RTDS SIMULATION OF PV INVERTERS IN A SMALL POWER SYSTEM

SIMULATION SAGES

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THE PROBLEM

- Inverter based renewable energy sources are becoming more common.
- The introduction of these sources into the grid can cause instability in the system.
- Better understanding the effects on the power system can help us find innovative solutions to these issues.

PURPOSE OF THE PROJECT

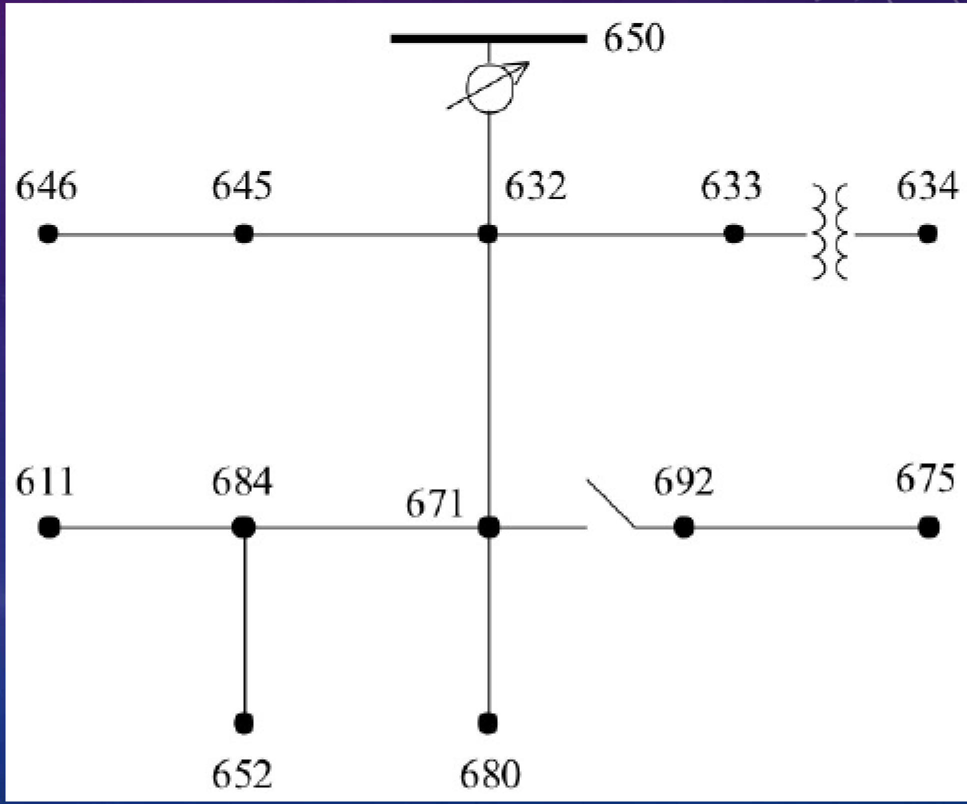
- Develop a model of a distribution system with multiple photovoltaic inverters.
- Implement external controls to coordinate real and reactive power output from the inverters.
- Condense our findings into a lab exercise for future engineering students.

TOOLS

- RTDS (Real Time Digital Simulator)
  - Facilitates real time simulation of power systems.
- RSCAD
  - Design tool for creating power system models to be simulated through an RTDS.
- SEL RTAC (Real Time Automation Controller)
  - Robust, all-purpose control unit used to communicate with and control PV inverters for this project.

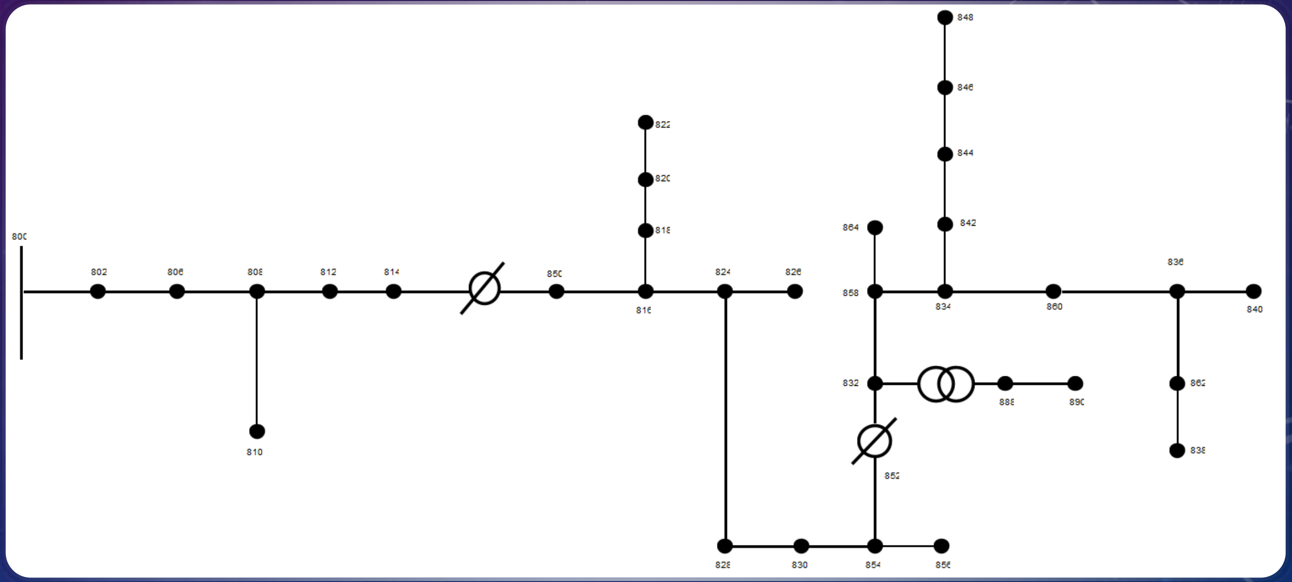
THE BASE SYSTEM: IEEE 13 BUS DISTRIBUTION MODEL

- Sufficient bus count to provide a distribution level network
- Few enough buses that basic work can be done on a single RTDS rack
- Enough buses to connect 3 PV arrays to the weakest points in the system and still maintain a decent model



DESIGN CONSIDERATION : IEEE 13 BUS

- Alternatives to the IEEE 13 Bus System:
  - <u>Custom System from scratch</u>
    - Time consuming to build
    - Does not add significant value
    - Beyond the project scope
  - <u>IEEE 34 Bus System</u>
    - Overly complex for the purposes of the project
    - Overly taxing for the RTDS



DESIGN CONSIDERATION: PV INVERTER MODEL

- Use an existing model
  - Already built model in RSCAD
  - We do not need to find design parameters ourselves
  - We do have to learn how the model was designed and how it fits in RSCAD
- Create our own model from scratch
  - Beyond the scope of the project
  - Models are already available

DESIGN VALIDATION PLAN

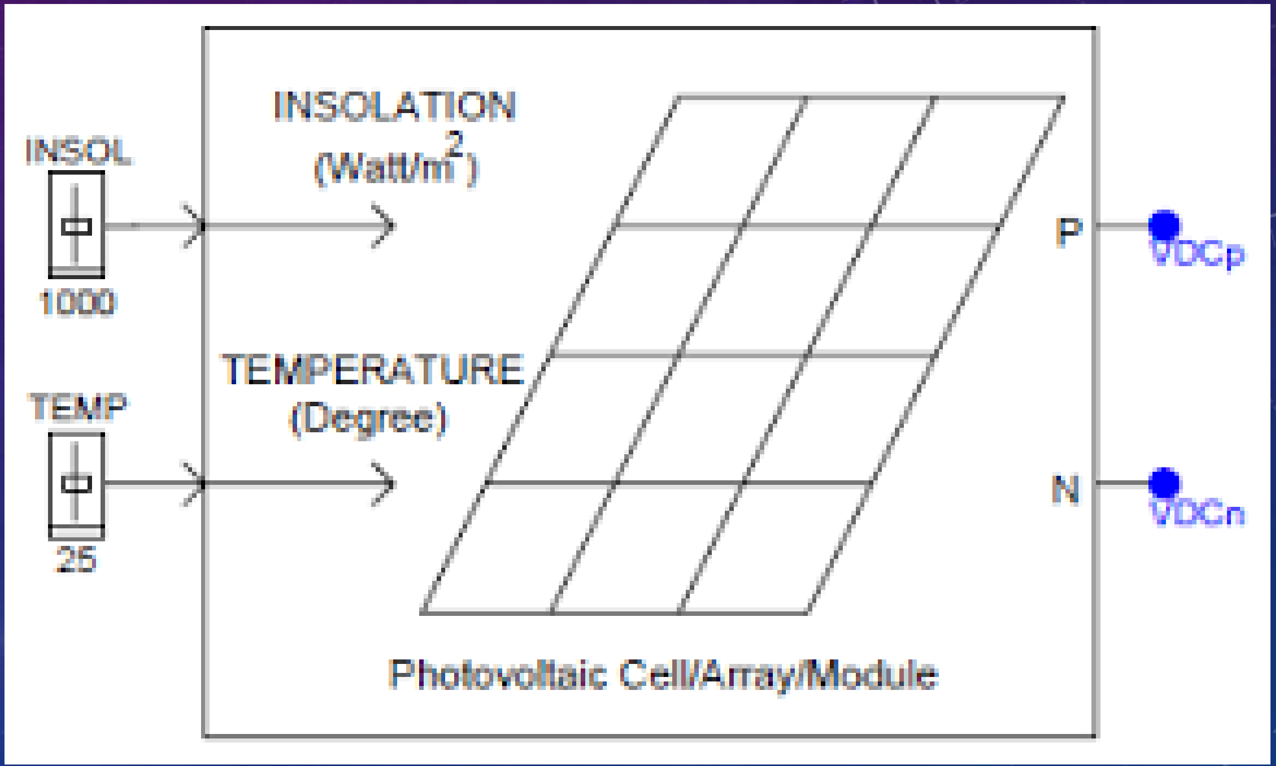
Requirement	Test	Test Subject	Target Date
Compiled RSCAD model of IEEE 13 bus power System with 3 PV Inverters Connected.	Model runs on RTDS	Power System RSCAD model	11/20/20
Controlled power output for each PV inverter.	Run model on RTDS and adjust power output controls in real time and verify the power readings are changing for specific busses.	Power System RSCAD model	12/4/20
PV inverter control through SEL RTAC	Run Model on RTDS and adjust PV inverter inputs. Verify the RTAC adjusts PV controls as planned.	Power System RSCAD model and SEL RTAC.	1/29/21
Functional RTAC HMI	Run model on RTDS and use HMI to manually adjust PV inverter controls in real time.	Power System RSCAD model and SEL RTAC HMI.	2/19/20
Lab procedure documentation is clear and usable for power students.	Invite a EE student to go through the procedure in the lab with the equipment and give feedback.	Lab procedure document	3/26/20

PROJECT LEARNING

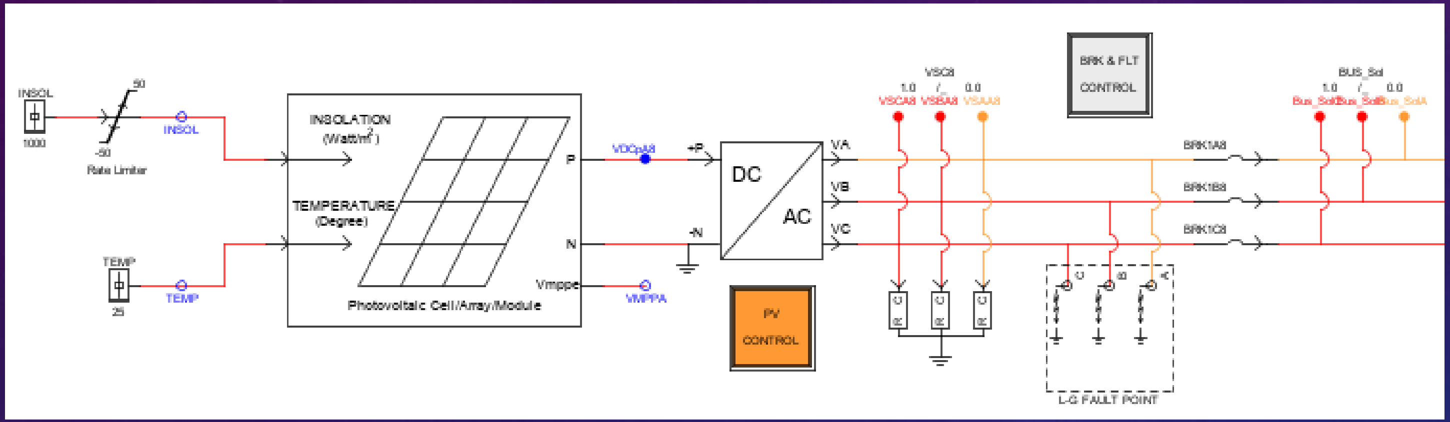
- RSCAD and interfacing with the RTDS
  - How RSCAD works
  - What a model needs to be useful
- IEEE 13 Bus model
  - What buses are weakest
  - How we can integrate other models into the predesigned bus network
- Photovoltaic Array Model in RSCAD
  - How this model is built
  - How to effectively use this model in our model system

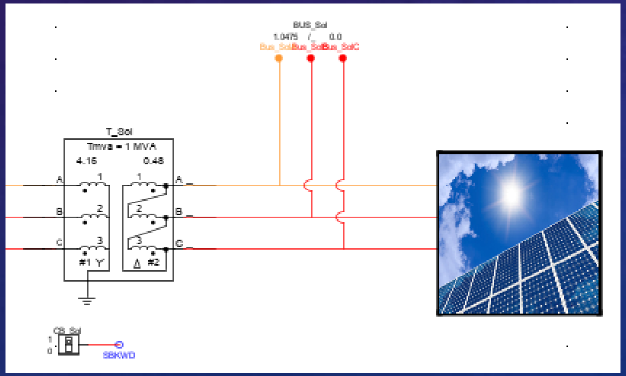
WHERE WE ARE NOW

- Customizing PV array model
  - Needs to be integrated into the 13 bus system
  - Has more variables than we need to consider for this project
  - How do we simplify the model while maintaining an accurate representation?



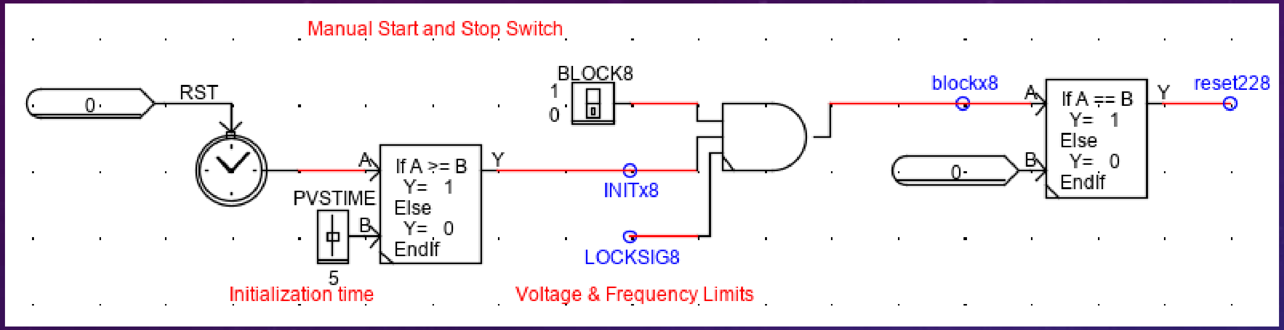
SIMULATION – PV MODULE

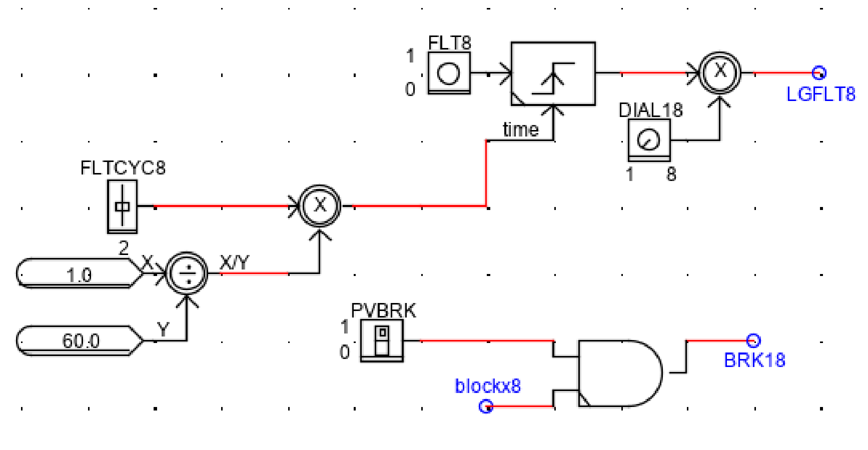




- Test Location of PV-Module
- DC Voltage 25 kV
- Inverter Output 0v

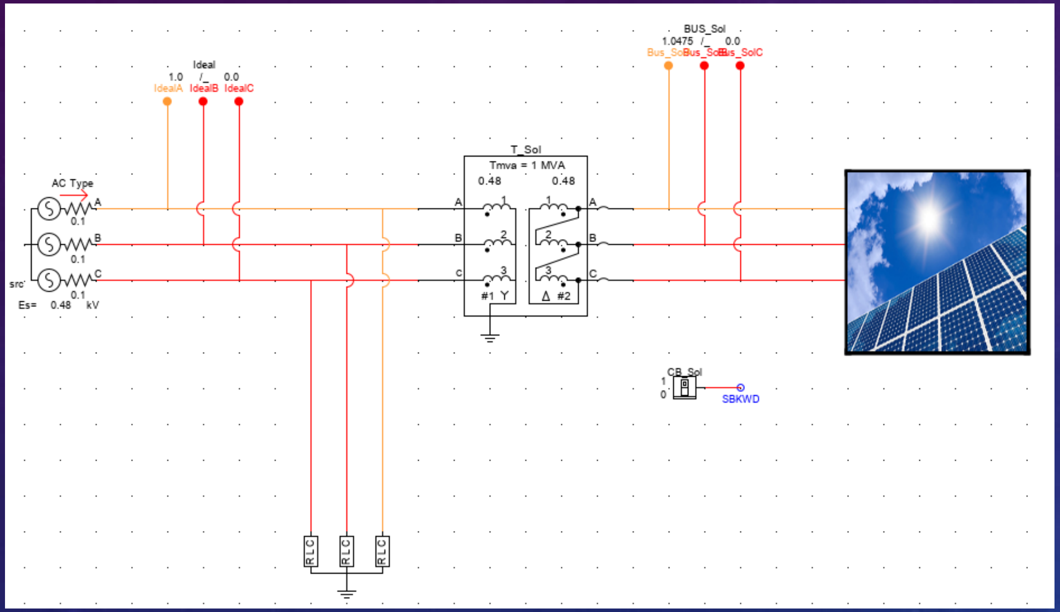
SIMULATION – INVERTER LOGIC





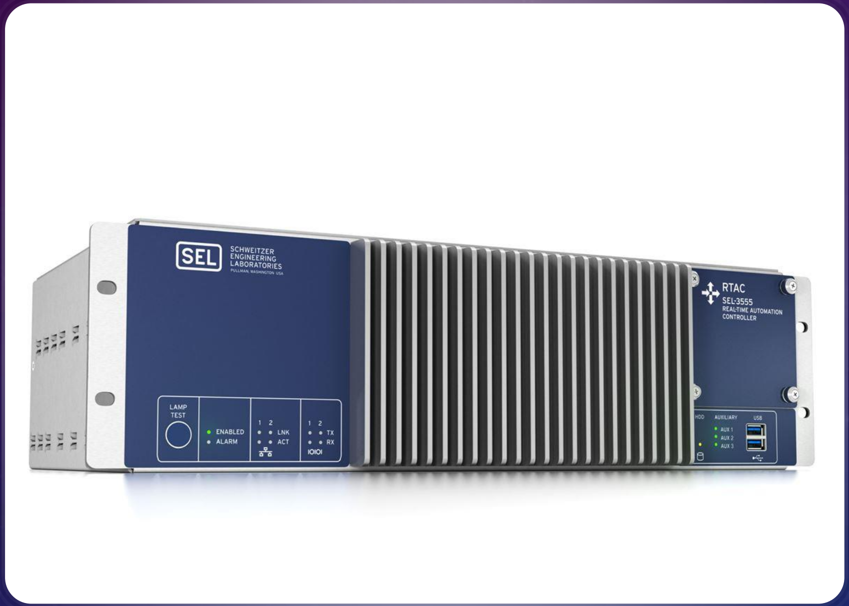
- Inverter Power Out 'Pmea8'
- Following the logic of the Circuit Breaker
- Blockx8
- Workaround

NEXT STEPS -- KISS



- Understand Inverter's Protection Logic
  - Do we need protection for our model system, given that it is presumed to be ideal?
  - How integral is the protection to the function of the model
- Build Simpler Test systems and build up
  - We need to learn what these models need to work in our system
- Place Hardware "in-the-loop"
  - A simple tie in of an RTAC to regulate power in real time would improve the system

END STATE



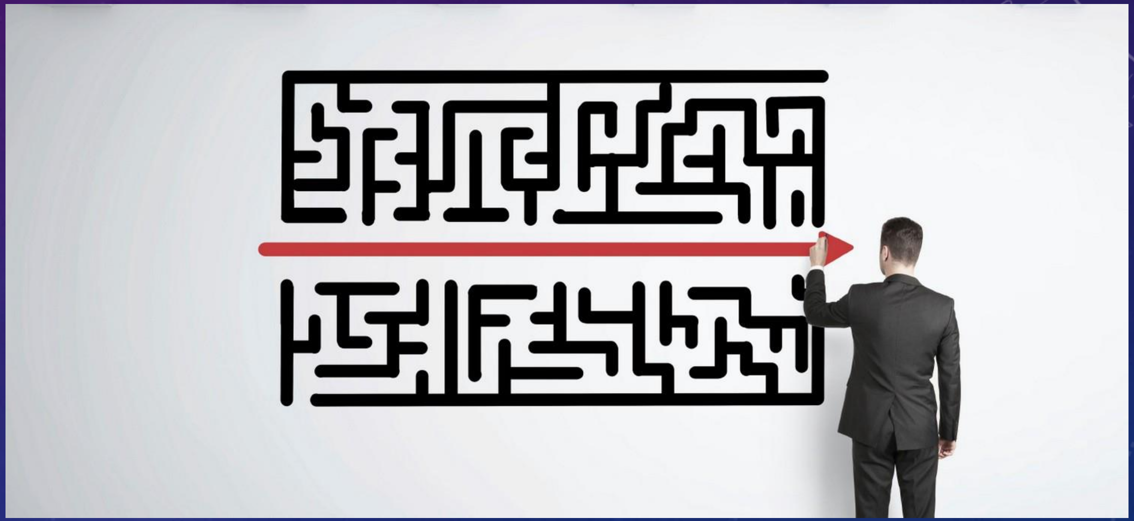
1. Complete grid-compatible PV model.
2. Develop a fully integrated model of the 13 bus system with 3 PV inverters connected.
3. Develop a control scheme for the PV inverters using the SEL RTAC.
4. Create an HMI for the RTAC control system.
5. Create lab procedure documents

DECISION POINTS

REDUCTION OF COMPLEXITY | LEARNING POINTS

Reduce:

- Distribution System
  - Loads
  - Transmission PI model
- PV Array
  - Fault elements
  - Protection elements



Supplemental Lab Objectives:

- Wire Diagrams (wet contact)
- Logic Diagram Development