The paper **"Analysis and Design of Artificial Neural Network Based Droop Control for Autonomous Hybrid Microgrid"** discusses an advanced control strategy for microgrids that integrates **solar photovoltaic (PV) and wind energy conversion systems (WECS)**. It focuses on overcoming the limitations of traditional **droop control** using **Artificial Neural Networks (ANNs)**.

Key Concepts of the Paper

1. Introduction

- Microgrids are small-scale, localized energy networks that can operate **independently (island mode)** or be connected to the main grid.
- Hybrid **distributed generation (DG) systems**, which include **solar and wind energy**, face challenges in maintaining **stable frequency and voltage**.
- **Droop control** is commonly used to manage **load sharing** among multiple inverters but has **limitations**:
  - **Sensitive to load variations**
  - **Depends on accurate parameter tuning**
  - **Cannot effectively compensate for line impedance mismatches**
- The paper proposes an **ANN-based droop control strategy** to address these challenges.

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2. System Description

- The proposed microgrid consists of **two parallel inverters** connected to:
  - **PV system** (through a DC-DC boost converter with **Grey Wolf Optimization (GWO)** for **Maximum Power Point Tracking (MPPT)**).
  - **WECS** (wind energy system) connected via an **AC-DC converter**.
- Both inverters are linked at a **common point of coupling (PCC)** through **LC filters** and **inductors**.
- **Control Strategy:**
  - Traditional droop control is replaced with **ANN-based droop control**.
  - A **feedforward neural network (FFNN)** is trained to adjust **voltage and frequency dynamically**.

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3. Control Strategy Components

A. Maximum Power Point Tracking (MPPT)

- **MPPT is essential** for renewable energy sources to **maximize power extraction**.
- The paper uses the **Grey Wolf Optimization (GWO) algorithm** for MPPT in the **PV system**.

- The **wind energy conversion system (WECS)** employs **Optimal Power Control (OPC)** for **MPPT**.

B. Voltage and Current Control

- A **nested control system** with **two control loops**:
    1. **Current Control Loop** (Fast Response)
    2. **Voltage Control Loop** (Slower Response)
- **Proportional-Integral (PI) controllers** are used for both loops.
- **MATLAB/Simulink is used for simulation** and **PID tuning**.

C. ANN-Based Droop Control

- Instead of **fixed droop coefficients**, an **ANN dynamically adjusts** the voltage and frequency.
- The **feedforward neural network (FFNN)** is trained using a **scaled conjugate gradient technique**.
- The training dataset consists of **45,000 samples** from a **single DG system**.
- The trained ANN **improves stability, reduces harmonic distortion, and handles load fluctuations efficiently**.

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4. Results and Discussion

- The proposed **ANN-based droop control** is tested in a **MATLAB/Simulink environment**.
- A **step load change (200Ω and 1.5mH at 0.4 sec)** is introduced in the **islanded microgrid**.
- **Comparison between traditional and ANN-based droop control:**
    - **Without ANN:** Total Harmonic Distortion (THD) = **6.12%**
    - **With ANN:** Total Harmonic Distortion (THD) = **5.11%**
    - **Conclusion:** ANN-based droop control significantly improves **voltage and frequency regulation**, **power quality**, and **stability**.

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5. Conclusion

- ANN-based droop control offers a **superior alternative** to traditional droop control by **enhancing load sharing**, **reducing harmonics**, and **adapting dynamically to varying conditions**.
- The **proposed system improves microgrid stability** while integrating renewable energy sources efficiently.

Key Takeaways

✅ **ANN-based droop control dynamically adjusts frequency and voltage**, making it more adaptive than traditional droop control.
✅ **THD reduction (from 6.12% to 5.11%)** shows improved power quality.
✅ **GWO-based MPPT** optimizes solar energy extraction.
✅ **MATLAB/Simulink simulations confirm the effectiveness** of the proposed ANN model.