A Novel Integration of Solar Fed Dynamic Voltage Restorer for Compensating Sag and Swell Voltage in Distribution System Using Enhanced Space Vector Pulse Width Modulation (ESVPWM)

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Abstract This proposed work describes a novel optimal use of the system to be used for Photovoltaic (PV) based on Dynamic Voltage Restorer (DVR) voltage restoration, voltage regulation functions, and an active filter is represented. The power transmitting in the distribution system needs to be high quality of power to drive a load with efficiency. The most of the loads are non-linear loads. It causes the Total Harmonics Distortion (THD) in the system. These THD produces the system oscillation, capacitor overloading, drops in efficiency, voltage fluctuation, which create the poor operating performances of the consumer utilities. Essentially, when the load voltage is greater or lesser (sag and swell) than the actual voltage, the control system will analyses the demanded load voltage and it will be compensate by the solar-based DVR, which will improvise the energy consumption of the system. Technically those sag and swell voltage will be minimized with the help of DVR, but it needs advance control technique which will provide the effectiveness of the system. In this work, the Enhanced Space Vector Pulse Width Modulation (ESVPWM) is performing a proper switching pulse to the DVR inverter, which helps to improve the energy stabilization in the distribution system. The proposed DVR has additional benefits the operating voltage will observe from the solar PV which had perturb and observe (P&O) based Maximum power point Tracking (MPPT) system and will efficiently provide the DC power. The execution of solar Fed DVR is simulated under dynamic conditions with the various

parameters like steady-state error, Efficiency, Total Harmonics Distortion (THD) in the load. All those conditions performed in MATLAB-SIMULINK 2017b software.

Keywords Dynamic Voltage Restorer, Distributed Energy Resources, Harmonic Compensation, Perturb and Observe (P&O) MPPT Algorithm, Enhanced Space Vector PWM (ESVPWM)

1. Introduction

Power stability is the essential factor in the industrial and business sectors working in a competitive environment. The most significant power quality problem of a distribution system is the voltage sag. It causes the low power distribution system, so this energy stabilization is an essential factor in the distribution system with the help of DVR, to improve the power quality is maintained as unity in the output source. The PV system reactive power is used to compensate for the non-linear load. The DVR achieve fast dynamic response is to control the hysteresis current [4]. This work discusses the use of a series of reactive injections in a short circuit system, large electric motors in the system load starting in an overload condition. One of the worst problems facing the industrial process industries considered voltage sag and swell.

unbalances the supply voltage along with distortions - drains the employee's voltage. Three-phase MEPLL absorbs essential positive, negative, and zero-order components through distorted - unbalanced waves [3-4].

Improving power quality using a DVR and enhancing the performance of a three-phase low-voltage rider integrated LVRT with a combined distributed generation (DG) system. The combine system PV and wind Power generator (WPG), which is an essential benefit of the load to provide the continues power [5]. Implementation the D-Q control system will advance to more utilizing and fast-response characteristic to the Superconducting Magnetic Energy Storage (SME) system is to regulate the transient output voltage waveforms suddenly after voltage disturbances [6]. The control Switching Frequency Based Sliding Mode scheme of the Conversion of Wind Energy System (WES) is regulating for wind power using DVR, for improved efficiency [7-12]. The DVR will enhance the DFIG wind turbine generation using stator flux decay compensation. Both the design and hardware results has been best, mainly two methodologies can adequately rotor current and improve the exhibition of the framework during network deficiencies [14].

The design methodology of the suggested FCL-DVR is fully discussed based on power systems computer-aided design (PSCAD)-electromagnetic transients including dc (EMTDC) simulation results validation is also carried out. Modeling and test ratings to ensure new FCL-DVR feedback capability for voltage compensation and fault current operation [15-18]. The new technique of DVR three-phase system has been recommended three-phase converter with a DC connector is to compensate for sag and swelling and voltage fluctuations - unbalanced voltage condition. This DVR architecture contains of two rectifier and inverter components with a combined DC links. The simplified design with control structures will optimize the test result [19]. A control scheme is presented using a two-step technique: first, to compensate for the DVR voltage speaker voltage; Second, the serial voltage phase exerts a reactive force. The implementation of this control method and its detailed testing has showing the reliability of the new technique solution of a DVR laboratory [20].

A significant power problem imposes a sudden reduction in the voltage drop from half a minute to a period of up to one cycle. Voltage compensation of substantial loads due to dynamic voltage restorer has its inevitable share of peak power among optional equipment [21]. DVR Voltage related power quality issues are identified as a cost-effective solution to protect complex loads. The reduction and capacity charge can be improved by the elimination of the extension needle transformer [22]. The term power is utilized to gauge control quality for modern, household, and business loads. In the electrical business, control quality is principally a basic concern [23]. Dynamic voltage restorer (DVR) with fuzzy controller is mounted. Simulated particle swarm optimization based (PSO)

technique and fuzzy system is employed to adjust the parameters like, steady-state error, THD [24]. The dynamic voltage restorer circuit is provided the basis for the model voltage recognition in the topology and control scheme [25]. The main objective is to increase the power line voltage difference (and to determine the product between the fluctuation of power) and to help the systems maintain the main side (load) voltage level which is based on the compensation methodology [26].

The strategy used to control DVR depends on the reference law standard of changing to a three-phase inverter with the assistance of a voltage controller for hysteresis to keep up the voltage profile sinusoidal in the straight load terminal against the voltage profile [27]. Many have suggested a smooth switching DVR voltage control principle using the AC - AC converter output of a three-phase between a transformer input and output. Furthermore, reducing the essential elements it shouldn't controls the system but also facilitates design consistency. Altogether things considered, certain exploratory outcomes are displayed to check the plausibility of the future delicate move 3 phase five-arm DVR [28]. The voltage drop or failure creates ineffective conflict on the customer side and application side. DVR is a semiconductor with a booster transformer which maintains the power quality in load side, that is, to decrease control quality issues in the power system arrangement [29]. The power generation provides a predictive voltage control scheme for the effective control of the Transformerless DVR. Predictive voltage control scheme uses a unique model of voltage source inverter (VSI) circuit and interfaces filter for the generation of the switching process of inverter switches. Furthermore, this system does not require any linear controller or modulation technique [30].

3. Materials and Methods

The proposed approach is to develop to regulate the voltage distortion in the real distribution system using DVR, and various operating blocks are illustrated in figure 2. A present power system, the advent of comprehensive different electronic devices, as well as the installation of sudden disturbing events, a variety of power quality (PQ) problems will create. Essentially Voltage fluctuation and distortion are created in the power distribution which can be eliminated by the reactive power compensator like Dynamic Voltage Restorer, in this system the solar and DC-DC converter produces the necessary Voltage to the DVR injected transformer to compensate the Voltage distraction. Finally, the proposed Enhance Space Vector PWM (ESVPWM) method will analyze the source and Load voltage variation and effectively provides the proper switching pulse to the DVR converter which will enhance power stability of the distribution system.

Figure 2. Proposed System Block Diagram

3.1. DVR Series Connected Topology

DVR is a series-connected electronic device that provides voltage on the transmission line to control the load side power. This system is typically connected between the distribution systems mainly on critical load feeder. The working operation of the DVR is compensated the load side voltage without any power disruption. Also, the voltage compensation for the transmitting system sags and swells, which can reduce the voltage transients and enhance the current limitations in the distribution systems to increase the voltage resonances.

Figure 3. Series-connected DVR

Figure 3 illustrates the circuit diagram for the series-connected DVR system, which consists of source voltage, DC link, injection transformer, load, active filter, and inverter.

3.1.1. DVR Voltage Correction Methods

The DVR voltage correction methods are ability to compensate the voltage fluctuation in the distribution system with a limited power rating and various load requirements. Some loads are very sensitive in preventing the use of power angle, and others voltage distortions are clearly analyzed with the control system. Hence, prevention methods depend on load properties. There are three several methods of a DVR voltage regulators listed below.

1. Pre-Sag-DIP Compensation (PSC or PDC)
2. In-Phase Compensation (IPC)
3. In-Phase Advance Compensation (IPAC)

3.1.2. PRE-SAG-DIP Compensation (PSC or PDC)

In this method the series injected real power cannot be controlled and it is calculated by external fault condition are previously determined and compensated by using Pre-Sag-Dip Compensation.

Figure 4. PDC based vector diagram

Figure 4, shows the reactive power of DVR equations are represented below,

$$S = 3 IV \quad (1)$$

$$= I \sqrt{(V_L^2 + V_s^2 - 2V_L V_s \cos(\theta_L - \theta_s))} \quad (2)$$

The real power of DVR is,

$$P = 3 I l (V_L \cos \theta_L - V_s \cos \theta_s) \quad (3)$$

The phase of DVR voltage is,

$$V = \sqrt{(V_L^2 + V_s^2 - 2V_L V_s \cos(\theta_L - \theta_s))} \quad (4)$$

$$\theta = \tan^{-1} \left(\frac{V_L \sin \theta_L - V_s \sin \theta_s}{V_L \cos \theta_L - V_s \cos \theta_s} \right) \quad (5)$$

Where,

P is an active power

V_s is source voltage

I is current

S is apparent power

V_L is load voltage

In this mode, the DVR regularly examines at the supply voltage. In the DVR system, energy is lost between the sag and swell voltages. In the case of compensation, both the magnitude and the phase angle of the load voltage is compensated by DVR. Figure 5 shows the pre-sag conditions of the vector representation. In this mode, the boosted voltage couldn't be controlled when the load voltage is reset. Determine the type of fault conditions and power applied to the load transfer line.

Figure 5. Phasors diagram of the PSC method

The voltage V_{inj} and phase angle θ_{inj} to be injected can be estimated as per equation.

$$V_{inj} = \sqrt{V_{sag}^2 + V_{presag}^2 + 2V_{sag} V_{presag} \cos \theta_{sag}} \quad (6)$$

$$\theta_{inj} = \tan^{-1} \frac{V_{presag} \sin \theta_{presag}}{V_{presag} \cos \theta_{presag} - V_{sag} \cos \theta_{sag}} \quad (7)$$

Where,

V_{inj} is injected voltage

θ_{inj} is phase angle

V_{sag} is sag voltage

V_{presag} is pre-sag voltage

3.1.3. In-Phase Compensation (IPC)

This is the most reliable and utilized system DVR method to compensate the load side voltage fluctuations the phasor diagram of IPC technique is shown in figure 6. In other words, this system demands the voltage to diminish the high level of real power, i.e., the energy storage device.

The phasors diagram of reactive power in DVR is shown in figure 6 and the mathematical formula of reactive power is represented as,

$$S = 3 I l V = 3 I l (V_L - V_s) \quad (8)$$

The real power of DVR is,

$$P = 3 I l V \cos \theta_s = 3 I l (V_L - V_s) \cos \theta_s \quad (9)$$

Scale and the DVR voltage angle,

$$V = V_L - V_s \quad (10)$$

Figure 6. Phasors diagram of the IPC method

3.1.4. In-Phase Advance Compensation (IPAC)

The combined operation of the both pre-sag and in-phase compensation is created to form an IPAC method. The phasor diagram of IPAC will be shown in figure 7, during this mode the active power is injected to the continuous loads. In different control strategies have limited timing and efficiency for regulating the load voltage which also needs an active power injection during compensation.

Phase advance methods prove useful in comparison to other methods because it only involves inject the reactive power compensation instead of active power. The dynamic force load is zero by injecting the compensated voltage right-angled to the current. The phase-in advance is much more detailed than the injected voltage or phase system. During high load condition the voltage phase shift will causes variance problem like, false zero interrupts and load power oscillation. Therefore, the phase advance

compensation tolerance must be adjusted for the phase angle or when the position angle moves from the wrong angle to the forward angle.

Figure 7. Phasors diagram of the IPAC method

3.1.5. Injection - Booster Transformer

The injection-booster transformer is specially designed to control the noise and voltage fluctuations in the transmission line. Mainly it booster transformer contains two side winding primary and secondary it will connected to the HV line for injection of reactive power when unbalanced load voltage the primary side receives the voltage from the solar-based inverter system for backup power processing. Additionally injection-booster transformer will isolate the load from the system using inverter switch. The single-phase circuit diagram of booster transformer will be represented in figure 8.

Figure 8. Booster transformer

3.2. PV-DVR System

The photovoltaic (PV) array is a combination PV cell that transforms solar energy into electrical energy. In this proposed model DVR based PV is connected DC to DC converter for providing in the stability DC voltage to the voltage source converter, the circuit diagram of the PV-DVR system is as represented in **figure 9**. It has been introduced between the photovoltaic and battery bank of the DC connection.

The rapid changing in climate conditions to produced

solar energy is unstable it requires DC-DC converter to provide constant voltage to the DVR inverter. It is working with the radiation intensity of the solar radiation, as well as the cell transition and temperature. Basic equations for batteries voltage, including PV array temperature change and voltage radiation intensity property, are being developed. One purpose of the photocurrent is that the voltage of the battery output voltage is often defined by the load current related to the amount of solar radiation. The circuit diagram of the solar cell is shown in **figure 10**.

Figure 9. Solar-based DVR system

Figure 10. Solar Cell

$$V_{pv} = \frac{nKT}{q \ln(\frac{I_{DC}}{I_{pv}} + 1)}$$

$$I_{pv} = I_{sc} - I_{pvo}$$

Where,

V_{pv} is photovoltaic voltage

I_{pv} is photovoltaic current

K is Boltzmann constant

T is cell reference temperature

I_{sc} is short circuit current

I_{pvo} is diode saturation current

3.2.1. Perturb and Observe (P&O) Based MPPT System

MPPT is an important measurement of solar power tracking. The Perturb and observe (P&O) MPPT algorithm

(12) apply a small increase or decrease of perturbing voltage dynamic voltage to the operating voltage of the PV unit.

(13) The PWM generator is a control signal (V_{ref}) used to generate solar output voltage (V_{PV}) and solar output current (I_{PV}). The flow chart of P&O MPPT method exhibited in **figure 11**.

The P&O MPPT operation mode is illustrated in the image above. The actual position (L) and V I parameters are measured by the value of the previous position ($L-1$). The real value is obtained from the specification of its previous condition is estimated from the product of V , and the first increase or reference voltage drop. The P&O MPPT will compare the V_{ref} and generated voltage and produce the rated pulse width modulation (PWM) for the voltage stabilization.

Figure 11. Flow chart for MPPT System

Figure 12. Circuit diagram for DC-DC Converter

3.2.2. DC to DC Converter

The converter circuit configurations, as shown in **figure 12**, which are used to regulate PV generated voltage and provide constant voltage to the circuit system. The DC to DC converter is used to improve the DC voltage when the input volt is lower than the output volt, and the boost converter is used to improve the voltage.

The general outline conditions of the converter are given below

$$VL = \frac{Vs}{1+\sigma} \quad (14)$$

Where,

$V_l = 0 - P$ voltage

$V_s = I-P$ Voltage

$\sigma =$ clock pulse

Inductance required for the activity in terms of continuous conduction mode (CCM's) is L_{min} ,

$$L_{min} = ((1 - \sigma)^2) \sigma R L 2 f_s \quad (15)$$

The capacitor voltage V_r is expressed at C_{min} ,

$$C_{min} \sigma - R L f_s V_r \quad (16)$$

The load current I_o as expressed as,

$$I_o = (1 - \sigma) I_s \quad (17)$$

Where I is the source current with the change in the current ∇I in light of the evaluation of inductance is given as,

$$\nabla I = \frac{V_s(VL - V_s)}{f_s L V_l} \quad (18)$$

Where, $V_s =$ source voltage

$V_l =$ Load voltage

3.3. ESVPWM Control Strategy

The Enhance SVPWM technique is the efficient, computationally intensive Pulse width modulation method techniques and it had a potential regulated frequency to the converter depend upon the application needs. The typical 3 phase voltage source circuit design for PWM inverter is presented in **figure 13**. R, R', Y, Y', B and B' are the six switches that give the output from Q1 to Q6. When an upper side transistor is turned on, that is, R, Y or B 1, according to the lower side transistor is switched off, that is, relative 'a', 'b' or 'c'. Therefore, transistors 'Q1', 'Q3', and 'Q5' are outputs of on and off positions can be used to determine the voltage.

Figure 13. ESVPWM inverter control

Figure 14. Vector Representations of the Switching Gates

Enhanced SVPWM method is presented in figure 14. A simple method of the Vref voltage vector is using eight changes to regulate the average inverter circuit output over a short period of time. In the same period, Vref should be T.

3.3.1. Determination of Time Durations $T_1 T_2 T_0$

From figure 11, can calculate the switching period,

$$T_1 = \frac{\sqrt{3}}{V_{dc}} T_z |V_{ref}| \left(\sin \frac{n\pi}{3} \cos \theta - \cos \frac{n\pi}{3} \sin \theta \right) \quad (19)$$

$$T_2 = \frac{\sqrt{3}}{V_{dc}} T_z |V_{ref}| \left(\sin \theta \cos \frac{(n-1)\pi}{3} - \cos \frac{(n-1)\pi}{3} \sin \theta \right) \quad (20)$$

$$T_0 = T_z - (T_1 + T_2) \quad (21)$$

$$T_z = \frac{1}{F_z} \quad (22)$$

Where $n=1$ within 6, is the vector region

T_z = sampling time

F_z = Switching frequency

i.e., vector 1 to 6 and $0 \leq \theta \leq 60^\circ$.

Table.1. ESPWM Switching Table

Vector	Q1	Q3	Q5	Q4	Q6	Q2	VAB	VBC	VCA
$V_0=\{000\}$	OFF	OFF	OFF	ON	ON	ON	0	0	0
$V_1=\{100\}$	ON	OFF	OFF	OFF	ON	ON	+VDC	0	-VDC
$V_2=\{110\}$	ON	ON	OFF	OFF	OFF	ON	0	+VDC	-VDC
$V_3=\{010\}$	OFF	ON	OFF	ON	OFF	ON	-VDC	+VDC	0
$V_4=\{011\}$	OFF	ON	ON	ON	ON	OFF	-VDC	0	+VDC
$V_5=\{001\}$	OFF	OFF	ON	ON	ON	OFF	0	-VDC	+VDC
$V_6=\{101\}$	ON	OFF	ON	OFF	ON	OFF	+VDC	-VDC	0
$V_7=\{111\}$	ON	ON	ON	OFF	OFF	OFF	0	0	0

3.3.2. ESPWM Algorithm Steps

Step 1: During the undesired condition to Change the switching time of the device, switch-mode type, and creates the real output of the control system produce different voltage vector.

Step 2: Method for converting a three-phase bridge arm of the eight switching state combinations can be created.

$V_0 - V_7$ Vectors

Step 3: In the sample time cycle, always beginning with the zero vector and ending with the zero vector, the plane is subdivided into six segments, two adjacent voltage vector switch and two zero vectors for a set of rotating space vector equivalent u_{ref} , followed by a regular polygon approximation.

Step 4: The component set U_α and U_β are U_c intended to define the three reference vector to determine the number of fields, define three reference vectors:

$$u_{ref1} = u_\beta \quad (23)$$

$$u_{ref2} = u_\alpha \sin \frac{\pi}{3} - u_\beta \sin \frac{\pi}{6} \quad (24)$$

$$u_{ref3} = u_\alpha \sin \frac{\pi}{3} - u_\beta \sin \frac{\pi}{6} \quad (25)$$

Step 5: The space voltage vector evaluation number N can be stated as:

$$N = Sgn(u_{ref1}) + 2Sgn(u_{ref2}) + 4Sgn(u_{ref1}) \quad (26)$$

Where, Sgn is space voltage vector.

Step 6: In a switching cycle, define the three-phase relative switching times, T_1, T_2 , and T_0 for the vector of switching points, for the point cutoff of the power pipe.

Step 7: The assumption is that A, B, high-level corresponding PWM ranges, where the C line switch is at the top of the switch's operating position when the low-level low-arm switch is in relative motion and does not switch on dead time and minimum pulse width.

Step 8: A phase change of the state status of restoration for each switch is selected to not only change the zero vector using the average allocation scheme

Step 9: To obtain the amplitude of the switching control pulse, A, B, C are the constant frequency and peak of the triangular wave as the carrier signal relative to the three-phase switching time waveform comparison.

Step 10: When the $V_S = V_{PK}$, regulate the pulse.

V_S =source voltage

V_{PK} =triangular wave voltage

Step 11: It can find the characteristic triangle where space vector u_{ref} locates inconveniently.

Step 12: The positioning of the new original center vector V_0 is another problem to be solved as the level of PWM increases, even with the difficulty of overlapping area handling for adjacent hexagons.

Step 13: The reference vector V_{ref} curve is coordinated by using at least three different switching positions of T_s during each transition period.

$$\text{switching period } (T_s) = \frac{1}{\text{switching frequency } (f_s)}$$

Step 14: Each circle along the same output line switching states can generate unwanted voltages, indicate switching states.

Step 15: End.

Figure 15. Flow chart for the proposed ESVPWM method

Figure 15 represents the proposed Enhanced Space Vector PWM (ESVPWM) based DVR inverter, and its switching techniques are clearly explained.

4. Results and Discussion

The Enhanced Space Vector PWM (ESVPWM) based DVR is implemented in MATLAB Simulink software system, and this design shown in **figure 16**, an Enhanced Space Vector PWM (ESVPWM) technique is provides an power quality in distribution system which performance are evaluated in the running condition.

The simulation represents the regulation of the source power to the grid. If the source variation of the power will be varied a series filter which will act as a reactive power of the system and it will compensate the power oscillation. At the initial time, the harmonics present in the non-linear load is high. After the conversion of series filter total harmonics,

which is present is low. The variation of proposed model with its output parameters like source voltage, load voltage and injection transformer voltage is view on the scope of the system.

Figure 16. Simulink Model ESVPWM based DVR

Figure 17. Solar Power generation voltage

Figure 17 shows the solar Power generation output voltage, which produced the maximum output $V=198$; the X-axis denotes the voltage generation In Various Time Duration.

Figure 18. Simulated waveforms of Source Voltage for the proposed DVR model

The source voltage will represent **Figure 18** the source of the system which will generate in the power generation area. The y-axis is indicating the maximum amplitude of the power $V=350$. The x-axis represents the period in a seconds. The waveform that clearly describes the oscillation of sag and swells present in the power generation side.

Figure 19. DVR Injected Voltage

The output power will not be constant always; it will depend upon non-linear loads. So, reactive power of a series filter will act like the injected voltage in the power line, which is represented in **figure 19**. The y-axis is indicating the amplitude of the power $V=125$. The x-axis represents the period in seconds.

Figure 20. Simulated waveforms of Three Phase balanced Source Voltage for the proposed DVR model.

The above **figure 20** demonstrates the three-phase load voltage waveform, the proposed Enhanced Space Vector PWM (ESVPWM) steps to adjust and control the oscillating power variation in the load side.

Figure 21. THD Analysis of the proposed control system with a DVR

The above **figure 21** demonstrates the THD investigations of the proposed method Enhanced Space Vector PWM (ESVPWM), produces the THD of 2.01%. With the fundamental frequency of 50HZ.

Figure 22. THD Analysis of the proposed control system without a DVR

Figure 22 shows the THD analyses of the proposed system without DVR compensation presents the load side THD value is 14.00 %.

Table 2. Performance analysis for DVR Features of the proposed and existing system

Parameters	PI	ESVPWM
Steady-state error (%)	1.8	0.9
Without DVR THD (%)	18	14
With DVR THD (%)	9.1	2.01
Efficiency (%)	88	91

Table 2 shows the comparison table for the (DVR), which are analyzed for the operating features of the existing system and proposed a system.

Steady-State Error:

Stability control is an essential characteristic of the system; Feedback control systems are used to compensate for disruption or unwanted inputs that enter an order.

$$e_c(t) = c_r(t) - c(t) \quad (27)$$

Where

$e_c(t)$ is a system error

$c_r(t)$ is requested output

$c(t)$ is practical output

Total Harmonics Distortion (THD)

The THD of any system can be calculated by the Equation (28)

$$THD = \frac{\sqrt{\sum_{n=2,3,\dots}^{\infty} V_n^2}}{V_1} \quad (28)$$

Where V_1 and V_n are the amplitude of the essential segment and harmonic requests of a waveform, separately. Considering every single harmonic application, which is required for an exact count of THD, is relatively unthinkable for those waveforms. Rather than Equation (28), another type of the THD recipe, which deals with the dominant estimation of the waveform, can consider every harmonic request in Equation (29).

$$THD = \sqrt{\frac{V_{rms}^2}{V_{1,rms}^2} - 1} \quad (29)$$

Where

V_1 , rms = Effective value of the fundamental component.

V_{rms} = Effective value of the whole waveform.

Figure 23 is the comparative analysis of the DVR control which evaluates with various parameters like steady-state error, efficiency and with and without THD results are evaluated with the existing system the proposed Enhanced Space Vector PWM (ESVPWM) produce effective results.

Figure 23. Performance analysis of the DVR system

Figure 24. THD Analysis

Figure 24 shows the Total Harmonics Distortion for the proposed model with DVR system produces the better result of 2.01%.

5. Conclusions

This work provides a necessary analysis of the DVR that can reduce the voltage sag and swell disturbances in the load side distribution system. The proposed Solar based DVR model will be designed in the MATLAB Simulink software 2017b and its performance are evaluated with various parameters like steady-state, efficiency and Total Harmonics distortion (THD) will be examined with dynamic running condition. Additionally the proposed Enhanced Space Vector PWM (ESVPWM) algorithm used proper switching pulses under required condition to improve power quality in distribution systems in officially accepted procedures as various power lines disturbances such as voltage restoration, voltage deviation and THD of the system also compensated. Under dynamic time and load varying conditions the proposed ESVPWM that's only produced better THD Result of 2.01%. Finally, the overall performance of the proposed solar-based DVR will improve the power quality of the distribution system in every arrangements of the proposed model and also increase the system efficiency 91% with low design cost.

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