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A Novel Power Quality Improvement of Matrix Converter Based Upfc

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ABSTRACT

This research shows how to use an improved direct power control approach (DPC) to make 3-phase matrix converters work as unified power flow controllers (UPQCs). Matrix converters (MCs) convert direct ac/ac power without dc energy storage connection characteristics; as a result, the Matrix Converter-with-UPFC (MC-UPFC) has reduced cost and volume, reduced capacitor power losses, and improved performance and stability. For an MC-UPFC dynamic representation consisting of one of the input filters, theoretical analysis of direct power control (DPC) with sliding mode control arrangements is recognised. As a consequence, ac supply reactive power may be directly regulated by selecting an appropriate matrix converter switching state that ensures good steady-state and dynamic responses, resulting in decreased volume and cost, as well as lower capacitor power losses and increased dependability. As a result, line active and reactive powers, as well as ac supply reactive power, may be directly regulated by selecting the right matrix converter operating state, ensuring high-quality steady-state and dynamic response conditions. DPC controllers' experimental outputs for MC-UPFC show a decoupled active and reactive power regulator with 0% steady-state tracking error and rapid reaction times. The experimental results of the advanced DPC-MC assure closer responses without producing overshoot and no steady-state faults, acquiring no cross-coupling in steady-state and dynamic approachment, when compared to a Matrix Converter-UPFC by active and reactive power linear modulators with a modified Venturing very high-frequency PWM controller.

Index Terms— Matrix Converter (MC), Direct Power Controlstechnique (DPC), And Unified Power-Flow Controller (UPFC), Power Factor.

I. INTRODUCTION

In recent years, deregulation of the energy market, along with increased investment, social issues, and environmental concerns, has made it more difficult to harm fossil fuels and obtain new licences to construct transmission line arrangements and high-power facilities. As a result of these circumstances, localised power production from non-conventional energy resources has increased. By delivering power flow during different lines, unified power-flow controllers (UPFC) make the process of power transmission networks approaching their maximum needs easier. UPFCs are now one of the most appealing, versatile, and powerful flexible ac transmission systems (FACTS) techniques available. The UPFC is the consequence of a shared dc connection capacitor between a static synchronous series compensator (SSSC) and a static synchronous compensator (STATCOM). A dc bank capacitor causes auxiliary losses, reduces converter life time, and increases the converter's cost, weight, and size. In recent decades, there has been a growing interest in innovative converter approaches that are capable of performing the same activities but using less storage. These converters are capable of creating the requisite ac/ac conversion capability by utilising bidirectional power electronic devices, ensuring near to appropriate sinusoidal input and output currents, voltages of irregular magnitude, and a variable power factor. These ac/ac converters with the least energy storage have the potential to allow separate reactive power regulators on the UPFC series and shunt converter positioned, while ensuring that the active power transmitted on the UPFC series is always absorbed/supplied by the STATCOM shunt association. The robustness of traditional UPFC regulators is unknown. Finally, the MC-ability UPFC's to modulate the whole collection of power flow was evaluated by determining the confidence of the matrix converter's output voltage on the regulation coefficient. Nonlinear arrangements in the modern era have shifted to improved control of PI controller components. Even yet, nonlinear robust modulators have the potential to recover more from the dynamic response of UPFCs. Direct power control approaches have been chosen in many power requiems in recent years due to their simplicity and high quality performance. The future DPC-MC control technique is designed, is associated with sliding mode-control arrangements, and accepts the real-time required assortment of adequate matrix vectors to manage input and output required electrical power in order to propose UPFCs, developing healthy behaviour to parameter considerations in variations and to instability. When referred to proportional-integral (PI) linear controller arrangements generated from linear reactive and active power circuits of UPFC with a regulated Venturing high-frequency PWM controller, sliding mode technique includes DPC-MC can maintain without zero steady-state faults and good tracking performance, and no overshoots, quick dynamic response conditions, while being easier to execute and acquiring less switching power. The developed DPC-MC P, Q control technique's steady-state and dynamic performance is operated and described utilising extensive simulation findings and experimental advancements. Using the nonlinear DPC technique for matrix converter dependent UPFC equipment, experimental and MATLAB/Simulation results explain decoupled active series and reactive power control by shunt/series, zero steady-state error tracking arrangement, and quick operating and switching times, acquiring errorless steady-state and dynamic responses.

II. MODELING OF THE UPFC POWER SYSTEM

2.1 General Architecture

An easiest power transmission network arrangement by the implemented matrix converter-UPFC is accessible in Fig. 1, where V_s and V_r are, the sending-end sinusoidal voltage and receiving-end produced voltages of the G_s and G_r generators associating with load Z_L correspondingly. The matrix converter is associated to transmission line 2, designed as a series resistance with series inductance (R_2 L_2 and L_2), during transformers coupling T_1 and T_2 . Fig.2 represents the reduced three-phase corresponding circuit of the matrix converter UPFC transmission arrangement model. For scheme of modeling, the power considerations and the transformers coupling are all treated as ideal. Moreover, the matrix converter is preferred ideal and performed like as a convenient voltage source, with required magnitude V_c and phase ρ. In the correspondent circuit, is to maintain required load bus voltage, The DPC-MC controller will pleasure the basic parameters as instability. Preferring a symmetrical and objective three-phase schemeand employing Kirchhoff laws to the three-phase corresponding circuit (Fig. 2), the ac transmission line currents are developed in **dq** coordinates

$$\frac{dI_d}{dt} = \omega I_q \frac{R_2}{L_2} I_d + \frac{1}{L_2}(V_{LD} - V_{Rod}) \dots (1)$$

$$\frac{dI_Q}{dt} = \omega I_d \frac{R_2}{L_2} I_q + \frac{1}{L_2}(V_{Lq} - V_{Roq}) \dots (2)$$

The active and reactive power of distribution end the generator are specified in **dq** originates

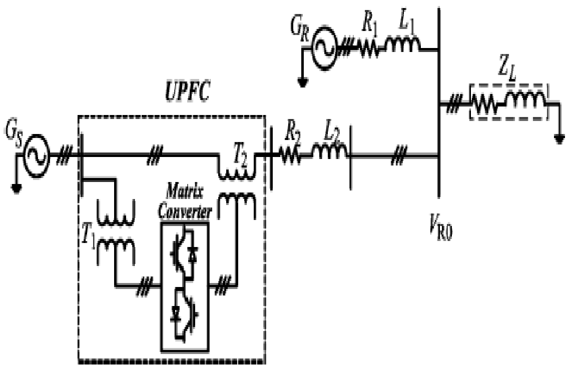
$$\begin{matrix} P \\ Q \end{matrix} = \begin{matrix} V_d & -V_q \\ V_q & V_d \end{matrix} * \begin{matrix} I_d \\ I_q \end{matrix} ..(3)$$

ConsideringV_{Rod}andV_{sd} as fixed and a moving rotating required frame modulated to the $sendig\ voltage\ V_s$ source therefore thatV_{sq} =0, active and reactive power P and Q are agreed by (4) and (5), correspondingly,

P=$V_d\ I_d$ …(4)

Q=$-V_d\ I_q$ …(5)

Dependent on the preferred active power and reactive powerP_{ref},Q_{ref} can be premeditated from (4) and (5) for current regulators. Nevertheless, permitting P, Q actual powers are susceptible to faults in the V_d ,V_q standards.



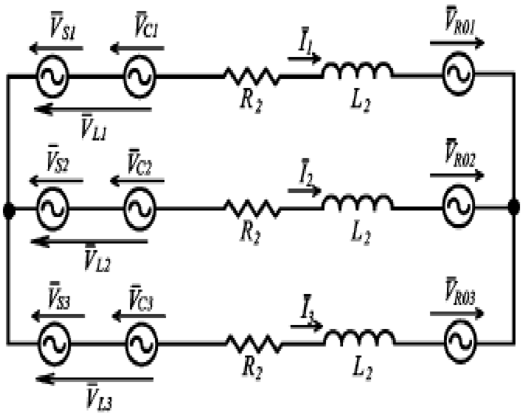


Fig.1.Transmission network with matrix converter UPFC Fig2Three-phase equivalent circuit of the matrix UPFC and transmission line

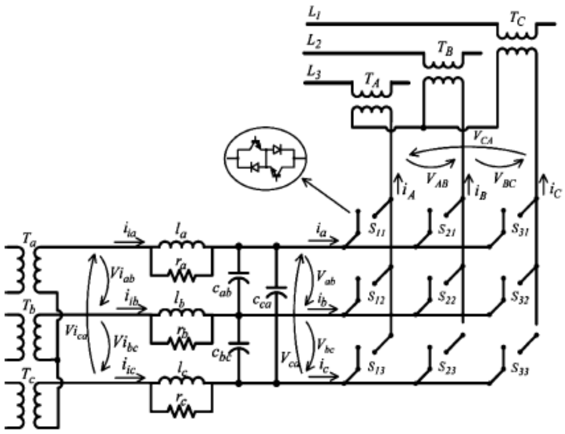


Fig.3Transmission Network with Matrix Converter UPFC

2.2 Matrix Converter Output Voltage and Input Current Vectors

A figure of the UPFC arrangement (Fig. 3) consisting of the three-phase input shunt transformer the three-phase series transformer and also used the three-phase matrix converter, designed by using an array of nine bidirectional IGBT switches $S_{kj}$with Switched-on and triggered-off ability, accepting the association of each one of three output phases straight to any individual of the three contribution (input) phases. The 3-phase (LC_r) input filter is necessary to reproduce a voltage-source limit to the matrix converter, preferring smooth and flexible input currents.

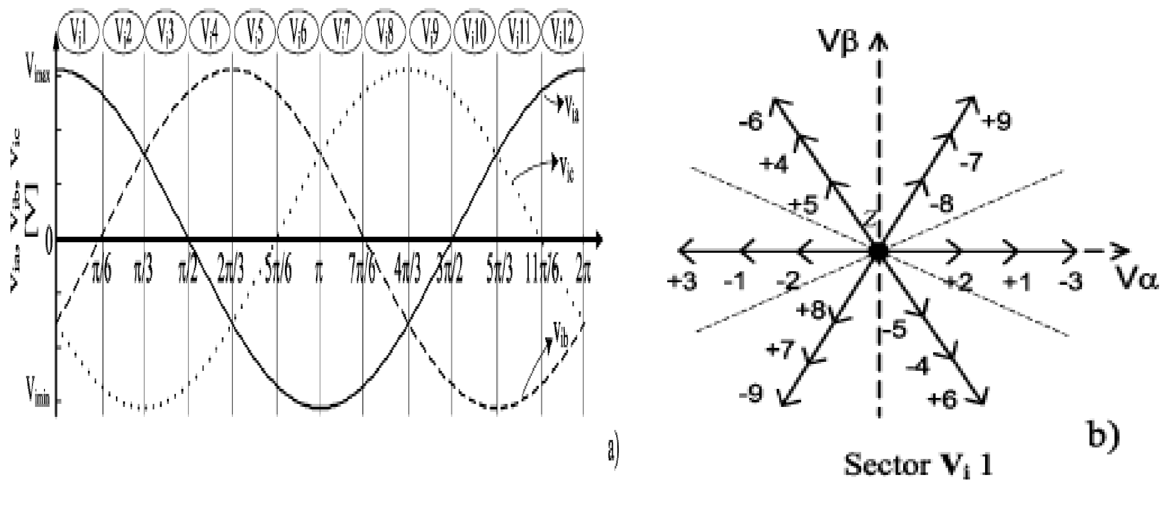


Fig.4.(a) Input voltages and their consequent sector. (b) Produced Output voltage state-space vector waveforms when the input voltages are located at sectorV_{i1}. Employing dq originates to the input filter state parameters available in Fig. 3 and desertion the function of the damping resistors, the below equations and calculations are implemented.

$$\frac{dI_D}{dt} = \omega I_q - \frac{1}{2\,L} V_d - \frac{1}{\sqrt[3]{3}L} V_q + \frac{1}{L} V_{id}$$

$$\frac{dIQ}{dt} = -\omega I_d - \frac{1}{2\,L} V_q + \frac{1}{\sqrt[3]{3}L} V_d + \frac{1}{L} V_{iq}$$

$$\frac{dV_d}{dt} = \omega V_q + \frac{1}{2\,C} I_{id} - \frac{1}{\sqrt[3]{3C}} I_{iq} - \frac{1}{2\,C} I_d + \frac{1}{\sqrt[3]{3C}} I_q$$

$$\frac{dV_q}{dt} = -\omega V_d + \frac{1}{2\,C} I_{iq} + \frac{1}{\sqrt[3]{3C}} I_{id} - \frac{1}{2\,C} I_q - \frac{1}{\sqrt[3]{3C}} I_q \;\ldots(6)$$

Where $V_{id}, V_{iq}, I_{id}, I_{iq}$ stand for, input currents and input voltages in **dq** variables correspondingly (at the shunt connected transformer secondary) and V_d, V_q, I_d, I_q represents those are input currents and voltages of matrix converter in **dq** system, respectively.

Considering ideal semiconductors, everyone in matrix converter acts as a bidirectional switch $S_{kij}(k, j \in \{1, 2, 3\}$ can guess two achievable states: "$S_{kij} = 1$ " if the switch is stopped or "$S_{kij} = 0$" if the switch is release. The nine matrix converter power electronic devices can be denoted as a 3*3 matrix (7)

$$S = \begin{matrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{matrix} \ldots(7)$$

The matrix converter model variable simples $\sum_{j=1}^{3} S_{kij}$.=1

Depended on (7), the association between load and input voltages can be uttered as

$$T[V_A \quad V_B \quad V_C] = S[V_a \quad V_b \quad V_c]T\ldots(8)$$

The source phase currents can be connected to the produced phase currents (9), with the transpose of matrix

$$[I_a \quad I_b \quad I_c]T = S[I_A \quad I_B \quad I_C]T\ldots(9)$$

From the 27 probable switching developments, time-variant vectors can be implemented in (Table I) denoting the matrix develops the voltages and source currents $\propto \beta$ in originates, and drowned in the $\propto \beta$ structure [Fig. 4(b)].

The active and reactive power controller DPC-MC will choose one of these 27 vectors at any specified time immediate

.III. DIRECT POWER CONTROL OF MC-UPFC

3.1 Line Active and Reactive Power Sliding Surface

The sliding method control assumption methodology is used to create DPC modulators for line power flow at this moment. As shown in Fig. 2, resource is needed in a steady condition. The currents of the transmission line may be measured using state values with first-order internal values based on the sources and switching period of impedance, as shown in (1) and (2) $\frac{L2}{R2}$. As a result, the transmission line's active and reactive powers are generated first-order dynamic responses with a well-built relative degree of one, because its first time derivative previously consisted of the control parameters from the perspective of control (the strong relative motion commonly designs the number of times the modulate required output variable should be modulated until a control input presents clearly in the dynamics performance). Assuming proportionality to a linear arrangement of the errors of the state variables apparatus, a robust sliding surface area to modulate the active and reactive variables with a relatively strong degree of one may be generated using the sliding method control assumption. Consequently, define the active power faults and the reactive power problem as the dive rgence between the powers required references$P_{ref}, Q_{ref}$and the actual power delivering P, Q equally

$e_p = P_{ref} - P$..(10)

$e_Q = Q_{ref} - Q$(11)

Then, the healthy sliding circumstances,$S_p\,(e_p\,,t)$and $S_Q\,(e_Q\,,t)$should be relative to these problems, being zero after accomplishment sliding approach

$S_p\,(e_p\,,t) = K_p\,\left(P_{ref} - P\right) = 0$..(12)

$S_Q\,(e_Q\,,t) = K_Q\,\left(Q_{ref} - Q\right) = 0$..(13)

The relative gains K_p and K_Q are selected to require suitable operating frequencies.

Group	Name	A	B	C	v_{AB}	v_{BC}	v_{CA}	i_a	i_b	i_c	V_o	δ_o	I_i	μ_i
	1g	a	b	c	v_{ab}	v_{bc}	v_{ca}	i_A	i_B	i_C	v_i	δ_i	$\sqrt{3}i_o$	μ_o
	2g	a	c	b	$-v_{ca}$	$-v_{bc}$	$-v_{ab}$	i_A	i_C	i_B	$-v_i$	$-\delta_i+4\pi/3$	$\sqrt{3}i_o$	$-\mu_o$
I	3g	b	a	c	$-v_{ab}$	$-v_{ca}$	$-v_{bc}$	i_B	i_A	i_C	$-v_i$	δ_i	$\sqrt{3}i_o$	$-\mu_o+2\pi/3$
	4g	b	c	a	v_{bc}	v_{ca}	v_{ab}	i_C	i_A	i_B	v_i	$\delta_i+4\pi/3$	$\sqrt{3}i_o$	$\mu_o+2\pi/3$
	5g	c	a	b	v_{ca}	v_{ab}	v_{bc}	i_B	i_C	i_A	v_i	$\delta_i+2\pi/3$	$\sqrt{3}i_o$	$\mu_o+4\pi/3$
	6g	c	b	a	$-v_{bc}$	$-v_{ab}$	$-v_{ca}$	i_C	i_B	i_A	$-v_i$	$-\delta_i+2\pi/3$	$\sqrt{3}i_o$	$-\mu_o+4\pi/3$
	+1	a	b	b	v_{ab}	0	$-v_{ab}$	i_A	$-i_A$	0	$\sqrt{2/3}v_{ab}$	0	$\sqrt{2}i_A$	$-\pi/6$
	-1	b	a	a	$-v_{ab}$	0	v_{ab}	$-i_A$	i_A	0	$-\sqrt{2/3}v_{ab}$	0	$-\sqrt{2}i_A$	$-\pi/6$
	+2	b	c	c	v_{bc}	0	$-v_{bc}$	0	i_A	$-i_A$	$\sqrt{2/3}v_{bc}$	0	$\sqrt{2}i_A$	$\pi/2$
	-2	c	b	b	$-v_{bc}$	0	v_{bc}	0	$-i_A$	i_A	$-\sqrt{2/3}v_{bc}$	0	$-\sqrt{2}i_A$	$\pi/2$
	+3	c	a	a	v_{ca}	0	$-v_{ca}$	$-i_A$	0	i_A	$\sqrt{2/3}v_{ca}$	0	$\sqrt{2}i_A$	$7\pi/6$
	-3	a	c	c	$-v_{ca}$	0	v_{ca}	i_A	0	$-i_A$	$-\sqrt{2/3}v_{ca}$	0	$-\sqrt{2}i_A$	$7\pi/6$
	+4	b	a	b	$-v_{ab}$	v_{ab}	0	i_B	$-i_B$	0	$\sqrt{2/3}v_{ab}$	$2\pi/3$	$\sqrt{2}i_B$	$-\pi/6$
	-4	a	b	a	v_{ab}	$-v_{ab}$	0	$-i_B$	i_B	0	$-\sqrt{2/3}v_{ab}$	$2\pi/3$	$-\sqrt{2}i_B$	$-\pi/6$
II	+5	c	b	c	$-v_{bc}$	v_{bc}	0	0	i_B	$-i_B$	$\sqrt{2/3}v_{bc}$	$2\pi/3$	$\sqrt{2}i_B$	$\pi/2$
	-5	b	c	b	v_{bc}	$-v_{bc}$	0	0	$-i_B$	i_B	$-\sqrt{2/3}v_{bc}$	$2\pi/3$	$-\sqrt{2}i_B$	$\pi/2$
	+6	a	c	a	$-v_{ca}$	v_{ca}	0	$-i_B$	0	i_B	$\sqrt{2/3}v_{ca}$	$2\pi/3$	$\sqrt{2}i_B$	$7\pi/6$
	-6	c	a	c	v_{ca}	$-v_{ca}$	0	i_B	0	$-i_B$	$-\sqrt{2/3}v_{ca}$	$2\pi/3$	$-\sqrt{2}i_B$	$7\pi/6$
	+7	b	b	a	0	$-v_{ab}$	v_{ab}	i_C	$-i_C$	0	$\sqrt{2/3}v_{ab}$	$4\pi/3$	$\sqrt{2}i_C$	$-\pi/6$
	-7	a	a	b	0	v_{ab}	$-v_{ab}$	$-i_C$	i_C	0	$-\sqrt{2/3}v_{ab}$	$4\pi/3$	$-\sqrt{2}i_C$	$-\pi/6$
	+8	c	c	b	0	$-v_{bc}$	v_{bc}	0	i_C	$-i_C$	$\sqrt{2/3}v_{bc}$	$4\pi/3$	$\sqrt{2}i_C$	$\pi/2$
	-8	b	b	c	0	v_{bc}	$-v_{bc}$	0	$-i_C$	i_C	$-\sqrt{2/3}v_{bc}$	$4\pi/3$	$-\sqrt{2}i_C$	$\pi/2$
	+9	a	a	c	0	$-v_{ca}$	v_{ca}	$-i_C$	0	i_C	$\sqrt{2/3}v_{ca}$	$4\pi/3$	$\sqrt{2}i_C$	$7\pi/6$
	-9	c	c	a	0	v_{ca}	$-v_{ca}$	i_C	0	$-i_C$	$-\sqrt{2/3}v_{ca}$	$4\pi/3$	$-\sqrt{2}i_C$	$7\pi/6$
	z_a	a	a	a	0	0	0	0	0	0	0	-	0	-
III	z_b	b	b	b	0	0	0	0	0	0	0	-	0	-
	z_c	c	c	c	0	0	0	0	0	0	0	-	0	-

Table I .Switching Combinations and Output Oltage/Input Current State-Space Vectors

3.2 Line Active and Reactive Power Direct Witching Laws

The DPC needs a nonlinear law, depended on the e_p and e_Q faults and to choose in genuine time the matrix converter conducting stages (vectors). Because there are no controllers and/or pole zero-aligned methods, high regulating speed is probable. To assurance permanence for active power and reactive power regulators to control the sliding-mode continuous circumstances (14) and (15) should be demonstrated

$S_p\left(e_p, t\right) \dot{S_p}\left(e_p, t\right) < 0$ (14)

$S_Q\left(e_Q, t\right) \dot{S_Q}\left(e_Q, t\right) < 0$ (15)

These surroundings denote that condition $S_p\left(e_p, t\right)>0$, then the $S_p\left(e_p, t\right)$ value should be minimized; significance that its time derived must be negative $S_p\left(e_p, t\right) < 0$. Likewise if, next $S_p\left(e_p, t\right) > 0$.

Considering to (12) and (14), the Scenario to decide the matrix vector must be

Condition $S_p\left(e_p, t\right) > 0 \rightarrow \dot{S_p}\left(e_p, t\right) < 0 \rightarrow P < P_{ref},$

$then\ select\ a\ vector\ sufficient\ to\ enhance\ p.$

Condition $S_p\left(e_p, t\right) < 0 \rightarrow \dot{S_p}\left(e_p, t\right) > 0 \rightarrow P > P_{ref},$

$then\ select\ a\ vector\ sufficient\ to\ reduced\ p.$

Condition $S_p\left(e_p, t\right) = 0, then\ select\ \ a\ vector\ which\ does\ not$

$specified\ variable\ the\ active\ power\ generation..$ (16)

The same process should be functional to the reactive power faults.

IV. CONCLUSION

This study provides improved non-linear direct power regulators for matrix converters connected with power transmission lines such as UPFCs, which are regulated utilising dependent sliding method control techniques. The implemented DPC can manage active and reactive power flow favourably, as demonstrated by MATLAB/simulation and testing results. The results show no steady-state defects, no susceptibility to no-modulated dynamics, no cross-coupling effects, and short reaction times, indicating that the achievable nonlinear DPC attitude is likely to be presented. With a tailored Venturing high-frequency PWM modulator technique, the resulting DPC-MC outputs were examined and validated to PI-linear active and reactive power regulators. As a consequence, ac supply reactive power may be directly regulated by selecting an appropriate matrix converter switching state that ensures good steady-state and dynamic responses, resulting in decreased volume and cost, as well as lower capacitor power losses and increased dependability. Even if the dynamic response method is correct, the PI presentation is poor when compared to DPC. Furthermore, PI regulators are controllers, and calculating a PWM modulator takes a long time. DPC is a physically powerful nonlinear manage contender for line active power and reactive power flow control, according to the results. It generates transmission-line power management as well as appropriate reactive power or power factor modulation at the transport end.

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