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IMPROVING ELECTRICITY QUALITY: REDUCING SAG WITH A FUZZY-BASED DYNAMIC VOLTAGE RESTORER

#1Mr.BUSANAVENA LAXMAN, *Assistant. Professor,*

#2DR.ARRAMARAJU PRASAD RAJU, *Professor & Principal,*

Department of Electrical and Electronics Engineering,

SREE CHAITANYA INSTITUTE OF TECHNOLOGICAL SCIENCES, KARIMNAGAR, TS.

ABSTRACT: This paper details the design and operation of a Dynamic Voltage Restorer (DVR) for use in the electrical power system during periods of low and high voltage. It makes use of fuzzy reasoning. All users of electrical energy are impacted by power system inefficiencies caused by the current magnitude of voltage changes. In this article, fuzzy logic is used to control the DVR during voltage sag and swell phases to improve electric power quality by minimizing harmonics, distortions, and voltage ripples.

***Keywords*:** Fuzzy Logic, DVR, Electric Power Quality

1.INTRODUCTION

Many important and fragile systems are being used more and more in information networks, process industries, and precision manufacturing processes. This has led to research on power quality in today's distributed systems. Power quality problems, like transients, sags, swells, and other changes to the source voltage's sinusoidal waveform, can affect how well different pieces of equipment work. You can experience voltage sags at any time. They can last from a half-cycle to a minute and have amplitudes of 10 to 90%. Also, their sizes could be uncertain because of things like how far away the fault is and how the transformer is connected. Depending on the type of fault, they could be balanced or unbalanced. Some sensitive machines, like those used in chemical or semiconductor plants, can break down or stop working because of voltage sag. It can also cause a big difference in current that can blow fuses or trip breakers. The customer may have to pay a lot for these effects, which can range from small differences in quality to production delays and broken equipment. There are several ways to lower voltage sags, but using a DVR is thought to be the most cost-effective.The ubiquitous "PI" controller is the most popular choice for managing DVRs due to its simple layout and usually superior performance across a wide range of tasks.

2.DYNAMIC VOLTAGE RESTORER(DVR)

A "Dynamic Voltage Restorer" (DVR), which is linked in series, can change the voltage on the load side of a distribution network. The DVR uses power electronic parts to provide a three-phase voltage source that can be handled separately. The load voltage is then brought back to a certain level by adding the source voltage to its voltage vector, which is made up of magnitude and angle. The main job of DVR is to keep sensitive loads safe from voltage drops and rises caused by the distribution network. This part of a distribution system is usually put between the source and the feeders for sensitive loads. It is possible to use DVR to do more than just fix voltage drops and rises. It can also limit fault currents, lower voltage transients, and fix line voltage harmonics. There are different circuit topologies and control systems that can be used to make a DVR.

3.CONFIGURATION OF DVR

The main parts of a DVR are an energy storage unit, an injection transformer, a harmonic filter, a

voltage source converter (VSC), and a control and safety unit. The DVR can store energy in external batteries or capacitors that are charged from the power line through a converter. A DVR's energy storage unit is usually made up of the DC Charging Circuit and Storage Devices. Energy storage devices are used to send the energy the VSC needs through a direct current (DC) link so that injection voltages can be made. There is a Voltage Source Inverter Availability Control Unit and a DC Link Load Energy Storage Unit. Figure 3: A diagram showing how to set up a DVR There are different kinds of energy storage systems, such as batteries, capacitors, and superconductive magnetic energy storage (SMES). In reality, how long the sag lasts and how it can be fixed depends on how much energy the DVR can store. Batteries are a common choice, and when set up with high power, they can work very well. Batteries, on the other hand, don't last forever and often need an expensive method to keep track of them. An interesting option to batteries is super capacitors, which can be directly paralleled across the input bus and have a wider voltage range than batteries. Because they have a lower energy density than a battery but a higher power density, super capacitors are great for small spurts of power that last up to a few seconds. Some super capacitors can keep their charge for a long time, making them work like batteries. In contrast to batteries, these super capacitors can be charged quickly and last a much longer time.

The DC Charging Circuit's jobs are to keep the standard DC link voltage steady and charge energy storage devices after adjusting for voltage sags and swells. The charge circuit can get power from an outside source or a rectifier that is connected to the distribution network's supply mains. A voltage source converter is a type of power electronics that can provide sinusoidal voltage at any frequency, size, and phase angle. The voltage needed to counteract voltage sag and swell events is made by the VSC in DVR setups. The VSC will often have to deal with uneven switching functions for all three phases. Because of this, it needs to be able to handle each phase separately. This is because most voltage sags and swells in distribution systems are not balanced. Because a sag on one phase can cause a rise on another, the VSC needs to be able to handle both at the same time. The output power of the inverter can be changed using different PWM methods. Due to the fact that semiconductor devices are not linear, high frequency harmonics at the output of the inverter circuit often affect the voltage waveform. At the output of the inverter circuit, a harmonic filter unit is often used to keep harmonic errors within acceptable limits. Even though the filter unit reduces harmonic distortion and improves the quality of the voltage it produces, it can also lower the voltage and shift the phase of the inverter's output, which needs to be taken into account when the compensating voltage is made. It is the job of the injection transformers to connect the voltage source converters' injected adjusting voltages to the incoming supply voltage. The high tension windings then connect the DVR to the sensitive loads in the distribution network. The injection transformer also separates the load from the system, which includes the VSC and control device. Three single-phase transformers are often used as injection transformers to add the compensating voltages to the system at the load line. When a transformer is built, the MVA rating, the voltage and current ratings for the main winding, the turn-ratio, and the short-circuit impedance values must all be correct. Because of the transformers, the DVR can be built at a lower power level, depending on the stepping up ratio. The converter switches' ability to handle higher currents will be the limiting factor in this case. The control unit of the DVR is solely responsible for creating the correcting voltage. It does this by controlling the PWM pulses that are sent to the gates of semiconductor switches in the VSC. To get the most out of the DVR's dynamic performance, it's important to have a good control system that can make changes quickly. In general, the DVR safety unit is made up of things like bypass switches, breakers, measuring and

protection relays, and more. Depending on the conditions of operation, the control and safety unit improves system performance and lowers losses related to DVR operation.

Transformer for adding voltage: The main job of this transformer is to connect the incoming supply voltage to the voltage source converters' supplied compensatory voltages. It also connects the DVR to the distribution network through the HV-windings. The design of this transformer is very important because of the problems it has with overheating, overloading, overrating, cost, and performance. The injected voltage has the basic power, the desired harmonics, the switching harmonics, and the dc voltage parts. The added voltage could oversaturate the transformer if it is not built correctly, which would make the DVR not work right.

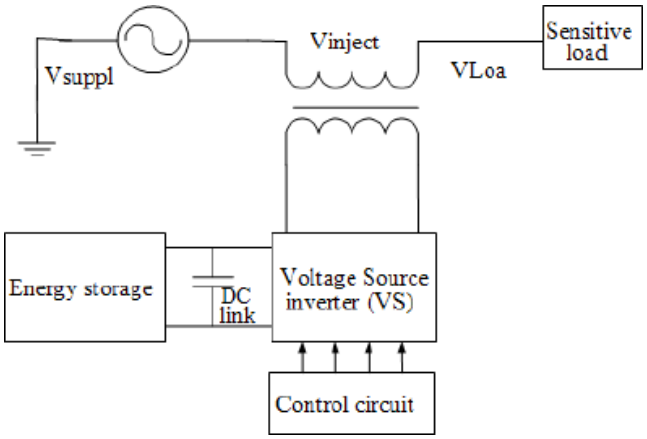


Figure 1. settings for the DVR in general

As the name suggests, the output filter's main job is to cut down on high frequency switching harmonics and keep the harmonic voltage content that the voltage source inverter produces at a safe level.It can only handle about 2% of the load's VA.

A voltage source inverter, or VSI, is a type of power electronics that can make linear voltage at any frequency, amplitude, or phase angle. It is made up of switching parts called IGCTs, IGBTs, and GTOs. In a DVR, the VSI is used to make up the missing part of the supply voltage or to briefly take the place of the supply voltage.

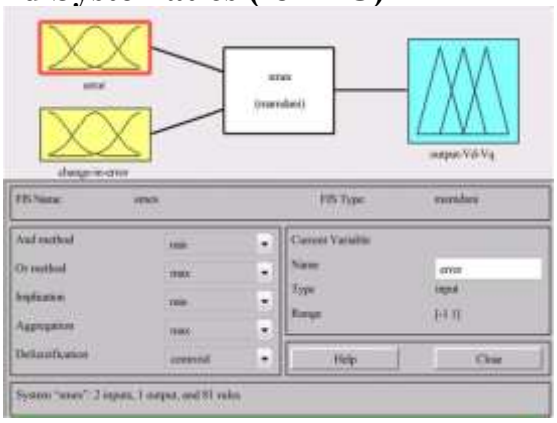
DC Energy Storage Device: The DC Energy Storage Device gives the DVR the power it needs during correction. Many ideas for storage systems have been put forward, such as flywheel energy storage, super-conducting magnetic energy storage (SMES), and super capacitors. These work best when you can respond quickly. You could also use a lead-acid battery. Battery use in DVRs was thought to be limited until recently, as it takes a long time for batteries to lose their power. Last but not least, regular capacitors can also be used.

Control system: The job of the control system is to keep the voltage magnitude at the point steady. When there are problems with the system, where a sensitive load is linked. In this study, the VSI is controlled by PWM and a PI controller. In a typical control system, there is a voltage correction method that figures out the reference voltage that the DVR should input. The error signal for the controller input is made up of the reference voltage and the amount of the injected voltage. This error is handled by a PI controller, which sends the outcome to the PWM signal generator. This generator then tells the DVR inverter how much power to inject.

4.FUZZY LOGIC CONTROLLER

People think of fuzzy logic theory as a branch of mathematics that blends probability theory, multi-valued logic, and artificial intelligence. It tries to model how people solve problems by using approximations to connect different sets of data and make decisions. Fuzzy logic controllers are well-known in the field of control theory because they can handle changes in dynamic system parameters and work better in both transient and steady state situations. The suggested Dynamic Voltage Restorer (DVR)'s voltage injection is managed by a fuzzy logic-based feedback controller in this work.

Fuzzy logic controllers are better than standard PI and PID controllers because they make systems more stable.



changes in factors during operation and how easy it is to put into place. The output of the inverter is based on the amount of energy stored in the dc link capacitors. These are part of the planned DVR's energy storage system and are charged straight from the power lines by a rectifier. But the normal PI and PID controllers can't handle these changes in the energy storage system's parameters because the amount of energy stored changes when the voltage drops or rises. This makes it hard to control the voltage injection. The suggested FLC method uses the ease of use of Mamdani type fuzzy systems in the creation of the controller and adaptation mechanism. A picture showing how a fuzzy logic controller works. The fuzzy logic-based control scheme is made up of four main functional parts: the knowledge base, fuzzification, the inference process, and defuzzification. There are rule bases and data bases that make up the information base. The database, which is made up of input and output membership functions, gives information for the right fuzzification and defuzzification processes. The rule-base is a set of linguistic rules that link the fuzzy input factors to the control actions that are wanted. Error (e) and change in error (ce), which are clear signals, are changed into fuzzy signals that can be identified by how many times they appear in the fuzzy sets. Using a set of language rules, the inference process turns the input situations into fuzzy output. The defuzzification process turns the fuzzy outputs into clear control signals by using the output membership function, which in this case is linked to changes in the control input (u). The defuzzification block makes sure that the output of the fuzzy logic controller is clear so that the PWM generator can work. The weighted average criterion, the mean-max membership, and the center-of-area (centroid) method are some of the defuzzification methods. The centroid method is used in this defuzzification method.

5.MATLAB SIMULATION RESULTS

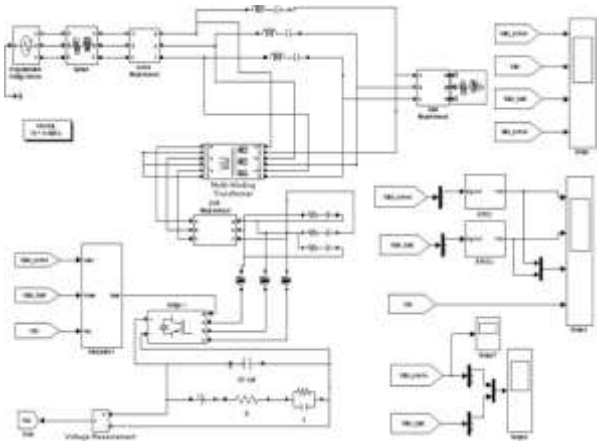


Figure 2. Picture in MATLAB SIMULINK

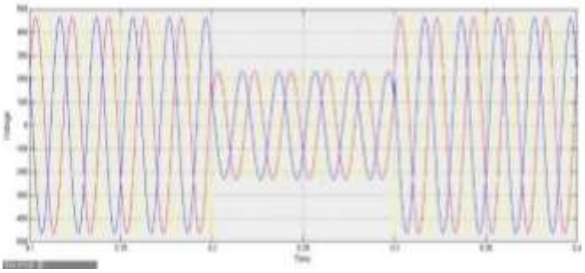


Figure 3. with drop in the voltage on the supply side.

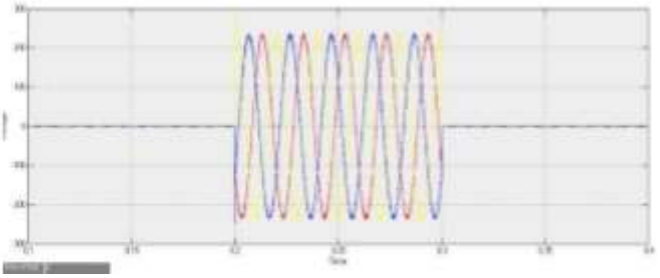


Figure 4 power when the DVR is having trouble

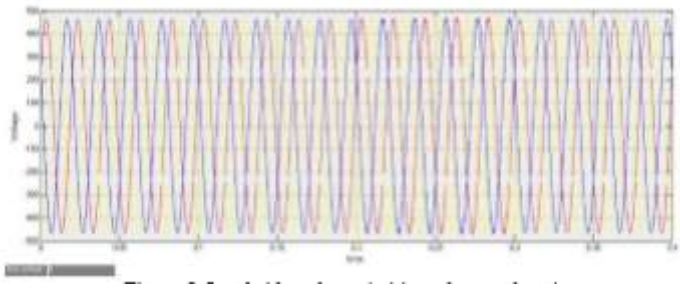


Figure 5. (Lowered sag voltage) Voltage on the load side

6. CONCLUSION

It is helpful to have DVRs in order to keep the energy from going up and down too much. They add the right voltage component to quickly fix any problems in the supply voltage so that the load voltage stays even and at its normal level. In this work, a reliable driver that works well was suggested for dynamic voltage restorers. ANFIS training makes the suggested controller based on the input and output data that is given. If you compare the suggested fuzzy controller to other fuzzy controllers, it has the fewest rules and is the cheapest. The lack of gains in this controller also solves the problem of how to change the gains of a normal fuzzy controller.

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