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Design and Analysis of ZSI based DVR for Improving the Voltage profile

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Abstract: The principle objective of this task is to protect sensitive weights from voltage droops or expands with Dynamic Voltage Restorer (DVR) utilizing VSI and ZSI. The Z-source inverters which have been actually proposed as an elective force change thought crushes the sensible and speculative obstacles and limitations of the standard voltage-source converter and current-source converter and gives a novel force change thought. Here the assessment is made between the display of DVR using VSI and ZSI. The sinusoidal condition of the yield voltage paying little notice to the load type is kept up by this voltage control system.

Keywords: DVR, voltage sag/swells, VSI, ZSI

INTRODUCTION

In the transmission line, the voltage is usually supplied from V1 but if a fault occurs, the transmission line fails to supply the nominal voltage to the load . This disturbance is detected by the DVR such that the difference voltage is determined and then the required voltage is injected through the transformer to the load side as V3 to maintain the constant power supply. The complete block diagram is as shown in fig 1.1.[1]-[2].

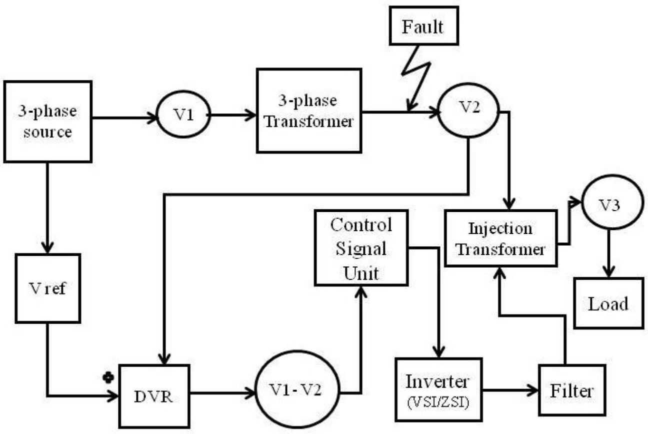


Fig.1.1 Complete block diagram of DVR

V1- Source voltage/Reference Source,
V2- Voltage after Fault,
V3-Constant Load Voltage
(V1-V2) Injected Voltage by DVR.

The ZSI is new single-stage electronic force converters with both electric potential buck and boost limits that have been proposed for use in power device energy change systems and motor drives with a front-end rectifying tube.The ZSI is a step-down or a step-up inverter that has a wide extent of reachable voltage[3]. The conventional V, I source inverters can't give such features. The essential part of the ZSI is executed by giving trigger including the shoot-through pulses.

During the shoot-through, the yield terminals of the inverter are shorted and the yield voltage to the load is zero. As such, the obligation proportion of the powerful states should be kept up to yield a sinusoidal voltage, which means shoot-through replaces a couple or the aggregate of the standard zero states. This shoot-through zero state gives the astounding step-down or step-up feature to the inverter [4]-[5].

I. WORKING OF ZSI

The fascinating segment of the ZSI is that the yield ac voltage can be any value among nothing and boundlessness paying little psyche to the source DC voltage. Differentiated and standard voltage – source versus current – source inverters, the sole qualification of a Z – Source Inverter is its X-shaped impedance network completed using a split inductor (L1, L2) and capacitors (C1, C2). The DC source can be either a voltage or a current source [6]. Switches used in the converter can be a mix of trading devices and threatening to look like rectifying valve as exhibited in the figure 2.1.

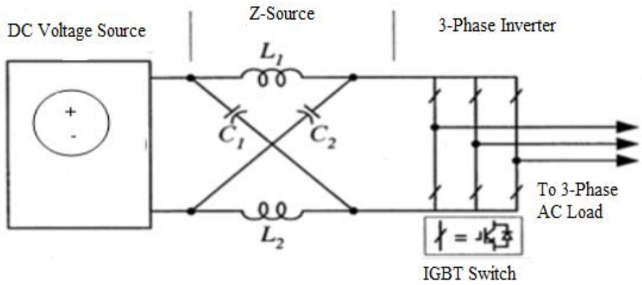


Fig.2.1. ZSI using the anti parallel combination of controller and rectifying valve

Six switches are utilized in the circuit each is customarily made out of a power optoelectronic and an anti-parallel rectifiyng valve to give bidirectional current stream and unidirectional voltage hindering ability. The normally utilized switches are MOSFET, IGBT, BJT, SCR, and GTO [7]-[8].The functioning methods of ZSI are explained as follows.

2.1.1 Method I

Working in one of the six conventional dynamic vectors by the inverter bridge.

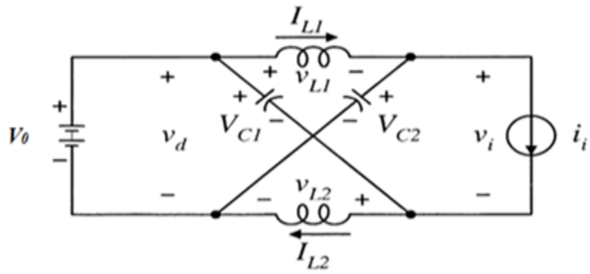


Fig.2.2 ZSI in one of the six active states

2.1.2 Method II

The equivalent circuit of the extension in this method is as shown in fig.

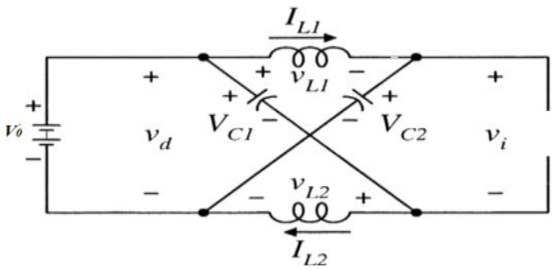


Fig.2.3. ZSI in one of the two traditional zero states

The inverter connect is working in one of the two standard zero vectors and shorting through either the upper or lower three gadgets, in this route going probably as an open circuit saw from the Z-source circuit. Again, under this strategy, the inductor conveys current, which adds to the line current's consonant diminishing as exhibited in the following. Fig 2.4.

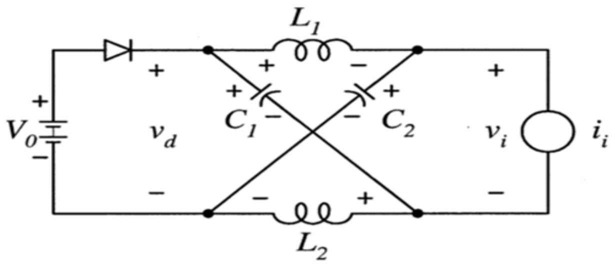


Fig.2.4. Non Shoot-Through States of the ZSI

2.1.3 Method III

The inverter bridge is operating in one of the seven shoot-through states. The same circuit of the inverter bridge in this method isolating the dc-interface from the AC line is as shown in fig.2.5.

The shoot-through mode used in each trading cycle during the standard zero vector time periods is made by the PWM direct. Dependent upon how much an electric potential support is required, the shoot-through stretch (T0) or its obligation cycle (T0/T) is settled. It will in general be seen that the shoot-through stretch is only a little piece of the trading cycle.

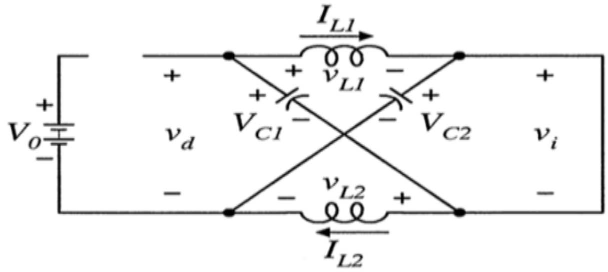


Fig.2.5 ZSI in the Shoot-Through State

In a 3-stage Z source inverter, one additional control limit is introduced to be explicit, the step-up Factor (B), which modifies the air ac yield voltage state of ordinary 3-stage PWM inverter as following.

V_{out} = BM (V_{dc}/2)...............(1)

V_{out} – Output voltage, B – Boost factor

M – Modulation index , V_{dc} – dc input voltage

If we replace BM with G, then we may rewrite (1) as

V_{out} = G(V_0/2)...............(2)

Where G – Inverter gain

G=BM.........................(3)

Step-up Factor is procured by introducing shoot-through of irrelevantly one bunch of the inverter arm for a short period of time which called shoot-through time.

$B = \frac{1}{1-2(\frac{To}{T})} = \frac{1}{1-2Do}$……..(4)

Where T_0 – Shoot through time , T – Switching period, D_0 – Shoot through duty ratio

II. ACTIVITY METHODS OF DVR

All around, the DVR is masterminded into three movement strategies: security technique, hold strategy, infusion technique.

Security technique: The direct voltage restorer is protected from the over current on the heap side as a result of a short out on the heap or tremendous inrush streams. The diversion switches take out the DVR from the structure by giving another approach to current.

Hold Strategy: In average predictable state conditions, the direct voltage restorer may either go into obstruct or implant little voltage to compensate for the voltage drop on transformer reactance. The short out action of DVR is generally the supported plan in a reliable state considering the way that the little voltage drops don't irritated the load requirements if the dispersal circuit isn't frail.

Infusion technique: The direct voltage restorer goes into imbuement mode when the droop is perceived. Three single-stage ac voltages are imbued in arrangement with the essential degree, phase, and wave shape for compensation. Such voltage sag, load conditions, and force rating of the device will choose the opportunity of compensating voltage droop. The DVR should ensure the unaltered burden voltage with the least energy dispersal for imbuement due to the massive cost of capacitors.

3.1 Direct Voltage Restorer Modeling:

The heap side voltage-controlled three-leg PWM inverter is used to make compensating electric potential. The model contains self-commutating IGBT switches with parallel diodes. The sinusoidal pulse width method (SPWM) structures the control framework. The control block delivers the ending signals for each switch with controllable adequacy, stage, and recurrence whenever hang is perceived. The inverter side filtering is applied to the system since it is closer to the consonant source.

A quick feed forward control technique is used to restrict the response time and expand the special presentation. Voltage rules, low symphonious mutilations, and no obstructions are recognized with this sort of control plan. Using root mean square regard calculation of the voltages to separate the droop doesn't give fast results considering the way that in any occasion one half periods at the line recurrence is required for assessment.

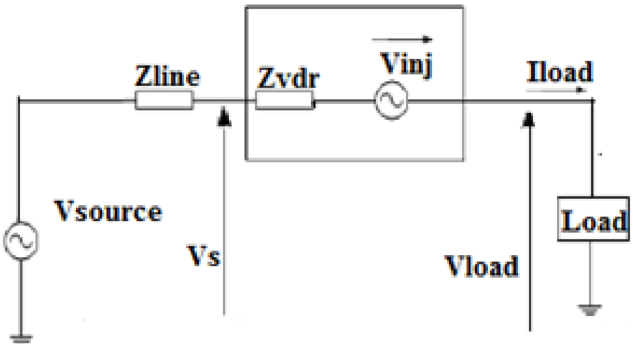


Fig.3.1Equivalent circuit of DVR

III. VOLTAGE CONTROL TECHNIQUES

There are two kinds of controlling the voltage.

1. V-Source Inverter – (Sinusoidal Pulse Width Modulation Technique)
2. Z-Source Inverter – (Basic Boost Control Technique)

4.1 SPWM:

The triggering pulses are made by differentiating a alternating reference pulses with a three-sided transporter wave of recurrence. The recurrence of reference signal chooses the inverter yield recurrence, and its apex magnitude direct the modulation index, and a while later consequently the root mean square yield voltage, which is shown in fig.4.1.

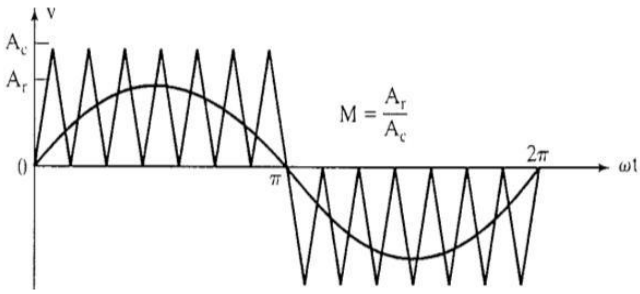


Fig.4.1 Generation of pulses using SPWM

4.2 Basic Boost Control Method:

The fundamental plan to control the ZSI is to transform the standard zero state into a shoot-through zero state while keeping the powerful trajectories unaltered, consequently we can keep up the alternating output and simultaneously accomplish voltage help from the shoot-through of the dc connect. This control approach installs shoot-through in all the pulse width modulation traditional zero states during one trading period. This keeps up the six unique states unaltered. The shoot-through duty ratio (Do) can be understood by utilizing the two straight lines. It is equivalent to the pinnacle worth of three-stage alternating reference. At whatever point the triangular carrier pulse, the inverter will work in shoot-through. Else, capacities as a standard pulse width modulation inverter. Fig.4.2 exhibits the tweak, basic boost control technique. Shoot-through beats are installed into the trading waveforms by a consistent OR gate.

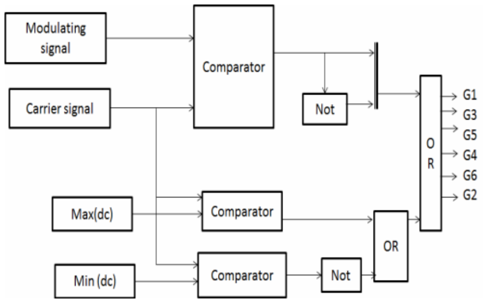


Fig.4.2 Implementation Diagram of SBC

To make trading beats, three-stage reference waveforms having top worth with modulation index are contrasted and a similar high-recurrence triangular signal. The comparator looks at this two references, creates triggering when (Vsin >Vtri) ON, (Vsin <Vtri) OFF. This triggering is shipped off the gates of the force MOSFET to withdrawal and entryway drive circuit.Figure.4.3 shows the triggering of the three-stage leg switches (S1, S3, S5-positive switches) and (S2, S4, S6-negative switches). Nonetheless, the subsequent electric potential pressure across the module is moderately above since some conventional zero states aren't used besides incompletely or completely. The trademark confines the possible electric potential on account of the constraint of module potential rating.

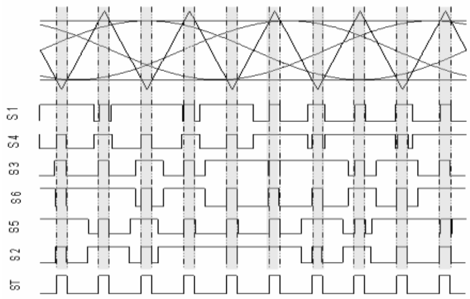


Fig.4.3 PWM Signals from Simple Boost Control

IV. SIMULATION MODEL OF DVR USING VSI IN MATLAB

4.1 Simulink model:

The Simulation model of DVR using VSI in MATLAB is as shown in fig.5.1.

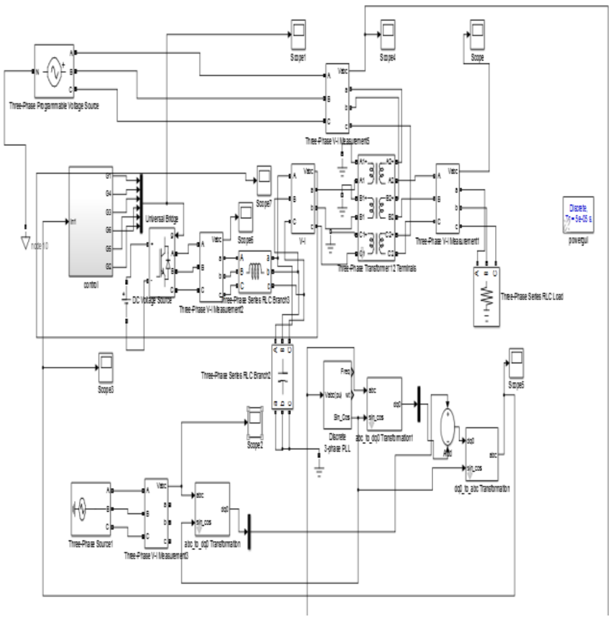


Fig.5.1 Simulation model of DVR using VSI in MATLAB

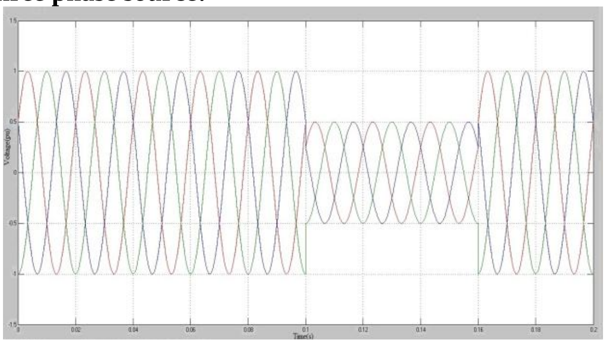
Parameters of the model:

Table 5.3 Parameters of DVR using VSI

Input voltage	415V (L-L, rms)
DC input voltage	240V
Load	10KW
Filter parameters	L=2850uH C=750uF

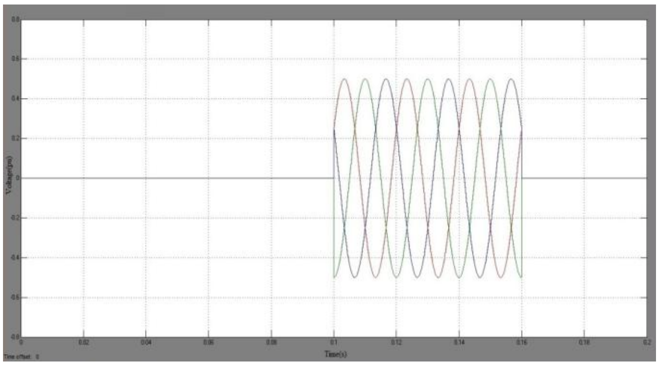
5.2 Result Analysis of DVR using VSI for sags

5.2.1 Voltage with sag by three phase source:



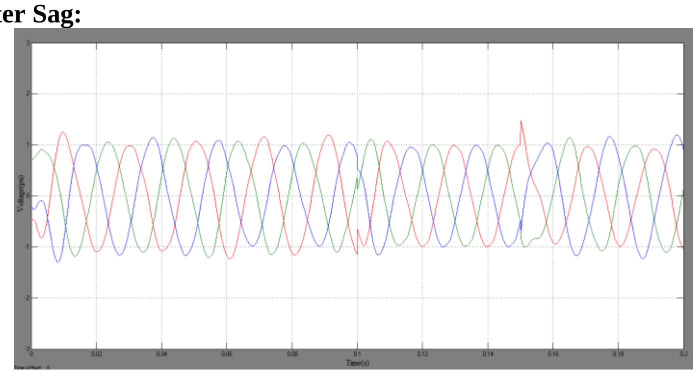
The figure shows the three-phase mimicked supply voltage. It has voltage sag of 0.5 p.u, starts at 0.1ms and kept until 0.15ms. The total sag span is 0.5ms.

5.2.2 Voltage injected by DVR:



Here the magnitude of voltage injected by the DVR is 0.5p.u during 0.1ms to 0.15ms.

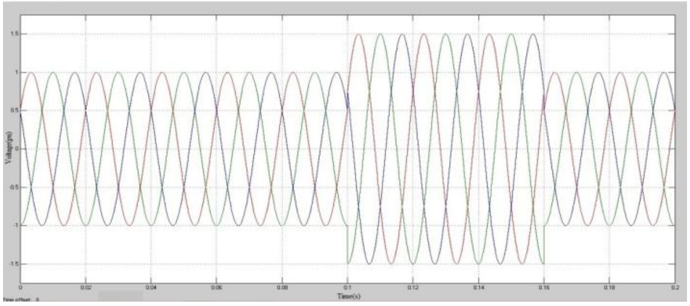
5.2.3 Load Voltage after Sag:



This is the yield voltage that is being provided to the purchaser whose extent is steady all through. It is gotten by the summation of input voltage with droop plus remunerated electric potential being provided by the DVR. For this situation, the remunerated potential is in line with the input voltage.

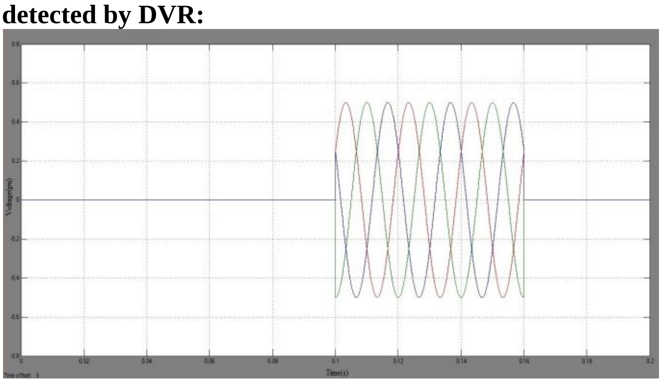
5.3 Result Analysis of DVR using VSI for swell:

5.3.1 Voltage with swell by three phase source:



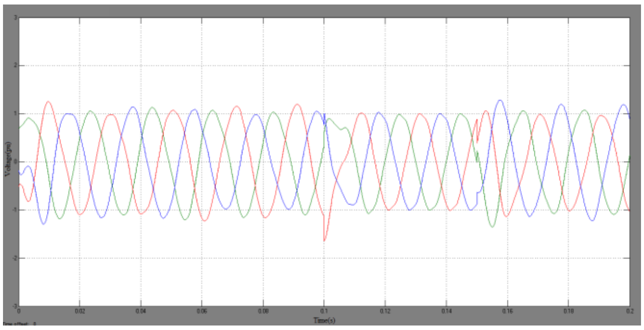
The figure shows the three-phase mimicked supply voltage. It has a voltage swell of 0.5 p.u, starts at 0.1ms and kept until 0.15ms. The total swell length is 0.5ms.

5.3.2 Voltage difference detected by DVR:



Here the magnitude of voltage detected by the DVR is 0.5p.u during 0.1ms to 0.15ms.

5.3.3 Load Voltage after Swell:



This is the output voltage that is being supplied to the consumer whose magnitude is constant throughout. It is obtained by the summation of source voltage with swell and compensated voltage being supplied by the DVR.

V. SIMULATION MODEL OF DVR USING ZSI IN MATLAB

6.1 Simulink model:

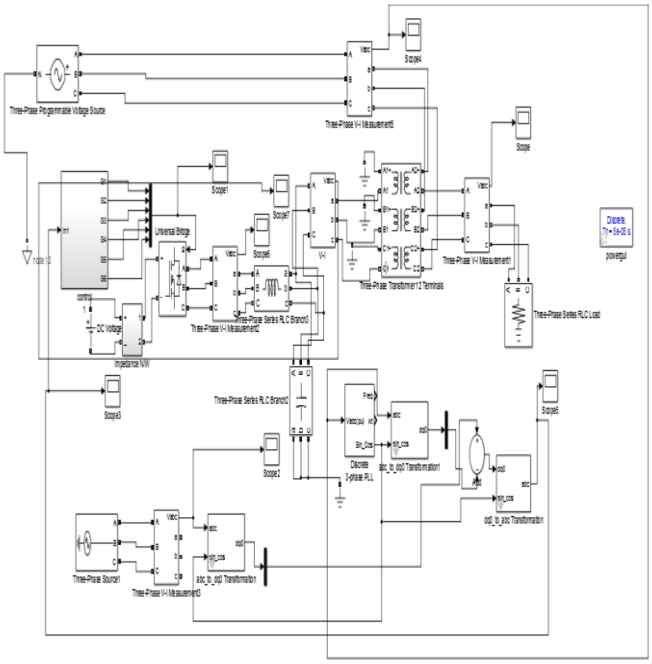


Fig.5.6 Simulation model of DVR using ZSI in MATLAB

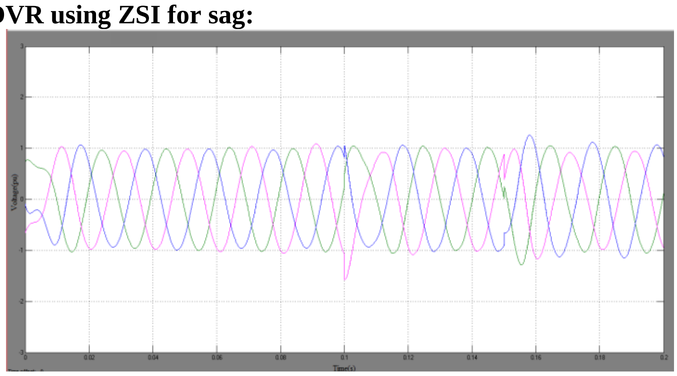
Result Analysis of DVR using ZSI for sag and swell

Parameters of the model:

Table 6.1 Parameters of DVR using ZSI

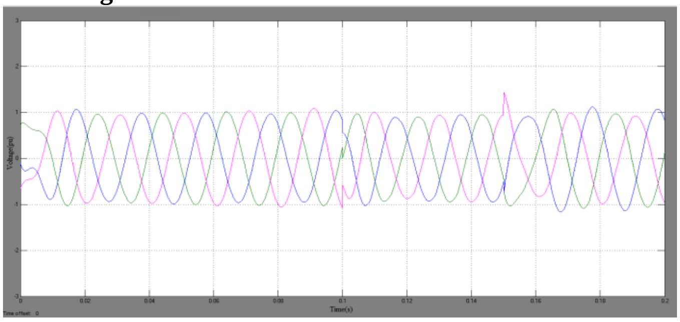
Input voltage	415V (L-L rms)
DC input voltage	100V
Load	10Kw
Impedance parameters	L=0.45nH, C=410nF
Filter parameters	L=3000uH, C=1000uF

6.2 Result Analysis of DVR using ZSI for sag:



Here voltage sag of 0.5p.u is started at 0.1ms and kept until 0.15ms. The all out sag length is 0.5ms. So the magnitude of voltage infused by the DVR is 0.5p.u during 0.1ms to 0.15ms. This is the yield voltage that is being provided to the consumer whose magnitude is steady all through. It is gotten by the summation of source voltage with droop and compensated voltage being provided by the DVR. For this situation, the compensated voltage is in stage with the supply voltage.

6.3 Result Analysis of DVR using ZSI for swell:

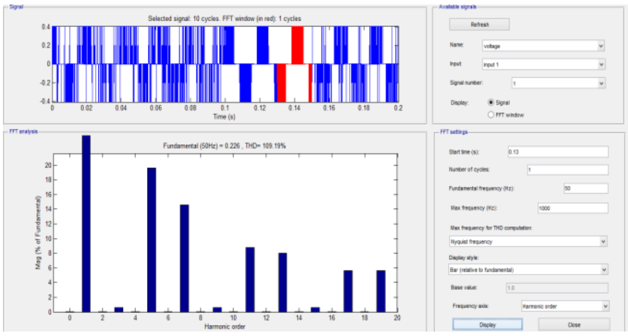


Here voltages swell of 0.5 p.u is started at 0.1ms and kept until 0.15ms. The complete swell span is 0.5ms. So the magnitude of voltage infused by the DVR is 0.5p.u during 0.1ms to 0.15ms. This is the yield voltage that is being provided to the consumer whose magnitude is consistent all through.

VI. TOTAL HARMONIC DISTORTION

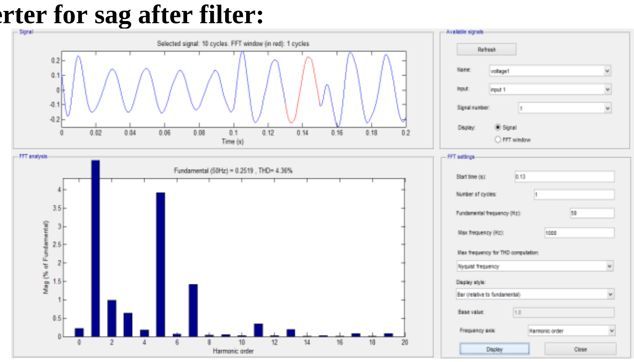
7.1 THD for VSI:

7.1.1 Line voltage of inverter for sag before filter



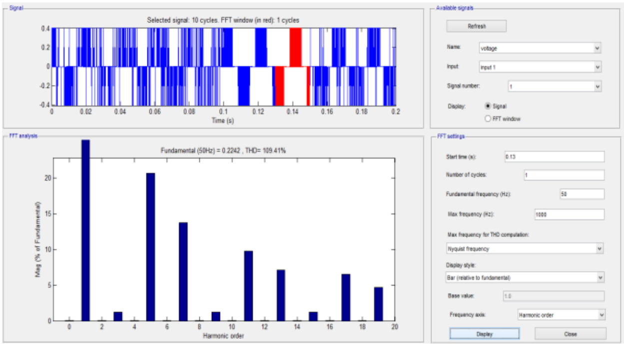
THD=109.19%

7.1.2 Line voltage of inverter for sag after filter:



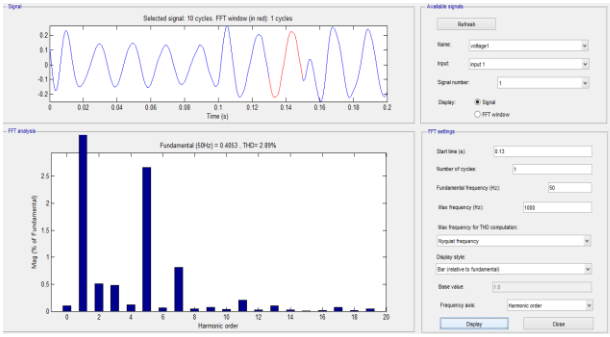
THD=4.36%

7.1.3 Line voltage of inverter for swell before filter:



THD=109.41%

7.1.4 Line voltage of inverter for swell after filter:



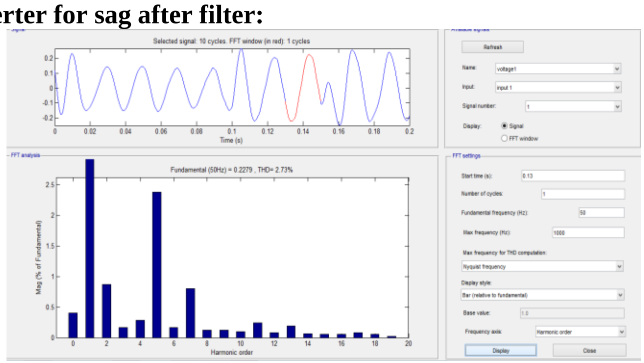
THD=2.89%

7.2 THD for ZSI:

7.2.1 Line voltage of inverter for sag before filter:

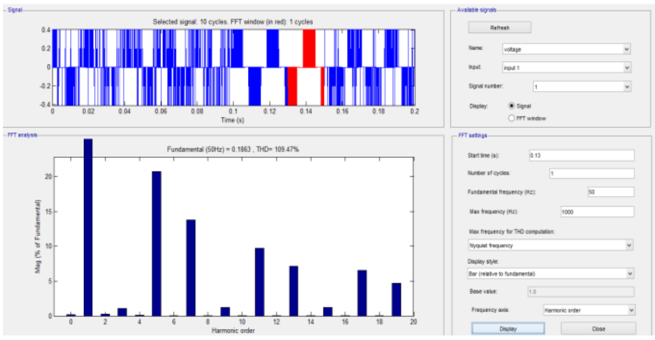
THD=109.28%

7.2.2 Line voltage of inverter for sag after filter:



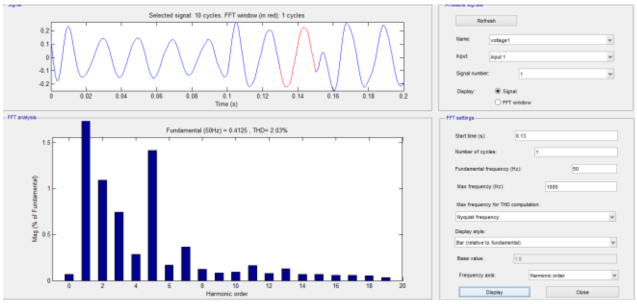
THD=2.73%

7.2.3 Line voltage of inverter for swell before filter:



THD=109.47%

7.2.4 Line voltage of inverter for swell after filter:



THD=2.03%

7.3 Comparison of THD for VSI and ZSI:

Table 7.1 Comparison of THD for VSI and ZSI

	Without filter	With filter
SAGS		
VSI	109.19%	4.36%
ZSI	109.28%	2.73%
SWELLS		
VSI	109.41%	2.89%
ZSI	109.47%	2.03%

VII. CONCLUSION

The Simulink model of DVR have been introduced utilizing two unique inverters technologies specifically VSI and ZSI. A control framework dependent on the Park's transformation which is a scaled error among the input of the direct voltage restorer and its reference for sag and swell has been introduced. Replica of the DVR execution shows satisfactory at moderating sags and swells. Final outcomes show that superior is conveyed by the DVR utilizing ZSI. DVR with VSI can just behave like a buck converter while DVR with ZSI goes about as both buck and boost converter. The comparison of THD among VSI and ZSI with and without filter for both electric potential sag and swell obtained.

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