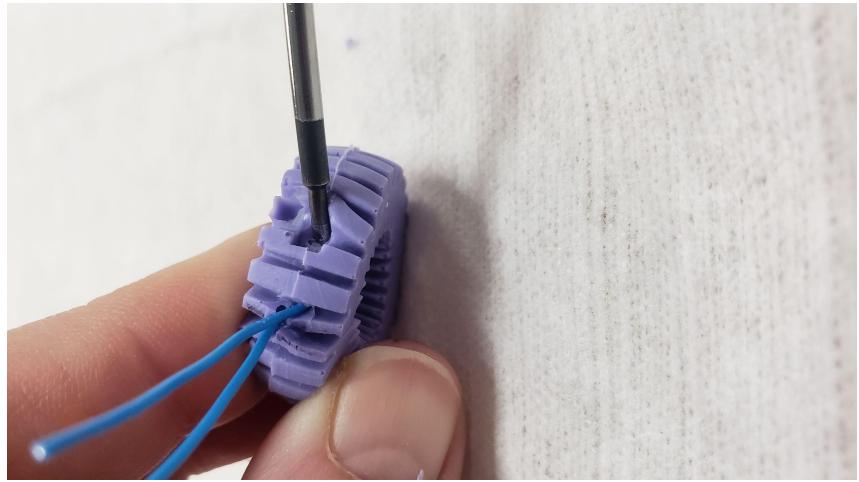
4. (only for the clamp-on design) Cutting Open the Clamp-on Toroids
- For the clamp-on design we need to have an opening on the toroid mold. Draw a guideline across the ridge which has the wires, continue the line through the center of the toroid, following an inner groove.



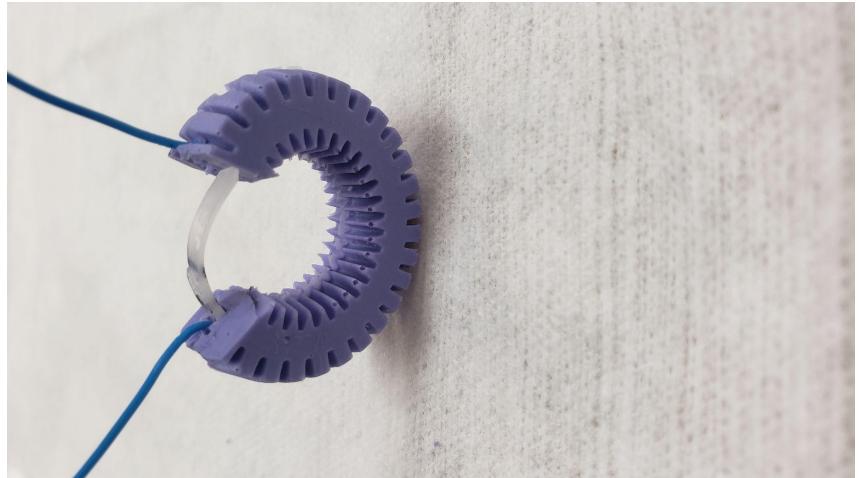
- Cut all the way through the guideline, taking care not to cut the wires and the cable tie. The cable tie will remain in place.



- c. Next, you will need to release the cable tie. Using the access notch, gently enter a small flat screwdriver at an angle less than 90 degrees to the toroid's surface. Feel for the locking tab on the cable tie and ease the screwdriver underneath it gently. Gently lift up on the tab while pulling the toroid apart. Once it is lifted enough the two sides should come apart.

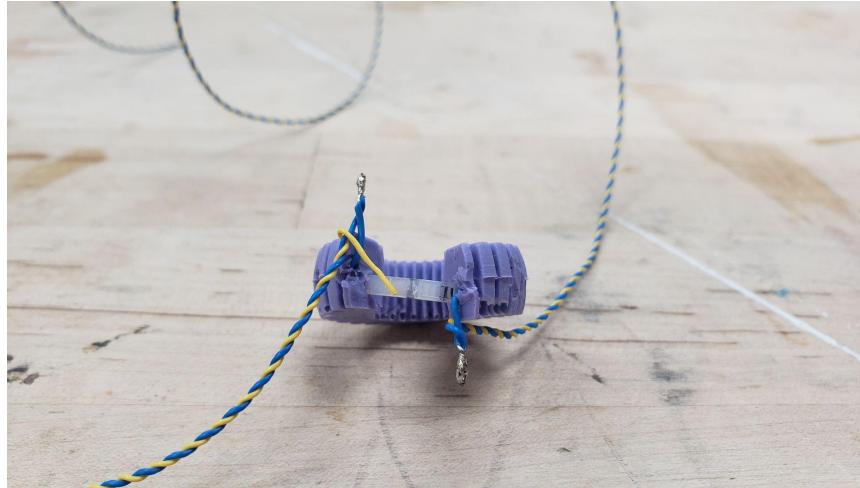


- d. The toroid should look as follows when its opened:



5. Winding the Twisted-Pair on the Toroid

- a. **(only for the clamp-on design)** For the clamp-on design, the twisted pair needs to be connected to the wire going through the center of the toroid. Cut the twisted pair in two pieces and solder the two ends of the wire going through the center to the blue wires on one end of the twisted pair as follows:



For the closed design, you can keep the twisted pair in one piece and directly start winding.

- b. Continue winding the twisted pair onto the entire toroid.



- c. Untwist the twisted pair on the end. Expose the yellow wire on the two sides and solder them together.

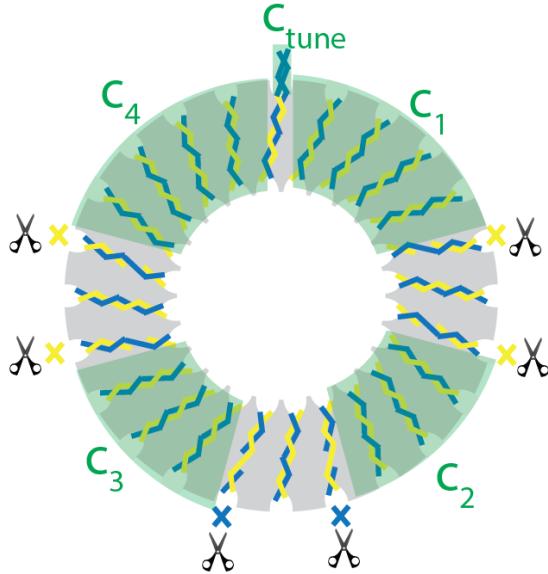


- d. Tuck in the soldered yellow wires. The two blue ends will be used for fine-tuning. The frequency is overestimated, tune the toroid by twisting the blue wires. This will reduce the resonant frequency.

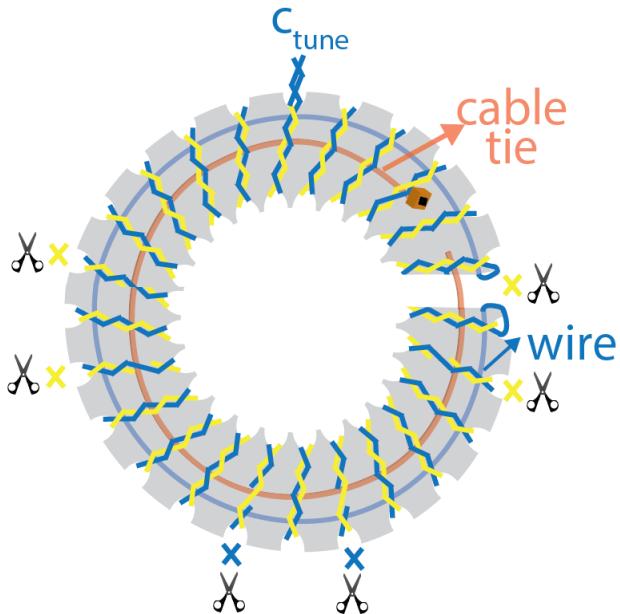


## 6. Making Cuts on the Toroid

- a. For the closed toroid six cuts have to be made in total. Starting from the top of the toroid (at  $c_{\text{tune}}$ ) and going clockwise, cut the yellow wire at turns 5, 7, 17, 19 and the blue wire at positions 11 and 13.



- b. For the clamp-on toroid, since there is already an opening at turn 5, we only need to make 5 cuts in total. These will be at the yellow wires on turns 7, 17 and 19 and on the blue wire at turns 11 and 13.



Note: For both designs if the resonance frequency is too high even with these cuts and several turns of the stray wire ( $c_{\text{tune}}$ ), additional cuts can be made on the yellow wire at turns 4 and/or 20.