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NOVA Block Gap Monitoring

Abstract

We propose a method to measure and monitor gaps between NOVA blocks.

The method works for all size gaps, allows for arbitrary segmentation, and is non-intrusive, inexpensive, and robust.

Introduction

NOVA will be assembled in blocks of planes , with gaps between them to allow future swelling due to PVC creep. On the scale of the detector planes (50 ft x 50 ft) the gaps are thin, between 0.3 cm and 2 cm. Yet they are important for the long term health of the detector. They are not easy to see, let alone measure and monitor.

The Gap Monitor --Requirements

We wish to measure a gap of about 1 cm to an accuracy of about 1 mm, and monitor changes to preferably a better accuracy.

Due to the stiffness of the block we may not need a very detailed map of the gap (although the method allows that). We do wish to get a reasonable resolution on the vertical gap profile (say, up to 12 bins), and a lesser resolution (say, up to 4 bins) in the horizontal profile. These are just starting numbers, and may be too fine-grained or too coarse. That is a different discussion.

The Method

We will apply conductive patches (of at least 1 sft in area) to the faces of the two blocks meeting at a gap.

The patches on one face are each connected by a thin wire to a connector at the walkway edge of the gap.

The matching patches on the face of the other block can be all interconnected, as a common reference plane, with a wire brought out to the same location as the connector. Capacities are measured between the reference plane wire and one of the patches via one pin on the connector.

The capacity can be measure manually with an inexpensive ($25.-) capacitance multi-meter, or can , if desired, be read out and monitored via a remote readout system. Since changes are expected to be slow, a monthly or quarterly manual reading may be adequate.

Tests

We have applied a pair of patches to a short piece of NOVA extrusion.

The patches were made by applying strips of aluminum tape (sold for sealing air ducts) along the cell tops. The tape is wider than a cell and the strips overlap. The tape sticks ferociously and permanently, and is easy to apply.

Connections were made using adhesive backed copper tape. Since a reliable galvanic contact to aluminum is difficult to assure in the long run, we use enough copper tape area to assure adequate capacitive coupling. In a test we applied a 1ò x 2 3/8ò tape over a layer of 1 mil ñmending tapeò to assure electrical isolation. The capacity was 580 pF. Without the mending tape layer the conductors should be twice as close, with a resulting capacity in excess of 1000 pF.

For the tests we ran copper tape across all the aluminum strips, resulting in an estimated coupling capacity of 4000 pF. This should have insignificant effect when in series with the patch capacitance of 125 pF for a 1 sft patch at ¼ò spacing. The connecting wires were soldered to the copper tape.

We performed a test with short wires, and another one connecting the multimeter via a total of 100ô of wire. The wire was laid out in a square to check for unwelcome induction effects. None were observed.

Test Results

The capacity of a plate capacitor in SI units is

C = epsilonzero * Area / gap size [Farad, m^2, m]

Where epsilonzero is 8.854 E-12 [F / m]

Fig. 1 shows the calculated capacitance (labeled ñfull Cò and ñthin Cò among various measured capacitances, plotted versus the inverse gap size in units of [1/inch].

The measured capacitance shows a surprising non-linearity. At the smaller gaps (e.g. ¼ò) it flattens wit decreasing gap size.

This is, it turns out, a geometric consequence of the undulating surface of the extrusion:

When the flat tops of one extrusion approach those of the opposing one, their capacitance increases as expected. The valleys, however are still reasonably far apart and contribute less to the overall capacitance.

That is illustrated by the two calculated curves.

The curve ñfull Cò is appropriate for large gaps where the undulation is not important.

The curve labeled ñthin gapsò uses only the flat top area (about 70%) of the extrusion. For small gaps this curve should represent that slop. The two calculations do a reasonable job, both for the absolute value and the slopes of the capacity versus inverse gap size.

Test Results with Long Wires

For ease of measuring it is important to bring all connections out to the block edge at the walkways. To address a concern about the extra wire capacity and possible noise pickup on the long wires we laid out connecting wires in a rectangle of sides 25 ft or so, on the floor in Lab 6. The resulting capacity curve is shown in Fig, 1 a s ñlong wire Cò. The curve seems consistent with the short wire results plus the wire capacitance, This is further illustrated by the curve labeled ñD(long wire)ò where the wire capacitance has been subtracted out. Small discrepancies can be blamed on the crude setup, e.g. using plywood shims as spacers.

Patch Application

We have found the duct type aluminum tape a suitable conductor (see Figure 1)

The tape must be applied to two surfaces:

a. The bottom of the first layer on the block raiser

b. The top of the completed block on the block raiser.

These tasks are consistent with the current assembly plan:

a. The tape can be applied to the bottoms of the first layer extrusions making use of the turning capability of the gluing machine. If we make this layer the ñreference planeò then it does not matter which way the extrusions are oriented.

b. On the top surface of the (lying) block , the patches can be applied while waiting for the glue to cure. Hand application with some reasonable fixturing will make the job fast and easy. Thin connecting wires are run in the ñvalleysò between cells to a simple connector at the edge of the plane.

c. Measurements are needed only infrequently and can be taken with a hand-held C-meter. Permanent readout systems are, of course, possible.

Field Test

John Cooper pointed out that we can field-test the scheme on the gap between the full-height test block and the ñbookendò. Sounds like a good idea!

Summary and Conclusions

We have shown a simple method to measure and monitor the gaps between blocks and superblocks. A field test has been proposed.

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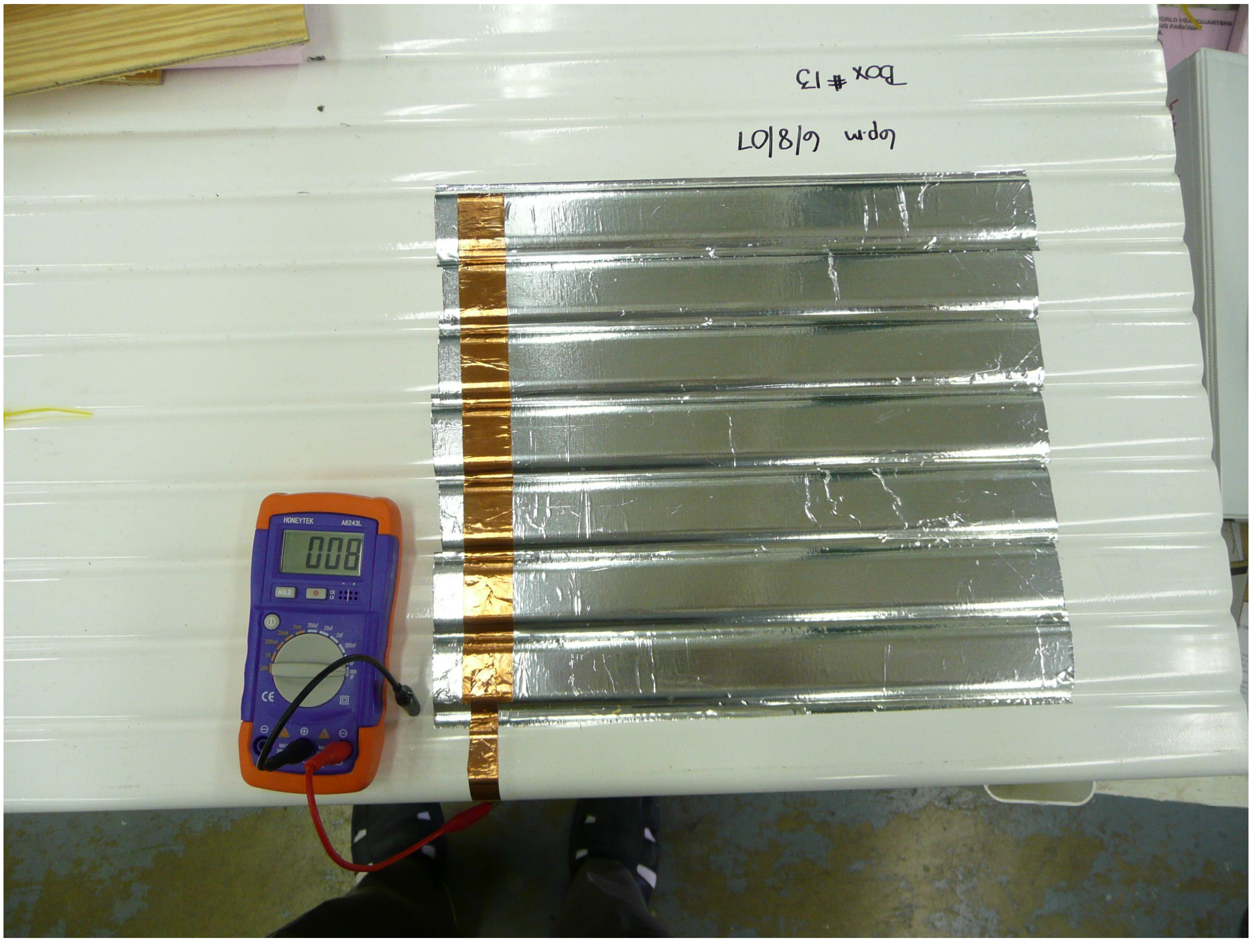
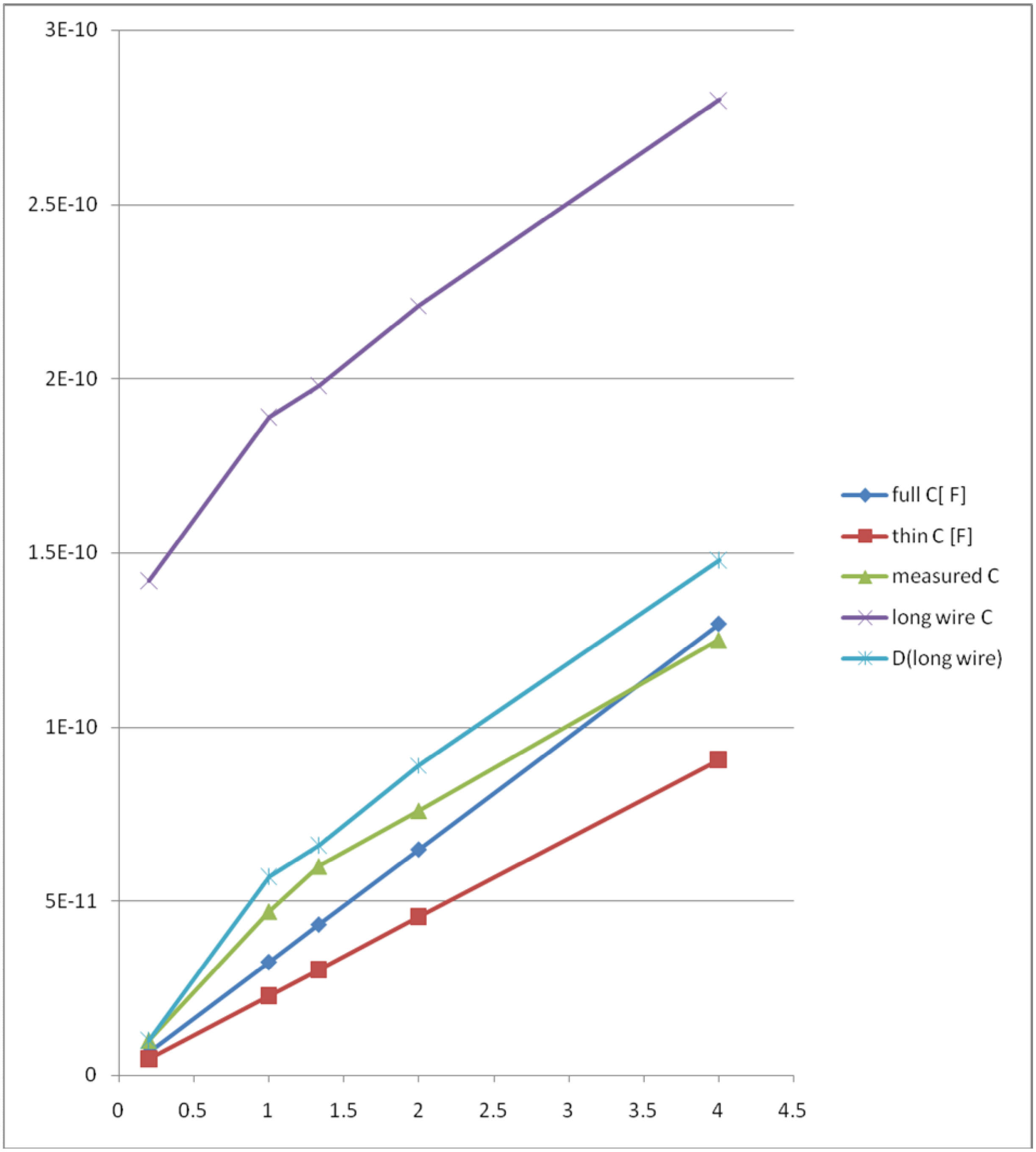


Figure 1:   Tape applied over about 1 sft area.

The copper tape couples to the Aluminum tape by conduction; however the capacitance between the tapes is also very large and guarantees a long term connection. The portable C-meter has a resolution of 1 pF.



Fig, 2: Summary of measurements.

Bottom group of lines: direct measurement of C versus inverse gap size.

The two measured curves are non-linear as explained in the text.

The straight lines are absolute calculations for large gaps (ñfull Cò) and thin gaps (ñthin C) and are the expected asymptotic slopes, in reasonable agreement with the data.

The upper curve was taking with a long loop of connecting wire and is, as expected, identical to the short wire curve, offset by the wire capacitance.