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A Class of Methods for Solving Nonlinear Equation

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ABSTRACT

We propose a new two-step iterative technique for solving nonlinear equations for PV cell on single diode based on the equivalent circuit of a solar cell. Some numerical examples show that the new proposed technique is comparable with the standard, classical methods and compete with Two-Point Bracketing technique. A new iterative method is used to compute the zeros of nonlinear equations of the cell.

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1. Introduction

One of the most important subjects in numerical methods is solving nonlinear equations of the functions. More attention has offered to improve many iterative methods for solving nonlinear equations of the functions for example PV cell on single diode. Rasheed et al. have suggested and studied many techniques for solving nonlinear equations with order of convergence using decomposition technique of the Two-Point Bracketing technique and other standard and classical methods. They used one of the first order derivatives of the functions, which is not a serious drawback. Therefore, we propose and study an algorithm for solving nonlinear equations which does not been included the derivative with the higher order of the function [1-115].

TPBM requires 8 evaluations of the function while the other technique (DM) needs 6 evaluation of the function. The following steps are investigate the procedure of this work: section two, three and four investigating the modelling and the root finding of TPBM and DM algorithms respectively while; section five and six indicate the numerical problems, discussion and conclusion results respectively.

2. – PV Model's Formula

KCL Kirchhoff's law is employed in order to depict the electrical parameters of PV cell scheme [30-50]

$$I = I_{ph} - I_{Diode}, I_{Diode} = I_0 \left[\exp\left(\frac{-V_{pv}}{nV_T}\right) - 1\right] \quad (1)$$

where:

I_0 is diode reverse saturation current measured in (A), I_{ph} is light current, n is diode ideality factor (unitless), $k = (1.38 \times 10^{-23} J/K)$ is Boltzmann constant, $q = (1.602 \times 10^{-19}\ C)$ is elementary charge, V_T is thermal voltage given by $V_T = \frac{kT}{q}$, $I_{ph}$is the light generated current in the cell, T is temperature (p-n junction), I_D is the voltage dependent current lost to recombination.

The current I_{pv} and power $P_{pv}$of the cell is given by $I_{pv} = \frac{V_{pv}}{R}$; $P_{pv} = I_{pv} \times V_{pv}$

The final equation from the circuit is given by

$$(I_{source}) - 10^{-12}\left(e^{\frac{-V}{1.2*0.026}} - 1\right) = V / R \quad (2)$$

3. Two-Point Bracketing Method (TPBM)

Step 1: for a given $[a_k, b_k]$

Step 2: compute c_k as follows $c_k = \frac{a_k+b_k}{2}$, c_k is between a_k and b_k. (3)

Step 3: If $|x_{n+1} - x_n| < \varepsilon$, $|f(x_n)| < \varepsilon$, $\varepsilon = 10^{-9}$ as a tolerance; stop else go to Step 2.

4. Dekker's Algorithm (DM)

This method obtain when we combine the Bisection and Secant Methods achieved by Dekker in 1969.

Step 1: The first one called linear interpolation secant method using the following formula

$$x_{n+1} = \begin{cases} x_n - \frac{x_n - x_{n-1}}{f(x_n) - f(x_{n-1})} f(x_n) & \text{if } f(x_{n-1}) \neq f(x_n) \\ m & \text{otherwise} \end{cases} \quad (4)$$

Step 2: the second one can be obtained by bisection method

$$m = \frac{a_n + b_n}{2}$$

Step 3: If$|f(a_n)| \geq |f(b_n)|$, $|f(x_n)| < \varepsilon$, $\varepsilon = 10^{-9}$ as a tolerance; stop else go to Step 1. (5)

where: a_n: the "contrapoint" this means that $f(x_n)$ and $f(b_k)$ have opposite signs, so the interval $[a_n, b_n]$ consist of the solution.

5. Results and Discussion

The estimate for the root of Eq. 2, two numerical iterations is applied to introduce the performance of the algebraic expression (TPBM)-Eq. 3 acquired in the present paper in order to solve non-linear equation with the initial value $x_0 = 1$ and we compare it with other algebraic expression (DM)-Eq. 4 with two initial values x_0 and x_1. For convergence criteria, the distance between two consecutive iterates is based on Eq. 5, less than 10^{-9}.

Five examples have been applied in Eq. 2 for numerical testing, R-values (1-5) ohm-(load resistance) of the circuit. All determinations are carried out with the algorithm precision introduced in Tables and Figures 1 to 5 and the number of function evaluations needed are extracted from the Eq. 2. The numerical examples and the approximate solutions produced by two techniques for solving Eq. 2.

The following Tables and Figs. indicate that TPBM algorithm needs 8 iterations while DM technique need 6 iterations to reach to the convergence which proves that DM is faster than TPBM.

Table 1 - Analysis of two iterative methods (TPBM and DM).

Iterations	V_{pv}-TPBM	I_{pv}- TPBM	P_{pv}-TPBM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-TPBM	ε-DM
1	0.959074734	0.959074734	0.919824345	0.929559074	0.929559074	0.864080071	0.036651599	0.007135939
2	0.938299156	0.938299156	0.880405306	0.923372033	0.923372033	0.852615911	0.015876021	0.000948898
3	0.926556800	0.926556800	0.858507503	0.922450286	0.922450286	0.850914530	0.004133665	2.71513e-05
4	0.922840947	0.922840947	0.851635413	0.922423171	0.922423171	0.850864506	0.000417812	3.65052e-08
5	0.922428568	0.922428568	0.850874463	0.922423135	0.922423135	0.850864439	5.43368e-06	8.33777e-14
6	0.922423135	0.922423135	0.850864441	0.922423135	0.922423135	0.850864439	9.5125e-10	0
7	0.922423135	0.922423135	0.850864439				0	

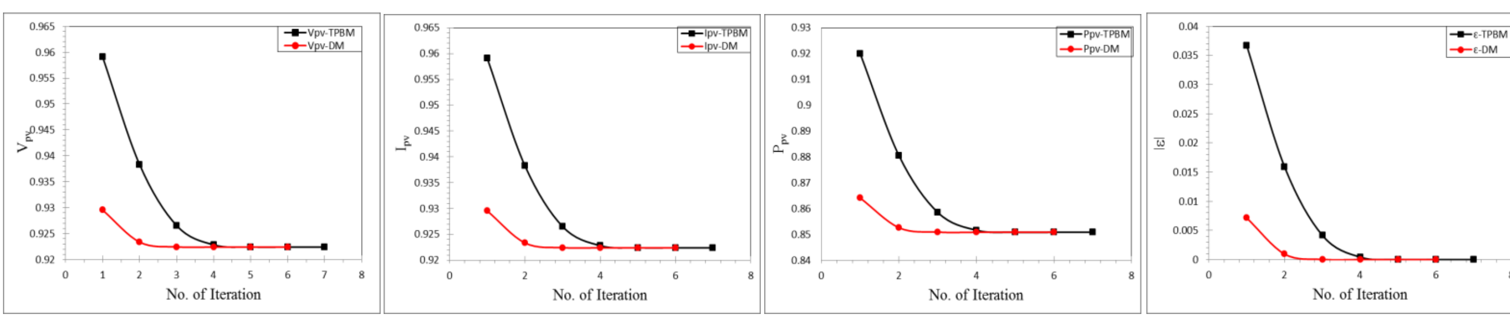

Fig. 1 – Analysis problems / examples of non-linear equation based on (TPBM and DM) models.

Table 2 - Analysis of two iterative methods (TPBM and DM).

Iterations	V_{pv}-TPBM	I_{pv}- TPBM	P_{pv}-TPBM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-TPBM	ε-DM
1	0.958226219	0.479113110	0.459098744	0.926358271	0.463179136	0.429069824	0.041190837	0.009322889
2	0.936128222	0.468064111	0.438168024	0.918551846	0.459275923	0.421868747	0.019092839	0.001516463
3	0.922636611	0.461318306	0.425629158	0.917098401	0.458549201	0.420534739	0.005601229	6.30186e-05
4	0.917752815	0.458876408	0.421135115	0.917035565	0.458517783	0.420477114	0.000717433	1.82939e-07
5	0.917051142	0.458525571	0.420491398	0.917035382	0.458517691	0.420476946	1.57593e-05	2.06313e-12
6	0.917035390	0.458517695	0.420476954	0.917035382	0.458517691	0.420476946	8.0588e-09	0
7	0.917035382	0.458517691	0.420476946				2.10942e-15	
8	0.917035382	0.458517691	0.420476946				0	

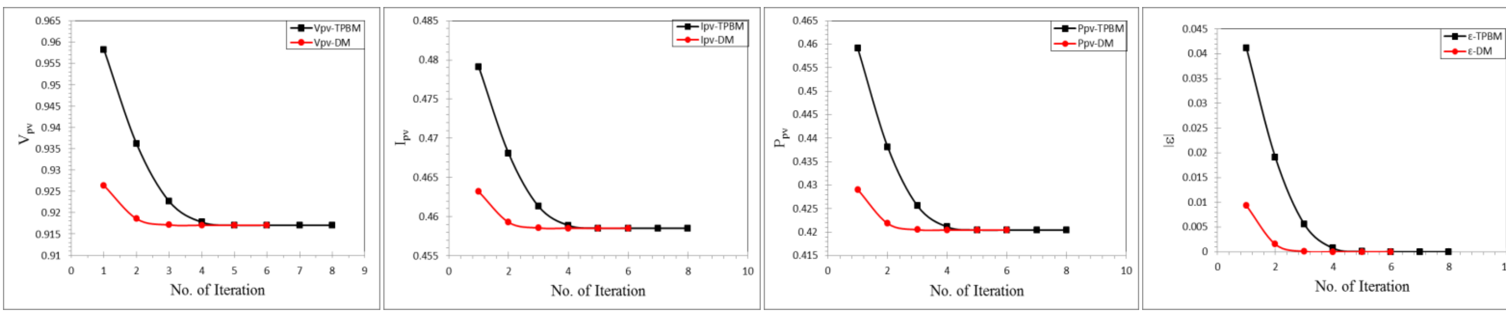

Fig. 2 – Analysis problems / examples of non-linear equation based on (TPBM and DM) models.

Table 3 - Analysis of two iterative methods (TPBM and DM).

Iterations	V_{pv}-TPBM	I_{pv}- TPBM	P_{pv}-TPBM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-TPBM	ε-DM
1	0.957364012	0.319121337	0.305515284	0.922895710	0.307631903	0.283912164	0.046960638	0.012492336
2	0.933839237	0.311279746	0.290685240	0.912935524	0.304311841	0.277817090	0.023435863	0.00253215
3	0.918236042	0.306078681	0.281052476	0.910560544	0.303520181	0.276373502	0.007832668	0.00015717
4	0.911689551	0.303896517	0.277059279	0.910404403	0.303468134	0.276278726	0.001286177	1.02901e-06
5	0.910452397	0.303484132	0.276307856	0.910403374	0.303467791	0.276278101	4.90229e-05	6.34423e-11
6	0.910403453	0.303467818	0.276278149	0.910403374	0.303467791	0.276278101	7.87086e-08	0
7	0.910403374	0.303467791	0.276278101				2.03837e-13	
8	0.910403374	0.303467791	0.276278101				0	

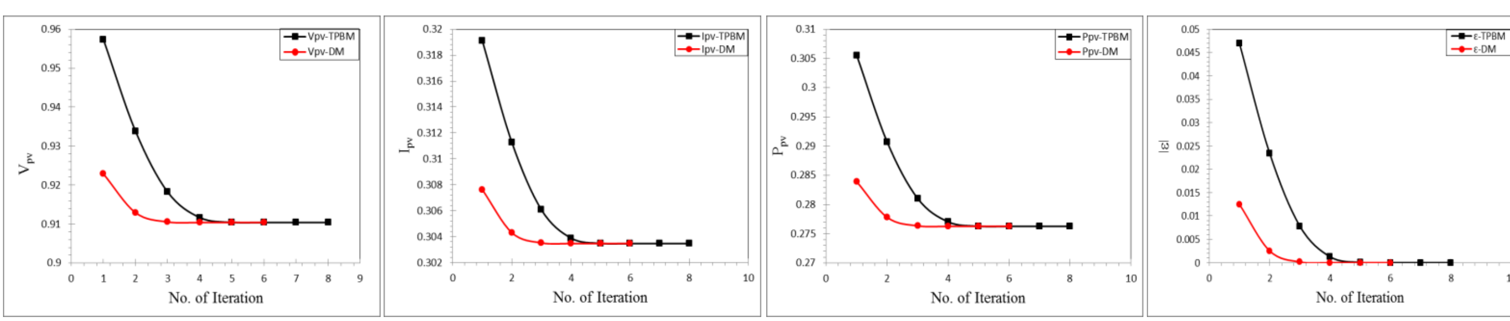

Fig. 3 – Analysis problems / examples of non-linear equation based on (TPBM and DM) models.

Table 4 - Analysis of two iterative methods (TPBM and DM).

Iterations	V_{pv}-TPBM	I_{pv}- TPBM	P_{pv}-TPBM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-TPBM	ε-DM
1	0.956487771	0.239121943	0.228717214	0.919134840	0.229783710	0.211202213	0.054747169	0.017394238
2	0.931420865	0.232855216	0.216886207	0.906254198	0.226563549	0.205324168	0.029680263	0.004513596
3	0.913234752	0.228308688	0.208499428	0.902178866	0.225544717	0.203481677	0.011494150	0.000438264
4	0.904212100	0.226053025	0.204399881	0.901747525	0.225436881	0.203287150	0.002471498	6.92307e-06
5	0.901910105	0.225477526	0.203360459	0.901740605	0.225435151	0.203284030	0.000169503	2.70324e-09
6	0.901741552	0.225435388	0.203284457	0.901740602	0.225435150	0.203284028	9.50472e-07	5.55112e-16
7	0.901740602	0.225435151	0.203284028	0.901740602	0.225435150	0.203284028	3.03456e-11	0
8	0.901740602	0.225435150	0.203284028				0	

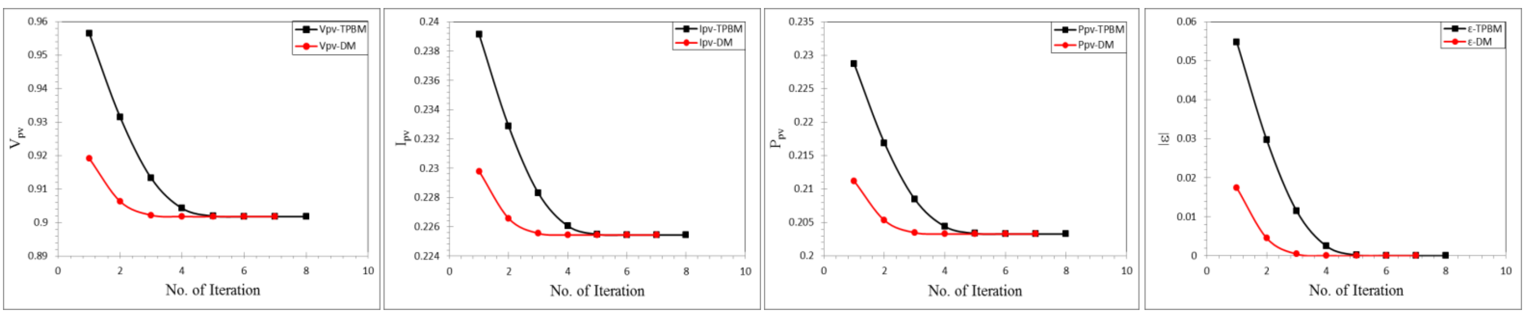

Fig. 4 – Analysis problems / examples of non-linear equation based on (TPBM and DM) models.

Table 5 - Analysis of two iterative methods (TPBM and DM).

Iterations	V_{pv}-TPBM	I_{pv}- TPBM	P_{pv}-TPBM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-TPBM	ε-DM
1	0.955597145	0.191119429	0.182633181	0.915032139	0.183006428	0.167456763	0.066504431	0.025939425
2	0.928860287	0.185772057	0.172556287	0.898096686	0.179619337	0.161315531	0.039767572	0.009003971
3	0.907465744	0.181493149	0.164698815	0.890585280	0.178117056	0.158628428	0.018373029	0.001492565
4	0.894506327	0.178901265	0.160028314	0.889157358	0.177831472	0.158120161	0.005413612	6.4643e-05
5	0.889801386	0.177960277	0.158349301	0.889092920	0.177818584	0.158097244	0.000708671	2.04935e-07
6	0.889109249	0.17782185	0.158103051	0.889092715	0.177818543	0.158097171	1.65338e-05	2.78855e-12
7	0.889092724	0.177818545	0.158097174	0.889092715	0.177818543	0.158097171	9.59538e-09	0
8	0.889092715	0.177818543	0.158097171				3.21965e-15	
9	0.889092715	0.177818543	0.158097171				0	

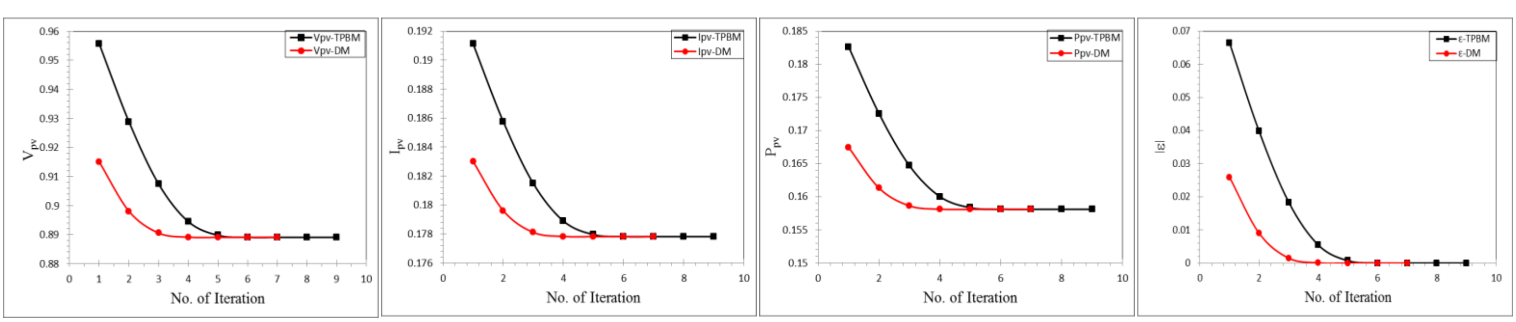

Fig. 5 – Analysis problems / examples of non-linear equation based on (TPBM and DM) models.

6. Conclusion

We suggested and analyzed new two-step iterative methods for solving nonlinear equations in the science and engineering field such as PV cell based on equivalent circuit of a single diode model. The new proposed iterative method DM has good efficient, some numerical experiments clarify the accuracy and performance of the proposed method is better than Two-Point Bracketing algorithm which has sixth iterations.

References

[1] Mohammed RASHEED, Suha SHIHAB, Taha RASHEED and Tarek Diab Ounis, "Parameters Determination of PV Cell Using Computation Methods", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 1-9.

[2] M. RASHEED, "Linear Programming for Solving Solar Cell Parameters", Insight-Electronic, vol. 1 (1) (2019), pp. 10-16.

[3] Mohammed RASHEED, Osama Alabdali, Suha SHIHAB and Taha RASHID, "Evaluation and Determination of the Parameters of a Photovoltaic Cell by an Iterative Method", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 34-42.

[4] M. RASHEED, S. SHIHAB, T. RASHID and T. D. Ounis, "Determination of PV Model Parameters Using Bisection and Secant Methods", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13, (1), (2021), 43-54.

[5] Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Olfa Maalej, "Determining the Voltage and Power of a Single Diode PV Cell in Matlab by Iteration", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 70-78.

[6] Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Olfa Maalej, "Numerical Simulation of Photovoltaic Cell", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 79-86.

[7] Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Marwa Enneffati, "Two Numerical Algorithms for Solving Nonlinear Equation of Solar Cell", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 87-94.

[8] Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Marwa Enneffati, "Some Step Iterative Method for Finding Roots of a Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 95-102.

[9] M. RASHEED, S. SHIHAB and T. RASHID, "The Single Diode Model for PV Characteristics Using Electrical Circuit", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 131-138.

[10] M. RASHEED, S. SHIHAB and T. RASHID, "Extraction of a Photovoltaic Cell's Single-Diode Model Parameters from Equivalent Circuit", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 147-154.

[11] M. RASHEED, S. SHIHAB and T. RASHID, "An Accurate and Fast Computational Algorithm Based on Hybrid Methods", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 173-183.

[12] M. RASHEED, S. SHIHAB and T. RASHID, Ola Abdulelah Abed AL-Farttoosi, "Comparison Study Between Classic Chord and Inverse Quadratic Interpolation Methods", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 184-192.

[13] M. RASHEED, S. SHIHAB and T. RASHID, "Experimental Results for a Nonlinear Equation Using Improved Newton-Raphson Estimation Method", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp.193-200.

[14] M. RASHEED, S. SHIHAB and T. RASHID, "Numerical Solving for Nonlinear Problems Using Iterative Techniques", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 201-209.

[15] M. RASHEED, S. SHIHAB and T. RASHID, "Predictor-Corrector Solutions for Nonlinear Equations", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 210-218.

[16] Ali Hasan Ali, Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Saad Abed Hamad, "A Novel Blurring and Sharpening Techniques Using Different Images Based on Heat Equations", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 45-57.

[17] Ali Hasan Ali, Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Saad Abed Hamad, "A Modified Heat Diffusion Based Method for Enhancing Physical Images", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 77-87.

[18] Ali Hasan Ali, Mohammed RASHEED, Suha SHIHAB, Taha RASHID and Saad Abed Hamad, "An Effective Color Image Detecting Method for Colorful and Physical Images", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 88-98.

[19] M. RASHEED, S. SHIHAB and T. RASHID, "Estimation of Single-Diode Model Parameters of PV Cell", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (1), (2021), pp. 139-146.

[20] M. M. Abbas and M. Rasheed, "Solid State Reaction Synthesis and Characterization of Cu doped TiO2 Nanomaterials", Journal of Physics: Conference Series, IOP Publishing, vol. 1795 (2021) 012059.

[21] M. RASHEED, S. SHIHAB and Omniea Wissam Sabah, "An investigation of the Structural, Electrical and Optical Properties of Graphene-Oxide Thin Films Using Different Solvents", Journal of Physics: Conference Series. IOP Publishing, 1795 (2021) 012052.

[22] M. Enneffatia, M. Rasheed, B. Louatia, K. Guidaraa, S. Shihab and R. Barillé, "Investigation of structural, morphology, optical properties and electrical transport conduction of Li0.25Na0.75CdVO4 compound", Journal of Physics: Conference Series. IOP Publishing, 1795 (2021) 012050.

[23] M. Rasheed, O. Y. Mohammed, S. Shihab and Aqeel Al-Adili, "A comparative Analysis of PV Cell Mathematical Model", Journal of Physics: Conference Series. IOP Publishing, 1795 (2021) 012042.

[24] M Rasheed, S Shihab, O Y Mohammed and Aqeel Al-Adili, "Parameters Estimation of Photovoltaic Model Using Nonlinear Algorithms", Journal of Physics: Conference Series. IOP Publishing, 1795 (2021) 012058.

[25] M. Rasheed, O. Y. Mohammed, S. Shihab and Aqeel Al-Adili, "Explicit Numerical Model of Solar Cells to Determine Current and Voltage", Journal of Physics: Conference Series. IOP Publishing, 1795 (2021) 012043.

[26] A A Abdulrahman, M RASHEED, S SHIHAB, "The Analytic of image processing smoothing spaces using wavelet", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.

[27] S Shihab, M Rasheed, O Alabdali and A A Abdulrahman, "A Novel Predictor-Corrector Hally Technique for Determining The Parameters for Nonlinear Solar Cell Equation", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.

[28] M A Sarhan, S Shihab, B E Kashem and M Rasheed, "New Exact Operational Shifted Pell Matrices and Their Application in Astrophysics", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.

[29] M Rasheed, S Shihab, O Alabdali and H H Hussein, "Parameters Extraction of a Single-Diode Model of Photovoltaic Cell Using False Position Iterative Method", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[30] M Rasheed, O Alabdali and S Shihab, "A New Technique for Solar Cell Parameters Estimation of The Single-Diode Model", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[31] M. Rasheed and R. Barillé, "Room temperature deposition of ZnO and Al: ZnO ultrathin films on glass and PET substrates by DC sputtering technique", Optical and Quantum Electronics, vol. 49 (5) (2017), pp. 1-14.
[32] M. Rasheed and Régis Barillé, Optical constants of DC sputtering derived ITO, TiO2 and TiO2: Nb thin films characterized by spectrophotometry and spectroscopic ellipsometry for optoelectronic devices, Journal of Non-Crystalline Solids, vol. 476 (2017), pp. 1-14.
[33] M. Rasheed and R. Barillé, Comparison the optical properties for Bi2O3 and NiO ultrathin films deposited on different substrates by DC sputtering technique for transparent electronics, Journal of Alloys and Compounds, vol. 728 (2017), pp. 1186-1198.
[34] T. Saidani, M. Zaabat, M. S. Aida, R. Barille, M. Rasheed, Y. Almohamed, Influence of precursor source on sol–gel deposited ZnO thin films properties, Journal of Materials Science: Materials in Electronics, vol. 28 (13) (2017), pp. 9252-9257.
[35] K. Guergouria A. Boumezoued, R. Barille, D. Rechemc, M. Rasheed M. Zaabata, ZnO nanopowders doped with bismuth oxide, from synthesis to electrical application, Journal of Alloys and Compounds, vol. 791 (2019), pp. 550-558.
[36] N. B. Azaza, S. Elleuch, M. Rasheed, D. Gindre, S. Abid, R. Barille, Y. Abid, H. Ammar, 3-(p-nitrophenyl) Coumarin derivatives: Synthesis, linear and nonlinear optical properties, Optical Materials, vol. 96, (2019), pp. 109328.
[37] D. Bouras, A. Mecif, R. Barillé, A. Harabi, M. Rasheed, A. Mahdjoub, M. Zaabat, Cu: ZnO deposited on porous ceramic substrates by a simple thermal method for photocatalytic application, Ceramics International, vol. 44 (17) (2018), pp. 21546-21555.
[38] W. Saidi, N. Hfaidh, M. Rasheed, M. Girtan, A. Megriche, M. EL Maaoui, Effect of B2O3 addition on optical and structural properties of TiO2 as a new blocking layer for multiple dye sensitive solar cell application (DSSC), RSC Advances, vol. 6 (73) (2016), pp. 68819-68826.
[39] A. AUKŠTUOLIS, M. Girtan, G. A. Mousdis, R. Mallet, M. Socol, M. Rasheed, A. Stanculescu, Measurement of charge carrier mobility in perovskite nanowire films by photo-CELIV method, Proceedings of the Romanian Academy Series a-Mathematics Physics Technical Sciences Information Science, vol. 18 (1) (2017), pp. 34-41.
[40] F. Dkhilalli, S. Megdiche, K. Guidara, M. Rasheed, R. Barillé, M. Megdiche, AC conductivity evolution in bulk and grain boundary response of sodium tungstate Na2WO4, Ionics, vol. 24 (1) (2018), pp. 169-180.
[41] F. Dkhilalli, S. M. Borchani, M. Rasheed, R. Barille, K. Guidara, M. Megdiche, Structural, dielectric, and optical properties of the zinc tungstate ZnWO4 compound, Journal of Materials Science: Materials in Electronics, vol. 29 (8) (2018), pp. 6297-6307.
[42] F. Dkhilalli, S. M. Borchani, M. Rasheed, R. Barille, S. Shihab, K. Guidara, M. Megdiche, Characterizations and morphology of sodium tungstate particles, Royal Society open science, vol. 5 (8) (2018), pp. 1-12.
[43] M. Enneffati, B. Louati, K. Guidara, M. Rasheed, R. Barillé, Crystal structure characterization and AC electrical conduction behavior of sodium cadmium orthophosphate, Journal of Materials Science: Materials in Electronics, vol. 29 (1) (2018), pp. 171-179.
[44] M. Enneffati, M. Rasheed, B. Louati, K. Guidara, R. Barillé, Morphology, UV–visible and ellipsometric studies of sodium lithium orthovanadate, Optical and Quantum Electronics, vol. 51 (9) (2019), vol. 299.
[45] E. Kadri, M. Krichen, R. Mohammed, A. Zouari, K. Khirouni, Electrical transport mechanisms in amorphous silicon/crystalline silicon germanium heterojunction solar cell: impact of passivation layer in conversion efficiency, Optical and Quantum Electronics, vol. 48 (12) (2016), pp. 1-15.
[46] E. Kadri, O. Messaoudi, M. Krichen, K. Dhahri, M. Rasheed, E. Dhahri, A. Zouari, K. Khirouni, R. Barillé, Optical and electrical properties of SiGe/Si solar cell heterostructures: Ellipsometric study, Journal of Alloys and Compounds, vol. 721 (2017), pp. 779-783.
[47] E. Kadri, K. Dhahri, A. Zaafouri, M. Krichen, M. Rasheed, K. Khirouni, R. Barillé, Ac conductivity and dielectric behavior of a−Si:H/c−Si1−yGey/p−Si thin films synthesized by molecular beam epitaxial method, Journal of Alloys and Compounds, vol. 705 (2017), pp. 708-713.
[48] Emna Kadri, Khaled Dhahri, Régis Barillé, Mohamed Rasheed. "Novel method for the determination of the optical conductivity and dielectric constant of SiGe thin films using Kato-Adachi dispersion model", Phase Transitions, 94(2), (2021), pp. 65–76.
[49] Mohammed Rasheed, Ali Hasan Ali, Osama Alabdali, Suha Shihab, Ahmed Rashid, Taha Rashid, Saad Abed Hamad, "The Effectiveness of the Finite Differences Method on Physical and Medical Images Based on a Heat Diffusion Equation", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[50] Mohammed Rasheed, Osama Alabdali, Suha Shihab, Ahmed Rashid, Taha Rashid, "On the Solution of Nonlinear Equation for Photovoltaic Cell Using New Iterative Algorithms", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[51] Mohammed Rasheed, Suha Shihab, Osama Alabdali, Ahmed Rashid, Taha Rashid, "Finding Roots of Nonlinear Equation for Optoelectronic Device", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[52] Mohammed Rasheed, Osama Alabdali, Suha Shihab, Ahmed Rashid, Taha Rashid, "Two Numerical Models for Solving Nonlinear Equation of Photovoltaic Cell", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[53] Mohammed Rasheed, Mustafa Nuhad Al-Darraji, Suha Shihab, Ahmed Rashid, Taha Rashid, "A Fast Strategy to Investigate The Electrical and Physical Parameters of Photovoltaic Cell", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[54] Mohammed Rasheed, Mustafa Nuhad Al-Darraji, Suha Shihab, Ahmed Rashid, Taha Rashid, "The numerical Calculations of Single-Diode Solar Cell Modeling Parameters", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[55] Mohammed Rasheed, Mustafa Nuhad Al-Darraji, Suha Shihab, Ahmed Rashid, Taha Rashid, "Solar PV Modelling and Parameter Extraction Using Iterative Algorithms", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[56] Osama Alabdali, Suha SHIHAB, Mohammed RASHEED and Taha RASHID, "Orthogonal Boubaker-Turki Polynomials Algorithm for Problems Arising in Engineering", Journal of Physics: Conference Series. IOP Publishing, (2021), in press.
[57] Suha Shihab and Shazad Shawki Ahmed, "Discrete Spectral Tau Shifted Chebyshev Method for Solving a System Volterra Integro-Fractional Differential Equations", AIP Conference Procedings, (2021), in press.
[58] M. A. Sarhan, S. SHIHAB and M. RASHEED, "Some Results on a Two Variables Pell Polynomials", Al-Qadisiyah Journal of Pure Science, vol. 26, (1), (2020), pp. 55-70.
[59] M. RASHEED, S. SHIHAB and T. RASHID, "Two Step and Newton- Raphson Algorithms in the Extraction for the Parameters of Solar Cell", Al-Qadisiyah Journal of Pure Science, vol. 26 (1), (2021), pp.143-154.
[60] Semaa Hassan Aziz, Suha SHIHAB and Mohammed RASHEED, "On Some Properties of Pell Polynomials", Al-Qadisiyah Journal of Pure Science, vol. 26 (1), (2021), pp. 39-54.

[61] S Gharbi, R Dhahri, M Rasheed, E Dhahri, R Barille, M Rguiti, A Tozri, Mohamed R Berber, "Effect of Bi substitution on nanostructural, morphologic, and electrical behavior of nanocrystalline La1-xBixNi0. 5Ti0. 5O3 (x= 0 and x= 0.2) for the electrical devices", Materials Science and Engineering: B, 270, 115191, (2021).
[62] Abdulrahman Asma, Abdulelah, Rasheed Mohammed, Shihab Suha, "Various Techniques for De-noise Image", Electronics Science Technology and Application, 7(4), (2020), 79-84.
[63] M. M. Delphi and S. N. Shihab, "State Parameterization Basic Spline Functions for Trajectory Optimization", Journal of Nature, Life and Applied Sciences, vol. 3 (4) (2019), pp. 110-119.
[64] S. Shihab and M. Delphi, "Direct Iterative Algorithm for Solving Optimal Control Problems Using B-Spline Polynomials", Emirates Journal for Engineering Research, vol. 24 (4) (2019), pp. 1-9.
[65] M. Delphi and S. Shihab, "Modified Iterative Algorithm for Solving Optimal Control Problems", Open Science Journal of Statistics and Application, vol. 6 (2) (2019), pp. 20-27.
[66] S. N. Shihab and T. N. Naif, "On the orthonormal Bernstein polynomial of order eight", Open Science Journal of Mathematics and Application, vol. 2 (2) (2014), pp. 15-19.
[67] S. N. Al-Rawi, "On the Solution of Certain Fractional Integral Equations", Journal of Kirkuk University–Scientific Studies, vol. 1 (2) (2006).
[68] M. S. Rasheed, H. S. Mahde, "Electronic Combination Lock Design Using Remote Control", Journal of the College of Basic Education, vol. 18 (75) (2012), pp. 265-280.
[69] M. S. Rasheed and Balqis M. Diah, "Study of the effects of acidic solutions on the physical properties of polymeric materials superimposed", Al-Mustansiriyah Journal of Science, vol. 13 (49) (2002), pp. 6.
[70] M. RASHEED and M. A. Sarhan, "Solve and Implement the main Equations of Photovoltaic Cell Parameters Using Visual Studio Program", Insight-Mathematics, vol. 1 (1) (2019), pp. 17-25.
[71] M. M. Abbas and M. RASHEED, "Investigation of structural, Mechanical, Thermal and Optical Properties of Cu Doped TiO2", Iraqi Journal of Physics (IJP), vol. 19 (48) (2021), pp. 1-9.
[72] Muna Muzahim Abbas, Mohammed Rasheed, "Solid State Reaction Synthesis and Characterization of Aluminum Doped Titanium Dioxide Nanomaterials", Journal of Southwest Jiaotong University, vol. 55 (2), pp. 1-10.
[73] M. S. Rasheed, "Approximate Solutions of Barker Equation in Parabolic Orbits", Engineering & Technology Journal, vol. 28 (3) (2010), pp. 492-499.
[74] M. S. Rasheed, "An Improved Algorithm For The Solution of Kepler‘s Equation For An Elliptical Orbit", Engineering & Technology Journal, vol. 28 (7) (2010), pp. 1316-1320.
[75] M. S. Rasheed, "Acceleration of Predictor Corrector Halley Method in Astrophysics Application", International Journal of Emerging Technologies in Computational and Applied Sciences, vol. 1 (2) (2012), pp. 91-94.
[76] M. S. Rasheed, "Fast Procedure for Solving Two-Body Problem in Celestial Mechanic", International Journal of Engineering, Business and Enterprise Applications, vol. 1 (2) (2012), pp. 60-63.
[77] M. S. Rasheed, "Solve the Position to Time Equation for an Object Travelling on a Parabolic Orbit in Celestial Mechanics", DIYALA JOURNAL FOR PURE SCIENCES, vol. 9 (4) (2013), pp. 31-38.
[78] M. S. Rasheed, "Comparison of Starting Values for Implicit Iterative Solutions to Hyperbolic Orbits Equation", International Journal of Software and Web Sciences (IJSWS), vol. 1 (2) (2013), pp. 65-71.
[79] M. S. Rasheed, "On Solving Hyperbolic Trajectory Using New Predictor-Corrector Quadrature Algorithms", Baghdad Science Journal, vol. 11 (1) (2014), pp. 186-192.
[80] M. S. Rasheed, "Modification of Three Order Methods for Solving Satellite Orbital Equation in Elliptical Motion", Journal of university of Anbar for Pure science, vol. 14 (1) (2020), pp. 33-37.
[81] M. Rasheed and M. A. Sarhan, "Characteristics of Solar Cell Outdoor Measurements Using Fuzzy Logic Method", Insight-Mathematics, vol. 1 (1) (2019), pp. 1-8.
[82] M. RASHEED and M. A. Sarhan, "Measuring the Solar Cell Parameters Using Fuzzy Set Technique", Insight-Electronic, vol. 1 (1) (2019), pp. 1-9.
[83] M. RASHEED, "Investigation of Solar Cell Factors using Fuzzy Set Technique", Insight-Electronic, vol. 1 (1) (2019), pp. 17-23.
[84] M. RASHEED and S. SHIHAB, "Analytical Modeling of Solar Cells", Insight Electronics, vol. 1 (2) (2019), pp. 1-9.
[85] S. SHIHAB and M. RASHEED, "Modeling and Simulation of Solar Cell Mathematical Model Parameters Determination Based on Different Methods", Insight Mathematics, vol. 1 (1) (2019), pp. 1-16.
[86] M. RASHEED and S. SHIHAB, "Parameters Estimation for Mathematical Model of Solar Cell", Electronics Science Technology and Application, vol. 6, (1) (2019), pp. 20-28.
[87] M. Rasheed and S. Shihab, "Numerical Techniques for Solving Parameters of Solar Cell", Applied Physics, vol. 3 (1) (2020), pp. 16-27.
[88] M. RASHEED and S. SHIHAB, "Modifications to Accelerate the Iterative Algorithm for the Single Diode Model of PV Model", Iraqi Journal of Physics (IJP), vol. 18 (47) (2020), pp. 33-43.
[89] M. S. Rasheed and S. Shihab, "Modelling and Parameter Extraction of PV Cell Using Single-Diode Model". Advanced Energy Conversion Materials, 1 (2) (2020), pp. 96-104. Available from: http://ojs.wiserpub.com/index.php/AECM/article/view/550.
[90] M. S. Rasheed and S. Shihab, "Analysis of Mathematical Modeling of PV Cell with Numerical Algorithm". Advanced Energy Conversion Materials, vol. 1 (2) (2020), pp. 70-79. Available from: http://ojs.wiserpub.com/index.php/AECM/article/view/328.
[91] M. A. Sarhan, "Effect of Silicon Solar Cell Physical Factors on Maximum Conversion Efficiency Theoretically and Experimentally", Insight-Electronic, vol. 1 (1) (2019), pp. 24-30.
[92] M. A. Sarhan, S. SHIHAB and M. RASHEED, "A novel Spectral Modified Pell Algorithm for Solving Singular Differential Equations", Al-Mustansiriyah Journal of Science, vol. 32, (1), (2021), pp. 18-24.
[93] Bushra Esaa Kashem, Suha SHIHAB, "Approximate solution of Lane-Emden problem via modified Hermite operation matrix method", Samarra Journal of Pure and Applied Science, 2(2) (2020), pp.57-67.
[94] Anam Alwan Salih, Suha SHIHAB, "New operational matrices approach for optimal control based on modified Chebyshev polynomials", Samarra Journal of Pure and Applied Science, 2(2) (2020), pp. 68-78.
[95] Anam Alwan Salih, Suha Shihab Alrawy, "Shifted modified chebyshev direct method for solving quadratic optimal control problem", Samarra Journal of Pure and Applied Science, 2(1), (2020), pp.67-75.

[96] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Ola Abdulelah Abed Al-Farttoosif, "In The Solution of Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 42-50.
[97] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Yasir Ahmed Mohammed Ridha AL-Sabbagh, "Iterative Methods for Finding Roots of Nonlinear Equations", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 51-59.
[98] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Yasir Ahmed Mohammed Ridha AL-Sabbagh, "Further Acceleration of Two-Point Bracketing Method for Determining the Voltages of Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 60-68.
[99] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Saja Saber Abdulwahhab, "Some Step Methods Applied to Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 69-77.
[100] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Saja Saber Abdulwahhab, "Various Iterative Methods for Solving Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 78-86.
[101] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Mustafa Abdulkareem Hussein Aldulaimi, "An Iterative Method to Solve Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 87-95.
[102] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Mustafa Abdulkareem Hussein Aldulaimi, "A Class of Methods for Solving Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 96-104.
[103] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Mohammed Hussein Jasim AL-Kinani, "A Special Iterative Algorithm for Solving Nonlinear Equations", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 105-113.
[104] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Mohammed Hussein Jasim AL-Kinani, "Use of Improved Algorithms for Solving Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 114-122.
[105] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Farazdack Fawzi Hamed Alshebeeb, "Multistep Iterative Algorithms for Solving Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 123-132.
[106] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Farazdack Fawzi Hamed Alshebeeb, "A Family of Iterative Algorithm for Solving Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 133-141.
[107] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Raghad Hatem Ahmed Mifrijawee, "Efficient Numerical Algorithms for Solving Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 142-150.
[108] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Raghad Hatem Ahmed Mifrijawee, "Hybrid Algorithms for Numerical Solution of Optoelectronics Applications", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 151-159.
[109] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Noghanian Toroghi Manoochehr, "An Accelerated Algorithm for Finding Roots of Nonlinear Equation", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 160-168.
[110] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, Noghanian Toroghi Manoochehr, "Numerical Solving of Nonlinear Equation Using Iterative Algorithms", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 169-177.
[111] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, "On Solving Nonlinear Equation Via Numerical Analysis for Photovoltaic Cell (HM-DM)", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 178-186.
[112] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, "Application of Numerical Analysis for Solving Nonlinear Equation (AHM-DM)", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 187-195.
[113] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, "Analysis of Non-Linear Device by means of Numerical Algorithms (2SM-DM)", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 196-204.
[114] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, "Various Numerical Methods for Solving Nonlinear Equation (IHorner-DM)", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 205-214.
[115] Suha SHIHAB, Mohammed RASHEED, Ahmed Rashid, Taha Rashid, Saad Hussein Abed Hamad, "Restarted Pell Algorithm for Solving Calculus of Variation Problems", Journal of Al-Qadisiyah for Computer Science and Mathematics, vol. 13 (2), (2021), pp. 215-226.