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Control Strategies to Improve the Performance of DC-AC Converter under Unbalanced AC Source

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ABSTRACT

A brand new series of manage techniques are presented to enhance the electricity controllability which make use of the zero collection additives with fuzzy control are proposed on this paper underneath this detrimental situation. In this paper, we're the usage of the fuzzy controller compared to other controllers due to the fact, the fuzzy controller is the maximum appropriate for the human choice-making mechanism, presenting the operation of an digital device with selections of specialists. In FLC, basic manage motion is decided by way of a fixed of linguistic policies. These regulations are decided through the system. For the reason that numerical variables are transformed into linguistic variables, mathematical modeling of the machine is not required in FLC. In case of the unbalanced ac supply voltage three-segment dc–ac strength converters suffer from electricity oscillation and over modern-day troubles that can be resulting from grid/generator faults. These problems are well deciding on and controlling the tremendous- and bad-series currents. The FLC contains of three elements: fuzzification, interference engine and defuzzification. The use of the simulation outcomes we are able to examine that by way of introducing right zero-series modern controls and corresponding circuit configurations, the strength converter can enable greater flexible control targets, accomplishing higher performances inside the introduced strength and the load cutting-edge when suffering from the unbalanced voltage.

Keywords: Fuzzy Logic Controller(FLC), Unbalanced AC Voltage

1. Introduction

The three-phase dc–ac converters are critical additives because the strength waft interface of dc and ac electric systems. A dc–ac voltage supply converter with a corresponding filter is used for conversion of electricity among the dc bus and the three-section ac assets as shown in Fig.1, depending at the programs and controls. which will be the power grid, generation gadgets, or the electric machines.

Inside the energy conversion technology the power electronics are so widely used, the disasters or shutting down of those spine dc–ac converters might also bring about extreme issues and fee. which will ensure certain availability of the strength deliver that the energy converters ought to be reliable to resist some faults or disturbances. within the wind power utility, in which both the total established capability and character potential of the power conversion machine are rather excessive.

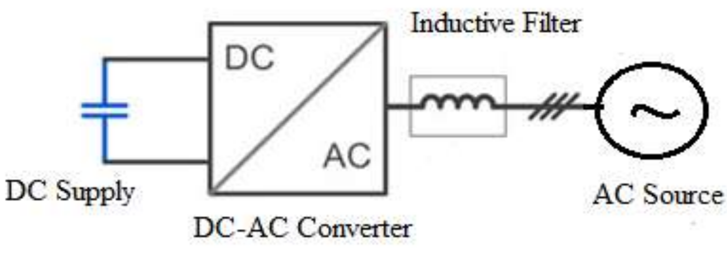

Fig.1- DC–AC power converter connected to unbalanced AC source

The DC - AC strength converter will be abruptly disconnected for this cause good sized affects on the grid stability could be decreased and also on the excessive price for upkeep/repair. As a result, for the wind turbine behavior below grid faults transmission system operators (TSOs) had been issuing strict requirements in keeping with the dip severity beneath diverse grid voltage dips for sure time, and in some uncritical situations (e.g., 90% voltage dip), the wind strength converter have to be related (or maybe hold producing energy) the energy converter might also want long-time operation [1]-[6].

To be able to maintain them generally working situations and linked to the ac supply underneath faults or disturbances, when the ac source shown in Fig. 1 turns into distorted. To overcome those problems special control techniques have been used for which can regulate both the effective- and bad series currents have been introduced [7]-[9]. But, by the use of those manage methods the ensuing performances visible to be nevertheless no longer best: either distorted load currents or energy oscillations may be provided, and thereby no longer handiest the ac source however additionally the power converter can be in addition pressured accompanying with the high priced layout concerns.

The main aim of this paper is to improve the energy manipulate limits underneath the unbalanced ac supply of an average 3-segment dc–ac converter machine. To enhance the energy manipulate capability beneath this detrimental circumstance a new series of manipulate techniques which utilizes the zero-collection additives are then proposed. The proposed control techniques have the capacity to be applied underneath other applications just like the motor/generator connections or micro grids, where the unbalanced ac voltage is possibly to be provided; therefore, the basic precept and feasibility are specifically focused.

2. Fuzzy Logic Controller

Fuzzy logic has distinct meanings. In a slim feel, fuzzy common sense is a logical gadget, which is an extension of multivalve common sense. However, in a much broader feel fuzzy common sense (FL) is almost synonymous with the concept of fuzzy units, a idea which relates to classes of items with unsharp boundaries in which membership is a matter of diploma. On this perspective, fuzzy good judgment in its narrow feel is a department of fl. Even in its extra slim definition, fuzzy logic differs both in idea and substance from conventional multivalve logical structures.

In FLC, simple control action is decided by way of a hard and fast of linguistic regulations. these guidelines are decided by using the gadget. because the numerical variables are transformed into linguistic variables, mathematical modeling of the gadget isn't required in FC.

The FLC accommodates of three parts: fuzzification, interference engine and defuzzification. The FC is characterized as

- Seven fuzzy units for each enter and output.
- Triangular club features for simplicity.
- Fuzzification the usage of continuous universe of discourse.
- Implication the use of mamdani's, 'min' operator.
- Defuzzification the use of the height technique.

Table 1- Fuzzy Rules

Change in error	Error						
	NB	NM	NS	Z	PS	PM	PB
NB	PB	PB	PB	PM	PM	PS	Z
NM	PB	PB	PM	PM	PS	Z	Z
NS	PB	PM	PS	PS	Z	NM	NB
Z	PB	PM	PS	Z	NS	NM	NB
PS	PM	PS	Z	NS	NM	NB	NB
PM	PS	Z	NS	NM	NM	NB	NB
PB	Z	NS	NM	NM	NB	NB	NB

Membership function values are assigned to the linguistic variables, using seven fuzzy subsets: NB (Negative Big), NM (Negative Medium), NS (Negative Small), ZE (Zero), PS (Positive Small), PM (Positive Medium), and PB (Positive Big). The Partition of fuzzy subsets and the shape of membership CE(k) E(k) function adapt the shape up to appropriate system. The value of input error and change in error are normalized by an input scaling factor.

In this system the input scaling factor has been designed such that input values are between -1 and +1. The triangular shape of the membership function of this arrangement presumes that for any particular E(k) input there is only one dominant fuzzy subset. The input error for the FLC is given as

$$E(k) = \frac{P_{ph(k)} - P_{ph(k-1)}}{V_{ph(k)} - V_{ph(k-1)}} \quad (1)$$

$$CE(k) = E(k) - E(k-1) \quad (2)$$

3. Three-Wire Converter System

In this paper, proposes the controllability and the performance of the energy electronics converter underneath an negative ac supply, as ever unbalanced ac voltage is first described. As proven in Fig. 3, the phasor diagram of the 3 segment distorted ac voltage are indicated, it's far assumed that the kind B fault takes place with the large voltage dip on phase A of the ac source. additionally, there are many other forms of voltage faults which have been described. In keeping with [2] and [15], any distorted three-section voltage can be expressed by using the sum of additives inside the fantastic sequence, terrible sequence, and zero series. For simplicity of evaluation, most effective the components with the fundamental frequency are taken into consideration on this paper, but, it is also viable to extend the evaluation to better order harmonics. The distorted three-segment ac source voltage may be represented as

$$V_s = V^+ + V^- + V^0$$

$$= \begin{bmatrix} v_a \\ v_a \\ v_a \end{bmatrix} = V^+ \begin{bmatrix} sin(\omega t + \varphi^+) \\ sin(\omega t - 120^0 + \varphi^+) \\ sin(\omega t + 120^0 + \varphi^+) \end{bmatrix} + V^- \begin{bmatrix} sin(\omega t + \varphi^-) \\ sin(\omega t + 120^0 + \varphi^-) \\ sin(\omega t - 120^0 + \varphi^-) \end{bmatrix} + V^0 \begin{bmatrix} sin(\omega t + \varphi^0) \\ sin(\omega t + \varphi^0) \\ sin(\omega t + \varphi^0) \end{bmatrix} \quad (3)$$

Where $V+, V-$, and $V0$ are the voltage amplitude in the positive, negative, and zero sequence, respectively. And $\phi+$, $\phi-$, and$\phi 0$ represent the initial phase angles in the positive sequence, negative sequence, and zero sequence, respectively.

Table 2- Converter Parameters

Rated output power P_o	9.8 MW
DC bus voltage V_{dc}	5.5 kV
Primary side voltage V_p	3.3 kV
Grid Voltage V_g	20 kV
Rated Load current	1.70 kA
Carrier frequency	740 Hz

A normally used 3-segment three-twine -level voltage supply dc–ac converter is chosen and essentially designed, as shown in Fig. four and table I, in which the converter configuration and the parameters are indicated, respectively. it is cited that the three-segment ac supply is represented right here with the aid of 3 windings with a not unusual impartial point, which may be the windings of an electric device or a transformer due to the fact there are handiest 3 wires and a commonplace impartial factor within the windings of the ac source, the currents flowing inside the three stages do now not include zero-sequence additives. As a end result, the 3-section load contemporary managed by the converter can be written as

$$I_C = I^+ + I^- \quad (4)$$

With the voltage of the ac source in (3) and the current controlled by the converter in (4), the instantaneous real power p and the imaginary power q in $\alpha\beta$ coordinate, as well as the real power p_0 in the zero coordinate can be calculated as

$$\begin{bmatrix} p \\ q \\ p_0 \end{bmatrix} = \begin{bmatrix} v_\alpha . i_\alpha + v_\beta . i_\beta \\ v_\alpha . i_\beta - v_\alpha . i_\beta \\ v_0 . 0 \end{bmatrix} = \begin{bmatrix} \bar{p} + P_{c2}\cos(2\omega t) + P_{s2}.\sin(2\omega t) \\ \bar{Q} + Q_{c2}\cos(2\omega t) + Q_{s2}.\sin(2\omega t) \\ 0 \end{bmatrix} \quad (5)$$

Then, the instantaneous three-phase real power $p_{3\Phi}$ and the imaginary power $q_{3\Phi}$ of the ac source/converter can be written as

$$\begin{bmatrix} p_{3\emptyset} \\ q_{3\emptyset} \end{bmatrix} = \begin{bmatrix} P + P_0 \\ q \end{bmatrix} = \begin{bmatrix} \bar{P} \\ \bar{Q} \end{bmatrix} + \begin{bmatrix} P_{c2} \\ Q_{c2} \end{bmatrix} \cos(2\omega t) + \begin{bmatrix} P_{c2} \\ Q_{c2} \end{bmatrix} \sin(2\omega t) \quad (6)$$

Where P and Q are the average parts of the real and imaginary power, P_{c2}, P_{s2} and Q_{c2},Q_{s2} are the oscillation parts, which can be calculated as

$$\bar{P} = \frac{3}{2}\left(v_d^+ . i_d^+ + v_q^+ . i_q^+ + v_d^- . i_d^- + v_q^- . i_q^-\right)$$

$$P_{c2} = \frac{3}{2}\left(v_d^- . i_d^+ + v_q^- . i_q^+ + v_d^+ . i_d^- + v_q^+ . i_q^-\right)$$

$$P_{S2} = \frac{3}{2}\left(v_q^- . i_d^+ - v_d^- . i_q^+ - v_q^+ . i_d^- + v_q^+ . i_q^-\right) \quad (7)$$

$$\bar{Q} = \frac{3}{2}\left(v_q^+ . i_d^+ - v_d^+ . i_q^+ + v_q^- . i_d^- - v_d^- . i_q^-\right)$$

$$Q_{c2} = \frac{3}{2}\left(v_q^- . i_d^+ - v_d^- . i_q^+ + v_q^+ . i_d^- - v_d^+ . i_q^-\right)$$

$$Q_{S2} = \frac{3}{2}\left(-v_d^- . i_d^+ - v_q^- . i_q^+ + v_d^+ . i_d^- + v_q^+ . i_q^-\right) \quad (8)$$

where a positive dq synchronous reference frame and a negative dq synchronous reference frame are applied, respectively, to the positive- and negative-sequence voltage/current. Each of the components on the corresponding positive- and negative-dq axis can be written as

$$v_d^+ = V^+\cos(\varphi^+)$$
$$v_q^+ = V^+ s\,in(\varphi^+)$$
$$v_d^- = V^-\cos(\varphi^-)$$
$$v_q^- = -V^-\sin(\varphi^-) \quad (9)$$
$$i_d^+ = I^+\cos(\delta^+)$$
$$i_q^+ = I^+ s\,in(\delta^+)$$
$$i_d^- = I^-\cos(\delta^-)$$
$$I_q^- = -I^-\sin(\delta^-) \quad (10)$$

Then, (7) and (8) can be formulated as a matrix relation as

$$\begin{bmatrix} \bar{P} \\ \bar{Q} \\ P_{s2} \\ P_{c2} \end{bmatrix} = \frac{3}{2} \begin{bmatrix} v_d^+ & v_q^+ & v_d^- & v_q^- \\ v_q^+ & -v_d^+ & v_q^- & -v_d^- \\ v_q^- & -v_d^- & -v_q^+ & v_d^+ \\ v_d^- & v_q^- & v_d^+ & v_q^+ \end{bmatrix} \begin{bmatrix} i_d^+ \\ i_q^+ \\ i_d^- \\ i_q^- \end{bmatrix} \qquad (11)$$

By using the equation (9) if the ac source voltage is determined, then the converter has 4 controllable freedoms (i+d, i+q, i−d ,and that i−q) to modify the modern-day flowing within the ac supply. That still means: 4 manage goals/functions can be mounted. Typically, the 3-segment common lively and reactive powers added by way of the converter are two fundamental necessities for a given software, then, two control goals should be first settled as

$$\bar{P}_{3\emptyset} = \bar{P} = P_{ref}$$
$$\bar{Q}_{3\emptyset} = \bar{Q} = Q_{ref} \qquad (12)$$

It is having one of a kind applications for the control of the average electricity also can have distinctive necessities, e.g., within the energy production software, the active energy reference P_{ref} injected to the grid is generally set as fantastic, in the period in-between so that it will help to aid the grid voltage the large amount of the reactive strength Q_{ref} may be wanted [12], [13]. As for the electrical device software, for the generator mode the P_{ref} is ready as poor and for the motor mode the P_{ref} is set as incredible, for magnetizing of the electrical system there can be no or only some reactive strength Q_{ref} necessities. at the same time as in maximum strength exceptional programs, e.g., STACOM, P_{ref} is typically set to be very small to provide the converter loss, and a massive amount of Q_{ref} is normally required[11],[14].

This paper mainly makes a speciality of the evaluation of control limits and the manage opportunities below the whole voltage dipping range. therefore, for the 3-section three-cord converter system, to gain another two control goals except there are only more contemporary manage freedoms are used (10). To similarly enhance the performances of the converter underneath the unbalanced ac supply those two including manipulate targets can be utilized. which have been usually investigated in [2]. on this paper, underneath the unbalanced ac supply two of the most noted control methods performed by three-cord converter shape are investigated.

4. Simulation Results

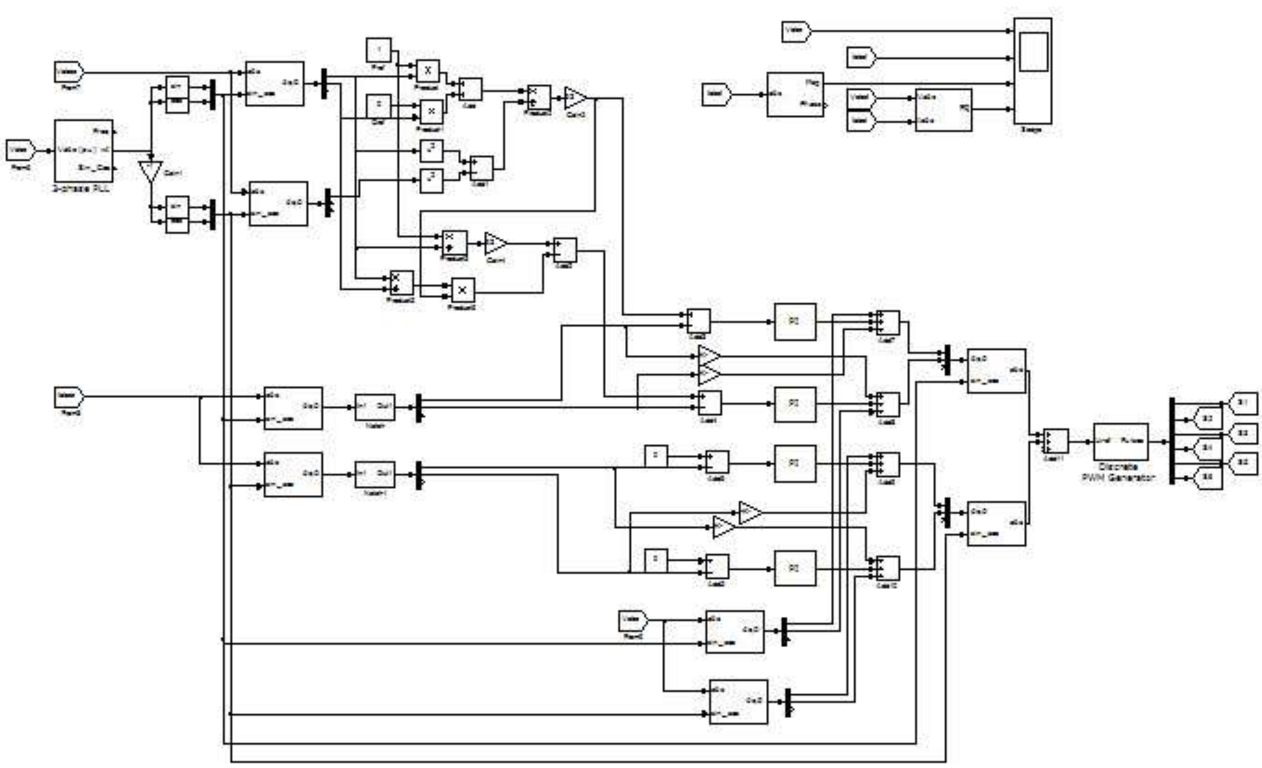

Fig.2- Simulink diagram of proposed system

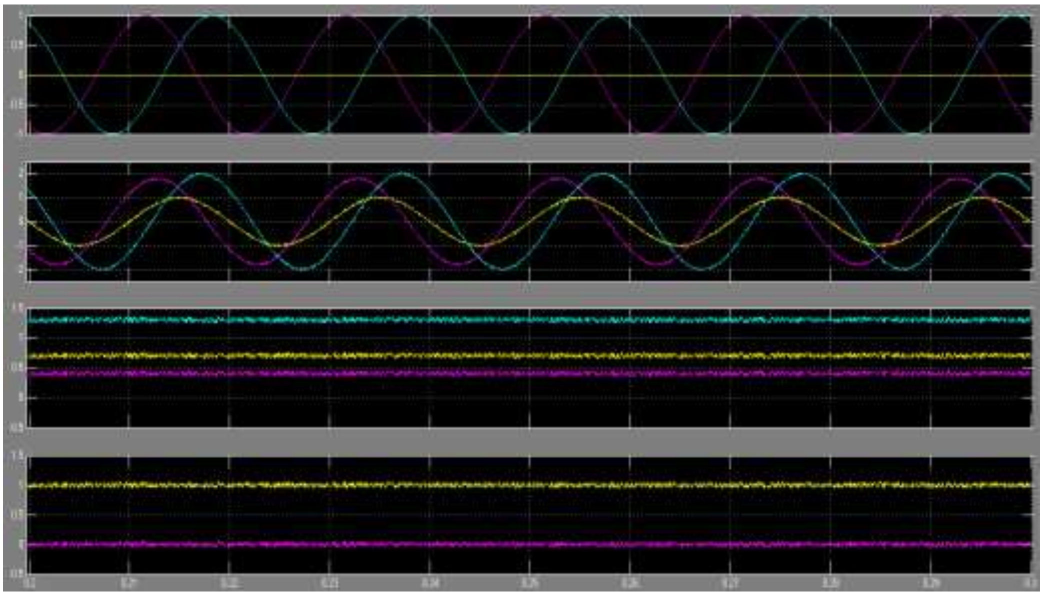

Fig.3-Simulation of the converter with no negative-sequence current control

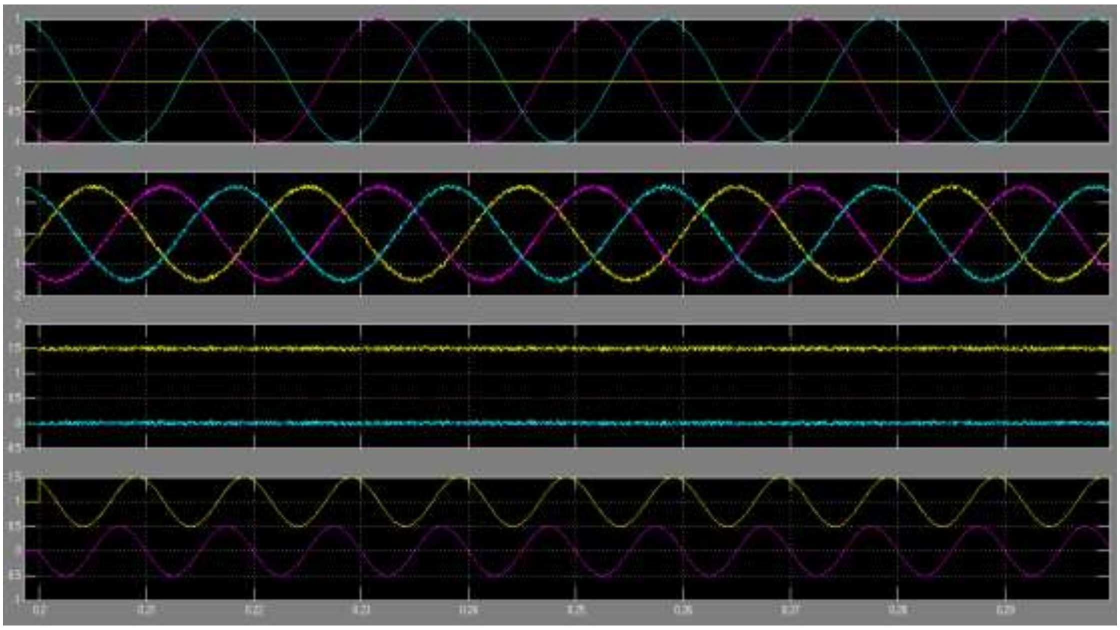

Fig.4-Simulation of converter control with no active and reactive power oscillation

CONCLUSION

The power oscillation and overload current will be presented due to unbalanced AC source. There are six current control freedoms in the three-phase converter structure with the zero sequence current paths. The extra two control freedoms coming from the zero sequence current can be utilized to extend the controllability of the converter and improve the control performance under the unbalanced ac source. It is possible to reduce or totally cancel the oscillation in both the active and the reactive power by utilizing the proposed control strategies. Meanwhile, the current amplitude of the faulty phase is significantly relieved without further increasing the current amplitude in the normal phases. The advantage and features of the proposed controls can be still maintained under various conditions when delivering the reactive power

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