Mitigation of Voltage Sag at Oil Refinery Having Induction Motor Load using Dynamic Voltage Restorer

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Abstract— Power quality is one of major concerns in the present era. It has become important, especially, with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supply. One of the major problems dealt by oil refinery industries constituting induction motor loads is the voltage sag. Depending on the depth and the duration of the voltage sag, the motor speed may recover to its normal value as the voltage amplitude recovers. Otherwise, the motor speed may slow down and the torque exerted by the motor could not supply the load. This paper presents the response of induction motors to voltage sags through MATLAB Simulation. To overcome this problem, Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks is used. Various conditions of sag is simulated and the results are presented in this paper. The performance of DVR is analyzed in this paper.
Key words: Power Quality; Voltage Sag; DVR; Refinery Industry

I. INTRODUCTION

The most important anxiety of customers-as oil and gas industries- is the dependability and excellence of the power supplied. It is extremely vital to industries to keep away from being affected by any undesired power turbulence that shrink their productivity, which is the serious driving force in a extremely aggressive trade situation. Even if power production in well-developed countries has arrived at dependable levels, the disturbances and lessening in power quality could not be totally circumvent. Furthermore, owing to the difficulty of a lot of power networks, increases the sensitivity of loads and electronic devices to power quality problems [1]. Clients oblige a constant and well-regulated voltage level to continue their production, therefore any disturbances for the supplied voltage waveform can cause problems to the critical loads connected to the system. The major power disturbance event is voltage sag [2]. The decrease of root mean square value (RMS) of the voltage for a short duration that last for 0.5 cycles to 1 minute, usually caused by a remote fault somewhere on the power distribution network (IEEE Standard 1159-1995). Voltage sag reduces the reliability of a power system, where sensitive loads are highly affected by any voltage deviation, such as voltage sag event [3]-[4]. The development introduced to power electronics and power switching device's capabilities in the last three decades have increased the penetration of power quality enhancement devices, particularly those used to correct voltage sag event or any undesired voltage event [5]-[6].

The main purpose of this paper is to plan and apply a DVR that will recompense for voltage sag up to 50% of the nominal voltage for oil and gas industry. The DVR when inserted between the supply and the load will be able to detect and recognize voltage sag event in milliseconds and compensate the voltage drop by boosting the point of common coupling at the critical load. Section II of the paper deals with the problem faced by oil and gas industries. Whereas section III shows the working operation of DVR. Moreover section IV shows the results obtained by using DVR for mitigation of SAG present in oil refineries. And the paper is concluded in last section of the paper.

II. PROBLEM FACED BY OIL REFINERIES

Process stability of industrial refinery plants is subjected to quite a lot of shutdowns owing to tripping of huge induction motors, either by under voltage or by over voltages or sometimes by the mechanical protection. The major reason for such accidental shutdowns was voltage sags. The Dynamic Voltage Restorer (DVR) has recently been commenced to protect the industrial amenities from voltage sags and other voltage disturbances. Existing configurations and control techniques for the DVR plan at protecting industries of high-tech, loads with adaptable speed drives and additional power-electronic based loads. Industries with induction motors loads necessitate a total diverse approach for the design and control of a suitable DVR [7]. Due to the inherit inertia of the induction motors and their capability to withstand short-duration, shallow sags, in addition to its tolerance to phase jumps, a DVR with low cost, fast response and simple controller could be configured to fulfill the voltage restoration requirements.

III. WORKING OF DVR

The dynamic voltage restorer (DVR) is used to pact with the voltage sag and to decrease the consequences of these turbulences on the perceptive loads [8]. Its utility is to sense the voltage sag and insert the voltage divergence between the pre-sag and post-sag voltage, such that the voltage is maintained and arrive at the load area as the pre-sag voltage magnitude. Fig 1 describes the power circuit of the DVR.

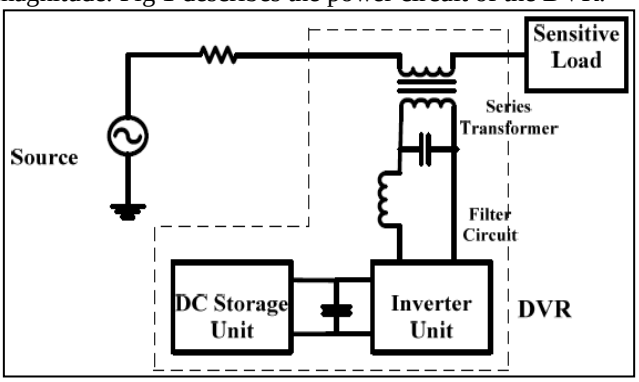

Fig. 1: Basic Structure of DVR

The DVR is a series connected power electronic device used to inject voltage of required magnitude and frequency. The basic structure of a DVR contains the

following components- Voltage Source Inverter (VSI), DC storage unit, Filter circuit, Series Transformer

The main function of the DVR is to insert voltage of necessary amount and frequency as most wanted by the power system network [9]. Through the standard operation, the DVR will be in stand-by approach. During the disturbances in the organization, the insignificant or rated voltage is compared with the voltage difference and the DVR injects the difference voltage that is necessary by the load [10]. The equivalent circuit of a DVR coupled to the power network is shown in Fig. 2. Here Vs is the supply voltage, Vinj is the voltage injected by the DVR and VL is the load voltage.

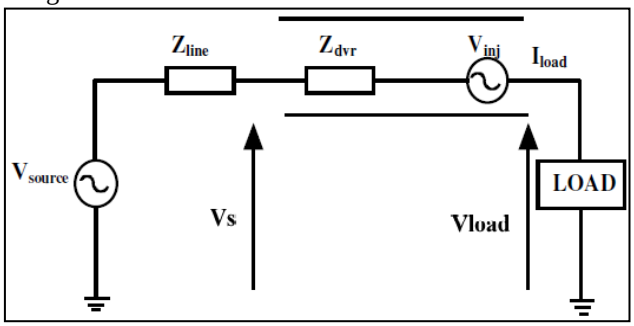

Fig. 2: Equivalent Circuit of DVR

The working of DVR and control strategy is shown in figure 3

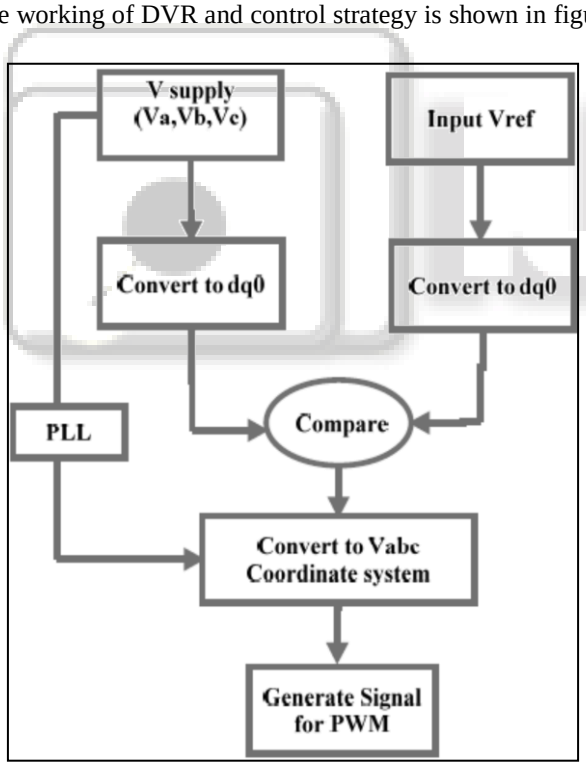

Fig. 3: Working Strategy of DVR

IV. RESULTS

The above mentioned system is simulated using MATLAB simulink 2016, where a three phase supply is provided to the load. When a three phase to ground fault occurs in the system at the load end sag is created in the system which is shown in figure 4. The sag created is hazardous to sensitive load. Therefore it should be removed as soon as possible. For this purpose DVR is designed and implemented in the system.

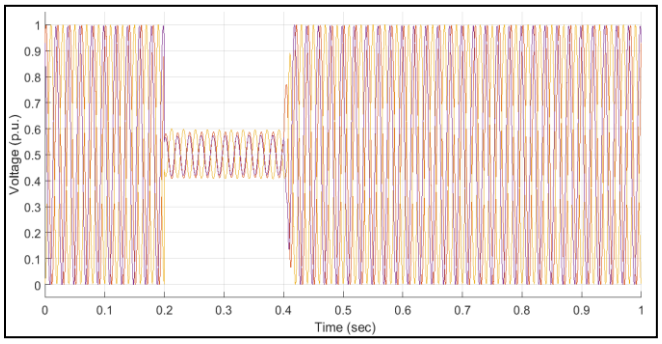

Fig. 4: Voltage Profile without DVR

The FFT analysis of voltage signal is shown in figure 5 where it is observed that the total harmonics distortion is found to 30%

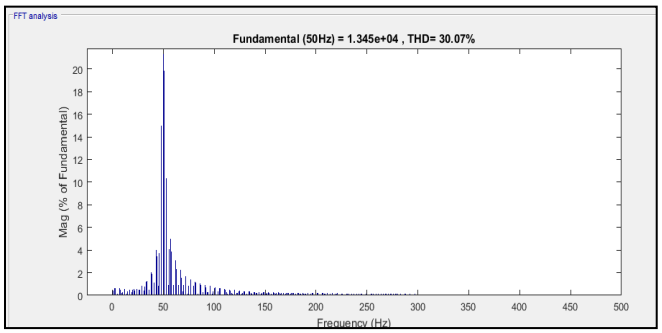

Fig. 5: FFT Analysis of Voltage without DVR

The calculations of the system are done on per unit. The voltage levels at all the phases are 1 p.u. when the fault occurs on load side at 0.2 seconds sag is introduced in the system which is cleared after 0.4 seconds after which the system voltage is restored to normal value. The sag duration of 0.2 seconds is enough to damage the load and may shut down the system which can affect the performance of the system. to avoid this DVR is connected whose control circuit is shown in figure 6.

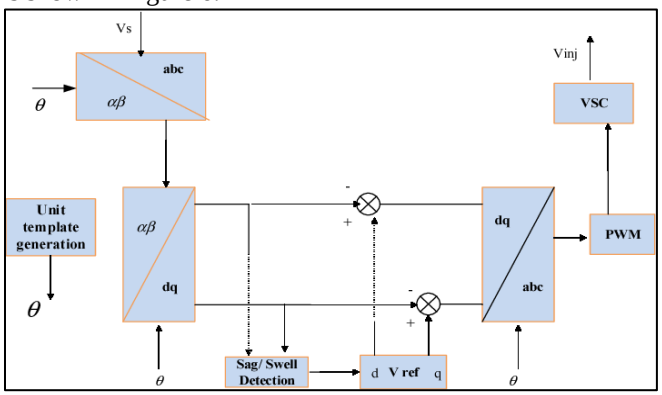

Fig. 6: Control Strategy of DVR

The control system mentioned in figure 6 is implemented on the system where sag was introduced. The MATLAB implementation is shown in figure 7 and the results are shown in figure 8

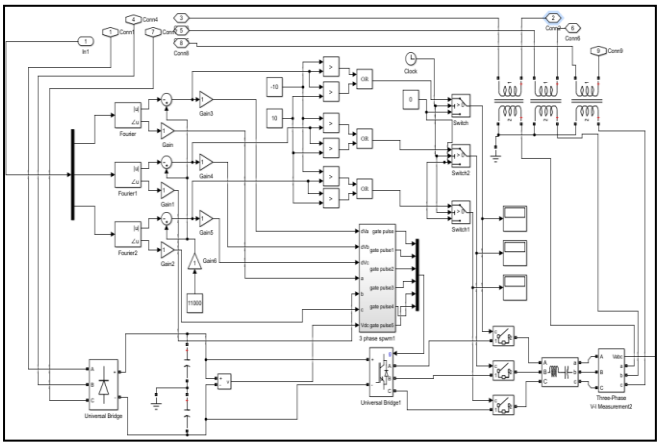

Fig. 7: Control Logic Implementation of DVR

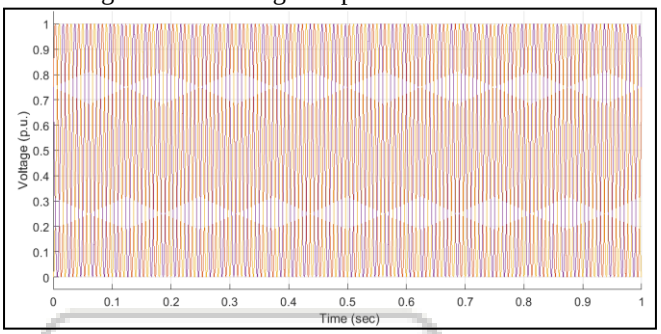

Fig. 8: Voltage Profile with DVR

Figure 8 indicates that the voltage is restored to 1 p.u. using DVR. The total harmonics distortion of voltage when DVR is implemented is shown in figure 9. Here it is observed that the inter-harmonics are also eliminated. Hence using DVR the voltage profile is also improved.

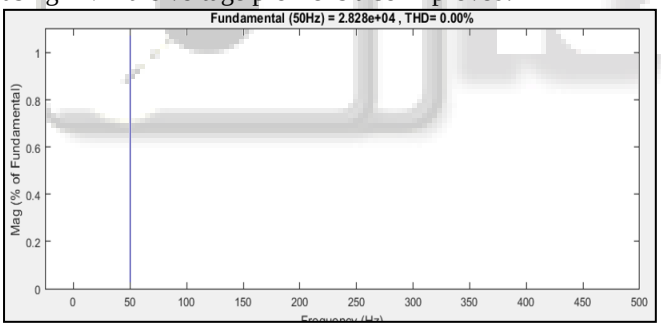

Fig. 9: FFT Analysis of Voltage with DVR

Figure 10 shows the injection of voltage by the DVR when sag of 40% is introduced in the system.

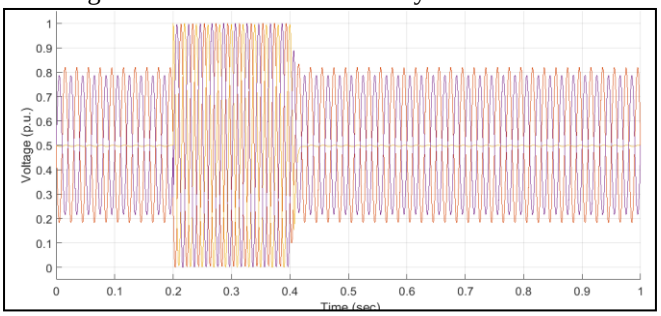

Fig. 10: Injected Voltage by DVR

V. CONCLUSION

Oil refinery industry is very crucial industry where the loss of power or tripping of circuit breakers affects the performance of the industry. Voltage sag is the major power quality disturbance which is faced by refinery industry. To enhance the performance of refinery industry dynamic voltage restorer is used in this paper which clearly indicates that the voltage sag can be eliminated using the control strategy of DVR. As seen from the results the voltage sag is eliminated and the voltage is restored to 1 p.u. It is also observed that whenever sag of 40% is introduced in the system inter-harmonics comes into picture which affects the life of the industry. The observed total harmonics distortion when 40% sag is introduced in the system is found to be 30% whereas when we use DVR the problem of inter-harmonics is also reduced.

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