A Web Service and Interface for Electronic Device Characterization

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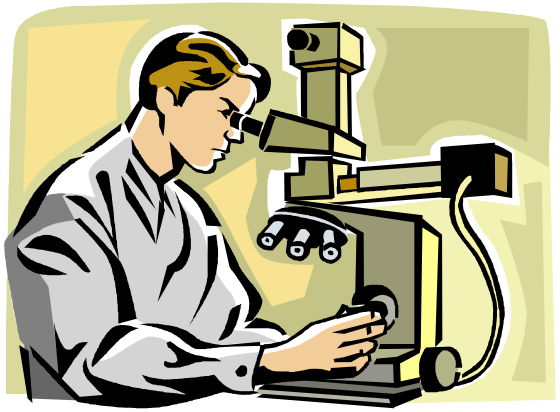
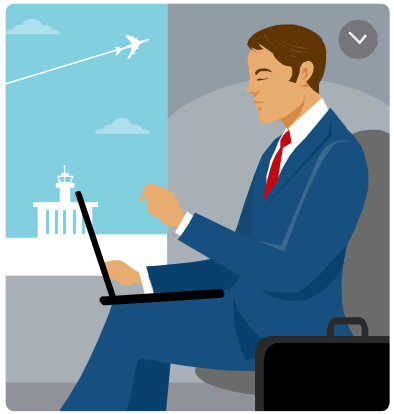
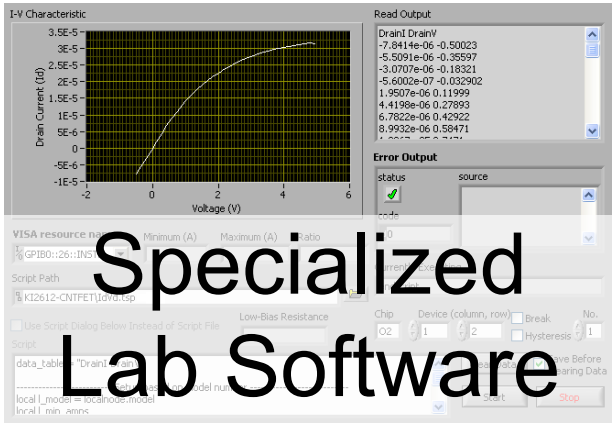
Session 2232

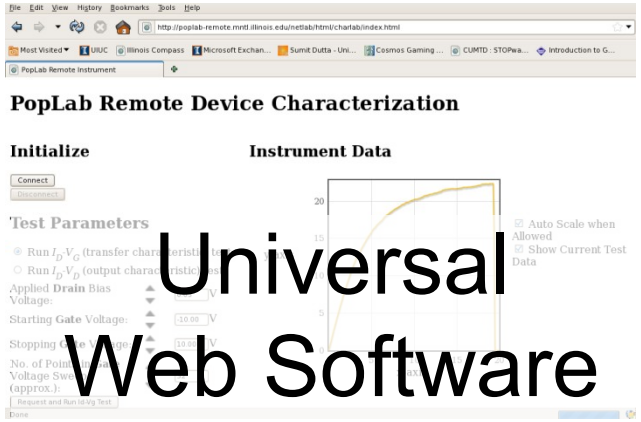
Labs for Everyone







Specialized Lab Software



Universal Web Software

The Theory Course Dilemma

- Large enrollment often
- Lab course challenging to set up
  - Facilities → expensive (>$100k)
  - Instructors → limited
- Consequence: exclusive focus on theory
- Solution:
  - "Lightweight" web interfaces for lab instruments
  - Use existing instructional or research lab

Outline and Objectives

- Goal: Lab exposure in theory classes
- Enabling virtual test and measurement with Web Services
- Creating Web interfaces for students
- Suggestions based on application in solid-state electronics course

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Web Service and Interface

Backend

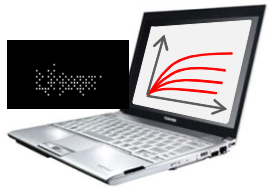
Device Under Test (DUT)

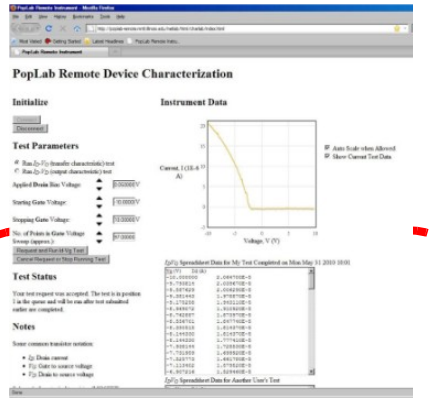
Keithley 2612
Source-Measurement Unit

GPIB
USB
IEEE-488 (GPIB)

LabView 8.6 Web Service
Server

Frontend



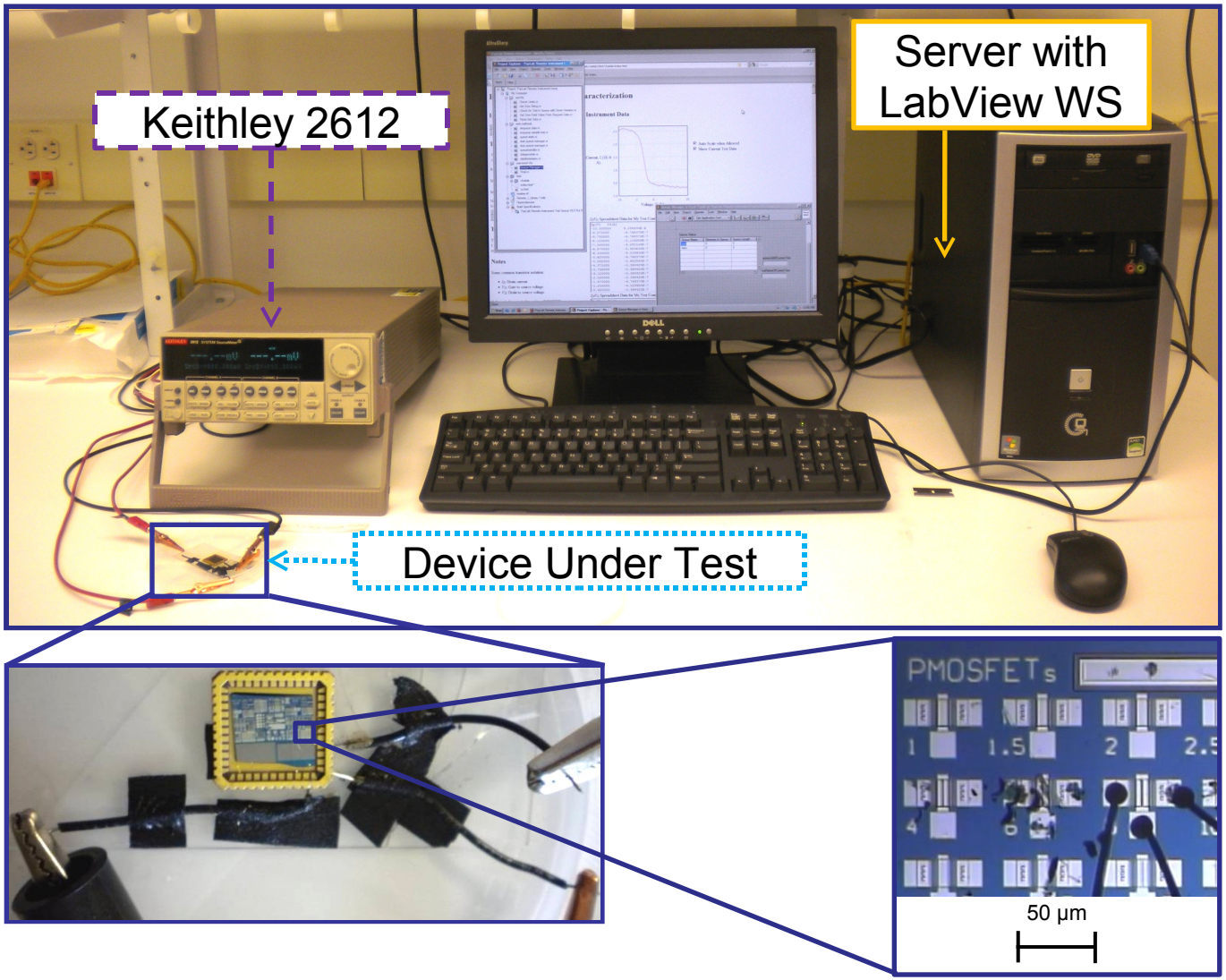


HTTP GET

XML

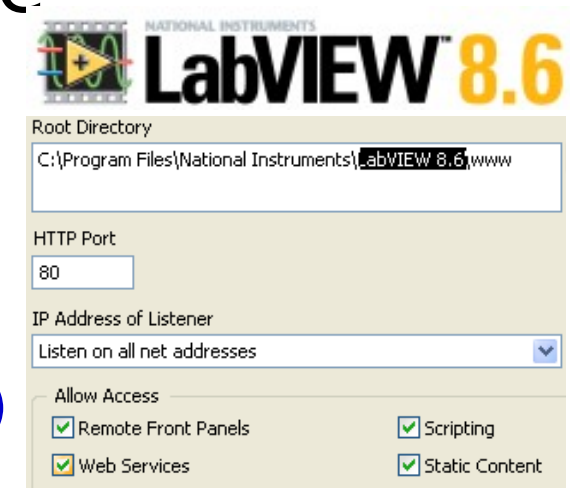
Website
(AJAX client)

Lab Setup


Keithley 2612
Server with LabView WS
Device Under Test
PMOSFETs
50 µm

LabView Web Service Requests

- Client-activated session management
  - Data Provider (connect/disconnect)
- Client-activated test queue
  - Queue Handler (test submission/canceling)
- Internal process
  - Queue Manager (dequeue tests)
  - Instrument Control (driver)



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Lightweight Messaging & Interface

- Consume ReSTful Web Service
  - User requests by HTTP GET
  - LabView response in XML
- AJAX used for underlying messaging
  - All tasks accomplished with mouse clicks
  - Plot continuously refreshes itself with data from instrument's currently running test

Stability of Technologies

- Web Service
  - XML understood on virtually all platforms
- Website interface
  - AJAX conducive to Web Services support
- Many other possible interfaces
  - Java applets
  - iPhone app
  - Application extensions

PopLab Remote Instrument - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://poplab-remote.mntl.illinois.edu/netlab/html/charlab/index.html

Most Visited Getting Started Latest Headlines PopLab Remote Instru...

PopLab Remote Instrument

PopLab Remote Device Characterization

Initialize

Connect
Disconnect

Test Parameters

Run I_D-V_G (transfer characteristic) test
Run I_D-V_D (output characteristic) test

Applied **Drain** Bias Voltage: 0.050000 V

Starting **Gate** Voltage: -10.0000 V

Stopping **Gate** Voltage: 10.00000 V

No. of Points in **Gate** Voltage Sweep (approx.): 97.00000

Request and Run Id-Vg Test
Cancel Request or Stop Running Test

Test Status

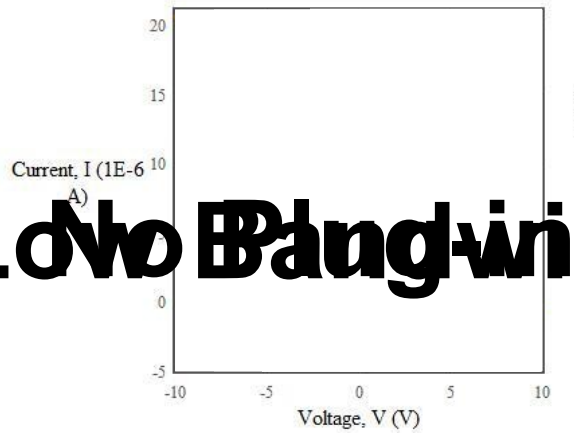
Your test request was accepted. The test is in position 1 in the queue and will be run after test submitted earlier are completed.

Notes

Some common transistor notation:

- I_D: Drain current
- V_G: Gate to source voltage
- V_D: Drain to source voltage

Instrument Data



Auto Scale when Allowed
Show Current Test Data

Low Bandwidth!

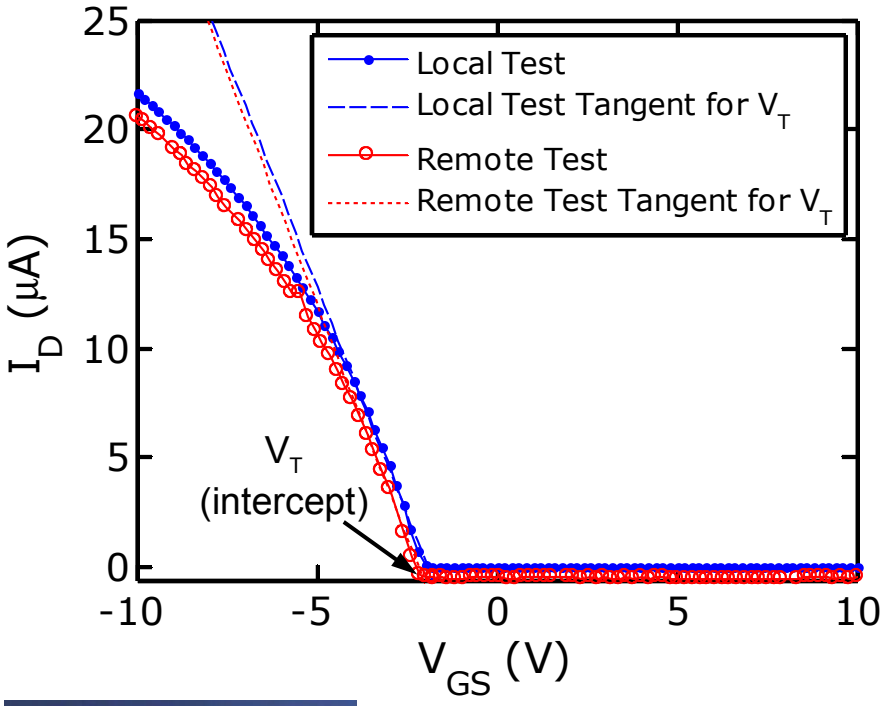
I_DV_G Spreadsheet Data for My Test Completed on Mon May 31 2010 10:01

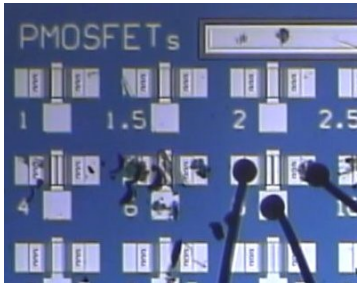
Vg (V)	Id (A)

Done

Data Quality

- 500+ bytes per data packet
- Data acquisition rate within 10 Hz
- Rate adjustable for desired measurement sensitivity





Local test V_T = -1.92 V

Remote test V_T = -2.18 V

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File Edit View History Bookmarks Tools Help

http://poplab.ece.uiuc.edu/440labtest.html

Wikipedia (en)

ACS Nano APL IEEE EDL IEEE TED Latest Headlines Nano Letters Nanotechnology Science

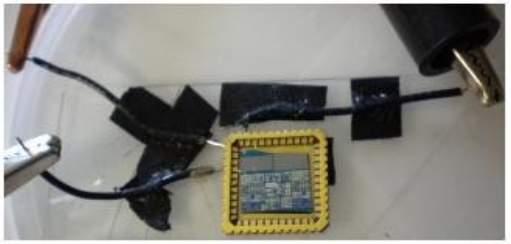
Online Real Time MOSFET Measur... | PopLab Remote Instrument | Online Real Time MOSFET Measure...

Online Real Time MOSFET Measurements in ECE 440

Websites Used

1. PopLab Remote Instrument
2. Answer Submission Survey

Instructions



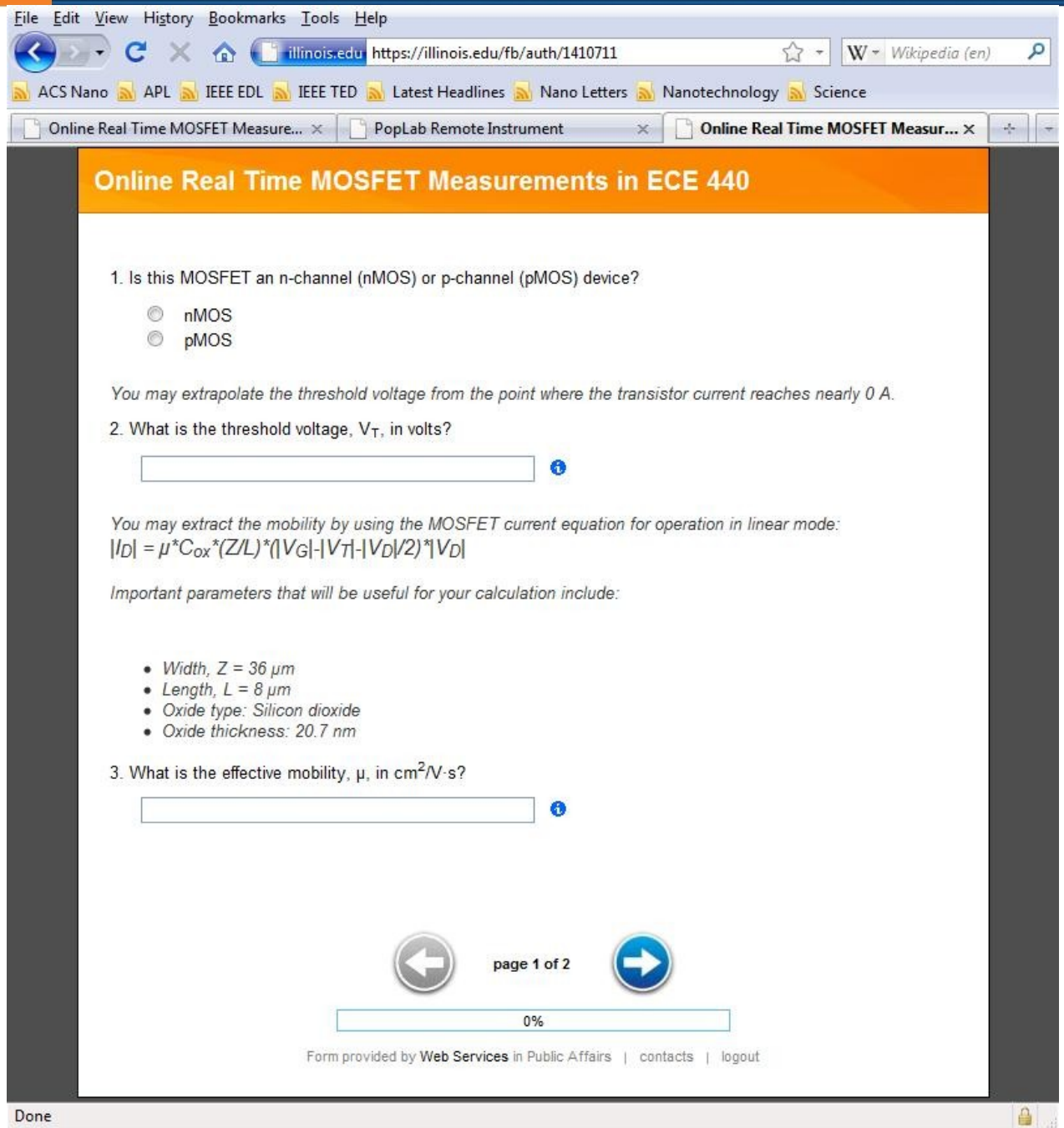
You will perform measurements on a MOSFET located in the Pop Lab.

1. If you are off-campus, first connect to the U of I network using VPN.
2. Open the PopLab Remote Instrument (opens in a new window).
3. Click "Connect."
4. Choose the I_D-V_G test.
5. Set V_D = 0.05 V and V_G to go between -10 V to 10 V.
6. Ask for about 30-60 data points (you may get fewer).
7. Once ready, click to "Request and Run" the test (test will take ~30 seconds).
8. Copy/paste the raw data output to a spreadsheet or text file for further analysis.
9. Click "Disconnect."
10. Please fill out the answer survey (opens in a new window).

Notes on using the interface:

- You will only see data if you are connected (be sure to click "Connect"). If another user is connected, you will see his or her test running and then your test will run. Your tests will generally be labeled as "My Test," though in some browsers your test might get misidentified as someone else's, in which case you should identify your test based on when the results appear.
- If I_D goes below zero, you may take those values to be zero.
- On rare occasions the first point in the test will actually be from the previous test due to a glitch in the instrument. Please disregard any unusual first points.
- You may receive fewer points back than requested depending on the latency of your connection. Try requesting at least double the points you really need to get all data.
- If you have questions please contact sdutta3@illinois.edu.

Done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https://illinois.edu/fb/auth/1410711
Wikipedia (en)
ACS Nano APL IEEE EDL IEEE TED Latest Headlines Nano Letters Nanotechnology Science
Online Real Time MOSFET Measure...
PopLab Remote Instrument
Online Real Time MOSFET Measur...
Online Real Time MOSFET Measurements in ECE 440
1. Is this MOSFET an n-channel (nMOS) or p-channel (pMOS) device?
nMOS
pMOS
You may extrapolate the threshold voltage from the point where the transistor current reaches nearly 0 A.
2. What is the threshold voltage, V_T, in volts?
You may extract the mobility by using the MOSFET current equation for operation in linear mode:
$|I_D| = \mu * C_{ox} * (Z/L) * (|V_G| - |V_T| - |V_D|/2) * |V_D|$
Important parameters that will be useful for your calculation include:
Width, Z = 36 μm
Length, L = 8 μm
Oxide type: Silicon dioxide
Oxide thickness: 20.7 nm
3. What is the effective mobility, μ, in $cm^2/V \cdot s$?
page 1 of 2
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Form provided by Web Services in Public Affairs | contacts | logout
Done

Feedback & Integration into Courses

- Highest impact in theoretical classes
  - Complements curriculum, does not replace it
  - Instructional lab classes still valuable
- Different instruments/tests in Web Service
- Different interface for each audience
- Assign a test and data analysis problem for each topic, before exam

Conclusions and Direction

- Low-bandwidth, real-time lab measurements with Web Services
- Introduce as ancillary, new aspect of theoretical classes
- Flexible and reusable
- Could further standardize
  - Web Services Resource Framework

Download It!

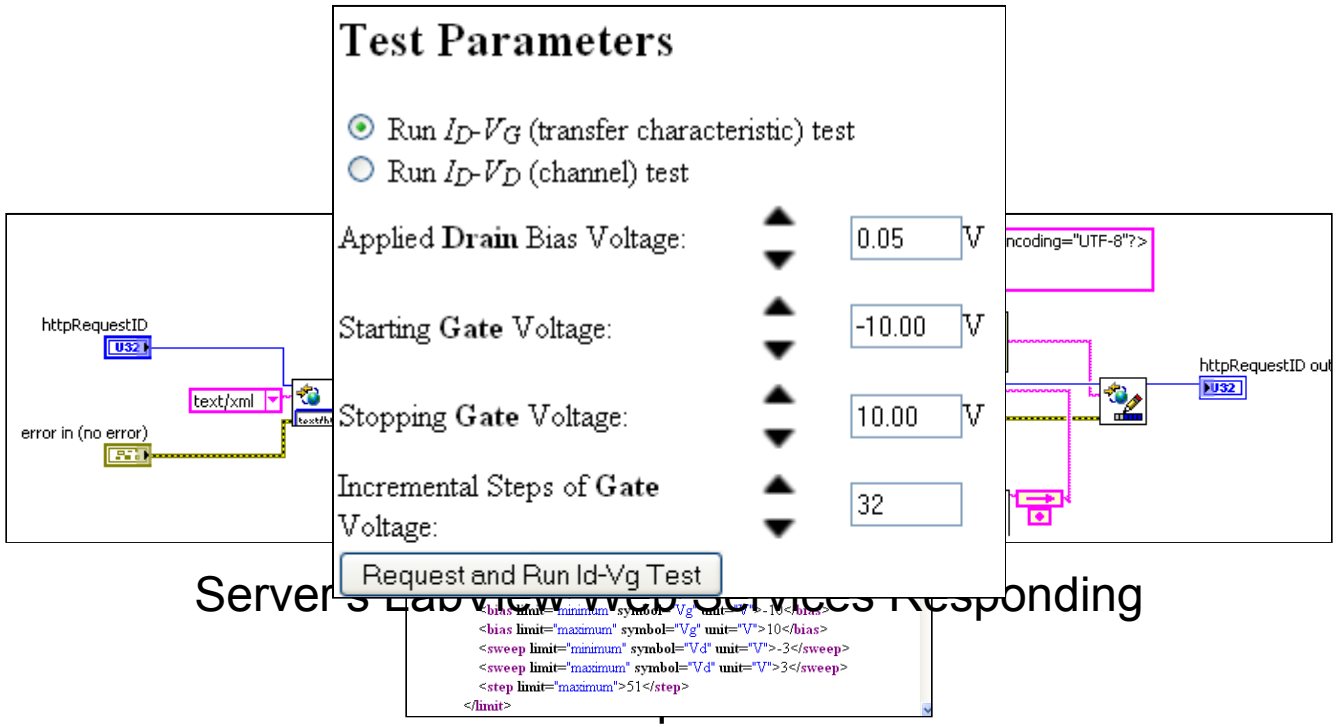
- Remote Lab Web Services
  http://remotelab.sourceforge.net

Our Implementation Uses:
- LabView 8.6 software
- Keithley 2612 hardware

Acknowledgments

- Mark Bohr at Intel for hardware donation
- Dr. J. C. Lee for LabView assistance
- Josh Potts and Jeremy Bird for IT support
- NSF CCF-0829907 and CAREER ECCS-0954423

Web Technology Illustrated



Server's LabVIEW Web Services Responding

Response Sent to Client,
Interpreted by Client