e-ISSN: 2455-5703

Current Control using Artificial Neural Network for SPV Grid Connected System

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Abstract

This paper introduces another strong innovation for current control system in view of Artificial Neural system (ANN). Advancement of sustainable power source intently take after with vulnerability. Execution of state space vector balance can improve the execution of inverter for network interconnection. This paper demonstrates the execution of SPWM technique for under regulation and over regulation for duty cycle of static switch. Singular preparing technique have been embraced for preparing of every hub of the neural system. MATLAB based Simulink strategy has been received to approve the rationale and design. ANN instrument base has been embraced for preparing reason.
Keyword- ANN, Back Propagation Algorithm, Pulse Width Modulation (PWM), SPVM, Training of Node

I. Introduction

Mindfulness for practical improvement drives as to think for inexhaustible based vitality creation. To meet the lattice, stack, request it is required to associate more number of sustainable sources to the current framework. The vast majority of the inexhaustible sources are variable and irregular in nature their by influencing the execution of energy creation. So as to interconnect a variable sources with the current steady lattice mark voltage it is required to interface a power hardware modulator which can synchronize both the static and variable sources.

Distinctive current control technique are introduced in the literature in light of their strategy for control. From the literature it can be discovered that there are two sorts of controller in particular straight and non-direct controller. Straight controller demonstrates a decent execution even the most recent decade due to their simple in charge. However their execution wind up lazy amid islanding method of activity making extreme harm the remote gadgets. Time free non-straight controller might be executed to tackle this sort of issue. Non-straight controller are of two sorts. They are time period of reference and recurrence edge of reference.

Hysteresis controller is one of the frequency reference controller where data transmission of the controller is changed in accordance with control the stream of real and reactive power for the inverter. However this sort of controller at some point requires a huge data transfer capacity for its execution and acknowledgment. This requires a vast variety in the duty cycle and at some point prompts changeless brake down of the static gadgets. Use of ANN procedure have been create over the most recent couple of years for usage of energy electronic converters with less transmission capacity. PWM in light of ANN can't unravel the present control system. Research have likewise been misused in the field of state space vector tweak for checking the relevance of ANN based strategy. One of the trouble looked by the majority of the specialist is the preparation of every individual node for a non-direct control strategy.

This paper uses the idea of two point based trajectories to confine the non-linearity sub net for every individual hub has been embraced for preparing of way on choice of factors to be received while exchanging the cloud information.

Universal Standards require for planning of controller have been embraced by entirely sticking to IEC62116, IEC61727 and IEEE1547 guidelines. Extensive examination of the controller has been completed in the present work. Some structure are additionally thought about as far as their quality and execution both under ordinary and irregular condition.

II. Space vector modulation

Space vector based Pulse Width Modulation comprises of three leg and six number of static switches similarly circulated on every leg. The exchanging activity is described by second number of states. Here N speaks to the quantity of legs. So this sort of inverter has eight number of conditions of task beginning from Si (where I = 1, 2… 7). The yield voltage is a qualities of these condition of task. The goal of SPWM is to deliver a reference voltage by joining three vector produced voltage by entirely clinging to direction.

The part of activity can be created by agreeably controlling the Pulse generation. The point of controlling the pulse generator is to create exchanging voltages inside an inspecting period so it can be firmly coordinated with reference voltage.

Execution of SVPWM relies upon the measure of adjustment of Modulation Index, m is the modulation index typically speaks to the standardized direct reference voltage, "m" can be assessed by taking the proportion between input reference vector extent and fundamental peak value i.e.

$$m = \frac{v_s^x}{v_{step}} \qquad (1)$$

Where v_s^x represents the input reference vector magnitude and v_{step} is the fundamental peak value.
Again,

$$v_{step} = \frac{2v_{dc}}{\pi} \qquad (2)$$

Radius of largest circle inscribed in the hexagon represents the maximum input reference and hence

$$v_{step} = \frac{2}{3} v_{dc} \cos\left(\frac{\pi}{6}\right) = 0.577V_{dc} \qquad (3)$$

Consequently, greatest estimation of modulation index can be discovered by consolidating eq (1) to eq (3). In this way, (4) Eq (4) speaks to around 90.7% of the crucial wave is accessible in the linear region. This demonstrates a 13% expansion in the accessibility of wave shape can be discovered when contrasted with sinusoidal PWM.
Present discussion and conditions demonstrates that SPWM can be controlled in two ways. These are:

1) By controlling the m and
2) By keeping up the time span for each pulse.
3) By monitoring the duty cycle of the inverter.

As of now examined the most extreme estimation of the adjustment record is 0.907. Along these lines, these number of back to back vector voltage can be instigated inside the hexagon in a testing period. The conditions for successful duty cycle for "m" lies in the middle of 0 to 0.907 can be portrayed as:

$$d_1 = \frac{2\sqrt{3}}{\pi} M \sin\left(\frac{\pi}{3} - \alpha\right) \qquad (5)$$

$$d_2 = \frac{2\sqrt{3}}{\pi} M \sin(\alpha) \qquad (6)$$

$$d_0 = 1 - d_1 - d_2 \qquad (7)$$

Where, $d_1 =$ Duty cycle for time interval $\frac{2t_1}{T_s}$

$d_2 =$ Duty cycle for time interval $\frac{2t_2}{T_s}$

$d_0 =$ Duty cycle for time interval $\frac{2t_0}{T_s}$

Voltage vector relating to these three duty cycle are to be specific (I) Voltage vector for d1 that slacks (ii) Voltage vector for d2 that leads (iii) Voltage vector comparing to zero switching vector. The planning interim for every vector can be acquired by duplicating the duty cycle with period. $\frac{T_s}{2}$.

III. NEURAL NETWORK BASED SVPWM

The yield of SVPWM based inverter can be controlled by controlling the modulation index (m) and angle for every part. Along these lines, usage for ANN can be refined with two sub net line

1) Sub net for Amplitude (m)
2) Sub net for Angle (θ)

For any joined point α, duty cycle can be discovered by utilizing conditions (5) to (7). For part beginning from (1) to (6), duty cycle can be gotten as takes after
Sector 1

$$d_A - ON = \frac{d_0}{2}$$

$$d_B - ON = \frac{d_0}{2} + d_1 \quad (8)$$

$$d_c - ON = \frac{d_0}{2} + d_1 + d_2$$

Sector 2

$$d_A - ON = \frac{d_0}{2} + 2$$

$$d_B - ON = \frac{d_0}{2} \quad (9)$$

$$d_c - ON = \frac{d_0}{2} + d_1 + d_2$$

Sector 3

$$d_A - ON = \frac{d_0}{2} + d_1 + d_2 \quad (10)$$

$$d_B - ON = \frac{d_0}{2}$$

$$d_C - ON = \frac{d_0}{2} + d_1$$

Sector 4

$$d_A - ON = \frac{d_0}{2} + d_1 + d_2$$

$$d_B - ON = \frac{d_0}{2} + d_2 \quad (11)$$

$$d_c - ON = \frac{d_0}{2}$$

Sector 5

$$d_A - ON = \frac{d_0}{2} + d_1$$

$$d_B - ON = \frac{d_0}{2} + d_1 + d_2 \quad (12)$$

$$d_c - ON = \frac{d_0}{2}$$

Sector 6

$$d_A - ON = \frac{d_0}{2}$$

$$d_B - ON = \frac{d_0}{2} + d_1 + d_2 \quad (13)$$

$$d_c - ON = \frac{d_0}{2} + d_2$$

Combining eqn(8) to eqn (13), the generalized form can be obtained as follows:

$$d_A - ON = \frac{1}{2} + \frac{\sqrt{3}}{\pi} Mh_{10}(\alpha^x) \quad (14)$$

$$d_B - ON = \frac{1}{2} + \frac{\sqrt{3}}{\pi} Mh_{20}(\alpha^x) \quad (15)$$

$$d_C - ON = \frac{1}{2} + \frac{\sqrt{3}}{\pi} M h_{20}(\alpha^x) \qquad (16)$$

Where

$$h_{10} = \begin{bmatrix} -\sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \\ -\sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \\ \sin\left(\frac{\pi}{3}-\alpha\right)+\sin(\alpha) \\ \sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \end{bmatrix}$$

$$h_{20} = \begin{bmatrix} \sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \\ -\sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \\ -\sin\left(\frac{\pi}{3}-\alpha\right)+\sin(\alpha) \\ \sin\left(\frac{\pi}{3}-\alpha\right)+\sin(\alpha) \end{bmatrix}$$

$$h_{30} = \begin{bmatrix} \sin\left(\frac{\pi}{3}-\alpha\right)+\sin(\alpha) \\ \sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \\ -\sin\left(\frac{\pi}{3}-\alpha\right)-\sin(\alpha) \\ -\sin\left(\frac{\pi}{3}-\alpha\right)+\sin(\alpha) \end{bmatrix}$$

Database for preparing the neurons can be acquired from h10, h20, h30 separately at a stage interim of 2°.

IV. VALIDATION OF CONTROLLER

The controller was demonstrated and outlined through Artificial Neural Network with Matlab Simulink Model. Neural Network and its related availability was displayed through ANN Module.

The Simulated model outline of ANN based Space Vector PWM was appeared in the Fig. 1. The reenactment for the Inverter was completed with the accompanying parameters
DC Link voltage = 400V,
Load resistance = 25 Ω,
Load inductance = 98mH,
Load Capacitance=20μF

An switching Frequency of around 12 kHz was utilized for activating of different gate. Execution of the present controller was recorded and is utilized to prepare the neural systems for future recreations. Detail comes about are appeared in underneath Fig.1 the THD of the load voltage is picked as the inverter performance index.

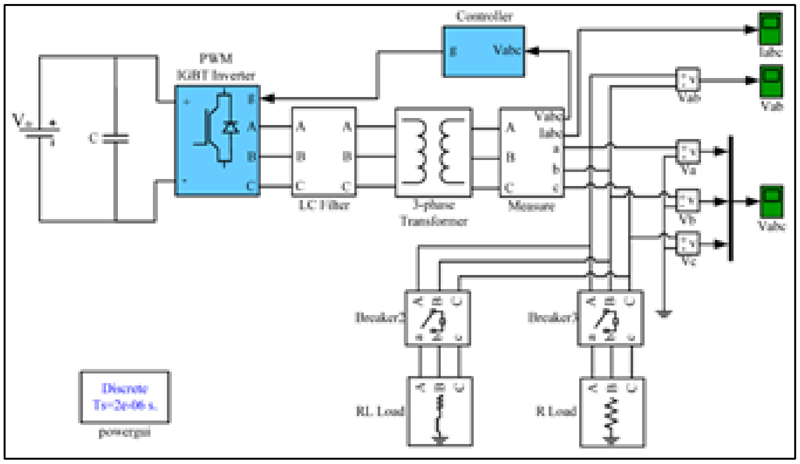

Fig. 1: Simulink Model based on ANN

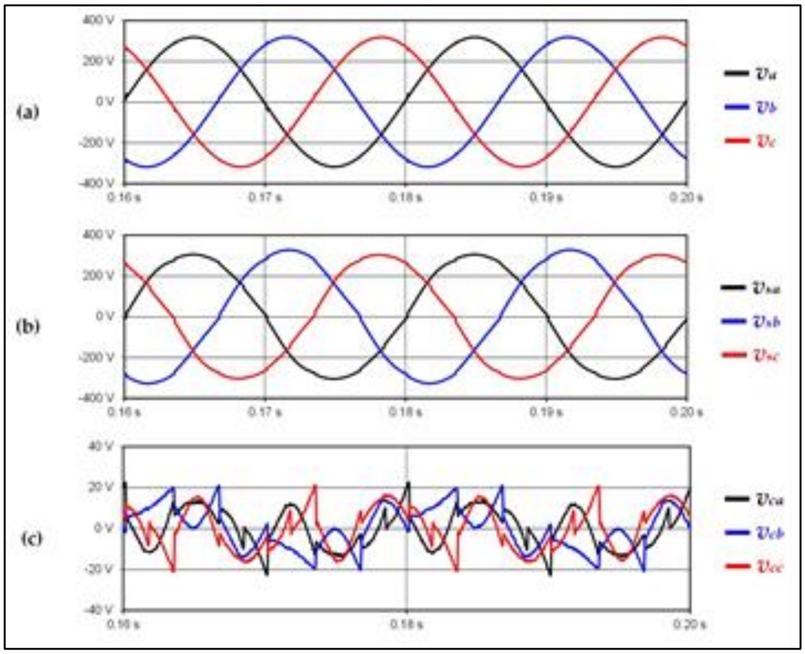

Fig. 2: Voltage Profile during GRID, SPV and the Net Error in the Synchronization

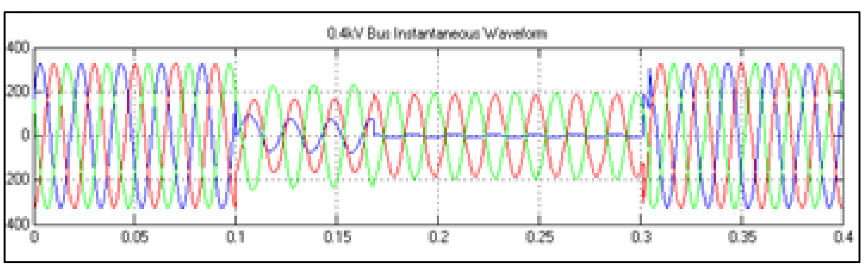

Fig. 3: (a) Voltage Waveform During a small Disturbance at LV Side

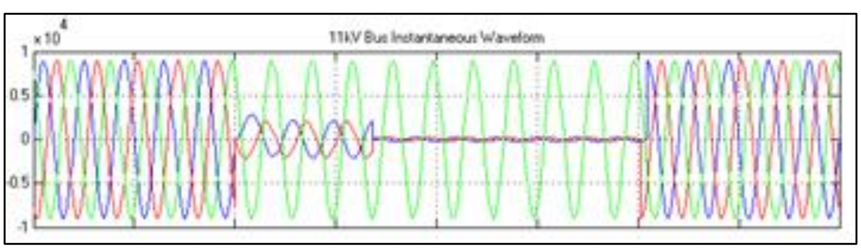

Fig. 3: (b) Current Waveform During a small Disturbance at LV Side

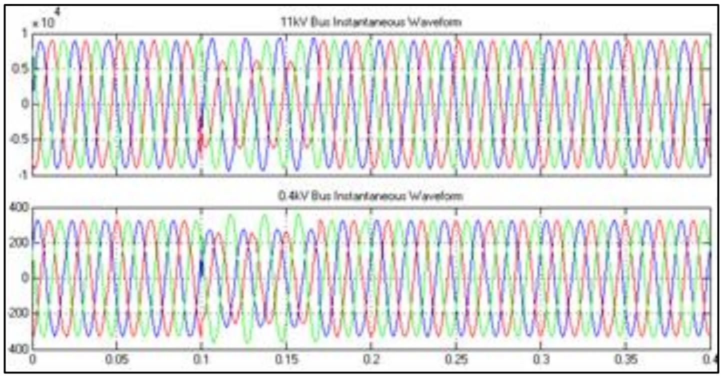

Fig. 4: Waveform during Normal Operating Conditions

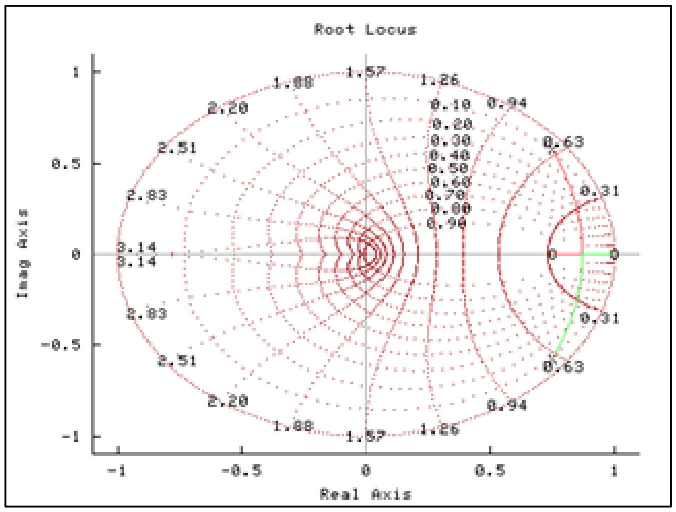

Fig. 5: Root Locus of the Controller Based on ANN

Figure 2 demonstrates the Voltage Wave Form of GRID, SPV and the Net Error in the Synchronization. Figure 3 and figure 4 speaks to the Waveform amid a little unsettling influence at LV Side and at typical working conditions separately. In the Figure 5, we get the Root Locus of the Controller Based on ANN. In this manner the outcomes demonstrate that the framework has a few points of interest when contrasted with different techniques and can be actualized in various courses, extending from its number of levels to hexagonal power control circles. In this way, tolerating to advanced world in type of non-costly and simple in taking care of.

V. Conclusion

An ANN demonstrated VSC in space Vector PWM has been depicted in this paper, which establishes to be very much worked at a regulation modulation index of 0.5. The root locus plot of the considered inverter demonstrates that the inverter is steady under any sort of fault for a length of 2 to 5 cycles.

Acknowledgement

The author would like to thank the School of Electrical Engineering for giving the help and essential research center office for fruitful testing of the model and calculation.

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