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Automatic Control of Advance Intelligent Micro Grid Based on SVPWM for Two Levels VSC

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ABSTRACT: In this paper design accepts of automatic control of advance intelligent micro Grid system are discussed for the enhancement of power quality and minimization of power loss. The space vector pulse width modulation technique used two level switching techniques for control the grid load. Space vector modulation (SVM) is one of the preferred real-time modulation techniques and is widely used for digital control of voltage source converters. A power quality conditioner with a shunt and a series inverter has been presented for interfacing micro grids to the utility grid. The shunt inverter is responsible for keeping a set of balanced, distortion-free voltages within the micro-grid, while the series inverter is controlled to inject unbalanced voltages in series along the feeder to balance the line currents with no real and reactive power generated. During utility voltage sags, the series inverter can also be controlled to limit the flow of large fault currents. Collectively, the conditioner has already been shown to raise the quality of power within the micro-grid, and the quality of currents flowing between the micro-grid and utility.

KEYWORDS: Micorgrid, Voltage, STATCOM, Signals**.**

I. INTRODUCTION

Economic, technology and environmental incentives are changing the face of electricity generation and transmission. Centralized generating facilities are giving way to smaller, more distributed energy resources partially due to the loss of traditional economies of scale. Distributed Energy Resources (DER) encompasses a wide range of prime mover technologies, such as internal combustion (IC) engines, gas turbines, micro turbines, photovoltaic systems, fuel cells, wind-power and ac storage. Most emerging technologies such as micro turbines, photovoltaic systems, fuel cells and ac storage have an inverter to interface with the electrical distribution system. These emerging technologies have lower emissions and the potential to have lower cost negating traditional economies of scale. The applications include power support at substations, deferral of T&D upgrades, high fuel efficiency through capturing waste heat, use of renewable energy, higher power quality and smarter distribution systems [2]. Intelligent microgrids are required to integrate distributed generation (DG), distributed storage (DS), and dispersed loads into the future smart grid. This will be a key point to cope with new functionalities, as well as to integrate renewable energy resources into the grid. Those small grids should be able to generate and store energy near to the consumption points. This avoids large distribution lines coming from big power plants located far away from the consumption areas. The impact of these distribution lines could result in low efficiency due to the high conduction losses, voltage collapse caused by reactive power instabilities, low reliability due to single point failures and contingencies, among other problems [4]. Real-time optimization is therefore feasible in microgrids, through frequent adjustments of generator outputs to minimize costs or meet other targets. Optimization may include power flow to the public network: energy for storage can be bought when prices are low, and then used when the grid connection is unavailable. Energy Management Systems (EMS) have been proposed to coordinate such functions [5]. Section II discusses about local and wide control, Section III discusses about the proposed methodology. Section IV discusses comparative result analysis. Finally, concluded in section V.

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II. LOCAL AND WIDE AREA CONTROL

Local controls are those that use inputs from within the same substation in which the control outputs are applied (i.e., no distance communication connection is required). The inputs are usually analog values (voltage, current, power, re-active power) and the control can be digital (opening/closing circuit breakers) or settings that are either discrete like transformer taps or continuous like the voltage regulator of a generator. In wide-area controls have included any control that requires some communication link to either gather the input or to send out the control signal [7].

A. POWER SYSTEM PROTECTION

The most fundamental control that is needed to operate the power system stems from safety concerns and the practical necessity of protecting electrical equipment from high currents that arise from faults. The simple fuse has evolved to today's sophisticated microprocessor based relays that control circuit breakers. Even the isolation of equipment from faults requires sophisticated equipment to sense the currents, recognize the faulted conditions, and coordinate the different protective devices. Relays may operate for a number of other reasons beyond simply high currents, including excessive frequency deviation, low or high voltages, or indications of instability. Thus, although not traditionally thought of in this way, protection is the front line of control.

B. VOLTAGE CONTROL

Voltage control has traditionally been a local feedback control. Generator excitation can be controlled to maintain a set terminal voltage by producing or absorb reactive power. Within the transmission network, voltage can also be maintained by the use of tap-changing transformers or switched capacitors/reactors to provide/absorb reactive power. These are generally slower controls that either follow fixed time schedules or are switched at preset levels. More recently, power electronics have been used as a fast control of the production/absorption of reactive power.

C. *SECONDARY (REGIONAL) VOLTAGE CONTROL*

Some countries have implemented, or begun to implement, secondary voltage control schemes that are analogous to AGC control for frequency. These secondary schemes typically monitor voltage at key buses and then schedule voltage over a wider region to maintain the key bus voltage. These voltage set-points are then sent to the local voltage controllers This type of voltage can also be supplemented by a tertiary scheme of scheduling voltages throughout the system, typically to optimize security or minimize losses.

D. COMMUNICATIONS FOR WIDE AREA CONTROLS

Most of the power system controls are local and this is particularly so for the faster controls. The only common wide-area feedback control system is AGC, which resides at the control center. The regional voltage control (used in Europe) and the SPS/RAS control have dedicated communication and computer systems for each scheme.

III. PROPOSED METHODS

A. VECTOR CONTROL

To overcome the problems associated with the scalar control strategy, a control scheme based on the dynamic equations of a grid connected converter is described. A block diagram of the vector control strategy is shown in Figure 1.

The instantaneous grid voltages and currents in the three-phase a-b-c- stationary frame are measured and transformed into the two-phase α-β stationary frame by using the α-β transformation. The rotating angle, θ, of the grid voltage is obtained from the transformed voltages V_α and V_β. The angle is used as the reference angle for the transformations in order to synchronize the transformed signals with the grid voltage. The voltages and currents in the α-β can further be transformed into two DC signal components in the d-q rotating frame which rotates at the AC grid voltage frequency. As far as the control system is concerned, the grid voltage now appears as a constant DC disturbance which is much more easily compensated than the sinusoidal varying value in the stationary frame previously discussed. If the d-axis voltage is aligned with the vector of the grid voltage, the d and q- axis components account for the active power and reactive power current respectively.

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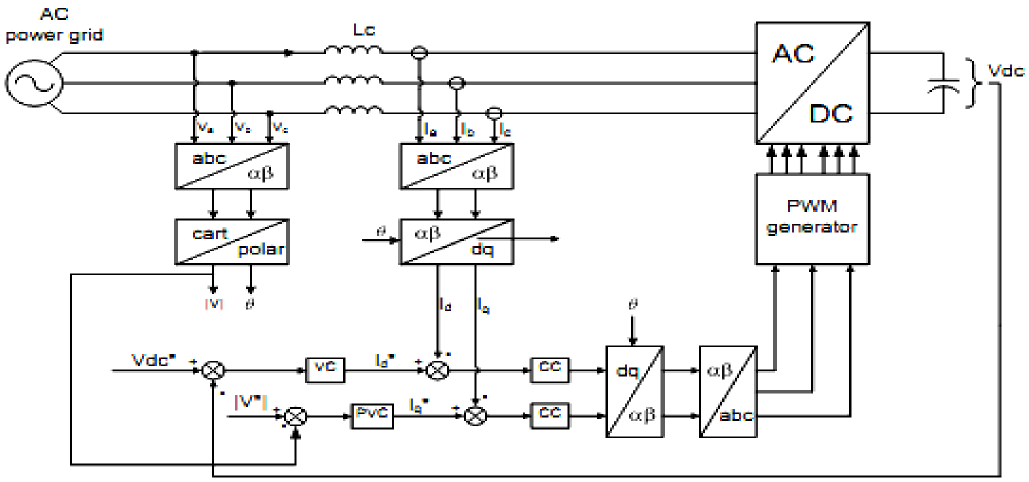

Figure 1: Vector Control Strategy.

The DC voltage is kept constant by the DC voltage controller (VC). The output of the DC voltage controller gives the active power reference (I_d*). The PCC (point of common coupling) voltage is kept constant by the PCC voltage controller (PVC).The output of the PCC voltage controller is the reactive power reference (I_q*). The reference demands (I_d* and I_q*) are compared with the measured and transformed currents (I_d and I_q). Two current controllers are used, one for each axis, to generate the voltage demands V_d' and V_q' which are transformed to V_a' V_b' and V_c', which are then passed to the PWM generator to produce the associated voltages at the ac terminals of the converter. Grid current is usually controlled in order to control active and reactive power exchange. The basic current control techniques employed in grid connected converters are reviewed in the next section.

B. STATCOM

STATCOM is a member of the Flexible AC transmission systems (FACTS) family that is connected in shunt with ac power systems. STATCOM has played an important role in the power industry since the 1980s. STATCOM provides many advantages, in particular the fast response time and superior voltage support capability. STATCOM is used for dynamic voltage control to suppress short term voltage fluctuations because its dynamic performance far exceeds other VAr compensators. STATCOM is a DC-AC voltage source converter with an energy storage unit, usually a DC capacitor. Power electronic switches are used to derive an approximately sinusoidal output voltage from a DC source. The power circuit diagram of a VSC-based STATCOM is illustrated in Figure 2 where six IGBTs with its anti-parallel diodes and a DC-link capacitor are used to produce the three-phase voltage. The STATCOM is coupled to the ac power grid via coupling inductors L_c. The coupling inductors are also used to filter out the current harmonic components that are generated by the pulsating output voltage of the power converter.

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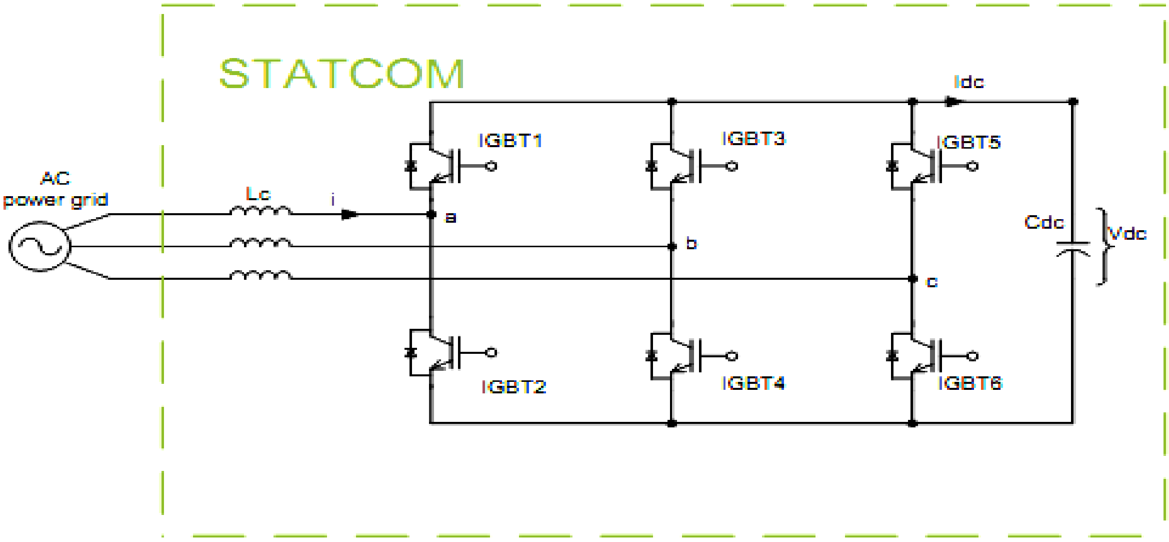

Figure 2: Power circuit diagram of a STATCOM.

C. SWITCHING SEQUENCE

With the space vectors selected and their dwell times calculated, the next step is to arrange switching sequence. In general, the switching sequence designs for a given $\vec{V}_{ref}$ is not unique, but it should satisfy the following two requirements for the minimization of the device switching frequency:

The transition from one switching state to the next involves only two switches in the same inverter leg, one being switched on and the other switched off. The transition for $\vec{V}_{ref}$ moving from one sector in the space vector diagram to the next requires no or minimum number of switching. Figure 3 shows a typical seven-segment switching sequence and inverter out-put voltage waveforms for $\vec{V}_{ref}$ in sector I, where $\vec{V}_{ref}$ is synthesized by $\vec{V}_1$, $\vec{V}_2$ and $\vec{V}_0$. The sampling period T_s is divided into seven segments for the selected vectors.

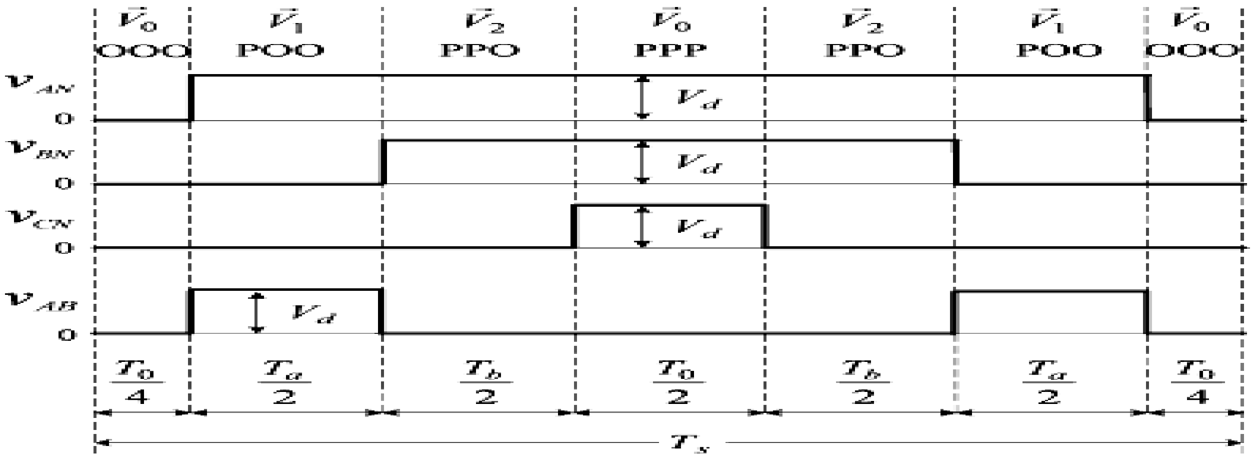

Figure 3: Seven Segment sequence for $\vec{V}_{ref}$ in sector I.

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The following can be observed:

- The dwell times for the seven segments add up to the sampling period ($T_s = T_a + T_b + T_0$).
- Design requirement (a) is satisfied. For instance, the transition from [OOO] to [POO] is accomplished by turning S_1 on and S_4 off, which involves only two switches.
- The redundant switching sates for $\vec{V}_0$ are utilized to reduce the number of switching per sampling period. For the $T_0/4$ segment in the center of the sampling period, the switching state [PPP] is selected, whereas for the $T_0/4$segments on both sides, the state [OOO] is used.
- Each of the switches in the inverter turns on and off once per sampling period. The switching frequency f_{sw} of the devices is thus equal to the sampling frequency f_{sp}, that is, $f_{sw} = f_{sp} = 1/T_s$.

Table 1 gives the seven-segment switching sequences for $\vec{V}_{ref}$ residing in all six sectors. Note that all the switching sequences start and end with switching state [OOO], which indicates that the transition for $\vec{V}_{ref}$ moving from one sector to the next does not require any switching.

Table 1 Seven Segment Switching Sequence

Sector	**Switching Segment**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
I	$\vec{V}_0$	$\vec{V}_1$	$\vec{V}_2$	$\vec{V}_0$	$\vec{V}_2$	$\vec{V}_1$	$\vec{V}_0$
	000	P00	PPO	PPP	PPO	POO	OOO
II	$\vec{V}_0$	$\vec{V}_3$	$\vec{V}_2$	$\vec{V}_0$	$\vec{V}_2$	$\vec{V}_3$	$\vec{V}_0$
	000	OPO	PPO	PPP	PPO	OPO	OOO
III	$\vec{V}_0$	$\vec{V}_3$	$\vec{V}_4$	$\vec{V}_0$	$\vec{V}_4$	$\vec{V}_3$	$\vec{V}_0$
	000	OPO	OPP	PPP	OPP	OPO	OOO
IV	$\vec{V}_0$	$\vec{V}_5$	$\vec{V}_4$	$\vec{V}_0$	$\vec{V}_4$	$\vec{V}_5$	$\vec{V}_0$
	000	OOP	OPP	PPP	OPP	OOP	OOO
V	$\vec{V}_0$	$\vec{V}_5$	$\vec{V}_6$	$\vec{V}_0$	$\vec{V}_6$	$\vec{V}_5$	$\vec{V}_0$
	000	OOP	POP	PPP	POP	OOP	OOO
VI	$\vec{V}_0$	$\vec{V}_1$	$\vec{V}_6$	$\vec{V}_0$	$\vec{V}_6$	$\vec{V}_1$	$\vec{V}_0$
	000	POO	POP	PPP	POP	POO	OOO

IV. COMPARATIVE RESULTS ANALYSIS

In this section we discuss the complete simulation model with shows the result for the automatic control grid model. Here we used the performance parameter block to set the initial values and design the FFT block for the further analysis. Firstly here we configure the initial parameters in simulation and configuration options. Here figure 4 shows the complete model of analysis tools.

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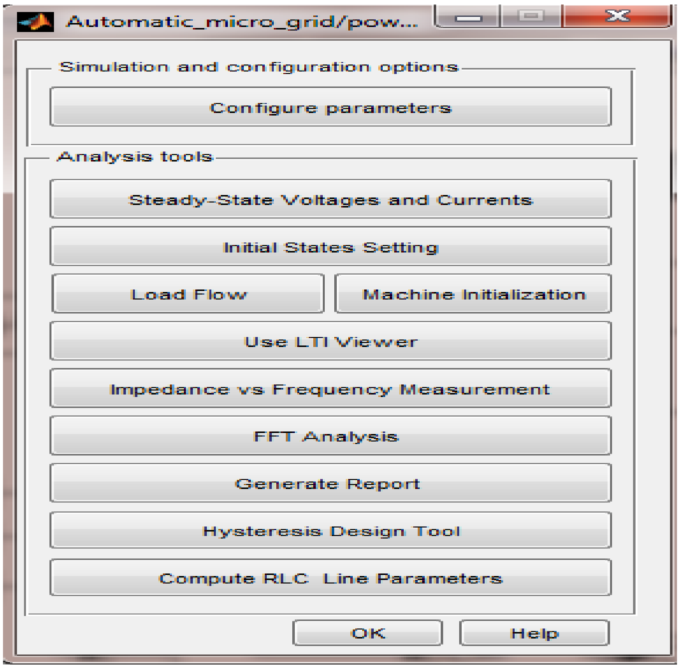

Figure 4: Shows the Power GUI window.

here we discuss the about the experimental result and shows here the simulation window for the results. Here we contains the FFT window and FFT analysis section window with display and analysis window using tools and the selected signals cycles shows in different colors red and blue. This all simulation results work with the frequency of 50 Hertz.

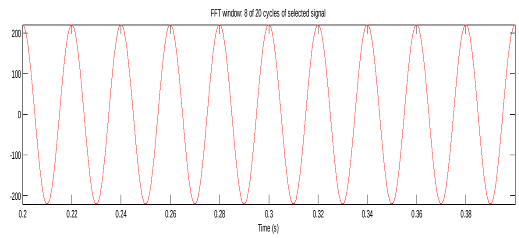

Figure 5: FFT window for 8 of 20 cycles of selected signal.

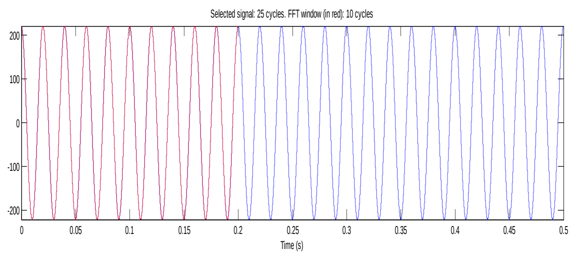

Figure 6: Selected analysis window for 8 of 25 cycles of selected signal in shows red and blue color.

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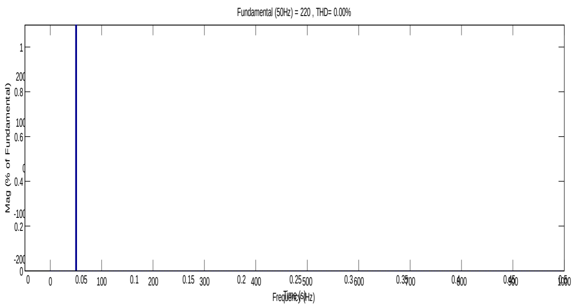

Figure 7: Simulation of FFT window for 50 Hertz.

V. CONCLUSION AND FUTURE WORK

In this paper design automatic micro grid central controller is designed for handling the distributed energy resources. Whenever a fault occurs on main grid, the controller isolates the micro grid from the main grid. After isolation, the controller removes the non-critical load from the micro grid. Two types of central controllers are designed based on voltage control and power control. In power control based controller, firstly it measures the power available from the distributed energy resources and switch on the critical loads in priority order according to the power availability. The second controller works on voltage stability. In this controller, it shuts down the non-critical load until the voltage does not come in the nominal limits. In future used communication features among the different kind of loads can be explored with the help of wireless communication.

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