LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Installation Procedure for Advanced LIGO Mode Cleaner into LASTI HAM

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1 PURPOSE AND SCOPE

This document is the standard guideline for properly handling and installing the Advanced LIGO Mode Cleaner Triple Pendulum Suspension into a HAM chamber at the LIGO Advanced System Test Interferometer (LASTI.) It contains a step by step check list to aid in the installation process (see Appendix 1). This is done to prevent over-looking important installation details, which when omitted, have in the past, proven to damage suspended optics. This procedure picks up at the point where the metal optic has been suspended, the magnets checked and the osems installed. The optic height and tilt measurements should be logged. The OSEM open-light voltages should be recorded and OSEMs set at 60% of the open light voltage. Damping should be checked and readings recorded. The optics table, on which the suspension is destined, should contain the counter weight payload and be level and sitting at the proper elevation.

2 HAZARDS

The Mode Cleaner suspension is heavy and awkward to maneuver, and requires two people coordinating their movements carefully, to prevent personnel from becoming injured or damaging property.

3 CONTAMINATION AND CONTROLS

To provide reasonable assurance against the inadvertent introduction of contaminants to the optic, fixturing and/or the vacuum envelope, all personnel assisting with installations should be familiar with the LIGO Hanford Observatory Contamination Control Plan, LIGO-M990034 and the LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022. It is important that proper clean room attire is worn in the appropriate areas, while handling the suspension assemblies and its related fixtures.

4 REQUIREMENTS

The minimum gowning requirements for working in close proximity to a suspension assembly in the Optics Lab are: *Bouffant Cap, Frock, Overshoe Covers, Face Mask and UHV Gloves*, all from the approved supply. When doing the actual installation into an open chamber while working under the soft wall enclosure, the minimum garment requirements are: *Full Hood, Face Mask, Clean Room Coveralls, Clean Room Knee High Boots, and UHV Gloves,* all from the approved supply. If you are going to be entering into the chamber, *Inside Chamber Overshoe Covers* are to be worn over the *Clean Room Knee High Boots,* donning them at the time you transition to the chamber interior, making sure the *Inside Chamber Overshoe Covers* do not come in contact with surfaces on the exterior of the chamber. The forgoing is just a part of the protocols required when working with contamination-sensitive hardware. It is a must that the Contamination Control Plan be followed in its entirety.

APPENDIX 1 INSTALLATION PROCEDURES

1. Check the alignment between the magnets and OSEMs. Magnets should still be centered in the OSEM openings.
2. Using a low power HeNe laser for an optic lever transmitter and a quad diode receiver, clamp the test mass in its balanced position. Check that the 4 bottom support screws are *lightly touching* the test mass. Next contact the test mass with the 4 face stop screws while maintaining the alignment. Next clamp the test mass with the 4 top safety stop screws while maintaining the alignment.

Add picture….

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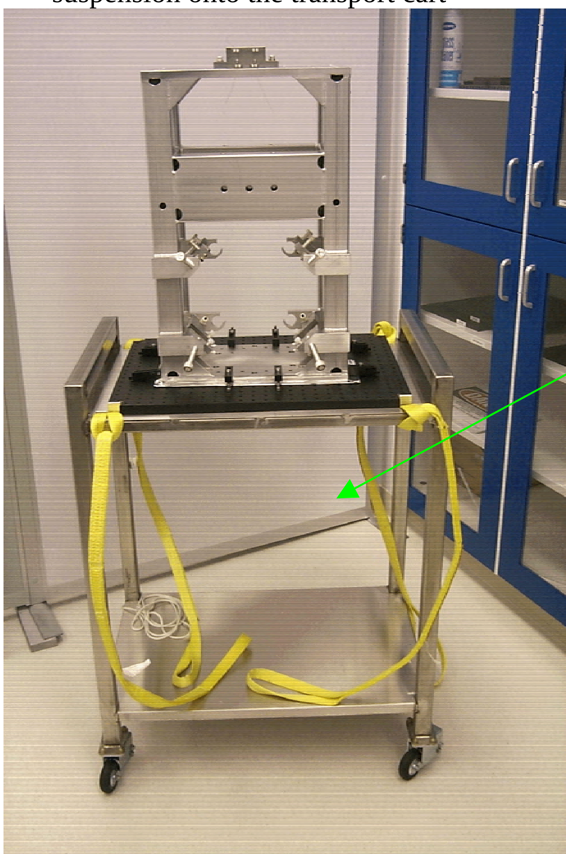
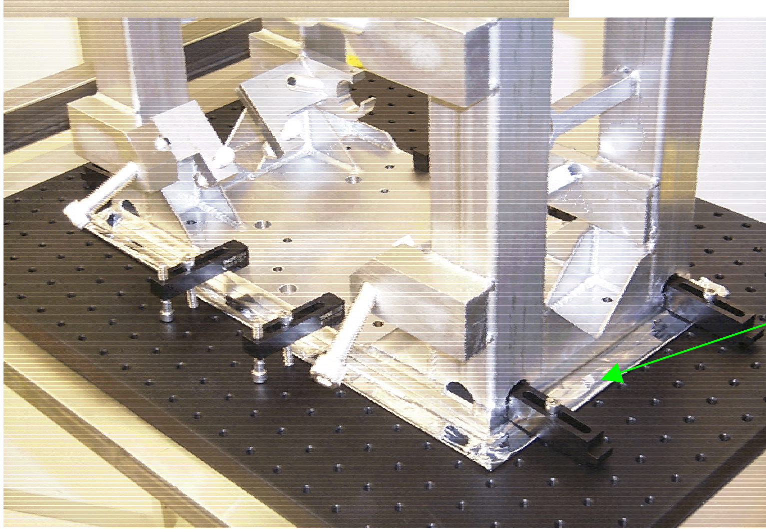
3. Position the suspension near the edge of the optics table, in close proximity to the *transport cart*. Place clean UHV foil on the top of the transport cart. Wrap the OSEM "pig tails" in a UHV foil pouch to prevent them from dangling free or wrap them through the structure.
4. One person should man the transport cart to prevent it from moving, pushing it against the optics table.
5. With a second and third person facing each other, keeping hands clear of critical components, grip the suspension structure in a comfortable, balanced position, and upon a "count down", lift the suspension onto the transport cart



Shows the stainless steel *Transport Cart* with its shock absorbing casters. There is an optical bread board fastened to the cart to enable the structure to be clamped down during transport. There are four nylon slings for craning purposes. Use eight "dog clamps" to secure the

UPDATE PICTURES

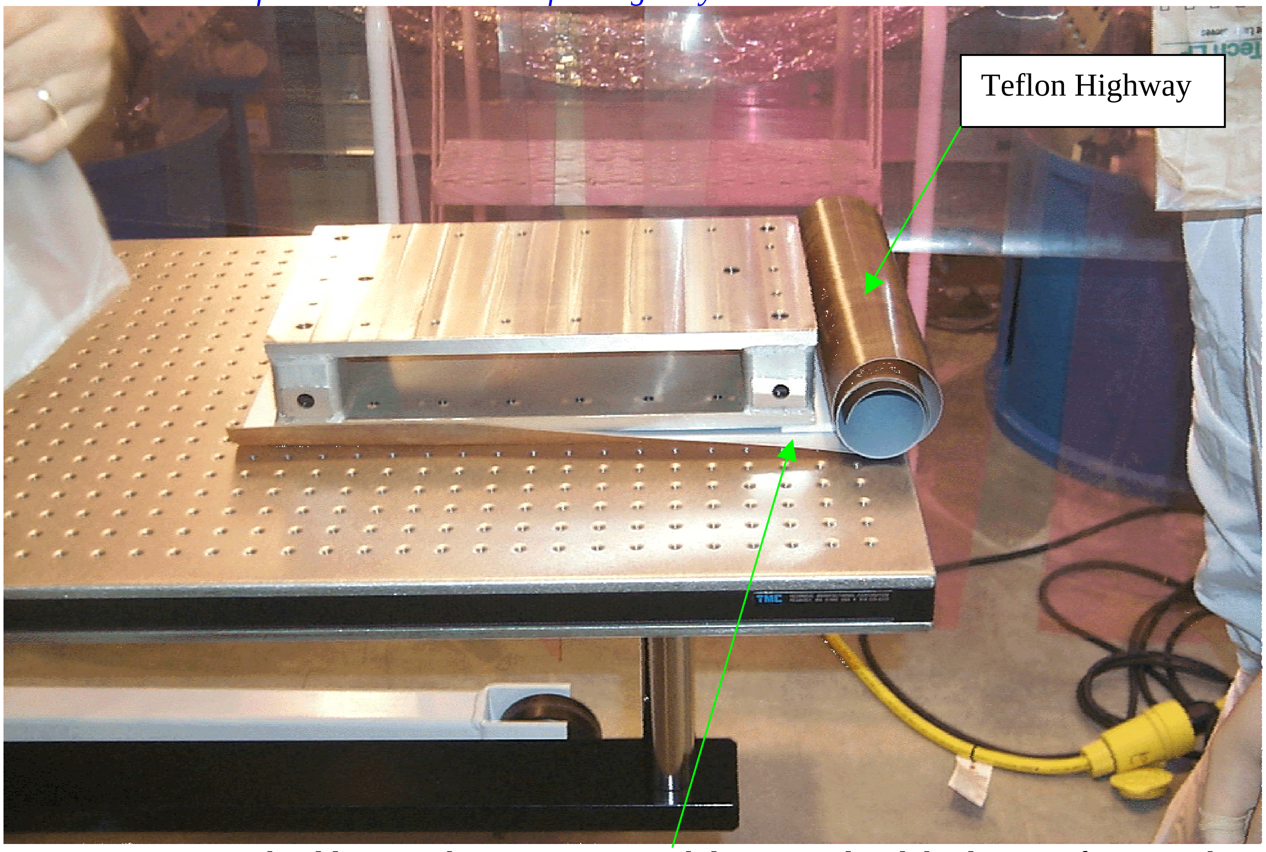


UHV Aluminum Foil
"Dog" Clamps
2 styles from Thor Labs

5. Bolt the *optical breadboard and posts* to the forks of the *straddle*.
6. Position the straddle and the transport cart in close proximity to each other to facilitate easy transferring of the suspension onto the bread board

(Straddle with roller truck installed in place. (This set up is only used to install the lift table into BSC chambers).

9. Place the *Teflon highway* on the center of the bread board.
10. Place the *Teflon blocks* onto the *Teflon highway*.



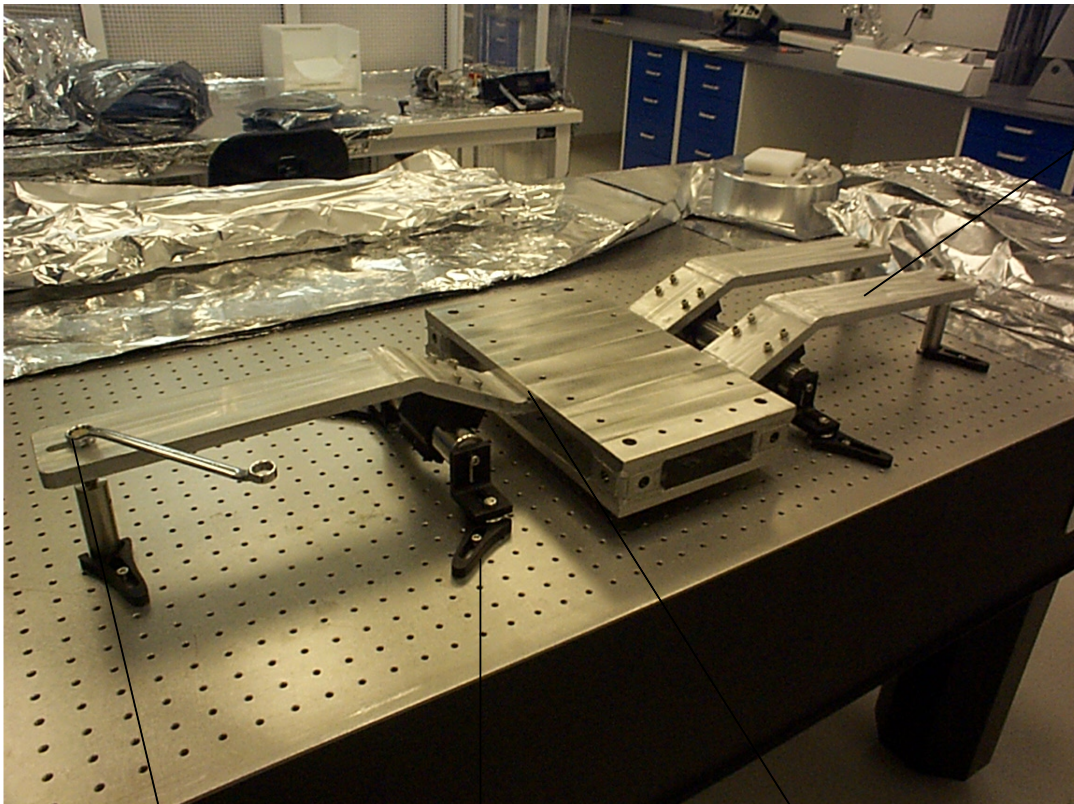
New Picture

11. One person should secure the transport cart while a second and third person facing each other, keeping their hands clear of critical areas, grip the structure in a comfortable, balanced position and upon a countdown, lift the suspension from the transport cart onto the Teflon blocks.
12. Steer the straddle with the suspension to the opening of the chamber and raise the bread board height up to the optic table height. Push the straddle forward, gently to meet the HAM optic table.

Note: The optics table should have its counter weights in place and be level at its proper elevation. Check using a Starrett model 98 level.005"/ foot rated accuracy or equivalent spirit level

15. Roll out a *"Teflon Highway"* using more of the Teflon strip toward the final location where the suspension will be installed.
16. Install the "Belly Bars" across the chamber opening.
17. Slide the structure along the Teflon highway to its location. Reference the optic table hole patterns.
18. Recheck table level especially if counterweights have been moved.

19. Install the *3 point lifting hardware* onto the HAM optic table. Bolt the Lifting Lever Blocks to the top of the bottom plate of the structure on the sides. The step on the short end of the arm of the lifting lever sits in the slot in the Lifting Lever Block Clamp down the 6 posts. Carefully tighten down on the 2 bolts located in the top of the posts at the long end of the lever arms. This will raise the structure allowing the removal of the Teflon blocks and highway. After removing the Teflon, lower the structure by loosening the two 3/8" screws.



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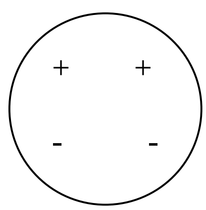
20. Remove the 2pt. lifting fixture.
21. Attach *the prism mount, and prism* to the structure.
22. Check the initial transverse and axial positions with Theodolite.
23. Install the *brass pusher bars* using optical table mounting holes and or clean class B dog clamps to secure them. Transport to correct location using theodolite readings of prism position, orient angle using laser autocollimator. Position should be ~ 1/2 mm or better in location.
24. Connect the OSEM cabling and verify sensor signals (see below-by B. Kells).
25. CHECK TABLE LEVELNESS.
26. Back off stop screws: top -> bottom-> face.
27. Turn on *the controller or Dspace system* and verify damping of optic.
28. Recheck orientation of optic using laser autocollimator with optic suspended.
29. SNUG FACE STOPS
30. Remove *pushers*.
31. Attach suspension to table using class A dog clamps.
32. Remove compensation counter weights.
33. CHECK TABLE LEVELNESS.
34. Secure the OSEM pig tail wires to the structure so not to obscure the beam path using class A clean stainless steel wire.
35. Release face stops, set up *optical lever*.
36. Final chamber check.
37. Release face stops and exit.

Global Control OSEM Sensor Consistency Check *by Bill Kells*

When a suspension is installed we assume that the tower package, including OSEMs and their wiring, has been properly tested to identify and route the OSEM signals. Once installed this is again “checked” by verifying damping for pitch, yaw, position, and side motion. However, this verification via damping might be ambiguous, since it is often found that the degrees of freedom are sufficiently coupled to allow induced [anti] damping. Motivated by at least one situation where the as installed OSEM wiring identification was called into doubt due to such ambiguities, this more explicit check of the wiring as installed OSEM response was developed. It is based on comparing known mirror motion, as established by the optical lever, with direct individual OSEM shadow sensor photo-diode levels. Therefore, this test is restricted to suspended optics with optical lever monitors. However, this could be extended to any suspended optic if an auxiliary optical lever monitoring its motion could be set up. As described here the check assumes that the OSEM actuation is correctly wired, and only the shadow sensing readout is tested. A similar procedure might be developed to test the actuation, but would not be so straight forward since control of individual OSEM actuation is not accessible leads to coupled motions. A distinct feature of this check is that it requires no perturbation of the fully operational suspension. For instance it can be performed once the optic is inaccessible, under vacuum.

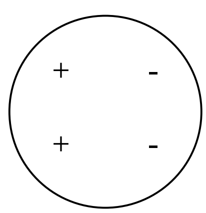
First I describe the generic procedure (subsequently a specific, quantitative example is summarized). Two steps may be distinguished:

STEP 1. The correlations between suspension pitch and yaw bias setting and optical lever pitch and yaw readings are established. One anticipates that variation of pitch bias changes only lever pitch to some good approximation, and similarly for yaw. In general there will be some degree of pitch/yaw cross coupling. The level of this which can be tolerated for unambiguous OSEM verification will have to be decided on an individual basis. Then for a significant pitch bias shift one expects the 4 OSEM shadow sensor voltage levels to change:



with overall sign ambiguity

and for a significant yaw bias shift:



with overall sign ambiguity

where the convention here is a view looking at the optic from the back:

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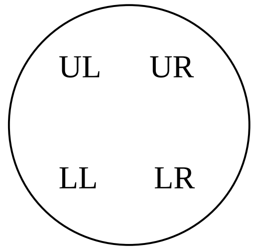
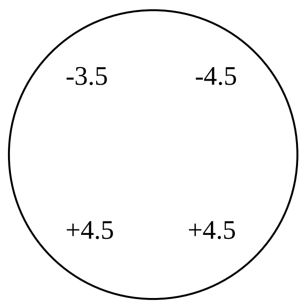


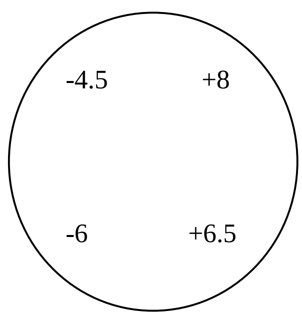
STEP 2. Now the above expected shadow sensor voltage change patterns are determined by measuring the (~DC) analog voltages extracted at the “J3” test point connection on the LOS controller satellite box. If both pitch and yaw expected voltage change patterns are confirmed, then the OSEM sensors must be routed correctly through to the satellite box.

As an example, this procedure was actually applied to the LHO 2K interferometer Y arm ITM. For both pitch and yaw, the bias was changed by +19.0 slider units (nearly full scale, with the not being tested degree of freedom bias set to 0 slider units). The measured J3 voltage changes were:

For pitch:



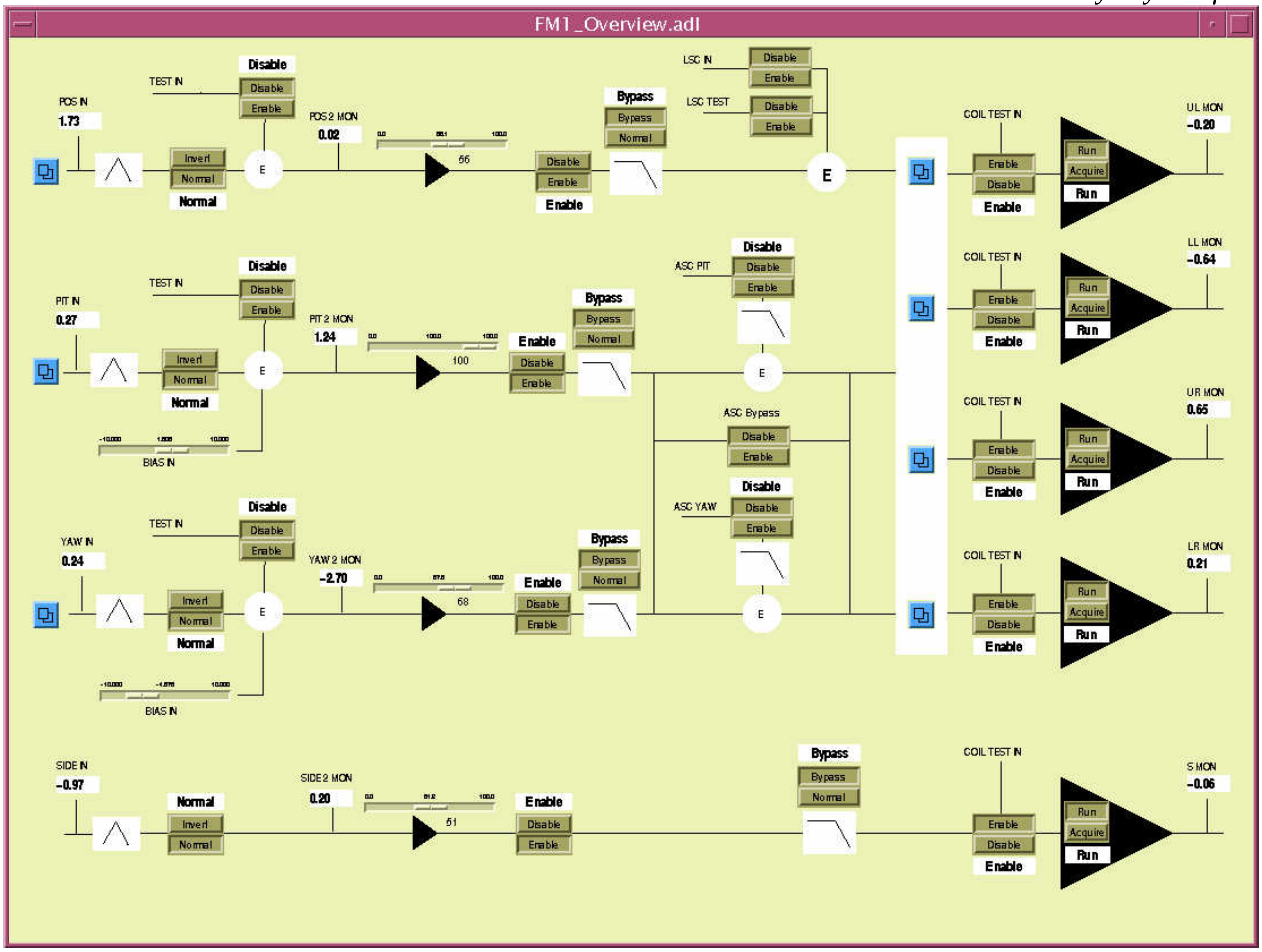
And for yaw:



Where all numbers refer to milli-volts, of level change. Note that the typical OSEM sensor voltage at this test point is ~ 1.6 volts, so that the difference measured here is quite small. However it is unambiguously determined by using a digital oscilloscope with a large number of traces averaged and the scale greatly expanded. The relative signs of the above pitch compared to the yaw data, is not relevant for the basic OSEM routing determination. However it does reveal the relative sense of the pitch vs. yaw slider actuation and drive matricies.

5 TESTING THE DAMPING OPTIC D.O.F.

By Jay Heefner



1. Disable all d.o.f. and set the polarity and gains to the nominal (anticipated) values for the optic under test. Monitor the side channel with a scope and enable the side damping. Make certain that the optic is damping.

3. Monitor the pitch d.o.f. using a scope and enable the pitch d.o.f. Convince yourself that optic is damping. Invert the polarity and ring up the pitch. Flip the polarity back and observe how many cycles it takes for the optic to damp. I believe it should be between 5 and 10 for "optimal" damping.
4. Monitor yaw and repeat step 3.
5. Monitor positions and repeat step 3.
6. Monitor side again and repeat step 3.
7. Now all d.o.f. should be damped. Individually monitor each coil output. The observed wave-form should not be "rail to rail" waveform. This is usually easy to see since the extremes of the waveform will be flat tops (i.e. noticeable clipping). If this is observed begin the debug procedure by first checking that all of the coils can be "seen" by the controller. This is done by measuring the coil resistance and the appropriate pins on the cable coming from the controller.

This is a brief synopsis of what we used to do. The procedure that you use may be slightly different, but is probably equivalent.