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DVR CONTROL FORMULATION AND DESIGN BY REDUCING RATINGS THROUGH THE UTILIZATION OF A BATTERY ENERGY STORAGE SYSTEM

[1]Prashanthi Gopireddy, [2]Dr. Prasanth Sai Duvvapu, [3]Vamshi Dhandugudum, [4]V Balaji
[2]Professor,[1,3]Assistant Professor, [4]Student, [1,2,3,4]Department of Electrical and Electronics Engineering , Siddhartha Institute of Engineering and Technology, Hyderabad, India.

ABSTRACT
In this article, several voltage infusion strategies for dynamic voltage restorers (DVRs) are examined with a focus on a different method used to reduce the rating of the voltage source converter (VSC) used as a component of DVR. The capacitor-supported DVR is proposed to be controlled by yet another approach. A DVR's control is displayed with a reduced VSC rating. The unit vectors are used to assess the reference load voltage. The notion of synchronous reference frame is used to explain the voltage shift from pivoting vectors to the stationary edge. Using a lower rating, the correction for voltage sags, swells, and harmonics is demonstrated. The motivations behind lowering the voltage source converter's (VSC) rating as a part of DVR permit the compensation of current consonant fixings, consolidating unequal current made in single- stage nonlinear weights. The key pay of the executed with diminished rating of DVR and took after control arrangement for pay conditions is presentations for the way of power through test results by MATLAB/SIMULINK.

Key words: Dynamic voltage restorer (DVR), power quality, unit vector, voltage harmonics, voltage sag, voltage swells.

INTRODUCTION
Because to the increased usage of sensitive and important equipment, such as correspondence systems, processing businesses, and precise assembly forms, POWER QUALITY concerns in the current dissemination frameworks are addressed in the literature [1]–[6]. The operation of these hardware components is impacted by power quality issues such as transients, sags, swells, and various bends in the sinusoidal waveform of the supply voltage. Custom power devices, for instance, are advancements that provide security against problems with power quality. The majority of custom power devices fall into one of three categories: dynamic voltage restorers (DVRs), shunt-associated compensators (such as circulatory static compensators), and unified force quality conditioners, which combine arrangement and shunt-associated compensators. [2]–[6]. The DVR can control the heap voltage from problems including supply voltage harmonics, sag, and swell in the supply voltages manage the heap voltage from the issues, for example, sag, swell, and harmonics in the supply voltages. Subsequently, it can shield the basic buyer loads from stumbling and ensuing misfortunes [2]. The custom force gadgets are produced and introduced at purchaser point to meet the force quality models.

Voltage lists in an electrical lattice are not generally conceivable to stay away from in view of the finite clearing time of the flaws that cause the voltage hangs and the proliferation of droops from the transmission and dispersion frameworks to the low- voltage loads. Voltage droops are the normal purposes behind intrusion underway plants and for end-client gear glitches by and large. Specifically, stumbling of gear in a generation line can bring about creation interference and significant costs because of loss of generation. One answer for this issue is to make the hardware itself more tolerant

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to lists, either by canny control or by putting away "ride-through" vitality in the gear. An option arrangement, rather than changing every segment in a plant to be tolerant against voltage lists, is to introduce a plant wide uninterruptible force supply framework for more power intrusions or a DVR on the approaching supply to alleviate voltage hangs for shorter periods [8]–[23].

DVRs can dispense with the greater part of the sags and minimize the danger of burden stumbling for profound droops, however their primary downsides are their standby misfortunes, the gear cost, furthermore the security plan required for downstream shortcircuits. Numerous arrangements and their issues utilizing DVRs are accounted for, for example, the voltages in a three-stage framework are adjusted [8] and a vitality advanced control of DVR is talked about in [10]. Modern case of DVRs are given in [11], and distinctive control techniques are investigated for various sorts of voltage hangs in [12]–[18]. A correlation of various topologies and control techniques is introduced for a DVR in [19]. The configuration of a capacitor-upheld DVR that secures hang, swell, bending, or unbalance in the supply voltages is examined in [17]. The execution of a DVR with the high-recurrence join transformer is talked about in [24]. In this paper, the control and execution of a DVR are exhibited with a diminished rating voltage source converter (VSC). The synchronous reference Frame (SRF) hypothesis is utilized for the control of the DVR.

OPERATION OF DVR

The schematic of a DVR-connected system is shown in Fig.1

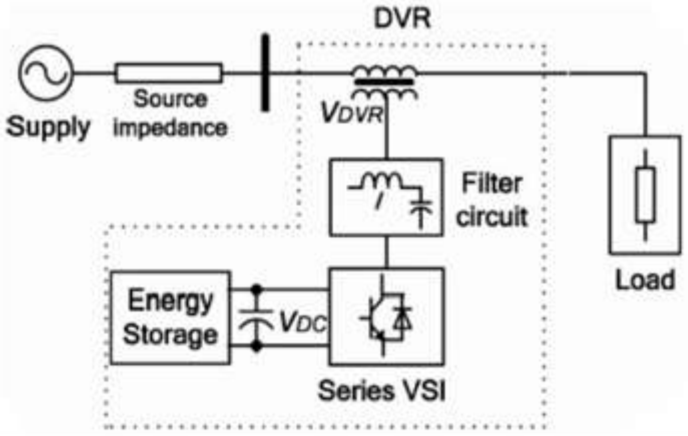


Fig.1 Basic circuit of DVR

The voltage Vinj is embedded such that the heap voltage Vload is steady in extent and is undistorted, in spite of the fact that the supply voltage Vs is not consistent in size or is misshaped.

Fig. 2 shows a schematic of a three-phase DVR connected to restore the voltage of a three-phase critical load. A three-phase supply is connected to a critical and sensitive load through a three-phase series injection transformer.

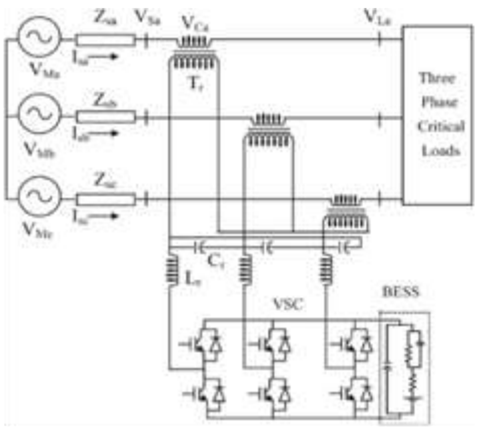


Fig.2. Schematic of the DVR-connected system

The comparable voltage of the supply of stage VMa is associated with the purpose of basic coupling (PCC) VSa through short out impedance Zsa. The voltage infused by the DVR in stage VCa is such that the heap voltage VLa is of evaluated size and undistorted. A three-stage DVR is associated with the line to infuse a voltage in arrangement utilizing three single-stage transformers Tr. Lr and Cr speak to the filter parts used to filter the swells in the infused voltage. A three-leg VSC with protected door bipolar transistors (IGBTs) is utilized as a DVR, and a BESS is associated with its dc transport.

CONTROL OF DVR

The sectional diagram of current control scheme is shown in Fig.3

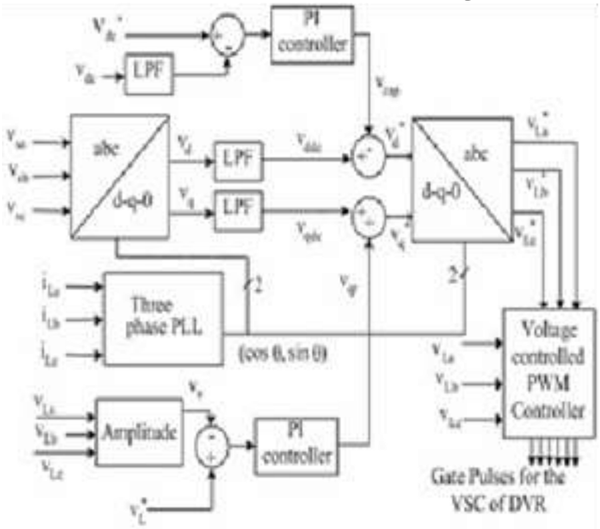


Fig.3 Control Block of the DVR that uses the SRF Method of Control.

The present control proposition is fundamentally required to current references, that are utilized to repays the undesirable burden parts. In this area the source voltage, load current and the dc-voltage converter are measured, while the common streams are produced precisely from the present reference generator. Fig. 3 demonstrates a control piece of the DVR in which the SRF hypothesis is utilized for reference signal estimation. The voltages at the PCC Versus and at the heap terminal VLa detested for determining the IGBTs' door signals. The reference

load voltage V∗L is separated utilizing the inferred unit vector [23]. Load voltages (VLa,VLb,VLc) are changed over to the pivoting reference outline utilizing abc−dqochange utilizing Park's change with unit vectors(sin,θ,cos,θ) determined utilizing a stage bolted circle as

$$\begin{bmatrix} V_{Lq} \\ V_{Ld} \\ V_{L0} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ \sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}\begin{bmatrix} V_{Laref} \\ V_{LBref} \\ V_{Lcref} \end{bmatrix} \quad (1)$$

Reference DVR voltages (v∗dvra, v∗dvrb ,v∗dvrc) and actual DVR voltages(vdvra,vdvrb,vdvrc) are used in a are used in a pulse width modulated (PWM) controller to generate gating pulses to a VSC of the DVR.

Voltages at the PCC vS are converted to the rotating reference frame using abc−dqo conversion oscillatory components of the voltage are eliminated

$$V_{Dd} = V_{Sd} - V_{Ld} \quad (2)$$

$$V_{Dq} = V_{Sq} - V_{Lq} \quad (3)$$

$$V_{Dd}^{*} = V_{Sd}^{*} - V_{Ld} \quad (4)$$

$$V_{Dq}^{*} = V_{Sq}^{*} - V_{Lq} \quad (5)$$

Thus, reference load voltages (V∗La,V∗Lb,V∗Lc) and voltages at the PCC Vs are additionally changed over to the pivoting reference outline. At that point, the DVR voltages are acquired in the turning reference outline as

$$\begin{bmatrix} V^*_{dvra} \\ V^*_{dvrb} \\ V^*_{dvrc} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta & 1 \\ \cos\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta - \frac{2\pi}{3}\right) & 1 \\ \cos\left(\theta + \frac{2\pi}{3}\right) & \sin\left(\theta - \frac{2\pi}{3}\right) & 1 \end{bmatrix} \begin{bmatrix} V^*_{Dq} \\ V^*_{Dd} \\ V^*_{Do} \end{bmatrix} \quad (6)$$

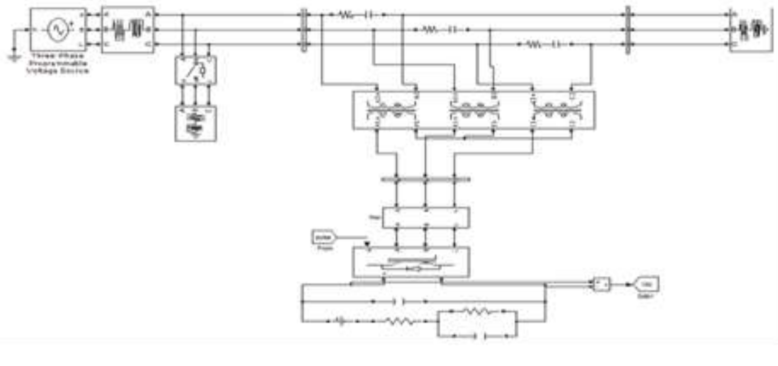
voltages in the d- and q-axes are

$Vd = Vddc + Vdac$ (7)
$Vq = Vqdc + Vqac$ (8)
The remunerating methodology for pay of voltage quality issues considers that the heap terminal voltage
The reference DVR voltages are obtained in the rotating reference frame ought to be of appraised size and undistorted. With a specific end goal to keep up the dc transport voltage of the self-upheld capacitor, a Fuzzy controller is utilized at the dc transport voltage of the DVR And
$Vcap(n) = Vcap(n{-}1) + Kp1(Vde(n) - Vde(n{-}1) +$

The error between the reference and actual DVR voltages in the rotating reference frame is regulated using two logic controllers. Reference DVR voltages in the abc frame are obtained from a reverse Park's transformation taking ∗Dd from (4),V∗Dq from (5),V∗D0 as zero as
$Ki1Vde(n))$ (9)
Where vde(n) =v dc−vdc(n) is the error between the reference v∗dc and sensed dc voltages vdc at then the sampling instant. The referenced-axis load voltage is therefore expressed as follows:

vqr for voltage regulation of the load terminal voltage. The amplitude of load voltage VL at the PCC is calculated from the ac voltages (VLa,VLb,VLc) as load voltages (VLa,VLb,VLc) and reference load voltages is used over a controller to generate gating pulse to the VSC of the DVR.

MODELING AND SIMULATION
Where vte(n) =V ∗ L−VL(n) denotes the error between the reference V∗L and actual VL(n) load terminal voltage amplitudes at then the sampling instant. The reference load quadrature axis voltage is expressed as follows:
The DVR-connected system consisting of a three-phase supply, three-phase critical loads, and the series injection transformers shown in Fig. 2 is modeled in MATLAB/Simulink environment along with a sim power system toolbox and is shown in
Reference load voltages (v ∗ La ,v ∗Lb ,v ∗Lc) in the abc frame are obtained from a reverse Park's transformation as in (7). The error between sensed



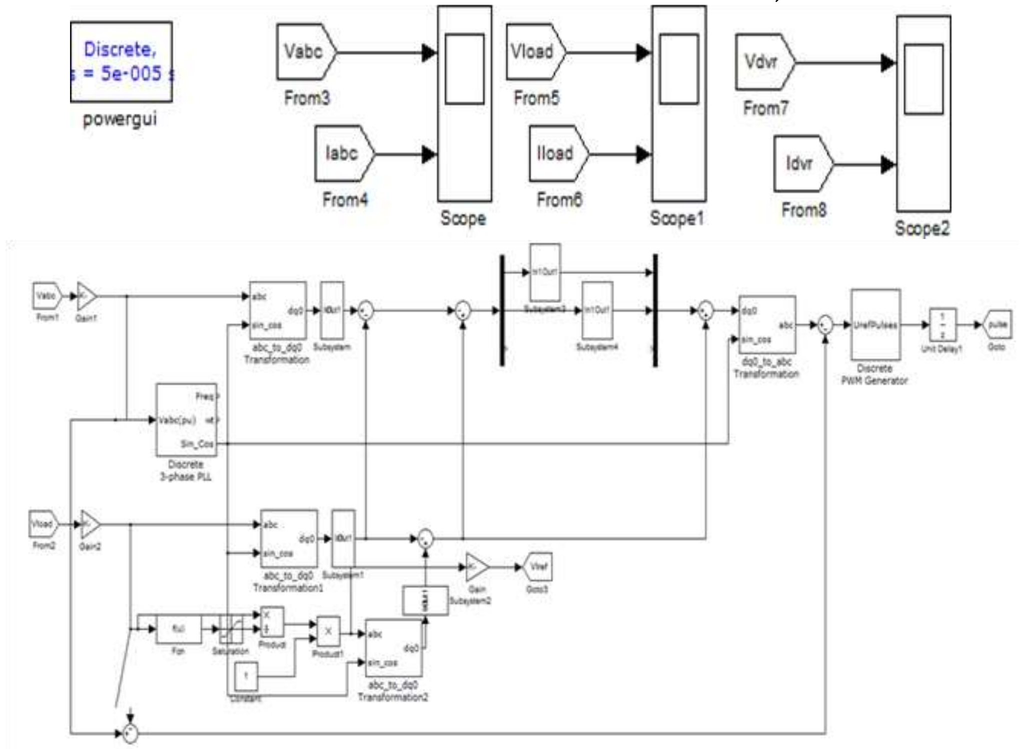


Fig.4 Matlab based model of the BEES- supported DVR connected system.

IV MODELING AND SIMULATION RESULTS::

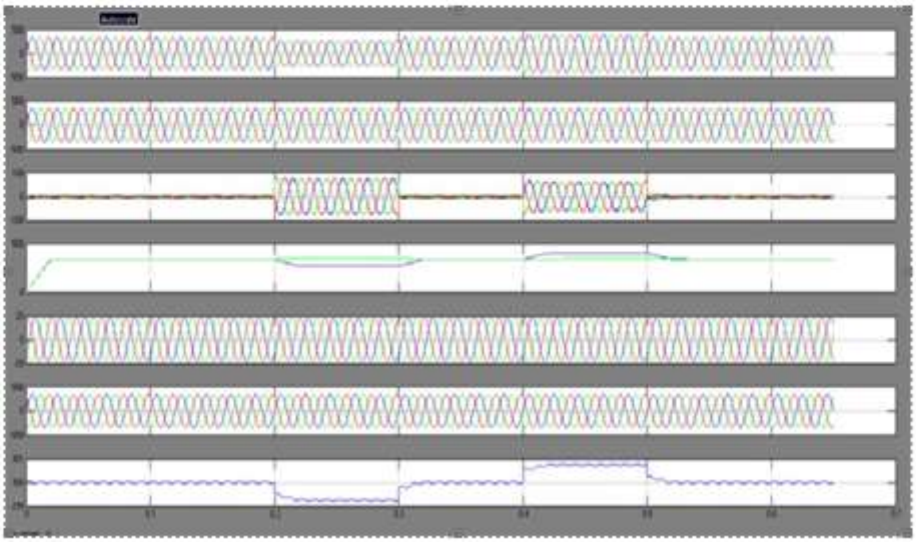


Fig5. Dynamic performance of DVR with in phase injection during voltage sag and swell applied to critical load.

V PERFORMANCE OF DVR

The execution of the DVR is exhibited for various supply voltage unsettling influences, for example, voltage hang and swell. Fig.4 demonstrates the transient execution of the framework under voltage list and voltage swell conditions. At 0.2 s, a droop in supply voltage is made for five cycles, and at 0.3 s, a swell in the supply voltages is made for five cycles. It is watched that the heap voltage is directed to steady plentifulness under both droop and swell conditions. PCC voltages Versus, load voltages VL, DVR voltages VC, sufficiency of burden voltage VL and PCC voltage Versus, source streams Is, reference load voltages VL ref, and dc transport voltage Vdc are additionally delineated in Fig3. The heap voltage is kept up sinusoidal by infusing appropriate pay voltage by the DVR. The total harmonic distortions (THDs) of the voltage at the PCC, supply current and burden voltage are appeared in Figs. 6-7, separately.

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It is watched that the heap voltage THD is lessened to a level of 0.51% from the source voltage of 6.41%. The sizes of the voltage infused by the DVR for alleviating the same sorts of hang in the supply with various edges of infusion are watched. . The infusion of voltage in quadrature with the line current.

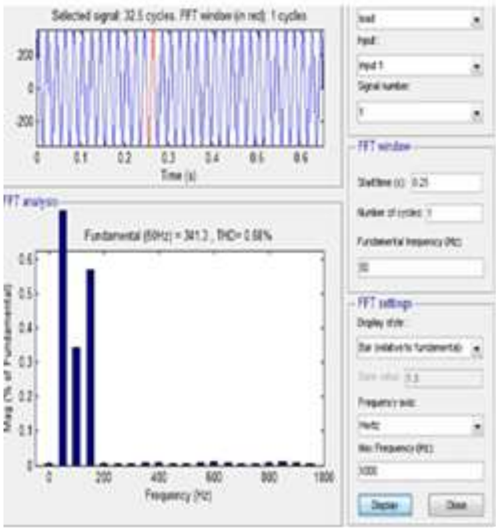

Fig.6. Load voltage and harmonic spectrum during Disturbance

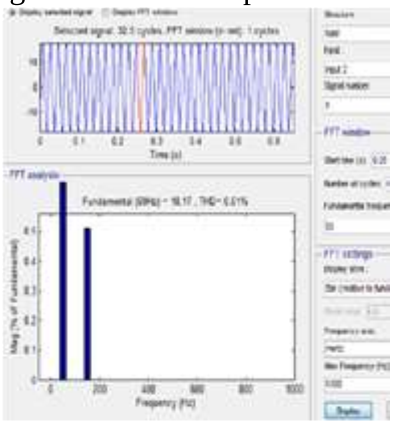

Fig.7. Load current and harmonic spectrum during the disturbance.

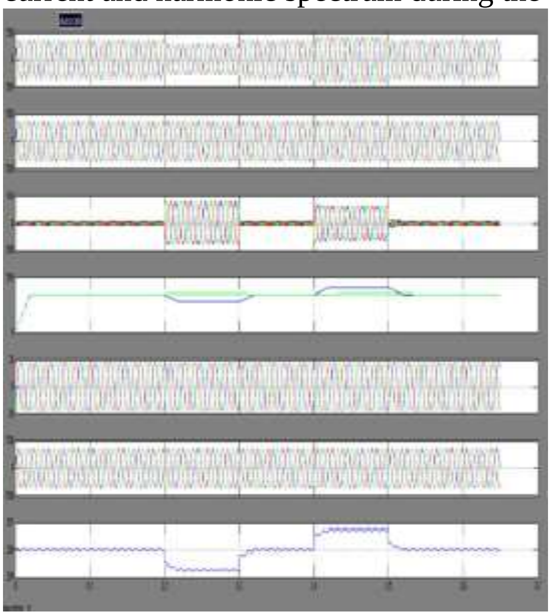
Fig.8.Dynamic performance of the capacitor– supported DVR During a Voltage Sag.

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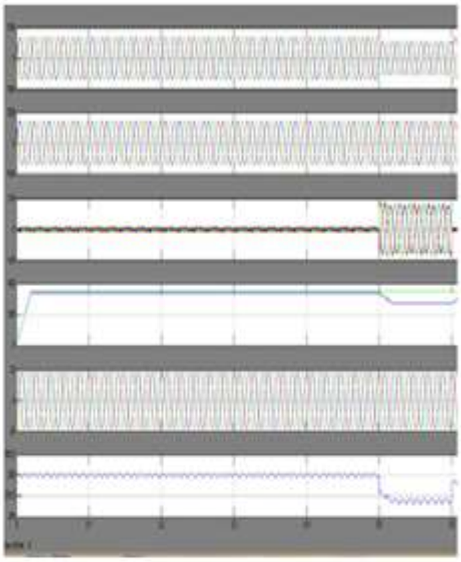

Fig.9.Dynamic performance of the capacitor – supported DVR During a Voltage Swell.

VI CONCLUSION

This paper shows the operation of a DVR has been shown with another control method utilizing different voltage infusion plans. An examination of the execution of the DVR with various plans has been performed with a diminished rating VSC, including a capacitor-upheld DVR. The reference load voltage has been evaluated utilizing the technique for unit vectors, and the control of DVR has been accomplished, which minimizes the blunder of voltage infusion. The SRF hypothesis has been utilized for assessing the reference DVR voltages. It is inferred that the voltage infusion in-stage with the PCC voltage results in least appraising of DVR yet at the expense of a vitality source at its dc transport.

APPENDEX

AC line voltage: 415 V, 50 Hz

Line impedance: Ls=3.0mH,Rs=0.01 Ω Linear loads: 10-kVA 0.80-pf lag Ripple filter: Cf =10μF,Rf =4.8Ω

DVR with BESS

DC voltage of DVR: 300 V AC inductor: 2.0 mH

Gains of the d-axis PI controller: Kp1=0.5, Ki1=0.35

Gains of the q-axis PI controller: Kp2=0.5, Ki2=0.35

PWM switching frequency: 10 kHz DVR with dc bus capacitor supported DC voltage of DVR: 300 V

AC inductor: 2.0 mH

DC bus voltage PI controller: Kp1=0.5, Ki1=0.35

AC load voltage PI controller: Kp2=0.1, Ki2=0.5

PWM switching frequency: 10 kHz

Series transformer: three-phase transformer of rating 10 kVA, 200 V/300 V.

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