Experiences With Using The RTDS Simulator As A Tool In University Undergraduate Teaching

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USER SPOTLIGHT SERIES BY RTDS Technologies

BACKGROUND

- Although currently a representative for RTDS Technologies, I was previously an academic (and RTDS Technologies customer) in South Africa.
- I was responsible, as its Technical Manager, for developing and running the **Real Time Power Systems Studies (RTPSS) Centre**, a collaborative initiative between the Durban University of Technology **(DUT)**, University of KwaZulu-Natal **(UKZN)**, and **Eskom** (South Africa's state power utility and the main industry funder).
- Somewhat unusually, although applied research was one of Eskom's goals in establishing the RTPSS Centre, it was not the main goal.
- The main goals of the RTPSS Centre were:
  - ➢ To address critical skills shortage in power systems and power engineering;
  - ➢ To foster collaboration between industry and academia in these fields.

BACKGROUND

- By chance the industry (Eskom) representatives on the RTPSS Centre Steering Committee were protection engineers.
  - This led to a 10-year collaborative partnership in which RTDS real time simulators were used to train undergraduate students in protection principles via Final Year Design / Thesis project assignments.
  - Also led to applied industry research and testing of protection systems in the Centre and stimulated a new graduate-student research area at the university.
- In addition to protection systems, I was responsible for a final-year undergraduate course in Power Systems Stability.
  - RTDS real-time simulators were also used for undergraduate teaching in this area, both in the form of Final Year Design / Thesis projects and as a platform for live demonstrations of stability phenomena during selected lecture periods.

PRESENTATION FOCUS

Since many university real-time simulator installations are research focused, this presentation aims to share some experiences from an alternative use case in undergraduate teaching, in particular:

- How we dealt with the challenge of training final-year undergraduate students to use a real-time simulator and connect hardware protection and control equipment to the simulator for closed-loop testing during their projects.

- How we dealt with the challenge of allowing students to carry out open-ended, self-directed work required in final-year thesis project assignments on expensive simulator and interfacing equipment.

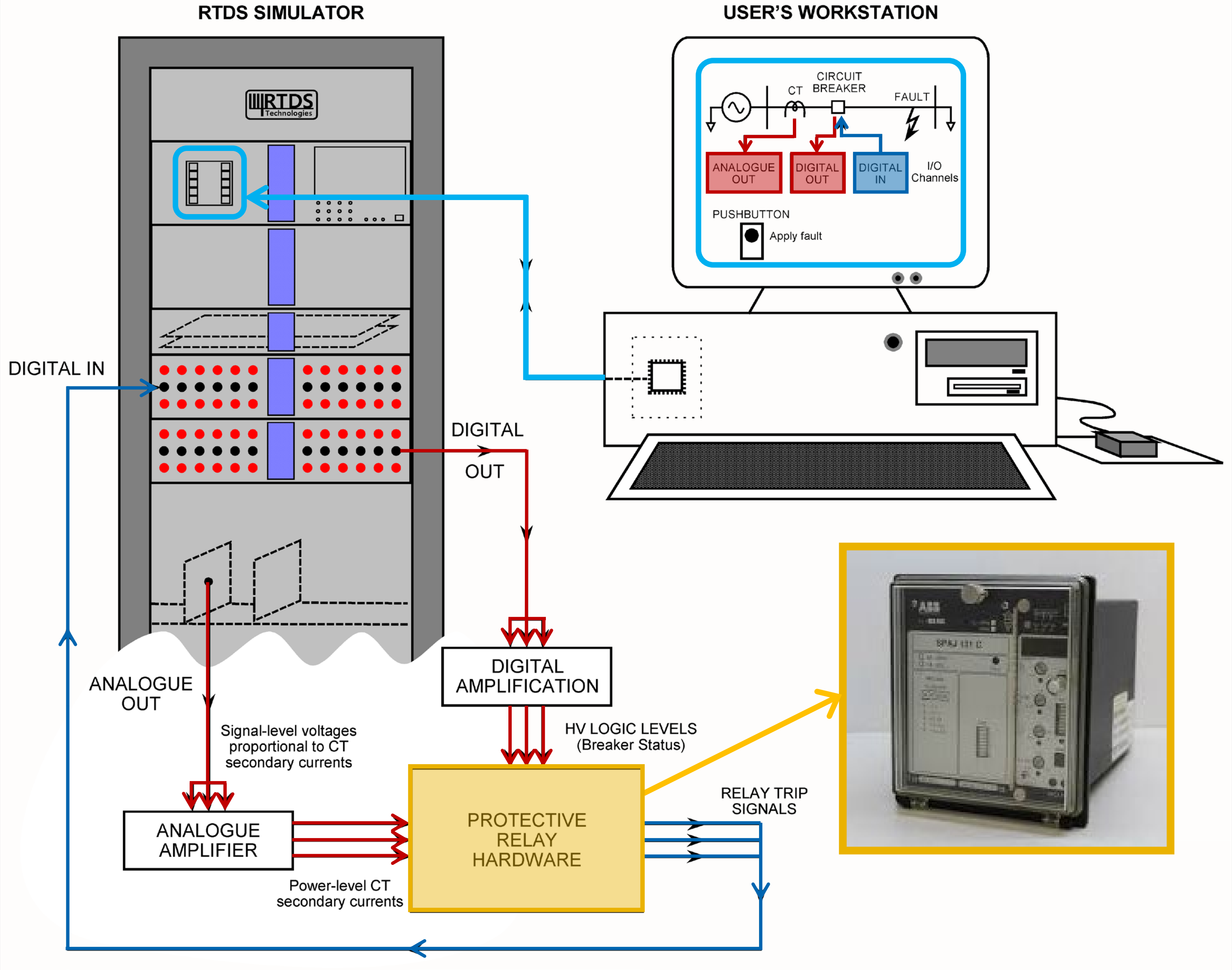
- Discuss some typical real-time simulator project assignments and teaching and demonstration examples arising from this initiative.

TRAINING / LEARNING APROACH FOR FINAL-YEAR RTDS SIMULATOR PROJECTS

Thirteen-week duration of the projects divided into three key stages:

- Highly-structured initial stage (1 week) – pure student training;
- Semi-structured intermediate stage (approximately 2 weeks) – close oversight of students starting to work independently on simulators and their project hardware;
- Final stage, self-directed student work on project assignment (10 weeks) – no further training for students, project supervision only.

Highly-structured initial one-week simulator training



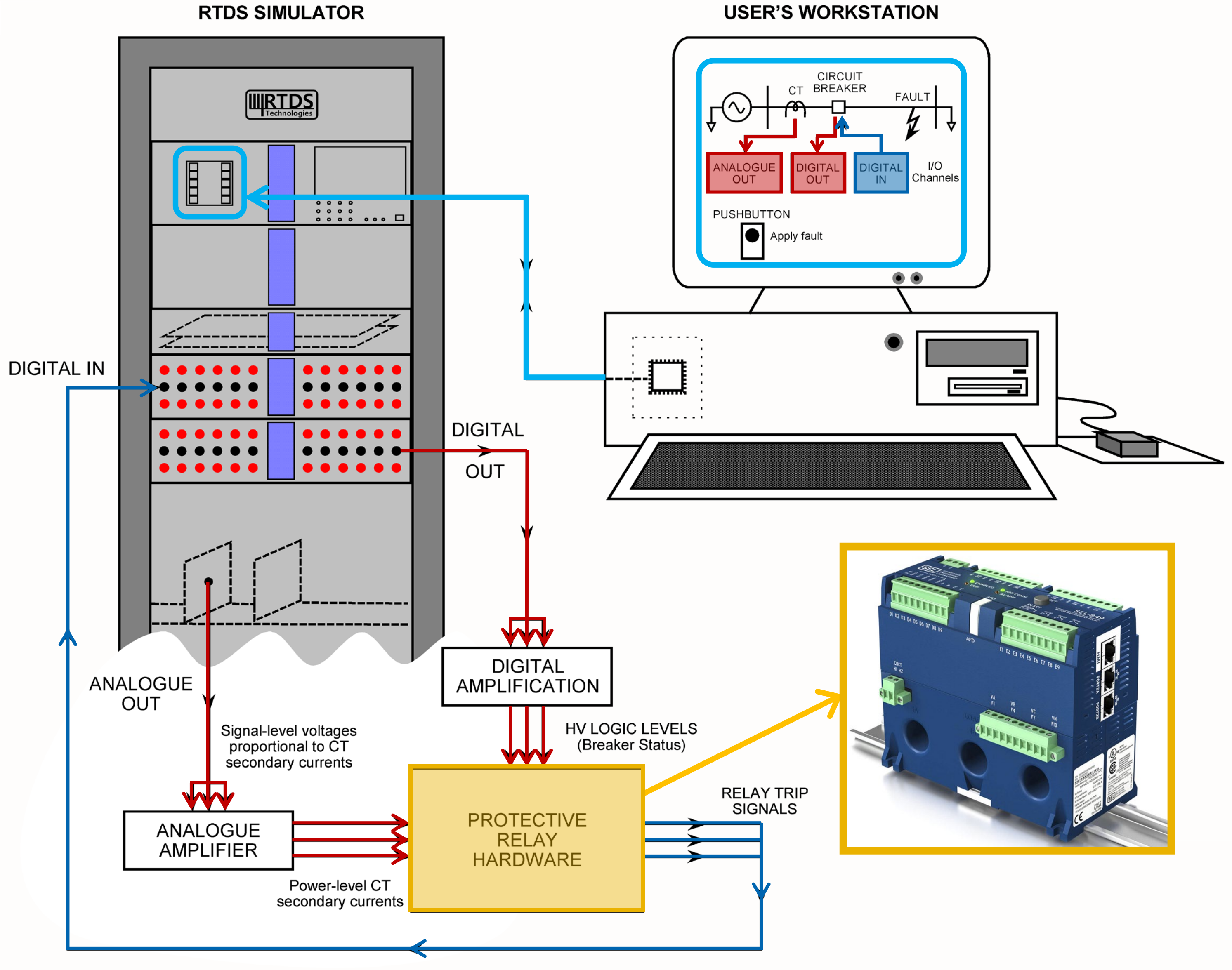
Compile and run simple power system simulation cases.

Configure I/O for HIL tests:

- Analogue outputs.
- Digital outputs.
- Digital inputs.

Set the hardware O/C relay and verify closed-loop, HIL tripping for simple fault scenarios.

Highly-structured initial one-week simulator training



Compile and run simple power system simulation cases.

Configure I/O for HIL tests:

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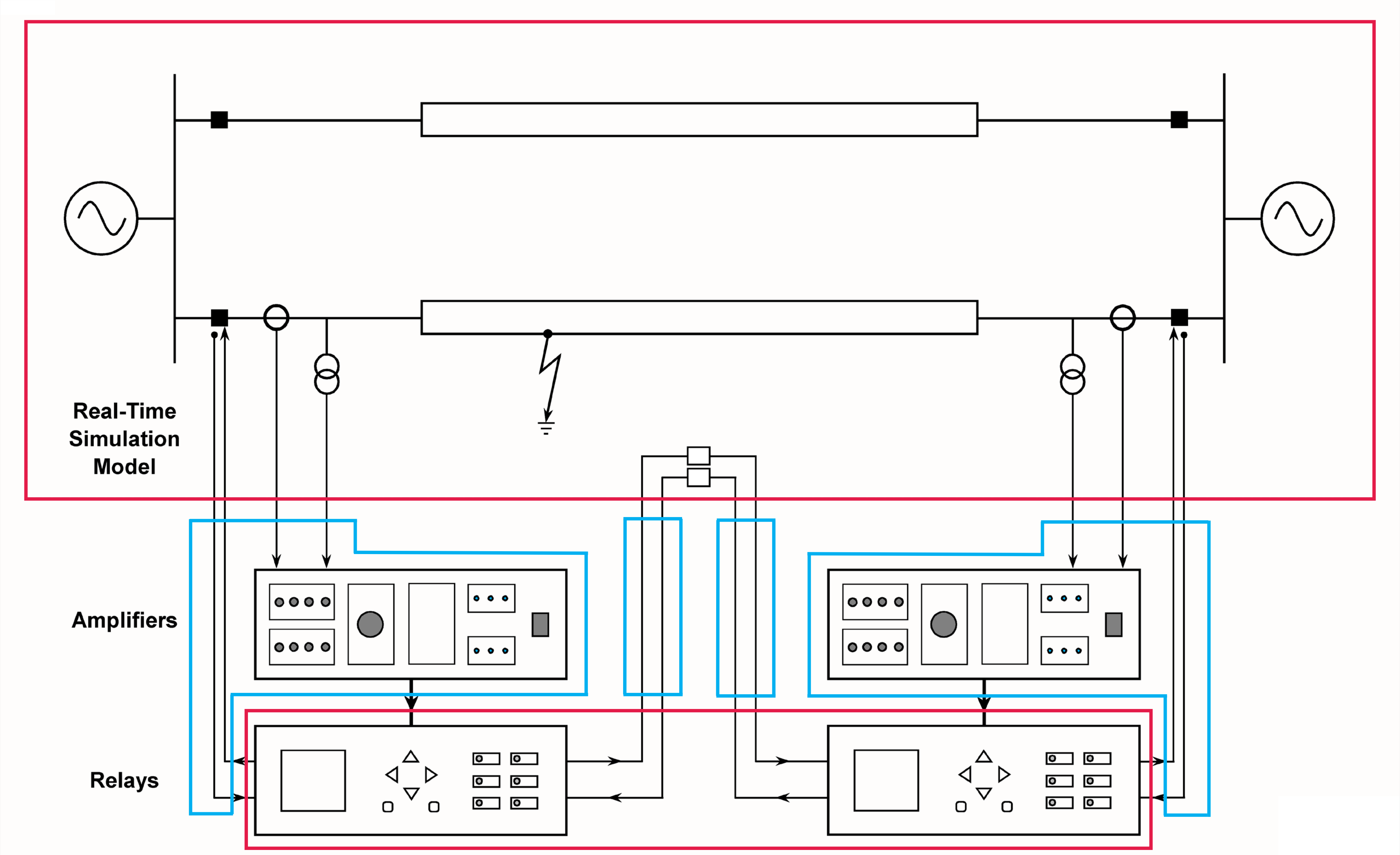
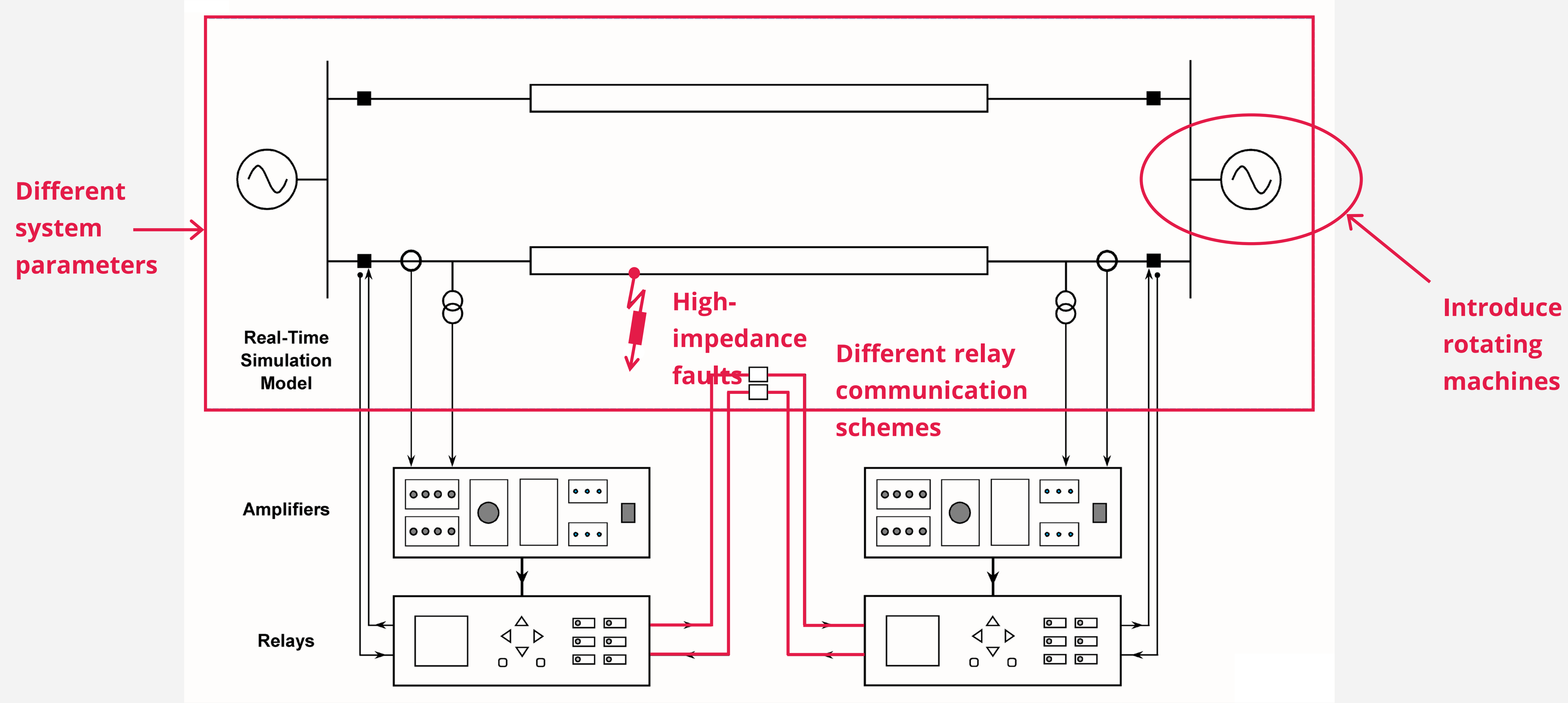
Semi-structured two-week intermediate stage

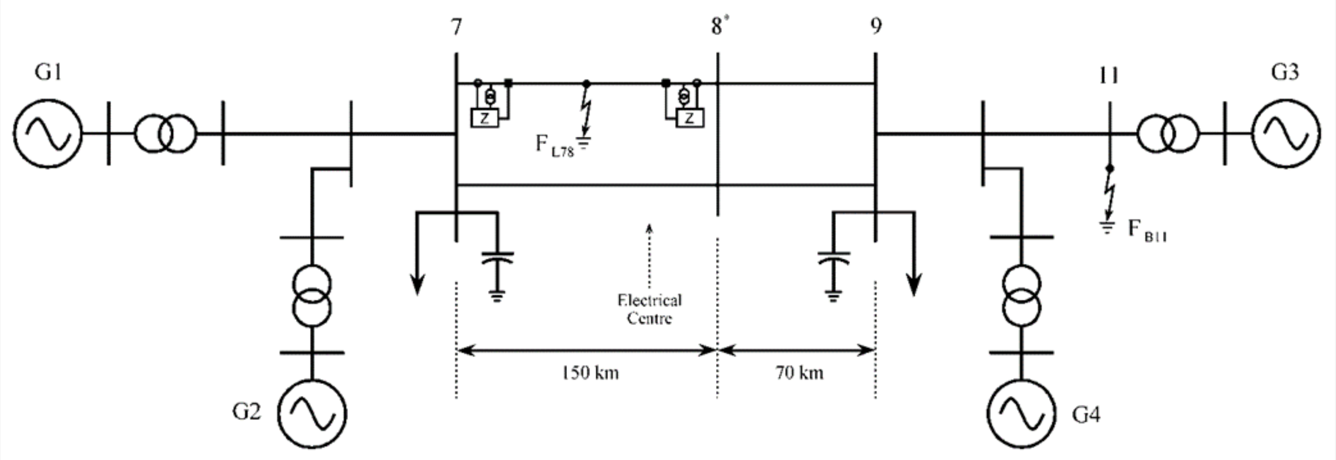


Final self-directed learning stage – the same system topology can be used as the basis for many unique project assignments

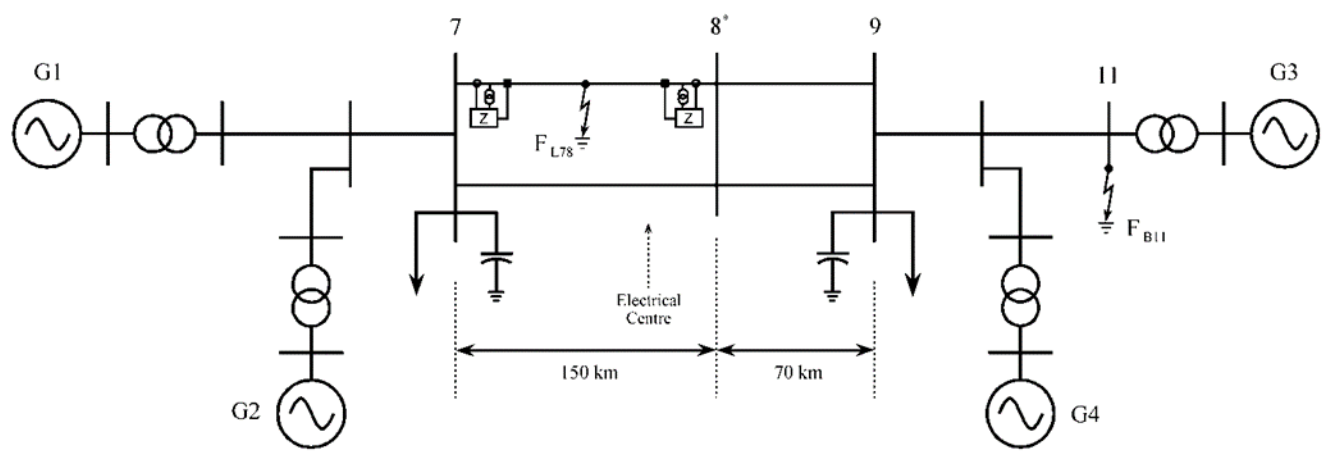


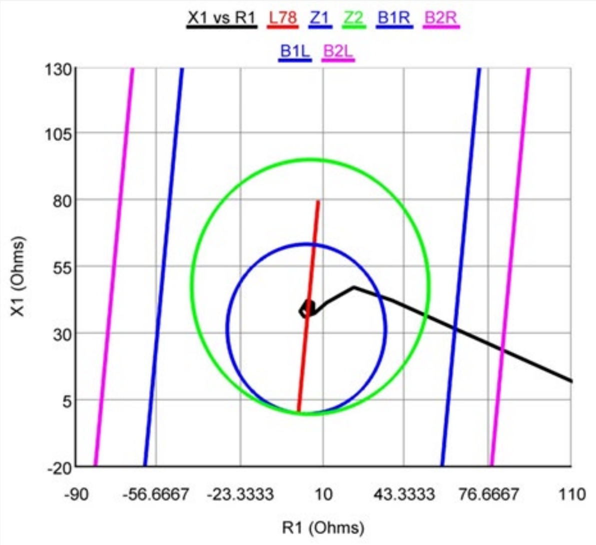
PROJECT EXAMPLES: PROTECTION SYSTEMS

Kundur’s four-generator, two-area study system used to extend a standard distance protection project to include out of step settings for stable and unstable generator swings.

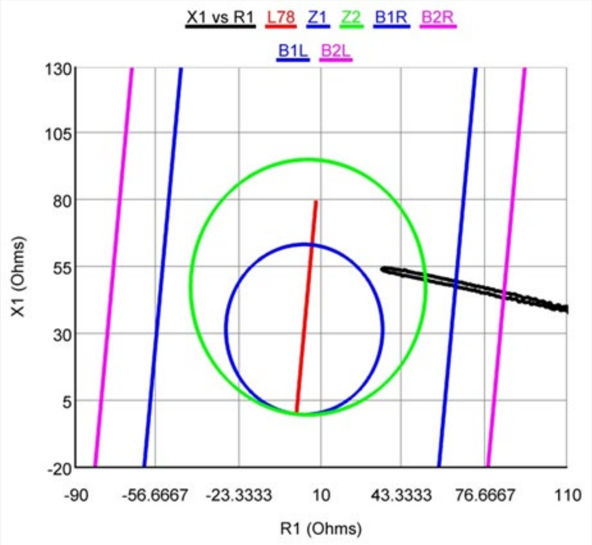


Distance Protection Project with OOS Tripping / Blocking Settings - Results

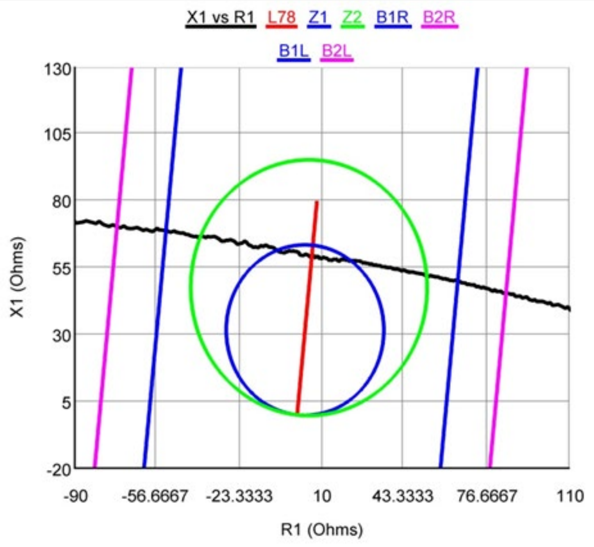




Internal fault on protected line.



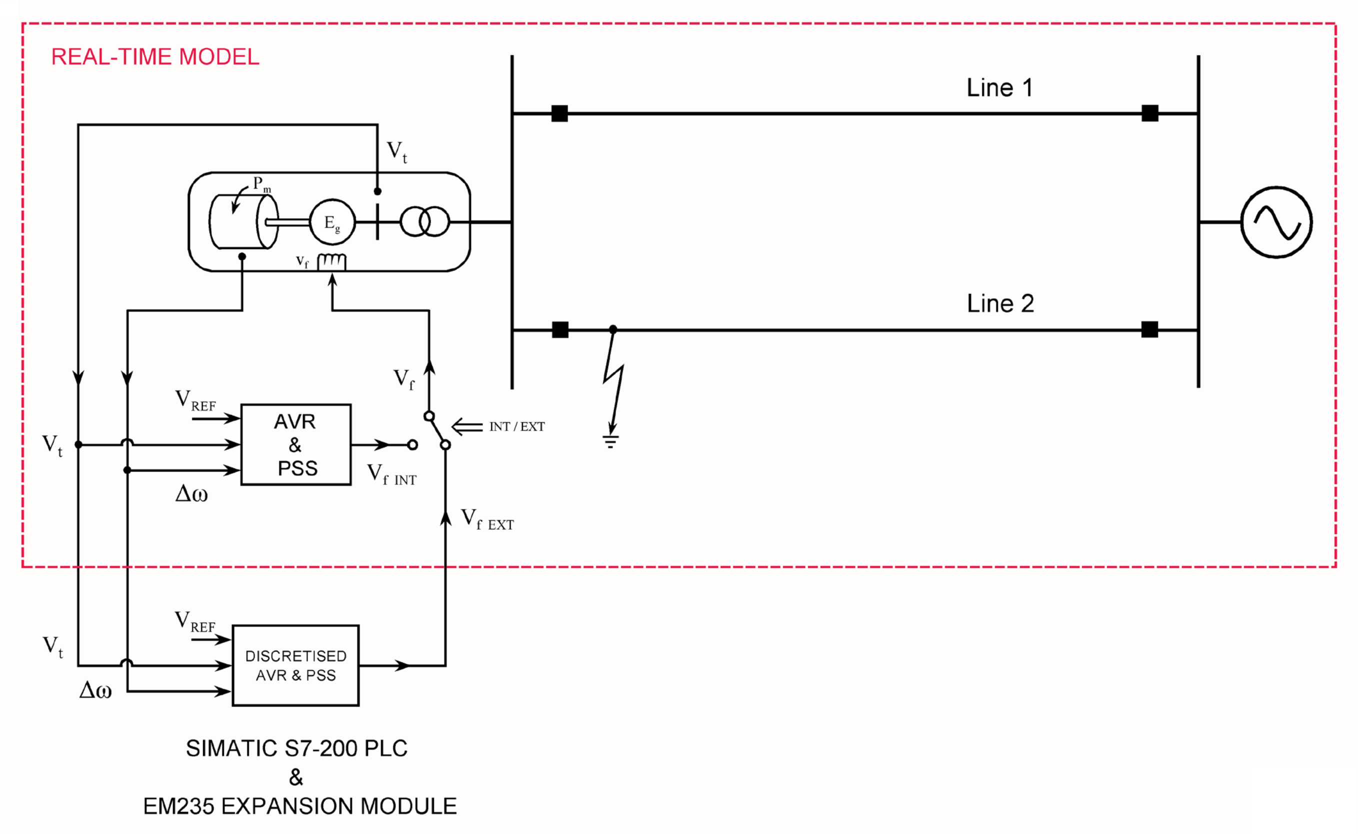
Stable inter-area swing encroaching into relay zones on protected line.

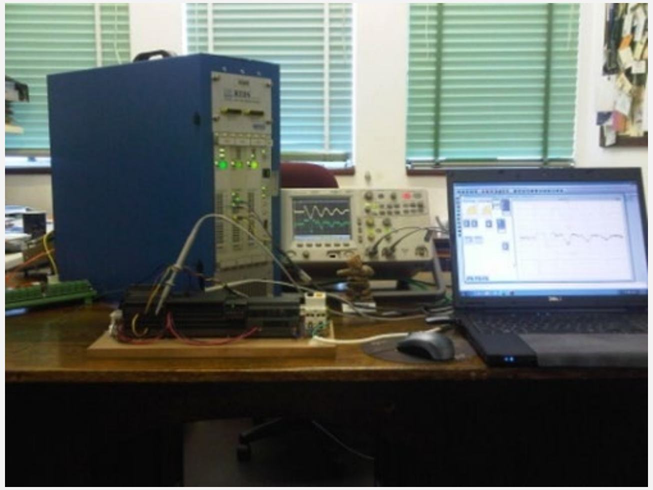


Unstable inter-area swing passing through relay zones on protected line.

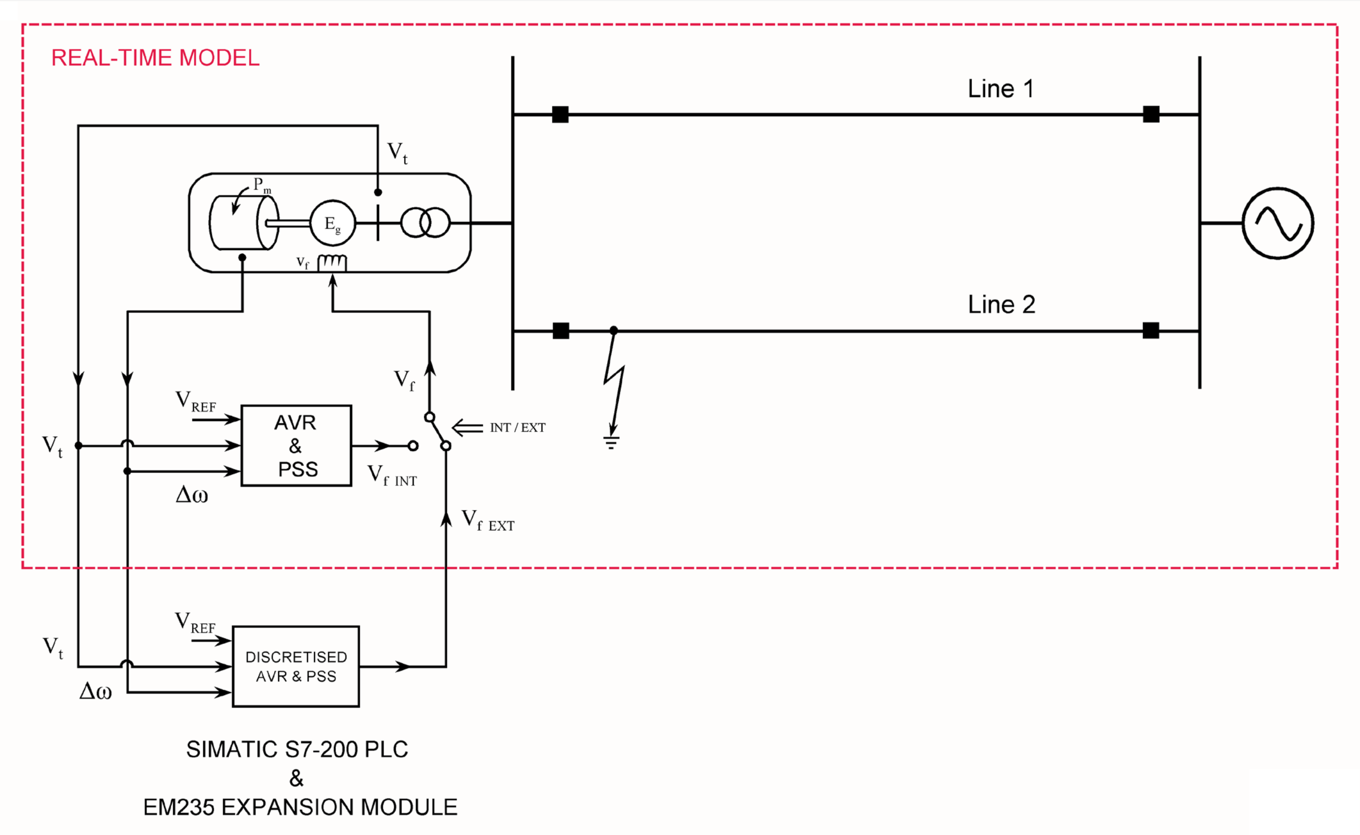
PROJECT EXAMPLES: GENERATOR CONTROLS

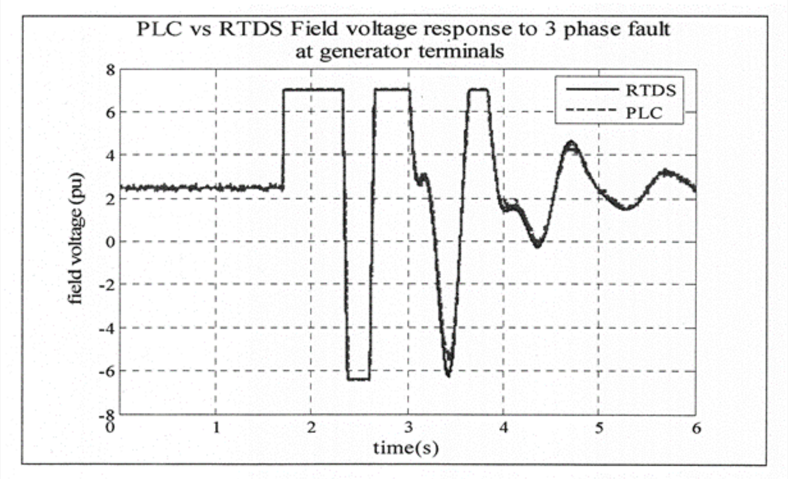
RTDS model of Kundur's single-generator, infinite bus study system used as a basis for HIL automatic voltage regulator (AVR) and power system stabiliser (PSS) project

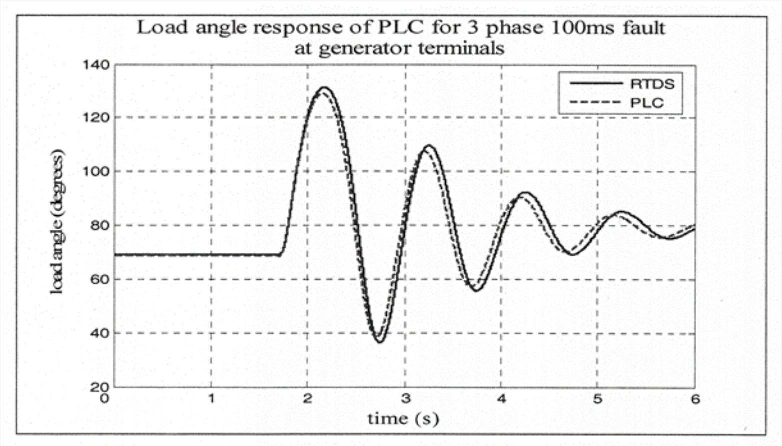




AVR & PSS on Siemens PLC Project – RTDS Simulator HIL Results

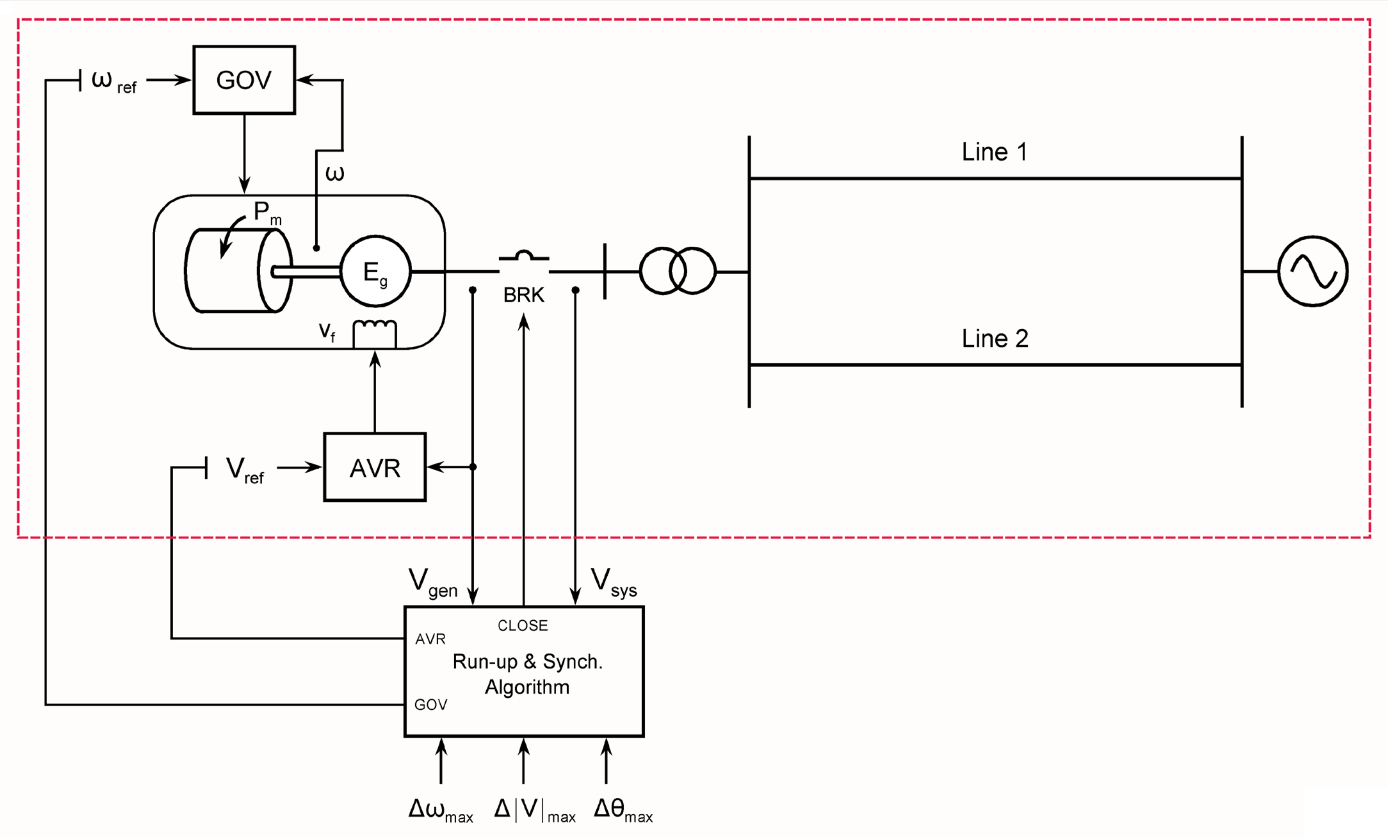






PROJECT EXAMPLES: GENERATOR CONTROLS

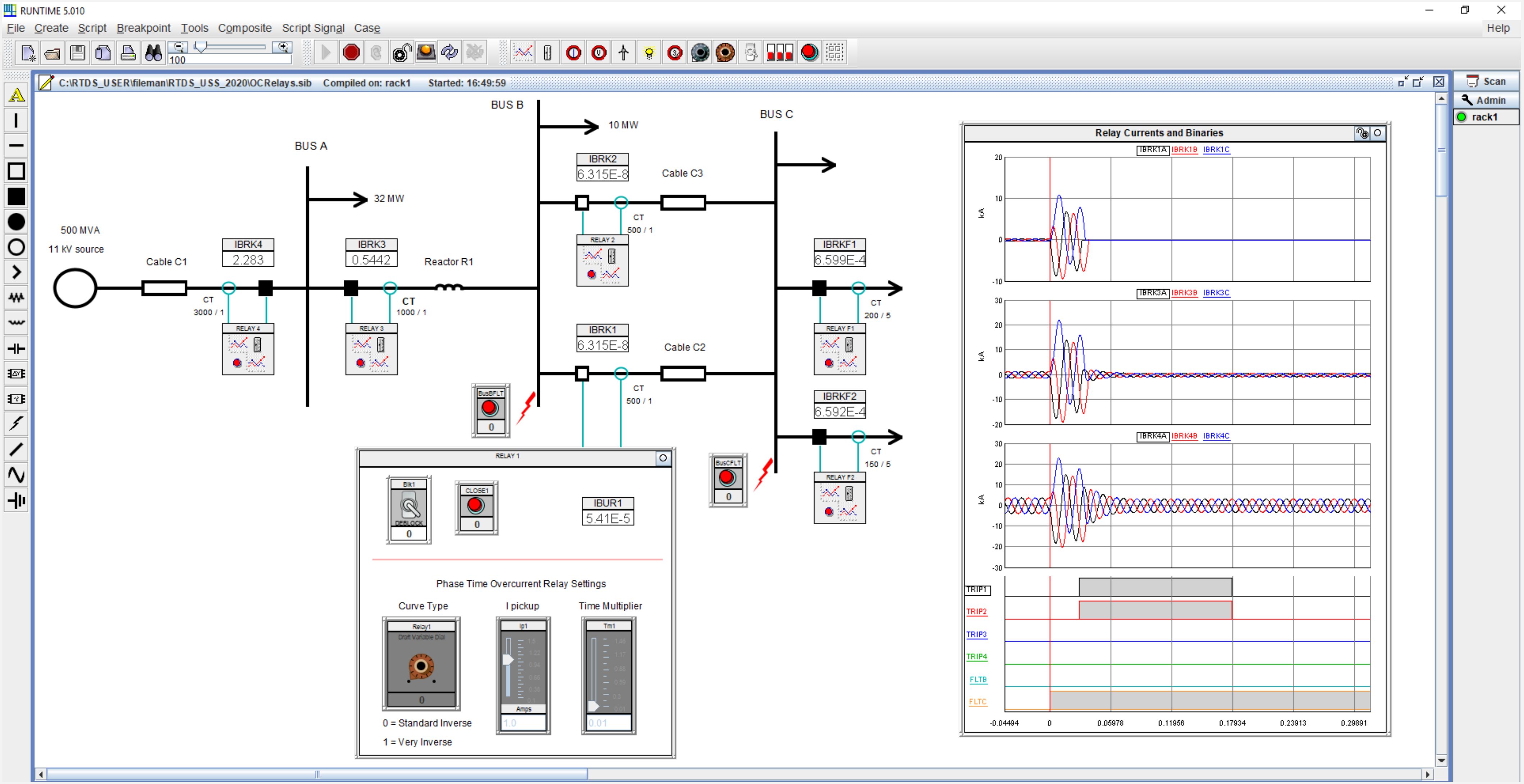
Design and implement controller to automatically run up and synchronise the generator in Kundur's single-machine, infinite bus study system.



ALL-SIMULATION CLASS DEMOS AND LAB EXAMPLES

To close with, a very brief overview of the kind of real-time simulation case examples developed for class demonstrations in power system stability and simulation-only laboratories in power system protection…

O/C Relay Time and Current Grading (ALSTOM Network Protection & Automation Guide, Ex. 9.20.1)



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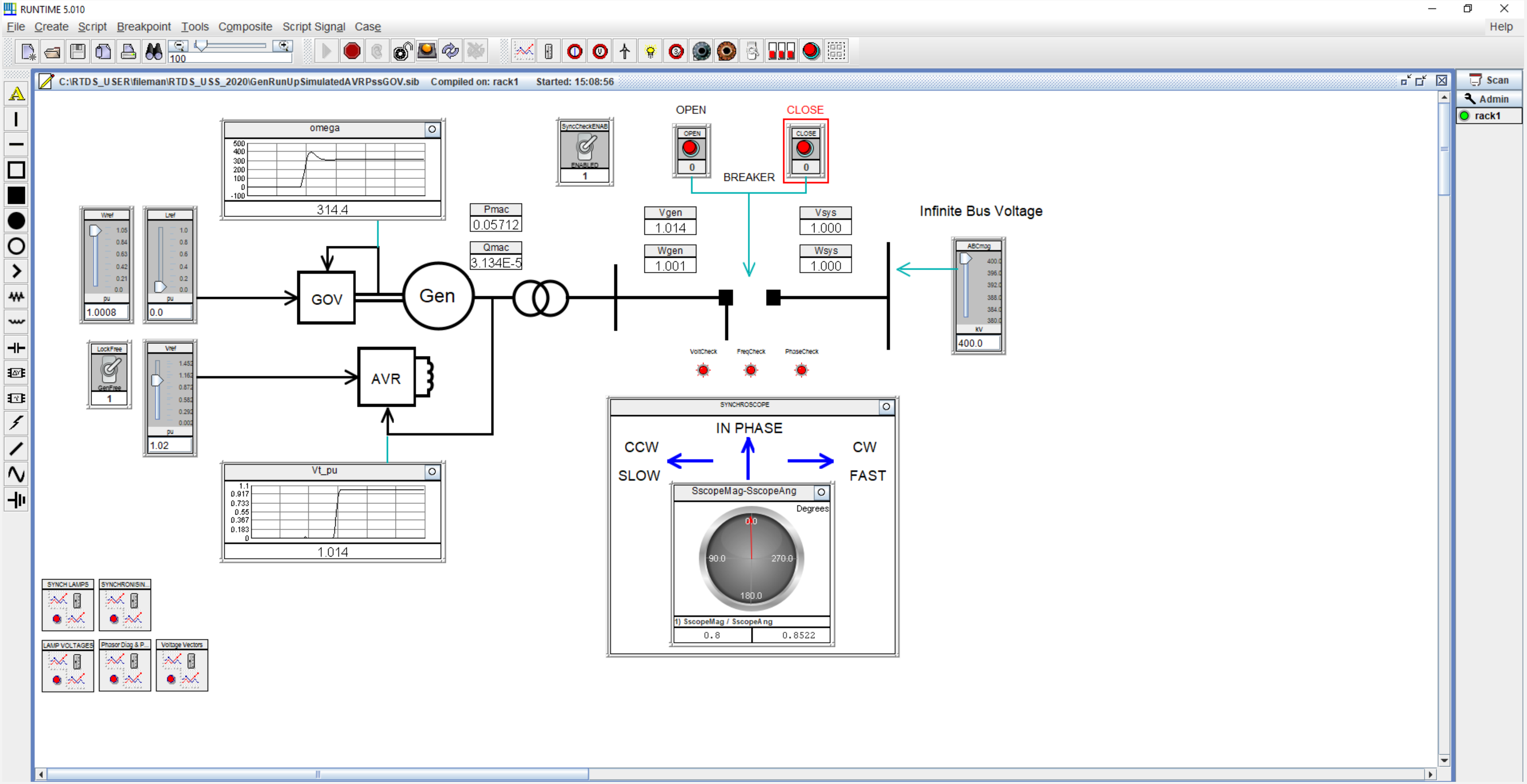
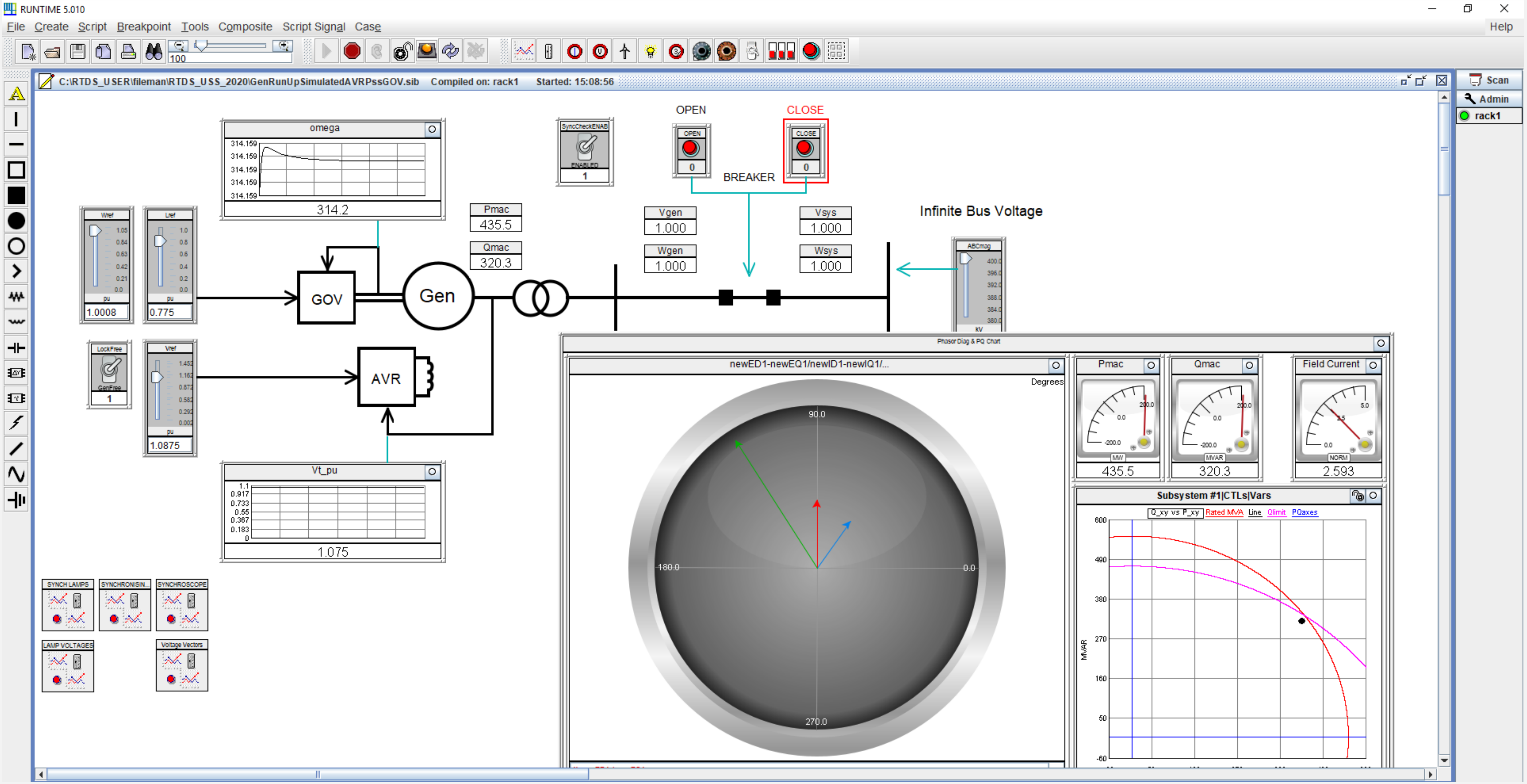
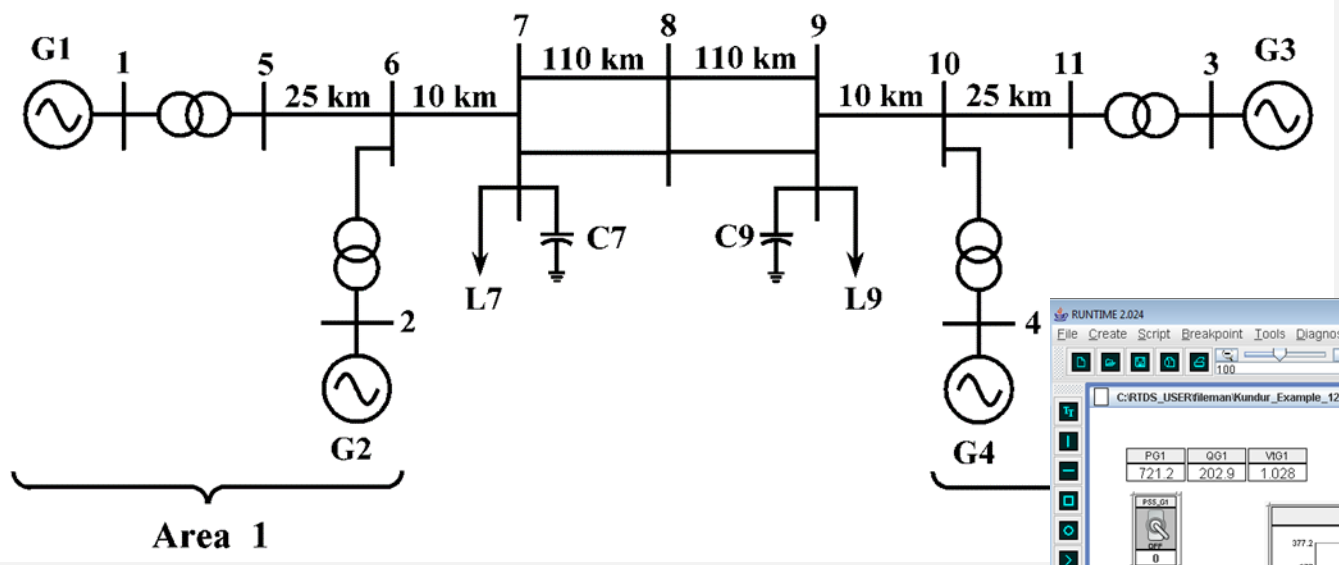
Generator Governor and Excitation Controls Demo (Manual run up and synchronisation)

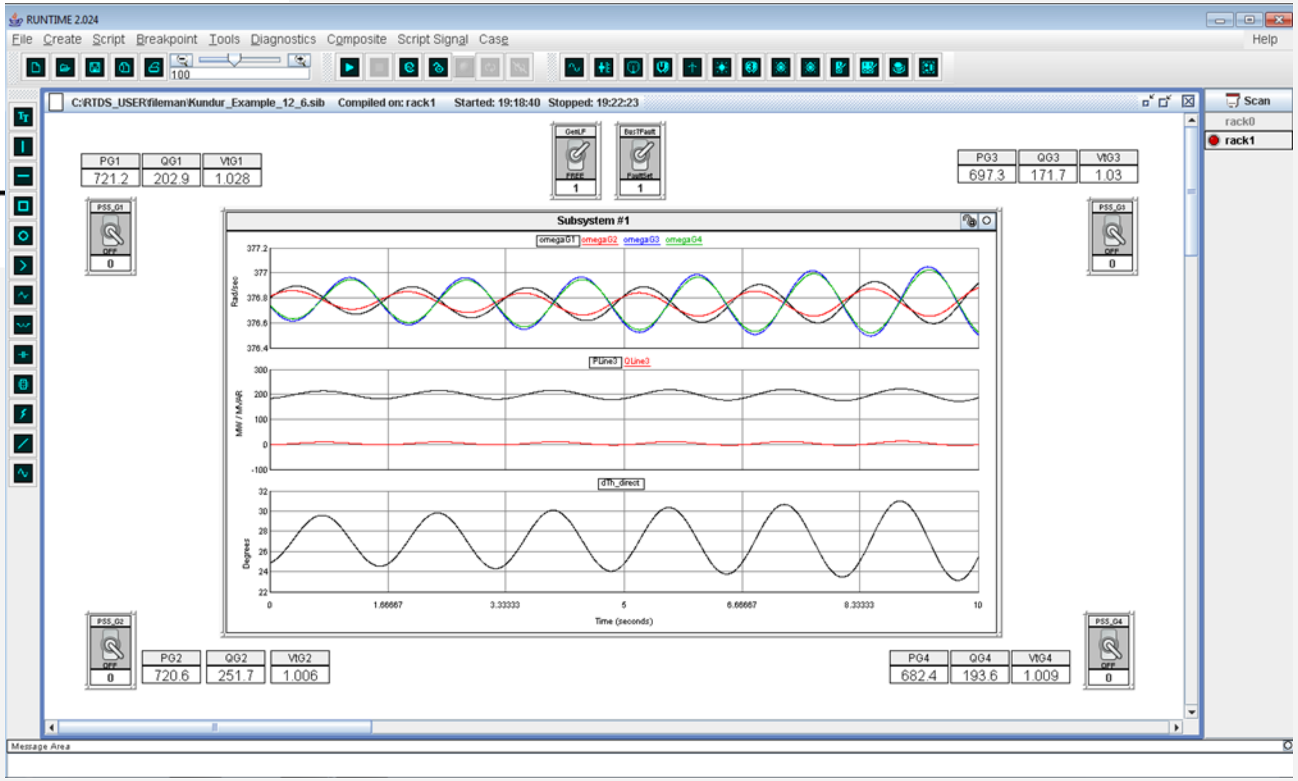


Generator Governor and Excitation Controls Demo (Generator Phasor Diagram & PQ Chart)

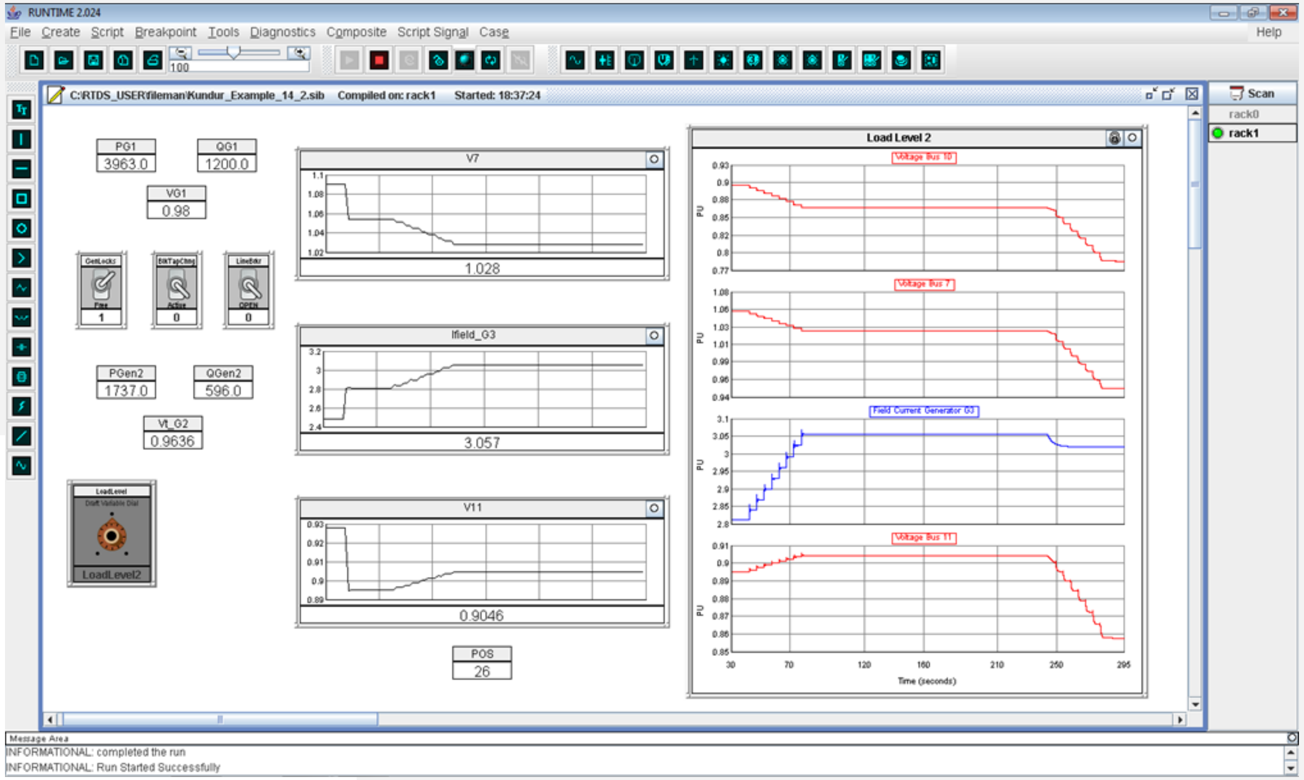


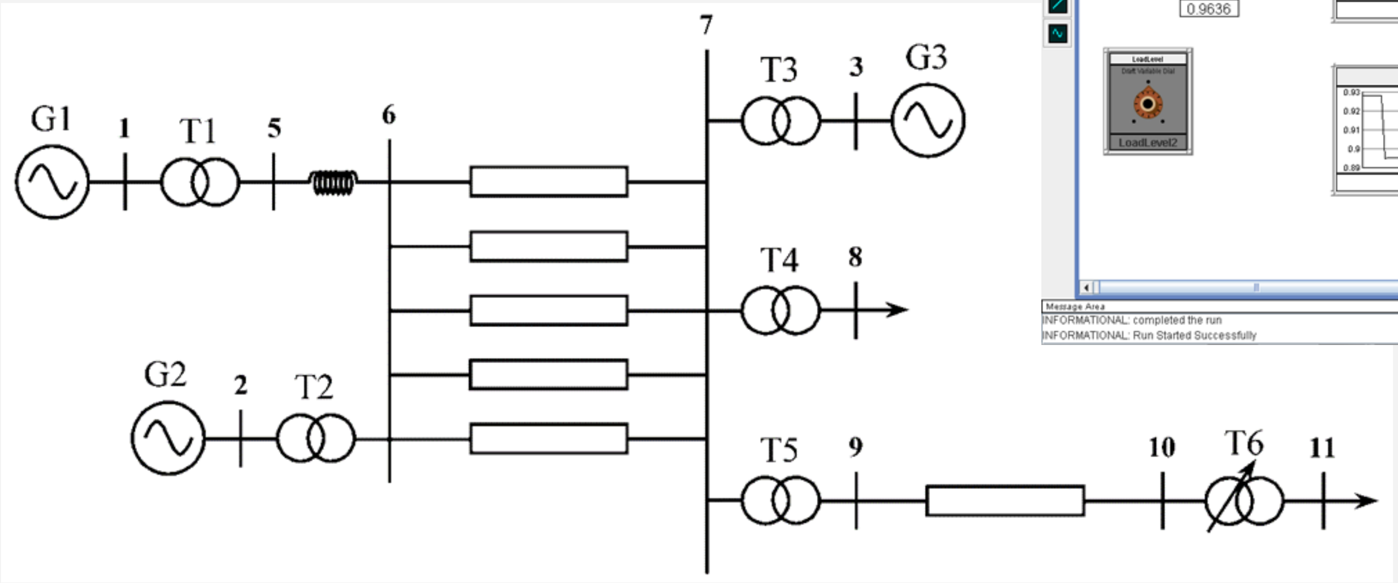
Inter-Area Modes and Power System Stabilisers (Kundur Example 12.6)





Voltage Instability & Voltage Collapse (Kundur Example 14.2)





CONCLUSION

This presentation has shared some experiences of using RTDS Technologies' real-time simulator platform as an aid in undergraduate teaching at a university.

Whilst many universities purchase real-time simulators for research work, our experience was that these facilities can also be leveraged to enhance the education of undergraduate students as well.

In so doing, we found our research group and its profile greatly enhanced and were able to leverage further industrial funding as a result.