International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.7 September - October – 2023
DOI:10.46647/ijetms.2023.v07i05.024 ISSN: 2581-4621

OPTIMAL PLACEMENT AND RATING OF CUSTOM POWER DEVICES IN 15-BUS SYSTEM FOR POWER QUALITY IMPROMENT WITH STATIC SYNCHRONOUS COMPENSATORS (STATCOMs) AND ACTIVE LINE POWER CONDTIONER

Mandeep Kumar Munnu[1], Dr. Jayanti Choudhary[2]
[1]Research Scholar, Electrical Engineering Department, National Institute of Technology, Patna, India
[2]Assistant Professor, Electrical Engineering Department, National Institute of Technology National Institute Technology Patna

Abstract—This paper presents on power quality improvement in distributed radial network by using custom power device (CPD). In power system, the power quality issue become more complex at all level. Here, for this concern, we introduce a concept of custom power, basically it is a power electronics controller, to provide a quality of power to the supplier as much as for consumers. Custom power device (CPD) including active power line conditioner (APLC) and static synchronous compensators (STATCOMs), simulating on modified distributed IEEE-15 bus distorted bus system with the help of MATLAB Simulink software to explore performance and the efficiency of each device under various quality (power)disturbances includes voltage swell and sag, interruption in power and total harmonics distortion as well as the performances of allocated CPD in control the voltage quality and reactive power. Here, we used the particle swarm optimization to determine optimal location and sizes of CPD. Here, simulation results reveal all the effect of each device to compensate several types of power quality disturbance depends on the devices configurations and in this paper we much emphasized on STATCOMs and its arrangement.
Index Terms-*Static synchronous compensators (STATCOMs), Active Voltage conditioners (AVC) Custom power device (CPD), Active line conditioner (APLC), Smart grid, Power quality*.

1.INTRODUCTION:

Custom power is a strategy and an advance version to an overcome power system problem like voltage sag, voltage swell and quality (power) related problem and it is requirement for industrial and commercial consumers. The application of power electronics controller devices into power distribution system with custom power device's is tool to supply a quality of power, demanded by the sensitive users. These types of devices main aim to provide rapid load voltage regulation with controlled reactive power in the system.
We know that the power electrical system includes mainly three functional units:

- Generation
- Transmission
- Distribution

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For consideration of reliability in power system, generation unit generated a satisfactory amount of power, transmission system sends maximum power over long distances without overloading and distribution system has must delivered electrical power to every consumer's premises form bulk power system.

STATCOM -The Static Synchronous Compensators (shunt device) is a compensating device it means that it is a shunt connected reactive-power compensation devices that is capable for generating or absorbing reactive power in which the output can be varied to control the specific parameters of an electrical power system. Now in modern day, we have required high-power transfers in our electrical network transmission system and for this, FACTs devices such as SVCs, STATCOMs be required at a large scale. The STATCOMs perform dual role in the power system it means that it can restore active power as well as reactive power compensation.

The word Synchronous in STATCOMs show that its able to generate and also absorb reactive power to stabilized the of the whole power system network can either absorb or generate reactive power in stabilized the voltage of an entire power system network.

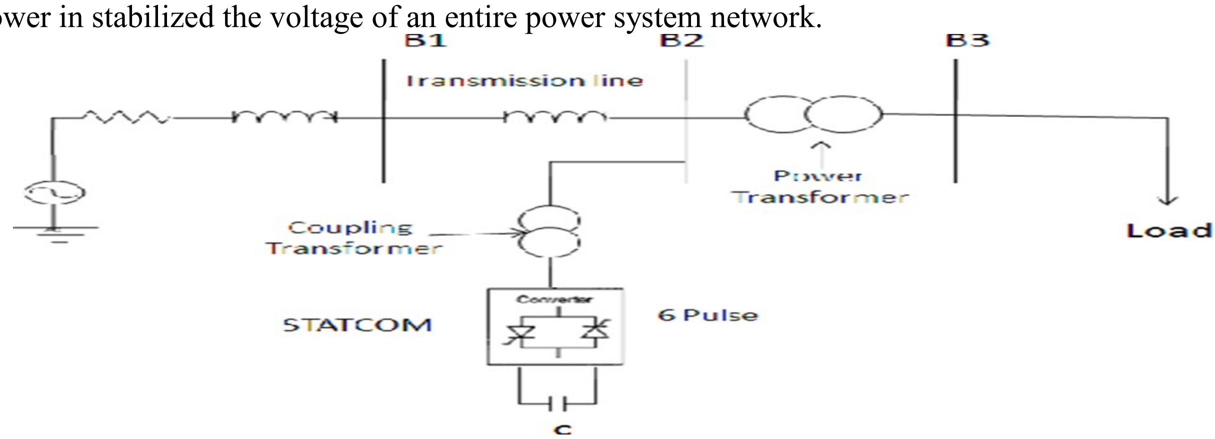

Fig.1. STATCOM.

Equation for Active power and reactive power:

$$S = P - jQ = 3\frac{V_S V_C}{X_L}\sin\alpha - j3(\frac{V_S V_C}{X_L}\cos\alpha - \frac{V_S^2}{X_L})$$

Here *P* is the active and *Q* is the reactive power.

Vs, Vs. and α are supply, receiving end voltages and angle between it respectively.

ACTIVE POWER LINE CONDITIONER

The Active line conditioner is improved and advanced Active power filters with sightly differences [5-11].

i) It is only installed at some selected buses

ii) It could improve and also control total harmonics distortion in term of voltage as well as individual voltage harmonics at all buses within five percentage IEEE-519 standards limit.

iii) Despite of injecting equal-but-opposite harmonic currents, it optimized references current as well as the inject harmonic current in opposite direction for compensate the non-linear load variation for overall network total harmonic distortion.

We can say on the basis of operation and characteristic, the active power line conditioner is active power filter and this is very effective that mean it an efficient device using for harmonics [5,6]. By using optimization technique, here, we used particle swarm optimization method, we can optimize the particular bus for installation to minimize the power system voltage distortion as much as possible.

Here, in this approach some disadvantages are exist:

(1) For one system, we can used one active line conditioner due to its acts as harmonics generation.

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(2) We opt a heuristic way to find placement and rating of it but some new algorithms which are based on developed by Chang and Grady, to reduce the weakness of [5,6] and we can used only in continuous mode.

2. MODELING AND CONTROL OF THE PROPOSED CUSTOM POWER DEVICE (CPD)

A. Static Synchronous Compensator (STATCOM)

STATCOM

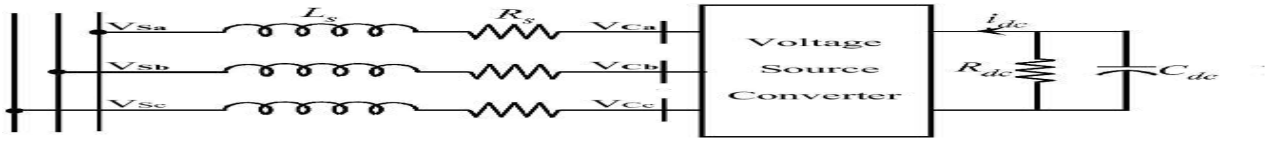

Fig.2 Diagram of a 3-phase transmission line with STATCOM**.**

Power flow model of STATCOM:

Let $V_j \angle \theta_j$ be the utility bus voltage at bus j, $V \angle \delta$ be the inverted voltage (ac) at the output of STATCOM, referred to as jth bus side, X be the reactance of the line between the jth bus and the STATCOM, and Q be the reactive power exchange for the STATCOM.

Simulation of Modelling of 25KV,100 MVA system WITH STATCOM and Non-linear Load.

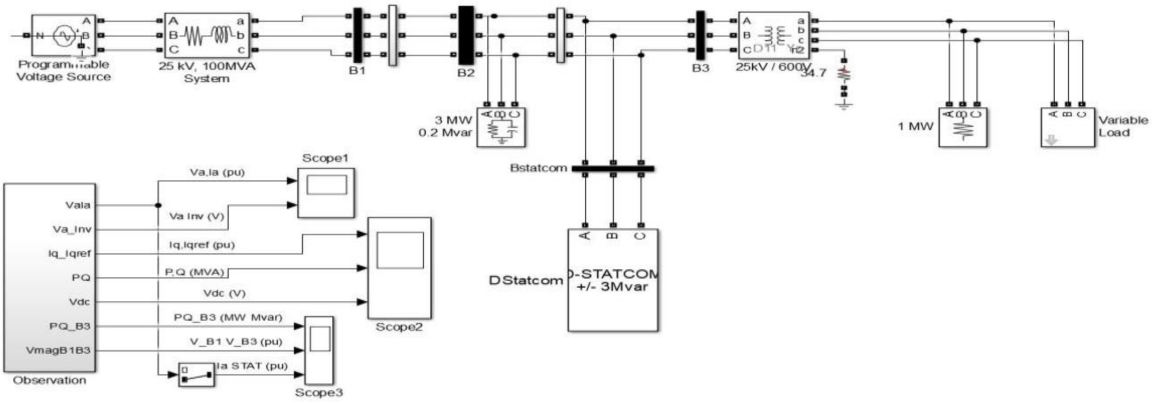

FIG.3 Simulation of STATCOM

CONTROL DESIGN:

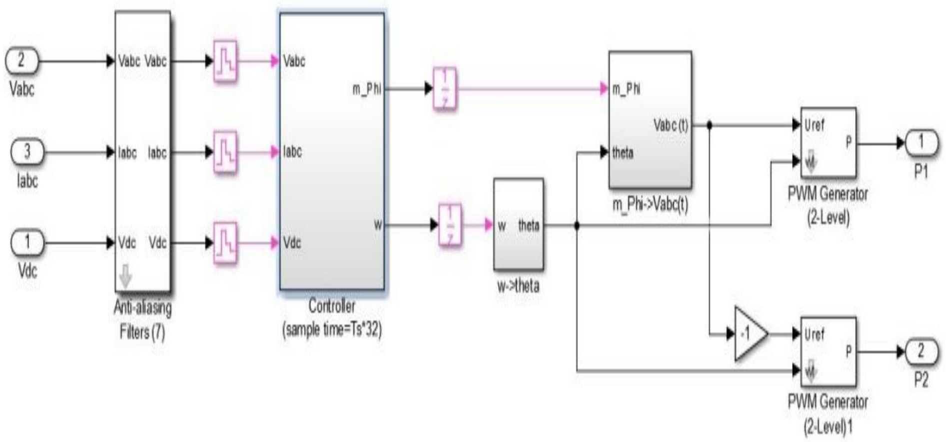

FIG.4 OUTPUT DISPLAY

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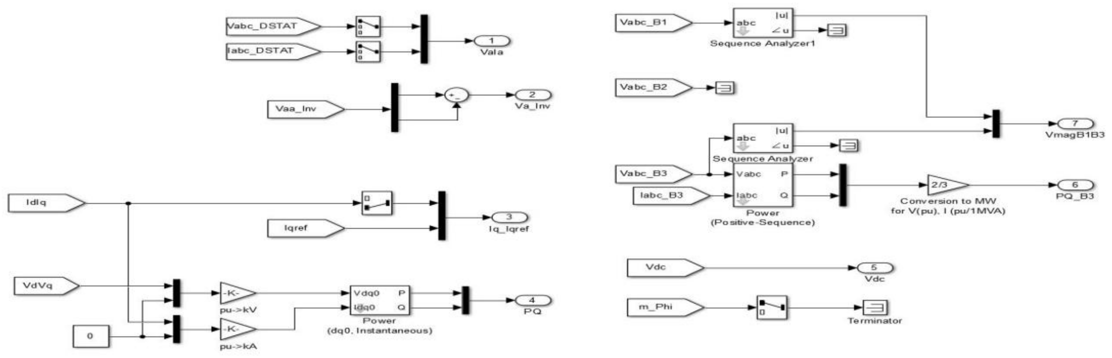


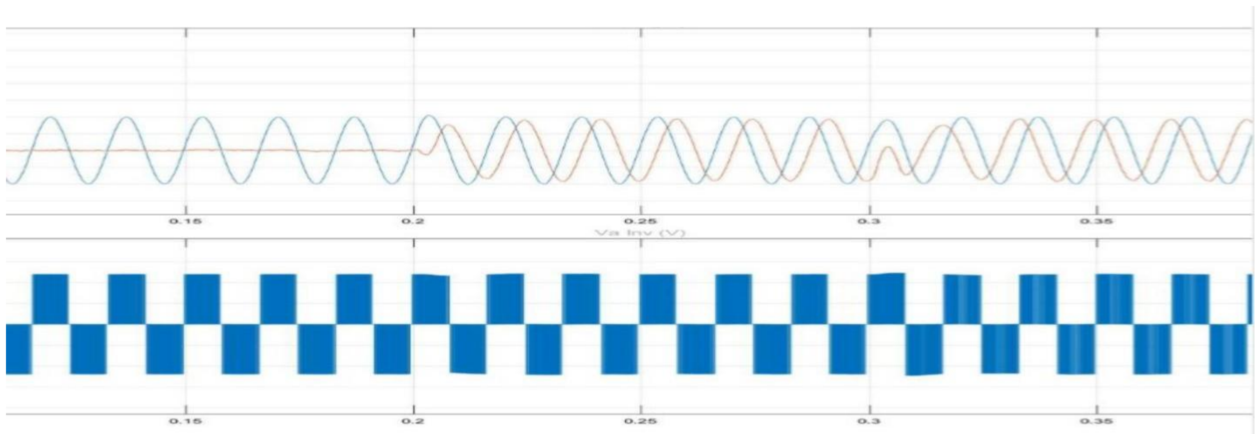


Fig 6. Voltage of phase a and current of phase **2.** Voltage source output.

SCOPE2

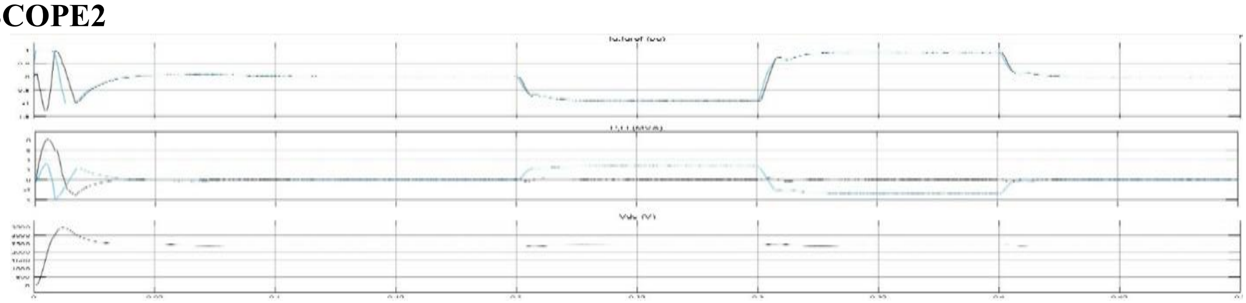
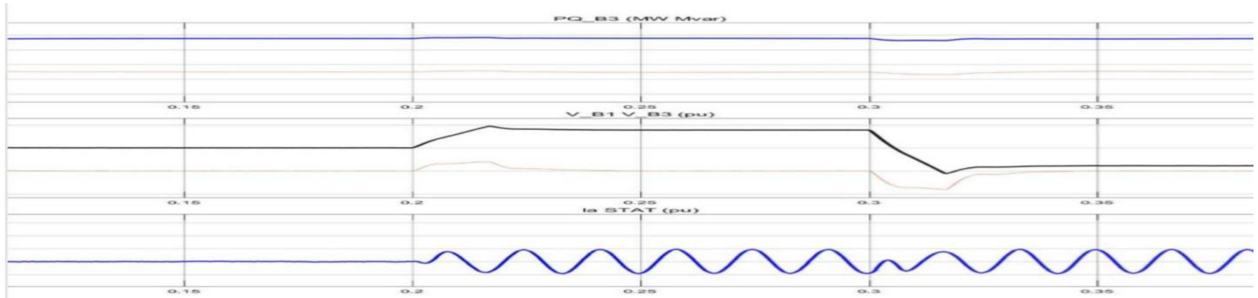


Fig. 7 Quadrature current and references current. 2.Active and reactive power.3.DC voltage.

SCOPE3:



1.Active and reactive power compensation.
2.Voltage of feeder B1 and B2.
3.current of phase-a of STA

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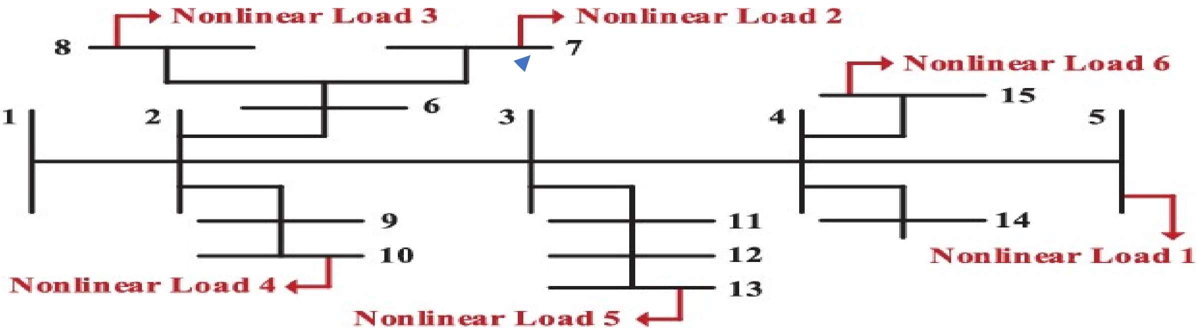

Fig 7. 15-IEEE bus with 5 nonlinear loads.

TABLE 1. Nonlinear loads parameters.

Harmonic Order	5	7	11	13	17
Harmonic Magnitude [%]	22.60	11.44	9.00	6.48	5.62
Harmonic Phase angle [Degree]	180	180	0	0	180

SIMULATION OF NEUTRAL POINT CLAMPED INVERTER

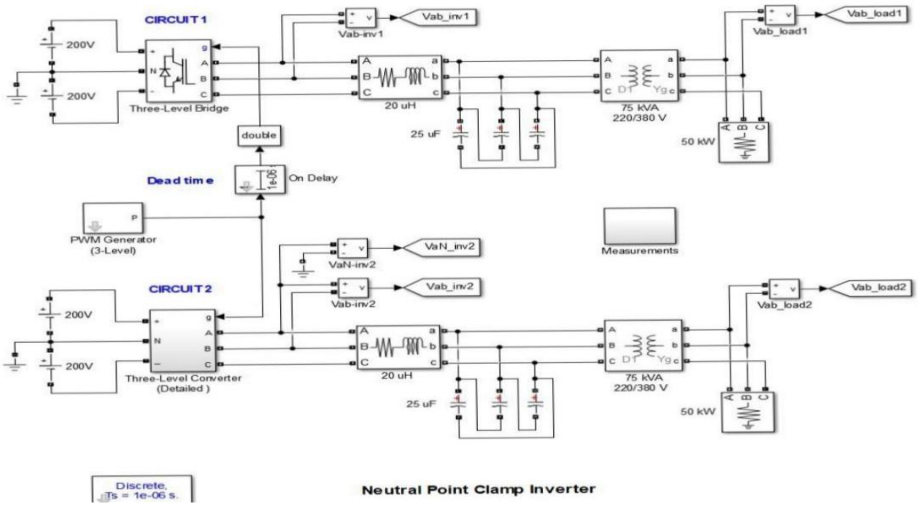

FIG.8 NEUTRAL POINT CLAMP INVERTER

MODELLING AND SIMULATION OF CPD

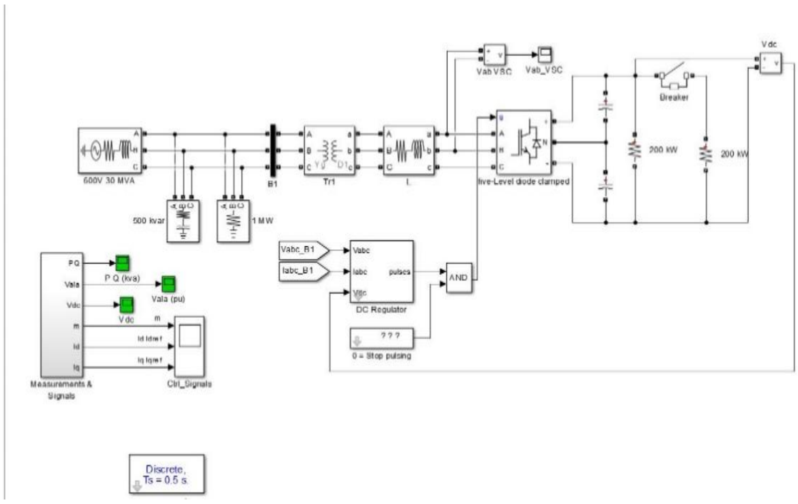

FIG.8

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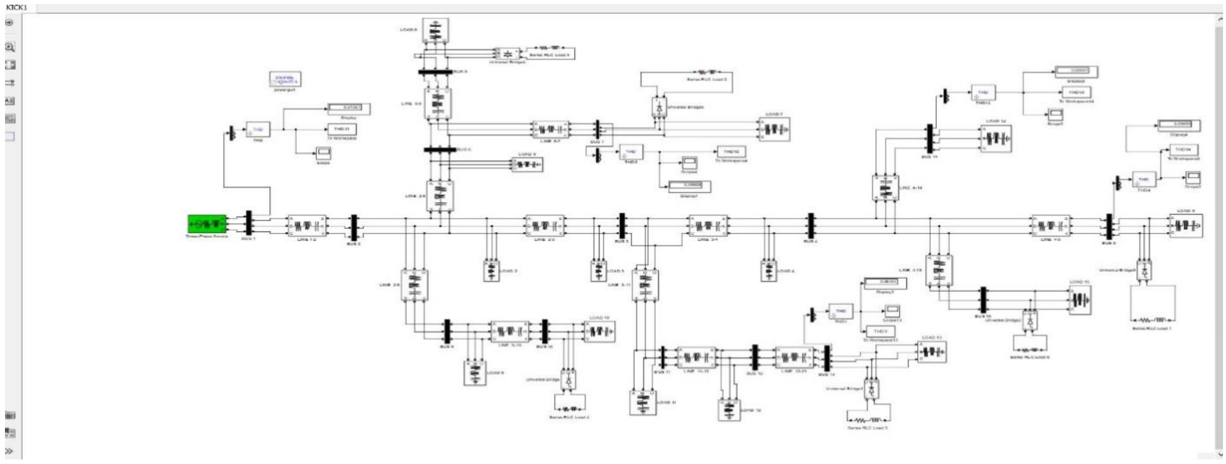

FIG.9 15-BUS SG

Results1. Response of the system after injecting CPDs.

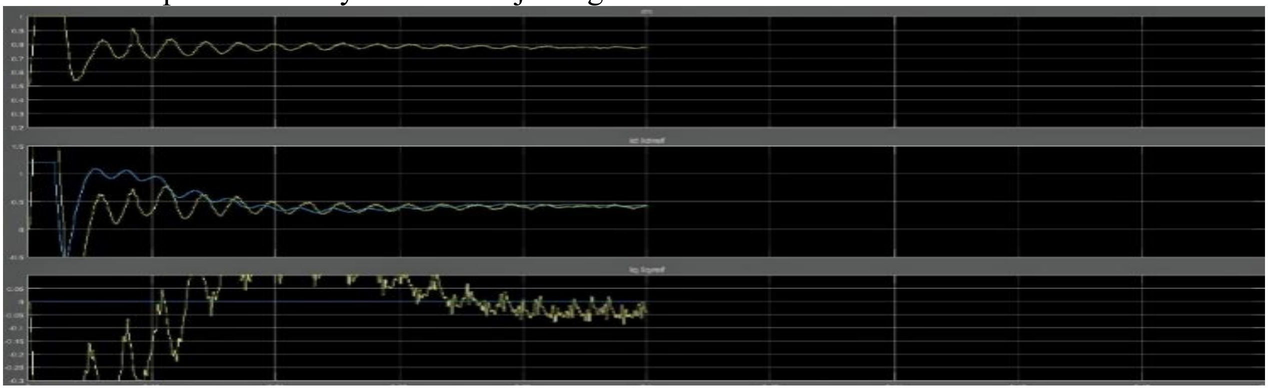

Fig. 10

The Particle Swarm optimization algorithm used for optimal allocation and rating of multiple CPDs. The size of CPD connected to bus k can be expressed as following.

$$I_k,\ cpd_{size} = \sqrt{\sum_{h=1}^{H} |Ik, \text{cpd}|^2} \quad k=1\ldots\ldots..n$$

Here k,h are the bus number and the harmonic order respectively while K and H reveal their maximum value.

The selected constraints associated are upper Vt and lower Vt limits for the fundamental bus voltages, upper limit for the total harmonic distortion maximum and upper limit for individual bus voltage harmonics according to the IEEE-519 [10] as well as an upper limit for the maximum size of each CPD.

Switching strategy of five level neutral clamped inverter.

S1	S2	S3	S4	S5	S6	S7	S8	Output
on	Off	Off	On	Off	Off	on	on	1/2Vdc
off	off	On	On	On	Off	On	On	Vdc
On	off	Off	On	Off	Off	On	On	1/2Vdc
off	off	Off	Off	Off	Off	Off	Off	zero
off	on	on	Off	Of	Off	On	On	1/2Vdc
off	off	On	On	Off	On	On	Off	-Vdc

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off	On	On	Off	Off	Off	On	On	1/2Vdc
off	off	Off	Off	Off	Off	Off	off	zero

TABLE 2 RATING AND PLACEMENT OF STSTCOMS FOR HARMONICS COMPESARTION:

BUS NO.	Voltage Harmonics [%]					THDv [%]	V_{fund} [pu]	Icpd [pu]	Icpd component[pu]	
	5	7	11	13	17				$I_{STATCOMS}$	I_{ALPC}
2	0.72	0.65	0.69	0.05	0.07	2.22	0.939	0	0	0
3	0.70	0.26	0.49	0.44	0.20	3.04	0.933	0.152	0.119	0.093
4	1.77	1.07	149	0.44	0.78	3.88	0.919	0	0	0
5	2.62	1.58	2.12	0.97	1.38	4.91	0.901	0	0	0
6	0.49	1.34	0.97	0.21	0.43	4.57	0.910	0.120	0.078	0.090
7	1.07	1.71	141	0.18	0.03	4.87	0.902	0	0	0
8	1.10	1.81	154	0.28	0.12	4.98	0.901	0	0	0
9	1.70	132	152	0.71	0.79	3.42	0.929	0	0	0
10	2.42	1.89	2.23	130	144	4.75	0.919	0	0	0
11	0.72	0.18	0.17	109	0.73	3.03	0.913	0	0	0
12	0.73	0.10	0.56	199	148	3.75	0.905	0	0	0
13	0.69	0.13	1.03	2.74	2.17	4.99	0.903	0.121	0.107	0.056
14	1.77	107	149	0.44	0.80	3.87	0.906	0	0	0
15	2.52	1.51	2.04	0.90	1.30	4.76	0.900	0	0	0
Ave.	1.39	104	127	0.84	0.84	4.07	0.910	-	-	-
TOTAL	-	-	-	-	-	-	-	0.393	0.304	0.239

PSO CONSTRAINTS		OPTIMAL LOCATIONS OF CUSTOM POWER DEVICES OF OPTIMIZATION		
Weighting factor		CPD1	CPD2	CPD3
W THD	W size	BUS5/0.05	BUS7/0.39	BUS8/0.015
0	1	BUS5/0.04	BUS8/0.15	BUS9/0.45
0.4	0.6	BUS4/0.05	BUS8/0.4	BUS8/0.48
0.8	0.2	BUS3/0.04	BUS6/0.5	BUS 13/0.5
1	0	BUS5/0.04	BUS5/0.4	BUS9/0.5

CONCLUSION:

The placement of STATCOM can enhance voltage profile, stability and reduces real power losses.To improvement in the power quality and voltage regulation. It makes system rapid faster compare to other FACTs devices. The role of nonlinear loads is to influence all levels of power system harmonics control.The custom power device controlled the total harmonics distortion of all buses under the valuable limit of 5% according to IEEE-519 standards also and the bus voltages above limit of 0.9pu. The objective function weighting factors also have significant impacts on custom power device siting/sizing solutions. Large values of Wsize result in more custom power device units with smaller total rating and total harmonic distortions in terms of voltages values approaches the upper limit of 5% while larger values of W_{THD} result in smaller THDv levels. Total harmonic distortion becomes 22 % to 4.89%.

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