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TECHNICAL ISSUES FOR PV SYSTEM CONNECTED GRID.

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Abstract : **Technical issue pertaining to the LLLG (Line-Line-Line-Ground) fault in a photovoltaic (PV) connected grid system. A specific reference is made to a 100-kW PV array that is connected to a 25-kV grid. The system includes components such as a 5-kHz DC-DC boost converter, a 10-kvar capacitor bank, and a 100-kVA 260V/25kV three-phase coupling transformer. The grid itself consists of a 25-kV distribution feeder and a 120 kV equivalent transmission system.**

The LLLG fault, which refers to a three-phase line-to-line-to-line-to-ground fault, is a critical concern in PV grid-connected systems. This fault can lead to abnormal conditions such as voltage imbalances, increased harmonic content, and potential damage to the system components. Therefore, understanding and mitigating the LLLG fault is essential for the reliable operation of PV grids.Several research studies and industry reports have addressed the LLLG fault issue in PV-connected grids. These references provide insights into fault detection techniques, fault current analysis, and protective measures to prevent or minimize the impact of LLLG faults. By incorporating advanced fault detection algorithms, protective relays, and appropriate grounding strategies, the adverse effects of LLLG faults can be mitigated, ensuring the stability and resilience of the PV grid system.

***IndexTerms* – LLLG FAULT, PV SYSTEM , UNITY GRID, DC-DC BOOST CONVERTER**

Introduction: In recent years, the integration of photovoltaic (PV) systems into the grid has gained significant attention due to the growing demand for clean and renewable energy sources. However, this integration poses several technical challenges that need to be addressed to ensure the reliable and efficient operation of the grid. One such challenge is the occurrence of Low-Level Line-to-Ground (LLLG) faults in PV-connected gridsWhen a fault, such as a short circuit or ground fault, occurs in a PV-connected grid, it can lead to various issues, including voltage and frequency instability, power quality degradation, and even potential damage to the PV system components. These faults can have a significant impact on the overall grid performance and reliability.

to mitigate the effects of lllg faults, several measures can be implemented. one approach is the utilization of a dc-dc boost converter, which allows for voltage regulation and control during fault conditions. by implementing this converter, the pv system can continue to operate within acceptable voltage limits even when faults occur. furthermore, the addition of a capacitor bank can help improve the power factor and provide reactive power support to the grid. this helps in stabilizing the system voltage and reducing the potential voltage dips during fault conditions. additionally, a three-phase coupling transformer is employed to facilitate the connection between the pv system and the utility grid, ensuring proper voltage transformation and isolation.

the utility grid, consisting of a distribution feeder operating at 25 kv and an equivalent transmission system at 120 kv, plays a crucial role in the integration of the pv array. it serves as the main interface for power exchange between the pv system and the grid, enabling the delivery of generated electricity to consumers and supporting grid stability

in this paper, we will explore the technical issues associated with lllg faults in pv-connected grids, specifically focusing on the integration of a 100-kw pv array with a 25-kv grid. we will investigate the performance of a 5-khz dc-dc boost converter, a 10-kvar capacitor bank, and a 100-kva 260v/25kv three-phase coupling transformer in mitigating the impacts of lllg faults. Through simulation studies and analysis, we aim to gain insights into the behavior of the system under fault conditions and evaluate the effectiveness of the proposed mitigation measures.

I. METHODOGY :

The proposed methodology focuses on the control of current, active power, and reactive power injected into the grid to ensure efficient operation. The overall system comprises various components, including a PV panel, MPPT controller, boost converter, three-phase voltage source inverter, sinusoidal filter, step-up delta/star transformer, distribution network, phase-locked loop, dq-abc transformation block, PWM generator, load, and grid .for the purpose of modeling and simulation using MATLAB, the 330 sunSolar SPR Panel is selected as the PV panel. The MPPT controller ensures maximum power point tracking for the PV panel. The boost converter converts the constant DC voltage output of the PV panel into a sinusoidal AC voltage of 1980 Hv magnitude. This AC voltage is further boosted up to 5-kHz KV using a step-up delta/star transformer.

To maintain synchronization with the grid, a phase-locked loop (PLL) is employed to track the phase angle required for the dq-abc transformation leakage block. The transformed signal is then converted back to the abc reference frame and fed into the PWM generator, which generates pulses for the grid-connected PV inverter.Within the system, various resistances and reactances are present. L and R represent the resistance and reactance of the transformer, while L1 and R1 represent the resistance and inductance of the distribution network.

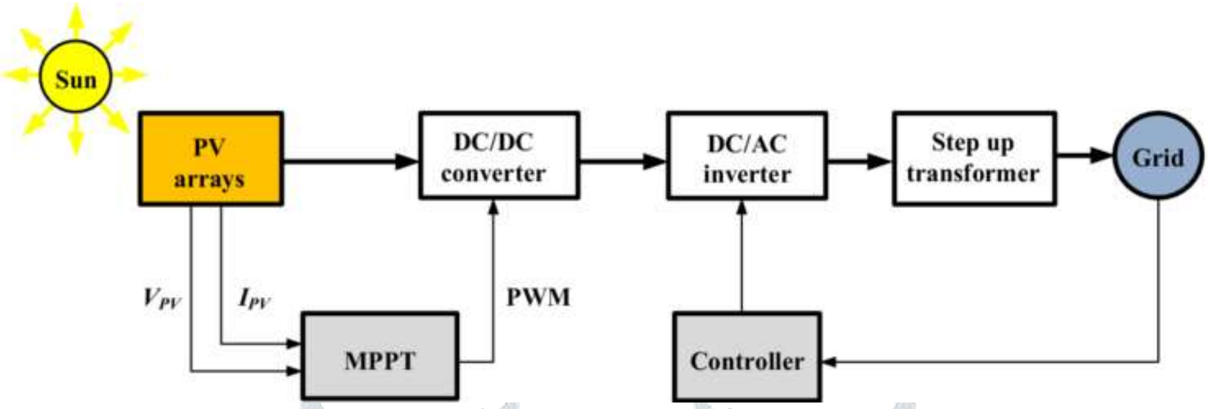

Figure 1 Block diagramme of proposed system.

II. SOLAR PV SYSTEM

Solar cells are essential components of photovoltaic panels and are predominantly made from silicon, although other materials can also be used. Solar cells harness the photoelectric effect exhibited by certain semiconductors, allowing them to convert electromagnetic radiation, specifically sunlight, into electrical current. By arranging the solar cell in an appropriate layout, the charged particles generated from incident radiation can be efficiently converted into an electrical current.

The amount of electricity generated by a solar cell is directly influenced by the intensity of sunlight it receives. When sunlight directly hits the front side of the PV cell at a perpendicular angle, the solar cell operates at its optimum power generation capacity. In a solar photovoltaic system, the fundamental building block is the solar cell. These cells are interconnected in series and parallel configurations to form PV modules and arrays.

A single solar cell can be represented as a combination of a current source, a diode, and two resistors. These elements work together to form the basic equivalent circuit of a solar PV system The basic equivalent circuit of solar PV system is presented in Fig. 2.

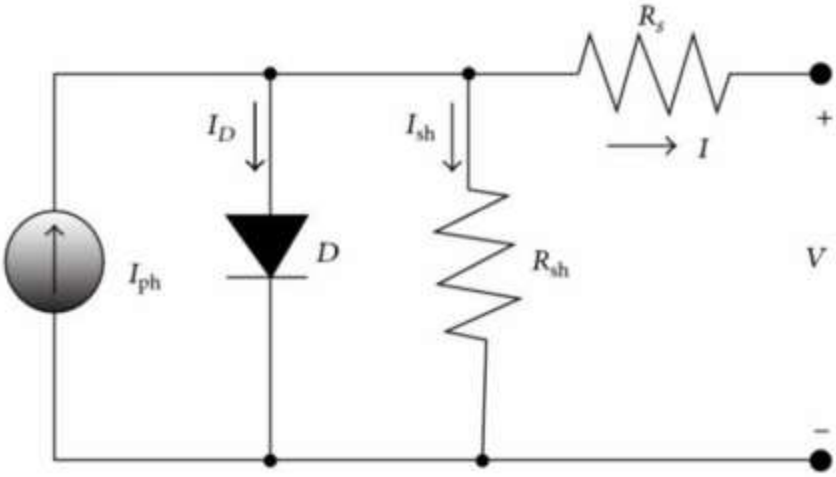

Figure 2. A Single-Diode model of Solar cell

The terminal current of the cell can be determined by applying Kirchhoff's law of current. In this context, several currents contribute to the overall terminal current. These include Iph, which represents the current generated by the photoelectric effect, Id, the diode current, and Ish, the current flowing through the shunt resistance. Additionally, the cell possesses inherent series resistance, RS, and parallel resistance, Rsh.

By considering these factors and applying Kirchhoff's law of current, the total terminal current of the cell can be calculated

I_ph = I_Light - I_0 * (exp((V + I_terminal * R_s) / (n * V_t)) - 1)

I_d = I_0 * (exp((V + I_terminal * R_s) / (n * V_t)) - 1)

I_sh = (V + I_terminal * R_s) / R_sh

Where:
I_Light is the current generated by the incident light.
I_0 is the reverse saturation current of the diode.
V is the voltage across the terminals of the cell.
R_s is the series resistance.
n is the diode ideality factor.
V_t is the thermal voltage (V_t = k * T / q, where k is Boltzmann's.

The characteristics of a photovoltaic module can be depicted by the I-V (current-voltage) and P-V (power-voltage) characteristic curves, as shown in Figure 3. Due to the nonlinearity of the PV equations, these curves exhibit a nonlinear nature. From Figure 3, it can be observed that the level of irradiation directly influences the output current of the solar cell, whereas the temperature affects the output voltage of the solar cell.

For the purpose of modeling and simulation using MATLAB, the 330 sunpower Solar Panel has been selected as the specific module under consideration.

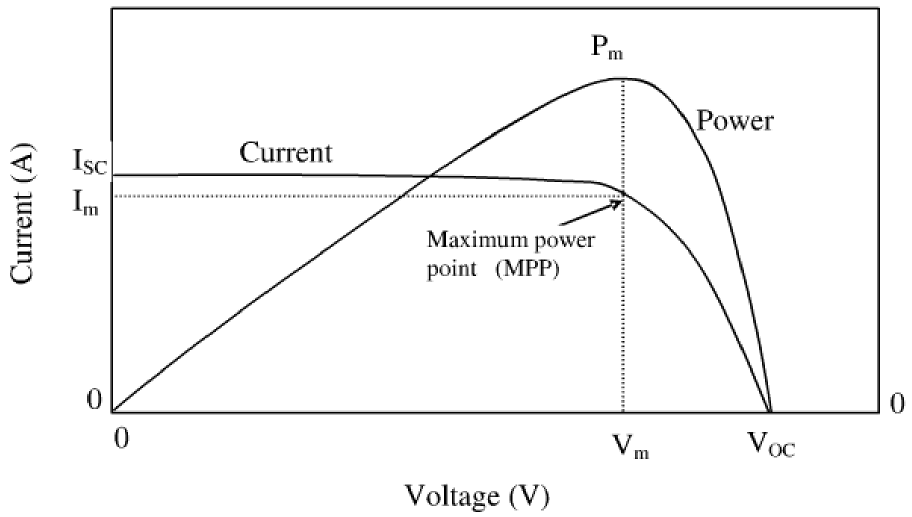

Figure 3 I-V& p-v characteristics of solar module

III. Boost Converter and MPPT Technique

. In order to increase the low output voltage of a PV array, the utilization of a step-up converter becomes essential. A DC-DC converter, acting as a switching mode regulator, can be employed to convert an uncontrolled DC voltage into a controlled DC output voltage. Control of the converter is typically achieved through pulse width modulation (PWM) and the switching device at a fixed frequency.

The boost converter operates in two distinct modes. In Mode I, when the switch is closed, the current gradually increases through the inductor while the diode remains off. In Mode II, when the switch is opened, the current flows through the inductor, diode, capacitor, and the load. The duty ratio (D) of the switch plays a crucial role in the converter's operation. The duty ratio is defined as the ratio of the time the switch is closed to the total switching period.

as the ratio of the time the switch is closed to the total switching period. It represents the fraction of time during each switching cycle that the switch remains closed. The duty ratio D is typically expressed as a value between 0 and 1, where D = 0 indicates that the switch is always open, and D = 1 indicates that the switch is always closed

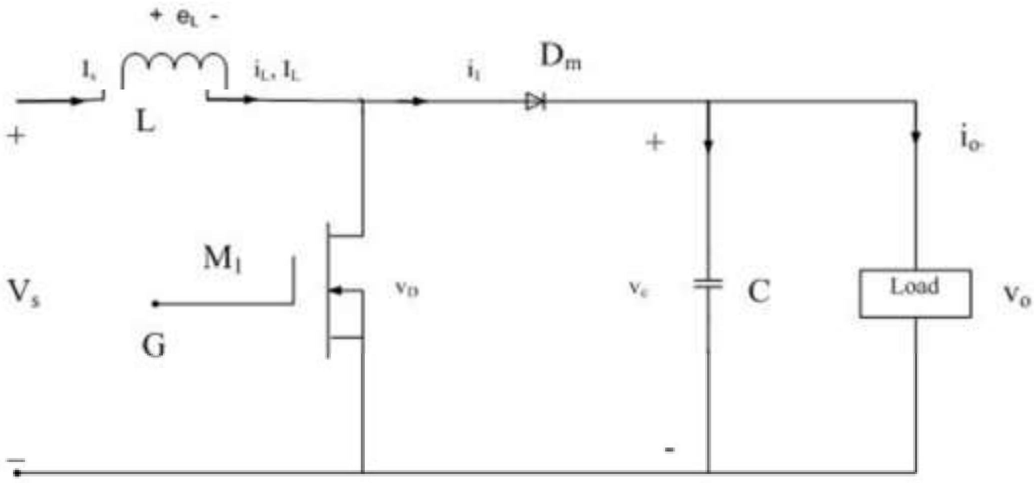

Figure 4 shematic diagrame of boost converter

IV. VSI and It's Control Techniques

In the realm of inverters, two main types can be distinguished based on the voltage and current requirements at the load end. These types are known as Current Source Inverter (CSI) and Voltage Source Inverter (VSI). While both types have their applications, VSI is more commonly used and well-known, as most applications necessitate a constant voltage supply.

In the case of grid-connected three-phase inverters, they are typically implemented as Voltage Source Inverters (VSIs). These VSIs are designed to deliver a constant voltage at the output end, ensuring a consistent supply to the load. Additionally, they are capable of maintaining the required load torque, making them suitable for various applications.

V- Simulation Result and fault

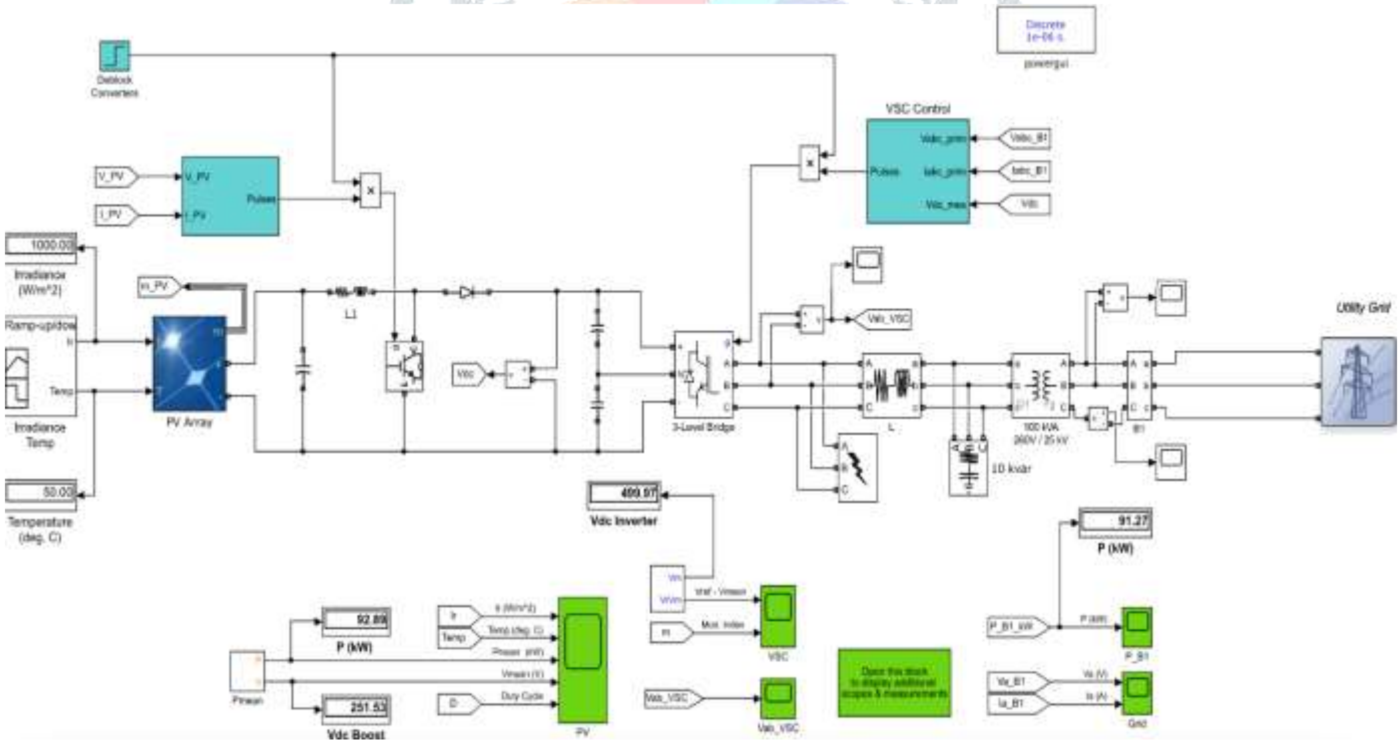

Figure 5. Sumilation Of Pv connected grid without Fault

V-1 – Simulation Result without any Fault

The model was executed, and the following sequence of events was observed on the scopes:

The simulation commenced under standard test conditions, with a temperature of 25 degrees C and an irradiance of 1000 W/m^2.

From t=0 sec to t=0.05 sec, the pulses to the Boost and VSC converters were blocked. As a result, the PV voltage corresponded to the open-circuit voltage, which was calculated as NserVoc=564.2=321 V. The three-level bridge operated as a diode rectifier, and the DC link capacitors were charged to a level above 500 V.

At t=0.05 sec, the Boost and VSC converters were unblocked. The DC link voltage was regulated and maintained at Vdc=500V. The duty cycle of the boost converter remained fixed at D=0.5, as indicated on the PV scope.

Steady state conditions were achieved at t=0.25 sec. Consequently, the resulting PV voltage, V_PV, was calculated as (1-D)*Vdc=(1-0.5)*500=250 V. The PV array output power was determined to be 96 kW, while the specified maximum power at an irradiance of 1000 W/m^2 was 100.7 kW. On the Grid scope, it was observed that phase A voltage and current at the 25 kV bus were in phase, indicating unity power factor.

At t=0.4 sec, the MPPT (Maximum Power Point Tracking) function was enabled. The MPPT regulator initiated regulation of the PV voltage by varying the duty cycle, aiming to extract the maximum power from the array. The maximum power of 100.4 kW was achieved when the duty cycle was D=0.454.

At t=0.6 sec, the PV array mean voltage was measured to be 274 V, consistent with the PV module specifications (NserVmp=554.7=273.5 V).

From t=0.6 sec to t=1.1 sec, the sun irradiance was gradually reduced from 1000 W/m^2 to 250 W/m^2. The MPPT function continued to track the maximum power during this period.

At t=1.2 sec, when the irradiance reached 250 W/m^2, the duty cycle was determined to be D=0.461. The corresponding PV voltage and power were recorded as Vmean=268 V and Pmean=24.3 kW, respectively. Notably, the MPPT function continued to track the maximum power during this rapid change in irradiance.

From t=1.2 sec to t=2.5 sec, the sun irradiance was gradually restored back to 1000 W/m^2, and the temperature was increased to 50 degrees C. This temperature increase led to a decrease in the array output power from 100.7 kW (at 25 degrees C) to 93 kW.

These observations provide insights into the behavior of the PV system under different conditions, including variations in irradiance and temperature

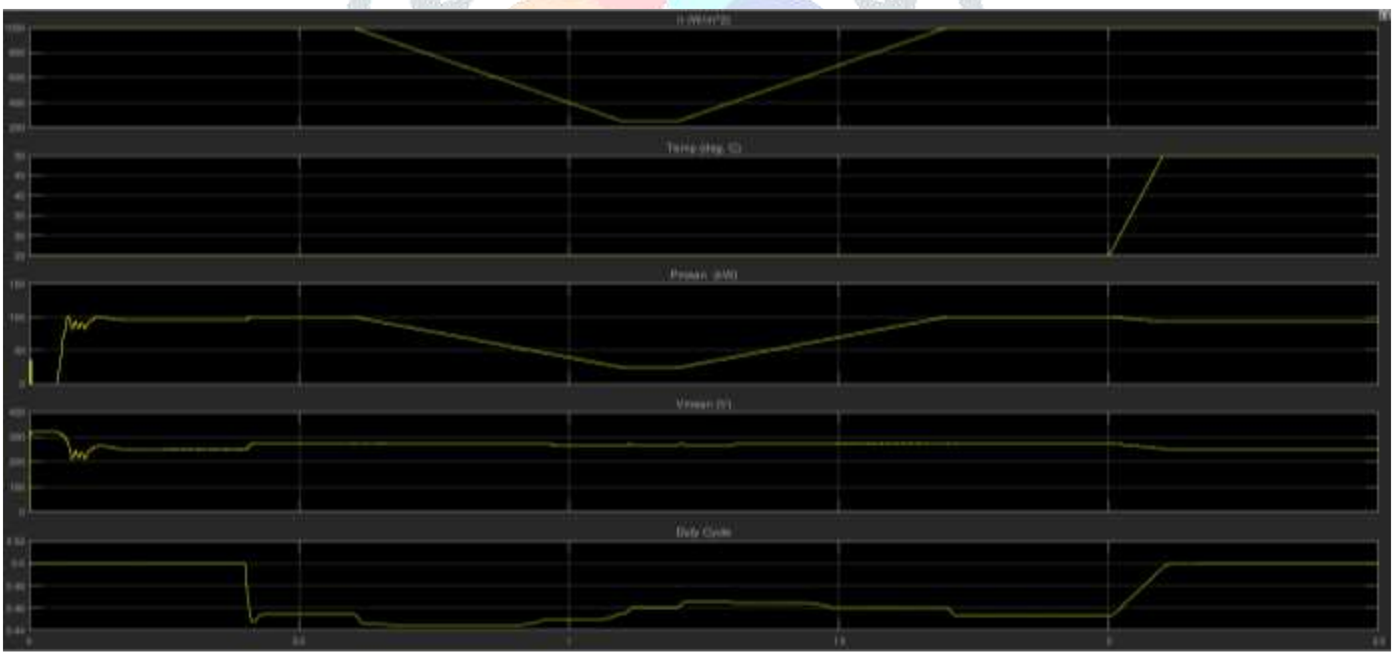

Figure 6 Pv wave form without any fault

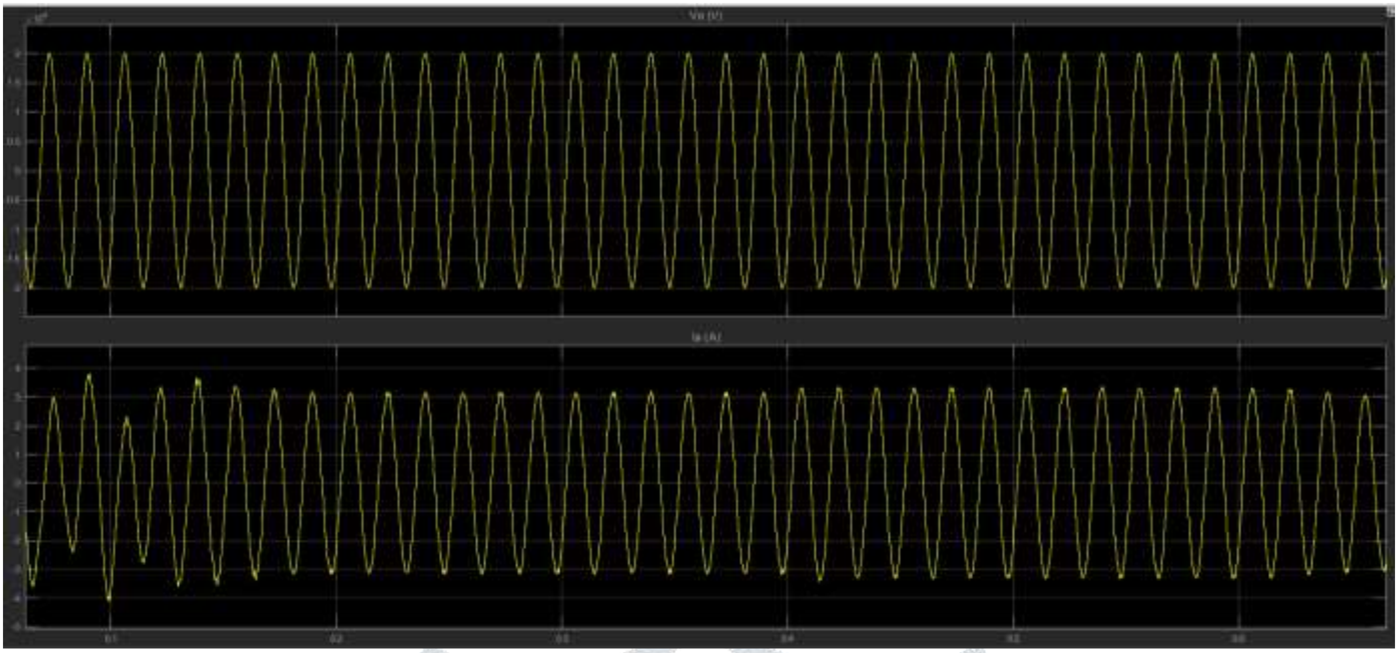

Figure 7Grid wave form without Any Fault

V-2 – Simulation Result with LLLG Fault

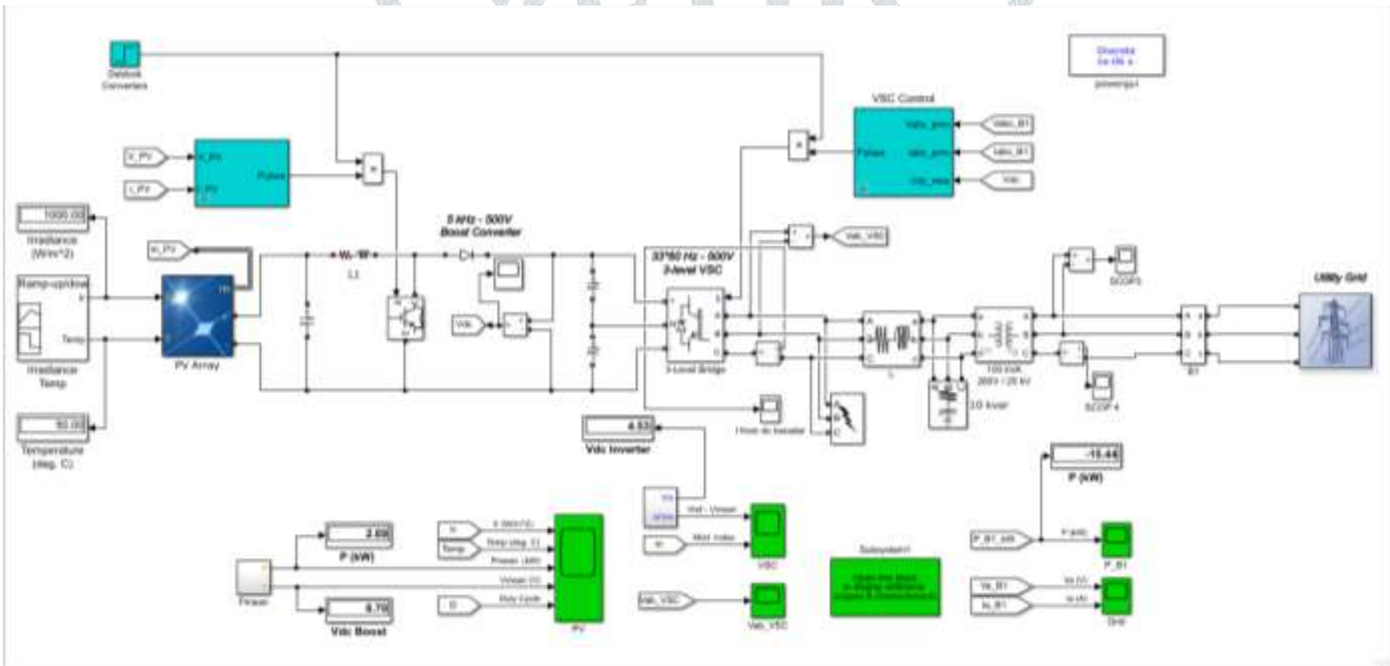

Figure 8 Sumilation of Pv connected Grid with LLLG fault

V-2 – Simulation Result with LLLG Fault

The LLLG fault will cause a significant increase in fault current flowing through the grid. This fault current can be analyzed to determine its magnitude and waveform, which helps in understanding the impact of the fault in our system

LLLG faults has caused a significant drop in grid voltage, leading to voltage instability in the system. If the grid voltage drops below the minimum operating threshold of the PV system, it may become unable to maintain proper operation and synchronization with the grid.

LLLG faults result has increased fault currents flowing through the system, including the PV array, boost converter, and VSC

PV systems connected to the grid typically have requirements for fault ride-through capability, which means the ability to ride through and remain connected during grid faults

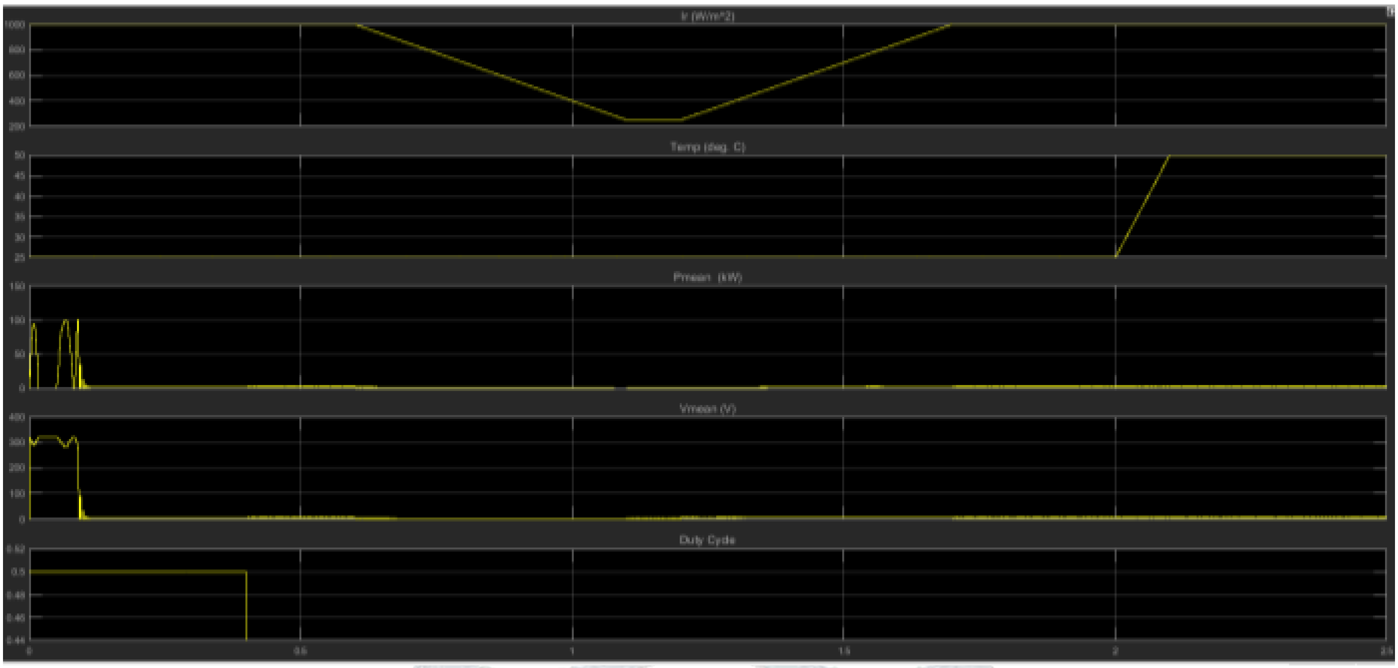

Figure 9 Sumilation of Pv WaveForm with LLLG fault

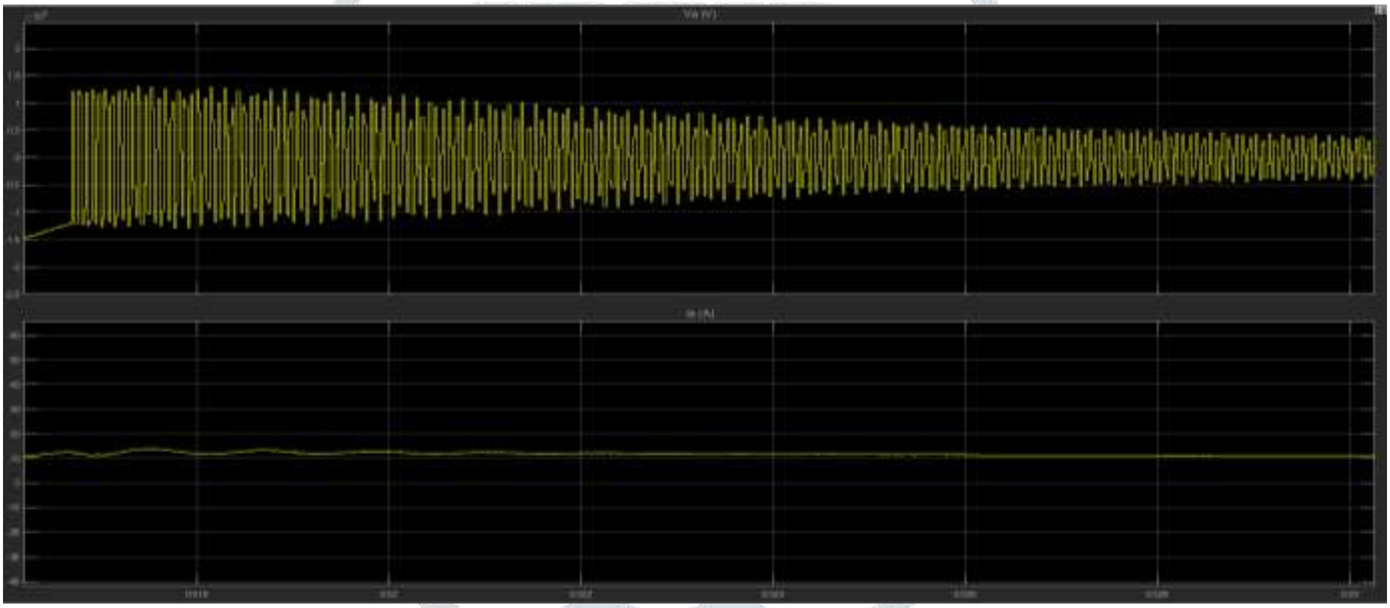

Figure 10. Grid WaveForm with LLLG fault

VI. Conclusion

Connecting a photovoltaic (PV) system to the grid introduces numerous benefits, including renewable energy generation and reduced reliance on fossil fuels. However, it is crucial to consider the behavior of the PV system during fault conditions, such as a line-to-line-to-ground (LLLG) fault. During an LLLG fault, the PV system connected to the grid may experience instability or collapse for various reasons.

The primary factors contributing to the collapse of a PV system during an LLLG fault include voltage instability, grid protection mechanisms, lack of fault ride-through capability, and overcurrent protection. The fault can cause a significant drop in grid voltage, resulting in voltage instability within the PV system. Additionally, grid protection mechanisms, such as relays or circuit breakers, may operate to isolate the faulted section from the grid, leading to disconnection of the PV system. If the PV system lacks appropriate fault ride-through capability or exceeds grid code limits, it may disconnect or collapse during the fault. Furthermore, increased fault currents during the LLLG fault can trigger overcurrent protection mechanisms, resulting in disconnection from the grid

Reference

1. Prakash Kumar Hota1, *, Babita Panda2, Bhagabat Panda2 *Prakash Kumar Hota, Babita Panda, Bhagabat P*.

2. Lupangu, C., and R. C. Bansal. "A review of technical issues on the development of solar photovoltaic systems." Renewable and Sustainable Energy Reviews 73 (2017): 950-965**.**

3. Eltawil MA, Zhao Z. Grid-connected photovoltaic power systems: Technical and potential problems—A review. Renewable and sustainable energy reviews. 2010 Jan 1;14(1):112-29.

4. Erge, Thomas, Volker U. Hoffmann, and Klaus Kiefer. "The German experience with grid-connected PV-systems." *Solar Energy* 70, no. 6 (2001): 479-487.

5. Wong, Jianhui, Yun Seng Lim, Jun Huat Tang, and Ezra Morris. "Grid-connected photovoltaic system in Malaysia: A review on voltage issues." *Renewable and Sustainable Energy Reviews* 29 (2014): 535-545.

6. Ropp, Michael Eugene. *Design issues for grid-connected photovoltaic systems*. Georgia Institute of Technology, 1998.

7. Kouro, Samir, Jose I. Leon, Dimitri Vinnikov, and Leopoldo G. Franquelo. "Grid-connected photovoltaic systems: An overview of recent research and emerging PV converter technology." *IEEE Industrial Electronics Magazine* 9, no. 1 (2015): 47-61.

8. Obi, Manasseh, and Robert Bass. "Trends and challenges of grid-connected photovoltaic systems–A review." *Renewable and Sustainable Energy Reviews* 58 (2016): 1082-1094.

9. ElNozahy, M. S., and M. M. A. Salama. "Technical impacts of grid-connected photovoltaic systems on electrical networks—A review." *Journal of Renewable and Sustainable Energy* 5, no. 3 (2013): 032702.

10. Raturi, Atul, Aman Singh, and Ravita D. Prasad. "Grid-connected PV systems in the Pacific Island Countries." *Renewable and Sustainable Energy Reviews* 58 (2016): 419-428.

11. Kumar, Mahesh. "Technical issues and performance analysis for grid connected PV system and present solar power scenario." In *2020 International Conference on Electrical and Electronics Engineering (ICE3)*, pp. 639-645. IEEE, 2020.