



# Smart Battery Compliance Testing

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# Agenda

- Background
- Important areas for testing
- Battery usage patterns
- Battery Tester Proposal
- Summary

# Some testing already happening

- Trying to validate battery data / safety
- Testing static characteristics
- Making interesting testing assumptions
- Worst case safety tests
- But ...
  - Is the testing adequate?
  - Is testing focused on the right characteristics?
  - Are the testing assumptions OK?
  - Do we want others to define tests (WHQL)?

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# Important Areas for Testing

- Safety Related
  - Charging parameters / detects incorrect charging
  - Battery Internal Protection
- Battery data
  - Remaining time / mWH
  - Accurate and responsive voltage/current
- Alarms
  - Reliable / predictable

# Safety

- Over-charge
  - Charge fully then force charge
    - Does battery send over-charge alarms?
    - Does battery send zero voltage/current?
    - Does battery manipulate thermistor value?
    - Does battery disconnect?
- Over-current
  - Short battery / high load
    - Does protection work?
    - Does protection reset?

# Capacity Information

- Accurate full charge / remaining capacity
  - OSPM
    - Remaining time - PM policy input
    - Low capacity alarm - data integrity
  - User
    - Fuel gauge
    - Remaining time

# Battery Data

- Accurate Voltage and Current readings
  - OS can track system power
  - OS can characterize devices' power
- Response time
  - Not well specified - implied in average ~1 sec
- Must be accurate in very dynamic environment
  - NB may exhibit  $>5W$  changes in  $<1\mu s$  every 800us



# Alarms

- Low capacity alarm
  - Prevent unexpected shutdown and data loss
  - Maximize run time
- Fully discharged alarm
- Over-temp / over-charged

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# Battery Usage Patterns

- Storage - out of the notebook
- NB Suspended
- Typical running NB
  - Running typical apps (I.e. Word, PowerPoint)
- Fully loaded NB
  - Playing DVD movie
  - Playing games (Doom)

# Battery Stored

- Testing to determine the “off” drain of the battery - apparent self-discharge
- No spec requirement to meet
- The lower the better

# Notebook Suspend

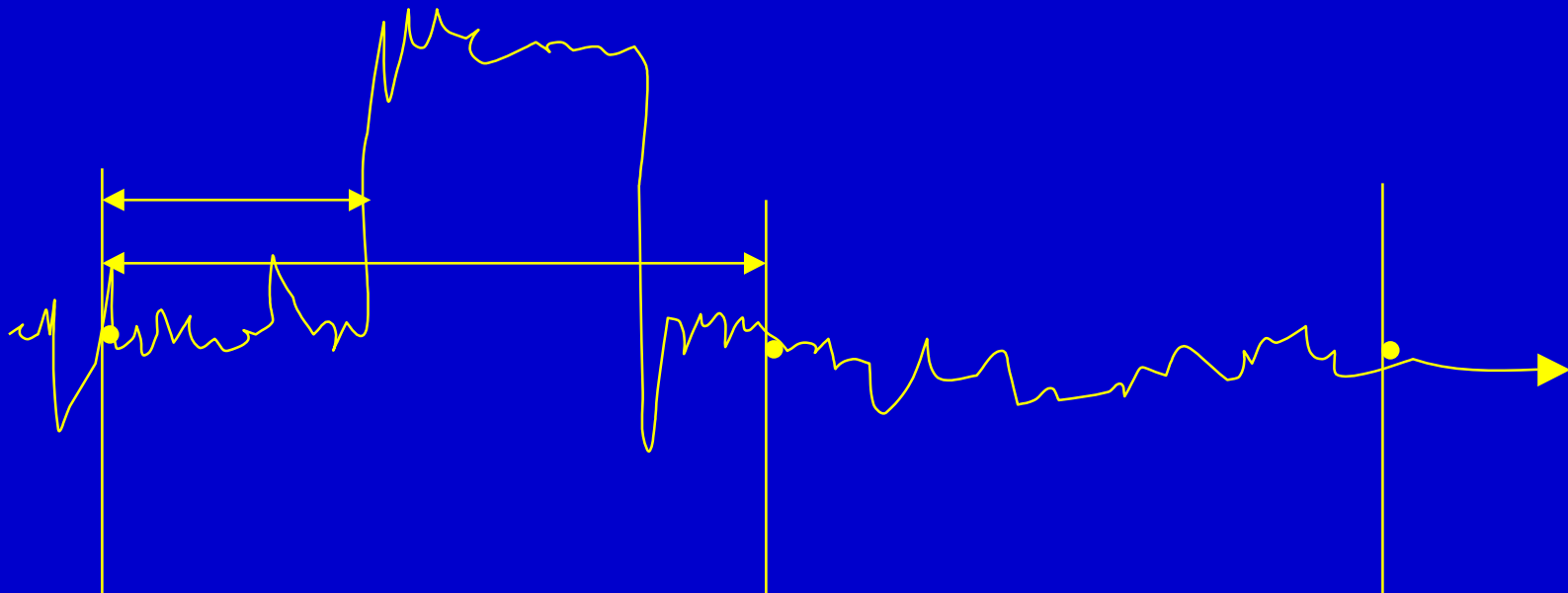
- The load is relatively constant in the range of 20-200mW

# Notebook - Typical Operation

- Load is very dynamic
  - PM is device specific - on/off
  - Infrequent - disk, back light
  - Rapid - CPU
- CPU load
  - $\ll 1W$  when halted  $> 5W$  running
  - Fast slew rates  $< 1\mu s$
  - Periodic -  $800\mu s$  -  $14ms$
- Dynamic constant power loads ranging from 8 to 25W

# Sample Power Trace

- Load can be very dynamic
  - Duty cycle SW/user dependent
  - Periodicity varies by OS/application



# Notebook - Fully Loaded

- Application load requires 100% of the system
  - no PM possible
- Limiting factors are thermal
- Constant power loads ranging from 12W to >25W - relatively static



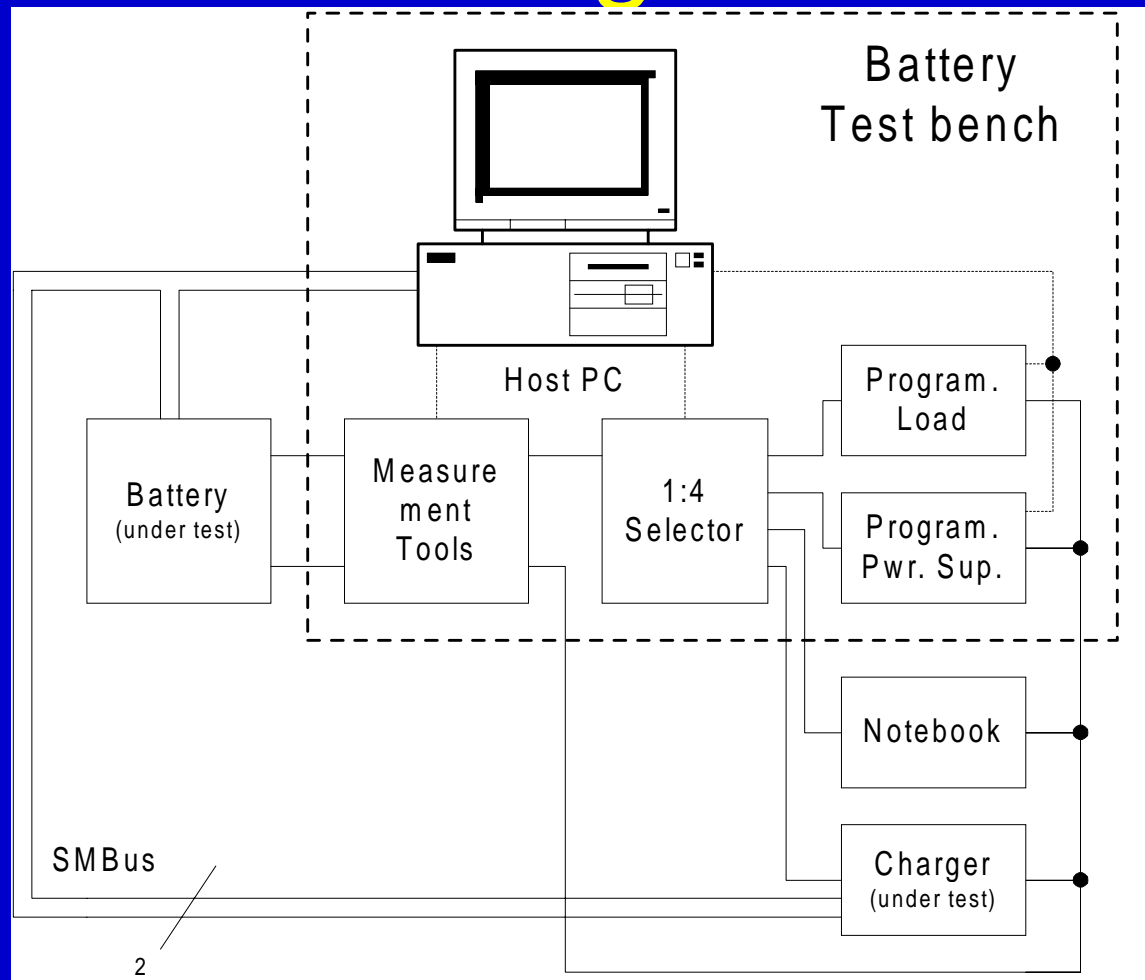
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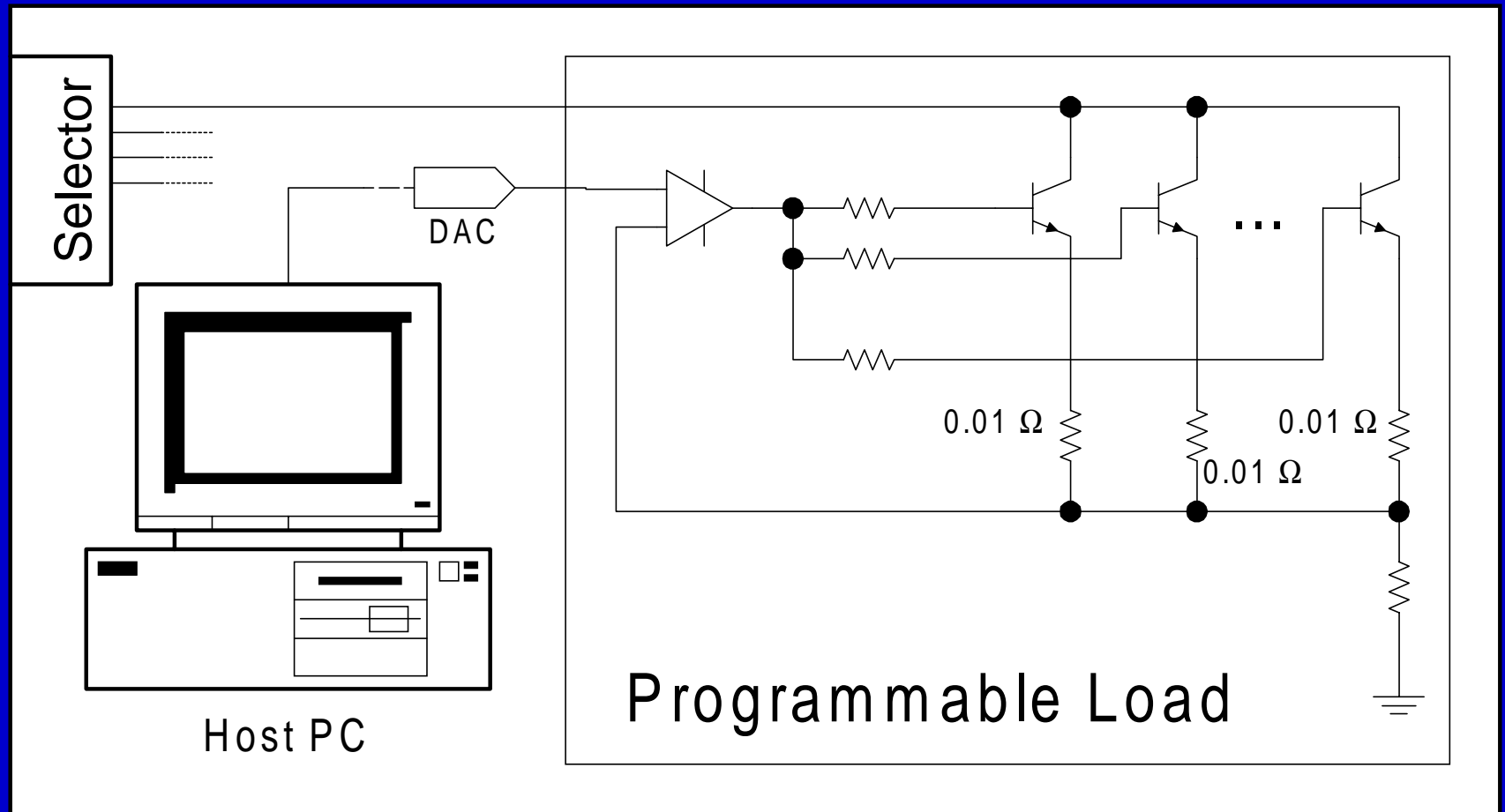
# Testing Methodology

- Testing should be rapid
- Testing should be as automated as possible
- Testing should be repeatable
- Testing should yield best coverage
- Testing should focus on most important areas

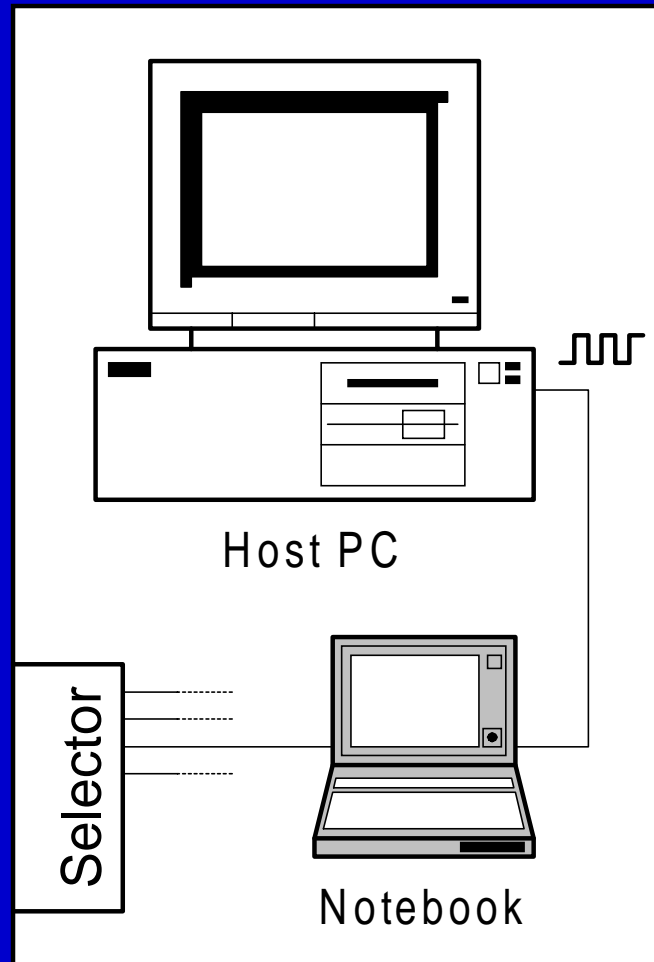
# Battery Tester - Block Diagram



# Battery Tester - Dynamic Load



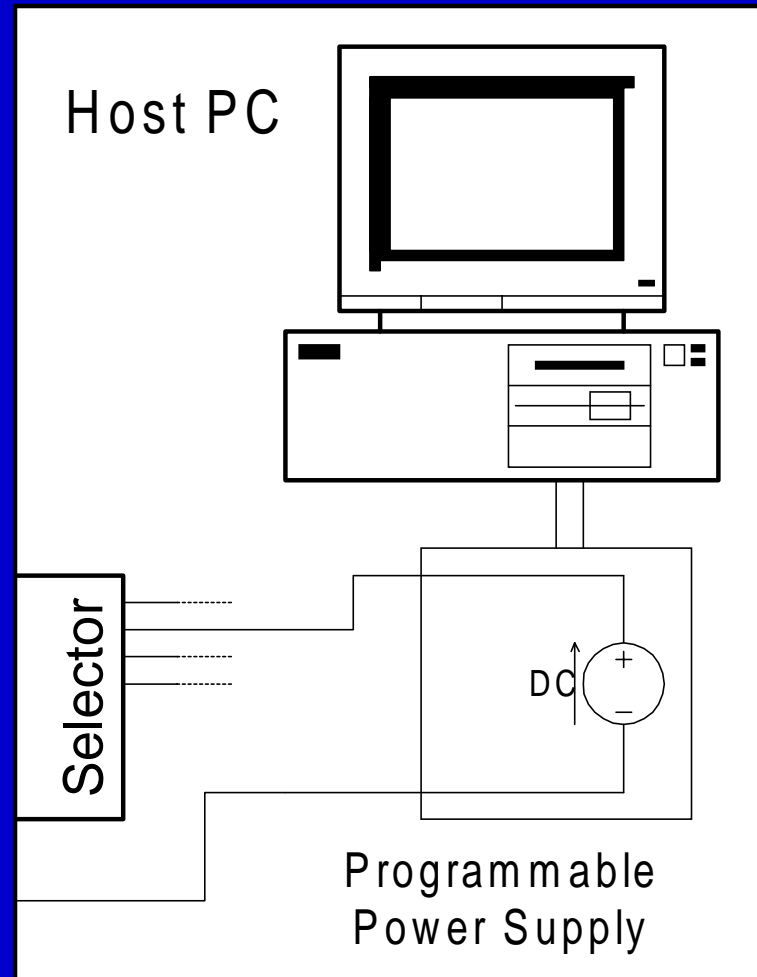
# Battery Tester - NB power data



# Battery Capacity Testing

- Test typical battery use
  - Use real load data collected from NB
  - Running repeatable SW load (e.g. BattMark)
  - Verify battery supplies energy (TimeToEmpty)
- Test maximum battery use
  - Use real load from NB
  - Run maximum load (DVD video, DOOM)
  - Verify run time

# Battery Tester - Over-charge Test



# Over Charge Test

- Fully charge battery
- Attempt to “force” charge battery
  - Read thermistor - out of band stop charge signal
  - Read charge voltage/current look for zero
  - Look OverCharge/TerminateCharge alarms

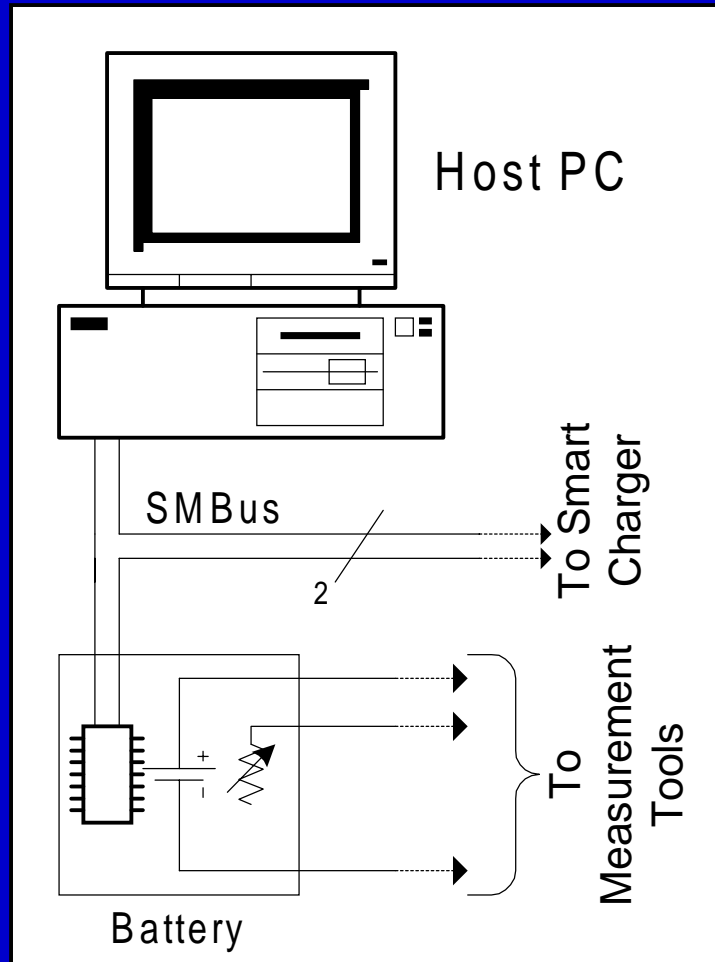


# Summary

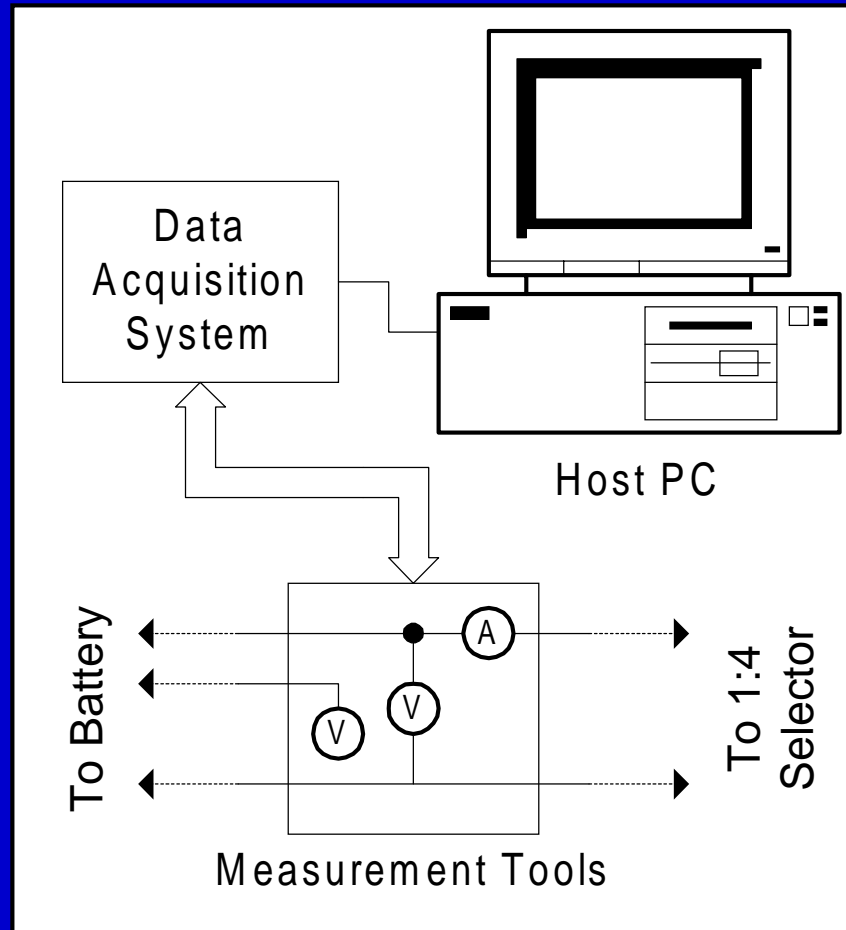
- Smart Battery testing is going to happen
- SBS-IF can lead by designing tests
- Focus testing on safety and important data
- Test using typical NB power use patterns

# Backup

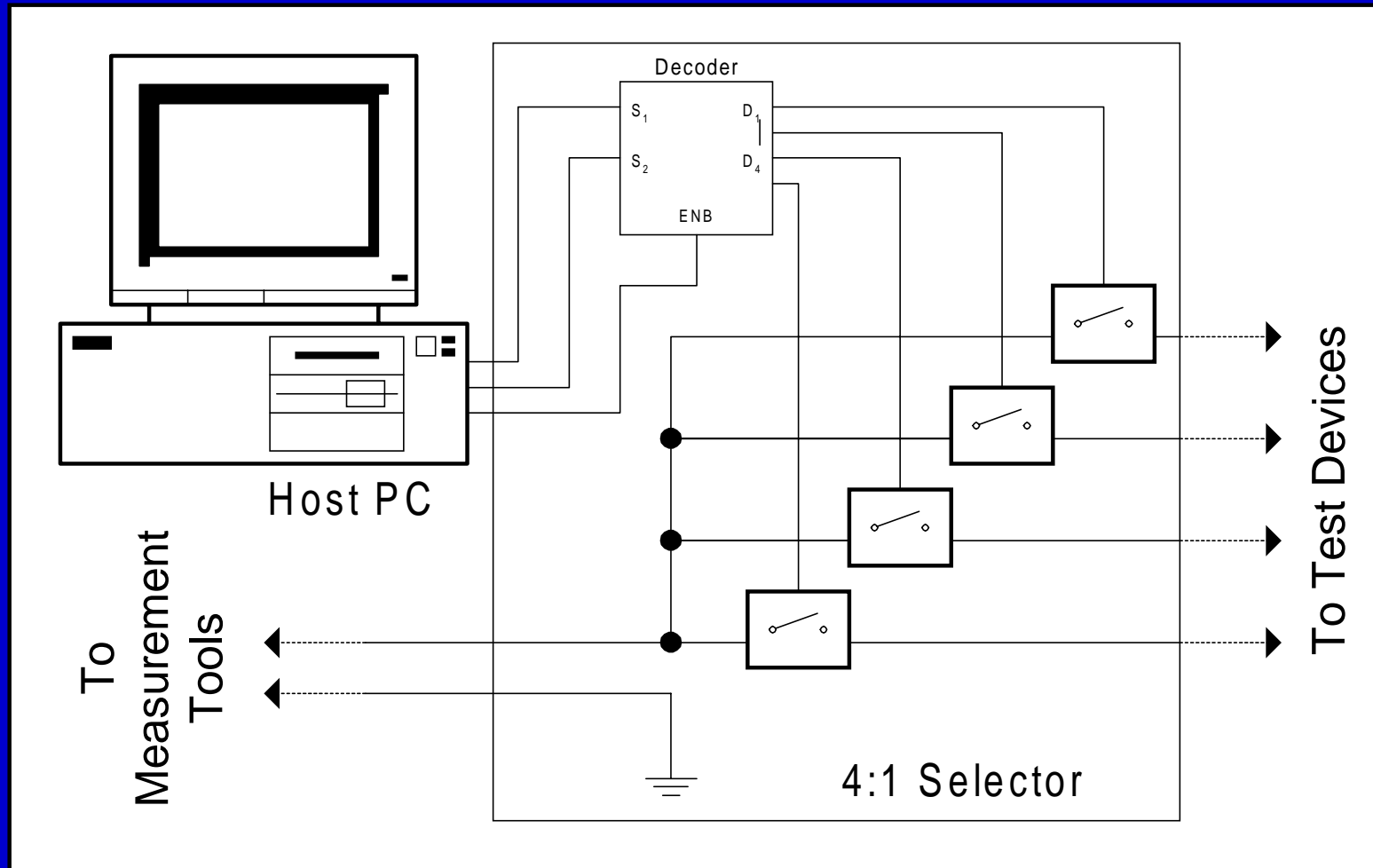
# Battery Tester - SMBus



# Battery Tester - DAQ System



# Battery Tester - Test setup



# Smart Charger Test

