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Minimizing harmonic distortion impact cause by CS using meta heuristic technique

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Abstract

Non-linear load in the distribution system has caused negative impact to its power quality especially on harmonic distortion. Charging Station (CS) is a non-linear load that widely promoted with the aim to support the continuous usage of Electric Vehicle (EV). This research is focusing on optimal placement and sizing of multiple passive filter to mitigate harmonic distortion due to CS usage at distribution system. There are 6 units of CS which being placed in low voltage buses which indirectly will inject harmonic to the system during charging. Power system harmonic flow, passive filter, CS, battery and the analysis will be model in MATLAB. Multi-objective function which are weight summation approach (WSA) and Pareto Front are used to assist meta heuristic technique which is Modified Lightning Search Algorithm (MLSA) to identify optimum location and sizing of passive filter based on improvement on propose five parameters. From the result, the optimal placements and sizing of passive filter able to reduce the maximum Total Harmonic Distortion (THD) for voltage, current and apparent losses respectively. Therefore, the propose method is suitable to reduce harmonic distortion as well as apparent losses at distribution system with present of CS.

Keywords*: apparent losses, harmonic distortion, impact of charging station, meta heuristic, passive filter*

1. Introduction

Unstable price for crude oil and vision to reduce carbon dioxide emission has caused many countries start to change their direction to EV which more environmental friendly and more stable in price. This indirectly has increase the number of CS installation in the distribution network [1]. Based on [2, 3], the charging behaviour from a large number of customers will cause bad effects to the distribution system especially on harmonic distortion issues. Other than that, various existing studies reported that the CS increase THD voltage and current especially when the number connected to the grid simultaneously is increased [4]. Moreover, the sudden increase of load due to the EV usage may create chaotic situation especially on power losses in distribution network.

Generally, when many CS are installed in the distribution system, total load will be increased, causing the distribution transformer to transfer extra amount of power to EV customer which indirectly causes overheat on distribution transformers [5]. Next, the unplanned CS installation may cause high power losses especially when all EV are operated simultaneously and causing utility loss in profit. Other than that, some researchers' works have shown that the uncoordinated EV charging can introduce higher peak demand which is a drawback to the overall power losses of the grid [5, 6]. Since the CS involve converting AC source to DC source, this indirectly create power quality issue such as harmonic distortion [7]. There are three categories of CS, which are CS Level 1, Level 2 and Level 3. The Level 1 and 2 CSs are considered as having a slow charging characteristic which are normally installed at low voltage distribution system. CS Level 3 has a fast charging characteristic which has higher power consumption and normally installed at medium voltage network. There are many approaches introduced to overcome these problems in improving the distribution system performance. In the case of power losses problem, the most popular approaches nowadays are by placing a capacitor bank [8], filter placement [9] and coordinating EV charging schedule [10]. Next, filter placement [9] and improving CS topology [11] are the examples of approaches which can be used in minimizing harmonic distortion impact in distribution system caused by CS.

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Next, due to the complexity of the distribution system nowadays especially after rapid development of EV and presence of distribution generation, the method to solve the problems has become critical and unique for every problem [12]. Although passive filter is able to sink the harmonic based on design, it should not be randomly located at any place in the system because it also can cause losses and harmonic distortion to become more severe. Proper research needs to be conducted to identify the best placement and sizing to maximize benefit to the distribution system.

2. Research Method

In general, there will be two types of harmonic that need to be mitigated in distribution network, which are voltage and current harmonic. Voltage harmonic is measured at the bus while current harmonic is measured at the lines and cables. In order to model the value of harmonic in the distribution system, it is important to identify the source of harmonic distortion connected to the network. In this research, CS is the main source of harmonic distortion injection to the network. Harmonic load flow method used in this research will be presented. Next, CS and battery modelling will be discussed in detail. Then, design of passive filter, which is single tuned filter will be derived. Constraint for this research will identify in detail. Finally, meta heuristic technique, MLSA with Weight Summation Approach (WSA) assistance and MLSA with Pareto assistance will be presented in finding optimal placement and sizing of passive filters.

2.1. Harmonic Load Flow

Many techniques have been used to perform harmonic load flow analysis [13, 14]. Generally, there are two methods used to run harmonic load flow, which are time domain analysis and frequency domain analysis [14]. In this research, frequency domain analysis was selected due to the capability of the method to save computational time when dealing with large scale power system analysis [14]. In addition, the current injection analysis method which is also known as current penetration method was used to determine voltage and current harmonic. Basic principle of this method is by injecting ideal current sources based on related frequency to represent harmonic current spectrum. The injected current will flow through system impedance which indirectly causes voltage distortion and current distortion [15].

Therefore, parameters affecting the forming of harmonic admittance bus are the line impedances, load impedances and filter impedances values. In (1) and (2) represent the line impedance formulation and the impedance for single tuned filter at harmonic *h* respectively which indirectly cater for resonance impact.

$$Z_{i,h} = R_i + jh\omega L_i \tag{1}$$

$$Z_{Filter,h} = R_{Filter} + jh\omega L_{Filter} - j\frac{1}{h\omega C_{Filter}} \tag{2}$$

where:

$Z_{i,h}$ - Line impedance for i^{th} line at h^{th} harmonic order

R_i - Line resistance for i^{th} line

L_i - Line inductance for i^{th} line

$Z_{Filter,h}$ - Filter impedance at h^{th} harmonic order

R_{Filter} - Filter resistance

L_{Filter} - Filter inductance

C_{Filter} - Filter capacitance

The impact of harmonic can be seen when all orders are added up together with fundamental order. In (3), (4) and (5) show the impedance formulation for the load used in setting up the harmonic admittance matrix. Based on the equations, the load will be changed to impedance form which will later be translated in harmonic impedance order. The harmonic flow is calculated using in (6), which consists of harmonic admittance matrix and harmonic current injection as (7) and (8).

$$Z_{L,h} = R_L + jX_{L,h} \tag{3}$$

$$R_L = \frac{V_L^2}{P_L} \tag{4}$$

$$X_{L,h} = \frac{V_L^2}{hQ_L} \tag{5}$$

where:

$Z_{L,h}$ - Load impedance at h^{th} harmonic order
R_L - Load resistance
$X_{L,h}$ - Load inductance at h^{th} harmonic order
V_L - Load Voltage
P_L - Load Active Power
Q_L - Load Reactive Power

$$\overline{I_h} = \frac{\overline{V_h}}{\overline{Z_h}} = \overline{Y_h}.\overline{V_h} \tag{6}$$

$$\overline{Y_h} = \begin{bmatrix} \bar{y}_{11,h} & \bar{y}_{12,h} & .. & \bar{y}_{1N,h} \\ \bar{y}_{21,h} & \bar{y}_{22,h} & .. & : \\ : & : & .. & : \\ \bar{y}_{N1,h} & .. & .. & \bar{y}_{NN,h} \end{bmatrix} \tag{7}$$

$$\bar{I}_h = \begin{bmatrix} \bar{I}_{1,h} \\ \bar{I}_{2,h} \\ : \\ \bar{I}_{N,h} \end{bmatrix} \tag{8}$$

2.2. 10-Bus Radial Distribution System and CS Location

A typical 10-Bus Radial Distribution System was used to investigate the optimal placement and sizing of variable passive filter. The harmonic distortion pattern for individual EV charger was modelled based on actual single phase charger impact as measured by Bass et. al [16]. Figure 1 show a single line diagram for IEEE 10-bus radial distribution system with low voltage 415 V buses residential feeder that consist of several CS respectively connected at bus number 10. Total numbers of buses in the network (medium and low voltages) were 28-buses. There were 6 unit of CS installed at low voltage area in this distribution system. Line data for 28-Bus radial distribution system is shown at Table 1.

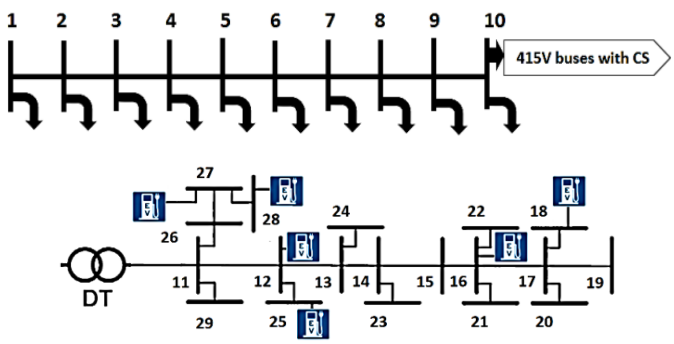

Figure 1. 28-Bus radial distribution system with EV load

Table 1. Line Data for 28-Bus Radial Distribution System

Line No	Start Bus	End Bus	R (ohm)	X (ohm)	P (kW)	Q (kVAr)	CS
1	1	2	0.1233	0.4127	736	184	
2	2	3	0.014	0.6057	392	392	
3	3	4	0.7463	1.2060	716	178.4	
4	4	5	0.6984	0.6084	639.2	736	
5	5	6	1.9831	1.7276	644	240	
6	6	7	0.9053	0.7886	312	44	
7	7	8	2.0552	1.1640	460	24	
8	8	9	4.7953	2.7160	392	52	
9	9	10	5.3434	3.0264	656	80	
10	10	11	0.0000	0.0654	2	0.4	
11	11	12	0.0415	0.0145	2	0.4	1 unit
12	11	26	0.0424	0.0189	2	0.4	
13	11	29	0.0444	0.0198	2	0.4	
14	12	13	0.0369	0.0165	2	0.4	
15	12	25	0.0520	0.0232	2	0.4	1 unit
16	13	14	0.0524	0.0234	2	0.4	
17	13	24	0.0005	0.0002	2	0.4	
18	14	15	0.2002	0.0199	2	0.4	
19	14	23	1.7340	0.1729	2	0.4	
20	15	16	0.2607	0.0260	2	0.4	1 unit
21	16	17	1.3605	0.1357	2	0.4	
22	16	21	0.1400	0.0140	2	0.4	
23	16	22	0.7763	0.0774	2	0.4	
24	17	18	0.5977	0.0596	2	0.4	1 unit
25	17	19	0.1423	0.0496	2	0.4	
26	17	20	0.0837	0.0292	2	0.4	
27	26	27	0.3123	0.0311	2	0.4	1 unit
28	27	28	0.0163	0.0062	2	0.4	1 unit

2.3. CS and Battery Modelling

CS is typically divided into three categories which are level 1, level 2 and level 3 as per SAE Standard [17]. The level of the CS is based on the power consumed by the charging station and types of specification connection. In addition, CS modelling in this research has considered the harmonic distortion value achievable by individual CS based on the battery characteristic and SOC. EV coordination requires accurate modelling of battery and CS characteristic. At lower SOC, higher current is required to charge the battery while voltage increases proportionally with SOC. Starting at 80% of SOC, voltage level reaches its maximum value and the current starts to reduce inversely proportional with SOC until the battery is fully charged. In this research, 6 types of battery that have different capacity and specification will be used to show variety and practicallity of EV in the distribution system. All battery will be put at different SOC level as per Table 2.

Table 1. EV Battery Specification

Type	Battery Capacity (kW)	Charging Rate (A)	Power usage (kW)	CS Efficiency	SOC (%)
1	10	0.052	0.52	0.93	47.92
2	15	0.125	1.875	0.93	54.18
3	10	0.235	2.35	0.93	46.24
4	15	0.15	2.25	0.93	47.37
5	10	0.215	2.15	0.93	40.38
6	20	0.102	2.04	0.93	55.99

2.4. Passive Filter Modelling

The main function of a passive filter is to sink the harmonic current that flow in the system based on a selected frequency. The filter impedance will become very low to allow the harmonic to sink. Among several passive filter types, single tuned filter is the most popular type of filter which is used widely in dealing with harmonic pollution especially in the industrial area [18]. Figure 2 shows a typical design of a single tuned filter. In this paper, 4 units of single tuned filters is considered as 1 set of filter which can eliminate four frequencies. In [19] is used to calculate capacitor, inductance and resistance components respectively as in (9), (10) and (11). Capacitor is calculated based on injected reactive power (*Q*) and voltage (*V*) at that bus, meanwhile inductance and resistance is based on the chosen harmonics (n) that need to be reduced. Three sets of filter will be used to eliminate 3rd, 5th, 7th and 9th harmonic order in the network.

$$C_{Filter} = \frac{Q}{2\pi f V^2} \quad (9)$$

$$L_{Filter} = \frac{V^2}{2n^2 Q^2 \pi f} \quad (10)$$

$$R_{Filter} = \frac{V^2}{n.Q_u.Q} \quad (11)$$

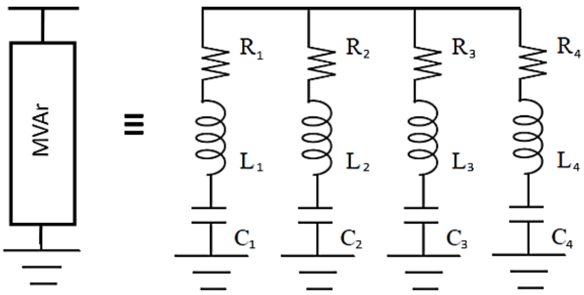

Figure 2. 1 Set of passive filter

2.5. Modified Lightning Search Algorithm, WSA, Pareto and Fuzzy

Modified Lightning Search Algorithm (MLSA), which is developed based on the improvements made to the existing LSA [20, 21], is proposed in this research. The important equations used in MLSA are approximately similar to LSA. There are four improvements that made at existing LSA to produce MLSA which detail out at [9, 12]. Load flow technique that use in this research presented in detailed at [9,12, 22, 23]. Multi-objective technique which are WSA and Pareto also been presented in detail at [9, 12]. The parameters that use to assist MLSA are presented at (17) to (21) at [12]. Fuzzy technique that use in this research use same method as per mention at [9, 12, 24, 25].

2.6. Assumption and Constraint

Since 3 passive filters will be placed in the low voltage system, the total variables will become 6, which are 3 locations and 3 optimal sizes. All these parameters will have its own constraints that needs to fulfill. In general, the parameters can be fraction into 2 categories which are:

a. Filter location:

   The filter will be place in low voltage bus to minimize any harmonic injection to upper feeder. There are 3 locations in 28-bus radial distribution system. Furthermore, only 3 passive filter will be placed at low voltage 415 buses system. The constraints are as follows:

   $$a_i \le Filter_i \le s_i, \; i = 11 \ldots 29 \quad (12)$$

b. Filter reactive value:

   Each individual variable filter reactive value is limited to:

$0kVAr \leq Q_i \leq 30kVAr$, i = 1…3 (13)

3. Results and Analysis

From the existing system without passive filter, maximum THD_V is recorded at bus 18 with 13.546% and maximum THD_i is recorded at lines between busses 10 and 11 with the value 137.53%. Apparent losses S_{loss} recorded at 0.1941MVA. MLSA with WSA assistance technique is presented at [9, 12] which 5 parameters to be considered. Coefficient for all 5 parameters will be determined based on trial and error for all possible combination. Passive filter placement using MLSA with different coefficient of WSA as shown at Table 3. Based on 37 simulations with different coefficient, the best coefficient determines using fuzzy method as per simulation number 35. The result achieve from MLSA with WSA able to reduce maximum THD_V to 9.72175% while maximum THD_i also improve to 39.94711%. However, apparent losses increases to 0.21452MVA which cause the objective to improve all 5 parameters not achieve using this method.

Next, simulation using MLSA with Pareto and Fuzzy technique, there are 4337 sets of "non-dominated" solutions. For this research, the best solution was chosen based on the improvement for all 5 parameters which is able to achieve better THD_I for all lines in the distribution system. From 4337 sets of solution, there are only 2005 sets of solution that show improvement for all five parameters which were then used in the fuzzy stage. Table 4 shows 10 best result using MLSA with Pareto and Fuzzy assistance while Table 5 shows the location and sizing of passive filter for that 10 best result. Based on the result, all parameter are improve with maximum THD_V improve to 11.25281%, maximum THD_I reduce to 58.62805% and apparent losses S_{loss} able to minimize to 0.192308%.

Next, Table 6 shows the best solution gather for both techniques. Although using WSA method able to reduce THD_V and THD_I significantly compare to Pareto and Fuzzy method, it is important to make sure all parameter improve to give stability on overall system. Figure 3 shows the THD_V for medium voltage busses which directly shows significant reduction of THD_V. Moreover, THD_I for all lines at medium voltage system also improve significantly. Based on the result at Figure 3 and Figure 4, shows that the appropriate placement and sizing of passive filter able to divert most of harmonic distortion from injected to medium distribution system.

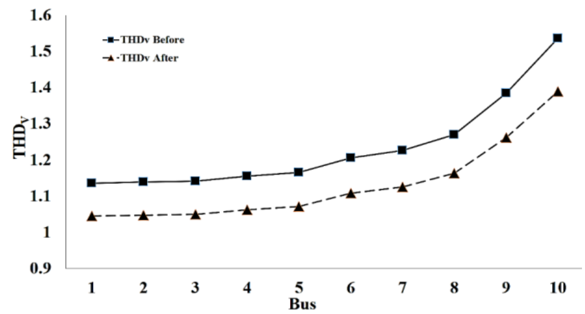

Figure 3. THD_V before and after using MLSA with pareto and Fuzzy asisstance

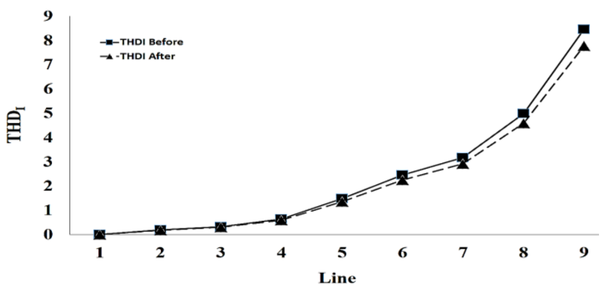

Figure 4. THD_I before and after using MLSA with pareto and Fuzzy asisstance

Table 2. Result using Different Coefficient of WSA with Fuzzy

No	C1	C2	C3	C4	C5	Fitness 1	Fitness 2	Fitness 3	Fitness 4	Fitness 5	Total Fitness	Fuzzy Weightage
1	1	0	0	0	0	9.66467	42.65678	2.15171	60.24787	0.21409	0.71348	0.02760
2	0	1	0	0	0	12.28642	36.47050	1.85975	52.07300	0.21269	0.26518	0.02703
3	0	0	1	0	0	12.28640	36.46687	1.85960	52.06885	0.21269	0.32691	0.02703
4	0	0	0	1	0	12.31091	36.80869	1.87700	52.55605	0.21237	0.32997	0.02690
5	0	0	0	0	1	12.77327	61.39409	2.96151	82.92214	0.19093	0.98362	0.01972
6	0.6	0.1	0.1	0.1	0.1	9.67017	43.78328	2.20341	61.69546	0.19945	0.64039	0.02727
7	0.5	0.1	0.1	0.1	0.2	10.25258	42.05591	2.10160	58.84472	0.20044	0.68943	0.02733
8	0.4	0.1	0.1	0.1	0.3	9.67044	43.79376	2.20383	61.70714	0.19945	0.70314	0.02726
9	0.3	0.1	0.1	0.1	0.4	10.24881	43.76833	2.18511	61.18301	0.19757	0.74276	0.02682
10	0.2	0.1	0.1	0.1	0.5	9.67145	43.79781	2.20398	61.71132	0.19945	0.76589	0.02726
11	0.1	0.1	0.1	0.1	0.6	10.24777	43.74964	2.18436	61.16221	0.19757	0.79497	0.02682
12	0	0.1	0.1	0.1	0.7	12.21425	43.73864	2.18071	61.05992	0.19500	0.81168	0.02503
13	0.7	0.1	0.1	0.1	0	9.72227	39.95185	2.03163	56.88559	0.21451	0.60289	0.02832
14	0.4	0.2	0.2	0.2	0	9.72174	39.95163	2.03161	56.88518	0.21451	0.48803	0.02832
15	0.3	0.2	0.2	0.2	0.1	10.35701	39.36403	2.00438	56.12267	0.21398	0.53780	0.02791
16	0.2	0.2	0.2	0.2	0.2	9.68295	43.86451	2.20671	61.78788	0.19943	0.56741	0.02723
17	0.1	0.2	0.2	0.2	0.3	10.25497	42.11783	2.10409	58.91445	0.20041	0.59465	0.02731
18	0	0.2	0.2	0.2	0.4	12.16217	40.95526	2.04285	57.19984	0.19925	0.61381	0.02594
19	0.1	0.3	0.3	0.3	0	12.28651	36.49497	1.86074	52.10083	0.21266	0.36658	0.02702
20	0.05	0.3	0.3	0.3	0.05	12.28664	36.51680	1.86165	52.12631	0.21265	0.37615	0.02702
21	0	0.3	0.3	0.3	0.1	12.28643	36.47888	1.86007	52.08209	0.21267	0.38533	0.02703
22	0	0.33	0.33	0.33	0	12.28638	36.47522	1.85992	52.07789	0.21268	0.30332	0.02703
23	0.4	0.1	0.2	0.3	0	9.72186	39.95376	2.03170	56.88755	0.21451	0.49471	0.02832
24	0.3	0.1	0.2	0.3	0.1	10.27749	41.40353	2.08281	58.31859	0.20339	0.54558	0.02745
25	0.2	0.1	0.2	0.3	0.2	10.27840	41.48906	2.08620	58.41360	0.20333	0.57479	0.02743
26	0.1	0.1	0.2	0.3	0.3	12.22599	37.92030	1.91005	53.48137	0.20580	0.60379	0.02673
27	0	0.1	0.2	0.3	0.4	12.20755	39.11395	1.95358	54.70026	0.20166	0.61572	0.02645
28	0.4	0.2	0.3	0.1	0	9.72167	39.94854	2.03149	56.88172	0.21451	0.48802	0.02832
29	0.3	0.2	0.3	0.1	0.1	9.72208	39.94836	2.03149	56.88166	0.21452	0.52677	0.02832
30	0.2	0.2	0.3	0.1	0.2	10.30350	41.50690	2.08796	58.46292	0.20301	0.56848	0.02740
31	0.1	0.2	0.3	0.1	0.3	10.28867	42.11829	2.11664	59.26586	0.20110	0.59684	0.02723
32	0	0.2	0.3	0.1	0.4	12.20721	38.63221	1.93150	54.08195	0.20321	0.61075	0.02659
33	0.4	0.3	0.2	0.1	0	10.35693	39.36036	2.00423	56.11855	0.21399	0.49739	0.02791
34	0.3	0.3	0.2	0.1	0.1	10.27748	41.40172	2.08273	58.31651	0.20339	0.53255	0.02745
35	0.2	0.3	0.2	0.1	0.2	9.72175	39.94711	2.03143	56.88017	0.21452	0.55884	0.02832
36	0.1	0.3	0.2	0.1	0.3	12.20698	38.58316	1.92951	54.02625	0.20324	0.59014	0.02661
37	0	0.3	0.2	0.1	0.4	12.19274	39.58366	1.97709	55.35864	0.20068	0.60416	0.02632

Table 3. 10 best result using MLSA with Pareto and Fuzzy Assistance

No	Fitness Parameter										
	fit_1	fit_2	fit_3	fit_4	fit_5	μ_{fit}^{1}	μ_{fit}^{2}	μ_{fit}^{3}	μ_{fit}^{4}	μ_{fit}^{5}	μ_j
1	11.25281	58.62805	2.80798	78.62344	0.192308	0.169285	0.573712	0.506363	0.506363	0.009282	0.000953
2	11.61052	61.11209	2.910424	81.49187	0.193966	0.142878	0.555651	0.488354	0.488354	0.000741	0.000905
3	12.32458	63.10932	2.945035	82.46098	0.193666	0.090164	0.541129	0.482269	0.482269	0.00229	0.000863
4	12.34637	63.12998	2.978306	83.39255	0.193057	0.088555	0.540979	0.476421	0.476421	0.005427	0.000857
5	12.3698	63.04883	2.967456	83.08876	0.193802	0.086825	0.541569	0.478328	0.478328	0.001587	0.000857
6	11.45858	67.19198	3.093372	86.61442	0.194015	0.154094	0.511444	0.456192	0.456192	0.000491	0.000852
7	11.15087	67.91327	3.154354	88.32191	0.194036	0.17681	0.506199	0.445472	0.445472	0.00038	0.00085
8	11.94368	65.36564	3.078693	86.20339	0.193547	0.118282	0.524723	0.458773	0.458773	0.0029	0.000844
9	12.31909	64.72496	3.013716	84.38404	0.193844	0.090568	0.529381	0.470196	0.470196	0.00137	0.000843
10	12.84223	62.13873	3.011849	84.33176	0.19338	0.051949	0.548186	0.470524	0.470524	0.003762	0.000834

Table 4. Passive Filter Location and Sizing using MLSA with Pareto and Fuzzy Assistance

No	Bus				Size 1	Size 2	Size 3	Size 4	Fitness 1	Fitness 2	Fitness 3	Fitness 4	Fitness 5
1	28	18	11	16	0.020682	0.027732	0.029792	0.021177	11.25281	58.62805	2.80798	78.62344	0.192308
2	13	11	28	22	0.021605	0.024334	0.029577	0.019244	11.61052	61.11209	2.910424	81.49187	0.193966
3	16	19	14	29	0.026388	0.023912	0.014071	0.021907	12.32458	63.10932	2.945035	82.46098	0.193666
4	11	14	16	21	0.029335	0.026361	0.011421	0.024668	12.34637	63.12998	2.978306	83.39255	0.193057
5	29	22	14	18	0.023792	0.017471	0.029397	0.019033	12.3698	63.04883	2.967456	83.08876	0.193802
6	28	21	18	12	0.015196	0.025577	0.028027	0.010057	11.45858	67.19198	3.093372	86.61442	0.194015
7	28	16	14	15	0.019643	0.023167	0.018329	0.022763	11.15087	67.91327	3.154354	88.32191	0.194036
8	27	17	18	26	0.028875	0.011478	0.026834	0.023873	11.94368	65.36564	3.078693	86.20339	0.193547
9	29	17	12	19	0.012571	0.024723	0.026984	0.021008	12.31909	64.72496	3.013716	84.38404	0.193844
10	11	16	14	26	0.029168	0.024957	0.027254	0.024191	12.84223	62.13873	3.011849	84.33176	0.19338

Table 5. Passive Filter Location and Sizing with Best Solution for Both Techniques

Parameter	Existing		MLSA with WSA		MLSA with Pareto	
	Bus	MVAr	Bus	MVAr	Bus	MVAr
Passive Filter 1	-	-	22	0.029995	28	0.020682
Passive Filter 2	-	-	27	0.029999	18	0.027732
Passive Filter 3	-	-	28	0.029998	11	0.029792
Passive Filter 4	-	-	20	0.029994	16	0.021177
Max THD_V	13.54593		9.72175		11.25281	
Max THD_I	137.53168		39.94711		58.62805	
THD_I mean	5.68835		2.03143		2.80798	
THD_I sum	159.27392		56.88017		78.62344	
S_{loss}	0.194110		0.21452		0.192308	

4. Conclusion

Preliminary results have shown that increasing the number of CS in the system will cause higher harmonics in the distribution system. In order to eliminate these harmonics, appropriate passive filters are needed to be installed in parallel with all the CSs. However, it is not practical to install filters at all buses. Therefore, MLSA with WSA and Pareto was used to propose a solution for obtaining the appropriate passive filter placement and size to cater for require voltage harmonics, current harmonic and apparent power losses. Fuzzy techniques also implemented to assist in determine the best solution among all solution. Three sets - four unit single tuned filters connected in parallel to selected buses were used to reduce the four harmonic order. The design adopted in this paper was based on the minimum number of filters used to cater for a big distribution system. From the final results, it has been proven that the proposed strategy using MLSA with Pareto and Fuzzy asistance is able to give the best placement and size of passive filters in radial distribution system with improvement on overall THD_V, THD_I and S_{loss}.

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