SIMULATIONOFUPFCANDDPFCFATCSDEVICESFOR OSCILLATIONDAMPINGINTHEPOWERSYSTEM

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Abstract:Theelectricityisconsideredasthebackbone for industrialrevolution.Todaythedemandandconsumption ofelectricalenergyhasincreasedsteadily.Tomeet this increasingdemandverycomplexinterconnected power systems arebuilt.Thesecomplexnetworks aresubjected to poweroscillations. Thispaperpresentsaconceptofa distributed powerflow controller (DPFC) and Unified PowerFlowController(UPFC)fordampingoscillation in PowerSystem.The DPFCisderivedfromtheunifiedpower flow controller(UPFC).TheDPFCcanbeseen asaUPFC with aneliminatedcommonDClink.ThecostoftheDPFC isalso much lower thantheUPFCbecausenohigh-voltage isolationisrequiredattheseriesconverter partandthe ratingofthecomponents ofislow.Thispaperproposesa newcontrol schemetoimprove thestability ofasystemby optimaldesignofdistributed powerflowcontroller (DPFC) basedstabilizer. Thepurpose oftheworkistodesignan oscillation dampingcontroller forDPFCtodamplow frequencyelectromechanicaloscillations.The shuntand seriesconvertersintheDPFCcanexchangeactivepowerat thethird-harmonicfrequency,andtheseriesconvertersare abletoinjectcontrollable activeandreactivepoweratthe fundamentalfrequency.Theproposedsystemissimulated byusingMATLAB/SIMULINK.

I. INTRODUCTION

Thereisahighdemandforpowerflow controlinpower systems ofthefuture,andcombined FACTSdevicesarethe mostsuitable devices.Togetanewpowerflowcontrolling devicethathascombinedperformances ofFACTSdevices, acceptable costofelectricutilitiesandreliability ofpower systems.DPFC isaconnected FACTS device,which has takenaUFPCatitsbeginning phase.TheDPFChascontrol capabilityassameasthatofUPFC,independentadjustment ofthelineimpedance,thetransmission angle,andthebus voltage.TheDPFCeliminates thecommonDClinkthatis usedtoplugintheshuntandseriesconverter back-to-back within theUPFC.ByemployingtheDFACTSconceptasthe seriesconverter oftheDPFC,thecostisgreatlyreduced due tothesmallratingofthecomponentsintheseriesconverters. Equallywell,the reliabilityoftheDPFCisimprovedbecause oftheredundancyofferedbythemultipleseriesconverters. Inapowerscheme, thereisagreat desireforafastand reliablecontrolofthepowerflow controllerbecauseofthe growingrequirementofenergy,theagingofnetworkflow and distributedgenerations. UPFC isthe most powerful device withintheFACTSfamily.Itcansimultaneouslycheck all the parametersof the system:the line resistance,the transmission angle,andthebusvoltagemagnitude.The Distributed PowerFlowController (DPFC)recently representedin [3], is a newdevice withinthe familyof FACTSdevices.The DPFC providesahigherreliabilitythan conventional FACTS devicesatalowercost.Itisinferred from theUPFCandhasthesamecapabilitytocorrectallthe parameters ofthepowersystem[4]simultaneously.The common DClinkbetween theshuntandseriesconvertersis eliminated inDPFCconcept,whichoffersflexibility for independent assignmentofseriesandshuntconverter.The DPFCusesthetransmission linetoexchangeactivepower betweenconvertersatthe3rdharmonicfrequency [4]. Likewise,seriesconverterdistribution reducescostbecause nohighvoltageisolation andhighpowerratingcomponents arerequiredattheseriespart.Byusing thetwoapproaches eliminatingthecommonDClinkand passingaroundthe seriesconverter, theUPFCisfurtherdevelopedintoanew combinedFACTSdevice.Fig.1 showstheDistributedPower FlowController (DPFC).Thispaperintroduces aconceptof distributed powerflow controller (DPFC) that is derived fromthe UPFC.Thesame asthe UPFC,the DPFCcan controlallsystemparameters. TheDPFCeliminatesthe common DClinkbetween theshuntandseriesconverters. Theseriesconverter oftheDPFCworksthedistributed FACTS(D-FACTS) concept.EquatingwiththeUPFC,the DPFChavetwomajorbenefits:-

- lowcostbecauseofthelow-voltageisolationand thelowcomponentratingoftheseriesconverter and
- Highreliabilitybecauseoftheredundancyofthe seriesconverters.

This paperbeginswith presentingtheprincipleoftheDPFC, followedbyitssteady-stateanalysis.

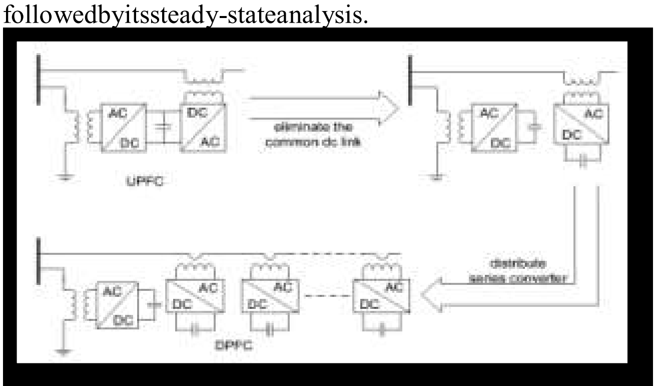


Fig.1:SchematicrepresentationfromUPFCtoDPFC

II. UPFCWORKING

Unifiedpowerflow controller(UPFC)isaseriesshunt FACTSdevice.ItconsistsofacombinationofSSSCin series andSTATCOMinshuntwiththetransmissionline.These twovoltagesourceconvertersareconnectedbyacommon d.c.linkcapacitor. Fig.3.1showstheschematic diagram of UPFC. The seriespart injectsthe voltage of controllable magnitudeinthetransmission linetocontroltherealand reactivepowerofthe powersystem.Theshuntpartisusedto maintainthevoltageacrossthed.c. linkcapacitorandthebus voltage where it is connectedbyinjectingthe currentof controllablemagnitude inthesystem.Eachvoltagesource convertercancontrol themagnitude andphaseangleofthe outputvoltagesofseriesandshuntconverters bycontrolling theamplitude ofmodulation index (*Mb*,*Me*)andphase-angle (*δb*,*δe*)ofseriesandshuntrespectively.

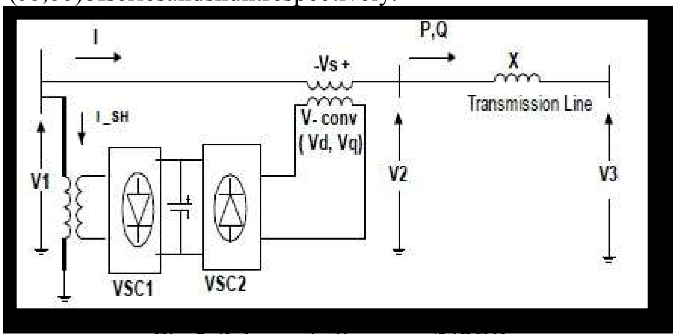


Fig.2-SchematicdiagramofUPFC

III.CONTROLCONCEPTOFUPFC

The classical connectionof UPFC with transmissionline shownonthefigure-2. TheUPFC usesatwoback-to back VSCs,operated from acommon dclink.Theconverter2 injectsthecontrollable voltagebothmagnitudeandphase angletotheconnectedlineviaseriestransformer. The converter1calledSTATCOM suppliesorabsorbedthereal powerdemandby theconverter 2viadclinkwhichthen supportthe realpowerexchangebetweenthem. Conceptually theUPFCcanautomaticallycontrolallthesystemparameter that affectthepowerflow inaline,namely,voltage, impedance, andphaseangle,hence,thenamesuggested “unified”. TheUPFC provides complete controloverpower flowintheline.AcircuitequivalentdiagramoftheUPFCis showinthefig.3.

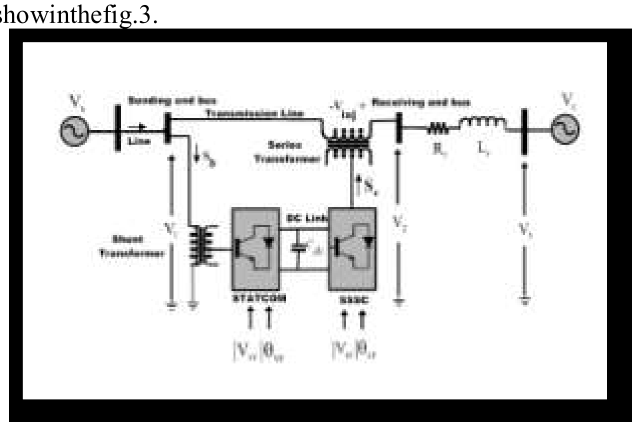


Fig.2.ConnectiondiagramofUPFCwithtransmissionline

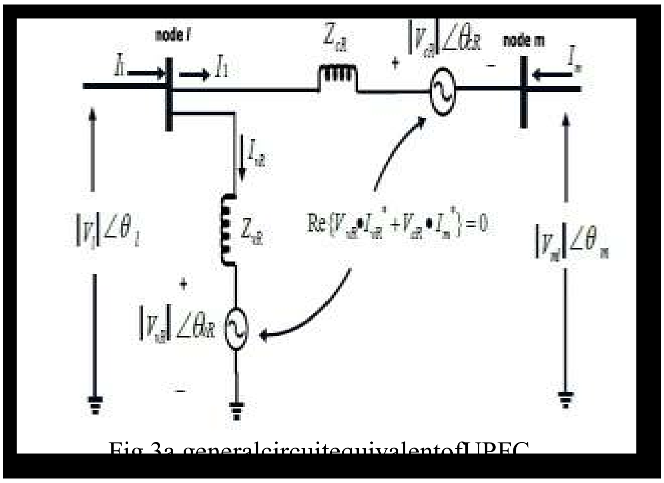


Fig.3a.generalcircuitequivalentofUPFC

IV.OVERVIEWOFDPFC

Byintroducing removalofthecommonDClinkand distribution oftheseriesconverterintotheUPFC,theDPFC isaccomplished. SimilarastheUPFC,theDPFCconsistsof shuntandseriesconnectedconverters.The shuntconverteris similarasanSTATCOM whiletheseriesconverter employs theDSSCconcept,whichis tousemultiplesingle-phase convertersasareplacementforonethree-phase converter. EachconverterwithintheDPFCisindependent anddelivers itsDCcapacitortosupplythe requiredDCvoltage.The form oftheDPFCisshowninFig.4.

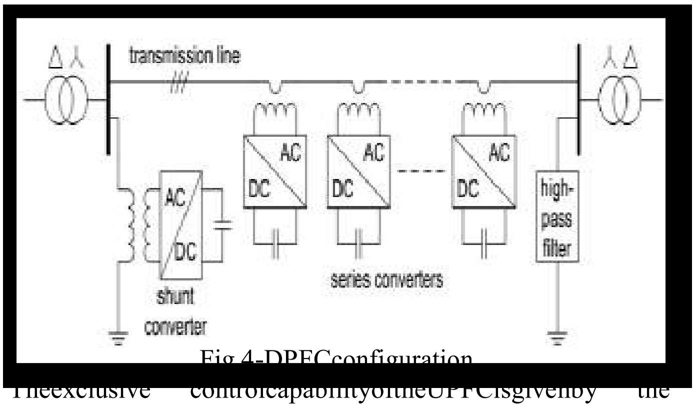


Fig.4-DPFCconfiguration

Theexclusive controlcapabilityoftheUPFCisgivenby the back-to-back construction betweentheshuntandseries converters, which allows the active power to easily exchange. TotensuretheDPFChasthesamecontrol capabilityastheUPFC,amethodthatallowsactivepower exchangebetweenconverterswithaneliminatedDClinkbe needed.

Three-PhaseSystemwithoutUPFC

The 3-Phase system with two areas of economic load dispatchisshowninfig5.The Nonlinearload of3-phaseR- L load and also the industrial load is connected in this system. Thereis3-phasefaultisalsocreatedinthesystem. Duetothenon linearloadand3-phase faultthereis oscillation andwaveform distortion occursinthatsystem whichisshowninthe simulationresults.

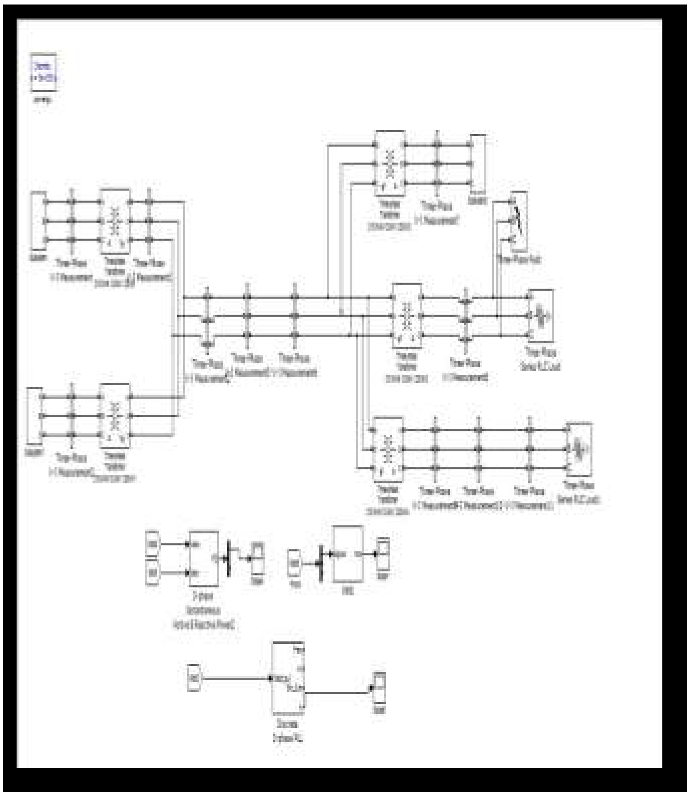


Fig-5Three-PhasesystemwithNonlinearloadand3-phase fault

Thesimulation resultsoftheabovethreephasesystemare shown inthe fig below of simulation results. There arevoltagevalueandtheactiveandreactive poweralso fluctuating andoscillations arereproducedinthethreephase system.

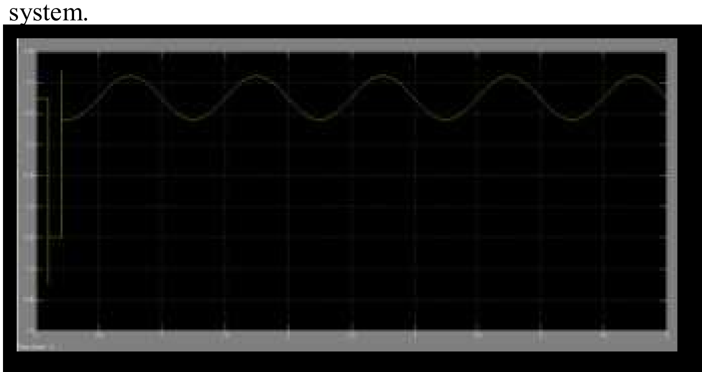


Fig-6OscillationoccursintheActiveandReactivepower values

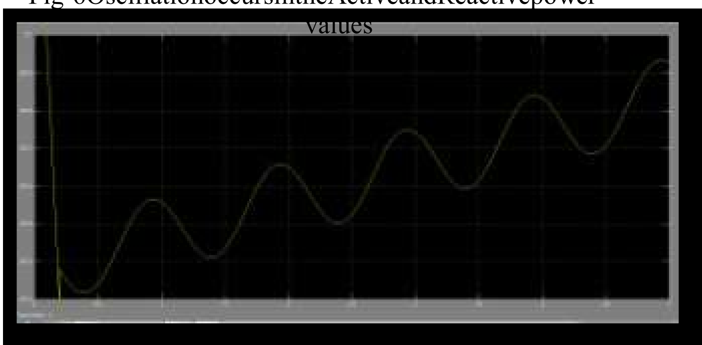


Fig7-OscillationoccursinPLLoutput

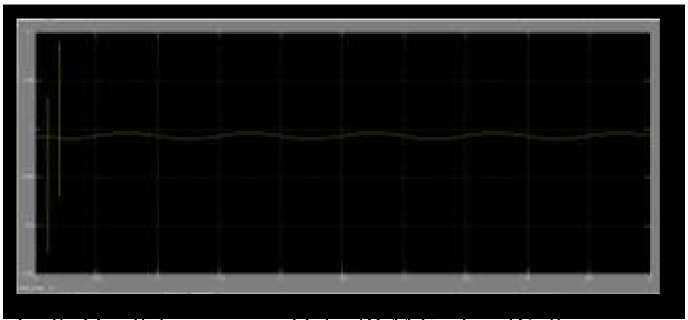


Fig8--OscillationoccursinOutputR.M.SvalueofVoltage

ThreePhasesystemwithUPFC

Thethreephasesystem showsintheabovefig5isnow integratedwithUPFCdevice.NowUPFCsubsystem is includesVSC (VoltagesourceConverter)inseriesandshunt configuration. ThereisPLLcontrollerwiththeindividual phasecontrollingcontrolstrategy isprovidedinthisMatlabsimulation ofbelowfigwiththeirsubsystem andcontrol strategy:-

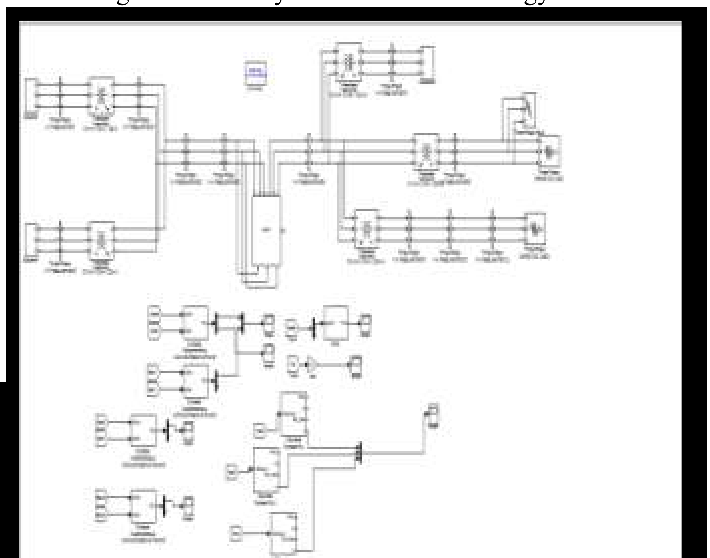


Fig9-ThreePhasesystemwithUPFCdeviceintegrationin thesystem

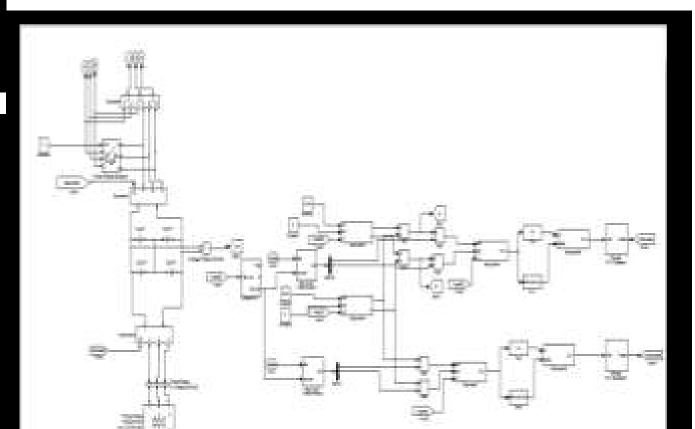


Fig10-TheUPFCdeviceSubsystem

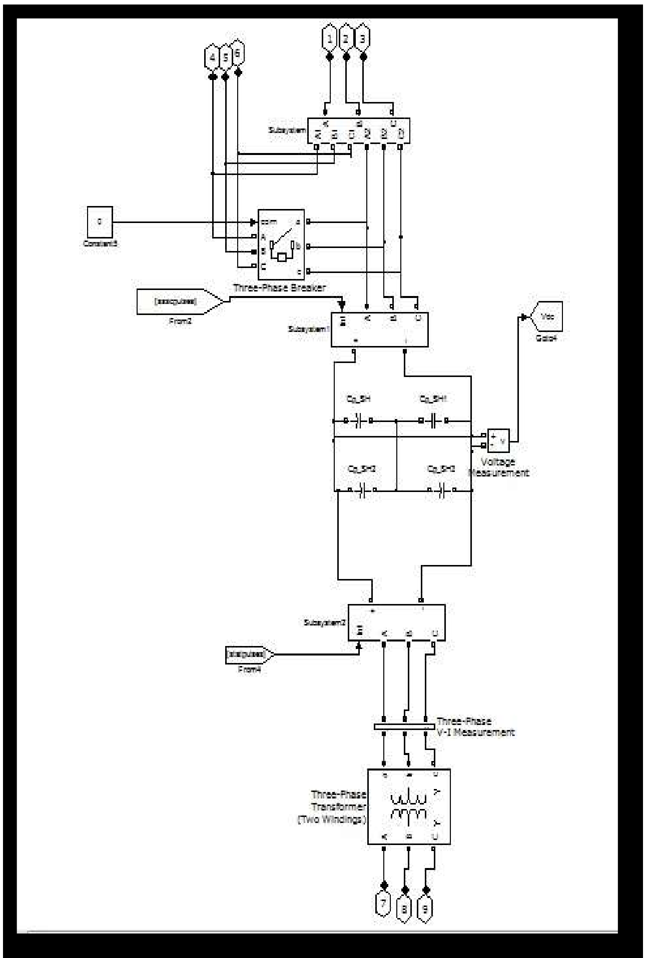


Fig11-VSCConverterSubsysteminUPFCdevice Configuration

TheVSCConverterintheUPFCsubsystemforACtoDC andDCtoACconversion.TheTriggeringpulsesgivento thissystemforcontinuous anddampingoscillation inthis systemareprovidedfromthecontrolstrategy ofPLL controllerofeachindividualphasecontrollingsubsystem. ThePLLcontrolstrategyis showninthefigbelow.-

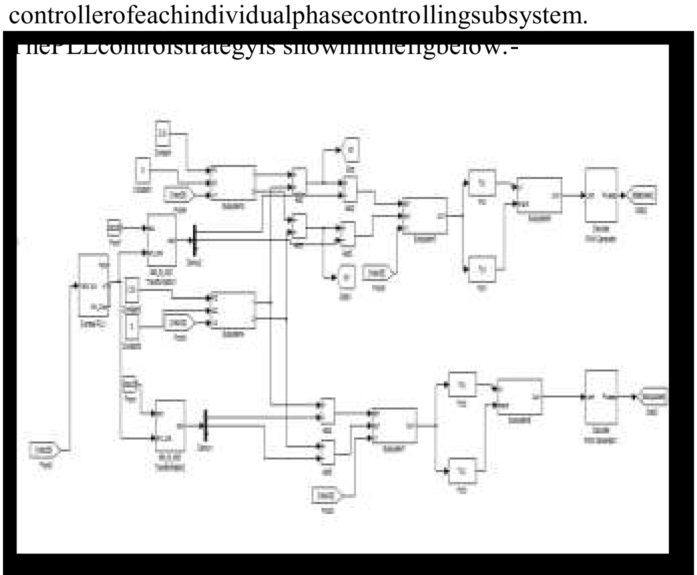


Fig12-PLLcontrolStrategyintheSubsystem

Now theindividual phasecontrolofthisproposedcontrol strategy isshowninthefigbelow.Thecontrolstrategy and theirconfigurationare showninthefig13.

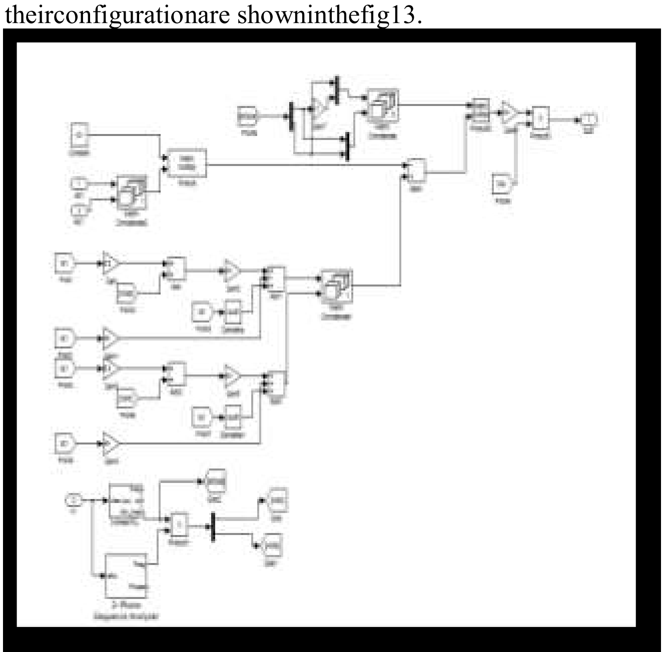


Fig13-EachandIndividualthreephasecontrolstrategy

NowthesimulationresultsaftertheconnectionofUPFCin the proposed system oscillations are damping from the system.Thedampingsimulationresultsareshowninthefig below:-

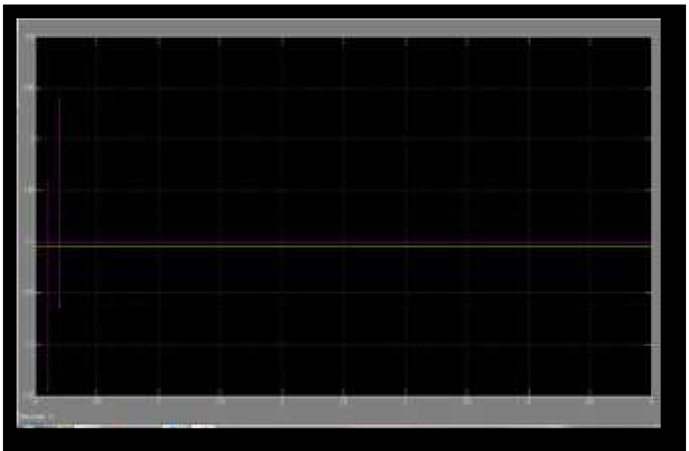
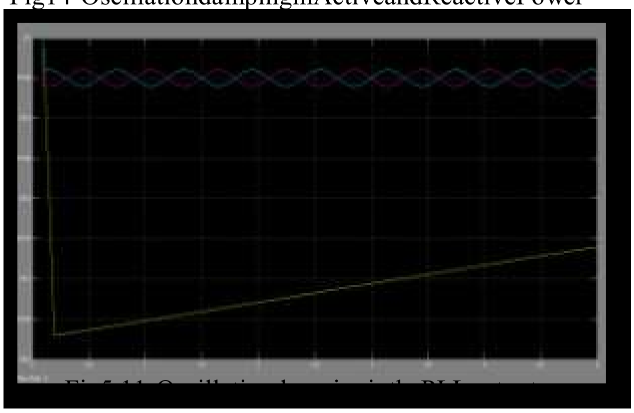


Fig14-OscillationdampinginActiveandReactivePower



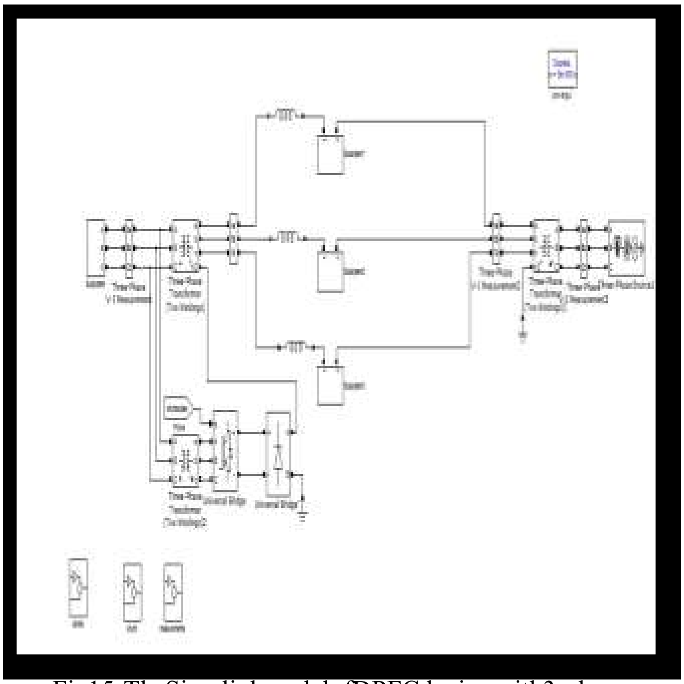


Fig15-TheSimulinkmodelofDPFCdevice with3-phase system

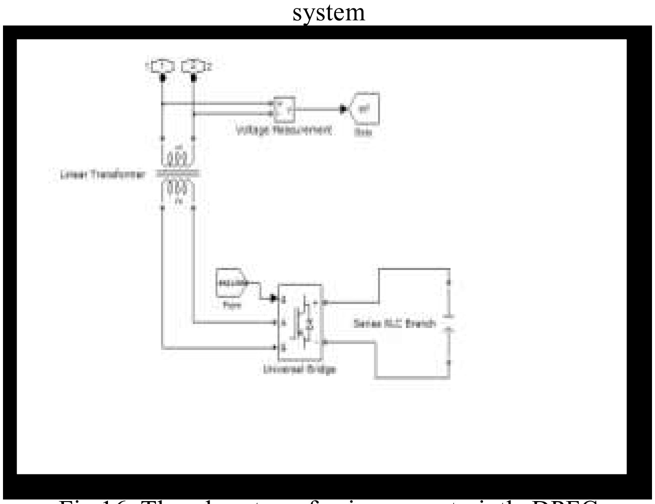


Fig.16–ThesubsystemofseriesconverterintheDPFC

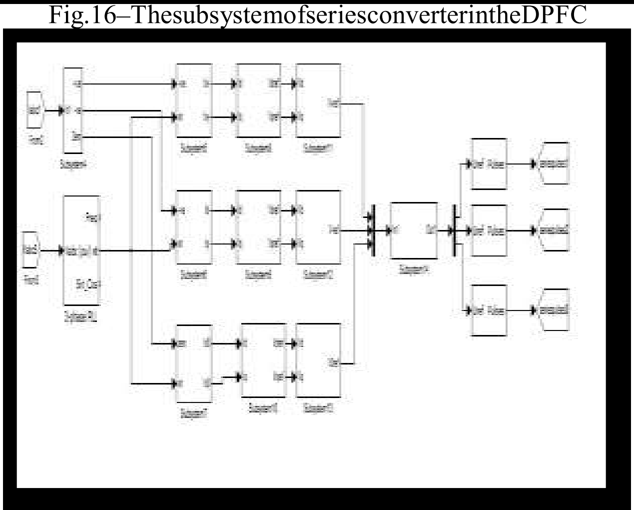


Fig.17-Controlstrategyfor seriesconverter

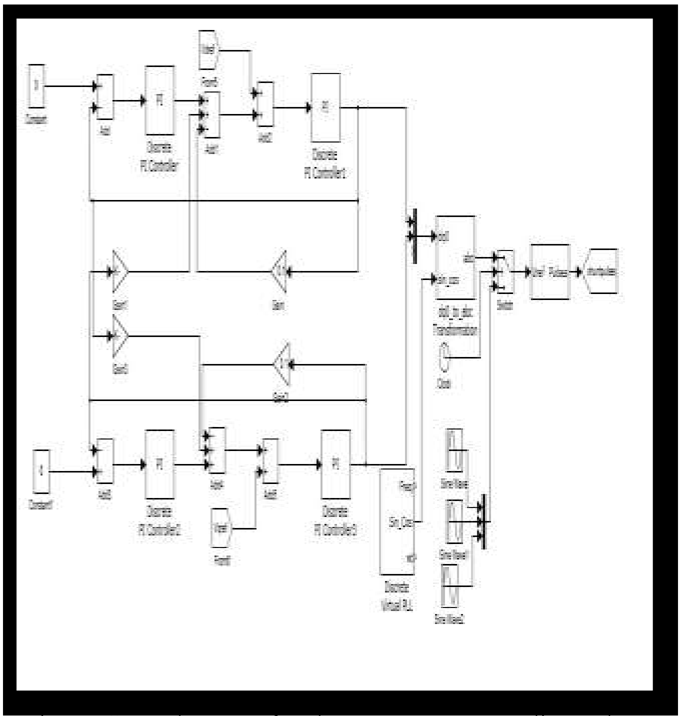


Fig.18-Controlstrategyfor shuntconverterat sendingend

ThecontrolstrategyforseriesandshuntconverterofDPFC hasshownintheabovefig.17andfig.18whichisworking withthePLLandPIcontrollerwithtriggeringpulsesfor constant voltageand current managementin the 3-phase system. Nowthesimulation resultsofDPFCforoscillation damping andmitigationofphasedisplacement isshowninthebelow sections.

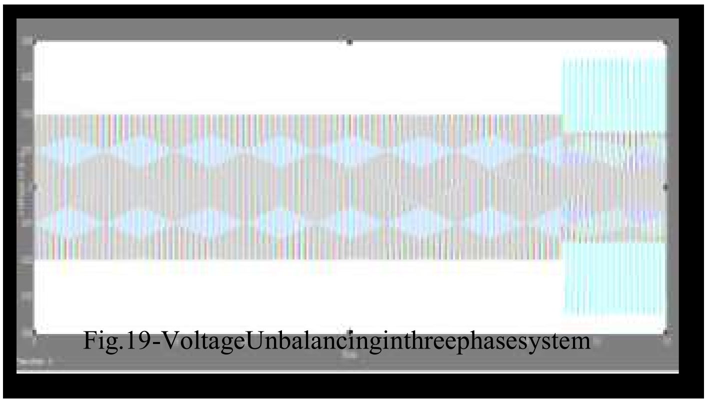


Fig.19-VoltageUnbalancinginthreephasesystem

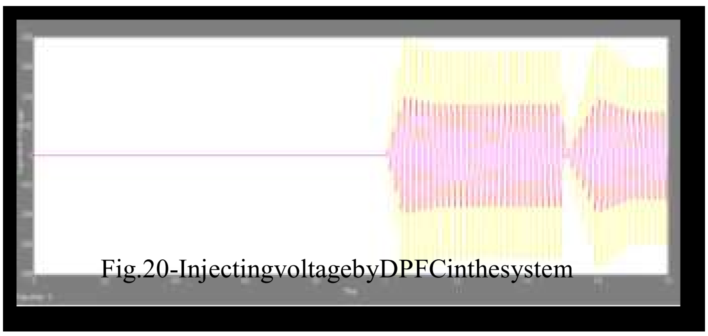


Fig.20-InjectingvoltagebyDPFCinthesystem

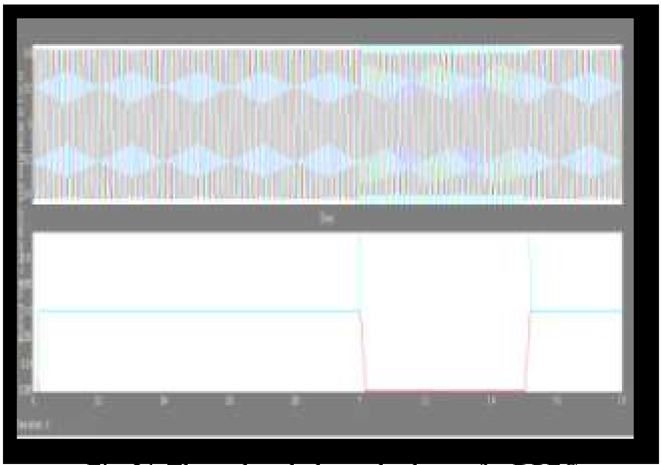


Fig-21-ThreephasebalancedvoltageafterDPFC

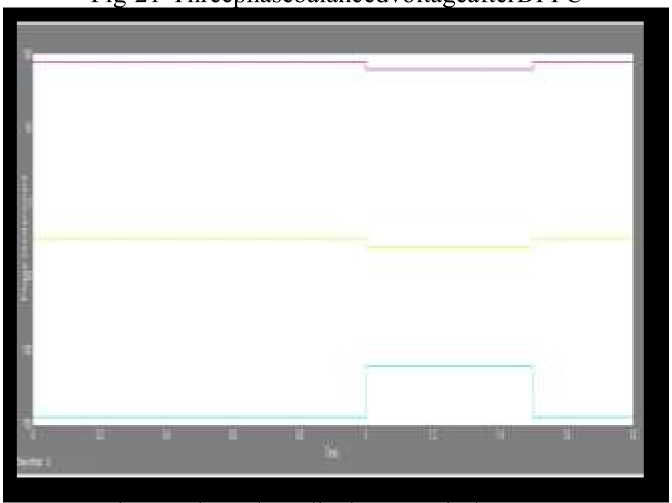


Fig.22-Threephasedisplacementinthesystem

V. CONCLUSION

ThispapershowcasingtheapplicationofUPFCandDPFC fordamping powersystemoscillations.Thetwoareapower systemwas usedtoanalyzetheroleofUPFCfordampingthe oscillations. ThestudyshowsthattheDPFCisderivedfrom theunifiedpowerflow controller (UPFC). TheDPFCcanbe seenasaUPFCwith aneliminatedcommon DClink.Itwas observedthattheresultsofthreephaseunbalanced condition system withnonlinearandD.Cloadhave thedistorted waveform ofvoltageandcurrentandatothersidetheactive andreactivepoweralsounstable.ThesimulationofUPFC for oscillation dampingis shows in MatlabSimulink software.The MatlabsimulationofDPFCisalso doneinthis projectfor voltagebalancingandoscillationdamping.

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