**Timeline**

Below is a suggested breakdown of tasks and milestones for each week, keeping in mind ~10 hours of effort per week.

**Week 1: Setup & Literature Review (Estimated 10 hours)**

1. **Literature Scan (4–5 hours)**
   * Identify key references on synthetic inertia and fast frequency response in low-inertia grids.
   * Focus on *control strategies* and *typical test systems.* IEEE or IET journals and major power conferences (e.g., IEEE PES GM) are good starting points.
2. **Test System Selection (1–2 hours)**
   * Decide on IEEE 9-bus vs. 39-bus or a simpler microgrid model.
   * Acquire the system data or model files if already available (MATLAB/Simulink often has standard examples for the 9-bus system).
3. **Simulation Tool Setup (3 hours)**
   * Install or configure your chosen simulation environment.
   * Run a basic “no-disturbance” power flow or time-domain simulation on your chosen system to confirm everything works.

**Deliverable**:

* A short literature summary (~1 page) describing relevant control methods for SI and FFR.
* Confirmation that you can run a baseline load-flow or dynamic simulation on your chosen test system.

**Week 2: Baseline Modeling & Inertia Reduction (Estimated 10 hours)**

1. **Baseline Dynamic Model (4–5 hours)**
   * Configure the chosen test system for a typical operating scenario.
   * Ensure conventional synchronous generators have inertia constants that reflect moderate inertia levels.
2. **Introduce High Renewable Penetration (3–4 hours)**
   * Replace or reduce synchronous generators with inverter-based renewables (e.g., wind or PV).
   * Lower the overall inertia in the system so that frequency stability becomes more sensitive.
3. **Baseline Disturbance Test (1 hour)**
   * Define a standard disturbance scenario (e.g., a 10% load step increase, a small generation trip).
   * Run a time-domain simulation to see the unmitigated frequency response.

**Deliverable**:

* A baseline simulation model with high renewable penetration and documented inertia parameters.
* Preliminary plots of frequency response under a selected disturbance (no advanced controls yet).

**Week 3: Implement Synthetic Inertia Control (Estimated 10 hours)**

1. **Control Theory & Parameters (2–3 hours)**
   * Review a simple “virtual synchronous machine” or droop-based synthetic inertia approach.
   * Identify the key control parameters (e.g., inertial gain, damping factor).
2. **Implementation in the Model (5–6 hours)**
   * Attach the synthetic inertia block to one or more inverter-based generators.
   * Calibrate the control parameters so that the system remains stable (avoid overly aggressive or conservative settings).
3. **Preliminary Testing (1–2 hours)**
   * Re-run the same disturbance as in Week 2.
   * Compare frequency nadir, ROCOF, and settling time with the baseline (no SI).

**Deliverable**:

* A working synthetic inertia control block integrated into the test system.
* Simulation results/plots demonstrating the effect of SI on frequency events.

**Week 4: Implement Fast Frequency Response Control (Estimated 10 hours)**

1. **Control Strategy Selection (2–3 hours)**
   * Choose a battery or energy storage system for FFR.
   * Use a simple droop-based or wide-band frequency measurement to trigger injection/absorption of power.
2. **Model Integration (4–5 hours)**
   * Add the FFR resource into the same test system.
   * Fine-tune the droop settings, ramp rates, or power limits to ensure stable behavior.
3. **Initial Simulations (1–2 hours)**
   * Repeat the same disturbance scenario.
   * Observe frequency metrics, particularly how quickly and effectively the storage responds compared to SI.

**Deliverable**:

* Model with both SI (from Week 3) and FFR resources implemented (though typically you’d test them separately at first).
* Simulation data/plots showing FFR performance.

**Week 5: Comparison & Sensitivity Studies (Estimated 10 hours)**

1. **Side-by-Side Comparison (3–4 hours)**
   * Run the test system under these scenarios:
     1. No advanced frequency control (baseline)
     2. Synthetic Inertia only
     3. Fast Frequency Response only
     4. Possibly SI + FFR combined
   * Record frequency nadir, ROCOF, settling time, overshoot, etc.
2. **Sensitivity Analysis (3–4 hours)**
   * Vary key parameters (e.g., inertia constants, droop gains, battery size) and observe outcomes.
   * Possibly vary the disturbance severity (a bigger load step or generator trip).
3. **Data Organization (2–3 hours)**
   * Organize simulation results into clear tables or plots for final documentation.

**Deliverable**:

* A set of frequency-response curves comparing different control methods.
* A short bullet-point summary listing how each method performs and any trends noted in the sensitivity analysis.

**Week 6: Final Refinement & Documentation (Estimated 10 hours)**

1. **Refine/Optimize Controls (2–3 hours)**
   * If time permits, do a final pass adjusting control gains to see if you can further improve performance.
   * Document any “lessons learned” in tuning.
2. **Draw Conclusions (3–4 hours)**
   * Synthesize your results: Which method is best under what conditions?
   * Discuss potential trade-offs (cost, complexity, resource sizing).
3. **Write Final Report & Presentation (3–4 hours)**
   * Summarize project goals, methodology, key findings, and future work ideas.
   * Create a short (10–15 slides) presentation or a concise written report (~10 pages) with graphs.

**Deliverable**:

* **Final Documentation**: A written report or slide deck with your background research, methods, results, and conclusions.
* **Model & Scripts**: Organized simulation files so the project is reproducible.

**Tips for Success**

* **Keep Models Simple**: You only have ~60 total hours. Resist the temptation to add extra complexity (e.g., complex aggregator logic or multiple advanced controllers) unless you’re ahead of schedule.
* **Start with Defaults**: Use reference parameters for synchronous generators and invertors from standard literature or built-in examples, then make small changes.
* **Log Everything**: Save every result as you tune parameters, so you can easily revert if new settings cause instability.
* **Focus on Key Metrics**: Frequency nadir and ROCOF are standard in this type of study; you don’t need to measure 10 different stability indicators.
* **Document Iteratively**: Write short “notes to self” each week; this speeds up final reporting in Week 6.

**Summary**

By following this 6-week, 10-hours-per-week plan, you’ll build a credible proof-of-concept project that compares synthetic inertia and fast frequency response in a low-inertia power system. You’ll gain both a conceptual understanding (from the literature) and hands-on experience (from modeling and simulation). Once complete, you’ll have clear, data-driven insights on how each approach affects grid stability—and a polished set of simulations, plots, and a final report that demonstrate your power-engineering skills.