Experiences And Observations Gained From Using A Real-Time Simulator Facility For Undergraduate Project Work

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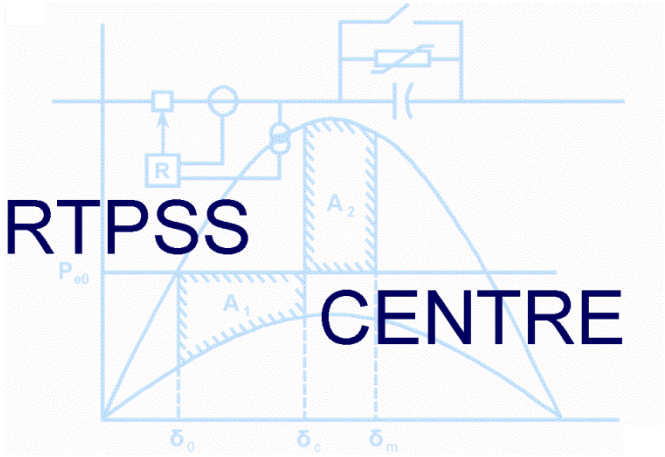

RTPSS CENTRE

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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Introduction

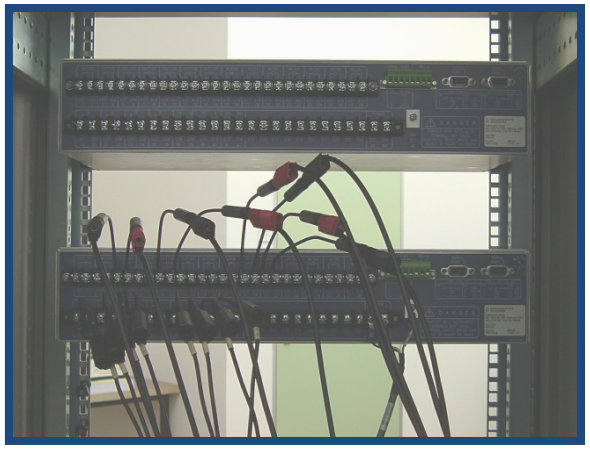
- RTDS simulators first came to the RTPSS Centre at DUT in approximately 2002.
- Initially 1 rack with 10 3PC cards – now 10 fixed and 1 portable rack with a mix of 3PC, GPC, PB5 cards.
- The intention behind the establishment of the RTPSS Centre was:
  - to promote power systems as a career option amongst students (critical skills shortage);
  - to foster collaboration between academia and industry;
  - for the state power utility (Eskom), jointly funding the Centre, to evaluate RTDS simulator technology.

Introduction

- **Because of the power utility partner's interests, the technical focus of the RTDS simulator usage has primarily been protection systems, but also power system stability and control, FACTS, machines and drives.**
- **Very strong focus on hardware-in-loop testing and advanced problem solving of protection schemes associated with practical, operational problems encountered in the utility environment.**
- **Undergraduate "teaching" in protection and power system stability and control.**
- **Postgraduate projects (mostly at Masters level).**
- **RTDS-based training courses for academia and industry.**

RTPSS Centre Facilities

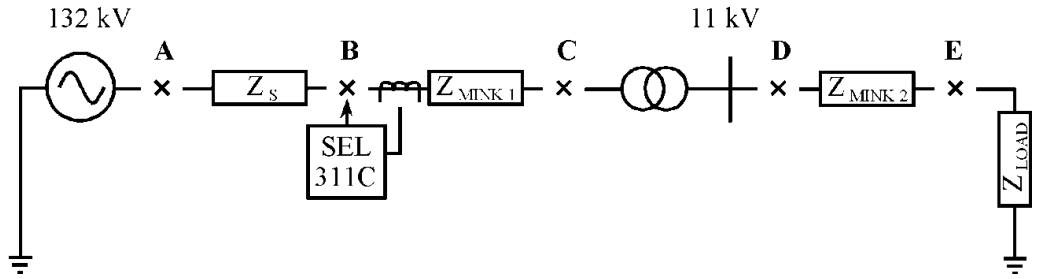
Undergraduate Thesis Projects In Protection: Early, Baby Steps

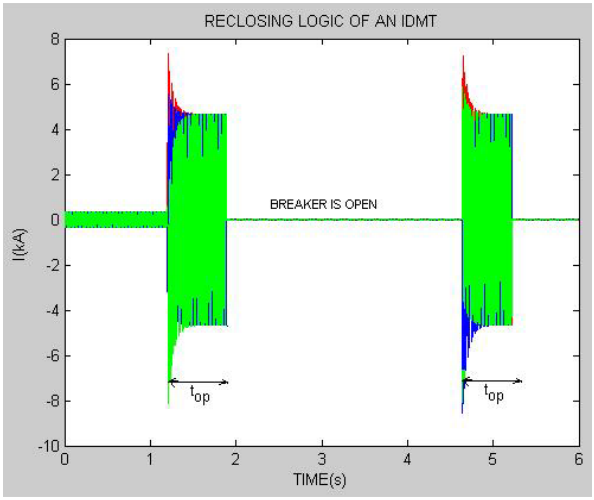


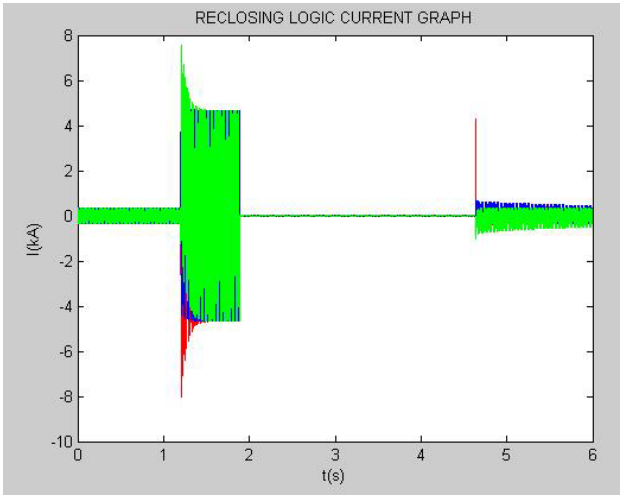
In the early days of the RTPSS Centre, the scope of the undergraduate projects was less ambitious than in later years for a number of reasons:

- The limited facilities then available;
- the simulator itself was far more challenging to master for undergraduate students than nowadays;
- less domain knowledge in the protection area itself.

Undergraduate Thesis Projects In Protection: Early, Baby Steps

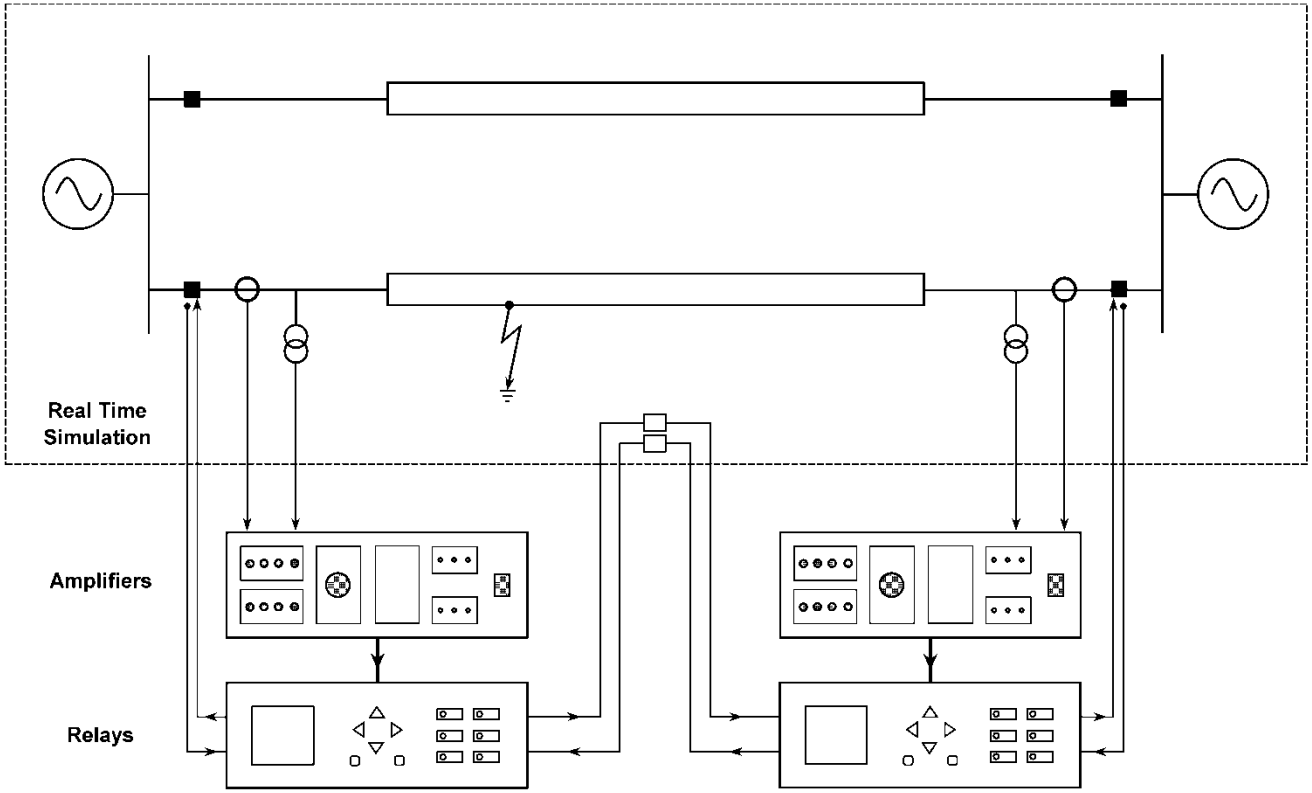






Projects limited to a single, hardware-in-loop relay, focussed either on simple overcurrent or distance protection applications.

Undergraduate Thesis Projects: More Advanced Topics

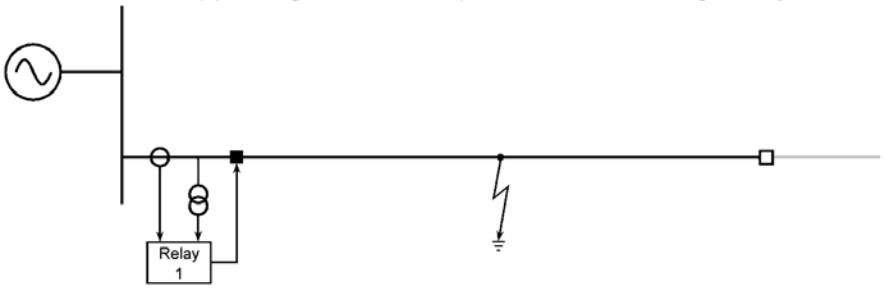


Standard, structured approach to simulator training, hardware interfacing and basic impedance relay settings to ensure students master the protection fundamentals in a formalised manner in the early parts of the project.

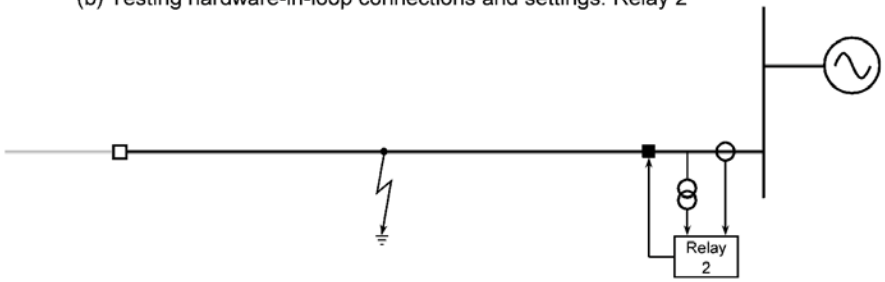
Each project then has different system parameters and a unique unstructured technical settings challenge in order to provide an open-ended design aspect.

Structured model development, hardware-in-loop relay connection, and basic settings verification phase

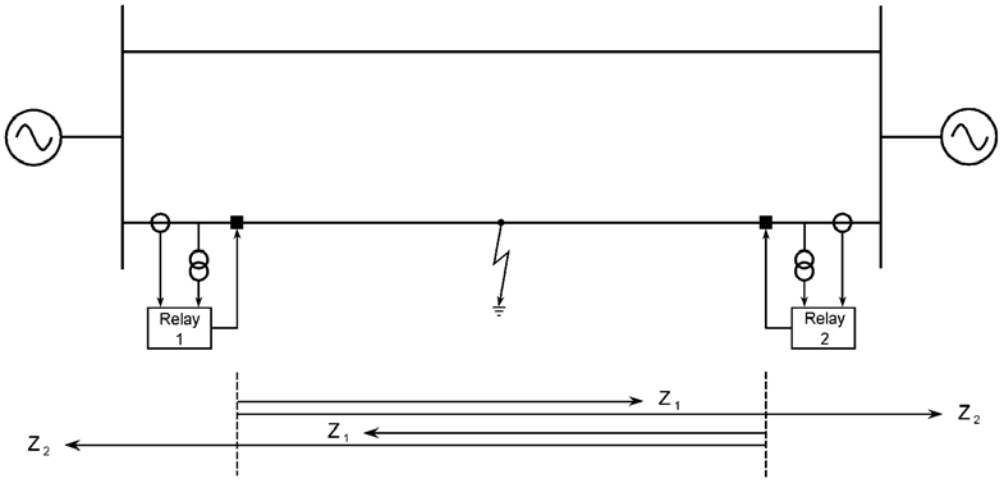
(a) Testing hardware-in-loop connections and settings: Relay 1



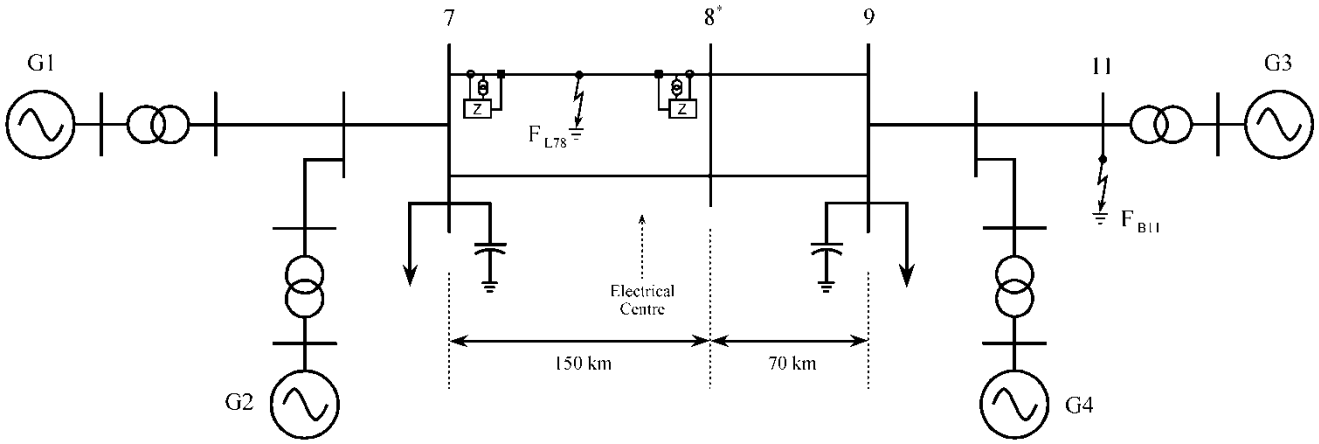
(b) Testing hardware-in-loop connections and settings: Relay 2

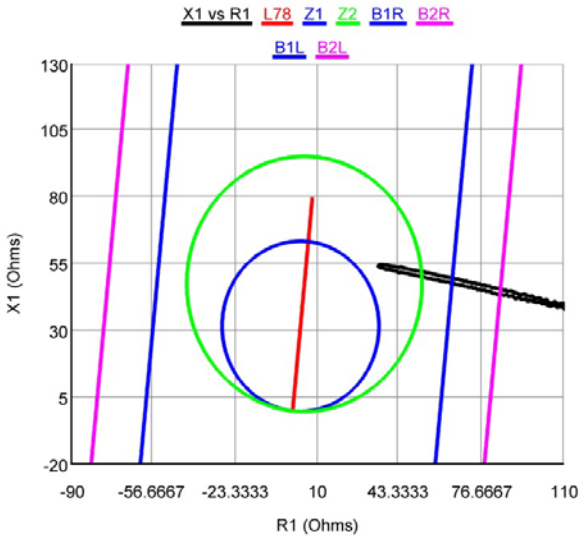


(c) Testing hardware-in-loop connections and settings: Full Scheme

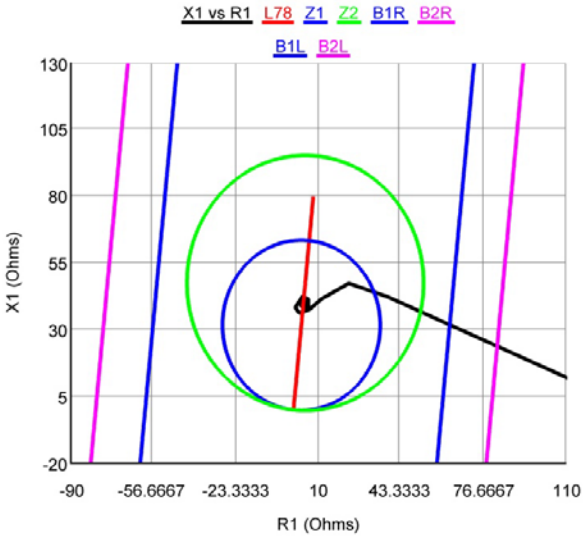


Example of open-ended settings aspect unique to a particular project:

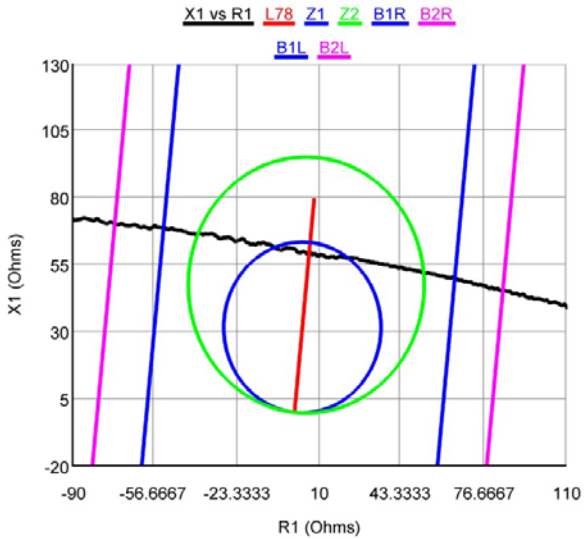




Impedance locus for external fault and stable swing.

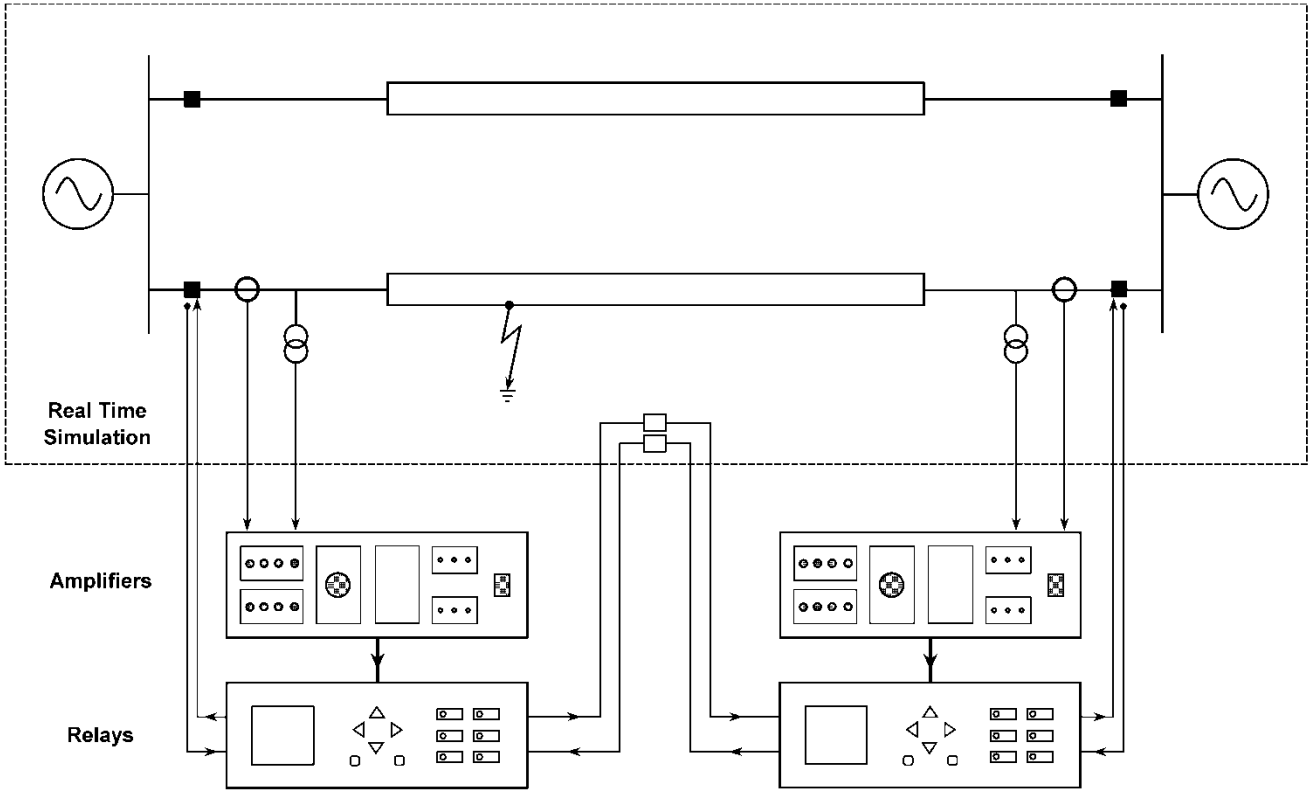


Impedance locus for internal fault.



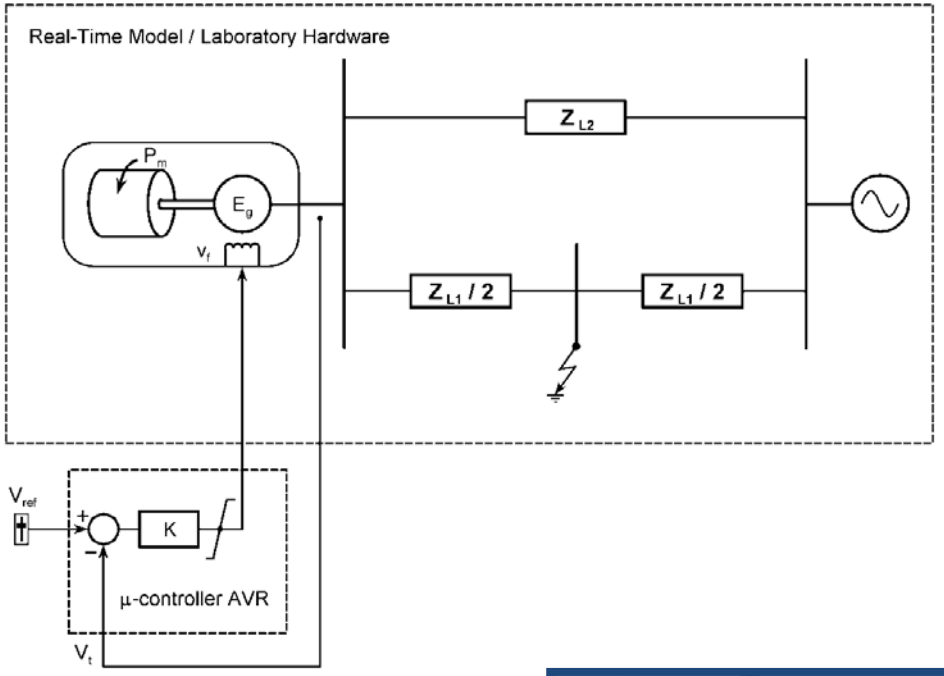
Impedance locus for external fault and unstable swing.

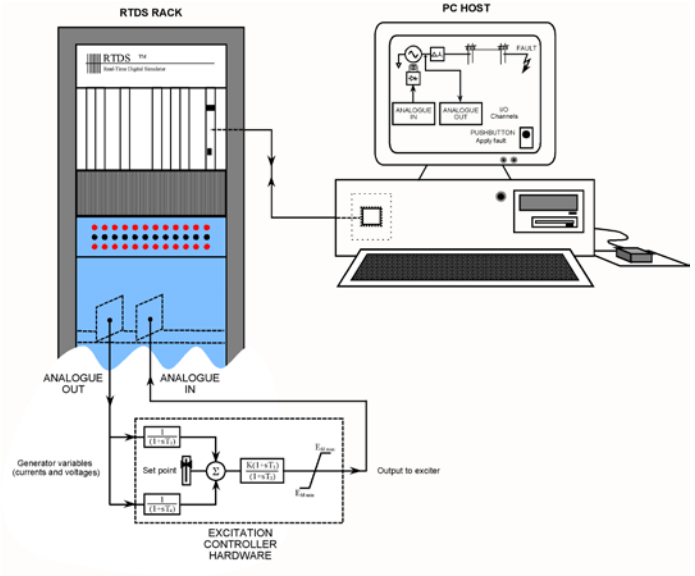
Variations added to the open-ended phase of such projects:

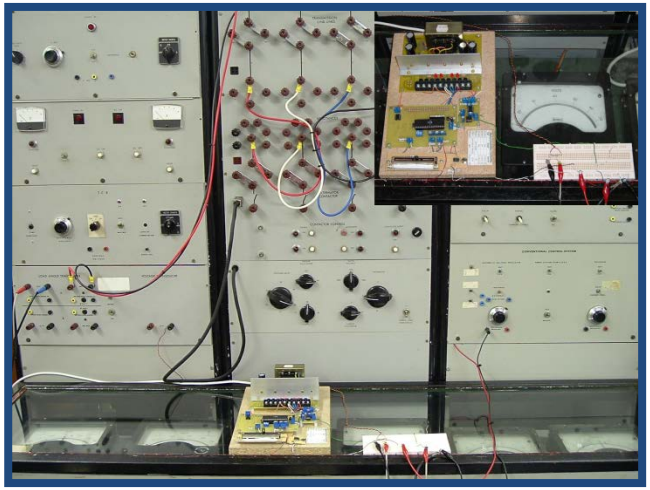


- High resistance faults;
- Weak-end infeed;
- Reclosing and synchronisation checking;
- Discrimination between electrical faults and generator swings;
- Parallel lines with mutual coupling, cross country faults etc.

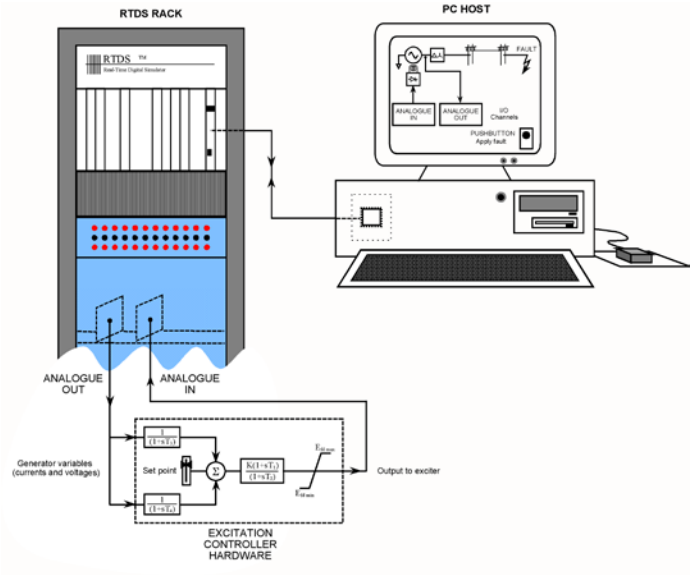
Early projects in power system stability and control: Microcontroller-based generator AVR

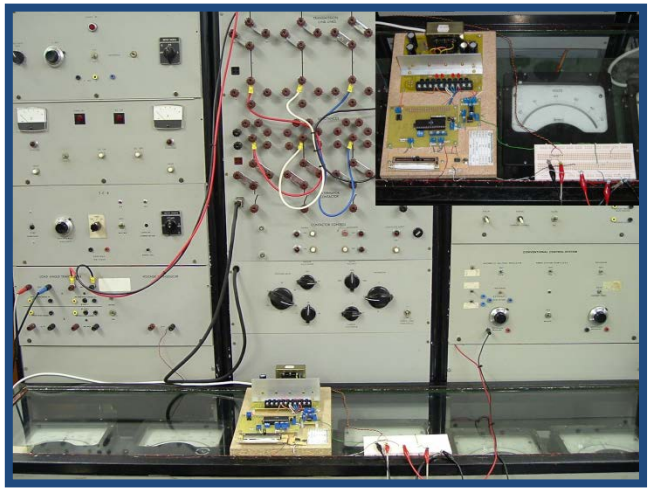


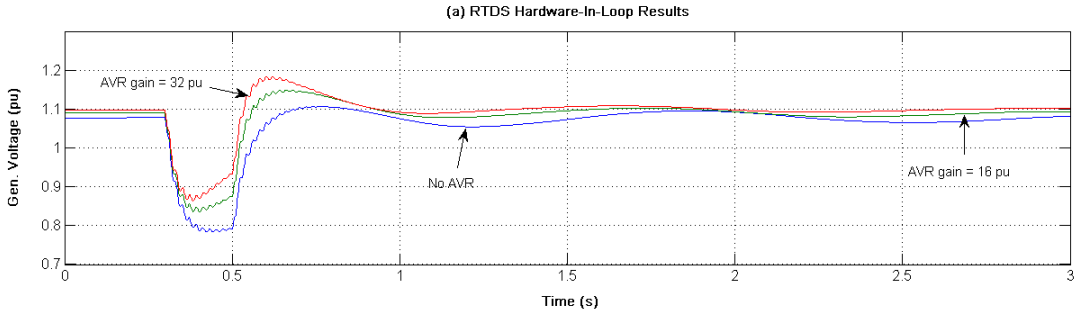


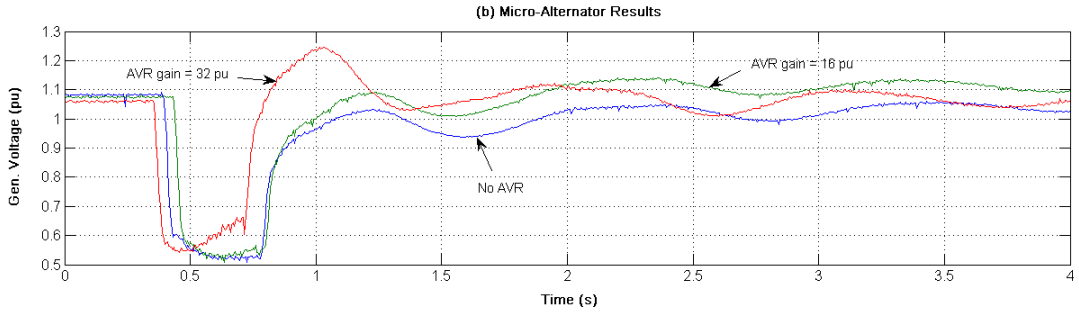


Early projects in power system stability and control: Microcontroller-based generator AVR

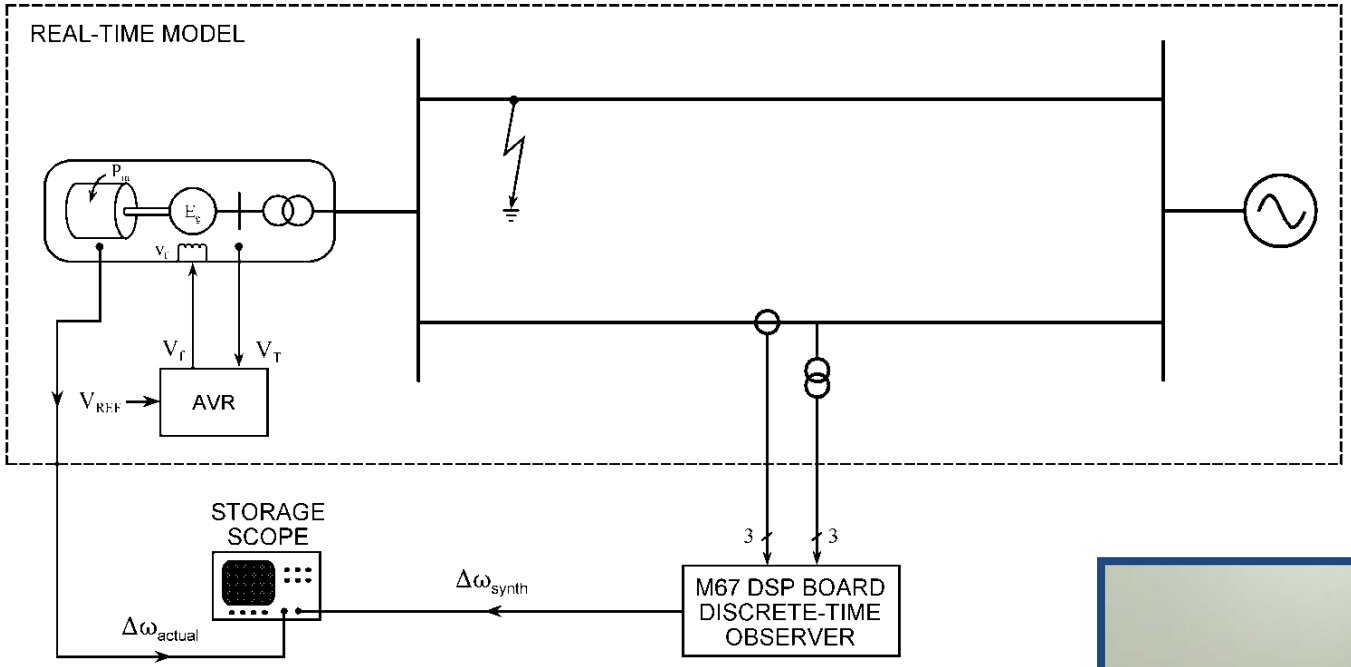


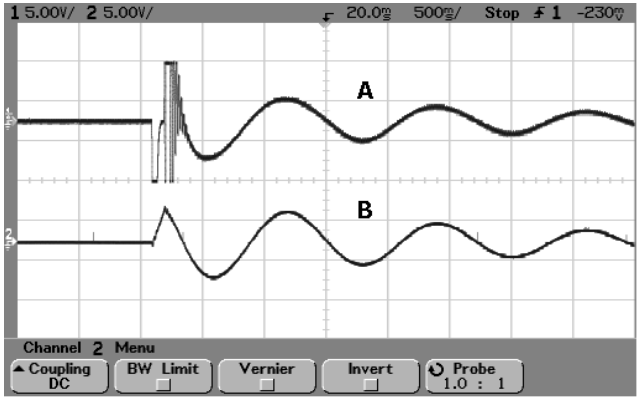




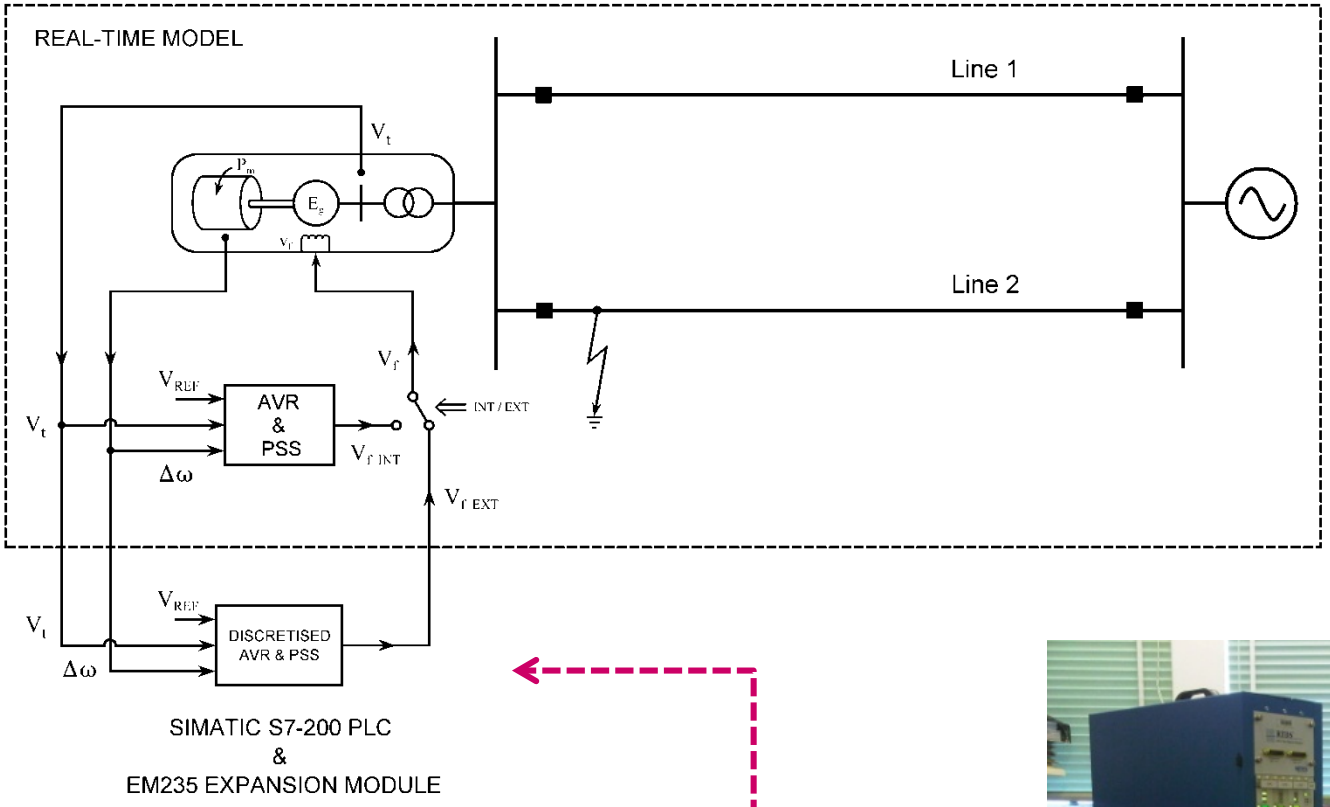


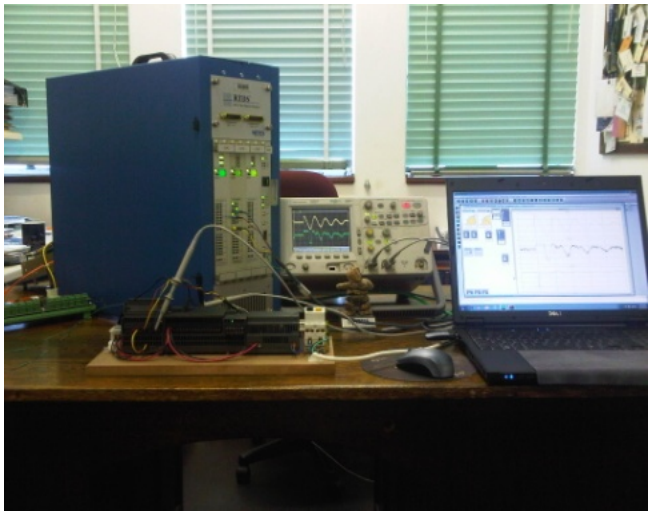
Early projects in power system stability and control: DSP-based generator speed observer



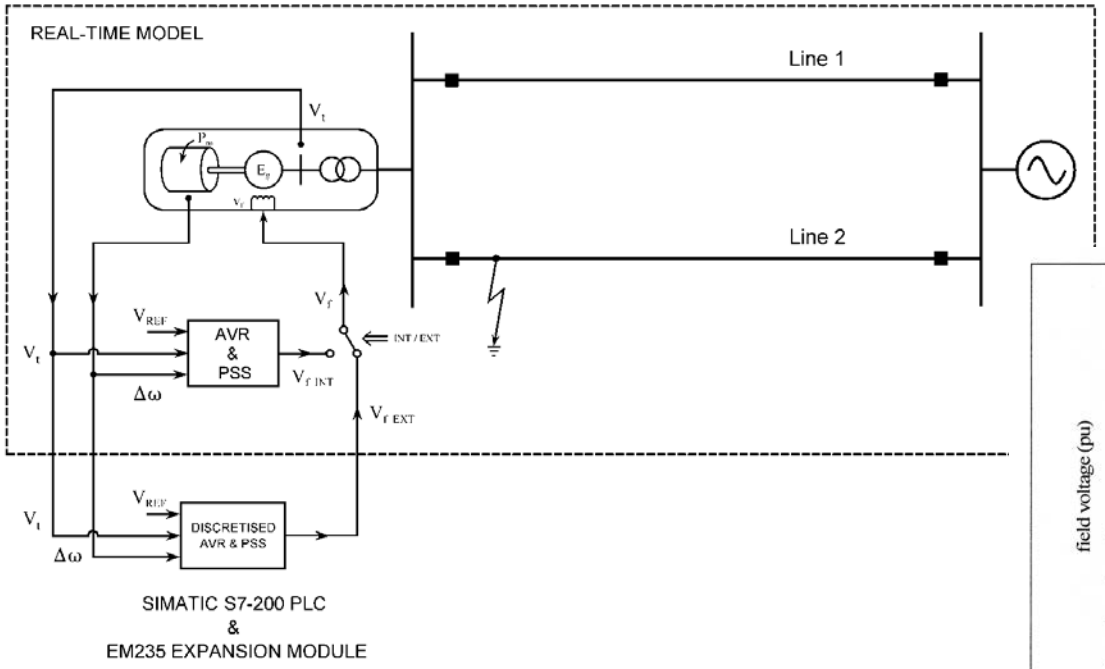


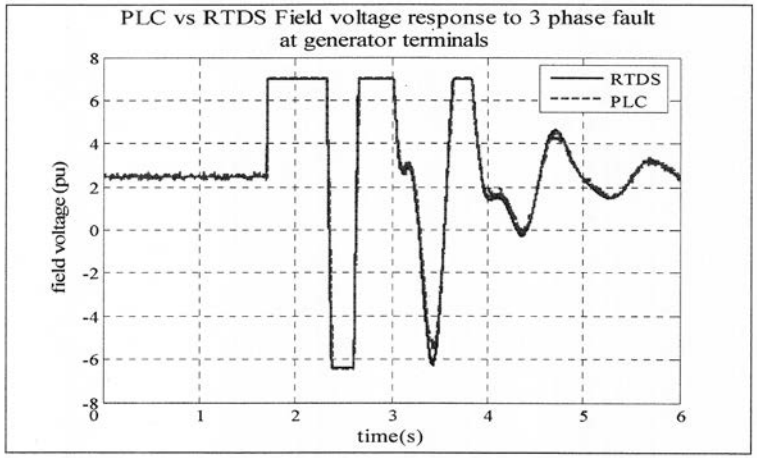
Power system stability and control project: HIL AVR & PSS testing

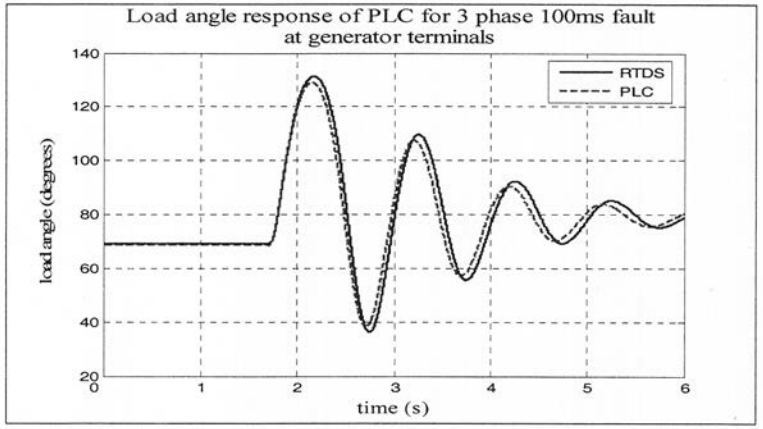




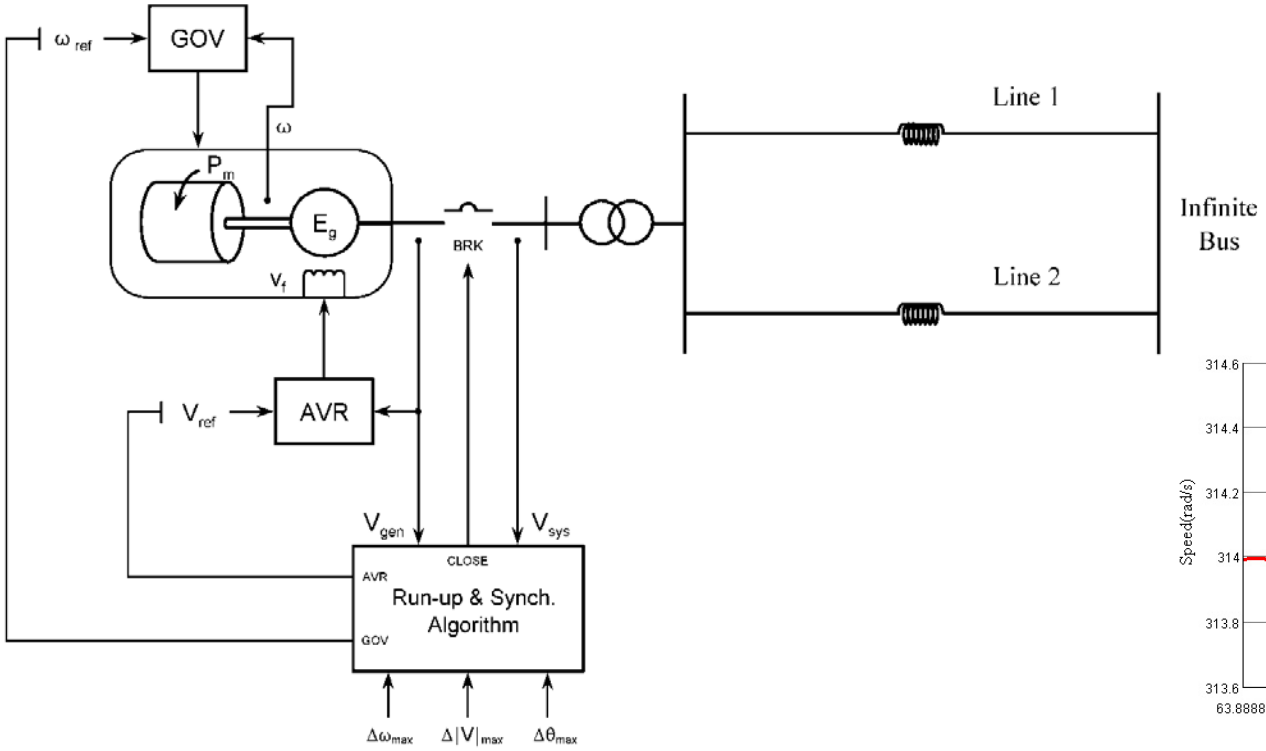
Power system stability and control project: HIL AVR & PSS testing

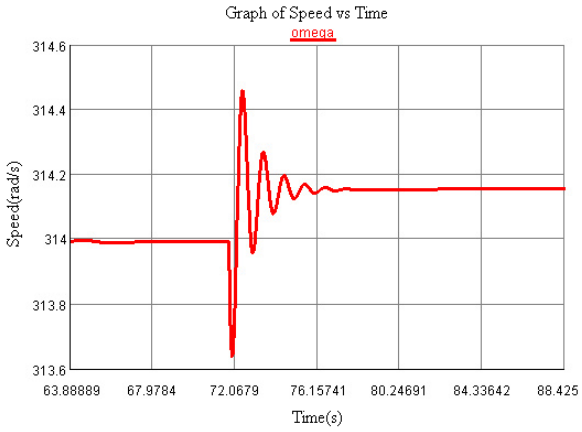


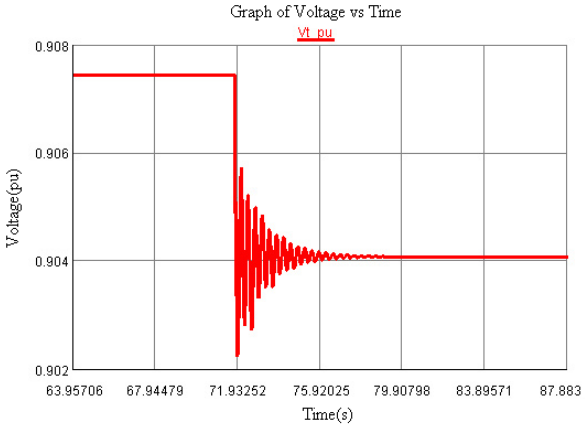




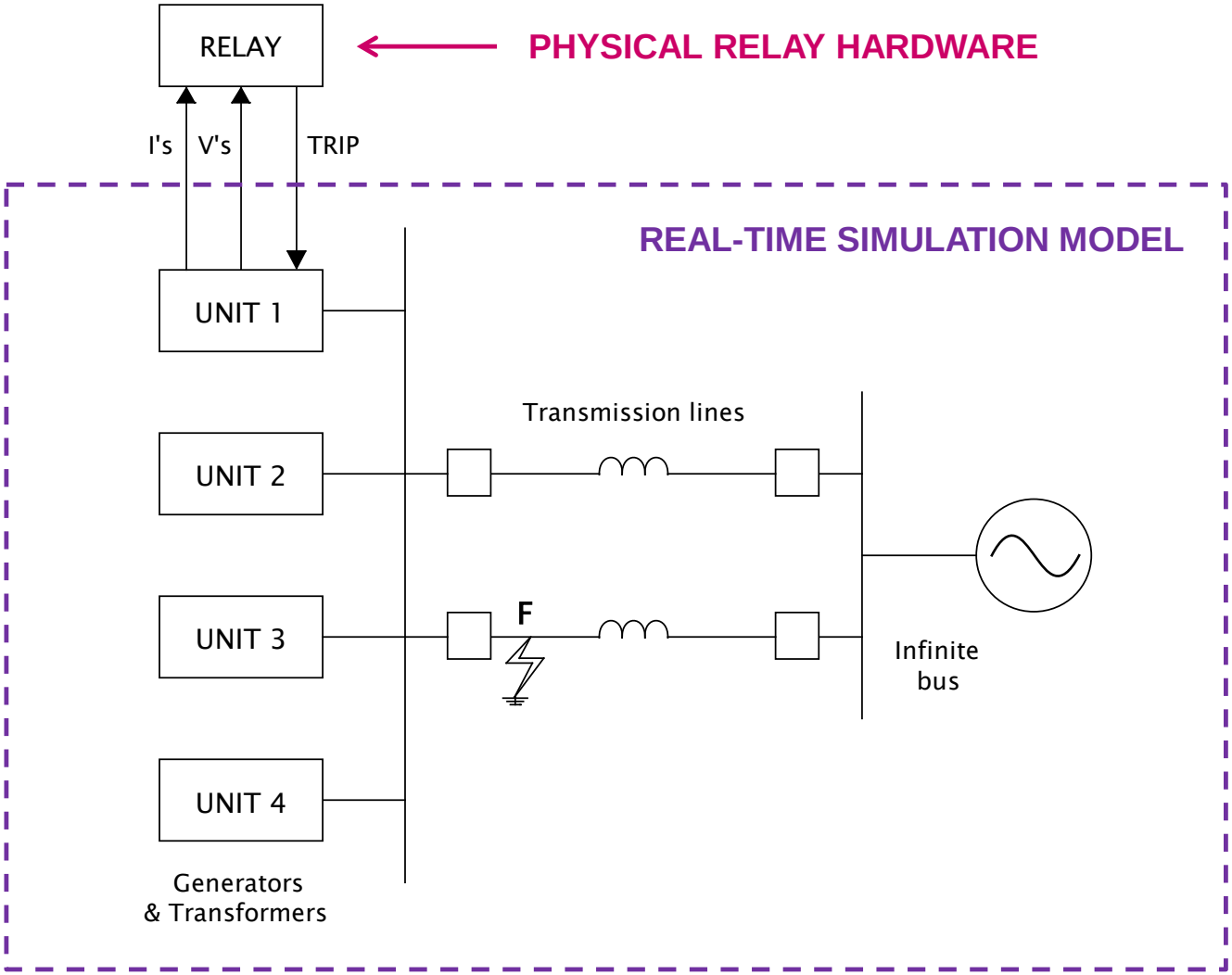
Power system stability and control project: Automatic run up and synchronisation of a power station generator



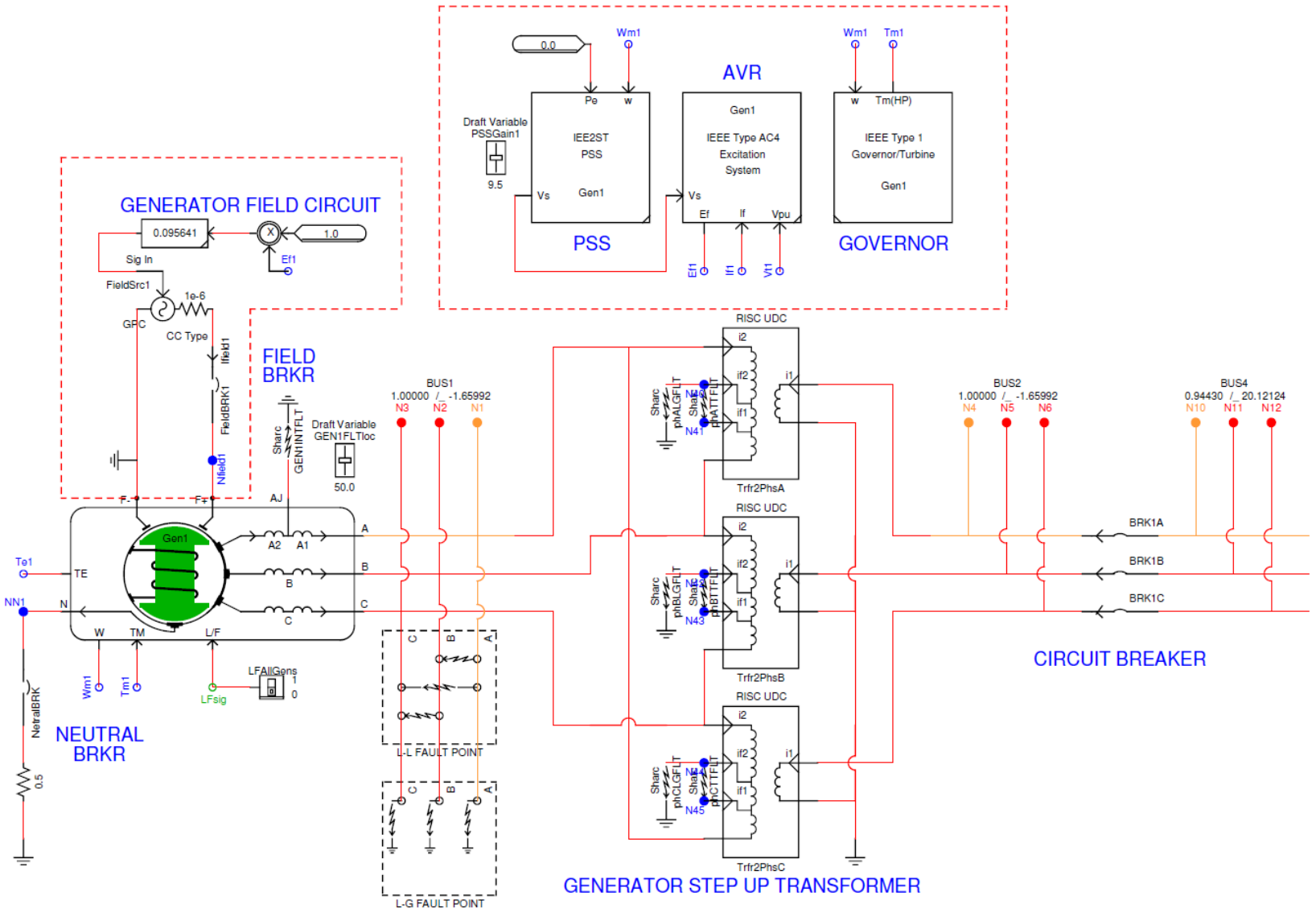




Postgraduate Projects: Generator Protection

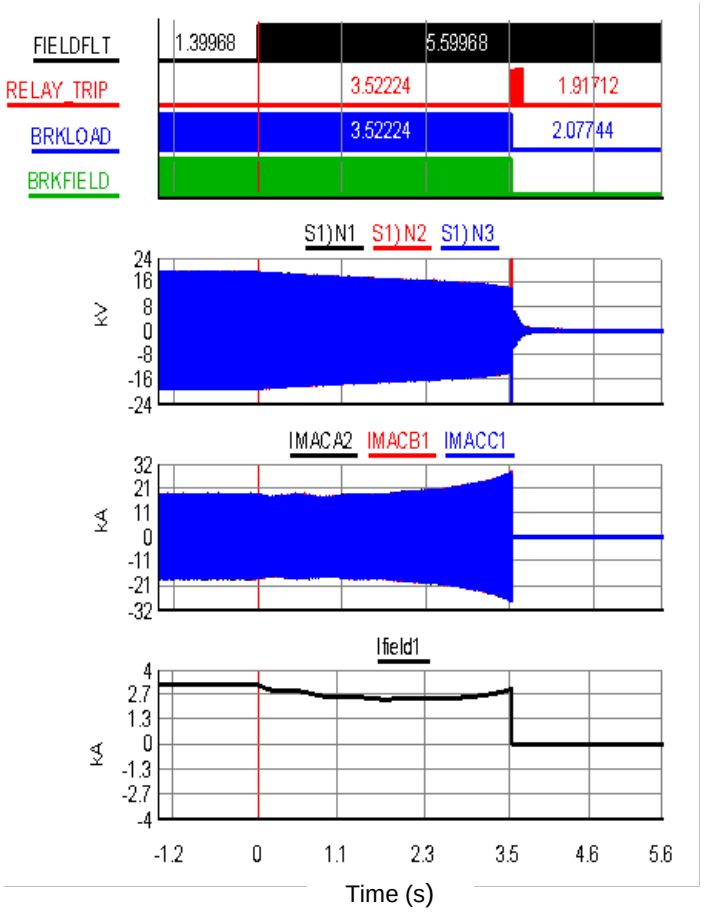


Real-Time Model For Testing Generator Protection Relay Functions and their Coordination with Excitation Controls

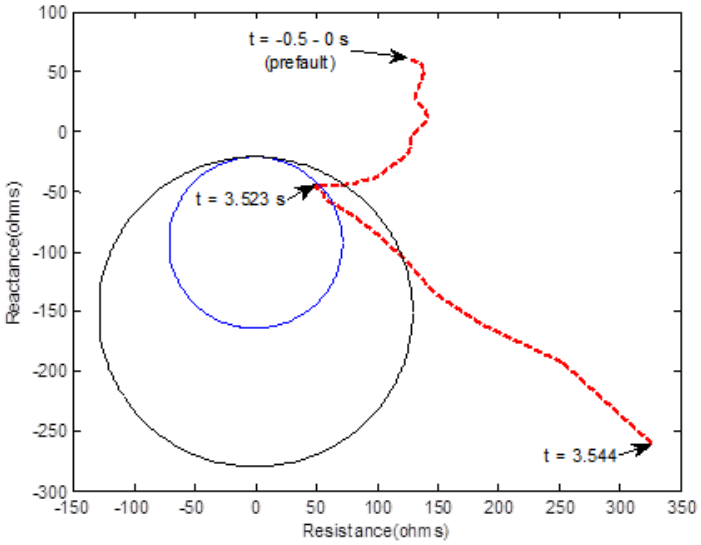



HIGH VOLTAGE DIGITAL INTERFACE PANEL
OMICRON
CMS 156
CMA 156
RTDS ™
Real-Time Digital Simulator
DIGITAL CHANNELS
DIGITAL IN
GROUND
PIN
SEL-421
PROTECTION AUTOMATION CONTROL
SEL
SCHWEITZER ENGINEERING LABORATORIES
SEL-300G
GENERATOR RELAY
SEQUENTIAL EVENTS RECORDER
SELOGIC® CONTROL EQUATIONS
SEL SCHWEITZER ENGINEERING LABORATORIES
Single line diagram of the system

Loss of field protection (40): short-circuit fault at field terminals.



Real-time simulation variables



Relay variables: impedance locus overlaid onto the relay's loss-of-field element operating characteristics

Conclusion

The use of RTDS simulators at the DUT RTPSS Centre has resulted in excellent "cross pollination" of knowledge and skills between utility and university through joint projects, which in turn has allowed undergraduate-level student training in electrical protection systems at a level typically much higher than would otherwise be possible.


RTDS


RTDS