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# A Bidirectional AC/DC Converter with Feed Forward Scheme by Using Neural Network Control in Microgrid System

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**ABSTRACT**: This paper present a well-simplified PWM by using neural network control with feedforward scheme for bidirectional ac/dc converter in microgrid system. In this proposed project PI controller is replace by a neural network in feedforward scheme for ac/dc converter. There are many advantages of neural network over PI such as fast switching response, reduce overshoot, undershoot problem due to disturbances. These disturbances such as fault occurrences, system loads and varying environmental condition causes overshoot and undershoot problem. The major problem in PWM bidirectional ac/dc converter is current harmonics, and this disadvantage can be minimizes with the proposed system.
Both, existing controller with PI and modified with neural network controller with feedforward scheme PWM for bidirectional ac/dc converter is compared in THD and magnitude of output dc voltage. It produces large fundamental voltage. Result verified with MATLAB simulink.

**KEYWORDS:** Bidirectional ac/dc converter, Microgrid, THD, Neural controller, Feedforward control scheme.

## I. INTRODUCTION

There are lots of renewable source of energy like solar, wind, tidal and geothermal etc. present on the earth. As there is limited amount of conventional source of energy like coal, diesel and petroleum. So, to utilize these renewable source of energy efficiently a proper channel or medium between these sources and ac grid, a bidirectional ac/dc converter either single or three phase is required. Therefore, a single phase bidirectional ac/dc converter is proposed in this paper. A microgrid consists of distributed energy resources (DERs), ac/dc converter and energy storage system. DERs are connected to dc loads and if there is deficiency of power to supply these loads the bidirectional ac/dc converter can simultaneously change the direction of flow i.e. from ac grid to dc loads. Similarly, if there is any disturbance in ac grid, so at that time power transfer from battery energy system to ac loads. PWM converters provide high dc output voltage and low harmonic ac current. In proposed PWM converter switches operated at higher frequency so as high order harmonics can easily be removed by using simple filter. The existing system have PI controller in feedforward control scheme have some disadvantage like it has slower response during transient condition and hence produces overshoot and undershoot problem in output dc voltage. So to eliminate this problem a proposed bidirectional ac/dc converter PWM with feedforward scheme having neural network controller has used. Until now, several PWM techniques are used like BPWM, UPWM, HPWM and SHEPWM. The proposed project has several advantages over existing such as lower THD, higher fundamental output voltage and low ac line current harmonics. So efficiency get improved.

## II. SYSTEM DESCRIPTION

A microgrid is a discrete energy system consisting of distributed energy sources (including demand management, storage, and generation) and loads capable of operating in parallel with, or independently from, the main power grid. Supply voltage from ac grid is supplied dc load through bidirectional ac/dc converter at this stage battery is on charging i.e. state of charging (SOC). For single phase bidirectional ac/dc converter for IGBT switches with parallel diodes are used.

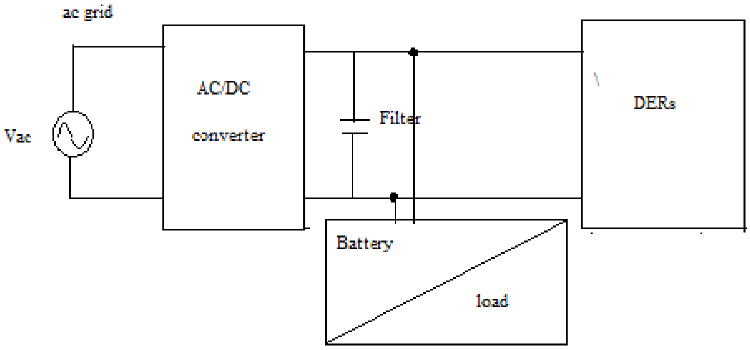


Fig 1. Proposed single phase bidirectional ac/dc converter

The proposed PWM causes only one switch to active during rectifier or inverter operation of converter and hence reduces switching losses. Battery is in state of discharging during inverter operation i.e. power is transfer from dc grid to ac grid. When power flows from dc to ac the battery get discharged so the state of charge (SOC) is goes to decrease linearly. A power flow direction (PFD) block is used which helps in changing the power flow direction simultaneously. Suppose there is any disturbance on ac grid side and difficulty in supply the power to connected ac load then at that time charged battery supplies the ac load with the help of ac/dc converter.

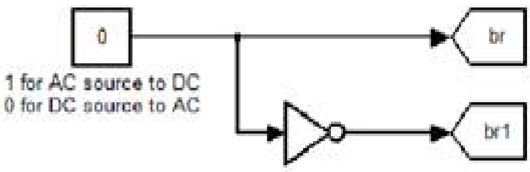


Fig 2 – Power flow direction (PFD)

In above figure br and br1 is the breakers, '0' shows that power flow from ac source to dc load i.e. rectifier operation and '1' shows that PFD is from DC source to AC load i.e. inverter operation. When power flows from ac source to dc loads breaker one is active and breaker br1 is disable. A simply NOT gate is connected to the input of breaker 1 i.e. when br is ON at that time br1 is OFF and vice- versa. In this project neural network for voltage and current control is applied due to which a minimized THD occurred.

## III. PROPOSED SIMPLIFIED PWM STRATEGY

To explain the operation of proposed bidirectional PWM converter, let us first consider inverter mode This proposed project has advantage of good voltage regulation which enhance the power quality of output power supplied to the dc loads. Consider a single-phase bidirectional ac/dc converter consist four IGBT switches with anti-parallel diodes. Any time when switching an inductor, you need a snubber circuit. This is to prevent the inductor to generate a large negative voltage during negative current changes: $V=L\frac{di}{dt}$ . Therefore, a large negative change in the inductor current will cause a large negative voltage, easily destroying any semiconductor in its way.

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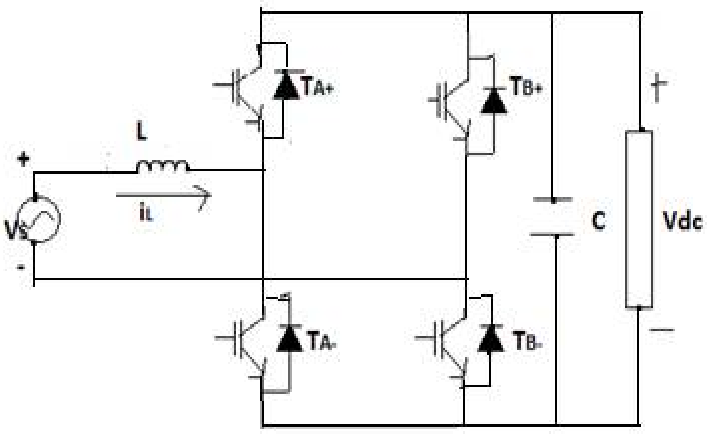


Fig 3 Application of single- phase bidirectional ac/dc converter in renewable energy system

The proposed PWM has good ac current shaping, and good dc voltage regulation and hence reduce harmonic pollution in ac grid shaping. The switching statuses of the proposed PWM for inverter mode are shown in above table 1.

TABLE I
Inverter mode switching combination in the proposed simplified PWM

| | Status | $T_{A+}$ | $T_{A-}$ | $T_{B+}$ | $T_{B-}$ | Inductor status |
|---|---|---|---|---|---|---|
| $V_S$ >0 | F | OFF | OFF | ON | OFF | $V_L > 0$ |
| | G | OFF | OFF | OFF | ON | |
| | H | ON | OFF | OFF | ON | $V_L < 0$ |
| $V_S$<0 | I | OFF | ON | OFF | OFF | $V_L < 0$ |
| | J | OFF | OFF | ON | OFF | |
| | K | OFF | OFF | ON | OFF | $V_L > 0$ |

Consider the ac grid voltage operating in positive half cycle $V_S$>0; at this instant input current is in reverse direction $i_L$< 0. As shown in table both status F and G charges inductor current as voltage across the inductor is positive. Status H discharge the inductor current as voltage across the inductor is negative. Similarly during $V_S$< 0, both status J and K discharges the inductor current as the voltage across the inductor is positive. There is one thing common in all the status is that only one switch is active during a one cycle, this shows reduced switching stress and hence increase the life of switching device. The ac grid line can be increased or decreased easily in both rectifier mode and inverter mode to obtain bidirectional flow and line current shaping.

## IV. INTRODUCTION OF NEURAL NETWORK

The neural network based controller offers very fast implementation of proposed PWM. In this project a multilayer neural network is used The proposed project employs a feedforward neural network, which receives the command voltage and angle information and generate PWM waves for single phase bidirectional ac/dc converter with the help of logic circuits. The data to be used to train it is by back propagation algorithm are generated by the simulation of converter.

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### V. FEEDFORWARD NEURAL NETWORK CONTROL

To explain the control operation of single- phase bidirectional ac/dc converter, first assume that converter operate in inverter mode. One can choose either status F and G or G and H during positive half- cycle.
According to status F

$$V_S + L\frac{di}{dt} = 0 \qquad (1)$$

And in status H,

$$V_S + L\frac{di}{dt} + V_{dc} = 0 \qquad (2)$$

Therefore , the state- space averaged equation is developed as follows:

$$V_S + (1- D_{ON})\, V_{dc} = 0 \qquad (3)$$

$$D_{ON} = (1+\frac{Vs}{Vdc}) \qquad (4)$$

During negative half cycle $V_S< 0$, either status I and K or J and K can be chosen

$$V_S - D_{ON}\, V_{dc} = 0$$

$$D_{ON} = \frac{Vs}{Vdc} \qquad (5)$$

Duty ratio is expressed in terms of control signal and the peak value of carrier waveform i.e. triangular wave.

$$D_{ON} = \frac{Vcont}{Vtri}$$

So,

$$V_{cont} = \begin{cases} \left(1+\frac{Vs}{Vdc}\right) Vtri, & if\ Vs > 0 \\ \frac{Vs}{Vdc}\ Vtri & ,if\ Vs < 0 \end{cases} \qquad (6)$$

**MODELLING:**

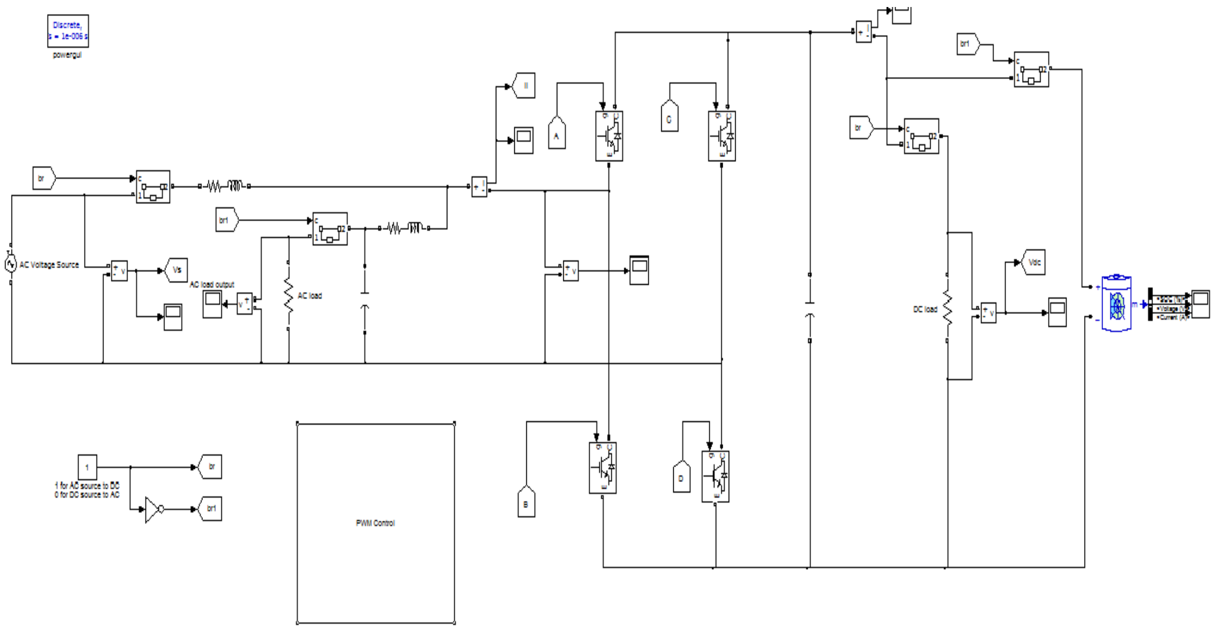

Fig 4 Model of proposed bidirectional ac/dc PWM converter with feedforward neural network control

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## VI. EXPERIMENTAL RESULT

TABLE 2.
SIMULATION PARAMETERS OF THE PROPOSED AC/DC CONVERTER SYSTEM

| Parameter | Value |
|---|---|
| Inductance | 1.65Mh |
| Capacitance | 1400µF |
| Output voltage command $V^*_{dc}$ | 300V |
| AC grid voltage $V_S$ | $100\sqrt{2}\, sin\omega t$ |
| Load | 150Ω |
| Switching frequency | 40KHz |
| DERs(only inverter mode) | 4A |

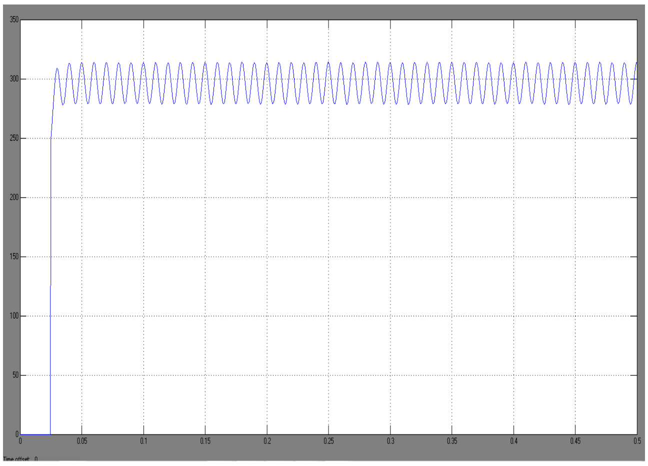

Fig 5 DC output voltage of proposed bidirectional ac/dc PWM converter with feedforward PI control

Fig 5 shows the dc voltage of the proposed bidirectional ac/dc PWM converter with feedforwar PI control , in which problem of overshoot and undershoot occurs. And reduces the efficiency of the system.

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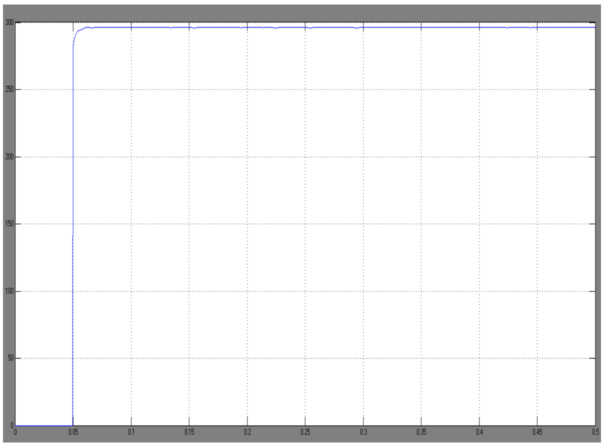

Fig 6 DC output voltage of existing bidirectional ac/dc PWM converter with feedforward neural network control

Fig 6 shows the dc output voltage of existing bidirectional ac/dc PWM converter with feedforward neural network control which improves the efficiency of the system by 98% as we see from the waveform the problem of overshoot get reduces. Also THD get decreased.

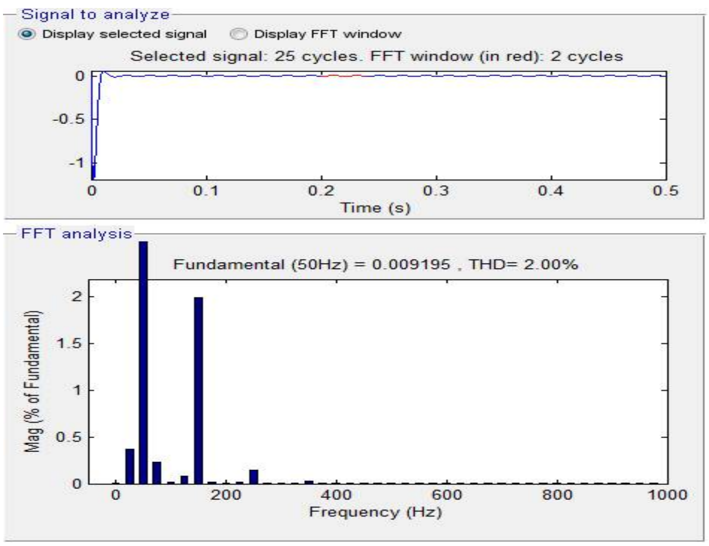


Fig. 7 FFT analysis of existing bidirectional ac/dc converter with feedforward neural network controller , above- dc output voltage, below- THD

Fig 7 shows the total harmonic distortion in dc output voltage in case of neural network controller in feedforward scheme in bidirectional ac/dc converter. At 50 Hz frequency, THD in dc voltage is only 2% which is so small as compared to THD in existing model(PI controller).

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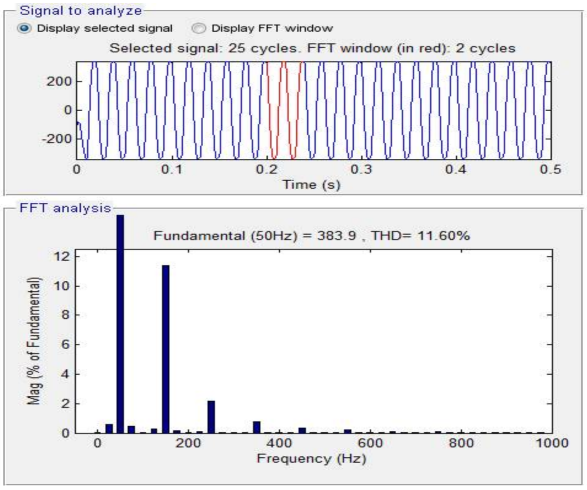


Fig 8 FFT analysis of proposed bidirectional ac/dc converter with feedforward PI controller

In figure 8 FFT analysis of proposed bidirectional ac/dc converter with feedforward PI controller in which THD is 11.06% and hence only 88.94% efficiency. So to improve the efficiency and reducing the harmonics, we proposed a system i.e. bidirectional ac/dc converter with feedforward neural network controller in microgrid system.

## VII. CONCLUSION

This paper presented a PWM strategy using feedforward neural- network control in bidirectional ac/dc converter. The total harmonic distortion in existing (PI) model is 11.06 % and 2% in proposed system so we get reduced harmonics in proposed model. In addition, it improves the system efficiency to 98% as well as reduces overshoot and undershoot problem in dc output voltage. So overall, power quality of dc output voltage is enhances**.** The magnitude of fundamental output voltage is higher than the magnitude of fundamental output voltage of the existing model i.e. with PI controller. Both the simulation and experimental result verify the validity of proposed PWM strategy and control scheme.

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