Model Predictive Control of Four Level NNPC DSTATCOM for Power Quality Improvement in Distribution System

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***Abstract*—Two level Voltage Source Inverters (VSI) are the viable solution for Distribution Static Compensator (DSTATCOM) applications in secondary distribution system, where the voltage levels are either 415 V or 230 V. However, the limitations of two level VSIs in primary distribution system (3.3 kV - 33 kV) are the requirement of higher rating switches or series connection of lower rating switches, which motivates the replacement two level VSIs with multi-level inverters (MLI). Therefore, in this paper Model Predictive Control (MPC) of four level Nested Neutral Point Clamped (NNPC) MLI based DSTATCOM is proposed. In the proposed work cost function is framed as a combination of DSTATCOM currents and capacitor voltages which can compensate the current related power quality issues as well as eliminate the requirement of additional PI controllers for voltage regulation of flying capacitors . Weighting factors Tuning during multi constraint case is a tedious task. To overcome this limitation, a Multi-Criteria Decision Making (MCDM) method namely simple additive weighting method is used in the proposed work which reduces the difficulties in the weighting factor tuning. The performance of the proposed control algorithm is evaluated using simulation which shows the efficacy of the proposed control algorithm.**

***Index Terms*—DSTATCOM, Power Quality, MLI, MPC.**

I. INTRODUCTION

In the global market most of the industries are working under primary voltage distribution system, where the voltage levels are ranging from 3 kV to 33 kV. These industries require reactive and harmonic currents to operate their equipment's, which result in several current related power quality issues [1]. Distribution Static Compensator (DSTATCOM) is a shunt connected Custom Power Device (CPD), utilized to overcome these power quality issues [2], [3]. In literature, two-level Voltage Source Inverters (VSI) are used by most of the researchers to implement the DSTATCOM [4]. These two-level VSIs are very efficient solution in secondary distribution system. However, these topologies require either higher rating switches or series connected lower rating switches to achieve the required voltage rating in primary distribution system. The unavailability, increased cost and maintenance required by the higher rating switches and complex control of series connected switches, motivate the replacement of two-level inverters with Multi-Level Inverters (MLI) [5]. The other advantages of MLI are low dv/dt, THD and switching losses and the output filter size is also less [6], [7]. Among all the MLI's cascaded H-bridge (CHB), neutral point clamped (NPC) and flying capacitor (FC) topologies are treated as conventional topologies and they are used in most of the industrial applications [7]. However, the limitation of CHB is higher number of switches and phase shifting transformers, NPC is number of clamping diodes and FC is number of capacitors. These limitations are conquered by replacing them with a Nested Neutral Point Clamped (NNPC) inverter, which requires lesser number switches, clamping diodes and flying capacitors and it does not require transformers unlike CHB inverters [8]. Therefore, in this paper a four level NNPC inverter is used as DSTATCOM for reactive power compensation, harmonic mitigation and neutral current compensation. In general, DSTATCOM draw active power from distribution system to maintain constant voltage across its dc link. To achieve this measured dc link voltage is compared with the actual dc link voltage and the difference between them is passed through a PI controller to estimate the required active power component of the DSTATCOM. Similarly, it is required to regulate constant voltage across the flying capacitors of NNPC DSTATCOM and it is achieved using either improving the modulation technique or using additional PI controllers, which increases the control complexity. With traditional PWM and hysteresis controllers, the necessary number of PI controllers are proportionately increases with increase in number of capacitors which further increases the control complexity. The recent advancements in Model Predictive Control (MPC) has the flexibility of adding additional control parameters to the cost function such as capacitor voltages, which eliminate the requirement of additional PI controllers to reduce the control complexity [9], [10]. Therefore, in the proposed work cost function consists of current error and capacitor voltage error as two separate control parameters. However, the additional control parameter can be added to the cost function using a weighting factor and the tuning of weighting factor is an elusive task [11]. The evolution Multi-Criteria Decision Making Methods (MCDM) simplifies the selection of optimal switching state under multiple control parameter case. Therefore, in this paper one of the MCDM namely simple additive weighting method is applied to simplify the weighting factor selection for MPC [12].

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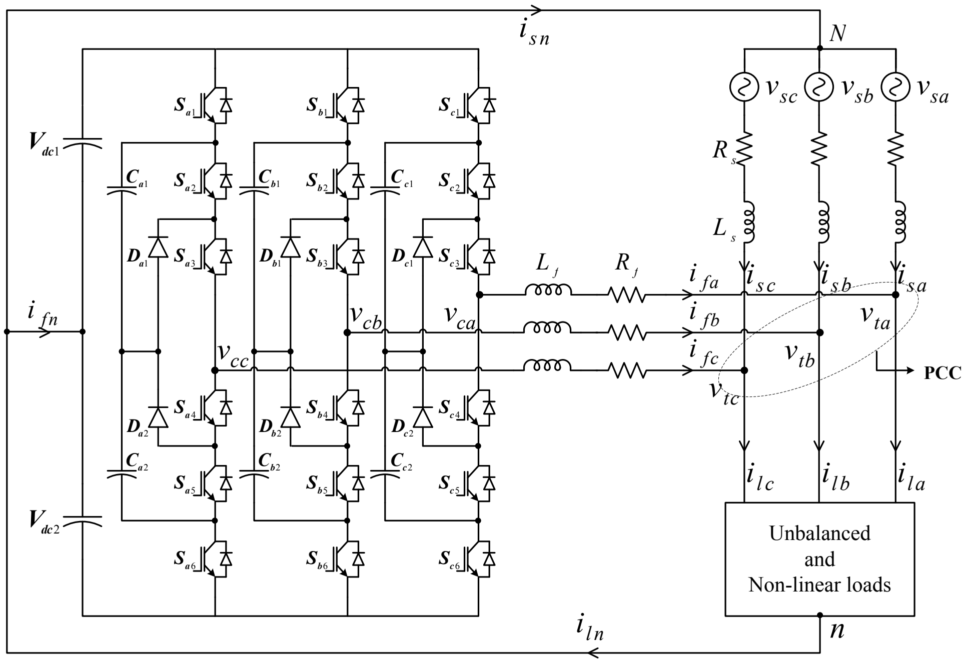

Fig. 1. Schematic diagram of NNPC DSTATCOM connected distribution system

Finally, in this paper, MPC of NNPC DSTATCOM is proposed for industrial applications in distribution system to mitigate the harmonic currents, compensate the reactive power and neutral currents. NNPC has the advantages of lower number of switches, clamping diodes and flying capacitors along with natural advantages of MLIs. The application of MPC eliminates the requirement of multiple PI controllers and simple additive weighting method simplifies the weighting factor selection process.

The proposed work is organized as follows. Section II of this paper is explanation about NNPC DSTATCOM and also concentrating on simple additive weighting method based MPC for DSTATCOM control. Simulation results are presented in section III followed by conclusion in final Section.

II. NNPC DSTATCOM along with Proposed Control Algorithm

The connection diagram of four level NNPC DSTATCOM connected to distribution system is shown in Fig. 1. In this topology, each leg is accompanied with 6 switches, 2 capacitors and 2 diodes to achieve four level voltage across its output terminals. The dc link of this DSTATCOM topology is shared by two capacitors and mid-point of it, is connected to the neutral wire to compensate the unbalance in load currents. The voltage across each dc link capacitor is half of the complete dc link voltage and in the same way flying capacitors of each leg are maintained to $\frac{1}{3}$ times of the dc link voltage. The output of the inverter is connected at Point of Common Coupling (PCC) using interfacing inductors, which eliminate the ripples in compensator currents. Control algorithm for NNPC DSTATCOM is shown in Fig. 2. The major tasks in the implementation of this control algorithm are reference current generation using synchronous reference frame theory, predictive model of NNPC DSTATCOM and cost function optimization using simple additive weighting method.

A. Reference current generation using Synchronous reference frame theory

Load currents, DSTATCOM currents, PCC voltages and dc link voltages are required to sense to implement this control algorithm. The sensed load currents are in abc-frame, using Parks transformation they are converted to dq frame. This parks transformation require the information about synchronization angle, which will be obtained by using a three-phase phase locked loop (PLL) and PCC voltages. The obtained d-axis and q-axis currents contain fundamental and harmonic components ($I_{ld} = \overline{I}_{ld} + \tilde{I}_{ld}$, $I_{lq} = \overline{I}_{lq} + \tilde{I}_{lq}$). However, to obtain the sinusoidal reference source currents with unity power factor it is necessary to eliminate the complete q-axis current and harmonic component from the d-axis current. Therefore the d-axis currents is passed through a low pass filter (LPF) to eliminate the harmonic component from it. Reference source currents is the combination of dc component of d-axis load current and the current required to maintain the constant voltage across the dc link of NNPC DSTATCOM ($I_s^* = \overline{I}_{ld} + \overline{I}_{dc}$). The error between reference and actual dc link voltage is passed through a PI controller which will generate the required reference source current component. The reference source currents converted to abc-frame using inverse Parks transformation. The implementation of Model Predictive Control (MPC) required reference DSTATCOM currents and they obtained by subtracting reference source currents from sensed load currents ($i_f^* = i_l - i_s^*$). The control of NNPC

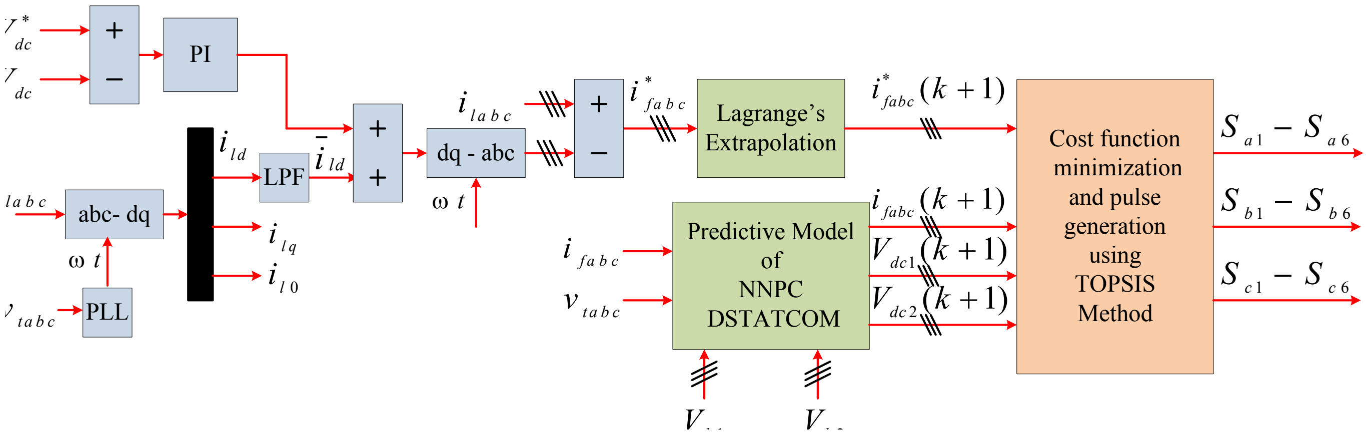

Fig. 2. Control algorithm for NNPC DSTATCOM

DSTATCOM with MPC involves the generation of future values of DSTATCOM currents using present currents, therefore it is also required to estimate the reference DSTATCOM currents at$(k+1)^{th}$ state from $i^*_f(k)$ using second order Lagrange extrapolation.

$$i^*_f(k+1) = 3i^*_f(k) - 3i^*_f(k-1) + i^*_f(k-2) \tag{1}$$

B. Predictive Model of NNPC DSTATCOM

The predictive model of the DSTATCOM is used to estimate the compensator currents and voltages of the flying capacitors at $(k+1)^{th}$ state. From Fig. 1, the output voltage of the inverter is the sum of voltage drop across the interfacing inductor and voltage at the PCC and it can be written as

$$v_c = L_f \frac{\mathrm{d}i_f}{\mathrm{d}t} + R_f i_f + v_t \tag{2}$$

$$\frac{\mathrm{d}i_f}{\mathrm{d}t} = \frac{(v_c - v_t)}{L_f} - \frac{i_f R_f}{L_f} \tag{3}$$

The above equation can be simplified using Forward Euler approximation, and according to this method

$$\frac{\mathrm{d}i_f}{\mathrm{d}t} = \frac{i_f(k+1) - i_f(k)}{T_s} \tag{4}$$

substitute (3) in (2) and simplify (2) for $i_f(k+1)$

$$i_f(k+1) = \frac{(v_c(k) - v_t(k))T_s}{L_f} + i_f(k)\Big(1 - \frac{R_f T_s}{L_f}\Big) \tag{5}$$

From (5), it is observed that DSTATCOM current at $(k+1)^{th}$ state is depending upon filter current, inverter output voltage and PCC voltage at k^{th} state. Similarly, it is necessary to find the expression for voltages of flying capacitors and the flying capacitors of the NNPC DSTATCOM are regulated to $(1/3)^{rd}$ of the dc link voltage. In general the voltage across flying capacitor at $(k+1)^{th}$ is depends upon present voltage and current flowing through the capacitor.

$$V_{dcj1}(t) = V_{dcj1}(0) + \frac{1}{C_{j1}} \int_{0+}^{t} i_{Cj1}(\lambda)\mathrm{d}\lambda$$
$$V_{dcj2}(t) = V_{dcj2}(0) + \frac{1}{C_{j2}} \int_{0+}^{t} i_{Cj2}(\lambda)\mathrm{d}\lambda. \tag{6}$$

The discrete time model of the above expression can be written as

$$V_{dcj1}(k+1) = V_{dcj1}(k) + \frac{T_s}{C_{j1}} i_{Ci1}(k)$$
$$V_{dcj2}(k+1) = V_{dcj2}(k) + \frac{T_s}{C_{j2}} i_{Cj2}(k). \tag{7}$$

where j=a,b,c and T_s represents the step time. In the above expression $V_{dcj1}(k)$ and $V_{dcj2}(k)$ can be measured directly using voltage sensing devices. $i_{Ci1}(k)$ and $i_{Cj2}(k)$ depends upon the switching state and current flowing through that phase and it is given as

$$i_{C1}(k) = (S_{j1} - S_{j2})i_f(k)$$
$$i_{C2}(k) = (S_{j5} - S_{j6})i_f(k) \tag{8}$$

C. Cost function formation

In the proposed control algorithm, cost function is the combination of filter currents and flying capacitor voltages. The cost function related to filter currents can be written as

$$C_1 = \mid i^*_f(k+1) - i_f(k+1) \mid \tag{9}$$

In the above equation $i^*_f(k+1)$ is given in (1) and $i_f(k+1)$ is given in (5). From (5) it is observed that, actual filter current is depending upon the inverter output voltage which in turn depends on the switching states. Each leg of the NNPC DSTATCOM have 6 switches and each phase is providing four outpt voltage levels. Therefore, NNPC DSTATCOM is having 64 different switching combinations. For each available switching state, the control algorithm will calculate the filter current and compare them with the reference filter currents.

TABLE I
VOLTAGE LEVELS WITH RESPECT TO SWITCHING STATES

State	S_1	S_2	S_3	S_4	S_5	S_6	v_c
N_2	0	0	0	1	1	1	$\frac{-V_{dc}}{2}$
N_1	1	0	0	1	1	0	$\frac{-V_{dc}}{6}$
P_1	0	1	1	0	0	1	$\frac{V_{dc}}{6}$
P_2	1	1	1	0	0	0	$\frac{V_{dc}}{2}$

The switching state which is giving the minimum error has to selected and applied for the next instant. Voltages with reference to switching states are given in Table 1. As mentioned, in addition to current control, it is required to regulate each flying capacitor of NNPC DSTATCOM to $1/3$ of the complete dc link voltage. Conventionally, each flying capacitor require a separate PI controller to regulate its voltage with respect to reference value. However, the advantage of MPC *i.e.*, easy inclusion and treatment of additional constraints can eliminate the requirement of additional PI controllers by simply including an additional control parameter in the already existing cost function. The cost function related to capacitor voltage is given as

$$\begin{aligned} C_2 =& \mid V_{dc}^* - V_{dca1}(k+1) \mid + \mid V_{dc}^* - V_{dca2}(k+1) \mid + \\ & \mid V_{dc}^* - V_{dcb1}(k+1) \mid + \mid V_{dc}^* - V_{dcb2}(k+1) \mid + \\ & \mid V_{dc}^* - V_{dcc1}(k+1) \mid + \mid V_{dc}^* - V_{dcc2}(k+1) \mid . \end{aligned} \tag{10}$$

As mentioned, the flying capacitors of the NNPC DSTATCOM is regulated to one third of the complete dc link voltage. Therefore, in (10) V_{dc}^* is considered as $\frac{V_{dc}}{3}$ and flying capacitor voltages will be obtained from (7). After framing the individual cost function, the complete sot function can be written as

$$C = C_1 + \lambda C_2 \tag{11}$$

where λ represents the weighting factor, which is used to balance the importance between the two cost functions. In general there is no proper way of selecting the weighting factor values and it is basically a trial and error type of selection and its value is ranging from $(0 - \infty)$. Therefore, the selection of tuning factor is a complex task. However, the Multi-Criteria Decision Making (MCDM) methods makes the selection of weighting factors very simple and easy in implementation. In the proposed work one of the MCDM method namely simple additive weighting method is used and the step by step procedure of this method is explained in the following section.

D. Cost function minimization using simple additive weighting method

It is mentioned that the cost function of the proposed control algorithm is formed using filter currents and flying capacitor voltages.

Step 1: Initially both the control parameters are evaluated for all the switching states and they are represented as

$$C_{PQ} = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \\ \vdots & \vdots \\ C_{p1} & C_{p2} \end{bmatrix}_{pq} \tag{12}$$

where 'p'represents the number of switching states which is equal to 64 and 'q'represents the number of individual cost functions which is equal to 2.

Step 2: Select the minimum and maximum values among the available values for both the cost functions.

$$\begin{aligned} C_{m1} = min(C_{i1}), C_{M1} = max(C_{i1}) \\ C_{m2} = min(C_{i2}), C_{M2} = max(C_{i2}) \end{aligned} \tag{13}$$

where 'i'varies from 1 to 'p'.

Step 3: In this step normalized data is calculated from the obtained values from step 1 and step 2, using the following formula.

$$X_{i1} = \sigma_1\Big(\frac{C_{m1} - C_{i1}}{C_{m1} - C_{M1}}\Big); X_{i2} = \sigma_2\Big(\frac{C_{m2} - C_{i2}}{C_{m2} - C_{M2}}\Big) \tag{14}$$

The values σ_1 and σ_2 depends upon the relative importance between the two cost function and the sum of σ_1 and σ_2 should be always equal to unity [11]. The primary objective of the of the proposed work is the minimization of current related power quality issues followed by capacitor voltage regulation. Therefore, in the proposed work the value of σ_1 is chosen as 0.75 (higher priority) and the value of σ_2 is chosen as 0.25.

Step 4: Calculate the summation of normalized data (ie $X_{i1} + X_{i2}$) for each available switching state.

$$Q = X_{i1} + X_{i2} \tag{15}$$

Step 5: Finally, select a switching state which will give the maximum value of Q and apply it for upcoming instant, which will reduce both current and voltage errors.

Table II shows switching state selection of NNPC DSTATCOM using simple additive weighting method. C_1, C_2 represents the values of individual cost functions for each available switching states. X_1, X_2 represents the normalized data obtained from C_1, C_2. It is already mentioned multiplication factors considered for C_1, C_2 are 0.75 and 0.25. It is observed from Table II that the maximum value of Q is 0.968723 and it is obtained for switching state $N_2P_1N_2$. This switching state will give third minimum current error and ninth minimum voltage error. Therefore, this state will be applied to the next sampling instant.

TABLE II
SWITCHING STATE SELECTION USING SIMPLE ADDITIVE WEIGHTING METHOD

State	C_1	C_2	X_1	X_2	Q
$N_2N_2N_2$	5.7245	16.7611	0.495608	0.211525	0.707132
$N_2N_2N_1$	5.6512	16.8187	0.50113	0.185635	0.686765
$N_2N_2P_1$	7.3029	16.7035	0.376695	0.237415	0.61411
$N_2N_2P_2$	8.9546	16.7611	0.25226	0.211525	0.463785
$N_2N_1N_2$	4.0728	16.7894	0.620043	0.198804	0.818847
$N_2N_1N_1$	3.9995	16.847	0.625565	0.172914	0.798479
$N_2N_1P_1$	5.6512	16.7318	0.50113	0.224694	0.725824
$N_2N_1P_2$	7.3029	16.7894	0.376695	0.198804	0.575499
$N_2P_1N_2$	**2.4211**	**16.7328**	**0.744478**	**0.224245**	**0.968723**
$N_2P_1N_1$	2.3478	16.7905	0.75	0.19831	0.94831
$N_2P_1P_1$	3.9995	16.6752	0.625565	0.250135	0.8757
$N_2P_1P_2$	5.6512	16.7328	0.50113	0.224245	0.725375
$N_2P_2N_2$	2.5623	16.7611	0.73384	0.211525	0.945365
$N_2P_2N_1$	2.489	16.8187	0.739362	0.185635	0.924997
$N_2P_2P_1$	4.1407	16.7035	0.614927	0.237415	0.852342
$N_2P_2P_2$	5.7924	16.7611	0.490492	0.211525	0.702017
$N_1N_2N_2$	5.7695	16.8844	0.492218	0.156104	0.648322
$N_1N_2N_1$	5.6962	16.942	0.49774	0.130214	0.627954
$N_1N_2P_1$	7.3479	16.8267	0.373305	0.182039	0.555344
$N_1N_2P_2$	8.9996	16.8844	0.24887	0.156104	0.404974
$N_1N_1N_2$	4.1178	16.9127	0.616653	0.143384	0.760036
$N_1N_1N_1$	4.0445	16.9703	0.622175	0.117494	0.739669
$N_1N_1P_1$	5.6962	16.855	0.49774	0.169319	0.667058
$N_1N_1P_2$	7.3479	16.9127	0.373305	0.143384	0.516689
$N_1P_1N_2$	2.4661	16.8561	0.741088	0.168824	0.909912
$N_1P_1N_1$	2.3928	16.9137	0.74661	0.142934	0.889544
$N_1P_1P_1$	4.0445	16.7985	0.622175	0.194714	0.816889
$N_1P_1P_2$	5.6962	16.8561	0.49774	0.168824	0.666564
$N_1P_2N_2$	2.6073	16.8844	0.73045	0.156104	0.886554
$N_1P_2N_1$	2.534	16.942	0.735972	0.130214	0.866186
$N_1P_2P_1$	4.1857	16.8267	0.611537	0.182039	0.793576
$N_1P_2P_2$	5.8374	16.8844	0.487102	0.156104	0.643206
$P_1N_2N_2$	7.4212	17.1455	0.367783	0.038745	0.406528
$P_1N_2N_1$	7.3479	17.2031	0.373305	0.012855	0.38616
$P_1N_2P_1$	8.9996	17.0878	0.24887	0.06468	0.31355
$P_1N_2P_2$	10.6513	17.1455	0.124435	0.038745	0.16318
$P_1N_1N_2$	5.7695	17.1738	0.492218	0.026025	0.518242
$P_1N_1N_1$	5.6962	17.2314	0.49774	0.000135	0.497875
$P_1N_1P_1$	7.3479	17.1161	0.373305	0.05196	0.425265
$P_1N_1P_2$	8.9996	17.1738	0.24887	0.026025	0.274895
$P_1P_1N_2$	4.1178	17.1172	0.616653	0.051465	0.668118
$P_1P_1N_1$	4.0445	17.1748	0.622175	0.025575	0.64775
$P_1P_1P_1$	5.6962	17.0596	0.49774	0.077355	0.575095
$P_1P_1P_2$	7.3479	17.1172	0.373305	0.051465	0.42477
$P_1P_2N_2$	4.259	17.1455	0.606015	0.038745	0.64476
$P_1P_2N_1$	4.1857	17.2031	0.611537	0.012855	0.624392
$P_1P_2P_1$	5.8374	17.0878	0.487102	0.06468	0.551782
$P_1P_2P_2$	7.4891	17.1455	0.362667	0.038745	0.401412
$P_2N_2N_2$	9.0729	16.7611	0.243348	0.211525	0.454872
$P_2N_2N_1$	8.9996	16.8187	0.24887	0.185635	0.434505
$P_2N_2P_1$	10.6513	16.7035	0.124435	0.237415	0.36185
$P_2N_2P_2$	12.303	16.7611	0	0.211525	0.211525
$P_2N_1N_2$	7.4212	16.7894	0.367783	0.198804	0.566587
$P_2N_1N_1$	7.3479	16.847	0.373305	0.172914	0.546219
$P_2N_1P_1$	8.9996	16.7318	0.24887	0.224694	0.473564
$P_2N_1P_2$	10.6513	16.7894	0.124435	0.198804	0.323239
$P_2P_1N_2$	5.7695	16.7328	0.492218	0.224245	0.716463
$P_2P_1N_1$	5.6962	16.7905	0.49774	0.19831	0.69605
$P_2P_1P_1$	7.3479	16.6752	0.373305	0.250135	0.62344
$P_2P_1P_2$	8.9996	16.7328	0.24887	0.224245	0.473115
$P_2P_2N_2$	5.9107	16.7611	0.48158	0.211525	0.693105
$P_2P_2N_1$	5.8374	16.8187	0.487102	0.185635	0.672737
$P_2P_2P_1$	7.4891	16.7035	0.362667	0.237415	0.600082
$P_2P_2P_2$	9.1408	16.7611	0.238232	0.211525	0.449757

III. SIMULATION RESULTS

In this section the performance NNPC DSTATCOM has analyzed for non linear and unbalanced loads using simulation. Various parameters considered for the simulation are mentioned in Table III. Load-1 is connected to the supply through out simulation, and Load-2 is turned on at 1 s, to validate the performance of the control algorithm during transient operation. Fig. 3, shows the performance of the NNPC DSTTACOM during transient operation. During 0.9 to 1 s, rms values of the load currents are 346.8 A, 283.5 A, 240 A with THDs 34.36%, 35.26%, 35.93% respectively for a, b and c phases. These values indicates that the load currents are unbalanced and non-linear. NNPC DSTATCOM injects currents to compensate the unbalance and non-linearity in the load currents. The rms values of source currents are 266.8 A, 267.8 A, 267.3 A with THDs 2.28%, 2.18%, 2.10%, which indicates that they are balanced and sinusoidal. From Fig. 3, it is observed that source current and PCC voltage are in-phase, which indicates that the power factor is unity. Load-2 is connected to the supply at 1 s and the performance of the compensator during transient operation is satisfactory which is observed form Fig. 3. During Load-2, the rms values of source currents are 424.5 A, 425.6 A, 426.3 A and the THDs are 1.39%, 1.34%, and 1.29%.

TABLE III
SIMULATION PARAMETERS

Parameter	Value
Supply voltage	3300 V
Feeder Impedance	0.07 Ω, 0.2 mH
Interfacing Inductor	2 mH
DC link voltage	8000 V
DC link capacitance	2600 μF
Flying capacitor	2600 μF
Flying capacitor voltage	(8000/3) V
Load-1	Three single phase diode bridge rectifiers with RL loads 4Ω, 150 mH on a phase 5Ω, 150 mH on b phase 6Ω, 150 mH on b phase
Load-2	Three phase diode bridge rectifier with RL load values as 20Ω, 50 mH
Sampling time (T_s)	10 μs

The second function of the proposed control algorithm is related to voltage regulation of flying capacitors. As mentioned that, the voltage across the flying capacitor is regulated to $\frac{1}{3}V_{dc}$. Fig. 4, shows the complete dc link voltage and voltage across the individual flying capacitors. The DC link of the NNPC DSTATCOM is regulated to 8000 V, where as the individual flying capacitor is regulated to 2666 V.

Fig. 5 shows the neutral currents of load, DSTATCOM and source. From this figure it is observed that, the entire neutral current is flowing through the DSTATCOM which makes source currents balanced and current flowing through the source neutral is almost zero. Fig. 6, shows the phase angle relation between voltage and current at the PCC. From this figure, it is observed that, before compensation the power

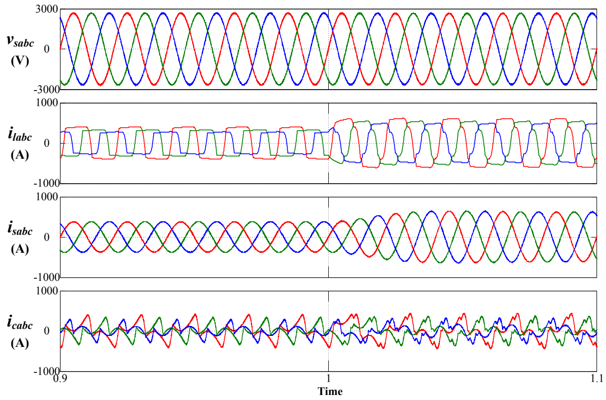

Fig. 3. DSTATCOM performance during transient operation

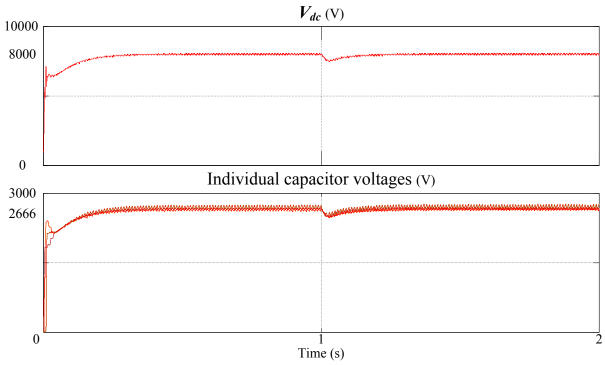

Fig. 4. Voltages across capacitors

factor is not unity. Whenever NNPC DSTATCOM is connected to the system, it makes source power factor unity, which means the complete reactive power required by the load is supplied by the DSTATCOM.

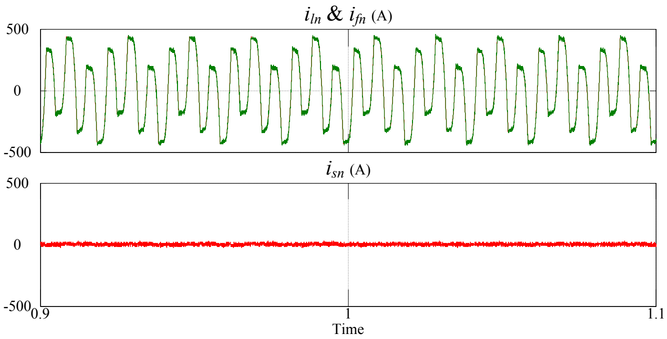

Fig. 5. Neutral currents

IV. Conclusion

In this paper MPC of NNPC DSTATCOM is proposed to compensate the current relate power quality problems such as harmonic, reactive and neutral currents and also to maintain constant voltage across each flying capacitor. The cost function of the proposed control algorithm contains two control parameters, one is to compensate the current related power quality

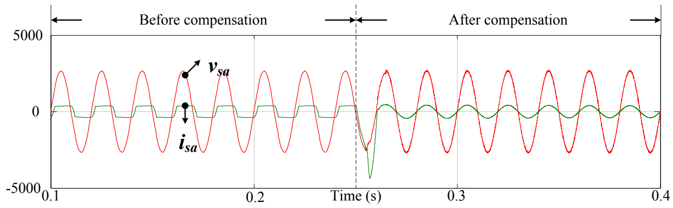

Fig. 6. Unity power factor operation

issues and the other is to maintain constant voltage across the flying capacitors of NNPC DSTATCOM. Simplification of weighting factor tuning during multi-constraint case is achieved using simple additive weighting method, which will reduce the weighting factor range from $(0-\infty)$ to $(0-1)$. Finally, simulation results proved that the control algorithm is simple and efficient.

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