

# A New Optimization Algorithm for Photovoltaic Maximum Power Point Trackers

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**Abstract:** Recently, demand for a fast optimization algorithm is becoming crucial, especially for photovoltaic maximum power point trackers (MPPT). Several algorithms are readily available; however, their ability to fast obtain the optimum values is not reasonably fast. In this paper, a modification on the dual tangent optimization algorithm is being suggested. It assumes a parabolic geometry of the power voltage (PV) curve with the onset slightly closer to the open circuit voltage. Instead of reading two consecutive power points on the PV curve each iteration, the proposed algorithm only requires one for an iteration to take place. The algorithm is investigated and compared to the basic algorithm as well as the parabolic curve fitting optimization methods. Results show that the proposed algorithm can reach global maximum faster than later methods with reduced number of iterations. Thus, this algorithm is promising and might be an alternative to methods that require heavy computational resources for online and offline optimization.

**Key Words:** Optimization, Searching algorithm, MPPT, Dual tangent, PV

## 1. Introduction

Optimization is a contemporary required paradigm for a wide range of applications that require huge computations or real time analysis. Researches in many fields such as biology, business and engineering require substantial computations to achieve optimality. Supercomputers frame works are being developed to speed up processing time and aid in finding optimal solutions. In photovoltaic applications, high powerful computational devices are usually economically infeasible especially with household or light PV projects. A trade-off between efficiency and cost is essential in such PV projects. Special optimisation algorithms known by MPPT trackers are effective as they are especially designed for the PV application. However, unwanted delays in finding the optimal parameters leads in degrading the system performance and losing sun power. Therefore, the development of an easily implemented, fast and reliable optimizer is a necessity for both on grid and off grid PV systems.

Many optimization techniques are found in literature. But none can be said to be absolutely superior to other techniques. Each technique might be optimal for some applications. Perturb and observe method is one of the most used methods. It is easily programmed and used for single variable systems but the used fixed step prevents reaching the optimal value. Although it can be programmed with variable step size it become very slow when near the maximum (1) (2). Also, the basic perturb and observe is not suitable for finding the global maximum unless several random restarts are forced. The latter problem is also found with the incremental conductance method since reaching the maximum requires the first derivative to be zero (3). On the other hand, genetic algorithm methods such the particle swarm optimisation (PSO) methods are very efficient in finding local and global maxima. However, they use a vast number of particles even when getting close to a maximum (4).

The power voltage diagram of any photo voltage system has a special geometry shown in **Error! Reference source not found.** The shape of this curve remains the same for a variety of input conditions such as the irradiance. A new method called the dual tangent algorithm was especially suggested for PV systems having this geometry (5). This method assumes only a single maximum available in a predefined range of input voltage. The first tangent in this method has positive slope and lies to the left of the onset. On the right side the tangent has negative slope (6). The intersection between those tangents occurs near the maximum (7). Through multiple iterations the maximum is achieved. This method was proven to reach the maximum with a few iterations as shown in **Error! Reference source not found.** However, each iteration requires the accurate calculations of the slope. Hence, two points on the PV curve should be obtained by physical measurement devices (8) (9) (10). Taking the measurements is a slow process in comparison to the controller iteration time required. Although the PV curve is not a parabola, some researchers suggested parabolic and circular curve fitting (11) (12) (13). These methods use one instead of a

couple of measurement points for each iteration. However, these methods require the controller to be equipped with special mathematical functions and capabilities for curve fitting and obtaining the maximum.

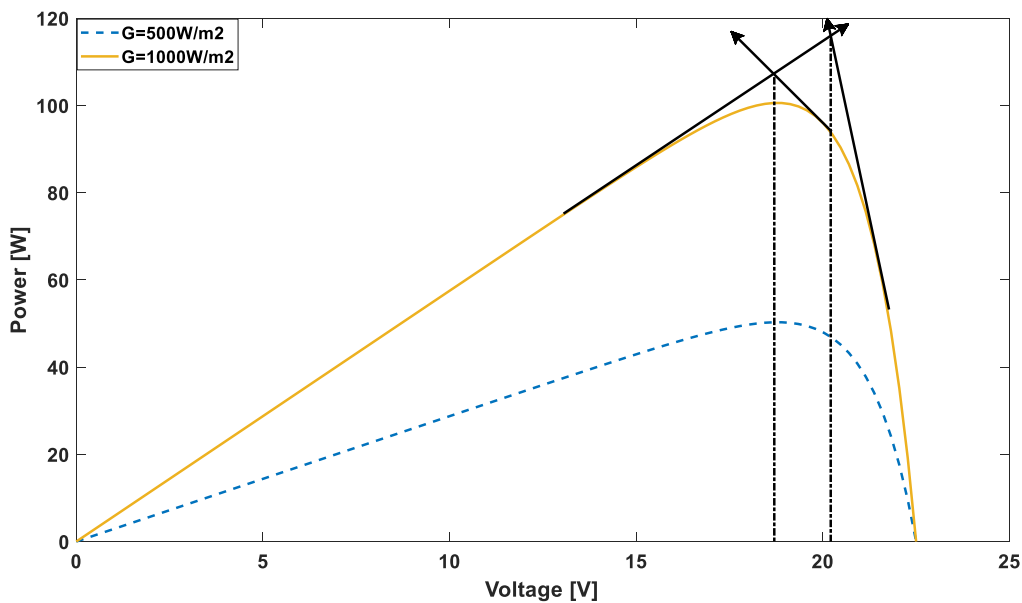


Figure 1: PV diagram of the 100D solar panel showing the Apex

In this research we are presenting a new algorithm that anticipates the local and global maxima by modifying the dual tangent algorithm. For which, each iteration requires only one actual measurement. This method is intended to solve one-dimensional and single-objective optimization problems. Instead of having PV curve tangents, lines formed from the new measurement and previous one pointing towards the maximum through a special algorithm. This method is called two lines pointing method (TLP). This research includes a comparison with the two changing and parabolic fitting methods.

## 2. Methodology

The TLP method is similar to the dual tangent algorithm in which it requires two lines around the onset to be mathematically defined. The TLP optimizer does not seem to have a straight forward algorithm as the new measurement does not provide a slope. The new measurement point can form a line with either the previous left or right point. Hence, any mistake in forming the correct line will fail in pointing towards the maximum.

It is important to make sure that the first tangent has a positive slope and the second tangent has negative one. At start, two tangents are mathematically obtained which requires four physical measurements. The two tangents can be modelled using line equation as

$$L1 = y1 + \frac{y1 - y0}{dx} (x - x1) \tag{1}$$

$$L2 = y2 + \frac{y3 - y2}{dx} (x - x2) \tag{2}$$

where  $L1$  and  $L2$  are the ascending and descending tangents respectively and  $(x, y)$  denotes voltage and power points on the PV curve. The small incremental change in voltage  $dx$  is calculated as

$$dx = x1 - x0 = x3 - x2 \tag{3}$$

Also, the incremental change is defined to obtain an adjacent point used by the dual tangent method. Both the new point and the adjacent point are used to calculate the slope. It is important to make sure that the first tangent has a positive slope and the second tangent has negative one. The intersection point is defined when  $L1 = L2$ . By solving Equation 1 and Equation 2, the expected maximum power voltage  $x$  is

$$x = \frac{(y1 - y2)dx - x1(y1 - y0) + x2(y3 - y2)}{y3 - y1 + y0 - y2} \tag{4}$$

and hence can be written in terms of the slope as

$$x_{int} = \frac{(y1 - y2) - x1m1 + x2m2}{m2 - m1} \tag{5}$$

## A New Optimization Algorithm for Photovoltaic Maximum Power Point Trackers

where  $m1$  and  $m2$  are left (ascending) and right (descending) lines near the onset on PV curve. In next iterations, the left points  $(x_0, y_0)$ ,  $(x_1, y_1)$  are updated to  $(x_1, y_1)$  and  $(x_{int}, y_{int})$ , respectively if the percentage of change of new left slope is smaller than that for the right slope. The right points remain unchanged. Otherwise, the left points remain unchanged and the right points are updated. If the predicted slope is not found, then the algorithm should start over and over. The mid-point will be considered as a new boundary. Mathematical modelling of PV system.

### 3. Mathematical model of PV system

A PV module is able to harness the sun photon and convert them into electrical energy. The module is composed from sets of P-N semiconductors. These P-N semiconductors can be connected in series to increase voltage, in parallel to increase current or both to increase current and voltage. The current of a single photovoltaic P-N device can be mathematically described as

$$I = I_{ph} - I_0 \left[ \exp\left(\frac{qV + IR_s}{AkT}\right) - 1 \right] - \frac{V + IR_s}{R_p} \quad 6$$

where  $I_{ph}$ ,  $I_0$ ,  $V$ ,  $T$ ,  $R_s$  and  $R_p$  are photo generated current, leakage current, voltage across the P-N junction, temperature, series resistance and parallel resistance, respectively. The constants  $q$ ,  $A$  and  $k$  are the charge of electron =  $1.6 * 10^{-19}C$ , ideality factor and Boltzman constant  $k = 1.38 * 10^{-23}J/K$ , respectively. Equation 6 can be simplified to (10)

$$I = I_{ph} - I_0 \left[ \exp\left(\frac{qV}{AkT}\right) - 1 \right] \quad 7$$

The power generated by the photo voltaic device is

$$P = V \left( I_{ph} - I_0 \left[ \exp\left(\frac{qV}{AkT}\right) - 1 \right] \right) \quad 8$$

Static efficiency of the MPPT controller is used to check how close the solar power generated due to each iteration due to the maximum solar power available (10). The static efficiency is given by

$$\eta_{mppt} = \frac{P_{obtained}}{P_{max}} * 100\% \quad 9$$

The PV module used in this study is the RENOGY RNG-100D. **Error! Reference source not found.** shows electrical characteristics of the 100D PV module at STC condition. Mathematical model of the PV module is tested and compared to the data provided by the manufacturer. The PV curve generated by the model in **Error! Reference source not found.** shows great match with that published.

Parameter (symbol)	Value
Maximum Power ( $P_{max}$ )	100 W
Maximum Power Voltage ( $V_{max}$ )	18.9 V
Maximum Power Current ( $I_{max}$ )	5.29 A
Open Circuit Voltage ( $V_{oc}$ )	22.5 V
Short Circuit Current ( $I_{sc}$ )	5.75 A
Test Irradiance (STC)	1000 W/m <sup>2</sup>
Test module Temperature (T)	25 °C

Table 1: Electric characteristics of the RNG 100D solar module

### 4. Results and discussion

Matlab was used to model the TLP and dual tangent Algorithms. While the “polyfit” function in Matlab was used for parabolic fitting. For maximizing the peak finding range, all MPPT trackers were forced to start from two voltage points 0V and open circuit voltage Voc.

#### Evolution of test points

The evolution of test points is shown in Figure 2. The dual tangent method (Figure 2A) was able to optimize the system and obtaining the max. The dual tangent method has most of the test points stacked around the peak. This is an indication that the points evolve very fast but slow down as they get closer to the maximum. The parabolic fitting method (Figure 2b) was unable to reach the maximum. However, the used code assumes the next evolution voltage point is the average point when the parabola is not pointing to the maximum among the predefined range. Though, the evolution of the test points in the parabolic fitting method speeds up when reaching the maximum. This method performs better than the dual tangent method in terms of the total number of test points only when working around the maximum. The proposed method (TLP method) is depicted in

## A New Optimization Algorithm for Photovoltaic Maximum Power Point Trackers

Figure 2C. It shows better performance as the points evolves very fast towards the peak. It generates lower number of test points in comparison to the later methods. Each iteration uses only one test point and therefore, the total number of test points is smaller than that for the other two methods.

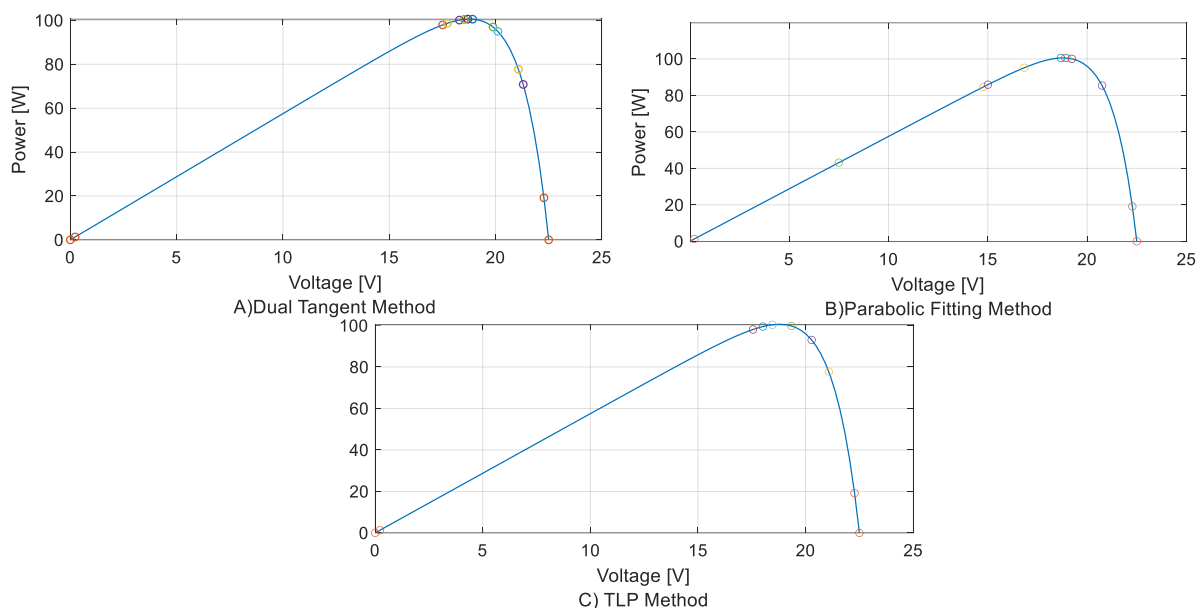


Figure 2: Evolution of test points at A) dual tangent method B) Parabolic fitting method and C) TLP method

### Power evolution vs the number of measurements

The comparison depicted in Figure 3 shows the power of each tracking method vs the number of measurements. The number of measurements is a more realistic factor than the number of iterations. Figure 3A shows that dual tangent MPPT converges to the maximum power point. Figure 3B shows the tracker oscillates around the maximum power point given that number of total test points is larger than it for dual tangent method. This method is still far stable and can be said to be inferior to the dual tangent tracking method. Figure 3C shows the TLP achieves better results than that for the dual tangent method. The power points achieved are advance by at least one measurement. With the steady and stable conversion, the Latter method can be said to be superior to the other methods.

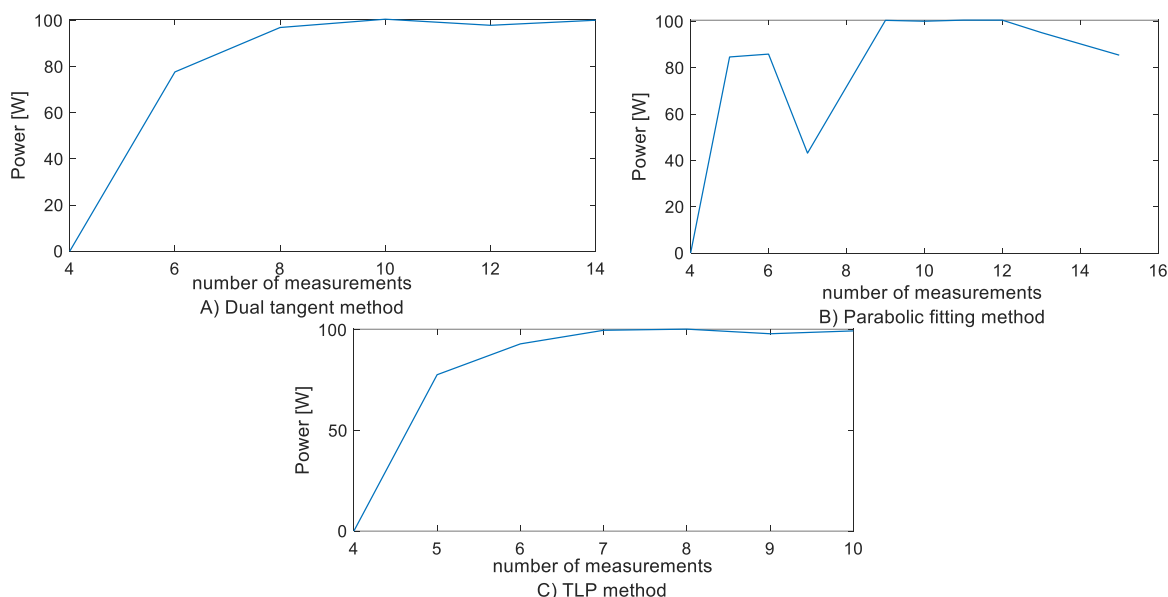


Figure 3: the evolution of MPPT power vs the number of measurements Voltage evolution vs the number of measurements

It is depicted in Figure 4 the evolution of voltage of the three studied MPPTs. Both the dual tangent and the TLP trackers converges to the voltage at maximum power. However, the proposed method (TLP) is faster than the dual tangent method. Figure 4B shows that the parabolic fitting method did not reach the maximum power voltage in a steady way. The larger voltage variation in this method degrades its dynamic performance.

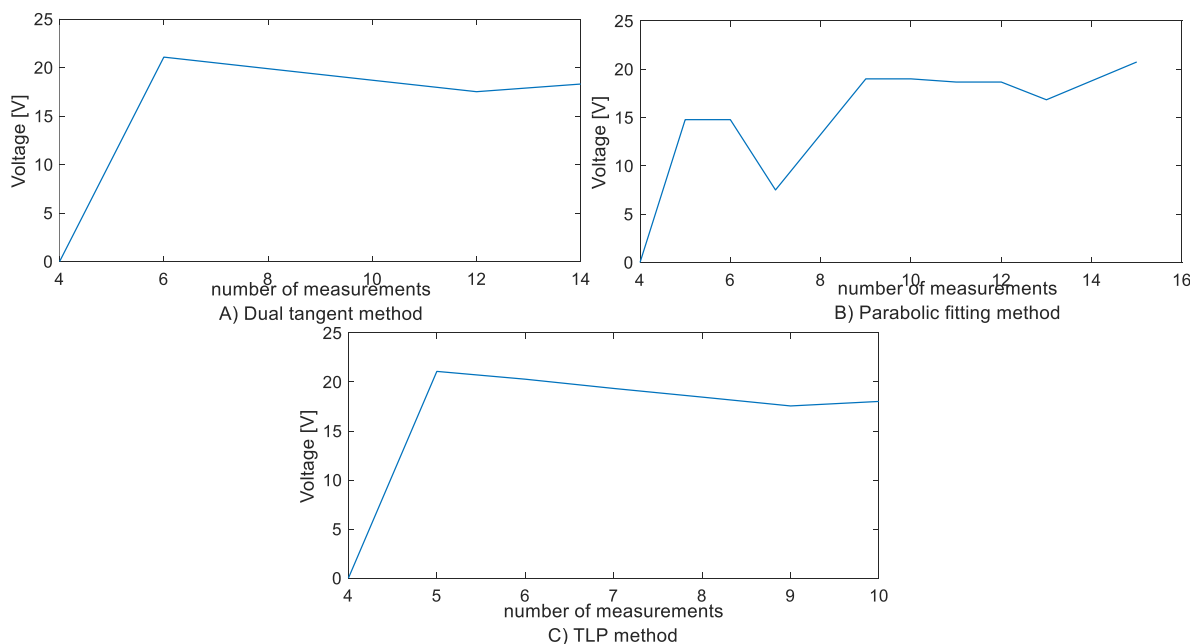


Figure 4: the evolution of MPPT voltage vs the number of measurements

**Overall performance**

The performance of the three power trackers is tabulated in Table 2. All trackers were able to find the maximum power. Dual line tracker provides more robust and accurate results than that for the TLP algorithm. It is important to mention that the parabolic fitting tracker did not converge to the maximum power point. Therefore, additional algorithms will be needed to correct its operation. The fastest tracker is the proposed TLP algorithm due to its lower number of measurement points. The deficiency of the proposed method is not big and still within the high performance region.

Method	Dual Tangent	Parabolic fitting	TLP
Measurements	14	15	10
$V_{max}$	18.7 V	18.68 V	18.46 V
$P_{max}$	100.57 W	100.56 W	100.36 W
Efficiency ( $\eta_{mppt}$ )	100%	99.99%	99.8%
Conversion speed	fast	slow	fastest

Table 2: Overall performance of the dual tangent, parabolic fitting and TLP algorithm

**5. Conclusion**

A novel optimization algorithm based on power voltage curve geometry named TLP is investigated. The proposed algorithm tweaks the dual tangent optimization algorithm. It allows the MPPT to head to the maximum power point using only one new reading point. The proposed tweak reduces the total number of actual voltage and power readings. The study is theoretical with a mathematical model built specifically for the RNG 100D PV panel and solved in Matlab.

The new algorithm is very efficient of about 99.8%. It can find the maximum power point with little voltage and power oscillations near onset. It enables the MPPT tracker to head to the maximum power starting with any test point. The speed and lower number of iterations and actual physical reading make the proposed method suitable for off grid on grid applications. The proposed method does not require sophisticated or high computational capability controllers. All mathematical operations use either algebraic equations or logic functions.

The study also showed the parabolic fitting method failed to find the maximum power of PV system. While, dual tangent method exhibited better than the parabolic fitting method but still inferior to the proposed method.

**References**

1. A New MPPT Scheme based on Trifurcation of P-V characteristic for Photovoltaic Power Generation. Muralidhar Nayak Bhukya, Venkata Reddy Kota. Volume 114 No. 10 2017, International Journal of Pure and Applied Mathematics, pp. 439-447.
2. A novel tangent error maximum power point tracking algorithm for photovoltaic system under fast multi-changing solar irradiances. Lele Peng, Shubin Zheng, Xiaodong Chai, Liming Li. 2018, Applied Energy, pp. 303-316.
3. An Efficient Fuzzy-Logic Based Variable-Step Incremental Conductance MPPT Method for Grid-Connected PV Systems. MAHMOUD N. ALI, KARAR MAHMOUD, MATTI LEHTONEN, MOHAMED M. F. DARWISH. 2021, IEEE access.
4. A State-of-the-Art Comprehensive Review on Maximum Power Tracking Algorithms for Photovoltaic Systems and New Technology of the Photovoltaic Applications. Ahmed Badawi, I. M.Elzein, Khaled Matter, Claude Ziad El-bayeh, Hassan Ali. 2025, energies.

## A New Optimization Algorithm for Photovoltaic Maximum Power Point Trackers

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5. A Dual Tangent Based Algorithm for Maximum Power Point Tracking of Solar PV Systems. Anubhav Jain, Chinmay Jain, Bhim Singh, Kamal-Al-Haddad, Amrith Chandra. Yokohama : IEEE, 2015. IECON2015.
6. Novel fast dynamic MPPT (maximum power point tracking) technique with the capability of very high accurate power tracking. Fathabadi, Hassan. 2016, Energy.
7. An Effective Design and Implementation of Hybrid MPP Tracking Scheme based on Linear Tangents & Neville Interpolation (LT-NI) Technique for Photovoltaic (PV) System. Muralidhar Nayak Bhukya, Venkata Reddy Kota, Shobha Rani Depuru, M Pala Prasad Reddy, Hemakumar Reddy. VOLUME XX, 2017 , IEEE access.
8. Innovative and precise MPP estimation using P–V curve geometry for photovoltaics. Gaurav Kumar, Milind B. Trivedi, Ashish K. Panchal. 2015, Applied Energy.
9. A Novel MPPT Technique for Single Stage Grid-Connected PV Systems: T4S. Luigi Costanzo, Massimo Vitelli. 2019, energies.
10. A quick and effective MPPT scheme for solar power generation during dynamic weather and partial shaded conditions. Muralidhar Nayak Bhukya, Venkata Reddy Kota. 2019, Engineering Science and Technology.
11. Tracking maximum power point in photovoltaic systems by calculating. ANAS EL FILALI, EL MEHDI LAADISSI, MALIKA ZAZI. 2018, ICSDE'18: Proceedings of the 2nd International Conference on Smart Digital Environment.
12. Comparison of Extremum-Seeking Control Techniques for . Her-Terng Yau, Chen-Han Wu. 2011, volume 4, Energies, pp. 2180-2195.
13. An improved Fractional MPPT Method by Using a Small Circle Approximation of the P–V Characteristic Curve. Ernesto Bárcenas-Bárcenas, Diego R. Espinoza-Trejo, José A. Pecina-Sánchez, Héctor A. Álvarez-Macías, Isaac Compeán-Martínez, Ángela Vértiz-Hernández. 2023, mathematics.