Mitigating Voltage Instability in the Saudi Grid for a Decarbonized, Fully Solar Power System

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Introduction

- The short circuit ratio (SCR) measures the system strength or fault levels in a power grid.
- SCR is determined by the ratio of short circuit capacity (SCMVA) to the inverter's rated power capacity at the point of interconnection (POI).
- Replacing synchronous generators (SGs) with solar photovoltaic (PV) decreases the system's SCR because of the reduction in SCMVA.
- A low SCR can negatively impact on the stability of the system.
- This may result in undesired trips and unplanned isolation of parts of the grid.
- Synchronous condensers (SC)s are synchronous machines without a prime mover, crucial for supporting grid voltage.
- By generating or absorbing reactive power, SCs maintain a balanced power supply and improve system efficiency.

Methodology

- The SCR at a given point is the ratio of the available fault level to the nominal active power output of the IBR as it is defined in the following equation [1,3]:

No.	Bus Num.	Bus Volt. Before-Contiguency (P.U)	Bus Volt. After-Contiguency (P.U)
1	West_1	1.0	0.9272
2	West_2	1.0	0.9273
3	South_1	1.0	0.9180
4	South_2	1.0	0.8980
5	West_5	0.98	0.8656
6	West_6	0.98	0.8700

Result

- The SCR reduction occurred due to solar PV integration is presented in the following figure:

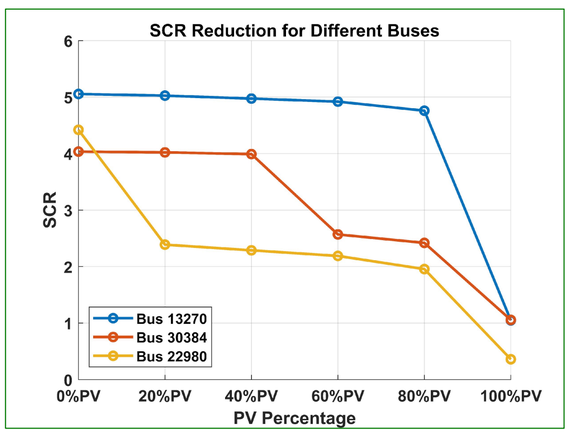

Fig. 1 shows SCR reduction as.

- Case A where SCs increase the SCR by 2: In this scenario, the total SCMVA contributed by the SCs equals twice the daily solar PV power requirement. The voltage response is depicted in Fig. 2, showing the waveforms that failed to return to steady-state and desired stabilization due to insufficient reactive power compensation.
- Case B where SCs increase the SCR by 3 : In this case, the total SCMVA supplied by the SCs is equivalent to thrice the daily solar PV power need. This means the SCR associated with the SCs is increased by 3. Fig. 3 displays the voltage response following a solar PV unit trip, which observes an improvement in both recovery time and smoothness.

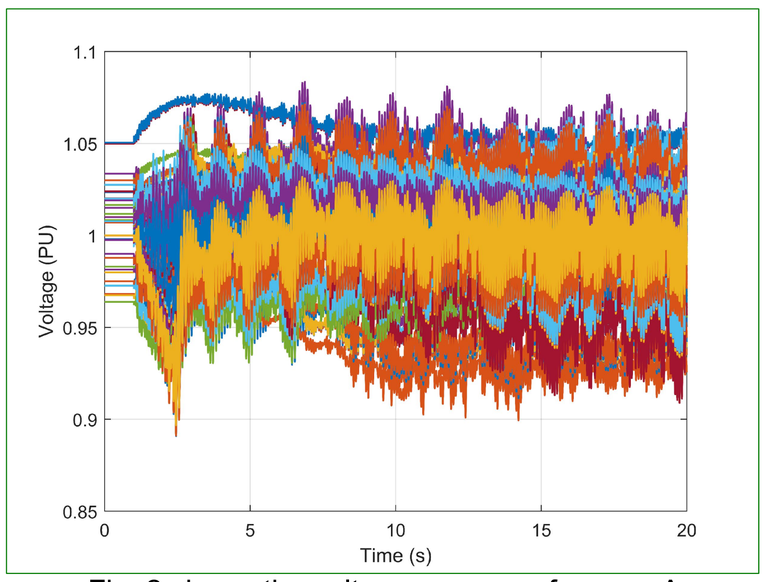

Fig. 2 shows the voltage response for case A.

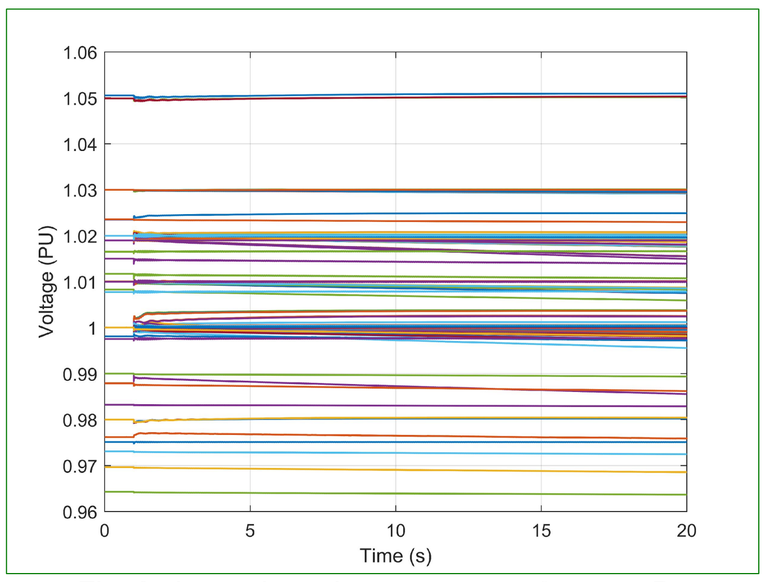

Fig. 3 shows the voltage response for case B.