FDRP Journal's

IJSREAT-0000965

📋 15

🖥 FDRP

🎓 Journal's

Document Details

Submission ID

trn:oid:::1:3201819276

Submission Date

Apr 1, 2025, 11:51 PM GMT+7

Download Date

Apr 1, 2025, 11:52 PM GMT+7

File Name

IJSREAT-0000965.docx

File Size

483.4 KB

6 Pages

2,357 Words

12,621 Characters

10% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text

Match Groups

26 Not Cited or Quoted 10%
Matches with neither in-text citation nor quotation marks

0 Missing Quotations 0%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

6% 🌐 Internet sources

6% 📖 Publications

3% 👤 Submitted works (Student Papers)

Match Groups

26 Not Cited or Quoted 10%
Matches with neither in-text citation nor quotation marks

0 Missing Quotations 0%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

6% 🌐 Internet sources

6% 📖 Publications

3% 👤 Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Publication	
Suleyman Adak. "Power Factor Analysis of Grid-Connected Solar Inverter under D…		1%

2	Publication	
"Automatic Control and Emerging Technologies", Springer Science and Business …		<1%

3	Internet	
www.jmi.ac.in		<1%

4	Internet	
www.coursehero.com		<1%

5	Internet	
acearchive.org		<1%

6	Internet	
dewesoft.com		<1%

7	Publication	
Edward Dodzi Amekah, Emmanuel Wendsongre Ramde, David Ato Quansah, Elvis …		<1%

8	Student papers	
University of Southern Queensland		<1%

9	Internet	
www.drmgrdu.ac.in		<1%

10	Internet	
www.researchgate.net		<1%

11	Internet	
www.thetechedvocate.org		<1%

12	Internet	
galaweb.jp		<1%

13	Internet	
rcvt.tu-sofia.bg		<1%

14	Internet	
link.springer.com		<1%

15	Internet	
tjet.udsm.ac.tz		<1%

16	Publication	
Edward Dodzi Amekah, Emmanuel Wendsongre Ramde, David Ato Quansah, Elvis ...		<1%

17	Publication	
John Bird, John Bird. "Electrical and Electronic Principles and Technology", Routle...		<1%

18	Publication	
Richard Hyde, Nathan Groenhout, Francis Barram, Ken Yeang. "Sustainable Retro...		<1%

19	Publication	
TatiReddy Ravi, K. Sathish Kumar, C. Dhanamjayulu, Baseem Khan, K Rajalakshmi...		<1%

Analysis of Power Factor Improvement in Renewable energy system

Manaullah Abid[1], Poola Khaderulla[2]*, Pola Sreenivasulu[3]

1-Department of Electrical engineering,
F/o Engineering & technology, Jamia Millia Islamia,
New delhi-110025, **manaullah** @jmi.ac.in

2,3- Dr. M.G.R. Educational and Research Institute,
(Deemed to be University with Special Autonomy Status)
*-corresponding Author

Abstract

The increasing demand for energy, combined with environmental concerns, has driven the adoption of renewable energy sources such as photovoltaic (PV) systems. However, integration of PV systems with the electrical grid often introduces issues related to power factor, which can reduce the overall efficiency and stability of the grid. This paper explores methods for improving the power factor in a system connected to the grid with a PV installation. We analyze the challenges of maintaining an optimal power factor in the presence of PV generation, including variations in solar irradiance and grid conditions. A hybrid power factor correction technique involving both passive and active compensation strategies is proposed. The integration of a reactive power controller with the PV inverter system is also examined to dynamically manage the power factor while ensuring maximum energy generation from the solar array. Simulation results demonstrate that the proposed approach effectively reduces harmonic distortion, minimizes reactive power losses, and stabilizes grid voltage, leading to enhanced grid performance and energy efficiency. The findings highlight the importance of advanced power factor correction techniques for reliable and sustainable integration of renewable energy systems into the electrical grid.

Keywords: PV, PF, PFC, Desired Power Factor, Proposed System.

1. Introduction

The integration of renewable energy sources, particularly photovoltaic (PV) systems, into the electrical grid has gained significant traction due to the need for sustainable energy solutions and reduced carbon emissions. However, while PV systems offer numerous advantages, such as reduced electricity costs and minimal environmental impact, they introduce several challenges to grid stability and power One of the most prominent issues is the which plays a crucial role in det a and a low factor can lead to inefficient energy use, higher transmission losses, and increased stress on grid infrastructure.

In a PV-integrated grid system, the power factor can be adversely affected by several factors, including the intermittent nature of solar power, fluctuations in solar irradiance, and the non-linear behavior of PV inverters. These fluctuations result in variations in the active and reactive power balance, making it difficult to maintain an optimal power factor at all times. If the power factor is not properly managed, it can lead to voltage instability, increased reactive power flow, and potential penalties from utility providers for not meeting power factor requirements.

This paper aims to explore methods for improving the power factor in a system connected to the grid with a PV installation. The study focuses on both passive and active power factor correction techniques, with an emphasis on the integration of reactive power control in PV inverters to optimize grid performance. Through simulation and analysis, we demonstrate the effectiveness of these approaches in enhancing the power factor, reducing losses, and ensuring reliable integration of PV systems into the electrical grid.

2.0. Determine the Power Factor Requirement

Determine the target power factor that the system needs to achieve. For example:

- Desired Power Factor (PF): 0.95 or 1.0 (depending on industry standards and local regulations).

2.1. Estimate Reactive Power Demand

- If the power factor needs to be improved, calculate the reactive power (Q) that is currently being supplied by the grid.
- Formula for reactive power:

  $Q= \sqrt{S^2 - P^2}$

2.2. Identify PV System Capacity To Improve Power Factor

- The PV system's role in improving power factor is by supplying active power (P) to the grid, which reduces the load on the grid.
- Determine the capacity of the PV system needed to supply a portion of the active power. This would be done based on the following:
- PV Power (kW) = Prequired =Pgrid× (1−target PF) For example, if the target power factor is 0.95 and the current PF is 0.8, the system should aim to deliver power to bring the PF closer to 1.

2.3. Sizing The PV System Based on Power Factor Improvement

A PV system can only provide real power (kW), and its contribution to reactive power is minimal. To improve power factor, the PV system must be sized appropriately to reduce the burden on grid-generated active power. This allows other components (such as capacitors or synchronous condensers) to better handle reactive power compensation.

- **Calculate the Active Power Supplied By The Grid:** If you know the load and the power factor of the grid, use the formula to calculate the real power from the apparent

power: $P=S \times PFP = S \times \text{PF}P=S \times PF$ Then, calculate the required increase in the real power (from the PV system) that will improve the power factor.

2.4. Final Calculation Example

Suppose:

- The total apparent power SSS required by the system is 100 kVA.
- The current power factor is 0.8.
- The desired power factor is 0.95.
- Step 1: Calculate real power required.

  P required=S×PF=100×0.8=80 kW

- Step 2: Calculate the reactive power.

  Q current= $\sqrt{S^2 - P^2}$

  $= \sqrt{100^2 - 80^2} = \sqrt{10000 - 6400}$

  $= \sqrt{3600}\ = 60$ kVAR
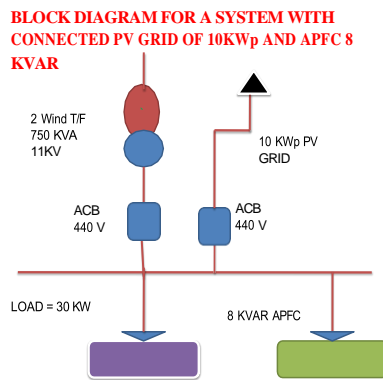
- Step 3: Calculate the target real power required for a PF of 0.95.

  P target=100×0.95=95 kWP

  This means the PV system will need to supply 15 kW of real power to meet the power factor target.

Designing a PV grid system for power factor improvement requires a careful assessment of the active power requirements and the current power factor. The PV system itself primarily provides active power (real power), which reduces the load on the grid and helps improve the power factor. For more effective PF correction, integrating additional reactive power compensation systems (like capacitors) is often necessary.

3.0. **Implementation of Proposed System:**

BLOCK DIAGRAM FOR A SYSTEM WITH CONNECTED PV GRID OF 10KWp AND APFC 8 KVAR

2 Wind T/F
750 KVA
11KV

10 KWp PV
GRID

ACB
440 V

ACB
440 V

LOAD = 30 KW

8 KVAR APFC

Fig.2 Block diagram for proposed system

3.1. 30 KW, 14 KVAR Load 3 Phase:

A 3-phase load with 30 kW of real power and 14 kVAR of reactive power, it is to calculate key electrical parameters such as apparent power (S), power factor (pf), and line current (I). Below are the calculations based on the given values.

Given:

- Real power (P) = 30 kW
- Reactive power (Q) = 14 kVAR
- Line-to-line voltage (V_L) = 400 V (assuming this value, but you can adjust if different)

3.2. Total Apparent Power (S):

The apparent power (S) is the vector sum of real and reactive power:

$$S2=P2+Q2 \quad S = sqrt \{P^2 + Q^2\}$$

Substituting the given values:

$$S2= (30)2+ (14)2$$
$$S = sqrt \{(30)^2 +(14)^2\}$$
$$S= sqrt \{900+196\} = sqrt \{1096\} \approx 33.12 \, kVA$$

So, the apparent power (S) is approximately 33.12 kVA.

3.3. Power Factor (PF)

So, the power factor is approximately 0.905 (lagging).

3.3.1. LINE CURRENT (I):

So, the line current (I) is approximately 47.8 A.

- Apparent Power (S): S≈33.12kVA
- Power Factor (pf): pf≈0.905
  pf≈0.905 (lagging)
- Line Current (I): I≈47.8 AI

3.3.2. FOR A 30 KW, 14 KVAR Load In A 3-Phase System with A 400 V Line To-Line Voltage:

- The apparent power is approximately 33.12 kVA.
- The power factor is approximately 0.905 (lagging), which indicates the load is inductive.
- The line current is approximately 47.8 A.

3.3.3. Key Parameters for A 10 Kwp Grid-Connected PV System:

- **Installed capacity (KWP)**: The system is designed to produce 10 kW under ideal conditions (full sunlight, optimal temperature, etc.). This is the "peak" power, but the actual output will depend on real-world conditions, such as:
  - Solar Irradiance: The amount of sunlight that hits the panels.
  - Temperature: Solar panel efficiency decreases with temperature.
  - Panel Orientation and Tilt: The angle and direction of the panels affect their energy production.
  - Inverter Efficiency: The efficiency of the inverter that converts DC electricity from the panels into AC for the grid.
- **Energy Production**: The actual energy produced by the system depends on how many hours per day the system operates at its peak output. For example:
  - In a location with good sunlight, the PV system may generate 10 kW during peak sunlight hours, but typically, PV systems do not operate at peak capacity all day.

- A typical Sunlight Peak hour might be around 4-6 hours per day, depending on location and season.

3.3.4. Energy Output Calculation:

Let's estimate the energy output of a 10 kWp PV system based on the following assumptions:

- Peak Power Output: 10 kW (under ideal conditions).
- Average Sunlight Hours per Day: 5 hours (this will vary by location).

The total energy produced per day (in kWh) can be estimated by:

Under ideal conditions, a 10 kWp PV system could produce approximately 50 kWh of energy per day.

4.0. Inverter and System Losses:

In reality, the system will experience some losses due to:

- Inverter Efficiency: Typically, around 90-98% for modern inverters.
- Cable Losses: Small losses in cables from the PV system to the inverter and from the inverter to the grid.
- Panel Efficiency: Solar panels usually operate at an efficiency of 15-20%, depending on the technology.

After considering typical losses, let's assume an overall system efficiency of 85%.

The adjusted energy output would be:

So, the actual energy output might be around 42.5 kWh per day.

4.1. System Performance over Time:

If the system operates for a full year, the total energy produced (assuming consistent daily output) can be estimated:

This is the total energy produced annually by the 10 kWp grid-connected PV system.

4.1.1. Grid Connection Considerations:

- A grid-connected PV system typically works in parallel with the electrical grid. During the day, the system can supply power to the grid when it's generating more electricity than the load requires.
- Net Metering: In some areas, the system may benefit from net metering, where excess electricity produced by the PV system is fed back into the grid, and the owner receives credits for the energy supplied to the grid.

- A 10 kWp PV system can produce 50 kWh per day under ideal conditions, but the actual output is typically lower due to inefficiencies and environmental factors.
- With typical system losses factored in, the expected energy output is around 42.5 kWh per day.
- Over the course of a year, this system could produce approximately 15,512.5 kWh of energy.

Improving of Power Factor:

For understanding power factor concept, it is assumed a load ,3 phase consumes 30 kilo Watts and 14 KVR from grid then KVA consumed from grid is KVA consumed from grid

$$KVA = sqrt (KW^2 +KVAR ^2)$$
$$=sqrt (30^2+14^2) =33.1058$$

$$Power\ Factor\ (PF) = KW/KVA$$
$$=30/33.1058=.906\ Lag$$

Then it is added 10 KWp +0 KVAR to the existing system for power factor study concept, which shows us that the power factor of the same system will be decreased after 10KWp PV Grid connected to System.
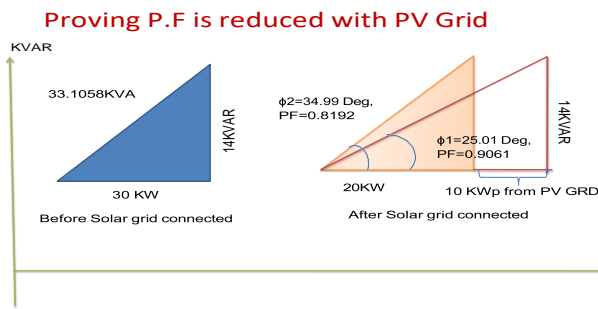
Fig-3Vector diagram PF Reduction

Now
the Consumption from the Grid
= Total Load -Solar capacity
=(30KW+14KVAR) -(10KW+0 KVAR)
=20KW+14KVAR

KVA from the Grid =sqrt $(20^2+14^2) = 24.4131$
Then
Power Factor (PF) = KW/KVA
$= 20/24.4131 = 0.8192$

Thus, the power factor of the system is reduced from 0.906 Lag to 0.8192 Lag when PV Grid Capacity 10 KWp is connected in ac system having load 30 KW+14 KVAR Proving P.F is improved with APFC:

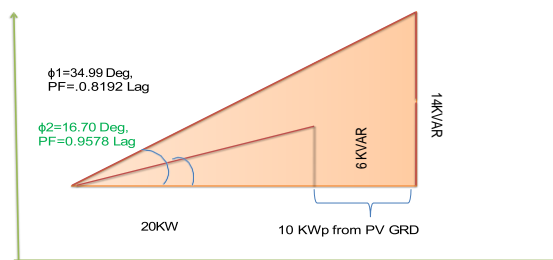
Fig-4Vector diagram for P.F Improvement

For improving the above Power Factor (PF) of 0.8192 Lag to 0.9578 Lag, A Capacitive bank (APFC Capacity of 8 KVAR) is proposed and explain below
Consumption from Grid
= Total Load -Solar capacity-APFC Capacity
= (30KW+14 KVAR) - (10KW+0 KVAR) - (0 KW + 8 KVAR)
= (20KW+6 KVAR)
KVA from the Grid= sqrt $(20^2+6^2) =20.88$
Now

Power Factor (PF) = KW/KVA
$= 20/20.88 = 0.9578$ Lag

Algorithm/Techniques/Tools Used:
1. MAT LAB
2. Digiscilant Factory

Simulation Results:
Power Factor is improved from 0.8192 Lag to 0.9578 Lag, Earlier the same System without having PV Grid, the factor was 0.906 Lag. After Connecting the PV Grid having 8 kvar to this System, the power factor decreases to 0.8192 Lag.

Presently the power factor is improved to 0.95 Lag.
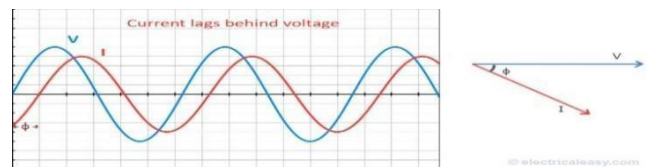
Simulation Diagram:

Fig.5Block diagram for proposed system

Presently the power factor is improved to 0.95 Lag

4.1.2. Conclusion

The project on power factor improvement in a

S. No	LOAD ON THE SYSTEM IN KW (+) or (-) KVAR	LOAD KVA	PF OF THE SYSTEM (KW/KVA)	REMARKS
1	20+J6	20.88	0.95 Lag	WHEN APFC SUPPLIES AT 8 KVAR
2	20+J4	20.39	0.98Lag	WHEN APFC SUPPLIES AT 10 KVAR
3	20+J0	20	1 UNITY	WHEN APFC SUPPLIES AT 14 KVAR
4	20-J6	28.88	0.95Lead	WHEN APFC SUPPLIES AT 20 KVAR

grid-connected photovoltaic (PV) system has demonstrated the critical importance of maintaining an optimal power factor for maximizing the efficiency and performance of

both the solar power system and the overall power grid. Key findings from this study include:

References/Biblogrphy

[1] Dareen Habash (Al Hussein Technical University Amman 11831, Jordan), Ahmad Azzam (Al Hussein Technical University Amman 11831, Jordan), Reda Issa(JEPCO Amman 11831, Jordan) , Emad Abdelsalam (Al Hussein Technical University Amman 11831, Jordan) and Hassan Qandil (University of North Texas Denton-Texas 76207, USA) "Impact of Grid-Connected Photovoltaic System on Low Volatage Distribution", IEEE Jordan International Joint Conference on Electrical Engineering and Information Technology   (JEEIT) 2023

[2] Yu-Kang Lo, Ting-Peng Lee, and Kuan-Hung Wu"Grid-Connected Photovoltaic System with Power Factor Correction", IEEE, May 2008,

[3] Edward Dodzi Amekah,Emmanuel Wendsongre Ramde,David Ato Quansah,Elvis Twumasi,Stefanie Meilinger and Schneiders Thorsten "Analyzing the consequences of power factor degradation in grid-connected solar photovoltaic systems", ELSEVIER /2024.

[4] Suleyman Adak (University of Mardin Artuklu, Turkey) "Power Factor Analysis of Grid -Connected Solar Inverter under Different Irradiance Levels throughout the Day", Energies 2024

[5] Mustafa M.A. Seedahmed, Makbul A.M. Ramli, Houssem R.E.H. Bouchekara, Ahmad H. Milyani, Muhyaddin Rawa, Firmansyah Nur Budiman, Rifqi Firmansyah Muktiadji and Syed Mahboob Ul Hassan "Optimal sizing of grid-connected photovoltaic system for a large commercial load in Saudi Arabia ", ELSEVIER /2021

[6] A A Petrov, N I Shurov(Novosibirsk State Technical University, Russia) "Hybrid system of power factor correction"IOP Conf. Series: Earth and Environmental Science 87,2017

Books:
  [1] Solar Engineering of Thermal Processes
       John A. Duffie, William A. Beckman, Wiley, 2013.
  [2] Photovoltaic Systems Engineering, Roger A. Messenger, Jerry Ventre
       CRC Press, 2010
  [3]Electric Power Systems: A Conceptual Introduction, Alexandra von
       Meier Wiley-IEEE Press,