# Inter-turn Fault Detection for Air Core Reactors

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# Problem Statement

To develop and test a relaying protection scheme to enable the detection of inter-turn faults in a shunt air core reactor.  The development of the relaying algorithm will be assisted with a small scale three phase model system operating at 208 VLL, as well as an RTDS model of the three phase shunt reactor.

Photo Courtesy of Kevin Damron

# Specifications

- 208 Volt line to line
- 5 Amps per phase max
- 60 Hz
- 3 phase wye connection
- 70 mH inductance (per phase)
  - 6 X 10mH (Jantzen) -15Gauge
  - 4  X 16 mH (Jantzen) - 18Gauge
- Series phase resistance TBD (inductor dependant)

# Deliverables

- RTDS model
  - Simulated results of the fault currents
- Scale model 3 phase air core
  - One coil of one phase will be hand wound
- Oscillography of faults on scale model
- Assist Asad with protection scheme development and testing

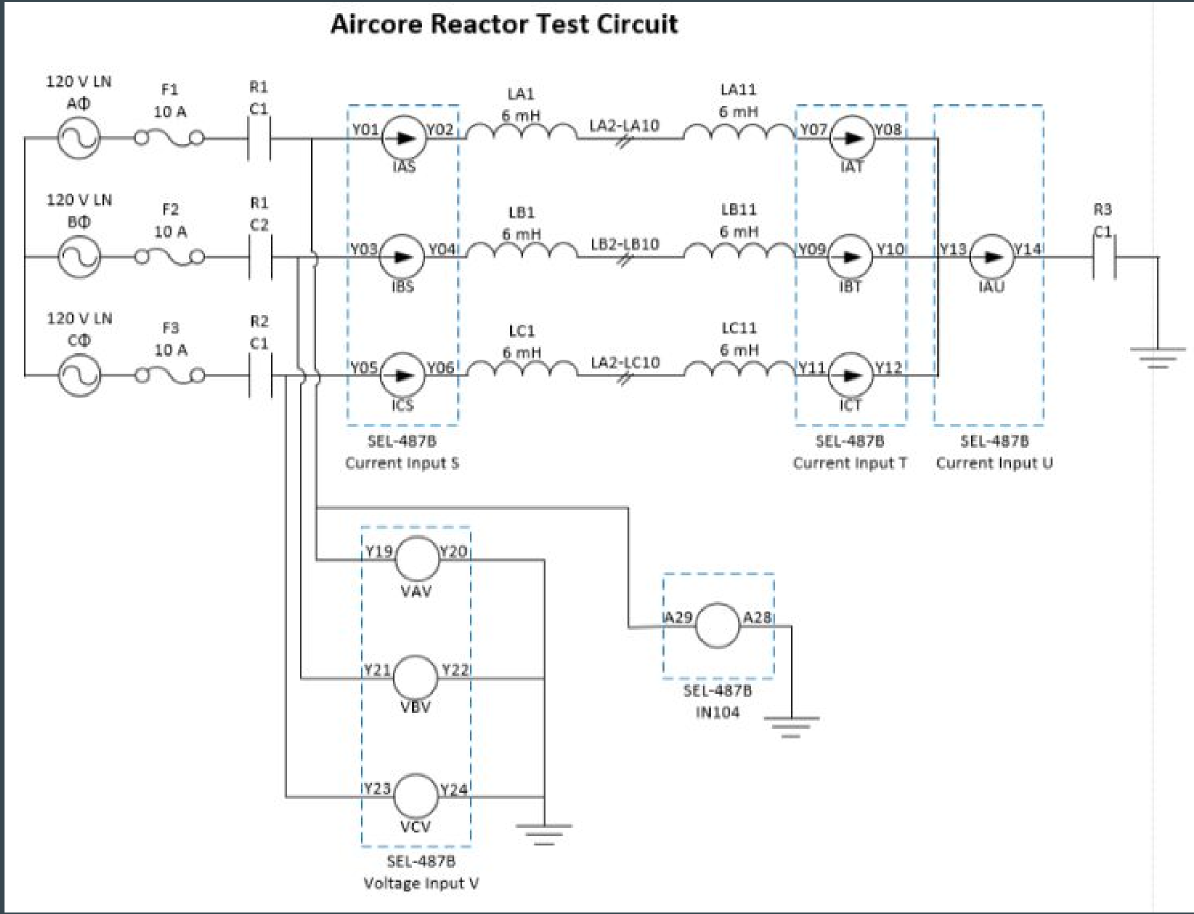
# Project Challenges

- Interturn fault creates high current in faulted turn
- Ensure an X/R ratio high enough to appropriately model the reactor
- Balance all phases so ground current is absolutely minimal
- Accurate RTDS model for proper fault prediction

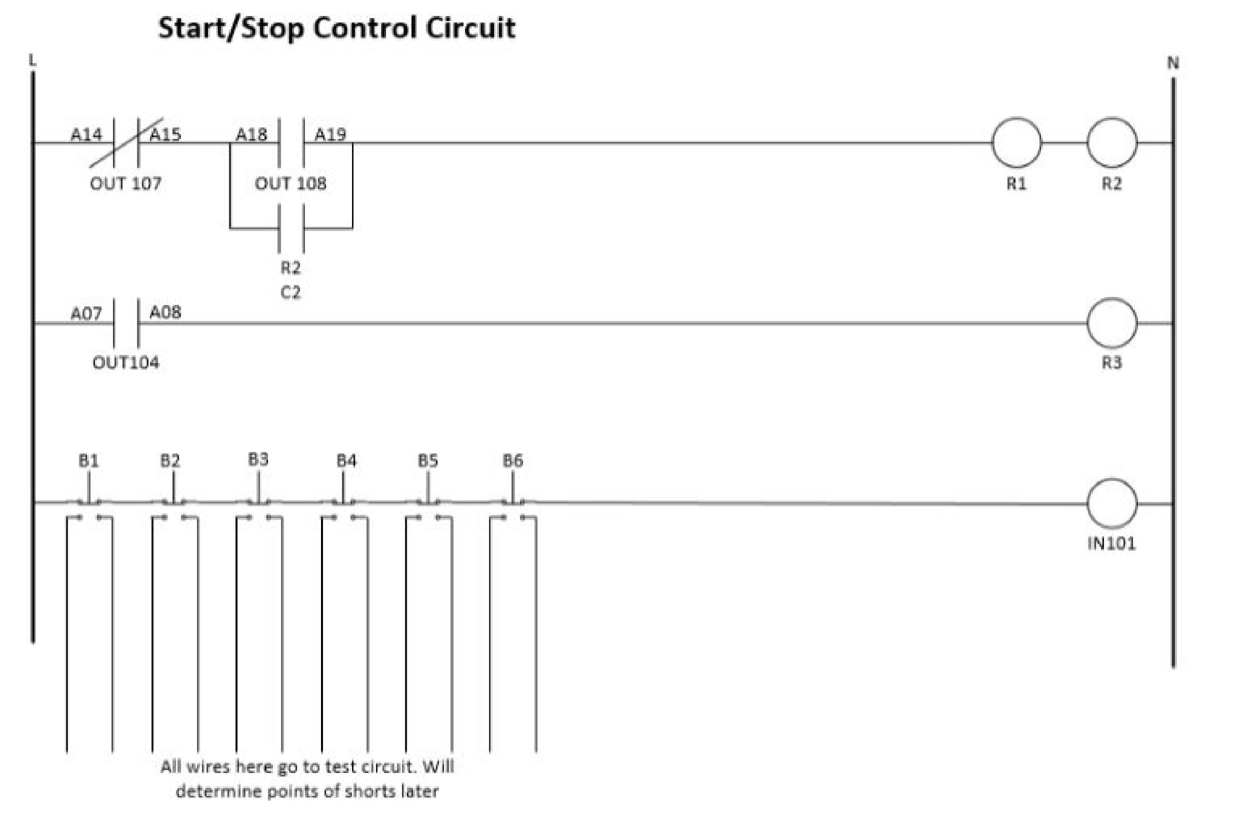
# Constraints

- Model power system
- Type of coil

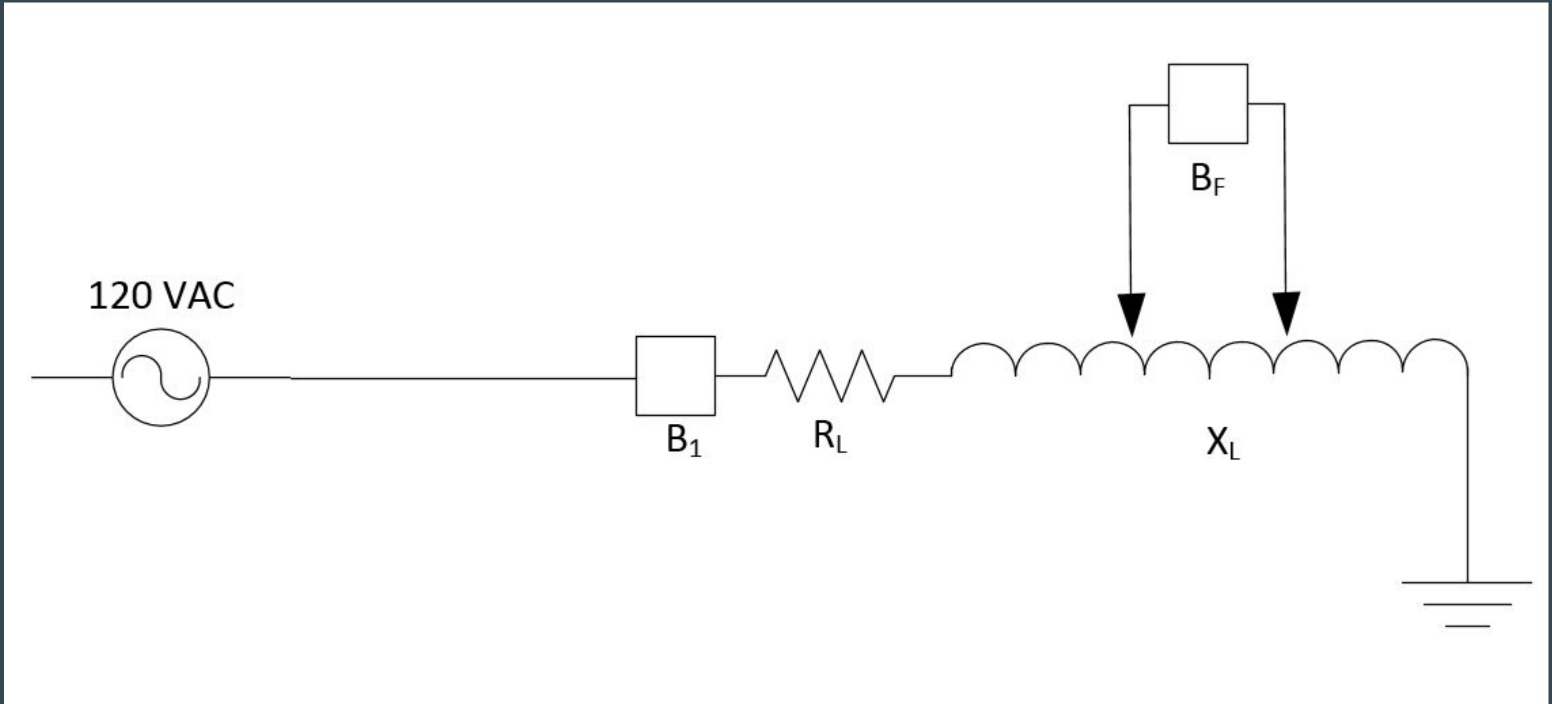
# Design (Physical Model)



# Design (Physical Model)

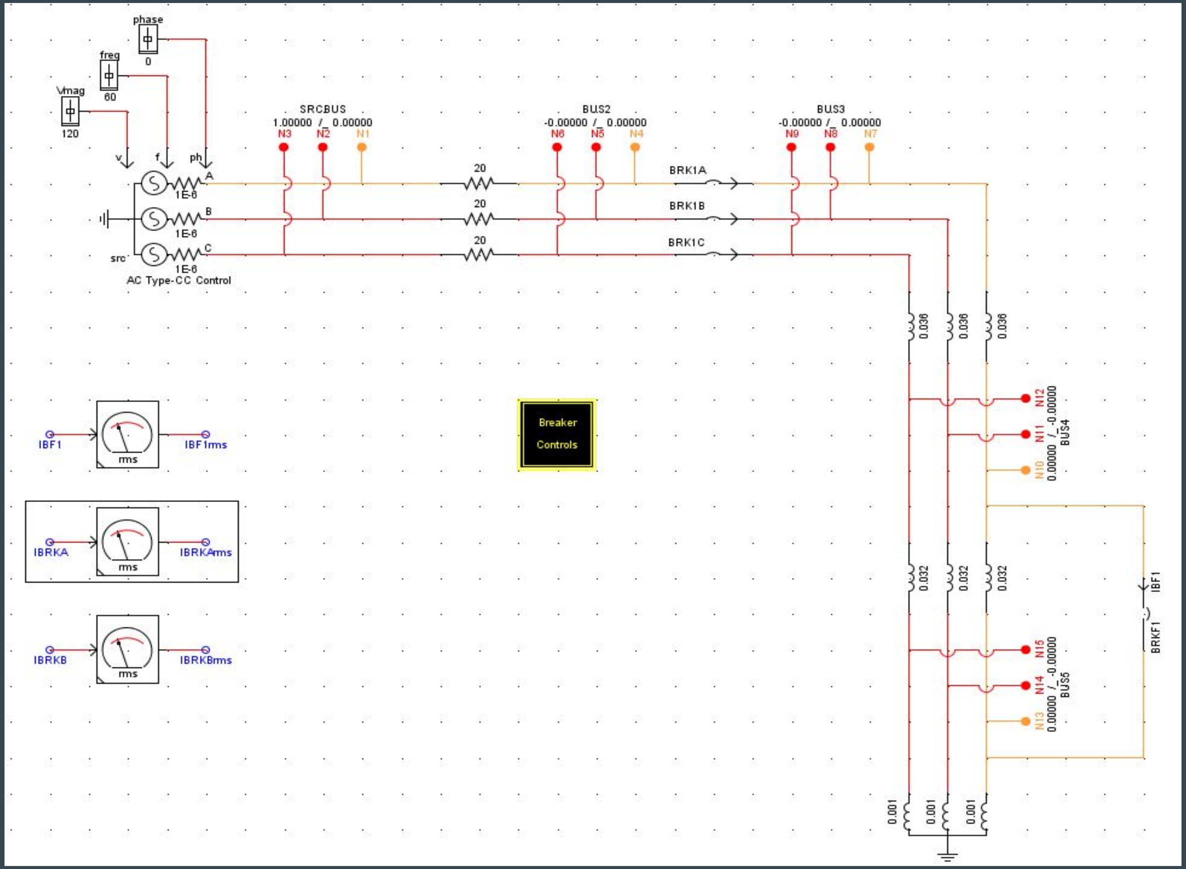


# One Line Diagram



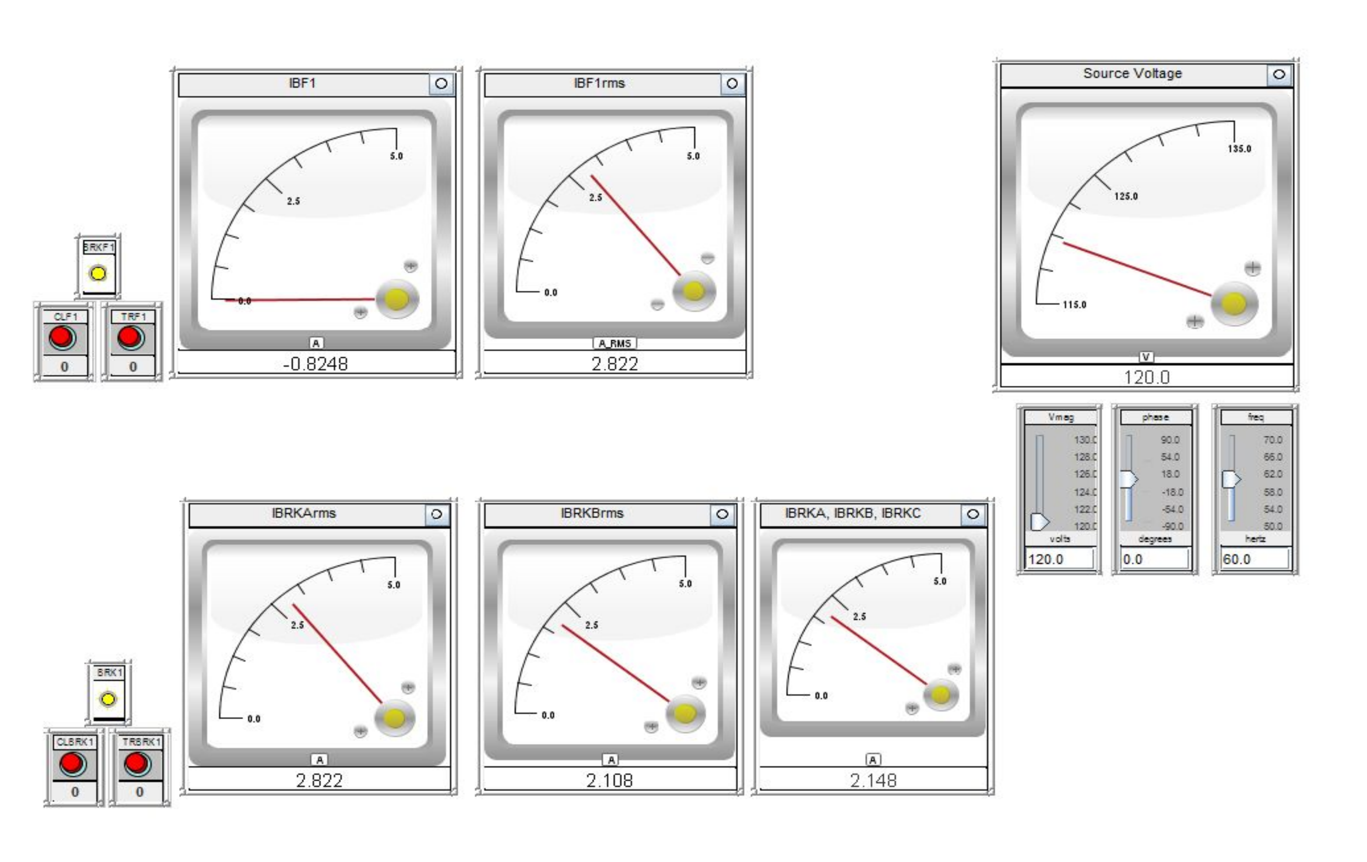

One line diagram used for RTDS modeling

# Design (RTDS)




RTDS draft model of three phase shunt reactor

# Design (RTDS)




RTDS runtime model for monitoring circuit behavior

# Pros and Cons of each Coil

## Jantzen

- Pros:
  - Light/small
  - High Inductance (16mH)
  - Cheap ($30)
- Cons:
  - X/R ratio (2.6)
  - Higher resistance (2.66 Ohms)

## Madisound

- Pros:
  - X/R ratio (3.6)
  - Lower resistance(.7 Ohms)
- Cons:
  - Heavy/Larger
  - Expensive ($100+)
  - Lower Inductance (6mH)

# Project Cost

Using the Jantzen Coils:

- 6 coils per phase
- $36 each

Total cost will be $648

Using the Madisound Coils:

- 11 coils per phase
- $100 for more than 30

Total cost will be $3,300

# Task Completions To Date

- Relay simulation rack wired
  - Ready to attach inductor coils once received
- RTDS model is ahead of schedule
  - Test fault and steady state current magnitudes from various circuit conditions
- Prototype inductor coils have arrived
  - Allowed for testing X/R ratio
  - Visualization of the size/weight of the model system

# Project Timeline (Fall Semester)

- Determine best inductor and place order
  - 11/21/2016
- Design and 3d print inductor mounting fixture
  - 11/29/2016
- Install inductors into existing test fixture
  - 12/16/2016

# Project Timeline (Spring Semester)

- Debug test circuit and continue RTDS simulations
  - January
- Wind inductor with inter-turn fault leads
  - December
- Capture fault data on test circuit and compare to RTDS model
  - March
- Test Avista existing protection as well as additional protection schemes and methods
  - April

# Questions???