LIGO Production Large Actuator Bobbin Assembly Procedure

Configuration Management Item Number:

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LIGO Document E1900023-v2

Prepared By:
QinetiQ North America, Technology Solutions Group
1901 S. Harbor City Blvd, Suite 700
Melbourne, FL 32901
(321) 768-650

Introduction:

This document defines the procedure to assemble the bobbins for the LIGO Production large actuators, including: winding the bobbin, curing the polyimide resin overcoat, cleaning the bobbin after the winding process, terminating the bobbin wires, and inspection of the complete bobbin assembly.

The first two sections list the materials and tools needed for this procedure. This is followed by the step-by-step instructions for assembling the bobbin.

List of Materials:

This section lists the materials that are used to build the bobbin assemblies. Note: all of these materials are on the LIGO approved list

- pre-cleaned[1] actuator bobbin, D1900018v1
- MWS Wire 20 AWG round copper magnet wire, heavy build polyimide ML (or HML) insulation
- PEEK terminal block – Accu-Glass p/n 111851
- terminal block mount – D070378v1
- fasteners

Verify that the following materials are within their shelf life

- HD Microsystems PI-2525 polyimide and T-9039 activator, which both should be stored in a freezer at 0° F when not in use.

List of Tools:

The following are tools are needed at various stages of this procedure.

- bobbin winding tool/jig
- bobbin clamps
- clean room gloves (McMaster Carr p/n 5995T9 or similar)
- cleaning wipes (McMaster Carr p/n 7089T11 or similar)
- applicator for resin --lint-free and non-contaminating, acid brush recommended
- plastic bags (McMaster Carr p/n 1959T49 or similar)
- mixing containers for polyimide and activator
- oven capable of 400° F curing temperature with a shut-off timer

Verify the following tools are within their calibration period

- ohmmeter with measurement accuracy of 0.1 ohm
- hi-pot tester, BK Precision Model 305
- torque wrench

IMPORTANT CLEAN ROOM INSTRUCTIONS

Follow LIGO Contamination Control Plan E0900047-v23 during assembly and packaging of clean components.

1. Verify that clean room is within normal operating limits, e.g. particle count is within acceptable limits, no visible contamination of the work area (dust, dirt, liquids, etc).

2. Wear proper clothing, garments and gloves when in the clean room as outlined.

3. Remove all unnecessary items from the work area.

4. Prior to and after winding, the bobbins should be kept in zip-lock clean room sealed plastic bags.

Large Actuator Winding Procedure:

The following is the step-by-step procedure to assemble and inspect a large actuator bobbin.

Collect the Materials and Tools

1. Collect the materials per the above 'List of Materials'.
2. Collect the tools per the above 'List of Tools'.
3. Remove pre-cleaned bobbin from zip-lock bag
4. Mount the bobbin to the bobbin holder per …
5. Mount the bobbin holder to the coil winding tool.
6. Thoroughly mix T-9039 and PI-2525 in a ratio of 4:1; allow the mixture to sit overnight.

Winding the Bottom half of the Bobbin

During each of the following steps, care should be taken not to scratch or abrade the mag-wire insulation. This could lead to failure (shorting) of the coil assembly.

To meet the desired packing factor it is very important that a tight wrap be maintained such that the final layer does not protrude out of the bobbin slot.

7. Put the winding tool motor direction switch in the 'forward' position.
8. Zero the winding tool counter.
9. As shown in Figure , using the magnet wire, start the winding at the center of the bobbin, with the 'input' free end of the wire coming out of the terminal block zone. Be sure to leave at least 12 inches of wire free.
10. Wind the bottom half of the bobbin in the CCW direction (when looking from the bottom half side). Each layer should have number of turns/layer, number of layers and total turns per half as listed in Table 1.
11. After each layer, apply a thin coat of the resin.
12. After the top layer, apply a heavier coat of the resin and fill in the gaps between the wires.
13. The last layer should return the wire back to the center of the bobbin. Verify that the winding counter now reads 220.

Winding the Top half of the Bobbin

14. Put the winding tool motor direction switch in the 'reverse' position.
15. Once finished with the bottom half, cross the magnet wire to the other half, through the terminal block zone, as shown in Figure . Make sure the wire stays inside the zone, and doesn't protrude outside the bobbin perimeter.

16. As shown in Figure , wind the top half of the bobbin in the CW direction. ***This is the opposite direction of the bottom half!*** This half should have same turns/layer, # of layers, total turns per half as listed in Table 1.
17. After each layer, apply a thin coat of the resin.
18. After the top layer, apply a heavier coat of the resin and fill in the gaps between the wires.
19. The last layer should return the magnet wire back to the center of the bobbin, as shown in Figure 2. Verify that the winding counter now reads 0 +/- 4 counts.
20. Cut off at least 12+ inches slack for the 'output' wire.

Initial Hi-Pot and Resistance Check

21. Strip insulation from a short length of each end of the magnet wire to perform the following high-pot and DC resistance tests.
22. Apply 500VDC across the magnet wire to the aluminum bobbin for 60 seconds and verify there are no shorts in the winding. Verify that the insulation resistance is > 100 Mohms.
23. Measure the end-to-end DC resistance of the magnet wire using the ohm meter. Verify that it measures within the range listed in Table 1.
24. Using the ohm meter, verify there the magnet wire is not shorted to the aluminum bobbin.

Polyimide Curing

25. After both halves of the bobbin are wound, mount the bobbin heating fixture to the bobbin.
26. Place bobbin in a clean oven and heat from room temperature to 200^{o} C at 4^{o} C / min
27. Hold at 200^{o} C for 40 minutes.
28. Increase temperature to 300^{o} C at 4^{o} C / min.
29. Hold at 300^{o} C for 40 minutes.
30. Turn off the oven and allow the wound bobbin to cool slowly back to room temperature.
31. After cooling, verify the resin has cured.

Bobbin Inspection and Cleaning

32. Visually inspect the bobbin for wire protruding above the bobbin's center ribs and outer ribs. The wire and adhesive must be flush or sub-flush with the Aluminum ribs as shown in Figure 7. **If the bobbin fails this step it must be disassembled and re-wound.**
33. The aluminum surfaces of the bobbin must be visibly clean and free from polyimide residue.
34. All of the mounting holes of the bobbin must be visibly clean from polyimide residue.

Wire Terminating

35. Cut, strip each end of the magnet wire so that it can be inserted into the terminal block,
36. The lead from the bottom half should be connected to the positive terminal of the terminal block, and the lead from the top half should be connected to the negative terminal.
37. Mount the terminal block mount, and torque the screws per LIGO T1100066.
38. Attach the terminal block to the mount.

Final Hi-Pot and Resistance Check

39. Apply 500VDC across the mag-wire to the aluminum bobbin for 10 seconds and verify there are no shorts in the winding. Verify that the insulation resistance is > 100 Mohms.
40. Measure the end-to-end DC resistance of the mag-wire. Verify that it measures within the range listed in E1800363 Figure 1. Verify there the mag-wire is not shorted to the aluminum bobbin.

Bobbin Storage

41. Place the assembled bobbin into a ziplop bag, and move to storage bin.

Table 1: Specific Details of Actuator

	New Actuator (20 AWG)
Mag-wire size	20 AWG
# of turns per layer per half	22
# of layers	10
# of turns per half	220

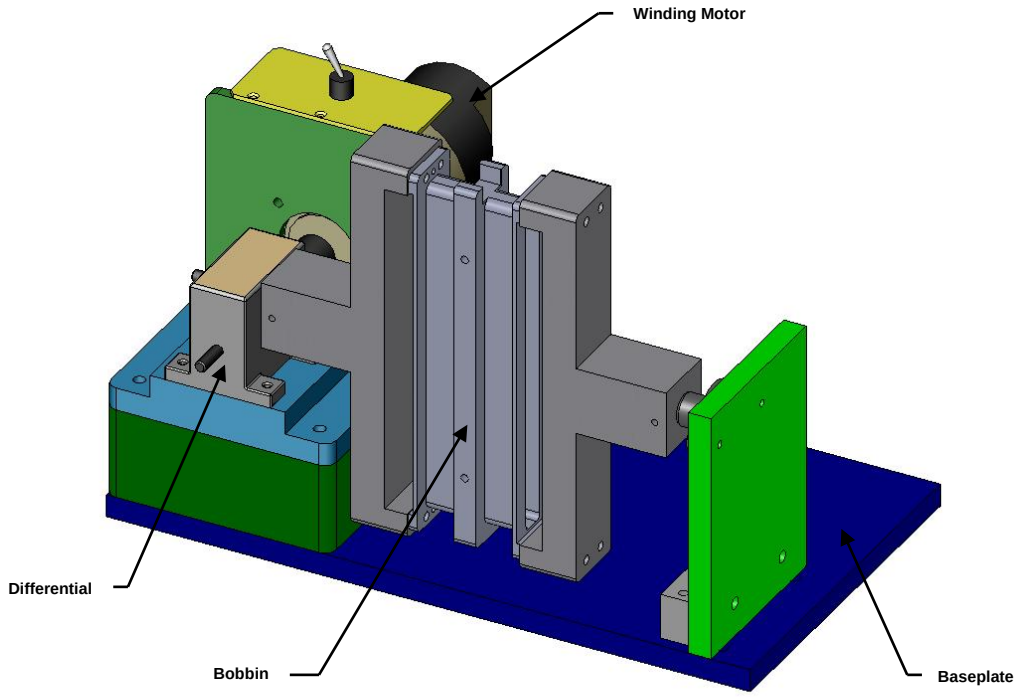

Figure 1: Bobbin Winding Tooling

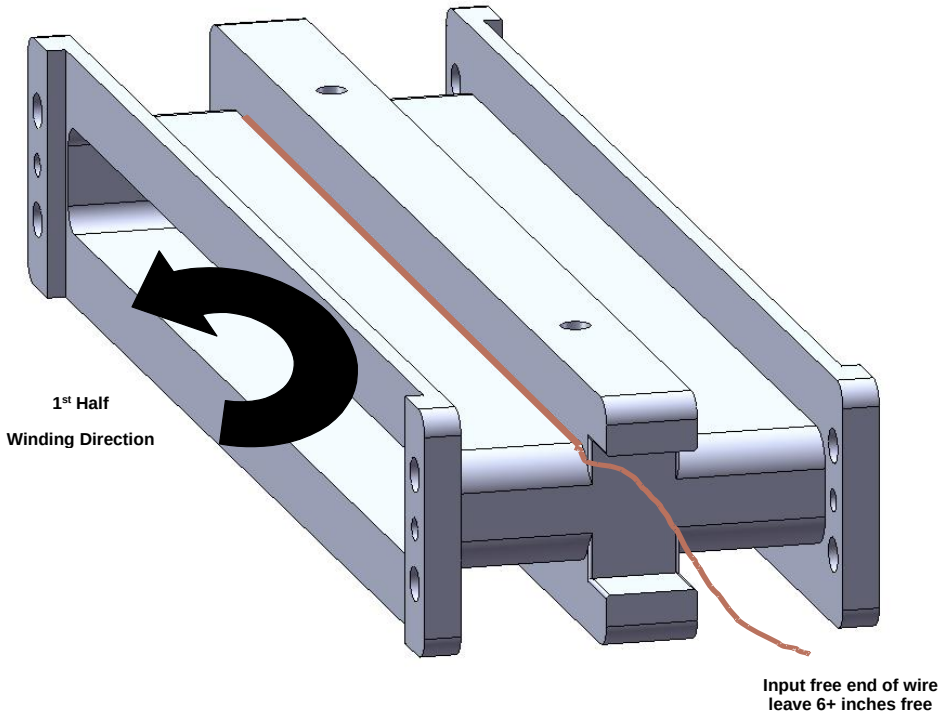

Figure 2: Start Winding the BOTTOM Half of the Bobbin from the Center Outward – Winding CCW Looking from the BOTTOM of the bobbin – The Input lead to BOTTOM half will be POSITIVE Lead

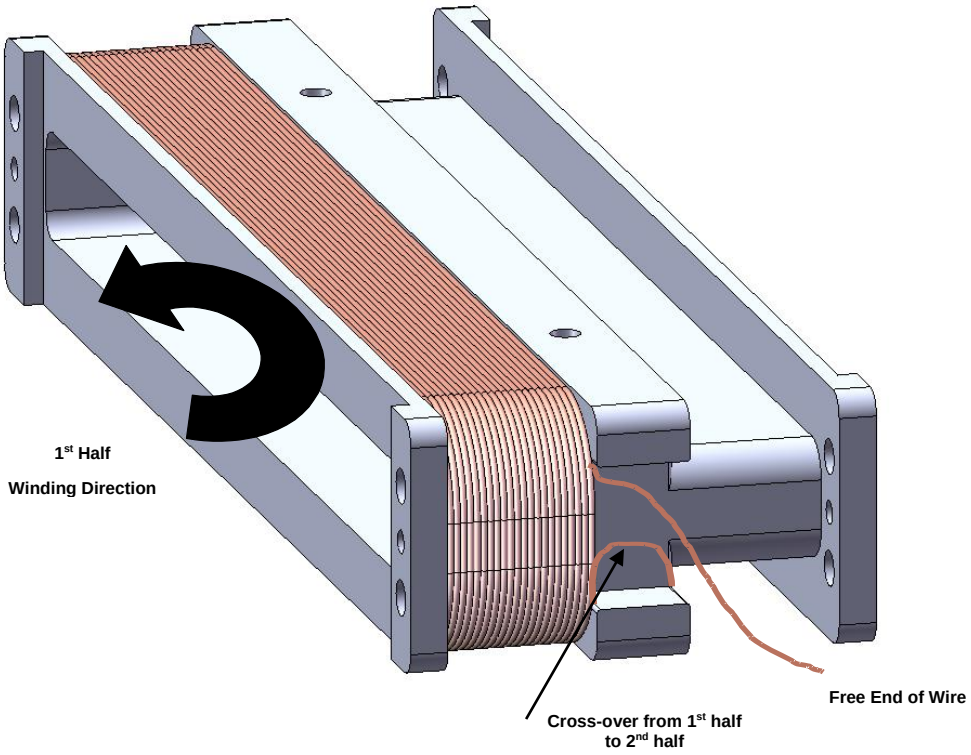

Figure 3: Finish the BOTTOM Bobbin Half and Cross the Wire over to the TOP Half inside the Termination Zone

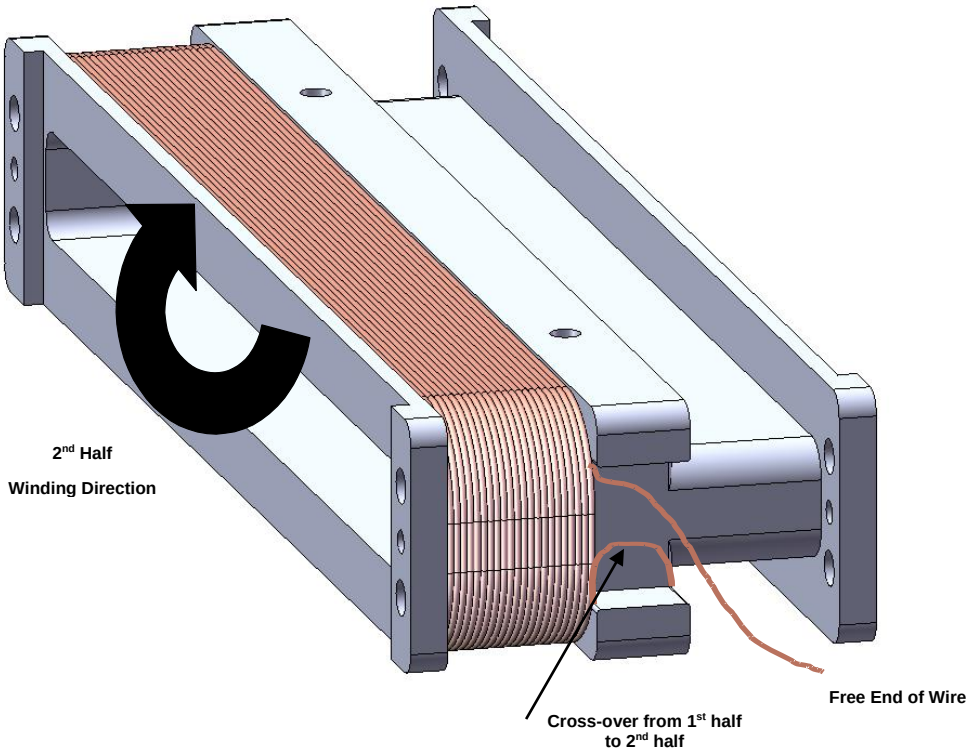

Figure 4: Start the TOP Half – Noting that it is Wound in Opposite Direction as the BOTTOM half

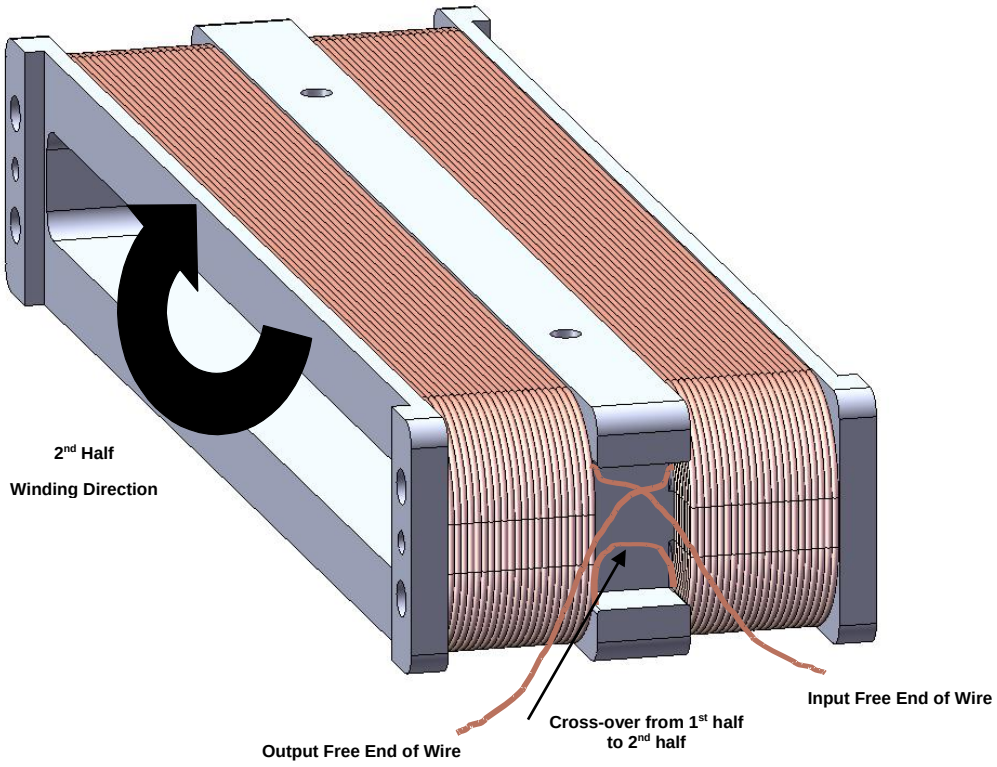

Figure 2: Finish the TOP Half with 'Output' Wire Coming out in the Termination Zone

The lead from the TOP half will be the NEGATIVE Lead

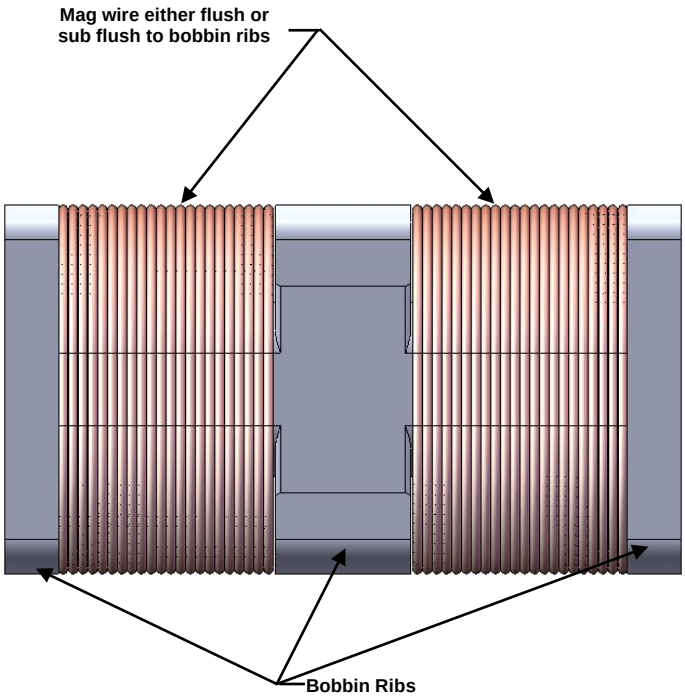

Figure 3: End View Mag-wire flush or sub-flush