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Power Quality Improvement in DTC of Induction Motor Drive Using VSC Based UPFC

Abu Talib[1], Prof. Gautam Kumar Panda[2], Prof. Pradip Kumar Saha[3]

PG Scholar, Department of Electrical Engineering, Jalpaiguri Government Engineering College, Jalpaiguri, West Bengal, India [1]

HOD and Professor, Department of Electrical Engineering, Jalpaiguri Government Engineering College, Jalpaiguri, West Bengal, India [2]

Professor, Department of Electrical Engineering, Jalpaiguri Government Engineering College, Jalpaiguri, West Bengal, India [3]

ABSTRACT: A The Power Quality (PQ) in distribution system is affected during its starting when it draws large current. Voltage Sag is one of the Power Quality problem created by the induction motor. When it is connected to a source, there is a dip in the voltage which could be critical for the entire system. The power electronics based fact devices called unified power flow control (upfc) used in this paper to improve power quality during starting of induction motor with dtcscheme . The result will be analysed by comparing the THD of the source side with and without upfc. Among all control methods for induction motor drives, Direct Torque Control (DTC) seems to be particularly interesting being independent of machine rotor parameters and requiring no speed or position sensors.This paper is aimed to analyze DTC of induction motor with statcom for power quality improvement.

KEYWORDS: Direct torque control (DTC), induction motor, Power Quality, Voltage Source Converter (VSC), UPFC, THD

I.INTRODUCTION

The DTC based induction motor drive (IMD) uses a single-phase or three-phase uncontrolled ac-dc converter (for rectification of ac mains voltage), an energy storage element (capacitor filter for smoothening the dc link voltage), and a three-phase voltage source inverter (VSI) for feeding a three-phase squirrel cage induction motor. Such type of utility interface suffers from problems related to power quality such as poor power factor, injection of current harmonics into the ac mains, variation in dc link voltage with fluctuations in the voltage of input ac supply, equipment overheating due to harmonic current absorption, voltage distortion at the point of common coupling (PCC) due to the voltage drop caused by harmonics currents flowing through system impedance and decreased rectifier efficiency. These power quality problemscan cause malfunction of sensitive electronic equipments, interference in telephone and communication lines due to highfrequency switching, failure of switching capacitors and other power equipment and loss of data.

Early UPFC generally used the zigzag transformer in the main circuit topology as voltage source inverter. However, the zigzag transformer has some difficulties, which is hard to overcome in terms of cost, transformer loss as well as the control. When the inverter is used as the main circuit topology, UPFC has a little floor space, easy to split-phase control, high reliability, and easy expansion of capacity, etc. In addition, because it has no use for the zigzag transformer, it makes the existing UPFC free of the most serious problems such as device over-voltage caused by the magnetic saturation and nonlinearity in the transformer excitation circuit .So the inverter structure for large capacity STATCOM is concerned by a large number of engineering designers more and more.

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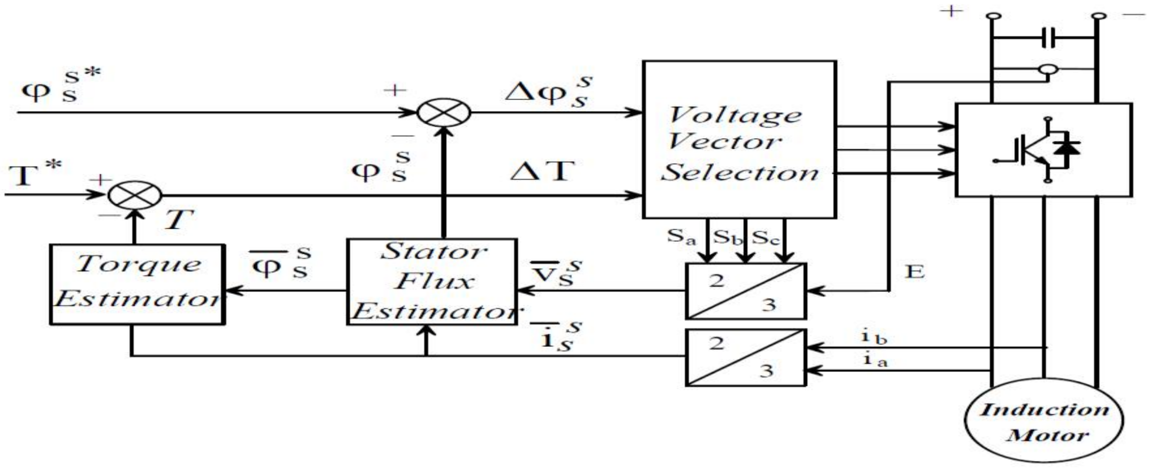
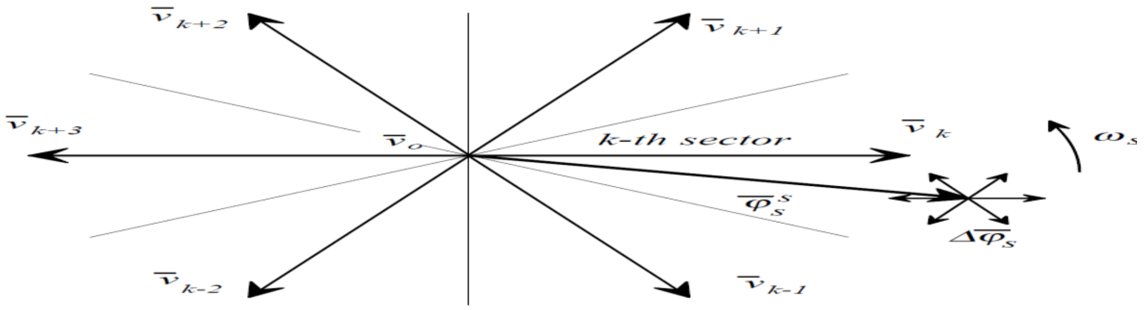
II. DTC BASED INDUCTION MOTOR DRIVE

In principle the DTC method selects one of the six nonzero and two zero voltage vectors of the inverter on the basis of the instantaneous errors in torque and stator flux magnitude.



Assuming the voltage drop Rsiss small, the stator flux is driven in the direction of the stator voltage v ss

$\Delta\overline{\varphi}_s^s \cong \overline{v}_s^s \, \Delta T$ where□ T is the sampling period



$v_k \Longrightarrow$ radial positive voltage vector
$v_{k+1} \Longrightarrow$ forward positive "
$v_{k+2} \Longrightarrow$ forward negative "
$v_{k+3} \Longrightarrow$ radial negative "
$v_{k-1} \Longrightarrow$ backward positive "
$v_{k-2} \Longrightarrow$ backward negative "
v_0 e $v_7 \Longrightarrow$ zero "

The flux variation is proportional to E, □ T and has the same direction of the voltage vector applied

ROTOR FLUX AND TORQUE VARIATION

From the general equations written in the rotor reference frame, we can derive

$$\overline{\varphi}_r^r = \frac{L_m}{L_s}\,\frac{1}{1+s\sigma\tau_r}\,\overline{\varphi}_s^r \qquad \text{with} \qquad \sigma = 1-\frac{L_m^2}{L_s L_r}$$

This equation shows the nature of rotor flux dynamic response for changes in stator flux

$$T = \frac{3}{2}p\frac{L_m}{\sigma L_s L_r}\,\overline{\varphi}_s^r \bullet j\,\overline{\varphi}_r^r = \frac{3}{2}p\frac{L_m}{\sigma L_s L_r}\,\varphi_s\,\varphi_r\,\sin\vartheta_{sr}$$

Any stator flux vector variation determines a torque variation on the basis of two contributions

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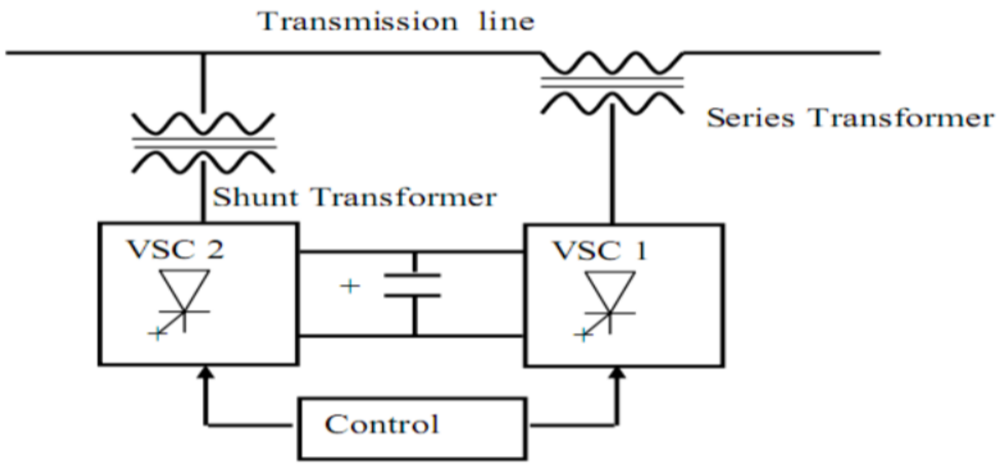
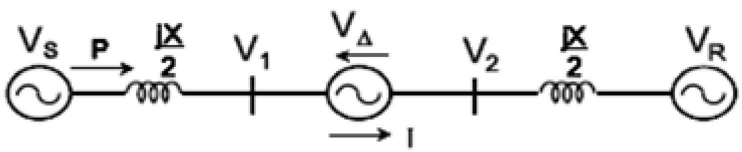
I) The variation of the stator flux magnitude
II) The variation of the stator flux phase angle with respect to rotor flux
Any command which causes the flux angle to change will determine a quick torque variation.

III. WORKING OF UPFC



The basic components of the UPFC are two voltage source inverters (VSIs) connected by a common dc storage capacitor which is connected to the power system through a coupling transformers. One (VSIs) is connected in shunt to the transmission system through a shunt transformer, while the other (VSIs) is connected in series to the transmission line through a series transformer. Three phase system voltage of controllable magnitude and phase angle (Vc) are inserted in series with the line to control active and reactive power flows in the transmission line. So, this inverter will exchange active and reactive power with in the line. The shunt inverter is operated in such a way as to demand this dc terminal power (positive or negative) from the line keeping the voltage across the storage capacitor (Vdc) constant. So, the net real power absorbed from the line by the UPFC is equal to the only losses of the inverters and the transformers. The remaining capacity of the shunt inverter can be used to exchange reactive power with the line so to provide a voltage regulation at the connection point.

The two VSI‟s can work independently from each other by separating the dc side. So in that case, the shunt inverter is operating as a (STATCOM) that generates or absorbs reactive power to regulate the voltage magnitude at the connection point. The series inverter is operating as (SSSC) that generates or absorbs reactive power to regulate the current flowing in the transmission line and hence regulate the power flows in the transmission line. The UPFC has many possible operating modes.



WITHOUT UPFC:-
I=2(V/X)sin(§/2); P=(V ^{2}/2sin§)
WITH UPFC:-
V=Vc*Jx/I;I=(2/X)(Vsin(§/2)-Vc/2)

IV. SIMULATION

With the help of the MATLAB Simulink model of three phase induction motor and UPFC is easily established .The following figure (shows the various parts of the motor model with

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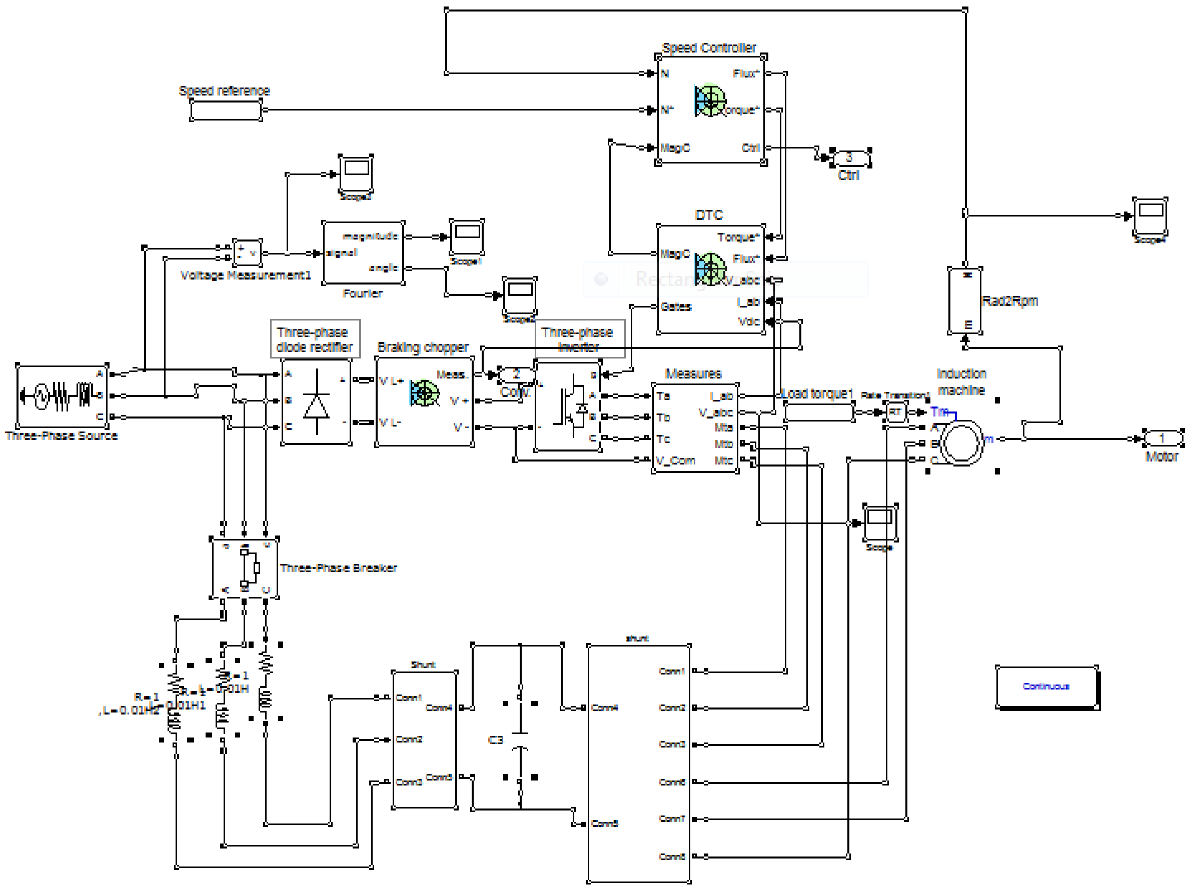

The speed controller is based on a PI regulator, shown below. The output of this regulator is a torque set point applied to the DTC controller block.The Torque & Flux calculator block is used to estimate the motor flux αβ components and the electromagnetic torque. This calculator is based on motor equation synthesis.The αβ vector block is used to find the sector of the αβ plane in which the flux vector lies. The αβ plane is divided into six different sectors spaced by 60 degrees.The Flux & Torque Hysteresis blocks contain a two-level hysteresis comparator for flux control and a three level hysteresis comparator for the torque control. The description of the hysteresis comparators is available below.The Switching table block contains two lookup tables that select a specific voltage vector in accordance with the output of the Flux & Torque Hysteresis comparators. This block also produces the initial flux in the machine.The Switching control block is used to limit the inverter commutation frequency to a maximum value specifiedby the user.

V. RESULTS AND DISCUSSIONS

Performance of the DTC based IMD is studied for both the configurations namely, with and without UPFC.
Waveforms consist of Fourier and FFT of source phase voltage (vas)rotor speed (Nr), electromagnetic torque (Te) for the rating of 5 HP, 460V, 60Hz, 1750rpm
The ac mains voltage waveform and its harmonic spectra at load is shown in which show that THD at no load.
From these results it can be concluded that it is necessary to use improved power quality converters at front end ofthe DTC based IMD. As the next step, a UPFC is employed in the waveforms of a DTC based IMD for load conditions fed from a STATCOM at the front end are shown in The ac mains current and its harmonic spectra for load.Fourier response with response show ripple within .09% and .07% with stacom. It can be noted that the THD of ac mains voltage at load is 0.01%. A significant improvement as compared to the case without UPFC where THD is 24.9%.Fourier response with and without statcom are shown

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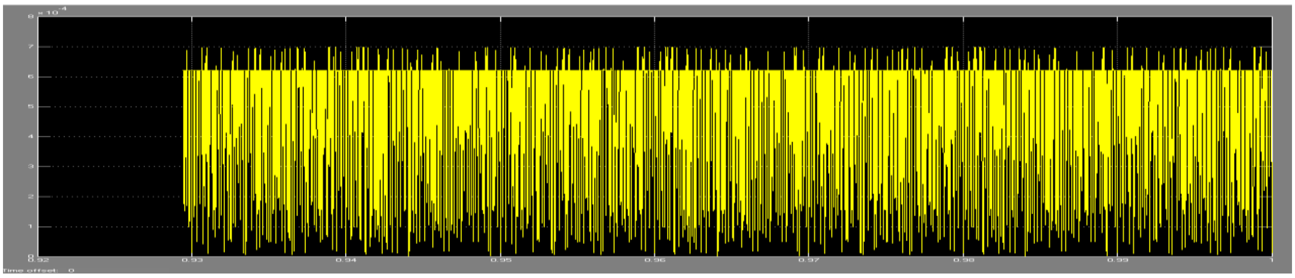
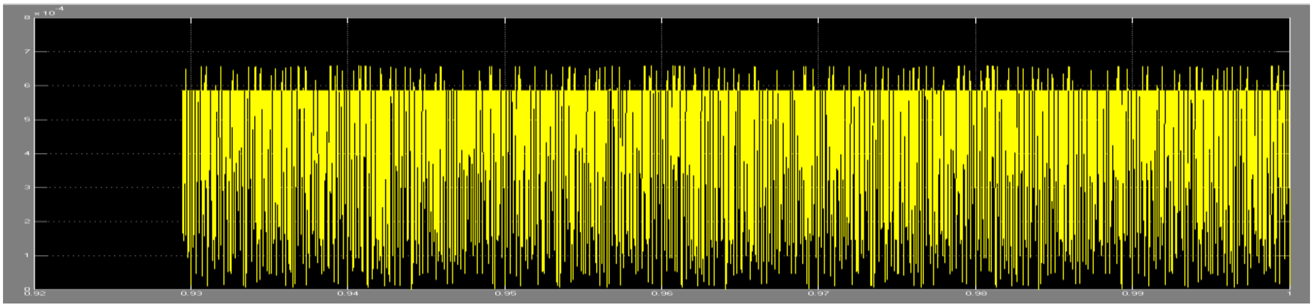
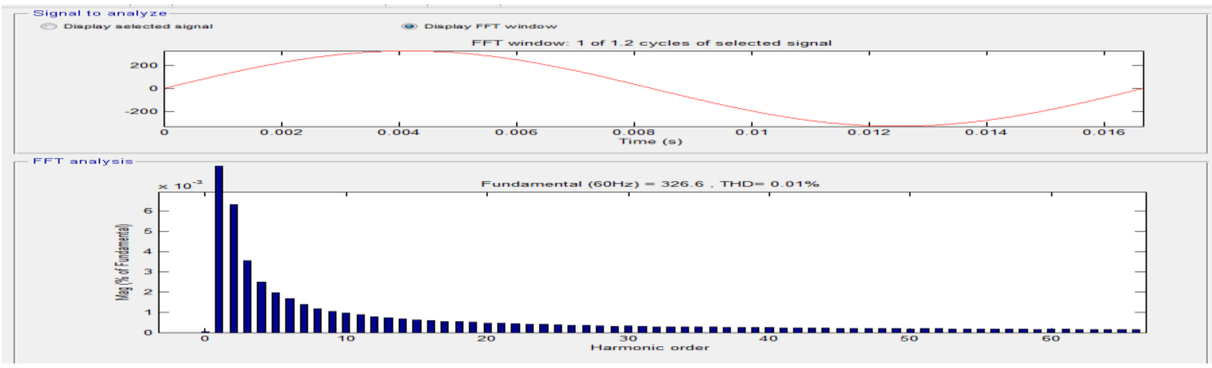
A. Without UPFC

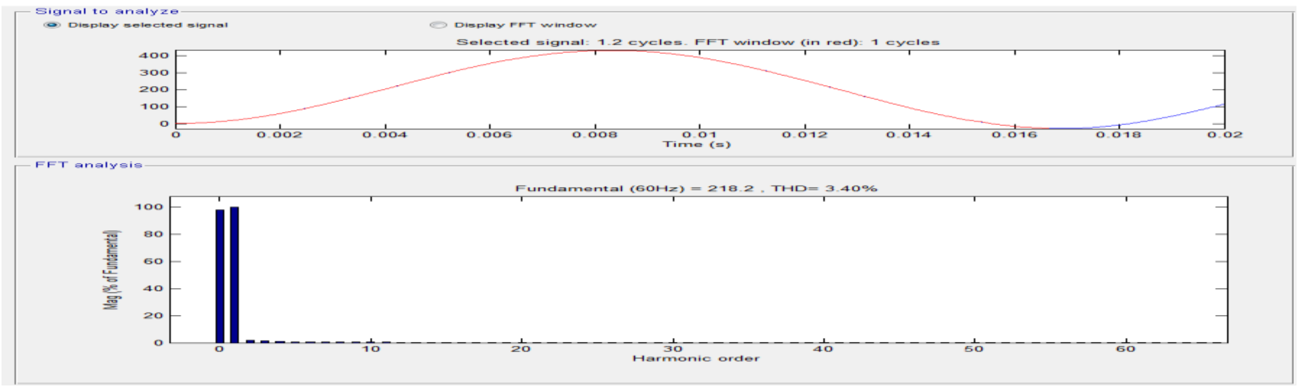


B.With UPFC



C.FFT (WITHOUT UPFC) THD=24.9%





D.FFT(WITH UPFC) THD=3.4%

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BIOGRAPHY

Abu Talib was born in West Bengal, India on May 02,1990He received his B.Tech degree in Electrical Engineering from Kalyani Government Engineering College, Kalyani, Nadia, West Bengal in 2012,currently he is doing M.Tech degree in Power Electronics and Drives from Jalpaiguri Govt. Engineering College, Jalpaiguri, West Bengal

Prof. Gautam Kumar Panda, Professor and Head, Department of Electrical Engineering,Department of Electrical Engineering, Jalpaiguri Government Engineering College, Jalpaiguri,WB- 735102,BE (Electrical) from J.G.E. College, Jalpaiguri, M.E.E(Electrical) Specialization: Electrical Machines & Drives from Jadavpur University.PhD from University of North Bengal. FIE, MISTE, Certified Energy Auditor.

Prof. Pradip Kumar Saha, Professor, Jalpaiguri Government Engineering College, Jalpaiguri,WB- 735102. BE (Electrical) from B.E. College, Shibpore. M.Tech((Electrical) Specialization: Machine Drives & Power Electronics from IIT- Kharagpur.PhD from University of North Bengal. FIE, MISTE, Certified Energy Auditor.