

## Avista Microgrid Automatic Generator Controller

### Meeting Minutes

1/20/2016

- Logbooks
  - Format
    - For each log entry include the date at the top of the page and an optional title if wanted. Then include the bulk of the information as project ideas, meeting notes, diagrams, pictures, and anything else you may find relevant to the project. Finally, at the bottom include your signature with the date you signed it. Also, if there is excess room at the bottom of your log entry draw a line under your signature and cross out the remaining space, so for your next entry you can start at the top of a page.
  - Due dates
    - No due dates have been posted yet, but be aware that Dr. Li will post them on the Mindworks webpage.
    - Log entries will be submitted to Dr. Li once he sets the first due date.
  - Expectations
    - Log entries should be complete and fill all requirements Dr. Li is looking for.
    - There is a link on the Mindworks webpage that gives more detailed information regarding log entries.
  
- Client Meetings
  - Agreeable hours
    - Our group meeting have been set for Tuesday at 1:30 PM.
    - There is also a weekly meeting on Monday with Dr. Johnson, where a time is still to be decided and will most likely be located in the ECE conference room.
    - There is also a bi-weekly meeting with Avista every Thursday, which occurs at 2:00 PM, but this time is subject to change.
  - Time/Location/Frequency
    - We need to talk to either Nathan or Alex to discuss the upcoming meeting schedule with Avista

- Define Project
  - Define a clear project outline
    - A discussion with the grad students needs to occur in order to talk about the scope of work that needs to be done and how to properly break up the project, so each group knows it's particular goal/task in doing the project.
  - Attempt to define a 'jumping-off' point (will require Pavan's Avista information)
    - We need to talk to Pavan and gather information from him
  - Attempt to define a separation of work from Research team
    - As mentioned before the separation of work still needs to be broken up and assigned, so we know which part of the project we need to complete.
  
- Team Contract
  - We are going to meet as a group and finish it together soon.
  
- Next meeting
  - Connor is the moderator for next meeting and Gigi will write the agenda
  
- To do
  - Talk to Alex, Nathan, Pavan about the project and obtain any maps/blueprints that they have
  - Download Powerworld if you don't already have it and get any existing models from the grad students
  - Define critical loads for our project
    - Define the energy capacity for these loads (100%, 50%, auxiliary)
    - Define hierarchy of loads
  - Define available micro-grid sources
    - Hydro? Solar?

1/26/2016

- Define project
    - Grad students are already researching different aspects of the project
      - Smart-wires/communication protocols
      - Grid resync
        - After contingency, resyncing the micro-grid with the main system
      - Photovoltaic research for predicted power
      - Micro-grid design/interconnection – converting maps to PowerWorld
    - Micro-grid stability/contingency planning
    - Other options?
      - Load Shedding
        - This is a dynamic micro-grid. We need to decide what to shed in order to keep certain loads operating
          - How exactly to shed loads. Alex might be helpful on this aspect
          - How to optimize the micro-grid composition
        - Priority loads
          - University district (Post St. East)
            - WSU, Gonzaga
          - Hospitals
          - Jail
          - Government complexes
          - Consult with Avista to find out critical load priority
            - Setup an appointment
        - Loads and generators are seasonal
          - Hydro – high during spring/summer, low fall-winter
        - Need load projection data/generation data
      - If the data is time constrained, we might be able to help Pavan
      - We could generate models while awaiting data
- Avista data
  - Awaiting approval for Avista data distribution from research group
    - The research group is also waiting for data correlation
    - Need Pavan for PowerWorld Data
      - Pavan is translating Spokane data from Synergy to PowerWorld
- Client meeting
  - Clarify time – Still Thursday 2pm?
    - Meeting 1/28/2016, every two weeks.
    - Boot meeting on the 23<sup>rd</sup> of February (for whether the project is aborted)
    - Meeting time may be moved to the morning (wait to be seen)
  - We will talk with load contact (We will have either Dr. Johnson or Pavan with us)

- Next meeting
  - We will discuss how to process after receiving and processing the amount of information we receive from Avista.
- To do
  - Attend the meeting with Avista on Thursday at 2:00pm. In addition, we will need to set up a meeting with an Avista engineer to obtain the necessary information (discussed above) to proceed.

2/2/2016

- Define Project
  - Load shedding/reconfiguration scheme
    - What should be shed?
    - Load shedding hierarchy
      - Banks, schools, jail, hospitals, transportation, government complexes...any others?
        - We can create our own load shedding hierarchy
        - We should talk to Erik about this
    - How to operate the micro-grid with a hierarchal setup?
      - What order should the breakers be opened to operate the grid/system correctly?
        - How to operate this grid?
        - John Gibson is the VP of Distribution for Avista (He may be a good contact)
        - Is there a central control for the grid?
        - Manual equipment upgrade? Digital system? Would we save money by not replacing equipment?
  
- Information/Data received from Pavan
  - Downtown network maps
  - Downtown Network PowerWorld
    - The files in this folder would not open (Software update?)
  - Load Data (From 2013 to 2015)
    - This data is for 3rd & Hatch 12F8 Sacred Heart
  - Avista lines in PowerWorld
    - It cannot be opened with the student version of PowerWorld (Exceeds 42 busses)
      - Talk to Dr. Johnson about getting full access to these large Powerworld documents
  - Dispatch map of Spokane
    - Google maps may be better
      - GIS map (We have access to them in McClure Lab)
  - Downtown Hydropower generation data (From 2013 to 2015)
  - Spokane one line diagram (115 kV – 230 kV)
  
- Set up a contact with Avista
  - Load contact?
    - Eric?
      - We have Erik's email now (Erik.Lee@avistacorp.com)

- To Do:
  - Client Interview (Due February 12<sup>th</sup>)
    - 20 questions about project for the clients
    - Write a transcript of the interviewer and write specifications (a list of customer needs). Due February 15<sup>th</sup> with client signature required
  - First Logbook review
    - Due February 26<sup>th</sup>
      - There is a grading sheet online for this

2/9/2016

- Avista Client Meeting Review
  - Discussion points
    - Avista needs AGC designs
  - Future plans
    - Define our project, again
  
- Project Redefinition
  - Plan for conference call meeting
    - Thursday the 11<sup>th</sup> at 2:00 pm
  - Plan meeting with Dr. Hess and Dr. Johnson
    - Meeting planned for 2/10/2016 at 11:30 am
    - Topic: redefining team: Caution large load's project

2/16/2016

- Master Controller
  - Proposal
    - Initial scope - Frequency control
      - Load sharing between generators
      - Load variation
  - Research
    - AGC/Governor Literature
      - Reinhold Rudenberg – text on generator droop (1960s)
        - Transient Performance of Electrical Power Systems
  
- Interview Questions
  - Review
    - The majority are questions for Avista
    - How does Avista want to share power between generators?
    - Is PowerWorld able to simulate frequency disturbances?
    - How to characterize generator? MATLAB?
      - Talk to Tracy Ralsted (Avista) and or Pavan
  - Possible deadline postponement
    - Talk to Dr. Li
  
- Economic Dispatch
  - Allocation of power to customers between generators
  
- To Do
  - Continue research on AGCs
  - Finish proposal/interview questions



2/23/2016

- Master Controller
  - Continue research
    - AGC
    - Governor Control
    - Feedback
  - Articles:
    - AGC of an Interconnected Hydrothermal Power System (also includes hydro simulation)
      - State Space Representation
      - Matlab simulation
        - 422- check in text (Thomas Overbye) to model system as in in article
    - A Review on Hydropower Plant Models and Control
      - Hydro plant Models
      - Governor
      - Plant Controllers
        - Go to work cited to review related articles
        - Implement PID controllers into system (good place to start), although there could be other programs to be used as well.
        - The basic law of control is the control will never be any better than the knowledge of your system.
- Interview Questions
  - Sent to Avista
- Due Dates
  - Logbooks – Friday 2/26
  - Team Logbook – Friday 2/26
- Other Information:
  - March 8<sup>th</sup> tour of hydropower dam talk to Pavan. Snapshot day will need to be rescheduled
  - Talk to Pavan regarding the network between the generators as he has already modeled the entire system and the generators interconnection is a subset of this.
  - We're still waiting on a response from Avista for our project proposal and interview questions
- To do:
  - Research about if the hospital's backup generators can sync to the grid
  - Develop a control loop of the system and model it with both generators
  - Get all the information we can from Avista (May need to get a background check)
- Research/questions:

- Is it common practice in frequency generation for the generators to operate above their nominal operating speed?
- Our system is separate from the normal NW main grid, how much above nominal rated frequency can we sync?
- Is our system required to operate at 60 HZ? Can we operate it at a different frequency level? 30 Hz?

3/1/2016

- Snapshot make-up
  - 15-20 min presentation
  - Dr. Li proposed 3/9 at 11:30am
    - Conflicts?
- Expo Registration
  - Online form
  - Complete by 3/7 and send confirmation to Dr. Li

3/6/2016

- Snapshot Presentation
  - 15-20 minutes
  - Powerpoint
    - Discuss scope and direction of project
      - Project Problem/Background
      - Project Definition
      - Project Plans
    - Plan for 5 minutes of speaking time per member
  - Dr. Li proposed 3/9 at 11:30am
    - Propose to move presentation to Thursday

3/8/2016

- Avista Tour
  - Generator Tours
    - Upper Falls
      - ~10MW
    - Monroe Street
      - ~12MW
  - AGC Project
    - Cannot user under-frequency load shedding; no relays installed
    - No sponsor yet
      - Questions have not been answered because of this

3/22/2016

- Research
  - Need control model for AGC
    - Paper (7) could serve as a useful guide
      - Load Frequency Control
        - Relationship between generated and load (real) power
      - Automatic Voltage Regulation
        - Relationship between generated and load reactive power
      - 
      - Simulink to model
  - Make assumptions about generator models
    - Ask Dr. Johnson about generator models

3/29/2016

- Research
  - Need control model for AGC
    - Paper (7) could serve as a useful guide
      - Load Frequency Control
        - Relationship between generated and load (real) power
      - Automatic Voltage Regulation
        - Relationship between generated and load reactive power
- Simulink to model
  - Create model representing our system
    - Initially start with a basic design, then expand it to be more detailed/specific
    - Make assumptions about generator models
      - Ask Dr. Johnson about generator models
- Prepare for design review
  - Expectations?
    - Doesn't need to be a PP but may be useful
    - It should be vigorously technical. We can also provide technical documents for audience if we decide to
    - Also, we need to give notifications to our professors and book a room
  - What kind of product should we have at this point?
    - We should have an almost finished model at this point
    - Also, future plans for next semester
- Moving forward without Avista
  - We will continue to make assumptions about the generators unless we are given any new data that is useful to us
- Wiki Page is being developed
  - Wiki page tutorial today at 3:30

4/5/2016

- Modeling
  - Generator Model
    - Powerworld Generator models for reference
      - Look at transient analysis?
    - Is there software for simulating micro-grids?
  - Exciter model
    - Monroe St. – Static exciter
    - Upper falls – rotating exciter
      - Look for field current on data plate
      - DC machine model – similar to inside-out synchronous machine
      - Estimate ratings and try to find a similar DC machine model
        - IEEE papers in the 1940s for DC machines with parameters
      - Transient two time constant models for DC machines – Overbye book
  - Pavan's data
- Design Review
  - Tentative date: Thursday, April 21
    - Ask Ryan and Dr. Johnson about getting Avista on the phone for Design Review
  - Attend one other Design Review
- Expo
  - Friday, April 29<sup>th</sup>
  - Expectations?
    - Need further clarifications about booth
- 1<sup>st</sup> semester deadline
  - Due: Friday, May 6<sup>th</sup>
    - Wiki Page
    - Portfolio
    - Logbooks
    - Peer reviews



4/12/2016

- Conceptual Research → Questions
  - Do we need to model the exciter if we have the  $I_f$  and  $E_a$  curve?
    - Graph represents steady state, how will we represent possible changes to the system?
    - Do we want to know changes to the system?
    - Transient graphs have scales that need multiplication by 10.
    - 421/422 book has exciter models → review
  
  - Should we adjust  $I_f$  for frequency control or for AVR (fast-decoupled load flow; i.e. the separation between  $I_f \rightarrow |E_a| \rightarrow Q$  and the angle between  $E_a$  and  $V_t \rightarrow \text{Power} \rightarrow \text{speed}$ ?
    - Back to flow for controlling real power/speed, but maybe  $I_f$  for small variations of frequency?
  
  - How should we control power/speed if  $I_f$  is decoupled, will it still vary the speed enough?
  
  - Reference material for synchronous generators and representing them their characteristics as gains/transfer functions
    - 421/422 book
  - Mechanical analogues reference:
- **System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems 5th Edition – Chapter 4**
  -

8/25/2016

- Recap
  - Monroe Street Model
- Validation via Simulink
  - Use known values for inputs of simulation
  - Compare and analyze outputs with calculated/reasonable values
  - Ask Avista about generator outputs (transient waveforms)
    - Pavan's group will know locations of capacitor banks
- Future plans
  - Upper Falls generator model and validation
    - SWAG factor will be large
    - X/R ratio is likely to be smaller in an older generator
  - Stability analysis (if everything else gets done)
- Weekly meeting
  - Thursdays 2:30pm, GJL 102
  
- To do
  - Draft a timeline for the semester
  - Expected deliverables
  - Set up a time for a design review (in about one month)

9/1/2016

- Timeline
  - Validate Monroe St. Model (early October)
  - Final deliverable of both models due around 2<sup>nd</sup> snapshot day
- Tentative Design Review Date
  - Capstone scheduled date: 9/23
    - Thursday, 9/22 at 2:30 pm – tentatively the NASA room
      - Check availability of Dr. Johnson and Dr. Li
- Calculation for model parameters:
  - Generator/Exciter
  - Governor
  - Turbine
- Expected Deliverables
  - Validated generator models (Monroe St. and Upper Falls) - Compare with Grad students and compare models of ATP vs. Simulink
  - Portfolio – Due 12/9
  - Wikipage – Due 12/9
  - Project Poster – Due 12/9
  - Logbooks with review form – Due 12/9
- Other Notes
  - Documents for Portfolio
    - Electronic copies of technical documents
    - Documents from Avista
    - Files we generated
    - Team assessment paper
  - Dr. Law has a lot of experience on synchronous generators
    - We can ask him what would be appropriate for validating our model
  - Can we get anything from Avista, so we can validate?
    - Current or power waveforms
    - Steady State Models
    - Transients when changing from one stage to another (load changes)

9/15/2016

- Timeline
  - Validate Monroe St. Model (early October)
  - Final deliverable of both models due around 2<sup>nd</sup> snapshot day
- Tentative Design Review Date
  - Capstone scheduled date: 9/23
    - Thursday, 9/22 at 2:30 pm – tentatively the NASA room
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    - Current or power waveforms
    - Steady State Models
    - Transients when changing from one stage to another (load changes)

9/22/2016

- Design Review Tomorrow (9/23/2016)
  - BEL NASA Room
  - 8:00 A.M.
  - Presentation Format
- Simulation
  - Synchronous Generator
    - Underdamped, so increase stator resistance for shorter settling time
      - Unfortunately, less accurate
    - Transients take a long time to settle – multiple transients
    - Find time constant from simulation graphs
      - If needed, there are two super computers at the university for use

9/29/2016

- Future Project Overview
  - Phase 1
    - Determine problematic parts of the system and fixing them
  - Phase 2
    - Create second hydro-station model (Upper Falls)
  - Phase 3
    - Combine the two models
      - How do you connect our two models together?
        - Is parallel efficient? We will need to look at Avista's map. Also, talk to Jordon about how these systems are connected together
      - Do we bring micro-grid to generators or generators to micro-grid? How do we get them to talk together?
  - Phase 4
    - Simulate the complete system and determine problems and fixing them
- Monroe St. Model
  - Changing to synchronous reference frame
  - Correct generator parameters (WECC testing data actually per-unit)
  - Updating exciter parameters (from powerworld files)
- Access to Jordan Scott's office for computer PowerWorld 19 access

10/6/2016

- Future Project Overview
  - Phase 1
    - Determine problematic parts of the system and fixing them
      - Will continue on to Phase 2 in conjunction with phase 1
  - Phase 2
    - Create second hydro-station model (Upper Falls)
      - Turbine will need to be assessed
      - Potentially generator
  - Phase 3
    - Combine the two models
      - Jordan or Pavan might have an idea of how to combine the models
  - Phase 4
    - Simulate the complete system and determine problems and fixing them
- Future Deadlines:
  - Logbooks Due – 10/7/16
  - Snapshot Day – 10/11/16
    - Can use poster-board from EXPO as long as we cover up old generator
    - Check time on mindworks, potentially 3:30-4:45
    - Dress attire: button-up

**WEDNESDAY, OCT 19<sup>TH</sup>. 2-3 MINUTE PRESENTATION TO AVISTA  
10:00 AM ECE CONFERENCE ROOM**

10/20/2016

- Upper Falls Model
  - Francis Turbine Model
  - Governor?
    - Would it be appropriate to use the same governor as the Monroe Street?
      - For now, do not include a governor
  
- Use Pavan's PW model and input a transient to compare
  - Run an FFT on the transient to find the poles in the system
  - Better yet, try to isolate the generator model from the rest of the system
  
- Monroe Street
  - Oscillations partially fixed
    - Generator alone: fixed
    - Full station model: partially fixed
      - The full model has more poles than the standalone generator model
  - Comparison/Validation
    - ATP
    - Power World
  
- Find a book on 'System Identification' - Taking an unknown system and creating a linear model from it



11/3/2016

- Work Updates
  - Validation
    - Powerworld Issues
    - ATP
  - 1. 2<sup>nd</sup> Turbine
    - Units
    - Forward loop – dampening factor to improve oscillations
  - 2. Simulink Progress
    - Load
      - Reference Dr. Law about Synchronous Generators with Turbines
    - Upper Falls unit plans
  
- Senior Design Expectations
  - Final Report
    - Model as we have it at the time (Final Draft with parameters)
    - Block Diagram, include equations
    - Simulations – appropriate results, performance if we increase torque (step input torque, we will see an increase on the speed)
    - Model for the other turbine
    - Combined model results with simulation
    - If you were the group to be given this report, here is what the guys in the previous semester did, give enough information so they understand and can continue the project
    - IEEE format – give next group exactly how we did it with results, be concise
  - Final Design Review?
    - Downsized Expo day
    - Poster costs:
      - Avista Project – Budget #: FSK 690 or 053, Talk to Arvilla
  
  - Put all final project information on jump drive for next group

11/17/2016

- Work Updates
  - Monroe Street Model
  - Post Falls Model – no dynamics
  - Started working on deliverables
    - Wiki Page
    - Portfolio
- How do we model gate position with no governor?
- Project definition
  - Report – put old project definition and updated project definition so we know where we started from.
- Report:
  - Step by step conclusion on how we made it to final model
- Wiki page:
  - Put final model on wikipage