FERMILAB
Technical Division
Test and Instrumentation Department

Prototype of Displacement capacitive sensor measurement system

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Revision History

Revision	Date	Section No.	Revision Description
1.0	08/17/2014	All	Initial Release

Review History

The review period for this document is TBD years/months.

Revision	Date	Comments
1.0	TBD (expected review date)	Initial Release

The capacitive displacement sensor was initially outlined in IEEE's Transaction on Instrumentation and Measurement journal in December of 1992. Figure 1 shows the schematic of that sensor. In this design, altering the capacitance of capacitor C_x will change the frequency of the square waves that are being measured. The measurement device could be made out of two plates, one of which can be connected to the antenna and moved relatively to the other plate changing the capacitance. Alternatively, it could be made of two concentric cylinders, one static cylinder and the other attached to the antenna. Moving the cylinder attached to the antenna will vary the capacitance between the two cylinders. Currently, when measuring the RF field, the antenna must be positioned manually between tests, as the antenna could become stuck if moved and we are given no information about the position of the antenna. This movement detection system will allow us to move an antenna reliably in liquid nitrogen for use in calibrating RF cavities.

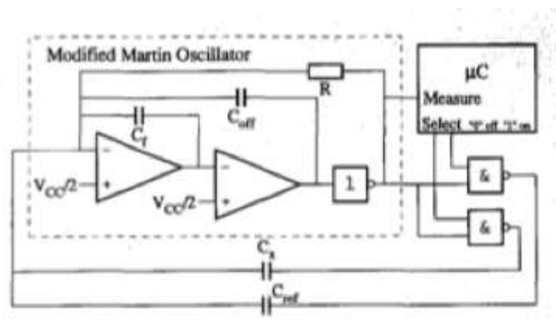

Figure 1: The schematic of the sensor from IEEE

To first test the concept of using the smart capacitive position sensor, a spice circuit simulator called LTspice was used to model the circuit and get a basic understanding of what the output would look like.

A mockup was then built on a breadboard using proprietary surface-mount to breadboard PCBs to mount the ICs to be utilized, and a general surface mount PCB for small components so that all of the surface mount capacitors could be in a similar position. Then, using a DAQ module NI PXI-1031 from National Instruments, a LabView program was made to count the pulses using the onboard counter in the DAQ module. A variable capacitor trimmer was used as "C_x" for the proof of concept. Figure 2 shows the final program, which had the ability to show as many previous data points as needed. Figure 3 is a photograph of the mock up of the circuit on a breadboard connected to the DAQ module.

Following that, a layout for the final PCB was made using Altium Designer. Using blueprints from Texas Instruments, the official "Launchpad" design specifications were integrated for easier use with the microcontroller we had .

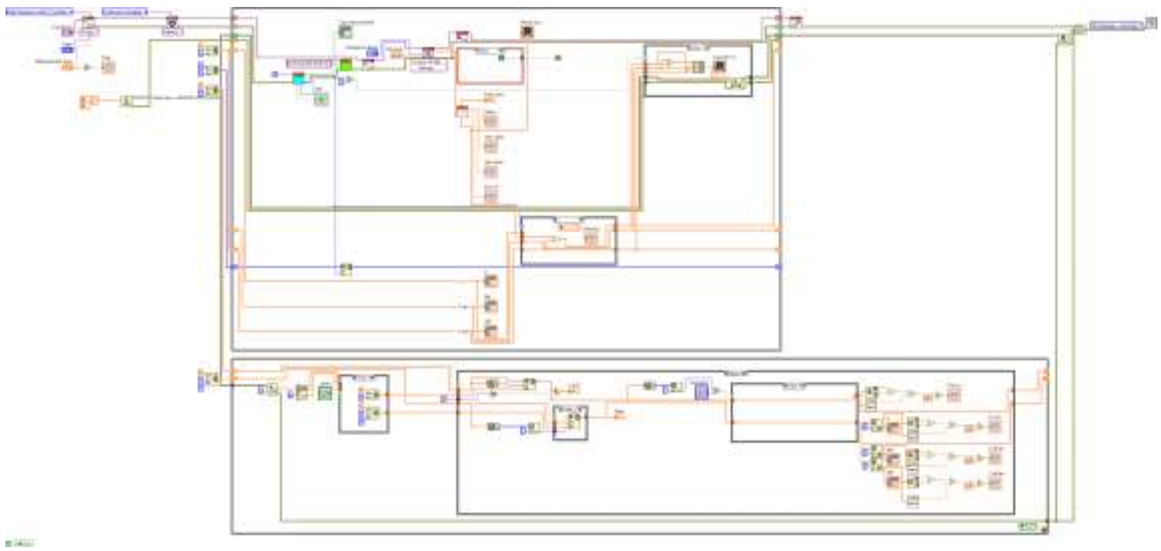

Figure 2: The final LabView program for testing the prototype

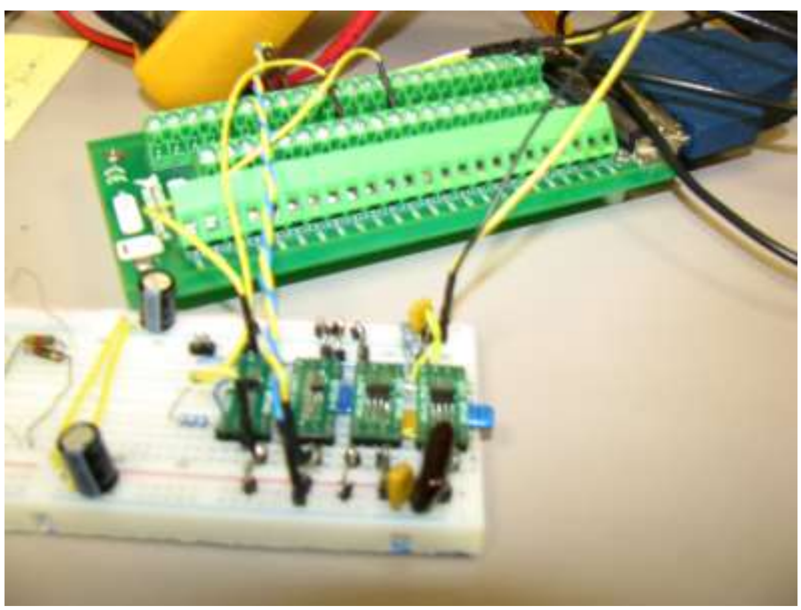

Figure 3: The proof-of-concept prototype (wires to the capacitors are disconnected)

The sensor worked well for short (~6 in.) cables connecting the circuitry to the capacitors. The results were repeatable and there was little noise. However, when replaced with long (~25 ft.) cables there was a lot of noise and the sensor was less reliable than with the short cables. The long cables also had a large capacitance, which made the small target capacitances less visible. A basic PCB design of the sensor is currently being redesigned to optimize the sensor and minimize noise. Figure 4 shows the 1st edition, whilst figure 5 shows the 2nd edition.

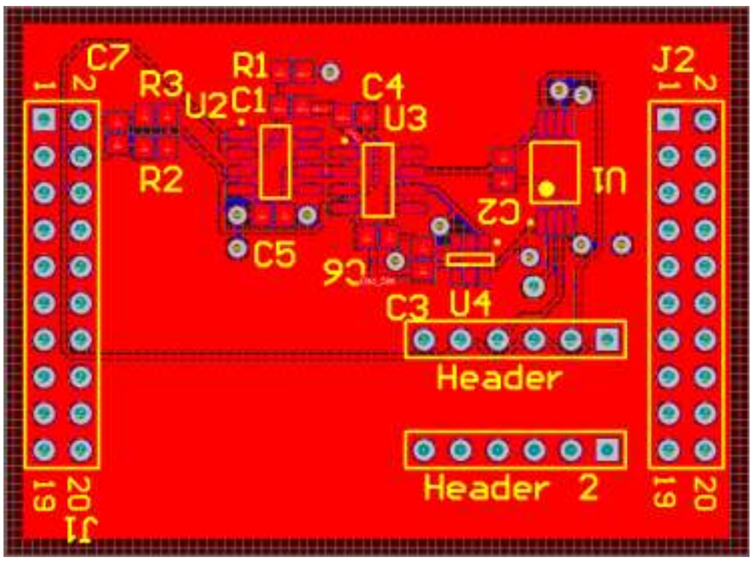

Figure 4: Version 1 of the PCB

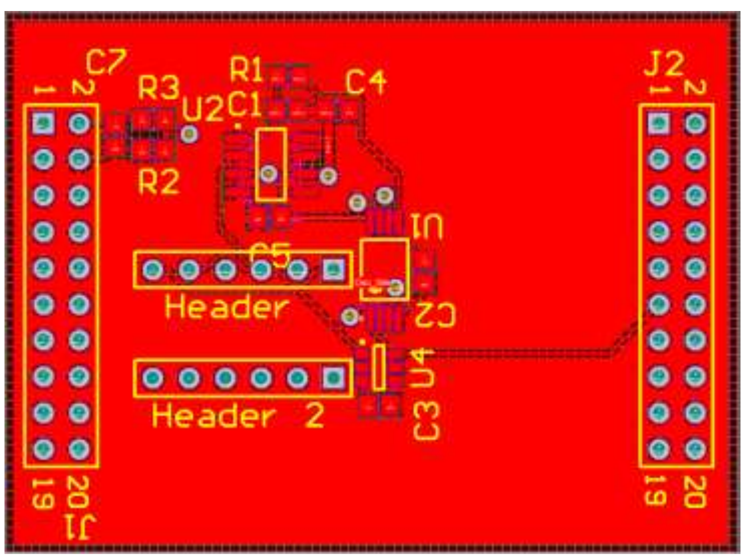

Figure 5: Version 2 of the PCB