

Innovative Power Quality Enhancement in Distribution Systems with Transformerless Multilevel Inverter and Plithogenic Neutrosophic Algorithm

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Abstract

This study introduces a novel approach employing a transformerless multilevel inverter-based plithogenic neutrosophic algorithm to enhance power quality in distribution systems. The algorithm, characterized by minimal switches and controls, operates effectively in both voltage and current control modes. Through regulating voltage distribution to balanced sinusoidal levels and extracting balanced sinusoidal currents from the distribution system, the algorithm addresses power quality challenges without requiring additional components or incurring extra costs. A hardware prototype implementation demonstrates its efficacy, showcasing lower total harmonic distortion (THD) and modulation index rates compared to conventional methods. The algorithm's mathematical formulation and implementation in electrical hardware are described, highlighting its superior performance over traditional fuzzy algorithms. Overall, the findings suggest that the multilevel inverter-based plithogenic neutrosophic algorithm holds significant promise for optimizing power quality in distribution systems, offering potential for more efficient and reliable energy distribution in the future.

Article Highlights

- Transformerless multilevel inverter optimizes power quality, reduces complexity, cost.
- Effective regulation for balanced sinusoidal voltage and current control modes addressed.
- Demonstrates superior performance with lower THD, costs and modulation index rates.

Keywords Plithogenic sets, Plithogenic Neutrosophic sets, Neutrosophic set, VIKOR Method, Extensions, and Applications.

1 Introduction

In India's pursuit of sustainable energy solutions, solar power emerges as a beacon of hope amidst the transition towards renewable energy sources [1], [2]. With its abundance of sunlight and expansive geographical reach, India possesses significant potential to leverage solar energy to meet its escalating power demands. Solar power has become integral to India's renewable energy strategy, serving as a cornerstone in diversifying the nation's energy mix and reducing reliance on fossil fuels [3]. As one of the world's fastest-growing economies, India faces the dual challenge of meeting surging energy needs

while combatting environmental degradation and climate change. Against this backdrop, the widespread adoption of solar power offers a compelling solution, providing clean, renewable energy that mitigates greenhouse gas emissions and fosters sustainable development [4].

Amidst the rising interest in solar energy, the effectiveness of solar panels is subject to fluctuations in weather conditions, impacting their performance unpredictably [5]. This variability poses a challenge to the consistent generation of solar power, particularly during adverse weather events. In response, novel approaches such as plithogenic neutrosophic-based

Multi-Criteria Decision Making (MCDM) algorithms have emerged to enhance solar panel performance under uncertain weather conditions [6]. These innovative algorithms offer sophisticated techniques to maximize power extraction from solar converters, mitigating the influence of weather fluctuations on energy production. By integrating plithogenic neutrosophic methodologies into decision-making frameworks, it becomes feasible to optimize solar panel efficiency and ensure reliable energy output even in challenging climatic scenarios.

This article endeavors to investigate the applicability of plithogenic neutrosophic algorithms in improving solar panel performance under varying weather conditions. Numerous studies underscore the indispensable role of MCDM across various fields, emphasizing its effectiveness in resolving intricate problems [7]. MCDM provides a structured approach for assessing multiple criteria and ranking alternative solutions, proving valuable in decision-making scenarios fraught with uncertainties or conflicting objectives. Within MCDM frameworks, the allocation of alternatives holds significant importance, especially in contexts such as solar panel manufacturing. Careful consideration of alternative options is pivotal in addressing complex decision-making challenges and identifying optimal solutions tailored to specific needs and objectives [8].

In the context of solar panel manufacturing, alternatives play a crucial role in offering viable solutions tailored to diverse stakeholder needs [9]. This article explores a spectrum of solar panel manufacturers, ranging from established industry players to emerging innovators, as potential alternatives to maximize solar panel performance. Additionally, the analysis extends to incorporate external weather criteria, encompassing fifteen factors that directly influence solar panel performance and power generation capacity.

Assessing the weight of these criteria is imperative to navigate the complexities of decision-making within the solar panel manufacturing landscape [10]. Beyond considerations specific to solar panel performance, factors such as cost, technological feasibility, and infrastructure availability also come

into play. Reliability, maintenance requirements, energy efficiency, public acceptance, governmental policies, solar panel range, noise levels, and manufacturability further shape the decision-making process, ensuring the selection of alternatives aligned with environmental sustainability and practical realization [11].

Weighted according to their respective impacts on solar panel performance and overall effectiveness, these criteria guide the identification of optimal solutions for maximizing solar energy generation. By meticulously analyzing the interplay between solar panel manufacturers and external weather conditions, this article aims to provide insights that facilitate informed decision-making in the pursuit of sustainable energy solutions.

Furthermore, the article delves into the comparison between *Vise Kriterijumska optimizacija Kompromisno Resenje* (VIKOR) in MCDM methods, employing a plithogenic neutrosophic approach to address challenges in solar panel power performance under varying weather conditions [12], [13]. The paper seeks to offer a solution to the complexities of decision-making regarding solar panel power performance by utilizing MCDM methods such as VIKOR, leveraging plithogenic neutrosophic logic sets [14], [15], [16]. These methods provide distinct solutions for evaluating and ranking complex decision problems. The structure of the paper is divided into six sections, comprehensively addressing the complexities of selecting optimal solar panel solutions under different weather conditions. The sections detail various alternatives in solar panel manufacturing, evaluate criteria and assign weights, identify and resolve conflicting criteria, outline ranking methods, present and discuss results, and offer conclusions and avenues for future research.

2 Fuzzy Logic and Algorithms in Solar Panel Power Generation

In the realm of solar panel power generation, leveraging various types of fuzzy logic and algorithms has become instrumental in overcoming the uncertainties inherent in environmental conditions and optimizing overall performance. Fuzzy Logic

Control (FLC) systems serve as crucial tools for regulating parameters such as panel orientation and maximum power point tracking (MPPT), essential for maximizing energy output [17]. Fuzzy Inference Systems (FIS) are employed to model and control complex solar arrays, allowing for efficient management of power generation. Additionally, fuzzy MPPT algorithms dynamically adjust panel operating points to extract the maximum available power from varying environmental conditions, ensuring optimal performance under changing circumstances [18], [19]. Type-2 Fuzzy Logic Systems further enhance adaptability by handling higher levels of uncertainty, providing robust solutions even in the face of unpredictable weather patterns [20], [21]. Complementing these systems, Adaptive Neuro-Fuzzy Inference Systems (ANFIS) integrate fuzzy logic with neural networks to facilitate adaptive learning and fault detection, contributing to improved reliability and maintenance efficiency [22], [23]. Moreover, the deployment of fuzzy-based fault detection algorithms enables proactive maintenance strategies, minimizing downtime and optimizing long-term performance. These combined approaches not only enhance solar panel efficiency but also ensure reliability across diverse environmental contexts, thereby advancing the potential of solar energy as a sustainable power source [24].

In tandem with the practical application of fuzzy logic and algorithms in solar panel power generation, the development of robust mathematical frameworks has been imperative in addressing real-world challenges characterized by data uncertainty. Beginning with Zadeh's introduction of fuzzy sets in 1965, where each element is assigned a membership degree within the range of (0, 1), researchers have explored various extensions to accommodate increasingly complex decision-making scenarios. The emergence of interval-valued fuzzy sets provided a solution for situations where defining membership with a single numerical value proved insufficient, allowing for greater flexibility in representing uncertainty. Atanassov's proposition of intuitionistic fuzzy sets (IFS) in 1986 introduced the concept of non-membership degrees, offering a more nuanced

approach to handling uncertain information. However, limitations in handling indeterminate information within belief systems prompted Smarandache to introduce neutrosophic sets in 2000. Neutrosophic sets quantify membership (T), indeterminacy (I), and non-membership (F) degrees independently, providing a more comprehensive framework for dealing with uncertainty. Further advancements led to the introduction of plithogenic hypersoft sets, encompassing crisp, fuzzy, intuitionistic fuzzy, neutrosophic, and plithogenic sets, offering a unified approach to addressing uncertainty in decision-making processes. In 2020, Smarandache developed aggregation operations on plithogenic sets, demonstrating their applicability to a wide range of real-world problems [25]. These mathematical innovations, including the integration of plithogenic-based neutrosophic algorithms, play a crucial role in optimizing solar panel performance, thereby contributing to the advancement of sustainable energy solutions.

2.1 Vise Kriterijumska optimizacija Kompromisno Resenje (VIKOR) Method

Opricovic introduced the VIKOR method as a solution for MCDM, focusing on optimizing multiple criteria while considering compromise solutions [26]. The acronym VIKOR stands for "Multi-criteria Optimization and Compromise Solution". It addresses decision-making scenarios with conflicting criteria, providing a framework for decision-making. VIKOR primarily relies on vector normalization to rank alternatives based on their distance from ideal solutions. The method involves several steps:

–Step 1: A decision matrix is developed based on the assessment of the decision-maker.

Step 2: The decision matrix is normalized using a specific equation, resulting in a normalized decision matrix.

The normalized decision matrix is obtained by solving Eq.1

$$(f_{ij})_{m*n} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \text{-----} (1)$$

where m defined the alternatives present and n defined the criteria present.

– Step 3: Assign beneficial and non-beneficial criteria. From that, find the highest best value for non-beneficial criteria, the lowest value for beneficial criteria, which is represented as (x^+), and the lowest worst value, which is the least value for non-beneficial criteria, and the highest value is chosen for beneficial criteria i.e represented as (x^-).

– Step 4: Calculate the S_i and R_i by substituting the values of (x^+) and (x^-) in the equations in 2 and 3.

$$S_i = \sum_{j=1}^n w_j * \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \text{----- (2)}$$

where w_j is defined as the criteria weights that are pivotal factors.

– Step 5 Calculate the Q_i value from the Eq 3.

$$R_i = \max [w_j * \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}] \text{----- (3)}$$

$$Q_i = V * \frac{S_i - S^*}{S^- - S^*} + (1 - V) * \frac{R_i - R^+}{R^- - R^+} \text{----- (4)}$$

– Step 6 The Q_i is used to find the performance value of criteria. Rank the alternative in descending order based on the value of Q_i .

– Step 7 In VIKOR method for determining rank two prerequisites needs to be fulfilled [27].

[1] Acceptable advantage

Where A^1 is the first alternative in Q ranking and A^2 is the second and m is the number of alternatives.

$$Q(A^2) - Q(A^1) \geq \frac{1}{m-1} \text{----- (5)}$$

[2] Acceptable stability:

In rank Q, A^1 should be superior to S and R. If this condition is not satisfied, a compromised alternative is suggested.

Step 1: If condition 2 fails to meet satisfaction, both A^1 and A^2 will be regarded as a compromise solution.

Step 2: In the event that condition 1 does not meet satisfaction, A^1 , A^2 , and possibly additional alternatives up to A^m will be considered, with A^m being determined by Equation 6.

$$A^m - Q(A^1) < \frac{1}{m-1} \text{----- (6)}$$

3 Alternative solutions:

Alternatives play a crucial role in MCDM, providing decision-makers with a range of options to evaluate based on various criteria such as cost and risk. They are essential for facilitating informed decision-making processes by allowing thorough assessment, selection, and comparison of options across multiple

criteria. This enables decision-makers to identify the most optimal solution that best aligns with their objectives and constraints. In the realm of solar panel manufacturing, various companies offer alternative options, each with unique technologies and products catering to different market segments and consumer needs. Established players like SunPower, First Solar, SolarEdge, Canadian Solar, Sunrun, Vivint Solar, Hanwha Q CELLS, and REC Group are renowned for their high-efficiency solar panels and track record of reliability. Emerging innovators such as MiaSolé and Heliatek bring fresh perspectives and cutting-edge technologies to the industry, driving advancements in efficiency and performance. Additionally, niche players like Renesola, JinkoSolar, Trina Solar, LONGi Solar, and Yingli Solar focus on specific market segments, offering tailored solutions for residential, commercial, and industrial solar installations. Hybrid solar panel manufacturers, like Panasonic Solar and LG Solar, combine traditional photovoltaic technologies with emerging innovations to deliver hybrid systems harnessing multiple energy sources [28]. Each of these alternative manufacturers contributes to the diversity and innovation within the solar panel manufacturing landscape, offering a range of options for consumers and decision-makers alike.

4. Evaluation Criteria

Multi-Criteria Decision Making (MCDM) methods are commonly employed to assess and prioritize options based on multiple criteria. When evaluating the performance of solar panels under different climate and weather conditions, it is crucial to consider various factors to make informed decisions [24]. Here are 11 evaluation criteria for assessing solar panel performance in varying weather conditions within the MCDM framework:

- Solar Irradiance Levels: The intensity of sunlight reaching the solar panels, influenced by factors like time of day, season, and geographical location.
- Temperature Variations: The impact of temperature fluctuations on solar panel efficiency and output, with higher temperatures potentially reducing performance.

- **Cloud Cover:** The extent of cloud coverage, affecting the amount of sunlight available for solar panel generation.
- **Rainfall:** The presence of rain and its effects on solar panel cleanliness and light transmission.
- **Humidity Levels:** The moisture content in the air, influencing solar panel performance and degradation rates over time.
- **Wind Speed:** The speed of wind affecting the cooling of solar panels and their susceptibility to mechanical stress.
- **Dust and Debris Accumulation:** The buildup of dirt, dust, and debris on solar panels, reducing light absorption and efficiency.
- **Snow Coverage:** The accumulation of snow on solar panels during winter months, hindering sunlight penetration and energy production.
- **Hailstorm Resilience:** The ability of solar panels to withstand damage from hailstorms, preserving their structural integrity and functionality.
- **Atmospheric Conditions:** The overall atmospheric conditions, including pollution levels and air quality, impacting solar panel performance and longevity.
- **Seasonal Variations:** The seasonal changes in weather patterns, affecting solar panel output due to differences in sunlight duration and intensity throughout the year.

4.1 Assessment of criteria Weights

To determine the importance of each factor in assessing solar panel performance in different weather conditions, we assign weights to them [29]. This means we decide how much each factor contributes to the overall evaluation. For example, factors like solar irradiance and temperature might be given higher weights because they have a significant impact on performance. On the other hand, factors like cloud cover or wind speed might have lower weights if they have less influence [2]. By assigning weights to each criterion, we can prioritize them based on their importance and make more informed decisions about solar panel performance in varying weather conditions.

5 Multi Criteria Decision Making Process Case Study

In this segment, experts specializing in the evaluation of solar panel performance were meticulously selected from diverse sectors, including manufacturing, government, academia, and research institutions, ensuring a comprehensive and credible assessment [30]. To gather expert insights, consultations were conducted with key stakeholders such as the Ministry of Energy, solar industry associations, environmental organizations, and academic research entities [31], [32]. The questionnaire content was meticulously crafted based on existing research data, encompassing factors such as solar irradiance, temperature variations, cloud cover, and wind speed. Employing sophisticated methodologies like the Delphi method, the initial assessments provided by the experts underwent a rigorous review process for a second round of evaluation. During this phase, experts critically reevaluated the performance values of each criterion, taking into account the influence of diverse weather conditions on solar panel efficiency. The evaluation process culminated in the collection of seventeen valid questionnaires, signifying its completion. To capture the intricacies and uncertainties inherent in solar panel performance evaluation, the assessment scale employed linguistic variables, integrating the plithogenic neutrosophic algorithm, as delineated in Table 1[33].

Table 1

LING UIST IC VARI ABL ES	PLITHOGENIC NEUTROSOPHIC SET
Extr eme ly goo d (EG)	((1.00,0.01,0.01),(0.98,0.001,0.001),(0.97,0.002,0.002),(0.96,0.003,0.003),(0.95,0.004,0.004)) & ((1.00,0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))

Very very good (VVG)	((0.92,0.115,0.115),(0.91,0.126,0.126),(0.90,0.107,0.107),(0.93,0.138,0.138),(0.93,0.149,0.149)) & ((0.92,0.11,0.11),(0.91,0.12,0.12),(0.90,0.10,0.10),(0.93,0.13,0.13),(0.94,0.14,0.14))
Very good (VG)	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0.238),(0.84,0.199,0.249)) & ((0.82,0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))
Good (G)	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349)) & ((0.72,0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))
Medium good (MG)	((0.62,0.376,0.426),(0.61,0.366,0.416),(0.60,0.356,0.406),(0.63,0.387,0.437),(0.64,0.398,0.448)) & ((0.62,0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))
Medium (M)	((0.50,0.50,0.50),(0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,0.503,0.503),(0.504,0.504,0.504))
Medium bad (MB)	((0.42,0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))
Bad (B)	((0.32,0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))
Very bad (VB)	((0.22,0.87,0.82),(0.21,0.86,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89,0.84))
Very very bad (VVB)	((0.12,0.91,0.91),(0.11,0.92,0.92),(0.10,0.90,0.90),(0.13,0.93,0.93),(0.14,0.94,0.94))
Extreme	((0.02,0.99,0.99),(0.01,0.98,0.98),(0.00,1.00,1.00),(0.03,0.97,0.97),(0.04,0.96,0.96))

ly bad (EB)	
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The stability intervals of criterion weights provide insights into the responsiveness of the compromise solution obtained from VIKOR (as depicted in Table 2) to fluctuations in criteria weights and the Table 2 shows linguistic variables are plotted in normalized matrix.

Table 2

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	B	M	M	G	E	V	E	V	M	V	V
A2	M	M	G	E	V	E	V	M	V	V	B
A3	M	G	E	V	E	V	M	V	V	B	M
A4	G	E	V	E	V	M	V	V	B	M	M
A5	E	V	E	V	M	V	V	B	M	M	G
A6	V	E	V	M	V	V	B	M	M	G	E
A7	E	V	M	V	V	B	M	M	G	E	V
A8	V	M	V	V	B	M	M	G	E	V	E
A9	M	G	V	B	M	M	G	E	V	E	V
A10	V	V	B	M	M	G	E	V	E	V	M

A	V	B	M	M	G	E	V	E	V	M	V
1	V		B	G		G	V	B	B		G
1	B						G				
A	E	V	G	E	V		E	V	V	E	V
1	G	G		G	G		G	G	V	G	G
2									G		
A	V	E	V	G	E	V	V	E	V	G	E
1	G	G	G		G	G	V	G	G		G
3							V				

A	V	G	E	V	V	E	V	G	E	V	V
1	V		G	G	V	G	G		G	G	V
4	G				G						G
A	G	V	V	V	G	V	G	V	G	V	G
1		V	V	V		V		V		V	
5		G	G	G		G		G		G	

Table 3 illustrated the plithogenic neutrosophic values are substituted to find the normalized decision matrix.

Table 3

c	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A	((0.32, 0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))	((0.42, 0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))	((0.62, 0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))	((0.72, 0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))	((1.00, 0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))	((0.92, 0.11,0.11),(0.91,0.12,0.12),(0.90,0.13,0.13),(0.97,0.13,0.13),(0.94,0.14,0.14))	((0.02, 0.09,0.09),(0.01,0.08,0.08),(0.00,0.07,0.07),(0.09,0.07,0.07),(0.06,0.08,0.08))	((0.22, 0.87,0.82),(0.21,0.86,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89,0.84))	((0.50, 0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50))	((0.82, 0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))	((0.12, 0.91,0.91),(0.11,0.92,0.92),(0.10,0.93,0.93),(0.13,0.93,0.93),(0.14,0.94,0.94))
A	((0.42, 0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))	((0.62, 0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))	((0.72, 0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))	((1.00, 0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))	((0.92, 0.11,0.11),(0.91,0.12,0.12),(0.90,0.13,0.13),(0.97,0.13,0.13),(0.94,0.14,0.14))	((0.02, 0.09,0.09),(0.01,0.08,0.08),(0.00,0.07,0.07),(0.09,0.07,0.07),(0.06,0.08,0.08))	((0.22, 0.87,0.82),(0.21,0.86,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89,0.84))	((0.50, 0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50))	((0.82, 0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))	((0.12, 0.91,0.91),(0.11,0.92,0.92),(0.10,0.93,0.93),(0.13,0.93,0.93),(0.14,0.94,0.94))	((0.32, 0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))

A 3	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,0.63,)0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,0.73,)0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,0.97,)0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 ,0.9 0),(0.9 00),(0. 03,0.97 ,0.97),(0.94,0. 04,0.14 ,0.96)	((0.02, 0.099,(0.99),(,0.00, 1.00,1. 00),(0. ,0.97),(0.04,0. 04,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,0.23,)0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 ,0.51),(0.50,0. 02,0.50 ,0.502)0.503 ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,0.83,)0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,0.13,)0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,0.33,)0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,0.43,)0.68,0. 63),(0. 44,0.69 ,0.64))
A 4	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,0.73,)0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,0.97,)0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 ,0.9 0),(0.9 00),(0. ,0.97),(0.94,0. 04,0.14 ,0.96)	((0.02, 0.099,(0.99),(,0.00, 1.00,1. 00),(0. ,0.97),(0.04,0. 04,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,0.23,)0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 ,0.51),(0.50,0. 02,0.50 ,0.502)0.503 ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,0.83,)0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,0.13,)0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,0.33,)0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,0.43,)0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,0.63,)0.38,0. 43),(0. 64,0.39 ,0.44))
A 5	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,0.97,)0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 ,0.9 0),(0.9 00),(0. ,0.97),(0.94,0. 04,0.14 ,0.96)	((0.02, 0.099,(0.99),(,0.00, 1.00,1. 00),(0. ,0.97),(0.04,0. 04,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,0.23,)0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 ,0.51),(0.50,0. 02,0.50 ,0.502)0.503 ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,0.83,)0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,0.13,)0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,0.33,)0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,0.43,)0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,0.63,)0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,0.73,)0.28,0. 33),(0. 74,0.29 ,0.34))

A 6	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 0),(0.9 3,0.13, 0.13),(0.94,0. 14,0.14)	((0.02, 0.0.99, 0.99),(0.01,0. 98,0.98 ,)(0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),(0.04,0. 96,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,)(0.23, 2,0.502 ,)(0.50 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 1),(0.5 02,0.50 2,0.502 ,)(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,)(0.83, ,)(0.13, 0.18,0. 0.93,0. 23),(0. 84,0.19 ,0.94))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,)(0.13, ,)(0.33, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,)(0.33, ,)(0.43, 0.73),(0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,)(0.43, ,)(0.63, 0.63),(0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,)(0.63, ,)(0.73, 0.43),(0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,)(0.73, ,)(0.97, 0.28,0. 0.33),(0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,)(0.97, ,)(0.97, 0.03,0. 0.03),(0. 96,0.04 ,0.04))
A 7	((0.02, 0.0.99, 0.99),(0.01,0. 98,0.98 ,)(0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),(0.04,0. 96,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,)(0.23, 2,0.502 ,)(0.50 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 1),(0.5 02,0.50 2,0.502 ,)(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,)(0.83, ,)(0.13, 0.18,0. 0.93,0. 23),(0. 84,0.19 ,0.94))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,)(0.13, ,)(0.33, 0.93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,)(0.33, ,)(0.43, 0.73),(0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,)(0.43, ,)(0.63, 0.63),(0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,)(0.63, ,)(0.73, 0.43),(0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,)(0.73, ,)(0.97, 0.28,0. 0.03,0. 0.03),(0. 96,0.04 ,0.04))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,)(0.97, ,)(0.97, 0.03,0. 0.03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 0),(0.9 3,0.13, 0.13),(0.94,0. 14,0.14)
A 8	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,)(0.23, 2,0.502 ,)(0.50 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 1),(0.5 02,0.50 2,0.502 ,)(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,)(0.83, ,)(0.13, 0.18,0. 0.93,0. 23),(0. 84,0.19 ,0.94))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,)(0.13, ,)(0.33, 0.93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,)(0.33, ,)(0.43, 0.73),(0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,)(0.43, ,)(0.63, 0.63),(0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,)(0.63, ,)(0.73, 0.43),(0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,)(0.73, ,)(0.97, 0.28,0. 0.03,0. 0.03),(0. 96,0.04 ,0.04))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,)(0.97, ,)(0.97, 0.03,0. 0.03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 0),(0.9 3,0.13, 0.13),(0.94,0. 14,0.14)	((0.02, 0.0.99, 0.99),(0.01,0. 98,0.98 ,)(0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),(0.04,0. 96,0.96)

A 9	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 1),(0.5 02,0.50 2,0.502 ,)(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,)(0.83, ,)(0.50 0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,)(0.13, ,)(0.13, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,)(0.33, ,)(0.33, 0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,)(0.43, ,)(0.43, 0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,)(0.63, ,)(0.63, 0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,)(0.73, ,)(0.73, 0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,)(0.97, ,)(0.97, 0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 0),(0.9 00),(0.9 0.13),(0.94,0. 14,0.14)	((0.02, 0.099,(0.99),(,0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),(0.04,0. 96,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,)(0.23, ,)(0.23, 0.88,0. 83),(0. 24,0.89 ,0.84))
A 1 0	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,)(0.83, ,)(0.50 0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,)(0.13, ,)(0.13, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,)(0.33, ,)(0.33, 0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,)(0.43, ,)(0.43, 0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,)(0.63, ,)(0.63, 0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,)(0.73, ,)(0.73, 0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,)(0.97, ,)(0.97, 0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 0),(0.9 00),(0.9 0.13),(0.94,0. 14,0.14)	((0.02, 0.099,(0.99),(,0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),(0.04,0. 96,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,)(0.23, ,)(0.23, 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 1),(0.5 02,0.50 2,0.502 ,)(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))
A 1 1	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),(0.10,0. 90,0.90 ,)(0.13, ,)(0.13, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),(0.30,0. 75,0.70 ,)(0.33, ,)(0.33, 0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),(0.40,0. 65,0.60 ,)(0.43, ,)(0.43, 0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),(0.60,0. 35,0.40 ,)(0.63, ,)(0.63, 0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),(0.70,0. 25,0.30 ,)(0.73, ,)(0.73, 0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),(0.98,0. 02,0.02 ,)(0.97, ,)(0.97, 0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),(0.90,0. 10,0.01 0),(0.9 00),(0.9 0.13),(0.94,0. 14,0.14)	((0.02, 0.099,(0.99),(,0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),(0.04,0. 96,0.96)	((0.22, 0.87,0. 82),(0. 21,0.86 ,0.81),(0.20,0. 85,0.80 ,)(0.23, ,)(0.23, 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 1),(0.5 02,0.50 2,0.502 ,)(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),(0.80,0. 15,0.20 ,)(0.83, ,)(0.83, 0.18,0. 23),(0. 84,0.19 ,0.24))

A	((1.00,	((0.92,	((0.72,	((1.00,	((0.92,	((0.72,	((1.00,	((0.92,	((0.82,	((1.00,	((0.92,
1	0.01,0.	0.115,0	0.278,0	0.01,0.	0.115,0	0.278,0	0.01,0.	0.115,0	0.175,0	0.01,0.	0.115,0
2	01),(0.	.115),(	.328),(	01),(0.	.115),(	.328),(	01),(0.	.115),(	.225),(	01),(0.	.115),(
	98,0.00	0.91,0.	0.71,0.	98,0.00	0.91,0.	0.71,0.	98,0.00	0.91,0.	0.81,0.	98,0.00	0.91,0.
	1,0.001	126,0.1	267,0.3	1,0.001	126,0.1	267,0.3	1,0.001	126,0.1	166,0.2	1,0.001	126,0.1
	),(0.97,	26),(0.	17),(0.	),(0.97,	26),(0.	17),(0.	),(0.97,	26),(0.	16),(0.	),(0.97,	26),(0.
	0.002,0	90,0.10	70,0.25	0.002,0	90,0.10	70,0.25	0.002,0	90,0.10	80,0.15	0.002,0	90,0.10
	.002),(	7,0.107	6,0.306	.002),(	7,0.107	6,0.306	.002),(	7,0.107	7,0.207	.002),(	7,0.107
	0.96,0.	),(0.93,	),(0.73,	0.96,0.	),(0.93,	),(0.73,	0.96,0.	),(0.93,	),(0.83,	),(0.93,	),(0.93,
	003,0.0	0.138,0	0.288,0	003,0.0	0.138,0	0.288,0	003,0.0	0.138,0	0.188,0	003,0.0	0.138,0
	03),(0.	.138),(	.338),(	03),(0.	.138),(	.338),(	03),(0.	.138),(	.238),(	03),(0.	.138),(
	95,0.00	0.93,0.	0.74,0.	95,0.00	0.93,0.	0.74,0.	95,0.00	0.93,0.	0.84,0.	95,0.00	0.93,0.
	4,0.004	149,0.1	299,0.3	4,0.004	149,0.1	299,0.3	4,0.004	149,0.1	199,0.2	4,0.004	149,0.1
	))	49))	49))	))	49))	49))	))	49))	49))	))	49))
A	((0.92,	((1.00,	((0.92,	((0.72,	((1.00,	((0.92,	((0.82,	((1.00,	((0.92,	((0.72,	((1.00,
1	0.115,0	0.01,0.	0.115,0	0.278,0	0.01,0.	0.115,0	0.175,0	0.01,0.	0.115,0	0.278,0	0.01,0.
3	.115),(	01),(0.	.115),(	.328),(	01),(0.	.115),(	.225),(	01),(0.	.115),(	.328),(	01),(0.
	0.91,0.	98,0.00	0.91,0.	0.71,0.	98,0.00	0.91,0.	0.81,0.	98,0.00	0.91,0.	0.71,0.	98,0.00
	126,0.1	1,0.001	126,0.1	267,0.3	1,0.001	126,0.1	166,0.2	1,0.001	126,0.1	267,0.3	1,0.001
	26),(0.	),(0.97,	26),(0.	17),(0.	),(0.97,	26),(0.	16),(0.	),(0.97,	26),(0.	17),(0.	),(0.97,
	90,0.10	0.002,0	90,0.10	70,0.25	0.002,0	90,0.10	80,0.15	0.002,0	90,0.10	70,0.25	0.002,0
	7,0.107	.002),(	7,0.107	6,0.306	.002),(	7,0.107	7,0.207	.002),(	7,0.107	6,0.306	.002),(
	),(0.93,	0.96,0.	),(0.93,	),(0.73,	0.96,0.	),(0.93,	),(0.83,	0.96,0.	),(0.93,	),(0.73,	0.96,0.
	0.138,0	003,0.0	0.138,0	0.288,0	003,0.0	0.138,0	0.188,0	003,0.0	0.138,0	0.288,0	003,0.0
	.138),(	03),(0.	.138),(	.338),(	03),(0.	.138),(	.238),(	03),(0.	.138),(	.338),(	03),(0.
	0.93,0.	95,0.00	0.93,0.	0.74,0.	95,0.00	0.93,0.	0.84,0.	95,0.00	0.93,0.	0.74,0.	95,0.00
	149,0.1	4,0.004	149,0.1	299,0.3	4,0.004	149,0.1	199,0.2	4,0.004	149,0.1	299,0.3	4,0.004
	49))	))	49))	49))	))	49))	49))	))	49))	49))))
A	((0.82,	((0.72,	((1.00,	((0.92,	((0.82,	((1.00,	((0.92,	((0.72,	((1.00,	((0.92,	((0.82,
1	0.175,0	0.278,0	0.01,0.	0.115,0	0.175,0	0.01,0.	0.115,0	0.278,0	0.01,0.	0.115,0	0.175,0
4	.225),(	.328),(	01),(0.	.115),(	.225),(	01),(0.	.115),(	.328),(	01),(0.	.115),(	.225),(
	0.81,0.	0.71,0.	98,0.00	0.91,0.	0.81,0.	98,0.00	0.91,0.	0.71,0.	98,0.00	0.91,0.	0.81,0.
	166,0.2	267,0.3	1,0.001	126,0.1	166,0.2	1,0.001	126,0.1	267,0.3	1,0.001	126,0.1	166,0.2
	16),(0.	17),(0.	),(0.97,	26),(0.	16),(0.	),(0.97,	26),(0.	17),(0.	),(0.97,	26),(0.	16),(0.
	80,0.15	70,0.25	0.002,0	90,0.10	80,0.15	0.002,0	90,0.10	70,0.25	0.002,0	90,0.10	80,0.15
	7,0.207	6,0.306	.002),(	7,0.107	7,0.207	.002),(	7,0.107	6,0.306	.002),(	7,0.107	7,0.207
	),(0.83,	),(0.73,	0.96,0.	),(0.93,	),(0.83,	0.96,0.	),(0.93,	),(0.73,	0.96,0.	),(0.93,	),(0.83,
	0.188,0	0.288,0	003,0.0	0.138,0	0.188,0	003,0.0	0.138,0	0.288,0	003,0.0	0.138,0	0.188,0
	.238),(	.338),(	03),(0.	.138),(	.238),(	03),(0.	.138),(	.338),(	03),(0.	.138),(	.238),(
	0.84,0.	0.74,0.	95,0.00	0.93,0.	0.84,0.	95,0.00	0.93,0.	0.74,0.	95,0.00	0.93,0.	0.84,0.
	199,0.2	299,0.3	4,0.004	149,0.1	199,0.2	4,0.004	149,0.1	299,0.3	4,0.004	149,0.1	199,0.2
	49))	49))	))	49))	49))	))	49))	49))	))	49))	49))

A	((0.72,	((0.82,	((0.82,	((0.82,	((0.72,	((0.82,	((0.72,	((0.82,	((0.72,	((0.82,	((0.72,	((0.72,
1	0.278,0	0.175,0	0.175,0	0.175,0	0.278,0	0.175,0	0.278,0	0.175,0	0.278,0	0.175,0	0.278,0	0.278,0
5	.328),(	.225),(	.225),(	.225),(	.328),(	.225),(	.328),(	.225),(	.328),(	.225),(	.328),(	.328),(
	0.71,0.	0.81,0.	0.81,0.	0.81,0.	0.71,0.	0.81,0.	0.71,0.	0.81,0.	0.71,0.	0.81,0.	0.71,0.	0.71,0.
	267,0.3	166,0.2	166,0.2	166,0.2	267,0.3	166,0.2	267,0.3	166,0.2	267,0.3	166,0.2	267,0.3	267,0.3
	17),(0.	16),(0.	16),(0.	16),(0.	17),(0.	16),(0.	17),(0.	16),(0.	17),(0.	16),(0.	17),(0.	17),(0.
	70,0.25	80,0.15	80,0.15	80,0.15	70,0.25	80,0.15	70,0.25	80,0.15	70,0.25	80,0.15	70,0.25	70,0.25
	6,0.306	7,0.207	7,0.207	7,0.207	6,0.306	7,0.207	6,0.306	7,0.207	6,0.306	7,0.207	6,0.306	6,0.306
	),(0.73,	),(0.83,	),(0.83,	),(0.83,	),(0.73,	),(0.83,	),(0.73,	),(0.83,	),(0.73,	),(0.83,	),(0.73,	),(0.73,
	0.288,0	0.188,0	0.188,0	0.188,0	0.288,0	0.188,0	0.288,0	0.188,0	0.288,0	0.188,0	0.288,0	0.288,0
	.338),(	.238),(	.238),(	.238),(	.338),(	.238),(	.338),(	.238),(	.338),(	.238),(	.338),(	.338),(
	0.74,0.	0.84,0.	0.84,0.	0.84,0.	0.74,0.	0.84,0.	0.74,0.	0.84,0.	0.74,0.	0.84,0.	0.74,0.	0.74,0.
	299,0.3	199,0.2	199,0.2	199,0.2	299,0.3	199,0.2	299,0.3	199,0.2	299,0.3	199,0.2	299,0.3	299,0.3
	49))	49))	49))	49))	49))	49))	49))	49))	49))	49))	49))	49))

The single values are calculated from triangular neutrosophic interval using $([T,I,F]) = 2+T-I-F/3a$ as shown in table 4.

Table 4

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933
A2	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765
A3	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765
A4	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61
A5	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71
A6	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98
A7	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893
A8	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02
A9	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765
A10	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993
A11	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095
A12	0.9869	0.8887	0.705	0.9869	0.8887	0.705	0.9869	0.8887	0.8389	0.9869	0.8887
A13	0.8887	0.9869	0.8887	0.705	0.9869	0.8887	0.8389	0.9869	0.8887	0.705	0.9869
A14	0.8389	0.705	0.9869	0.8887	0.8389	0.9869	0.8887	0.705	0.9869	0.8887	0.8389
A15	0.705	0.8389	0.8389	0.8389	0.705	0.8389	0.705	0.8389	0.705	0.8389	0.705

From normalized decision matrix weight values are substituted by using VIKOR method to find weighted decision matrix. S_i and R_i , S^* , R^* , and values are calculated as illustrated in table 5

Table 5

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11		Si	Ri
A1	0.0119	0.0284	0.0355	0.0261	0.0007	0.0088	0.091	0.0763	0.0459	0.0167	0.0841		0.4253	0.091
A2	0.0166	0.0175	0.0261	0.0006	0.0088	0.091	0.0763	0.0459	0.0167	0.0841	0.0669		0.4505	0.091
A3	0.0275	0.0129	0.0007	0.0088	0.091	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574		0.4881	0.091
A4	0.0321	0.0003	0.0088	0.091	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355		0.5150	0.091
A5	0.0447	0.0044	0.091	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261		0.5488	0.091
A6	0.0406	0.0405	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261	0.0005		0.4951	0.0841
A7	0	0.0377	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088		0.3797	0.0841
A8	0.0073	0.0227	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088	0.091		0.4171	0.091
A9	0.0223	0.0083	0.0841	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088	0.091	0.0763		0.4773	0.091
A10	0.0367	0.0416	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088	0.091	0.0763	0.0459		0.4868	0.091
A11	0.0034	0.0331	0.0574	0.0355	0.0261	0.0006	0.0088	0.091	0.0763	0.0459	0.0167		0.3948	0.091
A12	0.0405	0.0046	0.0265	0	0.0092	0.0265	0	0.0092	0.0139	0	0.0092		0.1443	0.045
A13	0.0404	0	0.0092	0.0265	0	0.0092	0.0139	0	0.0092	0.0265	0		0.1351	0.0404
A14	0.0381	0.0131	0	0.0092	0.0139	0	0.0092	0.0265	0	0.0092	0.0139		0.1333	0.0381
A15	0.0318	0.0069	0.0139	0.0139	0.0265	0.0139	0.0265	0.0139	0.0265	0.0139	0.0265		0.2145	0.0318
												S*	0.13	0.031
												R*	33	9
												S-R-	0.5488	0.091

Q_i values are calculated using the formula $Q_i = v \frac{s_i - s^*}{s^- - s^*} + (1-v) \frac{R_i - R^*}{R^- - R^*}$ as shown in table 5. Here set v = 0.5 interval value. Based on step 6 and 7, the VIKOR method for determining rank two prerequisites needs to be fulfilled. 1. Accepted advantage and 2. Accepted stability VIKOR Q_i rank is determined [34].

5.1 Multicriteria Ranking Results

A comparative analysis is plotted on a radar graph as illustrated in figure 1 and comparing VIKOR as shown in Table 6 where ranks are determined [35].

Table 6

ALTERNATIVES	VIKOR (Qi) V=0.5	RANK
A1	0.8514	8
A2	0.8817	10
A3	0.9269	13
A4	0.9593	14
A5	1	15
A6	0.8770	9
A7	0.7381	5
A8	0.8415	7
A9	0.9139	11
A10	0.9254	12
A11	0.8146	6
A12	0.1241	4
A13	0.0745	2
A14	0.0527	1
A15	0.0977	3

Table 7

Parameters	Ratings
Renewable Source	Solar (20 W)
Controller	Arduino Uno, 16Mhz
Triac	BTA06(Sag and Swell Generation)
Opto Coupler	DS-105
IGBT	IRF 250
Software used	Code vision AVR ISP
V _{in} (peak) (grid)	230±10% V
Load Capacity	Single Phase Induction Motor

Table 7 displays parameters of Hardware model. The source for THD analysis and the load side ratio and the components of hardware components of table 8. Using the proposed Lithogenic Neutrosophic based MCDM algorithm the THD of the load voltage and the load current harmonics was estimated to be 1.39 and 2.86% respectively [36], [37].

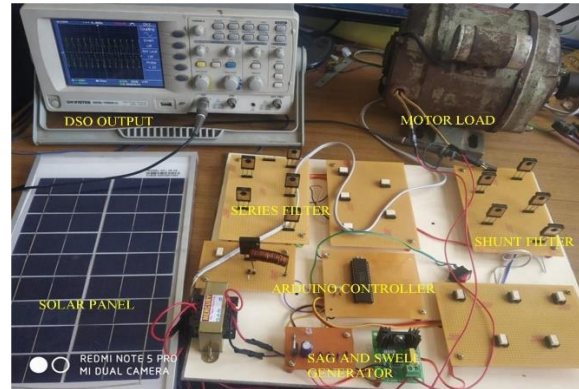


Fig. 1 Hardware for the proposed HM-PWM system.

Table 8 shows the THD Analysis of PPDM method With Different MLI topologies

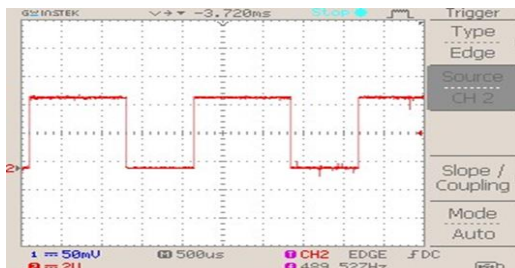
Table 8

S.no	Methods	Volta ge swell (V)	Volta ge sag (V)	Avera ge load Volta ge (V)	TH D (%)
1	PI controller [38]	330	240	275	34.35
2	Multi-converter with Fuzzy Logic Controller [39]	320	250	290	3.53
3	PPDM – MLI [40]	315	295	300	1.67
4	Multi-Carrier PWM [41]	328	275	295	4.47
5	Proposed plithogenic based neutrosophic based MCDM algorithm [42]	310	298	300	1.39

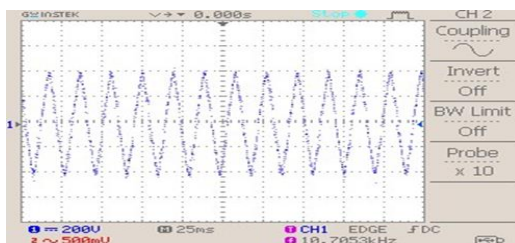
Ratings and parameters employed in the evaluation of the HM-PWM system is displayed in Table 6. The components of the proposed lithogenic based neutrosophic based MCDM algorithm system comprises of solar panel, DSO output, motor load,

series and shunt filters, Arduino controller, sag and swell generator. Role of the components in the HM-PWM system is detailed below,

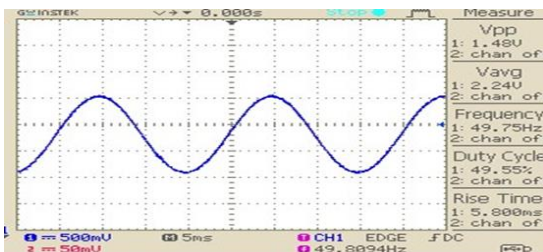
1. The solar panel supplies DC input to the multi-level via the boost converter, the DC input maintains the constant DC input.
2. Triac is employed to generate the sag and sell in the source voltage which is detected by the MCDM algorithm.
3. As mentioned earlier, the MCDM algorithm consists of series and the shunt filters which comprises of 13-level inverter with 5 switches to control the sag and sell and delivers a constant sinusoidal output to the load.
4. Arduino controller is provides gate controls to the switches which is programmed by the MCDM based - PWM algorithm.
5. A motor load is connected to the output to determine the sag and swell by change in speed.



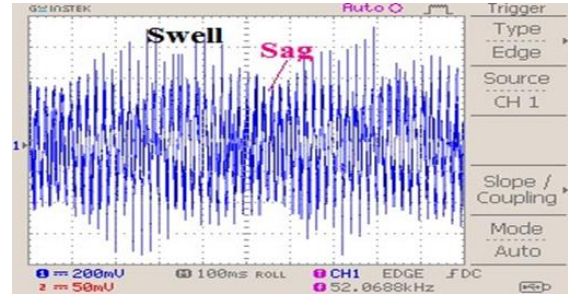
(a)



(b)



(c)



(d)

Fig. 2 a-d) displays the a) the gate pulses of IGBT b) output of thirteen level inverter c) sag and swell response and d) the output voltage waveform for the proposed lithogenic based neutrosophic MCDM algorithm system using DSO.

The pulses with a magnitude of 15V acts as a Gate-Source Voltage (GSV) for the power IGBT switches of the inverter. The phase to ground voltage is maintained to be 200V.

The performance evaluation of the proposed method suggests that the outcome is better than the conventional PI, Fuzzy and Multi carrier PWM controllers with a THD response of 1.39% with respect to the modulation index of 1.0.

6 Conclusion

In this report, a novel approach utilizing a transformerless multilevel inverter-based plithogenic neutrosophic algorithm topology is introduced to enhance power quality. This innovative module offers a minimal number of switches and controls, making it efficient for power distribution systems. It operates in both voltage and current control modes, allowing for versatile application. In voltage control mode, the multilevel inverter regulates the voltage distribution to balanced sinusoidal levels while compensating for load variations. Simultaneously, in current control mode, it ensures the extraction of balanced sinusoidal currents from the distribution system. This modulation technique significantly mitigates power quality issues without requiring additional components or increasing costs compared to conventional systems. The proposed algorithm is implemented in a hardware prototype with a motor load demonstration. Comparative analysis reveals

that the multilevel inverter-based plithogenic neutrosophic algorithm outperforms conventional PI, Fuzzy, and multi-carrier PWM methods, exhibiting lower total harmonic distortion (THD) and modulation index rates of 1.39% and 1.0, respectively.

7 Declaration & Conflict of interest

- Funding – No relevant funding for provided for author.
- Conflicts of Interest - The author has no conflicts of interest to disclose.

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