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An Improved Boost Charge Inverter Circuit for PV ApplicationwithoutStaticDevice

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Abstract—Theroleofrenewableenergysystemishighlyprescribednowadaysforelectrification problem in the emerging world. This will satisfy the electricity productiondemand in rural and remote areas. This paper is focusing about the leakage occurring in theampere ratings. The PV panel in combination with transformer based system will have thelimitationslikecurrentcostandweight,toovercomethiselectronictransformerisproposed.The hardware prototype including the gating circuit, Electronic transformer- inverter isimplementedusingBoostchargepump.***Keywords—***
Ampererating,Boostchargecircuit,commonmodevoltage,PVPanel,Solidstatetransformer(SST).

IINTRODUCTION

The purpose of this work is to generate improve the performance at low cost andreduced complexity under stable operation Solid State Transformer by reducing the leakageampererating.Intoday's worldincreasingofthepowerdemandhasbeenformulatedasgreatissue. In order to meet out the growing demand more researches are going in renewableenergy. In comparison to other sources of energy the demand will be met out easily as solarenergyiswidelyavailable.Thedemandelectricityisobtainedbyusingsolarenergyanditisfurther used to power the domestic appliances.The losses are made higher by providingisolationbetweensolarpanelandpowergridusingtransformerbyampereratingcompensatingfortheeconomicissueduetotheincreasedamperecurrentratinglosseswhichresultsfrompresenceofstatictransformerinPVsystem[1]-[6],[11],[12].Solartechnologiesusethesun'senergytoproduceelectricityandthedirectcurrentisobtainedfromphotovoltaicpanel. Photovoltaic cells are in continuous usage and the research people through theirinnovativemethodsfoundthedifferentmethodstoimprovethesystemefficiency.

Photovoltaicismorepopularingreenenergybasedpowergenerationandthistypeisrequired as it reduces the changes in climatic conditions with the systems extended betterdurability. One more advantage with PV Panels is that it offers green and sustainableenvironment.ThisreducestheemissionofCarbondioxideandtherebylimitationsofphotovoltaicelectricitycanbemetouteasilyasitconvertsartificiallightintoelectricity.Themodules connected within the array suggest the amount of electricity it can generate. Theelectricity produce by the PV cells is enormous when directly faced by the sun which is anaddedadvantageofsuchsystem.

A solar power system is designed to supply solar power by means of photovoltaicswith arrangement of components which includes solar panels to absorb as well as convertsunlight,asolarinverter,integratedbatteryarrangement,cablingandasolartrackingdeviceforoptional(increasestheoverallperformance).

Theoutputobtainedfromthesolarpanelsystemvarieswiththetemperaturechange,irradiance and also load conditions which is more important for Tracking of MaximumPower. The maximum power can be found with help of U-A and U-P curve characteristicwhichisattainedfromtheaboveparametersofPVpanel.

Animprovedboostchargeinverterisimplemented.Bymeansofconnectingcapacitor to the load the charge pump make control over the supply voltages changes with the help ofcontrolledswitchingdevices.Bymeansofconnectingcapacitortotheloadthechargepumpmake controloverthesupplyvoltageschangeswiththehelpofcontrolledswitchingdevices.Thesecharg epump circuitsmanipulatethevoltagelevelsintheorderofdouble,triple,half,invert the voltages and evenfractionally multiplies or either scales the voltages in themanner of ×3/2, ×4/3, ×2/3, etc. Hence it is an efficient device used to create discretemultiples of the input voltage and the circuit produces arbitrary workable voltages withchanging the modes based on the circuit design topologies and controller part. This paperproposes doubled output voltage using charge boost inverter. In H bridges inverter highvoltagesideisincorporatedwithboostcharges.Thecapacitorisbeingchargedwiththediodeat the instant the centre of half bridge becomes low. To drive the gate of the high-side FETthischargeisutilizedwhichfurtherincreasesafewvoltagesabovethesupplyvoltagetoturnthe devicetoonstate.

The size, weight and leakage current are increased due to the transformer in PVsystem. The PV system efficiency, weight and size are increased by eliminating the statictransformer [7]-[11]. The leakage current is produced due to the presence of galvanicisolation by static transformer. The Transformer less inverter topology like H5, HERIC isshownbelowwithblockdiagramofSST.

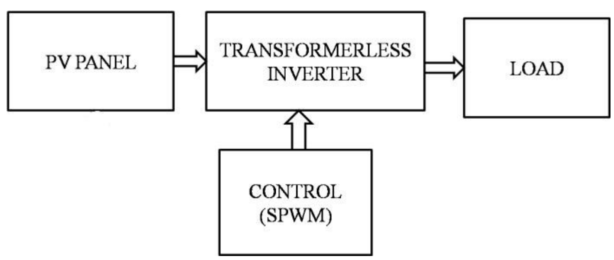


Figure1:HERICInverterTopologies

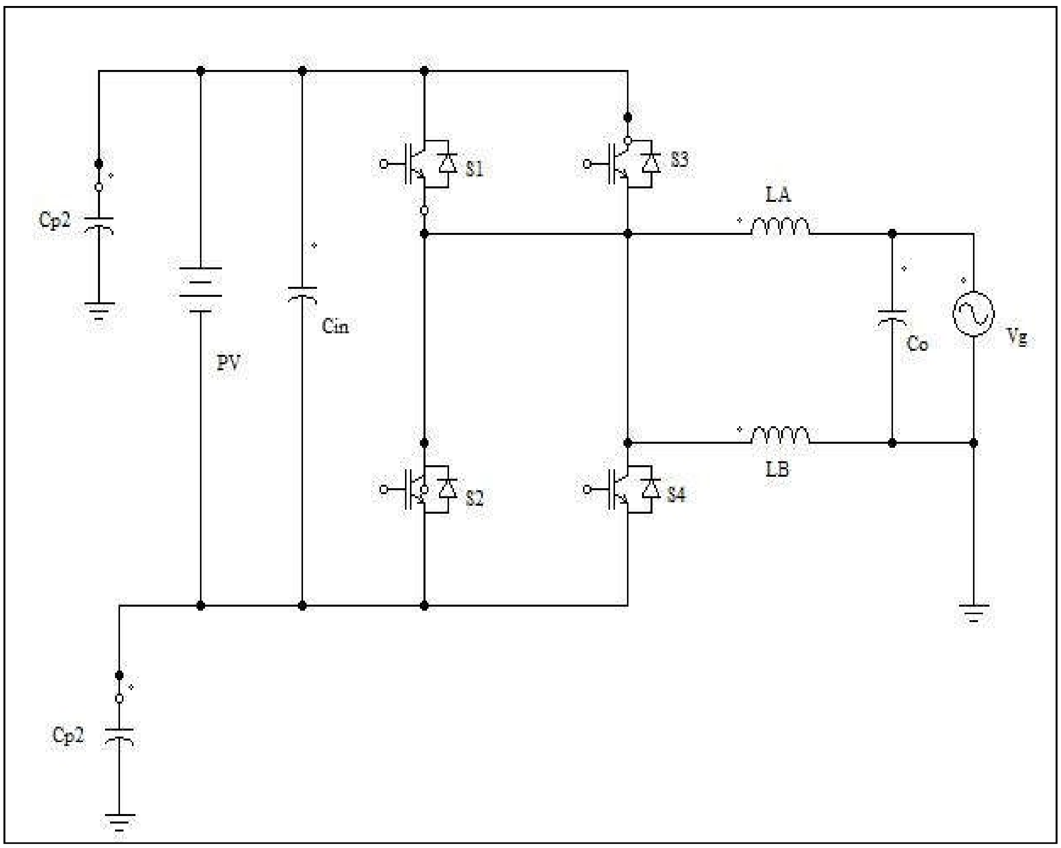
II HERICINVERTER TOPOLOGIES

A.ReviewStage

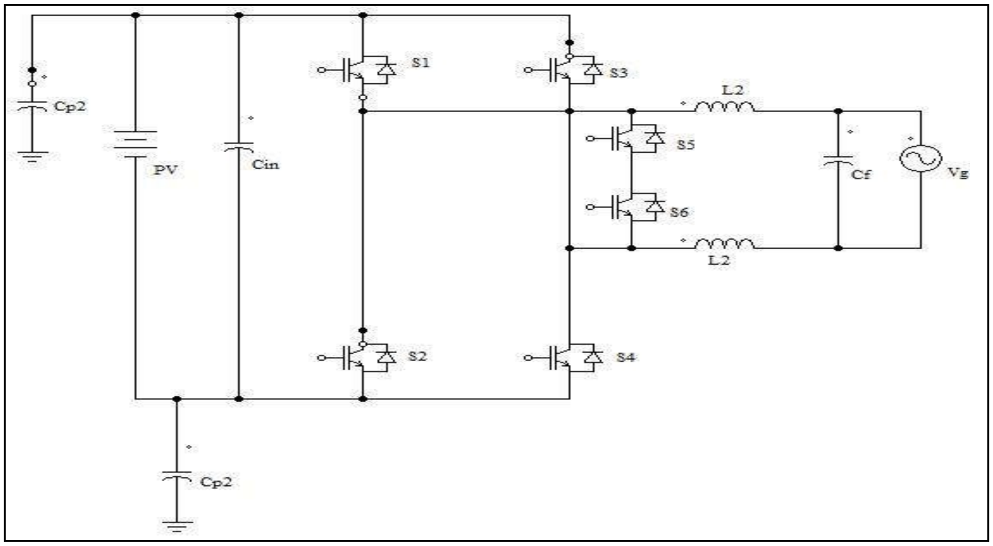
The different circuits with SST inverter are shown in Figure.2, which includesforwardbiasedinverterthatreducestheampereratings.ThePulsewidthmodulationtechn ique is used in this type of inverter. Paper imposes a better H5 inverter providing aboost converter placed in between the solar panels and the H5 inverter. Therefore circuitworks under continuous conduction to make the PV panel operating with maximum powerpointconditioninsuchawaytheboostconvertersaredesigned.Tolowertheleakagecurrente ffects many end results can be viewed like conventional inverters and the complicationinvolved is dc voltage utilization which amounts to half the percentage and hence the PVarrayusageshouldberestricted.H5boostconverteractasoptimizingtheimpedancebetweenthe solar array and the grid so the PV is made to operate continuously with the help of H5boostconverter.

The H5 inverter has 5 switches which has an additional switch for forward biasedbasedinvertertopology.Commonly,thisswitchisplacedneartheDCside.TheCMvoltageis presentalongwithsmall amountof leakagecurrent.InH5inverter three switcheswill on together at once which leads to less efficient converter. The reliable inverter with highefficientcircuitisshowninFigure2(b).Atatimetwoswitchesareoperatedsametimeeventhough the circuit consists of 6 switches. On comparison with the H5 inverter the efficiencyofthisinverterishigh.Forthepurposeofdecoupling,theacsidetwoadditionalswitchesareused.Aproblemwiththistypeisitslowfrequencyharmonicgenerationbecausethereactivepowerdoesnotflowinthecircuit.Thegrid'sneutralpointisfixedtoPV'Snegativeterminaltoreduceampereratings.

An improved Boost charge inverter circuit is analyzed in this paper. A capacitorparasiticcomponentiskeptatzerobyeliminatingCommonmodevoltageinthegrid'sreturnpath that is commonly connected with the boost charge negative terminal. There is nolimitationonmodulationtechniqueusedinboostchargecircuitwhicheliminatestheampererating. The complication in the circuit is reduced by size power loss, cost and improved inpowerqualitybyusingsemi-conductorswitches.Thusinverterpowerqualityisimprovedinabetterway.



(a)



(b)

Figure2:SSTcircuitmodel(a)H5inverter(b)HERICinverter

III SSTINVERTERANDSPWM

A. SwitchedCapacitorVoltage

For inverter to generate the reverse output voltage in this paper we are proposingboostchargeconcept.Theboostchargeinverterisusedwith2diodesandcapacitors.Figure3 shows the conventional H5 SST inverter topology. In this diagram, the conventional H-bridge is connected to the PV panel using the fifth change over transition control. Utilitygrid'sfrequencyandtheswitchingfrequencyissameaswell.It removesthePVpanelfromthe line side at zero state to disconnect the leakage ampere rating path. Hence the circuitampere current rating is drastically reduced. During the first half cycle the upper switchgroup(S_1,S_3)operatealternatelyatthepowergrid'ssupplycycleinasecond.InsecondhalfS$_3$ is turned on and S_1 is also on during the positive period.At supply frequency the controlprocessproducesthepuresquarewave.

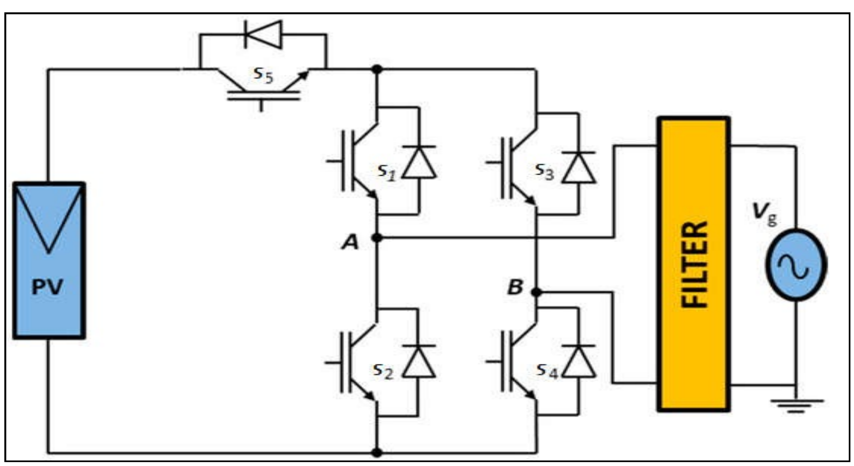


Figure3:H5SSTinvertertopology

BoostchargeinvertercircuitisshowninFigure4.Thecircuithas2capacitorsand diodes.ThecapacitorC1isusedtocouplevoltagepoint.ThevoltagegeneratedatpointAandC is equal in the return direct current output path. The voltages at terminal A and D arecoupled using capacitor 1. The diode1 and diode2 are used to boost the output voltage.Capacitor 1 is charged using the first diode when diode D2 is forward biased. During thisstate the diode 1 is reversed. Capacitor 1 and 2 are charged in parallel when D1 is forwardbiased.Atthisconditionthediode2isreversed.Duringtheconductionperiodthevoltageso fcapacitor 1 and 2 are maintained constant. By choosing perfect sequence for switching, theabovementionedconditionsareobtained.

Theboostchargecircuitcharacteristicsarelistedbelow:

- Realcomponentsnotpresentinthenewmethodologycircuittominimizethelosses.
- Byincreasingtheswitchingfrequencythecapacitorsizeisreduced.
- Ampereratinglossesarereduced.
- Timeperioddurationisdecreased

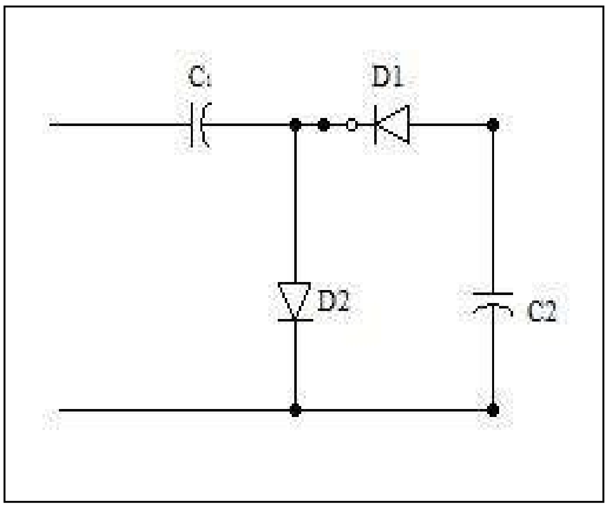


Figure4:Chargepumpcircuit.

TheproposedtopologyisshowninFigure.5.Thisconverterhasboostcharger,DiodesD1an dD2,CapacitorC1andC2andfourswitchingdeviceS1,S2,S3andS4.IntheFigure6the values of carrier and reference wave of modulation technique which generate the pulsesby Unipolar sinusoidalpulse width modulation (USPWM) for the switches in the inverter.The+Vand–Varetheupperandlowerlimitofthevoltageoutput.+Vand–Varegeneratingduringthefirstandsecondhalfcyclesofthevoltageoutput.

Working of the novel inverter is described in the Figure 7. In thistopology 3operatingstatesaredescribedinwhichtheFigure7(i)and(ii)explainsthefirstperiodofthesupply. The zero state and positive state are present in a cycle. The switches 1 and 3 will bealternately turned ON and OFF every half cycle. Throughout this state switch 2 will remainON.fsistheswitchingfrequency.TheS1andS2areONwhentheoutputvoltagesareequalto +V. The Figure 7 describes the +state of the inverter. Diode1 is reverse biased and theDiode2isforwardbiasedduringthisperiod.Thecapacitor2voltageiskeptconstant.Diode

2isusedtochargethecapacitor1.TheFigure7(ii)describeszerostateofinverter.Diode1isconnected parallel with the capacitor 1 and 2 during this state. The capacitor C2 is chargedwith -Ve polarity up to –V through C1.The boost circuit is charged using to generate thevoltage.ThenegativevoltagestateisshownintheFigure7(ii).Theswitch4and1isturnedONduringthiscondition.ThegeneratedvoltageinloadsideoftheinverterisobtainedacrossC2 when the switch 4 is turned on negatively. The capacitor C2 produces the negativevoltage.Bymeansofswitch 1andcapacitorCb,theC1capacitorischargedtokeepvoltageat constant. The controls S1 & S4 are tuned on continuously. In Figure 7(ii) shows the zerostate operation of first conduction which resembles the zero state operation of positive halfcycle.

TABLE1

ComparisonofdevicesusedinSSTinvertertopology

InverterType	Unipolar Device (Diode)	PowerElectronicSwitches	CurrentPath Switches
H5	0	5	3
HERIC	2	6	2
ProposedInverter	2	4	2

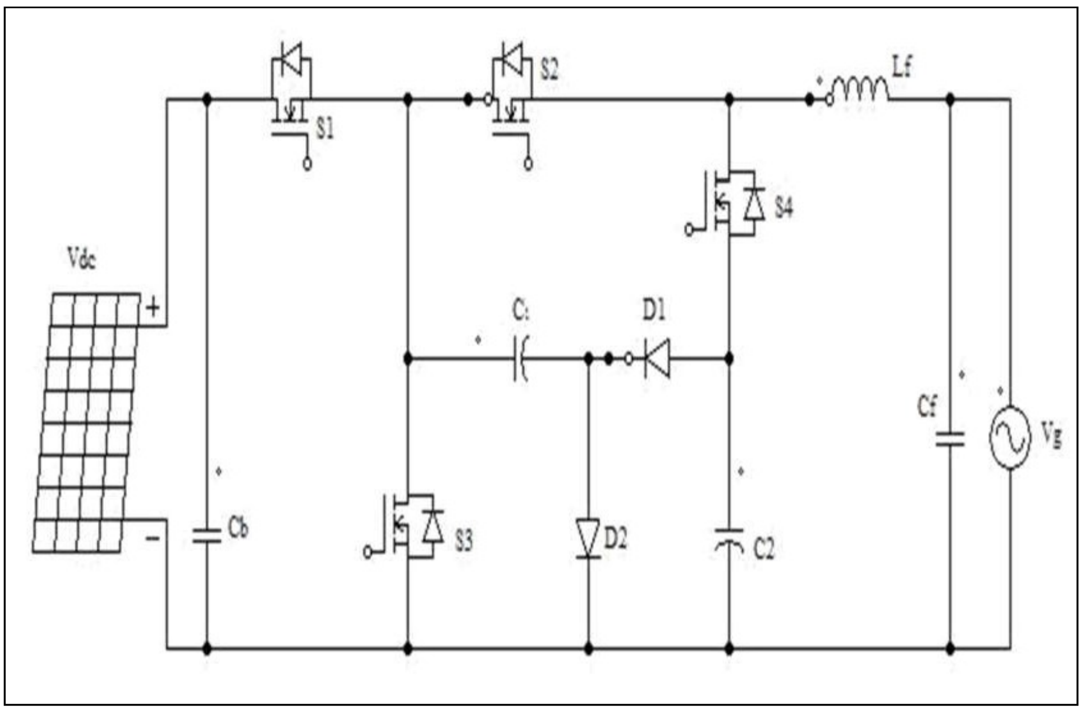


Figure5:ProposedSSTgridconnectedinverter

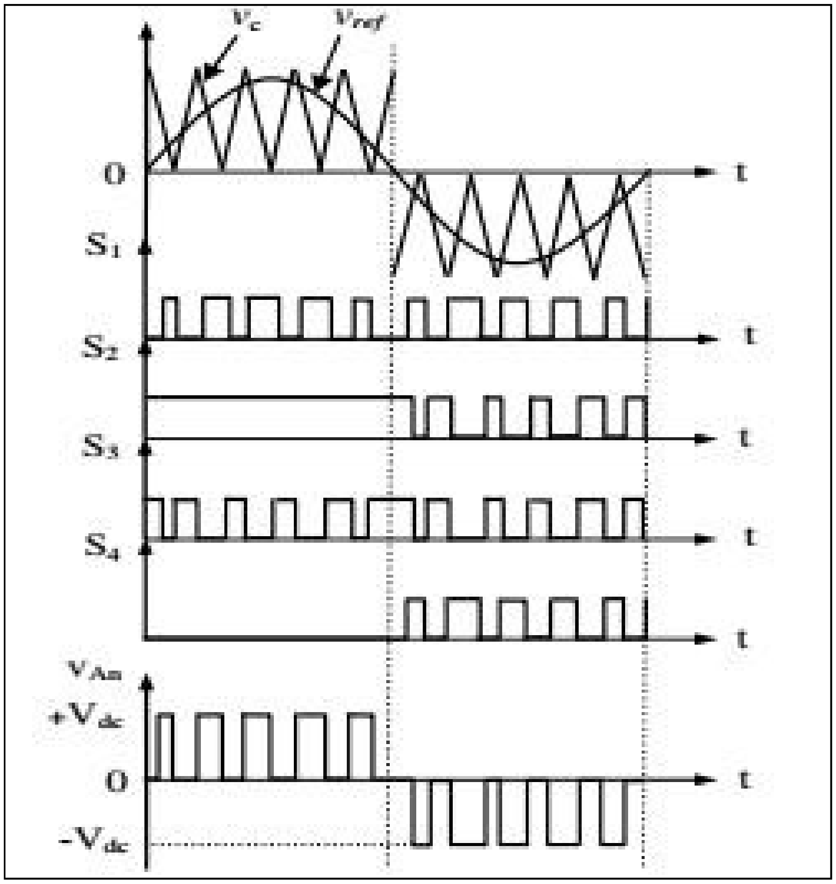
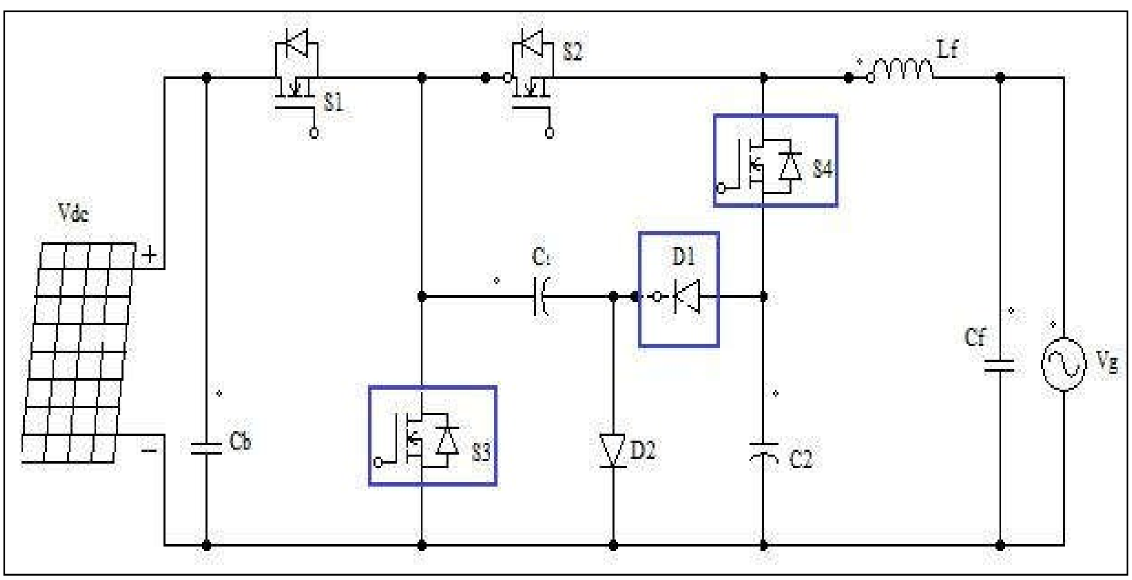
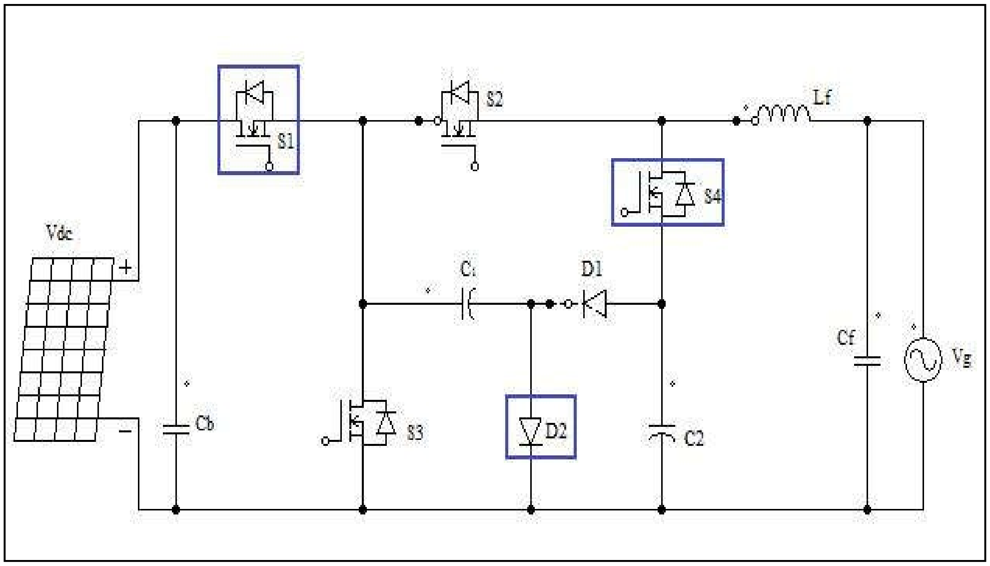


Figure6:UnipolarSPWMmethodforproposedtopology



(i)



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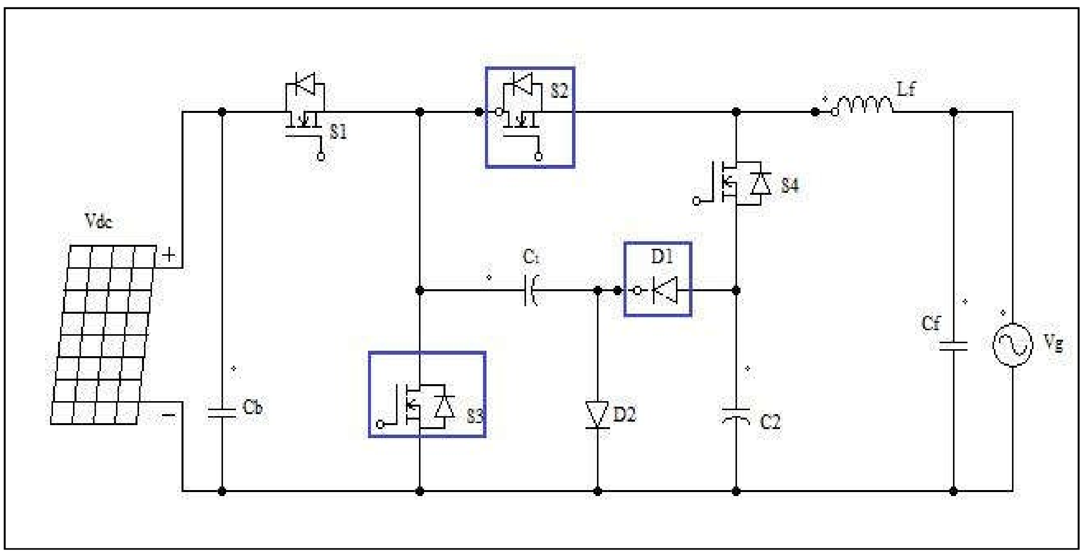

(iii)

Figure7:ProposedSSTinvertertopologyduring(i)firsthalfperiod(ii)zerostateand(iii)secondhalfperiod.

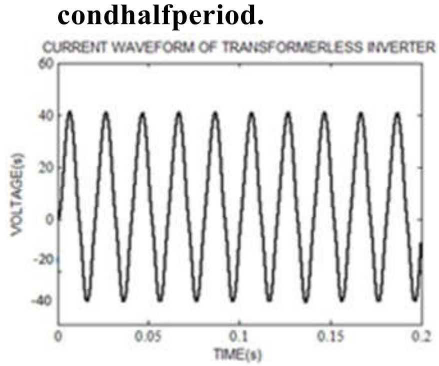

Figure8:Currentwaveformofinvertertopology

B. Comparisonofinvertermodel

The proposed inverter is related between H5, HERIC in the Table 1. The passiveelementsusedarebeingcomparedwithdiodes,noofswitchesandalsowiththecurrentpaths witches. From this comparison it is clear that less number of components is used. Henceefficiencyisimprovedandtheampereratingsarereduced.

IV HARDWARE IMPLEMENTATION

The proposed inverter hardware setup is shown in figure 8. The hardware prototypeincludes the gating circuit, inverter (without transformer) using charge pump with pulsegeneration using Arduino UNO and an opto-coupler. Input voltage of 24V is given to thehardware setup of single phase transformerless inverter using pump. The opto-coupler isgiven a supply of 5V using regulated power supply. It is seen that the program coding forsinusoidalpulsewidthmodulationisfedtoArduinofromwhich,Arduinooutputisgivenasthe input to the opto-coupler. Figure.10. and Figure.11.describes about switching pattern ofswitch S1, S3 and S2, S4. The output of the opto-coupler is given to the gate of the fourMOSFETswitchesinthecircuit.Whenalltheseconnectionsaregivenandthesupplytothehard wareisgivenitproducesanoutputof50V(pk-pk)at50Hzfrequency.Figure.12.showsthe current waveform of the hardware output which is similar to the simulation result infigure8.

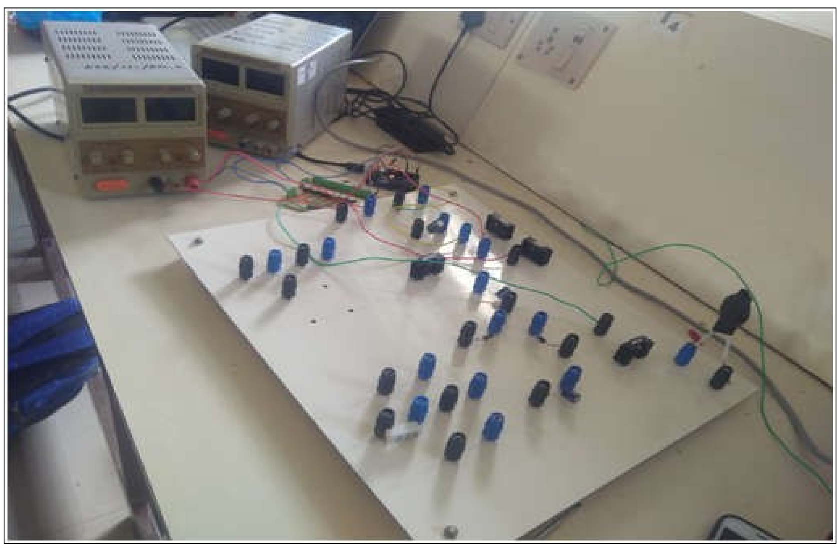

Figure8:ProposedInverterSetup

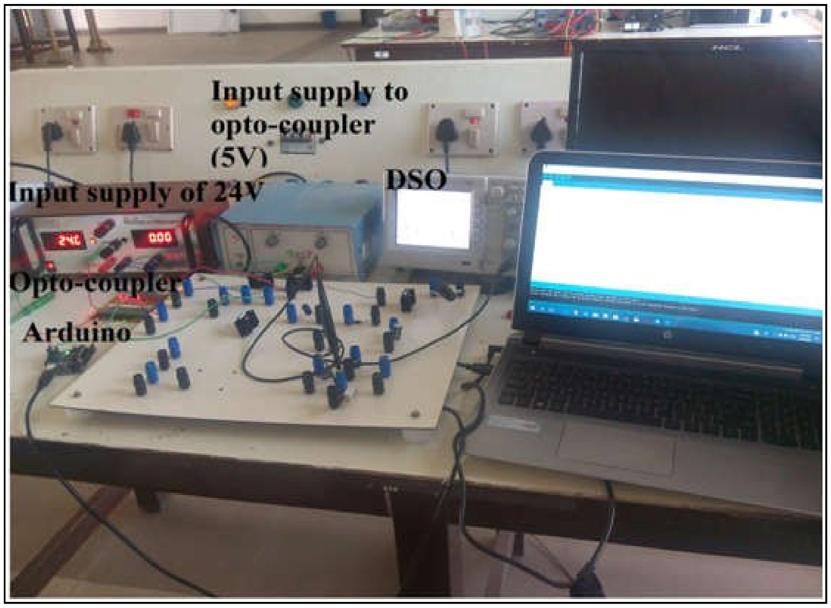

Figure9:Fullhardwaresetup

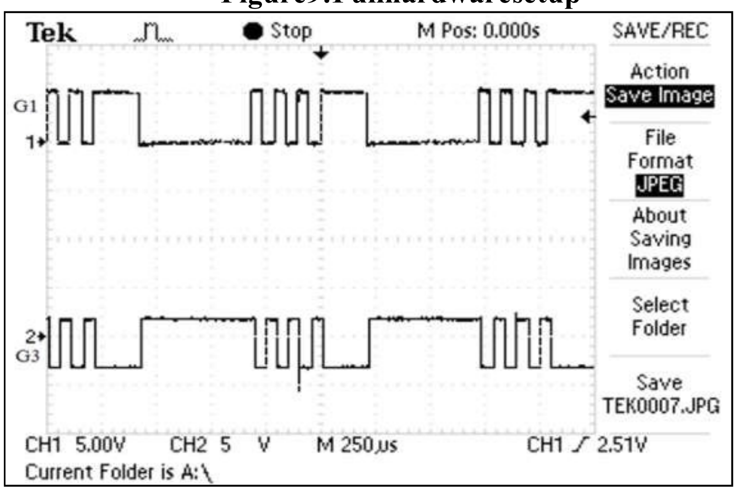

Figure10:GatingpulseofswitchS1andS3.

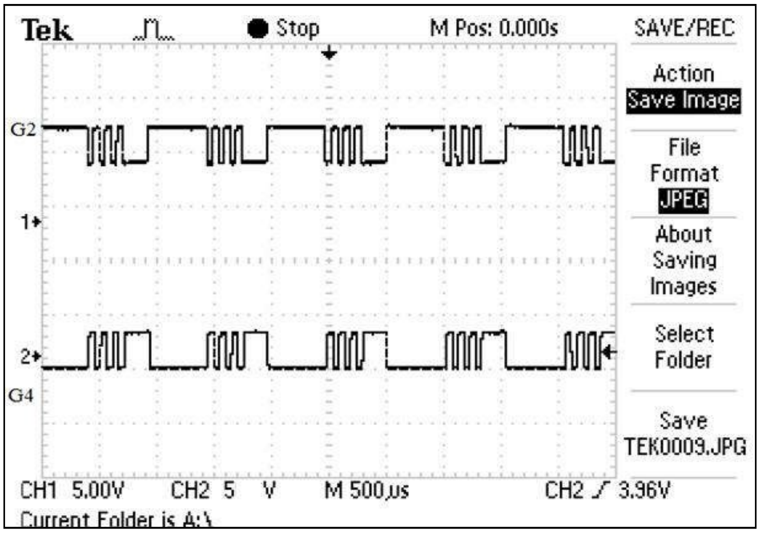

Figure11:GatingpulseofswitchS2andS4.

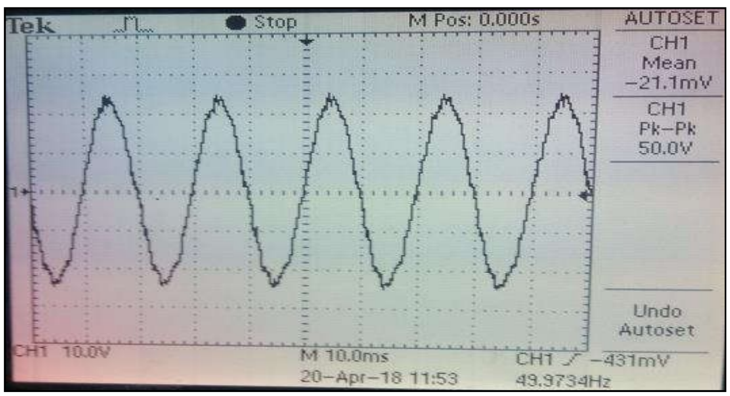

Figure12:Hardwareoutputofproposedinverter

TABLE2
InverterSpecifications

Parameter	Values	Notations
Inputvoltage	400V	V_{dc}
Switchingfrequency	20KHZ	f_s
LCfilter	14mF,130µF	L_f,C_f
Capacitances	220µF,330µ	C_1,C_2

V CONCLUSION

Thispapergivesanelaborateideatoanimprovedboostchargeinverterwithoutstaticdevice . The loss due to ampere rating is lowered when the return path supply is directed toground.ByusingUnipolarSPWMthetopologyisbeingmodulated.Sincethetransformerisnot present, the losses are reduced which gives a reduced size of the system. Minimumnumberofcomponentsisusedintheproposedsysteminthedrivercircuitwhichleadstolessnumberofcomponents.The powerdensityisincreased highlybecauseofthecircuit complexity is reduced. A nearly sinusoidal output voltage and current is obtained and theharmonic level is reduced. The novel inverter has many advantages compared with theHERICandH5inverter.Theoutputvoltageof50Vat50Hzisobtainedbyimplementingthehard waresetupwithSSTcombinedwithboostchargeinverter.

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