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Design and Control of 3-Phase, 4-Wire, 4-Leg VSC Based D-Statcom Using Synchronous Reference Frame Theory

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Abstract

Using A Synchronous Reference Frame (Srf)-Based Control Algorithm, This Paper Presents A Three-Phase, Four-Leg, Vsi-Based Ac Shunt D-Statcom Feeding Ac Voltage Controller With A Resistive-Inductive (Rl) Load For Maintaining Upf And Reducing Harmonic Current. When A Non-Linear Load Is Fed By A Three-Phase Source, This Theory Is Used To Calculate The Compensating Current. The Sim-Power System (Sps) Toolbox Is Used In The Matlab Environment To Simulate An Unbalanced Load In Pfc Mode.

1. Introduction

In Addition To The Burden Of Reactive Power, Unbalanced Phase Loading, And Harmonic Current Injection, The Distribution System, Particularly Three-Phase, Four-Wire Systems, Faces These Issues In The Current Era. Unbalanced Phase Loading Results In The Flow Of Neutral Current And An Unbalanced Load At The Load Point In A Three-Phase, Four-Wire System. On The Load Side, This Results In The Issue Of Poor Power Quality. With The Assistance Of Dstatcom Connected At The Point Of Common Coupling (Pcc), These Issues With Power Quality Can Be Resolved. Because Of This, There Is No. Of Dstatcom Topologies Like An H-Bridge Vsc With A Star-Delta Transformer, Three Single-Phase Vscs, And A Four-Leg Vsc [5]. Now, A "No" For Controlling The Switches. Of Control Algorithms Like The Synchronous Reference Theory (Srf) And The Instantaneous Reactive Power Theory (Irp). Bhattacharya And Others Have Examined This Classic Time-Domain Control Theory. For Load Balancing And Neutral Current Compensation, A Three-Phase, Four-Leg, Four-Wire Vsi-Based Dstatcom Is Used In The Following Paper. The Midpoint Of The Fourth Leg Of Dstatcom Is Connected To The Neutral Terminal In The Design Topology, And Its Switching Is Controlled So That The Neutral Current Is Zero.

The Aerospace Power Supply, The Voltage And Frequency Controller For An Isolated Wind Energy System, And The Grid-Connected Electrical Vehicle Charging Station Are All Examples Of Statcom Applications. The Primary Component Of An Active Power Filter, A Voltage Source Inverter (Vsi) That Is Operated In A Current-Controlled Mode, Was Developed To Address The Issue Of Poor Power Quality. Transformed Voltage And Current Signals Can Be Used To Calculate The Instantaneous Active And Reactive Power.

If We Are Able To Substitute Positive Sequence Voltages For Unbalance Supply Voltages In The Control Algorithm Based On The Instantaneous Symmetrical Components

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Theory For Both Stiff And Non-Stiff Sources, This Algorithm Performs Exceptionally Well. The Instantaneous Reactive Power Theory, Power Balance Theory, Indirect Current Control Technique, And Other Control Methods Have All Been Incorporated. An Indirect Current Control Method And A Synchronous Reference Frame Theory (Srf)-Based Control Algorithm Are Used To Implement A Four-Leg Vsc-Based Dstatcom In This Study. The Compact Power Circuit, Magnetic Circuit-Free Neutral Current Compensation, And Simple Dc Bus Voltag Maintenance Of The Four-Leg, Single-Capacitor Vsc Topology

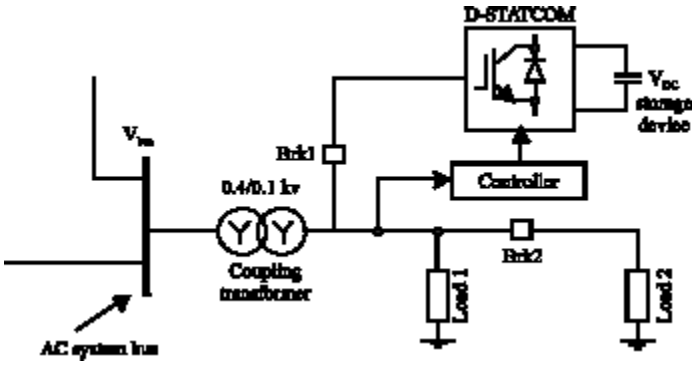

Fig.1 Schematic Diagram Of Test Circuit Of Dstatcom To Be Built In PSCAD

2. Literature Review

Customers' And Utilities' Awareness Of Power Quality Has Increased As A Result Of An Increasing Demand For High-Quality, Dependable Electrical Power And An Increasing Number Of Distorted Loads. Power Electronic Devices Like Flexible Ac Transmission System (Facts) And Custom Power Devices Have Introduced A New Technology That Gives The Power System Versatile New Control Capabilities For Improving Power Quality (Enslin, 1998; Singh And Other, 1999). Voltage Dips Are A Problem That Many Businesses And Utilities Face Today, Making Them One Of The Most Prevalent Issues With Power Quality. It Is Responsible For More Than 80% Of Power System Power Quality (Pq) Issues (Roger Et Al., 1996). A Voltage Dip Is When The Magnitude Of The Rms Voltage Decreases For A Brief Period Of Time (10 Msec To 1 Min). One Of The Most Common Causes Of Voltage Drops On Overhead Lines Is Lightning Faults. Based On The Vsc Principle, The Distribution Static Compensator Is The Most Efficient Of These. The D-Statcom's Two-Level Vsc's Electronic Valves Are Being Controlled By A Brand-New Pwm-Based Control Scheme.

The Idea Of Custom Power Is Based On The Use Of Power Electronic Controllers In Distribution Systems To Provide Dependable Power (Acha Et Al., 2002; 1995 Hingorani; Taylor And Others, 1995; Woodley And Other, 1995). Power Quality Goals Are Added To The List Of Reliability Objectives: Low Phase Unbalance, Tight Voltage Regulation, No Power Outages, And Low Harmonic Distortion (Sabin And Sundaram, 1996). There Were Initially Three Fundamental Components To The Family Of Custom Power Controllers

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(Hingorani, 1995; Taylor And Others, 1995): The Dynamic Voltage Restorer (Dvr), The Static Compensator (Dstatcom), And The Solid-State Breaker (Ssb). For Power Quality (Pq) Enhancements, A Distribution Static Compensator Is A Solid-State Power Controller With Rapid Response That Offers Adaptable Voltage Control At The Utility Distribution Feeder Connection Point. By Altering The Amplitude And Phase Angle Of The Converter Voltage In Relation To The Line Terminal Voltage, It Is Able To Exchange Both Active And Reactive Power With The Distribution System

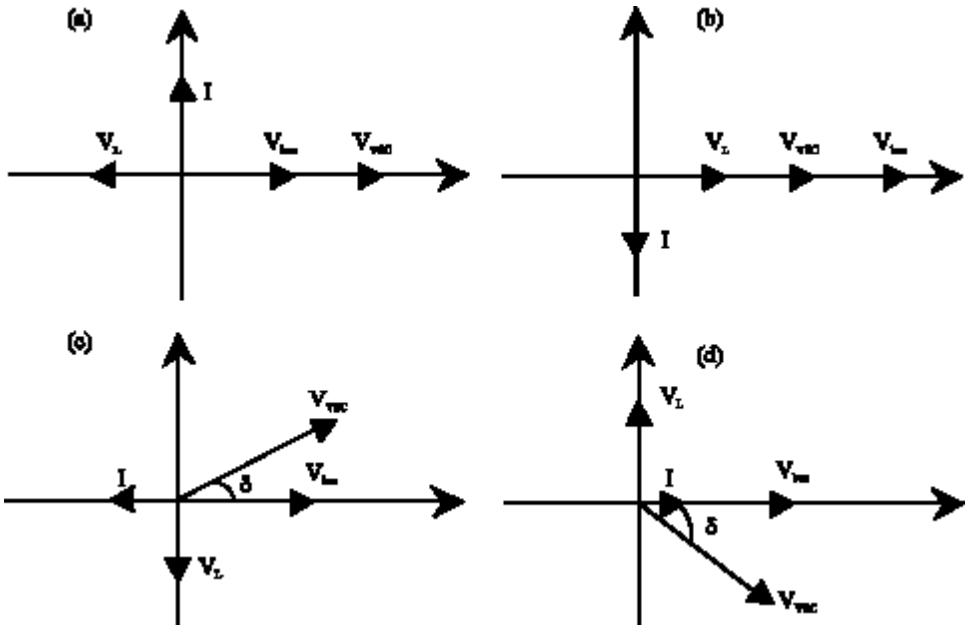

Fig.2 Vector Diagram Of D-Statcom (A) Capacitive Mode, (B) Inductive Mode, (C) Active Power Release And (D) Active Power Absorption

The Purpose Of Dstatcom Is To Control Reactive Power In Sync With System Voltage And Suppress Voltage Variation. Linearly And Continuously, It Can Compensate For Inductive And Capacitive Currents. The Vector Diagram For Capacitive And Inductive Modes, As Well As The Transition States From Capacitive To Inductive And Vice Versa, Is Depicted In Figure 3 At The Fundamental Frequency. In Both Capacitive And Inductive Modes, The Voltage Across The Coupling Transformer Reactance Vl And The Inverter Voltage (Vvsc) Are Equal To The Terminal Voltage (V Bus). I Mean That Dstatcom Supplies Reactive Power To The System If The Bus Terminal Voltage (Vbus) And Dstatcom's Output Voltage (Vvsc) Are In Phase. Additionally, Dstatcom Absorbs Reactive Power From The Power System If Vvsc Is Smaller Than Vbus. Although They Share The Same Phase, Vbus And Vvsc Actually Have A Small Phase Difference To Make Up For The Loss Of Transformer Winding And Inverter Switching. As A Result, They Draw Some Actual Power From The System

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3. Proposed System

Fig. 1 (A) Depicts The Fundamental Circuit Diagram Of The 3-Phase, 4-Wire, 4-Leg Vsc-Based Ac Shunt Dstatcom. The Resistive-Inductive (Rl) Load Of Three Single-Phase Ac Voltage Controllers Is Connected In Parallel To The Dstatcom Via A Three-Phase, Four-Wire System. The Synchronous Reference Frame (Srf) Theory Is Used To Generate The Switching Signals For The Six Igbts On The Three Legs Of Dstatcom. The Igbts On The Fourth Leg Are Connected So That The Neutral Current Is Zero. As A Result, Load Compensation And Neutral Current Elimination Are Achieved Using This Approach. In Order To Reduce The Ripple In The Injected Current And Connect The Voltage Source Converter (Vsi) To The System, Ac Inductors Are Used. To Lessen The Pcc Voltage Injection Ripple During Dstatcom Switching, Rc Filters Are Used In Parallel With The Load. Iii. Control Algorithm Fig. 1 (B) Depicts The Control Algorithm's Block Diagram. The System Voltages Va, Vb, And Vc, As Well As The Load Currents Ila, Ilb, And Ilc, Are Sensed And Utilized For The Generation Of A Reference Current. This Reference Current Is Then Utilized To Generate The Switching Signals For The Three Legs Of Dstatcom. The Following Transformation Is How Three-Phase Load Current Is Transformed Through The Park Transformation Into Two-Phase Revolving Vector Current With Direct Axis Id, Quadratic Axis Iq, And Zero Sequence I0

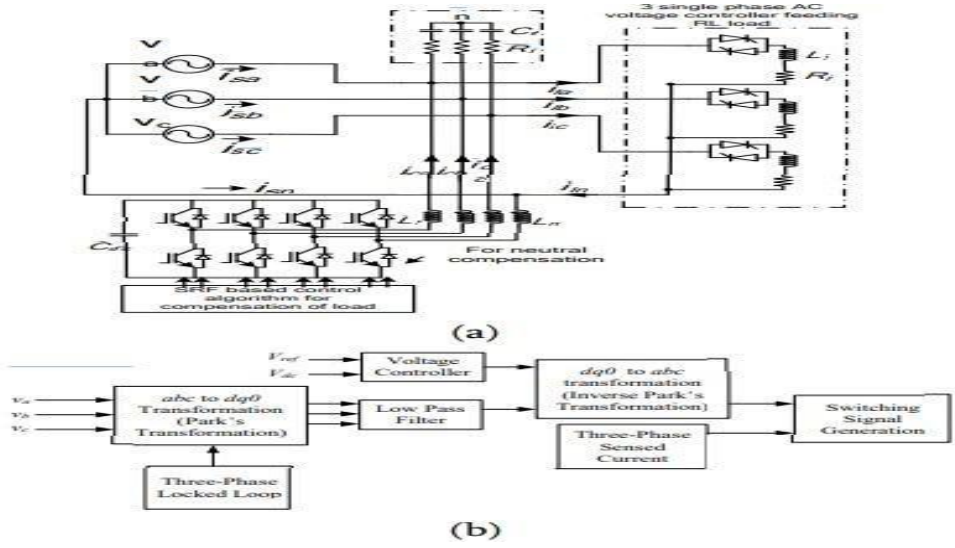

Fig.3 Proposed Structure

Mat-Lab Is A High-Performance Language For Technical Computing. The Name Mat Lab Stands For Matrix Laboratory. It Integrates Computation, Visualization, And Programming In An Easy- To-Use Environment Where Problems And Solutions Are Expressed In Familiar Mathematical Notation. Typical Uses Include Math And Computation Algorithm Development Data Acquisition Modeling, Simulation, And Prototyping Data Analysis, Exploration, And Visualization Scientific And Engineering Graphics Application Development, Including Graphical User Interface Building. Mat-Lab Is An Interactive System Whose Basic Data Element Is An Array That Does Not Require Dimensioning. This

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Allows You To Solve Many Technical Computing Problems, Especially Those With Matrix And Vector Formulations, In A Fraction Of The Time It Would Take To Write A Program In A Scalar No Interactive Language Such As C Or Fortran

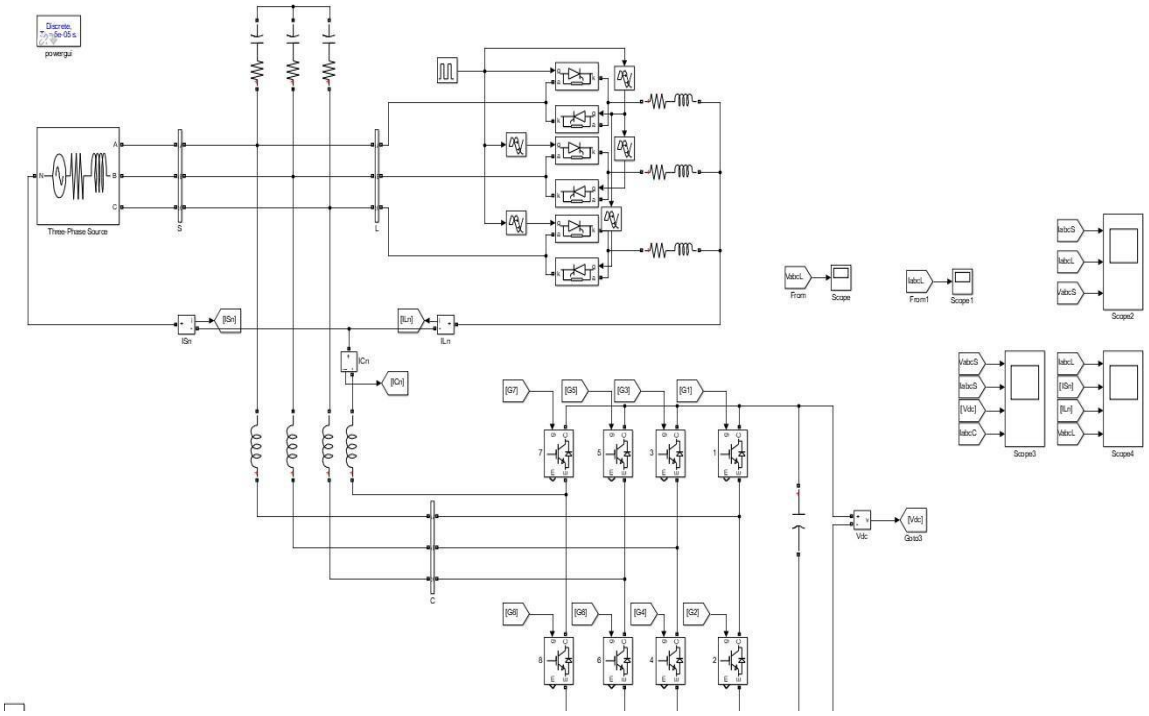

Fig.4 Simulink Model

5.Conclusion

Here, A Simulation Of A 3-Phase, 4-Wire, 4-Leg Vsi-Based Ac Shunt Called Dstatcom Was Used To Reduce The Harmonic Current In Three Single-Phase Ac Voltage Controllers With Rl Loads. The Synchronous Reference Frame (Srf) Theory Was Used To Control The Dstatcom. The Voltage Has Been Fairly Regulated, And The Harmonic Current Has Been Successfully Mitigated. The Voltage On The Dc Bus Has Been Regulated To Its Reference Level. Load Compensation And Neutral Current Elimination Were Found To Be Effective Using The Proposed Topology And Control Theory.

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