Controllable Loads for Remote, Nondestructive Testing of Power Systems

Center of Electric Power Engineering (CEPE)

Multi-University Research Initiative (MURI)

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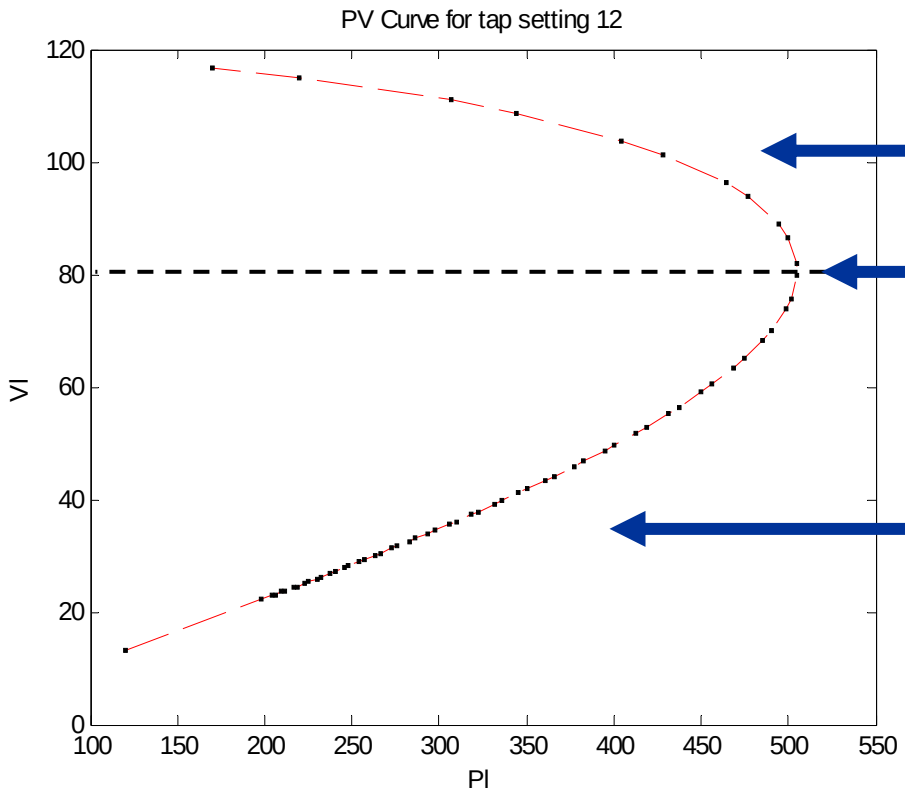
Steady State Stability Studies

The "Nose Curve"



Stable Region

Point of "Max Power Transfer"

Unstable Region: "Voltage Collapse"

Engineer must be able to study all regions in steady state.

Why Nondestructive Testing?

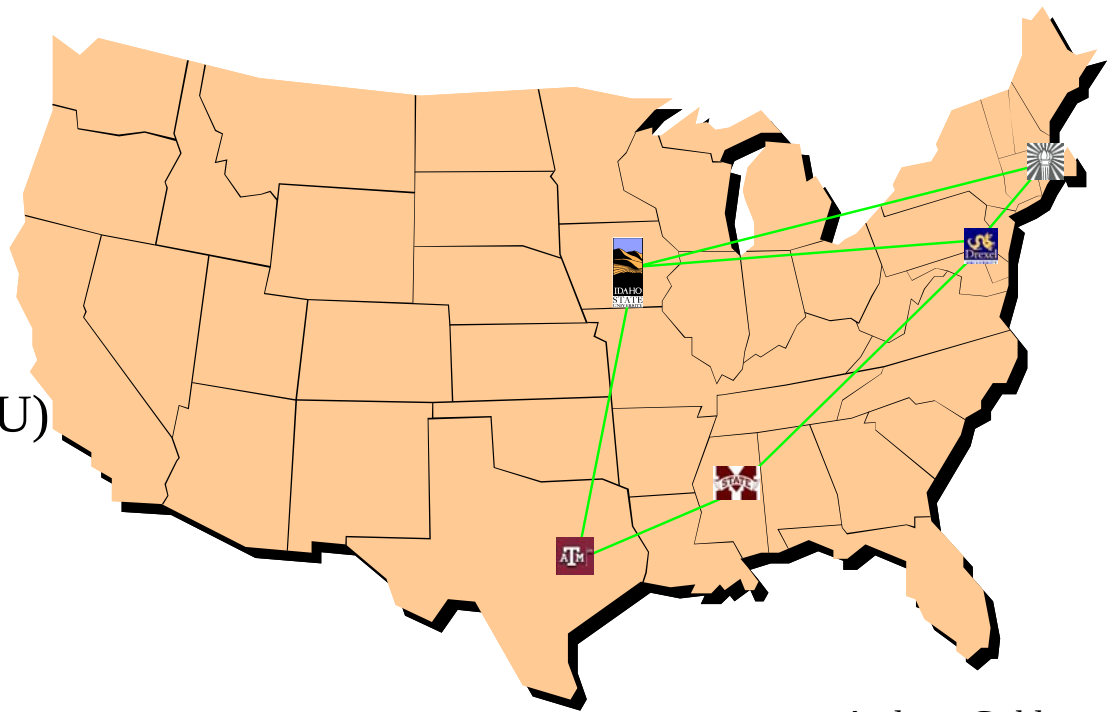
- Were we to perform these experiments without this feature one of two things would occur:
  - Without protection: behavior could be studied, however equipment would be damaged.
  - With protection: protection equipment would “trip out” the system before we could view the region of the curve we wish to study.

- Nondestructive testing allows us to view all regions of the PV curve in steady state. Providing full and safe access to the desired data.

MURI Project

- Multidisciplinary University Research Initiative (MURI)
  - Device Development for Remote, Nondestructive Testing of Power Systems

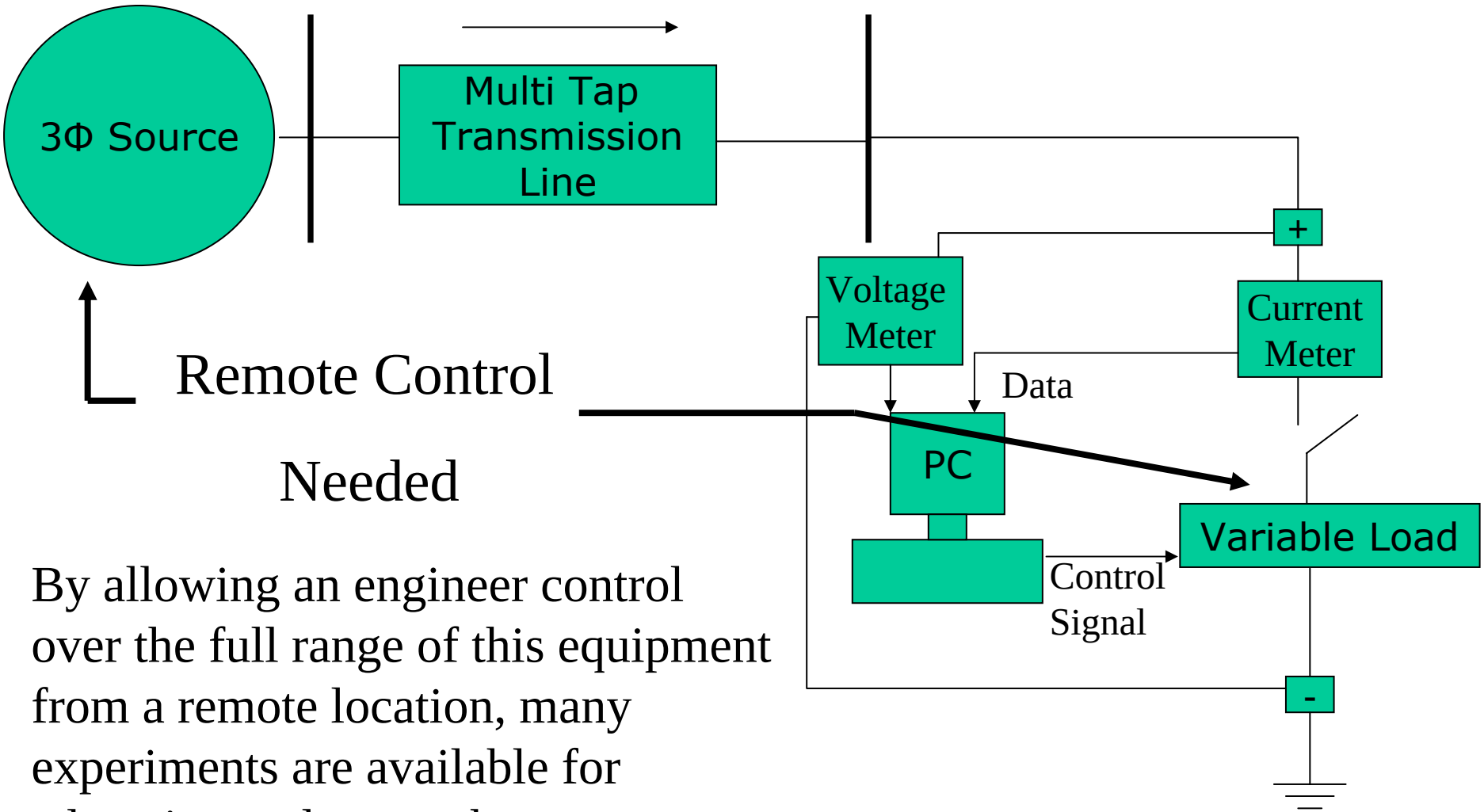
Drexel University (DU)
Iowa State University (ISU)
Northeastern University (NEU)
Mississippi State University (MSU)
Texas A&M University (TAMU)



Why add Remote Capability?

- Many Universities do not have the hardware to perform this type of experiment.
- Remote capability will allow students to study power system behavior from any location that is internet accessible.
- This is the first step in a project which will create a “virtual link” between several hardware labs across the country.
- This “virtual link” will allow several labs at different locations to run as one large power system.

Hardware Layout and Remote Access



Remote Control Needed

By allowing an engineer control over the full range of this equipment from a remote location, many experiments are available for education and research.

Controllable Source: Kikusui PCR6000W^2

Specs:

- 6kVA
- Single phase and 3-phase selectable
- AC1 to 300V
- 1 to 500.0Hz
- DC+/-1.4 to +/-424V
- PWM type

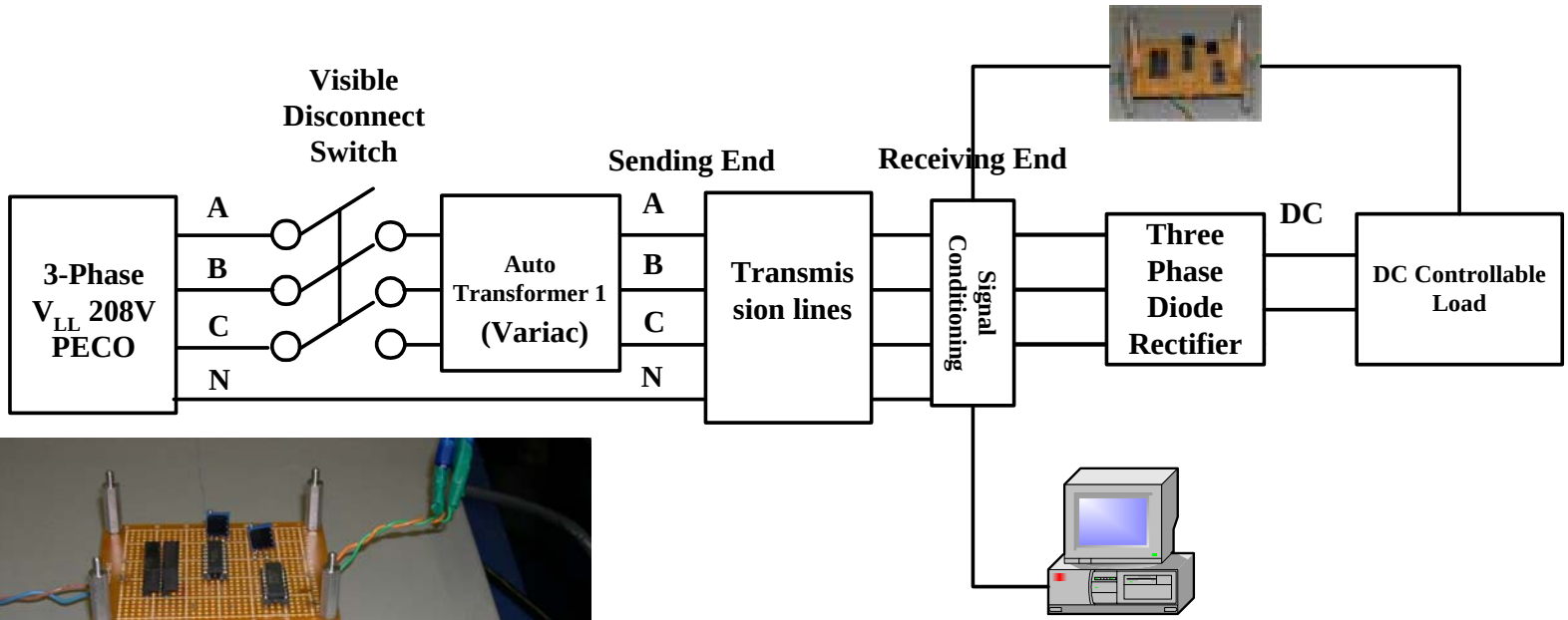
Actions:

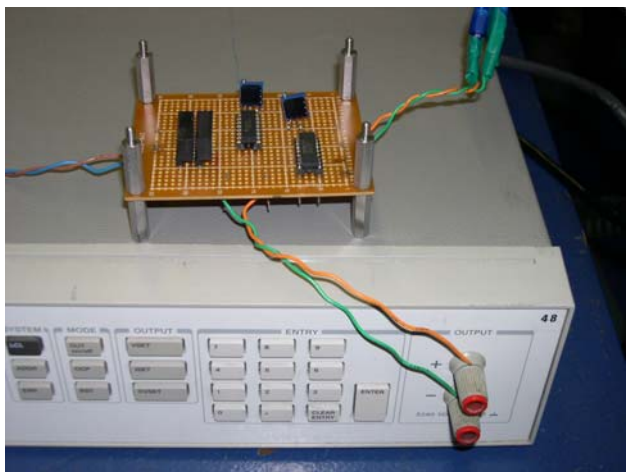
- Acquired
- Initial Testing Performed
- Procedures Written

Two Variable Loads

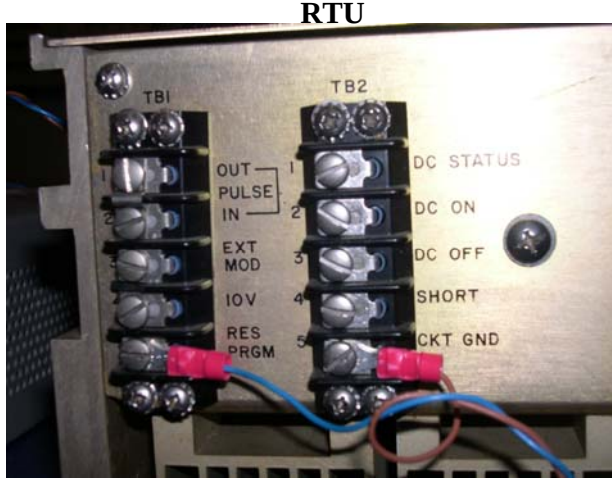
- Dynaload: Software modifications have been performed to expand the functionality of this device.
  - Advantages: off the shelf solution, existing digital control.
  - Disadvantages: limitations in its voltage, current and power. ratings.
  - Cost ~ $12,000
- Resistor Box: A new controllable resistive load to be custom designed and constructed in CEPE.
  - Advantages: larger power ratings allowing full use of existing laboratory equipment.
  - Cost ~ $2,000

Dynaload





Isolation board which allows for digital control of the Dynaload while protecting the DAQ card.



Digital control wires connected to the Dynaload.

Dynaload Front Panel

Analog Data Output

Manual Current Control

Trip in/out Switch

System Connections

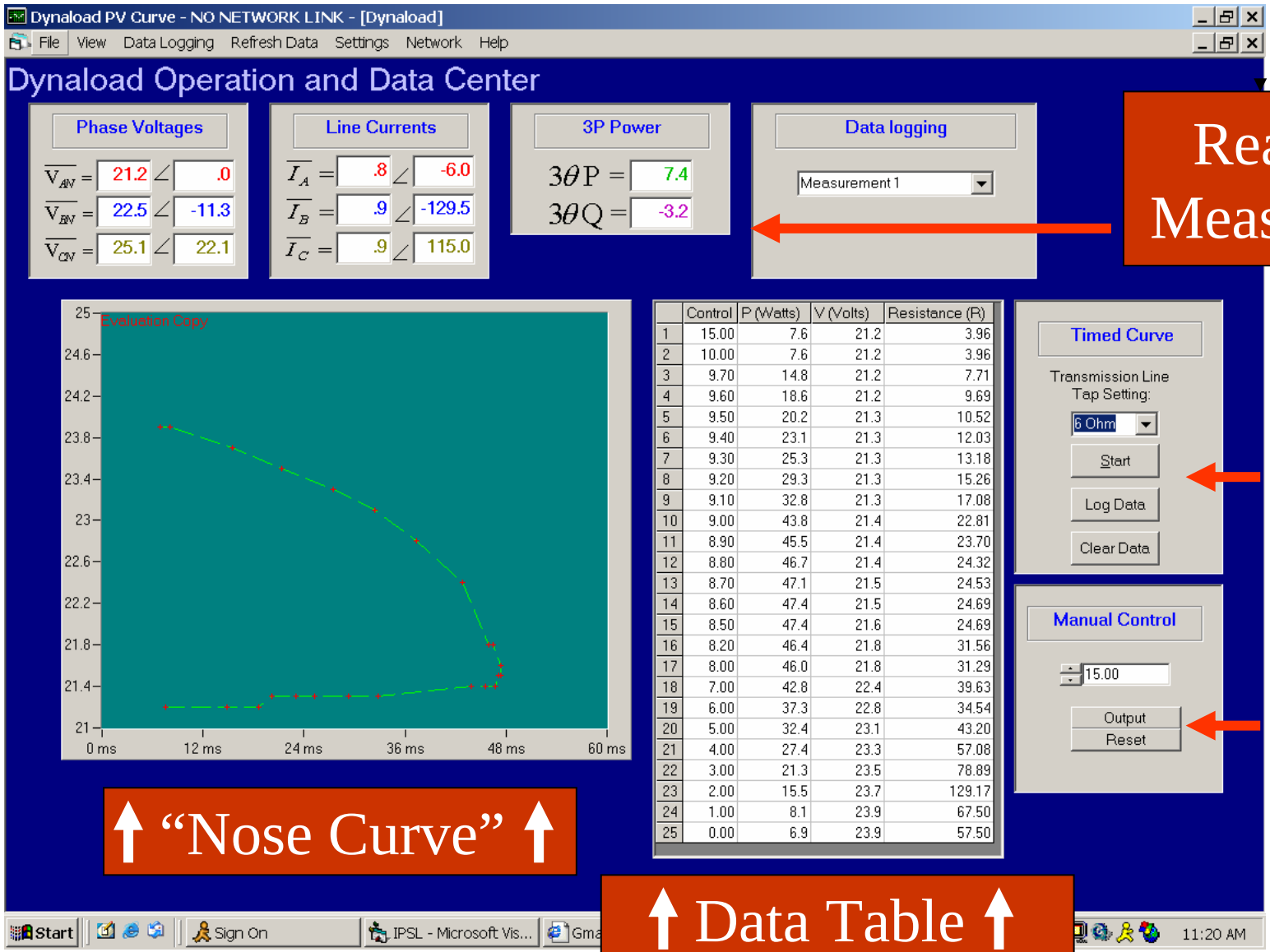
Dynaload Upgrades

- Existing software allows for manual computer control of the dynaload.

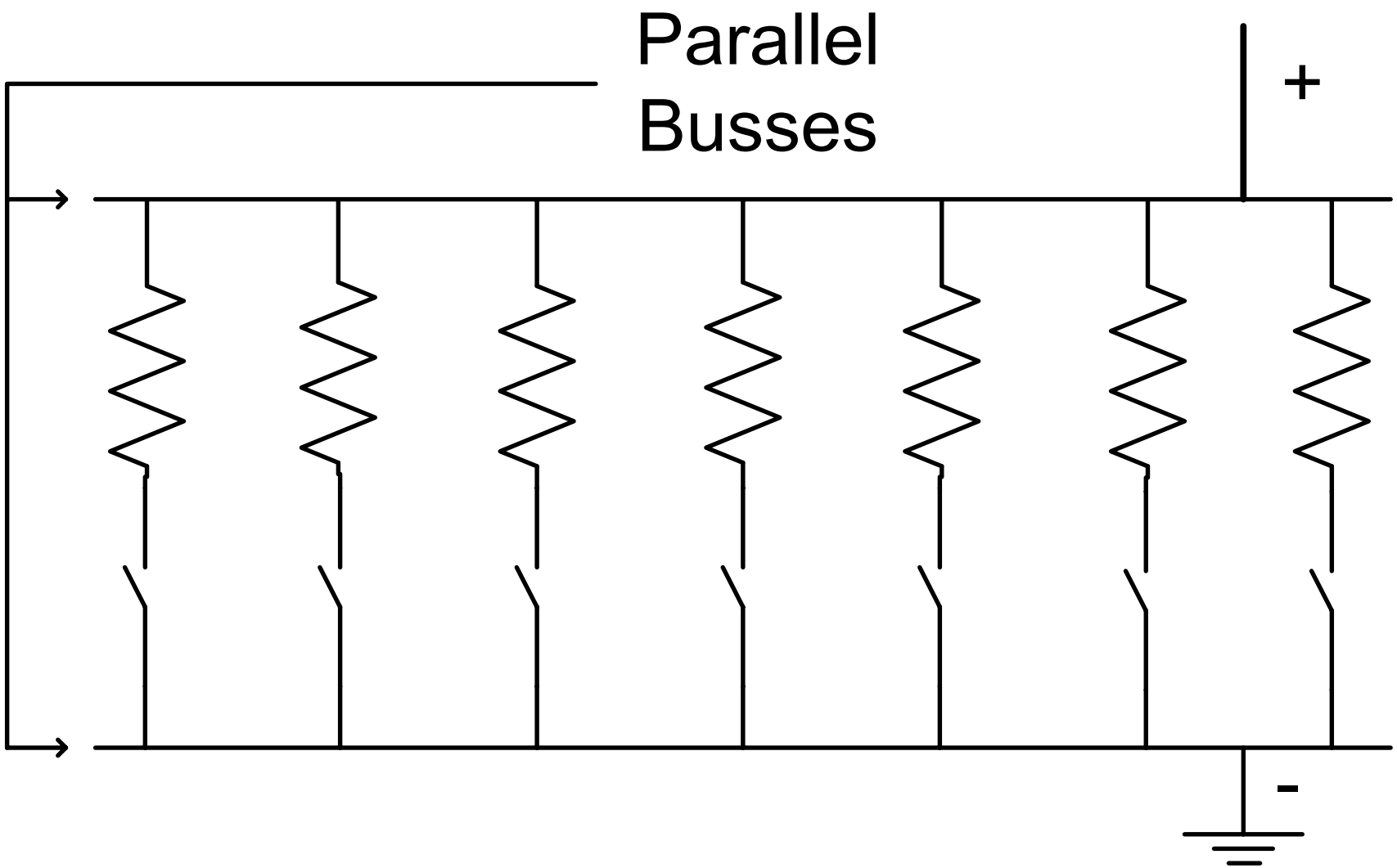
- Software upgrades have achieved:
  - Integration of dynaload control module and measurement module.
  - Automated stability study: one button click creates multiple measurements using a timer.

- Remote operation will be achieved by integrating the visual basic module with LabView network software.

New Dynaload UI



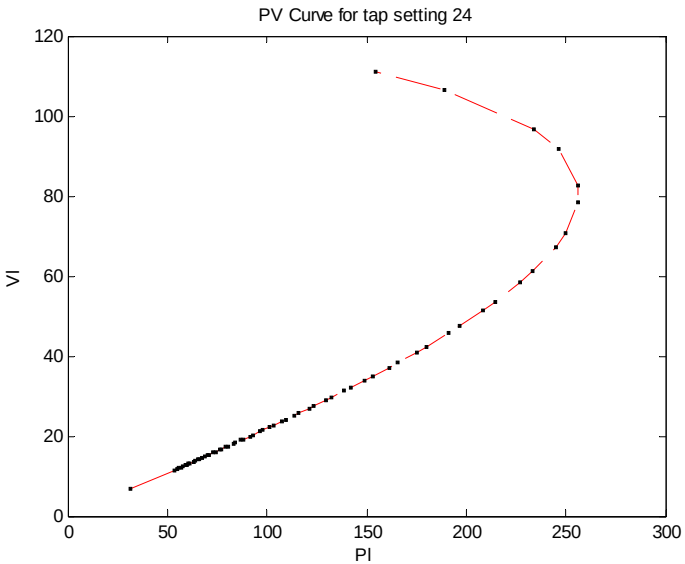
Custom Resistor Box



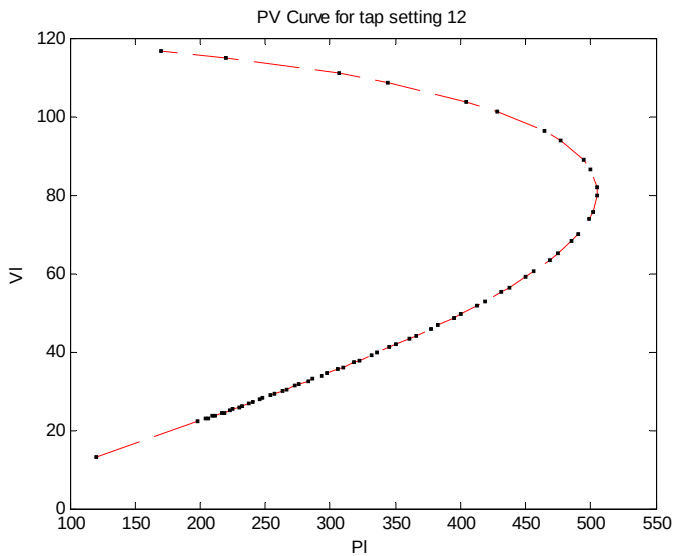
How Does it Work?

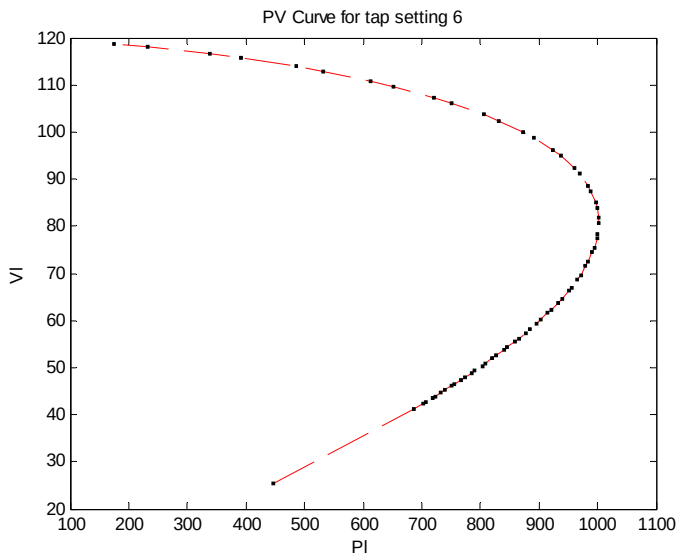
- "Normally Open Relay's" are semiconductor switches
  - Opened or closed by sending a digital signal through a Data Acquisition Card.
- Device acts as a discrete step variable load.
- By switching the resistors in and out of the parallel busses 127 "R" values are achieved.
- Produces the maximum range of experimentation given the existing equipment in the laboratory.

Design Considerations



- System was simulated in Matlab.
- PV curves created.
- Ability to produce the desired curves demonstrated.





Results and Conclusions

- Researched Specs and acquired Controllable Source.
- New interface for Dynaload.
- Automated steady state stability study with single button click.
- Simulation of Resistor Box and resulting behavior.
- Initial design specs and layout for Resistor Box.

- The hardware systems in development will provide the full capability of Steady State Stability Studies from any remote location with internet access.