Power Apparatus and System Design (EE49004), Spring 2021-22

Assignment: PASD_DDN_As-2

- **Date of announcement:** 10th March 2022, **Date of submission:** 24th March 2022
- **Mode of submission:** prepare a single pdf for the solution and submit it to MSteam
- **Name convention for the pdf:** RollNo_PASD_as2.pdf,
- **Total Mark**=50

Assignment statement

A 400kW solar PV installation as shown in Fig. 1 is connected to the distribution network at 11kV and is exporting power at unity power factor under steady-state operating conditions. The grid code mandates the PV plant to ride through symmetrical or asymmetrical voltage faults as per the voltage FRT characteristic curve depicted in Fig. 2. Correspondingly, the PV plant is required to support the network voltages by exchanging suitable reactive current as dictated by Fig. 3.

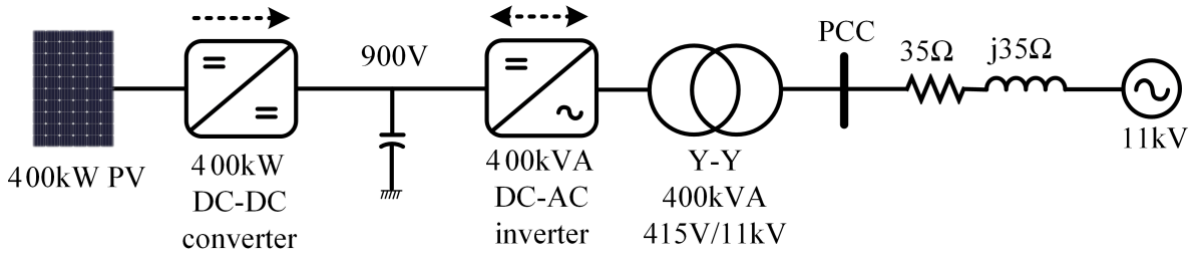

Fig. 1. Grid-connected solar PV plant

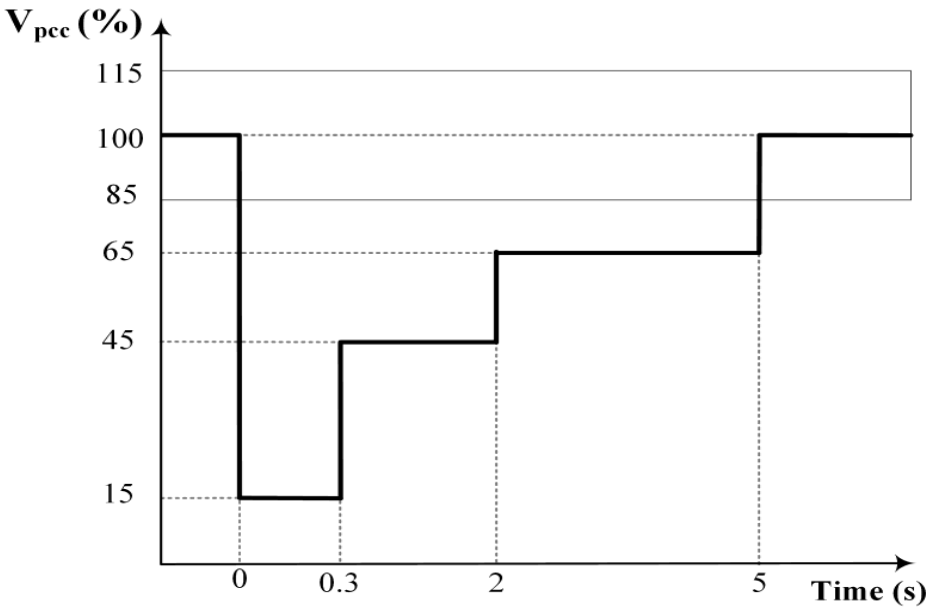

Fig. 2. Voltage FRT characteristic curve

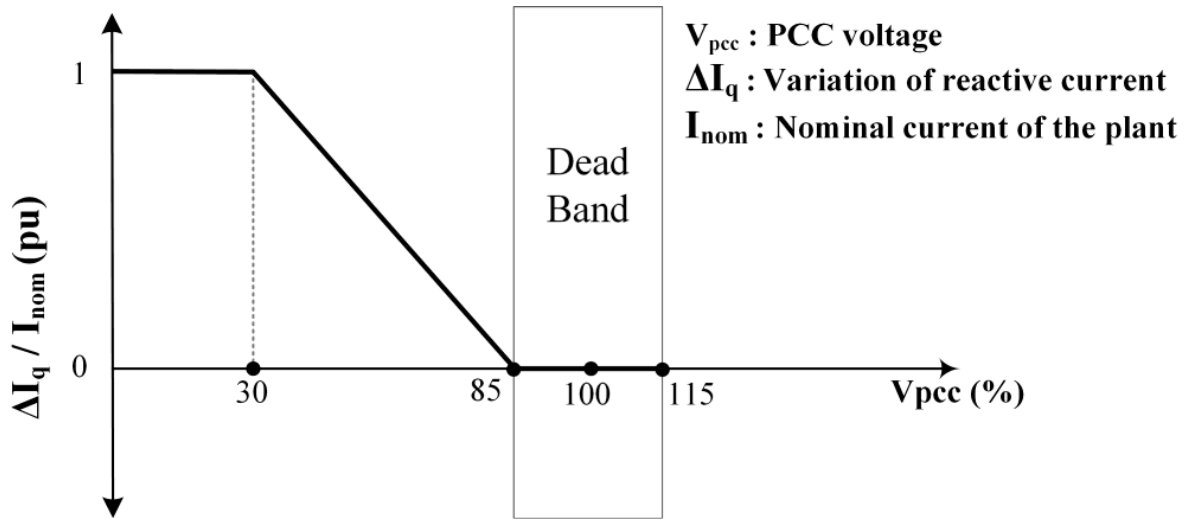

Fig. 3. Reactive current exchange requirement during voltage FRT operation

The inverter in the PV plant is capable of withstanding an over current of 1.25pu of its rated current for a duration of not more than 1s. Neglect losses in the converters, transformer and lines from PV to PCC. The retrofitting of the solar PV plant is required to meet the grid code requirements. Calculate the following for three different options as given below assuming that the PV plant is not operating in islanding condition under any circumstance.

1. Supercapacitor energy storage option at the DC bus

(a) Calculate the peak power rating of the DC-DC bidirectional converter for interfacing the energy storage with the DC bus.

(b) Calculate the total energy absorbed by the storage unit and the size of the supercapacitor bank required for the voltage FRT operation of the solar PV plant considering 55V, 130F supercapacitor units. The limit on the charge/discharge current of the supercapacitor unit is 1900A. Consider a DC-DC bidirectional converter with a voltage rating of (600V±10%)/900V with supercapacitor bank connected on the low voltage side and DC bus connected to the high voltage side.

(c) Draw a system level diagram as shown in Fig. 1 including the supercapacitor bank along with series/parallel combination if any.

2. Battery energy storage at the DC bus

(a) Calculate the size of the battery bank for the voltage FRT operation of the solar PV plant considering 2V, 400Ah lead acid battery unit. Consider a DC-DC bidirectional converter with a voltage rating of (600V±10%)/900V with battery bank connected on the low voltage side and DC bus connected to the high voltage side. Consider C/5 rate for safe charge/discharge operation of the battery bank.

(b) Draw a system level diagram as shown in Fig. 1 including the battery bank along with series/parallel combination if any.

3. Compare the energy storage options for voltage FRT operation based on the calculations performed in part 2 and 3. Also, justify the better energy storage option among them for voltage FRT application.