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Adaptive Active Damper for Improving the Stability of Grid-Connected Inverters: Review

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Abstract - A weak grid might cause instability in a system that uses a grid-connected inverter. The point of common coupling (PCC) can be coupled to an adaptive active damper, which will automatically adjust a virtual resistor to the critical value in order to stabilise the system. Additionally, a harmonic current reference compensation approach is employed to control the virtual resistor simulation throughout a broad frequency range. This study presents the use of the harmonic current reference compensation approach for the three phase adaptive active damper controlled by the decoupled synchronous d-q frame, synchronous α−β frame, and stationary α−β frame. This technique allows the adaptive active damper to directly regulate both reactive and active power while simultaneously enhancing the stability of the grid-connected inverters in the event of a weak grid.

Key Words: Active damper; grid-connected inverter; active and reactive power control; hybrid frame, pi controller and fuzzy logic controller

1.INTRODUCTION

When the dispersed power age frameworks collapse, the power lattice resembles a weak matrix that is attributed to a massive arrangement of network impedance values. The inverters often become unstable when linked to a weak grid, even though they are designed to be stable when coupled to a stiff grid via point of common coupling. An impedance-based stability criteria is commonly employed to evaluate the stability of the system. This considers two factors: (1) the inverter's stability in the presence of a stiff grid condition; and (2) the inverter's compliance with the Nyquist criteria on the ratio of grid impedance to output impedance.

To work on the steadiness of the framework either the control boundaries should be upgraded or the control calculation of the matrix associated inverter should be changed so that the result impedance becomes positive. These techniques make the framework strong and stable against the varieties in the lattice impedances and yet there is need of progress in the inside arrangement of the network associated inverters, power circuit and control calculations, which are typically separately planned [1].

In an elective technique, an outside damping resistor is associated in lined up at the purpose in like manner coupling in order to moist out the resonances between the framework and matrix associated inverters. This resistor when refreshed with power electronic converters in order to kill the expansion power misfortune in the framework is named as dynamic damper.

In most cases, active dampers are coupled with a variety of filtered grid-connected inverters. These filtrations might be of L sort, LC type, LCL type and so on. where the fundamental filtering type is the L type. A capacitor is connected in series to the filter in order to lower the voltage rating of the active damper. Additionally, it preserves the fundamental voltage component at the common coupling point. In comparison to other options, the use of an active damper and LCL filtered grid-connected inverter results in better attenuation of switching frequency harmonics, a smaller construction footprint, and greater feasibility [2].

Through the replication of a virtual resistor during symphonious frequencies and subsequent control of the resultant current symphonious parts so that it is relative to the location of normal coupling voltage music, the dynamic damper exhibits comparable working guidelines to that of the resistive dynamic power channel. Similar to an inverter connected to a lattice, the dynamic damper functions by introducing flows into the network. To achieve a wide control band width and high exchanging frequencies, the dynamic damper's power rating is kept lower in comparison to the network-associated inverters in the framework.

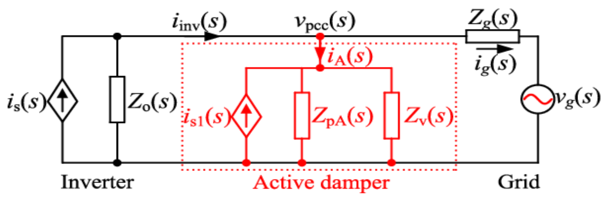

Fig.1 Active Damper System Connection

2. ADAPTIVE DAMPING

By modifying the controller the frequency characteristics of the system can be changed. The oscillations of the LCL filter can be damped by controlling the transfer function of the controller. This is done so as to remove undesired frequencies from the output voltage of inverter by making use of modulation signal modification of the PWM. This method is termed as active damping.

There are various ways to achieve active damping like using a filter to remove resonant frequencies from the inverter output voltage or making use of a resistor.

ACTIVE DAMIPNG USING NOTCH FILTER

A notch (negative peak) filter usually consists of LC resonant tank. Its transfer function is given by:

$$F_{notch} = \frac{L_n C_n s^2 + 1}{L_n C_n s^2 + R_n C_n s + 1}$$

$$L_n = 1mH$$

$$R_c = \frac{1}{3}\frac{1}{2\pi f_{0_v} C}$$

$$R_n = \sqrt{\frac{(2\pi f_n)^2 L_n C_n - 1}{(2\pi f_n C_n)^2}}$$

Here the frequency fn is the filter band width around the LCL filter resonant frequency $f0v$.

ACTIVE DAMPING USING VIRTUAL RESISTOR

This method of active damping using virtual resistor is based on LCL filter capacitor current sensing and multiplication of this current by the resistance of virtual damping resistor. The virtual voltage so obtained is subtracted from PWM modulating voltage.

The use of virtual resistor does not change the frequency characteristics of the system for frequencies higher than that of resonant frequency $f0v$. It showcases similar behavior as that of passive damping resistor. Even though it requires a sensor it is more robust as compared to others.

ADAPTIVE TUNING METHOD OF THE VIRTUAL RESISTOR

In practical applications, the information of the grid connected inverter and the grid impedance may be inaccessible, thus the desired damping resistor cannot be directly calculated with (8). Although the stability of the system can be guaranteed by synthesizing an extremely small resistor, it will lead to a large current flow in the active damper and increase the power loss. Note that when a system is destabilized, the resonance between the grid-connected inverter and the grid will dramatically amplify the harmonic components in the PCC voltage. Therefore, it is possible to adaptively regulate the virtual resistor Rv according to the harmonic content of the PCC voltage. If the harmonic content is within an acceptable range, it indicates that the system is stable and Rv could be increased, whereas if the harmonic content rapidly increases, it indicates that the present Rv is not small enough to stabilize the system, and Rv should be decreased until the system become stable again. The implementation of the adaptive tuning method . By squaring vpcch and sending the result to a low-pass filter GLPF(s) to eliminate the ripples, its mean-square value 2 Vpcch can be obtained, where Vpcch is the RMS value of vpcch. GLPF(s) can simply be a firstorder low-pass filter,

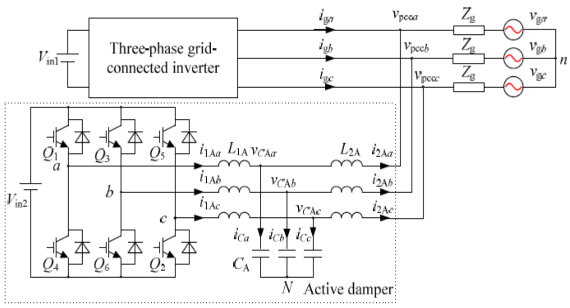

Fig. 2 Circuit Diagram of Three phase grid connected inverter with adaptive active damper

3. METHODOLOGY

The main focus of this explanation is on the adaptable dynamic damping method, which involves placing an external resistor at the point of normal contact to reduce reverberation between the lattice-connected inverters and the framework. Power electronic converters, also known as active dampers, have taken the position of this resistor in modern electronics. This technique is known as active damping. The model described in the dissertation, which is shown in Figure 2, shows how an active damper may be added to a grid-connected inverter that is running on a weak grid. The active damper in this case is implemented by a grid-connected inverter that is filtered via LCL. The working of versatile dynamic damper is like that of resistive dynamic power channel that reproduces a virtual resistor with symphonious frequencies so that the result current consonant parts are corresponding to point of normal contact consonant voltage.

There are different functional guideline utilized by the dynamic damper that is talked about beneath momentarily:

3.1 Active damper under hybrid frame

The hybrid frame makes use of the synchronous d-q frame's direct control of active and reactive power in addition to the harmonic current reference and filter capacitor current feedback from the stationary - frame.

To put it succinctly, the adaptive active damper automatically mimics a virtual resistor in order to dampen the resonance at the common coupling point and enhance the stability of gird-connected inverters in weak grid conditions. Likewise, it can likewise be taken as a LCL type network associated inverter that infuses current into the framework.

3.2. Fuzzy Logic Controller

Before the control algorithm for a shunt active filter is put into practice, the DC side capacitor voltage must be measured and compared to a reference value. The error and the shift in error are two factors that contribute to fluff handling. In a fuzzy controller, a set of language rules determines the control action. The advantage is that it can operate with erratic information sources and does not require a numerical model.

3.3 Design of Control Rules

The fuzzy control rule design involves defining the rules that relate the input variables to the output model properties. Since fuzzy logic controller is independent of system model, the design is majorly based on the intuitive feeling and experience of the process. The rules are expressed in English like language with syntax such as If {error *e* is Aand change of error *Δe* is B} then {control output is C}. For better control performance finer fuzzy petitioned subspaces (NL, NM, NS, ZE, PS, PM, PB) are used.

3.4 Advantages of Fuzzy Control

The advantages of fuzzy control over the adaptive control can be summed as follows:

- It relates output to input, without much understanding all the variables, permitting the design of system to be more accurate and stable than the conventional control system.
- the linguistic, not numerical; variables make the process similar to that of human thinking processThe fuzzy controller uses two input membership variables; error E and change in error dE. The fuzzy function has only one output. The function considered is 'mamdani' function with seven membership functions in each variable

4. CONCLUSIONS

An active damper, which mimics a resistor to damp the resonance between the grid-connected inverter and the grid, can be connected to the PCC to ensure the stability of a grid-connection system under weak grid conditions. A versatile tuning strategy for the virtual resistor in light of the location of the PCC voltage is proposed, which doesn't depend on the data of the lattice associated inverter or the framework. In addition, the active damper's equivalent circuit is derived, demonstrating that the virtual impedance and the original port impedance comprise its total port impedance. at the point when the framework is associated with various regulator based dynamic damper circuits, the music will be less in the event of FIS regulator when contrasted with PI regulator.

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