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Review on DVR for Power Quality of Sag and Swell

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ABSTRACT: The power quality issues are Voltage sag, Voltage swell, Interruption, Harmonic etc. Among such power quality problems, the voltage sag is by far the most serious disturbance within the distribution network. A voltage dip or sag is indeed a short-term decrease in RMS voltage which can be triggered by short-circuiting, overloading, or starting of the electric motors. A voltage dip or sag occurs when the voltage of the RMS reduces from 10 to 90 percent of the rated voltage for a yet another-half cycle with one minute. A few other sources describe the length of sag for a time frame from 0.5 cycles to very few seconds, and the longer duration of a low voltage would be named as "sustained sag." The performance of DVR is analyzed for Voltage sag and is compensated by appropriate voltage injection. Voltage sag is introduced for 10 cycles. From the results it can be drawn that DVR compensated for voltage sag.

KEYWORDS: Power Quality,Sag,Swell,Optimization.

I.INTRODUCTION

Voltage swell or sag represents the significant problems that arise in the form of sudden voltage drop or increase, which occurs significantly due to limited conditions of the circuit. [1] There are several multiple kinds of power electronic devices for improving power quality however DVR is indeed a very simple, versatile, and cost-effective system to reduce voltage swelling and sag. [2] DVR's main components as filter, power storage device, inverter, isolation transformer, and controller to eject or inject the suitable voltage to release the issue of power quality. The most common inverters as current source inverter (CSI) and voltage source inverter (VSI) have major drawbacks: the first disadvantage as AC output power would be less than DC Input power therefore only worked in buck mode, and the second disadvantage as two switches in the very same phase leg could never turn on at the same. Although this generates a power surge or short circuit. A high-frequency network here between the inverter bridge and voltage source has also been developed to address this issue. Thus, the impedance channel used between the bridge and the voltage source of the inverter. The voltage can indeed be adjusted in the Z-source inverter by adjusting the shooting and modulation index (MI) via the duty ratio. A simple Z-source network implementation, with appropriate configurations for switching, has been used. As well as accurate modulation methods and control lower the quantity of energy conversion phases within the energy conversion string. This increases the efficiency and reliability of the electronic power systems. [3, 4] The impedance networks have added as many changed topologies with passive and active elements to increase the voltage stress and gain in the network elements. Through changing the impedance networks to increase voltage gain, respectively., so many enhanced impedance networks have been implemented as a magnetically coupled impedance source (MICS) including the T-source, upper-zone source, TZ-source, Trans-Z-source, high-frequency Z-source, LCCT-Z-source, Quasi-LCCT-Z-source transformer. Both Quasi-LCCT-Z and LCCT-Z -source derive constant current from respective sources within these networks. The d is a continuous form of input currents from many other networks that can cause issues when renewable sources such as fuel cells, PV, etc. are used. Different methods have been developed to smooth the currents from the sources. To address these or certain altered system issues as discontinuous input current, and to smooth the current, etc., three winding systems named the Y-source Network is implemented. Y- Source inverter as modulation index (MI) has three freedom degrees, firing via duty ratio, and one additional concept named winding factor (K), and a Quasi Y-source inverter is often used in DVR as part of this study. The Quasi Y-source gets all of the benefits of the initial Y-source Inverter. But it could also generate a really high voltage gain, which operates consistently at quite a greater modulation index. So, this can take consistent input current that suits renewable sources better, etc.

1) Voltage Sag and Swell Definitions

Over the last 15 years, in the light of how power quality instruments evaluate voltage sags and swells, definitions have been developed. [8]. Power framework networks state sags as a decrease in voltage beneath a client characterized low farthest point via a single cycle with 2.55 seconds. Surges are currently named as swells, with the exception of that the voltage surpasses a specific client characterized high cutoff. While diverse definitions relating to the abundancy and length are still being used, the IEEE 1159-1995 Recommended Practice on Power Quality Monitoring has characterized them as takes after. [9].
Sag (dip) can be characterized as, "A decline to somewhere in the range of 0.1 and 0.9 pu in rms voltage or current at the power recurrence for spans of 0.5 cycles to 1 minute."
Swell can be characterized as, "An expansion to between 1.1 pu and 1.8 pu in rms voltage or current at the power recurrence spans from 0.5 to 1 minute."

2) Effects of Voltage Sag

The power quality issues are Voltage sag, Voltage swell, Interruption, Harmonic etc. Among such power quality problems, the voltage sag is by far the most serious disturbance within the distribution network. A voltage dip or sag is indeed a short-term decrease in RMS voltage which can be triggered by short-circuiting, overloading, or starting of the electric motors. A voltage dip or sag occurs when the voltage of the RMS reduces from 10 to 90 percent of the rated voltage for a yet another-half cycle with one minute. A few other sources describe the length of sag for a time frame from 0.5 cycles to very few seconds, and the longer duration of a low voltage would be named as "sustained sag." The performance of DVR is analyzed for Voltage sag and is compensated by appropriate voltage injection. Voltage sag is introduced for 10 cycles. From the results it can be drawn that DVR compensated for voltage sag.
The prime enthusiasm about voltage sags is their impact on delicate electric gadgets, for example, PCs, flexible programmable rationale controllers, speed drives, and additional power electronic gear [10]. The slightest touchy burdens fizzled if the voltage gets dropped to 30 % of the predefined voltage. Then again, the most delicate parts fizzled if the voltage gets dropped to 80-86 % of evaluated esteem. After the test outcomes, the ascertained list limit to influence generation at the utility PCC - purpose of basic coupling was 87 % of the ostensible voltage for in excess of 8.3 ms.

1.1 Dynamic Voltage Restorer

The cost of manufacturing and the unwavering quality of those strong state gadgets has been enhanced as new innovations developed. Along these invisible cost with unrivaled execution than the regular pneumatic or electrical gadgets accessible in the market place. [11, 12] [13-15]. Dynamic Voltage Restorers (DVR), Active Power Filters (APF), and Uninterruptible Power Supplies (UPS) are cases for generally utilized custom power gadgets. Among these, APF is utilized to relieve harmonic issues happening due to non-direct stacking conditions, while DVR and UPS are utilized to adjust for surge and voltage conditions [16-18].
Voltage sag may happen from an individual stage to three stages. Be that as it may, it has been discovered that solitary stage voltage sags are normal and most incessant in the power business. In this manner, the enterprises that utilize single and the three-stage supply will encounter just a few interferences across the generation process and will be obligatory to include some form of voltage compensation hardware.
Whenever the fault is detected, the DVR action starts. In the event of a fault resulting in voltage sag, the magnitude decline is coupled with the phase angle shift, and the remainder of the voltage magnitude with a specific phase shift is associated with the DVR. Using the least mode of active voltage injection in the DVR with a certain phase angle shift mostly in post fault voltage could indeed lead to incomprehensible DVR utilization [21]. Throughout the event that the dynamic voltage in the DVR is less substantial, it can, therefore, be expressed to load for steadiness.
The scale is determined by matching it with the same kind of current structures. This is used by experts to estimate the appropriate size of various software components, and instead combine them to have the final size.

1.1.1 DVR Location

The main goal is to just support individual customer or a multiple consumer with added value. Trying to apply a DVR to a low voltage (LV) or medium voltage (MV) device Ought to be realistic. A significant difference amid LV and MV link is generation of zero sequence currents and null sequence voltages.

- The 4-wire LV distribution system is illustrated in figure 1.3(b), the DVR have to protect low Z value i.e. impedance for i_o (i.e. zero sequence currents) and this current must, therefore, circulate within power converter or even in the injection transformer’s delta winding and the impedance caused by the location of DVR mostly on LV side is fairly large.

- The 3-wire MV distribution system is illustrated in figure 1.3(a) (Geena, 2019), the use of basic DVR configuration is feasible in certain countries and thus fairly easy to monitor because there is no zero-sequence part. With injection transformers, the DVR needs a very high degree of isolation, and the short circuit degree is indeed high in MV.
- MV-based execution of DVR may accomplish cheaper prices per megavolt ampere relative to deployment at LV level.

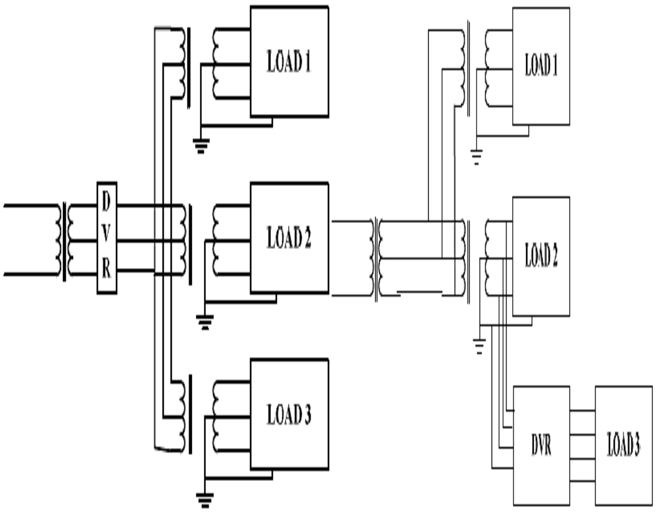

Figure 1.(a): DVR in the MV system **Figure 1.(b):** DVR in the LV system

1.1.2 Power Circuit

DVR 's basic topology and its power circuit comprise a booster/injection transformer, an energy storage device, a harmonic filter, a bypass interrupter, and a voltage source inverter. [23, 24].

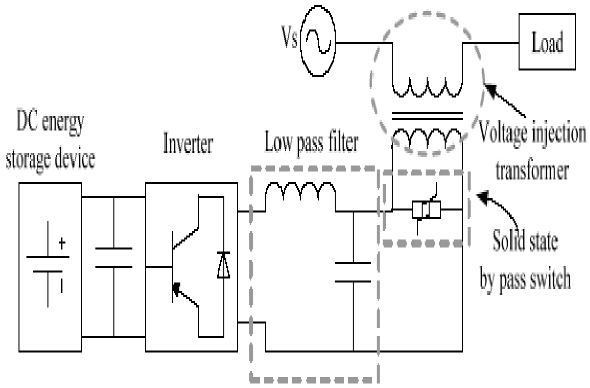

Figure 2: DVR Power Circuit

Injection / Booster transformer

The primary concept of the voltage injection transformer would be to link the distribution system to DVR through the High-Voltage windings and couple the inserted compensating voltage produced by the VSI to the arriving supply voltage after the control circuit has detected any voltage disturbance. three single-phase transformers. The injection transformer generates a voltage provided by the filtered VSI (voltage source inverter) output to required level and also serves a purpose of isolating distribution network and the DVR system[25]. In 1-Ø DVR, only 1-Ø transformer is attached and for 3-phase DVR, one single three-phase transformer can be attached in either star/open or delta/open

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configuration. The injection transformer winding configuration is very critical and mainly relies on the upstream power transformer.

- If delta-star transformers are being used in distribution feeders, v_o (zero-sequence voltages) do not flow via the transformer if earth fault happens at quite a higher voltage. Thus, it is necessary to restore positive sequence and compensate for negative voltage [26]. It makes the use of a delta-open injection transformer. The delta-open winding as seen in Figure 1.5(a) significantly increases DC connection voltage utilization.
- When using an earthed star-star distribution circuit transformer, v_o (zero-sequence voltages) shall be reimbursed for. A star-open injection transformer as seen in figure 1.5(b) can be used for this scenario with the injection of zero sequence voltages from DVR.

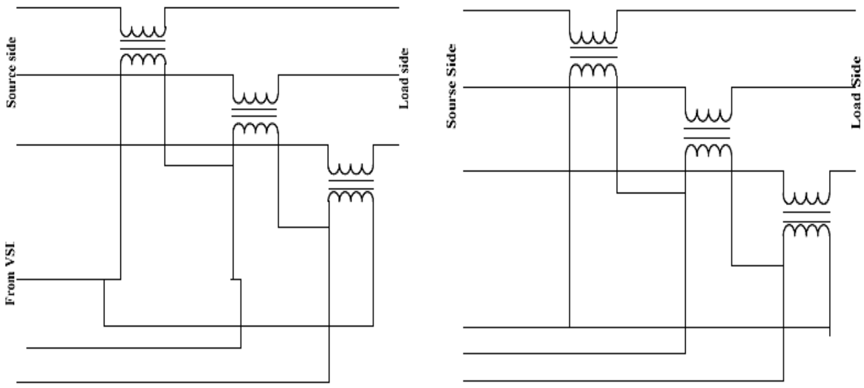

Figure3: Delta open configuration

The transformer ratio can be adjusted to optimize the converter utilization. The injection transformer rating is a crucial factor in determining the DVR output because it limits the DVR 's maximum compensation power, if a transformer is below the rating the injected voltage will saturate the transformer and results in the DVR 's inappropriate operation, this issue can be fixed by the transformer (over-rated), but this raises the DVR 's total price and size. [27].

II.RELATED WORK

Ali Reza Seifi, Amin Shabanpour Haghighi Abolfazl Kazemdehdashtii., In this paper, DVR compensation techniques are described to one another for the load side attached shunt converter topology of z-source inverter-based DVR to choose the best strategy. There have been 4 distinct configurations acknowledged for DVR that two of them seem to have ESS, and two topologies have really no energy storage and take electricity from the sun mostly during time of compensation. Here that the load side linked shunt converter topological configuration which extracts required power from the grid is used. The 3 DVR compensation methods that are researching and testing in this article are in-phase compensation, energy-optimized, pre-sag compensation methods. A detailed study via various diagrams will show the benefits or drawbacks of each compensation system. Equations are obtained for all approaches, and algorithm properties are contrasted. The simulation results demonstrate compensating based mostly on compensation methods by such a topology.

Dr. Vinay Bhatia, Dr. Jaydeep Chakarvorty, Geena Sharma.,The DVR is a simple, scalable, and efficient resolution to the issue related to voltage decay. The DVR seems to be an electronic power-dependent system that offers a controllable source of voltage (three-phase), whose voltage vector (magnitude and angle) attaches to the voltage of the source mostly during sag case to restore the voltage of a load to pre-sag circumstances. The DVR is created to safeguard the entire plant with certain MVA loads inside the range. Within a few milliseconds, the DVR will recover the voltage of the load. It suggests multiple configurations and control techniques for the DVR. This paper reviews an overview of DVR, its settings, features, techniques, modules, for offsetting, and control measures.

FredeBlaabjerg, Poh Chiang Loh, Yam P. Siwakoti., presents a "quasi-Y-source inverter" current inverter topology. The new inverter acquires all of the advantages provided by the initial Y-source inverter. Moreover, the novel topology draws constant current from the source that is needed for several renewable sources. It has dc-current-blocking capacitors that prevent saturation in the core of the transformer. The suggested inverter has been proved true by simulations and experimental results.

Vijay, S., Mohanvel, S & Mohana Priya, G., et al. uses the DVR integrated with Proton Exchange Membrane Fuel Cell to reduce the voltage sag. When the abrupt changes in system voltage occur, DVR acts as a system protection

compensation unit. The sum of compensating voltage is injected via injection transformer by DVR during voltage sag. To show the feasibility of the suggested procedure, the simulation findings produced utilizing MATLAB are analysed.
Kevin Olikaraclarified the large proportion of power quality problems that customers usually have faced can indeed be traced to harmonics, transients. However, several other factors of power quality can also affect processes and equipment, such as swells, under voltages, over voltages, swells, interruptions, DC notching, differences, vibration, voltage fluctuations, and frequency variations. Solutions exist for all of these types of conditions, but the main step that required to be done to minimize the capital and operating cost that is a direct consequence of the quality of power is to be able to calculate, track and envision the events and situations in power quality.

Ogheneovo, Kabiru Alani Hassan & Daniel Johnson., have correctly illustrated what quality of power is. It referred to the sources of power quality issues as insufficient grid, deviations/variations in voltage, distortions in waveform, and changes in frequency. Effects of power quality issues involve shortening and overheating equipment service life, process interruption, data loss, deterioration of its insulation. Although it is not possible to remove the triggers entirely, it may increase the efficiency of power supply and reduce the residual impact in supply. The established mitigation strategies include sufficient grid energy accessibility, need for interfacing devices (AVR, DVR, UPS, etc.), need for enhancing power quality devices (lightning arrester, tap adjusting transformer, SVS), including use filter to block harmonics, and sufficient grounding of electrical equipment.

Dr Sushma Gupta. &Rakeshwri Pal received a brief review of the literature on DVR arrangements and their controlling techniques. By choosing either of them we could offer solutions to various problems of power quality, such as voltage sag / swell compensation. To boost DVR efficiency, energy savings, reduce parts and losses, minimal power injection decreased rating, and specific reduction of harmonics ought to be rendered effort.

G.Kirthika, R. Abirami., DVR is among the most detailed FACTS devices that can individually regulate three parameter values. In this device a novel DVR design consisting of a 10-switch parallel to a series converter. In this condenser was suggested to inject voltage level from the string. It implies the ten-switch converter function in this setup is just the same as two converters coupled in traditional DVR. In this configuration requirements less power electronics switches and control scheme, and gate drive circuits become easier than traditional DVR configuration, utilizing series condenser parallel to ten switch converter reduces the THD injection voltage, removes output filter, even reduces the rated power of converters compared to conventional shunt and series converter DVR. This DVR is suggested for application.

D. M. Vilathgamuwa, C. J. Gajanayake et al., The DVR has gained wide acceptance as just an actual device for compensation of voltage sag. The capacity of a DVR to compensate mainly relies on the abilities of maximum voltage injection and the quantity of electricity contained inside the restoration. A proposed topology for DVR based mostly on Z-source inverter is suggested to enhance the device's voltage restore capacity. Z-source future capabilities along with the suggested inverter's shoot-through abilities would make sure a constant dc-voltage around the dc-link even after decreasing voltage in the storage systems attached in the dc-link during the voltage compensation process. Even if the dc-link power is available via a shunt connected auxiliary supply, with proposed topology, shunt transformer, the dc-link capacitor, and the voltage rating of the shunt converter may be held smaller. The suggested control methods and converter topology are validated via simulation and laboratory testing performed on a restorer proto-type.

G. Ramamohan Rao &Ravilla Madhusudan., introduces the simulation procedure and systematic modeling of a DVR based on SPWM, namely, Sinusoidal Pulse Width Modulation methodology for power quality issues, voltage sag, and swell. Power quality is a phenomenon expressed as a nonstandard voltage, frequency, or current that occurs in the equipment being used for end-use failure. The key issues dealt with here are the stress sag and swell. Custom power devices are being used for solving the issue such a device is the DVR, the most reliable and operative, custom control system used during power distribution systems. The Voltage Source Converter (VSC) control is facilitated with effective SPWM. The proposed DVR is designed utilizing MATLAB software and simulated with it.

Peng Yao; Z. J. Shen; Zhikang Shuai et al., this paper suggested an idea of the blame for the strong voltage restore (FCL-DVR) restricting current. The latest topology makes use of a crowbar bidirectional thyristor transfer over conventional consecutive DVR yield terminals. In the event of a heap short, the DVR controller can disable the DVR 's broken cycle and activates its crowbar thyristor to embed the DVR channel reactor in the frame to reduce the current of blame. The observation of the heap current and its level of progress is regarded as a state of guilt. Under different circumstances of responsibility, the FCL-DVR can operate with different protection techniques. The FCL-DVR outline involves the collection of critical parameters, such as DVR control rating, dc connects DVR voltage, yield channel reactors, and condensers, and proposed network connected transformers. In the light of strength, structures assisted PC plan (PSCAD)/electromagnetic homeless people like dc (EMTDC) reproduction, the design method of the planned FCL-DVR is fully talked about. On top of that, a downsized exploratory confirmation is completed. The show and test results both affirm the adequacy of the latest FCL-DVR idea for both blame current limiting capacities and pay voltages.

Mousumi Bala Panda, Khirod Kumar Senapati, et al., This paper uses a FLC to boost power efficiency for DVR and battery power storage systems, completely different voltage injection techniques for DVR square-based measurements studied with special emphasis on a substitution technique used to reduce the ratings. The replacement management technique for DVR-supported condenser control is expected to be used. Managing a DVR with a reduced-rating VSC is unquestionable. The voltage of the reference charge is measurable victimization of the unit vectors. The synchronous field of reference principle is being used for translating voltages to the stationary frame from rotating vectors. It is incontrovertible to compensate for the voltage swell, sag, and harmonics by using a reduced-rate DVR with a fuzzy logic controller.

Seyed Hossein Hosseini, Aziz Tashackori, et al., a 3-stage 4-wire DVR is suggested in this study to infuse the necessary voltage into the electrical power system in such a way that constant sinusoidal voltage is often seen on the stack side at significant blame events on the utility side. The suggested DVR consists of a 3-stage 4-leg inverter and a 3-stage high recurrence symphonic channel in which 3 single-stage control transformers connect with the utility. 3-D regulation of the space vector (3DSVM) is related to the suggested DVR to generate exchange beats for both the control switches. Fourth inserted wire encourages the DVR to repay the inventory of unbalanced voltage and swell which are problems of custom power quality in electrical utilities. Reproductions in PSCAD-EMTDC programming allow the implementation of the framework and the related exchange plan both under inconsistent and balanced droop and swell.

VG. Madhusudanan. S. Surendar., This paper examines the output of the DVR to compensate for different faults for multiple voltage sag levels and to reduce the Overall Harmonic Distortion during the relief cycle. The DVR is configured with a 3-phase VSI and is connected at the standard coupled point to normalize the side voltage of the load. The compensation with Space Vector Pulse Width Modulation Technique is based on PI. Substantial numerical simulation for load-side failures during different magnitudes of sag for unbalanced and balanced environments is performed utilizing fault generator. The outcome of simulation shows that DVR operates perfectly with the modulation technique, based on PI. In particular, DVR 's capacity and output for different energy storage capacities and assessment of insertion transformers are also evaluated. These controllers' output is verified with numerical simulation.

Ali Reza Dehghanzadeh, Mohamad Reza Banaei., This research presented a new cascaded multilevel inverter based on Z-source configuration. In this configuration, the output-based voltage is not restricted to DC voltage source comparing to existing multilevel inverter cascade and it can be continued to increase with Z network shoot-through status control. It is additionally more efficient against SCs. The output of the recommended topology is defined in the DVR structure within the closed-loop control system.Compensation capacity to raise the proposed DVR. This article discusses the operating principle, switching algorithm, and the features of the system topology. Utilizing MATLAB / SIMULINK technology the output of the recommended inverter and switching algorithm is verified with simulated results.

Laxman M Waghmare, Sanjay A Deokar., DVR represents a series-connected tool for voltage reduction sag/swell. This paper introduces a feed-forward pre-sag / swell voltage control system for regulating the voltage output of the modulated pulse width (PWM) voltage source (VSC) converter. Underneath the multiple balanced/unbalanced dynamic PQ disturbances the designed method provides a steady charge voltage. The suggested control scheme for DVR is a clearer, lower price, focused on the park's transformation. It can accurately compensate for multiple sags / swells and can provide fast reply under dynamic load conditions. The precise 440 volts, 50 Hz distribution system simulation was performed to evaluate DVR output in minimizing various voltage sag / swell for both the balancing and unbalancing load conditions.

Rudra Narayan Pradhan, Jenamani Pravas Kumar Chhotaray, Among the most significant issues in the current era 's research of energy systems is the enhancement of power efficiency. Because of the emergence of innovative industrial devices and responsive loads, everything becomes necessary now. At the distribution hand, the key issues with power quality are voltage sags and swells. There are several various options available for reducing voltage sags and swells; DVR is among the most general approaches. The DVR is a series compensating unit, which would be mainly useful for the application of medium voltage and low voltage. DVR's latest design was introduced by means of PI-controller, that helps to compensate for voltage swells/sags during a fault of 3- phases. Effects of the simulation test the efficiency of the model proposed.

Hideaki Fujita, Hirofumi Akagi, TakushiJimichi., This paper deals with a DVR, or a voltage-sag compensator consisting of a set of shunt converters and back-to-back connected series converters, 3 series transformers, and a dc capacitor mounted on the typical dc connection. The feature of the DVR seems to be the mount the shunt converter on the charge side and on the source side of the series converter. Such a system design permits the need for an incredibly small dc condenser to smooth the increasing dc-link voltage. This research presents a design technique for dc condenser underneath a state of voltage-sag and suggests a series converter method of control that helps in reducing the voltage-based ratings of the series transformers as well as the series converters. To verify the validity and efficacy of the control process, test results derived from a 200-V, 5-kW laboratory device have been shown.

Y. Prakash, S. Sankar et al., DVR is among the cuttingedge devices used in conveyance systems to protect consumers against unexpected voltage adequacy shifts. This paper breaks down crisis management in allocation systems by using the suggested multifunctional DVR monitoring protocol. Similarly, it is suggested that the P+Resonant controllers and Posicast multi-loop controller using podcast bear in mind the end goal of improving the transient reaction and simultaneously eliminating the relentless state error in the DVR reaction. The proposed measurement is related to a few alarming influences in stack voltage induced by starting acceptance engines, and a 3-stage cut off. Similarly, the capacity of the suggested DVR was attempted to reduce the existence of the downstream responsibility. The concept with this is that the DVR continues as a virtual impedance with the core point of maintaining the PCC voltage in the midst of downstream responsibility with no particular power infusion problem in the DVR. Tests of reproduction obtained utilizing MATLAB programming show the DVR's capacity to monitor the crisis conditions of the conveyance frameworks. The results of the replication suit the results of the apparatus.

J. Bangarraju, V. Rajagopal et al., This paper examines control of DVR utilizing SPLL (Software Phased Locked Loop) technique for pay of PQ unsettling influences in control DS (Distribution System) arrange. Utilizing this control technique, principal reference stack voltages are evaluated utilizing greatness of essential dynamic and responsive segments of source voltages. The SPLL methodology-based DVR is demonstrated in MATLAB R2013b condition utilizing SIMULINK to moderate voltage related PQ Issues are list/swell, unbalance and sounds. The MATLAB based DVR display is utilized for reenactment under unique and static conditions. Reenactment execution of SPLL based DVR is discovered that tasteful execution under time fluctuating straight/non-direct loads.

III.CONCLUSION

DVR proportional-repetitive control. Repetitive control could achieve zero steady-state error in monitoring the sinusoidal signal, but this does not respond quickly to a disturbance and requires at least one fundamental period for proper operation. In the stationary frame, the controlling system that is based on a proportional-repetitive controller is implemented to improve simultaneously fast dynamic response and zero steady-state error. Such a controller can account for fluctuations in power quality, like harmonic voltages, voltage imbalance, and voltage sag while at the same time DVR focuses on implementing a new method of sag detection and a compensating voltage generation. The traditional method of sag detection cannot detect voltage falls below a definite point

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