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Experimental Analysis of Adaptive Control of a Voltage Source Converter for Power Factor Correction

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Abstract

In this paper an adaptive manipulates is designed for a 3-phase voltage supply converter (VSC) performing as a static synchronous compensator to offer power element compensation. The proposed method is based on an approximate third order nonlinear version of the VSC that accounts for uncertainty in 3 device parameters. The layout guarantees asymptotic monitoring of q-axis modern and dc-voltage reference trajectories

Keywords:—*Adaptive Control, Voltage source converters (VSC), Power factor (Power Factor Correction), SPWM, Phase lock loop, THD, PCC*

I. Introduction

A passivity based controller is proposed in those copies with unbalanced cutting edge and parameter uncertainties. The VSC model is evolved the use of negative and high quality sequence dynamics. In contrast to the method proposed on this paper, not one of the previous work includes an adaptive manipulate for a version and statements concerning its performance are stepped forward in that regard. This paper improves on work by means of supplying experimental validation and an evidence of the way the controller achieves robust Monitoring overall performance. The paper is organized as follows: first, Third-order VSC models based totally on different electricity balances are offered. After a easy non-linear country transformation, a linear model is obtained and its adaptive control derived. Simulation and experimental validation show the approach's performance. A PI manage is cascaded with the d-axis contemporary manipulate to attain sturdy tracking of regular dc voltage. A manage approach is proposed for a 3rd order VSC model. Uses Lyapunov's stability outcomes and assumes a regular dc load modem so the controller is unbiased of circuit parameters. A non-linear sliding mode manage offers robustness to parameter uncertainty and disturbance inputs. Some other approach exploits the differential flatness of the machine and takes strength saved in the VSC and the q-axis modern day as linearizing output.

II. Techniques Description

2.1 Three-Phase VSC Modeling

A normal application of electricity factor correction using a VSC. The VSC is connected at a point of common coupling (percent) to a balanced three-section source and inductive load through clear out inductors. The inductive load introduces a segment shift among the AC source modern and voltage, and this leads to lagging energy factor seen from the AC supply. The VSC is in parallel with the burden to improve power factor. The three section VSC contains six insulated gate bipolar transistors (IGBTs) every with an ANT parallel diode to provide a path for a current when the transistor is off. The impedance of each filter inductor, which also includes IGBT conduction losses, is assumed balanced and equal to R+ $j\omega L$, where ω is the angular frequency of the AC source.

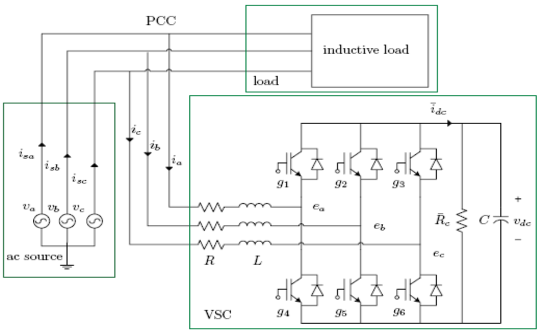

Figure 1: Circuit diagram for three phase

The AC source voltage are denoted v_a, v_b, v_c the AC source currents *isa, isb, isc,* the currents flowing into the converter are i_a, i_b, i_c and the VSC terminal voltages are ea, eb, ec. The VSC gating signals g1---g6 are binary valued and generated by sinusoidal pulse width modulation (SPWM). SPWM is based on comparing a triangular carrier wave with three-phase modulation signals. The phases of the modulation signals are shifted by $2\pi/3$ and by by δ relative to the ac source. The SPWM amplitude modulation index is denoted by *ma* and is determined by the ratio of the amplitudes of the modulation and carrier signals. Other choices of modulation are possible, e.g., space vector modulation, with straightforward modification.

2.2 Adaptive Control

Adaptive manage is the manage approach used by a controller which should adapt to a managed system with parameters which range, or are to begin with unsure. For instance, as an plane flies, its mass will slowly decrease as a result of gas consumption; a manipulate law is wanted that adapts itself to such converting conditions. Adaptive control isn't the same as sturdy manipulate in that it does now not want a priori facts approximately the boundaries on these unsure or time-various parameters; robust manipulate ensures that if the changes are within given bounds the manage regulation want now not be changed, whilst adaptive manage is involved with manipulate regulation changing them.

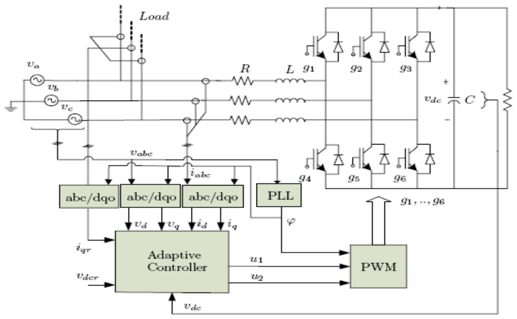

Figure 2: Circuit diagram Adaptive control

III. Simulation Design without Modulation

A simulation design modulation technique as shown in Figure 3 is 13 level symmetric MLI and figure 4 & 5 is corresponding voltage waveform & current distortion. Figure 6 & 8 is the proposed 13 & 31 levels Asymmetric MLI. Figure 7 is corresponding voltage waveform. The THD analysis is also compared for all the three simulations which is shown below in Figure 5, 8 & 9.

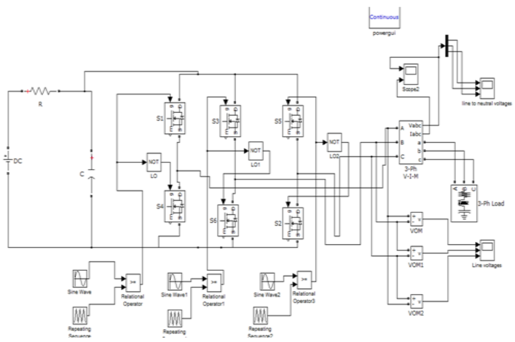

Figure 3: Voltage Source converter without adaptive control

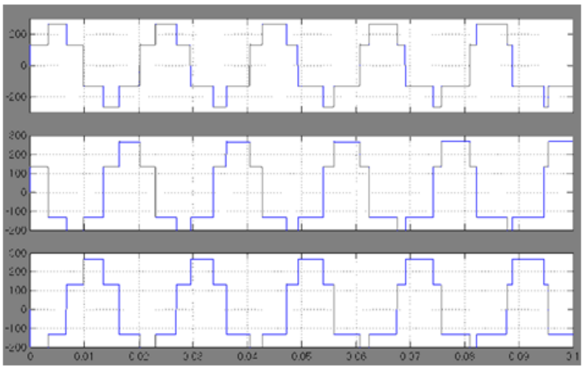

Figure 4: Line to neutral voltage waveform

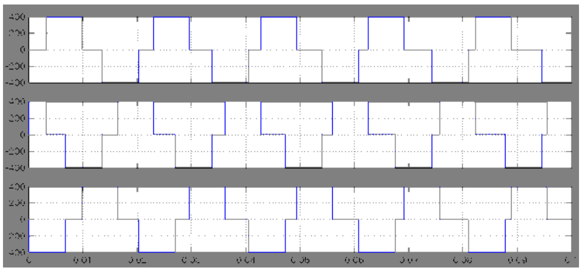

Figure 5: Line voltage waveform

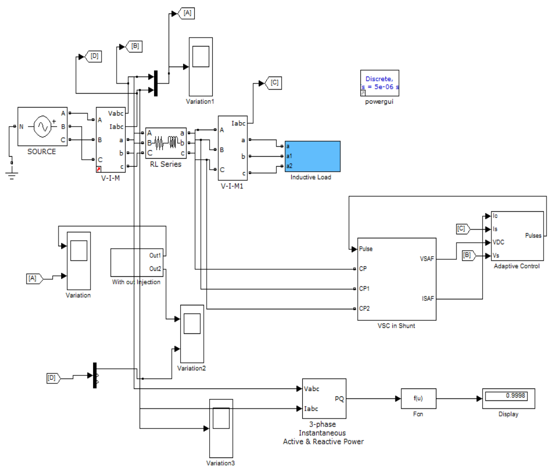

Figure 6. Proposed VSC with adaptive control

IV. Modulation Technique Types of Adaptive Control Technique

In general one should distinguish between:

1. Feed forward Adaptive Control
2. Feed back Adaptive Control as well as between
   - (i) Direct Methods and
   - (ii) Indirect Methods.

Direct methods are ones wherein the estimated parameters are those directly used in the adaptive controller. In contrast, indirect methods are those in which the estimated parameters are used to calculate required controller parameters There are several broad categories of feedback adaptive control (classification can vary):

Dual Adaptive Controllers [based on Dual control theory]

1. Optimal Dual Controllers [difficult to design]
2. Suboptimal Dual Controllers
3. Nondual Adaptive Controllers
4. Adaptive Pole Placement
5. Extremum Seeking Controllers
6. Iterative learning control
7. Gain scheduling
8. Model Reference Adaptive Controllers (MRACs)

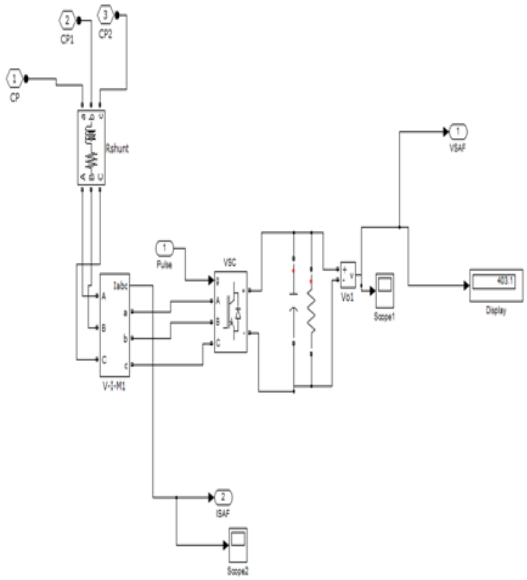

Figure 7. Shunt VSC

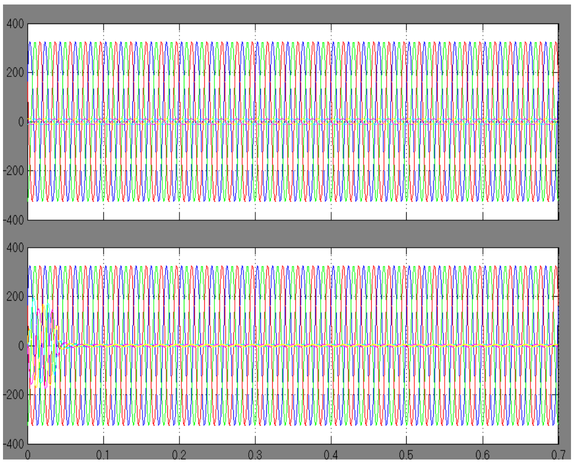

Figure 8. Voltage and current without injection

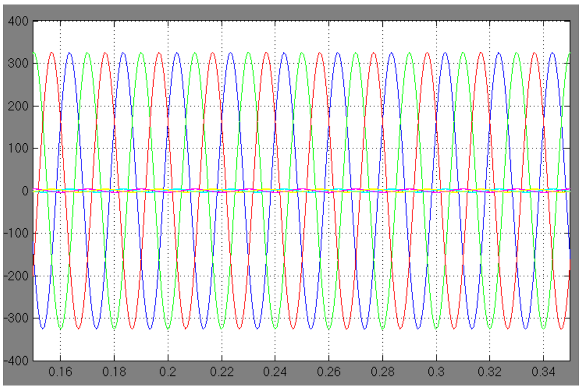

Figure 9. I/P voltage and Current waveform

V. Applications

When designing adaptive control systems, special consideration is necessary of convergence and robustness issues. Lyapunov stability is typically used to derive control adaptation laws and show convergence. Typical applications of adaptive control are (in general) Self-tuning of subsequently fixed linear controllers during the implementation phase for one operating point; Self-tuning of subsequently fixed robust controllers during the implementation phase for whole range of operating points; Self-tuning of fixed controllers on request if the process behaviour changes due to ageing, drift, wear etc.;

Adaptive control of linear controllers for nonlinear or time-varying processes; Adaptive control or self-tuning control of nonlinear controllers for nonlinear processes; Adaptive control or self-tuning control of multivariable controllers for multivariable processes (MIMO systems); Usually these methods adapt the controllers to both the process statics and dynamics. In special cases the adaptation can be limited to the static behavior alone, leading to adaptive control based on characteristic curves for the steady-states or to extremum value control, optimizing the steady state. Hence, there are several ways to apply adaptive control algorithms.

5.1 Advantages

For HVDC transmission. To reduce the complexity of the control design, design accounts for a more precise VSC model and statements regarding its performance are improved The DC voltage transient is indirectly controlled by d-axis current response. Power factor correction is achieved almost unity.

5.2 Increased voltage

A conclusion section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

VI. Conclusion

Various forms of stability may be discussed for the answers of differential equations describing dynamical systems. The most vital kind is that regarding the stableness of answers near to a degree of equilibrium. This can be mentioned by way of the theory of Lyapunov. In easy terms, if all solutions of the dynamical system that start out near an equilibrium factor stay near all the time, then is Lyapunov solid.

Extra strongly, if is Lyapunov solid and all answers that start out near converge to, then is asymptotically solid. The perception of exponential balance ensures a minimum rate of decay, i.e., an estimate of the way fast the answers converge. The concept of Lyapunov balance can be prolonged to countless-dimensional manifolds, in which it's far known as structural stability.

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