MRAM Neutron Accelerated Testing

Testing done at Los Alamos National Labs

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Launched by Motorola
freescale semiconductor

LANL Neutron Beam Overview

LANL Neutron Beam at WNR Facilty

- **Intensity: 100M x Ambient Neutron Flux at Sea Level New York City**
- **Energy Spectrum: Approx 1Mev to 800Mev per neutron**
- **Spectrum is close to Ambient Neutron flux from Sea level up to commercial aircraft altitudes**

Ambient Neutron Spectrum vs WNR Spectrum

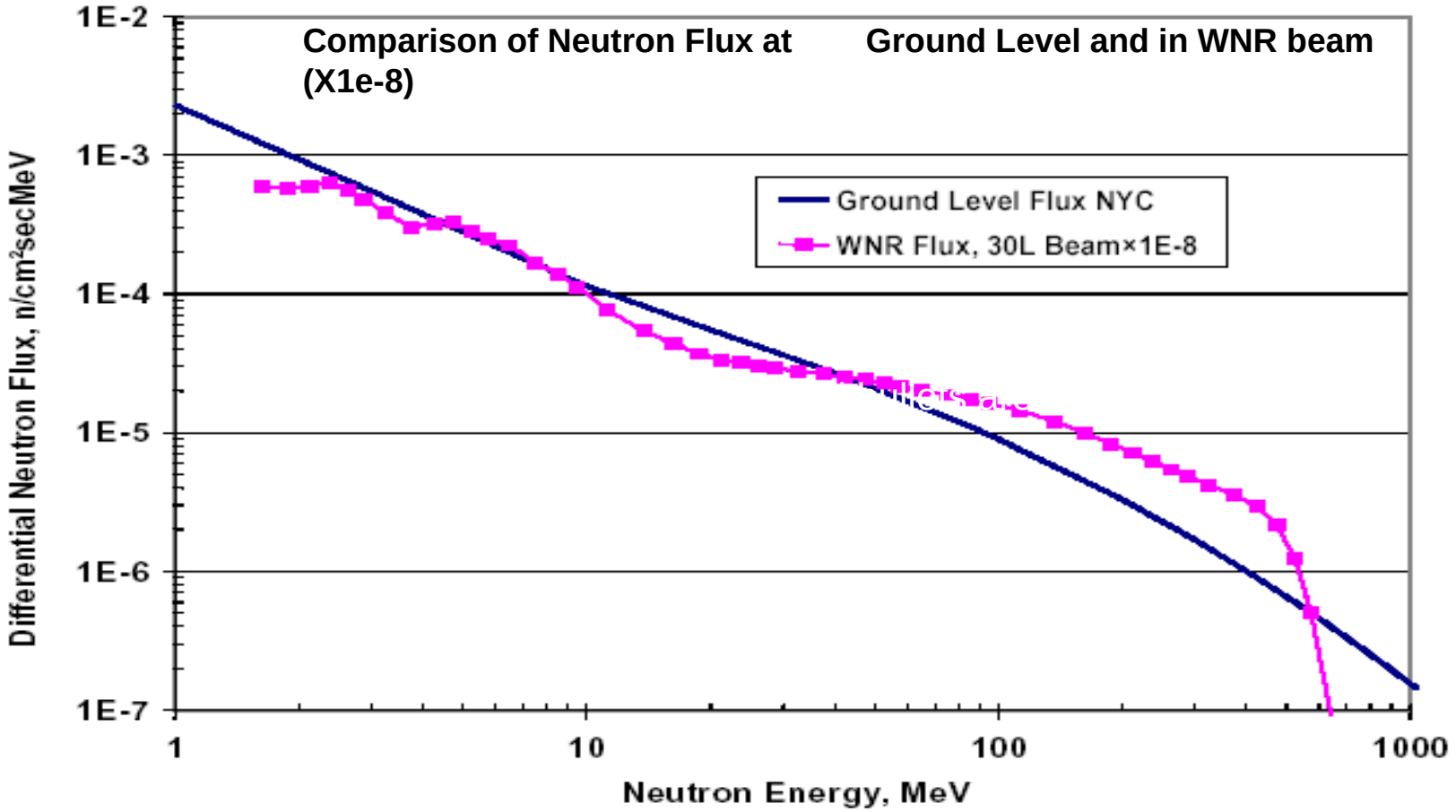


Chart from Los Alamos National Labs

Test Procedure

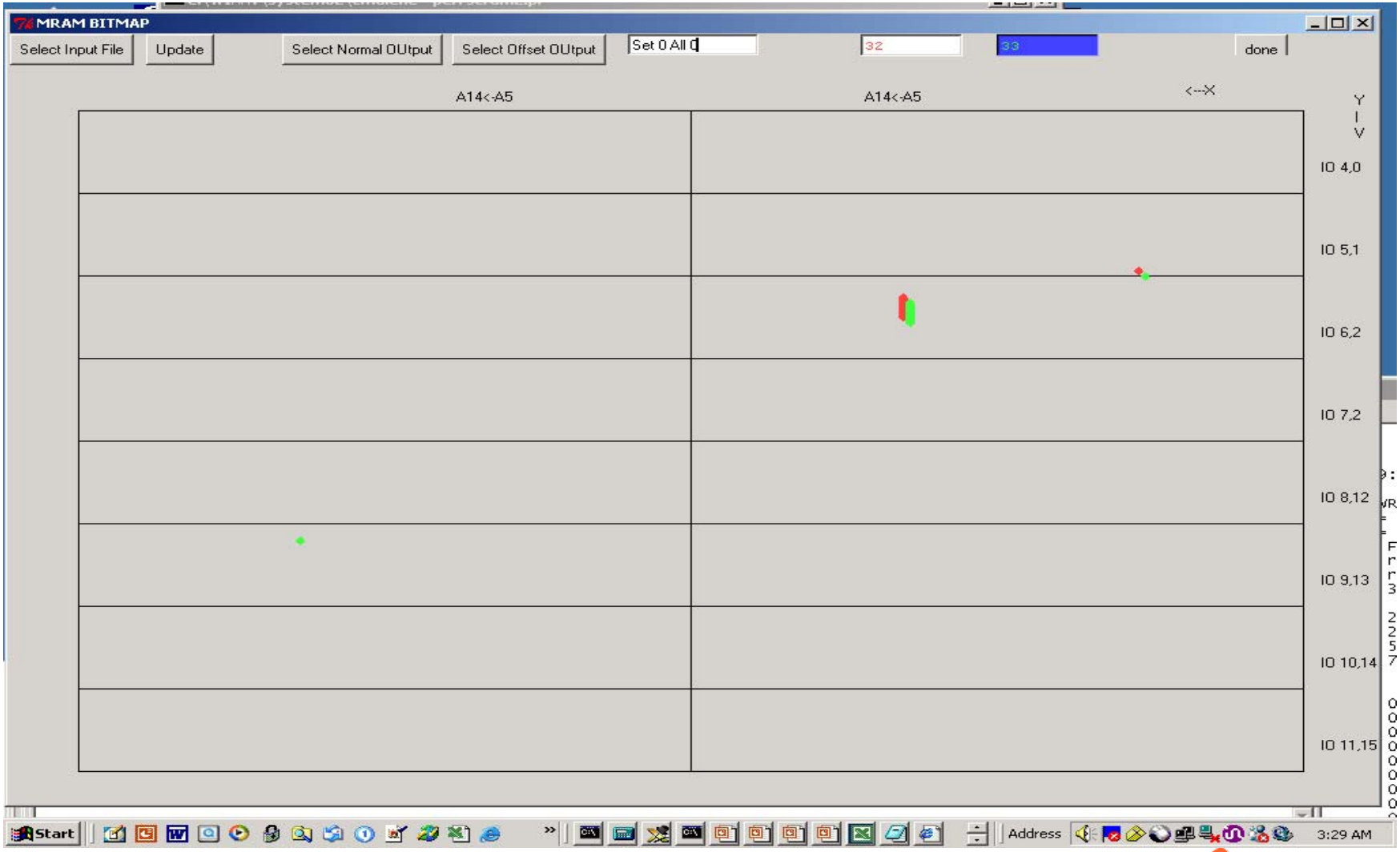
- **Write 8 devices with all ones and 8 devices with all zeroes.**
- **Expose sets of 4 devices with both data states to significantly different doses of neutrons**
- **Maintain 1 set of 4 with both data states as controls.**
- **Capture bit fail before and after beam exposure**
  - Used devices from Lot T38838

Data Summary

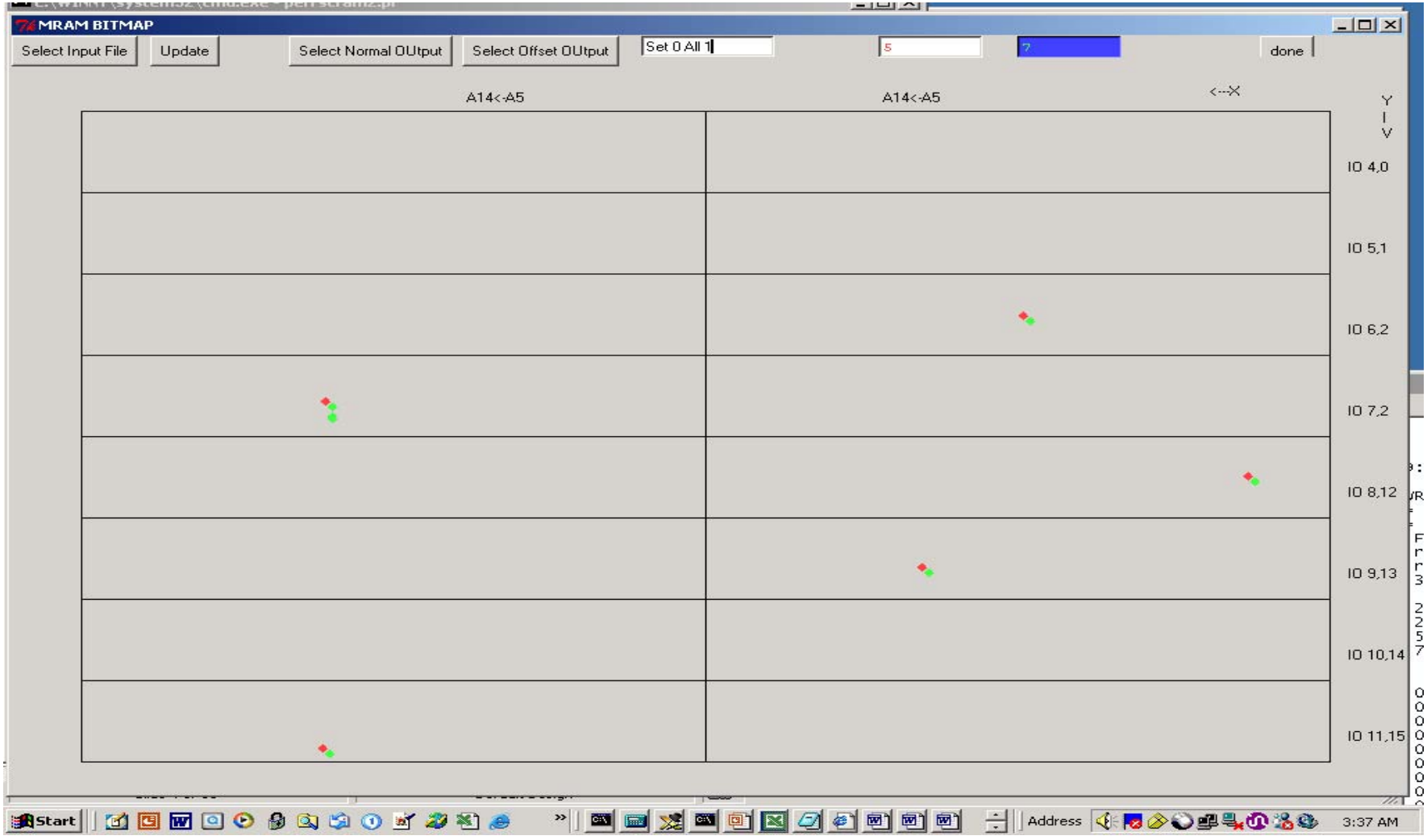
Run		Total Neutrons/cm2 >10Mev	Equivalent Device Hours in NYC	Total bit fails Pre	Total Bit Fails Post
0	Set 0	0		37	40
1.0	Set 1	853075578.5	60933969.89	11	3
2.0	Set 2	851959966.4	60854283.32	8	6
3.0	Set 3				
4.0	Set 3				
5.0	Set 3	14142335140	1010166796	4	3
6.0	Set 4				
7.0	Set 4				
8.0	Set 4				
8.1	Set 4				
9.0	Set 4				
10.0	Set 4				
11.0	Set 4	58341176078	4167226863	0	1

Neutrons are apparently good for MRAM! Worst case provides a FIT rate of no higher than 4.2. Number of fails, however, are too small, and within inherent non repeatability of setup.

Set0 All 0 Pre Post



Set0 All 1 Pre Post



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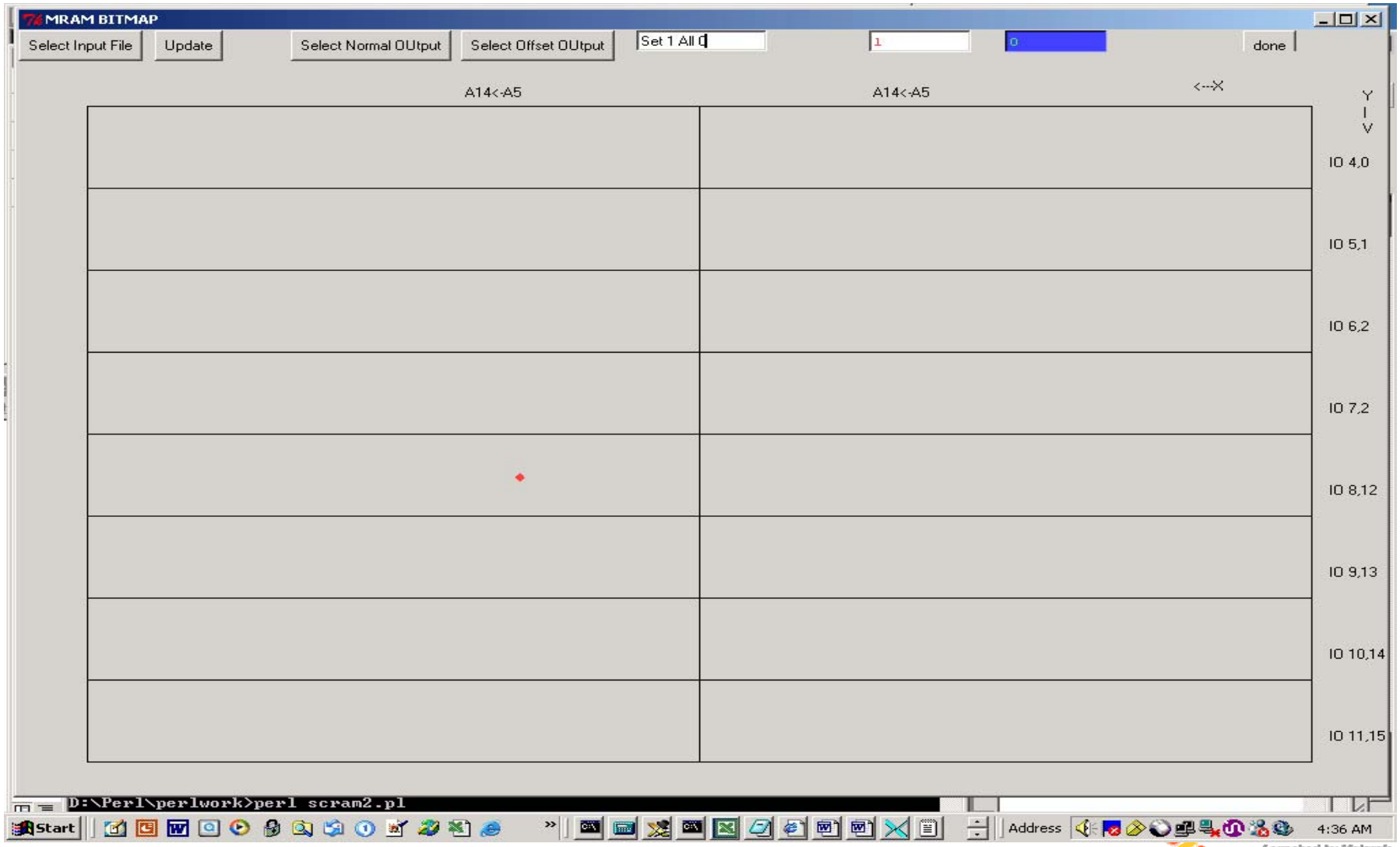
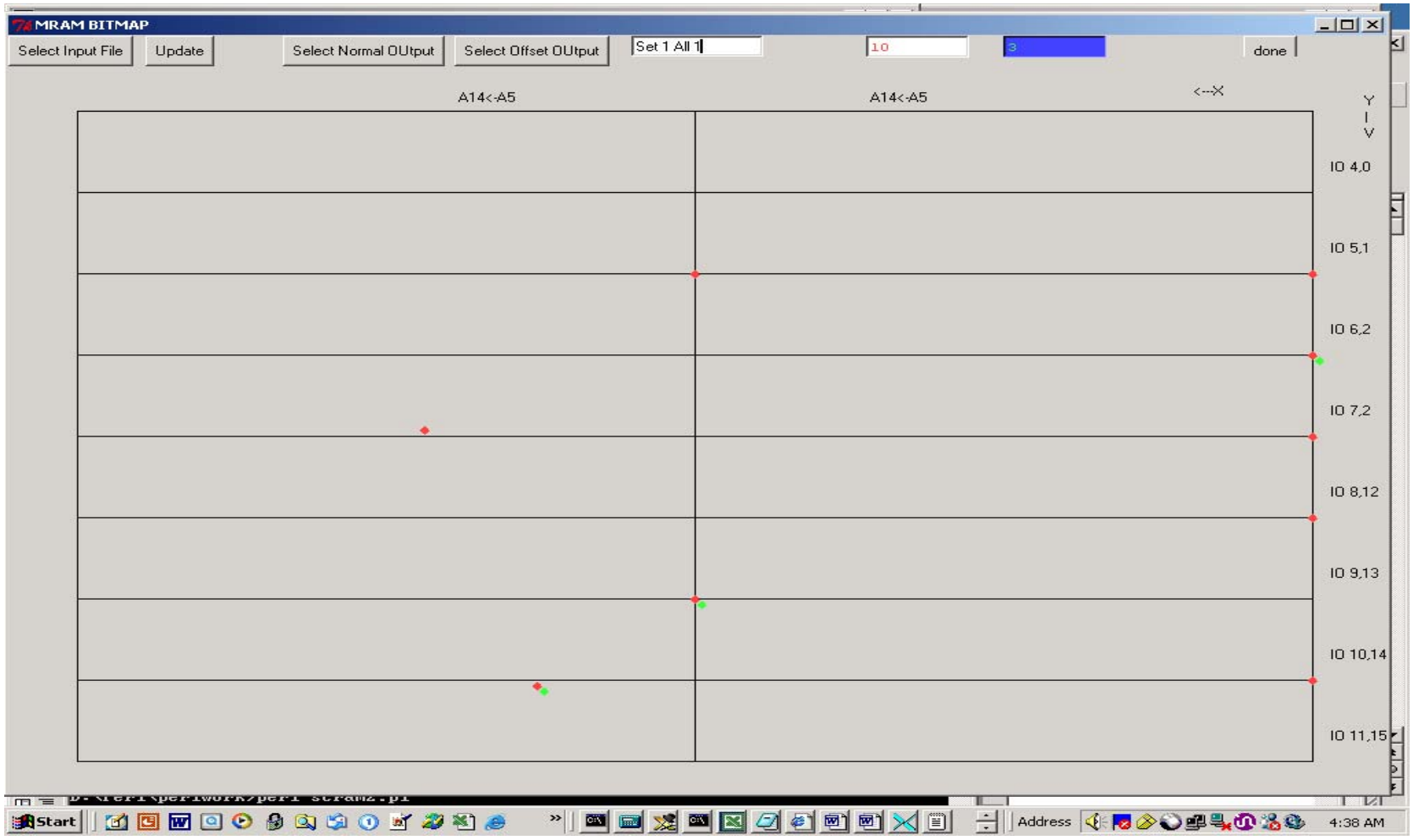
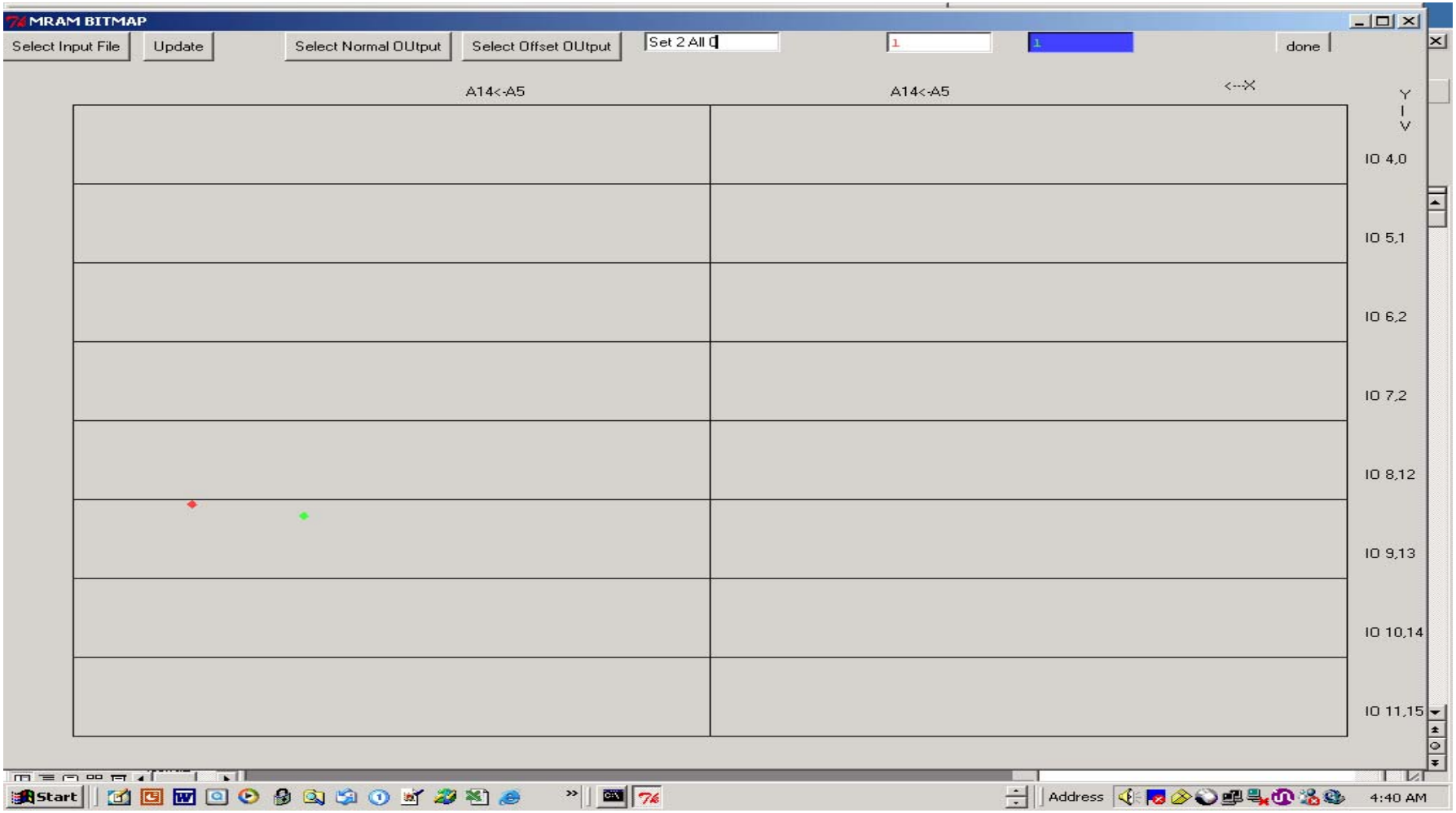


Set1 All 1 Pre Post



Set 2 All 0 Pre Post



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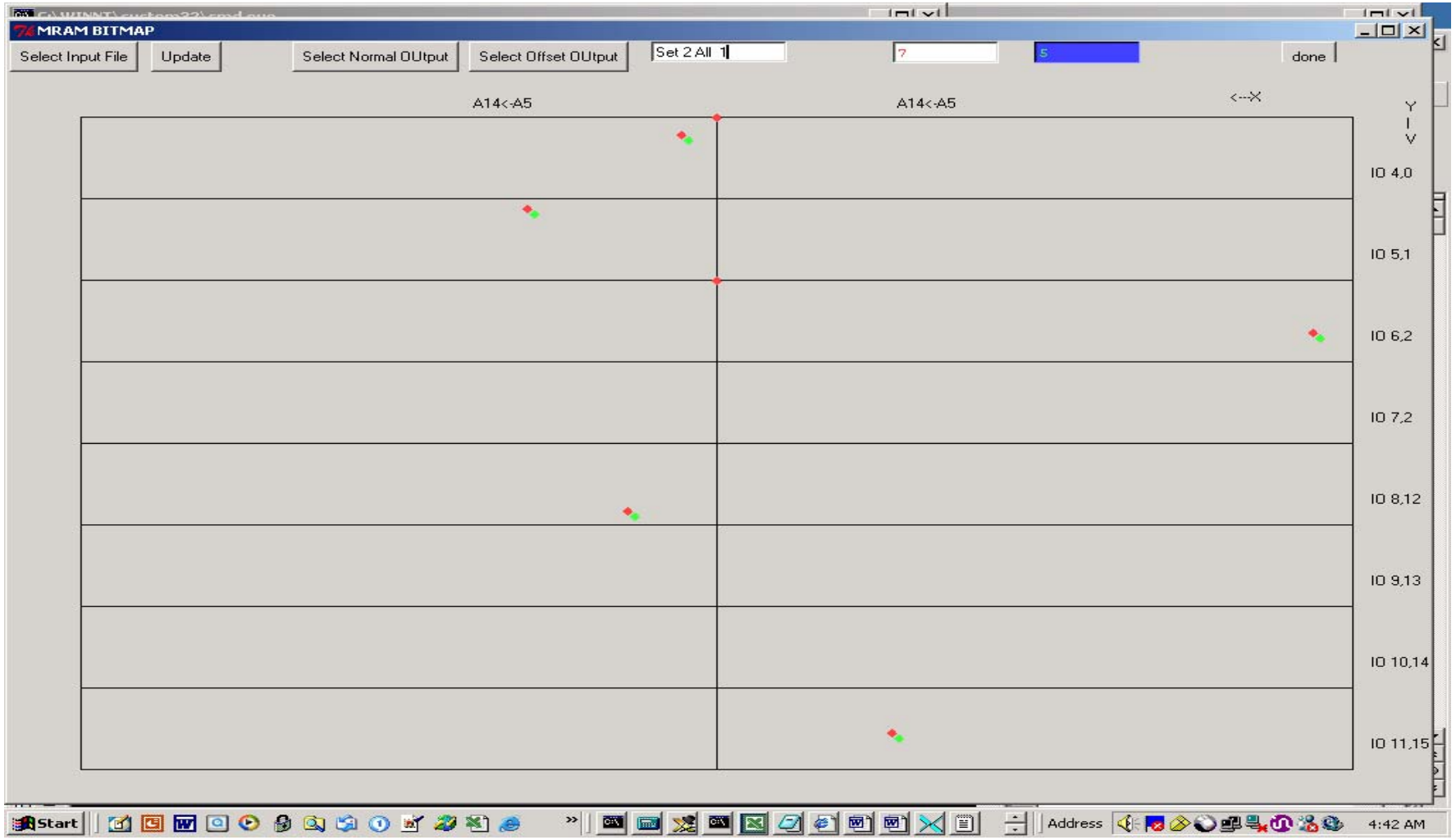
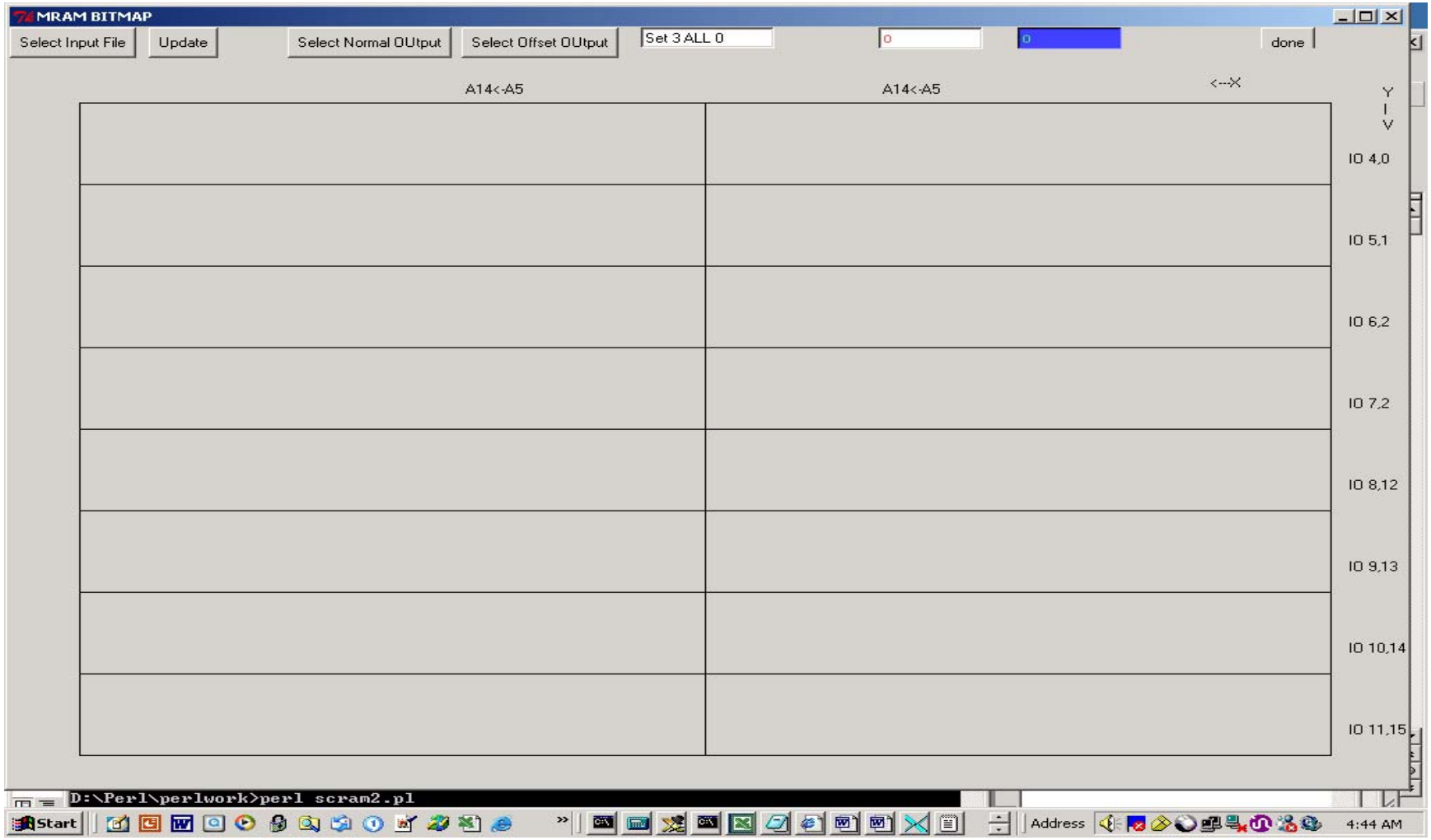
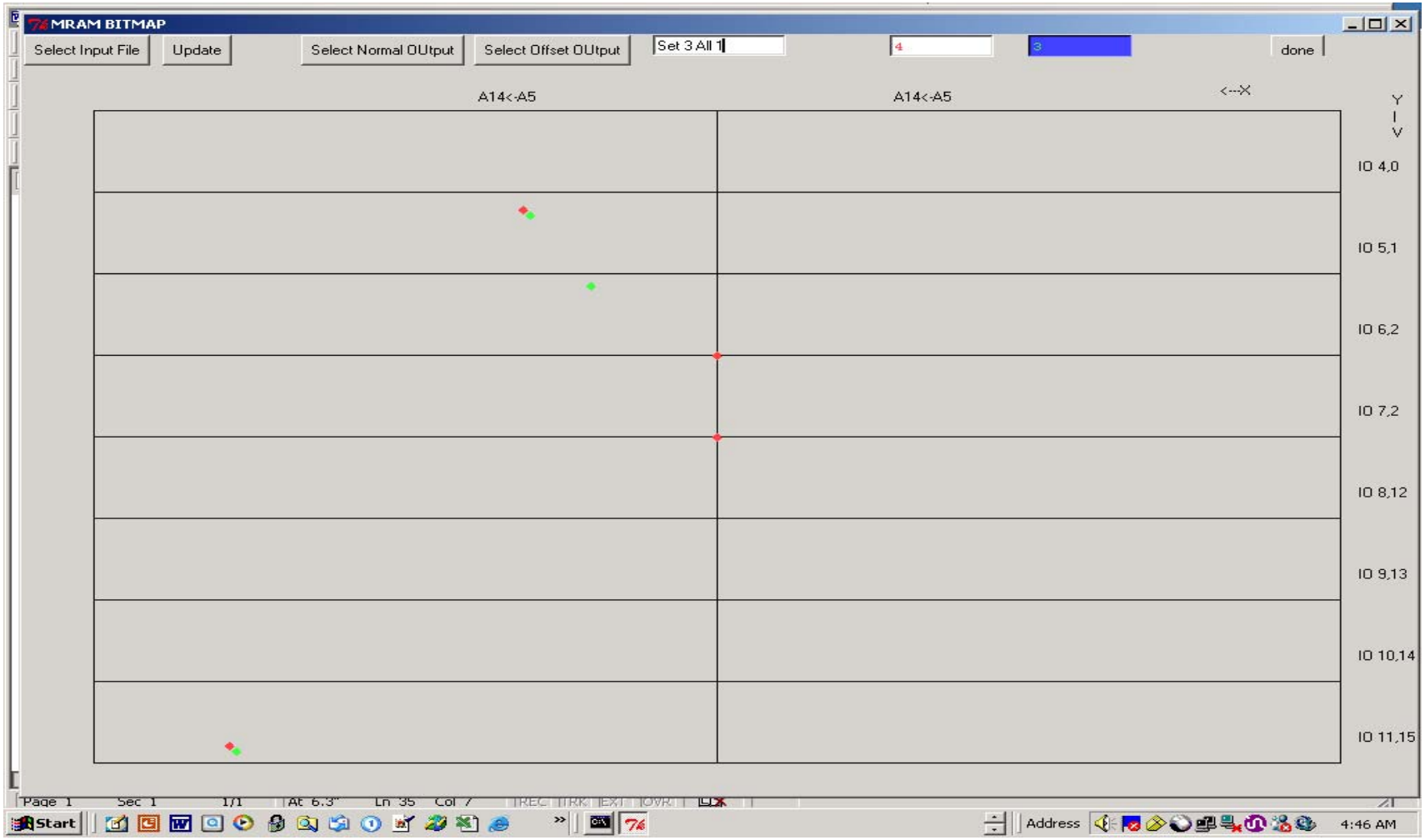


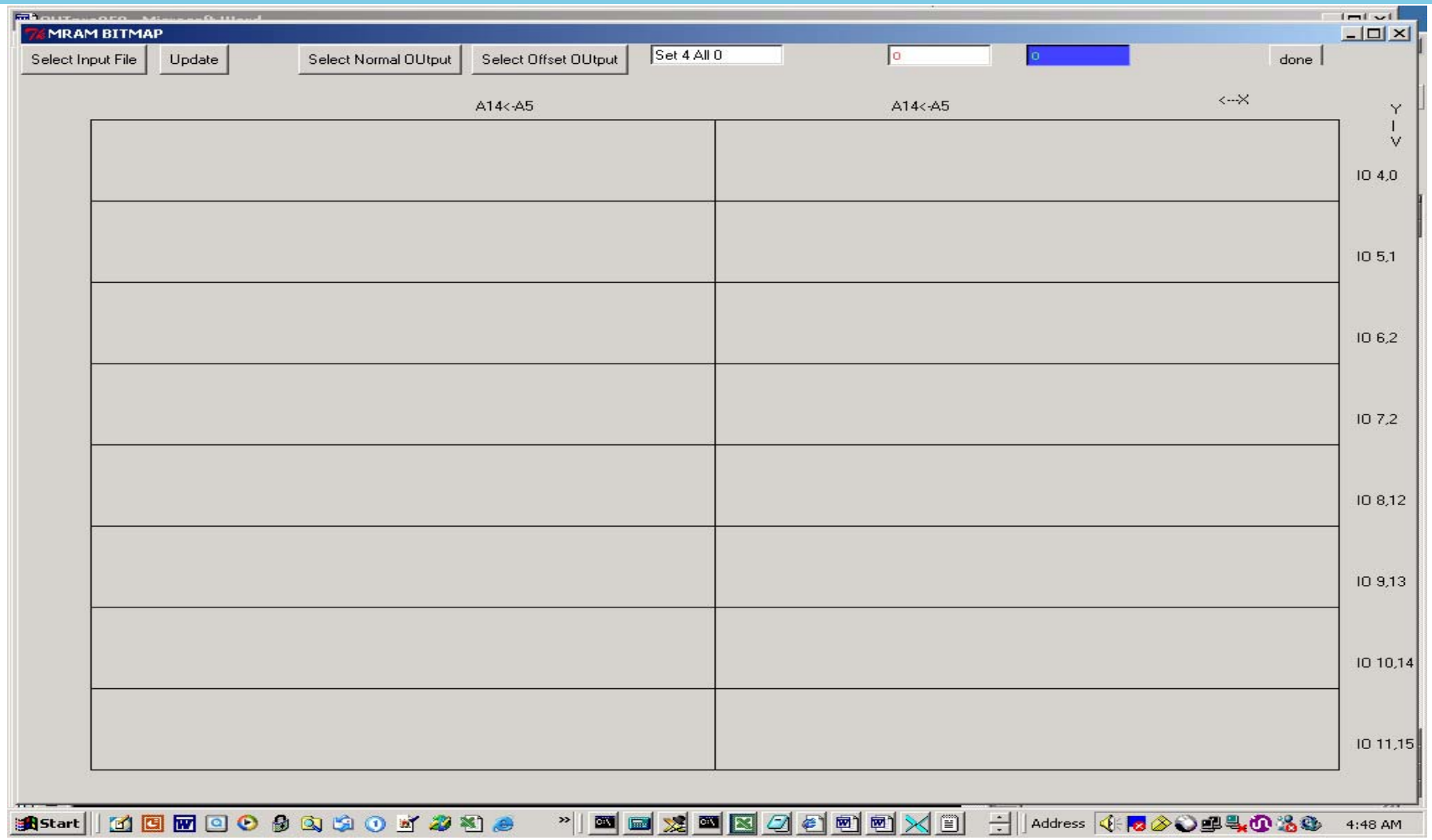
Set 3 All 0 Pre Post



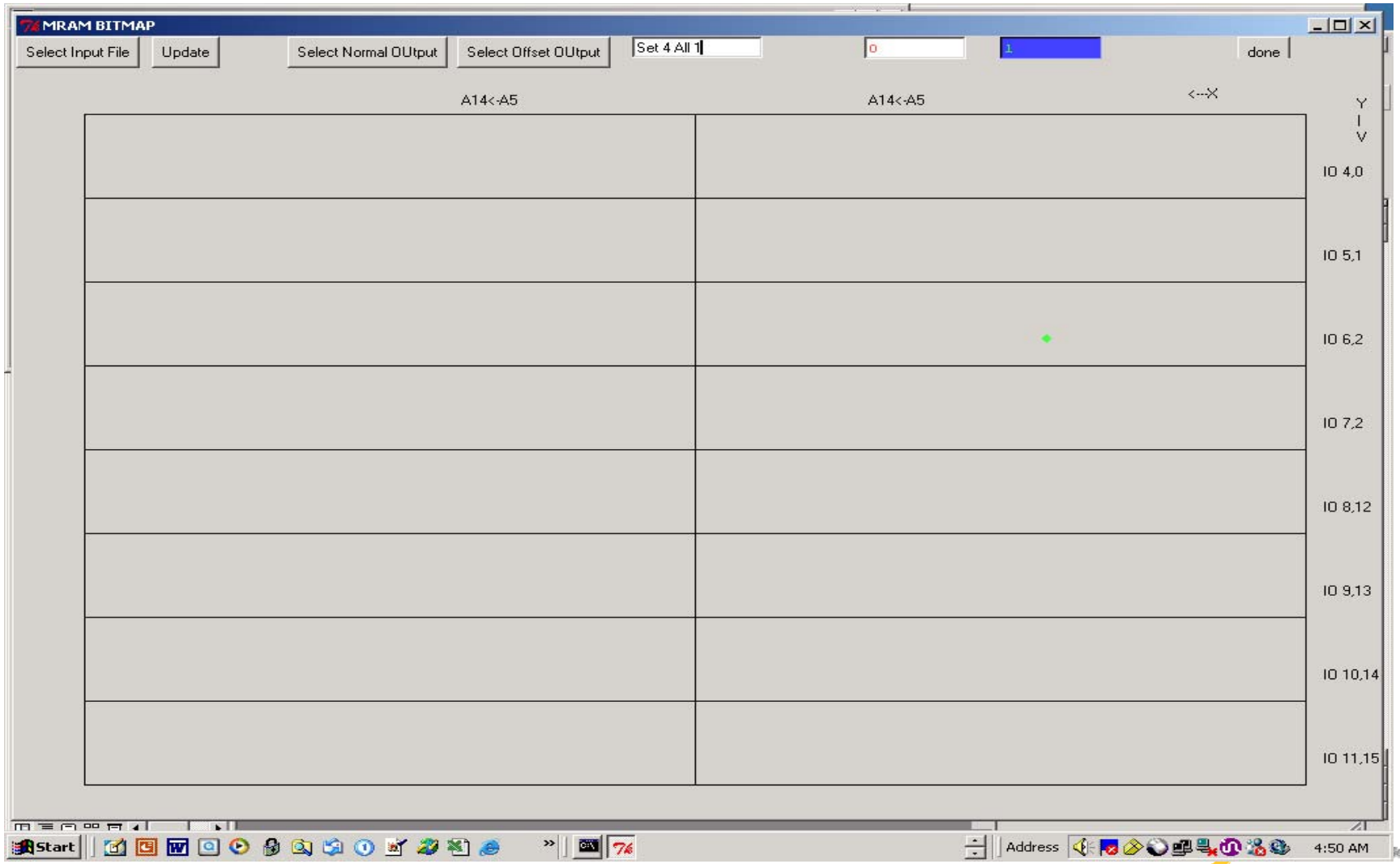
Set 3 All 1 Pre Post



Set 4 All 0 Pre Post



Set 4 All 1 Pre Post



Conclusions

- **MRAM Static SER FIT rate due to neutrons is likely 100's X less than the latest SRAM technologies**
- **To Do:**
  - Characterize dynamic MRAM neutron accelerated SER
  - If MRAM bitcell proves as robust as expected against neutron accelerated soft error, it may be used to characterize transistor technologies in periphery against neutron accelerated dynamic SER
  - MRAM Alpha accelerated soft error needs verification.