Lessons in Programming and Reliability

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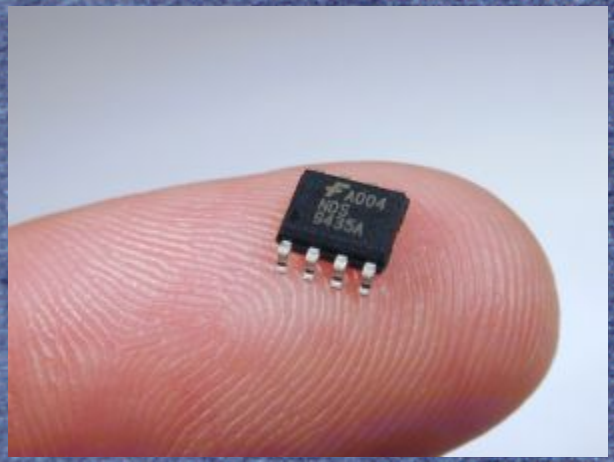
Massively Parallel Semiconductor Test System

Nano-electronics

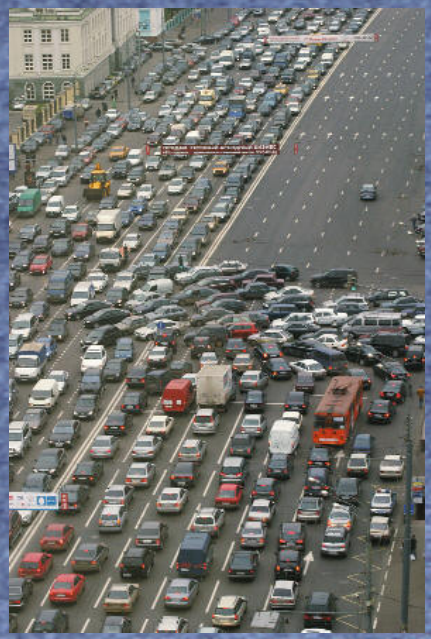


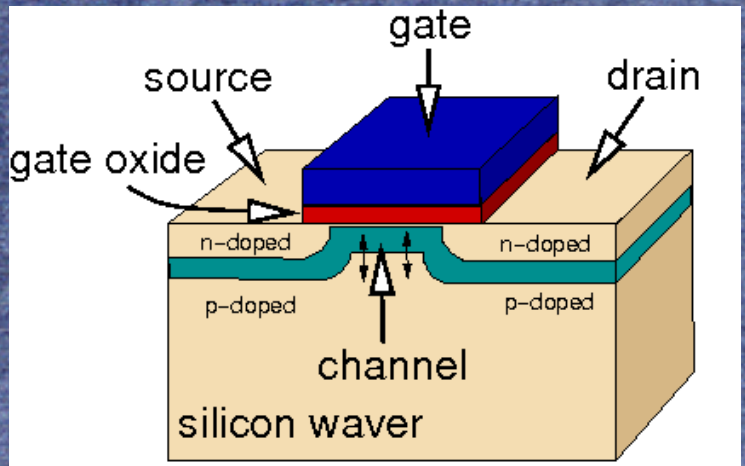
Transistors and Defects

All modern electronics are based on the transistor. Think of a transistor like an electronic switch – it's either open or closed.

Defects can arise in transistors – broken bonds or improperly excited electrons – eventually leading to the transistor breaking down.

Modern day transistors can be as few as 50 atoms across – meaning that one broken bond, a single defect, can cause huge fluxuations.



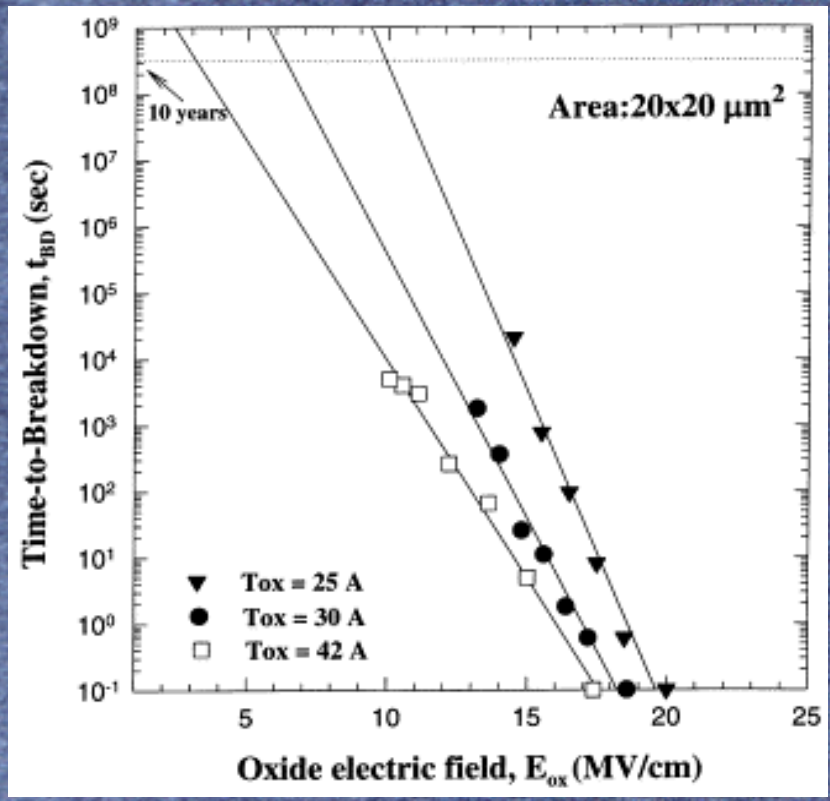


Metal–Oxide Field–Effect Transistor (MOSFET)

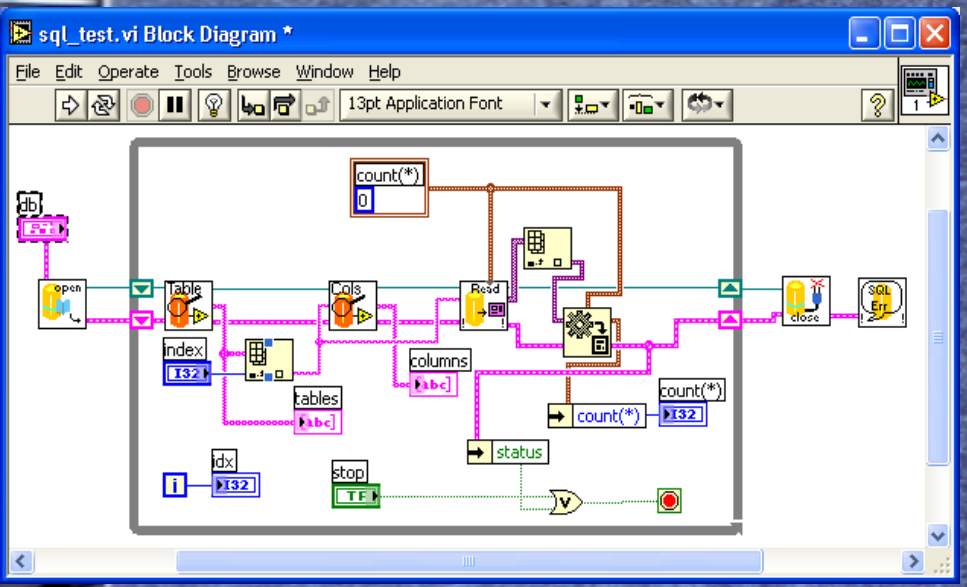
Reliability Testing

We need to know how long these transistors are going to last.

We don't want to plug it in and wait 10 years for it to malfunction, so NIST is doing accelerated long term testing. We run the transistors at high stresses – voltage and temperature – and extrapolate the lifetime at the use voltage.



Labview vs Scripting Languages

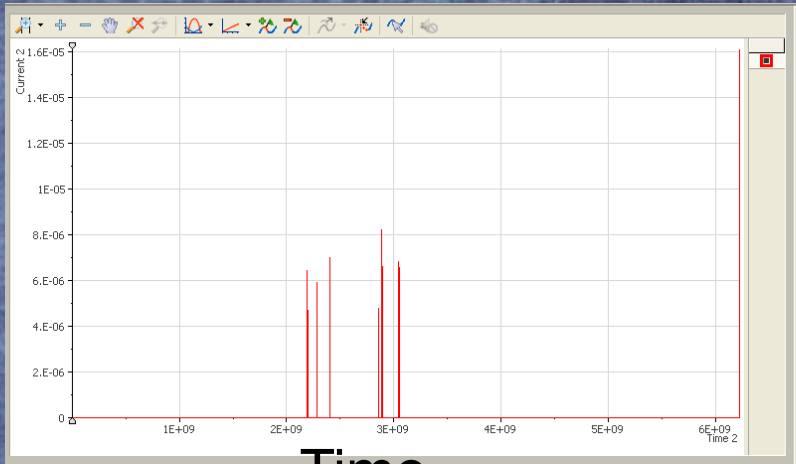


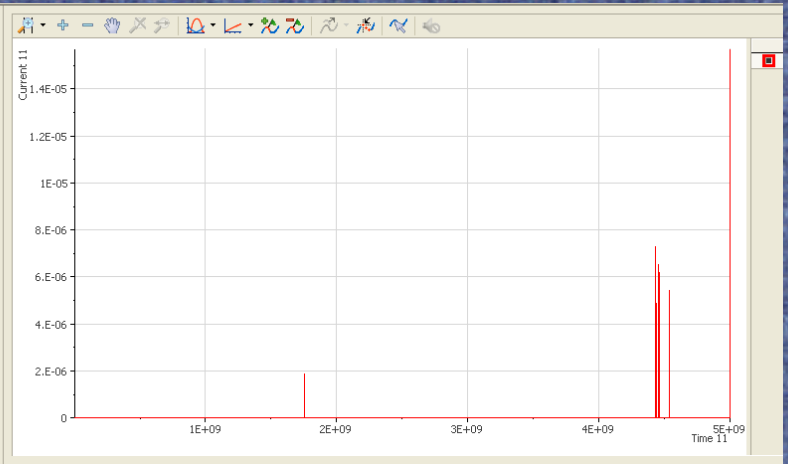

```
BOOL CMymfc29BAuto::DisplayDialog()
{
    // TODO: Add your dispatch handler code here
    TRACE("Entering CMymfc29BAuto::DisplayDialog %p\n", this);
    BOOL bRet = TRUE;
    AfxLockTempMaps();  // See MFC Tech Note #3
    CWnd* pTopWnd = CWnd::FromHandle(::GetTopWindow(NULL));
    try
    {
        CPromptDlg dlg /*(pTopWnd)*/;
        if (m_vaTextData.vt == VT_BSTR)
        {
            // converts double-byte character to single-byte character
            dlg.m_strData = m_vaTextData.bstrVal;
        }
        dlg.m_lData = m_lData;
        if (dlg.DoModal() == IDOK)
        {
            m_vaTextData = COleVariant(dlg.m_strData).Detach();
            m_lData = dlg.m_lData;
            bRet = TRUE;
        }
        else
        {
            bRet =  FALSE;
        }
    }
    catch (CException* pe)
    {
        TRACE("Exception: failure to display dialog\n");
        bRet =  FALSE;
        pe->Delete();
    }
    AfxUnlockTempMaps();
    return bRet;
}
```

When you know nothing about computer science, labview is easier to muddle through than other programming languages.

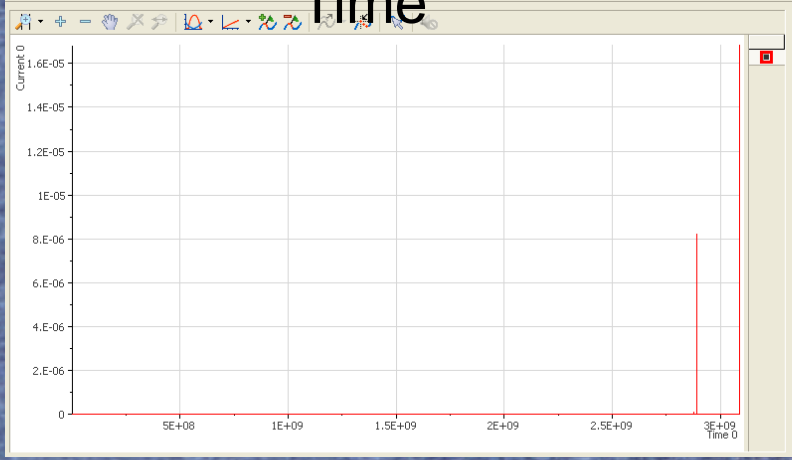
Data Processing

Voltage





Time

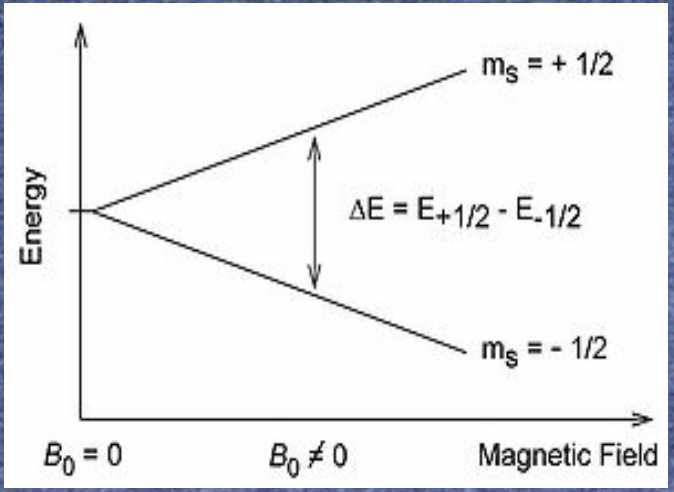


Selected Ch...

Name	Time 2	Current 2	Current 0	Current 11
Number	7	9	3	36
Length	6220342	6220342	3088093	5000888
Unit				
Channel Contents				
1	1203	-5.73667272727...	-2.22162727272...	-1.00352727272...
2	2078	-5.61041818181...	1.609327272727...	-1.01219090909...
3	3078	-5.68140909090...	2.384181818181...	-9.27127272727...
4	4078	-5.67978181818...	1.479281818181...	-1.06259090909...
5	5078	-5.75835454545...	3.489581818181...	-8.40967272727...
6	6078	-5.64943636363...	2.909790909090...	-8.99488181818...
7	7078	-5.72691818181...	2.519654545454...	-8.27420909090...
8	8078	-5.62721818181...	2.758072727272...	-9.41209090909...
9	9078	-5.66244545454...	2.519654545454...	-7.64022727272...
10	10078	-5.87051818181...	1.793554545454...	-8.7077E-10
11	11094	-5.66623636363...	3.489581818181...	-7.14171818181...
12	12078	-5.94366363636...	2.926045454545...	-8.03037272727...
13	13078	-5.74318181818...	3.906809090909...	-6.59444545454...
14	14078	-5.80224545454...	8.886509090909...	-8.95695454545...
15	15078	-5.81416363636...	3.1157E-10	-6.26932727272...
16	16078	-5.81958181818...	3.4083E-10	-9.17372727272...
17	17078	-5.93011818181...	2.0103E-10	-6.88162727272...
18	18094	-5.69278181818...	1.381745454545...	-7.73776363636...
19	19094	-5.96913636363...	3.982672727272...	-7.88407272727...
20	20094	-5.80224545454...	2.703881818181...	-8.20376363636...
21	21078	-5.79844545454...	8.290463636363...	-9.65590909090...
22	22094	-5.78436363636...	4.334881818181...	-5.83041818181...
23	23078	-5.82011818181...	6.556509090909...	-9.18990909090...

Each graph represents four and a half months of data, with one data point taken every second. This means there are about 10,000,000 data points plotted here.

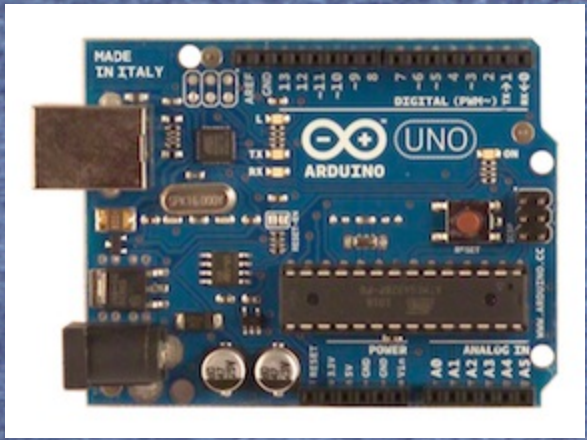
Electron Spin Resonance



We can use high-definition ESR to find the identity and position of individual defects, on the atomic scale. Normally, ESR could only be used to look at defects on the scale of 10^12.

Because it is so precise and accurate, it needs a very tightly controlled voltage.

Digital to Analog Converter

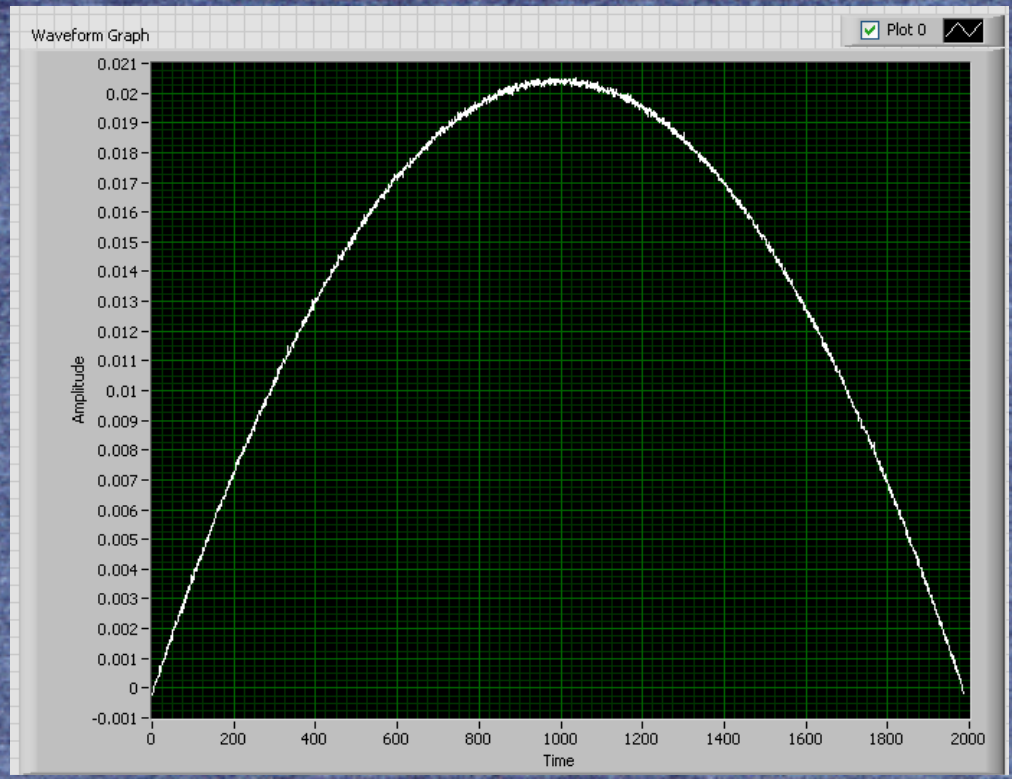


An 18 bit DAC divides the voltage range into 2^18 segments. As our voltage range was -10V to 5V, the step size for the DAC was 15V/2^18, or about 57 microvolts.

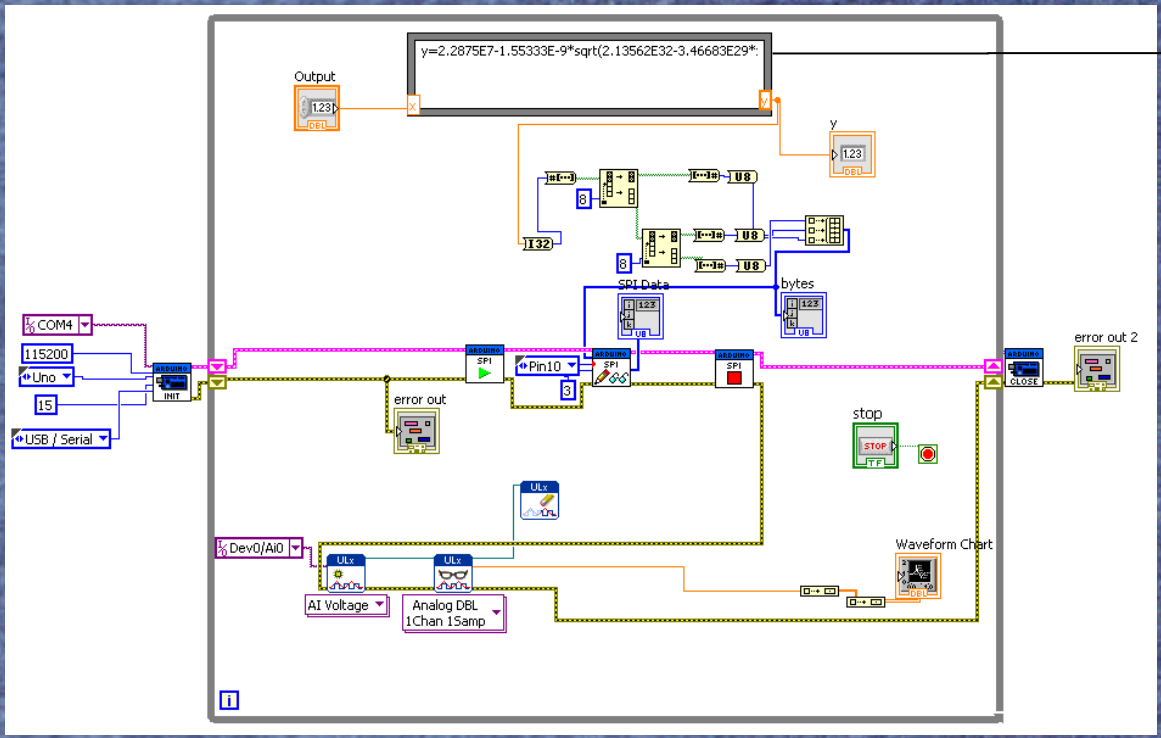
My job was to get the computer to successfully talk with the DAC, and ensure its accuracy.

Difficulties

- Noise can come from anywhere, so it's often difficult to identify the problem.
- Problems I have faced working on the DAC include:
- Interface firmware
- Software
- Program I designed
- Hardware
- Wiring
- Voltage Source

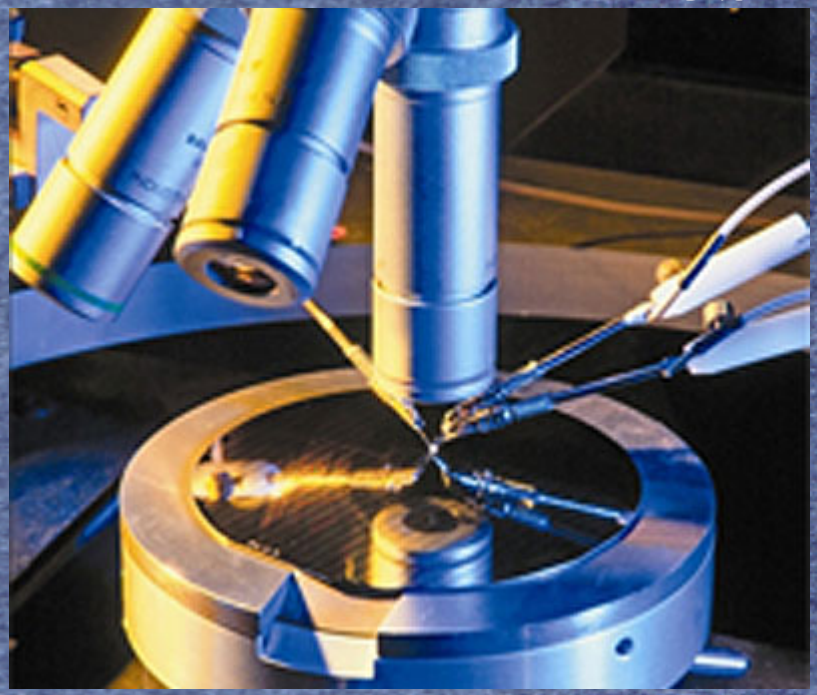


Programming



This is the equation converting the value we want into a number the DAC can read.

Massively Parallel Semiconductor Test System



NIST is working on a system that would be able to run thousands of tests simultaneously – it would use electronics designed and built at NIST and they can process the data using the software and techniques I discovered.

Acknowledgments

NIST

John Suele

Charles Cheung

Zakarie Chbili

Kevin Terrant

AIP

Fellow Interns