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Some Step Iterative Method for Finding Roots of a Nonlinear Equation

Mohammed RASHEED[a,*], Suha SHIHAB[b], Taha RASHID[c], Marwa Enneffati[d]

[a]*Applied Science Department, University of Technology, Baghdad, Iraq, e-mail: rasheed.mohammed40@yahoo.com, 10606@uotechnology.edu.iq.*

[b]*Applied Science Department, University of Technology, Baghdad, Iraq, e-mail:alrawy1978@yahoo.com, 100031@uotechnology.edu.iq.*

[c]*Computerand Microelectronics System, Faculty of Engineering, University Technology Malaysia (UTM),Skudai 81310, Johor Bahru, Malaysia, e-mail: tsiham95@gmail.com, taha1988@graduate.utm.my.*

[d] *Laboratory of spectroscopic characterization and optic materials, University of Sfax, Faculty of Sciences, B.P. 1171, 3000, Sfax-Tunisia or Department of physics, Faculty of Science, Taif University, Saudi Arabia, e-mail: marwa.enneffati@gmail.com, Phone: (00966) 54 271 7680.*

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ABSTRACT

In this paper, we suggest and analyze some new iterative method free from second derivative for solving nonlinear equations for PV cell. By iteration, first one requires nine evaluations while the second one needs seven evaluations of the function and one of its first derivative with good efficiency. Many experiments are presented for showing the performance and efficiency of these numerical techniques. Proposed method perhaps sighted as an alternative to the standard and known methods.

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1. Introduction

It is famous that a broad class of example which emerge in variant branches of Engineering, applied and pure science could be elaborated in the general scope of the nonlinear equations $y = f(x_n) = 0$, because of their important, many numerical techniques have been proposed and investigated with certain conditions. These numerical techniques have been raised using variant methods such as Taylor series, Newton's method, Dekker's, secant and bisection, Regular Falsi, homotopy perturbation methods.

*Corresponding author: Mohammed RASHEED

Email addresses: rasheed.mohammed40@yahoo.com , 10606@uotechnology.edu.iq

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Researchers has been presented that the algorithms perhaps harness to perfection the iterative algorithms for solving non-linear experiments for different fields for example pure and applied science and engineering [1-30]. Two algorithms are suggested and described free 2nd derivatives of the function. Several techniques improved for advancement the convergence of Newton's algorithm for obtaining minimum iterations [31-66].

Some new iterative Dekker's algorithm based on Newton's method have been investigated and performed in this paper; in order to solve zeros for non-linear equation for optoelectronic application. The procedure of the present work is: in section two described a non-linear sample; in section three investigates the zeros finding for Newton's technique; while section four illustrates Dekker's method; in section five include the discussion of the results; finally, in section six the conclusion.

2. The Voltage V_{pv}: Non-Linear Equation: Physical Field

Figure 1 displays equivalent circuit of PV cell.

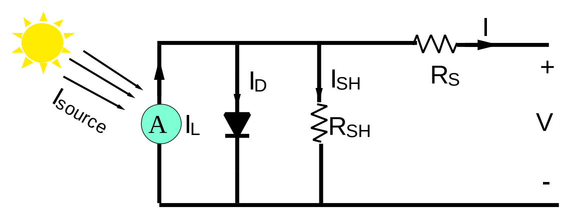

Fig. 1 – PV cell: equivalent Circuit.

The voltage drop in a closed network is calculated by (KCL) Kirchhoff's current law

$$I = \mathrm{I_{ph}} - \mathrm{I_D} \tag{1}$$

$$\mathrm{I_D} = \mathrm{I_0} \times (e^{(-V_{pv}/mV_T)} - 1) \tag{2}$$

$$\mathrm{I} = \mathrm{I_{ph}} - \mathrm{I_0}\left(\mathrm{e}^{(-V_{pv}/mV_T)} - 1\right) \tag{3}$$

where:

$\mathrm{I_0}$, $1 < \mathrm{m} < 2$, $\mathrm{I_{ph}}$, k, $\mathrm{V_T} = \mathrm{kT/q} = 26$ mV, q, and T: reverse saturation current, the recombination factor, the photocurrent (A), Boltzmann constant= 1.38×10^{-23}J/K, thermic voltage, the electron charge= 1.6×10^{-19} C and temperature (K) respectively.

$$\mathrm{I_{ph}} = \mathrm{I_{source}} \tag{4}$$

$$\mathrm{I_D} = \mathrm{I_s} \times \left(\mathrm{e}^{(V_D/mV_T)} - 1\right) \tag{5}$$

Consolidate Eq. 4 in Eq. 5 yields

$$(\mathrm{I_{source}}) - 10^{-12}\left(e^{(-V/1.2\times0.026)} - 1\right) = \mathrm{V/R} \tag{6}$$

$$\mathrm{I_{pv}} = \mathrm{V_{pv}}/R;\ \mathrm{P_{pv}} = \mathrm{I_{pv}} \times \mathrm{V_{pv}} \tag{7}$$

where $\mathrm{I_s}$ reverse saturation current= 10^{-12}A. In parallel, $\mathrm{V} = \mathrm{V_D} = \mathrm{V_{pv}}$

3. Newton's Method (NRM)

The following algorithm suggestion for solving Eq. 6 by using NRM

[1] Let the initial guess $\mathrm{x_0} = 1$.
[2] Define $\mathrm{x} = 0$
[3] while $\mathrm{i} \leq \mathrm{x_0}$
[4] Compute $\mathrm{x_{n+1}} = \mathrm{x_n} - \frac{\mathrm{f(x_n)}}{\acute{\mathrm{f}}\mathrm{(x_n)}}$ for n = 0, 1, 2, ... The approximate solution (8)

[5] If $|x_i - x_{i-1}| < \varepsilon = 10^{-9}$ (tolerance); then determine x_{n+1} and stop. (9)
[6] Put $n = n + 1$; $i = i + 1$ and go to 2.
[7] Output.

4. Dekker's Algorithm (DM)

This method obtain when we combine the Bisection and Secant Methods achieved by Dekker in 1969. The first one called linear interpolation secant method using the following formula

$$s = b_k - [\, b_k - b_{k-1} / f(b_k) - f(b_{k-1})] \times f(b_k) \quad \text{if } f(b_k) \neq f(b_{k-1}) \tag{10}$$

$$s = m \quad \text{otherwise} \tag{11}$$

while the second one can be obtained by bisection method

$$m = a_k + b_k/2 \tag{12}$$

where: a_k : "contrapoint," i.e., a point for example $f(b_k)$ and $f(a_k)$ have an opposite signs. So, the solution of the function in the interval $[a_k, b_k]$. moreover, $|f(a_k)| \geq |f(b_k)|$, thus; b_k: the better estimate a_k for the undefined solution, b_k: the current iterate (the current guess for the root of f), and b_{k-1}: the previous iterate, the first iteration, putt $a_0 = b_{k-1}$, the tolerance $\varepsilon = 10^{-9}$.

5. Remarks and Discussion

In this section, we shall display numerical results acquired using employing the iterative algorithms (8) and (9) in order to solve non-linear equation of PV cell Eq. 6 with multiplicity load resistance values R = 1 to 5 ohm. In order to investigate and compare the performance of the two techniques have been used in this paper, we used the same non-linear equation (6). The consistency and stability of the results have been calculated by testing the convergence of the two techniques NRM and IRFM. Consequently, the approximate solution depicted and each of the techniques has estimated the list of errors using the two methods. The computational values listed in the Tables 1-5 were achieved using matlab. The errors presented are the absolute value and significant approximations using the different algorithms have been presented in the following tables. The NRM requires ten evaluations whereas IRFM requires eight evaluations. This indicates that the proposed method IRFM considered a very good alternative technique to the NRM.

Table 1 - Comparison of NRM and DM.

Iterations	V_{pv}-NRM	I_{pv}- NRM	P_{pv}-NRM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-NRM	ε- DM
1	1	1	1	0.956342897	0.956342897	0.914591738	0.077576865	0.033919763
2	0.971416861	0.971416861	0.943650719	0.935676402	0.935676402	0.875490329	0.048993727	0.013253267
3	0.946732606	0.946732606	0.896302627	0.924881651	0.924881651	0.855406068	0.024309472	0.002458516
4	0.929865706	0.929865706	0.864650231	0.922517679	0.922517679	0.851038869	0.007442571	9.45447E-05
5	0.923247893	0.923247893	0.852386673	0.922423278	0.922423278	0.850864704	0.000824759	1.43773E-07
6	0.922434	0.922434	0.850884484	0.922423135	0.922423135	0.850864439	1.08655E-05	3.33178E-13
7	0.922423136	0.922423136	0.850864443	0.922423135	0.922423135	0.850864439	1.9025E-09	0
8	0.922423135	0.922423135	0.850864439				1.11022E-16	
9	0.922423135	0.922423135	0.850864439				0	

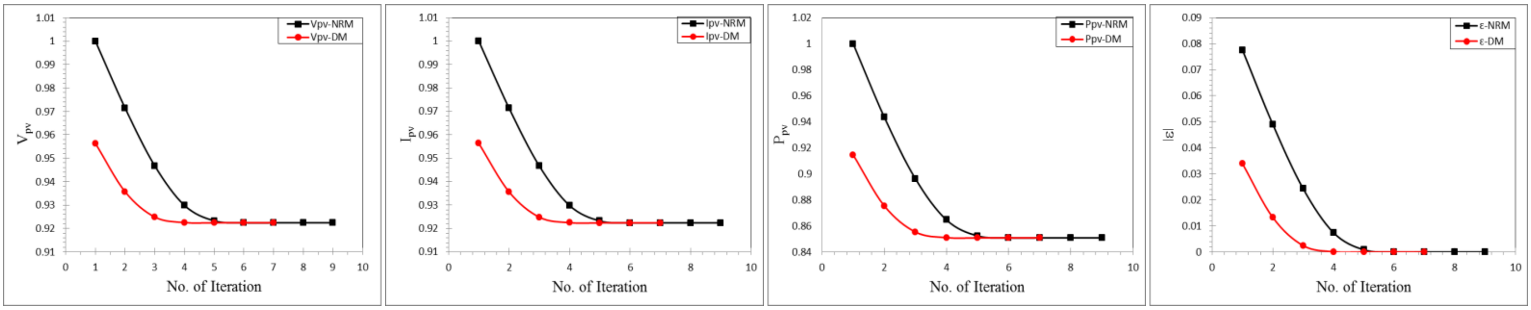

Fig. 2 – Comparison of NRM and DM iterative techniques with the absolute error values and R = 1.

The examine function in Eq. 6 after 1st derivative using two methods NRM and RFM and the approximation V_{pv} for the examine function including the initial estimate value v_0 with the (tolerance ε) value are displayed in Table 2.

Table 2 - Comparison of NRM and DM.

Iterations	V_{pv}-NRM	I_{pv}- NRM	P_{pv}-NRM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-NRM	ε- DM
1	1	0.5	0.5	0.955509809	0.477754904	0.456499497	0.082964618	0.038474426
2	0.971030472	0.485515236	0.471450089	0.933452268	0.466726134	0.435666569	0.05399509	0.016416886
3	0.945421967	0.472710983	0.446911348	0.920708719	0.46035436	0.423852273	0.028386584	0.003673337
4	0.926834477	0.463417238	0.429511073	0.917245199	0.4586226	0.420669378	0.009799094	0.000209817
5	0.918438746	0.459219373	0.421764865	0.917036095	0.458518047	0.4204776	0.001403363	7.12519E-07
6	0.917066885	0.458533442	0.420505836	0.917035382	0.458517691	0.420476946	3.15024E-05	8.24774E-12
7	0.917035399	0.458517699	0.420476961	0.917035382	0.458517691	0.420476946	1.61176E-08	0
8	0.917035382	0.458517691	0.420476946				4.21885E-15	
9	0.917035382	0.458517691	0.420476946				0	

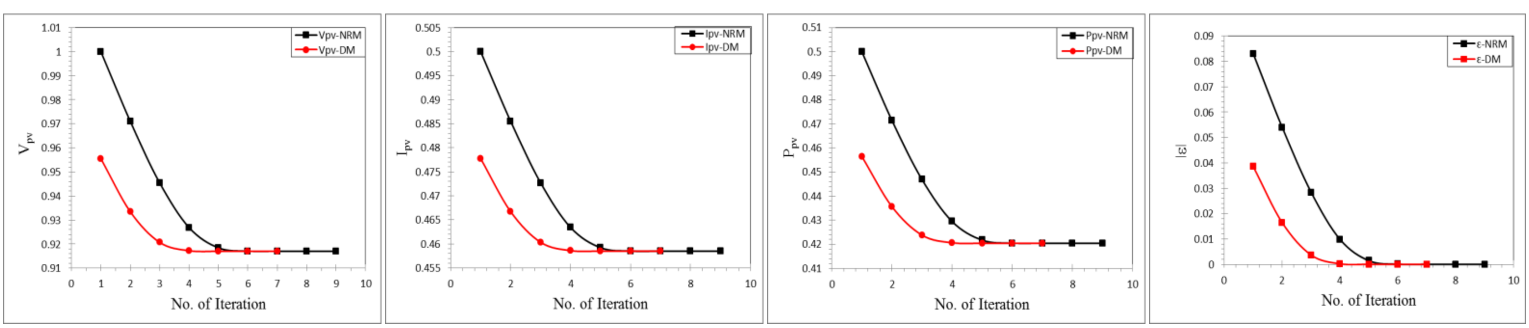

Fig. 3 - Comparison of NRM and DM iterative techniques with the absolute error values and R=2.

Table 3 - Comparison of NRM and DM.

Iterations	V_{pv}-NRM	I_{pv}- NRM	P_{pv}-NRM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-NRM	ε- DM
1	1	0.333333333	0.333333333	0.954668501	0.318222834	0.303797316	0.089596626	0.044265127
2	0.970643792	0.323547931	0.31404979	0.931130761	0.31037692	0.289001498	0.060240418	0.020727387
3	0.944084232	0.314694744	0.297098346	0.916050375	0.305350125	0.279716096	0.033680858	0.005647001
4	0.923594243	0.307864748	0.284342109	0.91089377	0.303631257	0.27657582	0.013190869	0.000490396
5	0.91287784	0.304292613	0.277781984	0.910407299	0.3034691	0.276280483	0.002474466	3.92473E-06
6	0.910501262	0.303500421	0.276337516	0.910403374	0.303467791	0.276278101	9.78883E-05	2.53289E-10
7	0.910403531	0.303467844	0.276278197	0.910403374	0.303467791	0.276278101	1.57417E-07	0
8	0.910403374	0.303467791	0.276278101				4.07563E-13	
9	0.910403374	0.303467791	0.276278101				0	

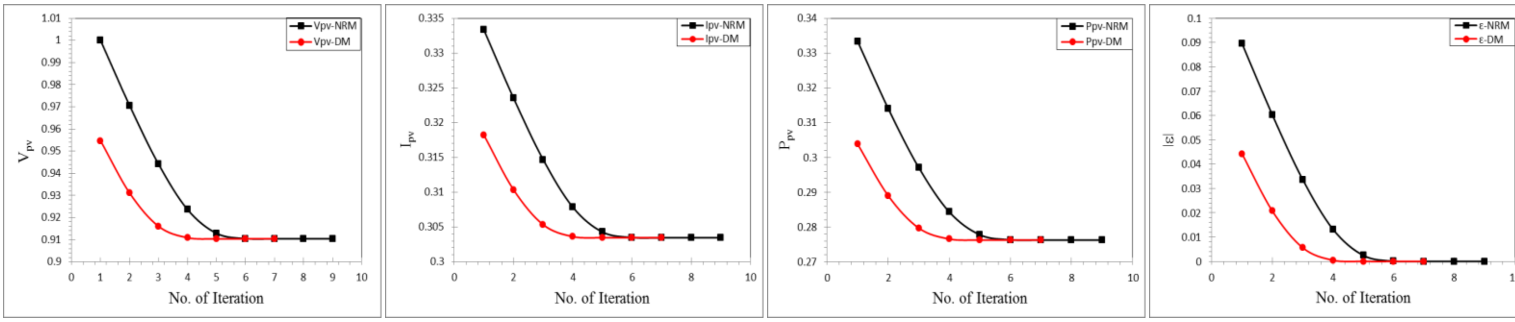

Fig. 4 - Comparison of NRM and DM iterative techniques with the absolute error values and R=3.

Table 4 - Comparison of NRM and DM.

Iterations	V_{pv}-NRM	I_{pv}- NRM	P_{pv}-NRM	V_{pv}-IRFM	I_{pv}-IRFM	P_{pv}-IRFM	ε-NRM	ε- IRFM
1	1	0.25	0.25	0.953818908	0.238454727	0.227442627	0.098259398	0.052078306
2	0.970256822	0.242564205	0.235349575	0.928705897	0.232176474	0.215623661	0.06851622	0.026965295
3	0.94271872	0.23567968	0.222179646	0.910811452	0.227702863	0.207394375	0.040978118	0.00907085
4	0.920123009	0.230030752	0.211656588	0.902978861	0.225744715	0.203842706	0.018382407	0.001238259
5	0.906346494	0.226586624	0.205365992	0.901765899	0.225441475	0.203295434	0.004605892	2.52971E-05
6	0.902077706	0.225519427	0.203436047	0.901740613	0.225435153	0.203284033	0.000337104	1.07408E-08
7	0.901742503	0.225435626	0.203284885	0.901740602	0.22543515	0.203284028	1.90088E-06	1.9984E-15
8	0.901740602	0.225435151	0.203284028	0.901740602	0.22543515	0.203284028	6.06911E-11	0
9	0.901740602	0.22543515	0.203284028				0	

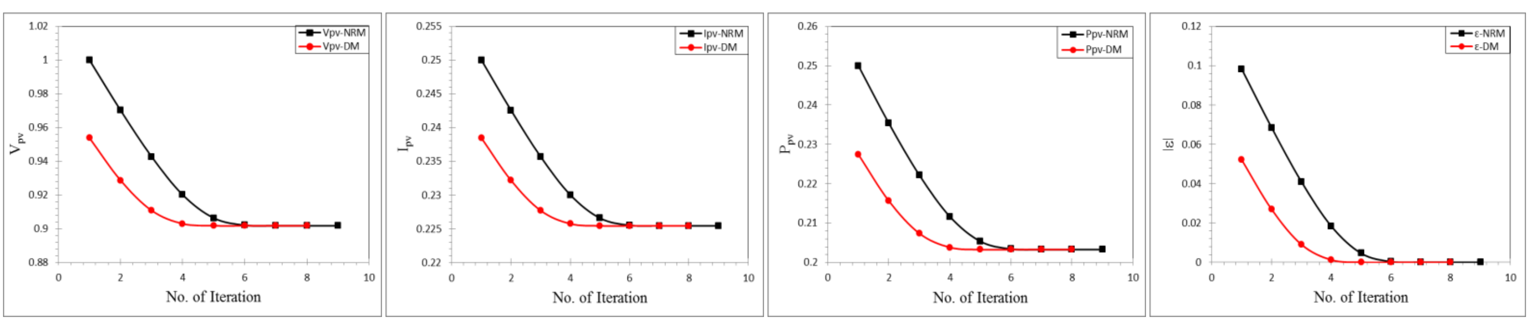

Fig. 5 - Comparison of NRM and DM iterative techniques with the absolute error values and R=4.

Table 5 - Comparison of NRM and DM.

Iterations	V_{pv}-NRM	I_{pv}- NRM	P_{pv}-NRM	V_{pv}-DM	I_{pv}-DM	P_{pv}-DM	ε-NRM	ε- DM
1	1	0.2	0.2	0.952960959	0.190592192	0.181626918	0.110907285	0.063868245
2	0.96986956	0.193973912	0.188129393	0.926171251	0.18523425	0.171558637	0.080776845	0.037078536
3	0.941324731	0.188264946	0.17721845	0.904871952	0.18097439	0.16375865	0.052232016	0.015779238
4	0.916395843	0.183279169	0.167956268	0.89266728	0.178533456	0.159370975	0.027303128	0.003574566
5	0.898535645	0.179707129	0.161473261	0.889306005	0.177861201	0.158173034	0.00944293	0.00021329
6	0.890477009	0.178095402	0.158589861	0.889093511	0.177818702	0.158097454	0.001384294	7.96312E-07
7	0.889125763	0.177825153	0.158108925	0.889092715	0.177818543	0.158097171	3.30483E-05	1.11464E-11
8	0.889092734	0.177818547	0.158097178	0.889092715	0.177818543	0.158097171	1.91907E-08	0
9	0.889092715	0.177818543	0.158097171				6.43929E-15	
10	0.889092715	0.177818543	0.158097171				0	

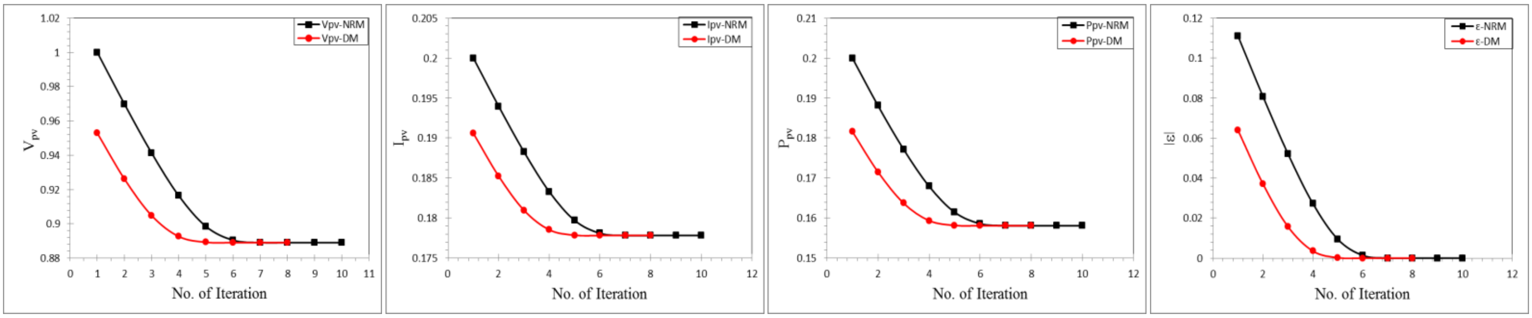

Fig. 6 - Comparison of NRM and DM iterative techniques with the absolute error values and R=5.

6. Conclusion

In this paper, we have proposed new iterative method free from second derivative for solving single diode of these methods per iterations. Several numerical experiments are produced in order to show the efficiency for these techniques.

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