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RESEARCH ARTICLE OPEN ACCESS

FFT Based Reference Signal Generation and Selective Harmonic Elimination PWM to Minimize Harmonics in Line Using DVR

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Abstract:

Series connected custom power device called as dynamic voltage restorer (DVR) is the most effective device used in electrical systems to compensate power quality problems. Traditional DVR compensates only voltage sag/swell in electrical grids. The main contribution of this project is that FFT based a novel reference generation method is used in DVR to compensate unbalanced voltage harmonics, simultaneously. In this study, FFT achieves voltage harmonics extraction and FFT controlled DVR compensates unbalanced selective voltage harmonics (5th, 7th, 11th and 13th) in the system. The performance of proposed controller method is presented and confirmed through simulation in MATLAB/Simulink environment.

Keywords — **FFT, DVR, SHE, PWM.**

I. INTRODUCTION

The inverter-based dynamic voltage restorers (DVRs) for preventing customers from momentary voltage disturbances on the utility side was demonstrated .And using the DVR Identification of voltage sag and swell initiates the process of mitigation. Dynamic Voltage restorer (DVR) is a type of FACTS controller placed in series to the power system to the power system network to nullify or reduce the affect of voltage sag or voltage swell in the system by injecting or absorbing compensating voltages in to the main power system line through a coupling transformer.

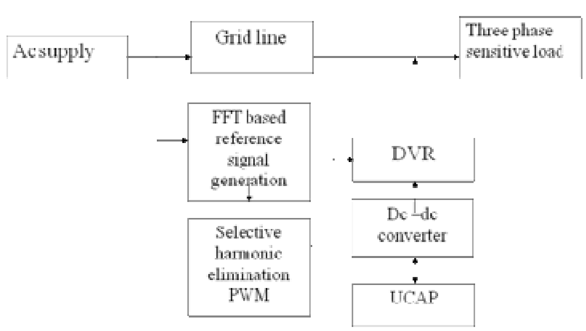


Fig 1.Block Diagram of Sag Detection

II. DYNAMIC VOLTAGE RESTORER USING UCAP IN FFT

A. DVR

The basic principle of dynamic voltage restoration is to inject a voltage of the magnitude and frequency necessary to restore the load side voltage to the desired amplitude and waveform, the source voltage is unbalanced. Generally, devices for dynamic voltage restoration employ gate turn off thrusters (GTO) solid state power electronic switches in a pulse-width modulated (PWM) inverter structure. The DVR is a solid state DC to AC switching power converter that injects a set of three phase AC output voltages in series and synchronicity with the distribution and transmission line voltages.

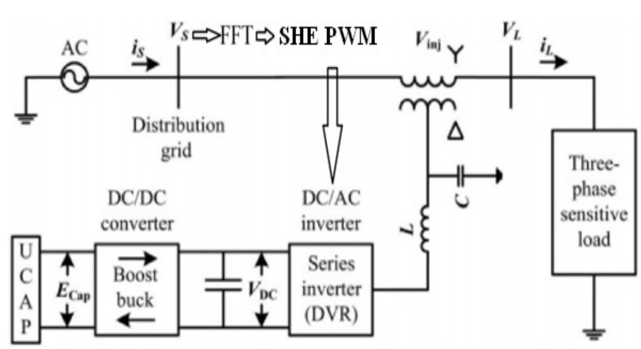


Fig 2.Block diagram of SHE PWM

As a power quality product has gained significant popularity. the usage of the DVR with rechargeable energy storage at the dc-terminal to meet the active power requirements of the grid during voltage disturbances. In order to avoid and minimize the active power injection into the grid. Due to the high cost of rechargeable energy storage, various other types of control strategies have also been developed in the literature to minimize the active power injection from the DVR. The high cost of the rechargeable energy storage prevents the penetration of the DVR as a power quality product. due to higher penetration in the market in the form of auxiliary energy storage for distributed energy resources (DERs) such as wind, solar, hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicle (PHEVs). Dc-terminal of power quality products such as static compensator (STATCOM) and DVR. Various types of rechargeable energy storage technologies based on superconducting magnets (SMES), flywheels (FESS), batteries (BESS), and ultra capacitors (UCAPs) are compared in for integration into advanced power applications such as DVR. In, cascaded H-bridge-based DVR with a thruster-controlled inductor is proposed to minimize the energy storage requirements. In flywheel energy storage is integrated into the DVR system to improve its steady-state series and shunt compensation. Transients, voltage sag, voltage swell, harmonics, flickers, electromagnetic interference, noise are some of the power quality issues that affect the normal operation of power system network out of which voltage sag and voltage swell are considered to be more dangerous power quality issues as they can produce serious threat to the power system network and loads connected at point of utilization as well. Small voltage sag can reduce the life time of the equipment connected at load section reducing the efficiency of operation. Swell in voltage can damage the load equipment connected to power system line.

Circuit Diagram of Sag Detection

The amplitude and phase angle of the injected voltages are variable, thereby allowing control of the real and reactive power exchange between the dynamic voltage restorer and the distribution system. As mentioned, the reactive power exchange between the DVR and the distribution system is internally generated by the DVR without AC passive reactive components.

Mathematical expression is given as follows by,

The above from the equivalent circuit, equation are found to be followed

$$V_{inj} = V_{load} + V_{source}$$

(1)

Where,

V_{DVR}= Voltage of DVR

V_{Load}= Desired Load Voltage

I_{Load}= Load Current

Z_{Line} = Line impedance

V_{Source}= Supply Voltage.

B. CARRIER BASED SINUSOIDAL PWM

The switches in the voltage source inverter can be turned on and off as required. In the simplest approach, the top switch is turned on, If turned on and off only once in each cycle, a square wave form results. However, if turned on several times in a cycle an improved harmonic profile and may be achieved. The harmonic components are merely shifted into the higher frequency range and are automatically filtered due to inductances in the ac system.

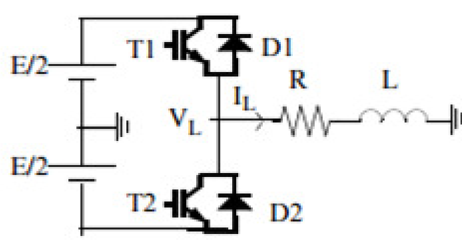
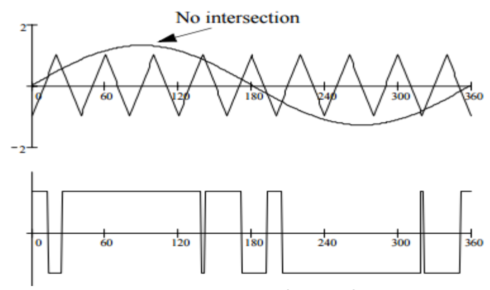


Fig 3.Simplified Diagram of Voltage Source Inverter

In the most straight forward implementation, with a high-frequency triangular ‘carrier’ wave. Depending on the signal voltage, it is larger or smaller than the carrier wave form, either it is positive or negative dc bus voltage is applied at the output. When the modulating signal is a sinusoid of amplitude Am, and the amplitude of the triangular carrier is Ac, the ratio m=Am/Ac. However, a higher carrier frequency does result in a larger number of switching per cycle and hence in an increased power loss. Typically switching frequencies in the 2-15 kHz range are considered adequate for power systems applications



Waveforms of PWM

C. UCAP SETUP

The choice of the number of UCAPs necessary for providing grid support depends on the amount of support needed, terminal voltage of the UCAP, dc-link voltage, and distribution grid voltages. In this paper, the experimental setup consists of three 48 V, 165F UCAPs (BMOD0165P048) manufactured by Maxwell Technologies, which are connected in series. Therefore, the terminal voltage of the UCAP bank is 144 V and the dc-link voltage is programmed to 260V. This would give the dc–dc converter a practical operating duty ratio of 0.44–0.72 in the boost mode while the UCAP is discharging and 0.27– 0.55 in the buck mode while the UCAP is charging from the grid through the dc-link and the dc–dc converter. It is practical and cost-effective to use three modules in the UCAP bank. Assuming that the UCAP bank can be discharged to 50% of its initial voltage (Vuc,ini) to final voltage (Vuc,fin) from 144 to 72 V, which translates to depth of discharge of 75%, the energy in the UCAP bank available for discharge is given by

$E_{UCAP} = \frac{1}{2} * C * (V_{uc,ini}^2 - V_{uc,fin}^2)$ 60W −min

D. SELECTIVE HARMONIC ELIMINATION (SHE) PWM

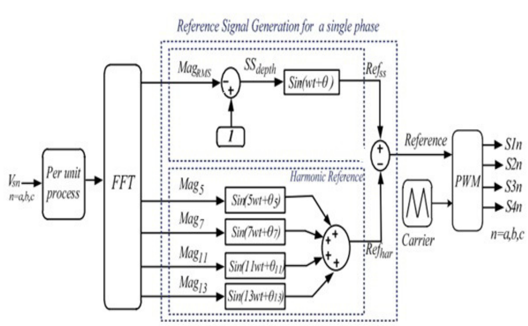


Fig 4.Circuit diagram of SHE PWM

The fig shows the conventional DVR and applied FFT based controller method. DVR is located in the front of sensitive load to mitigate negative effects of voltage disturbances at grid-side. Reference signal generation is the most significant subject to compensate voltage sag/swell/harmonics fast and accurately. In DVR controller mechanism, grid side voltages are measured against voltage sag/swell. Firstly, all voltage signals are converted to per unit (pu). Then the fundamental voltage and selective harmonic signals are obtained by using FFT method. In next step, reference signal is acquired via fundamental voltage and selective harmonic signals. In final process, reference signal is compared to a carrier signal for switching inverter gates. FFT provides to generate reference signals rapidly in addition to extraction of selective voltage harmonics. It is a faster process of discrete Fourier transform (DFT) because of reducing complex calculations in less time.

In generation of reference signal of voltage harmonics, the selective components (5th, 7th, 11th and 13th) for each phase are extracted using FFT, separately. The sine function of each selective component at its integer multiple of fundamental frequency gives reference signal of selective harmonics component.

III SIMULATION RESULTS

It will generate PWM for series inverter which functions as DVR it will generate PWM synchronized with supply voltage .It is a three phase inverter produces three phase ac output voltage with dc as input. It acts as a boost converter while UCAP discharging where DVR injects voltage into line because DVR operates at low level voltage compared to line .It acts as buck converter while charging,

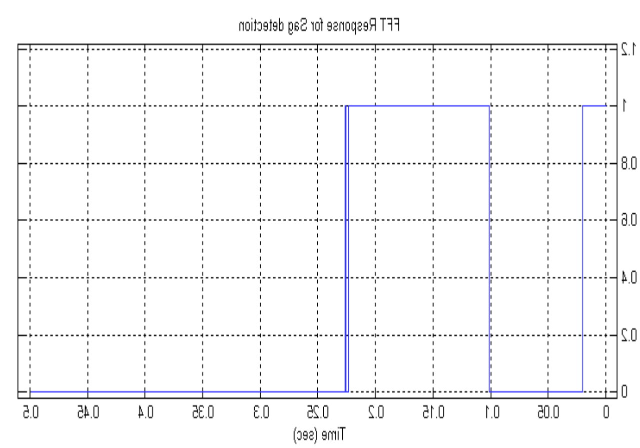


Fig 5.Waveform for FFT Controller

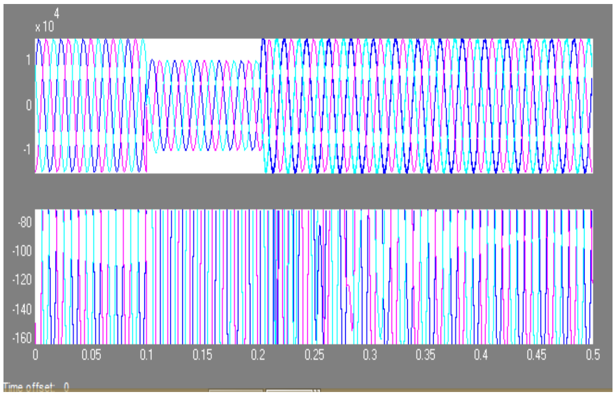


Fig 6.Waveform for Sag in Source Voltage

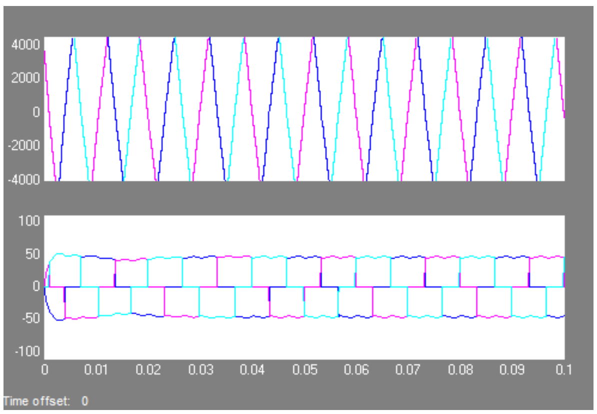


Fig 7.Waveform for Sag in Load Voltage

IV CONCLUSION

In this project, a novel FFT based controller method is first approach to compensate simultaneous unbalanced voltage sag and unbalanced selective voltage harmonics at grid-side voltage. In order to verify the effectiveness of proposed controller, the system is tested for non linear loads. FFT analyses for identification of voltage sag in different phases of power system network were shown. Mitigation of voltage sag with DVR was shown with results. According to simulation results, the proposed study achieves good performance in voltage harmonic elimination which reduces THD in addition to voltage sag compensation at grid-side voltages.

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