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- LIGO -
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Vacuum Feedthrough and Cabling Preliminary Design

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1 INTRODUCTION

1.1. Purpose

The purpose of this document is to outline preliminary designs for the electrical vacuum feedthroughs and cabling to be used within and to penetrate the LIGO vacuum chamber. The preliminary designs will be used to guide the design of individual systems that utilize vacuum feedthroughs and cabling and are a direct outcome of the Vacuum Feedthrough and Cabling Design Requirements Document (LIGO-T950095). Once the design has been completed, the materials and processes developed will be used by other systems and subsystems to provide for their vacuum cabling and feedthrough needs.

1.2. Scope

The preliminary designs described in this document pertain only to the cables, harnesses, mounting devices, vacuum feedthroughs, and vacuum connectors that are used within and to penetrate the LIGO vacuum chamber. The largest user of the devices developed in response to these specifications will be the suspension systems for each of the suspended optics.

It is the goal of the design process to produce devices, materials and guidelines that will meet imposed requirements in the following areas:

- Vacuum Compatibility and Contamination
- Mechanical/Vibrational Isolation
- Electrical Signal Compatibility including shielding to reduce induced and transmitted interference, current rating, impedance, etc.

1.3. Definitions

Vacuum Connector- connectors that are used inside the LIGO vacuum chamber.

Vacuum Feedthrough- an electrical connector that is used to penetrate the vacuum chamber. It can be a multiple pin or coaxial connector. When installed properly it will not compromise the vacuum chamber integrity.

Vacuum Cabling- cabling that is used to route electrical signals inside the vacuum chamber.

Cable Clamp- a mounting device that is used to securely fasten cables to the seismic stack elements or other components with the vacuum chamber.

1.4. Acronyms

- CDS- Control and Data System
- DRD- Design Requirements Document

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1.5. Applicable Documents

1.5.1. LIGO Documents

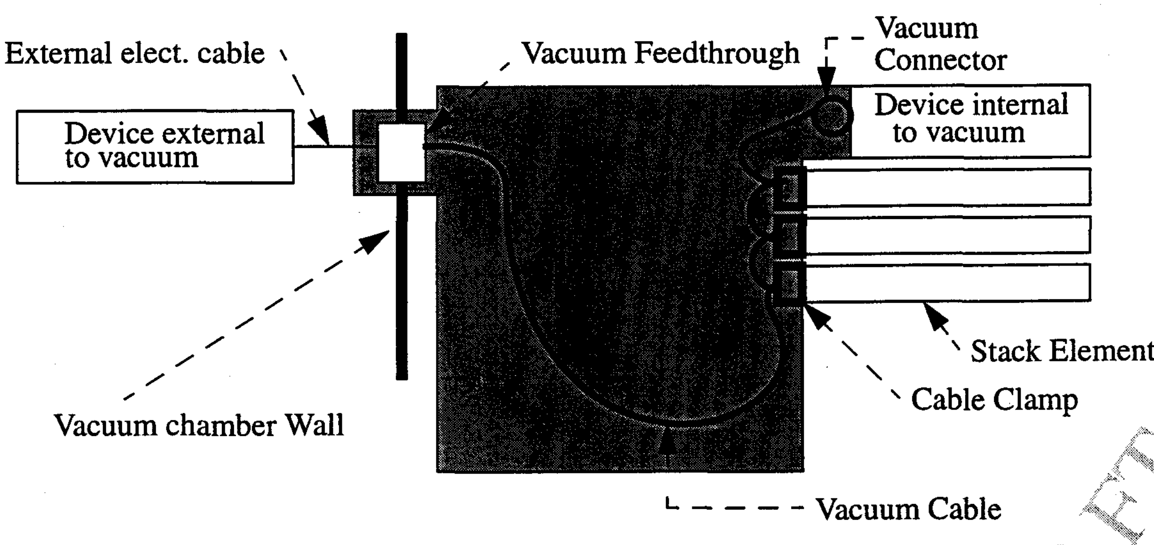
- *Vacuum Feedthrough and Cabling Design Requirements Document-* LIGO-T950095
- *LIGO List of Approved Vacuum Materials-* LIGO Document No. TBD
- *LIGO Vacuum Compatibility, Cleaning Methods and Procedures-*LIGO E960022
- *LIGO Detector Naming Convention-* LIGO T950111
- *Seismic Isolation Design Requirements Document-* LIGO T9600065

1.5.2. Non-LIGO Documents

N/A

2 SYSTEM OVERVIEW

The materials, techniques and procedures developed for the vacuum cabling and feedthroughs will be used as a component by a variety of detector subsystems. The figure below shows a typical configuration. The pieces that are part of the vacuum cabling and feedthrough subsystem are in the shaded region.



3 VACUUM FEEDTHROUGHS AND CONNECTORS

The various types of vacuum feedthrough can be broken into two categories: multi-conductor and coaxial/triaxial. Each of these is described below.

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3.1. Multi-conductor Vacuum Feedthroughs

Multi-conductor vacuum feedthroughs are available from several manufacturers including Ceramaseal and ISI (Insulated Seal Inc.). A this time it is planned that Ceramaseal part number 14444-02-W shall be used as the multi-conductor vacuum feedthrough. This connector is a standard 50 pin D connector. The connector(s) will be e-beam or laser welded to a Conflat flange of the appropriate size for the application. The interface with the vacuum equipment will be the conflat flange. Connection to the internal vacuum cabling will be made by soldering the internal pins of the ceramaseal connector to a piece of flexible Kapton circuit board (described below).

The ceramaseal connector, conflat flange and internal vacuum cabling will be provided as a complete unit for cleaning and installation.

3.2. Coaxial/Triaxial Vacuum Feedthroughs

At this time there is no requirement to provide coaxial/triaxial vacuum feedthroughs or cabling. In the event that future requirements arise, the connectors of choice for coaxial systems will be BNC and SMA. These connectors will be purchased commercially and e-beam welded to conflat flanges in a manner similar to that used for the multi-conductor feedthroughs.

Coaxial and Triaxial vacuum feedthroughs are available from several manufacturers including Ceramaseal and ISI. The coaxial connectors include: BNC, SMA, N, and Microdot. These connectors and triaxial connectors can be purchased as single ended connectors (pins on the vacuum side) or double ended (vacuum compatible connector on vacuum side). The choice of single ended or double ended connector configuration will be dictated by the type of cabling that is to be used internal to the vacuum system. If a commercial coaxial or triaxial cables are to used, the double ended configuration will be chosen. If flexible circuit board is to be used the single ended configuration will be chosen. Each of theses cable choices is described below.

4 VACUUM CABLING

The various types of vacuum cables can be broken into two categories: multi-conductor and coaxial/triaxial. Each of these is described below. In addition, each type of cable may require a fastening device.

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4.1. Multi-conductor Vacuum Cables

Multi-conductor vacuum cabling will be fabricated using flexible Kapton multi-layer circuit boards. The requirement to provide twisted pair cabling will be handled as shown in the figure below.

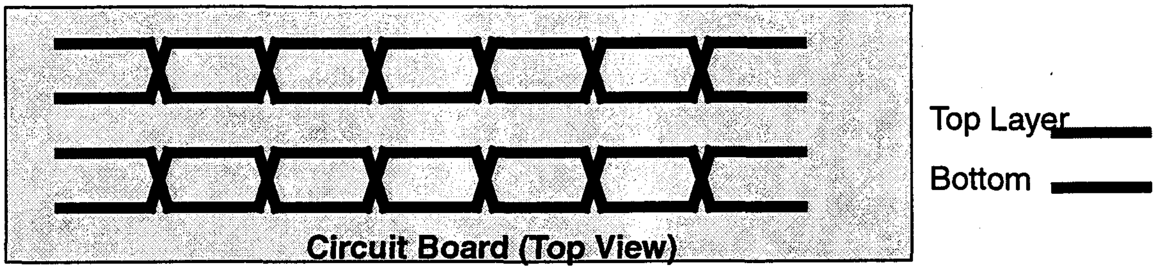

Figure 1: Twisted Pair Configuration

Each signal pair will be "twisted" by dithering the traces laterally on the circuit board and alternating the layers on which the signal and return are routed. Current handling capability will set by the trace width and plating thickness. Voltage standoff will be set by conductor pair spacing, but will typically be greater than 1000 VDC for standard layouts.

The requirement to provide for an overall shield for the cable will handled by using a multi-layer circuit board design with outer layer ground planes. This configuration is shown in the figure below.

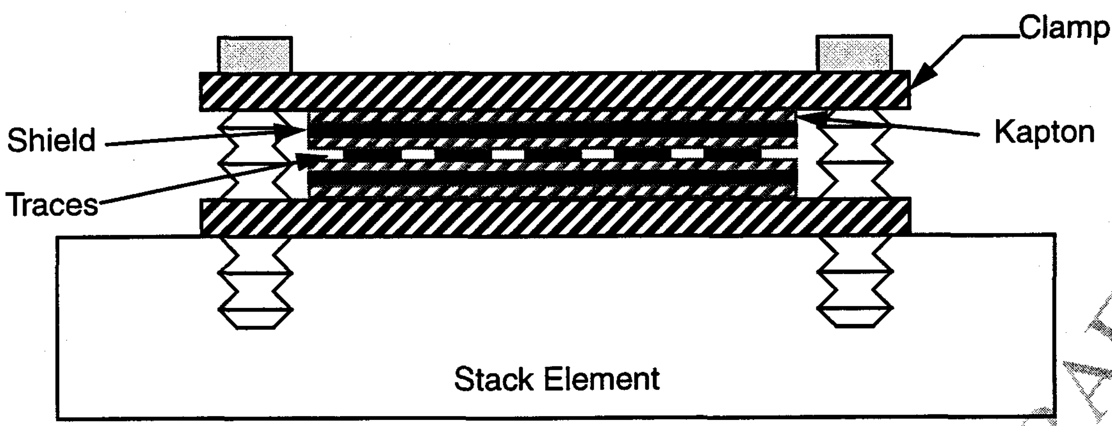

Figure 2: Shielded Cable Configuration Showing Stack Fasteners

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There are several manufacturers that can provide the flexible Kapton circuit board that are required. Two 15 foot prototypes of the cable required for the 40 meter beam splitter and recycling mirror are currently being fabricated by Flex-Link Products. In addition to the 15 foot cables additional 2 foot cables for connection to each OSEM coil are being fabricated. The figure below shows the design of the vacuum feedthroughs, cables and connectors required for the beam splitter and recycling mirror suspension system. The figure below is meant to be illustrative only and the actual design drawings for the system should be consulted for pinouts, dimensions, etc. The design drawings for the system are TBD.

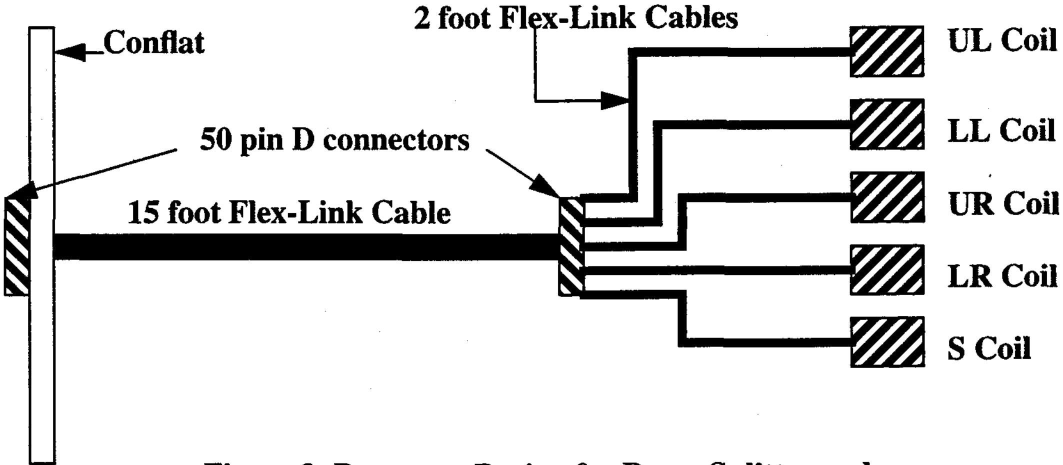

Figure 3: Prototype Design for Beam Splitter and Recycling Mirror Suspension

As can be from the figure, there are two 50 pin D connectors used in the design. The first, e-beam welded to the conflat flange is being used as a vacuum feedthrough connector. The second is attached to the optics platform at the top of the seismic isolation stack and is being used as a connection point for the individual cables that go to each of the OSEM coils.

Each of the 2 foot cables attach to the back of the OSEM coil form using TBD screws. Connection to the coil, photodiode and LED wires is made by soldering the wires to pads on the kapton cable.

4.2. Coaxial/Triaxial Vacuum Cables

There are two choices for internal coaxial/triaxial vacuum cabling. Commercially obtained Kapton insulated cables with attached connectors or fabricated transmission line Kapton cables.

Prefabricated Kapton cables can be obtained from several manufacturers including ISI. These cables come in various lengths and cable sizes and have vacuum compatible connectors attached. In addition, the cable material and connectors can be purchased separately and manufactured by LIGO. The stiffness of these cables will need to be investigated if these cables are to be used to connect devices located on seismically isolated optics tables.

Matched transmission line cabling can be fabricated using the Kapton circuit board technology described for multi-conductor cables. In this configuration the traces and planes would be

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adjusted such that 50 ohm transmission lines are created on the circuit board. This configuration is shown in the figure below.

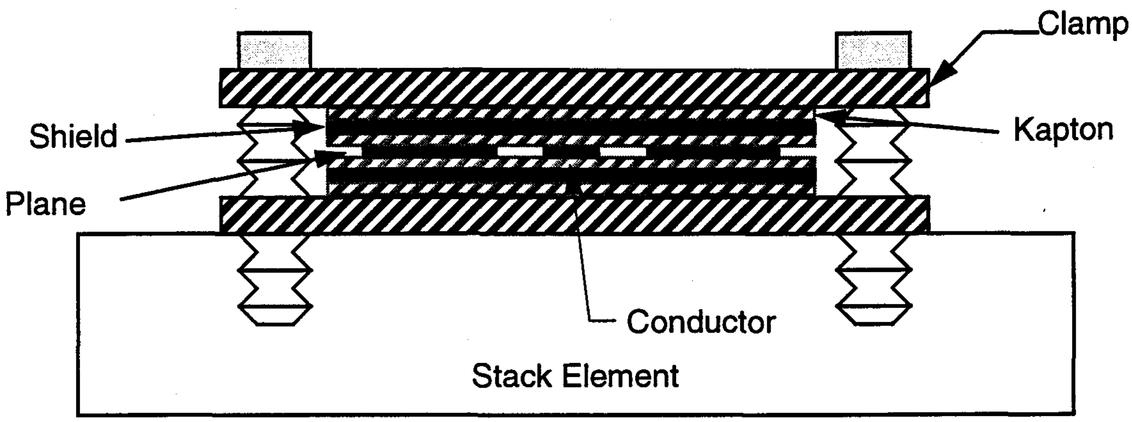

Figure 4: Transmission Line Configuration Showing Stack Fasteners

4.3. Seismic Stack Cable Fasteners

Fastening of cables to the seismic isolation stack to prevent transmission of high frequency vibration will be accomplished by clamping the cables at each stack element as shown in figures 2 and 4. The clamps will be fabricated from aluminum or stainless steel. Attachment to the seismic isolation stack element will be made via 10/32 screws.

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