Auto Balance Distribution Power System Based Intelligent Algorithm

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Abstract
One of the major problems with distribution power systems is the unbalance load produced by power demand of customers. This becomes a difficult mission to solve with traditional ways. So that, this paper suggested intelligent algorithm based on relocation the load on three phase power distribution system to balance the power between three phases of the distribution system, employing intelligent algorithm and relocation the load for certain factory demand for 8 hours of operation, results decreasing in fractional weights between phases. The balancing algorithm used as relocation the load in distribution systems applied to installations with systems for measuring power consumption in different time intervals and calculate the optimal summation of fractional weights of each phase and makes difference between summations of fractional weights is minimum. Moreever, in synchronism with communications and processing technologies, the solution of using suggested intelligent algorithm could be useful to implement with a smart grid.

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Introduction

Recently, the distribution systems must backing the continuous mounting of power demand, because of gain of new technologies and consumption usage of electrical appliances such as air conditioning systems, television sets, and washing machines [1]. In spite of the fact that, a balanced distribution system is better with similar power in phases, but due to consumption behaviors lead to undesirable unbalance through the distribution system [2]. Therefore, power balance helps to lessen power losses and improve the use of resources such as capacitor banks and transformers load tap changers [3]. Distribution systems have more users than transmission line systems [4], thus, measuring the consumption and carry out load balancing be complicated procedures [5].

Figure 1 shows that the sum of each of the voltages (and currents) at the star point is always zero. In a balanced system, the neutral current and neutral power is zero [6]. In a perfectly balanced system, the voltage and the current phases (a, b, c) are equal in magnitude and displaced by 120◦ [7]. Equations 1and 2 give a mathematical description for balanced distributed power system [8]:

$$\begin{aligned} v_a &= V_a sin(\omega t + \theta) \\ v_b &= V_b sin(\omega t + \theta + 120^0) \\ v_c &= V_c sin(\omega t + \theta - 120^0) \end{aligned} \quad (1)$$

And the current passing through the balanced distribution system can be illustrated by

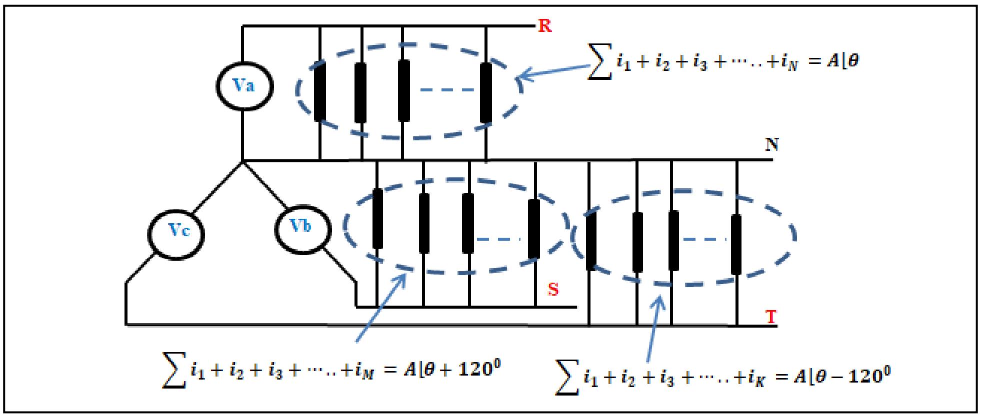
$$i_a = I_a sin(\omega t + \emptyset)$$

$$i_b = I_b sin(\omega t + \emptyset + 120^0) \qquad (2)$$

$$i_c = I_c sin(\omega t + \emptyset - 120^0)$$

Where $I_a = I_b = I_c$ for blanced distribution system

Fig. 1 Balanced power distributed system



Where Va Vb and Vc represent the peak of three phase source voltages respectively, while Ia , Ib and Ic represent the peak of three phase source currents respectively ω represent operating angular frequency and θ is voltage phase displacement of phase one (S) and Φ is current phase displacement of phase one (S).

The term power quality involves all conceivable situation in which the waveform of the supply voltage or load current splay from the sinusoidal waveform at rated frequency with amplitude identical to the rated r.m.s value for all three phases system [9-10]. The enormous ambit of power quality distribution system covers impulsive and oscillatory transients, voltage sags, short interruptions, as well as steady-state deviations, such as harmonics and flicker [11]. Customers do not related with any direct production loss related to the appearance of these power quality phenomena [12], but bad quality of the supply taken by many customers together will ultimately result in low power quality delivered to other customers for example both harmonics and unbalanced currents cause distortion unbalance in the phase voltages [13]. So that, suitable criterions are release to restriction the quantity of increasing harmonic currents, unbalance and flicker that may be appeared at load [14]. However the effect of mentioned drawbacks will effect on customers by:

- Phase failure: Phase failure take place when power distribution system is absent to one of the lines supplying power customer. For example the motor will continue to operate but will increse much amount of current that draws from the supply. However Phase failure will lead the two phases that remain supplied in a three-phase motor to increase current supplied by amount of 173% [15].
- Unbalanced voltage: phase A to phase B, phase B to phase C, and phase C to A must be have same amplitude voltage and phase shift of 1200. Unbalance phases voltages in three-phase systems can result unbalance current among the windings, the unbalanced phase shift can be lead to increase in winding temperature and the and increase in winding temperature issue that can be damaging to the motor [16].

- If two of the lines power supply to a three-phase motor are inversed, it will lead the motor to inverse the direction of rotation [17]. This can be a considerable issue with some types of equipment. The change direction of rotation can result gear box teeth to cut, chains to break, and the impeller of submersible fluid pumps to unscrew off the end of the induction motor shaft. It can not only cause damage to equipment but also injury to operators or personnel in the vicinity of the machine [18].

The need for devices for improving of the power quality phenomena is thus induced by regulatory effort. For all reasons described above, there is a growing interest in equipment for mitigation of power quality disturbances, especially in newer devices based on intelligent algorithms, able to deliver customized solutions to power quality problems. This paper provides an overview of power-electronic based devices to be installed at medium-voltage level for mitigation of power quality phenomena. According to the above classification, there are two major classes of mitigation equipment. Reactive power compensation and harmonic cancellation devices are mostly connected in shunt at the load bus, with the purpose of injecting a current to correct the current taken by the load. Mitigation of flicker will be treated in Section 2 and harmonic filtering in Section 3. Voltage dips and interruption mitigation devices are normally connected between the supply and the load, in order to correct the supply voltage.

Proposed Distribution Model

This paper suggest new method to redistribute the loads on three phase power system to get balance load distribution, the method suggests only single-phase loads connected to the distribution node and every load has a specific power value (demand), which depends only on summation of fractional weights of each phase demand and redistributed the loads between phases that have maximum and minimum fractional weights. Circuitry the load demands have the ability to connect to any phase of three phase of power source. Figure 2 shows suggested switches connection to each load that may be connected to one of the phases of the distribution system assuming that the switches states does not takes 1 just for one switch at certain time of operation.

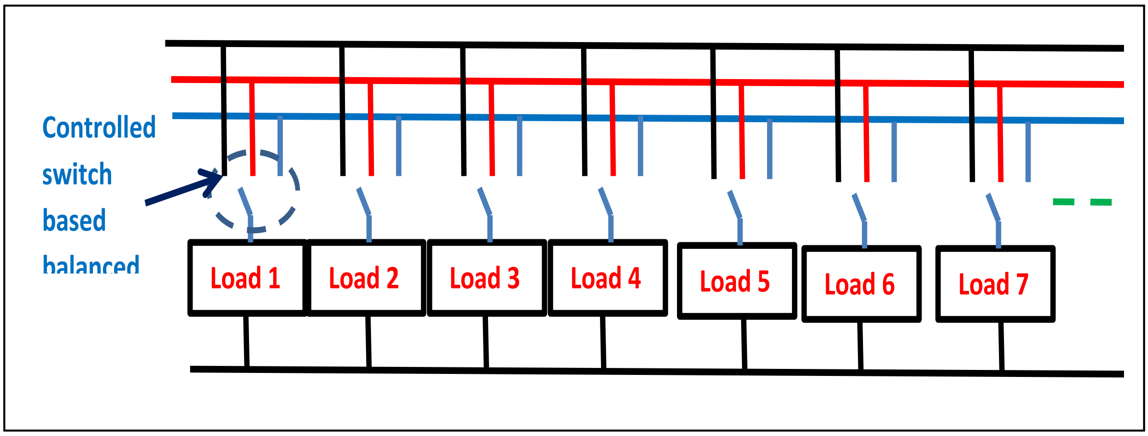


Fig2. Suggested controlled power distribution system

Mathematical Model

Consider the total active power consumption PM in a distribution phase is the summation of all individual active power consumption loads connected to the phase. If every load i has total active power PX, the following equations shows total power consumption for X loads:

$$\mathrm{P_M = P_1 + P_2 + P_3 + P_4 = \sum_{X=1}^{i} P_X} \qquad (3)$$

Moreover, total active power at three phase distribution system is the summation of the active power of each phase, PXj, as presented in Equation 4:

$$P_T = P_{M1} + P_{M2} + P_{M3} = \sum_{j=1}^{3} P_{Mj} \qquad (4)$$

The proposed method three switches for connecting each load to one specific phase. By considering Cij is the switch state of load i in phase j. so that, Equation (5) shows the total active power on each phase:

$$\begin{gathered}\mathrm{P_1C_{11} + P_2C_{21} + P_3C_{31} + P_4C_{41} + \cdots + P_iC_{i1} = P_{M1}}\\ \mathrm{P_1C_{12} + P_2C_{22} + P_3C_{32} + P_4C_{42} + \cdots + P_iC_{i2} = P_{M2}}\\ \mathrm{P_1C_{13} + P_2C_{23} + P_3C_{33} + P_4C_{43} + \cdots + P_iC_{i3} = P_{M3}}\end{gathered} \qquad (5)$$

Where Pi is the power load demand of each load i, PMj is total active power per phase, index j takes values 1,2 and 3 represents the phase that the load connected and Cij is the switch state of load Xi in phase j, which can be represented with a binary state:

$$\mathrm{C_{ij}} = \begin{cases} 1 \text{ when swich is ON state} \\ 0 \text{ when swich is OFF state} \end{cases} \qquad (6)$$

Where 1 indicates ON state and 0 indicates OFF state of the certain load. Moreover, each switch connects one load exclusively to one phase.

And since each phase feeds a portion of the total power of distribution system demand at every moment, equation (7) presents this situation for a three phase distribution system as:

$$\begin{gathered}\mathrm{P_{M1} = \beta_1 P_T}\\ \mathrm{P_{M2} = \beta_2 P_T}\\ \mathrm{P_{M3} = \beta_3 P_T}\end{gathered} \qquad (7)$$

And the general form of equation 7 can be illustrated as:

$$\mathrm{P_{Mj} = \sum_{j=1}^{3} \beta_j P_T} \qquad (8)$$

And

$$\sum_{j=1}^{3} \beta_j = \qquad (9)$$

Where βj is the fraction of the total power demand supplied by three phase distribution system. In a perfectly balanced distribution power system, β1 = β2 = β3 = 1/3.

Equation 8 applies to only one interval. Long-term load balance needs performing the analysis at different time intervals and obtaining the best switch configuration. Equation 10 shows the total power of phase 1 represented by PM1 in each period k (for k = 1 to F periods); and i represents the loads in the period k of phase j (for i = 1 to i loads) and Ckij is the connection of load i to phase j in period k:

$$\begin{gathered}\mathrm{P_{11}C_{111} + P_{12}C_{121} + P_{13}C_{131} + P_{14}C_{141} + \cdots + P_{1i}C_{1i1} = P_{M11}}\\ \mathrm{P_{12}C_{211} + P_{22}C_{221} + P_{32}C_{231} + P_{42}C_{241} + \cdots + P_{2i}C_{2i1} = P_{M21}}\\ -\\ \mathrm{P_{F1}C_{F11} + P_{F2}C_{F21} + P_{F3}C_{F31} + P_{F4}C_{F41} + \cdots + P_{Fi}C_{Fi1} = P_{MK1}}\end{gathered} \qquad (10)$$

And for phase 2 the power demand expression can be determined as:

$$\begin{gathered} P_{11}C_{112}+P_{12}C_{122}+P_{13}C_{132}+P_{14}C_{142}+\cdots+P_{1i}C_{1i2}=P_{M12} \\ P_{12}C_{212}+P_{22}C_{222}+P_{32}C_{232}+P_{42}C_{242}+\cdots+P_{2i}C_{2i2}=P_{M22} \quad (11) \\ - \\ P_{F1}C_{F12}+P_{F2}C_{F22}+P_{F3}C_{F32}+P_{F4}C_{F42}+\cdots+P_{Fi}C_{Fi2}=P_{MK2} \end{gathered}$$

In same method, power demand of phase 3 can be illustrated as:

$$\begin{gathered} P_{11}C_{113}+P_{12}C_{123}+P_{13}C_{133}+P_{14}C_{143}+\cdots+P_{1i}C_{1i3}=P_{M13} \\ P_{12}C_{213}+P_{22}C_{223}+P_{32}C_{233}+P_{42}C_{243}+\cdots+P_{2i}C_{2i3}=P_{M23} \qquad (12) \\ P_{F1}C_{F13}+P_{F2}C_{F23}+P_{F3}C_{F33}+P_{F4}C_{F43}+\cdots+P_{Fi}C_{Fi3}=P_{MK3} \end{gathered}$$

In general, the instantaneous power distribution system demand supplied to phase j in period k can be determined as:

$$P_{MKj}=\sum_{i=1}^{X}P_{ik}C_{kij} \qquad (13)$$

The general expression shows the instantaneous power distribution system load to every phase at every time interval, which is possible in smart grids. However, periodic switching based variable load allocation depending on phase demand ratio from total power supplied from distribution system.

Balancing Algorithm

The balancing algorithm builds upon the following steps:

Step1: Measuring the instantaneous power at each load allocation with constant time period P ik .

Step 2: Calculate the total power demand of three phase power system at suggested time period P T k.

Step 3: calculate fractional weight of each allocation load βkij.

Step 4: Calculate the summation of fractional weight that appeared in each phase, if power distribution system is balance β1 = β2 = β3 = 1/3 with acceptable threshold. And if the distribution power system is unbalance the summation of fractional weight exceeds the threshold value and β1 ≠ β2 ≠ β3 ≠ 1/3.

Step 5: Recognize maximum allocation fractional weight in phase that has minimum summation of fractional weight βk i (max) J (max), and recognize minimum allocation fractional weight without including unused allocations that have zero fractional weight in phase that has maximum summation of fractional weight C k i J (min) assuming C k i J (min) ≠ 0 with fractional weight matrix Ck i J (min) and Ck i J (min) .

Step 6: Change the fractional weight matrix by converting allocations between two recognized allocations to get switching matrix state Ck i (min) J (max) and Ck i (max) J (min) . Step 6 result a new switching matrix so steps (1, 2, 3 and 4) are repeated to determine ether that the system balance or not.

Step 7: if the system is unbalance new fractional weight matrix suggested based on recognize the phases with maximum and minimum summation of fractional weights βk J (min new) and βk J (max new) , after that change the fractional weight matrix by changing allocation of maximum fractional weight load found in maximum summation fractional weight Ck i J (max new) to first zero appeared in minimum summation fractional weight phase C k i J (min new) = 0. However the two nested iteration repeated until we get a three phase balance system. Figure 3 shows flowchart for suggested algorithm.

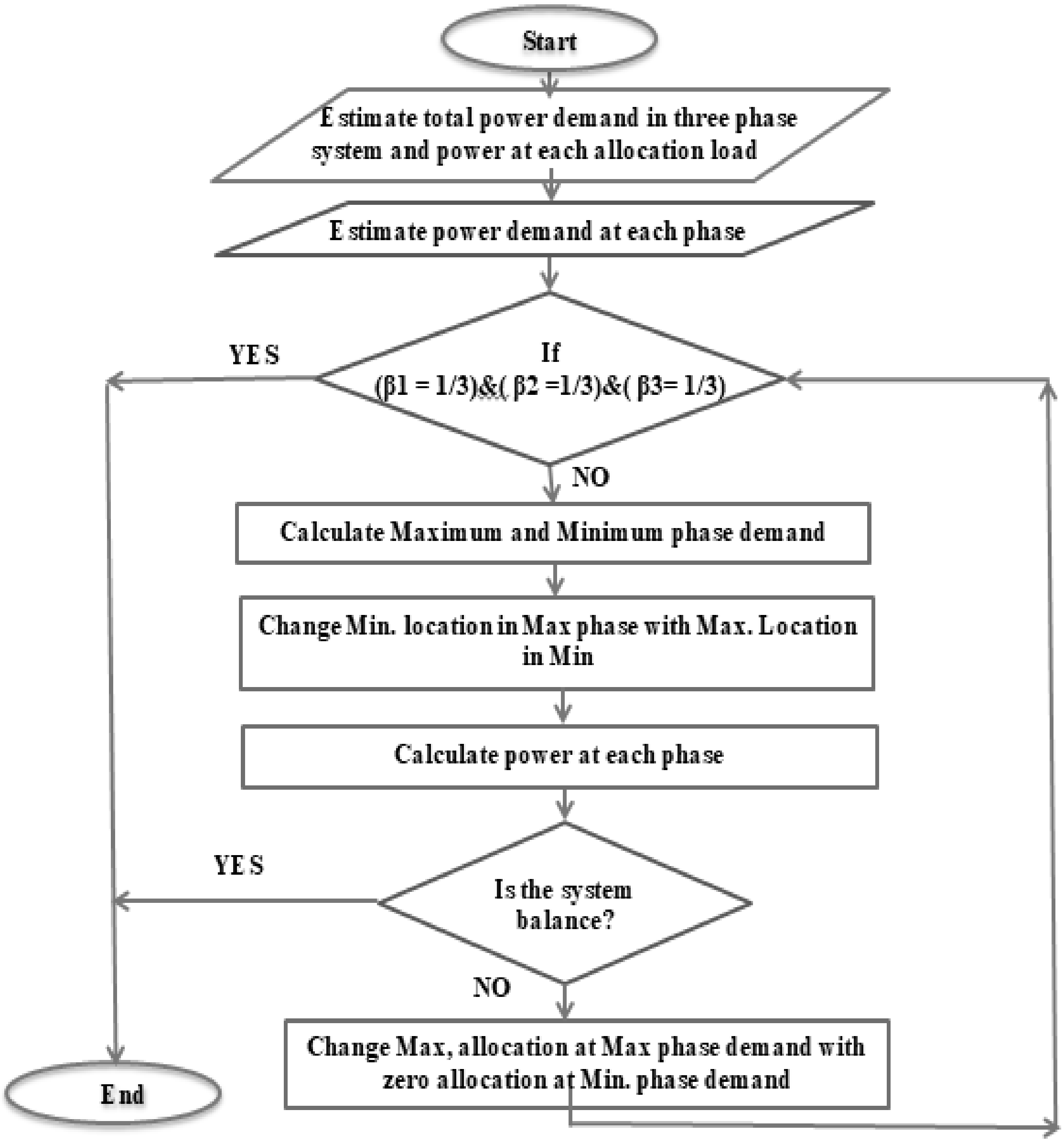


Fig.3 Auto balance distribution power system flowchart

Algorithm Testing

To improve suggested algorithm a case study unbalanced distributed power system has been suggested to visualize the performance of the algorithm. The method was tested with data for hourly demands in 8 periods of time (one day of working for a certain factory) and 18 possible allocations for single-phase loads connected to a three-phase system. Thus, Table I presents the initial load matrix.

Table 1 can be converted due to suggested mathematical model in two matrixes one represent the switching matrix which is denoted by 0 or 1 depends on allocation connection load and the other matrix represents fractional ratio of total power demand of distribution system, however tables 2 and 3 present switching matrix and fractional power matrix.

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Table 1 Load distribution matrix for one day work for a certain factory

Phase (j)	Load (X) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Summation of power at each phase	OT
1	1.2				6.5		4.45	6.325					3.5			0.75		1.3	24.025	
2		2.5		3.5							1.5			7.5		2.65			17.65	
3			7.5		2.525		7.23		7.25									0.85	25.355	H1
Total power demand for 3 phases at hour 1 of operation 67.03																				
1	1.2		1.2		6.5		4.45	6.325					3.5			0.75		1.3	25.225	
2		2.5		3.5		0.75					1.5			7.5		2.65			18.4	
3			7.5		2.525		7.23		7.25			3.5			1.75			0.85	30.605	H2
Total power demand for 3 phases at hour 2 of operation 74.23																				
1	1.2						4.45	6.325					3.5			0.75		1.3	17.525	
2		2.5		3.5							1.5			7.5		2.65			17.65	
3			7.5		2.525		7.23						1.25					0.85	19.355	H3
Total power demand for 3 phases at hour 3 of operation 56.36																				
1	1.2				6.5		4.45	6.325	8.5			4.5	3.5			0.75		1.3	36.935	
2		2.5		3.5							1.5			10		2.65			20.15	
3			7.5		2.525		7.23		7.25				7.5					0.85	32.855	H4
Total power demand for 3 phases at hour 4 of operation 89.49																				
1	1.2				6.5		4.45	6.325					3.5			0.75		1.3	24.025	
2		2.5		3.5		2.5					1.5			7.5		2.65			20.15	
3	0.75		7.5		2.525		1.5		7.25			3.5						0.85	23.875	H5
Total power demand for 3 phases at hour 5 of operation 68.05																				
1	1.2				6.5		4.45	6.325					3.5			0.75		1.3	24.025	
2		2.5		3.5				1.5			1.5			7.5		2.65			19.15	
3			7.5		2.525				7.25			0.95						0.85	19.0075	H6
Total power demand for 3 phases at hour 6 of operation 62.25																				
1	1.2				6.5		4.45	6.325					3.5			0.75		1.3	24.025	
2		2.5		3.5							1.5			7.5		2.65			17.65	
3			7.5			2.75			7.25				0.95					0.85	19.3	H7
Total power demand for 3 phases at hour 7 of operation 60.975																				
1	1.2				6.5		4.45	6.325					3.5			0.75		1.3	24.025	
2		2.5		3.5					7.25		1.5			7.5		2.65			24.9	
3			7.5		2.525		7.23					0.85						0.85	18.955	H8
Total power demand for 3 phases at hour 8 of operation 67.88																				

Table 2 represents the fractional weight matrix at which the weight of each load was estimated also the sum of fractional weight of each phase was illustrated with respect to total power demand at each operating time.

Table 2 Switching matrix for one day work for a certain factory

Phase (j)	Load (X) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	OT
1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	H1
3	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	
1	1	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	H2
3	0	0	1	0	1	0	1	0	1	0	0	1	0	0	1	0	0	1	
1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	H3
3	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	
1	1	0	0	0	1	0	1	0	1	0	0	1	1	0	0	1	0	1	
2	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	H4
3	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0	0	0	1	
1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	H5
3	1	0	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	1	
1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	0	0	1	0	0	1	0	0	1	0	1	0	0	H6
3	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	
1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	H7
3	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	
1	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	1	
2	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	1	0	0	H8
3	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	

Table 3 represents the fractional weight matrix at which the weight of each load was estimated also the sum of fractional weight of each phase was illustrated with respect to total power demand at each operating time.

Table 3 fractional weight of each load was estimated also the sum of fractional weight at each operating time.

j	Load (X) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Summation of fractional weight	OT
1	.018	0	0	0	.097	0	.066	.094	0	0	0	0	.052	0	0	.011	0	.019	0.375	
2	0	.037	0	.052	0	0	0	0	0	0	.022	0	0	.112	0	.039	0	0	0.263	
3	0	0	.112	0	.034	0	.107		.108	0	0	0	0	0	0	0	0	.013	0.362	H1
Total fractional weight for 3 phases at hour 1 =1 (with unbalanced system)																				
1	.016	0	.016	0	.086	0	.059	.085	0	0	0	0	.047	0	0	.01	0	.018	0.337	
2	0	.034	0	.047	0	.01	0	0	0	0	.02	0	0	.101	0	.036	0	0	0.248	
3	0	0	.101	0	.033	0	.097	0	.098	0	0	.047	0	0	0.02	0	0	.011	0.415	H2
Total fractional weight for 3 phases at hour 2 =1 (with unbalanced system)																				
1	.022	0	0	0	0	0	.079	.112	0	0	0	0	.062	0	0	.013	0	.023	0.311	
2	0	.044	0	.062	0	0	0	0	0	0	.027	0	0	.133	0	.047	0	0	0.313	H3
3	0	0	.133	0	.045	0	.128	0	0	0	0	0	.022	0	0	0	0	.015	0.376	
Total fractional weight for 3 phases at hour 3 =1 (with unbalanced system)																				
1	.013	0	0	0	.073	0	.05	.071	.095	0	0	.05	.039	0	0	.008	0	0.015	0.414	
2	0	.028	0	.039	0	0	0	0	0	0	.017	0	0	.112	0	.03	0	0	0.226	
3	0	0	.084	0	.028	0	.081	0	.081	0	0	0	.084	0	0	0	0	.009	0.36	H4
Total fractional weight for 3 phases at hour 4 =1 (with unbalanced system)																				
1	.018	0	0	0	.096	0	.065	.093	0	0	0	0	.052	0	0	.011	0	.019	0.354	
2	0	.037	0	.052	0	.037	0	0	0	0	.022	0	0	.11	0	.039	0	0	0.297	
3	.011	0	.11	0	.037	0	.022	0	.107	0	0	.052	0	0	0	0	0	.013	0.349	H5
Total fractional weight for 3 phases at hour 5=1 (with unbalanced system)																				
1	.019	0	0	0	.104	0	.072	.102	0	0	0	0	.056	0	0	.012	0	.021	0.386	
2	0	.04	0	.056	0	0	0	.024	0	0	.024	0	0	.121	0	.043	0	0	0.308	
3	0	0	.121	0	.041	0	0	0	.116	0	0	.015	0	0	0	0	0	.014	0.306	H6
Total fractional weight for 3 phases at hour 6=1 (with unbalanced system)																				
1	.02	0	0	0	.107	0	.073	.104	0	0	0	0	.058	0	0	.012	0	.021	0.395	
2	0	.041	0	.058	0	0	0	0	0	0	.025	0	0	.123	0	.044	0	0	0.291	
3	0	0	.123	0	0	.045	0	0	.119	0	0	0	.016	0	0	0	0	.014	0.314	H7
Total fractional weight for 3 phases at hour 7=1 (with unbalanced system)																				
1	.018	0	0	0	.096	0	.066	.092	0	0	0	0	.052	0	0	.011	0	.019	0.354	
2	0	.037	0	.052	0	0	0	0	.107	0	.022	0	0	.11	0	.039	0	0	0.367	
3	0	0	.11	0	.037	0	.107	0	0	0	0	.013	0	0	0	0	0	.013	0.279	H8
Total fractional weight for 3 phases at hour 8=1 (with unbalanced system)																				

Table 3 shows that the power distribution system for the factory during 8 hours of operation is unbalanced since the summation of fractional weight of each phase is not equal, for example at hour 1 β1= 0.375, β2= 0.263 and β3= 0.362, so that the suggested algorithm applied by selecting phase with maximum summation fractional weight (phase 1) and phase with minimum summation fractional weight (phase 2) and searching for locations (xj) that have maximum weight in phase1 and minimum weight in phase 2. However the searching process find that location 5 in phase 1 has fractional weight C151= .097 (max. weight) while the searching process find that location 11 in phase 2 has fractional weight C1 11 2= .022 (min. weight exception location with zero weight). The second step of proposed algorithm is to exchange fractional weight in mentioned location, however the fractional weight matrix suggested as shown in table 4.

Table 4 fractional weight of each load and summation of fractional weight for each phase after first iteration of proposed algorithm

j	Load (X) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Summation of fractional weight
1	.018	0	0	0	.022	0	.066	.094	0	0	0	0	.052	0	0	.011	0	.019	0.282
2	0	.037	0	.052	0	0	0	0	0	0	.097	0	0	.112	0	.039	0	0	0.337
3	0	0	.112	0	.034	0	.107		.108	0	0	0	0	0	0	0	0	.013	0.356
Total fractional weight for 3 phases at hour 1 =1 (with unbalanced system)																			

Table 4 shows that after the first location exchange the power distribution system still unbalanced, so new iteration suggested by recognizing maximum allocation fractional weight Ck i (max) J (max) in phase that has maximum summation of fractional weight β j max., however the suggested searching process gives location 3 in phase 3 with fractional weight C1 3 3= .112, also this iteration needs to recognize phase that has minimum summation of fractional weight which is according table 4 β1= 0.282, and searching for first zero weight location in this phase, the searching process appeared at location 2 of phase 1 which has minimum summation of fractional weight C1 2 1= 0. Finally exchange recognized allocations. However, fractional weight matrix after second iteration shown in table 5.

Table 5 fractional weight of each load and summation of fractional weight for each phase after second iteration of proposed algorithm

j	Load (X)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Summation of fractional weight
1	.018	.112	0	0	.022	0	.066	.094	0	0	0	0	.052	0	0	.011	0	.019	0.394
2	0	.037	0	.052	0	0	0	0	0	0	.097	0	0	.112	0	.039	0	0	0.337
3	0	0	0	0	.034	0	.107		.108	0	0	0	0	0	0	0	0	.013	0.262
Total fractional weight for 3 phases at hour 1 =1 (with unbalanced system)																			

Table 5 shows that the system is still unbalanced, so that the suggested will repeat until getting balanced distribution system. After 6 iteration and with threshold = 0.015 the fractional weight matrix of first hour of operation will be as shown in table 6.

Table 6 fractional weight of each load and summation of fractional weight for each phase after 6 iterations of proposed algorithm

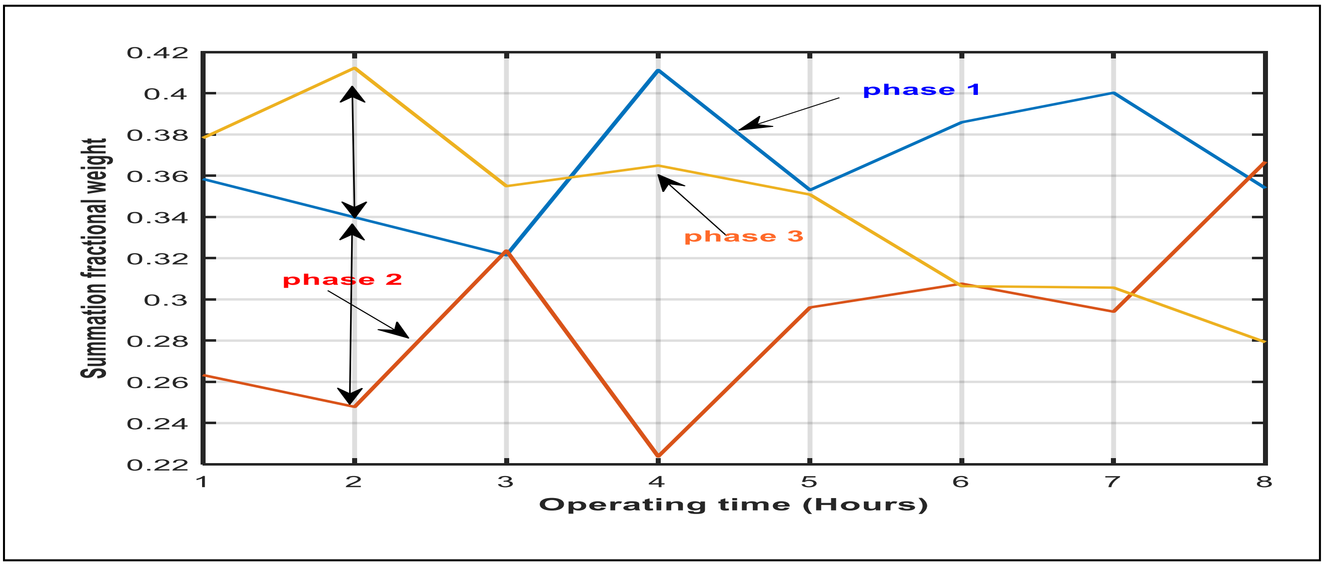
j	Load (X)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Summation of fractional weight
1	.112	0	0	0	0	0	.066	.094	0	0	0	0	.052	0	0	0	0	.019	0.34
2	.013	.037	.038	.052	.097	.018	0	0	0	0	.022	0	0	.011	0	.039	0	0	0.33
3	0	0	0	0	.112	0	.108	0	.108	0	0	0	0	0	0	0	0	0	0..33
Total fractional weight for 3 phases at hour 1 =1 (with balanced system)																			

Table 6 shows that the summation of fractional weight of each phase gives a balance power distribution system, according that the switching matrix of distribution system changed to be according table 7.

Table 7. Switching matrix after applying proposed algorithm

	Load (X)																	
j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1
2	1	1	1	1	1	1	0	0	0	0	1	0	0	1	0	1	0	0
3	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0

The operation of proposed algorithm continuous to measure power at allocation , the total power at each phase and total power demand in three phase distribution system every one hour, and determine either that the system is balanced or not. However applying the measurement process at each hour gives summation fractional weight deviation as shown in figure 4.



x

Fig. 4 Summation of fractional weight of unbalanced system.

Figure 4 shows that summation of fractional weight has a greet deviation with variation between 0.23 to 0.41 and result (β1- β2 >threshold), (β1- β3 >threshold)and (β2 -β3>threshold) and this leads to get unbalanced distribution system, so applying the proposed balancing technique gives summation of fractional weight has a lower deviation with variation between 0.23 to 0.41 and result (β1- β2 <=threshold), (β1- β3 <=threshold)and (β2-β3<=threshold), however summation of fractional weight deviation during 8 hours of operation after applying proposed balancing algorithm shown in figure 5.

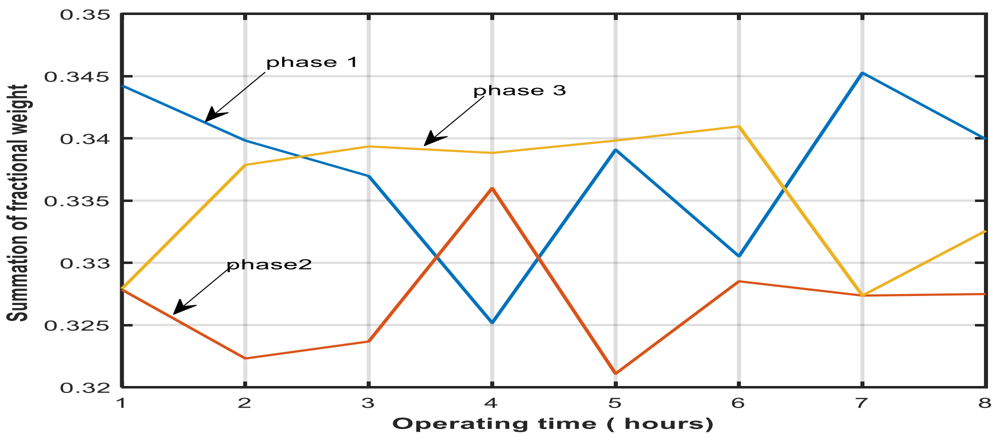


Figure 5 Summation of fractional weight of balanced system.

Figure 5 shows that due to proposed intelligent algorithm improvement by summation fractional weights by 25% if it is compared with distribution system operate without suggested algorithm. Improving of the power quality condition is thus induced by regulatory effort.

Conclusion

This paper provides intelligent algorithm and relocation the load on three phase power distribution system by suggesting convenient connections to each one of the phases, in different time periods. The proposed intelligent algorithm does not need switching during the analysis time that required estimating optimal connection during the time period, so that the algorithm does not affect power quality of the distribution system. Additionally, the method uses different load with different fractional weights on each phase to minimize the chance of inconvenient solutions and finds optimal load balance with branch and bound. The method was tested with example data and with information from a real system for a certain factory operates with unbalanced load at different time intervals, decreasing the difference between summations of fractional weights of three phase system leads to make distribution power system balanced.

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