4-25-2018

A Sixteen-Channel Nanoammeter Current Measurement System for Profiling Charged Particle Beams

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A SIXTEEN-CHANNEL NANOAMMETER CURRENT MEASUREMENT SYSTEM FOR PROFILING CHARGED PARTICLE BEAMS

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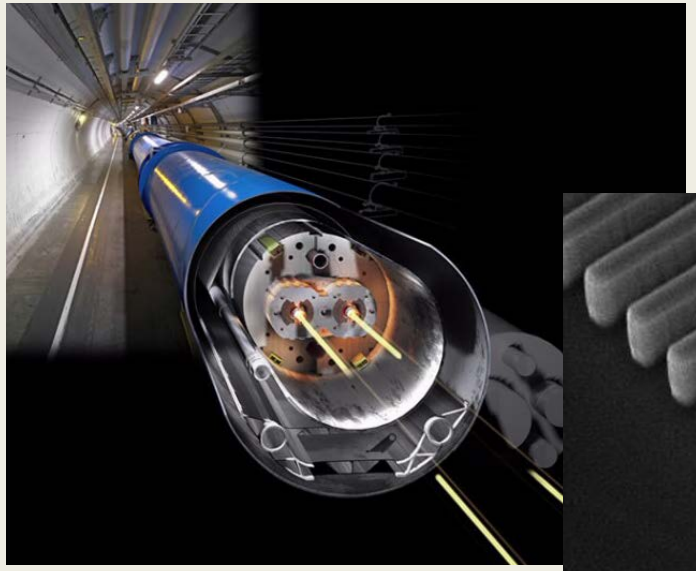
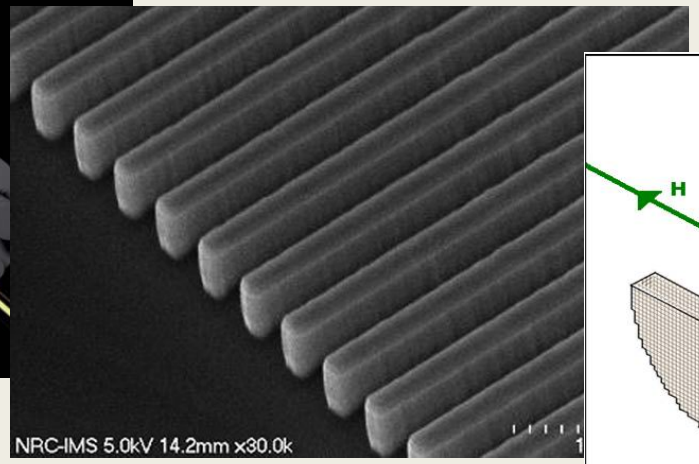
Purpose of an Ion Beam Profile Monitor

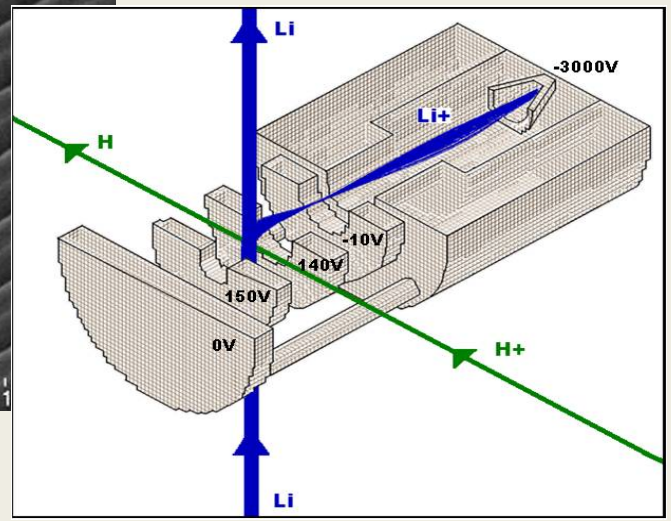
- Profiles size, shape, location of a beam of ions
- Used with particle accelerator beams and ion beam lithography systems, and atomic physics experiments



LHC



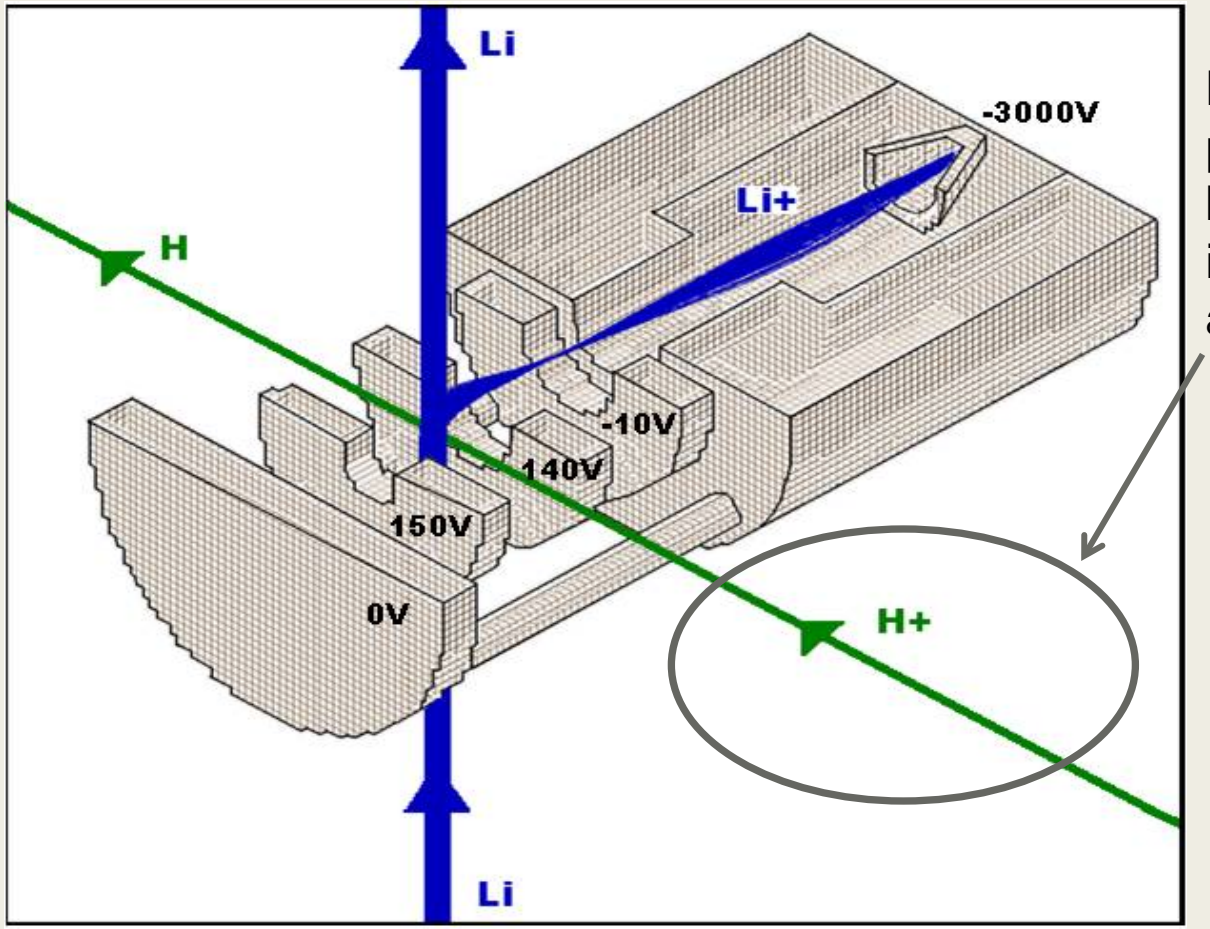
Lithography



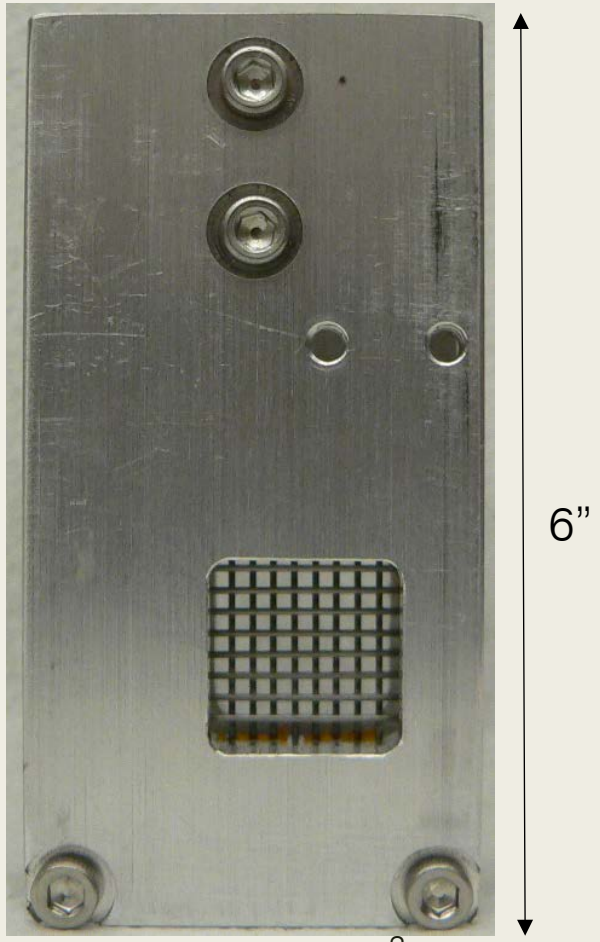
Prof. Oxley's Lab

BPM used in Ion-Atom Collisions

$$H^+ + Li \rightarrow H + Li^+$$

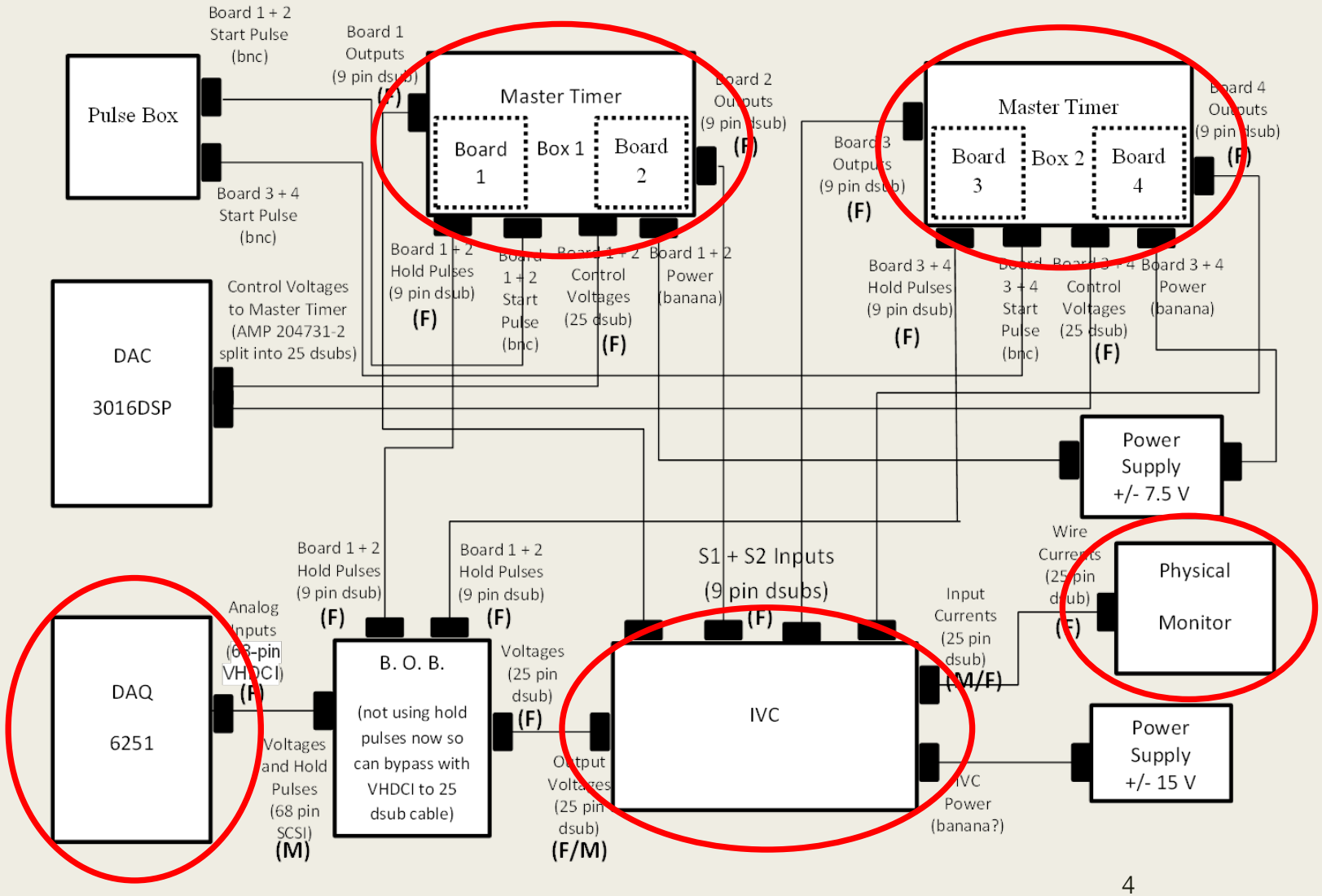


BPM inserted in path of input ion beam to measure its size, shape, and intensity.



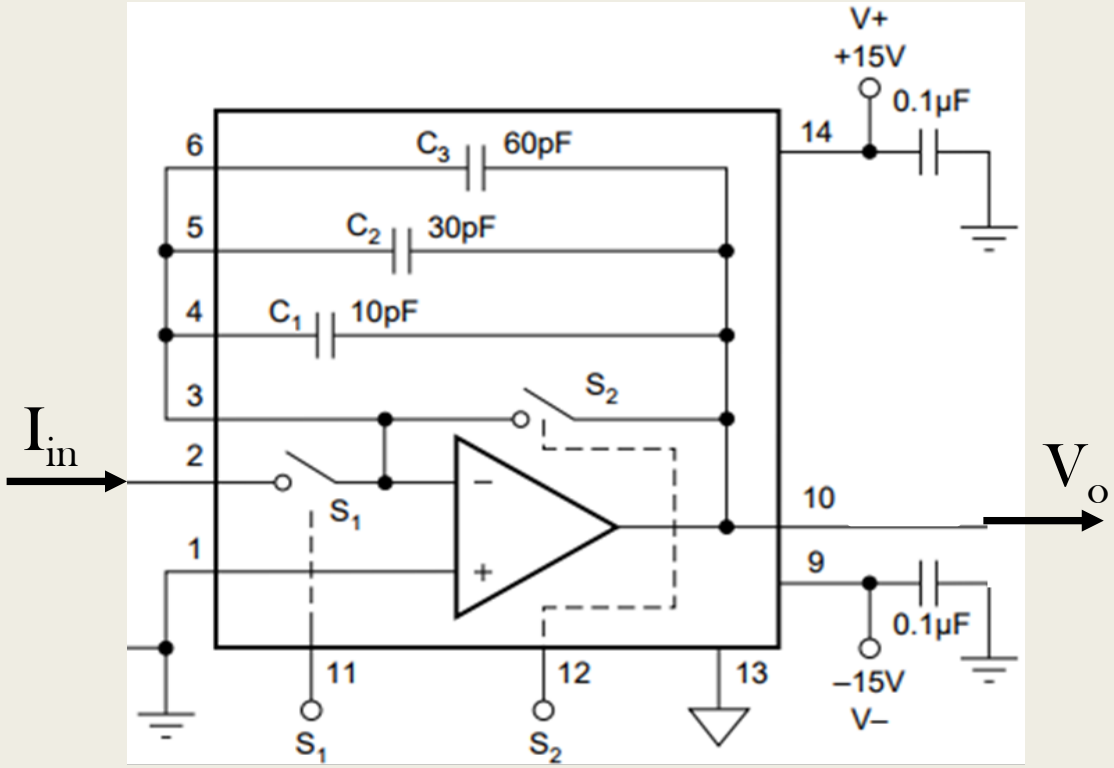
Our System Overview

- Physical Monitor: Grid of 16 wires, 8 horizontal and 8 vertical, that the ion beam passes through generating currents
- IVC: 16 circuits that convert the currents from each wire into voltages
- Master Timer: 16 circuits that control the integration period for how long the IVCs convert each current
- DAQ: Reads voltages into the computer which displays beam profile



IVC – Precision Switched Integrator Transimpedance Amplifier

Circuit Diagram



Gain Equation

$$V_O = -I_{IN} T_{INT} / C_{INT}$$

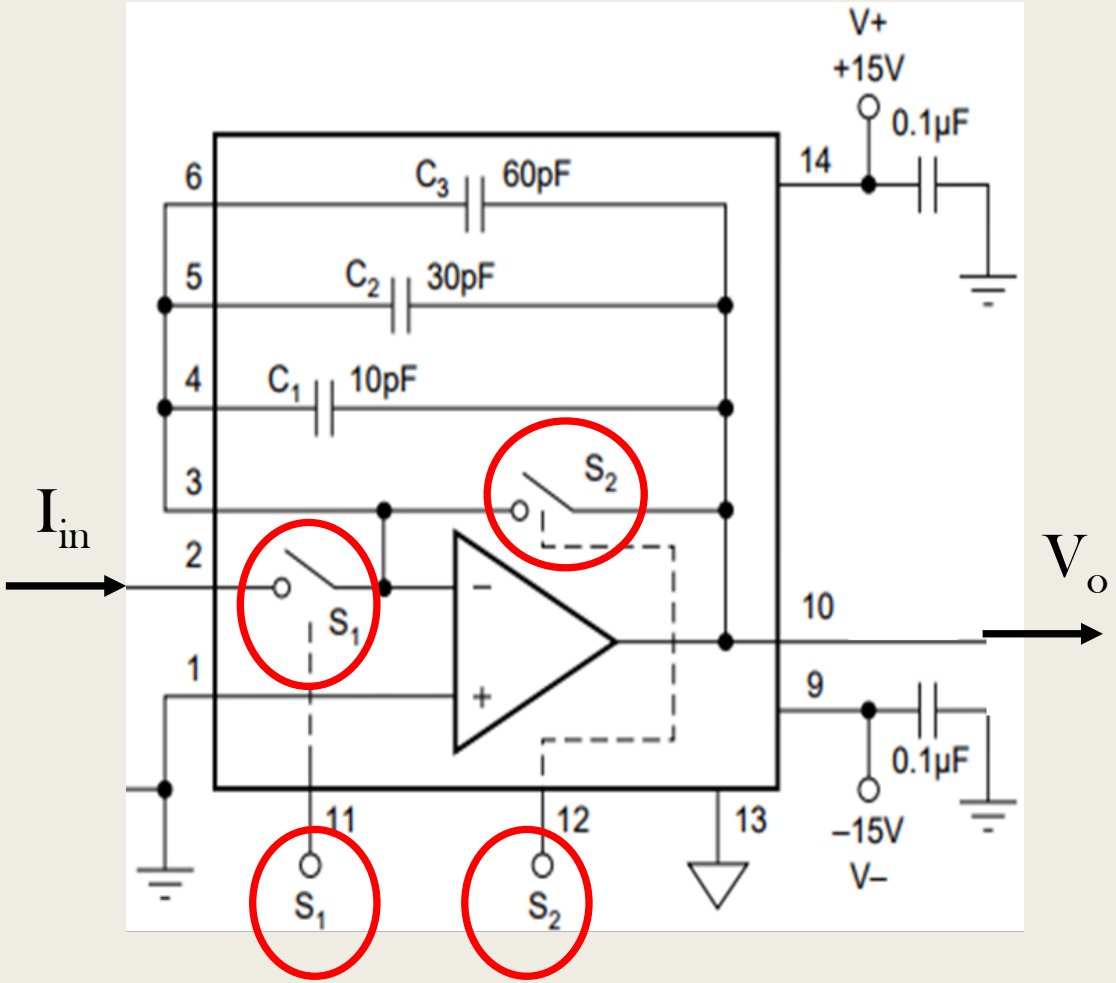
- Amount of V_o depends on T_{int}, which we control

IVC Switches

- S_1: When closed, allows current into IVC
- S_2: When closed, removes accumulated charge from capacitors

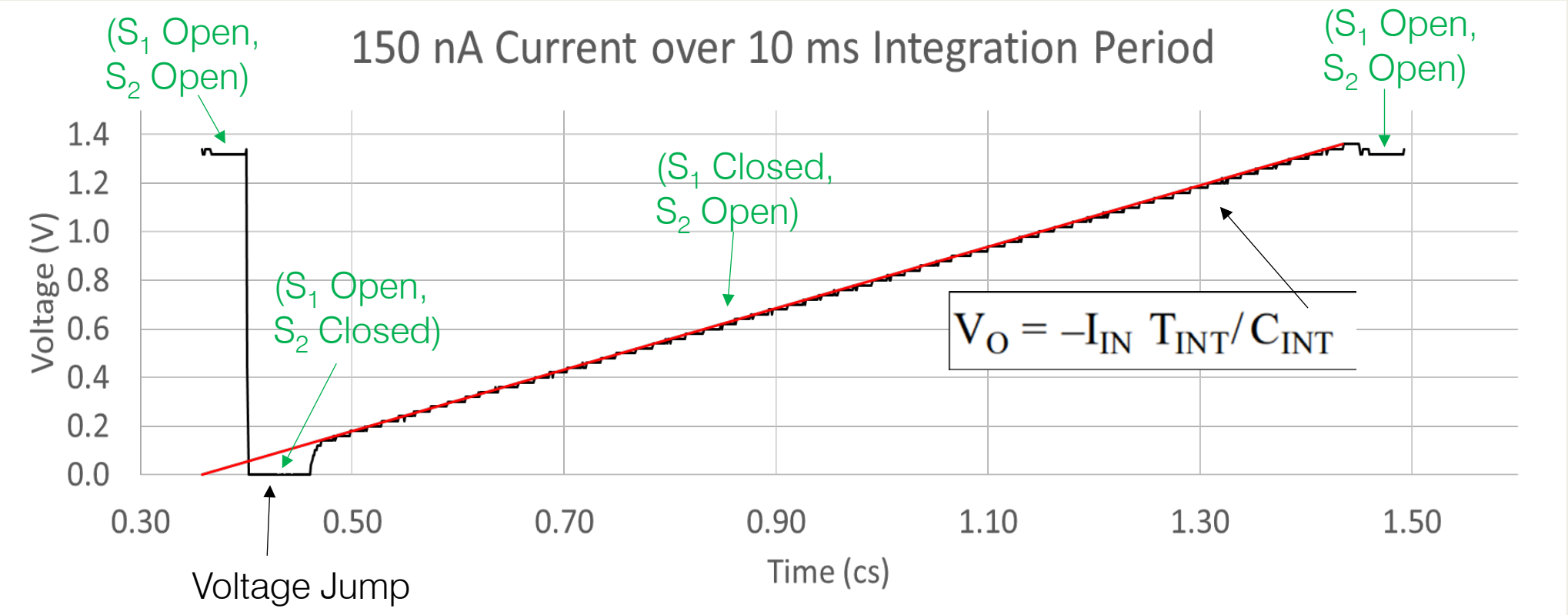
Combinations

- S_1 Closed/S_2 Open: Integration of current to voltage
- S_1 Open/S_2 Open: Integrated voltage in IVC held constant
- S_1 Open/S_2 Closed: Accumulated charge removed from capacitors, resetting circuit
- S_1 Closed/S_2 Closed: Current lost-Avoid!



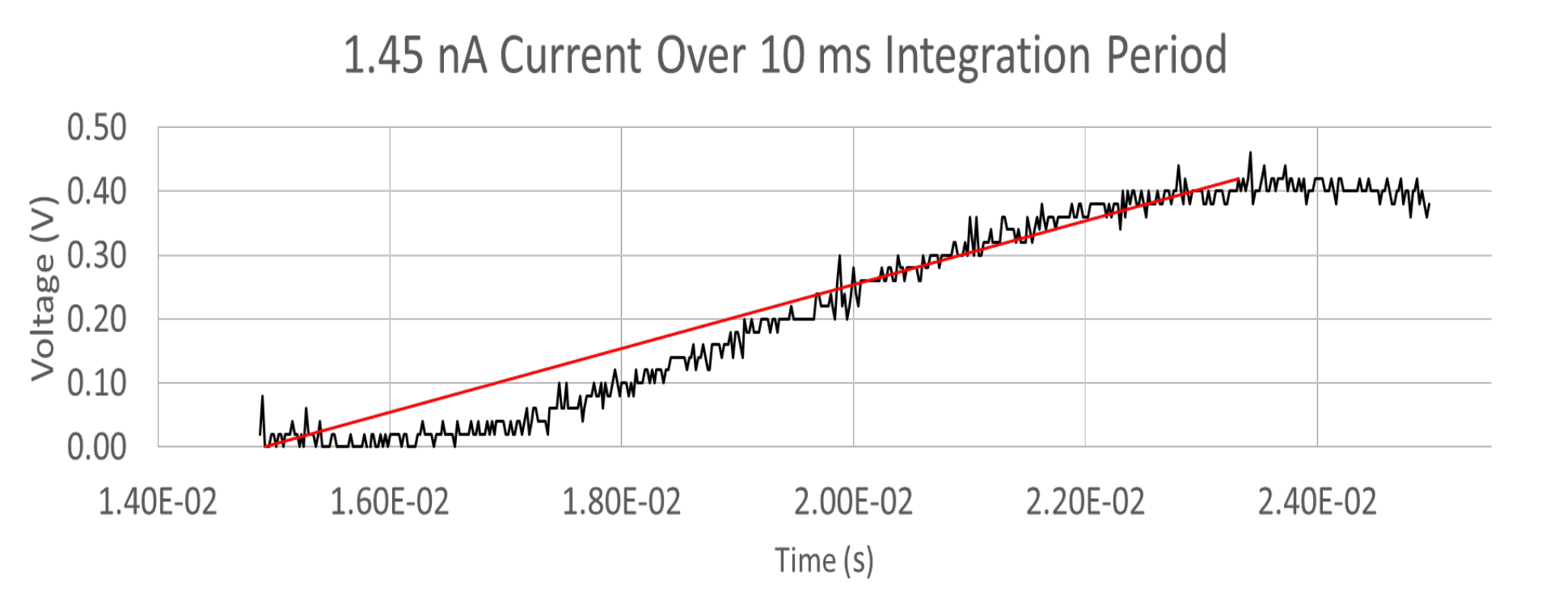
IVC Functionality

- S_1: Input Current Switch
- S_2: Capacitor Reset Switch



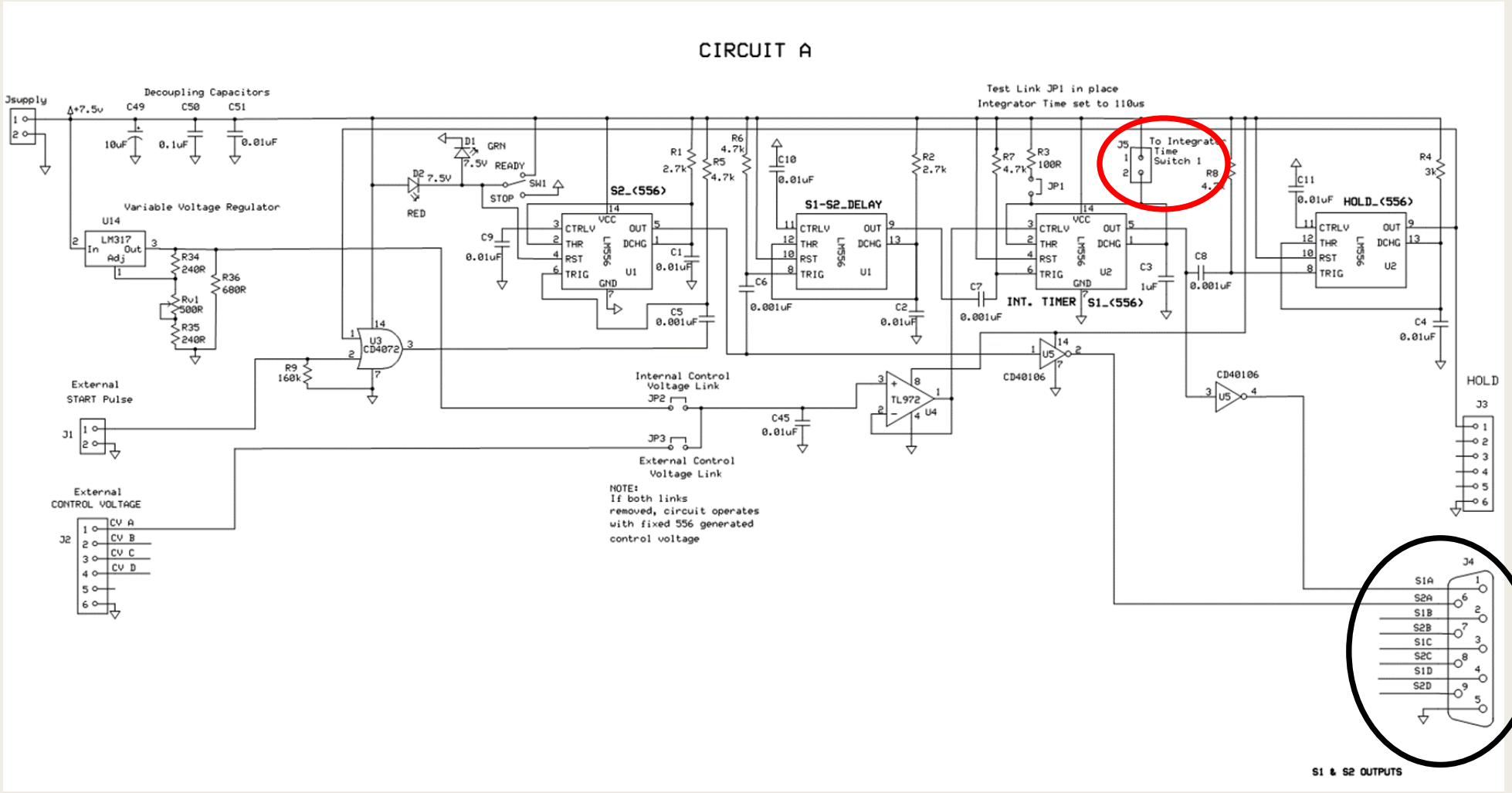
- Can measure C_{int} from slope of graph

IVC Issue – 60 Hz Fluctuation



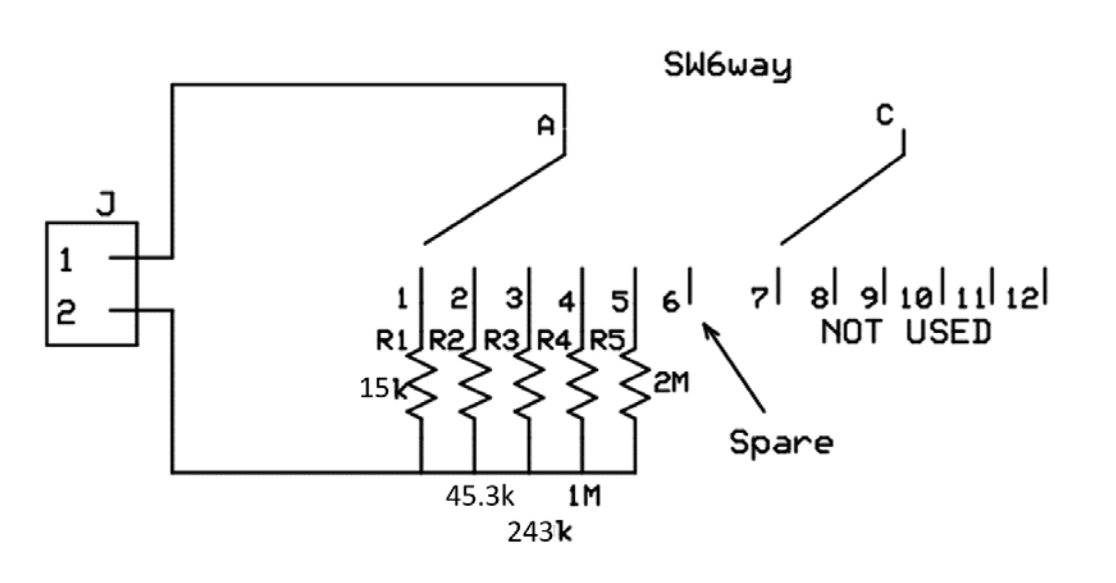
- 60 Hz pickup averages to 0 with appropriate T_{int} = integer multiple of 60 Hz period

Master Timer To Control S_1 and S_2



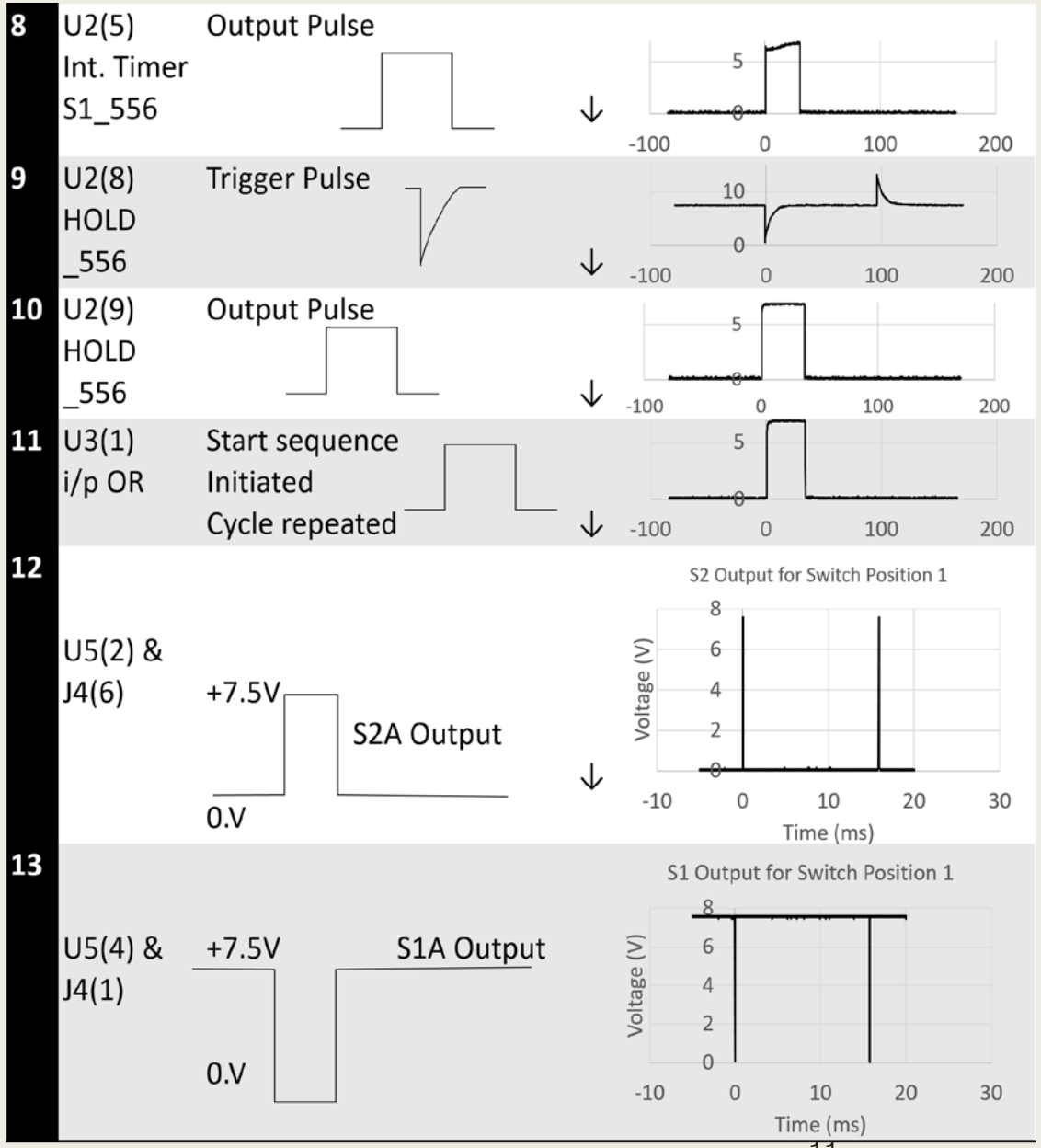
Outputs to S_1 and S_2

Master Timer Integration Switches



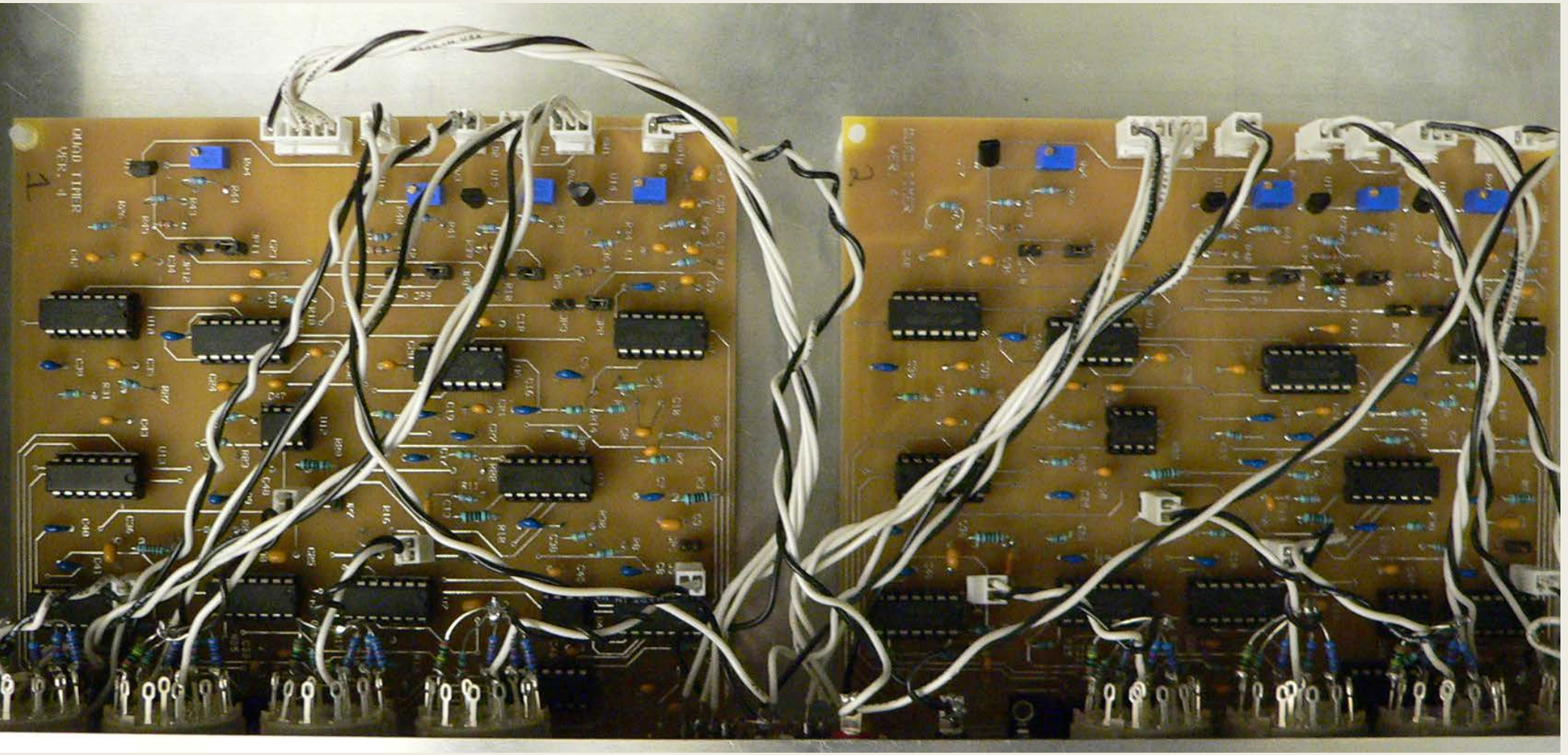
Switch Position	Integration Time	Gain (assuming 100 pf IVC capacitance)
1	16.7 ms	0.167 V/nA
2	50.1 ms	0.501 V/nA
3	267 ms	2.67 V/nA
4	1100 ms	11 V/nA
5	2200 ms	22 V/nA

Master Timer Testing



Master Timer Finished Product - Boards

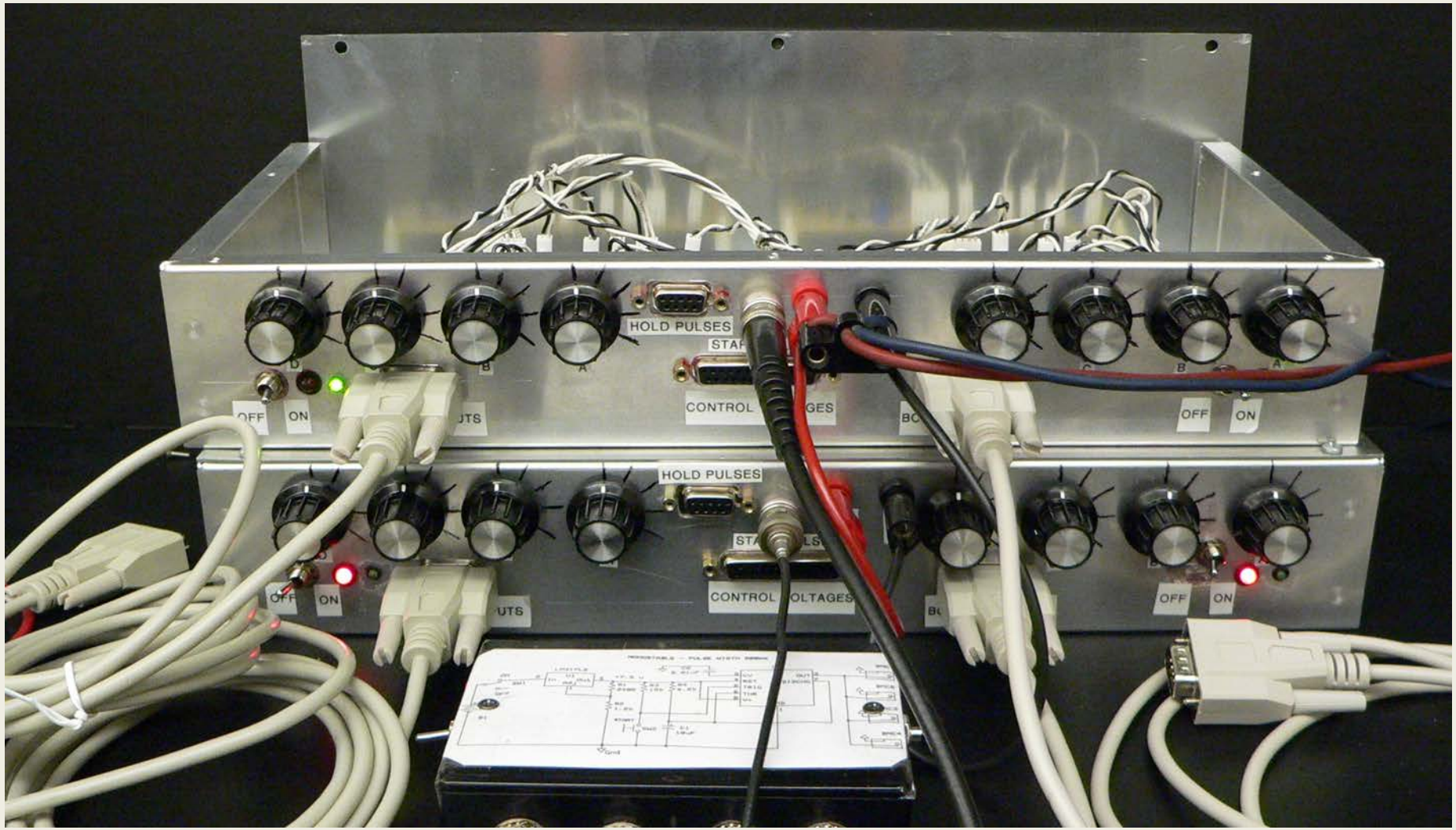
Scale: 6 inches



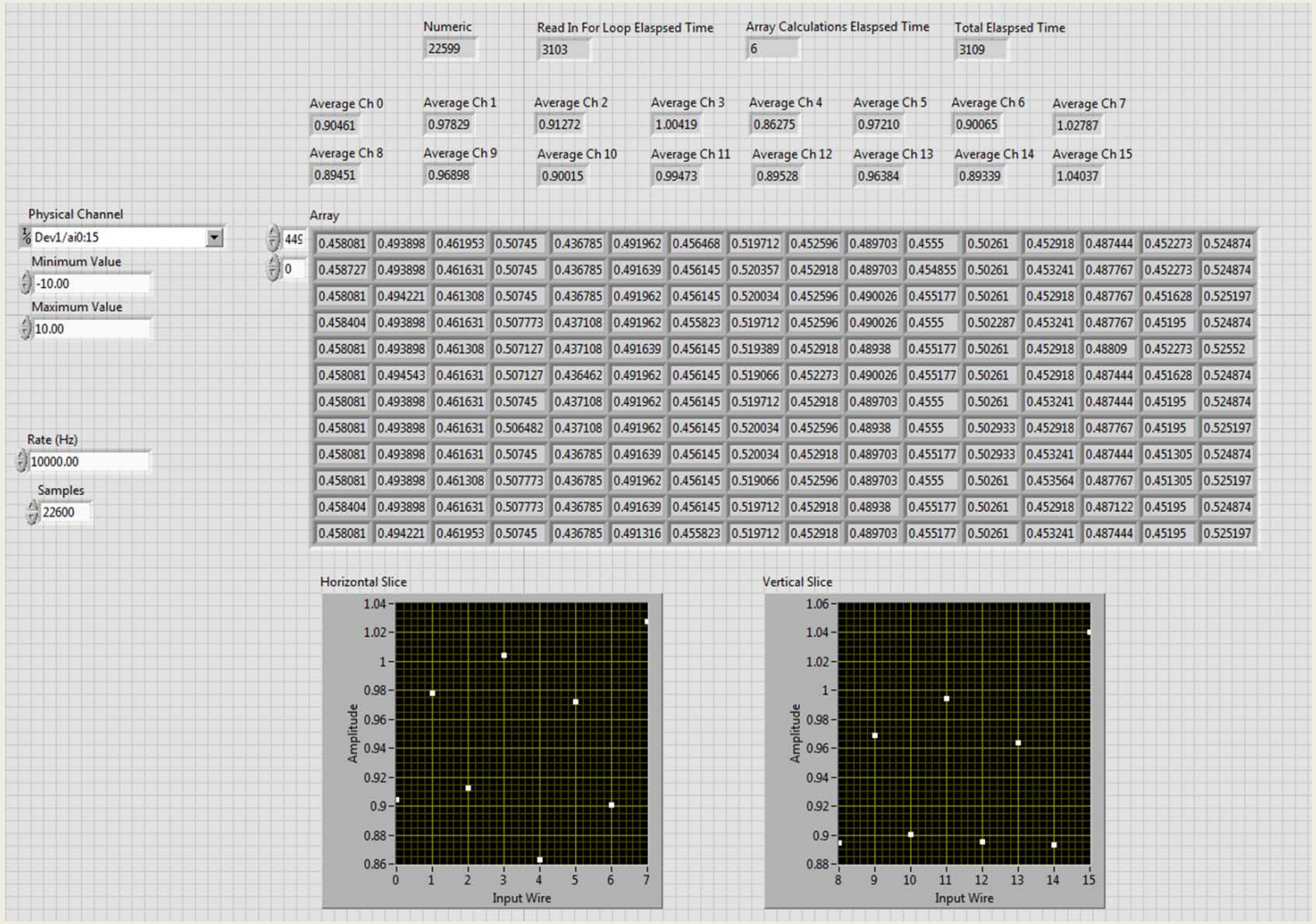
- 1 Board controls 4 IVC chips

Master Timer Finished Product - Boxes

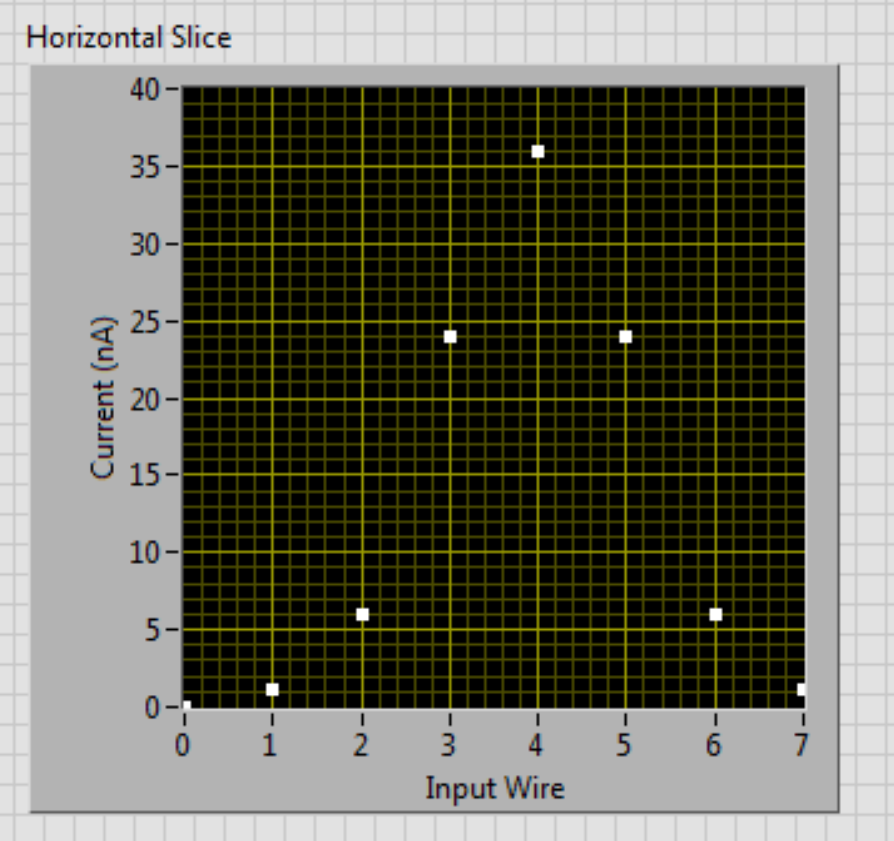
Scale: 15 inches

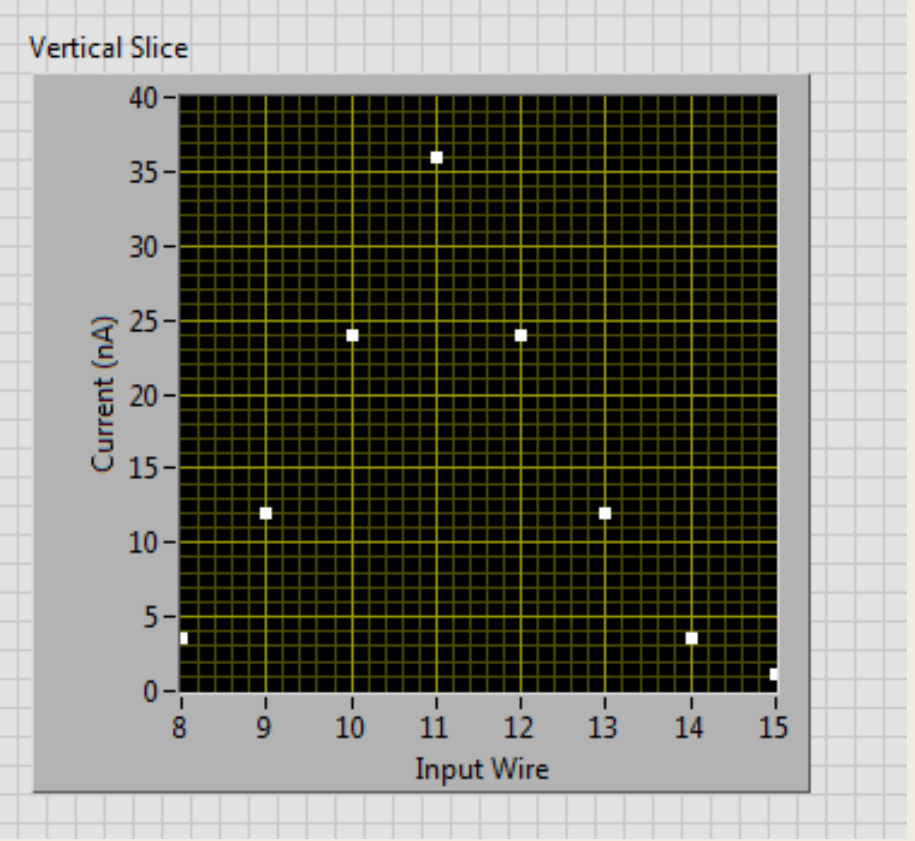


LabVIEW Data Acquisition



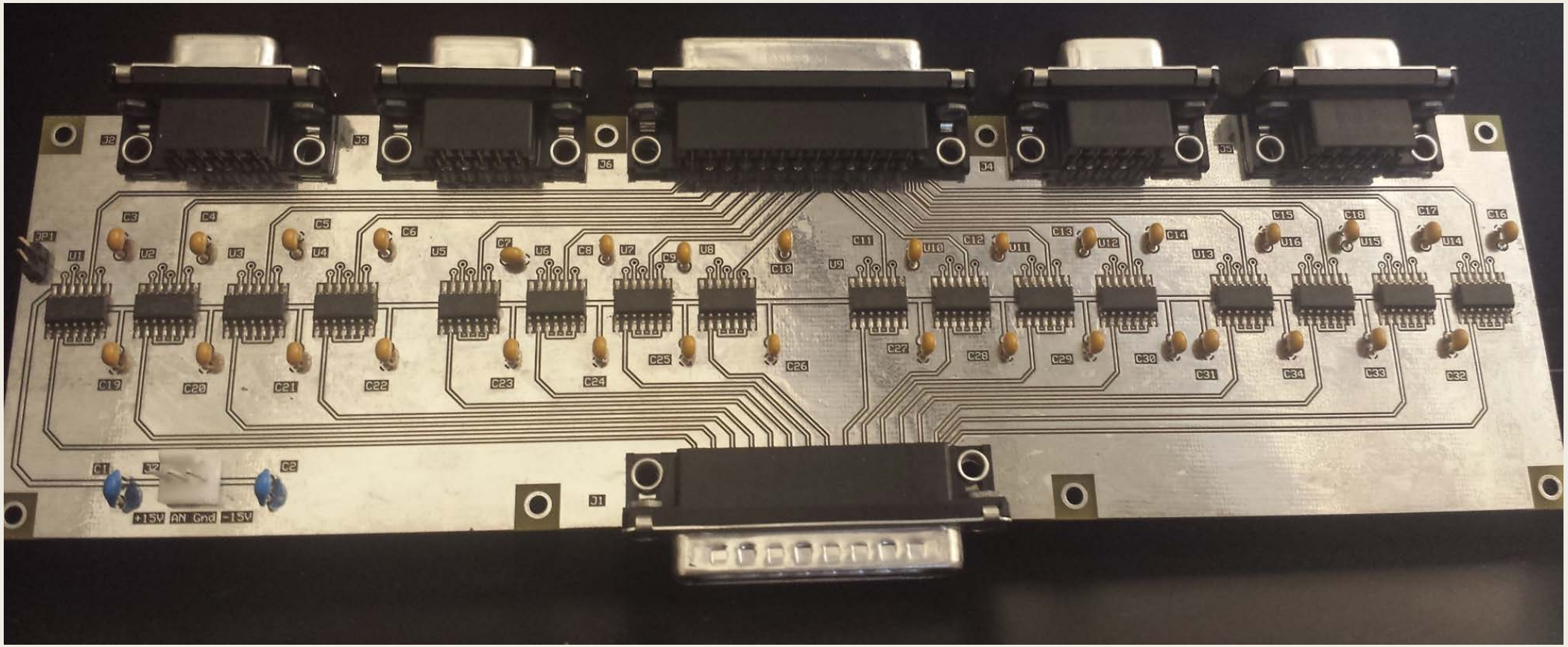
Data Acquisition Expected Profile





Continuing Work – IVC Board

Scale: 9 inches



Thanks to:

- Prof. Paul Oxley
- Dick Miller
- Holy Cross Physics Department