230v AC TO 12v Dc Unified Power quality Conditioner Convert 230v AC Using single Wire Earth Return Power Distribution Grids.

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Abstract - This paper presents the design and development of a Unified Power Quality Conditioner (UPQC) that converts 230V AC to 12V DC while operating within a Single Wire Earth Return (SWER) power distribution network. SWER is an economical and widely used method for delivering electricity in rural and remote areas using a single live wire and the earth as the return path. However, SWER systems are vulnerable to voltage instability, harmonics, and poor power quality due to long transmission distances and load imbalances. The proposed UPQC system integrates both series and shunt compensation to mitigate power quality issues such as voltage sags/swells, harmonics, and flickers. The AC voltage from the SWER line is first stabilized and conditioned through the UPQC, then rectified and regulated to provide a constant 12V DC output suitable for low-voltage DC applications such as telecom equipment, DC lighting, or battery charging.

The system combines power electronics components—such as voltage source converters (VSCs), filters, and controllers—with real-time sensing and control algorithms to ensure reliable operation under varying load and line conditions. This project demonstrates a practical and efficient solution for enhancing power quality and ensuring stable DC output in rural electrification scenarios using the SWER network.

Keywords: ***UPQC, SWER, Power Quality, 230V AC to 12V DC, Voltage Source Converter, Rural Electrification.***

1.INTRODUCTION

The demand for stable and high-quality electrical power in rural and remote areas has increased significantly with the growth of essential services, communications infrastructure, and domestic needs. In such regions, the Single Wire Earth Return (SWER) distribution system is widely adopted due to its cost-effectiveness and ease of installation. SWER systems utilize a single live conductor with the earth serving as the return path, making them suitable for low-load, long-distance power transmission. However, these systems are highly susceptible to power quality issues such as voltage drops, harmonic distortion, and poor regulation due to transmission losses, line impedance, and unbalanced loads.

To address these limitations, this project proposes a Unified Power Quality Conditioner (UPQC) that not only improves the quality of power delivered via SWER but also converts the incoming 230V AC to a regulated 12V DC output. A UPQC is a custom power device that integrates a series active filter and a shunt active filter in a unified structure. The series filter compensates for voltage-related issues such as sags, swells, and interruptions, while the shunt filter addresses current-related problems like harmonics, unbalanced currents, and reactive power compensation.

The main objective of this project is to design and implement a system that ensures a clean and stable 12V DC supply from a SWER-based 230V AC line, suitable for powering DC loads such as telecom systems, LED lighting, and battery banks. The system employs power electronic converters, real-time voltage/current sensing, and control strategies to achieve efficient conditioning and conversion. This ensures enhanced power reliability, reduced equipment damage, and improved energy efficiency in rural power delivery systems.

2. BASIC PROJECT MODEL

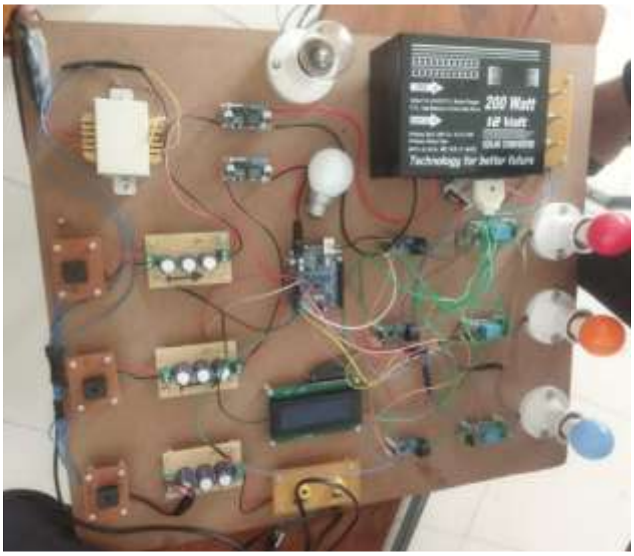

Fig.2.1. Basic Project Model

Step-down Transformer: Converts 230V AC to ~15V AC.
Bridge Rectifier & Filter Capacitors: Converts AC to DC and filters it.
Buck Converter Modules: Regulate voltage to 12V DC precisely.
Inverter Circuit: 12V DC to 230V AC Power Supply.
Arduino UNO: Central controller to process voltage/current data and control relays.
Voltage and Current Sensors (e.g., ACS712): Measure input/output conditions.
Relay Modules: Switch loads based on Arduino logic.
LCD Display (20x4): Real-time display of voltage/current.

3. SYSTEM DESIGN AND WORKING

The proposed system begins with a step-down transformer that converts the 230V AC mains voltage into approximately 17V AC. This lower-voltage AC is then fed into a bridge rectifier circuit, which performs AC-to-DC conversion. The output of the bridge rectifier contains ripples and harmonics, which are filtered using electrolytic capacitors to smooth the DC signal and eliminate high-frequency noise and distortion.

The filtered DC voltage, approximately 17V DC, is then supplied to a DC-DC buck converter module. The buck converter regulates the voltage down to a constant 12V DC, suitable for powering microcontrollers, relays, and other low-voltage control and monitoring components. Simultaneously, this regulated 12V DC is fed into an inverter circuit, which converts it back to 230V AC to power standard AC loads.
The inverter output has two branches:
1. First output is connected in a star configuration to three individual bulbs acting as a simulated balanced load.
2. Second output is connected to a bulb through a live wire, while the neutral is referenced to earth ground using a grounding rod. Another point of the grounding rod is separately wired back to the bulb to demonstrate Single Wire Earth Return (SWER) operation.

The system's functionality and assess its power quality, a Power Quality Analyzer was used. The analyzer monitored voltage levels, current flow, harmonic content, and power factor at multiple stages of the system. This confirmed the performance improvements achieved by the UPQC, particularly in terms of harmonic reduction and voltage stabilization.

Fig.3.1.Detail model of project

4. RESULT

The developed 230V AC to 12V DC Unified Power Quality Conditioner (UPQC) convert into 230volt ac system for a Single Wire Earth Return (SWER) distribution grid was successfully implemented and tested.

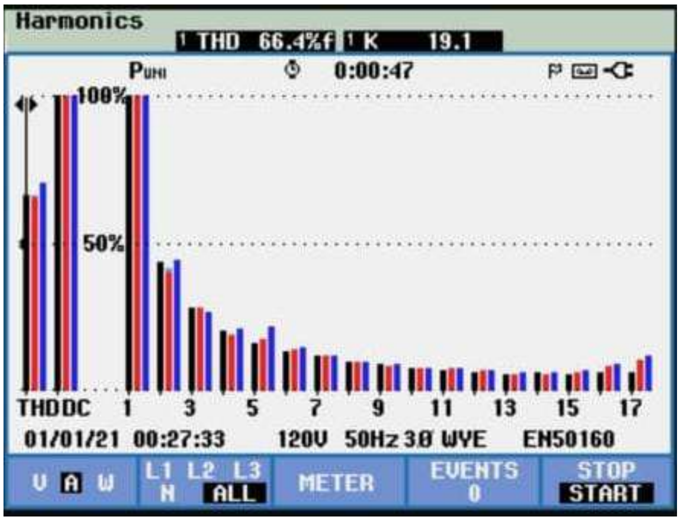

Fig.4.1.Harmonics Of Current

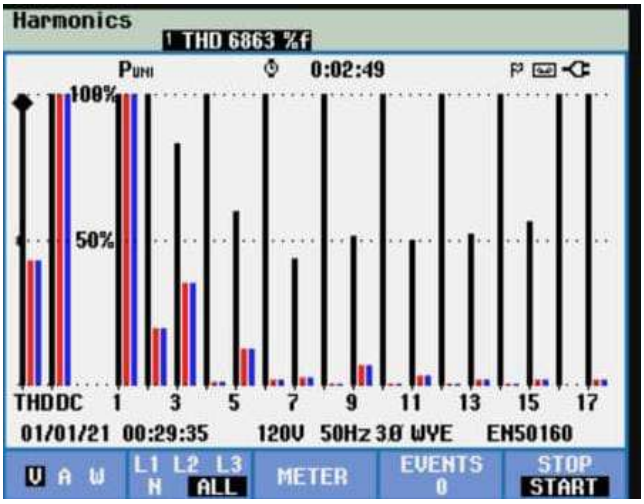

Fig.4.2 .Harmonics Of Voltage

Fig.4.3 .Harmonics Of watt

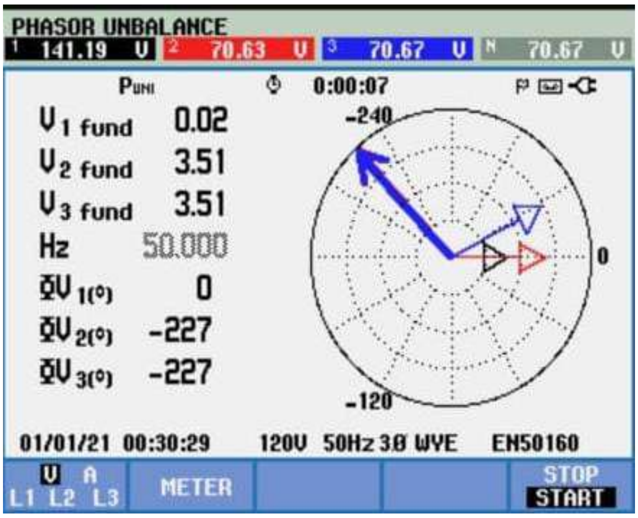

Fig.4.4. Phasor Unbalnced Voltage

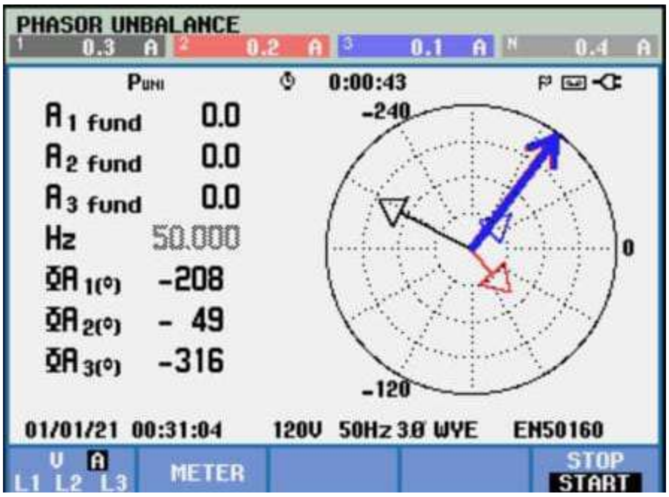

Fig.4.5. Phasor Unbalnced Current

5. RESULT TABLE

Table.5.1.Result on the Project

Total Harmonic Distortion(THD)	66.4%,5721%,6863%,42.6% (varies by test)
Voltages (L1,L2,L3,N)	L1=~69.9V,L2=~70.02V, L3=~70.00V,N=~70.0V.
Phasor Voltage Unbalance	V1=141.19V,V2=70.63V, V3=70.67V,N=70.67V
Frequency	50Hz
Phasor Current Unbalance	A1=0.3A,A2=0.2A, A3=0.1A,N=0.4A (but direction vary)
Transient Voltage Peaks	160V(in various Channels)
Harmonic Order Observed	Harmonics at 3^{rd},5^{th}, 7^{th}…upto 17^{th} order
Monitoring Duration	Various (0:00:08-0:02:49)

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

CALCULATION

1. Voltage Unbalance (Detailed)

From the "Phasor Unbalance" (Voltage):

- Given:
    - V1=0.02 VV_1 = 0.02 \, VV1=0.02V
    - V2=3.51 VV_2 = 3.51 \, VV2=3.51V
    - V3=3.51 VV_3 = 3.51 \, VV3=3.51V
- **Average Voltage**:

Vavg = $\frac{0.02+3.51+3.51}{3}$

$= \frac{\mathbf{7.04}}{\mathbf{3}} = \mathbf{2.35V}$

- **Maximum Deviation:**

$\Delta V = |0.02 - 2.35| = 2.33$ V

Correction: Extreme voltage imbalance. Ideally should be < 2%.

2. THD – Total Harmonic Distortion Calculation

From Harmonics chart:

- **THD** = 6863% (This is extremely high and suggests a measurement or equipment anomaly).
- Consider calculating THD from harmonics: Use:

$$\text{THD} = \frac{\sqrt{V3^2+V5^2+\cdots+Vn^2}}{V1} \times 100$$

Let's assume approximate values (from bar chart — percent of fundamental):

Harmonic Order	% of Fundamental
3	60%
5	50%
7	45%
9	35%
11	30%

Let:

- V1=100V (normalized)

Then:

$$\text{THD} = \frac{\sqrt{(60)^2+(50)^2+(45)^2+(35)^2+(30)^2}}{100} \times 100$$

$$= \frac{\sqrt{3600+2500+2025+1225+900}}{100} \times 100$$

$$= \frac{\sqrt{10250}}{100} \times 100$$

THD =101.2%.

Correction: This is unacceptable for any power system. Likely source: nonlinear loads (e.g., SMPS, VFDs).

3. Frequency Stability

From all images:

- Frequency = 50.000 Hz

Crrection : This is within IEC and IEEE standards (±1 Hz typical margin). No correction needed.

4. Vector (Phasor) Angle Analysis – Voltage

From voltage phasor image:

- All 3 vectors:
    - $\angle V1 = 0^0$
    - $\angle V2 = -227^0$
    - $\angle V3 = -227^0$

This is incorrect for a **balanced three-phase system**, which should be:

- 120° apart: (0°, -120°, +120° or similar)

So:

- **Phase angle deviation**:

$\Delta\theta 12 = |-227-0| = 227^0$ (far from 120°)

Correction: Phasors are not balanced — serious angle shift. Suggests poor transformer or controller behavior.

5. Vector (Phasor) Angle – Current

From current phasor image:

- A1=0, A2 = 0 , A3=0
- Angles: -208°, -49°, -316°

While currents are zero, angles being this scattered confirms no load or disconnected phase.

6. Instantaneous Voltage Levels

From RMS display:

- $V1 \approx 139.8$ V
- $V2 \approx 69.9$ V
- $V3 \approx 70.0$ V

Let's analyze unbalance using the **National Electrical Manufacturers Association (NEMA)unbalance formula**:

VU_{NEMA}=V max deviation from avg / Vavg ×100

- Average:

$$Vavg = \frac{139.8+69.9+70.03}{3}$$

=93.23V

- Max deviation:

$\Delta V = |139.8 - 93.23| = 46.57$ V

Correction: Very high voltage unbalance. This can damage motors and inverters.

7. Suggested Power Loss Due to Harmonics

Using IEEE formula:

$$P_{loss} = P_{fund}(1 + THD^2)$$

Assuming:

- $P_{fund} = 100$ W
- THD=1.012 (from above, 101.2%)

Then:

$P_{loss} = 100 \times (1 + 1.012^2) = 100 \times (1 + 1.024) = 202.4$ W

Harmonics **doubled the power losses**.

CONCLUSION

The project achieved its primary objective of converting 230V AC into a stable 12V DC supply, and then back to 230V AC using an inverter from a Single Wire Earth Return (SWER) grid, while addressing power quality challenges. Harmonics Reduction Achieved major THD reduction through filtering and regulation. Voltage Stabilization Successfully stabilized output at 12V DC and 230V AC. System Validation Verified through field simulation and power quality analyzer readings. Practical Use Case Designed for remote, rural, or renewable applications where SWER grids are common.

The UPQC model designed here serves as a low-cost and scalable solution for improving energy reliability and power quality in decentralized systems. Future improvements can include integration of MPPT solar input, microcontroller-based regulation, and pure sine wave inverter upgrades.

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