**Project Description:**

The power grid is the critical infrastructure of a nation. Relays are used to protect various components in the power grid such as transmission lines and generators. These relays are essentially small computing devices that can analyze the currents and voltages of a component in real time and take decisions to operate a switch. The relays trade off conflicting requirements of keeping the generator or transmission line in service as much as possible without false disconnections, while at the same time making sure that the components are protected from any over voltages or overcurrents. They use complicated signal processing algorithms and information about the power system to reduce false operations and accurately take the decision of protecting device. In this senior design project, the students will explore the merits of merging machine learning with conventional relays to improve their accuracy and to offer additional information for system restoration such as fault localization and identifying the type of fault

Protective Relays Communications: there is not relay in industry that can communicated efficiently its information to the engineer at the office (relay’s current setting).

The innovation part of this project would come from the creation of an application that would show the setting of each relay in the field, and being able to change the settings remotely.

The other part would be, the relay would calculate the most optimal settings for the given feeder installation.

* 9/15/2022 – Meeting

Overall goal – team management / work

* Common issues with Relays?
  + Limitations
  + How used currently?
  + What people want to do with relays?
* Relays and machine learning
* Reading assignments about relays, narrow problem set, problems with relays, future problems if changes are not made as the grid changes
* [5:46 PM] Rocky Mosley (Student)
* hardware/software integration; repository, cost analysis, roles and responsibilities
* [5:48 PM] Rocky Mosley (Student)
* tasks, timeline, due outs
* [5:50 PM] Rocky Mosley (Student)
* strengths and weaknesses of the group members
* [5:50 PM] Rocky Mosley (Student)
* challenges of distance and time differences

GitHub

Assignment 2 Due – 9/30/2022

*Determine roles 🡪*

Lead - Don

Hardware – Don / Jorge

Software – Theron?

Calendar / drafting documents – Rocky / Kyle?

Organization / team communications - Rocky / Kyle?

* Monday – 5:00 pm meeting 2 with some notes from above.

1.<https://www.eaton.com/mx/en-us/products/electrical-circuit-protection/fundamentals-of-protective-relays.html>

**Relay Categories**

Relays can be divided into five functional categories.

1. **Protective relays**   
   Protective relays are one of the critical components of the electrical power grid that serve to detect defective equipment or other dangerous or intolerable conditions and can either initiate or permit switching or simply provide an alarm to provide a safer, more reliable delivery system.
2. **Monitoring relays**  
   Verify conditions on the power system or in the protection system
3. **Programming relays**  
   Establish or detect electrical sequences
4. **Regulating relays**Activate when an operating parameter deviated from predetermined limits
5. **Auxiliary relays**  
   Operating in response to the opening or closing of the operating circuit to supplement another relay or device. These include timers, sealing units, lock-out relays, closing relays, trip relays, etc.

2.https://www.quisure.com/blog/faq/what-are-the-common-faults-of-relay

**Common failure phenomena of relays (Troubleshooting)**

The following table lists some common failure modes of relays and the possible causes of relay failure.

|  |  |  |
| --- | --- | --- |
| **Invalid phenomenon** | **Invalid mode** | **Reason for invalid** |
|  |  |  |
| Relay does not operate | No voltage at the coil end | Open circuit of power supply line Wrong wiring or short circuit Poor welding of lead-in pin |
| Insufficient voltage at coil end | Low supply voltage The power cord is too long The voltage specification of the selected relay is too high |
| The coil is blocked | Poor welding Coil broken |
| Relay failure | Dropped or get a strong impact Contact failure |
| Polarized relay coil end polarity is wrong | The transportation process is impacted and the state changes Circuit wiring error |
| Relay does not release | The residual voltage at the coil end is too high | The coil end has the influence of other energy storage elements There is leakage current or bypass current on the coil |
| Relay failure | Dropped or get a strong impact Contact failure |
| Relay action is unstable | Unstable power supply | Excessive ripple of power supply Insufficient voltage Coil resistance out of tolerance |
| Relay parameters are unstable | Droped or get a strong impact Short-circuit between the turns of the coils |
| Relay malfunction | Is the control procedure wrong Excessive vibration in service environment |
| NO contact bonding, Or NC contact bonding | Excessive current | Excessive load Excessive surge current |
| Abnormal vibration of contacts | Large external vibration The AC relay is not working stably and there is a beep The relay action is unstable |
| Relay action frequency is too high The ambient temperature is too high The use of the relay has exceeded the expected life |  |
| NO contact is not closed, Or the NC contact is not closed | Too much contact resistance | Poor welding Foreign matter between contacts The use environment is harsh, causing the contacts to oxidize or sulfide |
| No current at the contact | Load circuit break Circuit wiring error or short circuit Poor soldering of lead pins |
| The use of the relay has exceeded the expected life |  |

**Relay Failures:**

1. Trip open
2. Shut
3. Short through

**Ideas:**

Security 🡪 Single sided radio air wave.

Power conversion 🡪 proof of concept to provide interchangeability.

5V, 12V, 24V, 48V, … 120V.

Plug and play 🡪 universal pin layout

Coil 🡪 replacement device or material?

Temperature limitations.

TA Meeting Friday @ 0600 AZ time (link in email)

**Meeting 9/22/2022 (Amar – Mentor meeting)**

Electromagnetic transient simulation (toolbox?) – PowerWorld (software) (e-Tap?)

* Logic imported into PowerWorld.
* Build relays

PW – Work with MATLAB? Python? Any others?

Build Relays using WaveForm (ASU App)

* No power systems.

Communications Security specifically or just risk analysis for large asset.

* What are the existing security measures or approaches?

Communications—Substation 🡪 relay 🡪 2nd communication channel to validate information from the 1st channel.

* If changes occur or a channel is corrupted, then 2nd channel helps recover the information and keep the relays working properly.
* Control relays vs Distribution Relays
  + Control – (ice cube) no feedback, cycle count, temperature.
  + **Stats or health of relay as feedback (smarter devices)**

Making a dumb device smart can be a small task that opens a door to big changes in industry.

* All the current devices are fail-safe / non-fail-safe.
* Need to get an idea in realtime of what is going on.
* What is the simplest way to do so? Bluetooth?
* Maintenance before failure improves reliability of overall system.
* Devices are already expensive this will add value and therefore cost.

Adding some kind of cheap microprocessor may allow the first step of making devices smarter.

* Difficult to simulate real life issues that cause temperature or tripping issues.
* To capture abnormalities or malfunctions there are libraries that can be used.

Limit scope to make the project do-able.

* What is our overall goal?
* What is do-able?

Bluetooth 🡪 Physically go to site with tablet or device.

* Optimal settings
* More secure than WIFI

*Final Thoughts?*

* Small smart relays – make system more reliable
  + Is the reliability worth the added cost?
  + What is added cost?
* Every relay is different
  + Different wear and tear
  + Difficult to predict with simulations
  + What kind of limitations or identifiers could we watch for that is a predictor of wear and tear?
    - Temperature and resistance goes up as nearing failure.
* Choose a type of wear and tear…
  + Could build a library one by one with each type.
  + Figure out end of life identifiers for each type.
  + Can collect old relays that still work
    - Comparing to brand new will provide data
  + How to distinguish between old and new just using WaveForms (voltage / current stats).
    - More distortion of the voltage and current, more glitches due to physical components within the relay.
    - Temperature indirectly can give similar information / identify issues.
      * Study existing approaches.
* Replacement cost
  + Failure in an emergency vs having a plan phase
    - Loss of work (machinery stops)
    - Security loss
* Algorithm
  + More data = better algorithms
  + Failure analysis from companies that take relays back after failure.
  + Published?

For next time 🡪 Report 1 – Due 9/30/2022

* Photos of relays.