Three-Phase Solid State Transformer (SST) Simulink Model

This repository contains a comprehensive MATLAB/Simulink implementation of a Three-Phase Solid State Transformer (SST). Unlike conventional transformers, this SST utilizes a multi-stage power electronic conversion process to provide enhanced grid services, such as reactive power compensation, voltage regulation, and harmonic isolation.

Topology Architecture

The model follows the classic three-stage SST topology:

1. Input Stage: High-Voltage AC/DC Rectifier

- Function: Converts the high-voltage AC grid input into a regulated DC bus.
- Control: Employs SRF (Synchronous Reference Frame) control to maintain a unity power factor and stable DC link voltage.

2. Isolation Stage: High-Frequency Dual Active Bridge (DAB)

- Function: Provides galvanic isolation via a high-frequency transformer (HFT).
- Benefit: Significantly reduces the physical footprint compared to 50/60 Hz transformers.
- Components: Visible in the center of the model are the H-bridges and the center-tapped/isolation transformer blocks.

3. Output Stage: Low-Voltage DC/AC Inverter

- Function: Converts the isolated DC voltage back to a regulated three-phase AC output for the load.
- Filtering: An LCL filter is used to ensure high-quality sinusoidal output by filtering high-frequency switching noise.

Control Strategy

The control architecture (bottom section of the model) is distributed across the stages:

- Grid Synchronization: An SRF-PLL tracks the grid phase angle (ωt) to align the inverter output with the network.
- Decoupled Current Control: The dq-frame controllers manage active (I_d) and reactive (I_d) power independently.
- Voltage Regulation: PI controllers (labeled PI(s)) process the error between reference values and measured feedback to generate PWM signals.

Current Simulation Status

The provided Scope output indicates a Transient Instability issue:

- Symptom: The output voltage (V_{abc}) and current (I_{abc}) exhibit divergent oscillations starting at t = 0.15 s.
- Observation: Current magnitudes reach 10^5 A, indicating numerical divergence, likely due to high PI gains or a phase-mismatch in the PLL.
- Diagnosis: The SST is currently "hunting" for stability and failing, likely requiring retuning of the DAB phase-shift or the inverter current loops.

Usage

1. Software: MATLAB R202a with Simscape Electrical.
2. Solver: Set to Discrete with a sample time of $1*10^{-6}$ as configured in the powergui.
3. Tuning: Adjust the Kp and Ki gains in the dq control blocks to stabilize the output.