Triboelectric Effect in ESD Drive Cable

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Abstract

Measurements were performed on Cooner Wire Inc. part number CW2040-3650 F to determine the triboelectric voltage generated when the cable is vibrated using a calibrated test fixture.

1 Overview

The question was raised as to whether ground motion can induce sufficient triboelectrically generated voltage noise in the Electro-static Drive (ESD) cabling so as to create a noticable motion in the LIGO optics. A sample of the proposed cable was obtained, and a test setup was devised to quantify the effect.

2 Test Setup

2.1 Description

A loud speaker was driven by a function generator. The peak-to-peak piston motion of the loud speaker cone was measured while the speaker was being driven at a known amplitude and frequency. The assumption was made that the cone deflection would, to first order, be directly proportional to drive voltage, so extrapolations can be made at lower drive amplitudes. The cantilever portion of the cable under test measured about 11 inches.

Measurement Test Setup

2.2 Measurement Test Results

The induced cable voltages at different drive amplitudes and a constant frequency of 73 Hz are shown below. Two different termination impedances were used on the input to the SR-785 Dynamic Signal Analyzer.

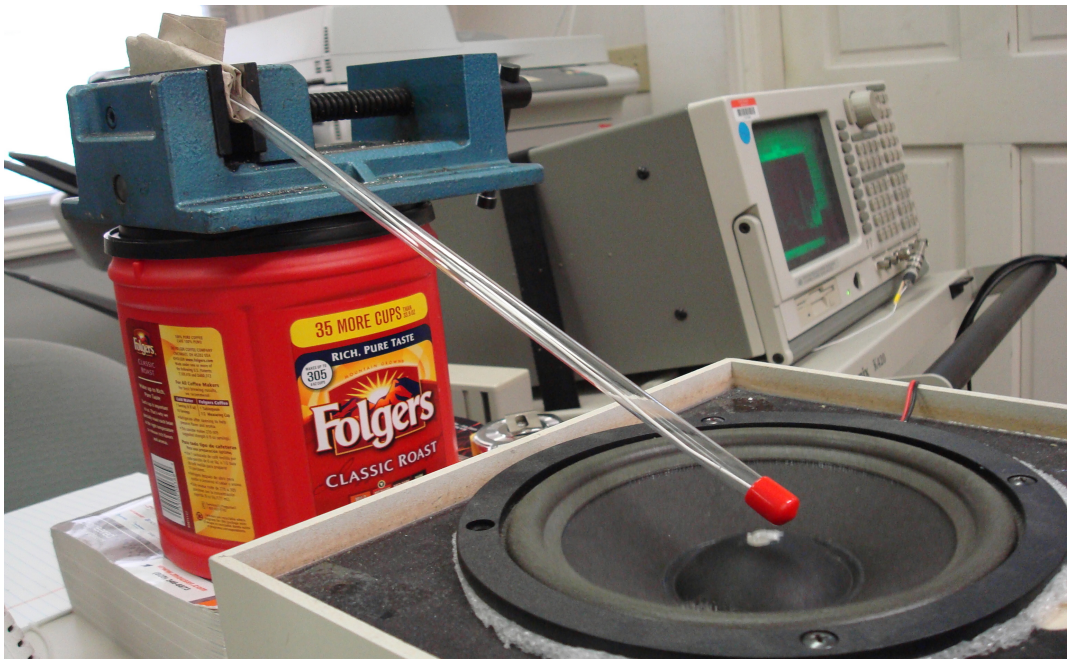
Drive (Volts p-p) 73Hz	dBv rms 1 MΩ	dBv rms 50 Ω
7	-68	-154
3.5	-73	≤-157
1.75	-79.6	≤-157
0.7	-97.2	≤-157
0.35	-100	≤-157
0.2	-104	≤-157
0.07	-113.5	≤-157
0.035	-118	≤-157
0.020	-123	≤-157
0.010	-127	≤-157

For the 50 Ω case, the induced cable voltages are below the SR-785 noise floor for all but the highest drive amplitude. It is interesting to note that the

current flowing through the termination resistor is the same for the 1 MΩ and 50 Ω case, seeminly implying the generation mechanism behaves like a current source.

2.3 Cross-check

To preclude the possibility that the induced voltages are due to electromagnetic pickup, the test cable was disconnected from the speaker cone. The physical geometry of the test cable was kept the same with respect to the loud speaker. The induced voltage was reduced to -93 dBv rms indicating the previous results are more likely due to acoustic perterbation than electromagnetic. It is possible that the observed effect is attributable to motion of the cable in the static magnetic field of the loud speaker magnet, but regardless of the mechanism, the results yield an upper bound. The test setup for this check is shown below:



Test Cable Removed from Speaker

Varying the frequency of the drive from 10 Hz to 1kHz does produce a frequency dependent induced voltage due to standing waves on the test coaxial cable, and also due to the shape of the loud speaker's frequency response. Even taking this into account, the peak to peak observed triboelectric voltage is still around 10dB, so the test yields an order of magnitude for the upper limit.