Models of Undergraduate Research

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What is undergraduate research?

"… universities should treat learning as not yet wholly solved problems and hence always in research mode" W. von Humboldt, 1810

- Reflect on what do you think is undergraduate research

Agenda

- Introduction
- What is undergraduate research (UR)?
- Motivations for UR depending on institution
- Some models of UR
- Examples

Introduction

- Perspectives on education
  - Does education only entails teaching?
- Balance among our various responsibilities as educators
  - How to deal with the various constraints with regards to teaching and research and service?

Introduction

- **RESEARCH AND EDUCATION ACTIVITIES:**

  Equal weight????
- **RICH FELDER:**

  "The Myth of the Superhuman Professor"
- **ERNEST BOYER'S SCHOLARSHIP MODEL:**
  - Integration
  - Application
  - Discovery
  - Teaching

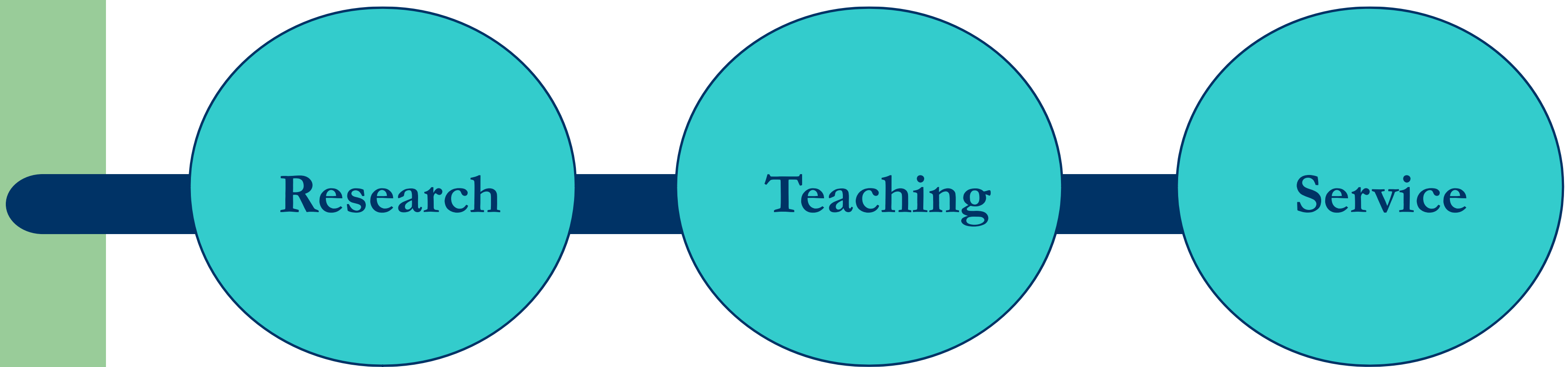
Boyer’s Scholarship

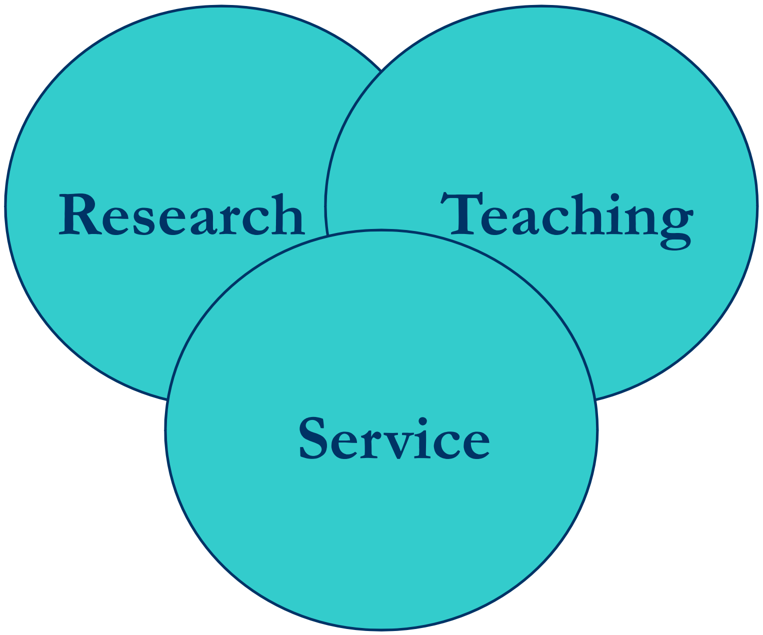
- **Discovery:** Build new knowledge through traditional research (Publishing, producing and/or performing creative work, creating infrastructure)
- **Integration** Interpret the use of knowledge across disciplines. Preparing a comprehensive literature review. Writing a textbook for use in multiple disciplines. Collaborating with colleagues to design and deliver a core course.

Boyer's Scholarship

- **Application** Aid society and professions in addressing problems. Serving industry or government as an external consultant. Assuming leadership roles in professional organizations. Advising student leaders, thereby fostering their professional growth
- **Teaching** Study teaching models and practices to achieve optimal learning. Advancing learning theory through classroom research. Developing and testing instructional materials. Mentoring graduate students. Designing and implementing a program-level assessment system

UR: LOOKING FOR A BALANCE





Carnegie Classification of Academic Institutions (before 2005)

- **Research universities I** 50 or more doctoral degrees, and at least $40 million or more in Federal research support
- **Research universities II** between $15.5 million and $40 million in Federal research support per year
- **Doctorate-granting I** (at least 40 PhDs in 5 disciplines), **II** (20 or more doctoral degrees in one discipline or 10 in 3)
- **Master's (comprehensive) universities and colleges I** At least 2,500 students), **II** (between 1,500 and 2,500 students)
- **Baccalaureate (liberal arts) colleges I** (highly selective, primarily undergraduate colleges) **II** (less restrictive)
- **Associate of arts colleges**
- **Professional schools and other specialized institutions**

Carnegie Classification of Academic Institutions (2005)

- **Doctorate-granting universities** (at least 20 PhDs per year): very high research activity, high research activity, and doctoral/research universities.
- **Master's colleges and universities** (at least 50 master's degrees and fewer than 20 doctoral degrees per year)
- **Baccalaureate colleges** (fewer than 50 master's degrees or 20 doctoral degrees per year)
- **Associate's colleges** (2 year institutions)
- **Special focus institutions** (single field or a set of related fields)
- **Tribal colleges**

What is Undergraduate Research?

"An inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline"

Council for Undergraduate Research

- Do you agree with this definition?
- Is it possible to perform this type of UR in your institution?

What is Undergraduate Research?

"A broad definition of the undergraduate as researcher to describe student engagement at all levels in research and inquiry into disciplinary, professional and community-based problems and issues"

University of Gloucestershire, UK

STUDENTS AS PARTICIPANTS

Research-tutored

Research-based

EMPHASIS ON RESEARCH CONTENT

EMPHASIS ON RESEARCH PROCESSES AND PROBLEMS

Research-led

Research-oriented

STUDENTS AS AUDIENCE

Curriculum design and linking research and teaching

Source: Healey and Jenkins, 2008

Advantages of Undergraduate Research

- Students: advanced knowledge and improved critical thinking skills. Turn them from passive to active learners.
- Faculty: expanded scope of their research group and training of potential graduate students
- Institution: improved educational experience for students

Motivations for Undergraduate Research

- At Doctorate-granting universities
  - Comply with teaching objectives of funding agencies' RFPs
  - Effective way of integrating research and teaching
  - Mentoring opportunities for graduate students

Motivations for Undergraduate Research

- At Master's colleges and universities
  - Begin training of potential graduate students
  - Foster graduate education among undergraduates
  - Comply with teaching objectives of funding agencies' RFPs
  - Effective way of integrating research and teaching
  - Mentoring opportunities for graduate students

Motivations for Undergraduate Research

- At Baccalaureate colleges, special focus institutions and Tribal colleges
  - Improved learning experience for students
  - Opportunity for faculty to perform research

Motivations for Undergraduate Research

- At Associate's colleges, special focus institutions and some tribal colleges
  - Provide basic research skills to students
  - Improved learning experience for students

Models for Undergraduate Research

- UR in undergraduate courses
- Undergraduate students in graduate courses
- UR as part of research projects
- Institutional UR programs
- Agency-sponsored UR programs
- UR as part of long-term research projects

UR in undergraduate courses

- Group or individual research projects
  - Written report
  - Oral Presentations: Open to public, turned to service
  - Class publication
- Assigned reading of technical literature
  - Written summaries, short presentations

Undergraduate students in graduate courses

- Group or individual research projects
  - Written report
  - Oral Presentations: Open to public, turned to service
  - Class publication
  - Peer-reviewed conference papers
- Assigned reading of technical literature
  - Written summaries, short presentations
- Case studies

UR as part of research projects

- Student becomes part of a professor's research group
- Mentoring from professor and from graduate students
- Training in research skills useful in their careers or graduate school

Institutional UR programs

- IAP is an example of programs that Departments or Institutions establish to provide UR opportunities
- At UPRM, there are several examples: Institute for Community Development, Institute for Undergraduate Research, Science on Wheels among others

UR as part of long-term research projects

- Research Centers such as the NSF Center for Power Electronics Systems (CPES) provide many opportunities for UR
  - Be part of Center-sponsored research projects
  - Formal Research Experiences for Undergraduates (REU)
    - Internal and External
    - Example: UPRM's REU with students from PUPR

Agency-sponsored UR programs

- Agencies such as NSF and NASA have formal undergraduate research programs
- For example, the NSF's Louis Stokes Alliance for Minority Participation (LSAMP) provides funding for student stipends and research materials for UR.
  - The Puerto Rico LS-AMP is run by the CRSE, and in its fourth stage included a more structured Mentoring experience for participating Faculty and students

Examples of Implementing UR

- "Student as a Scholar" from the first to final year. Requires a fundamental shift in how the curriculum is planned and structured (from teacher to learner-centered).***
  - However… Humboldt in 1810 discussed how research and teaching had to go together in a university setting….
- Affinity Research Groups

*** Source: D. Hodge, *Student as a Scholar Conference*, April 2007

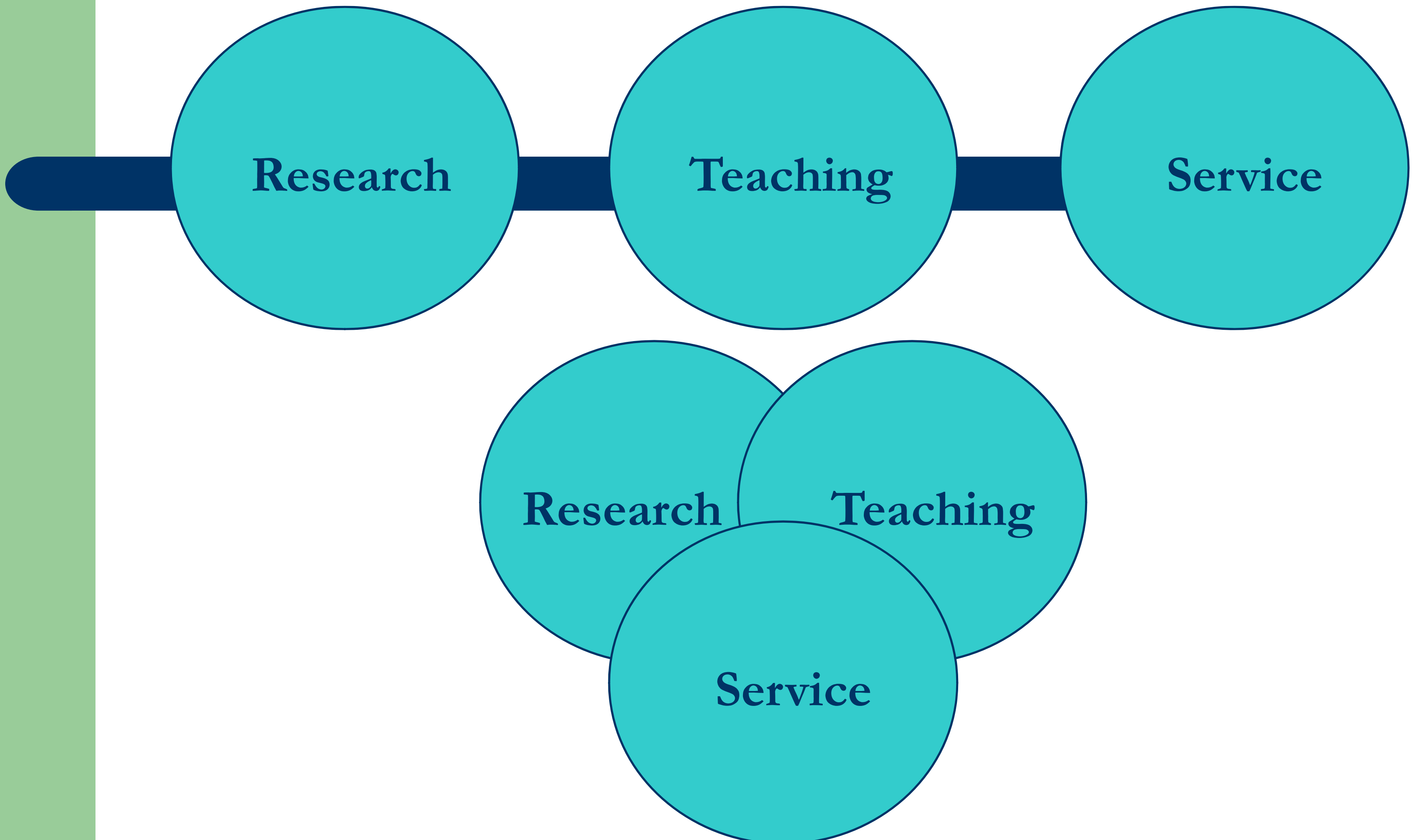
Two Personal Examples

- Living in Chaos: My first undergraduate research mentoring experience

- Fighting the Establishment: An outstanding undergraduate (an eventually graduate) researcher

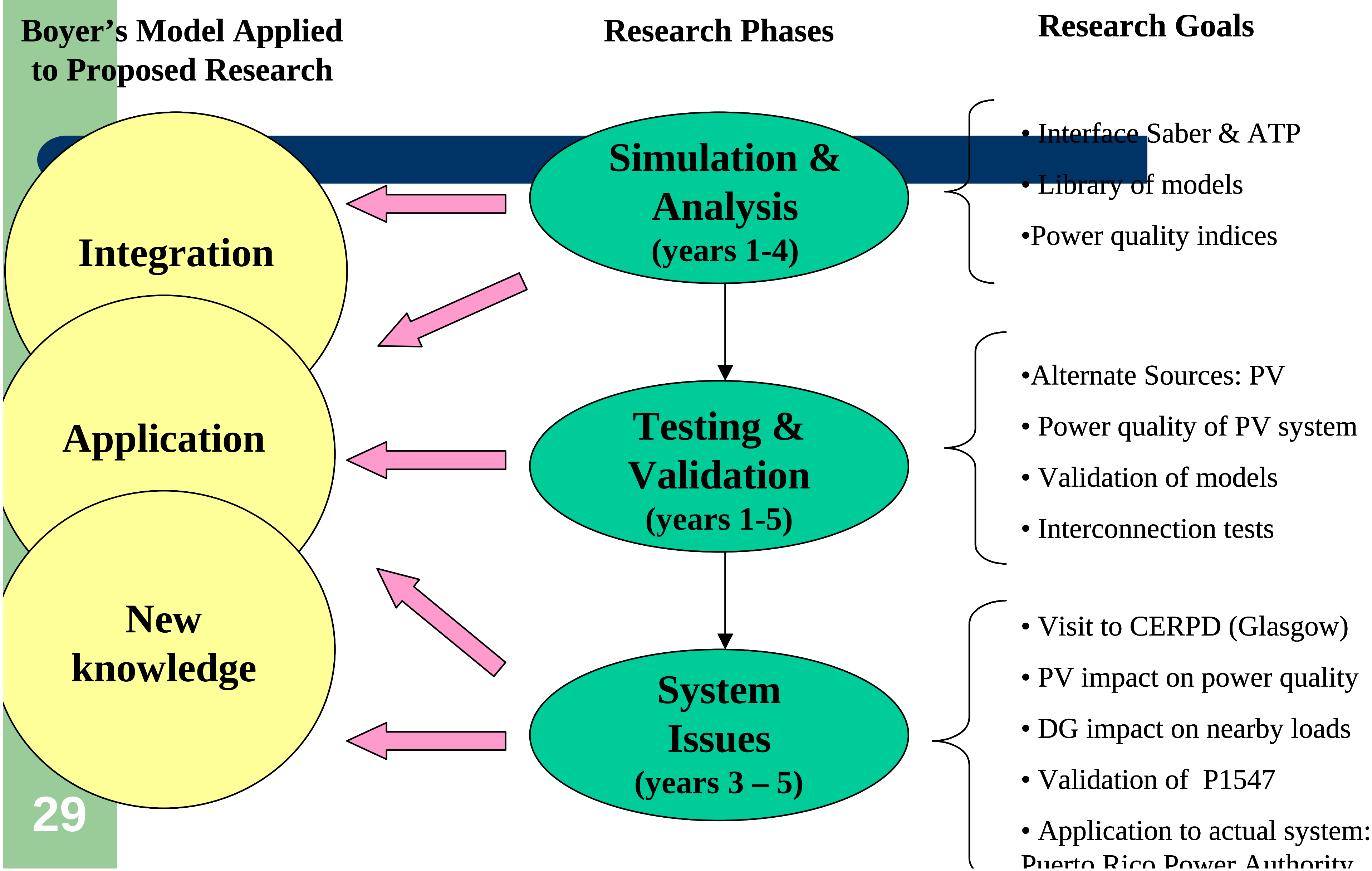
My two-cents: No one-size-fits-all. Try new things but be yourself. Adapt strategies to your circumstances, and enjoy whatever you do.

UR: LOOKING FOR A BALANCE



The Scholarship of Teaching and Learning (SoTL) presents alternative integrations. Look for Elton's paper (references) for more information on SoTL.

Boyer's Model Applied



POWER ENGINEERING EDUCATION

- ENGINEERING EDUCATION CRISIS
- RENOVATION EFFORTS
  - U.S. & local
- CHANGE IN THE EDUCATIONAL PARADIGM

SCHOLARSHIP OF TEACHING

- Undergraduate research in power quality
- Courses on power quality, energy conversion, and power electronics
- Power quality laboratory modules
- Demonstrations
- Caribbean Colloquium on Power Quality
- Energy Systems Seminar Series:
  - Distributed generation, alternate energy sources, social and ethical implications in power engineering, industry presentations

Final Thought

"We are all researchers now…Teaching and research are becoming ever more intimately related… In a 'knowledge society' all students – certainly all graduates – have to be researchers. Not only are they engaged in the production of knowledge; they must be educated to cope with the risks and uncertainties generated by the advance of science" (Scott, 2002)

From http://www.northumbria.ac.uk/sd/central/ar/lts/researchandteaching/

SOME USEFUL REFERENCES

- Council on Undergraduate Research http://www.cur.org
- M. Healey & A. Jenkins. "Transforming the student experience through developing institutional strategies to mainstream undergraduate research and inquiry for all students," Higher Education Academy Annual Conference, July 2008. *www.heacademy.ac.uk/assets/York/documents/events/conference/2008/Mick_Healey_Alan_Jenkins.doc*
- Student as a Scholar Conference, April 2007, CA. http://www.aacu.org/meetings/undergraduate_research/index.cfm
- Undergraduate Research Centers http://urc.arizona.edu/
- Rich Felder's Website http://www.ncsu.edu/felder-public/RMF.html
- FIE Conferences http://fie-conference.org/
- E. Boyer, "Scholarship Reconsidered," Carnegie Foundation, 1990.
- L. Elton's paper on the Scholarship of Teaching and Learning, http://academics.georgiasouthern.edu/ijsotl/v2n1/invited_essays/Elton/Invited_Essay_Elton.pdf

INDUSTRIAL AFFILIATES PROGRAM
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DEVELOPMENT OF TOOLS FOR THE STUDY OF CHAOTIC BEHAVIOR IN POWER ELECTRONICS

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Students

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OBJECTIVES

- COMPLETE A LITERATURE REVIEW
- SIMULATE POWER ELECTRONICS DEVICES
- ANALYZE VOLTAGE AND CURRENT FROM SIMULATIONS
- IDENTIFY CHAOTIC COMPONENTS IN POWER ELECTRONICS CIRCUITS
- DETERMINE HOW TO MINIMIZE OR CONTROL THE IMPACT OF CHAOS IN THE DEVICES
- PROVIDE A TEACHING TOOL TO DEMONSTRATE POWER ELECTRONICS PRINCIPLES

POWER ELECTRONICS

DEFINITION

ENERGY PROCESSING

CONVERTER TOPOLOGIES

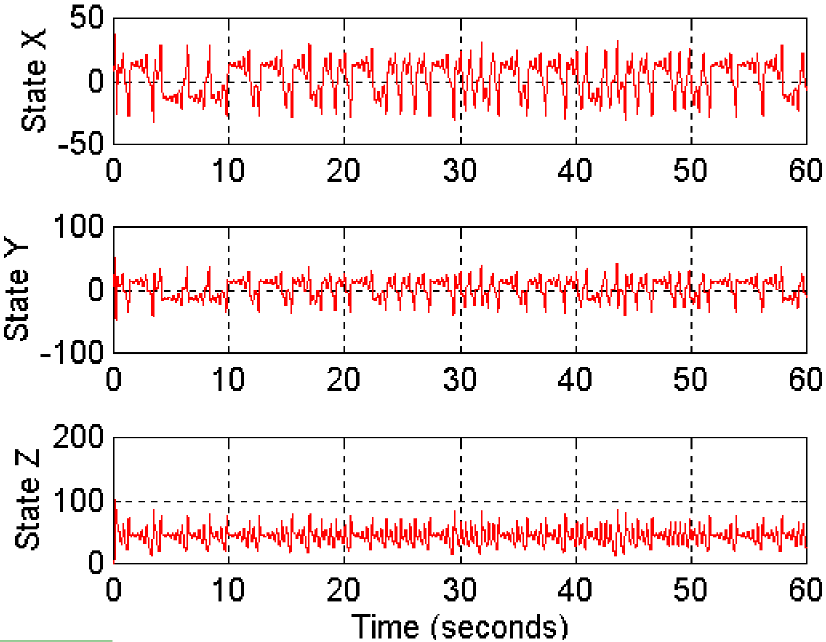
NONLINEAR PROBLEMS

- CHAOS

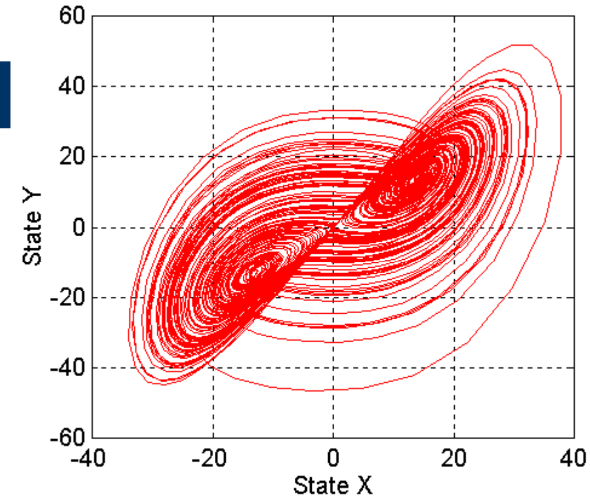
WHAT IS CHAOS?

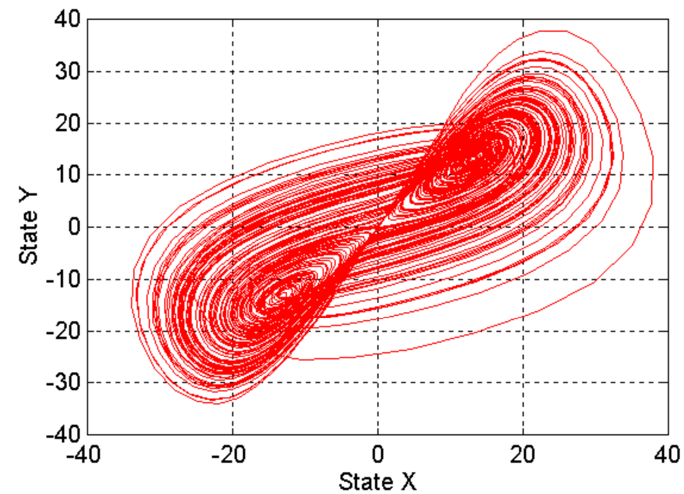
- CHAOS OCCURS IN NONLINEAR SYSTEMS
- SENSITIVITY TO INITIAL CONDITIONS IS A CHARACTERISTIC OF CHAOS
- NOT STOCHASTIC BUT DETERMINISTIC PHENOMENON
- IRREGULAR, NON-PERIODIC, BOUNDED BEHAVIOR
- POSSIBLE TO IDENTIFY CHAOS FROM MEASUREMENTS
- LYAPUNOV EXPONENTS: MEASURE SENSITIVITY TO INITIAL CONDITIONS (DIVERGENCE OF NEARBY TRAJECTORIES)

EXAMPLE OF A CHAOTIC SYSTEM



ATTRACTOR FROM STATE EQUATIONS





ATTRACTOR FROM RECONSTRUCTED STATES

MODELING TOOLS AND PROGRAMS

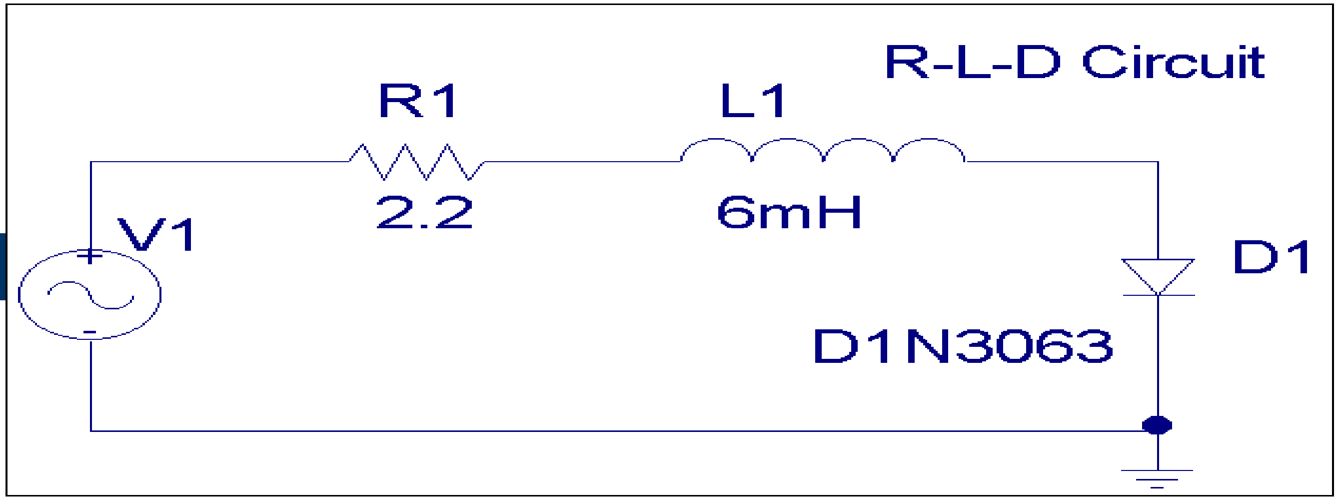
SPICE

ELECTRONIC WORKBENCH

MATLAB

FORTRAN

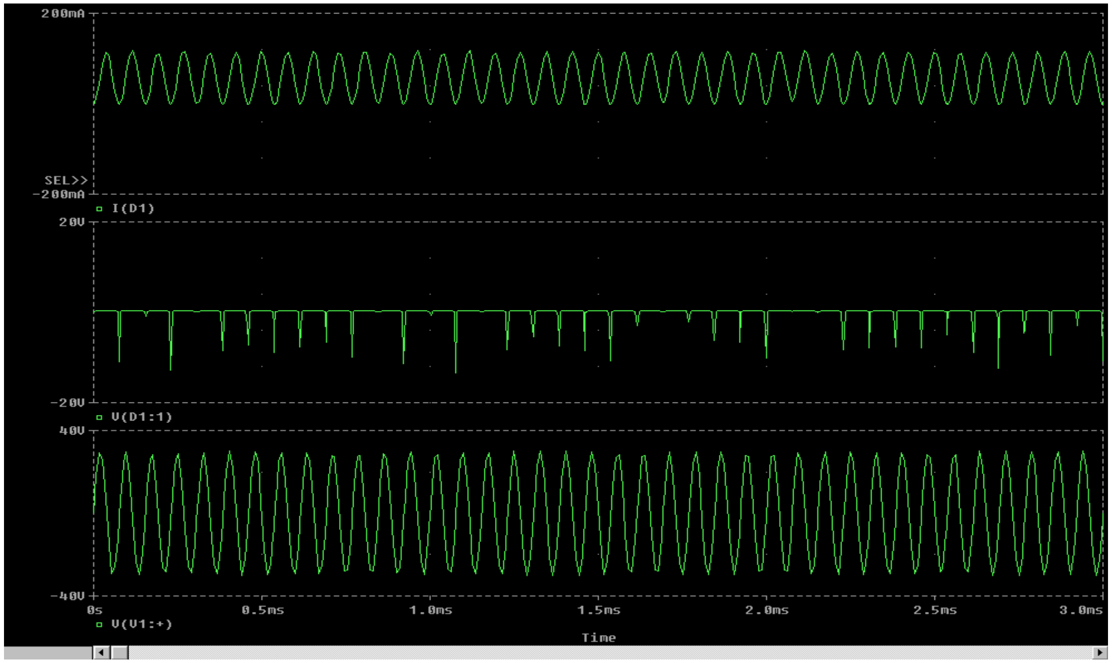
CHAOS IN AN RLD CIRCUIT



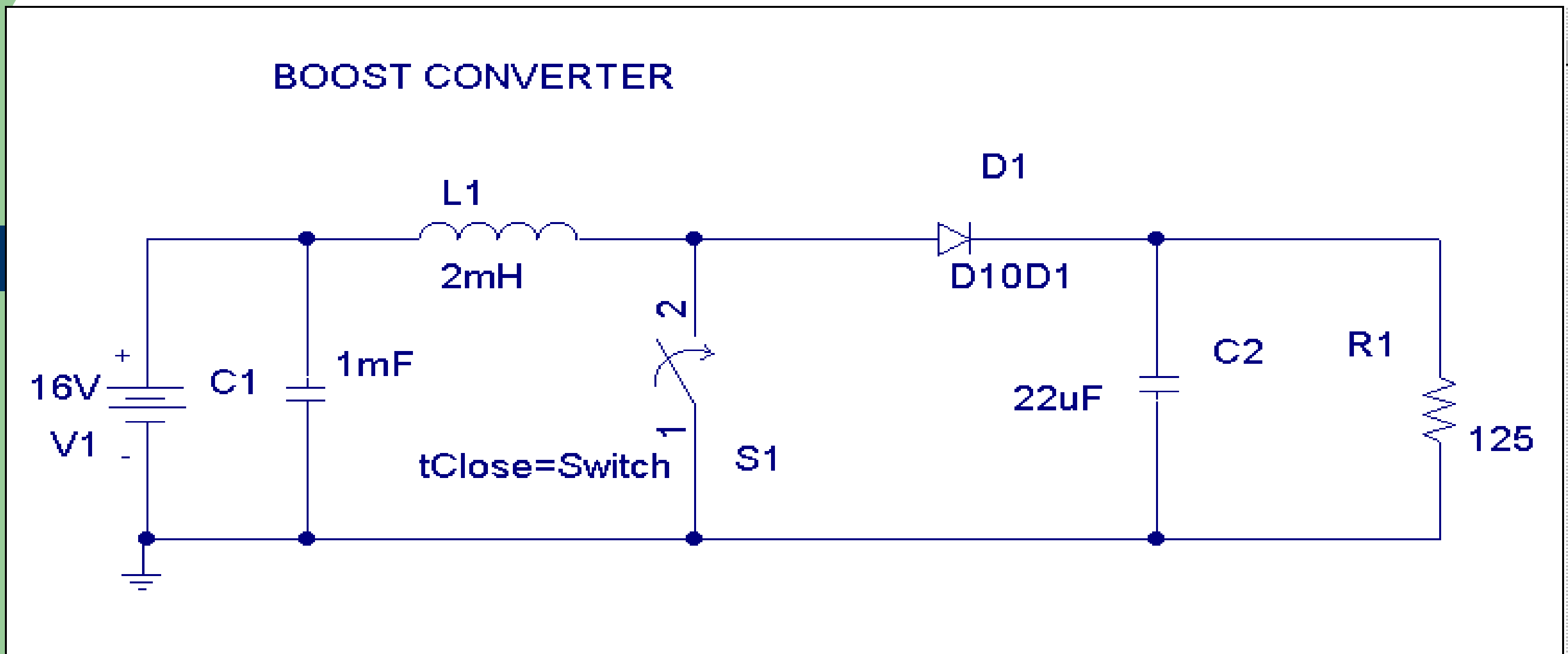
DIODE CURRENT

DIODE VOLTAGE

INPUT VOLTAGE



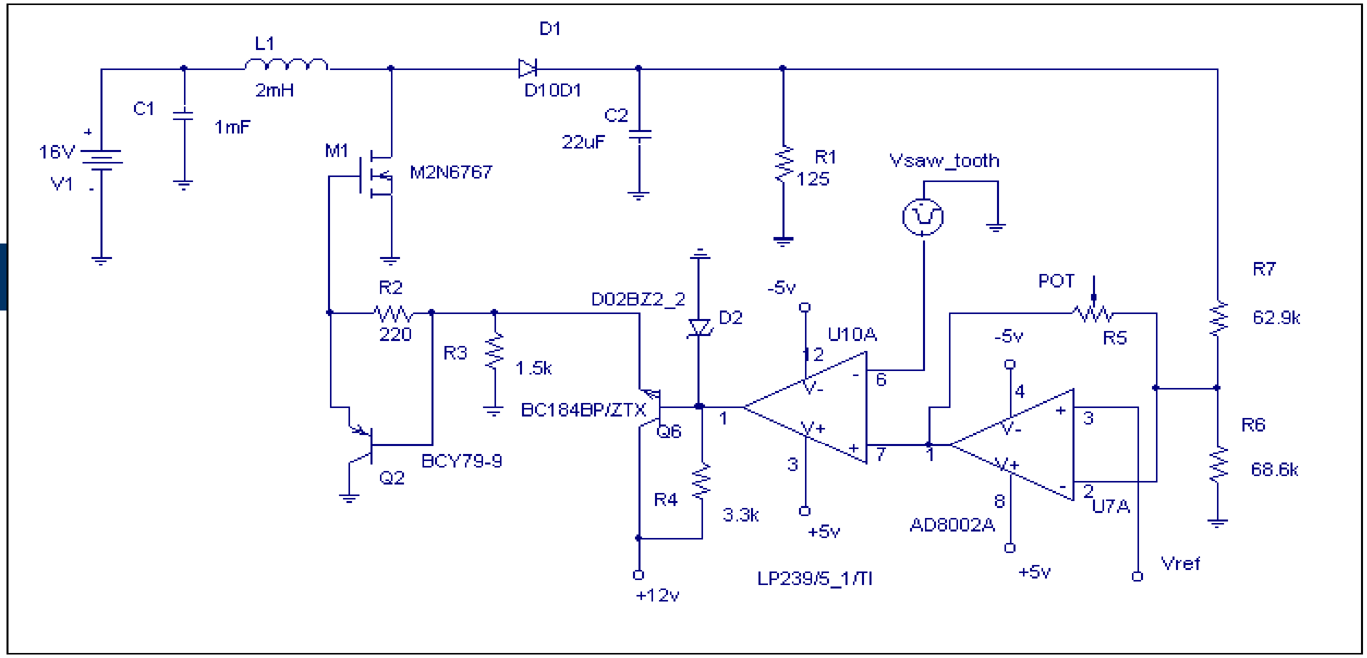
BOOST CONVERTER



DISCONTINUOUS MODE

“IDLING” INTERVAL OPERATION

CHAOS IN BOOST CONVERTER



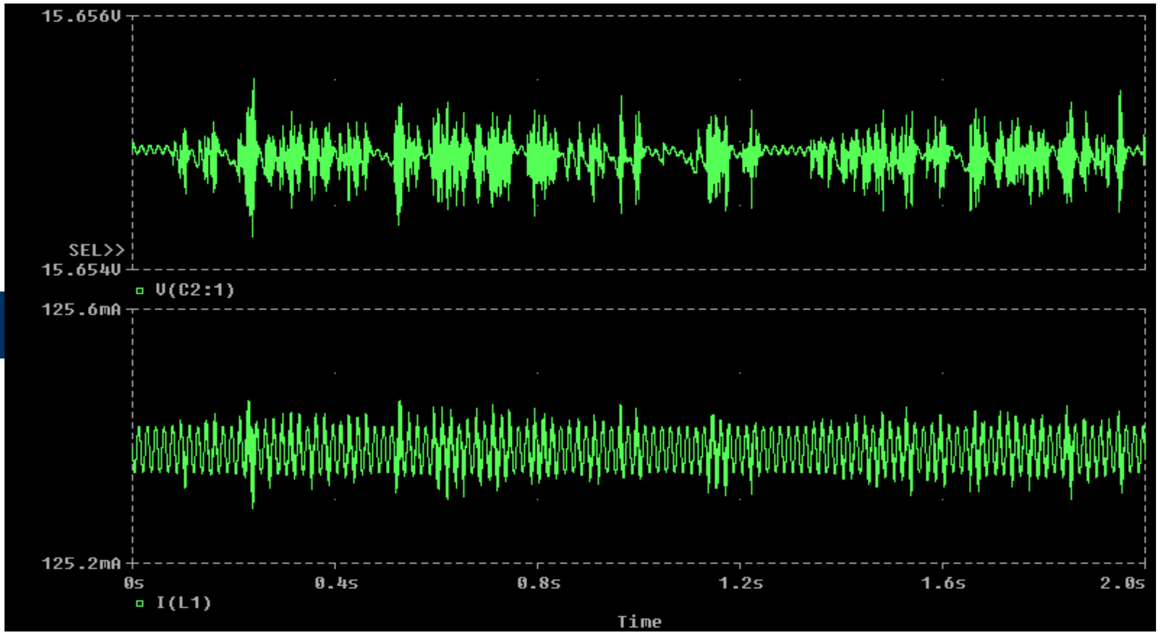
VCOM <= VSAW-TOOTH: SWITCH OFF

VCOM >= VSAW-TOOTH: SWITCH ON

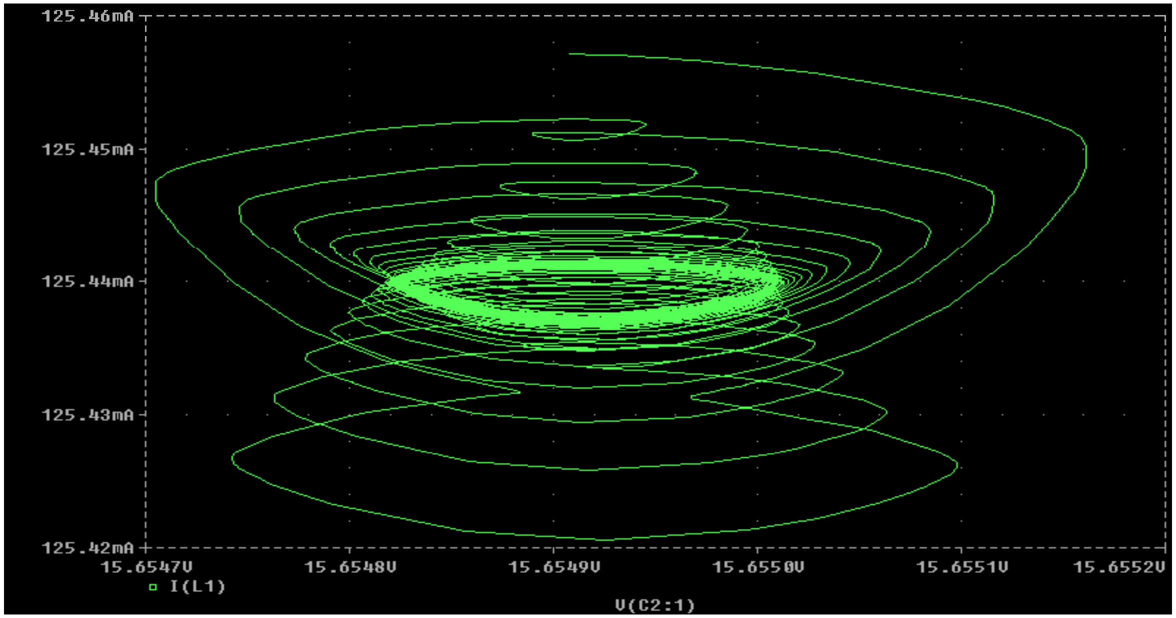
CHAOS CAUSED BY PWM SWITCHING REGULATORS

Capacitor Voltage

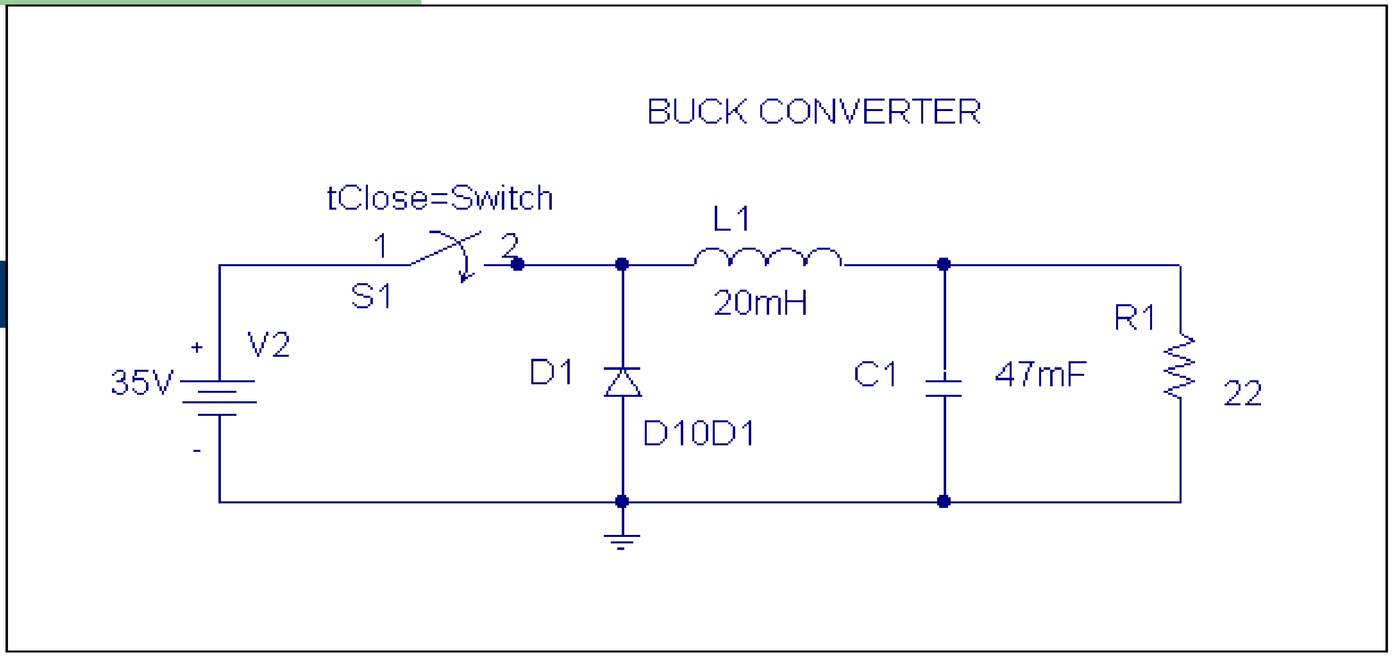
Inductor Current



ATTRACTOR

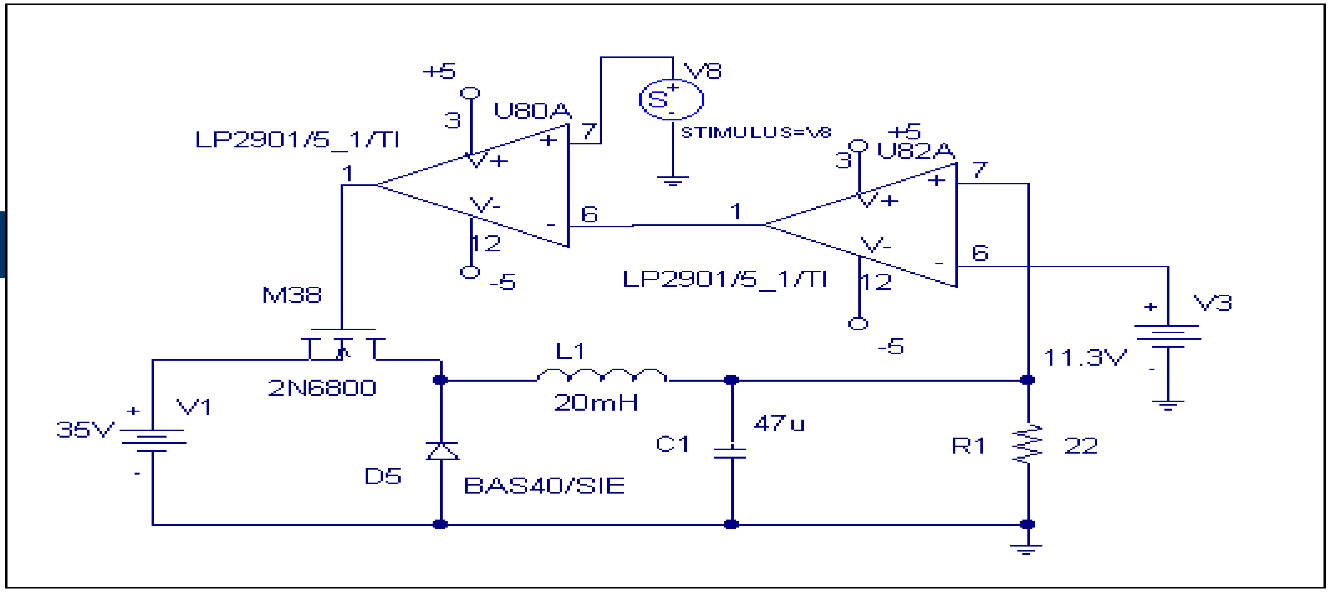


BUCK CONVERTER



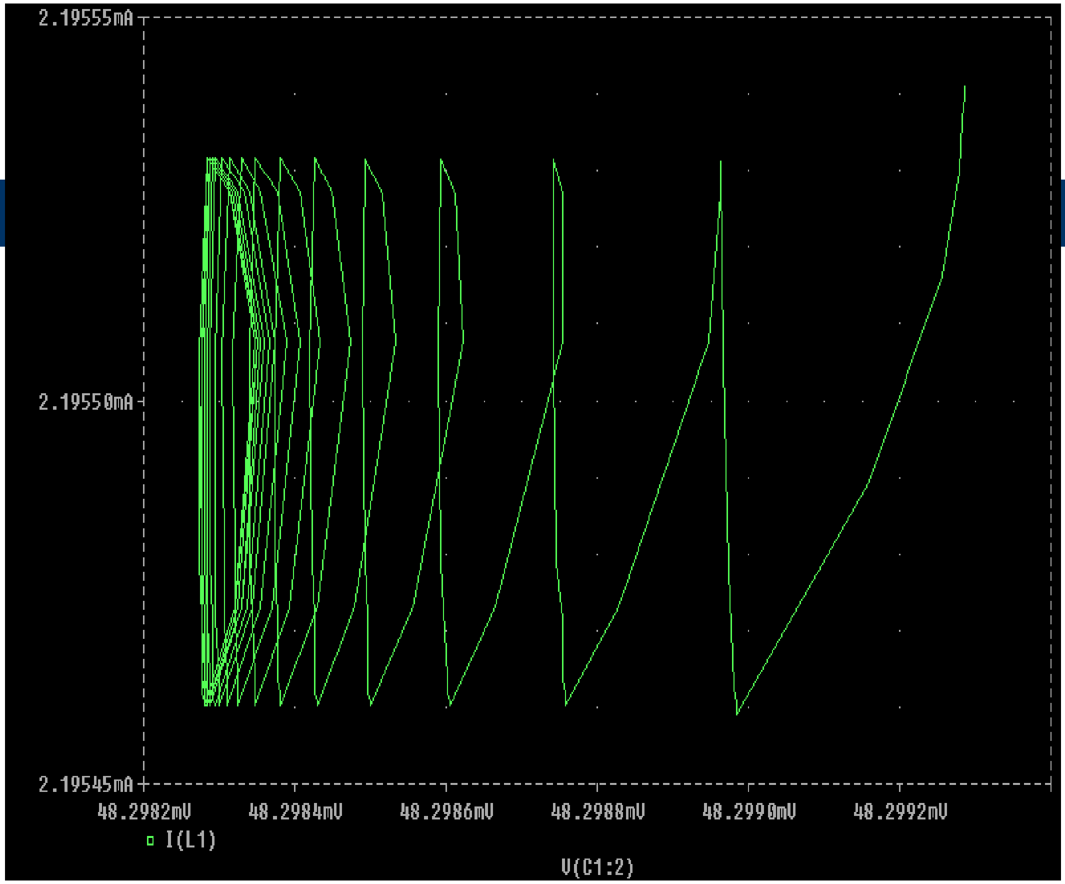
CONTINUOUS MODE OPERATION
PWM CONTROL

CHAOS IN BUCK CONVERTER



SWITCHING STATES

VALUES OF INPUT VOLTAGE

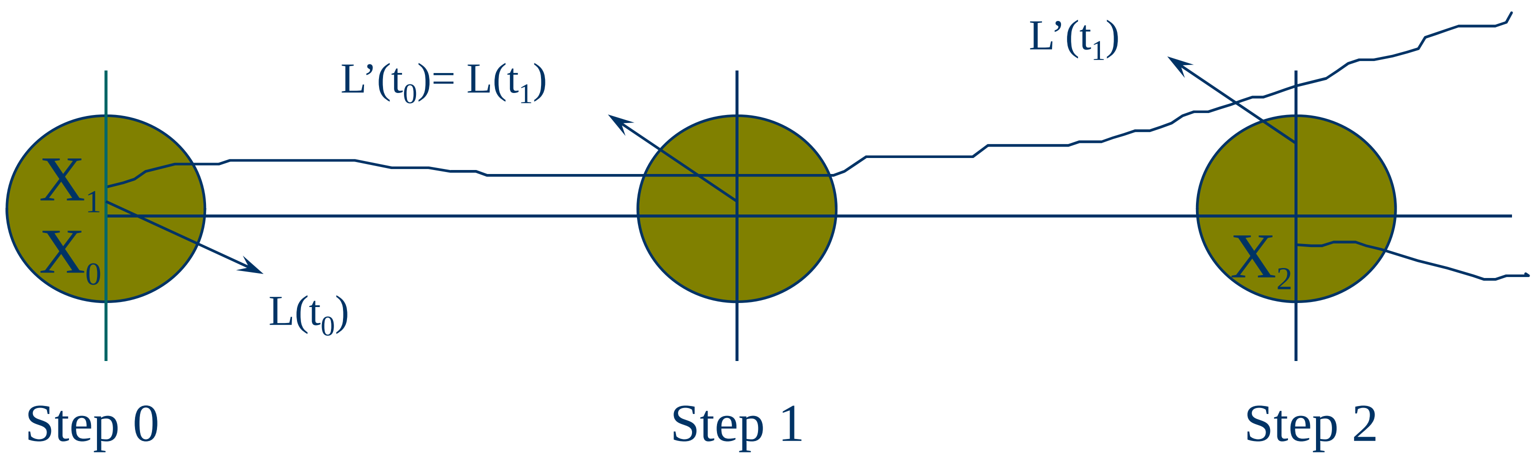


BUCK ATTRACTOR

LYAPUNOV EXPONENTS

WOLF'S ALGORITHM: ESTIMATE LARGEST LYAPUNOV EXPONENT

$$\lambda_1 = \frac{1}{t_M - t_o} \sum_{k=1}^{M} \log_2 \frac{L'(t_k)}{L(t_{k-1})}$$



LYAPUNOV EXPONENTS

- THE LYAPUNOV EXPONENT PROVIDES A QUANTITATIVE DESCRIPTION OF CHAOTIC BEHAVIOR
- A POSITIVE LYAPUNOV EXPONENT IS AN INDICATION OF SENSITIVITY TO INITIAL CONDITIONS (I.E., CHAOS)
- THE LARGEST LE CALCULATED FROM CONVERTER CURRENTS WAS POSITIVE

MITIGATION TECHNIQUES

REDUCE SWITCHING FREQUENCY

MINIMIZE FLUCTUATION CURRENT

AVOID PROTECTIVE MODE

TESTING COMPONENTS

BENEFITS FOR THE STUDENT

- LEARNED HOW TO MODEL POWER ELECTRONICS CIRCUITS
- ACQUIRED KNOWLEDGE OF CHAOS THEORY AND ITS APPLICATIONS IN ELECTRICAL ENGINEERING
- IMPROVED PROGRAMMING SKILLS
- DEVELOPED EXPERTISE IN SEARCHING PROFESSIONAL JOURNALS AND CONFERENCE PUBLICATIONS
- BECAME FAMILIAR WITH TECHNICAL WRITING AND PRESENTATION TECHNIQUES
- A TRUE TEAM WORK EXPERIENCE

CONCLUSIONS

- DEVELOPED SIMULATIONS FOR POWER ELECTRONICS DEVICES USING SPICE AND ELECTRONIC WORKBENCH
- DEVELOPED PROGRAMS FOR THE STUDY OF CHAOTIC BEHAVIOR
- COMPLETED LITERATURE REVIEW ON CHAOS IN POWER ELECTRONICS
- STUDIED CHAOS IN CURRENT AND VOLTAGE TIME SERIES FROM SIMULATIONS
- FUTURE WORK
- CHAOS IS A TRULY EXCITING FIELD - THAT'S WHAT NATURE REALLY IS !!!

Electrical and Computer Engineering Department
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Distributed Generation

Doeg Rodríguez-Sanabria
Efraín O'Neill-Carrillo

POWER ENGINEERING @ UPRM
Energizing the Future

ES^3
Energy Systems
Seminar Series

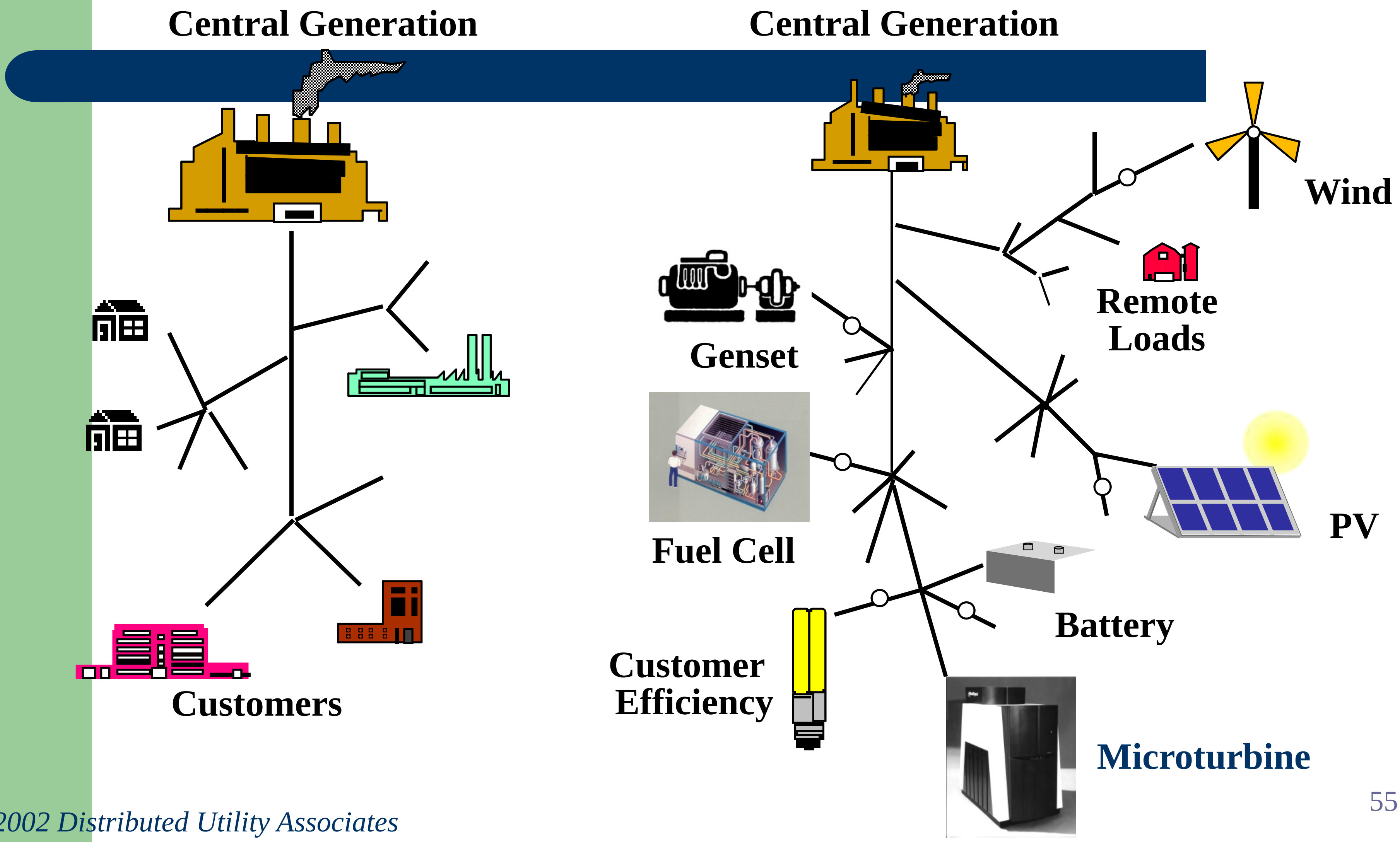
What is Distributed Generation (DG)?

- Small-scale power generation technologies located close to the load being served. Thus, connected to the distribution level
- Connected close to served loads
- Typically 10MW capacity or less
- Can also be called generational distributed resources (DR), Distributed generation (DG), distributed energy resources (DER) or dispersed power (DP)

Types of DG

- Photovoltaic cells
- Microturbines
- Fuel Cells
- Wind turbines

A future with DG



Reasons for installing DG

- Increased power quality and grid security
- Provide more reliable service
- Allow for custom power applications
- Mitigation of generation deficit
- Approximately 20% of all new generation by the year 2010 will be DG

Economics of DG

- Capital cost
- Fuel cost
- Operation and maintenance costs
- Efficiency
- Operating mode (hours) / Energy profile support
- Power quality
- Siting / environmental and other costs

Why is DG better? Is it cheaper?

- Economics is not the only driver for DG
- Power quality and integrity are major drivers for DG - energy managers.
- Emerging Technology DGs offer lower maintenance costs than conventional gen
- Improvement in environmental performance.
- Operating hours - base load Vs. peak shaving / standby
- Shelter from high volatility in electricity prices

Technology	Recip. Eng.: Diesel	Recip Eng.: NG	Micro-turbine	Combust. Gas Turbine	Fuel Cell
Size	30kW - 6+MW	30kW - 6+MW	30-400kW	0.5 - 30+MW	100-3000 kW
Installed Cost ($/kW)	600-1,000	700-1,200	1,200-1,700	400-900	4,000-5,000
Elec. Efficiency (LHV)	30-43%	30-42%	14-30%	21-40%	36-50%
Overall Efficiency	~80-85%	~80-85%	~80-85%	~80-90%	~80-85%
Total Maintenance Costs ($/kWh)	0.005 - 0.015	0.007-0.020	0.008-0.015	0.004-0.010	0.0019-0.0153
Footprint (sqft/kW)	.22-.31	.28-.37	.15-.35	.02-.61	.9
Emissions (gm / bhp-hr unless otherwise noted)	NO_x: 7-9 CO: 0.3-0.7	NO_x: 0.7-13 CO: 1-2	NO_x: 9-50ppm CO: 9-50ppm	NO_x: <9-50ppm CO:<15-50ppm	NO_x: <0.02 CO: <0.01

DG's Pros & Cons

Positives

- Growth prospects are solid across all technology types
- Potential benefits to grid, air quality, energy sector, job market, and manufacturing sector, and end users just being recognized
- New legislation, agencies, incentive programs present prospects for growth

Negatives

- Inconsistent and conflicting policies coming from various State entities
- Tariff structures that thwart or inhibit development
  - standby charges, demand charges, exit fees
- Complex vs simplified compliance requirements
  - many jurisdictions, lack of standardization
- Incumbent utilities slow to embrace private ownership
- Lack of strong DER industry trade / advocacy group

Possibilities or uses of DG

- Voltage regulation services
- Network stability services
- Mitigation of energy imbalances
- Increase of service reliability
- DG sitting can be included in DN expansion plans

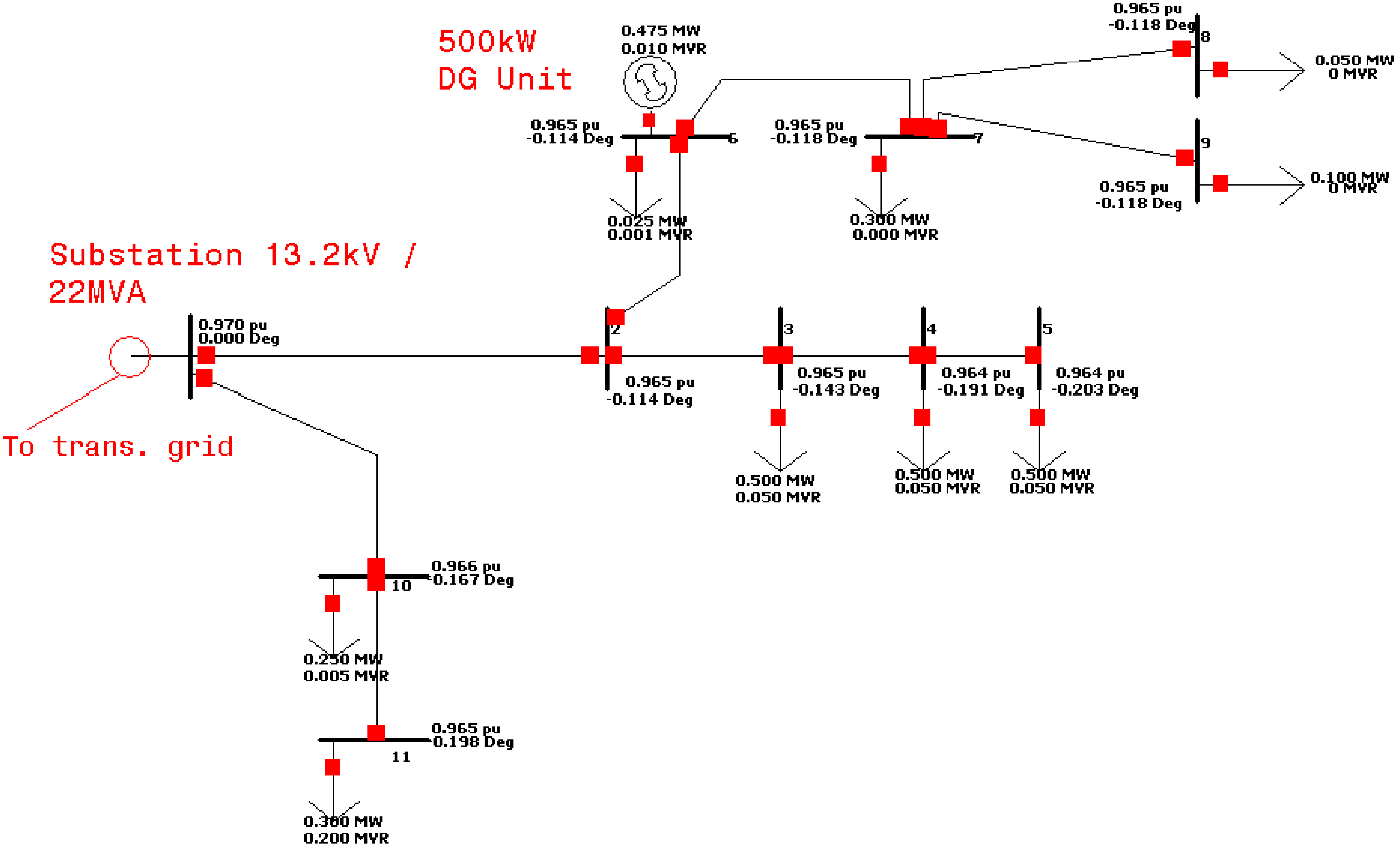
Impacts of DG sitting

- Feeder dependence for voltage regulation
- Modification of network voltage level profiles
- Transformer tap setting conflicts
- Multiple fault currents

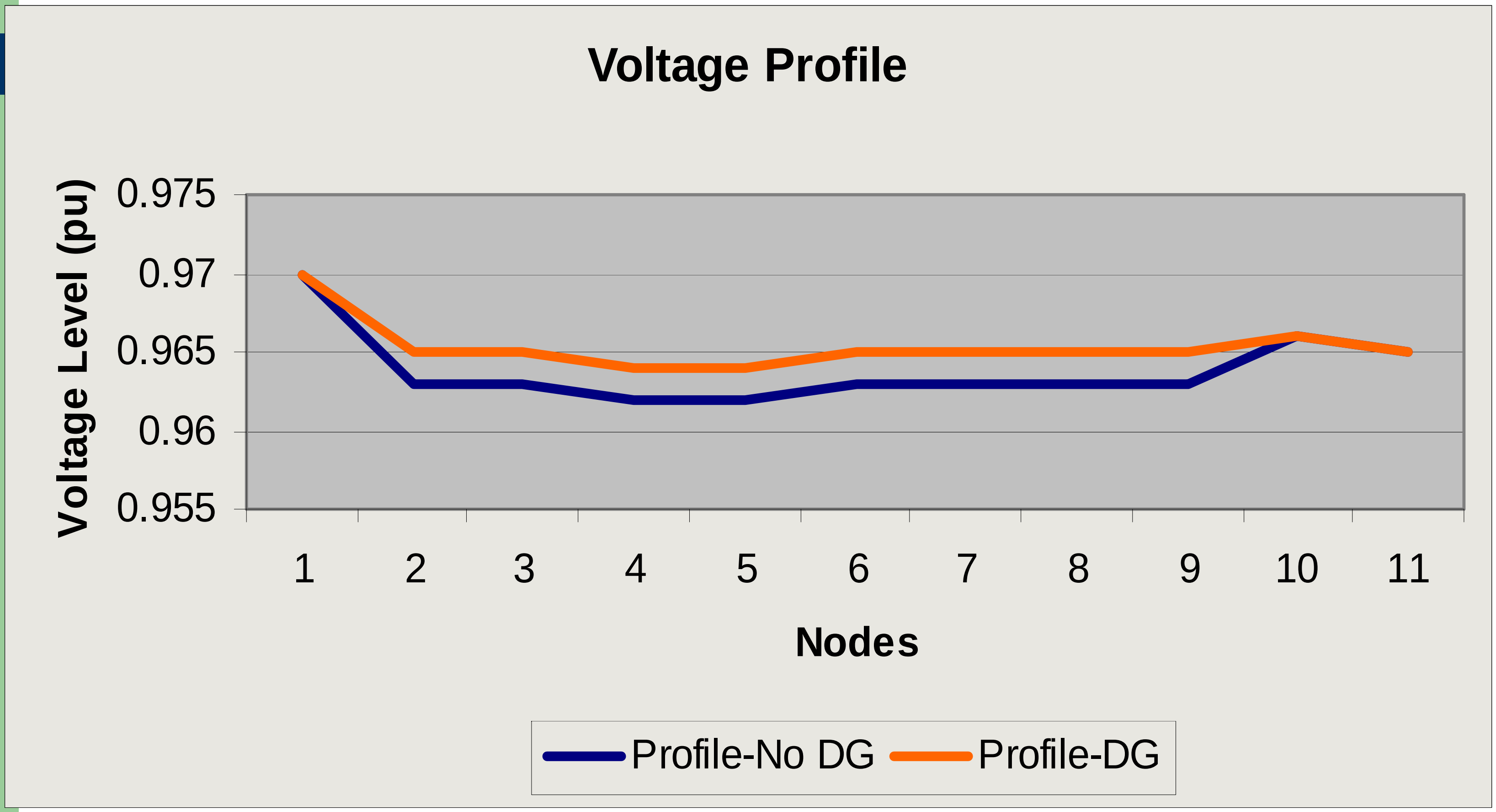
Impacts of DG sitting

- Increased fault current due to DG current injection
- Flicker caused by DG units may cause "regulator hunting"
- Possibility of harmonic current injection by PE interfaced DG

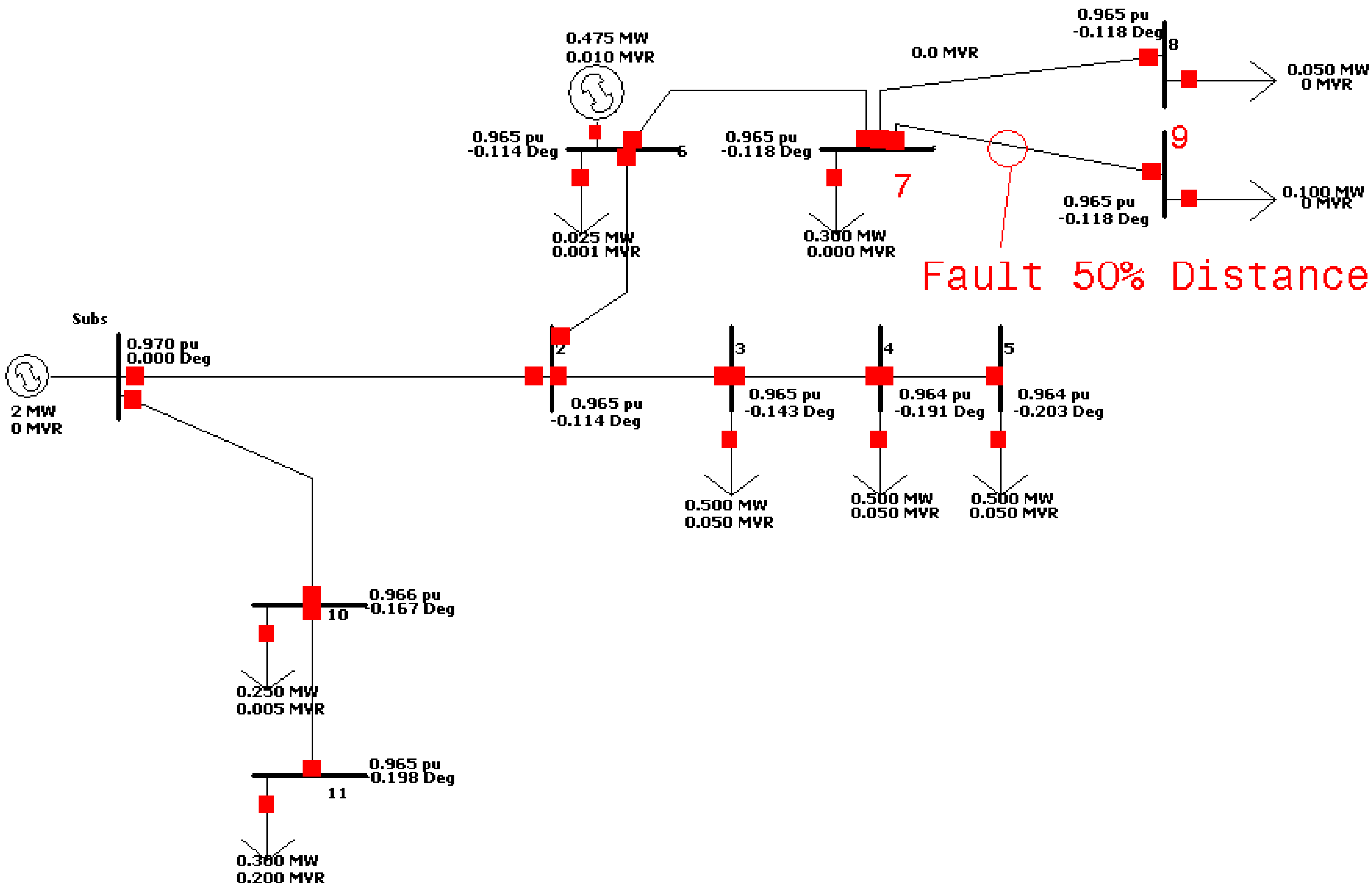
Rural Distribution Feeder - 13.2kV



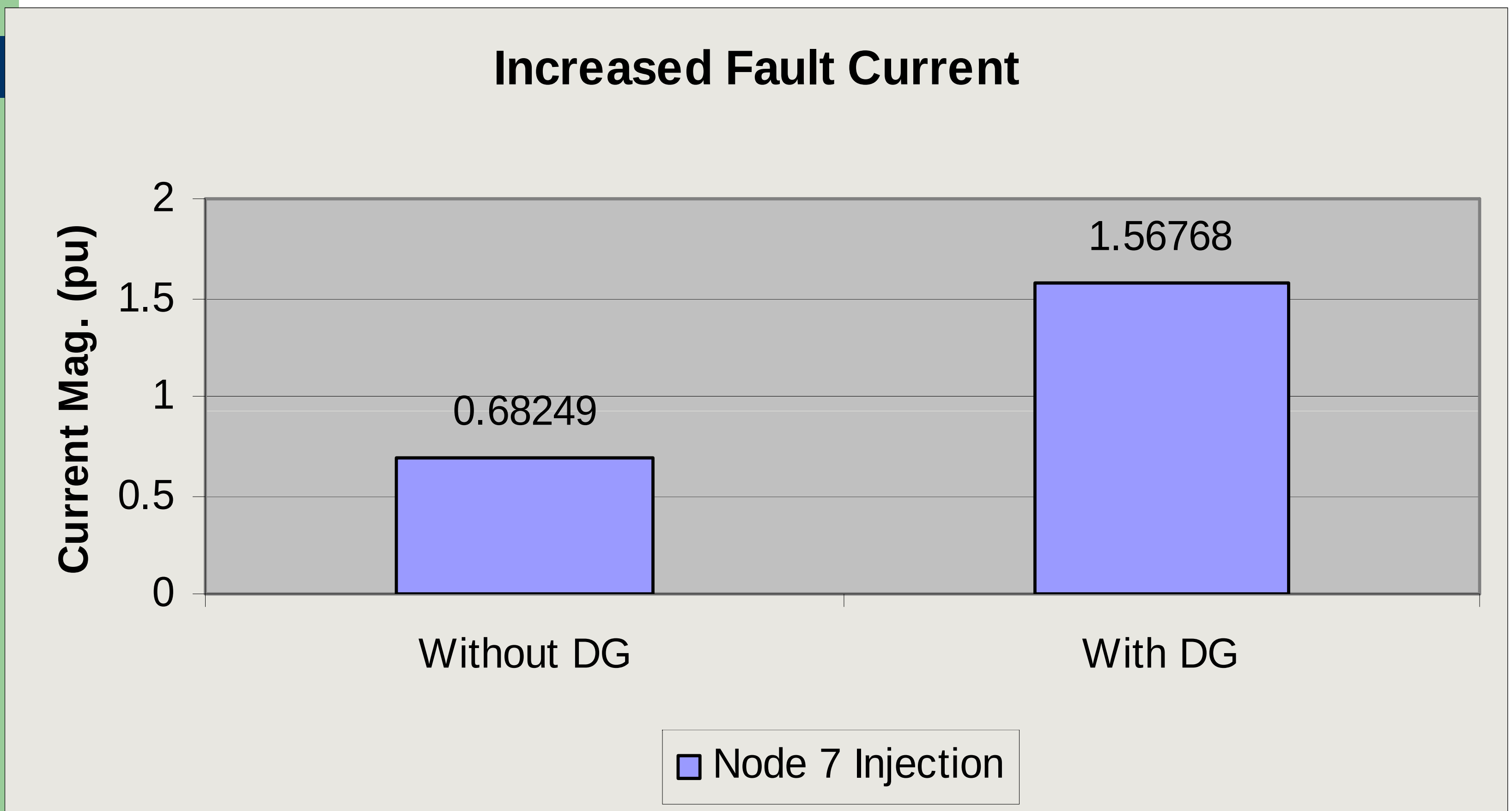
Voltage profile impact



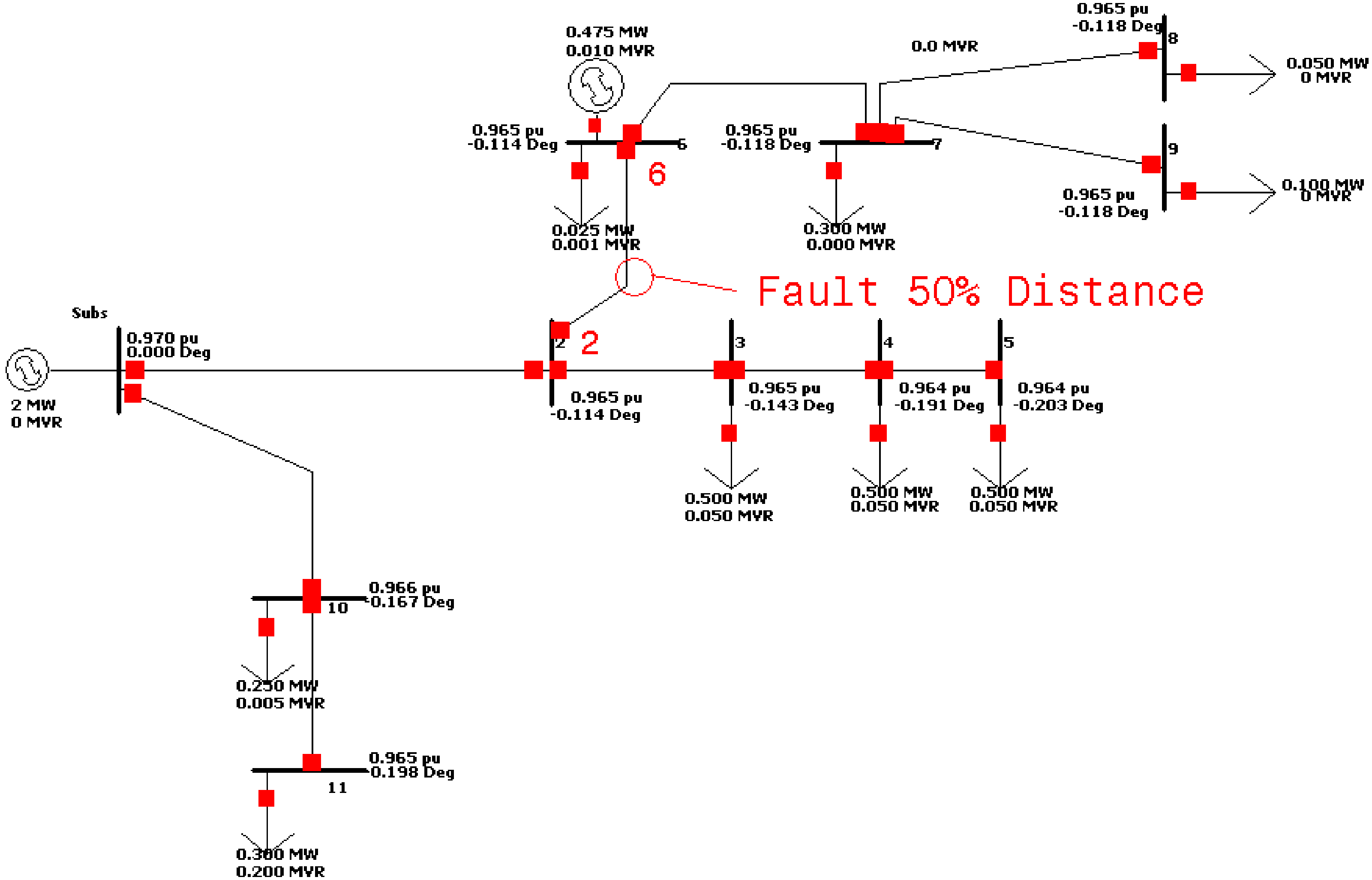
Fault event 1-Line-Ground



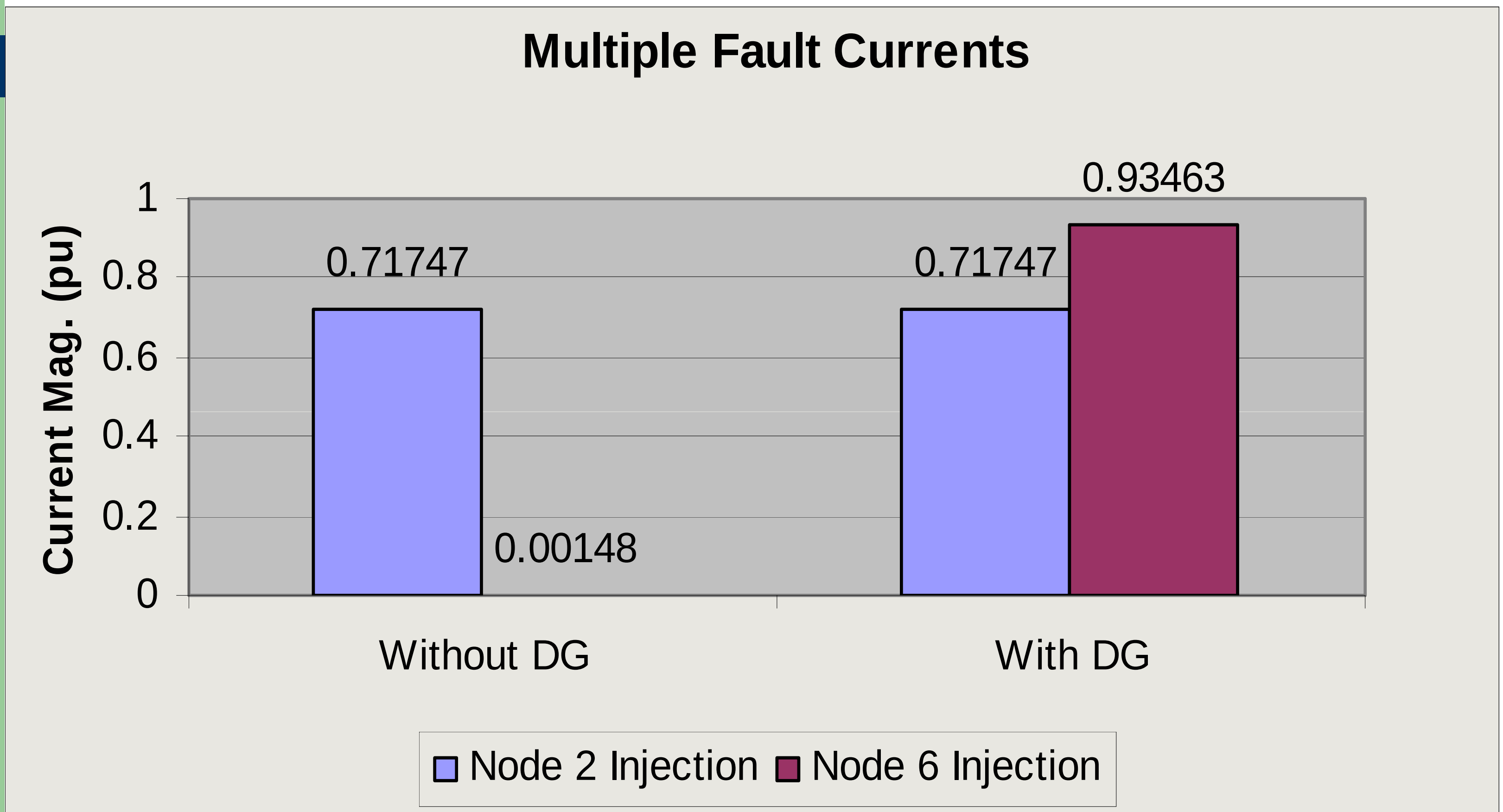
Fault Current Increase



Multiple fault currents



Multiple Fault Current Creation



Future Work

- Transient response of DG units in presence of faults
- ATP modeling of DG units
- Creation of Educational modules
- Creation of updated protection schemes for DN featuring DG
- Propose DG interconnection for use in local power systems