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A Fuzzy Controlled Phase Shift Full Bridge Converter with Stable Output Voltage for Variable Input Source

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ABSTRACT
For intelligent dc distributed power systems (DC-DPSs), data communication plays a vital role in system control and device monitoring. To achieve communication in a cost-effective way, power/signal dual modulation (PSDM), a method that integrates data transmission with power conversion, can be utilized. In this paper, an improved PSDM method using phase shift full-bridge (PSFB) converter is proposed. This method introduces a phase control-based freedom in the conventional PSFB control loop to realize communication using the same power conversion circuit. In this way, decoupled data modulation and power conversion are realized without extra wiring and coupling units, and thus, the system structure is simplified. More importantly, the signal intensity can be regulated by the proposed perturbation depth, and so this method can adapt to different operating conditions. A PVA is connected as input with variable solar irradiation to the PSFB. The PSFB is controlled by feedback loop-controlled fuzzy controller which maintains the output voltage at 100V even during change in input voltage. A simulation is carried out in MATLAB with fuzzy controlled carrying the phase angle of S3 and S4 switches to ensure maintenance of output voltage at 100V. All the graphs are represented in time domain analysis with variable input and constant output voltages.

Keywords:- Phase shift full bridge converter Dc motor, PI controller, Fuzzy controller.
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INRODUCTION
In a DC-DPS, various diverse age, stockpiling, and utilization gadgets are associated with a typical dc transport. Related points, including conveyed age (DG), high-voltage dc (HVDC) systems and micro grids (MGs) are the blend of a few or the majority of the segments referenced before and have been broadly talked about. Possible DC-DPS are appeared in Fig. 1. In these systems, two plans are normally utilized for dc-transport voltage guideline: ace slave control and hang control. In ace slave control, the ace converter directs the dc-transport voltage through a correspondence connection and ward upon the speed and dependability of the correspondence connect. In a customary hang control, the connection among voltage and current is controlled by fixed hang trademark, with the end goal that the complete power is adjusted without correspondence. Be that as it may, the dc-transport voltage moves in various conditions, contingent upon the area of the converters and the length of the wire. To build the precision of the dc-transport voltage control, low speed correspondence is fused into the improved hang control. Subsequently, information correspondence is basic to construct an elite DC-DPS.

Traditionally, wired correspondence innovations, for example, CAN and RS-485 have been broadly utilized and demonstrated to be solid arrangements. Be that as it may, extra correspondence link expands establishment cost and system multifaceted nature.

For NB-PLC connected in a dc system, there are two limitations. To start with, the range covers with the harmonics created by power electronic converters, and subsequently, correspondence is helpless against the exchanging recurrence clamor. Second, the capacitance of the dc-transport is enormous, shifting from 10 µF to a few mF, thus moderately high-power coupling circuits are required.

Generally speaking, the utilization of NB-PLC in DC-DPS is a test. The power/signal double modulation (PSDM) idea proposed in gives conceivable strategy for accomplishing NB-PLC in DC-DPS. It installs signals into power change by moving therecurrence of the exchanging power supply inborn consonant. Nonetheless, this strategy depends on fundamental PWM converters, and the signal power can't be directed. To acknowledge information correspondence in a DC-DPS comprising of a few phase move full-connect (PSFB) converters while overcoming the previously mentioned obliges, an improved NB-PLC approach dependent on PSDM is proposed in this paper. This strategy uses another opportunity in regular power control circle of the PSDM converter, to insert information modulation into power convenient. Two hypothetically particular modulation procedures, which are recurrence based and phase based, separately, are examined and analyzed. At that point the proposed phase modulation is examined in detail. Likewise, the idea of bother profundity is proposed to depict the signal power guideline. The proposed technique has the benefits of decoupled control, customizable signal force, and simplified equipment, and it has been verified by reproduction and model trial.

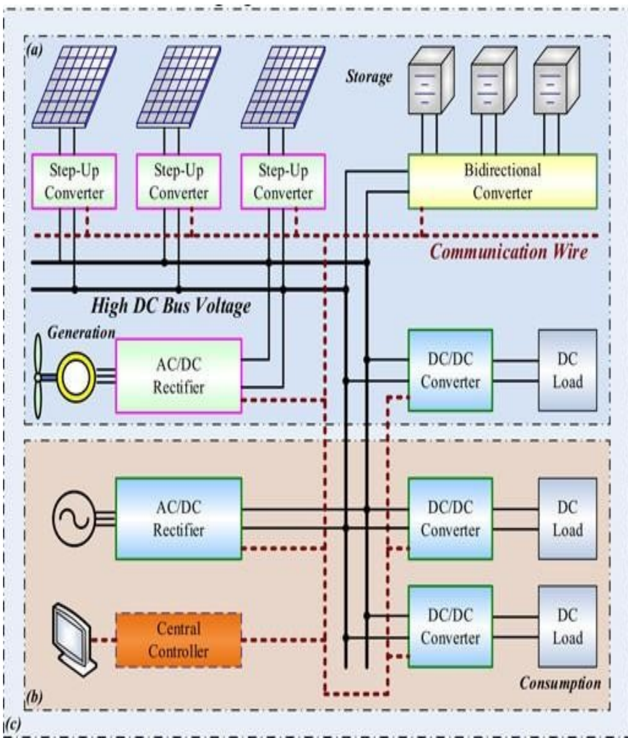

Fig.1.1: DC –Distributed Power System (DPS).

II PSFB CONVERTER, PV AND CONTROLSTRATEGIES

In ordinary power gadgets converters, high-recurrence harmonics at frequencies up to a few several kilohertz are viewed as futile and present negative impacts including diminished the power quality, corrupted EMC, etc. Be that as it may, high-recurrence signal can be used as information transporter. In regular power-line correspondence systems, signal coupling circuits, which builds the system unpredictability and cost, are utilized to infuse high-recurrence transporter into the power line. The standard of the PSDM technique is to use the inherent harmonic delivered by power electronic converter as information bearer. In this manner, information modulation can be accomplished without the coupling units in regular PLC.

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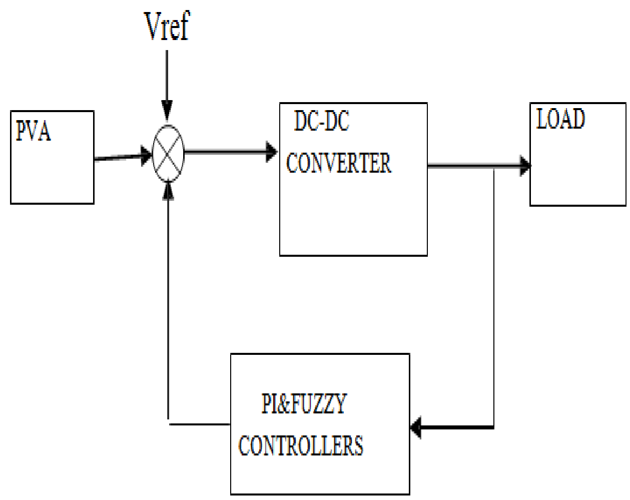

Fig 2.1: Block diagram.

The Photo Voltage Array (PVA) is connected to the dc-dc converter or Phase Shift Full Bridge Converter. The input of PVA is based on solar radiations and output of the PVA is dc. The input of converter is variable and this converter converts the dc-ac and ac-dc. After this conversion the output voltage is compare with reference voltage (Vref), after comparison if any error is found, then it goes to controllers (PI, Fuzzy). Thecontrollers control the error by using phase angles. Then output of controller is connected to the load.

2.2 PHASE SHIFT FULL BRIDGE CONVERTER

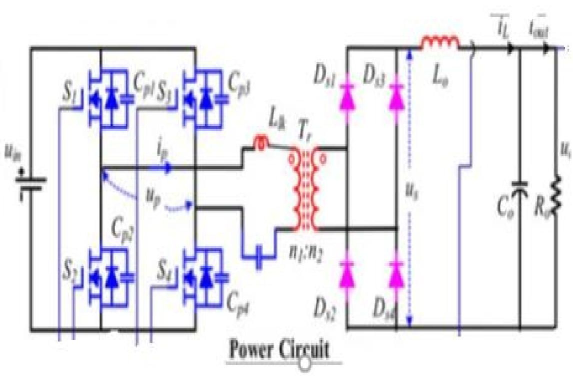

Fig 2.2: Topology of a PSFB converter.

Phase move full extension (PSFB) is a prominent topology, which has been generally connected in DC-DPS. By exploiting inherent capacitor and spillage inductance, zero voltage switch (ZVS) can be acknowledged to improve the efficiency.

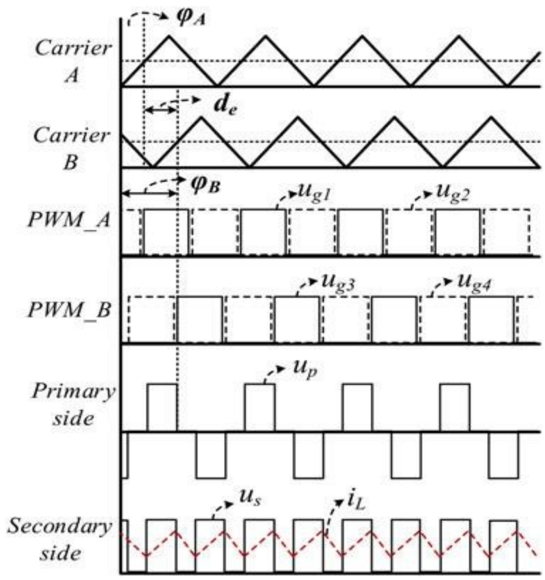

Fig. 2.3: Key waveforms of a PSFB converter.

A common circuit structure and a computerized control plan of a PSFB converter are appeared in Fig. 2.2, and the key waveforms are appeared in Fig.2.3. This circuit is constrained by an advanced signal processor (DSP), in which two PWM generator modules are relegated to the main leg and slacking leg, individually, creating four door drive signals. In this area, the strategies for embedding data into PWM signal however without influencing the power yield are examined in detail.

u_C (t)= utri (2πft + ϕ) ……………………… (1)

Where - f and ϕ are the recurrence and phase rakish of the transporter, individually.

These two parameters can be controlled. The other basic parameter is obligation cycle d, which is set continually to 1/2 by contrasting the bearer wave and a dc reference set at1/2.

Assume the parameters in the two PWM modules relating to the main leg and slacking

leg are fA, dA, ϕA and fB , dB , ϕB , individually. It is required that

fA= fB= f

ϕB−ϕA= deπ (0 <de < 1) ………………… (2)
Where,
Deπ **-**is the phase move between the main leg and slacking leg and manages the yield proportion of voltage pulse.

The yield voltage of the PSFB circuit is

U out = ndeUdc………………. (3),
Where
n is turns proportion of transformer Tr and Udc is the info voltage.
The relative phase between the main leg and slacking leg ϕB− ϕAis dictated by power control. Be that as it may, by defining the differential phase and the regular phase as
ϕd = ϕB − ϕA/2 …………………………….. (4)
ϕc = ϕB + ϕA/2 …………………………….. (5)
At that point ϕA and ϕB can be communicated as
ϕA = ϕc − ϕdϕB = ϕc + ϕd ………………… (6)

2.3 FREQUENCY SHIFT MODULATION

It tends to be seen that the normal phase ϕc is a decoupled control opportunity,which can be balanced to insert information. Fig.2.9. displays the previously mentionedtwo strategies by tweaking f and ϕ. Exchanging Frequency Shift Modulation (FSK).As per the previously mentioned examination, the exchanging recurrence f is immaterial to the power control calculation, which implies the recurrence is a control opportunity to convey data. To regulate data into the exchanging swell, a common approach is recurrence move keying (FSK).

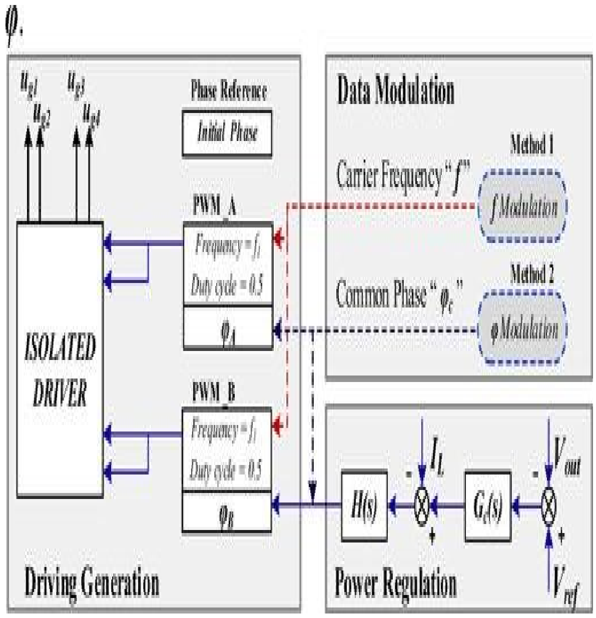

Fig 2.4: Control scheme of a PSFB converter.

In a twofold FSK procedure for instance, the circuit works at recurrence f1 or f2 chosen by the information to be sent. The regulated bearer can be communicated as uc(t)= utri (2πf1t) , when sending information "0" utri (2πf2t) , when sending information "1" . Thusly, information are infused into the converter. Rectified by an extension in the auxiliary side, the circuit yields a dc voltage with FSK-adjusted swell, whose central consonant is double the bearer recurrence. The principal consonant of this dc voltage swell is

fs(t)= A1 sin 2π ∗2f1t ………….... (8)

When sending information "0"
A2 sin 2π ∗2f2t, when sending information "1"

2.4 PHASE SHIFT MODULATION

Phase move keying is a typical strategy for information modulation. In a PSFD Converter, the differential phase is important to power guideline, yet the basic phase can be balanced freely to actualize information correspondence. In such a plan, the PWM bearer is never again an unadulterated triangular wave. To guarantee the autonomy of power guideline and information correspondence, it is required that

uA(t − Td)= uB (t) …………… (9)

Where uA and uB are the bearer rushes of the main leg and slacking leg, separately, and Td is the postpone time relating to the obligation cycle of the power yield. Accept that in each period, transporter wave is a triangular wave with an information regulated phase rakish ϕ(t). The adjusted transporters of the main leg and the slacking leg can be communicated as

ucA (t)= utri (2πft + ϕ (t)) ………… (10)

ucB (t)= utri(2πft + deπ + ϕ(t + de/2f)) …. (11)

In a computerized controlled system, the transporter phase is changed each period, so that ϕ(t) can be communicated as a discrete arrangement ϕ[n], the connection among ϕ(t) and ϕ[n] is

ϕ (t)= ϕ (n/f)= ϕ[n] ……………….. (12)
Where n = Int(t · f).

On the off chance that ϕ [n]=0, the circuit worked in customary mode; generally, the information bearer can be presented by choosing a legitimate digit grouping. Along these lines, structured recurrence part can be infused into the converter. In recipient, the recurrence segment can be recognized and demodulated as information "1." Recurrence modulation and phase modulation are fundamental modulation methodologies, and both can be utilized in PSDM systems. Be that as it may, recurrence modulation technique has the disadvantage that the sufficiency of the transporter is dictated by the power controller,and the signal force can't be controlled freely, so it is inadmissible for long range correspondence. On the opposite, phase modulation system connected in PSFB converter is flexible. It not just gives a power controllable way to deal with adjust to complex task condition, yet additionally stays away from the signal force lessening brought about by power guideline. By choosing diverse digit succession, distinctive recurrence transporter with variable adequacy can be delivered. Phase modulation on PWM transporter is appropriate for information correspondence connected in PSFB converters because of its benefits.

III RESULTSANDANALYSIS

3.1 INTRODUTION

The results of output voltage with variable input supply can be obtained. The characteristics of dc motor can be obtained.

3.2 RESULTS OF PROPOSED CIRCUIT WITHOUT FEEDBACK LOOP CONTROL

Mat lab Simulink result of proposed circuit without feedback loop control in fig.3.1.The PVA is connected to the DC-DC converter with the R-Load. The output voltage and waveforms of the without feedback loop controller is shown in scope.

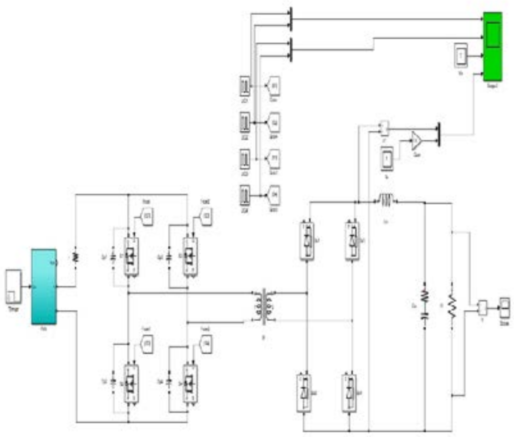

Fig 3.1: Proposed circuit without feedback loop control

The Photo Voltaic Array (PVA) is connected to the primary compression of MOSFET'S. Which convertes DC to high frequency AC.On the secondary side DIODE Bridge is used convertes high frequency AC to DC.The output voltage for the open loopcontrol system is varying from

102V to 92V to 121V with respect to changing solar radiations.

3.3 RESULTS OFPROPOSED CIRCUIT WITH FEEDBACK LOOP OF PI CONTROLLER

MatlabSimulink results of proposed circuit with feedback loop of PI Controller in fig. 3.2.In this circuit, the output voltage of without feedback loop controller is controlled by using the PI controller and with the dc motor load. The outputs of comparison voltages, waveforms and characteristics of the motor are shown in scopes.

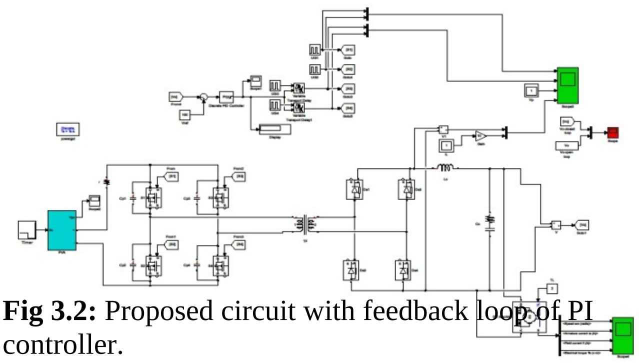

Fig 3.2: Proposed circuit with feedback loop of PI controller.

The Photo Voltaic Array (PVA) is connected to the primary compression of MOSFET'S. Which convertes DC to high frequency AC.On the secondary side DIODE Bridge is used convertes high frequency AC to DC.The output voltage for the open loop control system is varying from 102V to 92V to 121V with respect to changing solar radiation.This variable voltage is controlled by a closed loop controlled system,whichvaries the phase angle of S3 and S4 generating constant DC voltage even during variable solar radiations. The output voltage is compared to reference values generating and error fet to PI controller.PI controller generates the phase angle shift for S3 and S4 switches. These values are dynamic with respect to changing in solar radiation.

5.3.1 INPUT VOLTAGE

Output voltage of PVA is shown in fig. 3.3.The output voltage of PVA is input of the circuit and the PVA input is variable.The voltage is varies from 102V to 92V to121V.Time in mile sec and voltage in volts. X-Axis is taken as time and Y-Axis is taken as voltage.

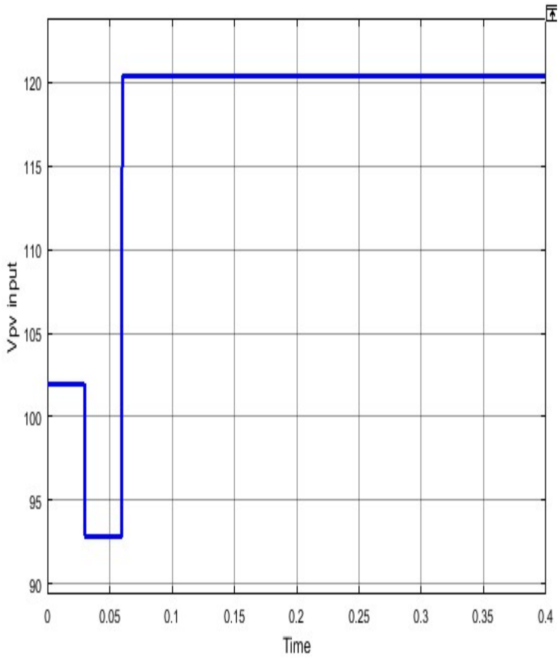

Fig 3.3: Input voltage.

3.3.2 CHARACTERISTICS OF WITHOUT FEEDBACK LOOP PI CONTROL

The characteristics of without feedback loop PI control is shown in fig.3.4.The VG1,VG2,VG3,VG4 and primary voltage, secondary voltage and also load current in PI controller is shown in below figure. X – Axis is taken as time in msec and Y-Axis is taken as Voltage in volts and Current in amperes.

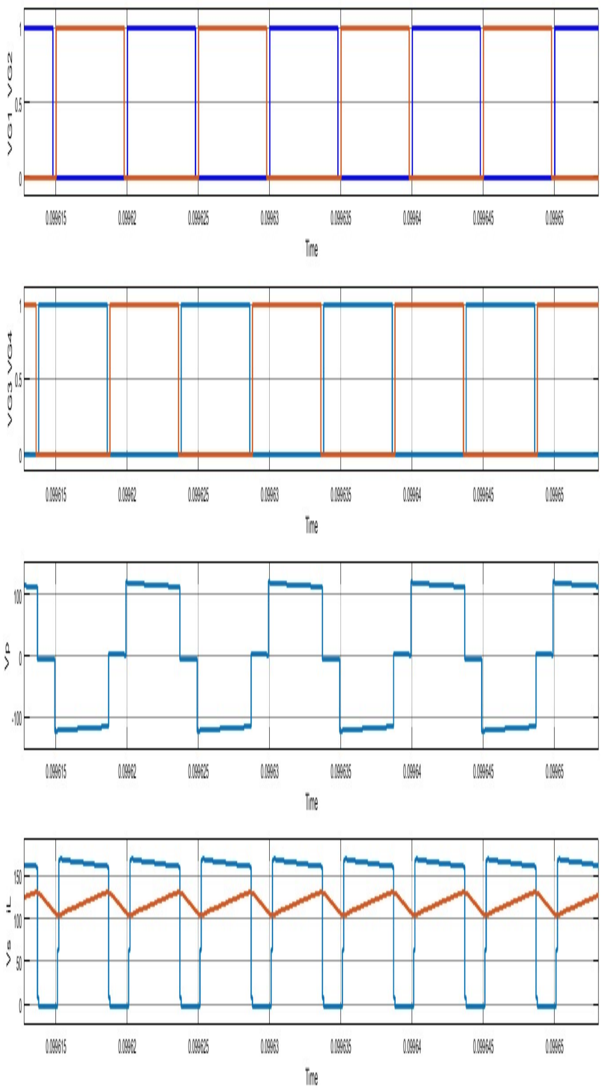

Fig 3.4: Characteristics without feedback loop control.

3.3.3 CHARACTERISTICS OF WITH FEEDBACK LOOP PI CONTROLLER

The characteristics of PI Controller with feedback loop is shown in fig.3.5.The VG1,VG2,VG3,VG4 and primary voltage, secondary voltage and also load current are shown in below figure. Time in msec, voltage in volts and current in amperes. X-Axis is taken as time and Y-Axis is taken as Voltage and Current.

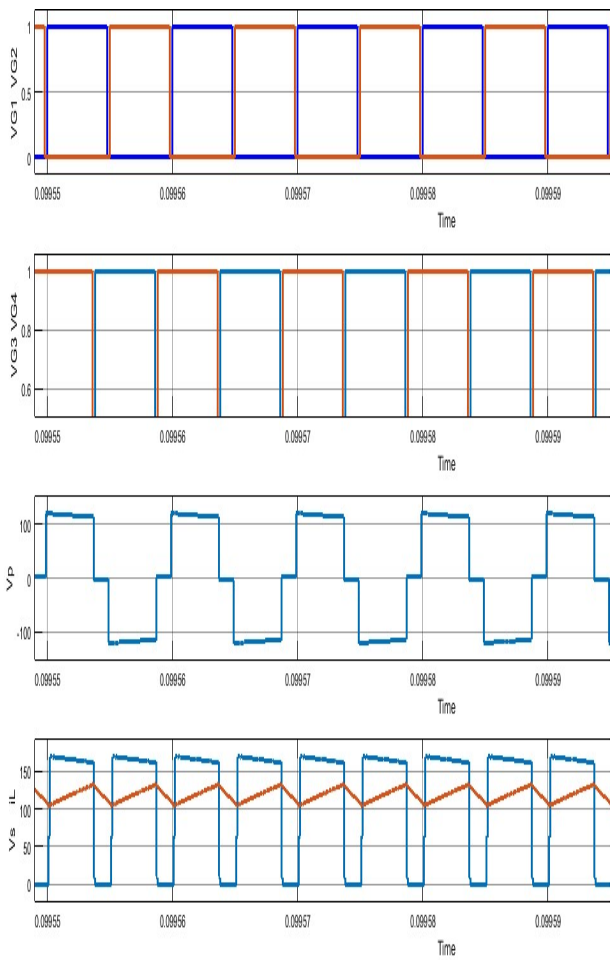

Fig 3.5: Characteristics of PI Controller with feedback loop control.

The blue color line is VG1and VG2is red color line. The Vg1 starts conduction at0.0995 sec to 0.09956 sec with 1v voltage, in this period of time Vg1 conducts positive and negative cycle. The Vg2 starts conduction at 0.09955 to 0.09956 sec same voltages. The Vg1, Vg2 are conducts simultaneously. As well as Vg3 and vg4 conducts simultaneously with 0.09955 sec to 0.09956 sec, the voltage is same. The primary voltage varies from 0v to positive 100v to negative 100v at the time period of 0.09955 sec to0.09956 sec. The secondary voltage varies from 0v to150v 0v (2 times) at the time period of 0.09955 sec to 0.09956 sec.

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3.3.4 OUTPUTVOLTAGE COMPARISON OF OPEN LOOP AND CLOSED LOOP PI CONTROL

Output voltage comparison of open loop and closed loop PI Controller is shown in fig. X-axis is taken as time in msec. Y-axis is taken as voltage in volts.

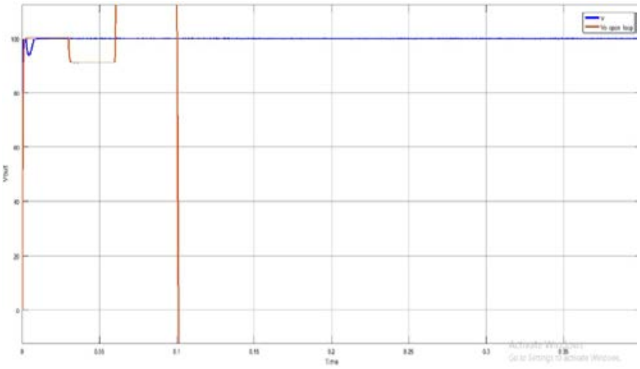

Fig 3.6: Output voltage comparison of open loop and closed loop PI Controller.

The open loop voltage varies from 0v to 100v at the period of time 0 to 0.03 sec, and then it maintains the 90v at 0.03 sec to 0.05 sec. After this the voltage varies from 90v to 120v at 0.05 sec to 0.1 sec. The closed loop system is maintained constant voltage by using the controller. The closed loop voltage is constant i.e 100v.

3.3.5 CHARACTERISTICS OF DC MOTOR WITH PI CONTROLLER

The characteristics of dc motor with PI controller is shown in fig.5.7.X-axis is taken as time msec. Y-axis is taken as amp to armature current, field current, speed in red/sec,torque in newton meter. The speed of the motor is based on load torque. If load torque is increase, then speed increased and load also increased. The speed of motor is 58 red/sec. The speed of the motor is settled at 0.05sec. The armature current varies from 0 amp to 42 amp. The maximum current is 42A.The field current is zero. The torque of motor is 81 n-m. If torque is increased load current, speed are increased. The maximum torque is 81 n-m.

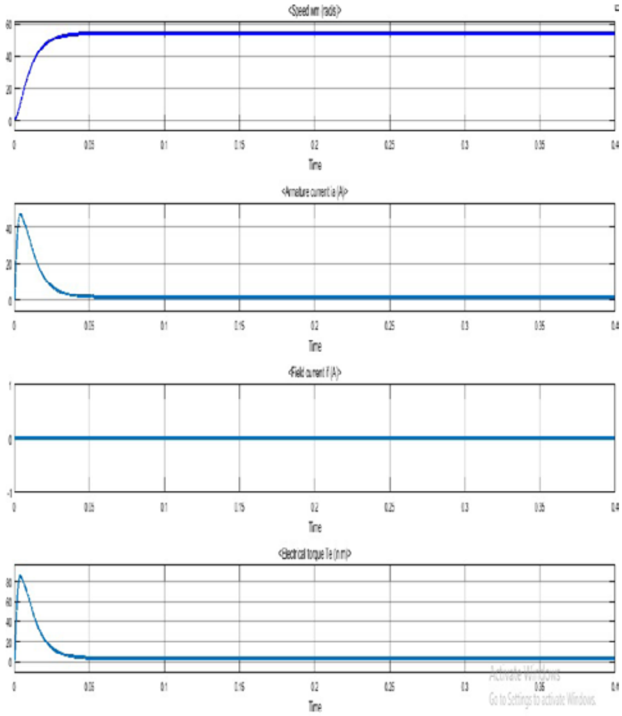

Fig 3.7: Characteristics of DC machine with PI Controller.

3.4 RESULTS OF PROPOSED CIRCUIT WITH FEEDBACK LOOP OF FUZZY CONTROLLER

Matlab simulink results of proposed circuit with feedback loop of FUZZY Controller in fig. 3.8. The output voltage of without feedback loop controller is controlled by using the Fuzzy controller and with the dc motor load.

The Photo Voltaic Array (PVA) is connected to the primary compression of MOSFET'S. Which convertes DC to high frequency AC.On the secondary side DIODE Bridge is used convertes high frequency AC to DC.The output voltage for the open loop contol system is varying from 102V to 92V to 121V with respect to changing solar radiation.This variable voltage is controlled by a closed loop controlled system, which varies the phase angle of S3 and S4 generating constant DC voltage even during variable solar radiations. The output voltage is compared to reference values generating and error fet to Fuzzy controller.

Fuzzy controller generates the phase angle shift for S3 and S4 switches. These values are dynamic with respect to changing in solar radiation.

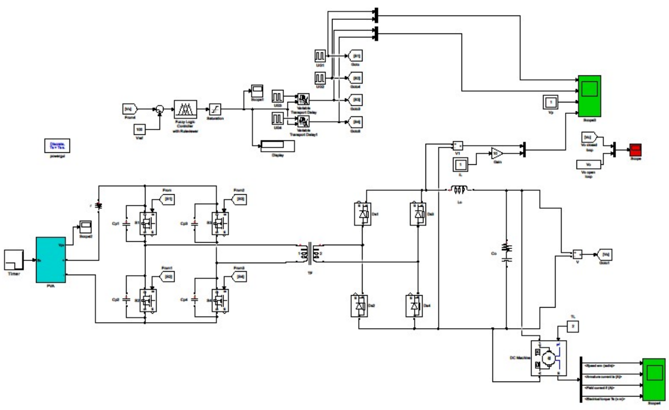

Fig 3.8: Proposed circuit with feedback loop of FUZZY controller.

3.4.1CHARACTERISTICSOFFUZZYCONTROLLER WITHFEEDBACKCONTROL

The characteristics of fuzzy controller with feedback control is shown in fig.3.9.The VG1,VG2,VG3,VG4 and primary voltage, secondary voltage and also load current in fuzzy controller is shown in below figure. X-axis is taken as time in msec and Y-axis is taken as voltage in volts, current in amp.

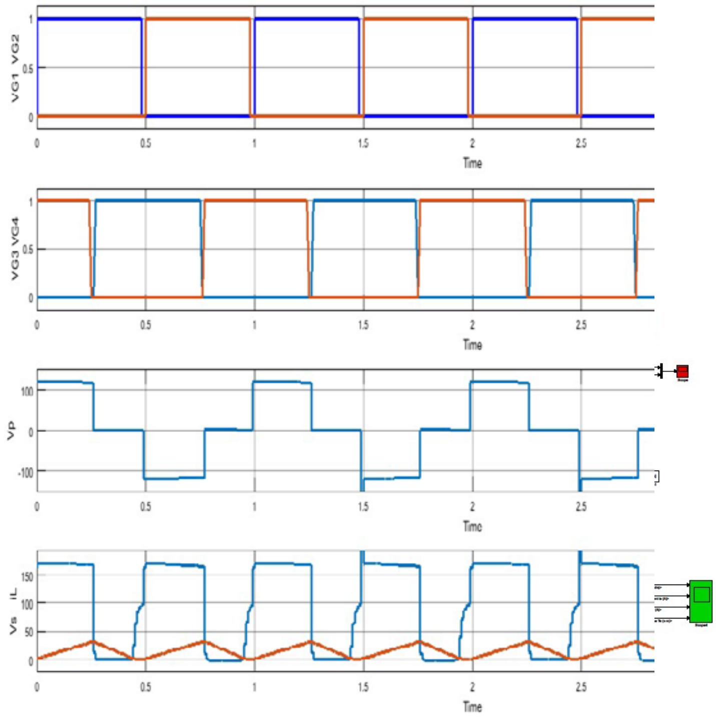

Fig 3.9: Characteristics of Fuzzy Controller with feedback control.

The blue color line is VG3and VG4is red color line. The Vg3 starts conduction at0 msec to 0.5 msec with 1v voltage, in this period of time Vg3 conducts positive and negative cycle. The Vg4 starts conduction at 0.5 to 1msec with same voltage. The Vg3, Vg4 are conducts simultaneously. As well as Vg3 and vg4 conducts simultaneously with0 msec to 1 msec, the voltage is same. The primary voltage varies from 0v to positive100v to negative 100v at the time period of 0 msec to 1 msec. The secondary voltage varies from 0v to160v.

3.4.2 OUTPUT VOLTAGE COMPARISON OF OPEN LOOP AND CLOSED LOOP FUZZY CONTROLLER

The output voltage comparison of open loop and closed loop Fuzzy controller is shown in fig.3.10. X-axis is taken as time in msec. Y-axis is taken as voltage in volts. The open loop voltage varies from 0v to 100v at the period of time 0 to 0.03 sec, and then it maintains the 90v at 0.03 sec to 0.05

sec. After this the voltage varies from 90v to115v at 0.05 sec to 0.1 sec. The closed loop system is maintained constant voltage by using the controller. The closed loop voltage is constant i.e 100v.

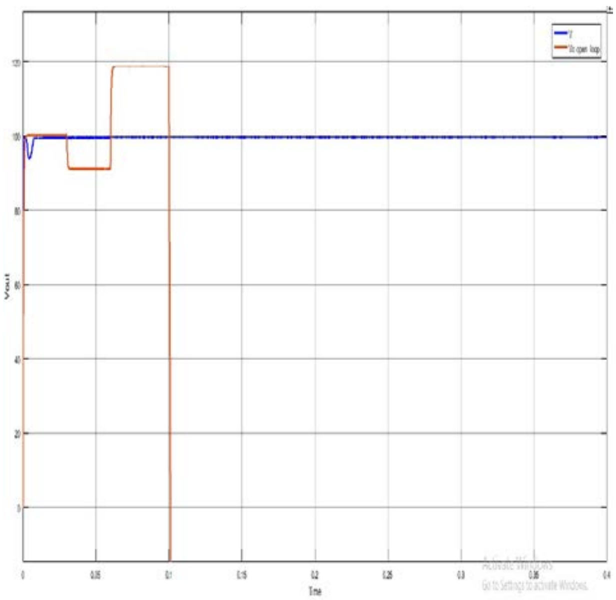

Fig 3.10: Output voltage comparison of open loop and closed loop Fuzzy controller.

3.4.3 CHARACTERISTICS OF DC MOTOR WITH FUZZY CONTROLLER

The characteristics of speed, armature current, torque of dc motor with Fuzzy controller is in fig.5.11. X-axis is taken as time msec. Y-axis is taken as amp to armature current, field current, speed in red/sec and torque in newton meter. The speed of the motor is based on load torque. If load torque is increase, then speed increased and load also increased. The speed of motor is 58 red/sec. The speed of the motor is settled at 0.05sec. The armature current varies from 0 amp to 42.5 amp. The maximum current is 42.5A.The field current is zero. The torque of motor is 82 n-m. If torque is increased load current, speed are increased. The maximum torque is 82 n-m.

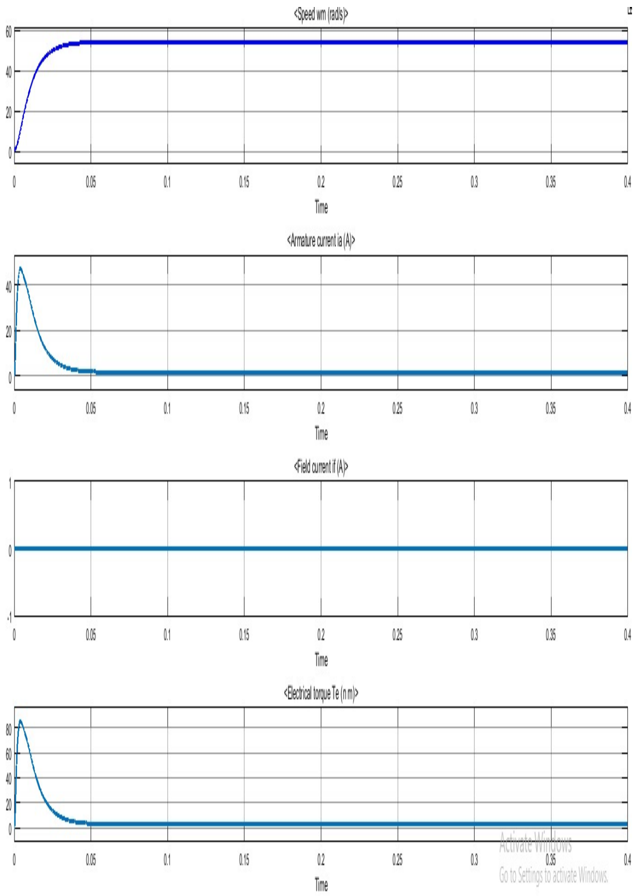

Fig 3.11: Characteristics of dc motor with fuzzy controller.

Compression of PI and FUZZY controllers

Controllers	Input voltage(volts)	Output voltage(volts)	Armature Current(amp)	Torque(n.m)	Time (msec)
PI	**90V-120V**	**100V**	**42**	**81**	**0.12**
Fuzzy	**90V-120V**	**100V**	**42.5**	**82**	**0.1**

The input and output of PI and Fuzzy controller same. The armature current of PI controller is less than the fuzzy controller. The torque of Fuzzy controller is more than the PI controller and settling time of Fuzzy controller is first as compared to PI controller.

IV CONCLUSION

This work shows an improved dc power-line correspondence approach executed utilizing the PSDM in PSFB converters. The PSDM method introduced a phase control based freedom in the conventional PSFB control loop to realize communication using the same power conversion circuit. In this way, decoupled data modulation and power conversion are realized without extra wiring and coupling units, and thus, the system structure is simplified. The base circuit is modulated with pulses generated without feedback controller and with feedback controller. Both controllers' outputs are same, but the fuzzy controller output is settled first. A simulation is carried out in MATLAB with fuzzy and PI controlled carrying the phase angles of S3 and S4 switches to ensure maintenance of output voltage at 100V.

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