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#### 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

Zach St. Pierre Prof. Oxley Department of Physics College of the Holy Cross

#### 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



#### **BPM used in Ion-Atom Collisions**

 $H^+ + Li \to H + Li^+$ 



# 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<sub>1</sub>: When closed, allows current into IVC
- S<sub>2</sub>: When closed, removes accumulated charge from capacitors

<u>Combinations</u>

- S<sub>1</sub> Closed/S<sub>2</sub> Open: Integration of current to voltage
- S<sub>1</sub> Open/S<sub>2</sub> Open: Integrated voltage in IVC held constant
- S<sub>1</sub> Open/S<sub>2</sub> Closed: Accumulated charge removed from capacitors, resetting circuit
- S<sub>1</sub> Closed/S<sub>2</sub> Closed: Current lost-Avoid!



# **IVC** Functionality

- S<sub>1</sub>: Input Current Switch
- S<sub>2</sub>: Capacitor Reset Switch



• Can measure C<sub>int</sub> from slope of graph

## IVC Issue – 60 Hz Fluctuation



 60 Hz pickup averages to 0 with appropriate T<sub>int</sub> = integer multiple of 60 Hz period

8

## Master Timer To Control S<sub>1</sub> and S<sub>2</sub>



9

#### 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

		Numeric 22599			5	Read In For Loop Elaspsed Time A 3103			Array (	Array Calculations Elaspsed Time 6				sed Time			
		Average Ch 0 0.90461 Average Ch 8 0.89451		Average Ch 1 0.97829 Average Ch 9 0.96898		Average Ch 2 0.91272 Average Ch 10 0.90015		/erage Ch 3 .00419 /erage Ch 1: .99473	Avera 0.862 1 Avera 0.89	Average Ch 4 0.86275 Average Ch 12 0.89528		Average Ch 5 0.97210 Average Ch 13 0.96384		6 Aver 1.0. 14 Aver 1.04	Average Ch 7 1.02787 Average Ch 15 1.04037		
Physical Channel		Array															
1/2 Dev1/ai0:15	449	0 459091	0 402808	0.461052	0 50745	0.426795	0 401062	0 456469	0 510712	0.452506	0 490702	0 4555	0.50261	0.452019	0 497444	0.452272	0.524974
Minimum Value	40	0.450707	0.495090	0.401935	0.50745	0.436785	0.491902	0.456145	0.519712	0.452019	0.480703	0.45355	0.50201	0.452341	0.407767	0.452275	0.524074
-10.00	210	0.458727	0.493898	0.461631	0.50745	0.430785	0.491639	0.456145	0.520357	0.452918	0.489703	0.45485	0.50261	0.453241	0.487767	0.452273	0.524874
Maximum Value		0.458081	0.49422	0.461308	0.50745	0.430785	0.491962	0.456145	0.520034	0.452596	0.490026	0.45517	0.50261	0.452918	0.487767	0.451628	0.525197
10.00		0.458404	0.493898	0.461631	0.50777:	3 0.43/108	0.491962	0.455823	0.519/12	0.452596	0.490026	0.4555	0.502287	0.453241	0.487767	0.45195	0.524874
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Rate (Hz)		0.458081	0.493898	0.461631	0.506482	0.437108	0.491962	0.456145	0.520034	0.452596	0.48938	0.4555	0.502933	0.452918	0.487767	0.45195	0.525197
10000.00		0.458081	0.493898	0.461631	0.50745	0.436785	0.491639	0.456145	0.520034	0.452918	0.489703	0.45517	7 0.502933	0.453241	0.487444	0.451305	0.524874
Samples		0.458081	0.493898	0.461308	0.507773	0.436785	0.491962	0.456145	0.519066	0.452596	0.489703	0.4555	0.50261	0.453564	0.487767	0.451305	0.525197
22600		0.458404	0.493898	0.461631	0.507773	0.436785	0.491639	0.456145	0.519712	0.452918	0.48938	0.45517	7 0.50261	0.452918	0.487122	0.45195	0.524874
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### Data Acquisition Expected Profile





## Continuing Work – IVC Board

Scale: 9 inches



#### Thanks to:

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