Evaluation of Cable Crosstalk and Shielding
LIGO-T1100264-v1
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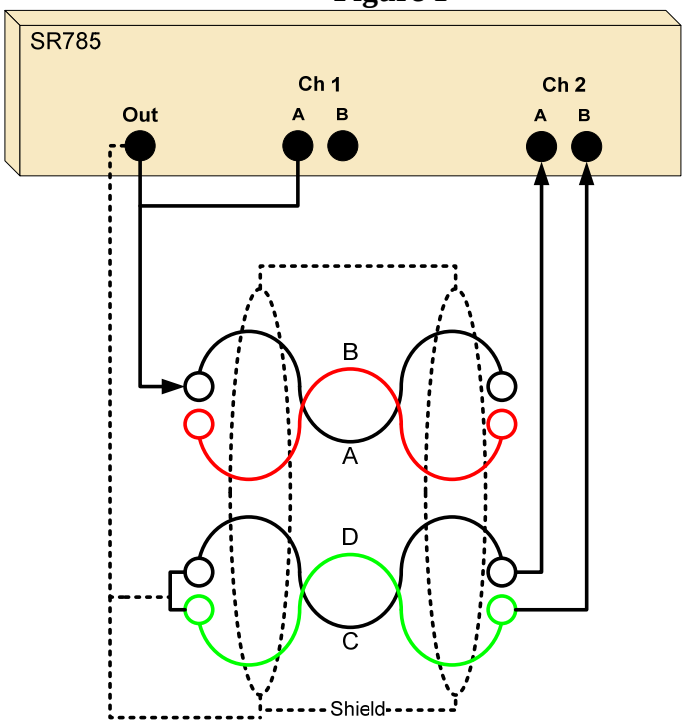
11 May, 2011

1. **Overview –** aLIGO uses numerous general purpose cables to differentially transmit audio frequency signals throughout the observatory. Given the large number of cables needed, it is desirable to choose a cable that is readily available, electrically suitable from a shielding and crosstalk standpoint, and easy to use in cable assembly manufacture. Audio frequency analog signals are to be transmitted and received utilizing fully differential techniques over distances ranging from a few feet to hundreds of feet. Crosstalk measurements on adjacent pairs within a bundle were taken on two candidate cable types to guide the choice for a suitable instrumentation and control cable for audio frequency use in aLIGO.

   Two types of cable were analyzed: Alpha part number **2214C** (overall shield, 22 AWG, 4 twisted pair, 100 feet total length), and Alpha part number **6054C** (individual shield, 22 AWG, 4 twisted pair, 100 feet total length).

2. **Test Setup (Alpha 2214C) –** As shown in **Figure** 1, an SR785 Dynamic Signal Analyzer is used to drive one wire in a pair (either A or B) while receiving the differential signal induced in the other pair (C and D). Ideally, there would be no coupling. In reality, due to factors ranging from real finite isolation in the cable pairs, and finite isolation in the test setup, there is coupling of energy from the driven cable to the adjacent pair.

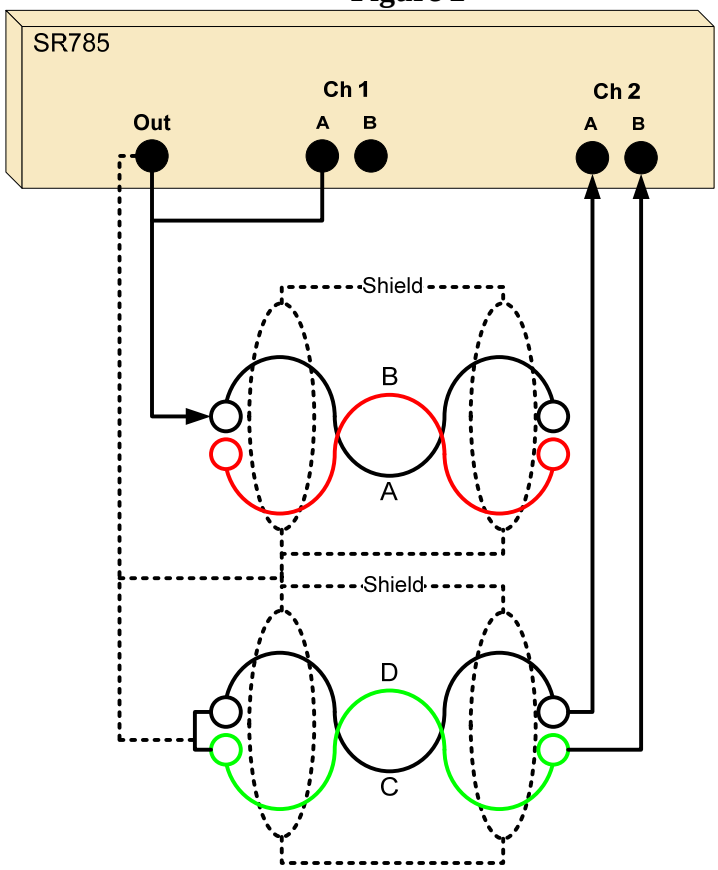
Figure 1



The transmitting cable is left open on the remote end whereas the receiving cable pair is shorted together at the source end and grounded to the shield. This simulates the best case source impedance balance, and the Thevenin equivalent circuit of an ideal voltage source driving the receiving cable pair.

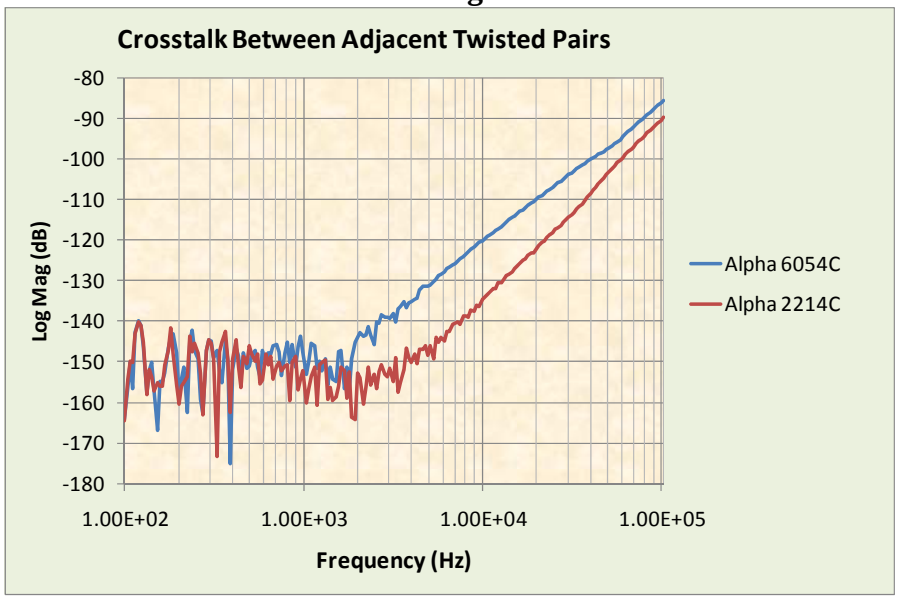
3. **Test Setup (Alpha 6054C) –** As shown in **Figure 2** the Alpha 6054C cable has individual shields. The test setup is modified per the diagram to connect the two shields at the source end of the measurement. The other aspects of the measurement remain the same as the previous cable test.

Figure 2



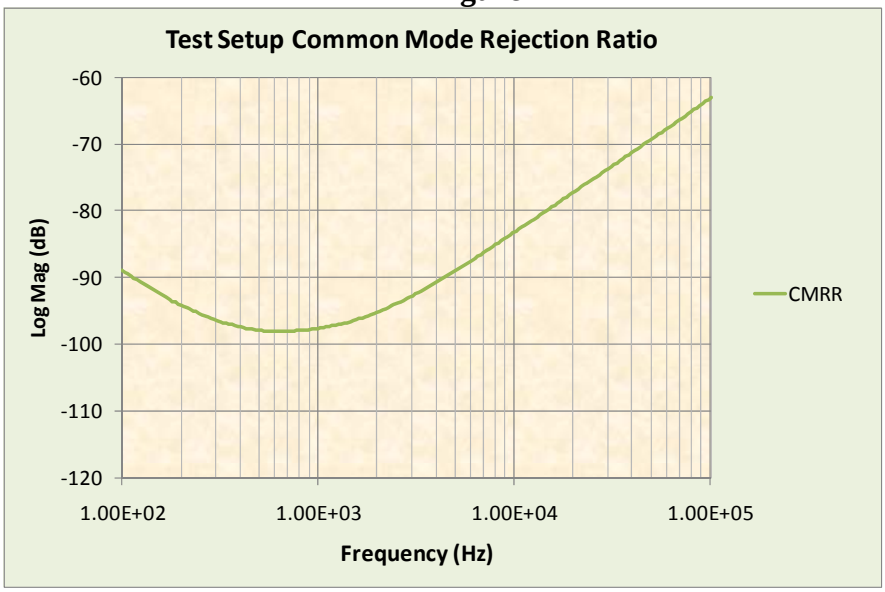
4. **Test Results -** Figure 3 shows the somewhat surprising result that the cable with individual shields seems to have more crosstalk than the cable with only an overall shield. Also, there is evidence of a coupling that varies as >20dB per decade above a few kHz. The coupling slope anomaly is likely related to the common mode rejection ratio (CMRR) of the test setup. A measurement was taken of the CMRR in Figure 4

Figure 3



5. **Common Mode Rejection Ratio –** Figure 4 shows the CMRR of the test setup obtained by shorting the cables attached to Ch. 2, A and B inputs and driving them in common mode.

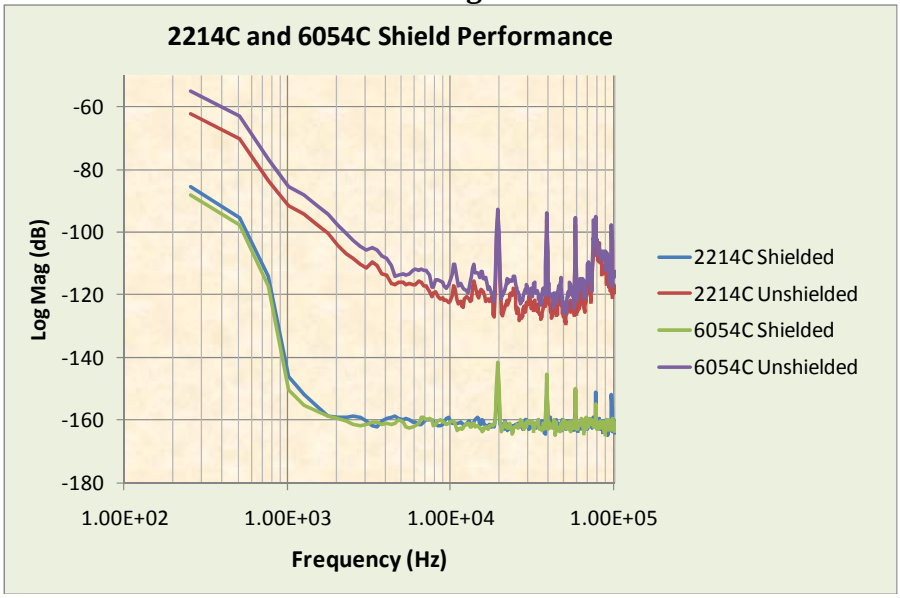
Figure 4



6. **Cable Shield Performance –** A rough look at the cable shield performance (obtained by connecting or disconnecting the cable shield) is shown in **Figure 5**. The unshielded case is

just the background noise in the lab. The noise floor of the shielded case is dominated by the SR785 measurement noise floor, but the peaks at 20 kHz and beyond provide some insight into the shield performance to ambient noise. Approximately 45dB or so of shielding can be seen in this crude measurement.

Figure 5



7. **Conclusion –** For aLIGO audio frequency cable runs at both observatories, the crosstalk observed in adjacent twisted pairs is probably acceptable for both cable types tested (overall shield and individual shield). The Alpha Wire 2214C cable is a better choice based on flexibility, availability, cost, weight and ease/cost of termination. The cable shield performance is comparable in both cables. The cables tested have a wire size of 22 AWG. 24 AWG cable would be a sensible choice for cables that have little current flowing within. The performance ought to be essentially identical if 22 or 24 wire gauge is the only variable.