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CO-ORDINATION OF MATRIX CONVERTER WITH DYNAMIC LOAD VARIATIONS FOR POWER QUALITY IMPROVEMENT

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ABSTRACT

Here, in this paper, a cascaded current–voltage control method is advance for inverters to simultaneously increase the power quality of the inverter variable load voltage and the current variable with the grid system. It also allows seamless change of the working manner from stand-alone to grid-connected system or vice versa. The control method added an internal voltage loop and an external current loop, with both controllers' models using the Hotedious control method. This better to a very less total harmonic distortion in both the interfering variable load voltage and the current change with the grid system at the same time. This method can be worn to single-phase inverters and three-phase four-wire inverters. It allows grid-connected system to inject fair better currents to the grid system even while then variable loads are unfair and nonlinear. The demonstration under different method, with comparisons made to the current repeated controller modified with a current proportional–resonant controller is occurrence to experimental the better performance of the proposed method.

Keyword: H ∞ Controlling Process, Micro Grids System, Power Quality Method, Tedious Controls, Seamless Exchange, Total Harmonic Distortion (THD).

I. INTRODUCTION

Microgrids are appear as a effect of rapidly increases distributed power production network. Improving the controlling working and operational methods of microgrid system gives environmental and economic improvements. The initiation of microgrids increase to better power quality system, reduces transmission crowding, decreases quality and system losses, and better facilitates the improved of renewable energy methods. Microgrids are generally working in the grid-connected method; while, it is also expect to increase sufficient production capacity, controls, and working methods to supply at less a part of the variable load after that having disconnected from the distribution network and to remain working as a standalone process. Generally, the inverters wore in microgrids acts as current sources while they are having to the grid system and as voltage sources while they work autonomous. This includes the changes of the process when the working method is changed from islanded to grid-connected system. It is advantage to working inverters like voltage sources since there is not to change the process while the operation method is exchanged. A parallel control method consistsofanexternalvoltagecontrollinganda grid current process was proposed in to order to getting seamless transfer via changing the direction to the process without changing the method. Another power quality draw back in microgrids is the total harmonic distortion (THD) of the inverter variable load voltage and the current changed with the grid system when it needs to be continuous low according to industrial variations.

This may fault have been believe impossible since there even be nonlinear variable loads. Here, a cascaded control construction consisting of an internal-loop voltage controller and an external-loop current process is proposed to increase this, after hat observed that the inverter LCL filter system can be divided into two different parts This LC part can be worn to operating the voltage controlling and the grid system interface inductor can be worn to design the current controller.

The voltage controller is accountable for the power quality system of the inverter variable load voltage and power dispatch and synchronization with the grid system, and the current controller is accountable for the power condition of the grid system current, the power interchanged with the grid system and the excess current protection. As a result, the inverter can manage with irregular variable loads for three-phase applications.Inotherwords,harmoniccurrentsandirregular variable load currents are all carrying locally and do not cause the grid system. Experimental outputs are presented to describe the better working of the proposed control method

II. PROPOSED CONTROL SCHEME

Fig. 1 shows the scheme of a single-phase inverter attached to the grid system. It exiting of an inverter bridge system, an *LC* filter scheme, and a grid system interfacing inductor coupled with a circuit breaker. It is worth noting that the variable loads are attached in parallel with the filter capacitor method.

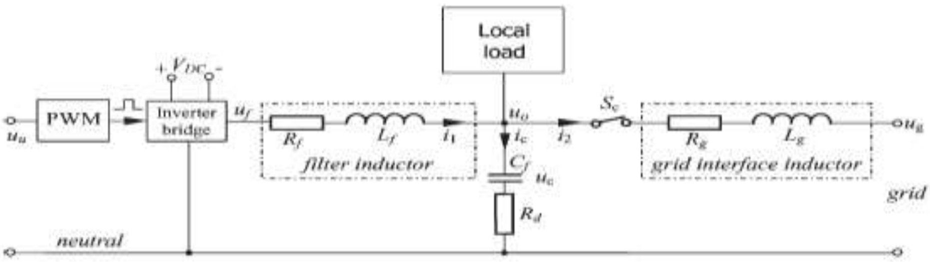

Fig.1.Sketch of a Grid-Connected Single-Phase Inverter with Local Loads

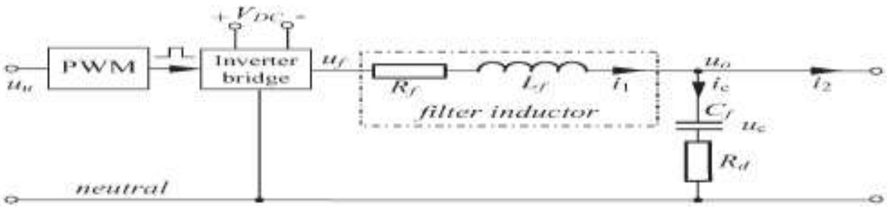

Fig.2. Control Plant Pufor the Inner Voltage Controller

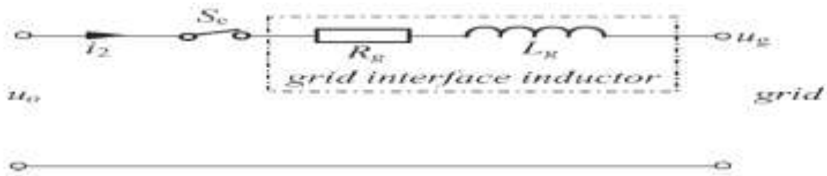

Fig. 3 Control Plant Pi for the Outer Current Controller

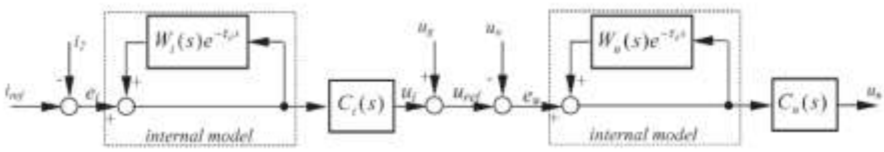

Fig. 4. Proposed cascaded current–voltage controller for inverters, where both controllers adopt the *H*∞repetitive strategy

The current $i1$ passing through the filter inductor connection is called the filter inductor current here; in this paper, and the current $i2$ passing through the grid system interfacing inductor is called the grid system current. The basically managing is to support low value of THD for the inverter variable load voltage u_o and, similarly, for the grid current $i2$. As a result of fact, the system can be consider as two separated parts, as shown in Figs. 2 and 3, cascaded connection together. Here, a cascaded controller process can be affect and designed.

The proposed controller method, as shown in Fig. 4, it consists of two loops are: an internal voltage loop to control the inverter variable load voltage u_o and an external current loop to controls the grid current $i2$. The following primary principles of controlling operation theory about cascaded control system, if the dynamics of the external loop is designed to be lesser than that of the internal loop, then those two loops can be designed differently. While the inverter is synchronize and connected with the grid system, the voltage and the frequency are obtained by the grid system. The main role of the external-loop current controller is to transform a clean current with the grid system even though in the exiting of grid voltage variations and nonlinear variable loads attached to the inverter.

The current regulating system can be worm for over current protection method, but basically, it is added in the drive circuits of the inverter bridge method. Further the main feature is that the grid voltage u_g is support forward and increased to the output of the current controlling method. This is wornas a synchronization mechanism and it does not results the designer of the controller system as will be seen later session.

III. DESIGN OF THE VOLTAGE CONTROLLER

The outline of the voltage controller will be defined herein following the complete method suggests. Animportantquality different from what is have is that the control plant of the voltage control is no longer the while LCL filter yet like that LC filter system, as shown in Fig. 2.

3.1 State-Space Model of the Plant Pu

The corresponding controlling plant shown in Fig. 2 for the voltage controller exiting of the inverter bridge and the LC filter of L_f and C_f parameters. The filter inductor is designed with a series winding resistance process. The PWM block, running with the help of inverter is designed by using an average voltage nearer to the ranges of the available dc-link voltage in order that the average value of $u_f$above a sampling interval is equal to u_u. As aeffect, the PWM block and the inverter bridge method can be disregard when scheming the controller.

The filter inductor current i1 and the capacitor voltage uc are select as state variables xu = [i1 uc]T . The external input wu = [i2 u_{ref}]T_{exist} of the grid current i2 and the referral voltage u_{ref} . The control input is uu. The output signal from the plant Pu is the follow error eu = uref − uo, where uo = uc + Rd(i1 − i2) is the inverter variable load voltage. The plant Pu can be obtained by the state equation

$$\dot{x}_u = A_u x_u + B_{u1} w_u + B_{u2} u_u \quad (1)$$

and the output equation

$$y_u = e_u = C_{u1} x_u + D_{u1} w_u + D_{u2} u_u \quad (2)$$

The corresponding plant transfer function is then

$$P_u = \left[\begin{array}{c|cc} A_u & B_{u1} & B_{u2} \\ \hline C_{u1} & D_{u1} & D_{u2} \end{array}\right]. \quad (3)$$

3.2 Formulation of the Standard H∞ Problem

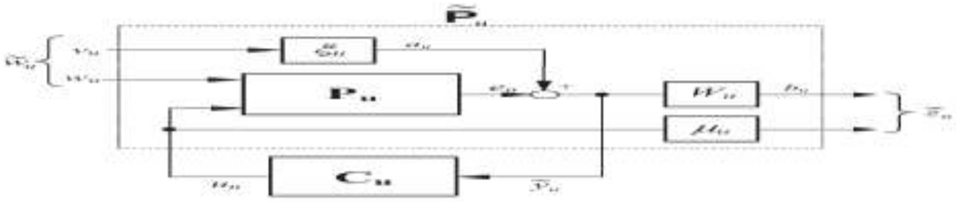

Fig.5. Formulation of the H∞ Control Problem for the Voltage Controller

In order to more guarantee the stability of the internal voltage loop, an H∞ controlling problem, as shown in Fig. 5, is formulate to decrease the H∞ norms of the transfer function of T˜zu˜wu =
Fl(˜ Pu, Cu) from ˜ wu = [vu wu]T to ˜zu = [zu1 zu2]T, after that it opening the confined positive feedback loop of the internal method and including weighting parameter valuesξu and μu. The closed loop system can be constitute as

$$\begin{bmatrix} \tilde{z}_u \\ \tilde{y}_u \end{bmatrix} = \tilde{P}_u \begin{bmatrix} \tilde{w}_u \\ u_u \end{bmatrix}$$
$$u_u = C_u \tilde{y}_u \qquad (4)$$

where ˜ Pu is the generalized plant and Cu is the voltage controller to be designed.

The feature of how to select Wu can be determined. A weighting parameter ξu is included to controlling the main relative importance of vu with respect to wu, and other weighting variable μu is included to adjusting the relative importance of uu with respect to bu. The parameters ofξu and μu also placed a role in guaranteeing the stability of the connectedsystem; see more details. It could be found out that the generalized plant ˜ Pu is realized as

$$\tilde{P}_u = \left[\begin{array}{cc|cc:c} A_u & 0 & 0 & B_{u1} & B_{u2} \\ B_{w_u}C_{u1} & A_{w_u} & B_{w_u}\xi_u & B_{w_u}D_{u1} & B_{w_u}D_{u2} \\ \hline D_{w_u}C_{u1} & C_{w_u} & D_{w_u}\xi_u & D_{w_u}D_{u1} & D_{w_u}D_{u2} \\ 0 & 0 & 0 & 0 & \mu_u \\ \hdashline C_{u1} & 0 & \xi_u & D_{u1} & D_{u2} \end{array}\right] \qquad (5)$$

The controller Cu can then be found according to the generalized plant ˜Pu using the H∞ control theory, e.g., by using the function hinfsynprovided in MATLAB.

IV. DESIGN OF THE CURRENT CONTROLLER

As mentioned before, when modelling the external-loop current controller, it can be suppose that the inner voltage loop paths the referral voltage perfectly, i.e., uo = uref . Hence, the regulated plant for the current loop is easily the grid connected inductor, as shown in Fig. 3. The formulating of the H∞ control problem to model the H∞ compensator Ci is similarly to that in the instance of the voltage controlling loop shown in Fig.5 yet with a different plant Pi and the subscript u exchanged with i.

4.1 State-Space Model of the Plant Pi

Since it can be assumed those areuo = uref , there is uo = ug + ui or ui = uo − ug from Figs. 3 and 4, i.e., ui is basically the voltage dropped on the grid inductor. The feedforwarded grid system voltage ug provides a base variable load voltage for the inverter. The same voltage ug getting on both sides of the grid connected interface inductor Lg, and it does not results the controller model. Hence, the feedforwarded voltage pathway can be eliminated.

TABLE I

PARAMETERS OF THE INVERTER

Parameter	Value	Parameter	Value
L_f	$150\mu H$	R_f	0.045Ω
L_g	$450\mu H$	R_g	0.135Ω
C_f	$22\mu F$	R_d	1Ω

4.2 Formulation of the Standard H∞ Problem

Actually, a standard H∞control problem can be formulating as in the occurrence of the voltage controller shown in Fig. 5, exchanging the method of subscript u with i. The resulting generalized plant can be obtained as

$$\tilde{P}_i = \left[\begin{array}{cc|cc:c} A_i & 0 & 0 & B_{i1} & B_{i2} \\ B_{w_i}C_{i1} & A_{w_i} & B_{w_i}\xi_i & B_{i1}D_{i1} & B_{w_i}D_{i2} \\ \hline D_{w_i}C_{i1} & C_{w_i} & D_{w_i}\xi_i & D_{w_i}D_{i1} & D_{w_i}D_{i2} \\ 0 & 0 & 0 & 0 & \mu_i \\ \hdashline C_{i1} & 0 & \xi_i & D_{i1} & D_{i2} \end{array}\right] \quad (6)$$

with weighting parametersareξi and μi and low-pass filter Wi =

$$\left[\begin{array}{c|c} A_{w_i} & B_{w_i} \\ \hline C_{w_i} & D_{w_i} \end{array}\right],$$

Which can be selected similarly as the corresponding ones for the voltage controller. The controller Ci can then be found according to the generalized plant ˜ Pi using the H∞ control theory, e.g., by using the function hinfsyn provided in MATLAB.

V. DESIGN EXAMPLE

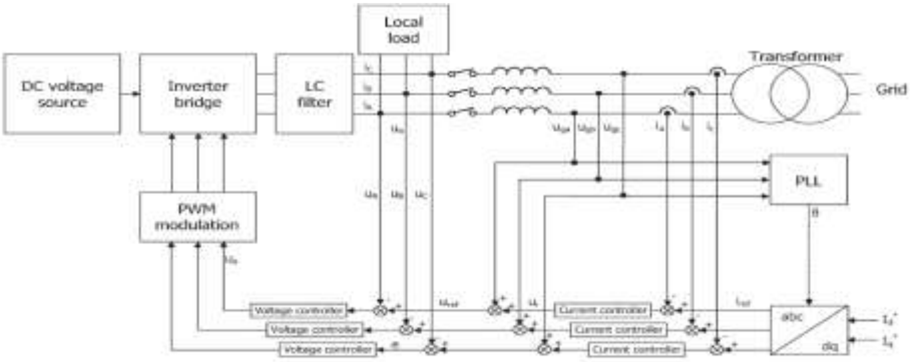

Fig.6. Sketch of a Grid-Connected Three-Phase Inverter Using the Proposed Strategy

As an example of the controllers would be modelled in this segment for an experimentallysystem in which existing of an inverter board system, a three-phase LC filter process, a three-phase grid system interface inductor, a board inhere of voltage and current system of sensors, a connection wye-wye transformer (Rating are 12 V/230 V/50 Hz), a dSPACE DS1104 R&D system controlling board with ControllingDesk software's and MATLAB Simulink/SimPower software packages.

The inverter boardexisting of two separate independent three-phase inverters and have the capacity to generate PWM voltages from a fixed 42-V dc voltage source system. One inverter was worn to generating a constant neutral line for the three-phase inverter controlling method. The generated three-phase voltage was attached to the grid via a controlling circuit breaker mechanism and connected a step-up transformer.

In summary, the suggest control method is able to achieved seamless transfer of operational methods from stand-alone in to a grid-connected systemor vice versa connection.

VI. EXPERIMENTAL RESULTS

The above-implemented controller was implemented in order to estimate its better performance in both stand-alone and grid-connected system methods with differential conditional loads. The seamless movable of the workingmodes was also transfer out. The H∞ repetitively current controller was exchange with a proportional–resonant (PR) system current regulating for reduce or comparison in the grid-connected system model. In the stand-alone model, because the grid system current referral was fixed to zero and the circuit breaker was switched off (which manner that the current controller was not properly functioning), the experimental outputs with both the tedious current controller method and another PR current controller are similarly and thus no comparative outputs are on the condition for the stand-alone model.The PR controller was modelled according to with the plant wornin Ci−PR(s)=0 .735+ 20s s2 /10000π2 .

VII. CONCLUSION

The cascaded current–voltage control method has been suggested for inverters in micro-grid systems. It existing of an internal voltage loopand an external currentloopandoffersexcellent performance in terms of THD system calculation for both the inverter variable load voltage and the grid current method. In particularly, while nonlinear and unstable loads are attached to the inverter in the grid-connected method.

The proposed method significant increases the THD calculations of the inverter variableloadvoltageandthegrid system currentatthesametime operation. The controllers are modelled using the H∞tedious control here in this paper yet could be designed worn other alternatives as well. The suggest strategy also improves seamless exchange between thestand-aloneconditionandthegrid-connectedmethods.The control strategycould be worn for single-phase systems or three-phase systems connected. As a affect, the nonlinear distortions harmonic currents and unstable variable load currents are all carry locally and do not affects the grid system.AnExperimental setup outputsunderdifferent scenarios haveindicated the excellent improved performance of the suggested strategy.

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