Transient Over-Voltages, Surge Protection and Insulation Coordination

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July 24, 2009

Power Engineering at The Ohio State University

- **Four Professors**
- **One Professor Emeritus**
- **Research areas:**

  Power system

  Electric machine and drive

  Power electronics

  High voltage engineering

- OSU has offered electric power engineering courses continuously since 1895
- Currently in quarter system (10 weeks/quarter)
- Will change to semester in 2012

Offered Courses

Core:

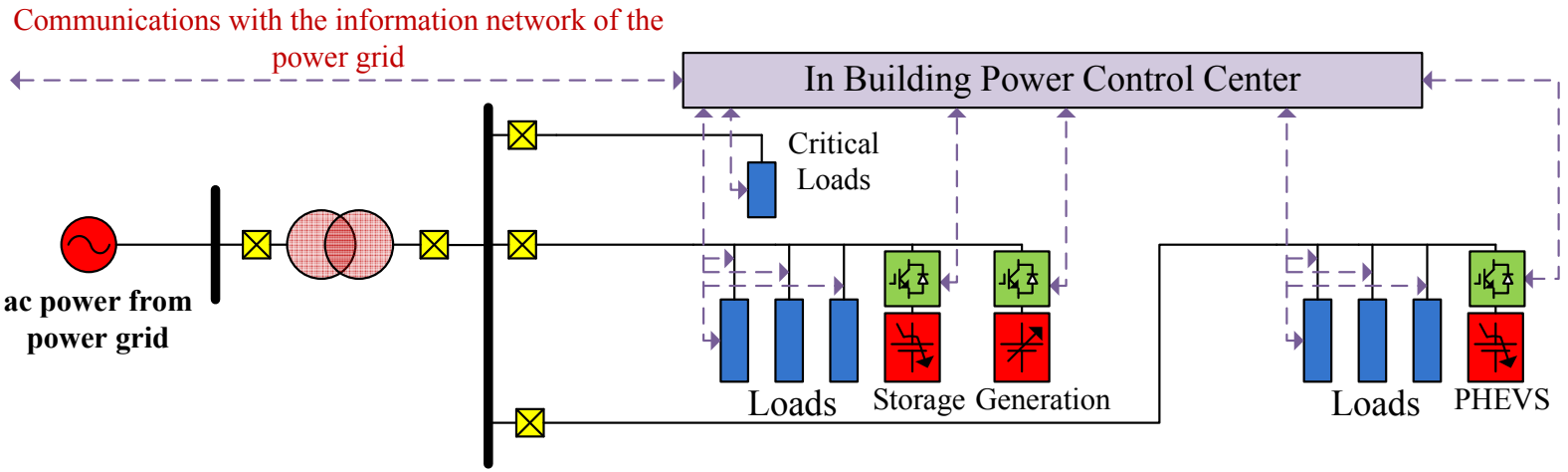
- **ECE 341 (3) Energy Conversion**

Technical Electives:

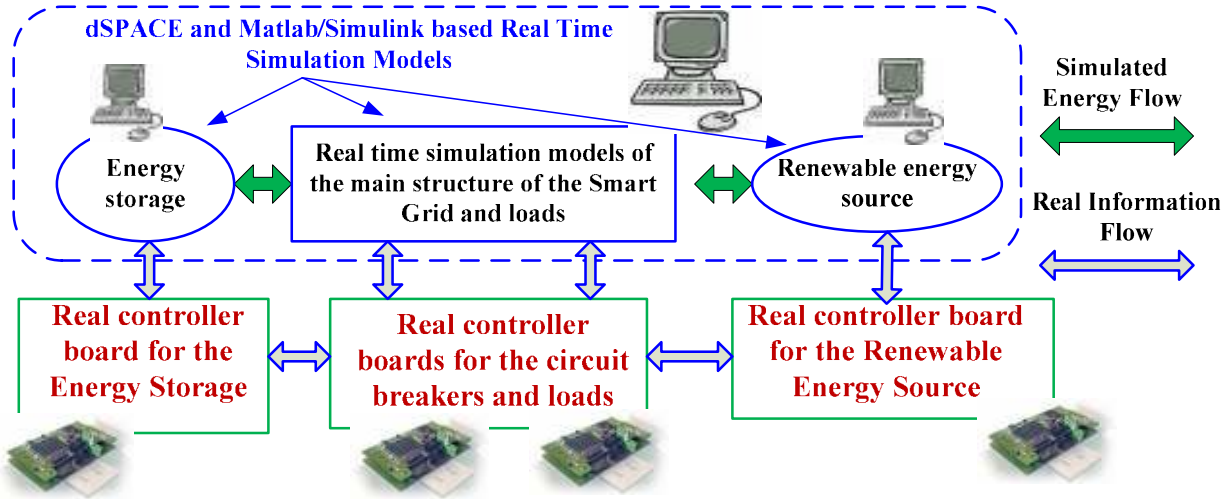
- **ECE 447 (2) Energy Conversion Lab**
- **ECE 624 (3) Power Electronic Devices and Circuits**
- **ECE 628 (2) Power Electronic Devices and Circuits Laboratory**
- **ECE 724 (3) Power Electronic Devices and Circuits II**
- **ECE 643 (3) Electric Machines**
- **ECE 744 (3) Modern Control of Industrial Electrical Machinery**
- **ECE 647 (2) Micro Controller Systems for Industrial Applications Lab**
- **ECE 640 (3) Industrial/Commercial Power Systems**
- **ECE 740 (3) Electric Power System Analysis**
- **ECE 741 (3) Electric Power System Protection**
- **EE 747 (4) High Voltage Engineering and Laboratory**

A Hardware-in-the-loop based Virtual Smart Grid Test Bed

Smart Grid Concept:



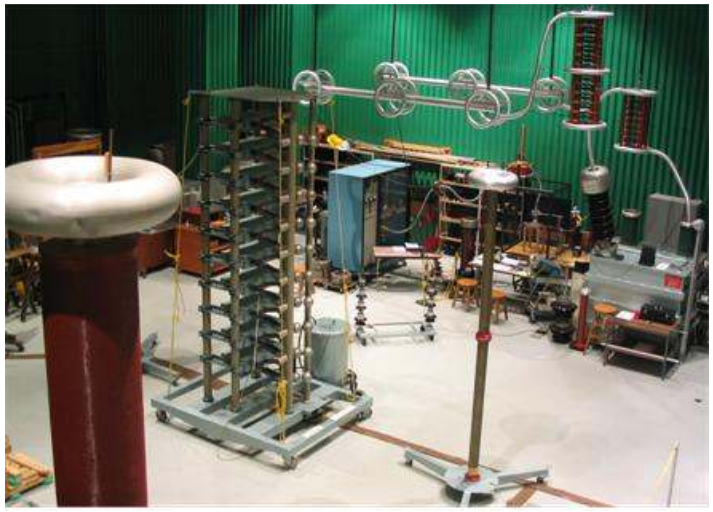
Virtual Test Bed:



Supported by OSU Instructional Innovation Grant.

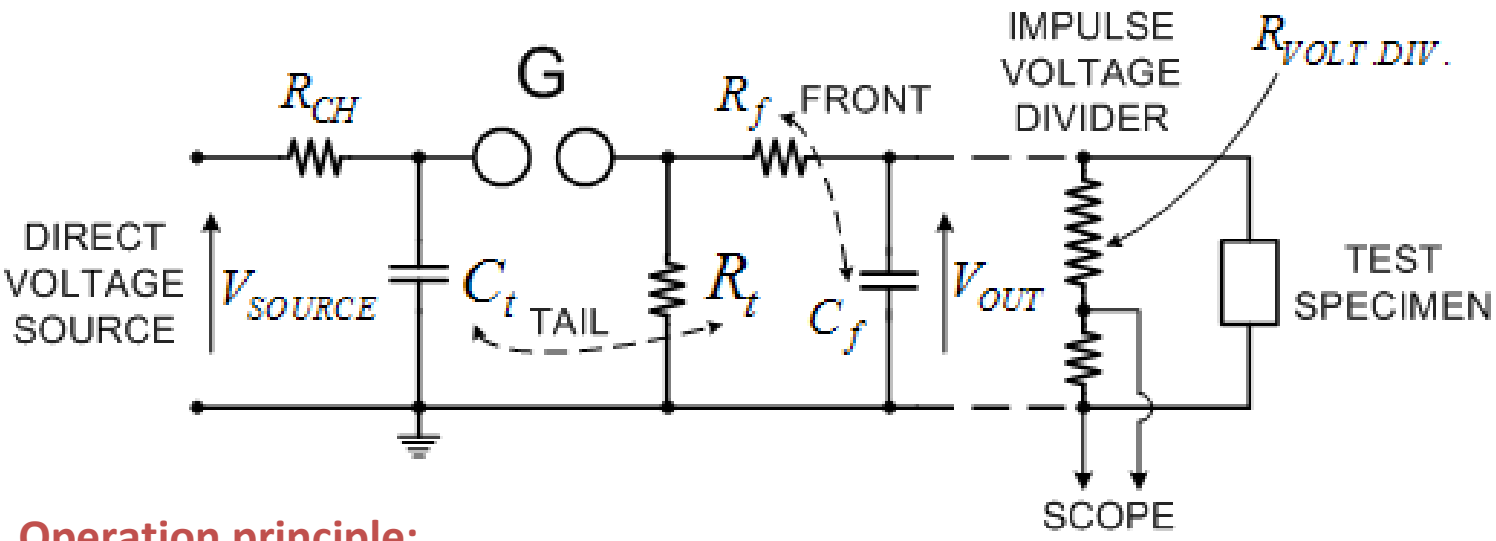
High Voltage Related Teaching

- **EE 747 (4) High Voltage Engineering and Laboratory**
  - **45 student +**
  - **5 groups**
  - **9 experiments/quarter**
  - **3 lectures (1 hour) and 5 lab sessions (2 hours)**



- The High Voltage related activities were started in the 1950's by Prof. Neal A. Smith.
- The current 3600 square foot high voltage laboratory was envisioned and built by Prof. Stephen A. Sebo.
- The long term development goal is a High Voltage and Power Electronics Laboratory for megawatt implementations of green and renewable energy.

Single Stage Impulse Voltage Generator

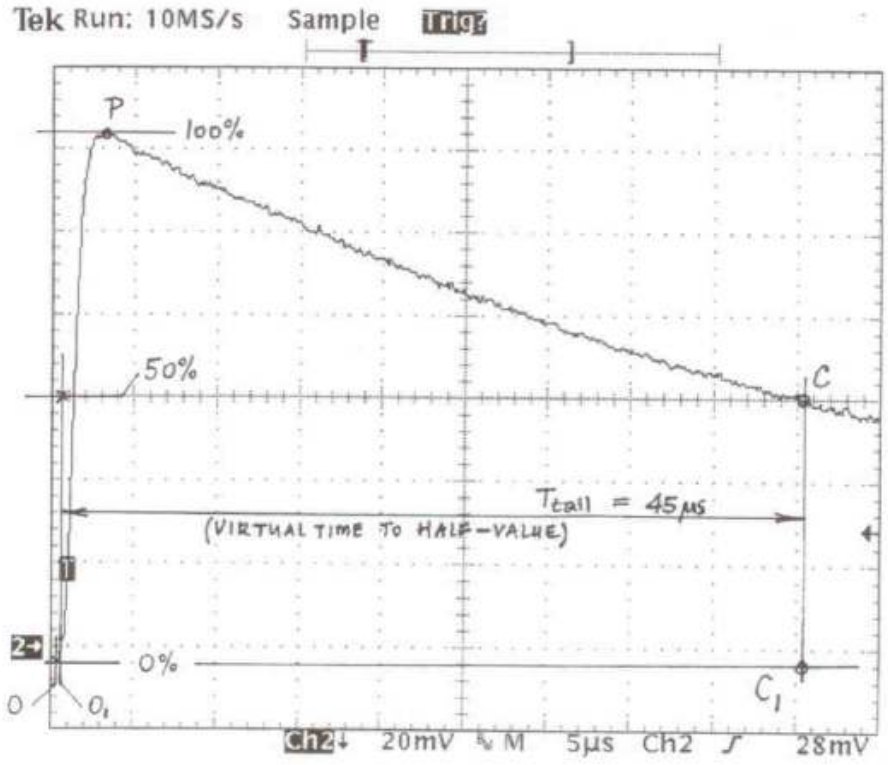


Operation principle:

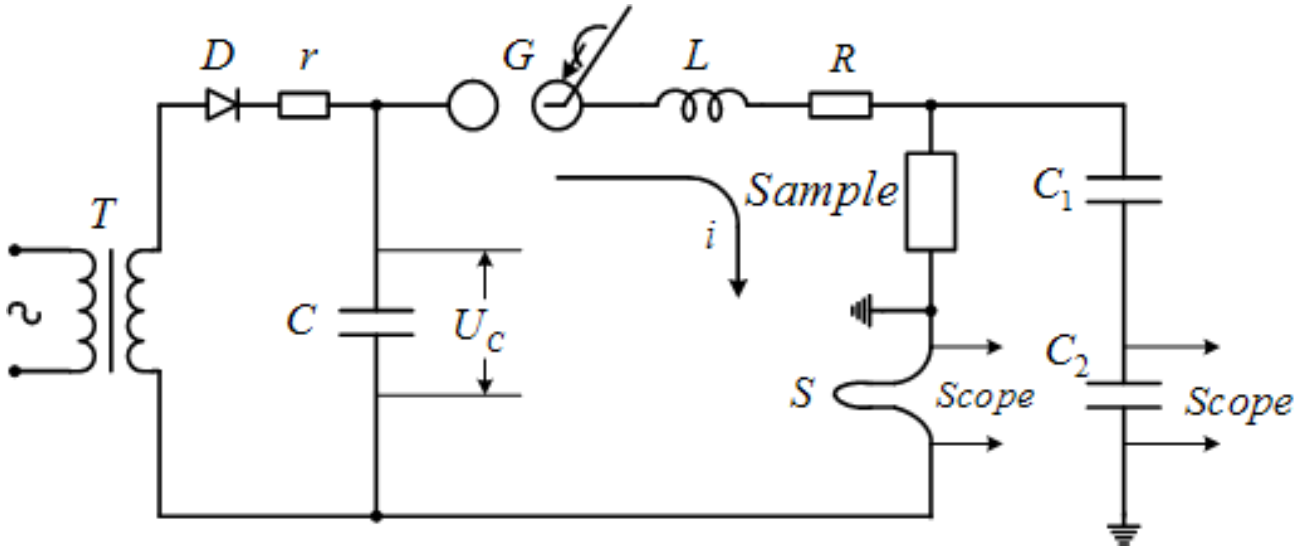
- C_t is charged by the input dc source through R_{CH}
- Before "*G*" sparks over, C_f is **not** charged

•After "G" sparks over, C_t charges C_f through R_f $C_t >> C_f$ impulse voltage appears on the voltage divider and test specimen.

OSU Ten-stage 1 MV Impulse Voltage Generator



Impulse Current Generation Circuit

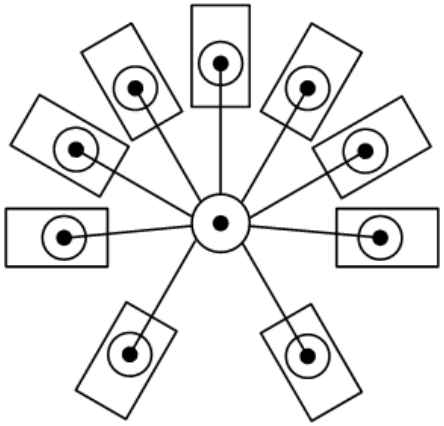


R and L are distributed resistance and inductance in the connections, capacitors, and measuring resistor, S.

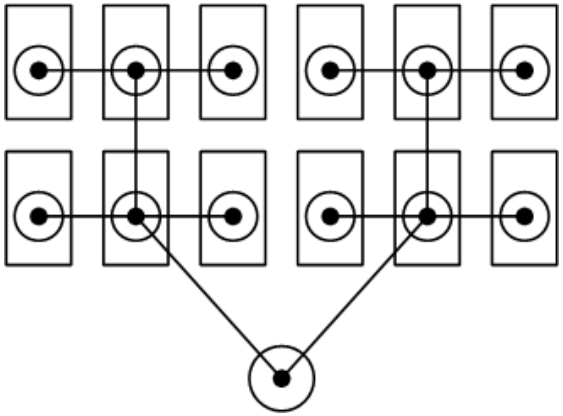
Test sample usually has small impedance.

Practical Arrangement of the Capacitors

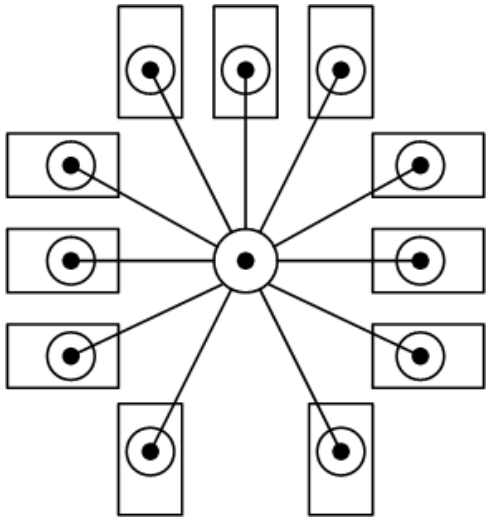
Goal: Minimize the stray inductance and evenly distribute current



Cylinder structure



Compact structure with uneven busbars

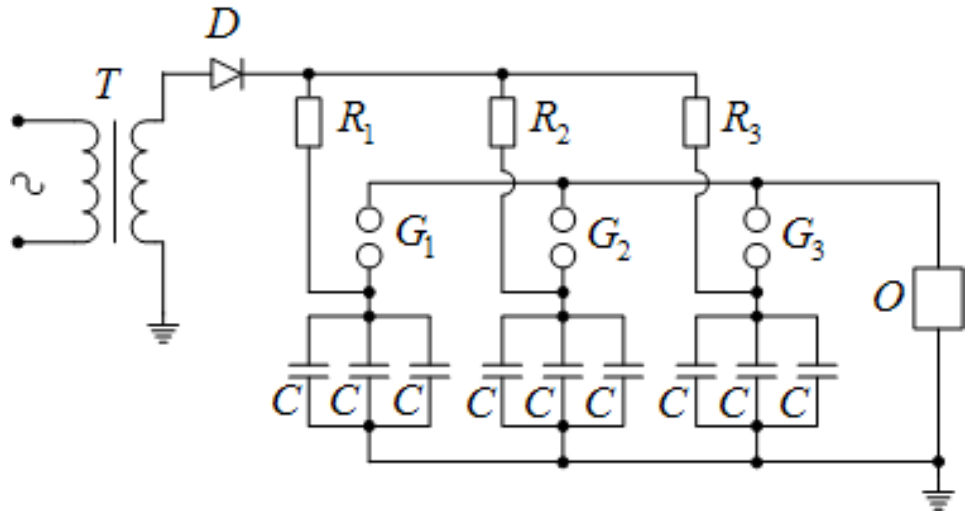


Square case structure

Grounding and Protection

Single grounding point is preferred: safety, measurement accuracy and equipment safety.

Fuse resistor and bleeding resistor are often used for the capacitor bank.

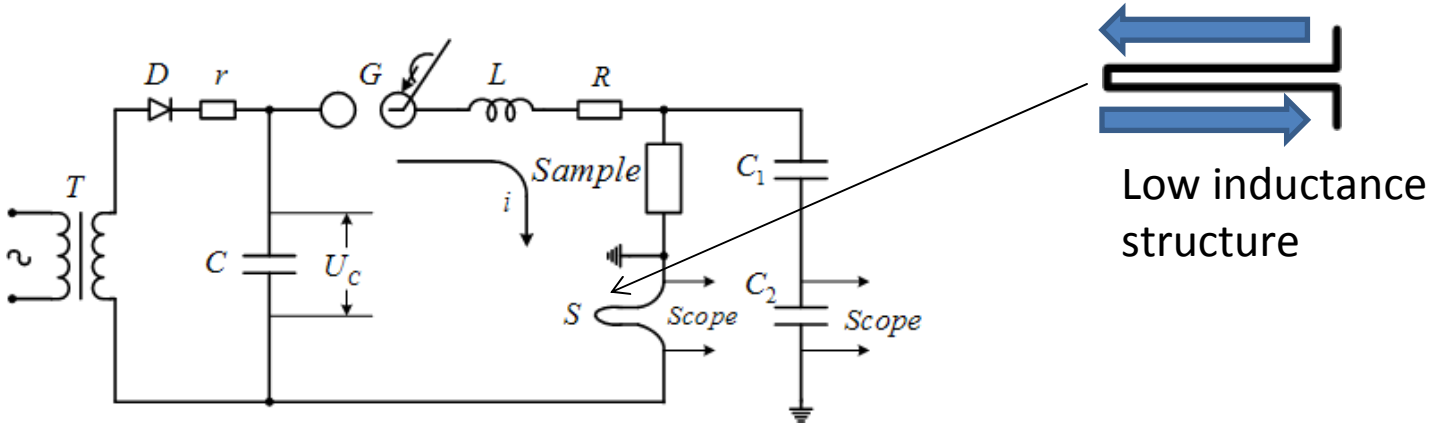


When one capacitor is damaged to short circuit condition, all the other capacitor will discharge through that capacitor. If the total capacitance is too large (energy is too high), explosion can happen.

It is preferred to group capacitors when a large number of capacitors are needed.

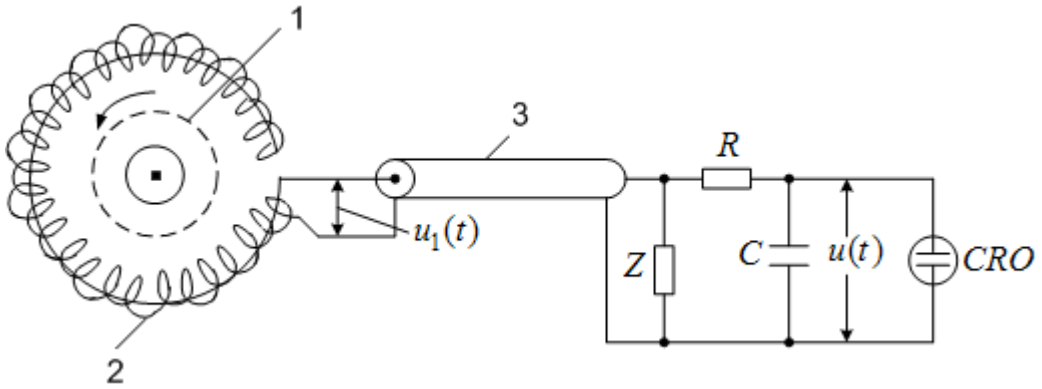
Impulse Current Measurement

Low inductance resistor:



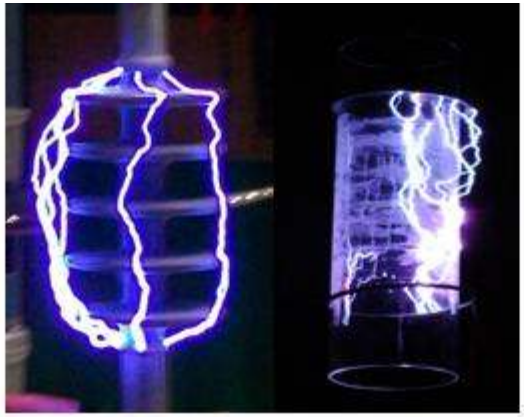
Low inductance structure

Rogovski coil:

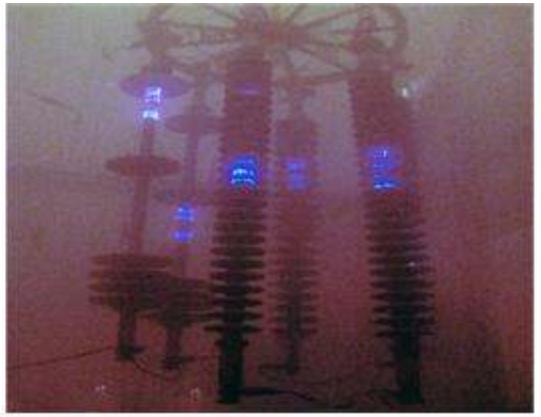


High Voltage Experiments

5 MV Tesla



Flashover



Fog Chamber

http://www.youtube.com/watch?v=aWf-V2-kr9Q

http://www.youtube.com/watch?v=romZnL8DWOc

Thanks.