



*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO T1400220-v1

*LIGO*

18 March 2014

Fast Shutter D1003318 Assembly Instructions

Jeff Lewis

Distribution of this document:  
LIGO Scientific Collaboration

This is an internal working note  
of the LIGO Laboratory.

**California Institute of Technology**  
LIGO Project – MS 18-34  
1200 E. California Blvd.  
Pasadena, CA 91125  
Phone (626) 395-2129  
Fax (626) 304-9834  
E-mail: info@ligo.caltech.edu

**Massachusetts Institute of Technology**  
LIGO Project – NW22-295  
185 Albany St  
Cambridge, MA 02139  
Phone (617) 253-4824  
Fax (617) 253-7014  
E-mail: info@ligo.mit.edu

**LIGO Hanford Observatory**  
P.O. Box 159  
Richland WA 99352  
Phone 509-372-8106  
Fax 509-372-8137

**LIGO Livingston Observatory**  
P.O. Box 940  
Livingston, LA 70754  
Phone 225-686-3100  
Fax 225-686-7189

<http://www.ligo.caltech.edu/>

## 1 Introduction

The assembly of the Fast Shutter can be considered in two primary parts: the Bobbin sub-assembly and the rest of the shutter.

## 2 Tools needed

- 80 grit aluminum oxide sandpaper
- Spring clamps (see pictures below in the assembly instructions)
- Flat surface around which a clamp can be used (a surplus blade spring was used)
- Short bars for clamping (surplus D1102129 Linear Motor Side Plates were used)
- 0.250" thick PEEK or aluminum bar (see pictures below in assembly instructions)
- UHV aluminum foil
- Compass
- Allen wrenches
- Clean razor blade
- Soldering iron

## 3 Materials needed

- All items in the BOM of D1003318
- 60 cm Cooner Wire CZ1104 or CZ1105 flex wire per shutter
- Alloy 63/37 Tin/Lead solder
- Masterbond EP30-2 epoxy (do not use if expired)

## 4 Assembly Procedures

### 4.1 Bobbin Assembly

1. Cut off two 30 cm lengths of flex wire (see section 2 for details) and strip 3/8" insulation from one end of both wires.
2. Cut the coil wires from the bobbin such that the solder joint will be positioned per the assembly drawing. The coil wires should neither be tight nor too loose. Strip 3/8" insulation from the ends of both coil wires.

3. Wrap the stripped section of flex wire to the stripped section of a coil wire. The stripped ends should be together while the insulated parts of the wire are touching each other. Solder the joint. Repeat for the other coil wire.
4. Mix up a small batch of EP30-2 epoxy and glue the soldered joints into the small hole of the D1300972 PEEK Wire Brackets.
5. Let the epoxy cure overnight and then trim the soldered wire joints that stick out from the D1300972 PEEK Wire Brackets so they are nearly flush with one side of the D1300972 PEEK Wire Brackets.
6. Snap the D1300972 brackets into the D1300320 PEEK Bobbin, orienting the flex wires upward along the side of the Bobbin per the assembly drawing.
7. Roughen the mirror bonding surfaces of the D1300320 PEEK Bobbin with 80 grit sandpaper if not already done. Be careful to not damage the coil wires. Clean the areas with acetone to remove contaminants and imbedded particles.
8. Class A clean and bake the bobbin sub-assembly.
9. Mount a clean thin flat plate to the work bench or optical table (a foil wrapped blade spring was used) such that it is at a small angle.
10. Roughen the backside of the D1300969 mirror in the area where it will be bonded to the bobbin. Also roughen the bottom of the mirror. Be extremely careful to not damage the HR surface of the mirror. Wearing gloves, it is possible to grasp the sides of the mirror and rub the backside against 80 grit sandpaper. Sand in a direction to put sanding lines horizontal to the installed orientation of the mirror. This also facilitates only sanding the lower half of the backside of the mirror since the upper half extends above the D1300320 Bobbin.
11. Carefully clean the mirror with acetone and methanol to remove contamination and imbedded particles. Be careful to not scratch the HR surface of the mirror. Drag wipe the mirror surface with methanol and lens tissue as a final step.
12. Mix up a small batch of EP30-2 epoxy and apply a small amount to both sides of the DD1300972 PEEK Wire Brackets. This is best done with two people where one person spreads the "feet" of the D1300320 Bobbin while the other person dabs in a bit of epoxy with a very small screwdriver, needle, or thin wire. Wipe up any excess epoxy that leaks to the outside of the Bobbin.
13. Lay the Bobbin on the blade spring, apply a clamp plate (see section 2 above), and then clamp together with a spring clamp. See Figure 1 below.

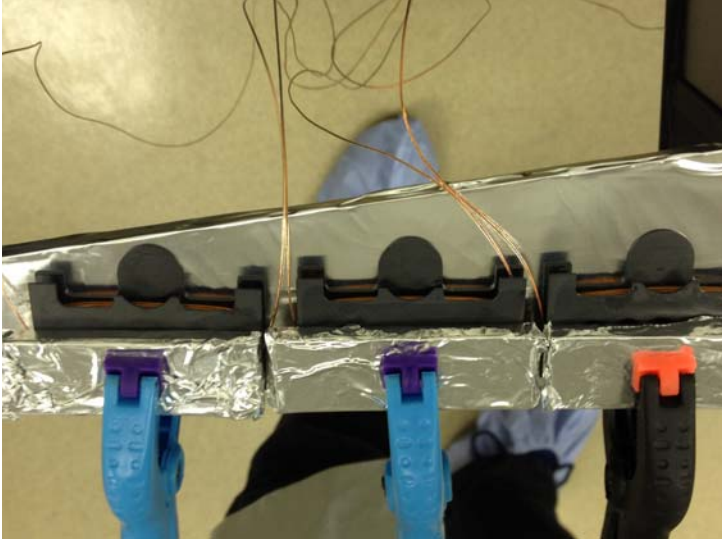


Figure 1. Bobbins clamped to spring blade.

14. After a few minutes, remove the clamp, clamp plate, and bobbin and wipe up any more epoxy that might have leaked through the holes in the Bobbin. Reassemble the Bobbin and clamp assembly on the blade spring after wiping the excess epoxy. Failing to do this step might result in the Bobbin being glued to the blade spring and clamp plate.
15. Apply epoxy to the Bobbin and/or mirror to bond it to the Bobbin. Only a small amount of epoxy is needed for the backside of the mirror since both surfaces are flat. More epoxy is needed at the bottom of the mirror when it is bonded to the coil wires. Only a very small amount of epoxy is needed for the HR side of the mirror since only a small area of this side is bonded to the Bobbin. Place the mirror into the Bobbin and visually align the mirror to be centered and perpendicular. Be very careful not to get epoxy on the HR surface. Carefully use clean acetone and lens tissue to remove epoxy from the HR surface if needed. See Figure 2.

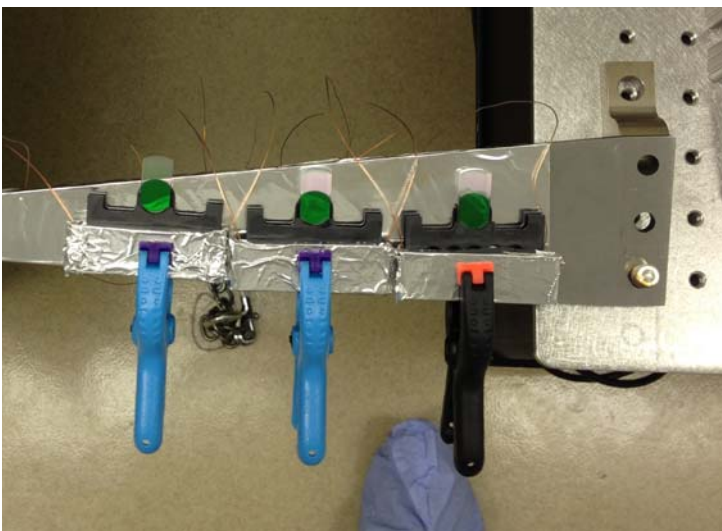


Figure 2. Mirrors placed into the Bobbins. Note that the blade spring is angled.

16. Let the epoxy cure at room temperature for at least 24 hours. Remove from the blade spring. With the blade perpendicular to the surface being worked on, use a clean razor blade to scrape all epoxy from the outer surfaces of the bobbin. This is important because even tiny amounts of epoxy will cause the bobbins to drag in the shutter. Use care to catch all the bits of epoxy and PEEK shaved off. Use IPA to wash the bobbin but do not allow the IPA to touch the epoxy nearest to the mirror because it will dissolve a little bit of the epoxy and leave a mess on the mirror surface.
17. Drag wipe the mirror as necessary to be sure it is clean before the subsequent baking step.
18. Vacuum bake the Bobbin assembly at 50°C for 48 hours.

## 4.2 Linear Motor and Shutter Body Assembly

WARNING: WORKING WITH STRONG PERMANENT MAGNETS REQUIRES CAUTION TO PREVENT PERSONAL INJURY AND DAMAGE TO COMPONENTS. GRASP ALL COMPONENTS FIRMLY AND ANTICIPATE THAT THE MAGNETS WILL ATTRACT EACH OTHER AND FERROMAGNETIC PARTS AND WORK WITH THEM ACCORDINGLY. BE CAREFUL TO NOT PINCH THE GLOVES. WEARING SMALLER GLOVES THAN USUAL IS RECOMMENDED TO NOT HAVE EXCESS MATERIAL AT THE FINGERTIPS. BE SURE TO REMOVE ANY PIECES OF GLOVE MATERIAL WHICH IS PINCHED AND TORN OFF AS THESE PIECES WILL BE CONTAMINANTS IN THE VACUUM SYSTEM.

1. Starting with Class A cleaned components, lay out UHV foil to cover the work surface.
2. Carefully place the four D1200998 magnets on each of the four D1102129 Linear Motor Side Plates as shown in Figure 3. Use the compass to orient the magnets such that there are two magnet/plate pairs with S facing outward and two with N facing outward. Note that the poles of the magnets are on the large flat faces (not on the ends) so aim the compass at the large faces.

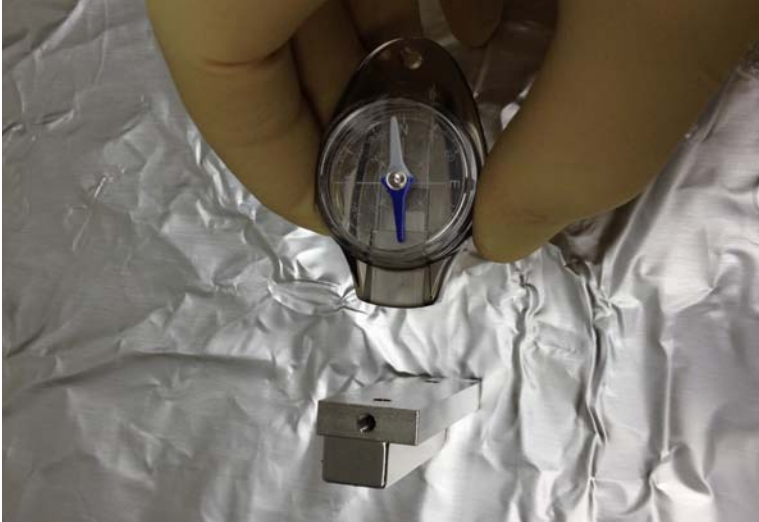


Figure 3. Magnet on a side plate.

3. With a D1200999 aluminum shim between, stack two of these magnet/plate pairs with one N out and one S out. Don't forget the shim! Repeat for the other pair.

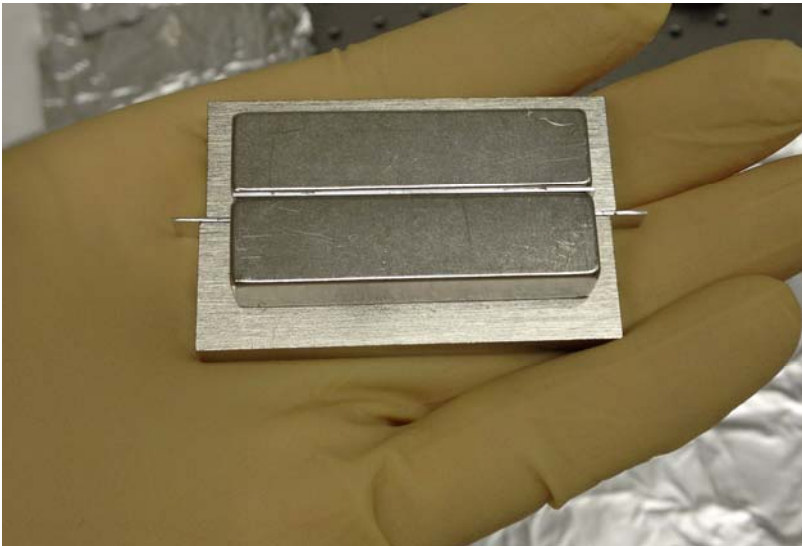


Figure 4. Two magnets, two side plates, and an aluminum shim.

4. Place a 0.250" thick aluminum or PEEK bar on top of the magnets of one pair and then place the other pair on top of the bar. Orient the magnet pairs per the D1003318 drawing. See Figure 5.

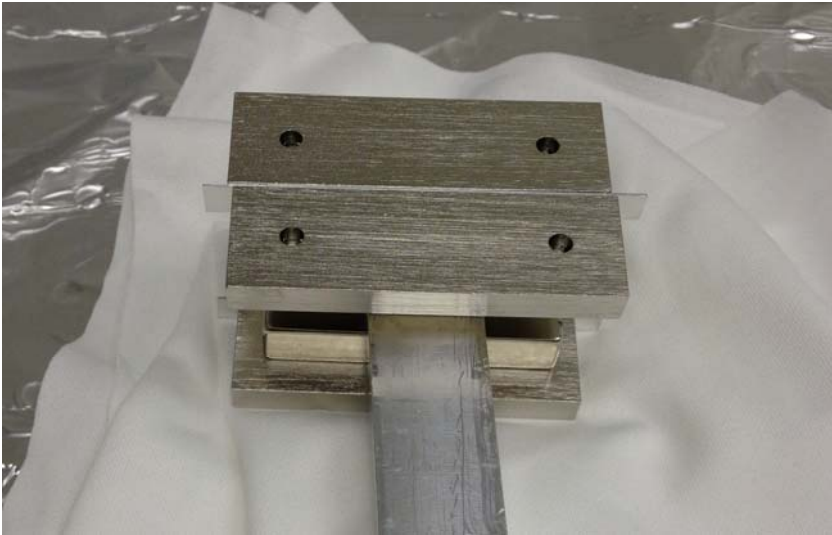


Figure 5. 0.250" thick aluminum bar. PEEK would be better.

5. Add the D1200990 PEEK guide plates and the D1102112 (bottom) and D1102113 (top) side plates to the linear motor per the D1003318 drawing. Ensure that the D1200990 guide plates extend  $\frac{1}{4}$ " above the D1102113 side plates. No need to measure  $\frac{1}{4}$ ", instead just make the bottom of the guide plate even with the bottom of the lower magnet.

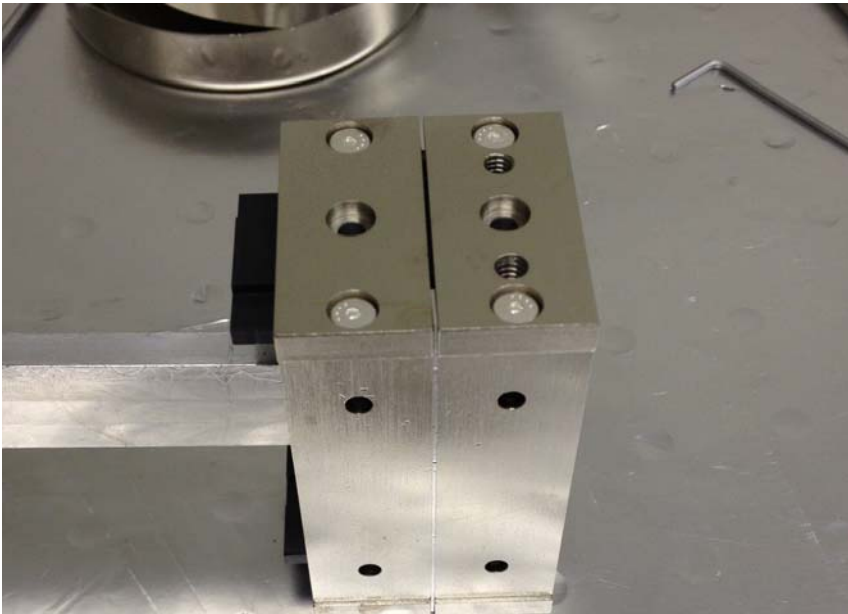


Figure 6. Note the (black) PEEK guide plates protruding out the top. Note that the #6-32 screws described in the next step are already installed.

6. Install and tighten the eight #6-32x.375 Ag plated cap screws. Tightening these screws will hold the guide plates in position. Be careful installing the screws as the heads use a tiny Allen wrench which is prone to slipping if too much torque is applied. There are no additional screws positively locking the guide plates in position but they seem to be well clamped anyway.

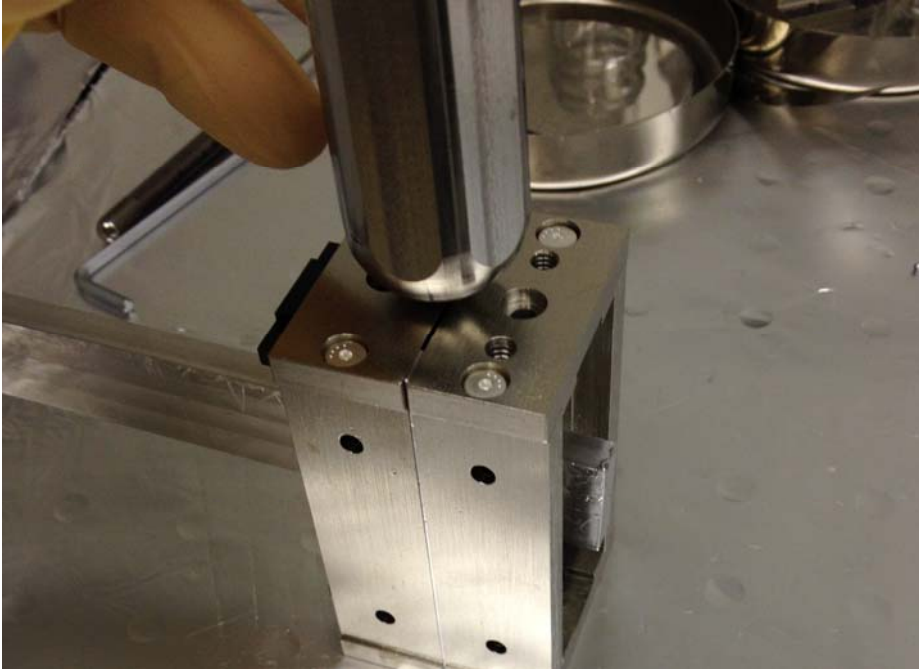


Figure 7. It may be necessary to lightly tap the side or end plates to get them nicely aligned to each other.

7. Install two ¼-20 helicoils into the D1003326 Base and two into the D1003324 bracket per the D1003318 drawing.
8. Assemble the D1003324, D1003325, D1003326, and PEEK electrical connector block per the D1003318 drawing.
9. Install the linear motor sub-assembly into the shutter body and install the four Ag coated #6-32 screws and washers.
10. Pull out the 0.250" thick aluminum or PEEK bar which was used to separate the magnets, if not done previously.
11. Install the Viton tubing and shoulder screws onto the D1003325 Hardstop.
12. With a cleanroom wipe and IPA, wipe the entire shutter body. Wrap the wipe around a screwdriver or similar object to wipe particles out of the cavity where the bobbin will be inserted.
13. Install the PEEK wire connector block with the two #4-40 screws.
14. The Fast Shutter assembly should look like Figure 8 at this point.





Figure 8. Fast Shutters sans Bobbins

### 4.3 Installing the Bobbin Assembly into the Shutter

1. Insert the Bobbin Assembly into the shutter according to the orientation of the D1003318 drawing.
2. Estimate the length necessary for routing the flex wires per D1003318 and cut them to length.
3. Cut two 1.5" lengths of 2mm x 4mm Viton tubing and insert over the flex wires.
4. Strip the insulation and crimp on pins to the flex wires.
5. Use the aluminum cable clamps to hold the Viton tubing and flex wires in place on the shutter.
6. Carefully adjust the wire length so that the wire loop helps to keep the flex wires from being trapped between the end of the Bobbins and the Guide Plates. Bend/straighten the flex wires as necessary to achieve a nice positioning. Tighten the aluminum wire clamps on the Viton tubing and flex wire to lightly pinch (by way of bending the Viton tubing sharply between the D1003324 Shutter Bracket and the D1102113 top side plate) in order to secure the wire and prevent the length of the loop from changing over time.
7. Use a 1.5 volt battery or other low voltage source to test for the correct polarity of the flex wires coming from the bobbin. Install the wires into the PEEK terminal block. Note the ++ sign on the top of the terminal block.