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Voltage Sag Compensation by Use of Dynamic Voltage Restorers with Adaptive Fuzzy Controllers

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ABSTRACT: In this paper the fuzzy logic controllers (FLCs) gives to be the special arrangement when the process is uncooperative complex for investigation by conventional procedure or when the accessible data information are interpreted subjectively, estimated. In writing, the present FLCs all in all comprises of two input sources (error and change) and one output. The number of membership functions is chosen in most cases to be five or seven regardless of the approach used for the design. In this paper, we present Adaptive Fuzzy Controllers (AFCs) way to deal with improve the two sources of inputs one output FLCs. Adaptive Fuzzy Controllers provides fast response and better %THD compared to Fuzzy and PR controller. The investigation is applied to control a Dynamic Voltage Restorers (DVRs) based Adaptive Fuzzy controllers in voltage sag mitigation. An analytical study shows that the present system significantly increases the DVRs sag support time (more than 50%) compared with the existing phase jump compensation system. This system can also be seen as a considerable reduction in dc link capacitor size for new installing. The results are shown in simulation utilizing MATLAB/SIMULINK.

Key words: Adaptive Fuzzy Controller's, DVR's, Voltage sag, VSI

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I. INTRODUCTION

In late patterns, an expanded number of delicate burdens have been incorporated in electrical power structures. Thusly, the interest for high power quality and voltage soundness has been expanded essentially [1]. Influence quality issues are real worry of the modern and business electrical purchasers because of tremendous misfortune as far as time and cash. Flaws at either the transmission or conveyance level may cause voltage droop in the whole framework or an extensive piece of it. Likewise, under overwhelming burden conditions, a huge voltage drop may happen in framework. Voltage hangs can happen at any moment of time, with amplitudes running from 10 – 90% and a term going on for a large portion of a cycle to one moment [2]. Further, they could be either adjusted or unequal, contingent upon the kind of blame and they could have flighty extents, contingent upon components, for example, separate from the blame and transformer associations. Voltage droop can cause touchy gear, (for example, found in semiconductor or compound plants) to come up short, or shutdown, and additionally make a vast current unbalance that could blow circuits or excursion breakers. These impacts can be pricey for the client, going from minor quality varieties to generation downtime and hardware harm [3]. There are a wide range of strategies to alleviate voltage lists and swells, however the utilization of a DVR is viewed as the most cost effective technique [4].

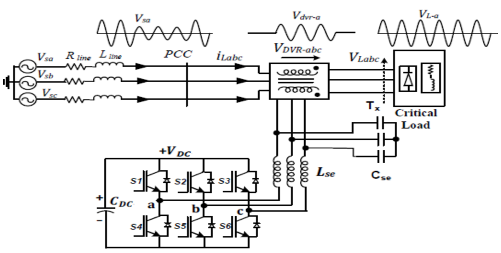


Fig. 1 Basic DVRs based system configuration.

DVRs is an arrangement custom power gadget proposed to shield delicate burdens from the impacts of voltage unsettling influences, for example, voltage lists at the purpose of basic coupling (PCC). DVRs basically comprises of an arrangement associated infusion transformer, a voltage source inverter, inverter yield channel and a vitality stockpiling gadget associated with the dc-interface. The fundamental task of DVRs is to infuse a voltage of the required size, stage point and recurrence in arrangement with dispersion feeder to keep up the ideal abundancy and waveform for load voltage notwithstanding when the voltage is uneven or misshaped. The most well-known decision for the control of the DVRs is the alleged PI controller since it has a basic structure and it can offer moderately an attractive execution over a wide scope of activity. The primary issue of this straightforward controllers is the right decision of the PI gains and the way that by utilizing settled additions, the controller may not give the required control execution, when there are varieties in the framework parameters and working conditions. To take care of these issues fuzzy rationale control seems, by all accounts, to be the most encouraging because of its vigor. Additionally, a numerical model isn't required to portray the framework in fuzzy rationale based plan. In any case, the fundamental issue with the ordinary fuzzy controllers is that the parameters related with the participation capacities and the principles depend extensively on the instinct of the specialists. On the off chance that it is required to change the parameters, it is to be finished by experimentation as it were. There is no logical enhancement technique inbuilt in the general fuzzy derivation framework [5]. To conquer this issue of streamlining, specialists have utilized a wide range of strategies over the previous decades, these strategies incorporate hereditary calculations [6]-[9], Particle swarm [10], [11], Immune Algorithm [12], neural systems [13], [14], developmental programming [15], geometric strategies [16], fuzzy identicalness relations [17], heuristic strategies [18], inclination descent[7], Kalman sifting, H∞ separating, the simplex strategy, minimum squares, backpropagation, and other numerical methods. In this paper we present an unconstrained streamlining dependent on Adaptive Fuzzy controllers (AFCs) to create an ideal fuzzy controller from a given un-upgraded fuzzy controller. The given fuzzy controller comprises of two data sources and one yield with seven enrollment capacities, however the produced ideal fuzzy controller's comprises of one info and one yield with just three participation capacities.

II. PESENT SYSTEM OPEARTING PRINCIPLE

A Dynamic Voltage Restorers (DVRs) is an arrangement associated strong state gadget that injects voltage into the system so as to control the heap side voltage. The DVRs was first introduced in 1996. It is regularly introduced in a circulation system between the supply and the basic load feeder. Its essential capacity is to quickly support up the heap side voltage in case of an aggravation so as to maintain a strategic distance from any power disturbance to that heap. There are different circuit topologies and control conspires that can be utilized to actualize a DVRs. Notwithstanding its primary assignment which is voltage droops and swells pay, DVRs can likewise included different highlights, for example, line voltage sounds pay, decrease of drifters in voltage and blame current restrictions. The general setup of the DVRs comprises of a voltage injection t/f, filter and DC energy storage device, Voltage Source Inverter (VSI), and a Control framework as appeared in Figure 2.

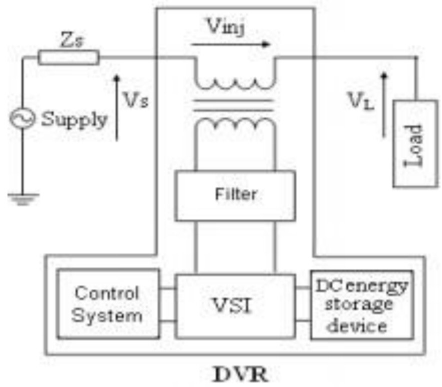


Figure 2. DVRs general configuration

The fundamental capacity of the DVRs is to infuse a powerfully controlled voltage Vinj created by a constrained commutated converter in arrangement to the transport voltage by methods for a voltage infusion transformer. The transitory amplitudes of the three infused stage voltages are controlled, for example, to dispense with any inconvenient impacts of a transport blame to the heap voltage VL. This implies any differential voltages caused by unsettling influences in the air conditioner feeder will be repaid by a comparable voltage. The DVRs works freely of the sort of blame or any occasion that occurs in the framework. For most functional cases, an increasingly sparing plan can be accomplished by just remunerating the positive and negative arrangement segments of the voltage aggravation seen at the contribution of the DVRs (on the grounds that the zero grouping some portion of an unsettling influence won't go through the progression down transformer which has limitless impedance for this part). The DVRs has two methods of activity which are: backup mode and lift mode. In reserve mode (Vinj=0), the voltage infusion transformer's low voltage winding is shorted through the converter. No exchanging of semiconductors happens in this method of activity, on the grounds that the individual inverter legs are activated, for example, to build up a short out way for the transformer association. The DVRs will be more often than not in this mode. In lift mode

(Vinj>0), the DVRs is infusing a remuneration voltage through the voltage infusion transformer because of a location of a supply voltage unsettling influence.

III. DVRs OPERATION

The phasor portrayals of these techniques are given in Fig. 3. The phasors VG and VG speak to the evaluated and hang network voltages, separately, while, VL and VL are stack voltages when list. To viably feature the distinctions among these techniques, PDVR and QDVR are additionally fused in the phasor charts. This is essentially to outline the measure of dynamic and responsive forces requested by every technique. Every one of the amounts are drawn thinking about the heap current (IL) as reference phasor.

$$< V_{sag-max} \leq (1 - cos\theta_L)$$

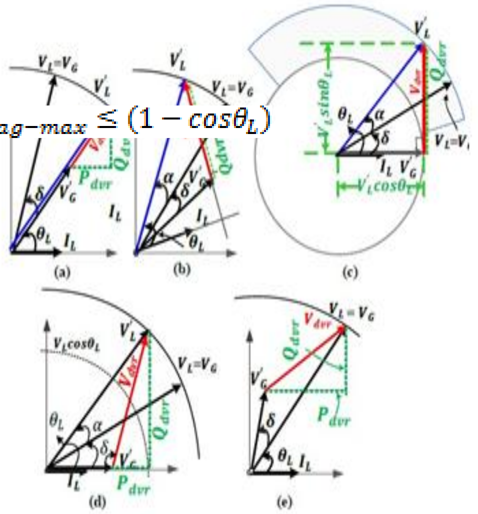


Fig. 3 Per-phase phasor representation of basic compensation topologies for DVRs. (a) In-phase injection, (b) quadrature injection, (c) quadrature injection limiting case, (d) energy optimized injection, and (e) presag injection.

A. In-phase compensation

In this kind of remuneration, DVRs infuses littlest conceivable voltage greatness in stage with the drooped lattice voltage However, as observed from Fig. 3(a) this technique can't right the stage hop. The DVRs infused voltage size and point are given as,

$$V_{DVR} = \sqrt{2}(VL - V_G^{'}) \quad \text{..........1}$$

$$< V_{DVR} = \theta_L \quad \text{..........................2}$$

b. Quadrature Injection (Reactive Compensation)

In this technique, the DVRs infuses voltage in quadrature with the heap current, that is, it redresses the hang with just receptive power. Utilizing Fig. 3(b), the infused voltage extent and point are given as,

$$V_{DVR} = \sqrt{2}\sqrt{V_L^2 + V_G^2 - 2V_L V_G COS(\alpha + \beta)} \quad \text{....3}$$

$$< V_{DVR} = \frac{\pi}{2V} \quad \text{..........................4}$$

Where, is stage bounce in the network voltage because of the droop and is the stage hop actuated because of responsive power pay. As detailed in [12], the most extreme list profundity that can be repaid utilizing quadrature infusion is firmly related with the heap control factor, and can be communicated as,

………5

The corresponding maximum injected voltage is given as,

$$V_{DVR-max} = \frac{V_G^{'}}{1 - \Delta V_{sag,max}} sin\theta_L \quad \text{…………..6}$$

Fig. 3(c) shows the limiting case for quadrature injection where DVRs supports the full load reactive power while the grid operates at unity power factor.

c. Energy Optimized Injection

This strategy is created in [15] to upgrade the execution of quadrature infusion technique for the droop profundity more profound than limit in (5), where the DVRs infuses certain dynamic power. The DVRs voltage size and infusion edge can be determined from Fig. 3(d).

$$V_{DVR} = \sqrt{2}\sqrt{V_L^2 + V_G^{'2} - 2V_L V_G^{'2} COS(\theta_L)} \quad \text{…….. 7}$$

$$< V_{DVR} = tan^{-1}\left(\frac{V_L(sin\theta_L)}{V_L^{'}cos\theta_L - V_G cos\theta_L}\right) \quad \text{……..8}$$

d. Presag compensation

In this technique, both load voltage extent and stage are reestablished to presag values. In contrast to the past strategies in Figs. 3(a), (b) and (d), the presag technique in Fig. 3(e) can effectively remunerate the stage bounce. Be that as it may, this stage hop redress requires an extra dynamic power from the dc interface capacitor.

$$V_{DVR} = \sqrt{2}\sqrt{V_L^2 + V_G'^2 - 2V_L V_G' cos(\delta)} \quad ....9$$

$$< V_{DVR} = tan^{-1}\left(\frac{V_L(sin\theta_L) - V_G' sin\theta_l - \delta}{V_G' cos(\theta_L - \delta) - V_L cos\theta_L}\right) \quad ..10$$

IV. PRESENT CONTROL SCHEME OF DVR's

Fig. 4 demonstrates the itemized square graph for the proposed control technique with least dynamic power injection with Adaptive Fuzzy controller. A method of reasoning unit is used to consistently moniter the network voltage for hang area using (1). To obtain the reference stack voltage, the control structure is parceled into two sub-modules: (1) stage bounce identification in addition to DVRs infusion point computation, and (2) MAP infusion. To achieve a decoupled dynamic and resactive power control, time of the line current is considered as the reference and is gotten by the PLL. The stage bounce identification square procedures the DVRs beginning (presag infusion) edge, and last (MAP infusion) edge. At the point when the change is over the MAP square gives the reference voltage. As showed up in the Fig. 3 the acquired DVRs reference voltage is thought about and genuine voltage in stationary reference plot. The ANFIS controller with a significant gain at the system pivotal repeat is used for correct after of V*dvr. To make up for DVRs structure misfortunes V*dvr is added as feed-forward flag to the yield of ANFIS controller. The dc associate voltage is constantly seen in an iterative control circle to deal with the infused voltage edge and as needs be avoids over-balance. Note that this square is potentially required when hang significance is close to the system design limit.

For hang discovery, the supreme contrast between reference stack voltage (1 p.u.) and real matrix voltage (p.u.) in synchronous reference outline is determined as pursues

$$\Delta V_{sag} = \left|1 - \sqrt{V_{gd}^2 + V_{gq}^2}\right| \quad ....11$$

As soon as $\Delta V_{sag} > 0.1$, it is recognized as voltage sag

To ensure a smooth changeover, a transition ramp is defined between initial and final operating points, as given below.

$$\Delta V_{sag} = \begin{cases} \frac{\pi}{2} + \gamma \quad if & \Delta V_{sag} \le (1 - cos\theta_L) \\ \pi - tan^{-1}\left(\frac{V_L(sin\theta_L)}{V_L cos\theta_L - V_G'}\right) \quad if & \Delta V_{sag} > (1 - cos\theta_L) \end{cases} \quad ......12$$

Where determines the slope of transition curve and is chosen as 30 ms.

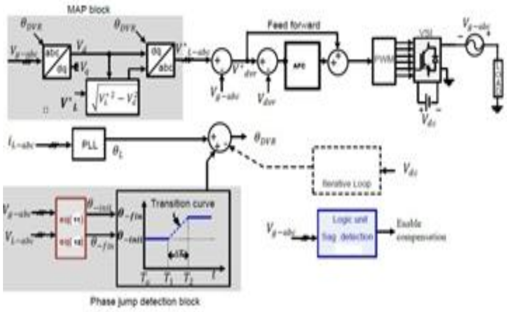


Fig. 4. Detailed control block diagram for the proposed phase jump compensation method with minimum active power injection with AFC Controller

V. SIMULATION RESULTS

The Proposed reproduction results for two distinct situations are given in CASE 1 and CASE 2. In the primary situation, a droop profundity of half [higher than the limit in(5)]. A symmetrical voltage list, for 10 cycles, isstarted at time t=0.1 Fig 7 (a)). As saw from Fig 7 (b), the heap does not perceive any adjustment in the voltage stage or size. The DVRs infused voltage and dynamic receptive power profiles are appeared in Figs that as Fig 7 (c) and Fig 7 (d), individually. It very well may be seen that the DVR's reestablishes the stage hop by infusing most extreme dynamic power toward the start and controller bit by bit moves to MAP mode after 1 cycle. Fig. Fig 7 (e) demonstrates a consistent drop in dc interface voltage anyway once the controller goes into MAP mode, a slower fall rate can be taken note. In the second situation, a hang profundity of 23% [lower than the limit given in(5)]. As observed from the outcomes in Fig 8, the DVRs effectively remunerates the load voltage stage and greatness with the present strategy. Since the voltage droop profundity is lower than the limit in (5), the controller settles in oneself supporting mode. A decrease in dc connect voltage can be seen (Fig 8 (e)) amid the initial two cycles (stage bounce reclamation in addition to progress period) in any case, as the controller moves into self-supporting mode the dc interface voltage is managed back to the reference esteem. This can be seen from the Fig 8 (d) also, where, the infused dynamic power is certain for the initial two cycles and negative onwards (self-supporting mode).

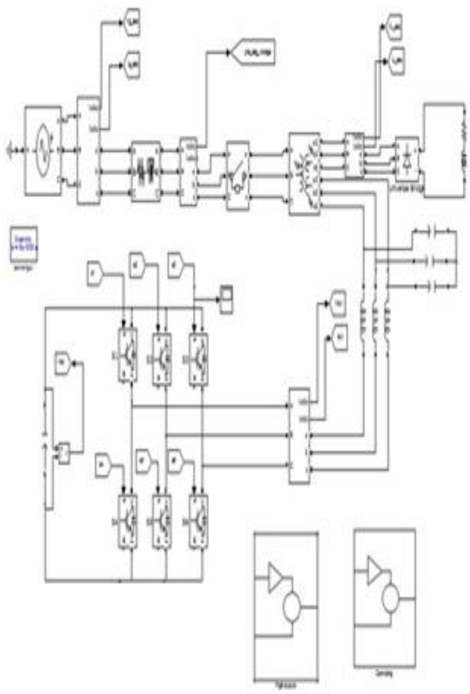


Fig 5: Simulink/MATLAB circuit diagram of proposed system

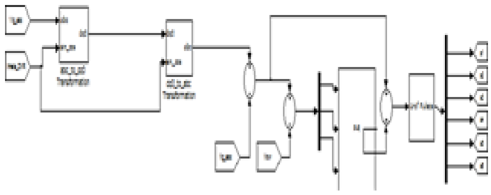


Fig 6: Existing PR Controller subsystem

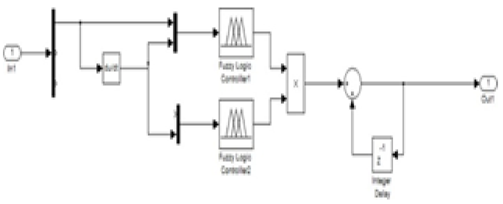
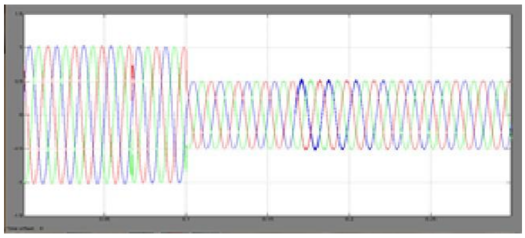
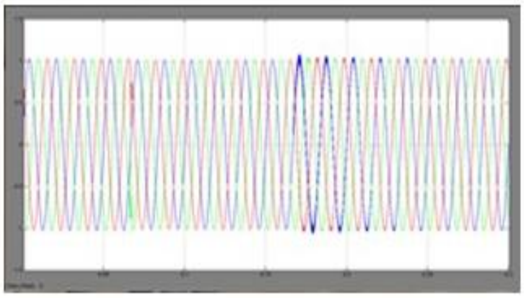


Fig 7: Proposed Adaptive Fuzzy Controller's subsystem

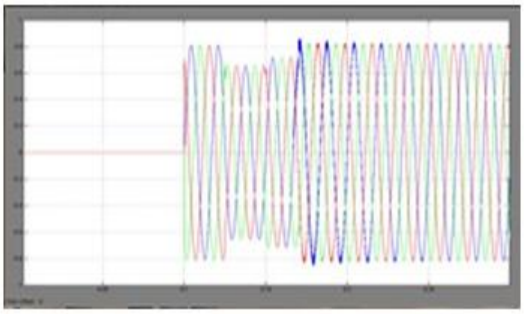
CASE 1: PROPOSED COMPENSATION of SAG COMPENSATION METHOD FOR 50% SAG DEPTH.



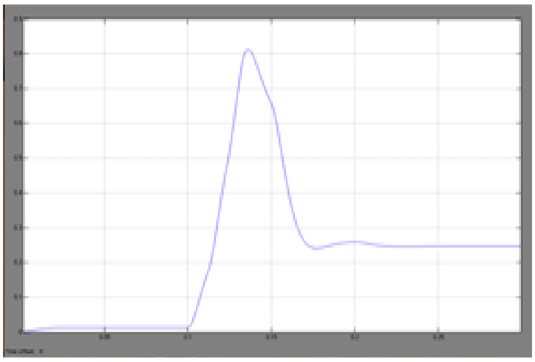
(a) PCC voltage



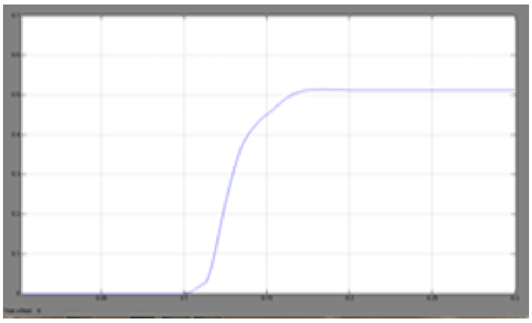
(b) Load voltage.
(c)

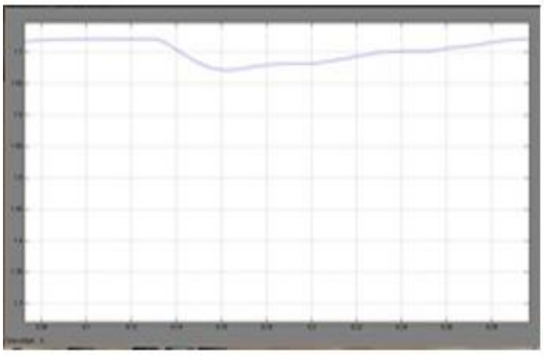


(c) DVRs voltage



(d) DVRs Active power

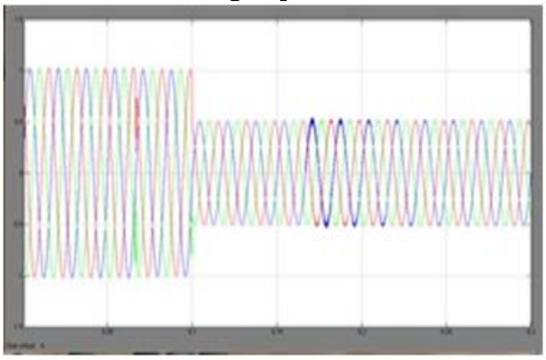




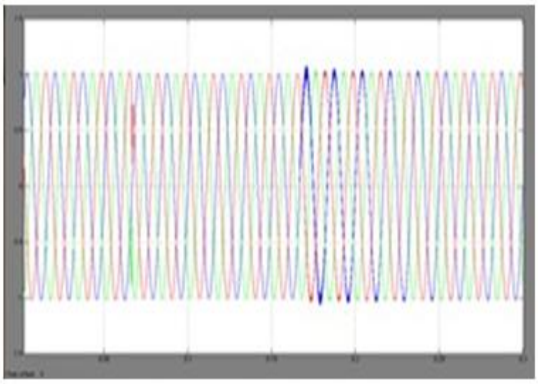
(e) dc link voltage.

Fig 8. Simulation results for the proposed sag compensation method for 50% sag depth.

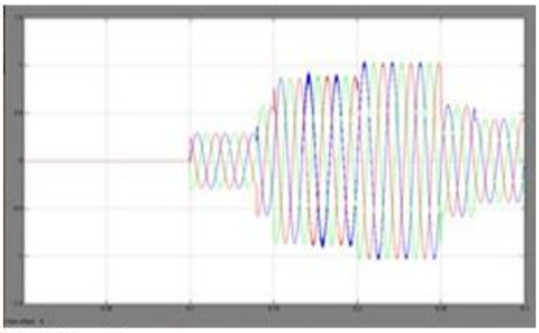
Case 2: The Proposed Sag Compensation Method For 23% Sag Depth.



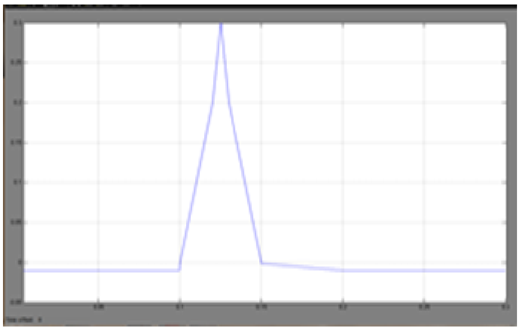
(a) PCC voltage,



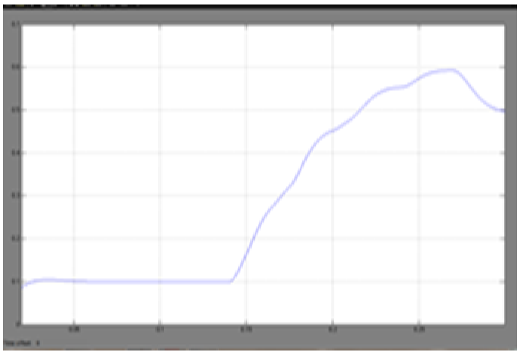
(b) Load voltage



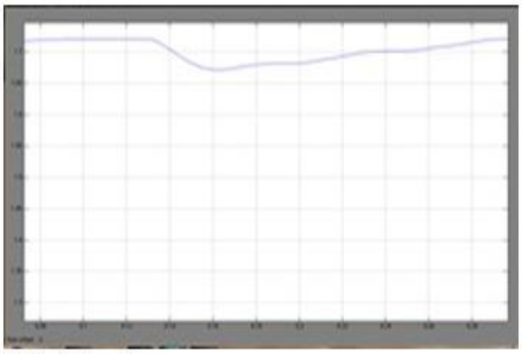
(c) DVRs voltage



(d) DVRs active power



(e)Reactive power



(f) Dc link voltage

Fig 9. Simulation results for the proposed sag compensation method for 23% sag depth.

The below table shows Comparison of base paper and extension THD% OF V_{pcc}, V_{dvr}, V_{load}

For 50% sag depth

Existing THD Values	Extension THD Values
V_{pcc} = 6.23%	V_{pcc} =2.00%
V_{dvr} =6.34%	V_{dvr} =2.08%
V_{load} =11.66%	V_{load} =2.69%

For 23% sag depth

Existing THD Values	Extension THD Values
V_{pcc} = 2.82%	V_{pcc} =1.41%
V_{dvr} =3.74%	V_{dvr} =2.76%
V_{load} =10.09%	V_{load} =2.00%

VI. CONCLUSION

This paper deal with basic unconstrained advancement strategy dependent on Adaptive Fuzzy controllers to analyze the inputs and the quantity of membership element of a given fuzzy controllers. The technique was applied to a fuzzy controllers of two sources of inputs and one output in controlling a DVRs. The present controllers is generated by Adaptive Fuzzy controllers preparing as indicated by a given input output information taken from the DVRs simulation. The simulation results have demonstrated very nearly a same performance with a slight negligible difference in dynamic response of the two controllers. Compared with the given the conventional PR controller, the present Adaptive Fuzzy controllers one is the easiest and most cost proficient controllers. Moreover this controllers has no gains to adjust and solve the problem of traditional controllers gain tuning.

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